AO 120 (Rev. 08/10)

TO:	REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK
Mail Stop 8 **Director of the U.S. Patent and Trademark Office** **P.O. Box 1450** **Alexandria, VA 22313-1450**	

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court for the Eastern District of Texas, Marshall Division on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
2:24-cv-00203	3/20/2024	for the Eastern District of Texas, Marshall Division

PLAINTIFF	DEFENDANT
APEX BEAM TECHNOLOGIES LLC	SAMSUNG ELECTRONICS CO., LTD. and SAMSUNG ELECTRONICS AMERICA, INC.

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	11,063,727	7/13/2021	Apex Beam Technologies LLC
2	11,374,721	6/28/2022	Apex Beam Technologies LLC
3	11,457,426	9/27/2022	Apex Beam Technologies LLC
4	11,546,110	1/3/2023	Apex Beam Technologies LLC
5	11,626,904	4/11/2023	Apex Beam Technologies LLC

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1		
2		
3		
4		
5		

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE

Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director
Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy

AO 120 (Rev. 08/10)

TO:	Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court for the Eastern District of Texas, Marshall Division on the following

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2:24-cv-00203	3/20/2024	for the Eastern District of Texas, Marshall Division

PLAINTIFF	DEFENDANT
APEX BEAM TECHNOLOGIES LLC	SAMSUNG ELECTRONICS CO., LTD. and SAMSUNG ELECTRONICS AMERICA, INC.

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	11,917,581	2/27/2024	Apex Beam Technologies LLC
2	10,965,434	3/30/2021	Apex Beam Technologies LLC
3	11,139,944	10/5/2021	Apex Beam Technologies LLC
4	11,108,639	8/31/2021	Apex Beam Technologies LLC
5	10,986,695	4/20/2021	Apex Beam Technologies LLC

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
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AO 120 (Rev. 08/10)

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In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court for the Eastern District of Texas, Marshall Division on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

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2:24-cv-00203	3/20/2024	for the Eastern District of Texas, Marshall Division

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APEX BEAM TECHNOLOGIES LLC	SAMSUNG ELECTRONICS CO., LTD. and SAMSUNG ELECTRONICS AMERICA, INC.

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	10,979,128	4/13/2021	Apex Beam Technologies LLC
2	11,637,615	4/25/2023	Apex Beam Technologies LLC
3			
4			
5			

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
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UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/950,726	09/22/2022	Xiaobo ZHANG	ZL0205-0004-US-CON3	6005

155075 7590 02/27/2024

Zhong Law, LLC
51 JFK Parkway
1st Floor West
Short Hills, NJ 07078

EXAMINER
ELALLAM, AHMED

ART UNIT	PAPER NUMBER
2471	

NOTIFICATION DATE	DELIVERY MODE
02/27/2024	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

ip@remotedocket.com
szhao@zhong-law.com
zhong@zhong-law.com

APPLICATION NO.	ISSUE DATE	PATENT NO.
17/950,726	27-Feb-2024	11917581

Zhong Law, LLC
51 JFK Parkway
Short Hills, NJ 07078

EGRANT NOTIFICATION

Your electronic patent grant (eGrant) is now available, which can be accessed via Patent Center at https://patentcenter.uspto.gov

The electronic patent grant is the official patent grant under 35 U.S.C. 153. For more information, please visit https://www.uspto.gov/electronicgrants

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/950,726	02/27/2024	11917581	ZL0205-0004-US-CON3	6005

155075 7590 02/07/2024

Zhong Law, LLC
51 JFK Parkway
1st Floor West
Short Hills, NJ 07078

ISSUE NOTIFICATION

The projected patent number and issue date are specified above. The patent will issue electronically. The electronically issued patent is the official patent grant pursuant to 35 U.S.C. § 153. The patent may be accessed on or after the issue date through Patent Center at https://patentcenter.uspto.gov/. The patent will be available in both the public and the private sides of Patent Center. Further assistance in electronically accessing the patent, or about Patent Center, is available by calling the Patent Electronic Business Center at 1-888-217-9197.

The USPTO is implementing electronic patent issuance with a transition period, during which period the USPTO will mail a ceremonial paper copy of the electronic patent grant to the correspondence address of record. Additional copies of the patent (i.e., certified and presentation copies) may be ordered for a fee from the USPTO's Certified Copy Center at https://certifiedcopycenter.uspto.gov/index.html. The Certified Copy Center may be reached at (800)972-6382.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 0 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Center (https://patentcenter.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Patents Stakeholder Experience (OPSE), Stakeholder Support Division (SSD) at (571)-272-4200.

INVENTOR(s) (Please see PATENT CENTER site https://patentcenter.uspto.gov for additional inventors):

Xiaobo ZHANG, Shanghai, CHINA;

APPLICANT(s) (Please see PATENT CENTER site https://patentcenter.uspto.gov for additional applicants):

APEX BEAM TECHNOLOGIES LLC, MARSHALL, TX;

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The USA offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to encourage and facilitate business investment. To learn more about why the USA is the best country in the world to develop technology, manufacture products, and grow your business, visit SelectUSA.gov.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17950726
	Filing Date	2022-09-22
	First Named Inventor	Xiaobo ZHANG
	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

	64	11044744	B2	2021-06-22	Yuxin Wang	
	65	10700752	B2	2020-06-30	Byounghoon JUNG	
	66	9379788	B2	2016-06-28	Thorsten Clevorn	
	67	10171212	B2	2019-01-01	Hanjun Park	

If you wish to add additional U.S. Patent citation information please click the Add button. Add

U.S.PATENT APPLICATION PUBLICATIONS Remove

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20110171212	A1	2011-07-14	Claus Belka	
	2	20060164981	A1	2006-07-27	Patrik Olsson	
	3	20100039970	A1	2010-02-18	Aris Papasakellariou	
	4	20100202382	A1	2010-08-12	Sung Jun Park	
	5	20100202560	A1	08/2010 ~~2010-08-06~~	Xiliang Luo	

Change(s) applied to document.

/M.E.G./

12/29/2023

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.E/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	17950726
Filing Date	2022-09-22
First Named Inventor	Xiaobo ZHANG
Art Unit	2471
Examiner Name	AHMED ELALLAM
Attorney Docket Number	ZL0205-0004-US-CON3

Change(s) applied to document, /M.E.G./ 12/29/2023	2	20180070341	A1	03/2018 ~~2022-02-15~~	~~Huawei Technologies Co Ltd~~	Islam et al.
	3	20180097678	A1	04/2018 ~~2020-02-04~~	~~Spreadtrum Communications Shanghai Co Ltd~~	Zhou et al.
	4	20190109695	A1	04/2019 ~~2020-02-25~~	~~LG Electronics Inc~~	Kim et al.
	5	20140148204	A1	2014-12-09	~~InterDigital Patent Holdings Inc~~	Zeira et al.
Change(s) applied to document, /M.E.G./ 12/29/2023	6	20170279579	A1	09/2017 ~~2019-09-17~~	~~Samsung Electronics Co Ltd~~	Qian et al.
	7	20180279289	A1	2018-09-27	~~Huawei Technologies Co Ltd~~	Islam et al.
	8	20180279327	A1	09/2018 ~~2019-10-15~~	~~FG Innovation Co Ltd Sharp Corp~~	Ying et al.
	9	20200099499	A1	03/2020 ~~2021-07-06~~	~~Samsung Electronics Co Ltd~~	Yeo et al.
	10	20110038330	A1	2011-02-17	Luo et al	
	11	20110176519	A1	2011-07-21	Vitthaladevuni et al	
	12	20130308608	A1	2013-11-16	Hu et al	

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.E/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17950726
	Filing Date	2022-09-22
	First Named Inventor	Xiaobo ZHANG
	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

Change(s) applied to document, /M.E.G./ 12/29/2025

	9	10462739	B2	2019-10-29	~~Samsung Electronics Co Ltd~~	Papasakellariou
	10	10660081	B2	2020-05-19	~~LG Electronics Inc~~	You et al.
	11	10660120	B2	2020-05-19	~~LG Electronics Inc~~	Kim et al.
	12	11051293	B2	2021-06-29	~~InterDigital Patent Holdings Inc~~	Tsai et al.
	13	11197283	B2	2021-12-07	~~Huawei Technologies Co Ltd~~	Lyu et al.
	14	11252717	B2	2022-02-15	~~Huawei Technologies Co Ltd~~	Islam et al.
	15	9131490	B2	2015-09-08	Feng et al	
	16	9380568	B2	2016-06-28	Harrison et al	

If you wish to add additional U.S. Patent citation information please click the Add button. Add

U.S.PATENT APPLICATION PUBLICATIONS Remove

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20180054800	A1	02/2018 ~~2018-11-26~~	~~Samsung Electronics Co Ltd~~	Yeo et al.

EFS Web 2.1.17

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.E/

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	17950726
Filing Date	2022-09-22
First Named Inventor	Xiaobo ZHANG
Art Unit	2471
Examiner Name	AHMED ELALLAM
Attorney Docket Number	ZL0205-0004-US-CON3

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
Change(s) applied to document. /M.E.G./ 12/29/2023	1	10135663	B2	2018-11-20	~~Huawei Technologies Co Ltd~~	Qu et al.
	2	10159097	B2	2018-12-18	~~Qualcomm Inc~~	Ji et al.
	3	10271295	B2	2019-04-23	~~InterDigital Patent Holdings Inc~~	Tsai et al.
	4	10419177	B2	2019-09-17	~~Samsung Electronics Co Ltd~~	Qian et al.
	5	8644864	B2	2014-02-04	~~InterDigital Patent Holdings Inc~~	Zeira et al.
	6	10135663	B2	2018-11-20	~~Huawei Technologies Co Ltd~~	Qu et al.
	7	10356778	B2	2019-07-16	~~Asustek Computer Inc~~	Tseng et al.
	8	10448414	B2	2019-10-15	~~FG Innovation Co Ltd Sharp Corp~~	Ying et al.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.E/

UNITED STATES
PATENT AND TRADEMARK OFFICE

P.O. Box 1450
Alexandria, VA 22313 - 1450
www.uspto.gov

ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
17/950,726	**01/09/2024 03:08:08 PM Z ET**	**ZL0205-0004-US-CON3**

Title of Invention

METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	6005	FILED BY	Eddie Rowell
PATENT CENTER #	63864387	FILING DATE	09/22/2022
CUSTOMER #	155075	FIRST NAMED INVENTOR	Xiaobo ZHANG
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	Jialin Zhong

Documents

TOTAL DOCUMENTS: 1

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
17950726_Issue_Fee.pdf	1	Issue Fee Payment (PTO-85B)	193 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
17950726_Issue_Fee.pdf	86677E6545E82908D9AF7642797B5122AFE5A7B4A6E9573C6C63DD36CAA4560C37146C3941A2ECB2250DD64D3A59794932850C9954688E62B16B8D303C5ECFC9

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as

described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via the USPTO patent electronic filing system.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications. **Because electronic patent issuance may occur shortly after issue fee payment, any desired continuing application should preferably be filed prior to payment of this issue fee in order not to jeopardize copendency.**

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

155075 7590 12/06/2023
Zhong Law, LLC
51 JFK Parkway
1st Floor West
Short Hills, NJ 07078

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via the USPTO patent electronic filing system or by facsimile to (571) 273-2885, on the date below.

Eddie Rowell	(Typed or printed name)
/Eddie Rowell/	(Signature)
January 9, 2024	(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/950,726	09/22/2022	Xiaobo ZHANG	ZL0205-0004-US-CON3	6005

TITLE OF INVENTION: METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$480	$0.00	$0.00	$480	03/06/2024

EXAMINER	ART UNIT	CLASS-SUBCLASS
ELALLAM, AHMED	2471	340-007460

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/AIA/122 or PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/AIA/47 or PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 Zhong Law, LLC
2
3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: APEX BEAM TECHNOLOGIES LLC
(B) RESIDENCE: (CITY and STATE OR COUNTRY): Marshall, Texas

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ☒ Corporation or other private group entity ❑ Government

4a. Fees submitted: ☒ Issue Fee ❑ Publication Fee (if required)

4b. Method of Payment: *(Please first reapply any previously paid fee shown above)*

☒ Electronic Payment via the USPTO patent electronic filing system ❑ Enclosed check ❑ Non-electronic payment by credit card (Attach form PTO-2038)

☒ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. 602313

5. **Change in Entity Status** (from status indicated above)

❑ Applicant certifying micro entity status. See 37 CFR 1.29
NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.

❑ Applicant asserting small entity status. See 37 CFR 1.27
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.

❑ Applicant changing to regular undiscounted fee status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature /Jialin Zhong/ Date January 9, 2024

Typed or printed name Jialin Zhong Registration No. 62,937

UNITED STATES
PATENT AND TRADEMARK OFFICE

P.O. Box 1450
Alexandria, VA 22313 - 1450
www.uspto.gov

ELECTRONIC PAYMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
17/950,726	01/09/2024 03:08:08 PM Z ET	ZL0205-0004-US-CON3

Title of Invention

METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	6005	FILED BY	Eddie Rowell
PATENT CENTER #	63864387	AUTHORIZED BY	Jiajin Zhang
CUSTOMER #	155075	FILING DATE	09/22/2022
CORRESPONDENCE ADDRESS	-	FIRST NAMED INVENTOR	Xiaobo ZHANG

Payment Information

PAYMENT METHOD	PAYMENT TRANSACTION ID	PAYMENT AUTHORIZED BY
CARD / 9295	E202419F09156743	Eddie Rowell

FEE CODE	DESCRIPTION	ITEM PRICE($)	QUANTITY	ITEM TOTAL($)
2501	UTILITY ISSUE FEE	480.00	1	480.00
			TOTAL AMOUNT:	$480.00

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage

submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/950,726	09/22/2022	Xiaobo ZHANG	ZL0205-0004-US-CON3	6005

155075 7590 12/26/2023

Zhong Law, LLC
51 JFK Parkway
1st Floor West
Short Hills, NJ 07078

EXAMINER	
ELALLAM, AHMED	

ART UNIT	PAPER NUMBER
2471	

NOTIFICATION DATE	DELIVERY MODE
12/26/2023	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

ip@remotedocket.com
szhao@zhong-law.com
zhong@zhong-law.com

Corrected ***Notice of Allowability***	**Application No.** 17/950,726	**Applicant(s)** ZHANG, Xiaobo	
	Examiner AHMED ELALLAM	**Art Unit** 2471	**AIA (FITF) Status** Yes

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☑ This communication is responsive to IDS filed on 11/19/23.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☑ The allowed claim(s) is/are 1-24 . As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see **http://www.uspto.gov/patents/init_events/pph/index.jsp** or send an inquiry to **PPHfeedback@uspto.gov.**

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☐ All b) ☐ Some* c) ☐ None of the:

   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____ .

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____ .

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☑ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date 11/19/23.
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date. _____.
5. ☑ Examiner's Amendment/Comment
6. ☐ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/AHMED ELALLAM/
Primary Examiner, Art Unit 2471

Notice of Pre-AIA or AIA Status

1. The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

Noted on the IDS:

The IDS filed on 11/19/2023 has been considered.

The IDS filed on 11/19/23 is subject to the following remarks by the Examiner.

Applicant filed two different sets of claims on 07/20/23, and prior to filing the amended claims on 09/24/23, Applicant called the Examiner in order to amend the claims as presented on 09/23/23, Examiner had agreed, and noted the litigations concerning the patented Applications 15/956,742, now patent No. 10462767; US Application 16/577,854, now patent No. 10/966,178; and US Application 17/180,885, now patent 11457426. Applicants agreed to amend the claims in order to have a better patent. Examiner inadvertently did not record the substance of the telephonic Interview prior to the amended claims filed on 09/24/23. Similarly Applicant did not hint to such interview in the record.

Therefore, there is the presumption that Applicant had amended the claims in order to avoid being litigated and/or litigating.

Applicant provided an excessive amount of US references, Foreign references (some without English translation and/or US application/patents counterpart), and non-patent literature without any relevance to the claimed subject matter.

It is also believed that many references are being indicated in the following cited documents:

A) APEX BEAMTECHNOLOGIES LLC v. ONE PLUS TECHNOLOGY (SHENZHEN) CO.,LTD.,DEFENDANT' SINVALIDITYCONTENTIONS, CaseNo.2:22-cv-00032 JRG,November21,2022.

B) APEX BEAMTECHNOLOGIES LLC v. SAMSUNG ELECTRONICS Co.,LTD.,ETAL.,,DEFENDANT'SINVALIDITYCONTENTIONS,CaseNo.2:22-cv-00188-JRG,March2,2023.

C) APEX BEAMTECHNOLOGIES LLC v. ZTE CORPORATION, DEFENDANT'SIN VALIDITY CONTENTIONS,CaseNo.2:22-cv-00031-JRG-RSP, March2,2023.

D) APEX BEAMTECHNOLOGIES LLC v. TCT MOBILE INTERNATIONAL LIMITED,DEFENDANTS'INITIAL INVALIDITY CONTENTIONS, JRG, November9,2023.

E) APEX BEAM TECHNOLOGIES LLC v. ONEPLUS TECHNOLOGY (SHENZHEN) CO., LTD., DEFENDANT'S INVALIDITY CONTENTIONS, Case No. 2:22-cv-00032-JRG, November 21, 2022

F) APEX BEAM TECHNOLOGIES LLC v. SAMSUNG ELECTRONICS Co., LTD., ET AL.,, DEFENDANT'S INVALIDITY CONTENTIONS, Case No. 2:22-cv-00188-JRG, March 2, 2023.

G) APEX BEAM TECHNOLOGIES LLC v. ZTE CORPORATION, DEFENDANT'S INVALIDITY CONTENTIONS, Case No. 2:22-cv-00031-JRG-RSP, March 2, 2023.

H) APEXBEAMTECHNOLOGIESLLCv.TCTMOBILEINTERNATIONALLIMITED,DEFENDANTS'INITIAL INVALIDITY CONTENTIONS, JRG, November9,2023. and

I) SAMSUNG ELECTRONICS CO., LTD., AND SAMSUNG ELECTRONICS AMERICA, INC., v. APEX BEAM TECHNOLOGIES LLC, PETITION FOR INTER PARTES REVIEW, Case IPR2023-0059, February 28, 2023.

Therefore, the excessive amount of information presented in the IDS filed on 11/19/23 would require several experts in the related field, as evidenced by the content of the above documents. Therefore, Applicant has the initial burden to point out any relevant information concerning the filed IDS in light of the above documents. Nevertheless, Examiner had spent a greater amount of time beyond the allocated time for reviewing the IDS, and the allowability of the claims stand proper given the request to amend the claims as 09/24/23.

Conclusion

2. Any inquiry concerning this communication or earlier communications from the examiner should be directed to AHMED ELALLAM whose telephone number is (571)272-3097. The examiner can normally be reached 9-5.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Chi Pham can be reached on 571-2723179. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of published or unpublished applications may be obtained from Patent Center. Unpublished application information in Patent Center is available to registered users. To file and manage patent submissions in Patent Center, visit: https://patentcenter.uspto.gov. Visit https://www.uspto.gov/patents/apply/patent-center for more information about Patent Center and https://www.uspto.gov/patents/docx for information about filing in DOCX format. For additional questions, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/AHMED ELALLAM/ A
Primary Examiner, Art Unit 2471
12/20/2023

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

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First Named Inventor	Xiaobo ZHANG
Art Unit	2471
Examiner Name	AHMED ELALLAM
Attorney Docket Number	ZL0205-0004-US-CON3

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
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	1							☐

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NON-PATENT LITERATURE DOCUMENTS Remove

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.E/

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	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

	1	R1-1610145, Qualcomm, October 1, 2016	☒
	2	R1-1610239, Nokia, Alcatel-Lucent Shanghai Bell, September 30, 2016	☒
	3	R1-1611385, China Academy of Telecommunications Technology (CATT), November 5, 2016	☒
	4	R1-1611415, ZTE, ZTE Microelectronics, November 5, 2016	☒
	5	R1-1611417, ZTE, ZTE Microelectronics, November 5, 2016	☒
	6	R1-1612056, Qualcomm, November 5, 2016	☒
	7	R1-1612493, Samsung, November 4, 2016	☒
	8	R1-1612862, Nokia, Alcatel-Lucent Shanghai Bell, November 4, 2016	☒
	9	R4-161779, Qualcomm Incorporated, April 26, 2016	☒
	10	3GPP TR 36.897 V13.0.0 Release 13, 3rd Generation Partnership Project (3GPP), June 2015	☒
	11	R1-1704867, LG Electronics, March 25, 2017	☒

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	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

	12	R1-1609662, Nokia, Alcatel-Lucent Shanghai Bell, September 30, 2016	☒
	13	R2-1703344, LG Electronics, March 24, 2017	☒
	14	3GPP R1-1704398, April 7, 2017	☒
	15	3GPP R1-1704877, April 7, 2017	☒
	16	R1-1609256, October 14, 2016	☒
	17	APEX BEAM TECHNOLOGIES LLC v. ONEPLUS TECHNOLOGY (SHENZHEN) CO., LTD., DEFENDANT'S INVALIDITY CONTENTIONS, Case No. 2:22-cv-00032-JRG, November 21, 2022	☒
	18	APEX BEAM TECHNOLOGIES LLC v. SAMSUNG ELECTRONICS CO., LTD., ET AL.,, DEFENDANT'S INVALIDITY CONTENTIONS, Case No. 2:22-cv-00188-JRG, March 2, 2023	☒
	19	APEX BEAM TECHNOLOGIES LLC v. ZTE CORPORATION, DEFENDANT'S INVALIDITY CONTENTIONS, Case No. 2:22-cv-00031-JRG-RSP, March 2, 2023	☒
	20	APEX BEAM TECHNOLOGIES LLC v. TCT MOBILE INTERNATIONAL LIMITED, DEFENDANTS' INITIAL INVALIDITY CONTENTIONS, Docket No. 2:21-cv-00438-JRG, November 9, 2023	☒
	21	SAMSUNG ELECTRONICS CO., LTD., AND SAMSUNG ELECTRONICS AMERICA, INC., v. APEX BEAM TECHNOLOGIES LLC, PETITION FOR INTER PARTES REVIEW, Case IPR2023-0059, February 28, 2023	☒

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	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

EXAMINER SIGNATURE			
Examiner Signature	/AHMED ELALLAM/	Date Considered	12/20/2023

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

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	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/JIALIN ZHONG/	Date (YYYY-MM-DD)	2023-11-19
Name/Print	JIALIN ZHONG	Registration Number	62937

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.E/

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
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Examiner Name	AHMED ELALLAM
Attorney Docket Number	ZL0205-0004-US-CON3

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	6185432	B2	2001-02-06	Sridhar Vembu	
	2	7945222	B2	2011-05-17	Harel et al.	
	3	8027374	B2	2011-09-27	Wei Sun	
	4	8116693	B2	2012-02-14	Haim Harel	
	5	8654667	B2	2014-02-18	Bin Li	
	6	9131490	B2	2015-09-08	Sujuan Feng	
	7	9236992	B2	2016-01-12	Jae Hoon Chung	
	8	9264195	B2	2016-02-16	Jonghyun Park	

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	Attorney Docket Number	ZL0205-0004-US-CON3

	9	9294310	B2	2016-03-22	Huan Wu	
	10	9380568	B2	2016-06-28	Robert Mark Harrison	
	11	9425934	B2	2016-08-23	Hanbyul Seo	
	12	9474063	B2	2016-10-18	Jin-Kyu Han	
	13	9497750	B2	2016-11-15	Chaojun Li	
	14	9510335	B2	2016-11-29	Hyunsoo Ko	
	15	9520973	B2	2016-12-13	Jinmin Kim	
	16	9538516	B2	2017-01-03	Inkwon Seo	
	17	9572149	B2	2017-02-14	Yu Zhou	
	18	9603081	B2	2017-03-21	Inkwon Seo	
	19	9730200	B2	2017-08-08	Bingyu Qu	

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	20	9787387	B2	2017-10-10	Sung-Hyun Moon	
	21	9860033	B2	2018-01-02	Tamer Kadous	
	22	9867176	B2	2018-01-09	Zhongfeng Li	
	23	9877312	B2	2018-01-23	Youn-Sun Kim	
	24	9882691	B2	2018-01-30	Jiwon Kang	
	25	9883503	B2	2018-01-30	Hanbyul Seo	
	26	9900891	B2	2018-02-20	Muhammad Nazmul Islam	
	27	9923613	B2	2018-03-20	Kilbom LEE	
	28	9955474	B2	2018-04-24	Jihyun Lee	
	29	10050758	B2	2018-08-14	Hanbyul Seo	
	30	10148400	B2	2018-12-04	Ranran Zhang	

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	Attorney Docket Number	ZL0205-0004-US-CON3

	31	10218461	B2	2019-02-26	Lilei Wang	
	32	10298372	B2	2019-05-21	Yuan Zhu	
	33	10299267	B2	2019-05-21	Jian Wang	
	34	10425139	B2	2019-09-24	Li Guo	
	35	10454555	B2	2019-10-22	Youngwoo Kwak	
	36	10506576	B2	2019-12-10	Makesh Pravin JOHN WILSON	
	37	10567057	B2	2020-02-18	Jonghyun Park	
	38	10631291	B2	2020-04-21	Kilbom LEE	
	39	10700752	B2	2020-06-30	Byounghoon JUNG	
	40	10778303	B2	2020-09-15	Yung-soo Kim	
	41	10785747	B2	2020-09-22	Eunsun Kim	

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	Attorney Docket Number	ZL0205-0004-US-CON3

	42	10790953	B2	2020-09-29	Kijun KIM	
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	1	3G Evolution: HSPA and LTE for Mobile Broadband, 2007, Erik Dahlman, Stefan Parkvall, Johan Skold, Per Beming dated	☒
	2	3GPP TR 25.892 version 6.0.0 release 6, June 28, 2004, 3rd Generation Partnership Project (3GPP) 3rd Generation	☒
	3	3GPP TR 36.873 version 12.2.0 release 12, July 3, 2015 , 3rd Generation Partnership Project (3GPP) 3rd Generation	☒
	4	3GPP TR 36.897 version 13.0.0 release 13, July 3, 2015 , 3rd Generation Partnership Project (3GPP) 3rd Generation	☒
	5	3GPP TR 37.840 version 12.1.0 release 12, January 6, 2014, 3rd Generation Partnership Project (3GPP) 3rd Generation	☒

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17950726
	Filing Date	2022-09-22
	First Named Inventor	Xiaobo ZHANG
	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

	6	3GPP TR 38.802 version 1.2.0 release 14, March 1, 2017, 3rd Generation Partnership Project (3GPP) 3rd Generation	☒
	7	3GPP TR 38.802 version 14.0.0 release 14, March 25, 2017, 3rd Generation Partnership Project (3GPP) Author(s)	☒
	8	3GPP TS 36.133 version 12.8.0 release 12, 3rd Generation Partnership Project (3GPP), dated September 9, 2015	☒
	9	3GPP TS 36.133 version 13.2.0 release 13, 3rd Generation Partnership Project (3GPP), dated January 8, 2016	☒
	10	3GPP TS 36.211 version 12.3.0 release 12, 3rd Generation Partnership Project (3GPP), dated October 2, 2014	☒
	11	3GPP TS 36.211 version 12.5.0 release 12, 3rd Generation Partnership Project (3GPP), dated March 16, 2015	☒
	12	3GPP TS 36.211 version 12.8.0 release 12, 3rd Generation Partnership Project (3GPP), dated January 26, 2016	☒
	13	3GPP TS 36.211 version 12.8.0 release 12, 3rd Generation Partnership Project (3GPP), dated January 6, 2016	☒
	14	3GPP TS 36.211 version 13.2.0 release 13, 3rd Generation Partnership Project (3GPP), dated August 24, 2016	☒
	15	3GPP TS 36.211 version 14.2.0 release 14, 3rd Generation Partnership Project (3GPP), dated April 18, 2017	☒
	16	3GPP TS 36.211 version 8.9.0 release 8, 3rd Generation Partnership Project (3GPP), dated December 9, 2009	☒

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	17	3GPP TS 36.211 version 11.3.0 release 11, 3rd Generation Partnership Project (3GPP), dated June 26, 2013	☒
	18	3GPP TS 36.211 version 12.5.0 release 12, 3rd Generation Partnership Project (3GPP), dated March 16, 2015	☒
	19	3GPP TS 36.211 version 13.0.0 release 13, 3rd Generation Partnership Project (3GPP), dated January 5, 2016	☒
	20	3GPP TS 36.212 version 12.2.0 release 12, 3rd Generation Partnership Project (3GPP), dated September 23, 2014	☒
	21	3GPP TS 36.212 version 12.2.0 release 12, 3rd Generation Partnership Project (3GPP), dated October 2, 2014	☒
	22	3GPP TS 36.212 version 12.4.0 release 12, 3rd Generation Partnership Project (3GPP), dated March 18, 2015	☒
	23	3GPP TS 36.212 version 12.8.0 release 12, 3rd Generation Partnership Project (3GPP), dated March 27, 2016	☒
	24	3GPP TS 36.212 version 12.8.0 release 12, 3rd Generation Partnership Project (3GPP), dated March 27, 2016	☒
	25	3GPP TS 36.212 version 12.8.0 release 12, 3rd Generation Partnership Project (3GPP), dated April 22, 2016	☒
	26	3GPP TS 36.212 version 13.0.0 release 13, 3rd Generation Partnership Project (3GPP), dated January 5, 2016	☒
	27	3GPP TS 36.212 version 13.3.0 release 13, 3rd Generation Partnership Project (3GPP), dated September 29, 2016	☒

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	28	3GPP TS 36.212 version 14.2.0 release 14, 3rd Generation Partnership Project (3GPP), dated April 11, 2017	☒
	29	3GPP TS 36.213 version 12.11.0 release 12, 3rd Generation Partnership Project (3GPP), dated September 29, 2016	☒
	30	3GPP TS 36.213 version 12.3.0 release 12, 3rd Generation Partnership Project (3GPP), dated October 2, 2014	☒
	31	3GPP TS 36.213 version 12.8.0 release 12, Project (3GPP) ETSI publication of 3rd Generation, dated May 3, 2016	☒
	32	3GPP TS 36.213 version 12.8.0 release 12 Annex A, 3rd Generation Partnership Project (3GPP), dated January 6, 2016	☒
	33	3GPP TS 36.213 version 12.8.0 release 12, Cover, 3rd Generation Partnership Project (3GPP), dated January 6, 2016	☒
	34	3GPP TS 36.213 version 12.8.0 release 12, Section 14, 3rd Generation Partnership Project (3GPP), dated January 6, 2016	☒
	35	3GPP TS 36.213 version 12.8.0 release 12, Sections 0-9, 3rd Generation Partnership Project (3GPP), dated January 6, 2016	☒
	36	3GPP TS 36.213 version 12.8.0 release 12, Sections 10-13, 3rd Generation Partnership Project (3GPP), dated January 6, 2016	☒
	37	3GPP TS 36.213 version 13.0.0 release 13, 3rd Generation Partnership Project (3GPP), dated January 5, 2016	☒
	38	3GPP TS 36.213 version 13.2.0 release 13, 3rd Generation Partnership Project (3GPP), dated August 5, 2016	☒

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	39	3GPP TS 36.214 version 12.0.0 release 12, 3rd Generation Partnership Project (3GPP), dated October 2, 2014	☒
	40	3GPP TS 36.214 version 12.2.0 release 12, 3rd Generation Partnership Project (3GPP), dated April 24, 2015	☒
	41	3GPP TS 36.214 version 13.0.0 release 13, 3rd Generation Partnership Project (3GPP), dated December 15, 2015	☒
	42	3GPP TS 36.300 version 12.3.0 release 12, 3rd Generation Partnership Project (3GPP), dated September 29, 2014	☒
	43	3GPP TS 36.300 version 12.8.0 release 12, 3rd Generation Partnership Project (3GPP), dated January 4, 2016	☒
	44	3GPP TS 36.300 version 12.8.0 release 12, 3rd Generation Partnership Project (3GPP), dated January 18, 2016	☒
	45	3GPP TS 36.300 version 14.3.0 release 14, Project (3GPP) ETSI publication of 3rd Generation, dated July 27, 2017	☒
	46	3GPP TS 36.302 version 12.1.0 release 12, 3rd Generation Partnership Project (3GPP), dated September 29, 2014	☒
	47	3GPP TS 36.302 version 12.6.0 release 12, 3rd Generation Partnership Project (3GPP), dated January 18, 2016	☒
	48	3GPP TS 36.304 version 12.2.0 release 12, 3rd Generation Partnership Project (3GPP), dated September 29, 2014	☒
	49	3GPP TS 36.304 version 12.8.0 release 12, 3rd Generation Partnership Project (3GPP), dated August 25, 2016	☒

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	50	3GPP TS 36.304 version 12.8.0 release 12, Project (3GPP) 3rd Generation Partnership, dated July 1, 2016	☒

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Examiner Signature	/AHMED ELALLAM/	Date Considered	12/20/2023

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	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/JIALIN ZHONG/	Date (YYYY-MM-DD)	2023-11-19
Name/Print	JIALIN ZHONG	Registration Number	62937

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	17950726
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First Named Inventor	Xiaobo ZHANG
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Examiner Name	AHMED ELALLAM
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	Attorney Docket Number	ZL0205-0004-US-CON3

	1	R1-1610145, Qualcomm, October 1, 2016	☒
	2	R1-1610239, Nokia, Alcatel-Lucent Shanghai Bell, September 30, 2016	☒
	3	R1-1611385, China Academy of Telecommunications Technology (CATT), November 5, 2016	☒
	4	R1-1611415, ZTE, ZTE Microelectronics, November 5, 2016	☒
	5	R1-1611417, ZTE, ZTE Microelectronics, November 5, 2016	☒
	6	R1-1612056, Qualcomm, November 5, 2016	☒
	7	R1-1612493, Samsung, November 4, 2016	☒
	8	R1-1612862, Nokia, Alcatel-Lucent Shanghai Bell, November 4, 2016	☒
	9	R4-161779, Qualcomm Incorporated, April 26, 2016	☒
	10	3GPP TR 36.897 V13.0.0 Release 13, 3rd Generation Partnership Project (3GPP), June 2015	☒
	11	R1-1704867, LG Electronics, March 25, 2017	☒

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	12	R1-1609662, Nokia, Alcatel-Lucent Shanghai Bell, September 30, 2016	☒
	13	R2-1703344, LG Electronics, March 24, 2017	☒
	14	3GPP R1-1704398, April 7, 2017	☒
	15	3GPP R1-1704877, April 7, 2017	☒
	16	R1-1609256, October 14, 2016	☒
	17	APEX BEAM TECHNOLOGIES LLC v. ONEPLUS TECHNOLOGY (SHENZHEN) CO., LTD., DEFENDANT'S INVALIDITY CONTENTIONS, Case No. 2:22-cv-00032-JRG, November 21, 2022	☒
	18	APEX BEAM TECHNOLOGIES LLC v. SAMSUNG ELECTRONICS CO., LTD., ET AL.,, DEFENDANT'S INVALIDITY CONTENTIONS, Case No. 2:22-cv-00188-JRG, March 2, 2023	☒
	19	APEX BEAM TECHNOLOGIES LLC v. ZTE CORPORATION, DEFENDANT'S INVALIDITY CONTENTIONS, Case No. 2:22-cv-00031-JRG-RSP, March 2, 2023	☒
	20	APEX BEAM TECHNOLOGIES LLC v. TCT MOBILE INTERNATIONAL LIMITED, DEFENDANTS' INITIAL INVALIDITY CONTENTIONS, Docket No. 2:21-cv-00438-JRG, November 9, 2023	☒
	21	SAMSUNG ELECTRONICS CO., LTD., AND SAMSUNG ELECTRONICS AMERICA, INC., v. APEX BEAM TECHNOLOGIES LLC, PETITION FOR INTER PARTES REVIEW, Case IPR2023-0059, February 28, 2023	☒

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Name/Print	JIALIN ZHONG	Registration Number	62937

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Doc description: Information Disclosure Statement (IDS) Filed

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	17950726
Filing Date	2022-09-22
First Named Inventor	Xiaobo ZHANG
Art Unit	2471
Examiner Name	AHMED ELALLAM
Attorney Docket Number	ZL0205-0004-US-CON3

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	7	R2-1702662, Ericsson, dated April 3-7, 2017 (Meeting dates) March 25, 2017 (Publication)	☒
	8	R2-1703344, LG Electronics, dated April 3-7, 2017 (Meeting date) March 24, 2017 (Publication)	☒
	9	R2-1703561, Qualcomm Incorporated, dated April 3-7, 2017 (Meeting dates) March 25, 2017 (Publication)	☒
	10	R2-1706926, Qualcomm Incorporated, dated June 27-29, 2017 (Meeting dates) June 17, 2017 (Publication)	☒
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	21	R1-1701581, ZTE Corporation et al., February 7, 2017	☒
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	27	R1-1700539, Panasonic, January 10, 2017	☒
	28	R1-1704618, Guangdong OPPO Mobile Telecom, March 25, 2017	☒
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	30	R1-1708334, InterDigital, Inc., May 6, 2017	☒
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	32	3GPP TS 36.212 version 14.2.0 Release 14 (“TS 36.212”), 3rd Generation Partnership Project (3GPP), April 2017	☒
	33	3GPP TS 36.306 version 14.2.0 Release 14 (“TS 36.306”), 3rd Generation Partnership Project (3GPP), April 2017	☒

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	36	4G: LTE / LTE-Advanced for Mobil Broadband (“Dahlman 2011”), Dahlman et al., 2011	☒
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	38	R1-1613589, Samsung, Ericsson, NTT DOCOMO, Intel, Verizon, KT, November 19, 2016	☒
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	42	R1-1704456, MediaTek Inc., March 25, 2017	☒
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	48	R1-153175, Ericsson, May 16, 2015	☒
	49	R1-154127, Samsung, August 14, 2015	☒
	50	R1-1609525, Intel Corporation, October 1, 2016	☒

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EXAMINER SIGNATURE

Examiner Signature	/AHMED ELALLAM/	Date Considered	12/20/2023

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

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	Attorney Docket Number	ZL0205-0004-US-CON3

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/JIALIN ZHONG/	Date (YYYY-MM-DD)	2023-11-19
Name/Print	JIALIN ZHONG	Registration Number	62937

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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EXAMINER SIGNATURE

Examiner Signature	/AHMED ELALLAM/	Date Considered	12/20/2023

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OR

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☐ See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/JIALIN ZHONG/	Date (YYYY-MM-DD)	2023-11-19
Name/Print	JIALIN ZHONG	Registration Number	62937

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	17950726
Filing Date	2022-09-22
First Named Inventor	Xiaobo ZHANG
Art Unit	2471
Examiner Name	AHMED ELALLAM
Attorney Docket Number	ZL0205-0004-US-CON3

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	10	9380568	B2	2016-06-28	Robert Mark Harrison	
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
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	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

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A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/JIALIN ZHONG/	Date (YYYY-MM-DD)	2023-11-19
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	1	3GPP TS 36.304 version 14.0.0 release 14, 3rd Generation Partnership Project (3GPP), dated October 3, 2016	☒
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	5	3GPP TS 36.321 version 12.6.0 release 12, 3rd Generation Partnership Project (3GPP), dated June 30, 2015	☒
	6	3GPP TS 36.321 version 12.8.0 release 12, 3rd Generation Partnership Project (3GPP), dated January 4, 2016	☒
	7	3GPP TS 36.321 version 12.8.0 release 12, 3rd Generation Partnership Project (3GPP), dated January 18, 2016	☒
	8	3GPP TS 36.321 version 14.3.0 release 14, Project (3GPP) ETSI publication of 3rd Generation, dated July 27, 2017	☒
	9	3GPP TS 36.331 version 12.3.0 release 12, 3rd Generation Partnership Project (3GPP), dated September 29, 2014	☒
	10	3GPP TS 36.331 version 12.8.0 release 12, 3rd Generation Partnership Project (3GPP), dated January 18, 2016	☒
	11	3GPP TS 36.331 version 13.0.0 release 13, 3rd Generation Partnership Project (3GPP), dated January 6, 2016	☒

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	Filing Date	2022-09-22
	First Named Inventor	Xiaobo ZHANG
	Art Unit	2471
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	Attorney Docket Number	ZL0205-0004-US-CON3

	12	3GPP TS 36.331 version 13.3.0 release 13, 3rd Generation Partnership Project (3GPP), dated October 3, 2016	☒
	13	3GPP TS 36.331 version 13.5.0 release 13, 3rd Generation Partnership Project (3GPP), dated April 11, 2017	☒
	14	3GPP TS 38.212 version 15.2.0 release 15, 3rd Generation Partnership Project (3GPP), dated June 29, 2018	☒
	15	3GPP TS 38.214 version 15.2.0 release 15, 3rd Generation Partnership Project (3GPP), dated June 29, 2018	☒
	16	3GPP TS 38.306 version 15.5.0 release 15, 3rd Generation Partnership Project (3GPP), dated April 11, 2019	☒
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	19	4G LTE/LTE Advanced for Mobile Broadband, Erik Dahlman, dated 2011	☒
	20	4G LTE/LTE Advanced for Mobile Broadband, Erik Dahlman, dated 2014	☒
	21	1st 5G Algorithm Innovation Competition - Filtered-OFDM, Terasic Inc., dated 2015	☒
	22	A Comparison of Symbol-wise and Self-contained Frame Structure for 5G Services, Mohamed Ibrahim, dated 2016	☒

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	42	R1-130140, ZTE, dated January 28-February 1, 2013 (Meeting dates) January 19, 2013 (Publication)	☒
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	44	R1-144047, LG Electronics, dated October 6-10, 2014 (Meeting dates) September 27, 2014 (Publication)	☒

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	46	R1-151365, CATT, dated April 20-24, 2015 (Meeting dates) April 11, 2015 (Publication)	☒
	47	R1-151535, LG Electronics, dated April 20-24, 2015 (Meeting date) April 11, 2015 (Publication)	☒
	48	R1-153175, Ericsson, dated May 25-29, 2015 (Meeting date) May 16, 2015 (Publication)	☒
	49	R1-154127, Samsung, dated August 24-28, 2015 (Meeting date) August 14, 2015 (Publication)	☒
	50	R1-1608671, ZTE, ZTE Microelectronics, dated October 10-14, 2016 (Meeting dates) October 1, 2016 (Publication)	☒

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EXAMINER SIGNATURE

Examiner Signature	/AHMED ELALLAM/	Date Considered	12/20/2023

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[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

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	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/JIALIN ZHONG/	Date (YYYY-MM-DD)	2023-11-19
Name/Print	JIALIN ZHONG	Registration Number	62937

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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Examiner Signature	/AHMED ELALLAM/	Date Considered	12/20/2023

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☐ See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/JIALIN ZHONG/	Date (YYYY-MM-DD)	2023-11-19
Name/Print	JIALIN ZHONG	Registration Number	62937

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

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Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	17950726
Filing Date	2022-09-22
First Named Inventor	Xiaobo ZHANG
Art Unit	2471
Examiner Name	AHMED ELALLAM
Attorney Docket Number	ZL0205-0004-US-CON3

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	19	R1-1613589, Samsung, Ericsson, NTT DOCOMO, Intel, Verizon, KT, dated 14-18, 2016 (Meeting dates) November 19, 2016 (Publication)	☒
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	21	R1-164147, Intel Corporation, dated May 23-27, 2016 (Meeting dates) May 14, 2016 (Publication)	☒
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	23	R1-167028, KT Corp., dated August 22-26, 2016 (Meeting dates) August 12, 2016 (Publication)	☒
	24	R1-167287, Nokia, Alcatel-Lucent Shanghai Bell, dated August 22-26, 2016 (Meeting dates) August 12, 2016 (Publication)	☒
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	32	R1-1701979, NEC, dated February 13-17, 2017 (Meeting date) February 4, 2017 (Publication)	☒
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	34	R1-1704342, AT&T, dated April 3-7, 2017 (Meeting dates) March 25, 2017 (Publication)	☒
	35	R1-1704456, MediaTek Inc., dated April 3-7, 2017 (Meeting dates) March 25, 2017 (Publication)	☒
	36	R1-1704465, MediaTek Inc., dated April 3-7, 2017 (Meeting dates) March 25, 2017 (Publication)	☒
	37	R1-1704551, CATT, dated April 3-7, 2017 (Meeting date) March 25, 2017 (Publication)	☒
	38	R1-1704553, CATT, dated April 3-7, 2017 (Meeting date) March 25, 2017 (Publication)	☒
	39	R1-1704618, Guangdong OPPO Mobile Telecom, dated April 3-7, 2017 (Meeting dates) March 25, 2017 (Publication)	☒
	40	R1-1704867, LG Electronics, dated April 3-7, 2017 (Meeting date) March 25, 2017 (Publication)	☒
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	42	R1-1707475, CATT, dated May 15-19, 2017 (Meeting date) May 6, 2017 (Publication)	☒
	43	R1-1707782, Spreadtrum Communications, dated May 15-19, 2017 (Meeting dates) May 5, 2017 (Publication)	☒
	44	R1-1707830, MediaTek Inc., dated May 15-19, 2017 (Meeting dates) May 7, 2017 (Publication)	☒

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	45	R1-1707832, MediaTek Inc., dated May 15-19, 2017 (Meeting dates) May 7, 2017 (Publication)	☒
	46	R1-1707954, Samsung, dated May 15-19, 2017 (Meeting dates) May 6, 2017 (Publication)	☒
	47	R1-1708135, Huawei, HiSilicon, dated May 15-19, 2017 (Meeting dates) May 6, 2017 (Publication)	☒
	48	R1-1708334, InterDigital, Inc., dated May 15-19, 2017 (Meeting dates) May 6, 2017 (Publication)	☒
	49	R1-1708336, InterDigital, Inc., dated May 15-19, 2017 (Meeting dates) May 6, 2017 (Publication)	☒
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CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

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A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/JIALIN ZHONG/	Date (YYYY-MM-DD)	2023-11-19
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Doc description: Information Disclosure Statement (IDS) Filed

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	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

	23	R1-167028, KT Corp., dated August 22-26, 2016 (Meeting dates) August 12, 2016 (Publication)	☒
	24	R1-167287, Nokia, Alcatel-Lucent Shanghai Bell, dated August 22-26, 2016 (Meeting dates) August 12, 2016 (Publication)	☒
	25	R1-167520, Lenovo, dated August 22-26, 2016 (Meeting dates) August 12, 2016 (Publication)	☒
	26	R1-1700192, CATT, dated January 16-20, 2017 (Meeting dates) January 10, 2017 (Publication)	☒
	27	R1-1700539, Panasonic, January 16-20, 2017 (Meeting dates) January 10, 2017 (Publication)	☒
	28	R1-1700563, Guangdong OPPO Mobile Telecom, dated January 16-20, 2017 (Meeting dates) January 9, 2017 (Publication)	☒
	29	R1-1700703, InterDigital Communications, dated January 16-20, 2017 (Meeting dates) January 10, 2017 (Publication)	☒
	30	R1-1700771, Ericsson, dated January 16-20, 2017 (Meeting dates) January 10, 2017 (Publication)	☒
	31	R1-1701581, ZTE, ZTE Microelectronics, dated January 13-17, 2017 (Meeting dates) February 7, 2017 (Publication)	☒
	32	R1-1701979, NEC, dated February 13-17, 2017 (Meeting date) February 4, 2017 (Publication)	☒
	33	R1-1702676, Ericsson, dated February 13-17, 2017 (Meeting dates) February 7, 2017 (Publication)	☒

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.E/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17950726
	Filing Date	2022-09-22
	First Named Inventor	Xiaobo ZHANG
	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

	34	R1-1704342, AT&T, dated April 3-7, 2017 (Meeting dates) March 25, 2017 (Publication)	☒
	35	R1-1704456, MediaTek Inc., dated April 3-7, 2017 (Meeting dates) March 25, 2017 (Publication)	☒
	36	R1-1704465, MediaTek Inc., dated April 3-7, 2017 (Meeting dates) March 25, 2017 (Publication)	☒
	37	R1-1704551, CATT, dated April 3-7, 2017 (Meeting date) March 25, 2017 (Publication)	☒
	38	R1-1704553, CATT, dated April 3-7, 2017 (Meeting date) March 25, 2017 (Publication)	☒
	39	R1-1704618, Guangdong OPPO Mobile Telecom, dated April 3-7, 2017 (Meeting dates) March 25, 2017 (Publication)	☒
	40	R1-1704867, LG Electronics, dated April 3-7, 2017 (Meeting date) March 25, 2017 (Publication)	☒
	41	R1-1705961, Nokia, Alcatel-Lucent Shanghai Bell, dated April 3-7, 2017 (Meeting dates) March 24, 2017 (Publication)	☒
	42	R1-1707475, CATT, dated May 15-19, 2017 (Meeting date) May 6, 2017 (Publication)	☒
	43	R1-1707782, Spreadtrum Communications, dated May 15-19, 2017 (Meeting dates) May 5, 2017 (Publication)	☒
	44	R1-1707830, MediaTek Inc., dated May 15-19, 2017 (Meeting dates) May 7, 2017 (Publication)	☒

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.E/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17950726
	Filing Date	2022-09-22
	First Named Inventor	Xiaobo ZHANG
	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

	45	R1-1707832, MediaTek Inc., dated May 15-19, 2017 (Meeting dates) May 7, 2017 (Publication)	☒
	46	R1-1707954, Samsung, dated May 15-19, 2017 (Meeting dates) May 6, 2017 (Publication)	☒
	47	R1-1708135, Huawei, HiSilicon, dated May 15-19, 2017 (Meeting dates) May 6, 2017 (Publication)	☒
	48	R1-1708334, InterDigital, Inc., dated May 15-19, 2017 (Meeting dates) May 6, 2017 (Publication)	☒
	49	R1-1708336, InterDigital, Inc., dated May 15-19, 2017 (Meeting dates) May 6, 2017 (Publication)	☒
	50	R1-1710078, CATT, dated June 27-30, 2017 (Meeting dates) June 17, 2017 (Publication)	☒

If you wish to add additional non-patent literature document citation information please click the Add button Add

EXAMINER SIGNATURE

Examiner Signature	/AHMED ELALLAM/	Date Considered	12/20/2023

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.E/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17950726
	Filing Date	2022-09-22
	First Named Inventor	Xiaobo ZHANG
	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/JIALIN ZHONG/	Date (YYYY-MM-DD)	2023-11-19
Name/Print	JIALIN ZHONG	Registration Number	62937

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.E/

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.E/

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

155075 7590 12/06/2023

Zhong Law, LLC
51 JFK Parkway
1st Floor West
Short Hills, NJ 07078

EXAMINER	
ELALLAM, AHMED	
ART UNIT	PAPER NUMBER
2471	

DATE MAILED: 12/06/2023

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/950,726	09/22/2022	Xiaobo ZHANG	ZL0205-0004-US-CON3	6005

TITLE OF INVENTION: METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$480	$0.00	$0.00	$480	03/06/2024

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 40% the amount of undiscounted fees, and micro entity fees are 20% the amount of undiscounted fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Maintenance fees are due in utility patents issuing on applications filed on or after Dec. 12, 1980. It is patentee's responsibility to ensure timely payment of maintenance fees when due. More information is available at www.uspto.gov/PatentMaintenanceFees.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via the USPTO patent electronic filing system.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications. **Because electronic patent issuance may occur shortly after issue fee payment, any desired continuing application should preferably be filed prior to payment of this issue fee in order not to jeopardize copendency.**

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

155075 7590 12/06/2023
Zhong Law, LLC
51 JFK Parkway
1st Floor West
Short Hills, NJ 07078

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via the USPTO patent electronic filing system or by facsimile to (571) 273-2885, on the date below.

(Typed or printed name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/950,726	09/22/2022	Xiaobo ZHANG	ZL0205-0004-US-CON3	6005

TITLE OF INVENTION: METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$480	$0.00	$0.00	$480	03/06/2024

EXAMINER	ART UNIT	CLASS-SUBCLASS
ELALLAM, AHMED	2471	340-007460

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/AIA/122 or PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/AIA/47 or PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1_____
2_____
3_____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. Fees submitted: ❑Issue Fee ❑Publication Fee (if required)

4b. Method of Payment: *(Please first reapply any previously paid fee shown above)*

❑ Electronic Payment via the USPTO patent electronic filing system ❑ Enclosed check ❑ Non-electronic payment by credit card (Attach form PTO-2038)

❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. _____

5. **Change in Entity Status** (from status indicated above)

❑ Applicant certifying micro entity status. See 37 CFR 1.29
NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.

❑ Applicant asserting small entity status. See 37 CFR 1.27
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.

❑ Applicant changing to regular undiscounted fee status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/950,726	09/22/2022	Xiaobo ZHANG	ZL0205-0004-US-CON3	6005

155075 7590 12/06/2023

Zhong Law, LLC
51 JFK Parkway
1st Floor West
Short Hills, NJ 07078

EXAMINER	
ELALLAM, AHMED	
ART UNIT	**PAPER NUMBER**
2471	

DATE MAILED: 12/06/2023

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 30 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. The United States Patent and Trademark Office (USPTO) collects the information in this record under authority of 35 U.S.C. 2. The USPTO's system of records is used to manage all applicant and owner information including name, citizenship, residence, post office address, and other information with respect to inventors and their legal representatives pertaining to the applicant's/ owner's activities in connection with the invention for which a patent is sought or has been granted. The applicable Privacy Act System of Records Notice for the information collected in this form is COMMERCE/PAT-TM-7 Patent Application Files, available in the Federal Register at 78 FR 19243 (March 29, 2013).
https://www.govinfo.gov/content/pkg/FR-2013-03-29/pdf/2013-07341.pdf

Routine uses of the information in this record may include disclosure to:

1) law enforcement, in the event that the system of records indicates a violation or potential violation of law;
2) a federal, state, local, or international agency, in response to its request;
3) a contractor of the USPTO having need for the information in order to perform a contract;
4) the Department of Justice for determination of whether the Freedom of Information Act (FOIA) requires disclosure of the record;
5) a Member of Congress submitting a request involving an individual to whom the record pertains, when the individual has requested the Member's assistance with respect to the subject matter of the record;
6) a court, magistrate, or administrative tribunal, in the course of presenting evidence, including disclosures to opposing counsel in the course of settlement negotiations;
7) the Administrator, General Services Administration (GSA), or their designee, during an inspection of records conducted by GSA under authority of 44 U.S.C. 2904 and 2906, in accordance with the GSA regulations and any other relevant (i.e., GSA or Commerce) directive, where such disclosure shall not be used to make determinations about individuals;
8) another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c));
9) the Office of Personnel Management (OPM) for personnel research purposes; and
10) the Office of Management and Budget (OMB) for legislative coordination and clearance.

If you do not furnish the information requested on this form, the USPTO may not be able to process and/or examine your submission, which may result in termination of proceedings, abandonment of the application, and/or expiration of the patent.

Notice of Allowability	Application No. 17/950,726	Applicant(s) ZHANG, Xiaobo	
	Examiner AHMED ELALLAM	Art Unit 2471	AIA (FITF) Status Yes

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☑ This communication is responsive to Terminal Disclaimer filed on 11/13/23.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☑ The allowed claim(s) is/are 1-24 . As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see **http://www.uspto.gov/patents/init_events/pph/index.jsp** or send an inquiry to **PPHfeedback@uspto.gov.**

4. ☑ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☑ All b) ☐ Some* c) ☐ None of the:

   1. ☐ Certified copies of the priority documents have been received.
   2. ☑ Certified copies of the priority documents have been received in Application No. 15/956,742 .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____ .

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____ .

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☑ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date 11/13/23.
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date. _____.
5. ☐ Examiner's Amendment/Comment
6. ☑ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/AHMED ELALLAM/
Primary Examiner, Art Unit 2471

Notice of Pre-AIA or AIA Status

1. The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

Reasons for Allowance

2. The following is an examiner's statement of reasons for allowance:

The prior art cited by the Applicants and by the Examiner do not teach or suggest a method comprising:

A method in a User Equipment (UE) for paging, comprising:

monitoring a first signaling in X time intervals; and

receiving a first radio signal;

wherein X is a positive integer; the first signaling is used for determining scheduling information for the first radio signal; the scheduling information comprises **time-frequency resource, adopted Modulation Coding Scheme (MCS), and subcarrier spacing of subcarriers in occupied frequency domain resource**; the first radio signal carries a paging message; the frequency domain resource used for transmitting the first signaling belongs to a first subband; the first subband comprises a positive integer number of consecutive subcarriers in frequency domain; and **location of the first subband in frequency domain is used for determining the X time intervals**.

Applicants cited a plethora of documents relating to the related patent US.10462767 being litigated. However, it is not obvious to a person of skill in the art to render the claimed subject matter recited given the underlined combined elements as specified above.

Independent claims 6, 11, 16 and 20 have similar subject matter and allowed for similar reasons.

Conclusion

3. Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Any inquiry concerning this communication or earlier communications from the examiner should be directed to AHMED ELALLAM whose telephone number is (571)272-3097. The examiner can normally be reached 9-5.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Chi Pham can be reached on 571-2723179. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of published or unpublished applications may be obtained from Patent Center. Unpublished application information in Patent Center is available to registered users. To file and manage patent submissions in Patent Center, visit: https://patentcenter.uspto.gov. Visit https://www.uspto.gov/patents/apply/patent-center for more information about Patent Center and https://www.uspto.gov/patents/docx for information about filing in DOCX format. For additional questions, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/AHMED ELALLAM/
Primary Examiner, Art Unit 2471
11/16/2023

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/950,726	ZHANG, Xiaobo
	Examiner	Art Unit
	AHMED ELALLAM	2471

CPC - Searched*		
Symbol	**Date**	**Examiner**
H04W68/02 OR H04L1/1812 OR H04L5/0053 OR H04L25/00 OR H04W36/0088 OR H04W68/005 OR H04W72/23 OR H04L5/0007 OR H04L5/0044 OR H04L5/0008 OR H04L5/001 OR H04L27/2666 OR H04L27/2678 OR H04W72/0453	11/04/2023	AE
H04W68/02 OR H04L1/1812 OR H04L5/0053 OR H04L25/00 OR H04W36/0088 OR H04W68/005 OR H04W72/23 OR H04L5/0007 OR H04L5/0044 OR H04L5/0008 OR H04L5/001 OR H04L27/2666 OR H04L27/2678 OR H04W72/0453	11/16/2023	AE

CPC Combination Sets - Searched*		
Symbol	**Date**	**Examiner**

US Classification - Searched*			
Class	**Subclass**	**Date**	**Examiner**

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	**Date**	**Examiner**
PE2E	11/04/2023	AE
PE2E	11/16/2023	AE
H04W68/02 OR H04L1/1812 OR H04L5/0053 OR H04L25/00 OR H04W36/0088 OR H04W68/005 OR H04W72/23 OR H04L5/0007 OR H04L5/0044 OR H04L5/0008 OR H04L5/001 OR H04L27/2666 OR H04L27/2678 OR H04W72/0453	11/16/2023	AE

/AHMED ELALLAM/ Primary Examiner, Art Unit 2471	

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/950,726	ZHANG, Xiaobo
	Examiner	Art Unit
	AHMED ELALLAM	2471

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner
H04W	68/02 68/005 72/23 72/0453	11/16/2023	AE
H04L	5/0053 27/2666 72/0453	11/16/2023	AE

/AHMED ELALLAM/ Primary Examiner, Art Unit 2471	

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/950,726	ZHANG, Xiaobo
	Examiner	Art Unit
	AHMED ELALLAM	2471

CPC						
Symbol					Type	Version
H04W	/	68	/	02	F	2013-01-01
H04L	/	5	/	0053	I	2013-01-01
H04W	/	36	/	0088	I	2013-01-01
H04L	/	1	/	1812	I	2013-01-01
H04L	/	25	/	00	I	2013-01-01
H04W	/	68	/	005	I	2013-01-01
H04W	/	72	/	23	I	2023-01-01
H04L	/	5	/	0007	A	2013-01-01
H04L	/	5	/	0044	A	2013-01-01

CPC Combination Sets							
Symbol					Type	Set	Ranking	Version
	/		/					

NONE		Total Claims Allowed:	
(Assistant Examiner)	(Date)	24	
/AHMED ELALLAM/ Primary Examiner, Art Unit 2471	16 November 2023	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	5

U.S. Patent and Trademark Office — Part of Paper No.: 20231116

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/950,726	ZHANG, Xiaobo
	Examiner	Art Unit
	AHMED ELALLAM	2471

INTERNATIONAL CLASSIFICATION				
CLAIMED				
H04W	/	68	/	02
H04W	/	68	/	02
H04L	/	5	/	00

NON-CLAIMED				
H04W	/	36	/	00

US ORIGINAL CLASSIFICATION	
CLASS	SUBCLASS

CROSS REFERENCES(S)						
CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)					

NONE (Assistant Examiner)	(Date)	Total Claims Allowed: 24	
/AHMED ELALLAM/ Primary Examiner, Art Unit 2471 (Primary Examiner)	16 November 2023 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 5

U.S. Patent and Trademark Office — Part of Paper No.: 20231116

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/950,726	ZHANG, Xiaobo
	Examiner	**Art Unit**
	AHMED ELALLAM	2471

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☑ T.D. ☐ R.1.47

CLAIMS

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
1	1	11	10	22	19										
2	2	13	11	23	20										
3	3	14	12	6	21										
4	4	15	13	12	22										
5	5	16	14	18	23										
7	6	17	15	24	24										
8	7	19	16												
9	8	20	17												
10	9	21	18												

NONE (Assistant Examiner) (Date)	**Total Claims Allowed:** 24	
/AHMED ELALLAM/ Primary Examiner, Art Unit 2471 (Primary Examiner) 16 November 2023 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 5

U.S. Patent and Trademark Office Part of Paper No.: 20231116

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	17950726
Filing Date	2022-09-22
First Named Inventor	Xiaobo ZHANG
Art Unit	2471
Examiner Name	AHMED ELALLAM
Attorney Docket Number	ZL0205-0004-US-CON3

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
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Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.E/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17950726
	Filing Date	2022-09-22
	First Named Inventor	Xiaobo ZHANG
	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

	1	3GPP TSG RAN WG1 Meeting #89, R1-1707475, Discussion on DL beam management, dated May 2017	☒
	2	3GPP TSG RAN WG1 NR Ad-Hoc#2, R1-1710596, Discussion of beam recovery procedure, dated June 2017	☒
	3	Apex Beam Technologies LLC v. TCT MOBILE INTERNATIONAL LIMITED, DEFENDANTS' MOTION TO DISMISS PLAINTIFF'S FIRST AMENDED COMPLAINT FOR PATENT INFRINGEMENT, Case 2:21-cv-00438-JRG Document 32, dated 09/14/23	☒
	4	Apex Beam Technologies LLC v. TCT MOBILE INTERNATIONAL LIMITED, PLAINTIFF APEX BEAM TECHNOLOGIES LLC'S SUR-REPLY IN OPPOSITION TO DEFENDANTS' MOTION TO DISMISS, Case 2:21-cv-00438-JRG Document 39, dated 10/13/23	☒
	5	Apex Beam Technologies LLC v. TCT MOBILE INTERNATIONAL LIMITED, DEFENDANTS' REPLY IN SUPPORT OF DEFENDANTS' MOTION TO DISMISS PLAINTIFF'S FIRST AMENDED COMPLAINT, Case 2:21-cv-00438-JRG Document 34, dated 10/06/23	☒
	6	Apex Beam Technologies LLC v. TCT MOBILE INTERNATIONAL LIMITED, PLAINTIFF APEX BEAM TECHNOLOGIES LLC'S RESPONSE IN OPPOSITION TO DEFENDANTS' MOTION TO DISMISS, Case 2:21-cv-00438-JRG Document 33, dated 09/28/23	☒
	7	Apex Beam Technologies LLC v. Samsung Electronics Co., Ltd. et al., SAMSUNG ELECTRONICS CO., LTD. AND SAMSUNG ELECTRONICS AMERICA, INC.'S FIRST AMENDED ANSWER TO PLAINTIFF'S FIRST AMENDED COMPLAINT FOR PATENT INFRINGEMENT, Case 2:22-cv-00031-JRG-RSP Document 63, dated 09/28/23	☒
	8	Apex Beam Technologies LLC v. ZTE Corp., PLAINTIFF APEX BEAM TECHNOLOGIES LLC'S OPENING CLAIM CONSTRUCTION BRIEF, Case 2:22-cv-00031-JRG-RSP Document 69, dated 11/03/23	☒

If you wish to add additional non-patent literature document citation information please click the Add button Add

EXAMINER SIGNATURE

Examiner Signature	/AHMED ELALLAM/	Date Considered	11/16/2023

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.E/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17950726
	Filing Date	2022-09-22
	First Named Inventor	Xiaobo ZHANG
	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/JIALIN ZHONG/	Date (YYYY-MM-DD)	2023-11-13
Name/Print	JIALIN ZHONG	Registration Number	62937

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

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4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.E/

PE2E SEARCH - Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
L415	1617	(paging page) same numerolog$4	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2023/11/16 05:14 PM
L416	81	L11 and sub$1band same sub$1carrier adj2 spacing	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2023/11/16 05:14 PM
L417	452	L11 and sub$1band and sub$1carrier adj2 spacing	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2023/11/16 05:14 PM
L418	43	(5G new adj radio numerolog$4) and sub$1band same sub$1carrier adj2 spacing and IMSI same ("1024" "4096" "16384" C-RNTI)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2023/11/16 05:14 PM
L420	750697	(H04W68/02 OR H04L1/1812 OR H04L5/0053 OR H04L25/00 OR H04W36/0088 OR H04W68/005 OR H04W72/23 OR H04L5/0007 OR H04L5/0044 OR H04L5/0008 OR H04L5/001 OR H04L27/2666 OR H04L27/2678 OR H04W72/0453).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2023/11/16 05:14 PM
L421	756	L390 AND numerolog$4 WITH (paging page)	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/11/16 05:14 PM
L423	55	L391 AND sub$1band SAME sub$1carrier adj2 spacing	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2023/11/16 05:14 PM

L424	43	L393 AND (@ad<= "20170419" @rlad<= "20170419" @prad<= "20170419")	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/11/16 05:14 PM
L425	18	L394 AND time adj2 (interval duration).clm.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/11/16 05:14 PM
L426	14	L395 AND schedul$4.clm.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/11/16 05:14 PM
L427	11	L395 AND (page paging).clm.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL,	OR	ON	ON	2023/11/16 05:14 PM

			NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L428	150	L391 AND (page paging).clm.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/11/16 05:14 PM
L429	52	L398 AND schedul$4.clm.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/11/16 05:14 PM
L430	11	L399 AND (mcs AND subcarrier near2 spacing).clm.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/11/16 05:14 PM
L431	11	L400 AND (@ad<= "20170419" @rlad<=	(US-PGPUB; USPAT; USOCR; FIT (AP, AT,	OR	ON	ON	2023/11/16 05:14 PM

		"20170419" @prad<= "20170419")	AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L432	7	(DCI AND (mcs AND subcarrier near2 spacing) AND (page paging)).clm.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/11/16 05:14 PM
L434	0	L403 AND ((mcs AND subcarrier near2 spacing) AND (page paging)).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2023/11/16 05:14 PM
L435	11	((mcs AND subcarrier near2 spacing) AND (page paging)).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2023/11/16 05:14 PM
L436	7	L407 AND (monitor$4 AND interval).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2023/11/16 05:14 PM
L437	7	L407 AND (monitor$4).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2023/11/16 05:14 PM
L438	14	N30 AND (((mcs modulation*) AND (subcarrier sub-carrier) near2 spacing) AND (page paging)).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2023/11/16 05:44 PM
L440	10	L438 AND (@ad<= "20170419" @rlad<= "20170419" @prad<= "20170419")	(US-PGPUB; USPAT)	OR	ON	ON	2023/11/16 05:44 PM

PE2E SEARCH - Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp

N16	80553	(H04L1/1812 OR H04L25/00 OR H04L5/0007 OR H04L5/0044 OR H04L5/0053 OR H04W36/0088 OR H04W68/005 OR H04W68/02 OR H04W72/042 OR H04W72/1289 H04W84/027).CPC.	(US-PGPUB; USPAT)	OR	OFF	OFF	2023/11/16 05:15 PM
N17	525	N1 AND (5G new ADJ radio numerolog$4) AND sub$1band SAME sub$1carrier AND sub$1carrier adj2 spacing AND MCS	(US-PGPUB; USPAT)	OR	ON	ON	2023/11/16 05:15 PM
N18	14	N2 AND monitor$5 SAME ($1DCCH DCI DSCCH page paging signal signal$1ing schedul$5 (physical ADJ layer ADJ signaling DCI PDCCH NR-PDCCH PDCCH WITH (Common ADJ Search ADJ Space CSS UE-Specific ADJ Search ADJ Space USS)) (PDCCH SAME CRC SAME scrambl$4 SAME (Paging ADJ Radio ADJ Network ADJ Temporary ADJ (Identity id identifier) P-RNTI))) SAME (L M N X Y Z) SAME (time interval interval duration) SAME integer	(US-PGPUB; USPAT)	OR	ON	ON	2023/11/16 05:15 PM
N19	11	N4 AND (@ad<= "20170419" @rlad<= "20170419" @prad<= "20170419")	(US-PGPUB; USPAT)	OR	ON	ON	2023/11/16 05:15 PM
N20	80553	(H04L1/1812 OR H04L25/00 OR H04L5/0007 OR H04L5/0044 OR H04L5/0053 OR H04W36/0088 OR H04W68/005 OR H04W68/02 OR H04W72/042 OR H04W72/1289 H04W84/027).CPC.	(US-PGPUB; USPAT)	OR	OFF	OFF	2023/11/16 05:15 PM
N21	525	N1 AND (5G new ADJ radio numerolog$4)	(US-PGPUB; USPAT)	OR	ON	ON	2023/11/16 05:15 PM

		AND sub$1band SAME sub$1carrier AND sub$1carrier adj2 spacing AND MCS					
N22	14	N2 AND monitor$5 SAME ($1DCCH DCI DSCCH page paging signal signal$1ing schedul$5 (physical ADJ layer ADJ signaling DCI PDCCH NR-PDCCH PDCCH WITH (Common ADJ Search ADJ Space CSS UE-Specific ADJ Search ADJ Space USS)) (PDCCH SAME CRC SAME scrambl$4 SAME (Paging ADJ Radio ADJ Network ADJ Temporary ADJ (Identity id identifier) P-RNTI))) SAME (L M N X Y Z) SAME (time interval interval duration) SAME integer	(US-PGPUB; USPAT)	OR	ON	ON	2023/11/16 05:15 PM
N23	11	N4 AND (@ad<= "20170419" @rlad<= "20170419" @prad<= "20170419")	(US-PGPUB; USPAT)	OR	ON	ON	2023/11/16 05:15 PM
N24	64676	(H04W68/02 OR H04L5/0053 OR H04W72/042 OR H04L5/0007 OR H04L5/0044 OR H04W72/1289 OR H04L27/).CPC.	(US-PGPUB; USPAT)	OR	OFF	OFF	2023/11/16 05:15 PM
N25	351	N10 AND monitor$5 SAME ($1DCCH DCI DSCCH page paging signal signal$1ing schedul$5 (physical ADJ layer ADJ signaling DCI PDCCH NR-PDCCH PDCCH WITH (Common ADJ Search ADJ Space CSS UE-Specific ADJ Search ADJ Space USS)) (PDCCH SAME CRC SAME scrambl$4 SAME (Paging ADJ Radio ADJ Network ADJ Temporary ADJ (Identity id identifier) P-RNTI))) SAME (L M N X Y Z) SAME (time	(US-PGPUB; USPAT)	OR	ON	ON	2023/11/16 05:15 PM

		interval interval duration) SAME integer					
N26	14	N11 AND (5G new ADJ radio numerolog$4) AND sub$1band SAME sub$1carrier AND sub$1carrier adj2 spacing AND MCS	(US-PGPUB; USPAT)	OR	ON	ON	2023/11/16 05:15 PM
N27	31	N11 AND (monitor$4 near5 (plurality number X L M N O P K) near5 (interval period duration)).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2023/11/16 05:15 PM
N28	13	N13 AND (@ad<= "20170419" @rlad<= "20170419" @prad<= "20170419")	(US-PGPUB; USPAT)	OR	ON	ON	2023/11/16 05:15 PM
N29	21	("10462739"|"10462767"|"10660120"|"10966178"|"20170279579"|"20180097678"|"20190109695"|"20180070341"|"10135663"|"10356778"|"11051293"|"11252717"|"10271295"|"10448414"|"20140148204"|"10159097"|"20180054800"|"10660081"|"20200099499"|"8644864"|"20180279289").PN.	(US-PGPUB; USPAT)	OR	ON	ON	2023/11/16 05:15 PM
N30	127091	(H04W68/02 OR H04L1/1812 OR H04L5/0053 OR H04L25/00 OR H04W36/0088 OR H04W68/005 OR H04W72/23 OR H04L5/0007 OR H04L5/0044 OR H04L5/0008 OR H04L5/001 OR H04L27/2666 OR H04L27/2678 OR H04W72/0453).cpc.	(US-PGPUB; USPAT)	OR	OFF	OFF	2023/11/16 05:40 PM

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(54) Title: CHANNEL INFORMATION FEEDBACK METHOD, AND PILOT AND BEAM TRANSMISSION METHOD, SYSTEM AND DEVICE

(54) 发明名称: 信道信息的反馈方法、导频及波束发送方法、系统及装置

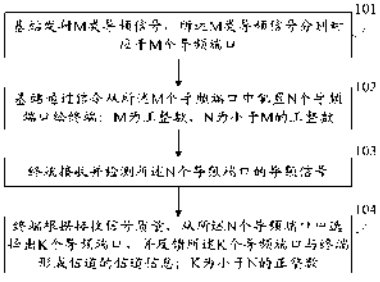


图 1 / FIG.1

101 TRANSMITTING, BY A BASE STATION, M TYPES OF PILOT SIGNALS, WHEREIN THE M TYPES OF PILOT SIGNALS RESPECTIVELY CORRESPOND TO M PILOT PORTS

102 CONFIGURING, BY THE BASE STATION, N PILOT PORTS FROM THE M PILOT PORTS TO A TERMINAL THROUGH SIGNALLING, WHERE M IS A POSITIVE INTEGER, AND N IS A POSITIVE INTEGER LESS THAN M

103 RECEIVING AND DETECTING, BY THE TERMINAL, PILOT SIGNALS OF THE N PILOT PORTS

104 ACCORDING TO THE QUALITY OF THE RECEIVED SIGNALS, SELECTING, BY THE TERMINAL, K PILOT PORTS FROM THE N PILOT PORTS, AND FEEDING BACK CHANNEL INFORMATION ABOUT A CHANNEL FORMED BY THE K PILOT PORTS AND THE TERMINAL, WHERE K IS A POSITIVE INTEGER LESS THAN N

(57) **Abstract**: Disclosed are a channel information feedback method, and a pilot and beam transmission method, system and device. The channel information feedback method comprises: transmitting, by a base station, M types of pilot signals, wherein the M types of pilot signals respectively correspond to M pilot ports; configuring, by the base station, N pilot ports from the M pilot ports to a terminal through signalling, where M is a positive integer, and N is a positive integer less than M; receiving and detecting, by the terminal, pilot signals of the N pilot ports; and according to the quality of the received signals, selecting K pilot ports from the N pilot ports, and feeding back channel information about a channel formed by the K pilot ports and the terminal, where K is a positive integer less than N.

(57) **摘要**: 本发明公开了一种信道信息的反馈方法、导频及波束发送方法、系统及装置，所述信道信息的反馈方法包括：基站发射 M 类导频信号，所述 M 类导频信号分别对应于 M 个导频端口；基站通过信令从所述 M 个导频端口中配置 N 个导频端口给终端；M 为正整数，N 为小于 M 的正整数；终端接收并检测所述 N 个导频端口的导频信号；根据接收信号质量，从所述 N 个导频端口中选择出 K 个导频端口，并反馈所述 K 个导频端口与终端形成信道的信道信息；K 为小于 N 的正整数。

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本国际公布:

— 不包括国际检索报告，在收到该报告后将重新公布(细则 48.2(g))。

信道信息的反馈方法、导频及波束发送方法、系统及装置

技术领域

本发明涉及通信中的信道信息反馈技术，尤其涉及信道信息的反馈方法、导频及波束发送方法、系统及装置。

背景技术

在无线通信系统中，发送端和接收端采取空间复用的方式，使用多根天线来获取更高的数据传输速率。相对于一般的空间复用方式，一种增强的空间复用方式是通过接收端反馈信道信息给发送端，发送端根据获得的信道信息采用发射预编码技术进行数据的传输，能够极大提高传输性能。对于单用户多输入多输出（MIMO，Multi-Input Multi-Output），直接使用信道特征矢量信息进行预编码；对于多用户 MIMO，需要更加准确的信道信息。

在第四代移动电话行动通信标准（4G，fourth Generation of mobile phone mobile communications standards）的一些技术，如长期演进（LTE，Long Term Evolution）802.16m 标准规范中，信道信息的反馈主要是利用较简单的单一码本的反馈方法，而 MIMO 的发射预编码技术的性能更依赖于码本反馈的准确度。基于码本的信道信息量化反馈的基本原理如下：

假设有限反馈信道容量为 B bps/Hz，那么可用的码字的个数为 $N=2^B$ 个。信道矩阵的特征矢量空间经过量化构成码本空间 $\Re=\{F_1,F_2\cdots F_N\}$。发射端与接收端共同保存或实时产生此码本。接收端采用获得的信道矩阵 H，并根据一定准则从 $\Re$ 中选择一个与信道最匹配的码字 $\hat{F}$，并将码字序号 i 反馈至发射端。这里，码字序号是指预编码矩阵指示符（PMI，Precoding Matrix Indicator）。发射端根据此序号 i 查询到相应的预编码码字 $\hat{F}$，而获得信道信

息，这里，$\hat{r}$表示信道的特征矢量信息。

随着无线通信技术的高速发展，用户端的无线应用越来越丰富，这带动了无线数据业务迅速增长，然而，这也给无线接入网络带来了巨大的挑战。多天线技术是应对无线数据业务爆发式增长挑战的关键技术，目前4G支持的多天线技术仅仅支持最大 8 端口的水平维度波束赋形技术。多天线技术的演进主要围绕着以下几个目标：①更大的波束赋形/预编码增益；②更多的空间复用层数及更小的层间干扰；③更全面的覆盖；④更小的站点间干扰。大型 MIMO（Massive MIMO）是下一代无线通信中 MIMO 演进的最主要的技术。

对于 Massive MIMO 技术，基站侧配置有大规模天线阵列，比如 100 个天线，甚至更多，在数据传输的时候，利用多用户 MIMO（MU-MIMO，Multi-User-MIMO）技术同时同频复用多个用户，一般情况，天线数目是复用用户数目的 5 至 10 倍左右。无论是在视距环境的强相关信道，还是富散射下的非相关信道，任意两个用户的信道之间的相关系数随着天线数目的增加成指数形式衰减，比如当基站侧配置有 100 根天线时，任意两个用户的信道之间相关系数趋近于 0，也即是说多用户对应信道之间接近正交。另一方面，大阵列可以带来非常可观的阵列增益和分集增益。

对于 Massive MIMO 技术，由于大量天线的引入，每根天线都需要发送信道状态信息参考符号（CSI-RS，Channel State Information-Reference Symbol），而终端检测 CSI-RS 并通过信道估计获得每个传输资源对应的信道矩阵，根据信道矩阵获得最佳的基带上每个频域子带预编码矢量和宽带的最佳传输层数信息，然后基于码本反馈技术进行反馈，这种方式在 Massive MIMO 中应用时存在比较大的问题。主要体现在如下方面：导频开销会随天线数目的增多而增加，除此之外，由于使用传统的码本反馈技术反馈时，使用的码本中需要包含非常多的码字，码字的选择十分困难，造

成终端的复杂度增加，难以实现；码本反馈的开销很大，导致上行链路的开销巨大。利用码本反馈技术很难在大规模天线系统中获得比较好的性能。

综上所述，对于大规模的天线系统，信道信息反馈的效率和反馈的复杂度是重要的技术问题，目前还没有有效的方法能够提高信道信息的反馈效率和降低反馈的复杂度，严重影响了 Massive MIMO 的工业实用性。

发明内容

为解决上述技术问题，本发明实施例提供了信道信息的反馈方法、导频及波束发送方法、系统及装置。

本发明实施例提供的信道信息的反馈方法包括:

基站发射 M 类导频信号，所述 M 类导频信号分别对应于 M 个导频端口；基站通过信令从所述 M 个导频端口中配置 N 个导频端口给终端；M 为正整数，N 为小于 M 的正整数;

终端接收并检测所述 N 个导频端口的导频信号；根据接收信号质量，从所述 N 个导频端口中选择出 K 个导频端口，并反馈所述 K 个导频端口与终端形成信道的信道信息；K 为小于 N 的正整数。

优选地，所述信道信息至少包括以下之一：K 个导频端口的索引信息、K 个导频端口之间的幅度比例信息、K 个导频端口之间的相位差信息、K 个导频端口的接收功率信息、K 个导频端口的信干噪比信息。

优选地，所述方法还包括:

通过相同的一组天线虚拟化形成所述 K 个导频端口；其中，K 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

优选地，所述方法还包括:

通过相同的一组天线虚拟化形成所述 N 个导频端口；其中，述 N 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

优选地，所述方法还包括:

所述基站根据所述终端反馈的信道统计信息确定所述 N 个导频端口；其中，所述信道统计信息为相关矩阵信息；所述 N 个导频端口对应的虚拟化预编码权值为相关矩阵特征矢量。

优选地，所述 N 个导频端口对应的虚拟化预编码权值为：DFT 矢量 v_k、或者 DFT 矢量的克罗内克积 $f(v_k, v_l)$；其中，

$$v_k = \begin{bmatrix} 1 & e^{j\phi_k} & \cdots & e^{j(n-1)\phi_k} \end{bmatrix}^H$$

$$f(v_k, v_l) = v_k \otimes v_l \text{ 或者 } f(v_k, v_l) = \begin{bmatrix} v_k \\ v_l \end{bmatrix}$$

其中，k,l 为正整数，j 为虚数单位，n 为大于 1 的正整数，ϕ_k 为相位参数；$[\ ]^H$ 表示共轭转置运算，$\otimes$ 为直乘符号。

优选地，所述方法还包括：

终端根据基站配置的功率门限从所述 N 个导频端口中选择出 K 个导频端口；其中，所述功率门限为相对门限或绝对门限。

优选地，所述方法还包括：

基站根据终端的上报的终端信息，从所述 M 个导频端口中配置 N 个导频端口给所述终端。

优选地，所述方法还包括：

终端反馈导频端口的选择信息，所述导频端口的选择信息采用选择的导频端口数目和选择的导频端口标识联合编码；其中，不同的导频端口被选择的概率不同，不同的导频端口数目对应的状态位不同。

本发明实施例提供的导频发送方法包括：

基站发射 M 类导频信号，所述 M 类导频信号分别对应于 M 个导频端口；基站通过信令从所述 M 个导频端口中配置 N 个导频端口给终端；M 为正整数，N 为小于 M 的正整数。

优选地，所述方法还包括：

通过相同的一组天线虚拟化形成所述 N 个导频端口；其中，述 N 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

优选地，所述方法还包括:

所述基站根据所述终端反馈的信道统计信息确定所述 N 个导频端口；其中，所述信道统计信息为相关矩阵信息；所述 N 个导频端口对应的虚拟化预编码权值为相关矩阵特征矢量。

优选地，所述 N 个导频端口对应的虚拟化预编码权值为：离散傅里叶变换 DFT 矢量 v_k 、或者由 DFT 矢量的克罗内克积 $f(v_k,v_l)$；其中，

$$v_k=\begin{bmatrix}1 & e^{j\phi_k} & \cdots & e^{j(n-1)\phi_k}\end{bmatrix}^H$$

$$f(v_k,v_l)=v_k\otimes v_l \text{ 或者 } f(v_k,v_l)=\begin{bmatrix}v_k\\ v_l\end{bmatrix}$$

其中，k,l 为正整数，j 为虚数单位，n 为大于 1 的正整数，ϕ_k 为相位参数；$[\ ]^H$ 表示共轭转置运算，$\otimes$ 为直乘符号。

优选地，所述方法还包括:

基站根据终端的上报的终端信息，从所述 M 个导频端口中配置 N 个导频端口给所述终端。

本发明实施例提供的信道信息的反馈方法包括:

终端接收并检测由基站配置的 N 个导频端口的导频信号；根据接收信号质量，从所述 N 个导频端口中选择出 K 个导频端口，并反馈所述 K 个导频端口与终端形成信道的信道信息；K 为小于 N 的正整数。

优选地，所述信道信息至少包括以下之一：K 个导频端口的索引信息、K 个导频端口之间的幅度比例信息、K 个导频端口之间的相位差信息、K 个导频端口的接收功率信息、K 个导频端口的信干噪比信息。

优选地，所述方法还包括：所述方法还包括:

终端根据基站配置的功率门限从所述 N 个导频端口中选择出 K 个导频

端口；其中，所述功率门限为相对门限或绝对门限。

优选地，所述方法还包括：

终端反馈导频端口的选择信息，所述导频端口的选择信息采用选择的导频端口数目和选择的导频端口标识联合编码；其中，不同的导频端口被选择的概率不同，不同的导频端口数目对应的状态位不同。

优选地，所述方法还包括：

通过相同的一组天线虚拟化形成所述 K 个导频端口；其中，K 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

本发明实施例提供的波束发送方法包括：

基站预先选定 P 个波束权值，并根据终端反馈的信道相关矩阵对所述 P 个波束权值进行处理，获得 P 个新波束；将所述 P 个新波束发送至终端；

终端从所述 P 个新波束中选择 Q 个波束，并将所述 Q 个波束将反馈至基站。

优选地，所述信道相关矩阵是多个终端的相关矩阵信息的叠加合并。

优选地，所述 P 个波束权值为：P 个 DFT 矢量、或者是两个 DFT 矢量的函数。

本发明实施例提供的信道信息的反馈系统包括：基站、终端；其中，

所述基站，配置为发射 M 类导频信号，所述 M 类导频信号分别对应于 M 个导频端口；通过信令从所述 M 个导频端口中配置 N 个导频端口给终端；M 为正整数，N 为小于 M 的正整数；

所述终端，配置为接收并检测所述 N 个导频端口的导频信号；根据接收信号质量，从所述 N 个导频端口中选择出 K 个导频端口，并反馈所述 K 个导频端口与终端形成信道的信道信息；K 为小于 N 的正整数。

优选地，所述信道信息至少包括以下之一：K 个导频端口的索引信息、K 个导频端口之间的幅度比例信息、K 个导频端口之间的相位差信息、K

个导频端口的接收功率信息、K 个导频端口的信干噪比信息。

优选地，所述终端，还配置为通过相同的一组天线虚拟化形成所述 K 个导频端口；其中，K 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

优选地，所述基站，还配置为通过相同的一组天线虚拟化形成所述 N 个导频端口；其中，述 N 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

优选地，所述基站，还配置为根据所述终端反馈的信道统计信息确定所述 N 个导频端口；其中，所述信道统计信息为相关矩阵信息；所述 N 个导频端口对应的虚拟化预编码权值为相关矩阵特征矢量。

优选地，所述 N 个导频端口对应的虚拟化预编码权值为：离散傅里叶变换 DFT 矢量 v_k、或者 DFT 矢量的克罗内克积 $f(v_k,v_l)$；其中，

$$v_k=\begin{bmatrix}1 & e^{j\phi_k} & \cdots & e^{j(n-1)\phi_k}\end{bmatrix}^H$$

$$f(v_k,v_l)=v_k\otimes v_l \text{ 或者 } f(v_k,v_l)=\begin{bmatrix}v_k\\v_l\end{bmatrix}$$

其中，k,l 为正整数，j 为虚数单位，n 为大于 1 的正整数，ϕ_k 为相位参数；$[\ ]^H$ 表示共轭转置运算，$\otimes$ 为直乘符号。

优选地，所述终端，还配置为根据基站配置的功率门限从所述 N 个导频端口中选择出 K 个导频端口；其中，所述功率门限为相对门限或绝对门限。

优选地，所述基站，还配置为根据终端的上报的终端信息，从所述 M 个导频端口中配置 N 个导频端口给所述终端。

优选地，所述终端，还配置为反馈导频端口的选择信息，所述导频端口的选择信息采用选择的导频端口数目和选择的导频端口标识联合编码；其中，不同的导频端口被选择的概率不同，不同的导频端口数目对应的状

态位不同。

本发明实施例提供的基站包括：发射单元、配置单元；其中，

所述发射单元，配置为发射 M 类导频信号，所述 M 类导频信号分别对应于 M 个导频端口；

所述配置单元，配置为通过信令从所述 M 个导频端口中配置 N 个导频端口给终端；M 为正整数，N 为小于 M 的正整数。

优选地，所述基站还包括：虚拟化单元，配置为通过相同的一组天线虚拟化形成所述 N 个导频端口；其中，述 N 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

优选地，所述配置单元，还配置为根据所述终端反馈的信道统计信息确定所述 N 个导频端口；其中，所述信道统计信息为相关矩阵信息；所述 N 个导频端口对应的虚拟化预编码权值为相关矩阵特征矢量。

优选地，所述 N 个导频端口对应的虚拟化预编码权值为：离散傅里叶变换 DFT 矢量 v_k、或者由 DFT 矢量的克罗内克积 $f(v_k,v_l)$；其中，

$$v_k=\begin{bmatrix}1 & e^{j\phi_k} & \cdots & e^{j(n-1)\phi_k}\end{bmatrix}^H$$

$$f(v_k,v_l)=v_k\otimes v_l \text{ 或者 } f(v_k,v_l)=\begin{bmatrix}v_k\\ v_l\end{bmatrix}$$

其中，k,l 为正整数，j 为虚数单位，n 为大于 1 的正整数，ϕ_k 为相位参数；$[\ ]^H$ 表示共轭转置运算，$\otimes$ 为直乘符号。

优选地，所述配置单元，还配置为根据终端的上报的终端信息，从所述 M 个导频端口中配置 N 个导频端口给所述终端。

本发明实施例提供的终端包括：接收单元、选择单元、反馈单元；其中，

所述接收单元，配置为接收并检测由基站配置的 N 个导频端口的导频信号；

所述选择单元，配置为根据接收信号质量，从所述 N 个导频端口中选择出 K 个导频端口；

所述反馈单元，配置为反馈所述 K 个导频端口与终端形成信道的信道信息；K 为小于 N 的正整数。

优选地，所述信道信息至少包括以下之一：K 个导频端口的索引信息、K 个导频端口之间的幅度比例信息、K 个导频端口之间的相位差信息、K 个导频端口的接收功率信息、K 个导频端口的信干噪比信息。

优选地，所述选择单元，还配置为根据基站配置的功率门限从所述 N 个导频端口中选择出 K 个导频端口；其中，所述功率门限为相对门限或绝对门限。

优选地，所述反馈单元，还配置为反馈导频端口的选择信息，所述导频端口的选择信息采用选择的导频端口数目和选择的导频端口标识联合编码；其中，不同的导频端口被选择的概率不同，不同的导频端口数目对应的状态位不同。

优选地，所述终端还包括：虚拟化单元，配置为通过相同的一组天线虚拟化形成所述 K 个导频端口；其中，K 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

本发明实施例提供的波束发送系统包括：基站、终端；其中，

所述基站，配置为预先选定 P 个波束权值，并根据终端反馈的信道相关矩阵对所述 P 个波束权值进行处理，获得 P 个新波束；将所述 P 个新波束发送至终端；

所述终端，配置为从所述 P 个新波束中选择 Q 个波束，并将所述 Q 个波束将反馈至基站。

优选地，所述信道相关矩阵是多个终端的相关矩阵信息的叠加合并。

优选地，所述 P 个波束权值为：P 个 DFT 矢量、或者是两个 DFT 矢量

的函数。

本发明实施例的技术方案中，基站发射 M 类导频信号，所述 M 类导频信号分别对应于 M 个导频端口；基站通过信令从所述 M 个导频端口中配置 N 个导频端口给终端；M 为正整数，N 为小于 M 的正整数，如此，将 M 个导频端口的信道信息的维度降低至了 N 个导频端口的信道信息的维度，使得终端从所述 N 个导频端口中选择 K 个导频端口可以基于相关性确定的一个子空间内进行信道信息的反馈。并且，通过终端从所述 N 个导频端口中选择 K 个导频端口进行信道信息的反馈，能够进一步降低信道信息的维度，大大节约了信道信息反馈的开销。

附图说明

图 1 为本发明实施例一的信道信息的反馈方法的流程示意图；

图 2 为本发明实施例二的导频发送方法的流程示意图；

图 3 为本发明实施例三的信道信息的反馈方法的流程示意图；

图 4 为本发明实施例四的波束发送方法的流程示意图；

图 5 为本发明实施例一的信道信息的反馈系统的结构组成示意图；

图 6 为本发明实施例二的基站的结构组成示意图；

图 7 为本发明实施例三的终端的结构组成示意图；

图 8 为本发明实施例四的波束发送系统的结构组成示意图；

图 9 为本发明实施例的基站预编码的示意图；

图 10 为本发明实施例的 DFT 矢量预编码的示意图；

图 11 为本发明实施例的信道相关矩阵预编码的示意图；

图 12 为本发明实施例的基于波束权值进行信道信息反馈的示意图。

具体实施方式

为了能够更加详尽地了解本发明实施例的特点与技术内容，下面结合

附图对本发明实施例的实现进行详细阐述，所附附图仅供参考说明之用，并非用来限定本发明实施例。

图 1 为本发明实施例一的信道信息的反馈方法的流程示意图，本示例中的信道信息的反馈方法应用于信道信息的反馈系统中，如图 1 所示，本示例中的信道信息的反馈方法包括以下步骤:

步骤 101: 基站发射 M 类导频信号，所述 M 类导频信号分别对应于 M 个导频端口。

这里，M 为大于 1 的整数，例如 M 为 64。

具体地，参照图 9，基站具有 Nt 根相同的发射天线，Nt 为大于 1 的整数，每根发射天线发射出一路信号，Nt 根发射天线发射出 Nt 路信号，本实施例对 Nt 根发射天线发射出的 Nt 路信号进行虚拟化，而得到 M 类导频信号。这里，虚拟化具体为预编码，即对 Nt 路信号分别乘以对应的 Nt 个权值，而得到一类导频信号。基于此，Nt 个权值组成一套权值矢量，维度为 Nt，每类导频信号对应的所述一套权值矢量不同，也即 M 类导频信号对应于 M 套权值矢量。应当注意的是，由于权值矢量具有方向性，因此通过权值矢量进行预编码的导频信号也具备方向性。

步骤 102: 基站通过信令从所述 M 个导频端口中配置 N 个导频端口给终端; M 为正整数，N 为小于 M 的正整数。

优选地，所述方法还包括:

基站根据终端的上报的终端信息，从所述 M 个导频端口中配置 N 个导频端口给所述终端。

优选地，所述方法还包括:

通过相同的一组天线虚拟化形成所述 N 个导频端口; 其中，述 N 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

优选地，所述方法还包括:

所述基站根据所述终端反馈的信道统计信息确定所述 N 个导频端口；其中，所述信道统计信息为相关矩阵信息；所述 N 个导频端口对应的虚拟化预编码权值为相关矩阵特征矢量。

优选地，所述 N 个导频端口对应的虚拟化预编码权值为：离散傅里叶变换（DFT，Discrete Fourier Transform）矢量v_k、或者 DFT 矢量的克罗内克积$f(v_k,v_l)$；其中，

$$v_k=\begin{bmatrix}1 & e^{j\phi_k} & \cdots & e^{j(n-1)\phi_k}\end{bmatrix}^H$$

$$f(v_k,v_l)=v_k\otimes v_l \text{ 或者 } f(v_k,v_l)=\begin{bmatrix}v_k\\ v_l\end{bmatrix}$$

其中，k,l为正整数，j为虚数单位，n为大于 1 的正整数，ϕ_k为相位参数；$[\ ]^H$表示共轭转置运算，$\otimes$为直乘符号。

具体地，参照图 10，预设的波束权值可以是 DFT 矢量，M 类导频信号，也即 M 个导频端口对应的 M 个 DFT 矢量如公式（1）：

$$\begin{aligned}\mathbf{v_1}&=\begin{bmatrix}1 & e^{j\phi_1} & \cdots & e^{j(P1-1)\phi_1}\end{bmatrix}^H\\ \mathbf{v_2}&=\begin{bmatrix}1 & e^{j\phi_2} & \cdots & e^{j(P2-1)\phi_2}\end{bmatrix}^H\\ &\cdots\\ \mathbf{v_M}&=\begin{bmatrix}1 & e^{j\phi_M} & \cdots & e^{j(PM-1)\phi_M}\end{bmatrix}^H\end{aligned} \qquad (1)$$

其中，$\mathbf{v_1}$，$\mathbf{v_2}$，…，$\mathbf{v_M}$表示 M 个 DFT 矢量；$P1$，$P2$，…，PM均等于 Nt；ϕ_1，ϕ_2，…，ϕ_M为 0 至2π中均匀量化的相位参数；$[\quad\cdots\quad]^H$表示转置共轭。

上述 DFT 矢量利用了多径的原理，即以 DFT 矢量去对应径的最优波束权值。由于信道是由多径合成的，因此对于 M 类导频信号，有些导频端口收到较强的导频信号，收到较强导频信号也即多径分量较强；有些导频端口收到较弱的导频信号，收到较弱导频信号也即多径分量较弱。

上述方案中，Nt 根发射天线为线性阵列，当 Nt 根发射天线为其他形式

的天线阵列，例如二维天线阵列时，M 个导频信号对应的波束权值为两个 DFT 矢量的函数形式，如公式（2）:

$$f\left(\mathbf{v}_i, \mathbf{v}_j\right) = \mathbf{v}_i \otimes \mathbf{v}_j \qquad (2)$$

其中，$\mathbf{v}_i$和$\mathbf{v}_j$如公式（1）所示，$\mathbf{v}_i$对应的Pi和$\mathbf{v}_j$对应的Pj相乘等于发射天线的数目 Nt。

二维天线阵列的 M 个导频信号对应的波束权值还可以通过公式（3）得到:

$$f\left(\mathbf{v}_i, \mathbf{v}_j\right) = \begin{bmatrix} \mathbf{v}_i \\ \mathbf{v}_j \end{bmatrix} \qquad (3)$$

其中，$\mathbf{v}_i$和$\mathbf{v}_j$如公式（1）所示，$\mathbf{v}_i$对应的Pi以及$\mathbf{v}_j$对应的Pj均等于发射天线的数目的一半 Nt/2。

这里，不是每个终端都需要检测 M 类导频信号对应的 M 个导频端口，基站可以针对每个终端配置一些端口进行检测，比如对于用户设备（UE，User Equipment）1 可以配置 N1=16 个导频端口进行检测，对于 UE2 可以配置 N2=8 个导频端口进行检测，具体的导频端口可以是基站根据终端的位置信息或终端上报的一些粗的信道信息进行确定。

步骤 103：终端接收并检测所述 N 个导频端口的导频信号。

具体地，基站将 N 个导频端口的端口信息发送至终端。并且，终端根据所述端口信息，对所述 N 个导频端口的 N 类导频信号进行检测，以得到所述 N 类导频信号对应的接收功率；终端基于所述 N 类导频信号对应的接收功率，从所述 N 个导频端口中选择 K 个导频端口；终端将 K 个导频端口的信道信息发送至基站。

具体地，终端接收基站发送的 N 个导频端口的端口信息。这里，基站根据终端的位置信息或信道信息在生成的 M 个导频端口中选择 N 个导频端口，其中，N<M。

步骤 104：终端根据接收信号质量，从所述 N 个导频端口中选择出 K 个导频端口，并反馈所述 K 个导频端口与终端形成信道的信道信息；K 为小于 N 的正整数。

优选地，所述方法还包括:

终端根据基站配置的功率门限从所述 N 个导频端口中选择出 K 个导频端口；其中，所述功率门限为相对门限或绝对门限。

终端获取基站发送的端口信息后，在相应的端口位置上进行导频信号的检测，以得到所述 N 类导频信号对应的接收功率。具体地，当 N 为 8 时，

终端检测到导频信号 0 的接收功率为 a_0 dBm;

终端检测到导频信号 1 的接收功率为 a_1 dBm;

终端检测到导频信号 2 的接收功率为 a_2 dBm;

……

终端检测到导频信号 7 的接收功率为 a_7 dBm。

优选地，所述信道信息至少包括以下之一：K 个导频端口的索引信息、K 个导频端口之间的幅度比例信息、K 个导频端口之间的相位差信息、K 个导频端口的接收功率信息、K 个导频端口的信干噪比信息。

具体地，将所述 N 类导频信号对应的接收功率分别与预设的门限值进行比较;

当所述接收功率大于或等于所述门限值时，确定所述接收功率对应的导频端口为第一类端口;

当所述接收功率小于所述门限值时，确定所述接收功率对应的导频端口为第二类端口;

从所述 N 个导频端口中选择所述第一类端口，所述第一类端口的个数为 K。

或者，在所述 N 类导频信号对应的接收功率中确定出最大的接收功率;

将所述 N 类导频信号对应的接收功率分别与所述最大的接收功率进行比较；

当所述接收功率与所述最大的接收功率的比值大于或等于预设的阈值时，确定所述接收功率对应的导频端口为第一类端口；

当所述接收功率与所述最大的接收功率的比值小于所述阈值时，确定所述接收功率对应的导频端口为第二类端口；

从所述 N 个导频端口中选择所述第一类端口，所述第一类端口的个数为 K。

优选地，基站预先设置导频端口的最大数目，K 小于或等于所述导频端口的最大数目。

上述方案中，从所述 N 个导频端口中选择 K 个导频端口的两种选择方式可以结合，具体为：所选择的导频端口的导频信号的接收功率大于或等于所述门限值，并且所选择的导频端口的导频信号的接收功率与所述最大的接收功率的比值大于或等于预设的阈值时，所述导频端口为第一类端口。

优选地，所述方法还包括：

通过相同的一组天线虚拟化形成所述 K 个导频端口；其中，K 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

优选地，所述方法还包括：

终端反馈导频端口的选择信息，所述导频端口的选择信息采用选择的导频端口数目和选择的导频端口标识联合编码；其中，不同的导频端口被选择的概率不同，不同的导频端口数目对应的状态位不同。

本实施例中，在从所述 N 个导频端口中选择 K 个导频端口之后，还上报 K 个导频端口的选择信息，具体地，每个导频端口被选到的概率是不一样的，部分导频端口的选择概率高，部分导频端口的选择概率低，因此可以通过编码表示导频端口的概率。例如，以在 N=8 个导频端口中选出 K=2

个导频端口为例，编码信息如表 1 所示。

0000	Port1,Port2	1000	Port2,Port4
0001	Port1,Port3	1001	Port2,Port5
0010	Port1,Port4	1010	Port2,Port6
0011	Port1,Port5	1011	Port2,Port7
0100	Port1,Port6	1100	Port2,Port8
0101	Port1,Port7	1101	Port3,Port4
0110	Port1,Port8	1110	Port3,Port5
0111	Port2,Port3	1111	Port4,Port5

表 1

例如，以 N=8 个导频端口中选出 K=3 个导频端口为例，编码信息如表 2 所示。

0000	Port1,Port2,Port3	1000	Port1,Port3,Port6
0001	Port1,Port2,Port4	1001	Port1,Port3,Port7
0010	Port1,Port2,Port5	1010	Port1,Port3,Port8
0011	Port1,Port2,Port6	1011	Port2,Port3,Port4
0100	Port1,Port2,Port7	1100	Port2,Port3,Port5
0101	Port1,Port2,Port8	1101	Port2,Port3,Port6
0110	Port1,Port3,Port4	1110	Port2,Port3,Port7
0111	Port1,Port3,Port5	1111	Port2,Port3,Port8

表 2

另外，考虑到选择到的导频端口的数目也是不等概率的，例如，选到导频端口的数目为 2 和选到导频端口的数目为 4 的概率不同，因此，也可以进行导频端口数目与导频端口概率的联合编码，以压缩编码开销，编码信息如表 3 所示。

0000	Port1,Port2	1000	Port2,Port4
0001	Port1,Port3	1001	Port3,Port4
0010	Port1,Port4	1010	Port3,Port5
0011	Port1,Port5	1011	Port4,Port5
0100	Port1,Port6	1100	Port1,Port2,Port3
0101	Port1,Port7	1101	Port1,Port2,Port4
0110	Port1,Port8	1110	Port1,Port3,Port4
0111	Port2,Port3	1111	Port2,Port3,Port4

表 3

所述相位差信息是各接收天线收到的波束信号的平均后，再计算相位差。

具体地，对于选择的导频端口，终端反馈导频端口的幅度/功率信息，以及相位信息，这里较佳的是反馈导频端口之间的相对信息，比如幅度/功率比例，相位差信息。幅度功率比例可以采用以下方式：指示最强功率的导频端口，并反馈与最强功率的导频端口的幅度或功率的比例，具体地，如表 4 所示，首先指示一个幅度或功率的量级，然后再指示一个在该量级上的一个系数。该系数可以均匀量化。相位差信息可以在 0 至 2π 内均匀量化反馈。

00	$10^{-0.5}$

01	10^{-1}
10	$10^{-1.5}$
11	10^{-2}

表 4

这里，当波束权值为 DFT 矢量时，接收功率信息、相位差信息具体为多径的幅度和相位差信息，基站基于接收到的信道信息，可以重新构造波束权值，进而优化预编码。

图 2 为本发明实施例二的导频发送方法的流程示意图，本示例中的导频发送方法应用于基站中，如图 2 所示，本示例中的导频发送方法包括以下步骤：

步骤 201：基站发射 M 类导频信号，所述 M 类导频信号分别对应于 M 个导频端口。

步骤 202：基站通过信令从所述 M 个导频端口中配置 N 个导频端口给终端；M 为正整数，N 为小于 M 的正整数。

优选地，所述方法还包括：

通过相同的一组天线虚拟化形成所述 N 个导频端口；其中，述 N 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

优选地，所述方法还包括：

所述基站根据所述终端反馈的信道统计信息确定所述 N 个导频端口；其中，所述信道统计信息为相关矩阵信息；所述 N 个导频端口对应的虚拟化预编码权值为相关矩阵特征矢量。

优选地，所述 N 个导频端口对应的虚拟化预编码权值为：离散傅里叶变换 DFT 矢量 v_k、或者由 DFT 矢量的克罗内克积 $f(v_k, v_l)$；其中，

$$v_k = \begin{bmatrix} 1 & e^{j\psi_k} & \cdots & e^{j(n-1)\psi_k} \end{bmatrix}^H$$

$$f(v_k, v_l) = v_k \otimes v_l \text{ 或者 } f(v_k, v_l) = \begin{bmatrix} v_k \\ v_l \end{bmatrix}$$

其中，k,l 为正整数，j 为虚数单位，n 为大于 1 的正整数，ϕ_k 为相位参数；$[\ ]^H$ 表示共轭转置运算，$\otimes$ 为直乘符号。

优选地，所述方法还包括:

基站根据终端的上报的终端信息，从所述 M 个导频端口中配置 N 个导频端口给所述终端。

图 3 为本发明实施例三的信道信息的反馈方法的流程示意图，本示例中的信道信息的反馈方法应用于终端中，如图 3 所示，本示例中的信道信息的反馈方法包括以下步骤:

步骤 301：终端接收并检测由基站配置的 N 个导频端口的导频信号。

步骤 302：根据接收信号质量，从所述 N 个导频端口中选择出 K 个导频端口。

优选地，所述方法还包括：所述方法还包括:

终端根据基站配置的功率门限从所述 N 个导频端口中选择出 K 个导频端口；其中，所述功率门限为相对门限或绝对门限。

步骤 303：反馈所述 K 个导频端口与终端形成信道的信道信息；K 为小于 N 的正整数。

优选地，所述信道信息至少包括以下之一：K 个导频端口的索引信息、K 个导频端口之间的幅度比例信息、K 个导频端口之间的相位差信息、K 个导频端口的接收功率信息、K 个导频端口的信干噪比信息。

优选地，所述方法还包括:

终端反馈导频端口的选择信息，所述导频端口的选择信息采用选择的导频端口数目和选择的导频端口标识联合编码；其中，不同的导频端口被选择的概率不同，不同的导频端口数目对应的状态位不同。

优选地，所述方法还包括:

通过相同的一组天线虚拟化形成所述 K 个导频端口；其中，K 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

图 4 为本发明实施例四的波束发送方法的流程示意图，本示例中的波束发送方法应用于波束发送系统中，如图 4 所示，本示例中的波束发送方法包括以下步骤:

步骤 401: 基站预先选定 P 个波束权值，并根据终端反馈的信道相关矩阵对所述 P 个波束权值进行处理，获得 P 个新波束；将所述 P 个新波束发送至终端。

优选地，所述信道相关矩阵是多个终端的相关矩阵信息的叠加合并。

具体地，将接收到的一个以上信道相关子矩阵进行叠加，而得到信道相关矩阵;

根据所述信道相关矩阵的特征矢量，对多个发射天线对应的信号进行预编码，而得到 M 类导频信号。

具体地，参照图 11，预设的波束权值还可以是信道相关矩阵 **R**，基站接收一个以上 UE 反馈的信道相关子矩阵，并将一个以上信道相关子矩阵进行叠加，得到信道相关矩阵 **R**。这里，信道相关子矩阵为终端的信道相关矩阵信息，例如信道相关矩阵 **R** 的每个元素的信息、信道相关矩阵 **R** 的特征值信息、信道相关矩阵 **R** 的特征矢量信息。

当波束权值为信道相关矩阵 **R** 时，基站基于接收到的一个以上终端发送的信道信息对所述相关矩阵 **R** 进行叠加，以重新构造波束权值，进而优化预编码。

具体地，参照图 12，基站预先选定 P 个波束权值，这 P 个波束权值可以是比较均匀的一些权值，即弦距离要大于一个门限，例如 0.9。选定的 P 个波束权值可以是一些 DFT 矢量，也可以是由格拉斯曼（Grassmanian）方法生成的一些 Nt 维空间中均匀的矢量。

终端反馈其对应的信道相关子矩阵，这个信道相关子矩阵是终端测量获取的。基站可以将一个终端的信道相关子矩阵或者多个终端的信道相关子矩阵的叠加值**R**作为波束权值旋转矩阵，将波束权值旋转矩阵乘以选定的P个波束权值，然后进行归一化的功率处理。

进行旋转后，均匀的 P 个波束会根据**R**中的相关性进行分布调整，对于部分子空间波束比较密集，部分子空间波束比较稀疏。而终端的特征矢量更多的处于波束比较密集的子空间。

终端在收到的导频信号中选择最优的一个或多个导频端口对应的信息上报至基站，基站可以根据终端上报的端口信息，查询到对应的导频端口及对应的波束权值，利用该波束权值进行预编码。

优选地，所述P个波束权值为：P个DFT矢量、或者是两个DFT矢量的函数。

步骤402：终端从所述P个新波束中选择Q个波束，并将所述Q个波束将反馈至基站。

图 5 为本发明实施例一的信道信息的反馈系统的结构组成示意图，如图5所示，所述系统包括：基站51、终端52；其中，

所述基站51，配置为发射M类导频信号，所述M类导频信号分别对应于M个导频端口；通过信令从所述M个导频端口中配置N个导频端口给终端52；M为正整数，N为小于M的正整数；

所述终端52，配置为接收并检测所述N个导频端口的导频信号；根据接收信号质量，从所述N个导频端口中选择出K个导频端口，并反馈所述K个导频端口与终端52形成信道的信道信息；K为小于N的正整数。

优选地，所述信道信息至少包括以下之一：K个导频端口的索引信息、K 个导频端口之间的幅度比例信息、K 个导频端口之间的相位差信息、K个导频端口的接收功率信息、K个导频端口的信干噪比信息。

优选地，所述终端 52，还配置为通过相同的一组天线虚拟化形成所述 K 个导频端口；其中，K 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

优选地，所述基站 51，还配置为通过相同的一组天线虚拟化形成所述 N 个导频端口；其中，述 N 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

优选地，所述基站 51，还配置为根据所述终端 52 反馈的信道统计信息确定所述 N 个导频端口；其中，所述信道统计信息为相关矩阵信息；所述 N 个导频端口对应的虚拟化预编码权值为相关矩阵特征矢量。

优选地，所述 N 个导频端口对应的虚拟化预编码权值为：离散傅里叶变换 DFT 矢量 v_k、或者 DFT 矢量的克罗内克积 $f(v_k,v_l)$；其中，

$$v_k=\begin{bmatrix}1 & e^{j\phi_k} & \cdots & e^{j(n-1)\phi_k}\end{bmatrix}^H$$

$$f(v_k,v_l)=v_k\otimes v_l \text{ 或者 } f(v_k,v_l)=\begin{bmatrix}v_k\\ v_l\end{bmatrix}$$

其中，k,l 为正整数，j 为虚数单位，n 为大于 1 的正整数，ϕ_k 为相位参数；$[\ ]^H$ 表示共轭转置运算，$\otimes$ 为直乘符号。

优选地，所述终端 52，还配置为根据基站 51 配置的功率门限从所述 N 个导频端口中选择出 K 个导频端口；其中，所述功率门限为相对门限或绝对门限。

优选地，所述基站 51，还配置为根据终端 52 的上报的终端 52 信息，从所述 M 个导频端口中配置 N 个导频端口给所述终端 52。

优选地，所述终端 52，还配置为反馈导频端口的选择信息，所述导频端口的选择信息采用选择的导频端口数目和选择的导频端口标识联合编码；其中，不同的导频端口被选择的概率不同，不同的导频端口数目对应的状态位不同。

本领域技术人员应当理解，图 5 所示的信道信息的反馈系统中的基站 51 和终端 52 的实现功能可参照前述信道信息的反馈方法的相关描述而理解。

图 6 为本发明实施例二的基站的结构组成示意图，如图 6 所示，所述基站包括：发射单元 61、配置单元 62；其中，

所述发射单元 61，配置为发射 M 类导频信号，所述 M 类导频信号分别对应于 M 个导频端口；

所述配置单元 62，配置为通过信令从所述 M 个导频端口中配置 N 个导频端口给终端；M 为正整数，N 为小于 M 的正整数。

优选地，所述基站还包括：虚拟化单元 63，配置为通过相同的一组天线虚拟化形成所述 N 个导频端口；其中，述 N 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

优选地，所述配置单元 62，还配置为根据所述终端反馈的信道统计信息确定所述 N 个导频端口；其中，所述信道统计信息为相关矩阵信息；所述 N 个导频端口对应的虚拟化预编码权值为相关矩阵特征矢量。

优选地，所述 N 个导频端口对应的虚拟化预编码权值为：离散傅里叶变换 DFT 矢量 v_k 、或者由 DFT 矢量的克罗内克积 $f(v_k,v_l)$；其中，

$$v_k=\begin{bmatrix}1 & e^{j\phi_k} & \cdots & e^{j(n-1)\phi_k}\end{bmatrix}^H$$

$$f(v_k,v_l)=v_k\otimes v_l \text{ 或者 } f(v_k,v_l)=\begin{bmatrix}v_k\\ v_l\end{bmatrix}$$

其中，k,l 为正整数，j 为虚数单位，n 为大于 1 的正整数，ϕ_k 为相位参数；$[\ ]^H$ 表示共轭转置运算，$\otimes$ 为直乘符号。

优选地，所述配置单元 62，还配置为根据终端的上报的终端信息，从所述 M 个导频端口中配置 N 个导频端口给所述终端。

本领域技术人员应当理解，图 6 所示的基站中的各单元的实现功能可

参照前述导频发送方法的相关描述而理解。

在实际应用中，所述基站中的发射单元 61、配置单元 62 以及虚拟化单元 63 可由基站中的中央处理器（CPU，Central Processing Unit）、或数字信号处理器（DSP，Digital Signal Processor）、或可编程门阵列（FPGA，Field－Programmable Gate Array）实现。

图 7 为本发明实施例三的终端的结构组成示意图，如图 7 所示，所述终端包括：接收单元 71、选择单元 72、反馈单元 73；其中，

所述接收单元 71，配置为接收并检测由基站配置的 N 个导频端口的导频信号；

所述选择单元 72，配置为根据接收信号质量，从所述 N 个导频端口中选择出 K 个导频端口；

所述反馈单元 73，配置为反馈所述 K 个导频端口与终端形成信道的信道信息；K 为小于 N 的正整数。

优选地，所述信道信息至少包括以下之一：K 个导频端口的索引信息、K 个导频端口之间的幅度比例信息、K 个导频端口之间的相位差信息、K 个导频端口的接收功率信息、K 个导频端口的信干噪比信息。

优选地，所述选择单元 72，还配置为根据基站配置的功率门限从所述 N 个导频端口中选择出 K 个导频端口；其中，所述功率门限为相对门限或绝对门限。

优选地，所述反馈单元 73，还配置为反馈导频端口的选择信息，所述导频端口的选择信息采用选择的导频端口数目和选择的导频端口标识联合编码；其中，不同的导频端口被选择的概率不同，不同的导频端口数目对应的状态位不同。

优选地，所述终端还包括：虚拟化单元 74，配置为通过相同的一组天线虚拟化形成所述 K 个导频端口；其中，K 个导频端口中的每个导频端口

均对应一套虚拟化预编码权值。

本领域技术人员应当理解，图 7 所示的终端中的各单元的实现功能可参照前述信道信息的反馈方法的相关描述而理解。

在实际应用中，所述终端中的接收单元 71、选择单元 72、反馈单元 73 以及虚拟化单元 74 可由终端中的 CPU、或 DSP、或 FPGA 实现。

图 8 为本发明实施例四的波束发送系统的结构组成示意图，如图 8 所示，所述系统包括：基站 81、终端 82；其中，

所述基站 81，配置为预先选定 P 个波束权值，并根据终端 82 反馈的信道相关矩阵对所述 P 个波束权值进行处理，获得 P 个新波束；将所述 P 个新波束发送至终端 82；

所述终端 82，配置为从所述 P 个新波束中选择 Q 个波束，并将所述 Q 个波束将反馈至基站 81。

优选地，所述信道相关矩阵是多个终端 82 的相关矩阵信息的叠加合并。

优选地，所述 P 个波束权值为：P 个 DFT 矢量、或者是两个 DFT 矢量的函数。

本领域技术人员应当理解，图 8 所示的波束发送系统中的基站 81、终端 82 的实现功能可参照前述波束发送方法的相关描述而理解。

在本申请所提供的几个实施例中，应该理解到，所揭露的设备和方法，可以通过其它的方式实现。以上所描述的设备实施例仅仅是示意性的，例如，所述单元的划分，仅仅为一种逻辑功能划分，实际实现时可以有另外的划分方式，如：多个单元或组件可以结合，或可以集成到另一个系统，或一些特征可以忽略，或不执行。另外，所显示或讨论的各组成部分相互之间的耦合、或直接耦合、或通信连接可以是通过一些接口，设备或单元的间接耦合或通信连接，可以是电性的、机械的或其它形式的。

上述作为分离部件说明的单元可以是、或也可以不是物理上分开的，

作为单元显示的部件可以是、或也可以不是物理单元，即可以位于一个地方，也可以分布到多个网络单元上；可以根据实际的需要选择其中的部分或全部单元来实现本实施例方案的目的。

另外，在本发明各实施例中的各功能单元可以全部集成在一个处理单元中，也可以是各单元分别单独作为一个单元，也可以两个或两个以上单元集成在一个单元中；上述集成的单元既可以采用硬件的形式实现，也可以采用硬件加软件功能单元的形式实现。

本领域普通技术人员可以理解：实现上述方法实施例的全部或部分步骤可以通过程序指令相关的硬件来完成，前述的程序可以存储于一计算机可读取存储介质中，该程序在执行时，执行包括上述方法实施例的步骤；而前述的存储介质包括：移动存储设备、只读存储器（ROM，Read Only Memory）、磁碟或者光盘等各种可以存储程序代码的介质。

或者，本发明上述集成的单元如果以软件功能模块的形式实现并作为独立的产品销售或使用时，也可以存储在一个计算机可读取存储介质中。基于这样的理解，本发明实施例的技术方案本质上或者说对现有技术做出贡献的部分可以以软件产品的形式体现出来，该计算机软件产品存储在一个存储介质中，包括若干指令用以使得一台计算机设备（可以是个人计算机、服务器、或者网络设备等）执行本发明各个实施例所述方法的全部或部分。而前述的存储介质包括：移动存储设备、只读存储器（ROM，Read Only Memory）、磁碟或者光盘等各种可以存储程序代码的介质。

以上所述，仅为本发明的具体实施方式，但本发明的保护范围并不局限于此，任何熟悉本技术领域的技术人员在本发明揭露的技术范围内，可轻易想到变化或替换，都应涵盖在本发明的保护范围之内。因此，本发明的保护范围应以所述权利要求的保护范围为准。

以上所述，仅为本发明的较佳实施例而已，并非用于限定本发明的保

护范围。

权利要求书

1、一种信道信息的反馈方法，所述方法包括:

基站发射 M 类导频信号，所述 M 类导频信号分别对应于 M 个导频端口；基站通过信令从所述 M 个导频端口中配置 N 个导频端口给终端；M 为正整数，N 为小于 M 的正整数;

终端接收并检测所述 N 个导频端口的导频信号；根据接收信号质量，从所述 N 个导频端口中选择出 K 个导频端口，并反馈所述 K 个导频端口与终端形成信道的信道信息；K 为小于 N 的正整数。

2、根据权利要求 1 所述的信道信息的反馈方法，其中，所述信道信息至少包括以下之一：K 个导频端口的索引信息、K 个导频端口之间的幅度比例信息、K 个导频端口之间的相位差信息、K 个导频端口的接收功率信息、K 个导频端口的信干噪比信息。

3、根据权利要求 1 所述的信道信息的反馈方法，其中，所述方法还包括:

通过相同的一组天线虚拟化形成所述 K 个导频端口；其中，所述 K 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

4、根据权利要求 1 所述的信道信息的反馈方法，其中，所述方法还包括:

通过相同的一组天线虚拟化形成所述 N 个导频端口；其中，所述 N 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

5、根据权利要求 4 所述的信道信息的反馈方法，其中，所述方法还包括:

所述基站根据所述终端反馈的信道统计信息确定所述 N 个导频端口；其中，所述信道统计信息为相关矩阵信息；所述 N 个导频端口对应的虚拟化预编码权值为相关矩阵特征矢量。

6、根据权利要求 1 所述的信道信息的反馈方法，其中，所述 N 个导频端口对应的虚拟化预编码权值为：离散傅里叶变换 DFT 矢量 v_k 、或者 DFT 矢量的克罗内克积 $f(v_k,v_l)$；其中，

$$v_k=\begin{bmatrix}1 & e^{j\phi_k} & \cdots & e^{j(n-1)\phi_k}\end{bmatrix}^H$$

$$f(v_k,v_l)=v_k\otimes v_l \text{ 或者 } f(v_k,v_l)=\begin{bmatrix}v_k\\ v_l\end{bmatrix}$$

其中，k,l 为正整数，j 为虚数单位，n 为大于 1 的正整数，ϕ_k 为相位参数；$[\ ]^H$ 表示共轭转置运算，$\otimes$ 为直乘符号。

7、根据权利要求 1 所述的信道信息的反馈方法，其中，所述方法还包括:

终端根据基站配置的功率门限从所述 N 个导频端口中选择出 K 个导频端口；其中，所述功率门限为相对门限或绝对门限。

8、根据权利要求 1 所述的信道信息的反馈方法，其中，所述方法还包括:

基站根据终端的上报的终端信息，从所述 M 个导频端口中配置 N 个导频端口给所述终端。

9、根据权利要求 1 至 8 任一项所述的信道信息的反馈方法，其中，所述方法还包括:

终端反馈导频端口的选择信息，所述导频端口的选择信息采用选择的导频端口数目和选择的导频端口标识联合编码；其中，不同的导频端口被选择的概率不同，不同的导频端口数目对应的状态位不同。

10、一种导频发送方法，所述方法包括:

基站发射 M 类导频信号，所述 M 类导频信号分别对应于 M 个导频端口；基站通过信令从所述 M 个导频端口中配置 N 个导频端口给终端；M 为正整数，N 为小于 M 的正整数。

11、根据权利要求 10 所述的导频发送方法，其中，所述方法还包括:

通过相同的一组天线虚拟化形成所述 N 个导频端口；其中，述 N 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

12、根据权利要求 10 所述的导频发送方法，其中，所述方法还包括:

所述基站根据所述终端反馈的信道统计信息确定所述 N 个导频端口；其中，所述信道统计信息为相关矩阵信息；所述 N 个导频端口对应的虚拟化预编码权值为相关矩阵特征矢量。

13、根据权利要求 10 所述的导频发送方法，其中，所述 N 个导频端口对应的虚拟化预编码权值为：离散傅里叶变换 DFT 矢量 v_k、或者由 DFT 矢量的克罗内克积 $f(v_k,v_l)$；其中，

$$v_k=\begin{bmatrix}1 & e^{j\phi_k} & \cdots & e^{j(n-1)\phi_k}\end{bmatrix}^H$$

$$f(v_k,v_l)=v_k\otimes v_l \text{ 或者 } f(v_k,v_l)=\begin{bmatrix}v_k\\ v_l\end{bmatrix}$$

其中，k,l 为正整数，j 为虚数单位，n 为大于 1 的正整数，ϕ_k 为相位参数；$[\ ]^H$ 表示共轭转置运算，$\otimes$ 为直乘符号。

14、根据权利要求 10 至 13 任一项所述的导频发送方法，其中，所述方法还包括:

基站根据终端的上报的终端信息，从所述 M 个导频端口中配置 N 个导频端口给所述终端。

15、一种信道信息的反馈方法，所述方法包括:

终端接收并检测由基站配置的 N 个导频端口的导频信号；根据接收信号质量，从所述 N 个导频端口中选择出 K 个导频端口，并反馈所述 K 个导频端口与终端形成信道的信道信息；K 为小于 N 的正整数。

16、根据权利要求 15 所述的信道信息的反馈方法，其中，所述信道信息至少包括以下之一：K 个导频端口的索引信息、K 个导频端口之间的幅

度比例信息、K 个导频端口之间的相位差信息、K 个导频端口的接收功率信息、K 个导频端口的信干噪比信息。

17、根据权利要求 15 所述的信道信息的反馈方法，其中，所述方法还包括：所述方法还包括：

终端根据基站配置的功率门限从所述 N 个导频端口中选择出 K 个导频端口；其中，所述功率门限为相对门限或绝对门限。

18、根据权利要求 15 所述的信道信息的反馈方法，其中，所述方法还包括：

终端反馈导频端口的选择信息，所述导频端口的选择信息采用选择的导频端口数目和选择的导频端口标识联合编码；其中，不同的导频端口被选择的概率不同，不同的导频端口数目对应的状态位不同。

19、根据权利要求 15 至 18 任一项所述的信道信息的反馈方法，其中，所述方法还包括：

通过相同的一组天线虚拟化形成所述 K 个导频端口；其中，K 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

20、一种波束发送方法，所述方法包括：

基站预先选定 P 个波束权值，并根据终端反馈的信道相关矩阵对所述 P 个波束权值进行处理，获得 P 个新波束；将所述 P 个新波束发送至终端；

终端从所述 P 个新波束中选择 Q 个波束，并将所述 Q 个波束将反馈至基站。

21、根据权利要求 20 所述的波束发送方法，其中，所述信道相关矩阵为多个终端的相关矩阵信息的叠加合并。

22、根据权利要求 20 或 21 所述的波束发送方法，其中，所述 P 个波束权值为：P 个 DFT 矢量、或者两个 DFT 矢量的函数。

23、一种信道信息的反馈系统，所述系统包括：基站、终端；其中，

所述基站，配置为发射 M 类导频信号，所述 M 类导频信号分别对应于 M 个导频端口；通过信令从所述 M 个导频端口中配置 N 个导频端口给终端；M 为正整数，N 为小于 M 的正整数；

所述终端，配置为接收并检测所述 N 个导频端口的导频信号；根据接收信号质量，从所述 N 个导频端口中选择出 K 个导频端口，并反馈所述 K 个导频端口与终端形成信道的信道信息；K 为小于 N 的正整数。

24、根据权利要求 23 所述的信道信息的反馈系统，其中，所述信道信息至少包括以下之一：K 个导频端口的索引信息、K 个导频端口之间的幅度比例信息、K 个导频端口之间的相位差信息、K 个导频端口的接收功率信息、K 个导频端口的信干噪比信息。

25、根据权利要求 23 所述的信道信息的反馈系统，其中，所述终端，还配置为通过相同的一组天线虚拟化形成所述 K 个导频端口；其中，K 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

26、根据权利要求 23 所述的信道信息的反馈系统，其中，所述基站，还配置为通过相同的一组天线虚拟化形成所述 N 个导频端口；其中，述 N 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

27、根据权利要求 26 所述的信道信息的反馈系统，其中，所述基站，还配置为根据所述终端反馈的信道统计信息确定所述 N 个导频端口；其中，所述信道统计信息为相关矩阵信息；所述 N 个导频端口对应的虚拟化预编码权值为相关矩阵特征矢量。

28、根据权利要求 23 所述的信道信息的反馈系统，其中，所述 N 个导频端口对应的虚拟化预编码权值为：离散傅里叶变换 DFT 矢量 v_k、或者 DFT 矢量的克罗内克积 $f(v_k, v_l)$；其中，

$$v_k = \begin{bmatrix} 1 & e^{j\phi_k} & \cdots & e^{j(n-1)\phi_k} \end{bmatrix}^H$$

$$f(v_k,v_l)=v_k\otimes v_l \text{ 或者 } f(v_k,v_l)=\begin{bmatrix}v_k\\v_l\end{bmatrix}$$

其中，k,l 为正整数，j 为虚数单位，n 为大于 1 的正整数，ϕ_k 为相位参数；$[\ ]^H$ 表示共轭转置运算，$\otimes$ 为直乘符号。

29、根据权利要求 23 所述的信道信息的反馈系统，其中，所述终端，还配置为根据基站配置的功率门限从所述 N 个导频端口中选择出 K 个导频端口；其中，所述功率门限为相对门限或绝对门限。

30、根据权利要求 23 所述的信道信息的反馈系统，其中，所述基站，还配置为根据终端的上报的终端信息，从所述 M 个导频端口中配置 N 个导频端口给所述终端。

31、根据权利要求 23 至 30 任一项所述的信道信息的反馈系统，其中，所述终端，还配置为反馈导频端口的选择信息，所述导频端口的选择信息采用选择的导频端口数目和选择的导频端口标识联合编码；其中，不同的导频端口被选择的概率不同，不同的导频端口数目对应的状态位不同。

32、一种基站，所述基站包括：发射单元、配置单元；其中，

所述发射单元，配置为发射 M 类导频信号，所述 M 类导频信号分别对应于 M 个导频端口；

所述配置单元，配置为通过信令从所述 M 个导频端口中配置 N 个导频端口给终端；M 为正整数，N 为小于 M 的正整数。

33、根据权利要求 32 所述的基站，其中，所述基站还包括：虚拟化单元，配置为通过相同的一组天线虚拟化形成所述 N 个导频端口；其中，述 N 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

34、根据权利要求 32 所述的基站，其中，所述配置单元，还配置为根据所述终端反馈的信道统计信息确定所述 N 个导频端口；其中，所述信道统计信息为相关矩阵信息；所述 N 个导频端口对应的虚拟化预编码权值为相关矩阵特征矢量。

35、根据权利要求 32 所述的基站，其中，所述 N 个导频端口对应的虚拟化预编码权值为：离散傅里叶变换 DFT 矢量 v_k、或者由 DFT 矢量的克罗内克积 $f(v_k,v_l)$；其中，

$$v_k=\begin{bmatrix}1 & e^{j\phi_k} & \cdots & e^{j(n-1)\phi_k}\end{bmatrix}^H$$

$$f(v_k,v_l)=v_k\otimes v_l \text{ 或者 } f(v_k,v_l)=\begin{bmatrix}v_k\\v_l\end{bmatrix}$$

其中，k,l 为正整数，j 为虚数单位，n 为大于 1 的正整数，ϕ_k 为相位参数；$[\ ]^H$ 表示共轭转置运算，$\otimes$ 为直乘符号。

36、根据权利要求 32 至 35 任一项所述的基站，其中，所述配置单元，还配置为根据终端的上报的终端信息，从所述 M 个导频端口中配置 N 个导频端口给所述终端。

37、一种终端，所述终端包括：接收单元、选择单元、反馈单元；其中，

所述接收单元，配置为接收并检测由基站配置的 N 个导频端口的导频信号；

所述选择单元，配置为根据接收信号质量，从所述 N 个导频端口中选择出 K 个导频端口；

所述反馈单元，配置为反馈所述 K 个导频端口与终端形成信道的信道信息；K 为小于 N 的正整数。

38、根据权利要求 37 所述的终端，其中，所述信道信息至少包括以下之一：K 个导频端口的索引信息、K 个导频端口之间的幅度比例信息、K 个导频端口之间的相位差信息、K 个导频端口的接收功率信息、K 个导频端口的信干噪比信息。

39、根据权利要求 37 所述的终端，其中，所述选择单元，还配置为根据基站配置的功率门限从所述 N 个导频端口中选择出 K 个导频端口；其中，

所述功率门限为相对门限或绝对门限。

40、根据权利要求 37 所述的终端，其中，所述反馈单元，还配置为反馈导频端口的选择信息，所述导频端口的选择信息采用选择的导频端口数目和选择的导频端口标识联合编码；其中，不同的导频端口被选择的概率不同，不同的导频端口数目对应的状态位不同。

41、根据权利要求 37 至 40 任一项所述的终端，其中，所述终端还包括：虚拟化单元，配置为通过相同的一组天线虚拟化形成所述 K 个导频端口；其中，K 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

42、一种波束发送系统，所述系统包括：基站、终端；其中，

所述基站，配置为预先选定 P 个波束权值，并根据终端反馈的信道相关矩阵对所述 P 个波束权值进行处理，获得 P 个新波束；将所述 P 个新波束发送至终端；

所述终端，配置为从所述 P 个新波束中选择 Q 个波束，并将所述 Q 个波束将反馈至基站。

43、根据权利要求 42 所述的波束发送系统，其中，所述信道相关矩阵为多个终端的相关矩阵信息的叠加合并。

44、根据权利要求 42 或 43 所述的波束发送系统，其中，所述 P 个波束权值为：P 个 DFT 矢量、或者两个 DFT 矢量的函数。

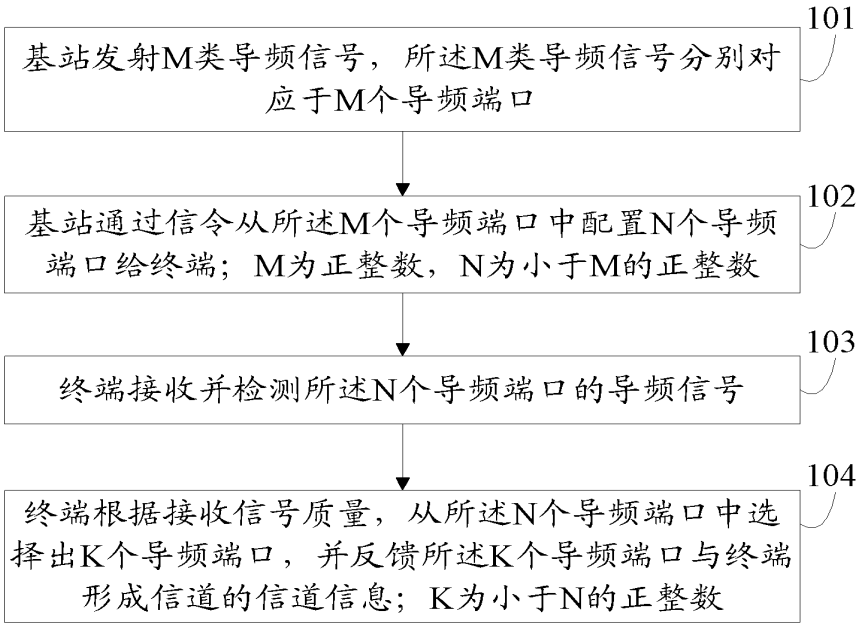

101
基站发射M类导频信号，所述M类导频信号分别对应于M个导频端口
102
基站通过信令从所述M个导频端口中配置N个导频端口给终端；M为正整数，N为小于M的正整数
103
终端接收并检测所述N个导频端口的导频信号
104
终端根据接收信号质量，从所述N个导频端口中选择出K个导频端口，并反馈所述K个导频端口与终端形成信道的信道信息；K为小于N的正整数

图 1

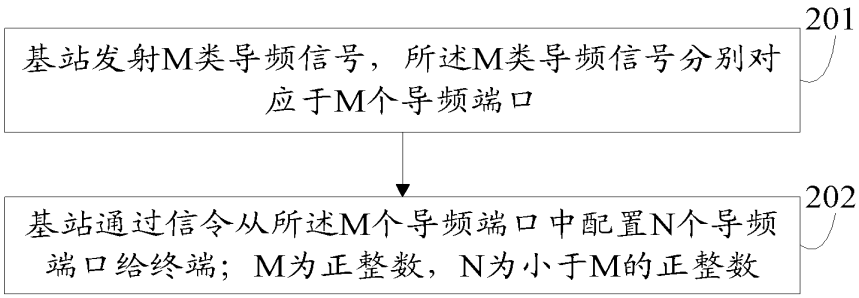

201
基站发射M类导频信号，所述M类导频信号分别对应于M个导频端口
202
基站通过信令从所述M个导频端口中配置N个导频端口给终端；M为正整数，N为小于M的正整数

图 2

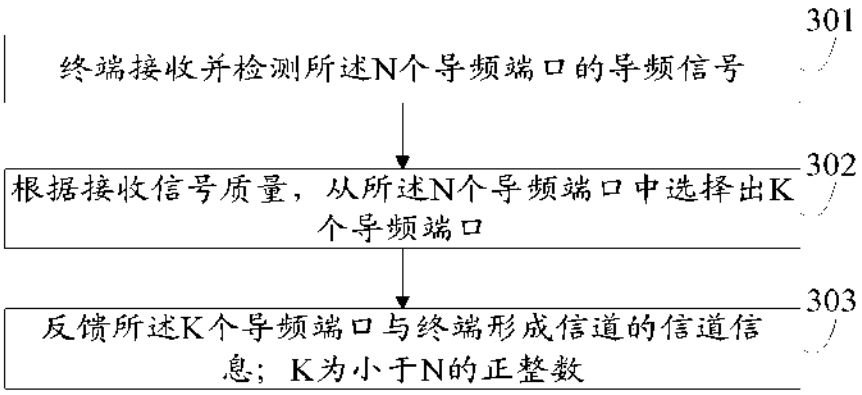

301
终端接收并检测所述N个导频端口的导频信号
302
根据接收信号质量，从所述N个导频端口中选择出K个导频端口
303
反馈所述K个导频端口与终端形成信道的信道信息；K为小于N的正整数

图 3

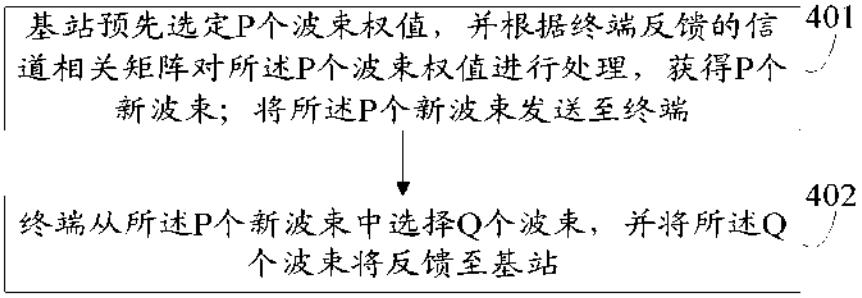

401
基站预先选定P个波束权值，并根据终端反馈的信道相关矩阵对所述P个波束权值进行处理，获得P个新波束；将所述P个新波束发送至终端
402
终端从所述P个新波束中选择Q个波束，并将所述Q个波束将反馈至基站

图 4

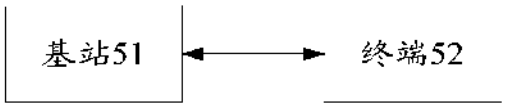

基站51
终端52

图 5

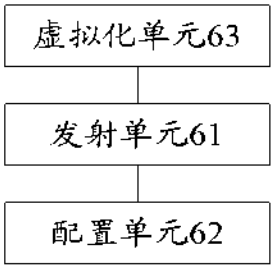

虚拟化单元63
发射单元61
配置单元62

图 6

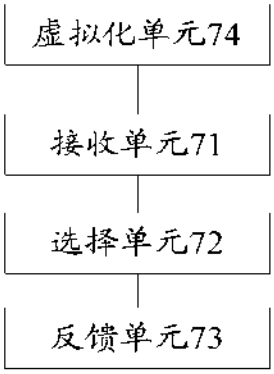


图 7

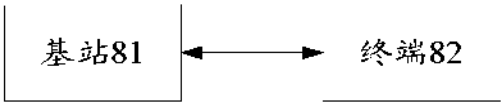


图 8

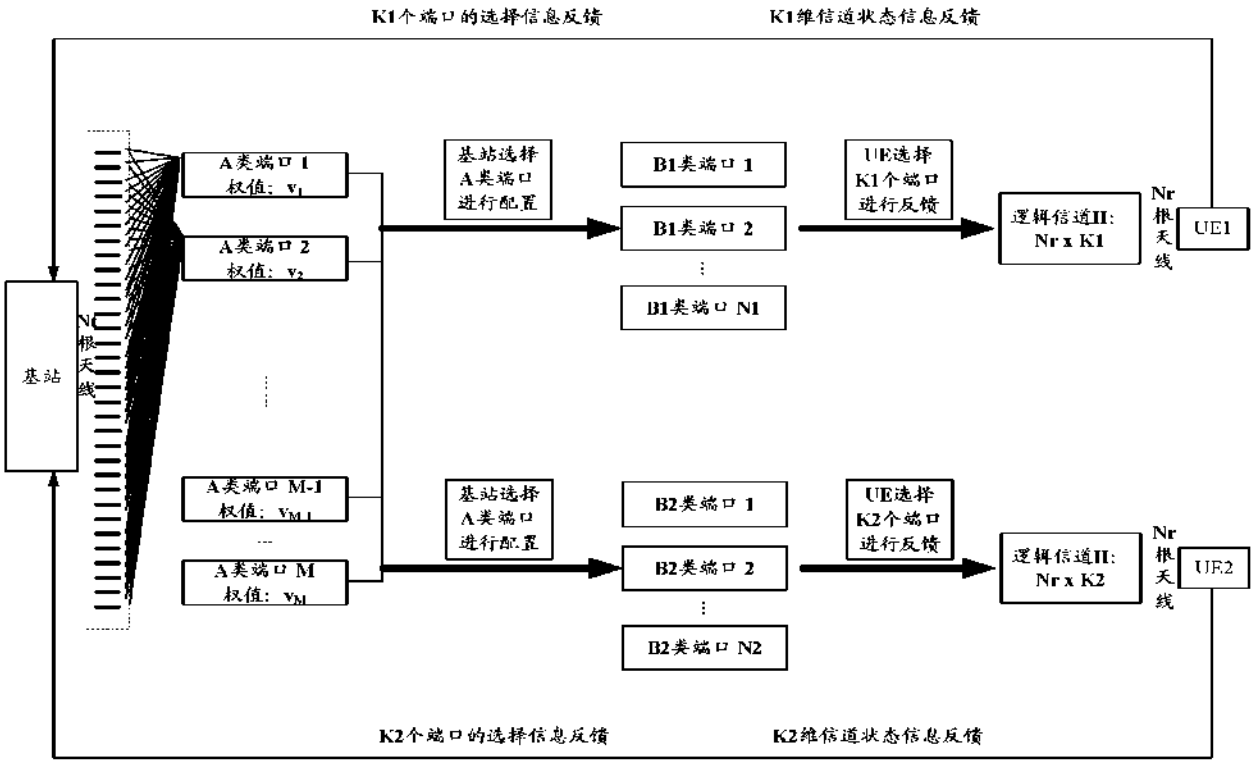

K1个端口的选择信息反馈
K1维信道状态信息反馈
基站
N根天线
A类端口 1
权值：v_1
A类端口 2
权值：v_2
A类端口 M-1
权值：v_{M-1}
A类端口 M
权值：v_M
基站选择A类端口进行配置
B1类端口 1
B1类端口 2
B1类端口 N1
UE选择K1个端口进行反馈
逻辑信道II：Nr x K1
Nr根天线
UE1
基站选择A类端口进行配置
B2类端口 1
B2类端口 2
B2类端口 N2
UE选择K2个端口进行反馈
逻辑信道II：Nr x K2
Nr根天线
UE2
K2个端口的选择信息反馈
K2维信道状态信息反馈

图 9

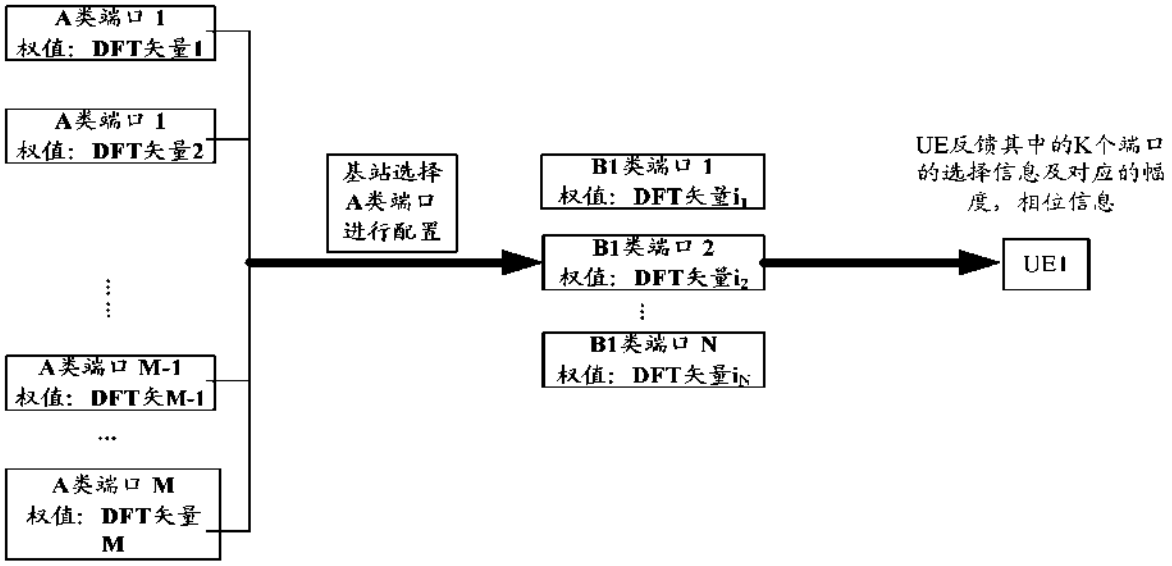

A类端口 1
权值：DFT矢量1
A类端口 1
权值：DFT矢量2
A类端口 M-1
权值：DFT矢M-1
A类端口 M
权值：DFT矢量M
基站选择A类端口进行配置
B1类端口 1
权值：DFT矢量i_1
B1类端口 2
权值：DFT矢量i_2
B1类端口 N
权值：DFT矢量i_N
UE反馈其中的K个端口的选择信息及对应的幅度，相位信息
UE1

图 10

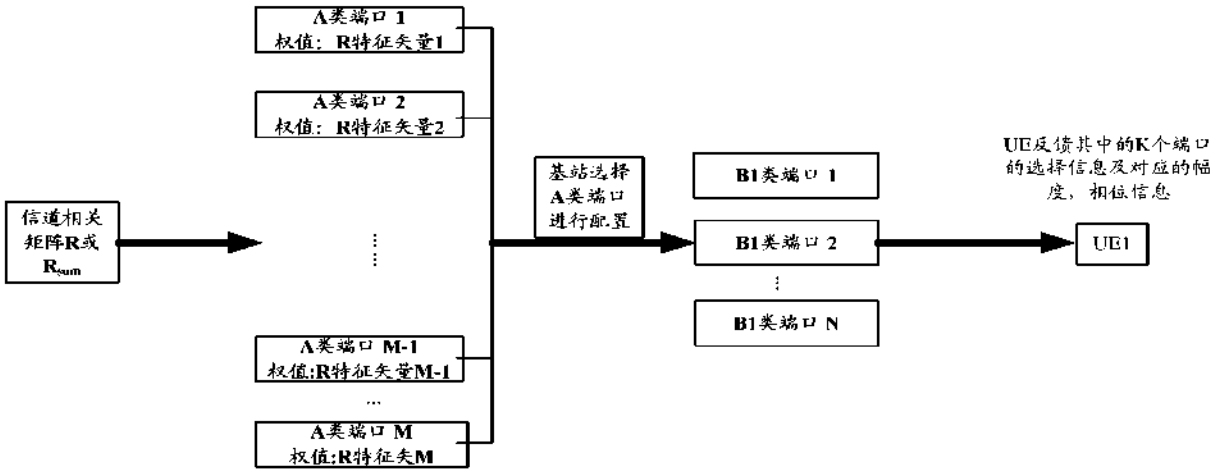

A类端口 1
权值：R特征矢量1
A类端口 2
权值：R特征矢量2
A类端口 M-1
权值:R特征矢量M-1
A类端口 M
权值:R特征矢M
信道相关矩阵R或 R_{sum}
基站选择A类端口进行配置
B1类端口 1
B1类端口 2
B1类端口 N
UE反馈其中的K个端口的选择信息及对应的幅度，相位信息
UE1

图 11

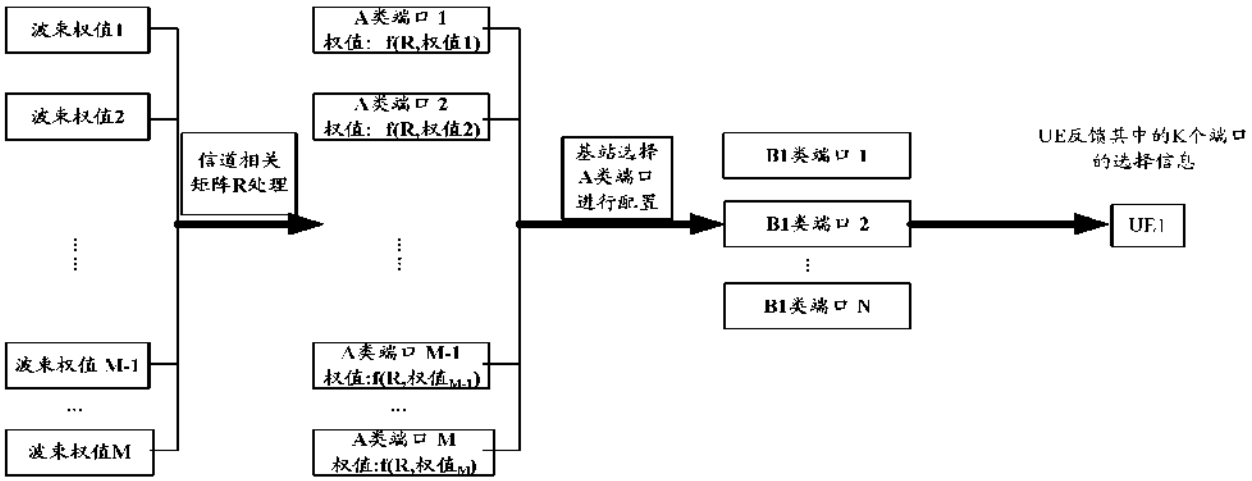

波束权值1
波束权值2
波束权值 M-1
波束权值M
信道相关矩阵R处理
A类端口 1
权值：f(R,权值1)
A类端口 2
权值：f(R,权值2)
A类端口 M-1
权值:f(R,权值$_{M-1}$)
A类端口 M
权值:f(R,权值$_{M}$)
基站选择A类端口进行配置
B1类端口 1
B1类端口 2
B1类端口 N
UE反馈其中的K个端口的选择信息
UE1

图 12

(12) 按照专利合作条约所公布的国际申请

(19) 世界知识产权组织
国 际 局

(43) 国际公布日
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(81) 指定国 (除另有指明，要求每一种可提供的国家保护): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW。

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(54) Title: COMMUNICATION QUALITY MEASUREMENT METHOD AND DEVICE

(54) 发明名称 : 一种通信质量测量的方法和装置

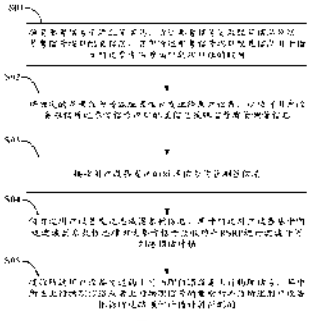


图 1 / Fig.1

501 Resource configuration information, wherein the reference signal resource configuration information comprises: reference signal port configuration information, and the reference signal port configuration information is used for indicating the mapping from a reference signal port to a port group

502 Sending the determined reference signal resource configuration information to a user equipment, so that the user equipment acquires signal quality measurement information according to the reference signal port configuration information

503 Receiving the signal quality measurement information sent by the user equipment

504 Sending filter coefficient information to the user equipment for the user equipment to filter reference signal receiving power (RSRP) based on the filter coefficient information and to obtain a path loss estimation value 505 Receiving an uplink physical channel or an uplink physical signal sent by the user equipment, wherein the transmitting power of the uplink physical channel or the uplink physical signal is obtained by the user equipment according to the calculation of the path loss estimation value

(57) **Abstract**: A method and device for indicating signal power. The method comprises: acquiring reference signal resource configuration information, wherein the reference signal resource configuration information at least comprises: reference signal port configuration information, and reference signal power information of at least one port group; or the reference signal resource configuration information at least comprises: the reference signal port configuration information, and a ratio of the power of a data channel with respect to the power of a reference signal in at least one port group; and sending the acquired reference signal resource configuration information to a user equipment. As a result, accurate signal quality measurement information or more accurate channel state information is acquired in a multi-antenna system.

(57) **摘要**: 一种用于指示信号功率的方法和装置，其中，该方法包括：获取参考信号资源配置信息，其中，所述参考信号资源配置信息至少包括：参考信号端口配置信息，和至少一个端口组的参考信号功率信息；或者，所述参考信号资源配置信息至少包括：参考信号端口配置信息，和至少一个端口组中的数据信道的功率相对于参考信号的功率的比值；将获取的参考信号资源配置信息发送给用户设备。使得在多天线系统中获取到准确的信号质量测量信息，或者获取到更准确的信道状态信息。

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RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG)。

本国际公布:

— 包括国际检索报告(条约第 21 条(3))。

一种通信质量测量的方法和装置

技术领域

本发明涉及通信技术领域，特别涉及一种通信质量测量的方法和装置。

背景技术

在通信技术领域中，信号通常可以划分为两类，一类信号携带来自高层的信息，另一类信号则不携带来自高层的信息，该类信号通常用于辅助或者指示前一类信号的接收。信号的发射功率对于上述两类信号都是非常重要的参数，例如：参考信号的功率可以用于导出路径损耗估计值，该路径损耗估计值可以作为开环控制的一部分实现上行功率控制，或者作为小区（或者发射节点，或者接收节点）选择的基础。物理下行共享信道（PDSCH，Physical Downlink Shared CHannel）信号相对于参考信号（如：小区特定的参考信号（CRS，Cell-Specific Reference Signal）或者信道状态信息参考信号(CSI-RS, Channel State Information Reference Signal)的功率比值，可以用于导出信道状态信息（CSI，Channel State Information），便于实现调度和链路自适应。

在现有长期演进（LTE，Long Time Evolution） R8—R11版本中，与功率有关的参数是由基站或者网络侧确定，并通过高层信令通知给用户设备（UE，User Equipment）。由于传统基站天线配置具有固定的下倾角，上行和下行链路经历类似的路径损耗，从而下行路径损耗可以很好地用于估计上行路径损耗。因此，上述基站或者网络侧发送的功率有关的参数可以不区分天线端口，尤其是多个天线端口的情况，不区分天线端口的情况下，通过下行路径损耗可以很好地用于估计上行路径损耗。该技术对于传统基站天线配置特别是各个天线端口发射功率相同的情况可以很好的工作。另一方面，用户设备（User Equipment，UE）上报的本小区/节点或者邻小区/节点的参考信号接收功率（RSRP，Reference Signal Received Power）可以用于基站或者演进节点B（evolved Node，eNB）为UE选择服务小区或者节点。现有技术中RSRP是由不同天线口之间进行平均从而得到估计。

为了降低系统费用同时达到更高的系统容量和覆盖要求，有源天线系统（AAS，Active Antenna System）在实践中已广泛部署，目前即将启动的LTE R12标准正在考虑引入AAS系统之后对通信性能的增强。有别于传统的基站天线，

AAS进一步提供了天线垂直向的设计自由度，上行和下行链路可以采用独立的下倾角，并且，不同天线端口的功率可能不同。此外，对于AAS基站而言，即使相同数量的天线端口，其天线阵列结构也可能不同。从而相同编号的天线端口，在不同阵列结构的天线端口也可能有不同的发射功率。在这种情况下，现有技术中基于下行参考信号接收功率实现功率控制，或者小区/节点选择的方法将不再有效。现有技术中，无法正确区分天线口发射功率不同的情况，不能提供准确有效估计上行路径损耗，以及估计信道状态信息的技术方案。

发明内容

本发明实施例提供一种通信质量测量的方法和装置，克服了现有技术中不能在多天线系统中获取到准确的信号质量测量信息，或者获取到更准确的信道状态信息的问题。

第一方面，提供了一种通信质量测量的方法，包括：

确定参考信号资源配置信息，所述参考信号资源配置信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系；

将所述参考信号资源配置信息发送给用户设备，以使得所述用户设备根据所述参考信号端口配置信息获取信号质量测量信息。

在第一种可能的实现方式中，根据第一方面，所述参考信号资源配置信息还包括：至少两个端口组的参考信号功率信息，用于所述用户设备根据所述参考信号端口配置信息并结合所述至少两个端口组的参考信号功率信息，获取所述信号质量测量信息；

其中，所述至少两个端口组的参考信号功率信息，包括：

第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的比值；

或者，第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的差分。

在第二种可能的实现方式中，结合第一方面或第一种可能的实现方式，所述信号质量测量信息为参考信号接收功率 RSRP，所述方法还包括：

向所述用户设备发送滤波器系数信息，用于所述用户设备基于所述滤波器

系数信息对所述参考信号接收功率 RSRP 进行滤波并得到路损估计值。

在第三种可能的实现方式中，结合第二种可能的实现方式，所述方法还包括:

接收所述用户设备发送的上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率为所述用户设备根据所述路损估计值计算得到的。

在第四种可能的实现方式中，结合第一方面或第一种可能的实现方式，所述信号质量测量信息包括:

参考信号接收功率 RSRP，参考信号接收质量 RSRQ，或者参考信号强度指示 RSSI 其中任一项或者任意组合。

在第五种可能的实现方式中，结合第一方面或第一种可能的实现方式至第四种可能的实现方式的任意一种，其特征在于，所述方法还包括:

接收用户设备发送的所述信号质量测量信息。

第二方面，提供了一种通信质量测量的方法，包括:

接收基站发送的参考信号资源配置信息，所述参考信号资源配置信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系;

根据所述参考信号端口配置信息，得到至少一个端口组中的参考信号端口信息;

根据所述至少一个端口组中的参考信号端口信息获取信号质量测量信息。

在第一种可能的实现方式中，根据第二方面，所述根据所述参考信号端口配置信息，得到至少一个端口组中的参考信号端口信息包括:

根据所述参考信号端口配置信息，得到指定的一个端口组中的参考信号端口信息;

所述根据所述至少一个端口组中的参考信号端口信息获取信号质量测量信息包括:

根据所述指定的一个端口组中的参考信号端口信息获取所述信号质量测量信息。

在第二种可能的实现方式中，根据第一方面的第一种可能的实现方式，当

所述信号质量测量信息为参考信号接收功率 RSRP 时，所述根据所述指定的一个端口组中的参考信号端口信息获取所述信号质量测量信息，包括：

根据公式：$RSRP(r,p)=\frac{1}{K_s-1}\sum_{m=0}^{K_s-1}\hat{h}_p(m)\cdot\hat{h}_p(m+1)$ 得到第 r 个接收天线第 p 个端口的参考信号接收功率 $RSRP(r,p)$ 并通过组合 $RSRP(r,p)$ 得到所述 RSRP；其中，$\hat{h}_p(m)$ 为标号为 m 的参考信号 RE 上的信道估计；K_s 是在测量带宽内可利用的参考信号 RE 的样本总数；p 为所述指定的一个端口组中参考信号端口号，r 为接收天线的索引。

在第三种可能的实现方式中，结合第二方面，所述参考信号资源配置信息还包括：至少两个端口组的参考信号功率信息，用于所述用户设备根据所述参考信号端口配置信息并结合所述至少两个端口组的参考信号功率信息获取所述信号质量测量信息。

在第四种可能的实现方式中，结合第二方面第三中可能的实现方式，所述根据所述参考信号端口配置信息并结合至少两个端口组的参考信号功率信息获取信号质量测量信息，包括：

根据所述参考信号端口配置信息得到所述至少两个端口组对应的信号质量测量信息；

根据所述至少两个端口组的参考信号功率信息，对所得到的至少两个端口组对应的信号质量测量信息按端口组功率进行加权平均，得到所述信号质量测量信息。

在第五种可能的实现方式中，结合第二方面第四中可能的实现方式，所述根据所述至少两个端口组的参考信号功率信息，对所得到的至少两个端口组对应的信号质量测量信息按端口组功率进行加权平均，得到信号质量测量信息，包括：

根据公式：$SQ=\left(\sum_{g=0}^{n-1}p_g\cdot SQ_g\right)\Big/\left(\sum_{g=0}^{n-1}p_g\right)$，得到信号质量测量信息，

其中，SQ_g 为指定端口组的信号质量测量信息，其中，g 为指定端口组的编号，n 为指定端口组的个数，$n\geq 2$；p_g 为指定端口组的参考信号功率，其中，

指定端口组的参考信号功率根据所述至少两个端口组的参考信号功率信息得到。

在第六种可能的实现方式中，结合第二方面第二种可能的实现方式至第五种可能的实现方式的任意一种，所述至少两个端口组的参考信号功率信息，包括:

第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的比值;

或者，第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的差分。

在第七种可能的实现方式中，结合第二方面至第六种可能的实现方式的任意一种，所述方法还包括:

向基站发送所述信号质量测量信息。

在第八种可能的实现方式中，结合第二方面至第七种可能的实现方式的任意一种，所述信号质量测量信息为参考信号接收功率 RSRP，所述方法还包括:

接收基站发送的滤波器系数信息;

基于所述滤波器系数信息对所述参考信号接收功率 RSRP 进行滤波，并得到路损估计值。

在第九种可能的实现方式中，结合第二方面的第八种可能的实现方式，所述方法还包括:

向基站发送上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率根据所述路损估计值计算得到。

在第十种可能的实现方式中，结合第二方面，所述信号质量测量信息，包括: 参考信号接收功率 RSRP，参考信号强度指示 RSSI，或者参考信号接收质量 RSRQ。

第三方面，提供一种通信质量测量的方法，包括:

向用户设备发送参考信号资源配置信息，所述参考信号资源配置信息包括: 参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射关系，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功率比值;

接收用户设备发送的信道状态信息 CSI，其中，所述 CSI 为所述用户设备根据所述参考信号端口配置信息和所述功率比值信息得到。

在第一种可能的实现方式中，根据第三方面，在所述功率比值信息中：

所述至少一个端口组中的每个端口组内的各天线端口上数据信道相对于参考信号的功率比值都相同；

或者，所述至少一个端口组中的一个端口组内各个端口上的数据信道与其它端口组内各个端口的数据信道相对于参考信号的功率比值相同。

在第二种可能的实现方式中，根据第三方面或者第三方面第一种可能的实现方式，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的多套功率比值，

所述接收用户设备发送的信道状态信息 CSI，包括接收用户设备发送的多套信道状态信息 CSI，其中每一套信道状态信息 CSI 为所述用户设备根据所述多套功率比值中的一套功率比值得到的。

在第三种可能的实现方式中，结合第三方面或第一种可能的实现方式或第二种可能的实现方式，所述信道状态信息 CSI 包括：信道质量指示 CQI，预编码矩阵指示 PMI，或秩指示 RI 其中任意一个或者任意组合。

第四方面，提供了一种通信质量测量方法，所述方法包括：

接收基站发送的参考信号资源配置信息，所述参考信号资源配置信息包括：参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射关系，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功率比值；

根据所述参考信号端口配置信息和所述功率比值信息，得到所述至少一个端口组内每个天线端口上数据信道相对于参考信号的功率比值，

并根据所述每个天线端口上数据信道相对于参考信号的功率比值，得到信道状态信息 CSI；

向基站发送所述信道状态信息 CSI。

在第一种可能的实现方式中，根据第四方面，所述根据所述每个天线端口上数据信道相对于参考信号的功率比值，得到信道状态信息 CSI，包括：

根据所述每个天线端口上的参考信号得到所述每个天线端口对应的信道

测量值;

根据所述每个天线端口对应的信道测量值，和所述每个天线端口上数据信道相对于参考信号的功率比值，得到所述每个天线端口上数据信道的信道估计值;

根据所述每个天线端口上数据信道的信道估计值得到信道状态信息 CSI。

在第二种可能的实现方式中，结合第一种可能的实现方式，所述根据所述每个天线端口对应的信道测量值，和所述每个天线端口上数据信道相对于参考信号的功率比值，得到所述每个天线端口上数据信道的信道估计值，包括:

根据公式 $\hat{\mathbf{h}}_p = \sqrt{\rho_p}\mathbf{h}_p$ 得到天线端口 p 上数据信道的信道估计值;

其中，p 为所述天线端口的索引，ρ_p 为天线端口 p 上数据信道相对于参考信号的功率比值，$\mathbf{h}_p$ 为天线端口 p 对应的信道测量值，$\hat{\mathbf{h}}_p$ 为天线端口 p 上数据信道的信道估计值。

在第三种可能的实现方式中，结合第四方面或第一种可能的实现方式或第二种可能的实现方式，在所述功率比值信息中，

所述至少一个端口组中的每个端口组内的各天线端口上数据信道相对于参考信号的功率比值相同;

或者，所述至少一个端口组中的一个端口组内的各个端口上的数据信道与其它端口组内各个端口上的数据信道相对于参考信号的功率比值相同。

在第四种可能的实现方式中，结合第四方面，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的多套功率比值;

所述向基站发送所述信道状态信息 CSI，包括:

向基站发送所述多套信道状态信息 CSI，其中每一套信道状态信息 CSI 为根据所述多套功率比值中的一套功率比值得到的。

在第五种可能的实现方式中，结合第四方面或第一种可能的实现方式至第四种可能的实现方式的任意一种，所述信道状态信息 CSI 包括: 信道质量指示 CQI，预编码矩阵指示 PMI，或秩指示 RI 其中任意一个或者任意组合。

第五方面，提供了一种网络侧装置，所述网络侧装置包括: 确定单元，和第一发送单元;

所述确定单元，用于确定参考信号资源配置信息，所述参考信号资源配置

信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系；

所述第一发送单元，用于将所述确定单元确定的所述参考信号资源配置信息发送给用户设备，以使得所述用户设备根据所述参考信号端口配置信息获取信号质量测量信息。

在第一种可能的实现方式中，根据第五方面，所述确定单元确定的所述参考信号资源配置信息还包括：至少两个端口组的参考信号功率信息，用于所述用户设备根据所述参考信号端口配置信息并结合所述至少两个端口组的参考信号功率信息，获取所述信号质量测量信息；

其中，所述至少两个端口组的参考信号功率信息，包括：

第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的比值；

或者，第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的差分。

在第二种可能的实现方式中，结合第五方面或第一种可能的实现方式，当所述信号质量测量信息为参考信号接收功率 RSRP 时，所述第一发送单元还用于向所述用户设备发送滤波器系数信息，用于所述用户设备基于所述滤波器系数信息对所述参考信号接收功率 RSRP 进行滤波并得到路损估计值。

在第三种可能的实现方式中，结合第二种可能的实现方式，所述装置还包括：

第一接收单元，用于接收所述用户设备发送的上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率为所述用户设备根据所述路损估计值计算得到的。

在第四种可能的实现方式中，结合第五方面或第一种可能的实现方式，所述信号质量测量信息包括：

参考信号接收功率 RSRP，参考信号接收质量 RSRQ，或者参考信号强度指示 RSSI 其中任一项或者任意组合。

在第五种可能的实现方式中，结合第五方面或第一种可能的实现方式至第四种可能的实现方式的任意一种，其特征在于，所述装置还包括：第二接收单

元，

所述第二接收单元用于接收用户设备发送的所述信号质量测量信息。

第六方面，提供了一种用户设备，所述用户设备包括：第三接收单元，第一获取单元，和第二获取单元；

所述第三接收单元，用于接收基站发送的参考信号资源配置信息，所述参考信号资源配置信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系；

所述第一获取单元，用于根据所述第三接收单元接收的所述参考信号端口配置信息，得到至少一个端口组中的参考信号端口信息；

所述第二获取单元，用于根据所述第一获取单元得到所述至少一个端口组中的参考信号端口信息获取信号质量测量信息。

在第一种可能的实现方式中，根据第六方面，所述第一获取单元，具体用于根据所述第三接收单元接收的所述参考信号端口配置信息，得到指定的一个端口组中的参考信号端口信息；

所述第二获取单元，具体用于根据所述第一获取单元得到的所述指定的一个端口组中的参考信号端口信息获取所述信号质量测量信息。

在第二种可能的实现方式中，根据第六方面的第一种可能的实现方式，当所述信号质量测量信息为参考信号接收功率 RSRP 时，所述第二获取单元具体用于：

根据公式：$$RSRP(r,p)=\frac{1}{K_s-1}\sum_{m=0}^{K_s-1}\hat{h}_p(m)\cdot\hat{h}_p(m+1)$$ 得到第 r 个接收天线第 p 个端口的参考信号接收功率 $RSRP(r,p)$ 并通过组合 $RSRP(r,p)$ 得到所述 RSRP；其中，$\hat{h}_p(m)$ 为标号为 m 的参考信号 RE 上的信道估计；K_s 是在测量带宽内可利用的参考信号 RE 的样本总数；p 为所述指定的一个端口组中参考信号端口号，r 为接收天线的索引。

在第三种可能的实现方式中，结合第六方面，所述第三接收单元接收的所述参考信号资源配置信息还包括：至少两个端口组的参考信号功率信息，

所述第二获取单元还用于根据所述参考信号端口配置信息并结合所述至少两个端口组的参考信号功率信息获取所述信号质量测量信息。

在第四种可能的实现方式中，结合第六方面第三中可能的实现方式，所述第二获取单元具体用于：

根据所述参考信号端口配置信息得到所述至少两个端口组对应的信号质量测量信息；

根据所述至少两个端口组的参考信号功率信息，对所得到的至少两个端口组对应的信号质量测量信息按端口组功率进行加权平均，得到所述信号质量测量信息。

在第五种可能的实现方式中，结合第六方面第四中可能的实现方式，所述第二获取单元根据所述至少两个端口组的参考信号功率信息，对所得到的至少两个端口组对应的信号质量测量信息按端口组功率进行加权平均，得到所述信号质量测量信息，包括

根据公式：$SQ = \left(\sum_{g=0}^{n-1} p_g \cdot SQ_g\right) \Big/ \left(\sum_{g=0}^{n-1} p_g\right)$，得到信号质量测量信息，

其中，SQ_g 为指定端口组的信号质量测量信息，其中，g 为指定端口组的编号，n 为指定端口组的个数，$n \geq 2$；p_g 为指定端口组的参考信号功率，其中，指定端口组的参考信号功率根据所述至少两个端口组的参考信号功率信息得到。

在第六种可能的实现方式中，结合第六方面第二种可能的实现方式至第五种可能的实现方式的任意一种，所述第三接收单元接收到的所述至少两个端口组的参考信号功率信息包括：

第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的比值；

或者，第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的差分。

在第七种可能的实现方式中，结合第六方面至第六种可能的实现方式的任意一种，所述用户设备还包括：第二发送单元，用于向基站发送所述信号质量

测量信息。

在第八种可能的实现方式中，结合第六方面至第七种可能的实现方式的任意一种，所述第三接收单元，还用于当所述信号质量测量信息为参考信号接收功率 RSRP，接收基站发送的滤波器系数信息；

所述用户设备还包括：第三获取单元，

所述第三获取单元，用于基于所述第三接收单元接收的所述滤波器系数信息对所述参考信号接收功率 RSRP 进行滤波，并得到路损估计值。

在第九种可能的实现方式中，结合第六方面的第八种可能的实现方式，所述用于装置还包括：第三发送单元，

所述第三发送单元，还用于向基站发送上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率根据所述路损估计值计算得到。

在第十种可能的实现方式中，结合第六方面，所述信号质量测量信息，包括：参考信号接收功率 RSRP，参考信号强度指示 RSSI，或者参考信号接收质量 RSRQ。

第七方面，提供了一种网络侧装置，所述装置包括：第四发送单元，第四接收单元；

所述第四发送单元，用于向用户设备发送参考信号资源配置信息，所述参考信号资源配置信息包括：参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射关系，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功率比值；

所述第四接收单元，用于接收用户设备发送的信道状态信息 CSI，其中，所述 CSI 为所述用户设备根据所述参考信号端口配置信息和所述功率比值信息得到。

在第一种可能的实现方式中，根据第七方面，在所述功率比值信息中：

所述至少一个端口组中的每个端口组内的各天线端口上数据信道相对于参考信号的功率比值都相同；

或者，所述至少一个端口组中的一个端口组内各个端口上的数据信道与其

它端口组内各个端口的数据信道相对于参考信号的功率比值相同;

在第二种可能的实现方式中,根据第七方面或者第七方面第一种可能的实现方式,所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的多套功率比值,

所述第四接收单元,具体用于接收用户设备发送的多套信道状态信息CSI,其中每一套信道状态信息CSI为所述用户设备根据所述多套功率比值中的一套功率比值得到的。

在第三种可能的实现方式中,结合第七方面或第一种可能的实现方式或第二种可能的实现方式,所述第四接收单元接收的所述信道状态信息CSI包括:信道质量指示CQI,预编码矩阵指示PMI,或秩指示RI其中任意一个或者任意组合。

第八方面,提供了一种用户设备,所述用户设备包括:第五接收单元,第四获取单元,第五获取单元,和第五发送单元;

所述第五接收单元,用于接收基站发送的参考信号资源配置信息,所述参考信号资源配置信息包括:参考信号端口配置信息和功率比值信息,其中,所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射关系,所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功率比值;

所述第四获取单元,用于根据所述第五接收单元接收的所述参考信号端口配置信息和所述功率比值信息,得到所述至少一个端口组内每个天线端口上数据信道相对于参考信号的功率比值;

所述第五获取单元,用于根据所述第四获取单元得到的所述每个天线端口上数据信道相对于参考信号的功率比值,得到信道状态信息CSI;

所述第五发送单元,用于向基站发送所述第五获取单元得到的所述信道状态信息CSI。

在第一种可能的实现方式中,根据第八方面,所述第五获取单元,具体用于:

根据所述每个天线端口上的参考信号得到所述每个天线端口对应的信道测量值;

根据所述每个天线端口对应的信道测量值，和所述每个天线端口上数据信道相对于参考信号的功率比值，得到所述每个天线端口上数据信道的信道估计值；

根据所述每个天线端口上数据信道的信道估计值得到信道状态信息 CSI。

在第二种可能的实现方式中，结合第一种可能的实现方式，所述第五获取单元根据所述每个天线端口对应的信道测量值，和所述每个天线端口上数据信道相对于参考信号的功率比值，得到所述每个天线端口上数据信道的信道估计值，包括：

根据公式 $\hat{\mathbf{h}}_p = \sqrt{\rho_p}\mathbf{h}_p$ 得到天线端口 p 上数据信道的信道估计值；

其中，p 为所述天线端口的索引，ρ_p 为天线端口 p 上数据信道相对于参考信号的功率比值，$\mathbf{h}_p$ 为天线端口 p 对应的信道测量值，$\hat{\mathbf{h}}_p$ 为天线端口 p 上数据信道的信道估计值。

在第三种可能的实现方式中，结合第八方面或第一种可能的实现方式或第二种可能的实现方式，在所述功率比值信息中，

所述至少一个端口组中的每个端口组内的各天线端口上数据信道相对于参考信号的功率比值相同；

或者，所述至少一个端口组中的一个端口组内的各个端口上的数据信道与其它端口组内各个端口上的数据信道相对于参考信号的功率比值相同。

在第四种可能的实现方式中，结合第八方面，所述第五接收单元接收的所述参考信号资源配置信息包括：参考信号端口配置信息和功率比值信息；

其中，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的多套功率比值；

所述第五发送单元，具体用于：

向基站发送所述多套信道状态信息 CSI，其中每一套信道状态信息 CSI 为根据所述多套功率比值中的一套功率比值得到的。

在第五种可能的实现方式中，结合第八方面或第一种可能的实现方式至第四种可能的实现方式的任意一种，所述第五获取单元得到的所述信道状态信息

CSI 包括：信道质量指示 CQI，预编码矩阵指示 PMI，或秩指示 RI 其中任意一个或者任意组合。

第九方面，提供了一种网络侧装置，所述网络侧装置包括：接收器、处理器和发射器；其中，

所述处理器，用于确定参考信号资源配置信息，所述参考信号资源配置信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系；

所述发射器，用于将所述参考信号资源配置信息发送给用户设备，以使得所述用户设备根据所述参考信号端口配置信息获取信号质量测量信息。

在第一种可能的实现方式中，根据第九方面，所述处理器确定的所述参考信号资源配置信息还包括：至少两个端口组的参考信号功率信息，用于所述用户设备根据所述参考信号端口配置信息并结合所述至少两个端口组的参考信号功率信息，获取所述信号质量测量信息；

其中，所述至少两个端口组的参考信号功率信息，包括：

第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的比值；

或者，第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的差分。

在第二种可能的实现方式中，结合第九方面或第一种可能的实现方式，当所述信号质量测量信息为参考信号接收功率 RSRP 时，所述发射器还用于向所述用户设备发送滤波器系数信息，用于所述用户设备基于所述滤波器系数信息对所述参考信号接收功率 RSRP 进行滤波并得到路损估计值。

在第三种可能的实现方式中，结合第二种可能的实现方式，所述接收器用于接收所述用户设备发送的上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率为所述用户设备根据所述路损估计值计算得到的。

在第四种可能的实现方式中，结合第九方面或第一种可能的实现方式，所述信号质量测量信息包括：

参考信号接收功率 RSRP，参考信号接收质量 RSRQ，或者参考信号强度

指示 RSSI 其中任一项或者任意组合。

在第五种可能的实现方式中，结合第九方面或第一种可能的实现方式至第四种可能的实现方式的任意一种，所述接收器还用于接收用户设备发送的所述信号质量测量信息。

第十方面，提供了一种用户设备，所述用户设备包括：接收器，处理器和发射器；

所述接收器，用于接收基站发送的参考信号资源配置信息，所述参考信号资源配置信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系；

所述处理器，用于根据所述参考信号端口配置信息，得到至少一个端口组中的参考信号端口信息；根据所述至少一个端口组中的参考信号端口信息获取信号质量测量信息。

在第一种可能的实现方式中，根据第十方面，所述处理器，具体用于：

根据所述参考信号端口配置信息，得到指定的一个端口组中的参考信号端口信息；

根据所述指定的一个端口组中的参考信号端口信息获取所述信号质量测量信息。

在第二种可能的实现方式中，根据第十方面的第一种可能的实现方式，当所述信号质量测量信息为参考信号接收功率 RSRP 时，所述处理器根据所述指定的一个端口组中的参考信号端口信息获取所述信号质量测量信息，包括：

根据公式：$RSRP(r,p)=\frac{1}{K_s-1}\sum_{m=0}^{K_s-1}\hat{h}_p(m)\cdot\hat{h}_p(m+1)$ 得到第 r 个接收天线第 p 个端口的参考信号接收功率 $RSRP(r,p)$ 并通过组合 $RSRP(r,p)$ 得到所述 RSRP；其中，$\hat{h}_p(m)$ 为标号为 m 的参考信号 RE 上的信道估计；K_s 是在测量带宽内可利用的参考信号 RE 的样本总数；p 为所述指定的一个端口组中参考信号端口号，r 为接收天线的索引。

在第三种可能的实现方式中，结合第十方面，所述接收器接收的所述参考

信号资源配置信息还包括：至少两个端口组的参考信号功率信息，用于所述用户设备根据所述参考信号端口配置信息并结合所述至少两个端口组的参考信号功率信息获取所述信号质量测量信息。

在第四种可能的实现方式中，结合第十方面第三中可能的实现方式，所述处理器根据所述参考信号端口配置信息并结合至少两个端口组的参考信号功率信息获取信号质量测量信息，包括：

根据所述参考信号端口配置信息得到所述至少两个端口组对应的信号质量测量信息；

根据所述至少两个端口组的参考信号功率信息，对所得到的至少两个端口组对应的信号质量测量信息按端口组功率进行加权平均，得到所述信号质量测量信息。

在第五种可能的实现方式中，结合第十方面第四中可能的实现方式，所述处理器根据所述至少两个端口组的参考信号功率信息，对所得到的至少两个端口组对应的信号质量测量信息按端口组功率进行加权平均，得到信号质量测量信息，包括：

根据公式：$SQ = \left(\sum_{g=0}^{n-1} p_g \cdot SQ_g \right) \Big/ \left(\sum_{g=0}^{n-1} p_g \right)$，得到信号质量测量信息，

其中，SQ_g 为指定端口组的信号质量测量信息，其中，g 为指定端口组的编号，n 为指定端口组的个数，$n \geq 2$；p_g 为指定端口组的参考信号功率，其中，指定端口组的参考信号功率根据所述至少两个端口组的参考信号功率信息得到。

在第六种可能的实现方式中，结合第十方面第二种可能的实现方式至第五种可能的实现方式的任意一种，所述接收器接收到的所述至少两个端口组的参考信号功率信息，包括：

第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的比值；

或者，第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的差分。

在第七种可能的实现方式中，结合第十方面至第六种可能的实现方式的任

意一种，所述发射器用于向基站发送所述信号质量测量信息。

在第八种可能的实现方式中，结合第十方面至第七种可能的实现方式的任意一种，当所述信号质量测量信息为参考信号接收功率 RSRP 时，所述接收器还用于接收基站发送的滤波器系数信息；

所述处理器，还用于基于所述滤波器系数信息对所述参考信号接收功率 RSRP 进行滤波，并得到路损估计值。

在第九种可能的实现方式中，结合第十方面的第八种可能的实现方式，所述发射器还用于向基站发送上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率根据所述路损估计值计算得到。

在第十种可能的实现方式中，结合第十方面，所述信号质量测量信息，包括：参考信号接收功率 RSRP，参考信号强度指示 RSSI，或者参考信号接收质量 RSRQ。

第十一方面，提供了一种网络侧装置，所述网络侧装置包括：发射器，和接收器，

所述发射器，用于向用户设备发送参考信号资源配置信息，所述参考信号资源配置信息包括：参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射关系，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功率比值；

所述接收器，用于接收用户设备发送的信道状态信息 CSI，其中，所述 CSI 为所述用户设备根据所述参考信号端口配置信息和所述功率比值信息得到。

在第一种可能的实现方式中，根据第十一方面，在所述功率比值信息中：

所述至少一个端口组中的每个端口组内的各天线端口上数据信道相对于参考信号的功率比值都相同；

或者，所述至少一个端口组中的一个端口组内各个端口上的数据信道与其它端口组内各个端口的数据信道相对于参考信号的功率比值相同。

在第二种可能的实现方式中，根据第十一方面或者第七方面第一种可能的实现方式，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的多套功率比值；

所述接收器接收用户设备发送的信道状态信息 CSI，包括：接收用户设备发送的多套信道状态信息 CSI，其中每一套信道状态信息 CSI 为所述用户设备根据所述多套功率比值中的一套功率比值得到的。

在第三种可能的实现方式中，结合第十一方面或第一种可能的实现方式或第二种可能的实现方式，所述接收器接收的所述信道状态信息 CSI 包括：信道质量指示 CQI，预编码矩阵指示 PMI，或秩指示 RI 其中任意一个或者任意组合。

第十二方面，提供了一种用户设备，所述用户设备包括：接收器，处理器，和发射器；

所述接收器，用于接收基站发送的参考信号资源配置信息，所述参考信号资源配置信息包括：参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射关系，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功率比值；

所述处理器，用于根据所述参考信号端口配置信息和所述功率比值信息，得到所述至少一个端口组内每个天线端口上数据信道相对于参考信号的功率比值，并根据所述每个天线端口上数据信道相对于参考信号的功率比值，得到信道状态信息 CSI；

所述发射器，用于向基站发送所述信道状态信息 CSI。

在第一种可能的实现方式中，根据第十二方面，所述处理器根据所述每个天线端口上数据信道相对于参考信号的功率比值，得到信道状态信息 CSI，包括：

根据所述每个天线端口上的参考信号得到所述每个天线端口对应的信道测量值；

根据所述每个天线端口对应的信道测量值，和所述每个天线端口上数据信道相对于参考信号的功率比值，得到所述每个天线端口上数据信道的信道估计值；

根据所述每个天线端口上数据信道的信道估计值得到信道状态信息 CSI。

在第二种可能的实现方式中，结合第一种可能的实现方式，所述处理器根据所述每个天线端口对应的信道测量值，和所述每个天线端口上数据信道相对

于参考信号的功率比值，得到所述每个天线端口上数据信道的信道估计值，包括:

根据公式$\hat{\mathbf{h}}_p = \sqrt{\rho_p}\mathbf{h}_p$得到天线端口 p 上数据信道的信道估计值；

其中，p为所述天线端口的索引，ρ_p为天线端口 p上数据信道相对于参考信号的功率比值，$\mathbf{h}_p$为天线端口 p对应的信道测量值，$\hat{\mathbf{h}}_p$为天线端口 p上数据信道的信道估计值。

在第三种可能的实现方式中，结合第十二方面或第一种可能的实现方式或第二种可能的实现方式，在所述功率比值信息中，

所述至少一个端口组中的每个端口组内的各天线端口上数据信道相对于参考信号的功率比值相同；

或者，所述至少一个端口组中的一个端口组内的各个端口上的数据信道与其它端口组内各个端口上的数据信道相对于参考信号的功率比值相同。

在第四种可能的实现方式中，结合第十二方面，所述所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的多套功率比值；

所述发射器具体用于:

向所述基站发送所述多套信道状态信息 CSI，其中每一套信道状态信息 CSI 为根据所述多套功率比值中的一套功率比值得到的。

在第五种可能的实现方式中，结合第十二方面或第一种可能的实现方式至第四种可能的实现方式的任意一种，所述处理器得到的所述信道状态信息 CSI 包括：信道质量指示 CQI，预编码矩阵指示 PMI，或秩指示 RI 其中任意一个或者任意组合。

本发明实施例提供一种通信质量测量的方法和装置，将参考信号资源配置信息发送给用户侧 UE，UE 可以根据其中一个端口组或者多个端口组的参考信号质量处理得到最终的信号质量测量信息，使得 UE 侧可以将端口根据不同的端口组进行区分，不同于现有技术中不能区分不同端口的发射功率的情况。因而，一方面，使得 UE 能够获取的信号质量测量信息，可以使得 UE 进行更为准确的小区选择和上行功率控制；另一方面，使得 UE 能够获取的信道状态信息，可以使得 UE 进行更为准确的调制与编码方案（MCS，Modulation and Coding Scheme)选择或者调度，从而提高系统的吞吐量。

附图说明

为了更清楚地说明本发明实施例或现有技术中的技术方案，下面将对实施例或现有技术描述中所需要使用的附图作简单地介绍，显而易见地，下面描述中的附图仅仅是本发明的一些实施例，对于本领域普通技术人员来讲，在不付出创造性劳动性的前提下，还可以根据这些附图获得其他的附图。

图 1 是本发明实施例一提供的一种通信质量测量的方法的流程图；

图 2 是本发明实施例二提供的一种通信质量测量的方法的流程图；

图 3 是不同的均匀线阵天线阵配置示意简图；

图 4 是不同的交叉极化天线阵配置示意简图；

图 5 是本发明实施例三提供的一种通信质量测量的方法的流程图；

图 6 是本发明实施例四提供的一种通信质量测量的方法的流程图；

图 7 是本发明实施例五提供的一种网络侧装置示意简图；

图 8 是本发明实施例六提供的一种用户设备示意简图；

图 9 是本发明实施例七提供的一种网络侧装置示意简图；

图 10 是本发明实施例八提供的一种用户设备示意简图；

图 11 是本发明实施例九提供的一种网络侧装置示意简图；

图 12 是本发明实施例十提供的一种用户设备示意简图；

图 13 是本发明实施例十一提供的一种网络侧装置示意简图；

图 14 是本发明实施例十二提供的一种用户设备示意简图。

具体实施方式

下面将结合本发明实施例中的附图，对本发明实施例中的技术方案进行清楚、完整地描述，显然，所描述的实施例仅仅是本发明一部分实施例，而不是全部的实施例。基于本发明中的实施例，本领域普通技术人员在没有作出创造性劳动前提下所获得的所有其他实施例，都属于本发明保护的范围。

实施例一

本发明实施例提供了一种通信质量测量的方法，如图 1 所示，所述方法包括:

步骤 S01，确定参考信号资源配置信息，所述参考信号资源配置信息包括:参考信号端口配置信息，其中所述参考信号端口配置信息用于指示所述参考信

号端口到端口组的映射;

其中，该操作具体可以是由基站或者网络侧（例如通用陆地无线接入(UTRAN， Universal Terrestrial Radio Access Network)）；或者演进的UTRAN(Evolved UTRAN)，或者演进节点 B（evolved node B）执行。

当所述参考信号资源配置信息包括：参考信号端口配置信息，可选的，参考信号资源配置信息还可以包括：至少一个端口组的参考信号功率信息时，将该参考信号资源配置信息发送给用户设备（UE，User Equipment），使得用户设备根据该参考信号资源配置信息获取信号质量测量信息，由于参考信号端口被分配到多个组，UE 可以根据其中一个端口组或者多个端口组的参考信号质量处理得到最终的信号质量测量信息，使得 UE 侧可以对端口根据不同的端口组进行区分，不同于现有技术中不能区分不同端口的发射功率的情况。因而，该方案获取的信号质量测量信息，可以使得 UE 进行更为准确的小区选择和上行功率控制。

还需要理解的是，对于所述参考信号资源配置信息中包括的参考信号端口配置信息的详细说明，可以参考实施例二中步骤 101 中的说明。

进一步，该参考信号资源配置信息还可以包括：参考信号配置或者参考信号子帧配置其中任一项。使得 UE 可以根据该信息接收参考信号。需要理解的是，但本发明实施例不限制参考信号配置或者参考信号子帧配置其中任一项一定是由参考信号资源配置信息下发给 UE 的，也可以是以其他信息的形式下发给 UE，需要指出的是，所述参考信号配置或者参考信号子帧配置还可以是预定义的，或者根据事先已知的参数如小区 ID 或者 UE ID 隐式导出，为基站或者 UE 所共知；本发明实施例不限制。

步骤 S02，将确定的参考信号资源配置信息发送给用户设备，以使得用户设备根据所述参考信号端口配置信息获取信号质量测量信息。

具体的，上述信号质量测量信息可以包括：

参考信号接收功率 RSRP，参考信号接收质量 RSRQ，或者参考信号强度指示 RSSI 其中任一项或者任意组合。

通过上述实施例一中说明的方法，该方法通过网络侧确定参考信号资源配置信息，并将该参考信号资源配置信息发送给用户侧，所述参考信号资源配置

信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射。所述方法可以避免逐端口指示参考信号功率相关信息从而减少信令开销之外，端口组内各个端口采用统一的功率指示而不同的端口组可以彼此独立指示其功率相关信息，充分利用了天线配置或者天线阵列的结构，从而可以使得系统能够根据天线配置或者天线阵列结构灵活选择参考信号功率相关信息；由于天线阵列可以具有对称的权重，利用该权重的对称性，可以降低波束赋形或者旁瓣抑制的设计复杂性。

进一步，将参考信号资源配置信息发送给用户侧 UE，UE 可以根据其中至少一个端口组的参考信号质量处理得到最终的信号质量测量信息，使得 UE 侧可以将端口根据不同的端口组进行区分，不同于现有技术中不能区分不同端口的发射功率的情况。使得 UE 能够获取的信号质量测量信息，可以使得 UE 进行更为准确的小区选择和上行功率控制。

可选的，所述方法还包括:

步骤 S03：接收用户设备发送的所述信号质量测量信息。

可选的，当信号质量测量信息为参考信号接收功率 RSRP，所述方法还包括:

步骤 S04：向所述用户设备发送滤波器系数信息，用于所述用户设备基于所述滤波器系数信息对所述参考信号接收功率 RSRP 进行滤波并得到路损估计值。

具体的，所述向用户设备发送滤波器系数信息，可以是与步骤 S02 中所述将所确定的参考信号资源配置信息发送给用户设备在同一时间发送，如在相同的子帧发送；也可以是与步骤 S02 中所述将所确定的参考信号资源配置信息发送给用户设备之前或者之后发送；所述滤波器系数信息与所述参考信号资源配置信息可以在相同或者不同的高层信令如 RRC 信令的信元（Information Element,简称 IE）或者下行控制信息（Downlink Control Information，简称 DCI）中发送。

可选的，所述方法还包括:

步骤 S05：接收所述用户设备发送的上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率为所述用户设备根据所述

路损估计值计算得到的。

可选的，所述参考信号资源配置信息还包括：至少两个端口组的参考信号功率信息，用于所述用户设备根据所述参考信号端口配置信息并结合所述至少两个端口组的参考信号功率信息，获取所述信号质量测量信息；

其中，所述至少两个端口组的参考信号功率信息，包括：

第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的比值；

或者，第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的差分。

可选的，所述参考信号端口配置信息为单索引，或者为双索引，或者为联合编码后的索引。

可选的，所述端口组的参考信号功率信息，至少包括：一个端口组中的各端口的参考信号功率相同。

其中，所述第一端口组为所述至少一个端口组中的一个端口组。

实施例二

本发明实施例提供了一种用于通信质量测量的方法，如图 2 所示，该方法包括：

步骤 101，接收基站发送的参考信号资源配置信息，所述参考信号资源配置信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系；

具体的，UE 接收参考信号资源配置信息，可以是 UE 通过高层信令(如：无线资源控制（RRC，Radio Resource Control）信令)或者动态信令(如：下行控制信息（DCI，Downlink Control Information）)，接收 eNB 通知的参考信号资源配置信息，或者基于小区标识（ID，Identity）得到参考信号的资源配置信息。所述高层信令可以通过物理下行共享信道（Physical Downlink Shared Channel，简称 PDSCH）等数据信道发送；所述动态信令如 DCI 通过物理下行控制信道（Physical Downlink Control Channel，简称 PDCCH）或者增强的 PDCCH（Enhanced PDCCH，简称 ePDCCH）等控制信道发送。

需要理解的是，参考信号端口配置信息，用于指示参考信号端口到端口组

的映射，参考信号端口到端口组中的映射关系可以是预定义的，为基站和用户设备所共知，因此，基站侧和用户设备侧都可以识别出该参考信号端口配置消息。

还需要理解的是，通过参考信号端口组与对应端口的映射关系信息和端口组的映射索引，可以唯一确定该端口组中包括的端口，如下表 1 至 3 中所示，在获知参考信号端口组与对应端口的映射关系信息和端口组的映射索引，设备可以获知对应的端口组中的端口。其中，端口组中包括的端口可以是预定义的，对于不同的索引，预定义的端口组可以根据规划得到。需要说明的是，一个参考信号端口与一个天线端口相对应，一个天线端口对应一个参考信号端口。天线信号端口的信道信息根据测量参考信号端口得到。因此，通常所述预定义的端口组可以根据天线端口阵列配置规划得到。

一个参考信号端口或者天线端口往往与一个物理天线，或者一个虚拟天线相对应，其中所说的虚拟天线可以通过多个物理天线的加权组合得到。实际的天线部署可能具有不同的天线配置和天线端口阵列形式。例如，图 3 所示为不同的均匀线阵（ULA，Uniform Linear Array）天线端口阵列配置。其中，天线端口阵列 A 为 2 行 4 列的均匀线阵,天线端口阵列 B 为 2 行 8 列的均匀线阵，天线端口阵列 C 为 4 行 4 列的均匀线阵；尽管天线端口阵列 B 与阵列 C 都具有 16 个端口，但是其阵列形式也不同。再如图 4 所示为不同的交叉极化（XPO ，Cross-polarization，）天线阵配置。其中，天线端口阵列 A 为 2 行 2 列的交叉极化天线阵，天线端口阵列 B 为 2 行 4 列的均匀线阵，天线端口阵列 C 为 4 行 2 列的均匀线阵，不同的极化天线可以处于相同的列；尽管天线端口阵列 B 与阵列 C 都具有 16 个端口，但是其阵列形式也不同。以下天线端口阵列简称天线阵列。

可选地，作为另一实施例，所述参考信号端口配置信息，包括参考信号端口数和映射索引，其中所述映射索引用于指示参考信号端口组与对应端口的映射。以如图 3 中的天线阵列 A 和如图 4 中的天线阵列 A 所示的 8 天线阵列为例，所述参考信号端口配置信息，包括参考信号端口数为 8 和映射索引为 0 或者 1。其中所述预定义的参考信号端口到端口组中的映射关系可以通过函数定义，也可以通过预定义的表格规定。例如表格 1 中所示，第一行可以是图 3

中天线阵列 A 的参考信号端口配置信息，该映射指示信息中包括：参考信号端口数为 8 个，映射索引为 0，端口组为 0 和 1 两组。表格 1 中第二行可以是图 4 中天线阵列 A 的参考信号端口配置信息，该映射指示信息中包括：参考信号端口数为 8 个，映射索引为 1，端口组为 0 和 1 两组。需要指出的是，本实施例中参考信号端口和参考信号端口组可以与天线端口和天线端口组互换。

表格 1-端口到端口组的映射

索引	端口到端口组的映射	
	0	1
0	0,3,4,7	1,2,5,6
1	0,1,4,5	2,3,6,7

进一步，当映射索引值为 0 时，端口组 0 包含参考信号端口（或者天线端口）0,3,4 和 7，端口组 1 包含参考信号端口（或者天线端口）1,2,5 和 6；当映射索引值为 1 时，端口组 0 包含参考信号端口（或者天线端口）0,1,4 和 5，端口组 1 包含参考信号端口（或者天线端口）2,3,6 和 7。

以如图 3 中的天线阵列 B 或者 C 和如图 4 中的天线阵列 B 或者 C 所示的 16 天线阵列为例，所述参考信号端口配置信息，包括参考信号端口数为 16 和映射索引为 0 或者 1 或者 2 或者 3。其中所述预定义的参考信号端口到端口组中的映射关系可以通过函数定义，也可以通过预定义的表格规定。例如表格 2 所示：

表格 2-端口到端口组的映射

索引	端口到端口组的映射			
	0	1	2	3
0	0,3,8,11	4,7,12,15	1,2,9,10	5,6,13,14
1	0,1,12,13	2,3,14,15	4,5,8,9	6,7,10,11

2	0,7,8,15	1,6,9,14	2,5,10,13	3,4,11,12
3	0,3,12,15	1,2,13,14	4,7,8,11	5,6,9,10

其中，图 3 中天线阵列 B 可以假设为表 2 中第一行，即映射索引值为 0，端口组 0 包含参考信号端口（或者天线端口）0,3,8 和 11，端口组 1 包含参考信号端口（或者天线端口）4,7,12 和 15，端口组 2 包含参考信号端口（或者天线端口）1,2,9 和 10，端口组 3 包含参考信号端口（或者天线端口）5,6,13 和 14。当映射索引值为 1 或 2 或 3 时，各个端口组包含的参考信号端口可以由上述表格依次类推。

可选的，作为另一实施例，所述参考信号端口配置信息，可以包括端口组映射双索引（m，n）。此时，所述预定义的参考信号端口到端口组中的映射关系可以通过函数定义，也可以通过预定义的表格规定。例如表格 3 所示：

表格 3-端口到端口组的映射

双索引 (m, n)	端口到端口组的映射			
	0	1	2	3
(2,4)	0,1,4,5	2,3,6,7	-	-
(2,8)	0,3,8,11	4,7,12,15	1,2,9,10	6,7,10,11
(4,4)	0,1,12,13	2,3,14,15	4,5,8,9	6,7,10,11

可选的，双索引(m，n)可以指示参考信号端口数为 m 和 n 的乘积。

进一步地，所述双索引信息，可以进行联合编码，例如，上述表格 3 中的双索引的联合编码，如表格 3a 或者 3b 所示。

表格 3a-端口到端口组的映射

双索引(m, n)的联合编码	双索引(m, n)	端口到端口组的映射			
		0	1	2	3
0	(2,4)	0,1,4,5	2,3,6,7	-	-
1	(2,8)	0,3,8,11	4,7,12,15	1,2,9,10	6,7,10,11
2	(4,4)	0,1,12,13	2,3,14,15	4,5,8,9	6,7,10,11

或者

表格 3b-端口到端口组的映射

映射索引	双索引(m, n)	端口到端口组的映射			
		0	1	2	3
0	(2,4)	0,1,4,5	2,3,6,7	-	-
1	(2,8)	0,3,8,11	4,7,12,15	1,2,9,10	6,7,10,11
2	(4,4)	0,1,12,13	2,3,14,15	4,5,8,9	6,7,10,11

可选的，端口组的划分可以是以 4 个参考信号端口（或者天线端口）为一个端口组。

需要进一步指出的是，端口组的划分也可以不限于含有 4 个参考信号端口的端口组，还可以是 2 或 8 个或者其他构成形式的端口组。同时，每个端口组内含有的参考信号端口号，也不限于上述取值，可以根据实际的天线配置或者部署灵活选择。上述预定义的端口组映射以及映射指示信息，可以使得系统能够自适应更多的天线配置和天线阵列部署。

可选的，所述参考信号资源配置信息还可以包括：参考信号配置，或者参

考信号子帧配置其中任意一项。所述参考信号配置可以包括：参考信号端口使用的子载波，或者正交频分复用（OFDM，Orthogonal Frequency Division Multiplexing）符号，或者码资源其中任意一项；所述参考信号子帧配置可以包括：参考信号端口占用的子帧位置，子帧周期，或者子帧偏移其中任意一项。需要指出的是，所述参考信号配置或者参考信号子帧配置还可以是预定义的，或者根据事先已知的参数如小区 ID 或者 UE ID 隐式导出，为基站或者 UE 所共知；本发明实施例不作限制。

步骤 102，根据所述参考信号端口配置信息，得到至少一个端口组中的参考信号端口信息；

步骤 103，根据所述至少一个端口组中的参考信号端口信息获取信号质量测量信息。

具体地，所述参考信号或者信号，具体可以包括小区特定参考信号 CSR；或者，信道状态信息参考信号（CSI-RS，Channel State Information Reference Signal）或者解调参考信号（DMRS， DeModulation Reference signal），但不限于当前的举例。

所述信号质量测量信息，可以为参考信号接收功率（RSRP，Reference Signal Received Power）或者参考信号接收质量（RSRQ，Reference Signal Received Quality）或者参考信号强度指示（RSSI，Reference Signal Strength Indicator），还可以是其它基于参考信号定义的信号质量测量信息。

本实施例以参考信号接收功率 RSRP 为例，详细说明其中一种实现，对于其他的实现方案本方案不做限制，且对于获取其他信号质量测量信息的方案也不做限制。

可选的，步骤 103 中根据所述参考信号端口配置信息，得到至少一个端口组中的参考信号端口信息可以包括：

根据所述参考信号端口配置信息，得到指定的一个端口组中的参考信号端口信息；

步骤 103 中所述根据所述至少一个端口组中的参考信号端口信息获取信号质量测量信息包括：

根据所述指定的一个端口组中的参考信号端口信息获取所述信号质量测

量信息。

以表 2 中的映射索引为 0 举例，此时端口组 0 含有的参考信号端口为 0，3，8 和 11。其中每个天线端口的复数 RSRP 测量可以为相邻两个参考信号资源单元（RE，Resource Element）的相关，其中，这里的相邻的两个 RE 可以是指频域上相邻的两个 RE，或者时域上相邻的两个 RE，或者是时频域上相邻的两个 RE。

$$RSRP(r,p)=\frac{1}{K_s-1}\sum_{m=0}^{K_s-1}\hat{h}_p(m)\cdot\hat{h}_p(m+1),p=0,3,8,11 \quad (1)$$

其中，$\hat{h}_p(m)$ 为标号为 m 的参考信号 RE 上的信道估计；K_s 是在测量带宽内可利用的参考信号 RE 的样本总数；p 为所述指定的一个端口组中参考信号端口号，r 为接收天线的索引。通过组合(combine) $RSRP(r,p)$ 可以得到天线端口组 0 对应的 RSRP，得到第 r 个接收天线第 p 个端口的参考信号接收功率 $RSRP(r,p)$ 并通过组合 $RSRP(r,p)$ 得到所述 RSRP。例如：上述 $RSRP(r,p)$ 对各个端口 p 和接收天线作线性（相关或者非相关）平均后取绝对值可以得到端口组 0 对应的 RSRP；或者上述 $RSRP(r,p)$ 对其中某一个端口 p 和各个接收天线作线性（相干或者非相关）平均后取绝对值可以得到端口组 0 对应的 RSRP。依次类推，也可以利用其它端口组的参考信号得到 RSRP。

本实施例步骤 103 中所述用于得到 RSRP 的端口组以及该端口组中的端口可以是预定义的（例如：端口组 0，以及端口组 0 中的端口 0，或者是端口组 0 中的端口 0 和 3，或者是该端口组 0 中的所有端口，或者其它）或者由基站 eNB 通过高层信令如 RRC 信令或者下行控制信息通知。以上基于一个端口组或者一个端口组中的部分或者全部端口得到 RSRP，不必逐端口测量 RSRP，可以降低 UE 的 RSRP 测量的实现复杂性，同时，端口组预定义或者通知，使得 UE 和 eNB 对测量的理解一致，从而保证 RSRP 测量的一致性。同时，不同的端口组可以彼此独立指示其功率，充分利用了图 3 和图 4 所示的天线配置和天线阵列的结构，可以适应天线结构的变化灵活指示，从而可以保证基站 eNB

能够自适应多种天线配置和天线阵列。

可选的，当步骤 101 中 UE 接收的参考信号资源配置信息中包括的一个或者多个端口组的参考信号功率信息，用作指示对应端口组中各个端口的参考信号功率。

以 16 个参考信号端口为例，4 端口组的参考信号功率可以如表 4 所示：

表格 4—端口组的参考信号功率表

端口组号	0	1	2	3
参考信号功率	p0	p1	p2	p3

此时，端口组 0 包含的参考信号端口的功率为 p0，端口组 1,2 和 3 中包含的参考信号端口的功率可以依次类推，分别为 p1 ,p2 和 p3。

或者，上述一个或者多个端口组的参考信号功率信息，还可以用其中一个端口组（例如端口组 0）的参考信号功率以及其它一个(例如端口组 1)或者多个端口组(例如端口组 1，2，3)相对于该端口组（例如端口组 0）的参考信号功率比值共同表示；例如端口组 0 的参考信号功率为 p0，端口组 1，2 和 3 相对于端口组 0 的参考信号功率比值分别为 ρ1, ρ2 和 ρ3。此时 UE 可以得到端口组 1，2 和 3 的参考信号功率分别为 p0*ρ1, p0 *ρ2 和 p0*ρ3。

此外，所述一个或者多个端口组的参考信号功率信息，还可以用于其中一个端口组（例如端口组 0）的参考信号功率以及其它一个(例如端口组 1)或者多个端口组(例如端口组 1，2，3)相对于该端口组（例如端口组 0）的参考信号功率的差分来表示；例如端口组 0 的参考信号功率为 p0，端口组 1，2 和 3 相对于端口组 0 的参考信号功率的差分分别为 d1,d2 和 d3。此时 UE 可以得到端口组 1，2 和 3 的参考信号功率分别为 p0+d1, p0+d2 和 p0+d3。

上述采用端口组分别指示参考信号功率信息，除了可以避免逐端口指示参考信号功率从而减少信令开销之外，端口组内各个端口采用统一的功率指示而不同的端口组可以彼此独立指示其功率，充分利用了天线配置或者天线阵列的结构，从而可以使得系统能够根据天线配置或者天线阵列结构灵活选择参考信号功率。同时，需要进一步指出的是，尽管端口组的划分不限于含有 4 个参考

信号端口的端口组，上述表格 1，2，3 中的端口组划分以及各个端口的构成可以进一步使得图 3 或者图 4 中的天线阵列具有关于阵列结构对称的功率，即各个端口相对于阵列可以具有对称的权重，利用该权重的对称性，可以降低波束赋形或者旁瓣抑制的设计复杂性。

进一步，以上所述参考信号功率也可以用每资源单元的能量（EPRE，Energy Per Resource Element）表示。

可选的，所述至少两个端口组的参考信号功率信息，包括：

第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的比值；

或者，第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的差分。

其中，上述可选的，根据所述参考信号端口配置信息并结合至少两个端口组的参考信号功率信息获取信号质量测量信息，包括：

根据所述参考信号端口配置信息得到所述至少两个端口组对应的信号质量测量信息；

根据所述至少两个端口组的参考信号功率信息，对所得到的至少两个端口组对应的信号质量测量信息按端口组功率进行加权平均，得到所述信号质量测量信息。

具体地，可以是通过多于一个端口组中的参考信号的接收功率组合得到。

以端口组 0，1，2，和 3 共 4 个端口组为例，可以基于上述得到一个端口组的 RSRP 的方法，分别得到端口组 0，1，2，和 3 对应的参考信号接收功率 $RSRP_g$， $g=0,1,2,3$。根据步骤 101 接收到的参考信号资源配置信息还包括：至少两个端口组的参考信号功率信息，用于所述用户设备根据所述参考信号端口配置信息并结合所述至少两个端口组的参考信号功率信息获取所述信号质量测量信息。

所述根据所述至少两个端口组的参考信号功率信息，对所得到的至少两个端口组对应的信号质量测量信息按端口组功率进行加权平均，得到信号质量测量信息，包括：

根据公式：$$SQ=\left(\sum_{g=0}^{n-1}p_g\cdot SQ_g\right)\Big/\left(\sum_{g=0}^{n-1}p_g\right) \quad (2)$$

得到信号质量测量信息，

其中，SQ_g 为指定端口组的信号质量测量信息，其中，g 为指定端口组的编号，n 为指定端口组的个数，$n\geq 2$；p_g 为指定端口组的参考信号功率，其中，指定端口组的参考信号功率根据所述至少两个端口组的参考信号功率信息得到。

以上所述多个端口组可以是全部端口组，也可以是部分端口组，因此，预置的端口信息可以是全部端口组，也可以是部分端口组。其中部分端口组可以是预先约定的（如端口组 0 和端口组 1）或者由基站 eNB 通过高层信令如 RRC 信令或者下行控制信息通知。以上多个端口组得到 RSRP，可以对各个端口组得到的 RSRP 进行平滑或者滤波等处理从而进一步提高了 RSRP 测量的精度，同时避免 UE 逐端口计算从而降低实现复杂性。此外端口组的配置，可以保证基站 eNB 能够自适应多种天线配置和天线阵列。

同样的，采用类似的方法，基于参考信号资源配置信息中的参考信号端口配置信息，以及参考信号配置或者子帧配置，接收基站发送的参考信号，UE 还可以进一步得到一个或者多个端口组的参考信号接收质量（RSRQ，Reference signal Received Quality）或者参考信号强度指示（RSSI）等信号质量测量信息。其中，RSSI 是接收的宽带总功率包括干扰和热噪声，RSRQ 为 RSRP 与 RSSI 的比。

进一步地，所述用于通信质量测量的方法，还可以包括：

步骤 104，所述 UE 向基站 eNB 上报所述信道质量测量信息，例如 RSRP，便于实现小区选择或者小区切换。

可选的，当所述信号质量测量信息为参考信号接收功率 RSRP，该通信质量测量的方法还可以包括：

步骤 105，接收基站发送的滤波器系数信息；

步骤 106，基于所述滤波器系数信息对所述参考信号接收功率 RSRP 进行滤波，并得到路损估计值。

具体的，所述用户设备接收基站发送的滤波器系数信息，可以是与步骤101 中所述接收参考信号资源配置信息在同一时间接收，如在相同的子帧接收；也可以是与步骤 101 中所述接收参考信号资源配置信息之前或者之后接收；所述滤波器系数信息与所述参考信号资源配置信息可以在相同或者不同的高层信令如 RRC 信令的信元（Information Element,简称 IE）或者下行控制信息（Downlink Control Information，简称 DCI）中接收。

具体地，如步骤 103 所述方法，可以获得一个或者多个端口组中的参考信号接收功率，例如可以得到端口组 0，1，2，和 3 对应的参考信号接收功率 $RSRP_g$，$g=0,1,2,3$ 。

所述路径损耗估计可以基于一个端口组的参考信号接收功率和对应的参考信号功率得到：

$PL(g)$ = 端口组 g 的参考信号功率 - 高层滤波的端口组 g 的 RSRP

其中 $PL(g)$ 表示基于端口组 g 得到的 PL 估计，其中高层滤波器参数由高层信令通知。可以利用其中一个端口组的 PL 得到，例如端口组 0；所述高层滤波的端口组 g 的 RSRP 利用高层信令通知的高层滤波器参数对端口组 g 的 RSRP 进行滤波得到。

以上所述用于得到 PL 估计的端口组可以是预定义的（如端口组 0）或者由基站 eNB 通过高层信令如 RRC 信令或者下行控制信息通知。以上基于一个端口组得到 PL 估计，可以降低 UE PL 估计的实现复杂性，同时，保证 PL 估计的一致性。同时端口组的配置，可以保证基站 eNB 能够自适应多种天线配置和天线阵列。

所述路径损耗估计也可以基于多个端口组的参考信号接收功率和对应的参考信号功率得到。具体地，所述 PL 估计可以是多个端口组得到 PL 估计的线性平均。

以上所述多个端口组可以是全部端口组，也可以是部分端口组。其中部分端口组可以是预先约定的（如端口组 0 和端口组 1）或者由基站 eNB 通过高层信令如 RRC 信令或者下行控制信息通知。以上多个端口组得到 PL 估计，可以进一步提高 PL 估计的精度，同时避免 UE 实现复杂性过高。此外端口组的配置，可以保证基站 eNB 能够自适应多种天线配置和天线阵列。

进一步地，所述用于通信质量测量的方法，还可以包括:

步骤 107，向基站发送上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率根据所述路损估计值计算得到。

所述物理信道可以是物理上行控制信道 PUCCH 或者物理上行共享 PUSCH 等；所述物理信号可以是侦听参考信号（SRS， Sounding Reference signal）或者用于上行物理信道的解调参考信号（DMRS， DeModulation R 俄 ference Signal）。

具体地，根据上述得到的路损估计，物理上行控制信道 PUCCH 的发射功率设置可以定义为如下式（3）:

$$P_{\mathrm{PUCCH}}(i)=\min\left\{P_{\mathrm{CMAX,c}}(i),P_{\mathrm{O_PUCCH}}+PL_c+h\left(n_{CQI},n_{HARQ},n_{SR}\right)+\Delta_{\mathrm{F_PUCCH}}(F)+\Delta_{TxD}(F')+g(i)\right\}$$

其中，$P_{\mathrm{CMAX,c}}(i)$ 是服务小区 c 子帧 i UE 上配置的最大发射功率，$P_{\mathrm{O_PUCCH}}$ 是一个由高层提供的小区特定参数 $P_{\mathrm{O_NOMINAL_PUCCH}}$ 和 UE 特定参数 $P_{\mathrm{O_UE_PUCCH}}$ 的和构成的参数。$h\left(n_{CQI},n_{HARQ},n_{SR}\right)$ 是一个依赖于 PUCCH 格式的值，其中 n_{CQI} 对应于 CQI 的信息比特数；对于参数 n_{SR}，如果子帧 i 为没有相关上行数据传输的 UE 配置调度请求（SR）则 $n_{SR}=1$ 否则 $n_{SR}=0$；参数 n_{HARQ} 是在子帧 i 发送的 HARQ-ACK 比特数. 参数 $\Delta_{\mathrm{F_PUCCH}}(F)$ 由高层提供，每一个 $\Delta_{\mathrm{F_PUCCH}}(F)$ 的取值对应于一个 PUCCH 格式（F）. 对于参数 $\Delta_{TxD}(F')$，如果 UE 被高层配置为在两个天线端口上发射 PUCCH，$\Delta_{TxD}(F')$ 的取值由高层提供，其中每种 PUCCH 格式 F' is 是预定义的，否则 $\Delta_{TxD}(F')=0$. $g(i)$ 是 UE 当前的 PUCCH 功率控制状态。PL_c 为 UE 针对小区 C 利用步骤 104 所述方法得到路径损耗的估计值。

再如，根据上述得到的路损估计，物理上行共享信道 PUSCH 的发射功率设置可以定义为如下式（4）:

$$P_{\mathrm{PUSCH,c}}(i)=\min\left\{P_{\mathrm{CMAX},c}(i),10\log_{10}(M_{\mathrm{PUSCH,c}}(i))+P_{\mathrm{O_PUSCH,c}}(j)+\alpha_c(j)\cdot PL_c+\Delta_{\mathrm{TF,c}}(i)+f_c(i)\right\}$$

其中，$P_{\mathrm{CMAX,c}}(i)$ 是服务小区 c 子帧 i UE 上配置的最大发射功率；$M_{\mathrm{PUSCH,c}}(i)$

是PUSCH 资源分配的带宽，用资源块RB表示，对子帧i和服务小区c有效。$P_{O_PUSCH,c}(j)$是一个由高层提供的分量$P_{O_NOMINAL_PUSCH,c}(j)$和分量$P_{O_UE_PUSCH,c}(j)$构成的参数，其中j=0,1。$\alpha_c \in \{0, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1\}$ 是一个3比特参数，由高层提供。$\Delta_{TF,c}(i)$是一个由高层信令确定的与传输格式相关的参数。$f_c(i)$ 是UE当前的PUSCH 功率控制调整状态。PL_c为UE针对小区C利用步骤104所述方法得到路径损耗的估计值。

再如，根据上述得到的路损估计，侦听参考信号SRS 的发射功率设置可以定义为如下式:

$$P_{SRS,c}(i) = \min\left\{ P_{CMAX,c}(i), P_{SRS_OFFSET,c}(m) + 10\log_{10}(M_{SRS,c}) + P_{O_PUSCH,c}(j) + \alpha_c(j)\cdot PL_c + f_c(i) \right\}$$

其中$P_{SRS_OFFSET,c}(m)$ 是服务小区c的高层半静态配置的参数，其中m=0和m=1。对于SRS传输触发类型0，则 m=0；触发类型1，则 m=1. $M_{SRS,c}$是服务小区c子帧 i的SRS传输带宽。$f_c(i)$ 是服务小区c的当前PUSCH功率控制调整状态。$P_{O_PUSCH,c}(j)$和$\alpha_c(j)$ 是预定义的参数，如LTE 36.213 中 5.1.1.1 节定义其中 $j=1$. PL_c为UE针对小区C利用步骤104所述方法得到路径损耗的估计值。

采用上述路损估计用于上行信道的开环控制，可以进一步提高功率控制的可靠性，同时，可以保证基站eNB能够自适应多种天线配置和天线阵列。

实施例三

本发明实施例提供一种用于通信质量测量的方法，如图5所示，所述方法包括:

步骤S21，确定参考信号资源配置信息，并向用户设备发送参考信号资源配置信息，所述参考信号资源配置信息包括：参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考

信号的功率比值。

当所述参考信号资源配置信息包括: 参考信号端口配置信息和功率比值信息，将该参考信号资源配置信息发送给用户设备（UE，User Equipment），使得用户设备根据该参考信号资源配置信息获取信道状态信息 CSI，由于参考信号端口被分配成多个组，UE 可以根据其中一个端口组或者多个端口组的参考信号质量处理得到最终的信号质量测量信息，使得 UE 侧可以将端口根据不同的端口组进行区分，不同于现有技术中不能区分不同端口的发射功率的情况。因而，该方案获取的信道状态信息，可以使得 UE 进行更为准确的调制与编码策略（MCS，Modulation and Coding Scheme)选择或者调度，从而提高系统的吞吐量。

步骤 S22，接收用户设备发送的信道状态信息 CSI，其中，所述 CSI 为所述用户设备根据所述参考信号端口配置信息和所述功率比值信息得到。

其中，所述信道状态信息 CSI 包括: 信道质量指示 CQI，预编码矩阵指示 PMI，或秩指示 RI 其中任意一个或者任意组合。

通过上述实施例三中说明的方法，该方法通过网络侧确定参考信号资源配置信息，并将该参考信号资源配置信息发送给用户侧，其中，所述参考信号资源配置信息至少包括: 端口组参考信号功率相关信息，以及参考信号端口配置信息，其中所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射。所述方法可以避免逐端口指示参考信号功率相关信息从而减少信令开销之外，端口组内各个端口采用统一的功率指示而不同的端口组可以彼此独立指示其功率相关信息，充分利用了天线配置或者天线阵列的结构，从而可以使得系统能够根据天线配置或者天线阵列结构灵活选择参考信号功率相关信息; 由于天线阵列可以具有对称的权重，利用该权重的对称性，可以降低波束赋形或者旁瓣抑制的设计复杂性。

进一步，将参考信号资源配置信息发送给用户侧 UE，UE 可以根据其中一个端口组或者多个端口组的参考信号质量处理得到最终的信号质量测量信息，使得 UE 侧可以将端口根据不同的端口组进行区分，不同于现有技术中不能区分不同端口的发射功率的情况。使得 UE 能够获取的信道状态信息，可以使得 UE 进行更为准确的调制与编码方案（MCS，Modulation and Coding

Scheme)选择或者调度，从而提高系统的吞吐量。

可选的，所述参考信号端口配置信息为单索引，或者为双索引，或者为联合编码后的索引。详细说明参考实施例一，此处不重述。

可选的，在步骤 S21 中所述功率比值信息中：

所述至少一个端口组中的每个端口组内的各天线端口上数据信道相对于参考信号的功率比值都相同；

或者，所述至少一个端口组中的一个端口组内各个端口上的数据信道与其它端口组内各个端口的数据信道相对于参考信号的功率比值相同。

可选的，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的多套功率比值，

所述接收用户设备发送的信道状态信息 CSI，包括接收用户设备发送的多套信道状态信息 CSI，其中每一套信道状态信息 CSI 为所述用户设备根据所述多套功率比值中的一套功率比值得到的。

其中，本实施例中所说的“多套”，是指采用多套取值；所述多套取值可以采用多套格式相同的信令。例如：

一种信令格式为：至少一个端口组中的各个端口的数据信道相对于参考信号的功率比值都相同，即端口组内各个端口间内功率相同；

另一种信令格式为：一个端口组内各个端口的数据信道与其它端口组内各个端口的数据信道相对于参考信号的功率比值相同，但端口组内各个端口间内功率不同；

上述例举了两种不同的信令格式，可以理解为对本实施例的具体举例，不应该理解对本实施例的限制。

实施例四

本发明实施例提供一种通信质量测量的方法，该方法与上述实施例二类似，不同之处在于，用户侧 UE 在接收到网络侧发送的参考信号资源配置信息后，将该信息用于获取信道状态信息，使得 UE 根据信道状态信息可以进行对应的调制与编码方案 MCS 选择或者资源调度。

如图 6 所示，所述方法包括：

步骤 201，接收基站发送的参考信号资源配置信息，所述参考信号资源配

置信息包括：参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功率比值；

其中，所述参考信号资源配置信息中包括的参考信号端口配置信息的详细说明，可以参考步骤 101 中的参考信号端口配置信息中的说明。即参考信号端口配置信息，用于指示参考信号端口到端口组的映射，参考信号端口到端口组中的映射关系是预定义的。

其中，所述数据信道可以是物理下行共享信道（PDSCH，Physical Downlink Shared Channel），也可以是用于传输控制信息的信道；数据信道的功率可以是每资源单元的能量（EPRE， Energy Per Resource Element）；

具体地，所述 UE 接收参考信号资源配置，可以是 UE 通过高层信令如无线资源控制（RRC， Radio Resource Control）信令或者动态信令如下行控制信息（DCI， Downlink Control Information）接收 eNB 通知的参考信号资源配置或者基于小区标识 ID 得到所述参考信号的资源配置。

具体地，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射。

一个参考信号端口往往与一个物理天线或者一个虚拟天线相对应，其中虚拟天线可以通过多个物理天线的加权组合得到。实际的天线部署可能具有不同的天线配置和天线阵列形式。需要指出的是，本实施例中参考信号端口和参考信号端口组可以与天线端口和天线端口组互换使用。

可选地，所述参考信号端口配置信息，用于指示所述参考信号端口到端口组的映射关系，可以包括参考信号端口数和映射索引，其中所述映射索引用于指示参考信号端口组与对应端口的映射。以如图 3 中的天线阵列 A 和如图 4 中的天线阵列 A 所示的 8 天线阵列为例，所述参考信号端口配置信息，包括参考信号端口数为 8 和映射索引为 0 或者 1。其中所述预定义的参考信号端口到端口组中的映射关系可以通过函数定义，也可以通过预定义的表格规定，如表 1 所示。

以如图 3 中的天线阵列 B 或者 C 和如图 4 中的天线阵列 B 或者 C 所示的 16 天线阵列为例，所述参考信号端口配置信息，包括参考信号端口数为 16 和

映射索引为 0 或者 1 或者 2 或者 3。其中所述预定义的参考信号端口到端口组中的映射关系可以通过函数定义，也可以通过预定义的表格规定，如表 2 所示。

具体地，所述参考信号端口配置信息，可以包括双索引（m, n）。此时，所述预定义的参考信号端口到端口组中的映射关系可以通过函数定义，也可以通过预定义的表格规定，如表 3 所示。

进一步地，双索引 (m, n) 可以指示参考信号端口数为 m 和 n 的乘积。

进一步地，所述双索引信息，可以进行联合编码，例如，上述表格 3 中的双索引的联合编码，如表格 3a 或者 3b 所示。

可选的，端口组的划分可以是以 4 个参考信号端口/天线端口为一个端口组。

需要进一步指出的是，端口组的划分不限于含有 4 个参考信号端口的端口组，还可以是 2 或 8 个或者其他构成形式的端口组。同时，每个端口组内含有的参考信号端口号，也不限于上述取值，可以根据实际的天线配置或者部署灵活选择。上述预定义的端口组映射以及映射指示信息，可以使得系统能够自适应更多的天线配置和天线阵列部署。

步骤 201 中在所述功率比值信息中，所述至少一个端口组中的每个端口组内的各天线端口上数据信道相对于参考信号的功率比值相同；以 16 个参考信号端口为例，假定数据信道为 PDSCH，功率对应于 EPRE，则 4 端口组的信号功率比值可以为：

表格 4-功率比值

端口组号	0	1	2	3
PDSCH EPRE 相对于参考信号 EPRE 的比值	ρ0	ρ1	ρ2	ρ3

进一步地，所述至少一个端口组内的各天线端口上数据信道相对于参考信号的功率比值相等。以表格 4 为例，其中端口组 0 中各个端口上的数据信道相对于参考信号的功率比值可以相等。

可选地，作为另一实施例，步骤 201 中在所述功率比值信息中，所述至少

一个端口组中的一个端口组内的各个端口上的数据信道与其它端口组内各个端口上的数据信道相对于参考信号的功率比值相同。

具体地，以 4 端口的端口组为例，例如端口组 0 的各个端口为 0,1,4,5；端口组 1 的各个端口为 2,3,6,7。端口组 0 中的数据信道相对于参考信号的功率比值如表格 4a 所示：

表格 4a-端口组 0 的功率比值

端口号	0	1	4	5
PDSCH EPRE 相对于参考信号 EPRE 的比值	ρ0	ρ1	ρ2	ρ3

端口组 0 内的各个端口与端口组 1 中各个端口对应的数据信道对于参考信号的功率比值相同，即端口组 1 的各个端口 2,3,6,7 对应的数据信道对于参考信号的功率比值分别为 ρ0，ρ1，ρ2 和 ρ3。

可选地，作为另一实施例，步骤 201 中所述一个或者一个以上端口组的数据信道相对于参考信号的功率比值可以包含多套取值。各套取值可以为如表格 4 或者 4a 所示的取值。

此外，所述参考信号资源配置信息还可以包括：参考信号配置，或者参考信号子帧配置其中任意一项。所述参考信号配置可以包括参考信号端口使用的子载波或者 OFDM 符号或者码资源；所述参考信号子帧配置可以包括参考信号端口占用的子帧位置、子帧周期或者子帧偏移。需要指出的是，所述参考信号配置或者参考信号子帧配置还可以是预定义的，或者根据事先已知的参数如小区 ID 或者 UE ID 隐式导出，为基站或者 UE 所共知；本发明实施例不作限制。

步骤 202，根据所述参考信号端口配置信息和所述功率比值信息，得到所述至少一个端口组内每个天线端口上数据信道相对于参考信号的功率比值；

步骤 203，根据所述每个天线端口上数据信道相对于参考信号的功率比值，得到信道状态信息 CSI；

具体地，根据所述每个天线端口上数据信道相对于参考信号的功率比值，得到信道状态信息 CSI，可以包括:

根据所述每个天线端口上的参考信号得到所述每个天线端口对应的信道测量值;

根据所述每个天线端口对应的信道测量值，和所述每个天线端口上数据信道相对于参考信号的功率比值，得到所述每个天线端口上数据信道的信道估计值;

根据所述每个天线端口上数据信道的信道估计值得到信道状态信息 CSI。

需要指出的是，本发明并不对得到所述至少一个端口组中的每个参考信号端口对应的信道测量值和得到所述至少一个端口组中的每个天线端口对应的数据信道相对于参考信号的功率比值的执行次序进行限定。

具体地，所述参考信号，具体可以包括小区特定参考信号 CSR; 或者，接收信道状态信息参考信号（CSI-RS，Channel State Information Reference Signal）或者解调参考信号（DMRS， DeModulation Reference signal）。

所述信道状态信息（CSI，Channel State Information），可以为信道质量指示（CQI，Channel Quality Indicator/Index）或者预编码矩阵指示（PMI，Precoding Matrix Indictor/Index）或者秩指示（RI，Rank Indicator），还可以是其它信道状态信息如预编码类型指示（PTI，Precoder Type Indicator）等。

具体地，UE基于PDSCH信号的EPRE相对于信道状态信息参考信号（CSI-RS，Channel State Information Reference Signal） EPRE的比值，计算信道状态信息时得到对应的PDSCH在天线端口上的发射功率。

以 16 个参考信号端口为例，假定步骤 201 中通知的参考信号端口配置信息，包括参考信号端口数为 16 和映射索引为 1，其映射关系如表 2 所示，功率比值如表 4 所示。则根据表 2 和表 4 可知，

参考信号端口 0,1,12 和 13 对应的 PDSCH 相对于参考信号的 EPRE 或者功率比值为 ρ0;

参考信号端口 2,3,14 和 15 对应的 PDSCH 相对于参考信号的 EPRE 或者功率比值为 ρ1;

参考信号端口 4,5,8 和 9 对应的 PDSCH 相对于参考信号的 EPRE 或者功

率比值为 ρ2；

参考信号端口 6,7,10 和 11 对应的 PDSCH 相对于参考信号的 EPRE 或者功率比值为 ρ3。

注意，所述参考信号端口与天线端口一一对应。

此外，所述UE根据所述参考信号资源配置信息接收参考信号，可以得到所述各个天线端口对应的信道测量值如下：

$$\mathbf{H}=\begin{bmatrix}\mathbf{h}_0 & \mathbf{h}_1 & \cdots & \mathbf{h}_{15}\end{bmatrix}$$

其中，$\mathbf{h}_p, p=0,...,15$ 为天线端口 p 对应的信道测量值，所述测量值可以根据具体的参考信号如CSI RS等基于最小二乘法等方式得到，此为现有技术，不尽一步赘述。

根据上述各个天线端口对应的信道测量值，UE可以根据PDSCH相对于参考信号的EPRE或者功率比值得到各个天线端口上数据信道PDSCH的信道测量或者信道估计值为：

$$\hat{\mathbf{H}}=\begin{bmatrix}\hat{\mathbf{h}}_0 & \hat{\mathbf{h}}_1 & \cdots & \hat{\mathbf{h}}_{15}\end{bmatrix}$$

其中，天线端口p上数据信道PDSCH的信道测量或者信道估计值 $\hat{\mathbf{h}}_p$ 为：

$$\hat{\mathbf{h}}_p=\sqrt{\rho_p}\mathbf{h}_p$$

其中，p 为所述天线端口的索引，ρ_p 为天线端口 p 上数据信道相对于参考信号的功率比值，$\mathbf{h}_p$ 为天线端口 p 对应的信道测量值，$\hat{\mathbf{h}}_p$ 为天线端口 p 上数据信道的信道估计值，即，

$$\hat{\mathbf{h}}_p=\begin{cases}\sqrt{\rho 0}\mathbf{h}_p, p=0,1,12,13\\ \sqrt{\rho 1}\mathbf{h}_p, p=2,3,14,15\\ \sqrt{\rho 2}\mathbf{h}_p, p=4,5,8,9\\ \sqrt{\rho 3}\mathbf{h}_p, p=6,7,10,11\end{cases}$$

则UE可以基于以下方程计算信道状态信息CSI如下方程（5）：

$$\mathbf{y} = \hat{\mathbf{H}}\mathbf{P}\mathbf{s} + \mathbf{n} \quad (5)$$

其中，**P**为预编码矩阵，对于非预编码的系统，P为单位阵。**s**为发送的信息符号如调制符号，**n**为干扰和噪声矢量，**y**为接收信号。

根据上述方程（5）得到信道状态信息如信道质量指示（channel quality indicator, 简称CQI）或者预编码矩阵指示（PMI，Precoding Matrix Indicator/Index）/秩指示（RI，Rank Indicator/Index）其中任意一个或者任意组合。其中，根据上述方程（5）得到信道状态信息如CQI，或者PMI，或者RI的具体过程是已有技术，此处不再进一步赘述。

可选地，作为另一实施例，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的多套功率比值；

以16个参考信号端口为例，假定步骤201中通知的参考信号端口配置信息，包括参考信号端口数为16和映射索引为1，其映射关系如表2所示，功率比值如表4b所示。则根据表2和表4b可知，

参考信号端口0,1,12和13对应的PDSCH相对于参考信号的EPRE或者第一套功率比值为x0；

参考信号端口2,3,14和15对应的PDSCH相对于参考信号的EPRE或者第一套功率比值为x1；

参考信号端口4,5,8和9对应的PDSCH相对于参考信号的EPRE或者第一套功率比值为x2；

参考信号端口6,7,10和11对应的PDSCH相对于参考信号的EPRE或者第一套功率比值为x3；

参考信号端口0,1,12和13对应的PDSCH相对于参考信号的EPRE或者第二套功率比值为y0；

参考信号端口2,3,14和15对应的PDSCH相对于参考信号的EPRE或者第二套功率比值为y1；

参考信号端口4,5,8和9对应的PDSCH相对于参考信号的EPRE或者第二套功率比值为y2；

参考信号端口6,7,10和11对应的PDSCH相对于参考信号的EPRE或者第二套功率比值为y3。

表格 4b-端口组 0 的多套功率比值

端口号	0	1	4	5
PDSCH EPRE 相对于参考信号 EPRE 的第一套比值	x0	x1	x2	x3
PDSCH EPRE 相对于参考信号 EPRE 的第二比值	y0	y1	y2	y3

步骤 204，向基站发送所述信道状态信息 CSI;

具体地，可以通过物理上行控制信道 PUCCH 或物理上行共享信道 PUSCH 向基站发送所述信道状态信息。

可选地，所述向基站发送所述信道状态信息 CSI，包括：向基站发送所述多套信道状态信息 CSI，其中每一套信道状态信息 CSI 为根据所述多套功率比值中的一套功率比值得到的。

以 16 个参考信号端口为例，假定步骤 201 中通知的参考信号端口配置信息，包括参考信号端口数为 16 和映射索引为 1，其映射关系如表 2 所示，功率比值如表 4b 所示。则根据表 2 和表 4b 可知，UE 向基站发送两套信道状态信息 CSI。其中第一套 CSI 根据以下表格 4c 中第一套功率比值计算:

表格 4c 中端口组 0 的第一套功率比值

端口号	0	1	4	5
PDSCH EPRE 相对于参考信号 EPRE 的比值	x0	x1	x2	x3

其中，第二套 CSI 根据以下表格 4d 中第二套功率比值计算:

表格 4d 中端口组 0 的第二套功率比值

端口号	0	1	4	5
PDSCH EPRE 相对于参考信号 EPRE 的比值	y0	y1	y2	y3

上述采用端口组分别指示数据信道的功率相对于参考信号的功率的比值，除了可以减少信令开销之外，可以使得系统能够根据天线配置或者天线阵列结构灵活配置信号功率。同时，需要进一步指出的是，尽管端口组的划分不限于含有 4 个参考信号端口的端口组，上述表格 1，2，3 中的端口组划分以及各个端口的构成可以进一步使得图 3 或者图 4 中的天线阵列具有关于阵列结构对称的功率，即各个端口相对于阵列可以具有对称的权重，便于实现波束赋形或者旁瓣抑制。

实施例五

本发明实施例提供了一种网络侧装置，如图 7 所述，所述装置包括：确定单元 601，和第一发送单元 602;

所述确定单元 601，用于确定参考信号资源配置信息，所述参考信号资源配置信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系;

所述第一发送单元 602，用于将所述确定单元确定的所述参考信号资源配

置信息发送给用户设备，以使得所述用户设备根据所述参考信号端口配置信息获取信号质量测量信息。

本实施例说明的网络侧装置可以是网络侧的基站，其各单元功能的实现可以参照实施例一中相应步骤的描述，此处不重述。

通过上述实施例五中说明的装置，通过网络侧确定参考信号资源配置信息，并将该参考信号资源配置信息发送给用户侧，所述参考信号资源配置信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系。该装置可以避免逐端口指示参考信号功率相关信息从而减少信令开销之外，端口组内各个端口采用统一的功率指示而不同的端口组可以彼此独立指示其功率相关信息，充分利用了天线配置或者天线阵列的结构，从而可以使得系统能够根据天线配置或者天线阵列结构灵活选择参考信号功率相关信息；由于天线阵列可以具有对称的权重，利用该权重的对称性，可以降低波束赋形或者旁瓣抑制的设计复杂性。

进一步，将参考信号资源配置信息发送给用户侧 UE，UE 可以根据其中至少一个端口组的参考信号质量处理得到最终的信号质量测量信息，使得 UE 侧可以将端口根据不同的端口组进行区分，不同于现有技术中不能区分不同端口的发射功率的情况。使得 UE 能够获取的信号质量测量信息，可以使得 UE 进行更为准确的小区选择和上行功率控制。

可选的，所述确定单元 601 确定的所述参考信号资源配置信息还包括：至少两个端口组的参考信号功率信息，用于所述用户设备根据所述参考信号端口配置信息并结合所述至少两个端口组的参考信号功率信息，获取所述信号质量测量信息；

其中，所述至少两个端口组的参考信号功率信息，包括：

第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的比值；

或者，第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的差分。

可选的，当所述信号质量测量信息为参考信号接收功率 RSRP 时，所述第一发送单元 602 还用于向所述用户设备发送滤波器系数信息，用于所述用户设

备基于所述滤波器系数信息对所述参考信号接收功率 RSRP 进行滤波并得到路损估计值。

可选的，所述装置还包括:

第一接收单元 603，用于接收所述用户设备发送的上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率为所述用户设备根据所述路损估计值计算得到的。

可选的，所述信号质量测量信息包括:

参考信号接收功率 RSRP，参考信号接收质量 RSRQ，或者参考信号强度指示 RSSI 其中任一项或者任意组合。

可选的，所述装置还包括：第二接收单元 604，

所述第二接收单元用于接收用户设备发送的所述信号质量测量信息。

其中，第一接收单元 603 和第二接收单元 604 可以是集成在同一个实体模块中，或者可以理解为由同一模块实现，采用第一、第二接收单元的描述，是为了更好的理解该网络侧装置的中各模块之间的连接关系。

实施例六

本发明实施例提供了一种用户设备，如图 8 所示，该用户设备包括：第三接收单元 701，第一获取单元 702，和第二获取单元 703;

所述第三接收单元 701，用于接收基站发送的参考信号资源配置信息，所述参考信号资源配置信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系;

所述第一获取单元 702，用于根据所述第三接收单元接收的所述参考信号端口配置信息，得到至少一个端口组中的参考信号端口信息;

所述第二获取单元 703，用于根据所述第一获取单元得到所述至少一个端口组中的参考信号端口信息获取信号质量测量信息。

关于本实施例说明的用户设备，其各单元功能的实现可以参照实施例二中相应步骤的描述，此处不重述。

通过上述实施例七中说明的装置，该装置通过接收网络侧确定参考信号资源配置信息，其中，所述参考信号资源配置信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系。

所述装置可以避免逐端口指示参考信号功率相关信息从而减少信令开销之外，端口组内各个端口采用统一的功率指示而不同的端口组可以彼此独立指示其功率相关信息，充分利用了天线配置或者天线阵列的结构，从而可以使得系统能够根据天线配置或者天线阵列结构灵活选择参考信号功率相关信息；由于天线阵列可以具有对称的权重，利用该权重的对称性，可以降低波束赋形或者旁瓣抑制的设计复杂性。

进一步，将参考信号资源配置信息发送给用户侧 UE，UE 可以根据其中至少一个端口组的参考信号质量处理得到最终的信号质量测量信息，使得 UE 侧可以将端口根据不同的端口组进行区分，不同于现有技术中不能区分不同端口的发射功率的情况。使得 UE 能够获取的信号质量测量信息，可以使得 UE 进行更为准确的小区选择和上行功率控制。

可选的，所述第一获取单元 702，具体用于根据所述第三接收单元接收的所述参考信号端口配置信息，得到指定的一个端口组中的参考信号端口信息；

所述第二获取单元 703，具体用于根据所述第一获取单元得到的所述指定的一个端口组中的参考信号端口信息获取所述信号质量测量信息。

可选的，当所述信号质量测量信息为参考信号接收功率 RSRP 时，所述第二获取单元 703 具体用于：

$$RSRP(r,p)=\frac{1}{K_s-1}\sum_{m=0}^{K_s-1}\hat{h}_p(m)\cdot\hat{h}_p(m+1)$$

根据公式：得到第 r 个接收天线第 p 个端口的参考信号接收功率 $RSRP(r,p)$ 并通过组合 $RSRP(r,p)$ 得到所述 RSRP；其中，$\hat{h}_p(m)$ 为标号为 m 的参考信号 RE 上的信道估计；K_s 是在测量带宽内可利用的参考信号 RE 的样本总数；p 为所述指定的一个端口组中参考信号端口号，r 为接收天线的索引。

可选的，所述第三接收单元 701 接收的所述参考信号资源配置信息还包括：至少两个端口组的参考信号功率信息，

所述第二获取单元还用于根据所述参考信号端口配置信息并结合所述至少两个端口组的参考信号功率信息获取所述信号质量测量信息。

可选的，所述第二获取单元 703 具体用于：

根据所述参考信号端口配置信息得到所述至少两个端口组对应的信号质量测量信息；

根据所述至少两个端口组的参考信号功率信息，对所得到的至少两个端口组对应的信号质量测量信息按端口组功率进行加权平均，得到所述信号质量测量信息。

可选的，所述第二获取单元 703 根据所述至少两个端口组的参考信号功率信息，对所得到的至少两个端口组对应的信号质量测量信息按端口组功率进行加权平均，得到所述信号质量测量信息，包括：

根据公式：$SQ = \left(\sum_{g=0}^{n-1} p_g \cdot SQ_g \right) \Big/ \left(\sum_{g=0}^{n-1} p_g \right)$，得到信号质量测量信息，

其中，SQ_g 为指定端口组的信号质量测量信息，其中，g 为指定端口组的编号，n 为指定端口组的个数，$n \geq 2$；p_g 为指定端口组的参考信号功率，其中，指定端口组的参考信号功率根据所述至少两个端口组的参考信号功率信息得到。

可选的，所述第三接收单元 701 接收到的所述至少两个端口组的参考信号功率信息包括：

第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的比值；

或者，第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的差分。

可选的，所述用户设备还包括：第二发送单元 704，用于向基站发送所述信号质量测量信息。

可选的，

所述第三接收单元 701，还用于当所述信号质量测量信息为参考信号接收功率 RSRP，接收基站发送的滤波器系数信息；

所述用户设备还包括：第三获取单元 705，

所述第三获取单元 705，用于基于所述第三接收单元接收的所述滤波器系

数信息对所述参考信号接收功率 RSRP 进行滤波，并得到路损估计值。

可选的，所述用于装置还包括：第三发送单元 706，

所述第三发送单元 706，还用于向基站发送上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率根据所述路损估计值计算得到。

其中，第三发送单元 706 和第二发送单元 704 具有可以由同一个实体模块实现，此次是便于理解的分开进行说明。

可选的，所述信号质量测量信息，包括：参考信号接收功率 RSRP，参考信号强度指示 RSSI，或者参考信号接收质量 RSRQ。

实施例七

本发明实施例提供了一种网络侧装置，如图 9 所示，所述装置包括：第四发送单元 801，第四接收单元 802;

所述第四发送单元 801，用于向用户设备发送参考信号资源配置信息，所述参考信号资源配置信息包括: 参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射关系，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功率比值;

所述第四接收单元 802，用于接收用户设备发送的信道状态信息 CSI，其中，所述 CSI 为所述用户设备根据所述参考信号端口配置信息和所述功率比值信息得到。

通过上述实施例七中说明的网络侧装置，该装置通过网络侧确定参考信号资源配置信息，并将该参考信号资源配置信息发送给用户侧，其中，参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射关系，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功率比值。该装置可以避免逐端口指示参考信号功率相关信息从而减少信令开销之外，端口组内各个端口采用统一的功率指示而不同的端口组可以彼此独立指示其功率相关信息，充分利用了天线配置或者天线阵列的结构，从而可以使得系统能够根据天线配置或者天线阵列结构灵活选择参考信号功率相关信息；由于天线阵列可以具有对称的权重，利用该

权重的对称性，可以降低波束赋形或者旁瓣抑制的设计复杂性。

进一步，将参考信号资源配置信息发送给用户侧 UE，UE 可以根据其中一个端口组或者多个端口组的参考信号质量处理得到最终的信号质量测量信息，使得 UE 侧可以将端口根据不同的端口组进行区分，不同于现有技术中不能区分不同端口的发射功率的情况。使得 UE 能够获取的信道状态信息，可以使得 UE 进行更为准确的调制与编码方案（MCS，Modulation and Coding Scheme)选择或者调度，从而提高系统的吞吐量。

可选的，在所述功率比值信息中：

所述至少一个端口组中的每个端口组内的各天线端口上数据信道相对于参考信号的功率比值都相同；

或者，所述至少一个端口组中的一个端口组内各个端口上的数据信道与其它端口组内各个端口的数据信道相对于参考信号的功率比值相同；

可选的，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的多套功率比值，

所述第四接收单元，具体用于接收用户设备发送的多套信道状态信息 CSI，其中每一套信道状态信息 CSI 为所述用户设备根据所述多套功率比值中的一套功率比值得到的。

可选的，所述第四接收单元接收的所述信道状态信息 CSI 包括：信道质量指示 CQI，预编码矩阵指示 PMI，或秩指示 RI 其中任意一个或者任意组合。

本实施例提供的网络侧装置，可以是网络侧的基站，其各单元功能的实现可以参照实施例三中相应步骤的描述，此处不重述。

实施例八

本发明实施例提供了一种用户设备，如图 10 所示，所述用户设备包括：第五接收单元 901，第四获取单元 902，第五获取单元 903，和第五发送单元 904；

所述第五接收单元 901，用于接收基站发送的参考信号资源配置信息，所述参考信号资源配置信息包括：参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射关系，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功

率比值;

所述第四获取单元 902，用于根据所述第五接收单元接收的所述参考信号端口配置信息和所述功率比值信息，得到所述至少一个端口组内每个天线端口上数据信道相对于参考信号的功率比值;

所述第五获取单元 903，用于根据所述第四获取单元得到的所述每个天线端口上数据信道相对于参考信号的功率比值，得到信道状态信息 CSI;

所述第五发送单元 904，用于向基站发送所述第五获取单元得到的所述信道状态信息 CSI。

本发明实施例提供了一种用户设备，该装置可以根据其中一个端口组或者多个端口组的参考信号质量处理得到最终的信号质量测量信息，使得 UE 侧可以将端口根据不同的端口组进行区分，不同于现有技术中不能区分不同端口的发射功率的情况。使得 UE 能够获取的信道状态信息，可以使得 UE 进行更为准确的调制与编码方案（MCS，Modulation and Coding Scheme)选择或者调度，从而提高系统的吞吐量。

可选的，所述第五获取单元，具体用于:

根据所述每个天线端口上的参考信号得到所述每个天线端口对应的信道测量值;

根据所述每个天线端口对应的信道测量值，和所述每个天线端口上数据信道相对于参考信号的功率比值，得到所述每个天线端口上数据信道的信道估计值;

根据所述每个天线端口上数据信道的信道估计值得到信道状态信息 CSI。

可选的，所述第五获取单元根据所述每个天线端口对应的信道测量值，和所述每个天线端口上数据信道相对于参考信号的功率比值，得到所述每个天线端口上数据信道的信道估计值，包括:

根据公式 $\hat{\mathbf{h}}_p = \sqrt{\rho_p}\mathbf{h}_p$ 得到天线端口 p 上数据信道的信道估计值;

其中，p 为所述天线端口的索引，ρ_p 为天线端口 p 上数据信道相对于参考信号的功率比值，$\mathbf{h}_p$ 为天线端口 p 对应的信道测量值，$\hat{\mathbf{h}}_p$ 为天线端口 p 上数据

信道的信道估计值。

可选的，在所述功率比值信息中，

所述至少一个端口组中的每个端口组内的各天线端口上数据信道相对于参考信号的功率比值相同；

或者，所述至少一个端口组中的一个端口组内的各个端口上的数据信道与其它端口组内各个端口上的数据信道相对于参考信号的功率比值相同。

可选的，所述第五接收单元接收的所述参考信号资源配置信息包括：参考信号端口配置信息和功率比值信息；

其中，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的多套功率比值；

所述第五发送单元，具体用于：

向基站发送所述多套信道状态信息 CSI，其中每一套信道状态信息 CSI 为根据所述多套功率比值中的一套功率比值得到的。

可选的，所述第五获取单元得到的所述信道状态信息 CSI 包括：信道质量指示 CQI，预编码矩阵指示 PMI，或秩指示 RI 其中任意一个或者任意组合。

本实施例提供的用户设备，其各单元功能的实现可以参照实施例四中相应步骤的描述，此处不重述。

实施例九

提供一种网络侧装置，能支持无线通信技术，且本实施例的通信设备中各个单元之间可以按照实施例一中所述的方法进行数据包的传输，结构示意图如图11所示，包括：分别连接到总线上的处理器21、接收器23和发射器24，

可选的，所示网络侧装置还可以包括：存储器20；

其中：

存储器20中用来储存从接收器23输入的数据，且还可以储存处理器21处理数据的必要文件等信息；接收器23和发射器24是通信设备与其它设备通信的端口。

其中，所述处理器 21，用于确定参考信号资源配置信息，所述参考信号资源配置信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系；

所述发射器 24，用于将所述参考信号资源配置信息发送给用户设备，以使得所述用户设备根据所述参考信号端口配置信息获取信号质量测量信息。

可选的，所述处理器 21 确定的所述参考信号资源配置信息还包括：至少两个端口组的参考信号功率信息，用于所述用户设备根据所述参考信号端口配置信息并结合所述至少两个端口组的参考信号功率信息，获取所述信号质量测量信息；

其中，所述至少两个端口组的参考信号功率信息，包括：

第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的比值；

或者，第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的差分。

可选的，当所述信号质量测量信息为参考信号接收功率 RSRP 时，所述发射器还用于向所述用户设备发送滤波器系数信息，用于所述用户设备基于所述滤波器系数信息对所述参考信号接收功率 RSRP 进行滤波并得到路损估计值。

可选的，所述接收器 23 用于接收所述用户设备发送的上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率为所述用户设备根据所述路损估计值计算得到的。

可选的，所述信号质量测量信息包括：

参考信号接收功率 RSRP，参考信号接收质量 RSRQ，或者参考信号强度指示 RSSI 其中任一项或者任意组合。

可选的，所述接收器 23 还用于接收用户设备发送的所述信号质量测量信息。

本实施例说明的网络侧装置可以是网络侧的基站，其各单元功能的实现可以参照实施例一中相应步骤的描述，此处不重述。

实施例十

本实施例提供一种用户设备，能支持无线通信技术，且本实施例的通信设备中各个单元之间可以按照实施例二中所述的方法进行数据包的传输，结构示意图如图12所示，包括：分别连接到总线上的处理器31、接收器33和发射器34，

可选的，所示网络侧装置还可以包括：存储器30;

其中：

存储器30中用来储存从接收器33输入的数据，且还可以储存处理器31处理数据的必要文件等信息；接收器33和发射器34是通信设备与其它设备通信的端口。

所述接收器 33，用于接收基站发送的参考信号资源配置信息，所述参考信号资源配置信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系；

所述处理器 31，用于根据所述参考信号端口配置信息，得到至少一个端口组中的参考信号端口信息；根据所述至少一个端口组中的参考信号端口信息获取信号质量测量信息。

可选的，所述处理器 31，具体用于：

根据所述参考信号端口配置信息，得到指定的一个端口组中的参考信号端口信息；

根据所述指定的一个端口组中的参考信号端口信息获取所述信号质量测量信息。

可选的，当所述信号质量测量信息为参考信号接收功率 RSRP 时，所述处理器根据所述指定的一个端口组中的参考信号端口信息获取所述信号质量测量信息，包括：

根据公式：$$RSRP(r,p)=\frac{1}{K_s-1}\sum_{m=0}^{K_s-1}\hat{h}_p(m)\cdot\hat{h}_p(m+1)$$ 得到第 r 个接收天线第 p 个端口的参考信号接收功率 $RSRP(r,p)$ 并通过组合 $RSRP(r,p)$ 得到所述 RSRP；其中，$\hat{h}_p(m)$ 为标号为 m 的参考信号 RE 上的信道估计；K_s 是在测量带宽内可利用的参考信号 RE 的样本总数；p 为所述指定的一个端口组中参考信号端口号，r 为接收天线的索引。

可选的，所述接收器 33 接收的所述参考信号资源配置信息还包括：至少

两个端口组的参考信号功率信息，用于所述用户设备根据所述参考信号端口配置信息并结合所述至少两个端口组的参考信号功率信息获取所述信号质量测量信息。

可选的，所述处理器 31 根据所述参考信号端口配置信息并结合至少两个端口组的参考信号功率信息获取信号质量测量信息，包括：

根据所述参考信号端口配置信息得到所述至少两个端口组对应的信号质量测量信息；

根据所述至少两个端口组的参考信号功率信息，对所得到的至少两个端口组对应的信号质量测量信息按端口组功率进行加权平均，得到所述信号质量测量信息。

可选的，所述处理器 31 根据所述至少两个端口组的参考信号功率信息，对所得到的至少两个端口组对应的信号质量测量信息按端口组功率进行加权平均，得到信号质量测量信息，包括：

根据公式：$SQ=\left(\sum_{g=0}^{n-1}p_g\cdot SQ_g\right)\Big/\left(\sum_{g=0}^{n-1}p_g\right)$，得到信号质量测量信息，

其中，SQ_g 为指定端口组的信号质量测量信息，其中，g 为指定端口组的编号，n 为指定端口组的个数，$n\geq 2$；p_g 为指定端口组的参考信号功率，其中，指定端口组的参考信号功率根据所述至少两个端口组的参考信号功率信息得到。

可选的，所述接收器 33 接收到的所述至少两个端口组的参考信号功率信息，包括：

第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的比值；

或者，第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的差分。

可选的，所述发射器 34 用于向基站发送所述信号质量测量信息。

可选的，当所述信号质量测量信息为参考信号接收功率 RSRP 时，所述接收器还用于接收基站发送的滤波器系数信息；

所述处理器 31，还用于基于所述滤波器系数信息对所述参考信号接收功

率 RSRP 进行滤波，并得到路损估计值。

可选的，所述发射器 34 还用于向基站发送上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率根据所述路损估计值计算得到。

可选的，所述信号质量测量信息，包括：参考信号接收功率 RSRP，参考信号强度指示 RSSI，或者参考信号接收质量 RSRQ。

实施例十一

提供一种网络侧装置，能支持无线通信技术，且本实施例的通信设备中各个单元之间可以按照实施例三中所述的方法进行数据包的传输，结构示意图如图13所示，包括：分别连接到总线上的处理器41、接收器43和发射器44，

可选的，所示网络侧装置还可以包括：存储器40;

其中：

存储器40中用来储存从接收器43输入的数据，且还可以储存处理器41处理数据的必要文件等信息；接收器43和发射器44是通信设备与其它设备通信的端口。

其中，所述发射器 44，用于向用户设备发送参考信号资源配置信息，所述参考信号资源配置信息包括：参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射关系，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功率比值；

所述接收器 43，用于接收用户设备发送的信道状态信息 CSI，其中，所述 CSI 为所述用户设备根据所述参考信号端口配置信息和所述功率比值信息得到。

可选的，在所述功率比值信息中：

所述至少一个端口组中的每个端口组内的各天线端口上数据信道相对于参考信号的功率比值都相同；

或者，所述至少一个端口组中的一个端口组内各个端口上的数据信道与其它端口组内各个端口的数据信道相对于参考信号的功率比值相同。

可选的，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的多套功率比值；

所述接收器接收用户设备发送的信道状态信息 CSI，包括：接收用户设备发送的多套信道状态信息 CSI，其中每一套信道状态信息 CSI 为所述用户设备根据所述多套功率比值中的一套功率比值得到的。

可选的，所述接收器接收的所述信道状态信息 CSI 包括：信道质量指示 CQI，预编码矩阵指示 PMI，或秩指示 RI 其中任意一个或者任意组合。

本实施例提供的网络侧装置，可以是网络侧的基站，其各单元功能的实现可以参照实施例三中相应步骤的描述，此处不重述。

实施例十二

本实施例提供一种用户设备，能支持无线通信技术，且本实施例的通信设备中各个单元之间可以按照实施例四中所述的方法进行数据包的传输，结构示意图如图14所示，包括：分别连接到总线上的处理器51、接收器53和发射器54，

可选的，所示网络侧装置还可以包括：存储器50；

其中，存储器50中用来储存从接收器53输入的数据，且还可以储存处理器51处理数据的必要文件等信息；接收器53和发射器54是通信设备与其它设备通信的端口。

所述接收器 53，用于接收基站发送的参考信号资源配置信息，所述参考信号资源配置信息包括：参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射关系，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功率比值；

所述处理器 51，用于根据所述参考信号端口配置信息和所述功率比值信息，得到所述至少一个端口组内每个天线端口上数据信道相对于参考信号的功率比值，并根据所述每个天线端口上数据信道相对于参考信号的功率比值，得到信道状态信息 CSI；

所述发射器 54，用于向基站发送所述信道状态信息 CSI。

可选的，所述处理器 51 根据所述每个天线端口上数据信道相对于参考信

号的功率比值，得到信道状态信息 CSI，包括：

根据所述每个天线端口上的参考信号得到所述每个天线端口对应的信道测量值；

根据所述每个天线端口对应的信道测量值，和所述每个天线端口上数据信道相对于参考信号的功率比值，得到所述每个天线端口上数据信道的信道估计值；

根据所述每个天线端口上数据信道的信道估计值得到信道状态信息 CSI。

可选的，所述处理器 51 根据所述每个天线端口对应的信道测量值，和所述每个天线端口上数据信道相对于参考信号的功率比值，得到所述每个天线端口上数据信道的信道估计值，包括：

根据公式 $\hat{\mathbf{h}}_p = \sqrt{\rho_p}\mathbf{h}_p$ 得到天线端口 p 上数据信道的信道估计值；

其中，p 为所述天线端口的索引，ρ_p 为天线端口 p 上数据信道相对于参考信号的功率比值，$\mathbf{h}_p$ 为天线端口 p 对应的信道测量值，$\hat{\mathbf{h}}_p$ 为天线端口 p 上数据信道的信道估计值。

可选的，在所述功率比值信息中，

所述至少一个端口组中的每个端口组内的各天线端口上数据信道相对于参考信号的功率比值相同；

或者，所述至少一个端口组中的一个端口组内的各个端口上的数据信道与其它端口组内各个端口上的数据信道相对于参考信号的功率比值相同。

可选的，所述所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的多套功率比值；

所述发射器具体用于：

向所述基站发送所述多套信道状态信息 CSI，其中每一套信道状态信息 CSI 为根据所述多套功率比值中的一套功率比值得到的。

可选的，所述处理器得到的所述信道状态信息 CSI 包括：信道质量指示 CQI，预编码矩阵指示 PMI，或秩指示 RI 其中任意一个或者任意组合。

本领域普通技术人员可以理解上述实施例的各种方法中的全部或部分步

骤是可以通过程序来指令相关的硬件来完成，该程序可以存储于一计算机可读存储介质中，存储介质可以包括：ROM、RAM、磁盘或光盘等。

以上对本发明实施例所提供的通信质量测量的方法和装置，进行了详细介绍，本文中应用了具体个例对本发明的原理及实施方式进行了阐述，以上实施例的说明只是用于帮助理解本发明的方法及其核心思想；同时，对于本领域的一般技术人员，依据本发明的思想，在具体实施方式及应用范围上均会有改变之处，综上所述，本说明书内容不应理解为对本发明的限制。

权 利 要 求

1、一种通信质量测量的方法，其特征在于，包括:

确定参考信号资源配置信息，所述参考信号资源配置信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系;

将所述参考信号资源配置信息发送给用户设备，以使得所述用户设备根据所述参考信号端口配置信息获取信号质量测量信息。

2、根据权利要求 1 所述的方法，其特征在于，所述参考信号资源配置信息还包括: 至少两个端口组的参考信号功率信息，用于所述用户设备根据所述参考信号端口配置信息并结合所述至少两个端口组的参考信号功率信息，获取所述信号质量测量信息;

其中，所述至少两个端口组的参考信号功率信息，包括:

第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的比值;

或者，第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的差分。

3、根据权利要求 1 或者 2 所述方法，其特征在于，所述信号质量测量信息为参考信号接收功率 RSRP，所述方法还包括:

向所述用户设备发送滤波器系数信息，用于所述用户设备基于所述滤波器系数信息对所述参考信号接收功率 RSRP 进行滤波并得到路损估计值。

4、根据权利 3 所述方法，其特征在于，所述方法还包括:

接收所述用户设备发送的上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率为所述用户设备根据所述路损估计值计算得到的。

5、根据权利要求 1 或者 2 所述方法，其特征在于，所述信号质量测量信息包括:

参考信号接收功率 RSRP，参考信号接收质量 RSRQ，或者参考信号强度指示 RSSI 其中任一项或者任意组合。

6、根据权利要求 1 至 5 任一项所述方法，其特征在于，所述方法还包括:

接收用户设备发送的所述信号质量测量信息。

7、一种通信质量测量的方法，其特征在于，包括:

接收基站发送的参考信号资源配置信息，所述参考信号资源配置信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系;

根据所述参考信号端口配置信息，得到至少一个端口组中的参考信号端口信息;

根据所述至少一个端口组中的参考信号端口信息获取信号质量测量信息。

8、根据权利要求 7 所述方法，其特征在于，所述根据所述参考信号端口配置信息，得到至少一个端口组中的参考信号端口信息包括:

根据所述参考信号端口配置信息，得到指定的一个端口组中的参考信号端口信息;

所述根据所述至少一个端口组中的参考信号端口信息获取信号质量测量信息包括:

根据所述指定的一个端口组中的参考信号端口信息获取所述信号质量测量信息。

9、根据权利要求 8 所述方法，其特征在于，当所述信号质量测量信息为参考信号接收功率 RSRP 时，所述根据所述指定的一个端口组中的参考信号端口信息获取所述信号质量测量信息，包括:

根据公式: $$RSRP(r,p)=\frac{1}{K_s-1}\sum_{m=0}^{K_s-1}\hat{h}_p(m)\cdot\hat{h}_p(m+1)$$ 得到第 r 个接收天线第 p 个端口的参考信号接收功率 $RSRP(r,p)$ 并通过组合 $RSRP(r,p)$ 得到所述 RSRP; 其中，$\hat{h}_p(m)$ 为标号为 m 的参考信号 RE 上的信道估计; K_s 是在测量带宽内可利用的参考信号 RE 的样本总数; p 为所述指定的一个端口组中参考信号端口号，r 为接收天线的索引。

10、根据权利要求 7 所述方法，其特征在于，所述参考信号资源配置信息

还包括：至少两个端口组的参考信号功率信息，用于所述用户设备根据所述参考信号端口配置信息并结合所述至少两个端口组的参考信号功率信息获取所述信号质量测量信息。

11、根据权利要求 10 所述方法，其特征在于，所述根据所述参考信号端口配置信息并结合至少两个端口组的参考信号功率信息获取信号质量测量信息，包括：

根据所述参考信号端口配置信息得到所述至少两个端口组对应的信号质量测量信息；

根据所述至少两个端口组的参考信号功率信息，对所得到的至少两个端口组对应的信号质量测量信息按端口组功率进行加权平均，得到所述信号质量测量信息。

12、根据权利要求 11 所述方法，其特征在于，所述根据所述至少两个端口组的参考信号功率信息，对所得到的至少两个端口组对应的信号质量测量信息按端口组功率进行加权平均，得到信号质量测量信息，包括：

根据公式：$SQ = \left(\sum_{g=0}^{n-1} p_g \cdot SQ_g \right) \Big/ \left(\sum_{g=0}^{n-1} p_g \right)$，得到信号质量测量信息，

其中，SQ_g 为指定端口组的信号质量测量信息，其中，g 为指定端口组的编号，n 为指定端口组的个数，$n \geq 2$；p_g 为指定端口组的参考信号功率，其中，指定端口组的参考信号功率根据所述至少两个端口组的参考信号功率信息得到。

13、根据权利要求 10 至 12 任一项所述的方法，其特征在于，所述至少两个端口组的参考信号功率信息，包括：

第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的比值；

或者，第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的差分。

14、根据权利要求 7 至 13 任一项所述的方法，其特征在于，所述方法还包括：

向基站发送所述信号质量测量信息。

15、根据权利要求 7 至 14 任一项所述方法，其特征在于，所述信号质量测量信息为参考信号接收功率 RSRP，所述方法还包括:

接收基站发送的滤波器系数信息;

基于所述滤波器系数信息对所述参考信号接收功率 RSRP 进行滤波，并得到路损估计值。

16、根据权利要求 15 所述方法，其特征在于，所述方法还包括:

向基站发送上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率根据所述路损估计值计算得到。

17、根据权利要求 7 所述方法，其特征在于，所述信号质量测量信息，包括: 参考信号接收功率 RSRP，参考信号强度指示 RSSI，或者参考信号接收质量 RSRQ。

18、一种通信质量测量的方法，其特征在于，包括:

向用户设备发送参考信号资源配置信息，所述参考信号资源配置信息包括: 参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射关系，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功率比值;

接收用户设备发送的信道状态信息 CSI，其中，所述 CSI 为所述用户设备根据所述参考信号端口配置信息和所述功率比值信息得到。

19、根据权利要求 18 所述的方法，其特征在于，在所述功率比值信息中:

所述至少一个端口组中的每个端口组内的各天线端口上数据信道相对于参考信号的功率比值都相同;

或者，所述至少一个端口组中的一个端口组内各个端口上的数据信道与其它端口组内各个端口的数据信道相对于参考信号的功率比值相同。

20、根据权利要求 18 或者 19 所述的方法，其特征在于，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的多套功率比值，

所述接收用户设备发送的信道状态信息 CSI，包括接收用户设备发送的多套信道状态信息 CSI，其中每一套信道状态信息 CSI 为所述用户设备根据所述多套功率比值中的一套功率比值得到的。

21、根据权利要求 18 至 20 任一项所述方法，其特征在于，所述信道状态

信息 CSI 包括：信道质量指示 CQI，预编码矩阵指示 PMI，或秩指示 RI 其中任意一个或者任意组合。

22、一种通信质量测量方法，其特征在于，所述方法包括:

接收基站发送的参考信号资源配置信息，所述参考信号资源配置信息包括: 参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射关系，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功率比值;

根据所述参考信号端口配置信息和所述功率比值信息，得到所述至少一个端口组内每个天线端口上数据信道相对于参考信号的功率比值，

并根据所述每个天线端口上数据信道相对于参考信号的功率比值，得到信道状态信息 CSI;

向基站发送所述信道状态信息 CSI。

23、根据权利要求 22 所述方法，其特征在于，所述根据所述每个天线端口上数据信道相对于参考信号的功率比值，得到信道状态信息 CSI，包括:

根据所述每个天线端口上的参考信号得到所述每个天线端口对应的信道测量值;

根据所述每个天线端口对应的信道测量值，和所述每个天线端口上数据信道相对于参考信号的功率比值，得到所述每个天线端口上数据信道的信道估计值;

根据所述每个天线端口上数据信道的信道估计值得到信道状态信息 CSI。

24、根据权利要求 23 所述方法，其特征在于，所述根据所述每个天线端口对应的信道测量值，和所述每个天线端口上数据信道相对于参考信号的功率比值，得到所述每个天线端口上数据信道的信道估计值，包括:

根据公式 $\hat{\mathbf{h}}_p = \sqrt{\rho_p}\mathbf{h}_p$ 得到天线端口 p 上数据信道的信道估计值;

其中，p 为所述天线端口的索引，ρ_p 为天线端口 p 上数据信道相对于参考信号的功率比值，$\mathbf{h}_p$ 为天线端口 p 对应的信道测量值，$\hat{\mathbf{h}}_p$ 为天线端口 p 上数据信道的信道估计值。

25、根据权利要求 22 至 24 任一项所述的方法，其特征在于，在所述功率比值信息中，

所述至少一个端口组中的每个端口组内的各天线端口上数据信道相对于参考信号的功率比值相同；

或者，所述至少一个端口组中的一个端口组内的各个端口上的数据信道与其它端口组内各个端口上的数据信道相对于参考信号的功率比值相同。

26、根据权利要求 22 所述的方法，其特征在于，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的多套功率比值；

所述向基站发送所述信道状态信息 CSI，包括：

向基站发送所述多套信道状态信息 CSI，其中每一套信道状态信息 CSI 为根据所述多套功率比值中的一套功率比值得到的。

27、根据权利要求 22 至 26 任一项所述方法，其特征在于，所述信道状态信息 CSI 包括：信道质量指示 CQI，预编码矩阵指示 PMI，或秩指示 RI 其中任意一个或者任意组合。

28、一种网络侧装置，其特征在于，所述网络侧装置包括：确定单元，和第一发送单元；

所述确定单元，用于确定参考信号资源配置信息，所述参考信号资源配置信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系；

所述第一发送单元，用于将所述确定单元确定的所述参考信号资源配置信息发送给用户设备，以使得所述用户设备根据所述参考信号端口配置信息获取信号质量测量信息。

29、根据权利要求 28 所述装置，其特征在于，所述确定单元确定的所述参考信号资源配置信息还包括：至少两个端口组的参考信号功率信息，用于所述用户设备根据所述参考信号端口配置信息并结合所述至少两个端口组的参考信号功率信息，获取所述信号质量测量信息；

其中，所述至少两个端口组的参考信号功率信息，包括：

第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的比值；

或者，第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的差分。

30、根据权利要求 28 或 29 所述装置，其特征在于，当所述信号质量测量信息为参考信号接收功率 RSRP 时，所述第一发送单元还用于向所述用户设备发送滤波器系数信息，用于所述用户设备基于所述滤波器系数信息对所述参考信号接收功率 RSRP 进行滤波并得到路损估计值。

31、根据权利要求 30 所述装置，其特征在于，所述装置还包括：

第一接收单元，用于接收所述用户设备发送的上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率为所述用户设备根据所述路损估计值计算得到的。

32、根据权利要求 28 或者 29 所述装置，其特征在于，所述信号质量测量信息包括：

参考信号接收功率 RSRP，参考信号接收质量 RSRQ，或者参考信号强度指示 RSSI 其中任一项或者任意组合。

33、根据权利要求 28 至 32 任一项所述装置，其特征在于，所述装置还包括：第二接收单元，

所述第二接收单元用于接收用户设备发送的所述信号质量测量信息。

34、一种用户设备，其特征在于，所述用户设备包括：第三接收单元，第一获取单元，和第二获取单元；

所述第三接收单元，用于接收基站发送的参考信号资源配置信息，所述参考信号资源配置信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系；

所述第一获取单元，用于根据所述第三接收单元接收的所述参考信号端口配置信息，得到至少一个端口组中的参考信号端口信息；

所述第二获取单元，用于根据所述第一获取单元得到所述至少一个端口组中的参考信号端口信息获取信号质量测量信息。

35、根据权利要求 34 所述用户设备，其特征在于，所述第一获取单元，具体用于根据所述第三接收单元接收的所述参考信号端口配置信息，得到指定的一个端口组中的参考信号端口信息；

所述第二获取单元，具体用于根据所述第一获取单元得到的所述指定的一个端口组中的参考信号端口信息获取所述信号质量测量信息。

36、根据权利要求 35 所述用户设备，其特征在于，当所述信号质量测量信息为参考信号接收功率 RSRP 时，所述第二获取单元具体用于：

根据公式：$RSRP(r,p)=\frac{1}{K_s-1}\sum_{m=0}^{K_s-1}\hat{h}_p(m)\cdot\hat{h}_p(m+1)$ 得到第 r 个接收天线第 p 个端口的参考信号接收功率 $RSRP(r,p)$ 并通过组合 $RSRP(r,p)$ 得到所述 RSRP；其中，$\hat{h}_p(m)$ 为标号为 m 的参考信号 RE 上的信道估计；K_s 是在测量带宽内可利用的参考信号 RE 的样本总数；p 为所述指定的一个端口组中参考信号端口号，r 为接收天线的索引。

37、根据权利要求 34 所述用户设备，其特征在于，所述第三接收单元接收的所述参考信号资源配置信息还包括：至少两个端口组的参考信号功率信息，

所述第二获取单元还用于根据所述参考信号端口配置信息并结合所述至少两个端口组的参考信号功率信息获取所述信号质量测量信息。

38、根据权利要求 37 所述用户设备，其特征在于，所述第二获取单元具体用于：

根据所述参考信号端口配置信息得到所述至少两个端口组对应的信号质量测量信息；

根据所述至少两个端口组的参考信号功率信息，对所得到的至少两个端口组对应的信号质量测量信息按端口组功率进行加权平均，得到所述信号质量测量信息。

39、根据权利要求 38 所述用户设备，其特征在于，所述第二获取单元根据所述至少两个端口组的参考信号功率信息，对所得到的至少两个端口组对应的信号质量测量信息按端口组功率进行加权平均，得到所述信号质量测量信息，包括：

根据公式：$SQ=\left(\sum_{g=0}^{n-1}p_g\cdot SQ_g\right)\Big/\left(\sum_{g=0}^{n-1}p_g\right)$，得到信号质量测量信息，

其中，SQ_g为指定端口组的信号质量测量信息，其中，g 为指定端口组的编号，n 为指定端口组的个数，$n \geq 2$；p_g为指定端口组的参考信号功率，其中，指定端口组的参考信号功率根据所述至少两个端口组的参考信号功率信息得到。

40、根据权利要求 37 至 39 任一项所述用户设备，其特征在于，所述第三接收单元接收到的所述至少两个端口组的参考信号功率信息包括：

第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的比值；

或者，第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的差分。

41、根据权利要求 34 至 40 任一项所述用户设备，其特征在于，所述用户设备还包括：第二发送单元，用于向基站发送所述信号质量测量信息。

42、根据权利要求 34 至 41 任一项所述用户设备，其特征在于，

所述第三接收单元，还用于当所述信号质量测量信息为参考信号接收功率 RSRP，接收基站发送的滤波器系数信息；

所述用户设备还包括：第三获取单元，

所述第三获取单元，用于基于所述第三接收单元接收的所述滤波器系数信息对所述参考信号接收功率 RSRP 进行滤波，并得到路损估计值。

43、根据权利要求 42 所述用户设备，其特征在于，所述用于装置还包括：第三发送单元，

所述第三发送单元，还用于向基站发送上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率根据所述路损估计值计算得到。

44、根据权利要求 42 所述用户设备，其特征在于，所述信号质量测量信息，包括：参考信号接收功率 RSRP，参考信号强度指示 RSSI，或者参考信号接收质量 RSRQ。

45、一种网络侧装置，其特征在于，所述装置包括：第四发送单元，第四接收单元；

所述第四发送单元，用于向用户设备发送参考信号资源配置信息，所述参

考信号资源配置信息包括：参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射关系，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功率比值；

所述第四接收单元，用于接收用户设备发送的信道状态信息 CSI，其中，所述 CSI 为所述用户设备根据所述参考信号端口配置信息和所述功率比值信息得到。

46、根据权利要求 45 所述装置，其特征在于，在所述功率比值信息中：

所述至少一个端口组中的每个端口组内的各天线端口上数据信道相对于参考信号的功率比值都相同；

或者，所述至少一个端口组中的一个端口组内各个端口上的数据信道与其它端口组内各个端口的数据信道相对于参考信号的功率比值相同。

47、根据权利要求 45 或 46 所述装置，其特征在于，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的多套功率比值，

所述第四接收单元，具体用于接收用户设备发送的多套信道状态信息 CSI，其中每一套信道状态信息 CSI 为所述用户设备根据所述多套功率比值中的一套功率比值得到的。

48、根据权利要求 45 或 47 所述装置，其特征在于，所述第四接收单元接收的所述信道状态信息 CSI 包括：信道质量指示 CQI，预编码矩阵指示 PMI，或秩指示 RI 其中任意一个或者任意组合。

49、一种用户设备，其特征在于，所述用户设备包括：第五接收单元，第四获取单元，第五获取单元，和第五发送单元；

所述第五接收单元，用于接收基站发送的参考信号资源配置信息，所述参考信号资源配置信息包括：参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射关系，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功率比值；

所述第四获取单元，用于根据所述第五接收单元接收的所述参考信号端口配置信息和所述功率比值信息，得到所述至少一个端口组内每个天线端口上数

据信道相对于参考信号的功率比值;

所述第五获取单元，用于根据所述第四获取单元得到的所述每个天线端口上数据信道相对于参考信号的功率比值，得到信道状态信息 CSI;

所述第五发送单元，用于向基站发送所述第五获取单元得到的所述信道状态信息 CSI。

50、根据权利要求 49 所述用户设备，其特征在于，所述第五获取单元，具体用于:

根据所述每个天线端口上的参考信号得到所述每个天线端口对应的信道测量值;

根据所述每个天线端口对应的信道测量值，和所述每个天线端口上数据信道相对于参考信号的功率比值，得到所述每个天线端口上数据信道的信道估计值;

根据所述每个天线端口上数据信道的信道估计值得到信道状态信息 CSI。

51、根据权利要求 50 所述用户设备，其特征在于，所述第五获取单元根据所述每个天线端口对应的信道测量值，和所述每个天线端口上数据信道相对于参考信号的功率比值，得到所述每个天线端口上数据信道的信道估计值，包括:

根据公式 $\hat{\mathbf{h}}_p = \sqrt{\rho_p}\mathbf{h}_p$ 得到天线端口 p 上数据信道的信道估计值;

其中，p 为所述天线端口的索引，ρ_p 为天线端口 p 上数据信道相对于参考信号的功率比值，$\mathbf{h}_p$ 为天线端口 p 对应的信道测量值，$\hat{\mathbf{h}}_p$ 为天线端口 p 上数据信道的信道估计值。

52、根据权利要求 49 至 51 任一项所述用户设备，其特在于，在所述功率比值信息中，

所述至少一个端口组中的每个端口组内的各天线端口上数据信道相对于参考信号的功率比值相同;

或者，所述至少一个端口组中的一个端口组内的各个端口上的数据信道与其它端口组内各个端口上的数据信道相对于参考信号的功率比值相同。

53、根据权利要求 49 所述用户设备，其特在于，所述第五接收单元接收的所述参考信号资源配置信息包括: 参考信号端口配置信息和功率比值信息;

其中，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的多套功率比值；

所述第五发送单元，具体用于：

向基站发送所述多套信道状态信息 CSI，其中每一套信道状态信息 CSI 为根据所述多套功率比值中的一套功率比值得到的。

54、根据权利要求 49 至 53 任一项所述用户设备，所述第五获取单元得到的所述信道状态信息 CSI 包括：信道质量指示 CQI，预编码矩阵指示 PMI，或秩指示 RI 其中任意一个或者任意组合。

55、一种网络侧装置，其特征在于，所述网络侧装置包括：接收器、处理器和发射器；其中，

所述处理器，用于确定参考信号资源配置信息，所述参考信号资源配置信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系；

所述发射器，用于将所述参考信号资源配置信息发送给用户设备，以使得所述用户设备根据所述参考信号端口配置信息获取信号质量测量信息。

56、根据权利要求 55 所述网络侧装置，其特征在于，所述处理器确定的所述参考信号资源配置信息还包括：至少两个端口组的参考信号功率信息，用于所述用户设备根据所述参考信号端口配置信息并结合所述至少两个端口组的参考信号功率信息，获取所述信号质量测量信息；

其中，所述至少两个端口组的参考信号功率信息，包括：

第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的比值；

或者，第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的差分。

57、根据权利要求 55 或 56 所述网络侧装置，其特征在于，当所述信号质量测量信息为参考信号接收功率 RSRP 时，所述发射器还用于向所述用户设备发送滤波器系数信息，用于所述用户设备基于所述滤波器系数信息对所述参考信号接收功率 RSRP 进行滤波并得到路损估计值。

58、根据权利要求 57 所述网络侧装置，其特征在于，所述接收器用于接

收所述用户设备发送的上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率为所述用户设备根据所述路损估计值计算得到的。

59、根据权利要求 55 或 56 所述网络侧装置，其特征在于，所述信号质量测量信息包括:

参考信号接收功率 RSRP，参考信号接收质量 RSRQ，或者参考信号强度指示 RSSI 其中任一项或者任意组合。

60、根据权利要求 55 或 59 所述网络侧装置，其特征在于，所述接收器还用于接收用户设备发送的所述信号质量测量信息。

61、一种用户设备，其特征在于，所述用户设备包括: 接收器，处理器和发射器;

所述接收器，用于接收基站发送的参考信号资源配置信息，所述参考信号资源配置信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系;

所述处理器，用于根据所述参考信号端口配置信息，得到至少一个端口组中的参考信号端口信息; 根据所述至少一个端口组中的参考信号端口信息获取信号质量测量信息。

62、根据权利要求 60 所述用户设备，其特征在于，所述处理器，具体用于:

根据所述参考信号端口配置信息，得到指定的一个端口组中的参考信号端口信息;

根据所述指定的一个端口组中的参考信号端口信息获取所述信号质量测量信息。

63、根据权利要求 62 所述用户设备，其特征在于，当所述信号质量测量信息为参考信号接收功率 RSRP 时，所述处理器根据所述指定的一个端口组中的参考信号端口信息获取所述信号质量测量信息，包括:

根据公式: $RSRP(r,p)=\frac{1}{K_s-1}\sum_{m=0}^{K_s-1}\hat{h}_p(m)\cdot\hat{h}_p(m+1)$ 得到第 r 个接收天线第 p 个端口的参考信号接收功率 $RSRP(r,p)$ 并通过组合 $RSRP(r,p)$ 得到所述 RSRP; 其中，$\hat{h}_p(m)$

为标号为 m 的参考信号 RE 上的信道估计；K_s是在测量带宽内可利用的参考信号 RE 的样本总数；p 为所述指定的一个端口组中参考信号端口号，r 为接收天线的索引。

64、根据权利要求 60 所述用户设备，其特征在于，所述接收器接收的所述参考信号资源配置信息还包括：至少两个端口组的参考信号功率信息，用于所述用户设备根据所述参考信号端口配置信息并结合所述至少两个端口组的参考信号功率信息获取所述信号质量测量信息。

65、根据权利要求 64 所述用户设备，其特征在于，所述处理器根据所述参考信号端口配置信息并结合至少两个端口组的参考信号功率信息获取信号质量测量信息，包括：

根据所述参考信号端口配置信息得到所述至少两个端口组对应的信号质量测量信息；

根据所述至少两个端口组的参考信号功率信息，对所得到的至少两个端口组对应的信号质量测量信息按端口组功率进行加权平均，得到所述信号质量测量信息。

66、根据权利要求 65 所述用户设备，其特征在于，所述处理器根据所述至少两个端口组的参考信号功率信息，对所得到的至少两个端口组对应的信号质量测量信息按端口组功率进行加权平均，得到信号质量测量信息，包括：

根据公式：$SQ=\left(\sum_{g=0}^{n-1}p_g\cdot SQ_g\right)\Big/\left(\sum_{g=0}^{n-1}p_g\right)$，得到信号质量测量信息，

其中，SQ_g为指定端口组的信号质量测量信息，其中，g 为指定端口组的编号，n 为指定端口组的个数，$n\geq 2$；p_g为指定端口组的参考信号功率，其中，指定端口组的参考信号功率根据所述至少两个端口组的参考信号功率信息得到。

67、根据权利要求 61 至 66 任一项所述用户设备，其特征在于，所述接收器接收到的所述至少两个端口组的参考信号功率信息，包括：

第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的比值；

或者，第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的差分。

68、根据权利要求 61 至 67 任一项所述用户设备，其特征在于，所述发射器用于向基站发送所述信号质量测量信息。

69、根据权利要求 61 至 68 任一项所述用户设备，其特征在于，当所述信号质量测量信息为参考信号接收功率 RSRP 时，所述接收器还用于接收基站发送的滤波器系数信息；

所述处理器，还用于基于所述滤波器系数信息对所述参考信号接收功率 RSRP 进行滤波，并得到路损估计值。

70、根据权利要求 69 所述用户设备，其特征在于，所述发射器还用于向基站发送上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率根据所述路损估计值计算得到。

71、根据权利要求 61 所述用户设备，其特征在于，所述信号质量测量信息，包括：参考信号接收功率 RSRP，参考信号强度指示 RSSI，或者参考信号接收质量 RSRQ。

72、一种网络侧装置，其特征在于，所述网络侧装置包括：发射器，和接收器，

所述发射器，用于向用户设备发送参考信号资源配置信息，所述参考信号资源配置信息包括：参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射关系，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功率比值；

所述接收器，用于接收用户设备发送的信道状态信息 CSI，其中，所述 CSI 为所述用户设备根据所述参考信号端口配置信息和所述功率比值信息得到。

73、根据权利要求 72 所述网络侧装置，其特征在于，在所述功率比值信息中：

所述至少一个端口组中的每个端口组内的各天线端口上数据信道相对于参考信号的功率比值都相同；

或者，所述至少一个端口组中的一个端口组内各个端口上的数据信道与其

它端口组内各个端口的数据信道相对于参考信号的功率比值相同。

74、根据权利要求 72 或 73 所述网络侧装置，其特征在于，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的多套功率比值；

所述接收器接收用户设备发送的信道状态信息 CSI，包括：接收用户设备发送的多套信道状态信息 CSI，其中每一套信道状态信息 CSI 为所述用户设备根据所述多套功率比值中的一套功率比值得到的。

75、根据权利要求 72 至 74 任一项所述网络侧装置，其特征在于，所述接收器接收的所述信道状态信息 CSI 包括：信道质量指示 CQI，预编码矩阵指示 PMI，或秩指示 RI 其中任意一个或者任意组合。

76、一种用户设备，其特征在于，所述用户设备包括：接收器，处理器，和发射器；

所述接收器，用于接收基站发送的参考信号资源配置信息，所述参考信号资源配置信息包括：参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射关系，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功率比值；

所述处理器，用于根据所述参考信号端口配置信息和所述功率比值信息，得到所述至少一个端口组内每个天线端口上数据信道相对于参考信号的功率比值，并根据所述每个天线端口上数据信道相对于参考信号的功率比值，得到信道状态信息 CSI；

所述发射器，用于向基站发送所述信道状态信息 CSI。

77、根据权利要求 76 所述用户设备，其特征在于，所述处理器根据所述每个天线端口上数据信道相对于参考信号的功率比值，得到信道状态信息 CSI，包括：

根据所述每个天线端口上的参考信号得到所述每个天线端口对应的信道测量值；

根据所述每个天线端口对应的信道测量值，和所述每个天线端口上数据信道相对于参考信号的功率比值，得到所述每个天线端口上数据信道的信道估计值；

根据所述每个天线端口上数据信道的信道估计值得到信道状态信息 CSI。

78、根据权利要求 77 所述用户设备，其特征在于，所述处理器根据所述每个天线端口对应的信道测量值，和所述每个天线端口上数据信道相对于参考信号的功率比值，得到所述每个天线端口上数据信道的信道估计值，包括：

根据公式 $\hat{\mathbf{h}}_p = \sqrt{\rho_p}\mathbf{h}_p$ 得到天线端口 p 上数据信道的信道估计值；

其中，p 为所述天线端口的索引，ρ_p 为天线端口 p 上数据信道相对于参考信号的功率比值，$\mathbf{h}_p$ 为天线端口 p 对应的信道测量值，$\hat{\mathbf{h}}_p$ 为天线端口 p 上数据信道的信道估计值。

79、根据权利要求 76 至 78 任一项所述用户设备，其特征在于，在所述功率比值信息中，

所述至少一个端口组中的每个端口组内的各天线端口上数据信道相对于参考信号的功率比值相同；

或者，所述至少一个端口组中的一个端口组内的各个端口上的数据信道与其它端口组内各个端口上的数据信道相对于参考信号的功率比值相同。

80、根据权利要求 76 所述用户设备，其特征在于，所述所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的多套功率比值；

所述发射器具体用于：

向所述基站发送所述多套信道状态信息 CSI，其中每一套信道状态信息 CSI 为根据所述多套功率比值中的一套功率比值得到的。

81、根据权利要求 76 至 80 任一项所述用户设备，其特征在于，所述处理器得到的所述信道状态信息 CSI 包括：信道质量指示 CQI，预编码矩阵指示 PMI，或秩指示 RI 其中任意一个或者任意组合。

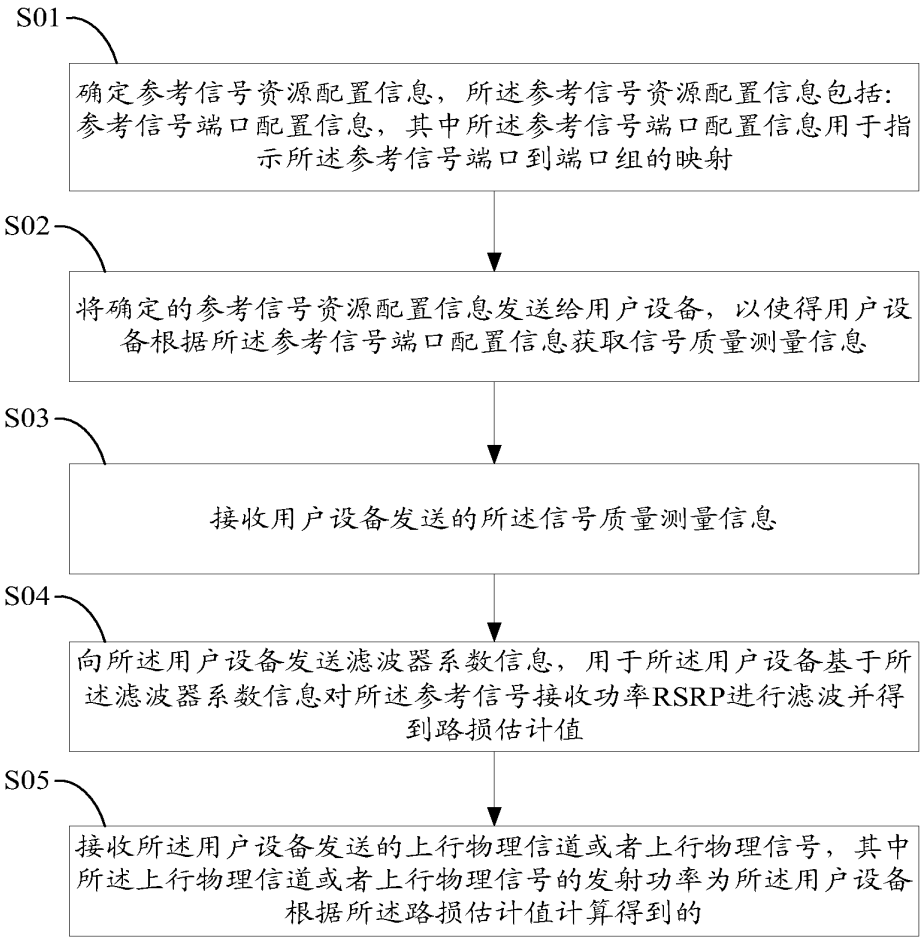

S01
确定参考信号资源配置信息，所述参考信号资源配置信息包括：参考信号端口配置信息，其中所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射
S02
将确定的参考信号资源配置信息发送给用户设备，以使得用户设备根据所述参考信号端口配置信息获取信号质量测量信息
S03
接收用户设备发送的所述信号质量测量信息
S04
向所述用户设备发送滤波器系数信息，用于所述用户设备基于所述滤波器系数信息对所述参考信号接收功率RSRP进行滤波并得到路损估计值
S05
接收所述用户设备发送的上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率为所述用户设备根据所述路损估计值计算得到的

图 1

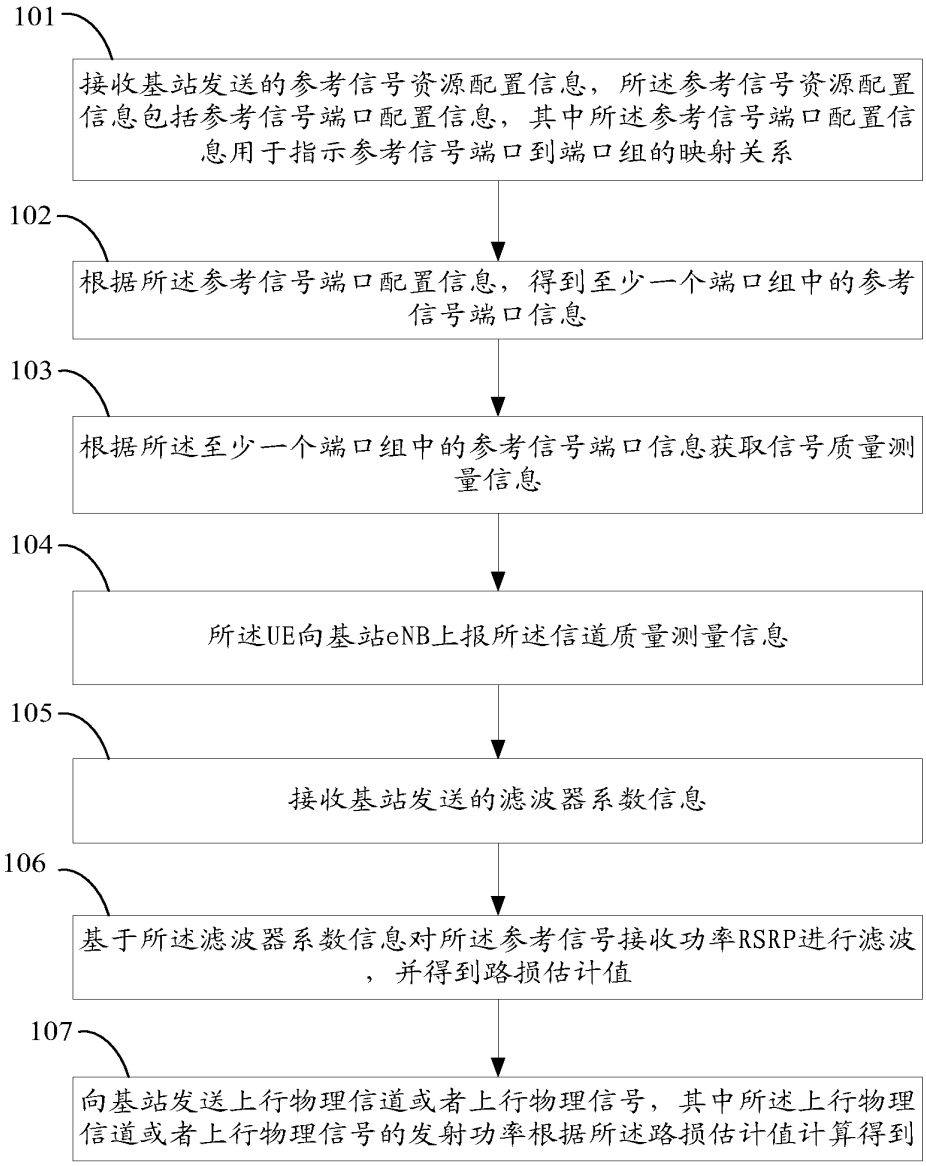

101
接收基站发送的参考信号资源配置信息，所述参考信号资源配置信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系
102
根据所述参考信号端口配置信息，得到至少一个端口组中的参考信号端口信息
103
根据所述至少一个端口组中的参考信号端口信息获取信号质量测量信息
104
所述UE向基站eNB上报所述信道质量测量信息
105
接收基站发送的滤波器系数信息
106
基于所述滤波器系数信息对所述参考信号接收功率RSRP进行滤波，并得到路损估计值
107
向基站发送上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率根据所述路损估计值计算得到

图 2

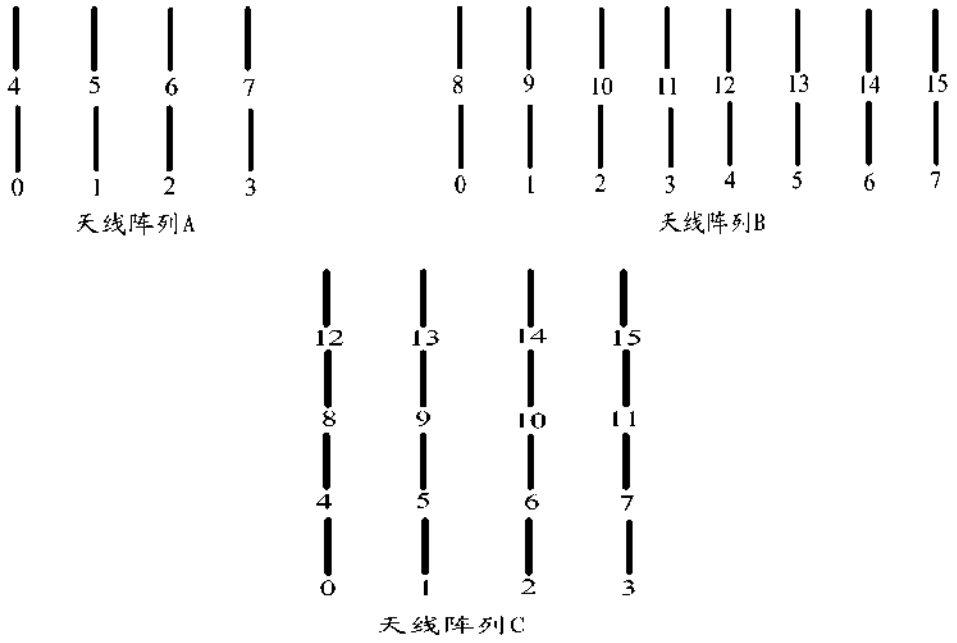

4 5 6 7
0 1 2 3
天线阵列A
8 9 10 11 12 13 14 15
0 1 2 3 4 5 6 7
天线阵列B
12 13 14 15
8 9 10 11
4 5 6 7
0 1 2 3
天线阵列C

图 3

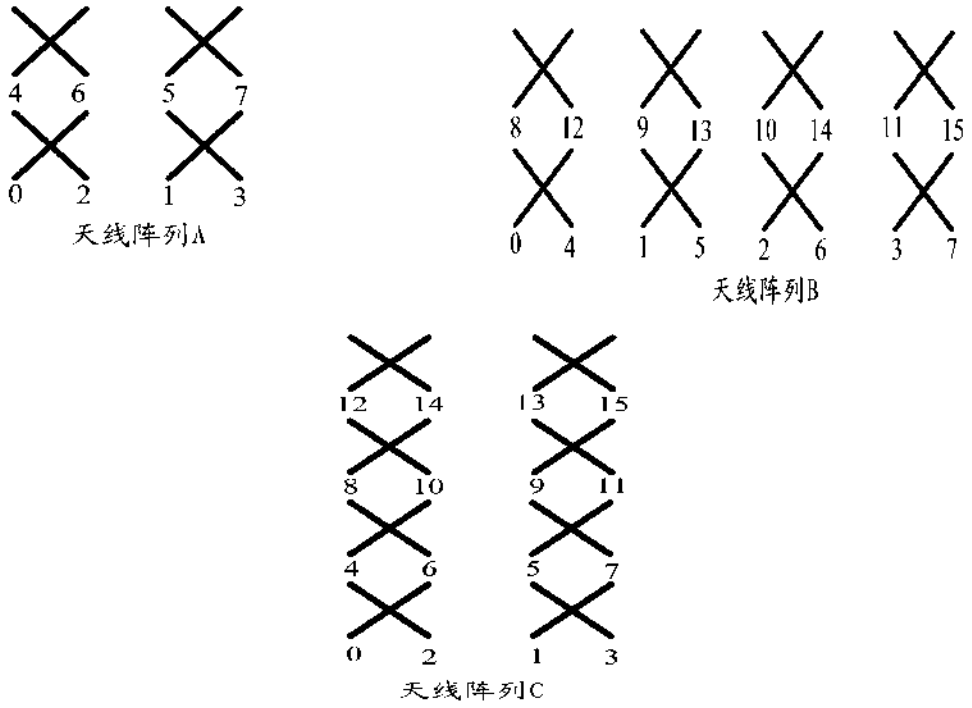

4 6 5 7
0 2 1 3
天线阵列A
8 12 9 13 10 14 11 15
0 4 1 5 2 6 3 7
天线阵列B
12 14 13 15
8 10 9 11
4 6 5 7
0 2 1 3
天线阵列C

图 4

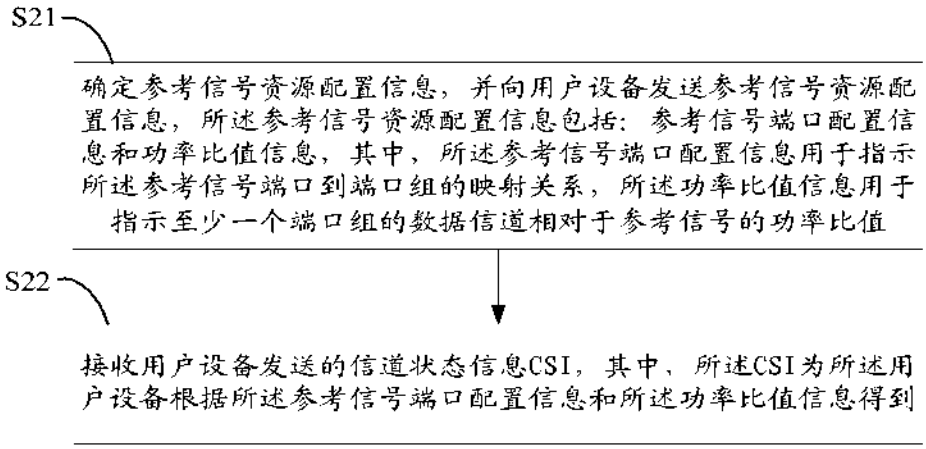

S21
确定参考信号资源配置信息，并向用户设备发送参考信号资源配置信息，所述参考信号资源配置信息包括：参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射关系，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功率比值
S22
接收用户设备发送的信道状态信息CSI，其中，所述CSI为所述用户设备根据所述参考信号端口配置信息和所述功率比值信息得到

图 5

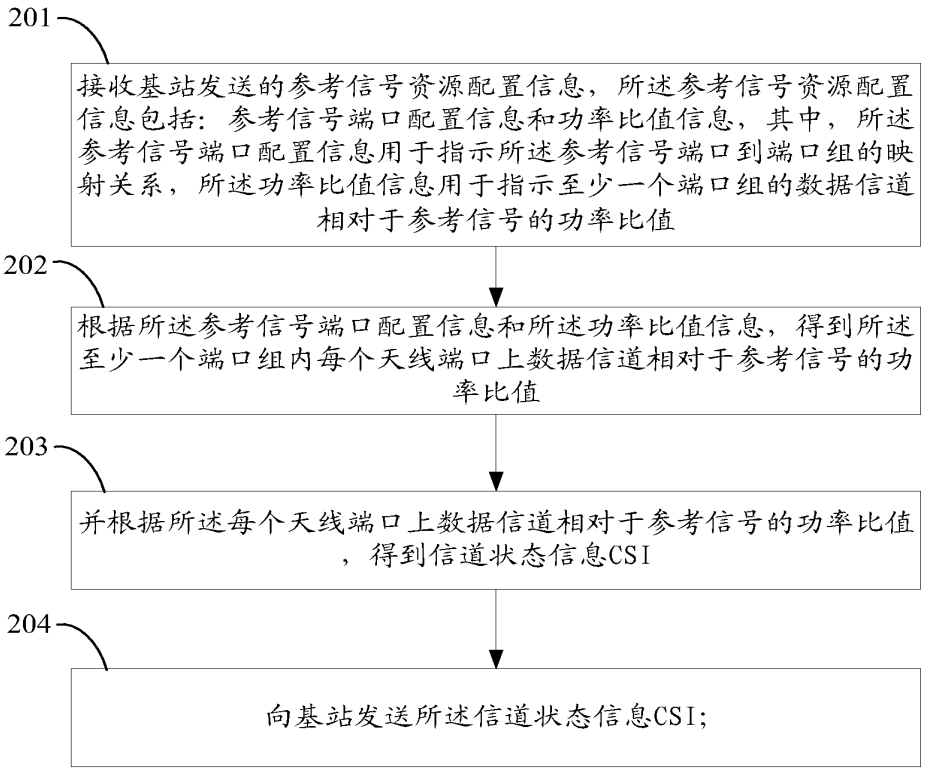

201
接收基站发送的参考信号资源配置信息，所述参考信号资源配置信息包括：参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射关系，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功率比值
202
根据所述参考信号端口配置信息和所述功率比值信息，得到所述至少一个端口组内每个天线端口上数据信道相对于参考信号的功率比值
203
并根据所述每个天线端口上数据信道相对于参考信号的功率比值，得到信道状态信息CSI
204
向基站发送所述信道状态信息CSI;

图 6

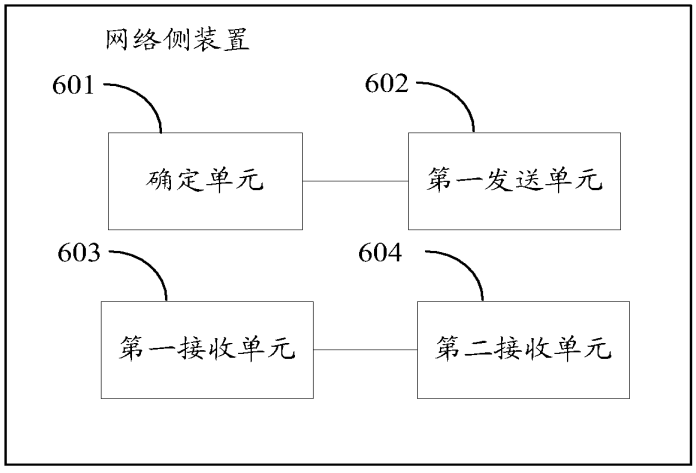

网络侧装置
601
确定单元
602
第一发送单元
603
第一接收单元
604
第二接收单元

图 7

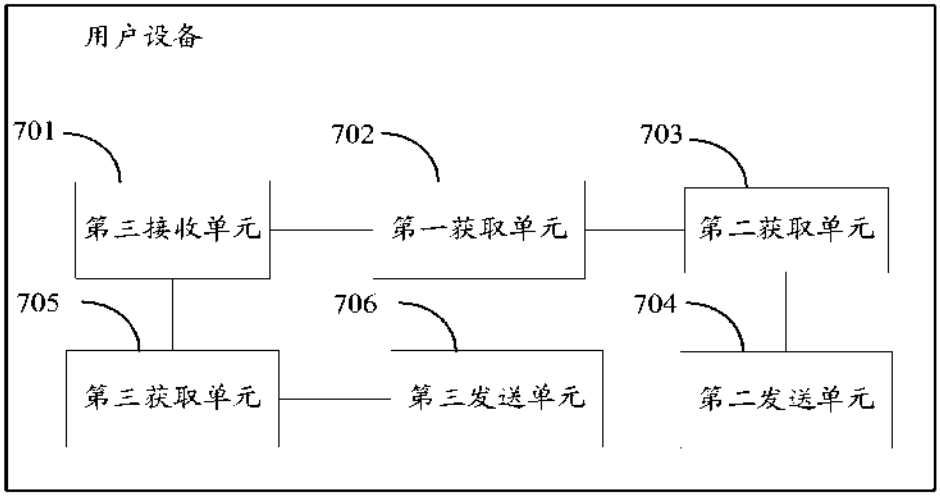

用户设备
701
702
703
第三接收单元
第一获取单元
第二获取单元
705
706
704
第三获取单元
第三发送单元
第二发送单元

图 8

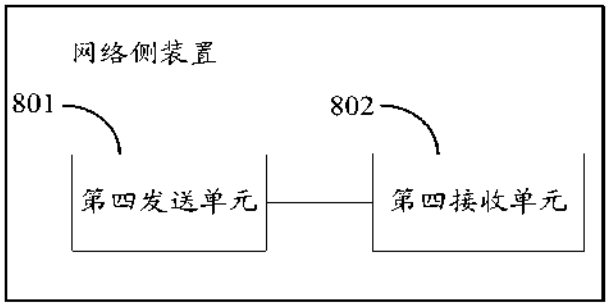

网络侧装置
801
802
第四发送单元
第四接收单元

图 9

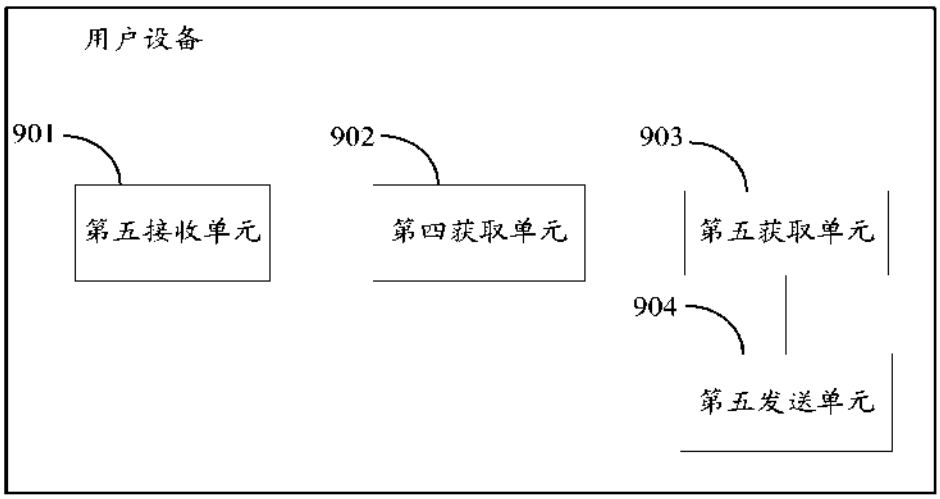

用户设备
901
第五接收单元
902
第四获取单元
903
第五获取单元
904
第五发送单元

图 10

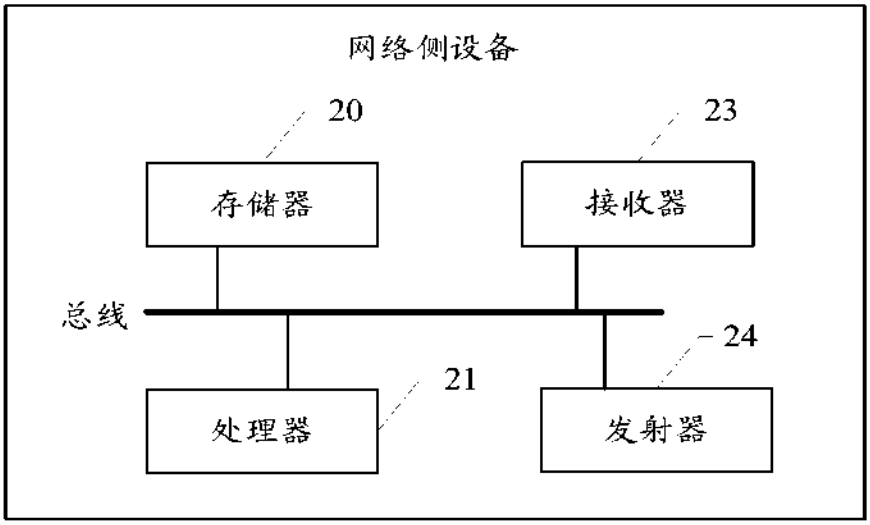

网络侧设备
20
存储器
23
接收器
总线
24
21
处理器
发射器

图 11

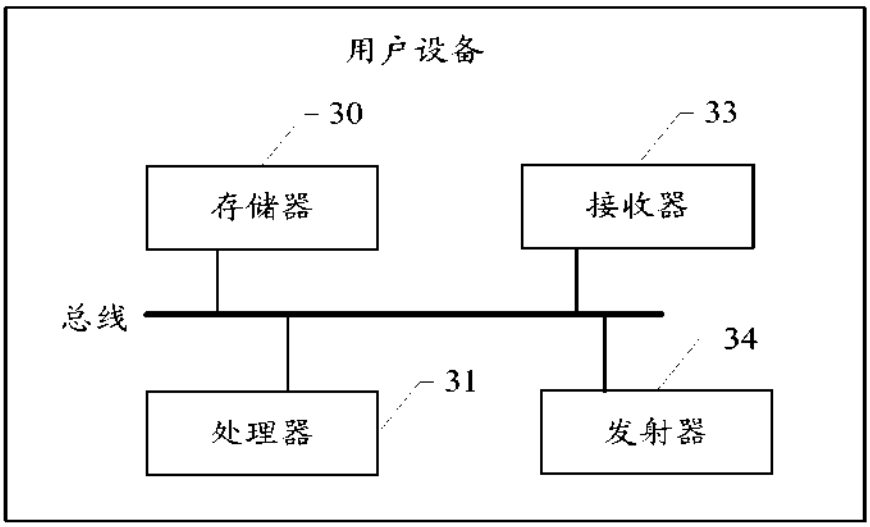

用户设备
30
33
存储器
接收器
总线
34
31
处理器
发射器

图 12

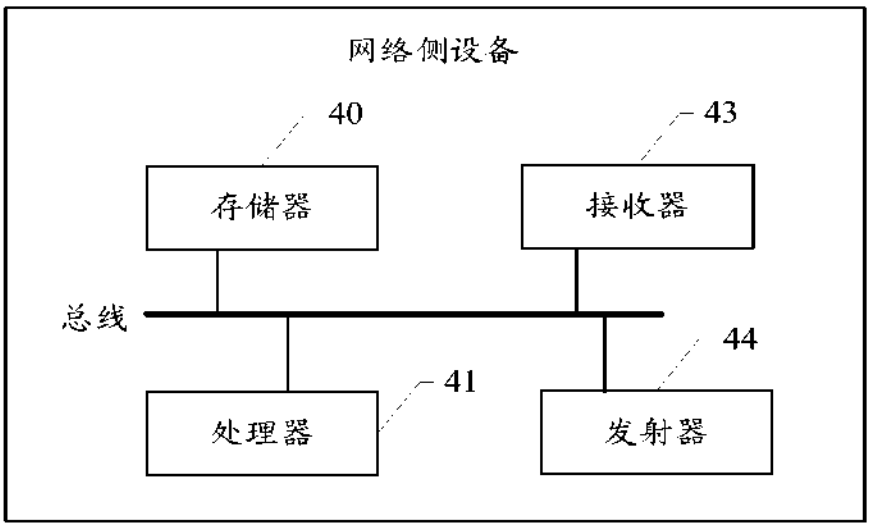

网络侧设备
40
43
存储器
接收器
总线
44
41
处理器
发射器

图 13

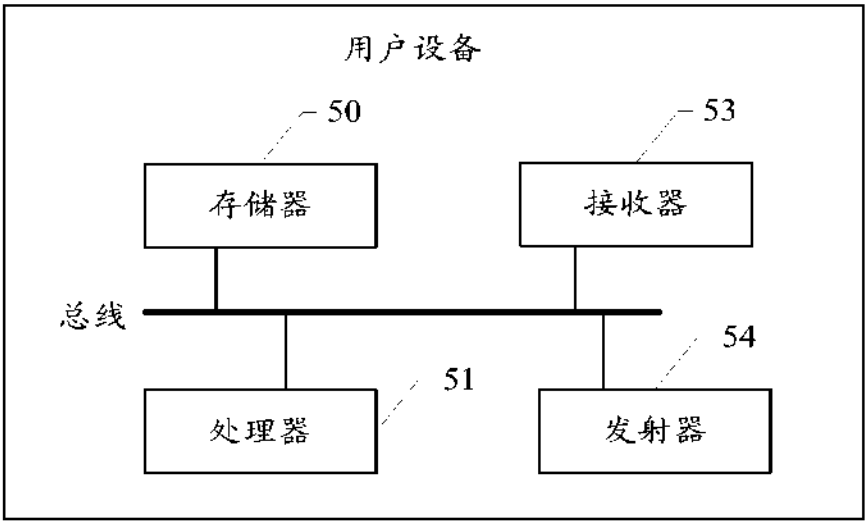


图 14

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2013/077477

A. CLASSIFICATION OF SUBJECT MATTER

H04W 24/00 (2009.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: H04W, H04L, H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNABS, CPRSABS, CNTXT, VEN, CNKI: RS, CSR, DMRS, CSI-RS, port, port group, map, CSI, channel quality, communication quality, pre-coding matrix indication, rank indication, pre-coding type indication, CQI, PMI, RI, PTI, power ratio, psrp, rsrq, rssi, reference signal received power, reference signal received quality, reference signal strength indicator; reference w signal, antenna w port, channel w state w information, channel w quality w indicator, channel w quality w index, power

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 102687438 A (LG ELECTRONICS INC.), 19 September 2012 (19.09.2012), claims 1, description, paragraphs 101-142	1, 3-9, 14, 28, 30-36, 41, 55, 57-63, 68
Y		2, 10-13, 15-27, 29, 37-40, 42-54, 56, 64-67, 69-81
Y	CN 102255689 A (ZTE CORP.), 23 November 2011 (23.11.2011), description, paragraphs 80-85 and 182	2, 10-13, 15-27, 29, 37-40, 42-54, 56, 64-67, 69-81

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 February 2014 (26.02.2014)	**13 March 2014 (13.03.2014)**
Name and mailing address of the ISA/CN: State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No.: (86-10) 62019451	Authorized officer **LIU, Jia** Telephone No.: (86-10) **62412046**

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2013/077477

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 102958147 A (HUAWEI TECHNOLOGIES CO., LTD.), 06 March 2013 (06.03.2013), the whole document	1-81
A	CN 102378114 A (CHINA MOBILE COMMUNICATIONS CORPORATION), 14 March 2012 (14.03.2012), the whole document	1-81

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2013/077477

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 102687438 A	19.09.2012	WO 2011087272 A2	21.07.2011
		AU 2011205920 A1	31.05.2012
		US 2012230290 A1	13.09.2012
		KR 20120127391 A	12.11.2012
		AU 2011205920 A2	20.12.2012
		WO 2011087272 A3	01.12.2011
		CA 2784034 A1	21.07.2011
		JP 2013517662 A	16.05.2013
		EP 2526639 A2	28.11.2012
CN 102255689 A	23.11.2011	WO 2013007088 A1	17.01.2013
CN 102958147 A	06.03.2013	WO 2013023551 A1	21.02.2013
CN 102378114 A	14.03.2012	None	

Form PCT/ISA/210 (patent family annex) (July 2009)

国际检索报告

国际申请号
PCT/CN2013/077477

A. 主题的分类

H04W 24/00 (2009.01) i

按照国际专利分类(IPC)或者同时按照国家分类和 IPC 两种分类

B. 检索领域

检索的最低限度文献(标明分类系统和分类号)

IPC: H04W, H04L, H04Q

包含在检索领域中的除最低限度文献以外的检索文献

在国际检索时查阅的电子数据库(数据库的名称，和使用的检索词（如使用）)

CNABS, CPRSABS, CNTXT, VEN, CNKI：参考信号，RS，CSR，DMRS，CSI-RS，端口，端口组，映射，CSI，信道状态信息，信道质量，通信质量，信道质量指示，预编码矩阵指示，秩指示、预编码类型指示，CQI，PMI，RI，PTI，功率比，psrp，rsrq，rssi，参考信号接收功率，参考信号接收质量，参考信号强度指示；reference w signal, antenna w port, channel w state w information, channel w quality w indicator, channel w quality w index, power

C. 相关文件

类　型*	引用文件，必要时，指明相关段落	相关的权利要求
X	CN 102687438 A (LG 电子株式会社) 19.9 月 2012(19.09.2012) 权利要求 1，说明书第 101 142 段	1、3-9、14、28、30-36、41、55、57-63、68
Y		2、10-13、15-27、29、37-40、42-54、56、64-67、69-81
Y	CN 102255689 A (中兴通讯股份有限公司) 23.11 月 2011(23.11.2011) 说明书第 80 85 段、第 182 段	2、10-13、15-27、29、37-40、42-54、56、64-67、69-81

☒ 其余文件在 C 栏的续页中列出。　　☒ 见同族专利附件。

* 引用文件的具体类型：

"A" 认为不特别相关的表示了现有技术一般状态的文件

"E" 在国际申请日的当天或之后公布的在先申请或专利

"L" 可能对优先权要求构成怀疑的文件，或为确定另一篇引用文件的公布日而引用的或者因其他特殊理由而引用的文件（如具体说明的）

"O" 涉及口头公开、使用、展览或其他方式公开的文件

"P" 公布日先于国际申请日但迟于所要求的优先权日的文件

"T" 在申请日或优先权日之后公布，与申请不相抵触，但为了理解发明之理论或原理的在后文件

"X" 特别相关的文件，单独考虑该文件，认定要求保护的发明不是新颖的或不具有创造性

"Y" 特别相关的文件，当该文件与另一篇或者多篇该类文件结合并且这种结合对于本领域技术人员为显而易见时，要求保护的发明不具有创造性

"&" 同族专利的文件

国际检索实际完成的日期	国际检索报告邮寄日期
26.2 月 2014（26.02.2014）	**13.3 月 2014 (13.03.2014)**
ISA/CN 的名称和邮寄地址： 中华人民共和国国家知识产权局 中国北京市海淀区蓟门桥西土城路 6 号 100088 传真号：　(86-10)62019451	受权官员 刘佳 电话号码：(86-10) **62412046**

PCT/ISA/210 表(第 2 页) (2009 年 7 月)

国际检索报告

国际申请号
PCT/CN2013/077477

C(续). 相关文件

类 型	引用文件，必要时，指明相关段落	相关的权利要求
A	CN 102958147 A (华为技术有限公司) 06.3 月 2013(06.03.2013) 全文	1 81
A	CN 102378114 A (中国移动通信集团公司) 14.3 月 2012(14.03.2012) 全文	1 81

国际检索报告
关于同族专利的信息

国际申请号
PCT/CN2013/077477

检索报告中引用的专利文件	公布日期	同族专利	公布日期
CN 102687438 A	19.09.2012	WO 2011087272 A2	21.07.2011
		AU 2011205920 A1	31.05.2012
		US 2012230290 A1	13.09.2012
		KR 20120127391 A	12.11.2012
		AU 2011205920 A2	20.12.2012
		WO 2011087272 A3	01.12.2011
		CA 2784034 A1	21.07.2011
		JP 2013517662 A	16.05.2013
		EP 2526639 A2	28.11.2012
CN 102255689 A	23.11.2011	WO 2013007088 A1	17.01.2013
CN 102958147 A	06.03.2013	WO 2013023551 A1	21.02.2013
CN 102378114 A	14.03.2012	无	

(12) 특허협력조약에 의하여 공개된 국제출원

(19) 세계지식재산권기구
국제사무국

(43) 국제공개일
2016 년 8 월 4 일 (04.08.2016)

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(10) 국제공개번호
WO 2016/122257 A1

(51) 국제특허분류:
H04L 5/00 (2006.01) *H04B 7/02* (2006.01)
H04B 7/06 (2006.01)

(21) 국제출원번호: PCT/KR2016/001014

(22) 국제출원일: 2016 년 1 월 29 일 (29.01.2016)

(25) 출원언어: 한국어

(26) 공개언어: 한국어

(30) 우선권정보:
10-2015-0015603 2015 년 1 월 30 일 (30.01.2015) KR
10-2015-0018919 2015 년 2 월 6 일 (06.02.2015) KR
10-2015-0051184 2015 년 4 월 10 일 (10.04.2015) KR
10-2015-0064053 2015 년 5 월 7 일 (07.05.2015) KR
10-2015-0091400 2015 년 6 월 26 일 (26.06.2015) KR
10-2015-0105272 2015 년 7 월 24 일 (24.07.2015) KR
10-2015-0114925 2015 년 8 월 13 일 (13.08.2015) KR
10-2015-0114927 2015 년 8 월 13 일 (13.08.2015) KR
10-2016-0000596 2016 년 1 월 4 일 (04.01.2016) KR
10-2016-0004344 2016 년 1 월 13 일 (13.01.2016) KR
10-2016-0011000 2016 년 1 월 28 일 (28.01.2016) KR

(71) 출원인: 한국전자통신연구원 (ELECTRONICS AND TELECOMMUNICATIONS RESEARCH INSTITUTE) [KR/KR]; 34129 대전시 유성구 가정로 218, Daejeon (KR).

(72) 발명자: 문성현 (MOON, Sung-Hyun); 35201 대전시 서구 만년로 45, 103 동 709 호, Daejeon (KR). 김철순 (KIM, Cheulsoon); 34129 대전시 유성구 가정로 218, Daejeon (KR). 신우람 (SHIN, Wooram); 34127 대전시 유성구 죽동로 251, 307 동 1802 호, Daejeon (KR). 박기윤 (PARK, Gi Yoon); 34071 대전시 유성구 지족로 317, 106 동 1601 호, Daejeon (KR). 고영조 (KO, Young Jo); 35213 대전시 서구 청사서로 70, 102 동 706 호, Daejeon (KR). 남준영 (NAM, Junyoung); 34061 대전시 유성구 송림로 13, 106 동 1102 호, Daejeon (KR).

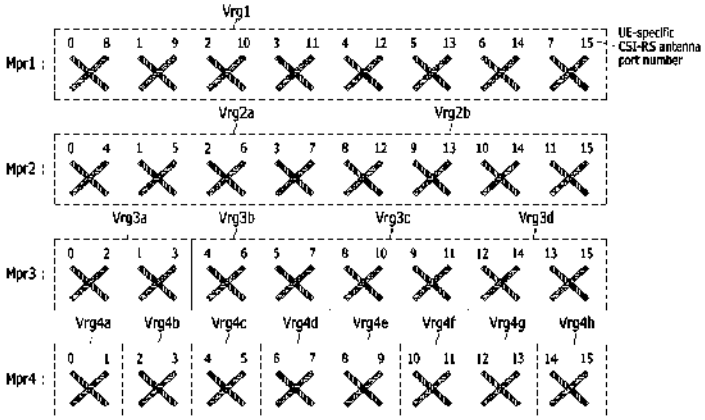
(74) 대리인: 팬코리아특허법인 (PANKOREA PATENT AND LAW FIRM); 06234 서울시 강남구 논현로 85 길 70, 13 층, Seoul (KR).

(81) 지정국 (별도의 표시가 없는 한, 가능한 모든 종류의 국내 권리의 보호를 위하여): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE,

[다음 쪽 계속]

(54) Title: METHOD AND APPARATUS FOR TRANSMITTING DOWNLINK REFERENCE SIGNAL, AND METHOD AND APPARATUS FOR TRANSMITTING CONTROL INFORMATION IN MULTI-CELL COLLABORATIVE COMMUNICATION SYSTEM

(54) 발명의 명칭 : 하향링크 참조 신호를 전송하는 방법 및 장치, 그리고 다중 셀 협력 통신 시스템에서 제어 정보를 전송하는 방법 및 장치



(57) Abstract: Provided is a method for a base station to set channel state information (CSI)-reference signal (RS). The base station sets a CSI-RS antenna port for a terminal. For the terminal, the base station selects one of at least one port number mapping rule for mapping a port number to the CSI-RS antenna port. Further, the base station notifies the terminal of the selected port number mapping rule.

(57) 요약서: 기지국이 CSI(channel state information)-RS(reference signal)를 설정하는 방법이 제공된다. 상기 기지국은, 단말을 위한 CSI-RS 안테나 포트를 설정한다. 상기 기지국은, 상기 CSI-RS 안테나 포트에 포트 번호를 맵핑하기 위한 적어도 하나의 포트 번호 맵핑 규칙 중 하나를, 상기 단말을 위해 선택한다. 그리고 상기 기지국은, 상기 선택된 포트 번호 맵핑 규칙을 상기 단말에게 알린다.

WO 2016/122257 A1

PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) 지정국 (별도의 표시가 없는 한, 가능한 모든 종류의 역내 권리의 보호를 위하여): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), 유라시아 (AM, AZ, BY, KG, KZ, RU, TJ, TM), 유럽 (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

공개:

— 국제조사보고서와 함께 (조약 제 21 조(3))

명세서

발명의 명칭: 하향링크 참조 신호를 전송하는 방법 및 장치, 그리고 다중 셀 협력 통신 시스템에서 제어 정보를 전송하는 방법 및 장치

기술분야

[1] 본 발명은 하향링크 참조 신호를 전송하는 방법 및 장치에 관한 것이다.

[2] 또한 본 발명은 채널 상태 정보를 측정하는 방법 및 장치에 관한 것이다.

[3] 또한 본 발명은 다중 셀 협력 통신 시스템에서 제어 정보를 전송하는 방법 및 장치에 관한 것이다.

배경기술

[4] 무선 통신 시스템의 다중 입출력(MIMO: multiple-input multiple-output) 방식은 복수의 송신 안테나와 복수의 수신 안테나를 사용하여 송수신하는 방법이다. MIMO 시스템에서 송수신 안테나 간 복수의 무선 채널 경로가 생성되며, 송수신단은 이를 분리 또는 병합함으로써, 데이터 전송 용량을 증대시키거나 전송 품질을 향상시킬 수 있다. MIMO 기법으로는 공간 다중화(spatial multiplexing) 기법과 공간 다이버시티(spatial diversity) 기법이 있다. LTE(long term evolution) 시스템에 도입된 하향링크 MIMO 기법으로는, 송신 다이버시티(transmit diversity), CDD (cyclic delay diversity), 빔포밍(beamforming) 및 공간 다중화 방식 등이 있다. 또한 동일 자원에서 동시에 복수의 단말에 데이터를 전송하는 다중 사용자 MIMO (MU-MIMO: multiuser MIMO) 기법이 지원된다.

[5] LTE 규격에서의 안테나 포트(antenna port)는 하나 또는 복수의 물리 안테나 요소(antenna element)의 가중치 합(weighted sum)에 의해 구현되는 논리적 안테나 단위로써, 주로 송신단에서 정의된다. 안테나 포트는 참조 신호(RS: reference signal)가 전송되는 기본 단위이기도 하다. 따라서 단말은 물리 안테나 요소가 아닌 각 안테나 포트에 대하여 채널을 추정하고 이를 기반으로 채널 상태 정보(CSI: channel state information) 측정 및 보고를 수행한다. LTE 하향링크 참조 신호인 CRS(cell-specific RS), URS(user equipment-specific RS), 및 CSI-RS에는 각기 다른 안테나 포트 번호가 부여된다. URS의 목적은 단말의 PDSCH(physical downlink shared channel) 복호를 위함이므로, URS는 DMRS(demodulation RS)로 부르기도 한다. CRS를 위한 안테나 포트 번호는 0번 내지 3번이고, URS를 위한 안테나 포트 번호는 7번 내지 14번, CSI-RS를 위한 안테나 포트 번호는 15번 내지 22번일 수 있다. 안테나 포트와 물리 안테나 요소(들) 간의 맵핑을 안테나 가상화(antenna virtualization)라고 한다. 단말은 기본적으로 각 안테나 포트에 어떤 가상화가 적용되었는지를 알 수 없다.

[6] CSI-RS는 단말이 CSI를 획득하기 위한 목적으로 기지국이 전송하는 하향링크 참조신호로써, LTE Release 10에서 도입되었다. CSI-RS는 후술할 ZP(zero-power)

CSI-RS와의 구별을 위해 NZP(non-zero-power) CSI-RS라 불려지기도 한다. 기존 Release 8/9 시스템에서는 단말의 CSI 획득을 위해 CRS가 이용되었으나, Release 10부터는 최대 8개의 레이어(layer)의 하향링크 전송을 지원하기 위해 기존의 CRS보다 낮은 밀도를 갖는 새로운 채널 추정용 참조신호의 도입이 필요하게 되었다. CSI-RS 설정 정보는 단말 특정적(user equipment-specific) RRC(radio resource control) 시그널링을 통해 단말에게 전송된다. 단말에게 설정 가능한 CSI-RS 안테나 포트 수는, Release 13 현재까지 1, 2, 4, 8, 12, 그리고 16이다. 각 CSI-RS 안테나 포트 수에 대하여, PRB(physical resource block) 페어(pair) 당 CSI-RS 전송이 차지하는 총 RE의 개수는, 2, 2, 4, 8, 12, 그리고 16이다.

[7] 시간 축에서의 CSI-RS 전송 주기는, 5, 10, 20, 40, 또는 80 ms 로 설정(configured)될 수 있다. 현재 규격에 의하면, 각 CSI-RS 안테나 포트는 주파수 축에서 12 자원 요소(RE: resource element)의 간격을 가진다.

[8] 한편, FD(full dimension)-MIMO(또는 3차원 MIMO) 시스템에서 기지국이 3차원 빔포밍을 수행하기 위해서는, 단말이 기존의 수평 축에 대한 CSI 뿐만 아니라 수직 축에 대한 CSI의 측정 및 보고를 수행할 필요가 있다. 2차원 안테나 배열의 크기가 큰 경우에, 단말에 설정 가능한 CSI-RS 안테나 포트 수를 늘리는 방법이 연구되고 있다.

[9] 또한 기존의 단말은 CSI-RS 안테나 포트 배열을 1차원으로만 인식한다. 단말이 CSI-RS 안테나 포트 배열을 2차원(2D: two dimensions) 또는 3차원(3D: three dimensions)으로 인식하는 방법이 필요하다.

발명의 상세한 설명

기술적 과제

[10] 본 발명이 해결하고자 하는 과제는, MIMO 무선 통신 시스템에서 CSI-RS를 설정하고 전송하는 방법 및 장치를 제공하는 것이다.

[11] 또한 본 발명이 해결하고자 하는 과제는, 단말에 설정 가능한 CSI-RS 안테나 포트 수를 늘리는 방법 및 장치를 제공하는 것이다.

[12] 또한 본 발명이 해결하고자 하는 과제는, CSI-RS 안테나 포트 배열을 1차원 또는 다차원으로 인식하는 방법 및 장치를 제공하는 것이다.

[13] 또한 본 발명이 해결하고자 하는 과제는, 무선 통신 시스템에서 CSI-RS 전송 오버헤드를 줄이기 위하여 다중 셀 협력 통신을 위한 제어 정보를 설정하는 방법 및 장치에 관한 것이다.

[14] 또한 본 발명이 해결하고자 하는 과제는, CSI-RS 자원으로써 설정될 수 있는 RE를 확장하는 방법 및 장치에 관한 것이다.

[15] 또한 본 발명이 해결하고자 하는 과제는, 상기 확장된 RE를 이용해 CSI-RS 를 전송하는 방법 및 장치에 관한 것이다.

과제 해결 수단

[16] 본 발명의 실시예에 따르면, 기지국이 CSI(channel state

information)-RS(reference signal)를 설정하는 방법이 제공된다. 상기 기지국의 CSI-RS 설정 방법은, 단말을 위한 CSI-RS 안테나 포트를 설정하는 단계; 상기 CSI-RS 안테나 포트에 포트 번호를 맵핑하기 위한 적어도 하나의 포트 번호 맵핑 규칙 중 하나를, 상기 단말을 위해 선택하는 단계; 및 상기 선택된 포트 번호 맵핑 규칙을 상기 단말에게 알리는 단계를 포함한다.

[17] 상기 단말을 위한 CSI-RS 안테나 포트를 설정하는 단계는, 상기 CSI-RS 안테나 포트가 제1 축, 제2 축, 및 제3 축 중 적어도 2개를 따라 배치되는 CSI-RS 안테나 포트 배열을 설정하는 단계를 포함할 수 있다.

[18] 상기 선택된 포트 번호 맵핑 규칙에 무관하게, 상기 제1 축, 상기 제2 축, 및 상기 제3 축에 포트 번호가 맵핑되는 축 순서는, 기 설정될 수 있다.

[19] 상기 단말을 위한 CSI-RS 안테나 포트를 설정하는 단계는, 상기 CSI-RS 안테나 포트 배열에 포함된 CSI-RS 안테나 포트 중에서 상기 제1 축으로 배치되는 CSI-RS 안테나 포트의 수, 상기 제2 축으로 배치되는 CSI-RS 안테나 포트의 수, 및 상기 제3 축으로 배치되는 CSI-RS 안테나 포트의 수 중 적어도 하나를, 상기 단말에게 전송하는 단계를 더 포함할 수 있다.

[20] 상기 단말을 위한 CSI-RS 안테나 포트를 설정하는 단계는, 상기 제1 축, 상기 제2 축, 및 상기 제3 축 중 하나의 축에 따라 배치되는 CSI-RS 안테나 포트의 수가 상기 단말에게 설정되는 전체 CSI-RS 안테나 포트의 수와 동일한 경우에, 상기 하나의 축에 따라 배치되는 CSI-RS 안테나 포트의 수를 상기 단말에게 전송하는 것을 생략하는 단계를 더 포함할 수 있다.

[21] 상기 단말을 위한 CSI-RS 안테나 포트를 설정하는 단계는, 상기 CSI-RS 안테나 포트 배열에 포함된 CSI-RS 안테나 포트 중에서 상기 제1 축으로 배치되는 CSI-RS 안테나 포트의 수와 상기 제3 축으로 배치되는 CSI-RS 안테나 포트의 수를 합하여, 제1 값을 구하는 단계; 및 상기 CSI-RS 안테나 포트 배열에 포함된 CSI-RS 안테나 포트 중에서 상기 제2 축으로 배치되는 CSI-RS 안테나 포트의 수 및 상기 제1 값 중 적어도 하나를, 상기 단말에게 전송하는 단계를 더 포함할 수 있다.

[22] 상기 선택된 포트 번호 맵핑 규칙은, 상기 단말에 의한 채널 추정 시에, 상기 단말로 하여금 상기 단말에게 설정된 전체 CSI-RS 안테나 포트를 상기 선택된 포트 번호 맵핑 규칙에 대응하는 개수 만큼의 CSI-RS 안테나 포트 그룹으로 나누도록 하고, 상기 CSI-RS 안테나 포트 그룹 별로 상기 각 CSI-RS 안테나 포트 그룹에 속하는 CSI-RS 안테나 포트에 상기 기 설정된 축 순서에 따라 포트 번호를 부여하도록 할 수 있다.

[23] 상기 각 CSI-RS 안테나 포트 그룹에 속하는 CSI-RS 안테나 포트의 수는, 상기 단말에게 설정되는 전체 CSI-RS 안테나 포트의 수의 약수일 수 있다.

[24] 상기 선택된 포트 번호 맵핑 규칙을 상기 단말에게 알리는 단계는, 상기 선택된 포트 번호 맵핑 규칙을 나타내는 비트 코드를, 상기 단말에게 전송하는 단계를 포함할 수 있다.

[25] 상기 선택된 포트 번호 맵핑 규칙을 상기 단말에게 알리는 단계는, 상기 선택된 포트 번호 맵핑 규칙에 따라 생성되는 상기 CSI-RS 안테나 포트 그룹의 개수를 나타내는 비트 코드를, 상기 단말에게 전송하는 단계를 포함할 수 있다.

[26] 상기 단말에게 설정되는 전체 CSI-RS 안테나의 수는 8개 보다 더 많을 수 있다.

[27] 상기 제1 축은 수평(horizontal) 축이고, 상기 제2 축은 수직(vertical) 축이고, 상기 제3 축은 편파(polarization) 축일 수 있다.

[28] 상기 기지국의 CSI-RS 설정 방법은, 제1 축, 제2 축, 및 제3 축에 포트 번호가 맵핑되는 축 순서들 중에서 하나를, 상기 단말을 위해 선택하는 단계; 및 상기 선택된 축 순서를 상기 단말에게 알리는 단계를 더 포함할 수 있다.

[29] 상기 단말을 위한 CSI-RS 안테나 포트를 설정하는 단계는, 상기 CSI-RS 안테나 포트가 상기 제1 축, 상기 제2 축, 및 상기 제3 축 중 적어도 2개를 따라 배치되는 CSI-RS 안테나 포트 배열을 설정하는 단계를 포함할 수 있다.

[30] 또한 본 발명의 다른 실시예에 따르면, 단말이 CSI(channel state information)를 측정하는 방법이 제공된다. 상기 단말의 CSI 측정 방법은, 기지국으로부터, CSI-RS(reference signal) 안테나 포트를 위한 제1 포트 번호 맵핑 규칙을 수신하는 단계; 상기 제1 포트 번호 맵핑 규칙에 기초해, 상기 CSI-RS 안테나 포트를 상기 제1 포트 번호 맵핑 규칙에 대응하는 개수 만큼의 CSI-RS 안테나 포트 그룹으로 나누는 단계; 상기 CSI-RS 안테나 포트 그룹 별로 상기 각 CSI-RS 안테나 포트 그룹에 속하는 CSI-RS 안테나 포트에 포트 번호를 부여하는 단계; 및 상기 포트 번호가 부여된 CSI-RS 안테나 포트에 대하여, 채널 추정을 수행하는 단계를 포함한다.

[31] 상기 단말의 CSI 측정 방법은, 상기 제1 포트 번호 맵핑 규칙과 다른 제2 포트 번호 맵핑 규칙에 따라, 상기 CSI-RS 안테나 포트에 포트 번호를 재부여하는 단계; 및 상기 포트 번호가 재부여된 CSI-RS 안테나 포트에 대하여, 상기 채널 추정의 결과에 기초해 CSI 측정을 수행하는 단계를 더 포함할 수 있다.

[32] 상기 제1 포트 번호 맵핑 규칙을 수신하는 단계는, 상기 제1 포트 번호 맵핑 규칙을 나타내는 비트 코드를 상기 기지국으로부터 수신하는 단계를 포함할 수 있다.

[33] 상기 CSI-RS 안테나 포트는 제1 축, 제2 축, 및 제3 축 중 적어도 2개를 따라 배치될 수 있다.

[34] 상기 CSI-RS 안테나 포트에 포트 번호를 부여하는 단계는, 상기 CSI-RS 안테나 포트 그룹 중에서 제1 CSI-RS 안테나 포트 그룹에 속하는 CSI-RS 안테나 포트에, 상기 제1 축, 상기 제2 축, 및 상기 제3 축에 포트 번호가 부여되는 축 순서에 따라 포트 번호를 부여하는 단계; 및 상기 CSI-RS 안테나 포트 그룹 중에서 제2 CSI-RS 안테나 포트 그룹에 속하는 CSI-RS 안테나 포트에, 상기 축 순서에 따라 포트 번호를 부여하는 단계를 포함할 수 있다.

[35] 상기 제2 CSI-RS 안테나 포트 그룹에 부여된 첫번째 포트 번호는, 상기 제1 CSI-RS 안테나 포트 그룹에 부여된 마지막 포트 번호 다음의 포트 번호일 수

있다.

[36] 또한 본 발명의 또 다른 실시예에 따르면, 단말이 CSI(channel state information)를 측정하는 방법이 제공된다. 상기 단말의 CSI 측정 방법은, 기지국으로부터, CSI-RS(reference signal) 안테나 포트를 설정받는 단계; 상기 기지국으로부터 상기 CSI-RS 안테나 포트에 대한 포트 번호 부여 여부 정보를 수신하는 단계; 상기 포트 번호 부여 정보에 기초해, 상기 CSI-RS 안테나 포트 중 일부에 포트 번호를 부여하는 단계; 및 상기 포트 번호가 부여된 CSI-RS 안테나 포트를 이용하여, CSI를 측정하는 단계를 포함한다.

[37] 상기 포트 번호 부여 여부 정보를 수신하는 단계는, 상기 CSI-RS 안테나 포트의 수만큼의 길이를 가지며 상기 CSI-RS 안테나 포트 별 포트 번호 부여 여부를 나타내는 비트맵을, 상기 기지국으로부터 수신하는 단계를 포함할 수 있다.

[38] 상기 CSI-RS 안테나 포트 중 일부에 포트 번호를 부여하는 단계는, 상기 비트맵에 속하는 비트 중에서 제1 값을 가지는 비트에 대응하는 CSI-RS 안테나 포트에 포트 번호를 부여하는 단계를 포함할 수 있다.

[39] 상기 포트 번호 부여 여부 정보를 수신하는 단계는, 상기 CSI-RS 안테나 포트의 수의 절반의 길이를 가지며 상기 CSI-RS 안테나 포트 쌍 별 포트 번호 부여 여부를 나타내는 비트맵을, 상기 기지국으로부터 수신하는 단계를 포함할 수 있다.

[40] 상기 CSI-RS 안테나 포트 중 일부에 포트 번호를 부여하는 단계는, 상기 비트맵에 속하는 비트 중에서 제1 값을 가지는 비트에 대응하는 CSI-RS 안테나 포트 쌍에 포트 번호를 부여하는 단계를 포함할 수 있다.

[41] 상기 CSI-RS 안테나 포트 쌍은, 동일한 RE(resource element)를 통해 전송되는 2개의 CSI-RS 안테나 포트를 포함할 수 있다.

[42] 상기 CSI-RS 안테나 포트는 CSI-RS 안테나 포트 배열에 포함되며 제1 축, 제2 축, 및 제3 축 중 적어도 2개에 따라 배치될 수 있다.

[43] 상기 포트 번호 부여 여부 정보를 수신하는 단계는, 상기 제1 축으로 배치되는 CSI-RS 안테나 포트의 수와 상기 제2 축으로 배치되는 CSI-RS 안테나 포트의 수를 합한 값 만큼의 길이를 가지며 상기 CSI-RS 안테나 포트 배열의 각 행과 각 열에 대한 포트 번호 부여 여부를 나타내는 비트맵을, 상기 기지국으로부터 수신하는 단계를 포함할 수 있다.

[44] 상기 단말의 CSI 측정 방법은, 상기 단말에게 설정된 전체 CSI-RS 안테나 포트를 위한 RE(resource element) 중에서 상기 포트 번호가 부여된 CSI-RS 안테나 포트를 위한 RE를 제외한 나머지에서 PDSCH(physical downlink shared channel)가 수신되는 것이 가능함을 가정하는 단계를 더 포함할 수 있다.

발명의 효과

[45] 본 발명의 실시예에 따르면, MIMO 안테나 통신 시스템에서 기지국은 채널 추정을 위해 단말에게 다수의 채널 추정용 RS 안테나 포트를 설정할 수 있고,

이를 단말에게 전송할 수 있다.

[46] 또한 본 발명의 실시예에 따르면, 단말에 설정 가능한 CSI-RS 안테나 포트 수를 늘릴 수 있다.

[47] 또한 본 발명의 실시예에 따르면, 단말은 CSI-RS 안테나 포트 배열을 1차원 또는 다차원(예, 2차원, 3차원)으로 인식할 수 있다. 즉, 단말은 자신에게 설정된 1차원 또는 다차원(예, 2차원, 3차원) CSI-RS 안테나 포트의 포트 번호를 인식할 수 있다.

[48] 또한 본 발명의 실시예에 따르면, 기지국은 CSI-RS를 효율적으로 설정할 수 있고 이를 통해 CSI-RS를 효율적으로 전송할 수 있다.

[49] 또한 본 발명의 실시예에 따르면, 단말의 CSI 보고를 위해 설정된 NZP(non-zero-power) CSI-RS 자원 영역의 일부를 해당 단말의 PDSCH(physical downlink shared channel) 수신을 위해 이용함으로써, CSI-RS 전송 오버헤드 문제를 해결할 수 있고, PDSCH 전송 자원의 감소로 인한 데이터 전송률 하락을 방지할 수 있다.

[50] 또한 본 발명의 실시예에 따르면, 기지국이 단말에게 PDSCH 레잇 매칭(rate matching) 정보 및 의사 동일 위치성(QCL: quasi-co-location) 정보를 설정할 수 있고, 이를 이용하여 기지국과 단말은 PDSCH 전송을 수행할 수 있다.

[51] 또한 본 발명의 실시예에 따르면, 주파수 축으로 인접한 복수의 PRB 페어를 이용하여 채널 추정용 RS(예, CSI-RS)를 설정함으로써, 채널 추정용 RS를 위한 자원 풀을 확장할 수 있다. 이를 통해, FD(full dimension)-MIMO 시스템에서 채널 추정용 RS를 효율적으로 전송할 수 있다.

도면의 간단한 설명

[52] 도 1은 CSI-RS 안테나 포트의 수가 2인 경우에 CSI-RS 자원 요소(RE: resource element)집합의 맵핑을 나타내는 도면이다.

[53] 도 2는 CSI-RS 안테나 포트의 수가 4인 경우에 CSI-RS RE 집합의 맵핑을 나타내는 도면이다.

[54] 도 3은 CSI-RS 안테나 포트의 수가 8인 경우에 CSI-RS RE 집합의 맵핑을 나타내는 도면이다.

[55] 도 4는 단말이 복수의 TP로부터 하향링크 협력 전송을 수신하는 경우를 나타내는 도면이다.

[56] 도 5는 3개의 TP가 하나의 서브프레임 내의 서로 다른 RE들을 이용하여 CSI-RS 자원을 설정하는 방법을 나타내는 도면이다.

[57] 도 6은 단말을 위한 PDSCH RE를 맵핑하는 방법을 나타내는 도면이다.

[58] 도 7은 본 발명의 실시예에 따른, 기지국이 방법 Ma110을 이용하는 경우에 단말을 위한 PDSCH RE를 맵핑하는 방법을 나타내는 도면이다.

[59] 도 8은 본 발명의 실시예에 따른, 3개의 TP가 2개의 서브프레임 내의 서로 다른 RE들을 이용하여 CSI-RS 자원을 설정하는 방법을 나타내는 도면이다.

[60] 도 9는 본 발명의 실시예에 따른, 방법 Mb100을 이용해 CSI-RS 자원을 설정하는 방법을 나타내는 도면이다.

[61] 도 10a 및 도 10b는 본 발명의 다른 실시예에 따른, 방법 Mb100을 이용해 CSI-RS 자원을 설정하는 방법을 나타내는 도면이다.

[62] 도 11은 본 발명의 또 다른 실시예에 따른, 방법 Mb100을 이용해 CSI-RS 자원을 설정하는 방법을 나타내는 도면이다.

[63] 도 12은 본 발명의 실시예에 따른, 방법 Mb200을 이용해 16개의 CSI-RS 안테나 포트에 대한 자원을 설정하는 방법을 나타내는 도면이다.

[64] 도 13a 및 도 13b는 본 발명의 실시예에 따른, 방법 Mb200을 이용해 12개의 CSI-RS 안테나 포트에 대한 자원을 설정하는 방법을 나타내는 도면이다.

[65] 도 14는 본 발명의 실시예에 따른, 방법 Mb200을 이용해 32개의 CSI-RS 안테나 포트에 대한 자원을 설정하는 방법을 나타내는 도면이다.

[66] 도 15은 본 발명의 다른 실시예에 따른, 방법 Mb200을 이용해 CSI-RS 자원을 설정하는 방법을 나타내는 도면이다.

[67] 도 16a 및 도 16b는 본 발명의 실시예에 따른, 방법 Mb201를 이용해 6개의 CSI-RS 안테나 포트에 대한 자원을 설정하는 방법을 나타내는 도면이다.

[68] 도 17는 본 발명의 실시예에 따른, 방법 Mb110을 이용해 컴포넌트 CSI-RS configuration를 집성하는 방법을 나타내는 도면이다.

[69] 도 18은 본 발명의 다른 실시예에 따른, 방법 Mb110을 이용해 복수의 컴포넌트 CSI-RS configuration를 집성하는 방법을 나타내는 도면이다.

[70] 도 19는 본 발명의 실시예에 따른, 방법 Mb130을 이용해 복수의 컴포넌트 CSI-RS configuration를 집성하는 방법을 나타내는 도면이다.

[71] 도 20는 본 발명의 실시예에 따른, 방법 Mb200의 PRB 번들링이 사용되는 경우에 복수의 컴포넌트 CSI-RS configuration를 집성하는 방법을 나타내는 도면이다.

[72] 도 21은 본 발명의 실시예에 따른, 번들링된 PRB 페어들의 인덱스를 시간적으로 교차시켜 CSI-RS를 전송하는 방법을 나타내는 도면이다.

[73] 도 22은 2차원 CSI-RS 안테나 포트 배열의 예를 나타내는 도면이다.

[74] 도 23a 및 도 23b는 본 발명의 실시예에 따른, 2차원 CSI-RS 안테나 포트 배열에 단말 특정적 CSI-RS 안테나 포트 번호가 맵핑되는 방법을 나타내는 도면이다.

[75] 도 24은 복수의 단말에게 서로 다른 CSI-RS 안테나 포트 집합을 설정하는 방법을 나타내는 도면이다.

[76] 도 25a는 복수의 단말에 대한 CSI-RS 자원 설정의 예를 나타내는 도면이다.

[77] 도 25b는 본 발명의 실시예에 따른, 단말에 설정된 CSI-RS 안테나 포트들의 포트 번호가 방법 Mc200에 의해 재배열됨으로써, 포트 번호와 RE들 간의 맵핑 관계가 기존과 달라지는 경우를 나타내는 도면이다.

[78] 도 26a 및 도 26b는 본 발명의 실시예에 따른, 방법 Mc220이 사용되는 경우에, 기지국이 단말에게 새로운 포트 번호 순열(sequence)을 알리기 위한 규칙(또는

정보)을 암시적인 시그널링을 통해 알려주는 경우를 나타내는 도면이다.

[79] 도 26c, 도 26d, 도 26e, 및 도 26f는 본 발명의 실시예에 따른, 방법 Mc221에 의해 기지국이 단말에게 도 26a에 예시된 포트 번호 맵핑 중 하나를 알려주는 경우에, 단말이 CSI-RS RE 집합을 구성하는 RE들에 CSI-RS 안테나 포트 번호들을 맵핑하는 경우를 나타내는 도면이다

[80] 도 27은 본 발명의 실시예에 따른, 방법 Mc220이 사용되는 경우에, 복수의 단말에 대한 CSI-RS 안테나 포트 번호 맵핑을 나타내는 도면이다.

[81] 도 28은 본 발명의 실시예에 따른, 방법 Mc220이 사용되는 경우에, 복수의 단말에 대한 CSI-RS 자원 설정을 나타내는 도면이다.

[82] 도 29a, 도 29b, 도 29c, 도 29d, 및 도 29e는 본 발명의 다른 실시예에 따른, 방법 Mc221을 위해 사용될 수 있는 복수의 안테나 포트 번호 맵핑 규칙을 나타내는 도면이다.

[83] 도 30는 본 발명의 실시예에 따른, 방법 Mc310이 사용되는 경우에, CSI-RS 자원 설정을 나타내는 도면이다.

[84] 도 31은 본 발명의 실시예에 따른, 방법 Mc310이 사용되는 경우에, CSI-RS 안테나 포트 번호 맵핑을 나타내는 도면이다.

[85] 도 32a, 도 32b, 및 도 32c는 방법 Mc300을 위한 다른 실시예를 나타내는 도면이다.

[86] 도 33a, 도 33b, 및 도 33c는 방법 Mc300을 위한 또 다른 실시예를 나타내는 도면이다.

[87] 도 34은 방법 Mc300을 위한 또 다른 실시예를 나타내는 도면이다.

[88] 도 35은 CSI-RS 안테나 포트의 2차원 십자 배열로써, 두 1차원 배열의 교차점에 CSI-RS 안테나 포트가 중복 할당되는 2차원 십자 배열을 나타내는 도면이다.

[89] 도 36는 CSI-RS 안테나 포트의 2차원 십자 배열로써, 두 1차원 배열의 교차점에 CSI-RS 안테나 포트가 중복 할당되지 않는 2차원 십자 배열을 나타내는 도면이다.

[90] 도 37은 본 발명의 실시예에 따른, 기지국을 나타내는 도면이다.

[91] 도 38은 본 발명의 실시예에 따른, 단말을 나타내는 도면이다.

발명의 실시를 위한 형태

[92] 아래에서는 첨부한 도면을 참고로 하여 본 발명의 실시예에 대하여 본 발명이 속하는 기술 분야에서 통상의 지식을 가진 자가 용이하게 실시할 수 있도록 상세히 설명한다. 그러나 본 발명은 여러 가지 상이한 형태로 구현될 수 있으며 여기에서 설명하는 실시예에 한정되지 않는다. 그리고 도면에서 본 발명을 명확하게 설명하기 위해서 설명과 관계없는 부분은 생략하였으며, 명세서 전체를 통하여 유사한 부분에 대해서는 유사한 도면 부호를 붙였다.

[93] 명세서 전체에서, 단말(terminal)은, 이동 단말(mobile terminal), 이동국(mobile station), 진보된 이동국(advanced mobile station), 고신뢰성 이동국(high reliability

mobile station), 가입자국(subscriber station), 휴대 가입자국(portable subscriber station), 접근 단말(access terminal), 사용자 장비(user equipment) 등을 지칭할 수도 있고, 단말, 이동 단말, 이동국, 진보된 이동국, 고신뢰성 이동국, 가입자국, 휴대 가입자국, 접근 단말, 사용자 장비 등의 전부 또는 일부의 기능을 포함할 수도 있다.

[94] 또한, 기지국(base station, BS)은, 진보된 기지국(advanced base station), 고신뢰성 기지국(high reliability base station), 노드B(node B), 고도화 노드B(evolved node B, eNodeB), 접근점(access point), 무선 접근국(radio access station), 송수신 기지국(base transceiver station), MMR(mobile multihop relay)-BS, 기지국 역할을 수행하는 중계기(relay station), 기지국 역할을 수행하는 고신뢰성 중계기(high reliability relay station), 리피터, 매크로 기지국, 소형 기지국 등을 지칭할 수도 있고, 기지국, 진보된 기지국, HR-BS, 노드B, eNodeB, 접근점, 무선 접근국, 송수신 기지국, MMR-BS, 중계기, 고신뢰성 중계기, 리피터, 매크로 기지국, 소형 기지국 등의 전부 또는 일부의 기능을 포함할 수도 있다.

[95] 한편, 본 명세서에서, 'A 또는 B'는, 'A', 'B', 또는 'A와 B 모두'를 포함할 수 있다.

[96]

[97] 1. 다중 셀 협력 통신 시스템에서 제어 정보를 전송하는 방법

[98] 셀 기반의 무선통신 시스템에서 셀 경계에 위치한 단말은, 일반적으로 인접 셀로부터 받는 간섭 신호로 인해 높은 전송률을 제공받는 데 한계를 가진다. 다중 셀 협력(CoMP: cooperative multi-point) 전송 기술은, 복수의 인접한 셀들 또는 전송 점(TP: transmission point)들이 서로 협력하여 셀 간 간섭을 완화하거나 회피함으로써, 셀 경계 단말의 데이터 전송률을 높이는 기술이다.

[99] 단말은 다중 셀 협력 전송을 위해, 자신이 속한 서빙 셀 뿐만 아니라 이웃 셀(들) 혹은 TP(들)에 대한 하향링크 채널 상태 정보(CSI: channel state information)를 측정하고, 이를 보고해야 할 수도 있다. 이를 위해, 기지국은 전송 모드(TM: transmission mode) 10으로 설정된 단말에게 복수의 CSI 프로세스 (process)를 설정할 수 있다. 하나의 CSI 프로세스는 채널 측정을 위한 CSI-RS(reference signal)와 간섭 측정을 위한 CSI-IM(interference measurement)의 자원 설정 정보를 포함하며, 각 CSI 프로세스로부터 유도된 CSI 정보는 독립적인 주기(periodicity)와 서브프레임 오프셋(subframe offset)에 따라 단말에 의해 기지국으로 보고된다.

[100] 한편, 기지국이 단말에게 설정된 모든 NZP CSI-RS 자원을 제외한 영역에서 PDSCH(physical downlink shared channel)를 전송하면, PDSCH 전송 자원의 감소로 인해 데이터 전송률이 떨어질 수도 있다. 이러한 CSI-RS 전송 오버헤드 문제는 FD(full dimension)-MIMO(multiple-input multiple-output) 시스템에서 더욱 두드러지나, 비단 이 경우에만 국한되지 않고, TP들이 기존 규격이 지원하는 범위 내에서 CSI-RS를 전송하는 경우에도 마찬가지로 해결해야 할 과제이다.

[101]

[102] 도 1은 CSI-RS 안테나 포트의 수가 2인 경우에 CSI-RS RE(resource element)집합(set)의 맵핑을 나타내는 도면이고, 도 2는 CSI-RS 안테나 포트의 수가 4인 경우에 CSI-RS RE 집합의 맵핑을 나타내는 도면이고, 도 3은 CSI-RS 안테나 포트의 수가 8인 경우에 CSI-RS RE 집합의 맵핑을 나타내는 도면이다.

[103] CSI-RS가 전송되는 자원 요소(RE: resource element)의 맵핑은 각 안테나 포트 수마다 미리 정해진 패턴을 따르고, 미리 정해진 CSI-RS 자원 풀(resource pool) 내에서 설정될 수 있다. CSI-RS 자원 설정(CSI-RS resource configuration, 이하 'CSI-RS configuration')은 노멀(normal) CP(cyclic prefix) 및 확장(extended) CP 각각에 대하여 정의되어 있다. 또한 CSI-RS configuration은 FDD(frequency division duplex)와 TDD(time division duplex) 모두에 설정 가능한 것과 TDD에만 설정될 수 있는 것으로 구분된다.

[104] 도 1 내지 도 3 각각은 노멀 CP가 설정되고 CSI-RS 안테나 포트 수가 2, 4, 또는 8인 경우에, CSI-RS configuration 0~19번에 대한 RE 맵핑을 나타낸다.

[105] 도 1 내지 도 3에 예시된 바와 같이, 하나의 하향링크 서브프레임은 2개의 타임 슬롯을 포함한다. 구체적으로 노멀 CP가 설정되는 경우에, 하나의 서브프레임은, 짝수의 타임 슬롯(이하 '슬롯0')과 슬롯0 이후의 홀수의 타임 슬롯(이하 ' 슬롯1')을 포함한다. 슬롯0과 슬롯1 각각은 시간 축으로 7개의 OFDM(Orthogonal Frequency Division Multiplexing) 심볼(0번~6번)과 주파수 축으로 12개의 부반송파(0번~11번)를 포함한다. 즉, 하나의 서브프레임 또는 PRB(physical resource block) 페어(pair) 내의 슬롯0과 슬롯1 각각에는 84개(=7x12)의 RE가 존재한다. 하나의 서브프레임 또는 PRB 페어 내의 RE 중 일부는 CRS 전송을 위한 RE로 설정될 수 있고, 일부는 DMRS(demodulation reference signal) 전송을 위한 RE로 설정될 수 있고, 일부는 CSI-RS 전송을 위한 RE로 설정될 수 있다. 예를 들어, 도 1에서 슬롯0의 OFDM 심볼 5번과 6번에 대응하며 부반송파 9번에 대응하는 2개의 RE에는, CSI-RS configuration 0번의 CSI-RS 안테나 포트 15번과 16번이 맵핑(설정)된다. 즉, CSI-RS configuration 0번~19번 각각을 위한 2개의 CSI-RS 안테나 포트(15번, 16번)는 2개의 RE에 맵핑된다. 이하에서는 설명의 편의를 위해서, 슬롯 내의 OFDM 심볼 n번에 대응하며 PRB 페어 내의 부반송파 k번에 대응하는 RE를, RE(n, k)라 한다.

[106] 다른 예를 들어, 도 2에서 슬롯1의 RE(2, 11)와 RE(3, 11)에는 CSI-RS configuration 1번의 CSI-RS 안테나 포트 15번과 16번이 맵핑되고, 슬롯1의 RE(2, 5)와 RE(3, 5)에는 CSI-RS configuration 1번의 CSI-RS 안테나 포트 17번과 18번이 맵핑된다. 즉, CSI-RS configuration 0번~9번 각각을 위한 4개의 CSI-RS 안테나 포트(15번~18번)는 4개의 RE에 맵핑된다.

[107] 또 다른 예를 들어, 도 3에서 슬롯0의 RE(5, 9)와 RE(6, 9)에는 CSI-RS configuration 0번의 CSI-RS 안테나 포트 15번과 16번이 맵핑되고, 슬롯0의 RE(5, 3)와 RE (6, 3)에는 CSI-RS configuration 0번의 CSI-RS 안테나 포트 17번과 18번이 맵핑되고, 슬롯0의 RE(5, 8)와 RE(6, 8)에는 CSI-RS configuration 0번을 위한

CSI-RS 안테나 포트 19번과 20번이 맵핑되고, 슬롯0의 RE(5, 2)와 RE(6, 2)에는 CSI-RS configuration 0번을 위한 CSI-RS 안테나 포트 21번과 22번이 맵핑된다. 즉, CSI-RS configuration 0번~4번 각각을 위한 8개의 CSI-RS 안테나 포트(15번~22번)는 8개의 RE에 맵핑된다.

[108] 한편, 동일한 RE를 통해 전송되는 CSI-RS 안테나 포트들(예, CSI-RS 안테나 포트 15번, 16번) 간에는 안테나 포트 간 다중화 방식으로써 코드 분할 다중화(CDM: Code Division Multiplexing)가 적용된다. 예를 들어, 도 1에서 슬롯0의 RE(5, 9)를 통해 CSI-RS 안테나 포트 15번과 16번이 전송되고, 슬롯0의 RE(6, 9)를 통해 CSI-RS 안테나 포트 15번과 16번이 전송된다. 이러한 경우에, 동일한 RE를 통해 전송되는 CSI-RS 안테나 포트 15번과 16번을 구별하기 위해서, CSI-RS 안테나 포트 15번과 16번 간에는 CDM이 적용된다.

[109] 한편, 서로 다른 RE를 통해 전송되는 CSI-RS 안테나 포트들(예, CSI-RS 안테나 포트 15번, 17번) 간에는 안테나 포트 간 다중화 방식으로써 주파수 분할 다중화(FDM: Frequency Division Multiplexing)가 적용된다. 예를 들어, 도 2에서 슬롯0의 RE(5, 9)와 RE(6, 9)를 통해 CSI-RS 안테나 포트 15번가 전송되고, 슬롯0의 RE(5, 3)와 RE(6, 3)를 통해 CSI-RS 안테나 포트 17번가 전송된다. 이러한 경우에, 서로 다른 RE를 통해 전송되는 CSI-RS 안테나 포트 15번과 17번을 구별하기 위해서, CSI-RS 안테나 포트 15번과 17번 간에는 FDM이 적용된다.

[110] 한편, 본 명세서의 도면들에 표기된 CSI-RS set A는 CSI-RS configuration A번을 의미하고, X, Y는 CSI-RS 안테나 포트의 번호를 나타낸다. 본 명세서의 도면들에 표기된 X_A, Y_A는 CSI-RS configuration A번에서의 CSI-RS 안테나 포트 X번과 Y번을 나타내거나, 또는 단말 A(단, UE-A는 UE-a, UE-b, UE-c, ...)를 위한 CSI-RS 안테나 포트 X번과 Y번을 나타낼 수 있다. 본 명세서에서, CSI-RS 안테나 포트 또는 CSI-RS 안테나 포트 X번이 전송된다는 것은, CSI-RS 안테나 포트의 CSI-RS 또는 CSI-RS 안테나 포트 X번의 CSI-RS가 전송된다는 것을 포함할 수 있다.

[111] 한편, 단말은 PDSCH 레잇 매칭(rate matching)을 수행할 때, ZP CSI-RS로 설정된 RE에 PDSCH가 맵핑되지 않음을 가정한다. ZP CSI-RS는 크게 두 가지 용도로 이용될 수 있다. 첫째로, 기지국은 인접 셀의 CSI-RS가 전송되는 RE에서 신호를 전송하지 않음으로써(즉, 해당 RE에 뮤팅(muting)을 적용함으로써), 인접 셀에 대한 단말의 CSI-RS 측정 성능을 향상시키고자 할 수 있다. 이 때, 기지국은 뮤팅이 적용되는 RE들을 단말에게 ZP CSI-RS 설정을 통해 알려줄 수 있다. 둘째로, 단말의 간섭 신호 측정을 위한 자원을 설정하기 위한 용도로, ZP CSI-RS가 설정될 수 있다. 현재 규격에 따르면, Release 12 TDD eIMTA(enhanced interference mitigation & traffic adaptation)가 설정된 단말을 제외하고는, 간섭 신호의 측정에 이용되는 CSI-IM 자원은 항상 단말에게 설정된 ZP CSI-RS 자원 영역 내에서만 설정될 수 있다.

[112] 한편, LTE 규격은 전송 모드(TM: transmission mode) 10의 CoMP 기반 PDSCH

전송을 위해, DCI(downlink control information) 포맷 2D 내에 PQI(PDSCH RE mapping and quasi-co-location indicator) 필드를 정의하였다. PQI 필드에 기초해, 단말은 DCI 포맷 2D를 통해 스케줄링되는 PDSCH의 RE 맵핑 정보와 PDSCH 안테나 포트의 의사 동일 위치성(QCL: quasi-co-location) 정보를 획득할 수 있다. PQI 필드는 2 비트로 구성되고, 아래의 표 1과 같이 비트열의 값에 따라 최대 4개의 파라미터 집합 (parameter set)을 지시(indicate)할 수 있다.

[113] [표1]

PQI field in DCI format 2D

Value of 'PDSCH RE Mapping and Quasi-Co-Location Indicator' field	Description
'00'	Parameter set 1 configured by higher layers
'01'	Parameter set 2 configured by higher layers
'10'	Parameter set 3 configured by higher layers
'11'	Parameter set 4 configured by higher layers

[114] 이하에서는, 상기 파라미터 집합을 PQI 파라미터 집합이라 부르기로 한다. 4개의 PQI 파라미터 집합 각각은 파라미터 crs-PortsCount-r11, 파라미터 crs-FreqShift-r11, 파라미터 mbsfn-SubframeConfigList-r11, 파라미터 csi-RS-ConfigZPId-r11, 파라미터 pdsch-Start-r11, 및 파라미터 qcl-CSI-RS-ConfigNZPId-r11을 포함할 수 있다. PQI 파라미터 집합은 RRC 시그널링을 통해 단말에게 설정될 수 있다.

[115] 한편, 기지국이 단말에게 DPS(dynamic point selection) 전송을 지원하고자 하는 경우에, 각 PQI 파라미터 집합은 서로 다른 셀 또는 TP(이하에서는 '셀 또는 TP'를 TP로 통칭함)에 대응될 수 있다. 이러한 DPS 전송에 대해서는, 도 4를 참고하여 자세히 설명한다.

[116]

[117] 도 4는 단말이 복수의 TP로부터 하향링크 협력 전송을 수신하는 경우를 나타내는 도면이다. 도 4에서는 설명의 편의를 위해, 기지국에 의해 제어되는 3개의 인접한 TP들(TP1, TP2, TP3)이 단말에 대한 신호 전송을 위해 협력하는 경우를 예시하였다.

[118] 기지국은 단말에 3개의 CSI 프로세스를 이용하여 각 TP(TP1~TP3)에 대한 CSI-RS 및 CSI-IM을 설정할 수 있고, 단말은 이에 따라 각 TP(TP1~TP3)에 대하여 독립적으로 CSI 측정 및 보고를 수행할 수 있다.

[119] 기지국은 단말이 보고한 CSI를 기반으로 TP(TP1~TP3) 중에서 단말에게 PDSCH를 전송할 TP를 선택하고, 선택된 TP를 통해 해당 단말을 위한 PDSCH를 전송한다. 이 때 기지국은 PDSCH 스케줄링 정보를 포함하는 DCI 포맷 2D의 PQI 필드를 통해, PDSCH를 전송하는 TP에 대응하는 PQI 파라미터 집합을

지시함으로써, 단말에게 해당 PDSCH가 어떤 TP로부터 전송되었는지를 암시적으로(implicitly) 알려줄 수 있다.

[120] 한편, 기지국은 TP들(TP1~TP3)이 전송하는 CSI-RS가 동일한 자원 상에 오버랩되어 전송되도록 설정할 수도 있고, 서로 간의 간섭을 회피하기 위해 서로 다른 자원에서 전송되도록 설정할 수도 있다. 후자의 경우에, 각 TP(TP1~TP3)는 CoMP 협력 집합 내 다른 TP들에 의해 CSI-RS가 전송되는 RE들을 ZP CSI-RS로써 설정하고 뮤팅을 수행함으로써, 단말의 CSI-RS 채널 추정 성능을 향상시킬 수 있다. 상기 DPS 전송에서 상기 후자의 경우를 위한 CSI-RS 자원 설정이 도 5에 예시되어 있다.

[121]

[122] 도 5는 3개의 TP(TP1~TP3)가 하나의 서브프레임 내의 서로 다른 RE들을 이용하여 CSI-RS 자원을 설정하는 방법을 나타내는 도면이다.

[123] 도 5에 예시된 바와 같이, 3개의 TP(TP1~TP3)의 NZP CSI-RS RE 집합들은 하나의 서브프레임 내에서 서로 다른 자원 영역에 설정된다. 도 5에서는 각 TP(TP1~TP3)의 CSI-RS 안테나 포트 수가 4인 경우를 예시하였다. 예를 들어, 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 3), 및 RE(6, 3)에는, TP(TP1)을 위한 CSI-RS 안테나 포트 15~18번이 맵핑된다. 다른 예를 들어, 슬롯1의 RE(2, 9), RE(3, 9), RE(2, 3), 및 RE(3, 3)에는, TP(TP2)을 위한 CSI-RS 안테나 포트 15~18번이 맵핑된다. 또 다른 예를 들어, 슬롯1의 RE(2, 8), RE(3, 8), RE(2, 2), 및 RE(3, 2)에는, TP(TP3)을 위한 CSI-RS 안테나 포트 15~18번이 맵핑된다.

[124]

[125] 도 6은 단말을 위한 PDSCH RE를 맵핑하는 방법을 나타내는 도면이다.

[126] 현재 규격에 의하면 전송 모드 10 기반의 하향링크 PDSCH를 수신하는 단말은 각 CSI 프로세스마다 설정된 NZP CSI-RS 자원 영역 모두에서 PDSCH 데이터가 전송되지 않음을 가정한다. 예를 들어, 단말이 도 5에 예시된 바와 같이, CRS, DMRS, 및 CSI-RS를 설정받은 경우에, 단말이 가정하는 PDSCH의 RE 맵핑은 도 6에 예시된 바와 같을 수 있다. 도 6에서는 PDCCH(physical downlink control channel) 영역의 OFDM 심볼 수가 3인 경우를 예시하였다. 구체적으로, 슬롯0의 OFDM 심볼 0~2번에 해당하는 RE들 중 일부는 CRS RE로써 설정되고, 나머지는 PDCCH RE로써 설정된다. 슬롯0의 OFDM 심볼 3~6번과 슬롯1의 0~6번에 해당하는 RE들 중 일부는 CRS RE로써, 일부는 DMRS RE로써, 일부는 CSI-RS RE로써, 나머지는 PDSCH RE로써 설정된다. 도 6에 예시된 바와 같이, 3개의 TP(TP1~TP3)의 CSI-RS RE 집합에는 PDSCH가 맵핑되지 않는다.

[127] 한편, FD-MIMO가 적용되는 시스템의 경우에, 대규모 안테나 배열 이득을 충분히 얻기 위해, CoMP 협력 집합에 속한 각 TP가 다수의 CSI-RS 안테나 포트를 전송하는 경우가 고려될 수 있다. 예를 들어, 도 4의 예시에서, 3개의 TP(TP1~TP3) 각각이 16, 32, 또는 64개의 CSI-RS 안테나 포트를 전송할 수 있다. 이 때, 각 TP(TP1~TP3)의 CSI-RS 전송 주기가 5 ms라고 하면, CSI-RS 전송

오버헤드가 하향링크 전체 자원 영역에서 차지하는 비중은 CSI-RS 포트 수가 16, 32, 64인 경우에, 각각 5.71%, 11.43%, 22.86%로 매우 큰 비중을 차지한다. 따라서 기존과 같이 단말에게 설정된 모든 NZP CSI-RS 자원을 제외한 영역에서 PDSCH를 전송하면, PDSCH 전송 자원의 감소로 인해 오히려 데이터 전송률이 떨어질 수 있다. 즉, 다중 셀 협력 전송 기법과 FD-MIMO의 결합이 제한적일 수 있다. 이러한 CSI-RS 전송 오버헤드 문제는 FD-MIMO 시스템에서 더욱 두드러지나, 비단 이 경우에만 국한되지 않고, TP들이 기존 규격이 지원하는 범위 내에서 CSI-RS를 전송하는 경우에도 마찬가지로 해결해야 할 과제이다.

[128] 이하에서는, 상기 문제점(예, CSI-RS 전송 오버헤드 문제 등)을 해결하기 위한 방법에 대해서 설명한다. 구체적으로, 단말의 CSI 보고를 위해 설정된 NZP CSI-RS 자원 영역의 일부가 해당 단말의 PDSCH 수신을 위해 이용될 수 있도록, 하향링크 제어 정보를 설계하는 방법 및 하향링크 제어 정보를 시그널링하는 방법에 대해서 설명한다. 더욱 구체적으로는, 아래의 방법 Ma100의 개념을 사용하기 위한 다양하고 구체적인 방법들에 대해서 설명한다.

[129] 방법 Ma100은 NZP CSI-RS configuration(또는 NZP CSI-RS ID)에 의해 단말에게 설정된 CSI-RS RE 집합에 단말이 수신하고자 하는 PDSCH가 맵핑되었는지 여부(이하 'PDSCH 맵핑 여부')를, 단말에게 알려주는 방법이다. NZP CSI-RS ID는 NZP CSI-RS configuration을 나타내는 식별자이다.

[130] Release 12 규격에 따르면, CSI 프로세스는 하나의 CSI-RS configuration을 포함하고, CSI-RS configuration은 고유의 NZP CSI-RS ID를 가진다. 한편, FD-MIMO를 위해 Release-13에 도입된 CSI 프로세스는, CSI 보고 유형에 따라 클래스-A와 클래스-B로 구분된다. 클래스-B의 CSI 보고를 위한 CSI 프로세스(이하 '클래스-B CSI 프로세스')는 복수의 NZP CSI-RS configuration을 포함할 수 있고, 클래스-B CSI 프로세스에 포함되는 각 NZP CSI-RS configuration은 고유의 NZP CSI-RS ID를 가진다.

[131] 방법 Ma100은 단말이 전송 모드(TM) 10으로 설정되어 있고 DCI 포맷 2D에 의해 스케줄링된 PDSCH를 수신하는 경우에 주로 적용될 수 있다. 방법 Ma100에서 PDSCH 맵핑 여부를 기지국이 단말에게 알려주는 데 이용될 수 있는 시그널링으로는, 물리계층 시그널링(예, 물리계층 제어 채널의 제어 필드 파라미터), MAC(media access control) 시그널링(예, MAC PDU(protocol data unit) 형태의 제어 정보, 또는 MAC 헤더 형태의 제어 정보), RRC 시그널링(예, RRC 제어 메시지 또는 IE(information element) 형태의 제어 파라미터) 등이 고려될 수 있다. 특히, 물리계층 시그널링 또는 MAC 시그널링 방식을 통한 제어 시그널링은, 해당 단말을 위한 스케줄링 정보와 함께 구성되거나 또는 동시에 전송되는 방법을 통하여 동적(dynamic) 자원 활용이 가능하다는 장점을 가질 수 있다. 또 다른 방법으로써, RRC 시그널링을 이용하여 단말에게 방법 Ma100의 적용 여부와 설정 정보를 알리고, 물리계층 시그널링 또는 MAC 시그널링을 통하여 CSI-RS RE 집합에 대한 PDSCH 맵핑 여부만을 알리는 방법이 사용될

수도 있다.

[132] 단말은 방법 Ma100에 기초해 어떤 NZP CSI-RS configuration에 의해 설정된 CSI-RS RE 집합에서 PDSCH를 수신하도록 지시받은 경우에, 해당 RE 집합에서 CSI-RS와 PDSCH가 혼합된 신호를 수신하는 것을 기대할 수 있다. 이 때, 단말은 CSI-RS와 PDSCH는 CoMP 협력 집합 내의 서로 다른 TP에서 각각 전송됨을 기대할 수 있다. 이는 규격에 명시적으로 정의될 수도 있으나, 규격에 명시적으로 드러내지 않고 단말이 방법 Ma100에 기초한 PDSCH 수신 지시에 의해 암시적으로 이를 알 수 있도록 하는 방법도 가능하다. 따라서 이 경우에, 단말은 해당 RE 집합에서 CSI-RS 기반 채널 추정과 PDSCH 데이터 검출 및 복호를 모두 수행할 수 있다. 이를 위해, 단말은 3가지 수신 방식들(동시(joint) 채널 추정 및 데이터 복호, SIC(successive interference cancellation)의 적용(단, CSI-RS 우선), SIC의 적용(단, PDSCH 우선)) 중 하나를 사용할 수 있다.

[133] 구체적으로, 단말이 동시 채널 추정 및 데이터 복호 방식을 사용하는 경우에, CSI-RS 기반 채널 추정과 PDSCH 데이터 복호를 동시에 한꺼번에(jointly) 수행할 수 있다. 또는 단말이 CSI-RS를 우선으로 하는 SIC 방식을 사용하는 경우에, 먼저 PDSCH 신호를 간섭으로 간주한 상태에서 CSI-RS 기반의 채널 추정을 수행하고, 다음으로 수신 신호에서 CSI-RS 신호를 제거한 후 PDSCH 복호를 수행할 수 있다. 또는 단말이 PDSCH를 우선으로 하는 SIC 방식을 사용하는 경우에, 먼저 CSI-RS 신호를 간섭으로 간주한 상태에서 PDSCH 데이터 복호를 수행하고, 다음으로 수신 신호에서 PDSCH 신호를 제거한 후 CSI-RS 기반의 채널 추정을 수행할 수 있다.

[134] 상술한 동시 채널 추정 및 데이터 복호 방법은, 채널 추정과 데이터 복호를 반복적(iterative)으로 수행하는 방법을 포함할 수 있다. 이 때, 단말은 첫 단계로 채널 추정을 먼저 수행할 수도 있고, 데이터 복호를 먼저 수행할 수도 있다. 상술한 3가지의 방식들 중 첫 번째 방식(동시 채널 추정 및 데이터 복호 방식) 및 두 번째 방식(CSI-RS를 우선으로 하는 SIC 방식)은, 다중 셀 협력 전송의 경우 외에도, 단말이 인접 셀로부터 강한 CSI-RS 간섭을 수신하는 경우에 PDSCH의 수신 성능 향상을 위해 적용될 수 있다. 그러나 다중 셀 협력 전송이 아닌 경우에는 기지국이 인접 셀(들)의 CSI-RS 설정 정보를 단말에게 별도의 시그널링을 통해 알려주고, 단말은 해당 인접 셀(들)로부터 수신하는 CSI-RS 간섭 신호를 이용하여 인접 셀(들)에 대한 채널 추정을 추가적으로 수행해야 하므로, 시그널링 오버헤드와 단말의 수신 복잡도가 증가할 수 있다. 반면에 다중 셀 협력 전송(특히, DPS)을 위해 다수의 CSI 프로세스를 설정받은 단말에 상기 3가지의 수신 방식들이 적용되는 경우에는, 별도의 CSI-RS configuration이 불필요하고 단말의 기존 동작 대비 복잡도 증가가 크지 않을 수 있다는 장점이 있다.

[135] 단말은 자신이 상술한 간섭 제거 수신 기능을 지원하는지 여부에 대한 캐퍼빌리티(capability) 정보를 기지국에게 전송할 수 있다. 기지국은 단말의

캐퍼빌리티 정보를 이용하여 해당 단말에 본 명세서에서 기술되는 방법들을 적용할지 여부를 판단할 수 있다.

[136] 한편, 방법 Ma100에서 CSI-RS RE 집합에 PDSCH가 맵핑되었는지의 여부를 기지국이 단말에게 지시자 전송을 통해 알려줄 수 있다. 이하에서는, 기지국이 단말에게 PDSCH 맵핑 여부를 알리기 위하여 단말에게 전송하는 지시자를, 맵핑 지시자라 한다. 한편, 기지국은 단말에게 PDSCH 맵핑 여부를 암시적인 시그널링을 통해 알려줄 수도 있다. 여기서 암시적인 시그널링을 통해 알려주는 방법은, 맵핑 지시자의 형태가 아닌 다른 형태의 시그널링, 또는 단말에게 다른 용도로 전송되는 시그널링을 이용하는 방법을 포함할 수 있다. 본 명세서에서, 맵핑 지시자를 설정하거나 전송한다는 것은, 상기 암시적인 시그널링을 통해 알려주는 것을 포함할 수 있다.

[137] 이 때 단말에게 PDSCH를 전송하는 TP는 PDSCH가 전송되는 RE에서 동시에 CSI-RS를 전송할 수 없으므로, 맵핑 지시자의 유효 범위는 CoMP 협력 집합 내의 TP들 중에서 단말에게 PDSCH를 전송하는 TP를 제외한 나머지 TP(들)에 대한 CSI-RS RE 집합(들)이 될 수 있다. 즉, 현재 규격에 따르면, 단말은 QCL type B로 설정된 경우에, DCI 포맷 2D에 의해 지시되는 PQI 파라미터 집합의 'qcl-CSI-RS-ConfigNZPId-r11'이 가리키는 하나의 NZP CSI-RS ID에 대응하는 CSI-RS RE 집합에는 상기 맵핑 지시자가 적용되지 않으며, 단말은 이 CSI-RS RE 집합에서 PDSCH를 수신하는 것을 기대하지 않을 수 있다.

[138] 한편, 하나의 PQI 파라미터 집합 내에서 PDSCH와 동일한 QCL이 가정되는 NZP CSI-RS ID는 향후 복수 개로 확장될 수 있다. 이 경우에, 상기 맵핑 지시자의 유효 범위는, 단말에 설정된 NZP CSI-RS ID(들) 중에서, DCI 포맷 2D에 의해 단말에 지시되는 PQI 파라미터 집합 내 QCL 가정을 위한 NZP CSI-RS ID(들)(이하 'QCL NZP CSI-RS ID(들)')을 제외한 나머지 NZP CSI-RS ID(들)에 대한 CSI-RS RE 집합(들)이 될 수 있다. 현재 규격에 따르면, QCL type B인 경우, QCL NZP CSI-RS ID는 'qcl-CSI-RS-ConfigNZPId-r11'이 가리키는 하나의 NZP CSI-RS ID를 의미한다. QCL NZP CSI-RS ID는 향후 복수의 NZP CSI-RS configuration에 대응될 수 있다. 이 경우에, 상기 맵핑 지시자의 유효 범위는, QCL NZP CSI-RS ID(들)에 대응되는 모든 CSI-RS configuration(들)을 제외한 나머지 CSI-RS configuration(들)에 대한 CSI-RS RE 집합(들)이 될 수 있다.

[139] 또한 QCL NZP CSI-RS ID에 대응하는 CSI-RS 자원 영역과 QCL NZP CSI-RS ID(들)을 제외한 다른 NZP CSI-RS ID에 대응하는 CSI-RS 자원 영역이 일부 또는 완전히 겹치는 경우에도, 단말은 QCL NZP CSI-RS ID에 대응하는 CSI-RS 자원 영역에서 PDSCH를 수신하는 것을 기대하지 않을 수 있다. 이 때, 다른 NZP CSI-RS ID에 대한 맵핑 지시자의 적용 범위는, 해당 CSI-RS 자원 영역에서 QCL NZP CSI-RS ID에 대응하는 CSI-RS 자원 영역을 제외한 나머지 영역이 될 수 있다.

[140] 또는, 단말에게 PDSCH를 전송하는 TP와 PDSCH를 전송하지 않는 TP를

구분하지 않고, CoMP 협력 집합 내의 모든 TP들을 맵핑 지시자의 유효 범위에 포함시키는 방법이 고려될 수도 있다. 즉, 단말은 QCL NZP CSI-RS ID(들)을 포함한 모든 NZP CSI-RS ID(들)에 대한 CSI-RS RE 집합(들)에서 맵핑 지시자에 의해 PDSCH를 수신하는 것을 가정할 수 있다. 이 경우에, 기지국은 어떤 TP에서도 CSI-RS와 PDSCH가 동일 자원 상에 맵핑되지 않도록 PDSCH를 스케줄링할 수 있다. 단말은 스케줄링받은 PDSCH의 자원이 CoMP 협력 집합에 포함되는 모든 TP의 CSI-RS 자원과 일부 또는 전부 오버랩되는 경우에, DCI의 설정 또는 수신 오류로 간주하고 해당 서브프레임에서 PDSCH를 수신하지 않을 수 있다. 또는 상기 경우에도, 단말은 맵핑 지시자에 따른 동작을 동일하게 수행함을 가정할 수도 있다.

[141] 이하에서는 RRC 시그널링에 의해 맵핑 지시자를 단말에 설정하는 방법에 대하여 설명한다.

[142] 방법 Ma110은, 맵핑 지시자가 PQI 파라미터 집합별로 설정될 수 있고, 하나의 맵핑 지시자는 단말에 설정된 NZP CSI-RS ID들에 대해서 공통적으로 적용되는 방법이다.

[143] 예를 들어, 방법 Ma110에서 맵핑 지시자는 1 비트일 수 있다. 기지국은 단말에게 1 비트의 맵핑 지시자를 통해, QCL NZP CSI-RS ID(들)을 제외한 나머지 NZP CSI-RS ID들에 대응하는 CSI-RS RE 집합에 대한 PDSCH RE 맵핑을 가정할 지 여부를 알려줄 수 있다. 또는, 기지국은 단말에게 1 비트의 맵핑 지시자를 통해, PQI 파라미터 집합별로, QCL NZP CSI-RS ID(들)을 포함한 모든 NZP CSI-RS ID들에 대응하는 CSI-RS RE 집합에 대한 PDSCH RE 맵핑을 가정할 지 여부를 알려줄 수 있다.

[144] 방법 Ma110에서 맵핑 지시자는 각 PQI 파라미터 집합 내에 포함되어 정의될 수 있다.

[145]

[146] 도 7은 본 발명의 실시예에 따른, 기지국이 방법 Ma110을 이용하는 경우에 단말을 위한 PDSCH RE를 맵핑하는 방법을 나타내는 도면이다.

[147] 설명의 편의를 위해서, 도 4의 DPS 전송에서 단말이 DCI 포맷 2D를 통해 TP(TP1)로부터 PDSCH를 수신하는 경우(즉, 단말에게 스케줄링된 PDSCH의 QCL 정보가 TP(TP1)가 전송하는 NZP CSI-RS의 ID를 포함하는 경우)를 가정하여 방법 Ma110을 설명한다.

[148] 단말이 TP(TP1)로부터 PDSCH를 수신하는 데 필요한 PDSCH RE 맵핑 정보와 QCL 정보가 PQI 파라미터 집합 1에 설정되었다고 가정하자. 기지국은 표 1에 따라 DCI 포맷 2D의 PQI 필드를 00으로 설정(configure)한다. 이 때, 기지국이 방법 Ma110을 사용하면, 단말이 TP(TP2)와 TP(TP3)가 전송하는 CSI-RS의 RE들에서 TP(TP1)의 PDSCH를 수신할 지 여부를, 맵핑 지시자를 통해 설정할 수 있다. 맵핑 지시자는 상술한 바와 같이 1 비트일 수 있고, RRC 시그널링에 의해 단말에 설정될 수 있다. 예를 들어, PQI 파라미터 집합 1에 대응되는 맵핑

지시자의 값이 0인 경우에, 단말은 TP(TP2)와 TP(TP3)에 의해 전송되는 CSI-RS의 RE들에 PDSCH가 맵핑되지 않았음을 가정하고, 도 6에 예시된 PDSCH RE 맵핑을 가정할 수 있다. 반대로 맵핑 지시자의 값이 1인 경우에, 단말은 TP(TP2)와 TP(TP3)에 의해 전송되는 CSI-RS의 RE들에 PDSCH가 맵핑되었음을 가정하고, 도 7에 예시된 PDSCH RE 맵핑을 가정할 수 있다. 구체적으로, 도 7에는 CSI-RS RE들 중에서 PDSCH를 전송하는 TP(TP1)를 위한 CSI-RS RE(예, 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 3), RE(6, 3))를 제외한 나머지 CSI-RS RE들이 PDSCH RE로써 설정되는 경우를 예시하였다. 즉, TP(TP2)를 위한 CSI-RS RE들(예, 슬롯1의 RE(2, 9), RE(3, 9), RE(2, 3), RE(3, 3))과 TP(TP3)를 위한 CSI-RS RE들(예, 슬롯1의 RE(2, 8), RE(3, 8), RE(2, 2), RE(3, 2))이, TP(TP1)의 PDSCH를 송수신하기 위한 RE로써 설정된다. 결국, PDSCH RE는 도 6에 예시된 PDSCH RE와 상기 8개의 RE들(예, RE(2, 9), RE(3, 9), RE(2, 8), RE(3, 8), RE(2, 3), RE(3, 3), RE(2, 2), RE(3, 2))을 포함한다. 상기 8개의 RE들(예, RE(2, 9), RE(3, 9), RE(2, 8), RE(3, 8), RE(2, 3), RE(3, 3), RE(2, 2), RE(3, 2))에서는, TP(TP2, TP3)의 CSI-RS와 TP(TP1)의 PDSCH가 송수신될 수 있다.

[149] 한편, 맵핑 지시자의 값이 1인 경우에, 단말은 해당 8개의 RE들(예, RE(2, 9), RE(3, 9), RE(2, 8), RE(3, 8), RE(2, 3), RE(3, 3), RE(2, 2), RE(3, 2))에서 CSI-RS 기반의 채널 추정과 PDSCH 수신을 모두 수행해야 하는 부담이 있으나, 기지국 그리고/또는 단말이 PDSCH에 대한 CSI-RS 간섭을 적절히 제어하는 경우에 PDSCH 수신 성능을 높이거나 전송 용량을 증대시킬 수 있다.

[150] 방법 Ma110의 다른 예로써, 맵핑 지시자의 값이 0인 경우에, 단말은 CoMP 협력 집합에 포함되는 모든 TP들(예, TP1, TP2, TP3)에 의해 전송되는 CSI-RS의 RE들(즉, 단말에 설정된 모든 NZP CSI-RS ID에 대한 CSI-RS RE 집합(들))에 PDSCH가 맵핑되지 않았음을 가정할 수 있다. 반대로 맵핑 지시자의 값이 1인 경우에, 단말은 CoMP 협력 집합에 포함되는 모든 TP들(예, TP1, TP2, TP3)에 의해 전송되는 CSI-RS의 RE들에 PDSCH가 맵핑되었음을 가정할 수 있다.

[151] 방법 Ma110에서, DCI 포맷 2D의 PQI 필드가 가리키는 PQI 파라미터 집합의 QCL NZP CSI-RS ID(들)을 포함하는 CSI 프로세스가 클래스-B CSI 프로세스인 경우에, 단말은 맵핑 지시자가 해당 클래스-B CSI 프로세스에 포함되는 모든 NZP CSI-RS ID들에 적용됨을 가정할 수 있다. 또는 상기 경우에, 단말은 맵핑 지시자가 해당 클래스-B CSI 프로세스에 포함되는 NZP CSI-RS ID들 중 일부에 적용됨을 가정할 수도 있다. 또는 상기 경우에, 단말은 맵핑 지시자가 해당 클래스-B CSI 프로세스에 포함되는 NZP CSI-RS ID들 중에 PQI 파라미터 집합 내에 설정된 QCL NZP CSI-RS ID(들)에만 적용됨을 가정할 수도 있다. 상기의 경우에, 단말은 맵핑 지시자가 적용되지 않는 NZP CSI-RS ID에 의해 설정된 CSI-RS RE 집합에는 맵핑 지시자의 값과 무관하게 항상 PDSCH가 전송되지 않음을 가정할 수도 있다.

[152] 방법 Ma111은, 맵핑 지시자가 PQI 파라미터 집합별로 설정될 수 있고, 하나의

PQI 파라미터 집합 내에서 맵핑 지시자는 NZP CSI-RS ID별로 설정될 수 있는 방법이다.

[153] 방법 Ma111은 방법 Ma110보다 더 세부적인 설정이 가능한 방법이다. 예를 들어, 맵핑 지시자는 1 비트일 수 있고, 맵핑 지시자는 단말에게 설정된 NZP CSI-RS ID 중에서 QCL NZP CSI-RS ID(들)을 제외한 나머지 NZP CSI-RS ID 각각을 위해 정의될 수 있다. 이 경우에, 각 PQI 파라미터 집합별 맵핑 지시자의 수는 상기 나머지 NZP CSI-RS ID들의 개수의 최대값일 수 있다. Release 12 규격에 따르면 단말은 최대 3개의 CSI 프로세스를 설정받을 수 있고, 하나의 CSI 프로세스는 하나의 NZP CSI-RS ID를 가질 수 있으므로, 맵핑 지시자의 수는 최대 2일 수 있다.

[154] Release 13 규격에 의하면, 클래스-B CSI 보고를 지원하는 단말은 CSI 프로세스당 NZP CSI-RS ID를 최대 8개까지 설정받을 수 있으므로, 이 경우에 PQI 파라미터 집합별 맵핑 지시자의 수는 최대 16일 수 있다.

[155] 또는 방법 Ma111에서, PQI 파라미터 집합별로, 맵핑 지시자는 단말에게 설정된 모든 NZP CSI-RS ID 각각을 위해 정의될 수 있다. 이 경우에, PQI 파라미터 집합별 맵핑 지시자의 수는 단말에게 설정된 NZP CSI-RS ID의 수와 같을 수 있다.

[156] 방법 Ma111에서 하나 또는 복수의 맵핑 지시자들은 각 PQI 파라미터 집합 내에 포함되어 정의될 수 있다. 예를 들어, 도 4의 DPS 전송에서 단말이 DCI 포맷 2D를 통해 TP(TP1)로부터 PDSCH를 수신하는 경우를 가정하면, 기지국은 단말을 위한 PQI 파라미터 집합 내에서 NZP CSI-RS ID 별로 맵핑 지시자를 설정함으로써, 해당 단말에게 PDSCH를 전송하지 않는 TP들(TP2, TP3)을 위한 CSI-RS RE 중에서 일부 TP(예, TP2)를 위한 CSI-RS RE를 PDSCH RE로써 설정하고 나머지 TP(예, TP3)를 위한 CSI-RS RE를 PDSCH RE로써 설정하지 않을 수 있다.

[157] 방법 Ma112는, 맵핑 지시자가 PQI 파라미터 집합별로 설정될 수 있고, 하나의 PQI 파라미터 집합 내에서 맵핑 지시자는 CSI 프로세스별로 설정될 수 있는 방법이다.

[158] 방법 Ma112에서, 예를 들어, 맵핑 지시자는 1 비트일 수 있고, 맵핑 지시자는 단말에게 설정된 CSI 프로세스 중에서 PQI 필드에 의해 지시되며 QCL NZP CSI-RS ID(들)을 포함하는 CSI 프로세스를 제외한 나머지 CSI 프로세스 각각을 위해 정의될 수 있다. 또는 방법 Ma112에서, PQI 파라미터 집합별로, 맵핑 지시자는 단말에 설정된 모든 CSI 프로세스 각각을 위해 정의될 수 있다. 클래스-B CSI 프로세스를 설정받은 단말에 대하여, 방법 Ma111은 PQI 파라미터 집합별로 다수의 맵핑 지시자를 설정해야 할 수도 있는 반면에, 방법 Ma112는 PQI 파라미터 집합별 맵핑 지시자의 수가 해당 캐리어 내에서 단말에 설정된 CSI 프로세스 수를 넘지 않는다.

[159] 방법 Ma113은, 맵핑 지시자가 모든 PQI 파라미터 집합과 모든 NZP CSI-RS

ID들에 공통적으로 적용되는 방법이다.

[160] 방법 Ma113은 단말이 DCI 포맷 2D의 PQI 필드 값과 무관하게, 단일 맵핑 지시자의 설정값을 따라 PDSCH 레잇 매칭(rate matching) 및 PDSCH 자원 요소 맵핑을 수행하는 방법이다. 이 때, 맵핑 지시자는 1 비트일 수 있다. 다중 셀 협력 통신은, 통상적으로 셀 경계(또는 TP 경계)의 단말이 복수의 TP들로부터 비슷한 장기(long-term) 채널 특성을 겪을 때 동적인 TP 선택에 의한 단기(short-term) 채널 선택 이득을 얻고자 하는 방법이다. 상기 맵핑 지시자가 반고정적인 RRC 시그널링에 의해 전송되는 경우에는, CSI-RS 간섭 제거 후의 PDSCH 수신 성능을 보장하는 것은 방법 Ma113으로 충분할 수 있다.

[161] 방법 Ma113에서도 마찬가지로, QCL NZP CSI-RS ID(들)에는 맵핑 지시자가 적용되지 않을 수 있다. 즉, 단말은 QCL NZP CSI-RS ID(들)에 대응하는 CSI-RS RE 집합에서는 PDSCH를 수신하는 것을 기대하지 않을 수 있다. 또는 방법 Ma113에서, QCL NZP CSI-RS ID(들)에도 맵핑 지시자가 동일하게 적용될 수 있다. 즉, 단말은 맵핑 지시자 값에 따라, QCL NZP CSI-RS ID(들)에 대응하는 CSI-RS RE 집합에서도 PDSCH를 수신하는 것을 기대할 수 있다.

[162] 한편, 방법 Ma113에서 맵핑 지시자는 PQI 파라미터 집합과 동일한 또는 상위 레벨의 정보에 포함될 수 있다.

[163] 한편, 상술한 바와 같이, 다중 셀 협력 전송이 아닌 경우에는 기지국이 인접 셀(들)의 CSI-RS configuration 정보를 단말에게 별도의 시그널링을 통해 알려주어야 하는데, 이러한 경우에, 기지국이 각 인접 셀에 대한 CSI-RS configuration마다 상기 맵핑 지시자를 정의하고 이를 CSI-RS configuration과 함께 단말에게 알려주는 방법이 사용될 수도 있다. 또는 방법 Ma113과 유사하게, 하나의 맵핑 지시자를 정의하고 이를 모든 인접 셀(들)에 대한 CSI-RS configuration에 공통적으로 적용하는 방법이 고려될 수도 있다.

[164] 이하에서는 물리계층 시그널링에 의해 맵핑 지시자를 단말에게 설정하는 방법에 대하여 설명한다.

[165] 방법 Ma120은, 단말의 PDSCH 스케줄링 정보를 포함하는 하향링크 DCI에 맵핑 지시자를 포함시키는 방법이다.

[166] 단말은 하향링크 DCI에 포함된 맵핑 지시자를 통해, 자신이 설정받은 CSI-RS RE 집합(들)에 PDSCH 데이터가 맵핑되었는지 여부를 동적으로 지시받을 수 있다. 기지국은 단말의 채널 상태에 따라, 단말이 서로 다른 TP에 의해 전송되는 CSI-RS와 PDSCH를 어떤 CSI-RS RE 집합에서 모두 성공적으로 수신할 수 있다고 판단되는 경우에, PDSCH 전송을 위해 해당 RE 집합을 추가로 이용하고, 그렇지 않다고 판단되는 경우에는, 해당 RE 집합에 PDSCH 데이터를 맵핑시키지 않을 수 있다.

[167] CoMP 전송인 경우(즉, 하향링크 DCI가 DCI 포맷 2D인 경우)에, 방법 Ma120에서 맵핑 지시자는 단말에게 설정된 NZP CSI-RS ID 중에서 QCL NZP CSI-RS ID(들)을 제외한 나머지 모든 NZP CSI-RS ID(들)을 위해 공통으로

정의되거나(방법 Ma110과 유사), 나머지 NZP CSI-RS ID 별로 각각 정의될 수 있다(방법 Ma111과 유사). 전자의 경우에 맵핑 지시자를 위한 필드는 1 비트일 수 있다. 또는 방법 Ma120에서 맵핑 지시자는 단말에게 설정된 NZP CSI-RS ID 중에서 QCL NZP CSI-RS ID(들)을 포함한 모든 NZP CSI-RS ID(들)을 위해 공통으로 정의되거나(방법 Ma110과 유사), 모든 NZP CSI-RS ID에 대하여 각각 정의될 수 있다(방법 Ma111과 유사). 전자의 경우에, 맵핑 지시자를 위한 필드는 1 비트일 수 있다.

[168] CoMP 전송이 아닌 경우에, 방법 Ma120에서 맵핑 지시자는 모든 인접 셀(들)의 NZP CSI-RS configuration을 위해 공통으로 정의되거나, 인접 셀의 NZP CSI-RS configuration 별로 각각 정의될 수 있다. 전자의 경우에 맵핑 지시자를 위한 필드는 1 비트일 수 있다.

[169] 방법 Ma120을 구성하는 또 다른 방법으로써, PDSCH 데이터를 맵핑시키고자 하는 RE 집합을 나타내는 NZP CSI-RS ID(들)의 집합, 또는 PDSCH 데이터를 맵핑시키지 않고자 하는 RE 집합을 나타내는 NZP CSI-RS ID(들)의 집합을 RRC 시그널링을 통해 미리 설정해 두고, DCI 내의 맵핑 지시자 필드(또는 이에 상응하는 필드)를 이용하여 단말에게 PDSCH 맵핑 여부를 상기 NZP CSI-RS ID 집합 단위로 동적으로 알려주는 방법이 있다. 상기 NZP CSI-RS ID 집합은 하나 또는 복수 개 설정될 수 있다. 설정 가능한 NZP CSI-RS ID 집합이 하나인 경우, DCI 내의 맵핑 지시자 필드는 1 비트로 충분할 수 있다. 설정 가능한 NZP CSI-RS ID 집합이 N개인 경우에, DCI 내의 맵핑 지시자 필드는 예를 들어 $\text{ceil}(\log_2(N+1))$ 비트를 필요로 할 수 있다. 여기서 ceil(.)는 소수점 이하 올림 연산을 의미한다.

[170] 상기 맵핑 지시자(또는 이에 상응하는 시그널링)에 기초한 방법들은, 단말이 복수의 CSI 프로세스에 의해 복수의 NZP CSI-RS ID를 설정받은 경우에만 적용 가능하도록, 제한될 수도 있다. 또는 상기 맵핑 지시자(또는 이에 상응하는 시그널링)에 기초한 방법들은, 단말이 설정받은 CSI 프로세스 수와 무관하게, 단말이 복수의 NZP CSI-RS ID를 설정받은 경우에만 적용 가능하도록, 제한될 수도 있다. 또는 상기 맵핑 지시자에 기초한 방법들은 단말이 QCL type B로 설정되는 경우에만 적용 가능하도록, 제한될 수도 있다. 단말이 QCL type A로 설정되는 경우에는, 상기 맵핑 지시자에 기초한 방법들의 적용이 불필요할 수 있다.

[171] 이하에서는 동일한 문제(예, CSI-RS 전송 오버헤드 문제 등)를 ZP CSI-RS를 이용하여 해결하는 방법에 대하여 설명한다.

[172] 방법 Ma130은, CoMP 협력 집합에 속한 TP들 중에서 PDSCH를 송신하는 TP를 제외한 나머지 TP(들)에 대해 설정된 CSI-RS RE 집합(들)에서, 단말이 PDSCH를 수신할 것을 기대하는 방법이다.

[173] 현재 규격에 의하면 단말은 하향링크 DCI 중에서 DCI 포맷 2D를 제외한 하향링크 DCI를 통해 PDSCH를 스케줄링받는 경우에, 단말은 서빙 셀에 의해 전송되는 CSI-RS의 RE들에서는 PDSCH가 전송되지 않고 인접 셀에 의해

전송되는 CSI-RS의 RE들에서는 해당 영역이 ZP CSI-RS로 설정되지 않는 한 PDSCH가 전송됨을 가정하므로, 단말은 이미 방법 Ma130을 따르고 있다. 그러나 단말이 DCI 포맷 2D를 통해 PDSCH를 스케줄링받는 경우에는, 단말은 자신이 설정받은 모든 NZP CSI-RS RE들을 제외한 자원 영역에 대해 PDSCH RE 맵핑을 수행하도록 되어 있다. 방법 Ma130이 사용되면, 단말은 후자의 경우에, 단말에게 설정된 NZP CSI-RS ID 중에서 DCI에 의해 지시되는 QCL NZP CSI-RS ID(들)을 제외한 나머지 NZP CSI-RS ID(들)에 대응하는 RE 집합(들)에서 해당 영역이 ZP CSI-RS로 설정되지 않는 한 PDSCH가 전송됨을 가정한다. 따라서 기지국은 단말에 설정된 어떤 CSI-RS RE 집합을 해당 단말로의 PDSCH 전송을 위해 이용하고자 하는 경우에, 해당 CSI-RS RE 집합을 ZP CSI-RS로 설정하지 않을 수 있고, 해당 CSI-RS RE 집합을 해당 단말로의 PDSCH 전송을 위해 이용하지 않고자 하는 경우에, 해당 CSI-RS RE 집합을 ZP CSI-RS로 설정할 수 있다. 도 4에 예시된 DPS 전송을 가정하면, 도 7에 예시된 PDSCH RE 맵핑은 전자의 경우(ZP CSI-RS로써 설정 안하는 경우)에 해당하고, 도 6에 예시된 PDSCH RE 맵핑은 후자의 경우(ZP CSI-RS로써 설정하는 경우)에 해당한다.

[174]

[175] 도 8은 본 발명의 실시예에 따른, 3개의 TP가 2개의 서브프레임 내의 서로 다른 RE들을 이용하여 CSI-RS 자원을 설정하는 방법을 나타내는 도면이다.

[176] DPS 전송에 참여하는 각 TP가 하나의 단말에 전송하는 CSI-RS들이 서로 다른 서브프레임에서 전송되도록 설정될 수도 있다. 이것은, 전송 모드(TM)가 10인 단말이 설정받은 복수의 NZP CSI-RS configuration들이 동일한 서브프레임 내에 설정되지 않은 경우에 대응한다.

[177] 구체적으로, 도 8에는 단말이 3개의 TP(TP1~TP3) 각각에 대하여 4개의 CSI-RS 안테나 포트(15~18번)를 2개의 인접한 서브프레임(서브프레임 n, 서브프레임 n+1)에 걸쳐 설정받은 경우를 예시하였다. 예를 들어, 서브프레임 n의 슬롯0에 속하는 RE(5, 9), RE(6, 9), RE(5, 3), 및 RE(6, 3)은 TP(TP1)을 위한 CSI-RS RE로써 설정되고, 서브프레임 n의 슬롯1에 속하는 RE(2, 9), RE(3, 9), RE(2, 3), 및 RE(3, 3)은 TP(TP2)을 위한 CSI-RS RE로써 설정되고, 서브프레임 n+1의 슬롯1에 속하는 RE(2, 8), RE(3, 8), RE(2, 2), 및 RE(3, 2)은 TP(TP3)을 위한 CSI-RS RE로써 설정된다.

[178] 단말이 DCI 포맷 2D를 통해 TP(TP1)로부터 PDSCH를 수신하는 경우를 가정하자. 방법 Ma130이 사용되면, 기지국은 단말이 TP(TP2)과 TP(TP3)에 의해 전송되 CSI-RS의 RE들에서 PDSCH를 수신할 지 여부를, ZP CSI-RS 설정을 통해 결정한다. 그러나 현재 규격에서 단말은 PQI 파라미터 집합별로 하나의 ZP CSI-RS configuration만을 설정받을 수 있다. 결국, 단말이 TP(TP2)와 TP(TP3)에 의해 전송되는 CSI-RS의 RE들 전부에서 PDSCH를 수신하지 않도록 설정하는 것은, 2개의 ZP CSI-RS configuration이 요구되므로, 현재 규격에서는 불가능하다.

[179] 한편, 향후 FD-MIMO를 지원하기 위한 다수의 CSI-RS 안테나 포트를 설정하는

방법으로써, 하나의 CSI 프로세스를 통해 하나 또는 복수의 NZP CSI-RS configuration들을 복수의 서브프레임에 걸쳐 설정하는 방법이 고려될 수 있다. 이 경우에도, 단말의 정확한 PDSCH 레잇 매칭(rate matching)을 위해서, PQI 파라미터 집합마다 복수의 ZP CSI-RS configuration을 설정하는 것이 필요할 수도 있다. 또는 방법 Ma130이 사용되지 않는 경우라 하더라도, 예를 들어, DPS 전송에 참여하는 TP가 복수의 단말에 대한 CSI-RS를 서로 다른 서브프레임에서 전송하는 경우에, 마찬가지로 복수의 ZP CSI-RS ID가 필요할 수도 있다.

[180] 방법 Ma131은, 각 PQI 파라미터 집합이 복수의 ZP CSI-RS ID를 포함하는 방법이다. ZP CSI-RS ID는 ZP CSI-RS configuration을 나타내는 식별자이다.

[181] ZP CSI-RS 설정 주기가 최소 5 ms임을 고려하면, 방법 Ma131에서 하나의 PQI 파라미터 집합에 포함될 수 있는 ZP CSI-RS ID의 수는, 최대 5개일 수 있다. 또는 RRC 시그널링 오버헤드를 고려하여, 하나의 PQI 파라미터 집합에 포함될 수 있는 ZP CSI-RS ID의 수는 2개 또는 3개로 제한될 수 있다.

[182] 한편, 기존 규격에서 하나의 단말이 설정받을 수 있는 Release 11 ZP CSI-RS ID는 최대 4개이므로, 방법 Ma131의 적용을 위해, 하나의 단말이 설정받을 수 있는 ZP CSI-RS ID의 수를 늘리는 방법이 고려될 수 있다. 이와 동시에, DPS 전송에 참여하는 TP의 수가 최대 3개라고 가정하면, 하나의 단말이 설정받을 수 있는 ZP CSI-RS ID의 수는 최대 15개일 수 있다.

[183] 방법 Ma132는, 하나의 ZP CSI-RS ID를 통해 복수의 서브프레임에 ZP CSI-RS를 설정하는 방법이다.

[184] 하나의 ZP CSI-RS ID에 대응하는 RE들의 집합을, ZP CSI-RS RE 집합이라 부르기로 한다. 이에 따르면, 기존 규격에서 하나의 ZP CSI-RS ID 또는 ZP CSI-RS RE 집합은 하나의 ZP CSI-RS configuration에 대응한다.

[185] 방법 Ma132는 각 PQI 파라미터 집합이 기존처럼 하나의 ZP CSI-RS ID만을 포함하되, 하나의 ZP CSI-RS ID가 복수의 ZP CSI-RS configuration 또는 하나의 ZP CSI-RS configuration list에 대응할 수 있도록 하는 방법이다. 예를 들어, 단말에게 설정된 하나의 ZP CSI-RS ID가 3개의 ZP CSI-RS configuration을 나타내는 경우에, 3개의 ZP CSI-RS configuration 각각은 3개의 서브프레임 각각에 적용될 수 있다.

[186] 한편, ZP CSI-RS configuration list에 포함되는 ZP CSI-RS configuration(들)은, 기존 규격의 ZP CSI-RS configuration과 동일할 수 있다. 또는 시그널링 오버헤드를 줄이기 위해, ZP CSI-RS configuration list에 포함되는 모든 configuration들이 동일한 주기성을 가진다고 가정되거나, ZP CSI-RS configuration list에 포함되는 configuration들 간의 상대적인 서브프레임 오프셋만을 단말에게 설정하는 방법이 고려될 수도 있다.

[187] ZP CSI-RS 설정 주기가 최소 5 ms임을 가정하면, 방법 Ma132에서 하나의 ZP CSI-RS ID에 대응하는 ZP CSI-RS configuration의 수는 최대 5일 수 있다.

[188] 방법 Ma132는, 기존의 ZP CSI-RS ID와 ZP CSI-RS configuration과의 관계를

그대로 유지한 채, ZP CSI-RS 그룹 ID를 정의하고, 하나의 ZP CSI-RS 그룹 ID가 복수의 ZP CSI-RS ID를 나타낼 수 있도록 하는 방법으로 해석될 수도 있다.

[189] 한편, 방법 Ma132와, 하나의 단말이 설정받을 수 있는 최대 ZP CSI-RS ID의 수를 늘리는 방법이 동시에 사용되는 방법도 고려될 수 있다. 또한 방법 Ma132와 방법 Ma131이 동시에 사용되는 방법도 고려될 수 있다.

[190] 방법 Ma133은, DRS(discovery reference signal) 설정을 위해 Release 12에서 도입된 ZP CSI-RS ID를 각 PQI 파라미터 집합에 포함시키는 방법이다.

[191] Release 12에서 도입된 DRS를 수신할 수 있는 단말은, 기존의 Release 11 ZP CSI-RS configuration에 더하여, DRS 설정을 위해 최대 5개의 ZP CSI-RS ID를 추가로 설정받을 수 있다. 따라서 방법 Ma133이 사용되는 경우에, 기지국은 DRS를 지원하는 Release 12 단말에게, 최대 9개의 ZP CSI-RS ID를 이용하여 PDSCH RE 맵핑 정보(또는 PDSCH 맵핑 여부 정보)를 동적으로 전송할 수 있다. 따라서 방법 Ma133은, 현재 규격에 정의되어 있는 ZP CSI-RS ID만으로도, 상기 문제점(예, CSI-RS 전송 오버헤드 문제 등)을 어느 정도 해결할 수 있다.

[192] 방법 Ma130, 방법 Ma131, 방법 Ma132, 또는 방법 Ma133의 ZP CSI-RS 설정 방법은, 단말의 CSI-RS 간섭 제거를 위한 시그널링 이외에 다른 용도로도 이용될 수 있다.

[193]

[194] 2. 하향링크 참조 신호를 전송하는 방법

[195] 2.1. CSI-RS 자원 설정

[196] 본 명세서에서, CSI-RS configuration이라 함은 CSI-RS 자원 설정 그 자체를 의미할 수도 있고, 경우에 따라서는 CSI-RS 자원 설정(resource configuration)에 의해 설정되는 CSI-RS 자원 구성(resource composition) 또는 CSI-RS RE 집합을 의미할 수도 있다.

[197] 노멀 CP에 대한 CSI-RS configuration은 아래의 표 2을 따른다.

[198] [표2]

노멀 CP에 대한 CSI-RS configuration

	CSI-RS configuration	Number of CSI reference signals configured					
		1 or 2		4		8	
		(k',l')	n_s mod 2	(k',l')	n_s mod 2	(k',l')	n_s mod 2
Frame structure type 1 and 2	0	(9,5)	0	(9,5)	0	(9,5)	0
	1	(11,2)	1	(11,2)	1	(11,2)	1
	2	(9,2)	1	(9,2)	1	(9,2)	1
	3	(7,2)	1	(7,2)	1	(7,2)	1
	4	(9,5)	1	(9,5)	1	(9,5)	1
	5	(8,5)	0	(8,5)	0		
	6	(10,2)	1	(10,2)	1		
	7	(8,2)	1	(8,2)	1		
	8	(6,2)	1	(6,2)	1		
	9	(8,5)	1	(8,5)	1		
	10	(3,5)	0				
	11	(2,5)	0				
	12	(5,2)	1				
	13	(4,2)	1				
	14	(3,2)	1				
	15	(2,2)	1				
	16	(1,2)	1				
	17	(0,2)	1				
	18	(3,5)	1				
	19	(2,5)	1				

Frame structure type 2 only	20	(11,1)	1	(11,1)	1	(11,1)	1
	21	(9,1)	1	(9,1)	1	(9,1)	1
	22	(7,1)	1	(7,1)	1	(7,1)	1
	23	(10,1)	1	(10,1)	1		
	24	(8,1)	1	(8,1)	1		
	25	(6,1)	1	(6,1)	1		
	26	(5,1)	1				
	27	(4,1)	1				
	28	(3,1)	1				
	29	(2,1)	1				
	30	(1,1)	1				
	31	(0,1)	1				

[199] 표 2에서 CSI-RS configuration 0~19번은 FDD와 TDD에 공통으로 적용될 수 있고, CSI-RS configuration 20~31번은 TDD에만 적용될 수 있다. TDD 시스템에서는 전송 모드(TM: transmission mode) 7로 설정된 단말을 위해 안테나 포트 5번의 DMRS가 전송될 가능성이 있으므로, 안테나 포트 5번의 DMRS와의 자원 오버랩을 피하기 위해, CSI-RS configuration 20~31번이 추가로 정의된다. 표 2에서 각각의 CSI-RS configuration이 가리키는 인덱스 쌍 (k',l')은 CSI-RS RE 집합의 기준점이 되는 RE를 의미한다. (k',l')을 기준으로 하나의 PRB 페어 내에서 CSI-RS RE 집합이 어떻게 정해지는 지는, 규격에 미리 정의되어 있다.

[200] 본 명세서에서 CSI-RS 패턴이라 함은, 각 CSI-RS 안테나 포트 수별로 CSI-RS 자원 풀 내에서 규격에 미리 정의된 CSI-RS 자원 구성을 의미하고, 경우에 따라서는 CSI-RS 안테나 포트의 주파수 축 자원 밀도까지를 포함할 수도 있다. 도 1 내지 도 3에 보이듯이, 현재 규격에는 1, 2, 4, 그리고 8개의 CSI-RS 안테나 포트에 대하여 CSI-RS 패턴이 정의되어 있다.

[201] 한편, Release 13에 도입된 12개 및 16개의 CSI-RS 안테나 포트에 대해서는, 하나의 고정된 CSI-RS 패턴이 정의된 것이 아니라, 기존의 4개 또는 8개의 CSI-RS 안테나 포트의 CSI-RS configuration을 복수 개 집성(aggregation)하여 자원을 구성하도록 되어 있다. 구체적으로, 12개의 CSI-RS 안테나 포트는 기존의 4개 안테나 포트의 CSI-RS configuration을 3개 집성하여 구성되고, 16개의 CSI-RS 안테나 포트는 기존의 8개 안테나 포트의 CSI-RS configuration을 2개 집성하여 구성된다. 본 명세서에서, CSI-RS 자원 집성의 요소로 이용되는 CSI-RS configuration을 '컴포넌트 CSI-RS configuration'이라 한다.

[202] 또한, 12개 및 16개의 CSI-RS 안테나 포트에 대해서는, length-2 CDM (이하 'CDM-2')와 length-4 CDM (이하 'CDM-4') 중 하나가 선택적으로 적용될 수 있다.

[203] 한편, Release 13에 도입된 단말의 CSI 보고 유형은 클래스-A와 클래스-B로 구분된다. 전송 모드(transmission mode)가 10인 경우, 기지국은 단말에게, CSI 프로세스 내의 CSI 보고 유형을 가리키는 파라미터를 이용하여 클래스-A 또는 클래스-B CSI 보고를 설정할 수 있다. 본 명세서에서는, 전송 모드를 구분하지 않고, 클래스-A CSI 보고를 위해 단말에 설정되는 CSI-RS 설정 파라미터들의 집합을 '제1 CSI-RS 설정'이라 하고, 클래스-B CSI 보고를 위해 단말에 설정되는 CSI-RS 설정 파라미터들의 집합을 '제2 CSI-RS 설정'이라 한다. 전송 모드가 10인 경우, 제1 CSI-RS 설정은 클래스-A CSI 보고를 위한 CSI 프로세스 내에서의 CSI-RS 설정 파라미터들의 집합을 의미하고, 제2 CSI-RS 설정은 클래스-B CSI 보고를 위한 CSI 프로세스 내에서의 CSI-RS 설정 파라미터들의 집합을 의미한다.

[204] 제1 CSI-RS 설정은 12개 또는 16개의 CSI-RS 안테나 포트의 자원 설정 정보를 포함할 수 있다. 즉, 제1 CSI-RS 설정은 12개 또는 16개의 CSI-RS 안테나 포트의 자원 집성을 위한 복수의 컴포넌트 CSI-RS configuration과 CDM 유형 (즉, CDM-2 또는 CDM-4)을 가리키는 파라미터를 포함할 수 있다. 제2 CSI-RS 설정은 하나 또는 복수의 CSI-RS configuration을 포함하고, 이 때 제2 CSI-RS 설정에 포함되는 각 CSI-RS configuration은 기존 1, 2, 4, 또는 8개의 CSI-RS 안테나 포트의 CSI-RS configuration이다. 하나의 제2 CSI-RS 설정 내에서, CSI-RS configuration들은 서로 다른 CSI-RS 안테나 포트 수를 가질 수 있고, 전송 모드가 10인 경우, 각기 다른 고유의 NZP CSI-RS ID를 가질 수 있다.

[205]

[206] 2.2. 제1 CSI-RS 설정을 확장하는 방법

[207] 제1 CSI-RS 설정은 8, 12, 그리고 16 이외의 CSI-RS 안테나 포트 수로 확장될 수 있다. 예를 들어, 제1 CSI-RS 설정은 16이 넘는 8의 배수인 CSI-RS 안테나 포트 수로 확장될 수 있다. 또는, 제1 CSI-RS 설정은 16이 넘는 4의 배수인 CSI-RS 안테나 포트 수로 확장될 수 있다. 또는, 제1 CSI-RS 설정은 16이 넘는 짝수인 CSI-RS 안테나 포트 수로 확장될 수 있다. 또는, 제1 CSI-RS 설정은 8 이상의 짝수인 CSI-RS 안테나 포트 수를 포함하도록 확장될 수 있다. 이 때, 설정 가능한 CSI-RS 안테나 포트 수는 N을 넘지 않도록 제한될 수 있다. 여기서 N은 16보다 큰 임의의 자연수이다. 예를 들어, N은 32 또는 64일 수 있다.

[208] 상기 새로운 CSI-RS 안테나 포트 수에 대해서도, 현재 규격과 마찬가지로, 복수의 컴포넌트 CSI-RS configuration을 집성하는 방법이 적용될 수 있다. 예를 들어, 20개의 CSI-RS 안테나 포트는 기존의 4개 안테나 포트의 CSI-RS configuration을 5개 집성하여 구성될 수 있고, 24개의 CSI-RS 안테나 포트는 기존의 4개 안테나 포트의 CSI-RS configuration을 6개 집성하여 구성되거나, 기존의 8개 안테나 포트의 CSI-RS configuration을 3개 집성하여 구성될 수 있다.

[209] 또는 상기 새로운 CSI-RS 안테나 포트 수의 일부 또는 전부, 그리고/또는 기존 CSI-RS 안테나 포트 수에 대해서, 컴포넌트 CSI-RS configuration별로 독립적인

CSI-RS 안테나 포트 수를 가지도록 하는 방법이 적용될 수 있다. 예를 들어, 20개의 CSI-RS 안테나 포트는 기존의 8개 안테나 포트의 CSI-RS configuration 2개와 기존의 4개 안테나 포트의 CSI-RS configuration 1개를 집성하여 구성될 수 있다.

[210] 또는 상기 새로운 CSI-RS 안테나 포트 수의 일부 또는 전부, 그리고/또는 기존 CSI-RS 안테나 포트 수에 대해서, 모든 컴포넌트 CSI-RS configuration이 동일한 CSI-RS 안테나 포트 수를 가지되, 이 중에서 하나의 컴포넌트 CSI-RS configuration에 대해서는 단말이 일부 CSI-RS 안테나 포트만을 수신하고 CSI 측정 및 보고에 이용할 것을 가정하는 방법이 적용될 수 있다. 예를 들어, 단말은 제1 CSI-RS 설정을 구성하는 컴포넌트 CSI-RS configuration(들) 중에 마지막 컴포넌트 CSI-RS configuration에 대해서 일부 CSI-RS 안테나 포트만을 가정할 수 있다. 예를 들어, 20개의 CSI-RS 안테나 포트는 기존의 8개 안테나 포트의 CSI-RS configuration을 3개 집성하여 구성하되, 마지막 컴포넌트 CSI-RS configuration에 대해서는 단말이 8개의 안테나 포트 중에서 4개(예, CSI-RS 안테나 포트 15~18번)만을 수신함을 가정할 수 있다. 단말이 일부 CSI-RS 안테나 포트만을 가정하는 컴포넌트 CSI-RS configuration에 대해서, 단말이 가정하는 CSI-RS 안테나 포트 수는 기지국에 의해 단말에게 시그널링될 수 있다.

[211] 본 명세서에서, 제1 CSI-RS 설정에 적용될 수 있는 방법들은, 상기 확장에 의한 새로운 CSI-RS 안테나 포트 수의 설정에도 동일하거나 유사하게 적용될 수 있음을 가정한다.

[212]

[213] 2.3. CSI-RS 자원 설정을 확장하는 방법

[214] 도 1 내지 도 3에 예시된 바와 같이, 현재의 LTE 규격에 따르면, 노멀 CP가 설정되는 경우에, 하나의 PRB 페어 내에서 CSI-RS 전송을 위해 이용될 수 있는 RE는 총 40개이다. 이하에서는, PRB 페어 내에서(또는 PRB 번들링(bundling)이 사용되는 경우에는 복수의 PRB 페어 내에서) CSI-RS 자원으로써 설정 가능한 RE들의 집합을, CSI-RS 자원 풀이라 한다. CSI-RS 자원 풀을 확장하는 것은 FD-MIMO 시스템에서 다수의 CSI-RS 안테나 포트를 전송하는 것에 도움이 될 수 있다. 하나의 서브프레임 내에서 CSI-RS 자원 풀을 확장하기 위한 방법으로써, 크게 두 가지 방법이 고려될 수 있다.

[215] 첫 번째 방법은 하나의 PRB 페어 내에서 CSI-RS 자원 풀에 포함되는 RE의 수를 늘리는 방법이다. 두 번째 방법은 하나의 PRB 페어 내 CSI-RS 자원 풀에 포함되는 RE 개수를 40개로 유지한 채, 주파수 축으로 인접한 복수의 PRB 페어를 번들링하여 CSI-RS 자원 풀을 확장하는 방법이다. 후자의 방법에 따르면, CSI-RS 자원 설정을 위해 이용될 수 있는 RE의 수가 늘어나는 반면에, 전체 시스템 대역폭 내에서 각 CSI-RS 안테나 포트에 할당되는 RE의 수는 줄어든다. 예를 들어, PRB 페어 번들이 2개의 인접한 PRB 페어를 포함하는 경우에, 하나의 PRB 페어 번들 내에서 CSI-RS 자원 풀은 총 80개의 RE를 포함하지만, 각 CSI-RS

안테나 포트의 시퀀스를 구성하는 심볼의 수는 기존 대비 절반으로 줄어든다. CSI-RS 안테나 포트별 주파수 축 RE의 밀도가 줄어들면, 단말의 채널 추정 시 이용 가능한 채널 샘플의 수가 줄어들게 되고, 이는 채널 특성과 채널 추정 알고리즘에 따라 채널 추정 성능에 영향을 미칠 수도 있다. 한편, 현재 규격에 의하면, 단말의 CSI 측정 및 보고는 적어도 서브밴드(subband) 단위로 수행되므로, 실제로 보고되는 CSI의 정확도나 스케줄러 성능의 열화는 미미할 수 있다.

[216] 이하에서는 상기 후자의 방법에 초점을 맞추어, CSI-RS 패턴을 확장하는 방법에 대하여 설명한다. 즉, PRB 페어 번들을 기본 단위로 하여, 기존의 CSI-RS 패턴을 다수의 안테나 포트로 확장하는 방법에 대하여 기술한다.

[217] 또한 1, 2, 4, 또는 8개의 CSI-RS 안테나 포트에 대해서도 PRB 번들링을 이용하여, 기존보다 CSI-RS 패턴이 더 낮은 주파수 축 밀도를 갖도록 하는 방법에 대해서도 설명한다. 또한 상기 확장된 CSI-RS 패턴들을 조합하여 단말에 설정하는 방법에 대해서도 설명한다. 이하에서 기술되는 방법들 각각을, 다음의 4가지 경우로 구분하여 순차적으로 설명한다. 첫 번째 경우를 위주로 기술하고, 나머지 경우들에 대해서는 간략히 설명하기로 한다.

[218] - 노멀 CP가 설정되는 경우에, FDD와 TDD에 모두 적용될 수 있는 CSI-RS 자원 설정

[219] - 노멀 CP가 설정되는 경우에, TDD에만 적용될 수 있는 CSI-RS 자원 설정

[220] - 확장 CP가 설정되는 경우에, FDD와 TDD에 모두 적용될 수 있는 CSI-RS 자원 설정

[221] - 확장 CP가 설정되는 경우에, TDD에만 적용될 수 있는 CSI-RS 자원 설정

[222] 한편, 본 발명의 실시예에 따른 방법들은, 안테나 가상화(virtualization) 방식에 따라 그 효과가 달라질 수 있다. 본 명세서에서 가상화라 함은 안테나 포트와 물리 안테나 요소(들) 간의 맵핑을 의미하며, 디지털 신호 처리 기반의 통신 시스템에서 안테나 가상화는 안테나 포트 가상화와 TXRU(transceiver unit) 가상화를 포함할 수 있다. 여기서 TXRU는, 입력 신호의 위상(phase)과 진폭(amplitude)을 독립적으로 제어하고 출력할 수 있는 RF 장치의 단위를 의미하고, 통상적으로 RF 체인이라 부르기도 한다. 안테나 포트 가상화는 안테나 포트와 TXRU(들) 간의 맵핑을 의미하고, TXRU 가상화는 TXRU와 물리 안테나 요소(들) 간의 맵핑을 의미한다. 단말은 기본적으로 각 안테나 포트에 적용된 가상화를 알 수 없다.

[223] 본 명세서에서 CSI-RS는 일반적으로 통용되듯이 NZP(non-zero-power) CSI-RS를 의미하고, ZP(zero-power) CSI-RS와는 구별되는 것으로 가정한다.

[224]

[225] 2.3.1. 노멀 CP가 설정되는 경우에, FDD와 TDD에 모두 적용될 수 있는 CSI-RS 자원 설정 방법

[226] 첫째로, 노멀 CP가 설정되는 경우에, FDD와 TDD 프레임 구조에 공통적으로

적용되는 CSI-RS 자원 설정 방법에 대하여 기술한다.

[227] 제안하는 방법을 설명하기에 앞서, 먼저 PRB 페어 번들을 정의한다. 본 명세서에서 PRB 페어 번들(이하, 'PRB 번들')은 CSI-RS 패턴이 정의되는 기본 단위로써, 주파수 축에서 인접한 PRB 페어들의 묶음(또는 집합)을 의미한다. 즉, CSI-RS 패턴은 하나의 PRB 번들 내에서 정의되고, 이 CSI-RS 패턴이 전 대역에 걸쳐 복수의 PRB 번들에 동일하게 반복되어 맵핑된다. 이 때 PRB 번들의 크기, 즉 PRB 번들에 포함되는 PRB 페어의 개수를 N^bundle_RB로 정의하고, 전체 시스템 대역폭(system bandwidth)이 갖는 PRB 번들의 개수를 N^DL_bundle로 정의한다. 전 대역의 PRB 개수를 N^DL_RB라 하면, N^DL_bundle = ceil(N^DL_RB/N^bundle_RB)이 된다. 예를 들어, LTE 시스템에서 시스템 대역폭이 10 MHz인 경우에, N^DL_RB는 50이고, 이 때 PRB 번들의 크기를 3으로 설정하면 총 PRB 번들의 개수는 N^DL_bundle = ceil(50/3) = 17이고, 마지막 PRB 번들의 크기는 2가 된다. 기존 LTE 규격에 정의된 CSI-RS 패턴은 N^bundle_RB = 1인 경우에 해당한다.

[228]

[229] 이하에서는 PRB 번들링(단, N^bundle_RB > 1)에 대하여 설명한다. PRB 번들에 포함되는 복수의 PRB 페어를 이용하여, CSI-RS 패턴이 정의될 수 있다. 이러한 경우에, CSI-RS 패턴을 확장하는 방법으로써, 크게 방법 Mb100과 방법 Mb200이 고려될 수 있다.

[230] 방법 Mb100은, CSI-RS 패턴에 포함되는 CSI-RS 안테나 포트들의 RE 집합이 PRB 번들에 포함되는 복수의 PRB 페어들 중에서 하나의 PRB 페어 내에만 맵핑(설정)되는 방법이다.

[231] 방법 Mb100은 PRB 번들링이 미적용된 기존 규격의 CSI-RS 패턴을 재활용할 수 있다. 즉, 방법 Mb100은 1, 2, 4, 또는 8개의 CSI-RS 안테나 포트를 설정하고자 하는 경우에, 표 2을 이용한 기존의 CSI-RS configuration 시그널링을 재사용할 수 있다. 이 경우에, 기지국은 단말에게 PRB 번들의 크기(N^bundle_RB) 그리고/또는 PRB 번들 내 CSI-RS RE 집합이 맵핑되는 PRB 페어의 인덱스를 추가로 알려주어야 할 수 있다. 여기서 PRB 번들에 포함된 PRB 페어 중에서 CSI-RS RE 집합이 맵핑되는 PRB 페어의 인덱스는 0 이상 N^bundle_RB 미만의 정수로 표현될 수 있고, 이를 본 명세서에서 편의상 PRB shift라 한다. N^bundle_RB 그리고/또는 PRB shift는 미리 정해진 규칙에 의해 고정된 값을 가질 수도 있고, 단말별로 설정될 수도 있다.

[232] 전자의 예로써, N^bundle_RB는 CSI-RS 안테나 포트 수별로 미리 정해진 값을 가질 수 있다. 예를 들어, N^bundle_RB는 X개의 CSI-RS 안테나 포트 수까지는 1이고, X보다 큰 CSI-RS 안테나 포트 수에 대해서는 1보다 큰 값으로 정해질 수 있다. 여기서 X는 1 이상의 정수값으로 표현될 수 있다. 한편, 후자의 예로써, 단말이 전송 모드 10을 설정받은 경우, N^bundle_RB는 단말에 CSI 프로세스별로 설정될 수 있다.

[233]

[234] 도 9는 본 발명의 실시예에 따른, 방법 Mb100을 이용해 CSI-RS 자원을 설정하는 방법을 나타내는 도면이다.

[235] 구체적으로, 도 9에는 기지국이 2개의 PRB 페어에 번들링을 적용하고, 동일 서브프레임 내에서 단말들(UE-a, UE-b, UE-c, UE-d) 각각에게 8, 4, 2, 또는 1개의 CSI-RS 안테나 포트를 설정하는 경우가 예시되어 있다.

[236] 이 때, 모든 단말의 경우에 N^bundle_RB는 공통으로 2이고, 단말(UE-a)와 단말(UE-d)를 위한 PRB shift는 1이고, 단말(UE-b)와 단말(UE-c)를 위한 PRB shift는 0이다. PRB 번들의 크기가 2이므로, 도면에 예시된 모든 안테나 포트들의 주파수 축 밀도는 기존의 절반이 된다.

[237] 예를 들어, PRB 페어 1번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 5), RE(3, 5), RE(2, 10), RE(3, 10), RE(2, 4), 및 RE(3, 4)는 단말(UE-a)을 위한 CSI-RS RE(예, CSI-RS 안테나 포트 15~22번)로써 설정된다. PRB 페어 1번 내의 슬롯0의 RE(5, 3), 및 RE(6, 3)는 단말(UE-d)을 위한 CSI-RS RE(예, CSI-RS 안테나 포트 15번)로써 설정된다. PRB 페어 0번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 5), 및 RE(3, 5)는 단말(UE-b)을 위한 CSI-RS RE(예, CSI-RS 안테나 포트 15~18번)로써 설정된다. PRB 페어 0번 내의 슬롯0의 RE(5, 9), 및 RE(6, 9)는 단말(UE-c)을 위한 CSI-RS RE(예, CSI-RS 안테나 포트 15~16번)로써 설정된다. 본 명세서의 도면들에는 주파수 대역이 낮은 PRB 페어일수록 낮은 PRB 페어 인덱스를 가지는 것으로 예시되어 있으나, 반대로 주파수 대역이 높은 PRB 페어가 낮은 PRB 페어 인덱스를 가지는 것을 가정할 수도 있다.

[238] 방법 Mb100에 따르면, 하나의 PRB 페어 내 일부 RE들을 복수의 단말이 주파수 축에서 PRB 페어를 교대로 번갈아 가면서 사용할 수 있다. 도 9에 예시된 실시예에서, 단말(UE-a)와 단말(UE-b)는 슬롯1의 RE(2,5), RE(3,5), RE(2,11), 및 RE(3,11)을 사용한다.

[239] 방법 Mb100에서 PRB 번들의 크기(N^bundle_RB)는 임의의 자연수가 될 수 있다. 그러나 기지국이 너무 많은 수의 PRB 페어를 번들링하면 CSI 측정(measurement) 정확도가 떨어지므로, PRB 번들의 크기(N^bundle_RB)의 최대값이 적당한 값으로 미리 정의될 수도 있다. 예를 들어, PRB 번들의 크기가 서브밴드(subband)의 크기를 넘지 않도록(즉, N^bundle_RB가 하나의 서브밴드가 가지는 RB 개수 이하가 되도록), 제한될 수 있다. 또는 PRB 번들의 크기가 서브밴드의 크기의 약수만 가능하도록 제한될 수 있다. 또는 N^bundle_RB 값이 1과 2만 가능하도록 제한을 두는 방법도 고려될 수 있다.

[240] 전술하였듯이, 현재 규격에 의하면, CSI-RS 패턴은 1, 2, 4, 그리고 8개의 CSI-RS 안테나 포트에 대해서만 정의되어 있고, 12개 및 16개의 CSI-RS 안테나 포트는 복수의 컴포넌트 CSI-RS configuration을 집성하여 구성된다. 한편, 1, 2, 4, 그리고 8 이외의 CSI-RS 안테나 포트 수에 대하여, 상기 자원 집성에 의하지 않고, CSI-RS 패턴을 정의하는 방법이 고려될 수 있다. 이 경우에, 방법 Mb100은

현재의 CSI-RS 자원 풀로는 64개의 CSI-RS 안테나 포트에 적용될 수 없다는 제약을 가진다. 또한 기지국이 방법 Mb100을 이용해 32개의 CSI-RS 안테나 포트를 설정하고자 하는 경우에도, 하나의 PRB 페어 내에서 CDM-2와 FDM의 결합만으로는 CSI-RS 패턴이 정의될 수 없고, TDM 또는 length-4 이상의 CDM과의 결합을 통해서만 CSI-RS 패턴이 정의될 수 있으므로, CSI-RS 설정 및 전송을 위해 최소 4개의 OFDM 심볼이 필요하다. 따라서 32개의 CSI-RS 안테나 포트를 설정하는 경우는 16개 이하의 CSI-RS 안테나 포트를 설정하는 경우보다 오실레이터(oscillator)의 impairment로 인한 OFDM 심볼 간 phase drift 현상에 상대적으로 더 노출될 수 있다.

[241] 방법 Mb100의 장점 중 하나는 하나의 PRB 페어 내에서 기존의 CSI-RS 패턴이 동일하게 유지되므로, 기지국은 CSI-RS 전송 시에 PRB 번들링이 적용될 수 있는 단말과 PRB 번들링이 적용될 수 없는 기존(legacy) 단말이 일부 RE를 공유하도록 할 수 있다는 것이다.

[242]

[243] 도 10a 및 도 10b는 본 발명의 다른 실시예에 따른, 방법 Mb100을 이용해 CSI-RS 자원을 설정하는 방법을 나타내는 도면이다.

[244] 구체적으로 도 10a 및 도 10b에는, CSI-RS를 위해 PRB 번들링이 적용된 새로운 단말과 PRB 번들링을 적용받을 수 없는 기존 단말(또는 PRB 번들링이 적용되지 않은 새로운 단말)의 CSI-RS 설정이 자원을 공유하는 경우가 예시되어 있다.

[245] 도 10a에는 단말(UE-a)와 단말(UE-b)가 동일한 CSI-RS configuration에 의해 8개의 CSI-RS 안테나 포트를 설정받고, 단말(UE-a)에 대해서는 방법 Mb100에 의해 2개의 PRB 페어에 번들링이 적용된 경우가 예시되어 있다. 예를 들어, PRB 페어 0번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 5), RE(3, 5), RE(2, 4), 및 RE(3, 4)는 단말(UE-a)를 위한 CSI-RS RE로써 설정된다. 각 PRB 페어 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 5), RE(3, 5), RE(2, 4), 및 RE(3, 4)는 PRB 번들링을 적용받지 않은 단말(UE-b)를 위한 CSI-RS RE로써 설정된다. 결국, PRB 페어 0번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 5), RE(3, 5), RE(2, 4), 및 RE(3, 4)는 단말(UE-a)과 단말(UE-b)을 위한 CSI-RS RE로써 설정된다.

[246] 도 10b에는, 기지국이 단말(UE-a)에게 방법 Mb100을 이용해 2개의 PRB 페어의 번들링을 설정하고, PRB 페어 0번에 8개의 안테나 포트의 CSI-RS 패턴을 설정하고, 단말(UE-b)에게는 4개의 CSI-RS 안테나 포트를 PRB 번들링 없이 설정하는 경우가 예시되어 있다. 예를 들어, PRB 페어 0번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 5), RE(3, 5), RE(2, 4), 및 RE(3, 4)는 단말(UE-a)를 위한 CSI-RS RE로써 설정된다. 각 PRB 페어 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 5), 및 RE(3, 5)는 단말(UE-b)를 위한 CSI-RS RE로써 설정된다. 결국, PRB 페어 0번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 5), 및 RE(3, 5)는 단말(UE-a)과 단말(UE-b)을 위한 CSI-RS RE로써 설정된다.

[247] 도 10a 및 도 10b에 예시된 방법은 단말(UE-a)과 단말(UE-b)에 대한 CSI-RS 자원 설정이 일부 RE들을 공유함으로써, 두 단말(UE-a, UE-b)의 CSI-RS RE 집합 간에 교집합이 없도록 설정하는 방식에 비해, CSI-RS 전송 오버헤드를 줄일 수 있다.

[248]

[249] 도 11은 본 발명의 또 다른 실시예에 따른, 방법 Mb100을 이용해 CSI-RS 자원을 설정하는 방법을 나타내는 도면이다.

[250] 구체적으로 도 11에는 기지국이 복수의 단말에게 PRB 번들 내의 서로 다른 PRB 페어를 이용하여 CSI-RS 자원을 설정하고, 복수의 단말로 하여금 동일한 RE를 주파수 축에서 공유하도록 하는 방법이 예시되어 있다. 도 11에서 단말들(UE-a, UE-b, UE-c, UE-d)은 PRB 번들링을 설정받을 수 있는 단말이고, 각 단말(UE-a, UE-b, UE-c, UE-d)은 2개의 PRB 페어의 번들링을 설정받을 수 있다.

[251] 기지국은 단말(UE-a)와 단말(UE-b)에게 8개의 CSI-RS 안테나 포트를 위한 동일한 CSI-RS configuration과 N^bundle_RB = 2를 공통으로 설정하고, 단말(UE-a)을 위한 PRB shift는 0으로, 단말(UE-b)을 위한 PRB shift는 1로 설정한다. 예를 들어, PRB 페어 0번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)는 단말(UE-a)를 위한 CSI-RS RE로써 설정된다. PRB 페어 1번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)는 단말(UE-b)를 위한 CSI-RS RE로써 설정된다.

[252] 이 때, 단말(UE-a)와 단말(UE-b)를 위한 CSI-RS는 서로 다른 PRB 페어를 통해 전송되므로, 단말(UE-a)와 단말(UE-b)를 위한 CSI-RS에 서로 다른 가상화를 적용하는 것이 가능하다. 즉, 단말 특정적(user equipment-specific) CSI-RS 빔포밍이 가능하다. 이는, 단말(UE-a)와 단말(UE-b)가 가지는 채널이 빔 공간 내 또는 벡터 공간 내에서 서로 방향성이 다른 경우에, 유용하다.

[253] 기지국은 단말(UE-c)와 단말(UE-d)에게 2개의 CSI-RS 안테나 포트를 설정한다. 단말(UE-c)와 단말(UE-d)을 위한 CSI-RS 설정에 적용되는 원리는, 단말(UE-a) 및 단말(UE-b)의 예시와 동일하다. 예를 들어, PRB 페어 0번 내의 슬롯1의 RE(2, 11), 및 RE(3, 11)는 단말(UE-c)를 위한 CSI-RS RE로써 설정된다. PRB 페어 1번 내의 슬롯1의 RE(2, 11), 및 RE(3, 11)는 단말(UE-d)를 위한 CSI-RS RE로써 설정된다.

[254]

[255] 방법 Mb200은, CSI-RS 패턴에 포함되는 CSI-RS 안테나 포트들의 RE 집합이 PRB 번들에 포함되는 모든 PRB 페어들에 균일한 수(또는 최대한 균일한 수)로 맵핑되는 방법이다.

[256] 방법 Mb200에서 CSI-RS 안테나 포트들이 N^bundle_RB개의 PRB 페어들에 동일한 개수로 맵핑되기 위해서는, N^bundle_RB가 2의 지수승이어야 한다. 따라서 방법 Mb100에서 PRB 번들의 크기는 임의의 자연수가 되어도 무방한 데 반해, 방법 Mb200에서는 PRB 번들의 크기는 2의 지수승으로 제한되는 것이

효과적일 수 있다.

[257]

[258] 도 12는 본 발명의 실시예에 따른, 방법 Mb200을 이용해 16개의 CSI-RS 안테나 포트에 대한 자원을 설정하는 방법을 나타내는 도면이다.

[259] 구체적으로 도 12에는 2개의 PRB 페어가 번들링된 경우를 예시하고 있다.

[260] 도 12에 예시된 바와 같이, 기지국은 기존의 8개의 CSI-RS 패턴에 PRB 번들링과 안테나 포트 간 다중화(FDM)를 적용하고 주파수 축으로 2배만큼 CSI-RS 패턴을 확장하여, 16개의 CSI-RS 안테나 포트의 패턴을 설정할 수 있다.

[261] 이 때, 하나의 서브프레임 내에서 설정 가능한 CSI-RS configuration의 수는 5개(예, 0번 내지 4번)이다. 예를 들어, PRB 페어 0번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)와 PRB 페어 1번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)는, CSI-RS configuration 0번를 위한 CSI-RS RE(예, CSI-RS 안테나 포트 15~30번)로써 설정된다.

[262] 도 12에 예시된 실시예에 따르면, 방법 Mb100과 마찬가지로, 2개의 PRB 페어를 묶어 번들링한 만큼, 각 CSI-RS 안테나 포트의 주파수 축 자원 밀도는 절반으로 줄어든다.

[263]

[264] 도 13a 및 도 13b는 본 발명의 실시예에 따른, 방법 Mb200을 이용해 12개의 CSI-RS 안테나 포트에 대한 자원을 설정하는 방법을 나타내는 도면이다.

[265] 구체적으로 도 13a 및 도 13b에는 2개의 PRB 페어가 번들링된 경우를 예시하고 있다. CSI-RS 안테나 포트 수가 16인 경우와 달리, CSI-RS 안테나 포트 수가 12인 경우에는, 만약 기지국이 2개의 PRB 페어에 CSI-RS 안테나 포트를 균일하게 나누어 설정하고자 한다면, 하나의 PRB 페어 내에 6개의 CSI-RS 안테나 포트를 맵핑해야 한다. 이 경우에, 기존 규격상에 하나의 PRB 페어 내에서 설정되는 6개의 CSI-RS 안테나 포트에 대한 패턴이 정의되어 있지 않으므로, 6개의 CSI-RS 안테나 포트를 위한 새로운 패턴이 정의되어야 한다. 이를 피하기 위해, 12개의 CSI-RS 안테나 포트를 2개의 PRB 페어에 불균일하게 나누어 맵핑하는 방법이 고려될 수 있다.

[266] 도 13a 및 도 13b에는 기지국이 PRB 페어 0번과 1번 각각에 8개와 4개의 CSI-RS 안테나 포트를 맵핑하는 경우가 예시되어 있다.

[267] PRB 페어 0번에는 기존 규격상의 8개의 CSI-RS 안테나 포트에 대한 패턴이 적용되고, PRB 페어 1번에는 기존 규격상의 4개의 CSI-RS 안테나 포트에 대한 패턴이 적용된다.

[268] 이 때, 하나의 서브프레임 내에서 설정 가능한 CSI-RS configuration의 수는 5개(예, 0번 내지 4번)이다. 예를 들어, 도 13a에 예시된 실시예에서, PRB 페어 0번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)와 PRB 페어 1번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 3), 및 RE(6,

3)는, CSI-RS configuration 0번를 위한 CSI-RS RE(예, CSI-RS 안테나 포트 15~26번)로써 설정된다. 도 13b에 예시된 실시예에서, PRB 페어 0번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)와 PRB 페어 1번 내의 슬롯0의 RE(5, 8), RE(6, 8), RE(5, 2), 및 RE(6, 2)는, CSI-RS configuration 0번를 위한 CSI-RS RE(예, CSI-RS 안테나 포트 15~26번)로써 설정된다.

[269] 이 때 도 13a 및 도 13b에 예시된 CSI-RS 패턴들과 같이, PRB 페어 1번에 설정된 RE들의 집합이 PRB 페어 0번에 설정된 RE들의 집합에 포함되는 것은, 다른 단말들에 대한 ZP CSI-RS 설정에 효과적일 수 있다.

[270]

[271] 도 14는 본 발명의 실시예에 따른, 방법 Mb200을 이용해 32개의 CSI-RS 안테나 포트에 대한 자원을 설정하는 방법을 나타내는 도면이다.

[272] 구체적으로, 도 14에는 2개의 PRB 페어가 번들링되는 경우가 예시되어 있다.

[273] 기지국은 기존 규격상의 8개의 CSI-RS 안테나 포트의 패턴에 PRB 번들링과 안테나 포트 간 다중화(FDM)를 적용하고 주파수 축으로 CSI-RS 패턴을 4배만큼 확장하여, 32개의 CSI-RS 안테나 포트의 패턴을 설정할 수 있다.

[274] 이 때, 하나의 서브프레임 내에 설정 가능한 CSI-RS configuration의 수는 1개(예, 0번)이다. 예를 들어, 도 14에 예시된 실시예에서, PRB 페어 0번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 9), RE(3, 9), RE(2, 8), RE(3, 8), RE(2, 5), RE(3, 5), RE(2, 4), RE(3, 4), RE(2, 3), RE(3, 3), RE(2, 2), 및 RE(3, 2)와, PRB 페어 1번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 9), RE(3, 9), RE(2, 8), RE(3, 8), RE(2, 5), RE(3, 5), RE(2, 4), RE(3, 4), RE(2, 3), RE(3, 3), RE(2, 2), 및 RE(3, 2)는, CSI-RS configuration 0번를 위한 CSI-RS RE(예, CSI-RS 안테나 포트 15~46번)로써 설정된다.

[275] 한편, 도 12 내지 도 14에 예시된 실시예는 CSI-RS 패턴을 정의하는 특정 예시일 뿐이다. 기지국은 CSI-RS 자원 풀 내에서 다양한 CSI-RS 패턴들을, 방법 Mb200을 이용하는 상기 방법과 동일 또는 유사한 방법을 통해, 정의할 수 있다.

[276] 한편, 방법 Mb100과 마찬가지로, 방법 Mb200이 이용되는 경우에도, 1, 2, 4, 또는 8개의 CSI-RS 안테나 포트에 대하여 PRB 번들링이 적용될 수 있다.

[277]

[278] 도 15는 본 발명의 다른 실시예에 따른, 방법 Mb200을 이용해 CSI-RS 자원을 설정하는 방법을 나타내는 도면이다.

[279] 구체적으로 도 15에는 기지국이 2개의 PRB 페어를 번들링하여, 단말(UE-a, UE-b, UE-c, UE-d) 각각에게 8, 4, 2, 또는 1개의 CSI-RS 안테나 포트를 설정하는 경우가 예시되어 있다.

[280] 2, 4, 또는 8개 안테나 포트를 갖는 CSI-RS 패턴 각각은, 기존의 1, 2, 또는 4개 안테나 포트의 CSI-RS 패턴에 PRB 번들링과 안테나 포트 간 다중화(FDM)가 적용되고 주파수 축으로 CSI-RS 패턴이 2배 확장되는 형태로 정의될 수 있다.

예를 들어, PRB 페어 0번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 5), 및 RE(3, 5)와, PRB 페어 1번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 5), RE(3, 5)는 단말(UE-a)를 위한 CSI-RS RE(예, CSI-RS 안테나 포트 15~22번)로써 설정된다. PRB 페어 0번 내의 슬롯1의 RE(5, 8) 및 RE(6, 8)와, PRB 페어 1번 내의 슬롯1의 RE(5, 8) 및 RE(6, 8)는 단말(UE-b)를 위한 CSI-RS RE(예, CSI-RS 안테나 포트 15~18번)로써 설정된다. PRB 페어 0번 내의 슬롯0의 RE(5, 9) 및 RE(6, 9)와, PRB 페어 1번 내의 슬롯0의 RE(5, 9) 및 RE(6, 9)는 단말(UE-c)를 위한 CSI-RS RE(예, CSI-RS 안테나 포트 15~16번)로써 설정된다.

[281] 도 15에 예시된 단말(UE-a)와 단말(UE-b)에 대한 CSI-RS 자원 설정의 경우에, PRB 번들링이 적용되지 않은 8개 또는 4개 안테나 포트의 CSI-RS 자원 설정에 대비하여, CSI-RS 자원의 주파수 축 밀도가 절반으로 줄어든다. 이로 인해, CSI-RS 전송 오버헤드가 절반으로 줄어든다.

[282] 하지만 도 15에 예시된 단말(UE-d)에 대한 CSI-RS 자원 설정을 통해 알 수 있듯이, 단말에 설정되는 CSI-RS 안테나 포트의 수가 1이고 PRB 번들링이 사용되는 경우에는, 방법 Mb200의 원리가 적용될 수 없다. 이를 일반화하면, PRB 번들의 크기가 단말에 설정되는 CSI-RS 안테나 포트 수보다 크면, 방법 Mb200의 원리가 적용될 수 없다. 이 경우에는, 예외적으로, 방법 Mb100과 유사하게, CSI-RS RE 집합이 PRB 번들 내에서 하나의 PRB 페어에만 맵핑되도록 할 수 있다. 이 때, CSI-RS RE 집합이 맵핑되는 PRB 페어는 미리 정해질 수 있다. 예를 들어, 도 15에서, PRB 페어 0번 내의 슬롯0의 RE(5, 3) 및 RE(6, 3)는 단말(UE-d)를 위한 CSI-RS RE(예, CSI-RS 안테나 포트 15번)로써 설정된다.

[283] 또한 단말(UE-c)에 대한 CSI-RS 자원 설정을 통해 알 수 있듯이, 단말에 설정되는 CSI-RS 안테나 포트 수가 2인 경우에는, PRB 번들링이 사용되더라도 CSI-RS 전송 오버헤드의 감소가 없다. 즉, PRB 번들의 크기가 CSI-RS 안테나 포트 수와 동일하면, 방법 Mb200이 사용될 수는 있으나, 오버헤드 감소 효과가 없다. 이를 고려하여, PRB 번들의 크기(N^bundle_RB)가 단말에 설정하고자 하는 CSI-RS 안테나 포트 수보다 작은 값 또는 약수로만 설정되도록 제한을 두는 방법이 사용될 수도 있다.

[284] 한편, 방법 Mb200에서 PRB 번들의 크기(N^bundle_RB)가 CSI-RS 안테나 포트 수의 약수가아닌 경우에는, 모든 안테나 포트들이 PRB 번들 내에서 최대한 균일하게 맵핑되고 난 후에, 어떤 PRB 페어에서는 다른 PRB 페어(들)보다 더 적은 수의 RE에 안테나 포트들이 맵핑될 수 있다. 이 때, 모든 PRB 페어에서 동일한 수의 RE에 안테나 포트들이 맵핑되도록 하기 위하여, 더 적은 수의 RE가 맵핑된 PRB 페어(들)의 나머지 RE(들)에 CSI-RS 안테나 포트를 15번부터 다시 순차적으로 맵핑하는 방법이 고려될 수 있다. 또는 상기 나머지 RE(들)에 CSI-RS를 맵핑하지 않는 방법이 고려될 수 있다. 하지만 이러한 방법들은, CSI-RS 안테나 포트들 간 자원 할당의 불균형이나 비효율적 자원 할당으로 인한 채널 추정 성능 열화 등의 문제를 해결하기 어렵다. 따라서 방법 Mb200이

사용되는 경우에, PRB 번들의 크기(N^bundle_RB)는 CSI-RS 안테나 포트 수의 약수인 것이 좋다. PRB 번들의 크기(N^bundle_RB)는 2의 지수승으로만 설정되도록 제한되더라도, 대부분의 경우에 PRB 번들의 크기(N^bundle_RB)는 CSI-RS 안테나 포트 수의 약수가 되도록 설정하는 것이 가능하다.

[285] 방법 Mb200에 따르면, 동일한 RE에 PRB 번들에 포함되는 PRB 페어마다 서로 다른 CSI-RS 안테나 포트가 맵핑되므로, PRB 번들링이 적용될 수 있는 새로운 단말과 기존 단말이 NZP CSI-RS 전송 자원을 공유하는 것이 어렵다. 반면에, 방법 Mb200에 따르면 모든 PRB 페어들에 CSI-RS RE들의 수와 위치가 동일하게 설정되므로, 방법 Mb200은 기존 단말이 해당 RE들을 ZP CSI-RS로써 설정받고 PDSCH 레잇 매칭을 수행하는 데는 방법 Mb100보다 유리하다.

[286] 방법 Mb200에서도 PRB 번들의 크기(N^bundle_RB)의 최대값이 설정될 수 있다. PRB 번들의 크기(N^bundle_RB)가 하나의 서브밴드가 가지는 RB 개수를 넘지 않도록 제한될 수 있다. 또는 PRB 번들의 크기가 서브밴드의 크기의 약수만 가능하도록 제한될 수 있다. 또는 PRB 번들의 크기(N^bundle_RB)는 1과 2만이 가능하도록 제한될 수 있다.

[287] 방법 Mb201은, 방법 Mb200의 변형된 방법으로, PRB 번들을 따로 정의하지 않고, CSI-RS 안테나 포트들을 전체 시스템 대역상의 모든 PRB 페어들에 균일한 개수로 (또는 최대한 균일한 개수로) 맵핑하는 방법이다.

[288] 방법 Mb201은, 방법 Mb200의 특별한 경우(special case)로 해석될 수 있다. 즉, 방법 Mb201은, 방법 Mb200에서 PRB 번들의 크기가 시스템 대역폭과 동일하게 설정되는 경우(N^bundle_RB = N^DL_RB)와 동등하다. 그러나 이 경우에, 일반적으로 단말에 설정되는 CSI-RS 안테나 포트 수보다 훨씬 많은 수의 RE들이 전 대역에 걸쳐 존재하므로, 각 CSI-RS 안테나 포트를 복수의 RE들에 맵핑하는 규칙이 새로 정의되어야 할 수도 있다. 모든 CSI-RS 안테나 포트를 15번부터 시작하여 순차적으로 맵핑하는 것을 반복하는 방법이 사용될 수 있다. 이 때, 하나의 PRB 페어 내에서의 안테나 포트 맵핑 규칙으로는, 기존 1, 2, 4, 또는 8개의 CSI-RS 안테나 포트의 패턴을 따르는 방법이 사용될 수도 있고(도 16a), 또는 새로운 방법(도 16b)이 사용될 수도 있다. 이에 대하여, 도 16a 및 도 16b를 참고하여 설명한다.

[289]

[290] 도 16a 및 도 16b는 본 발명의 실시예에 따른, 방법 Mb201를 이용해 6개의 CSI-RS 안테나 포트에 대한 자원을 설정하는 방법을 나타내는 도면이다. 도 16a 및 도 16b에 예시된 실시예에서는 지금까지 기술된 실시예들과 달리, 주파수가 높은 PRB 페어일수록 낮은 PRB 페어 인덱스를 가진다.

[291] 구체적으로, 도 16a에는, 기존 1, 2, 4, 또는 8개의 CSI-RS 안테나 포트의 패턴을 따르는 방법이 사용되는 경우가 예시되어 있다. 각 PRB 페어 내에서 8개 안테나 포트에 대한 CSI-RS 패턴의 맵핑 순서가 사용된다. 예를 들어, PRB 페어 0번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 5), RE(3, 5), RE(2,

4), 및 RE(3, 4)는, CSI-RS RE(예, CSI-RS 안테나 포트 15~20번, CSI-RS 안테나 포트 15~16번)로써 설정된다. PRB 페어 1번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 5), RE(3, 5), RE(2, 4), 및 RE(3, 4)는, CSI-RS RE(예, CSI-RS 안테나 포트 17~20번, CSI-RS 안테나 포트 15~18번)로써 설정된다. PRB 페어 2번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 5), RE(3, 5), RE(2, 4), 및 RE(3, 4)는, CSI-RS RE(예, CSI-RS 안테나 포트 19~20번, CSI-RS 안테나 포트 15~20번)로써 설정된다.

[292] 도 16b에는 기존의 맵핑 규칙을 무시하는 새로운 방법이 사용되는 경우가 예시되어 있다. 예를 들어, PRB 페어 0번 내의 슬롯1의 RE(2, 10) 및 RE(3, 10)는 CSI-RS 안테나 포트 17~18번으로써 설정되고, PRB 페어 0번 내의 슬롯1의 RE(2, 5) 및 RE(3, 5)는 CSI-RS 안테나 포트 19~20번으로써 설정된다.

[293] 이와 같이, CSI-RS 안테나 포트 수가 2의 지수승이 아니면, 도 16a 및 도 16b에 예시된 바와 같이, 각 CSI-RS 안테나 포트 번호에 맵핑되는 RE들이 주파수 축으로 등간격으로 배치되지 않는 경우가 발생할 수 있다. 이로 인해, 채널 추정 성능의 열화 또는 복잡도 증가가 발생할 수 있다.

[294] 방법 Mb201은 방법 Mb200과 마찬가지로, PRB 번들링에 의해 확장된 새로운 CSI-RS 설정 자원이 기존 단말의 NZP CSI-RS 자원 설정과 공유되기가 어렵고, 새로운 설정 자원을 기존 단말이 ZP CSI-RS로써 설정받고 PDSCH 레잇 매칭을 수행하기에는 유리하다.

[295] 지금까지 PRB 번들링을 이용하여 CSI-RS 패턴을 주파수 축으로 확장 또는 변경하는 방법들을 기술하였다. 상기 방법들을 ZP CSI-RS의 설정에 동일하게 적용하여 ZP CSI-RS 자원 설정을 위해서도 PRB 번들링이 가능하도록 확장하는 방법이 고려될 수 있다. 예를 들어, ZP CSI-RS의 설정에 방법 Mb100가 적용되는 경우에, 기지국은 단말에게, 비트맵에 의해 지시되는 ZP CSI-RS RE 집합이 PRB 번들 내에서 어느 PRB 페어에 맵핑되는지를, 즉, PRB shift를 알려줄 수 있다. 또는, 하나의 ZP CSI-RS 설정이 복수의 비트맵을 포함할 수 있다. 이 때, 비트맵의 수는 PRB 번들의 크기(N^bundle_RB)와 동일하고, 비트맵과 PRB 페어가 일대일 맵핑될 수 있다. 다른 예를 들어, ZP CSI-RS의 설정에 방법 Mb200이 적용되는 경우에, PRB 번들의 크기는 2일 수 있다. 이 때, 비트맵의 길이는 기존 길이의 2배가 되고, 비트맵의 각 비트는, PRB 페어 0번과 1번에 공통으로, 표 2에서 2개의 CSI-RS 안테나 포트일 경우의 각 CSI-RS configuration이 가리키는 RE 집합에 대응될 수 있다. 즉, 비트맵의 각 비트는 PRB 페어 0번의 2개의 RE와 PRB 페어 1번의 2개의 RE에 대응될 수 있다.

[296] 상기와 같이 ZP CSI-RS 설정에 PRB 번들링이 적용됨으로써, 셀 간 간섭 제어 또는 간섭 측정(interference measurement)이 용이할 수 있다. 예를 들어, 인접 셀이 PRB 번들링된 NZP CSI-RS를 전송할 때, 서빙 셀은 단말에게 해당 자원을 동일한 PRB 번들링이 적용된 ZP CSI-RS로써 설정하여, 정확한 간섭 측정 또는 자원 낭비 없는 PDSCH 자원 할당이 가능하도록 할 수 있다.

[297] 한편, CSI-RS에 PRB 번들링이 적용되면 각 CSI-RS 안테나 포트의 주파수 축 RE 밀도가 줄어듦으로, CSI-RS 안테나 포트 별로 전송되어야 하는 CSI-RS 심볼의 개수가 줄어든다. 이 때, CSI-RS 시퀀스(sequence) 생성 및 심볼 맵핑에 대하여 두 가지 방법이 고려될 수 있다. 첫째는 각 안테나 포트 별로 줄어든 CSI-RS RE의 밀도에 맞추어 CSI-RS 시퀀스를 생성하고, 시퀀스를 구성하는 심볼들을 설정된 RE들에 주파수 축에서 순차적으로 맵핑하는 방법이다. 둘째는 각 안테나 포트 별로 기존과 동일한 길이의 CSI-RS 시퀀스를 생성하고, 시퀀스를 구성하는 심볼들을 설정된 RE들에 기존의 심볼과 PRB 페어 간 맵핑과 동일하게(즉, 띄엄띄엄) 맵핑하는 방법이다. 후자의 방법은, PRB 번들링이 적용될 수 있는 새로운 단말과 기존 단말이 CSI-RS 시퀀스를 공유하여 동일 자원 상에서 CSI-RS가 전송될 수 있다는 장점을 가진다.

[298] 한편, 방법 Mb100과 방법 Mb200에서는, 마지막 PRB 번들의 크기가 N^bundle_RB 보다 작을 수 있다. 예를 들어, 대역폭이 50 RB인 시스템의 경우에, CSI-RS의 PRB 번들 크기가 3으로 설정되면, 마지막 PRB 번들의 크기는 2가 된다. 마지막 PRB 번들에도 동일한 CSI-RS 패턴이 적용되되, PRB 페어의 부족으로 인해 맵핑될 자원이 존재하지 않는 CSI-RS 안테나 포트에 대해서는 맵핑을 생략하는 방법이 고려될 수 있다. 또는 마지막 PRB 번들에서는 CSI-RS를 전송하지 않는 방법이 고려될 수 있다.

[299] 한편, 지금까지 상술한 복수의 PRB 페어를 번들링하여 CSI-RS 자원을 설정하는 모든 방법은, 제2 CSI-RS 설정을 위해 적용될 수 있다. 제2 CSI-RS 설정은 하나 또는 복수의 CSI-RS configuration을 포함할 수 있는데, 이 때, 각 CSI-RS configuration별로 상술한 방법들이 적용될 수 있다. 즉, PRB 번들링의 적용 여부, PRB 번들의 크기, 그리고 PRB shift가 CSI-RS configuration별로 정의될 수 있다. 또는, PRB 번들링의 적용 여부, PRB 번들의 크기, 그리고 PRB shift 중 하나 또는 복수가 제2 CSI-RS 설정을 구성하는 모든 CSI-RS configuration에 공통으로 정의될 수 있다. 또는, PRB 번들링의 적용 여부, PRB 번들의 크기, 그리고 PRB shift 중 하나 또는 복수가 제2 CSI-RS 설정을 구성하는 CSI-RS configuration들 중 일부 CSI-RS configuration(들)의 집합에 공통으로 정의될 수 있다.

[300] 이하에서는 PRB 번들링을 적용하고 복수의 컴포넌트 CSI-RS configuration을 집성(aggregation)하여 단말에게 CSI-RS 자원을 설정하는 방법에 대하여 기술한다.

[301] 먼저 방법 Mb100을 위한 CSI-RS 자원 집성 방법에 대하여 기술한다. 가장 자유도가 높은 집성 방법은, 컴포넌트 CSI-RS configuration별로 PRB 번들의 크기를 독립적으로 설정하는 방법이지만, 이하에서는 집성되는 모든 컴포넌트 CSI-RS configuration들이 동일한 PRB 번들 크기를 가지는 경우만을 고려하기로 한다. CSI-RS 자원 집성의 경우에도, PRB 번들의 크기는 단말에 시그널링될 수도 있고, 미리 정해진 값을 따를 수도 있다. 이 때, PRB shift의 시그널링 유무에

따라 방법 Mb110 내지 방법 Mb130으로 구분될 수 있다.

[302] 방법 Mb110은, 컴포넌트 CSI-RS configuration 별로 PRB shift를 설정하는 방법이다.

[303] 방법 Mb110은, 방법 Mb120과 방법 Mb130에 비해 CSI-RS 자원 집성의 자유도가 높은 방법이다. 이 때, CSI-RS 자원 집성을 위한 파라미터는, 각 컴포넌트 CSI-RS configuration에 대한 CSI-RS 설정 정보 외에, 각 컴포넌트 CSI-RS configuration별 PRB shift를 포함하고, 모든 컴포넌트 CSI-RS configuration에 공통인 PRB 번들의 크기(N^bundle_RB)를 추가로 포함할 수도 있다.

[304] 각 컴포넌트 CSI-RS configuration을 위하여 설정 가능한 CSI-RS 안테나 포트 수는, Release 13 규격의 4 또는 8만을 포함할 수도 있고, 전술한 새로운 포트 수를 포함하여 4 또는 8 이외의 다른 포트 수(들)을 더 포함할 수도 있다.

[305] 안테나 포트 수가 1, 2, 4, 또는 8인 경우에, 컴포넌트 CSI-RS configuration은 기존 규격에 따른 CSI-RS configuration일 수 있고, 이외의 포트 수인 경우에, 컴포넌트 CSI-RS configuration은 새롭게 정의되는 CSI-RS configuration일 수 있다.

[306] PRB shift는 방법 Mb100에서 상술한 바와 같이, 0 이상 N^bundle_RB 미만의 정수 값으로 표현될 수 있다.

[307]

[308] 도 17은 본 발명의 실시예에 따른, 방법 Mb110을 이용해 복수의 컴포넌트 CSI-RS configuration을 집성하는 방법을 나타내는 도면이다.

[309] 단말(UE-e)에게는, 8개의 CSI-RS 안테나 포트를 포함하는 컴포넌트 CSI-RS configuration 2개가 집성되어 총 16개의 CSI-RS 안테나 포트가 설정된다. 예를 들어, PRB 페어 0번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)는, 단말(UE-e)을 위하여, 컴포넌트 CSI-RS configuration 0번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~22번)로써 설정된다. PRB 페어 1번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)는, 단말(UE-e)을 위하여, 컴포넌트 CSI-RS configuration 1번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~22번)로써 설정된다.

[310] 상술한 파라미터 예시에 따르면, 단말(UE-e)에게 전송되는 파라미터는, 각 컴포넌트 CSI-RS configuration의 CSI-RS 설정 정보 외에, 각 컴포넌트 CSI-RS configuration을 위한 PRB shift를 포함하고, 2인 PRB 번들의 크기(N^bundle_RB)를 추가로 포함할 수도 있다. 컴포넌트 CSI-RS configuration 0번을 위한 PRB shift는 0이고, 컴포넌트 CSI-RS configuration 1번을 위한 PRB shift는 1이다.

[311] 이 때, 단말(UE-e)을 위한 컴포넌트 CSI-RS configuration들(0번, 1번)의 안테나 포트 간 다중화 방식으로는, 두 개의 컴포넌트 CSI-RS configuration(0번, 1번)가 동일 OFDM 심볼 상에 할당되었으므로, FDM이 사용될 수 있다.

[312] 한편, 도 17에 예시된 실시예에서, 단말(UE-f)에게는, 2개의 컴포넌트 CSI-RS configuration이 집성되어 총 10개의 CSI-RS 안테나 포트가 설정된다. 예를 들어, PRB 페어 1번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 5), RE(3, 5), RE(2, 4), 및 RE(3, 4)는, 단말(UE-f)을 위하여, 컴포넌트 CSI-RS configuration 0번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~22번)로써 설정된다. PRB 페어 1번 내의 슬롯1의 RE(5, 9) 및 RE(6, 9)는, 단말(UE-f)을 위하여, 컴포넌트 CSI-RS configuration 1번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~16번)로써 설정된다.

[313] 단말(UE-f)에게 전송되는 파라미터는, 각 컴포넌트 CSI-RS configuration의 CSI-RS 설정 정보 외에, 각 컴포넌트 CSI-RS configuration을 위한 PRB shift를 포함하고, 2인 PRB 번들의 크기(N^bundle_RB)를 추가로 포함할 수도 있다. 컴포넌트 CSI-RS configuration 0번과 컴포넌트 CSI-RS configuration 1번을 위한 PRB shift는 모두 1이다.

[314] 이 때, 단말(UE-f)을 위한 두 개의 컴포넌트 CSI-RS configuration(0번, 1번)는 서로 다른 OFDM 심볼에 할당되었으므로, 컴포넌트 CSI-RS configuration들(0번, 1번)의 안테나 포트 간 다중화 방식으로는, FDM은 사용될 수 없고, TDM이 사용될 수 있다.

[315]

[316] 도 18은 본 발명의 다른 실시예에 따른, 방법 Mb110을 이용해 복수의 컴포넌트 CSI-RS configuration을 집성하는 방법을 나타내는 도면이다.

[317] 구체적으로 도 18에는, 하나의 단말(UE-e)에게, 3개의 컴포넌트 CSI-RS configuration(0번, 1번, 2번)이 집성되어 총 48개의 CSI-RS 안테나 포트가 설정되는 경우가 예시되어 있다.

[318] PRB 번들 크기(N^bundle_RB)는 2이고, 각 컴포넌트 CSI-RS configuration (0번~2번)의 안테나 포트 수는 16개이다. 예를 들어, PRB 페어 0번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)와 PRB 페어 0번 내의 슬롯1의 RE(2, 9), RE(3, 9), RE(2, 8), RE(3, 8), RE(2, 3), RE(3, 3), RE(2, 2), 및 RE(3, 2)는, 단말(UE-e)을 위하여, 컴포넌트 CSI-RS configuration 0번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~30번)로써 설정된다. PRB 페어 0번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 5), RE(3, 5), RE(2, 4), 및 RE(3, 4)와 PRB 페어 0번 내의 슬롯1의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)는, 단말(UE-e)을 위하여, 컴포넌트 CSI-RS configuration 1번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~30번)로써 설정된다. PRB 페어 1번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)와 PRB 페어 1번 내의 슬롯1의 RE(2, 9), RE(3, 9), RE(2, 8), RE(3, 8), RE(2, 3), RE(3, 3), RE(2, 2), 및 RE(3, 2)는, 단말(UE-e)을 위하여, 컴포넌트 CSI-RS configuration 2번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~30번)로써 설정된다.

[319]

[320] 방법 Mb120은, 모든 컴포넌트 CSI-RS configuration에 PRB shift를 동일한 값으로 설정하는 방법이다.

[321] 방법 Mb120은 방법 Mb110에 비해, 설정에 다소 제한을 가하는 대신에, 시그널링 오버헤드를 줄일 수 있는 방법이다. 방법 Mb120에 의하면 모든 컴포넌트 CSI-RS configuration의 CSI-RS RE들이 동일한 PRB 페어 상에 맵핑되므로, 다수의 CSI-RS 안테나 포트를 집성하는 것이 어려울 수 있다.

[322]

[323] 방법 Mb130은, PRB shift가 단말에 시그널링되지 않고 미리 정해진 규칙을 따르는 방법이다.

[324] 방법 Mb130은 방법 Mb110과 방법 Mb120에 비해, 설정에 다소 제한을 가하는 대신에, 시그널링 오버헤드를 줄일 수 있는 방법이다. 미리 정해진 집성 규칙을 위한 한 방법으로써, PRB shift는 각 컴포넌트 CSI-RS configuration의 인덱스의 함수로 정해지는 방법이 고려될 수 있다. 예를 들어, 각 컴포넌트 CSI-RS configuration을 위한 PRB shift는 해당 컴포넌트 CSI-RS configuration 인덱스를 PRB 번들의 크기(N^bundle_RB)로 모듈로(modulo) 연산을 취한 결과값에 의해 정해질 수 있다 (이하 '방법 Mb130-1'). 또는, PRB 번들의 크기(N^bundle_RB)는 컴포넌트 CSI-RS configuration의 수로 정해지고, 각 컴포넌트 CSI-RS configuration을 위한 PRB shift는 해당 컴포넌트 CSI-RS configuration의 인덱스로 정해질 수 있다 (이하 '방법 Mb130-2').

[325] 이 때, CSI-RS 자원 집성을 위한 파라미터는, 각 컴포넌트 CSI-RS configuration의 CSI-RS 설정 정보만을 포함하거나, 모든 컴포넌트 CSI-RS configuration에 공통인 PRB 번들의 크기(N^bundle_RB)를 추가로 포함할 수도 있다.

[326]

[327] 도 19는 본 발명의 실시예에 따른, 방법 Mb130을 이용해 복수의 컴포넌트 CSI-RS configuration을 집성하는 방법을 나타내는 도면이다.

[328] 단말(UE-e)에게는, 방법 Mb130-1에 의해, 3개의 컴포넌트 CSI-RS configuration이 집성되어 총 10개의 CSI-RS 안테나 포트가 설정된다. 예를 들어, PRB 페어 0번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 5), 및 RE(3, 5)는, 단말(UE-e)을 위하여, 컴포넌트 CSI-RS configuration 0번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~18번)로써 설정된다. PRB 페어 1번 내의 슬롯1의 RE(5, 9), RE(6, 9), RE(5, 3), 및 RE(6, 3)는, 단말(UE-e)을 위하여, 컴포넌트 CSI-RS configuration 1번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~18번)로써 설정된다. PRB 페어 0번 내의 슬롯1의 RE(5, 9) 및 RE(6, 9)는, 단말(UE-e)을 위하여, 컴포넌트 CSI-RS configuration 2번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~16번)로써 설정된다.

[329] 이 경우에, 컴포넌트 CSI-RS configuration 0번 내지 컴포넌트 CSI-RS

configuration 2번을 위한 PRB 번들의 크기(N^bundle_RB)는 모두 2이다. 또한, 컴포넌트 CSI-RS configuration 0번 내지 컴포넌트 CSI-RS configuration 2번을 위한 PRB shift는 해당 컴포넌트 CSI-RS configuration 인덱스를 PRB 번들의 크기(N^bundle_RB)로 모듈로 연산을 취한 결과값, 즉, 0, 1, 및 0으로 각각 정해진다.단말(UE-f)에게는, 방법 Mb130-2에 의해, 8개의 CSI-RS 안테나 포트를 포함하는 컴포넌트 CSI-RS configuration 2개가 집성되어 총 16개의 CSI-RS 안테나 포트가 설정된다. 예를 들어, PRB 페어 0번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)는, 단말(UE-f)을 위하여, 컴포넌트 CSI-RS configuration 0번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~22번)로써 설정된다. PRB 페어 1번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)는, 단말(UE-f)을 위하여, 컴포넌트 CSI-RS configuration 1번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~22번)로써 설정된다.

[330] 이 경우에, PRB 번들의 크기(N^bundle_RB)는 컴포넌트 CSI-RS configuration의 수인 2로 정해진다. 또한, 컴포넌트 CSI-RS configuration 0번과 컴포넌트 CSI-RS configuration 1번을 위한 PRB shift는 해당 컴포넌트 CSI-RS configuration 인덱스, 즉, 0과 1로 각각 정해진다.

[331]

[332] 다음으로 방법 Mb200을 위한 CSI-RS 자원 집성 방법에 대하여 기술한다.

[333] 상술한 바와 마찬가지로, 집성되는 모든 컴포넌트 CSI-RS configuration들이 동일한 PRB 번들 크기를 가진다고 가정하면, CSI-RS 자원 집성을 위한 파라미터는, 각 컴포넌트 CSI-RS configuration에 대한 CSI-RS 설정 정보만을 포함하거나, 모든 컴포넌트 CSI-RS configuration에 공통인 PRB 번들의 크기(N^bundle_RB)를 추가로 포함할 수도 있다.

[334]

[335] 도 20은 본 발명의 실시예에 따른, 방법 Mb200의 PRB 번들링이 사용되는 경우에 복수의 컴포넌트 CSI-RS configuration을 집성하는 방법을 나타내는 도면이다.

[336] 구체적으로 도 20에는 PRB 번들 크기(N^bundle_RB)는 2이고, 집성되는 컴포넌트 CSI-RS configuration의 수는 2인 경우가 예시되어 있다.

[337] 컴포넌트 CSI-RS configuration 0번과 1번 모두에는 방법 Mb200의 PRB 번들링에 의해 확장된 CSI-RS 패턴이 적용되고, 컴포넌트 CSI-RS configuration 0번과 1번은 모두 8개의 CSI-RS 안테나 포트 수를 가진다. 예를 들어, PRB 페어 0번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 3), 및 RE(6, 3)와 PRB 페어 1번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 3), 및 RE(6, 3)는, 단말(UE-e)을 위하여, 컴포넌트 CSI-RS configuration 0번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~22번)로써 설정된다. PRB 페어 0번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 5), 및 RE(3, 5)와 PRB 페어 1번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 5), 및

RE(3, 5)는, 단말(UE-e)을 위하여, 컴포넌트 CSI-RS configuration 1번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~22번)로써 설정된다.

[338] 한편, 지금까지 상술한 복수의 PRB 페어를 번들링하여 CSI-RS 자원을 설정하는 모든 방법에 대하여, 서로 다른 서브프레임들에 대하여, PRB 페어의 인덱스를 주기적으로 교차하여 CSI-RS를 전송하는 방법이 적용될 수 있다.

[339]

[340] 도 21은 본 발명의 실시예에 따른, 번들링된 PRB 페어들의 인덱스를 시간적으로 교차시켜 CSI-RS를 전송하는 방법을 나타내는 도면이다.

[341] 도 13a 및 도 13b에 예시된 바와 같이, 기지국이 방법 Mb200에 따라 2개의 PRB 페어를 번들링하여 단말에게 12개의 CSI-RS 안테나 포트를 설정하는 경우에, 기지국은 도 21에 예시된 바와 같이, CSI-RS 전송 서브프레임마다 PRB 페어의 위치를 교대로 바꾸어 CSI-RS를 전송할 수 있다.

[342] 구체적으로, CSI-RS 전송 주기를 T라고 가정하면, CSI-RS 전송 서브프레임 n+T 내의 PRB 페어 0번과 1번의 위치가 CSI-RS 전송 서브프레임 n 내의 PRB 페어 0번과 1번의 위치와 맞바뀐 형태로, CSI-RS가 전송될 수 있다.

[343] 이를 통해, 단말은 각 CSI-RS 안테나 포트에 대하여, 시스템 대역 내 모든 PRB 페어의 주파수 영역을 위한 채널 추정을 수행할 수 있으므로, CSI 측정 정확도가 향상될 수 있다.

[344] 한편, 지금까지 상술한 복수의 PRB 페어를 번들링하여 CSI-RS 자원을 집성하는 모든 방법은, 제1 CSI-RS 설정을 위해 적용될 수 있다. 또한, 전술하였듯이, 상술한 CSI-RS 자원 집성 방법들은 새로운 CSI-RS 안테나 포트 수의 설정을 위해서도 동일하거나 유사하게 적용될 수 있다.

[345] 한편, 방법 Mb100 및 방법 Mb100의 세부 방법들에 CDM-4를 적용하는 방법으로써, PRB 번들링이 적용되지 않는 기존 규격의 경우와 마찬가지로, 각각의 컴포넌트 CSI-RS configuration 내에서 CDM-4를 적용하는 방법이 사용될 수 있다. 이 경우에, 컴포넌트 CSI-RS configuration의 안테나 포트 수가 4 또는 8이라면, 기존 규격의 CDM-4 패턴이 동일하게 적용될 수 있다. 반면에, 방법 Mb200 및 방법 Mb200의 세부 방법들에 CDM-4를 적용하기 위하여, 각각의 컴포넌트 CSI-RS configuration 내에서 CDM-4가 적용되면, CDM-4 패턴을 구성하는 RE들 간의 주파수 축 거리가 멀어져 채널 추정 성능이 열화될 수 있다. 이 경우에, 하나의 CDM-4 패턴이 복수(예를 들면, 2개)의 컴포넌트 CSI-RS configuration들 간에 걸쳐서 정의되도록 하는 방법이 사용될 수 있다.

[346]

[347] 2.3.2. 노멀 CP가 설정되는 경우에, TDD에만 적용되는 CSI-RS 자원 설정 방법

[348] 표 2에서 CSI-RS configuration 20~31번에 대한 CSI-RS 패턴과 자원 맵핑은, 안테나 포트 5번의 DMRS 전송 자원과의 오버랩을 피하기 위해 설계되었다. 이 때, PRB 번들링이 적용되지 않은 하나의 PRB 페어 내의 CSI-RS 자원 풀은 24개의 RE들을 포함한다. 이 경우에도, 앞서 기술한 모든 PRB 번들링 방법들과

그 원리가 동일 또는 유사하게 적용될 수 있다. 다만, 하나의 PRB 페어 내에서 24개가 넘는 수의 CSI-RS 안테나 포트의 패턴을 정의하거나 24개가 넘는 수의 CSI-RS 안테나 포트를 집성하는 것은 불가능하다.

[349]

[350] 2.3.3. 확장 CP가 설정되는 경우에, FDD와 TDD에 공통적으로 적용될 수 있는 CSI-RS 자원 설정 방법

[351] 확장 CP가 설정되는 경우에 FDD와 TDD에 공통적으로 적용되는 CSI-RS configuration은, 기존 규격 상에서 0번부터 15번까지 총 16개이다. 하나의 PRB 페어 내의 CSI-RS 자원 풀은 32개의 RE들을 포함한다. 이 경우에도, 앞서 기술한 모든 PRB 번들링 방법들과 그 원리가 동일 또는 유사하게 적용될 수 있다.

[352]

[353] 2.3.4. 확장 CP가 설정되는 경우에, TDD에만 적용되는 CSI-RS 자원 설정 방법

[354] 확장 CP가 설정되는 경우에, 기존 규격상의 CSI-RS configuration 16~27번의 CSI-RS 자원 설정은, 안테나 포트 5번의 DMRS 전송 자원과의 오버랩을 최대한 피하도록 설계된다. 이 경우에 하나의 PRB 페어 내의 CSI-RS 자원 풀은 24개의 RE들을 포함한다. 이 경우에도, 앞서 기술한 모든 PRB 번들링 방법들과 그 원리가 동일 또는 유사하게 적용될 수 있다. 다만, 하나의 PRB 페어 내에서 24개가 넘는 수의 CSI-RS 안테나 포트의 패턴을 정의하거나 24개가 넘는 수의 CSI-RS 안테나 포트를 집성하는 것은 불가능하다.

[355]

[356] 한편, 지금까지 하향링크 RS가 CSI-RS인 경우를 예로 들어, 본 발명의 실시예를 설명하였으나, 이는 예시일 뿐이다. 본 발명의 실시예는, 하향링크 RS가 CSI-RS가 아닌 다른 RS인 경우에도 적용될 수 있다.

[357]

[358] 3. CSI-RS 안테나 포트 배열을 고려한 자원 설정 방법

[359] 단말은 기지국으로부터 시그널링받은 CSI-RS 설정 정보(예, CSI-RS 안테나 포트 수, RE 맵핑 정보)에 기초하여, 설정받은 각 CSI-RS 안테나 포트에 대하여 채널 추정(예, 채널 정보 획득)을 수행한다. 그리고 나서 단말은 CSI-RS 안테나 포트들에 대하여 획득한 채널 정보를 기초로 하여, CSI 측정 및 보고를 수행한다. 여기서 CSI 측정은, 단말이 채널 추정을 통해 획득한 하향링크 채널 정보를 이용하여 PMI(precoding matrix indicator), RI(rank indicator), 그리고/또는 CQI(channel quality indicator)를 결정하는 일련의 과정을 의미한다. 현재 규격에 의하면, 단말은 CSI를 측정할 때 자신이 기지국에 보고한 PMI에 대응하는 프리코딩 행렬의 각 행이 CSI-RS 안테나 포트에 15번부터 순차적으로 대응됨을 가정한다. 예를 들어, 단말이 4개의 CSI-RS 안테나 포트를 설정받은 경우에, 단말은 기지국에 의해 이용되는 프리코딩 행렬의 1행 내지 4행이 CSI-RS 안테나 포트 15번 내지 18번의 채널을 위한 프리코딩 가중치임을 가정하고 CSI를 측정한다. 이 때, 단말은 총 CSI-RS 안테나 포트 수만을 알고 있을 뿐, CSI-RS

안테나 포트들이 실제로 어떤 배치를 갖는지 명시적으로(explicitly) 알지 못한다.

[360] 한편, 상술한 바와 같이, FD-MIMO(또는 3차원 MIMO) 시스템에서 기지국이 3차원 빔포밍을 수행하기 위해서는, 단말이 기존의 수평 축에 대한 CSI 뿐만 아니라 수직 축에 대한 CSI에 대해서도 CSI 측정 및 보고를 수행할 필요가 있다.

[361] 이하에서는, CSI-RS 안테나 포트 번호를, 셀 특정적(cell-specific) CSI-RS 안테나 포트 번호와 단말 특정적(user equipment-specific) CSI-RS 안테나 포트 번호로 구분하여 기술한다. 셀 특정적 CSI-RS 안테나 포트 번호는 기지국에 의해 전송되는 모든 CSI-RS 안테나 포트에 대하여 기지국의 입장에서 매겨지는 번호를 의미하는 것으로 가정하고, 셀 특정적 CSI-RS 안테나 포트 번호는 0번부터 순차적으로 번호 매김되는 것으로 가정한다. 단말 특정적 CSI-RS 안테나 포트는 각 단말에 설정된 CSI-RS 안테나 포트에 대하여 각 단말의 입장에서 매겨지는 번호를 의미하는 것으로 가정한다. LTE 규격에는, 단말의 CSI-RS 안테나 포트 번호가 15번부터 순차적으로 번호 매김되는 것으로 정의되어 있으나, 이하에서는 설명의 편의를 위하여, 0번부터 순차적으로 번호 매김되는 것으로 가정한다. 본 명세서에서, CSI-RS 안테나 포트 번호가 셀 특정적인 경우 또는 단말 특정적인 경우로 명시되지 않은 경우, 이는 단말 특정적 CSI-RS 안테나 포트 번호를 의미함을 가정한다.

[362]

[363] 3.1. 2차원 CSI-RS 안테나 포트 배열 정보를 설정하는 방법

[364] 2차원 CSI-RS 안테나 포트 배열을 위해 제1 차원(first dimension)과 제2 차원(second dimension)이 정의될 수 있다. 일반적으로 2차원 CSI-RS 안테나 포트 배열을 위한 제1 차원과 제2 차원은, 2차원 공간 상에서 두 개의 서로 다른 임의의 방향성을 나타낼 수 있다. 예를 들어, 제1 차원과 제2 차원은, 수평(horizontal) 차원과 수직(vertical) 차원을 포함할 수 있다. 수평 차원과 수직 차원은, 2차원 공간 상에서 두 개의 직교하는 임의의 차원 또는 방향성을 나타낼 수 있다. 예를 들어, 상기 2차원 공간은 CSI-RS 안테나 포트들이 맵핑되는 물리 안테나 요소들로 구성되는 2차원 안테나 배열 평면일 수 있다. 수평 차원 및 수직 차원은, 수평 축 및 수직 축, 또는 수평 방향 및 수직 방향과 동일한 의미로 사용될 수 있다. 이하에서는, 설명의 편의를 위해서, CSI-RS 안테나 포트 배열을 위한 제1 차원과 제2 차원을 수평 축과 수직 축으로 부르기로 한다.

[365] 한편, CSI-RS 안테나 포트 배열은 단일 편파(polarization)를 가질 수도 있고, 다중 편파를 가질 수도 있다. 여기서, CSI-RS 안테나 포트의 편파라 함은, CSI-RS 안테나 포트가 맵핑되는 물리 안테나 요소(들)이 가지는 편파를 의미한다. 이 때, CSI-RS 안테나 포트 배열을 위해, 상술한 공간 차원과는 별도로, 편파 차원이 정의될 수 있다. 본 명세서에서, CSI-RS 안테나 포트 배열을 위한 편파 차원은, CSI-RS 안테나 포트들이 맵핑되는 물리 안테나 요소들의 편파(예, 0도 내지 180도)로 구성되는 차원을 의미한다. 이하에서는, CSI-RS 안테나 포트 배열을 위한 편파 차원을 편파 축으로 부르기로 한다.

[366]

[367] 도 22은 2차원 CSI-RS 안테나 포트 배열의 예를 나타내는 도면이다.

[368] 구체적으로 도 22에는, 수평 축, 수직 축, 및 편파 축으로의 CSI-RS 안테나 포트 수가 모두 2이고, CSI-RS 안테나 포트 번호가, 0번부터 시작하여 수평 축, 편파 축, 및 수직 축의 순서로 번호 매김된 경우가 예시되어 있다. 여기서, 편파 축의 서로 다른 CSI-RS 안테나 포트들은, 서로 다른 편파를 갖는 물리 안테나 요소(들)에 맵핑되는 CSI-RS 안테나 포트들을 의미한다.

[369] 또한, 도 22에서 편파 축으로 존재하는 2개의 CSI-RS 안테나 포트 각각이 +45도와 -45도의 막대(bar)로써 표현된 것은, 일반적으로 이중 편파 안테나 배열로써 사용되는 교차 편파(cross-polarization) 안테나 배열에서, 2개의 CSI-RS 안테나 포트들 각각이 +45도 편파 안테나 요소(들)과 -45도 편파 안테나 요소(들) 각각에 맵핑되는 것을 의미한다. 그러나, 본 명세서의 도면들에서 이중 편파를 가지는 CSI-RS 안테나 포트 배열의 편파 방향성이 +45도와 -45도인 것은 단지 예시일 뿐, 본 발명의 범위가 이들 예에 의하여 한정되지 않는다.

[370] 상술한 바와 같이, CSI-RS 안테나 포트와 물리 안테나 요소(들) 간의 맵핑을 안테나 가상화(virtualization)라 한다. 이하에서 설명되는 기술의 원리는, 특정 안테나 가상화 방식에 의해 제약을 받지 않으므로, 이하에서는 안테나 가상화 방식에 대해서는 구체적으로 기술하지 않기로 한다.

[371] 단말은 CSI 측정 및 보고를 위해 이용되는 코드북의 형태에 따라, CSI-RS 안테나 포트 배열에 대하여 단일 편파 또는 이중 편파를 가정할 수 있다. 현재 규격에 의하면, 단말은 Release 8에 도입된 2개 또는 4개의 송신 안테나 포트를 위한 코드북을 CSI 보고에 이용하는 경우, CSI-RS 안테나 포트 배열이 단일 편파임을 가정할 수 있다. 반면에, 단말은 Release 10에 도입된 8개의 송신 안테나 포트를 위한 코드북 또는 Release 12에 추가로 도입된 4개의 송신 안테나 포트를 위한 코드북을 CSI 보고에 이용하는 경우, CSI-RS 안테나 포트 배열이 이중 편파임을 가정할 수 있다. 상기 코드북들은 1차원 CSI-RS 안테나 포트 배열을 통해 얻어지는 1차원 CSI를 보고하는 데 적합하며, 이러한 코드북을 1차원 코드북이라 부르기로 한다.

[372] 한편, 상술한 바와 같이, FD-MIMO 시스템을 위해, 단말이 2차원 CSI를 기지국에 보고하는 것이 필요할 수 있다. 2차원 CSI를 보고하는 데 적합한 코드북을 2차원 코드북이라 부르기로 한다. 단말은 2차원 코드북을 이용해, 2차원 CSI 뿐만 아니라 1차원 CSI도 보고할 수 있다. 단말은 2차원 코드북을 CSI 보고에 이용하는 경우, 2차원 CSI-RS 안테나 포트 배열의 공간 정보를 알아야 할 수 있다. 또는 단말은, 기지국에 PMI를 보고하지 않도록 설정된 경우라 하더라도, CQI 그리고/또는 RI를 결정하기 위해, 2차원 CSI-RS 안테나 포트 배열의 공간 정보를 알아야 할 수도 있다. 이와 별도로, 단말은 2차원 CSI-RS 안테나 포트 배열의 편파 정보를 알아야 할 수도 있다.

[373] 이하에서는, 2차원 CSI-RS 안테나 포트 배열의 수평 축과 수직 축의 CSI-RS

안테나 포트 수를 각각 N_1과 N_2라 한다. 2차원 CSI-RS 안테나 포트 배열이 단일 편파인 경우, N_1과 N_2의 곱은 2차원 CSI-RS 안테나 포트 배열의 총 CSI-RS 안테나 포트 수와 동일하고, 2차원 CSI-RS 안테나 포트 배열이 이중 편파인 경우, N_1과 N_2의 곱은 2차원 CSI-RS 안테나 포트 배열의 총 CSI-RS 안테나 포트 수의 절반이다.

[374] 단말이 CSI-RS 안테나 포트 배열의 편파 정보를 획득하기 위한 방법으로, 기지국이 단말에게 CSI-RS 안테나 포트 배열이 단일 편파인지 이중 편파인지를 알려주는 방법이 고려될 수 있다. 이를 위해, 기지국은 단말에게 편파 정보(예, 1비트)를 명시적으로 시그널링할 수 있다. 또는, 기지국은 단말에게 편파 정보를 암시적으로 알려줄 수 있다. 예를 들어, 기지국은 단말에게 2차원 CSI-RS 안테나 포트 배열의 총 CSI-RS 안테나 포트 수를 알려주고, 추가로 N_1과 N_2의 곱을 알려줄 수 있다. 단말은 N_1과 N_2의 곱이 총 CSI-RS 안테나 포트 수와 일치하는 경우, CSI-RS 안테나 포트 배열이 단일 편파임을 가정하고, N_1과 N_2의 곱이 총 CSI-RS 안테나 포트 수의 절반인 경우, CSI-RS 안테나 포트 배열이 이중 편파임을 가정할 수 있다. 다른 방법은, 단말에 의해 가정되는 편파 축 CSI-RS 안테나 포트 수를 코드북별로 규격에 미리 정의하는 방법이다. 예를 들어, 단말이 2차원 코드북을 CSI 보고에 이용하도록 설정된 경우, 단말이 CSI-RS 안테나 포트 배열을 이중 편파로 가정하는 것이 규격에 명시될 수 있다. 또 다른 방법은, 단말에 의해 가정되는 편파 축 CSI-RS 안테나 포트 수를 규격에 정의하지 않고, 이를 단말이 코드북의 형태에 따라 적절한 값을 가정하도록 하는 방법이다. 예를 들어, 2차원 코드북이 이중 편파 (또는 교차 편파) 안테나 포트 배열에 대한 CSI 보고에 적합함이 규격에 정의되고, 단말은 2차원 코드북을 CSI 보고에 이용하도록 설정된 경우, CSI-RS 안테나 포트 배열이 이중 편파임을 가정할 수 있다.

[375] 한편, 단말이 2차원 CSI-RS 안테나 포트 배열의 공간 정보를 획득하기 위한 방법으로, 기지국이 단말에게 2차원 CSI-RS 안테나 포트 배열의 공간 정보를 알려주는 방법이 고려될 수 있다. 이를 위해, 기지국은 단말에게 2차원 CSI-RS 안테나 포트 배열의 공간 정보를 시그널링할 수 있다. 구체적으로, 기지국은 단말에게 N_1과 N_2를 시그널링할 수 있다. 또는, 기지국은 단말에게 N_1과 N_2의 곱을 시그널링하고, 추가로 N_1과 N_2 중 하나를 시그널링할 수 있다. 이 때, CSI-RS 안테나 포트 배열이 단일 편파인지 또는 이중 편파인지와는 무관하게, 상기 방법들이 사용될 수 있다. 여기서, 시그널링은 명시적인 시그널링과 암시적인 시그널링을 모두 포함할 수 있다.

[376] 예를 들어, 기지국이 단말에게 도 22에 예시된 8개의 CSI-RS 안테나 포트들을 설정하고자 하는 경우에, 기지국은 단말에게 N_1=2 및 N_2=2를 시그널링하고, CSI-RS 안테나 포트 배열이 이중 편파임을 추가로 알려줄 수 있다. 다른 예를 들어, 주어진 코드북에 의해 CSI-RS 안테나 포트 배열이 단일 편파인지 또는 이중 편파인지가 미리 정의되고, 기지국이 단말에게 N_1=2 및 N_2=2를 시그널링할

수 있다. 또 다른 예를 들어, 기지국은 단말에게 총 CSI-RS 안테나 포트 수가 8임을 알려주고, 추가로 N_1=2 및 N_2=2를 시그널링할 수 있다. 또 다른 예를 들어, 기지국은 단말에게 총 CSI-RS 안테나 포트 수가 8임을 알려주고, 추가로 N_1과 N_2의 곱이 4임을 알려줄 수 있다. 또 다른 예를 들어, 기지국은 단말에게 총 CSI-RS 안테나 포트 수가 8임을 알려주고, CSI-RS 안테나 포트 배열의 공간 축 또는 편파 축 배치 구조를 알려주지 않을 수 있다.

[377] 상술한 바와 같이 본 명세서에서, 기지국이 단말에게 정보를 전달하기 위한 시그널링은, 물리계층 시그널링(예, 물리계층 제어 채널의 제어 필드 파라미터), MAC 시그널링(예, MAC PDU 형태의 제어 정보, 또는 MAC 헤더 형태의 제어 정보), RRC 시그널링(예, RRC 제어 메시지 또는 IE 형태의 제어 파라미터) 등을 포함할 수 있다. 특히, 물리계층 시그널링 또는 MAC 시그널링 방식을 통한 제어 시그널링은, 해당 단말을 위한 스케줄링 정보와 함께 구성되거나 또는 동시에 전송되는 방법을 통하여 동적(dynamic) 자원 활용이 가능하다는 장점을 가질 수 있다.

[378] 이하에서는, 단말이 설정받은 CSI-RS 안테나 포트들로 구성되는 CSI-RS 안테나 포트 배열 상에 단말 특정적 CSI-RS 안테나 포트 번호들이 맵핑되는 방법에 대하여 기술한다. 설명의 편의를 위해, CSI-RS 안테나 포트 배열은 일반적으로 2차원임을 가정한다. 그러나, 본 명세서에서, 따로 언급이 없더라도, 2차원 CSI-RS 안테나 포트 배열은 1차원 CSI-RS 안테나 포트 배열을 포함할 수 있고, 2차원 CSI-RS 안테나 포트 배열에 적용되는 방법들은 1차원 CSI-RS 안테나 포트 배열에도 동일 또는 유사하게 적용될 수 있다.

[379] 단말 특정적 CSI-RS 안테나 포트 번호가 2차원 CSI-RS 안테나 포트 배열 상에서 수평 축, 수직 축, 및 편파 축에 어떤 순서로 맵핑되는지를 미리 정해두는 방법(이하 '방법 Mc100')이 사용될 수 있다. 방법 Mc100은 단말이 N_1 및 N_2 값을 알고, 추가로 2차원 CSI-RS 안테나 포트 배열이 단일 편파인지 이중 편파인지를 알고 있는 경우에 적용될 수 있다.

[380]

[381] 도 23a 및 도 23b는 본 발명의 실시예에 따른, 2차원 CSI-RS 안테나 포트 배열에 단말 특정적 CSI-RS 안테나 포트 번호가 맵핑되는 방법을 나타내는 도면이다.

[382] 도 23a 및 도 23b에는, 기지국이 방법 Mc100에 기초해 단말에게 도 22에 예시된 8개의 CSI-RS 안테나 포트를 설정하는 경우에, 해당 단말이 CSI-RS 안테나 포트 배열 상에서 인식하는 단말 특정적 CSI-RS 안테나 포트 번호가 예시되어 있다.

[383] 구체적으로, 도 23a에는 단말 특정적 CSI-RS 안테나 포트 번호가 수평 축, 편파 축, 및 수직 축의 순서로 증가하는 경우가 예시되어 있다. 도 23b에는 단말 특정적 CSI-RS 안테나 포트 번호가 수직 축, 수평 축, 및 편파 축의 순서로 증가하는 경우가 예시되어 있다.

[384] 한편, 단말 특정적 CSI-RS 안테나 포트 번호가 2차원 CSI-RS 안테나 포트 배열 상에서 수평 축 및 수직 축에 어떤 순서로 맵핑되는지를 미리 정해두는

방법(이하 '방법 Mc101')이 사용될 수 있다. 방법 Mc101은 단말이 2차원 CSI-RS 안테나 포트 배열이 단일 편파인지 또는 이중 편파인지를 모르는 경우에 적용될 수 있다. 이 때, 2차원 CSI-RS 안테나 포트 배열이 단일 편파인지 또는 이중 편파인지와 무관하게, N_1과 N_2의 곱은 2차원 CSI-RS 안테나 포트 배열의 총 CSI-RS 안테나 포트 수와 동일할 수 있다. 예를 들어, 단말 특정적 CSI-RS 안테나 포트 번호가 0번부터 시작하여, 수평 축에 먼저 순차적으로 맵핑되고, 다음으로 수직 축에 맵핑될 수 있다.

[385] 방법 Mc100과 방법 Mc101의 CSI-RS 안테나 포트 번호 맵핑 규칙은, 상기와 같이 명시적으로 정의될 수 있다. 또는, 단말이 수평 축 PMI와 수직 축 PMI를 나누어 보고하는 경우 또는 단말이 수평 축 PMI, 수직 축 PMI, 및 편파 축 PMI를 나누어 보고하는 경우에, 방법 Mc100과 방법 Mc101의 CSI-RS 안테나 포트 번호 맵핑 규칙은, CSI 측정 시 단말에 의해 가정되는 기지국 프리코딩에 대한 정의를 통해, 암시적으로 정의될 수도 있다. 즉, 단말은 CSI 측정을 수행할 때, 단말은 기지국이 아래의 수학식 1의 프리코딩을 적용함을 가정할 수 있다.

[386] [수식1]

$$\begin{bmatrix} y^{(0)}(i) \\ \vdots \\ y^{(P-1)}(i) \end{bmatrix} = W(i) \cdot \begin{bmatrix} x^{(0)}(i) \\ \vdots \\ x^{(V-1)}(i) \end{bmatrix}$$

[387] 수학식 1에서, $x^{(m)}(i)$ (단, m=0,…,V-1)는 i번째 시점에서 m번째 데이터 레이어(layer)를 통해 전송되는 데이터 심볼을 의미하고, $y^{(n)}(i)$ (단, n=0,…,P-1)는 i번째 시점에서 n번째 CSI-RS 안테나 포트를 통해 전송되는 프리코딩된 데이터 심볼을 의미하고, W(i)는 P개의 행과 V개의 열로 구성되는, i번째 시점에서의 프리코딩 행렬을 의미한다. 여기서, P는 CSI-RS 안테나 포트 수이고, V는 데이터 레이어의 수이다. 이 때, 단말이 보고하는 수평 축 PMI, 수직 축 PMI, 및 편파 축 PMI에 대응하는 프리코딩 행렬 각각을, $W_1(i)$, $W_2(i)$, $W_P(i)$라 정의한다. 여기서, 수평 축 PMI의 행렬 및 $W_1(i)$는, N_1개의 행과, 단말이 보고하는 수평 축 랭크(rank)와 동일한 개수의 열을 가진다. 수직 축 PMI의 행렬 및 $W_2(i)$는 N_2개의 행과, 단말이 보고하는 수직 축 랭크와 동일한 개수의 열을 가진다. 편파 축 PMI의 행렬 및 $W_P(i)$는, 1개 또는 2개의 행을 가지고(예, CSI-RS 안테나 배열이 단일 편파인 경우에 1개의 행을 가지고, CSI-RS 안테나 배열이 이중 편파인 경우에 2개의 행을 가지고), 단말이 보고하는 편파 축 랭크와 동일한 개수의 열을 가진다.

[388] 상기 정의에 기초하면, W(i)는 $W_1(i)$, $W_2(i)$, 및 $W_P(i)$의 크로네커 곱(Kronecker product)으로 표현되거나, W(i)는 $W_1(i)$와 $W_2(i)$의 크로네커 곱으로 표현될 수 있다. 예를 들어, 방법 Mc100에서 CSI-RS 안테나 포트 배열 상에 단말 특정적 CSI-RS 안테나 포트 번호가 수평 축, 편파 축, 및 수직 축의 순서로 맵핑되도록 하는 방법은, 아래의 수학식 2와 같은 크로네커 곱의 순서를 가지도록 수학식

1의 W(i)를 정의할 수 있다.

[389] [수식2]

$$W(i) = W_2(i) \otimes W_P(i) \otimes W_1(i)$$

[390] 다른 예를 들어, 방법 Mc101에서 CSI-RS 안테나 포트 배열 상에 단말 특정적 CSI-RS 안테나 포트 번호가 수평 축에 먼저, 수직 축에는 나중에 맵핑되도록 하는 방법은, 아래의 수학식 3과 같이 수학식 1의 W(i)를 정의할 수 있다.

[391] [수식3]

$$W(i) = W_2(i) \otimes W_1(i)$$

[392] 또 다른 예를 들어, 방법 Mc101에서 CSI-RS 안테나 포트 배열 상에 단말 특정적 CSI-RS 안테나 포트 번호가 수직 축에 먼저, 수평 축에는 나중에 맵핑되도록 하는 방법은, 아래의 수학식 4와 같이 수학식 1의 W(i)를 정의할 수 있다.

[393] [수식4]

$$W(i) = W_1(i) \otimes W_2(i)$$

[394] 한편, 단말이 수평 축 PMI와 수직 축 PMI를 나누어 보고하지 않고 하나의 통합(joint) PMI를 보고하는 경우에, 기지국의 프리코더를 수학식 2 내지 수학식 4와 같이 수평 축 프리코더와 수직 축 프리코더로 구분하는 것이 성립되지 않을 수 있다. 이 경우에는, W(i)의 행 인덱스 p (단, p=0, 1, …, P-1)와 수평 축 CSI-RS 포트 인덱스 p_1 (단, p_1=0, 1, …, N_1-1), 수직 축 CSI-RS 포트 인덱스 p_2 (단, p_2=0, 1, …, N_2-1), 그리고/또는 편파 축 CSI-RS 포트 인덱스 p_P (단, 단일 편파인 경우 p_P=0, 이중 편파인 경우 p_P=0, 1) 간의 관계를 정의하는 방법(수학식 5, 수학식 6)이 고려될 수 있다. 예를 들어, 방법 Mc100에 대하여, 단말은 아래의 수학식 5를 가정할 수 있다.

[395] [수식5]

$$p = N_2 N_1 p_P + N_2 p_1 + p_2$$

[396] 수학식 5에 따르면, 단말은 CSI-RS 안테나 포트 배열 상에 단말 특정적 CSI-RS 안테나 포트 번호가 수직 축, 수평 축, 및 편파 축의 순서로 맵핑됨을 가정할 수 있다.

[397] 또 다른 예를 들어, 방법 Mc101에 대하여, 단말은 아래의 수학식 6을 가정할 수 있다.

[398] [수식6]

$$p = N_2 p_1 + p_2$$

[399] 수학식 6에 따르면, 단말은 CSI-RS 안테나 포트 배열 상에 단말 특정적 CSI-RS 안테나 포트 번호가 수직 축 및 수평 축의 순서로 맵핑됨을 가정할 수 있다.

[400] 방법 Mc100 및 방법 Mc101과 다른 방법으로써, 복수의 CSI-RS 안테나 포트 번호 맵핑 규칙을 미리 정해두고, 기지국이 단말에게 복수의 CSI-RS 안테나 포트

번호 맵핑 규칙 중에서 어떤 것을 적용할지를 시그널링하는 방법(이하 '방법 Mc110')이 고려될 수 있다.

[401] 예를 들어, 기지국은 단말에게 1 비트의 시그널링을 통해, 미리 정의된 맵핑 규칙1 및 맵핑 규칙2 중 어느 것을 따를 것을 지시할 수 있다. 구체적으로, 맵핑 규칙1은 CSI-RS 안테나 포트 배열 상에 CSI-RS 안테나 포트 번호가 수평 축, 편파 축, 및 수직 축의 순서로 증가하는 규칙이고, 맵핑 규칙2는 CSI-RS 안테나 포트 배열 상에 CSI-RS 안테나 포트 번호가 수직 축, 수평 축, 및 편파 축의 순서로 증가하는 규칙일 수 있다.

[402]

[403] 3.2. CSI-RS 안테나 포트 번호를 재배열하는 방법

[404] 도 24은 복수의 단말에게 서로 다른 CSI-RS 안테나 포트 집합을 설정하는 방법을 나타내는 도면이다.

[405] FD-MIMO 시스템에서는, 송신 안테나 배열의 크기가 증가함에 따라, 기지국이 복수의 단말에게 서로 다른 CSI-RS 안테나 포트 수를 설정하거나, 복수의 단말에게 안테나 배열의 서로 다른 부분을 이용하여 데이터를 전송하고자 할 수 있다. 예를 들어, 기지국이 16개의 TXRU(transceiver unit)를 가지는 경우에, 다중 안테나를 활용한 성능 이득을 충분히 얻기 위해서는, 단말에게 16개의 CSI-RS 안테나 포트를 전송하는 것이 유리하다. 그러나 어떤 단말은 16개의 CSI-RS 안테나 포트를 설정받는 것이 불가능할 수도 있다. 16개의 CSI-RS 안테나 포트를 설정받는 것이 불가능한 단말로는, 저비용(low-cost) 단말, LTE Release 13 이전의 기존(legacy) 단말 등일 수 있다. 이 때, 예를 들어, 기지국은 도 24에 예시된 바와 같이, 복수의 단말에게 서로 다른 CSI-RS 안테나 포트 배열 또는 집합(set)을 설정할 수 있다. 즉, 기지국은 단말(UE-a)에게 16개의 CSI-RS 안테나 포트(셀 특정적 CSI-RS 안테나 포트 0번~15번)를 설정하고, 단말(UE-b)에게 4개의 CSI-RS 안테나 포트(셀 특정적 CSI-RS 안테나 포트 9번, 10번, 13번, 14번)를 설정할 수 있다.

[406]

[407] 도 25a는 복수의 단말에 대한 CSI-RS 자원 설정의 예를 나타내는 도면이다.

[408] 도 24에 도시된 예시에서, 단말(UE-a)와 단말(UE-b) 각각은 16개와 4개의 CSI-RS 안테나 포트에 대한 자원 설정을 필요로 한다. 이 때, 기지국은 도 25a에 예시된 자원 할당과 같이, 단말(UE-a)와 단말(UE-b)를 위한 CSI-RS 자원 설정에 서로 다른 RE 집합을 할당할 수 있다. 예를 들어, 기지국은 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 9), RE(3, 9), RE(2, 8), RE(3, 8), RE(2, 5), RE(3, 5), RE(2, 4), RE(3, 4), RE(2, 3), RE(3, 3), RE(2, 2), 및 RE(3, 2)를, 단말(UE-a)을 위한 CSI-RS RE(예, 단말 특정적 CSI-RS 안테나 포트 0~15번)로써 설정할 수 있다. 기지국은 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 3), 및 RE(6, 3)를, 단말(UE-b)을 위한 CSI-RS RE(예, 단말 특정적 CSI-RS 안테나 포트 0~3번)로써 설정할 수 있다.

[409] 도 24 및 도 25a에 예시된 방법은, 각 단말을 위한 CSI-RS에 서로 다른 가상화(virtualization)를 적용할 수 있다는 장점을 가지지만, CSI-RS 전송에 소요되는 RE의 수가 증가되는 단점을 가질 수 있다. 기지국은 CSI-RS 전송 오버헤드를 고려하여, 더 적은 안테나 포트 수가 할당된 단말(UE-b)을 위한 CSI-RS RE 집합이 단말(UE-a)을 위한 CSI-RS RE 집합에 포함되도록 설정할 수 있다. 다시 말하면, 기지국은 서로 다른 CSI-RS 안테나 포트 집합이 설정된 복수의 단말로 하여금 CSI-RS 전송 자원을 최대한 공유하도록 설정할 수 있다. 그러나 현재 규격에 의하면, 일부 경우를 제외하고는, 기지국이 상기와 같이 복수의 단말로 하여금 CSI-RS 전송 자원을 공유하도록 설정하는 것이 어렵다.

[410] 이하에서는 상기 문제(예, CSI-RS 전송 오버헤드, CSI-RS 전송 자원 공유)를 해결하기 위한 방법으로써, 단말에 설정된 CSI-RS 안테나 포트들의 포트 번호를 재배열(re-ordering)하는 방법 (이하 방법 'Mc200')에 대하여 기술한다.

[411] 방법 Mc200에서, CSI-RS 안테나 포트들의 포트 번호를 재배열한다고 함은, 단말이 CSI-RS configuration 시그널링에 의해 설정받은 CSI-RS 안테나 포트들의 단말 특정적 포트 번호를 기존 포트 번호라고 할 때, 기존 포트 번호들을 새로운 포트 번호들로 대체함을 의미한다. 예를 들어, 단말이 4개의 CSI-RS 안테나 포트를 설정받은 경우, 포트 번호를 1번, 3번, 0번, 및 2번으로 재배열한다고 함은, CSI-RS 안테나 포트들의 기존 포트 번호 0번 내지 3번을 각각 1번, 3번, 0번, 및 2번으로 대체함을 의미한다. 다른 예를 들어, 8개의 포트를 갖는 컴포넌트 CSI-RS configuration 2개가 집성되어 총 16개의 CSI-RS 안테나 포트가 단말에 설정되는 경우에, 포트 번호를 재배열한다고 함은, 컴포넌트 CSI-RS configuration 0번을 구성하는 CSI-RS 안테나 포트의 기존 포트 번호 0~7번 및 컴포넌트 CSI-RS configuration 1번을 구성하는 CSI-RS 안테나 포트의 기존 포트 번호 0~7번을 새로운 포트 번호들(0~15번)로 대체함을 의미한다.

[412] 기존 규격에서, 단말에 설정된 CSI-RS 안테나 포트들의 포트 번호와 해당 CSI-RS RE 집합을 구성하는 RE들 간의 맵핑 관계는 도 1 내지 도 3에 도시되어 있다. 예를 들어, 단말이 표 2에 따라 CSI-RS configuration 0번에 의해 4개의 CSI-RS 안테나 포트를 설정받은 경우, CSI-RS 안테나 포트 0번과 1번(도 2에서의 15번과 16번)은 슬롯0의 RE(5,9) 및 RE(6,9)에 맵핑되고, CSI-RS 안테나 포트 2번과 3번(도 2에서의 17번과 18번)은 슬롯0의 RE(5,3) 및 RE(6,3)에 맵핑된다. 다른 예를 들어, 단말이 표 2에 따라 CSI-RS configuration 1번에 의해 8개의 CSI-RS 안테나 포트를 설정받은 경우, CSI-RS 안테나 포트 0번과 1번(도 3에서의 15번과 16번)은 슬롯1의 RE(2,11) 및 RE(3,11)에 맵핑되고, CSI-RS 안테나 포트 2번과 3번(도 3에서의 17번과 18번)은 슬롯1의 RE(2,5) 및 RE(3,5)에 맵핑되고, CSI-RS 안테나 포트 4번과 5번(도 3에서의 19번과 20번)은 슬롯1의 RE(2,10) 및 RE(3,10)에 맵핑되고, CSI-RS 안테나 포트 6번과 7번(도 3에서의 21번과 22번)은 슬롯1의 RE(2,4) 및 RE(3,4)에 맵핑된다.

[413]

[414] 도 25b는 본 발명의 실시예에 따른, 단말에 설정된 CSI-RS 안테나 포트들의 포트 번호가 방법 Mc200에 의해 재배열됨으로써, 포트 번호와 RE들 간의 맵핑 관계가 기존과 달라지는 경우를 나타내는 도면이다.

[415] 구체적으로 도 25b에는, 단말(UE-a)에게 4개의 CSI-RS 안테나 포트가 설정되고, 방법 Mc200에 의해, CSI-RS 안테나 포트들의 포트 번호가 0번, 2번, 1번, 및 3번으로 재배열되는 경우가 예시되어 있다.

[416] 기존 포트 번호 0번 내지 3번이 새로운 포트 번호 0번, 2번, 1번, 및 3번으로 대체됨에 따라, 기존의 맵핑 관계에서 CSI-RS 안테나 포트 0번 내지 3번이 맵핑되었던 RE 각각에, CSI-SR 안테나 포트 0번, 2번, 1번, 및 3번이 각각 맵핑된다. 즉, CSI-RS 안테나 포트 0번과 2번은 슬롯0의 RE(5,9) 및 RE(6,9)에 맵핑되고, CSI-RS 안테나 포트 1번과 3번은 슬롯0의 RE(5,3) 및 RE(6,3)에 맵핑된다.

[417] 한편, 도 25b에는, 단말(UE-b)에게 8개의 CSI-RS 안테나 포트가 설정되고, 방법 Mc200에 의해, CSI-RS 안테나 포트들의 포트 번호가 0번, 1번, 4번, 5번, 2번, 3번, 6번, 및 7번으로 재배열되는 경우가 예시되어 있다.

[418] 기존 포트 번호 0번 내지 7번이 새로운 포트 번호 0번, 1번, 4번, 5번, 2번, 3번, 6번, 및 7번으로 대체됨에 따라, 기존의 맵핑 관계에서 CSI-RS 안테나 포트 0번 내지 7번이 맵핑되었던 RE 각각에, CSI-RS 안테나 포트 0번, 1번, 4번, 5번, 2번, 3번, 6번, 및 7번이 각각 맵핑된다. 즉, CSI-RS 안테나 포트 0번과 1번은 슬롯1의 RE(2,11) 및 RE(3,11)에 맵핑되고, CSI-RS 안테나 포트 2번과 3번은 슬롯1의 RE(2,10) 및 RE(3,10)에 맵핑되고, CSI-RS 안테나 포트 4번과 5번은 슬롯1의 RE(2,5) 및 RE(3,5)에 맵핑되고, CSI-RS 안테나 포트 6번과 7번은 슬롯1의 RE(2,4) 및 RE(3,4)에 맵핑된다.

[419] 방법 Mc200에서, 단말이 CSI-RS 안테나 포트들의 포트 번호 재배열 정보를 획득하는 방법으로써, 기지국이 단말에게 포트 번호 재배열 정보를 알려주는 방법이 고려될 수 있다. 예를 들어, 기지국은 기존 포트 번호들을 대체할 새로운 포트 번호들을 단말에게 명시적으로 알려줄 수 있다. 다른 예를 들어, 기지국은 단말이 기존 포트 번호들을 대체할 새로운 포트 번호들을 알 수 있도록 하는 재배열 규칙을 단말에게 알려줄 수 있다.

[420] 도 25b의 예에서, 기지국은 단말(UE-a)에게 CSI-RS 안테나 포트 번호의 재배열 정보로써 새로운 포트 번호들의 순열 (0, 2, 1, 3)을 알려줄 수 있다. 또는, 기지국은 단말(UE-a)이 새로운 포트 번호 순열이 (0, 2, 1, 3)임을 알 수 있도록 하는 재배열 규칙을 단말(UE-a)에게 알려줄 수 있다. 또한, 기지국은 단말(UE-b)에게 CSI-RS 안테나 포트 번호의 재배열 정보로써 새로운 포트 번호들의 순열 (0, 1, 4, 5, 2, 3, 6, 7)을 알려줄 수 있다. 또는, 기지국은 단말(UE-b)이 새로운 포트 번호 순열이 (0, 1, 4, 5, 2, 3, 6, 7)임을 알 수 있도록 하는 재배열 규칙을 단말(UE-b)에게 알려줄 수 있다.

[421]

[422] 방법 Mc210은, 단말에 설정되는 CSI-RS 안테나 포트들에 적용되는 새로운 포트 번호들의 순열로써 가능한 모든 경우의 수를 정의하고, 이 중에서 하나를 단말에게 시그널링하는 방법이다.

[423] 방법 Mc210에서, 새로운 포트 번호들의 순열은 기존 포트 번호들의 순열을 포함할 수 있다. 방법 Mc210은 단말에 설정되는 CSI-RS 안테나 포트들의 포트 번호를 임의의 순서로 배열할 수 있다는 장점을 가지나, 반면에 시그널링 오버헤드가 크다는 단점을 가진다. 단말에 설정된 CSI-RS 안테나 포트 수를 N이라 할 때, N개의 포트 번호를 순서를 고려하여 나열하는 방법은 총 N!가지이므로, 방법 Mc200에 따른 시그널링에 소요되는 비트 수는, ceil($\log_2$(N!))을 따른다. 여기서 연산 부호 '!'는 팩토리얼(factorial) 연산을 나타내고, 'ceil()'은 올림(ceiling) 연산을 의미한다. 또는, CSI-RS 설정에 CDM-2가 적용되는 경우에, CSI-RS 안테나 포트 쌍이 CDM에 의해 동일 자원 상에 맵핑되면, 방법 Mc210에 따른 시그널링에 소요되는 비트 수는 1비트만큼 절약될 수 있다.

[424]

[425] 방법 Mc220은, 단말에 설정되는 CSI-RS 안테나 포트들에 적용되는 새로운 포트 번호들의 순열 (또는 새로운 포트 번호들의 순열을 생성하기 위한 규칙이나 정보)을 하나 또는 복수 개 미리 정의하고, 이 중에서 하나를 단말에게 시그널링하는 방법이다.

[426] 방법 Mc220에서, 새로운 포트 번호들의 순열은 기존 포트 번호들의 순열을 포함할 수 있다. 방법 Mc210과 방법 Mc220은 새로운 포트 번호들의 순열을 단말에게 암시적인 방법으로 시그널링하는 방법을 포함할 수 있다. 암시적인 시그널링의 경우, 기지국은 단말에게 새로운 포트 번호 순열 그 자체가 아니라, 단말에게 새로운 포트 번호 순열을 알릴 수 있는 규칙이나 정보를 시그널링할 수 있다.

[427] 방법 Mc220은 방법 Mc210에 비해 적은 시그널링 오버헤드를 가지는 방법이다. 방법 Mc220에서, 적어도 하나의 포트 번호 순열 또는 포트 번호 순열 생성 규칙을 정함에 있어서, CSI-RS 안테나 포트 배열의 형태와 CSI-RS 안테나 포트 배열 상의 포트 번호 맵핑 규칙이 고려될 수 있다.

[428]

[429] 도 26a 및 도 26b는 본 발명의 실시예에 따른, 방법 Mc220이 사용되는 경우에, 기지국이 단말에게 새로운 포트 번호 순열(sequence)을 알리기 위한 규칙(또는 정보)을 암시적인 시그널링을 통해 알려주는 경우를 나타내는 도면이다.

[430] 구체적으로 도 26a 및 도 26b에는, 단말에 설정된 16개의 CSI-RS 안테나 포트들이, CSI-RS 안테나 포트 배열(수평 축 포트 수=8, 수직 축 포트 수=1, 교차 편파)을 구성하는 경우가 예시되어 있다.

[431] 도 26a에는 기지국이 단말에 설정하고자 하는 CSI-RS 안테나 포트 배열 상의 포트 번호 맵핑(Mpr1, Mpr2, Mpr3, Mpr4)이 예시되어 있다. 한편, 도 26b에는 단말이 CSI 측정 및 보고를 수행할 때 가정하는 포트 번호 맵핑이 예시되어 있다.

구체적으로, 도 26b에 예시된 맵핑에 적용된 규칙은, CSI-RS 안테나 포트 배열에 공간 축(또는 수평 축), 편파 축의 순서로 포트 번호를 맵핑하는 규칙이다. 이 때, 단말이 CSI 측정 및 보고를 수행할 때 가정하는 포트 번호 맵핑 규칙은, 상술한 방법들이 적용되어, 규격에 미리 정의될 수 있다.

[432] 도 26a에 예시된 포트 번호 맵핑(Mpr1, Mpr2, Mpr3, Mpr4)은, 총 CSI-RS 안테나 포트들(16개의 CSI-RS 안테나 포트)을 하나 또는 복수의 CSI-RS 안테나 포트 그룹으로 나누고, 각 CSI-RS 안테나 포트 그룹 내에서 특정 순서(예, 공간 축, 편파 축의 순서)로 CSI-RS 안테나 포트 번호를 맵핑하는 규칙이 적용된 것이다. 이 때, 각 CSI-RS 안테나 포트 그룹 내에서 포트 번호가 맵핑되는 축의 순서는, 단말이 CSI 측정 및 보고를 수행할 때 가정하는 포트 번호 맵핑 축의 순서와 동일할 수 있다. 구체적으로, 포트 번호 맵핑(Mpr1)의 경우, 16개의 CSI-RS 안테나 포트들이 하나의 CSI-RS 안테나 포트 그룹(Vrg1)으로 나뉜다. 포트 번호 맵핑(Mpr2)의 경우, 16개의 CSI-RS 안테나 포트들이 2개의 CSI-RS 안테나 포트 그룹(Vrg2a, Vrg2b)으로 나뉜다. 포트 번호 맵핑(Mpr3)의 경우, 16개의 CSI-RS 안테나 포트들이 4개의 CSI-RS 안테나 포트 그룹(Vrg3a, Vrg3b, Vrg3c, Vrg3d)으로 나뉜다. 포트 번호 맵핑(Mpr4)의 경우, 16개의 CSI-RS 안테나 포트들이 8개의 CSI-RS 안테나 포트 그룹(Vrg4a, Vrg4b, Vrg4c, Vrg4d, Vrg4e, Vrg4f, Vrg4g, Vrg4h)으로 나뉜다. 이 때, CSI-RS 안테나 포트 그룹의 수는, 공간 축 CSI-RS 안테나 포트 수인 8의 약수들일 수 있다.

[433] 방법 Mc220을 위한 암시적인 시그널링의 예로써, 기지국이 단말에게 적어도 하나의 포트 번호 맵핑들 중에서 하나를 알려주는 방법(이하 '방법 Mc221')이 고려될 수 있다. 예를 들어, 기지국은 단말에게 도 26a에 예시된 포트 번호 맵핑(Mpr1, Mpr2, Mpr3, Mpr4) 중 하나를 단말에게 알려줄 수 있다. 방법 Mc221이 사용되는 경우에, 단말은 기지국으로부터 설정받은 맵핑의 포트 번호들이 CSI 측정 및 보고를 수행할 때 가정하는 맵핑의 포트 번호들에 일치되도록 한다. 이를 위해, 단말은 기지국으로부터 설정받은 맵핑의 포트 번호를 기존 포트 번호로 간주하고, CSI 측정 및 보고를 수행할 때 가정하는 맵핑의 포트 번호를 새로운 포트 번호로 간주하여, 기존 포트 번호들을 새로운 포트 번호들로 재배열할 수 있다.

[434] 도 26a의 예시에서, 기지국이 방법 Mc221을 기초로 하여 단말에게 포트 번호 맵핑(Mpr1)을 알려준 경우에, 맵핑(Mpr1)의 기존 포트 번호가 새로운 포트 번호와 일치하므로, 단말은 CSI-RS 안테나 포트 번호를 재배열할 필요가 없다. 한편, 기지국이 단말에게 포트 번호 맵핑(Mpr2)을 알려준 경우에, 단말은 맵핑(Mpr2)과 도 26b의 맵핑 간의 관계에 따라, 기존 CSI-RS 안테나 포트 번호 0번 내지 15번을, 각각 0번, 1번, 2번, 3번, 8번, 9번, 10번, 11번, 4번, 5번, 6번, 7번, 12번, 13번, 14번, 및 15번으로 대체할 수 있다. 또는 기지국이 단말에게 포트 번호 맵핑(Mpr3)을 알려준 경우에, 단말은 맵핑(Mpr3)과 도 26b의 맵핑 간의 관계에 따라, 기존 CSI-RS 안테나 포트 번호 0번 내지 15번을, 각각 0번, 1번, 8번,

9번, 2번, 3번, 10번, 11번, 4번, 5번, 12번, 13번, 6번, 7번, 14번, 및 15번으로 대체할 수 있다. 또는 기지국이 단말에게 포트 번호 맵핑(Mpr4)을 알려준 경우에, 단말은 맵핑(Mpr4)과 도 26b의 맵핑 간의 관계에 따라, 기존 CSI-RS 안테나 포트 번호 0번 내지 15번을, 각각 0번, 8번, 1번, 9번, 2번, 10번, 3번, 11번, 4번, 12번, 5번, 13번, 6번, 14번, 7번, 및 15번으로 대체할 수 있다.

[435]

[436] 도 26c, 도 26d, 도 26e, 및 도 26f는, 본 발명의 실시예에 따른, 방법 Mc221에 의해 기지국이 단말에게 도 26a에 예시된 포트 번호 맵핑(Mpr1~Mpr4) 중 하나를 알려주는 경우에, 단말이 CSI-RS RE 집합을 구성하는 RE들에 CSI-RS 안테나 포트 번호들을 맵핑하는 경우를 나타내는 도면이다.

[437] 구체적으로, 도 26c 내지 도 26f에는, 8개의 포트를 갖는 컴포넌트 CSI-RS configuration 2개(0번, 1번)가 집성되어, 총 16개의 CSI-RS 안테나 포트가 단말에 설정된 경우가 예시되어 있다. 이 때, 각 컴포넌트 CSI-RS configuration에는 기존 규격상의 8개 포트에 대한 CSI-RS 패턴이 동일하게 적용되었다. 즉, 컴포넌트 CSI-RS configuration 0번은 CSI-RS RE 집합을 구성하는 RE로써, 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)를 포함한다. 컴포넌트 CSI-RS configuration 1번은 CSI-RS RE 집합을 구성하는 RE로써, 슬롯1의 RE(2, 9), RE(3, 9), RE(2, 8), RE(3, 8), RE(2, 3), RE(3, 3), RE(2, 2), 및 RE(3, 2)를 포함한다. 도 26c 내지 도 26f에서, 컴포넌트 CSI-RS configuration 0번에 대응되는 CSI-RS 안테나 포트 번호는 0~7번이고, 컴포넌트 CSI-RS configuration 1번에 대응되는 CSI-RS 안테나 포트 번호는 8~15번임을 가정한다.

[438] 도 26c에 예시된 포트-RE 맵핑은 단말이 포트 번호 맵핑(Mpr1)을 설정받은 경우에 대응하고, 도 26d에 예시된 포트-RE 맵핑은 단말이 포트 번호 맵핑(Mpr2)을 설정받은 경우에 대응하고, 도 26e에 예시된 포트-RE 맵핑은 단말이 포트 번호 맵핑(Mpr3)을 설정받은 경우에 대응하고, 도 26f에 예시된 포트-RE 맵핑은 단말이 포트 번호 맵핑(Mpr4)을 설정받은 경우에 대응한다.

[439] 예를 들어, 단말이 방법 Mc221에 의해 포트 번호 맵핑(Mpr1)을 설정받은 경우에, 도 26c에 예시된 포트-RE 맵핑을 따를 수 있다. 즉, 단말은 맵핑(Mpr1)을 설정받은 경우에, CSI-RS 안테나 포트 번호를 재배열할 필요가 없으므로, 각 컴포넌트 CSI-RS configuration별로 기존 규격상의 포트-RE 맵핑을 따를 수 있다.

[440] 다른 예를 들어, 단말이 방법 Mc221에 의해 포트 번호 맵핑(Mpr2)을 설정받은 경우에, 도 26d에 예시된 포트-RE 맵핑을 따를 수 있다. 즉, 단말은 맵핑(Mpr2)과 도 26b의 맵핑 간의 관계에 따라, 기존 포트 번호 4~5번이 맵핑되었던 슬롯0의 RE(5, 8) 및 RE(6, 8)에 포트 번호 8~9번이 맵핑되고, 기존 포트 번호 6~7번이 맵핑되었던 슬롯0의 RE(5, 2) 및 RE(6, 2)에 포트 번호 10~11번이 맵핑되고, 기존 포트 번호 8~9번이 맵핑되었던 슬롯1의 RE(2, 9) 및 RE(3, 9)에 포트 번호 4~5번이 맵핑되고, 기존 포트 번호 10~11번이 맵핑되었던 슬롯1의 RE(2, 3) 및 RE(3, 3)에 포트 번호 6~7번이 맵핑됨을 가정할 수 있다.

[441] 또 다른 예를 들어, 단말이 방법 Mc221에 의해 포트 번호 맵핑(Mpr3)을 설정받은 경우에, 도 26e에 예시된 포트-RE 맵핑을 따를 수 있다. 즉, 단말은 맵핑(Mpr3)과 도 26b의 맵핑 간의 관계에 따라, 기존 포트 번호 2~3번이 맵핑되었던 슬롯0의 RE(5, 3) 및 RE(6, 3)에 포트 번호 8~9번이 맵핑되고, 기존 포트 번호 4~5번이 맵핑되었던 슬롯0의 RE(5, 8) 및 RE(6, 8)에 포트 번호 2~3번이 맵핑되고, 기존 포트 번호 6~7번이 맵핑되었던 슬롯0의 RE(5, 2) 및 RE(6, 2)에 포트 번호 10~11번이 맵핑되고, 기존 포트 번호 8~9번이 맵핑되었던 슬롯1의 RE(2, 9) 및 RE(3, 9)에 포트 번호 4~5번이 맵핑되고, 기존 포트 번호 10~11번이 맵핑되었던 슬롯1의 RE(2, 3) 및 RE(3, 3)에 포트 번호 12~13번이 맵핑되고, 기존 포트 번호 12~13번이 맵핑되었던 슬롯1의 RE(2, 8) 및 RE(3, 8)에 포트 번호 6~7번이 맵핑됨을 가정할 수 있다.

[442] 또 다른 예를 들어, 단말이 방법 Mc221에 의해 포트 번호 맵핑(Mpr4)을 설정받은 경우에, 도 26f에 예시된 포트-RE 맵핑을 따를 수 있다. 즉, 단말은 맵핑(Mpr4)과 도 26b의 맵핑 간의 관계에 따라, 기존 포트 번호 0~1번이 맵핑되었던 슬롯0의 RE(5, 9) 및 RE(6, 9)에 포트 번호 0번과 8번이 맵핑되고, 기존 포트 번호 2~3번이 맵핑되었던 슬롯0의 RE(5, 3) 및 RE(6, 3)에 포트 번호 2번과 10번이 맵핑되고, 기존 포트 번호 4~5번이 맵핑되었던 슬롯0의 RE(5, 8) 및 RE(6, 8)에 포트 번호 1번과 9번이 맵핑되고, 기존 포트 번호 6~7번이 맵핑되었던 슬롯0의 RE(5, 2) 및 RE(6, 2)에 포트 번호 3번과 11번이 맵핑되고, 기존 포트 번호 8~9번이 맵핑되었던 슬롯1의 RE(2, 9) 및 RE(3, 9)에 포트 번호 4번과 12번이 맵핑되고, 기존 포트 번호 10~11번이 맵핑되었던 슬롯1의 RE(2, 3) 및 RE(3, 3)에 포트 번호 6번과 14번이 맵핑되고, 기존 포트 번호 12~13번이 맵핑되었던 슬롯1의 RE(2, 8) 및 RE(3, 8)에 포트 번호 5번과 13번이 맵핑되고, 기존 포트 번호 14~15번이 맵핑되었던 슬롯1의 RE(2, 2) 및 RE(3, 2)에 포트 번호 7번과 15번이 맵핑됨을 가정할 수 있다.

[443]

[444] 도 26a에 예시된 바와 같이, 단말에게 설정된 총 CSI-RS 안테나 포트 수를 하나 또는 복수의 CSI-RS 안테나 포트 그룹으로 나누고 각 그룹 내에서부터 포트 번호를 맵핑하는 규칙이 사용되는 경우에, 기지국이 단말에게 포트 번호 맵핑 그 자체를 알려주는 대신, CSI-RS 안테나 포트 그룹의 수(이하 '

$$N_{group}$$

')를 알려주는 방법(이하 '방법 Mc222')이 고려될 수 있다. 또는, 이와 동등한 효과를 얻기 위해, 기지국이 단말에게 CSI-RS 안테나 포트 그룹의 크기(즉, CSI-RS 안테나 포트 그룹별 CSI-RS 안테나 포트 수, 이하 '

$$N_{ports}^{group}$$

')를 알려주는 방법(이하 '방법 Mc223')이 고려될 수 있다.

[445] 예를 들어, 도 26a에 예시된 맵핑(Mpr1, Mpr2, Mpr3, Mpr4)이 이용되는 경우에, 기지국은 방법 Mc222를 기초로 하여, 단말에게

$$N_{group}$$

값으로써, 1, 2, 4, 및 8 중에서 하나를 알려줄 수 있다. 또는, 기지국은 방법 Mc223을 기초로 하여, 단말에게

$$N_{ports}^{group}$$

값으로써, 16, 8, 4, 및 2 중에서 하나를 알려줄 수 있다.

[446] 방법 Mc221에서, 기지국이 단말에게 알려줄 수 있는 포트 번호 맵핑의 가짓수가 하나라 하더라도, 기지국은 단말에게 포트 번호 맵핑을 알려줄 수 있다. 예를 들어, 방법 Mc221을 위해, 도 26a에 예시된 포트 번호 맵핑(Mpr1, Mpr2, Mpr3, Mpr4) 중에서 포트 번호 맵핑(Mpr2)만이 이용될 수 있다. 이 경우에, 기지국은 단말에게 포트 번호 맵핑(Mpr2) 정보를 시그널링할 수 있다. 또는 기지국은 방법 Mc222를 기초로 하여, 단말에게

$$N_{group}$$

값으로써 2를 알려줄 수 있다. 또는 기지국은 방법 Mc223을 기초로 하여, 단말에게

$$N_{ports}^{group}$$

값으로써 8을 알려줄 수 있다.

[447] 방법 Mc221에서, 기지국이 단말에게 알려줄 수 있는 포트 번호 맵핑의 가짓수가 하나인 경우에, 포트 번호 맵핑 또는 그 규칙은 단말에 설정된 CSI-RS 안테나 포트 수별로 다를 수 있다. 예를 들어, 도 26a에 예시된 맵핑 규칙이 사용된다면, 단말에 설정된 CSI-RS 안테나 포트 수가 16인 경우에

$$N_{ports}^{group}$$

값은 8이고, 단말에 설정된 CSI-RS 안테나 포트 수가 12인 경우에

$$N_{ports}^{group}$$

값은 4일 수 있다. 이 때, 기지국은 방법 Mc223을 기초로 하여, 단말에 설정된 CSI-RS 안테나 포트 수가 16인 경우, 단말에게

$$N_{ports}^{group}$$

값으로써 8을 알려주고, 단말에 설정된 CSI-RS 안테나 포트 수가 12인 경우, 단말에게

$$N_{ports}^{group}$$

값으로써 4를 알려줄 수 있다.

[448] 도 26a에 예시된 맵핑 규칙이 적용되는 경우, CSI-RS 안테나 포트 그룹의 수(

$$N_{group}$$

)는 CSI-RS 자원 집성에 이용되는 컴포넌트 CSI-RS configuration의 수로 정해질 수 있다. 예를 들어, 도 26c 내지 도 26f에 예시된 바와 같이, 8개의 포트를 갖는 컴포넌트 CSI-RS configuration 2개가 집성되어 16개의 CSI-RS 안테나 포트가 단말에 설정되는 경우에, CSI-RS 안테나 포트 그룹의 수(

$$N_{group}$$

)는 2일 수 있다. 다른 예를 들어, 4개의 포트를 갖는 컴포넌트 CSI-RS configuration 3개가 집성되어 12개의 CSI-RS 안테나 포트가 단말에 설정되는 경우에, CSI-RS 안테나 포트 그룹의 수(

$$N_{group}$$

)는 3일 수 있다.

[449] 한편, 방법 Mc220 내지 방법 Mc223이 사용되는 경우에, 단말이 가정하는 포트-RE 맵핑은, 수학식 7로 표현될 수 있다. 수학식 7에서, p'은 각 CSI-RS 안테나 포트 그룹별 CSI-RS 안테나 포트 번호를 의미하고, p는 단말에 설정된 전체 CSI-RS 안테나 포트들에 대한 새로운 포트 번호를 의미하고, i는 CSI-RS 안테나 포트 그룹의 색인을 의미한다. 수학식 7에서, p'은 각 CSI-RS 안테나 포트 그룹별로 0부터 (

$$N_{ports}^{group}$$

-1)까지의 정수 값을 가지고, p는 0부터 (

$$N_{group}$$

*

$$N_{ports}^{group}$$

-1)까지의 정수 값을 가지고, i는 0부터 (

$$N_{group}$$

-1)까지의 정수 값을 가진다.

[450] 예를 들어,

N_{ports}^{group}

개의 포트를 갖는 컴포넌트 CSI-RS configuration가

N_{group}

개 집성되어 단말에게 총 (

N_{group}

*

N_{ports}^{group}

)개의 CSI-RS 안테나 포트가 설정되는 경우에, p'은 각 컴포넌트 CSI-RS configuration별 CSI-RS 안테나 포트 번호이고, p는 집성된 CSI-RS 안테나 포트들에 대한 새로운 포트 번호일 수 있다.

[451] [수식7]

$$p = \begin{cases} p' + \frac{N_{ports}^{group}}{2} i, & \text{for } p' \in \left\{0, \cdots, \frac{N_{ports}^{group}}{2} - 1\right\} \\ p' + \frac{N_{ports}^{group}}{2}(i + N_{group} - 1), & \text{for } p' \in \left\{\frac{N_{ports}^{group}}{2}, \cdots, N_{ports}^{group} - 1\right\} \end{cases}$$

[452] 구체적으로, 기지국이 방법 Mc221을 기초로 하여 단말에게 도 26a에 예시된 포트 번호 맵핑(Mpr2, Mpr3, Mpr4)을 알려주는 경우에, 단말은 수학식 7에 따라 기존 포트 번호들을 새로운 포트 번호들로 대체할 수 있다. 포트 번호 맵핑(Mpr2)의 경우,

N_{group}

은 2이고,

N_{ports}^{group}

는 8이다. 포트 번호 맵핑(Mpr3)의 경우,

N_{group}

은 4이고,

N_{ports}^{group}

는 4이다. 포트 번호 맵핑(Mpr4)의 경우,

N_{group}

은 8이고,

N_{ports}^{group}

는 2이다.

[453] 예를 들어, 단말이 기지국으로부터 포트 번호 맵핑(Mpr2)을 설정받은 경우에, 단말에게 설정되는 16개의 CSI-RS 안테나 포트는, 8개의 포트를 갖는 컴포넌트 CSI-RS configuration이 2개 집성된 것임을 가정하자. 이 때, 상술한 바와 같이, 각 CSI-RS 안테나 포트 그룹은 각 컴포넌트 CSI-RS configuration에 대응될 수 있다. 단말은 수학식 7에 따라, 컴포넌트 CSI-RS configuration 0번의 기존 포트 번호 15~18번을 새로운 포트 번호 15~18번으로 유지하고, 컴포넌트 CSI-RS configuration 0번의 기존 포트 번호 19~22번을 새로운 포트 번호 23~26번으로 대체하고, 컴포넌트 CSI-RS configuration 1번의 기존 포트 번호 15~18번을 새로운 포트 번호 19~22번으로 대체하고, 컴포넌트 CSI-RS configuration 1번의 기존 포트 번호 19~22번을 새로운 포트 번호 27~30번으로 대체할 수 있다. 예를 들어, 단말은 도 26c에 예시된 바와 같이 CSI-RS 자원을 설정받은 경우에, 수학식 7에 따라, 도 26d에 예시된 포트-RE 맵핑을 가정할 수 있다.

[454] 한편, 방법 Mc222 및 방법 Mc223이 사용되는 경우에도, 단말은 수학식 7에 따라 기존 포트 번호들을 새로운 포트 번호들로 대체할 수 있다. 예를 들어, 기지국은 포트 번호 맵핑(Mpr2)을 단말에게 알리기 위한 방법으로써, 방법 Mc222를 기초로, 단말에게

N_{group}

값으로써 2를 알려줄 수 있다. 또는 기지국은 포트 번호 맵핑(Mpr2)을 단말에게 알리기 위한 방법으로써, 방법 Mc223을 기초로, 단말에게

N_{ports}^{group}

값으로써 8을 알려줄 수 있다. 상기 경우에도, 상술한 바와 같이, 단말은 수학식 7에 따라, 각 CSI-RS 안테나 포트 그룹별(또는 각 컴포넌트 CSI-RS configuration별) 기존 포트 번호들을, 새로운 포트 번호들로 대체할 수 있다.

[455]

[456] 도 27은 본 발명의 실시예에 따른, 방법 Mc220이 사용되는 경우에, 복수의 단말에 대한 CSI-RS 안테나 포트 번호 맵핑을 나타내는 도면이다.

[457] 방법 Mc220에 따르면, 기지국은 16개의 CSI-RS 안테나 포트를 설정받을 수 있는 단말을 위한 CSI-RS 자원 설정과 8개의 CSI-RS 안테나 포트를 설정받을 수

있는 단말을 위한 CSI-RS 자원 설정이 일부 RE들을 공유하도록 할 수 있다. 예를 들어, 도 27에 예시된 바와 같이, 기지국이 단말(UE-a)에게 16개의 CSI-RS 안테나 포트를 설정하고 단말(UE-b)에게 16개의 CSI-RS 안테나 포트 중 좌측 4개 열에 해당하는 8개의 CSI-RS 안테나 포트를 설정하고자 하는 경우에, 기지국은 상술한 방법 Mc221의 실시예에 따라, 단말(UE-a)에게 도 26b에 예시된 CSI-RS 안테나 포트 번호 맵핑(Mpr2)을 따를 것을 지시할 수 있다.

[458] 이를 통해, 16개의 CSI-RS 안테나 포트를 설정받은 단말(UE-a)의 8개의 CSI-RS 안테나 포트와 8개의 CSI-RS 안테나 포트를 설정받은 단말(UE-b)의 8개의 CSI-RS 안테나 포트는 동일한 RE에 맵핑될 수 있다.

[459]

[460] 도 28은 본 발명의 실시예에 따른, 방법 Mc220이 사용되는 경우에, 복수의 단말에 대한 CSI-RS 자원 설정을 나타내는 도면이다.

[461] 구체적으로 도 28에는, 도 27에 예시된 CSI-RS 안테나 포트 배열 상의 포트 번호 맵핑이 사용되는 경우에, 단말(UE-a)와 단말(UE-b)에 대한 CSI-RS RE 맵핑이 예시되어 있다. 이 때, 8개의 포트를 갖는 컴포넌트 CSI-RS configuration 2개가 집성되어 총 16개의 CSI-RS 안테나 포트가 단말(UE-a)에게 설정된 경우가 예시되어 있다. 예를 들어, 서브프레임 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 9), RE(3, 9), RE(2, 8), RE(3, 8), RE(2, 5), RE(3, 5), RE(2, 4), RE(3, 4), RE(2, 3), RE(3, 3), RE(2, 2), 및 RE(3, 2)는, 단말(UE-a)을 위한 CSI-RS RE(예, CSI-RS 안테나 포트 0~15번)로써 설정된다. 동일 서브프레임 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 5), RE(3, 5), RE(2, 4), 및 RE(3, 4)는, 단말(UE-b)을 위한 CSI-RS RE(예, CSI-RS 안테나 포트 0~7번)로써 설정된다.

[462] 단말(UE-a)은 CSI 측정 및 보고를 수행하는 경우에, 도 26b의 포트 번호 맵핑을 가정할 수 있다. 이러한 경우에, 단말(UE-a)은 도 27의 맵핑과 도 26b의 맵핑 간의 관계에 따라, 기존 포트 번호 4~5번이 맵핑되었던 슬롯1의 RE(2, 10) 및 RE(3, 10)에 포트 번호 8~9번이 맵핑되고, 기존 포트 번호 6~7번이 맵핑되었던 슬롯1의 RE(2, 4) 및 RE(3, 4)에 포트 번호 10~11번이 맵핑되고, 기존 포트 번호 8~9번이 맵핑되었던 슬롯1의 RE(2, 9) 및 RE(3, 9)에 포트 번호 4~5번이 맵핑되고, 기존 포트 번호 10~11번이 맵핑되었던 슬롯1의 RE(2, 3) 및 RE(3, 3)에 포트 번호 6~7번이 맵핑됨을 가정할 수 있다. 단말(UE-a)에 설정된 16개의 CSI-RS 안테나 포트(0~15번) 중에서 CSI-RS 안테나 포트 0~3번 및 8~11번은, 단말(UE-b)에 설정된 CSI-RS 안테나 포트 0~7번과 동일한 CSI-RS RE 집합을 공유할 수 있다. 즉, 동일 서브프레임 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 5), RE(3, 5), RE(2, 4), 및 RE(3, 4)는, 단말(UE-a)의 CSI-RS 안테나 포트 0~3번 및 8~11번과 단말(UE-b)의 CSI-RS 안테나 포트 0~7번에 의해 공유된다.

[463] 이는, 도 25a에 예시된 CSI-RS 자원 설정 방법에 비해, CSI-RS 전송 오버헤드를 1/3 절감시킬 수 있다. 이와 유사하게, 기지국이 단말(UE-a)에게 16개의 CSI-RS

안테나 포트를 설정하고 단말(UE-b)에게 4개 또는 2개의 CSI-RS 안테나 포트를 설정하고자 하는 경우에, 기지국은 상술한 방법 Mc220의 실시예에 따라, 단말(UE-a)에게 도 26a에 예시된 CSI-RS 안테나 포트 번호 맵핑 규칙(Mpr3) 또는 CSI-RS 안테나 포트 번호 맵핑 규칙(Mpr4)을 따를 것을 지시할 수 있다. 이 때, 단말(UE-b)는 16개의 CSI-RS 안테나 포트를 설정받을 수 없는 기존 단말일 수 있다.

[464] 도 26a 및 도 26b에 예시된 실시예는 16개의 CSI-RS 안테나 포트를 위한 방법이지만, 이는 예시일 뿐이고, 여기에 적용된 CSI-RS 안테나 포트 번호 맵핑의 원리는 다른 수의 CSI-RS 안테나 포트가 설정되는 경우에도 유사하게 적용될 수 있다. 이 때, CSI-RS 안테나 포트 수를 N이라 하면, CSI-RS 안테나 포트 번호 맵핑 또는 CSI-RS 안테나 포트 번호 맵핑 규칙을 N의 약수의 개수만큼 정의하는 방법이 고려될 수 있다. 한편, 단말이 1보다 큰 수직 축 CSI-RS 안테나 포트 수를 설정받은 경우에도, 도 26a 및 도 26b에 예시된 실시예와 같이, 수평 축 및 편파 축에 대해서만 상술한 방법이 적용될 수도 있다.

[465]

[466] 도 29a, 도 29b, 도 29c, 도 29d, 및 도 29e는 본 발명의 다른 실시예에 따른, 방법 Mc221을 위해 사용될 수 있는 복수의 안테나 포트 번호 맵핑 규칙을 나타내는 도면이다.

[467] 구체적으로 도 29a 내지 도 29e는 수평 축, 수직 축, 및 편파 축으로 구성된 16개의 CSI-RS 안테나 포트에 포트 번호 0~15번을 맵핑하는 방법을 나타낸다.

[468] 도 26b에 예시된 실시예에 적용된 원리와 유사하게, 도 29a 내지 도 29e에 예시된 CSI-RS 안테나 포트 그룹 맵핑 규칙은, 전체 CSI-RS 안테나 포트들을 하나 또는 복수의 CSI-RS 안테나 포트 그룹으로 나누고, 각 CSI-RS 안테나 포트 그룹 내에서 특정 순서(예, 수평 축, 편파 축, 및 수직 축의 순서)로 CSI-RS 안테나 포트 번호를 순차적으로 부여한다.

[469] 구체적으로, 도 29a에 예시된 포트 번호 맵핑의 경우에, 16개의 CSI-RS 안테나 포트들이 하나의 CSI-RS 안테나 포트 그룹(Vrg5)으로 나뉜다. 또는 도 29b에 예시된 포트 번호 맵핑의 경우에, 16개의 CSI-RS 안테나 포트들이 2개의 CSI-RS 안테나 포트 그룹(Vrg6a, Vrg6b)으로 나뉜다. 또는 도 29c에 예시된 포트 번호 맵핑의 경우에, 16개의 CSI-RS 안테나 포트들이 4개의 CSI-RS 안테나 포트 그룹(Vrg7a, Vrg7b, Vrg7c, Vrg7d)으로 나뉜다. 또는 도 29d에 예시된 포트 번호 맵핑의 경우에, 16개의 CSI-RS 안테나 포트들이 4개의 CSI-RS 안테나 포트 그룹(Vrg8a, Vrg8b, Vrg8c, Vrg8d)으로 나뉜다. 또는 도 29e에 예시된 포트 번호 맵핑의 경우에, 16개의 CSI-RS 안테나 포트들이 8개의 CSI-RS 안테나 포트 그룹(Vrg9a, Vrg9b, Vrg9c, Vrg9d, Vrg9e, Vrg9f, Vrg9g, Vrg9h)으로 나뉜다. 이 때, 도 29a 내지 도 29e에 예시된 CSI-RS 안테나 포트 그룹에 포함되는 CSI-RS 안테나 포트 수는, 16개, 8개, 4개, 4개, 또는 2개로써, 총 CSI-RS 안테나 포트 수인 16의 약수들일 수 있다.

[470] 방법 Mc221이 사용되는 경우에, 기지국은 16개의 CSI-RS 안테나 포트를 설정받은 단말에게, 도 29a 내지 도 29e에 예시된 CSI-RS 안테나 포트 번호 맵핑 중 하나를 알려줄 수 있다. 상술한 바와 같이, 단말은 기지국으로부터 설정받은 CSI-RS 안테나 포트 번호 맵핑(도 29a 내지 도 29e에 예시된 CSI-RS 안테나 포트 번호 맵핑 중 하나)와 CSI 측정 및 보고를 수행할 때 가정하는 포트 번호 맵핑 간의 관계를 고려하여, CSI-RS 안테나 포트 번호를 재배열할 수 있다.

[471] 예를 들어, 단말이 CSI 측정 및 보고를 수행할 때 도 29a에 예시된 포트 번호 맵핑을 가정하고, 단말이 기지국으로부터 도 29a 내지 도 29e에 예시된 CSI-RS 안테나 포트 번호 맵핑 중에서 도 29c에 예시된 CSI-RS 안테나 포트 번호 맵핑을 설정 받는 경우를 가정하자. 단말은 기지국으로부터 설정받은 도 29c에 예시된 맵핑의 CSI-RS 안테나 포트 번호들을 기존 포트 번호로 간주하고, CSI 측정 및 보고를 수행할 때 가정하는 도 29a에 예시된 맵핑의 CSI-RS 안테나 포트 번호들을 새로운 포트 번호로 간주하여, 기존 포트 번호들을 새로운 포트 번호들로 대체할 수 있다. 즉, 단말은 도 29c의 맵핑과 도 29a의 맵핑 간의 관계에 따라, 기존 CSI-RS 안테나 포트 번호 0번 내지 15번을, 각각 0번, 4번, 8번, 12번, 1번, 5번, 9번, 13번, 2번, 6번, 10번, 14번, 3번, 7번, 11번, 및 15번으로 대체할 수 있다.

[472] 다른 예를 들어, 방법 Mc221이 사용되는 경우에, 기지국은 16개의 CSI-RS 안테나 포트를 설정받은 단말에게, 도 29a 내지 도 29c에 예시된 CSI-RS 안테나 포트 번호 맵핑 중 하나를 알려줄 수 있다.

[473] 한편, 도 29a 내지 도 29e의 예시에서, 기지국은 방법 Mc222를 기초로 하여, 단말에게 CSI-RS 안테나 포트 그룹의 수로써, 1, 2, 4, 및 8 중에서 하나를 알려줄 수 있다. 또는, 기지국은 방법 Mc223을 기초로 하여, 단말에게 CSI-RS 안테나 포트 그룹의 크기로써, 16, 8, 4, 및 2 중에서 하나를 알려줄 수 있다. 도 29c에 예시된 맵핑을 위한 CSI-RS 안테나 포트 그룹의 수와 크기는 도 29d에 예시된 맵핑을 위한 CSI-RS 안테나 포트 그룹의 수와 크기와 동일하므로, 방법 Mc222 또는 방법 Mc223이 사용되는 경우에, 도 29c에 예시된 맵핑과 도 29d에 예시된 맵핑은 구별되지 못할 수 있다. 따라서, 방법 Mc222 또는 방법 Mc223이 사용되는 경우에는, 서로 다른 맵핑이 동일한 CSI-RS 안테나 포트 그룹의 수와 크기를 갖지 않도록 정의되는 것이 필요하다. 예를 들어, 방법 Mc222 또는 방법 Mc223을 위해, 도 29c에 예시된 맵핑과 도 29d에 예시된 맵핑 중에서 어느 하나만이 이용될 수 있다.

[474] 한편, 도 29a 내지 도 29e에 예시된 바와 같이, CSI-RS 안테나 포트들이 수평 축 및 편파 축 뿐만 아니라 수직 축으로도 배치되어 있는 경우에는, 도 26b에 예시된 실시예와 달리, CSI-RS 안테나 포트들을 그룹화하는 방법이 더 다양할 수 있다.

[475] 한편, 방법 Mc220은 CSI-RS 안테나 포트 그룹의 개념 없이 간단한 형태로도 실시될 수 있다. 예를 들어, 기지국은 CSI-RS 안테나 포트 번호 맵핑에 방법 Mc100을 위한 맵핑 순서들 중 어떤 맵핑 순서를 적용할지를, 단말에게 알려줄 수

있다. 즉, CSI-RS 안테나 포트 번호가 수평 축, 편파 축, 및 수직 축의 순서로 매겨지는 방법 Mc100를 위한 맵핑 순서와, CSI-RS 안테나 포트 번호가 수직 축, 수평 축, 및 편파 축의 순서로 매겨지는 방법 Mc100를 위한 맵핑 순서가 사전에 정의되고, 기지국은 1 비트의 시그널링을 통해, 상기 2개의 맵핑 순서들 중 하나를 사용할 것을 단말에게 지시할 수 있다.

[476] 방법 Mc220에 따르면, CSI-RS 안테나 포트 번호 맵핑의 수가 적을 때는 시그널링 오버헤드가 작으나, CSI-RS 안테나 포트 번호 맵핑의 수에 따라 시그널링 오버헤드가 밑이 2인 로그 함수에 비례하여 증가한다. 따라서, CSI-RS 안테나 포트 번호 맵핑의 수가 매우 많은 경우에, 방법 Mc220은 오히려 비효율적일 수 있다.

[477]

[478] 3.3. 다양한 CSI-RS 안테나 포트 수의 설정 방법

[479] 한편, 기지국은 1차원 또는 2차원의 다양한 안테나 형상 및 안테나 배열의 크기를 가질 수 있다. 다양한 크기의 송신 안테나 형상에 대하여, 단말이 효율적인 CSI 측정을 수행하기 위해서는, 단말이 다양한 CSI-RS 안테나 포트 수를 설정받을 수 있도록 하는 것이 중요하다. 예를 들어, 단말에게 기존 규격상의 1, 2, 4, 또는 8개의 CSI-RS 안테나 포트뿐만 아니라 3, 5, 6, 또는 7개의 CSI-RS 안테나 포트를 설정할 수 있도록 하는 방법이 고려될 수 있다. CSI-RS 안테나 포트 수를 확장하는 경우에도, 예를 들어, 단말에게 2의 지수승(예, 16개, 32개, 또는 64개 등)의 CSI-RS 안테나 포트 수만을 설정할 수 있도록 정하는 방법이 있을 수 있으나, 임의의 자연수 또는 임의의 짝수 등과 같이 더 다양한 CSI-RS 안테나 포트 수를 단말에게 설정할 수 있도록 정하는 방법도 고려될 수 있다. 단말에게 다양한 CSI-RS 안테나 포트 수를 설정 가능하도록 하기 위해서는, 기존의 CSI-RS 설정 방법이 확장 또는 개선되어야 할 수 있다.

[480] 지금까지 기술된 방법들의 경우, 단말은 자신이 설정받은 모든 CSI-RS 안테나 포트들을 이용하여 CSI 측정 및 보고를 수행한다. 이하에서는 단말이 자신이 설정받은 CSI-RS 안테나 포트들 중 일부만을 이용하여 CSI 측정 및 보고를 수행하도록 하는 방법(이하 '방법 Mc300')에 대하여 기술한다.

[481] 방법 Mc300에서, 기지국은 CSI-RS configuration 시그널링에 의해 단말에게 설정된 CSI-RS 안테나 포트들 중에서, 단말이 실제 CSI 측정 및 보고에 이용할 CSI-RS 안테나 포트들을 시그널링을 통해 단말에게 알려줄 수 있다. 본 명세서에서, 방법 Mc300에 의해 선택되며 단말의 CSI 측정 및 보고에 이용되는 CSI-RS 안테나 포트를, 유효 CSI-RS 안테나 포트로 부르기로 한다. 단말은 CSI 측정 및 보고를 위해, 유효 CSI-RS 안테나 포트들에만 포트 번호를 새로 부여할 수 있다. 이 때, 유효 CSI-RS 안테나 포트에 부여되는 포트 번호를, 유효 CSI-RS 안테나 포트 번호로 부르기로 한다.

[482] 방법 Mc300에서, CSI-RS configuration 시그널링에 의해 단말에게 설정될 수 있는 CSI-RS 안테나 포트 수는 제한적일 수 있다. 예를 들어, CSI-RS configuration

시그널링에 의해 단말에게 설정될 수 있는 CSI-RS 안테나 포트 수는 1, 2, 4, 그리고 8을 포함할 수 있다. 다른 예를 들어, CSI-RS configuration 시그널링에 의해 단말에게 설정될 수 있는 CSI-RS 안테나 포트 수는 1, 2, 4, 8, 12, 그리고 16을 포함할 수 있다. 반면에, 유효 CSI-RS 안테나 포트 수는 더 다양한 값을 가질 수 있다. 예를 들어, 기지국은 단말에게 기존 규격상의 CSI-RS configuration 시그널링을 이용하여 8개의 CSI-RS 안테나 포트를 설정하고, 방법 Mc300을 이용하여, 이 중에서 5개의 CSI-RS 안테나 포트들만을 유효 CSI-RS 안테나 포트로 설정할 수 있다.

[483] 방법 Mc300 중에서 기지국이 유효 CSI-RS 안테나 포트들을 단말에게 알려주는 방법에 대하여, 먼저 기술한다.

[484] 방법 Mc310은, 단말에게 설정된 CSI-RS 안테나 포트들 각각에 대한 유효성 여부를, 단말에게 알리는 방법이다.

[485] 단말에게 설정된 CSI-RS 안테나 포트 수를 N이라 할 때, 방법 Mc310을 위해, 단말에게 길이 N인 비트맵을 시그널링하는 방법이 사용될 수 있다. 단말은 비트맵에 포함되는 각 비트의 이진 정보를 통해, 각 CSI-RS 안테나 포트의 유효성 여부를 알 수 있다. 예를 들어, 단말(UE-a)이 도 25a에 예시된 바와 같이 CSI-RS를 설정받은 경우에, 기지국은 해당 단말(UE-a)에게 방법 Mc310에 따라, 1111100010100111의 비트맵을 시그널링할 수 있다. 이 때, 비트맵에 포함되는 각 비트가 1이면 해당 CSI-RS 안테나 포트가 유효함(즉, CSI 측정 및 보고에 이용됨)을 의미할 수 있고, 0이면 해당 CSI-RS 안테나 포트가 유효하지 않음을 의미할 수 있다. 비트맵의 MSB(most significant bit)는 방법 Mc300이 적용되기 전에 단말에게 설정된 CSI-RS 안테나 포트 0번(예, LTE 규격에서는 15번)에 대응하고, 비트맵의 LSB(least significant bit)으로 갈수록 CSI-RS 안테나 포트 번호가 증가함을 가정한다. 단말(UE-a)은 1111100010100111 비트맵의 수신을 통해, CSI-RS configuration 시그널링에 의해 원래 설정받은 총 16개의 CSI-RS 안테나 포트들 중에서 총 10개의 CSI-RS 안테나 포트들이 유효함을 인식할 수 있다. 여기서, 선택된 10개의 유효 CSI-RS 안테나 포트는 1111100010100111 비트맵의 비트들 중 1 값을 가지는 비트에 대응한다. 이 때, 10개의 유효 CSI-RS 안테나 포트들에 0번부터 9번까지의 유효 CSI-RS 안테나 포트 번호가 부여될 수 있다. 이 경우에, 단말(UE-a)에게 최종적으로 설정된 CSI-RS 안테나 포트들에 대한 RE 맵핑은, 도 30에 예시된 바와 같을 수 있다.

[486]

[487] 도 30는 본 발명의 실시예에 따른, 방법 Mc310이 사용되는 경우에, CSI-RS 자원 설정을 나타내는 도면이다.

[488] 서브프레임 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 9), RE(3, 9), RE(2, 5), RE(3, 5), RE(2, 3), RE(3, 3), RE(2, 2), 및 RE(3, 2)는, 단말(UE-a)을 위한 CSI-RS RE(예, 유효 CSI-RS 안테나 포트 0~9번)로써 설정된다. 특히, 서브프레임 내의 슬롯1의 RE(2, 10) 및 RE(3, 10)에는,

단말(UE-a)을 위한 하나의 유효 CSI-RS 안테나 포트(4번)가 맵핑되고, 서브프레임 내의 슬롯1의 RE(2, 9) 및 RE(3, 9)에는, 단말(UE-a)을 위한 하나의 유효 CSI-RS 안테나 포트(5번)가 맵핑된다. 단말(UE-a)은 상기 선택된 10개의 유효 CSI-RS 안테나 포트들(0~9번)만을 이용하여, CSI 측정 및 보고를 수행할 수 있다.

[489] 다른 예를 들어, 단말(UE-b)가 도 25a에 예시된 바와 같이 CSI-RS를 설정받은 경우에, 기지국은 단말(UE-b)에게 방법 Mc310에 따라, 1010 비트맵을 시그널링할 수 있다. 단말(UE-b)은 1010 비트맵의 수신을 통해, CSI-RS configuration 시그널링에 의해 원래 설정받은 총 4개의 CSI-RS 안테나 포트들 중에서 총 2개의 CSI-RS 안테나 포트들이 유효함을 인식할 수 있다. 여기서, 상기 선택된 2개의 유효 CSI-RS 안테나 포트는, 1010 비트맵의 비트들 중 1 값을 가지는 비트에 대응한다.

[490] 이 때, 단말(UE-b)은 상기 선택된 2개의 유효 CSI-RS 안테나 포트들에 0번과 1번의 포트 번호를 순차적으로 부여할 수 있다. 이 경우에, 단말(UE-b)에게 설정된 유효 CSI-RS 안테나 포트들에 대한 RE 맵핑은, 도 30에 예시된 바와 같을 수 있다. 예를 들어, 서브프레임 내의 슬롯0의 RE(5, 9) 및 RE(6, 9)에는, 단말(UE-b)을 위한 하나의 유효 CSI-RS 안테나 포트(0번)가 맵핑되고, 서브프레임 내의 슬롯0의 RE(5, 3) 및 RE(6, 3)에는, 단말(UE-b)을 위한 하나의 유효 CSI-RS 안테나 포트(1번)가 맵핑된다. 단말(UE-b)는 상기 선택된 2개의 유효 CSI-RS 안테나 포트들(0번, 1번)만을 이용하여, CSI 측정 및 보고를 수행할 수 있다.

[491] 한편, CSI-RS configuration에 의해 단말에게 설정되는 CSI-RS 안테나 포트들 중에서 CDM이 적용되는 2개의 CSI-RS 안테나 포트들(하나의 포트 쌍)은, 2개의 RE를 공유한다. 즉, 방법 Mc300이 적용되기 전의 CSI-RS configuration에 의한 CSI-RS 안테나 포트 2k번과 2k+1번(단, k=0, 1, 2,...)은 포트 쌍을 이루고, 동일 자원을 통해 전송될 수 있다. 이를 고려하여, 단말에게 설정된 CSI-RS 안테나 포트 수를 N이라 할 때, 방법 Mc310을 위해 단말에게 길이 N/2인 비트맵을 시그널링하는 방법이 사용될 수 있다. 이 때, 비트맵의 각 비트는 CDM을 통해 묶이는 각 CSI-RS 안테나 포트 쌍에 대한 유효성 여부를 의미할 수 있다. 예를 들어, 비트맵의 첫 번째 비트는 CSI-RS configuration에 의한 CSI-RS 안테나 포트 0번과 1번에 대응하고, 비트맵의 두 번째 비트는 CSI-RS configuration에 의한 CSI-RS 안테나 포트 2번과 3번에 대응할 수 있다.

[492] 방법 Mc320은, 단말에게 설정된 CSI-RS 안테나 포트 배열의 각 행(row)과 각 열(column)에 대한 유효성 여부를 알리는 방법이다.

[493] 방법 Mc310에서와 마찬가지로, 방법 Mc320을 위해, 단말에게 비트맵을 시그널링하는 방법이 사용될 수 있다. 단말에게 설정된 수평 축과 수직 축 CSI-RS 안테나 포트 수 각각을 N_1와 N_2라 할 때, 단말에게 시그널링되는 비트맵의 길이는 N_1와 N_2의 합이 될 수 있다. 예를 들어, 비트맵에서 N_2개의

최상위 비트들이 N_2개의 행에 대한 유효성 여부를 나타내고, 비트맵에서 N_1개의 최하위 비트들이 N_1개의 열에 대한 유효성 여부를 나타낸다고 가정하자. 만약 기지국이 단말에게 N_2=2 및 N_1=8로 설정하고 1011110000 비트맵을 단말에게 시그널링한 경우에, 단말은 1011110000 비트맵을 통해서, 단말에게 설정된 CSI-RS 안테나 포트 배열(2x8)에 속한 2개의 행 중에서 첫 번째 행이 선택되고, 해당 CSI-RS 안테나 포트 배열(2x8)에 속한 8개의 열 중에서 첫 번째 열 내지 네 번째 열이 선택되었음을 인식할 수 있다.

[494] 따라서, 단말에게 설정된 CSI-RS 안테나 포트들이 2차원 배열로 배치되어 있는 경우에, 방법 Mc320은 단말에게 전송되는 비트맵의 길이를 줄일 수 있다는 장점을 가진다. 반면에, 단말에게 설정된 CSI-RS 안테나 포트들이 1차원 배열로 배치되는 경우에는, 방법 Mc320에 따른 시그널링 오버헤드는 방법 Mc310에 따른 시그널링 오버헤드와 동일할 수 있다. 한편, 방법 Mc320에서 CSI-RS 안테나 포트 배열이 도 24 내지 도 29e에 예시된 바와 같이 교차 편파 배열인 경우에, 단말에게 시그널링되는 비트맵의 각 비트는 서로 다른 편파를 갖는 CSI-RS 안테나 포트 쌍(들)에 대응할 수 있다.

[495] 상술한 바와 같이, 방법 Mc300에서, 방법 Mc310 또는 방법 Mc320을 통해 단말이 유효 CSI-RS 안테나 포트들을 알고 나면, 단말은 유효 CSI-RS 안테나 포트들에 대하여 포트 번호를 새로 부여할 수 있다. 이 때, CSI-RS 안테나 포트 배열 상의 포트 번호 맵핑 규칙으로는, 상기 방법들(예, 방법 Mc100, 방법 Mc101, 방법 Mc200, 방법 Mc220 등)뿐만 아니라 이와 다른 방법들이 사용될 수 있다. 즉, 방법 Mc300을 위해, 방법 Mc310 또는 방법 Mc320의 시그널링 방법과 방법 Mc100 내지 방법 Mc220의 CSI-RS 안테나 포트 배열 상의 포트 번호 맵핑 방법이 결합되어 사용될 수 있다. 이에 대하여, 도 31을 참고하여 설명한다.

[496]

[497] 도 31은 본 발명의 실시예에 따른, 방법 Mc310이 사용되는 경우에, CSI-RS 안테나 포트 번호 맵핑을 나타내는 도면이다.

[498] 구체적으로, 도 31에는 기지국이 단말(UE-a)에게 16개의 CSI-RS 안테나 포트와 N_1=8 및 N_2=1을 설정하고, 방법 Mc310에 기초해 단말(UE-a)에게 1111100011111000 비트맵을 시그널링하는 경우가 예시되어 있다. 이 때, 도 31의 (a1)에 예시된 바와 같이, CSI-RS 안테나 포트 배열 상의 포트 번호(0~15번)는 수평 축 및 편파 축의 순서로 부여될 수 있다.

[499] 단말(UE-a)은 방법 Mc310에 의해 설정받은 총 10개의 유효 CSI-RS 안테나 포트들(포트 번호 0~4번, 포트 번호 8~12번)에, 유효 CSI-RS 안테나 포트 번호를 0번부터 9번까지 새롭게 맵핑할 수 있다. 예를 들어, 단말(UE-a)은 도 31의 (b1)에 예시된 바와 같이, 상기 선택된 10개의 유효 CSI-RS 안테나 포트에 수평 축 및 편파 축의 순서로 유효 CSI-RS 안테나 포트 번호(0~9번)를 부여할 수 있다. 단말(UE-a)은 10개의 유효 CSI-RS 안테나 포트(유효 포트 번호 0~9번)에 대하여 CSI 측정 및 보고를 수행할 수 있다.

[500] 한편, 방법 Mc300에서 기지국이 단말에게 CSI-RS를 전송하는 경우에, 기지국이 단말에게 CSI-RS configuration 시그널링을 통해 설정된 CSI-RS 안테나 포트(방법 Mc300이 적용되기 전의 CSI-RS 안테나 포트) 모두를 송신하는 방법(이하 '방법 Mc330')이 사용될 수 있다. 또는 방법 Mc300에서 기지국이 단말에게 CSI-RS를 전송하는 경우에, 기지국이 유효 CSI-RS 안테나 포트들(예, 비트맵의 비트들 중 1 값을 가지는 비트에 대응하는 CSI-RS 안테나 포트)만을 단말에게 전송하는 방법(이하 ' 방법 Mc331')이 사용될 수도 있다.

[501] 방법 Mc331이 사용되는 경우에, 유효 CSI-RS 안테나 포트들이 맵핑되는 RE들의 위치는, CSI-RS configuration 시그널링에 의한 RE 맵핑(방법 Mc300에 의해 CSI-RS 안테나 포트들이 선택되기 이전)을 따를 수 있다.

[502] 한편, 기존 규격에 따르면, 단말은 PDSCH RE 맵핑 및 PDSCH 레잇 매칭을 수행할 때, CSI-RS configuration 시그널링에 의해 설정받은 CSI-RS RE 집합에 PDSCH가 맵핑되지 않음을 가정한다. 방법 Mc300이 사용되는 경우에, PDSCH가 맵핑되지 않는 CSI-RS RE 집합이, CSI-RS configuration에 의해 단말에게 설정된 CSI-RS 안테나 포트들의 RE 집합(방법 Mc300이 사용되기 전의 CSI-RS RE 집합)과 방법 Mc300에 의한 유효 CSI-RS 안테나 포트들의 RE 집합 중 어느 것을 의미하는지 정의될 필요가 있다. 예를 들어, 도 30에 예시된 단말(UE-a)을 가정하자. CSI-RS RE 집합에 대한 전자의 정의에 따르면, 단말(UE-a)은 슬롯1의 RE(2, 4), RE(3, 4), RE(2, 8), 및 RE(3, 8)에서 PDSCH를 수신할 수 없다. CSI-RS RE 집합에 대한 후자의 정의에 따르면, 단말(UE-a)은 슬롯1의 RE(2, 4), RE(3, 4), RE(2, 8), 및 RE(3, 8)에서 PDSCH를 수신할 수 있다. CSI-RS RE 집합에 대한 전자의 정의를 이용하는 방법은, 기지국의 CSI-RS 전송에 방법 Mc330 또는 방법 Mc331이 적용되는 경우를 위해 고려될 수 있다. CSI-RS RE 집합에 대한 후자의 정의를 이용하는 방법은, 기지국의 CSI-RS 전송에 방법 Mc331이 적용되는 경우를 위해서 고려될 수 있다.

[503] 이하에서는 방법 Mc300의 다른 실시예들에 대하여 기술한다.

[504]

[505] 도 32a, 도 32b, 및 도 32c는 방법 Mc300을 위한 다른 실시예를 나타내는 도면이다.

[506] 도 32a 내지 도 32c에서 (a1)은 4개의 CSI-RS 안테나 포트가 1차원 교차 편파 배열로 배치되는 경우를 나타낸다. 여기서, 셀 특정적 CSI-RS 안테나 포트 번호는 수평 축 및 편파 축의 순서로 맵핑됨을 가정하였다.

[507] 이 때, 기지국은 단말(UE-c), 단말(UE-d), 및 단말(UE-e)로 하여금 각각 셀 특정적 CSI-RS 안테나 포트 0~3번, 셀 특정적 CSI-RS 안테나 포트 0번과 2번, 및 셀 특정적 CSI-RS 안테나 포트 1번과 3번에 대하여 CSI 측정 및 보고를 수행하도록 설정하고자 할 수 있다.

[508] 이를 위한 평범한(trivial) 방법은, 각 단말(UE-c, UE-d, UE-e)의 CSI-RS를 서로 다른 자원 영역에 겹치지 않도록 설정하는 것이다. 이 때, 단말들(UE-c, UE-d,

UE-e)을 위한 CSI-RS가 동일한 서브프레임에 설정됨을 가정하면, 하나의 PRB 페어 내에서 CSI-RS 전송을 위해 소요되는 총 RE의 수는 8개이다. 반면에 방법 Mc300과 방법 Mc310이 사용되면, 기지국은 3개의 단말들(UE-c, UE-d, UE-e)에 대한 CSI-RS 전송이 하나의 PRB 페어 내에서 4개의 RE들만을 차지하도록 설정할 수 있다. 구체적으로, 기지국은 단말(UE-c), 단말(UE-d), 및 단말(UE-e)에게 동일한 CSI-RS configuration 시그널링을 통해 4개의 CSI-RS 안테나 포트를 설정하고, 방법 Mc310에 따라, 단말(UE-c)에게 1111 비트맵을, 단말(UE-d)에게 1010 비트맵을, 단말(UE-e)에게 0101 비트맵을 추가로 시그널링할 수 있다.

[509] 1111 비트맵을 시그널링 받은 단말(UE-c)은 CSI-RS configuration 시그널링에 의해 설정받은 4개의 CSI-RS 안테나 포트들 모두에 유효 포트 번호(0~3번)를 부여할 수 있다. 결과적으로, 도 32a의 (b1)에 예시된 바와 같이, 단말(UE-c)은 수평 축의 길이가 2인 1차원 교차 편파 CSI-RS 안테나 포트 배열(Apa1a)에 대하여, CSI 측정 및 보고를 수행할 수 있다.

[510] 1010 비트맵을 시그널링 받은 단말(UE-d)은 CSI-RS configuration 시그널링에 의해 설정받은 4개의 CSI-RS 안테나 포트들 중 포트 0번과 2번에만 유효 포트 번호(0번, 1번)를 부여할 수 있다. 결과적으로, 도 32b의 (b2)에 예시된 바와 같이, 단말(UE-d)은 수평 축의 길이가 1인 교차 편파 CSI-RS 안테나 포트 배열(Apa1b)에 대하여, CSI 측정 및 보고를 수행할 수 있다.

[511] 0101 비트맵을 시그널링 받은 단말(UE-e)은 CSI-RS configuration 시그널링에 의해 설정받은 4개의 CSI-RS 안테나 포트들 중 포트 1번과 3번에만 유효 포트 번호(0번, 1번)를 부여할 수 있다. 결과적으로, 도 32c의 (b3)에 예시된 바와 같이, 단말(UE-e)은 수평 축의 길이가 1인 교차 편파 CSI-RS 안테나 포트 배열(Apa1c)에 대하여, CSI 측정 및 보고를 수행할 수 있다.

[512] 이와 같이, 방법 Mc300과 방법 Mc310에 따르면, CSI-RS 전송 오버헤드가 절반으로 줄어들 수 있고, 이를 통해, 결국 데이터 전송 용량 증대의 효과가 얻어질 수 있다.

[513]

[514] 도 33a, 도 33b, 및 도 33c는 방법 Mc300을 위한 또 다른 실시예를 나타내는 도면이다.

[515] 도 33a 내지 도 33c에서 (a1)은 4개의 CSI-RS 안테나 포트가 1차원 단일 편파 배열로 배치된 경우를 나타낸다.

[516] 이 때, 도 32a 내지 도 32c에 예시된 실시예에서와 동일하게, 기지국은 단말(UE-c), 단말(UE-d), 및 단말(UE-e)로 하여금 각각 셀 특정적 CSI-RS 안테나 포트 0번 내지 3번, 셀 특정적 CSI-RS 안테나 포트 0번과 2번, 및 셀 특정적 CSI-RS 안테나 포트 1번과 3번에 대하여 CSI 측정 및 보고를 수행하도록 설정하고자 할 수 있다.

[517] 이를 위해, 기지국은 방법 Mc300과 방법 Mc310을 사용하고, 도 32a 내지 도

32c에 예시된 실시예에서와 동일하게, CSI-RS 자원 설정 및 비트맵을 단말(UE-c, UE-d, UE-e) 각각에게 시그널링할 수 있다. 구체적으로, 기지국은 단말(UE-c, UE-d, UE-e)에게 동일한 CSI-RS configuration 시그널링을 통해 4개의 CSI-RS 안테나 포트를 설정하고, 단말(UE-c)에게 1111 비트맵을, 단말(UE-d)에게 1010 비트맵을, 단말(UE-e)에게 0101 비트맵을 추가로 시그널링할 수 있다.

[518] 1111 비트맵을 시그널링 받은 단말(UE-c)은 CSI-RS configuration 시그널링에 의해 설정받은 4개의 CSI-RS 안테나 포트들 모두에 유효 포트 번호(0~3번)를 부여할 수 있다. 그 결과로, 도 33a의 (b1)에 예시된 바와 같이, 단말(UE-c)은 길이 4인 1차원 단일 편파 CSI-RS 안테나 포트 배열(Apa2a)에 대하여, CSI 측정 및 보고를 수행할 수 있다.

[519] 1010 비트맵을 시그널링 받은 단말(UE-d)은 CSI-RS configuration 시그널링에 의해 설정받은 4개의 CSI-RS 안테나 포트들 중 포트 0번과 2번에만 유효 포트 번호(0번, 1번)를 부여할 수 있다. 그 결과로, 도 33b의 (b2)에 예시된 바와 같이, 단말(UE-d)은 길이 2인 1차원 단일 편파 CSI-RS 안테나 포트 배열(Apa2b)에 대하여, CSI 측정 및 보고를 수행할 수 있다.

[520] 0101 비트맵을 시그널링 받은 단말(UE-e)은 CSI-RS configuration 시그널링에 의해 설정받은 4개의 CSI-RS 안테나 포트들 중 포트 1번과 3번에만 유효 포트 번호(0번, 1번)를 부여할 수 있다. 그 결과로, 도 33c의 (b3)에 예시된 바와 같이, 단말(UE-e)은 길이 2인 1차원 단일 편파 CSI-RS 안테나 포트 배열(Apa2c)에 대하여, CSI 측정 및 보고를 수행할 수 있다.

[521] 이 때, 만약 CSI-RS 안테나 포트와 물리 안테나 요소(들) 간에 일대일 맵핑을 가정한다면, 단말(UE-d)와 단말(UE-e)에게 보이는 물리 안테나 요소들 간의 간격은 단말(UE-c)에게 보이는 물리 안테나 요소들 간 간격의 2배가 된다. 즉, 방법 Mc300과 방법 Mc310에 따르면, 복수의 단말은 공통의 CSI-RS 전송을 이용하여 서로 다른 안테나 간격을 갖는 안테나 배열에 대한 CSI 측정 및 보고를 수행할 수 있다. 상기 자원 설정의 효과는 도 32a 내지 도 32c에 예시된 실시예에서와 마찬가지로, 4개의 RE들만으로 얻어질 수 있다.

[522]

[523] 도 34은 방법 Mc300을 위한 또 다른 실시예를 나타내는 도면이다.

[524] 구체적으로 도 34에는, 16개의 CSI-RS 안테나 포트가 2차원 단일 편파 배열로 배치된 경우가 예시되어 있다. 이 때, 수평 축의 CSI-RS 안테나 포트 수는 8이고 수직 축의 CSI-RS 안테나 포트 수는 2이다. 여기서, 셀 특정적 CSI-RS 안테나 포트 번호는 수평 축 및 수직 축의 순서로 맵핑됨을 가정하였다.

[525] 기지국은 단말(UE-c)와 단말(UE-e)로 하여금 각각 8개의 열 중 좌측 4개의 열과 우측 4개의 열에 대하여 CSI 측정 및 보고를 수행하도록 하고, 단말(UE-d)로 하여금 셀 특정적 CSI-RS 안테나 포트 10~13번에 대하여 CSI 측정 및 보고를 수행하도록 하고자 할 수 있다.

[526] 방법 Mc300이 사용되면, 기지국은 총 16개의 RE들만을 이용하여 단말들(UE-c,

UE-d, UE-e)로 하여금 상기 CSI-RS 측정 및 보고 동작을 수행하도록 할 수 있다.

[527] 기지국이 선택된 CSI-RS 안테나 포트들을 단말에게 알려주기 위하여, 방법 Mc310을 사용할 수 있다. 이 경우에, 기지국은 단말들(UE-c, UE-d, UE-e)에게 동일한 CSI-RS configuration 시그널링을 통해 16개의 CSI-RS 안테나 포트를 설정하고, 단말(UE-c)에게 1111000011110000 비트맵을, 단말(UE-d)에게 0000000000111100 비트맵을, 단말(UE-e)에게 0000111100001111 비트맵을 시그널링할 수 있다.

[528] 한편, 기지국이 선택된 CSI-RS 안테나 포트들을 단말에게 알려주기 위하여, 방법 Mc320을 사용할 수도 있다. 이 경우에, 기지국은 단말들(UE-c, UE-d, UE-e)에게 동일한 CSI-RS configuration 시그널링을 통해 16개의 CSI-RS 안테나 포트를 설정하고, 단말(UE-c)에게 1111110000 비트맵을, 단말(UE-d)에게 0100111100 비트맵을, 단말(UE-e)에게 1100001111 비트맵을 시그널링할 수 있다. 여기서, 방법 Mc320에 따른 비트맵에서 N_2개의 최상위 비트들(좌측에 표기된 비트들)은 N_2개의 행에 대한 사용 여부(포트 번호 부여 여부)를 나타내고, 방법 Mc320에 따른 비트맵에서 N_1개의 최하위 비트들(우측에 표기된 비트들)은 N_1개의 열에 대한 사용 여부(포트 번호 부여 여부)를 나타내는 것으로 가정한다.

[529] 비트맵을 시그널링 받은 단말(UE-c)은 CSI-RS configuration 시그널링에 의해 설정받은 16개의 CSI-RS 안테나 포트들 중 1번째 내지 4번째 열에 대응하는 8개의 포트(포트 번호 0~3번, 8~11번)에만 유효 포트 번호(0~7번)를 부여할 수 있다. 그 결과로, 단말(UE-c)은 2차원 단일 편파 CSI-RS 안테나 포트 배열(Apa3a)에 대하여, CSI 측정 및 보고를 수행할 수 있다.

[530] 비트맵을 시그널링 받은 단말(UE-d)은 CSI-RS configuration 시그널링에 의해 설정받은 16개의 CSI-RS 안테나 포트들 중 4개의 포트(포트 번호 10~13번)에만 유효 포트 번호(0~3번)를 부여할 수 있다. 그 결과로, 단말(UE-d)은 1차원 단일 편파 CSI-RS 안테나 포트 배열(Apa3b)에 대하여, CSI 측정 및 보고를 수행할 수 있다.

[531] 비트맵을 시그널링 받은 단말(UE-e)은 CSI-RS configuration 시그널링에 의해 설정받은 16개의 CSI-RS 안테나 포트들 중 5번째 내지 8번째 열에 대응하는 8개의 포트(포트 번호 4~7번, 12~15번)에만 유효 포트 번호(0~7번)를 부여할 수 있다. 그 결과로, 단말(UE-e)은 2차원 단일 편파 CSI-RS 안테나 포트 배열(Apa3c)에 대하여, CSI 측정 및 보고를 수행할 수 있다.

[532] 한편, 방법 Mc300 및 방법 Mc300을 위한 세부 방법들은, 방법 Mc220 및 방법 Mc220을 위한 세부 방법들과 결합되어 사용될 수도 있다.

[533]

[534] 3.4. CSI-RS 안테나 포트의 2차원 십자 배열 구성

[535] 한편, 도 35 및 도 36에 예시된 바와 같이, 두 개의 1차원 CSI-RS 안테나 포트 배열이 각각 수평 축과 수직 축으로 나열되어 교차하는 구조를 가지는 2차원 CSI-RS 안테나 포트 배열이 고려될 수 있다.

[536] 도 35는 CSI-RS 안테나 포트의 2차원 십자 배열을 나타내는데, 구체적으로 두 1차원 배열의 교차점에 CSI-RS 안테나 포트가 중복 할당되는 2차원 십자 배열을 나타낸다.

[537] 도 35에 예시된 (Case-A)는, 두 1차원 배열의 교차점이 수평 배열의 첫번째 요소와 수직 배열의 첫번째 요소인 경우이다. 도 35에 예시된 (Case-B)는, 두 1차원 배열의 교차점이 수평 배열의 두번째 요소와 수직 배열의 첫번째 요소인 경우이다. 도 35의 (Case-A) 및 (Case-B)에는, 수평 배열에 CSI-RS 안테나 포트(0~3번)이 할당되고, 수직 배열에 CSI-RS 안테나 포트(4번, 5번)이 할당되는 경우가 예시되어 있다.

[538] 두 1차원 배열의 교차점에 CSI-RS 안테나 포트 번호가 중복 할당되는 경우에, 단말에게 설정되는 총 CSI-RS 안테나 포트 수는 N_2와 N_1의 합이다. 예를 들어, 도 35에 예시된 실시예에서, 단말에게 설정되는 총 CSI-RS 안테나 포트 수는 6(=2+4)이다.

[539]

[540] 도 36는 CSI-RS 안테나 포트의 2차원 십자 배열을 나타내는데, 구체적으로 두 1차원 배열의 교차점에 CSI-RS 안테나 포트가 중복 할당되지 않는 2차원 십자 배열을 나타낸다.

[541] 도 36에 예시된 (Case-A)는, 두 1차원 배열의 교차점이 수평 배열의 첫번째 요소와 수직 배열의 첫번째 요소인 경우이다. 도 36에 예시된 (Case-B)는, 두 1차원 배열의 교차점이 수평 배열의 두번째 요소와 수직 배열의 첫번째 요소인 경우이다. 도 36의 (Case-A) 및 (Case-B)에는, 수평 배열에 CSI-RS 안테나 포트(0~3번)이 할당되고, 수직 배열에 CSI-RS 안테나 포트(4번)이 할당되는 경우가 예시되어 있다.

[542] 두 1차원 배열의 교차점에 CSI-RS 안테나 포트 번호가 중복 할당되지 않고 하나만 할당되는 경우에, 단말에게 설정되는 총 CSI-RS 안테나 포트 수는 N_2+N_1-1 이다. 예를 들어, 도 36에 예시된 실시예에서, 단말에게 설정되는 총 CSI-RS 안테나 포트 수는 5(=2+4-1)이다.

[543] 한편, 이러한 십자 배열 구조는 2차원 또는 3차원 배열의 모든 원소들에 대하여 CSI-RS를 전송하는 구조에 비해, CSI-RS 전송을 위해 소요되는 오버헤드가 적다는 장점을 가진다. 하지만, 그만큼 단말이 CSI 측정을 위해 이용할 수 있는 채널 정보가 감소되므로, 실제 채널의 행(또는 열) 간 상관도(correlation)가 적은 환경에서는 채널 추정의 정확도가 떨어질 수 있다.

[544] CSI-RS 안테나 포트가 십자 배열로 구성되는 경우에도, 단말이 2차원 CSI-RS 안테나 포트 배열의 수평 축 및 수직 축 길이를 알고 있는 것이, CSI 측정 및 보고에 도움될 수 있다. 또한 이 경우에, 단말이 1차원 수직 배열과 1차원 수평 배열 간의 교차점 위치 또는 해당 교차점 위치에 할당된 CSI-RS 안테나 포트 번호를 아는 것이, CSI 측정 및 보고에 도움될 수 있다. 단말이 교차점에 관한 정보를 획득하기 위한 방법으로써, 두 가지 방법(방법 Mc500, 방법 Mc501)이

고려될 수 있다.

[545] 방법 Mc500은, 단말이 미리 정해진 규칙에 따라 수직 배열과 수평 배열의 교차점을 획득하는 방법이다. 방법 Mc501은, 수직 배열과 수평 배열의 교차점에 관한 정보를 기지국이 단말에게 전송하는 방법이다.

[546] 방법 Mc500에서 교차점은 미리 정해진 규칙에 따라 시간적으로(예, 서브프레임 마다, 주기적으로 등) 변할 수도 있고, 고정적일 수도 있다. 수평 축 및 수직 축 CSI-RS 안테나 포트 배열이 맵핑될 수 있는 전체 2차원 배열 공간을 열의 개수가 N_1이고 행의 개수가 N_2인 2차원 행렬로써 표현한다고 가정하면, 후자의 방법(교차점이 고정적임)은 예를 들어, 교차점의 위치를 2차원 행렬의 (1,1) 원소 지점으로 정해놓을 수 있다. 전자의 방법(교차점이 시간적으로 변함)은 예를 들어, 교차점의 위치가 수직 축에서 시간적으로 변하도록(즉, 교차점의 위치가 순차적으로 2차원 행렬의 (1,1), (2,1), ..., (N_2,1) 원소 지점이 되도록) 정할 수 있다.

[547] 한편, 도 36에 예시된 바와 같이, 교차점에 CSI-RS 안테나 포트 번호가 중복되지 않게 하나만 할당되는 경우에, 하나의 RB 페어 내에서 CSI-RS 전송을 위해 이용되는 RE가 1개 절약될 수 있다. 이를 위해, 단말에게 N_2+N_1-1개의 CSI-RS 안테나 포트를 설정하기 위한 방법이 필요할 수 있다. 그 방법 중 하나로써, 기지국이 단말에게 수평 축 또는 수직 축 CSI-RS 안테나 포트 수를 독립적으로 설정하는 경우에, 기지국은 단말에게 기존 설정을 동일하게 적용하되, 수평 축과 수직 축 방향 중 어느 한 방향의 CSI-RS 안테나 포트 수가 기존 설정에서의 해당 방향 포트 수보다 1만큼 적다는 것을 단말이 인식하도록 할 수 있다. 이 때, 기존 설정 대비 1개가 줄어든 N_2+N_1-1개의 CSI-RS 안테나 포트에 대한 포트 번호를 단말이 알아야 한다. 포트 번호 맵핑 규칙은 규격에 미리 정의될 수도 있고, 기지국이 단말에게 관련 정보를 시그널링할 수도 있다.

[548]

[549] 도 37은 본 발명의 실시예에 따른, 기지국(100)을 나타내는 도면이다.

[550] 기지국(100)은 프로세서(110), 메모리(120), 및 RF(radio frequency) 변환기(130)를 포함한다.

[551] 프로세서(110)는 본 명세서에서 기지국, 셀, 또는 TP와 관련하여 기술된 기능, 절차, 및 방법들을 구현하도록 구성될 수 있다. 또한, 프로세서(110)는 기지국(100)의 각 구성을 제어할 수 있다.

[552] 메모리(120)는 프로세서(110)와 연결되고, 프로세서(110)의 동작과 관련된 다양한 정보를 저장한다.

[553] RF 변환기(130)는 프로세서(110)와 연결되고, 무선 신호를 송신 또는 수신한다.

[554]

[555] 도 38은 본 발명의 실시예에 따른, 단말(200)을 나타내는 도면이다.

[556] 단말(200)은 프로세서(210), 메모리(220), 및 RF 변환기(230)를 포함한다.

[557] 프로세서(210)는 본 명세서에서 단말과 관련하여 기술된 기능, 절차, 및

방법들을 구현하도록 구성될 수 있다. 또한, 프로세서(210)는 단말(200)의 각 구성을 제어할 수 있다.

[558] 메모리(220)는 프로세서(210)와 연결되고, 프로세서(210)의 동작과 관련된 다양한 정보를 저장한다.

[559] RF 변환기(230)는 프로세서(210)와 연결되고, 무선 신호를 송신 또는 수신한다.

[560]

[561] 이상에서 본 발명의 실시예에 대하여 상세하게 설명하였지만 본 발명의 권리범위는 이에 한정되는 것은 아니고 다음의 청구범위에서 정의하고 있는 본 발명의 기본 개념을 이용한 당업자의 여러 변형 및 개량 형태 또한 본 발명의 권리범위에 속하는 것이다.

[562]

청구범위

[청구항 1] 기지국이 CSI(channel state information)-RS(reference signal)를 설정하는 방법으로서,
단말을 위한 CSI-RS 안테나 포트를 설정하는 단계;
상기 CSI-RS 안테나 포트에 포트 번호를 맵핑하기 위한 적어도 하나의 포트 번호 맵핑 규칙 중 하나를, 상기 단말을 위해 선택하는 단계; 및
상기 선택된 포트 번호 맵핑 규칙을 상기 단말에게 알리는 단계
를 포함하는 기지국의 CSI-RS 설정 방법.

[청구항 2] 제1항에 있어서,
상기 단말을 위한 CSI-RS 안테나 포트를 설정하는 단계는,
상기 CSI-RS 안테나 포트가 제1 축, 제2 축, 및 제3 축 중 적어도 2개를 따라 배치되는 CSI-RS 안테나 포트 배열을 설정하는 단계를 포함하고,
상기 선택된 포트 번호 맵핑 규칙에 무관하게, 상기 제1 축, 상기 제2 축, 및 상기 제3 축에 포트 번호가 맵핑되는 축 순서는 기 설정되는
기지국의 CSI-RS 설정 방법.

[청구항 3] 제2항에 있어서,
상기 단말을 위한 CSI-RS 안테나 포트를 설정하는 단계는,
상기 CSI-RS 안테나 포트 배열에 포함된 CSI-RS 안테나 포트 중에서 상기 제1 축으로 배치되는 CSI-RS 안테나 포트의 수, 상기 제2 축으로 배치되는 CSI-RS 안테나 포트의 수, 및 상기 제3 축으로 배치되는 CSI-RS 안테나 포트의 수 중 적어도 하나를, 상기 단말에게 전송하는 단계를 더 포함하는
기지국의 CSI-RS 설정 방법.

[청구항 4] 제2항에 있어서,
상기 단말을 위한 CSI-RS 안테나 포트를 설정하는 단계는,
상기 제1 축, 상기 제2 축, 및 상기 제3 축 중 하나의 축에 따라 배치되는 CSI-RS 안테나 포트의 수가 상기 단말에게 설정되는 전체 CSI-RS 안테나 포트의 수와 동일한 경우에, 상기 하나의 축에 따라 배치되는 CSI-RS 안테나 포트의 수를 상기 단말에게 전송하는 것을 생략하는 단계를 더 포함하는
기지국의 CSI-RS 설정 방법.

[청구항 5] 제2항에 있어서,
상기 단말을 위한 CSI-RS 안테나 포트를 설정하는 단계는,
상기 CSI-RS 안테나 포트 배열에 포함된 CSI-RS 안테나 포트 중에서 상기 제1 축으로 배치되는 CSI-RS 안테나 포트의 수와 상기 제3 축으로 배치되는 CSI-RS 안테나 포트의 수를 합하여, 제1 값을 구하는 단계; 및
상기 CSI-RS 안테나 포트 배열에 포함된 CSI-RS 안테나 포트 중에서 상기 제2 축으로 배치되는 CSI-RS 안테나 포트의 수 및 상기 제1 값 중 적어도

하나를, 상기 단말에게 전송하는 단계를 더 포함하는
기지국의 CSI-RS 설정 방법.

[청구항 6] 제2항에 있어서,
상기 선택된 포트 번호 맵핑 규칙은,
상기 단말에 의한 채널 추정 시에, 상기 단말로 하여금 상기 단말에게 설정된 전체 CSI-RS 안테나 포트를 상기 선택된 포트 번호 맵핑 규칙에 대응하는 개수 만큼의 CSI-RS 안테나 포트 그룹으로 나누도록 하고, 상기 CSI-RS 안테나 포트 그룹 별로 상기 각 CSI-RS 안테나 포트 그룹에 속하는 CSI-RS 안테나 포트에 상기 기 설정된 축 순서에 따라 포트 번호를 부여하도록 하는
기지국의 CSI-RS 설정 방법.

[청구항 7] 제6항에 있어서,
상기 각 CSI-RS 안테나 포트 그룹에 속하는 CSI-RS 안테나 포트의 수는 상기 단말에게 설정되는 전체 CSI-RS 안테나 포트의 수의 약수인
기지국의 CSI-RS 설정 방법.

[청구항 8] 제1항에 있어서,
상기 선택된 포트 번호 맵핑 규칙을 상기 단말에게 알리는 단계는,
상기 선택된 포트 번호 맵핑 규칙을 나타내는 비트 코드를, 상기 단말에게 전송하는 단계를 포함하는
기지국의 CSI-RS 설정 방법.

[청구항 9] 제6항에 있어서,
상기 선택된 포트 번호 맵핑 규칙을 상기 단말에게 알리는 단계는,
상기 선택된 포트 번호 맵핑 규칙에 따라 생성되는 상기 CSI-RS 안테나 포트 그룹의 개수를 나타내는 비트 코드를, 상기 단말에게 전송하는 단계를 포함하는
기지국의 CSI-RS 설정 방법.

[청구항 10] 제2항에 있어서,
상기 단말에게 설정되는 전체 CSI-RS 안테나의 수는 8개 보다 더 많고,
상기 제1 축은 수평(horizontal) 축이고, 상기 제2 축은 수직(vertical) 축이고, 상기 제3 축은 편파(polarization) 축인
기지국의 CSI-RS 설정 방법.

[청구항 11] 제1항에 있어서,
제1 축, 제2 축, 및 제3 축에 포트 번호가 맵핑되는 축 순서들 중에서 하나를, 상기 단말을 위해 선택하는 단계; 및
상기 선택된 축 순서를 상기 단말에게 알리는 단계를 더 포함하고,
상기 단말을 위한 CSI-RS 안테나 포트를 설정하는 단계는,
상기 CSI-RS 안테나 포트가 상기 제1 축, 상기 제2 축, 및 상기 제3 축 중 적어도 2개를 따라 배치되는 CSI-RS 안테나 포트 배열을 설정하는 단계를

포함하는
기지국의 CSI-RS 설정 방법.

[청구항 12] 단말이 CSI(channel state information)를 측정하는 방법으로서,
기지국으로부터, CSI-RS(reference signal) 안테나 포트를 위한 제1 포트 번호 맵핑 규칙을 수신하는 단계;
상기 제1 포트 번호 맵핑 규칙에 기초해, 상기 CSI-RS 안테나 포트를 상기 제1 포트 번호 맵핑 규칙에 대응하는 개수 만큼의 CSI-RS 안테나 포트 그룹으로 나누는 단계;
상기 CSI-RS 안테나 포트 그룹 별로 상기 각 CSI-RS 안테나 포트 그룹에 속하는 CSI-RS 안테나 포트에 포트 번호를 부여하는 단계; 및
상기 포트 번호가 부여된 CSI-RS 안테나 포트에 대하여, 채널 추정을 수행하는 단계
를 포함하는 단말의 CSI 측정 방법.

[청구항 13] 제12항에 있어서,
상기 제1 포트 번호 맵핑 규칙과 다른 제2 포트 번호 맵핑 규칙에 따라, 상기 CSI-RS 안테나 포트에 포트 번호를 재부여하는 단계; 및
상기 포트 번호가 재부여된 CSI-RS 안테나 포트에 대하여, 상기 채널 추정의 결과에 기초해 CSI 측정을 수행하는 단계
를 더 포함하는 단말의 CSI 측정 방법.

[청구항 14] 제12항에 있어서,
상기 제1 포트 번호 맵핑 규칙을 수신하는 단계는,
상기 제1 포트 번호 맵핑 규칙을 나타내는 비트 코드를 상기 기지국으로부터 수신하는 단계를 포함하는
단말의 CSI 측정 방법.

[청구항 15] 제12항에 있어서,
상기 CSI-RS 안테나 포트는 제1 축, 제2 축, 및 제3 축 중 적어도 2개를 따라 배치되고,
상기 CSI-RS 안테나 포트에 포트 번호를 부여하는 단계는,
상기 CSI-RS 안테나 포트 그룹 중에서 제1 CSI-RS 안테나 포트 그룹에 속하는 CSI-RS 안테나 포트에, 상기 제1 축, 상기 제2 축, 및 상기 제3 축에 포트 번호가 부여되는 축 순서에 따라 포트 번호를 부여하는 단계; 및
상기 CSI-RS 안테나 포트 그룹 중에서 제2 CSI-RS 안테나 포트 그룹에 속하는 CSI-RS 안테나 포트에, 상기 축 순서에 따라 포트 번호를 부여하는 단계를 포함하고,
상기 제2 CSI-RS 안테나 포트 그룹에 부여된 첫번째 포트 번호는 상기 제1 CSI-RS 안테나 포트 그룹에 부여된 마지막 포트 번호 다음의 포트 번호인
단말의 CSI 측정 방법.

[청구항 16] 단말이 CSI(channel state information)를 측정하는 방법으로서,

기지국으로부터, CSI-RS(reference signal) 안테나 포트를 설정받는 단계;
상기 기지국으로부터 상기 CSI-RS 안테나 포트에 대한 포트 번호 부여 여부 정보를 수신하는 단계;
상기 포트 번호 부여 정보에 기초해, 상기 CSI-RS 안테나 포트 중 일부에 포트 번호를 부여하는 단계; 및
상기 포트 번호가 부여된 CSI-RS 안테나 포트를 이용하여, CSI를 측정하는 단계
를 포함하는 단말의 CSI 측정 방법.

[청구항 17] 제16항에 있어서,
상기 포트 번호 부여 여부 정보를 수신하는 단계는,
상기 CSI-RS 안테나 포트의 수만큼의 길이를 가지며 상기 CSI-RS 안테나 포트 별 포트 번호 부여 여부를 나타내는 비트맵을, 상기 기지국으로부터 수신하는 단계를 포함하고,
상기 CSI-RS 안테나 포트 중 일부에 포트 번호를 부여하는 단계는,
상기 비트맵에 속하는 비트 중에서 제1 값을 가지는 비트에 대응하는 CSI-RS 안테나 포트에 포트 번호를 부여하는 단계를 포함하는
단말의 CSI 측정 방법.

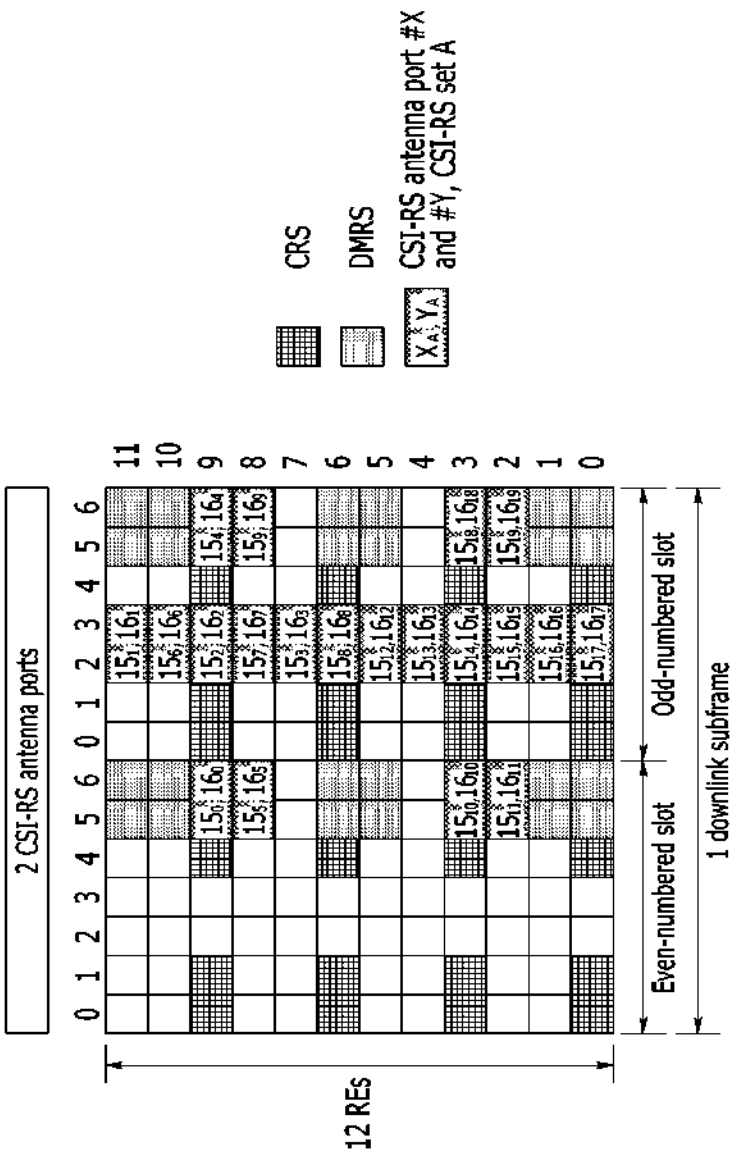
[청구항 18] 제16항에 있어서,
상기 포트 번호 부여 여부 정보를 수신하는 단계는,
상기 CSI-RS 안테나 포트의 수의 절반의 길이를 가지며 상기 CSI-RS 안테나 포트 쌍 별 포트 번호 부여 여부를 나타내는 비트맵을, 상기 기지국으로부터 수신하는 단계를 포함하고,
상기 CSI-RS 안테나 포트 중 일부에 포트 번호를 부여하는 단계는,
상기 비트맵에 속하는 비트 중에서 제1 값을 가지는 비트에 대응하는 CSI-RS 안테나 포트 쌍에 포트 번호를 부여하는 단계를 포함하고,
상기 CSI-RS 안테나 포트 쌍은 동일한 RE(resource element)를 통해 전송되는 2개의 CSI-RS 안테나 포트를 포함하는
단말의 CSI 측정 방법.

[청구항 19] 제16항에 있어서,
상기 CSI-RS 안테나 포트는 CSI-RS 안테나 포트 배열에 포함되며 제1 축, 제2 축, 및 제3 축 중 적어도 2개에 따라 배치되고,
상기 포트 번호 부여 여부 정보를 수신하는 단계는,
상기 제1 축으로 배치되는 CSI-RS 안테나 포트의 수와 상기 제2 축으로 배치되는 CSI-RS 안테나 포트의 수를 합한 값 만큼의 길이를 가지며 상기 CSI-RS 안테나 포트 배열의 각 행과 각 열에 대한 포트 번호 부여 여부를 나타내는 비트맵을, 상기 기지국으로부터 수신하는 단계를 포함하는
단말의 CSI 측정 방법.

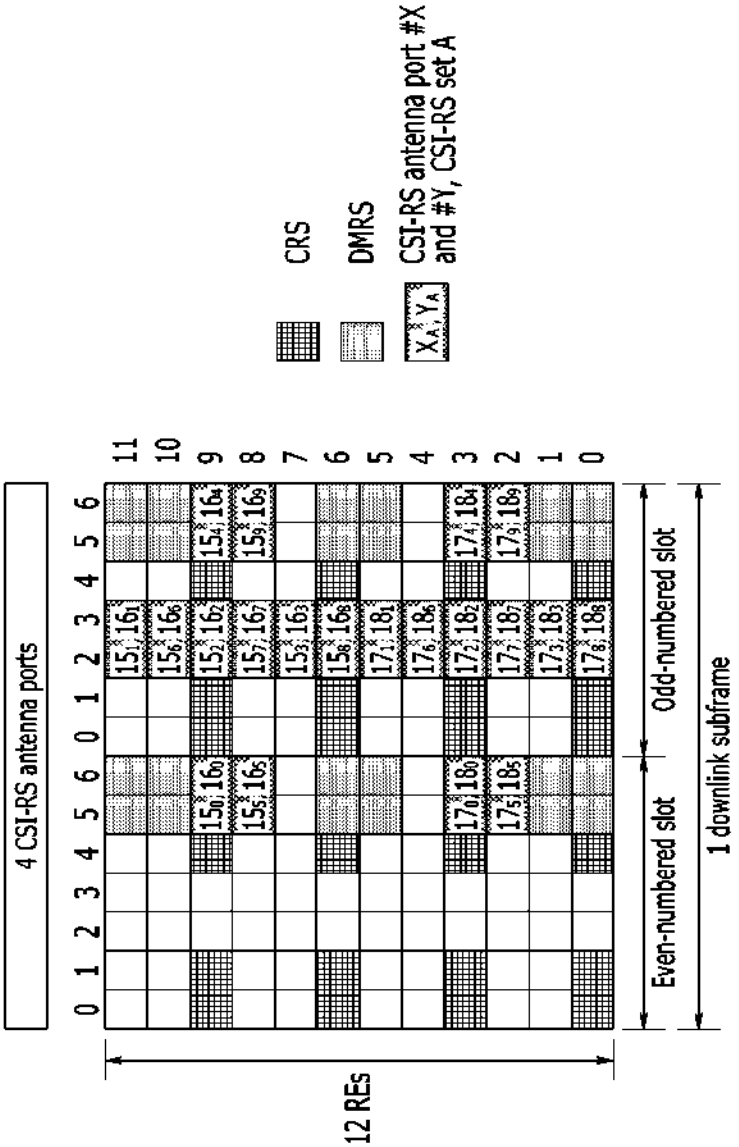
[청구항 20] 제16항에 있어서,

상기 단말에게 설정된 전체 CSI-RS 안테나 포트를 위한 RE(resource element) 중에서 상기 포트 번호가 부여된 CSI-RS 안테나 포트를 위한 RE를 제외한 나머지에서 PDSCH(physical downlink shared channel)가 수신되는 것이 가능함을 가정하는 단계
를 더 포함하는 단말의 CSI 측정 방법.

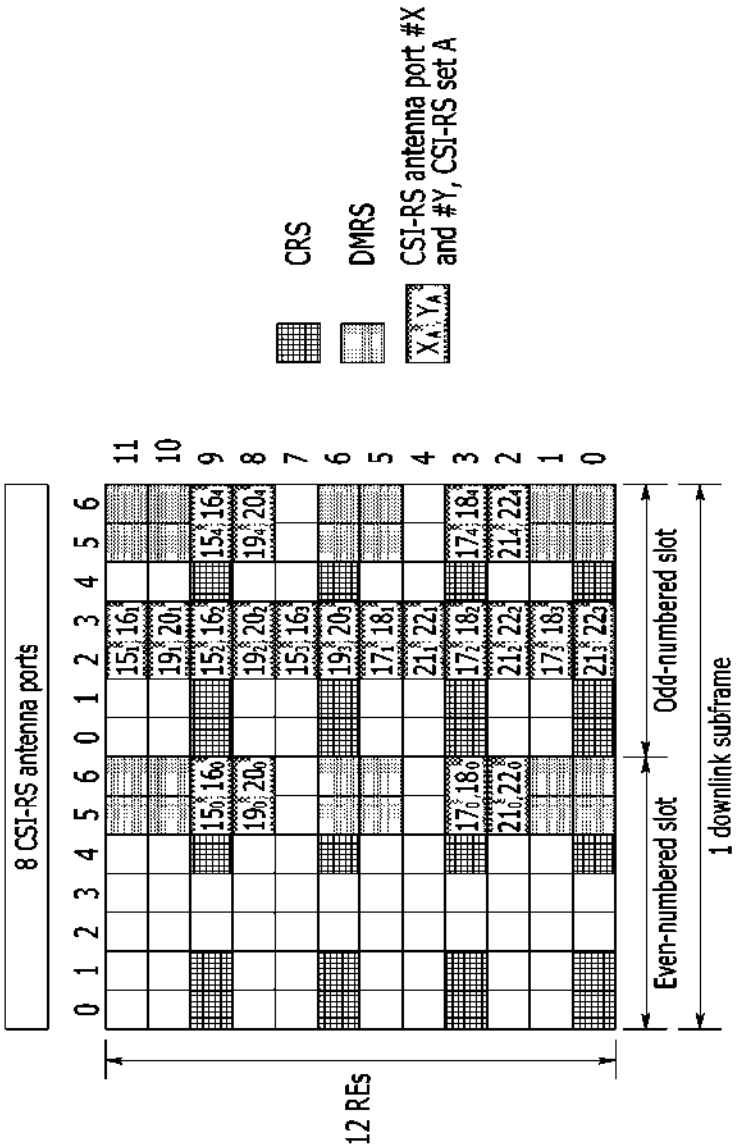
[도1]


CRS
DMRS
CSI-RS antenna port #X and #Y, CSI-RS set A
2 CSI-RS antenna ports
12 REs
Even-numbered slot
Odd-numbered slot
1 downlink subframe

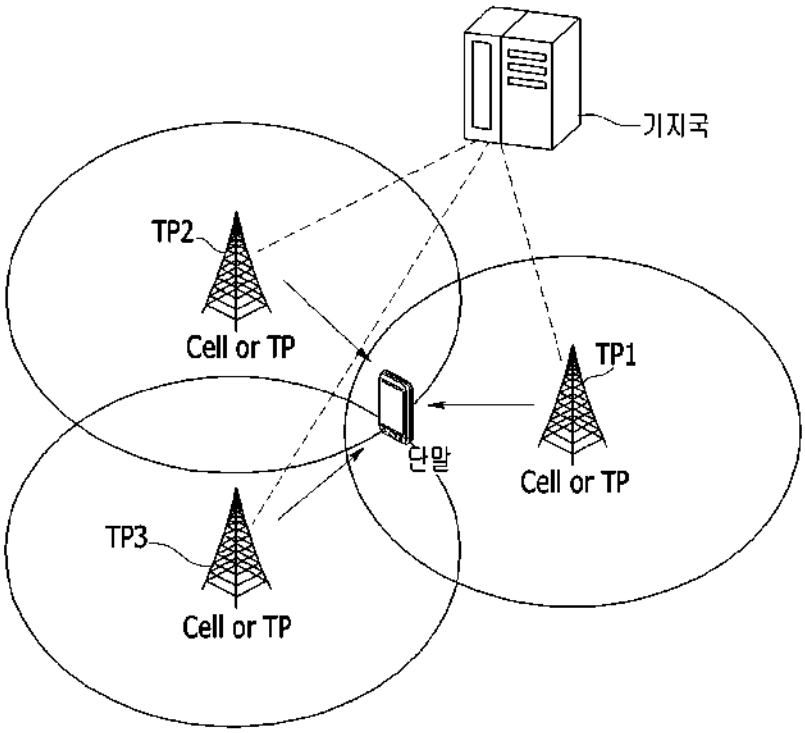
[도2]


CRS
DMRS
CSI-RS antenna port #X and #Y, CSI-RS set A
4 CSI-RS antenna ports
Even-numbered slot
Odd-numbered slot
1 downlink subframe
12 REs

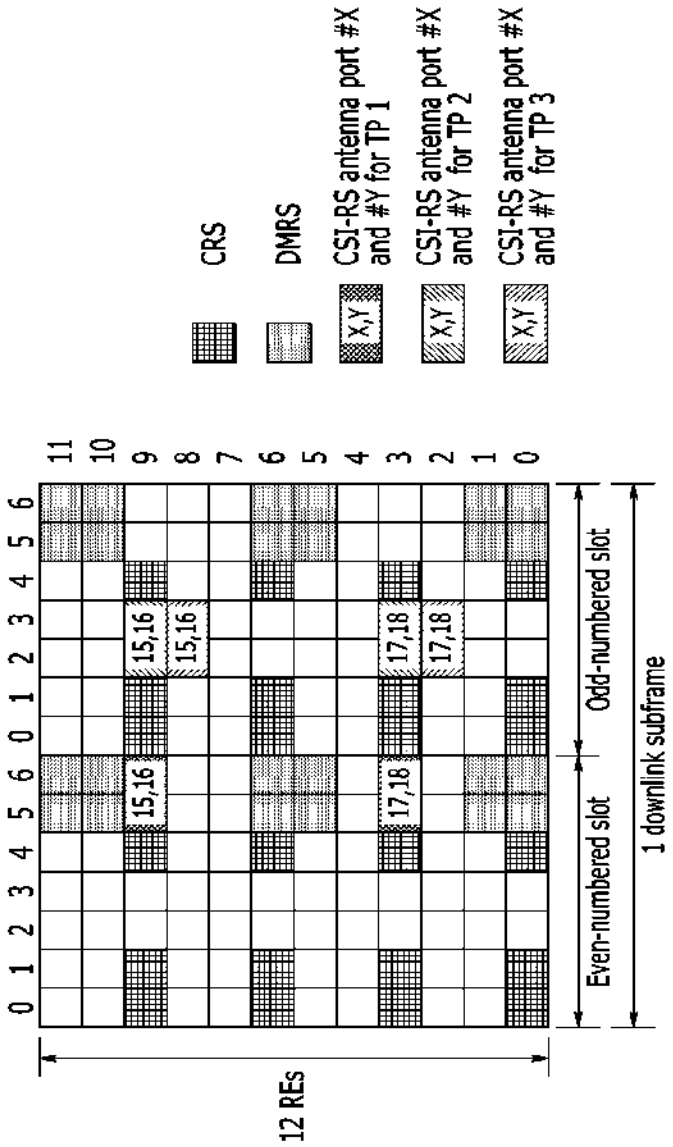
[도3]


CRS
DMRS
CSI-RS antenna port #X and #Y, CSI-RS set A
8 CSI-RS antenna ports
Even-numbered slot
Odd-numbered slot
1 downlink subframe
12 REs

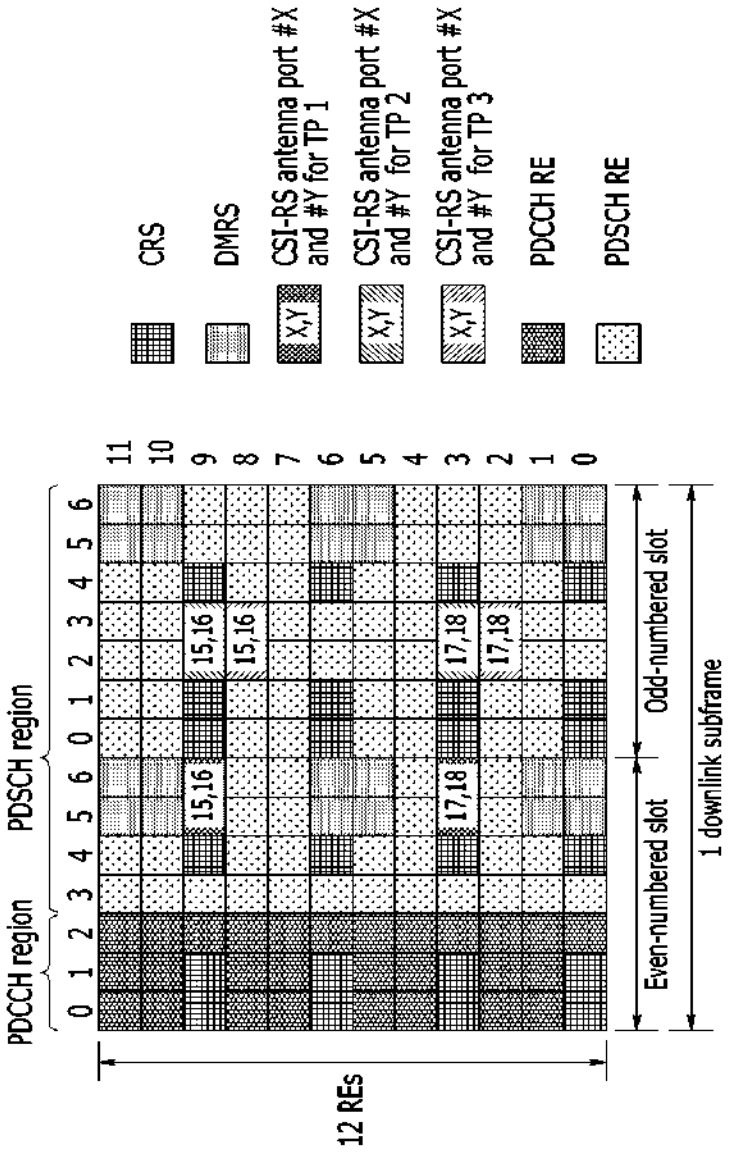
[도4]



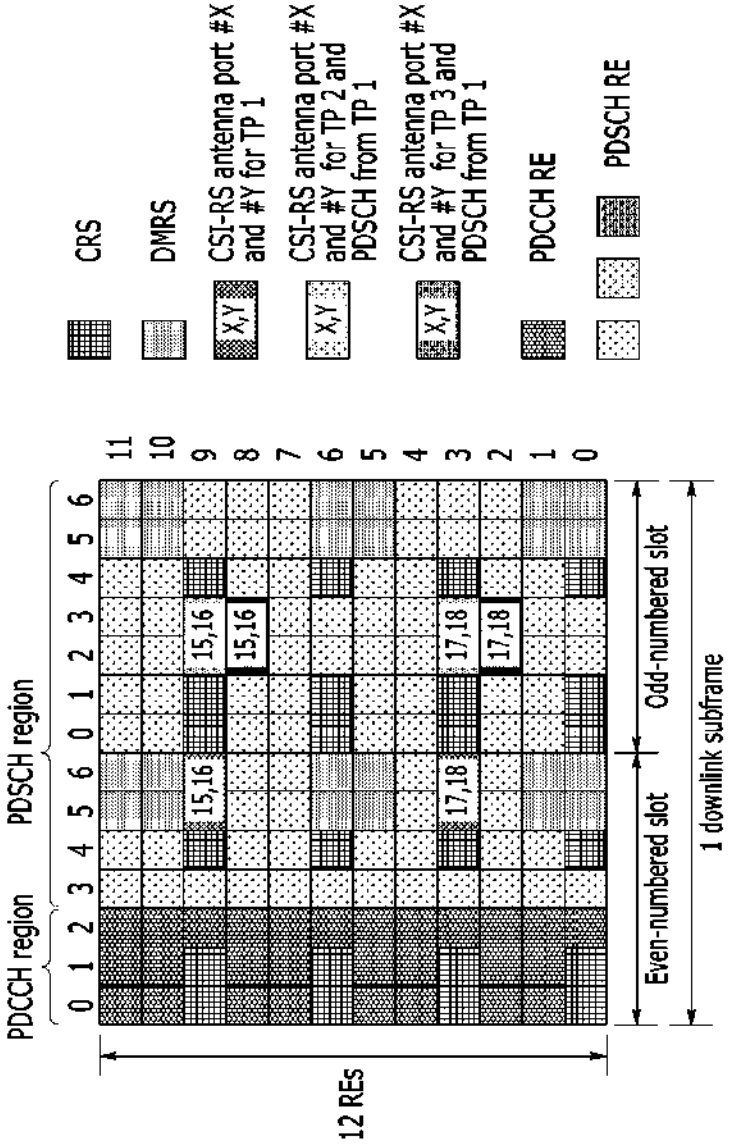
[도5]


CRS
DMRS
CSI-RS antenna port #X and #Y for TP 1
CSI-RS antenna port #X and #Y for TP 2
CSI-RS antenna port #X and #Y for TP 3
X,Y
0 1 2 3 4 5 6 0 1 2 3 4 5 6
11 10 9 8 7 6 5 4 3 2 1 0
15,16
17,18
Even-numbered slot
Odd-numbered slot
1 downlink subframe
12 REs

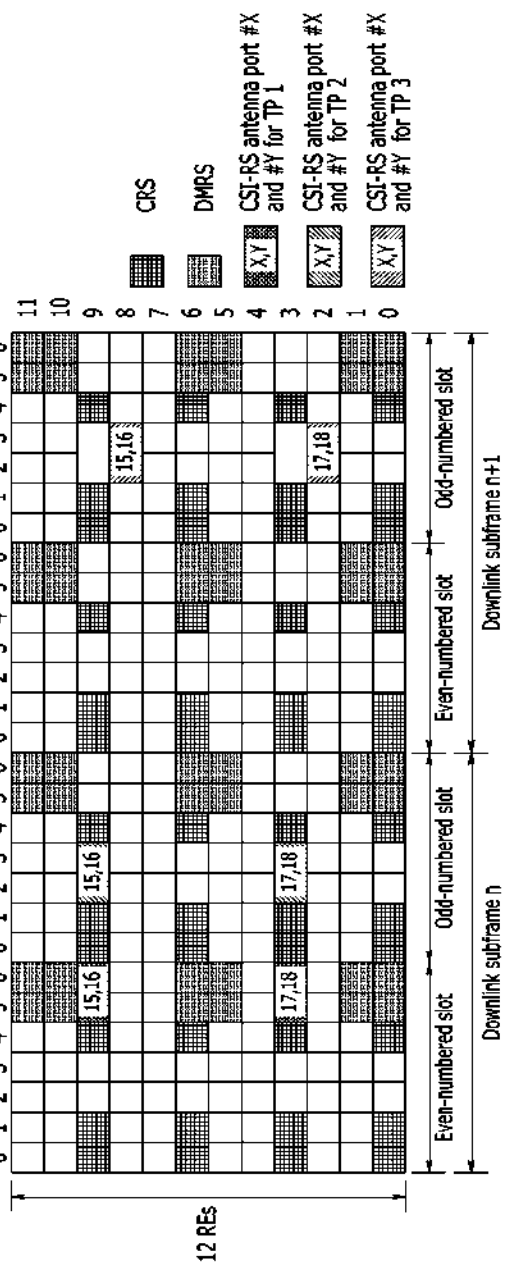
[도6]


CRS
DMRS
CSI-RS antenna port #X and #Y for TP 1
CSI-RS antenna port #X and #Y for TP 2
CSI-RS antenna port #X and #Y for TP 3
PDCCH RE
PDSCH RE
X,Y
PDCCH region
PDSCH region
0 1 2 3 4 5 6 0 1 2 3 4 5 6
11 10 9 8 7 6 5 4 3 2 1 0
15,16
17,18
12 REs
Even-numbered slot
Odd-numbered slot
1 downlink subframe

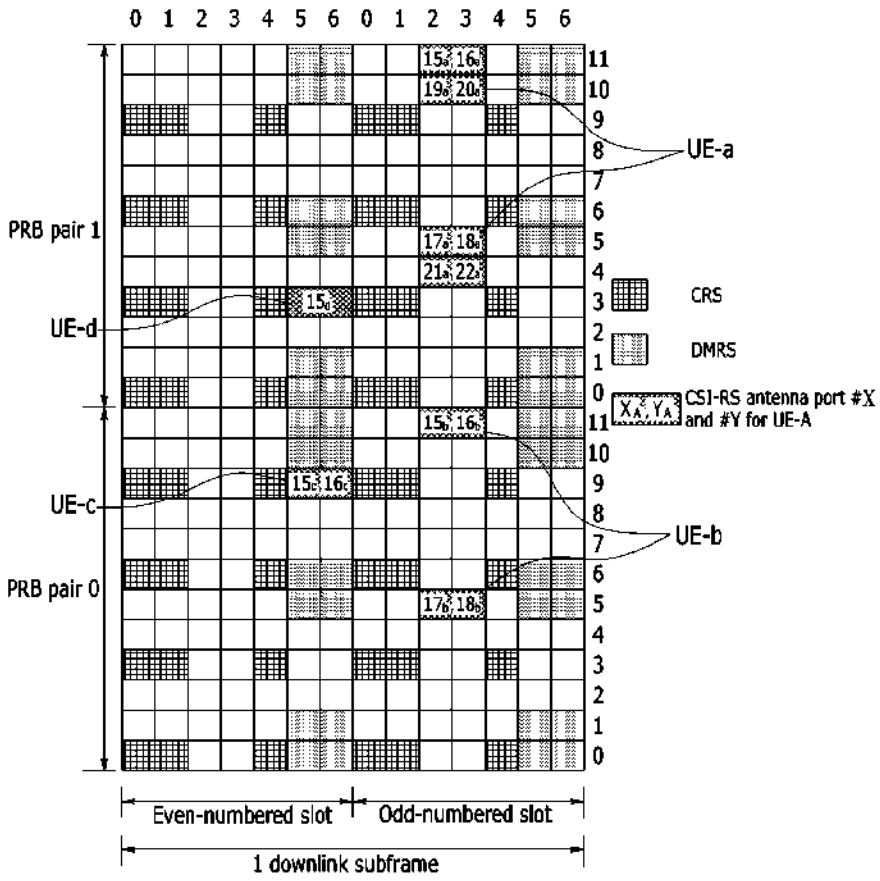
[도7]


CRS
DMRS
CSI-RS antenna port #X and #Y for TP 1
CSI-RS antenna port #X and #Y for TP 2 and PDSCH from TP 1
CSI-RS antenna port #X and #Y for TP 3 and PDSCH from TP 1
PDCCH RE
PDSCH RE
X,Y
PDCCH region
PDSCH region
15,16
17,18
Even-numbered slot
Odd-numbered slot
1 downlink subframe
12 REs

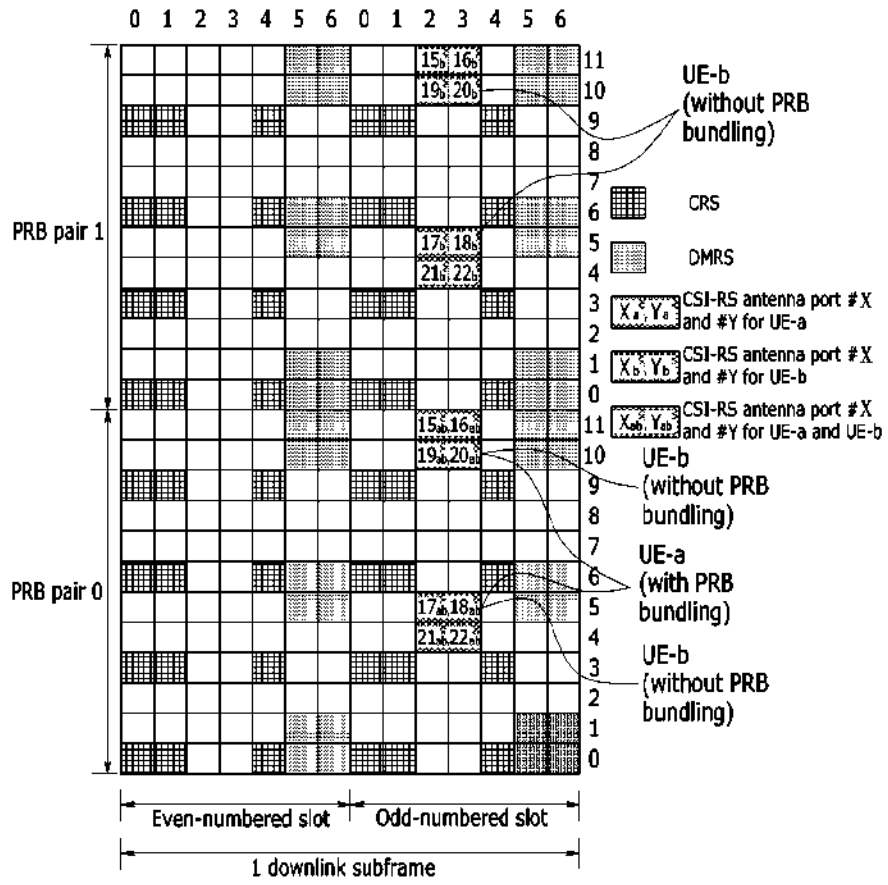
[도8]


CRS
DMRS
CSI-RS antenna port #X and #Y for TP 1
CSI-RS antenna port #X and #Y for TP 2
CSI-RS antenna port #X and #Y for TP 3
X,Y
15,16
17,18
12 REs
Even-numbered slot
Odd-numbered slot
Downlink subframe n
Downlink subframe n+1

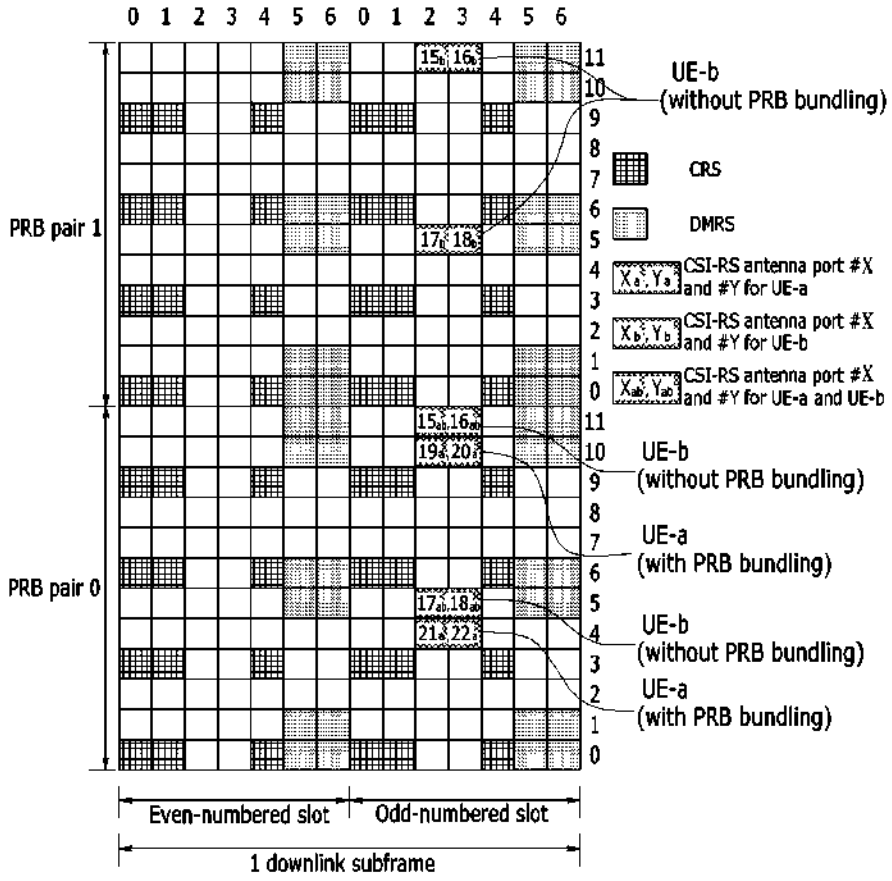
[도9]


0 1 2 3 4 5 6 0 1 2 3 4 5 6
PRB pair 1
PRB pair 0
UE-a
UE-b
UE-c
UE-d
CRS
DMRS
CSI-RS antenna port #X and #Y for UE-A
Even-numbered slot
Odd-numbered slot
1 downlink subframe

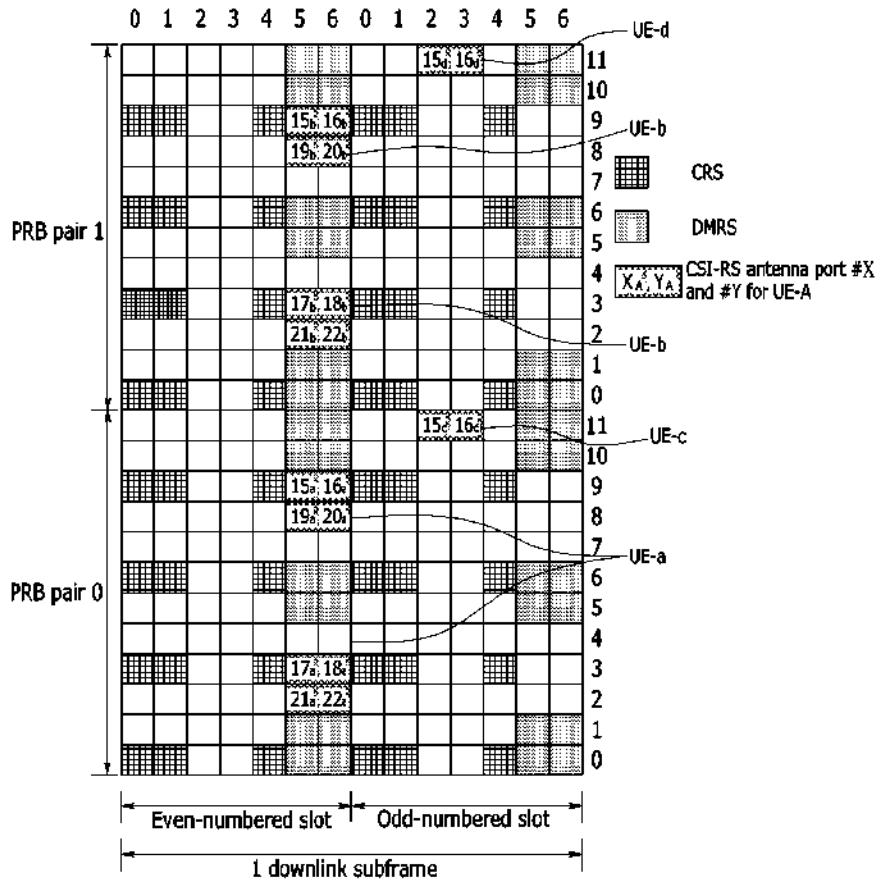
[도10a]


0 1 2 3 4 5 6 0 1 2 3 4 5 6
PRB pair 1
PRB pair 0
UE-b (without PRB bundling)
CRS
DMRS
CSI-RS antenna port #X and #Y for UE-a
CSI-RS antenna port #X and #Y for UE-b
CSI-RS antenna port #X and #Y for UE-a and UE-b
UE-b (without PRB bundling)
UE-a (with PRB bundling)
UE-b (without PRB bundling)
Even-numbered slot
Odd-numbered slot
1 downlink subframe

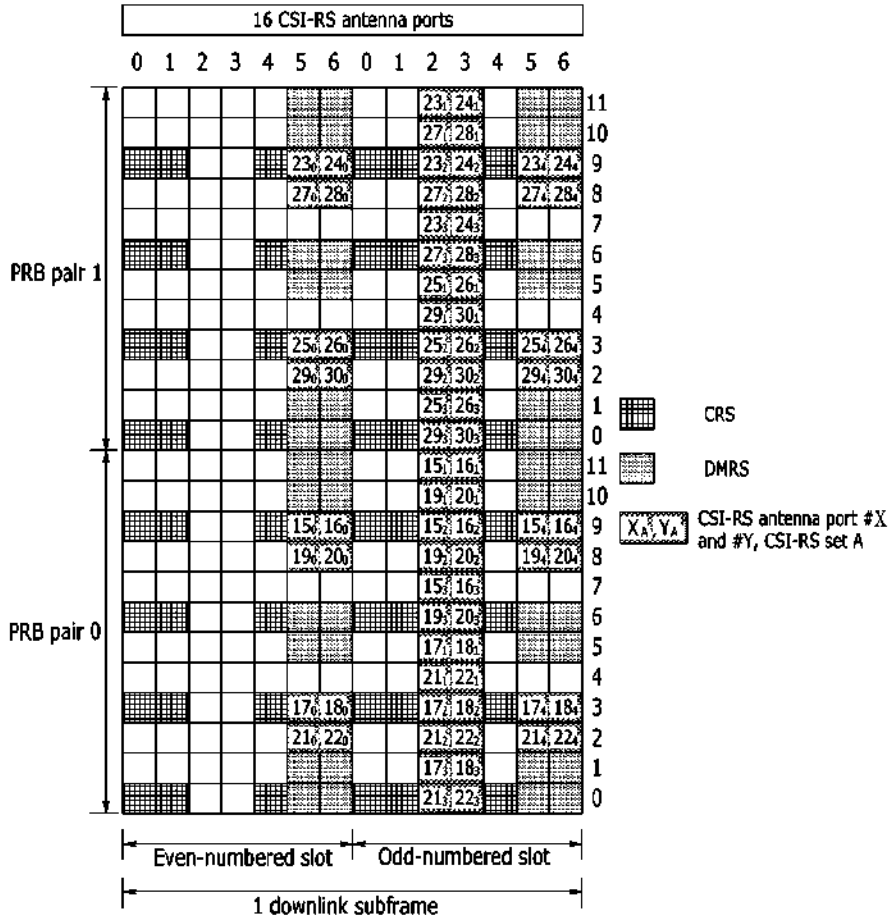
[도10b]


0 1 2 3 4 5 6 0 1 2 3 4 5 6
PRB pair 1
PRB pair 0
UE-b (without PRB bundling)
CRS
DMRS
CSI-RS antenna port #X and #Y for UE-a
CSI-RS antenna port #X and #Y for UE-b
CSI-RS antenna port #X and #Y for UE-a and UE-b
UE-b (without PRB bundling)
UE-a (with PRB bundling)
UE-b (without PRB bundling)
UE-a (with PRB bundling)
Even-numbered slot
Odd-numbered slot
1 downlink subframe

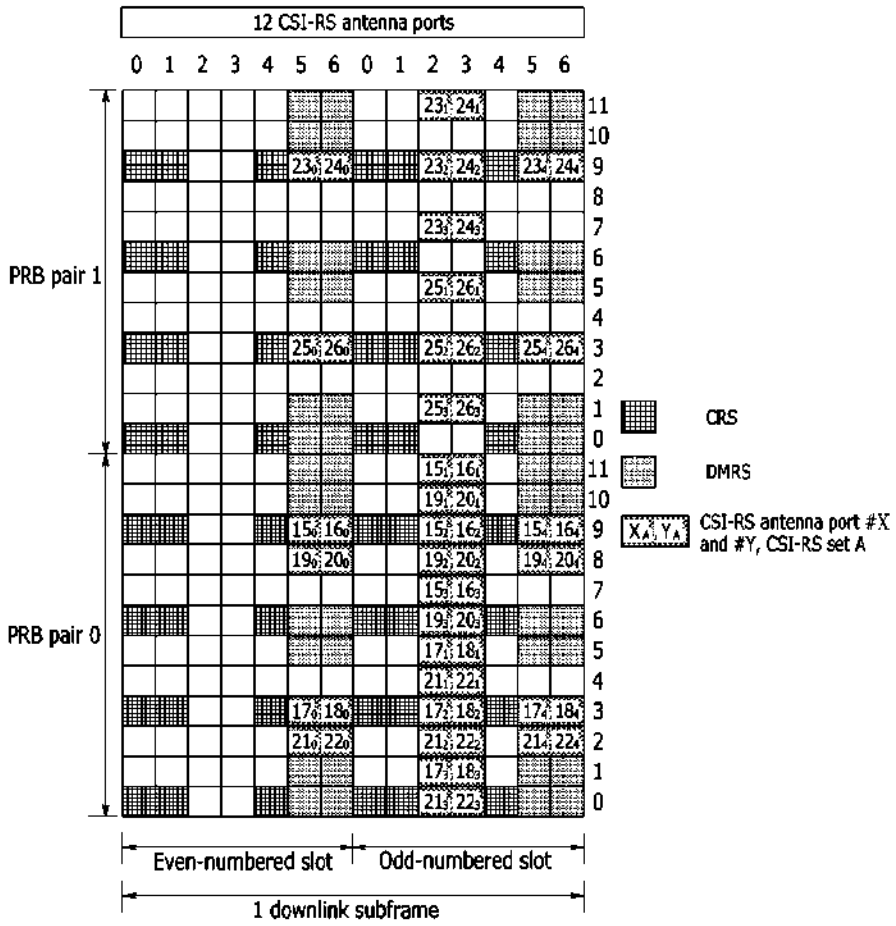
[도11]


0 1 2 3 4 5 6 0 1 2 3 4 5 6
UE-d
UE-b
UE-b
UE-c
UE-a
CRS
DMRS
CSI-RS antenna port #X and #Y for UE-A
PRB pair 1
PRB pair 0
Even-numbered slot
Odd-numbered slot
1 downlink subframe

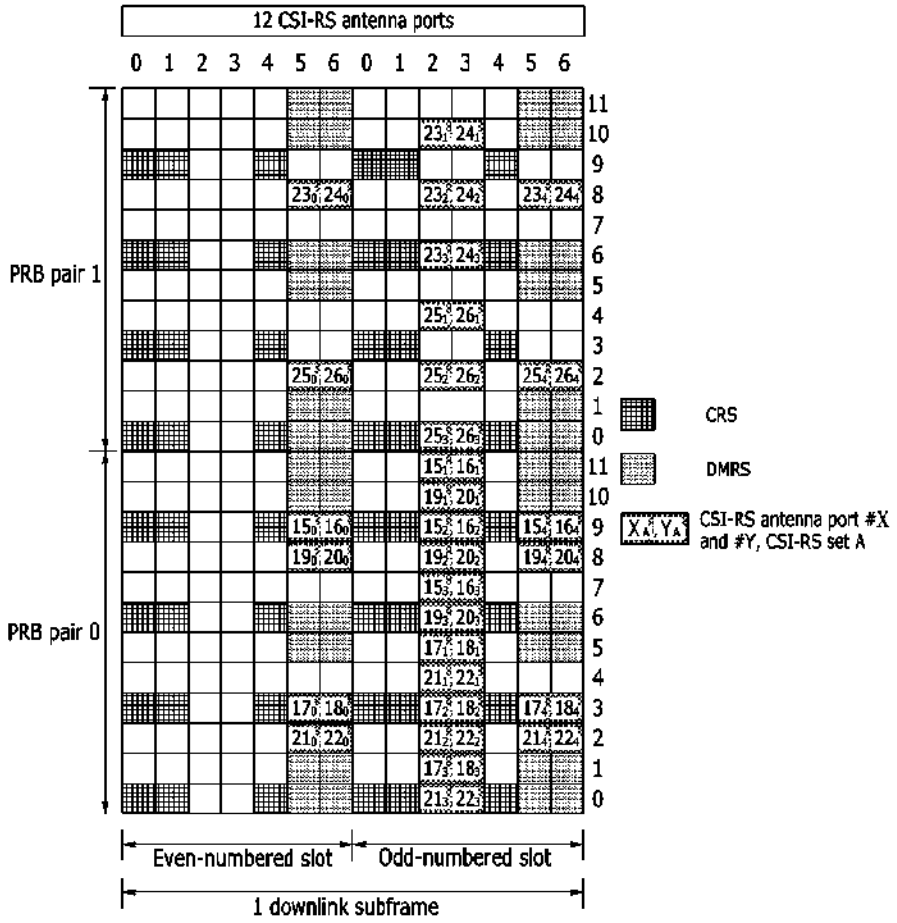
[도12]


16 CSI-RS antenna ports
0 1 2 3 4 5 6 0 1 2 3 4 5 6
PRB pair 1
PRB pair 0
CRS
DMRS
CSI-RS antenna port #X and #Y, CSI-RS set A
Even-numbered slot
Odd-numbered slot
1 downlink subframe

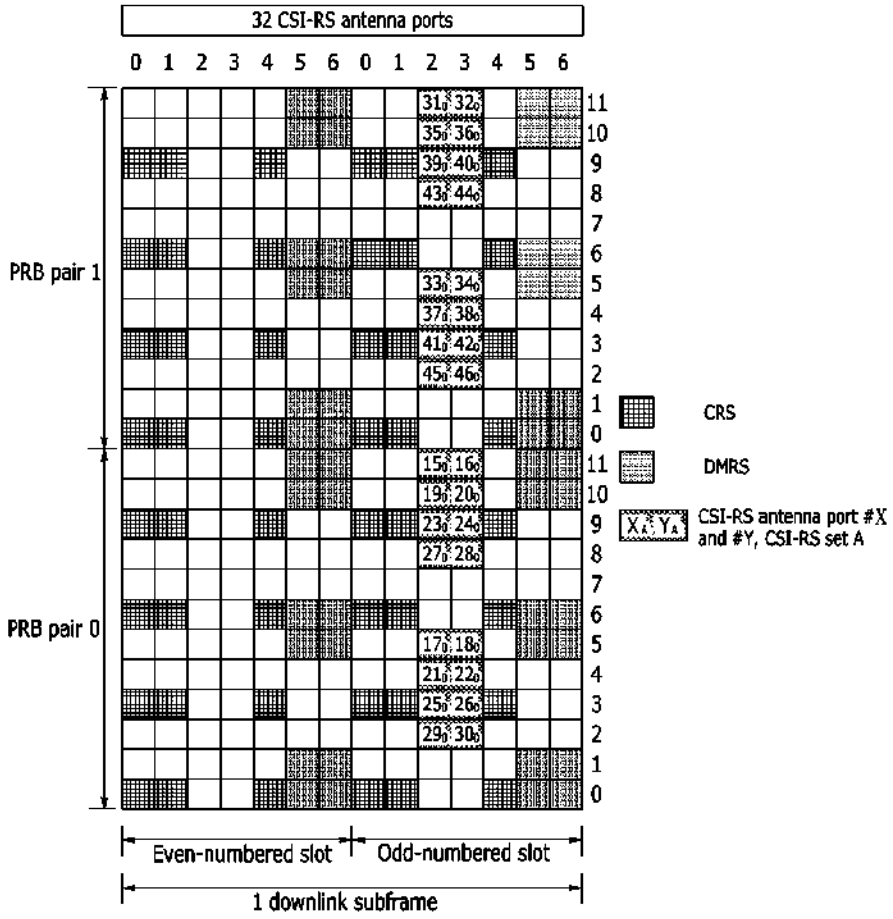
[도13a]


12 CSI-RS antenna ports
0 1 2 3 4 5 6 0 1 2 3 4 5 6
PRB pair 1
PRB pair 0
11 10 9 8 7 6 5 4 3 2 1 0 11 10 9 8 7 6 5 4 3 2 1 0
CRS
DMRS
CSI-RS antenna port #X and #Y, CSI-RS set A
Even-numbered slot
Odd-numbered slot
1 downlink subframe

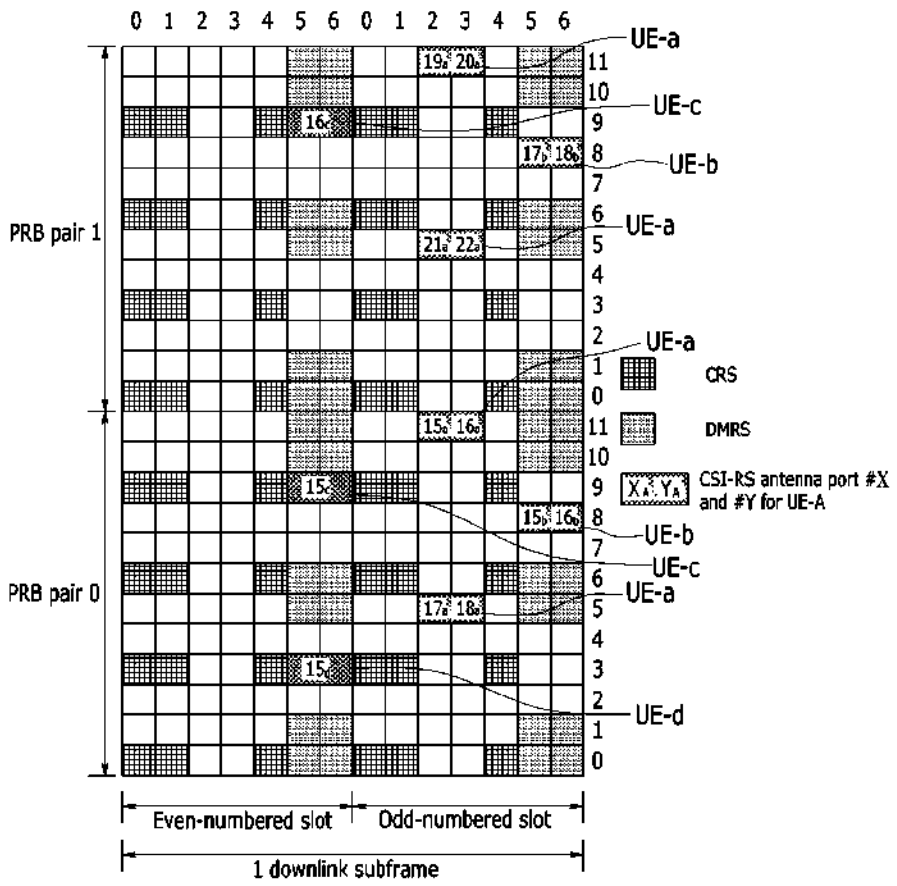
[도13b]


12 CSI-RS antenna ports
0 1 2 3 4 5 6 0 1 2 3 4 5 6
PRB pair 1
PRB pair 0
11 10 9 8 7 6 5 4 3 2 1 0
11 10 9 8 7 6 5 4 3 2 1 0
CRS
DMRS
CSI-RS antenna port #X and #Y, CSI-RS set A
Even-numbered slot
Odd-numbered slot
1 downlink subframe

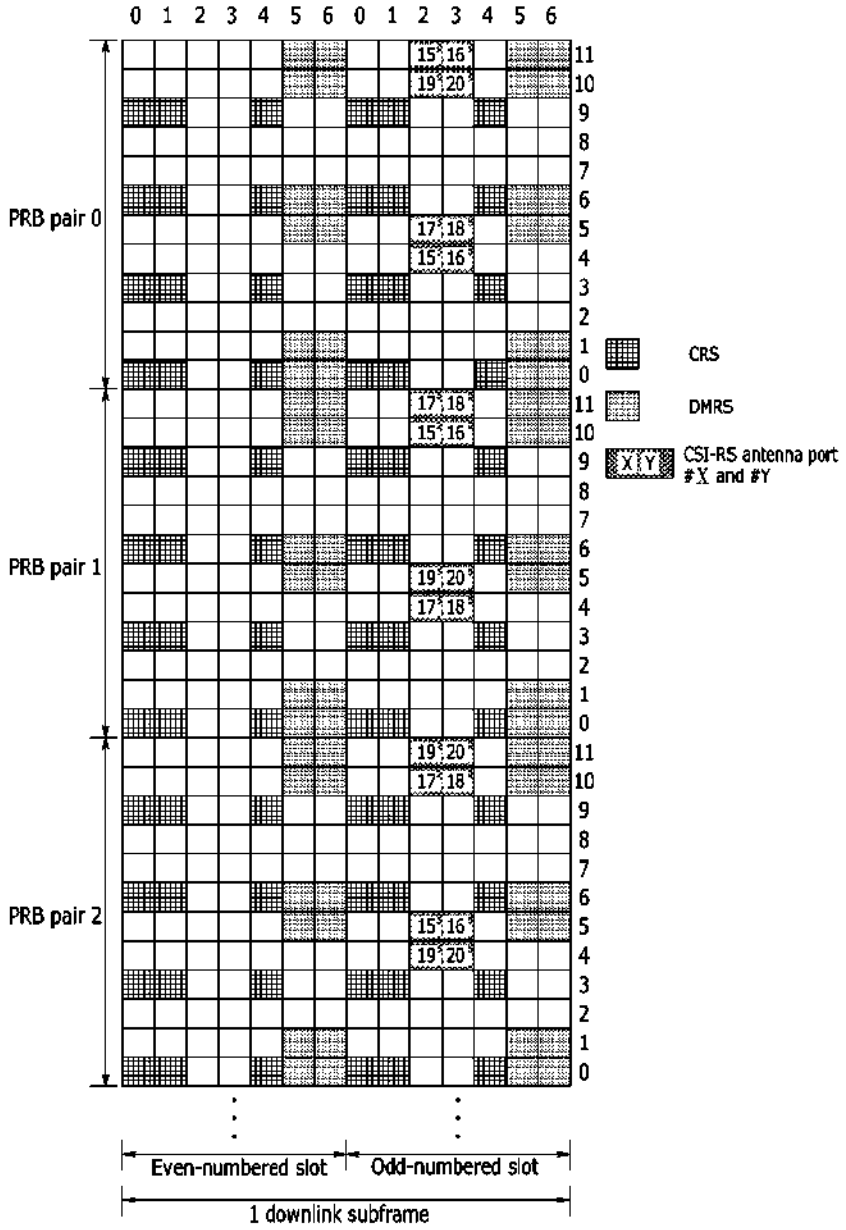
[도14]


32 CSI-RS antenna ports
0 1 2 3 4 5 6 0 1 2 3 4 5 6
PRB pair 1
PRB pair 0
Even-numbered slot
Odd-numbered slot
1 downlink subframe
CRS
DMRS
CSI-RS antenna port #X and #Y, CSI-RS set A

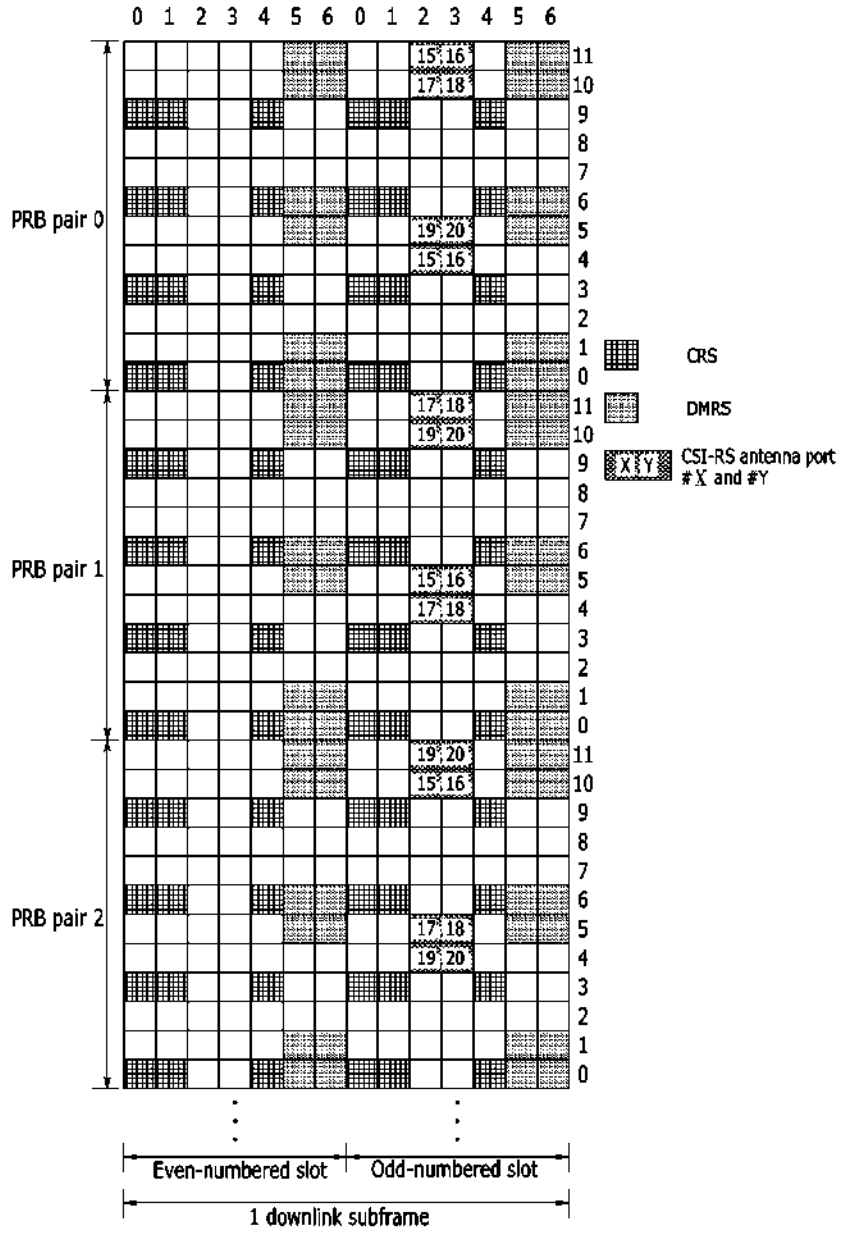
[도15]


0 1 2 3 4 5 6 0 1 2 3 4 5 6
UE-a
UE-c
UE-b
UE-a
UE-a
UE-b
UE-c
UE-a
UE-d
PRB pair 1
PRB pair 0
CRS
DMRS
CSI-RS antenna port #X and #Y for UE-A
Even-numbered slot
Odd-numbered slot
1 downlink subframe

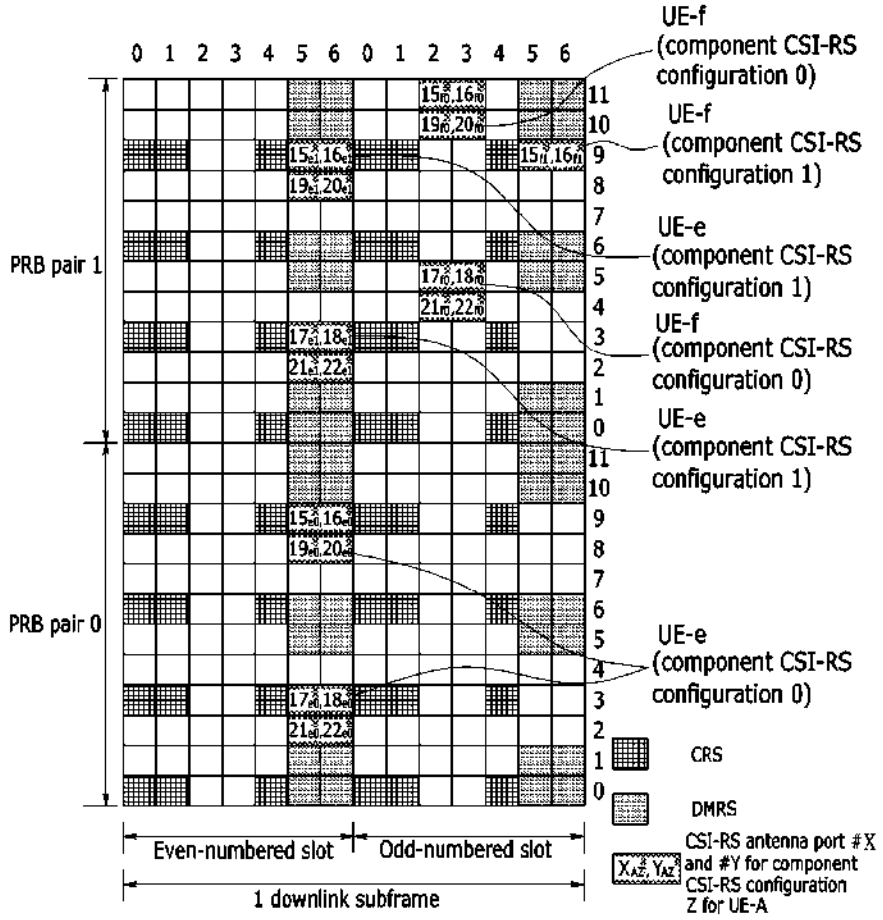
[도16a]


0 1 2 3 4 5 6 0 1 2 3 4 5 6
PRB pair 0
PRB pair 1
PRB pair 2
CRS
DMRS
CSI-RS antenna port #X and #Y
Even-numbered slot
Odd-numbered slot
1 downlink subframe

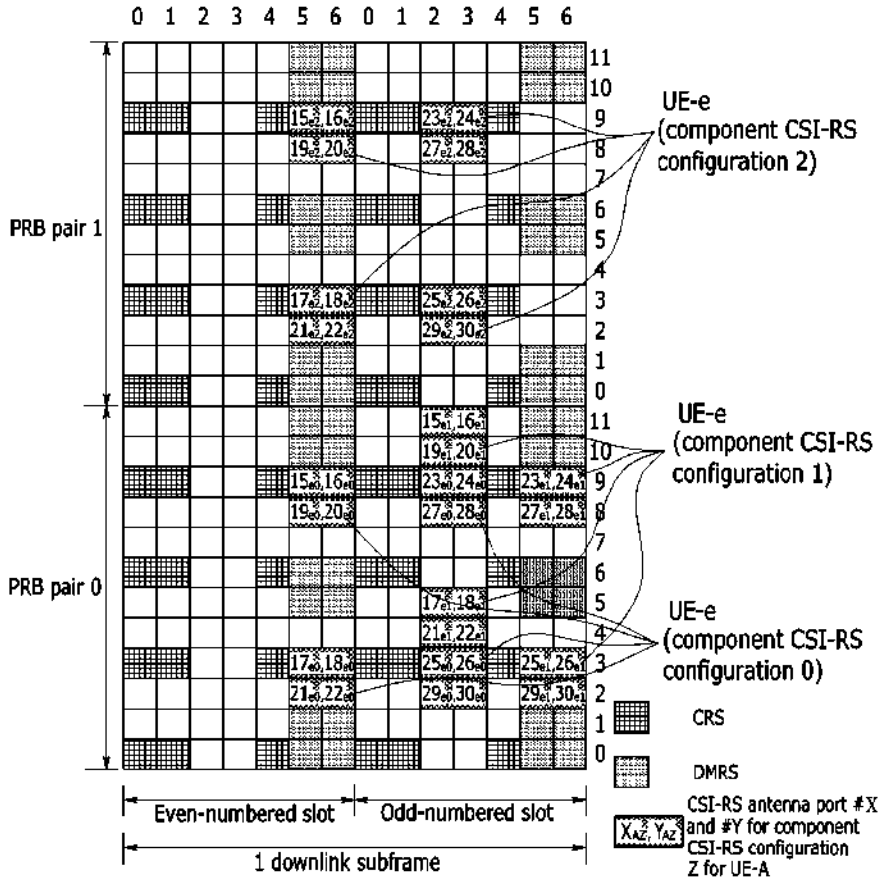
[도16b]


0 1 2 3 4 5 6 0 1 2 3 4 5 6
PRB pair 0
PRB pair 1
PRB pair 2
15 16
17 18
19 20
CRS
DMRS
X Y
CSI-RS antenna port #X and #Y
Even-numbered slot
Odd-numbered slot
1 downlink subframe

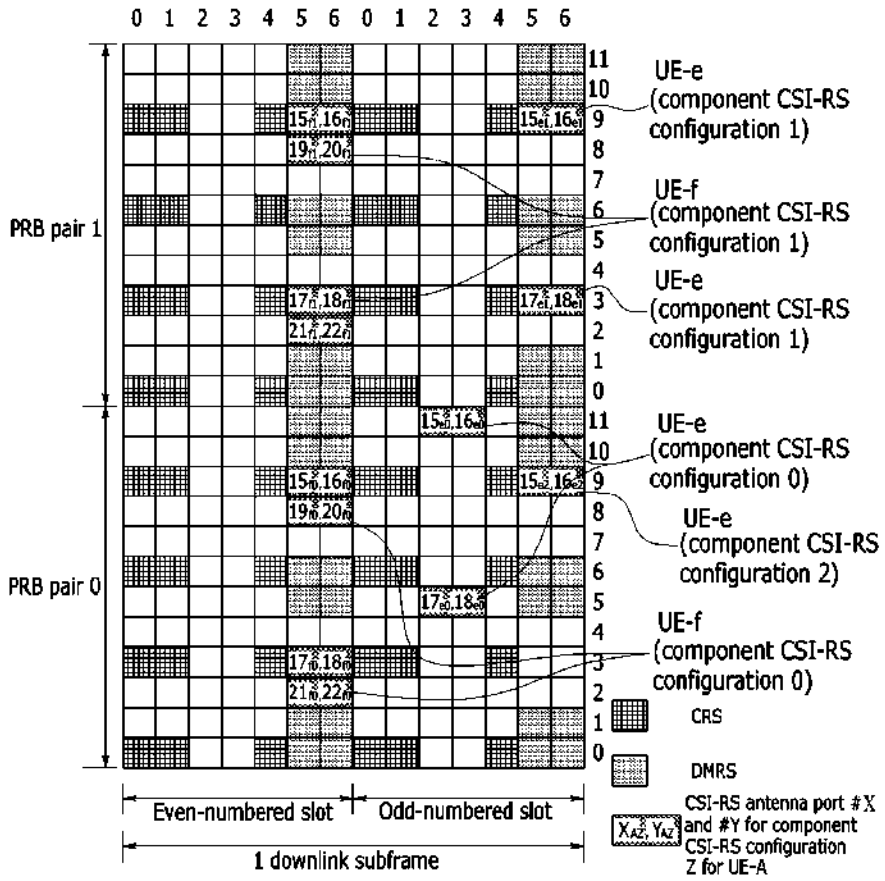
[도17]


0 1 2 3 4 5 6 0 1 2 3 4 5 6
PRB pair 1
PRB pair 0
UE-f (component CSI-RS configuration 0)
UE-f (component CSI-RS configuration 1)
UE-e (component CSI-RS configuration 1)
UE-f (component CSI-RS configuration 0)
UE-e (component CSI-RS configuration 1)
UE-e (component CSI-RS configuration 0)
CRS
DMRS
CSI-RS antenna port #X and #Y for component CSI-RS configuration Z for UE-A
Even-numbered slot
Odd-numbered slot
1 downlink subframe

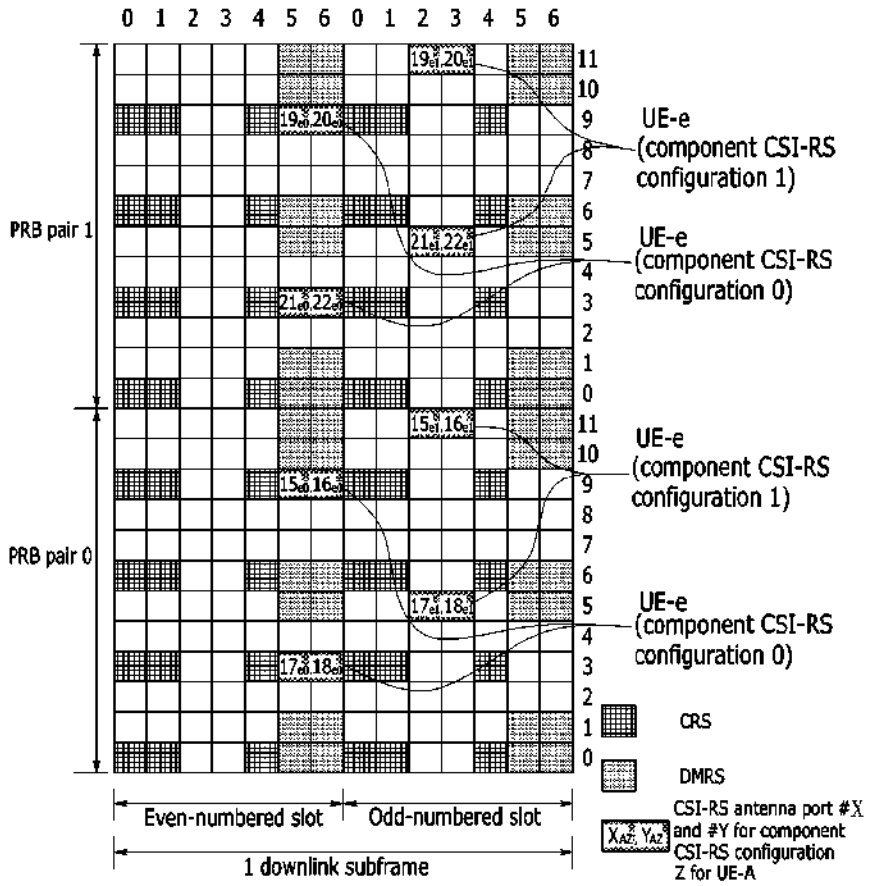
[도18]


0 1 2 3 4 5 6 0 1 2 3 4 5 6
11
10
9
8
7
6
5
4
3
2
1
0
PRB pair 1
PRB pair 0
UE-e
(component CSI-RS
configuration 2)
UE-e
(component CSI-RS
configuration 1)
UE-e
(component CSI-RS
configuration 0)
CRS
DMRS
CSI-RS antenna port #X
and #Y for component
CSI-RS configuration
Z for UE-A
Even-numbered slot
Odd-numbered slot
1 downlink subframe

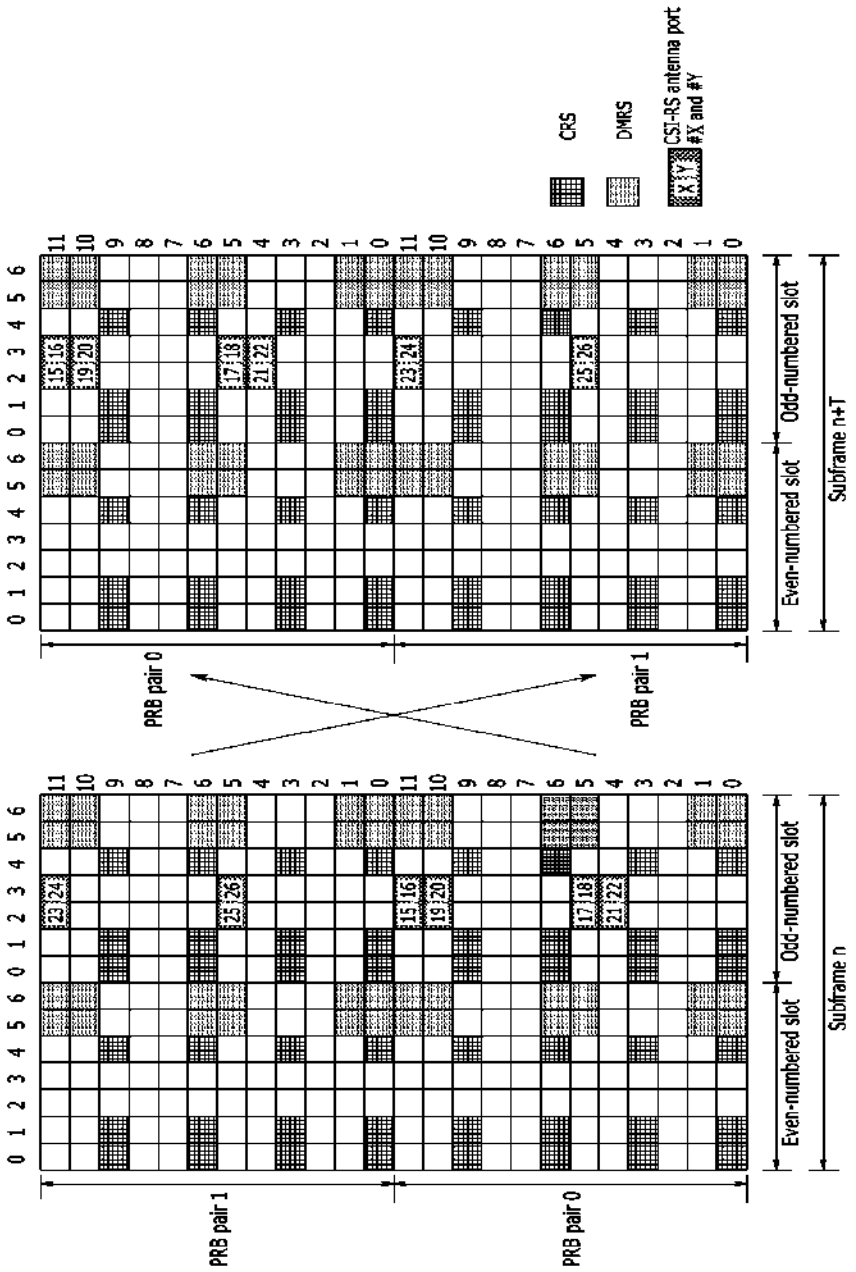
[도19]


0 1 2 3 4 5 6 0 1 2 3 4 5 6
PRB pair 1
PRB pair 0
UE-e (component CSI-RS configuration 1)
UE-f (component CSI-RS configuration 1)
UE-e (component CSI-RS configuration 1)
UE-e (component CSI-RS configuration 0)
UE-e (component CSI-RS configuration 2)
UE-f (component CSI-RS configuration 0)
CRS
DMRS
CSI-RS antenna port #X and #Y for component CSI-RS configuration Z for UE-A
Even-numbered slot
Odd-numbered slot
1 downlink subframe

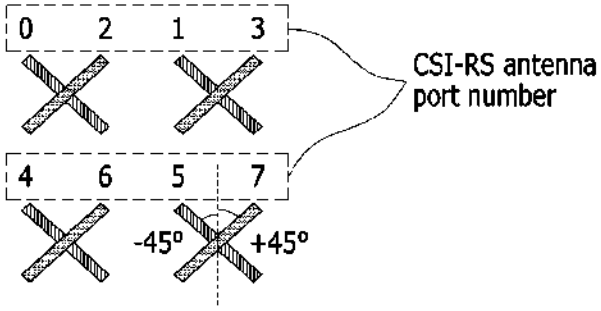
[도20]


0 1 2 3 4 5 6 0 1 2 3 4 5 6
PRB pair 1
PRB pair 0
UE-e (component CSI-RS configuration 1)
UE-e (component CSI-RS configuration 0)
UE-e (component CSI-RS configuration 1)
UE-e (component CSI-RS configuration 0)
CRS
DMRS
CSI-RS antenna port #X and #Y for component CSI-RS configuration Z for UE-A
Even-numbered slot
Odd-numbered slot
1 downlink subframe

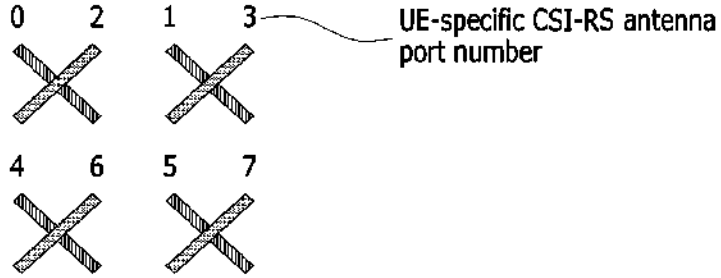
[도21]


CRS
DMRS
CSI-RS antenna port #X and #Y
PRB pair 0
PRB pair 1
PRB pair 1
PRB pair 0
Even-numbered slot
Odd-numbered slot
Subframe n+T
Even-numbered slot
Odd-numbered slot
Subframe n

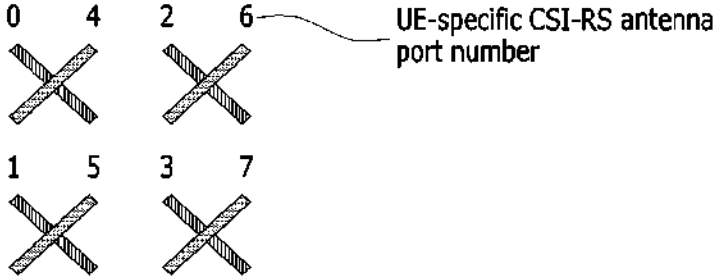
[도22]



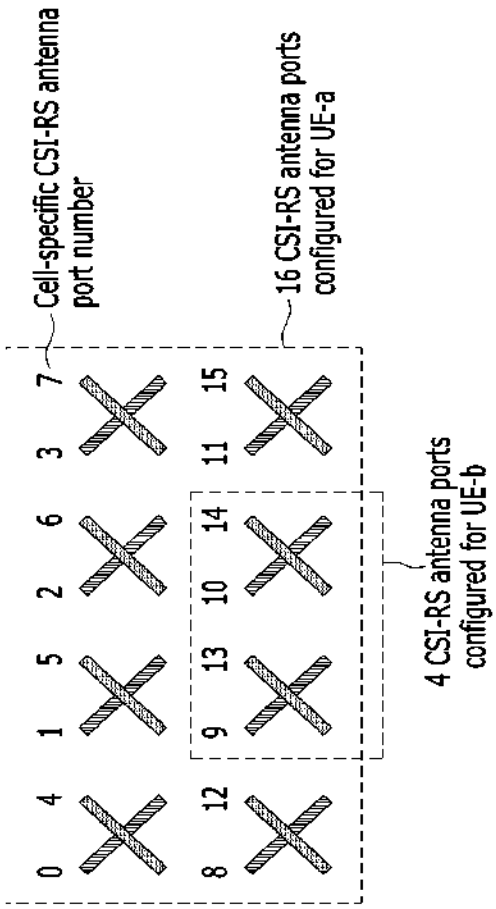
[도23a]



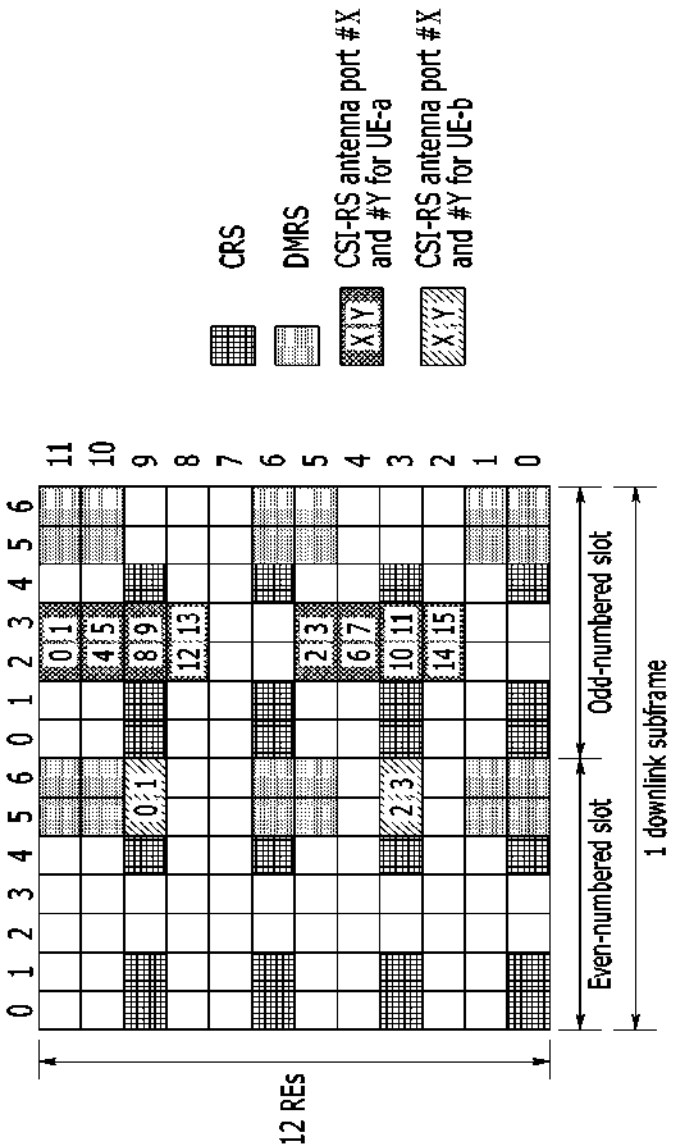
[도23b]



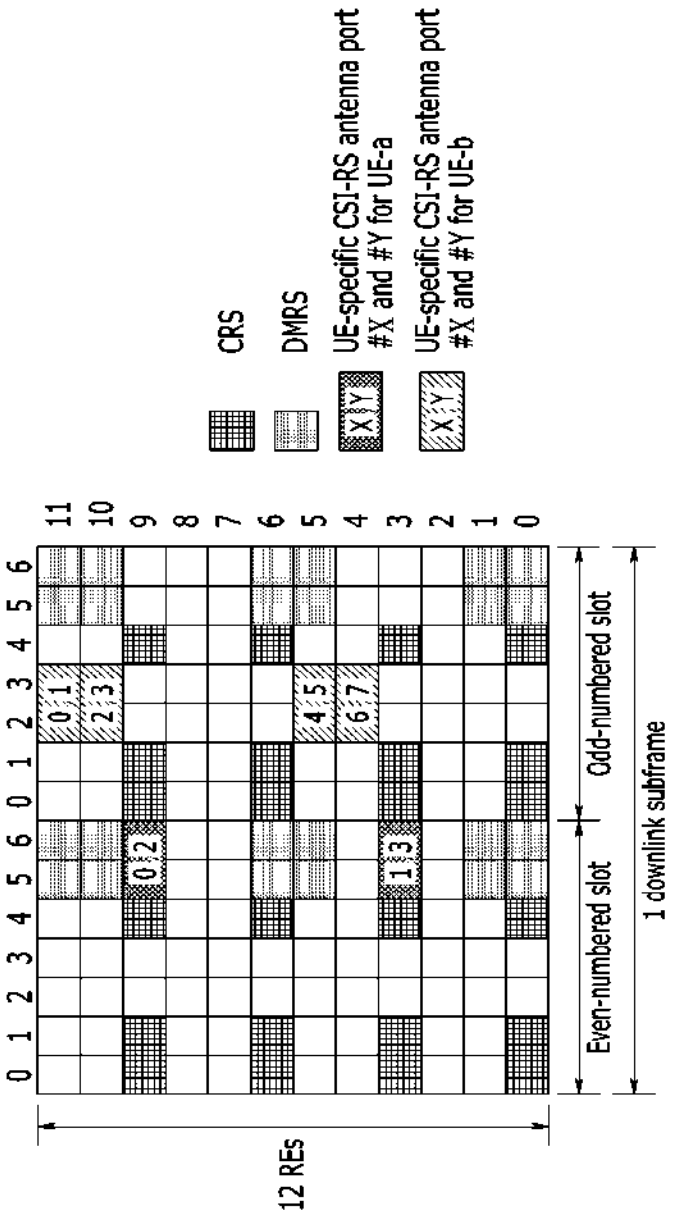
[도24]


Cell-specific CSI-RS antenna port number
16 CSI-RS antenna ports configured for UE-a
4 CSI-RS antenna ports configured for UE-b
0
4
1
5
2
6
3
7
8
12
9
13
10
14
11
15

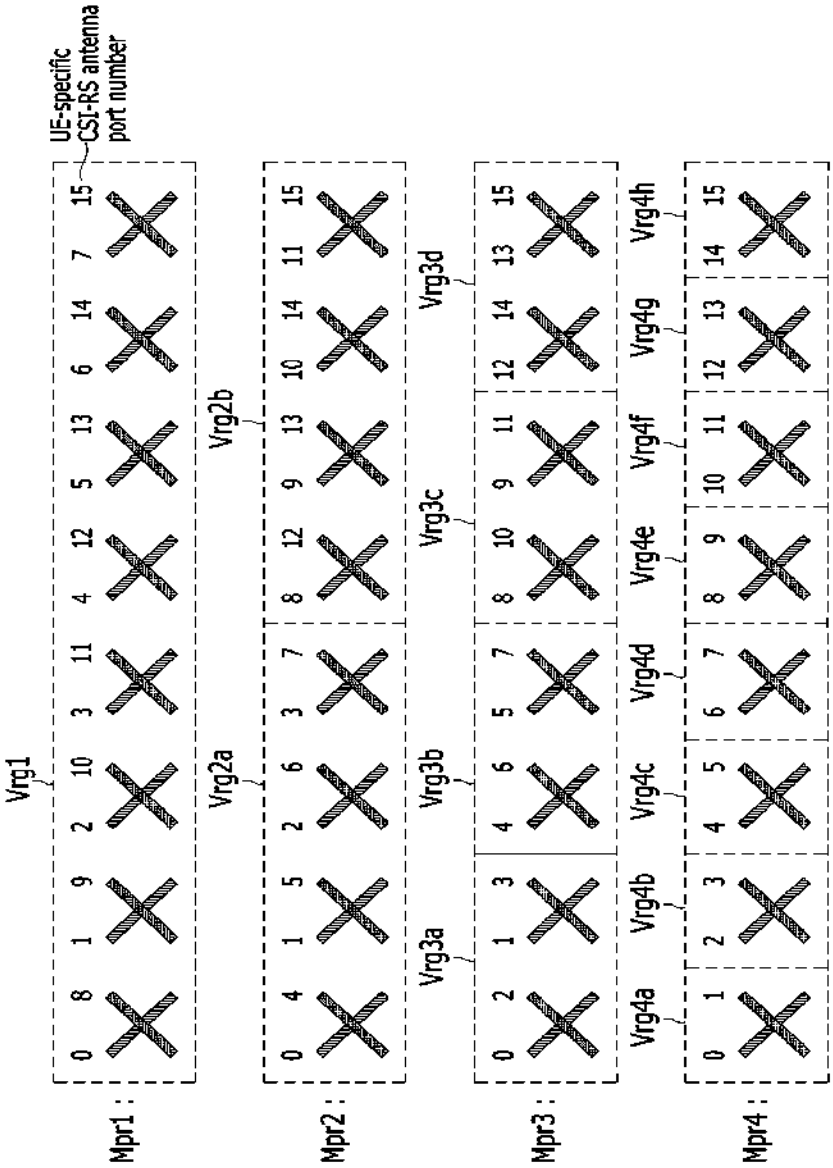
[도25a]


CRS
DMRS
CSI-RS antenna port #X and #Y for UE-a
CSI-RS antenna port #X and #Y for UE-b
X,Y
11 10 9 8 7 6 5 4 3 2 1 0
0 1 2 3 4 5 6
0 1
4 5
8 9
12 13
2 3
6 7
10 11
14 15
0 1
2 3
Odd-numbered slot
Even-numbered slot
1 downlink subframe
12 REs

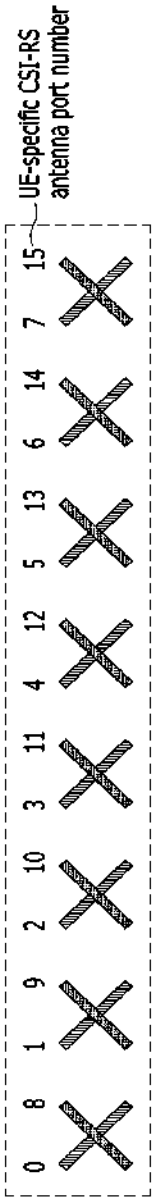
[도25b]


CRS
DMRS
UE-specific CSI-RS antenna port #X and #Y for UE-a
UE-specific CSI-RS antenna port #X and #Y for UE-b
Even-numbered slot
Odd-numbered slot
1 downlink subframe
12 REs

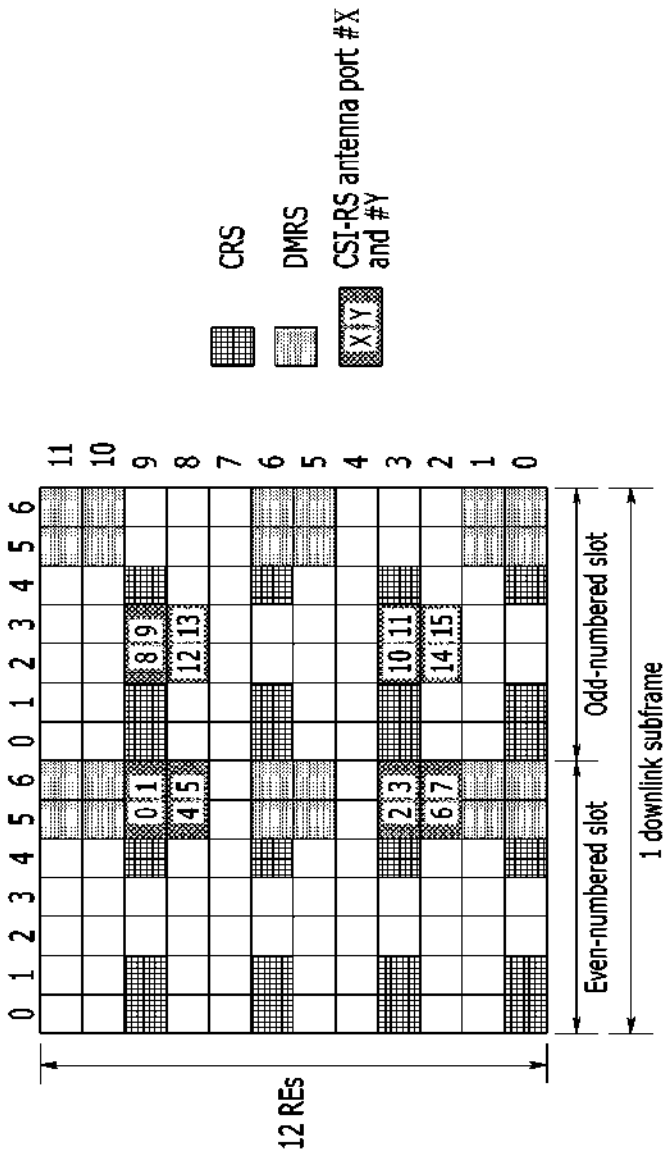
[도26a]


UE-specific CSI-RS antenna port number
Vrg1
Vrg2a
Vrg2b
Vrg3a
Vrg3b
Vrg3c
Vrg3d
Vrg4a
Vrg4b
Vrg4c
Vrg4d
Vrg4e
Vrg4f
Vrg4g
Vrg4h
Mpr1 :
Mpr2 :
Mpr3 :
Mpr4 :

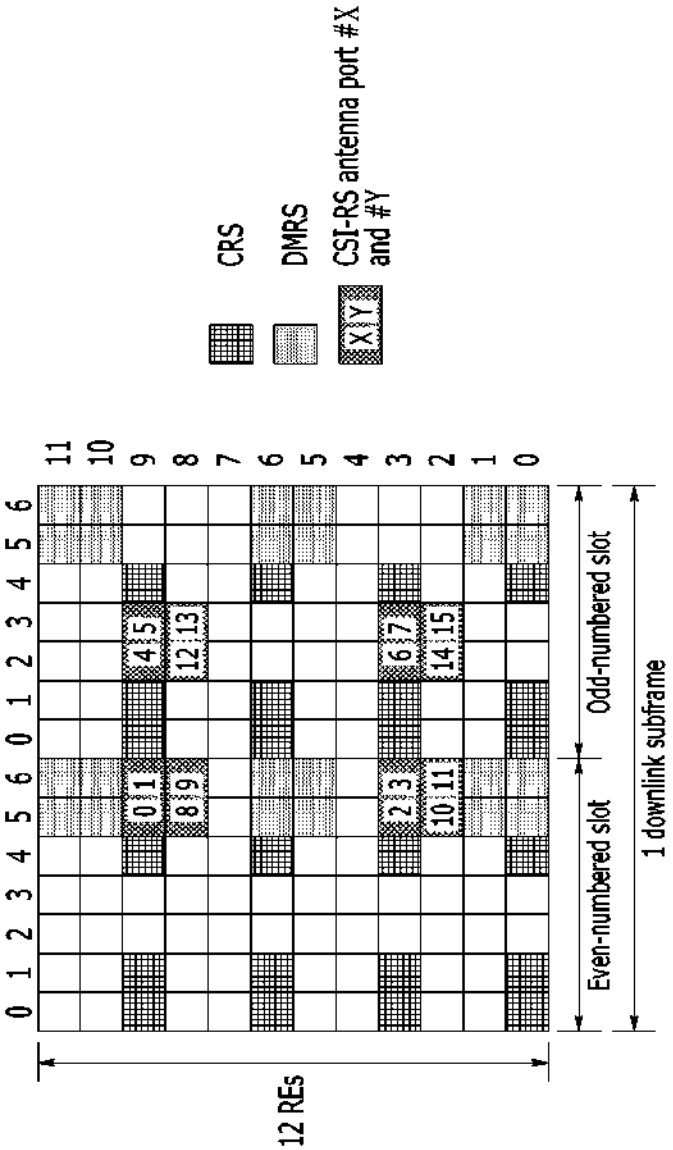
[도26b]


UE-specific CSI-RS antenna port number
15
7
14
6
13
5
12
4
11
3
10
2
9
1
8
0

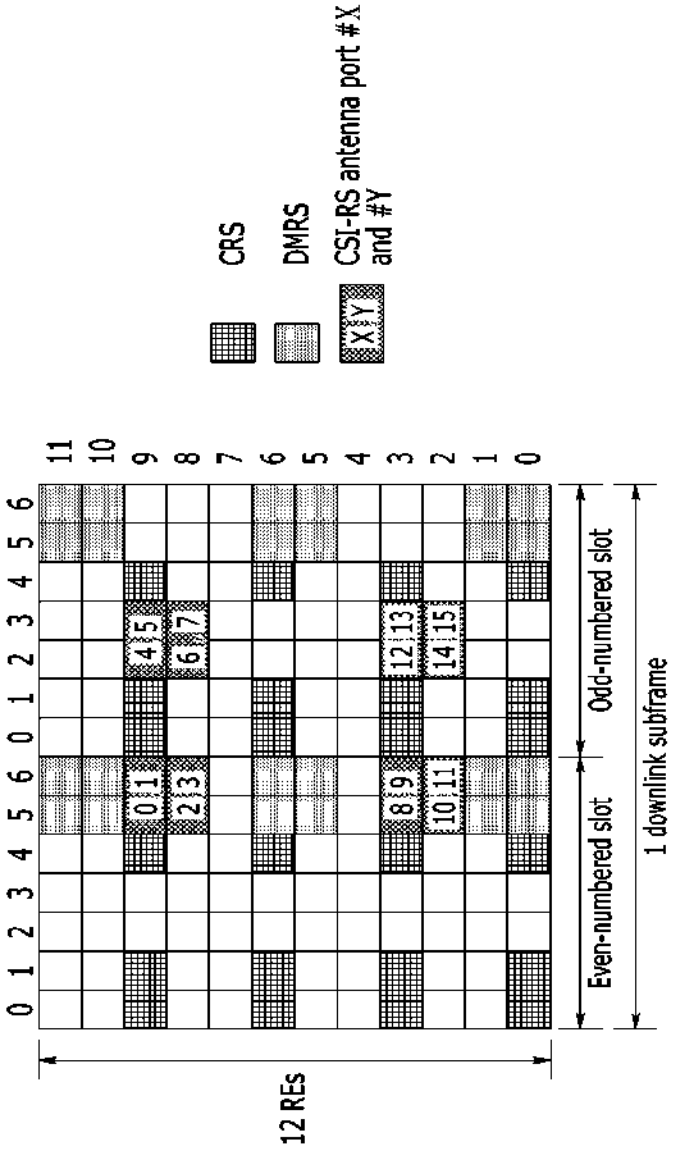
[도26c]


CRS
DMRS
CSI-RS antenna port #X and #Y
X Y
0 1 2 3 4 5 6
11 10 9 8 7 6 5 4 3 2 1 0
0 1
4 5
8 9
12 13
2 3
6 7
10 11
14 15
Even-numbered slot
Odd-numbered slot
1 downlink subframe
12 REs

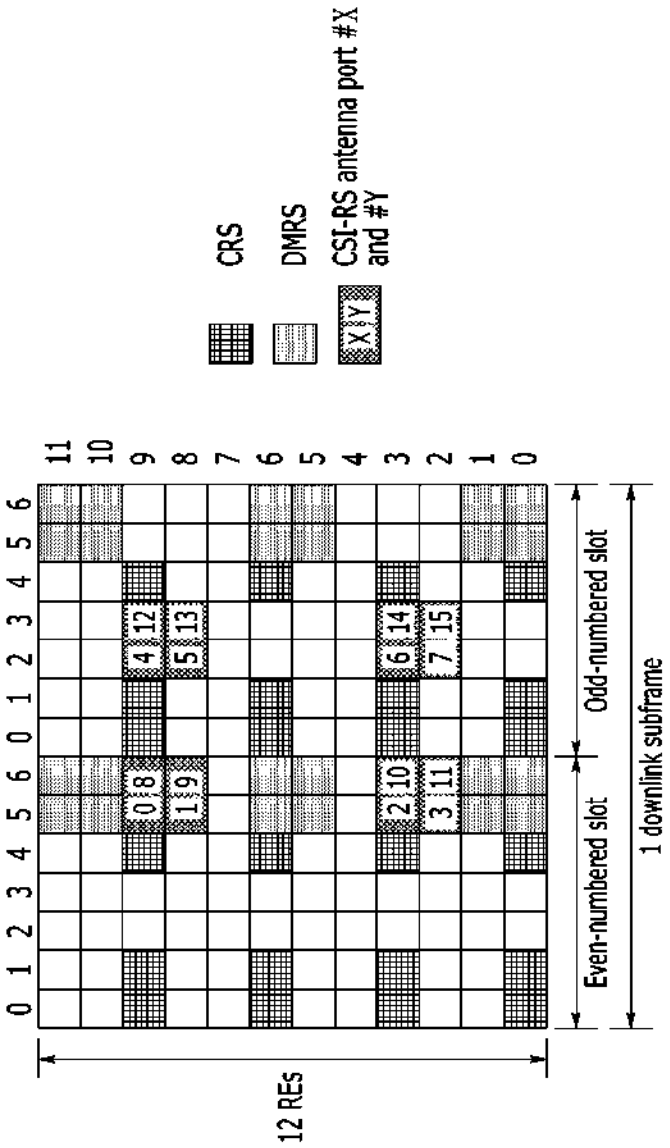
[도26d]


CRS
DMRS
CSI-RS antenna port #X and #Y
X Y
11 10 9 8 7 6 5 4 3 2 1 0
0 1 2 3 4 5 6
0 1
8 9
4 5
12 13
2 3
10 11
6 7
14 15
Even-numbered slot
Odd-numbered slot
1 downlink subframe
12 REs

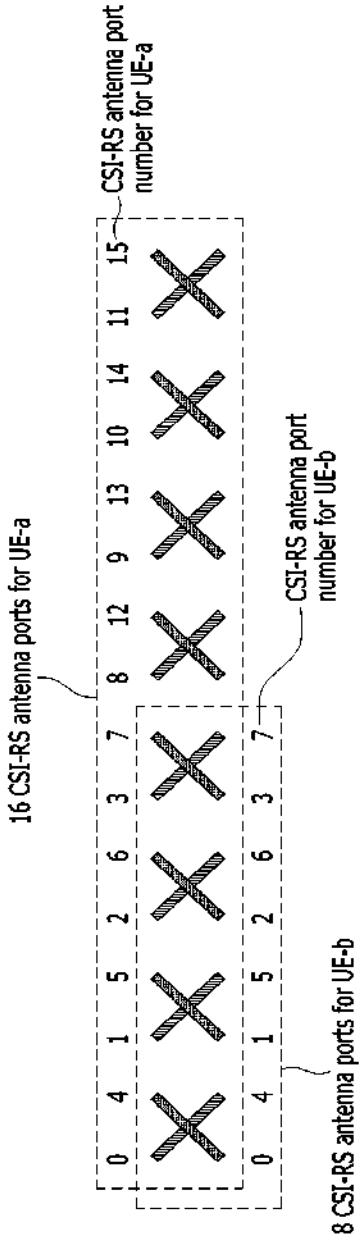
[도26c]


CRS
DMRS
CSI-RS antenna port #X and #Y
X Y
11 10 9 8 7 6 5 4 3 2 1 0
0 1 2 3 4 5 6
0 1
2 3
4 5
6 7
8 9
10 11
12 13
14 15
Odd-numbered slot
Even-numbered slot
1 downlink subframe
12 REs

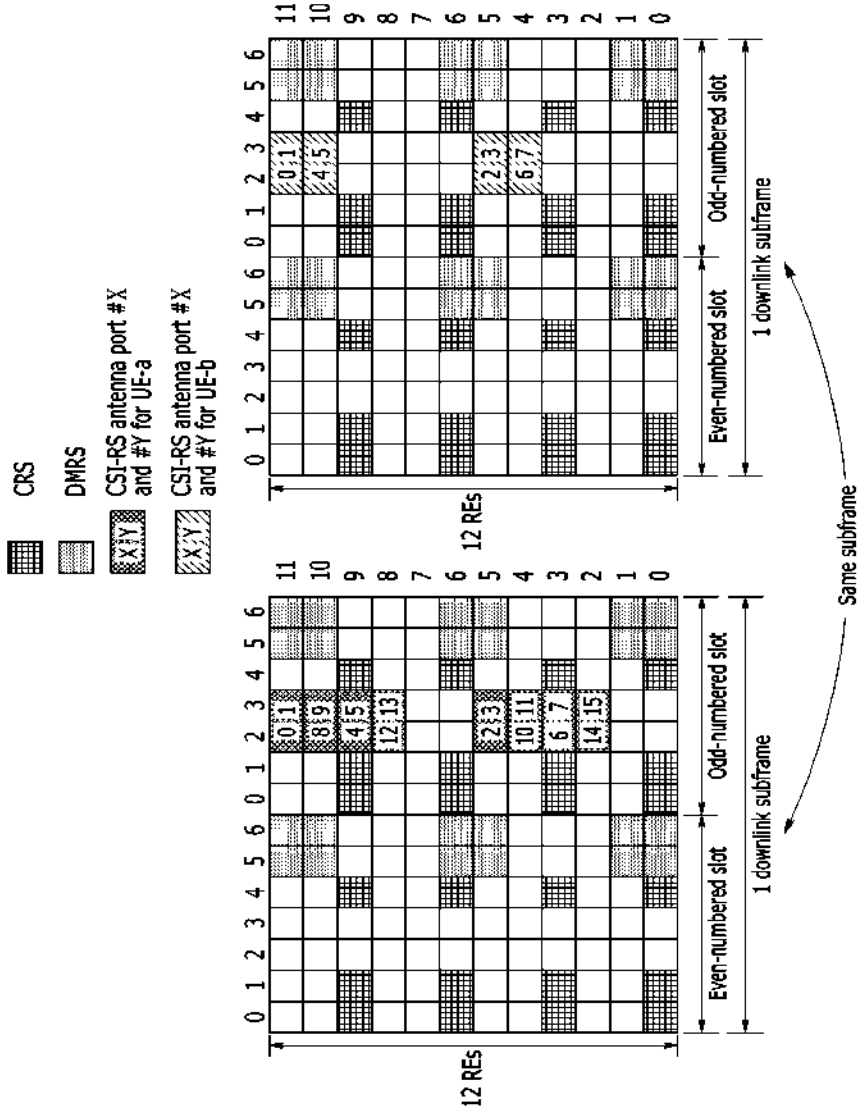
[도26f]


CRS
DMRS
CSI-RS antenna port #X and #Y
X Y
11 10 9 8 7 6 5 4 3 2 1 0
0 1 2 3 4 5 6
0 8
1 9
4 12
5 13
2 10
3 11
6 14
7 15
Odd-numbered slot
Even-numbered slot
1 downlink subframe
12 REs

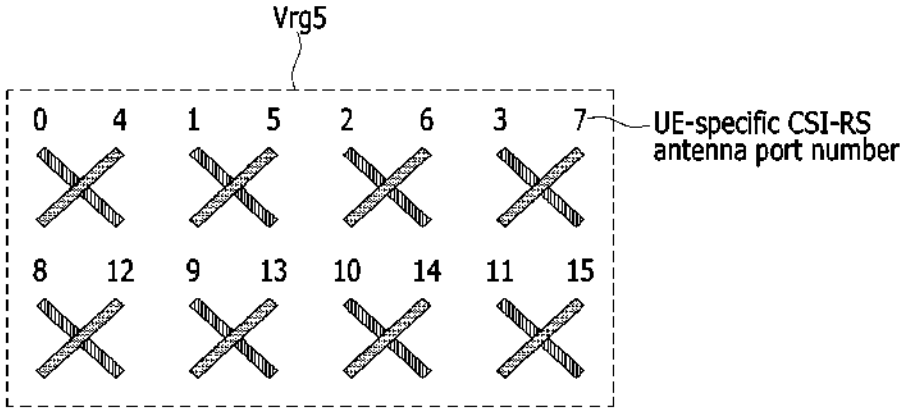
[도27]


CSI-RS antenna port number for UE-a
16 CSI-RS antenna ports for UE-a
CSI-RS antenna port number for UE-b
8 CSI-RS antenna ports for UE-b
0 4 1 5 2 6 3 7 8 12 9 13 10 14 11 15
0 4 1 5 2 6 3 7

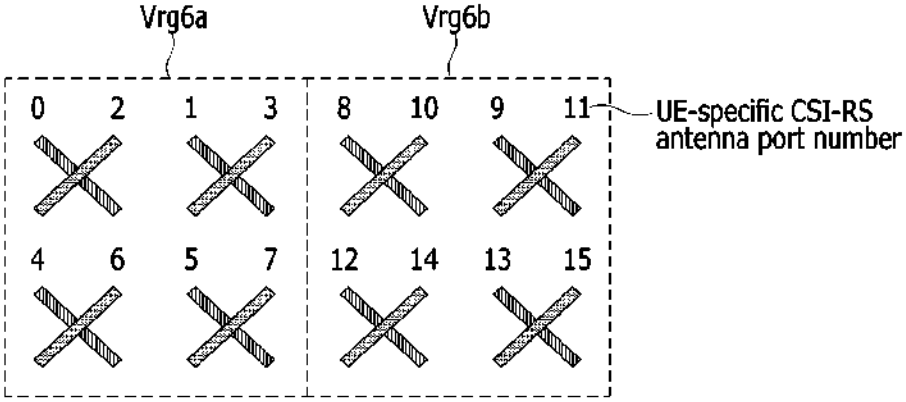
[도28]


CRS
DMRS
CSI-RS antenna port #X and #Y for UE-a
CSI-RS antenna port #X and #Y for UE-b
Odd-numbered slot
Even-numbered slot
1 downlink subframe
Same subframe
12 REs

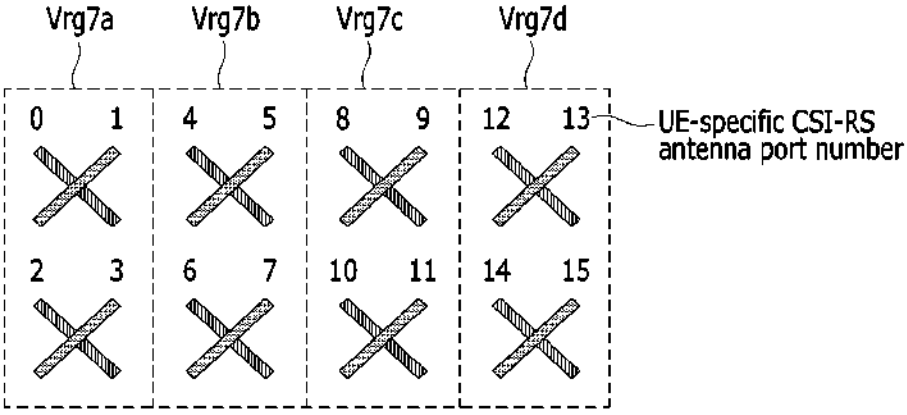
[도29a]


Vrg5
0 4 1 5 2 6 3 7
8 12 9 13 10 14 11 15
UE-specific CSI-RS antenna port number

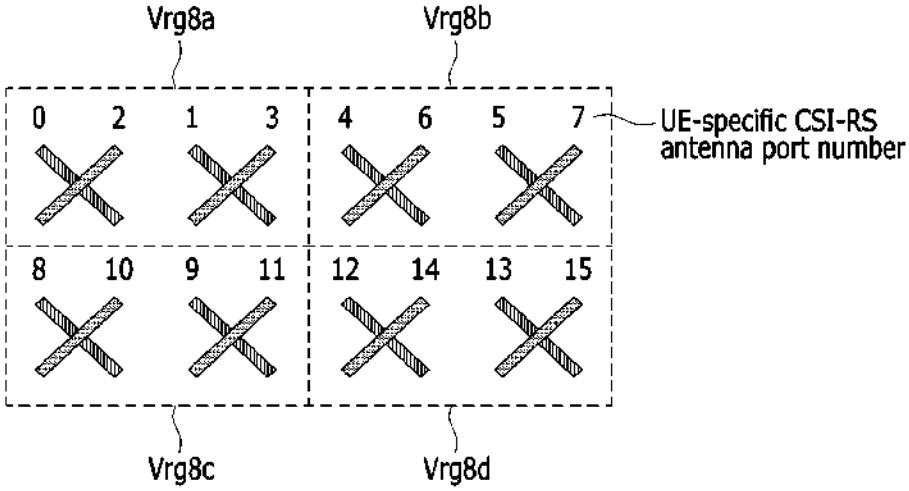
[도29b]



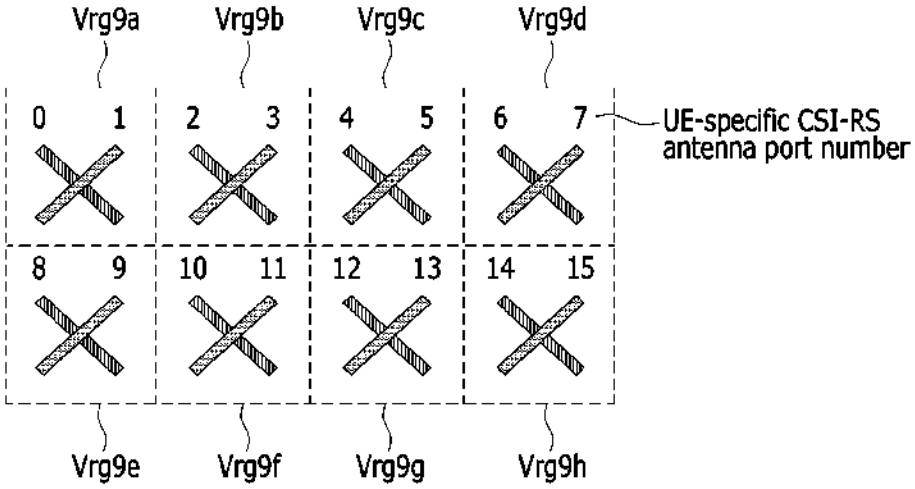
[도29c]



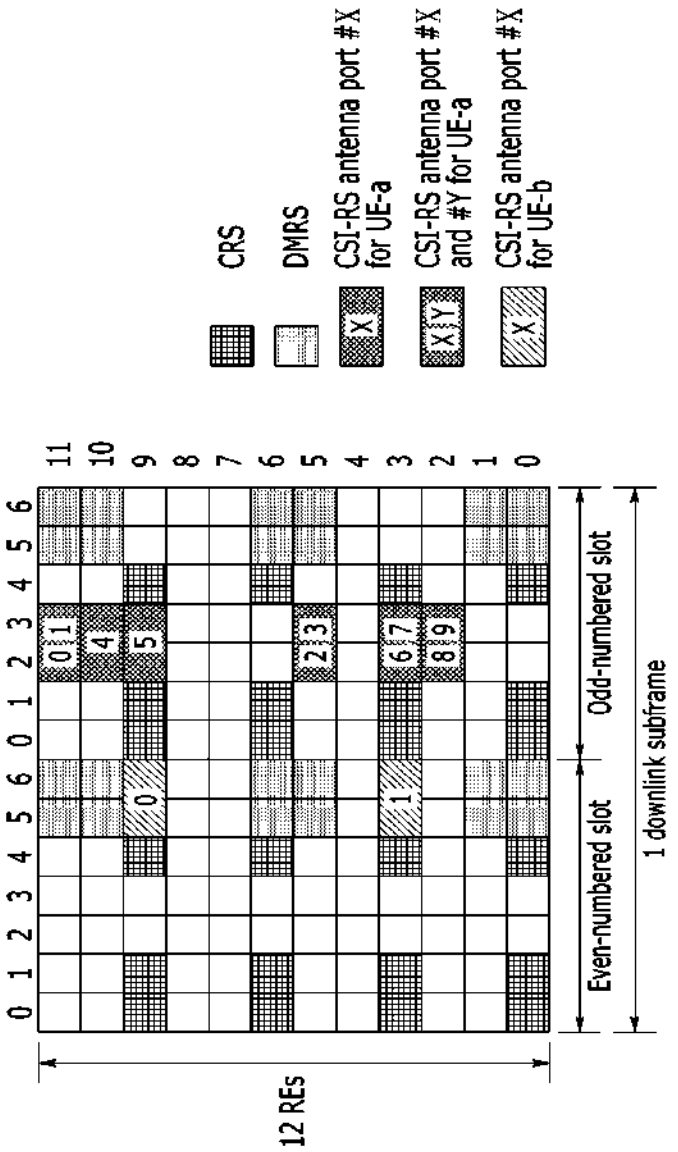
[도29d]



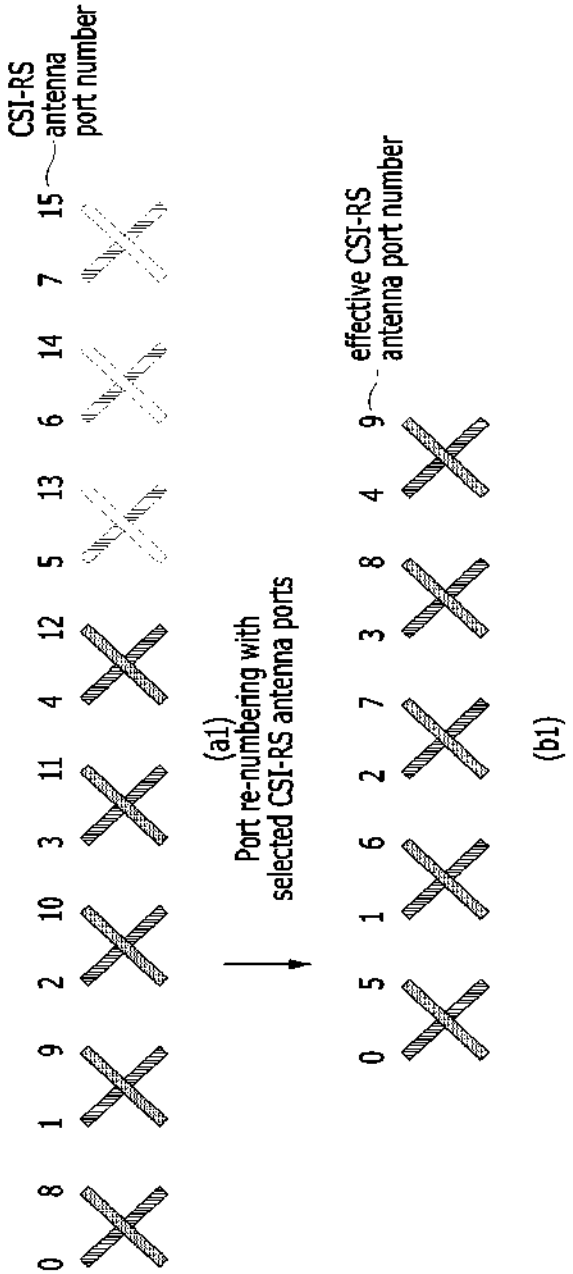
[도29c]


Vrg9a
Vrg9b
Vrg9c
Vrg9d
0 1
2 3
4 5
6 7
UE-specific CSI-RS antenna port number
8 9
10 11
12 13
14 15
Vrg9e
Vrg9f
Vrg9g
Vrg9h

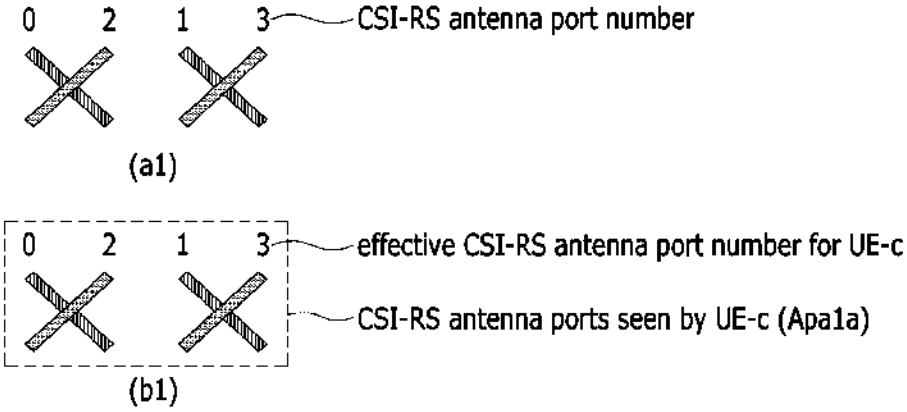
[도30]


CRS
DMRS
CSI-RS antenna port #X for UE-a
CSI-RS antenna port #X and #Y for UE-a
CSI-RS antenna port #X for UE-b
X
X Y
X
0 1 2 3 4 5 6 7 8 9 10 11
0 1 2 3 4 5 6
Even-numbered slot
Odd-numbered slot
1 downlink subframe
12 REs

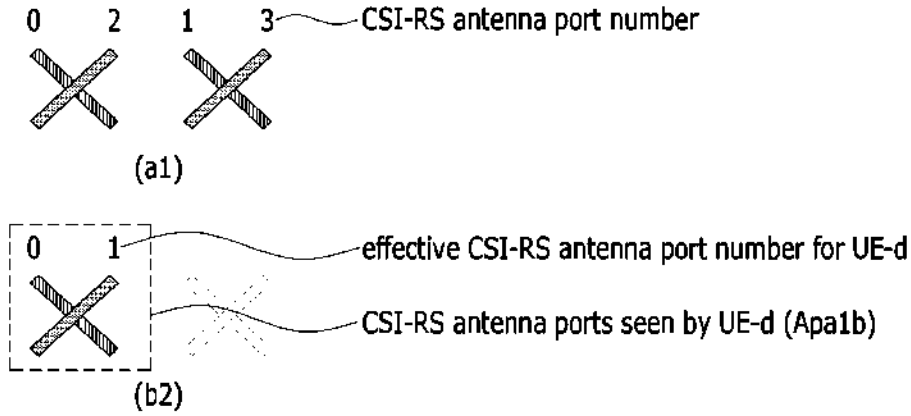
[도31]


CSI-RS antenna port number
0 8 1 9 2 10 3 11 4 12 5 13 6 14 7 15
(a1)
Port re-numbering with selected CSI-RS antenna ports
effective CSI-RS antenna port number
0 5 1 6 2 7 3 8 4 9
(b1)

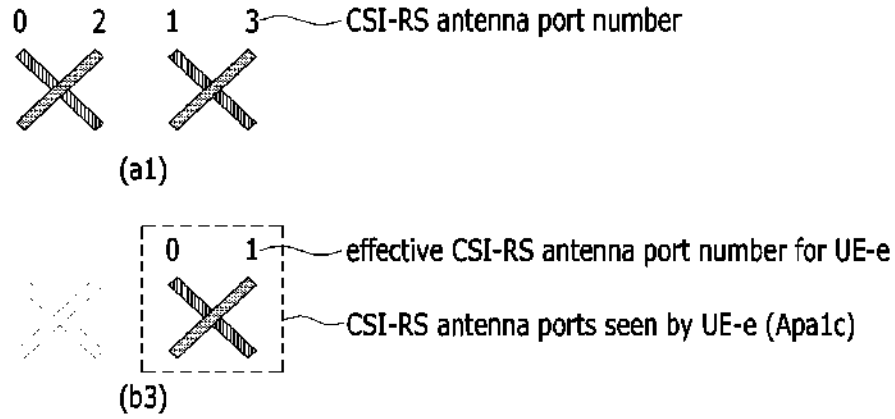
[도32a]



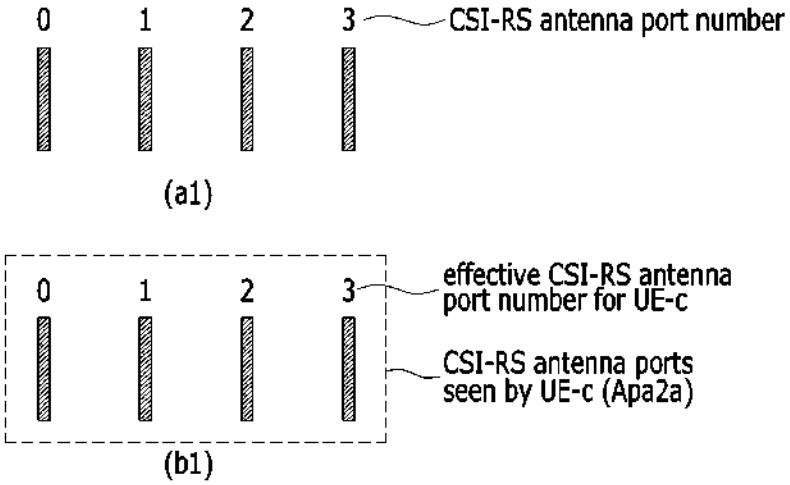
[도32b]



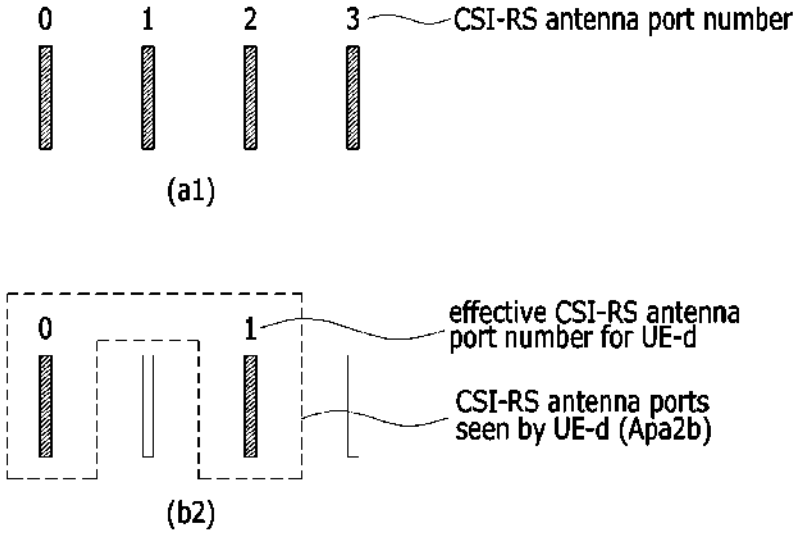
[도32c]



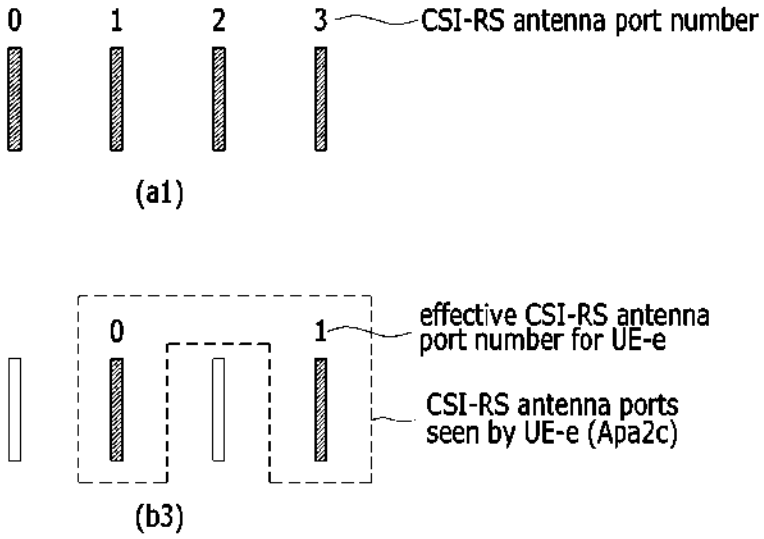
[도33a]


0
1
2
3
CSI-RS antenna port number
(a1)
0
1
2
3
effective CSI-RS antenna port number for UE-c
CSI-RS antenna ports seen by UE-c (Apa2a)
(b1)

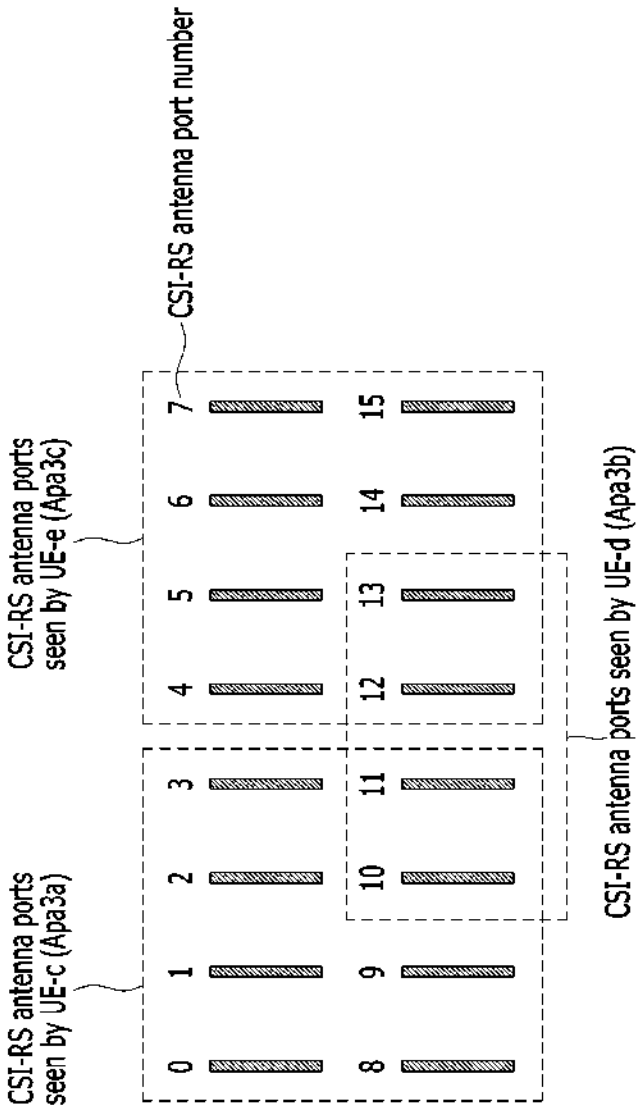
[도33b]


0
1
2
3
CSI-RS antenna port number
(a1)
0
1
effective CSI-RS antenna port number for UE-d
CSI-RS antenna ports seen by UE-d (Apa2b)
(b2)

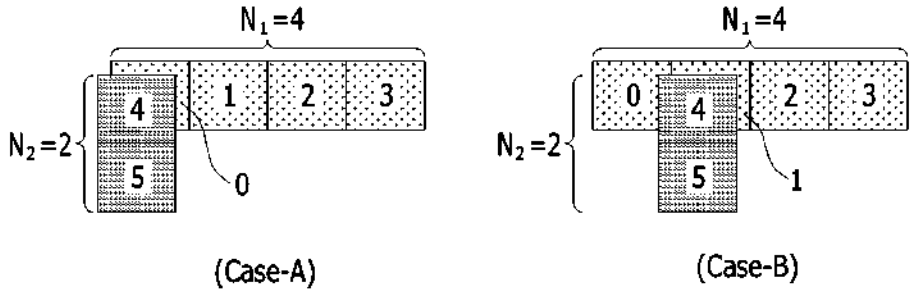
[도33c]


0
1
2
3
CSI-RS antenna port number
(a1)
0
1
effective CSI-RS antenna port number for UE-e
CSI-RS antenna ports seen by UE-e (Apa2c)
(b3)

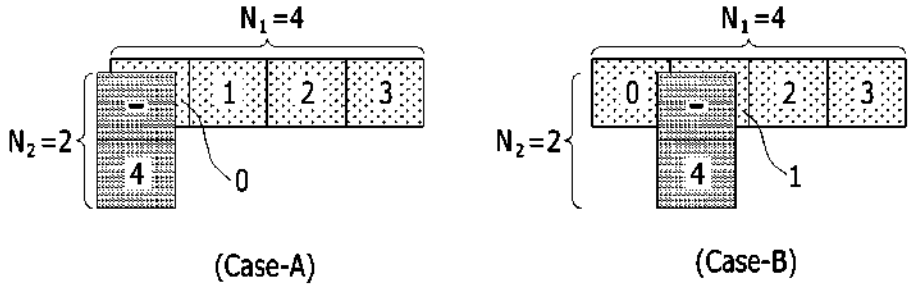
[도34]


CSI-RS antenna port number
CSI-RS antenna ports seen by UE-e (Apa3c)
CSI-RS antenna ports seen by UE-c (Apa3a)
CSI-RS antenna ports seen by UE-d (Apa3b)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

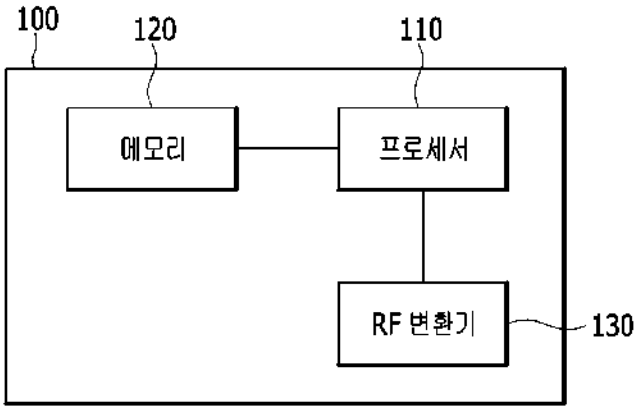
[도35]


N1=4
N2=2
4
1
2
3
5
0
(Case-A)
N1=4
N2=2
0
4
2
3
5
1
(Case-B)

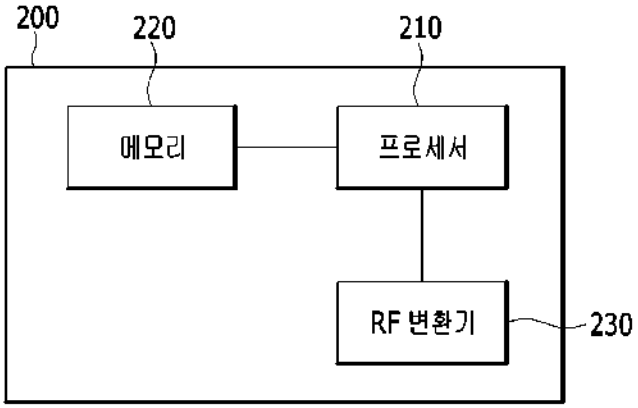
[도36]


N1=4
N2=2
1
2
3
4
0
(Case-A)
N1=4
N2=2
0
2
3
4
1
(Case-B)

[도37]


100
120
110
메모리
프로세서
RF 변환기
130

[도38]


200
220
210
메모리
프로세서
RF 변환기
230

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2016/001014

A. CLASSIFICATION OF SUBJECT MATTER

H04L 5/00(2006.01)i, H04B 7/06(2006.01)i, H04B 7/02(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04L 5/00; H04W 72/04; H04W 24/08; H04B 7/04; H04B 7/06; H04B 7/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Utility models and applications for Utility models: IPC as above
Japanese Utility models and applications for Utility models: IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS (KIPO internal) & Keywords: CSI-RS antenna port, port number mapping rule, the number of ports, CSI-RS antenna group, bit code, horizontal shaft, vertical shaft, polarization shaft, numbering, re-numbering, shaft order, port number state information, bitmap, PDSCH

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2014-0098689 A1 (INTERDIGITAL PATENT HOLDINGS, INC.) 10 April 2014 See paragraphs [0123]-[0234]; and figures 10A-14C.	1-20
A	WO 2014-069821 A1 (PANTECH CO., LTD.) 08 May 2014 See paragraphs [82]-[94]; and figures 6, 7.	1-20
A	WO 2014-161145 A1 (PANASONIC INTELLECTUAL PROPERTY CORPORATION OF AMERICA) 09 October 2014 See page 7, line 7-page 13, line 22; and figures 6-9	1-20
A	US 2014-0192917 A1 (SAMSUNG ELECTRONICS CO., LTD.) 10 July 2014 See paragraphs [0100]-[0120]; and figures 14-18.	1-20
A	US 2013-0100901 A1 (SAMSUNG ELECTRONICS CO., LTD.) 25 April 2013 See paragraphs [0082]-[0094]; and figures 5-7.	1-20

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
04 MAY 2016 (04.05.2016)	**04 MAY 2016 (04.05.2016)**
Name and mailing address of the ISA/KR Korean Intellectual Property Office Government Complex-Daejeon, 189 Seonsa-ro, Daejeon 302-701, Republic of Korea Facsimile No. 82-42-472-7140	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2016/001014

Patent document cited in search report	Publication date	Patent family member	Publication date
US 2014-0098689 A1	10/04/2014	EP 2901571 A1	05/08/2015
		JP 2015-536099 A	17/12/2015
		TW 201429182 A	16/07/2014
		WO 2014-052806 A1	03/04/2014
WO 2014-069821 A1	08/05/2014	KR 10-2014-0057005 A	12/05/2014
		US 2015-0288497 A1	08/10/2015
WO 2014-161145 A1	09/10/2014	CN 105191164 A	23/12/2015
		EP 2982049 A1	10/02/2016
US 2014-0192917 A1	10/07/2014	AU 2014-205792 A1	30/04/2015
		CN 104885499 A	02/09/2015
		EP 2944111 A1	18/11/2015
		KR 10-2015-0104556 A	15/09/2015
		US 9178583 B2	03/11/2015
		WO 2014-109557 A1	17/07/2014
US 2013-0100901 A1	25/04/2013	AU 2012-326774 A1	29/05/2014
		AU 2012-326774 A2	03/07/2014
		CA 2853003 A1	25/04/2013
		CN 104012016 A	27/08/2014
		EP 2584731 A2	24/04/2013
		EP 2584731 A3	03/09/2014
		JP 2015-501586 A	15/01/2015
		KR 10-2013-0043602 A	30/04/2013
		RU 2014120168 A	27/11/2015
		US 2015-0092729 A1	02/04/2015
		US 8913576 B2	16/12/2014
		WO 2013-058624 A1	25/04/2013

Form PCT/ISA/210 (patent family annex) (January 2015)

국 제 조 사 보 고 서

국제출원번호
PCT/KR2016/001014

A. 발명이 속하는 기술분류(국제특허분류(IPC))

H04L 5/00(2006.01)i, H04B 7/06(2006.01)i, H04B 7/02(2006.01)i

B. 조사된 분야

조사된 최소문헌(국제특허분류를 기재)

H04L 5/00; H04W 72/04; H04W 24/08; H04B 7/04; H04B 7/06; H04B 7/02

조사된 기술분야에 속하는 최소문헌 이외의 문헌

한국등록실용신안공보 및 한국공개실용신안공보: 조사된 최소문헌란에 기재된 IPC

일본등록실용신안공보 및 일본공개실용신안공보: 조사된 최소문헌란에 기재된 IPC

국제조사에 이용된 전산 데이터베이스(데이터베이스의 명칭 및 검색어(해당하는 경우))

eKOMPASS(특허청 내부 검색시스템) & 키워드: CSI-RS 안테나 포트, 포트 번호, 맵핑 규칙, 포트의 수, CSI-RS 안테나 그룹, 비트 코드, 수평 축, 수직 축, 편파 축, 번호 부여, 세부역, 축 순서, 포트 번호 부여 여부 정보, 비트맵, PDSCH

C. 관련 문헌

카테고리*	인용문헌명 및 관련 구절(해당하는 경우)의 기재	관련 청구항
A	US 2014-0098689 A1 (INTERDIGITAL PATENT HOLDINGS, INC.) 2014.04.10 단락 [0123]-[0234]; 및 도면 10A-14C 참조.	1-20
A	WO 2014-069821 A1 (주식회사 팬택) 2014.05.08 단락 [82]-[94]; 및 도면 6, 7 참조.	1-20
A	WO 2014-161145 A1 (PANASONIC INTELLECTUAL PROPERTY CORPORATION OF AMERICA) 2014.10.09 페이지 7, 라인 7 - 페이지 13, 라인 22; 및 도면 6-9 참조.	1-20
A	US 2014-0192917 A1 (SAMSUNG ELECTRONICS CO., LTD.) 2014.07.10 단락 [0100]-[0120]; 및 도면 14-18 참조.	1-20
A	US 2013-0100901 A1 (SAMSUNG ELECTRONICS CO., LTD.) 2013.04.25 단락 [0082]-[0094]; 및 도면 5-7 참조.	1-20

☐ 추가 문헌이 C(계속)이 기재되어 있습니다.

☒ 대응특허에 관한 별지를 참조하십시오.

* 인용된 문헌의 특별 카테고리

"A" 특별히 관련이 없는 것으로 보이는 일반적인 기술수준을 정의한 문헌

"E" 국제출원일보다 빠른 출원일 또는 우선일을 가지나 국제출원일 이후에 공개된 선출원 또는 특허 문헌

"L" 우선권 주장에 의문을 제기하는 문헌 또는 다른 인용문헌의 공개일 또는 다른 특별한 이유(이유를 명시)를 밝히기 위하여 인용된 문헌

"O" 구두 개시, 사용, 전시 또는 기타 수단을 언급하고 있는 문헌

"P" 우선일 이후에 공개되었으나 국제출원일 이전에 공개된 문헌

"T" 국제출원일 또는 우선일 후에 공개된 문헌으로, 출원과 상충하지 않으며 발명의 기초가 되는 원리나 이론을 이해하기 위해 인용된 문헌

"X" 특별한 관련이 있는 문헌. 해당 문헌 하나만으로 청구된 발명의 신규성 또는 진보성이 없는 것으로 본다.

"Y" 특별한 관련이 있는 문헌. 해당 문헌이 하나 이상의 다른 문헌과 조합하는 경우로 그 조합이 당업자에게 자명한 경우 청구된 발명은 진보성이 없는 것으로 본다.

"&" 동일한 대응특허문헌에 속하는 문헌

국제조사의 실제 완료일	국제조사보고서 발송일
2016년 05월 04일 (04.05.2016)	2016년 05월 04일 (04.05.2016)

ISA/KR의 명칭 및 우편주소
대한민국 특허청
(35208) 대전광역시 서구 청사로 189,
4동 (둔산동, 정부대전청사)
팩스 번호 +82-42-481-8578

심사관
김희곡
전화번호 +82-42-481-8264

서식 PCT/ISA/210 (두 번째 용지) (2015년 1월)

국 제 조 사 보 고 서
대응특허에 관한 정보

국제출원번호
PCT/KR2016/001014

국제조사보고서에서 인용된 특허문헌	공개일	대응특허문헌	공개일
US 2014-0098689 A1	2014/04/10	EP 2901571 A1	2015/08/05
		JP 2015-536099 A	2015/12/17
		TW 201429182 A	2014/07/16
		WO 2014-052806 A1	2014/04/03
WO 2014-069821 A1	2014/05/08	KR 10-2014-0057005 A	2014/05/12
		US 2015-0288497 A1	2015/10/08
WO 2014-161145 A1	2014/10/09	CN 105191164 A	2015/12/23
		EP 2982049 A1	2016/02/10
US 2014-0192917 A1	2014/07/10	AU 2014-205792 A1	2015/04/30
		CN 104885499 A	2015/09/02
		EP 2944111 A1	2015/11/18
		KR 10-2015-0104556 A	2015/09/15
		US 9178583 B2	2015/11/03
		WO 2014-109557 A1	2014/07/17
US 2013-0100901 A1	2013/04/25	AU 2012-326774 A1	2014/05/29
		AU 2012-326774 A2	2014/07/03
		CA 2853003 A1	2013/04/25
		CN 104012016 A	2014/08/27
		EP 2584731 A2	2013/04/24
		EP 2584731 A3	2014/09/03
		JP 2015-501586 A	2015/01/15
		KR 10-2013-0043602 A	2013/04/30
		RU 2014120188 A	2015/11/27
		US 2015-0092729 A1	2015/04/02
		US 8913576 B2	2014/12/16
		WO 2013-058624 A1	2013/04/25

(12) 按照专利合作条约所公布的国际申请

(19) 世界知识产权组织
国 际 局

(43) 国际公布日
2018 年 11 月 8 日 (08.11.2018)

WIPO | PCT

(10) 国际公布号
WO 2018/201861 A1

(51) 国际专利分类号:
H04L 29/02 (2006.01)

(21) 国际申请号: PCT/CN2018/082472

(22) 国际申请日: 2018 年 4 月 10 日 (10.04.2018)

(25) 申请语言: 中文

(26) 公布语言: 中文

(30) 优先权:
201710307962.5 2017年5月4日 (04.05.2017) CN

(71) 申请人: 电信科学技术研究院有限公司 (CHINA ACADEMY OF TELECOMMUNICATIONS TECHNOLOGY) [CN/CN]; 中国北京市海淀区学院路40号, Beijing 100191 (CN)。

(72) 发明人: 陈润华 (CHEN, Runhua); 中国北京市海淀区学院路40号, Beijing 100191 (CN)。 高秋彬 (GAO, Qiubin); 中国北京市海淀区学院路40号, Beijing 100191 (CN)。 李辉 (LI, Hui); 中国北京市海淀区学院路40号, Beijing 100191 (CN)。

(74) 代理人: 北京银龙知识产权代理有限公司 (DRAGON INTELLECTUAL PROPERTY LAW FIRM); 中国北京市海淀区西直门北大街32号院枫蓝国际中心2号楼10层, Beijing 100082 (CN)。

(81) 指定国 (除另有指明, 要求每一种可提供的国家保护): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK,

(54) Title: MESSAGE DECODING METHOD, SENDING TERMINAL DEVICE AND RECEIVING TERMINAL DEVICE

(54) 发明名称: 一种消息解码方法、发送端设备和接收端设备

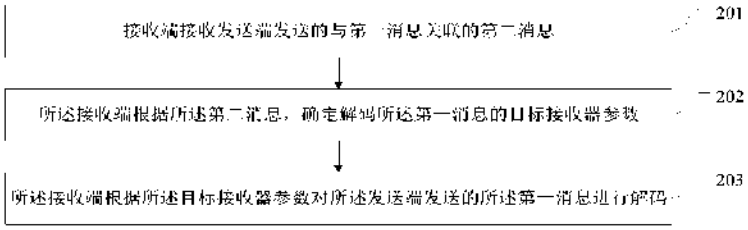


图 2

201 A receiving terminal receives a second message sent by a sending terminal and associated with a first message
202 The receiving terminal determines target receiver parameters for decoding the first message, according to the second message
203 The receiving terminal decodes the first message sent by the sending terminal according to the target receiver parameters

(57) **Abstract:** Provided in embodiments of the present disclosure are a message decoding method, a sending terminal device and a receiving terminal device. The method may comprise: a receiving terminal device receiving a second message sent by a sending terminal and associated with a first message; the receiving terminal device determining target receiver parameters for decoding the first message, according to the second message; the receiving terminal device decoding the first message sent by the sending terminal device according to the target receiver parameters. In this way, an embodiment of the present disclosure can implement a receiving terminal device determining receiver parameters according to a second message associated with a first message, and can increase message transmission functionality.

(57) 摘要: 本公开实施例提供一种消息解码方法、发送端设备和接收端设备。该方法可包括: 接收端设备接收发送端设备发送的与第一消息关联的第二消息; 所述接收端设备根据所述第二消息, 确定解码所述第一消息的目标接收器参数; 所述接收端设备根据所述目标接收器参数对所述发送端设备发送的所述第一消息进行解码。这样本公开实施例可以实现接收端设备根据与第一消息关联的第二消息确定接收器参数, 且还可以提高消息传输性能。

WO 2018/201861 A1

[见续页]

LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW。

(84) 指定国(除另有指明，要求每一种可提供的地区保护)：ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), 欧亚 (AM, AZ, BY, KG, KZ, RU, TJ, TM), 欧洲 (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG)。

本国际公布：

— 包括国际检索报告(条约第21条(3))。

一种消息解码方法、发送端设备和接收端设备

相关申请的交叉引用

本申请主张在 2017 年 5 月 4 日在中国提交的中国专利申请号 No. 201710307962.5 的优先权，其全部内容通过引用包含于此。

技术领域

本公开实施例涉及通信技术领域，特别涉及一种消息解码方法、发送端设备和接收端设备。

背景技术

随着通信技术的发展，目前通信设备均支持多天线系统。例如：支持高达 128、256 或者 512 个天线单元，以及高达 128、256 或者 512 个收发单元，其中每个天线单元连接一个收发单元。此外，目前通信设备还支持多波束，不同的波束的覆盖范围可以不同。这样发送端设备（例如：网络侧设备）在发送消息时，就可以在多个发送器参数（例如：发送波束）中选择相应的发送器参数进行发送，以提高通信性能。而接收端设备（例如：用户终端）如何选择相应的接收器参数（例如：接收波束）对发送端设备发送的消息进行解码目前还未明确。可见，接收端设备如何选择相应的接收器参数对发送端设备发送的消息进行解码是当前急需解决的技术问题。

发明内容

本公开实施例的目的在于提供一种消息解码方法、发送端设备和接收端设备，以解决接收端设备如何选择相应的接收器参数对发送端设备发送的消息进行解码的技术问题。

为了达到上述目的，在第一个方面中，本公开实施例提供一种消息解码方法，包括：

接收端设备接收发送端设备发送的与第一消息关联的第二消息；

所述接收端设备根据所述第二消息，确定解码所述第一消息的目标接收

器参数；以及

所述接收端设备根据所述目标接收器参数对所述发送端设备发送的所述第一消息进行解码。

在本公开的一个可行实施例中，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端设备默认的接收器参数。

在本公开的一个可行实施例中，所述接收端设备默认的接收器参数包括：

所述接收端设备当前使用的接收器参数、所述接收端设备接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端设备向所述发送端设备上报时间最近的发送器参数对应的接收器参数。

在本公开的一个可行实施例中，所述参数指示信息显式或者隐式指示所述目标接收器参数。

在本公开的一个可行实施例中，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端设备选择的发送器参数，所述接收端设备将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

在本公开的一个可行实施例中，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

在本公开的一个可行实施例中，所述参数切换指示集对应的调度时间单位在时域上周期性存在；和/或

所述参数切换指示集对应的调度时间单位由所述发送端设备半静态或半持续配置，并通知所述接收端设备。

在本公开的一个可行实施例中，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，

以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前，所述接收端设备根据所述目标接收器参数对所述第一消息进行解码，包括：

若所述第二消息包括参数指示信息，则所述接收端设备根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示信息，则所述接收端设备丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示信息，则所述接收端设备根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息不包括参数指示信息，则所述接收端设备根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端设备根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端设备丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端设备根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段指示没有参数指示信息或者没有参数改变，则所述接收端设备根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

在本公开的一个可行实施例中，所述方法还包括：

所述接收端设备接收所述发送端设备发送的第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第

二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

在本公开的一个可行实施例中，所述第三消息用于指示 M 个时间单位内的第二消息是否包括参数指示信息，所述 M 为大于或者等于 1 的整数， 所述 M 个时间单位连续或者不连续。

在本公开的一个可行实施例中，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

在本公开的一个可行实施例中，所述空域的接收器参数包括所述接收端设备的接收波束。

在第二个方面中，本公开实施例还提供一种消息解码方法，包括：

发送端设备向接收端设备发送与第一消息关联的第二消息，所述第二消息用于所述接收端设备确定解码所述第一消息的目标接收器参数；以及

所述发送端设备向所述接收端设备发送所述第一消息。

在本公开的一个可行实施例中，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端设备默认的接收器参数。

在本公开的一个可行实施例中，所述接收端设备默认的接收器参数包括：

所述接收端设备当前使用的接收器参数、所述接收端设备接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端设备向所述发送端设备上报时间最近的发送器参数对应的接收器参数。

在本公开的一个可行实施例中，所述参数指示信息显式或者隐式指示所述目标接收器参数。

在本公开的一个可行实施例中，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端设备选择的发送器参数，所述接收端设备将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

在本公开的一个可行实施例中，若所述第二消息是在预先确定的参数切

换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

在本公开的一个可行实施例中，所述参数切换指示集对应的调度时间单位在时域上周期性存在；和/或

所述参数切换指示集对应的调度时间单位由所述发送端设备半静态或半持续配置，并通知所述接收端设备。

在本公开的一个可行实施例中，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前。

在本公开的一个可行实施例中，所述方法还包括：

所述发送端设备向所述接收端设备发送第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

在本公开的一个可行实施例中，所述第三消息用于指示 M 个时间单位内的第二消息是否包括参数指示信息，所述 M 为大于或者等于 1 的整数， 所述 M 个时间单位连续或者不连续。

在本公开的一个可行实施例中，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

在本公开的一个可行实施例中，所述空域的接收器参数包括所述接收端设备的接收波束。

在第三个方面中，本公开实施例还提供一种接收端设备，包括：

第一接收模块，用于接收发送端设备发送的与第一消息关联的第二消息；

确定模块，用于根据所述第二消息，确定解码所述第一消息的目标接收

器参数；以及

解码模块，用于根据所述目标接收器参数对所述发送端设备发送的所述第一消息进行解码。

在本公开的一个可行实施例中，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端设备默认的接收器参数。

在本公开的一个可行实施例中，所述接收端设备默认的接收器参数包括：

所述接收端设备当前使用的接收器参数、所述接收端设备接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端设备向所述发送端设备上报时间最近的发送器参数对应的接收器参数。

在本公开的一个可行实施例中，所述参数指示信息显式或者隐式指示所述目标接收器参数。

在本公开的一个可行实施例中，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端设备选择的发送器参数，所述接收端设备将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

在本公开的一个可行实施例中，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

在本公开的一个可行实施例中，所述参数切换指示集对应的调度时间单位在时域上周期性存在；和/或

所述参数切换指示集对应的调度时间单位由所述发送端设备半静态或半持续配置，并通知所述接收端设备。

在本公开的一个可行实施例中，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，

以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前；

所述解码模块用于若所述第二消息包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示信息，则根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息不包括参数指示信息，则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示字段，且所述参数指示字段指示没有参数指示信息或者没有参数改变，则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

在本公开的一个可行实施例中，所述接收端设备还包括：

第二接收模块，用于接收所述发送端设备发送的第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间

隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

在本公开的一个可行实施例中，所述第三消息用于指示 M 个时间单位内的第二消息是否包括参数指示信息，所述 M 为大于或者等于 1 的整数， 所述 M 个时间单位连续或者不连续。

在本公开的一个可行实施例中，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

在本公开的一个可行实施例中，所述空域的接收器参数包括所述接收端设备的接收波束。

在第四个方面中，本公开实施例还提供一种发送端设备，包括：

第一发送模块，用于发送端设备向接收端设备发送与第一消息关联的第二消息，所述第二消息用于所述接收端设备确定解码所述第一消息的目标接收器参数；以及

第二发送模块，用于向所述接收端设备发送所述第一消息。

在本公开的一个可行实施例中，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端设备默认的接收器参数。

在本公开的一个可行实施例中，所述接收端设备默认的接收器参数包括：

所述接收端设备当前使用的接收器参数、所述接收端设备接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端设备向所述发送端设备上报时间最近的发送器参数对应的接收器参数。

在本公开的一个可行实施例中，所述参数指示信息显式或者隐式指示所述目标接收器参数。

在本公开的一个可行实施例中，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端设备选择的发送器参数，所述接收端设备将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

在本公开的一个可行实施例中，若所述第二消息是在预先确定的参数切

换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

在本公开的一个可行实施例中，所述参数切换指示集对应的调度时间单位在时域上周期性存在；和/或

所述参数切换指示集对应的调度时间单位由所述发送端设备半静态或半持续配置，并通知所述接收端设备。

在本公开的一个可行实施例中，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前。

在本公开的一个可行实施例中，所述发送端设备还包括：

第三发送模块，用于向所述接收端设备发送第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

在本公开的一个可行实施例中，所述第三消息用于指示 M 个时间单位内的第二消息是否包括参数指示信息，所述 M 为大于或者等于 1 的整数， 所述 M 个时间单位连续或者不连续。

在本公开的一个可行实施例中，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

在本公开的一个可行实施例中，所述空域的接收器参数包括所述接收端设备的接收波束。

在第五个方面中，本公开实施例还提供一种接收端设备，包括：处理器、收发机、存储器、用户接口和总线接口，其中：

所述处理器，用于读取所述存储器中的程序，执行本公开实施例提供的

接收端设备对应的消息解码方法中的步骤。

在第六个方面中，本公开实施例还提供一种发送端设备，包括：处理器、收发机、存储器、用户接口和总线接口，其中：

所述处理器，用于读取所述存储器中的程序，执行本公开实施例提供的发送端设备对应的消息解码方法的步骤。

在第七个方面中，本公开实施例还提供一种计算机可读存储介质，所述计算机可读存储介质上存储有计算机程序，所述计算机程序被处理器执行时实现本公开实施例提供的接收端设备对应的消息解码方法中的步骤。

在第八个方面中，本公开实施例还提供一种计算机可读存储介质，所述计算机可读存储介质上存储有计算机程序，所述计算机程序被处理器执行时实现本公开实施例提供的发送端设备对应的消息解码方法的步骤。

本公开实施例所提供的上述技术方案至少具有如下有益效果：

根据本公开实施例，接收端设备接收发送端设备发送的与第一消息关联的第二消息；所述接收端设备根据所述第二消息，确定解码所述第一消息的目标接收器参数；所述接收端设备根据所述目标接收器参数对所述发送端设备发送的所述第一消息进行解码。这样可以实现接收端设备根据与第一消息关联的第二消息确定接收器参数，且还可以提高消息传输性能。

附图说明

为了更清楚地说明本公开文本实施例或相关技术中的技术方案，下面将对实施例描述中所需要使用的附图作简单地介绍，显而易见地，下面描述中的附图仅仅是本公开文本的一些实施例，对于本领域普通技术人员来讲，在不付出创造性劳动的前提下，还可以根据这些附图获得其他的附图。

图 1 为本公开实施例可应用的网络结构示意图；

图 2 为本公开实施例提供的一种消息解码方法的流程图；

图 3 为本公开实施例提供的一种消息发送的示意图；

图 4 为本公开实施例提供的另一种消息发送的示意图；

图 5 为本公开实施例提供的另一种消息发送的示意图；

图 6 为本公开实施例提供的另一种消息发送的示意图；

图 7 为本公开实施例提供的另一种消息解码方法的流程图；

图 8 为本公开实施例提供的一种接收端设备的结构示意图；

图 9 为本公开实施例提供的另一种接收端设备的结构示意图；

图 10 为本公开实施例提供的一种发送端设备的结构示意图；

图 11 为本公开实施例提供的另一种发送端设备的结构示意图；

图 12 为本公开实施例提供的另一种接收端设备的结构示意图；以及

图 13 为本公开实施例提供的另一种发送端设备的结构示意图。

具体实施方式

为使本公开要解决的技术问题、技术方案和优点更加清楚，下面将结合附图及具体实施例进行详细描述。

参见图 1，图 1 为本公开实施例可应用的网络结构示意图。如图 1 所示，包括发送端设备 11 和接收端设备 12。其中，发送端设备 11 可以是基站或者终端，而接收端设备 12 也可以是终端或者基站。例如：发送端设备 11 为基站，接收端设备 12 为终端，则可以实现终端与基站之间的通信，又或者发送端设备 11 为终端，则接收端设备 12 为基站，也可以实现终端与基站之间的通信，又或者发送端设备 11 为基站，接收端设备 12 也为基站，则可以实现基站与基站之间的通信，又或者发送端设备 11 为终端，接收端设备 12 也为终端，则可以实现终端与终端之间的通信。当然，本公开实施例中，并不限定发送端设备 11 只能是终端或者基站，例如：发送端设备 11 还可以是其他的网络侧设备。同理，接收端设备 12 也并不限定只是终端或者设备，例如：接收端设备 12 还可以是其他的网络侧设备，对此本公开实施例不作限定。其中，附图 1，以发送端设备 11 为基站，接收端设备 12 为终端进行举例示意。终端可以是用户终端（User Equipment，UE），例如：可以是手机、平板电脑（Tablet Personal Computer）、膝上型电脑（Laptop Computer）、个人数字助理（personal digital assistant，简称 PDA）、移动上网装置（Mobile Internet Device，MID）或可穿戴式设备（Wearable Device）等终端侧设备。需要说明的是，在本公开实施例中并不限定终端的具体类型。基站可以是宏站，如 LTE eNB、5G NR NB 等；也可以是小站，如低功率节点（LPN：low power node）pico、

femto 等小站，或者可以是接入点（AP，access point）。基站也可以是中央单元（CU，central unit）与其管理和控制的多个传输接收点（TRP，Transmission Reception Point）共同组成的网络节点。另外，一个基站下有一个或多个小区（例如：不同的频点或扇区分裂）。需要说明的是，在本公开实施例中并不限定基站的具体类型。

请参考图 2，图 2 是本本公开实施例提供一种消息解码方法的流程图，如图 2 所示，包括以下步骤：

201、接收端设备接收发送端设备发送的与第一消息关联的第二消息；

202、所述接收端设备根据所述第二消息，确定解码所述第一消息的目标接收器参数；以及

203、所述接收端设备根据所述目标接收器参数对所述发送端设备发送的所述第一消息进行解码。

其中，上述第一消息可以是发送端设备需要向接收端设备发送的信号，例如：数据和/或控制消息等等，如上述第一消息可以是下行链路信号。另外，本公开实施例中，可以将第一消息定义为 msg1。而上述第二消息可以理解为用于通知接收端设备接收器参考的消息，例如：控制消息或者调度消息等等。另外，本公开实施例中第二消息可以定义为 msg2。

上述根据所述第二消息，确定解码所述第一消息的目标接收器参数可以是，若上述第二消息中包括了参数指示信息，则确定该参数指示信息指示的接收器参数作为上述目标器参数，若上述第二消息中不包括参数指示信息，则确定默认的接收器参数作为上述目标器参数。即本公开实施例中，上述第二消息可以存在两种情况，一种是存在参数指示信息，该情况下接收端设备可能需要进行接收器参数切换，再对发送端设备发送的消息进行解码。另一种是不存在参数指示信息，该情况下接收端设备可能不需要进行波束接收器参数切换，直接对接收端设备发送的消息进行解码。另外，目标接收器参数可以是接收端设备中接收器的相关参数，例如：接收波束、均衡器和接收滤波器等参数中的至少一项，对此本公开实施例不作限定。例如：以目标接收器参数为目标接收波束为例，上述确定解码所述第一消息的目标接收波束还可以是在接收端设备的多个接收波束（Rx 波束）中选择一个或者多个接收波

束。且接收端设备的多个接收器参数可以是与发送端设备无关的，或者接收端设备的多个接收器参数对于发送端设备来说也可以是已知的，例如：通过预配置或反馈通知发送端设备，对此本公开实施例不作限定。

本公开实施例中，通过上述步骤就可以实现通过专门的第二消息向接收端设备通知发送端设备发送的第一消息的接收波束，从而使得接收端设备和发送端设备获得更准确的波束组合信息，支持多波束传输，以及提高波束传输性能。另外，本公开实施例可以用于在无线通信系统中的接收端设备的模拟波束切换，以及还可以用于接收端设备的数字波束切换等，对此本公开实施例不作限定。

在本公开的一个可行实施例中，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端设备默认的接收器参数。

该实施方式中，可以实现上述第二消息中包括或者不包括参数指示信息，若包括，则将参数指示信息指示的接收器参数作为上述目标接收器参数。其中，参数指示信息指示接收波束可以是与接收端设备当前使用的接收器参数为不同的接收器参数，这时接收端设备需要进行接收器参数切换。而使用默认的接收器参数，可以不进行切换，例如：默认的接收器参数就可以是接收端设备当前使用的接收器参数，以快速对发送端设备发送的消息进行解码。另外，本公开实施例中，第二消息中的参数指示信息可以是，第二消息中的参数指示字段，即第二消息中可以存在或者不存在该参数指示字段。

例如：所述接收端设备默认的接收器参数包括：

所述接收端设备当前使用的接收器参数、所述接收端设备接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端设备向所述发送端设备上报时间最近的发送器参数对应的接收器参数。

该实施方式中，通过上述默认波束可以减少接收器参数的切换，例如：减少接收波束的切换，以提高传输性能。例如，第二消息与第一消息之间可以不存在间隙。

另外，本公开实施例中，上述参数指示信息可以显式或者隐式指示所述

目标接收器参数。例如：显式或者隐式指示所述目标接收波束。

其中，显式指示可以理解为直接指示，例如：以接收波束举例，接收端设备具有一组 L 个预配置的接收波束，这些对于发送端设备可以是已知的。这样上述参数指示信息例如可以携带 Log2（L）位的字段，以指示接收端设备的推荐接收波束。在接收到第二消息后，接收端设备就可以确定对应的接收波束用于解码 msg1。而上述隐式指示可以理解为间接指示，例如：上述参数指示信息可以是指示发送波束（Tx 波束），通过指示的发送波束隐式指示该发送波束对应的接收波束。该实施方式中，通过上述显式或者隐式的方式可以实现灵活地向接收端设备指示接收波束，以提高系统的灵活性。

在本公开的一个可行实施例中，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端设备选择的发送器参数，所述接收端设备将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

该实施方式中，可以实现通过发送器参数来隐式指示接收器参数，例如：以目标接收器参数为目标波束举例，发送端设备可以具有用于下行链路传输的 M 个候选发送波束。发送端设备配置 M 个参考符号（RS）资源，并将每个发送波束应用于相应的 RS 资源。对于每个 RS 资源，接收端设备可以测试一组候选接收波束，并确定每个 RS 资源（例如发送波束）的最佳接收波束。在本公开的一个可行实施例中，接收端设备可以将至少推荐的发送波束的信息反馈给发送端设备，例如，以推荐的 RS 资源的形式，但这一步是可选的。在发送第一消息之前，发送端设备以第二消息的方式发送其选定的发送波束的指示。接收端设备接收到第二消息后，获得所使用的发送波束的信息，并获得最佳的接收波束作为上述目标接收波束，该最佳的接收波束可以是从先前的测量已知并保存在接收端设备中。

该实施方式中，可以实现通过发送器参数来隐式指示接收器参数，从而有利于接收端设备与发送端设备之间的传输。当然，在一些实施方式中，发送端设备可以是根据接收端设备返回的推荐信息自主选择相应的发送器参数，例如：发送波束。

在本公开的一个可行实施例中，若所述第二消息是在预先确定的参数切

换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

该实施方式中，上述参数切换指示集（BSIS）对应的调度时间单位可以是子帧或者时隙（slots）等时间单位。且发送端设备和接收端设备对 BSIS 可以具有一致的认识。只有在 BSIS 对应的 slot（这里以 slot 为例）中，第二消息才可能会携带参数指示信息，否则第二消息不携带参数指示信息。这意味着在 BSIS 对应的时隙之外的所有时隙中可以不执行接收器参数切换，例如：接收波束切换，而仅在周期性的选定时隙（例如 BSIS 中的时隙）中执行接收器参数切换。

另外，由于第二消息包括参数指示信息时，所述第二消息与所述第一消息之间存在间隙，这样接收端设备可以是在该间隙切换进行接收器参数切换，例如：接收波束切换，从而不影响消息的传输。而所述第二消息不包括参数指示信息时，所述第二消息与所述第一消息之间可以不存在间隙，这样可以节约传输资源。这是因为该情况下，接收端设备可能是不需要进行接收器参数切换，例如：接收波束切换，进而第二消息和第一消息连续传输也不会影响接收端设备的解码。且上述第二消息和第一消息可以采用相同的频域资源发送的，或者采用相同的信道发送等，对此本公开实施例不作限定。

例如：对于在 BSIS 中的时隙中发送的第二消息，携带参数指示信息。在这种情况下，同一时隙中的第一消息和第二消息之间有切换时间。否则对于 BSIS 外的时隙中的第二消息传输，发送端设备发送第二消息，而不携带波束指示字段。在这种情况下，接收端设备可以准备在第二消息之后立即接收第一消息（没有间隙）。例如：图 3 所示的第二个 slot。另外，当尝试在每个时隙中接收到第二消息或者第一消息时，接收端设备可以根据假定存在或者不存在参数指示信息来解码第二消息。换句话说，在 BSIS 中的时隙中，第二消息可以携带参数指示信息，接收端设备尝试解码第二消息，假设有一个参数指示信息。在其他时隙中，接收器解码第二消息，假设没有参数指示信息。

在第二消息不携带参数指示信息的时隙中，接收端设备仍然可以选择一个接收器参数（例如：接收波束）来解码第一消息。接收端设备可以使用在最新的携带参数指示字段的第二消息中指示的接收器参数。如果没有接收到参数指示信息，则接收机可以使用默认的接收器参数来解码第一消息。

在本公开的一个可行实施例中，所述参数切换指示集对应的调度时间单位在时域上周期性存在；和/或

所述参数切换指示集对应的调度时间单位由所述发送端设备半静态或半持续(semi-persistent)配置，并通知所述接收端设备。

其中，上述参数切换指示集对应的调度时间单位在时域上周期性存在可以是，上述参数切换指示集对应的调度时间单位具有周期性，例如：参数切换指示集在时域中可以周期性地具有预配置的周期和定时偏移，其中，该定时偏移可以是相对于另一个定时参考的偏移，如帧边界。例如，参数切换指示集可以具有 10ms 的周期，其指示在 10 个 slots 中的 1 个中发送的第二消息可能会携带参数指示信息，而其他 9 个 slots 中的第二消息不携带参数指示信息。上述参数切换指示集对应的调度时间单位由所述发送端设备半静态或半持续配置，并通知所述接收端设备可以是，发送端设备半静态或半持续配置，并通知接收端设备参数切换指示集的集合，即指示多个参数切换指示集。或者上述参数切换指示集可以由接收端设备获得，并作为推荐被反馈给发送端设备。发送端设备可以使用接收端设备推荐的参数切换指示集，或覆盖接收端设备推荐的参数切换指示集，并选择一个新的参数切换指示集。发送端设备可以需要向接收端设备指示是否确认接收端设备推荐的参数切换指示集，或者将其选择的参数切换指示集指示给接收端设备。

在本公开的一个可行实施例中，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前，所述接收端设备根据所述目标接收器参数对所述第一消息进行解码，包括：

若所述第二消息包括参数指示信息，则所述接收端设备根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示信息，则所述接收端设备丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示信息，则所述接收端设备根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息不包括参数指示信息，则所述接收端设备根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

该实施方式中，所述第一消息分为时域上连续的第一部分内容和第二部分内容可以是接收端设备将第一消息分为两个部分，这里将第一消息分为两个部分可以理解为将第一消息看作两个部分，这是因为此时接收端设备还未接收到第一消息，不能对其进行拆分。

例如：发送端设备可以发送携带与接收第一消息有关的下行调度信息的第二消息。第二消息可以携带或不携带参数指示信息，对此接收端设备可以没有先验知识。如果第二消息没有参数指示信息，则第二消息的有效载荷较小（表示为 A 位）。如果第二消息具有参数指示信息，则第二消息的有效载荷较大（表示为 B 位，其中 B> A）。在发送端设备发送第二消息后，接收端设备可以尝试用盲解码第二消息。因为接收端设备没有关于第二消息的有效载荷的先验信息，因此需要基于不同的可能的第二消息有效载荷来执行盲解码。例如，接收端设备将执行假设有效载荷 A 位的第二消息的一次盲解码，以及假设 B 位的有效载荷的另一个第二消息的盲解码。这样根据第二消息的实际有效负载，两个盲解码之一将成功解码第二消息。之后，接收端设备就可以将第一消息分为第一部分内容和第二部分内容 （part 1 and part 2），第一部分内容在第二部分内容前面，并且在时域中为时分复用（TDM）。第一消息的第一部分部分紧随着第二消息，即两者没有间隙，第一消息的第二部分内容紧邻第一部分内容，例如：图 4 所示的第二个 slot。

另外，由于第一部分内容和第二部分内容属于同一消息，从而接收端设备可以分别对第一部分内容和第二部分内容执行符号级处理。

该实施方式中，由于若所述第二消息包括参数指示信息时，则所述接收

端设备使用所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码，其中，所述发送端设备未发送所述第一部分内容。例如：图 4 所示的第一个 slot。这样可以提高接收端设备解码的准确性。

另外，由于第二消息包括参数指示信息时，可以丢弃所述第一部分内容，以及使用所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码。即可以丢弃图 4 所示的第二个 slot 的第一部分内容，同样能够保证发送端设备与接收端设备之间的性能，这是因为在该情况下发送端设备可以在第一部分内容中传输非重要信息，而在第二部分内容中传输重要信息。当然，本公开实施例并不以此为限，在第一消息包括参数指示信息时，还可以是发送端设备可以在第一部分内容中传输重要信息，而在第二部分内容中传输非重要信息。

另外，由于第二消息包括参数指示信息时，可以使用默认的接收器参数对所述第一部分内容进行解码，以及使用所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码。这样可以实现接收到准备地解码第一部分部分和第二部分内容。

另外，由于第二消息不包括参数指示信息，可以实现使用默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。即图 4 所示的第三个 slot。

另外，发送端设备和接收端设备可以将其对接收端设备上确切的第一消息解码行为的理解对齐。这可以由网络半静态地或半持续地配置给接收端设备，或者使用另一个动态控制消息动态地指示给接收端设备。

可选的，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前，所述接收端设备根据所述目标接收器参数对所述发送端设备发送的所述第一消息进行解码，包括：

若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端设备根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端设备丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端设备根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段指示没有参数指示信息或者没有参数改变，则所述接收端设备根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

该实施方式中，可以实现第二消息始终具有参数指示字段，例如：波束指示字段，例如 S 比特位。且参数指示字段具有至少一个状态指示，即没有参数指示信息或者没有参数改变的状态指示，以及还可以指示用于解码第一消息的接收器参数的其他状态。因此，第二消息的有效载荷预先已知到发送端设备和接收端设备。例如对应于 4 个可能的接收器参数指示状态的 S=2。一个状态向接收机指示存在“没有参数指示信息或者没有参数改变”，而其他 3 个状态指示到接收机的接收器参数。

另外，该实施方式中，关于第一消息的第一部分内容和第二部分内容可以参考上一实施方式中的相应描述，此处不作赘述。

且关于第二消息中是否包括参数指示信息的情况，如何对第一部分内容和第二部分内容的解码，可以参见上述实施方式的相应描述，此处不作赘述，且可以达到相同或相似的有益效果。

在本公开的一个可行实施例中，所述方法还包括：

所述接收端设备接收所述发送端设备发送的第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

其中，上述第三消息可以定义为 msg3，该实施方式中，通过第三消息通

知接收端设备第二消息是否包括参数指示信息，更为具体的可以指示第二消息指示的接收器参数对于接收端设备是否存在接收器参数改变，这样可以实现当不存在接收器参数改变或者不包括参数指示信息时，接收端设备甚至可以不接收第二消息，直接使用当前的接收器参数对第一消息进行解码。另外，在一些实施方式中，第三消息可以具有固定有效载荷，其中第二消息中的参数指示信息的存在或者不存在对应于第三消息中的两个不同状态。例如，第三消息有 1 位表示第二消息是否携带参数指示信息。

另外，本公开实施例中，上述第三消息可以对应于一个第二消息，即一个第三消息指示一个第二消息，例如：如图 5 所示。且第三消息、第二消息可以是以相同的调度时间单位（例如，时隙）发送，其中图 5 给出了一个示例。可以以不同的调度时间单位发送的第三消息和第二消息。如果第二消息有参数指示信息，第一消息和第二消息之间可以有一个间隙。如果第二消息没有参数指示信息，第一消息和第二消息之间可以没有间隙。

在本公开的一个可行实施例中，所述第三消息用于指示 M 个时间单位内的第二消息是否包括参数指示信息，所述 M 为大于或者等于 1 的整数， 所述 M 个时间单位连续或者不连续。

该实施方式中，可以实现通过第三消息指示多个第二消息，例如：第三消息用于指示 M 个时隙中的 M 个第二消息是否包括参数指示信息，这样可以节省消息开销。另外，上述 M 的值和 M 个第二消息的时间位置可以预定义的半静态或半持续配置的，并且对发送端设备和接收端设备均是已知的。其中，图 6 示出了一个例子，其中 M = 3。一旦接收到第三消息，该第三消息就向接收端设备指示相应的 M 个时隙中的第二消息是否携带参数指示信息。

另外，第三消息可以是可以在每个调度时间单位（例如 slots）或在由发送端设备预配置的时隙的子集（例如，具有预先配置的传输周期和偏移）中被发送。对于后一种情况，发送端设备可以事先向接收端设备指示第三消息的发生。

在本公开的一个可行实施例中，本公开实施例中，目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

这样可以实现根据发送端设备的第二消息灵活选择时域、频域和空域中

的至少一项的接收器参数，对第一消息进行解码。在本公开的一个可行实施例中，所述空域的接收器参数包括所述接收端设备的接收波束。这样可以实现接收端设备根据与第一消息关联的第二消息确定接收波束，且还可以提高波束传输性能。

需要说明的是，本公开实施例介绍的多种可选的实施方式均可以相互结合实现，也可以单独实现，对此本公开实施例不作限定。

本公开实施例，接收端设备接收发送端设备发送的与第一消息关联的第二消息；所述接收端设备根据所述第二消息，确定解码所述第一消息的目标接收器参数；所述接收端设备根据所述目标接收器参数对所述发送端设备发送的所述第一消息进行解码。这样可以实现接收端设备根据与第一消息关联的第二消息确定接收器参数，且还可以提高消息传输性能。

请参阅图 7，图 7 是本公开实施例提供的另一种消息解码方法的流程图，如图 7 所示，包括以下步骤：

701、发送端设备向接收端设备发送与第一消息关联的第二消息，所述第二消息用于所述接收端设备确定解码所述第一消息的目标接收器参数；以及

702、所述发送端设备向所述接收端设备发送所述第一消息。

在本公开的一个可行实施例中，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端设备默认的接收器参数。

在本公开的一个可行实施例中，所述接收端设备默认的接收器参数包括：

所述接收端设备当前使用的接收器参数、所述接收端设备接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端设备向所述发送端设备上报时间最近的发送器参数对应的接收器参数。

在本公开的一个可行实施例中，所述参数指示信息显式或者隐式指示所述目标接收器参数。

在本公开的一个可行实施例中，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端设备选择的发送器参数，所述接收端设备将预先为所述发送器参数选择的接收器参数作为所述目标接

收器参数。

在本公开的一个可行实施例中，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

在本公开的一个可行实施例中，所述参数切换指示集对应的调度时间单位在时域上周期性存在；和/或

所述参数切换指示集对应的调度时间单位由所述发送端设备半静态或半持续配置，并通知所述接收端设备。

在本公开的一个可行实施例中，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前。

在本公开的一个可行实施例中，所述方法还包括：

所述发送端设备向所述接收端设备发送第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

在本公开的一个可行实施例中，所述第三消息用于指示 M 个时间单位内的第二消息是否包括参数指示信息，所述 M 为大于或者等于 1 的整数， 所述 M 个时间单位连续或者不连续。

在本公开的一个可行实施例中，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

在本公开的一个可行实施例中，所述空域的接收器参数包括所述接收端设备的接收波束。

需要说明的是，本实施例作为与图 2 所示的实施例中对应的发送端设备

的实施方式，其具体的实施方式可以参见图 2 所示的实施例的相关说明，为了避免重复说明，本实施例不再赘述，且还可以达到相同或相似有益效果。

请参考图 8，图 8 是本公开实施例提供一种接收端设备的结构图，如图 8 所示，接收端设备 800 包括：

第一接收模块 801，用于接收发送端设备发送的与第一消息关联的第二消息；

确定模块 802，用于根据所述第二消息，确定解码所述第一消息的目标接收器参数；以及

解码模块 803，用于根据所述目标接收器参数对所述发送端设备发送的所述第一消息进行解码。

在本公开的一个可行实施例中，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端设备默认的接收器参数。

在本公开的一个可行实施例中，所述接收端设备默认的接收器参数包括：

所述接收端设备当前使用的接收器参数、所述接收端设备接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端设备向所述发送端设备上报时间最近的发送器参数对应的接收器参数。

在本公开的一个可行实施例中，所述参数指示信息显式或者隐式指示所述目标接收器参数。

在本公开的一个可行实施例中，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端设备选择的发送器参数，所述接收端设备将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

在本公开的一个可行实施例中，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息

之间不存在间隙。

在本公开的一个可行实施例中，所述参数切换指示集对应的调度时间单位在时域上周期性存在；和/或

所述参数切换指示集对应的调度时间单位由所述发送端设备半静态或半持续配置，并通知所述接收端设备。

在本公开的一个可行实施例中，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前；

所述解码模块 803 用于若所述第二消息包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块 803 用于若所述第二消息包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块 803 用于若所述第二消息包括参数指示信息，则根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块 803 用于若所述第二消息不包括参数指示信息，则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码；或者

所述解码模块 803 用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块 803 用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块 803 用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第

二部分内容进行解码；或者

所述解码模块 803 用于若所述第二消息包括参数指示字段，且所述参数指示字段指示没有参数指示信息或者没有参数改变，则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

在本公开的一个可行实施例中，如图 9 所示，所述接收端设备 800 还包括：

第二接收模块 804，用于接收所述发送端设备发送的第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

在本公开的一个可行实施例中，所述第三消息用于指示 M 个时间单位内的第二消息是否包括参数指示信息，所述 M 为大于或者等于 1 的整数， 所述 M 个时间单位连续或者不连续。

在本公开的一个可行实施例中，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

在本公开的一个可行实施例中，所述空域的接收器参数包括所述接收端设备的接收波束。

需要说明的是，本实施例中上述接收端设备 800 可以是本公开实施例中方法实施例中任意实施方式的接收端设备，本公开实施例中方法实施例中接收端设备的任意实施方式都可以被本实施例中的上述接收端设备 800 所实现，以及达到相同或相似的有益效果，此处不再赘述。

请参阅图 10，图 10 是本公开实施例提供的一种发送端设备的结构图，如图 10 所示，发送端设备 1000 包括：

第一发送模块 1001，用于发送端设备向接收端设备发送与第一消息关联的第二消息，所述第二消息用于所述接收端设备确定解码所述第一消息的目标接收器参数；

第二发送模块 1002，用于向所述接收端设备发送所述第一消息。

在本公开的一个可行实施例中，若所述第二消息包括参数指示信息，则

所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端设备默认的接收器参数。

在本公开的一个可行实施例中，所述接收端设备默认的接收器参数包括：

所述接收端设备当前使用的接收器参数、所述接收端设备接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端设备向所述发送端设备上报时间最近的发送器参数对应的接收器参数。

在本公开的一个可行实施例中，所述参数指示信息显式或者隐式指示所述目标接收器参数。

在本公开的一个可行实施例中，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端设备选择的发送器参数，所述接收端设备将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

在本公开的一个可行实施例中，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

在本公开的一个可行实施例中，所述参数切换指示集对应的调度时间单位在时域上周期性存在；和/或

所述参数切换指示集对应的调度时间单位由所述发送端设备半静态或半持续配置，并通知所述接收端设备。

在本公开的一个可行实施例中，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前。

在本公开的一个可行实施例中，如图 11 所示，所述发送端设备还包括：

第三发送模块 1003，用于向所述接收端设备发送第三消息，所述第三消

息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

在本公开的一个可行实施例中，所述第三消息用于指示 M 个时间单位内的第二消息是否包括参数指示信息，所述 M 为大于或者等于 1 的整数，所述 M 个时间单位连续或者不连续。

在本公开的一个可行实施例中，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

在本公开的一个可行实施例中，所述空域的接收器参数包括所述接收端设备的接收波束。

需要说明的是，本实施例中上述发送端设备 1000 可以是本公开实施例中方法实施例中任意实施方式的发送端设备，本公开实施例中方法实施例中发送端设备的任意实施方式都可以被本实施例中的上述发送端设备 1000 所实现，以及达到相同或相似的有益效果，此处不再赘述。

请参考图 12，图 12 是本公开实施例提供的另一种接收端设备的结构图，如图 12 所示，该接收端设备包括：处理器 1200、收发机 1210、存储器 1220、用户接口 1230 和总线接口，其中：

处理器 1200，用于读取存储器 1220 中的程序，执行下列过程：

通过收发机 1210 接收端设备接收发送端设备发送的与第一消息关联的第二消息；

根据所述第二消息，确定解码所述第一消息的目标接收器参数；

根据所述目标接收器参数对所述发送端设备发送的所述第一消息进行解码。

其中，收发机 1210，用于在处理器 1200 的控制下接收和发送数据。

在图 12 中，总线架构可以包括任意数量的互联的总线和桥，具体由处理器 1200 代表的一个或多个处理器和存储器 1220 代表的存储器的各种电路链接在一起。总线架构还可以将诸如外围设备、稳压器和功率管理电路等之类的各种其他电路链接在一起，这些都是本领域所公知的，因此，本文不再对

其进行进一步描述。总线接口提供接口。收发机 1210 可以是多个元件，即包括发送机和接收机，提供用于在传输介质上与各种其他装置通信的单元。针对不同的用户设备，用户接口 1230 还可以是能够外接内接需要设备的接口，连接的设备包括但不限于小键盘、显示器、扬声器、麦克风、操纵杆等。

处理器 1200 负责管理总线架构和通常的处理，存储器 1220 可以存储处理器 1200 在执行操作时所使用的数据。

在本公开的一个可行实施例中，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端设备默认的接收器参数。

在本公开的一个可行实施例中，所述接收端设备默认的接收器参数包括：

所述接收端设备当前使用的接收器参数、所述接收端设备接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端设备向所述发送端设备上报时间最近的发送器参数对应的接收器参数。

在本公开的一个可行实施例中，所述参数指示信息显式或者隐式指示所述目标接收器参数。

在本公开的一个可行实施例中，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端设备选择的发送器参数，所述接收端设备将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

在本公开的一个可行实施例中，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

在本公开的一个可行实施例中，所述参数切换指示集对应的调度时间单位在时域上周期性存在；和/或

所述参数切换指示集对应的调度时间单位由所述发送端设备半静态或半

持续配置，并通知所述接收端设备。

在本公开的一个可行实施例中，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前，所述根据所述目标接收器参数对所述第一消息进行解码，包括：

若所述第二消息包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示信息，则根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息不包括参数指示信息，则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段指示没有参数指示信息或者没有参数改变，则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

在本公开的一个可行实施例中，处理器 1200 还用于：

通过收发机 1210 接收所述发送端设备发送的第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

在本公开的一个可行实施例中，所述第三消息用于指示 M 个时间单位内的第二消息是否包括参数指示信息，所述 M 为大于或者等于 1 的整数， 所述 M 个时间单位连续或者不连续。

在本公开的一个可行实施例中，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

在本公开的一个可行实施例中，所述空域的接收器参数包括所述接收端设备的接收波束。

需要说明的是，本实施例中上述接收端设备可以是图 1-图 7 所示的实施例中的终端，图 1-图 7 所示实施例中接收端设备的任意实施方式都可以被本实施例中的上述接收端设备所实现，以及达到相同或相似的有益效果，此处不再赘述。

请参考图 13，图 13 是本公开实施例提供的另一种发送端设备的结构图，如图 13 所示，该发送端设备包括：处理器 1300、收发机 1310、存储器 1320、用户接口 1330 和总线接口，其中：

处理器 1300，用于读取存储器 1320 中的程序，执行下列过程：

通过收发机 1310 向接收端设备发送与第一消息关联的第二消息，所述第二消息用于所述接收端设备确定解码所述第一消息的目标接收器参数；

通过收发机 1310 向所述接收端设备发送所述第一消息。

其中，收发机 1310，用于在处理器 1300 的控制下接收和发送数据。

在图 13 中，总线架构可以包括任意数量的互联的总线和桥，具体由处理器 1300 代表的一个或多个处理器和存储器 1320 代表的存储器的各种电路链接在一起。总线架构还可以将诸如外围设备、稳压器和功率管理电路等之类的各种其他电路链接在一起，这些都是本领域所公知的，因此，本文不再对

其进行进一步描述。总线接口提供接口。收发机 1310 可以是多个元件，即包括发送机和接收机，提供用于在传输介质上与各种其他装置通信的单元。针对不同的用户设备，用户接口 1330 还可以是能够外接内接需要设备的接口，连接的设备包括但不限于小键盘、显示器、扬声器、麦克风、操纵杆等。

处理器 1300 负责管理总线架构和通常的处理，存储器 1320 可以存储处理器 1300 在执行操作时所使用的数据。

在本公开的一个可行实施例中，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端设备默认的接收器参数。

在本公开的一个可行实施例中，所述接收端设备默认的接收器参数包括：

所述接收端设备当前使用的接收器参数、所述接收端设备接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端设备向所述发送端设备上报时间最近的发送器参数对应的接收器参数。

在本公开的一个可行实施例中，所述参数指示信息显式或者隐式指示所述目标接收器参数。

在本公开的一个可行实施例中，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端设备选择的发送器参数，所述接收端设备将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

在本公开的一个可行实施例中，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

在本公开的一个可行实施例中，所述参数切换指示集对应的调度时间单位在时域上周期性存在；和/或

所述参数切换指示集对应的调度时间单位由所述发送端设备半静态或半

持续配置，并通知所述接收端设备。

在本公开的一个可行实施例中，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前。

在本公开的一个可行实施例中，处理器 1300 还用于：

通过收发机 1310 向所述接收端设备发送第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

在本公开的一个可行实施例中，所述第三消息用于指示 M 个时间单位内的第二消息是否包括参数指示信息，所述 M 为大于或者等于 1 的整数， 所述 M 个时间单位连续或者不连续。

在本公开的一个可行实施例中，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

在本公开的一个可行实施例中，所述空域的接收器参数包括所述接收端设备的接收波束。

需要说明的是，本实施例中上述发送端设备可以是图 1-图 7 所示的实施例中的发送端设备，图 1-图 7 所示实施例中发送端设备的任意实施方式都可以被本实施例中的上述发送端设备所实现，以及达到相同或相似的有益效果，此处不再赘述。

在本申请所提供的几个实施例中，应该理解到，所揭露方法和装置，可以通过其它的方式实现。例如，以上所描述的装置实施例仅仅是示意性的。例如，所述单元的划分，仅仅为一种逻辑功能划分，实际实现时可以有另外的划分方式，例如多个单元或组件可以结合或者可以集成到另一个系统，或一些特征可以忽略，或不执行。另一点，所显示或讨论的相互之间的耦合或直接耦合或通信连接可以是通过一些接口，装置或单元的间接耦合或通信连接，可以是电性，机械或其它的形式。

另外，在本公开各个实施例中的各功能单元可以集成在一个处理单元中，也可以是各个单元单独物理包括，也可以两个或两个以上单元集成在一个单元中。上述集成的单元既可以采用硬件的形式实现，也可以采用硬件加软件功能单元的形式实现。

上述以软件功能单元的形式实现的集成的单元，可以存储在一个计算机可读取存储介质中。上述软件功能单元存储在一个存储介质中，包括若干指令用以使得一台计算机设备（可以是个人计算机，服务器，或者网络设备等）执行本公开各个实施例所述收发方法的部分步骤。而前述的存储介质包括：U 盘、移动硬盘、只读存储器（Read-Only Memory，简称 ROM）、随机存取存储器（Random Access Memory，简称 RAM）、磁碟或者光盘等各种可以存储程序代码的介质。

以上所述是本公开的优选实施方式，应当指出，对于本技术领域的普通技术人员来说，在不脱离本公开所述原理的前提下，还可以作出若干改进和润饰，这些改进和润饰也应视为本公开的保护范围。

权 利 要 求 书

1. 一种消息解码方法，包括：

接收端设备接收发送端设备发送的与第一消息关联的第二消息；

所述接收端设备根据所述第二消息，确定解码所述第一消息的目标接收器参数；以及

所述接收端设备根据所述目标接收器参数对所述发送端设备发送的所述第一消息进行解码。

2. 如权利要求 1 所述的方法，其中，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端设备默认的接收器参数。

3. 如权利要求 2 所述的方法，其中，所述接收端设备默认的接收器参数包括：

所述接收端设备当前使用的接收器参数、所述接收端设备接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端设备向所述发送端设备上报时间最近的发送器参数对应的接收器参数。

4. 如权利要求 2 或 3 所述的方法，其中，所述参数指示信息显式或者隐式指示所述目标接收器参数。

5. 如权利要求 4 所述的方法，其中，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端设备选择的发送器参数，所述接收端设备将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

6. 如权利要求 1-5 中任一项所述的方法，其中，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

7. 如权利要求 6 所述的方法，其中，所述参数切换指示集对应的调度时间单位在时域上周期性存在；和/或

所述参数切换指示集对应的调度时间单位由所述发送端设备半静态或半持续配置，并通知所述接收端设备。

8. 如权利要求 1-5 中任一项所述的方法，其中，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前，所述接收端设备根据所述目标接收器参数对所述第一消息进行解码，包括：

若所述第二消息包括参数指示信息，则所述接收端设备根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示信息，则所述接收端设备丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示信息，则所述接收端设备根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息不包括参数指示信息，则所述接收端设备根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端设备根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端设备丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端设备根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段指示没有参数指示信息或者没有参数改变，则所述接收端设备根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

9. 如权利要求 1-5 中任一项所述的方法，其中，所述方法还包括：

所述接收端设备接收所述发送端设备发送的第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

10. 如权利要求 9 所述的方法，其中，所述第三消息用于指示 M 个时间单位内的第二消息是否包括参数指示信息，所述 M 为大于或者等于 1 的整数，所述 M 个时间单位连续或者不连续。

11. 如权利要求 1-5 中任一项所述的方法，其中，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

12. 如权利要求 11 所述的方法，其中，所述空域的接收器参数包括所述接收端设备的接收波束。

13. 一种消息解码方法，包括：

发送端设备向接收端设备发送与第一消息关联的第二消息，所述第二消息用于所述接收端设备确定解码所述第一消息的目标接收器参数；以及

所述发送端设备向所述接收端设备发送所述第一消息。

14. 如权利要求 13 所述的方法，其中，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端设备默认的接收器参数。

15. 如权利要求 14 所述的方法，其中，所述接收端设备默认的接收器参数包括：

所述接收端设备当前使用的接收器参数、所述接收端设备接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端设备向所述发送端设备上报时间最近的发送器参数对应的接收器参数。

16. 如权利要求 14 或 15 所述的方法，其中，所述参数指示信息显式或者隐式指示所述目标接收器参数。

17. 如权利要求 16 所述的方法，其中，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端设备选择的发送器参数，所述接收端设备将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

18. 如权利要求 13-17 中任一项所述的方法，其中，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

19. 如权利要求 18 所述的方法，其中，所述参数切换指示集对应的调度时间单位在时域上周期性存在；和/或

所述参数切换指示集对应的调度时间单位由所述发送端设备半静态或半持续配置，并通知所述接收端设备。

20. 如权利要求 13-17 中任一项所述的方法，其中，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前。

21. 如权利要求 13-17 中任一项所述的方法，其中，所述方法还包括：

所述发送端设备向所述接收端设备发送第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

22. 如权利要求 21 所述的方法，其中，所述第三消息用于指示 M 个时间单位内的第二消息是否包括参数指示信息，所述 M 为大于或者等于 1 的整数，所述 M 个时间单位连续或者不连续。

23. 如权利要求 13-17 中任一项所述的方法，其中，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

24. 如权利要求 23 所述的方法，其中，所述空域的接收器参数包括所述接收端设备的接收波束。

25. 一种接收端设备，包括：

第一接收模块，用于接收发送端设备发送的与第一消息关联的第二消息；

确定模块，用于根据所述第二消息，确定解码所述第一消息的目标接收器参数；以及

解码模块，用于根据所述目标接收器参数对所述发送端设备发送的所述第一消息进行解码。

26. 如权利要求 25 所述的接收端设备，其中，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端设备默认的接收器参数。

27. 如权利要求 25 或 26 所述的接收端设备，其中，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

28. 如权利要求 25 或 26 所述的接收端设备，其中，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前；

所述解码模块用于若所述第二消息包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示信息，则根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息不包括参数指示信息，则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示字段，且所述参数指示字段指示没有参数指示信息或者没有参数改变，则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

29. 如权利要求 25 或 26 所述的接收端设备，其中，所述接收端设备还包括：

第二接收模块，用于接收所述发送端设备发送的第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

30. 一种发送端设备，包括：

第一发送模块，用于发送端设备向接收端设备发送与第一消息关联的第二消息，所述第二消息用于所述接收端设备确定解码所述第一消息的目标接收器参数；以及

第二发送模块，用于向所述接收端设备发送所述第一消息。

31. 如权利要求 30 所述的发送端设备，其中，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端设备默认的接收器参数。

32. 如权利要求 30 或 31 所述的发送端设备，其中，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

33. 如权利要求 30 或 31 所述的发送端设备，其中，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前。

34. 如权利要求 30 或 31 所述的发送端设备，其中，所述发送端设备还包括：

第三发送模块，用于向所述接收端设备发送第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

35. 一种接收端设备，包括：处理器、存储器及存储在所述存储器上并可在所述处理器上运行的计算机程序，所述计算机程序被所述处理器执行时实现如权利要求 1 至 12 中任一项所述的消息解码方法中的步骤。

36. 一种发送端设备，包括：处理器、存储器及存储在所述存储器上并可在所述处理器上运行的计算机程序，所述计算机程序被所述处理器执行时实现如权利要求 13 至 24 中任一项所述的消息解码方法中的步骤。

37. 一种计算机可读存储介质，所述计算机可读存储介质上存储有计算

机程序，所述计算机程序被处理器执行时实现如权利要求 1 至 12 中任一项所述的消息解码方法中的步骤。

38. 一种计算机可读存储介质，所述计算机可读存储介质上存储有计算机程序，所述计算机程序被处理器执行时实现如权利要求 13 至 24 中任一项所述的消息解码方法中的步骤。

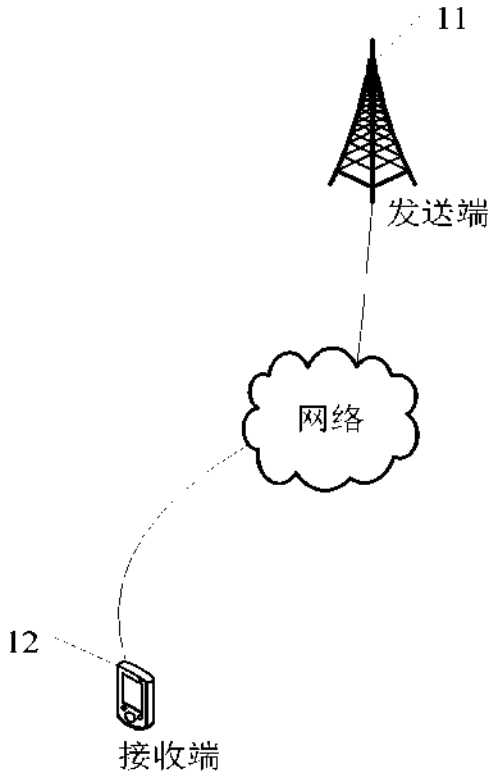

11
发送端
网络
12
接收端

图 1

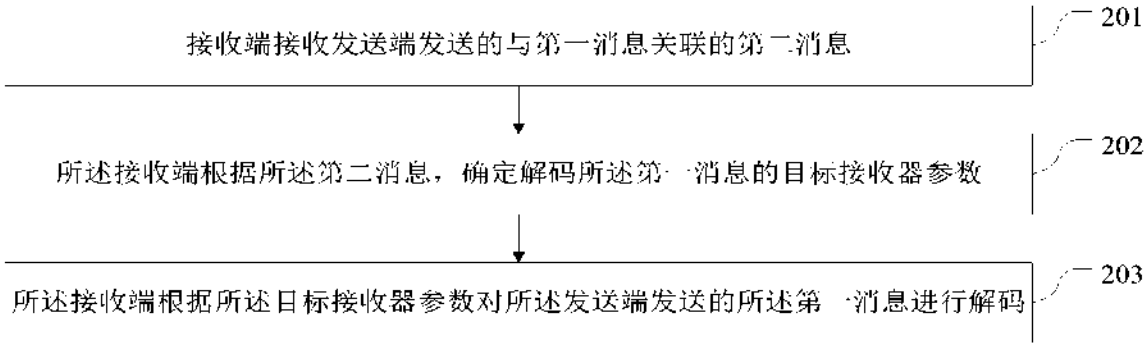

接收端接收发送端发送的与第一消息关联的第二消息
201
所述接收端根据所述第二消息，确定解码所述第一消息的目标接收器参数
202
所述接收端根据所述目标接收器参数对所述发送端发送的所述第一消息进行解码
203

图 2

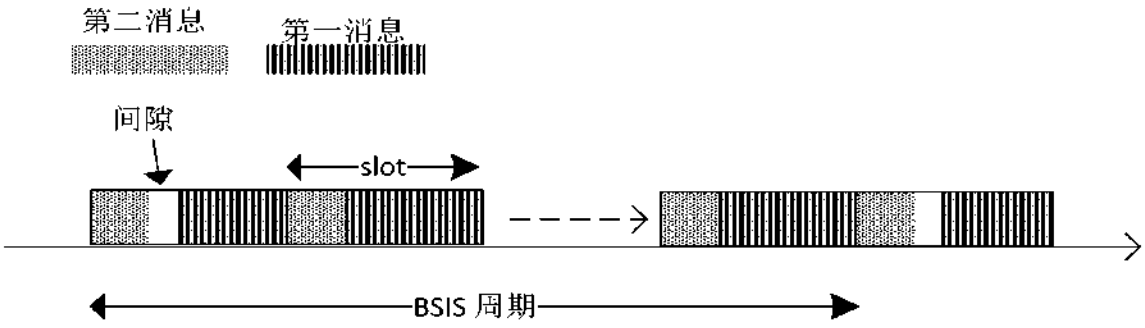

第二消息
第一消息
间隙
slot
BSIS 周期

图 3

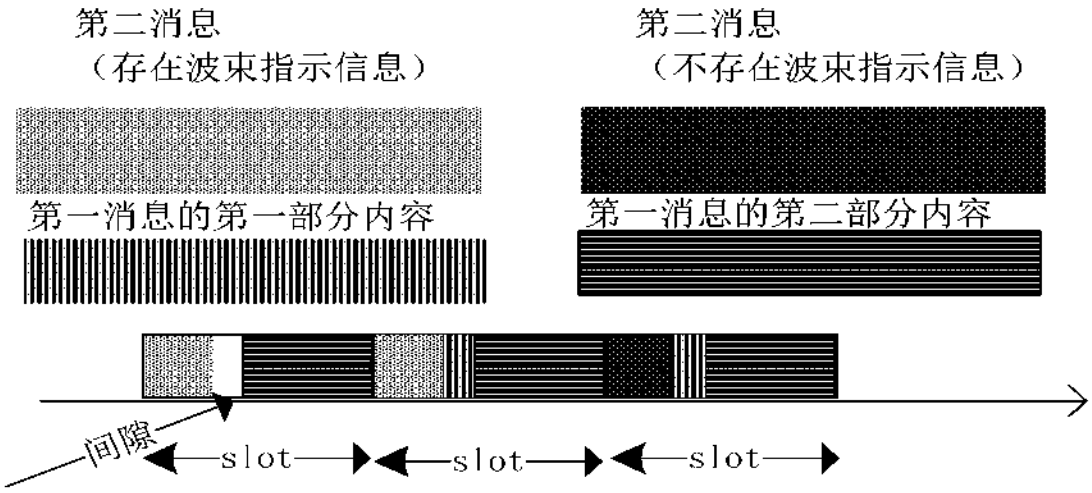

第二消息
（存在波束指示信息）
第二消息
（不存在波束指示信息）
第一消息的第一部分内容
第一消息的第二部分内容
间隙
slot
slot
slot

图 4

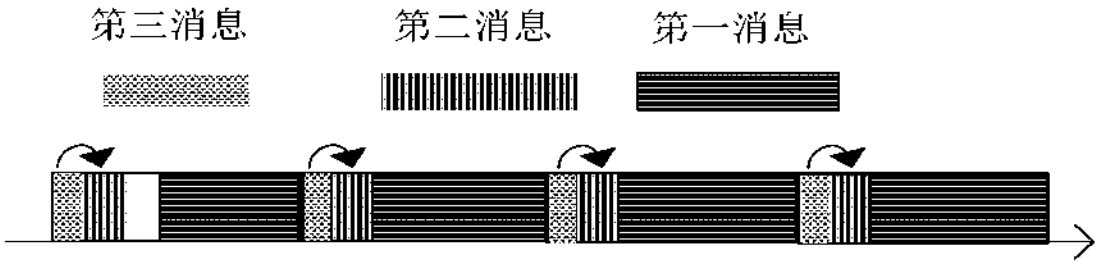

第三消息
第二消息
第一消息

图 5

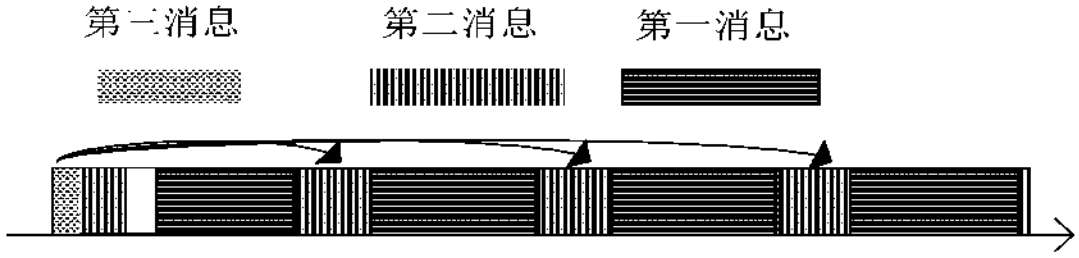

第三消息
第二消息
第一消息

图 6

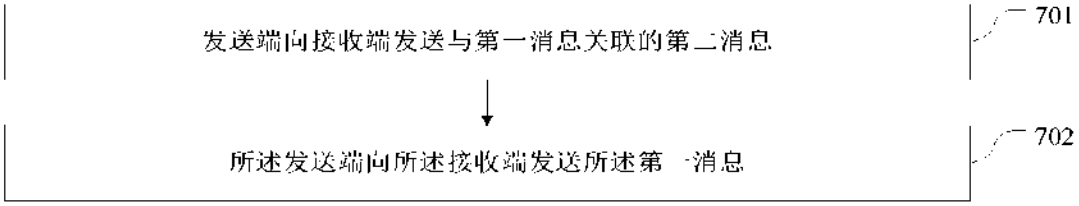

发送端向接收端发送与第一消息关联的第二消息
701
所述发送端向所述接收端发送所述第一消息
702

图 7

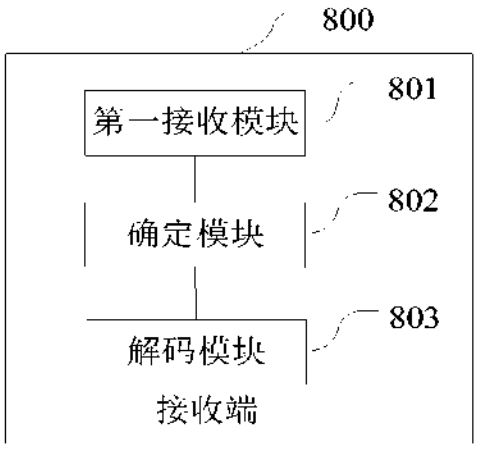

800
801
第一接收模块
802
确定模块
803
解码模块
接收端

图 8

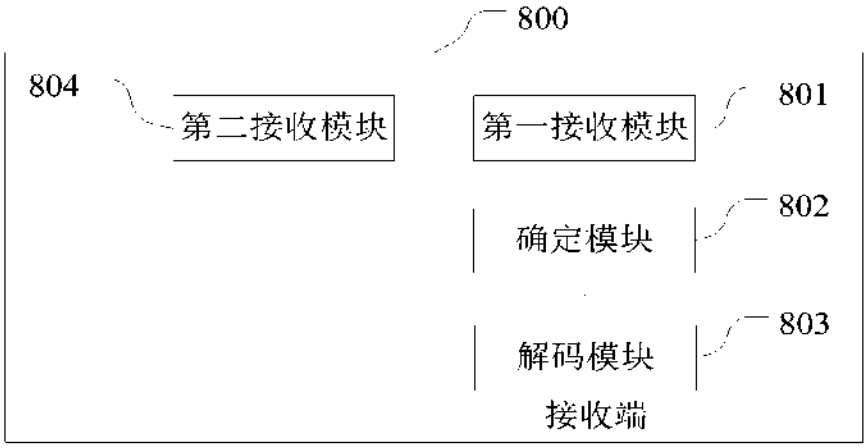

800
804
第二接收模块
第一接收模块
801
802
确定模块
803
解码模块
接收端

图 9

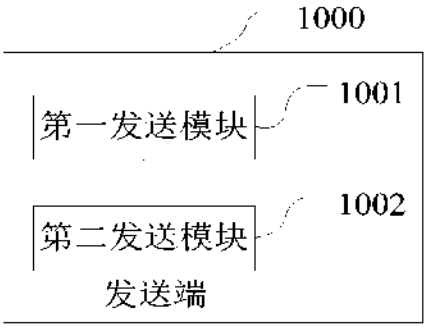

1000
1001
第一发送模块
1002
第二发送模块
发送端

图 10

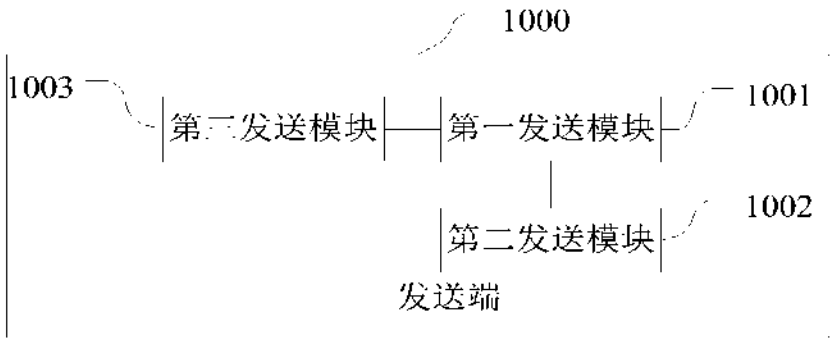

1000
1003
第三发送模块
第一发送模块
1001
1002
第二发送模块
发送端

图 11

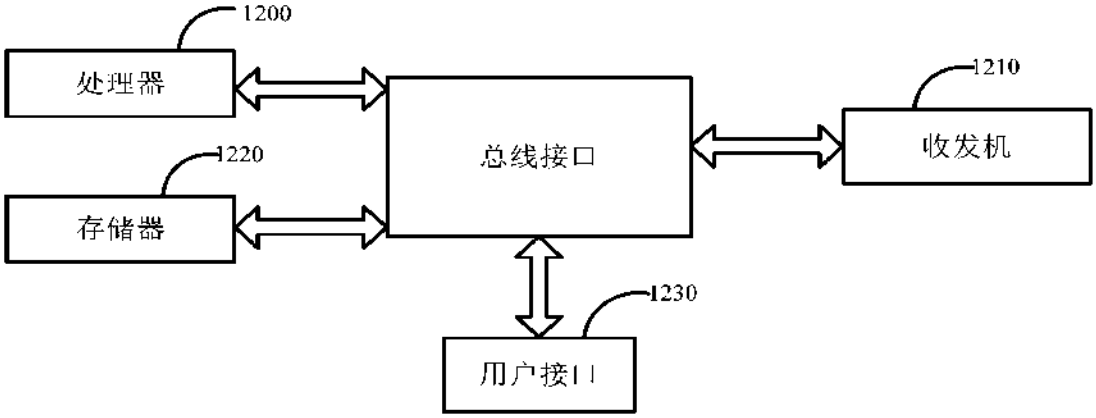

1200
处理器
1210
总线接口
收发机
1220
存储器
1230
用户接口

图 12

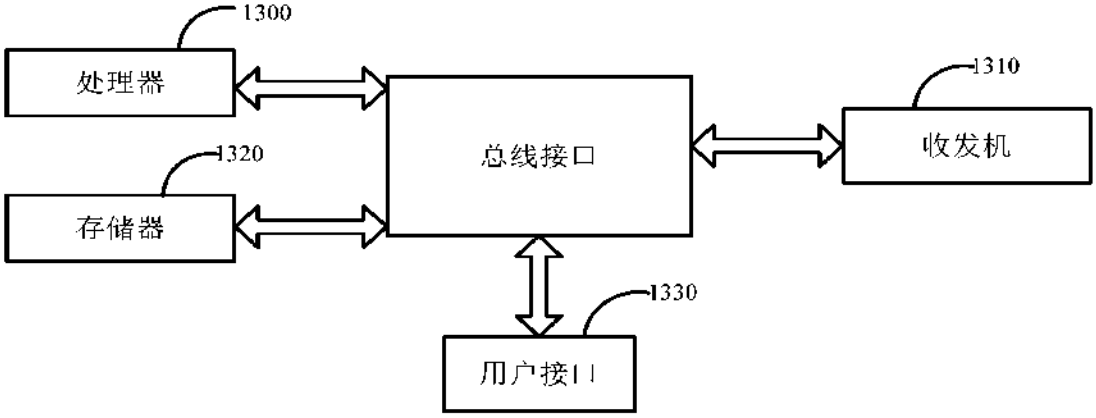

1300
处理器
1310
总线接口
收发机
1320
存储器
1330
用户接口

图 13

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2018/082472

A. CLASSIFICATION OF SUBJECT MATTER

H04L 29/02 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04L; H04W; H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNPAT, CNKI, EPODOC, WPI, 3GPP: 解码, 盲检, 检测, 指示, 推荐, 通知, 接收器参数, 接收参数, 波束, decod???, indicat???, inform???, beam, receiv+, parameter

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CATT, "Beam Management for Control and Data Channel", 3GPP TSG RAN WG1 AH_NR Meeting R1-1700192, 20 January 2017 (20.01.2017), section 2	1-38
X	CATT, "Beamforming for Data and Control Channel", 3GPP TSG RAN WG1 Meeting #87 R1-1611386, 18 November 2016 (18.11.2016), section 2	1-38
A	SONY, "RACH Procedure for Multi-beam Operation", 3GPP TSG RAN WG1 Meeting #88bis R1-1705212, 07 April 2017 (07.04.2017), entire document	1-38
A	INTEL CORPORATION, "On Beam Indication on Control and Data Channel", 3GPP TSG RAN WG1 #88 R1-1702200, 17 February 2017 (17.02.2017), entire document	1-38
A	CN 104380140 A (TELEFONAKTIEBOLAGET LM ERICSSON), 25 February 2015 (25.02.2015), entire document	1-38
A	EP 2661033 A2 (MEDIA TEK SINGAPORE PTE LTD.), 06 November 2013 (06.11.2013), entire document	1-38

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
05 June 2018	27 June 2018
Name and mailing address of the ISA State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No. (86-10) 62019451	Authorized officer LIU, Hanyan Telephone No. 86-010-53961659

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2018/082472

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2016066536 A1 (SONY CORPORATION et al.), 06 May 2016 (06.05.2016), entire document	1-38

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2018/082472

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 104380140 A	25 February 2015	US 2016195603 A1	07 July 2016
		WO 2013185322 A1	19 December 2013
		EP 2748633 A1	02 July 2014
EP 2661033 A2	06 November 2013	US 2016191136 A1	30 June 2016
		US 2013343211 A1	26 December 2013
WO 2016066536 A1	06 May 2016	CN 107079454 A	18 August 2017
		US 2017303255 A1	19 October 2017
		JP 2017533671 A	09 November 2017
		EP 3213574 A1	06 September 2017

Form PCT/ISA/210 (patent family annex) (January 2015)

国际检索报告

国际申请号
PCT/CN2018/082472

A. 主题的分类

H04L 29/02(2006.01)i

按照国际专利分类(IPC)或者同时按照国家分类和IPC两种分类

B. 检索领域

检索的最低限度文献(标明分类系统和分类号)

H04L; H04W; H04Q

包含在检索领域中的除最低限度文献以外的检索文献

在国际检索时查阅的电子数据库(数据库的名称，和使用的检索词（如使用）)

CNPAT, CNKI, EPODOC, WPI, 3GPP: 解码, 盲检, 检测, 指示, 推荐, 通知, 接收器参数, 接收参数, 波束, decod???, ind?cat???, inform???, beam, receiv+, parameter

C. 相关文件

类 型*	引用文件，必要时，指明相关段落	相关的权利要求
X	CATT. "Beam management for control and data channel" 3GPP TSG RAN WG1 AH NR Meeting R1-1700192, 2017年 1月 20日 (2017-01-20), 第2节	1-38
X	CATT. "Beamforming for data and control channel" 3GPP TSG RAN WG1 Meeting #87 R1-1611386, 2016年 11月 18日 (2016-11-18), 第2节	1-38
A	SONY. "RACH Procedure for Multi-beam Operation" 3GPP TSG RAN WG1 Meeting #88bis R1-1705212, 2017年 4月 7日 (2017-04-07), 全文	1-38
A	INTEL CORPORATION. "On beam indication on control and data channel" 3GPP TSG RAN WG1 #88 R1-1702200, 2017年 2月 17日 (2017-02-17), 全文	1-38
A	CN 104380140 A (爱立信中国通信有限公司) 2015年 2月 25日 (2015-02-25) 全文	1-38
A	EP 2661033 A2 (MEDIA TEK SINGAPORE PTE LTD.) 2013年 11月 6日 (2013-11-06) 全文	1-38

☑ 其余文件在C栏的续页中列出。　　☑ 见同族专利附件。

* 引用文件的具体类型:

"A" 认为不特别相关的表示了现有技术一般状态的文件

"E" 在国际申请日的当天或之后公布的在先申请或专利

"L" 可能对优先权要求构成怀疑的文件，或为确定另一篇引用文件的公布日而引用的或者因其他特殊理由而引用的文件（如具体说明的）

"O" 涉及口头公开、使用、展览或其他方式公开的文件

"P" 公布日先于国际申请日但迟于所要求的优先权日的文件

"T" 在同请日或优先权日之后公布，与申请不相抵触，但为了理解发明之理论或原理的在后文件

"X" 特别相关的文件，单独考虑该文件，认定要求保护的发明不是新颖的或不具有创造性

"Y" 特别相关的文件，当该文件与另一篇或者多篇该类文件结合并且这种结合对于本领域技术人员为显而易见时，要求保护的发明不具有创造性

"&" 同族专利的文件

国际检索实际完成的日期	国际检索报告邮寄日期
2018年 6月 5日	2018年 6月 27日
ISA/CN的名称和邮寄地址 中华人民共和国国家知识产权局(ISA/CN) 中国北京市海淀区蓟门桥西土城路6号 100088 传真号 (86-10)62019451	受权官员 刘寒艳 电话号码 86-010-53961659

表 PCT/ISA/210 (第2页) (2015年1月)

国际检索报告

国际申请号
PCT/CN2018/082472

C. 相关文件

类 型*	引用文件，必要时，指明相关段落	相关的权利要求
A	WO 2016066536 A1 (SONY CORPORATION等) 2016年 5月 6日 (2016 - 05 - 06) 全文	1 38

表 PCT/ISA/210 (第2页) (2015年1月)

国际检索报告
关于同族专利的信息

国际申请号
PCT/CN2018/082472

检索报告引用的专利文件			公布日（年/月/日）	同族专利			公布日（年/月/日）
CN	104380140	A	2015年 2月 25日	US	2016195603	A1	2016年 7月 7日
				WO	2013185322	A1	2013年 12月 19日
				EP	2748633	A1	2014年 7月 2日
EP	2661033	A2	2013年 11月 6日	US	2016191136	A1	2016年 6月 30日
				US	2013343211	A1	2013年 12月 26日
WO	2016066536	A1	2016年 5月 6日	CN	107079454	A	2017年 8月 18日
				US	2017303255	A1	2017年 10月 19日
				JP	2017533671	A	2017年 11月 9日
				EP	3213574	A1	2017年 9月 6日

表 PCT/ISA/210（同族专利附件）（2015年1月）

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(19) World Intellectual Property Organization
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H04W 4/00 (2009.01)

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PCT/US2016/060554

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(30) Priority Data:

62/250,803	4 November 2015 (04.11.2015)	US
62/290,790	3 February 2016 (03.02.2016)	US
62/308,042	14 March 2016 (14.03.2016)	US

(71) Applicant: **INTERDIGITAL PATENT HOLDINGS, INC.** [US/US]; 200 Bellevue Parkway, Suite 300, Wilmington, Delaware 19809 (US).

(72) Inventors: **LEE, Moon-il**; 2 Huntington Quadrangle, 4th Floor, South Wing, Melville, New York 11747-4508 (US). **STERN-BERKOWITZ, Janet A.**; 2 Huntington Quadrangle, 4th Floor, South Wing, Melville, New York 11747-4508 (US). **AHN, Jaehyun**; 5th F Bethel Building, 21-6 Teheran-ro 34gil, Gangnam-gu, Seoul 06222 (KR). **ADJAKPLE, Pascal, M.**; 2 Huntington Quadrangle, 4th Floor, South Wing, Melville, New York 11747-4508 (US).

(74) Agent: **DUNSAY, Jonathan M.**; Volpe and Koenig, P.C., 30 South 17th Street, United Plaza, Suite 1800, Philadelphia, PA 19103 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: METHODS AND MACHINE TYPE COMMUNICATION, MTC, DEVICE, IMPLEMENTING PAGING PROCEDURES FOR REDUCED BANDWITH MTC DEVICES

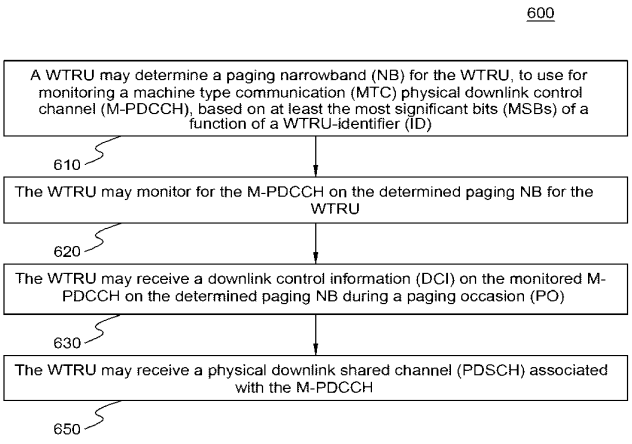


FIG. 6

(57) Abstract: Methods for paging for reduced bandwidth wireless transmit/receive units, WTRUs, in machine type communication, MTC, are provided. A WTRU determines (610) a paging narrowband, NB, for the WTRU, to use for monitoring an MTC physical downlink control channel, M-PDCCH, based on at least the most significant bits, MSBs, of a function of a WTRU-identifier, WTRU-ID. The WTRU monitors (620) for the M-PDCCH on the determined paging NB for the WTRU. The WTRU then receives (630) a downlink control information, DCI, on the monitored M-PDCCH on the determined paging NB during a paging occasion, PO.The WTRU then receives (650) a physical downlink shared channel, PDSCH, associated with the M-PDCCH. Alternatively, the WTRU monitors (420) the M-PDCCH in the M-PDCCH search space, wherein the M-PDCCH has a starting enahnced control channel element, ECCE, index for a WTRU group containing the WTR, and wherein the M-PDCCH includes (430) the DCI.

WO 2017/079574 A1

Published:

— *with international search report (Art. 21(3))*

METHODS AND MACHINE TYPE COMMUNICATION, MTC, DEVICE, IMPLEMENTING PAGING PROCEDURES FOR REDUCED BANDWITH MTC DEVICES

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 62/250,803 filed November 4, 2015, U.S. Provisional Application No. 62/290,790 filed February 3, 2016, and U.S. Provisional Application 62/308,042 filed March 14, 2016, the contents of which are hereby incorporated by reference herein.

BACKGROUND

[0002] As wireless communication systems such as Long Term Evolution (LTE) systems mature and their network deployment evolve, it may be beneficial for network operators to reduce the cost of the communication network, maintenance needs of the communication network or both. One technique to reduce the cost of the network may be to reduce the channel bandwidth and data rate used to communicate with devices.

[0003] For example, a portion of the channel bandwidth rather than the entire channel bandwidth may be supported by the devices in the network and/or the network itself when communicating with such devices. Current wireless communication systems, for example, LTE, have recently considered a bandwidth reduction for some devices including machine type communication (MTC) devices to some level, for example, 1.4 megahertz (MHz).

SUMMARY

[0004] Methods for paging for reduced bandwidth wireless transmit/receive units (WTRUs) in machine type communication (MTC) are provided. A WTRU may determine a paging narrowband (NB) for the WTRU, to use for monitoring an MTC physical downlink control channel (M-PDCCH), based on at least the most significant bits (MSBs) of a function of a WTRU-identifier (WTRU-ID). The WTRU may monitor for the M-PDCCH on the

determined paging NB for the WTRU. The WTRU may then receive a downlink control information (DCI) on the monitored M-PDCCH on the determined paging NB during a paging occasion (PO). The DCI may include a scrambled cyclic redundancy check (CRC). The CRC may be scrambled with a Paging Radio Network Temporary Identifier (P-RNTI). Also, the WTRU may receive a physical downlink shared channel (PDSCH) associated with the M-PDCCH.

[0005] In an example, the WTRU may determine the paging NB based on at least the 3 MSBs of a function of the WTRU-ID. In another example, the WTRU may determine the paging NB based on at least the 4 MSBs of a function of the WTRU-ID.

[0006] Further, the PDSCH may be scheduled by the DCI. In an example, the DCI may include a paging message. In another example, the DCI may include system information update related information. In a further example, the PDSCH may include a paging message. In an additional example, the PDSCH may include system information update related information.

[0007] In addition, a WTRU may monitor for a M-PDCCH in an M-PDCCH search space. The WTRU may receive an M-PDCCH in the M-PDCCH search space, wherein the M-PDCCH has a starting enhanced control channel element (ECCE) index for the WTRU group containing the WTRU. Further, the WTRU may decode the M-PDCCH, wherein the M-PDCCH includes a DCI. In addition, the WTRU may receive a PDSCH associated with the M-PDCCH.

[0008] Further, the WTRU may receive, decode, and/or demodulate the PDSCH based on the DCI, wherein the PDSCH includes a paging message. The WTRU may then change operations based on the paging message. For example, the WTRU may change from idle mode to connected mode based on the paging message. In an example, the ECCE aggregation level may be 16.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] A more detailed understanding may be had from the following description, given by way of example in conjunction with the accompanying drawings wherein:

[0010] FIG. 1A is a system diagram of an example communications system in which one or more disclosed embodiments may be implemented;

[0011] FIG. 1B is a system diagram of an example wireless transmit/receive unit (WTRU) that may be used within the communications system illustrated in FIG. 1A;

[0012] FIG. 1C is a system diagram of an example radio access network and an example core network that may be used within the communications system illustrated in FIG. 1A;

[0013] FIG. 2 is an exemplary timing diagram which illustrates hyper frames and paging within hyper frames;

[0014] FIG. 3 is an exemplary diagram which illustrates WTRU group-specific starting enhanced control channel element (ECCE) indexes;

[0015] FIG. 4 is a diagram of an example flow chart showing a WTRU receiving a machine type communication (MTC) physical downlink control channel (M-PDCCH) with a starting ECCE index based on the WTRU group of the WTRU;

[0016] FIG. 5 is an exemplary diagram which illustrates WTRU group-specific random ECCE ordering;

[0017] FIG. 6 is a diagram of an example flow chart showing a WTRU using a WTRU-ID to determine a paging narrowband (NB) to use for monitoring an M-PDCCH;

[0018] FIG. 7 is a diagram illustrating an example of code-block segment multiplexing in a physical downlink shared channel (PDSCH), which may be scheduled by an associated physical downlink control channel (PDCCH) in a paging occasion (PO); and

[0019] FIG. 8 is a diagram illustrating an example of code-block segments transmitted via multiple PDSCHs, which may be scheduled by an associated PDCCH in a PO.

DETAILED DESCRIPTION

[0020] FIG. 1A is a diagram of an example communications system 100 in which one or more disclosed embodiments may be implemented. The communications system 100 may be a multiple access system that provides content, such as voice, data, video, messaging, broadcast, etc., to multiple wireless users. The communications system 100 may enable multiple wireless users to access such content through the sharing of system resources, including wireless bandwidth. For example, the communications systems 100 may employ one or more channel access methods, such as code division multiple access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), orthogonal FDMA (OFDMA), single-carrier FDMA (SC-FDMA), and the like.

[0021] As shown in FIG. 1A, the communications system 100 may include wireless transmit/receive units (WTRUs) 102a, 102b, 102c, 102d, a radio access network (RAN) 104, a core network 106, a public switched telephone network (PSTN) 108, the Internet 110, and other networks 112, though it will be appreciated that the disclosed embodiments contemplate any number of WTRUs, base stations, networks, and/or network elements. Each of the WTRUs 102a, 102b, 102c, 102d may be any type of device configured to operate and/or communicate in a wireless environment. By way of example, the WTRUs 102a, 102b, 102c, 102d may be configured to transmit and/or receive wireless signals and may include user equipment (UE), a mobile station, a fixed or mobile subscriber unit, a pager, a cellular telephone, a personal digital assistant (PDA), a smartphone, a laptop, a netbook, a personal computer, a wireless sensor, consumer electronics, and the like.

[0022] The communications systems 100 may also include a base station 114a and a base station 114b. Each of the base stations 114a, 114b may be any type of device configured to wirelessly interface with at least one of the WTRUs 102a, 102b, 102c, 102d to facilitate access to one or more communication networks, such as the core network 106, the Internet 110, and/or the other networks 112. By way of example, the base stations 114a, 114b may be a base transceiver station (BTS), a Node-B, an eNode B, a Home

Node B, a Home eNode B, a site controller, an access point (AP), a wireless router, and the like. While the base stations 114a, 114b are each depicted as a single element, it will be appreciated that the base stations 114a, 114b may include any number of interconnected base stations and/or network elements.

[0023] The base station 114a may be part of the RAN 104, which may also include other base stations and/or network elements (not shown), such as a base station controller (BSC), a radio network controller (RNC), relay nodes, etc. The base station 114a and/or the base station 114b may be configured to transmit and/or receive wireless signals within a particular geographic region, which may be referred to as a cell (not shown). The cell may further be divided into cell sectors. For example, the cell associated with the base station 114a may be divided into three sectors. Thus, in one embodiment, the base station 114a may include three transceivers, i.e., one for each sector of the cell. In another embodiment, the base station 114a may employ multiple-input multiple-output (MIMO) technology and, therefore, may utilize multiple transceivers for each sector of the cell.

[0024] The base stations 114a, 114b may communicate with one or more of the WTRUs 102a, 102b, 102c, 102d over an air interface 116, which may be any suitable wireless communication link (for example, radio frequency (RF), microwave, infrared (IR), ultraviolet (UV), visible light, etc.). The air interface 116 may be established using any suitable radio access technology (RAT).

[0025] More specifically, as noted above, the communications system 100 may be a multiple access system and may employ one or more channel access schemes, such as CDMA, TDMA, FDMA, OFDMA, SC-FDMA, and the like. For example, the base station 114a in the RAN 104 and the WTRUs 102a, 102b, 102c may implement a radio technology such as Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access (UTRA), which may establish the air interface 116 using wideband CDMA (WCDMA). WCDMA may include communication protocols such as High-Speed Packet Access (HSPA) and/or Evolved HSPA (HSPA+). HSPA may include High-Speed Downlink Packet Access (HSDPA) and/or High-Speed Uplink Packet Access (HSUPA).

[0026] In another embodiment, the base station 114a and the WTRUs 102a, 102b, 102c may implement a radio technology such as Evolved UMTS Terrestrial Radio Access (E-UTRA), which may establish the air interface 116 using Long Term Evolution (LTE) and/or LTE-Advanced (LTE-A).

[0027] In other embodiments, the base station 114a and the WTRUs 102a, 102b, 102c may implement radio technologies such as IEEE 802.16 (i.e., Worldwide Interoperability for Microwave Access (WiMAX)), CDMA2000, CDMA2000 1X, CDMA2000 EV-DO, Interim Standard 2000 (IS-2000), Interim Standard 95 (IS-95), Interim Standard 856 (IS-856), Global System for Mobile communications (GSM), Enhanced Data rates for GSM Evolution (EDGE), GSM EDGE (GERAN), and the like.

[0028] The base station 114b in FIG. 1A may be a wireless router, Home Node B, Home eNode B, or access point, for example, and may utilize any suitable RAT for facilitating wireless connectivity in a localized area, such as a place of business, a home, a vehicle, a campus, and the like. In one embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.11 to establish a wireless local area network (WLAN). In another embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.15 to establish a wireless personal area network (WPAN). In yet another embodiment, the base station 114b and the WTRUs 102c, 102d may utilize a cellular-based RAT (for example, WCDMA, CDMA2000, GSM, LTE, LTE-A, etc.) to establish a picocell or femtocell. As shown in FIG. 1A, the base station 114b may have a direct connection to the Internet 110. Thus, the base station 114b may not be required to access the Internet 110 via the core network 106.

[0029] The RAN 104 may be in communication with the core network 106, which may be any type of network configured to provide voice, data, applications, and/or voice over internet protocol (VoIP) services to one or more of the WTRUs 102a, 102b, 102c, 102d. For example, the core network 106 may provide call control, billing services, mobile location-based services, pre-paid calling, Internet connectivity, video distribution, etc., and/or perform high-level security functions, such as user authentication. Although not shown in

FIG. 1A, it will be appreciated that the RAN 104 and/or the core network 106 may be in direct or indirect communication with other RANs that employ the same RAT as the RAN 104 or a different RAT. For example, in addition to being connected to the RAN 104, which may be utilizing an E-UTRA radio technology, the core network 106 may also be in communication with another RAN (not shown) employing a GSM radio technology.

[0030] The core network 106 may also serve as a gateway for the WTRUs 102a, 102b, 102c, 102d to access the PSTN 108, the Internet 110, and/or other networks 112. The PSTN 108 may include circuit-switched telephone networks that provide plain old telephone service (POTS). The Internet 110 may include a global system of interconnected computer networks and devices that use common communication protocols, such as the transmission control protocol (TCP), user datagram protocol (UDP) and the internet protocol (IP) in the TCP/IP internet protocol suite. The networks 112 may include wired or wireless communications networks owned and/or operated by other service providers. For example, the networks 112 may include another core network connected to one or more RANs, which may employ the same RAT as the RAN 104 or a different RAT.

[0031] Some or all of the WTRUs 102a, 102b, 102c, 102d in the communications system 100 may include multi-mode capabilities, i.e., the WTRUs 102a, 102b, 102c, 102d may include multiple transceivers for communicating with different wireless networks over different wireless links. For example, the WTRU 102c shown in FIG. 1A may be configured to communicate with the base station 114a, which may employ a cellular-based radio technology, and with the base station 114b, which may employ an IEEE 802 radio technology.

[0032] FIG. 1B is a system diagram of an example WTRU 102. As shown in FIG. 1B, the WTRU 102 may include a processor 118, a transceiver 120, a transmit/receive element 122, a speaker/microphone 124, a keypad 126, a display/touchpad 128, non-removable memory 130, removable memory 132, a power source 134, a global positioning system (GPS) chipset 136, and other peripherals 138. It will be appreciated that the WTRU 102 may include any

sub-combination of the foregoing elements while remaining consistent with an embodiment.

[0033] The processor 118 may be a general purpose processor, a special purpose processor, a conventional processor, a digital signal processor (DSP), a plurality of microprocessors, one or more microprocessors in association with a DSP core, a controller, a microcontroller, Application Specific Integrated Circuits (ASICs), Field Programmable Gate Array (FPGAs) circuits, any other type of integrated circuit (IC), a state machine, and the like. The processor 118 may perform signal coding, data processing, power control, input/output processing, and/or any other functionality that enables the WTRU 102 to operate in a wireless environment. The processor 118 may be coupled to the transceiver 120, which may be coupled to the transmit/receive element 122. While FIG. 1B depicts the processor 118 and the transceiver 120 as separate components, it will be appreciated that the processor 118 and the transceiver 120 may be integrated together in an electronic package or chip.

[0034] The transmit/receive element 122 may be configured to transmit signals to, or receive signals from, a base station (for example, the base station 114a) over the air interface 116. For example, in one embodiment, the transmit/receive element 122 may be an antenna configured to transmit and/or receive RF signals. In another embodiment, the transmit/receive element 122 may be an emitter/detector configured to transmit and/or receive IR, UV, or visible light signals, for example. In yet another embodiment, the transmit/receive element 122 may be configured to transmit and receive both RF and light signals. It will be appreciated that the transmit/receive element 122 may be configured to transmit and/or receive any combination of wireless signals.

[0035] In addition, although the transmit/receive element 122 is depicted in FIG. 1B as a single element, the WTRU 102 may include any number of transmit/receive elements 122. More specifically, the WTRU 102 may employ MIMO technology. Thus, in one embodiment, the WTRU 102 may include two or more transmit/receive elements 122 (for example, multiple

antennas) for transmitting and receiving wireless signals over the air interface 116.

[0036] The transceiver 120 may be configured to modulate the signals that are to be transmitted by the transmit/receive element 122 and to demodulate the signals that are received by the transmit/receive element 122. As noted above, the WTRU 102 may have multi-mode capabilities. Thus, the transceiver 120 may include multiple transceivers for enabling the WTRU 102 to communicate via multiple RATs, such as UTRA and IEEE 802.11, for example.

[0037] The processor 118 of the WTRU 102 may be coupled to, and may receive user input data from, the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128 (for example, a liquid crystal display (LCD) display unit or organic light-emitting diode (OLED) display unit). The processor 118 may also output user data to the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128. In addition, the processor 118 may access information from, and store data in, any type of suitable memory, such as the non-removable memory 130 and/or the removable memory 132. The non-removable memory 130 may include random-access memory (RAM), read-only memory (ROM), a hard disk, or any other type of memory storage device. The removable memory 132 may include a subscriber identity module (SIM) card, a memory stick, a secure digital (SD) memory card, and the like. In other embodiments, the processor 118 may access information from, and store data in, memory that is not physically located on the WTRU 102, such as on a server or a home computer (not shown).

[0038] The processor 118 may receive power from the power source 134, and may be configured to distribute and/or control the power to the other components in the WTRU 102. The power source 134 may be any suitable device for powering the WTRU 102. For example, the power source 134 may include one or more dry cell batteries (for example, nickel-cadmium (NiCd), nickel-zinc (NiZn), nickel metal hydride (NiMH), lithium-ion (Li-ion), etc.), solar cells, fuel cells, and the like.

[0039] The processor 118 may also be coupled to the GPS chipset 136, which may be configured to provide location information (for example, longitude and latitude) regarding the current location of the WTRU 102. In addition to, or in lieu of, the information from the GPS chipset 136, the WTRU 102 may receive location information over the air interface 116 from a base station (for example, base stations 114a, 114b) and/or determine its location based on the timing of the signals being received from two or more nearby base stations. It will be appreciated that the WTRU 102 may acquire location information by way of any suitable location-determination method while remaining consistent with an embodiment.

[0040] The processor 118 may further be coupled to other peripherals 138, which may include one or more software and/or hardware modules that provide additional features, functionality and/or wired or wireless connectivity. For example, the peripherals 138 may include an accelerometer, an e-compass, a satellite transceiver, a digital camera (for photographs or video), a universal serial bus (USB) port, a vibration device, a television transceiver, a hands free headset, a Bluetooth® module, a frequency modulated (FM) radio unit, a digital music player, a media player, a video game player module, an Internet browser, and the like.

[0041] FIG. 1C is a system diagram of the RAN 104 and the core network 106 according to an embodiment. As noted above, the RAN 104 may employ an E-UTRA radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 116. The RAN 104 may also be in communication with the core network 106.

[0042] The RAN 104 may include eNode-Bs 140a, 140b, 140c, though it will be appreciated that the RAN 104 may include any number of eNode-Bs while remaining consistent with an embodiment. The eNode-Bs 140a, 140b, 140c may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 116. In one embodiment, the eNode-Bs 140a, 140b, 140c may implement MIMO technology. Thus, the eNode-B 140a, for example, may use multiple antennas to transmit wireless signals to, and receive wireless signals from, the WTRU 102a.

[0043] Each of the eNode-Bs 140a, 140b, 140c may be associated with a particular cell (not shown) and may be configured to handle radio resource management decisions, handover decisions, scheduling of users in the uplink and/or downlink, and the like. As shown in FIG. 1C, the eNode-Bs 140a, 140b, 140c may communicate with one another over an X2 interface.

[0044] The core network 106 shown in FIG. 1C may include a mobility management entity gateway (MME) 142, a serving gateway 144, and a packet data network (PDN) gateway 146. While each of the foregoing elements are depicted as part of the core network 106, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

[0045] The MME 142 may be connected to each of the eNode-Bs 140a, 140b, 140c in the RAN 104 via an S1 interface and may serve as a control node. For example, the MME 142 may be responsible for authenticating users of the WTRUs 102a, 102b, 102c, bearer activation/deactivation, selecting a particular serving gateway during an initial attach of the WTRUs 102a, 102b, 102c, and the like. The MME 142 may also provide a control plane function for switching between the RAN 104 and other RANs (not shown) that employ other radio technologies, such as GSM or WCDMA.

[0046] The serving gateway 144 may be connected to each of the eNode Bs 140a, 140b, 140c in the RAN 104 via the S1 interface. The serving gateway 144 may generally route and forward user data packets to/from the WTRUs 102a, 102b, 102c. The serving gateway 144 may also perform other functions, such as anchoring user planes during inter-eNode B handovers, triggering paging when downlink data is available for the WTRUs 102a, 102b, 102c, managing and storing contexts of the WTRUs 102a, 102b, 102c, and the like.

[0047] The serving gateway 144 may also be connected to the PDN gateway 146, which may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, such as the Internet 110, to facilitate communications between the WTRUs 102a, 102b, 102c and IP-enabled devices.

[0048] The core network 106 may facilitate communications with other networks. For example, the core network 106 may provide the WTRUs 102a, 102b, 102c with access to circuit-switched networks, such as the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, 102c and traditional land-line communications devices. For example, the core network 106 may include, or may communicate with, an IP gateway (for example, an IP multimedia subsystem (IMS) server) that serves as an interface between the core network 106 and the PSTN 108. In addition, the core network 106 may provide the WTRUs 102a, 102b, 102c with access to the networks 112, which may include other wired or wireless networks that are owned and/or operated by other service providers.

[0049] Other network 112 may further be connected to an IEEE 802.11 based wireless local area network (WLAN) 160. The WLAN 160 may include an access router 165. The access router may contain gateway functionality. The access router 165 may be in communication with a plurality of access points (APs) 170a, 170b. The communication between access router 165 and APs 170a, 170b may be via wired Ethernet (IEEE 802.3 standards), or any type of wireless communication protocol. AP 170a is in wireless communication over an air interface with WTRU 102d.

[0050] As wireless communication systems such as LTE systems mature and their network deployment evolve, it may be beneficial for network operators to reduce the cost of the communication network, maintenance needs of the communication network or both. One technique to reduce the cost of the network may be to reduce the channel bandwidth and data rate used to communicate with devices. For example, a portion of the channel bandwidth rather than the entire channel bandwidth may be supported by the devices in the network and/or the network itself when communicating with such devices. Current wireless communication systems, for example, LTE, have recently considered a bandwidth reduction for some devices including machine type communication (MTC) devices to some level, for example, 1.4 megahertz (MHz). The considered level may enable more compatibility with legacy systems and reduce the time and/or cost of a new design, since, for

example LTE may already support operation with a system bandwidth of 1.4 MHz. Further bandwidth reduction, however, may be desirable for some devices, for example, smart watches and alarms, for example to reduce costs even further. Further reduction of the bandwidth, for example, on the order of 200 kilohertz (kHz), has been suggested. Additional system design may be needed to support operation with a reduced bandwidth which may be less compatible with legacy system operation.

[0051] A reduced bandwidth (BW) WTRU may be a WTRU which may support or may only support a certain limited BW, for example, RF BW or a certain limited number of resource blocks (RBs) in the downlink (DL) and/or uplink (UL), which may be independent of the BW of the eNode-B or cell with which the WTRU may communicate. For example, a reduced BW WTRU, which may also be referred to as a limited BW WTRU, may support or may only support a certain number of RBs, for example, 6 RBs or 1 RB, or a certain BW, for example, 1.4 MHz or 180 kHz, for transmission and/or reception. Such a WTRU may communicate with an eNode-B or cell for which the BW may be larger, for example, 20 MHz or 100 RBs.

[0052] An enhanced machine type communication (eMTC) WTRU may be a limited BW WTRU which may support a first number of RBs and/or a BW of a first bandwidth. A first number may be represented by N1 and a first bandwidth may be represented by B1. N1 may, for example, be 6 and B1 may, for example be 1.4 MHz. In an example, 6 RBs may correspond to a BW of 1.4 MHz. An eMTC WTRU may be used to represent a non-limiting example of a limited BW WTRU. Another WTRU which may be referred to as a narrowband LTE (NB-LTE) or narrowband internet of things (NB-IoT) WTRU may be a limited BW WTRU which may support a second number of RBs and/or a BW of a second bandwidth. A second number may be represented by N2 and a second bandwidth may be represented by B2. N2 may be less than N1. B2 may be less than B1. N2 may, for example, be 1 and B2 may, for example, be 180 kHz. In an example, 1 RB may correspond to a BW of 180 kHz. An NB-LTE WTRU and/or NB-IoT WTRU may be used to represent a non-limiting example of a limited BW WTRU. A narrowband (NB) WTRU may be used to

represent a non-limiting example of a WTRU or limited BW WTRU. WTRU, limited BW WTRU, BW limited WTRU, reduced BW WTRU, limited capability WTRU, low cost-MTC (LC-MTC) WTRU, low-complexity WTRU, MTC WTRU, eMTC WTRU, NB-IoT WTRU, eMTC, NB-IoT, and NB WTRU may be used interchangeably herein. An RB may be a physical RB (PRB). The terms RB and PRB may be used interchangeably herein.

[0053] A limited BW WTRU may use or require special procedures to operate in a portion of the full BW of the cell. Reduced bandwidth, limited bandwidth, and bandwidth limited may be used interchangeably herein. A WTRU which may support the full BW of a cell may be referred to as a full BW WTRU. BW may include a number of RBs and/or a location in a band such as the center of the band.

[0054] A WTRU may at least sometimes communicate, behave, or operate in a manner which may be consistent, or for example, at least partially consistent, with that of a full BW WTRU and may also at least sometimes, for example, some other times than when operating as a full BW WTRU, communicate, behave, or operate in a manner which may be consistent, or for example, at least partially consistent, with that of a reduced BW WTRU. For example, a WTRU which may support the full BW of a cell may communicate, behave, or operate in a manner which may be consistent, or for example, at least partially consistent with that of a reduced BW WTRU at certain times such as when it may be coverage limited or when it may operate in a coverage enhanced mode. A WTRU, such as this example WTRU, may be or may be considered a full BW WTRU at times and/or a reduced BW WTRU at times, for example at other times.

[0055] A WTRU may be or may be considered to be a reduced BW WTRU while it may, may need to, or may intend to behave or operate like, or for example, at least partially like, a reduced BW WTRU. A WTRU that may communicate, for example, with an eNode-B, behave, or operate in a manner which may be consistent, or for example, at least partially consistent with that of a reduced BW WTRU may be or may be considered to be a reduced BW WTRU, for example at least sometimes, such as when the WTRU may

communicate, behave, or operate in a manner which may be consistent, or for example, at least partially consistent, with that of a reduced BW WTRU.

[0056] It should be noted that the terms eNB, eNode-B and cell may be used interchangeably herein. Embodiments and examples described for reduced BW WTRUs may be applied to coverage limited WTRUs and vice versa.

[0057] Coverage limited and reduced BW WTRUs are examples of WTRUs which may use the example methods and procedures described herein. These coverage limited and reduced BW WTRUs are non-limiting examples of such example WTRUs. Application to a WTRU of any kind, with any capabilities, or reduced capabilities may still be consistent with the example methods and procedures described herein.

[0058] The term physical downlink control channel (PDCCH) may be replaced by enhanced PDCCH (EPDCCH), machine type communication (MTC) physical downlink control channel (M-PDCCH), or another DL control channel, and vice versa and still be consistent with the example methods and procedures described herein. The terms component carrier (CC) and serving cell may be used interchangeably herein. The terms WTRU, WTRU medium access control (MAC) entity, and MAC entity may be used interchangeably herein.

[0059] The terms a WTRU, a certain WTRU or certain WTRUs may be replaced by at least a WTRU, at least a certain WTRU or at least certain WTRUs and still be consistent with the example methods and procedures described herein. The phrase intended for may be replaced by at least intended for or intended for at least and still be consistent with the example methods and procedures described herein.

[0060] The example methods and procedures described herein may be described for a random access response (RAR), paging channel (PCH), or physical downlink shared channel (PDSCH) carrying or which may carry a RAR or PCH. These are used as non-limiting examples. RAR may be replaced by PCH or PCH PDSCH and vice versa and still be consistent with the example methods and procedures described herein. The channel or other

contents which may be carried by the PDSCH may be replaced with any channel or contents and still be consistent with the example methods and procedures described herein.

[0061] Example methods and procedures involving coverage enhancement (CE) are disclosed herein. A coverage enhanced WTRU may be a WTRU which may require coverage enhancement or a WTRU which may employ coverage enhancement techniques or may support a CE mode. The terms coverage limited WTRU and coverage enhanced WTRU may be used interchangeably herein. CE may refer to extending or improving coverage, for example for low data rate applications. CE may refer to extending or improving coverage, for example to enable communication with devices with reduced capabilities such as devices employing a single receiver or devices using a reduced bandwidth. CE may refer to extending or improving coverage, for example to enable communication with devices for which communication may be hampered such as indoor devices or devices in basements where penetration losses may impede communication. In at least some examples, CE may involve extending or improving coverage by reducing the data rate. In at least some examples, CE may involve extending or improving coverage by employing repetition techniques. In at least some examples, CE may be used for MTC applications. In at least some examples, CE may be used for NB or NB-IoT applications. The terms CE operation and coverage enhanced operation may be used interchangeably herein.

[0062] A repetitive transmission of a physical channel may be used for CE. The CE level may be determined based on the number of repetitions, for example, that may be needed or used to achieve the intended coverage improvement. The terms repetition number, number of repetitions, repetition level, and CE level may be used interchangeably herein.

[0063] A CE mode may be used with one or more CE levels, or for example, repetition levels. The CE levels or repetition levels supported within a CE mode may be changed dynamically.

[0064] An eMTC WTRU may be for example, a low-cost WTRU. An eMTC WTRU may be for example, a WTRU with limited or reduced

capabilities. Limited or reduced capabilities may include at least one of a limited or reduced BW capability, for example a BW using 6 RBs , low throughput performance, and a single RF chain at the receiver. An eMTC WTRU may be delay tolerant. An eMTC WTRU may be served in an LTE network which may or may not have a system BW larger than the eMTC supportable BW that may for example be a BW of 1.4 MHz.

[0065] An eMTC WTRU may support coverage enhanced operation. For example, two CE modes of operation may be supported such as CE mode-A and CE mode-B. Normal and small CE levels may be supported in CE mode-A, and medium and large CE levels may be supported in CE mode-B. Normal CE may be the same as normal operation or no CE, which may involve for example, no use of repetitions for CE.

[0066] An NB-IoT WTRU may be, for example, a low-cost WTRU. An NB-IoT WTRU may be, for example, a WTRU with limited or reduced capabilities that may, for example, be more limited or reduced more than the capabilities of an eMTC WTRU in at least one aspect. For example an NB-IoT WTRU may support or use a further reduced BW, for example, a BW of 1 RB, that may be smaller than the supportable BW for an eMTC WTRU.

[0067] An NB-IoT WTRU may, or may be intended to, support CE, for example, with up to 20 decibel (dB) CE, with a battery life that may be longer than the intended or expected battery life of an eMTC WTRU. An NB-IoT WTRU may be intended or expected to support a battery life such as 10 years. The population of NB-IoT WTRUs in a cell may be significantly larger than for other types of devices.

[0068] Example methods and procedures of paging are discussed herein. As used herein, paging may refer to network initiated connection setup. As used herein, paging may refer to a mechanism that a network may use to provide information such as system information modification information or warning system information, for example Earthquake and Tsunami Warning System (ETWS) information, to one or more WTRUs that may, for example, employ techniques for battery saving such as discontinuous reception (DRX). In some examples, paging may be used when a WTRU is in idle mode. In other

examples, paging may be used when a WTRU is in connected mode. A WTRU may, for example periodically, monitor a PDCCH for a DL control information (DCI) or DL assignment on a PDCCH masked with a Paging Radio Network Temporary Identifier (P-RNTI), for example in idle mode and/or in connected mode. When a WTRU detects or receives a DCI or DL assignment using a P-RNTI, the WTRU may demodulate the associated or indicated PDSCH RBs and/or may decode a Paging Channel (PCH) that may be carried on an associated or indicated PDSCH. A PDSCH which may carry PCH may be referred to as a PCH PDSCH. The terms paging, paging message, and PCH may be used interchangeably herein. As used herein, the terms downlink control channel, DL control channel for NB WTRU, M-PDCCH, PDCCH, NB PDCCH (NB-PDCCH), internet of things PDCCH (IoT-PDCCH), and NB IoT-PDCCH (NB-IoT-PDCCH) may be used interchangeably.

[0069] The paging frame (PF) and subframe within that PF, for example, the paging occasion (PO), that a WTRU may monitor for the paging channel, for example in idle mode, may be determined based on the WTRU identifier (ID), for example, WTRU_ID or UE_ID, and parameters which may be specified by the network. The parameters may include the Paging Cycle (PC) length, for example in frames, which may be the same as a discontinuous reception (DRX) cycle and another parameter, for example, nB, which together may enable the determination of the number of PF per PC and the number of PO per PF which may be in the cell. The WTRU ID, in an example, may be the WTRU international mobile subscriber identity (IMSI) mod 1024. The terms WTRU ID, WTRU-ID, and WTRU_ID may be used interchangeably herein.

[0070] From the network perspective, there may be multiple PFs per paging cycle and multiple POs within a PF, for example, more than one subframe per paging cycle may carry PDCCH masked with a P-RNTI. Additionally, from the WTRU perspective, a WTRU may monitor a PO per paging cycle, and such a PO may be determined based on the parameters specified herein, which may be provided to the WTRU via system information, dedicated signaling information, and the like. POs may include pages for one

or more specific WTRUs, or they may include system information change pages which may be directed to each of the WTRUs, multiple WTRUs, or all WTRUs. In idle mode, a WTRU may receive pages for reasons such as an incoming call or system information update changes.

[0071] In connected mode, a WTRU may receive pages related to system information change, for example, and the WTRU may not receive WTRU-specific pages such as those that may be used for an incoming call. As such, a WTRU in connected mode may not monitor a specific PO. Additionally, for frequency division duplex (FDD), the PO subframes may be limited to certain subframes such as subframes 0, 4, 5 and 9 and/or for time division duplex (TDD), the PO subframes may be limited to certain subframes such as subframes 0, 1, 5 and 6.

[0072] As used herein, DRX may refer to a WTRU monitoring for DL control signaling or a DL control channel at certain times, for example only at certain times, during a cycle. For example, a WTRU using DRX may monitor for a DL control channel during certain time periods, for example only during certain time periods. During other time periods, the WTRU may switch off at least part of its receiver circuitry and reduce power consumption. A time period may, for example, be a subframe. Example methods for operation using DRX are discussed herein.

[0073] In idle mode, for example, radio resource control (RRC) idle mode and/or evolved packet system (EPS) connection management (ECM) idle mode, a WTRU may monitor for or listen to a paging message to know about one or more of: an incoming call, a system information change, an Earthquake and Tsunami Warning System (ETWS) notification for ETWS capable WTRUs, a commercial mobile alert service (CMAS) notification and an extended access barring (EAB) parameters modification.

[0074] A WTRU may monitor PDCCH for P-RNTI discontinuously, for example to reduce battery consumption when there may be no pages for the WTRU. DRX may be or may include the process of monitoring PDCCH discontinuously. In idle mode, DRX may be or may include the process of

monitoring PDCCH discontinuously for P-RNTI, for example to monitor or listen for a paging message during RRC idle state.

[0075] The terms idle mode, idle state, RRC idle mode, RRC idle state, and RRC_IDLE mode or state may be used interchangeably herein. The terms RRC idle and ECM idle may be used interchangeably herein. DRX may also be enabled and/or used in connected mode. When in connected mode, if DRX is configured, the MAC entity may monitor the PDCCH discontinuously, for example using DRX operation. The terms connected mode, connected state, and RRC_CONNECTED mode or state may be used interchangeably herein.

[0076] Examples of operation in idle mode DRX are discussed herein. A WTRU may use one or more DRX parameters that may be broadcast, for example in a system information block (SIB) such as a SIB2, to determine the PF and/or PO to monitor for paging. The WTRU may, for example, alternatively, use one or more WTRU specific DRX cycle parameters that may be signaled to the WTRU, for example by the MME through non-access stratum (NAS) signaling.

[0077] Table 1 provides examples of DRX parameters including example ranges and an example source of the DRX parameter, for example, an eNode-B or an MME.

Table 1. Example DRX Cycle Parameters.

DRX parameter	Notation	Value Range	Configuring Network Node
WTRU Specific DRX cycle	TWTRU	32, 4, 128 and 256 radio frames where each radio frame may be 10 milliseconds (ms)	MME, for example, via NAS signaling
Cell specific DRX cycle	TCELL	32, 4, 128 and 256 radio frames	eNode-B, for example, via system information such as a SIB2
Number of POs per DRX cycle, for example, DRX cycle across all users in the cell	nB	4T, 2T, T, T/2, T/4, T/8, T/16, T/32 where T may be the DRX cycle of the WTRU, for example, TCELL or the smaller of TWTRU, if provided, and TCELL	eNode-B, for example, via system information such as a SIB2

[0078] The DRX cycle T of a WTRU may indicate the number of radio frames in the paging cycle. A larger value of T may result in less WTRU battery power consumption. A smaller value of T may increase WTRU battery power consumption. A DRX cycle may be cell specific or WTRU specific.

[0079] A DRX cycle provided by an eNode-B may be cell specific and may be provided to at least some, or for example all, WTRUs in a cell. The DRX cycle that may be provided by the eNode-B may be the default paging cycle. A DRX cycle provided by an MME may be WTRU specific. The WTRU may use the smaller of the default paging cycle and the WTRU specific DRX cycle as its DRX or paging cycle. An MME may provide a WTRU specific DRX cycle to a WTRU using NAS signaling, for example as 'WTRU specific DRX cycle'. An MME may provide a WTRU specific DRX cycle to an eNode-B in a PAGING S1 AP message, as 'Paging DRX', for example, for an MME initiated paging message that may be intended for the WTRU.

[0080] The WTRU and/or eNode-B may use the minimum of the default and WTRU specific DRX cycle. For example, T = Min (T_{WTRU}, T_{CELL}) in radio

frames. A WTRU with a DRX cycle of N (for example, 128) radio frames may wake up or may need to wake up every N x frame time (for example, every 1.28 seconds for a frame time of 10 ms) and look for a paging message.

[0081] The parameter nB may indicate the number of paging occasions or POs in a cell specific DRX cycle. The parameter may be cell specific. Configuration of the nB value may depend on the paging capacity that may be desired or used in a cell. A larger value of nB may be used, for example to increase paging capacity. A smaller value of nB may be used, for example for a smaller paging capacity.

[0082] The eNode-B and/or WTRU may calculate the WTRU's PFs according to the following relation: a PF is given by the following equation or occurs when SFN mod T = (T div N)*(WTRU_ID mod N), where N = min (T, nB) and div may represent division. The WTRU specific PO within the PF may be determined from a set of paging subframes. The set may be a function of predefined allowed subframes for paging and/or the number of POs per PF which may be a function of at least nB and/or T. The system frame number (SFN) may have a range of values such as 0 through 1023.

[0083] Examples of connected mode DRX are discussed herein. In connected mode, a PF and PO may be determined in a similar manner as in idle mode. The DRX cycle parameters may be different for idle and connected modes. A WTRU may monitor a PO, for example, any PO, in a PC in connected mode, for example to obtain system information change information.

[0084] Extended DRX (eDRX) is disclosed herein. It may be desirable to have extended or longer DRX cycles, for example for devices such as MTC devices. Extended or longer DRX cycles may be useful for some devices such as delay tolerant devices and may, for example, reduce battery consumption and/or increase battery life for those devices. A new time unit, for example, a hyper frame (HF), may be used, for example, with, as an extension of, or on top of radio frames and/or SFN timing, for example, legacy SFN timing.

[0085] FIG. 2 is an exemplary timing diagram which illustrates HFs and paging within HFs. One HF may include an SFN cycle, for example, 1024 radio frames or 10.24 s. A HF may have a Hyper-System Frame Number (H-

SFN). An H-SFN cycle may be 1024 SFN cycles. An H-SFN cycle may last 1024*1024*10 ms, for example, 174.76 minutes. In an example shown in timing diagram 200, HF 210 may have H-SFN 0 and may contain an SFN cycle of 1024 radio frames, from radio frame 0 through radio frame 1023. Likewise, HF 220 may have H-SFN 1023 and contain its own SFN cycle of 1024 radio frames. H-SFN cycle 230 may contain 1024 HFs, including HF 210 through HF 220.

[0086] An idle mode extended DRX (I-eDRX) cycle may include up to 256 H-SFN cycles and may, for example, last 256*1024*10 ms, for example, 43.69 minutes. The H-SFN may be broadcast by the cell. The H-SFN may increment at SFN cycle boundaries.

[0087] The H-SFN in which a WTRU may become reachable for paging may be referred to as a paging hyper frame (PH) or as the WTRU's PH. The PH may be applicable, or only applicable, in ECM-IDLE. The PH may be computed as a function of the extended DRX cycle and/or WTRU ID, for example, IMSI mod 1024. Within a PH, the determination of the PF and/or PO may follow the regular DRX rules and/or formulas. A WTRU's paging window (PW) may be the window or time span corresponding to the set of PFs in the WTRU's PH during which the WTRU may monitor for paging and/or may be paged. The PW may include a subset of the available PFs in the PH. In an example shown in timing diagram 200, PW 250 may include PF 260, PF 270 and PF 280. PF 260, PF 270 and PF 280 may be PFs within PH 290. eDRX cycle 295 may include PH 290. The PW may be signaled to the WTRU, for example by the MME in a NAS message. In a PF, a WTRU may monitor or only monitor one PO. Paging to a WTRU may be repeated in one or more of a WTRU's PFs in its PW, for example if the WTRU does not respond to a previous page.

[0088] A cell's support of idle mode extended DRX may be implicitly indicated by the broadcast of H-SFN. For long DRX cycles, it may be useful for the MME to have some awareness of when the WTRU may be become reachable, for example to avoid storing paging requests at the eNode-B for a long time. In connected mode, the DRX cycle may be extended up to the SFN

limit, for example, by extending the range of values for long DRX cycles to 10.24 seconds.

[0089] A large population of NB WTRUs may be multiplexed within a limited number of paging resources. If the distribution of WTRUs among paging resources is based on WTRU-ID, for example IMSI or IMSI modulo 1024, there may, for example still be a large number of WTRUs sharing the same paging resources in time and/or frequency, for example sharing the same PO and/or paging NB.

[0090] A NB WTRU may monitor M-PDCCH in a PO or each of its POs. If the M-PDCCH, or a DCI in the M-PDCCH, indicates the scheduling of an associated PDSCH for paging message, the NB WTRU may receive the associated PDSCH, for example, to check if there may be a paging message targeted to the NB WTRU.

[0091] Since a large number of NB WTRUs may share the same paging resources, a NB WTRU may receive the associated PDSCH when the paging message may not be targeted to the NB WTRU. The reception of an associated PDSCH that may not be intended for the WTRU may, for example, increase the WTRU's battery consumption unnecessarily. If the NB WTRU is in a CE level that may use a large number of repetitions, the impact to the WTRU may be worse, and may be, for example, significantly worse.

[0092] A NB WTRU may monitor M-PDCCH, for example in a PO or in each PO, in a NB WTRU specific or a NB WTRU group specific manner. The M-PDCCH may implicitly or explicitly indicate the necessity of receiving and/or decoding the M-PDCCH and/or an associated PDSCH, for example by a WTRU or group of WTRUs. For example, the M-PDCCH may implicitly or explicitly indicate the intended recipient or recipients of the M-PDCCH, an associated PDSCH, a page, a paging message or a PDSCH carrying a paging message or channel. Further, an implicit indication of paging reception, the need for paging reception, or the intended recipient or recipients of a M-PDCCH, a PDSCH, a page, a paging message or a PDSCH carrying a paging message or channel may be employed which uses one or more of: a scrambling indication; a scrambling sequence such as a scrambling sequence for M-

PDCCH randomization, a WTRU group-specific or WTRU-specific scrambling sequence, an information type specific scrambling sequence, or a scrambling sequence for paging reception; a starting enhanced control channel element (ECCE) index for M-PDCCH randomization, a bit interleaver for M-PDCCH randomization; and/or one or more Radio Network Temporary Identifiers (RNTIs).

[0093] In an example, a scrambling sequence may be used to randomize a bit sequence of an M-PDCCH. A WTRU that may use the same scrambling sequence to descramble the received bits may receive or may be able to receive the M-PDCCH. In an example, only a WTRU that may use the same scrambling sequence to descramble the received bits may receive or may be able to receive the M-PDCCH.

[0094] The bit sequence of an M-PDCCH may be a bit sequence before the modulation of M-PDCCH. For example, the bit sequence of an M-PDCCH may be a bit sequence after rate matching. A coded bit sequence may be an input bit sequence of the rate matching and an output bit sequence of the rate matching may be the bit sequence of an M-PDCCH. A DCI with cyclic redundancy check (CRC) scrambled by an RNTI may be an input bit sequence of the channel coding block and an output bit sequence may be a coded bit sequence.

[0095] The bit sequence of an M-PDCCH may be a bit sequence before the channel coding. For example, a DCI with CRC scrambled by an RNTI may be the bit sequence of an M-PDCCH.

[0096] For the RNTI, one or more of following examples may apply. The RNTI may be a P-RNTI, for example, if the DCI may be used for the paging. In another example, the RNTI may be a group-specific P-RNTI which may be associated with a scrambling sequence. In a further example, the RNTI may be the N least significant bits (LSBs) of a WTRU-ID that may be used for paging. N may be the number of CRC bits, which may be referred to as NCRC. For example, the 16 LSBs of a WTRU-ID, for example, IMSI or System Architecture Evolution (SAE)-Temporary Mobile Subscriber Identity (s-TMSI), may be used. The N bits used for the RNTI may be the same N bits that

correspond to WTRU-ID modulo (2^N), for example, IMSI modulo (2^N), where N may be 16.

[0097] In an example, a bit sequence of M-PDCCH $b(0),\ldots,b(M_{\text{bit}}-1)$ may be scrambled with a certain scrambling sequence, $c(i)$, where M_{bit} may be the number of bits in the bit sequence of an M-PDCCH. The result of a WTRU-specific or a WTRU group-specific scrambling sequence may be referred to as $\tilde{b}(0),\ldots,\tilde{b}(M_{\text{bit}}-1)$.

[0098] In an example, the $\tilde{b}(0),\ldots,\tilde{b}(M_{\text{bit}}-1)$ bit sequence may be determined based on $\tilde{b}(i)=(b(i)+c(i))\text{mod}2$, where mod2 may be modulo-2 operation. Further, the scrambling sequence $c(i)$ may be a Pseudo-random sequence that may be determined based on an initialization value, c_{init}, where i may be a bit index of the bit sequence.

[0099] The certain scrambling sequence may be determined based on at least one of whether the M-PDCCH or scrambling sequence may be WTRU-specific or WTRU group-specific, information type in the associated DCI and information type in the associated PDSCH. The initialization value (c_{init}) may be determined based on at least the WTRU-ID, at least the associated WTRU group number, at least the information type in the associated DCI, at least the information type in the associated PDSCH and/or an RNTI.

[0100] In an example, a WTRU which may monitor or attempt to decode a bit sequence of M-PDCCH may use its associated scrambling sequence. The associated scrambling sequence may be determined based on at least one of whether the M-PDCCH or scrambling sequence may be WTRU-specific or WTRU group-specific, and/or information type in the DCI. For example, the associated scrambling sequence may be determined based on the type of the information in the DCI for which the WTRU may be monitoring, such as WTRU-specific or WTRU group-specific paging. In an example, the WTRU may perform descrambling with an input bit sequence of the channel decoder. Also, the WTRU may perform descrambling with an output bit sequence of the channel decoder. In an example, if the bit sequence of M-PDCCH received at the WTRU receiver is $d(0),\ldots,d(M_{\text{bit}}-1)$, the $\tilde{d}(0),\ldots,\tilde{d}(M_{\text{bit}}-1)$ sequence may be

referred to as a descrambled bit sequence with the associated scrambling sequence $c(i)$. As an example, the WTRU may perform descrambling with $\tilde{d}(i) = (d(i) + c(i)) \bmod 2$.

[0101] A WTRU-specific scrambling sequence and/or a WTRU group-specific scrambling sequence may be provided and/or used. In an example, a WTRU-specific or WTRU group-specific scrambling sequence, for example a first scrambling sequence, may be used to scramble a bit sequence of an M-PDCCH, for example in a PO or each PO. In an example, a WTRU or a WTRU group that may use the same scrambling sequence, for example the first scrambling sequence, may decode or may be able to decode the M-PDCCH. For example only a WTRU or a WTRU group that may use the same scrambling sequence, for example the first scrambling sequence, may decode or may be able to decode the M-PDCCH.

[0102] In an example of using a WTRU group-specific scrambling sequence, N_g scrambling sequences may be used for N_g WTRU groups for a PO and a bit sequence of M-PDCCH intended or targeted for a WTRU group, for example a first WTRU group, within N_g WTRU groups may be scrambled with the corresponding scrambling sequence, for example a first scrambling sequence. In an example, the WTRU group using the corresponding scrambling sequence, for example the first scrambling sequence, may receive or may be able to receive the M-PDCCH. In a further example, only the WTRU group using the corresponding scrambling sequence, for example the first scrambling sequence, may receive or may be able to receive the M-PDCCH. The WTRU group-specific scrambling sequence may be determined based on at least one of following: a modulo operation that may, for example, be based on at least N_g and the WTRU-ID; a hashing function that may, for example, be based on N_g and the WTRU-ID; and the WTRU group number that may, for example, be determined based on at least a CE level.

[0103] A modulo operation may be used where the modulo operation may be based on at least N_g and the WTRU-ID (N_{WTRUID}). The WTRU group number (N_{group}) may be determined by WTRU-ID modulo N_g (for example

$N_{group} = (N_{WTRUID}) \bmod N_g$). A subframe number and/or a frame number (for example SFN) may be used. For example, $N_{group} = (N_{WTRUID} \cdot N_{Frame}) \bmod N_g$.

[0104] A hashing function may be used where the hashing function may be based on N_g and the WTRU-ID. In this case, for example, $N_{group} = (A \cdot N_{WTRUID}) \bmod N_g$, where the A may be a prime number (for example A = 39,827), or $N_{group} = ((A \cdot N_{WTRUID}) \bmod D) \bmod N_g$, where the D may be a prime number which may be different from A (for example D = 65,537). The hashing function may be based on a subframe number and/or a frame number.

[0105] The WTRU group number may be determined based on at least a CE level. For example, WTRUs with a first CE level (for example CE level-1) may be grouped as a first WTRU group and WTRUs with a second CE level (for example CE level-2) may be grouped as a second WTRU group.

[0106] The WTRU-ID may be at least one of an RNTI allocated for a WTRU, IMSI, and s-TMSI, and/or a part of at least one of the allocated RNTI, IMSI, and s-TMSI. For example, WTRU-ID may be IMSI modulo M or s-TMSI modulo N. M and/or N may be 1024. A and/or D may be a function of N_g. A and/or D may be fixed and/or configured, for example, by the eNode-B via signaling. A N_{WTRUID} may be the WTRU-ID or a portion of or function of the WTRUs IMSI or s-TMSI. For example N_{WTRUID} for a WTRU may be IMSI-10, or IMSI modulo X, where X may be a number less than or equal to 1024.

[0107] In an example of using a WTRU specific scrambling sequence, a WTRU specific scrambling sequence may be used for a bit sequence of M-PDCCH intended or targeted for a WTRU, where the WTRU specific scrambling sequence may be determined based on at least a WTRU-ID or a part of a WTRU-ID. In MME initiated paging, the WTRU-ID may be provided by the MME to the eNode-B in an S1 paging message or request.

[0108] In an example, the scrambling sequence may be determined based on the specific information type which may be carried in the DCI. For example, a first scrambling sequence may be used for a bit sequence of an M-PDCCH in which the DCI may carry a first information type and a second

scrambling sequence may be used for a bit sequence of an M-PDCCH in which the DCI may carry a second information type.

[0109] The first information type may include, but not be limited to, at least one or more system information update indications such as system information modification indication, an ETWS indication, a CMAS indication, and an EAB parameter modification indication. One or more system information indications may be a single bit to indicate the system information update or multiple bits to indicate the system information update of multiple SIs, for example, SIBs or SI-messages. An additional indicator may be included, for example, a flag bit to indicate a DCI format or a DCI type. The scrambling sequence for the first information type may be based on at least one of cell-specific parameters, such as for example, a physical cell-ID.

[0110] The second information type may be at least scheduling information of the associated PDSCH. The scrambling sequence for the second information type may be based on at least one of WTRU-specific parameters, such as for example, a WTRU-ID.

[0111] In another example, the scrambling sequence may be determined based on the information type carried in a DCI and/or WTRU-ID. For example, a first scrambling sequence may be used for a bit sequence of an M-PDCCH in which the DCI may carry a first information type, and a second scrambling sequence may be used for a bit sequence of an M-PDCCH in a which the DCI may carry a second information type. The first scrambling sequence may be predefined. The second scrambling sequence may be determined based on a WTRU-ID.

[0112] In an example, the PO for the first information type and the second information type may the same. Further, a WTRU may monitor M-PDCCH for both the first information type and the second information type. Also, a WTRU may monitor M-PDCCH for the first information type in a subset of POs or all POs. A WTRU may monitor M-PDCCH for the second information type in a subset of POs or all POs.

[0113] In another example, the PO for the first information type and the second information type may be different. The time and/or frequency location

of the PO for the first information type may be determined based on at least one cell-specific parameter. The cell-specific parameters may include, for example, a physical cell-ID, a system bandwidth, a subframe number, a frame number such as an SFN and the like. The time and/or frequency location of the PO for the second information type may be determined based on at least one WTRU-specific parameter, such as, for example, a WTRU-ID.

[0114] Examples which include the use of a scrambling sequence for paging reception are disclosed herein. A WTRU may determine a bit scrambling sequence, for example, an M-PDCCH bit scrambling sequence according to one or more examples described herein. In an example, the WTRU may monitor for an M-PDCCH in a PO. The WTRU may descramble the received signal or M-PDCCH using the bit scrambling sequence. The WTRU may determine if the descrambled M-PDCCH may carry a DCI masked with an RNTI that the WTRU may use for paging. The RNTI may be, for example, a P-RNTI. If the WTRU determines the DCI is masked with the RNTI, such as, for example, the P-RNTI, the WTRU may read the contents of the DCI to obtain one or more of system information update information and/or PDSCH scheduling information. The WTRU may use the scheduling information to receive an associated PDSCH that may carry one or more paging records or paging messages.

[0115] Examples using a starting ECCE index for M-PDCCH randomization are disclosed herein. In an example, an M-PDCCH search space may be used for monitoring for an M-PDCCH or a DCI, where the starting ECCE index, for example for monitoring, may be determined based on at least one WTRU-specific parameter. For example, a WTRU may use an M-PDCCH search space for monitoring for a an M-PDCCH or a DCI, where the starting ECCE index, for example for monitoring, may be determined based on at least one WTRU-specific parameter. As used herein, control channel element (CCE), ECCE and NB-IoT control channel element (NCCE) may be used interchangeably.

[0116] FIG. 3 is an exemplary diagram which illustrates WTRU group-specific starting ECCE indexes. Diagram 300 shows an example of ECCEs in a

subframe 310 at ECCE aggregation level 16. In other examples, other ECCE aggregation levels such as 1, 2, 4, 8 and 32 may be used. In an example shown in FIG. 3, a WTRU may use a different starting ECCE index depending upon the group the WTRU is in. For example, the WTRUs may be divided among four WTRU groups, numbered WTRU group #1 through WTRU group #4. WTRUs in WTRU group #1 may use a starting ECCE index 330 with a starting ECCE of 1, WTRUs in WTRU group #2 may use a starting ECCE index 350 with a starting ECCE of 5, WTRUs in WTRU group #3 may use a starting ECCE index 370 with a starting ECCE of 9, and WTRUs in WTRU group #4 may use a starting ECCE index 390 with a starting ECCE of 12.

[0117] FIG. 4 is a diagram of an example flow chart showing a WTRU receiving a machine type communication (MTC) physical downlink control channel (M-PDCCH) with a starting ECCE index based on the WTRU group of the WTRU. In an example shown in chart 400, a WTRU may monitor for an M-PDCCH in an M-PDCCH search space 410. The WTRU may monitor for the M-PDCCH using a starting ECCE index for the WTRU group containing the WTRU. The WTRU may then receive the M-PDCCH in the M-PDCCH search space, wherein the M-PDCCH may have a starting ECCE index for the WTRU group containing the WTRU 420. In an example corresponding to the WTRU groups shown in FIG. 3, the WTRU may be in WTRU group #2 and may therefore monitor for and/or receive an M-PDCCH with a starting ECCE index 350 of 5. Further, the WTRU may decode the M-PDCCH, wherein the M-PDCCH includes a DCI 430. The WTRU may receive a PDSCH associated with the M-PDCCH 440 or the DCI, for example a PDSCH scheduled by the M-PDCCH or the DCI. In an example, the WTRU may receive, decode, attempt to decode, demodulate, and/or attempt to demodulate the PDSCH based on the DCI, wherein the PDSCH may include a paging message. As a result, the WTRU may change its operation based on the paging message. For example, the WTRU may change from idle mode to connected mode based on the paging message. The WTRU may then begin to transmit and receive in connected mode. In another example, the WTRU may already be in connected

mode and may change its system operation based on system information change information in the page message.

[0118] In another example, an M-PDCCH search space may be used for a DCI monitoring, where the starting ECCE index and ordering (for example, an ascending order, a descending order, a random order and/or a predefined order) may be used to determine an M-PDCCH candidate. For example, if a number of ECCEs, $N_{ECCE,}$ is available in the search space and an ECCE aggregation level is the same as N_{ECCE} for an M-PDCCH candidate, one or more M-PDCCH candidates may be determined based on the starting ECCE index and/or ordering.

[0119] An M-PDCCH candidate may be defined or configured with N_{ECCE} ECCEs which may be aggregated in an ascending order, descending order, ascending order with a starting ECCE index, or descending order with a starting ECCE index. In an example, the starting ECCE index and/or ordering may be determined based on at least one WTRU-specific parameter. In a further example, the starting ECCE index and/or ordering may be determined based on at least information type carried in the DCI.

[0120] In another example, an M-PDCCH search space may be used for a DCI monitoring, where the ECCE aggregation may be based on a sequence. The sequence for the ECCE ordering may be determined based on at least one WTRU-specific parameter.

[0121] FIG. 5 is an exemplary diagram which illustrates WTRU group-specific random ECCE ordering. A sequence for the ECCE ordering may be determined based on at least one WTRU-specific parameter as shown in diagram 500. Similar to FIG. 3, FIG. 5 shows an example of ECCEs in a subframe 510, at ECCE aggregation level 16. In an example, a sequence may determine the ECCE ordering for ECCE aggregation. In a further example, the sequence for ECCE ordering may be determined based on at least one of: a WTRU-specific parameter, an information type carried in the DCI, an RNTI that may be used for CRC scrambling, a DCI format used and a CE level or repetition number such as, for example a repetition number of an M-PDCCH candidate.

[0122] In yet a further example, a set of random sequences may be predefined or configured, for example for a group of WTRUs. A sequence may correspond to a starting ECCE index. A sequence may correspond to ECCE aggregation ordering.

[0123] In an example shown in FIG. 5, a WTRU may use a different starting ECCE index depending upon a random sequence that may be defined, configured and/or used by or for the group the WTRU is in. For example, the WTRUs may be divided among four WTRU groups, numbered WTRU group #1 through WTRU group #4. WTRUs in WTRU group #1 may use a first random sequence 530 that may correspond to a starting ECCE index of 4, WTRUs in WTRU group #2 may use a second random sequence 550 that may correspond to a starting ECCE index of 5, WTRUs in WTRU group #3 may use a third random sequence 570 that may correspond to a starting ECCE index of 9, and WTRUs in WTRU group #4 may use a fourth random sequence 590 that may correspond to a starting ECCE index of 12. A random sequence, for example, within the set, may be determined based on at least one of: a WTRU-specific parameter, an information type carried in the DCI, an RNTI that may be used for CRC scrambling, a DCI format used, or a CE level or repetition number, such as, for example, a repetition number of an M-PDCCH candidate.

[0124] Examples using a bit interleaver for M-PDCCH randomization are disclosed herein. In an example, a bit sequence for an M-PDCCH may be interleaved with an interleaving sequence. The interleaving sequence may be a sequence with the length of the bit sequence. The bit positions may be interleaved based on the interleaving sequence. In an example, the interleaving sequence may be determined based on one or more of at least one WTRU-specific parameter, an information type carried in the DCI, an RNTI that may be used for CRC scrambling, a DCI format used, and a CE level or repetition number such as, for example a repetition number of an M-PDCCH candidate. In a further example, a WTRU may use the interleaving sequence to de-interleave the received bit sequence before it may attempt to decode the received bit sequence.

[0125] In an example, one or more RNTIs may be used for a DCI, for example to indicate to a WTRU whether to decode an associated PDSCH. For example, a cell-specific P-RNTI and one or more WTRU group specific P-RNTIs may be used. A WTRU may attempt to decode the M-PDCCH with the cell-specific P-RNTI and/or an associated WTRU group specific P-RNTI in a PO. In an example, a first P-RNTI may be used for a DCI carrying a first information type. In a further example, a second P-RNTI may be used for a DCI carrying a second information type. Also, in a PO, a WTRU may attempt to decode a DCI with the first P-RNTI and/or the second P-RNTI.

[0126] A first P-RNTI may be used for a DCI carrying a first information type. The first P-RNTI may be a cell-specific P-RNTI. The first information type may include but not be limited to at least one or more system information update indications such as a system information modification indication, an ETWS indication, a CMAS indication, and an EAB parameter modification indication. One or more system information indications may be a single bit to indicate the system information update or multiple bits to indicate the system information update of multiple SIs, such as, for example, SIBs or SI-messages. An additional indicator may be included, such as, for example a flag bit to indicate a DCI format or a DCI type. The first P-RNTI may be based on at least one cell-specific parameter, such as, for example a physical cell-ID.

[0127] A second P-RNTI may be used for a DCI carrying a second information type. A set of P-RNTIs may be predefined or configured for the second P-RNTI and one of the predefined or configured P-RNTIs may be determined in a WTRU-specific or a WTRU group specific manner. A modulo operation with a WTRU-ID and/or the number of P-RNTIs configured may be used to determine the associated P-RNTI. A hashing function may be used with a WTRU-ID and/or the number of P-RNTIs configured to determine the associated P-RNTI.

[0128] In a PO, a WTRU may attempt to decode a DCI with the first P-RNTI. The WTRU may also attempt to decode a DCI with the second P-RNTI which may be associated with the WTRU. If a WTRU may successfully decode a DCI with the first P-RNTI, then the WTRU may not monitor a DCI with the

second P-RNTI. If a WTRU may not successfully decode a DCI with the second P-RNTI, then the WTRU may assume that the associated PDSCH may not be scheduled.

[0129] An explicit indication of paging reception is disclosed herein including the use of: a paging occasion type; a monitoring indicator for a paging occasion, a paging type, a paging message, a paging window, among others; multiple monitoring indicators; and multiple monitoring indicators with explicit and implicit indications. In examples, one or more paging occasion types may be used, configured, or defined, for example for a RRC idle WTRU and/or a RRC connected WTRU.

[0130] A first paging occasion type may be used for a paging message transmission in which a WTRU may monitor for a paging message. The paging message may include one or more paging records and/or one or more system information update indications. In an example, the paging message may be carried in a DCI. In a further example, the paging message may be carried in a PDSCH and the scheduling information of the PDSCH may be provided in an associated DCI. Also, the paging message may be carried in a PDSCH without an associated DCI for the scheduling information. Further, the contents of the paging message may be indicated from the associated DCI. For example, a DCI may indicate the information type included in the paging message.

[0131] In an example, a second paging occasion type may be used for one or more system information update indications. In a further example, one or more paging occasion types may be located in a same time/frequency resource and monitored separately.

[0132] The time/frequency locations for one or more paging occasion types may be determined independently. A time/frequency location of a first paging occasion type may be determined based on at least one WTRU-specific parameter, such as, for example, a WTRU-ID. A time/frequency location of a second paging occasion type may be determined based on at least one cell-specific parameter, such as, for example, a physical cell-ID, (e)DRX cycle, system bandwidth and the like.

[0133] In an example, a DCI format or DCI contents may be different according to the paging occasion type. Further, an associated RNTI may be different according to the paging occasion type.

[0134] In an example, an indication for monitoring, for example, a monitoring indicator, of one or more of PO types may be transmitted in a broadcast channel, such as, for example, in a MIB, in a DCI in common search space and the like. For example, a broadcast channel may be transmitted in every x ms and one or more POs may be associated with a broadcast transmission. The broadcast transmission may indicate if a WTRU may need to monitor one or more POs associated with the broadcast transmission. A WTRU may attempt to decode or read a broadcast channel which may carry the monitoring indicator before it may monitor one or more POs. In an example, a monitoring indicator may be associated with one or more PO types. For example, the monitoring indicator may be associated with a first PO type. In a further example, the monitoring indicator may be associated only with a first PO type. In another example, the monitoring indicator may be associated with a second PO type. In a still further example, the monitoring indicator may be associated only with a second PO type. In an example, the monitoring indicator may be set to TRUE or FALSE. Based on the monitoring indicator, a WTRU may monitor a WTRU-group specific PO which may be determined based on at least one of a WTRU-specific parameter, such as, for example a WTRU-ID, or a cell-specific PO that may be determined based on at least one cell-specific parameter, such as, for example, a physical cell-ID.

[0135] A monitoring indicator may be associated with one or more POs. For example, a monitoring indicator may be associated with POs within a certain time window. If a WTRU receives the monitoring indicator, the WTRU may attempt to receive or monitor POs within the certain time window.

[0136] A monitoring indicator may indicate a WTRU group index and a WTRU group associated with the monitoring indicator may monitor the POs. In an example, the monitoring indicator may indicate which WTRU group may need to monitor POs. The WTRU group may include all WTRU groups for a system information update. In another example, the monitoring indicator

may have a number of states, such as four states and may indicate at least one of the states. The states may, for example include cell common paging, a first WTRU group, a second WTRU group, and a third WTRU group. In an example, the cell common page may be or occur in a cell-specific PO. A WTRU may monitor a PO or monitor for a page according to a monitoring indicator state.

[0137] A monitoring indicator may indicate a PO type and a WTRU may monitor POs corresponding to the PO type. In an example, a WTRU may receive a monitoring indicator which indicates a first PO type, and then the WTRU may monitor POs corresponding to the first PO type. Further, a WTRU may receive a monitoring indicator which indicates a first PO type, and then the WTRU may monitor POs corresponding to the first PO type only.

[0138] In another example, a monitoring indicator may be used with a WTRU group specific M-PDCCH scrambling sequence, a WTRU group specific RNTI, a WTRU group specific starting ECCE index, and/or a WTRU group specific interleaver. A monitoring indicator may be used to indicate if a WTRU may need to monitor POs associated with it and an implicit indication of paging reception schemes may be used in each PO. A WTRU may, for example, attempt to decode, receive, or monitor the monitoring indicator and, if the monitoring indicator indicates that the WTRU may need to monitor the POs, the WTRU may attempt to decode or monitor the POs, for an M-PDCCH, for example, with its associated scrambling sequence, starting ECCE index, RNTI, and/or interleaving sequence. Further, a WTRU may first attempt to decode, receive, or monitor the monitoring indicator and, if the monitoring indicator indicates that the WTRU may need to monitor the POs, the WTRU may attempt to decode or monitor the POs, for an M-PDCCH, for example, with its associated scrambling sequence, starting ECCE index, RNTI, and/or interleaving sequence.

[0139] In an example, one or more monitoring indicators may be used and a WTRU may determine if the WTRU may need to monitor, receive, or attempt to decode an M-PDCCH and/or a PDSCH carrying paging related information. A monitoring indicator may be used to determine if a WTRU

needs to monitor or attempt to decode a M-PDCCH in a PO, which may be referred to as a PO (paging occasion) monitoring indicator. A monitoring indicator may be used to determine if a WTRU needs to receive an associated PDSCH which may carry a paging message (PM), which may be referred to as a PM monitoring indicator. A monitoring indicator may be used to determine if a WTRU needs to monitor POs within a paging window (PW), which may be referred to as a PW monitoring indicator. A PW may include one or more POs for a WTRU. A PW may be defined or determined based on a number of POs. For example, a PW may be defined to include N_{PO} POs where N_{PO} may be a positive integer number.

[0140] A monitoring indicator may be used to determine if a WTRU needs to receive, attempt to decode, or monitor a subsequent monitoring indicator. A WTRU may receive a monitoring indicator before it may decode, monitor, attempt to decode, receive, or attempt to receive a signal, for example an M-PDCCH or a PDSCH, in a PO. Two monitoring indicators may be used and a first monitoring indicator may be a PO monitoring indicator and a second monitoring indicator may be a PM monitoring indicator. The first monitoring indicator may be transmitted in a broadcast channel. The second monitoring indicator may be transmitted in a DCI, for example in an M-PDCCH.

[0141] A PM monitoring indicator may be comprised of one or more bits to indicate at least one of the following: a presence of an associated PDSCH which may carry a paging message; a WTRU group index, or WTRU group ID, which may be associated with a paging message; and a type of information carried in a paging message.

[0142] In another example, one or more monitoring indicators may be used and each monitoring indicator may be used to indicate a WTRU group, a WTRU group index or a WTRU group ID. A WTRU which may be associated with a WTRU group, a WTRU group index or a WTRU group ID may need to monitor or receive a paging message, for example when a monitoring indicator for the WTRU group, the WTRU group index or the WTRU group ID indicates to monitor or read a paging message. A hierarchical WTRU group index may

be used, where a first WTRU group index may include a set of WTRUs or WTRU-IDs and a second WTRU group index may include a subset of WTRUs or WTRU-IDs within the set of WTRUs or WTRU-IDs indicated from the first WTRU group index. The first WTRU group index may be determined based on a WTRU-ID, for example, IMSI, and the second WTRU group index may be determined based on a different WTRU-ID, for example, s-TMSI. The first WTRU group index may be determined based on a modulo operation based on WTRU-ID and the number of WTRU groups for the first WTRU group index, and the second WTRU group index may be determined based on a hashing function with a WTRU-ID and the number of WTRU groups for the second WTRU group index.

[0143] A combination of a first monitoring indicator and a second monitoring indicator may be used to determine a WTRU group index. If N1 WTRU groups for a first monitoring indicator and N2 WTRU groups for a second monitoring indicator are used, the combined WTRU group may be indicated as N1 x N2 WTRU groups.

[0144] Examples of using multiple monitoring indicators for paging with explicit and implicit indications are discussed herein. In an example, one or more monitoring indicators may be used and a first monitoring indicator may be based on one or more explicit bits while a second monitoring indicator may be based on an RNTI. For example, a WTRU may receive or receive an indication from a PO monitoring indicator in a first channel and the WTRU may receive or receive an indication from a PM monitoring indicator in a second channel.

[0145] In an example, the first channel may be a broadcast channel and the second channel may be a physical downlink control channel, for example, an M-PDCCH. In another example, the first channel may be an M-PDCCH monitored in a cell-specific time/frequency resource, such as, for example, a common search space, and the second channel may be an M-PDCCH monitored in a WTRU-specific or WTRU-group specific time/frequency resource, such as, for example, a WTRU-specific or WTRU group-specific search space. In a further example, the PO monitoring indicator may be one or

more bits transmitted in a broadcast channel. Also, the PM monitoring indicator may be a set of RNTIs reserved for the PM monitoring indication.

[0146] Example methods for a WTRU to perform a paging NB determination are discussed herein. A WTRU may determine the NB to use for paging in its PO, for example based on at least one of its WTRU ID, the number of paging NBs, , and the DL system bandwidth. The WTRU ID may be an IMSI or an s-TMSI. An option is to use IMSI modulo 1024 to determine the NB, for example, since IMSI modulo 1024 may be used to determine the WTRU's PO. The number of paging NBs may be broadcast, may be received via broadcast signaling, and/or may be received via system information. A paging NB may be a NB that may be used for paging. In an example, a NB may be or may represent a set of RBs or subcarriers within a system BW.

[0147] The parameters used for paging may include DRX cycle, nB and the like. Depending on the parameters that may be used for paging and the number of NBs, the use of IMSI modulo 1024 to determine the NB, however, may result in some or all WTRUs in a given PO determining the same NB. This may defeat the purpose of having multiple NBs for paging.

[0148] Several example solutions are discussed herein for a WTRU to better determine a NB for paging. In an example solution, IMSI-10 may be used to represent IMSI modulo 1024 or the least significant 10 bits of an IMSI. For MME initiated paging of a WTRU, the MME may include the IMSI-10 and/or the s-TMSI for the WTRU in the S1 paging message to the eNode-B to request the page. When paging a WTRU, an eNode-B may know the IMSI-10 and/or the s-TMSI of the WTRU. The WTRU and/or eNode-B may use one or both of these values to determine the WTRU's NB for paging. For example, the WTRU and/or eNode-B may use one or both of these values to determine the WTRU's NB for paging in the WTRU's PO.

[0149] A function, such as a hashing function, that may be based on at least the WTRU ID may be used by a WTRU and/or eNode-B to determine the NB for paging. For example, the function may be based on at least IMSI-10 or IMSI modulo X. In an example, the hashing function may be based on at least IMSI-10 or IMSI modulo X.

[0150] For example, a function such as a hashing function may be used based on N_b and/or the WTRU ID. In an example, N_b may be the number of NBs. In a further example, N_b may be the number of NBs to use for paging or that may be used for paging. For example, the NB for a WTRU, NB_{WTRU}, may be determined, for example, by the WTRU and/or eNode-B according to:

$$NB_{WTRU} = (A \cdot N_{WTRUID}) \bmod N_b \quad \text{Equation (1)}$$

where the A may be a prime number, for example, A = 39827. In a further example, NB_{WTRU}, may be determined according to:

$$NB_{WTRU} = ((A \cdot N_{WTRUID}) \bmod D) \bmod N_b \quad \text{Equation (2)}$$

where D may be a prime number which may be different from A, for example, D = 65537.

[0151] A and/or D may be a function of N_b. A and/or D may be fixed and/or configured, for example, by the eNode-B via signaling. N_{WTRUID} may be the WTRU ID or a portion of or function of the WTRU's IMSI or s-TMSI. For example N_{WTRUID} for a WTRU may be IMSI-10, IMSI modulo X, where X may be a number less than or equal to 1024 or IMSI modulo Y, where Y may be a number less than or equal to 16,384. The number of NBs for paging may be provided by the eNode-B and/or received by the WTRU in signaling such as higher layer signaling which may be broadcast, for example, in system information.

[0152] Additional IMSI bits or an additional portion or function of the IMSI may be used by a WTRU and/or eNode-B to determine the NB for paging. The MME may include the additional bits in the S1 paging message to the eNode-B. The eNode-B may receive the additional bits and may use them to determine the NB in which to page the WTRU.

[0153] For example, the most significant B bits of IMSI modulo Z may be used to determine the NB for paging, where Z may be at least one of (2^B) x 1024, (2^C) x 1024 and a number less than or equal to 16,384. In an example, C may be a number or integer that may be different than B. Further, the B MSBs, for example the value of the B MSBs, MB, may be used to determine the NB, for example according to MB modulo N_b.

[0154] In an example, if there are up to 16 narrowbands for paging, B may be 4. The 4 MSBs of IMSI modulo 16,384 may be used to determine the NB for paging, where IMSI modulo 16,384 may be derived from IMSI modulo Z and Z = (2^B) x 1024. Since B may be 4, then (2^4) x 1024 = 16 x 1024 = 16,384. Further, since B may be 4, the 4 MSBs, M4, may be used to determine the NB, for example according to M4 modulo N_b. M4 may be used to represent the 4 MSBs or the value of the 4 MSBs.

[0155] In another example, B may be 3 and C may be 4. The 3 MSBs of IMSI modulo 16,384 may be used to determine the NB for paging, where IMSI modulo 16,384 may be derived from IMSI modulo Z and Z = (2^C) x 1024. Since C may 4, then (2^4) x 1024 = 16 x 1024 = 16,384. Further, since B may be 3, the 3 MSBs, M3, may be used to determine the NB, for example according to M3 modulo N_b. M3 may be used to represent the 3 MSBs or the value of the 3 MSBs.

[0156] In other examples, different numbers of narrowbands for paging may be used and still be consistent with the examples discussed herein. Further, in other examples, different values for B, for C or for both may be used.

[0157] The 14 bits, IMSI-14, that may correspond to IMSI modulo 16,384 may be used to determine the NB, for example according to IMSI-14 modulo N_b. Further, the 14 bits, IMSI-14, that may correspond to IMSI modulo 16,384 may be used to determine the NB, for example according to IMSI-14 modulo N_b modified by one or more other parameters.

[0158] FIG. 6 is a diagram of an example flow chart showing a WTRU using a WTRU-ID to determine a paging NB to use for monitoring an M-PDCCH. As shown in flow chart 600, a WTRU may determine a paging NB for the WTRU, to use for monitoring an M-PDCCH, based on at least the MSBs of a function of a WTRU-ID 610. The WTRU may monitor for the M-PDCCH on the determined paging NB for the WTRU 620. For example, the WTRU may monitor for the M-PDCCH on the determined paging NB in or during a PO that may be a PO of the WTRU. The WTRU may monitor for an M-PDCCH masked with a P-RNTI or for an M-PDCCH or DCI with a CRC scrambled

with a P-RNTI. The WTRU may then receive a DCI on the monitored M-PDCCH on the determined paging NB during a PO 630 that may be a PO of the WTRU. The DCI may include a CRC that may be scrambled with a P-RNTI. The WTRU may receive a physical downlink shared channel (PDSCH) associated with the M-PDCCH 650 or the DCI, for example a PDSCH scheduled by the M-PDCCH or the DCI. The WTRU may receive system information update related information and/or a paging message in or from the DCI or the PDSCH.

[0159] In a further example, the most significant N bits of IMSI-10 may be used to determine the NB for paging. N may be a function of the number of NBs configured or available, for example, in a PO, for paging.

[0160] In the embodiments and examples described herein, the term mobile subscriber identification number (MSIN) may be substituted for IMSI and vice versa and still be consistent with embodiments and examples disclosed herein. Further, various example numbers of digits may be used for MSIN and IMSI, including but not limited to 8, 10, 14, 16, 32, 64 and the like.

[0161] Examples of a WTRU determining a paging HF are discussed herein. Within a PH, WTRUs with the same IMSI modulo 1024 may determine the same PF and the same PO. Depending on the paging parameters, WTRUs may not be distributed well among the PFs and the PO.

[0162] IMSI may be comprised of decimal digits (0 through 9) and may include one or more of mobile country code (MCC), mobile network code (MNC) and MSIN. An IMSI may use binary-coded decimal (BCD) representation. IMSI may comprise 64 bits where each digit may by coded over 4 separate bits. The digits 0 to 9 may be encoded 0000 to 1001 and there may be two digits per octet. For the function IMSI modulo X, IMSI may be the decimal representation of the IMSI, the BCD representation of the IMSI, the hexadecimal representation of the IMSI, or another representation of the IMSI.

[0163] One or more of the examples described herein for the determination of a paging NB, for example, for and/or by a WTRU, may be applied to the determination of one or more of PH, PF, and PO, for example,

for and/or by a WTRU. A separate, for example, different function, aspect, or portion of the WTRU-ID, for example, IMSI or s-TMSI, may be used for each of PH and PF determination for and/or by a WTRU.

[0164] A $WTRU_ID_{PH}$ may represent the function, aspect, or portion of the WTRU-ID that may be used in the PH calculation. $WTRU_ID_{PF}$ may represent the function, aspect, or portion of the WTRU-ID that may be used in the PF calculation. $WTRU_ID_{PH}$-10 may represent $WTRU_ID_{PH}$ modulo 1024. $WTRU_ID_{PF}$-10 may represent $WTRU_ID_{PF}$ modulo 1024. For MME initiated paging of a WTRU, the MME may include $WTRU_ID_{PH}$-10 and/or $WTRU_ID_{PF}$-10 in the S1 paging message to the eNode-B to request the page.

[0165] A $WTRU_ID_{PH}$-10 and/or the $WTRU_ID_{PF}$-10 may be given to the eNode-B by the MME. A $WTRU_ID_{PH}$-10 and/or the $WTRU_ID_{PF}$-10 may be given to the eNode-B by the MME as a bit string of size 10. The bits may follow the normal binary representation or the BCD representation.

[0166] When paging a WTRU, an eNode-B may know $WTRU_ID_{PH}$-10 and/or $WTRU_ID_{PF}$-10. The WTRU and/or eNode-B may use one or both of these values to determine the WTRU's PH and/or PF. The WTRU and/or eNode-B may use $WTRU_ID_{PH}$-10 to determine the WTRU's PH or PHs for paging. The WTRU and/or eNode-B may use $WTRU_ID_{PF}$-10 to determine the WTRU's PF or PFs for paging.

[0167] In an example, $WTRU_ID_{PH}$ may be the WTRU's MSIN. MSIN may be the least N1, for example, 9, significant decimal digits of the IMSI in decimal representation, for example, if the concatenation of MCC and MNC is 6 digits. MSIN may be the least N2, for example, 10, significant decimal digits of the IMSI, for example, if the IMSI is 15 digits. $WTRU_ID_{PF}$ may be the WTRU's IMSI. $WTRU_ID_{PH}$-10 may be MSIN modulo 1024 and/or the $WTRU_ID_{PF}$-10 may be IMSI modulo 1024.

[0168] In another example, $WTRU_ID_{PH}$ may be the IMSI and $WTRU_ID_{PF}$ may be the MSIN. In another example, if the concatenation of the MCC and MNC part of the IMSI is an even number, the IMSI may be transformed such that the concatenation of the MCC and the MNC part of the

IMSI is an odd number. For example, one may be added or subtracted from the concatenation of the MCC and MNC part of the IMSI.

[0169] In another example, MSIN-10Q may be used to represent FLOOR [MSIN/1024] or (FLOOR [MSIN/1024]) modulo 1024. $WTRU_ID_{PH}$-10 may be MSIN-10Q.

[0170] Modified paging reception examples are disclosed herein. In an example, a WTRU may determine its PH, PF, and PO according to a set of rules, such as, for example, regular rules. The WTRU may receive and/or use additional configuration or information to determine when to monitor or skip monitoring for paging, for example, when to monitor or skip monitoring for a M-PDCCH masked with a paging RNTI, and/or receive or skip receiving an associated PDSCH or PCH.

[0171] At least some of the configuration and/or information may be provided by or received from an MME via NAS signaling or via an eNode-B via RRC signaling. The WTRU may maintain the configuration and/or information while in idle mode. A WTRU may monitor for paging in the PFs of its PW in one PH per I-eDRX cycle. In an example, a WTRU may be configured to skip its PH in one or more I-eDRX cycles and/or to skip one or more PFs in its PW.

[0172] In an example, whether the WTRU ID is an odd or even number may be used to determine whether a WTRU may read or receive, or may skip reading or receiving, a page in a PF and/or a PH. Reading and/or receiving a page may correspond to monitoring for M-PDCCH with a paging RNTI. Reading and/or receiving a page may correspond to receiving, decoding, and/or reading a PDSCH which may be associated with, indicated by, or allocated by an M-PDCCH with a paging RNTI. Reading and/or receiving a page may correspond to receiving, decoding, and/or reading a PDSCH that may carry a paging message. Skipping reading or receiving a page may be the same as not reading or receiving or not attempting to read or receive a page. Skipping reading or receiving a page may be the same as skipping one or more of a PO, PF or a PH.

[0173] A WTRU may read or monitor for a page, for example, in a PO, if WTRU ID is an odd number and skip reading or monitoring for a page, for example, in a PO, if WTRU ID is an even number, for example if reading and/or monitoring by a WTRU with an odd number WTRU ID is indicated. A WTRU may read or monitor for a page, for example, in a PO if the WTRU ID is an even number and skip reading or monitoring for a page, for example, in a PO if WTRU ID is an odd number, for example if reading and/or monitoring by a WTRU with an even number WTRU ID is indicated.

[0174] $WTRU_ID_{PH}$-10 and/or $WTRU_ID_{PF}$-10 may be substituted for WTRU ID and still be consistent with this disclosure. WTRU ID may be IMSI modulo 1024, MSIN modulo 1024, and/or FLOOR [MSIN/1024], among others.

[0175] Whether odd numbered WTRUs or even numbered WTRUs may receive a page in a PF or PO may be determined based on one or more of: a WTRU ID odd/even indicator; a PH odd/even indicator; and/or a PF odd/even indicator.

[0176] One bit may be used for an indicator. One state of the bit may be used to indicate even and the other state may be used to indicate odd. 0 may be used for even and 1 for odd or vice versa. One or more of the indicators may be signaled, for example, by the eNode-B, for example in the MIB, in a SIB, or in the M-PDCCH for paging.

[0177] A WTRU may read one or more of the indicators prior to at least one of its PHs and/or PFs and/or POs. The WTRU may read one or more of the indicators in an M-PDCCH for paging in one of its POs. The WTRU may determine the state of one or more of the indicators and based on the state or states the WTRU may determine whether to monitor for a page and/or receive a PDSCH that may carry a page. An indicator in the MIB may be used by a WTRU to determine whether to monitor for a paging M-PDCCH in one or more POs. An indicator in the M-PDCCH for paging may be used by a WTRU to determine whether to reads a PDSCH associated with the M-PDCCH that may carry a paging message.

[0178] For example, for WTRU ID odd/even = even and PH odd/even = odd, a WTRU with an even WTRU ID may read or monitor for a page in, for

example, only in, an odd numbered PH. The WTRU may skip reading or monitoring for a page in an even numbered PH. A WTRU with an odd WTRU ID may skip reading or monitoring for a page when WTRU odd/even is set to even, for example, in one or more, for example, both odd and even PHs.

[0179] In an example, (0,0) may mean the WTRU ID is even and PH is even, (1,0) may mean the WTRU ID is odd and PH is even, (0,1) may mean the WTRU ID is even and PH is odd, and (1,1) may mean the WTRU ID and PH are odd. The eNode-B may use one of these codes as a paging reading indicator, for example, at any time.

[0180] In another example, a single bit for odd/even WTRU ID may be used. A WTRU with an even WTRU ID may read or monitor for a page when WTRU odd/even is set to even and may skip reading or monitoring for a page when WTRU odd/even is set to odd. A WTRU with an odd WTRU ID may read or monitor for a page when WTRU odd/even is set to odd and may skip reading or monitoring for a page when WTRU odd/even is set to even.

[0181] The eNode-B may signal some or all of the bits of the current value of the paging reading indicator in the MIB, or in the SIB or in M-PDCCH (or PDCCH). The WTRU may make the determination to skip a PH based on the value of the paging indicator signaled by the eNode-B. The WTRU may make the determination to skip a PF based on the value of the paging reading indicator.

[0182] The eNode-B may use a paging reading indicator to indicate to one or more WTRUs to skip or read a page in a PH and/or PF. The eNode-B may use separate paging reading indicators to indicate to skip or read a page in a PF and to skip or read pages in all the PFs in a PH.

[0183] Odd/even indication may be replaced by a group ID that may represent another way to distinguish groups. More bits may be used as is appropriate. For example, there may be 4 groups and the least significant 2 bits of the WTRU ID may be used for the determination of which WTRUs may read or monitor for pages.

[0184] In a PO, multiple paging messages intended for multiple WTRUs may be multiplexed into a transport block and jointly coded by a channel

coder, where the WTRUs may have a different coverage level, thus requiring repetitions targeting for a worst coverage case. This may result in resource waste for paging transmissions.

[0185] In an example, multiple paging messages may be separately coded as code-block segments within a PDSCH transmission. For example, a PDSCH, for example, an NB-PDSCH carrying one or more paging message(s) may be scheduled by an associated PDCCH, for example, an NB-PDCCH, in each PO. The paging messages multiplexed in the PDSCH may be split into one or more code-block segments.

[0186] Each code-block segment may be coded separately by a channel code, for example, a turbo code, convolutional code, or block code. Each code-block segment may be attached with a CRC. A code-block segment may be associated with one or more paging messages. A code-block segment may be associated with one or more coverage levels. A code-block segment may be associated with a WTRU-ID. The WTRU-ID used for PO determination and code-block segment determination may be different. For example, the PO may be determined based on a first WTRU-ID, for example, IMSI-10, while the code-block segment may be determined based on a second WTRU-ID, for example, s-TMSI.

[0187] FIG. 7 is a diagram illustrating an example of code-block segment multiplexing in a PDSCH which may be scheduled by an associated PDCCH in a PO. The paging message, paging information, and paging record may be used interchangeably. As shown in diagram 700, code-block segments 710, 720 and 780 may be each associated with one or more respective coverage levels or CE levels. For example, code-block segment 710 may be associated with CE level 1, code-block segment 720 may be associated with CE level 2 and code-block segment 780 may be associated with CE level 3.

[0188] A PDSCH carrying one or more paging messages may be transmitted over multiple subframes. The number of subframes used for the PDSCH transmission may be indicated from the associated PDCCH. The number of subframes for the PDSCH transmission may be determined based on the transport block size, where the transport block size may include all

code-block segments multiplexed in the PDSCH. The number of repetitions may be indicated from the associated PDCCH. For example, the number of subframes Ns for the PDSCH transmission may be determined as a function of the transport block size and the number of repetitions Nrep may be indicated from the associated PDCCH. The total number of subframes used for the PDSCH transmission including repetitions may be Ns x Nrep.

[0189] A NB-subframe may include one of more subframes. The NB-subframe length may be determined based on the transport block size of the PDSCH transmission.

[0190] A code-block segment may be transmitted within an NB-subframe, where the NB-subframe length, for example, as a number of subframes, TTIs, ms, or the like, may be determined based on the size of the code-block segment. Multiple code-block segments may be multiplexed in a PDSCH. In an example shown in FIG. 7, code-block segments 710, 720 and 780 may be multiplexed in PDSCH 790. In an example, if Nc code-block segments are multiplexed in a PDSCH, the PDSCH may be transmitted over Nc NB-subframes. A NB-subframe length associated with a code-block segment may be determined based on the code-block segment size. The size of code-block segments may be indicated in the associated PDCCH. Based on the code-block segment sizes, a WTRU may determine the NB-subframe length of each code-block segment.

[0191] One or more code-block segments may be multiplexed in a PDSCH and the time/frequency resource locations for each code-block segment may be predefined. A WTRU may monitor all code-block segments within the PDSCH or a WTRU may monitor a subset of code-block segments. Each code-block segment may be associated with a CE level and a WTRU with a certain CE level may monitor, attempt to decode, or receive a code-block segment associated with the CE level. Each code-block segment may be associated with a WTRU-ID or a WTRU-group ID, and a WTRU may monitor, attempt to decode, or receive a code-block segment associated with the WTRU-ID or a WTRU-group ID.

[0192] In an example, multiple paging messages may be separately coded as code-block segments and each code-block segment may be transmitted in a PDSCH. For example, if Nc code-block segments are transmitted, the Nc PDSCHs may be transmitted and the Nc PDSCHs may be scheduled in an associated PDCCH in a PO. Each PDSCH carrying a code-block segment may be transmitted in one or more subframes. The starting subframe of each PDSCH carrying a code-block segment may be determined based on the last subframe of the associated PDCCH. Alternatively, the starting subframe of each PDSCH carrying a code-block segment may be determined based on the last subframe of the associated PDCCH and the size of the code-block segment. The number of subframes for a PDSCH carrying a code-block segment may be determined based on the size of the code-block segment. The size of the code-block segment may be a number of bits for the code-block segment after coding and rate-matching.

[0193] FIG. 8 is a diagram illustrating an example of code-block segments transmitted via multiple PDSCHs which may be scheduled by an associated PDCCH in a PO. An associated PDCCH transmitted in a PO may schedule one or more PDSCHs carrying paging messages. A PDSCH may be associated with a code-block segment.

[0194] As shown in diagram 800, code-block segments 810, 820 and 860 may be each associated with one or more respective coverage levels or CE levels, in a manner similar to that in FIG. 7. For example, code-block segment 810 may be associated with CE level 1, code-block segment 820 may be associated with CE level 2 and code-block segment 860 may be associated with CE level 3. However, in FIG. 8, each different respective PDSCH may be associated with each different respective code-block segment. For example, code-block segment 810 may be associated with PDSCH 870, code-block segment 820 may be associated with PDSCH 880 and code-block segment 860 may be associated with PDSCH 890.

[0195] The PDSCHs may be multiplexed in the time domain. For example, the PDSCHs may be transmitted in a different time (e.g., different

time window). The starting subframe of the PDSCHs may be predetermined based on the last subframe of the associated PDCCH.

[0196] In another example, the PDSCHs carrying code-block segments may be transmitted without an associated PDCCH. In each PO, one or more time windows may be configured, used, or allocated and a WTRU may attempt to decode, monitor, or receive a PDSCH carrying a code-block segment in a time window. The code-block segment size for a PDSCH may be predefined. One or more code-block segment sizes may be used and a WTRU may attempt to decode all candidate code-block segment sizes. The time windows for PDSCHs may be non-overlapped. Each time window may be associated with a CE level or WRTU-ID.

[0197] In another example, one or more PDSCHs carrying code-block segments may be transmitted and a first PDSCH may be scheduled by an associated PDCCH and the subsequent PDSCH(s) may be scheduled based on the previous PDSCH. An indication may be transmitted in a PDSCH to indicate whether a subsequent PDSCH carrying code-block segment may follow or may be transmitted. The indication may be based on a sequence masked in the CRC. For example, if the CRC is masked with a first sequence, there may not be a subsequent PDSCH while if the CRC is masked with a second sequence, there may be a subsequent PDSCH. The indication may be a bit transmitted in a code-block segment. A scheduling information may be transmitted with the indication. The first PDSCH may be based on the highest CE level, for example, a largest repetition number, and a subsequent PDSCH may be based on a lower CE level. The terms code-block segment and paging message may be interchangeably used herein.

[0198] The following examples include sending a direct indication in a paging DCI without PDSCH scheduling. When an eNode-B updates, or changes, a frequency location of an anchor RB, for example an anchor PRB, which may contain a synchronization signal and/or broadcasting signals such as a NB master information block (NB-MIB) and/or a NB-SIB, the eNode-B may need to indicate the update, or changes, via paging for WTRUs that are in RRC idle mode. If the indication bits are transmitted in a paging message, the

resource overhead may be increased significantly since the eNode-B may need to send this signal in all POs.

[0199] In an example, a WTRU may monitor or attempt to decode a DCI located in a NB-PDCCH search space. The NB-PDCCH may be in a PO. The NB-PDCCH and/or the PO may be intended for the WTRU. The DCI may carry one or more information types. The terms information type and DCI contents may be used interchangeably herein. One or more of following example parameters may apply.

[0200] A first information type may be scheduling information of the associated PDSCH carrying a paging message. A second information type may be a direct indication which may be related to a system configuration. The second information type may not include scheduling information of the associated PDSCH.

[0201] The information type related to system configuration may include at least one of following parameters or indications: a system information update indication; a public warning indication, such as an ETWS or a CMAS indication; an access barring parameter, such as an EAB parameter modification indication; scheduling information of one or more SIBs, where one or more SIBs may be transmitted without an associated DL control channel (NB-PDCCH); configuration information related to the anchor RB, for example the anchor PRB, for NB-IoT; a same-physical cell-ID (PCI) indicator, which may indicate if the PCI for a cell-specific reference signal (CRS) port and the PCI for an NB reference signal (NB-RS) are the same; and a valueTag, which may include one or more bits to indicate which SIB or SIBs are updated.

[0202] The scheduling information of a SIB or SIBs may include at least one of the following parameters: transport block size (TBS), frequency location, frequency hopping related information, and coverage level, which may be, for example, a repetition number. As described herein, an anchor RB, for example an anchor PRB, may include or may include transmission of at least one of the following: a synchronization signal (for example, a NB primary synchronization signal (NB-PSS), a NB secondary synchronization signal NB-

SSS and the like), a broadcast signal (for example, an NB physical broadcast channel (NB-PBCH), an NB-SIB and the like), and a NB-PDCCH common search space. The configuration information for an anchor RB, for example an anchor PRB, may include at least one of the following parameters: a RB location, for example a PRB location, within a system bandwidth, a raster offset, and a PCI of the NB-Sync.

[0203] In an example, the information type for the DCI may be determined based on a flag field in the DCI. For example, the flag field may indicate the information type carried. In another example, the information type for the DCI may be determined based on a RNTI used for the DCI. A first RNTI (e.g., P-RNTI-1) may be used if the DCI carries scheduling information of a corresponding PDSCH. A second RNTI (e.g., P-RNTI-2) may be used if the DCI carries direct information such as one or more indications related to a system configuration. In other examples, the information type for the DCI may be determined based on a scrambling sequence used for the DCI or a starting ECCE index used.

[0204] In examples, an eNode-B may page one or more WTRUs to indicate or provide a broadcast transmission or a multicast transmission. For example, for a downlink burst transmission to a group of WTRUs or all WTRUs in a cell, such as, for example, for or to perform a software upgrade of one or more NB-IoT devices, an eNode-B may page or may need to page the group of WTRUs or all WTRUs in the cell. For example, the eNode-B may need to page the group of WTRUs or all WTRUs in the cell if the WTRUs are in RRC idle. The eNode-B may need to transmit the downlink burst for each WTRU via WTRU-dedicated resources. This may result in inefficient resource utilization and WTRU battery consumption. A downlink burst transmission may be used herein as a non-limiting example of a broadcast or multicast transmission.

[0205] In an example, a common PO may be used for a downlink burst transmission. For example, a DCI scrambled with a certain RNTI, such as, for example, a downlink burst RNTI (DB-RNTI), may be monitored by a WTRU in

a PDCCH search space in the common PO. The DCI may schedule a PDSCH carrying a downlink burst traffic.

[0206] A WTRU may monitor or attempt to decode the DCI in a PDCCH search space. The PDCCH search space may be located in a certain time/frequency resource configured or used for the common PO. The time/frequency resource for a common PO may be determined based on at least one of the following parameters: system parameters, such as, for example, system bandwidth, physical cell-ID, duplex mode, TDD subframe configuration; subframe number and/or radio frame number, for example SFN; WTRU-ID, such as, for example, full or partial information of IMSI, s-TMSI and the like; operation mode, such as, for example, in-band, guard-band, and stand-alone operation; one or more coverage levels, which may be represented by, for example, repetition numbers; WTRU category and/or WTRU capabilities; and paging NBs, which may be configured or determined.

[0207] The DCI may activate and/or deactivate the PDSCH transmission for downlink burst transmission. The PDSCH may be transmitted in predefined time/frequency resources. The predefined time/frequency resources may be transmitted with a duty cycle.

[0208] In an example, a scheduling information of the downlink burst may be transmitted in a broadcast channel or in system information, such as, for example, in a MIB or a SIB. A WTRU may receive an indication or may be indicated, triggered, or informed to read the broadcast channel or the system information. The indication may be signaled in a paging message or as a direct indication in a DCI for paging. The scheduling information of the downlink burst may be transmitted in a broadcast channel or in system information. A WTRU may receive or attempt to decode the broadcast channel or system information if the WTRU receives a system information update indication.

[0209] In an example, an ordered PDSCH transmission may be used for the downlink burst transmission. For example, downlink burst traffic may be split into *N*_burst transport blocks and may be numbered in an increasing order. Each transport block may be transmitted in a PDSCH transmission. Scheduling information for the downlink burst transmission may indicate the

number of transport blocks, represented by, for example *N*_burst, for the downlink burst transmission. Scheduling information for a PDSCH carrying one or more downlink burst transport blocks may indicate the ordering number of the PDSCH.

[0210] Each transport block may be transmitted in a certain time and/or frequency resource. A transport block with a certain transport block number may be associated with a certain subframe number, a certain SFN and/or a certain hyper frame number. Therefore, a WTRU may determine, assume, or understand which transport block may be transmitted in a certain time/frequency resource for the burst transmission. If a WTRU fails to receive a subset of the transport blocks of the *N*_burst transport blocks, the WTRU may receive the failed transport blocks in a next downlink burst transmission. A transport block with a certain transport block number may be associated with a certain frequency resource. The certain time/frequency resources may be configured via higher layer signaling.

[0211] Each PDSCH carrying a transport block may be transmitted with a repetition, where the repetition number may be indicated in the scheduling information. The repetition number may include a value of "1" as a no repetition case.

[0212] In an example, a WTRU that fails to receive one or more PDSCH transmissions for a downlink burst transmission may perform one or more of following actions. The WTRU may attempt to receive the failed PDSCH transmission in a following transmission or a following transmission window. A maximum number of attempts may be predefined or configured by higher layers. The maximum number of attempts may include a value of "1".

[0213] If the WTRU fails to receive one or more PDSCH transmissions after the maximum number of attempts, the WTRU may attempt to change operation mode, such as, for example, from RRC idle mode to RRC connected mode, and/or the WTRU may initiate a random access or random access channel (RACH) procedure.

[0214] In another example, a WTRU that fails to receive one or more PDSCH transmissions for a downlink burst transmission may perform one or

more of the following actions. The WTRU may send a corresponding hybrid automatic repeat request acknowledgement (HARQ-ACK) transmission in an associated HARQ-ACK resource. A HARQ transmission for reception failure may be a negative acknowledgement (NACK). A subset of physical random access channel (PRACH) resources may be reserved as an associated HARQ-ACK resource for the downlink burst transmission. For example, a WTRU may send a HARQ transmission that may be a NACK on a PRACH resource when it fails to receive one or more PDSCH transmissions for a downlink burst transmission. A set of physical uplink control channel (PUCCH) resources may be configured, indicated, or used for HARQ transmission, for example for NACK transmission. For example, a WTRU may send a HARQ transmission that may be a NACK on a PUCCH resource that may be configured or indicated when it fails to receive one or more PDSCH transmissions for a downlink burst transmission.

[0215] Although features and elements are described above in particular combinations, one of ordinary skill in the art will appreciate that each feature or element can be used alone or in any combination with the other features and elements. In addition, the methods described herein may be implemented in a computer program, software, or firmware incorporated in a computer-readable medium for execution by a computer or processor. Examples of computer-readable media include electronic signals (transmitted over wired or wireless connections) and computer-readable storage media. Examples of computer-readable storage media include, but are not limited to, a read only memory (ROM), a random access memory (RAM), a register, cache memory, semiconductor memory devices, magnetic media such as internal hard disks and removable disks, magneto-optical media, and optical media such as CD-ROM disks, and digital versatile disks (DVDs). A processor in association with software may be used to implement a radio frequency transceiver for use in a WTRU, UE, terminal, base station, RNC, or any host computer.

* * *

CLAIMS

What is claimed is:

1. A method performed in a machine type communication (MTC) wireless transmit/receive unit (WTRU), the method comprising:

determining, by the WTRU, a paging narrowband (NB) for the WTRU, to use for monitoring an MTC physical downlink control channel (M-PDCCH), based on at least the most significant bits (MSBs) of a function of a WTRU-identifier (WTRU-ID);

monitoring, by the WTRU, for the M-PDCCH on the determined paging NB for the WTRU;

receiving, by the WTRU, a downlink control information (DCI) on the monitored M-PDCCH on the determined paging NB during a paging occasion (PO); and

receiving, by the WTRU, a physical downlink shared channel (PDSCH) associated with the M-PDCCH.

2. The method of claim 1, wherein the WTRU determines the paging NB based on at least the 3 MSBs of a function of the WTRU-ID.

3. The method of claim 1, wherein the WTRU determines the paging NB based on at least the 4 MSBs of a function of the WTRU-ID.

4. The method of claim 1, wherein the DCI includes a cyclic redundancy check (CRC) that is scrambled with a Paging Radio Network Temporary Identifier (P-RNTI).

5. The method of claim 1, wherein the PDSCH is scheduled by the DCI.

6. The method of claim 1, wherein the DCI includes system information update related information.

7. The method of claim 1, where in the PDSCH includes system information update related information.

8. The method of claim 1, wherein the PDSCH includes a paging message.

9. The method of claim 1, wherein the WTRU-ID is a WTRU international mobile subscriber identity (IMSI).

10. The method of claim 9, wherein the function includes IMSI mod 16,384.

11. The method of claim 1, wherein determining the paging NB for the WTRU is further based on a number of NBs for paging.

12. A machine type communication (MTC) wireless transmit/receive unit (WTRU), the WTRU comprising:

a processor configured to determine a paging narrowband (NB) for the WTRU, to use for monitoring an MTC physical downlink control channel (M-PDCCH), based on at least the most significant bits (MSBs) of a function of a WTRU-identifier (WTRU-ID);

a transceiver operatively coupled to the processor, the transceiver and processor configured to monitor for the M-PDCCH on the determined paging NB for the WTRU;

the transceiver and processor configured to receive a downlink control information (DCI) on the monitored M-PDCCH on the determined paging NB during a paging occasion (PO); and

the transceiver and processor configured to receive a physical downlink shared channel (PDSCH) associated with the M-PDCCH.

13. The WTRU of claim 12, wherein the WTRU determines the paging NB based on at least the 3 MSBs of a function of the WTRU-ID.

14. The WTRU of claim 12, wherein the WTRU determines the paging NB based on at least the 4 MSBs of a function of the WTRU-ID.

15. The WTRU of claim 12, wherein the DCI includes a cyclic redundancy check (CRC) that is scrambled with a Paging Radio Network Temporary Identifier (P-RNTI).

16. The WTRU of claim 12, wherein the PDSCH is scheduled by the DCI.

17. The WTRU of claim 12, wherein the DCI includes system information update related information.

18. The WTRU of claim 12, wherein the PDSCH includes system information update related information.

19. The WTRU of claim 12, wherein the PDSCH includes a paging message.

20. The WTRU of claim 12, wherein the WTRU-ID is a WTRU international mobile subscriber identity (IMSI).

21. The WTRU of claim 20, wherein the function includes IMSI mod 16,384.

22. The WTRU of claim 12, wherein the determining the paging NB for the WTRU is further based on a number of NBs for paging.

23. A method performed in a machine type communication (MTC) wireless transmit/receive unit (WTRU), the method comprising:

monitoring, by the WTRU, for an MTC physical downlink control channel (M-PDCCH) in an M-PDCCH search space;

receiving, by the WTRU, an M-PDCCH in the M-PDCCH search space, wherein the M-PDCCH has a starting enhanced control channel element (ECCE) index for a WTRU group containing the WTRU;

decoding, by the WTRU, the M-PDCCH, wherein the M-PDCCH includes a downlink control information (DCI); and

receiving, by the WTRU, a physical downlink shared channel (PDSCH) associated with the M-PDCCH.

24. The method of claim 23, further comprising:

demodulating, by the WTRU, the PDSCH based on the DCI, wherein the PDSCH includes a paging message.

25. The method of claim 24, wherein the WTRU changes operations based on the paging message.

26. The method of claim 25, wherein the WTRU changing operations includes the WTRU changing from idle mode to connected mode based on the paging message.

27. The method of claim 23, wherein an ECCE aggregation level is 16.

28. The method of claim 23, further comprising:

receiving, by the WTRU, the PDSCH based on the DCI, wherein the PDSCH includes a paging message.

29. The method of claim 23, further comprising:

decoding, by the WTRU, the PDSCH based on the DCI, wherein the PDSCH includes a paging message.

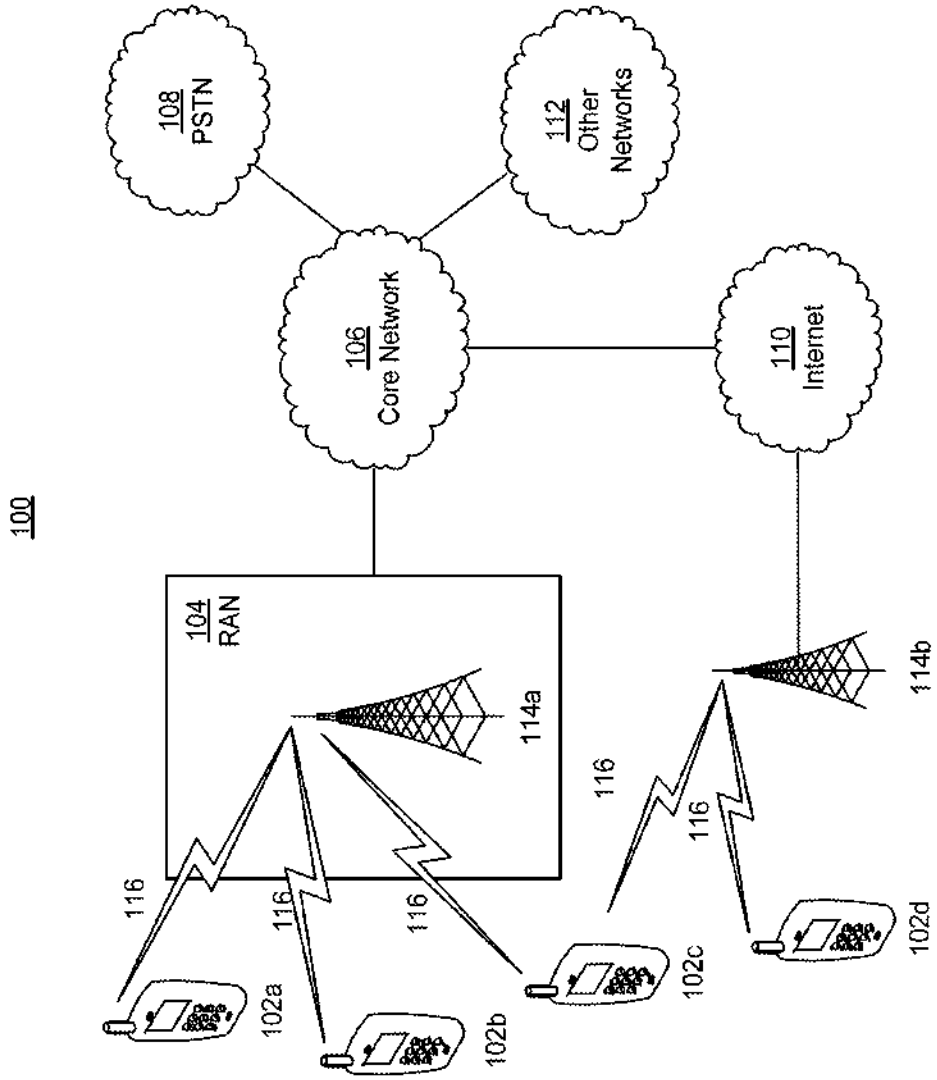

100
108 PSTN
112 Other Networks
106 Core Network
110 Internet
104 RAN
114a
114b
116
116
116
116
116
102a
102b
102c
102d

FIG. 1A

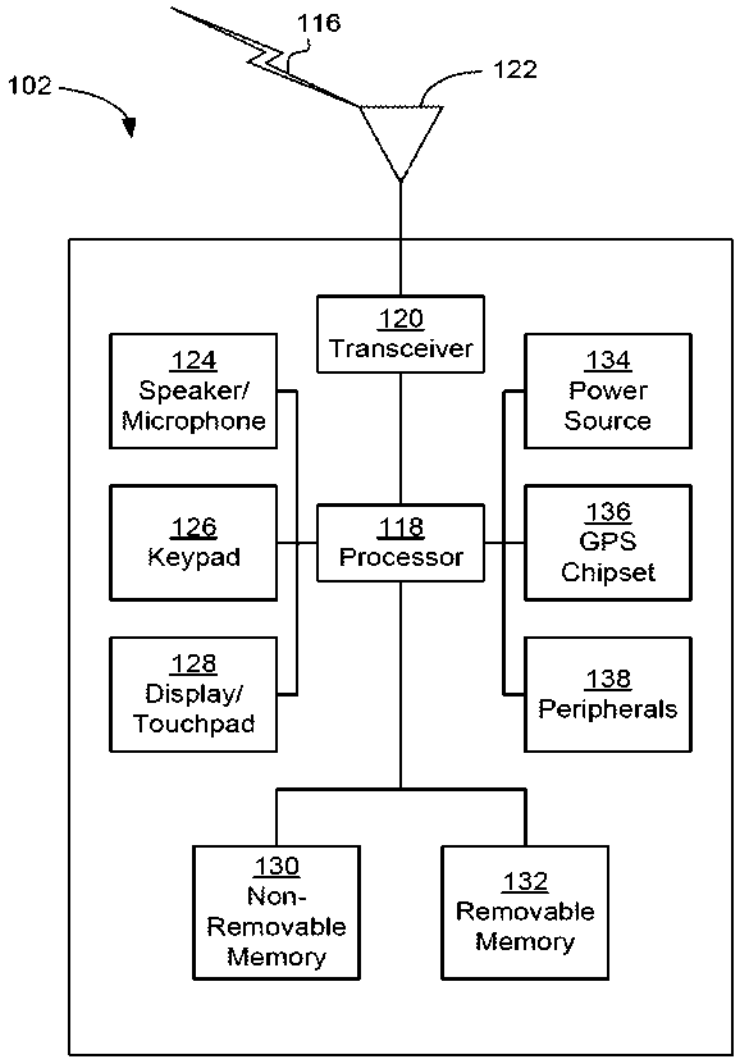

116
122
102
120
Transceiver
124
Speaker/
Microphone
134
Power
Source
126
Keypad
118
Processor
136
GPS
Chipset
128
Display/
Touchpad
138
Peripherals
130
Non-
Removable
Memory
132
Removable
Memory

FIG. 1B

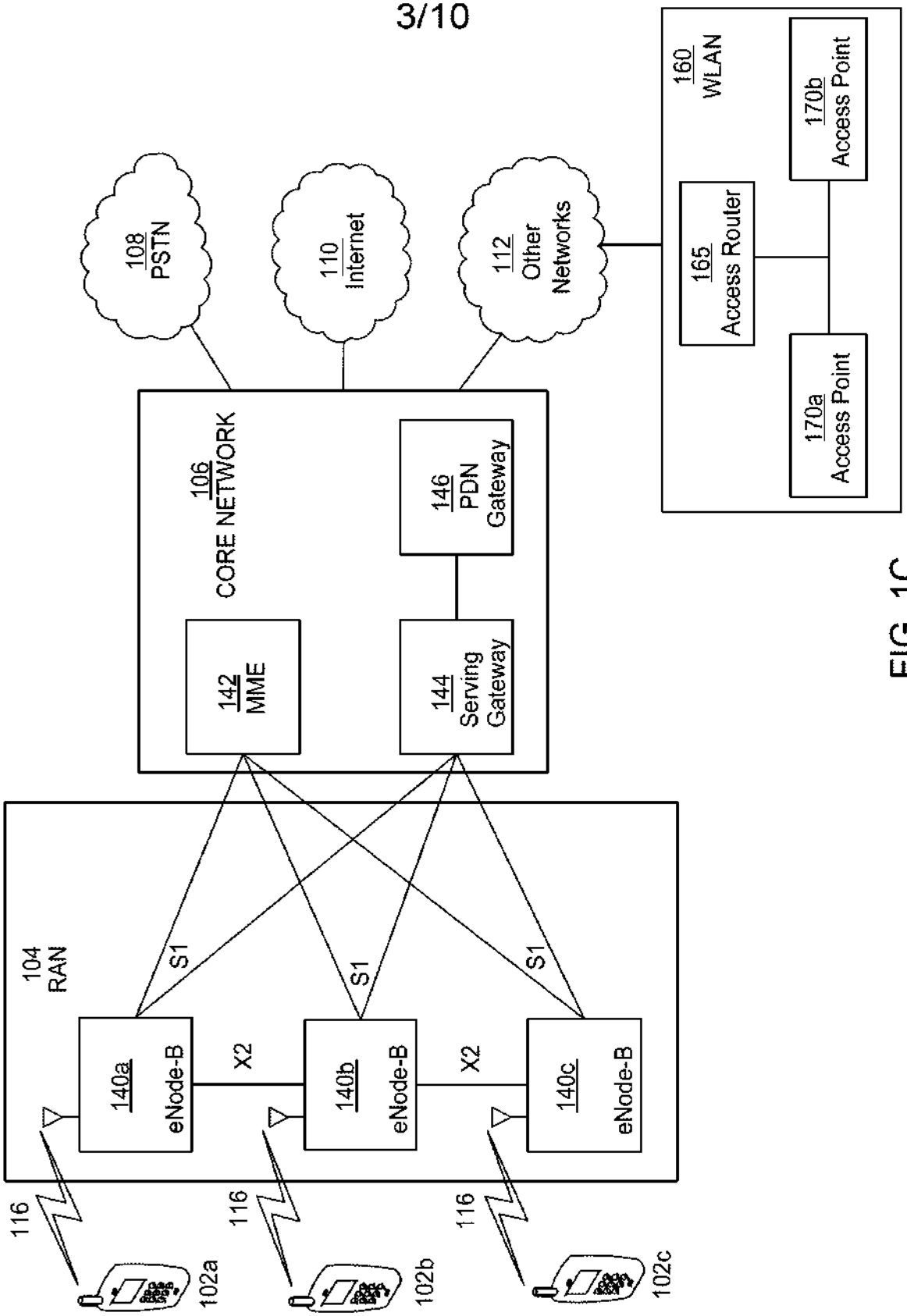

102a
102b
102c
116
116
116
104
RAN
140a
eNode-B
140b
eNode-B
140c
eNode-B
X2
X2
S1
S1
S1
106
CORE NETWORK
142
MME
144
Serving
Gateway
146
PDN
Gateway
108
PSTN
110
Internet
112
Other
Networks
160
WLAN
165
Access Router
170a
Access Point
170b
Access Point

FIG. 1C

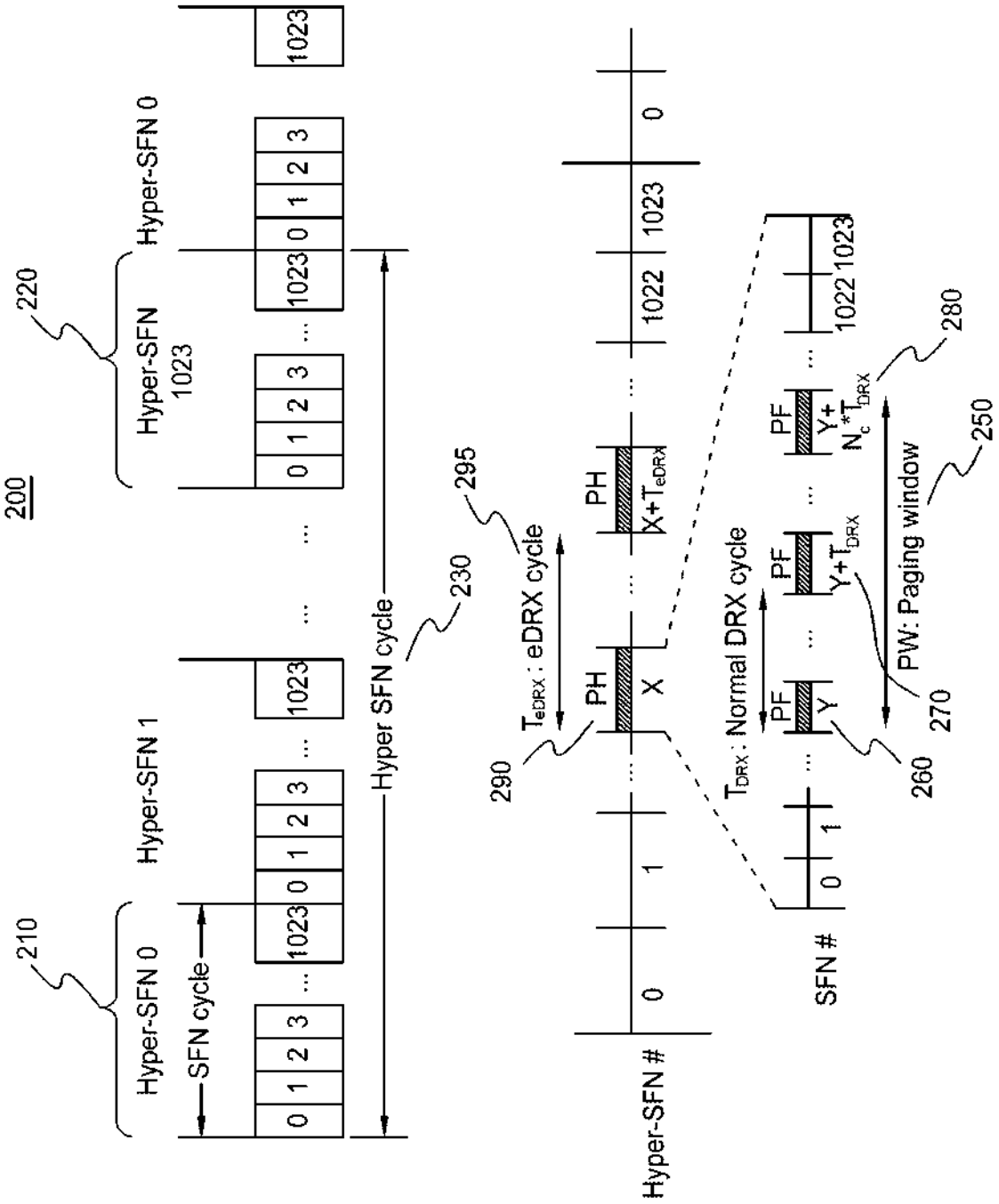

200
210
Hyper-SFN 0
SFN cycle
Hyper-SFN 1
0 1 2 3 ... 1023
220
Hyper-SFN
1023
Hyper-SFN 0
Hyper SFN cycle
230
295
T_{eDRX} : eDRX cycle
290
Hyper-SFN #
PH
X
$X+T_{eDRX}$
T_{DRX} : Normal DRX cycle
SFN #
PF
Y
$Y+T_{DRX}$
$Y+N_c*T_{DRX}$
260
270
PW: Paging window
250
280

FIG. 2

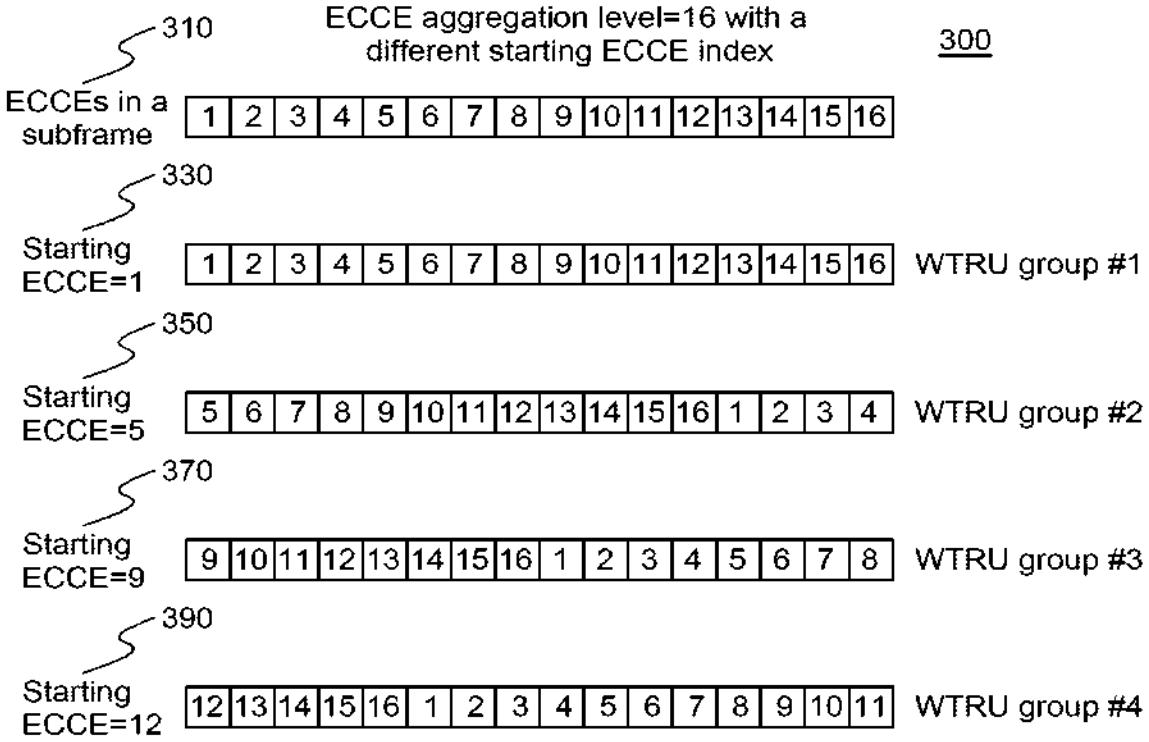

ECCE aggregation level=16 with a different starting ECCE index
300
310
ECCEs in a subframe
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
330
Starting ECCE=1
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
WTRU group #1
350
Starting ECCE=5
5 6 7 8 9 10 11 12 13 14 15 16 1 2 3 4
WTRU group #2
370
Starting ECCE=9
9 10 11 12 13 14 15 16 1 2 3 4 5 6 7 8
WTRU group #3
390
Starting ECCE=12
12 13 14 15 16 1 2 3 4 5 6 7 8 9 10 11
WTRU group #4

FIG. 3

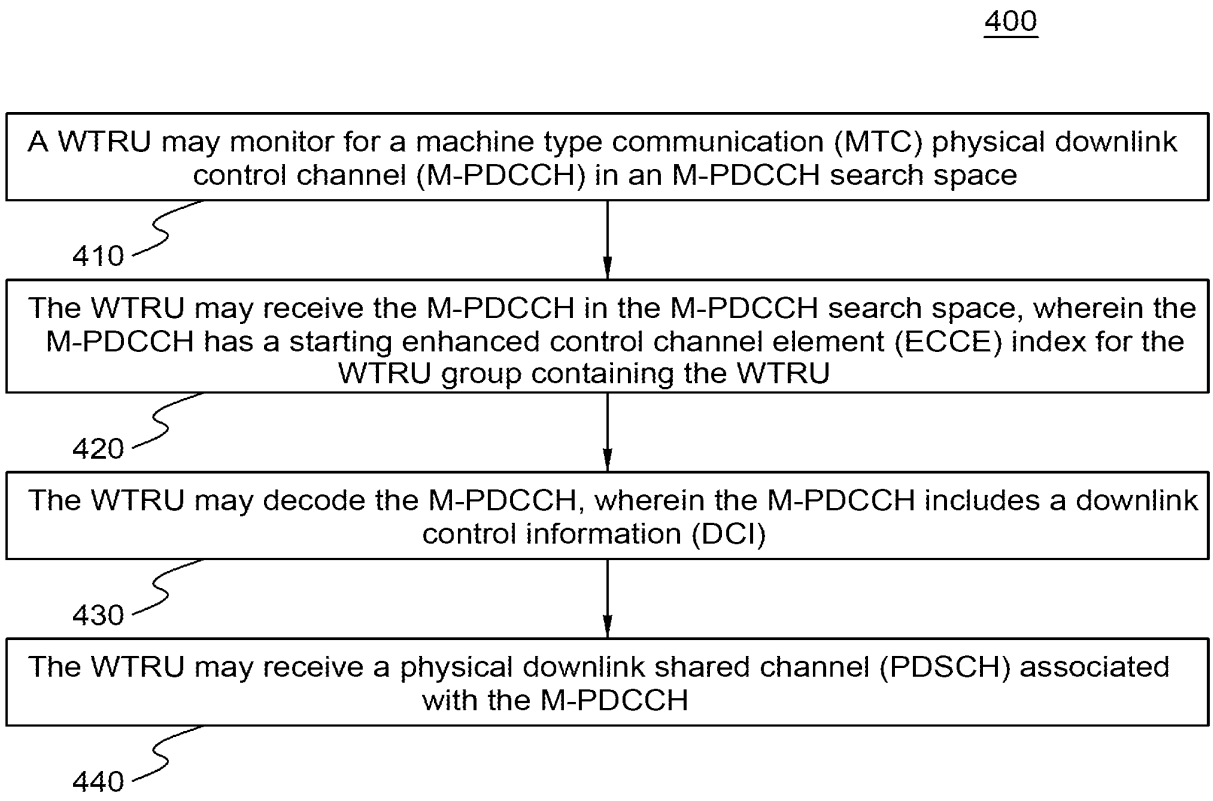

400
A WTRU may monitor for a machine type communication (MTC) physical downlink control channel (M-PDCCH) in an M-PDCCH search space
410
The WTRU may receive the M-PDCCH in the M-PDCCH search space, wherein the M-PDCCH has a starting enhanced control channel element (ECCE) index for the WTRU group containing the WTRU
420
The WTRU may decode the M-PDCCH, wherein the M-PDCCH includes a downlink control information (DCI)
430
The WTRU may receive a physical downlink shared channel (PDSCH) associated with the M-PDCCH
440

FIG. 4

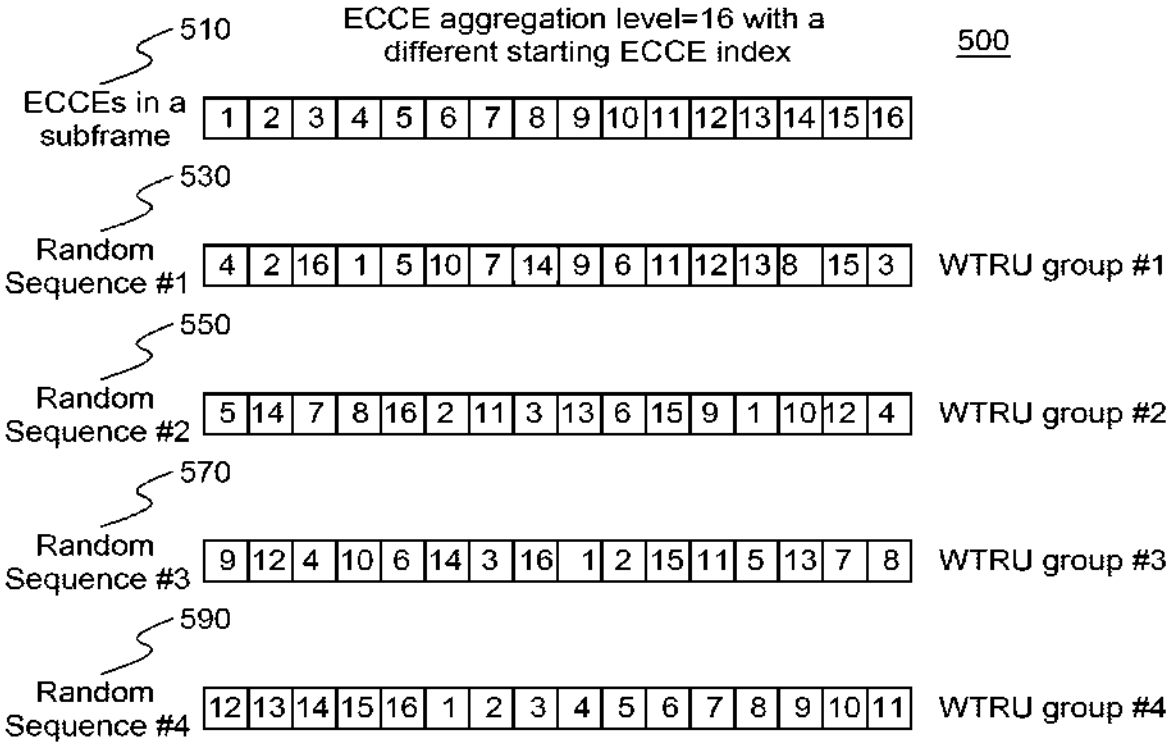

510
ECCE aggregation level=16 with a different starting ECCE index
500
ECCEs in a subframe
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
530
Random Sequence #1
4 2 16 1 5 10 7 14 9 6 11 12 13 8 15 3
WTRU group #1
550
Random Sequence #2
5 14 7 8 16 2 11 3 13 6 15 9 1 10 12 4
WTRU group #2
570
Random Sequence #3
9 12 4 10 6 14 3 16 1 2 15 11 5 13 7 8
WTRU group #3
590
Random Sequence #4
12 13 14 15 16 1 2 3 4 5 6 7 8 9 10 11
WTRU group #4

FIG. 5

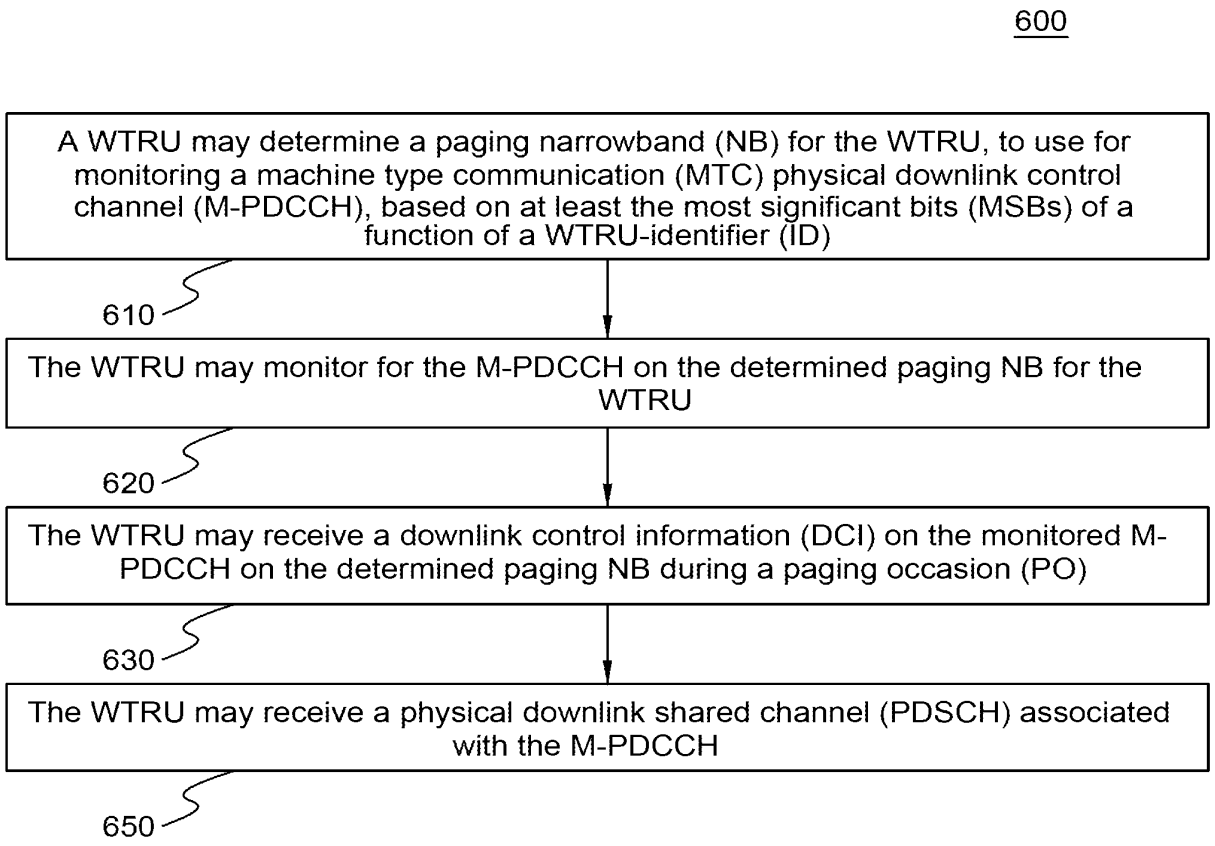

600
A WTRU may determine a paging narrowband (NB) for the WTRU, to use for monitoring a machine type communication (MTC) physical downlink control channel (M-PDCCH), based on at least the most significant bits (MSBs) of a function of a WTRU-identifier (ID)
610
The WTRU may monitor for the M-PDCCH on the determined paging NB for the WTRU
620
The WTRU may receive a downlink control information (DCI) on the monitored M-PDCCH on the determined paging NB during a paging occasion (PO)
630
The WTRU may receive a physical downlink shared channel (PDSCH) associated with the M-PDCCH
650

FIG. 6

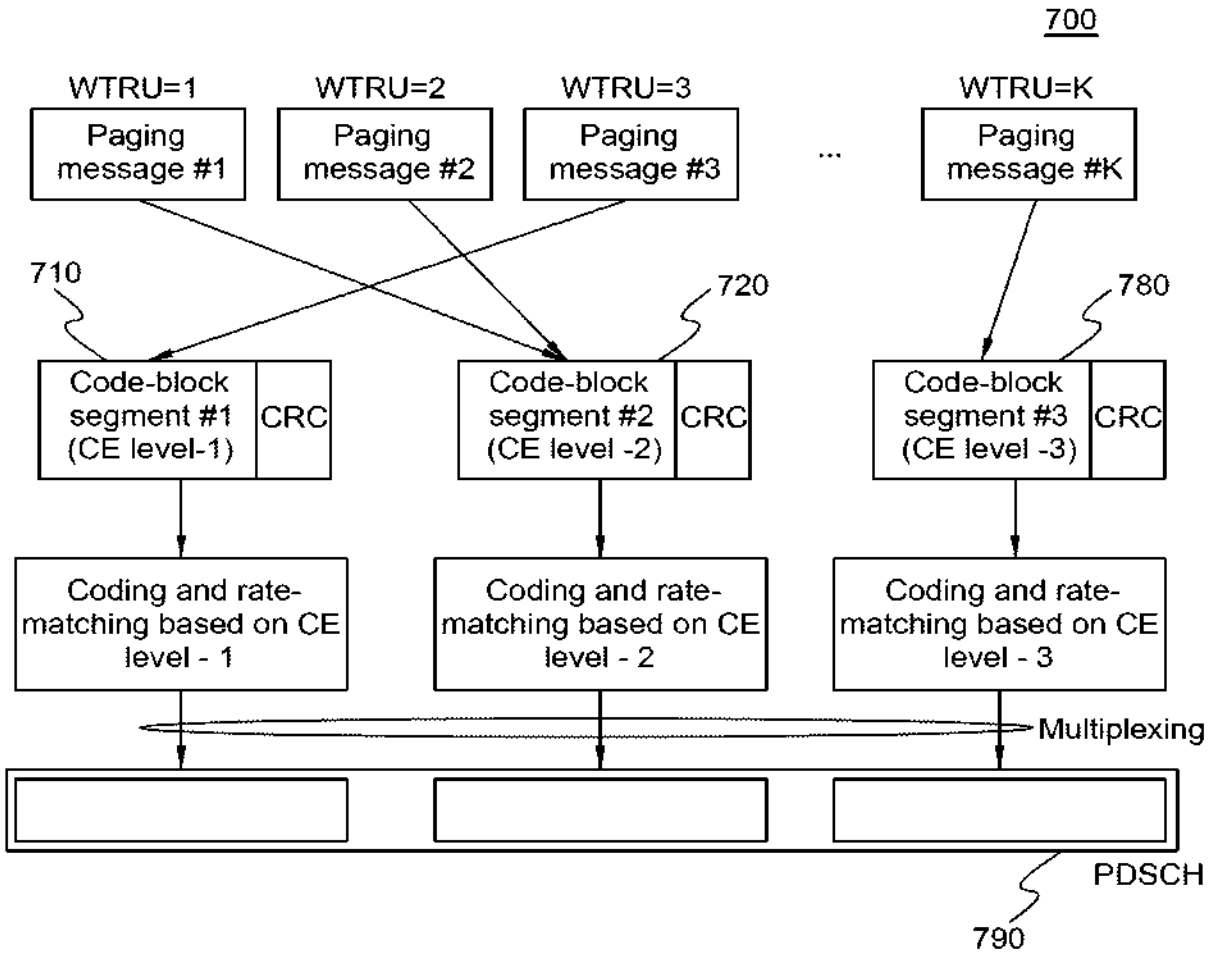

700
WTRU=1
WTRU=2
WTRU=3
...
WTRU=K
Paging message #1
Paging message #2
Paging message #3
Paging message #K
710
720
780
Code-block segment #1 (CE level-1)
CRC
Code-block segment #2 (CE level -2)
CRC
Code-block segment #3 (CE level -3)
CRC
Coding and rate-matching based on CE level - 1
Coding and rate-matching based on CE level - 2
Coding and rate-matching based on CE level - 3
Multiplexing
PDSCH
790

FIG. 7

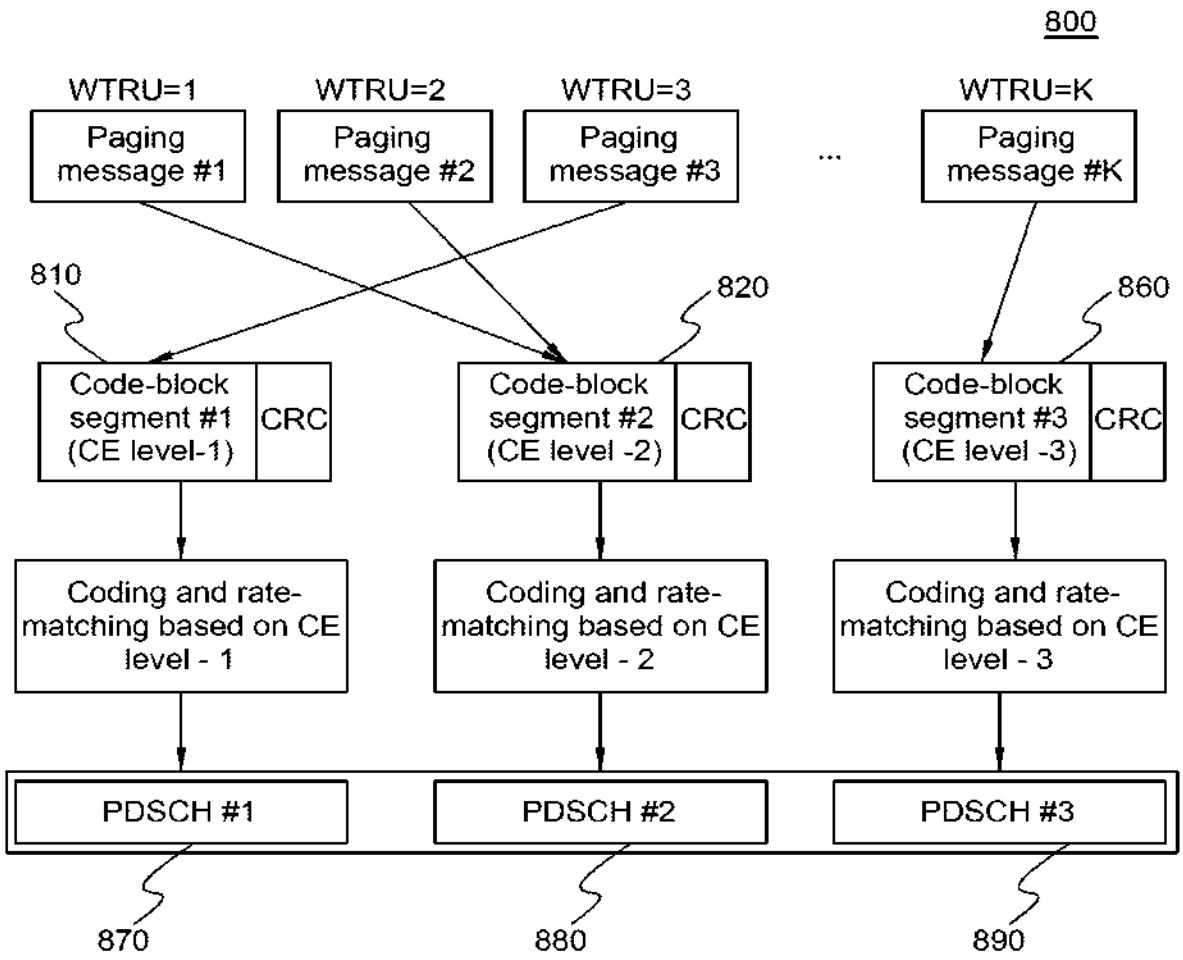

800
WTRU=1
WTRU=2
WTRU=3
WTRU=K
Paging message #1
Paging message #2
Paging message #3
...
Paging message #K
810
820
860
Code-block segment #1 (CE level-1)
CRC
Code-block segment #2 (CE level -2)
CRC
Code-block segment #3 (CE level -3)
CRC
Coding and rate-matching based on CE level - 1
Coding and rate-matching based on CE level - 2
Coding and rate-matching based on CE level - 3
PDSCH #1
PDSCH #2
PDSCH #3
870
880
890

FIG. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/060554

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W68/00
ADD. H04W4/00 H04L5/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2014/069946 A1 (LG ELECTRONICS INC [KR]) 8 May 2014 (2014-05-08) abstract paragraphs [0008] - [0014], [0048], [0051], [0052], [0060], [0061], [0076], [0093], [0095], [0096], [0100] - [0101] paragraphs [0121] - [0123], [0127], [0130] - [0133]; claim 1 ----- -/--	1-29

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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Date of the actual completion of the international search	Date of mailing of the international search report
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Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Englund, Terese

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	US 2013/194931 A1 (LEE MOON-IL [US] ET AL) 1 August 2013 (2013-08-01) abstract paragraphs [0004], [0005], [0038] - [0041], [0044], [0120], [0149], [0196] - [0201], [0203], [0204], [0209] paragraphs [0221] - [0222], [0224], [0226], [0244], [0245], [0248] - [0251], [0254], [0255] paragraphs [0262], [0269] - [0270], [0276]	1-29
X	US 2015/146692 A1 (YI YUNJUNG [KR] ET AL) 28 May 2015 (2015-05-28) paragraphs [0054], [0055], [0063], [0064], [0065], [0070], [0074], [0076], [0079] - [0083], [0106], [0116], [0151]	1-29
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2016/060554

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		WO 2014069946 A1	08-05-2014
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		WO 2011100497 A1	18-08-2011

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(74) Agent: **LEWIS, Darren John**; D YOUNG & CO LLP, 120 Holborn, London EC1N 2DY (GB).

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[Continued on next page]

(54) Title: IDENTIFICATION OF DOWNLINK MESSAGES USING REPEATED TRANSMISSION

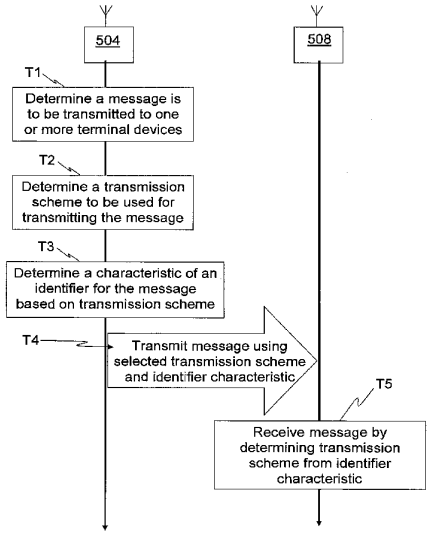


Fig. 9

(57) Abstract: A wireless telecommunication system comprises a base station arranged to communicate messages to one or more terminal devices over a radio interface. The radio interface has a radio frame structure comprising a plurality of subframes, wherein a message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes (e.g. one subframe) or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes (e.g. with repeat transmissions in a plurality of subframes). The message is transmitted in association with an identifier to indicate a terminal device to which the message is addressed. A characteristic for the identifier, for example a value or control region search space for the identifier, is dependent on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme. A terminal device to which the message is addressed determines the transmission scheme from the characteristic of the identifier and receives the message accordingly.

WO 2015/113664 A1

TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

IDENTIFICATION OF DOWNLINK MESSAGES USING REPEATED TRANSMISSION

BACKGROUND

Field

The present disclosure relates to telecommunications apparatus and methods. In particular, certain embodiments relate to schemes for communicating allocations of transmission resources of a shared channel in a wireless telecommunications system.

Description of Related Art

The "background" description provided herein is for the purpose of generally presenting the context of the disclosure. Work of the presently named inventors, to the extent it is described in this background section, as well as aspects of the description which may not otherwise qualify as prior art at the time of filing, are neither expressly or impliedly admitted as prior art against the present invention.

Mobile communication systems have evolved over the past ten years or so from the GSM System (Global System for Mobile communications) to the 3G system and now include packet data communications as well as circuit switched communications. The third generation partnership project (3GPP) is developing a fourth generation mobile communication system referred to as Long Term Evolution (LTE) in which a core network part has been evolved to form a more simplified architecture based on a merging of components of earlier mobile radio network architectures and a radio access interface which is based on Orthogonal Frequency Division Multiplexing (OFDM) on the downlink and Single Carrier Frequency Division Multiple Access (SC-FDMA) on the uplink.

Third and fourth generation mobile telecommunication systems, such as those based on the 3GPP defined UMTS and Long Term Evolution (LTE) architecture are becoming able to support more sophisticated services than simple voice and messaging services offered by previous generations of mobile telecommunication systems. For example, with the improved radio interface and enhanced data rates provided by LTE systems, a user is able to enjoy high data rate applications such as mobile video streaming and mobile video conferencing that would previously only have been available via a fixed line data connection. The demand to deploy third and fourth generation networks is therefore strong and there is a corresponding desire to extend the coverage available in such telecommunications systems (i.e. there is a desire to provide more reliable access to wireless telecommunications systems for terminal devices operating in coverage-limited locations).

A typical example of a coverage-limited terminal device might be a so-called machine type communication (MTC) device, such as a smart meter located in a customer's house and periodically transmitting information back to a central MTC server relating to the customer's consumption of a utility, such as gas, water, electricity and so on. Such a terminal device might operate in a coverage-limited location because, for example, it may be located in a basement or other location with relatively high penetration loss. Further information on characteristics of MTC-type devices can be found, for example, in the corresponding standards, such as ETSI TS 122 368 V10.530 (2011-07) / 3GPP TS 22.368 version 10.5.0 Release 10) [1]. Some typical characteristics of MTC type terminal devices / MTC type data might include, for example, characteristics such as low mobility, high delay tolerance, small data transmissions, infrequent transmission and group-based features, policing and addressing.

In some situations a terminal device in a coverage-limited situation in a particular communication cell served by a base station might be unable to receive communications from the base station unless specific provision is made for it to do so. One way to increase coverage in this situation would be for the base station to increase the power of its transmissions. However, a blanket increase in transmission power from a base station could be expected to give rise to increased interference in neighbouring communication cells. An alternative approach would be for the base station to in effect focus / concentrate its available transmission power budget into a subset of transmission resources (e.g. in terms of frequency) which are selected from within the base station's overall transmission resources and allocated for transmissions to coverage-limited terminal devices. However, this approach can again lead to increased interference in neighbouring cells and may in some cases require increased coordination among base stations to optimise performance.

Another approach for providing coverage extension is to rely on repeated transmissions of signalling in multiple subframes. A terminal device may then combine the signalling received for a plurality of repeated transmissions to increase the likelihood of successfully decoding the signalling, e.g. using chase combining / maximal ratio combining techniques. This repeated transmission approach may be applied for control signalling (e.g. sent on a physical downlink control channel such as PDCCH in LTE) and / or other signalling (e.g. sent on a physical downlink shared channel such as PDSCH in LTE).

One draw-back of a repeated transmission approach for providing coverage extension is a corresponding increase in the amount of transmission resources needed to communicate with terminal devices, particularly in the amount of transmission resources needed to provide control messages to the terminal devices, and the inventors have recognised how this issue can be especially significant for certain types of communications, as discussed further below. There is therefore a need for schemes which can allow for communications with terminal devices to be made over a number of subframes with a reduction in the overall amount of transmission resources needed to support this as compared to conventional techniques.

SUMMARY

According to a first aspect of the present disclosure, there is provided a method of operating a terminal device communicating with a base station in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the method comprises receiving a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel, determining a validity period for the control message, and receiving a plurality of other messages from the base station on the downlink data channel using the allocated transmission resources within the validity period for the control message.

According to a second aspect of the present disclosure, there is provided a terminal device for communicating with a base station in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the

downlink data channel, and wherein the terminal device comprises a controller unit and a transceiver unit configured to operate together to receive a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to receive a plurality of other messages from the base station on the downlink data channel using the allocated transmission resources within the validity period for the control message.

According to a third aspect of the present disclosure, there is provided circuitry for a terminal device communicating with a base station in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to cause the terminal device to receive a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to receive a plurality of other messages from the base station on the downlink data channel using the allocated transmission resources within the validity period for the control message

According to a forth aspect of the present disclosure, there is provided a method of operating a base station communicating with a terminal device in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the method comprises transmitting a control message to the terminal device conveying an indication of allocated transmission resources on the downlink data channel, determining a validity period for the control message, and transmitting a plurality of other messages to the terminal device on the downlink data channel using the allocated transmission resources within the validity period for the control message.

According to a fifth aspect of the present disclosure, there is provided a base station for communicating with a terminal device in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the base station comprises a controller unit and a transceiver unit configured to operate together to transmit a control message to the terminal device conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to transmit a plurality of other messages to the terminal device on the downlink data channel using the allocated transmission resources within the validity period for the control message.

According to a sixth aspect of the present disclosure, there is provided circuitry for a base station communicating with a terminal device in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the

downlink data channel, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to cause the base station to transmit a control message to the terminal device conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to transmit a plurality of other messages to the terminal device on the downlink data channel using the allocated transmission resources within the validity period for the control message.

According to a seventh aspect of the present disclosure, there is provided a method of operating a base station for communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein the method comprises selecting a characteristic for the identifier in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

According to an eighth aspect of the present disclosure, there is provided a base station for communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the base station comprises a controller unit and a transceiver unit configured to operate together such that the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein a characteristic for the identifier is selected in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

According to a ninth aspect of the present disclosure, there is provided circuitry for a base station communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the circuitry comprises a controller element and a transceiver element configured to operate together such that the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein a characteristic for the identifier is selected in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

According to a 10th aspect of the present disclosure, there is provided a method of operating a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission

resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the method comprises determining from an identifier associated with the message that the message is addressed to the terminal device, and further determining from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

According to an 11th aspect of the present disclosure, there is provided a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the terminal device comprises a controller unit and a transceiver unit configured to operate together to determine from an identifier associated with the message that the message is addressed to the terminal device, and to further determine from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

According to a twelfth aspect of the present disclosure, there is provided circuitry for a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to determine from an identifier associated with the message that the message is addressed to the terminal device, and to further determine from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

Further respective aspects and features are defined by the appended claims.

The foregoing paragraphs have been provided by way of general introduction, and are not intended to limit the scope of the following claims. The described embodiments, together with further advantages, will be best understood by reference to the following detailed description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the disclosure and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein like reference numerals designate identical or corresponding parts throughout the several views, and wherein:

Figure 1 provides a schematic diagram illustrating an example of a mobile telecommunication system;

Figure 2 provides a schematic diagram illustrating a LTE radio frame;

Figure 3 provides a schematic diagram illustrating an example of a LTE downlink radio subframe;

Figure 4 provides a schematic diagram illustrating a LTE "camp-on" procedure;

Figure 5 schematically represents a wireless telecommunications system according to an embodiment of the disclosure;

Figure 6 schematically represents a series of downlink subframes for communicating with a terminal device operating in the wireless telecommunications system of Figure 5;

Figure 7 schematically represents a series of downlink subframes for communicating with a terminal device operating in the wireless telecommunications system of Figure 5 in accordance with an embodiment of the disclosure;

Figure 8 is a signalling ladder diagram representing communications between a base station and a terminal device operating in accordance with an embodiment of the disclosure; and

Figure 9 is a signalling ladder diagram representing communications between a base station and a terminal device operating in accordance with another embodiment of the disclosure.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Figure 1 provides a schematic diagram illustrating some basic functionality of a mobile telecommunications network / system 100 operating in accordance with LTE principles and which may be adapted to implement embodiments of the disclosure as described further below. Various elements of Figure 1 and their respective modes of operation are well-known and defined in the relevant standards administered by the 3GPP (RTM) body and also described in many books on the subject, for example, Holma H. and Toskala A [2]. It will be appreciated that operational aspects of the telecommunications network which are not specifically described below may be implemented in accordance with any known techniques, for example according to the relevant standards.

The network 100 includes a plurality of base stations 101 connected to a core network 102. Each base station provides a coverage area 103 (i.e. a cell) within which data can be communicated to and from terminal devices 104. Data is transmitted from base stations 101 to terminal devices 104 within their respective coverage areas 103 via a radio downlink. Data is transmitted from terminal devices 104 to the base stations 101 via a radio uplink. The core network 102 routes data to and from the terminal devices 104 via the respective base stations 101 and provides functions such as authentication, mobility management, charging and so on. Terminal devices may also be referred to as mobile stations, user equipment (UE), user terminal, mobile radio, and so forth. Base stations may also be referred to as transceiver stations / nodeBs / e-nodeBs, and so forth.

Mobile telecommunications systems such as those arranged in accordance with the 3GPP defined Long Term Evolution (LTE) architecture use an orthogonal frequency division modulation (OFDM) based interface for the radio downlink (so-called OFDMA) and a single carrier frequency division multiple access scheme (SC-FDMA) on the radio uplink. Figure 2 shows a schematic diagram illustrating an OFDM based LTE downlink radio frame 201. The LTE downlink radio frame is transmitted from a LTE base station

(known as an enhanced Node B) and lasts 10 ms. The downlink radio frame comprises ten subframes, each subframe lasting 1 ms. A primary synchronisation signal (PSS) and a secondary synchronisation signal (SSS) are transmitted in the first and sixth subframes of the LTE frame. A physical broadcast channel (PBCH) is transmitted in the first subframe of the LTE frame.

Figure 3 is a schematic diagram of a grid which illustrates the structure of an example conventional downlink LTE subframe. The subframe comprises a predetermined number of symbols which are transmitted over a 1ms period. Each symbol comprises a predetermined number of orthogonal subcarriers distributed across the bandwidth of the downlink radio carrier.

The example subframe shown in Figure 3 comprises 14 symbols and 1200 subcarriers spread across a 20MHz bandwidth and in this example is the first subframe in a frame (hence it contains PBCH). The smallest allocation of physical resource for transmission in LTE is a resource block comprising twelve subcarriers transmitted over one subframe. For clarity, in Figure 3, each individual resource element is not shown, instead each individual box in the subframe grid corresponds to twelve subcarriers transmitted on one symbol.

Figure 3 shows in hatching resource allocations for four LTE terminals 340, 341, 342, 343. For example, the resource allocation 342 for a first LTE terminal (UE 1) extends over five blocks of twelve subcarriers (i.e. 60 subcarriers), the resource allocation 343 for a second LTE terminal (UE2) extends over six blocks of twelve subcarriers (i.e. 72 subcarriers), and so on.

Control channel data can be transmitted in a control region 300 (indicated by dotted-shading in Figure 3) of the subframe comprising the first "n" symbols of the subframe where "n" can vary between one and three symbols for channel bandwidths of 3MHz or greater and where "n" can vary between two and four symbols for a channel bandwidth of 1.4MHz. For the sake of providing a concrete example, the following description relates to host carriers with a channel bandwidth of 3MHz or greater so the maximum value of "n" will be 3 (as in the example of Figure 3). The data transmitted in the control region 300 includes data transmitted on the physical downlink control channel (PDCCH), the physical control format indicator channel (PCFICH) and the physical HARQ indicator channel (PHICH). These channels transmit physical layer control information. Control channel data can also or alternatively be transmitted in a second region of the subframe comprising a number of subcarriers for a time substantially equivalent to the duration of the subframe, or substantially equivalent to the duration of the subframe remaining after the "n" symbols. The data transmitted in this second region is transmitted on the enhanced physical downlink control channel (EPDCCH). This channel transmits physical layer control information which may be in addition to that transmitted on other physical layer control channels.

PDCCH and EPDCCH contain control data indicating which subcarriers of the subframe have been allocated to specific terminals (or all terminals or subset of terminals). This may be referred to as physical-layer control signalling / data. Thus, the PDCCH and/or EPDCCH data transmitted in the control region 300 of the subframe shown in Figure 3 would indicate that UE1 has been allocated the block of resources identified by reference numeral 342, that UE2 has been allocated the block of resources identified by reference numeral 343, and so on.

PCFICH contains control data indicating the size of the control region (i.e. between one and three symbols for channel bandwidths of 3 MHz or greater and between two and four symbols for channel bandwidths of 1.4 MHz).

PHICH contains HARQ (Hybrid Automatic Request) data indicating whether or not previously transmitted uplink data has been successfully received by the network.

Symbols in a central band 310 of the time-frequency resource grid are used for the transmission of information including the primary synchronisation signal (PSS), the secondary synchronisation signal (SSS) and the physical broadcast channel (PBCH). This central band 310 is typically 72 subcarriers wide (corresponding to a transmission bandwidth of 1.08 MHz). The PSS and SSS are synchronisation signals that once detected allow a LTE terminal device to achieve frame synchronisation and determine the physical layer cell identity of the enhanced Node B transmitting the downlink signal. The PBCH carries information about the cell, comprising a master information block (MIB) that includes parameters that LTE terminals use to properly access the cell. Data transmitted to terminals on the physical downlink shared channel (PDSCH), which may also be referred to as a downlink data channel, can be transmitted in other resource elements of the subframe. In general PDSCH conveys a combination of user-plane data and non-physical layer control-plane data (such as Radio Resource Control (RRC) and Non Access Stratum (NAS) signalling). The user-plane data and non-physical layer control-plane data conveyed on PDSCH may be referred to as higher layer data (i.e. data associated with a layer higher than the physical layer).

Figure 3 also shows a region of PDSCH containing system information and extending over a bandwidth of R344. A conventional LTE subframe will also include reference signals which are discussed further below but not shown in Figure 3 in the interests of clarity.

The number of subcarriers in a LTE channel can vary depending on the configuration of the transmission network. Typically this variation is from 72 sub carriers contained within a 1.4MHz channel bandwidth to 1200 subcarriers contained within a 20MHz channel bandwidth (as schematically shown in Figure 3). As is known in the art, data transmitted on the PDCCH, PCFICH and PHICH is typically distributed on the subcarriers across the entire bandwidth of the subframe to provide for frequency diversity. Therefore a conventional LTE terminal must be able to receive the entire channel bandwidth in order to receive and decode the control region.

Figure 4 illustrates a LTE “camp-on” process, that is, the process followed by a terminal so that it can decode downlink transmissions which are sent by a base station via a downlink channel. Using this process, the terminal can identify the parts of the transmissions that include system information for the cell and thus decode configuration information for the cell.

As can be seen in Figure 4, in a conventional LTE camp-on procedure, the terminal first synchronizes with the base station (step 400) using the PSS and SSS in the centre band and then decodes the PBCH (step 401). Once the terminal has performed steps 400 and 401, it is synchronized with the base station.

For each subframe, the terminal then decodes the PCFICH which is distributed across the entire bandwidth of carrier 320 (step 402). As discussed above, a LTE downlink carrier can be up to 20 MHz wide (1200 subcarriers) and a standard LTE-compliant terminal therefore has to have the capability to receive and decode transmissions on a 20 MHz bandwidth in order to decode the PCFICH. Accordingly, at the PCFICH decoding stage, with a 20MHz carrier band, the terminal operates at a larger bandwidth

(bandwidth of R320) than during steps 400 and 401 (bandwidth of R310) relating to synchronization and PBCH decoding.

The terminal then ascertains the PHICH locations (step 403) and decodes the PDCCH (step 404), in particular for identifying system information transmissions and for identifying its dedicated allocation grants. The allocation grants are used by the terminal to locate system information and to locate its data in the PDSCH. Both system information and dedicated allocations are transmitted on PDSCH and scheduled within the carrier band 320. Steps 403 and 404 also require a standard LTE-compliant terminal to operate on the entire bandwidth R320 of the carrier band. Allocation grants may also or alternatively be decoded from EPDCCH.

At steps 402 to 404, the terminal decodes information contained in the control region 300 of a subframe. As explained above, in LTE, the three control channels mentioned above (PCFICH, PHICH and PDCCH) can be found across the control region 300 of the carrier where the control region extends over the range R320 and occupies the first one, two or three OFDM symbols of each subframe as discussed above. In a subframe, typically the control channels do not use all the resource elements within the control region 300, but they are scattered across the entire region, such that a LTE terminal has to be able to simultaneously receive the entire control region 300 for decoding each of the three control channels.

The terminal can then decode the PDSCH (step 405) which contains system information or data transmitted for this terminal.

As explained above, in a LTE subframe the PDSCH generally occupies groups of resource elements which follow the control region. The data in the blocks of resource elements 340, 341, 342, 343 allocated to the different mobile communication terminals (UEs) and the system information data in the block of resources 344 shown in Figure 3 have a smaller bandwidth than the bandwidth of the entire carrier. To decode these blocks a terminal first receives the PDCCH spread across the frequency range R320 and/or the EPDCCH to determine if the (E)PDCCH indicates there are PDSCH resources in the subframe that need to be decoded by the UE. The intended recipient(s) for (E)PDCCH signalling in LTE is established through the use of radio network temporary identifiers (RNTI). (E)PDCCH signalling is addressed to a particular RNTI by using the RNTI to scramble cyclic redundancy check (CRC) bits associated with the (E)PDCCH signalling. Each connected UE in a cell is associated with a Cell RNTI (C-RNTI) that may be used to address PDCCH signalling to that particular UE. In addition there are other RNTIs defined and these may be used to simultaneously address groups of terminal devices. For example, a System Information RNTI (SI-RNTI) is defined and PDSCH transmissions comprising SI are allocated by (E)PDCCH signalling addressed to SI-RNTI. Various other RNTIs are defined for various other types of signalling. Some examples include a random-access RNTI (RA-RNTI), a Paging RNTI (P-RNTI), a Transmit Power Control Physical Uplink Control Channel RNTI (TPC-PUCCH-RNTI) and a Transmit Power Control Physical Uplink Shared Channel-RNTI (TPC-PUSCH-RNTI).

Thus, once a UE has received a downlink subframe, the UE searches for (E)PDCCH signalling associated with any RNTI that apply for the UE in the subframe to identify any corresponding allocations of transmission resources on PDSCH. If there is an allocation message addressed to the UE on (E)PDCCH the UE will proceed to decode the PDSCH in the relevant frequency range (if any) indicated by the PDCCH. So for example, UE 1 discussed above decodes the whole control region 300 to

determine its resource allocation and then extracts the relevant data from the corresponding resource block 342.

Figure 5 schematically shows a telecommunications system 500 according to an embodiment of the disclosure. The telecommunications system 500 in this example is based broadly on a LTE-type architecture. As such many aspects of the operation of the telecommunications system 500 are standard and well understood and not described here in detail in the interest of brevity. Operational aspects of the telecommunications system 500 which are not specifically described herein may be implemented in accordance with any known techniques, for example according to the established LTE-standards and known variations thereof.

The telecommunications system 500 comprises a core network part (evolved packet core) 502 coupled to a radio network part. The radio network part comprises a base station (evolved-nodeB) 504, a first terminal device 506 and a second terminal device 508. It will of course be appreciated that in practice the radio network part may comprise a plurality of base stations serving a larger number of terminal devices across various communication cells. However, only a single base station and two terminal devices are shown in Figure 5 in the interests of simplicity.

As with a conventional mobile radio network, the terminal devices 506, 508 are arranged to communicate data to and from the base station (transceiver station) 504. The base station is in turn communicatively connected to a serving gateway, S-GW, (not shown) in the core network part which is arranged to perform routing and management of mobile communications services to the terminal devices in the telecommunications system 500 via the base station 504. In order to maintain mobility management and connectivity, the core network part 502 also includes a mobility management entity (not shown) which manages the enhanced packet service, EPS, connections with the terminal devices 506, 508 operating in the communications system based on subscriber information stored in a home subscriber server, HSS. Other network components in the core network (also not shown for simplicity) include a policy charging and resource function, PCRF, and a packet data network gateway, PDN-GW, which provides a connection from the core network part 502 to an external packet data network, for example the Internet. As noted above, the operation of the various elements of the communications system 500 shown in Figure 5 may be broadly conventional apart from where modified to provide functionality in accordance with embodiments of the disclosure as discussed herein.

In this example, it is assumed the first terminal device 506 is a conventional smart-phone type terminal device communicating with the base station 504. Thus, and as is conventional, this first terminal device 506 comprises a transceiver unit 506a for transmission and reception of wireless signals and a controller unit 506b configured to control the smart phone 506. The controller unit 506b may comprise a processor unit which is suitably configured / programmed to provide the desired functionality using conventional programming / configuration techniques for equipment in wireless telecommunications systems. The transceiver unit 506a and the controller unit 506b are schematically shown in Figure 5 as separate elements. However, it will be appreciated that the functionality of these units can be provided in various different ways, for example using a single suitably programmed general purpose computer, or suitably configured application-specific integrated circuit(s) / circuitry. As will be appreciated the conventional terminal device 506 will in general comprise various other elements associated with its operating functionality.

In this example, it is assumed the second terminal device 508 is a machine-type communication (MTC) terminal device according to an embodiment of the disclosure and located in an area of restricted coverage. As discussed above, MTC devices may be typically characterised as semi-autonomous or autonomous wireless communication devices communicating small amounts of data. Examples include so-called smart meters which, for example, may be located in a customer's house and periodically transmit information back to a central MTC server data relating to the customer's consumption of a utility such as gas, water, electricity and so on. MTC devices may in some respects be seen as devices which can be supported by relatively low bandwidth communication channels having relatively low quality of service (QoS), for example in terms of latency. It is assumed here the MTC terminal device 508 in Figure 5 is such a device. It will, however, the appreciated that embodiments of the disclosure may also be implemented for other types of terminal device.

As with the smart phone 506, the MTC device 508 comprises a transceiver unit 508a for transmission and reception of wireless signals and a controller unit 508b configured to control the MTC device 508. The controller unit 508b may comprise a processor unit which is suitably configured / programmed to provide the desired functionality described herein using conventional programming / configuration techniques for equipment in wireless telecommunications systems. The transceiver unit 508a and the controller unit 508b are schematically shown in Figure 5 as separate elements for ease of representation. However, it will be appreciated that the functionality of these units can be provided in various different ways, for example using a single suitably programmed general purpose computer, or suitably configured application-specific integrated circuit(s) / circuitry, or using a plurality of discrete circuitry / processing elements for providing different elements of the desired functionality. It will be appreciated the MTC device 508 will in general comprise various other elements associated with its operating functionality in accordance with established wireless telecommunications techniques (e.g. a power source, possibly a user interface, and so forth).

The base station 504 comprises a transceiver unit 504a for transmission and reception of wireless signals and a controller unit 504b configured to control the base station 504. The controller unit 504b may comprise a processor unit which is suitably configured / programmed to provide the desired functionality described herein using conventional programming / configuration techniques for equipment in wireless telecommunications systems. The transceiver unit 504a and the controller unit 504b are schematically shown in Figure 5 as separate elements for ease of representation. However, it will be appreciated that the functionality of these units can be provided in various different ways, for example using a single suitably programmed general purpose computer, or suitably configured application-specific integrated circuit(s) / circuitry or using a plurality of discrete circuitry / processing elements for providing different elements of the desired functionality. It will be appreciated the base station 504 will in general comprise various other elements associated with its operating functionality. For example, the base station 504 will in general comprise a scheduling entity responsible for scheduling communications. The functionality of the scheduling entity may, for example, be subsumed by the controller unit 504b.

Thus, the base station 504 is configured to communicate data with the smart phone 506 over a first radio communication link 510 and communicate data with the MTC device 508 over a second radio communication link 512. Both radio links may be supported within a single radio frame structure associated with the base station 504. It is assumed here the base station 504 is configured to communicate with the smart phone 506 over the first radio communication link 510 in accordance with the

established principles of LTE-based communications and to communicate with the MTC-device 506 over the second radio communication link 512 in accordance with embodiments of the disclosure as described herein. It will be appreciated the base station may readily obtain information indicating the different classes of terminal device which are attached to the base station in accordance with conventional techniques. That is to say, the base station will be aware that the smart phone is of a device class that includes conventional smartphones and the MTC device is of a device class that includes MTC devices. Furthermore, the base station may establish using conventional techniques that the MTC device 508 is a device operating in a coverage limited situation such that steps are needed to increase the likelihood of the MTC device being able to decode downlink transmissions.

As noted above, in a LTE-based wireless telecommunications system some of the fundamental information required for a terminal device to operate in a cell is transmitted on PBCH in the Master Information Block (MIB). Other information regarding the system configuration is divided among System Information Blocks (SIBs) referred to as SIB1, SIB2, SIB3,...etc. (there are 16 SIBs defined as of Release 11 LTE). The SIBs are transmitted in system information (SI) messages, which, apart from SIB1, may contain multiple SIBs (termed first SI, second SI, etc.). There may be one or several SI messages transmitted at different periodicities. Each SI message may convey multiple SIBs suitable for scheduling with the same periodicity. The timings for SIB1 message transmissions are fixed on an 80 ms period and they occur in the fifth subframe of radio frames when System Frame Number (SFN) is a multiple of 8 (i.e. SFN mod 8 = 0). There are retransmissions of SIB1 messages provided in every other radio frame within the 80 ms period. The timings for other SIB transmission messages are configured in SIB1. The transmission resource allocations for the SI messages on PDSCH within a subframe are provided to terminal devices using PDCCH allocation messages addressed to SI-RNTI (System Information Radio Network Temporary Identifier - currently 0xFFFF in LTE). At higher layers, SI is carried on the logical broadcast control channel (BCCH).

In LTE the SI messages are transmitted within periodically occurring time domain windows (referred to as SI-windows) using dynamic scheduling. Each SI message is associated with a SI-window and the SI-windows of different SI messages do not overlap. That is, within one SI-window only the corresponding SI message is transmitted. The length of the SI-window is common for all SI messages, and is configurable. Within the SI-window, the corresponding SI message can be transmitted a number of times in any subframe other than MBSFN (multicast-broadcast single frequency network) subframes, uplink subframes in TDD (time division duplex), and subframe #5 of radio frames for which SFN (system frame number) mod 2 = 0. Terminal devices acquire the detailed time-domain scheduling (and other information, e.g. frequency-domain scheduling, transport format) from decoding SI-RNTI on PDCCH. A single SI-RNTI is used to address SystemInformationBlockType1 as well as all SI messages. SystemInformationBlockType1 configures the SI-window length and the transmission periodicity for the SI messages.

The system information in a cell may be changed, although typically this happens rarely with system information perhaps remaining unchanged for hours, days, or even weeks.

For changes of system information other than those related to EAB (Extended Access Barring), ETWS (Earthquake Tsunami Warning System) and CMAS (Commercial Mobile Alert System), there is a BCCH modification period defined (which may be referred to as a “SI modification period”). SI modification period boundaries are defined on radio frames for which SFN mod q = 0, for a cell-specific value of q.

When there is a change in system information, the new system information is transmitted from the start of a new SI modification period.

The general process for implementing a change in system information in a LTE-based network is described, for example, in Section 5.2.1.3 of ETSI TS 136 331 V11.4.0 (2013-07) / 3GPP TS 36.331 version 11.4.0 Release 11 [3]. In summary, a base station indicates a change of system information as follows.

1. When the network changes system information it notifies terminal devices about the change by transmitting a PDCCH resource allocation message addressed to the paging RNTI (P-RNTI). This directs the terminal devices to decode PDSCH resources containing a Paging message with a SystemInfoModification flag set to true. This may be done, for example, throughout one SI modification period. Both RRC_IDLE and RRC_CONNECTED terminal devices check for paging messages periodically. It may be noted that EAB alterations, ETWS and CMAS notifications may be separately modified with separate flags in a paging message (but can also be modified along with other SIBs).

2. In a following SI modification period, the network transmits the modified system information, and may increment a SystemInfoValueTag in SIB1. This value tag can indicate changes in any SIB, but it might not be used for EAB, ETWS, CMAS and some regularly changing SI parameters such as CDMA2000 system time. Terminal devices can use SystemInfoValueTag to verify if currently stored system information is still valid, for example on return from being out of coverage when the UE may have missed a system information change notification in paging.

More details on system information and changes in system information in a LTE-based system can be found in ETSI TS 136 331 V11.4.0 (2013-07) / 3GPP TS 36.331 version 11.4.0 Release 11 [3].

As discussed above, it has been proposed to improve coverage for terminal devices in a wireless telecommunications system by introducing repetitions of a transmission which a terminal device may combine to provide an increased likelihood of successful decoding.

Figure 6 schematically represents an approach for providing coverage extension through repeated transmissions for an SI message in accordance with existing techniques. Figure 6 schematically shows a sequence of LTE downlink subframes (labelled as subframes "A", "B", "C", …, "L" to aid explanation) with shading to schematically indicate which regions in which subframes are used to convey system information. The subframes represented in Figure 6 comprise four groups of three contiguous subframes with spaces between the groups as schematically indicated by dotted lines and discussed further below. Although not shown in Figure 6, the gaps between the groups comprise a continuing sequence of subframes used for other communications that are not relevant to the system information messaging considered here. As discussed above, each subframe comprises a control region 600 and a PDSCH region 602. The control regions 600 for the respective subframes are labelled in Figure 6 with the identification letter for the relevant subframe, i.e. as 600A, 600B, 600C, etc. The PDSCH regions for the respective subframes are similarly labelled in Figure 6 as 602A, 602B, 602C, etc. Each subframe represented in Figure 6 is in essence a simplified version of what is represented in Figure 3. Thus, the control regions 600 support the PCFICH, PHICH and PDCCH channels as discussed above while the PDSCH regions 602 support user-plane data and system information (among other things) and the EPDCCD if implemented. The most significant aspect of the control region 600 in the context of

embodiments of the present disclosure relate to the PDCCH and so for simplicity the control regions 600 may sometimes be referred to herein as PDCCH regions 600.

Before explaining the repeated transmissions approach to providing coverage extension represented in Figure 6 it is considered helpful to clarify some aspects of the terminology to be used herein. The term "repeat transmission" (and related terms) will be used to refer to a transmission in an individual subframe which is part of a sequence of transmissions that are being repeated for the purposes of providing coverage extension for a message being conveyed between a base station and a terminal device (such as a PDCCH message or a PDSCH message). Thus in a coverage extension context, the transmission of a (E)PDCCH message comprises a plurality of "repeat transmissions" on (E)PDCCH and the transmission of a PDSCH message comprises a plurality of "repeat transmissions" on PDSCH. The term "re-transmission" (and related terms) will be used to refer to the transmission of a message that has already been sent at least once before. These terms should be interpreted accordingly unless the context demands otherwise.

For the example repeat transmission approach to coverage extension represented in Figure 6 it is assumed for ease of representation the approach relies on providing only three repeat transmissions for each PDCCH message and each PDSCH message. It will, however, be appreciated that in practice larger numbers of repeat transmissions will typically be involved, for example there may be tens or hundreds of repeats comprising each message to provide a correspondingly higher degree of coverage extension. Furthermore, it will be appreciated that PDCCH messages and PDSCH messages may comprise different numbers of repeat transmissions (for example because different coding schemes are adopted meaning that different numbers of repeat transmissions are needed for a given probability of successful reception).

Thus, referring to Figure 6, subframes A, B and C are used to signal a PDCCH message addressed to SI-RNTI by sending three repeat PDCCH transmissions in the respective PDCCH regions 600A, 600B, 600C. Each PDCCH repeat transmission addressed to SI-RNTI in the PDCCH regions 600A, 600B, 600C in effect comprises a duplication of the same downlink control information which a terminal device can combine to seek to establish the content of the PDCCH message. For this example repeat-transmission based coverage extension scheme it is assumed a particular type of message subject to repeat transmissions is addressed to the same RNTI (e.g. SI-RNTI for a system information related type of messages) as if the same type of message were subject to conventional single-subframe transmission. However, as discussed further below, in accordance with certain embodiments of the disclosure identifiers having different characteristics (e.g. values) may be used for a given type of message depending on whether the messages to be sent in accordance with a first transmission scheme (e.g. using a conventional single subframe based transmission approach) or a second transmission scheme (e.g. using a repeat-transmission scheme for coverage extension). Furthermore, it will be appreciated the approach of using identifiers associated with a particular type of message having different characteristics according to what transmission scheme is to be used to transmit the message can be used in accordance with embodiments of the disclosure with or without the use of validity periods as disclosed herein.

The PDCCH message comprising the three repeat transmissions in the PDCCH regions of subframes A, B and C indicates resource blocks to be used for a subsequent PDSCH message comprising the transmission of system information. This PDSCH message itself comprises a plurality of repeat transmissions, and, in this example, are represented by shading in the PDSCH regions 602D, 602E and 602F of subframes D, E and F. The transmission resources, for example in terms of specific resource

elements, used to convey the repeat transmissions of the system information message in the PDSCH regions 602D, 602E and 602F are indicated in the corresponding PDCCH message addressed to SI-RNTI and comprising the repeat transmissions in PDCCH regions 600A, 600B, 600C in accordance with conventional resource allocation techniques in the context of coverage extension using repeat transmissions. Whilst the shading in Figure 6 schematically represents the same frequency resources being used for each repeat transmission in the respective PDSCH regions 602D, 602E and 602F of the subframes D, E, F, in principle the repeat-transmission approach may be configured to include frequency hopping for the different repeat transmissions comprising the PDSCH message sent in subframes D, E, F. The nature of any such frequency hopping may be pre-defined, for example it may be pre-specified according to an operating standard for the wireless telecommunications system, or it may be established in previous RRC (radio resource control) signalling, or it may be indicated in the PDCCH message.

As schematically represented in Figure 6 there is a gap between subframes C and D. This follows the currently-proposed approaches for repeat-transmission coverage extension whereby the transmission of a PDSCH message comprising a plurality of repeat transmissions does not start until after all repeat transmissions of the corresponding PDCCH message have been sent. This is to help reduce the buffering requirements at the terminal device. Furthermore, current proposals indicate there should be no overlap between the end of the repeat transmissions comprising the PDCCH message and the start of the repeat transmissions comprising the PDSCH message. It will, however, be appreciated the specific implementation of such aspects of a repeat transmission approach for providing coverage extension are not significant to the principles underlying the present disclosure. That is to say, the principles described herein may equally be implemented in association with other repeat transmission approaches (e.g. with repeat transmissions of PDCCH and its corresponding PDSCH occurring in the same subframe).

In subframes following the transmission of the system information message as schematically indicated in subframes D, E and F in Figure 6, the wireless telecommunications system continues to operate in accordance with its normal operating techniques until subframe G represented. Subframe G represents the beginning of another system information message. As noted above, system information messages can be regularly retransmitted in accordance with LTE techniques, and in this regard the system information message beginning at subframe G is considered in this example to be a re-transmission of the system information message transmitted using subframes A to F as discussed above. The specific timing of the re-transmission of system information (i.e. the timing of subframe G relative to subframe A) may follow any conventional system information re-transmission schedule. The principles underlying the re-transmission of the system information message starting from subframe G follow those described above. Thus, a PDCCH message addressed to SI-RNTI is sent using the PDCCH regions 600G, 600H and 600I of subframes G, H and I to allocate resources for a PDSCH message comprising three repeat transmissions in the PDSCH regions 602J, 602K and 602L in subframes J, K and L as indicated by shading in Figure 6. It may be noted in this example the frequencies of the resource elements for the re-transmission of the system information message on PDSCH in subframes J, K, L is different from that used in subframes D, E, F for the previous transmission, but this is not of any particular significance. Furthermore, the transmissions of the PDSCH message in subframes D, E, F, J, K, L may comprise different so-called redundancy versions of the PDSCH message comprising different combinations of information bits and redundancy bits arising from a forward error correction coding process.

It will be appreciated the transmission resources represented in Figure 6 which are not involved in the SI message signalling discussed above can be used for other communications in the network in the usual manner. In particular, it will be appreciated that although the entirety of the PDCCH regions associated with repeat transmissions of the PDCCH for the system information messages are shown shaded in Figure 6, this is merely to highlight those subframes in which a PDCCH for the system information messages is transmitted compared to those where it is not, and in practice these regions will comprise multiple PDCCH messages addressing different terminal devices for allocating resources for various different types of communication on PDSCH.

System information signalling in LTE is sent on what is approaching a more or less continuous basis. This means there is a considerable amount of PDSCH traffic for broadcasting system information messages comprising the SIBs. There is a corresponding requirement for PDCCH signalling to schedule the PDSCH resources for system information messages. The inventors have recognised that this can become a significant issue in a coverage extension scenario where a number of repetitions are expected, as illustrated in Figure 6. This is because for each PDSCH message comprising a plurality of PDSCH repeat transmissions (i.e. the PDSCH message sent using resources in subframes D, E and F and the PDSCH message sent using resources in subframes J, K and L) there is a corresponding SI-RNTI PDCCH message comprising a plurality of PDCCH repeat transmissions (i.e. the PDCCH message sent using resources in subframes A, B and C and the PDCCH message sent using resources in subframes G, H and I). With the potential for perhaps a hundred or more repeat transmissions to provide coverage extension to the edge of a base station's corresponding cell for system information messages a large fraction of the available control region resources will be needed to support this function following the approach of Figure 6. There is of course a corresponding increase in the use of PDSCH resources with the approach represented in Figure 6, but it is to be expected that in many situations it will be PDCCH resources that are more at a premium owing to the limited resources available in the control channel region for PDCCH and the priority typically given to PDSCH over EPDCCH in the PDSCH region. This is especially likely in networks supporting large numbers of MTC devices since these are likely to have a higher ratio of control signalling to data signalling as compared to the traffic profiles typically associated with conventional terminal devices. The increased PDCCH and/or EPDCCH resources needed to support repeat transmissions of system information messages could ultimately make it difficult to schedule unicast PDSCH transmissions to terminal devices operating within the system because of a lack an availability of control region resources to indicate the allocation of PDSCH resources and/or a lack of PDSCH region resource to indicate the allocation of PDSCH resources.

To address this type of issue there have been proposals to stop using PDCCH and EPDCCH messages resource allocations for PDSCH messages comprising system information (i.e. for system information messages). One proposal (described in the 3GPP document R1-135422, "On the need of PDCCH for SIB and other Common Channel", Mediatek, RAN1#75, San Francisco, November 2013 [4]) is to avoid providing any scheduling information in respect of system information-carrying PDSCH transmissions. Instead, a terminal device will be expected to perform blind searching of the PDSCH region to identify if there are any relevant system information transmissions. A drawback with this approach is a significant increase in the processing load required for terminal devices. To reduce the processing load required at the terminal device to a more manageable level the system information messages could be confined to a restricted subset of transmission resources comprising the PDSCH region. However, this approach still requires additional processing tasks to be performed by the terminal device and introduces reduced

scheduling flexibility. Another proposal (described in the 3GPP document R1-134207, "Coverage enhancement techniques for PBCH", Alcatel-Lucent, Alcatel-Lucent Shanghai Bell, RAN1#74bis, Guangzhou, October 2013 [5]) is to avoid using PDCCH messages to provide scheduling information in respect of system information-carrying PDSCH messages. Instead it is proposed that some of the spare bits currently available in the Master Information Block (MIB) in LTE are used for providing scheduling indications for system information messages. However, there are a limited number of spare bits available for this and so the approach does not allow for any significant degree of flexibility in scheduling system information messages, and furthermore the approach further reduces the number of spare bits available for other uses.

In view of these issues, the inventors have developed an alternative approach for reducing the amount of control signalling required to support resource allocations for higher-layer transmissions in a wireless telecommunications system. In particular, but not exclusively, the inventors have developed an approach which may be applied for reducing the amount of control-channel signalling required to support resource allocations for downlink messages, such as system information messages, and in particular for messages which may be subject to re-transmissions on a defined schedule and which may, in some cases, be sent using a repeat transmission approach to provide a degree of coverage extension.

Figure 7 is similar to, and represents various aspects that will be understood from, Figure 6, but shows an approach in accordance with certain embodiments of the present disclosure. Figure 8 is a signalling ladder diagram schematically representing modes of operation for the terminal device 508 and the base station 504 schematically represented in Figure 5 in accordance with some embodiments of the present disclosure for implementing an approach of the kind represented in Figure 7. In broad summary, some embodiments of the disclosure introduce the concept of a validity period for a PDCCH message to thereby indicate transmission resources that may be used for a plurality of PDSCH messages within the validity period. That is to say the control message transmitted on the PDCCH is considered valid for a period that is longer than the period needed to transmit a single PDSCH message (whether in one subframe or with repeat transmissions in a plurality of subframes to provide coverage extension). This means multiple PDSCH messages can in effect be scheduled using the control-region resources of only a single PDCCH message. There are various different ways in which the validity period may be established/determined, as discussed further below.

For the example represented in Figure 7, and as with Figure 6, it is assumed system information is being transmitted from a base station to a terminal device with a repeat transmission approach to providing coverage extension. Again the example approach to coverage extension represented in Figure 7 is assumed for ease of representation to rely on providing only three repeat transmissions for each PDCCH and PDSCH message. However, as noted above, it will be appreciated that in practice larger numbers of repeat transmissions will typically be involved, for example there may be tens or hundreds of repeats comprising each message to provide a correspondingly higher degree of coverage extension. Furthermore, it will be appreciated that PDCCH messages and PDSCH messages need not necessarily comprise the same number of repeat transmissions (for example different coding schemes may be adopted meaning that different numbers of repeat transmissions are appropriate to provide a desired probability of successful reception for each message).

Thus Figure 7 schematically represents an approach for providing coverage extension through repeated transmissions for a plurality of SI messages with reduced control signalling overhead in accordance with

an embodiment of the disclosure. Figure 7 schematically shows a sequence of LTE downlink subframes (labelled as subframes "O", "P", "Q", …, "Z" to aid explanation) with shading to schematically indicate which regions in which subframes are used to convey messages associated with the system information. The subframes represented in Figure 7 comprise four groups of three contiguous subframes with spaces between the groups as schematically indicated by dotted lines. Although not shown in Figure 7, the gaps between the groups comprise a continuing sequence of subframes used for other communications that are not relevant to the system information messaging considered here. As discussed above, each subframe comprises a control region 700 and a PDSCH region 702. The control regions 700 for the respective subframes are labelled in Figure 7 with the identification letter for the relevant subframe, i.e. as 700O, 700P, 700Q, etc. The PDSCH regions for the respective subframes are similarly labelled in Figure 6 as 702O, 702P, 702Q, etc.

As already noted above, aspects of the operation of a wireless telecommunications system in accordance with embodiments of the disclosure, for example as shown in Figure 7 and 8, which are not specifically described herein may be implemented in accordance with any conventional techniques. In this regard, insofar as the operation of embodiments of the disclosure follow conventional techniques the respective subframes represented in Figure 7 may be similar to that is represented in Figure 3. Thus, the control regions 700 support PCFICH, PHICH and PDCCH channels as discussed above while the PDSCH regions 702 support user-plane data and system information (among other things) and EPDCCH if implemented. The most significant aspect of the control region 700 in the context of embodiments of the present disclosure relate to the PDCCH and so for simplicity the control regions 700 may sometimes be referred to herein as PDCCH regions 700.

Thus referring to Figure 7 subframes O, P and Q are used to signal a PDCCH message addressed to SI-RNTI by sending three repeat PDCCH transmissions in the respective PDCCH regions 700O, 700P, 700Q. Each PDCCH repeat transmission addressed to SI-RNTI in the PDCCH regions 700O, 700P, 700Q in effect comprises a duplication of the same downlink control information which a terminal device can combine to seek to establish the content of the PDCCH message addressed to SI-RNTI in accordance with conventional techniques for coverage extension through repeat transmissions. For this example implementation of a repeat-transmission based coverage extension scheme it is again assumed a particular type of message subject to repeat transmissions is addressed to the same RNTI (e.g. SI-RNTI for a system information related type of messages) as if the same type of message were subject to conventional single-subframe transmission. However, as discussed further below, in accordance with certain embodiments of the disclosure identifiers having different characteristics (e.g. in terms of their value or control region search space) may be used for a given type of message depending on whether the messages to be sent in accordance with a first transmission scheme (e.g. using a conventional single subframe based transmission approach) or a second transmission scheme (e.g. using a repeat-transmission scheme for coverage extension). Furthermore, it will be appreciated the approach of using identifiers associated with a particular type of message having different characteristics according to the transmission scheme is to be used in accordance with embodiments of the disclosure may or may not also implement an approach using validity periods as disclosed herein.

The PDCCH message sent in subframes O, P and Q in Figure 7 differs from a conventional PDCCH message, for example of the kind transmitted in subframes A, B and C of Figure 6, in that it is associated with a validity period that is sufficient to span the transmission of a plurality of PDSCH messages. This is

different from the conventional approach in which a PDCCH message is simply associated with a single PDSCH message. The validity period for the PDCCH message is known to both the base station and the terminal device. For example, the validity period may be based on a defined standard for operations in accordance with an embodiment of the disclosure, whereby the base station and the terminal device can each determine the validity period from the defined standard. In other embodiments the base station may have flexibility to select the validity period, for example according to current scheduling requirements, and to communicate an indication of the validity period to the terminal device(s) to which the PDCCH message is addressed. Some example implementation of this approach are discussed further below.

The PDCCH message comprising the three repeat transmissions in the PDCCH regions of subframes O, P and Q indicate transmission resource blocks to be used for a subsequent PDSCH message comprising the transmission of system information. This PDSCH message itself comprises a plurality of repeat transmissions, and, in this example, are represented by shading in the PDSCH regions 702R, 702S and 702T of subframes D, E and F. The manner in which the PDCCH message indicates the corresponding PDSCH resources in subframes R, S and T may be in accordance with conventional techniques/signalling protocols. That is to say, the transmission resources, for example in terms of specific resource elements, used to convey the repeat transmissions of the system information message in the PDSCH regions 702R, 702S and 702T may be indicated in the corresponding PDCCH message addressed to SI-RNTI and comprising the repeat transmissions in PDCCH regions 700O, 700P, 700Q in accordance with conventional resource allocation techniques in the context of coverage extension using repeat transmissions. Whilst the shading in Figure 7 schematically represents the same frequency resources being used for each repeat transmission in the respective PDSCH regions 702R, 702S and 702T of the subframes R, S and T, in principle the repeat-transmission approach may be configured to include frequency hopping for the different repeat transmissions comprising the PDSCH message sent in subframes R, S and T. The nature of any such frequency hopping may be pre-defined, for example it may be pre-specified according to an operating standard for the wireless telecommunications system, or it may be established in previous RRC (radio resource control) signalling, or it may be indicated in the PDCCH message.

As schematically represented in Figure 7 there is a gap between subframes C and D. This again follows the currently-proposed approaches for repeat-transmission coverage extension whereby the transmission of a PDSCH message comprising a plurality of repeat transmissions does not start until after all repeat transmissions of the corresponding PDCCH message have been sent. Furthermore, some proposals indicate there should be no overlap between the end of the repeat transmissions comprising the PDCCH message and the start of the repeat transmissions comprising the PDSCH message. It will, however, be appreciated the specific implementation of such aspects of a repeat transmission approach for providing coverage extension are not significant to the principles underlying the present disclosure. That is to say, the principles described herein may equally be implemented in association with other repeat transmission approaches (e.g. with repeat transmissions of PDCCH and an associated PDSCH occurring in the same subframe).

Thus, the communication of the PDCCH message in subframes O, P and Q and the corresponding communication of the PDSCH message conveying system information in subframes R, S and T as represented in Figure 7 may follow the same general principles as the approach represented in Figure 6. Similarly, in subframes following the repeat-transmission approach for transmitting the system information

message as schematically indicated in subframes R, S and T in Figure 7, the wireless telecommunications system may continue to operate in accordance with its normal operating techniques for conveying other messages.

As noted above, system information messages are regularly retransmitted in accordance with LTE techniques, and the approach of Figure 7 differs from the approach of Figure 6 in respect of how a subsequent transmission of system information is scheduled on PDSCH in subframes X, Y and Z. In particular, the approach of Figure 7 differs from the approach of Figure 6 if the subsequent retransmission of system information occurs within the validity period associated with the previously-received PDCCH message in subframes O, P and Q initially sent in association with the previously-received system information message on PDSCH in subframes R, S and T. In LTE the transmission of system information follows a defined timing schedule, for example based on the system information window defined for the relevant system information. Thus, a base station and a terminal device are able to independently determine in which subframe a system information message will be transmitted on PDSCH (or which plurality of subframes in the case of coverage extension through repeat-transmissions as in this example). Thus, in the example of Figure 7, a terminal device to which the system information is addressed can determine that a system information message is to be transmitted in subframes X, Y and Z.

Referring back to Figure 6, the terminal device receiving the system information on PDSCH in subframes J, K and L can similarly determine in accordance with conventional techniques that the transmission will occur in these subframes. However, to determine the specific resources (e.g. in terms of specific OFDM carriers / resource blocks) on which the transmissions will occur within the relevant subframe(s) the terminal device must first receive the corresponding PDCCH allocation message sent in subframes G, H and I.

However, in the approach of Figure 7 in accordance with an embodiment of the present disclosure the resource allocation used for the PDSCH transmissions of the system information message on subframes X, Y and Z is determined from the previous resource allocation message sent on PDCCH in subframes O, P and Q. For example, in accordance with one approach the specific PDSCH resources (e.g. in terms of frequency) to be used for transmitting the subsequent system information message in subframes X,Y and Z are assumed to be the same as the specific PDSCH resources (e.g. in terms of frequency) used for transmitting the system information message in subframes R, S and T and indicated in the PDCCH message sent in subframes O, P and Q. However, it will be appreciated that other mappings can be adopted. For example, the frequencies to be used can be configured to shift in accordance with a predefined pattern for each retransmission within the validity period for the PDCCH message.

Thus, in accordance with an embodiment of the disclosure, and in contrast to the approach in the corresponding subframes in Figure 6, there is no PDCCH message sent in subframes U, V and W to support the system information message sent on PDSCH in subframes X, Y and Z. Instead it is determined that a previous PDCCH message remains valid (because its associated validity period has yet to expire), and the resources used for conveying the system information message on PDSCH in subframes X, Y and Z are derived from the previous PDCCH.

This approach has an advantage of freeing up the control-channel resources, in particular in subframes U, V and W for the example subframes represented in Figure 7. The approach can also help reduce the

amount of processing required by the terminal device (since the terminal device does not need to decode a separate PDCCH message for each and every PDSCH message). Furthermore the approach can reduce latency in situations that require high repetition numbers because there is no need to wait to receive a series of PDCCH repetitions before receiving each series of PDSCH repetitions.

It will be appreciated the transmission resources represented in Figure 7 that are not involved in the SI message signalling discussed above can be used for other communications in the network in the usual manner. In particular, it will be appreciated that although the entirety of the PDCCH regions associated with repeat transmissions of the PDCCH for the system information messages are shown shaded in Figure 7, this is merely to highlight those subframes in which a PDCCH for the system information messages is transmitted compared to those where it is not, and in practice these regions will comprise multiple PDCCH messages addressing different terminal devices for allocating resources for various different types of communication on PDSCH.

Thus, to summarise an approach in accordance with an embodiment of the disclosure as represented in Figure 7, and with reference to Figure 8, a base station 504 is transmitting system information messages to terminal devices, including terminal device 508, according to a pre-defined timing schedule. The predefined timing schedule may follow conventional LTE techniques for transmitting system information. It is assumed the processing represented in Figure 8 starts just prior to subframe O at the beginning of the series of subframes represented in Figure 7 and while there is no currently valid PDCCH message for the relevant system information. Thus, in a first step S1 in Figure 8 the base station determines a validity period that is to apply for an upcoming control-plane message that is to be transmitted to allocate resources for system information messages on PDSCH. The duration of a validity period for a given PDCCH message may be fixed / predetermined according to a specific implementation, for example by a network operator, or may be selectable by a base station according to current conditions. The validity period might be relatively short, for example it might only comprise the time required to transmit two PDSCH messages to provide a potential saving of one PDCCH message transmission. On the other hand, the validity period might be significant number, for example hundreds, thousands, tens of thousands, or even more subframes. In general a longer validity period may be preferred to reduce the number of PDCCH message transmissions, while an overly-long validity period may be considered to overly restrict scheduling flexibility. An appropriate validity period in a given situation may depend on current traffic conditions within a cell supported by a base station. For example, if a base station is currently supporting a large number of terminal devices it may be more appropriate to select a relatively long validity period to provide a correspondingly large saving in PDCCH message transmissions. However, if a base station is currently supporting only a small number of terminal devices with low traffic requirements (i.e. such that PDCCH congestion is not an overly significant concern), it may be more appropriate to select a relatively short validity period to provide a corresponding increase in scheduling flexibility (example to take better account of fluctuations in radio propagation conditions or traffic changes). In one example a current proportion of non-MTC traffic may be used to help determine an appropriate validity period for a repeated PDCCH. Generally speaking, the higher this proportion, the higher the proportion of non-delay-tolerant non-small-message terminal devices in the cell whose performance may be disrupted by a heavy use of control channel resources due to repeated PDCCH transmission. Therefore, as the proportion of relatively higher priority terminal devices (e.g. non-MTC terminal devices) increases, the base station may opt for longer PDCCH validity times, especially for use in association with SI-messages.

In step S2 the base station transmits a control-plane message, which can also be referred to as a control message (using repeat transmissions for coverage extension in this example) to allocate the resources for subsequent system information messages on PDSCH. This control message is received and decoded by the terminal device 508. This aspect of the operation may be based generally on conventional techniques, for example using a PDCCH message addressed to an SI-RNTI in LTE. Furthermore, the specific resources selected by the base station for allocation to the system information messages may be selected in accordance with established scheduling techniques in wireless communication systems. Thus, step S2 correspond with the transmissions made in subframes O, P and Q of Figure 7.

In step S3 the terminal device determines the validity period for the control-plane message received in step S2. There are various ways in which the terminal device may determine the validity period for the control-plane resource allocation message in accordance with various embodiments of the disclosure, and some examples are discussed further below.

In step S4 the base station proceeds to transmit a system information message (using repeat transmissions for coverage extension in this example) in accordance with the resource allocation identified by the control-plane (PDCCH) message of step S2. This aspect of the operation may be made broadly in accordance with conventional techniques. The terminal device seeks to receive and decode this system information message (SI message #1) in accordance with conventional techniques.

In step S5 the base station determines it is time to transmit another system information message (SI message #2) according to the predefined timing for periodic system information transmissions in the wireless telecommunications system. The base station further determines the validity period for the control-plane message sent in step S2 has not yet expired. Accordingly, the base station does not send any new control-plane message to support the new system information message that is about to be transmitted (SI message#2). Instead the base station proceeds to transmit the system information message (using repeat transmissions for coverage extension in this example) in accordance with resource allocations derived from the previously-sent control-plane (PDCCH) message of step S2. For example, the base station may be configured to simply use the same frequency resources for transmitting SI message #2 in step S5 as were used for transmitting SI message #1 in step S2. The terminal device likewise determines the expected transmission timing for the new system information message (SI message #2) from the predefined timing for system information transmissions and also determines the validity period for the previous control-plane message received in step S2 has not expired. Accordingly, the terminal device need not seek to receive a new control-plane message to indicate the PDSCH resources for the new system information message that is to be next transmitted (SI message#2). Instead the terminal device simply assumes the transmission is to be made in the relevant subframes (determined according to the predefined timing) on frequency resources derived from the previously-sent control-plane (PDCCH) message of step S2. Once the terminal device has determined the specific resources on which to expect the system information message in step S5 (SI message #2) it may proceed to receive and decode the system information message in accordance with conventional PDSCH transmission techniques.

As noted above the timing s for specific SI messages in LTE are based on SI windows. Conventionally it is the transmission of an associated PDCCH message addressed to the relevant system information RNTI which determines the precise subframe(s) in which the system information message PDSCH is transmitted. However, in accordance with certain embodiments of the disclosure there can be PDSCH

messages conveying system information in an SI windows without there being a corresponding PDCCH message in that SI window. There are a number of different ways in which a terminal device can determine the relevant subframe for a further PDSDH message transmitted within the validity period of a previously-received PDCCH message in accordance with embodiments of the disclosure. In one case, the base station may be configured to send the PDSCH message in a predefined subframe of the SI window. In principle this could be permanently fixed for all PDSCH system information messages at the cost of reduced scheduling flexibility. In another case the subframe(s) could be based on the subframe(s) used in association with the initial PDCCH message. For example, if the initial PDCCH indicates a system information message is to be sent in subframe number n (or starting in subframe n for repeat transitions for coverage extension) within a particular SI window, subsequent PDSCH messages within the validity period of the PDCCH might also be sent in (or start in) subframe n of the relevant SI window. In another example, the base station may retain the flexibility to send (or start sending when using repeat transmissions) the subsequent system information message in any subframe within the SI window. In this case a terminal device may check for a newly addressed PDCCH message in the subframes in the SI window in the normal way, and if a new PDCCH message is not found, the terminal device may decode the PDSCH resources indicated in accordance with a previously-received still valid PDCCH message in the same subframe(s) relative to the SI window as for the previous transmission. In principle, with sufficient processing power, the terminal device could simply seek to decode the relevant resources in all subframes of an SI window to see if an SI message can be decoded.

The process of the base station sending further system information messages, and the terminal device receiving the further information messages, based on transmission resource allocation information indicated in the control-plane message of step S2 may continue (as schematically indicated in step S6 for transmitting SI message #n) until the validity period for the control-plane message received in step S2 has expired, as schematically indicated in step S7.

Following step S7 the processing in effect cycles back to where it started prior to step S1. The base station may thus determine a new validity period for a new control message to be sent in a further step corresponding with step S2 (the base station determines that a new PDCCH message is required because the previous one has expired). Processing may then continue from this point in the manner discussed above.

Thus, the various example schemes represented in Figures 7 and 8, and described above, provide an approach in which control-plane messages, and in particular SI-messages, are associated with a validity period that extends for more than one message transmission of the associated PDSCH. For example, for SIBs in SI-messages, one SI-RNTI addressed PDCCH message can provide the control information for multiple transmissions of SIBs, and in general over multiple SI-windows. Similar operation for other types of message, for example messages addressed to other common search-space RNTIs, may be adopted in accordance with other examples. This kind of approach can help reduce control resource requirements, which can be especially important in the context of coverage extension where according to conventional techniques PDCCH (comprising multiple repeat transmissions) messages would have to be transmitted every time an SI-message (comprising multiple repeat transmissions) needed to be sent.

As noted above, SIBs in system information messages can in some cases remain unchanged for extended period, for example a few hours. A terminal device may thus combine system information message transmissions from across multiple SI-windows if it does not successfully decode an SI-

message at first attempt and with a sufficiently long validity period this can be achieved in accordance with the approaches described herein with reduced control signalling requirements than current schemes.

As noted above, there are various different ways in which the validity period for a PDCCH message may be established. In one simple example the period may be defined according to an operating standard of the wireless telecommunications system. Both the base station and the terminal device can in effect be hardwired with the validity period (or multiple validity periods associated with different types of messages). In another example the base station may have flexibility for determining a suitable validity period according to the implementation and traffic conditions at hand. In this case there are various different ways in which the validity period could be conveyed to a terminal device.

In one example the base station may be configured to convey a selected validity period to terminal devices by selecting a particular transmission characteristic, for example timing, for the PDCCH message with which the validity period is associated. According to current proposals for repeat transmission coverage extension in LTE, the starting subframe of a PDCCH message being transmitted in multiple subframes should be confined to a subset of subframes. This is because in some circumstances the terminal device may be required to blindly search over the possible numbers of repetitions the PDCCH might comprise. If it were allowed for a PDCCH messages comprising an arbitrary number of repeat transmissions to start in an arbitrary subframe this could be expected to give rise to significant complexity in the processing required of the terminal device. To address this there has been proposed an approach in which, for example, a PDCCH message comprising N repeats can only begin in subframes having a subframe number that is a multiple of N (i.e. 0, N, 2N, 3N,…). This reduces the set of possible repetition numbers the UE needs to consider per subframe. Thus, a similar approach could be used to convey information on PDCCH validity. This can be done by linking the validity period to the starting subframe number of the associated PDCCH message. For example, a PDCCH message commencing in subframe M might be taken to indicate a validity period corresponding to M SI-windows for the relevant system information. Thus, a terminal device can readily establish the relevant validity period from the timing of the relevant control-claim message. It may be noted that in some circumstances it may be preferable to assign longer PDCCH validity periods to PDSCH messages that comprise high numbers of repetitions.

In another example the base station may be configured to convey a selected validity period to terminal devices through explicit signalling, for example in the downlink control information (DCI) of the relevant PDCCH message. Thus, the DCI may comprise an indication of a number of subframes / radio frames corresponding to the validity period or may comprise an indication of a specific subframe / radio frame in which the validity period is to expire. In the application to the transmission of system information messages it may be preferable to indicate timings in respect of a number of SI-windows of validity.

In yet another example the terminal devices may be configured to simply assume the validity period for a given PDCCH message addressed to a given RNTI (e.g. SI-RNTI) extends until a subsequent PDCCH message addressed to the relevant RNTI is received. That is to say, the PDCCH message may be considered to remain valid until it is replaced by another PDCCH message. In this respect, in terms of the processing schematically represented in Figure 8, this corresponds with the terminal device determining the validity period for the control message (corresponding to step S3) at the same time at which the validity period expires (responding to step S7), with this being triggered by a new PDCCH message being received by the terminal device. In this approach a terminal device may thus monitor for a new PDCCH message addressed to the relevant RNTI in each subframe of each SI-window in the normal way until a

new PDCCH message is received to in effect define the end the validity period for the previous PDCCH message addressed to that RNTI.

Thus, one principle of the approaches described above in accordance with some embodiments of the disclosure is to associate a PDCCH message with a time defining its validity, that time being extensible beyond the time taken to convey a corresponding PDSCH message. A terminal device may thus assume the PDSCH resource allocation, MCS (modulation and coding scheme), TBS (transport block size), etc. in the DCI of the PDCCH message is valid for receiving multiple PDSCH messages during the PDCCH validity time. No further PDCCHs for multiple PDSCH messages need be sent during the validity time. Thus, in the case of SIB transmissions, the transmission of all SI-messages (including all transmissions within a SI-window of a particular SI-message), may be scheduled with a single transmission of SI-RNTI PDCCH with an appropriately configured validity period.

One particular situation in which approaches in accordance with the embodiments described above might be expected to be useful is where the transmissions are used to provide coverage extension on both PDCCH and PDSCH. However, similar principles can be applied where coverage extension is not being used, for example in respect of messages sent within single subframes.

Whilst the above-described embodiments have focused on system information messages, it will be appreciated that similar principles can be applied for other types of messages in wireless telecommunications systems, and especially for messages which rely on resource allocations occurring with some degree of predictable timing. For example, similar principles can be used for control signalling addressed to other common search space RNTIs, such as RA-RNTI and P-RNTI.

Thus a random access RNTI addressed PDCCH message received by a terminal device during an initial cell access may be associated with a validity period such that the transmission resources identified in association with the random access RNTI PDCCH message are taken to apply for later random access procedures in accordance with the principles set out above. The specific subframe of a RAR (random access response) window in which a subsequent RAR arrives can be established in a manner similar to that described above for system information within a predefined series of subframes comprising an SI-window

Similarly, a paging RNTI addressed PDCCH message may be associated with an extended validity in accordance with the principles described above. Thus a PDSCH resource allocation associated with a PDCCH message addressed to a paging RNTI transmitted in one subframe may be taken to indicate a PDSCH resource allocation in a subsequent subframe within a validity period associated with the PDCCH message. This may be especially appropriate for paging when a terminal device is in idle mode since there is a higher degree of predictability as to when paging messages may be sent according to a currently configured DRX, discontinuous reception, cycle. That is to say, the concept of PDDCH validity timers as discussed herein may be applied to the most recent P-RNTI PDCCH used to decode a paging message by an RRC_IDLE UE. An RRC_IDLE UE is only expected to monitor specific subframes for P-RNTI and is in DRX for other subframes. If the relevant PDCCH validity timer expires before a subsequent paging message is to be sent, the base station may provide a new P-RNTI PDCCH message to schedule the next paging message as normal. Otherwise the IDLE UE may assume the most recent such PDCCH is still valid. For an RRC_CONNECTED UE, there is less predictability as regards whether a particular subframe should contain P-RNTI PDCCH or not. For a connected mode terminal device the

principles described herein for paging messages might, for example, be used for subframes in which the UE would check for P-RNTI if it were in fact in IDLE mode. In other subframes the base station may send conventional paging signalling using PDCCH to page the UE in connected mode.

In a wireless telecommunications using repeat-transmissions for coverage extension there may be terminal devices which are not in coverage-limited locations and able to successfully decode individual ones of the PDCCH (or EPDCCH) repeat transmissions in each subframe. For example, and referring to Figure 7, a non-coverage-limited terminal device may be able to successfully decode the individual PDCCH repeat transmission in the control region 700O of subframe O. If this terminal device is not aware of the use of repeat-transmissions for coverage extension (for example because it is a legacy / conventional terminal device) it might be expected to assume the PDCCH information derived from the control region 700O subframe O applies to a system information transmission on PDSCH in the same subframe (i.e. in PDSCH region 702O). However, the terminal device would fail to receive the system information transmission (because it is not sent in accordance with this particular repeat-transmission protocol). Potentially this terminal device could seek to do this for each and every repeat transmission and so waste a considerable amount of processing effort needlessly decoding individual PDCCH repeat transmissions and associated PDSCH resources in the expectation of receiving system information messages which are not in fact being sent in those subframes. This is an issue which applies generally for repeat transmission approaches for coverage extension and is not specific to approaches based on validity periods as discussed herein.

Thus in accordance with certain embodiments of the disclosure an identifier (RNTI) having different characteristics (e.g. in terms of value or associated control region search space) may be associated with SI messages sent using a repeat transmission approach as compared to SI messages sent without using a repeat transmission approach. More generally, in a wireless telecommunications system supporting different transmission schemes for a given type (classification / category) of message (e.g. a message comprising a given radio resource control, RRC, information element, such as a system information related message or a paging request related message), a characteristic of an identifier associated with the message (i.e. an identifier to indicate which terminal device(s) the message is for) may be selected according to the transmission scheme used for the message. This approach may be implemented in accordance with certain embodiments of the disclosure regardless of whether the wireless telecommunications system also implements an approach using validity periods as described herein (i.e. the approach may be implemented in association with the principles of the repeat transmission scheme represented in Figure 6 as well as that represented in Figure 7). That is to say, the concept of associating a validity period with a control message and the concept of using different identifier characteristics according to a transmission scheme being used may be used together in combination or separately from one another in accordance with different embodiments of the disclosure.

A terminal device having the ability to receive transmissions using the repeat transmission approach can identify the transmissions as such directly from the associated identifier characteristic and receive the message accordingly. The characteristic for the identifier can be selected so that a terminal device not having the ability to receive transmissions using a repeat transmission approach, for example a legacy terminal device, does not recognise the message as being addressed to the terminal device, and so in effect ignores it. Such a terminal device may in effect ignore the message because, for example, the identifier has a value which is not recognised as a value relevant to the terminal device or because a search space for a control message conveying the identifier is not searched by the terminal device.

Thus, if in a particular implementation it is assumed that a repeat transmission approach to coverage extension is intended primarily for MTC-type devices, an MTC-specific system information radio network temporary identifier (MTC-SI-RNTI) may be established. PDCCH messages associated with repeat transmissions for conveying system information messages may thus be addressed to MTC-SI-RNTI instead of an SI-RNTI used for conveying system information that is not sent using repeat transmissions. More generally some embodiments of the disclosure propose introducing other repetition specific RNTIs to address messages that rely on repetitions for coverage extension to complement corresponding RNTIs in existing systems. Thus, system information messages to be sent in accordance with a non-repeat transmission technique may be associated with a conventional system information identifier (e.g. SI-RNTI) while system information messages to be sent in accordance with a repeat-transmission technique may be associated with a modified system information identifier (e.g. REPEAT-SI-RNTI).

Similar issues can arises for other common RNTIs associated with other types of message that may be sent using a repeat transmission approach. Thus corresponding RNTIs having different characteristics may also be established for these. For example, for each of SI-RNTI, P-RNTI, RA-RNTI, TPC-PUCCH-RNTI, TPC-PUSCH-RNTI and M-RNTI to be used for addressing non-repeat transmission messages, there may be established a corresponding RNTI having a different value to be used for addressing repeat-transmission messages (e.g. what might be generally referred to as REPEAT-RNTIs, such as REPEAT-SI-RNTI, REPEAT-P-RNTI, REPEAT-RA-RNTI, REPEAT-TPC-PUCCH-RNTI, REPEAT-TPC-PUSCH-RNTI and REPEAT-M-RNTI). Thus an approach in accordance with an embodiment of the disclosure may be used in association with messages selected from the group comprising: (i) a message associated with transmitting system information; (ii) a message associated with transmitting a paging message; (iii) a message associated with transmitting a random access response message; (iv) a message associated with transmitting power control information for an uplink control channel; (v) a message associated with transmitting power control information for an uplink data channel; and (vi) a message associated with a broadcast and / or multicast service. A similar approach can be taken for types of message associated with other common RNTIs which may be introduced in future.

In some implementations in which a message to be transmitted using a repeat-transmission approach in association with an identifier having a characteristic selected to indicate this, a component part of the message (e.g. a repeat transmission) may also be transmitted in one, or more, subframes in association with an identifier having a characteristic that would be used if the message were being transmitted using a conventional single-transmission approach. This will allow legacy terminal devices who are able to receive the message from only a single repeat transmission to in effect receive the message based on one of the repeat transmissions.

One advantage of associating identifiers for a given type of message with different characteristics based on the transmission scheme is the potential for more complete use of the available transmission resources. For example, referring to Figure 7, the initial SI-RNTI addressed PDCCH repeat transmission in the control region 700O of subframe O is part of a repeat transmission comprising three repeat transmissions in the respective control regions of subframes O, P and Q. This PDCCH message identifies resources (and other parameters) associated with a PDSCH message to be subsequently transmitted starting from subframe R as discussed above. As previously noted, it is expected for repeat-transmission based coverage extension there will be no PDSCH signalling associated with the PDCCH message until after the repeat transmissions comprising the PDCCH message had been made. In principle the PDSCH

transmission resources in the PDSCH regions 702O, 702P and 702Q of subframes O, P and Q corresponding to the resources allocated by the PDCCH message for use in subframe starting from subframe R could be used to support other transmissions. For example, the respective control regions 700O, 700P, 700R could include conventional single-subframe PDCCH messages allocating the relevant PDSCH transmission resources for another purpose, for example unicast data. However, it would be confusing for a legacy terminal device to decode a unicast PDCCH message and a SI PDCCH message resource allocation identifying the same resources in the same subframe. Thus by preventing the legacy terminal device from decoding the SI PDCCH signalling (through use of an appropriate distinguishing characteristic for the identifier as discussed herein), the legacy terminal device is free to receive unicast data on the relevant PDSCH resources (in association with an appropriately addressed PDCCH transmission indicating these resources).

In implementations in which the distinguishing characteristic for the identifier is its value (i.e. with one value, such as SI-RNTI, indicating conventional single-subframe transmission, and another value, such as REPEAT-SI-RNTI, indicating repeat-transmission coverage extension), the "new" REPEAT-RNTIs may be defined in accordance with an operating standard for the wireless telecommunications network in parallel with the corresponding RNTIs. For example, as noted above, in LTE the SI-RNTI has a fixed value 0xFFFF. In accordance with an embodiment of the disclosure a fixed value for a REPEAT-SI-RNTI may be selected from one of the currently reserved RNTIs in LTE (from 0xFFF4 to 0xFFC). Thus, if, for example, a value 0xFFF5 is allocated as REPEAT-SI-RNTI (i.e. an identifier for a system information related message sent using repeat transmissions), a PDCCH addressed to 0xFFFF can be identified as corresponding to a system information message sent without repetition whereas a PDCCH addressed to 0xFFF5 can be identified as corresponding to a system information message sent using repetition. A terminal device that is unaware of repetition will in effect ignore the PDCCH addressed to 0xFFF5 as this will not be recognised as a valid RNTI for the terminal device. Corresponding principles apply where EPDCCH is used.

In the above-described example the value of the RNTI is the characteristic used to distinguish between the different transmission schemes. However, in accordance with other embodiments of the disclosure, other characteristics can be used to distinguish identifiers to indicate different transmission schemes. For example, in LTE there are currently eight "spare" values that could be used as new REPEAT-RNTIs. This is a sufficient number of values to provide a corresponding RNTI to be used in association with a transmission scheme comprising repeat transmissions for all currently-existing common RNTIs. However, it may be considered preferable in some cases to avoid using these "spare" values so they remain free for other uses, or there may be a need for more REPEAT-RNTIs (for example, to provide multiple extra RNTI for a given type of message, e.g. a system information message, to indicate another aspect of the transmission scheme, for example the number of repeats). Thus, in accordance with some embodiments a REPEAT-RNTI may in fact have a value that is the same as its corresponding "conventional" RNTI (e.g. 0xFFFF for SI-RNTI and REPEAT-SI-RNTI) but be associated with a different search space. As is well known a terminal device will typically search a defined subset of control region resources to seek to identify any control messages associated with an identifier (RNTI) common to a plurality of terminal devices. The subset of control region resources is known as a search space and comprises a plurality of candidate PDCCH for the terminal device to check. This search space approach is taken to reduce the amount of processing required by the terminal device to seek to identify any relevant control messages. Thus, PDCCH signalling associated with the existing common RNTIs are constrained to a particular set of

candidate PDCCH comprising the common search space. In accordance with some embodiments of the disclosure the characteristic of the identifier which is used to distinguish the different potential transmission schemes may be based on the specific PDCCH resources used.

For example, a PDCCH message to be transmitted in accordance with a conventional single-subframe approach may be associated with an identifier, such as SI-RNTI, in the common search space in the usual way. However, a PDCCH message to be transmitted in accordance with a repeat-transmission approach may instead be associated with the same value of identifier, such as SI-RNTI, but transmitted on PDCCH resources outside the common search space. Thus in accordance with some implementations the distinguishing characteristic for the identifier based on the transmission scheme may be a search space with which the identifier is associated. Thus a PDCCH message addressed to SI-RNTI within a particular search space (e.g. the common search space in LTE) can be identified as corresponding to a system information message sent without repetition whereas a PDCCH transmission addressed to SI-RNTI outside the particular search space (e.g. outside the common search space in LTE) can be identified as corresponding to a system information message sent using repetition. A terminal device that is unaware of repetition will in effect ignore the PDCCH addressed to SI-RNTI outside the common search space as the terminal device will not search for the SI-RNTI outside the common search. Corresponding principles apply where EPDCCH is used. Thus in effect, identifiers associated with repeat transmissions may be associated with a newly-defined search space which is outside the search space used for the corresponding identifiers for conventional single-subframe transmissions. In some examples the new search space may support only a single aggregation level, for example an aggregation level 8 (the high aggregation level being appropriate in view of the coverage extension context). The new search space may be smaller (i.e. comprise fewer candidate PDCCH) than the search space for existing common RNTIs. This can help reduce the blind search load associated with the repeat transmissions comprising a message transmitted using a repeat transmission for coverage extension.

It will appreciated the advantages of establishing a new search space comprising a reduced number of candidate PDCCHs with a single relatively high aggregation level to be used in association with identifiers for repeat transmission messages can be applied even in circumstances where different identifier values are associated with the different transmission schemes. In such cases the repeat-specific identifier values may be selected from among the values that are available for use as identifiers in the wireless telecommunications system. In one example, as referred to above, a repeat-specific identifier values may simply match its corresponding non-repeat specific identify value (e.g. SI-RNTI) with the different search space in which a control message associated with the identifier is transmitted providing the distinguishing characteristic for the identifier for the selected transmission scheme. However, in another implementation the repeat-specific identifier values may be selected from, for example, identifiers available for other uses, for example in LTE from identifiers available for cell-specific RNTIs (which may range from 0x001 to 0xFFF3). This approach can in principle provide a relatively large number of repeat-specific identifiers. For example, one or more of the values normally used for C-RNTI can be in effect reserved as one or more repeat-specific RNTIs, such as REPEAT-SI-RNTI in the terminology used above, and likewise for types / classes / classifications of messages other than system information related messages, such as paging messages and random access a response messages etc. Thus a base station could in effect reserve (re-allocate) in its cell a number of RNTI values for one purpose as actually being for use as repeat-specific RNTIs. If any of the re-allocated subset of RNTIs comprising the repeat-specific RNTI is detected by a terminal device as addressing a PDCCH in the newly-defined search space, the terminal

device may be configured to interpret this as a repeat-specific RNTI. This may be based on the base station conveying in previous signalling to terminal devices that support repeat-transmission communications an indication of the relevant RNTI(s). Alternatively, or in addition, the relevant RNTI(s) may be defined in accordance with an operating standard of the network for reallocation within the new search space. If the PDCCH candidates comprising the new search space do not overlap with those of the pre-existing common search space and UE-specific search space used by legacy devices, then the RNTIs allocated as repeat-specific RNTIs within the new search space could continue to be used in the other search space without giving rise to the potential for confusion for legacy terminal devices. If, on the other hand, the PDCCH candidates comprising the new search space do overlap with those of the pre-existing common search space or UE-specific search space, then the base station may be configured to avoid allocating any of a currently re-allocated RNTI to terminal devices in accordance with the usual function for the RNTI (i.e. a C-RNTI reallocated for use as a repeat-specific identifier should not be allotted to a terminal device for use as a C-RNTI). This can be remedied as a straightforward matter of RNTI scheduling (for example, the base station can in effect simply treat the re-allocated RNTIs as being already allotted for use).

If multiple RNTI are made available for use for a given type of message, the particular RNTI selected for use in association with a particular message may be used to indicate a further characteristic of the message, for example a number of repeats or a specific PDCCH validity period where implemented. This can provide the base station with a simple mechanism for modifying the specific repeat and all validity period parameters associated with a particular message, thereby improving overall flexibility.

Determining which identifiers a terminal device should search for to seek to identify messages to be sent to the terminal device using a repeat transmission scheme can be done in accordance with the usual principles by linking it to transmission mode (TM) configuration. In one implementation the repeat-specific RNTIs provided in accordance with embodiments of the disclosure might apply in all transmission modes as the principles governing their use will in many respects be similar to conventional, search space RNTIs. There could also be a link with the category/type of the terminal device. For example, a new terminal device category identifier could be introduced (e.g. category 0) to indicate the terminal device is a particular type of terminal device, for example an MTC-based terminal device. The repeat-specific identifiers may then be considered to apply to all transmission modes for terminal devices of category 0 (if the repeat-transmission based scheme is limited to category 0 terminal devices), as well as for additional terminal device categories if the use of the repeat-transmission based scheme is more widely supported.

Figure 9 is a signalling ladder diagram schematically representing modes of operation for the terminal device 508 and the base station 504 schematically represented in Figure 5 in accordance with some embodiments of the present disclosure.

Processing begins in step T1 when the base station determines that a message is to be transmitted to one or more terminal devices. The message may, for example, be a broadcast message or a multicast message. The determination that a message is to be transmitted may be made in accordance with conventional operating procedures for the wireless communications system. For example, if the message is a system information message, step T1 may arise in accordance with a conventional timing schedule for transmitting system information messages. If the message is a paging message, step T1 may arise because an event has arisen which requires a terminal device to be paged. In this example it is assumed the message which is to be transmitted is a system information message which is relevant for (i.e.

address to an identifier associated with) terminal device 508. Furthermore, it is assumed the message may be transmitted in accordance with either one of a first transmission scheme using transmission resources in a first number of radio subframes (e.g. using conventional single-subframe transmission) or a second transmission scheme using transmission resources in a plurality radio subframes (e.g. using repeat-transmission for coverage extension).

In step T2 the base station determines which of the first and second transmission schemes are to be used for transmitting the message. That is to say, in this example, the base station determines whether or not a conventional single subframe approach or a repeat-transmission approach for coverage extension will be used for the message. There are a number of factors that may govern this determination, either individually or in combination. For example, the terminal devices in the wireless telecommunication system may comprise a first set of terminal devices and a second set of terminal devices step and T2 may be based on whether the one or more terminal devices to which the message is to be sent comprises terminal devices in the first or second sets. For example, the first set of terminal devices may comprise terminal devices that do not require coverage extension techniques to receive messages (or simply do not support coverage extension), whereas the second set of terminal devices may comprise terminal devices that do require coverage extension techniques to receive messages (and support repeat-transmission based coverage extension). Whether or not a specific terminal device requires coverage extension may, for example, be based on a measured radio propagation metric associated with the terminal device, for example a path loss, block error rate, a bit error rate, a packet error rate, a frame error rate, a symbol error rate, or negative or positive acknowledgement signalling rate (ACK/NACK) associated with communications with the terminal device. In another implementation the decision may take account of a specific identity or category for the one or more terminal devices to which the messages to be sent.

In step T3 the base station determines a characteristic of an identifier for the message based on the transmission scheme determined in step T2. This characteristic may be selected in accordance with any of the principles discussed above (e.g. use of different values for the identifier or different search spaces to be used with the identifier).

In step T4 the message is transmitted in accordance with the transmission scheme determined in step T2 and in association with an identifier, e.g. RNTI, having the characteristic determined in step T3. For example, the message may be transmitted in accordance with a repeat-transmission scheme as described herein with an identifier selected to have a characteristic to identify this, for example in accordance with any of the principles discussed above. In this regard the message may comprise one or other or both of a control message transmitted on a downlink control channel, e.g. a PDCCH message and another message transmitted on a downlink data channel, e.g. PDSCH (i.e. such that the identifier is transmitted separately from the message).

In step T5 the terminal device receives the transmitted signalling from the base station and determines the transmission scheme being used from the characteristic of the identifier. The terminal device may then proceed to receive and decode the message in accordance with the transmission scheme being used.

Thus, the process represented in Figure 9 demonstrates a mechanism by which a base station can readily indicates to terminal devices the transmission scheme being used for a given message. Once the terminal device has determined the transmission scheme, subsequent operation, for example in terms of

receiving the message, they be performed in accordance with conventional principles for receiving such messages. Furthermore, these techniques may be modified to incorporate a validity period approach such as discussed above.

Thus there has been described a wireless telecommunication system that comprises a base station and a terminal device communicating over a radio interface. The radio interface supports a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel (e.g. a physical downlink shared channel) for conveying other messages from the base station to the terminal device. The control messages convey information on resource allocations for the other messages on the downlink data channel. The other messages may comprise user-plane messages or control-plane messages. The terminal device is configured to receive a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel and determine a validity period for the control message. During the validity period for the control message the terminal device is configured to receive a plurality of the other messages from the base station on the downlink data channel using the allocated transmission resources.

There has also been described a wireless telecommunication system that comprises a base station arranged to communicate messages to one or more terminal devices over a radio interface. The radio interface has a radio frame structure comprising a plurality of subframes, wherein a message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes (e.g. one subframe) or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes (e.g. with repeat transmissions in a plurality of subframes). The message is transmitted in association with an identifier to indicate a terminal device to which the message is addressed. A characteristic for the identifier, for example a value or control region search space for the identifier, is dependent on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme. A terminal device to which the message is addressed determines the transmission scheme from the characteristic of the identifier and receives the message accordingly.

Further particular and preferred aspects of the present invention are set out in the accompanying independent and dependent claims. It will be appreciated that features of the dependent claims may be combined with features of the independent claims in combinations other than those explicitly set out in the claims.

Thus, the foregoing discussion discloses and describes merely exemplary embodiments of the present invention. As will be understood by those skilled in the art, the present invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. Accordingly, the disclosure of the present invention is intended to be illustrative, but not limiting of the scope of the invention, as well as other claims. The disclosure, including any readily discernible variants of the teachings herein, define, in part, the scope of the foregoing claim terminology such that no inventive subject matter is dedicated to the public.

Respective features of the present disclosure are defined by the following two groups of numbered paragraphs:

Group 1 of numbered paragraphs:

Paragraph 1. A method of operating a terminal device communicating with a base station in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the method comprises receiving a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel, determining a validity period for the control message, and receiving a plurality of other messages from the base station on the downlink data channel using the allocated transmission resources within the validity period for the control message.

Paragraph 2. The method of paragraph 1, wherein the other messages comprise system information messages.

Paragraph 3. The method of any preceding paragraph, wherein the system information messages comprise one or more system information blocks.

Paragraph 4. The method of any preceding paragraph, wherein the radio interface is based on a radio frame structure comprising a plurality of subframes, wherein each subframe comprises a control channel region for supporting the downlink control channel and a shared channel region for supporting the downlink data channel, and wherein respective ones of the control and / or the other messages comprise transmissions over a plurality of subframes.

Paragraph 5. The method of any preceding paragraph, wherein the validity period for the control message is determined in dependence on an identifier used in association with the control message.

Paragraph 6. The method of paragraph 5, wherein the identifier comprises an indication of one or more terminal devices to which the control message is addressed.

Paragraph 7. The method of any preceding paragraph, wherein the validity period for the control message is determined in dependence on a transmission characteristic of the control message.

Paragraph 8. The method of paragraph 7, wherein the transmission characteristic of the control message comprises a transmission time associated with the control message.

Paragraph 9. The method of any preceding paragraph, wherein the radio interface is based on a radio frame structure comprising a plurality of subframes, and wherein the timing of a subframe used to convey a first one of the plurality of other messages is used to determine the timing of a subframe used to convey a second one of the plurality of other messages within the validity period for the control message.

Paragraph 10. The method of any preceding paragraph, wherein the timing of a subframe used to convey the first one of the plurality of other messages relative to a first predefined range of subframes is used to determine the timing of a subframe used to convey the second one of the plurality of other messages relative to a second predefined range of subframes.

Paragraph 11. The method of any preceding paragraph, wherein the validity period is determined in dependence on a validity period indicator received in association with the control message.

Paragraph 12. The method of any preceding paragraph, wherein the validity period is determined in dependence on the time at which a subsequent control message is received.

Paragraph 13. The method of any preceding paragraph, wherein the other messages comprise random access response messages and / or paging messages..

Paragraph 14. A terminal device for communicating with a base station in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the terminal device comprises a controller unit and a transceiver unit configured to operate together to receive a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to receive a plurality of other messages from the base station on the downlink data channel using the allocated transmission resources within the validity period for the control message.

Paragraph 15. Circuitry for a terminal device communicating with a base station in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to cause the terminal device to receive a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to receive a plurality of other messages from the base station on the downlink data channel using the allocated transmission resources within the validity period for the control message

Paragraph 16. A method of operating a base station communicating with a terminal device in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the method comprises transmitting a control message to the terminal device conveying an indication of allocated transmission resources on the downlink data channel, determining a validity period for the control message, and transmitting a plurality of other messages to the terminal device on the downlink data channel using the allocated transmission resources within the validity period for the control message.

Paragraph 17. A base station for communicating with a terminal device in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the base station comprises a controller unit and a transceiver unit configured to operate together to transmit a control message to the terminal device conveying an indication of allocated transmission resources on the downlink data

channel, to determine a validity period for the control message, and to transmit a plurality of other messages to the terminal device on the downlink data channel using the allocated transmission resources within the validity period for the control message.

Paragraph 18. Circuitry for a base station communicating with a terminal device in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to cause the base station to transmit a control message to the terminal device conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to transmit a plurality of other messages to the terminal device on the downlink data channel using the allocated transmission resources within the validity period for the control message.

Group 2 of numbered paragraphs:

Paragraph 1. A method of operating a base station for communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein the method comprises selecting a characteristic for the identifier in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

Paragraph 2. The method of any preceding paragraph, wherein the first number of radio subframes comprises a single radio subframe and the second number of radio subframes comprises a plurality of radio subframes.

Paragraph 3. The method of any preceding paragraph, wherein terminal devices in the wireless telecommunications system comprise a first set of terminal devices and a second set of terminal devices, and wherein the method comprises determining whether to transmit the message in accordance with the first transmission scheme or the second transmission scheme in dependence on whether a terminal device to which the message is to be transmitted is a member of the first set of terminal devices or the second set of terminal devices.

Paragraph 4. The method of any preceding paragraph, wherein the method comprises determining whether to transmit the message in accordance with the first transmission scheme or the second transmission scheme in dependence on a radio propagation parameter associated with radio communications between the base station and a terminal device to which the message is to be transmitted.

Paragraph 5. The method of paragraph 4, wherein the radio propagation parameter is selected from the group comprising: a path loss; an error rate; a positive acknowledgment, ACK, signalling rate; and a negative acknowledgment signalling, NACK, rate.

Paragraph 6. The method of any preceding paragraph, wherein the method comprises determining whether to transmit the message in accordance with the first transmission scheme or the second transmission scheme in dependence on an identity and / or type of a terminal device to which the message is to be transmitted.

Paragraph 7. The method of any preceding paragraph, wherein the radio interface supports a downlink control channel for conveying control messages from the base station to terminal devices and a downlink data channel for conveying other messages from the base station to terminal devices, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the message comprises a control message transmitted on the downlink control channel.

Paragraph 8. The method of any preceding paragraph, wherein the radio interface supports a downlink control channel for conveying control messages from the base station to terminal devices and a downlink data channel for conveying other messages from the base station to terminal devices, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the message comprises one of the other messages transmitted on the downlink data channel.

Paragraph 9. The method of any preceding paragraph, wherein the identifier to indicate a terminal device to which the message is addressed is transmitted separately from the message.

1 Paragraph 0. The method of any preceding paragraph, wherein the identifier comprises a radio network temporary identifier, RNTI.

Paragraph 11. The method of any preceding paragraph, wherein the identifier is a common to a plurality of terminal devices.

Paragraph 12. The method of any preceding paragraph, wherein the message comprises a broadcast message.

Paragraph 13. The method of any preceding paragraph, wherein the message comprises a multicast message.

Paragraph 14. The method of any preceding paragraph, wherein for a given type of message the characteristic for the identifier is selected from a first predefined characteristic for the identifier associated with the given type of message and a second predefined characteristic for the identifier associated with the given type of message according to whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

Paragraph 15. The method of any preceding paragraph, wherein the message is selected from the group comprising: (i) a message associated with transmitting system information; (ii) a message associated with transmitting a paging message; (iii) a message associated with transmitting a random access response message; (iv) a message associated with transmitting power control information for an uplink control

channel; (v) a message associated with transmitting power control information for an uplink data channel; and (vi) a message associated with a broadcast and / or multicast service.

Paragraph 16. The method of any preceding paragraph, wherein for a message to be transmitted in accordance with the second transmission scheme, a component of the message transmitted in one of the second number of subframes is associated with a characteristic for the identifier corresponding to that which would be used if the message were to be transmitted in accordance with the first transmission scheme.

Paragraph 17. The method of any preceding paragraph, wherein the characteristic for the identifier comprises a value for the identifier.

Paragraph 18. The method of any preceding paragraph, wherein the characteristic for the identifier comprises a search space in which a terminal device searches using the identifier to determine if a message has been addressed to the terminal device.

Paragraph 19. The method of any preceding paragraph, wherein the method comprises selecting the characteristic for the identifier from a plurality of different characteristics associated with different types of message.

Paragraph 20. The method of any preceding paragraph, wherein the characteristic for the identifier to be selected for a message to be transmitted in accordance with the second transmission scheme is defined in accordance with an operating standard for the wireless telecommunications system.

Paragraph 21. The method of any preceding paragraph, further comprising the base station pre-defining the characteristic for the identifier to be selected for a message to be transmitted in accordance with the second transmission scheme.

Paragraph 22. The method of paragraph 21, wherein the pre-defining the characteristic for the identifier is a value for the identifier selected from among a plurality of values.

Paragraph 23. A base station for communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the base station comprises a controller unit and a transceiver unit configured to operate together such that the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein a characteristic for the identifier is selected in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

Paragraph 24. Circuitry for a base station communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the circuitry comprises a controller element and a transceiver element configured to operate together such that the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of

radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein a characteristic for the identifier is selected in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

Paragraph 25. A method of operating a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the method comprises determining from an identifier associated with the message that the message is addressed to the terminal device, and further determining from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

Paragraph 26. A terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the terminal device comprises a controller unit and a transceiver unit configured to operate together to determine from an identifier associated with the message that the message is addressed to the terminal device, and to further determine from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

Paragraph 27. Circuitry for a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to determine from an identifier associated with the message that the message is addressed to the terminal device, and to further determine from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

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[3] ETSI TS 136 331 V11.4.0 (2013-07) / 3GPP TS 36.331 version 11.4.0 Release 11)

[4] 3GPP document R1-135422, “On the need of PDCCH for SIB and other Common Channel”, Mediatek, RAN1#75, San Francisco, November 2013

[5] 3GPP document R1-134207, “Coverage enhancement techniques for PBCH”, Alcatel-Lucent, Alcatel-Lucent Shanghai Bell, RAN1#74bis, Guangzhou, October 2013.

5

CLAIMS

What is claimed is:

1. A method of operating a base station for communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein the method comprises selecting a characteristic for the identifier in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

2. The method of claim 1, wherein the first number of radio subframes comprises a single radio subframe and the second number of radio subframes comprises a plurality of radio subframes.

3. The method of claim 1, wherein terminal devices in the wireless telecommunications system comprise a first set of terminal devices and a second set of terminal devices, and wherein the method comprises determining whether to transmit the message in accordance with the first transmission scheme or the second transmission scheme in dependence on whether a terminal device to which the message is to be transmitted is a member of the first set of terminal devices or the second set of terminal devices.

4. The method of claim 1, wherein the method comprises determining whether to transmit the message in accordance with the first transmission scheme or the second transmission scheme in dependence on a radio propagation parameter associated with radio communications between the base station and a terminal device to which the message is to be transmitted.

5. The method of claim 4, wherein the radio propagation parameter is selected from the group comprising: a path loss; an error rate; a positive acknowledgment, ACK, signalling rate; and a negative acknowledgment signalling, NACK, rate.

6. The method of claim 1, wherein the method comprises determining whether to transmit the message in accordance with the first transmission scheme or the second transmission scheme in dependence on an identity and / or type of a terminal device to which the message is to be transmitted.

7. The method of claim 1, wherein the radio interface supports a downlink control channel for conveying control messages from the base station to terminal devices and a downlink data channel for conveying other messages from the base station to terminal devices, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the message comprises a control message transmitted on the downlink control channel.

8. The method of claim 1, wherein the radio interface supports a downlink control channel for conveying control messages from the base station to terminal devices and a downlink data channel for conveying other messages from the base station to terminal devices, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the message comprises one of the other messages transmitted on the downlink data channel.

9. The method of claim 1, wherein the identifier to indicate a terminal device to which the message is addressed is transmitted separately from the message.

10. The method of claim 1, wherein the identifier comprises a radio network temporary identifier, RNTI.

11. The method of claim 1, wherein the identifier is a common to a plurality of terminal devices.

12. The method of claim 1, wherein the message comprises a broadcast message.

13. The method of claim 1, wherein the message comprises a multicast message.

14. The method of claim 1, wherein for a given type of message the characteristic for the identifier is selected from a first predefined characteristic for the identifier associated with the given type of message and a second predefined characteristic for the identifier associated with the given type of message according to whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

15. The method of claim 1, wherein the message is selected from the group comprising: (i) a message associated with transmitting system information; (ii) a message associated with transmitting a paging message; (iii) a message associated with transmitting a random access response message; (iv) a message associated with transmitting power control information for an uplink control channel; (v) a message associated with transmitting power control information for an uplink data channel; and (vi) a message associated with a broadcast and / or multicast service.

16. The method of claim 1, wherein for a message to be transmitted in accordance with the second transmission scheme, a component of the message transmitted in one of the second number of subframes is associated with a characteristic for the identifier corresponding to that which would be used if the message were to be transmitted in accordance with the first transmission scheme.

17. The method of claim 1, wherein the characteristic for the identifier comprises a value for the identifier.

18. The method of claim 1, wherein the characteristic for the identifier comprises a search space in which a terminal device searches using the identifier to determine if a message has been addressed to the terminal device.

19. The method of claim 1, wherein the method comprises selecting the characteristic for the identifier from a plurality of different characteristics associated with different types of message.

20. The method of claim 1, wherein the characteristic for the identifier to be selected for a message to be transmitted in accordance with the second transmission scheme is defined in accordance with an operating standard for the wireless telecommunications system.

21. The method of claim 1, further comprising the base station pre-defining the characteristic for the identifier to be selected for a message to be transmitted in accordance with the second transmission scheme.

22. The method of claim 21, wherein the pre-defining the characteristic for the identifier is a value for the identifier selected from among a plurality of values.

23. A base station for communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the base station comprises a controller unit and a transceiver unit configured to operate together such that the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein a characteristic for the identifier is selected in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

24. Circuitry for a base station communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the circuitry comprises a controller element and a transceiver element configured to operate together such that the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein a characteristic for the identifier is selected in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

25. A method of operating a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the method comprises determining from an identifier associated with the message that the message is addressed to the terminal device, and further determining from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

26. A terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the terminal device comprises a controller unit and a transceiver unit configured to operate together to determine from an identifier associated with the message that the message is addressed to the terminal device, and to further determine from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

27. Circuitry for a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to determine from an identifier associated with the message that the message is addressed to the terminal device, and to further determine from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

1/8

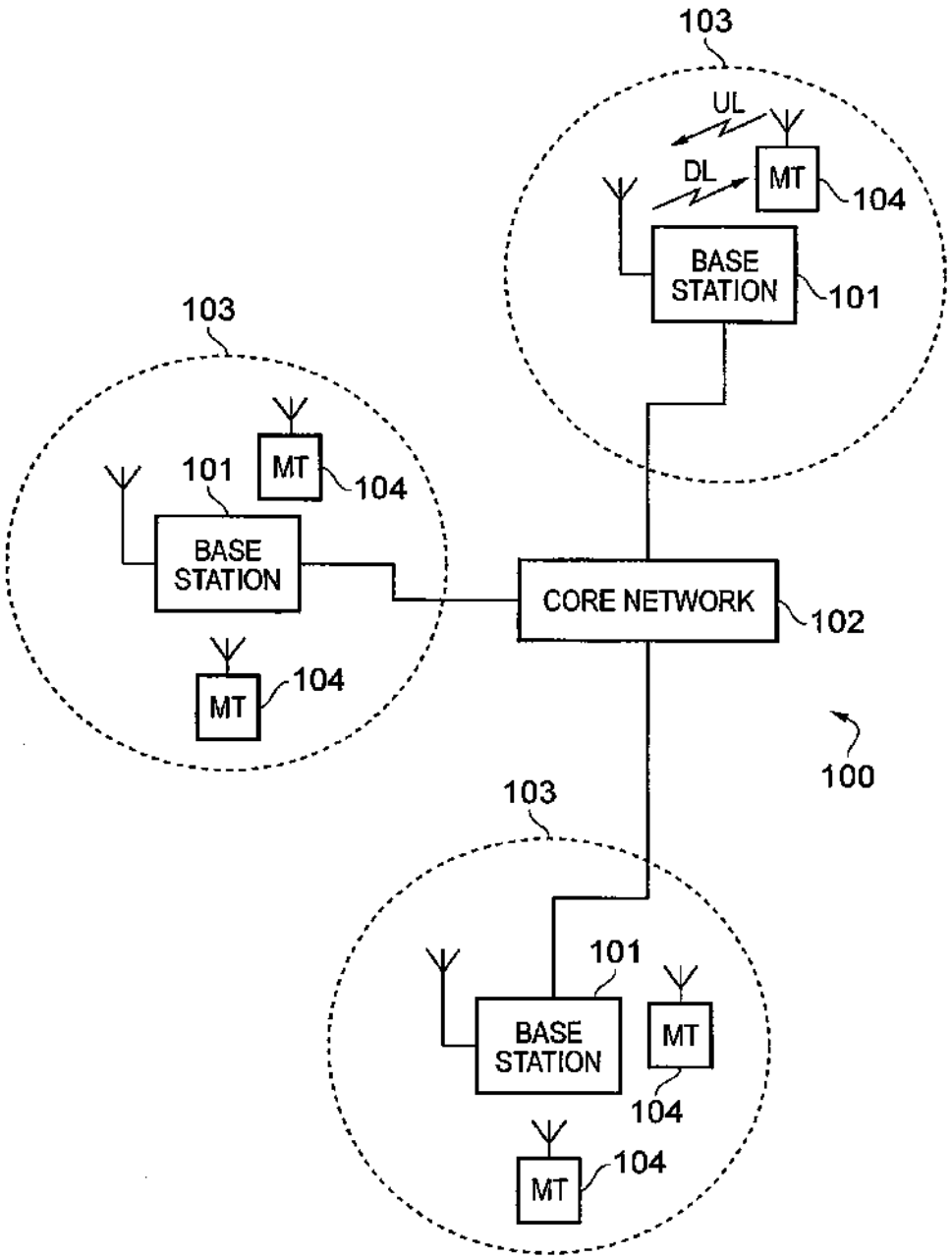

103
UL
DL
MT
104
BASE STATION
101
103
101
MT
104
BASE STATION
CORE NETWORK
102
MT
104
100
103
101
BASE STATION
MT
104
MT
104

FIG. 1

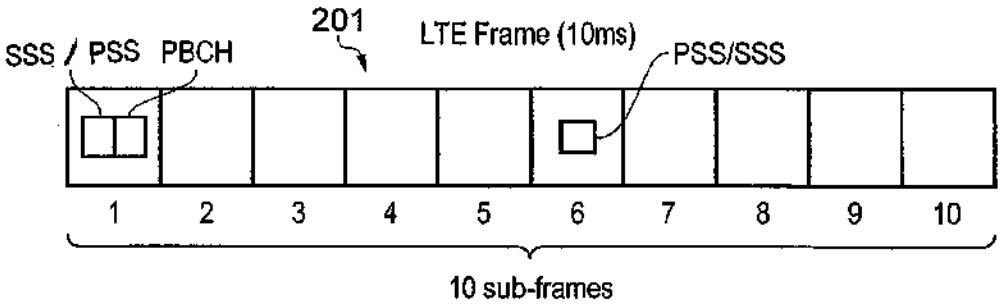

SSS / PSS
PBCH
201
LTE Frame (10ms)
PSS/SSS
1
2
3
4
5
6
7
8
9
10
10 sub-frames

FIG. 2

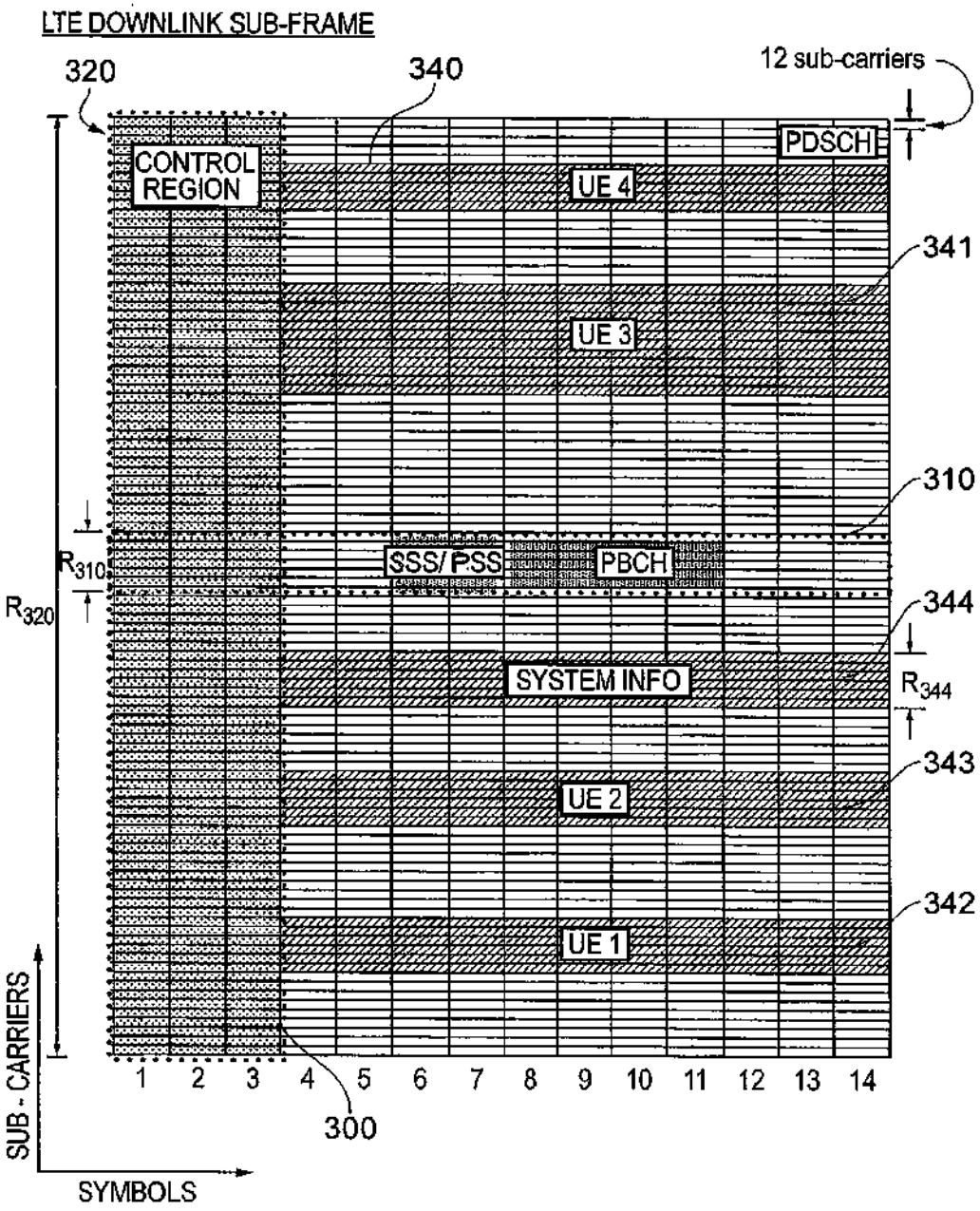

LTE DOWNLINK SUB-FRAME
320
340
12 sub-carriers
CONTROL REGION
PDSCH
UE 4
341
UE 3
310
R_{310}
SSS/ PSS
PBCH
R_{320}
344
SYSTEM INFO
R_{344}
343
UE 2
342
UE 1
SUB - CARRIERS
1 2 3 4 5 6 7 8 9 10 11 12 13 14
300
SYMBOLS

FIG. 3

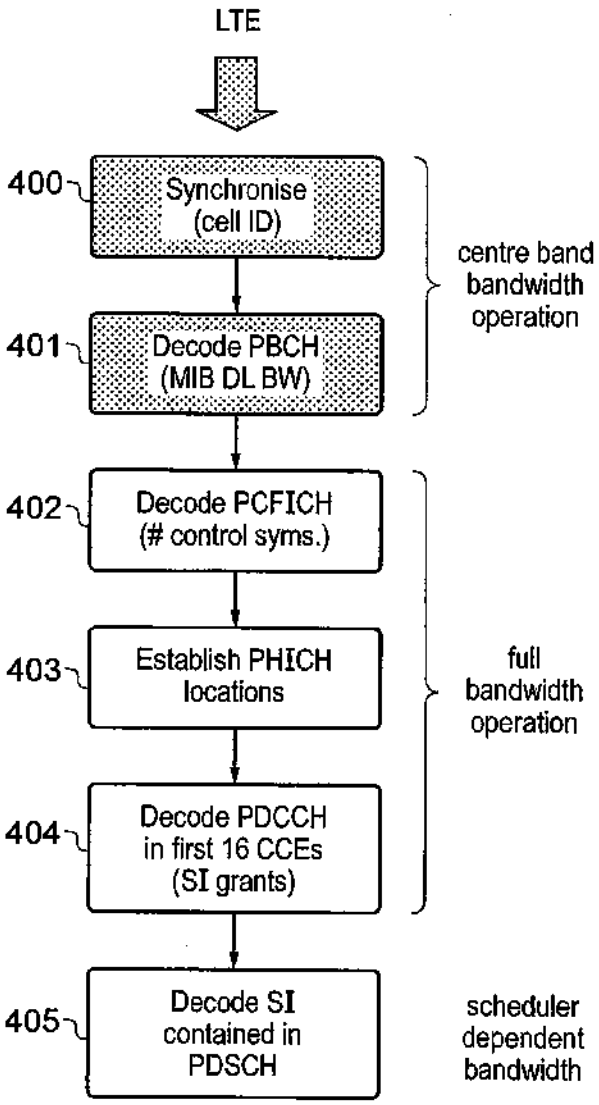

LTE
400
Synchronise (cell ID)
401
Decode PBCH (MIB DL BW)
centre band bandwidth operation
402
Decode PCFICH (# control syms.)
403
Establish PHICH locations
404
Decode PDCCH in first 16 CCEs (SI grants)
full bandwidth operation
405
Decode SI contained in PDSCH
scheduler dependent bandwidth

FIG. 4

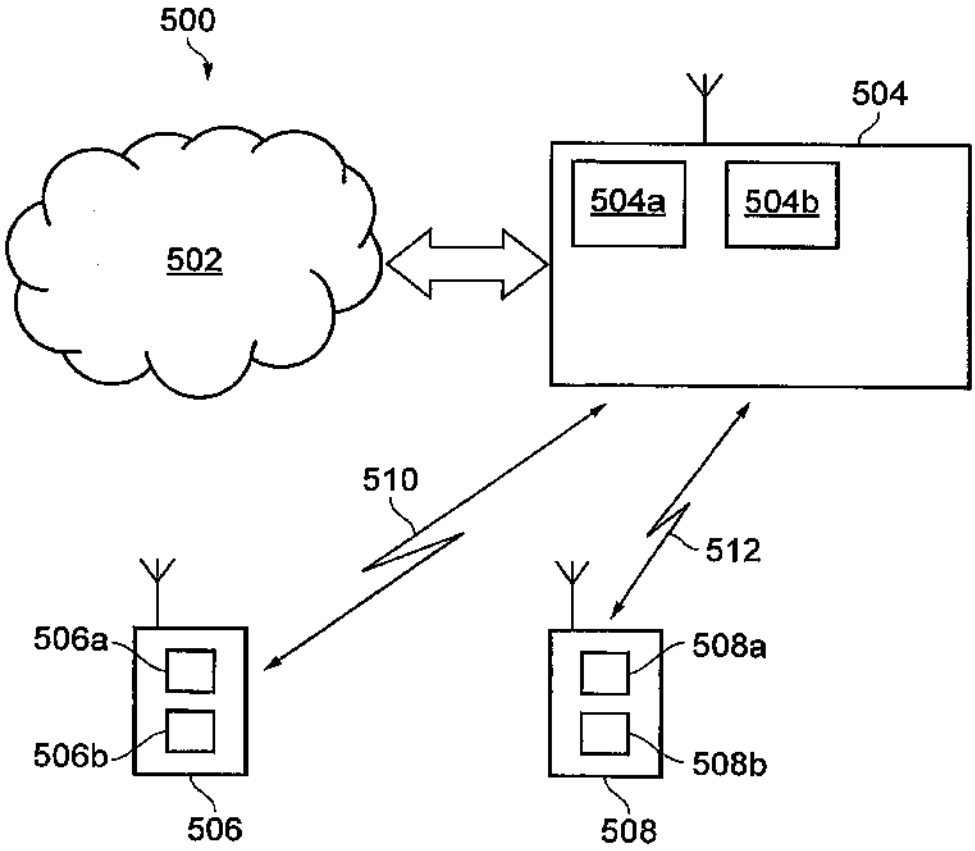


FIG. 5

Fig. 6

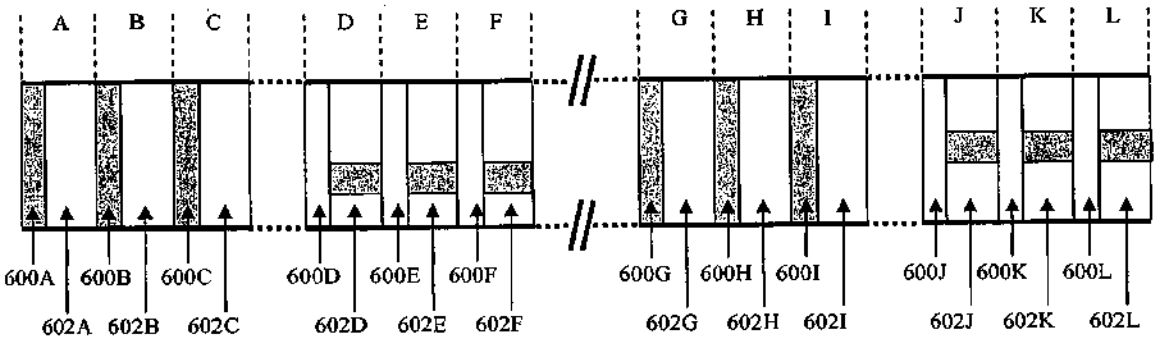
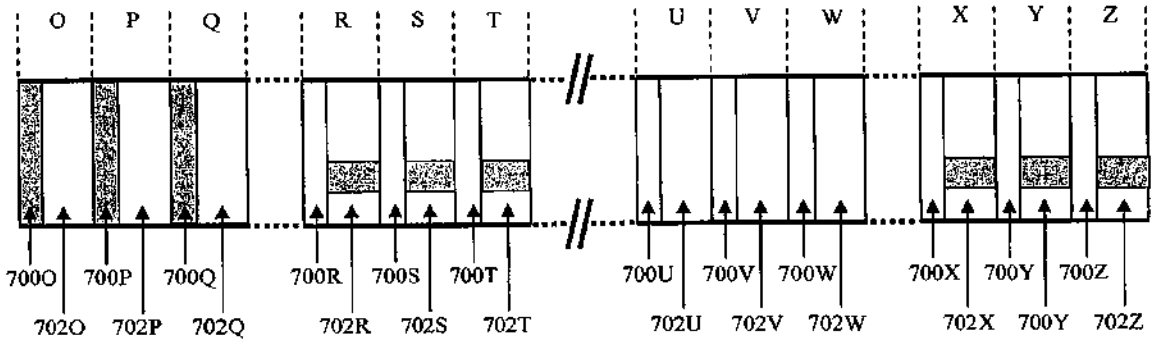

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K
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600G
600H
600I
600J
600K
600L
602A
602B
602C
602D
602E
602F
602G
602H
602I
602J
602K
602L

Fig. 7


O
P
Q
R
S
T
U
V
W
X
Y
Z
700O
700P
700Q
700R
700S
700T
700U
700V
700W
700X
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702V
702W
702X
702Y
702Z

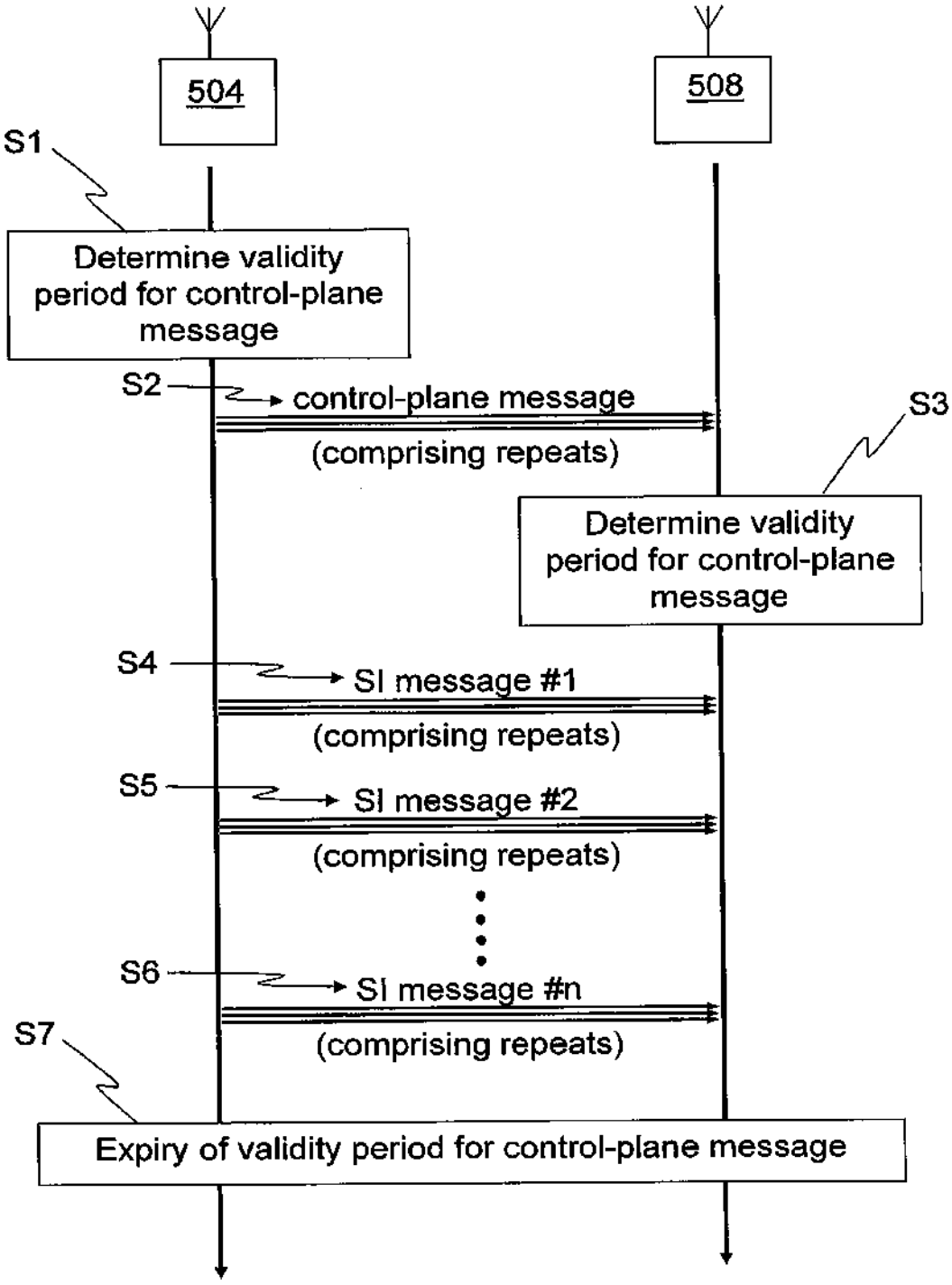

504
508
S1
Determine validity period for control-plane message
S2
control-plane message
(comprising repeats)
S3
Determine validity period for control-plane message
S4
SI message #1
(comprising repeats)
S5
SI message #2
(comprising repeats)
S6
SI message #n
(comprising repeats)
S7
Expiry of validity period for control-plane message

Fig. 8

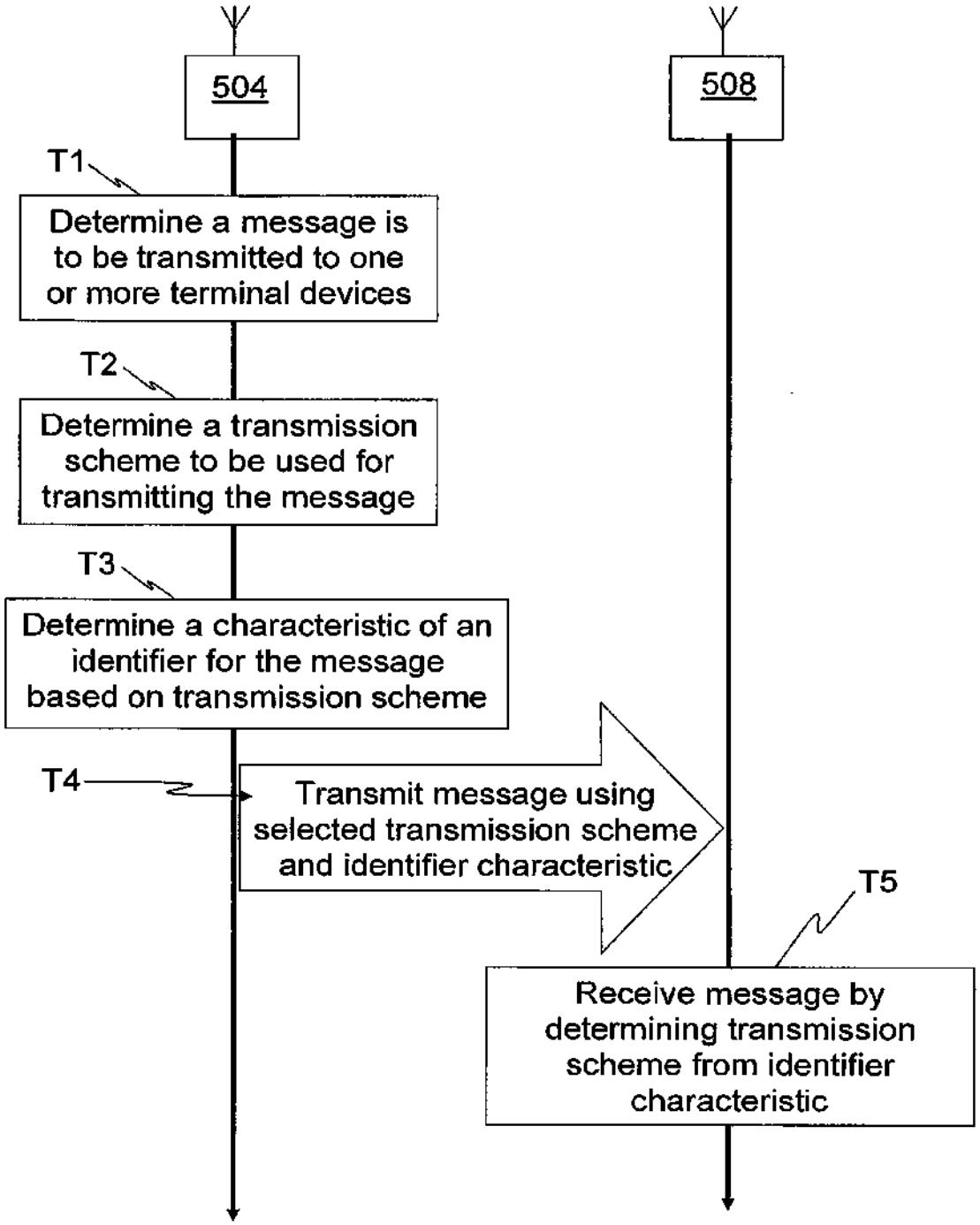

504
508
T1
Determine a message is to be transmitted to one or more terminal devices
T2
Determine a transmission scheme to be used for transmitting the message
T3
Determine a characteristic of an identifier for the message based on transmission scheme
T4
Transmit message using selected transmission scheme and identifier characteristic
T5
Receive message by determining transmission scheme from identifier characteristic

Fig. 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2014/074456

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W72/04
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W H04B H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2013/315159 A1 (XIA JINHUAN [CN] ET AL) 28 November 2013 (2013-11-28) paragraph [0005] - paragraph [0006] paragraph [0036]; figure 5 paragraph [0045]; figure 7 paragraph [0052] paragraph [0062]	1-27

X	EP 2 611 244 A2 (QUALCOMM INC [US]) 3 July 2013 (2013-07-03)	1,23-27
A	paragraph [0029]; figures 3,10 paragraph [0075]	2-22

	-/--	

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 February 2015	04/03/2015

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Cortés Gómez, F

1

Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	SONY: "PDSCH baseband bandwidth reduction for low complexity MTC UE", 3GPP DRAFT; R1-135763, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. San Francisco, USA; 20131111 - 20131115 13 November 2013 (2013-11-13), XP050735408, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN/RAN1/Docs/ [retrieved on 2013-11-13]	1,23-27
A	Section 2.1 Section 2.5 -----	2-22
X	NTT DOCOMO: "Discussion on Multi-level PRACH Coverage Enhancement", 3GPP DRAFT; R1-135509 PRACH_COVERAGE, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. San Francisco, USA; 20131111 - 20131115 13 November 2013 (2013-11-13), XP050735182, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN/RAN1/Docs/ [retrieved on 2013-11-13]	1,23-27
A	Section 5 -----	2-22

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2014/074456

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		EP 2346294 A1	20-07-2011
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ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
17/950,726	**11/19/2023 10:47:29 PM Z ET**	**ZL0205-0004-US-CON3**

Title of Invention

METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	6005	FILED BY	Jialin Zhong
PATENT CENTER #	63311403	FILING DATE	09/22/2022
CUSTOMER #	155075	FIRST NAMED INVENTOR	Xiaobo ZHANG
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	-

Documents

TOTAL DOCUMENTS: 98

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
ZL0205-0004-US-CON3_IDS final2.pdf	8	Information Disclosure Statement (IDS) Form (SB08)	600 KB
ZL0205-0004-US-CON3_IDS final3.pdf	8	Information Disclosure Statement (IDS) Form (SB08)	599 KB
ZL0205-0004-US-CON3_IDS final5.pdf	6	Information Disclosure Statement (IDS) Form (SB08)	599 KB
ZL0205-0004-US-CON3_IDS final4.pdf	8	Information Disclosure Statement (IDS) Form (SB08)	599 KB
ZL0205-0004-US-CON3_IDS final1.pdf	31	Information Disclosure Statement (IDS) Form (SB08)	605 KB

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3GPP TS 36.300 v14.3.0 2017-7 pp126-180.pdf	5E7D01372F6B9ACB26EAB36D37FF95E4156FA996F824C083CE2D31D9BD6297F976DBAFB865ADE7703961E7C0608B902B05A4BBB3D8E9E6C1D0DC76B395791017
3GPP TS 36.300 v14.3.0 2017-7 pp1-70.pdf	454310D0421C9FD8FE05793AFB5128D742CAC2FFAEED155345A3B1182B26EFBB8B9CE473B9D67BF3C8660925002A50E93C86F0B4A51B83EB9416FF04775433ED
3GPP TS 36.300 v14.3.0 2017-7 pp71-125.pdf	94B54C44EFBDDB5328B70515E6D6AB65914742E21B57DA94AD872C7D1FC6BF03DCBFA72CE2519127F208CD9AF5F42233C07841CB6F20D1883395ACF5CE21B59A
3GPP TS 36.300 v14.3.0 2017-	6EA257367E2F21BABE31C39F7BE1ADCAE6D528BFE7BA8259

7 pp231-285.pdf	08AC99C97D17438B9DEDAA5B5CBC7287D226414FA16226EE82DE2502D0F9F7E6C226D66D06B3E9FE
3GPP TS 36.300 v14.3.0 2017-7 pp181-230.pdf	A3A49BFA369B0F9834E9350574C547D5C889CC5301DFEB6F69D894F0D339BD8775691EAE46596A7BAE4011116E8782865C6417BE2024F6D93F60C29683D2F3EF
4G LTE-LTE Advanced for Mobile Broadband Dahlman 2011 pp201-291.pdf	72B49DFACBF34A81175724043239E58DB30CCE1203F55AFF2FCDC43D3458362650A47197AB3FE72212DD73903BB3CFB0EBDEB9B6AC1257FC3989747B73E97097
4G LTE-LTE Advanced for Mobile Broadband Dahlman 2011 pp1-100.pdf	6EEA4CA4E13D04006F6E01024105166B08132B5DFB1C2609A95D4400629BC0BC8493B80660ECD35DE69C724CD8CADC0B82152D58173FED49972AC5F167C362C
4G LTE-LTE Advanced for Mobile Broadband Dahlman 2011 pp101-200.pdf	B14A584F7019A95256568A19C02B47D64AD1AE5C280E64AADA9F86E8B44509494D8CDF4D47C5662C7D3B9736DE69459D6D13BCA3C1473E6DFE2CFA449ACCB50E
3GPP TS 36.331 v13.5.0 2017-4 pp101-200.pdf	3F6E202001F2F4A3F1EE33E27DBB716FF1A7C5202D2444BF3AFFCB5B43A6276475F43ECC1E0865351C8E00206F82ED717E78A202981779BD8C16DBC1CD5FA69A
3GPP TS 36.331 v13.5.0 2017-4 pp201-300.pdf	4320F7A26492E8BFB1BB1F3C668269F822520DF9FAF53E52EE33CE6B0C088B730B030884E2767420CD3F5D9F7DE0397E7504BD40AF752ED2E35EAE5A9D13C4CD
3GPP TS 36.331 v13.5.0 2017-4 pp400-500.pdf	53869F4B87034C86DAE5AE4E3894A4F7F98F124614ACBA84CA427CEBA8162B4740015156261746A6D08AAEEE00EF57994D7808B54FDC319F5958874FDCFB5144
3GPP TS 36.331 v13.5.0 2017-4 201-399.pdf	DA9DE95902D6262A52438B33AE3C7A7C17DA6B8D84AA24148FF20E716A83B02E56FDCCC9F87AB5561023E35BDE9037A34AB6C7A7924958155BE02513663F8E28
3GPP TS 36.331 v13.5.0 2017-4 pp1-100.pdf	3BD43B5A53A296A6B304EFD1471F82C3929CDE71E782A9CEE89288737073A00CE2F67D2FE891918D8BEF1084EA9E849063048FEE0ACCCC253B0BA85369C14CB0
3GPP TS 36.331 v13.5.0 2017-	7353D9F6153100004E5D491B79FE174D69012543718 9BD98D5

4 pp501-645.pdf	D8A4A361178AA97F17A617422A3C43859FB8901801F6E05A1B7DB0E1FF4E9F8105AA7C7ECD35D0
3GPP TS 36.331 v13.3.0 2016-9 pp301-400.pdf	25A346E8C150D507C80923F90BE038352B13969ECF3A7D19D0D77A21C9B2932B8E0B39DBFADD66E39E5D7A8BEB83438940D97F8FA099F57D6952D12E04CA2FDC
3GPP TS 36.331 v13.3.0 2016-9 pp401-500.pdf	8A430C3B15964BBC4361DCF2B934553137D00DEF945252111BA88D0C51CA17B8CBF80C96D43C2483FF58AE37099C2970707B33A87E197AA386899E17661DFF34
3GPP TS 36.331 v13.3.0 2016-9 pp101-200.pdf	E14148A22E9607E0EF6C88CD68FCD5F7E0DFCF986F2CD5691188C9374BDE2B433A474EB9B3DB0D0D639C311888447E3F85E7617CA69B35DC6E2ABBB567E830D7
3GPP TS 36.331 v13.3.0 2016-9 pp501-600.pdf	16BB407BCCF4AB035A8AEDE3AC110E90EBE5B0B5A2834840EF6AB1E463A960A13E4C47C23B71C183BB2E2924D71EA1C28A6AE9936A4748CA140C6AE8100FE13B
3GPP TS 36.331 v13.3.0 2016-9 pp201-300.pdf	BA28442FA307CB0457B5318C435B3048C6094945D341E758E9B304B27425DC04AF2DAF5D59F6DCD5B204AD0A5CA8AAAE442FFD97BCB3955665FDC7E9480DB324
3GPP TS 36.331 v13.3.0 2016-9 pp1-100.pdf	C01F99E9B1C603B8C5A97CF2E8E41621BABBD3BD446B22B3EC6D3DDD9924BEC5887D975378BE8E7B6A2BEA55D455EF79FDE3C04659ACF7556ACB31720C194F57
3GPP TS 36.331 v13.0.0 2015-12 pp401-507.pdf	4982AAAA53751590301 3BDAC88F2E49D9A89EFFB3BD2FA2F916DF86C257BB5517ABE6D37ABAC5F01A13DD11BA79A6716C0C7BFD4513A33015520CBCFFCB92907
3GPP TS 36.331 v13.0.0 2015-12 pp301-400.pdf	AA4BD203D714B4A7A09BDDDD78F66B93AE63BC5BFD10B93DE7274719D37A8239BF2C2A3E0F3DB8AC6DF4D31DE3B6825624F7302F9E92E431BD97CC6F7FAB50EE
3GPP TS 36.331 v13.0.0 2015-12 pp201-300.pdf	CB84D73783CE25AC5FBF6664E54B6641C8475CD8276821A3251314B7A6C0B48ECF45103A8046D28705A67E0074D70C00F5D5B844D91424C7F2B6E77FB8203E86
3GPP TS 36.331 v13.0.0 2015-	862FA01D42774012D71AA4D1F6C67E94F53E84FE083866DEB

12 PP101-200.pdf	F03911EAC261C6B1FCA5EE58F827A2A16F2BDBFF494784BA9538703545A839E3AA57A7802D5B238
3GPP TS 36.331 v13.0.0 2015-12 pp1-100.pdf	4564515BF584DBF68AD1AD73FBB58974CB3F8E3D8E298490B649B2BC34108599B4C427FB73FA3EE6444A8A436853087F3932449CA4A9E00268F4D81E63FE62EF
3GPP TS 36.331 v12.8.0 2016-1 pp201-300.pdf	719526C533E742BD22449D4669D533546F852FFA3E81AD64255EB39B8E90DB71A87AF7A57A24E0EFAAF936F0EEBD1A2171CE66AC5A189E8FE9503F235AD08FB9
3GPP TS 36.331 v12.8.0 2016-1 pp401-500.pdf	7C996A2790F754063E77BD207EB791CFB2FDB0E7AE798782BAF3D79E4612C3DBDEFE60C1953146E9B27B5AC2B6DEFCC073A3764F82F93150F713EBE3575181AB
3GPP TS 36.331 v12.8.0 2016-1 pp501-593.pdf	DAEFE414490E7811E9DCB4AC86DEA119DC14236C7A39F7997C880C08C883BD5D70804A78ABC3A719AB996566A08110324C0D7EC2F1F7816A50C2F2CE76195945
3GPP TS 36.331 v12.8.0 2016-1 pp301-400.pdf	6A512E6A7B9A46381F561A07381CD86D9E3275F0C72256010FFBB925315A8FC14A397FF5C3D7A9776ACBA89B82C04E4A32A750B50D325786B300299C2FE03D49
3GPP TS 36.331 v12.8.0 2016-1 pp101-200.pdf	65F13FA9EDDEFC11DC97A74806A480F1779ADF50203ADB10F3165E80D6D04ACD7E7C04B038DA777D06FEBB479B14901F1899008507E2D61B510BD09A32A4E85E
3GPP TS 36.331 v12.8.0 2016-1 pp1-100.pdf	323D936FD30B0D20E7A890F3BDF0C20FC0C124811F30998DE17665A50AEC07F8436423F98802562DA0BDA7A9CFEFDDA36A60D59D059CCB69CBE63393CE642728
3GPP TS 36.331 v12.8.0 2015-12 pp401-456.pdf	ED80FA1886EF41947AABA160A90AE54567AACC837ACC38582C3D6A76B2E3DBF0C6026CD8E8C0F3E9B2128D95E4B765FD36DBCDBDF99F8922DA6961BCC397F3CB
3GPP TS 36.331 v12.8.0 2015-12 pp301-400.pdf	C421D0AF6BA689C7EFB973001B7765A1AB379D3BD282091B1614BFF6BB39EA86AC0A6F6A040DD15648E7776E27047C1DD5B100130BECAE37FF50F796284ECB2C
3GPP TS 36.331 v12.8.0 2015-	659283129256 7D8FA171727CDAA66A85B7060C4E2ADB8EF70

12 pp201-300.pdf	706719B961173F081885CFF51AF1989D4B545052737A059E7A28B9DA112B3A4EF17E13E9551F4FE
3GPP TS 36.331 v12.8.0 2015-12 pp101-200.pdf	3792B0D5302388AC3AC471BE8705EECF3242EEEEAB7B733D8F66B96B6D74F4CFEE0B023EB62CCD16FBCC9D089C12B37ADB8F255C6ADFEFC87A3FDAB0D5575EDF
3GPP TS 36.331 v12.8.0 2015-12 pp1-100.pdf	F3A8FE6BD05EBD9770FB72E5E06B7E6FAFCF7AAF431F3DFC2597BED34B92C303296312B4F286B2FA435B597A4C4BB17BC821F38DE02FB79ECB41295F7F4007C6
3GPP TS 36.331 v12.3.0 2014-9 pp301-383.pdf	5C5E2BD3B80CD69626C061D8DFCE45F77BAE975833E904C167D163A64B071BCEB41B98A482404D95A903B19D987D16E7909C69193DE00E57993496BEFD982D2A
3GPP TS 36.331 v12.3.0 2014-9 pp201-300.pdf	2C81E9FE2CA08AB5940182C35C47D4DFCA28848920E1241D898FD920B88258ED10E625F8C571B8D92125DA9C87DDA3B6475D4BE98553DDDBD8600DCD7134F08A
3GPP TS 36.331 v12.3.0 2014-9 pp101-200.pdf	76EC57BC4B78F777EE1D22005804D7459E8ABE81E04DD35EBF3A9AC6F54A46A775B8AB49F6679E65A27D5E94270692297E8DFD7ADB742F58EE0928F96BFC07D3
3GPP TS 36.331 v12.3.0 2014-9 pp1-100.pdf	2E19B21AF68369A350FD701D2DD2CE16710EE7C78F8C7F2DF914AA108BD6143BBEB748930311869CE374C9B317D25BCD85877E9D9EFB71820DEAB03C0D079B6A
3GPP TS 36.300 v12.8.0 2016-1 pp226-261.pdf	ADABA9F5FDDE111AE947F741C30C841A2B25D6A9FA8A1320285932B9EBA4684C40075F93B529F5B4997C98D9A02C180993F9C22F40E946213E9F3E5E49599FBB
3GPP TS 36.300 v12.8.0 2016-1 pp1-60.pdf	3A583BEF8A1B9C0B1B6EAB17D4B274D44144AD3A1C88951C3344C03698E7A104F053AF2CD07970EB394C54C0B2938547D267DB801871ED0CB19309A46AD71C57
3GPP TS 36.300 v12.8.0 2016-1 pp181-225.pdf	11BCF5522251012180 36F87D10ECA7290189C3A8C5043591E034CA9928E619B060546F62839BAB450B17DE1632CB74D4D7656759789829E2C49C6ACCD4E0C117
3GPP TS 36.300 v12.8.0 2016-	C15186B924D24D9255C3A8B9861353659E9F87067B14B6B65C

1 pp121-180.pdf	879A27B5B8027A1D270685958CC1B8605C13FE7EAB8C4FB11 2BB211FC761990037F951E9436B07
3GPP TS 36.300 v12.8.0 2016-1 pp61-120.pdf	874504874AD39BC488979A7E65DB2ACA71D31519647051EAB FA9A207F506F6175E54352620D6B44F675B700B4802DF337304 AAD99DD29001A09552E15EEAEB52

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(Not for submission under 37 CFR 1.99)

Application Number	17950726
Filing Date	2022-09-22
First Named Inventor	Xiaobo ZHANG
Art Unit	2471
Examiner Name	AHMED ELALLAM
Attorney Docket Number	ZL0205-0004-US-CON3

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	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

	1	R1-1610145, Qualcomm, October 1, 2016	☒
	2	R1-1610239, Nokia, Alcatel-Lucent Shanghai Bell, September 30, 2016	☒
	3	R1-1611385, China Academy of Telecommunications Technology (CATT), November 5, 2016	☒
	4	R1-1611415, ZTE, ZTE Microelectronics, November 5, 2016	☒
	5	R1-1611417, ZTE, ZTE Microelectronics, November 5, 2016	☒
	6	R1-1612056, Qualcomm, November 5, 2016	☒
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	9	R4-161779, Qualcomm Incorporated, April 26, 2016	☒
	10	3GPP TR 36.897 V13.0.0 Release 13, 3rd Generation Partnership Project (3GPP), June 2015	☒
	11	R1-1704867, LG Electronics, March 25, 2017	☒

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	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

	12	R1-1609662, Nokia, Alcatel-Lucent Shanghai Bell, September 30, 2016	☒
	13	R2-1703344, LG Electronics, March 24, 2017	☒
	14	3GPP R1-1704398, April 7, 2017	☒
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	17	APEX BEAM TECHNOLOGIES LLC v. ONEPLUS TECHNOLOGY (SHENZHEN) CO., LTD., DEFENDANT'S INVALIDITY CONTENTIONS, Case No. 2:22-cv-00032-JRG, November 21, 2022	☒
	18	APEX BEAM TECHNOLOGIES LLC v. SAMSUNG ELECTRONICS CO., LTD., ET AL.,, DEFENDANT'S INVALIDITY CONTENTIONS, Case No. 2:22-cv-00188-JRG, March 2, 2023	☒
	19	APEX BEAM TECHNOLOGIES LLC v. ZTE CORPORATION, DEFENDANT'S INVALIDITY CONTENTIONS, Case No. 2:22-cv-00031-JRG-RSP, March 2, 2023	☒
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	21	SAMSUNG ELECTRONICS CO., LTD., AND SAMSUNG ELECTRONICS AMERICA, INC., v. APEX BEAM TECHNOLOGIES LLC, PETITION FOR INTER PARTES REVIEW, Case IPR2023-0059, February 28, 2023	☒

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	Examiner Name	AHMED ELALLAM
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A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/JIALIN ZHONG/	Date (YYYY-MM-DD)	2023-11-19
Name/Print	JIALIN ZHONG	Registration Number	62937

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4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

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(54) METHOD, EQUIPMENT AND SYSTEM FOR COORDINATED MULTI-POINT TRANSMISSION/ RECEPTION

(57) A method, a device, and a system for CoMP coordinated multi-point transmission are disclosed, where the method includes: obtaining reference signal received power RSRP of a cell in a measurement set of a user equipment UE; determining that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold; and combining a cell whose RSRP is greater between the first cell and the second cell with the serving cell of the UE into a coordinated set of the UE, and performing coordinated multi-point transmission on the UE, thereby improving an effect of CoMP.

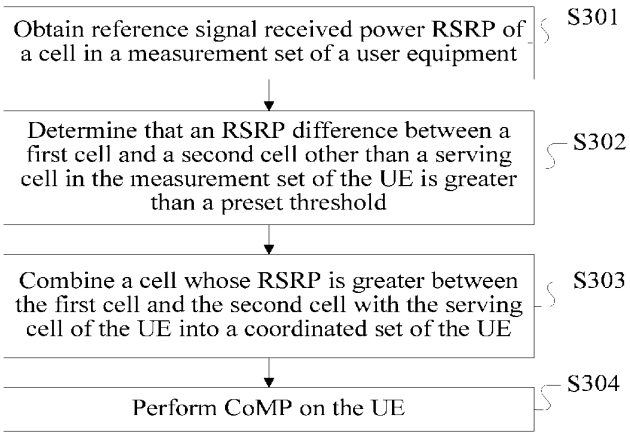


FIG. 3

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Description

TECHNICAL FIELD

[0001] The present invention relates to the field of network technologies, and in particular, to a method, a device, and a system for coordinated multi-point transmission.

BACKGROUND

[0002] CoMP (Coordinated Multi-point Transission/reception, coordinated multi-point transmission) is one of key technologies of LTE-A (Long Term Evolution-Advanced, long term evolution-advanced), and is used to expand coverage of a high data rate and increase average throughput of a system, thereby improving performance of a cell edge user.

[0003] FIG. 1 is a schematic diagram of a CoMP technology. CoMP is a cooperative sending and receiving technology, where one base station (for example, eNodeB x in FIG. 1) is connected to several access points (for example, Point x in FIG. 1), and one access point may include one or more antennas. Multiple users (User Equipment, UE for short) (UE x) may be served by one or more access points located at one same base station or different base stations. A coordination center controller may obtain information from a distributed access point, and allocate a resource to meet a QoS (Quality of Service, quality of service) requirement of a user, thereby maximizing performance of an entire network.

[0004] In the CoMP technology, signals of a serving cell and multiple coordination cells may be simultaneously sent or received, which is equivalent to increasing the number of antennas at a transmit end or a receive end, and demodulation performance is improved through a multiple input multiple output (Multiple Input Multiple Output, MIMO for short) receiver.

[0005] A main principle of uplink-based intra-eNodeB (Intra-eNodeB) CoMP is that, antennas in different cells of one same base station are used for receiving a signal of a certain user, and a combined gain and an interference suppression gain of the signal received by the multiple antennas may be obtained at the same time, and the combined gain of the signal is greater for a user closer to a boundary between two cells. By taking FIG. 2 as an example, a user is located at a boundary between cells, a Cell 0 and a Cell 1, and the Cell 1 is a serving cell for the user. When the user is closer to the boundary of the cell Cell 0, power of a signal of the user received by the cell Cell 0 is greater, and a combined gain of the signal is higher.

[0006] However, it is very complicated to implement CoMP for all users. Due to a limitation on a processing capability of a device at present, it is very difficult to implement this solution in practice. In a case of joint reception for some cells with excessively low signal to interference plus noise ratios (SINR), performance may decrease instead due to the influence of channel estimation. Therefore, how to select a CoMP coordinated set and which UEs are to be selected, where CoMP is performed on the UEs for optimization in terms of performance and complexity, become very important.

[0007] Currently, a mainstream solution in the prior art is to determine whether to perform CoMP on a UE by using whether a difference between RSRP (Reference Signal Receiving Power, reference signal received power) of a serving cell and RSRP of another neighboring cell is greater than a predetermined threshold. However, this selection manner does not take an interference factor into consideration, and in practice, interference on the serving cell and interference on another cell are usually very different. Therefore, a UE selected according to an RSRP difference between the serving cell and the another cell is usually not a UE for which a highest gain is obtained when CoMP is performed, which reduces an effect of CoMP.

SUMMARY

[0008] In view of this, embodiments of the present invention provide a method, a device, and a system for coordinated multi-point transmission, which can select a user equipment located at a cell overlapping area to perform coordinated multi-point transmission, thereby improving an effect of coordinated multi-point transmission.

[0009] To achieve the foregoing objectives, in one aspect, the present invention provides a method for CoMP coordinated multi-point transmission, where the method includes:

obtaining reference signal received power RSRP of a cell in a measurement set of a user equipment UE;
determining that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold; and
combining a cell whose RSRP is greater between the first cell and the second cell with the serving cell of the UE into a coordinated set of the UE, and performing coordinated multi-point transmission on the UE.

[0010] In another aspect, the present invention further provides a device for coordinated multi-point transmission, where the device includes:

an RSRP obtaining unit, configured to obtain reference signal received power RSRP of all cells in a measurement set of a user equipment UE;
a determining unit, configured to determine that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold;
a coordinated set joining unit, configured to combine a cell whose RSRP is greater between the first cell

and the second cell with the serving cell of the UE into a coordinated set of the UE; and

a transmitting unit, configured to perform coordinated multi-point transmission on the UE.

[0011] In still another aspect, the present invention further provides a system, including the device for coordinated multi-point transmission.

[0012] It can be seen that, in the method, the device, and the system for coordinated multi-point transmission provided by the embodiments of the present invention, whether to perform CoMP on a UE is determined based on whether two cells whose RSRP difference is greater than a threshold exist in a measurement set of the UE other than a serving cell. In the embodiments of the present invention, a UE near a cell overlapping area can be selected, and a relatively high gain can be obtained for such UE during CoMP, thereby improving an effect of CoMP.

BRIEF DESCRIPTION OF DRAWINGS

[0013] To describe the technical solutions in the embodiments of the present invention or in the prior art more clearly, the following briefly introduces accompanying drawings required for describing the embodiments or the prior art. Apparently, the accompanying drawings in the following description show merely some embodiments of the present invention, and a person of ordinary skill in the art may still derive other drawings according to these accompanying drawings without creative efforts.

FIG. 1 is a schematic diagram of a CoMP technology in the prior art;

FIG. 2 is a schematic diagram of a cell of an Intra-eNodeB CoMP technology;

FIG. 3 is a schematic flow chart of a method for coordinated multi-point transmission according to an embodiment of the present invention;

FIG. 4 is a schematic flow chart of a method for coordinated multi-point transmission according to another embodiment of the present invention;

FIG. 5 is a schematic diagram of an application scenario for a method for coordinated multi-point transmission according to an embodiment of the present invention;

FIG. 6 is a schematic structural diagram of a device for coordinated multi-point transmission according to an embodiment of the present invention; and

FIG. 7 is a schematic structural diagram of a device for coordinated multi-point transmission according to another embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

[0014] To make the objectives, technical solutions, and advantages of the embodiments of the present invention more comprehensible, the following clearly and completely describes the technical solutions in the embodiments of the present invention with reference to the accompanying drawings in the embodiments of the present invention. Apparently, the embodiments to be described are merely a part rather than all of the embodiments of the present invention. All other embodiments obtained by a person of ordinary skill in the art based on the embodiments of the present invention without creative efforts shall fall within the protection scope of the present invention.

[0015] FIG. 3 is a schematic flow chart of a method for coordinated multi-point transmission according to an embodiment of the present invention. An embodiment of the present invention provides a method for coordinated multi-point transmission, where, as shown in FIG. 3, the method includes:

Step S301: Obtain reference signal received power RSRP of a cell in a measurement set of a user equipment (UE).

[0016] Specific implementation of obtaining RSRP may adopt the prior art, for example, a method defined in the 3GPP 36.214 protocol. The present invention does not limit implementation of obtaining RSRP.

[0017] In addition, the measurement set may be determined by using the following method: A base station of a serving cell of the UE delivers a periodic measurement configuration to the UE. After receiving the periodic measurement configuration, the UE measures all available cells of a configured frequency to obtain signal quality, and reports the signal quality to the base station of the serving cell. The base station adds a cell whose signal quality exceeds a threshold set on a network to the measurement set of the UE. It may also be stipulated that cells whose signal quality ranks in the top several places are added to the measurement set of the UE, which is not limited by the present invention. Cells in the measurement set may belong to different base stations, or may belong to one same base station.

Step S302: Determine that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold. Subtraction may be performed on RSRP values of every two cells other than the serving cell in the measurement set of the UE to obtain an absolute value of an RSRP difference between two cells other than the serving cell in the measurement set, and the absolute value of the difference is compared with a threshold preset in advance.

[0018] For example, when there are two cells other than the serving cell of the UE in the measurement set, subtraction is performed on RSRP of the two cells for comparison with a preset threshold. It is assumed that there are three cells other than the serving cell of the UE

in the measurement set cell 1, cell 2, and cell 3. Subtraction is performed on RSRP values of every two cells of cell 1, cell 2, and cell 3 to obtain |RSRP cell 1 - RSRP cell 2|, |RSRP cell 1 - RSRP cell 3|, and |RSRP cell 3 - RSRP cell 2|, and the three values are compared with the preset threshold. As long as there is one of the three values which is greater than the preset threshold (or greater than or equal to the preset threshold, which is not limited in the present invention), CoMP may be performed on the UE.

When a first cell and a second cell that meet the foregoing condition exist, it indicates that the UE is located at an overlapping area of the serving cell and another cell, and a relatively high gain is obtained for the UE during CoMP.

Step S303: Combine a cell whose RSRP is greater between the first cell and the second cell with the serving cell of the UE into a coordinated set of the UE, and perform CoMP on the UE. A specific method for coordinated multi-point transmission may also be implemented through the prior art.

[0019] In the method provided by the embodiment, whether to perform CoMP on a UE is determined based on whether two cells whose RSRP difference is greater than a threshold exist in a measurement set of the UE other than a serving cell. Interference between cells other than the serving cell is usually close. Therefore, a UE near a cell overlapping area can be selected more accurately, and a relatively high gain can be obtained for such UE during CoMP, thereby improving an effect of CoMP.

[0020] FIG. 4 is a schematic flow chart of a method for coordinated multi-point transmission according to another embodiment of the present invention. As shown in FIG. 4, the method for coordinated multi-point transmission in embodiment 1 includes:

Step S401: Obtain reference signal received power (RSRP) of a cell in a measurement set of a UE.

[0021] For a specific method, reference may be similarly made to step S301 in the foregoing embodiment.

Step S402: Determine that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold.

For a specific method, reference may be similarly made to step S302 in the foregoing embodiment.

Step S403: Combine a cell whose RSRP is greater between the first cell and the second cell with the serving cell of the UE into a coordinated set of the UE.

For a specific method, reference may be similarly made to step S303 in the foregoing embodiment.

Step S404: After step S403, obtain a gain between a post-SINR (Posted-SINR) of the UE in the coordinated set and a post-SINR of the UE in the serving cell.

In a scenario where coverage is limited, a relative gain may be used as the gain in step S404. The relative gain may be determined according to the following formula:

$$\frac{\log_2(1+SINR_1)-\log_2(1+SINR_0)}{\log_2(1+SINR_0)},$$

where $SINR_0$ is the post-SINR of the UE in the serving cell of the UE, and $SINR_1$ is a post-SINR of the UE in a cell other than the serving cell in the coordinated set of the UE, where the cell other than the serving cell in the coordinated set of the UE may also be called a coordination cell of the UE; and

$\log_2(1+SINR_1)$ is throughput which is of the UE in the coordinated set of the UE and is determined according to the Shannon's formula, and $\log_2(1+SINR_0)$ is throughput which is of the UE in the serving cell of the UE and is determined according to the Shannon's formula.

[0022] In a scenario where a capacity is limited, an absolute gain may be used as the gain in step S404.

[0023] The absolute gain may be determined according to the following formula:

$$\log_2(1+SINR_1)-\log_2(1+SINR_0),$$

where $SINR_0$ is the post-SINR of the UE in the serving cell of the UE, and $SINR_1$ is the post-SINR of the UE in the cell other than the serving cell in the coordinated set of the UE; and

$\log_2(1+SINR_1)$ is the throughput which is of the UE in the coordinated set of the UE and is determined according to the Shannon's formula, and $\log_2(1+SINR_0)$ is the throughput which is of the UE in the serving cell of the UE and is determined according to the Shannon's formula.

Step S405: Perform CoMP on a UE whose gain is greater than the preset threshold.

In practice, alternatively, UEs may also be sorted according to gains obtained through calculation in step S404, and a UE with a highest gain is selected preferably for performing CoMP, until a processing resource is used up.

[0024] In the embodiment, by taking a case that a hardware resource is limited into consideration, it is possible that CoMP can be performed on only a part of UEs. After UEs near a cell overlapping area are selected through

step S401 to step S403, these UEs are sorted according to their gains, and CoMP is preferably performed on a UE with a highest gain, so that efficiency of CoMP may be fully improved with a limited resource.

[0025] It should be noted that, in the embodiment, the step for obtaining the gains of the UEs may be performed in each transmission time interval (TTI), or may be performed on each resource block (RB). Certainly, a granularity implemented in the step for obtaining the gains of the UEs may be divided according to another granularity.

[0026] In each of the foregoing embodiments, cells in the measurement set of the UE may belong to one same base station, or at least two cells may belong to different base stations.

[0027] If cells in the measurement set of the UE belong to one same base station, intra-eNodeB CoMP (Intra-eNodeB CoMP) is implemented when CoMP is performed on the UE.

[0028] If at least two cells in the measurement set of the UE belong to different base stations and the coordinated set of the UE also includes cells that belong to at least two base stations, inter-eNodeB CoMP is implemented when CoMP is performed on the UE.

[0029] Specific implementation of the method for coordinated multi-point transmission in the present invention is described in detail in the following through several specific examples.

[0030] Example 1: As shown in FIG. 5, it is assumed that a serving cell of a UE is Cell 0. In a measurement set of the UE, three cells are included, namely, a serving cell of the UE Cell0 and two other neighboring cells Cell 1 and Cell 2.

[0031] First, RSRP of Cell 0, Cell 1, and Cell 2 are obtained, and are marked as RSRP0, RSRP1, and RSRP2, respectively.

[0032] When it is determined that an absolute value of a difference between the RSRP1 and the RSRP2 is greater than a preset threshold, it indicates that the UE is located at a cell overlapping area. In FIG. 5, the UE is located at an overlapping area between cells Cell 0 and Cell 1, and a cell corresponding to a greater RSRP value between the RSRP1 and the RSRP2 and the serving cell Cell 0 are included in a coordinated set of the UE. For example, when the absolute value of the difference between the RSRP1 and the RSRP2 is greater than the preset threshold, and it may be measured that RSRP1> RSRP2 due to a fact the UE is closer to Cell1 than to Cell2, Cell 0 and Cell 1 are included in the coordinated set of the UE. Next, CoMP is performed on the UE.

[0033] Example 2: It is assumed that there are three UEs, which may be marked as UE1, UE2, and UE3 respectively, Cell0 is a serving cell of all the three UEs, and measurement sets all include Cell0 and other two neighboring cells Cell 1 and Cell 2.

[0034] First, a process as described in the foregoing example 1 for obtaining of RSPR and formation of a coordinated set of each UE is separately implemented for UE1, UE2, and UE3.

[0035] Next, a gain between a post-SINR of UE1 in the coordinated set of UE1 and a post-SINR of UE1 in the serving cell Cell0 of UE1 is calculated, and is marked as D1. A gain between a post-SINR of UE2 in the coordinated set of UE2 and a post-SINR of UE2 in the serving cell Cell0 of UE2 is calculated, and is marked as D2. A gain between a post-SINR of UE3 in the coordinated set of UE3 and a post-SINR of UE3 in the serving cell Cell0 of UE3 is calculated, and is marked as D3.

[0036] It is assumed that D2>D1>D3, and UE1, UE2, and UE3 are sorted according to order of their gains as follows: UE2, UE1, UE3.

[0037] CoMP is preferably performed on UE2, and then UE1. If a processing resource is used up after CoMP is performed on UE1, CoMP is not performed on UE3.

[0038] In addition, there may be multiple first cells and second cells that meet a condition in the foregoing embodiments, for example, in a scenario such as that a UE is located at a cell overlapping area between base stations, or a base station is divided into six cells. It is assumed that in a measurement set of a UE, five cells are included, namely, Cell 0, Cell 1, Cell 2, Cell 3, and Cell 4. Cell 0 is a serving cell of the UE. After measurement, RSRP of Cell 1, Cell 2, Cell 3, and Cell 4 are RSRP1, RSRP2, RSRP3, and RSRP4, respectively.

[0039] It is found through comparison that: An absolute value of a difference between the RSRP1 and the RSRP2 is greater than a preset threshold; an absolute value of a difference between the RSRP3 and the RSRP4 is also greater than the preset threshold. In a case that a hardware resource is sufficient, a cell whose RSRP is greater in each pair of cells whose RSRP difference is greater than the preset threshold and that meet a condition may be used as a coordination cell of the UE, and the coordination cell of the UE and the serving cell of the UE are included in a coordinated set of the UE. It is assumed that, in the foregoing example, there are two pairs of cells that meet the condition, namely, {cell1, cell2} and {cell3, cell4}, RSRP corresponding to the two pairs of cells may be respectively marked as {RSRP1, RSRP2} and {RSRP3, RSRP4}. It is assumed that, |RSRP1-RSRP2| and |RSRP3-RSRP4| are both greater than the preset threshold, and RSRP1>RSRP2 and RSRP3>RSRP4. In this case, RSRP1 and RSRP3 may both be used as coordination cells of the UE. In this way, the coordinated set of the UE includes Cell 0, Cell1, and Cell3.

[0040] However, sometimes, in a case that the hardware resource is insufficient, the number of coordination cells in the coordinated set of the UE is limited. In this case, cells whose RSRP is greater in each pair of the cells whose RSRP difference is greater than the preset threshold and that meet the condition need to be compared, and a cell whose RSRP is greater is preferably selected as the coordination cell of the UE. Alternatively, whether RSRP of a cell whose RSRP is greater among the cells whose RSRP difference is greater than the preset threshold is also greater than the preset threshold is determined through comparison, and then the cell whose

RSRP is greater is used as the coordination cell of the UE. For example, in the foregoing example, it is further assumed that, a difference between the RSRP1 and the RSRP3 of two first cells is also greater than the threshold. Then, only Cell1 whose RSRP is greater is used as the coordination cell of the UE. In this case, the coordinated set of the UE includes only Cell 0 and Cell1.

[0041] FIG. 6 is a schematic structural diagram of a device for coordinated multi-point transmission according to an embodiment of the present invention. As shown in FIG. 6, the device for coordinated multi-point transmission includes:

An RSRP obtaining unit 601 is configured to obtain reference signal received power RSRP of all cells in a measurement set of a user equipment UE.

[0042] A determining unit 602 is configured to determine that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold.

[0043] A transmitting unit 603 is configured to combine a cell whose RSRP is greater between the first cell and the second cell with the serving cell of the UE into a coordinated set of the UE, and perform coordinated multi-point transmission on the UE.

[0044] In practice, the device for coordinated multi-point transmission in the embodiment may be a base station.

[0045] Specific implementation of obtaining RSRP by the RSRP obtaining unit 601 may adopt the prior art, for example, a method defined in the 3GPP 36.214 protocol. The present invention does not limit implementation of obtaining RSRP. Cells in the measurement set may belong to different base stations or may belong to one same base station.

[0046] The determining unit 602 may perform subtraction on RSRP values of every two cells other than the serving cell in the measurement set of the UE to obtain an absolute value of an RSRP difference between two cells other than the serving cell in the measurement set, and compare the absolute value of the difference with the threshold preset in advance.

[0047] FIG. 7 is a schematic structural diagram of a device for coordinated multi-point transmission according to another embodiment of the present invention. As shown in FIG. 7, the device for coordinated multi-point transmission includes:

An RSRP obtaining unit 701 is configured to obtain reference signal received power RSRP of all cells in a measurement set of a user equipment UE. Specific implementation of obtaining RSRP by the RSRP obtaining unit 701 may adopt the prior art, for example, a method defined in the 3GPP 36.214 protocol. The present invention does not limit implementation of obtaining RSRP. Cells in the measurement set may belong to different base stations or may belong to one same base station.

[0048] A determining unit 702 is configured to determine that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold. The determining unit 702 may perform subtraction on RSRP values of every two cells other than the serving cell in the measurement set of the UE to obtain an absolute value of an RSRP difference between two cells other than the serving cell in the measurement set, and compare the absolute value of the difference with the threshold preset in advance.

[0049] A gain obtaining unit 703 is further included, where the gain obtaining unit 703 is configured to obtain a gain between a post-SINR of the UE in the coordinated set of the UE and a post-SINR of the UE in the serving cell of the UE.

[0050] Specifically, in a scenario where coverage is limited, the gain obtained by the gain obtaining unit 703 may be a relative gain, where the relative gain may be determined according to the following formula:

$$\frac{\log_2(1+SINR_1)-\log_2(1+SINR_0)}{\log_2(1+SINR_0)},$$

where $SINR_0$ is the post-SINR of the UE in the serving cell of the UE, and $SINR_1$ is a post-SINR of the UE in a cell other than the serving cell in the coordinated set of the UE, where the cell other than the serving cell in the coordinated set of the UE may also be called a coordination cell of the UE; and

$\log_2(1 + SINR_1)$ is throughput which is of the UE in the coordinated set of the UE and is determined according to the Shannon's formula, and $\log_2(1+SINR_0)$ is throughput which is of the UE in the serving cell of the UE and is determined according to the Shannon's formula.

[0051] In a scenario where a capacity is limited, the gain obtained by the gain obtaining unit 604 may be an absolute gain.

[0052] The absolute gain may be determined according to the following formula:

$$\log_2(1+SINR_1)-\log_2(1+SINR_0),$$

where $SINR_0$ is the post-SINR of the UE in the serving cell of the UE, and $SINR_1$ is the post-SINR of the UE in the cell other than the serving cell in the coordinated set of the UE; and

$\log_2(1 + SINR_1)$ is the throughput which is of the UE in the coordinated set of the UE and is determined according to the Shannon's formula, and

$\log_2(1+SINR_0)$ is the throughput which is of the UE in the serving cell of the UE and is determined according to the Shannon's formula.

[0053] A process of obtaining gains of UEs by the gain obtaining unit 703 may be performed in each transmission time interval (TTI), or may be performed on each resource block (RB). Certainly, a granularity implemented in the step for obtaining the gains of the UEs may be divided according to another granularity.

[0054] A transmitting unit 704 is specifically configured to select a UE whose gain is greater than a preset threshold to perform coordinated multi-point transmission.

[0055] The device for coordinated multi-point transmission in the embodiment may be a base station.

[0056] In addition, an embodiment of the present invention further provides a system, where the system includes the device for coordinated multi-point transmission in the foregoing device embodiments.

[0057] Exemplary implementation manners of the present invention are described in the foregoing. It should be noted that, a person of ordinary skill in the art may further make several modifications and variations without departing from the principle of the present invention, and these modifications and variations should also be construed as falling within the protection scope of the present invention.

Claims

1. A method for CoMP coordinated multi-point transmission, comprising:

   obtaining reference signal received power RSRP of a cell in a measurement set of a user equipment UE;
   determining that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold; and
   combining a cell whose RSRP is greater between the first cell and the second cell with the serving cell of the UE into a coordinated set of the UE, and performing coordinated multi-point transmission on the UE.

2. The method according to claim 1, further comprising:

   obtaining a gain between a post-SINR of the UE in the coordinated set and a post-SINR of the UE in the serving cell; wherein
   the performing coordinated multi-point transmission on the UE comprises:

   selecting the UE whose gain is greater than a preset threshold to perform coordinated multi-point transmission.

3. The method according to claim 2, wherein the gain is a relative gain or an absolute gain.

4. The method according to claim 2 or 3, wherein the obtaining a gain between a post-SINR of the UE in the coordinated set and a post-SINR of the UE in the serving cell comprises:

   obtaining, in each transmission time interval (TTI), the gain between the post-SINR of the UE in the coordinated set and the post-SINR of the UE in the serving cell.

5. The method according to claim 2 or 3, wherein the obtaining a gain between a post-SINR of the UE in the coordinated set and a post-SINR of the UE in the serving cell comprises:

   obtaining, on each resource block (RB), the gain between the post-SINR of the UE in the coordinated set and the post-SINR of the UE in the serving cell.

6. The method according to any one of claims 1 to 5, wherein,
   cells in the measurement set of the UE belong to one same base station, or
   at least two of cells in the measurement set of the UE belong to different base stations.

7. A device for coordinated multi-point transmission, comprising:

   an RSRP obtaining unit, configured to obtain reference signal received power RSRP of all cells in a measurement set of a user equipment UE;
   a determining unit, configured to determine that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold; and
   a transmitting unit, configured to combine a cell whose RSRP is greater between the first cell and the second cell with the serving cell of the UE into a coordinated set of the UE, and perform coordinated multi-point transmission on the UE.

8. The device according to claim 7, further comprising:

   a gain obtaining unit, configured to obtain a gain between a post-SINR of the UE in the coordinated set and a post-SINR of the UE in the serving cell; wherein
   the transmitting unit is specifically configured to select the UE whose gain is greater than a preset threshold to perform coordinated multi-point transmission.

9. The device according to claim 7, wherein the gain obtaining unit is specifically configured to obtain, in each transmission time interval (TTI), the gain between the post-SINR of the UE in the coordinated set and the post-SINR of the UE in the serving cell; or the gain obtaining unit is specifically configured to obtain, on each resource block (RB), the gain between the post-SINR of the UE in the coordinated set and the post-SINR of the UE in the serving cell.

10. The device according to any one of claims 7 to 9, wherein the device is a base station.

11. A system, comprising the device for coordinated multi-point transmission according to any one of claims 7 to 9.

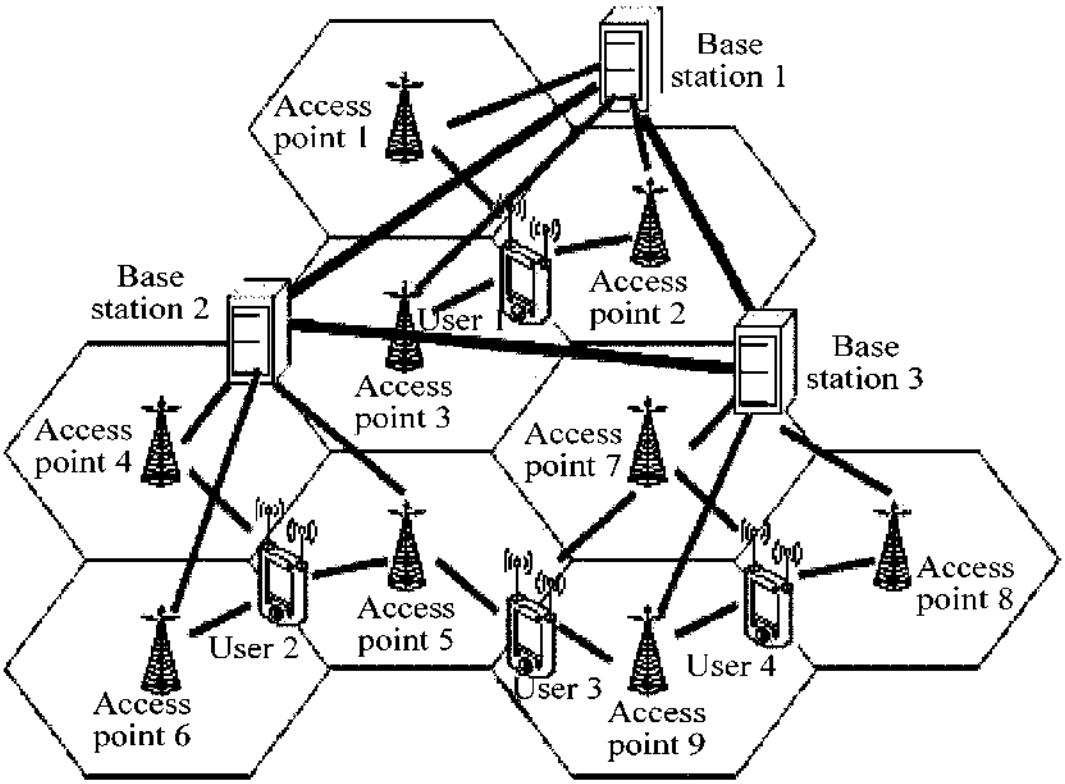

Base station 1
Access point 1
Base station 2
User 1
Access point 2
Base station 3
Access point 3
Access point 4
Access point 7
Access point 5
Access point 8
User 2
User 3
User 4
Access point 6
Access point 9

FIG. 1

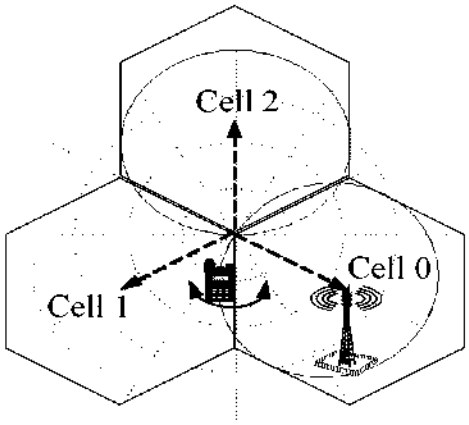

Cell 2
Cell 0
Cell 1

FIG. 2

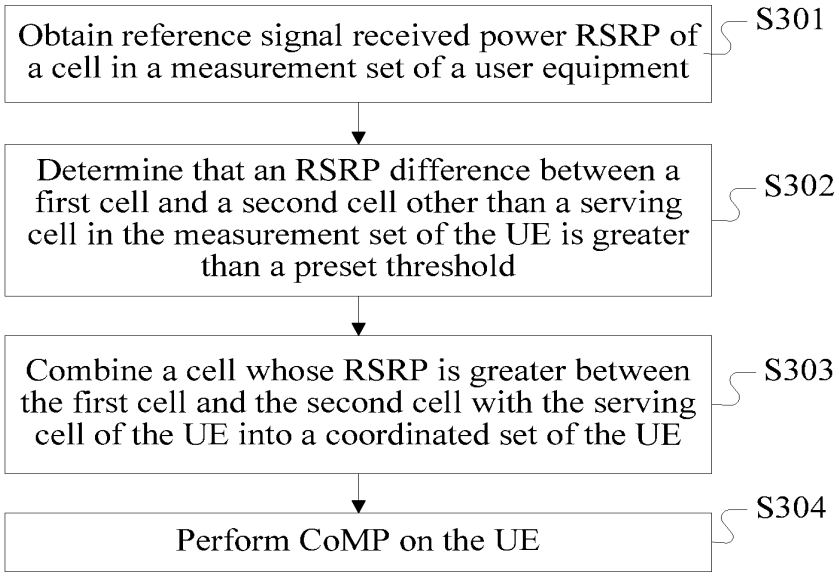

Obtain reference signal received power RSRP of a cell in a measurement set of a user equipment
S301
Determine that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold
S302
Combine a cell whose RSRP is greater between the first cell and the second cell with the serving cell of the UE into a coordinated set of the UE
S303
Perform CoMP on the UE
S304

FIG. 3

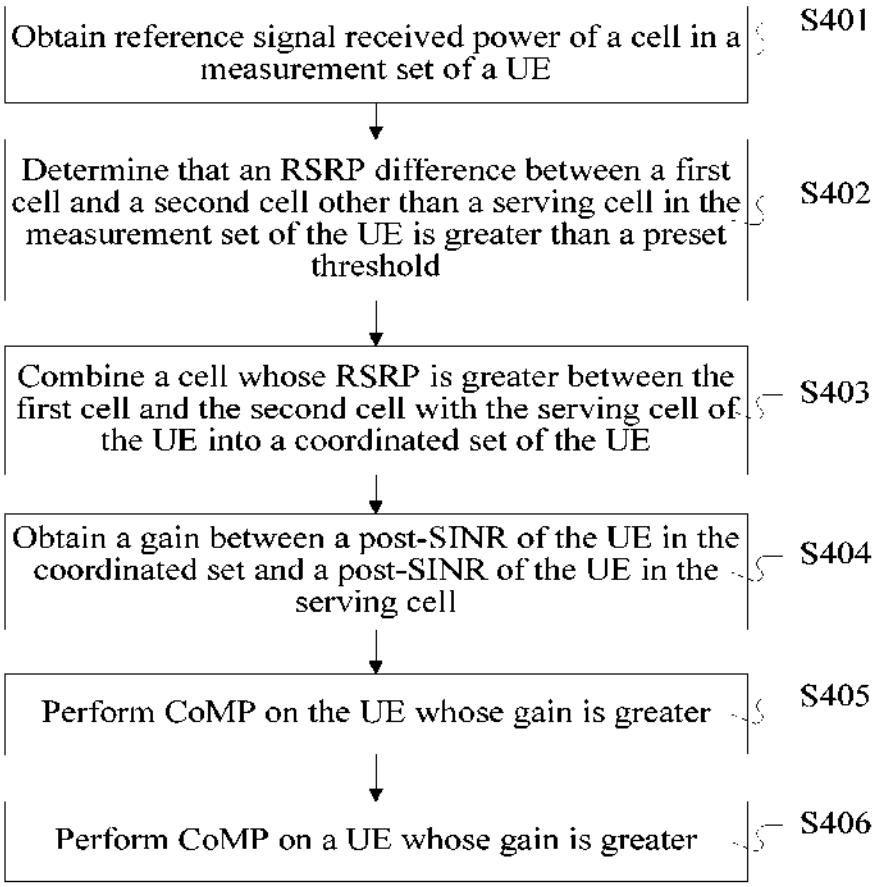

Obtain reference signal received power of a cell in a measurement set of a UE
S401
Determine that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold
S402
Combine a cell whose RSRP is greater between the first cell and the second cell with the serving cell of the UE into a coordinated set of the UE
S403
Obtain a gain between a post-SINR of the UE in the coordinated set and a post-SINR of the UE in the serving cell
S404
Perform CoMP on the UE whose gain is greater
S405
Perform CoMP on a UE whose gain is greater
S406

FIG. 4

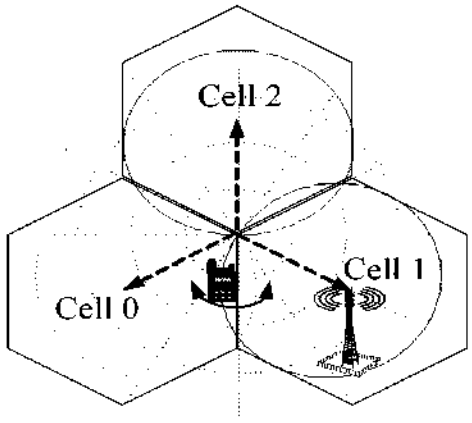

Cell 2
Cell 1
Cell 0

FIG. 5

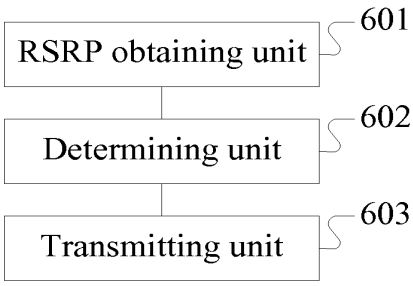

601
RSRP obtaining unit
602
Determining unit
603
Transmitting unit

FIG. 6

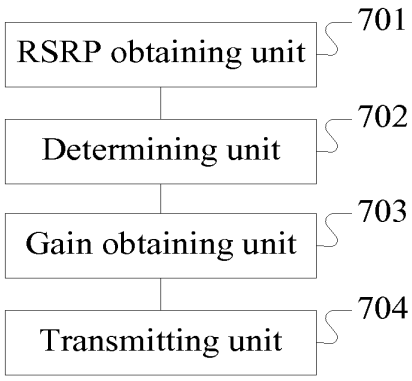

701
RSRP obtaining unit
702
Determining unit
703
Gain obtaining unit
704
Transmitting unit

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2011/077566

A. CLASSIFICATION OF SUBJECT MATTER

H04W 28/16 (2009.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: H04W, H04Q, H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNABS, CNTXT, CNKI: CoMP, coordinated multi-point, cell, transmission, reference signal received power, RSRP, quality, parameter, threshold, set

VEN, 3GPP: CoMP, coordinated multi-point transmission reception, cell?, RSRP, quality, parameter?, threshold?, set?

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 101895921 A (POTEVIO INSTITUTE OF TECHNOLOGY CO., LTD.), 24 November 2010 (24.11.2010), the whole document	1-11
A	CN 101873661 A (DATANG MOBILE COMMUNICATIONS EQUIPMENT CO., LTD.), 27 October 2010 (27.10.2010), the whole document	1-11
A	CN 102076096 A (SHANGHAI HUAWEI TECHNOLOGIES CO., LTD.), 25 May 2011 (25.05.2011), the whole document	1-11
A	CN 101815331 A (ZTE CORP.), 25 August 2010 (25.08.2010), the whole document	1-11

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 April 2012 (21.04.2012)	**03 May 2012 (03.05.2012)**
Name and mailing address of the ISA/CN: State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No.: (86-10) 62019451	Authorized officer **LV, Sihua** Telephone No.: (86-10) **62411386**

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2011/077566

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 101895921 A	24.11.2010	None	
CN 101873661 A	27.10.2010	None	
CN 102076096 A	25.05.2011	None	
CN 101815331 A	25.08.2010	None	

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(74) Agents: **MOORE, Michael S.** et al.; 1211 SW 5th Avenue, Suite 1600, Portland, Oregon 97204 (US).

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[Continued on next page]

(54) Title: ENODEB REFERENCE SIGNAL REDUCTION

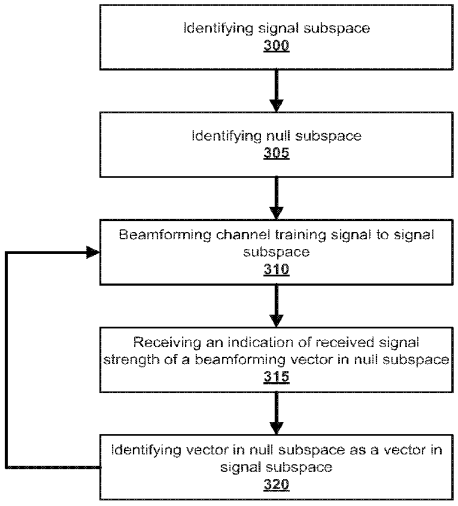


Figure 3

(57) Abstract: In embodiments, apparatuses, methods, and storage media may be described for reducing the overhead associated with the transmission of channel training signals from an eNodeB (eNB) of a wireless network. Specifically, the eNB may receive feedback from a user equipment (UE) regarding the received signal energy of a first and second beamformed signal produced with a first and second beamforming vector, respectively. The eNB may identify, based on the feedback of the received signal energy, a signal subspace and a null subspace. The eNB may then transmit a channel training signal to the signal subspace.

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EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *of inventorship (Rule 4.17(iv))*

Published:

— *with international search report (Art. 21(3))*

— *with amended claims (Art. 19(1))*

ENODEB REFERENCE SIGNAL REDUCTION

Cross Reference to Related Application

The present application claims priority to U.S. Provisional Patent Application No. 61/806,821, filed March 29, 2013, entitled "Advanced Wireless Communication Systems and Techniques," the entire disclosure of which is hereby incorporated by reference in its entirety.

Field

Embodiments of the present invention relate generally to the technical field of channel training signals in wireless systems.

Background

The background description provided herein is for the purpose of generally presenting the context of the disclosure. Work of the presently named inventors, to the extent it is described in this background section, as well as aspects of the description that may not otherwise qualify as prior art at the time of filing, are neither expressly nor impliedly admitted as prior art against the present disclosure. Unless otherwise indicated herein, the approaches described in this section are not prior art to the claims in the present disclosure and are not admitted to be prior art by inclusion in this section.

Full dimension multiple-input-multiple-output (FD-MIMO) is a study item for the upcoming Release 12 of the third generation partnership project (3GPP) long term evolution (LTE) specifications. In FD-MIMO systems, the eNodeB (eNB) may have 16 or more different antenna elements that are configured for beamforming on one or more antenna ports to user equipment (UEs). Ideally, the throughput of the eNB in FD-MIMO systems may be expected to significantly increase with a large number of antenna elements.

However, in frequency division duplex (FDD) mode, beamforming may require channel training signals. Specifically, channel training signals may be reference signals that are sent by the eNB to each UE. The UE(s) may then respond with channel feedback based on the received channel training signals. This feedback may be used to identify the resources used to beamform one or more additional signals to the UE. Currently, the overhead associated with transmitting the channel training signals may increase linearly with the number of antenna elements. For large antenna arrays having, for example, 30 antenna elements, the overhead associated with transmitting the channel training signals may become prohibitive because the throughput gains realized through use of FD-MIMO

may be offset by the overhead incurred through transmission of the channel training signals.

Brief Description of the Drawings

Embodiments will be readily understood by the following detailed description in conjunction with the accompanying drawings. To facilitate this description, like reference numerals designate like structural elements. Embodiments are illustrated by way of example and not by way of limitation in the figures of the accompanying drawings.

Figure 1 schematically illustrates a high-level example of a network system comprising a UE and an eNB, in accordance with various embodiments.

Figure 2 depicts an example of different subspaces for FD-MIMO transmissions from an eNodeB (eNB) to a plurality of user equipment (UEs), in accordance with various embodiments.

Figure 3 depicts an example of a process flow for transmitting channel training signals, in accordance with various embodiments.

Figure 4 schematically illustrates an example system that may be used to practice various embodiments described herein.

Detailed Description

Apparatuses, methods, and storage media are described herein for reducing the overhead associated with the transmission of channel training signals such as the channel state information reference signal (CSI-RS). As described above, the number of antenna ports of an eNB may linearly increase with an increase in the number of antenna elements used by the eNB. This increase in antenna ports may increase transmissions of channel training signals, which in turn may increase resource overhead of the eNB.

The channel training signals may be shared between the antenna ports in order to reduce the resource overhead of the eNB. However, time sharing of the channel training signals may introduce latency or delay to transmissions of the eNB. As noted above, the channel training signals may be transmitted from the eNB, and the UE may feed back information related to the channel training signals, and more specifically the radio resources used to transmit the channel training signals. Based on the fed back information, the eNB may identify radio resources that should be used for further communication with the UE.

However, the latency introduced by time sharing of the channel training signals may be detrimental because the latency may be such that the radio resources in the cell may have changed significantly between the transmission of the channel training signal

and the identification of the channel resources to use to transmit further signals using the feedback based on the transmission of the channel training signal. In other words, the fed back information from a UE receiving the channel training signals may not necessarily correspond to the radio resources of the cell at the time of transmission of the additional signal(s) from the eNB. This change may be due to interference caused by multiple UEs, the UE moving, or other reasons. Therefore, time sharing of the channel training signals may reduce overall performance of the cell.

By contrast, the present disclosure may relate to selectively transmitting one or more channel training signals to particular signal subspaces. Specifically, the channel training signals may be beamformed to those signal subspaces. Typically, beamforming may include multiplying a signal by an antenna-specific or antenna-port specific weighting vector, which may be referred to as a beamforming vector. The beamforming vector may affect the phase of the signal, the amplitude of the signal, or some other characteristic of the signal. The weighted signal produced by this weighting may be referred to as a beamformed signal. By multiplying one or more antenna transmissions by the weighting vector, the beamformed signal may only be transmitted to a specific signal subspace.

Specifically, a signal subspace may be a vector space defined by a subset of the possible beamforming vectors. In other words, transmissions of the signal to the signal subspace may include weighting the signal by one or more beamforming vectors of the possible beamforming vectors to produce a beamformed signal, and transmitting the beamformed signal from the eNB. The signal subspace may be identified by identifying the beamforming vectors with which the UEs receive the signal with a relatively high signal energy. Specifically, as noted above, the eNB may initially transmit one or more training signals to one or more UEs, and receive feedback information from the UEs regarding the received signal. For example, the feedback may include information regarding strength or magnitude of the received signal energy, or the phase of the received signal. Based on that fedback information, the eNB may be able to identify the beamforming vectors that produce a relatively high amount of signal energy at the UEs. The identified beamforming vectors that produce a relatively high amount of signal energy at the UEs may then be used to identify the signal subspace on which the channel training signals should be transmitted. The eNB may then transmit the channel training signals to that signal subspace using the identified beamforming vectors.

The null subspace may then be identified as the remainder of the beamforming vectors that are not used for the beamforming signal transmission to the signal subspace.

In some embodiments an additional channel training signal may be beamformed to only a portion of the null subspace, as explained in greater detail below. In embodiments, the number of beamforming vectors used to generate a beamformed signal for the signal subspace may be significantly less than the number of beamforming vectors in the null subspace. Therefore, the transmission overhead of the eNB may be significantly reduced. For example, the dimension of the null space may be several times that of the signal subspace that is useful for data communications. Therefore, skipping the channel training in the entire null space may reduce the training overhead by multiple times. For example, simulations indicate that by not transmitting the channel training signal to the entire null subspace, the resource overhead of the cell may be reduced by up to 50% while the throughput of an FD-MIMO eNB with 16 antenna elements may only be reduced by 5%. The overhead reduction may be expected to increase significantly for eNBs with antenna arrays of 64 or 128 antenna elements. For example, an eNB with 128 antenna elements transmitting data to 10 UEs may need up to 128 antenna ports in legacy systems, while only needing up to 10 antennas ports (one antenna port per UE) in wireless cells of the present disclosure.

In some embodiments, and as described in further detail below, one or both of the signal and/or null subspaces may vary over time due to mobile channel variation. Because the eNB may identify or update the signal subspace and null subspace according to the feedback indications of training signals that were beamformed by the previous beamforming vectors, the currently updated signal subspace and null subspaces may not be exactly the same as the previous signal and null subspaces where the previous beamforming vectors are located. Therefore, in some embodiments, the newly identified subspace may not fully include the previous beamforming vector. However, since the channel variation may be relatively slow in many embodiments such that the subspaces are substantially correlated in time, i.e. very alike, the previous and the current signal and null subspace may be substantially the same.

In the following detailed description, reference is made to the accompanying drawings which form a part hereof wherein like numerals designate like parts throughout, and in which is shown by way of illustration embodiments that may be practiced. It is to be understood that other embodiments may be utilized and structural or logical changes may be made without departing from the scope of the present disclosure. Therefore, the following detailed description is not to be taken in a limiting sense.

Various operations may be described as multiple discrete actions or operations in

turn, in a manner that is most helpful in understanding the claimed subject matter. However, the order of description should not be construed as to imply that these operations are necessarily order dependent. In particular, these operations may not be performed in the order of presentation. Operations described may be performed in a different order than the described embodiment. Various additional operations may be performed and/or described operations may be omitted in additional embodiments.

For the purposes of the present disclosure, the phrases "A and/or B" and "A or B" mean (A), (B), or (A and B). For the purposes of the present disclosure, the phrase "A, B, and/or C" means (A), (B), (C), (A and B), (A and C), (B and C), or (A, B and C).

The description may use the phrases "in an embodiment," or "in embodiments," which may each refer to one or more of the same or different embodiments. Furthermore, the terms "comprising," "including," "having," and the like, as used with respect to embodiments of the present disclosure, are synonymous.

Figure 1 schematically illustrates a wireless communication network 100 in accordance with various embodiments. The wireless communication network 100 (hereinafter "network 100") may be an access network of a 3GPP LTE network such as evolved universal terrestrial radio access network (E-UTRAN). The network 100 may include an eNodeB (eNB, also referred to as an evolved NodeB) 105, configured to wirelessly communicate with a UE 110.

As shown in Figure 1, the UE 110 may include a transceiver module 120. The transceiver module 120 may be coupled with one or more of a plurality of antenna elements 125 of the UE 110 for communicating wirelessly with other components of the network 100, e.g., eNB 105 or another UE. The antenna elements 125 may be powered by a power amplifier 130 which may be a component of the transceiver module 120, as shown in Figure 1, or may be a separate component of the UE 110. In one embodiment, the power amplifier 130 provides the power for all transmissions on the antenna elements 125. In other embodiments, there may be multiple power amplifiers on the UE 110. The use of multiple antenna elements 125 may allow for the UE 110 to use transmit diversity techniques such as spatial orthogonal resource transmit diversity (SORTD), MIMO, or FD-MIMO. In certain embodiments the transceiver module 120 may contain both transmitter circuitry 155 and receiver circuitry 160. Specifically, the transmitter circuitry 155 may be configured to transmit a signal from the UE 110, for example using antenna elements 125. Similarly, the receiver circuitry 160 may be configured to receive a signal at the UE 110. Although Figure 1 depicts the transceiver module 120 including both the

transmitter circuitry 155 and the receiver circuitry 160, in other embodiments, the transceiver module 120 may be replaced by transmitter circuitry and receiver circuitry which are separate from one another (not shown). In other embodiments, the transceiver module 120 may be coupled with processor circuitry configured to alter, process, or transform signals or data received from, or sent to, the transceiver module 120 (not shown).

Similarly to the UE 110, the eNB 105 may include a transceiver module 140. The transceiver module 140 may be further coupled with one or more of a plurality of antenna elements 135 of the eNB 105 for communicating wirelessly with other components of the network 100, e.g., UE 110. The antenna elements 135 may be powered by a power amplifier 145 which may be a component of the transceiver module 140, as shown in Figure 1, or may be a separate component of the eNB 105. In one embodiment, the power amplifier 145 provides the power for all transmissions on the antenna elements 135. In other embodiments, there may be multiple power amplifiers on the eNB 105. The use of multiple antenna elements 135 may allow for the eNB 105 to use transmit diversity techniques such as SORTD, MIMO, or FD-MIMO. In certain embodiments the transceiver module 140 may contain both transmitter circuitry 165 and receiver circuitry 170 which may be similar to the transmitter circuitry 155 and receiver circuitry 160 described above. In other embodiments, the transceiver module 140 may be replaced by transmitter circuitry and receiver circuitry which are separate from one another (not shown). In other embodiments, the transceiver module 140 may be coupled with processor circuitry configured to alter, process, or transform signals or data received from, or sent to, the transceiver module 120 (not shown).

As noted above, an eNB such as eNB 105 may have a plurality of antenna ports, and each antenna port may correspond to one or more of the antenna elements 135. In embodiments the transceiver module 140 may additionally include, or otherwise be coupled with, a subspace identifier 150. As will be explained in additional detail below, the subspace identifier 150 may be configured to identify signal subspaces and/or null subspace(s) in the cell.

In embodiments, an antenna port may be perceived by a UE 110 over the air interface between the UE 110 and the eNB 105. In embodiments, one antenna port may be associated with one set of channel training symbols, for example the CSI-RS as described above. As will be described in further detail below, the UE 110 may measure the channel response of one or multiple antenna ports to generate feedback or make decisions. For

example, the UE 110 may measure the received power of antenna port 0 during a handover situation.

Therefore, in embodiments an antenna port may be the air interface perceived by UE 110. In embodiments herein, each antenna port may be formed by the eNB 105 using one or more (or all) antenna elements 135, with a beamforming weight assigned to each antenna element. In some embodiments, each antenna port may be associated with a set of beamforming weights, as described in further detail below. In embodiments described as examples below, the eNB 105 may form eight antenna ports using eight sets of weights, i.e. eight beamforming vectors. The eNB 105 may then let UEs in the cell know how the antenna ports are configured such that the UE can identify the resource in frequency and time allocated for the port.

In some embodiments, the eNB 105 may include a directional antenna with a narrow downtilt angle that uses multiple antenna elements with relatively fixed or constant beamforming weights. In the present disclosure, this directional antenna may be considered a single antenna element of the antenna elements 135 because the beamforming weights of the different antenna elements of the directional antenna may remain constant. Specifically, one or more of the antenna elements 135 may be omni-directional or unidirectional, and a directional antenna element of the antenna elements 135 may be physically implemented using multiple antenna elements with constant antenna weights.

Figure 2 depicts an example of a network 200 including an eNB 205, which may be similar to eNB 105, and UEs 210, 215, and 220, which may be similar to UE 110. Some of the UEs, for example UEs 210 and 220, may only include a single antenna element, while other UEs such as UE 215 may include two or more antenna elements. As can be seen, the eNB 205 may include a plurality of antenna elements 225 configured to transmit signals to, or receive signals from, UEs 210, 215, and 220. In the embodiment shown in Figure 2, the plurality of antenna elements 225 may include a first antenna element 230 through a sixteenth antenna element 235. In other embodiments, the eNB 205 may have more or less antenna elements in the plurality of antenna elements 225.

As used herein, "spaces" may refer to the vector spaces spanned by the antenna ports. For example, eNB 205 may have 16 antennas element in the plurality of antenna elements. If one antenna port is assigned to each antenna element in the plurality of antenna elements 225, then 16 antenna ports may be perceived by UEs 210, 215, and 220, and the dimension of the whole space may be 16. The 16 antenna ports may form a 16 by

1 vector space in linear algebra. The signal subspace may then be the "location" of the UEs in the whole space.

For example, the vector channel from the 16 antenna elements at the eNB to UE 210 may be denoted as $a = \begin{bmatrix} a_1 \\ \vdots \\ a_{16} \end{bmatrix}$, where a_i represents the channel response from the *i*th antenna element in the plurality of antenna elements 225 of eNB 205 to the receive antenna element of the UE 210. Similarly, the UE 215 may be equipped with two receive antenna elements and have two vector channels $b = \begin{bmatrix} b_1 \\ \vdots \\ b_{16} \end{bmatrix}$ and $c = \begin{bmatrix} c_1 \\ \vdots \\ c_{16} \end{bmatrix}$; and the UE 220 may have a vector channel $d = \begin{bmatrix} d_1 \\ \vdots \\ d_{16} \end{bmatrix}$. Because UE 215 has multiple vector channels, UE215 may have a matrix channel $\begin{bmatrix} b_1 & c_1 \\ \vdots & \vdots \\ b_{16} & c_{16} \end{bmatrix}$.

The signal subspace may be computed as follows as an example. Let the aggregated channel matrix of the active vector channels be $H = \begin{bmatrix} a_1 & b_1 & c_1 & d_1 \\ \vdots & \vdots & \vdots & \vdots \\ a_{16} & b_{16} & c_{16} & d_{16} \end{bmatrix}^T$. Let the singular value decomposition (SVD) of H be $H = U \begin{bmatrix} \sigma_1 & & & \\ & \sigma_2 & & \\ & & \sigma_3 & \\ & & & \sigma_4 \end{bmatrix} [v_1 \quad v_2 \quad v_3 \quad v_4]^H$, where σ_i represents the singular value of the ith eigen-mode; v_i is the corresponding beamforming vector of *i*th eigen-mode; and v_i is a 16 by 1 vector with complex values.

In this embodiment, the singular values may be ordered. Specifically, σ_i may be greater than or equal to σ_j for any $i < j$. If the eNB 205 is attempting to send a relatively high amount of signal to the aggregated UE side, which in this example may consist of the antenna elements of all three of the UEs 210, 215, and 220, using one antenna beam or one beamforming vector, then v_1 may be the beamforming vector because it corresponds to the largest singular value σ_1.

For this example, the dimension of the whole space may be 16 because there are 16 antenna elements in the plurality of antenna elements 225 of the eNB 200 and correspondingly 16 linearly independent channels to the receive antenna elements of each UE 210, 215, and 220. If the eNB 205 is configured to only use one antenna port for

channel training, then in this embodiment the eNB 205 may use the beamforming vector (or weight) v_1 for the antenna port. Namely, the *i*th entry of v_1 may be the beamforming weight for the *i*th antenna element of the eNB 205. Using v_1, the three UEs 210, 215, and 220 may receive the greatest amount of signal energy from the eNB 220 in total. Because in this example there may only be one beamformed signal, the three UEs 210, 215, and 220 may have to time share the beam. Similarly, if the eNB 205 is configured to use two antenna ports, then v_1 and v_2 or the linear combination of the two can be used as beamforming vectors for the two antenna ports for channel training.

The linear space spanned by vectors v_1 and v_2 within the whole space may be referred to as "subspace" or "signal subspace." If the eNB 205 sends two data streams over two beams, then there may exist two beamforming vectors within the signal subspace that can send the most energy to the aggregated UE side consisting of UEs 210, 215, and 220. The linear space within the whole space that is spanned by all the vectors orthogonal to the vectors in the signal subspace may be referred to as the null space (of the signal subspace). In this example, if eNB 205 uses two antenna ports, then the signal subspace may be spanned by v_1 and v_2 and any beamforming vectors orthogonal to v_1 and v_2 may be in the null space that may have 16-2=14 orthogonal vectors or dimensions. In other words, the null space may depend on the selection of the signal subspace. Note that in the example above v_3 and v_4 may be in the null space of v_1 and v_2 even though v_3 and v_4 may send energy to the aggregated UE side.

In the example above, the signal subspace is described with respect to beamforming vectors v_1 and v_2. However, as noted above in other embodiments the signal subspace may be described with respect to linear combinations of beamforming vectors v_1 and v_2. Specifically, as noted above beamforming vector v_1 may deliver the greatest amount of signal energy to UEs 210, 215, and 220. Beamforming vector v_2 may deliver the next greatest amount of signal energy to UEs 210, 215, and 220. In some embodiments, it may be desirable for one or more of UEs 210, 215, and 220 to perceive a relatively equal amount of signal energy from beamforming vectors v_1 and v_2. Therefore, in some embodiments beamforming vectors v_1 and v_2 may be added or subtracted from one another to produce one or more alternative beamforming vectors which may still be within the signal subspace defined by beamforming vectors v_1 and v_2, but produce a relatively equal amount of signal energy at one or more of UEs 210, 215, and 220.

Figure 3 depicts an example process 300 for identifying signal subspaces within a cell, and beamforming the channel training signal to the signal subspaces. Initially, the

signal subspace(s) may be identified at 300. In embodiments, and as described above, a signal subspace may be identified at 300 based on previous feedback(s) from the UEs 210, 215, and 220. Specifically, the eNB such as eNB 205 may transmit a pilot signal using each possible beamforming vector in the space. Each UE, for examples UEs 210, 215, and 220, may calculate the channel response of each beamforming vector as seen by the UE. The UE may then quantize the channel responses of all received beamforming vectors using vector or scalar quantization. To continue the example above with reference to Figure 2, four beamforming vectors (v_1, v_2, v_3, and v_4) may be selected by the eNB 205. Four pilot signals, one for each beamforming vector, may be transmitted from the eNB. If the UE has one receive antenna element, for example UEs 210 or 220, the channel response, which may indicate the received signal power of each beamformed pilot signal, of the eNB's four antenna ports may be a 4 by 1 vector with complex entries. The UE may then quantizes the 4 by 1 vector jointly using vector quantization i.e. codebook quantization. The index of the quantization codeword may then be fed back to the eNB.

If the UE has *m* receive antenna elements, for example UE 215 with two receive antenna elements, then the channel response of the four antenna ports may be a 4 by *m* matrix. The UE may select a desirable *k*-dimensional subspace of the 4 by *m* matrix, for example by using SVD. In embodiments, *k* may represent the number of spatial streams or rank that the UE desires. This *k*-dimensional subspace may in some embodiments be the best *k*-dimensional subspace, and may be based on the UE stepping through the available numbers of spatial streams for identifying the spatial stream that may maximize the throughput of the signal received by the UE from the eNB. The selected *k*-dimensional subspace may be quantized to produce a quantization index, and the quantization index may be fed back to the eNB. Additionally or alternatively, the eNB may be able to identify feedback information based on, for example, downlink or uplink sounding in time-division duplexing (TDD) mode. In some embodiments the feedback may be part of or associated with a rank indicator and/or precoding matrix indicator transmission of each UE.

In some embodiments the feedback may be based on an averaging function, a summation function, or some other mathematical function performed by the UE on a pilot or beamformed signal received from the eNB. As will be explained in greater detail below, in some embodiments the signal subspace may change based on changing conditions in the cell. Therefore, it may be desirable for the fedback information from the UE to be based only on one or more signals in a given time period such as a frame, a subframe, a plurality of frames, or some other time period in which the signal subspace is constant. Otherwise,

an averaging or summation function that spans a plurality of different signal subspaces may not be accurate.The combination of vectors received from the plurality of UEs may be used by the eNB to build the aggregated channel matrix *H* described above with respect to Figure 2.

The principal signal subspaces may be identified as corresponding to large singular values in the singular value decomposition of the fedback beamforming vectors. Specifically, as described above, the signal subspace may be identified as the signal subspace formed by the beamforming vectors that are capable of delivering the most signal power from the eNB to the UEs. A set of beamforming vectors that sufficiently covers the selected signal subspace may then be identified for additional transmissions of channel training signals from the eNB to the one or more UEs. In embodiments, each beamforming vector may be used for beamforming one channel training signal, for example a CSI-RS signal, using a given antenna port. In some embodiments, the beamforming vectors may or may not be orthogonal to one another. In some embodiments, set selection may be designed for feedback accuracy, a given feedback codebook, or based on the detection of channel variation.

Concurrently with, or subsequent to, the identification of the signal subspace at 300, the null subspace may be identified based on the singular value decomposition of the matrix formed by the fed back beamforming vectors received at the eNB from the UE. Specifically, the null subspace may be identified based on low singular values in the singular value decomposition formed by the fed back beamforming vectors received at the eNB from the UEs. Specifically, the null subspaces may correspond to beamforming vectors that produce relatively low signal power at the UEs. The eNB may then beamform one or more channel training signals, for example the CSI-RS, to the signal subspace at 310.

In some embodiments, after the signal subspace is identified at 300 and the null subspace is identified at 305, the strength of signals beamformed to the signal subspace may change. Specifically, a beamforming vector that produces a relatively high amount of signal energy at the UEs in the cell may instead begin to produce a relatively low amount of signal energy at the UEs. This may occur, for example, if a UE such as a mobile phone, personal digital assistant (PDA), laptop, or some other type of UE moves. Additionally or alternatively, the cell may experience a change in signal reflection, propagation, or interference. Based on this change in the strength of beamforming vectors, it may be desirable for the eNB to track variation in the channel or the cell. Specifically, UEs may

continuously provide feedback to the eNB, and it may be useful for the eNB to be able to dynamically modify this change in signal conditions in the cell based on the feedback from the UEs.

If the channel variation of a UE is within the signal subspace spanned by the current set of channel training signals, then the normal channel feedback procedures may be able to identify this change in the signal subspace. However, if a beamforming vector in the null subspace increases in strength, for example above the strength of a beamforming vector in the signal subspace, then there may be no feedback information from a UE that indicates this change in the beamforming vector of the null subspace because if the eNB is only beamforming signals to the signal subspace, then there may be no transmissions to the entire null subspace, or certain portions of the null subspace, by which the UE can feedback information to the eNB with regards to beamforming vectors in the null subspace.

In some embodiments it may therefore be desirable to identify whether the beamforming vectors of the signal subspace and the null subspace have changed. Therefore, in some embodiments, the eNB may receive an indication from a UE of a relatively high received signal strength of a beamforming vector in the null subspace at 315. Specifically, the eNB may occasionally beamform one or more channel training signals to the null subspace, and then analyze the singular values in the singular value decomposition formed by the fed back beamforming vectors received at the eNB from the UEs, as will be described in greater detail below. In some embodiments, because channel variation may usually be slow, the eNB may give processing priority to the beamforming feedback related to the signal subspace. Therefore, the channel training signals transmitted to the null subspace, for example by beamforming, may time share a single or a relatively low number of antenna ports so that the overhead that may result from the transmission of the channel training signals is reduced.

Based on the tracking the variation in the cell at 315, if the eNB receives feedback from one or more UEs that a transmission of a channel training signal using a beamforming vector in the null subspace has greater energy than a channel training signal beamformed using a beamforming vector in the signal subspace, then the eNB may identify the beamforming vector in the null subspace as part of the signal subspace at 320. The eNB may then return to beamforming the channel training signals in the signal subspace at 310.

To illustrate the process depicted in Figure 3 in more detail, the following specific

example may be useful. It will be understood that the following is merely an example and in other embodiments other values, equations, variables, or processes may be used. Generally, during the initial training phase, an eNB such as eNB 205 may receive feedback from one or more UEs in the cell. Based on that feedback, the signal subspace, which may contain almost all of the signal energy of the fed-back signals, and the null subspaces, which may contain a low amount or no signal energy of the fed-back signals, may be calculated at 300 and 305, respectively. The calculated information may then be used to configure future downlink training and reduce the signaling overhead by scanning the signal subspace for information from UEs with greater frequency than the null subspaces, as described above.

Initially, the variable k may represent the kth UE in a cell. t may represent a given orthogonal frequency division multiplexing (OFDM) symbol, and n may represent a subcarrier in the channel. Using this notation, the channel from an eNB to the kth UE may be written as $H_k[n,t] = \sum_{m=1}^{M} h_{k,m}[n,t]e_m = \sum_{m=1}^{M} g_{k,m}[n,t]w_m$. H_k may be, for example, a 16x1 vector in cells where the eNB includes 16 antenna elements, and there is only a single UE, and it may represent the spatial signature from the eNB to the UE that is obtained through uplink feedback. M may be the dimensionality of the channel, i.e. the number of subspaces in the cell. $h_{k,m}[n,t]$ may be the estimated channel, i.e. the channel response, for the kth UE on a given subcarrier n in OFDM symbol t. e_m may be a vector equal to, for example (0, 0, . . ., 0, 1, 0, 0, . . ., 0) with the 1 in the mth position and zeroes elsewhere, and represent the unit vector pointing to the mth direction. $g_{k,m}[n,t]$ may represent the channel coefficient for the kth UE in the mth dimension in OFDM symbol t and subcarrier n. w_m my represent the unit norm vector for the mth dimension, i.e. the normalization weighting factor.

As noted above, M may represent the dimensionality of the channel, i.e. the total number of subspaces in the cell. It may be desirable to compress the channel and reduce the dimensionality from M to $D < M$. In other words, all of the subspaces in the cell may have a dimensionality M, and the signal subspace may have a dimensionality $D < M$. In order to reduce the dimensionality of the channel, it may be desirable to find the optimal basis $w_1, \ldots, w_m$ such that $g_{k,m}[n]$ is approximately equal to 0 when $m > D$. Then, for $d = 1, 2, \ldots, D$, coefficients $g_{k,m}[n,t]$ may be given by $g_{k,d}[n,t] = w_d^H H_k[n,t]$.

One result of reducing the dimensionality from M to $D < M$ may be that, instead of

utilizing M reference signals to estimate the channel in the original M-dimensional space and feeding back that information, the eNB may only employ D reference signals. By beamforming these reference signals with the weights $w_1, \ldots, w_D$, each UE may estimate the coefficient $g_{k,m}[n]$ directly and send that information to the eNB.

By allowing the UE to estimate the coefficient $g_{k,m}[n]$ directly, the overhead of transmitting the channel training signals may be reduced by a factor of D/M. Additionally, because UEs may not need to actually know the beamforming vectors used to generate the beamformed signals in order to receive the beamformed signals, the process of reducing the dimensionality of the channel from M to D may be completely transparent to the UEs. In other words, the UEs may not receive an indication that channel training signals are being beamformed only to the signal subspace rather than to the full space of the cell. However, as described in further detail below, in some embodiments it may be useful for one or more of the UEs to receive an antenna port configuration schedule from the eNB so that the UE is able to identify, for feedback purposes, when the subspace configuration may remain relatively constant.

After receiving the feedback from the UE, the eNB may identify the signal and null subspaces in the cell. Specifically, the channel covariance matrix may be estimated at the end of the qth training phase (that is, the qth time that the channel training signals are transmitted from the eNB) as

$$R_q \approx \frac{1}{KTN}\sum_{k=1}^{K}\sum_{t=(q-1)T+1}^{qT}\sum_{n=1}^{N}\left(\frac{\hat{H}_k[t,n]}{\left\|\hat{H}_k[t,n]\right\|}\right)\left(\frac{\hat{H}_k[t,n]}{\left\|\hat{H}_k[t,n]\right\|}\right)^{H} = U_q \Lambda_q U_q^{H}$$

where R_q is the channel covariance matrix in the qth training phase. T may be the length of the training period for sample covariance matrix calculations at the eNB in terms of OFDM symbols. $\hat{H}_k$ may be the estimated channel for the kth UE. K may be the total number of UEs in the cell. N may be the total number of subcarriers used by the eNB. Superscript H may represent the transpose conjugate mathematical operation. U_q may be an M x M unitary matrix, and Λ_q may be a diagonal matrix of eigenvalues $\lambda_{q,1}, \ldots, \lambda_{q,D}$. In general, $U_q \Lambda_q U_q^{H}$ may be referred to as the SVD of the matrix formed by the fedback beamforming vectors received by the eNB from the UEs, and the eigenvalues may be the singular value corresponding to each eigenvector direction. An eigenvector may be a specific example of a beamforming vector. In other words, the eigenvalues from $\lambda_{q,1}$ to $\lambda_{q,D}$ may represent the strength of the signal received from signals beamformed using beamforming vectors in the signal subspaces, and the eigenvalues $\lambda_{q,D+1}$ to $\lambda_{q,M}$ may represent the strength of the

signals, or lack thereof, received from signals beamformed using beamforming vectors in the null subspaces. Without loss of generality, it may be assumed that $\lambda_{q,1} \geq \ldots \geq \lambda_{q,D} \geq \lambda_{q,D+1}$ which may be approximately equal to λ_M, which may be approximately equal to 0. Therefore, the basis for each signal subspace in the D-dimensional channel may be $\{u_{q,1}, \ldots, u_{q,D}\}$ where $u_{q,D}$ is the dth column of the unitary matrix U_q, that is the eigenvector corresponding to the dth strongest eigenvalue. These strongest eigenvectors may now be used to beamform reference signals to the signal subspace at 310.

However, as mentioned before, the signal subspace may change and one or more beamforming vectors in the null subspace may produce a better channel response than one or more beamforming vectors in the signal subspace. In order to track these movements, and the resultant changes in the channel, it may be desirable to occasionally scan at 315 one or more null subspaces that are orthogonal to the D-dimension signal subspace to identify new beamforming vector or vectors with components in the null subspaces that produce a better channel response than one or more beamforming vectors in the signal subspace. Specifically, the new beamforming vector may include two components. The first component may be in the existing subspace spanned by one or more vectors of the signal subspace. The other component may be in the null space, and may be viewed as a correction or adjustment to the component in the existing subspace. In embodiments, the correction component may be smaller than the component in the signal subspace. Because the basis for each signal subspace in the D-dimensional channel may be $\{u_{q,1}, \ldots, u_{q,D}\}$, the basis for each null subspace in the M-dimensional channel may be $\{u_{q,D+1}, \ldots, u_{q,M}\}$.

In order to scan the null subspaces, the eNB may beamform D-r reference signals with $u_{q,1}, \ldots, u_{q,D-r}$ and the remaining r reference signals may be beamformed with r vectors selected from $u_{q,D-r+1}, \ldots, u_{q,M}$ in order to cover the null subspaces of the M-dimensional space. UEs that receive one or more of the r reference signals may estimate and quantize their channel direction in the new space as $\tilde{g}_{k,d}[n,t] = \frac{u_{q,d}^{H} H_k[n,t]}{\left\| u_{q,d}^{H} H_k[n,t] \right\|}$ where $d = 1, 2, \ldots, D$. The estimated and quantized channel direction may be transmitted from the UE to the eNB along with a channel quality indicator (CQI) transmission (which may represent a signal to interference plus noise ratio (SINR)) to the eNB. The eNB may reconstruct the channel direction in the original M dimensional space as $\tilde{H}_k[t,n] \approx \sqrt{SINR_k[t,n]} \sum_{d=1}^{D-1} \tilde{g}_{k,d}[n,t] u_{k,d}$ to identify the relative strength of signals

received in the null subspace at 315. Based on these reconstructed channel directions, the eNB may be able to identify one or more of the beamforming vectors in the null subspaces as part of the signal subspace at 320.

Results of a simulated test using one embodiment of the present disclosure are presented below in Tables 1 and 2. In these simulations, it was assumed that an eNB such as eNB 205 included 16 antenna elements with eight antenna ports. The first seven antenna ports were selected to transmit channel training signals to the signal subspace, while the eighth antenna port was selected to periodically beamform a channel training signal to the null subspace. Specifically, the transmissions of the first seven channel training signals were weighted with the seven eigenvectors corresponding to the seven strongest eigenvalues to produce beamformed channel training signals. These seven eigenvectors may be considered to be in the signal subspace. The seven beamformed channel training signals were then respectively transmitted using the first seven antenna ports of the eNB. The eighth port was selected to time share the nine remaining eigenvectors, i.e. the beamforming vectors in the null subspace, that were orthogonal to the seven eigenvectors used to produce the beamformed channel training signals. Every five to ten frames, the eNB would update the first seven beamforming vectors, while the eighth eigenvector for tracking would be updated more often for time sharing the single port. In other words, while the first seven antenna ports transmitted the beamformed seven channel training signals produced by the seven strongest eigenvectors in each frame, the eighth port would sequentially transmit beamformed channel training signals produced using the ninth through sixteenth eigenvectors one at a time in respective frames (i.e. through time sharing of the eighth port).

Tables 1 and 2, below, depict simulated sample results for a 4x4 antenna configuration and a 16x1 antenna configuration, respectively. Specifically, Tables 1 and 2 depict the average cell throughput in Megabits per second (Mbps) and cell edge user throughput in kilobits per second per UE (kbps/UE). Tables 1 and 2 depicts results for a baseline measurement where the process of Figure 3 is not performed, a subspace tracking (SS) process with scalar quantization wherein the channel direction is quantized by a scalar quantizer with 3 bits per real dimension, an SS singular value decomposition (SVD) process wherein the channel direction is obtained by SVD, and a frequency division (FD) zero-forcing beamforming (ZFBF) process based on the instantaneous values of the effective channel where no channel compression is performed.

	Average Cell Throughput (Mbps)	Cell edge User Throughput (kbps/UE)
Baseline	19.57	671
SS, Scalar Quant.	23.29	757
SS, SVD	26.43	810
FD ZFBF, SVD	27.41	852

Table 1: Simulation Results for 4x4 Antenna Configuration

	Average Cell Throughput (Mbps)	Cell edge User Throughput (kbps/UE)
Baseline	19.57	671
SS, Scalar Quant.	31.46	1130
SS, SVD	36.76	1283
FD ZFBF, SVD	44.81	1591

Table 2: Simulation Results for 16x1 Antenna Configuration

In some embodiments, the process described above with respect to Figures 2 and 3 may cause the channel training signals to vary with time. For example, the channel reference signal (CRS) and CSI-RS may be beamformed on a vector that may vary with time. Therefore, in embodiments it may be useful for the UE to know the time boundary when the beamforming vectors of the channel training signals transmitted from the eNB in the signal subspace change. By knowing this time boundary, the UE may avoid providing feedback to the eNB regarding an average of the channel training signal across two different periods with two differently beamformed channel training signals.

Specifically, as noted above in some embodiments the signal subspace may change based on variations in the cell, positions of the UEs in the cell, or other factors.

Additionally, as described above the signal subspace may be constructed based on information fedback from UEs in the cell. However, if the signal conditions in the cell are changing, then based on this feedback the beamforming vectors in the signal subspace and the null subspace may change.

As noted above, in some embodiments the feedback may be based on one or more averaging, summation or some other mathematical operations of a UE of signals received from the eNB. However, in some embodiments if the beamforming vectors in the signal subspace and null subspace change, then information averaged over the change in signal subspace may not be desirable. Therefore, it may be useful for the UEs in the cell to not perform averaging or other mathematical operations that span two different signal subspace configurations. Specifically, in some embodiments the signal subspace may change with each radio frame, radio subframe, or plurality of radio frames, or according to some other time period. Therefore, an averaging, summation, or other mathematical operation of a UE may be limited to only a single time period rather than a plurality of time periods.

Therefore, in some embodiments the eNB may transmit an antenna port configuration schedule to one or more UEs. In some embodiments, the eNB may beamform the antenna port configuration schedule to one or more of the UEs, while in other embodiments the eNB may omnicast the antenna port configuration schedule to UEs in the cell. In some embodiments, the antenna port configuration schedule may include one or more of a start time at which the signal subspace configuration may remain constant, a duration at which the signal subspace configuration may remain constant, and/or an end time at which the signal subspace configuration may remain constant. In some embodiments the antenna port configuration schedule may be demarcated according to specific times, while in other embodiments the antenna port configuration schedule may indicate one or more known periods such as radio frames, subframes, etc. In some embodiments, the antenna port configuration schedule may include one or more of a start time at which the antenna port for the null space configuration may remain constant, a duration at which the null space configuration may remain constant, and/or an end time at which the null space may remain constant. In addition, the configuration information about how the large null space is stepped through by a small number of antenna ports may be sent by the eNB. By knowing the port scheduling of the null space, the UE may not average signals across two differently beamformed ports for the null space.

Embodiments of the present disclosure may be implemented into a system using

any suitable hardware and/or software to configure as desired. Figure 4 schematically illustrates an example system 400 that may be used to practice various embodiments described herein. Figure 4 illustrates, for one embodiment, an example system 400 having one or more processor(s) 405, system control module 410 coupled to at least one of the processor(s) 405, system memory 415 coupled to system control module 410, non-volatile memory (NVM)/storage 420 coupled to system control module 410, and one or more communications interface(s) 425 coupled to system control module 410.

In some embodiments, the system 400 may be capable of functioning as the UEs 110, 210, 215, or 220 as described herein. In other embodiments, the system 400 may be capable of functioning as the eNB 105 or 205 depicted in Figures 1 or 2 or any one of the other described embodiments. In some embodiments, the system 400 may include one or more computer-readable media (e.g., system memory or NVM/storage 420) having instructions and one or more processors (e.g., processor(s) 405) coupled with the one or more computer-readable media and configured to execute the instructions to implement a module to perform actions described herein.

System control module 410 for one embodiment may include any suitable interface controllers to provide for any suitable interface to at least one of the processor(s) 405 and/or to any suitable device or component in communication with system control module 410.

System control module 410 may include memory controller module 430 to provide an interface to system memory 415. The memory controller module 430 may be a hardware module, a software module, and/or a firmware module.

System memory 415 may be used to load and store data and/or instructions, for example, for system 400. System memory 415 for one embodiment may include any suitable volatile memory, such as suitable DRAM, for example. In some embodiments, the system memory 415 may include double data rate type four synchronous dynamic random-access memory (DDR4 SDRAM).

System control module 410 for one embodiment may include one or more input/output (I/O) controller(s) to provide an interface to NVM/storage 420 and communications interface(s) 425.

The NVM/storage 420 may be used to store data and/or instructions, for example. NVM/storage 420 may include any suitable non-volatile memory, such as flash memory, for example, and/or may include any suitable non-volatile storage device(s), such as one or more hard disk drive(s) (HDD(s)), one or more compact disc (CD) drive(s), and/or one or

more digital versatile disc (DVD) drive(s), for example.

The NVM/storage 420 may include a storage resource physically part of a device on which the system 400 may be installed or it may be accessible by, but not necessarily a part of, the device. For example, the NVM/storage 420 may be accessed over a network via the communications interface(s) 525.

Communications interface(s) 425 may provide an interface for system 400 to communicate over one or more network(s) and/or with any other suitable device. The system 400 may wirelessly communicate with the one or more components of the wireless network in accordance with any of one or more wireless network standards and/or protocols. In some embodiments the communications interface(s) 425 may include the transceiver module 140 and/or subspace identifier 150 of Figure 1.

For one embodiment, at least one of the processor(s) 405 may be packaged together with logic for one or more controller(s) of system control module 410, e.g., memory controller module 430. For one embodiment, at least one of the processor(s) 405 may be packaged together with logic for one or more controllers of system control module 410 to form a System in Package (SiP). For one embodiment, at least one of the processor(s) 405 may be integrated on the same die with logic for one or more controller(s) of system control module 410. For one embodiment, at least one of the processor(s) 405 may be integrated on the same die with logic for one or more controller(s) of system control module 410 to form a System on Chip (SoC).

In some embodiments the processor(s) 405 may include or otherwise be coupled with one or more of a graphics processor (GPU) (not shown), a digital signal processor (DSP) (not shown), wireless modem (not shown), digital camera or multimedia circuitry (not shown), sensor circuitry (not shown), display circuitry (not shown), and/or GPS circuitry (not shown).

In various embodiments, the system 400 may be, but is not limited to, a server, a workstation, a desktop computing device, or a mobile computing device (e.g., a laptop computing device, a handheld computing device, a tablet, a netbook, a smart phone, a gaming console, etc.). In various embodiments, the system 400 may have more or less components, and/or different architectures. For example, in some embodiments, the system 400 includes one or more of a camera, a keyboard, liquid crystal display (LCD) screen (including touch screen displays), non-volatile memory port, multiple antenna elements, graphics chip, application-specific integrated circuit (ASIC), and speakers.

Methods and apparatuses are provided herein for Example 1 may include an eNodeB (eNB) comprising: a plurality of antenna ports with a plurality of antenna elements; subspace identification circuitry coupled with the plurality of antenna elements, the subspace identification circuitry to: identify, based on feedback information, a plurality of beamforming weights for one or multiple antenna ports wherein a number of the antenna ports is less than a number of the plurality of antenna elements; and assign a beamforming weight in the plurality of beamforming weights to an antenna in the plurality of antenna elements; and transmitter circuitry coupled with the subspace identification circuitry, the transmitter circuitry to: beamform a channel training signal allocated for the antenna port with the beamforming weights; and transmit an antenna port configuration schedule from the plurality of antennas.

Example 2 may include the eNB of example 1, wherein the feedback information is based on downlink sounding, or uplink sounding, or a signal received from a user equipment (UE).

Example 3 may include the eNB of example 1, wherein the antenna port configuration schedule includes an indication of a time period where the beamforming weights will not change.

Example 4 may include the eNB of any of examples 1-3, wherein: the feedback information includes a first indication of a magnitude or phase of a first received signal of a first beamformed signal produced with a first beamforming vector and a second indication of a magnitude or phase of a second received signal of a second beamformed signal produced with a second beamforming vector; the subspace identification circuitry is further to identify a signal subspace that substantially includes the first beamforming vector based at least in part on the first indication, and a null subspace that substantially includes the second beamforming vector based at least in part on the second indication; and the transmitter circuitry is further to beamform the channel training signal to the signal subspace.

Example 5 may include the eNB of example 4, wherein the first received signal energy is higher than the second received signal energy.

Example 6 may include the eNB of example 4, wherein the channel training signal is a first channel training signal and the transmitter circuitry is further to beamform a second channel training signal to only a portion of the null subspace.

Example 7 may include the eNB of example 6, further comprising receiver circuitry coupled with the transmitter circuitry, the receiver circuitry to receive, in

response to the transmission of the additional training signal in the null subspace, a second feedback that includes a third indication of a magnitude or phase of a third received signal of a third beamformed signal produced with a third beamforming vector in the null subspace.

Example 8 may include the eNB of example 6, wherein the signal subspace is a first signal subspace and the subspace identification circuitry is further to identify a second signal subspace based at least in part on the third indication, wherein the second signal subspace includes the third beamforming vector.

Example 9 may include a method comprising: identifying, by an eNodeB (eNB), a first signal subspace in a space based at least in part on a first indication of a magnitude or a phase of a first received signal of a first beamforming signal using a first beamforming vector in the first signal subspace, the first signal subspace substantially including the first beamforming vector; identifying, by the eNB, a null subspace in the space based at least in part on a second indication of a magnitude or a phase of a second received signal of a second beamforming signal using a second beamforming vector in the null subspace, the null subspace substantially including the second beamforming vector; and beamforming, from an antenna port of the eNB, a channel training signal to the first signal subspace.

Example 10 may include the method of example 9, further comprising: receiving, by the eNB after the beamforming of the channel training signal, a third indication of a magnitude or a phase of a third received signal of a third beamforming signal using a third beamforming vector in the null subspace, the null subspace including a third beamforming vector; and identifying, by the eNB, a second signal subspace based at least in part on the third indication, the second signal subspace including the third beamforming vector.

Example 11 may include the method of example 10, wherein the channel training signal is a first channel training signal and the third indication is based at least in part on beamforming, by the eNB, a second channel training signal to at least a portion of the null subspace.

Example 12 may include the method of example 9, wherein the first signal subspace is based at least in part on a singular value decomposition of the first indication.

Example 13 may include the method of example 9, wherein the first received signal strength is greater than the second received signal strength.

Example 14 may include the method of any of examples 9-13, wherein the first indication, second indication, and third indication are received by the eNB from a user equipment (UE).

Example 15 may include the method of any of examples 9-13, wherein the antenna port includes a plurality of antenna elements of the eNB.

Example 16 may include the method of any of examples 9-13, wherein the channel training signal is a channel state information-reference signal (CSI-RS) signal.

Example 17 may include one or more computer readable media comprising instructions which, when executed by one or more processors of an eNodeB (eNB), cause the eNB to: identify a first signal subspace in a space based at least in part on a first indication of a magnitude or a phase of a first received signal of a first beamforming signal using a first beamforming vector in the signal subspace, the first signal subspace substantially including a first beamforming vector; identify a null subspace in the space based at least in part on a second indication of a magnitude or a phase of a second received signal of a second beamforming signal using a second beamforming vector in the null subspace, the null subspace substantially including the second beamforming vector; and beamform a channel training signal to the first signal subspace.

Example 18 may include the one or more computer readable media of example 17, further comprising instructions to: obtain, after the beamform of the channel training signal, a third indication of a magnitude or a phase of a third received signal of a third beamforming signal using a third beamforming vector in the null subspace, the null subspace including a third beamforming vector; and identify a second signal subspace based at least in part on the third indication, the second signal subspace including the third beamforming vector.

Example 19 may include the one or more computer readable media of examples 17 or 18, wherein the first received signal strength is greater than the second received signal strength.

Example 20 may include an eNodeB comprising: the one or more computer readable media of any of examples 17-19; and one or more processors coupled with the one or more computer-readable media and configured to execute the instructions.

Example 21 may include a method comprising: identifying, by an eNodeB (eNB) based on feedback information, a plurality of beamforming weights for one or multiple antenna ports, wherein the one or multiple antenna ports have a plurality of antenna elements, and a number of the antenna ports is less than a number of the plurality of antenna elements; assigning, by the eNB, a beamforming weight in the plurality of beamforming weights to an antenna in the plurality of antenna elements; beamforming, from the eNB, a channel training signal allocated for the antenna port with the

beamforming weights; and transmitting, from the eNB, an antenna port configuration schedule from the plurality of antennas.

Example 22 may include the method of example 21, wherein the feedback information is based on downlink sounding, or uplink sounding, or a signal received from a user equipment (UE).

Example 23 may include the method of example 21, wherein the antenna port configuration schedule includes an indication of a time period where the beamforming weights will not change.

Example 24 may include the method of any of examples 21-23, wherein the feedback information includes a first indication of a magnitude or phase of a first received signal of a first beamformed signal produced with a first beamforming vector and a second indication of a magnitude or phase of a second received signal of a second beamformed signal produced with a second beamforming vector and the method further comprises: identifying, by the eNB, a signal subspace that substantially includes the first beamforming vector based at least in part on the first indication, and a null subspace that substantially includes the second beamforming vector based at least in part on the second indication; and beamforming, from the eNB, the channel training signal to the signal subspace.

Example 25 may include the method of example 24, wherein the first received signal energy is higher than the second received signal energy.

Example 26 may include the method of example 24, wherein the channel training signal is a first channel training signal and the method further comprises beamforming, from the eNB, a second channel training signal to only a portion of the null subspace.

Example 27 may include the method of example 26, further comprising receiving, by the eNB and in response to the transmission of the additional training signal in the null subspace, a second feedback that includes a third indication of a magnitude or phase of a third received signal of a third beamformed signal produced with a third beamforming vector in the null subspace.

Example 28 may include the method of example 26, wherein the signal subspace is a first signal subspace and the method further comprising identifying, by the eNB, a second signal subspace based at least in part on the third indication, wherein the second signal subspace includes the third beamforming vector.

Example 29 may include an apparatus comprising: means to identify, based on feedback information, a plurality of beamforming weights for one or multiple antenna

ports, wherein the one or multiple antenna ports have a plurality of antenna elements, and a number of the antenna ports is less than a number of the plurality of antenna elements; means to assign a beamforming weight in the plurality of beamforming weights to an antenna in the plurality of antenna elements; means to beamform a channel training signal allocated for the antenna port with the beamforming weights; and means to transmit an antenna port configuration schedule from the plurality of antennas.

Example 30 may include the apparatus of example 29, wherein the feedback information is based on downlink sounding, or uplink sounding, or a signal received from a user equipment (UE).

Example 31 may include the apparatus of example 29, wherein the antenna port configuration schedule includes an indication of a time period where the beamforming weights will not change.

Example 32 may include the apparatus of any of examples 29-31, wherein the feedback information includes a first indication of a magnitude or phase of a first received signal of a first beamformed signal produced with a first beamforming vector and a second indication of a magnitude or phase of a second received signal of a second beamformed signal produced with a second beamforming vector and the apparatus further comprises: means to identify a signal subspace that substantially includes the first beamforming vector based at least in part on the first indication, and a null subspace that substantially includes the second beamforming vector based at least in part on the second indication; and means to beamform the channel training signal to the signal subspace.

Example 33 may include the apparatus of example 32, wherein the first received signal energy is higher than the second received signal energy.

Example 34 may include the apparatus of example 32, wherein the channel training signal is a first channel training signal and the apparatus further comprises means to beamform a second channel training signal to only a portion of the null subspace.

Example 35 may include the apparatus of example 34, further comprising means to receive, in response to the transmission of the additional training signal in the null subspace, a second feedback that includes a third indication of a magnitude or phase of a third received signal of a third beamformed signal produced with a third beamforming vector in the null subspace.

Example 36 may include the apparatus of example 34, wherein the signal subspace is a first signal subspace and the apparatus further comprises means to identify a second

signal subspace based at least in part on the third indication, wherein the second signal subspace includes the third beamforming vector.

Example 37 may include one or more computer readable media comprising instructions configured, upon execution of the instructions by a processor, to: identify, based on feedback information, a plurality of beamforming weights for one or multiple antenna ports, wherein the one or multiple antenna ports have a plurality of antenna elements, and a number of the antenna ports is less than a number of the plurality of antenna elements; assign a beamforming weight in the plurality of beamforming weights to an antenna in the plurality of antenna elements; beamform a channel training signal allocated for the antenna port with the beamforming weights; and transmit an antenna port configuration schedule from the plurality of antennas.

Example 38 may include the one or more computer readable media of example 37, wherein the feedback information is based on downlink sounding, or uplink sounding, or a signal received from a user equipment (UE).

Example 39 may include the one or more computer readable media of example 37, wherein the antenna port configuration schedule includes an indication of a time period where the beamforming weights will not change.

Example 40 may include the one or more computer readable media of any of examples 37-39, wherein the feedback information includes a first indication of a magnitude or phase of a first received signal of a first beamformed signal produced with a first beamforming vector and a second indication of a magnitude or phase of a second received signal of a second beamformed signal produced with a second beamforming vector and further comprising instructions to: identify a signal subspace that substantially includes the first beamforming vector based at least in part on the first indication, and a null subspace that substantially includes the second beamforming vector based at least in part on the second indication; and beamform the channel training signal to the signal subspace.

Example 41 may include the one or more computer readable media of example 40, wherein the first received signal energy is higher than the second received signal energy.

Example 42 may include the one or more computer readable media of example 40, wherein the channel training signal is a first channel training signal and further comprising instructions to beamform a second channel training signal to only a portion of the null subspace.

Example 43 may include the one or more computer readable media of example 42, further comprising instructions to receive, in response to the transmission of the additional training signal in the null subspace, a second feedback that includes a third indication of a magnitude or phase of a third received signal of a third beamformed signal produced with a third beamforming vector in the null subspace.

Example 44 may include the one or more computer readable media of example 42, wherein the signal subspace is a first signal subspace and further comprising instructions to identify a second signal subspace based at least in part on the third indication, wherein the second signal subspace includes the third beamforming vector.

Example 45 may include an apparatus comprising: means to identify a first signal subspace in a space based at least in part on a first indication of a magnitude or a phase of a first received signal of a first beamforming signal using a first beamforming vector in the first signal subspace, the first signal subspace substantially including the first beamforming vector; means to identify a null subspace in the space based at least in part on a second indication of a magnitude or a phase of a second received signal of a second beamforming signal using a second beamforming vector in the null subspace, the null subspace substantially including the second beamforming vector; and means to beamform, from an antenna port, a channel training signal to the first signal subspace.

Example 46 may include the apparatus of example 45, further comprising: means to receive, after the beamforming of the channel training signal, a third indication of a magnitude or a phase of a third received signal of a third beamforming signal using a third beamforming vector in the null subspace, the null subspace including a third beamforming vector; and means to identify a second signal subspace based at least in part on the third indication, the second signal subspace including the third beamforming vector.

Example 47 may include the apparatus of example 46, wherein the channel training signal is a first channel training signal and the third indication is based at least in part on a beamforming, by the eNB, of a second channel training signal to at least a portion of the null subspace.

Example 48 may include the apparatus of example 45, wherein the first signal subspace is based at least in part on a singular value decomposition of the first indication.

Example 49 may include the apparatus of example 45, wherein the first received signal strength is greater than the second received signal strength.

Example 50 may include the apparatus of any of examples 45-49, wherein the first indication, second indication, and third indication are received from a user equipment (UE).

Example 51 may include the apparatus of any of examples 45-49, wherein the antenna port includes a plurality of antenna elements of the eNB.

Example 52 may include the apparatus of any of examples 45-49, wherein the channel training signal is a channel state information-reference signal (CSI-RS) signal.

Example 53 may include an eNode B (eNB) comprising: subspace identification circuitry to: identify a first signal subspace in a space based at least in part on a first indication of a magnitude or a phase of a first received signal of a first beamforming signal using a first beamforming vector in the first signal subspace, the first signal subspace substantially including the first beamforming vector; and identify a null subspace in the space based at least in part on a second indication of a magnitude or a phase of a second received signal of a second beamforming signal using a second beamforming vector in the null subspace, the null subspace substantially including the second beamforming vector; and transmitter circuitry coupled with the subspace identification circuitry, the transmitter circuitry to beamform, from an antenna port of the eNB, a channel training signal to the first signal subspace.

Example 54 may include the eNB of example 53, further comprising: receiver circuitry coupled with the transmitter circuitry, the receiver circuitry to receive, after the beamforming of the channel training signal, a third indication of a magnitude or a phase of a third received signal of a third beamforming signal using a third beamforming vector in the null subspace, the null subspace including a third beamforming vector; and the subspace identification circuitry is further to identify a second signal subspace based at least in part on the third indication, the second signal subspace including the third beamforming vector.

Example 55 may include the eNB of example 54, wherein the channel training signal is a first channel training signal and the third indication is based at least in part on a beamforming, by the eNB, of a second channel training signal to at least a portion of the null subspace.

Example 56 may include the eNB of example 53, wherein the first signal subspace is based at least in part on a singular value decomposition of the first indication.

Example 57 may include the eNB of example 53, wherein the first received signal strength is greater than the second received signal strength.

Example 58 may include the eNB of any of examples 53-57, wherein the first indication, second indication, and third indication are received from a user equipment (UE).

Example 59 may include the eNB of any of examples 53-57, wherein the antenna port includes a plurality of antenna elements of the eNB.

Example 60 may include the eNB of any of examples 53-57, wherein the channel training signal is a channel state information-reference signal (CSI-RS) signal.

Although certain embodiments have been illustrated and described herein for purposes of description, this application is intended to cover any adaptations or variations of the embodiments discussed herein. Therefore, it is manifestly intended that embodiments described herein be limited only by the claims.

Where the disclosure recites "a" or "a first" element or the equivalent thereof, such disclosure includes one or more such elements, neither requiring nor excluding two or more such elements. Further, ordinal indicators (e.g., first, second or third) for identified elements are used to distinguish between the elements, and do not indicate or imply a required or limited number of such elements, nor do they indicate a particular position or order of such elements unless otherwise specifically stated.

Claims

What is claimed is:

1. An eNodeB (eNB) comprising:

a plurality of antenna ports with a plurality of antenna elements;

subspace identification circuitry coupled with the plurality of antenna elements, the subspace identification circuitry to:

identify, based on feedback information, a plurality of beamforming weights for one or multiple antenna ports wherein a number of the antenna ports is less than a number of the plurality of antenna elements; and

assign a beamforming weight in the plurality of beamforming weights to an antenna in the plurality of antenna elements; and

transmitter circuitry coupled with the subspace identification circuitry, the transmitter circuitry to:

beamform a channel training signal allocated for the antenna port with the beamforming weights; and

transmit an antenna port configuration schedule from the plurality of antennas.

2. The eNB of claim 1, wherein the feedback information is based on downlink sounding, or uplink sounding, or a signal received from a user equipment (UE).

3. The eNB of claim 1, wherein the antenna port configuration schedule includes an indication of a time period where the beamforming weights will not change.

4. The eNB of any of claims 1-3, wherein:

the feedback information includes a first indication of a magnitude or phase of a first received signal of a first beamformed signal produced with a first beamforming vector and a second indication of a magnitude or phase of a second received signal of a second beamformed signal produced with a second beamforming vector;

the subspace identification circuitry is further to identify a signal subspace that substantially includes the first beamforming vector based at least in part on the first indication, and a null subspace that substantially includes the second beamforming vector based at least in part on the second indication; and

the transmitter circuitry is further to beamform the channel training signal to the signal subspace.

5. The eNB of claim 4, wherein the first received signal energy is higher than the second received signal energy.

6. The eNB of claim 4, wherein the channel training signal is a first channel training signal and the transmitter circuitry is further to beamform a second channel training signal to only a portion of the null subspace.

7. The eNB of claim 6, further comprising receiver circuitry coupled with the transmitter circuitry, the receiver circuitry to receive, in response to the transmission of the additional training signal in the null subspace, a second feedback that includes a third indication of a magnitude or phase of a third received signal of a third beamformed signal produced with a third beamforming vector in the null subspace.

8. The eNB of claim 6, wherein the signal subspace is a first signal subspace and the subspace identification circuitry is further to identify a second signal subspace based at least in part on the third indication, wherein the second signal subspace includes the third beamforming vector.

9. A method comprising:

identifying, by an eNodeB (eNB), a first signal subspace in a space based at least in part on a first indication of a magnitude or a phase of a first received signal of a first beamforming signal using a first beamforming vector in the first signal subspace, the first signal subspace substantially including the first beamforming vector; and

identifying, by the eNB, a null subspace in the space based at least in part on a second indication of a magnitude or a phase of a second received signal of a second beamforming signal using a second beamforming vector in the null subspace, the null subspace substantially including the second beamforming vector; and

beamforming, from an antenna port of the eNB, a channel training signal to the first signal subspace.

10. The method of claim 9, further comprising:

receiving, by the eNB after the beamforming of the channel training signal, a third indication of a magnitude or a phase of a third received signal of a third beamforming signal using a third beamforming vector in the null subspace, the null subspace including a third beamforming vector; and

identifying, by the eNB, a second signal subspace based at least in part on the third indication, the second signal subspace including the third beamforming vector.

11. The method of claim 10, wherein the channel training signal is a first channel training signal and the third indication is based at least in part on beamforming, by the eNB, a second channel training signal to at least a portion of the null subspace.

12. The method of claim 9, wherein the first signal subspace is based at least in part on a singular value decomposition of the first indication.

13. The method of claim 9, wherein the first received signal strength is greater than the second received signal strength.

14. The method of any of claims 9-13, wherein the first indication, second indication, and third indication are received by the eNB from a user equipment (UE).

15. The method of any of claims 9-13, wherein the antenna port includes a plurality of antenna elements of the eNB.

16. The method of any of claims 9-13, wherein the channel training signal is a channel state information-reference signal (CSI-RS) signal.

17. One or more computer readable media comprising instructions which, when executed by one or more processors of an eNodeB (eNB), cause the eNB to:

identify a first signal subspace in a space based at least in part on a first indication of a magnitude or a phase of a first received signal of a first beamforming signal using a first beamforming vector in the signal subspace, the first signal subspace substantially including a first beamforming vector;

identify a null subspace in the space based at least in part on a second indication of a magnitude or a phase of a second received signal of a second beamforming signal using

a second beamforming vector in the null subspace, the null subspace substantially including the second beamforming vector; and

beamform a channel training signal to the first signal subspace.

18. The one or more computer readable media of claim 17, further comprising instructions to:

obtain, after the beamform of the channel training signal, a third indication of a magnitude or a phase of a third received signal of a third beamforming signal using a third beamforming vector in the null subspace, the null subspace including a third beamforming vector; and

identify a second signal subspace based at least in part on the third indication, the second signal subspace including the third beamforming vector.

19. The one or more computer readable media of claims 17 or 18, wherein the first received signal strength is greater than the second received signal strength.

20. An eNodeB comprising:

the one or more computer readable media of any of claims 17-19; and

one or more processors coupled with the one or more computer-readable media and configured to execute the instructions.

AMENDED CLAIMS
received by the International Bureau on 13 May 2014 (13.05.2014)

1. An eNodeB (eNB) comprising:

a plurality of antenna ports with a plurality of antenna elements;

subspace identification circuitry coupled with the plurality of antenna elements, the subspace identification circuitry to:

identify, based on feedback information, a plurality of beamforming weights for one or multiple antenna ports wherein a number of the antenna ports is less than a number of the plurality of antenna elements; and

assign a beamforming weight in the plurality of beamforming weights to an antenna in the plurality of antenna elements; and

transmitter circuitry coupled with the subspace identification circuitry, the transmitter circuitry to:

beamform a channel training signal allocated for the antenna port with the beamforming weights; and

transmit an antenna port configuration schedule from the plurality of antennas.

2. The eNB of claim 1, wherein the feedback information is based on downlink sounding, or uplink sounding, or a signal received from a user equipment (UE).

3. The eNB of claim 1, wherein the antenna port configuration schedule includes an indication of a time period where the beamforming weights will not change.

4. The eNB of any of claims 1-3, wherein:

the feedback information includes a first indication of a magnitude or phase of a first received signal of a first beamformed signal produced with a first beamforming vector and a second indication of a magnitude or phase of a second received signal of a second beamformed signal produced with a second beamforming vector;

the subspace identification circuitry is further to identify a signal subspace that includes the first beamforming vector based at least in part on the first indication, and a null subspace that includes the second beamforming vector based at least in part on the second indication; and

the transmitter circuitry is further to beamform the channel training signal to the signal subspace.

5. The eNB of claim 4, wherein the first received signal magnitude is higher than the second received signal magnitude.

AMENDED SHEET (ARTICLE 19)

6. The eNB of claim 4, wherein the channel training signal is a first channel training signal and the transmitter circuitry is further to beamform a second channel training signal to only a portion of the null subspace.

7. The eNB of claim 6, further comprising receiver circuitry coupled with the transmitter circuitry, the receiver circuitry to receive, in response to the transmission of the additional training signal in the null subspace, a second feedback that includes a third indication of a magnitude or phase of a third received signal of a third beamformed signal produced with a third beamforming vector in the null subspace.

8. The eNB of claim 6, wherein the signal subspace is a first signal subspace and the subspace identification circuitry is further to identify a second signal subspace based at least in part on the third indication, wherein the second signal subspace includes the third beamforming vector.

9. A method comprising:

identifying, by an eNodeB (eNB), a first signal subspace in a space based at least in part on a first indication of a magnitude or a phase of a first received signal of a first beamforming signal using a first beamforming vector in the first signal subspace, the first signal subspace including the first beamforming vector; and

identifying, by the eNB, a null subspace in the space based at least in part on a second indication of a magnitude or a phase of a second received signal of a second beamforming signal using a second beamforming vector in the null subspace, the null subspace including the second beamforming vector; and

beamforming, from an antenna port of the eNB, a channel training signal to the first signal subspace.

10. The method of claim 9, further comprising:

receiving, by the eNB after the beamforming of the channel training signal, a third indication of a magnitude or a phase of a third received signal of a third beamforming signal using a third beamforming vector in the null subspace, the null subspace including a third beamforming vector; and

identifying, by the eNB, a second signal subspace based at least in part on the third indication, the second signal subspace including the third beamforming vector.

11. The method of claim 10, wherein the channel training signal is a first channel training signal and the third indication is based at least in part on beamforming, by the eNB, a second channel training signal to at least a portion of the null subspace.

12. The method of claim 9, wherein the first signal subspace is based at least in part on a singular value decomposition of the first indication.

13. The method of claim 9, wherein the first received signal magnitude is greater than the second received signal magnitude.

14. The method of any of claims 9-13, wherein the first indication, second indication, and third indication are received by the eNB from a user equipment (UE).

15. The method of any of claims 9-13, wherein the antenna port includes a plurality of antenna elements of the eNB.

16. The method of any of claims 9-13, wherein the channel training signal is a channel state information-reference signal (CSI-RS) signal.

17. One or more computer readable media comprising instructions which, when executed by one or more processors of an eNodeB (eNB), cause the eNB to:

identify a first signal subspace in a space based at least in part on a first indication of a magnitude or a phase of a first received signal of a first beamforming signal using a first beamforming vector in the signal subspace, the first signal subspace including a first beamforming vector;

including the second beamforming vector; and

beamform a channel training signal to the first signal subspace.

18. The one or more computer readable media of claim 17, further comprising instructions to:

obtain, after the beamform of the channel training signal, a third indication of a magnitude or a phase of a third received signal of a third beamforming signal using a third beamforming vector in the null subspace, the null subspace including a third beamforming vector; and

identify a second signal subspace based at least in part on the third indication, the second signal subspace including the third beamforming vector.

19. The one or more computer readable media of claims 17 or 18, wherein the first received signal magnitude is greater than the second received signal magnitude.

20. An eNodeB comprising:

the one or more computer readable media of claims 17 or 18; and

one or more processors coupled with the one or more computer-readable media and configured to execute the instructions.

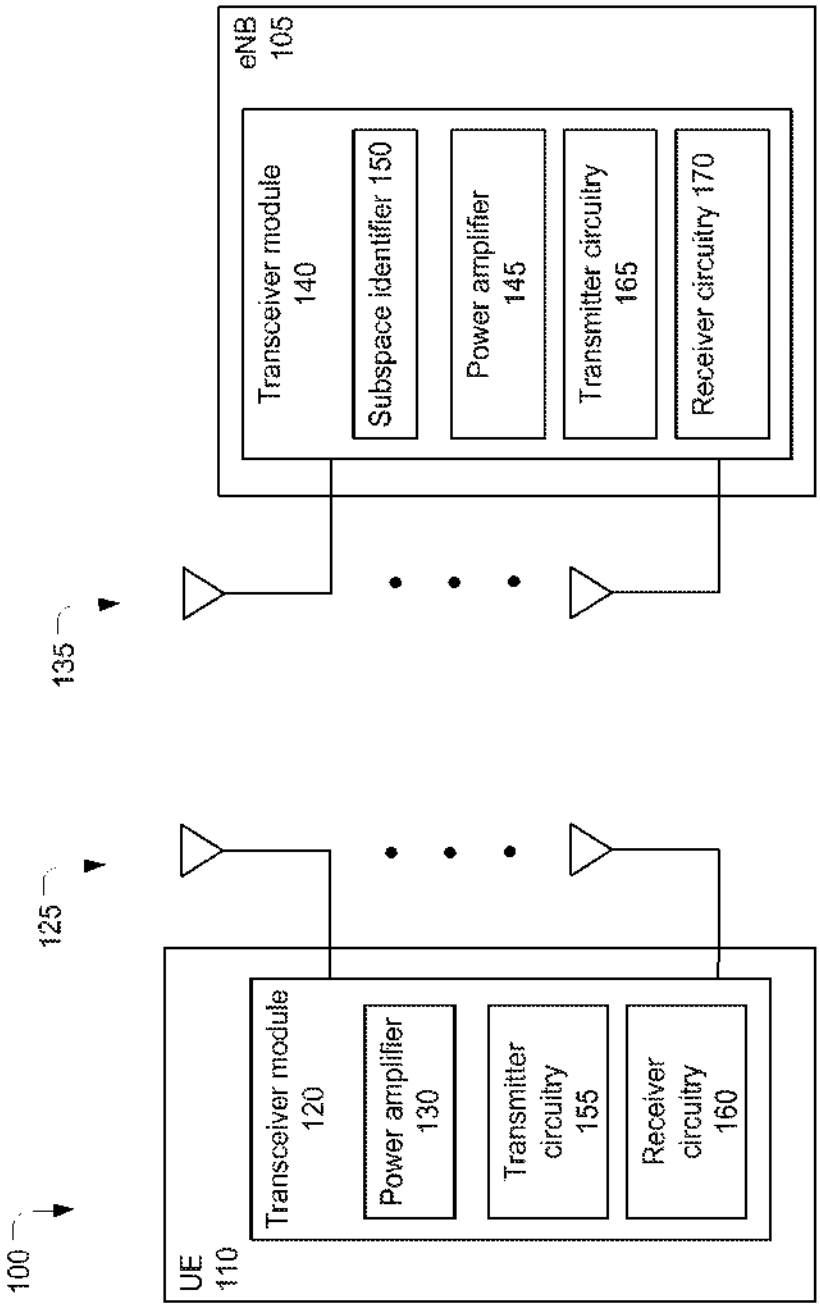

100
UE
110
Transceiver module
120
Power amplifier
130
Transmitter
circuitry
155
Receiver
circuitry
160
125
135
eNB
105
Transceiver module
140
Subspace identifier 150
Power amplifier
145
Transmitter circuitry
165
Receiver circuitry 170

Figure 1

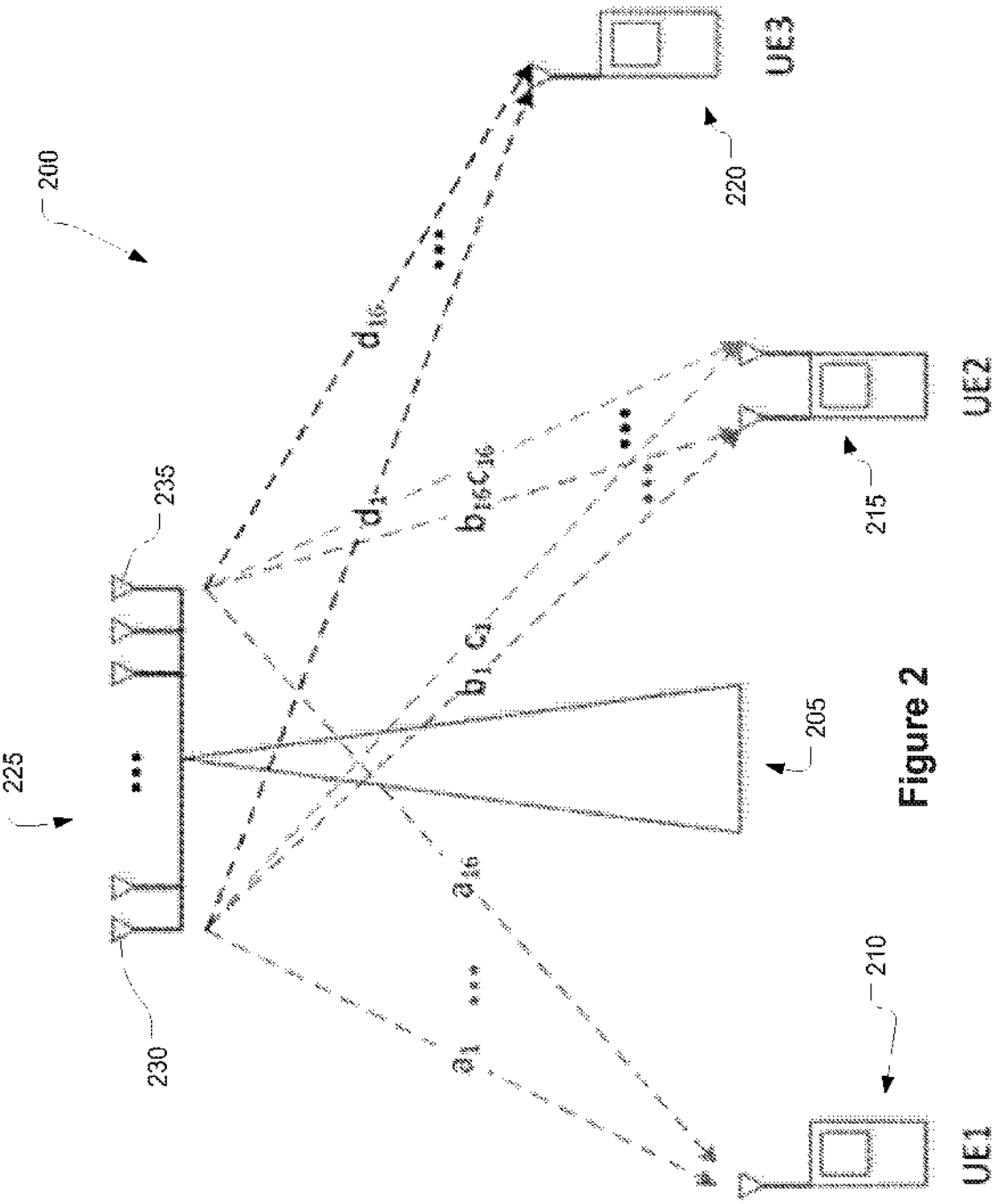


Figure 2

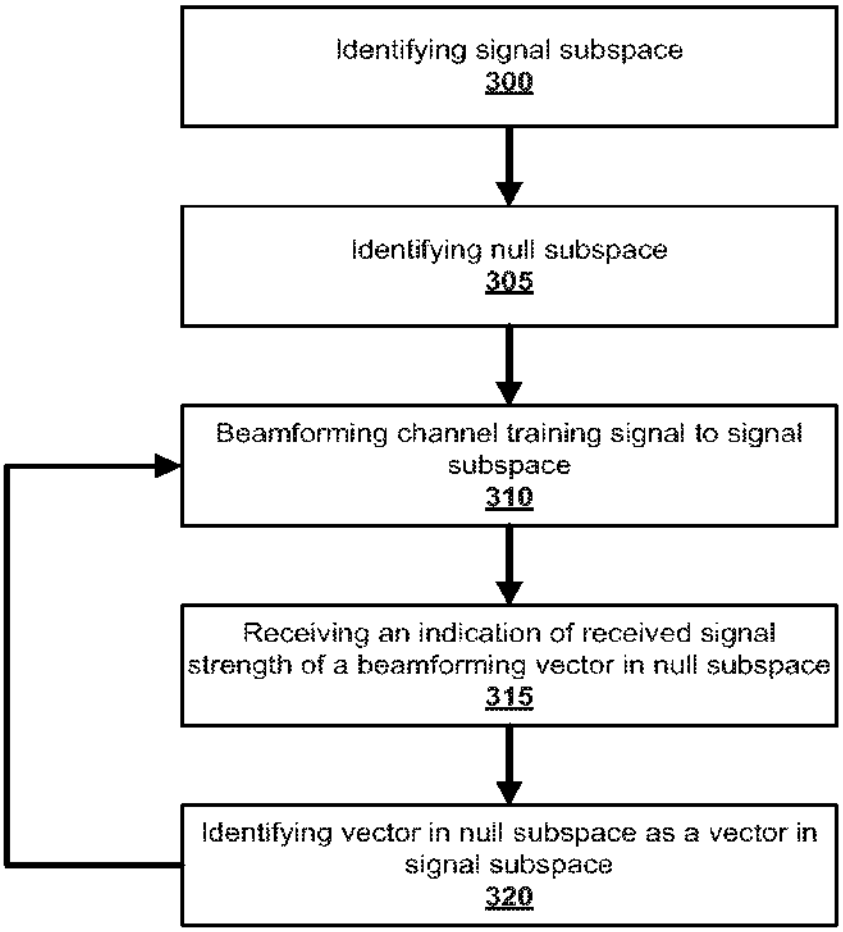

Identifying signal subspace
300
Identifying null subspace
305
Beamforming channel training signal to signal subspace
310
Receiving an indication of received signal strength of a beamforming vector in null subspace
315
Identifying vector in null subspace as a vector in signal subspace
320

Figure 3

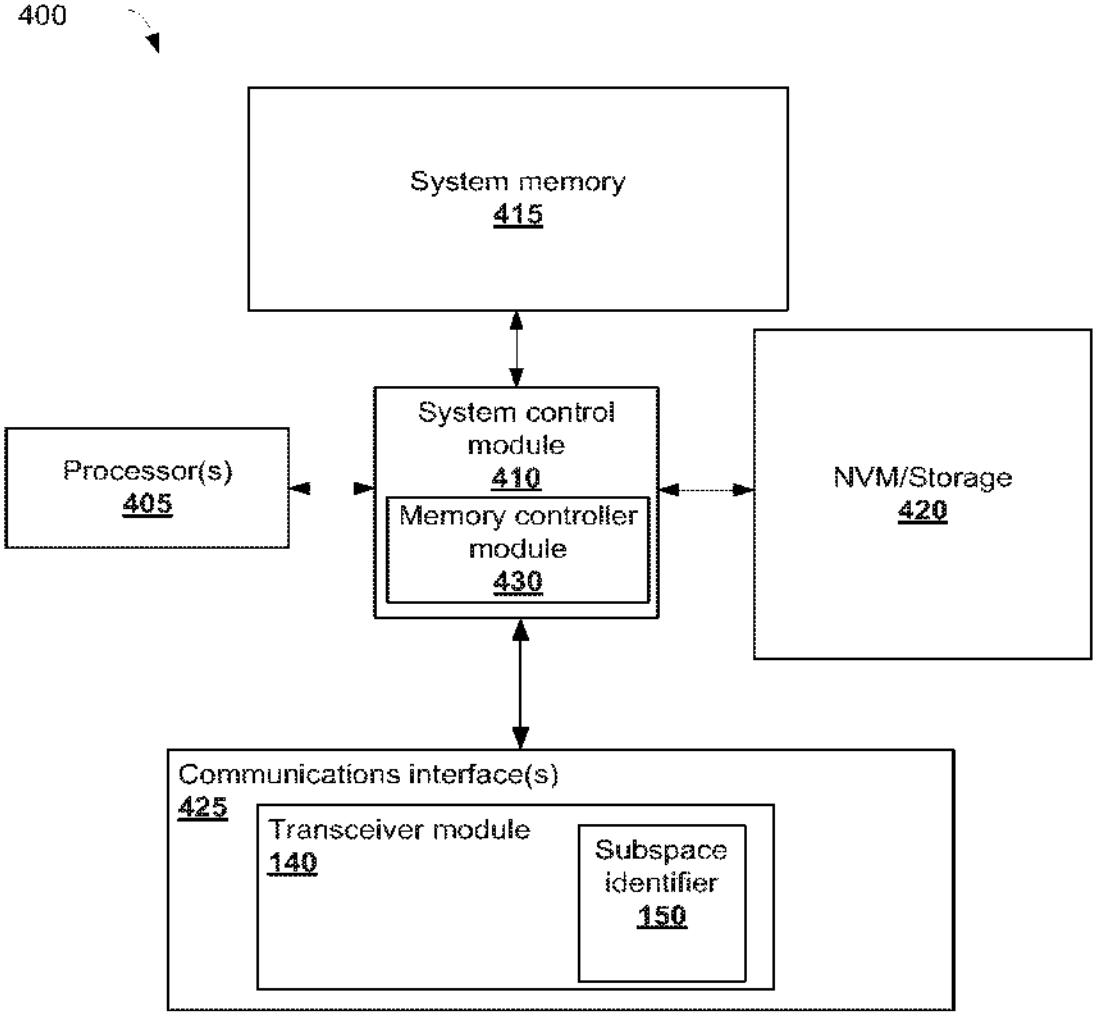

400
System memory
415
System control module
410
Memory controller module
430
Processor(s)
405
NVM/Storage
420
Communications interface(s)
425
Transceiver module
140
Subspace identifier
150

Figure 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/075463

A. CLASSIFICATION OF SUBJECT MATTER

H04B 7/06(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04B 7/06; H04B 7/00; H04B 7/02; H04B 17/00; H04M 1/00; H04Q 7/20; H04W 72/04; H04W 40/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: feedback, beamforming weight, channel training signal, beamform, antenna element, antenna port configuration schedule, signal subspace, null subspace, beamforming vector

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2009-0252250 A1 (ROBERT WENDELL HEATH, JR. et al.) 08 October 2009 See paragraphs 99-106, 115-125; and figs. 3, 5.	1-19
A	US 2009-0067375 A1 (WENDY C. WONG et al.) 12 March 2009 See paragraphs 31-99, 102-114; and figs. 2, 4.	1-19
A	US 2010-0075705 A1 (CORNELIUS VAN RENSBURG et al.) 25 March 2010 See paragraphs 50-67; and figs. 3, 4.	1-19
A	US 2013-0059619 A1 (TAE-YOUNG KIM et al.) 07 March 2013 See paragraphs 51-59, 83-91; and figs. 4, 7.	1-19
A	US 2011-0205963 A1 (YANG TANG et al.) 25 August 2011 See paragraphs 23-37, 50-58; and figs. 2a, 4.	1-19

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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Date of the actual completion of the international search	Date of mailing of the international search report
18 March 2014 (18.03.2014)	**19 March 2014 (19.03.2014)**

Name and mailing address of the ISA/KR
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Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/075463

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 20
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required addtional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of any additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2013/075463

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		US 8165533 B2	24/04/2012
US 2009-0067375 A1	12/03/2009	CN 101384023 A	11/03/2009
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		EP 2034626 A3	20/11/2013
		US 8085653 B2	27/12/2011
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US 2013-0059619 A1	07/03/2013	KR 10-2013-0025102 A	11/03/2013
		WO 2013-032188 A2	07/03/2013
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US 2011-0205963 A1	25/08/2011	None	

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Declarations under Rule 4.17:

— *as to the identity of the inventor (Rule 4.17(i))*

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— *with international search report (Art. 21(3))*

(54) **Title**: DEVICE, SYSTEM AND METHOD EMPLOYING UNIFIED FLEXIBLE 5G AIR INTERFACE

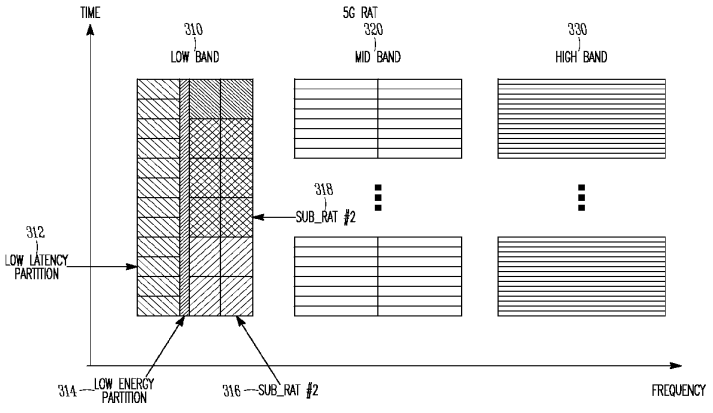


FIG. 3

(57) **Abstract**: An eNodeB (eNB), user equipment (UE) and method of providing a flexible Radio Access Technology (FRAT) are generally described. The information (resource allocation, partition information and numerology) of at least one of a plurality of RATs used by the eNB is provided to a UE. Each RAT has a flexible subcarrier spacing and symbol duration, which are integer multiples of a base subcarrier spacing and symbol duration, and is associated with at least one of different temporal and frequency resources. The symbol and/or frame structure of each RAT are independent. A Transmission Time Interval (TTI) boundary between the RATs is common, and the RATs comprise a common reference TTI duration. The information of the RATs is provided either via a different RAT than the RAT used by the UE for communication or via a dedicated carrier in the RAT used by the UE for communication.

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DEVICE, SYSTEM AND METHOD EMPLOYING UNIFIED FLEXIBLE 5G AIR INTERFACE

PRIORITY CLAIM

[0001] This application claims the benefit of priority to United States Provisional Patent Application Serial No. 62/114,733, filed February 11, 2015, and entitled "UNIFIED FLEXIBLE 5G NEW AIR INTERFACE DESIGN," which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] Embodiments pertain to radio access networks. Some embodiments relate to a unified communication framework using Radio Access Technologies (RAT) in 5th generation (5G) cellular networks.

BACKGROUND

[0003] The use of personal communication devices has increased astronomically over the last several decades. The penetration of mobile devices in modern society has continued to drive demand for a wide variety of networked devices in a number of disparate environments. The variety of available applications, especially video-related applications, has led to a concomitant increase in demand for increased bandwidth beyond that provided by Third Generation Partnership Project Long Term Evolution (3GPP LTE) and LTE advanced (LTE-A) systems.

[0004] The next generation wireless communication system, 5G, may provide access to information and sharing of data using a network that may be required to meet vastly different and sometimes conflicting performance dimensions and services driven by different services and use cases. It is therefore desirable that the next generation communication system be flexible and capable of providing high speed communications services for a wide ambit of devices under a multiplicity of circumstances.

BRIEF DESCRIPTION OF THE FIGURES

[0005] In the figures, which are not necessarily drawn to scale, like numerals may describe similar components in different views. Like numerals having different letter suffixes may represent different instances of similar components. The figures illustrate generally, by way of example, but not by way of limitation, various embodiments discussed in the present document.

[0006] FIG. 1 is a functional diagram of a 3GPP network in accordance with some embodiments.

[0007] FIG. 2 is a block diagram of a 3GPP device in accordance with some embodiments.

[0008] FIG. 3 illustrates one embodiment of a flexible Radio Access Technology (FRAT) of a 5G system in accordance with some embodiments.

[0009] FIG. 4 illustrates a unified frame structure in accordance with some embodiments.

[0010] FIG. 5 illustrates a Transmission Time Interval (TTI) boundary alignment in accordance with some embodiments.

[0011] FIG. 6 illustrates a symbol structure in accordance with some embodiments.

[0012] FIG. 7 illustrates frame structures within a TTI in accordance with some embodiments.

[0013] FIGS. 8A and 8B illustrate flowcharts of a uniform framework utilization method in accordance with some embodiments.

DETAILED DESCRIPTION OF THE INVENTION

[0014] The following description and the drawings sufficiently illustrate specific embodiments to enable those skilled in the art to practice them. Other embodiments may incorporate structural, logical, electrical, process, and other changes. Portions and features of some embodiments may be included in, or substituted for, those of other embodiments. Embodiments set forth in the claims encompass all available equivalents of those claims.

[0015] FIG. 1 is a functional diagram of a 3GPP network in accordance with some embodiments. The network may comprise a radio access network (RAN) (e.g., as depicted, the E-UTRAN or evolved universal terrestrial radio

access network) 100 and the core network 120 (e.g., shown as an evolved packet core (EPC)) coupled together through an S1 interface 115. For convenience and brevity sake, only a portion of the core network 120, as well as the RAN 100, is shown.

[0016] The core network 120 includes mobility management entity (MME) 122, serving gateway (serving GW) 124, and packet data network gateway (PDN GW) 126. The RAN 100 includes eNBs 104 (which may operate as base stations) for communicating with UE 102. The eNBs 104 may include macro eNBs and low power (LP) eNBs.

[0017] The MME is similar in function to the control plane of legacy Serving GPRS Support Nodes (SGSN). The MME manages mobility aspects in access such as gateway selection and tracking area list management. The serving GW 124 terminates the interface toward the RAN 100, and routes traffic packets (such as data packets or voice packets) between the RAN 100 and the core network 120. In addition, it may be a local mobility anchor point for inter-eNB handovers and also may provide an anchor for inter-3GPP mobility. Other responsibilities may include lawful intercept, charging, and some policy enforcement. The serving GW 124 and the MME 122 may be implemented in one physical node or separate physical nodes. The PDN GW 126 terminates a SGi interface toward the packet data network (PDN). The PDN GW 126 routes traffic packets between the EPC 120 and the external PDN, and may be a key node for policy enforcement and charging data collection. It may also provide an anchor point for mobility with non-LTE accesses. The external PDN can be any kind of IP network, as well as an IP Multimedia Subsystem (IMS) domain. The PDN GW 126 and the serving GW 124 may be implemented in one physical node or separated physical nodes.

[0018] The eNBs 104 (macro and micro) terminate the air interface protocol and may be the first point of contact for a UE 102. The eNBs 104 may communicate both with UEs 102 in a normal coverage mode and UEs 104 in one or more enhanced coverage modes. In some embodiments, an eNB 104 may fulfill various logical functions for the RAN 100 including but not limited to RNC (radio network controller functions) such as radio bearer management, uplink and downlink dynamic radio resource management and traffic packet

scheduling, and mobility management. In accordance with some embodiments, UEs 102 may be configured to communicate via orthogonal multiple access (OMA) communications such as Time Division Multiple Access (TDMA), Frequency Division Multiple Access (FDMA) Orthogonal FDMA (OFDMA), SC-FDMA or other communication signals with an eNB 104 over a multicarrier communication channel in accordance with the appropriate communication technique. The OFDM signals may comprise a plurality of orthogonal subcarriers. In accordance with some embodiments, UEs 102 may be configured to communicate via non-orthogonal multiple access (NOMA) signals.

[0019] The S1 interface 115 is the interface that separates the RAN 100 and the EPC 120. It is split into two parts: the S1-U, which carries traffic packets between the eNBs 104 and the serving GW 124, and the S1-MME, which is a signaling interface between the eNBs 104 and the MME 122.

[0020] With cellular networks, LP cells are typically used to extend coverage to indoor areas where outdoor signals do not reach well, or to add network capacity in areas with very dense phone usage, such as train stations. As used herein, the term low power (LP) eNB refers to any suitable relatively low power eNB for implementing a narrower cell (narrower than a macro cell) such as a femtocell, a picocell, or a micro cell. Femtocell eNBs are typically provided by a mobile network operator to its residential or enterprise customers. A femtocell is typically the size of a residential gateway or smaller and generally connects to the user's broadband line. Once plugged in, the femtocell connects to the mobile operator's mobile network and provides extra coverage in a range of typically 30 to 50 meters for residential femtocells. Thus, a LP eNB might be a femtocell eNB since it is coupled through the PDN GW 126. Similarly, a picocell is a wireless communication system typically covering a small area, such as in-building (offices, shopping malls, train stations, etc.), or more recently in-aircraft. A picocell eNB can generally connect through the X2 link to another eNB such as a macro eNB through its base station controller (BSC) functionality. Thus, LP eNB may be implemented with a picocell eNB since it is coupled to a macro eNB via an X2 interface. Picocell eNBs or other LP eNBs may incorporate some or all functionality of a macro eNB. In some cases, this may be referred to as an access point base station or enterprise femtocell.

[0021] As indicated in more detail below, communication over a 4G LTE network may be split up into 10ms frames, each of which may contain ten 1ms subframes. Each subframe of the frame, in turn, may contain two slots of 0.5ms. The eNB may schedule uplink and downlink transmissions over a variety of frequency bands. The allocation of resources in subframes used in one frequency band and may differ from those in another frequency band. Each slot of the subframe may contain 6-7 symbols, depending on the system used. In some embodiments, the subframe may contain 12 or 24 subcarriers. A resource grid may be used for downlink and uplink transmissions between an eNB and a UE. The resource grid may be a time-frequency grid, which is the physical resource in each slot. The smallest time-frequency unit in a resource grid may be denoted as a resource element (RE). Each column and each row of the resource grid may correspond to one OFDM symbol and one OFDM subcarrier, respectively. The resource grid may contain resource blocks (RBs) that describe the mapping of physical channels to resource elements and physical RBs (PRBs). A PRB may be the smallest unit of resources that can be allocated to a UE in the current 3GPP standard. A resource block may be 180 kHz wide in frequency and 1 slot long in time. In frequency, resource blocks may be either 12 x 15 kHz subcarriers or 24 x 7.5 kHz subcarriers wide. For most channels and signals, 12 subcarriers may be used per resource block, dependent on the system bandwidth. The duration of the resource grid in the time domain corresponds to one subframe or two resource blocks. Each resource grid may comprise 12 (subcarriers) *14 (symbols) =168 resource elements for normal cyclic prefix (CP) case. Several different physical channels may be conveyed using such resource blocks. As discussed in more detail below, in a 5G network, the sizes of the resource blocks, resource elements, and symbols, among others, may vary.

[0022] There may be several different physical downlink channels that are conveyed using such resource blocks, including the physical downlink control channel (PDCCH) and the physical downlink shared channel (PDSCH). Each subframe may contain a PDCCH, physical hybrid-ARQ indicator channel (PHICH), physical control format indicator channel (PCFICH) and the PDSCH. The PDCCH may normally occupy the first up to three symbols (four in the case

of narrow bandwidths of 1.4MHz) of each subframe and carry, among other things, information about the transport format and resource allocations related to the PDSCH channel and uplink scheduling grants for a physical uplink shared channel (PUSCH) transmission. The PHICH may be used to signal HARQ information in response to a PUSCH transmission. The PCFICH may inform the UE the control region size (e.g. one, two or three OFDM symbols) in each downlink subframe. The PDSCH may carry user data and higher layer signaling to a particular UE and occupy the remainder of the downlink subframe to avoid the resources in which downlink control channels (PDCCH/PHICH/PCFICH) are transmitted. Typically, downlink scheduling (assigning control and shared channel resource blocks to UEs within a cell) may be performed at the eNB based on channel quality information provided by the UEs, and then the downlink resource assignment information may be sent to a scheduled UE on the PDCCH used for (assigned to) PDSCH reception of the UE.

[0023] The PDCCH may contain downlink control information (DCI) in one of a number of formats that tell the UE where to find and how to decode the data, transmitted on PDSCH in the same subframe, from the resource grid. The DCI may provide details such as the number of resource blocks, resource allocation type, modulation scheme, transport block, redundancy version, coding rate etc. Each DCI format may have a cyclic redundancy code (CRC) and be scrambled with a Radio Network Temporary Identifier (RNTI) that identifies the target UE for which the PDSCH is intended. Use of the RNTI, which may be UE-specific, may limit decoding of the DCI information (and hence the corresponding PDSCH) to only the intended UE. The PDCCH may be located in any of a number of frequency/temporal regions, depending on whether the PDCCH is UE-Specific or common, as well as the aggregation level. The set of possible candidate locations for the PDCCH is defined in terms of search spaces. A search space is defined by a set of Control Channel Element (CCE) candidates with a number of aggregation level $L \in \{1,2,4,8\}$ where the UE may monitor to find its PDCCHs. A common search space may carry DCIs that are common for all UEs; for example, system information (using the SI-RNTI), paging (P-RNTI), PRACH responses (RA-RNTI), or UL TPC commands (TPC-PUCCH/PUSCH-RNTI). A UE-specific search space may carry DCIs for UE-

specific allocations using a Cell Radio-Network Temporary Identifier (C-RNTI) assigned to the UE, a semi-persistent scheduling (SPS C-RNTI), or an initial allocation (temporary C-RNTI). When configuring an SPS (either uplink or downlink), the SPS C-RNTI is provided by the eNB and the UE is configured by higher layers to decode a PDCCH with a CRC scrambled by the SPS C-RNTI. The UE may monitor the PDCCH having a CRC scrambled by the SPS C-RNTI in every subframe as the eNB can activate/re-activate/release the SPS at any time using a DCI format with a CRC scrambled by an SPS C-RNTI. The received DCI format with a CRC scrambled by the SPS C-RNTI can be a grant/assignment for a retransmission or for activation/re-activation/release of the SPS. 3GPP Technical Specification 36.213 has tabulated the validation procedure for activation/re-activation/release of SPS.

[0024] In addition to the PDCCH, an enhanced PDCCH (EPDCCH) may be used by the eNB and UE. The PDSCH may thus contain data in some of the resource blocks (RBs) and then EPDCCH contains the downlink control signals in others of the RBs of the bandwidth supported by the UE. Different UEs may have different EPDCCH configurations. The sets of RBs corresponding to EPDCCH may be configured, for example, by higher layer signaling such as Radio Resource Control (RRC) signaling for EPDCCH monitoring.

[0025] The Physical Uplink Control Channel (PUCCH) may be used by the UE to send Uplink Control Information (UCI) to the eNB. The PUCCH may be mapped to an UL control channel resource defined by an orthogonal cover code and two resource blocks (RBs), consecutive in time, with hopping potentially at the boundary between adjacent slots. The PUCCH may take several different formats, with the UCI containing information dependent on the format. Specifically, the PUCCH may contain a scheduling request (SR), acknowledgement responses/retransmission requests (ACK/NACK) or a Channel Quality Indication (CQI)/Channel State Information (CSI). The CQI/CSI may indicate to the eNB an estimate of the current downlink channel conditions as seen by the UE to aid channel-dependent scheduling and, if one MIMO transmission mode is configured to the UE, may include MIMO-related feedback (e.g. Precoder matrix indication, PMI).

[0026] FIG. 2 is a functional diagram of a 3GPP device in accordance with some embodiments. The device may be a UE or eNB, for example. In some embodiments, the eNB may be a stationary non-mobile device. The 3GPP device 200 may include physical layer circuitry 202 for transmitting and receiving signals using one or more antennas 201. The 3GPP device 200 may also include medium access control layer (MAC) circuitry 204 for controlling access to the wireless medium. The 3GPP device 200 may also include processing circuitry 206 and memory 208 arranged to perform the operations described herein.

[0027] In some embodiments, mobile devices or other devices described herein may be part of a portable wireless communication device, such as a personal digital assistant (PDA), a laptop or portable computer with wireless communication capability, a web tablet, a wireless telephone, a smartphone, a wireless headset, a pager, an instant messaging device, a digital camera, an access point, a television, a medical device (e.g., a heart rate monitor, a blood pressure monitor, etc.), or other device that may receive and/or transmit information wirelessly. In some embodiments, the mobile device or other device can be a UE 102 or eNB 104 configured to operate in accordance with 3GPP standards. In some embodiments, the mobile device or other device may be configured to operate according to other protocols or standards, including IEEE 802.11 or other IEEE standards. In some embodiments, the mobile device or other device may include one or more of a keyboard, a display, a non-volatile memory port, multiple antennas, a graphics processor, an application processor, speakers, and other mobile device elements. The display may be an LCD screen including a touch screen.

[0028] The antennas 201 may comprise one or more directional or omnidirectional antennas, including, for example, dipole antennas, monopole antennas, patch antennas, loop antennas, microstrip antennas or other types of antennas suitable for transmission of RF signals. In some multiple-input multiple-output (MIMO) embodiments, the antennas 201 may be effectively separated to take advantage of spatial diversity and the different channel characteristics that may result.

[0029] Although the 3GPP device 200 is illustrated as having several separate functional elements, one or more of the functional elements may be combined and may be implemented by combinations of software-configured elements, such as processing elements including digital signal processors (DSPs), and/or other hardware elements. For example, some elements may comprise one or more microprocessors, DSPs, field-programmable gate arrays (FPGAs), application specific integrated circuits (ASICs), radio-frequency integrated circuits (RFICs) and combinations of various hardware and logic circuitry for performing at least the functions described herein. In some embodiments, the functional elements may refer to one or more processes operating on one or more processing elements.

[0030] Embodiments may be implemented in one or a combination of hardware, firmware and software. Embodiments may also be implemented as instructions stored on a computer-readable storage device, which may be read and executed by at least one processor to perform the operations described herein. A computer-readable storage device may include any non-transitory mechanism for storing information in a form readable by a machine (e.g., a computer). For example, a computer-readable storage device may include read-only memory (ROM), random-access memory (RAM), magnetic disk storage media, optical storage media, flash-memory devices, and other storage devices and media. Some embodiments may include one or more processors and may be configured with instructions stored on a computer-readable storage device.

[0031] The term "machine readable medium" may include a single medium or multiple media (e.g., a centralized or distributed database, and/or associated caches and servers) configured to store one or more instructions. The term “machine readable medium” may include any medium that is capable of storing, encoding, or carrying instructions for execution by the 3GPP device 200 and that cause it to perform any one or more of the techniques of the present disclosure, or that is capable of storing, encoding or carrying data structures used by or associated with such instructions. The term “transmission medium” shall be taken to include any intangible medium that is capable of storing, encoding or carrying instructions for execution, and includes digital or analog

communications signals or other intangible medium to facilitate communication of such software.

[0032] As above, the upcoming 5G wireless communications technology systems may have a number of unique challenges, including carrying the inherent ability to provide different performances requirements for numerous different types of wireless devices. Higher data rates in particular may continue to drive network development and evolution for 5G system. It may be desirable for a 5G system to support a peak data rate of more than 10Gps and a minimum guaranteed user data rate of at least 100Mbps. In addition, it may be desirable for the 5G system to support the huge increase in variety and number of Internet of Things (IoT) and Machine-Type Communication (MTC)-type devices. MTC devices have been increasingly employed for different applications, using low operational power consumption and infrequent small burst transmissions. Moreover, it may be desirable for the 5G system to provide an extremely high level of reliable connectivity with guaranteed low latency, availability and reliability-of-service for mission critical MTC use cases.

[0033] In general, 5G systems may use a plurality of Radio Access Technologies (RATs), unlike previous 2G, 3G and 4G, systems. For example, an enormous amount of spectrum may be available through the use of higher frequency bands. In one example, the use of millimeter wave (mmWave) frequency bands ranging from 30 to 300GHz may provide the desired scalability, capacity and density for the 5G system. In this case, a new RAT may be defined for the mmWave band to achieve low latency and higher peak data rate. The RAT for mmWave band communications may differ from the RAT for one or more of the other frequency bands used to provide communication services. In some embodiments, the RATs may be used simultaneously by a single eNB for communications with different UEs.

[0034] In some embodiments, a 5G system may be provided that contains multiple RATs in a unified framework to support diverse applications, use cases and services and inter-networking in multiple frequency bands, including both licensed and unlicensed frequency bands. The RATs used in the licensed and unlicensed may be independent of each other. In some embodiments, flexible subcarrier spacing and symbol duration (i.e., configurable

numerology) may be provided across the frequency bands used in the 5G system. In addition, the 5G system may include mechanisms to multiplex multiple RATs, sub-RATs and other partitions in different or the same frequency resource or frequency bands.

[0035] The inter-networking in the unified frame structure may include, in some embodiments, a Transmission Time Interval (TTI) boundary alignment between multiple RATs may be provided to allow seamless scheduling, fallback and support of different RATs. In some embodiments, a TTI is the smallest unit of time in which the eNB is capable of scheduling any UE for uplink or downlink transmission. In some embodiments, the TTI boundary alignment may occur at a subframe or frame boundary. As used herein, a unified RAT with flexible air interface for the 5G system is referred to as a flexible Radio Access Technology (FRAT). A UE that communicates with an eNB operating using the FRAT may remain using a single air interface technology (i.e., RAT) or may switch between different RATs.

[0036] In some embodiments, a unified RAT with configurable numerologies may be used in the 5G system in which a base subcarrier spacing (Δf) and symbol duration (T) can be defined in the FRAT. In one example, to maintain the backward compatibility for existing LTE and LTE-Advanced systems, a base subcarrier spacing and symbol duration can be specified as Δf = 15KHz and T=66.7μs. Moreover, for convenience in some embodiments a single oscillator may be used, with the subcarrier spacing and symbol duration for different RATs specified as an integer number of the base subcarrier spacing and symbol duration, respectively.

[0037] Similarly, when a low latency use case and service is desired, a shortened symbol duration may be employed to reduce the latency by using larger subcarrier spacing. The subcarrier spacing and symbol duration may in this case be defined as $\Delta f_i = K*\Delta f$ and $T_i=(1/K)*T$. In one example, for frequency band between 6GHz and 30GHz, K can be chosen as 10, leading to a subcarrier spacing and symbol duration of 150KHz and 6.67μs, respectively. This may result in a 0.1ms TTI for low latency use case. In another example, for frequency bands below 6GHz, which includes the current LTE frequency range,

K can be selected by the network to be 2 or 4, and the corresponding subcarrier spacing and symbol duration changed proportional to the selected K value. Alternatively, the same subcarrier spacing and symbol duration can be defined for frequency bands below 6GHz (i.e., K =1), but a shorter TTI can be considered, e.g., with a fewer number of symbols, to support low latency use cases.

[0038] To efficiently support a massive number of MTC devices used in the 5G network, in other embodiments, the subcarrier spacing and symbol duration can be defined as $\Delta f_i = (1/K)*\Delta f$ and $T_i=K*T$. In such embodiments, K can be selected to be 10, and the subcarrier spacing and symbol duration 1.5KHz and 667μs, respectively. In this case, the subframe duration for MTC use cases can be defined to be 10ms, in the current generation LTE systems the length of a typical frame, rather than the typical 1ms. This may reduce the power consumption of MTC UEs by reducing the amount of time the MTC UE is active, thereby increasing the battery life of the MTC UEs.

[0039] A UE may be initially assigned the appropriate RAT by the eNB or other network device (such as the MME). In some embodiments, the UE may be configurable to communicate using any of the RATs, as indicated via the eNB, and can configure the subcarrier spacing and symbol duration accordingly. In some embodiments, the UE may be limited to communicating only using a subset of the RATs, and perhaps only a single RAT, e.g., when the UE is an MTC UE having a limited bandwidth and capabilities. The RAT may depend on the type of UE as well as the operating mode of the UE. For example, some UEs may change mode between a normal mode and an enhanced coverage mode in situations in which the link budget to the nearest serving eNB is worse than a typical link budget value in the network and additional link budget is to be obtained without increasing transmission power. Enhanced coverage mode may be employed by a variety of UEs, including a normal UE (e.g., a smartphone or the like), a machine-to-machine (M2M) UE or a stationary wireless UE (i.e., a UE that remains indefinitely in a single location) using MTC. The UE may determine whether additional link budget is desired, as well as how much additional link budget is desired, and enter an appropriate enhanced coverage mode (that provides the appropriate additional link budget). The different

enhanced coverage modes may correspond to different RATs. Some UEs, such as low cost, low complexity MTC UEs, further may be band limited and operate in a narrow bandwidth of e.g., to 1.4 MHz, for both control and data channels, leading to the ability to operate, e.g., in a single RAT unless the RAT is modified by the network.

[0040] FIG. 3 illustrates one embodiment of a FRAT of a 5G system in accordance with some embodiments. The FRAT 300 may contain one or more partitions in different frequency band regions 310, 320, 330. In one example, the low frequency band 310 may include frequencies used in 4G systems (up to 6 GHz), the mid-frequency band 320 may include higher frequencies (e.g., 6-30 GHz) and the high frequency band 330 may include the highest frequencies in the 5G system (e.g., mmWave, above 30 GHz). Although the RATs of only a low frequency band 310, a mid-frequency band 320, and a high frequency band 330 are shown, any number of RATs of different frequency bands may exist. The various RATs in frequency bands may each have a subcarrier spacing and symbol duration that is independent of the subcarrier spacing and symbol duration of another RAT in another frequency band (i.e., the RATs have configurable numerologies). Moreover, within each frequency band, one or more sub-RATs and partitions 312, 314, 316, 318 may be present with each sub-RAT or partition 312, 314, 316, 318 having a subcarrier spacing and symbol duration independent of the subcarrier spacing and symbol duration of another sub-RAT or partition 312, 314, 316, 318 and independent of the RAT in other frequency bands. As shown in FIG. 3, the sub_RATs 316, 318 in the low frequency band 310 may have the same subcarrier spacing and symbol duration and may be separated by frequency and/or time, while partitions 312, 314 may have different subcarrier spacings and symbol durations from each other and the sub_RATs 316, 318 and may be separated by frequency and/or time. Although the low frequency band 310 is shown as having multiple partitions 312, 314 and sub_RATs 316, 318, the mid frequency band 320 is shown as having two sub_RATs and the high frequency band 330 is shown as having no sub_RATs, the eNB may establish the number and type of RATs used within a particular frequency band differently.

[0041] In some embodiments, RATs and sub-RATs with same or different numerologies can be multiplexed. The multiplexing may be via Time-Division Multiplexing (TDM), Frequency-Division Multiplexing (FDM), code-division multiplex (CDM), spatial division multiplex (SDM), other possible orthogonal or non-orthogonal multiplexing schemes, or any combination thereof. For example, multiple RATs, sub-RATs or partitions with same or different numerologies can be multiplexed in a TDM manner. Each RAT, sub-RAT and partition may have a numerology, access scheme and modulation scheme that is independent of the numerology, access scheme and modulation scheme of the other RATs, sub-RATs and partitions. The numerologies, resource allocation and partition information in the time domain can be predefined or configured by higher layer signaling, e.g. via a Master Information Block (MIB), System Information Block (SIB) or UE-specific dedicated RRC signaling. If a MIB is used to indicate the partition configuration for multiple RATs, sub-RATs or partitions, the resource for the transmission physical broadcast channel (PBCH) used to carry the MIB may be predefined and known at the UEs. In some embodiments, the PBCH may be transmitted in a predetermined RAT, independent of the UE or number of RATs, sub-RATs or partitions supported. Once the UE receives the configuration information via the PBCH on the predetermined RAT, the UE may use a different RAT for further control and data communications; that is, the predetermined RAT and the RAT used by the UE to communicate may be independent.

[0042] In some embodiments, multiple RATs, sub-RATs or partitions with same or different numerologies can be multiplexed in a FDM manner. To minimize the interference between multiple RATs, sub-RATs or partitions with different numerologies, guard bands may be inserted at the edge of frequency resources allocated for the RATs, sub-RATs or partitions. Similar to the above, the numerologies and/or resource partition for multiple RATs, sub-RATs or partitions may be predefined or configured by high layer signaling via a MIB, SIB or UE-specific dedicated RRC signaling.

[0043] In embodiments in which numerologies and/or resource partition for multiple RATs, sub-RATs or partitions is predefined or dedicated carriers are allocated for different RATs, a dedicated downlink synchronization signal and

PBCHs may be transmitted on each RAT, sub-RAT or partition. In embodiments in which the numerologies and/or resource partition for multiple RATs, sub-RATs or partitions is configured using a MIB or SIB, a single MIB or SIB may be transmitted on one of the RAT, sub-RAT or partition. After successfully decoding the MIB or SIB, the UEs may be able to derive the resource information or numerologies for other RATs, sub-RATs or partitions. Thus, information provided from the eNB to the UE via a single transmission in a particular RAT, sub-RAT or partition may enable communications using different RATs, sub-RATs or partitions.

[0044] Particular RATs/sub-RATs/partitions may be used for different types of communications, with each having independently sized resource blocks. For example, as shown, the resources in a first partition 312 may be used for low-latency communications while the resources in a second partition 314 may be used for low energy communications. The first and second partitions 312, 314 may be multiplexed, as shown, using FDM such that the first and second partitions 312, 314 occupy the same time but different frequency resources. The first partition 312 may be associated with low latency communications in which the UE operates in a low latency mode and may have a short symbol duration and TTI, while the second partition 314 may be associated with low energy communications in which the UE operates in a low energy mode and may have a long symbol duration and TTI.

[0045] Other sub-RATs 316, 318 may similarly be FDM multiplexed with the first and second partitions 312, 314 and TDM multiplexed with each other. The sub-RATs 316, 318 may have a symbol duration and TTI between those associated with the first and second partitions 312, 314.

[0046] The RATs 320, 330 for the mid- and high- frequency band may be supported simultaneously with each other and the RAT 310 for low frequency band, while maintaining TTI boundary alignment between the different RATs 310, 320, 330. The RATs 320, 330 may similarly be FDM multiplexed with the first and second partitions 312, 314 and sub-RATs 316, 318. The RATs 320, 330 may have a symbol duration and TTI smaller than those associated with the first partition 312. As shown in FIG. 3, in some embodiments, the amount of temporal and/or frequency resources associated with the different RATs, sub-

RATs and partitions may differ among the different types, and the same type may be associated either with different amounts of temporal and/or frequency resources (e.g., as partitions 312, 314) or the same amount of temporal and/or frequency resources (e.g., as sub-RATs 316, 318). A given frequency and temporal range may be associated with a particular frame and symbol structure (as well as subcarrier spacing and symbol duration), with the frame and symbol structures of the frequency and temporal range independent of the frame and symbol structures of other frequency and temporal ranges.

[0047] FIG. 4 illustrates a unified frame structure in accordance with some embodiments. The unified frame structure contains frames 400, subframes 410, slots 420 and symbols 430. More specifically, each frame 400 may contain L subframes of equal duration and have an overall duration of X ms. Each subframe 410 may similarly comprise N slots of equal duration and have an overall duration of Y ms. Each slot may, in turn, comprise M symbols of equal duration. The slot and symbol durations may be different between subframes of different RATs depending on specific use cases, frequency bands and deployment scenarios. The frame structure of each of RAT may be independent of the frame structure of the other RATs. Thus, a particular RAT may have one or more of different L, N and/or M values, as well as different X and/or Y values, as the other RATs. This may also apply to the sub-RATs and partitions shown in FIG. 3.

[0048] FIG. 5 illustrates a Transmission Time Interval (TTI) boundary alignment in accordance with some embodiments. In some embodiments of the unified frame structure, it may be beneficial from a simplified design standpoint to periodically align the TTI boundary 530 between different RATs 510, 520, e.g., at a particular subframe or frame boundary after a predetermined number of subframes or frames. Thus, in some embodiments an integral number of TTIs 540 of a RAT 510 having a smaller TTI duration (low latency RAT) may be disposed within a single TTI 550 of a RAT 520 having a larger TTI duration. In the example shown in FIG. 5, the smaller TTI duration RAT 510 may have a TTI 540 of 0.1ms while the larger TTI RAT 520 may have a TTI 550 of 1ms. By implementing a TTI of 1ms, a low latency RAT TTI may align with the existing LTE specification TTI boundary. Having a common TTI boundary may support

cross-carrier/RAT scheduling for high frequency band RATs from low frequency band RATs based an anchor booster architecture. This is to say that, in some embodiments for cross-carrier/RAT scheduling, as shown a common PDCCH may be used to schedule other RATs, with the UE switching to a particular RAT to obtain the scheduling and then switching to another RAT to communicate and perhaps to obtain further scheduling information using that RAT. In some embodiments, the other RAT may contain a PDCCH for additional scheduling, while in other embodiments the other RAT may not contain a PDCCH, in which case the UE may periodically switch to the scheduling RAT to obtain scheduling information for the other RAT. In some embodiments, a UE may obtain initial scheduling information (e.g., when it initially powers on or otherwise accesses the eNB) from the initial RAT (e.g., a conventional 4G system RAT) and from then on, after switching to its assigned RAT, obtains scheduling information using that RAT. In other embodiments, each RAT may contain a PDCCH and scheduling is performed for the UE operating on the RAT. A licensed low frequency band RAT may provide reliable coverage for control signaling as an anchor cell, using the PDCCH shown in FIG. 5, while a high frequency band RAT may provide opportunistic boosting in data rate when channel conditions are favorable as booster cell.

[0049] FIG. 6 illustrates a symbol structure in accordance with some embodiments. FIG. 6 shows an OFDM symbol 610 and a unique word (UW) OFDM symbol 620. Each OFDM symbol 610 may contain a cyclic prefix (CP) 612 that comprises a replication of the initial portion of the OFDM symbol 610. The CP 612 may range in size from 1/4 to 1/32 of the symbol period 614. The CP 612 may be disposed at the end of the symbol or outside the symbol, depending on specific waveform, thereby creating a guard between the symbol and the adjacent symbol. In some embodiments, when OFDM downlink and SC-FDMA uplink waveforms are selected for a 5G RAT, the CP 612 may be inserted outside the symbol 610. In embodiments in which a UW OFDM symbol 620 or UW Discrete Fourier transform-Spread-Orthogonal Frequency Division Multiplexing (UW-DFT-s-OFDM) symbol is used, the UW 622 may be inserted within one symbol duration 624. The symbol structure may be independent for each of the RATs, such that whether or not a particular RAT a

CP or UW and whether the CP or UW is outside or within a symbol is independent of the symbol structure of any other RAT.

[0050] As shown in FIG. 6, the UW-OFDM 620 may be used to support different UW lengths based on different channel delay spreads while maintaining the same symbol duration (or FFT size). This enables both shorter UW 622 and longer UW 626 to be used in the same size symbol 624 as the UW 622, 624 is inserted within the FFT instead of being adding after the FFT size. The ability to maintain the same symbol duration may provide a greater flexibility to support a unified RAT design. In one example, using an OFDM symbol for a low frequency band (below 6GHz), a subcarrier spacing of 60KHz (i.e., K = 4, Δf =60KHz) may be used to achieve a 0.1ms TTI. This translates to OFDM symbols of T=16.7μs (66.7μs/K). Thus, 5 OFDM symbols may be able to be accommodated within one subframe (83.5μs) with a CP length of approximately 3.3μs (0.1ms - 83.5μs =16.5μs/5 CPs).

[0051] FIG. 7 illustrates frame structures within a TTI in accordance with some embodiments. In FIG. 7, various TTIs 710, 720, 730, 740 are illustrated in which the TTIs 710, 720, 730, 740 comprise UW-OFDM waveforms. The first TTI 710 shown in FIG. 7 may comprise a UW 712 and symbol 714 of typical length. In this example, the subcarrier spacing may be 15KHz and the symbol duration 716 may be 66.7μs. A total of 3 OFDM symbols 716 may be present in a TTI 710 of 200μs.

[0052] The second TTI 720 shown in FIG. 7 may comprise a low latency TTI 720 with short symbol duration. Such a TTI 720 can be used for use cases such as mission critical MTC applications and Vehicle–to-Vehicle applications, among others. The UW 722 and symbol 724 may each be smaller than the first TTI 710. In this example, the subcarrier spacing may be 30KHz and the symbol duration 726 may be 33.3μs. For a TTI 720 of the same length as the first TTI (e.g., 200μs), a total of 6 short OFDM symbols 726 may be present.

[0053] The third TTI 730 shown in FIG. 7 may comprise another low latency TTI 730 similar to the low latency TTI 720. The UW 732 and symbol 734 may each be smaller than the first TTI 710, the subcarrier spacing may be 30KHz and the symbol duration 736 may be 33.3μs. However, in this example

the TTI 730 may only be half the length as the first TTI (i.e., 100μs), corresponding to a total of 3 short OFDM symbols 736.

[0054] The fourth TTI 740 shown in FIG. 7 may comprise a low energy TTI 740, e.g., for use by MTC UEs. The UW 742 and symbol 744 may each have a longer duration smaller than the first TTI 710. In one example, the subcarrier spacing may be 5KHz and the symbol duration 746 may be 200μs. In this example, the TTI 740 may be 1ms, corresponding to a total of 5 long OFDM symbols 746.

[0055] The above TTIs 710, 720, 730, 740 may be FDM or TDM multiplexed based on the FRAT design. One or more of the UW-OFDM waveforms may be replaced by other waveforms so long as the same symbol duration is maintained. Other examples of OFDM waveforms may include ZT-OFDM and UW-DFTs-OFDM, among others. When different waveforms are used in the same carrier, multi-RATs can be supported where each RAT may have different waveform design. In some embodiments, existing LTE waveforms may be reused, i.e., OFDM waveforms may be used for downlink and SC-FDMA waveforms may be used for uplink communications. In some embodiments, OFDM may be used both downlink and uplink communications. In some embodiments, UW-based waveforms may be used both downlink and uplink communications. For example, UW-OFDM waveforms may be used for downlink communications and UW-DFT-s-OFDM waveforms may be used for uplink communications or either UW-OFDM or UW-DFT-s-OFDM waveforms may be used for both downlink and uplink communications. In some embodiment, filtered OFDM and filter-bank multiple carrier (FBMC) may be used. FBMC waveforms are produced using a nonrectangular sub-channel pulse shape in the time domain during OFDM-offset quadrature amplitude modulation (OQAM) transmission (in which the real part of QAM symbols are mapped to ½ of the multi-carrier symbols and the imaginary parts are mapped to an interlaced 1/2 of the multi-carrier symbols) and may lack a CP.

[0056] Tables 1-3 below illustrate various examples of 5G numerology.

Frequency Band	Subcarrier spacing	TTI	DL waveform	UL waveform

<3GHz (low power or MTC)	1.5KHz	10ms	OFDM	SC-FDMA
<3GHz	15KHz	1ms	OFDM	SC-FDMA
[3-6]GHz	75KHz	0.2ms	UW-OFDM	UW-DFT-s-OFDM
[6-30]GHz	480KHz	0.1ms	UW-OFDM	UW-DFT-s-OFDM
>30GHz	1.5MHz	0.1ms	DFT-s-OFDM	DFT-s-OFDM

Table 1: First 5G numerology example

Frequency Band	Subcarrier spacing	TTI	DL waveform	UL waveform
<3GHz (low power or MTC)	1.5KHz	10ms	UW-OFDM	UW-OFDM
<3GHz	15KHz	1ms	UW-OFDM	UW-OFDM
[3-6]GHz	75KHz	0.2ms	UW-OFDM	UW-OFDM
[6-30]GHz	480KHz	0.1ms	UW-DFT-s-OFDM	UW-DFT-s-OFDM
>30GHz	1.5MHz	0.1ms	OFDM	OFDM

Table 2: Second 5G numerology example

Frequency Band	Subcarrier spacing	TTI	DL waveform	UL waveform
<3GHz (low power or MTC)	1.5KHz	10ms	OFDM	OFDM
<3GHz	15KHz	1ms	OFDM	OFDM
[3,6]GHz	75KHz	0.2ms	OFDM	OFDM
[6,30]GHz	480KHz	0.1ms	UW-DFT-s-OFDM	UW-DFT-s-OFDM
>30GHz	1.5MHz	0.1ms	UW-DFT-s-OFDM	UW-DFT-s-OFDM

Table 3: Third 5G numerology example

[0057] FIGS. 8A and 8B illustrate flowcharts of a uniform framework utilization method in accordance with some embodiments. FIG. 8A in particular illustrates a flowchart of a uniform framework utilization method of an eNB such as the eNB shown in FIGS. 1 or 2 in accordance with some embodiments. As shown in FIG. 8A, the eNB may determine the unified framework at operation 802. The unified framework may include access scheme, modulation

scheme, frame structure, symbol structure, and configurable numerology including subcarrier spacing and symbol duration. The different frame and symbol structures may be associated with different temporal and/or frequency resources multiplexed respectively in a TDM or FDM manner.

[0058] At operation 804, the eNB may communicate specific unified framework configuration information of a particular RAT to one or more UEs serviced by the eNB. Different RAT information may be provided to different UEs attached to the eNB, in which different RATs may be associated with different frequency bands and/or time spans. The eNB may determine the configuration information to be provided to a particular UE based on the device type and/or data to be communicated between the UE and the eNB. The frequency bands may include both licensed and unlicensed frequency bands. The RAT information may include access and modulation scheme, frame and symbol structure, as well as numerology. The RAT information may also include resource allocation and partition information. The unified framework configuration information provided to each UE may be independent of the unified framework configuration information provided to any other UE. The RAT indicated by the eNB to the UE may be dependent on the type and/or operating mode of the UE.

[0059] The eNB may communicate with the UE at operation 806 using the RAT provided at operation 804. The information may include data and/or control information. For example, downlink communications from the eNB to the UE may include paging or control signals for channel estimation on the PDCCH and voice or video data from another UE on the PDSCH. The RAT information may be provided using a dedicated RAT that is different from the RAT used for communication with the UE or using a dedicated carrier on the RAT used for communication with the UE.

[0060] The eNB may, subsequent to communicating with the UE, receive an indication from the UE of a change of operating state of the UE at operation 808. The UE may, for example, be configured to operate in one or more of a normal mode, a low latency and low energy mode. The eNB may, at operation 804, assign the RAT to the UE based on the initial mode of the UE and

determine that an update of the operation mode of the UE has occurred at operation 808.

[0061] In response to determining at operation 808 that an update of the operation mode of the UE has occurred, the eNB may determine a new RAT and transmit the updated unified framework configuration information of the new RAT to the UE at operation 810. The new RAT may include a different frame and/or symbol structure and use a different frequency spectrum and/or time range. The eNB may then continue to communicate with the UE at operation 806.

[0062] FIG. 8B illustrates a uniform framework utilization method as performed by a UE in accordance with some embodiments. The UE may be the UE shown in FIGS. 1 or 2 and may attach to the eNB prior to communicating data. During the attachment, the UE may transmit the initial operation conditions to the eNB at operation 812. In particular, the UE may provide a UE type and/or operating mode during attachment. For example, the UE may be a MTC UE. The UE may moreover be configured to operate in a low latency and/or low energy mode. In some embodiments, a MTC UE may operate in an enhanced coverage, low energy mode.

[0063] In response to transmitting the operating conditions, unified framework configuration (RAT) information may be received by a particular UE at operation 814. The RAT information may be dependent on the type and/or operating mode of the UE. The RAT may be associated with a particular frequency band and/or time range. For example, when the UE operates in the low latency mode, a larger subcarrier spacing and shorter symbol duration may be indicated by the unified framework configuration information; while when the UE operates in the low energy mode, a smaller subcarrier spacing and longer symbol duration may be indicated by the unified framework configuration information.

[0064] Once the RAT received by the UE, the UE may then communicate using the RAT at operation 816. The UE may, for example, adjust FFT operating conditions and processing to meet the RAT information provided at operation 814. The UE may communicate with the eNB or may communicate directly with other UEs using device-to-device communication (D2D)

communication. The information may include uplink and downlink data and/or control information. For example, the information may include uplink communications of voice or video data for another UE or measurements of control signals for channel estimation.

[0065] The UE may, subsequent to communicating with the eNB, determine that a change of operating conditions is warranted at operation 818. For example, the UE may transition between the normal and enhanced coverage/low energy mode dependent on UE location, or between the normal and low latency mode dependent on the type of communication to transmit.

[0066] In response to determining that a change of operating conditions is warranted at operation 818, at operation 820 the UE may transmit an indication to the eNB indicating the change of operating state of the UE. The UE may instead determine that a change of operating conditions is desired at operation 820 and wait to change operating state until a new RAT is assigned to the UE.

[0067] In response to transmitting the indication at operation 820, the UE may return to operation 814 and receive a new RAT at operation 810. The new RAT may include a different frame and/or symbol structure and use a different frequency spectrum and/or time range. The eNB may then continue to communicate with the UE at operation 816.

[0068] Various examples of the disclosure are provided below. These examples are not intended to in any way limit the disclosure herein. In Example 1, user equipment (UE) may comprise processing circuitry configured to: configure a transceiver to receive a resource allocation from a network using a first Radio Access Technology (RAT), the first RAT selected from a plurality of RATs of a flexible RAT (FRAT) employed by the network, the plurality of RATs of the FRAT each comprising configurable numerology with flexible subcarrier spacing and symbol duration and associated with at least one of different temporal and frequency resources, the transceiver configurable to communicate using the plurality of RATs and configure the subcarrier spacing and symbol duration based on the numerology; and configure the transceiver to communicate using the first RAT.

[0069] In Example 2, the subject matter of Example 1 can optionally include that the processing circuitry is further configured to configure the transceiver to receive from an enhanced NodeB (eNB) higher layer signaling associated with the FRAT, the higher layer signaling indicating numerologies, resource allocation and partition information in at least one of a time and frequency domain.

[0070] In Example 3, the subject matter of one or any combination of Examples 1-2 can optionally include that the FRAT comprises a base subcarrier spacing and symbol duration, and at least one of the subcarrier spacing and symbol duration for different RATs of the FRAT is respectively specified as an integer number of the base subcarrier spacing or symbol duration.

[0071] In Example 4, the subject matter of one or any combination of Examples 1-3 can optionally include that the UE is a Machine-Type Communication (MTC) UE configured to operate in at least one of a low latency and low energy mode, and the first RAT comprises a larger subcarrier spacing and shorter symbol duration when the UE operates in the low latency mode and comprises a smaller subcarrier spacing and longer symbol duration when the UE operates in the low energy mode.

[0072] In Example 5, the subject matter of one or any combination of Examples 1-4 can optionally include that at least one of the plurality of RATs of the FRAT comprises at least one of a plurality of sub-RATs and partitions, each of the at least one of the plurality of sub-RATs and partitions comprising an independent configurable numerology with flexible subcarrier spacing and symbol duration and associated with at least one of different temporal and frequency resource, and the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are combined using at least one of a Time-Division Multiplexing (TDM), Frequency-Division Multiplexing (FDM), Code-Division Multiplexing (CDM), and Spatial Division Multiplexing (SDM).

[0073] In Example 6, the subject matter of one or any combination of Examples 1-6 can optionally include that the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are combined using TDM, and numerologies, resource allocation and partition information in a time domain are at least one of predefined or configured by higher-layer signaling via Master

Information Block (MIB), System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling, or the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are combined using FDM, guard bands are inserted at an edge of frequency resources allocated for the plurality of RATs and the at least one of the plurality of sub-RATs and partitions, and at least one of numerologies and resource partition for the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are at least one of predefined or configured by the higher-layer signaling.

[0074] In Example 7, the subject matter of one or any combination of Examples 1-6 can optionally include that a Transmission Time Interval (TTI) boundary between different RATs of the plurality of RATs is common, and the plurality of RATs comprise a common reference TTI duration.

[0075] In Example 8, the subject matter of one or any combination of Examples 1-7 can optionally include that a symbol structure of each of the plurality of RATs comprises a cyclic prefix (CP) or unique word (UW) outside or within a symbol, and the symbol structure of each of the plurality of RATs is independent of the symbol structure of the other RATs. ‘

[0076] In Example 9, the subject matter of one or any combination of Examples 1-8 can optionally include that the processing circuitry is further configured to configure the transceiver to communicate using Orthogonal Frequency-Division Multiplexing (OFDM) for downlink communications and one of Single Carrier Frequency-Division Multiple Access (SC-FDMA) and OFDM for uplink communications, and configure the transceiver to communicate using at least one of UW-OFDM and UW Discrete Fourier transform-Spread-Orthogonal Frequency Division Multiplexing (UW-DFT-s-OFDM).

[0077] In Example 10, the subject matter of one or any combination of Examples 1-9 can optionally include that a frame structure in each of the plurality of RATs comprises a frame comprising L subframes, each subframe comprising N slots, each slot comprising M symbols, and the frame structure of each of the plurality of RATs is independent of the frame structure of the other RATs.

[0078] In Example 11, the subject matter of one or any combination of Examples 1-10 can optionally include that the processing circuitry is further configured to configure the transceiver to receive numerologies, resource allocation and partition information via Master Information Block (MIB) carried by a physical broadcast channel (PBCH), a System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling in a second RAT, the first and second RATs being different.

[0079] In Example 12, the subject matter of one or any combination of Examples 1-11 can optionally include that the processing circuitry is configured to configure the transceiver to receive numerologies, resource allocation and partition information via a dedicated carrier in the first RAT, a dedicated carrier allocated for each of the plurality of RATs, and a dedicated downlink synchronization signal and physical broadcast channel (PBCH) is able to be received on each of the plurality of RATs.

[0080] In Example 13, the subject matter of one or any combination of Examples 1-12 can optionally include an antenna configured to transmit and receive communications between the transceiver and the eNB.

[0081] Example 14 comprises an apparatus of an eNode B (eNB) comprising processing circuitry configured to: configure a transceiver to transmit resource allocations for different Radio Access Technologies (RATs) to a plurality of user equipment (UE), at least two of the UEs associated with a different RAT, each RAT comprising an independent subcarrier spacing, symbol duration, frame structure and symbol structure; and configure the transceiver to communicate with each UE using the RAT associated with the UE.

[0082] In Example 15, the subject matter of Example 14 can optionally include that the processing circuitry is configured to configure the transceiver to transmit higher layer signaling indicating numerologies, resource allocation and partition information via Master Information Block (MIB) carried by a physical broadcast channel (PBCH), a System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling in a same RAT to each of the plurality of UEs.

[0083] In Example 16, the subject matter of one or any combination of Examples 14-15 can optionally include that the processing circuitry is

configured to configure the transceiver to transmit numerologies, resource allocation and partition information via a dedicated carrier allocated for each of the RATs, and a dedicated downlink synchronization signal and physical broadcast channel (PBCH) is able to be received on each of the RATs.

[0084] In Example 17, the subject matter of one or any combination of Examples 14-16 can optionally include that at least one of the subcarrier spacing and symbol duration for each of the RATs is respectively specified as an integer number of a base subcarrier spacing or symbol duration.

[0085] In Example 18, the subject matter of one or any combination of Examples 14-17 can optionally include that the RATs comprise a first RAT comprising a larger subcarrier spacing and shorter symbol duration configured for a UE operating in a low latency mode and a second RAT comprising a smaller subcarrier spacing and longer symbol duration configured for a UE operating in a low energy mode.

[0086] In Example 19, the subject matter of one or any combination of Examples 14-18 can optionally include that a Transmission Time Interval (TTI) boundary between the RATs is common, and the RATs comprise a common reference TTI duration.

[0087] In Example 20, the subject matter of one or any combination of Examples 14-19 can optionally include that a symbol structure of each of the RATs comprises a cyclic prefix (CP) or unique word (UW) outside or within a symbol, and the symbol structure of each of the RATs is independent of the symbol structure of the other RATs.

[0088] In Example 21, the subject matter of one or any combination of Examples 14-20 can optionally include that the processing circuitry is configured to at least one of: configure the transceiver to communicate using Orthogonal Frequency-Division Multiplexing (OFDM) for downlink communications and one of Single Carrier Frequency-Division Multiple Access (SC-FDMA) and OFDM for uplink communications, and configure the transceiver to communicate using at least one of UW-OFDM and UW Discrete Fourier transform-Spread-Orthogonal Frequency Division Multiplexing (UW-DFT-s-OFDM).

[0089] In Example 22 a non-transitory computer-readable storage medium that stores instructions for execution by one or more processors of a user equipment (UE) to configure the UE to communicate with an enhanced Node B (eNB), the one or more processors to configure the UE to: receive resource allocation, partition information and numerology, including subcarrier spacing and symbol duration, for a first Radio Access Technology (RAT) of a plurality of RATs used by the eNB, the UE configurable to configure the subcarrier spacing and symbol duration based on the numerology and to communicate using the plurality of RATs; and communicate using the first RAT.

[0090] In Example 23, the subject matter of Example 22 can optionally include that at least one of: a) at least one of the subcarrier spacing and symbol duration for the RATs is respectively specified as an integer number of a base subcarrier spacing or symbol duration, b) the UE is configured to operate in at least one of a low latency and low energy mode, and the first RAT comprises a larger subcarrier spacing and shorter symbol duration when the UE operates in the low latency mode and comprises a smaller subcarrier spacing and longer symbol duration when the UE operates in the low energy mode, and c) a Transmission Time Interval (TTI) boundary between the RATs is common, and the RATs comprise a common reference TTI duration.

[0091] In Example 24, the subject matter of one or any combination of Examples 22-23 can optionally include that at least one of: a) a symbol structure of each of the RATs comprises a cyclic prefix (CP) or unique word (UW) outside or within a symbol, and the symbol structure of each of the RATs is independent of the symbol structure of the other RATs, and b) a frame structure in each of the RATs comprises a frame comprising L subframes, each subframe comprising N slots, each slot comprising M symbols, and the frame structure of each of the RATs is independent of the frame structure of the other RATs.

[0092] In Example 25, the subject matter of one or any combination of Examples 22-24 can optionally include that the numerology, resource allocation and partition information is received via Master Information Block (MIB) carried by a physical broadcast channel (PBCH), a System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling in a second RAT, the first and second RATs being different.

[0093] Although an embodiment has been described with reference to specific example embodiments, it will be evident that various modifications and changes may be made to these embodiments without departing from the broader spirit and scope of the present disclosure. Accordingly, the specification and drawings are to be regarded in an illustrative rather than a restrictive sense. The accompanying drawings that form a part hereof show, by way of illustration, and not of limitation, specific embodiments in which the subject matter may be practiced. The embodiments illustrated are described in sufficient detail to enable those skilled in the art to practice the teachings disclosed herein. Other embodiments may be utilized and derived therefrom, such that structural and logical substitutions and changes may be made without departing from the scope of this disclosure. This Detailed Description, therefore, is not to be taken in a limiting sense, and the scope of various embodiments is defined only by the appended claims, along with the full range of equivalents to which such claims are entitled.

[0094] Such embodiments of the inventive subject matter may be referred to herein, individually and/or collectively, by the term “invention” merely for convenience and without intending to voluntarily limit the scope of this application to any single invention or inventive concept if more than one is in fact disclosed. Thus, although specific embodiments have been illustrated and described herein, it should be appreciated that any arrangement calculated to achieve the same purpose may be substituted for the specific embodiments shown. This disclosure is intended to cover any and all adaptations or variations of various embodiments. Combinations of the above embodiments, and other embodiments not specifically described herein, will be apparent to those of skill in the art upon reviewing the above description.

[0095] In this document, the terms "a" or "an" are used, as is common in patent documents, to include one or more than one, independent of any other instances or usages of "at least one" or "one or more." In this document, the term "or" is used to refer to a nonexclusive or, such that "A or B" includes "A but not B," "B but not A," and "A and B," unless otherwise indicated. In this document, the terms "including" and "in which" are used as the plain-English equivalents of the respective terms "comprising" and "wherein." Also, in the following claims, the

terms "including" and "comprising" are open-ended, that is, a system, UE, article, composition, formulation, or process that includes elements in addition to those listed after such a term in a claim are still deemed to fall within the scope of that claim. Moreover, in the following claims, the terms "first," "second," and "third," etc. are used merely as labels, and are not intended to impose numerical requirements on their objects.

[0096] The Abstract of the Disclosure is provided to comply with 37 C.F.R. §1.72(b), requiring an abstract that will allow the reader to quickly ascertain the nature of the technical disclosure. It is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims. In addition, in the foregoing Detailed Description, it can be seen that various features are grouped together in a single embodiment for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted as reflecting an intention that the claimed embodiments require more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive subject matter lies in less than all features of a single disclosed embodiment. Thus the following claims are hereby incorporated into the Detailed Description, with each claim standing on its own as a separate embodiment.

CLAIMS

What is claimed is:

1. User equipment (UE) comprising:

processing circuitry configured to:

configure a transceiver to receive a resource allocation from a network using a first Radio Access Technology (RAT), the first RAT selected from a plurality of RATs of a flexible RAT (FRAT) employed by the network, the plurality of RATs of the FRAT each comprising configurable numerology with flexible subcarrier spacing and symbol duration and associated with at least one of different temporal and frequency resources, the transceiver configurable to communicate using the plurality of RATs and configure the subcarrier spacing and symbol duration based on the numerology; and

configure the transceiver to communicate using the first RAT.

2. The UE of claim 1, wherein the processing circuitry is configured to:

configure the transceiver to receive from an enhanced NodeB (eNB) higher layer signaling associated with the FRAT, the higher layer signaling indicating numerologies, resource allocation and partition information in at least one of a time and frequency domain.

3. The UE of claim 1, wherein:

the FRAT comprises a base subcarrier spacing and symbol duration, and

at least one of the subcarrier spacing and symbol duration for different RATs of the FRAT is respectively specified as an integer number of the base subcarrier spacing or symbol duration.

4. The UE of claim 3, wherein:

the UE is a Machine-Type Communication (MTC) UE configured to operate in at least one of a low latency and low energy mode, and

the first RAT comprises a larger subcarrier spacing and shorter symbol duration when the UE operates in the low latency mode and comprises a smaller

subcarrier spacing and longer symbol duration when the UE operates in the low energy mode.

5. The UE of claim 1, wherein:

at least one of the plurality of RATs of the FRAT comprises at least one of a plurality of sub-RATs and partitions, each of the at least one of the plurality of sub-RATs and partitions comprising an independent configurable numerology with flexible subcarrier spacing and symbol duration and associated with at least one of different temporal and frequency resource, and

the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are combined using at least one of a Time-Division Multiplexing (TDM), Frequency-Division Multiplexing (FDM), Code-Division Multiplexing (CDM), and Spatial Division Multiplexing (SDM).

6. The UE of claim 5, wherein one of:

the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are combined using TDM, and numerologies, resource allocation and partition information in a time domain are at least one of predefined or configured by higher-layer signaling via Master Information Block (MIB), System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling, or

the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are combined using FDM, guard bands are inserted at an edge of frequency resources allocated for the plurality of RATs and the at least one of the plurality of sub-RATs and partitions, and at least one of numerologies and resource partition for the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are at least one of predefined or configured by the higher -layer signaling.

7. The UE of claim 1, wherein:

a Transmission Time Interval (TTI) boundary between different RATs of the plurality of RATs is common, and

the plurality of RATs comprise a common reference TTI duration.

8. The UE of claim 1, wherein:

a symbol structure of each of the plurality of RATs comprises a cyclic prefix (CP) or unique word (UW) outside or within a symbol, and

the symbol structure of each of the plurality of RATs is independent of the symbol structure of the other RATs.

9. The UE of claim 1, wherein the processing circuitry is configured to at least one of:

configure the transceiver to communicate using Orthogonal Frequency-Division Multiplexing (OFDM) for downlink communications and one of Single Carrier Frequency-Division Multiple Access (SC-FDMA) and OFDM for uplink communications, and

configure the transceiver to communicate using at least one of UW-OFDM and UW Discrete Fourier transform-Spread-Orthogonal Frequency Division Multiplexing (UW-DFT-s-OFDM).

10. The UE of claim 1, wherein:

a frame structure in each of the plurality of RATs comprises a frame comprising L subframes, each subframe comprising N slots, each slot comprising M symbols, and

the frame structure of each of the plurality of RATs is independent of the frame structure of the other RATs.

11. The UE of claim 1, wherein the processing circuitry is configured to:

configure the transceiver to receive numerologies, resource allocation and partition information via Master Information Block (MIB) carried by a physical broadcast channel (PBCH), a System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling in a second RAT, the first and second RATs being different.

12. The UE of claim 1, wherein:

the processing circuitry is configured to configure the transceiver to receive numerologies, resource allocation and partition information via a dedicated carrier in the first RAT, a dedicated carrier allocated for each of the plurality of RATs, and

a dedicated downlink synchronization signal and physical broadcast channel (PBCH) is able to be received on each of the plurality of RATs.

13. The UE of claim 1, further comprising an antenna configured to transmit and receive communications between the transceiver and the eNB.

14. An apparatus of an eNode B (eNB) comprising:

processing circuitry configured to:

configure a transceiver to transmit resource allocations for different Radio Access Technologies (RATs) to a plurality of user equipment (UE), at least two of the UEs associated with a different RAT, each RAT comprising an independent subcarrier spacing, symbol duration, frame structure and symbol structure; and

configure the transceiver to communicate with each UE using the RAT associated with the UE.

15. The apparatus of claim 14, wherein the processing circuitry is configured to:

configure the transceiver to transmit higher layer signaling indicating numerologies, resource allocation and partition information via Master Information Block (MIB) carried by a physical broadcast channel (PBCH), a System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling in a same RAT to each of the plurality of UEs.

16. The apparatus of claim 14, wherein the processing circuitry is configured to:

configure the transceiver to transmit numerologies, resource allocation and partition information via a dedicated carrier allocated for each of the RATs, and

a dedicated downlink synchronization signal and physical broadcast channel (PBCH) is able to be received on each of the RATs.

17. The apparatus of claim 14, wherein:

at least one of the subcarrier spacing and symbol duration for each of the RATs is respectively specified as an integer number of a base subcarrier spacing or symbol duration.

18. The apparatus of claim 14, wherein:

the RATs comprise a first RAT comprising a larger subcarrier spacing and shorter symbol duration configured for a UE operating in a low latency mode and a second RAT comprising a smaller subcarrier spacing and longer symbol duration configured for a UE operating in a low energy mode.

19. The apparatus of claim 14, wherein:

a Transmission Time Interval (TTI) boundary between the RATs is common, and

the RATs comprise a common reference TTI duration.

20. The apparatus of claim 14, wherein:

a symbol structure of each of the RATs comprises a cyclic prefix (CP) or unique word (UW) outside or within a symbol, and

the symbol structure of each of the RATs is independent of the symbol structure of the other RATs.

21. The apparatus of claim 14, wherein the processing circuitry is configured to at least one of:

configure the transceiver to communicate using Orthogonal Frequency-Division Multiplexing (OFDM) for downlink communications and one of Single Carrier Frequency-Division Multiple Access (SC-FDMA) and OFDM for uplink communications, and

configure the transceiver to communicate using at least one of UW-OFDM and UW Discrete Fourier transform-Spread-Orthogonal Frequency Division Multiplexing (UW-DFT-s-OFDM).

22. A non-transitory computer-readable storage medium that stores instructions for execution by one or more processors of a user equipment (UE) to configure the UE to communicate with an enhanced Node B (eNB), the one or more processors to configure the UE to:

receive resource allocation, partition information and numerology, including subcarrier spacing and symbol duration, for a first Radio Access Technology (RAT) of a plurality of RATs used by the eNB, the UE configurable to configure the subcarrier spacing and symbol duration based on the numerology and to communicate using the plurality of RATs; and

communicate using the first RAT.

23. The medium of claim 22, wherein at least one of:

a) at least one of the subcarrier spacing and symbol duration for the RATs is respectively specified as an integer number of a base subcarrier spacing or symbol duration,

b) the UE is configured to operate in at least one of a low latency and low energy mode, and

the first RAT comprises a larger subcarrier spacing and shorter symbol duration when the UE operates in the low latency mode and comprises a smaller subcarrier spacing and longer symbol duration when the UE operates in the low energy mode, and

c) a Transmission Time Interval (TTI) boundary between the RATs is common, and

the RATs comprise a common reference TTI duration.

24. The medium of claim 22, wherein at least one of:

a) a symbol structure of each of the RATs comprises a cyclic prefix (CP) or unique word (UW) outside or within a symbol, and

the symbol structure of each of the RATs is independent of the symbol structure of the other RATs, and

b) a frame structure in each of the RATs comprises a frame comprising L subframes, each subframe comprising N slots, each slot comprising M symbols, and

the frame structure of each of the RATs is independent of the frame structure of the other RATs.

25. The medium of claim 22, wherein:

the numerology, resource allocation and partition information is received via Master Information Block (MIB) carried by a physical broadcast channel (PBCH), a System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling in a second RAT, the first and second RATs being different.

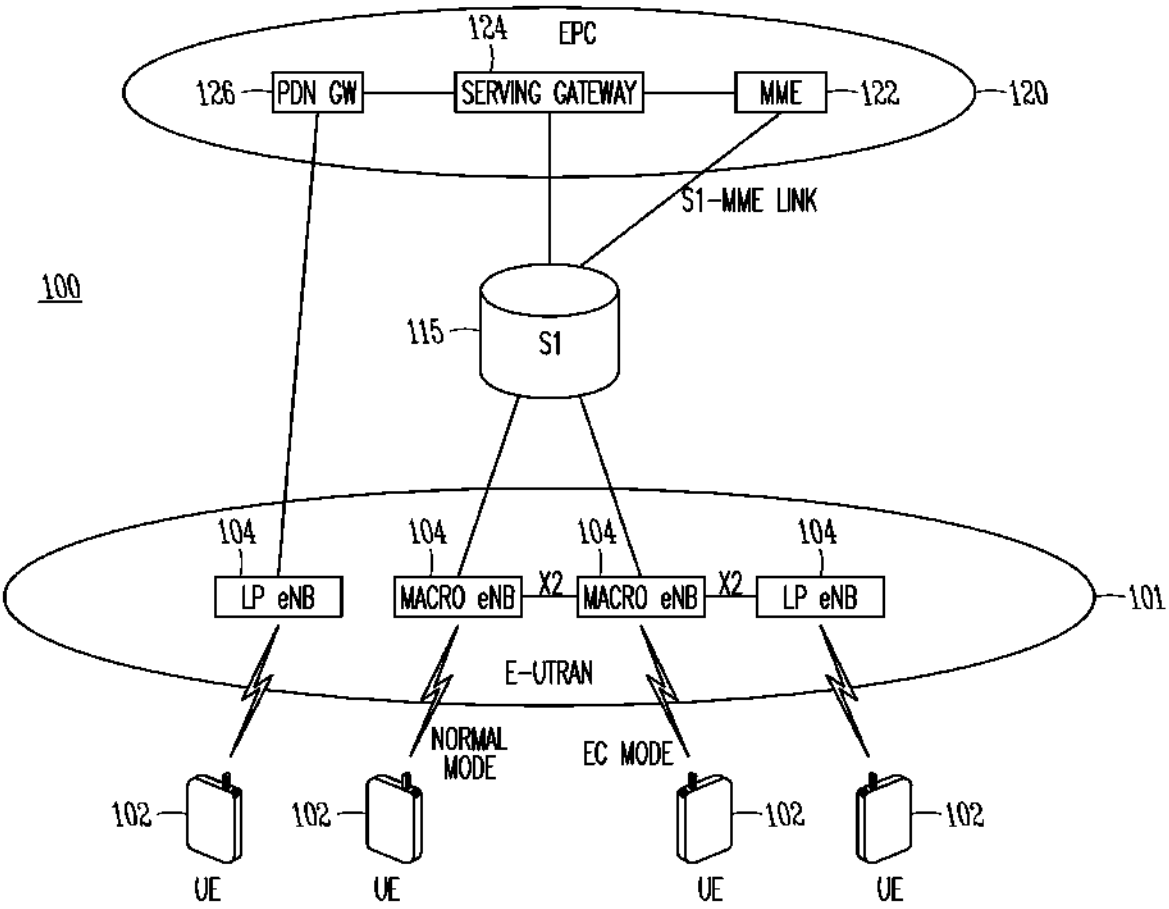

124
EPC
126
PDN GW
SERVING GATEWAY
MME
122
120
S1-MME LINK
100
115
S1
104
104
104
104
LP eNB
MACRO eNB
X2
MACRO eNB
X2
LP eNB
101
E-UTRAN
NORMAL MODE
EC MODE
102
102
102
102
UE
UE
UE
UE

FIG. 1

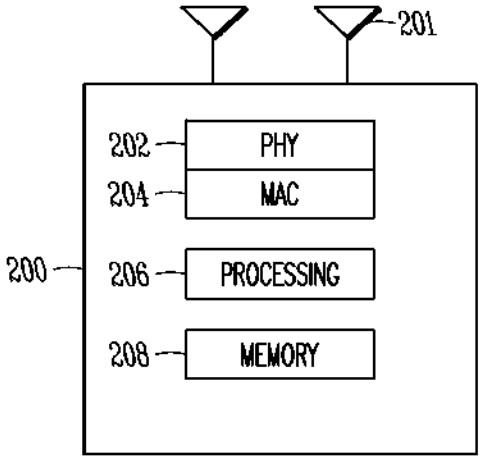


FIG. 2

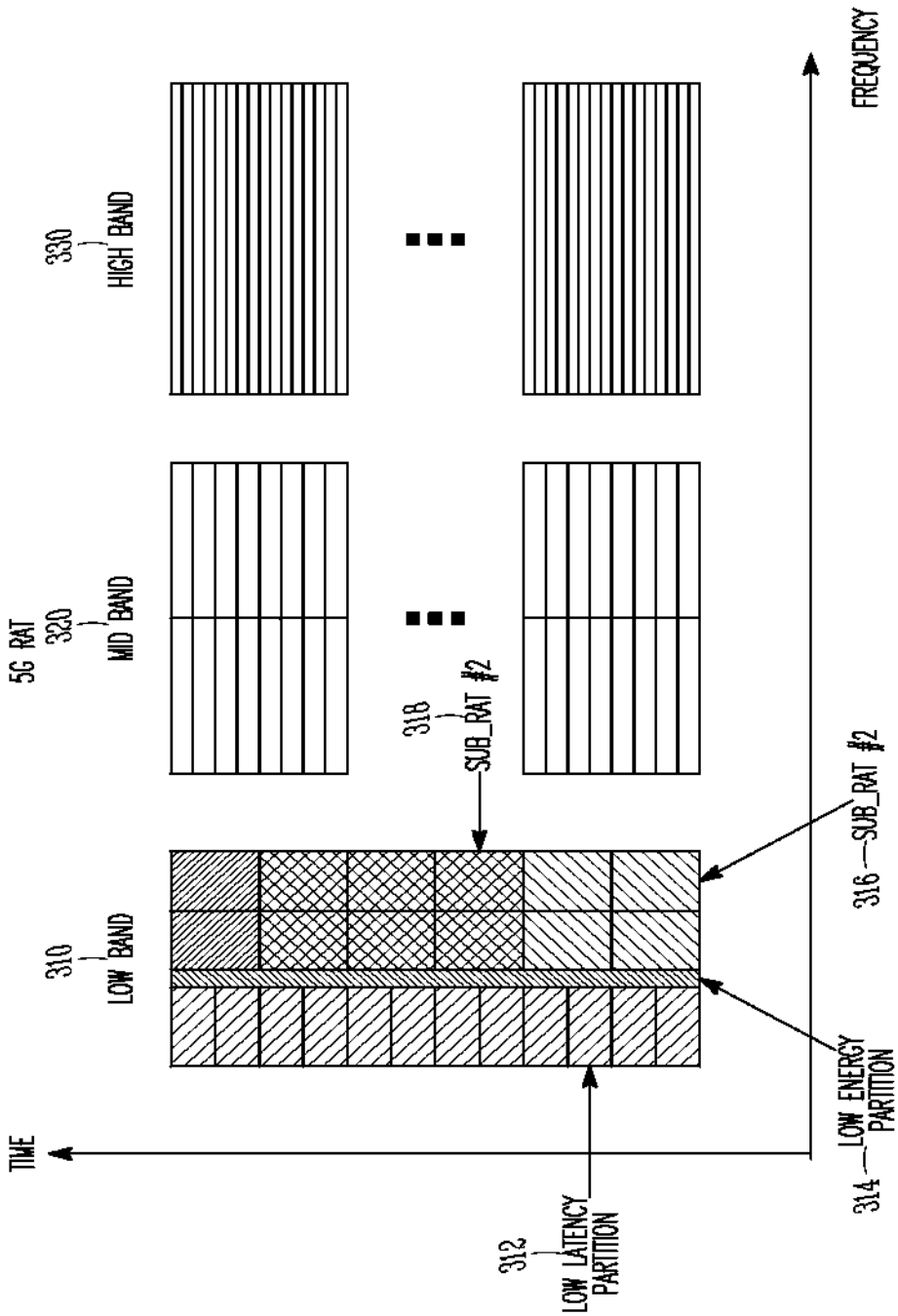

FREQUENCY
330
HIGH BAND
5G RAT
320
MID BAND
318
SUB_RAT #2
310
LOW BAND
316
SUB_RAT #2
TIME
314
LOW ENERGY PARTITION
312
LOW LATENCY PARTITION

FIG. 3

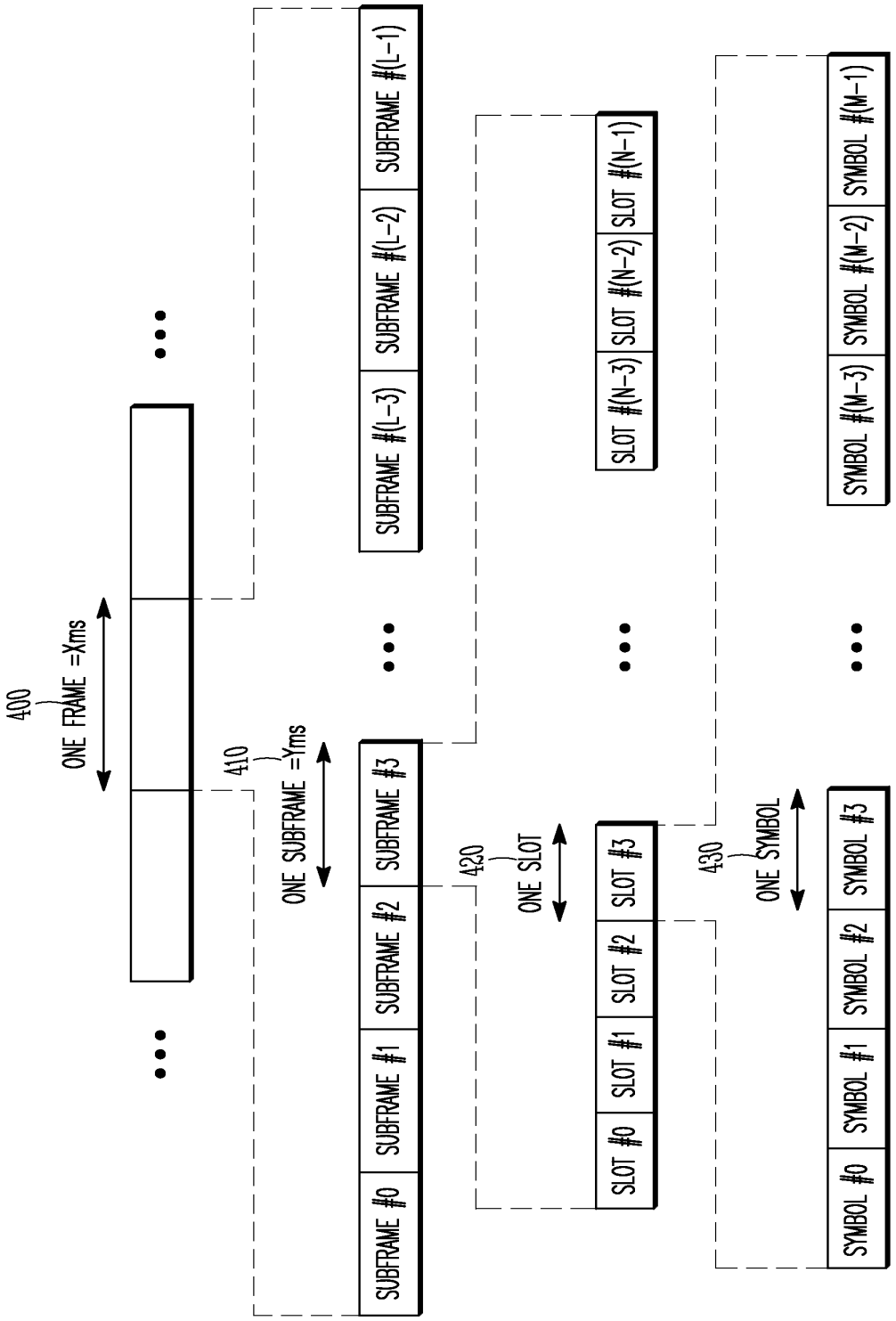

400
ONE FRAME =Xms
410
ONE SUBFRAME =Yms
SUBFRAME #0
SUBFRAME #1
SUBFRAME #2
SUBFRAME #3
SUBFRAME #(L-3)
SUBFRAME #(L-2)
SUBFRAME #(L-1)
420
ONE SLOT
SLOT #0
SLOT #1
SLOT #2
SLOT #3
SLOT #(N-3)
SLOT #(N-2)
SLOT #(N-1)
430
ONE SYMBOL
SYMBOL #0
SYMBOL #1
SYMBOL #2
SYMBOL #3
SYMBOL #(M-3)
SYMBOL #(M-2)
SYMBOL #(M-1)

FIG. 4

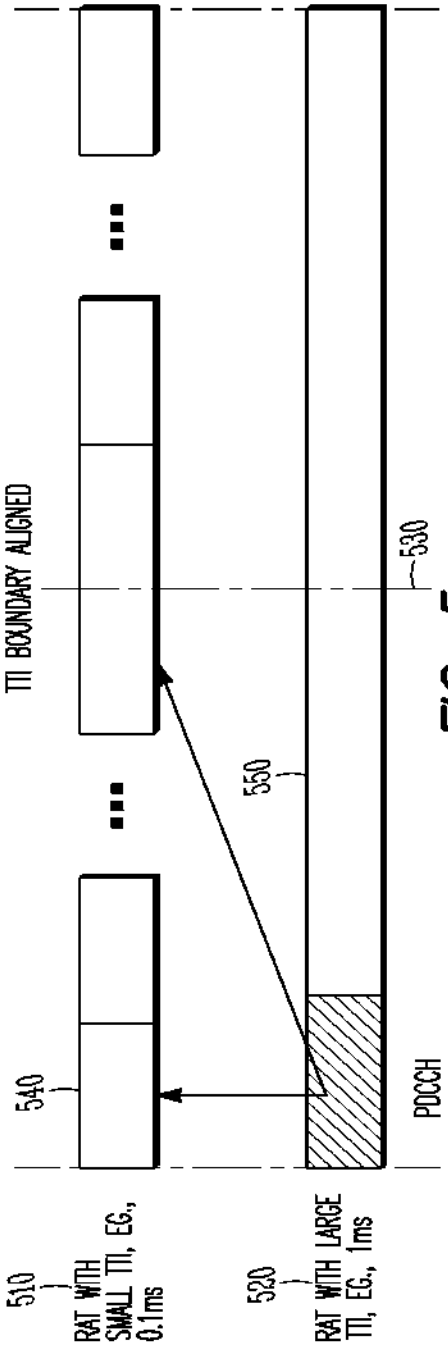

TTI BOUNDARY ALIGNED
530
550
540
PDCCH
510
RAT WITH SMALL TTI, EG., 0.1ms
520
RAT WITH LARGE TTI, EG., 1ms

FIG. 5

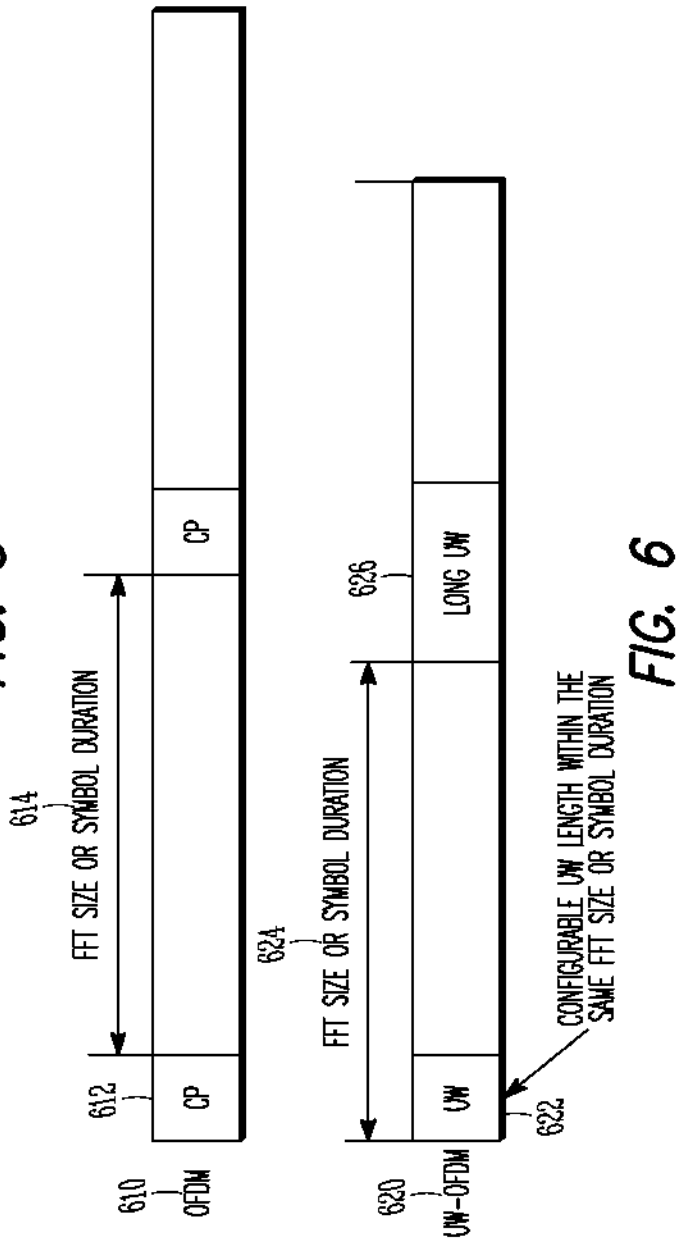

614
FFT SIZE OR SYMBOL DURATION
CP
612
610
OFDM
624
FFT SIZE OR SYMBOL DURATION
626
LONG UW
UW
622
620
UW-OFDM
CONFIGURABLE UW LENGTH WITHIN THE SAME FFT SIZE OR SYMBOL DURATION

FIG. 6

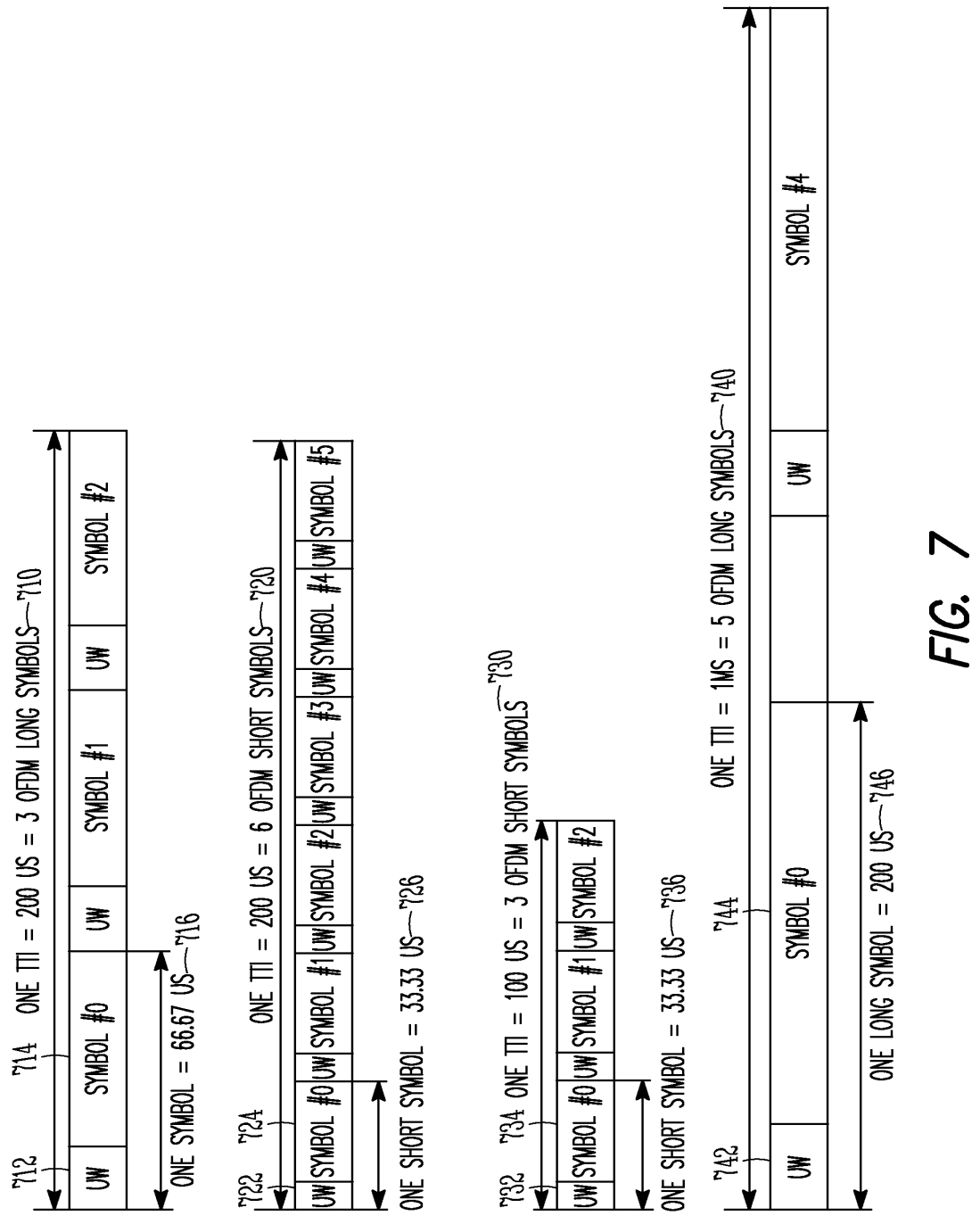

712
714
ONE TTI = 200 US = 3 OFDM LONG SYMBOLS
710
UW
SYMBOL #0
UW
SYMBOL #1
UW
SYMBOL #2
ONE SYMBOL = 66.67 US
716
722
724
ONE TTI = 200 US = 6 OFDM SHORT SYMBOLS
720
UW
SYMBOL #0
UW
SYMBOL #1
UW
SYMBOL #2
UW
SYMBOL #3
UW
SYMBOL #4
UW
SYMBOL #5
ONE SHORT SYMBOL = 33.33 US
726
732
734
ONE TTI = 100 US = 3 OFDM SHORT SYMBOLS
730
UW
SYMBOL #0
UW
SYMBOL #1
UW
SYMBOL #2
ONE SHORT SYMBOL = 33.33 US
736
742
744
ONE TTI = 1MS = 5 OFDM LONG SYMBOLS
740
UW
SYMBOL #0
UW
SYMBOL #4
ONE LONG SYMBOL = 200 US
746

FIG. 7

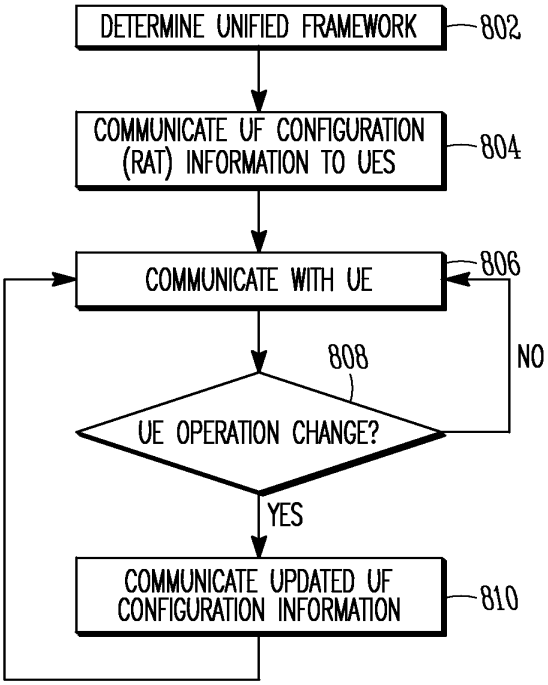

DETERMINE UNIFIED FRAMEWORK
802
COMMUNICATE UF CONFIGURATION (RAT) INFORMATION TO UES
804
COMMUNICATE WITH UE
806
808
UE OPERATION CHANGE?
NO
YES
COMMUNICATE UPDATED UF CONFIGURATION INFORMATION
810

FIG. 8A

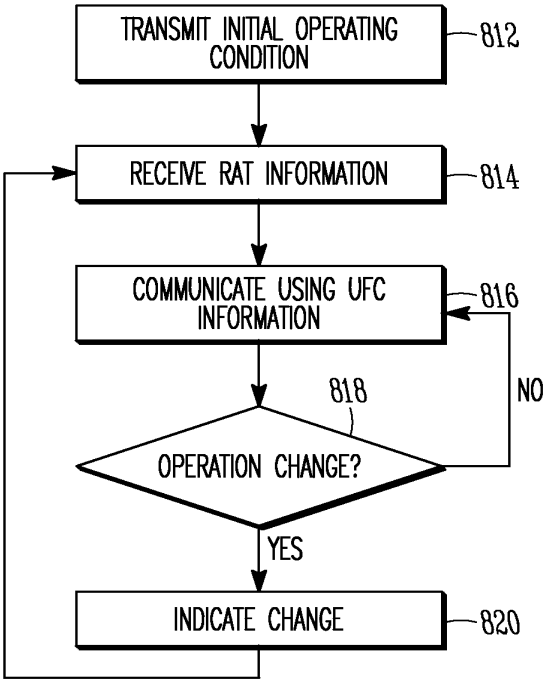

TRANSMIT INITIAL OPERATING CONDITION
812
RECEIVE RAT INFORMATION
814
COMMUNICATE USING UFC INFORMATION
816
818
OPERATION CHANGE?
NO
YES
INDICATE CHANGE
820

FIG. 8B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/044628

A. CLASSIFICATION OF SUBJECT MATTER

H04W 72/04(2009.01)i, H04W 92/10(2009.01)i, H04W 88/06(2009.01)i, H04W 88/08(2009.01)i, H04B 7/26(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W 72/04; H04L 5/00; H04Q 7/00; H04W 88/06; H04L 27/26; H04W 92/10; H04W 88/08; H04B 7/26

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: radio access technology (RAT), FRAT (flexible RAT), flexible subcarrier spacing and symbol duration, numerology, MTC, low latency, low energy, sub-RAT, partition, combination, TTI, unique word (UW), UW-OFDM, UW-DFT-s-OFDM, synchronization, broadcast

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2008-0130570 A1 (YOUNG-HO JUNG et al.) 5 June 2008 See paragraphs [0011], [0033]-[0045]; claims 1, 7; and figures 3-5.	1-25
Y	EEVA LAHETKANGAS et al., 'On the Flexible 5G Dense Deployment Air Interface for Mobile Broadband', In: 5G for Ubiquitous Connectivity (5GU), 2014 1st International Conference on, Page(s): 57-61, 26-28 November 2014 See pages 1-3; and figures 1, 4.	1-25
Y	US 2015-0029990 A1 (INTERDIGITAL PATENT HOLDINGS, INC.) 29 January 2015 See paragraphs [0066]-[0082]; and figure 1.	7,19
Y	US 2014-0140194 A1 (STEFAN FECHTEL) 22 May 2014 See paragraph [0024]; and figures 2A, 2B.	8,9,20,21
A	WO 2014-139562 A1 (NOKIA SOLUTIONS AND NETWORKS OY) 18 September 2014 See page 11, lines 19-32; claims 1, 8, 12; and figures 4, 5.	1-25

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 December 2015 (18.12.2015)	**21 December 2015 (21.12.2015)**

Name and mailing address of the ISA/KR
International Application Division
Korean Intellectual Property Office
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Telephone No. +82-42-481-8264

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2015/044628

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2008-0130570 A1	05/06/2008	KR 10-0969751 B1	13/07/2010
		KR 10-2008-0048293 A	02/06/2008
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US 2015-0029990 A1	29/01/2015	TW 201246857 A	16/11/2012
		US 2012-0230268 A1	13/09/2012
		US 8861461 B2	14/10/2014
		WO 2012-122170 A1	13/09/2012
US 2014-0140194 A1	22/05/2014	TW 201434298 A	01/09/2014
		WO 2014-079712 A1	30/05/2014
WO 2014-139562 A1	18/09/2014	None	

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(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
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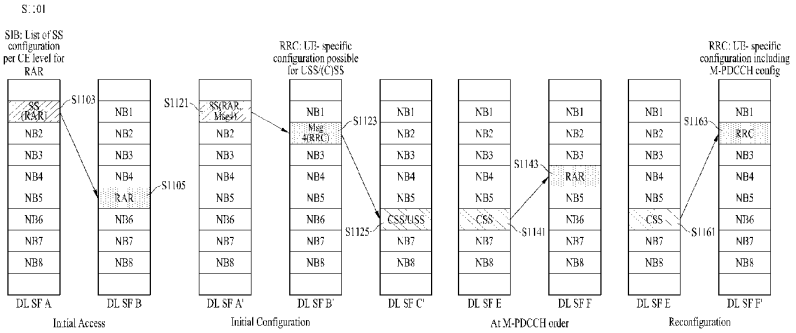
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(54) **Title**: METHOD AND USER EQUIPMENT FOR RECEIVING DOWNLINK CONTROL INFORMATION, AND METHOD AND BASE STATION FOR TRANSMITTING DOWNLINK CONTROL INFORMATION



(57) **Abstract**: A search space (hereinafter, CSS) for a control channel for scheduling a random access response may be configured by a system information block. A user equipment (UE) may attempt to receive a control channel for a random access response on the assumption that CSS is configured in accordance with a configuration based on the system information block. The UE may attempt to receive the control channel within a UE-specific search space (USS) by assuming that the USS is configured in accordance with the configuration of the CSS until a configuration for the USS is received.

Description

Title of Invention: METHOD AND USER EQUIPMENT FOR RECEIVING DOWNLINK CONTROL INFORMATION, AND METHOD AND BASE STATION FOR TRANSMITTING DOWNLINK CONTROL INFORMATION

Technical Field

[1] The present invention relates to a wireless communication system, and more particularly, to a method for transmitting or receiving downlink control information and a device therefor.

Background Art

[2] With appearance and spread of machine-to-machine (M2M) communication and a variety of devices such as smartphones and tablet PCs and technology demanding a large amount of data transmission, data throughput needed in a cellular network has rapidly increased. To satisfy such rapidly increasing data throughput, carrier aggregation technology, cognitive radio technology, etc. for efficiently employing more frequency bands and multiple input multiple output (MIMO) technology, multi-base station (BS) cooperation technology, etc. for raising data capacity transmitted on limited frequency resources have been developed.

[3] A general wireless communication system performs data transmission/reception through one downlink (DL) band and through one uplink (UL) band corresponding to the DL band (in case of a frequency division duplex (FDD) mode), or divides a prescribed radio frame into a UL time unit and a DL time unit in the time domain and then performs data transmission/reception through the UL/DL time unit (in case of a time division duplex (TDD) mode). A base station (BS) and a user equipment (UE) transmit and receive data and/or control information scheduled on a prescribed time unit basis, e.g. on a subframe basis. The data is transmitted and received through a data region configured in a UL/DL subframe and the control information is transmitted and received through a control region configured in the UL/DL subframe. To this end, various physical channels carrying radio signals are formed in the UL/DL subframe. In contrast, carrier aggregation technology serves to use a wider UL/DL bandwidth by aggregating a plurality of UL/DL frequency blocks in order to use a broader frequency band so that more signals relative to signals when a single carrier is used can be simultaneously processed.

[4] In addition, a communication environment has evolved into increasing density of nodes accessible by a user at the periphery of the nodes. A node refers to a fixed point

capable of transmitting/receiving a radio signal to/from the UE through one or more antennas. A communication system including high-density nodes may provide a better communication service to the UE through cooperation between the nodes.

Disclosure of Invention

Technical Problem

[5] Due to introduction of new radio communication technology, the number of user equipments (UEs) to which a BS should provide a service in a prescribed resource region increases and the amount of data and control information that the BS should transmit to the UEs increases. Since the amount of resources available to the BS for communication with the UE(s) is limited, a new method in which the BS efficiently receives/transmits uplink/downlink data and/or uplink/downlink control information using the limited radio resources is needed.

[6] The technical objects that can be achieved through the present invention are not limited to what has been particularly described hereinabove and other technical objects not described herein will be more clearly understood by persons skilled in the art from the following detailed description.

Solution to Problem

[7] A search space (hereinafter, CSS_RAR) for a control channel for scheduling a random access response may be configured by a system information block. A user equipment (UE) may attempt to receive a control channel for a random access response by assuming that CSS_RAR is configured in accordance with a configuration based on the system information block. If the UE receives the control channel for a random access response, the UE may receive the random access response to a random access preamble transmitted therefrom in accordance with control information carried by the control channel. The UE may attempt to receive a control channel within a UE-specific search space (hereinafter, USS) by assuming that the USS is configured in accordance with the configuration of the CSS until a configuration for the USS is received.

[8] In an aspect of the present invention, provided herein is a method for receiving, by a user equipment (UE), downlink control information (DCI) for the UE. The method comprises: receiving, by the UE, a common search space configuration for a common search space; receiving, by the UE, a first physical downlink control channel (PDCCH) scheduling a random access response; and receiving, by the UE, a second PDCCH carrying the DCI for the UE. The UE can monitor first PDCCH candidates of the common search space according to the common search space configuration in order to receive the first PDCCH. The UE can monitor second PDCCH candidates of a UE-specific search space in order to receive the second PDCCH. The UE can assume that configuration of the UE-specific search space is the same as that of the common search

space until the UE receives a UE-specific search space configuration.

[9] In another aspect of the present invention, provided herein is a method for transmitting, by a base station (BS), downlink control information (DCI) for a user equipment (UE). The method comprises: transmitting, by the BS, common search space configuration for a common search space; transmitting, by the BS to the UE, a first physical downlink control channel (PDCCH) scheduling a random access response; and transmitting, by the BS to the UE, a second PDCCH carrying the DCI for the UE. The BS can transmit the first PDCCH by using one of first PDCCH candidates of the common search space according to the common search space configuration. The BS can transmit the second PDCCH by using one of second PDCCH candidates of a UE-specific search space. The BS can configure the UE-specific search space according to the same configuration as the common search space configuration until the BS transmits a UE-specific search space configuration to the UE.

[10] In still another aspect of the present invention, provided herein a user equipment (UE) for receiving downlink control information (DCI) for the UE. The UE comprises a radio frequency (RF) unit and a processor connected to the RF unit. The processor can be configured to control the RF unit to receive common search space configuration for a common search space; control the RF unit to receive a first physical downlink control channel (PDCCH) scheduling a random access response; and control the RF unit to receive a second PDCCH carrying the DCI for the UE. The processor can be configured to monitor first PDCCH candidates of the common search space according to the common search space configuration in order to detect the firs PDCCH. The processor can be configured to monitor second PDCCH candidates of a UE-specific search space in order to detect the second PDCCH. The processor can be configured to assume that configuration of the UE-specific search space is the same as that of the common search space until the UE receives a UE-specific search space configuration.

[11] In a further aspect of the present invention, provided herein a base station (BS) for transmitting downlink control information (DCI) for a user equipment (UE). The BS comprises a radio frequency (RF) unit and a processor connected to the RF unit. The processor can be configured to control the RF unit to transmit common search space configuration for a common search space; control the RF unit to transmit a first physical downlink control channel (PDCCH) scheduling a random access response; and control the RF unit to transmit a second PDCCH carrying the DCI for the UE. The processor can be configured to control the RF unit to transmit the first PDCCH using one of first PDCCH candidates of the common search space according to the common search space configuration. The processor can be configured to control the RF unit to transmit the second PDCCH using one of second PDCCH candidates of a UE-specific search space. The processor can configure the UE-specific search space according to

the same as that of the common search space until the BS transmits a UE-specific search space configuration.

[12] In each aspect of the present invention, the common search space configuration can include information on a narrowband for the common search space. The second PDCCH candidates of the UE-specific search space can be configured on the same narrowband as the narrowband for the common search space until the UE-specific search space configuration is transmitted to the UE.

[13] In each aspect of the present invention, the common search space configuration can include information on a maximum number of repetitions for the first common search space. The second PDCCH candidates of the UE-specific search space can be configured based on the same number as the maximum number of repetitions for the common search space until the UE-specific search space configuration is transmitted to the UE.

[14] In each aspect of the present invention, the common search space configuration can include information on a first physical resource block (PRB) set for transmitting the first PDCCH. The same physical resource block set as the first PRB set can be used for the second PDCCH candidates until the UE-specific search space configuration is transmitted to the UE

[15] In each aspect of the present invention, the first PDCCH candidates of the common search space can be configured according to aggregation levels larger than or equal to 8 among a plurality of aggregation levels, whereas the second PDCCH candidates of the UE-specific search space can be configured according to the plurality of aggregation levels.

[16] In each aspect of the present invention, the UE can transmit a random access preamble using a physical random access channel (PRACH) resource. The UE can monitor the first PDCCH candidates in response to transmission of the random access preamble. The UE can receive the random access response according to control information carried by the first PDCCH. The BS can receive a random access preamble using a physical random access channel (PRACH) resource. The BS can transmit the first PDCCH in response to reception of the random access preamble. The BS can transmit the random access response according to control information carried by the first PDCCH.

[17] The above technical solutions are merely some parts of the embodiments of the present invention and various embodiments into which the technical features of the present invention are incorporated can be derived and understood by persons skilled in the art from the following detailed description of the present invention.

Advantageous Effects of Invention

[18] According to the present invention, uplink/downlink signals can be efficiently transmitted/received. Therefore, overall throughput of a radio communication system can be improved.

[19] According to one embodiment of the present invention, a low cost/complexity UE can perform communication with a BS at low cost while maintaining compatibility with a legacy system.

[20] According to one embodiment of the present invention, the UE can be implemented at low cost/complexity.

[21] According to one embodiment of the present invention, coverage can be enhanced.

[22] According to one embodiment of the present invention, the UE and the BS can perform communication with each other at a narrowband.

[23] It will be appreciated by persons skilled in the art that that the effects that can be achieved through the present invention are not limited to what has been particularly described hereinabove and other advantages of the present invention will be more clearly understood from the following detailed description.

Brief Description of Drawings

[24] The accompanying drawings, which are included to provide a further understanding of the invention, illustrate embodiments of the invention and together with the description serve to explain the principle of the invention.

[25] FIG. 1 illustrates the structure of a radio frame used in a wireless communication system.

[26] FIG. 2 illustrates the structure of a downlink (DL)/uplink (UL) slot in a wireless communication system.

[27] FIG. 3 illustrates a radio frame structure for transmission of a synchronization signal (SS).

[28] FIG. 4 illustrates the structure of a DL subframe used in a wireless communication system.

[29] FIG. 5 illustrates the structure of a UL subframe used in a wireless communication system.

[30] FIG. 6 illustrates an example of a signal band for MTC.

[31] FIG. 7 illustrates repeated transmission of a channel for coverage enhancement.

[32] FIG. 8 illustrates a configuration of a common search space (CSS) for paging according to the present invention.

[33] FIG. 9 illustrates a configuration of a common search space (CSS) for random access response (RAR) according to the present invention.

[34] FIG. 10 illustrates the example of the monitoring time region of USS and CSS.

[35] FIG. 11 illustrates a procedure of configuring a search space according to the present

invention.

[36] FIG. 12 illustrates a configuration of M-PDCCH repeated transmission according to the present invention.

[37] FIG. 13 is a block diagram illustrating elements of a transmitting device 10 and a receiving device 20 for implementing the present invention.

Mode for the Invention

[38] Reference will now be made in detail to the exemplary embodiments of the present invention, examples of which are illustrated in the accompanying drawings. The detailed description, which will be given below with reference to the accompanying drawings, is intended to explain exemplary embodiments of the present invention, rather than to show the only embodiments that can be implemented according to the invention. The following detailed description includes specific details in order to provide a thorough understanding of the present invention. However, it will be apparent to those skilled in the art that the present invention may be practiced without such specific details.

[39] In some instances, known structures and devices are omitted or are shown in block diagram form, focusing on important features of the structures and devices, so as not to obscure the concept of the present invention. The same reference numbers will be used throughout this specification to refer to the same or like parts.

[40] The following techniques, apparatuses, and systems may be applied to a variety of wireless multiple access systems. Examples of the multiple access systems include a code division multiple access (CDMA) system, a frequency division multiple access (FDMA) system, a time division multiple access (TDMA) system, an orthogonal frequency division multiple access (OFDMA) system, a single carrier frequency division multiple access (SC-FDMA) system, and a multicarrier frequency division multiple access (MC-FDMA) system. CDMA may be embodied through radio technology such as universal terrestrial radio access (UTRA) or CDMA2000. TDMA may be embodied through radio technology such as global system for mobile communications (GSM), general packet radio service (GPRS), or enhanced data rates for GSM evolution (EDGE). OFDMA may be embodied through radio technology such as institute of electrical and electronics engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20, or evolved UTRA (E-UTRA). UTRA is a part of a universal mobile telecommunications system (UMTS). 3rd generation partnership project (3GPP) long term evolution (LTE) is a part of evolved UMTS (E-UMTS) using E-UTRA. 3GPP LTE employs OFDMA in DL and SC-FDMA in UL. LTE-advanced (LTE-A) is an evolved version of 3GPP LTE. For convenience of description, it is assumed that the present invention is applied to 3GPP LTE/LTE-A. However, the

technical features of the present invention are not limited thereto. For example, although the following detailed description is given based on a mobile communication system corresponding to a 3GPP LTE/LTE-A system, aspects of the present invention that are not specific to 3GPP LTE/LTE-A are applicable to other mobile communication systems.

[41] For example, the present invention is applicable to contention based communication such as Wi-Fi as well as non-contention based communication as in the 3GPP LTE/LTE-A system in which an eNB allocates a DL/UL time/frequency resource to a UE and the UE receives a DL signal and transmits a UL signal according to resource allocation of the eNB. In a non-contention based communication scheme, an access point (AP) or a control node for controlling the AP allocates a resource for communication between the UE and the AP, whereas, in a contention based communication scheme, a communication resource is occupied through contention between UEs which desire to access the AP. The contention based communication scheme will now be described in brief. One type of the contention based communication scheme is carrier sense multiple access (CSMA). CSMA refers to a probabilistic media access control (MAC) protocol for confirming, before a node or a communication device transmits traffic on a shared transmission medium (also called a shared channel) such as a frequency band, that there is no other traffic on the same shared transmission medium. In CSMA, a transmitting device determines whether another transmission is being performed before attempting to transmit traffic to a receiving device. In other words, the transmitting device attempts to detect presence of a carrier from another transmitting device before attempting to perform transmission. Upon sensing the carrier, the transmitting device waits for another transmission device which is performing transmission to finish transmission, before performing transmission thereof. Consequently, CSMA can be a communication scheme based on the principle of "sense before transmit" or "listen before talk". A scheme for avoiding collision between transmitting devices in the contention based communication system using CSMA includes carrier sense multiple access with collision detection (CSMA/CD) and/or carrier sense multiple access with collision avoidance (CSMA/CA). CSMA/CD is a collision detection scheme in a wired local area network (LAN) environment. In CSMA/CD, a personal computer (PC) or a server which desires to perform communication in an Ethernet environment first confirms whether communication occurs on a network and, if another device carries data on the network, the PC or the server waits and then transmits data. That is, when two or more users (e.g. PCs, UEs, etc.) simultaneously transmit data, collision occurs between simultaneous transmission and CSMA/CD is a scheme for flexibly transmitting data by monitoring collision. A transmitting device using CSMA/CD adjusts data transmission thereof by sensing data transmission performed by another

device using a specific rule. CSMA/CA is a MAC protocol specified in IEEE 802.11 standards. A wireless LAN (WLAN) system conforming to IEEE 802.11 standards does not use CSMA/CD which has been used in IEEE 802.3 standards and uses CA, i.e. a collision avoidance scheme. Transmission devices always sense carrier of a network and, if the network is empty, the transmission devices wait for determined time according to locations thereof registered in a list and then transmit data. Various methods are used to determine priority of the transmission devices in the list and to re-configure priority. In a system according to some versions of IEEE 802.11 standards, collision may occur and, in this case, a collision sensing procedure is performed. A transmission device using CSMA/CA avoids collision between data transmission thereof and data transmission of another transmission device using a specific rule.

[42] In the present invention, a user equipment (UE) may be a fixed or mobile device. Examples of the UE include various devices that transmit and receive user data and/or various kinds of control information to and from a base station (BS). The UE may be referred to as a terminal equipment (TE), a mobile station (MS), a mobile terminal (MT), a user terminal (UT), a subscriber station (SS), a wireless device, a personal digital assistant (PDA), a wireless modem, a handheld device, etc. In addition, in the present invention, a BS generally refers to a fixed station that performs communication with a UE and/or another BS, and exchanges various kinds of data and control information with the UE and another BS. The BS may be referred to as an advanced base station (ABS), a node-B (NB), an evolved node-B (eNB), a base transceiver system (BTS), an access point (AP), a processing server (PS), etc. In describing the present invention, a BS will be referred to as an eNB.

[43] In the present invention, a node refers to a fixed point capable of transmitting/receiving a radio signal through communication with a UE. Various types of eNBs may be used as nodes irrespective of the terms thereof. For example, a BS, a node B (NB), an e-node B (eNB), a pico-cell eNB (PeNB), a home eNB (HeNB), a relay, a repeater, etc. may be a node. In addition, the node may not be an eNB. For example, the node may be a radio remote head (RRH) or a radio remote unit (RRU). The RRH or RRU generally has a lower power level than a power level of an eNB. Since the RRH or RRU (hereinafter, RRH/RRU) is generally connected to the eNB through a dedicated line such as an optical cable, cooperative communication between RRH/RRU and the eNB can be smoothly performed in comparison with cooperative communication between eNBs connected by a radio line. At least one antenna is installed per node. The antenna may mean a physical antenna or mean an antenna port, a virtual antennIn the present invention, a cell refers to a prescribed geographical area to which one or more nodes provide a communication service. Accordingly, in the present invention, communicating with a specific cell may mean communicating with an eNB

or a node which provides a communication service to the specific cell. In addition, a DL/UL signal of a specific cell refers to a DL/UL signal from/to an eNB or a node which provides a communication service to the specific cell. A node providing UL/DL communication services to a UE is called a serving node and a cell to which UL/DL communication services are provided by the serving node is especially called a serving cell. Furthermore, channel status/quality of a specific cell refers to channel status/ quality of a channel or communication link formed between an eNB or node which provides a communication service to the specific cell and a UE. The UE may measure DL channel state received from a specific node using cell-specific reference signal(s) (CRS(s)) transmitted on a CRS resource and/or channel state information reference signal(s) (CSI-RS(s)) transmitted on a CSI-RS resource, allocated by antenna port(s) of the specific node to the specific node. Detailed CSI-RS configuration may be understood with reference to 3GPP TS 36.211 and 3GPP TS 36.331 documents.

[44] Meanwhile, a 3GPP LTE/LTE-A system uses the concept of a cell in order to manage radio resources and a cell associated with the radio resources is distinguished from a cell of a geographic region.

[45] A "cell" of a geographic region may be understood as coverage within which a node can provide service using a carrier and a "cell" of a radio resource is associated with bandwidth (BW) which is a frequency range configured by the carrier. Since DL coverage, which is a range within which the node is capable of transmitting a valid signal, and UL coverage, which is a range within which the node is capable of receiving the valid signal from the UE, depends upon a carrier carrying the signal, the coverage of the node may be associated with coverage of the "cell" of a radio resource used by the node. Accordingly, the term "cell" may be used to indicate service coverage of the node sometimes, a radio resource at other times, or a range that a signal using a radio resource can reach with valid strength at other times. The "cell" of the radio resource will be described later in more detail.

[46] 3GPP LTE/LTE-A standards define DL physical channels corresponding to resource elements carrying information derived from a higher layer and DL physical signals corresponding to resource elements which are used by a physical layer but which do not carry information derived from a higher layer. For example, a physical downlink shared channel (PDSCH), a physical broadcast channel (PBCH), a physical multicast channel (PMCH), a physical control format indicator channel (PCFICH), a physical downlink control channel (PDCCH), and a physical hybrid ARQ indicator channel (PHICH) are defined as the DL physical channels, and a reference signal and a synchronization signal are defined as the DL physical signals. A reference signal (RS), also called a pilot, refers to a special waveform of a predefined signal known to both a BS and a UE. For example, a cell-specific RS (CRS), a UE-specific RS (UE-RS), a po-

sitioning RS (PRS), and channel state information RS (CSI-RS) may be defined as DL RSs. Meanwhile, the 3GPP LTE/LTE-A standards define UL physical channels corresponding to resource elements carrying information derived from a higher layer and UL physical signals corresponding to resource elements which are used by a physical layer but which do not carry information derived from a higher layer. For example, a physical uplink shared channel (PUSCH), a physical uplink control channel (PUCCH), and a physical random access channel (PRACH) are defined as the UL physical channels, and a demodulation reference signal (DM RS) for a UL control/data signal and a sounding reference signal (SRS) used for UL channel measurement are defined as the UL physical signals.

[47] In the present invention, a physical downlink control channel (PDCCH), a physical control format indicator channel (PCFICH), a physical hybrid automatic retransmit request indicator channel (PHICH), and a physical downlink shared channel (PDSCH) refer to a set of time-frequency resources or resource elements (REs) carrying downlink control information (DCI), a set of time-frequency resources or REs carrying a control format indicator (CFI), a set of time-frequency resources or REs carrying downlink acknowledgement (ACK)/negative ACK (NACK), and a set of time-frequency resources or REs carrying downlink data, respectively. In addition, a physical uplink control channel (PUCCH), a physical uplink shared channel (PUSCH) and a physical random access channel (PRACH) refer to a set of time-frequency resources or REs carrying uplink control information (UCI), a set of time-frequency resources or REs carrying uplink data and a set of time-frequency resources or REs carrying random access signals, respectively. In the present invention, in particular, a time-frequency resource or RE that is assigned to or belongs to PDCCH/PCFICH/PHICH/PDSCH/PUCCH/PUSCH/PRACH is referred to as PDCCH/PCFICH/PHICH/PDSCH/PUCCH/PUSCH/PRACH RE or PDCCH/PCFICH/PHICH/PDSCH/PUCCH/PUSCH/PRACH time-frequency resource, respectively. Therefore, in the present invention, PUCCH/PUSCH/PRACH transmission of a UE is conceptually identical to UCI/uplink data/random access signal transmission on PUSCH/PUCCH/PRACH, respectively. In addition, PDCCH/PCFICH/PHICH/PDSCH transmission of an eNB is conceptually identical to downlink data/DCI transmission on PDCCH/PCFICH/PHICH/PDSCH, respectively.

[48] Hereinafter, OFDM symbol/subcarrier/RE to or for which CRS/DMRS/CSI-RS/SRS/UE-RS/TRS is assigned or configured will be referred to as CRS/DMRS/CSI-RS/SRS/UE-RS/TRS symbol/carrier/subcarrier/RE. For example, an OFDM symbol to or for which a tracking RS (TRS) is assigned or configured is referred to as a TRS symbol, a subcarrier to or for which the TRS is assigned or configured is referred to as a TRS subcarrier, and an RE to or for which the TRS is

assigned or configured is referred to as a TRS RE. In addition, a subframe configured for transmission of the TRS is referred to as a TRS subframe. Moreover, a subframe in which a broadcast signal is transmitted is referred to as a broadcast subframe or a PBCH subframe and a subframe in which a synchronization signal (e.g. PSS and/or SSS) is transmitted is referred to a synchronization signal subframe or a PSS/SSS subframe. OFDM symbol/subcarrier/RE to or for which PSS/SSS is assigned or configured is referred to as PSS/SSS symbol/subcarrier/RE, respectively.

[49] In the present invention, a CRS port, a UE-RS port, a CSI-RS port, and a TRS port refer to an antenna port configured to transmit a CRS, an antenna port configured to transmit a UE-RS, an antenna port configured to transmit a CSI-RS, and an antenna port configured to transmit a TRS, respectively. Antenna ports configured to transmit CRSs may be distinguished from each other by the locations of REs occupied by the CRSs according to CRS ports, antenna ports configured to transmit UE-RSs may be distinguished from each other by the locations of REs occupied by the UE-RSs according to UE-RS ports, and antenna ports configured to transmit CSI-RSs may be distinguished from each other by the locations of REs occupied by the CSI-RSs according to CSI-RS ports. Therefore, the term CRS/UE-RS/CSI-RS/TRS ports may also be used to indicate a pattern of REs occupied by CRSs/UE-RSs/CSI-RSs/TRSs in a predetermined resource region. In the present invention, both a DMRS and a UE-RS refer to RSs for demodulation and, therefore, the terms DMRS and UE-RS are used to refer to RSs for demodulation.

[50] FIG. 1 illustrates the structure of a radio frame used in a wireless communication system.

[51] Specifically, FIG. 1(a) illustrates an exemplary structure of a radio frame which can be used in frequency division multiplexing (FDD) in 3GPP LTE/LTE-A and FIG. 1(b) illustrates an exemplary structure of a radio frame which can be used in time division multiplexing (TDD) in 3GPP LTE/LTE-A.

[52] Referring to FIG. 1, a 3GPP LTE/LTE-A radio frame is 10ms ($307,200T_s$) in duration. The radio frame is divided into 10 subframes of equal size. Subframe numbers may be assigned to the 10 subframes within one radio frame, respectively. Here, T_s denotes sampling time where T_s=1/(2048*15kHz). Each subframe is 1ms long and is further divided into two slots. 20 slots are sequentially numbered from 0 to 19 in one radio frame. Duration of each slot is 0.5ms. A time interval in which one subframe is transmitted is defined as a transmission time interval (TTI). Time resources may be distinguished by a radio frame number (or radio frame index), a subframe number (or subframe index), a slot number (or slot index), and the like.

[53] A radio frame may have different configurations according to duplex modes. In FDD mode for example, since DL transmission and UL transmission are discriminated

according to frequency, a radio frame for a specific frequency band operating on a carrier frequency includes either DL subframes or UL subframes. In TDD mode, since DL transmission and UL transmission are discriminated according to time, a radio frame for a specific frequency band operating on a carrier frequency includes both DL subframes and UL subframes.

[54] Table 1 shows an exemplary UL-DL configuration within a radio frame in TDD mode.

[55] [Table 1]

DL-UL configuration	Downlink-to-Uplink Switch-point periodicity	Subframe number									
		0	1	2	3	4	5	6	7	8	9
0	5ms	D	S	U	U	U	D	S	U	U	U
1	5ms	D	S	U	U	D	D	S	U	U	D
2	5ms	D	S	U	D	D	D	S	U	D	D
3	10ms	D	S	U	U	U	D	D	D	D	D
4	10ms	D	S	U	U	D	D	D	D	D	D
5	10ms	D	S	U	D	D	D	D	D	D	D
6	5ms	D	S	U	U	U	D	S	U	U	D

[56] In Table 1, D denotes a DL subframe, U denotes a UL subframe, and S denotes a special subframe. The special subframe includes three fields, i.e. downlink pilot time slot (DwPTS), guard period (GP), and uplink pilot time slot (UpPTS). DwPTS is a time slot reserved for DL transmission and UpPTS is a time slot reserved for UL transmission. Table 2 shows an example of the special subframe configuration.

[57] [Table 2]

Special subframe configuration	Normal cyclic prefix in downlink			Extended cyclic prefix in downlink		
	DwPTS	UpPTS		DwPTS	UpPTS	
		Normal cyclic prefix in uplink	Extended cyclic prefix in uplink		Normal cyclic prefix in uplink	Extended cyclic prefix in uplink
0	$6592 \cdot T_s$	$2192 \cdot T_s$	$2560 \cdot T_s$	$7680 \cdot T_s$	$2192 \cdot T_s$	$2560 \cdot T_s$
1	$19760 \cdot T_s$			$20480 \cdot T_s$		
2	$21952 \cdot T_s$			$23040 \cdot T_s$		
3	$24144 \cdot T_s$			$25600 \cdot T_s$		
4	$26336 \cdot T_s$			$7680 \cdot T_s$	$4384 \cdot T_s$	$5120 \cdot T_s$
5	$6592 \cdot T_s$	$4384 \cdot T_s$	$5120 \cdot T_s$	$20480 \cdot T_s$		
6	$19760 \cdot T_s$			$23040 \cdot T_s$		
7	$21952 \cdot T_s$			$12800 \cdot T_s$		
8	$24144 \cdot T_s$			-	-	-
9	$13168 \cdot T_s$			-	-	-

[58] FIG. 2 illustrates the structure of a DL/UL slot structure in a wireless communication system.

[59] Referring to FIG. 2, a slot includes a plurality of orthogonal frequency division multiplexing (OFDM) symbols in the time domain and includes a plurality of resource blocks (RBs) in the frequency domain. The OFDM symbol may refer to one symbol duration. Referring to FIG. 2, a signal transmitted in each slot may be expressed by a resource grid including $N^{DL/UL}_{RB} * N^{RB}_{sc}$ subcarriers and $N^{DL/UL}_{symb}$ OFDM symbols. N^{DL}_{RB} denotes the number of RBs in a DL slot and N^{UL}_{RB} denotes the number of RBs in a UL slot. N^{DL}_{RB} and N^{UL}_{RB} depend on a DL transmission bandwidth and a UL transmission bandwidth, respectively. N^{DL}_{symb} denotes the number of OFDM symbols in a DL slot, N^{UL}_{symb} denotes the number of OFDM symbols in a UL slot, and N^{RB}_{sc} denotes the number of subcarriers configuring one RB.

[60] An OFDM symbol may be referred to as an OFDM symbol, a single carrier frequency division multiplexing (SC-FDM) symbol, etc. according to multiple access schemes. The number of OFDM symbols included in one slot may be varied according to channel bandwidths and CP lengths. For example, in a normal cyclic prefix (CP) case, one slot includes 7 OFDM symbols. In an extended CP case, one slot includes 6

OFDM symbols. Although one slot of a subframe including 7 OFDM symbols is shown in FIG. 2 for convenience of description, embodiments of the present invention are similarly applicable to subframes having a different number of OFDM symbols. Referring to FIG. 2, each OFDM symbol includes $N^{DL/UL}_{RB} * N^{RB}_{sc}$ subcarriers in the frequency domain. The type of the subcarrier may be divided into a data subcarrier for data transmission, a reference signal (RS) subcarrier for RS transmission, and a null subcarrier for a guard band and a DC component. The null subcarrier for the DC component is unused and is mapped to a carrier frequency f_0 in a process of generating an OFDM signal or in a frequency up-conversion process. The carrier frequency is also called a center frequency f_c.

[61] One RB is defined as $N^{DL/UL}_{symb}$ (e.g. 7) consecutive OFDM symbols in the time domain and as N^{RB}_{sc} (e.g. 12) consecutive subcarriers in the frequency domain. For reference, a resource composed of one OFDM symbol and one subcarrier is referred to a resource element (RE) or tone. Accordingly, one RB includes $N^{DL/UL}_{symb} * N^{RB}_{sc}$ REs. Each RE within a resource grid may be uniquely defined by an index pair (k, l) within one slot. k is an index ranging from 0 to $N^{DL/UL}_{RB} * N^{RB}_{sc}$—1 in the frequency domain, and l is an index ranging from 0 to $N^{DL/UL}_{symb}$—1 in the time domain.

[62] Meanwhile, one RB is mapped to one physical resource block (PRB) and one virtual resource block (VRB). A PRB is defined as N^{DL}_{symb} (e.g. 7) consecutive OFDM or SC-FDM symbols in the time domain and N^{RB}_{sc} (e.g. 12) consecutive subcarriers in the frequency domain. Accordingly, one PRB is configured with $N^{DL/UL}_{symb} * N^{RB}_{sc}$ REs. In one subframe, two RBs each located in two slots of the subframe while occupying the same N^{RB}_{sc} consecutive subcarriers are referred to as a physical resource block (PRB) pair. Two RBs configuring a PRB pair have the same PRB number (or the same PRB index).

[63] FIG. 3 illustrates a radio frame structure for transmission of a synchronization signal (SS). Specifically, FIG. 3 illustrates a radio frame structure for transmission of an SS and a PBCH in frequency division duplex (FDD), wherein FIG. 3(a) illustrates transmission locations of an SS and a PBCH in a radio frame configured as a normal cyclic prefix (CP) and FIG. 3(b) illustrates transmission locations of an SS and a PBCH in a radio frame configured as an extended CP.

[64] If a UE is powered on or newly enters a cell, the UE performs an initial cell search procedure of acquiring time and frequency synchronization with the cell and detecting a physical cell identity N^{cell}_{ID} of the cell. To this end, the UE may establish synchronization with the eNB by receiving synchronization signals, e.g. a primary synchronization signal (PSS) and a secondary synchronization signal (SSS), from the eNB and obtain information such as a cell identity (ID).

[65] An SS will be described in more detail with reference to FIG. 3. An SS is categorized

into a PSS and an SSS. The PSS is used to acquire time-domain synchronization of OFDM symbol synchronization, slot synchronization, etc. and/or frequency-domain synchronization and the SSS is used to acquire frame synchronization, a cell group ID, and/or CP configuration of a cell (i.e. information as to whether a normal CP is used or an extended CP is used). Referring to FIG. 3, each of a PSS and an SSS is transmitted on two OFDM symbols of every radio frame. More specifically, SSs are transmitted in the first slot of subframe 0 and the first slot of subframe 5, in consideration of a global system for mobile communication (GSM) frame length of 4.6 ms for facilitation of inter-radio access technology (inter-RAT) measurement. Especially, a PSS is transmitted on the last OFDM symbol of the first slot of subframe 0 and on the last OFDM symbol of the first slot of subframe 5 and an SSS is transmitted on the second to last OFDM symbol of the first slot of subframe 0 and on the second to last OFDM symbol of the first slot of subframe 5. A boundary of a corresponding radio frame may be detected through the SSS. The PSS is transmitted on the last OFDM symbol of a corresponding slot and the SSS is transmitted on an OFDM symbol immediately before an OFDM symbol on which the PSS is transmitted. A transmit diversity scheme of an SS uses only a single antenna port and standards therefor are not separately defined. That is, a single antenna port transmission scheme or a transmission scheme transparent to a UE (e.g. precoding vector switching (PVS), time switched transmit diversity (TSTD), or cyclic delay diversity (CDD)) may be used for transmit diversity of an SS.

[66] Upon detecting a PSS, a UE may discern that a corresponding subframe is one of subframe 0 and subframe 5 because the PSS is transmitted every 5ms but the UE cannot discern whether the subframe is subframe 0 or subframe 5. Accordingly, the UE cannot recognize the boundary of a radio frame only by the PSS. That is, frame synchronization cannot be acquired only by the PSS. The UE detects the boundary of a radio frame by detecting an SSS which is transmitted twice in one radio frame with different sequences.

[67] The UE, which has determined time and frequency parameters necessary for demodulating a DL signal and transmitting a UL signal at an accurate time by performing a cell search procedure using PSS/SSS, can communicate with the eNB only after acquiring system information necessary for system configuration of the UE from the eNB.

[68] The system information is configured by a master information block (MIB) and system information blocks (SIBs). Each SIB includes a set of functionally associated parameters and is categorized into an MIB, SIB Type 1 (SIB 1), SIB Type 2 (SIB2), and SIB3 to SIB17 in accordance with the parameters.

[69] The MIB includes most frequently transmitted parameters which are essential for

initial access of the UE to a network of the eNB. The UE may receive the MIB through a broadcast channel (e.g. PBCH). The MIB includes a DL bandwidth (BW), PHICH configuration, and a system frame number (SFN). Accordingly, the UE may be explicitly aware of information about the DL BW, SFN, and PHICH configuration by receiving the MIB. Meanwhile, information which may be implicitly recognized by the UE through reception of the PBCH includes the number of transmit antenna ports of the eNB. Information about the number of transmit antennas of the eNB is implicitly signaled by masking (e.g. XOR operation) a sequence corresponding to the number of transmit antennas to a 16-bit cyclic redundancy check (CRC) used for error detection of the PBCH.

[70] The SIB1 includes parameters needed to determine if a specific cell is suitable for cell selection, as well as information about time-domain scheduling of the other SIBs. The SIB1 is received by the UE through broadcast signaling or dedicated signaling.

[71] DL carrier frequency and corresponding system bandwidth may be acquired by the MIB carried by the PBCH. UL carrier frequency and corresponding system bandwidth may be acquired by system information which is a DL signal. The UE which has received the MIB applies a DL BW value within the MIB to a UL-bandwidth (UL BW) until system information block type 2 (SystemInformationBlockType2, SIB2) is received if there is no valid system information stored in a corresponding cell. For example, the UE may identify a full UL system band, which may be used by itself for UL transmission, through UL-carrier frequency and UL-bandwidth information within the SIB2 by acquiring system information block type 2 (SystemInformationBlockType2, SIB2).

[72] In the frequency domain, a PSS/SSS and a PBCH are transmitted only in a total of 6 RBs, i.e. a total of 72 subcarriers, irrespective of actual system BW, wherein 3 RBs are in the left and the other 3 RBs are in the right centering on a DC subcarrier on corresponding OFDM symbols. Therefore, the UE is configured to detect or decode the SS and the PBCH irrespective of DL BW configured for the UE.

[73] After initial cell search, the UE may perform a random access procedure to complete access to the eNB. To this end, the UE may transmit a preamble through a physical random access channel (PRACH) and receive a response message to the preamble through a PDCCH and a PDSCH. In contention based random access, the UE may perform additional PRACH transmission and a contention resolution procedure of a PDCCH and a PDSCH corresponding to the PDCCH.

[74] After performing the aforementioned procedure, the UE may perform PDDCH/PDSCH reception and PUSCH/PUCCH transmission as general uplink/downlink transmission procedures.

[75] The random access procedure is also called RACH (random access channel)

procedure. The random access procedure is used for initial access, uplink synchronization adjustment, resource assignment, handover, etc. The random access procedure is classified into a contention-based process and a dedicated (i.e. non-contention-based) process. The contention-based random access procedure includes initial access and is normally used, whereas the dedicated random access procedure is limitedly used for handover. In the contention-based random access procedure, a UE randomly select a RACH preamble sequence. Accordingly, a plurality of UEs can simultaneously transmit the same RACH preamble sequence and thus a contention resolution procedure is not needed. In the dedicated random access procedure, a UE uses a RACH preamble sequence uniquely allocated thereto by an eNB. Accordingly, the UE can perform the random access procedure without colliding with other UEs.

[76] The contention-based random access procedure has the following four steps. Hereinafter, messages transmitted in steps 1 to 4 may be respectively referred to as Msg 1 to Msg 4.

[77] - Step 1: RACH preamble (via PRACH) (UE to eNB)

[78] - Step 2: Random access response (RAR) (via PDCCH and PDSCH) (eNB to UE)

[79] - Step 3: Layer 2/Layer 3 message (via PUSCH) (UE to eNB)

[80] - Step 4: Contention resolution message (eNB to UE)

[81] The dedicated random access procedure includes the following three steps. Hereinafter, uplink transmission (i.e. step 3) corresponding to a RAR may be performed as a part of the random access procedure. The dedicated random access procedure can be triggered using a PDCCH (hereinafter, referred to as PDCCH order) used for an eNB to command RACH preamble transmission.

[82] - Step 0: PACH preamble allocation through dedicated signaling (eNB to UE)

[83] - Step 1: RACH preamble (via PRACH) (UE to eNB)

[84] - Step 2: RAR (via PDCCH and PDSCH) (eNB to UE)

[85] After transmission of RACH preamble, the UE attempts to receive a random access response (RAR) within a predetermined time window. Specifically, the UE attempts to detect a PDCCH (hereinafter, referred to as RA-RNTI PDCCH) having an RA-RNTI (Random Access RNTI) (e.g., CRC is masked with RA-RNTI in the PDCCH) within the time window. The UE checks whether a RAR therefor is present in a PDSCH corresponding to the RA-RNTI PDCCH during RA-RNTI PDCCH detection. The RAR includes timing advance (TA) information indicating timing offset information for UL synchronization, UL resource allocation information (UL grant information), a temporary UE identifier (e.g., temporary cell-RNTI, TC-RNTI), etc. The UE can perform UL transmission (e.g., Msg3) in accordance with resource allocation information and TA value in the RAR. HARQ is applied to UL transmission corresponding to the RAR. Accordingly, the UE can receive acknowledgement information

(e.g., PHICH) corresponding to Msg 3 after transmission of Msg 3.

[86] The random access preamble, i.e., RACH preamble consists of a cyclic prefix of length T_{CP} and a sequence part of length T_{SEQ} in the physical layer. T_{CP} and T_{SEQ} depend on the frame structure and the random access configuration. The preamble format is controlled by higher layers. The following table shows examples of T_{CP} and T_{SEQ}.

[87] [Table 3]

Preamble format	T_{CP}	T_{SEQ}
0	$3168 \cdot T_s$	$24576 \cdot T_s$
1	$21024 \cdot T_s$	$24576 \cdot T_s$
2	$6240 \cdot T_s$	$2 \cdot 24576 \cdot T_s$
3	$21024 \cdot T_s$	$2 \cdot 24576 \cdot T_s$
4(see NOTE)	$448 \cdot T_s$	$4096 \cdot T_s$
NOTE: Frame structure type 2 and special subframe configuration with UpPTS lengths $4384 \cdot T_s$ and $5120 \cdot T_s$ only.		

[88] The random access preamble is transmitted in UL subframe(s). The transmission of a random access preamble is restricted to certain time and frequency resources. These resources are called PRACH resources. The PRACH resources, are enumerated in increasing order of the subframe number within the radio frame and the PRBs in the frequency domain such that index 0 correspond to the lowest numbered PRB and subframe within the radio frame. PRACH resources within the radio frame are indicated by a PRACH configuration index.

[89] For frame structure type 1 with preamble format 0-3, for each of the PRACH configurations there is at most one random access resource per subframe. The following table shows examples of the preamble formats and the subframes in which random access preamble transmission is allowed for a given configuration in frame structure type 1. The PRACH configuration index is given by a higher layer signal (transmitted by an eNB).

[90] [Table 4]

PRACH Configuration Index	Preamble Format	SFN	Subframe number	PRACH Configuration Index	Preamble Format	SFN	Subframe number
0	0	Even	1	32	2	Even	1
1	0	Even	4	33	2	Even	4
2	0	Even	7	34	2	Even	7
3	0	Any	1	35	2	Any	1
4	0	Any	4	36	2	Any	4
5	0	Any	7	37	2	Any	7
6	0	Any	1,6	38	2	Any	1,6
7	0	Any	2,7	39	2	Any	2,7
8	0	Any	3,8	40	2	Any	3,8
9	0	Any	1,4,7	41	2	Any	1,4,7
10	0	Any	2,5,8	42	2	Any	2,5,8
11	0	Any	3,6,9	43	2	Any	3,6,9
12	0	Any	0,2,4,6,8	44	2	Any	0,2,4,6,8
13	0	Any	1,3,5,7,9	45	2	Any	1,3,5,7,9
14	0	Any	0,1,2,3,4,5,6,7,8,9	46	N/A	N/A	N/A
15	0	Even	9	47	2	Even	9
16	1	Even	1	48	3	Even	1
17	1	Even	4	49	3	Even	4
18	1	Even	7	50	3	Even	7
19	1	Any	1	51	3	Any	1
20	1	Any	4	52	3	Any	4
21	1	Any	7	53	3	Any	7
22	1	Any	1,6	54	3	Any	1,6
23	1	Any	2,7	55	3	Any	2,7
24	1	Any	3,8	56	3	Any	3,8
25	1	Any	1,4,7	57	3	Any	1,4,7

26	1	Any	2,5,8	58	3	Any	2,5,8
27	1	Any	3,6,9	59	3	Any	3,6,9
28	1	Any	0,2,4,6,8	60	N/A	N/A	N/A
29	1	Any	1,3,5,7,9	61	N/A	N/A	N/A
30	N/A	N/A	N/A	62	N/A	N/A	N/A
31	1	Even	9	63	3	Even	9

[91] In Table 4, SFN denotes a system frame number.

[92] The first PRB, n^{RA}_{PRB}, allocated to the PRACH opportunity considered for preamble formats 0, 1, 2 and 3 is defined by $n^{RA}_{PRB}=n^{RA}_{PRBoffset}$, where the PRACH frequency offset $n^{RA}_{PRBoffset}$ is a PRB configured by higher layers and satisfies $0\leq n^{RA}_{PRBoffset}\leq N^{UL}_{RB}-6$.

[93] In case of frame structure type 2 with preamble formats 0 to 4, a plurality of random access resources may exist within UL subframe (or UpPTS for preamble format 4) in accordance with UL/DL configuration. The random access resources for the frame structure type 2 are defined in accordance with PRACH configuration index (see 3GPP TS 36.211 standard document).

[94] FIG. 4 illustrates the structure of a DL subframe used in a wireless communication system.

[95] Referring to FIG. 4, A DL subframe is divided into a control region and a data region in the time domain. Referring to FIG. 4, a maximum of 3 (or 4) OFDM symbols located in a front part of a first slot of a subframe corresponds to the control region. Hereinafter, a resource region for PDCCH transmission in a DL subframe is referred to as a PDCCH region. OFDM symbols other than the OFDM symbol(s) used in the control region correspond to the data region to which a physical downlink shared channel (PDSCH) is allocated. Hereinafter, a resource region available for PDSCH transmission in the DL subframe is referred to as a PDSCH region.

[96] Examples of a DL control channel used in 3GPP LTE include a physical control format indicator channel (PCFICH), a physical downlink control channel (PDCCH), a physical hybrid ARQ indicator channel (PHICH), etc.

[97] The PCFICH is transmitted in the first OFDM symbol of a subframe and carries information about the number of OFDM symbols available for transmission of a control channel within a subframe. The PCFICH notifies the UE of the number of OFDM symbols used for the corresponding subframe every subframe. The PCFICH is located at the first OFDM symbol. The PCFICH is configured by four resource element groups (REGs), each of which is distributed within a control region on the basis of cell ID. One REG includes four REs.

[98] A set of OFDM symbols available for the PDCCH at a subframe is given by the following Table.

[99] [Table 5]

Subframe	Number of OFDM symbols for PDCCH when $N^{DL}_{RB}>10$	Number of OFDM symbols for PDCCH when $N^{DL}_{RB}\leq 10$
Subframe 1 and 6 for frame structure type 2	1, 2	2
MBSFN subframes on a carrier supporting PDSCH, configured with 1 or 2 cell-specfic antenna ports	1, 2	2
MBSFN subframes on a carrier supporting PDSCH, configured with 4 cell-specific antenna ports	2	2
Subframes on a carrier not supporting PDSCH	0	0
Non-MBSFN subframes (except subframe 6 for frame structure type 2) configured with positioning reference signals	1, 2, 3	2, 3
All other cases	1, 2, 3	2, 3, 4

[100] A subset of downlink subframes within a radio frame on a carrier for supporting PDSCH transmission may be configured as MBSFN subframe(s) by a higher layer. Each MBSFN subframe is divided into a non-MBSFN region and an MBSFN region. The non-MBSFN region spans first one or two OFDM symbols, and its length is given by Table 5. The same CP as cyclic prefix (CP) used for subframe 0 is used for transmission within the non-MBSFN region of the MBSFN subframe. The MBSFN region within the MBSFN subframe is defined as OFDM symbols which are not used in the non-MBSFN region.

[101] The PCFICH carries a control format indicator (CFI), which indicates any one of values of 1 to 3. For a downlink system bandwidth $N^{DL}_{RB}>10$, the number 1, 2 or 3 of OFDM symbols which are spans of DCI carried by the PDCCH is given by the CFI. For a downlink system bandwidth $N^{DL}_{RB}\leq 10$, the number 2, 3 or 4 of OFDM symbols which are spans of DCI carried by the PDCCH is given by CFI+1. The CFI is coded in accordance with the following Table.

[102] [Table 6]

CFI	CFI code word<b_0, b_1, ..., b_{31}>
1	<0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1>
2	<1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0>
3	<1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1>
4(Reserved)	<0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0>

[103] The PHICH carries a HARQ (Hybrid Automatic Repeat Request) ACK/NACK (acknowledgment/negative-acknowledgment) signal as a response to UL transmission. The PHICH includes three REGs, and is scrambled cell-specifically. ACK/NACK is indicated by 1 bit, and the ACK/NACK of 1 bit is repeated three times. Each of the repeated ACK/NACK bits is spread with a spreading factor (SF) 4 or 2 and then mapped into a control region.

[104] The control information transmitted through the PDCCH will be referred to as downlink control information (DCI). The DCI includes resource allocation information for a UE or UE group and other control information. Transmit format and resource allocation information of a downlink shared channel (DL-SCH) are referred to as DL scheduling information or DL grant. Transmit format and resource allocation information of an uplink shared channel (UL-SCH) are referred to as UL scheduling information or UL grant. The size and usage of the DCI carried by one PDCCH are varied depending on DCI formats. The size of the DCI may be varied depending on a coding rate. In the current 3GPP LTE system, various formats are defined, wherein formats 0 and 4 are defined for a UL, and formats 1, 1A, 1B, 1C, 1D, 2, 2A, 2B, 2C, 3 and 3A are defined for a DL. Combination selected from control information such as a hopping flag, RB allocation, modulation coding scheme (MCS), redundancy version (RV), new data indicator (NDI), transmit power control (TPC), cyclic shift, cyclic shift demodulation reference signal (DM RS), UL index, channel quality information (CQI) request, DL assignment index, HARQ process number, transmitted precoding matrix indicator (TPMI), precoding matrix indicator (PMI) information is transmitted to the UE as the DCI. The following table shows examples of DCI formats.

[105] [Table 7]

DCI format	Description
0	Resource grants for the PUSCH transmissions (uplink)
1	Resource assignments for single codeword PDSCH transmissions
1A	Compact signaling of resource assignments for single codeword PDSCH
1B	Compact signaling of resource assignments for single codeword PDSCH
1C	Very compact resource assignments for PDSCH (e.g. paging/broadcast system information)
1D	Compact resource assignments for PDSCH using multi-user MIMO
2	Resource assignments for PDSCH for closed-loop MIMO operation
2A	Resource assignments for PDSCH for open-loop MIMO operation
2B	Resource assignments for PDSCH using up to 2 antenna ports with UE-specific reference signals
2C	Resource assignment for PDSCH using up to 8 antenna ports with UE-specific reference signals
3/3A	Power control commands for PUCCH and PUSCH with 2-bit/1-bit power adjustments
4	Scheduling of PUSCH in one UL Component Carrier with multi-antenna port transmission mode

[106] Other DCI formats in addition to the DCI formats defined in Table 7 may be defined.

[107] A plurality of PDCCHs may be transmitted within a control region. A UE may monitor the plurality of PDCCHs. An eNB determines a DCI format depending on the DCI to be transmitted to the UE, and attaches cyclic redundancy check (CRC) to the DCI. The CRC is masked (or scrambled) with an identifier (for example, a radio network temporary identifier (RNTI)) depending on usage of the PDCCH or owner of the PDCCH. For example, if the PDCCH is for a specific UE, the CRC may be masked with an identifier (for example, cell-RNTI (C-RNTI)) of the corresponding UE. If the PDCCH is for a paging message, the CRC may be masked with a paging identifier (for example, paging-RNTI (P-RNTI)). If the PDCCH is for system information (in more detail, system information block (SIB)), the CRC may be masked with system information RNTI (SI-RNTI). If the PDCCH is for a random access response, the CRC may be masked with a random access RNTI (RA-RNTI). For example, CRC masking

(or scrambling) includes XOR operation of CRC and RNTI at the bit level.

[108] Generally, a DCI format, which may be transmitted to the UE, is varied depending on a transmission mode configured for the UE. In other words, certain DCI format(s) corresponding to the specific transmission mode not all DCI formats may only be used for the UE configured to a specific transmission mode.

[109] For example, a transmission mode is semi-statically configured for the UE by a higher layer so that the UE may receive a PDSCH transmitted in accordance with one of a plurality of transmission modes which are previously defined. The UE attempts to decode a PDCCH using DCI formats only corresponding to its transmission mode. In other words, in order to maintain UE operation load according to blind decoding attempt, at a certain level or less, all DCI formats are not searched by the UE at the same time. Table 8 illustrates transmission modes for configuring multi-antenna technology and DCI formats for allowing a UE to perform blind decoding at the corresponding transmission mode. Particularly, Table 8 illustrates a relation between PDCCH and PDSCH configured by C-RNTI (Cell RNTI(Radio Network Temporary Identifier)).

[110] [Table 8]

Transmission mode	DCI format	Search Space	Transmission scheme of PDSCH corresponding to PDCCH
Mode 1	DCI format 1A	Common andUE specific by C-RNTI	Single-antenna port, port 0
	DCI format 1	UE specific by C-RNTI	Single-antenna port, port 0
Mode 2	DCI format 1A	Common andUE specific by C-RNTI	Transmit diversity
	DCI format 1	UE specific by C-RNTI	Transmit diversity
Mode 3	DCI format 1A	Common andUE specific by C-RNTI	Transmit diversity
	DCI format 2A	UE specific by C-RNTI	Large delay CDD or Transmit diversity
Mode 4	DCI format 1A	Common andUE specific by C-RNTI	Transmit diversity
	DCI format 2	UE specific by C-RNTI	Closed-loop spatial multiplexing or Transmit diversity
Mode 5	DCI format 1A	Common andUE specific by C-RNTI	Transmit diversity
	DCI format 1D	UE specific by C-RNTI	Multi-user MIMO
Mode 6	DCI format 1A	Common andUE specific by C-RNTI	Transmit diversity
	DCI format 1B	UE specific by C-RNTI	Closed-loop spatial multiplexing using a single transmission layer
Mode 7	DCI format	Common andUE	If the number of PBCH antenna ports

	1A	specific by C-RNTI	is one, Single-antenna port, port 0 is used, otherwise Transmit diversity
	DCI format 1	UE specific by C-RNTI	Single-antenna port, port 5
Mode 8	DCI format 1A	Common andUE specific by C-RNTI	If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used, otherwise Transmit diversity
	DCI format 2B	UE specific by C-RNTI	Dual layer transmission, port 7 and 8 or single-antenna port, port 7 or 8
Mode 9	DCI format 1A	Common andUE specific by C-RNTI	Non-MBSFN subframe: If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used, otherwise Transmit diversity.MBSFN subframe: Single-antenna port, port 7
	DCI format 2C	UE specific by C-RNTI	Up to 8 layer transmission, ports 7-14 or single-antenna port, port 7 or 8
Mode 10	DCI format 1A	Common andUE specific by C-RNTI	Non-MBSFN subframe: If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used, otherwise Transmit diversity.MBSFN subframe: Single-antenna port, port 7
	DCI format 2D	UE specific by C-RNTI	Up to 8 layer transmission, ports 7-14 or single antenna port, port 7 or 8

[111] Although transmission modes 1 to 10 are listed in Table 8, other transmission modes in addition to the transmission modes defined in Table 8 may be defined.

[112] Referring to Table 8, a UE configured to a transmission mode 9, for example, tries to decode PDCCH candidates of a UE-specific search space (USS) to a DCI format 1A, and tries to decode PDCCH candidates of a common search space (CSS) and the USS to a DCI format 2C. The UE may decode a PDSCH in accordance with DCI based on the DCI format successfully decoded. If DCI decoding from one of a plurality of PDCCH candidates to the DCI format 1A is successfully performed, the UE may decode the PDSCH by assuming that up to 8 layers from antenna ports 7 to 14 are transmitted thereto through the PDSCH, or may decode the PDSCH by assuming that a single layer from the antenna port 7 or 8 is transmitted thereto through the PDSCH.

[113] The PDCCH is allocated to first m number of OFDM symbol(s) within a subframe.

In this case, m is an integer equal to or greater than 1, and is indicated by the PCFICH.

[114] The PDCCH is transmitted on an aggregation of one or a plurality of continuous control channel elements (CCEs). The CCE is a logic allocation unit used to provide a coding rate based on the status of a radio channel to the PDCCH. The CCE corresponds to a plurality of resource element groups (REGs). For example, one CCE corresponds to nine resource element groups (REGs), and one REG corresponds to four REs. Four QPSK symbols are mapped to each REG. A resource element (RE) occupied by the reference signal (RS) is not included in the REG. Accordingly, the number of REGs within given OFDM symbols is varied depending on the presence of the RS. The REGs are also used for other downlink control channels (that is, PCFICH and PHICH).

[115] Assuming that the number of REGs not allocated to the PCFICH or the PHICH is N_{REG}, the number of available CCEs in a DL subframe for PDCCH(s) in a system is numbered from 0 to N_{CCE}—1, where $N_{CCE} = \text{floor}(N_{REG}/9)$.

[116] A PDCCH format and the number of DCI bits are determined in accordance with the number of CCEs. The CCEs are numbered and consecutively used. To simplify the decoding process, a PDCCH having a format including n CCEs may be initiated only on CCEs assigned numbers corresponding to multiples of n. The number of CCEs used for transmission of a specific PDCCH is determined by a network or the eNB in accordance with channel status. For example, one CCE may be required for a PDCCH for a UE (for example, adjacent to eNB) having a good downlink channel. However, in case of a PDCCH for a UE (for example, located near the cell edge) having a poor channel, eight CCEs may be required to obtain sufficient robustness. Additionally, a power level of the PDCCH may be adjusted to correspond to a channel status.

[117] In a 3GPP LTE/LTE-A system, a set of CCEs on which a PDCCH can be located for each UE is defined. A CCE set in which the UE can detect a PDCCH thereof is referred to as a PDCCH search space or simply as a search space (SS). An individual resource on which the PDCCH can be transmitted in the SS is called a PDCCH candidate. A set of PDCCH candidates that the UE is to monitor is defined in terms of SSs, where a search space $S^{(L)}_k$ at aggregation level $L \in \{1,2,4,8\}$ is defined by a set of PDCCH candidates. SSs for respective PDCCH formats may have different sizes and a dedicated SS and a common SS are defined. The dedicated SS is a UE-specific SS (USS) and is configured for each individual UE. The common SS (CSS) is configured for a plurality of UEs.

[118] The following table shows an example of aggregation levels for defining SS.

[119] [Table 9]

Search space $S^{(L)}_k$			Number of PDCCH candidates $M^{(L)}$
Type	Aggregation level L	Size [in CCEs]	
UE-specific	1	6	6
	2	12	6
	4	8	2
	8	16	2
Common	4	16	4
	8	16	2

[120] For each serving cell on which PDCCH is monitored, the CCEs corresponding to PDCCH candidates m of the search space $S^{(L)}_k$ are configured by "$L*\{Y_k+m'\}$ mod floor($N_{CCE,k}/L$}+i", where i=0,...,L—1. For the common search space $m'=m$. For the PDCCH UE specific search space, for the serving cell on which PDCCH is monitored, if the monitorng UE is configured with carrier indicator field then $m'=m+M^{(L)}*n_{CI}$ where n_{CI} is the carrier indicator field (CIF) value, else if the monitoring UE is not configured with carrier indicator field then $m'=m$, where m=0,1,...,$M^{(L)}$—1. $M^{(L)}$ is the number of PDCCH candidates to monitor at aggregation level L in the given search space. The carrier indication field value can be the same as a serving cell index (*Serv-CellIndex*). For the common search space, Y_k is set to 0 for the two aggregation levels L=4 and L=8. For the UE-specific search space $S^{(L)}_k$ at aggregation level D, the variable Y_k is defined by "$Y_k = (A\cdot Y_{k-1})$ mod D", where $Y_{-1}=n_{RNTI}\neq 0$, A=39827, D=65537 and k =floor(n_s/2). n_s is the slot number within a radio frame.

[121] The eNB transmits an actual PDCCH (DCI) on a PDCCH candidate in a search space and the UE monitors the search space to detect the PDCCH (DCI). Here, monitoring implies attempting to decode each PDCCH in the corresponding SS according to all monitored DCI formats. The UE may detect a PDCCH thereof by monitoring a plurality of PDCCHs. Basically, the UE does not know the location at which a PDCCH thereof is transmitted. Therefore, the UE attempts to decode all PDCCHs of the corresponding DCI format for each subframe until a PDCCH having an ID thereof is detected and this process is referred to as blind detection (or blind decoding (BD)).

[122] For example, it is assumed that a specific PDCCH is CRC-masked with a radio network temporary identity (RNTI) 'A' and information about data transmitted using a radio resource 'B' (e.g. frequency location) and using transport format information 'C' (e.g. transmission block size, modulation scheme, coding information, etc.) is transmitted in a specific DL subframe. Then, the UE monitors the PDCCH using RNTI

information thereof. The UE having the RNTI 'A' receives the PDCCH and receives the PDSCH indicated by 'B' and 'C' through information of the received PDCCH.

[123] FIG. 5 illustrates the structure of a UL subframe used in a wireless communication system.

[124] Referring to FIG. 5, a UL subframe may be divided into a data region and a control region in the frequency domain. One or several PUCCHs may be allocated to the control region to deliver UCI. One or several PUSCHs may be allocated to the data region of the UE subframe to carry user data.

[125] In the UL subframe, subcarriers distant from a direct current (DC) subcarrier are used as the control region. In other words, subcarriers located at both ends of a UL transmission BW are allocated to transmit UCI. A DC subcarrier is a component unused for signal transmission and is mapped to a carrier frequency f_0 in a frequency up-conversion process. A PUCCH for one UE is allocated to an RB pair belonging to resources operating on one carrier frequency and RBs belonging to the RB pair occupy different subcarriers in two slots. The PUCCH allocated in this way is expressed by frequency hopping of the RB pair allocated to the PUCCH over a slot boundary. If frequency hopping is not applied, the RB pair occupies the same subcarriers.

[126] The PUCCH may be used to transmit the following control information.

[127] - Scheduling request (SR): SR is information used to request a UL-SCH resource and is transmitted using an on-off keying (OOK) scheme.

[128] - HARQ-ACK: HARQ-ACK is a response to a PDCCH and/or a response to a DL data packet (e.g. a codeword) on a PDSCH. HARQ-ACK indicates whether the PDCCH or PDSCH has been successfully received. 1-bit HARQ-ACK is transmitted in response to a single DL codeword and 2-bit HARQ-ACK is transmitted in response to two DL codewords. A HARQ-ACK response includes a positive ACK (simply, ACK), negative ACK (NACK), discontinuous transmission (DTX), or NACK/DRX. HARQ-ACK is used interchangeably with HARQ ACK/NACK and ACK/NACK.

[129] - Channel state information (CSI): CSI is feedback information for a DL channel. CSI may include channel quality information (CQI), a precoding matrix indicator (PMI), a precoding type indicator, and/or a rank indicator (RI). In the CSI, MIMO-related feedback information includes the RI and the PMI. The RI indicates the number of streams or the number of layers that the UE can receive through the same time-frequency resource. The PMI is a value reflecting a space characteristic of a channel, indicating an index of a preferred precoding matrix for DL signal transmission based on a metric such as an SINR. The CQI is a value of channel strength, indicating a received SINR that can be obtained by the UE generally when the eNB uses the PMI.

[130] A general wireless communication system performs data transmission/reception through one downlink (DL) band and through one uplink (UL) band corresponding to

the DL band (in case of a frequency division duplex (FDD) mode), or divides a prescribed radio frame into a UL time unit and a DL time unit in the time domain and then performs data transmission/reception through the UL/DL time unit (in case of a time division duplex (TDD) mode). Recently, to use a wider frequency band in recent wireless communication systems, introduction of carrier aggregation (or BW aggregation) technology that uses a wider UL/DL BW by aggregating a plurality of UL/DL frequency blocks has been discussed. A carrier aggregation (CA) is different from an orthogonal frequency division multiplexing (OFDM) system in that DL or UL communication is performed using a plurality of carrier frequencies, whereas the OFDM system carries a base frequency band divided into a plurality of orthogonal subcarriers on a single carrier frequency to perform DL or UL communication. Hereinbelow, each of carriers aggregated by carrier aggregation will be referred to as a component carrier (CC).

[131] For example, three 20MHz CCs may be aggregated on each of a UL and a DL to support a bandwidth of 60MHz. The respective CCs may be contiguous or non-contiguous in the frequency domain. For convenience, although it has been described that the bandwidth of UL CC and the bandwidth of DL CC are the same as each other and symmetric to each other, the bandwidth of each CC may be independently determined. Asymmetrical carrier aggregation in which the number of UL CCs is different from the number of DL CCs may be implemented. DL/UL CC limited to a specific UE may be referred to as a serving UL/DL CC configured for the specific UE.

[132] Meanwhile, the 3GPP LTE-A standard uses the concept of a cell to manage radio resources. The "cell" associated with the radio resources is defined by combination of downlink resources and uplink resources, that is, combination of DL CC and UL CC. The cell may be configured by downlink resources only, or may be configured by downlink resources and uplink resources. If carrier aggregation is supported, linkage between a carrier frequency of the downlink resources (or DL CC) and a carrier frequency of the uplink resources (or UL CC) may be indicated by system information. For example, combination of the DL resources and the UL resources may be indicated by linkage of system information block type 2 (SIB2). In this case, the carrier frequency means a center frequency of each cell or CC. A cell operating on a primary frequency may be referred to as a primary cell (Pcell) or PCC, and a cell operating on a secondary frequency may be referred to as a secondary cell (Scell) or SCC. The carrier corresponding to the Pcell on downlink will be referred to as a downlink primary CC (DL PCC), and the carrier corresponding to the Pcell on uplink will be referred to as an uplink primary CC (UL PCC). A Scell means a cell that may be configured after completion of radio resource control (RRC) connection establishment and used to provide additional radio resources. The Scell may form a set of serving cells for the UE

together with the Pcell in accordance with capabilities of the UE. The carrier corresponding to the Scell on the downlink will be referred to as downlink secondary CC (DL SCC), and the carrier corresponding to the Scell on the uplink will be referred to as uplink secondary CC (UL SCC). Although the UE is in RRC-CONNECTED state, if it is not configured by carrier aggregation or does not support carrier aggregation, a single serving cell configured by the Pcell only exists.

[133] The eNB may activate all or some of the serving cells configured in the UE or deactivate some of the serving cells for communication with the UE. The eNB may change the activated/deactivated cell, and may change the number of cells which is/are activated or deactivated. If the eNB allocates available cells to the UE cell-specifically or UE-specifically, at least one of the allocated cells is not deactivated unless cell allocation to the UE is fully reconfigured or unless the UE performs handover. Such a cell which is not deactivated unless CC allocation to the UE is fully reconfigured will be referred to as Pcell, and a cell which may be activated/deactivated freely by the eNB will be referred to as Scell. The Pcell and the Scell may be discriminated from each other on the basis of the control information. For example, specific control information may be set to be transmitted and received through a specific cell only. This specific cell may be referred to as the Pcell, and the other cell(s) may be referred to as Scell(s).

[134] A configured cell refers to a cell in which carrier aggregation is performed for a UE based on measurement report from another eNB or UE among cells of an eNB and is configured per UE. The cell configured for the UE may be a serving cell in terms of the UE. For the cell configured for the UE, i.e. the serving cell, resources for ACK/NACK transmission for PDSCH transmission are reserved in advance. An activated cell refers to a cell configured to be actually used for PDSCH/PUSCH transmission among cells configured for the UE and CSI reporting and SRS transmission for PDSCH/PUSCH transmission are performed in the activated cell. A deactivated cell refers to a cell configured not to be used for PDSCH/PUSCH transmission by the command of an eNB or the operation of a timer and, if a cell is deactivated, CSI reporting and SRS transmission are also stopped in the cell.

[135] For reference, a carrier indicator (CI) denots a serving cell index (*ServCellIndex*), CI=0 is applied to Pcell. The serving cell index is a short ID used to identify a serving cell. For example, any one of integers from 0 to 'maximum number of carrier frequencies which can be configured for the UE at a time - 1' may be allocated to one serving cell as the serving cell index. That is, the serving cell index may be a logical index used to identify a specific serving cell among cells allocated to the UE rather than a physical index used to identify a specific carrier frequency among all carrier frequencies.

[136] Meanwhile, the 3GPP LTE-A standard uses the concept of a cell to manage radio

resources.

[137] The cell mentioned in the present invention means a cell of carrier aggregation which is combination of UL CC and DL CC unless specifically noted.

[138] Meanwhile, since one serving cell is only present in case of communication based on a single carrier, a PDCCH carrying UL/DL grant and corresponding PUSCH/PDSCH are transmitted on one cell. In other words, in case of FDD under a single carrier environment, a PDCCH for a DL grant for a PDSCH, which will be transmitted on a specific DL CC, is transmitted on the specific CC, and a PDCCH for a UL grant for a PUSCH, which will be transmitted on a specific UL CC, is transmitted on a DL CC linked to the specific UL CC. In case of TDD under a single carrier environment, a PDCCH for a DL grant for a PDSCH, which will be transmitted on a specific DL CC, is transmitted on the specific CC, and a PDCCH for a UL grant for a PUSCH, which will be transmitted on a specific UL CC, is transmitted on the specific CC.

[139] On the contrary, since a plurality of serving cells may be configured in a multi-carrier system, transmission of UL/DL grant through a serving cell having a good channel status may be allowed. In this way, if a cell carrying UL/DL grant which is scheduling information is different from a cell where UL/DL transmission corresponding to the UL/DL grant is performed, this will be referred to as cross-carrier scheduling.

[140] Hereinafter, the case where the cell is scheduled from itself and the case where the cell is scheduled from another cell will be referred to as self-CC scheduling and cross-CC scheduling, respectively.

[141] For data transmission rate enhancement and stable control signaling, the 3GPP LTE/LTE-A may support aggregation of a plurality of CCs and a cross carrier-scheduling operation based on the aggregation.

[142] If cross-carrier scheduling (or cross-CC scheduling) is applied, a PDCCH for downlink allocation for a DL CC B or DL CC C, that is, carrying a DL grant may be transmitted through a DL CC A, and a corresponding PDSCH may be transmitted through the DL CC B or DL CC C. For cross-CC scheduling, a carrier indicator field (CIF) may be introduced. The presence or absence of the CIF within the PDCCH may be semi-statically and UE-specifically (or UE-group-specifically) configured by higher layer signaling (e.g., RRC signaling).

[143] Meanwhile, if RRH technology, cross-carrier scheduling technology, etc. are introduced, the amount of PDCCH which should be transmitted by the eNB is gradually increased. However, since a size of a control region within which the PDCCH may be transmitted is the same as before, PDCCH transmission acts as a bottleneck of system throughput. Although channel quality may be improved by the introduction of the aforementioned multi-node system, application of various communication schemes, etc., the introduction of a new control channel is required to apply the legacy commu-

nication scheme and the carrier aggregation technology to a multi-node environment. Due to the need, a configuration of a new control channel in a data region (hereinafter, referred to as PDSCH region) not the legacy control region (hereinafter, referred to as PDCCH region) has been discussed. Hereinafter, the new control channel will be referred to as an enhanced PDCCH (hereinafter, referred to as EPDCCH).

[144] The EPDCCH may be configured within rear OFDM symbols starting from a configured OFDM symbol, instead of front OFDM symbols of a subframe. The EPDCCH may be configured using continuous frequency resources, or may be configured using discontinuous frequency resources for frequency diversity. By using the EPDCCH, control information per node may be transmitted to a UE, and a problem that a legacy PDCCH region may not be sufficient may be solved. For reference, the PDCCH may be transmitted through the same antenna port(s) as that(those) configured for transmission of a CRS, and a UE configured to decode the PDCCH may demodulate or decode the PDCCH by using the CRS. Unlike the PDCCH transmitted based on the CRS, the EPDCCH is transmitted based on the demodulation RS (hereinafter, DMRS). Accordingly, the UE decodes/demodulates the PDCCH based on the CRS and decodes/demodulates the EPDCCH based on the DMRS. The DMRS associated with EPDCCH is transmitted on the same antenna port $p \in \{107,108,109,110\}$ as the associated EPDCCH physical resource, is present for EPDCCH demodulation only if the EPDCCH transmission is associated with the corresponding antenna port, and is transmitted only on the PRB(s) upon which the corresponding EPDCCH is mapped. For example, the REs occupied by the UE-RS(s) of the antenna port 7 or 8 may be occupied by the DMRS(s) of the antenna port 107 or 108 on the PRB to which the EPDCCH is mapped, and the REs occupied by the UE-RS(s) of antenna port 9 or 10 may be occupied by the DMRS(s) of the antenna port 109 or 110 on the PRB to which the EPDCCH is mapped. In other words, a certain number of REs are used on each RB pair for transmission of the DMRS for demodulation of the EPDCCH regardless of the UE or cell if the type of EPDCCH and the number of layers are the same as in the case of the UE-RS for demodulation of the PDSCH.

[145] For each serving cell, higher layer signalling can configure a UE with one or two EPDCCH-PRB-sets for EPDCCH monitoring. The PRB-pairs corresponding to an EPDCCH-PRB-set are indicated by higher layers. Each EPDCCH-PRB-set consists of set of ECCEs numbered from 0 to $N_{ECCE,p,k}$—1, where $N_{ECCE,p,k}$ is the number of ECCEs in EPDCCH-PRB-set p of subframe k. Each EPDCCH-PRB-set can be configured for either localized EPDCCH transmission or distributed EPDCCH transmission.

[146] The UE shall monitor a set of EPDCCH candidates on one or more activated serving cells as configured by higher layer signaling for control information.

[147] The set of EPDCCH candidates to monitor are defined in terms of EPDCCH UE-

specific search spaces. For each serving cell, the subframes in which the UE monitors EPDCCH UE-specific search spaces are configured by higher layers.

[148] An EPDCCH UE-specific search space $ES^{(L)}_k$ at aggregation level $L \in \{1,2,4,8,16,32\}$ is defined by a set of EPDCCH candidates.

[149] For an EPDCCH-PRB-set p, the ECCEs corresponding to EPDCCH candidate m of the search space $ES^{(L)}_k$ are given by the following equation.

[150] [Math.1]

$$L\left\{ (Y_{p,k} + \left\lfloor \frac{m \cdot N_{ECCE,p,k}}{L \cdot M_p^{(L)}} \right\rfloor + b) \bmod \lfloor N_{\mathrm{ECCE},p,k} / L \rfloor \right\} + i$$

[151] where $i=0,\ldots,L-1$. $b=n_{CI}$ if the UE is configured with a carrier indicator field for the serving cell on which EPDCCH is monitored, otherwise $b=0$. n_{CI} is the carrier indicator field (CIF) value, which is the same as a serving cell index (*ServCellIndex*). $m=0,1,\ldots,$ $M^{(L)}_p-1$, $M^{(L)}_p$ is the number of EPDCCH candidates to monitor at aggregation level L in EPDDCH-PRB-set p. The variable $Y_{p,k}$ is defined by '$Y_{p,k} = (A_p \cdot Y_{p,k-1}) \bmod D$', where $Y_{p,-1}=n_{RNTI} \neq 0$, $A_0=39827$, $A_0=39829$,$D=65537$ and $k=\mathrm{floor}(n_s/2)$. n_s is the slot number within a radio frame.

[152] A UE is not expected to monitor an EPDCCH candidate, if an ECCE corresponding to that EPDCCH candidate is mapped to a PRB pair that overlaps in frequency with a transmission of either PBCH or PSS/SSS in the same subframe.

[153] An EPDCCH is transmitted using an aggregation of one or several consecutive enhanced control channel elements (ECCEs). Each ECCE consists of multiple enhanced resource element groups (EREGs). EEREGs are used for defining the mapping of enhanced control channels to resource elements. There are 16 EREGs, numbered from 0 to 15, per physical resource block (PRB) pair. Number all resource elements (REs), except resource elements carrying DMRS (hereinafter EPDCCH DMRS) for demoduation of the EPDCCH, in a physical resource-block pair cyclically from 0 to 15 in an increasing order of first frequency, then time. Therefore all the REs, except REs carrying the EPDCCH DMRS, in the PRB pair has any one of numbers 0 to 15. All REs with number i in that PRB pair constitutes EREG number i.As described above, it is noted that EREGs are distributed on frequency and time axes within the PRB pair and an EPDCCH transmitted using aggregation of one or more ECCEs, each of which includes a plurality of EREGs, is also distributed on frequency and time axes within the PRB pair.

[154] The number of ECCEs used for one EPDCCH depends on the EPDCCH format as given by Table 10, the number of EREGs per ECCE is given by Table 11. Table 10 shows an example of supported EPDCCH formats, and Table 11 shows an example of

the number of EREGs per ECCE, N^{EREG}_{ECCE}. Both localized and distributed transmission is supported.

[155] [Table 10]

EPDCCH format	Number of ECCEs for one EPDCCH, N^{ECCE}_{EPDCCH}			
	Case A		Case B	
	Localized transmission	Distributed transmission	Localized transmission	Distributed transmission
0	2	2	1	1
1	4	4	2	2
2	8	8	4	4
3	16	16	8	8
4	-	32	-	16

[156] [Table 11]

Normal cyclic prefix			Extended cyclic prefix	
Normal subframe	Special subframe,configuration3, 4, 8	Special subframe,configuration1, 2, 6, 7, 9	Normal subframe	Special subframe,configuration1, 2, 3, 5, 6
4		8		

[157] An EPDCCH can use either localized or distributed transmission, differing in the mapping of ECCEs to EREGs and PRB pairs. One or two sets of PRB pairs which a UE shall monitor for EPDCCH transmissions can be configured. All EPDCCH candidates in EPDCCH set S_p (i.e., EPDCCH-PRB-set) use either only localized or only distributed transmission as configured by higher layers. Within EPDCCH set S_p in subframe k, the ECCEs available for transmission of EPDCCHs are numbered from 0 to $N_{ECCE,p,k}$—1. ECCE number n is corresponding to the following EREG(s):

[158] - EREGs numbered $(n \bmod N^{ECCE}_{RB})+jN^{ECCE}_{RB}$ in PRB index floor(n/N^{ECCE}_{RB}) for localized mapping, and

[159] - EREGs numbered floor $(n/N^{Sm}_{RB})+jN^{ECCE}_{RB}$ in PRB indices $(n+j\max(1,N^{Sp}_{RB}/N^{EREG}_{ECCE}))\bmod N^{Sp}_{RB}$ for distributed mapping,

[160] where $j=0,1,\ldots,N^{EREG}_{ECCE}-1$, N^{EREG}_{ECCE} is the number of EREGs per ECCE, and $N^{ECCE}_{RB}=16/N^{EREG}_{ECCE}$ is the number of ECCEs per RB pair. The PRB pairs constituting EPDCCH set S_p are assumed to be numbered in ascending order from 0 to $N^{Sp}_{RB}-1$.

[161] Case A in Table 10 applies when:

[162] - DCI formats 2, 2A, 2B, 2C or 2D is used and $N^{DL}_{RB}\geq 25$, or

[163] - any DCI format when n_{EPDCCH}<104 and normal cyclic prefix is used in normal subframes or special subframes with configuration 3, 4, 8.

[164] Otherwise case B is used. The quantity n_{EPDCCH} for a particular UE is defined as the number of downlink resource elements (k,l) in a PRB pair configured for possible EPDCCH transmission of EPDCCH set S_0 and and fulfilling all of the following criteria,

[165] - they are part of any one of the 16 EREGs in the physical resource-block pair,

[166] - they are assumed by the UE not to be used for CRSs or CSI-RSs,

[167] - the index l in a subframe fulfils $l \geq l_{EPDCCHStart}$.

[168] where $l_{EPDCCHStart}$ is given based on higher layer signaling '*epdcch*-StartSymbol-r11', higher layer signaling '*pdsch*-Start-r11', or CFI value carried by PCFICH.

[169] The mapping to resource elements (k,l) on antenna port p meeting the criteria above is in increasing order of first the index k and then the index l, starting with the first slot and ending with the second slot in a subframe.

[170] For localized transmission, the single antenna port p to use is given by Table 12 with $n' = n_{ECCE,low} \bmod N^{ECCE}_{RB} + n_{RNTI} \bmod \min(N^{ECCE}_{EPDCCH}, N^{ECCE}_{RB})$, where $n_{ECCE,low}$ is the lowest ECCE index used by this EPDCCH transmission in the EPDCCH set, n_{RNTI} corresponds to the RNTI associated with the EPDCCH transmission, and N^{ECCE}_{EPDCCH} is the number of ECCEs used for this EPDCCH.

[171] [Table 12]

n'	Normal cyclic prefix		Extended cyclic prefix
	Normal subframes,Special subframes,configurations3, 4, 8	Special subframes, configurations1, 2, 6, 7, 9	Any subframe
0	107	107	107
1	108	109	108
2	109	-	-
3	110	-	-

[172] For distributed transmission, each resource element in an EREG is associated with one out of two antenna ports in an alternating manner where $p \in \{107,109\}$ for normal cyclic prefix and $p \in \{107,108\}$ for extended cyclic prefix.

[173] Recently, machine type communication (MTC) has come to the fore as a significant communication standard issue. MTC refers to exchange of information between a machine and an eNB without involving persons or with minimal human intervention. For example, MTC may be used for data communication for measurement/

sensing/reporting such as meter reading, water level measurement, use of a surveillance camera, inventory reporting of a vending machine, etc. and may also be used for automatic application or firmware update processes for a plurality of UEs. In MTC, the amount of transmission data is small and UL/DL data transmission or reception (hereinafter, transmission/reception) occurs occasionally. In consideration of such properties of MTC, it would be better in terms of efficiency to reduce production cost and battery consumption of UEs for MTC (hereinafter, MTC UEs) according to data transmission rate. Since the MTC UE has low mobility, the channel environment thereof remains substantially the same. If an MTC UE is used for metering, reading of a meter, surveillance, and the like, the MTC UE is very likely to be located in a place such as a basement, a warehouse, and mountain regions which the coverage of a typical eNB does not reach. In consideration of the purposes of the MTC UE, it is better for a signal for the MTC UE to have wider coverage than the signal for the conventional UE (hereinafter, a legacy UE).

[174] When considering the usage of the MTC UE, there is a high probability that the MTC UE requires a signal of wide coverage compared with the legacy UE. Therefore, if the eNB transmits a PDCCH, a PDSCH, etc. to the MTC UE using the same scheme as a scheme of transmitting the PDCCH, the PDSCH, etc. to the legacy UE, the MTC UE has difficulty in receiving the PDCCH, the PDSCH, etc. Therefore, the present invention proposes that the eNB apply a coverage enhancement scheme such as subframe repetition (repetition of a subframe with a signal) or subframe bundling upon transmission of a signal to the MTC UE having a coverage issue so that the MTC UE can effectively receive a signal transmitted by the eNB. For example, the PDCCH and PDSCH may be transmitted to the MTC UE having the coverage issue in a plurality of subframes (e.g. about 100 subframes).

[175] FIG. 6 illustrates an example of signals band for MTC.

[176] As one method for reducing the cost of the MTC UE, an operation of the MTC UE may be performed at a reduced UE downlink and uplink bandwidth of 1.4 MHz, for example, regardless of an operating system bandwidth of a cell. At this time, a subband (narrowband) for operating the MTC UE may always be located at the center (e.g., 6 center PRBs) of a cell as shown in FIG. 6(a), or several subbands for MTC may be provided for one subframe to multiplex MTC UEs as shown in FIG. 6(b), whereby the UEs may use their respective subbands different from each other or the UEs use the same subband not the subband of 6 center PRBs.

[177] In this case, the MTC UE cannot receive a legacy PDCCH transmitted through a full system band normally, and transmission of PDCCH for the MTC UE from an OFDM symbol region within which the legacy PDCCH is transmitted may not be preferable due to multiplexing issue with a PDCCH transmitted to another UE. As one method for

solving this, it is required to introduce a control channel transmitted within a subband where MTC is operated for the MTC UE. As a downlink control channel for such a low-complexity MTC UE, the legacy EPDCCH may be used as it is. Or, M-PDCCH for the MTC UE which is a control channel of a modified type of the legacy PDCCH/ EPDCCH may be introduced. Hereinafter, in the present invention, the legacy EPDCCH or M-PDCCH for the low-complexity MTC UE or normal complexity MTC UE will be referred to as M-PDCCH. Also, MTC-EPDCCH is hereinafter used to refer to M-PDCCH.

[178] A data channel (e.g., PDSCH, PUSCH) and/or a control channel (e.g., M-PDCCH, PUCCH, PHICH) may be transmitted for coverage enhancement (CE) of the UE by using a repetition or TTI bundling scheme through multiple subframes. The control/ data channel may be transmitted by additionally using cross-subframe channel estimation and frequency (narrowband) hopping for CE. In this case, cross-subframe channel estimation means a channel estimation method means channel estimation using a reference signal within a subframe of a corresponding channel and a reference signal within neighboring subframe(s).

[179] The MTC UE may need CE of 15dB, for example. However, all MTC UEs do not exist in an environment that CE is needed. Also, the same requirements of QoS are not applied to all MTC UEs. For example, since devices such as sensor and meter have low mobility and are likely to be located in a shaded area even while having a small amount of data transmission and reception, the devices may need high CE. However, wearable devices such as smart watch may have mobility and are likely to be located in a place not a shaded area while having a relatively large amount of data transmission and reception. Therefore, all MTC UEs do not need CE of high level, and their requirement capability may be varied depending on their type.

[180] In the present invention, an operation for monitoring M-PDCCH by means of an MTC UE (which needs coverage enhancement (CE)) will be suggested. Hereinafter, M-PDCCH monitoring, search space monitoring, or M-PDCCH candidates monitoring may mean that reception or detection of M-PDCCH is attempted within a corresponding search space or from one of M-PDCCH candidates configuring the corresponding search space.

[181] In the following embodiments, the expression "assume" may mean that an entity for transmitting a channel transmits the channel to be suitable for the corresponding "assumption". An entity for receiving the channel may receive or decode the channel to be suitable for the corresponding "assumption" provided that the channel has been transmitted to be suitable for the corresponding "assumption".

[182] FIG. 7 illustrates repeated transmission of a channel for coverage enhancement.

[183] A search space for M-PDCCH may be configured over a plurality of downlink

subframes. For example, M-PDCCH search space having an aggregation level L and a repetition level R is defined by a set of M-PDCCH candidates. In this case, each M-PDCCH candidate may be repeated within a set of R number of consecutive downlink subframes. Referring to FIG. 7, in an example of maximum repetitions R_{max}=8 and a possible repetition level of $R \in \{1, 2, 4, 0\}$, a UE may attempt decoding of M-PDCCH by assuming that repetition of M-PDCCH (transmitted at an aggregation level L) exists in each of R number of consecutive downlink subframes. For example, the UE may attempt decoding of M-PDCCH by regarding signals received from each of 8 subframes as those of the same M-PDCCH in case of a repetition level $R = 8$ and attempt decoding of different M-PDCCHs in each of 8 subframes in case of a repetition level $R = 1$.

[184] In FIG. 7, repetition of a channel is performed over consecutive downlink subframes. However, a data channel and/or a control channel (hereinafter, data/control channel) transmitted to/from the MTC UE which needs CE may be transmitted by being repeated through non-consecutive subframes. For example, the control/data channel for a specific MTC UE may not be in all downlink subframes but may be restricted to some downlink subframes. Non-consecutive downlink subframes available at the MTC UE may be configured in such a manner that a downlink subframe group comprised of one or more consecutive downlink subframes is repeated with a periodicity greater than the number of subframes within the downlink subframe group. In other words, the data/control channel may be transmitted not in physically consecutive subframes, but transmitted in transmitted in each of physically non-consecutive subframes (excluding uplink subframes in case of downlink transmission, downlink subframes in case of uplink transmission, and/or subframes except subframe used for other purpose of use and cannot be used for data/control channel transmission). Use of non-consecutive (downlink or uplink) subframes for repeated transmission of the data/control channel of the MTC UE may increase transmission/reception latency. However, as time diversity effect is obtained in the time domain by use of non-consecutive subframes, the number of repetitions or the number of subframes used for channel transmission may be reduced as compared with transmission based on consecutive subframes. Therefore, overall system throughput may be increased. The embodiments of the present invention, which will be described later, suggest UE operation and transmission subframe during transmission/reception of a corresponding channel when a data/control channel transmitted from MTC UE is transmitted with repetition through consecutive subframes or non-consecutive subframes.

[185] In the following embodiments, each search space within an interval where a UE monitors M-PDCCH (CSS and/or USS) may be configured over one or more (consecutive or non-consecutive) downlink subframes. That is, a search space for

reception of the same M-PDCCH may be configured in each of one or more downlink subframes.

[186] For example, referring to FIG. 8, in case of no CE or CE having a repetition level = 1, each of CSSs of FIG. 8 may be CSS on which a respective M-PDCCH can be transmitted. At this time, a CSS starting subframe may mean a first subframe of paging occasions for allowing a UE to monitor M-PDCCH for a paging message. As another example, referring to FIG. 9, in case of no CE or CE having a repetition level = 1, each of CSSs of FIG. 9 may be CSS on which a respective M-PDCCH can be transmitted. At this time, a CSS starting subframe may mean a first subframe of a RAR window for allowing a UE to monitor M-PDCCH for scheduling RAR.

[187] In case of coverage enhancement (CE), M-PDCCH may be transmitted by being repeated once or multiple times. Therefore, a search space where M-PDCCH (hereinafter, paging M-PDCCH) will be monitored may be configured repeatedly over a plurality of downlink subframes, and a UE may attempt repeated reception of M-PDCCH within search spaces within the plurality of downlink subframes. If CE having a repetition level greater than 1 is applied, for example, each CSS shown in FIG. 8 may be a plurality of consecutive subframes that may have repetitions of M-PDCCH. If CE having a repetition level greater than 1 is applied, as another example, a plurality of CSSs within the same paging occasion shown in FIG. 8 may be CSSs for repetitions of the same M-PDCCH. If CE having a repetition level greater than 1 is applied, as still another example, a plurality of CSSs over a plurality of paging occasions shown in FIG. 8 may be CSSs for repetitions of the same M-PDCCH.

[188] ■ Section 1. M-PDCCH CSS for paging message scheduling

[189] In Section 1, details on M-PDCCH CSS for paging message scheduling are discussed.

[190] The paging message is used to notify UE(s) under RRC_IDLE and UE(s) under RRC_CONNECTED of system information modification.

[191] An eNB initiates a paging process by transmitting the paging message at a paging occasion of a UE. The eNB may address a plurality of UEs within the paging message by including a paging record (*PagingRecord*) per UE. The paging record may include information indicating NAS (non-access stratum) identifier of a UE which is paged and information indicating the origin of paging. One paging occasion means a subframe having P-RNTI transmitted on PDCCH/M-PDCCH addressing the paging message. A paging frame (PF) means one radio frame that includes one or a plurality of paging occasion(s).

[192] The UE may use discontinuous reception (DRX) in an idle mode to reduce power consumption. If DRX is used, the UE monitors only one paging occasion per DRX cycle.

[193] The paging message may be transmitted through a PDSCH, and the PDSCH carrying the paging message may be scheduled by PDCCH/M-PDCCH.

[194] For paging message scheduling, multiple narrowbands can be configured by eNB. Then, a narrowband location for a paging occasion monitoring of a UE is determined by at least UE ID at least for paging record(s). However, the narrowband location and paging occasion for common signal transmission (e.g., SI update, earthquake and tsunami warning system (ETWS), and/or commercial mobile alert system (CMAS)) is not determined yet. To reduce UE complexity, it would be beneficial to apply the same paging occasion and narrowband location for paging record(s) reception and other information reception such as SI update, ETWS, and CMAS. For example, the UE may attempt reception of M-PDCCH for scheduling the paging message on the same narrowband at the same paging occasion for SI update and reception of ETWS and CMAS instead of monitoring different paging occasions and/or different narrowbands for SI update and reception of ETWS and CMAS.

[195] FIG. 8 illustrates a configuration of a common search space (CSS) for paging according to the present invention.

[196] Under the assumption that a paging occasion is a time region for M-PDCCH monitoring for paging message scheduling, a UE can monitor a common search space (CSS) within a paging occasion to check paging message transmission. Depending on duration of paging occasion and period of CSS starting subframe, there can be multiple CSS monitoring opportunities within a paging occasion as shown in FIG. 8. The period and offset of CSS starting subframe location can be configured by eNB. In this case, offset k_{offset} of the CSS starting subframe may mean a difference from a reference subframe n (e.g., subframe 0) to a subframe $n+k_{offset}$ in which the CSS starting subframe is first applied.

[197] The composition of decoding candidates (i.e. M-PDCCH candidates) and a subset of $\{L, R\}$ for CSS for paging should be composed to supports all UEs with different CE levels. In this case, L indicates an aggregation level, and M-PDCCH of the aggregation level L is transmitted using aggregation of L number of M-CCEs. ECCE may be used as M-CCE, and CCE for MTC UE may newly be defined as M-CCE for MTC UE.

[198] To transmit paging message adapt to the target CE level, a subset of $\{L, R\}$ of CSS for paging needs to be composed to cover all range of CE levels or all range of repetition numbers. One simple configuration is $\{8, R1\}$, $\{16, R1\}$, $\{24, R1\}$, $\{24, R2\}$, $\{24, R3\}$, $\{24, R4\}$ where $R1 = 1$ and $R4$ is the maximum repetition level.

[199] In the present invention, a paging occasion may be defined as an interval where a UE monitors a paging M-PDCCH. For example, the UE may attempt reception of (same) paging M-PDCCH (or M-PDCCH scrambled by P-RNTI) within CSS(s) existing in the paging occasion or paging M-PDCCH search space(s) as shown in FIG. 8. Since the

paging M-PDCCH may be transmitted in any one of CSS(s) within the paging occasion, the UE continuously monitors the CSS(s) within the paging occasion. If the paging M-PDCCH (or M-PDCCH scrambled by P-RNTI) is received within the corresponding interval, the UE may receive a PDSCH carrying the corresponding paging message even though a paging message scheduled by the corresponding M-PDCCH, that is, a PDSCH carrying paging is transmitted outside a paging occasion interval.

[200] A duration of the paging occasion may be configured to be a multiple of the number of subframes configuring CSSs or search spaces on which the paging M-PDCCH is transmitted. For example, if the paging M-PDCCH search space is configured in each of R number of (consecutive or non-consecutive) downlink subframes, the paging occasion may be configured to have a duration of R*X number of subframes (where X is a positive integer).

[201] ■ Section 2. M-PDCCH CSS for RAR scheduling

[202] FIG. 9 illustrates a configuration of a common search space (CSS) for RAR according to the present invention.

[203] There would be multiple narrowbands for CSS for RAR scheduling, and the narrowband location of a UE for RAR monitoring is determined by PRACH resource set.

[204] After transmitting PRACH, a UE would try to receive RAR. Similar to paging occasion, there can be multiple CSS regions within a RAR window as depicted in Figure 9. So, the UE can monitor M-PDCCH scheduling RAR in CSS region(s) within the RAR window.

[205] A subset of $\{L, R\}$ and composition of decoding candidates of CSS for RAR can depend on CE level of corresponding PRACH resource set. For example, for each CE level, PRACH resource set(s) and available repetition level(s) may be configured. In this case, the UE may monitor a CSS, that is, M-PDCCH in accordance with a set of $\{L, R\}$ configured for a CE level associated with a PRACH resource used for a successful RACH procedure. Regardless of CSS and USS, same composition of decoding candidates and same subset of $\{L, R\}$ can be used for same CE level of the search space. For example, the UE may monitor a CSS and a USS in accordance with $\{L, R\}$ of the same set with respect to the same CE level.

[206] The present invention suggests that a RAR window interval should be defined as an interval where a UE monitor M-PDCCH (hereinafter, RAR M-PDCCH) for scheduling RAR. That is, as shown in FIG. 9, the UE may attempt reception of RAR M-PDCCH (e.g., M-PDCCH scheduled by RA-RNTI) on CSS(s) existing within a RAR window or a search space(s) (hereinafter, RAR M-PDCCH search space) on which RAR M-PDCCH is transmitted. If the UE receives RAR M-PDCCH within the corresponding interval, the UE may receive a PDSCH through which the corresponding RAR is

transmitted, even though RAR (e.g., PDSCH carrying RAR) scheduled by the corresponding M-PDCCH is transmitted outside the RAR window interval.

[207] A duration of the RAR window may be configured to become a multiple of the number of subframes configuring CSSs or RAR M-PDCCH search spaces. For example, if RAR M-PDCCH search space is configured in each of R number of (consecutive or non-consecutive) downlink subframes, the RAR window may be configured to have a duration of R*X number of subframes (in this case, X is a positive integer).

[208] ■ Section 3. M-PDCCH CSS for other purposes

[209] M-PDCCH CSS can be used to transmit DCIs for other purposes except paging message and RAR scheduling. For example, M-PDCCH CSS can be used for transmission of DCI for unicast data, DCI for TPC, DCI for enhanced interference management and traffic adaptation (eIMTA), and DCI for enhanced PHICH (EPHICH). If CSS is used to transmit these DCIs, the narrowband location, monitoring subframe location, and decoding candidates composition need to be specified. Hereinafter, the CSS will be referred to as CSS_regular or CSS_others.

[210] CSS for these purposes (i.e. CSS_regular) can be located in the same narrowband to USS. Then, a UE does not need to re-tune its operating frequency to monitor this CSS.

[211] To reconfigure CE level of a UE, the CSS needs to support the maximum CE level of the cell considering CE level reconfiguration message can be transmitted by this CSS. Therefore, CE level or a subset of $\{L, R\}$ composing the CSS should support all CE level of the cell.

[212] FIG. 10 illustrates the example of the monitoring time region of USS and CSS.

[213] Period of starting subframe for M-PDCCH USS monitoring and CSS monitoring can be configured independently. The period of CSS monitoring can be longer than the period of USS, since CE level of USS and CSS can be different and CSS can be occurred sparsely to reduce UE complexity.

[214] Referring to Math Figure 1 which is a hashing function, it is noted that $Y_{p,k}$ is varied depending on n_{RNTI} which is UE ID. In this way, CCE(s) or ECCE(s) configuring decoding candidates in the USS is(are) determined UE-specifically to be monitored by a specific UE. M-PDCCH CSS can be monitored by a group of MTC UEs. Therefore, for CSS, there should not be a hashing function to randomize the starting ECCE location composing a search space UE-specifically.

[215] ■ Section 4. Coverage enhancement level of CSS

[216] For transmission of a broadcast PDSCH (e.g., paging, RAR), CSSs for other purposes such as unicast data, TPC, eIMTA DCI and EPHICH may exist, and USS where a UE monitors unicast data may exist. Hereinafter, a coverage enhancement level of corresponding search spaces will be described.

[217] The present invention suggests that a plurality of SS types exist as follows in accordance with a coverage enhancement level supported by a search space or repetitions of M-PDCCH.

[218] - Method 1.

[219] In view of the UE, two types of search spaces (SSs) may exist as follows:

[220] * SS type 1: SS supporting all coverage enhancement levels or all repetitions of M-PDCCH, and

[221] * SS type 2: SS where the number of repetitions of M-PDCCH which is supported is varied depending on a coverage enhancement level of the UE.

[222] In this case, the UE may assume that CSS for paging and/or CSS_regular has SS type 1, and CSS and/or USS for RAR has SS type 2.

[223] Alternatively, as SS monitored by the UE, one SS having SS type 1 and one SS having SS type 2 may exist. CSS for paging and/or CSS_regular may be the same as SS having SS type 1, and CSS and/or USS for RAR may be the same as SS having SS type 2.

[224] - Method 2.

[225] When N number of coverage enhancement levels (or the number of repetitions of M-PDCCH) supported by a cell exist, in view of the cell, a plurality of SS types may exist as follows:

[226] * SS type 1: SS supporting coverage enhancement level 1 (or the number of repetitions R_1 of M-PDCCH),

[227] * SS type 2: SS supporting coverage enhancement level 2 (or the number of repetitions R_2 of M-PDCCH),

[228] ...

[229] * SS type N: SS supporting coverage enhancement level N (or the number of repetitions R_N of M-PDCCH),

[230] * SS type N+1: SS supporting all coverage enhancement levels (or all repetitions for M-PDCCH).

[231] In this case, SS supporting the coverage enhancement level n may mean SS supporting the coverage enhancement levels 1 to n or the maximum number of repetitions R_n of M-PDCCH.

[232] In this case, the UE may assume that the CSS for paging and CSS_regular has SS type N+1, and the CSS for RAR and/or USS has SS type k if the coverage enhancement level of the UE is k.

[233] ■ Section 5. Relationship between search spaces

[234] **CSS for paging (i.e., CSS_paging)**

[235] It is a CSS for paging monitoring in RRC_IDLE state. Since UEs in different CE levels monitor the same CSS for paging scheduling, it should be designed to cover all

the CE levels. CSS_paging are configured by SIB. In other words, the configuration of CSS_paging may be transmitted through SIB. The UE may identify the configuration of CSS_paging by reading SIB. The UE may monitor M-PDCCH candidates of CSS within subframe(s) and/or narrowband(s) according to the CSS_paging configuration.

[236] **CSS for** RAR corresponding to initial RACH procedure (i.e., CSS_RAR)

[237] Using CSS for RAR, a UE can monitor RAR, Msg3 (for retransmission), and Msg4. Though it can be considered to allow separate SS configurations for Msg3 re-transmission and Msg4 scheduling M-PDCCH from the SS configuration for RAR, given that those (i.e. RAR, Msg3 and Msg4) will be used only for initial access, the present invention proposes that the same configuration is used for initial RACH procedure. Required configurations for CSS_RAR can be configured by SIB per CE level. Then, in a UE perspective, configurations for CSS_RAR can be determined based on the CE level of PRACH resource set used for the latest PRACH transmission.

[238] **CSS for others (i.e., CSS_others or CSS_regular)**

[239] M-PDCCH CSS can be used to transmit DCIs for other purposes except paging message and initial RAR scheduling. For example, CSS is required to transmit TPC, unicast data for reconfiguration (such as CE level, transmission mode, USS recon-figuration), a DCI transmitting multiple HARQ-ACK corresponding to PUSCH to multiple UEs (if supported), transmit RAR corresponding to PRACH triggered by M-PDCCH order. CSS for these purposes can be located in the same narrowband to USS once a UE is connected to the network. Then, a UE does not need to re-tune its operating frequency to monitor this CSS. A UE can monitor CSS_others (i.e., CSS_regular) and USS simultaneously.

[240] If there is a complexity issue, TDM of CSS and USS monitoring can be considered. In other words, CSS and USS are time-division multiplexed, whereby the CSS and the USS may not be monitored at the same time.

[241] If CSS for other purposes are not defined, legacy PUCCH TPC via DCI format 3/3A cannot be supported. Then, if downlink traffic is occurred sparsely, it could be difficult to adopt PUCCH power since PUCCH TPC is accomplished by accumulated way. So, other way to handle this issue needs to be considered such as absolute PUCCH TPC via DL grant or unicast DCI for PUCCH TPC transmitted by USS. Thus, at least for CE mode A (for TCP and reconfiguration), CSS_others needs to be supported.

[242] **USS**

[243] USS is a search space for unicast data scheduling. Configurations for USS can be configured by SIB and Msg4. If necessary, reconfiguration can be utilized by radio resource control (RRC) layer (i.e. RRC signal). Configurations for USS also can be applied for CSS_others. In this case, individual configurations for CSS_others and USS may not be required.

[244] FIG. 11 illustrates a procedure of configuring a search space according to the present invention.

[245] Referring to FIG. 11, the UE may receive a list of search space (SS) configurations per CE level for RAR through SIB (S1101). The UE may transmit RACH preamble through PRACH by using a PRACH resource. PRACH resource(s) per CE level may be configured by SIB. The UE may monitor M-PDCCH for scheduling a response to the RACH preamble transmitted therefrom, that is, a response to transmission of the PRACH in a search space (S1103). The UE may assume that a search space for M-PDCCH scheduling the RAR depends on SS configuration (e.g., CSS_RAR configuration) received through the SIB. The UE which has received RAR M-PDCCH may receive RAR in accordance with DCI carried by the RAR M-PDCCH (S1105).

[246] Initial configuration for RAR, Msg3 and/or Msg4 may depend on SS configuration per CE level received (S1101) through SIB (S1121). The UE may monitor M-PDCCH for scheduling Msg4, which includes CSS configuration/reconfiguration and/or USS configuration/reconfiguration parameters, in the SS according to initial configuration through SIB (S1121). For example, the UE may monitor Msg4 M-PDCCH by assuming that the maximum number of repetitions, narrowband, PRB-set, etc. which are the same as those of CSS for RAR, are also applied to M-PDCCH (hereinafter, Msg4 M-PDCCH) for scheduling Msg4 (S1121). The UE which has received Msg4 M-PDCCH may receive Msg4 in accordance with DCI of the Msg4 M-PDCCH (S1123). The Msg4 may carry RRC message that includes UE-specific configuration for USS and/or CSS. In this case, the UE may monitor M-PDCCH by applying the UE-specific SS configuration instead of initial SS configuration (S1125).

[247] The UE may monitor M-PDCCH order within the CSS according to the UE-specific CSS configuration (S1141). The UE which has received the M-PDCCH order may receive RAR in accordance with scheduling information carried by the M-PDCCH order (S1143).

[248] The UE may monitor M-PDCCH for scheduling RRC message having UE-specific reconfiguration parameter(s) within the CSS according to the UE-specific CSS configuration (S1161). The UE-specific reconfiguration may include M-PDCCH configuration. The UE which has received the M-PDCCH may receive a PDSCH carrying the RRC message in accordance with scheduling information (that is, DCI) of the M-PDCCH (S1163). The UE may reconfigure M-PDCCH search space in accordance with the UE-specific reconfiguration.

[249] Table 13 illustrates parameters and configuration details required for search spaces. All or some of the parameters illustrated in Table 13 may be configured and/or reconfigured in accordance with Table 13.

[250] [Table 13]

Parameters	Configuration details				Description
	CSS_paging	CSS_RAR	CSS_others	USS	
Subset of L	Fixed to {8, 16, 24}			{1, 2, 4, 8, 16, 24}	
R_{max}	Configurable by SIB.	Configured by SIB per CE level (configuration can be shared for CSS_RAR, CSS_others, USS).For CSS_others/USS, it can be reconfigured by RRC.			Subset of repetition numbers is determined based on R_{max}. Details are described in Subsection 5.1.
PRB-sets	Configured by SIB.	Configured by SIB per CE level specific and cell-specific.	Alt 1. Configured by Msg4 per UE.Alt 2. Configured by SIB per CE level (in this case, same configuration for CSS_RAR, CSS_others, USS).It can be reconfigured by RRC.		This configuration includes the number of PRB-sets, PRB size/ location of each PRB-set.
Transmission type	Configured by SIB per PRB-set.	Configured by SIB per PRB-set.	Alt 1. Configured by Msg4 per UE (the network ensures the same type is used beween CSS_others and USS in case both are monitored at the same time).Alt 2. Configured by SIB per CE level (in this case, same configuration for CSS_RAR, CSS_others, USS).It can be reconfigured by RRC.		
Narrowband	Determined	Based on	Default value can be		

	by UE ID among paging narrowbands configured by SIB.	PRACH resource set where RAR narrowband corresponding to each PRACH resource set is configured by SIB.	CSS_RAR's narrowband location. Configurable by Msg 4 per UEIt can be reconfigured by RRC.	
M-PDCCH monitoring starting	Alt 1. Configured by SIB per CE level.Alt 2. Configured by SIB regardless of CE level (one maximum value to reset monitoring starting subframe).			See FIG. 7 and Subsection 5.1.
M-PDCCH starting subframe	Determined by repetition number R per repetition number R.	Alt 1. Determined by R_{max} for CE Mode A, determined by repetition number R per repetition number R for CE Mode B.Alt 2. Determined by repetition number R per repetition number R.		See FIG. 7 and Subsection 5.1.

[251] In Table 13, a merged cell means that the configuration can be shared by corresponding search spaces, so individual configuration is not needed for each search space. For example, referring to Table 13, "Fixed to {8, 16, 24}" which is the description of a subset of an aggregation level L exists within a cell merged for CSS_paging, CSS_RAR and CSS_others (i.e., CSS_regular), and thus means that a corresponding parameter is not required to be configured individually for CSS_paging, CSS_RAR and CSS_others(i.e. CSS_reguar) and a common parameter is applied to CSS_paging, CSS_RAR and CSS_others. According to Table 13, the UE may attempt reception of M-PDCCH at an aggregation level $L\in\{8, 16, 24\}$ for CSS_paging, CSS_RAR and CSS_others, and may attempt reception of M-PDCCH at $L\in\{1, 2, 4, 8, 16, 24\}$ for the USS.

[252] Reconfigurable parameters in Table 13 mean that the same value as initial configuration or default configuration is applied until a corresponding parameter is reconfigured, whereby search space(s) is(are) configured.

[253] For example, referring to Table 13, the maximum number of repetitions R_{max} of M-PDCCH may be provided through SIB as a configuration for CSS_RAR. The UE may monitor CSS_RAR, CSS_others and/or USS by assuming that R_{max} included in the SIB is applied to CSS_RAR, CSS_others, and USS. That is, the UE may monitor rep-

etitions of M-PDCCH in SS within maximum R_{max} number of subframes. According to Table 13, since R_{max} for CSS_others and/or USS (hereinafter, CSS_others/USS) may be reconfigured, if R_{max} for CSS_others/USS is reconfigured by RRC signal, the UE may monitor CSS_others/USS in accordance with the reconfigured R_{max}. In other words, the UE may monitor CSS_others/USS in accordance with R_{max} for CSS_RAR until R_{max} for CSS_others/USS is received.

[254] For another example, referring to parameters of PRB-sets in Table 13, PRBs on which PRB-set(s) for CSS_RAR, that is, RAR M-PDCCH may be transmitted may be configured CE level-specifically and cell-specifically by SIB. Referring to Alt 2, these PRB-sets configured per CE level may be applied to CSS_others and USS by SIB. Since PRB-set parameter for CSS_others and USS may be reconfigured by RRC, the UE may monitor CSS_others/USS by applying PRB-set(s) for CSS_RAR until reconfiguration PRB-set parameter for CSS_others/USS is received, and may monitor CSS_others/USS by applying the reconfiguration PRB-set parameter if the reconfiguration PRB-set parameter for CSS_others/USS is received. For example, if PRB-set(s) of CSS_RAR are fixed to 6, the UE may monitor M-PDCCH USS by assuming all PRBs within a narrowband according to CSS_RAR configuration as PRB-set(s) for USS until configuration of separate PRB-set(s) for USS is received.

[255] For still another example, referring to a narrowband parameter of Table 13, a narrowband (hereinafter, RAR narrowband) having CSS_RAR may be determined based on a PRACH resource set. In this case, a corresponding RAR narrowband per PRACH resource set is configured by SIB. A default narrowband location of CSS_others and/or USS may be a narrowband location of CSS_RAR. A narrowband for CSS_others/USS may be configured per UE by Msg4, and may be reconfigured by RRC. Therefore, the UE may monitor CSS_others/USS on the same narrowband as that for CSS_RAR until a narrowband parameter for CSS_others/USS is received, and if Msg4 for CSS_others/USS or reconfiguration RRC message is received, may monitor CSS_others/USS on a narrowband according to the Msg4 or the RRC message.

[256] □ Subsection 5.1. Aggregation levels and repetition numbers

[257] Search space configuration parameters of Table 13 may be applied as follows in view of an aggregation level and the number of repetitions. For example, a subset (and/or starting subframe of M-PDCCH SS and/or starting subframe of M-PDCCH) of the number of repetitions R based on R_{max} may be determined in accordance with the following description.

[258] **CSS for paging (i.e., CSS_paging)**

[259] - Aggregation levels:

[260] Since data transmission scheduled by CSS is targeted to multicast/broadcast, similar

to PDCCH CSS, some high aggregation levels can be supported. Aggregation levels (ALs) {8, 16, 24} can be supported for normal CP and ALs {4, 8, 12} can be supported for extended CP.

[261] - Repetition numbers:

[262] A subset of R for CSS for paging monitoring depends on the maximum R (i.e., R_{max}) where R_{max} is configured by SIB. To support wide range of repetition numbers, the subset of R monitored for CSS_paging can be {$R_{max}/64$, $R_{max}/16$, $R_{max}/4$, R_{max}}.

[263] **CSS for** RAR corresponding to initial RACH procedure (i.e., CSS_RAR)

[264] - Aggregation levels:

[265] Similar to CSS_paging, ALs $L \in \{8, 16, 24\}$ can be supported for normal CP and ALs $L \in \{4, 8, 12\}$ can be supported for extended CP.

[266] - Repetition numbers:

[267] For CSS scheduling RAR, the subset of R depends on the maximum R (i.e., R_{max}) where R_{max} is configured by SIB per CE level. The subset of R monitored for CSS_RAR can be {$R_{max}/4$, $R_{max}/2$, R_{max}}.

[268] **CSS for others (i.e., CSS_others)**

[269] - Aggregation levels:

[270] Similar to CSS_paging, ALs $L \in \{8, 16, 24\}$ can be supported for normal CP and ALs $L \in \{4, 8, 12\}$ can be supported for extended CP.

[271] - Repetition numbers:

[272] For CSS_others, the subset of R depends on the maximum R (i.e., R_{max}) where R_{max} is configured by SIB per CE level or Msg4. R_{max} can be reconfigured by RRC if necessary. The subset of R monitored for CSS_others can be {$R_{max}/4$, $R_{max}/2$, R_{max}}. Or, to reduce UE complexity, the subset of R monitored for CSS_others can be {$R_{max}/2$, R_{max}}.

[273] **USS**

[274] - Aggregation levels:

[275] For CE Mode A, ALs $L \in \{1, 2, 4, 8, 16, 24\}$ are supported for normal CP. ALs $L \in \{1, 2, 4, 8, 12\}$ are supported for extended CP. For CE Mode B, ALs $L \in \{8, 16, 24\}$ is supported for normal CP. ALs $L \in \{4, 8, 12\}$ are supported for extended CP.

[276] - Repetition numbers:

[277] For USS, the subset of R depends on the maximum R (i.e., R_{max}) where R_{max} is configured by SIB per CE level or Msg4. R_{max} can be reconfigured by RRC if necessary. The subset of R monitored for USS can be {$R_{max}/4$, $R_{max}/2$, R_{max}}. Or, to support higher R to CSS_others for CE level reconfiguration reliably, subset of R monitored for USS can be {$R_{max}/8$, $R_{max}/4$, $R_{max}/2$}.

[278] ■ Section 6. Collision of M-PDCCH(s)

[279] If there are some subframes not available for downlink transmission, M-

PDCCH/PDSCH transmission or repetitions can be postponed till the next available subframe. It can be applied in case unavailable subframes are aligned between eNB and UE.

[280] FIG. 12 illustrates a configuration of M-PDCCH repeated transmission according to the present invention.

[281] If a small interval (e.g., cycle of starting subframe of M-PDCCH search space) of M-PDCCH search space is configured or a large number of invalid subframes, which cannot have M-PDCCH, are provided between M-PDCCH search space starting subframes, M-PDCCH2 transmission may not end until next starting subframe of the search space, in the same manner as M-PDCCH2 transmission of FIG. 12. That is, the subframes configuring two search spaces may be overlapped with each other. In this case, the UE may be in the status that the UE should perform monitoring for M-PDCCH transmitted in a previous search space and monitoring for M-PDCCH transmitted in a next search space. However, this operation may not be preferable due to buffer size and complexity issue of the UE. In this case, the UE may perform reception of M-PDCCH as follows.

[282] - Method 1. If a starting time (hereinafter, subframe #n) of next search space occurs before reception of M-PDCCH is ended, the UE may assume that the M-PDCCH is transmitted up to subframe #n-1 and is not transmitted in subframe #n. In this case, the UE may attempt reception of the M-PDCCH by using repetitions smaller than the number of expected repetitions of M-PDCCH.

[283] - Method 2. If a starting time (hereinafter, subframe #n) of next search space occurs before reception of M-PDCCH is ended, the UE may determine that the M-PDCCH that the UE is receiving is invalid, and may not perform reception of the corresponding M-PDCCH.

[284] - Method 3. If subframe(s) configuring two search spaces are overlapped with each other, the UE may determine that a search space existing at an earlier time is invalid, and may not perform reception of M-PDCCH for one of the two search space, which is first started in a time domain.

[285] FIG. 13 is a block diagram illustrating elements of a transmitting device 10 and a receiving device 20 for implementing the present invention.

[286] The transmitting device 10 and the receiving device 20 respectively include Radio Frequency (RF) units 13 and 23 capable of transmitting and receiving radio signals carrying information, data, signals, and/or messages, memories 12 and 22 for storing information related to communication in a wireless communication system, and processors 11 and 21 operationally connected to elements such as the RF units 13 and 23 and the memories 12 and 22 to control the elements and configured to control the memories 12 and 22 and/or the RF units 13 and 23 so that a corresponding device may

perform at least one of the above-described embodiments of the present invention.

[287] The memories 12 and 22 may store programs for processing and controlling the processors 11 and 21 and may temporarily store input/output information. The memories 12 and 22 may be used as buffers.

[288] The processors 11 and 21 generally control the overall operation of various modules in the transmitting device and the receiving device. Especially, the processors 11 and 21 may perform various control functions to implement the present invention. The processors 11 and 21 may be referred to as controllers, microcontrollers, microprocessors, or microcomputers. The processors 11 and 21 may be implemented by hardware, firmware, software, or a combination thereof. In a hardware configuration, application specific integrated circuits (ASICs), digital signal processors (DSPs), digital signal processing devices (DSPDs), programmable logic devices (PLDs), or field programmable gate arrays (FPGAs) may be included in the processors 11 and 21. Meanwhile, if the present invention is implemented using firmware or software, the firmware or software may be configured to include modules, procedures, functions, etc. performing the functions or operations of the present invention. Firmware or software configured to perform the present invention may be included in the processors 11 and 21 or stored in the memories 12 and 22 so as to be driven by the processors 11 and 21.

[289] The processor 11 of the transmitting device 10 performs predetermined coding and modulation for a signal and/or data scheduled to be transmitted to the outside by the processor 11 or a scheduler connected with the processor 11, and then transfers the coded and modulated data to the RF unit 13. For example, the processor 11 converts a data stream to be transmitted into K layers through demultiplexing, channel coding, scrambling, and modulation. The coded data stream is also referred to as a codeword and is equivalent to a transport block which is a data block provided by a MAC layer. One transport block (TB) is coded into one codeword and each codeword is transmitted to the receiving device in the form of one or more layers. For frequency up-conversion, the RF unit 13 may include an oscillator. The RF unit 13 may include N_t (where N_t is a positive integer) transmit antennas.

[290] A signal processing process of the receiving device 20 is the reverse of the signal processing process of the transmitting device 10. Under control of the processor 21, the RF unit 23 of the receiving device 20 receives radio signals transmitted by the transmitting device 10. The RF unit 23 may include N_r (where N_r is a positive integer) receive antennas and frequency down-converts each signal received through receive antennas into a baseband signal. The processor 21 decodes and demodulates the radio signals received through the receive antennas and restores data that the transmitting device 10 intended to transmit.

[291] The RF units 13 and 23 include one or more antennas. An antenna performs a function for transmitting signals processed by the RF units 13 and 23 to the exterior or receiving radio signals from the exterior to transfer the radio signals to the RF units 13 and 23. The antenna may also be called an antenna port. Each antenna may correspond to one physical antenna or may be configured by a combination of more than one physical antenna element. The signal transmitted from each antenna cannot be further deconstructed by the receiving device 20. An RS transmitted through a corresponding antenna defines an antenna from the view point of the receiving device 20 and enables the receiving device 20 to derive channel estimation for the antenna, irrespective of whether the channel represents a single radio channel from one physical antenna or a composite channel from a plurality of physical antenna elements including the antenna. That is, an antenna is defined such that a channel carrying a symbol of the antenna can be obtained from a channel carrying another symbol of the same antenna. An RF unit supporting a MIMO function of transmitting and receiving data using a plurality of antennas may be connected to two or more antennas.

[292] In the embodiments of the present invention, a UE operates as the transmitting device 10 in UL and as the receiving device 20 in DL. In the embodiments of the present invention, an eNB operates as the receiving device 20 in UL and as the transmitting device 10 in DL. Hereinafter, a processor, an RF unit, and a memory included in the UE will be referred to as a UE processor, a UE RF unit, and a UE memory, respectively, and a processor, an RF unit, and a memory included in the eNB will be referred to as an eNB processor, an eNB RF unit, and an eNB memory, respectively.

[293] The eNB processor of the present invention may configure or reconfigure CSS_paging in accordance with section 1, section 5 and/or section 6. The eNB processor may control the eNB RF unit to transmit SIB or RRC message, which includes configuration for CSS_paging, to the UE in accordance with section 1, section 5 and/or section 6. The eNB processor may control the eNB RF unit to transmit M-PDCCH for scheduling a paging message within CSS_paging according to CSS_paging configuration. The UE processor of the present invention may control the UE RF unit to receive configuration or reconfiguration information on CSS_paging from the eNB in accordance with section 1, section 5 and/or section 6. The UE may attempt reception of paging M-PDCCH from CSS_paging according to the CSS_paging configuration.

[294] The eNB processor of the present invention may configure or reconfigure CSS_RAR in accordance with section 2, section 5 and/or section 6. The eNB processor may control the eNB RF unit to transmit SIB or RRC message, which includes configuration for CSS_RAR, to the UE in accordance with section 2, section 5 and/or section 6. The eNB processor may control the eNB RF unit to transmit M-PDCCH for

scheduling RAR, Msg3 and/or Msg4 within a CSS according to CSS_RAR configuration. The UE processor of the present invention may control the UE RF unit to receive configuration or reconfiguration information on CSS_RAR from the eNB in accordance with section 2, section 5 and/or section 6. The UE may attempt reception of RAR M-MPDCCH, Msg3 M-PDCCH and/or Msg4 M-PDCCH from the CSS according to the CSS_RAR configuration.

[295] The eNB processor of the present invention may configure or reconfigure CSS_others in accordance with section 3, section 5 and/or section 6. The eNB processor may control the eNB RF unit to transmit SIB or RRC message, which includes configuration for CSS_others, to the UE in accordance with section 3, section 5 and/or section 6. The eNB processor may control the eNB RF unit to transmit M-PDCCH for other purpose within a CSS according to CSS_others configuration. The UE processor of the present invention may control the UE RF unit to receive configuration or reconfiguration information on CSS_others from the eNB in accordance with section 3, section 5 and/or section 6. The UE may attempt reception of M-PDCCH for other purpose from the CSS according to the CSS_others configuration.

[296] The eNB processor of the present invention may transmit initial configuration for CSS through SIB in accordance with section 6. The eNB processor may configure CSS and/or USS in accordance with the initial configuration until the other configuration (e.g., UE-specific configuration/reconfiguration) for SS is transmitted. The initial configuration may include a configuration (e.g., narrowband, PRB-set(s), starting subframe and/or period, and the number of maximum repetitions of SS) of time-frequency resources of SS. The eNB processor may transmit M-PDCCH in accordance with the initial configuration until the other configuration for SS is transmitted. For example, the eNB processor may control the eNB RF unit to transmit M-PDCCH by applying the number of repetitions R based on maximum R_{max} according to the initial configuration within the PRB-set according to the initial configuration on a narrowband according to the initial configuration. If the other configuration for SS is transmitted, the eNB processor may control the eNB RF unit to transmit M-PDCCH on the SS configured in accordance with the other configuration. The UE processor may receive the initial configuration for CSS through SIB in accordance with section 6. The UE processor may assume that CSS and/or USS is configured in accordance with the initial configuration until the other configuration (e.g., UE-specific configuration/reconfiguration) for SS is received. The UE processor may monitor M-PDCCH in accordance with the initial configuration until the other configuration for SS is transmitted. For example, the UE processor may control the UE RF unit to receive or monitor M-PDCCH by applying the number of repetitions R based on maximum R_{max} according to the initial configuration within the PRB-set according to the initial con-

figuration on a narrowband according to the initial configuration. If the other configuration for SS is received, the UE processor may control the UE RF unit to receive or monitor M-PDCCH on the SS configured in accordance with the other configuration.

[297] As described above, the detailed description of the preferred embodiments of the present invention has been given to enable those skilled in the art to implement and practice the invention. Although the invention has been described with reference to exemplary embodiments, those skilled in the art will appreciate that various modifications and variations can be made in the present invention without departing from the spirit or scope of the invention described in the appended claims. Accordingly, the invention should not be limited to the specific embodiments described herein, but should be accorded the broadest scope consistent with the principles and novel features disclosed herein.

Industrial Applicability

[298] The embodiments of the present invention are applicable to a BS, a UE, or other devices in a wireless communication system.

Claims

[Claim 1] A method for receiving, by a user equipment (UE), downlink control information (DCI) for the UE, the method comprising:
receiving, by the UE, a common search space configuration for a common search space;
receiving, by the UE, a first physical downlink control channel (PDCCH) scheduling a random access response by monitoring first PDCCH candidates of the common search space according to the common search space configuration; and
receiving, by the UE, a second PDCCH carrying the DCI for the UE by monitoring second PDCCH candidates of a UE-specific search space,
wherein the second PDCCH candidates of the UE-specific search space are monitored according to the same configuration as the common search space configuration until the UE receives a UE-specific search space configuration.

[Claim 2] The method according to claim 1,
wherein the common search space configuration includes information on a narrowband for the common search space, and
wherein the second PDCCH candidates of the UE-specific search space are monitored on the same narrowband as the narrowband for the common search space until the UE receives a UE-specific search space configuration.

[Claim 3] The method according to claim 1 or 2,
wherein the common search space configuration includes information on a maximum number of repetitions for the common common search space, and
wherein the second PDCCH candidates of the UE-specific search space are monitored based on the same number as the maximum number of repetitions for the common search space until the UE receives a UE-specific search space configuration.

[Claim 4] The method according to any one of claims 1 to 3,
wherein the common search space configuration includes information on a first physical resource block (PRB) set for monitoring the first PDCCH, and
wherein the same physical resource block set as the first PRB set is used for monitoring the second PDCCH candidates until the UE receives a UE-specific search space configuration.

[Claim 5] The method according to any one of claims 1 to 4,
wherein the first PDCCH candidates of the common search space are monitored according to aggregation levels larger than or equal to 8 among a plurality of aggregation levels, and the second PDCCH candidates of the UE-specific search space are monitored according to the plurality of aggregation levels.

[Claim 6] A method for transmitting, by a base station (BS), downlink control information (DCI) for a user equipment (UE), the method comprising:
transmitting, by the BS, common search space configuration for a common search space;
transmitting, by the BS to the UE, a first physical downlink control channel (PDCCH) scheduling a random access response by using one of first PDCCH candidates of the common search space according to the common search space configuration; and
transmitting, by the BS to the UE, a second PDCCH carrying the DCI for the UE by using one of second PDCCH candidates of a UE-specific search space,
wherein the second PDCCH candidates of the UE-specific search space are configured according to the same configuration as the common search space configuration until a UE-specific search space configuration is transmitted to the UE.

[Claim 7] The method according to claim 6,
wherein the common search space configuration includes information on a narrowband for the common search space, and
wherein the second PDCCH candidates of the UE-specific search space are configured on the same narrowband as the narrowband for the common search space until the UE-specific search space configuration is transmitted to the UE.

[Claim 8] The method according to claim 6 or 7,
wherein the common search space configuration includes information on a maximum number of repetitions for the first common search space, and
wherein the second PDCCH candidates of the UE-specific search space are configured based on the same number as the maximum number of repetitions for the common search space until the UE-specific search space configuration is transmitted to the UE.

[Claim 9] The method according to any one of claims 6 to 8,
wherein the common search space configuration includes information

on a first physical resource block (PRB) set for transmitting the first PDCCH, and
wherein the same physical resource block set as the first PRB set is used for the second PDCCH candidates until the UE-specific search space configuration is transmitted to the UE.

[Claim 10] The method according to any one of claims 6 to 9,
wherein the first PDCCH candidates of the common search space are configured according to aggregation levels larger than or equal to 8 among a plurality of aggregation levels, and the second PDCCH candidates of the UE-specific search space are configured according to the plurality of aggregation levels.

[Claim 11] A user equipment (UE) for receiving downlink control information (DCI) for the UE, the UE comprising:
a radio frequency (RF) unit, and
a processor connected to the RF unit, the processor configured to:
control the RF unit to receive common search space configuration for a common search space;
control the RF unit to receive a first physical downlink control channel (PDCCH) scheduling a random access response by monitoring first PDCCH candidates of the common search space according to the common search space configuration; and
control the RF unit to receive a second PDCCH carrying the DCI for the UE by monitoring second PDCCH candidates of a UE-specific search space,
wherein the second PDCCH candidates of the UE-specific search space are monitored according to the same configuration as the common search space configuration until the UE receives a UE-specific search space configuration.

[Claim 12] The UE according to claim 11,
wherein the common search space configuration includes information on a narrowband for the common search space, and
wherein the second PDCCH candidates of the UE-specific search space are monitored on the same narrowband as the narrowband for the common search space until the UE receives a UE-specific search space configuration.

[Claim 13] The UE according to claim 11 or 12,
wherein the common search space configuration includes information on a maximum number of repetitions for the common common search

space, and
wherein the second PDCCH candidates of the UE-specific search space are monitored based on the same number as the maximum number of repetitions for the common search space until the UE receives a UE-specific search space configuration.

[Claim 14] The UE according to any one of claims 11 to 13,
wherein the common search space configuration includes information on a first physical resource block (PRB) set for monitoring the first PDCCH, and
wherein the same physical resource block set as the first PRB set is used for monitoring the second PDCCH candidates until the UE receives a UE-specific search space configuration.

[Claim 15] The UE according to any one of claims 11 to 14,
wherein the first PDCCH candidates of the common search space are monitored according to aggregation levels larger than or equal to 8 among a plurality of aggregation levels, and the second PDCCH candidates of the UE-specific search space are monitored according to the plurality of aggregation levels.

[Claim 16] A base station (BS) for transmitting downlink control information (DCI) to a user equipment (UE), the BS comprising:
a radio frequency (RF) unit, and
a processor connected to the RF unit, the processor configured to:
control the RF unit to transmit common search space configuration for a common search space;
control the RF unit to transmit, to the UE, a first physical downlink control channel (PDCCH) scheduling a random access response by using one of first PDCCH candidates of the common search space according to the common search space configuration; and
control the RF unit to transmit, to the UE, a second PDCCH carrying the DCI for the UE by using one of second PDCCH candidates of a UE-specific search space,
wherein the second PDCCH candidates of the UE-specific search space are configured according to the same configuration as the common search space configuration until a UE-specific search space configuration is transmitted to the UE.

[Claim 17] The BS according to claim 16,
wherein the common search space configuration includes information on a narrowband for the common search space, and

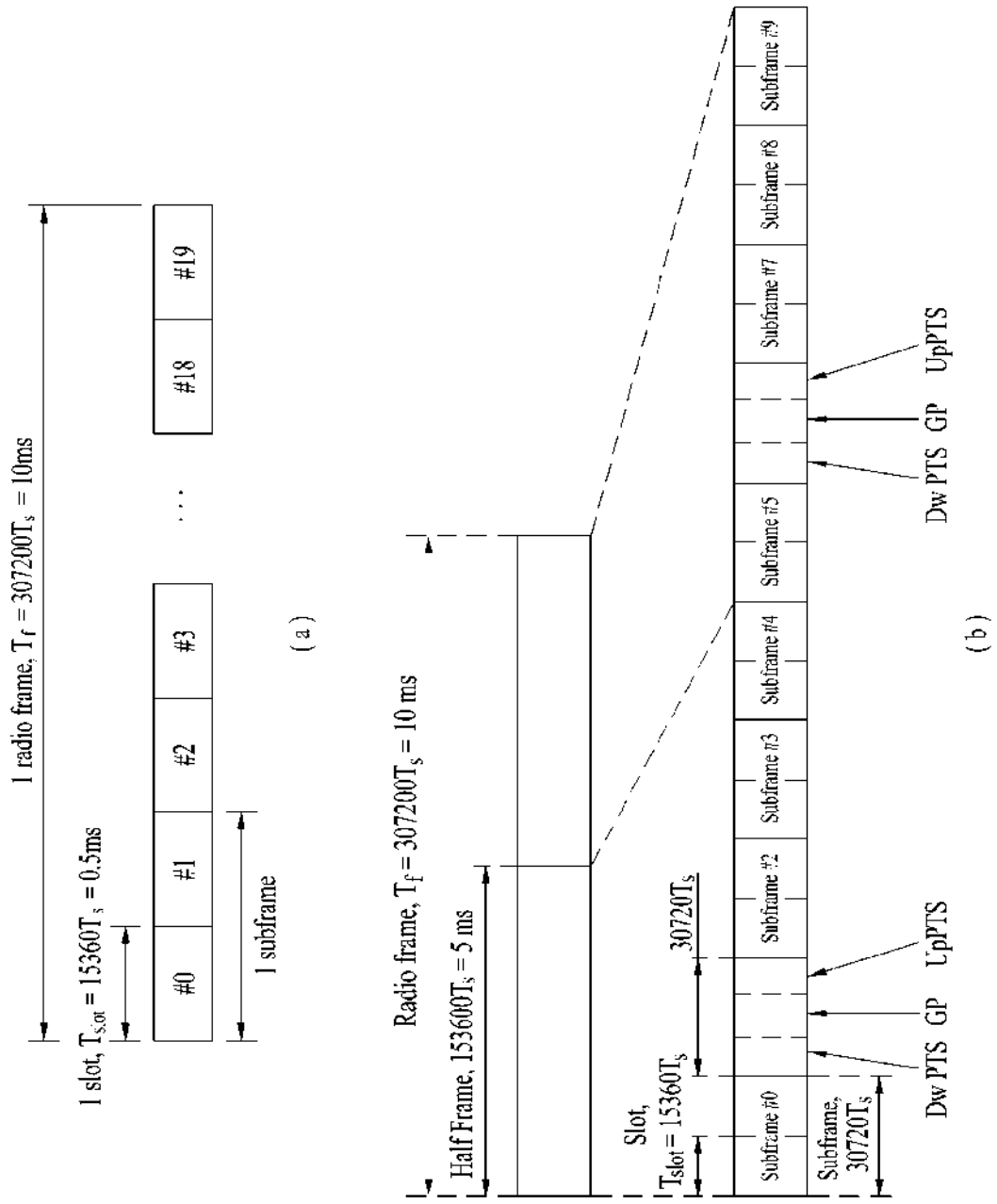
wherein the second PDCCH candidates of the UE-specific search space are configured on the same narrowband as the narrowband for the common search space until the UE-specific search space configuration is transmitted to the UE.

[Claim 18] The BS according to claim 16 or 17,
wherein the common search space configuration includes information on a maximum number of repetitions for the first common search space, and
wherein the second PDCCH candidates of the UE-specific search space are configured based on the same number as the maximum number of repetitions for the common search space until the UE-specific search space configuration is transmitted to the UE.

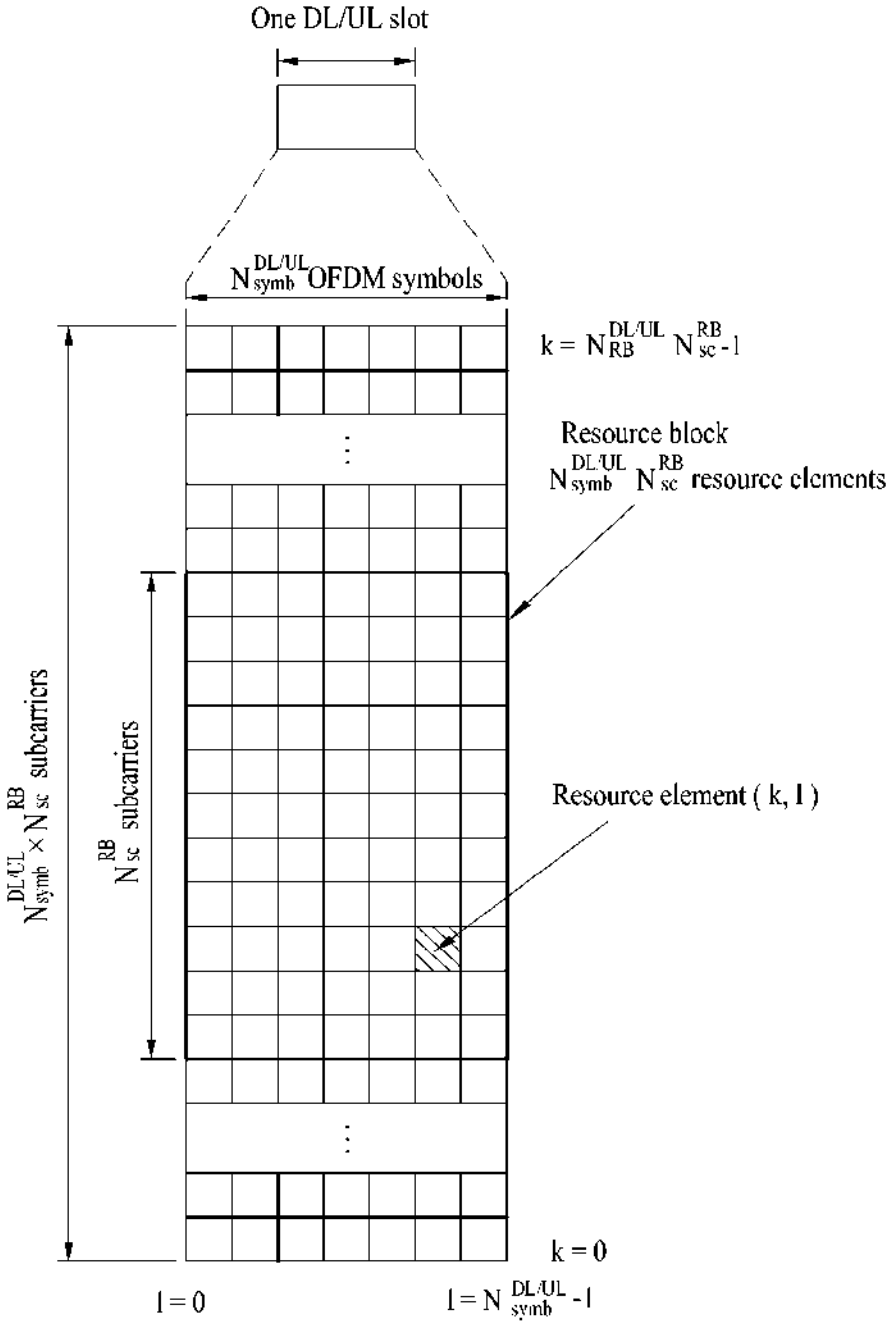
[Claim 19] The BS according to any one of claims 16 to 18,
wherein the common search space configuration includes information on a first physical resource block (PRB) set for transmitting the first PDCCH, and
wherein the same physical resource block set as the first PRB set is used for the second PDCCH candidates until the UE-specific search space configuration is transmitted to the UE.

[Claim 20] The BS according to any one of claims 16 to 19,
wherein the first PDCCH candidates of the common search space are configured according to aggregation levels larger than or equal to 8 among a plurality of aggregation levels, and the second PDCCH candidates of the UE-specific search space are configured according to the plurality of aggregation levels.

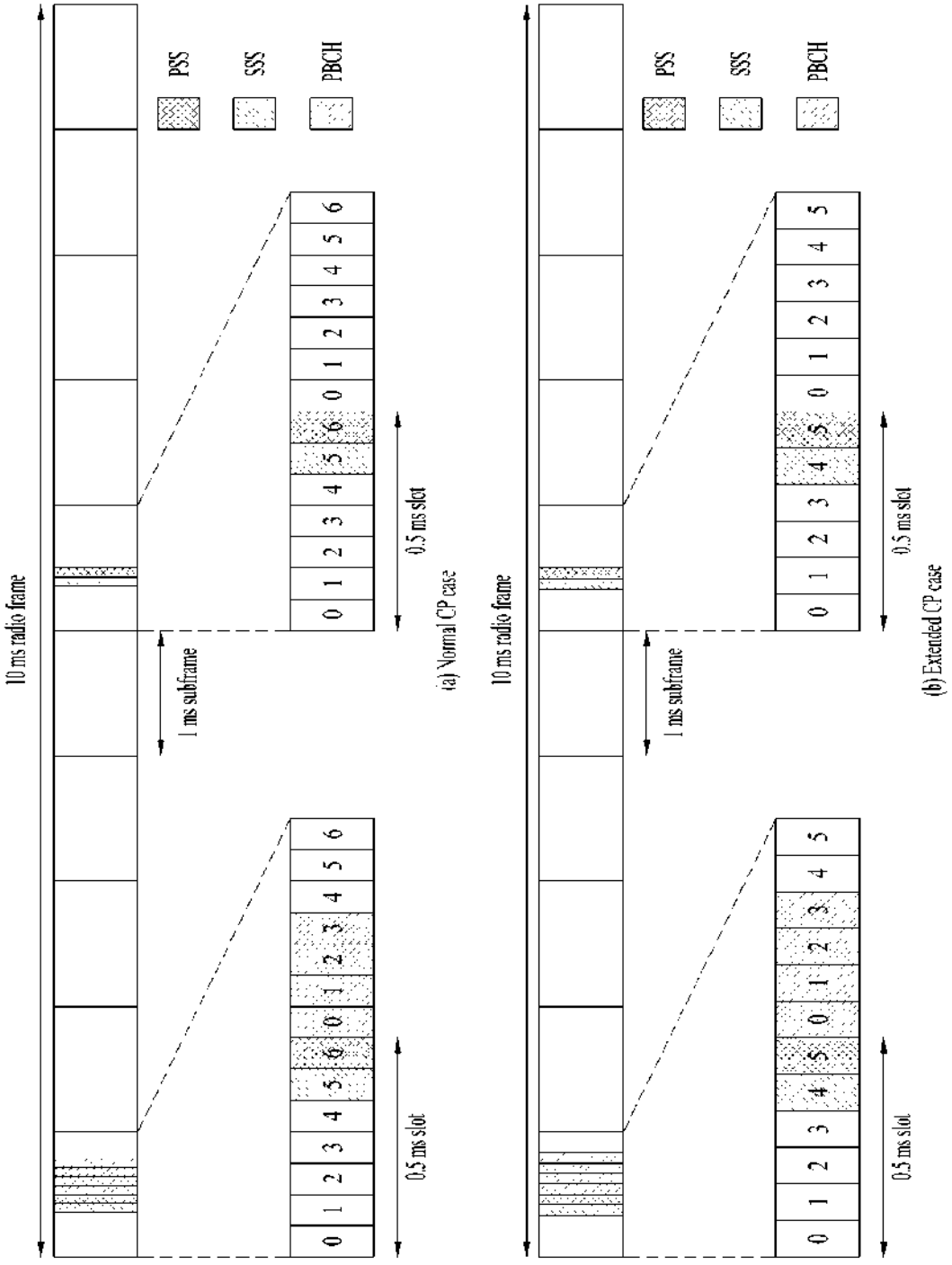
[Fig. 1]


1 radio frame, $T_f = 307200T_s = 10ms$
1 slot, $T_{slot} = 15360T_s = 0.5ms$
#0
#1
#2
#3
#18
#19
1 subframe
(a)
Radio frame, $T_f = 307200T_s = 10$ ms
Half Frame, $153600T_s = 5$ ms
Slot, $T_{slot} = 15360T_s$
$30720T_s$
Subframe, $30720T_s$
Subframe #0
Subframe #1
Subframe #2
Subframe #3
Subframe #4
Subframe #5
Subframe #6
Subframe #7
Subframe #8
Subframe #9
DwPTS
GP
UpPTS
DwPTS
GP
UpPTS
(b)

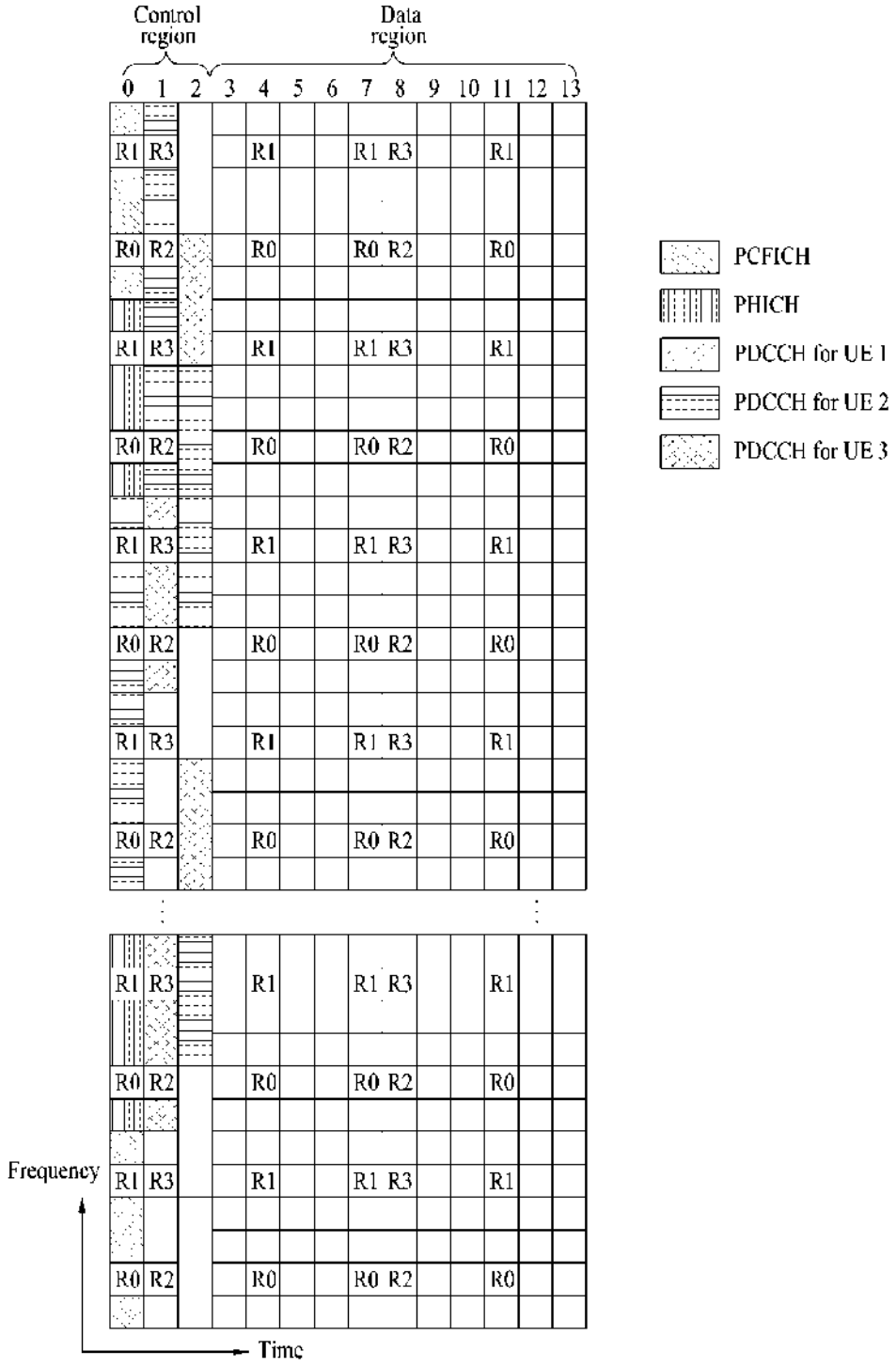
[Fig. 2]


One DL/UL slot
$N_{symb}^{DL/UL}$ OFDM symbols
$k = N_{RB}^{DL/UL} N_{sc}^{RB} - 1$
Resource block
$N_{symb}^{DL/UL} N_{sc}^{RB}$ resource elements
Resource element (k, l)
$N_{symb}^{DL/UL} \times N_{sc}^{RB}$ subcarriers
N_{sc}^{RB} subcarriers
k = 0
l = 0
$l = N_{symb}^{DL/UL} - 1$

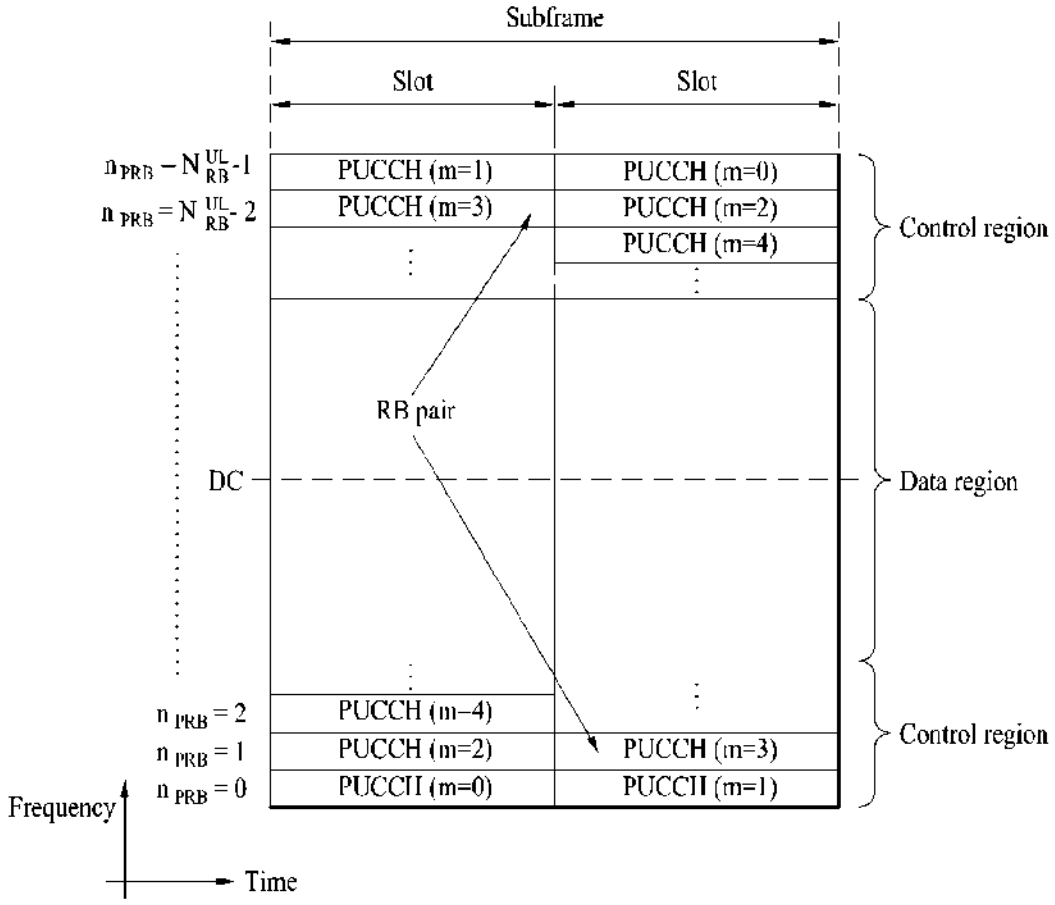
[Fig. 3]


10 ms radio frame
PSS
SSS
PBCH
1 ms subframe
0.5 ms slot
0 1 2 3 4 5 6
(a) Normal CP case
10 ms radio frame
PSS
SSS
PBCH
1 ms subframe
0.5 ms slot
0 1 2 3 4 5
(b) Extended CP case

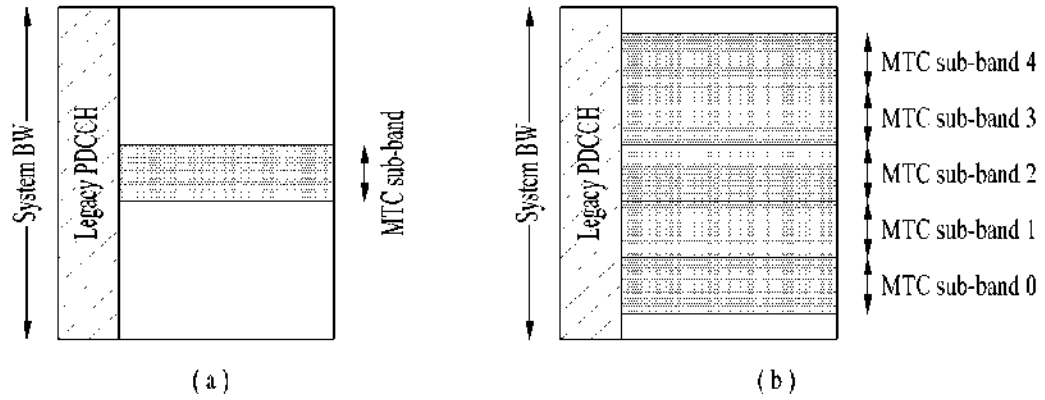
[Fig. 4]


Control region
Data region
0 1 2 3 4 5 6 7 8 9 10 11 12 13
R1 R3
R1
R1 R3
R1
R0 R2
R0
R0 R2
R0
PCFICH
PHICH
PDCCH for UE 1
PDCCH for UE 2
PDCCH for UE 3
Frequency
Time

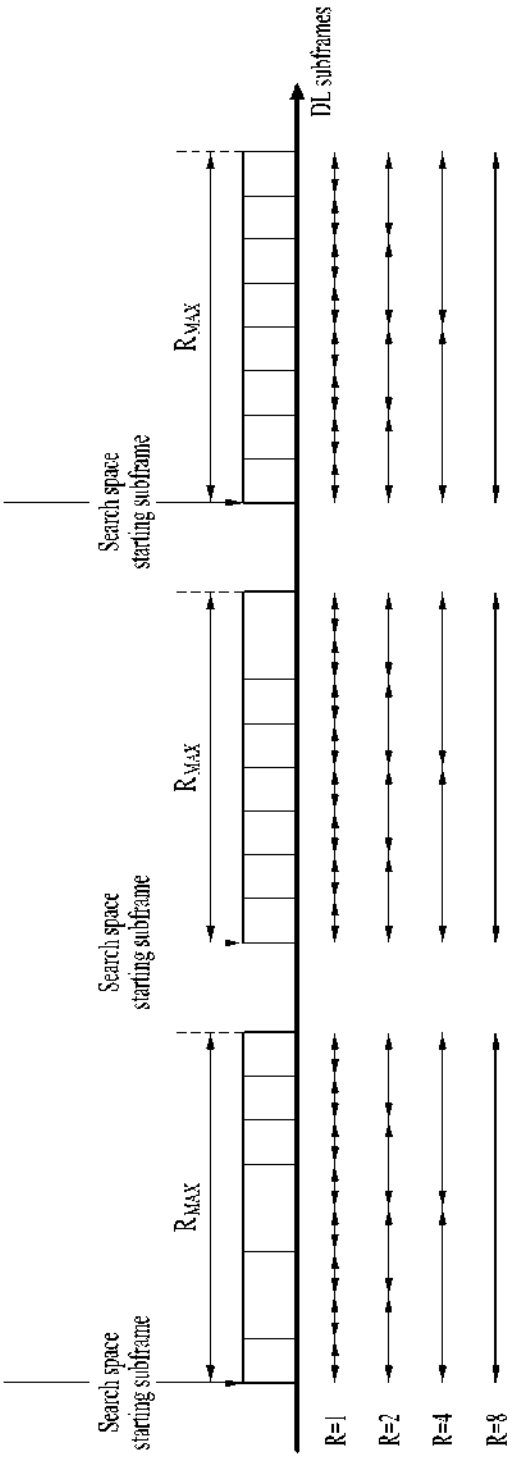
[Fig. 5]


Subframe
Slot
Slot
$n_{PRB} = N_{RB}^{UL} - 1$
$n_{PRB} = N_{RB}^{UL} - 2$
PUCCH (m=1)
PUCCH (m=0)
PUCCH (m=3)
PUCCH (m=2)
PUCCH (m=4)
Control region
RB pair
DC
Data region
$n_{PRB} = 2$
$n_{PRB} = 1$
$n_{PRB} = 0$
PUCCH (m=4)
PUCCH (m=2)
PUCCH (m=0)
PUCCH (m=3)
PUCCH (m=1)
Control region
Frequency
Time

[Fig. 6]


System BW
Legacy PDCCH
MTC sub-band
(a)
System BW
Legacy PDCCH
MTC sub-band 4
MTC sub-band 3
MTC sub-band 2
MTC sub-band 1
MTC sub-band 0
(b)

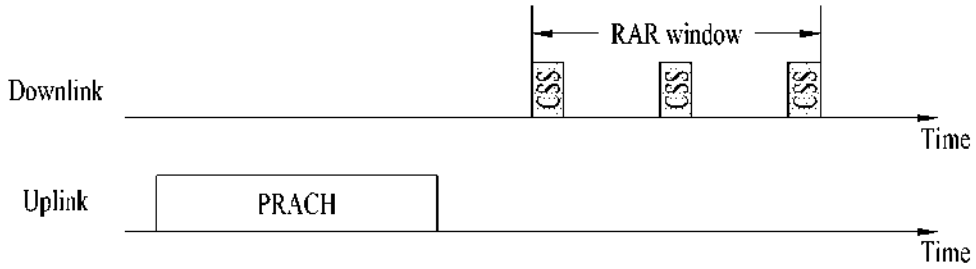
[Fig. 7]


DL subframes
Search space starting subframe
Search space starting subframe
Search space starting subframe
R_{MAX}
R_{MAX}
R_{MAX}
R=1
R=2
R=4
R=8

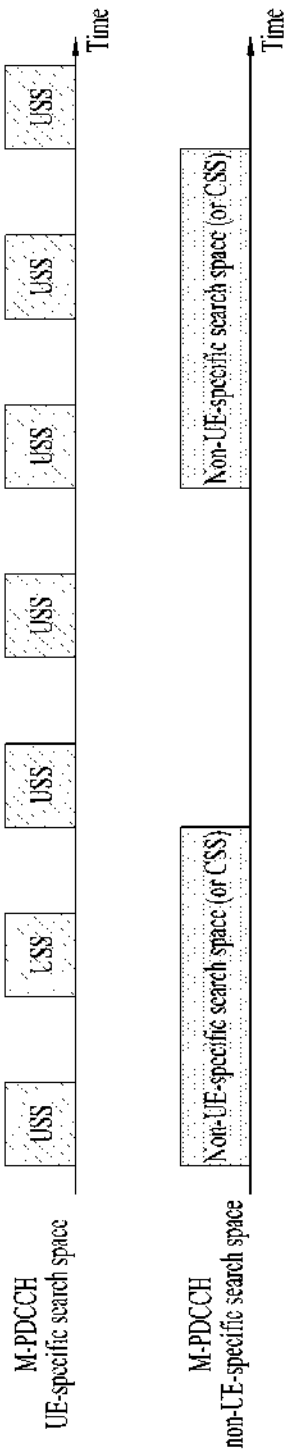
[Fig. 8]


Time
SSO
SSO
SSO
Paging occasion
SSO
SSO
SSO
Paging occasion

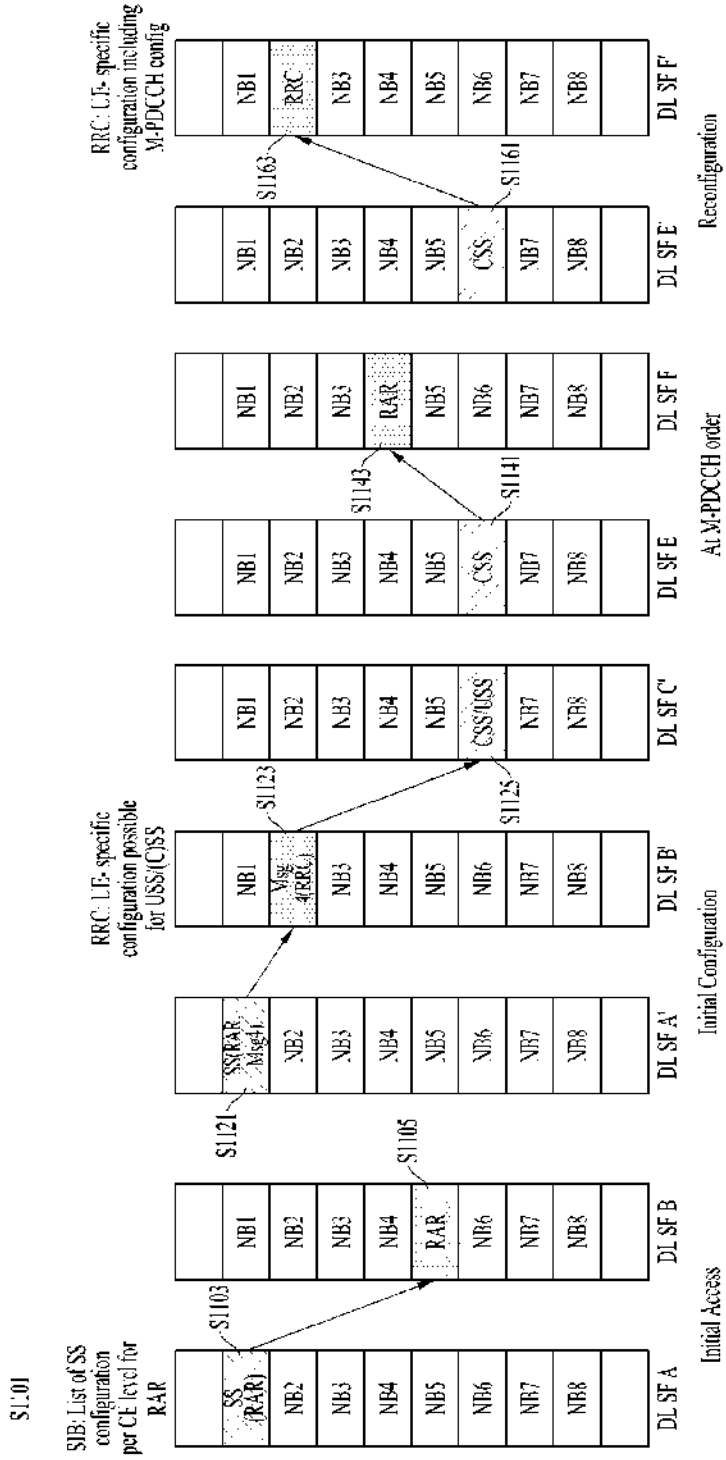
[Fig. 9]


RAR window
Downlink
CSS
CSS
CSS
Time
Uplink
PRACH
Time

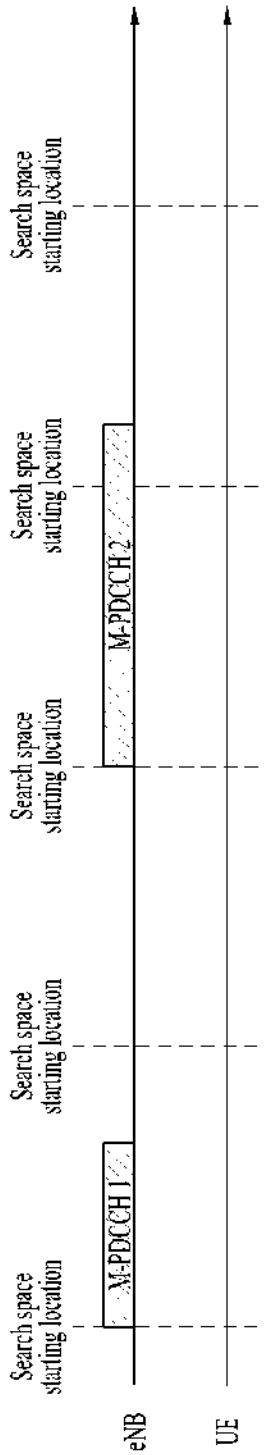
[Fig. 10]


Time
USS
USS
USS
USS
USS
USS
M-PDCCH
UE-specific search space
Time
Non-UE-specific search space (or CSS)
Non-UE-specific search space (or CSS)
M-PDCCH
non-UE-specific search space

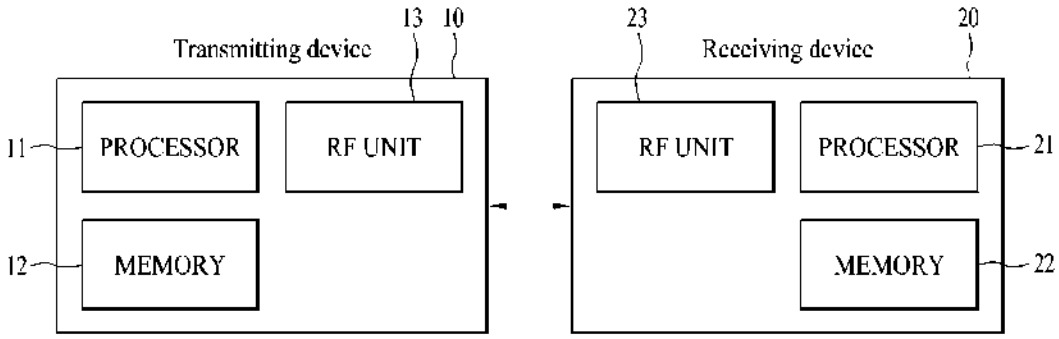
[Fig. 11]


S1101
SIB: List of SS configuration per CE level for RAR
SS (RAR)
NB1
NB2
NB3
NB4
NB5
NB6
NB7
NB8
DL SF A
S1103
RAR
DL SF B
Initial Access
S1105
S1121
SS/RAR Msg4
DL SF A'
RRC UE-specific configuration possible for USS/CSS
Msg 4(RRC)
DL SF B'
Initial Configuration
S1123
S1125
CSS/USS
DL SF C'
S1141
CSS
DL SF E
S1143
RAR
DL SF F
At M-PDCCH order
S1161
CSS
DL SF E'
S1163
RRC
DL SF F'
Reconfiguration
RRC UE-specific configuration including M-PDCCH config

[Fig. 12]


Search space starting location
Search space starting location
Search space starting location
Search space starting location
Search space starting location
M-PDCCH 1
M-PDCCH 2
eNB
UE

[Fig. 13]


Transmitting device
13
10
11
PROCESSOR
RF UNIT
12
MEMORY
23
Receiving device
20
RF UNIT
PROCESSOR
21
MEMORY
22

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2016/010542

A. CLASSIFICATION OF SUBJECT MATTER

H04L 5/00(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04L 5/00; H04W 72/04; H04W 24/08

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: common search space configuration, UE-specific search space, random access response, first PDCCH candidates, downlink control information, second PDCCH candidates, monitor, same configuration

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A		3-5,8-10,13-15,18-20
Y	LG ELECTRONICS, `Discussion on Resource configuration for low complexity MTC UEs`, R1-154229, 3GPP TSG RAN WG1 Meeting #82, Beijing, China, 15 August 2015 See sections 2, 3; and figs. 2, 3.	1,2,6,7,11,12,16,17
A	ZTE, `Further considerations on M-PDCCH for MTC`, R1-154432, 3GPP TSG RAN WG1 Meeting #82, Beijing, China, 15 August 2015 See sections 2-3.3.	1-20
A	US 2014-0307560 A1 (LG ELECTRONICS INC.) 16 October 2014 See paragraphs [0102]-[0149]; and figs. 6, 7.	1-20
A	US 2015-0181577 A1 (FUJITSU LIMITED) 25 June 2015 See paragraphs [0145]-[0153]; and fig. 7.	1-20

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
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Information on patent family members

International application No.

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		KR 10-2015-0024926 A	09/03/2015
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[Continued on next page]

(54) Title: TRANSMISSION SCHEMES AND MODES AND FALLBACK SCHEMES FOR THE ACCESS LINK OF SYSTEMS OPERATING IN HIGHER FREQUENCY BANDS

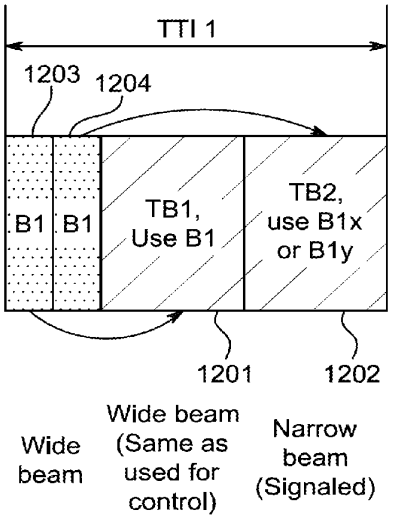


FIG. 12

(57) Abstract: A wireless transmit/receive unit (WTRU) configured to perform wireless communications in higher frequency bands (e.g., above 6 GHz) using a fallback scheme is provided. The WTRU includes a receiver configured to receive, in a time transmission interval (TTI), at least one control signal and a first data signal using a first beam associated with a first beam identifier (ID) and a second data signal, subsequent to the first data signal, using a second beam associated with a second beam ID different from the first beam ID, such that one of the at least one control signal indicates the second beam ID; and a processor configured to switch a receive beam of the receiver from the first beam to the second beam based on the second beam ID to receive the second data signal.

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TRANSMISSION SCHEMES AND MODES AND FALLBACK SCHEMES FOR THE ACCESS LINK OF SYSTEMS OPERATING IN HIGHER FREQUENCY BANDS

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of U.S. provisional application No. 62/253,473 filed November 10, 2015, the content of which is hereby incorporated by reference herein.

BACKGROUND

[0002] In order to meet the high data rate required for next generation of cellular communication systems, the wireless industry and academia have been exploring ways to leverage the large bandwidths available at above-6 GHz frequencies (e.g., centimeter wave (cmW) and millimeter wave (mmW) frequencies). One challenge of using these above-6 GHz frequencies may be issues with signal propagation, which has been considered unfavorable for wireless communication, especially in an outdoor environment.

[0003] The propagation of higher frequencies, such as these, may experience higher free space path loss. Rainfall and atmospheric gasses (e.g., oxygen, nitrogen, and hydrogen) may add further attenuation for above-6 GHz frequencies. In addition, foliage may cause attenuation and depolarization. Penetration and diffraction attenuation may also become more severe. As a result, Non Line-Of-Sight (NLOS) propagation path loss may be significant at above-6 GHz frequencies. For example, at mmW frequencies NLOS path loss may be more than 20 dB higher than Line-Of-Sight (LOS) path loss.

[0004] Outdoor mmW cellular networks may be feasible through the use of beamforming techniques. In addition, a large number of reflected and scattered multipath components (MPC) may be utilized to facilitate the mmW coverage in NLOS conditions.

SUMMARY

[0005] Embodiments provide a system, method, and apparatus for transmitting data between a wireless transmit/receive unit (WTRU) and a base station at a high carrier frequency.

[0006] According to an embodiment, a WTRU is configured to perform wireless communications in higher frequency bands using a fallback scheme. The WTRU includes a receiver configured to receive, in a time transmission interval (TTI), at least one control signal and a first data signal using a first beam associated with a first beam identifier (ID) and a second data signal, subsequent to the first data signal, using a second beam associated with a second beam ID different from the first beam ID. At least one of the control signal(s) indicates the second beam ID. The WTRU further includes a processor configured to switch a receive beam of the receiver from the first beam to the second beam based on the second beam ID to receive the second data signal.

[0007] According to an embodiment, a method implemented by a WTRU includes receiving, in a time transmission interval (TTI), at least one control signal and a first data signal using a first beam associated with a first beam identifier (ID) and a second data signal, subsequent to the first data signal, using a second beam associated with a second beam ID different from the first beam ID. At least one of the control signal(s) indicates the second beam ID. The method further includes switching a receive beam of the WTRU from the first beam to the second beam based on the second beam ID to receive the second data signal.

[0008] According to an embodiment, a wireless communication device is configured to perform wireless communications in higher frequency bands using a fallback scheme. The wireless communication device includes a transmitter configured to transmit, in a time transmission interval (TTI), at least one control signal and a first data signal using a first beam associated with a first beam identifier (ID) and a second data signal, subsequent to the first data signal, using a second beam associated with a second beam ID different from the first beam ID. At least one of the control signal(s) indicates the second beam ID. The wireless

communication device further includes a processor configured to switch a transmit beam of the transmitter from the first beam to the second beam based on the second beam ID to transmit the second data signal to a WTRU.

[0009] According to an embodiment, a method implemented in a wireless communication device includes a transmitting, in a time transmission interval (TTI), at least one control signal and a first data signal using a first beam associated with a first beam identifier (ID) and a second data signal, subsequent to the first data signal, using a second beam associated with a second beam ID different from the first beam ID. At least one of the control signal(s) indicates the second beam ID. The method further includes switching a transmit beam of the wireless communication device from the first beam to the second beam based on the second beam ID to transmit the second data signal to a WTRU.

[0010] According to an embodiment, a WTRU is configured to perform wireless communications in higher frequency bands using a fallback scheme. The WTRU includes a receiver configured to receive, in a time transmission interval (TTI), at least one control signal, a first transport block and a second transport block. The at least one control signal and the first transport block are received using a first beam, and the second transport block is received using a second beam that has a beam width that is more narrow than a beam width of the first beam. In addition, the first transport block and the second transport block are multiplexed using time division multiplexing such that the second transport block is received subsequent to the first transport block. The WTRU further includes a processor configured to switch a receive beam of the receiver from the first beam to the second beam, to receive the second transport block, based on beam information associated with the second beam received in one of the at least one control signal.

[0011] According to an embodiment, a method implemented by a WTRU includes receiving, in a time transmission interval (TTI), at least one control signal, a first transport block and a second transport block. The at least one control signal and the first transport block are received using a first beam, and

the second transport block is received using a second beam that has a beam width that is more narrow than a beam width of the first beam. In addition, the first transport block and the second transport block are multiplexed using time division multiplexing such that the second transport block is received subsequent to the first transport block. The method further includes switching a receive beam of the WTRU from the first beam to the second beam, to receive the second transport block, based on beam information associated with the second beam received in one of the at least one control signal.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] A more detailed understanding may be had from the following description, given by way of example in conjunction with the accompanying drawings wherein:

[0013] FIG. 1A is a system diagram of an example communications system in which one or more disclosed embodiments may be implemented;

[0014] FIG. 1B is a system diagram of an example wireless transmit/receive unit (WTRU) that may be used within the communications system illustrated in FIG. 1A;

[0015] FIG. 1C is a system diagram of an example radio access network and an example core network that may be used within the communications system illustrated in FIG. 1A;

[0016] FIG. 2 shows a diagram of an orthogonal frequency-division multiplexing (OFDM) frame structure over a 1-GHz system bandwidth according to one or more embodiments;

[0017] FIG. 3 shows a diagram of a single carrier frame structure over a 2-GHz system bandwidth according to one or more embodiments;

[0018] FIG. 4 shows a diagram illustrating a fully digitized beamforming system according to one or more embodiments;

[0019] FIG. 5 shows a diagram illustrating an analog beamforming system with one phase antenna array (PAA) and one radio frequency (RF) chain according to one or more embodiments;

[0020] FIGS. 6A and 6B show a diagram illustrating an analog beamforming system with one PAA and two RF chains according to one or more embodiments;

[0021] FIG. 7 shows a diagram illustrating an analog beamforming system with two PAAs and two RF chains according to one or more embodiments;

[0022] FIG. 8 shows a diagram illustrating an analog beamforming system with two PAAs and a single RF chain according to one or more embodiments;

[0023] FIG. 9 shows a diagram illustrating of a semi-static association between the control transmit (Tx) beam and data Tx beam according to one or more embodiments;

[0024] FIG. 10 shows a diagram illustrating an intra-transmission time interval (TTI) downlink (DL) assignment with a guard period according to one or more embodiments;

[0025] FIG. 11 shows a diagram illustrating a cross-TTI DL assignment with narrow beam indication according to one or more embodiments;

[0026] FIG. 12 shows a diagram for a dual transport block (TB) transmission scheme according to one or more embodiments;

[0027] FIG. 13 shows a diagram illustrating a use of a dual TB transmission scheme for data fallback according to one or more embodiments;

[0028] FIG. 14 shows a diagram illustrating another example of using a dual TB transmission scheme for data fallback according to one or more embodiments;

[0029] FIG. 15 shows a diagram illustrating an example of fallback TTI and linkage between fallback downlink control information (DCI) and fallback data, where the mB supports one RF chain according to one or more embodiments;

[0030] FIG. 16 shows a diagram illustrating an example of fallback TTI and linkage between fallback DCI and fallback data, where the mB supports multiple RF chains according to one or more embodiments;

[0031] FIG. 17 shows a diagram of fallback DCI mapped to the data region, and linkage to fallback data according to one or more embodiments;

[0032] FIG. 18 shows a diagram illustrating fallback DCI mapped to the data region using narrow beam transmission according to one or more embodiments;

[0033] FIG. 19 shows a flow diagram utilizing a dual TB transmission scheme according to one or more embodiments; and

[0034] FIG. 20 shows a flow diagram utilizing a dual TB transmission scheme according to one or more embodiments.

DETAILED DESCRIPTION

[0035] Embodiments described herein may define transmission modes (including reference signals and channel state information (CSI) feedback) and transmission schemes for operation of highly directional beamformed systems. In addition, embodiments may define how to mitigate control and/or data channel performance loss due to narrow beam misalignment, for systems operating in higher frequency bands (e.g. above-6 GHz frequencies).

[0036] The latter problem can further be broken down into two different scenarios. In the first scenario, a change in the wireless transmit/receive unit (WTRU) orientation may be such that the data channel performance using a narrow beam pair may be significantly degraded, while the downlink (DL) wide beam control channel may still be received by the WTRU. In the second scenario, the WTRU orientation change may be such that both the data and the control channels may not be received by the WTRU.

[0037] Embodiments may include downlink/uplink (DL/UL) transmission schemes for the access link of beamformed systems operating in the high frequency bands (e.g., above 6 GHz) using one or multiple radio frequency (RF) chains. In addition embodiments may define DL/UL transmission modes and modes of operations.

[0038] In addition to presenting transmission schemes and transmission modes for above 6 GHz systems, embodiments described herein may include

various scenarios where significant degradation of the control and/or data channel performance may occur due to transmit-receive (Tx-Rx) beam misalignment. Embodiments may addresses techniques for control and data fallback to maintain connectivity until a transmission mode change or a beam change is performed.

[0039] FIG. 1A is a diagram of an example communications system 100 in which one or more disclosed embodiments may be implemented. The communications system 100 may be a multiple access system that provides content, such as voice, data, video, messaging, broadcast, etc., to multiple wireless users. The communications system 100 may enable multiple wireless users to access such content through the sharing of system resources, including wireless bandwidth. For example, the communications systems 100 may employ one or more channel access methods, such as code division multiple access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), orthogonal FDMA (OFDMA), single-carrier FDMA (SC-FDMA), and the like.

[0040] As shown in FIG. 1A, the communications system 100 may include wireless transmit/receive units (WTRUs) 102a, 102b, 102c, 102d, a radio access network (RAN) 104, a core network 106, a public switched telephone network (PSTN) 108, the Internet 110, and other networks 112, though it will be appreciated that the disclosed embodiments contemplate any number of WTRUs, base stations, networks, and/or network elements. Each of the WTRUs 102a, 102b, 102c, 102d may be any type of device configured to operate and/or communicate in a wireless environment. By way of example, the WTRUs 102a, 102b, 102c, 102d may be configured to transmit and/or receive wireless signals and may include user equipment (UE), a mobile station, a fixed or mobile subscriber unit, a pager, a cellular telephone, a personal digital assistant (PDA), a smartphone, a laptop, a netbook, a personal computer, a wireless sensor, consumer electronics, and the like.

[0041] The communications systems 100 may also include a base station 114a and a base station 114b. Each of the base stations 114a, 114b may be any type of device configured to wirelessly interface with at least one of the WTRUs 102a, 102b, 102c, 102d to facilitate access to one or more communication networks, such as the core network 106, the Internet 110, and/or the other networks 112. By way of example, the base stations 114a, 114b may be a base transceiver station (BTS), a Node-B, an eNode B, a Home Node B, a Home eNode B, a site controller, an access point (AP), a wireless router, and the like. While the base stations 114a, 114b are each depicted as a single element, it will be appreciated that the base stations 114a, 114b may include any number of interconnected base stations and/or network elements.

[0042] The base station 114a may be part of the RAN 104, which may also include other base stations and/or network elements (not shown), such as a base station controller (BSC), a radio network controller (RNC), relay nodes, etc. The base station 114a and/or the base station 114b may be configured to transmit and/or receive wireless signals within a particular geographic region, which may be referred to as a cell (not shown). The cell may further be divided into cell sectors. For example, the cell associated with the base station 114a may be divided into three sectors. Thus, in one embodiment, the base station 114a may include three transceivers, i.e., one for each sector of the cell. In another embodiment, the base station 114a may employ multiple-input multiple-output (MIMO) technology and, therefore, may utilize multiple transceivers for each sector of the cell.

[0043] The base stations 114a, 114b may communicate with one or more of the WTRUs 102a, 102b, 102c, 102d over an air interface 116, which may be any suitable wireless communication link (e.g., radio frequency (RF), microwave, infrared (IR), ultraviolet (UV), visible light, etc.). The air interface 116 may be established using any suitable radio access technology (RAT).

[0044] More specifically, as noted above, the communications system 100 may be a multiple access system and may employ one or more channel access

schemes, such as CDMA, TDMA, FDMA, OFDMA, SC-FDMA, and the like. For example, the base station 114a in the RAN 104 and the WTRUs 102a, 102b, 102c may implement a radio technology such as Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access (UTRA), which may establish the air interface 116 using wideband CDMA (WCDMA). WCDMA may include communication protocols such as High-Speed Packet Access (HSPA) and/or Evolved HSPA (HSPA+). HSPA may include High-Speed Downlink Packet Access (HSDPA) and/or High-Speed Uplink Packet Access (HSUPA).

[0045] In another embodiment, the base station 114a and the WTRUs 102a, 102b, 102c may implement a radio technology such as Evolved UMTS Terrestrial Radio Access (E-UTRA), which may establish the air interface 116 using Long Term Evolution (LTE) and/or LTE-Advanced (LTE-A).

[0046] In other embodiments, the base station 114a and the WTRUs 102a, 102b, 102c may implement radio technologies such as IEEE 802.16 (i.e., Worldwide Interoperability for Microwave Access (WiMAX)), CDMA2000, CDMA2000 1X, CDMA2000 EV-DO, Interim Standard 2000 (IS-2000), Interim Standard 95 (IS-95), Interim Standard 856 (IS-856), Global System for Mobile communications (GSM), Enhanced Data rates for GSM Evolution (EDGE), GSM EDGE (GERAN), and the like.

[0047] The base station 114b in FIG. 1A may be a wireless router, Home Node B, Home eNode B, or access point, for example, and may utilize any suitable RAT for facilitating wireless connectivity in a localized area, such as a place of business, a home, a vehicle, a campus, and the like. In one embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.11 to establish a wireless local area network (WLAN). In another embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.15 to establish a wireless personal area network (WPAN). In yet another embodiment, the base station 114b and the WTRUs 102c, 102d may utilize a cellular-based RAT (e.g., WCDMA, CDMA2000, GSM, LTE, LTE-A, etc.) to establish a picocell or

femtocell. As shown in FIG. 1A, the base station 114b may have a direct connection to the Internet 110. Thus, the base station 114b may not be required to access the Internet 110 via the core network 106.

[0048] The RAN 104 may be in communication with the core network 106, which may be any type of network configured to provide voice, data, applications, and/or voice over internet protocol (VoIP) services to one or more of the WTRUs 102a, 102b, 102c, 102d. For example, the core network 106 may provide call control, billing services, mobile location-based services, pre-paid calling, Internet connectivity, video distribution, etc., and/or perform high-level security functions, such as user authentication. Although not shown in FIG. 1A, it will be appreciated that the RAN 104 and/or the core network 106 may be in direct or indirect communication with other RANs that employ the same RAT as the RAN 104 or a different RAT. For example, in addition to being connected to the RAN 104, which may be utilizing an E-UTRA radio technology, the core network 106 may also be in communication with another RAN (not shown) employing a GSM radio technology.

[0049] The core network 106 may also serve as a gateway for the WTRUs 102a, 102b, 102c, 102d to access the PSTN 108, the Internet 110, and/or other networks 112. The PSTN 108 may include circuit-switched telephone networks that provide plain old telephone service (POTS). The Internet 110 may include a global system of interconnected computer networks and devices that use common communication protocols, such as the transmission control protocol (TCP), user datagram protocol (UDP) and the internet protocol (IP) in the TCP/IP internet protocol suite. The networks 112 may include wired or wireless communications networks owned and/or operated by other service providers. For example, the networks 112 may include another core network connected to one or more RANs, which may employ the same RAT as the RAN 104 or a different RAT.

[0050] One or more of the WTRUs 102a, 102b, 102c, 102d in the communications system 100 may include multi-mode capabilities, i.e., the WTRUs 102a, 102b, 102c, 102d may include multiple transceivers for

communicating with different wireless networks over different wireless links. For example, the WTRU 102c shown in FIG. 1A may be configured to communicate with the base station 114a, which may employ a cellular-based radio technology, and with the base station 114b, which may employ an IEEE 802 radio technology.

[0051] FIG. 1B is a system diagram of an example WTRU 102. As shown in FIG. 1B, the WTRU 102 may include a processor 118, a transceiver 120, a transmit/receive element 122, a speaker/microphone 124, a keypad 126, a display/touchpad 128, non-removable memory 130, removable memory 132, a power source 134, a global positioning system (GPS) chipset 136, and other peripherals 138. It will be appreciated that the WTRU 102 may include any sub-combination of the foregoing elements while remaining consistent with an embodiment.

[0052] The processor 118 may be a general purpose processor, a special purpose processor, a conventional processor, a digital signal processor (DSP), a plurality of microprocessors, one or more microprocessors in association with a DSP core, a controller, a microcontroller, Application Specific Integrated Circuits (ASICs), Field Programmable Gate Array (FPGAs) circuits, any other type of integrated circuit (IC), a state machine, and the like. The processor 118 may perform signal coding, data processing, power control, input/output processing, and/or any other functionality that enables the WTRU 102 to operate in a wireless environment. The processor 118 may be coupled to the transceiver 120, which may be coupled to the transmit/receive element 122. While FIG. 1B depicts the processor 118 and the transceiver 120 as separate components, it will be appreciated that the processor 118 and the transceiver 120 may be integrated together in an electronic package or chip.

[0053] The transceiver 120, or any part thereof, may be configured to align its transmit beam, for transmitting an uplink transmission, with a receive beam of an eNode-B. Similarly, the transceiver 120, or any part thereof, may be configured to align its receive beam, for receiving a downlink transmission, with

a transmit beam of the eNode-B. The processor 118 may further be configured to determine a transmit beam and/or receive beam (e.g., based on received configuration or control information) for the transceiver 120 to use, and configure the transceiver 120 accordingly for communicating with the eNode-B.

[0054] The transmit/receive element 122 may be configured to transmit signals to, or receive signals from, a base station (e.g., the base station 114a) over the air interface 116. For example, in one embodiment, the transmit/receive element 122 may be an antenna configured to transmit and/or receive RF signals. In another embodiment, the transmit/receive element 122 may be an emitter/detector configured to transmit and/or receive IR, UV, or visible light signals, for example. In yet another embodiment, the transmit/receive element 122 may be configured to transmit and receive both RF and light signals. It will be appreciated that the transmit/receive element 122 may be configured to transmit and/or receive any combination of wireless signals.

[0055] In addition, although the transmit/receive element 122 is depicted in FIG. 1B as a single element, the WTRU 102 may include any number of transmit/receive elements 122. More specifically, the WTRU 102 may employ MIMO technology. Thus, in one embodiment, the WTRU 102 may include two or more transmit/receive elements 122 (e.g., multiple antennas) for transmitting and receiving wireless signals over the air interface 116.

[0056] The transceiver 120 may be configured to modulate the signals that are to be transmitted by the transmit/receive element 122 and to demodulate the signals that are received by the transmit/receive element 122. As noted above, the WTRU 102 may have multi-mode capabilities. Thus, the transceiver 120 may include multiple transceivers for enabling the WTRU 102 to communicate via multiple RATs, such as UTRA and IEEE 802.11, for example.

[0057] The processor 118 of the WTRU 102 may be coupled to, and may receive user input data from, the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128 (e.g., a liquid crystal display (LCD) display unit or organic light-emitting diode (OLED) display unit). The processor 118 may also

output user data to the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128. In addition, the processor 118 may access information from, and store data in, any type of suitable memory, such as the non-removable memory 130 and/or the removable memory 132. The non-removable memory 130 may include random-access memory (RAM), read-only memory (ROM), a hard disk, or any other type of memory storage device. The removable memory 132 may include a subscriber identity module (SIM) card, a memory stick, a secure digital (SD) memory card, and the like. In other embodiments, the processor 118 may access information from, and store data in, memory that is not physically located on the WTRU 102, such as on a server or a home computer (not shown).

[0058] The processor 118 may receive power from the power source 134, and may be configured to distribute and/or control the power to the other components in the WTRU 102. The power source 134 may be any suitable device for powering the WTRU 102. For example, the power source 134 may include one or more dry cell batteries (e.g., nickel-cadmium (NiCd), nickel-zinc (NiZn), nickel metal hydride (NiMH), lithium-ion (Li-ion), etc.), solar cells, fuel cells, and the like.

[0059] The processor 118 may also be coupled to the GPS chipset 136, which may be configured to provide location information (e.g., longitude and latitude) regarding the current location of the WTRU 102. In addition to, or in lieu of, the information from the GPS chipset 136, the WTRU 102 may receive location information over the air interface 116 from a base station (e.g., base stations 114a, 114b) and/or determine its location based on the timing of the signals being received from two or more nearby base stations. It will be appreciated that the WTRU 102 may acquire location information by way of any suitable location-determination method while remaining consistent with an embodiment.

[0060] The processor 118 may further be coupled to other peripherals 138, which may include one or more software and/or hardware modules that provide additional features, functionality and/or wired or wireless connectivity. For

example, the peripherals 138 may include an accelerometer, an e-compass, a satellite transceiver, a digital camera (for photographs or video), a universal serial bus (USB) port, a vibration device, a television transceiver, a hands free headset, a Bluetooth® module, a frequency modulated (FM) radio unit, a digital music player, a media player, a video game player module, an Internet browser, and the like.

[0061] FIG. 1C is a system diagram of the RAN 104 and the core network 106 according to an embodiment. As noted above, the RAN 104 may employ an E-UTRA radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 116. The RAN 104 may also be in communication with the core network 106.

[0062] The RAN 104 may include eNode-Bs 140a, 140b, 140c, though it will be appreciated that the RAN 104 may include any number of eNode-Bs while remaining consistent with an embodiment. The eNode-Bs 140a, 140b, 140c may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 116. In one embodiment, the eNode-Bs 140a, 140b, 140c may implement MIMO technology. Thus, the eNode-B 140a, for example, may use multiple antennas to transmit wireless signals to, and receive wireless signals from, the WTRU 102a.

[0063] Each of the eNode-Bs 140a, 140b, 140c may be associated with a particular cell (not shown) and may be configured to handle radio resource management decisions, handover decisions, scheduling of users in the uplink and/or downlink, and the like. As shown in FIG. 1C, the eNode-Bs 140a, 140b, 140c may communicate with one another over an X2 interface.

[0064] The core network 106 shown in FIG. 1C may include a mobility management entity gateway (MME) 142, a serving gateway 144, and a packet data network (PDN) gateway 146. While each of the foregoing elements are depicted as part of the core network 106, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

[0065] The MME 142 may be connected to each of the eNode-Bs 140a, 140b, 140c in the RAN 104 via an S1 interface and may serve as a control node. For example, the MME 142 may be responsible for authenticating users of the WTRUs 102a, 102b, 102c, bearer activation/deactivation, selecting a particular serving gateway during an initial attach of the WTRUs 102a, 102b, 102c, and the like. The MME 142 may also provide a control plane function for switching between the RAN 104 and other RANs (not shown) that employ other radio technologies, such as GSM or WCDMA.

[0066] The serving gateway 144 may be connected to each of the eNode Bs 140a, 140b, 140c in the RAN 104 via the S1 interface. The serving gateway 144 may generally route and forward user data packets to/from the WTRUs 102a, 102b, 102c. The serving gateway 144 may also perform other functions, such as anchoring user planes during inter-eNode B handovers, triggering paging when downlink data is available for the WTRUs 102a, 102b, 102c, managing and storing contexts of the WTRUs 102a, 102b, 102c, and the like.

[0067] The serving gateway 144 may also be connected to the PDN gateway 146, which may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, such as the Internet 110, to facilitate communications between the WTRUs 102a, 102b, 102c and IP-enabled devices.

[0068] The core network 106 may facilitate communications with other networks. For example, the core network 106 may provide the WTRUs 102a, 102b, 102c with access to circuit-switched networks, such as the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, 102c and traditional land-line communications devices. For example, the core network 106 may include, or may communicate with, an IP gateway (e.g., an IP multimedia subsystem (IMS) server) that serves as an interface between the core network 106 and the PSTN 108. In addition, the core network 106 may provide the WTRUs 102a, 102b, 102c with access to the networks 112, which may include other wired or wireless networks that are owned and/or operated by other service providers.

[0069] Other network 112 may further be connected to an IEEE 802.11 based wireless local area network (WLAN) 160. The WLAN 160 may include an access router 165. The access router may contain gateway functionality. The access router 165 may be in communication with a plurality of access points (APs) 170a, 170b. The communication between access router 165 and APs 170a, 170b may be via wired Ethernet (IEEE 802.3 standards), or any type of wireless communication protocol. AP 170a is in wireless communication over an air interface with WTRU 102d.

[0070] It should be noted that although 3GPP LTE may be used for example purposes, the techniques described herein may be applied to any other system.

[0071] The following list of definitions, although not intended to be limiting, may be helpful in understanding the following embodiments.

[0072] A "beam" may be one lobe (e.g. main/side/grating) of a transmit radiation pattern and receive gain pattern of an antenna array. The beam may also denote a spatial direction that may be represented with a set beamforming weights. The beam may be identified or associated with a reference signal, an antenna port, a beam identity (ID), and/or a scrambling sequence number. The beam may be transmitted and/or received at a specific time, frequency, code, and/or spatial resource. The beam may be formed digitally, in an analog manner, or both (i.e., hybrid beamforming). The analog beamforming may be based on fixed code-book or continuous phase shifting.

[0073] A "beam-specific reference signal" (BSRS) may be a sequence associated with a transmit beam used for beam acquisition, timing and/or frequency synchronization, channel estimation for a physical downlink directional control channel (PDDCCH), fine beam tracking, beam measurement, etc. BSRS may carry (e.g., implicitly carry) beam identity information. There may be different types of BSRS. For example, there may be BSRS for an mmW sector and its member segments. The segment may be referred as a beam direction (e.g., a narrow beam direction or a wide beam direction).

[0074] A “data channel beam” may be used to transmit a data channel, a Physical Downlink Shared Channel (PDSCH), a mPDSCH, a mmW PDSCH, a mmW data channel, a directional PDSCH, a beamformed data channel, a spatial data channel, a data channel slice, or a high frequency data channel. The data channel beam may be identified or associated with a reference signal, an antenna port, a beam identity (ID), and/or a scrambling sequence number. The data channel beam may be transmitted and/or received at a specific time, frequency, code, and/or spatial resource.

[0075] A “control channel beam” may be used to transmit a control channel, a control channel beam, a PDCCH, an mPDCCH, an mmW PDCCH, an mmW control channel, a directional PDCCH, a beamformed control channel, a spatial control channel, a control channel slice or a high frequency control channel. A control channel beam may be identified or associated with a reference signal, an antenna port, a beam identity (ID), a scrambling sequence number and may be transmitted and/or received at a specific time and/or frequency and/or code and/or spatial resources.

[0076] A “measurement beam” may be used to transmit a signal or channel for beam measurement. This may include a beam reference signal, a beam measurement reference signal, Cell Specific Reference Signal (CRS), Channel State Information-Reference Signal (CSI-RS), CSI-interference measurement (CSI-IM), etc. The measurement beam may be identified or associated with a reference signal, an antenna port, a beam identity (ID), and/or a scrambling sequence number. The measurement beam may be transmitted and/or received at a specific time, frequency, code, and/or spatial resource.

[0077] A “control channel beam duration” may be the length of time, which may be referred to in units of OFDM symbols, used within a scheduling interval for the transmission of one control channel beam.

[0078] A “control region” may be the length in theof time domain, which may be referred to in units of OFDM symbols, used within a scheduling interval for the transmission of all the control channel beams in that scheduling interval.

For example, a control region may be the number of OFDM symbols in a TTI occupied by all the control channel beams transmitted in the TTI.

[0079] A "data region" may be part of the scheduling interval in time domain, which may be referred to in units of OFDM symbols, used for the transmission of all data channel beams in that scheduling interval.

[0080] A "data fallback" may be an alternate scheme for data transmission, that may be used dynamically, irrespective of the transmission mode, to maintain the data communication between the base station and the WTRU. Data fallback schemes may be used in either downlink (DL), or uplink (UL), or both.

[0081] A "control fallback" may be an alternate scheme for signaling the control channel, that may be used dynamically, irrespective of the transmission mode, to maintain the control signaling between the base station and the WTRU.

[0082] In some embodiments described herein, the terms base station, eNode-B (eNB), mmW eNB (mB), Small Cell mmW eNB (SCmB), cell, small cell, primary cell (Pcell), and secondary cell (Scell) may be used interchangeably. In some embodiments, the term operate may be used interchangeably with transmit and/or receive. In some embodiments, the terms component carrier, mmW carrier may be used interchangeably with serving cell.

[0083] In some embodiments, the mB may transmit and/or receive one or more mmW channels and/or signals in a licensed band and/or an unlicensed band. In some embodiments, the WTRU may be substituted for eNB and/or vice versa and still be consistent with this disclosure. In some embodiments, UL may be substituted for DL and/or vice versa and still be consistent with this disclosure.

[0084] In some embodiments, a channel may refer to a frequency band that may have a center, or carrier frequency, and a bandwidth. Licensed and/or unlicensed spectrum may include one or more channels which may or may not overlap. Channel, frequency channel, wireless channel, and mmW channel may be used interchangeably. Accessing a channel may be the same as using (e.g., transmitting and/or receiving on or using) the channel.

[0085] In some embodiments, a channel refers to a mmW channel or signal, such as an uplink or downlink physical channel or signal. Downlink channels and signals may include one or more of the following: mmW synchronization signal, mmW broadcast channel, mmW cell reference signal, mmW beam reference signal, mmW beam control channel, mmW beam data channel, mmW hybrid automatic repeat request (ARQ) indicator channel, mmW demodulation reference signal, primary synchronization signal (PSS), secondary synchronization signal (SSS), demodulation reference signal (DMRS), CRS, CSI-RS, Physical Broadcast Channel (PBCH), Physical downlink Control Channel (PDCCH), Physical Hybrid ARQ Indicator Channel (PHICH), Enhanced Physical Downlink Control Channel (EPDCCH), and PDSCH. Uplink channels and signals may include one or more of the following: mmW Physical Random Access Channel (PRACH), mmW control channel, mmW data channel, mmW beam reference signal, mmW demodulation reference signal, PRACH, Physical Uplink Control Channel (PUCCH), sounding reference signal (SRS), DMRS and Physical Uplink Shared Channel (PUSCH). Channel and mmW channel may be used interchangeably. Channels and signals may be used interchangeably.

[0086] In some embodiments data/control may mean data and/or control signals and/or channels. Control may include synchronization. The data/control may be mmW data/control. Data/control and data/control channels and/or signals may be used interchangeably. Channels and signals may be used interchangeably. The terms control channel, control channel beam, PDCCH, mPDCCH, mmW PDCCH, mmW control channel, directional PDCCH, beamformed control channel, spatial control channel, control channel slice, high frequency control channel may be used interchangeably. The terms data channel, data channel beam, PDSCH, mPDSCH, mmW PDSCH, mmW data channel, directional PDSCH, beamformed data channel, spatial data channel, data channel slice, and high frequency data channel may be used interchangeably.

[0087] In some embodiments, channel resources may be resources (e.g., 3GPP LTE or LTE-A resources) such as time, frequency, code, and/or spatial

resources, which may, at least sometimes, carry one or more channels and/or signals. In some embodiments, channel resources may be used interchangeably with channels and/or signals.

[0088] The terms mmW beam reference signal, mmW reference resource for beam measurement, mmW measurement reference signal, mmW channel state measurement reference signal, mmW demodulation reference signal, mmW sounding reference signal, reference signal, CSI-RS, CRS, DM-RS, DRS, measurement reference signal, reference resource for measurement, CSI-IM, and measurement RS may be used interchangeably. mmW cell, mmW small cell, SCell, secondary cell, license-assisted cell, unlicensed cell, and Licensed Assisted Access (LAA) cell may be used interchangeably. The terms mmW cell, mmW small cell, PCell, primary cell, LTE cell, and licensed cell may be used interchangeably.

[0089] The terms interference and interference plus noise may be used interchangeably.

[0090] Multiple above-6 GHz frequency bands have been evaluated for next generation cellular networks. For example, 10 GHz and 15 GHz bands have been evaluated at the cmW frequency band. In addition, 28 GHz, 39 GHz, 60 GHz and 73 GHz bands have been evaluated at the mmW frequency band. These higher frequency bands may be allocated as licensed, lightly licensed, and unlicensed spectrums.

[0091] Depending on the allocation of the spectrum and its propagation characteristics, the above-6 GHz frequency bands may be deployed in various cellular network configurations. For example, mmW frequencies may be used for a homogenous network with mmW stand-alone Macro-, Micro- and Small Cell base stations. A heterogeneous network may consist of a mmW stand-alone small cell network overlaid with a LTE Macro- and/or Micro- network at sub-6 GHz frequencies. In such a network, a network node may be connected to both above-6 GHz frequencies (e.g., a mmW system) and below-6 GHz frequencies (e.g., a 2 GHz LTE system), which may be referred as Dual Connectivity. Carrier

aggregation may be applied to combine above-6 GHz carriers (e.g., mmW) and sub-6 GHz carriers (e.g., 2 GHz LTE carriers).

[0092] Embodiments described herein may apply to any above-6 GHz cellular deployment.

[0093] Waveforms, such as, for example, orthogonal frequency-division modulation (OFDM), broad-band Single Carrier (SC), SC-OFDM, Generalized OFDM, Filter Bank Multicarrier (FBMC), and Multi-Carrier Code Division Multiple Access (MC-CDMA) may be used for above-6 GHz systems. Waveforms may have different Peak to Average Power Ratio (PAPR) performance, sensitivity to transmitter non-linearity, Bit Error Rate (BER) performance, resource channelization, and implementation complexity.

[0094] While frame structure may depend on the applied waveform, it may also be dimensioned to meet the above-6 GHz system requirement. For example, in order to achieve very low latency, a higher-frequency cellular system may have a subframe length of 100 μs.

[0095] Referring to FIG. 2, FIG. 2 shows a diagram of an OFDM frame structure 200 over a 1-GHz system bandwidth. According to the OFDM-based frame structure 200 shown in FIG. 2, a frame 202 includes 10 sub-frames, each sub-frame includes 10 slots, and each slot includes 24 symbols. The OFDM-based frame structure 200 may have, for example, a sub-carrier spacing of 300 kHz with a corresponding symbol length (T_{symbol}) of 3.33 μs. Considering a cyclic prefix (CP) length may span over the entire length of the channel time dispersion in order to eliminate the inter-symbol-interference, one example of CP for a T_{symbol} of 3.33 μs may be selected at 1/4 of T_{symbol} (i.e., at 0.833 μs). This example numerology may be used for a range of above-6 GHz system bandwidths (e.g., from 50 MHz to 2 GHz) with corresponding Fast Fourier Transform (FFT) length.

[0096] Referring now to FIG. 3, FIG. 3 shows a diagram of a single carrier frame structure 300 over a 2-GHz system bandwidth. Another frame structure may be based on single carrier over an entire system bandwidth. The system bandwidth may range from 50 MHz to 2 GHz. One such example may be based

on 2 GHz bandwidth. The sampling frequency F_s may be 1.536 GHz with a 1024-FFT. A subframe 302 may include 10 time slots each of which may be 100 μs and may have 150 single carrier (FFT) blocks. Each single carrier block may have 1024 symbols that can be used for synchronization, reference, control, data, cyclic prefix or other system purposes.

[0097] An above-6 GHz system (e.g., cmW and mmW systems) may apply any waveform and frame structure or combination thereof as discussed above. Procedures described in this disclosure may apply to all these waveform and frame structure selections.

[0098] Above-6 GHz systems may use Frequency Division Duplex (FDD), Time Division Duplex (TDD), Spatial Division Duplex (SDD) or any combination of them in conjunction with either half-duplex or full-duplex mechanisms.

[0099] A full-duplex FDD system may use a duplex filter to allow simultaneous downlink and uplink operation at different frequencies separated by a duplex distance. A half-duplex FDD system may not use a duplex filter, as the downlink and uplink operation may take place at different time instance in its dedicated frequency. A TDD system may have the downlink and uplink operate at the same frequency at different time instances. A SDD system, for example, in a beamformed system, may enable a network node to transmit and receive at a same frequency and time instance but at different outgoing and incoming spatial directions.

[0100] An above-6 GHz network may use Frequency Division Multiple Access (FDMA), Time Division Multiple Access (TDMA), Spatial Division Multiple Access (SDMA), Code Division Multiple Access (CDMA), Non-Orthogonal Multiple Access (NOMA), or any combination thereof. FDMA, TDMA, SDMA and CDMA may be applied in an orthogonal manner to avoid interference.

[0101] Multiple network nodes may be assigned to use different frequency resources simultaneously in a FDMA system, or to access the system frequency resources at different time instances in a TDMA system. Moreover the network nodes may access the same frequency resources at the same time, but may use a

different code in a CDMA system. A SDMA system may assign a spatial resource to network nodes to operate at same frequency, time, and code resource. In a beamformed network, WTRUs may use different beams.

[0102] In a NOMA system, multiple network nodes may be assigned overlapping or identical resources in frequency, time, code or spatial domain, but may apply additional mechanisms to remove interference caused by the non-orthogonal use of the resource between users. For example, two WTRUs may be located relatively far from each other, and the difference of their path loss to the base station may be large. They may be assigned with the same frequency resource in the same subframe with very different transport formats. Superposition coding and a Successive Interference Rejection (SIC) receiver may be used for a WTRU to remove the received signal intended for the other.

[0103] An above-6 GHz system (e.g., cmW and mmW systems) may apply any duplex scheme and multiple access or combination of them as discussed above. Embodiments described herein may apply to all these duplex schemes and multiple access schemes.

[0104] An above-6 GHz system may have a number of physical channels and signals for various system purposes. Certain signals may be used for multiple system procedures.

[0105] The following are examples of downlink physical channels and signals.

[0106] A synchronization signal may be a pre-defined signal that may be used for cell timing/frequency synchronization. It may be transmitted according to pre-defined periodicity. In a beamformed system, the signal may provide beam timing and frequency acquisition.

[0107] A physical broadcast channel may carry broadcast information, such as cell specific system information.

[0108] A downlink reference signal may be a pre-defined sequence transmitted to enable various system procedures (e.g., channel estimation for control channel, channel statement measurement, timing and frequency fine-

tuning, system measurement, and the like). There may be different types of reference signals. In a beamformed system, a downlink reference signal may be used for beam acquisition, beam pairing, beam tracking, beam switch, beam measurement, and the like.

[0109] A physical downlink control channel may carry data related control information to identify, demodulate and decode the associated data channel properly.

[0110] A physical downlink data channel may carry payload information in the form of Medium Access Control (MAC) Protocol Data Unit (PDU) from the MAC layer. The resource allocation of this channel may be carried in the scheduling information in the physical downlink control channel.

[0111] A data demodulation reference signal may have symbols that may be transmitted for channel estimation of downlink control or data channel. The symbols may be placed together with the associated control or data symbols in the time and frequency domain according to pre-defined pattern. This may ensure correct interpolation and reconstruction of the channel.

[0112] The following are examples of uplink physical channels and signals.

[0113] An uplink reference signal may be used for uplink channel sounding, uplink system measurement, etc. In a beamformed system, an uplink reference signal may be used for uplink beam acquisition, beam pairing, beam tracking, beam switch, beam measurement, etc.

[0114] A physical random access channel (PRACH) may carry a pre-defined sequence in connection with a random access procedure.

[0115] A physical uplink control channel may carry uplink control information, such as channel state information, data acknowledgement, scheduling request, etc.

[0116] A physical uplink data channel may carry payload information in the form of MAC PDU from a UE MAC layer. The resource allocation of this channel may be conveyed in the downlink control channel.

[0117] A data demodulation reference signal may have symbols that may be transmitted for channel estimation of uplink control or data channel. The symbols may be placed together with the associated data symbols in the time and frequency domain according to pre-defined pattern to ensure correct interpolation and reconstruction of the channel.

[0118] An above-6 GHz system (e.g., cmW and mmW systems) may deploy the signals and channels discussed above. Embodiments described herein may apply to these physical signals and channels.

[0119] Beamforming may be important in above-6 GHz systems. Outage studies conducted at 28 GHz and 38 GHz in an urban area using a steerable 10°-beamwidth and a 24.5-dBi horn antenna have shown a consistent coverage may be achieved with a cell-radius of up to 200 meters. Currently, LTE WTRUs are assumed to have an Omni-directional beam pattern and may perceive a superimposed channel impulse response over the entire angular domain. Thus an aligned beam pair e.g., at mmW frequencies may provide an additional degree of freedom in the angular domain compared with the current LTE system.

[0120] Conventional LTE WTRUs may have an Omni-directional beam pattern and may perceive a superimposed channel impulse response over the entire angular domain. Thus, an aligned beam pair at, for example, mmW frequencies, may provide an additional degree of freedom in the angular domain compared with conventional LTE systems.

[0121] Referring now to FIG. 4, FIG. 4 shows a diagram illustrating fully digitized beamforming system 400 according to one or more embodiments. A phase antenna array (PAA) may be used for beamforming with element spacing, e.g., at 0.5λ. The phase antenna may apply different beamforming algorithms. A fully digitized beamforming approach may have a dedicated RF chain including an RF processor 401 and an analog-to-digital converter (ADC) 402 for each antenna element 403. The signal 404 processed by each antenna element 403 may be controlled independently in phase and amplitude to optimize the channel

capacity. A baseband (BB) processor 405 is configured to perform BB processing on each dedicated RF chain based on the signals received from each ADC 402.

[0122] Referring now to FIG. 5, FIG. 5 shows a diagram illustrating analog beamforming system 500 according to one or more embodiments. In this embodiment, the analog beamforming may be with one PAA and one RF chain. The analog beamforming may apply one RF chain for a number of antenna elements 503 that process the signal 504. Each antenna element 503 may be connected to a phase shifter 506 that may be used to set the weight for beamforming and steering. The RF chain further includes an RF processor 501 and an ADC 502 which provides an output to a BB processor 505. The implemented number of RF chains may be significantly reduced as well as the energy consumption.

[0123] The phase shifting and combining may be implemented in different stages (e.g., at RF state, at BB analog stage, or at Local Oscillator (LO) stage). One example is a single-beam analog configuration. It may operate one beam at a time and the single beam may be placed at, for example, the strongest angular direction such as a LOS path obtained from beam measurement. A broad beam pattern may cover a range of angular directions at the expense of reduced beamforming gain.

[0124] A hybrid beamforming may combine digital precoding and analog beamforming. The analog beamforming may be performed over the phase array antenna elements each associated with a phase shifter and all connected to one RF chain. The digital precoding may be applied on the baseband signal of each RF chain.

[0125] Examples of system parameters of the hybrid beamforming may be number of data streams (N_{DATA}), number of RF chains TRX (N_{TRX}), number of antenna ports (N_{AP}), number of antenna elements (N_{AE}), and number of phase antenna arrays (N_{PAA}). The configuration of these parameters may impact on the system function and performance as discussed below.

[0126] Referring now to FIGS. 6A and 6B, FIGS. 6A and 6B show a diagram illustrating analog beamforming system 600 with one PAA and two RF chains. One antenna port may carry a beamformed reference signal uniquely associated with this antenna port that may be used to identify the antenna port. One PAA may be connected to one RF chain or multiple RF chains depending on the system requirement and configuration. In FIGS. 6A and 6B, one PAA of size 4x4 with 16 antenna elements 603, for receiving a signal 604, may be connected to two RF chains and each RF chain may have a set of 16 phase shifters 606a and 606b. The PAA may form two narrow beam patterns within a $+45^{o}$ and -45° coverage in an azimuth plane. In this configuration, $N_{PAA} < N_{AP} = N_{TRX} < N_{AE}$. Each RF chain further includes an RF processor 601a or 601b and an ADC 602a or 602b which provide an output to a BB processor 605.

[0127] Referring now to FIG. 7, FIG. 7 shows a diagram illustrating analog beamforming system 700 with two PAAs and two RF chains. In an embodiment, there may two PAAs having a set of antenna elements 703a and 703b, respectively, for receiving signals 704a and 704b. Each antenna element 703a, 703b may be connected to a phase shifter 706a, 706b, respectively. Each PAA may have a dedicated RF chain, i.e., $N_{PAA} = N_{AP} = N_{TRX} \leq N_{AE}$, including an RF processor 701a, 701b and an ADC 702a, 702b which provide an output to a BB processor 705. This configuration may allow spatial independence between the two simultaneous signals 704a and 704b by placing the PAAs at different orientations (e.g., in an azimuth plane). An aligned PAA arrangement may provide an aggregated larger coverage.

[0128] Both abovementioned example configurations with two RF chains may apply MIMO with two data streams.

[0129] Referring now to FIG. 8, FIG. 8 shows a diagram illustrating analog beamforming system 800 with two PAAs having a set of antenna elements 803a and 803b, respectively, for receiving signals 804a and 804b. Each antenna element 803a, 803b may be connected to a phase shifter 806a, 806b, respectively. The PAAs are connected to a single RF chain that includes a switch 808, an RF

processor 801 and an ADC 802 that provides an output to a BB processor 805. Multiple PAAs may be connected to a single RF chain by using the switch 808 (i.e., $N_{AE} > N_{PAA} > N_{AP} = N_{TRX}$). Each PAA may form a narrow beam pattern covering from +45° to -45° in an azimuth plane. They may be oriented separately so a single-beam network node may have a good coverage by using a beam at different direction at different time instances.

[0130] An above-6 GHz system may apply different beamforming techniques, such as analogue, hybrid and digital beamforming. Embodiments described herein may apply to these beamforming techniques.

[0131] One or more embodiments may address the transmission schemes and transmission modes for highly directional antenna systems, and define the BRS association, the resource allocation and configuration for the fallback schemes, as well as the necessary CSI feedback.

[0132] Another embodiment may address the scenario where the data channel may exhibit a significant degradation, while the control channel may still be received. This scenario may occur for several reasons. For example, the scenario may be due to a change in orientation of the mobile device, which causes misalignment of the previously paired Tx-Rx narrow beams for data transmissions. Embodiments addressing this issue may be based on the fact that the control channel may still be received, and therefore it may be used for the data transmission at a lower rate. In other words, a main principle may be the use of the active control wide beam for data fallback, which may include both DL and UL data. The embodiments may include, but are not limited to: fallback to wide beam (both DL & UL data), and/or fallback to dual transport block (TB) transmission using wide and narrow beams for UE data in the same transmission time interval (TTI).

[0133] Another embodiment may address the scenario where both the control and the data channels are lost due to the beam misalignment. In this case, a two-step solution may be needed: the first step may identify a fallback for the control channel, and once the control channel can be decoded, a fallback may

be determined for the data channel. The embodiments may include: fallback for the DL control and the associated DL/UL data, using fallback TTI.

[0134] The following may provide details for embodiments of DL/UL transmission schemes for one and multiple RF chains.

[0135] Transmission schemes for a system operating at a high carrier frequency (e.g., above 6 GHz) may be defined as mapping of the modulated baseband symbols to the allocated space/time/frequency resources, individual transmit antenna(s), and the associated reference symbols.

[0136] As indicated above, systems operating at high carrier frequency (e.g., above 6 GHz) may need to use beamforming (analog, digital or hybrid) to compensate for a 20-30 dB pathloss since it becomes more significant as the carrier frequency becomes higher. The beamforming may be used at the transmitter and/or at the receiver. The highest beamforming may be achieved when both transmitter and receiver use beamforming and the beam directions are aligned (e.g., transmitter and receiver beams are paired). The transmit and receive beam widths may be determined as a function of the type, size and number of antenna elements of the phased array antenna (PAA).

[0137] A normal transmission scheme may be defined as a transmission scheme used when a transmitter and/or a receiver may control beams properly based on the current channel condition (e.g., wide or narrow transmit and/or receive beam pairing is complete). The system may operate within the expected SNR range. In a system, one or more normal transmission schemes may be defined.

[0138] A fallback transmission scheme may be defined as a transmission scheme used for one or more of following cases. A fallback transmission scheme may be used when the performance of the normal transmission scheme is significantly degraded. For example, a significant loss in SNR may occur due to a change of the WTRU orientation with respect to the mB or due to blocking. A fallback transmission scheme may be used when the channel status information (CSI) ages faster than a feedback cycle, so that a transmitter may not rely on the

reported CSI. A fallback transmission scheme may be used when a CSI is not available at the transmitter. Fallback transmission schemes may be defined for data channels, and for control channels. The transmission schemes in this disclosure may be not limited to a system with a high carrier frequency and may be used for a system with any carrier frequency.

[0139] A normal transmission scheme may use a single transmit RF chain or multiple transmit RF chains. If a single transmit RF chain is used, the normal transmission scheme may use analog beamforming. On the other hand, if multiple RF chains are used, the normal transmission scheme may use analog, digital, or hybrid beamforming. Although the beamforming capability is determined based on the number of RF chain and/or number of antenna element, embodiments described herein may be used for a system with any number of transmit/receive RF chains and/or antenna elements and still be consistent with this disclosure.

[0140] The beamforming capability described herein may include one or more of following: a number of beams supported, a beamwidth, a beam control ability (e.g., analog, digital, and hybrid), and a beam measurement/reporting. The number of beams may be interchangeably used as a number of beam steering vectors and a number of precoding vectors. The beamwidth may be interchangeably used as a beam steering vector and as a precoding vector.

[0141] A normal transmission scheme may use analog beamforming and may operate using either wide or narrow beams, with or without channel state information (CSI) feedback from the receiver (i.e., closed loop or open loop transmission schemes).

[0142] In an example, a WTRU may not have a receiver beamforming capability and an analog beamforming may be used only at the transmitter. Therefore, the beam pairing between transmitter beam and receiver beam may not be used. A transmission scheme may be defined without a beam pairing process. Therefore, a transmitter may not provide a transmit beam information

(e.g., the transmit beam ID) for a downlink transmission when a transmission scheme which may not support beam pairing process may be used.

[0143] In another example, a WTRU may have receiver beamforming capability and the analog beamforming may be used at both transmitter and receiver. A beam pairing scheme/process between transmitter beam and receiver beam may be used. A transmission scheme with beam pairing process may use one or more following methods. A downlink control channel may indicate the transmit beam information for the associated data channel. The downlink control channel may be, but is not limited to, a physical downlink control channel, MAC control message, higher layer radio resource control (RRC) signaling, or a broadcasting channel. A downlink control channel may indicate a receive beam information for the associated data channel. Therefore, a WTRU may use the receiver beam indicated from the downlink control channel. A transmitter may request a preferred transmit beam information from a receiver, or a receiver may be configured to report a preferred transmit beam information regularly.

[0144] The receiver beamforming may be indicated as a WTRU capability and a transmission scheme may be determined as a function of the receiver beamforming capability. For example, if a WTRU indicates no receiver beamforming support, a transmission scheme without beam pairing process may be used. On the other hand, if a WTRU indicates receiver beamforming support, a transmission scheme with beam pairing process may be used. For the transmission scheme determination according to the WTRU receiver beamforming capability, one or more of following operations may apply. Existence of a bit field in a downlink control channel may be used to indicate the transmit beamforming information may be determined as a function of the WTRU receiver beamforming capability. A downlink control information (DCI) format may be determined as a function of the WTRU receiver beamforming capability. A channel status information (CSI) reporting type may be determined as a function of the WTRU receiver beamforming capability. A downlink control type may be determined as a function of the WTRU receiver beamforming

capability. The relative timing between a downlink control channel and the associated data channel may be determined as a function of the WTRU beamforming capability.

[0145] Referring now to FIG. 9, FIG. 9 illustrates a diagram of a semi-static association between the control transmit (Tx) beam and data Tx beam. While the beams shown in FIG. 9 are described in the context of Tx beams used by a transmitter, it will be appreciated that a receiver uses a corresponding Rx beam in a similar manner. Therefore, Tx and Rx may be used interchangeably in the context of a transmitter or a receiver, respectively.

[0146] In FIG. 9, two TTIs 901 and 902 are shown. In TTI 901, a normal control Tx beam B1 (i.e., wide beam) is associated with a normal data Tx beam B1, which is a wide beam. In TTI 902, normal control Tx beams B1 and B2 (i.e., wide beams) are associated with normal data Tx beams B1 and B2, respectively, where the normal data Tx beams B1 and B2 are wide beams. A transmission scheme may use an implicit beam association between control channel and data channel, where a same transmit beam may be used for both the control channel and the associated data channel, as illustrated in FIG. 9. A WTRU or receiver may assume that a same transmit beam is used for the control channel and the associated data channel. A WTRU may use the same receiver beam for the control channel and the associated data channel as a WTRU may assume the same transmit beam is used. A WTRU may determine a preferred receiver beam during the control channel reception and use the determined receiver beam for the associated data channel.

[0147] For a transmission scheme which may use the same transmit beam for a control channel and the associated data channel, or may require the same receiver beam for a control channel and the associated data channel, the transmit beam information may not be indicated from the control channel. The transmit beam may be adapted either semi-statically or dynamically without the downlink beam indication. The beam may be changed semi-statically and the beam information may be transparent to a WTRU. The beam information for the

control channel and/or the associated data channel may be indicated via higher layer signaling. The beam may be changed dynamically without beam indication in the downlink control channel. The beam information for the control channel and/or the associated data channel may be determined based on the search space of the control channel. The beam information for the control channel and/or the associated data channel may be determined as a function of the location of the control channel within a search space. A beam index may be determined as a function of the starting control channel element (CCE) or enhanced control channel element (ECCE) index of the control channel. A beam index may be determined as a function of BRS used to demodulation the control channel.

[0148] A transmission scheme may use explicit beam association between control channel and the associated data channel, where the transmit beam for the control channel and the associated data channel may be determined independently (or separately). The transmit beam used for the data channel may be explicitly indicated from the corresponding control channel. The transmit beam described herein may include one or more of following parameters:, Tx or Rx beam width (e.g., beam subgroup), Tx or Rx beam direction (e.g., beam index) within the beam width, and a time-frequency resource associated with the beam. The beam index may be indicated as antenna port or reference signal sequence.

[0149] In an example, the transmission scheme using explicit beam association may dynamically switch the Tx beam within a TTI from the wide beam used for control channel to a narrow beam used for the associated data channel. The narrow beam may reside within the wide beam as a subset of the wide beam. As the transmit node dynamically switches from a wide to a narrow beam within a TTI, the receive node may need to also steer its receive beam to ensure that it can receive the narrow Tx beam correctly from the transmitter (e.g., mB). That is, the receiver configures its receive beam to be aligned with the narrow transmit beam. The DCI in the control channel may carry one or more of following parameters for the transmission scheme using explicit beam association: HARQ process number, transport block information, antenna

configuration (as needed), downlink assignment index (DAI), and/or power control indicator.

[0150] The DCI in the control channel may carry a beam ID or a beam index for the data channel. The beam ID or beam index may be interpreted differently according to the beam used for the control channel. For example, one or more wide beams may be used for the control channel. Additionally, a group of narrow beams, which may be associated with a wide beam, may be used for the associated data channel. Therefore, according to the wide beam used for the control channel, the narrow beam ID or beam index for the associated data channel may be different. The beam ID or beam index may be an index of a narrow beam within the group of narrow beams associated with the wide beam.

[0151] The wide beam for the control channel may be determined in a semi-static manner. For example, a higher layer signaling may be used to determine the wide beam and, based on the higher layer configured wide beam for control channel, the group of the narrow beam may be determined. The wide beam for the control channel may be determined as a function of the location of a WTRU-specific search space and/or location within the search space. The wide beam for the control channel may be determined during initial access procedure, random access procedure, and/or cell (re)selection procedure.

[0152] The DCI in the control channel may carry a bit field to request preferred beam reporting. If a WTRU receives an indication of preferred beam reporting, the WTRU may report a preferred narrow beam index in the corresponding uplink resource.

[0153] The DCI in the control channel may carry a bit field to request beam pairing.

[0154] Referring now to FIG. 10, FIG. 10 shows a diagram illustrating an intra-TTI DL assignment with a guard period to detect the Tx beam for data and switch the Rx beam. While the beams shown in 10 are described in the context of Tx beams used by a transmitter, it will be appreciated that a receiver uses a

corresponding Rx beam in a similar manner. Therefore, Tx and Rx may be used interchangeably in the context of a transmitter or a receiver, respectively.

[0155] In FIG. 10, two TTIs 1001 and 1002 are shown. In TTI 1001, a normal control Tx beam B1 (i.e., wide beam) is associated with a normal data Tx beam B1x, which is a narrow beam. A guard period G is present between the control Tx beam B1 and the normal data Tx beam B1x. In TTI 1002, normal control Tx beams B1 and B2 (i.e., wide beams) are associated with normal data Tx beams B1x and B2y, respectively, where the normal data Tx beams B1x and B2y are narrow beams. A guard period G is present between control Tx beam B2 and the data Tx beam B1x.

[0156] Spatially, narrow beams B2x, B2y, etc., are within the area of wide beam B2. Similarly, a number of narrow beams B1x, B1y, etc., reside within the area of wide beam B1. Thus, narrow beams B2x, B2y, etc., are associated with wide beam B2 and narrow beams B1x, B1y, etc., are associated with wide beam B1.

[0157] The WTRU may need to decode the control channel, and may extract from the DCI, the ID of the Tx beam (and thus information on the BRS) of the data channel. This may require a guard time G to be used between the end of the control region B1 and the start of the associated data Tx beam B1x, to allow the WTRU enough time to correctly steer its receive beam to receive the data channel (i.e., to align its (narrow) receive beam with the mB's transmit beam). Within a TTI, a guard period G may be achieved by creating a gap between the end of the control region and the start of the data region, as illustrated in FIG. 10. The length of the guard period may need to be set such that the WTRU may be able to decode the control channel and switch its receive beam before the start of the data region.

[0158] A guard period G may be present between the control channel and its associated data channel in a certain DCI format in which beam index is provided for the associated data channel. One or more of following parameters may apply.

[0159] A guard period G may be used for a WTRU with a certain receiver beamforming capability. For example, if a WTRU indicated that the WTRU has analog beamforming capability only at the receiver, the guard period G may be configured by the base station via higher layer signaling. Alternatively, a WTRU may indicate a required guard period for the receiver beamforming adaptation.

[0160] A guard period G may include the control channel reception time and receiver beam switching time. Therefore, the portion of control channel reception time may be used, depending on the WTRU receiver beamforming capabilities.

[0161] A guard period G may be present if the DCI in the control channel indicates that the beam index of the associated data channel is changed from the latest beam index. Alternatively, the guard period G may be present if the DCI in the control channel indicates that the beam index of the associated channel is different from the beam index of the control channel. A single bit or state in the DCI may indicate the beam index change confirmation, or guard period indication. Other bits or states may also indicate the beam index change.

[0162] If the length of the guard period G is smaller than the CP length, no explicit guard period may be used. If a system supports two or more CP lengths (e.g., a normal CP length and an extended CP length), the guard period G may be used in the normal CP case, while no guard period is used in the extended CP case. Therefore, the guard period G may be considered as '0' in FIG. 10 if the CP length is larger than beam switching time and the decoding time.

[0163] It should be noted that CP length and guard time can be interchangeably used. For example, CP length may be used in a certain waveform (e.g., OFDM) and guard time may be used in another waveform (e.g., single carrier modulation) but is not limited to a specific waveform. The CP may be used between modulation symbols and the guard period may be used between the control channel and the associated data channel.

[0164] Referring now to FIG. 11, FIG. 11 shows a diagram illustrating a cross-TTI DL assignment with narrow beam indication. Instead of creating guard

periods within a TTI, cross-TTI DL assignments may be used where a control Tx beam in one TTI is associated with a data Tx beam in a subsequent TTI. The subsequent TTI may immediately follow the corresponding TTI, or may follow by one or more TTIs. Suffixes "x", "y" and "z" are further used to identify different narrow data Tx beams associated with different wide control Tx beams. For example, B1x/B1y/B1z denote narrow beams associated to wide beam B1, B2x/B2y denote narrow beams associated to wide beam B2, and so on. In one or more instances, narrow data Tx beams (e.g., B1x and B2y) may be sequentially transmitted in the same TTI (e.g., TTI1). In other instances, narrow data Tx beams (e.g., B3x and B3y) may be transmitted in parallel in the same TTI (e.g., TTI3)

[0165] For the cross-TTI assignments, the control channel signaled during TTI "n" may point to DL data assignments for TTI "n+k". In this case, both the offset "k" and the narrow beam for data transmission may need to be signaled in the DCI in addition to the default information fields that may need to be carried in the DCI.

[0166] The above examples illustrate schemes using a single transport block (TB) per TTI. In another example, a transmission scheme may use two or more transport blocks (TBs) within a TTI.

[0167] Referring now to FIG. 12, FIG. 12 shows a diagram for a dual TB transmission scheme. Two or more transport blocks may be transmitted with a same beam as the control channel, or may be transmitted with different beams. For example, FIG. 12 illustrates two transport blocks 1201 and 1202 transmitted (multiplexed) in a TDM fashion within a single TTI (e.g., TTI1). The transmission of the individual transport blocks may use the same beam as the control channel (e.g., transport block 1201 which uses a wide beam), or may use a different beam (e.g., transport block 1202 which uses a narrow beam). In the latter case, the narrow beam ID may need to be signaled in the control region of the TTI.

[0168] In particular, as shown in FIG. 12, a first TB (TB1) may use the same wide beam or the same beam ID as the control channel, and a second TB

(TB2) may use a narrow beam or a beam ID that is different from the beam ID used by the control channel. The beam ID for TB2 may be signal in a DCI transmitted in control data B1 that is associated with TB2. In addition, the dual TB transmission scheme shown in FIG. 12 may be used to carry out a fallback transmission, to be described in more detail below. As a fallback mechanism, data carried by TB1 may be a subset of the data carried by TB2, and TB1 may use a lower modulation and coding scheme (MCS) value than TB2.

[0169] In an example which the two transport blocks may be transmitted in a TDM fashion, the control channel and the DL data assignment may be in the same TTI. For example, transport block 1201 may be associated with control Tx beam 1203 and transport block 1202 may be associated with control Tx beam 1204. The first transport block may be mapped on to a first codeword provided in the control Tx beam 1203 and the second transport block may be mapped on to a second codeword provided in control Tx beam 1204. The codeword may be associated with: a specific beam or beam ID, a BRS, and/or a time/frequency location. As used herein, a codeword represents user data before it is formatted for transmission.

[0170] There may be a one-to-one mapping between the transport block and the codeword. The mapping rule may be fixed. For instance, the first transport block may be mapped onto the first codeword and the second transport block may be mapped onto the second codeword. Alternatively, the mapping rule may be dynamically indicated. For instance, the first transport block may be mapped onto one of the codeword according to the indication. The number of codeword(s) could be equal to or smaller than the number of the transport block(s). If a single codeword is defined, irrespective of the number of transport block, the same beam may be used. Therefore, the transport blocks within a TTI may be mapped on to a single codeword.

[0171] Furthermore, the first codeword (codeword #1) may be transmitted on the same wide beam as the control channel, and the second codeword (codeword #2) may be transmitted on a narrow beam. In this case, mapping of

codeword #2 in the data region of the TTI may be done such that the WTRU has enough time to decode the control channel and switch its receive beam before it may start buffering and receiving the symbols corresponding to codeword #2.

[0172] In another example in which the two transport blocks are transmitted in a TDM fashion, the control channel and the DL data assignment may be in different TTIs. In this case, the network (e.g., mB) may include in the DCI the following information: the relative TTI offset of the DL data assignment and/or the Tx beam index (or beam ID) for both codewords. In this example, codeword #1 and codeword #2 may be mapped anywhere in the data region of the TTI (i.e., flexible mapping).

[0173] In an example, a normal transmission scheme in DL may use an open loop wide beam transmission with channel quality indication (CQI) only reporting for link adaptation purposes. For this scheme, the WTRU may use the BRS associated to the mB DL Tx wide beam, to perform channel estimation, receive the data channel and measure the CQI.

[0174] In another example, a normal Tx scheme may use closed loop narrow beam transmission. The WTRU may report, in addition to the CQI for the active beam, measurements on other detected narrow beams. For this scheme, the WTRU may use the BRS associated to the active narrow beam to perform channel estimation, receive the data channel, and report the CQI. Additionally, the WTRU may use BRS of other beams to perform and report other narrow beam measurements and report the beam ID of its preferred narrow beam.

[0175] One or more fallback transmission schemes are provided herein. The term “fallback transmission scheme” may be interchangeably used with the following: open-loop transmission scheme, coverage enhanced transmission scheme, beam diversity transmission scheme, beam sweeping transmission scheme, and transmit diversity scheme.

[0176] In one or more embodiments, a fallback transmission scheme may be defined as a transmission scheme which may not require a beam pairing process, WTRU reporting assistance for beam pairing, and/or beam ID indication

for the associated data channel. One or more of following parameters may apply for fallback transmission scheme. A certain DCI format may be used for fallback transmission scheme which may not include beam ID for the associated data channel. The control channel and/or data channel may be transmitted with one or more beams. A single wide beam may be used. Two or more wide beams may be used, where the two or more wide beams may be configured for a control channel and/or a data channel transmission. Two or more narrow beams associated with a wide beam which may be used in the normal transmission configured or used.

[0177] The control channel and/or data channel may be transmitted with repetitions. Two or more TTIs may be used for repetitions. A different beam may be used in each TTI. The beam ID in each TTI may be predefined or configured by higher layer signaling. Alternatively, the beam ID in each TTI may be determined as a function of the subframe number and/or SFN. The number of repetition of the fallback transmission scheme may be determined by one or more of following: configuration via higher layer signaling and/or broadcasting channel, a function of number of wide beams and/or number of narrow beams, an indication from the associated DCI, the time/frequency resource used during random access procedure, and/or system parameters.

[0178] In another example, a fallback transmission scheme may be defined as a transmission scheme which may be transmitted in a subset of the TTIs. A subset of TTIs may be defined or configured for the fallback transmission. A subset of TTIs may be defined or configured to monitor control channel associated with a fallback transmission. The subset of TTIs may be configured via higher layer signaling. The subset of TTIs may be determined as a function of the wide beam index associated with the control channel which is used for normal transmission. The subset of TTIs may be determined as a function of one or more of system parameters including physical cell ID, SFN number, and/or system bandwidth.

[0179] There may be a BRS association for normal and fallback transmission schemes. Each of two or more BRSs may be defined with a BRS

index associated with a beam. The BRS index may be defined according to the beam width. In an example, a BRS index associated with wide beam may be defined as W_x, where $x \in \{1,2,\ldots,N\}$, and a BRS index associated with narrow beam may be defined as N_y, where $y \in \{1,2,\ldots,M\}$. N wide beams and M narrow beams are used in the system with a BRS index. A WTRU may determine an associated receiver beam for each BRS index. The wide beams and the narrow beams may be independently defined. Alternatively, a wide beam may be associated with two or more narrow beams.

[0180] In another example, the BRS index may be defined in a hierarchical manner. For example, B_x, where $x \in \{1,2,\ldots,N\}$ may be defined as BRS index associated with a wide beam and each wide beam may be associated with two or more narrow beams B_xy, where $y \in \{1,2,\ldots,M\}$. Each wide beam may have two or more associated narrow beams. The number of narrow beam may be different according to the wide beam index.

[0181] According to the BRS index used, a WTRU may determine a receive beam to receive the signal and perform signal reception procedures. For example, the WTRU may form a receiver beam in analog, digital, or hybrid domain to receive the signal and buffer the signals before it starts demodulation.

[0182] In one or more embodiments, a first BRS index may be used to monitor and/or receive a control channel and a second BRS index may be used to receive an associated data channel. One or more of following parameters may apply.

[0183] The first BRS index may be associated with a wide beam and the second BRS index may be associated with a narrow beam. The first BRS index may be one of the beam indexes of wide beams. The second BRS index may be a narrow beam index associated with the first BRS index. For example, if the first BRS index is B_x, the narrow beam index may be B_xy, where the x is the same for both first BRS index and the second BRS index.

[0184] The first BRS index may be determined during random access procedures and the second BRS index may be determined by a transmitter (e.g., a

mB). For example, the first BRS index may be determined as a function of the PRACH resource used and the second BRS index may be indicated in the associated DCI.

[0185] The first BRS index may be determined during initial access procedures including cell selection/reselection procedures. The first BRS index may be determined as a function of the physical cell ID. The first BRS index may be determined based on the downlink measurement which may be used for cell selection/reselection. The first BRS index may be determined based on the time location of the synchronization signal received.

[0186] In one or more embodiments, a first BRS index may be used to monitor and/or receive a first type of control channel and a second BRS index may be used to monitor and/or receive a second type of control channel. One or more of following parameters may apply. The first BRS index and the second BRS index may be associated with a wide beam. The first BRS index may be associated with a wide beam and the second BRS index may be associated with a narrow beam. The second BRS index may be one of the narrow beams associated with the first BRS index. The second BRS index may be one of the narrow beams which may be independent from the wide beam index.

[0187] The first type of control channel may be a broadcasting/multi-casting channel and the second type of control channel may be a WTRU-specific control channel. For example, the first type of control channel may be defined as a common search space and the second type of the control channel may be defined as a WTRU-specific search space. A WTRU may monitor the first type of control channel in a common search space to receive a multi-casting and broadcasting channels including system information, group power control, paging, and MBMS. A WTRU may monitor the second type of control channel in a WTRU-specific search space to receive unicast traffic.

[0188] In one or more embodiments, the WTRU and the mB may operate using multiple transmission schemes. For example, both wide beams and narrow beams may be used in a first transmission scheme and wide beams may be only

used in a second transmission scheme. One or more of following parameters may apply. The first transmission scheme may be a normal transmission scheme and the second transmission may be a fallback transmission scheme.

[0189] The first transmission scheme may use one beam for a single transmission while the second transmission scheme may use beams available for a single transmission. The single transmission may be a control channel transmission or a data channel transmission. The single transmission may be a single transport block transmission for the data channel. In case of the control channel, the single transmission may be a single DCI transmission. The second transmission scheme may use beams available with repetitions. For example, N repetitions may be used with N beams. Therefore, one BRS index associated with a repetition transmission and all BRS indices are used with N repetitions, where N wide beams may be used in the system.

[0190] The first transmission scheme may use the BRS index indicated from a transmitter while the second transmission scheme may use a predefined BRS index. The predefined BRS index may be determined by one or more of following: a fixed number, a predefined sequence, a subframe number and/or frame number, time/frequency location, a WTRU ID, and/ or system parameters.

[0191] In one or more embodiments, a WTRU may report downlink reference signal received power (e.g., RSRP) for one or more BRS in order to provide physical layer (i.e., layer 1 (L1)) measurement and CSI feedback. For example, a hierarchical BRS structure may be used, wherein N wide beams may be used with M narrow beams for each N wide beams. It should be noted that the terms reference signal received power, downlink pathloss, pathloss, channel quality indicator, wideband channel quality indicator, RSRP and downlink measurement may be used interchangeably.

[0192] One or more of following parameters may apply for the downlink measurement reporting. A downlink measurement may be reported for the currently configured or used wide beam. A downlink measurement may be reported for a subset of N wide beams wherein the subset may be determined

based on currently configured or used wide beam. For example, adjacent wide beams of the currently configured or used wide beam may be determined as the subset. The downlink measurement reporting for a subset of N wide beams may include individual downlink measurement value for each wide beam within the subset. The downlink measurement reporting for a subset of N wide beams may include an index of the wide beam within the subset of N wide beams, which may provide the highest value and its associated downlink measurement value.

[0193] A downlink measurement may be reported for all N wide beams configured by mB. A WTRU may report one downlink measurement for a wide beam at a time. A reporting cycle (e.g., duty cycle) may be determined or configured for each wide beam. Therefore, each wide beam may have a same or a different reporting cycle. A time offset (e.g., TTIs) may be used for downlink measurement reporting for each wide beam.

[0194] In one or more embodiments, a WTRU may send a beam pairing, or beam re-pairing, request to a mB. For example, if a currently configured or used downlink transmit beam is below a predefined threshold, the WTRU may send a request of beam pairing between transmit and receive beams. The beam pairing request information may be transmitted in a higher layer configured uplink control resource. The higher layer configured uplink control resource may be the same as the uplink control resource configured for scheduling request. The beam pairing request information may be interchangeably used by a fallback transmission request.

[0195] The following provides a description of DL/UL transmission modes and modes of operation. In the current 3GPP specifications, the transmission modes may only be applicable to a downlink shared channel (DL-SCH) transmission, and may define the single or multi antenna transmission scheme, the specific antenna mapping, the reference symbols used for demodulation (e.g., CRS or DM-RS), and the associated CSI feedback. For systems operating at frequencies above 6 GHz, there may be a need to expand the concept of transmission mode to address aspects of the propagation channel specific to the

use of directional antennas (i.e., narrow and wide beams), such as: effects of change in the WTRU orientation, blocking effects, delay and angle spread, and so on.

[0196] One or more transmission modes may be used in a system and a transmission mode may use one or more transmission schemes. A WTRU may be configured with a transmission mode in a semi-static manner and the transmission schemes used within a transmission mode may be switched dynamically (e.g., according to a dynamic switching transmission mode). A transmission mode may be configured via higher layer signaling. A transmission mode may be determined as a function of at least one of the number of antenna ports, WTRU capability, and system parameters. A transmission mode may be determined based on the beamforming capability of a WTRU which may include the number of RF chains, number of receive beams, and/or beam switching time.

[0197] For example, a transmission mode may use two transmission schemes where a normal transmission scheme and a fallback transmission scheme may be used. One or more of following parameters may apply. Within a transmission mode, a transmission scheme used in a TTI may be determined by a DCI format received in the control region. A first transmission scheme may be used if a first DCI format (e.g., DCI format-A) is received in the control region and a second transmission scheme may be used if a second DCI format (e.g., DCI format-B) is received in the control region. The first transmission scheme may be a normal transmission scheme and the second transmission scheme may be a fallback transmission scheme.

[0198] The transmission scheme used in the TTI may be determined by a TTI type associated with a transmission. Each TTI may be associated with a transmission among the transmission schemes associated with the transmission mode. Therefore, the transmission scheme may be determined as a function of the subframe number and/or frame number.

[0199] The transmission scheme used in the TTI may be determined by a search space of the control channel. The control channel monitored by WTRU

may be split into multiple subsets and each subset may be associated with a certain transmission scheme.

[0200] The transmission scheme used in the TTI may be determined by an indication in the DCI.

[0201] A WTRU may monitor a control channel according to a first transmission scheme in all TTIs, while the WTRU may monitor a control channel according to a second transmission scheme in a subset of TTIs. The first transmission scheme may be a normal transmission scheme and the second transmission scheme may be a fallback transmission scheme. A WTRU may monitor the control channel for the second transmission scheme if one or more of the following applies: the WTRU is not scheduled for a certain number of consecutive TTIs, the WTRU sends a certain number of consecutive negative ACK corresponding to downlink transmissions, or a downlink measurement is below a predefined threshold.

[0202] A WTRU receiver may use a narrow beam in the first transmission scheme and the WTRU may use a wide beam in the second transmission.

[0203] A WTRU receiver may use a beam ID indicated in the associated control channel to receive the corresponding data channel for the first transmission scheme, and the WTRU may use a predefined beam to receive the corresponding data channel for the second transmission scheme. The predefined receiver beam for the second transmission scheme may be the same receiver beam used for the associated control channel. Alternatively, a sequence of beams may be predefined.

[0204] The following embodiments may include switching (in a semi-static or dynamic fashion) between fallback and normal transmission schemes and may address the following aspects: DCI and UE monitoring behavior, and WTRU behavior for switching between fallback and normal transmission schemes.

[0205] In one of more embodiments, it may be assumed that the WTRU may be connected to the mB via a narrow beam pair for the DL and UL data, and that the mB may use a wide beam for the DL control channel transmission. Thus,

an operation with data fallback to a wide beam is described such that, as the orientation of the WTRU may change, the paired narrow beams used for data transmission may become misaligned, and the data link may experience a sudden and significant drop in signal-to-noise ratio (SNR). If the change in the WTRU orientation does not exceed a certain value, the DL control channel transmissions using wide beams may still be received by the WTRU. This scenario may trigger the mB to dynamically switch the WTRU to a data fallback scheme that uses the same wide beam as for the DL control channel. The data fallback scheme may allow the WTRU to maintain connection using the current transmission mode, while the mB may perform a RRC reconfiguration of the transmission mode until the mB may perform a beam switch, or until the operating SNR using the current transmission mode may improve.

[0206] The following embodiments may address triggers that initiate the mB to use the data fallback, how the DL data fallback scheme is signaled to the WTRU, and how the WTRU data fallback scheme is signaled to the WTRU.

[0207] In one or more embodiments, signaling the DL data fallback to wide beam is described such that the mB may use the same wide beam as used for the control channel for the transmission of the DL fallback data. One or more of following parameters may apply. The WTRU may need to switch its receive beam for data to the beam used to receive the control channel. If control and fallback data are scheduled in the same TTI, a guard time may be needed between the control and the data regions of the TTI, as shown in FIG. 10. The fallback data may be scheduled for a subsequent TTI. The offset of the TTI carrying fallback data may be signaled in the DCI, may be pre-defined, or may be semi-statically configured.

[0208] A different DCI format may be used for fallback and normal transmission. For example, DCI-A may be used for normal transmission and DCI-B may be used for fallback transmissions. In the embodiment described above, the use of fallback DCI (DCI-B) may implicitly indicate the fallback data is

transmitted on the same wide beam as the control. In this case, the fallback DCI may not include the BRS and beam ID.

[0209] In another embodiment, the fallback DCI may explicitly indicate the data fallback beam. The fallback DCI may include at least one of the following pieces of information: BRS, beam ID, and the offset (in TTIs) of the DL data assignment. The fallback DCI may also include the preferred WTRU transmit beam for UL data fallback.

[0210] In another embodiment, the data fallback beam may be determined implicitly during the reception of the associated control channel. For example, a WTRU may perform a blind decoding of the associated control channel with one or more BRS candidates. The WTRU may determine one BRS for the associated control channel decoding. Based on the determined BRS for the associated control channel, the WTRU may determine the data fallback beam. In another example, a WTRU may perform a blind decoding of the associated control channel with one or more control channel candidates. The WTRU may determine the control fallback beam as a function of the control channel candidate. Based on the determined control fallback beam, the WTRU may determine the data fallback beam.

[0211] A WTRU may monitor for both a first DCI format (e.g. DCI-A) and a second DCI format (e.g., DCI-B) in each TTI. Alternatively, the WTRU may monitor for DCI-B only in configured TTIs. The use of DCI-A versus DCI-B may implicitly indicate a different timing rule for the associated data channel reception. In one example, the data channel associated to DCI-A may be transmitted in TTI n+k1 for a DCI-A signaled in TTI n, while the fallback data channel associated to DCI-B may be transmitted in TTI n+k2 for a DCI-B signaled in TTI n. The offset values k1 and k2 may be either explicitly included in the DCI, or the offset of the fallback data, k2, may be implicitly derived from the fallback DCI-B type.

[0212] Upon the detection of the fallback DCI-B on the control wide beam in TTI #n, the WTRU may configure its receive beam for DL data in TTI #n+k2,

where k2 may be explicitly signaled in DCI-B or implicitly derived from the fallback DCI-B type. This may be done using the appropriate BRS, which may be either the same BRS as used for the wide beam control, or determined based on the beam ID that may be signaled in DCI-B.

[0213] Additionally, the WTRU may transmit the UL Acknowledgment—Negative Acknowledgment (A/N) feedback using an UL beam that has the same orientation as the DL beam used for the data fallback reception. The timing for the transmission of the UL A/N feedback may be determined implicitly based on the TTI index (n+k2) of the fallback data transmission. For example, the UL A/N corresponding to the DL fallback data on TTI #n+k2 may be transmitted in TTI #n+k2+m. During TTI #n+k2+m, the mB may monitor the WTRU UL A/N feedback using an UL Rx beam with the same orientation as the DL Tx beam used for DL data fallback transmission during TTI #n+k2.

[0214] In an embodiment, a mB may indicate a fallback for UL data transmission. The fallback for UL data transmission may have at least one of the following parameters. First, a predefined wide beam may be used for uplink transmission. The predefined wide beam may be based on the beam used for UL control. The predefined wide beam may be a beam index. Second, a wider beam, which may be associated with the most recent narrow beam, may be used. For example, a wider beam may consist of one or more narrow beams that may be used for normal UL data transmission, and if a fallback UL transmission is triggered or indicated, the wider beam may be used for the UL fallback data transmission. Third, repetitions of the UL data transmission may be used. Fourth, the UL data transmission may be within a narrower bandwidth. Fifth, a higher transmission power may be used.

[0215] In an embodiment, the indication of a fallback UL data transmission may be transmitted in a DCI. For example, a reserved bit in a DCI, which may be used for uplink grant, may be used to indicate a fallback UL data transmission. In another example, a fallback DCI may be used and a WTRU may monitor for

the fallback DCI as well as for a normal DCI for normal UL data transmission (e.g., normal DCI). One or more of the following parameters may apply.

[0216] The fallback DCI may be monitored for in a subset of resources in which a WTRU may monitor for normal DCI. For example, if a WTRU monitors for normal DCI in every TTI, the WTRU may monitor for the fallback DCI in a subset of TTIs. A WTRU may monitor for both normal DCI and fallback DCI in a TTI, which may be a subset of TTIs determined for the fallback DCI.

[0217] The fallback DCI and the normal DCI may be monitored in a disjoint set of TTIs. For example, a first set of TTIs may be used for normal DCI and a second set of TTIs may be used for fallback DCI, and there may be no overlap between the first set and the second set. The first set of TTIs may be larger than the second set of TTIs. A transmission scheme for the associated UL data transmission may be different for the first set of TTIs and the second set of TTIs.

[0218] A fallback DCI may be received over multiple TTIs while a normal DCI may be received within a single TTI. For example, the fallback DCI may be transmitted with repetitions with multiple (e.g., consecutive) TTIs, while the normal DCI may be transmitted within a TTI.

[0219] When the fallback DCI is transmitted with repetitions, at least one of following parameters may apply. A different transmit beam (e.g., beam ID) may be used for each repetition. For example, if the number of repetitions (i.e., number of TTIs) is N, the transmit beam may change in each repetition. Therefore, N transmit beams may be used for a single fallback DCI transmission. If a total number of transmit beams at a transmitter is M and M is smaller than N, the M transmit beams may be cyclically used with N repetitions. Therefore, M transmit beams may be used for a single fallback DCI transmission with N repetitions. If a different transmit beam (e.g., beam ID) may be used for each repetition, a corresponding receiver beam may be used at a receiver.

[0220] The embodiments described herein may be used for the DCI that is used for normal and fallback downlink data transmissions, although an uplink

transmission beam may be replaced by a downlink receiver beam and still be consistent with the embodiments.

[0221] In one or more embodiments, the dual TB transmission scheme described above (see e.g., FIG. 12) may be used as a fallback transmission while operating in the dynamic switching transmission mode. Thus, an operation with dual TB based fallback Tx scheme is provided. As used herein, transport block and codeword may be used interchangeably.

[0222] When the mB detects that a particular WTRU needs data fallback, it may partition the transmission of the next transport block (MAC PDU) into two physical layer code words, which may be transmitted on a single spatial layer, in a TDM fashion within the TTI. The first codeword may use the same wide beam as the control channel, while the second codeword may use a narrow beam, with the beam ID or the beam index signaled by the mB in the DCI (see e.g., FIG. 12).

[0223] In an embodiment, the first codeword may use a robust coding and modulation scheme, and the data carried in the first codeword may be a subset of the data in the second codeword (current MAC PDU being transmitted). The WTRU may use the data that is correctly decoded in the first codeword to decode the second codeword.

[0224] Referring now to FIG. 13, FIG. 13 shows a diagram illustrating using a dual TB transmission scheme for data fallback. In an embodiment according to FIG. 13, the size of a MAC PDU 1301 to be transmitted may exceed a max Turbo coder block size and code block segmentation with M code blocks 1302 may be used. In this scenario, in a first transmission, the data transmitted by the first codeword may be a full code block of the MAC PDU carried in the second codeword, as illustrated in FIG. 13. The next (e.g., second) transmission of fallback data using this scheme may transmit, in the first codeword, the next code block of the current MAC PDU, and may re-transmit the full MAC PDU in the second codeword. This transmission scheme may continue (e.g., for M transmissions) until the WTRU correctly decodes the MAC PDU and the mB

receives an ACK for the current MAC PDU transmission. The A/N signaling for this scheme will be described in more detail below. Thus, a wide data Tx beam B1 may be used for transmitting TB1 (i.e., first codeword) of a transmission and a narrow data Tx beam B1x or B1y may be used for transmitting TB2 (i.e., second codeword).

[0225] Referring now to FIG. 14, FIG. 14 shows a diagram illustrating another example of using the dual TB transmission scheme for data fallback. In an embodiment according to FIG. 14, if a size of the MAC PDU does not exceed the max Turbo coder block size, the MAC PDU 1401 may be partitioned in M sub-blocks 1402. The first codeword may be used for sequential transmission of independently coded sub-blocks and the second codeword may be used for the transmission (and re-transmission) of the entire MAC PDU, as shown in FIG. 14. For example, for the first transmission of the fallback data, codeword #1 may transmit sub-block #1 of the MAC PDU, and codeword #2 may transmit the entire MAC PDU. For the first re-transmission (e.g., second transmission) of the fallback data, codeword #1 may carry sub-block #2, and codeword #2 may carry the full MAC PDU. The process may continue for a next transmission (e.g., third transmission) until the WTRU ACKs codeword #2. Thus, a wide data Tx beam B1 may be used for transmitting TB1 (i.e., first codeword) of a transmission and a narrow data Tx beam B1x or B1y may be used for transmitting TB2 (i.e., second codeword).

[0226] DL assignment for the dual TB transmission may be provided such that the dual TB transmission may be used as a normal transmission scheme, or as a fallback scheme. The DCI for the dual TB transmission scheme may include the default information: resource assignment information for each codeword (e.g., resource block allocation), HARQ process number, transport block information (modulation and coding scheme (MCS), redundancy version (RV), new data indicator (NDI), etc.), antenna configuration (as needed), DAI, power control indicator, and other flags as needed. Additionally, the DCI may include beam ID or beam index for each TB. In one or more embodiments, the beam ID or beam

index of the first codeword may implicitly be set to the beam ID or beam index used for the control channel transmission, and thus it may not be included in the DCI.

[0227] As the segmentation of the MAC PDU may be different for the fallback scheme as compared to the normal scheme, the segmentation configuration may be signaled to the WTRU. The type of segmentation may be indicated in the DCI, or may be included in the MAC header. For the case where the type of segmentation is included in the DCI, the DCI format for the dual TB scheme used for fallback may be different from the DCI format for the dual TB scheme used for normal transmission.

[0228] In one example, for the data fallback transmission, the DCI may include the following: a field indicating that a single MAC PDU is transmitted using the 2 CW scheme, a field indicating the number M of sub-blocks (or code blocks) the MAC PDU is partitioned in for mapping to codeword #1 (see e.g., FIG. 13 and FIG. 14), and the index (in the range 1 to M) of the sub-block (or code block) transmitted in the current TTI. The maximum value of M may be pre-defined. The choice for the maximum value of M may be a trade-off between the maximum transport block size to be transmitted with the fallback scheme, and the maximum number of TTIs the MAC PDU may be transmitted due to sub-block or code-block partitioning for transmission on codeword #1.

[0229] The dual TB transmission scheme may be used in all TTIs, or may be used in configured TTIs. When the scheme is used in all TTIs, the WTRU may need to monitor the normal DCI as well as the fallback DCI in all TTIs. When the scheme is used in configured TTIs, the WTRU may monitor the normal DCI and the fallback DCI during the configured TTIs, and may monitor the normal DCI only for the rest of the TTIs.

[0230] In one or more embodiments, HARQ retransmissions may be used when using the dual TB scheme. For example, when the dual TB scheme is used for fallback data, the mB may transmit in the first codeword, consecutive code blocks (or sub-blocks) of the original MAC PDU (as shown in FIG. 13 and FIG.

14). The WTRU may only transmit UL A/N signals for the second codeword. The mB may sequentially transmit code block (or sub-block) index 1, 2, ...M of the current MAC PDU on codeword #1 and the full MAC PDU on codeword #2. This may be done until the WTRU correctly decodes the MAC PDU on codeword #2. Due to HARQ processing latencies, and depending on how the DL fallback data transmissions are scheduled, it may happen that the mB transmits code block (or sub-block) k+1 after the WTRU has ACK-ed the MAC PDU after receiving code block (or sub-block) k. In this case, the WTRU may discard all the subsequent received buffers for the current MAC PDU.

[0231] In another embodiment, when the dual TB scheme is used for normal data transmission, the WTRU may transmit UL A/N signals for each codeword. In this case, if the WTRU correctly decodes codeword #1, but not codeword #2, the WTRU may send an ACK for codeword #1 and a NACK for codeword #2. When the mB receives an ACK for codeword #1 and a NACK for codeword #2, for the next transmission to the WTRU, the mB may transmit the next code block (or sub-block) of the sequence in codeword #1, and re-transmit the entire MAC PDU in codeword #2.

[0232] A control channel fallback operation is described such that fallback TTIs may be pre-defined TTIs within sub-frames, which may be used by the mB to transmit the control channel on multiple wide beams (i.e., perform wide beam sweeping) to WTRUs that may need control fallback. For example, for cases where the WTRU may change its orientation, or when blockage of an active beam pair may occur, the mB may determine the need to use a fallback transmission scheme for the control channel and the data channel of a specific WTRU. In this case, during the fallback TTIs, the mB may repeat the transmission of the control channel on several spatial beams, to enable the WTRU to correctly receive the control channel in one or more beams. The one or more beams may be different from the original active beam of the active beam pair. The mB may use a fallback DCI (e.g., DCI-B) to transmit the fallback control channel during the fallback TTIs.

[0233] To make efficient use of the spectrum resources, the fallback TTIs may be used for regular transmissions when fallback schemes are not used. Thus, the mB may use fallback schemes only if the mB determines it needs to. In this case, the mB may use normal DCI (e.g., DCI-A) for the control channel transmissions. During fallback TTIs, the WTRU may monitor for both the normal DCI (e.g., DCI-A) and the fallback DCI (e.g., DCI-B).

[0234] In one or more embodiments, when the mB determines the need for control fallback for a WTRU, it may use the same reference signal (BRS) for all control beams that it re-transmits to the WTRU. In this case, the WTRU may need knowledge of the number of repetitions of the control channel, as well as of the time and frequency resources that may be assigned to the fallback TTI. Accordingly, the WTRU may monitor the fallback TTIs using the same reference signals (BRS) as used for the normal transmission scheme.

[0235] In another embodiment, the mB may use different BRSs for each beam, which may enable the WTRU to perform beam measurements. In this case, a mapping of the mB Tx beam ID (or beam index, or BRS) to time-frequency resources within the fallback TTIs may need to be known at the WTRU. This mapping may be either cell-specific (in which case, it may be signaled on broadcast), or WTRU specific, which may be configured via RRC signaling.

[0236] Mapping of Tx beam for fallback DCI to resources (TTI/OFDM symbol) is provided according to one or more embodiments. As previously indicated, the first element that enables the control channel fallback operation may be the provisioning of fallback TTIs. The fallback TTIs may be either cell specific or WTRU specific.

[0237] In addition to provisioning the fallback TTIs, the WTRU may need to be able to find and decode the fallback control channel within the fallback TTIs. Therefore, a mapping between the mB transmit beam and the resources used for the fallback control channel may need to be defined. The mapping may be cell specific or WTRU specific and may be signaled to the WTRU via broadcast signals or RRC signaling. The signaling may include information on the number

of Tx wide beams supported by the mB, the number of fallback TTIs per sub-frame, the length of the control region in the fallback TTIs.

[0238] In one or more mapping embodiments, the number of mB Tx wide beams is denoted by Nwb, the size (in OFDM symbols) of the control region within a TTI is denoted by Lc, and the number of fallback TTIs per sub-frame is denoted by Nf. The mapping may be static, and pre-defined, as follows.

[0239] The sub-frame pattern periodicity, T, may be determined as the ratio between the number of mB wide beams (Nwb) and the number of OFDM symbols per sub-frame that may be used for fallback control signaling ($L_c N_f$).

[0240] The index of the fallback TTI (t_f) within a sub-frame may be fixed (pre-defined), or it may be WTRU specific. If the index of the fallback TTI is WTRU specific, in one example, the index may be set as: $t_f = mod\left(\frac{UE_{ID}}{N_f}\right)$. If more than one fallback TTIs per sub-frame are assigned to a WTRU, the index of the first fallback TTI may be calculated as indicated above. The indices of the subsequent fallback TTIs in the sub-frame may be at a fixed offset (pre-defined or signaled) with respect to the first fallback TTI.

[0241] The mapping between the mB Tx wide beam b, $(0 \le b \le N_{wb} - 1)$, the fallback TTI index $n, (0 \le n \le N_f - 1)$ within sub-frame k, $(0 \le k \le T - 1)$, and the OFDM symbol index (l), may be expressed as: $b = k \cdot N_f \cdot L_c + n \cdot L_c + l$.

[0242] In this example, the mB would transmit the fallback DCI on wide beam index b in sub-frame k, fallback TTI index n within sub-frame k, and OFDM index l within the fallback TTI. FIG. 15 shows a diagram of a mapping of Tx beams for fallback DCI to resources for a single RF chain mB. According to this mapping, Nwb = 6, Nf=1 and Lc = 3 and a WTRU and mB behavior during fallback TTI is provided according to such mapping.

[0243] In particular, FIG. 15 shows a diagram illustrating an example of fallback TTI and linkage between fallback DCI and fallback data, where the mB has one RF chain. In particular, a control channel fallback transmission scheme using fallback TTIs is shown such that a DL control channel in a fallback TTI

may be repeated for one or more beam identities in a TDM manner. A WTRU may monitor and/or attempt to decode one or more of the control channels. Furthermore, the WTRU may use one Rx beam or sweep its Rx beam over a set of predefined or configured beam indices for monitoring/decoding the control channels.

[0244] During the TTIs that the mB configures as fallback, the mB may sweep the wide beam control channel using fallback DCI (DCI-B) for the WTRUs that may need control fallback. During the TTIs configured for fallback, the WTRU may monitor for both the regular DCI (DCI-A) and the fallback DCI (DCI-B). During the TTIs not configured for fallback (i.e., non-fallback TTIs), the WTRU may monitor for the regular DCI (DCI-A). The WTRU may not monitor for the fallback DCI (DCI-B) during the non-fallback TTIs.

[0245] The fallback DCI (DCI-B) may point to the DL resource assignment (time, frequency and beam) for fallback data. The mB may schedule fallback data repeated on multiple wide beams (e.g., B1, B2, B3 in FIG. 15), using smaller TBs (i.e., a smaller TB size).

[0246] In one example, the association between the fallback control (DCI-B) and the fallback data is shown in FIG. 15. The fallback data may be assigned on the same wide beam as the wide beam used for signaling the fallback control (DCI-B). In this case, in addition to the regular information carried in the DCI, DCI-B may also signal the offset (in TTIs) of the TTI that carries the fallback data, with respect to the current TTI (the offset may also be set to zero). Alternatively, the DCI-B may signal the beam ID or the beam index, and correspondingly the BRS of the beam that carries the fallback data.

[0247] Referring now to FIG. 16, FIG. 16 shows a diagram illustrating an example of fallback TTI and linkage between fallback DCI and fallback data, where the mB supports multiple RF chains. Since the mB may support multiple Tx RF chains, the mB may simultaneously transmit multiple beams during either the control region of the TTI, or the data region, or both. For example, in FIG. 16, the mB may simultaneously transmit control channels on beams B1 and

B3 during the first time resource of the fallback TTI, followed by control channel on beams B2 and B3 during the second time resource of the fallback TTI, and so on. The time-frequency resources may be used across different beams in a SDM fashion. For this example, the mB may insert beam-specific reference signals (BRS) in the appropriate time-frequency resources to enable correct reception by the WTRU.

[0248] Uplink A/N feedback may be signaled by a WTRU that received fallback DCI-B using an UL Tx wide beam that matches the DL Rx beam that the fallback DCI-B was received on (as an example, use the same steering vector).

[0249] The WTRU may transmit UL A/N feedback for the fallback data that corresponds to the fallback DCI-Bs that the WTRU decoded. For example, if in FIG. 15, the UE successfully decoded DCI-B transmitted on beams B2 and B3 in the fallback TTI, but it did not decode DCI-B transmitted on beam B1, it may transmit UL A/N corresponding to the fallback data on Tx beam B2 in TTI4 and UL A/N corresponding to the fallback data on Tx beam B3 in TTI5.

[0250] The timing of the UL A/N feedback may be derived by the WTRU according to the duplexing mode that the system operates on. For example, if the system operates in a TDD mode (including dynamic or enhanced TDD operation), the UL A/N feedback for data received on Tx beam B2 in TTI4 may be transmitted in the UL transmission opportunity that meets the HARQ timing requirements. The mB may use the timing of the ACK transmitted by the WTRU, to determine the DL Tx beam ID of the successful reception of fallback control and data. Corresponding to that TTI, and in order to monitor for the UL A/N transmission from the WTRU, the mB may configure the UL Rx beam to match DL Tx beam B2.

[0251] The mB may continue transmitting fallback control (DCI-B) during the configured fallback TTIs, until either it receives a positive ACK for the current transport block, or a fallback timer expires.

[0252] If the WTRU correctly decodes a fallback DCI-B and its associated fallback data on a beam that is different from the current active beam, the mB

may issue a measurement request for that different beam, or the WTRU may send a measurement report of the (preferred) different beam. If a measurement (e.g., signal quality or strength) in the measurement report is above a threshold, the mB may issue a beam switch command to the WTRU, while maintaining the same transmission mode. In another solution, if the WTRU correctly decodes the fallback data on only one of the fallback beams used for re-transmission, the mB may directly issue a beam switch command to the WTRU for the ACK'ed beam, and maintain the same transmission mode.

[0253] Fallback DCI using wide beam sweeping in the PDSCH region may be provided in one or more embodiments. For example, FIG. 17 shows a diagram of fallback DCI mapped to the data region, and linkage to fallback data, where the mB supports one or more RF chains. Accordingly, the fallback TTIs may be still be defined and assigned as described above, but within the fallback TTIs, the fallback DCI (DCI-B) may be mapped to the data region. This approach may be used for scenarios that require control channel congestion mitigation. To enable the WTRU to decode the fallback DCI (DCI-B), the mapping between the transmitted beam and the specific time-frequency resources may need to be known by the WTRU. This mapping may be cell-specific or WTRU specific, and may be signaled to the WTRU via broadcast signaling (MIB or SIB) or via RRC signaling.

[0254] In the example illustrated in FIG. 17, the end of the data region (and the start of the region that may be used for the fallback control channel) may be indicated explicitly via signaling, implicitly to the WTRU, or may be pre-defined. For single Tx RF chain mBs, the mB may sweep the fallback DCI (DCI-B) on multiple beams in a TDM fashion, according to the beam to resource mapping. In this case, the mB may apply beam-specific reference signals (BRS) to the time-frequency resources used for each beam. In the fallback TTI (TTI2) of FIG. 17, fallback DCI-B may be transmitted on Beam B2 during the data region of the TTI. BRS specific to beam B2 may need to be inserted in the time-frequency resources used for the DCI-B transmission with beam B2.

Furthermore, BRS specific to beam B3 may need to be inserted in the time-frequency resources used for the DCI-B transmission with beam B3.

[0255] The mB may transmit fallback DCI in that data region if it determines the need to do so. If no WTRUs need fallback transmissions, the mB may reuse the time-frequency resources to schedule regular data. The WTRUs that may monitor for the fallback DCI during the fallback TTI may still attempt to blind decode the fallback control channel, but may not successfully detect the fallback control channel.

[0256] Referring now to FIG. 18, FIG. 18 shows a diagram illustrating fallback DCI mapped to the data region using narrow beam transmission. Accordingly, the fallback DCI may be transmitted in a narrow band within the assigned time-frequency resources in the data region of the TTI. This may allow the mB to use the rest of the frequency resource(s) for data transmission to the WTRUs operating in normal transmission mode. Mapping between the fallback TTI & time resource within a TTI and the mB DL beam for fallback DCI transmission may be done in a similar fashion as described above.

[0257] FIG. 19 shows a flow diagram utilizing a dual TB transmission scheme, for example, as shown in FIG. 12, according to one or more embodiments. While FIG. 12 may serve as an example of a dual TB transmission scheme, process 1900 shown in FIG. 19 can be applied to any dual TB transmission scheme.

[0258] The process 1900, implemented by a WTRU while operating in the high frequency bands (e.g., above 6 GHz), includes receiving multiple signals in a time transmission interval (TTI) (operations 1905, 1910 and 1920). In particular, the receiving of multiple signals includes receiving at least one control signal (operation 1905) using a first beam associated with a first beam identifier (ID), receiving a first data signal (operation 1910) using the first beam associated with the first beam ID, and receiving a second data signal (operation 1920), subsequent to the first data signal, using a second beam associated with a second beam ID different from the first beam ID. At least one of the control signal(s)

indicates the second beam ID. The process 1900 further includes switching a receive beam of the WTRU from the first beam to the second beam based on the second beam ID to receive the second data signal (operation 1915).

[0259] According to another embodiment, a method implemented by a WTRU includes receiving, in a time transmission interval (TTI), at least one control signal, a first transport block and a second transport block. The at least one control signal and the first transport block are received using a first beam, and the second transport block is received using a second beam that has a beam width that is more narrow than a beam width of the first beam. In addition, the first transport block and the second transport block are multiplexed using time division multiplexing such that the second transport block is received subsequent to the first transport block. The method further includes switching a receive beam of the WTRU from the first beam to the second beam, to receive the second transport block, based on beam information associated with the second beam received in one of the at least one control signal.

[0260] FIG. 20 shows a flow diagram utilizing a dual TB transmission scheme, for example, as shown in FIG. 12, according to one or more embodiments. While FIG. 12 may serve as an example of a dual TB transmission scheme, the process shown in FIG. 20 can be applied to any dual TB transmission scheme.

[0261] The process 2000, implemented by wireless communication device (e.g., a base station, eNB, mB, or the like) while operating in the high frequency bands (e.g., above 6 GHz), includes transmitting multiple signals in a time transmission interval (TTI) (operations 2005, 2010 and 2020). In particular, the transmitting of multiple signals includes transmitting at least one control signal (operation 2005) using a first beam associated with a first beam identifier (ID), transmitting a first data signal (operation 20910) using the first beam associated with the first beam ID, and transmitting a second data signal (operation 2020), subsequent to the first data signal, using a second beam associated with a second beam ID different from the first beam ID. At least one of the control signal(s)

indicates the second beam ID. The process 2000 further includes switching a transmit beam of the wireless communication device from the first beam to the second beam based on the second beam ID to transmit the second data signal (operation 2015).

[0262] According to another embodiment, a method implemented by a wireless communication device includes transmitting, in a time transmission interval (TTI), at least one control signal, a first transport block and a second transport block. The at least one control signal and the first transport block are transmitted using a first beam, and the second transport block is transmitted using a second beam that has a beam width that is more narrow than a beam width of the first beam. In addition, the first transport block and the second transport block are multiplexed using time division multiplexing such that the second transport block is transmitted subsequent to the first transport block. The method further includes switching a transmit beam of the wireless communication from the first beam to the second beam, to transmit the second transport block, based on beam information associated with the second beam transmitted in one of the at least one control signal.

[0263] Although features and elements are described above in particular combinations, one of ordinary skill in the art will appreciate that each feature or element can be used alone or in any combination with the other features and elements. In addition, the methods described herein may be implemented in a computer program, software, or firmware incorporated in a computer-readable medium for execution by a computer or processor. Examples of computer-readable media include electronic signals (transmitted over wired or wireless connections) and computer-readable storage media. Examples of computer-readable storage media include, but are not limited to, a read only memory (ROM), a random access memory (RAM), a register, cache memory, semiconductor memory devices, magnetic media such as internal hard disks and removable disks, magneto-optical media, and optical media such as CD-ROM disks, and digital versatile disks (DVDs). A processor in association with software

may be used to implement a radio frequency transceiver for use in a WTRU, UE, terminal, base station, RNC, or any host computer.

* * *

CLAIMS

What is claimed is:

1. A wireless transmit/receive unit (WTRU) configured to perform wireless communications in higher frequency bands using a fallback scheme, comprising:

a receiver configured to receive, in a time transmission interval (TTI), at least one control signal and a first data signal using a first beam associated with a first beam identifier (ID) and a second data signal, subsequent to the first data signal, using a second beam associated with a second beam ID different from the first beam ID, wherein one of the at least one control signal indicates the second beam ID; and

a processor configured to switch a receive beam of the receiver from the first beam to the second beam based on the second beam ID to receive the second data signal.

2. The WTRU of claim 1, wherein the first data signal is carried in a first transport block in the TTI and the second data signal is carried in a second transport block in the TTI.

3. The WTRU of claim 2, wherein the first transport block uses a lower modulation and coding scheme value than the second transport block.

4. The WTRU of claim 2, wherein the first transport block and the second transport block are multiplexed using time division multiplexing such that the second transport block is received subsequent to the first transport block.

5. The WTRU of claim 4, wherein the receiver is configured to receive the at least one control signal in a control region of the TTI that precedes the first and the second transport blocks.

6. The WTRU of claim 1, wherein the one of the at least one control signal includes downlink control information (DCI) that indicates the second beam ID.

7. The WTRU of claim 1, wherein the second beam is a subset of the first beam such that a beam width of the second beam is more narrow than a beam width of the first beam.

8. The WTRU of claim 1, wherein first data received in the first data signal is a subset of second data received in the second data signal.

9. The WTRU of claim 8, wherein the processor is configured to decode the second data using the received first data.

10. The WTRU of claim 1, wherein the at least one control signal includes a first control signal associated with the first data signal and a second control signal associated with the second data signal, wherein first control signal includes control information that indicates the first beam ID and the second control signal includes control information that indicates the second beam ID.

11. A method implemented by a wireless transmit/receive unit (WTRU) configured to perform wireless communications in higher frequency bands using a fallback scheme, the method comprising:

receiving, in a time transmission interval (TTI), at least one control signal and a first data signal using a first beam associated with a first beam identifier (ID) and a second data signal, subsequent to the first data signal, using a second

beam associated with a second beam ID different from the first beam ID, wherein one of the at least one control signal indicates the second beam ID; and

switching a receive beam of the WTRU from the first beam to the second beam based on the second beam ID to receive the second data signal.

12. The method of claim 11, wherein the first data signal is carried in a first transport block in the TTI and the second data signal is carried in a second transport block in the TTI.

13. The method of claim 12, wherein the first transport block uses a lower modulation and coding scheme value than the second transport block.

14. The method of claim 12, wherein the first transport block and the second transport block are multiplexed using time division multiplexing such that the second transport block is received subsequent to the first transport block.

15. The method of claim 14, further comprising:

receiving the at least one control signal in a control region of the TTI that precedes the first and the second transport blocks.

16. The method of claim 11, wherein the one of the at least one control signal includes downlink control information (DCI) that indicates the second beam ID.

17. The method of claim 11, wherein the second beam is a subset of the first beam such that a beam width of the second beam is more narrow than a beam width of the first beam.

18. The method of claim 11, wherein first data received in the first data signal is a subset of second data received in the second data signal.

19. The method of claim 18, further comprising:
decoding the second data using the received first data.

20. The method of claim 11, wherein the at least one control signal includes a first control signal associated with the first data signal and a second control signal associated with the second data signal, wherein first control signal includes control information that indicates the first beam ID and the second control signal includes control information that indicates the second beam ID.

21. A wireless transmit/receive unit (WTRU) configured to perform wireless communications in higher frequency bands using a fallback scheme, comprising:

a receiver configured to receive, in a time transmission interval (TTI), at least one control signal, a first transport block and a second transport block, wherein the at least one control signal and the first transport block are received using a first beam, and the second transport block is received using a second beam that has a beam width that is more narrow than a beam width of the first beam, and wherein the first transport block and the second transport block are multiplexed using time division multiplexing such that the second transport block is received subsequent to the first transport block; and

a processor configured to switch a receive beam of the WTRU from the first beam to the second beam, to receive the second transport block, based on beam information associated with the second beam received in one of the at least one control signal.

AMENDED CLAIMS
received by the International Bureau on 15 March 2017 (15.03.2017)

CLAIMS

What is claimed is:

1. A wireless transmit/receive unit (WTRU) configured to perform wireless communications, comprising:

a receiver configured to receive, in a time transmission interval (TTI), at least one control signal and a first data signal using a first beam associated with a first beam identifier (ID) and a second data signal, subsequent to the first data signal, using a second beam associated with a second beam ID different from the first beam ID, wherein one of the at least one control signal indicates the second beam ID; and

a processor configured to switch a receive beam of the receiver from the first beam to the second beam based on the second beam ID to receive the second data signal.

2. The WTRU of claim 1, wherein the first data signal is carried in a first transport block in the TTI and the second data signal is carried in a second transport block in the TTI.

3. The WTRU of claim 2, wherein the first transport block uses a lower modulation and coding scheme value than the second transport block.

4. The WTRU of claim 2, wherein the first transport block and the second transport block are multiplexed using time division multiplexing such that the second transport block is received subsequent to the first transport block.

5. The WTRU of claim 4, wherein the receiver is configured to receive the at least one control signal in a control region of the TTI that precedes the first and the second transport blocks.

6. The WTRU of claim 1, wherein the one of the at least one control signal includes downlink control information (DCI) that indicates the second beam ID.

7. The WTRU of claim 1, wherein the second beam is a subset of the first beam such that a beam width of the second beam is more narrow than a beam width of the first beam.

8. The WTRU of claim 1, wherein first data received in the first data signal is a subset of second data received in the second data signal.

9. The WTRU of claim 8, wherein the processor is configured to decode the second data using the received first data.

10. The WTRU of claim 1, wherein the at least one control signal includes a first control signal associated with the first data signal and a second control signal associated with the second data signal, wherein first control signal includes control information that indicates the first beam ID and the second control signal includes control information that indicates the second beam ID.

11. A method implemented by a wireless transmit/receive unit (WTRU) configured to perform wireless, the method comprising:

receiving, in a time transmission interval (TTI), at least one control signal and a first data signal using a first beam associated with a first beam identifier (ID) and a second data signal, subsequent to the first data signal, using a second beam associated with a second beam ID different from the first beam ID, wherein one of the at least one control signal indicates the second beam ID; and

switching a receive beam of the WTRU from the first beam to the second beam based on the second beam ID to receive the second data signal.

12. The method of claim 11, wherein the first data signal is carried in a first transport block in the TTI and the second data signal is carried in a second transport block in the TTI.

13. The method of claim 12, wherein the first transport block uses a lower modulation and coding scheme value than the second transport block.

14. The method of claim 12, wherein the first transport block and the second transport block are multiplexed using time division multiplexing such that the second transport block is received subsequent to the first transport block.

15. The method of claim 14, further comprising:

receiving the at least one control signal in a control region of the TTI that precedes the first and the second transport blocks.

16. The method of claim 11, wherein the one of the at least one control signal includes downlink control information (DCI) that indicates the second beam ID.

17. The method of claim 11, wherein the second beam is a subset of the first beam such that a beam width of the second beam is more narrow than a beam width of the first beam.

18. The method of claim 11, wherein first data received in the first data signal is a subset of second data received in the second data signal.

19. The method of claim 18, further comprising:

decoding the second data using the received first data.

20. The method of claim 11, wherein the at least one control signal includes a first control signal associated with the first data signal and a second

control signal associated with the second data signal, wherein first control signal includes control information that indicates the first beam ID and the second control signal includes control information that indicates the second beam ID.

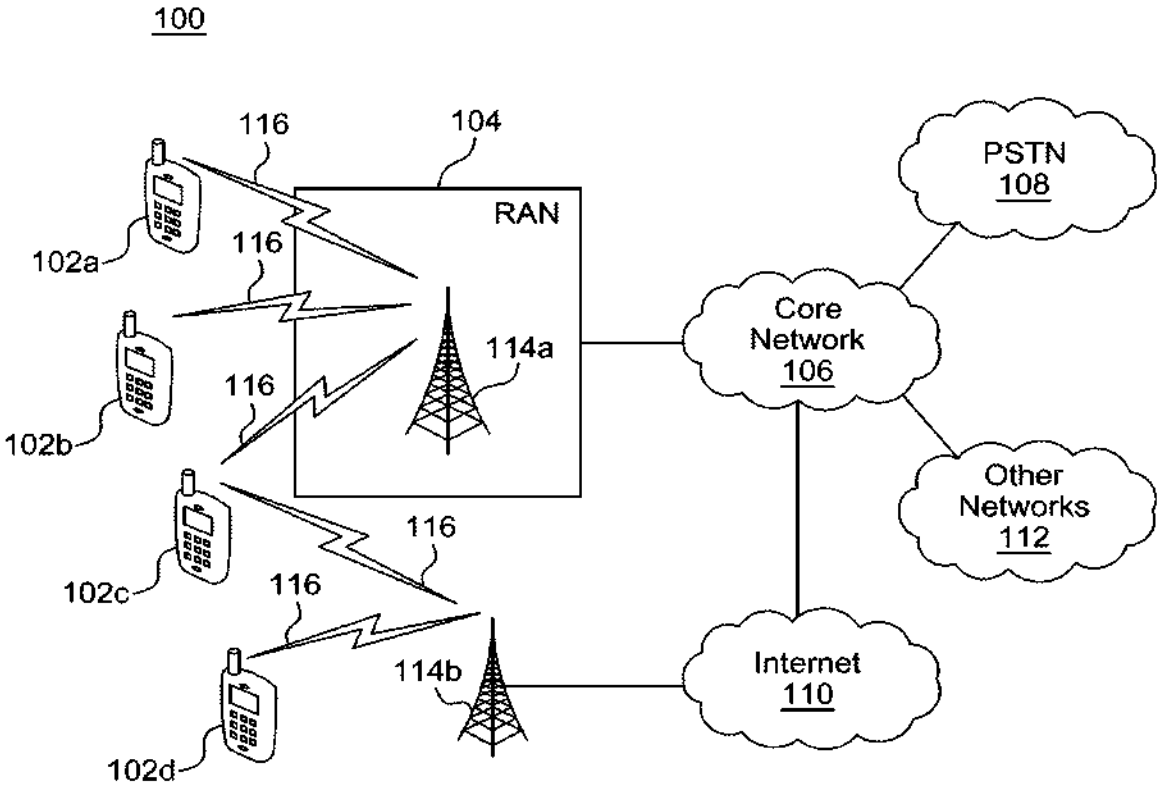

100
116
104
RAN
PSTN
108
102a
116
Core
Network
106
114a
102b
116
Other
Networks
112
116
102c
116
Internet
110
114b
102d

FIG. 1A

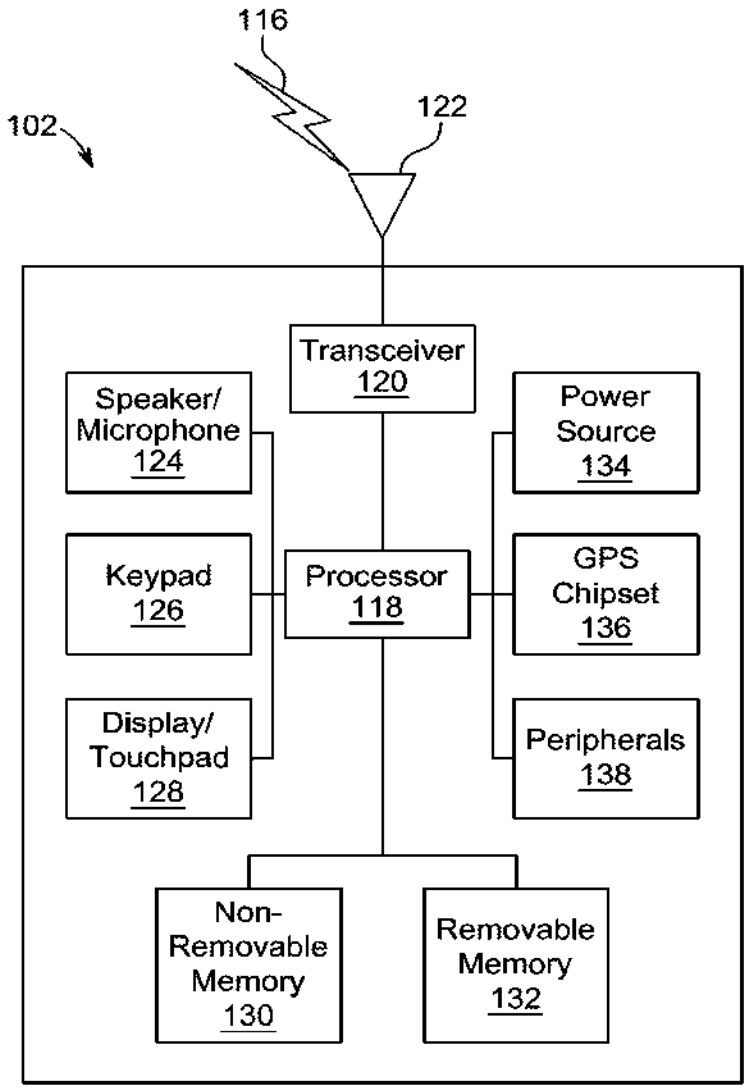

116
122
102
Transceiver
120
Speaker/
Microphone
124
Power
Source
134
Keypad
126
Processor
118
GPS
Chipset
136
Display/
Touchpad
128
Peripherals
138
Non-
Removable
Memory
130
Removable
Memory
132

FIG. 1B

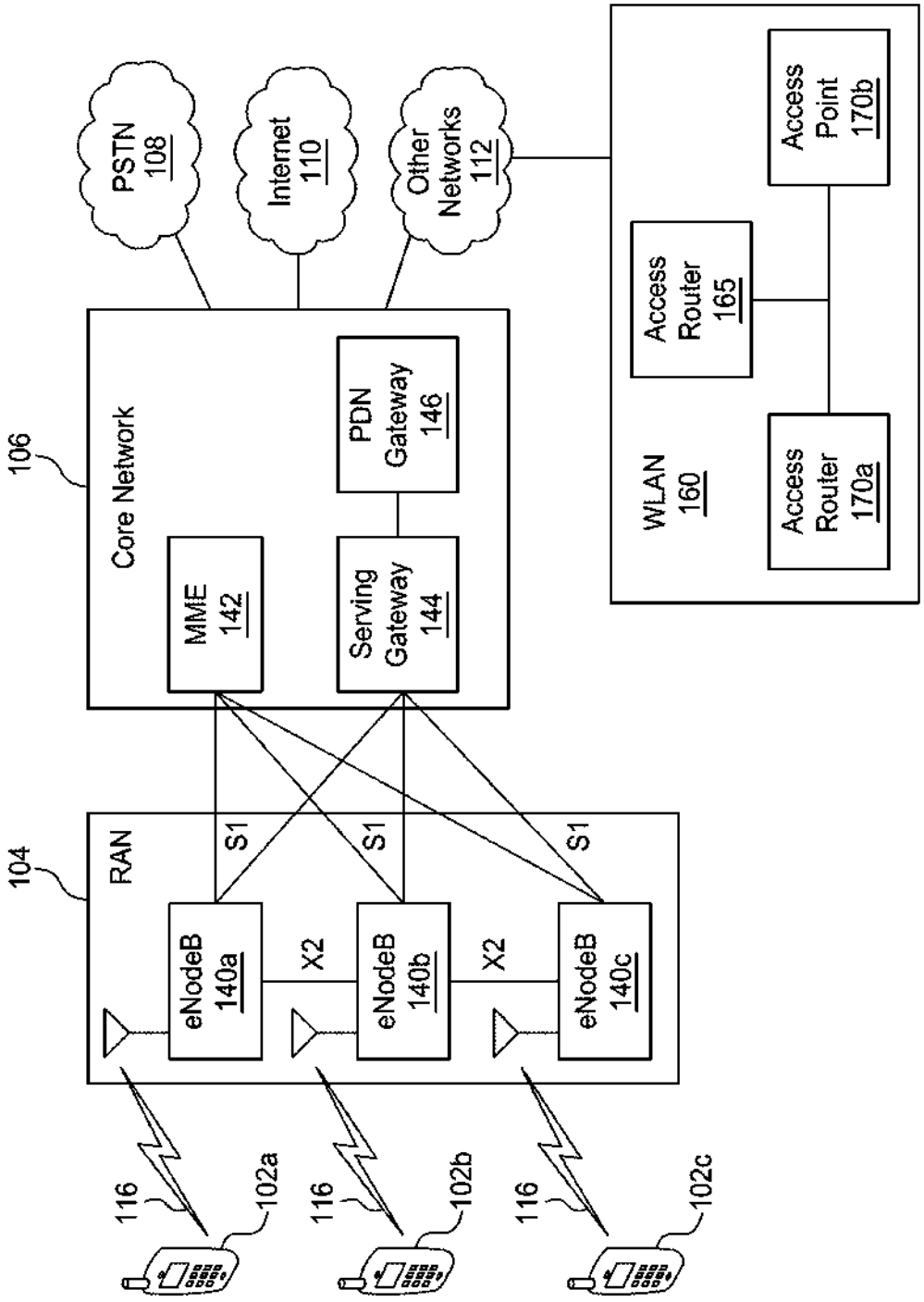

PSTN 108
Internet 110
Other Networks 112
106
Core Network
MME 142
PDN Gateway 146
Serving Gateway 144
WLAN 160
Access Router 165
Access Point 170b
Access Router 170a
104
RAN
S1
S1
S1
eNodeB 140a
eNodeB 140b
eNodeB 140c
X2
X2
116
116
116
102a
102b
102c

FIG. 1C

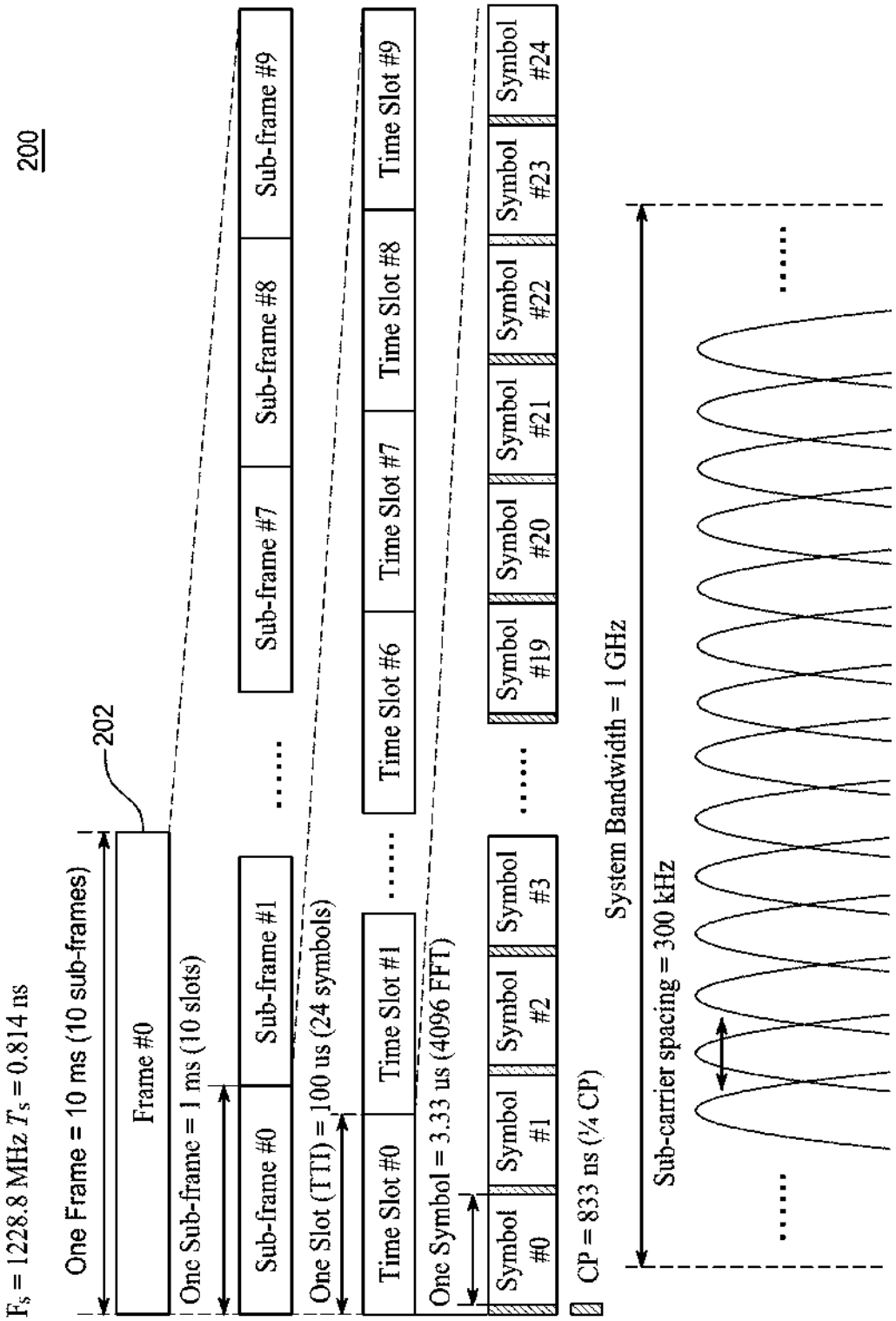

200
F_s = 1228.8 MHz T_s = 0.814 ns
One Frame = 10 ms (10 sub-frames)
202
Frame #0
One Sub-frame = 1 ms (10 slots)
Sub-frame #0
Sub-frame #1
Sub-frame #7
Sub-frame #8
Sub-frame #9
One Slot (TTI) = 100 us (24 symbols)
Time Slot #0
Time Slot #1
Time Slot #6
Time Slot #7
Time Slot #8
Time Slot #9
One Symbol = 3.33 us (4096 FFT)
Symbol #0
Symbol #1
Symbol #2
Symbol #3
Symbol #19
Symbol #20
Symbol #21
Symbol #22
Symbol #23
Symbol #24
CP = 833 ns (¼ CP)
System Bandwidth = 1 GHz
Sub-carrier spacing = 300 kHz

FIG. 2

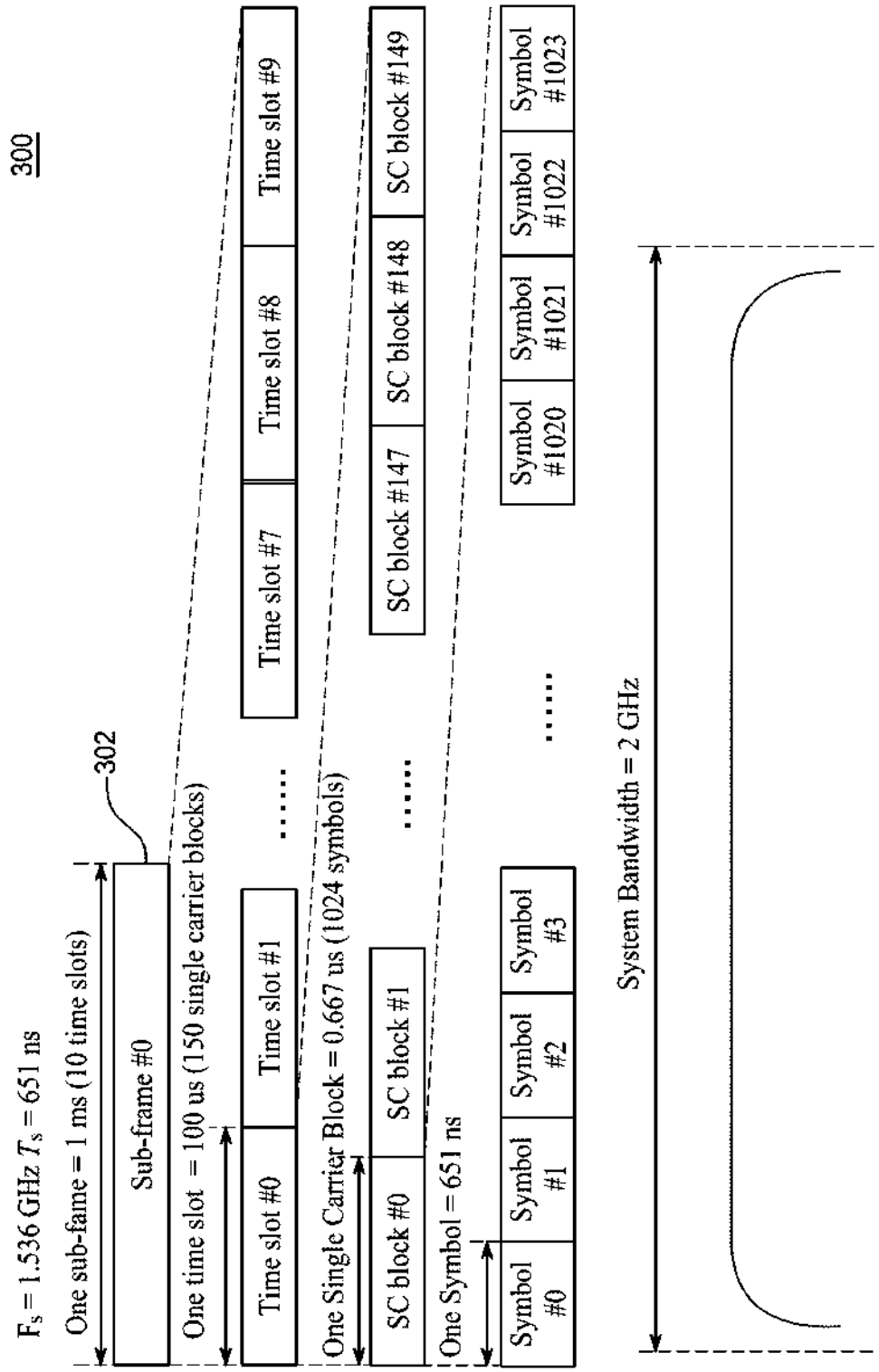

300
302
F_s = 1.536 GHz T_s = 651 ns
One sub-fame = 1 ms (10 time slots)
Sub-frame #0
One time slot = 100 us (150 single carrier blocks)
Time slot #0
Time slot #1
Time slot #7
Time slot #8
Time slot #9
One Single Carrier Block = 0.667 us (1024 symbols)
SC block #0
SC block #1
SC block #147
SC block #148
SC block #149
One Symbol = 651 ns
Symbol #0
Symbol #1
Symbol #2
Symbol #3
Symbol #1020
Symbol #1021
Symbol #1022
Symbol #1023
System Bandwidth = 2 GHz

FIG. 3

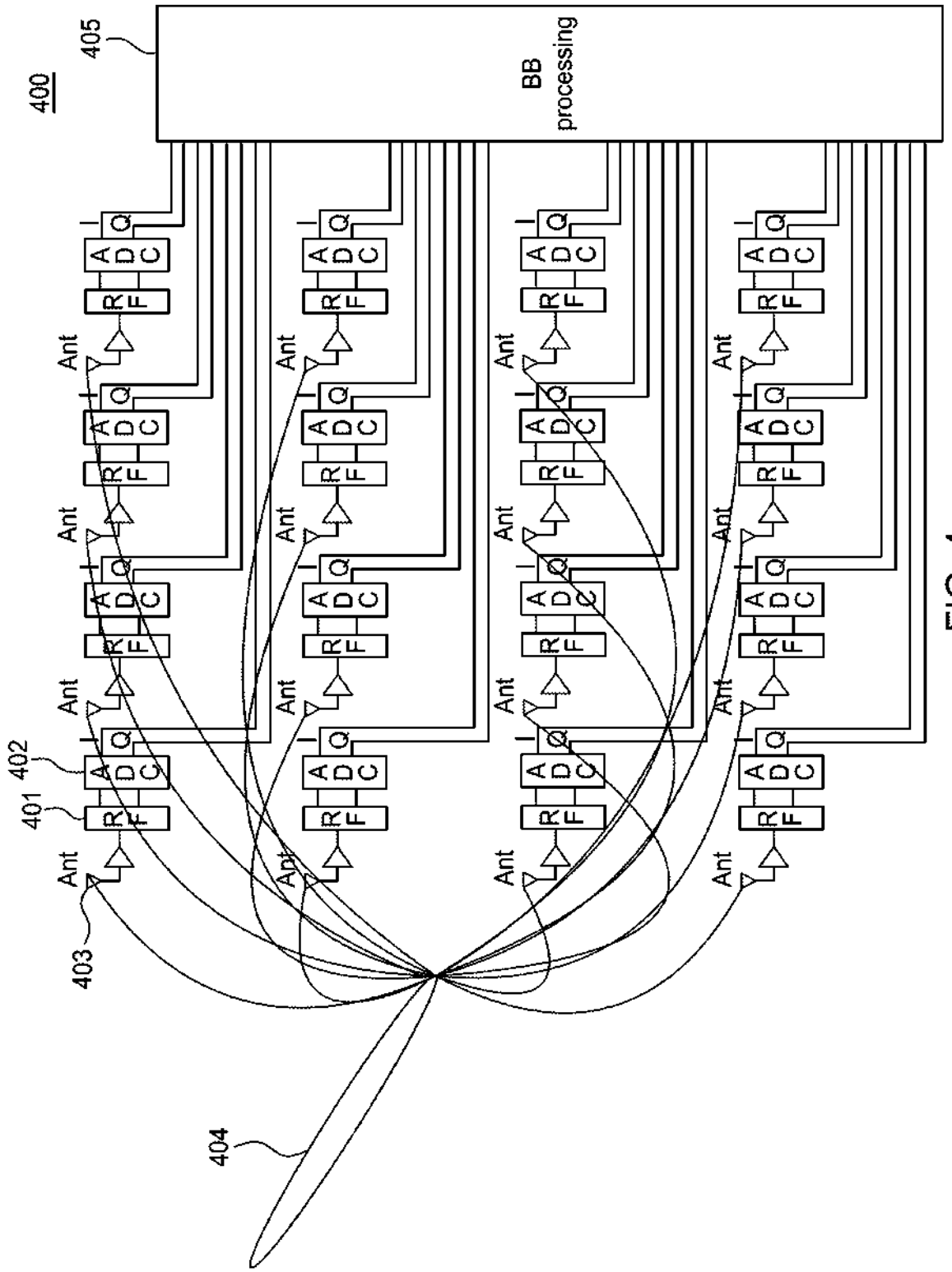


FIG. 4

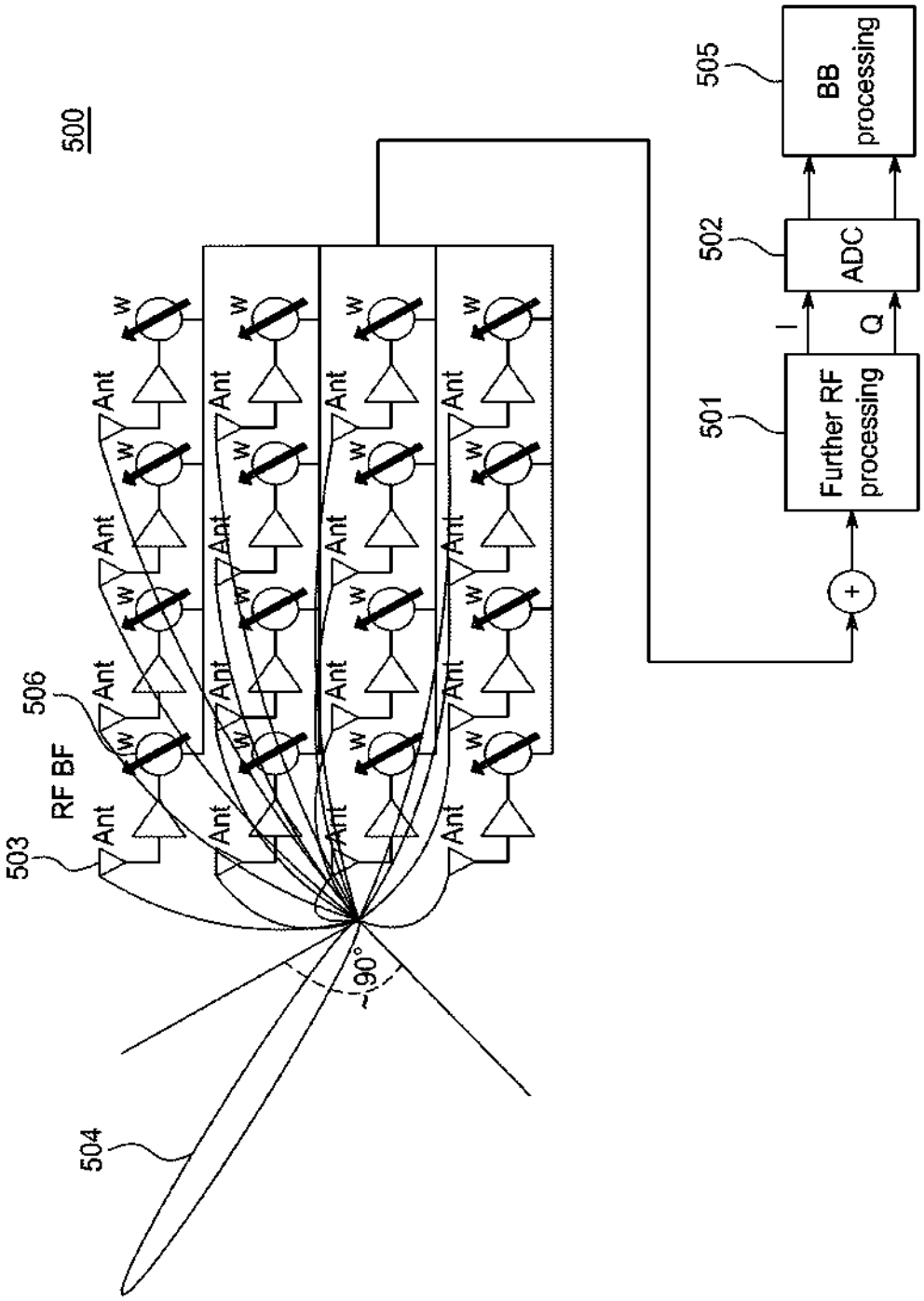

500
505
BB processing
502
ADC
I
Q
501
Further RF processing
+
506
RF BF
503
Ant
W
504
90°

FIG. 5

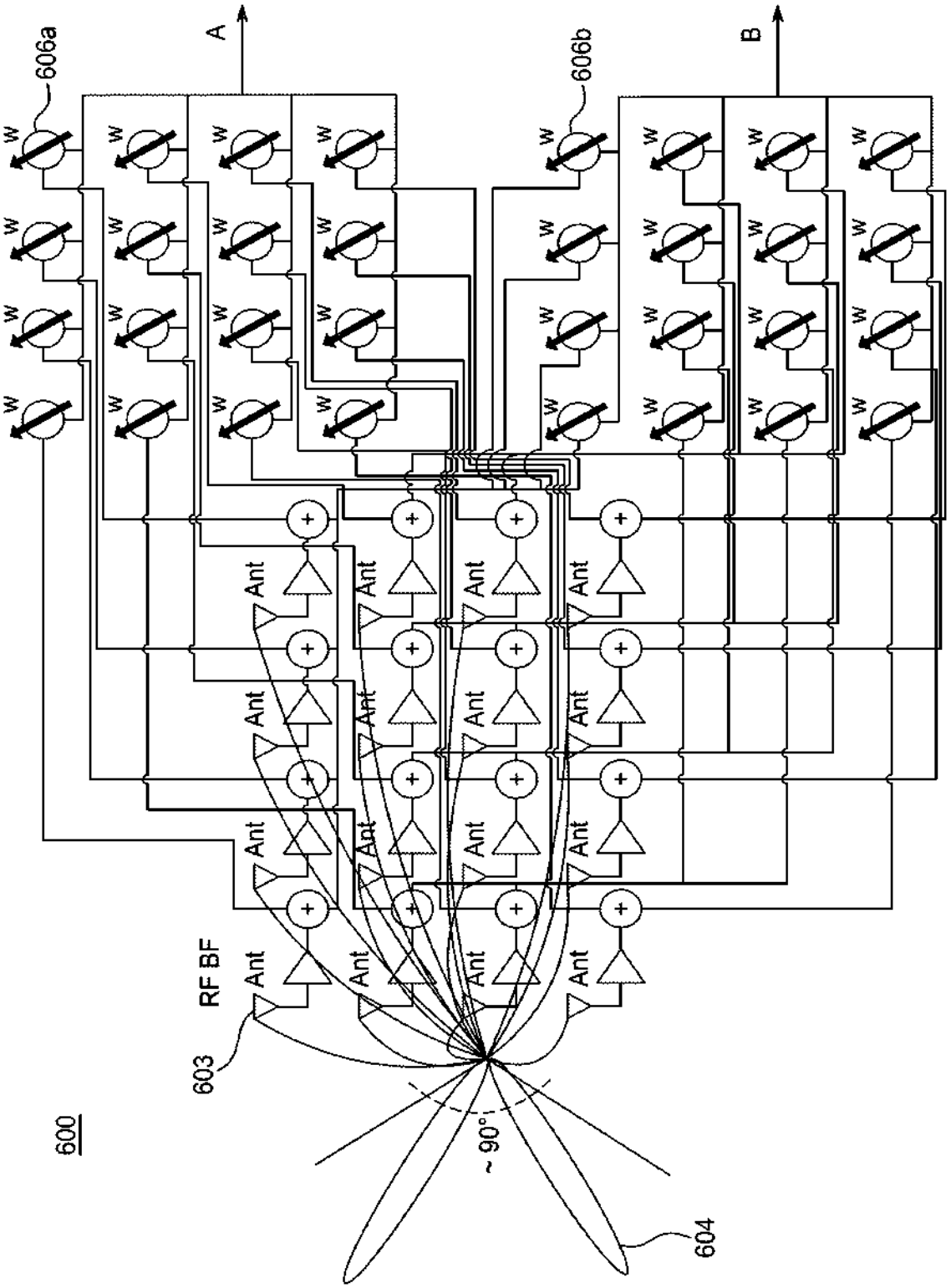


FIG. 6A

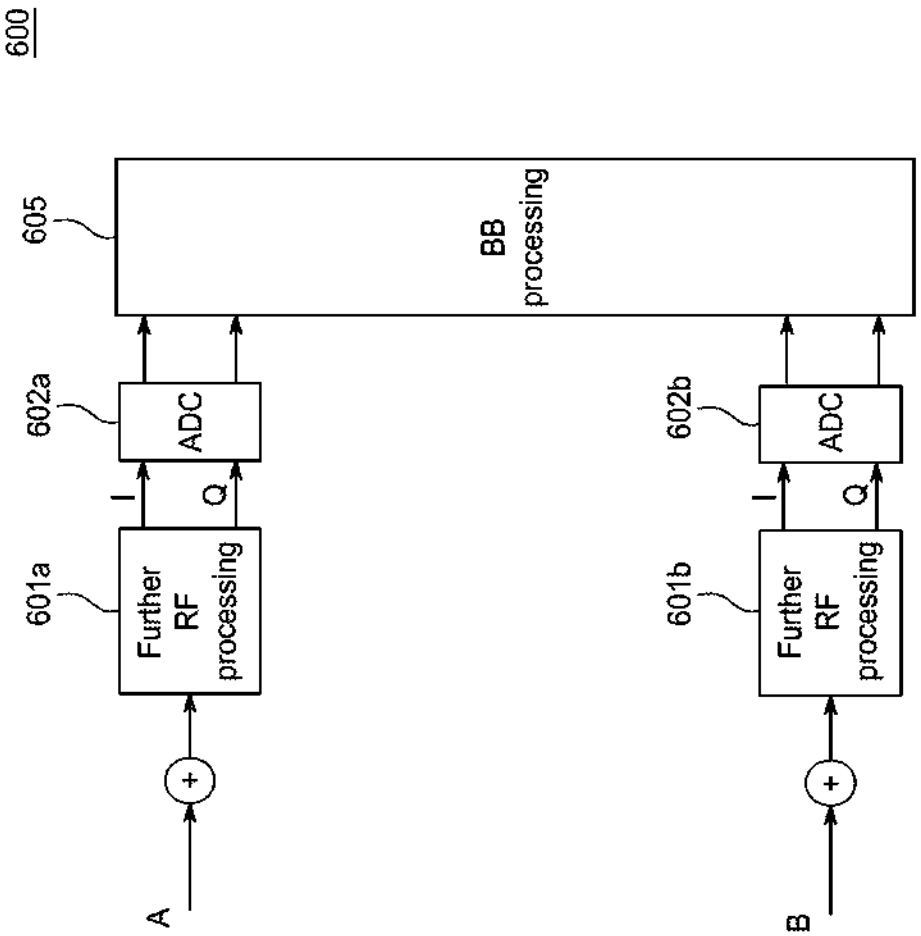

600
605
BB processing
602a
ADC
602b
ADC
I
Q
I
Q
601a
Further RF processing
601b
Further RF processing
A
B

FIG. 6B

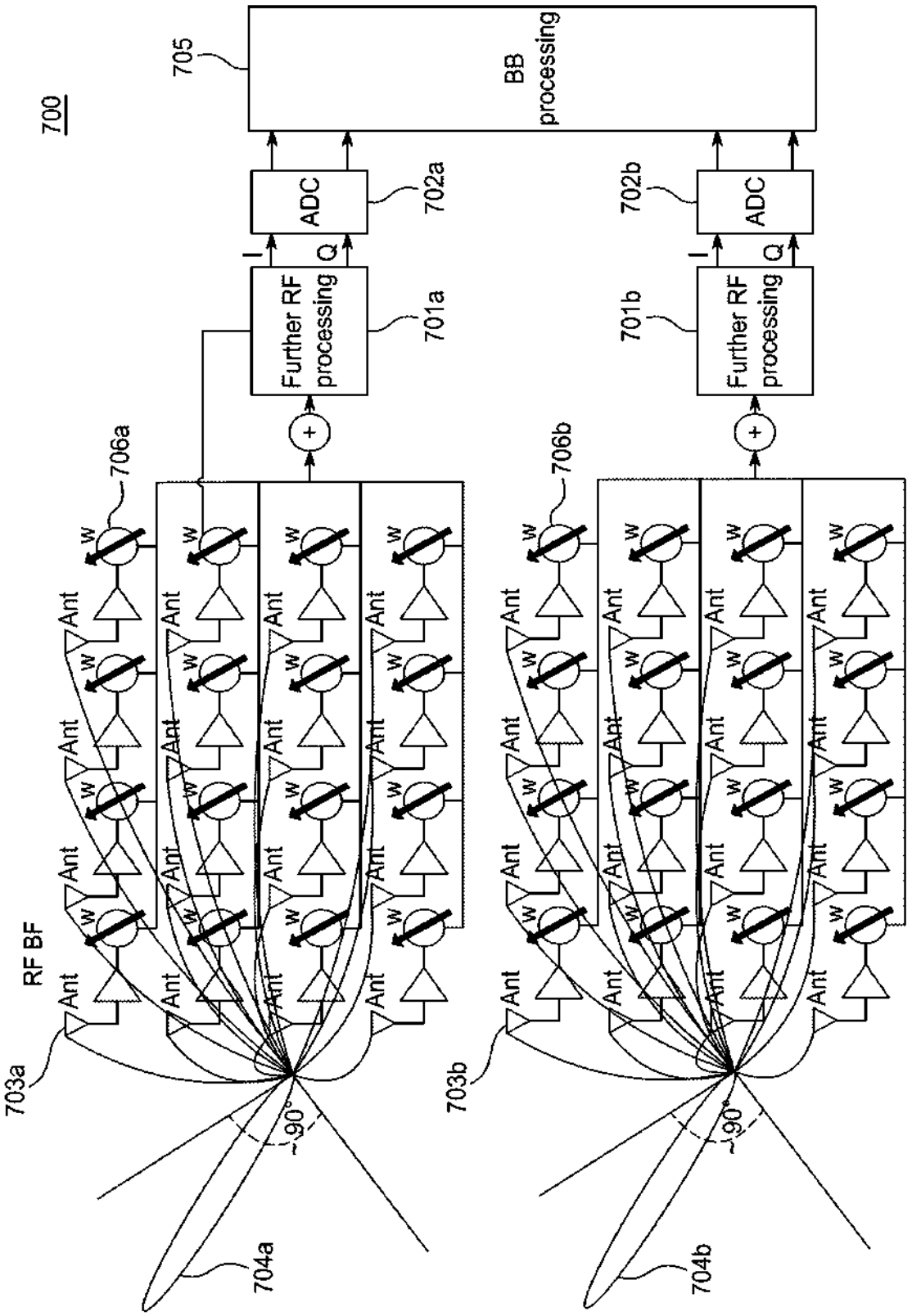

700
705
BB processing
ADC
702a
702b
I
Q
Further RF processing
701a
701b
706a
706b
RF BF
Ant
w
703a
703b
90°
704a
704b

FIG. 7

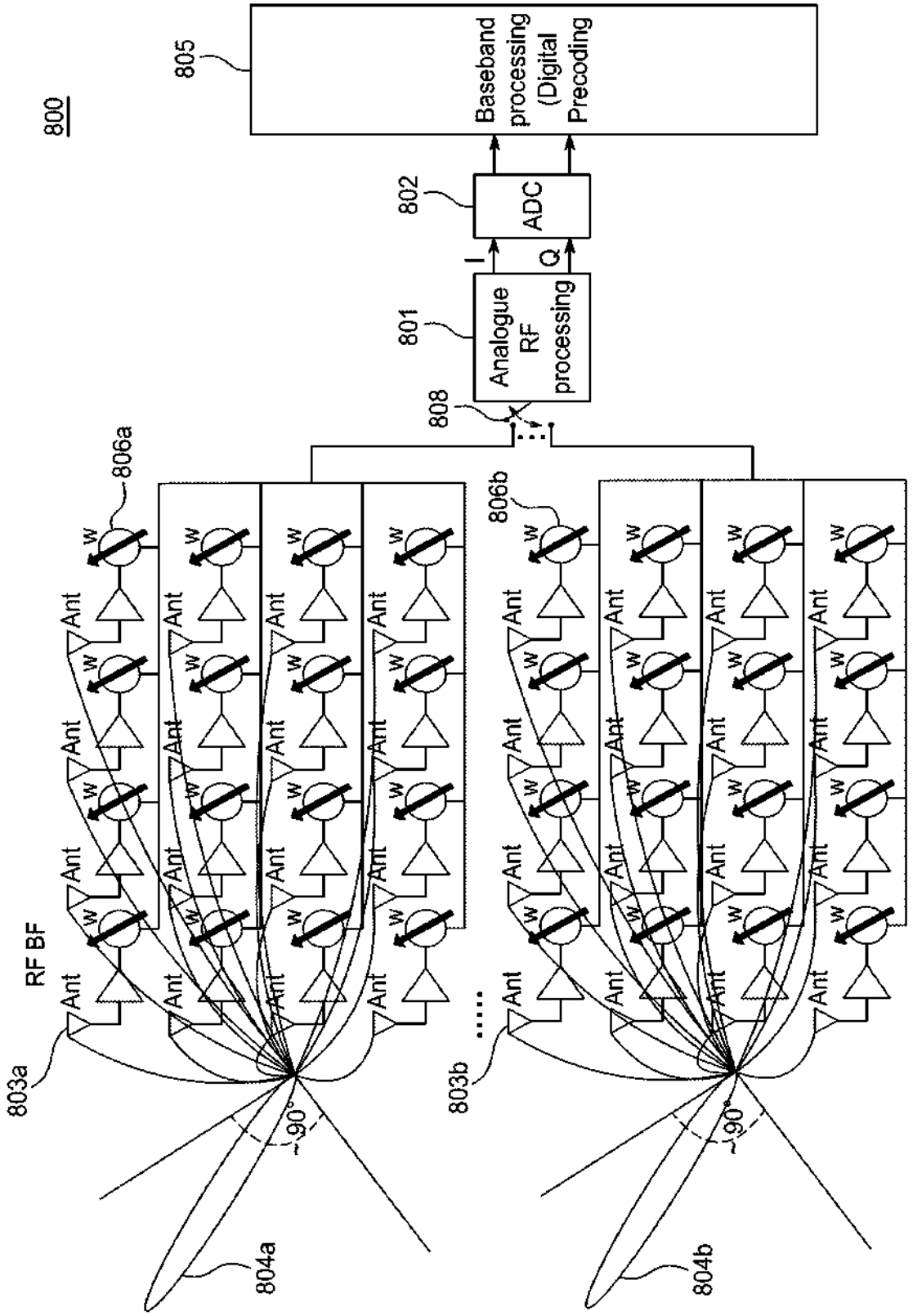

800
805
Baseband processing (Digital Precoding
802
ADC
I
Q
801
Analogue RF processing
808
806a
806b
RF BF
Ant
W
803a
803b
90°
804a
804b

FIG. 8

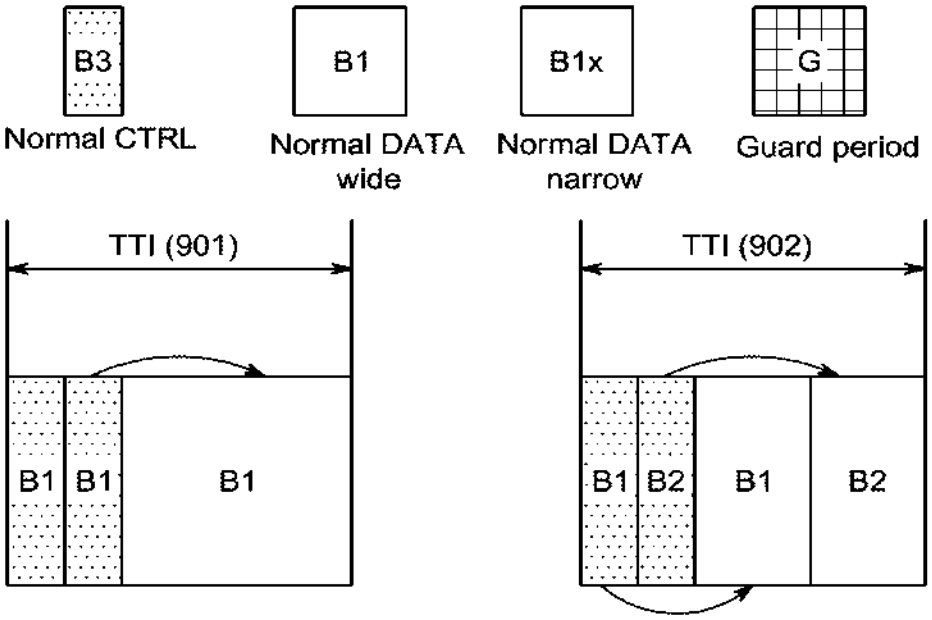

B3
Normal CTRL
B1
Normal DATA wide
B1x
Normal DATA narrow
G
Guard period
TTI (901)
B1
B1
B1
TTI (902)
B1
B2
B1
B2

FIG. 9

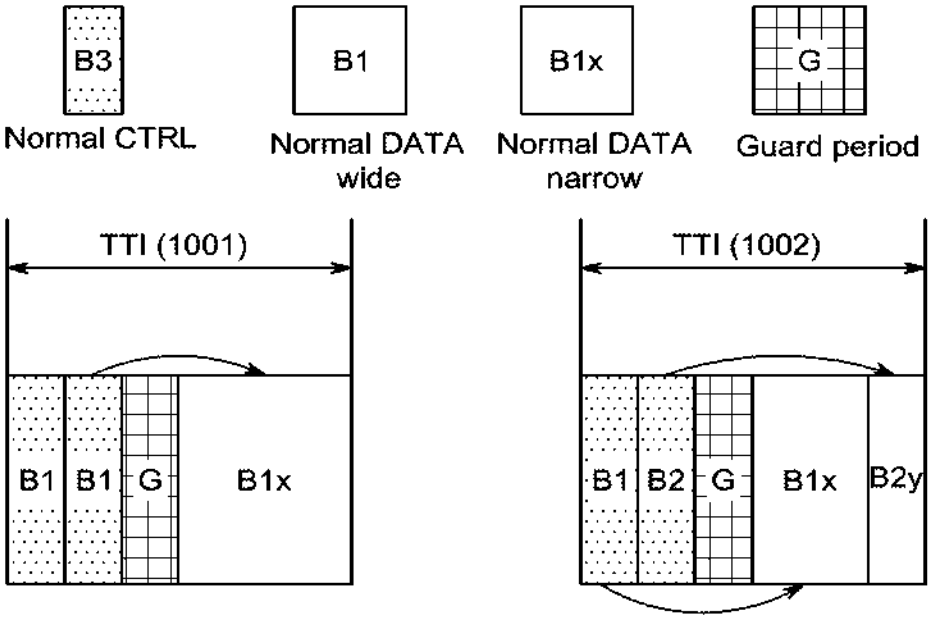

B3
Normal CTRL
B1
Normal DATA wide
B1x
Normal DATA narrow
G
Guard period
TTI (1001)
B1
B1
G
B1x
TTI (1002)
B1
B2
G
B1x
B2y

FIG. 10

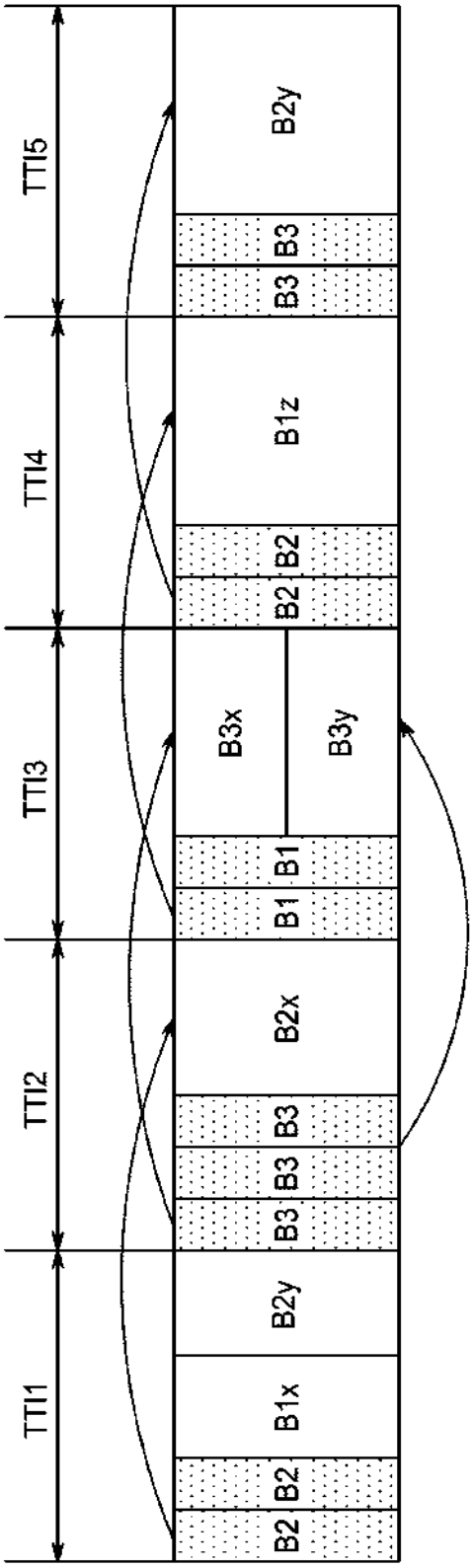

TTI1
TTI2
TTI3
TTI4
TTI5
B2
B2
B1x
B2y
B3
B3
B3
B2x
B1
B1
B3x
B3y
B2
B2
B1z
B3
B3
B2y

FIG. 11

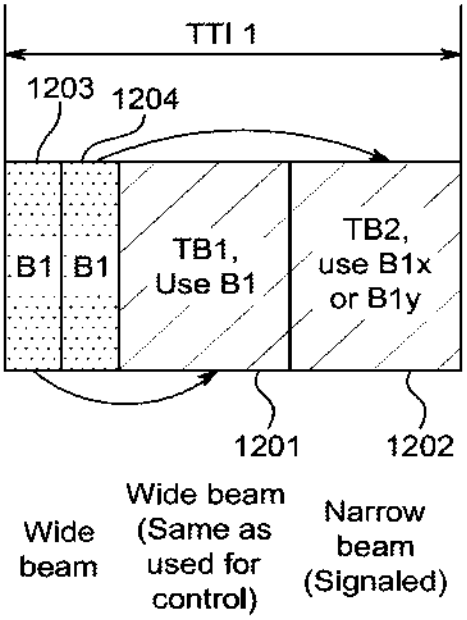

TTI 1
1203
1204
B1
B1
TB1,
Use B1
TB2,
use B1x
or B1y
1201
1202
Wide beam
Wide beam
(Same as
used for
control)
Narrow
beam
(Signaled)

FIG. 12

15/22

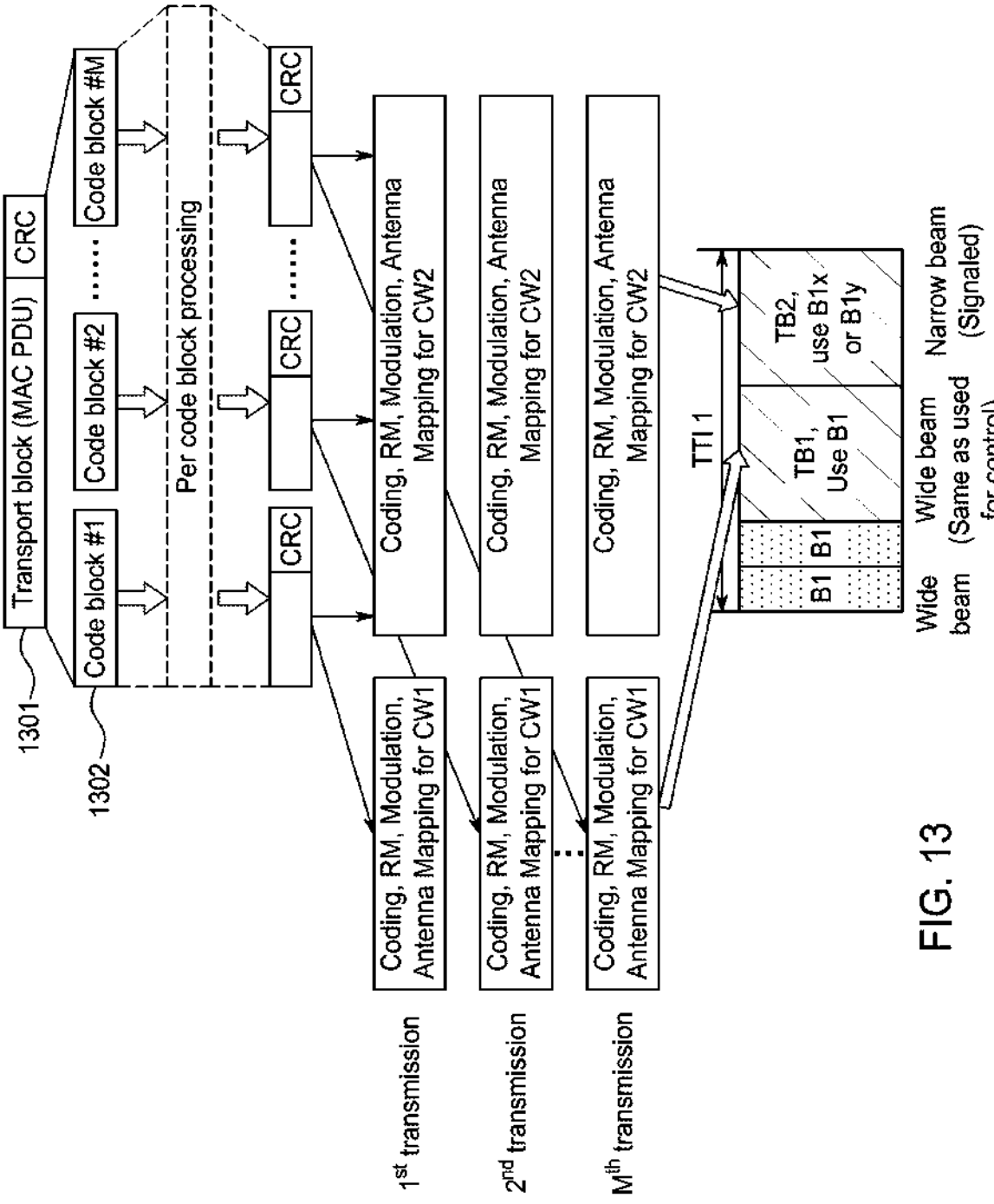

Transport block (MAC PDU)
CRC
Code block #1
Code block #2
Code block #M
Per code block processing
CRC
1301
1302
Coding, RM, Modulation, Antenna Mapping for CW1
Coding, RM, Modulation, Antenna Mapping for CW2
1st transmission
2nd transmission
Mth transmission
TTI 1
TB1, Use B1
TB2, use B1x or B1y
B1 B1
Wide beam
Wide beam (Same as used for control)
Narrow beam (Signaled)

FIG. 13

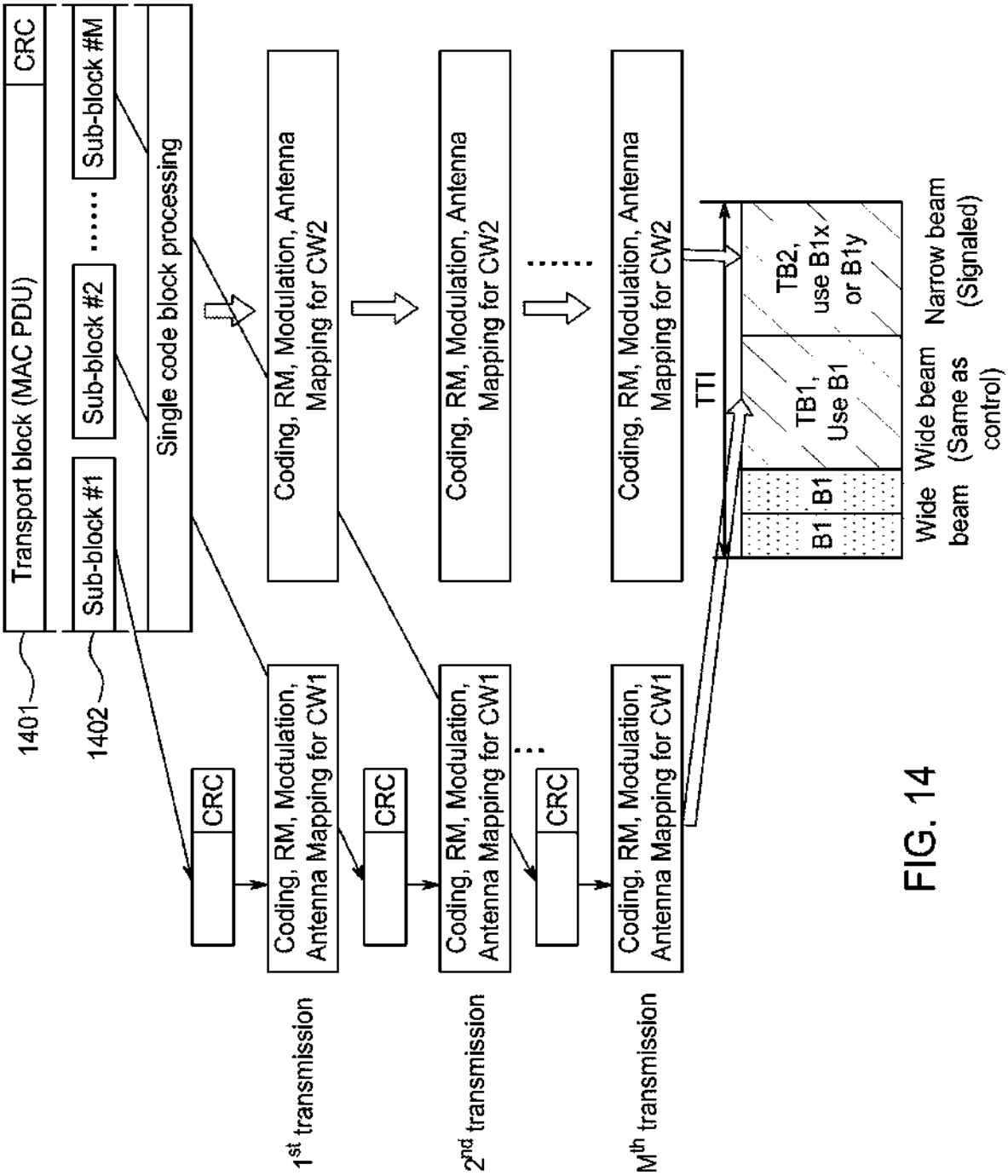

Transport block (MAC PDU)
CRC
Sub-block #1
Sub-block #2
.....
Sub-block #M
Single code block processing
1401
1402
CRC
Coding, RM, Modulation, Antenna Mapping for CW1
Coding, RM, Modulation, Antenna Mapping for CW2
1st transmission
2nd transmission
Mth transmission
TTI
TB1, Use B1
TB2, use B1x or B1y
B1
B1
Wide beam
Wide beam (Same as control)
Narrow beam (Signaled)

FIG. 14

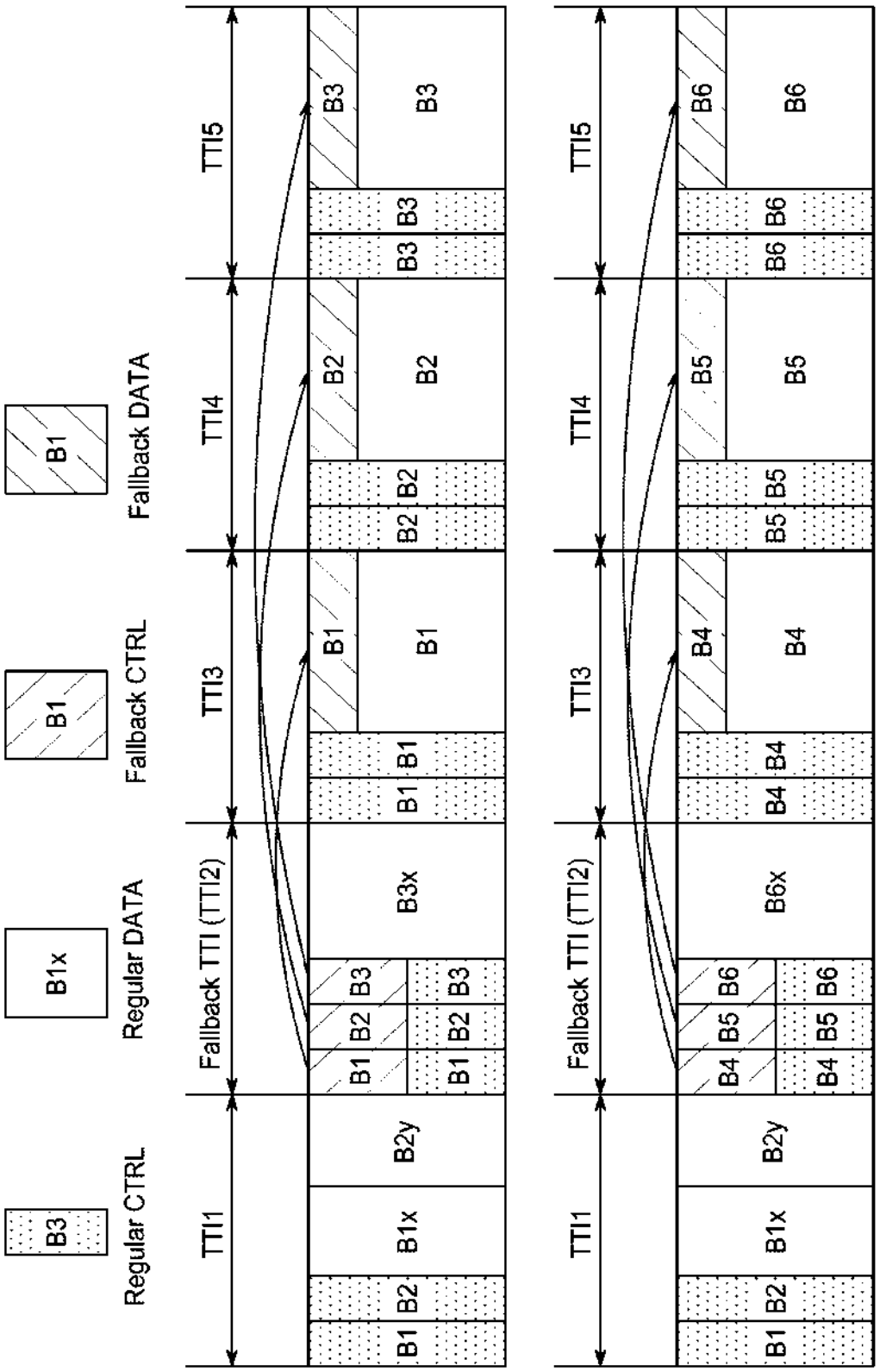

B3
Regular CTRL
B1x
Regular DATA
B1
Fallback CTRL
B1
Fallback DATA
TTI1
TTI3
TTI4
TTI5
Fallback TTI (TTI2)
B1x
B2y
B3x
B6x
B1
B2
B3
B4
B5
B6

FIG. 15

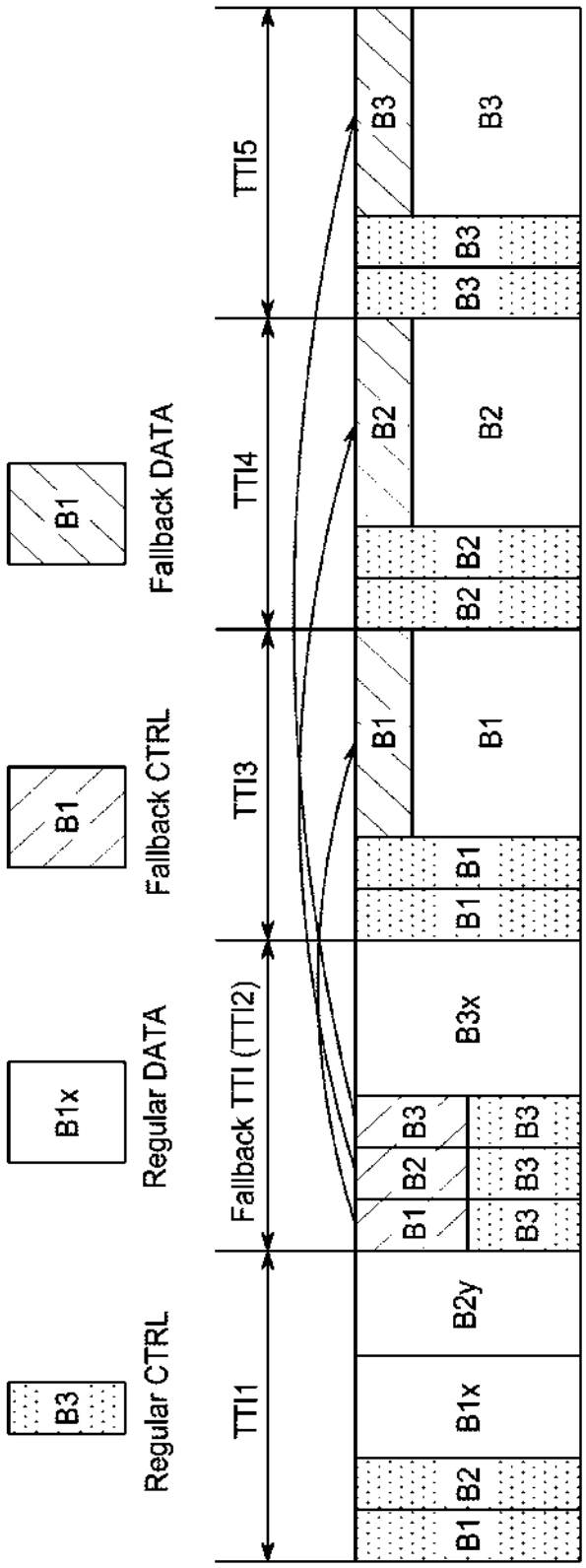

Regular CTRL
Regular DATA
Fallback CTRL
Fallback DATA
B3
B1x
B1
B1
TTI1
TTI2
TTI3
TTI4
TTI5
Fallback TTI (TTI2)
B1
B2
B1x
B2y
B3x
B1
B2
B3

FIG. 16

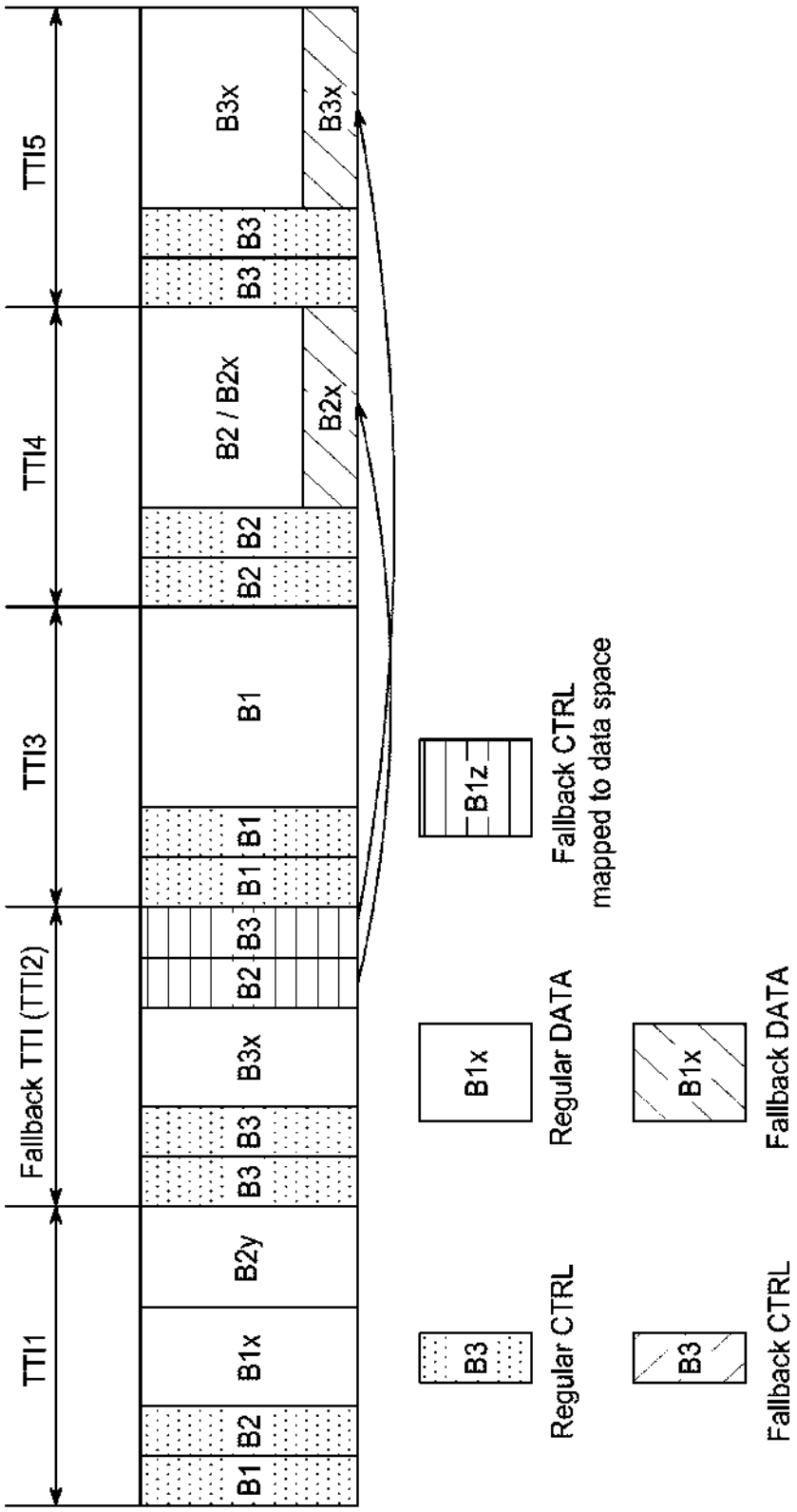

TTI1
TTI2
TTI3
TTI4
TTI5
Fallback TTI
B1
B2
B1x
B2y
B3
B3x
B1z
B2x
B2 / B2x
Fallback CTRL
mapped to data space
Regular DATA
Regular CTRL
Fallback DATA
Fallback CTRL

FIG. 17

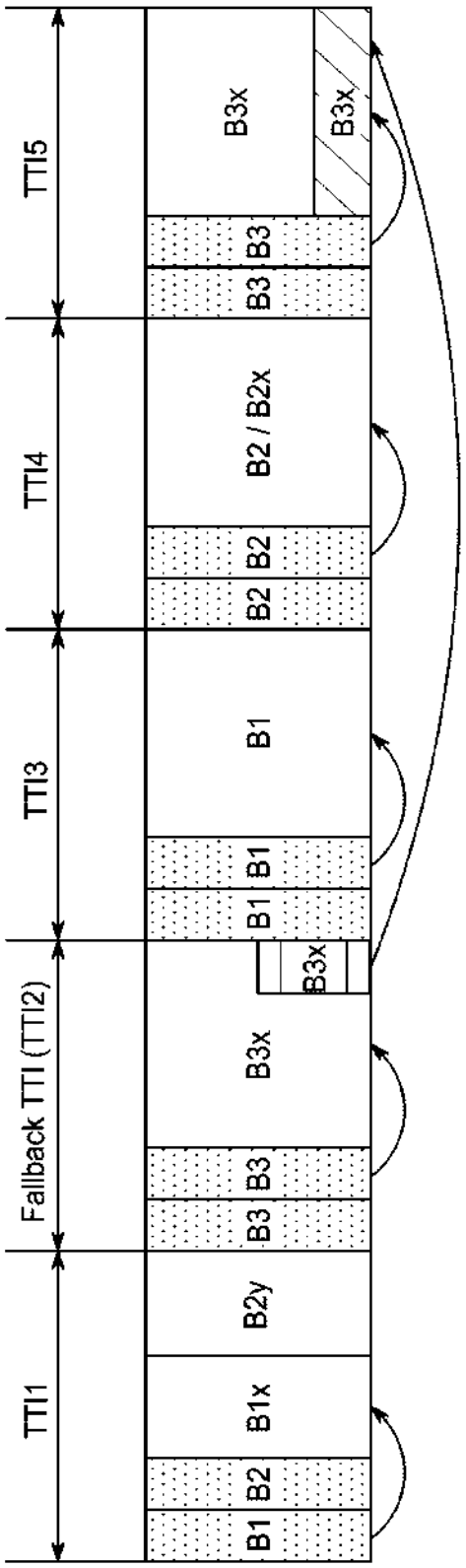

TTI1
TTI2
TTI3
TTI4
TTI5
Fallback TTI (TTI2)
B1
B2
B1x
B2y
B3
B3x
B1
B1
B2
B2 / B2x
B3
B3
B3x
B3x
B1x
B1z
B3
B1
Regular DATA
Narrow beam Fallback CTRL mapped to data space
Regular CTRL
Fallback DATA
Fallback CTRL

FIG. 18

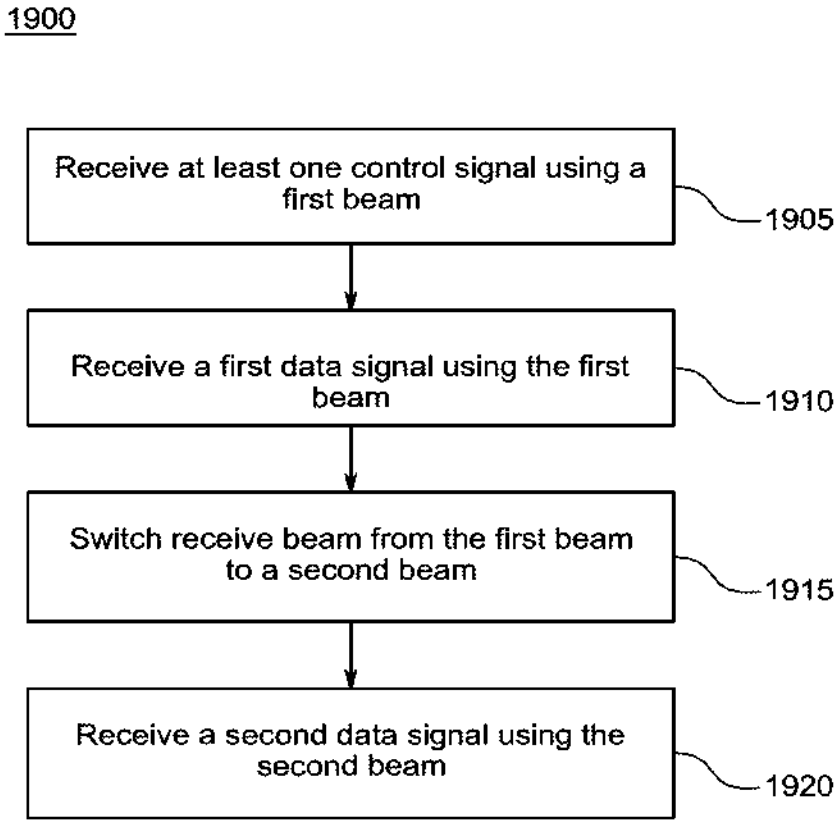

1900
Receive at least one control signal using a first beam
1905
Receive a first data signal using the first beam
1910
Switch receive beam from the first beam to a second beam
1915
Receive a second data signal using the second beam
1920

FIG. 19

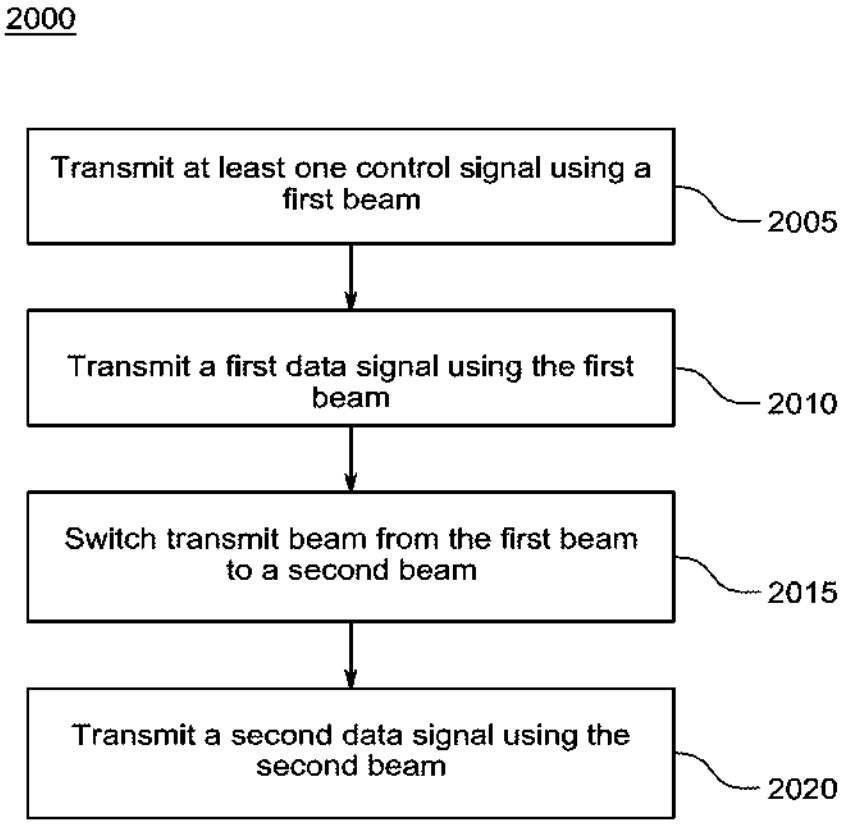

2000
Transmit at least one control signal using a first beam
2005
Transmit a first data signal using the first beam
2010
Switch transmit beam from the first beam to a second beam
2015
Transmit a second data signal using the second beam
2020

FIG. 20

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/061282

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04L5/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 1 562 306 A1 (CIT ALCATEL [FR]) 10 August 2005 (2005-08-10) paragraph [0014] - paragraph [0022] ----- -/--	1-21

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 January 2017	17/01/2017

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Koukourlis, Sotirios

1

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	INTEL CORPORATION: "On Cell Association in Phase Two Evaluation", 3GPP DRAFT; R1-144667_CELL_ASSOCIATION, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. San Francisco, USA; 20141117 - 20141121 17 November 2014 (2014-11-17), XP050875754, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN1/Docs/ [retrieved on 2014-11-17] the whole document -----	1-21
A	KYOCERA: "Dynamic Beamformed CSI-RS for Elevation Beamforming/FD-MIMO", 3GPP DRAFT; R1-151471, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. Belgrade, Serbia; 20150420 - 20150424 19 April 2015 (2015-04-19), XP050934343, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN1/Docs/ [retrieved on 2015-04-19] the whole document -----	1-21

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2016/061282

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 1562306 A1	10-08-2005	NONE	

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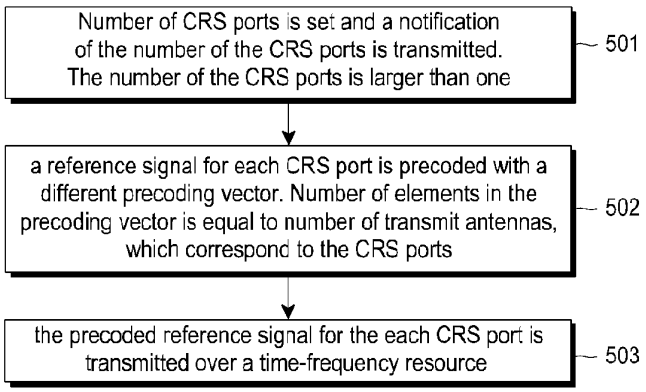
(74) Agents: **LEE, Keon-Joo** et al.; Mihwa Bldg., 16 Daehak-ro 9-gil, Chongro-gu, Seoul 110-524 (KR).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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[Continued on next page]

(54) Title: METHOD AND APPARATUS FOR REFERENCE SIGNAL TRANSMITTING AND RECEIVING IN ACTIVE ANTENNA SYSTEMS



(57) Abstract: Embodiments of the present disclosure provide reference signal transmitting and receiving methods and devices in an active antenna system. Port virtualization to a transmit antennas may be implemented for multiple cell-specific reference signal (CRS) antenna ports and applying different vertical beamforming vectors to implement port virtualization for the different CRS antenna ports. The User Equipment (UE) reports the maximum RSRP/RSRQ value measured based on multiple CRS ports, or the UE simultaneously reports multiple RSRP/RSRQ values and the information of the multiple CRS antenna ports. Therefore, the coverage problem of the CRS signal and Physical Broadcast Channel (PBCH)/Physical Downlink Control Channel (PDCCH)/Physical Downlink Shared Channel (PDSCH) demodulated based on CRS and the problem of measurement for Radio Resource Management (RRM) in the active antenna system may be avoided. Specifically, the following problems may be solved. 1) Coverage differences between CRS and PBCH/PDCCH/PDSCH demodulated based on CRS transmission and Enhanced PDCCH (E-PDCCH)/PDSCH signal transmission, which is measured based on the CSI-RS or demodulated based on the DMRS may be reduced or avoided. 2) The cell association problem due to the different vertical beamforming technologies adopted by the CSI-RS or DMRS and by the CRS may be avoided. 3) Deep spatial fading state may be avoided for CRS reception and PBCH/PDCCH/PDSCH demodulated based on the CRS.

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Published:

— *with international search report (Art. 21(3))*

Description

Title of Invention: METHOD AND APPARATUS FOR REFERENCE SIGNAL TRANSMITTING AND RECEIVING IN ACTIVE ANTENNA SYSTEMS

Technical Field

[1] The present disclosure relates to a field of mobile communication systems, and more particularly to a method and apparatus for reference signal transmitting and receiving in active antenna systems.

Background Art

[2] In mobile communication systems, the wireless fading channels are time-varying. In order to effectively detect signals, channel information is needed to implement relevant detection. In order to obtain the channel information, the base station transmits the signals or sequences, which are known to the UE, via wireless channels. And the UE obtains the channel information via detecting the known signals or sequences. The known signals or sequences are called pilot signals or reference signals.

[3] A Long Term Evolution/ Long Term Evolution-Advanced (LTE/LTE-A) system is a typical correlation detection system. There are seven kinds of pilot signals or reference signals according to the purposes as described below.

[4] A Cell-specific Reference Signal (CRS) is used for data demodulation of PBCH, PDCCH, and some of PDSCHs, measurement of Channel State Information (CSI) of downlink shared channel (PDSCH) of transmission modes 1 to 8.

[5] A Multimedia Broadcast Multicast Service Single Frequency Network Reference Signal (MBSFN- RS) is used for data demodulation of a Multicast Channel (MCH).

[6] A downlink User Equipment-specific Reference Signal (DMRS) is used for data demodulation of PDSCH of transmission modes 7 to 10.

[7] A Channel State Information Reference Signal (CSI-RS) is used for measurement of the CSI for PDSCH of transmission modes 9 to 10.

[8] A Positioning Reference Signal (PRS) is used for performing positioning function.

[9] An uplink Demodulation Reference Signal (DMRS) is used for data demodulation of physical uplink shared channel (PUSCH) and physical uplink control channel (PUCCH).

[10] An uplink Sounding Reference Signal (SRS) is used for measurement of uplink CSI and obtaining downlink channel information via channel reciprocity for TDD systems.

[11] Besides CSI measurement, data demodulation and synchronization assistance, the CRS is further used for measurement of Reference Signal Receive Power (RSRP/RSRQ) to implement path loss estimation, cell association, etc.

[12] Reference signal received power (RSRP/RSRQ), is defined as the linear average over the power contributions (in [W]) of the resource elements that carry cell-specific reference signals within the considered measurement frequency bandwidth.

[13] For RSRP/RSRQ determination the cell-specific reference signals R0 according to TS 36.211 shall be used. If the UE can reliably detect that R1 is available it may use R1 in addition to R0 to determine RSRP/RSRQ, where R0 and R1 are reference signal of CRS port 0 and port 1, respectively.

[14] Reference Signal Received Quality (RSRQ) is defined as the ratio K×RSRP/RSRQ / (E-UTRA carrier RSSI), where K is the number of RB's of the E-UTRA carrier RSSI measurement bandwidth. The measurements in the numerator and denominator shall be made over the same set of resource blocks.

[15] E-UTRA Carrier Received Signal Strength Indicator (RSSI), comprises the linear average of the total received power (in [W]) observed only in OFDM symbols containing reference symbols for antenna port 0, in the measurement bandwidth, over K number of resource blocks by the UE from all sources, including co-channel serving and non-serving cells, adjacent channel interference, thermal noise etc. If higher-layer signalling indicates certain subframes for performing RSRQ measurements, then RSSI is measured over all OFDM symbols in the indicated subframes.

[16] An antenna port is defined such that the channel over which a symbol on the antenna port is conveyed can be inferred from the channel over which another symbol on the same antenna port is conveyed. There is not necessarily a one-to-one relationship between the antenna port and physical antenna. The signal of each antenna port may be transmitted by combining signals over one antenna or multiple antennas. This process is called port virtualization.

[17] With development of antenna technologies, particularly active antenna array technologies, physical antenna elements are not only distributed in a horizontal dimension, but also distributed in both the vertical dimension and the horizontal dimension to form a 2-Dimension (2-D) antenna array. As shown in Fig. 1 and Fig. 2, Fig. 1 is a schematic diagram illustrating structure of an active antenna cross-polarized 2-D antenna array in accordance with an embodiment of the prior art. Fig. 2 is a schematic diagram illustrating structure of a co-polarized 2-D antenna array in accordance with an embodiment of the prior art. N is the number of antennas in a horizontal co-polarized direction and M is the number of antennas in the vertical dimension.

[18] Using the 2-D antenna array, thevertical beamforming and/or dynamic vertical sectorization is possible. Narrow beams, which directly point to the UE or avoid interfere to the UE using the same time frequency resource, are generated in the vertical dimension via multiplexing different weighting factor to each antenna. Therefore, the received signal power may be improved or the interference to the other UEs using the

same time frequency resources may be avoided.

[19] At present, although the LTE/LTE-A system supports that different reference signals may adopt different port virtualization methods, in the LTE/LTE-A specification, only passive antenna array is only taken into consideration in standardization process, the characteristics of the active antenna array are not taken into consideration.

[20] For the convenience of description, the wireless communication system with the active antenna array is called an active antenna system hereinafter. In order to obtain a vertical beamforming gain, a UE-specific vertical beamforming technology may be adopted for PDSCH. In order to ensure that UE in anywhere of a cell can receive the CRS, a cell-specific vertical beamforming vector may be adopted in the vertical dimension. In this way, the transmission of the CRS and transmission of data, which is measured based on the CSI-RS or demodulated based on the DMRSDMRS, may have different beamforming gains in the vertical dimension, resulting in different received signal strength. Fig. 3 is a diagram illustrating that the CRS and the PDSCH, which is measured based on the CSI-RS or demodulated based on the DMRS, adopt different vertical beamforming in accordance with an embodiment in the prior art.

[21] In LTE/LTE-A systems, cell association is implemented based on a Reference Signal Receiving Power RSRP/RSRQ value reported measured based on CRS port 0. Since the CRS and PDSCH, which is measured based on the CSI-RS or demodulated based on the DMRS, are transmitted with different vertical beamforming technologies, the cell association may be not suitable for PDSCH, which is measured based on the CSI-RS or demodulated based on the DMRS.

[22] Fig. 4 is a diagram illustrating the transmission of the CRS in accordance with an embodiment in the prior art. As shown in Fig. 4, the CRS is virtualized with a fixed vertical beamforming vector. Generally, in order to control interference to the adjacent cells, a down-tilt angle may be to be formed. For instance, in the typical Urban Marco (UMa) scenario, the base station (BS) antenna height is 25m, and the inter-site distance is 500m. The UEs are distributed outdoor or in low buildings with height of 18~24m. The 90 degree represents the horizontal direction, the 0 degree represents vertically pointing to the sky, and the 180 degree presents vertically pointing to the ground. Then, electronic down-tilt of CRS is 102 degree. In that case, the CRS vertical antenna array gain received by the UE is much small if the UE antenna height is larger than or equal to the BS antenna height. The signal strength of the CRS received by the UE is relatively weak no matter of accessing which cell. The CRS receiving for these UEs are in deep spatial fading.

[23] On the other hand, the RSRP/RSRQ value measured based on the CRS port 0 is used to estimate the path loss value for the uplink power control. Inappropriate RSRP/RSRQ report may affect performance of the uplink control in the active antenna

systems. In LTE/LTE-A standardization with passive antennas, it is assumed that the uplink path loss and downlink path loss is approximately symmetrical. This is because in the passive antenna system, the uplink channel and downlink channel may experience the same large-scale fading and similar antenna array gain. However, in the active antenna systems adopting the vertical beamforming, if the CRS adopts the fixed vertical beamforming, while the Maximal Ratio Combining (MRC) detection is used in the uplink receiving, the antenna gains for the uplink and downlink are asymmetric. Therefore, the downlink path loss estimated with the RSRP/RSRQ value is significantly different from the actual uplink path loss and the uplink power control performance may be further affected.

Disclosure of Invention

Technical Problem

[24] In view of the above, embodiments of the present disclosure provide reference signal transmitting and receiving methods in the active antenna systems. With these methods, the coverage problem of CRS signal and physical broadcast channel (PBCH)/physical downlink control channel (PDCCH)/physical downlink shared channel (PDSCH) demodulated based on CRS and the problem of measurement for radio resource management (RRM) in the active antenna systems may be avoided.

[25] Embodiments of the present disclosure further provide reference signal transmitting and receiving devices in the active antenna system. With these devices, the coverage problem of CRS signal and physical broadcast channel (PBCH)/physical downlink control channel (PDCCH)/physical downlink shared channel (PDSCH) demodulated based on CRS and the problem of measurement for radio resource management (RRM) in the active antenna systems may be avoided.

Solution to Problem

[26] According to the above objectives, the present disclosure is implemented as follows.

[27] A reference signal transmitting method in an active antenna system includes:

[28] setting number of Cell-specific Reference Signal (CRS) ports and transmitting a notification of number of the CRS ports, wherein the number of the CRS ports is larger than 1;

[29] precoding a reference signal with a different precoding vector for each of the CRS ports, wherein number of elements in the precoding vector is equal to number of transmit antennas, which correspond to the CRS ports; and

[30] transmitting the precoded reference signal for the each of the CRS ports over a corresponding frequency-time resource.

[31] A reference signal receiving method in an active antenna system includes:

[32] receiving a notification of number of Cell-specific Reference Signal (CRS) ports,

wherein the number of the CRS ports is larger than 1; and

[33] receiving a reference signal over a time-frequency resource.

[34] A reference signal transmitting device in an active antenna system includes:

[35] a notification module, to set number of Cell-specific Reference Signal (CRS) ports and transmit a notification of number of the CRS ports, wherein the number of the CRS ports is larger than 1;

[36] a precoding module, to precode a reference signal with a different precoding vector for each of the CRS ports, wherein number of elements in the precoding vector is equal to number of transmit antennas, which correspond to the CRS ports; and

[37] a transmitting module, to transmit the precoded reference signal for the each of the CRS ports over a corresponding frequency-time resource.

[38] A reference signal receiving device in an active antenna system includes:

[39] a signaling receiving module, to receive a notification of number of Cell-specific Reference Signal (CRS) ports, wherein the number of the CRS ports is larger than 1; and

[40] a signal receiving module, to receive a reference signal over a time-frequency resource.

[41] It can be seen from the above technical scheme that embodiments of the present disclosure implement port virtualization to transmit antennas via using multiple CRS antenna ports and applying different vertical beamforming vectors to the different CRS antenna ports. When the UE reports the RSRP/RSRQ value, the UE simultaneously reports the information of the CRS antenna ports. Therefore, the problems of unsatisfactory CRS signal coverage and RSRP/RSRQ report in the active antenna system may be solved. Specifically, following problems may be solved. 1) Differences between transmission signal coverage of the CRS and transmission signal coverage of data, which is measured based on the CSI-RS or demodulated based on the DMRS may be reduced or avoided. 2) The problem that differences between the vertical beamforming technologies adopted by the CSI-RS or DMRS and that adopted by the CRS make it inappropriate for the UE to access a cell may be avoided. 3) It may be avoided that when the UE with a specific-height antenna receives the data signal and/or control signal, which are demodulated based on the CRS, the vertical antenna array gain is in a deep spatial fading state.

Brief Description of Drawings

[42] Fig. 1 is a schematic diagram illustrating structure of an active cross-polarized 2-D antenna array in accordance with an embodiment of the prior art;

[43] Fig. 2 is a schematic diagram illustrating structure of a co-polarized 2-D antenna array in accordance with an embodiment of the prior art;

[44] Fig. 3 is a diagram illustrating that the CRS and the PDSCH, which is measured based on the CSI-RS or demodulated based on the DMRS, adopt different vertical beamforming for port virtualization in accordance with an embodiment in the prior art;

[45] Fig. 4 is a diagram illustrating the transmission of the CRS in accordance with an embodiment in the prior art;

[46] Fig. 5 is a flow chart illustrating a reference signal transmitting method in an active antenna system in accordance with an embodiment of the present disclosure;

[47] Fig. 6 is a flow chart illustrating a reference signal receiving method in an active antenna system in accordance with an embodiment of the present disclosure;

[48] Fig. 7 is a schematic diagram illustrating structure of a reference signal transmitting device in an active antenna system in accordance with an embodiment of the present disclosure;

[49] Fig. 8 is a schematic diagram illustrating structure of a reference signal receiving device in an active antenna system in accordance with an embodiment of the present disclosure;

[50] Fig. 9 is a flow chart illustrating a reference signal transmitting method in an active antenna system in accordance with a first embodiment of the present disclosure;

[51] Fig. 10 is a schematic diagram illustrating a CRS transmitting process in the physical layer in accordance with a first embodiment of the present disclosure;

[52] Fig. 11 is a diagram illustrating a CRS time-frequency resource pattern in accordance with a first embodiment of the present disclosure;

[53] Fig. 12 is a flow chart illustrating a reference signal transmitting method in an active antenna system in accordance with a second embodiment of the present disclosure;

[54] Fig. 13 is a diagram illustrating the process of PBCH/PDCCH/PDSCH, which is de-modulated based on a CRS, in accordance with a second embodiment of the present disclosure;

[55] Fig. 14 is a flow chart illustrating a reference signal receiving method in an active antenna system in accordance with a third embodiment of the present disclosure;

[56] Fig. 15 is a diagram illustrating a CRS time-frequency resource pattern in accordance with a third embodiment of the present disclosure;

[57] Fig. 16 is a flow chart illustrating a reference signal transmitting method in an active antenna system in accordance with a fourth embodiment of the present disclosure;

[58] Fig. 17 is a flow chart illustrating a first method for determining specific UE-specific information/configuration in accordance with a fourth embodiment of the present disclosure;

[59] Fig. 18 is a flow chart illustrating a second method for determining the specific UE-specific information/configuration in accordance with a fourth embodiment of the present disclosure;

[60] Fig. 19 is a diagram illustrating determination of UE-specific CSI-RS resource configuration with RSRP/RSRQ values in accordance with a fourth embodiment of the present disclosure; and

[61] Fig. 20 is a flow chart illustrating a third method for determining the specific UE-specific information/configuration in accordance with a fourth embodiment of the present disclosure.

Mode for the Invention

[62] To make the objective and technical solution of the merits of the present disclosure more apparent, the present disclosure may be described in detail with reference to accompanying Fig.s.

[63] In the active antenna system, following problems are caused when the reference signal is transmitted or received. 1) Coverage differences between CRS and PBCH/PDCCH/PDSCH demodulated based on CRS transmission and Enhanced PDCCH (E-PDCCH)/PDSCH signal transmission, which is measured based on the CSI-RS or demodulated based on the DMRS may be occurred. 2) Cell association using RSRP/RSRQ measured from CRS may not guarantee the best performance in PDSCH/EPDCCH reception due to different beamforming gains between CRS and PDSCH/EPDCCH/DMRS for port virtualization. 3) A fixed vertical weighted vector is used by CRS while the UE is distributed in a large range of height, which leads to deep spatial fading for some UEs of CRS/PBCH/PDCCH/PDSCH demodulated based on the CRS. Therefore, in order to avoid the above problems, an embodiment of the present disclosure using multiple CRS ports. Port virtualization to transmit antennas may be implemented for multiple Cell-specific Reference Signal (CRS) antenna ports and applying different vertical beamforming vectors to implement port virtualization for the different CRS antenna ports. When the User Equipment (UE) reports the maximum RSRP/RSRQ values measured based on multiple CRS ports, or the UE simultaneously reports multiple RSRP/RSRQ values and the information of the multiple CRS antenna ports.

[64] Further, on the premise that a same channel measurement effect is obtained, the method and device provided by embodiments may reduce the resource of CSI-RS, which are used by the UE to perform CSI measurement, and may reduce the path loss estimation error RSRP/RSRQ for uplink power control.

[65] Fig. 5 is a flow chart illustrating a reference signal transmitting method in an active antenna system in accordance with an embodiment of the present disclosure. The blocks are as follows.

[66] AT block 501, number of CRS ports is set and a notification of the number of the CRS ports is transmitted. The number of the CRS ports is larger than one.

[67] At block 502, a reference signal for each CRS port is precoded with a different precoding vector. Number of elements in the precoding vector is equal to number of transmit antennas, which correspond to the CRS ports.

[68] At block 503, the precoded reference signal for the each CRS port is transmitted over a time-frequency resource.

[69] After block 503, the method further includes:

[70] receiving RSRP/RSRQ information and/or CRS port information. Number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than or equal to 1.

[71] After block 502 and before block 503, the method further includes:

[72] respectively precoding a data signal and/or control signal corresponding to the each CRS port based on the precoding vector adopted by the each CRS port.

[73] When block 503 is performed, the precoded data signal and/or control signal is transmitted over the time-frequency resource.

[74] Fig. 6 is a flow chart illustrating a reference signal receiving method in an active antenna system in accordance with an embodiment of the present disclosure. The blocks are as follows.

[75] At block 601, a notification of number of CRS ports is received. The number of the CRS ports is larger than 1.

[76] At block 602, a precoded reference signal is received over a time-frequency resource.

[77] This method further includes: obtaining RSRP/RSRQ information and/or CRS port information by measurement based on the CRS ports. Number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than 1 or equal to 1.

[78] The method further includes: receiving a precoded data signal and/or control signal over the time-frequency resource.

[79] Fig. 7 is a schematic diagram illustrating structure of a reference signal transmitting device in an active antenna system in accordance with an embodiment of the present disclosure. As shown in Fig. 7, the reference signal transmitting device includes: a notification module, a precoding module and a transmitting module.

[80] The notification module is to set number of CRS ports and transmit a notification of the number of the CRS ports. The number of the CRS ports is larger than 1.

[81] The precoding module is to precode a reference signal with a different precoding vector for each CRS port. Number of elements in the precoding vector is equal to number of transmit antennas, which correspond to the CRS ports.

[82] The transmitting module is to transmit the precoded reference signal for the each CRS port over a time-frequency resource.

[83] The reference signal transmitting device further includes a RSRP/RSRQ receiving module. The RSRP/RSRQ receiving module is to receive RSRP/RSRQ information and/or CRS port information. Number of RSRP/RSRQ values in the RSRP/RSRQ in-

formation is larger than or equal to 1.

[84] In this reference signal transmitting device, the precoding module is further to respectively precode a data signal and/or control signal corresponding to each CRS port based on the precoding vector adopted by the each CRS port.

[85] The transmitting module is further to transmit the precoded data signal and/or control over the time-frequency resource.

[86] In this reference signal transmitting device, the RSRP/RSRQ receiving module is further to determine specific UE-specific information/configuration according to the RSRP/RSRQ information and/or CRS port information.

[87] Fig. 8 is a schematic diagram illustrating structure of a reference signal receiving device in an active antenna system in accordance with an embodiment of the present disclosure. As shown in Fig. 8, the reference signal receiving device includes: a signaling receiving module and a signal receiving module.

[88] The signaling receiving module is to receive a notification of number of CRS ports. The number of the CRS port is larger than 1.

[89] The signal receiving module is to receive a precoded reference signal over a time-frequency resource.

[90] The reference signal receiving device further includes: a measurement report module. The measurement report module is to obtain RSRP/RSRQ information and/or CRS port information by measurement based on the CRS ports and transmit the RSRP/RSRQ information and/or CRS port information. Number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than or equal to 1.

[91] In the reference signal receiving device, the signal receiving module is further to receive a precoded data signal and/or control signal over the time-frequency resource.

[92] The present disclosure is described hereinafter in detail with reference to several specific embodiments.

[93] Embodiment one

[94] Fig. 9 is a flow chart illustrating a reference signal transmitting method in an active antenna system in accordance with a first embodiment of the present disclosure. Blocks are as follows.

[95] At block 901, the number of CRS ports is set and a notification of the number of the CRS ports is transmitted. The number of the CRS ports is larger than one.

[96] At this block, the notification of the number of the CRS ports may be performed in an implicit way. Specifically, the notification of the number of the CRS ports is implicitly performed by different Physical Broadcast Channel (PBCH) Cyclic Redundancy Check (CRC) scrambling codes. After the CRC attachment of PBCH, the CRC bits are scrambled according to the eNodeB transmit antenna configuration with the sequence as indicated in Table 1, Thus, the CRS port index can be determined

based on CRC mask at the UE side.

[97] Table 1

[Table 1]

Number of transmit antenna ports at eNodeB	PBCH CRC mask<$x_{ant,0}$, $x_{ant,1}$, ..., $x_{ant,15}$>
1	<0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0>
2	<1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1>
4	<0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1>

[98] In the active antenna systems, the number of the CRS ports is a positive integer, which is larger than 1. The base station may determine the number of CRS ports considering CRS overheads and the UE distribution of , d and transmit the notification of the number of the CRS ports. For instance, in typical UMa scenarios, the BS antenna height of a base station antenna is 25m. The inter-site distance is 500m. The UEs are distributed outdoor or distributed in low buildings with height of 18-24m. All vertical leaving angles of the UE are larger than 90 degree (The 90 degree represents a horizontal direction. The 0 degree represents vertically pointing to the sky. The 180 degree presents vertically pointing to the ground). Considering the CRS overhead and UE distribution, the number of the CRS ports may be set as 2.

[99] At block 902, a reference signal for each CRS port is precoded with a different precoding vector. Number of elements in the precoding vector is equal to number of transmit antennas, which correspond to the CRS ports.

[100] At this block, the CRS port adopts a different precoding vector to implement port virtualization to transmit antennas. Fig. 10 is a schematic diagram illustrating a CRS transmitting process in the physical layer in accordance with a first embodiment of the present disclosure. The port virtualization to transmit antennas refers to precoding the reference signal for the CRS port with a precoding vector. The number of elements in the precoding vector is equal to the number of transmit antennas, which transmitting the same CRS.

[101] Take the typical UMa for example, assuming a physical antenna configuration is cross-polarized 2-D antenna array, M=10 and N=1. Both the two polarization directions include M antenna groups distributed in the vertical dimension, i.e. antenna group 0 and antenna group 1. Suppose the distance between two transmit antennas is half-wavelength. The virtualization from signals of CRS port 0 to the antenna group 0 is implemented via the precoding vector $W_0 = \left[w_0^{(0)} w_1^{(0)} \cdots w_{M-1}^{(0)} \right]^T$. The virtualization from signals of CRS port 1 to the antenna group 1 is implemented via the

$W_1 = [\, w_0^{(1)} w_1^{(1)} \cdots w_{M-1}^{(1)} \,]^T$, $w_m^{(p)} = \frac{1}{\sqrt{M}} \exp(-j \frac{2\Pi}{\lambda} m \cdot d_v \cdot \cos\theta_p)$, dv denotes the distance between the vertical antennas, p denotes the index of CRS port, m denotes the m-th element of the precoding vectors, θ_p denotes the down-tilt angle corresponding to the p-th port. For instance, the electronic down-tilt angle corresponding to the port 0 is 102 degree, and the electronic down-tilt angle corresponding to port 1 is 95 degree.

[102] At block 903, the precoded reference signal for each CRS port is transmitted over the time-frequency resource.

[103] At this block, Fig. 11 is a diagram illustrating a CRS time-frequency resource pattern in accordance with a first embodiment of the present disclosure.

[104] At block 904, RSRP/RSRQ information and/or CRS port information is received. Number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than or equal to 1.

[105] At this block, the RSRP/RSRQ information and/or CRS port information may be an RSRP/RSRQ value measured by a CRS port with the maximum receiving power and the corresponding CRS port index. As shown in table 2, the reporting range of RSRP/RSRQ is defined from -140 dBm to -44 dBm with 1 dB resolution. The mapping of measured quantity and CRS port index may be mapped in Table 2. 4 RSRP/RSRQ states indicating the number of the CRS antenna ports may be reported RSRP/RSRQ simultaneously with RSRP/RSRQ value.

[106] Table 2

[Table 2]

Reported value	Measured quantity value	Unit
RSRP/RSRQ _00	RSRP/RSRQ -140	dBm
RSRP/RSRQ _01	-140 $\leq$ RSRP/RSRQ < -139	dBm
RSRP/RSRQ _02	-139 $\leq$ RSRP/RSRQ < -138	dBm
...	...	...
RSRP/RSRQ _95	-46 $\leq$ RSRP/RSRQ < -45	dBm
RSRP/RSRQ _96	-45 $\leq$ RSRP/RSRQ < -44	dBm
RSRP/RSRQ _97	-44 $\leq$ RSRP/RSRQ	dBm
RSRP/RSRQ _98	Port 0	
RSRP/RSRQ _99	Port 1	
RSRP/RSRQ _100	Port 2	
RSRP/RSRQ _101	Port 3	

[107] As shown in table 3, the RSRP/RSRQ information and/or CRS port information may further be the RSRP/RSRQ value measured by the port.

[108] Table 3

[Table 3]

Reported value	Measured quantity value	Unit
RSRP/RSRQ _00	Port 0 RSRP/RSRQ < -140	dBm
RSRP/RSRQ _01	Port 0 -140 $\leq$ RSRP/RSRQ < -139	dBm
RSRP/RSRQ _02	Port 0 -139 $\leq$ RSRP/RSRQ < -138	dBm
...	...	...
RSRP/RSRQ _95	Port 0 -46 $\leq$ RSRP/RSRQ < -45	dBm
RSRP/RSRQ _96	Port 0 -45 $\leq$ RSRP/RSRQ < -44	dBm
RSRP/RSRQ _97	Port 0 -44 $\leq$ RSRP/RSRQ	dBm
RSRP/RSRQ _98	Port 1 RSRP/RSRQ < -140	dBm
RSRP/RSRQ _99	Port 1 -140 $\leq$ RSRP/RSRQ < -139	dBm
RSRP/RSRQ _100	Port 1 -139 $\leq$ RSRP/RSRQ < -138	dBm
...	...	...
RSRP/RSRQ _183	Port 1 -46 $\leq$ RSRP/RSRQ < -45	dBm
RSRP/RSRQ _184	Port 1 -45 $\leq$ RSRP/RSRQ < -44	dBm
RSRP/RSRQ _185	Port 1 -44 $\leq$ RSRP/RSRQ	dBm
...	...	...

[109] The RSRP/RSRQ information and/or CRS port information may further be the RSRP/RSRQ value measured by the CRS port 0 or a relative RSRP/RSRQ value of another port to that of the CRS port 0.

[110] The RSRP/RSRQ information and/or CRS port information may further be the RSRP/RSRQ values measured by K CRS ports. K is larger than 1 and less than total number of the CRS antenna ports. Corresponding antenna port index is also reported.

[111] With the above processing, since different CRS ports adopt different vertical beamforming, UE which is not covered by the beam of the CRS port 0, may be covered by the beam of another CRS port. Therefore, it may be reduced or avoided that when the terminal with the specific-height antenna receives the CRS, the vertical antenna gain remains at the deep spatial fading state for a long time of given UE.

[112] In this embodiment, the received RSRP/RSRQ information and/or CRS port information provides not only the information of the RSRP/RSRQ value measured based on the CRS port with the maximum receiving power, but also the port information corresponding to the RSRP/RSRQ value measured based on the CRS port with the maximum receiving power. The BS may implement subsequent optimization for PBCH/PDCCH/PDSCH transmission, cell association, uplink power control, etc. with the above information.

[113] Embodiment two

[114] Fig. 12 is a flow chart illustrating a reference signal transmitting method in an active antenna system in accordance with a second embodiment of the present disclosure. Specific blocks are as follows.

[115] At block 1201, number of CRS ports is set and a notification of the number of the CRS ports is transmitted. The number of the CRS ports is larger than one.

[116] At block 1202, a reference signal for each CRS port is precoded with a different precoding vector. Number of elements in the precoding vector is equal to number of transmit antennas, which correspond to the CRS ports.

[117] At block 1203, a data signal and/or control signal corresponding to the each CRS port is respectively precoded based on the precoding vector adopted by the each CRS port. Number of elements in the precoding vector is equal to number of transmit antennas, which transmit the data signal and/or control signal.

[118] At this block, port virtualization to transmit antenna processing is performed for PBCH/PDCCH/PDSCH, which is demodulated based on the CRS, using the precoding vectors corresponding to the CRS ports. The physical layer processing process of PBCH/PDCCH/PDSCH, which is demodulated based on the CRS, is shown in Fig. 13. Fig. 13 is a diagram illustrating a physical layer processing of PBCH/PDCCH/PDSCH, which is demodulated based on CRS, in accordance with the second embodiment of the present disclosure. For instance, the CRS of port 0 adopts the precoding vector W0 to implement the port virtualization to transmit antennas. The PBCH/PDCCH/PDSCH over port 0 also implements the port virtualization to transmit antennas with the same precoding vector. Other ports adopt similar processing.

[119] At block 1204, the precoded reference signal for the each CRS port and the precoded data signal and/or control signal for the each CRS port are transmitted over the time-frequency resource.

[120] At block 1205, the RSRP/RSRQ information and/or CRS port information is received. Number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than or equal to 1.

[121] With the method shown in Fig. 12, since the reference signal and PBCH/PDCCH/PDSCH, which is demodulated based on the CRS of each CRS port adopt

different vertical beamforming, UE, which is not covered by the beam of the CRS port 0, may be covered by the beam of another CRS ports. Therefore, it may be reduced or avoided that the deep spatial fading problem may be reduced or avoided. Thus, the coverage of PBCH/PDCCH/PDSCH, which is demodulated based on the CRS, is improved.

[122] Embodiment three

[123] Fig. 14 is a flow chart illustrating a reference signal receiving method in an active antenna system in accordance with a third embodiment of the present disclosure. Specific blocks are as follows.

[124] At block 1401, a notification of number of CRS ports is received. The number of the CRS port is larger than 1.

[125] At this block, the number of antenna ports may be determined according to PBCH scrambling mask via decoding the signals of the PBCH over the CRS port 0.

[126] At block 1402, a precoded reference signal is received over a time-frequency resource.

[127] As exclusively used at this block, the precoded reference signal may be received according to the CRS time-frequency resource pattern shown in Fig. 15. Fig. 15 is a diagram illustrating a CRS time-frequency resource pattern in accordance with a third embodiment of the present disclosure.

[128] At block 1403, RSRP/RSRQ information and/or CRS port information is obtained by measurement based on the CRS ports. Number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than or equal to 1.

[129] At this block, the RSRP/RSRQ value measured based on the CRS port with maximum receiving power and the corresponding CRS antenna port index may be reported. For instance, as shown in table 2, four states indicating the CRS antenna port index are reported during the report of the RSRP/RSRQ value. Alternatively, as shown in table 3, the RSRP/RSRQ value of the each port is reported at the same time. Alternatively, the RSRP/RSRQ value of the CRS port 0 and a relative RSRP/RSRQ value of another port to that of the CRS port 0 are reported. Alternatively, the RSRP/RSRQ values of N CRS ports and corresponding antenna port number information are reported. N is larger than 1 and less than total number of the CRS antenna ports.

[130] With the above processing, the base station may obtain more RSRP/RSRQ information of the CRS port, which is convenient for the network side to make further processing to obtain the corresponding gain.

[131] Embodiment four

[132] Fig. 16 is a flow chart illustrating a reference signal transmitting method in an active antenna system in accordance with a fourth embodiment of the present disclosure. Specific blocks are as follows.

[133] At block 1601, number of CRS ports is set and a notification of the number of the CRS ports is transmitted. The number of the CRS ports is larger than one.

[134] At this block, in typical UMa scenarios, the BS antenna height is 10m. The inter-site distance is 200m. The UEs are distributed outdoor or distributed in low buildings with the height of 18-24m. Taking account of that vertical leaving angles of the UEs are in a large range and taking account of factors, such CRS overhead influence, the number of the CRS ports is set as 4.

[135] At block 1602, each CRS port adopts a different precoding vector to implement port virtualization to transmit antennas.

[136] At this block, four different precoding vectors are adopted to implement the port virtualization to transmit antennas of four CRS ports. The virtualization of the CRS port 0 to the antenna group 0 is implemented via the precoding vector $W_0 = [w_0^{(0)} w_1^{(0)} \ldots w_{M-1}^{(0)}]^T$. The virtualization of the CRS port 1 to the antenna group 1 is implemented via the precoding vector $W_1 = [w_0^{(1)} w_1^{(1)} \ldots w_{M-1}^{(1)}]^T$.

$w_m^{(p)} = \frac{1}{\sqrt{M}} \exp(-j\frac{2\Pi}{\lambda} m \cdot d_v \cdot \cos\theta_p)$, dv denotes the distance between the vertical antennas, p denotes the index of the CRS port, m denotes the m-th element of the precoding vectors, θ_p denotes a down-tilt angle corresponding to the p-th port. The down-tilt angle corresponding to the port 0 is 102 degree, the downward inclination angle corresponding to the port 1 is 95 degree, the down-tilt angle corresponding to the port 2 is 85 degree, the down-tilt angle corresponding to the port 3 is 75 degree.

[137] At block 1603, the precoded reference signal of each CRS port is transmitted over the time-frequency resource.

[138] At block 1604, the RSRP/RSRQ information and/or CRS port information is received. Number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than or equal to 1.

[139] At this block, the RSRP/RSRQ information may be the RSRP/RSRQ value measured by the CRS port with the maximum receiving power. The corresponding port information is the CRS port index corresponding to the RSRP/RSRQ value of measured by the CRS port with the maximum receiving power. The RSRP/RSRQ information may include the RSRP/RSRQ value of the each CRS port. The RSRP/RSRQ information may include the RSRP/RSRQ values of partial CRS ports and the number index information of the partial CRS ports.

[140] At block 1605, after the RSRP/RSRQ information and/or CRS port information is received, specific UE-specific information/configuration is determined.

[141] At this block, the specific UE-specific information/configuration includes: one or

combination of information of cell association, a path loss value for uplink power control and/or UE-specific CSI-RS resource configuration.

[142] Specifically speaking, Fig. 17 is a flow chart illustrating a first method for determining UE-specific information/configuration in accordance with a fourth embodiment of the present disclosure. Following blocks are included.

[143] At block 1701, RSRP/RSRQ information and/or CRS port information is received.

[144] At block 1702, a cell association is determined based on the RSRP/RSRQ information.

[145] At this block, each CRS port adopts a different vertical beam. The RSRP/RSRQ information includes the vertical beamforming gain of the best direction. Therefore, the difference between the RSRP/RSRQ and the beamforming gain of the CSI-RS and DMRS after the UE-specific vertical beamforming adopted is relatively reduced. Therefore, the selected cell is more suitable for the PDSCH/E-PDCCH transmission of the UE.

[146] Fig. 18 is a flow chart illustrating a second method for determining the specific UE-specific information/configuration in accordance with a fourth embodiment of the present disclosure. Following blocks are included.

[147] At block 1801, RSRP/RSRQ information and/or CRS port information is received.

[148] At block 1802, a UE-specific CSI-RS resource configuration is determined based on the RSRP/RSRQ information.

[149] At this block, the UE-specific CSI-RS resource configuration is determined based on the correlation of beamforming vectors used for the CSI-RS resources port virtualization and the CRS ports virtualization, RSRP/RSRQ information and CRS port information. The CSI-RS resources in the active antenna system are grouped according to the correlation of the vertical beamforming vectors used for CSI-RS port virtualization and CRS port virtualization. After the RSRP/RSRQ information and/or CRS port information is received, the CSI-RS resources in the CSI-RS resource group corresponding to the CRS port with RSRP/RSRQ value measured with the maximum receiving power, may be determined as the UE-specific CSI-RS resource configuration. Alternatively, CSI-RS resources in CSI-RS resource groups corresponding to the two CRS ports with the RSRP/RSRQ values with the maximum receiving power and second maximum receiving power may be determined as the UE-specific CSI-RS resource configurations.

[150] A specific example is given hereinafter for illustration, suppose two CRS ports adopt two different vertical beams. In the transmission mode using the CSI-RS measurement and DMRS demodulation, such as transmission mode 10 of LTE/LTE-A, the UE-specific vertical beamforming may be implemented via configuring multiple CSI-RS resources and multiple CSI processes for the UE. Fig. 19 is a diagram illustrating de-

termination of UE-specific CSI-RS resource configuration with RSRP/RSRQ reporting in accordance with a fourth embodiment of the present disclosure. As shown in Fig. 19, 9 CSI-RS resources are conFig.d in the active antenna systems. Each CSI-RS resource adopts different vertical beams to perform the beamforming. The 9 CSI-RS resources are divided into three groups. Each group includes 3 CSI-RS resources and the 3 CSI-RS resources adopt adjacent vertical beams to implement port virtualization to transmit antennas. The coverage of the first group of CSI-RS vertical beams in the vertical dimension is close to that of the CRS beam 0. The coverage of the third group of CSI-RS vertical beams in the vertical dimension is close to that of the CRS beam 1. And the coverage of the second group of CSI-RS vertical beams in the vertical dimension is between that of two CRS beams.

[151] If the RSRP/RSRQ CRS port with largest RSRP/RSRQ value is CRS port 0, the first group of CSI-RS resources is allocated to the UE. If the reported port with the largest RSRP/RSRQ value is port 01, the third group of CSI-RS resources is allocated to the UE. If the reported two ports, the RSRP/RSRQ values of which are close to each other, the second group of CSI-RS resources are allocated to the UE.

[152] The UE performs feedback of three CSI processes based three conFig.d CSI-RS resources in one group, such as CSI-RS resource 2-1, CSI-RS resource 2-2 and CSI-RS resource 2-3 in the second group. The base station selects the best vertical beamforming direction based on CSI feedback. For instance, the vertical beamforming direction corresponding to the CSI-RS resource 2-3 is taken as the beamforming direction used by the UE in the data transmission.

[153] In the above second embodiment, apparently, if the CRS port information is not reported, the UE needs to measure 9 different CSI-RS configurations to select the best beam from the nine vertical beams and simultaneously complete nine CSI report processes. Using the RSRP/RSRQ and CRS port information report, the best beam may be selected from the nine vertical beams via measuring only three CSI-RS configurations and completing three CSI report processes.

[154] Fig. 20 is a flow chart illustrating a method for determining the specific UE-specific information/configuration in accordance with a fourth embodiment of the present disclosure. Following blocks are included.

[155] At block 2001, RSRP/RSRQ information and/or CRS port information is received.

[156] At block 2002, the path loss value for uplink power control of a UE is determined based on the RSRP/RSRQ information.

[157] At this block, each CRS port adopts a different vertical beam. The RSRP/RSRQ information is measured based on the vertical beamforming in the best direction. Therefore, the difference between the RSRP/RSRQ value and an uplink antenna array gain of receiver is relatively reduced. Therefore, the difference between the path loss

estimation based on the RSRP/RSRQ and the uplink actual path loss is reduced and thus the uplink power control performance is improved.

[158] It can be seen from the methods and devices provided by embodiments of the present disclosure, coverage differences between CRS and PBCH/PDCCH/PDSCH demodulated based on CRS transmission and Enhanced PDCCH (E-PDCCH)/PDSCH signal transmission, which is measured based on the CSI-RS or demodulated based on the DMRS may be reduced or avoided. The cell association problem due to the different vertical beamforming technologies adopted by the CSI-RS or DMRS and by the CRS may be avoided. Deep spatial fading state may be avoided for CRS reception and PBCH/PDCCH/PDSCH demodulated based CRS. On the premise that a same channel measurement effect is obtained, embodiments of the present disclosure may reduce the number of CSI-RS configurations, which are used by the UE to perform channel estimation. Embodiments of the present disclosure may reduce the differences between the path loss of RSRP/RSRQ value estimation and the uplink actual path loss and may improve the uplink power control performance.

[159] The foregoing description only describes preferred embodiments of the present invention and may not be used for limiting the protection scope thereof. Any modification, equivalent substitution, or improvement made without departing from the spirit and principle of the present invention should be covered by the protection scope of the present invention.

Claims

[Claim 1] A reference signal transmitting method in an active antenna system, comprising:
setting number of Cell-specific Reference Signal (CRS) ports and transmitting a notification of number of the CRS ports, wherein the number of the CRS ports is larger than 1;
precoding a reference signal with a different precoding vector for each of the CRS ports, wherein number of elements in the precoding vector is equal to number of transmit antennas, which correspond to the CRS ports; and
transmitting the precoded reference signal for the each of the CRS ports over a corresponding frequency-time resource.

[Claim 2] The transmitting method according to claim 1, further comprising:
receiving Reference Signal Receive Power (RSRP)/Reference Signal Received Quality (RSRQ) information and/or CRS port information;
wherein number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than or equal to 1.

[Claim 3] The transmitting method according to claim 2, wherein the RSRP/RSRQ information and/or CRS port information comprises:
an RSRP/RSRQ value measured by a CRS port with the maximum receiving power and a corresponding CRS port index; or
RSRP/RSRQ values measured by the CRS ports; or
an RSRP/RSRQ value measured by CRS port 0 and a relative RSRP/RSRQ value of another port to that of the CRS port 0; or
RSRP/RSRQ values measured by N CRS ports and corresponding CRS port indexes, N is larger than 1 and less than total number of the CRS ports.

[Claim 4] The transmitting method according to claim 2, further comprising:
determining specific UE-specific information/configuration according to the RSRP/RSRQ information and/or the CRS port information.

[Claim 5] The transmitting method according to claim 4, wherein the specific UE-specific information/configuration comprises one or any combination of: information of cell association, a path loss value for uplink power control and Channel State Information Reference Signal (CSI-RS) resource configuration.

[Claim 6] The transmitting method according to claim 5, wherein when the specific UE-specific information/configuration is the information of

cell association, determining the specific UE-specific information/ configuration according to the RSRP/RSRQ information and/or the CRS port information comprises:
determining the cell association according to an RSRP/RSRQ value measured by the CRS port with maximum receiving power.

[Claim 7] The transmitting method according to claim 5, when the specific UE-specific information/configuration is the path loss value for uplink power control, determining the specific UE-specific information/configuration according to the RSRP/RSRQ information and/or the CRS port information comprises:
determining the path loss value for uplink power control based on an RSRP/RSRQ value measured by the CRS port with the maximum receiving power.

[Claim 8] The transmitting method according to claim 5, when the specific UE-specific information/configuration is the CSI-RS resource configuration, determining the specific UE-specific information/configuration according to the RSRP/RSRQ information and/or CRS port information comprises:
determining the UE-specific CSI-RS resource configuration based on correlation of beamforming vectors used for CSI-RS port virtualization and CRS port virtualization.

[Claim 9] The transmitting method according to claim 8, wherein determining the UE-specific CSI-RS resource configuration comprises:
grouping CSI-RS resources in an active antenna system according to the correlation of beamforming vectors used for the CSI-RS port virtualization and the CRS port virtualization;
after receiving the reported RSRP/RSRQ information and/or the CRS port information, determining CSI-RS resources in a CSI-RS resource group corresponding to a CRS port with an RSRP/RSRQ value measured by the CRS port with the maximum receiving power, as the UE-specific CSI-RS resource configuration; or
determining CSI-RS resources in CSI-RS resource groups corresponding to two CRS ports with RSRP/RSRQ values measured with the maximum receiving power and second maximum receiving power, as the UE-specific CSI-RS resource configurations.

[Claim 10] The transmitting method according to claim 1, wherein before transmitting the precoded reference signal for the each of the CRS ports over the corresponding frequency-time resource, the method further

comprises:
respectively precoding a data signal and/or control signal corresponding to the each of the CRS ports based on the precoding vector adopted by the each of the CRS ports;
when transmitting the precoded reference signal for the each of the CRS ports over corresponding frequency-time resource, the method further comprises:
transmitting the precoded data signal and/or control signal for the each of the CRS ports over the corresponding frequency-time resource.

[Claim 11] A reference signal receiving method in an active antenna system, comprising:
receiving a notification of number of Cell-specific Reference Signal (CRS) ports, wherein the number of the CRS ports is larger than 1; and
receiving a reference signal over a time-frequency resource.

[Claim 12] The receiving method according to claim 11, further comprising:
obtaining Reference Signal Receive Power (RSRP)/Reference Signal Received Quality (RSRQ) information and/ or CRS port information by measurement based on the CRS ports; wherein number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than or equal to 1.

[Claim 13] The receiving method according to claim 11, wherein the RSRP/RSRQ information and/or CRS port information comprises:
an RSRP/RSRQ value measured by a CRS port with the maximum receiving power and a corresponding CRS port index; or
RSRP/RSRQ values measured by the CRS ports; or
an RSRP/RSRQ value measured by CRS port 0 and a relative RSRP/RSRQ value of another port to that of the CRS port 0; or
RSRP/RSRQ values measured by N CRS ports and corresponding CRS port indexes, N is larger than 1 and less than total number of the CRS ports.

[Claim 14] The receiving method according to claim 11, further comprising:
receiving a precoded data signal and/or control signal, which are demodulated based on the CRS ports.

[Claim 15] A reference signal transmitting device in an active antenna system, comprising:
a notification module, to set number of Cell-specific Reference Signal (CRS) ports and transmit a notification of number of the CRS ports, wherein the number of the CRS ports is larger than 1;
a precoding module, to precode a reference signal with a different

precoding vector for each of the CRS ports, wherein number of elements in the precoding vector is equal to number of transmit antennas, which correspond to the CRS ports; and

a transmitting module, to transmit the precoded reference signal for the each of the CRS ports over a corresponding frequency-time resource.

[Claim 16] The transmitting device according to claim 15, further comprising:

a Reference Signal Receive Power (RSRP)/Reference Signal Received Quality (RSRQ) receiving module, to receive Reference Signal Receive Power (RSRP)/Reference Signal Received Quality (RSRQ) information and/or CRS port information; wherein number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than or equal to 1.

[Claim 17] The transmitting device according to claim 16, wherein the RSRP/ RSRQ receiving module is further to determine specific UE-specific information/configuration according to the RSRP/RSRQ information and/or CRS port information.

[Claim 18] The transmitting device according to claim 15, wherein

the precoding module is further to respectively precode a data signal and/or control signal corresponding to the each of the CRS ports based on the precoding vector adopted by the each of the CRS ports; and

the transmitting module is further to transmit the precoded data signal and/or control over the time-frequency resource.

[Claim 19] A reference signal receiving device in an active antenna system, comprising:

a signaling receiving module, to receive a notification of number of Cell-specific Reference Signal (CRS) ports, wherein the number of the CRS ports is larger than 1; and

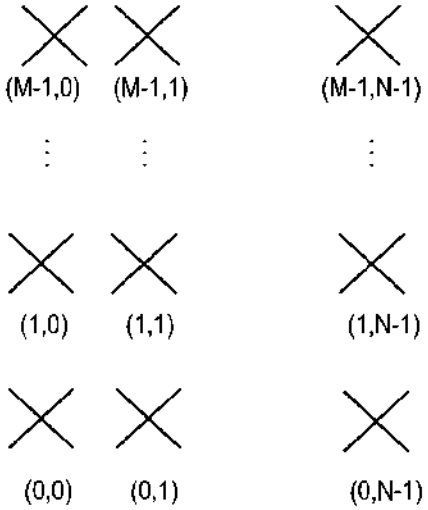
a signal receiving module, to receive a reference signal over a time-frequency resource.

[Claim 20] The receiving device according to claim 19, further comprising:

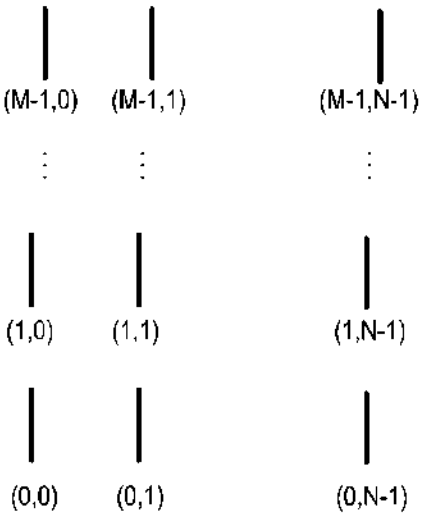
a measurement report module, to obtain Reference Signal Receive Power (RSRP)/ Reference Signal Received Quality (RSRQ) information and/or CRS port information by measurement based on the CRS ports; wherein number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than or equal to 1.

[Claim 21] The receiving device according to claim 19, wherein the signaling receiving module is further to receive a data signal and/or control signal over the time-frequency resource.

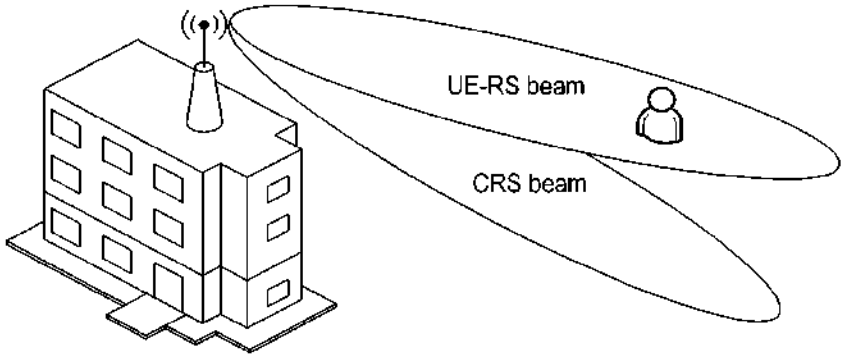
[Fig. 1]



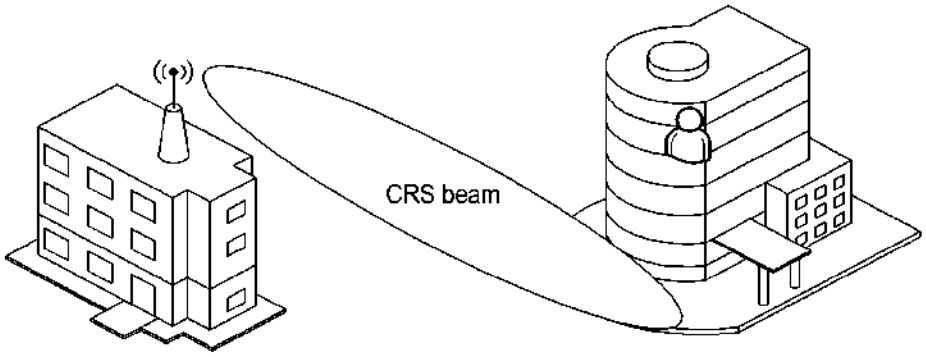
[Fig. 2]



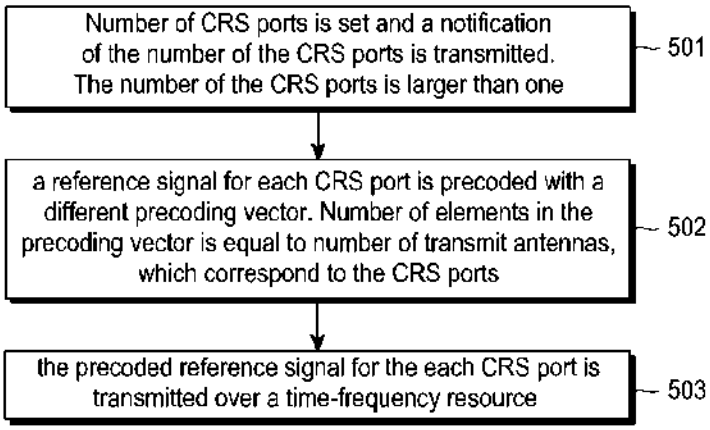
[Fig. 3]



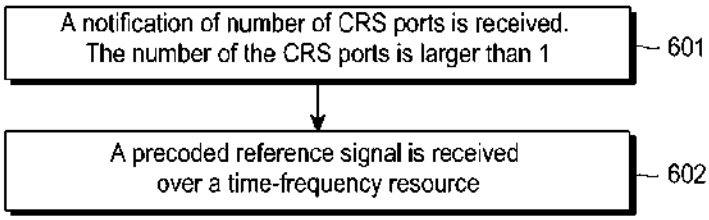
[Fig. 4]



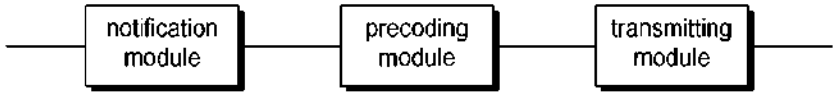
[Fig. 5]



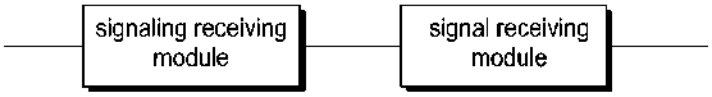
[Fig. 6]



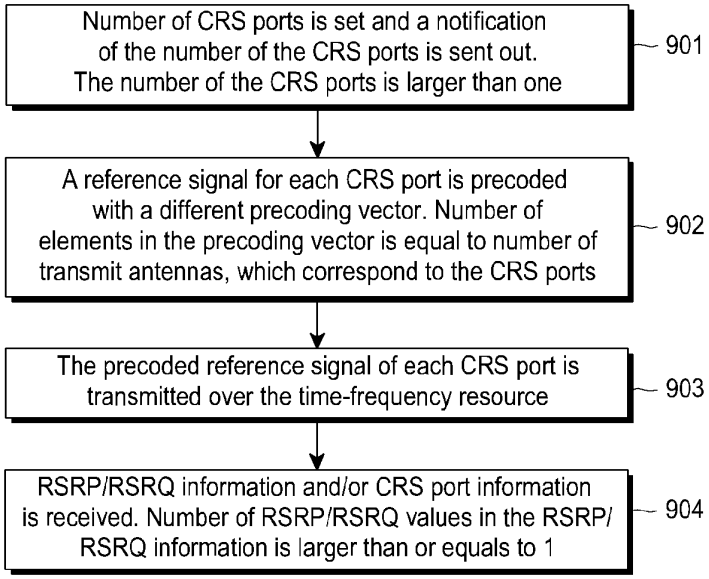
[Fig. 7]



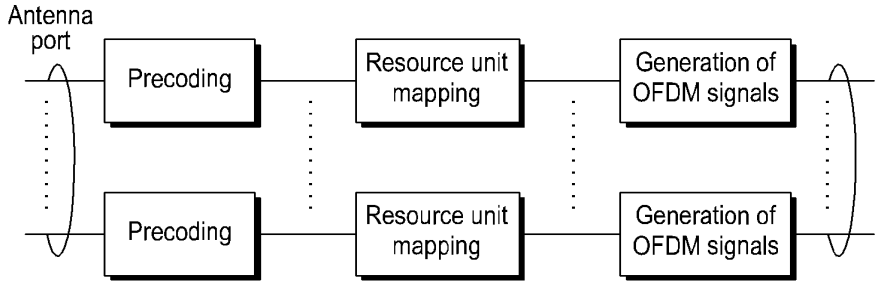
[Fig. 8]



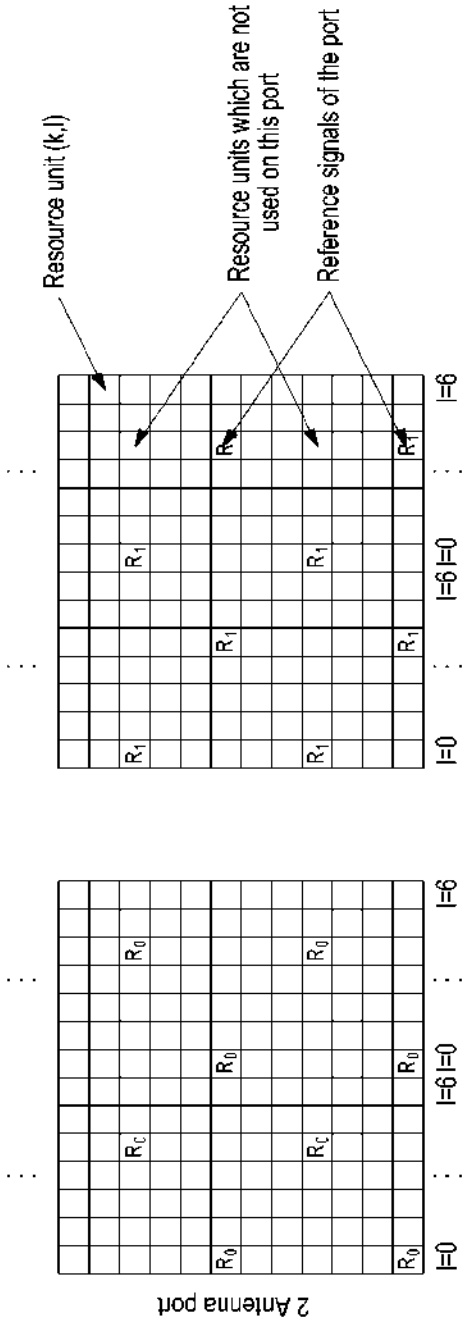
[Fig. 9]


Number of CRS ports is set and a notification of the number of the CRS ports is sent out. The number of the CRS ports is larger than one
901
A reference signal for each CRS port is precoded with a different precoding vector. Number of elements in the precoding vector is equal to number of transmit antennas, which correspond to the CRS ports
902
The precoded reference signal of each CRS port is transmitted over the time-frequency resource
903
RSRP/RSRQ information and/or CRS port information is received. Number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than or equals to 1
904

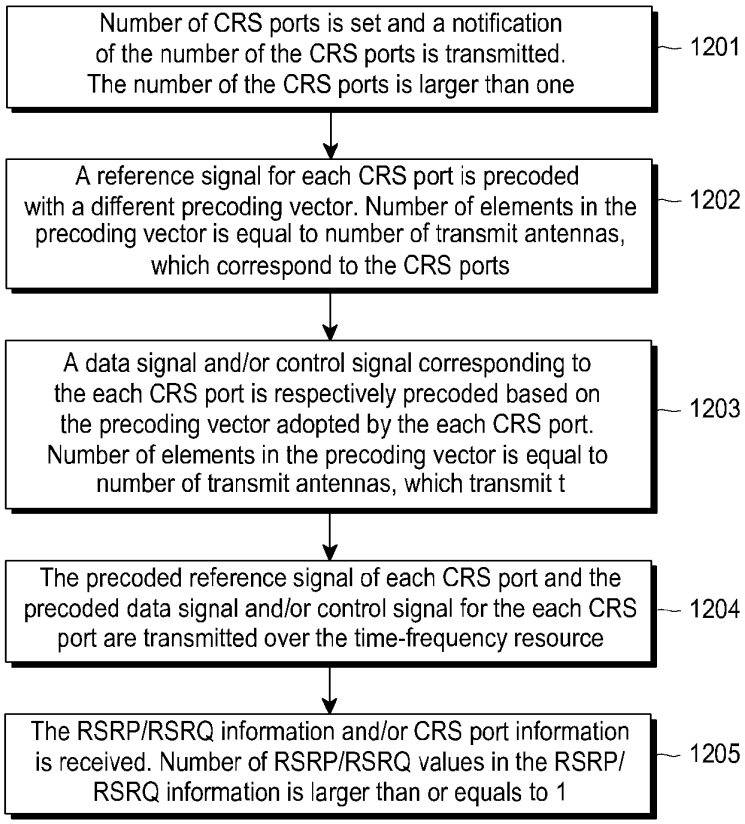
[Fig. 10]


Antenna port
Precoding
Precoding
Resource unit mapping
Resource unit mapping
Generation of OFDM signals
Generation of OFDM signals

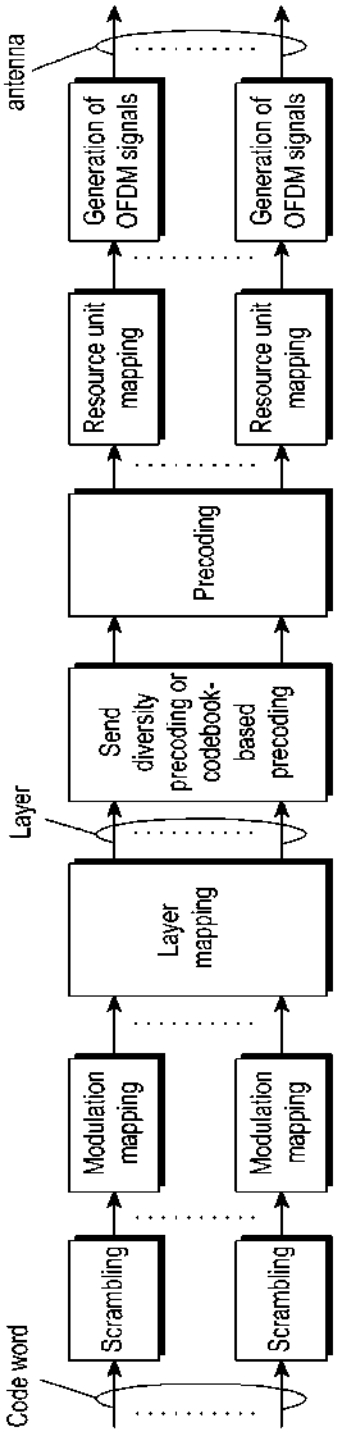
[Fig. 11]


Resource unit (k,l)
Resource units which are not used on this port
Reference signals of the port
l=6
l=6 l=0
l=0
2 Antenna port

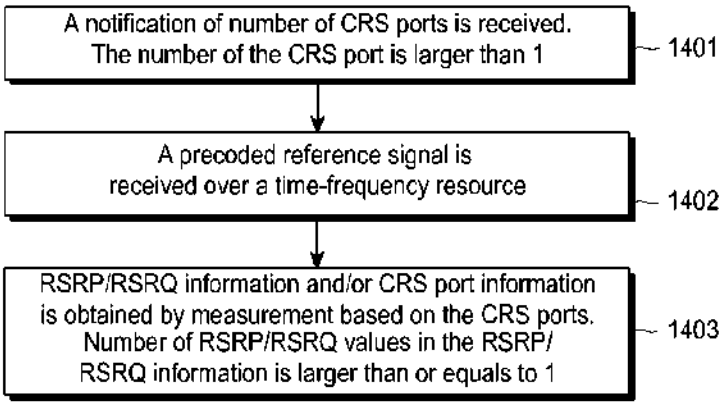
[Fig. 12]


Number of CRS ports is set and a notification of the number of the CRS ports is transmitted. The number of the CRS ports is larger than one
1201
A reference signal for each CRS port is precoded with a different precoding vector. Number of elements in the precoding vector is equal to number of transmit antennas, which correspond to the CRS ports
1202
A data signal and/or control signal corresponding to the each CRS port is respectively precoded based on the precoding vector adopted by the each CRS port. Number of elements in the precoding vector is equal to number of transmit antennas, which transmit t
1203
The precoded reference signal of each CRS port and the precoded data signal and/or control signal for the each CRS port are transmitted over the time-frequency resource
1204
The RSRP/RSRQ information and/or CRS port information is received. Number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than or equals to 1
1205

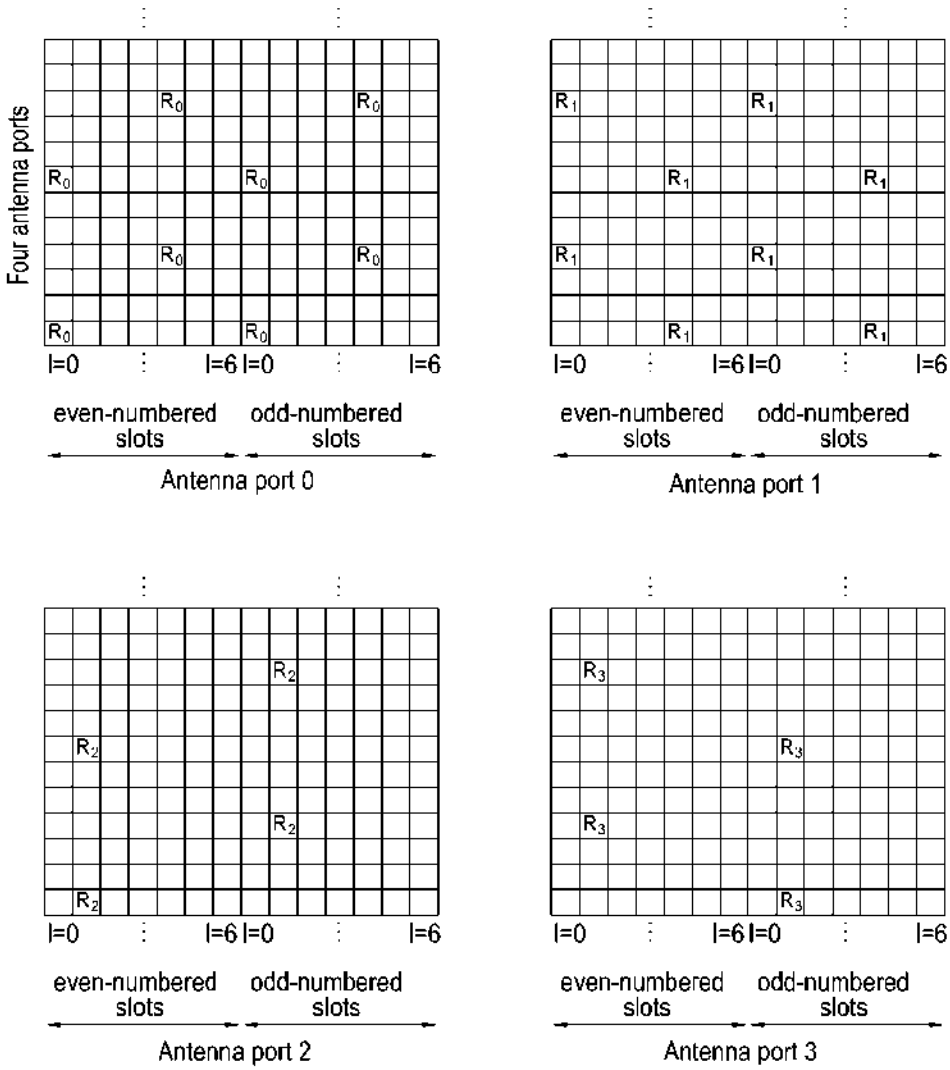
[Fig. 13]


Physical antenna
Generation of OFDM signals
Generation of OFDM signals
Resource unit mapping
Resource unit mapping
Precoding
Send diversity precoding or codebook-based precoding
Layer
Layer mapping
Modulation mapping
Modulation mapping
Scrambling
Scrambling
Code word

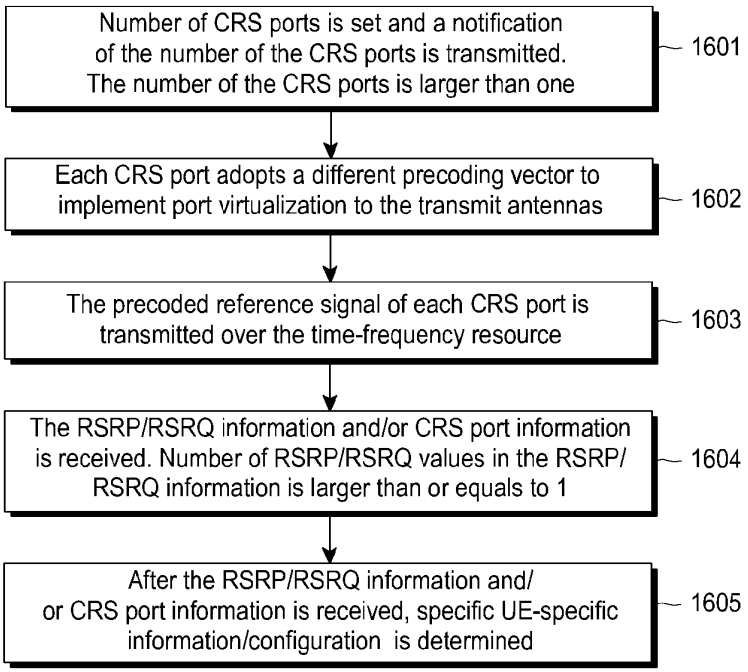
[Fig. 14]


A notification of number of CRS ports is received. The number of the CRS port is larger than 1
1401
A precoded reference signal is received over a time-frequency resource
1402
RSRP/RSRQ information and/or CRS port information is obtained by measurement based on the CRS ports. Number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than or equals to 1
1403

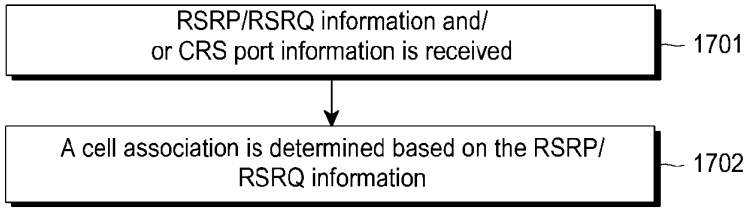
[Fig. 15]


Four antenna ports
l=0
l=6
even-numbered slots
odd-numbered slots
Antenna port 0
Antenna port 1
Antenna port 2
Antenna port 3

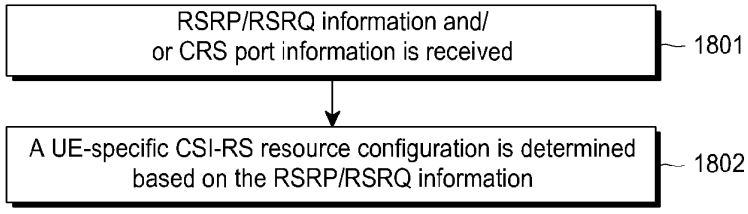
[Fig. 16]



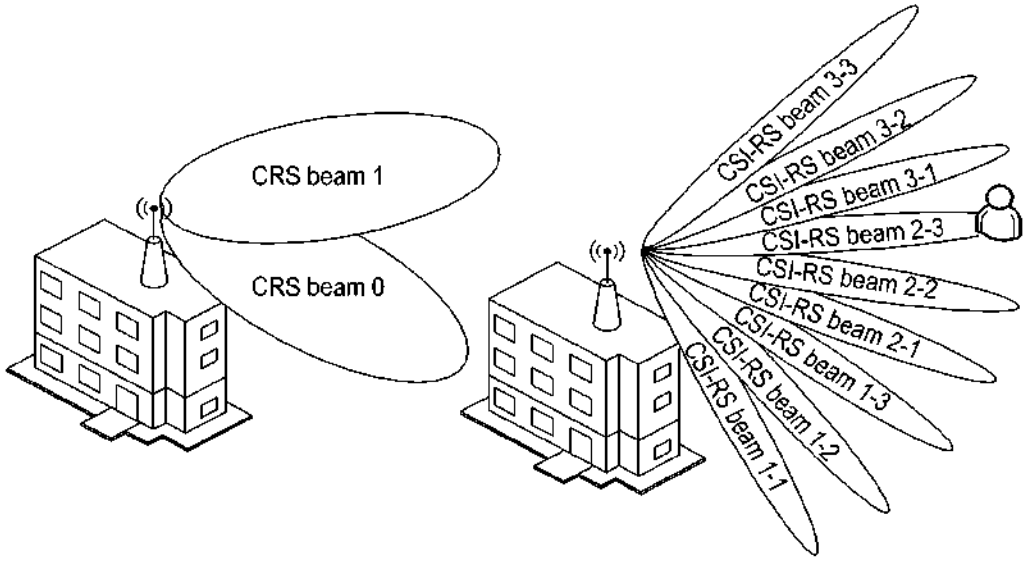
[Fig. 17]



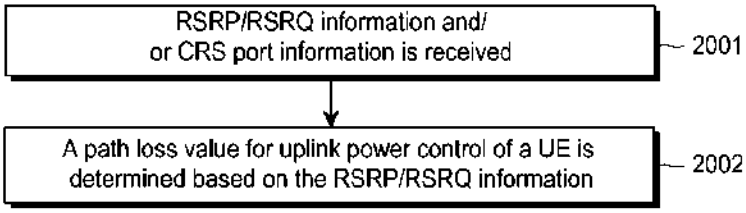
[Fig. 18]



[Fig. 19]


CRS beam 1
CRS beam 0
CSI-RS beam 3-3
CSI-RS beam 3-2
CSI-RS beam 3-1
CSI-RS beam 2-3
CSI-RS beam 2-2
CSI-RS beam 2-1
CSI-RS beam 1-3
CSI-RS beam 1-2
CSI-RS beam 1-1

[Fig. 20]


RSRP/RSRQ information and/
or CRS port information is received
2001
A path loss value for uplink power control of a UE is
determined based on the RSRP/RSRQ information
2002

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2015/006369

A. CLASSIFICATION OF SUBJECT MATTER

H04L 5/00(2006.01)i, H04L 1/06(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04L 5/00; H04L 1/06; H04B 7/06; H04W 72/00; H04B 7/04; H04W 24/08

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & keywords: CRS port, notify, precoding, RSRP/RSRQ(Reference Signal Receive Power/ Received Quality)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2013-0315191 A1 (TAKASHI YOSHIMOTO et al.) 28 November 2013 See paragraph [0099]; and figure 1.	1,11,14,15,19,21
A		2-10,12,13,16-18,20
Y	US 2103-0107746 A1 (FUJITSU LIMITED) 02 May 2013 See paragraphs [0089]-[0103]; claims 1, 5; and figures 1, 2.	1,11,14,15,19,21
A	US 2013-0329772 A1 (NIKLAS WERNERSSON et al.) 12 December 2013 See paragraphs [0093]-[0152]; and figures 6-9.	1-21
A	US 2014-0098689 A1 (INTERDIGITAL PATENT HOLDINGS, INC.) 10 April 2014 See paragraphs [0076]-[0079]; and figure 3.	1-21
A	WO 2014-073846 A1 (PANTECH CO., LTD.) 15 May 2014 See paragraphs [0252]-[0297]; and figures 28, 29.	1-21

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
08 October 2015 (08.10.2015)	**08 October 2015 (08.10.2015)**

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/KR2015/006369

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(22) International Filing Date:
14 August 2015 (14.08.2015)

(25) Filing Language: English

(26) Publication Language: English

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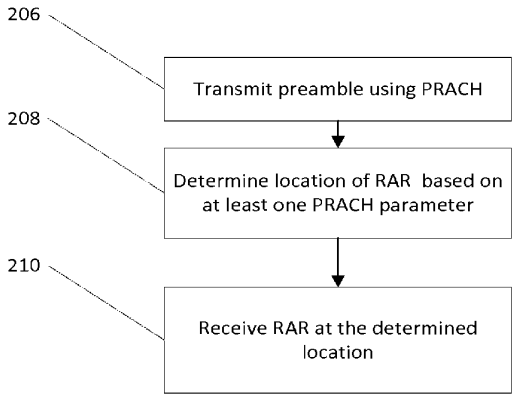


FIG. 2

(57) Abstract: A wireless transmit/receive unit (WTRU) may transmit a preamble using a physical random access channel (PRACH) and determine a location of a random access response (RAR) based on a parameter of the PRACH. The location may include a subframe and/or a frequency resource on which the RAR is transmitted. The RAR may be received at the location. A device may receive a preamble using a PRACH associated with a coverage enhancement (CE) level and/or a CE mode of a WTRU. The device may determine a location of an RAR based on a parameter of the PRACH. The location may include a subframe and/or a frequency resource on which the RAR is to be transmitted. The device may determine a number of repetitions of the RAR to transmit based on the CE level or CE mode. The RAR may be transmitted at the location with the determined number of repetitions.

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SUPPORTING RANDOM ACCESS AND PAGING PROCEDURES FOR REDUCED CAPABILITY WTRUS IN AN LTE SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of United States Provisional Patent Application 62/038,194, filed August 15, 2014; United States Provisional Patent Application 62/075,555, filed November 5, 2014; United States Provisional Patent Application 62/149,053, filed April 17, 2015; United States Provisional Patent Application 62/161,212, filed May 13, 2015; and United States Provisional Patent Application 62/204,341, filed August 12, 2015.

BACKGROUND

[0002] A coverage enhanced wireless transmit/receive unit (WTRU) may be a WTRU that may need or may use coverage enhancement or a WTRU that may support or use a coverage enhancement (CE) mode. A coverage limited WTRU may refer to a coverage enhanced WTRU, and *vice versa*.

[0003] A reduced bandwidth (BW) WTRU may be a WTRU that may support a certain limited bandwidth (*e.g.*, RF bandwidth) or a certain limited number of resource blocks (RBs) in the downlink (DL) and/or uplink (UL) that may be independent of the bandwidth of the eNB or cell with which the WTRU may communicate. For example, a limited bandwidth WTRU may support a certain number of RBs (*e.g.*, 6 RBs) or bandwidth (*e.g.*, 1.4 MHz) for transmission and/or reception. Such a WTRU may communicate with an eNB or cell for which the bandwidth may be larger (*e.g.*, 20 MHz or 100 RBs). This WTRU may use procedures to operate in a portion of the full bandwidth of the cell. Reduced bandwidth, limited bandwidth, and bandwidth limited may be used interchangeably.

SUMMARY

[0004] PRACH resource allocation and random access procedures may be provided for WTRUs that may be coverage limited and/or bandwidth limited. Some (*e.g.*, all) of the PRACH resources that may be allocated, *e.g.*, by an eNB, for coverage limited WTRUs may be located in

a bandwidth that may be supported by bandwidth limited WTRUs. WTRUs that may be both coverage limited and bandwidth limited may choose from and/or use one or more PRACH resources for PRACH transmission to an eNB. PRACH resources that may be allocated or designated for each of one or more (*e.g.*, all) levels of coverage limitation may include a subset that may be used by WTRUs that may be coverage limited and bandwidth limited.

[0005] PRACH resources may be allocated or designated for WTRUs that may be both coverage limited and bandwidth limited. WTRUs that may be both coverage limited and bandwidth limited may choose from and/or use these allocated or designated PRACH resources for PRACH transmission to an eNB. PRACH resources (which may be differentiated, for example, by one or more of preamble, time, and/or frequency) may be allocated and/or used for different levels of coverage limitation.

[0006] A WTRU may transmit a preamble using a PRACH and may determine a location of a random access response (RAR) based on a parameter of the PRACH, the location comprising at least one of a subframe or a frequency resource on which the RAR is transmitted. The WTRU may receive the RAR at the determined location.

[0007] A device may receive a preamble using a PRACH associated with at least one of a coverage enhancement (CE) level or a CE mode of a WTRU from which the preamble is received. The device may determine a location of an RAR based on a parameter of the PRACH. The location may comprise at least one of a subframe or a frequency resource on which the RAR is to be transmitted. The device may determine a number of repetitions of the RAR to transmit based on the CE level or CE mode. The device may transmit the RAR at the determined location with the determined number of repetitions.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. 1A is a system diagram of an example communications system in which one or more disclosed embodiments may be implemented.

[0009] FIG. 1B is a system diagram of an example wireless transmit/receive unit (WTRU) that may be used within the communications system illustrated in FIG. 1A.

[0010] FIG. 1C is a system diagram of an example radio access network and an example core network that may be used within the communications system illustrated in FIG. 1A.

[0011] FIG. 1D is a system diagram of another example radio access network and another example core network that may be used within the communications system illustrated in FIG. 1A.

[0012] FIG. 1E is a system diagram of another example radio access network and another example core network that may be used within the communications system illustrated in FIG. 1A.

[0013] FIG. 2 illustrates an example of preamble transmission and RAR reception by a WTRU.

[0014] FIG. 3A illustrates an example of preamble transmission and RAR reception by a WTRU.

[0015] FIG. 3B illustrates an example RA configuration.

[0016] FIG. 4A illustrates an example of preamble transmission and RAR reception by a WTRU.

[0017] FIG. 4B illustrates an example RA configuration.

[0018] FIG. 5 illustrates an example of preamble reception and RAR transmission.

DETAILED DESCRIPTION

[0019] A detailed description of illustrative embodiments will now be described with reference to the various Figures. Although this description provides a detailed example of possible implementations, it should be noted that the details are intended to be exemplary and in no way limit the scope of the application.

[0020] FIG. 1A is a diagram of an example communications system 100 in which one or more disclosed embodiments may be implemented. The communications system 100 may be a multiple access system that provides content, such as voice, data, video, messaging, broadcast, *etc.*, to multiple wireless users. The communications system 100 may enable multiple wireless users to access such content through the sharing of system resources, including wireless bandwidth. For example, the communications system 100 may employ one or more channel access methods, such as code division multiple access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), orthogonal FDMA (OFDMA), single-carrier FDMA (SC-FDMA), and the like.

[0021] As shown in FIG. 1A, the communications system 100 may include wireless transmit/receive units (WTRUs) 102a, 102b, 102c, and/or 102d (which generally or collectively may be referred to as WTRU 102), a radio access network (RAN) 103/104/105, a core network 106/107/109, a public switched telephone network (PSTN) 108, the Internet 110, and other networks 112, though it will be appreciated that the disclosed embodiments contemplate any

number of WTRUs, base stations, networks, and/or network elements. Each of the WTRUs 102a, 102b, 102c, 102d may be any type of device configured to operate and/or communicate in a wireless environment. By way of example, the WTRUs 102a, 102b, 102c, 102d may be configured to transmit and/or receive wireless signals and may include user equipment (UE), a mobile station, a fixed or mobile subscriber unit, a pager, a cellular telephone, a personal digital assistant (PDA), a smartphone, a laptop, a netbook, a personal computer, a wireless sensor, consumer electronics, and the like.

[0022] The communications system 100 may also include a base station 114a and a base station 114b. Each of the base stations 114a, 114b may be any type of device configured to wirelessly interface with at least one of the WTRUs 102a, 102b, 102c, 102d to facilitate access to one or more communication networks, such as the core network 106/107/109, the Internet 110, and/or the networks 112. By way of example, the base stations 114a, 114b may be a base transceiver station (BTS), a Node-B, an eNode B, a Home Node B, a Home eNode B, a site controller, an access point (AP), a wireless router, and the like. While the base stations 114a, 114b are each depicted as a single element, it will be appreciated that the base stations 114a, 114b may include any number of interconnected base stations and/or network elements.

[0023] The base station 114a may be part of the RAN 103/104/105, which may also include other base stations and/or network elements (not shown), such as a base station controller (BSC), a radio network controller (RNC), relay nodes, *etc.* The base station 114a and/or the base station 114b may be configured to transmit and/or receive wireless signals within a particular geographic region, which may be referred to as a cell (not shown). The cell may further be divided into cell sectors. For example, the cell associated with the base station 114a may be divided into three sectors. Thus, in one embodiment, the base station 114a may include three transceivers, *e.g.*, one for each sector of the cell. In another embodiment, the base station 114a may employ multiple-input multiple output (MIMO) technology and, therefore, may utilize multiple transceivers for each sector of the cell.

[0024] The base stations 114a, 114b may communicate with one or more of the WTRUs 102a, 102b, 102c, 102d over an air interface 115/116/117, which may be any suitable wireless communication link (*e.g.*, radio frequency (RF), microwave, infrared (IR), ultraviolet (UV), visible light, *etc.*). The air interface 115/116/117 may be established using any suitable radio access technology (RAT).

[0025] More specifically, as noted above, the communications system 100 may be a multiple access system and may employ one or more channel access schemes, such as CDMA, TDMA,

FDMA, OFDMA, SC-FDMA, and the like. For example, the base station 114a in the RAN 103/104/105 and the WTRUs 102a, 102b, 102c may implement a radio technology such as Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access (UTRA), which may establish the air interface 115/116/117 using wideband CDMA (WCDMA). WCDMA may include communication protocols such as High-Speed Packet Access (HSPA) and/or Evolved HSPA (HSPA+). HSPA may include High-Speed Downlink Packet Access (HSDPA) and/or High-Speed Uplink Packet Access (HSUPA).

[0026] In another embodiment, the base station 114a and the WTRUs 102a, 102b, 102c may implement a radio technology such as Evolved UMTS Terrestrial Radio Access (E-UTRA), which may establish the air interface 115/116/117 using Long Term Evolution (LTE) and/or LTE-Advanced (LTE-A).

[0027] In other embodiments, the base station 114a and the WTRUs 102a, 102b, 102c may implement radio technologies such as IEEE 802.16 (*e.g.*, Worldwide Interoperability for Microwave Access (WiMAX)), CDMA2000, CDMA2000 1X, CDMA2000 EV-DO, Interim Standard 2000 (IS-2000), Interim Standard 95 (IS-95), Interim Standard 856 (IS-856), Global System for Mobile communications (GSM), Enhanced Data rates for GSM Evolution (EDGE), GSM EDGE (GERAN), and the like.

[0028] The base station 114b in FIG. 1A may be a wireless router, Home Node B, Home eNode B, or access point, for example, and may utilize any suitable RAT for facilitating wireless connectivity in a localized area, such as a place of business, a home, a vehicle, a campus, and the like. In one embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.11 to establish a wireless local area network (WLAN). In another embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.15 to establish a wireless personal area network (WPAN). In yet another embodiment, the base station 114b and the WTRUs 102c, 102d may utilize a cellular-based RAT (*e.g.*, WCDMA, CDMA2000, GSM, LTE, LTE-A, *etc.*) to establish a picocell or femtocell. As shown in FIG. 1A, the base station 114b may have a direct connection to the Internet 110. Thus, the base station 114b may not be required to access the Internet 110 via the core network 106/107/109.

[0029] The RAN 103/104/105 may be in communication with the core network 106/107/109, which may be any type of network configured to provide voice, data, applications, and/or voice over internet protocol (VoIP) services to one or more of the WTRUs 102a, 102b, 102c, 102d. For example, the core network 106/107/109 may provide call control, billing services, mobile

location-based services, pre-paid calling, Internet connectivity, video distribution, *etc.*, and/or perform high-level security functions, such as user authentication. Although not shown in FIG. 1A, it will be appreciated that the RAN 103/104/105 and/or the core network 106/107/109 may be in direct or indirect communication with other RANs that employ the same RAT as the RAN 103/104/105 or a different RAT. For example, in addition to being connected to the RAN 103/104/105, which may be utilizing an E-UTRA radio technology, the core network 106/107/109 may also be in communication with another RAN (not shown) employing a GSM radio technology.

[0030] The core network 106/107/109 may also serve as a gateway for the WTRUs 102a, 102b, 102c, 102d to access the PSTN 108, the Internet 110, and/or other networks 112. The PSTN 108 may include circuit-switched telephone networks that provide plain old telephone service (POTS). The Internet 110 may include a global system of interconnected computer networks and devices that use common communication protocols, such as the transmission control protocol (TCP), user datagram protocol (UDP) and the internet protocol (IP) in the TCP/IP internet protocol suite. The networks 112 may include wired or wireless communications networks owned and/or operated by other service providers. For example, the networks 112 may include another core network connected to one or more RANs, which may employ the same RAT as the RAN 103/104/105 or a different RAT.

[0031] Some or all of the WTRUs 102a, 102b, 102c, 102d in the communications system 100 may include multi-mode capabilities, *e.g.*, the WTRUs 102a, 102b, 102c, 102d may include multiple transceivers for communicating with different wireless networks over different wireless links. For example, the WTRU 102c shown in FIG. 1A may be configured to communicate with the base station 114a, which may employ a cellular-based radio technology, and with the base station 114b, which may employ an IEEE 802 radio technology.

[0032] FIG. 1B is a system diagram of an example WTRU 102. As shown in FIG. 1B, the WTRU 102 may include a processor 118, a transceiver 120, a transmit/receive element 122, a speaker/microphone 124, a keypad 126, a display/touchpad 128, non-removable memory 130, removable memory 132, a power source 134, a global positioning system (GPS) chipset 136, and other peripherals 138. It will be appreciated that the WTRU 102 may include any sub-combination of the foregoing elements while remaining consistent with an embodiment. Also, embodiments contemplate that the base stations 114a and 114b, and/or the nodes that base stations 114a and 114b may represent, such as but not limited to transceiver station (BTS), a Node-B, a site controller, an access point (AP), a home node-B, an evolved home node-B

(eNodeB), a home evolved node-B (HeNB or HeNodeB), a home evolved node-B gateway, and proxy nodes, among others, may include some or all of the elements depicted in FIG. 1B and described herein.

[0033] The processor 118 may be a general purpose processor, a special purpose processor, a conventional processor, a digital signal processor (DSP), a plurality of microprocessors, one or more microprocessors in association with a DSP core, a controller, a microcontroller, Application Specific Integrated Circuits (ASICs), Field Programmable Gate Array (FPGAs) circuits, any other type of integrated circuit (IC), a state machine, and the like. The processor 118 may perform signal coding, data processing, power control, input/output processing, and/or any other functionality that enables the WTRU 102 to operate in a wireless environment. The processor 118 may be coupled to the transceiver 120, which may be coupled to the transmit/receive element 122. While FIG. 1B depicts the processor 118 and the transceiver 120 as separate components, it will be appreciated that the processor 118 and the transceiver 120 may be integrated together in an electronic package or chip. A processor, such as the processor 118, may include integrated memory (*e.g.*, WTRU 102 may include a chipset that includes a processor and associated memory). Memory may refer to memory that is integrated with a processor (*e.g.*, processor 118) or memory that is otherwise associated with a device (*e.g.*, WTRU 102). The memory may be non-transitory. The memory may include (*e.g.*, store) instructions that may be executed by the processor (*e.g.*, software and/or firmware instructions). For example, the memory may include instructions that when executed may cause the processor to implement one or more of the implementations described herein.

[0034] The transmit/receive element 122 may be configured to transmit signals to, or receive signals from, a base station (*e.g.*, the base station 114a) over the air interface 115/116/117. For example, in one embodiment, the transmit/receive element 122 may be an antenna configured to transmit and/or receive RF signals. In another embodiment, the transmit/receive element 122 may be an emitter/detector configured to transmit and/or receive IR, UV, or visible light signals, for example. In yet another embodiment, the transmit/receive element 122 may be configured to transmit and receive both RF and light signals. It will be appreciated that the transmit/receive element 122 may be configured to transmit and/or receive any combination of wireless signals.

[0035] In addition, although the transmit/receive element 122 is depicted in FIG. 1B as a single element, the WTRU 102 may include any number of transmit/receive elements 122. More specifically, the WTRU 102 may employ MIMO technology. Thus, in one embodiment, the

WTRU 102 may include two or more transmit/receive elements 122 (*e.g.*, multiple antennas) for transmitting and receiving wireless signals over the air interface 115/116/117.

[0036] The transceiver 120 may be configured to modulate the signals that are to be transmitted by the transmit/receive element 122 and to demodulate the signals that are received by the transmit/receive element 122. As noted above, the WTRU 102 may have multi-mode capabilities. Thus, the transceiver 120 may include multiple transceivers for enabling the WTRU 102 to communicate via multiple RATs, such as UTRA and IEEE 802.11, for example.

[0037] The processor 118 of the WTRU 102 may be coupled to, and may receive user input data from, the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128 (*e.g.*, a liquid crystal display (LCD) display unit or organic light-emitting diode (OLED) display unit). The processor 118 may also output user data to the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128. In addition, the processor 118 may access information from, and store data in, any type of suitable memory, such as the non-removable memory 130, the removable memory 132, and/or memory integrated with the processor 118. The non-removable memory 130 may include random-access memory (RAM), read-only memory (ROM), a hard disk, or any other type of memory storage device. The removable memory 132 may include a subscriber identity module (SIM) card, a memory stick, a secure digital (SD) memory card, and the like. In other embodiments, the processor 118 may access information from, and store data in, memory that is not physically located on the WTRU 102, such as on a server or a home computer (not shown).

[0038] The processor 118 may receive power from the power source 134, and may be configured to distribute and/or control the power to the other components in the WTRU 102. The power source 134 may be any suitable device for powering the WTRU 102. For example, the power source 134 may include one or more dry cell batteries (*e.g.*, nickel-cadmium (NiCd), nickel-zinc (NiZn), nickel metal hydride (NiMH), lithium-ion (Li-ion), *etc.*), solar cells, fuel cells, and the like.

[0039] The processor 118 may also be coupled to the GPS chipset 136, which may be configured to provide location information (*e.g.*, longitude and latitude) regarding the current location of the WTRU 102. In addition to, or in lieu of, the information from the GPS chipset 136, the WTRU 102 may receive location information over the air interface 115/116/117 from a base station (*e.g.*, base stations 114a, 114b) and/or determine its location based on the timing of the signals being received from two or more nearby base stations. It will be appreciated that the

WTRU 102 may acquire location information by way of any suitable location-determination implementation while remaining consistent with an embodiment.

[0040] The processor 118 may further be coupled to other peripherals 138, which may include one or more software and/or hardware modules that provide additional features, functionality and/or wired or wireless connectivity. For example, the peripherals 138 may include an accelerometer, an e-compass, a satellite transceiver, a digital camera (for photographs or video), a universal serial bus (USB) port, a vibration device, a television transceiver, a hands free headset, a Bluetooth® module, a frequency modulated (FM) radio unit, a digital music player, a media player, a video game player module, an Internet browser, and the like.

[0041] FIG. 1C is a system diagram of the RAN 103 and the core network 106 according to an embodiment. As noted above, the RAN 103 may employ a UTRA radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 115. The RAN 103 may also be in communication with the core network 106. As shown in FIG. 1C, the RAN 103 may include Node-Bs 140a, 140b, 140c, which may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 115. The Node-Bs 140a, 140b, 140c may each be associated with a particular cell (not shown) within the RAN 103. The RAN 103 may also include RNCs 142a, 142b. It will be appreciated that the RAN 103 may include any number of Node-Bs and RNCs while remaining consistent with an embodiment.

[0042] As shown in FIG. 1C, the Node-Bs 140a, 140b may be in communication with the RNC 142a. Additionally, the Node-B 140c may be in communication with the RNC 142b. The Node-Bs 140a, 140b, 140c may communicate with the respective RNCs 142a, 142b via an Iub interface. The RNCs 142a, 142b may be in communication with one another via an Iur interface. Each of the RNCs 142a, 142b may be configured to control the respective Node-Bs 140a, 140b, 140c to which it is connected. In addition, each of the RNCs 142a, 142b may be configured to carry out or support other functionality, such as outer loop power control, load control, admission control, packet scheduling, handover control, macrodiversity, security functions, data encryption, and the like.

[0043] The core network 106 shown in FIG. 1C may include a media gateway (MGW) 144, a mobile switching center (MSC) 146, a serving GPRS support node (SGSN) 148, and/or a gateway GPRS support node (GGSN) 150. While each of the foregoing elements are depicted as part of the core network 106, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

[0044] The RNC 142a in the RAN 103 may be connected to the MSC 146 in the core network 106 via an IuCS interface. The MSC 146 may be connected to the MGW 144. The MSC 146 and the MGW 144 may provide the WTRUs 102a, 102b, 102c with access to circuit-switched networks, such as the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, 102c and traditional land-line communications devices.

[0045] The RNC 142a in the RAN 103 may also be connected to the SGSN 148 in the core network 106 via an IuPS interface. The SGSN 148 may be connected to the GGSN 150. The SGSN 148 and the GGSN 150 may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, such as the Internet 110, to facilitate communications between and the WTRUs 102a, 102b, 102c and IP-enabled devices.

[0046] As noted above, the core network 106 may also be connected to the networks 112, which may include other wired or wireless networks that are owned and/or operated by other service providers.

[0047] FIG. 1D is a system diagram of the RAN 104 and the core network 107 according to an embodiment. As noted above, the RAN 104 may employ an E-UTRA radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 116. The RAN 104 may also be in communication with the core network 107.

[0048] The RAN 104 may include eNode-Bs 160a, 160b, 160c, though it will be appreciated that the RAN 104 may include any number of eNode-Bs while remaining consistent with an embodiment. The eNode-Bs 160a, 160b, 160c may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 116. In one embodiment, the eNode-Bs 160a, 160b, 160c may implement MIMO technology. Thus, the eNode-B 160a, for example, may use multiple antennas to transmit wireless signals to, and receive wireless signals from, the WTRU 102a.

[0049] Each of the eNode-Bs 160a, 160b, 160c may be associated with a particular cell (not shown) and may be configured to handle radio resource management decisions, handover decisions, scheduling of users in the uplink and/or downlink, and the like. As shown in FIG. 1D, the eNode-Bs 160a, 160b, 160c may communicate with one another over an X2 interface.

[0050] The core network 107 shown in FIG. 1D may include a mobility management gateway (MME) 162, a serving gateway 164, and a packet data network (PDN) gateway 166. While each of the foregoing elements are depicted as part of the core network 107, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

[0051] The MME 162 may be connected to each of the eNode-Bs 160a, 160b, 160c in the RAN 104 via an S1 interface and may serve as a control node. For example, the MME 162 may be responsible for authenticating users of the WTRUs 102a, 102b, 102c, bearer activation/deactivation, selecting a particular serving gateway during an initial attach of the WTRUs 102a, 102b, 102c, and the like. The MME 162 may also provide a control plane function for switching between the RAN 104 and other RANs (not shown) that employ other radio technologies, such as GSM or WCDMA.

[0052] The serving gateway 164 may be connected to each of the eNode-Bs 160a, 160b, 160c in the RAN 104 via the S1 interface. The serving gateway 164 may generally route and forward user data packets to/from the WTRUs 102a, 102b, 102c. The serving gateway 164 may also perform other functions, such as anchoring user planes during inter-eNode B handovers, triggering paging when downlink data is available for the WTRUs 102a, 102b, 102c, managing and storing contexts of the WTRUs 102a, 102b, 102c, and the like.

[0053] The serving gateway 164 may also be connected to the PDN gateway 166, which may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, such as the Internet 110, to facilitate communications between the WTRUs 102a, 102b, 102c and IP-enabled devices.

[0054] The core network 107 may facilitate communications with other networks. For example, the core network 107 may provide the WTRUs 102a, 102b, 102c with access to circuit-switched networks, such as the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, 102c and traditional land-line communications devices. For example, the core network 107 may include, or may communicate with, an IP gateway (*e.g.*, an IP multimedia subsystem (IMS) server) that serves as an interface between the core network 107 and the PSTN 108. In addition, the core network 107 may provide the WTRUs 102a, 102b, 102c with access to the networks 112, which may include other wired or wireless networks that are owned and/or operated by other service providers.

[0055] FIG. 1E is a system diagram of the RAN 105 and the core network 109 according to an embodiment. The RAN 105 may be an access service network (ASN) that employs IEEE 802.16 radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 117. As will be further discussed below, the communication links between the different functional entities of the WTRUs 102a, 102b, 102c, the RAN 105, and the core network 109 may be defined as reference points.

[0056] As shown in FIG. 1E, the RAN 105 may include base stations 180a, 180b, 180c, and an ASN gateway 182, though it will be appreciated that the RAN 105 may include any number of base stations and ASN gateways while remaining consistent with an embodiment. The base stations 180a, 180b, 180c may each be associated with a particular cell (not shown) in the RAN 105 and may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 117. In one embodiment, the base stations 180a, 180b, 180c may implement MIMO technology. Thus, the base station 180a, for example, may use multiple antennas to transmit wireless signals to, and receive wireless signals from, the WTRU 102a. The base stations 180a, 180b, 180c may also provide mobility management functions, such as handoff triggering, tunnel establishment, radio resource management, traffic classification, quality of service (QoS) policy enforcement, and the like. The ASN gateway 182 may serve as a traffic aggregation point and may be responsible for paging, caching of subscriber profiles, routing to the core network 109, and the like.

[0057] The air interface 117 between the WTRUs 102a, 102b, 102c and the RAN 105 may be defined as an R1 reference point that implements the IEEE 802.16 specification. In addition, each of the WTRUs 102a, 102b, 102c may establish a logical interface (not shown) with the core network 109. The logical interface between the WTRUs 102a, 102b, 102c and the core network 109 may be defined as an R2 reference point, which may be used for authentication, authorization, IP host configuration management, and/or mobility management.

[0058] The communication link between each of the base stations 180a, 180b, 180c may be defined as an R8 reference point that includes protocols for facilitating WTRU handovers and the transfer of data between base stations. The communication link between the base stations 180a, 180b, 180c and the ASN gateway 182 may be defined as an R6 reference point. The R6 reference point may include protocols for facilitating mobility management based on mobility events associated with each of the WTRUs 102a, 102b, 102c.

[0059] As shown in FIG. 1E, the RAN 105 may be connected to the core network 109. The communication link between the RAN 105 and the core network 109 may defined as an R3 reference point that includes protocols for facilitating data transfer and mobility management capabilities, for example. The core network 109 may include a mobile IP home agent (MIP-HA) 184, an authentication, authorization, accounting (AAA) server 186, and a gateway 188. While each of the foregoing elements are depicted as part of the core network 109, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

[0060] The MIP-HA may be responsible for IP address management, and may enable the WTRUs 102a, 102b, 102c to roam between different ASNs and/or different core networks. The MIP-HA 184 may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, such as the Internet 110, to facilitate communications between the WTRUs 102a, 102b, 102c and IP-enabled devices. The AAA server 186 may be responsible for user authentication and for supporting user services. The gateway 188 may facilitate interworking with other networks. For example, the gateway 188 may provide the WTRUs 102a, 102b, 102c with access to circuit-switched networks, such as the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, 102c and traditional land-line communications devices. In addition, the gateway 188 may provide the WTRUs 102a, 102b, 102c with access to the networks 112, which may include other wired or wireless networks that are owned and/or operated by other service providers.

[0061] Although not shown in FIG. 1E, it will be appreciated that the RAN 105 may be connected to other ASNs and the core network 109 may be connected to other core networks. The communication link between the RAN 105 the other ASNs may be defined as an R4 reference point, which may include protocols for coordinating the mobility of the WTRUs 102a, 102b, 102c between the RAN 105 and the other ASNs. The communication link between the core network 109 and the other core networks may be defined as an R5 reference, which may include protocols for facilitating interworking between home core networks and visited core networks.

[0062] A WTRU that may support the full bandwidth of a cell may be referred to as a full bandwidth WTRU. Bandwidth may include a number of RBs and/or a location in a band, such as the center of the band.

[0063] A WTRU may at least sometimes communicate, behave, or operate in a manner that may be consistent (*e.g.*, at least partially consistent) with that of a full bandwidth (BW) WTRU and may at least sometimes (*e.g.*, at other times) communicate, behave, or operate in a manner that may be consistent (*e.g.*, at least partially consistent) with that of a reduced BW WTRU. For example, a WTRU that may support the full bandwidth of a cell may communicate, behave, or operate in a manner that may be consistent (*e.g.*, at least partially consistent) with that of a reduced BW WTRU at certain times, such as when it may be coverage limited or when it may operate in coverage enhanced (CE) mode. A WTRU may be or may be considered a full BW WTRU and/or a reduced BW WTRU, for example, at least sometimes.

[0064] A WTRU may be or may be considered a reduced BW WTRU while it may (or may need to or may intend to) behave or operate like (*e.g.*, at least partially like) a reduced BW WTRU. A WTRU that may communicate (*e.g.*, with an eNB), behave, or operate in a manner that may be consistent (*e.g.*, at least partially consistent) with that of a reduced BW WTRU may be or may be considered to be a reduced BW WTRU, for example, at least sometimes, such as when the WTRU may communicate, behave, or operate in a manner that may be consistent (*e.g.*, at least partially consistent) with that of a reduced BW WTRU.

[0065] The examples disclosed herein may apply to eNBs and cells. The examples disclosed herein may apply to WTRUs such as coverage limited and reduced bandwidth (BW) WTRUs. The examples disclosed herein as being applicable to reduced BW WTRUs may apply to coverage limited WTRUs. The examples disclosed herein as being applicable to coverage limited WTRUs may apply to reduced BW WTRUs. The examples disclosed herein may apply to WTRUs of other types, with other capabilities, or with reduced capabilities.

[0066] For purposes of description and explanation, PDCCH may be replaced with EPDCCH, and *vice versa*, and may still be consistent with the examples disclosed herein. For purposes of description and explanation, PDCCH (or EPDCCH) may be replaced with a DL control channel or another DL control channel and may still be consistent with the examples disclosed herein. For purposes of description and explanation, component carrier (CC) and serving cell may be used interchangeably. For purposes of description and explanation, WTRU, WTRU MAC entity, and MAC entity may be used interchangeably. For purposes of description and explanation, eNB and cell may be used interchangeably. CE level may be replaced with number of repetitions, and *vice versa*, and may still be consistent with the examples disclosed herein. Repetition number, number of repetitions, and repetition level may be used interchangeably.

[0067] A WTRU or WTRUs may be replaced with at least a WTRU or at least WTRUs, and may still be consistent with the examples disclosed herein. Intended for may be replaced with at least intended for or with intended for at least and may still be consistent with the examples disclosed herein.

[0068] Examples disclosed herein may be disclosed for RAR, PCH, or for a physical downlink shared channel (PDSCH) that may carry RAR or PCH. Such examples are non-limiting. RAR may be replaced by PCH, PCH PDSCH, or PDSCH, and *vice versa*, and may still be consistent with the examples disclosed herein. The channel or other content that may be

carried by the PDSCH may be replaced by another channel or content and may still be consistent with the examples disclosed herein.

[0069] An eNB and/or a WTRU may use a random access procedure for WTRU initial access (for example, to a cell or eNB), reset of UL timing (for example, to reset or align WTRU UL timing with respect to a cell), and/or reset of timing during handover (for example, to reset or align WTRU timing with respect to the handover target cell). The WTRU may transmit a physical random access channel (PRACH) preamble sequence at a power P_{PRACH}, which may be based on configured parameters and/or measurements, and the WTRU may transmit the preamble using a time-frequency resource or resources. The configured parameters, which may be provided or configured by the eNB, may include one or more of initial preamble power (*e.g.*, preambleInitialReceivedTargetPower), a preamble format based offset (*e.g.*, deltaPreamble), a random access response window (*e.g.*, ra-ResponseWindowSize), a power ramping factor (*e.g.*, powerRampingStep), and/or a maximum number of retransmissions (*e.g.*, preambleTransMax). The PRACH resources (which may include preambles or sets of preambles and/or time/frequency resources that may be used for preamble transmission) may be provided or configured by the eNB. The measurements may include pathloss. The time-frequency resource or resources may be chosen by the WTRU from an allowed set or may be chosen by the eNB and signaled to the WTRU. Following WTRU transmission of a preamble, if the eNB may detect the preamble, it may respond with a random access response (RAR). If the WTRU may not or does not receive an RAR for the transmitted preamble (which may, for example, correspond to a certain preamble index and time/frequency resource), within an allotted time (for example, ra-ResponseWindowSize), the WTRU may send another preamble at a later time, at a higher power, (for example, higher than the previous preamble transmission by powerRampingStep) where the transmission power may be limited by a maximum power, for example, a WTRU-configured maximum power which may be for the WTRU as a whole (for example, P_{CMAX}) or for a serving cell of the WTRU (for example, $P_{CMAX,c}$). The WTRU may wait again for receipt of an RAR from the eNB. This sequence of transmitting and waiting may continue until the eNB may respond with an RAR or until the maximum number of random access preamble transmissions (for example, preambleTransMax) may have been reached. The eNB may transmit and the WTRU may receive the RAR in response to a single preamble transmission.

[0070] The term time/frequency or time-frequency may be used to represent time and/or frequency. The term time-frequency may be used to represent a specific time and frequency.

[0071] A random access procedure (*e.g.*, an instance of a random access procedure) may be contention-based or contention-free. A contention-free procedure may be initiated by a request, for example from an eNB, which may, for example, be via physical layer signaling such as a PDCCH order or by higher layer signaling such as an RRC reconfiguration message (*e.g.*, an RRC connection reconfiguration message) that may include mobility control information and may, for example, indicate or correspond to a handover request. For a contention-free procedure that may be initiated by PDCCH order in subframe n, the PRACH preamble may be transmitted in the first subframe (or the first subframe available for PRACH) $n+k_2$, where k_2 may be at least 6. When initiated by RRC command, there may be other delays that may be specified (for example, there may be minimum and/or maximum required or allowed delays). The WTRU may autonomously initiate a contention-based procedure for reasons that may include for example, initial access, restoration of UL synchronization, and/or recovering from radio link failure. For certain events, for example, events other than recovery from radio link failure, it may not be defined or specified as to how long after such an event the WTRU may send the PRACH preamble.

[0072] For a contention-free random access (RA) procedure, a network-signaled PRACH preamble may be used, *e.g.*, by a WTRU. For a contention-based random access procedure, the WTRU may autonomously choose a preamble where the preamble format and/or the time/frequency resource or resources available for preamble transmissions may be based on an indication or index (*e.g.*, prach configIndex) that may be provided or signaled by the eNB.

[0073] In an LTE system, one of the preambles transmitted at the progressively higher transmit powers may be detected by the eNB. An RAR may be sent by the eNB in response to that one detected preamble.

[0074] A WTRU may monitor (*e.g.*, periodically) the PDCCH for DL assignments on the PDCCH masked with a P-RNTI (Paging Radio Network Temporary Identifier (RNTI)) in idle mode and/or in connected mode. When such a DL assignment using the P-RNTI may be detected, the WTRU may demodulate the assigned PDSCH resource blocks (RBs) and may decode the paging channel (PCH) carried on that PDSCH. A PDSCH that may carry PCH may be a PCH PDSCH. Paging, paging message, paging information, and PCH may be used interchangeably.

[0075] In idle mode, the specific paging frame (PF) and subframe within that PF, for example, the paging occasion (PO) that a WTRU may monitor for the paging channel may be determined based on the WTRU ID (*e.g.*, WTRU_ID) and parameters that may be specified by

the network. The parameters may include the paging cycle (PC) length (*e.g.*, in frames), which may be the same as a DRX cycle and another parameter, *e.g.*, nB, which together may facilitate the determination of the number of PF per PC and the number of PO per PF that may be in the cell. The WTRU ID may be the WTRU IMSI or the WTRU IMSI modulo a number such as 1024. For example, the PO may be determined based on WTRU IMSI mod 1024.

[0076] There may be multiple PFs per paging cycle and multiple POs within a PF, for example, more than one subframe per paging cycle may carry PDCCH masked with a P-RNTI. A WTRU may monitor a (*e.g.*, one) PO per paging cycle, and such a PO may be determined based on WTRU ID and/or one or more of the parameters disclosed herein, which may be provided to the WTRU via system information, dedicated signaling information, and the like. POs may include pages for one or more specific WTRUs, or they may include system information change pages that may be directed to each of the WTRUs, some of the WTRUs, or all of the WTRUs. For WTRU-specific pages (*e.g.*, pages that may be specific to one or more WTRUs), a WTRU (*e.g.*, a WTRU in idle mode) may monitor one PO per PC that may be based on a WTRU ID. For pages that may indicate a system information change (*e.g.*, a change that has occurred or an upcoming system information change), a WTRU (*e.g.*, a WTRU in idle or connected mode) may monitor one or more POs in a system information modification period that may or may not be based on the WTRU ID.

[0077] In connected mode, a WTRU may receive pages related to a system information change, for example, and it may not receive WTRU-specific pages such as those that may be used for an incoming call. A WTRU in the connected mode may not monitor a specific PO (*e.g.*, a PO that may be based on its WTRU ID). For frequency division duplexing (FDD), the PO subframes may include certain subframes, such as subframes 0, 4, 5, and 9. For time division duplexing (TDD), the PO subframes may include certain subframes, such as subframes 0, 1, 5, and 6.

[0078] A number of repetitions, such as of a preamble, a control channel, a PDSCH (*e.g.*, an RAR PDSCH), a PUSCH, and/or a PUCCH may include the first transmission (or reception). A number of repetitions (*e.g.*, other repetitions) may exclude the first transmission (or reception). Inclusion may be substituted for exclusion and *vice versa* and still be consistent with the examples disclosed herein. Downlink control channel, downlink control channel for MTC WTRU, (E)PDCCH (*e.g.*, EPDCCH and/or PDCCH), PDCCH, and/or M-PDCCH may be used interchangeably. System information, system information for MTC WTRU, MTC-SIB, M-SIB, and/or SIB may be used interchangeably.

[0079] A random access (RA) procedure may be provided and/or used. An eNB or cell may support WTRUs with capabilities or limitations, such as coverage limited WTRUs and/or WTRUs with reduced capabilities, such as reduced bandwidth WTRUs. A WTRU may be coverage limited and/or reduced bandwidth. Reduced capabilities may or may also include reduced complexity, such as inclusion or use of (*e.g.*, only of) a single receive antenna and/or receiver chain and/or support for a reduced transport block size.

[0080] PRACH resources may be partitioned such that resources (*e.g.*, certain resources) which may be or include preambles and/or resources in time and/or frequency may be used by WTRUs such as coverage limited WTRUs and the use of the resources (*e.g.*, certain resources) may indicate to an eNB that the WTRU using the resources may be coverage limited and/or the coverage limitation of the WTRU using the resources may be of a certain level.

[0081] An eNB, for example, one that may support a bandwidth (BW) larger than that of a reduced bandwidth WTRU and/or that may support reduced bandwidth WTRUs, may allocate PRACH resources that may be used by at least certain WTRUs, such as reduced bandwidth WTRUs. The allocated resources may be located in a bandwidth (*e.g.*, number of RBs and/or band location such as a band center) in which a reduced bandwidth WTRU may or may be able to transmit. These resources may be the same as, separate from, or a subset of those which may be allocated for legacy or other WTRUs. The allocated resources may include preambles that may or may only be used by reduced bandwidth WTRUs.

[0082] PRACH resource allocation (*e.g.*, for resources that may be used by at least certain WTRUs) may include the designation of one or more of preambles (*e.g.*, certain preambles), times (*e.g.*, subframes or certain subframes), and/or frequencies (*e.g.*, RBs or certain RBs). PRACH resources (*e.g.*, for use by at least certain WTRUs) may be differentiated (*e.g.*, from resources that may not be used by the certain WTRUs) by at least one or more of preamble, time (*e.g.*, subframe allocation), and/or frequency (*e.g.*, RB allocation). Allocation and/or designation may be via signaling (*e.g.*, by the eNB), such as dedicated or broadcast signaling and/or system information.

[0083] PRACH resource allocation and random access procedures may be provided for WTRUs that may be coverage limited and/or bandwidth limited. Some (*e.g.*, all) of the PRACH resources that may be allocated, *e.g.*, by an eNB, for coverage limited WTRUs may be or may always be located in a bandwidth that may be supported by bandwidth limited WTRUs. WTRUs that may be coverage limited and/or bandwidth limited may choose from and/or use one or more PRACH resources (*e.g.*, from among the PRACH resources that may be allocated for coverage

limited WTRUs and/or may be located in a bandwidth that may be supported by bandwidth limited WTRUs) for PRACH transmission to an eNB. PRACH resources that may be allocated or designated for each of one or more (*e.g.*, all) levels of coverage limitation may include a subset (which may include the full set) that may be used by WTRUs that may be coverage limited and bandwidth limited.

[0084] An eNB may consider a coverage limited WTRU (*e.g.*, a WTRU that the eNB may determine to be coverage limited) as a bandwidth limited WTRU as well, for example, until informed or determined otherwise. The eNB may determine the WTRU to be coverage limited based on the PRACH resource the WTRU may have used (*e.g.*, transmitted) or the eNB may have received from the WTRU. The eNB may communicate with the WTRU accordingly.

[0085] An eNB that may receive a PRACH from a PRACH resource that may be designated or allocated for coverage limited WTRUs and that may be used by bandwidth limited WTRUs (*e.g.*, by designation or by location in the supportable bandwidth of the WTRU) may consider the WTRU that may have transmitted the PRACH as a bandwidth limited WTRU, for example, until informed or determined otherwise. The eNB may communicate with the WTRU accordingly.

[0086] PRACH resources may be specifically allocated or designated for WTRUs that may be both coverage limited and bandwidth limited. WTRUs that may be both coverage limited and bandwidth limited may choose from and/or use these allocated or designated PRACH resources for PRACH transmission to an eNB. Separate PRACH resources (which may be differentiated, for example, by one or more of preamble, time, and/or frequency) may be allocated and/or used for different levels of coverage limitation. For example, one level of coverage limitation, *e.g.*, the worst case level, may be used by WTRUs that may be both coverage limited and bandwidth limited.

[0087] An eNB that may receive a PRACH from a PRACH resource that may be designated or allocated for WTRUs that may be both coverage limited and bandwidth limited may consider the WTRU that may have transmitted the PRACH as both a coverage limited and bandwidth limited WTRU. Based on the PRACH resource, the eNB may also know the coverage limitation level. The eNB may communicate with the WTRU accordingly.

[0088] A random access response (RAR) may be provided and/or used. During a random access procedure with a WTRU, an eNB may not know if the WTRU is a reduced bandwidth WTRU, for example, until it may receive an indication or message from the WTRU, and may, for example, not know whether to respond to the WTRU in a reduced bandwidth.

[0089] An eNB may consider a WTRU that may have transmitted (or from which the eNB may have received) a PRACH in a certain bandwidth (*e.g.*, a certain number of RBs and/or a certain location such as a center set of RBs, such as the center 6 RBs) to be a reduced bandwidth WTRU, for example, until it receives an indication that the WTRU is not a reduced bandwidth WTRU. The indication may be provided by the WTRU in a message (*e.g.*, RRC message such as a RRC connection request or WTRU capabilities message, which may be from the WTRU).

[0090] When responding to PRACH from a WTRU such as one that may be or may be considered by an eNB to be a reduced bandwidth WTRU, the eNB may provide the random access response (RAR) in a way in which the WTRU may be able to receive it.

[0091] An eNB may, for example, until it knows or determines a WTRU is not a reduced bandwidth WTRU, limit transmissions intended for the WTRU to a maximum of a certain number R RBs (*e.g.*, 6) and/or location, such as a set (*e.g.*, a certain set) of R RBs (*e.g.*, the center R RBs). The eNB may or may also limit an UL grant (*e.g.*, the UL grant for msg3 of the RA procedure) size to a certain maximum number Y RBs (*e.g.*, 6 RBs) and/or location such as a set (*e.g.*, a certain set) of Y RBs (*e.g.*, the center Y RBs). R may be equal to Y. The RB location(s) may be provided (*e.g.*, by the eNB, in signaling such as broadcast signaling (*e.g.*, in system information). This may apply (*e.g.*, may only apply) for WTRUs that may or may be determined to be coverage limited (*e.g.*, based on the PRACH resource used by the WTRU).

[0092] An eNB that may receive a PRACH from a PRACH resource that may be allocated or designated for or used by at least certain, *e.g.*, bandwidth limited and/or coverage limited, WTRUs may do one or more of the following: provide RAR in a manner in which a WTRU, such as a bandwidth limited WTRU and/or a coverage limited WTRU, may receive the RAR, provide an UL grant for resources (*e.g.*, for message 3 of the RA procedure) in the bandwidth in which a bandwidth limited WTRU may transmit, and/or provide or continue to provide DL grants and/or UL grants for a limited bandwidth WTRU until, for example, it may receive an indication (explicit or otherwise) that the WTRU may not be a limited bandwidth WTRU. The indication may be included in an RRC message such as an RRC connection request message or a WTRU capabilities message, which may be from the WTRU.

[0093] Providing RAR in a manner in which a WTRU, such as a bandwidth limited WTRU and/or a coverage limited WTRU, may receive the RAR may include using EPDCCH (or both EPDCCH and PDCCH) to send the control information (*e.g.*, DCI format) that may indicate the location and/or parameters for the PDSCH that may carry the RAR. Providing RAR in a manner in which a WTRU, such as a bandwidth limited WTRU and/or a coverage limited WTRU, may

receive the RAR may include transmitting the PDSCH that may carry RAR in the bandwidth (*e.g.*, number of RBs and/or band location such as the center of the band) in which a limited bandwidth WTRU may receive it. Providing RAR in a manner in which a WTRU, such as a bandwidth limited WTRU and/or a coverage limited WTRU, may receive the RAR may include transmitting the RAR PDSCH in a fixed, known, or determined location and/or with one or more fixed, known, or determined parameters (*e.g.*, transmission parameters such as MCS) such that a DCI format may not be required or used (*e.g.*, for the RAR) by or for a WTRU, which may be a bandwidth limited WTRU or a coverage limited WTRU. The fixed, known, or determined location and/or parameters may be provided by the eNB in signaling, such as broadcast system information and/or may be a function of the PRACH or PRACH transmission to which the RAR may respond or may include a response.

[0094] A known location, parameter, or value may be determined by the WTRU and/or eNB. Known and determined may be used interchangeably.

[0095] Providing DL grants and/or UL grants for a limited bandwidth WTRU may include one or more of using EPDCCH (or both EPDCCH and PDCCH) to send the control information (*e.g.*, DCI format) associated with the grant, transmitting the granted PDSCH in the bandwidth (*e.g.*, number of RBs and/or band location such as the center of the band) in which a limited bandwidth WTRU may receive it, and/or granting UL resources in the bandwidth (*e.g.*, number of RBs and/or band location such as the center of the band) in which a limited bandwidth WTRU may transmit.

[0096] The location and/or transmission parameters of an RAR that may be intended for a WTRU (or at least a WTRU) that may be bandwidth limited and/or coverage limited may be a function of one or more parameters of the PRACH (*e.g.*, the PRACH resource) for which the RAR may provide or include a response. A location (*e.g.*, of an RAR) may be or may include time (*e.g.*, subframe) and/or frequency (*e.g.*, one or more RBs). A PRACH or PRACH resource parameter may be or may include time (*e.g.*, subframe or subframe set), frequency (*e.g.*, one or more RBs), and/or preamble.

[0097] An RAR may be or may represent a certain instance or repetition of an RAR. Repetitions of an RAR that may be combined by a WTRU, such as a WTRU that may be coverage limited, may be in the same or different locations (*e.g.*, subframes may be different and RBs may be the same or different) and/or may use the same or different parameters.

[0098] A WTRU, such as a bandwidth limited and/or coverage limited WTRU, may transmit a PRACH, *e.g.*, to an eNB. The WTRU and/or the eNB may determine the location of an RAR

that may be intended for the WTRU (or at least the WTRU), for example, in response to the PRACH transmission of the WTRU, based on one or more parameters of the PRACH (*e.g.*, the PRACH resource). For example, the RB or RBs in which a WTRU may transmit a PRACH may determine (or may be used by the WTRU and/or eNB to determine) the RB or RBs for the RAR that may correspond to the PRACH. The eNB may transmit and/or the WTRU may receive or attempt to receive the RAR in the determined location. Determination by the WTRU may be based on at least configuration, *e.g.*, of the relationship or correspondence between RAR location and/or parameters and PRACH parameters and/or PRACH resources, which may be provided by the eNB via signaling, such as broadcast signaling or in system information, which may be broadcast.

[0099] A location (*e.g.*, which may be fixed or known) and/or one or more transmission parameters (*e.g.*, which may be fixed or known) of an RAR that may be intended for a WTRU (or at least a WTRU), such as a WTRU that may be bandwidth limited and/or coverage limited, may be a function of a capability (or reduced capability) of the WTRU. For example, RAR location and/or one or more RAR transmission parameters may be a function of at least one of CE mode, CE level, and/or bandwidth limitation. The capability (or reduced capability) of the WTRU, such as the CE mode and/or CE level, and/or bandwidth limitation of the WTRU, may determine (or may be used by the WTRU and/or eNB to determine) the location (*e.g.*, subframes and/or RBs) and/or one or more transmission parameters (*e.g.*, MCS) for the RAR that may correspond to the PRACH. The eNB may transmit and/or the WTRU may receive or attempt to receive the RAR in the determined location. Determination by the WTRU may be based on at least configuration (*e.g.*, of RAR location and/or parameters) for one or more capabilities (or reduced capabilities, such as CE mode or level) that may be provided by the eNB via signaling such as broadcast signaling.

[0100] FIG. 2 illustrates an example of preamble transmission and RAR reception by a WTRU. The WTRU may transmit a preamble on or using a PRACH at 206. The WTRU may determine the location of the RAR based on at least one parameter of the PRACH at 208. The location of the RAR may comprise at least one of a subframe or a frequency resource on which the RAR may be or will be transmitted. A PRACH parameter may comprise at least one of a subframe, a frequency resource, *e.g.*, on which the preamble is transmitted, or the preamble. The WTRU may receive or may attempt to receive the RAR at the determined location at 210. The WTRU may transmit the preamble with repetitions, for example, when the WTRU is in CE mode, using CE, and/or using a CE level. The WTRU may receive and combine repetitions of an RAR to successfully receive and/or decode the RAR, for example, when the WTRU is in CE

mode, using CE, and/or using a CE level. The location of the RAR repetitions may be determined based on the at least one parameter of the PRACH and/or one or more other PRACH parameters. The association or correspondence between the one or more PRACH parameters and the RAR location (or locations, for example for repetitions) may be provided to and/or received by the WTRU via a configuration, *e.g.*, a random access (RA) configuration. The configuration may be provided and/or received in system information, which may be broadcast.

[0101] FIG. 3A illustrates another example of preamble transmission and RAR reception by a WTRU. The WTRU receives an RA configuration at 302. The WTRU determines one or more PRACH parameters based on the RA configuration at 304. The WTRU transmits a preamble on or using a PRACH at 306. The WTRU determines the location of the RAR based on at least one parameter of the PRACH at 308. The location of the RAR may comprise at least one of a subframe or a frequency resource on which the RAR may be or will be transmitted. A PRACH parameter may comprise at least one of a subframe, a frequency resource, *e.g.*, on which the preamble is transmitted, or the preamble. The WTRU may receive or may attempt to receive the RAR at the determined location at 310. The WTRU may transmit the preamble with repetitions, for example, when the WTRU is in CE mode, using CE, and/or using a CE level. The WTRU may receive and combine repetitions of an RAR to successfully receive and/or decode the RAR, for example, when the WTRU is in CE mode, using CE, and/or using a CE level. The location of the RAR repetitions may be determined based on the at least one parameter of the PRACH and/or one or more other PRACH parameters. The RA configuration may provide the WTRU with the association or correspondence between the one or more PRACH parameters and the RAR location (or locations, for example, for repetitions).

[0102] FIG. 3B illustrates an example RA configuration that includes one or more PRACH parameters 314 and one or more RAR locations 316. The RA configuration may provide the association or correspondence between one or more PRACH parameters and an RAR location or locations, for example for repetitions. The PRACH parameters and/or RAR locations may be associated with CE levels.

[0103] FIG. 4A illustrates an example of preamble transmission and RAR reception by a WTRU. The WTRU may receive an RA configuration at 402. The WTRU may determine PRACH parameters based on the RA configuration and/or CE level at 404. For example, the RA configuration may include one or more PRACH parameters or sets of PRACH parameters that may be associated with one or more CE levels. PRACH parameters may include one or more preambles and/or one or more PRACH time and/or frequency resources. The WTRU may

determine a preamble, *e.g.*, select a preamble from a set of one or more preambles. The WTRU may determine a subframe or set of subframes (*e.g.*, for repetition) from the one or more time resources. The WTRU may determine a frequency resource such as one or more (*e.g.*, a set of) PRBs from the one or more frequency resources. The CE level may be determined by the WTRU, for example, based on a measurement. The CE level may be determined by the WTRU according to a starting CE level and a number of prior failed random access attempts. For a WTRU that may be using a reduced BW but may not be in or using a CE mode, CE level may not be included in the determination of PRACH parameters at 404.

[0104] The WTRU may transmit a preamble based on the PRACH parameters at 406. For example, the WTRU may transmit the determined preamble on or using the determined PRACH. The WTRU may transmit the determined preamble in the determined subframe or set of subframes in the determined frequency resource (or frequency resources, *e.g.*, if frequency hopping is used for one or more repetitions).

[0105] The WTRU may determine the RAR location based on at least one PRACH parameter and/or CE level at 408. The RAR location may comprise at least one of a subframe and/or a frequency resource on which the RAR may be transmitted. For RAR with repetition, the location may comprise multiple (*e.g.*, a set of) subframes. For RAR with repetition, the location may comprise multiple (*e.g.*, a set of) frequency locations, *e.g.*, if frequency hopping is used.

[0106] The WTRU may determine the number of repetitions with which the RAR will be transmitted based on at least one PRACH parameter and/or CE level at 410. For some WTRUs, *e.g.*, a WTRU that may be using a reduced BW but may not be in or using a CE mode, this determination may not be made.

[0107] The WTRU may receive or may attempt to receive an RAR at the determined location and, optionally, with up to the determined number of repetitions at 412. The WTRU may receive a repetition of an RAR at one or more determined locations and may combine the repetitions to successfully receive and decode the RAR. The WTRU may receive and combine up to the determined number of repetitions at 412.

[0108] If the WTRU successfully receives an RAR within an RA response window, the WTRU may transmit a success message on resources which may be allocated or granted by the RAR. The success message may be a random access msg3 or another message. If the WTRU does not successfully receive an RAR within an RA response window, the WTRU may stop or may try again depending on the random access procedure and the number of attempts already made, *e.g.*, at one or more CE levels.

[0109] FIG. 4B illustrates another example RA configuration that includes one or more PRACH parameters 414 and one or more RAR locations 416. The RA configuration may provide the WTRU with the association or correspondence between one or more PRACH parameters and an RAR location or locations, for example for repetitions. The PRACH parameters and/or RAR locations may be associated with CE levels.

[0110] FIG. 5 illustrates an example of preamble reception and RAR transmission, for example by an eNB or cell. A preamble may be received on or using a PRACH associated with a CE level at 506. The location of the RAR and/or the number RAR repetitions may be determined based on at least one parameter of the PRACH at 508. The location of the RAR may comprise at least one of a subframe or a frequency resource on which the RAR may be or will be transmitted. A PRACH parameter may comprise at least one of a subframe, a frequency resource, *e.g.*, on which the preamble is transmitted or received, or the preamble. The RAR may be transmitted at the determined location and/or with the determined repetitions at 510.

[0111] RAR location may be used to represent the location of a PDSCH that may carry a (or at least one) RAR. RAR location may be used to represent the location of a control channel or control information, *e.g.*, one or more of a PDCCH, EPDCCH, M-PDCCH, a DCI, or a DCI format, that may include or carry a (or at least one) RAR or may indicate or be associated with a PDSCH that may carry a (or at least one) RAR.

[0112] RAR may be used to represent a PDSCH that may carry an RAR (or at least one RAR). RAR may be used to represent a control channel or control information, *e.g.*, one or more of a PDCCH, EPDCCH, M-PDCCH, a DCI, or a DCI format, that may include or carry a (or at least one) RAR or may indicate or be associated with a PDSCH that may carry a (or at least one) RAR.

[0113] At least one RAR transport block size (TBS) may be configured or fixed and may correspond to a number (*e.g.*, a certain number) of RA responses (*e.g.*, to a number or certain number of preambles). Padding may be used, for example, when the number of responses (*e.g.*, actual responses) may be less than the number (*e.g.*, the certain number) of RA responses or preambles to which the RAR TBS that may be configured or fixed may apply. TBS configuration may be by signaling, such as broadcast signaling, which may be from the eNB. There may be a separate RAR TBS value (*e.g.*, fixed or configured) for one or more CE levels. There may be at least one RAR TBS value for RAR that may be intended for (*e.g.*, at least for) a coverage limited and/or bandwidth limited WTRU. A WTRU, such as a WTRU that may be coverage limited and/or bandwidth limited, may receive or may expect to receive an RAR with a fixed or

configured TBS. An eNB may transmit an RAR that may be intended for (*e.g.*, at least for) a WTRU that may be coverage limited and/or bandwidth limited with a fixed or configured TBS.

[0114] There may be N CE levels and/or there may be PRACH resources (*e.g.*, separate PRACH resources) for one or more (*e.g.*, each) of the N CE levels. A WTRU that may transmit PRACH using the resources that may correspond to a certain CE level may receive or may expect to receive an RAR in time and/or frequency resources (*e.g.*, subframes and/or RBs) that may correspond to the CE level of the WTRU and/or the PRACH resources used by the WTRU. An eNB may transmit an RAR in time and/or frequency resources (*e.g.*, subframes and/or RBs) that may correspond to the resources in which the eNB may have received the PRACH that may correspond to a certain CE level. RAR for different CE levels may be in different frequency resources that may be in the same or different subframes.

[0115] A set of RAR transport block (TB) sizes (*e.g.*, possible or candidate TB sizes) may be fixed or configured (*e.g.*, by the eNB) and/or determined (*e.g.*, by the WTRU). A WTRU may try one or more of the TB sizes in the set to try to successfully receive the RAR, for example, when monitoring for and/or attempting to receive RAR.

[0116] A set of RAR candidates may be fixed or configured (*e.g.*, by the eNB) and/or determined (*e.g.*, by the WTRU). The RAR candidates may differ in one or more characteristics, which may include time (*e.g.*, subframe), frequency (*e.g.*, RBs), TBS, and/or one or more transmission parameters, such as MCS. A WTRU may try one or more of the RAR candidates to try to successfully receive the RAR, for example, when monitoring for and/or attempting to receive RAR.

[0117] An eNB, for example, one that may be unsure if a WTRU from which it may have received a PRACH transmission may be a limited bandwidth WTRU, may transmit RAR in a way in which a limited bandwidth WTRU may receive it and in a way in which a full bandwidth WTRU may receive it.

[0118] The eNB may transmit a PDSCH (which may be repeated in the case of coverage enhancement) that may carry a RAR that may be intended for (*e.g.*, at least) the WTRU. The eNB may transmit the DCI format for the PDSCH that may carry RAR in both PDCCH and EPDCCH. The PDCCH may indicate the location and/or parameters of the PDSCH to be the same as the location and/or parameters indicated by the EPDCCH. The PDSCH may be located in a bandwidth that may be received by a limited bandwidth WTRU. If a DCI format may not be needed for the RAR PDSCH (*e.g.*, for a coverage limited and/or limited bandwidth WTRU), then the EPDCCH may not be transmitted. The PDCCH may indicate the location and/or parameters

of the PDSCH to be the same as the configured or otherwise known or determined location and/or parameters. The PDSCH may provide a grant for UL resources in a bandwidth that a limited bandwidth WTRU may support.

[0119] The eNB may transmit two PDSCH (one or more of which may be repeated in the case of coverage enhancement), *e.g.*, in the same subframe. A PDSCH (*e.g.*, each of the two and/or the repetitions of the two) may carry a RAR that may be intended for (*e.g.*, at least for) the WTRU.

[0120] The eNB may transmit a DCI format for a first PDSCH in a PDCCH. The eNB may transmit a DCI format for a second PDSCH in an EPDCCH. The transmissions may be in the same subframe. The location of the first PDSCH may not be limited to a bandwidth that may be supported by a limited bandwidth WTRU. The location of the second PDSCH may be in (or limited to) a bandwidth that may be supported by a limited bandwidth WTRU. The eNB may not transmit a DCI format for the second PDSCH. The location and/or parameters for the second PDSCH may be configured (*e.g.*, by signaling from the eNB such as broadcast signaling and/or system information) and/or known or determined. One or more (*e.g.*, each) PDSCH may carry an RAR that may be intended for (*e.g.*, at least for) the WTRU from which it may have received the PRACH transmission.

[0121] The eNB may provide two UL grants (*e.g.*, each for a PUSCH transmission) that may be for WTRU transmission of a PUSCH which may carry RA procedure message 3. The two UL grants may be for resources in the same subframe. At least one UL grant may be for resources that a limited bandwidth WTRU may support (*e.g.*, be able to transmit in). The first and/or second (*e.g.*, at least the second) PDSCH may include an UL grant for resources which a limited bandwidth WTRU may support.

[0122] A full bandwidth WTRU (*e.g.*, that may have transmitted the PRACH that may have resulted in the eNB sending the RAR) may receive and/or decode the DCI format in the PDCCH and may receive the first PDSCH (*e.g.*, based on a DL grant in the PDCCH). The full bandwidth WTRU may transmit a PUSCH that may carry message 3 in UL resources granted by the first PDSCH. A limited bandwidth WTRU (*e.g.*, that may have transmitted the PRACH that may have resulted in the eNB sending the RAR) may receive and/or decode the DCI format in the EPDCCH and/or may receive the second PDSCH (*e.g.*, based on a DL grant in the EPDCCH or based on a known or determined location and/or known or determined parameters). The limited bandwidth WTRU may transmit message 3 in a PUSCH in UL resources granted by the second PDSCH.

[0123] The eNB may determine whether the WTRU may be a limited bandwidth WTRU based on the PUSCH in which the WTRU may transmit and/or the eNB may receive message 3 (*e.g.*, from the WTRU that may have been granted the UL resources).

[0124] One or more of a PRACH, PDCCH, EPDCCH, PDSCH, and/or PUSCH may be repeated, *e.g.*, in multiple subframes, for example, when coverage enhancement techniques may be used. Transmitting and/or receiving one of these channels may be replaced by transmitting or receiving one or more repetitions of the channel (*e.g.*, where the first instance of the channel may be considered a repetition of the channel) and still be consistent with this disclosure. For a WTRU or eNB to successfully receive a channel, one or more of the repetitions, which may include a first instance and one or more subsequent repetitions, may be combined.

[0125] An RAR may include an indication of a subframe (*e.g.*, a starting or ending subframe) and/or frequency (*e.g.*, RB or starting RB) of the PRACH transmission to which the RAR may correspond.

[0126] A WTRU may inform an eNB whether or not it is a limited bandwidth WTRU via a message, which may be, for example, an RRC message, such as an RRC connection request message or a WTRU capabilities message.

[0127] Non-receipt of an indication that a WTRU is a limited bandwidth WTRU in a message that may include such an indication (such as a RRC connection request or capabilities message) may be considered the same as receipt of an indication that the WTRU is not a reduced bandwidth WTRU. For example, if the eNB receives a message that may include a reduced bandwidth indication from a WTRU and a limited bandwidth indication is not included, the eNB may consider the WTRU to be a full bandwidth WTRU (*e.g.*, not a limited bandwidth WTRU).

[0128] The eNB may determine the bandwidth capability (*e.g.*, limited or non-limited) of a WTRU based on whether or not the eNB receives a limited bandwidth indication.

[0129] A RA response and/or RA-RNTI may be provided and/or used. After a WTRU may transmit a RA preamble, *e.g.*, regardless of a possible occurrence of a measurement gap, the WTRU may monitor a PDCCH, *e.g.*, of a serving cell such as the PCell, for random access response(s) (RARs) that may be identified by an RA-RNTI and that may arrive in an RA response window. The RA response window may start at a certain subframe, such as the subframe that may include the end of the preamble transmission plus a number of additional subframes, *e.g.*, three additional subframes. The RA response window may have a length in subframes, such as ra-ResponseWindowSize subframes, which may be configured or provided (*e.g.*, by the eNB) via signaling such as broadcast (*e.g.*, system information) signaling.

[0130] The RA-RNTI associated with the PRACH in which a preamble may be transmitted, may be computed, for example, as:

$$RA\text{-}RNTI = 1 + t_id + 10 * f_id$$

where t_id may be the index of the first subframe of the PRACH (*e.g.*, $0 \leq t_id < 10$), and/or f_id may be the index of the PRACH within that subframe, *e.g.*, in ascending order of frequency domain (*e.g.*, $0 \leq f_id < 6$). The WTRU may stop monitoring for RARs after successful reception of a RAR that may include a RA preamble identifier that may match the transmitted RA preamble.

[0131] For a coverage limited WTRU, preambles and/or RAR may be repeated. RA-RNTI for coverage limited WTRUs may collide with those for non-coverage limited WTRUs, and the RA response window definition may be insufficient for coverage limited WTRUs.

[0132] An eNB may transmit RAR in a coverage enhanced manner, for example when transmitting RAR to a UE which may be coverage limited. A WTRU, such as a coverage limited WTRU, may receive RAR in a coverage enhanced manner. Transmission and/or reception in a coverage enhanced manner may include at least one or more of the following, and/or a WTRU and/or eNB may perform transmission and/or reception in a coverage enhanced manner in accordance with at least one or more of the following.

[0133] Transmission and/or reception in a coverage enhanced manner may include transmission of repetitions of RAR, which may include repetitions of a PDSCH that may carry RAR and/or repetitions of the associated PDCCH and/or EPDCCH.

[0134] Transmission and/or reception in a coverage enhanced manner may include reception and/or combining of repetitions of RAR, which may include reception and/or combining repetitions of a PDSCH that may carry RAR and/or reception and/or combining repetitions of the associated PDCCH and/or EPDCCH.

[0135] Transmission and/or reception in a coverage enhanced manner may include use of a modified and/or extended RA response window (*e.g.*, with respect to the RA response window that may be used by or for a non-coverage limited WTRU or WTRUs that may not be in coverage enhanced (CE) mode).

[0136] Transmission and/or reception in a coverage enhanced manner may include transmission of an RNTI for the RAR PDCCH or EPDCCH, *e.g.*, CE-RA-RNTI, which may be specific to coverage limited WTRUs, for example, of a certain coverage enhancement level.

[0137] Transmission and/or reception in a coverage enhanced manner may include monitoring and/or reception of an RNTI for the RAR PDCCH or EPDCCH, *e.g.*, CE-RA-RNTI,

which may be specific to coverage limited WTRUs, for example, of a certain coverage enhancement level.

[0138] RA-RNTI or a new RNTI may be used for PDCCH and/or EPDCCH associated with PDSCH that may carry RAR, for example, for RAR intended for (*e.g.*, at least for) a WTRU that may be coverage limited and/or bandwidth limited.

[0139] PDCCH and/or EPDCCH associated with PDSCH that may carry RAR may be located in a common search space (*e.g.*, PDCCH common search space and/or EPDCCH common search space), for example, for RAR intended for (*e.g.*, at least for) a WTRU that may be coverage limited and/or bandwidth limited.

[0140] The eNB may transmit RAR in a coverage enhanced manner, for example, when responding to receipt of a PRACH preamble that may have been transmitted by a coverage limited WTRU and/or that may be considered or determined by the eNB to have been transmitted by a coverage limited WTRU.

[0141] The RA response window may start at a subframe, such as the subframe that may be or include the end of the preamble transmission (which may be the subframe of the last repetition of the preamble) plus a number of subframes (*e.g.*, three subframes). The start and/or length of the RA response window may be a function of at least one or more of the number of repetitions (or CE level) of the preamble (or PRACH transmission); the number of repetitions or expected repetitions of the RAR; the number of repetitions of the PDCCH and/or EPDCCH that may carry the control information for the RAR and/or that may use RA-RNTI (or CE-RA-RANTI); the gap (*e.g.*, in subframes) that may be between the last RA-RNTI (or CE-RA-RANTI) PDCCH (or EPDCCH) for the RAR and the first RAR; the ra-ResponseWindowSize; a value, *e.g.*, ce-ra-ResponseWindowSize, which may be a fixed value or a configured value (*e.g.*, by eNB signaling such as broadcast and/or system information signaling); a window offset value, which may be a fixed value or a configured value (*e.g.*, by eNB signaling such as broadcast and/or system information signaling); and/or the subframe allocation for the repetitions of the RAR.

[0142] The repetitions and/or expected repetitions of the preamble and/or associated PDCCH (or EPDCCH) and/or RAR may be based on the CE mode and/or level of the WTRU which may be indicated by the WTRU and/or understood by the eNB from the PRACH resource used by the WTRU for the random access. The gap may be a fixed value or a configured value (*e.g.*, by eNB signaling such as broadcast and/or system information signaling).

[0143] For example, if the WTRU may transmit the preamble Nrep times, the length of the window may be Nrep (or a multiple or Nrep such as 2) plus a fixed or configured (*e.g.*, by eNB signaling such as broadcast and/or system information signaling) value such as ra-

ResponseWindowSize or a value, *e.g.*, ce-ra-ResponseWindowSize, subframes. An offset may be added. For example, a CE response window size may be 2 x Nrep + ra-ResponseWindowSize + window offset.

[0144] If the number of times that the RAR may be (or may be expected to be) transmitted is Mrep, the length of the window may be Mrep (or a multiple of Mrep such as 2) plus a fixed or configured value such as ra-ResponseWindowSize or a value, *e.g.*, ce-ra-ResponseWindowSize, subframes. An offset may be added. For example, a CE response window size may be 2 x Mrep + ra-ResponseWindowSize + window offset. The window offset may be a gap of time in subframes between the last of the repetitions of the control channel that may indicate the grant for the RAR PDSCH and the first repetition (*e.g.*, first transmission) of the RAR PDSCH. If the number of repetitions of the control channel may be Crep and the number of repetitions of the RAR may be Rrep, the response window size may be a function of both and may be a function of the size of the gap between them, if any. For example, a CE response window size may be Crep + Rrep + ra-ResponseWindowSize + window offset. ra-ResponseWindowSize may be replaced by ce-ra-ResponseWindowSize or another parameter or value. The window offset may be 0 or a positive integer.

[0145] A subframe allocation for the repetitions of the RAR may be provided or configured by the eNB, for example, by signaling such as broadcast signaling. The subframe allocation may indicate in which subframes an RAR or a certain RAR may be transmitted and/or expected. For example, an RAR that may correspond to a certain CE mode, CE level, BW limitation, or PRACH resource may be transmitted or may only be transmitted in certain subframes. The subframes (*e.g.*, the certain subframes) may be indicated by at least one or more of a periodicity, an indication of the SFNs to which the periodicity may correspond (*e.g.*, x may be designated and periodicity may correspond to SFN mod x=0), and/or an offset (*e.g.*, from the start of the period). The response window start and/or length may be a function of the subframe allocation. For example, if the subframe allocation may have a periodicity of 4 subframes, the response window may be on the order of 4 times longer than if it may have a periodicity of 1 subframe.

[0146] The response window size, for example for TDD, may be a function of the number of DL (or non-UL) subframes in each frame, which may be based on the TDD UL/DL configuration that may be broadcast in a system information block (SIB, *e.g.*, SIB1) of the cell. When counting or considering subframes for RAR, for example for TDD, subframes may (or may only) refer to subframes in which RAR may be transmitted (*e.g.*, DL and/or non-UL subframes).

[0147] If some subframes may not include RAR (*e.g.*, UL subframes, some special subframes, and/or subframes that may include PBCH), then when counting or considering subframes for the RAR window, those subframes may be excluded from the count or consideration and the window may be longer in time than the count. For example, if the RAR response window may be 100 subframes, and 2 out of each 10 subframes in a frame may be excluded, the response window may use a span of 100/0.8 = 125 actual subframes for 100 counted subframes.

[0148] The length of the window may be or may be based on a new configured (*e.g.*, by eNB signaling such as broadcast and/or system information signaling) value, *e.g.*, ce-ra-ResponseWindowSize subframes, which may be a function of the CE level and which may take into account the repetitions of the RAR for the CE level.

[0149] The WTRU may monitor a control channel (*e.g.*, PDCCH and/or EPDCCH) for RA-RNTI and/or CE-RA-RNTI, for example, following transmission of the preamble repetitions that may be for the (*e.g.*, the current) coverage enhancement level of the WTRU. The WTRU may receive PDSCH carrying RAR. The WTRU may perform the monitoring in the response window. The WTRU may combine Crep repetitions (*e.g.*, a moving window of Crep repetitions) of the control channel until it may successfully receive the control channel. The WTRU may combine Rrep or up to Rrep (*e.g.*, a moving window of Rrep or up to Rrep repetitions of the RAR), for example, until it may successfully receive the RAR. A WTRU may or may only monitor a control channel for RA-RNTI and/or CE-RA-RNTI in subframes that may correspond to a subframe allocation that may correspond to a characteristic of the WTRU and/or the PRACH resource that the WTRU may have used for transmission. A WTRU characteristic may include one or more of CE mode, CE level, and/or bandwidth limitation.

[0150] The WTRU may monitor for (*e.g.*, receive or attempt to receive) PDSCH that may carry RAR in a fixed, known, and/or determined location, for example, following transmission of the preamble repetitions that may be for the current coverage enhancement level of the WTRU. The WTRU may perform the monitoring in the response window. The WTRU may combine Rrep or up to Rrep repetitions (*e.g.*, a moving window of Rrep or up to Rrep repetitions of the RAR), for example, until the WTRU may successfully receive an RAR that may include indication of the preamble that the WTRU may have transmitted.

[0151] A WTRU may or may only monitor the PDSCH that may carry RAR in subframes that may correspond to a subframe allocation that may correspond to a characteristic of the WTRU and/or the PRACH resource that the WTRU may have used for transmission.

[0152] A WTRU that may be both coverage limited and bandwidth limited may act at least in accordance with one or more examples disclosed herein for a coverage limited WTRU. For example, a WTRU, such as one that may be both coverage limited and bandwidth limited, may monitor a control channel for CE-RA-RNTI, transmit repeated preambles, combine repetitions of a control channel and/or PDSCH, transmit repeated PUSCH and/or PUCCH, and/or the like.

[0153] The RA-RNTI that may be used for RAR, *e.g.*, CE-RA-RNTI, which may be intended for (*e.g.*, at least for) a coverage limited WTRU, may be determined the same as for legacy WTRUs or may be different or offset from that calculation.

[0154] CE-RA-RNTI may be the same as or different from RA-RNTI. There may be a different CE-RA-RNTI or set of CE-RA-RNTIs for one or more CE levels (*e.g.*, each CE level) that may be supported by an eNB. A CE-RA-RNTI that may be intended (*e.g.*, at least intended) for or monitored for or expected by a certain WTRU may be a function of, for example, one or more of a CE mode (*e.g.*, the CE mode of the WTRU); a CE level (*e.g.*, the CE level of the WTRU); the first or last subframe (*e.g.*, the index of that subframe within a frame) of the preamble transmission (*e.g.*, of the WTRU); the SFN of the frame of the first or last subframe of the preamble transmission (*e.g.*, of the WTRU); the number of repetitions of the preamble (*e.g.*, by the WTRU or that may correspond to the CE mode or CE level of the WTRU); the frequency resource or the index of the frequency resource (*e.g.*, of the set of frequency resources that may be used by certain WTRUs, such as coverage limited WTRUs) of the PRACH or preamble transmission (*e.g.*, of the WTRU); and/or the set of RA-RNTIs.

[0155] For example, the first CE-RA-RNTI may be the first RNTI available after the last RA-RNTI. The first CE-RA-RNTI, *e.g.*, CE-RA-RNTI1, may be (11+10*f_id_max), where f_id_max may be the highest index PRACH in a subframe, *e.g.*, for legacy WTRUs. For example, for FDD, there may be one (*e.g.*, one legacy) PRACH in a subframe, so f_id_max may be 0. For TDD there may be up to six (*e.g.*, six legacy) PRACH configured by the eNB (*e.g.*, with indices 0-5), so f_id_max may be the number of PRACH configured minus 1.

[0156] A CE-RA-RNTI may be a function of the first CE-RA-RNTI, CE-RA-RNTI1, and the first subframe of the preamble transmission or the first PRACH transmission, *e.g.*, t_id where t_id may be an integer from 0 through 9. For example, CE-RA-RNTI may be CE-RA-RNTI1 + t_id.

[0157] CE-RA-RNTI may be CElevel x CE-RA-RNTI1 + t_id, where CElevel may be a value that may correspond to the coverage enhancement level (*e.g.*, a value of 0, 1, or 2 if there may be three coverage enhancement levels) of the WTRU for which the RAR may be intended. No coverage enhancement may or may not be considered a coverage enhancement level.

[0158] CE-RA-RNTI may be CElevel x (1 + t_id+10*f_id).

[0159] A DCI format may not be used for RAR. The PDSCH that may carry the RAR may indicate to the WTRU (*e.g.*, in the contents and/or one or more headers of the PDSCH) whether or not the RAR may include a response that may be intended (*e.g.*, at least intended) for the WTRU, for example, without the need for the WTRU to look for the preamble that it transmitted in the RAR.

[0160] The CRC of the PDSCH that may carry RAR may be scrambled with an RA-RNTI or CE-RA-RNTI or other indication that may correspond to the PRACH that may have been transmitted by a WTRU. The WTRU may discard PDSCH that may carry RAR if the RA-RNTI or CE-RA-RNTI or other indication with which its CRC may be scrambled may not match the one that may correspond to the PRACH transmission of the WTRU. The indication may be a function of one or more of the items described herein of which a CE-RA-RNTI may be a function.

[0161] An RAR may include an indication, such as an RA-RNTI or CE-RA-RNTI, that may assist the WTRU in determining if the RAR may include a response that may be intended for (*e.g.*, at least intended for) it. For example, the indication may be included in a fixed location in the RAR, such as in the MAC header or at the beginning of the RAR. The indication may be a function of one or more of the items described herein of which a CE-RA-RNTI may be a function.

[0162] The WTRU may use the indication to determine if an RAR may be intended (*e.g.*, at least intended) for it. If the WTRU may determine that the RAR may be intended (*e.g.*, at least intended) for it, the WTRU may look for an indication of the preamble that it may have transmitted in the RAR to find the response that may be intended for (*e.g.*, at least intended for) it. If the WTRU may determine that the RAR may not be intended for (*e.g.*, at least intended for) it, the WTRU may discard the RAR and/or may continue to look for an RAR that may include a response that may be intended for (*e.g.*, at least intended for) it.

[0163] A WTRU may monitor for PDSCH that may carry RAR that may be intended for (*e.g.*, at least intended for) the WTRU in a location and/or with one or more parameters that may be known or determined by the WTRU, for example, in accordance with one or more examples disclosed herein. If the WTRU may successfully receive and/or decode the PDSCH, the WTRU may determine whether (or that) the PDSCH may include an RAR and/or whether (or that) the PDSCH may include an RAR that may be intended for (*e.g.*, at least intended for) the WTRU and/or that may include a response (*e.g.*, at least a response) for the WTRU. The WTRU may make the determination based on at least one or more of: whether the RAR may include the

preamble or an indication of the preamble that the WTRU may have transmitted; whether the RAR may include a certain RA-RNTI or CE-RNTI or other indication that may indicate that the RAR may be intended for (or at least intended for) the WTRU. The WTRU may determine that the RAR may be intended for (or at least intended for) the WTRU if the RAR may include the preamble or an indication of the preamble that the WTRU may have transmitted, and/or if the RAR may include a certain RA-RNTI or CE-RNTI or other indication that may indicate that the RAR may be intended for (or at least intended for) the WTRU.

[0164] PRACH subframes may be provided and/or used. For coverage limited WTRUs, the WTRU may repeat the transmission of a preamble a number of times, such as 50 or 100. Given a set of PRACH resources in a (*e.g.*, each) subframe and the large number of repetitions, some rules for preamble selection may result in more collisions with, for example, preamble transmissions of other WTRUs, such as coverage limited or non-coverage limited WTRUs.

[0165] PRACH resources may be defined, for example, in a set of frames such as every frame or every other frame. Certain subframes in those frames may be designated as subframes for PRACH resources. A WTRU may transmit a PRACH preamble and/or may choose a PRACH preamble for transmission in a PRACH subframe.

[0166] A WTRU (*e.g.*, a coverage limited WTRU) may choose a preamble and a PRACH frequency resource, *e.g.*, from a set or pool of such preambles and frequency resources, in one subframe and may repeat that transmission in multiple subframes. If another WTRU may choose a preamble and PRACH frequency resource (*e.g.*, from the same set or pool) in one or more of the subframes in which the first WTRU may transmit its chosen preamble and frequency resource, the opportunities for collision may be increased by the number of repetitions.

[0167] The frames and/or subframes in which PRACH preamble transmission may start (*e.g.*, in which a WTRU may begin PRACH preamble transmission or send a first PRACH preamble transmission before repetitions) may be a reduced set (*e.g.*, a subset) of frames and/or subframes from the full set of frames and/or subframes in which PRACH preambles may be transmitted.

[0168] One or more frames and/or subframes may be designated, allocated, configured (*e.g.*, by an eNB such as by signaling, which may be dedicated or broadcast and/or system information signaling), and/or used as PRACH starting frames and/or subframes.

[0169] One or more PRACH starting frames and/or subframes may be defined, specified, configured (*e.g.*, by an eNB, such as by signaling, such as broadcast signaling and/or system information).

[0170] A starting frame and/or subframe may be a function of a system frame number (SFN).

[0171] A starting frame and/or subframe may be a function of at least one of a PRACH configuration index that may determine or identify one or more of the SFNs (*e.g.*, even or any) in which there may be PRACH resources (*e.g.*, PRACH SFNs), the subframes in each of the PRACH SFNs in which there may be PRACH resources, and/or the preamble format that may be used for transmission.

[0172] A starting frame and/or subframe may be a function of a CE level. A starting frame and/or subframe may be a function of the number of repetitions of the preamble, which may be a function of the CE level. A starting frame and/or subframe may be a function of a configured value (*e.g.*, signaled from the eNB), such as an offset, *e.g.*, a frame offset or subframe offset.

[0173] A starting frame and/or subframe may be a function of a FDD or TDD mode of operation and/or a TDD UL/DL configuration.

[0174] A PRACH starting frame may be a frame (*e.g.*, the first frame) in which a WTRU, such as a coverage limited WTRU, may transmit a certain PRACH preamble (or the first part of a certain PRACH preamble). The certain preamble may be the first preamble of a set of repeated preambles that the WTRU may transmit.

[0175] A PRACH starting subframe may be a subframe (*e.g.*, the first subframe) in which a WTRU such as a coverage limited WTRU, may transmit a PRACH preamble (or the first part of a PRACH preamble). The preamble may be the first preamble of a set of repeated preambles that the WTRU may transmit. A PRACH starting subframe may be in a PRACH starting frame. A PRACH starting subframe may be (or may be identified by) an offset (*e.g.*, in subframes) from the start (*e.g.*, subframe 0) of a PRACH starting frame.

[0176] For example, if a WTRU may (or may only) transmit a preamble beginning in subframe X1 and repeat that preamble in (or beginning in) subframes X2, X3, X4, … Xn, then X1 may be the PRACH starting subframe.

[0177] A WTRU, such as a coverage limited WTRU, may or may only transmit a preamble beginning in a starting PRACH subframe. The WTRU may repeat the preamble N times in (or beginning in) each of a certain N subframes which may be one or more of the next N subframes; the next N subframes that may be available or usable for PRACH transmission (*e.g.*, by the WTRU); the next N PRACH subframes; a designated, allocated, or configured set of N (*e.g.*, next N) subframes or PRACH subframes that may be based on the PRACH starting frame and/or subframe; and/or the same subframe as the starting subframe in one or more (*e.g.*, each) of the next N frames that may include PRACH resources.

[0178] PRACH subframes for CE mode may be the same or different from PRACH subframes for non CE mode use.

[0179] A WTRU that may transmit a preamble beginning in a certain starting PRACH frame and/or subframe, may repeat the preamble N times in (or beginning in) each of a certain N subframes, which may be the next N subframes or PRACH subframes that may be allocated, designated, or configured for the repetitions of a preamble that may have first been transmitted in the certain PRACH starting frame and/or subframe.

[0180] A WTRU, such as a coverage limited WTRU, may or may only select a PRACH resource from available PRACH resources (*e.g.*, preamble and/or frequency) in or for transmission in a PRACH starting frame and/or subframe. A frequency resource may be comprised of one or more RBs or PRBs. The WTRU may use the same resource (*e.g.*, preamble and/or frequency) for one or more (*e.g.*, each) of its (*e.g.*, subsequent N) repetitions of the preamble transmission. A WTRU may not (or may not be able or allowed) to choose a (*e.g.*, a new or another) PRACH resource in a subframe that may not be (or may not be considered to be) a PRACH starting frame and/or subframe. PRACH repetitions (*e.g.*, one or more repetitions) may have or may use different resources (*e.g.*, RBs or PRBs), for example, for frequency diversity. The resources that may be used for the repetitions may be identified (*e.g.*, explicitly), for example, by signaling or may be based on a pattern, such as a frequency hopping pattern.

[0181] A repetition rate of PRACH starting frames, *e,g.*, PFrep may be defined, allocated, or configured (*e.g.*, by an eNB such as by signaling such as dedicated or broadcast signaling and/or system information). A PFrep may be defined, allocated, or configured for CE mode and/or for one or more (*e.g.*, each) CE level, *e.g.*, PFrep(CE level). The PFrep(CE level) values may be the same or different. A PFrep(CE level) value may be a function of the CE level and/or the number repetitions (*e.g.*, preamble repetitions) that may be associated with the CE level.

[0182] PRACH starting frames, may satisfy the equation SFN mod (PFrep) = 0 or SFN mod (PFrep) = frame offset. PRACH starting frames for a CE level may satisfy the equation: SFN mod [PFrep (CE level)] = 0 or SFN mod [PFrep (CE level)] = frame offset.

[0183] PFrep may be a function of the number of repetitions of the PRACH that may be transmitted, for example, for a CE level. PFrep may be the next highest power of 2 from the number of repetitions of the PRACH that may be transmitted, for example for a CE level. For example, for a CE level that may use 50 repetitions, PFrep may be 64. PRrep may be a function of the number of PRACH resources (or available PRACH resources) in a subframe and/or which frames (*e.g.*, any or even) may include PRACH resources. If the number of repetitions may be a power of 2, PFrep may be the number of repetitions of the PRACH which may be transmitted.

[0184] Given a starting frame, starting subframes may be subframes (*e.g.*, certain subframes) within the starting frame and/or subframes (*e.g.*, certain subframes) offset from the start (*e.g.*,

subframe 0) of the starting frame. There may be multiple starting subframes associated with a starting frame. If there may be more than one starting subframe in or associated with a starting frame, a WTRU may choose one that may be designated or configured by the eNB (*e.g.*, for contention free RA) or may choose one randomly. If there may be multiple starting subframes to choose from in or associated with a starting frame, the PRACH resources in the multiple starting subframes may differ in some way such as by preamble(s) and/or frequency resources.

[0185] In an example, starting subframes may repeat every 64 frames and may be offset by 4 frames, *e.g.*, they may satisfy SFN mode 64 = 4. Available PRACH subframes in each frame may be subframes 1 and 3 (*e.g.*, according to a PRACH configuration). In frames that may satisfy SFN mode 64 = 4, a WTRU may select subframe 1 or 3 as a starting subframe, *e.g.*, randomly.

[0186] For a CE level with R repetitions (*e.g.*, preamble repetitions), PRACH starting subframes may be at least R subframes apart.

[0187] PRACH frames may be frames that may include PRACH resources. In an example, the number of repetitions (*e.g.*, preamble repetitions), for example for a CE level, may be R, PRACH frames may occur every F frames, and P subframes may be available per PRACH frame that may include PRACH. PRACH starting subframes, *e.g.*, for a CE level, may be based on or a function of at least one of R, F, and P. PRACH starting subframes may be at least CEIL [(R x F)/P] subframes apart. For example, for R = 100, P = 3, and F = 2, PRACH starting subframes may be at least CEIL [(R x F)/P] = CEIL [(100 x 2)/3] = 67 subframes apart. PRACH starting subframes may be apart by a function of CEIL [(R x F)/P]. For example, PRACH starting subframes may be apart by the next multiple of 10 subframes (*e.g.*, apart by the closest multiple of 10 greater than or equal to CEIL [(R x F)/P]) (*e.g.*, 70 subframes apart for R=100, P=3, and F=2). In another example, PRACH subframes may be apart by the next power of 2 subframes (e.g., apart by the closest power of 2 greater than or equal to CEIL [(R x F)/P]) (*e.g.*, 128 subframes apart for R=100, P=3, and F=2). In another example, PRACH subframes may be apart by the next multiple of a certain number of frames (e.g., apart by the closest multiple of the certain number greater than or equal to CEIL [(R x F)/P]). For example, the certain number of frames may be 4 frames or 40 ms and for R=100, P=3, and F=2, CEIL [(R x F)/P] = 67 and the PRACH subframes may be the next multiple of 40ms greater than 67 apart (*e.g.*, 80 ms apart).

[0188] A PRACH configuration index may indicate which frames and/or subframes may and/or may not include PRACH resources. One or more PRACH configuration indices may be provided for CE mode, *e.g.*, one may be provided for each CE level or one may be used for all

CE levels. The legacy PRACH configuration index may be used for CE mode or may be the default if a CE specific value may not be provided.

[0189] Certain preambles or sets of preambles may (*e.g.*, may only) be configured and/or used, *e.g.*, for PRACH transmission, in certain subframes or sets of subframes. Certain frequency resources or sets of frequency resources may (*e.g.*, may only) be configured and/or used, *e.g.*, for PRACH transmission, in certain subframes or sets of subframes. Allocations and/or usage such as these may enable or facilitate multiple starting subframes in the same frame.

[0190] RAR may be provided in reduced bandwidth, *e.g.*, for at least bandwidth limited WTRUs. For RAR that may be intended (or at least intended) for bandwidth limited WTRUs, if the PDSCH that may carry the RAR may be located in RBs, such as the center 6 RBs of the band, special handling may be used in some subframes, *e.g.*, subframes that may carry synchronization channels (*e.g.*, PSS and/or SSS) and/or a physical broadcast channel (PBCH).

[0191] In subframes that may carry PSS and/or SSS, transmission (*e.g.*, by the eNB) of a channel (*e.g.*, EPDCCH and/or PDSCH, for example, a PDSCH that may carry an RAR) that may be located in RBs that may include PSS and/or SSS, may not use the resource elements (REs) that may include the PSS and/or SSS signals. Not using certain REs may involve omitting transmitting in those REs. Not using certain REs may involve rate matching around those REs.

[0192] If the transmission of a channel (*e.g.*, a PDSCH that may carry RAR) may rate match around certain REs, such as REs that may include PSS and/or SSS, a WTRU that may receive or attempt to receive that channel may account for the rate matching in its reception and/or decoding of the channel.

[0193] Subframes that may carry PBCH may not be used for transmission and/or reception of PDSCH that may carry RAR for certain WTRUs, such as limited bandwidth WTRUs and/or coverage limited WTRUs. An eNB may not transmit RAR (and/or a repeated RAR) intended for a WTRU (*e.g.*, for a certain WTRU such as one that may be a limited bandwidth WTRU and/or a coverage limited WTRU) in a subframe that may carry PBCH. A WTRU (*e.g.*, one that may be bandwidth limited and/or coverage limited) may not monitor a subframe that may carry PBCH for EPDCCH. The RAR window size may exclude PBCH subframes from counting or consideration. A PBCH subframe may be a subframe that may not be used for RAR for at least some WTRUs, such as WTRUs that may be bandwidth limited and/or coverage limited.

[0194] An RAR message size may be reduced and/or limited in size (*e.g.*, compact RAR), for example, for RAR that may be intended for certain WTRUs such as bandwidth limited WTRUs and/or coverage limited WTRUs.

[0195] The size may be reduced by reducing or eliminating elements in the RAR that may relate to the UL grant for message 3 of the RA procedure.

[0196] A limited bandwidth WTRU and/or a coverage limited WTRU may or may only be able to transmit in (or within) a bandwidth that may include a certain RF bandwidth and/or a certain number of RBs. RA message 3, which may be in response to an RAR and/or which may include an RRC connection request message, may be or may need to be allocated resources and/or transmitted in (or within) that bandwidth (BW).

[0197] Since, for example, the possible locations for the transmission of message 3 may be limited (*e.g.*, to 6 RBs), one or more UL grant parameters may be reduced (*e.g.*, to fewer bits) or may be eliminated.

[0198] In an example, one or more UL resources may be predefined and/or configured. One or more of these UL resources may be dynamically selected (*e.g.*, by an index), *e.g.*, by the RAR, for use for UL transmission (*e.g.*, for message 3). This may enable reduction in the size of the UL grant. The WTRU may use this selected resource for UL transmission, *e.g.*, of message 3.

[0199] A WTRU may set its UL power, for example, after a random access (RA) procedure. WTRU transmit power for an UL channel, *e.g.*, a PUSCH, may include an open loop component and/or a closed loop component. The WTRU transmit power for the UL channel may be limited (*e.g.*, by the WTRU) to the WTRU maximum power, *e.g.*, the WTRU configured maximum output power. The open loop component may be at least a function of one or more of: the transmission bandwidth or number of resource blocks to be transmitted, pathloss, and/or one or more configured values. The closed loop component may be a function of transmit power control commands that may be received by the WTRU, *e.g.*, from an eNB. WTRU transmit power for an UL channel, *e.g.*, a PUSCH, may be or may also be a function of the power ramping performed by the WTRU during a random access (RA) procedure, such as an initial RA procedure (e.g., for RRC connection establishment) and/or a contention based RA procedure.

[0200] An example setting for WTRU transmit power for a UL channel, such as a PUSCH transmission, may be as follows for subframe i and serving cell c:

$$P_{PUSCH,c}(i) = min\begin{cases} P_{CMAX,c}(i), \\ 10\log_{10}\left(M_{PUSCH,c}(i)\right) + P_{O_PUSCH,c}(j) + \alpha_c(j)\cdot PL_c + \Delta_{TF,c}(i) + f_c(i) \end{cases}$$

and the value may be in dBm.

[0201] $P_{CMAX,c}$ may be the WTRU configured maximum output power. $M_{PUSCH,c}$ may be the number of resource blocks granted or allowed for the transmission. $P_{O_PUSCH,c}$ may be a configured value or a sum of configured values. α may be a configured value. PL may be the pathloss. $\Delta_{TF,c}$ may be an adjustment factor that may relate to the use of MIMO or the use of one

or more antennas. f_c may be a correction value, *e.g.*, a sum of a starting correction value, $f_c(0)$ and one or more other correction values that may correspond to transmit power control (TPC) commands that the WTRU may receive or may have received, *e.g.*, from an eNB. The starting correction value may be a function of an RA procedure power ramping. Inclusion of the effects of power ramping in the correction value that accumulates TPC commands may be by way of illustration and not limitation. The impact of RA power ramping on the power setting may be separate from the TPC commands. Adjustment for TPC commands may be omitted from the power setting.

[0202] If a WTRU does not perform power ramping during the RA procedure, *e.g.*, if the WTRU may transmit at maximum power or may always transmit at maximum power, *e.g.*, $P_{CMAX,c}$ for the PRACH power, the value to use for $f_c(0)$ and/or the initial power for an UL channel, such as PUSCH, may be undefined. An UL transmission may be or may include one or more of a PUSCH, PUCCH, and SRS. PUSCH may be a non-limiting example of an UL channel or transmission. Another UL channel or transmission, such as PUCCH or SRS, may be used consistently with the subject matter disclosed herein.

[0203] A random access response (RAR) may include one or more parameters that the WTRU may use to determine the value of $f_c(0)$ and/or its UL power setting for one or more channels, *e.g.*, for PUSCH. A UL transmission, *e.g.*, the first UL transmission, that a WTRU may make, *e.g.*, on a PUSCH, following PRACH preamble transmission may be message 3 of the RA procedure, which may be or may include an RRC connection (*e.g.*, RRC connection establishment) request. An RAR, *e.g.*, the RAR in which the WTRU may receive the grant for resources for message 3, may include an indication of an initial power to use for the PUSCH transmission. The RAR may include one or more parameters from which the initial power to use for the PUSCH transmission may be determined. The RAR may include the starting correction value $f_c(0)$ for the PUSCH transmission. The RAR may include a coverage enhancement (CE) level for PUSCH and/or one or more other subsequent UL and/or DL transmissions for the WTRU. The RAR may include a number of repetitions or a value or index that corresponds to a number of repetitions to use for PUSCH and/or one or more other subsequent UL and/or DL transmissions for the WTRU. The RAR may include a power offset or delta, *e.g.*, to subtract from the maximum power to determine the PUSCH power.

[0204] A WTRU may determine its UL power and/or UL repetitions, *e.g.*, PUSCH power and/or PUSCH repetitions, according to one or more of the parameters or values included in the RAR and may transmit according to the determined power and/or repetitions.

[0205] For example, the WTRU may determine its initial and/or subsequent PUSCH power based on a starting correction value $f_c(0)$ or a power offset that may be included in the RAR and may transmit PUSCH using the determined power.

[0206] The WTRU may determine UL power, for example, according to:

$$P_{PUSCH,c(i)} = min\left[P_{CMAX,c}(i), openlooppower(i) + f_c(i)\right]$$

[0207] The WTRU may use a value of $f_c(0)$ that it may have received in the RAR. The open loop power may be a function of the CE level, which may correspond to the CE level of the RA procedure for which the WTRU successfully received an RAR or the CE level that the WTRU received in the RAR. The open loop power may be a function of the number of PRACH repetitions for which the WTRU successfully received an RAR or the number of repetitions that the WTRU received in the RAR. A closed loop component may not be present, *e.g.*, $f_c(i)$ may be 0 or nonexistent for $i > 0$ or $i >= 0$. The closed loop component, if present, may be a function of the CE level or repetitions that may be updated, *e.g.*, dynamically.

[0208] The WTRU may transmit or may always transmit PUSCH at maximum power, *e.g.*, $P_{CMAX,c}$ or $P_{CMAX,c(i)}$. The WTRU may use a number of repetitions or a CE level that may be provided in the RAR for transmission of a channel such as PUSCH, for example, to account or compensate for the use of maximum power when the repetitions are combined at the receiver. For example, the open loop and/or closed loop part of the power control calculation may be a function of the CE level or the number of repetitions for the transmission of the UL channel, which may be included or indicated in the RAR.

[0209] The WTRU may set its PUSCH power (*e.g.*, initial PUSCH power) according to an initial value included in the RAR. The WTRU may reduce its power from maximum by at least a delta or offset provided in the RAR. The WTRU may determine UL power according to, for example:

$$P_{PUSCH,c}(i) = \min[P_{CMAX,c}(i), PUSCH_{initial} + closedlooppower(i)]$$

or

$$P_{PUSCH,c}(i) = \min[P_{CMAX,c}(i), P_{CMAX,c}(i) - \Delta + closedlooppower(i)]$$

[0210] There may be no closed loop component, *e.g.*, closedlooppower(i) may be 0. The initial closed loop value may be zero or the delta may be included in the closed loop value. The closed loop component may be a function of TPC commands, *e.g.*, accumulated TPC commands. The closed loop component may be a function of CE level or repetitions that may be the CE level or repetitions used for the RA procedure (*e.g.*, the successful RA procedure) and/or the CE level

or repetitions included in the RAR. The closed loop component and/or the CE level or repetitions that may impact the closed loop component may be updated, *e.g.*, dynamically.

[0211] One or more values not indicated as a function of subframe or TTI, *e.g.*, i, may be a function of subframe or TTI and may be consistent with the subject matter disclosed herein. For example, $P_{CMAX,c}$ and $P_{CMAX,c}(i)$ may be used interchangeably.

[0212] One or more values indicated as a function of subframe or TTI, *e.g.*, i, may not be a function of subframe or TTI and may be consistent with the subject matter disclosed herein.

[0213] The initial PUSCH power setting may be $P_{CMAX,c}$. The WTRU may determine the initial closed loop value or adjustment value, *e.g.*, $f_c(0)$, to be the value that may make the PUSCH value equal to $P_{CMAX,c}$.

[0214] For example, $P_{PUSCH,c}(i)$ may be determined by:

$$P_{PUSCH,c}(i) = openlooppower(i) + f_C(i)$$

or

$$P_{PUSCH,c}(i) = \min[P_{CMAX,c}(i), openlooppower(i) + f_c(i)]$$

[0215] The WTRU may determine (*e.g.*, may first determine) the initial PUSCH power based on no power ramp-up, *e.g.*, $P_{PUSCH\text{-}noramp}$. $P_{PUSCH\text{-}noramp}$ may be the value of openlooppower(0). The value of openlooppower(0) may be or may be set to $P_{PUSCH\text{-}noramp}$.. The WTRU may determine $f_c(0)$ according to the following: $f_c(0) = \max(0, P_{CMAX,c} - P_{PUSCH-noramp})$.

[0216] With this starting value of f_c, the starting value of the PUSCH power may be $P_{CMAX,c}$. The value of f_c may be adjusted by TPC commands and/or adjustments to CE level or repetitions. The value of $f_c(0)$ may be adjusted or may also be adjusted by a parameter provided in the RAR, such as a TPC command indicated in the RAR, *e.g.*, delta_msg2. $P_{PUSCH\text{-}noramp}$ may include the effects of a TPC command indicated in the RAR.

[0217] $f_c(0)$ may be determined according to the following:

$$f_c(0) = delta\ P_{rampup,c} + delta_msg2, c$$

where delta_msg2,c may be a TPC command indicated in the RAR.

[0218] The value of delta $P_{rampup,c}$ may be determined according to:

$$\begin{aligned} delta\ P_{rampup,c} \\ &= \max[0, P_{CMAX,c} - (10 \\ &\cdot log_{10}\left(M_{PUSCH,c}(0) + P0_{PUSCH,c}(2) + delta_{msg2}, c + alpha, c(2) \cdot PL\right. \\ &\left. + deltaTF, c(0) + CL\right)] \end{aligned}$$

where $M_{PUSCH,c}(0)$ may be the bandwidth of the PUSCH resource assignment expressed as a number of resource blocks valid for the subframe of the first PUSCH transmission in the serving cell c, and deltaTF,c(0) may be a power adjustment of first PUSCH transmission in the serving cell c. $P0_{PUSCH,c}(2)$ may equal the initial preamble power, *e.g.*, preambleInitialReceivedTargetPower, which may be configured by higher layers plus a message3 delta power value that may be configured by higher layers. CL may be an adjustment to compensate for the CE level or the number of repetitions for the PUSCH transmission, which may be included or indicated in the RAR. One or more of the elements of the above equation may be 0 or not included. The message3 delta power may be 0 or not exist.

[0219] The equation above may (*e.g.*, in effect) correspond to a delta $P_{rampup,c}$ value that may result in the initial power being maximum power. $f_c(0)$ and/or delta $P_{rampup,c}$ may be zero.

[0220] The WTRU may use the CE level and/or number of repetitions that it uses for the successful PRACH preamble transmission or transmissions, *e.g.*, the CE level and/or number of repetitions for which the WTRU successfully receives an RAR, as the CE level and/or number of repetitions for a PUSCH transmission, *e.g.*, the first PUSCH transmission, which may correspond to message 3 of the RA procedure.

[0221] A transmission power, such as an initial power, may be associated with a CE level or number of repetitions. This transmission power may be configured, for example, by signaling such as broadcast or higher layer signaling. The WTRU may set the PUSCH power (*e.g.*, the initial PUSCH power or message 3 PUSCH power) to this value and/or may set the PUSCH using or at this power. The power may be a minimum power for a CE level.

[0222] A CE level or number of repetitions may be updated. UL grants and/or TPC commands may include adjustments that may be applied to future UL transmissions and/or to future UL transmit power determinations. For example, an UL grant or TPC command may include a CE level or number of repetitions to use for an upcoming UL transmission. The WTRU may transmit, *e.g.*, may always transmit, the PUSCH at maximum power or may adjust the transmit power based on an open loop component and/or a closed loop component. The WTRU may transmit the PUSCH with a number of repetitions that may be provided with or separately from an UL grant or a TPC command. The WTRU may transmit the PUSCH with a number of repetitions that may correspond to a CE level that may be provided with or separately from an UL grant or a TPC command.

[0223] If the grant or TPC command corresponds to an UL transmission in subframe X or an UL transmission that may begin in subframe X, the WTRU may use the indicated CE level, repetitions, or power adjustment (*e.g.*, to increase or decrease the power) for the UL transmission

in subframe X or for the UL transmission that may begin in subframe X. The TPC command or UL grant may be repeated (*e.g.*, by the eNB) and/or received (*e.g.*, by the WTRU) in a set of subframes that may correspond to UL transmission by the WTRU in subframe X or to UL transmission that may begin in subframe X.

[0224] PUSCH power may be ramped. For example, the WTRU may ramp its PUSCH power if it has not received an ACK from the eNB for a number of PUSCH transmissions. This number may be configured, for example, by the eNB. The WTRU may increase its power by a certain delta value based on a number of unsuccessful transmissions, which may be determined based on the lack of receipt of ACK for the transmissions. The delta value may be configured, for example, by the eNB. The number of unsuccessful transmissions and/or the delta value may be a function of the CE level and/or the number of repetitions. The power may be increased for one or more retransmissions, *e.g.*, each of the retransmissions. The transmission power may not be increased above the maximum power. Increases to the power may be stopped when the maximum power is reached or when an increase would cause the power to exceed the maximum power.

[0225] One or more of the examples disclosed herein for an UL channel or transmission may be applicable to a downlink (DL) channel or transmission. For example, the examples disclosed herein in the context of UL grants may be applicable to DL grants, consistent with the subject matter disclosed herein. For example, a CE level or a number of repetitions to use for PDSCH reception or PUCCH transmission may be included in a DL grant.

[0226] Successful reception of an RAR may be or may include reception of an RAR that may be intended for the WTRU. Transmission of a PRACH or preamble may include transmission of repetitions of a PRACH or preamble. For purposes of illustration and description, PRACH and preamble may be used interchangeably.

[0227] A random access (RA) or RA procedure may be requested or initiated, for example, by a PDCCH order. For example, a WTRU may receive a request or indication, *e.g.*, from an eNB, to perform or initiate an RA or RA procedure. The request or indication may be or may be included in a PDCCH order that may be transmitted in a PDCCH region, for example, in a downlink control information (DCI). A WTRU, such as a low cost or reduced capability WTRU, may not be able to receive a PDCCH in a PDCCH region, *e.g.*, due to a limited capability (*e.g.*, reduced bandwidth and/or limited coverage). PDCCH order in a PDCCH region may not be supported for or by some WTRUs, such as low cost or reduced capability WTRUs or WTRUs that may not be able to receive a PDCCH in a PDCCH region.

[0228] PDCCH order is disclosed by way of example only and not limitation. Another request to perform or initiate an RA or RA procedure may be used and may still be consistent with this disclosure. For example, an RA request may be substituted for a PDCCH order and may still be consistent with this disclosure.

[0229] PDCCH order, M-PDCCH carrying PDCCH order, a DCI that may request or initiate contention-free (or contention-based) RA, a DCI carrying one or more PDCCH orders, and a DCI that may request or initiate RA may be used interchangeably herein.

[0230] CE level, number of repetitions, and repetition number may be substituted for each other and may still be consistent with this disclosure.

[0231] An RA procedure may be initiated on an individual basis or on a group basis. A DCI or PDCCH order or RA request that may indicate (or initiate) an RA, *e.g.*, a contention-free or contention-based RA, may be transmitted via an M-PDCCH. An M-PDCCH may be a downlink control channel that may be monitored and/or received by a WTRU, such as a low cost or reduced capability WTRU.

[0232] For purposes of description and explanation, RA may be replaced with RA procedure, and *vice versa*, and may still be consistent with the examples disclosed herein.

[0233] A DCI, such as a group DCI, may be used to initiate RA for one or more WTRUs. A DCI may include one or more PDCCH orders that may request or initiate an RA or RA procedure for one or more WTRUs. A PDCCH order may be associated with a WTRU. A PDCCH order may be associated with multiple WTRUs. If a PDCCH order requests or initiates RA, WTRUs associated with that PDCCH order (*e.g.*, WTRUs that receive that PDCCH order) may transmit a PRACH preamble, *e.g.*, a selected or assigned PRACH preamble. The assigned PRACH preamble may be configured, *e.g.*, by the eNB, such as by higher layer signaling. For example, a WTRU may be configured with a PRACH preamble for a contention-free RA via higher layer signaling. The PRACH preamble configured via higher layer signaling may be considered as a WTRU-specific PRACH preamble for contention-free RA. The assigned PRACH preamble may be indicated in or with the PDCCH order. A separate PRACH preamble may be indicated for a WTRU (*e.g.*, each WTRU) for which the PDCCH order is intended (or may be intended).

[0234] A PDCCH order may be used to initiate random access for multiple WTRUs, *e.g.*, individually. An eNB may indicate the random access initiation for a WTRU in a WTRU group that may monitor the same PDCCH order. For example, a bit field may include N bits that may be associated with N WTRUs, *e.g.*, in a group. A bit (*e.g.*, each bit) may indicate random access (e.g., a request to initiate random access) or not (*e.g.*, 0 for no initiation of RA, 1 for initiation of

RA). A WTRU (*e.g.*, each WTRU) may be indicated or configured with a bit location (*e.g.*, in the bit field) associated with or in the PDCCH order. A PRACH preamble for the PDCCH order may be configured via higher layer signaling for a WTRU (*e.g.*, each WTRU). A PRACH preamble index corresponding to each bit in the bit field for RA initiation may be transmitted in the PDCCH order.

[0235] Two or more PDCCH orders may be transmitted in a DCI. A (*e.g.*, each) PDCCH order may be associated with a WTRU.

[0236] A DCI or PDCCH may include information for initiating an RA procedure for one or more WTRUs. At least some of the information may be included separately for a WTRU (*e.g.*, each WTRU) for which the PDCCH order may be intended. At least some of the information may be common to one or more WTRUs (*e.g.*, all of the WTRUs) for which the PDCCH order may be intended.

[0237] A DCI or PDCCH order that may initiate an RA procedure may include a PRACH preamble index. A DCI or PDCCH order that may initiate an RA procedure may include a PRACH mask index and/or time resources for the PRACH transmission. A DCI or PDCCH order that may initiate an RA procedure may include a CE level and/or repetition number. A DCI or PDCCH order that may initiate an RA procedure may include a transmission (e.g., power) level and/or power level type (*e.g.*, maximum power or based on DL measurement). A DCI or PDCCH order that may initiate an RA procedure may include frequency resources (*e.g.*, a set of PRBs) for the PRACH transmission.. A DCI or PDCCH order that may initiate an RA procedure may include an on/off indicator (*e.g.*, on to initiate RA, or off for no initiation of RA)..

[0238] A DCI that may carry one or more PDCCH orders may be scrambled with an RNTI, *e.g.*, its CRC may be scrambled with an RNTI. A WTRU may be configured with and/or use one or more RNTIs, such as a WTRU-specific RNTI (*e.g.*, a C-RNTI). The WTRU may use the one or more RNTIs to determine whether a DCI is intended for it.

[0239] An RNTI may be used for the DCI carrying one or more PDCCH orders. The RNTI may be WTRU-specific. The RNTI may be a group RNTI or a common RNTI, such as one that may be used by multiple WTRUs. The RNTI may be referred to as a PDCCH order RNTI. The RNTI may or may not be specific to DCIs carrying one or more PDCCH orders.

[0240] For a WTRU, the PDCCH order RNTI may be the WTRU's C-RNTI. A PDCCH order may be transmitted in a WTRU-specific DCI, which may use C-RNTI.

[0241] The PDCCH order RNTI may be or may be determined as a function of at least one of a WTRU-ID (*e.g.*, C-RNTI), a CE level, and/or a PRACH preamble index. One or more of a C-RNTI, a CE level, and/or a PRACH preamble index may be configured via higher layers.

[0242] The PDCCH order RNTI may be or may be determined as a function of the PRACH preamble and/or resource that may be used for a contention-based RA procedure. For example, the PDCCH order RNTI may be a function of a recent (*e.g.*, the most recent) PRACH preamble and/or PRACH resource that the WTRU used (*e.g.*, successfully) for RRC connection establishment. The PDCCH order RNTI may be a function of a recent (*e.g.*, the most recent) PRACH preamble and/or PRACH resource that the WTRU used (*e.g.*, successfully) for a PDCCH-initiated RA procedure (*e.g.*, a contention-based RA procedure).

[0243] The PDCCH order RNTI may be or may be determined as a function of the time and/or frequency location of the RAR associated with a recent (*e.g.*, the most recent) PRACH preamble and/or PRACH resource that the WTRU used (*e.g.*, successfully) for a contention-based RA procedure (*e.g.*, for RRC connection establishment or PDCCH order initiated). The PDCCH order RNTI may be indicated via higher layers.

[0244] The time and/or frequency location in which a WTRU may monitor PDCCH order may be determined as a function of the PDCCH order RNTI.

[0245] An indication may be used to determine whether a DCI is intended to be used for the scheduling of unicast traffic (*e.g.*, PUSCH/PDSCH) or whether the DCI is intended to be used for a PDCCH order. The indication may be a bit field in the DCI. The indication may be based on the RNTI used for the DCI. A combination of two or more bit field conditions may be used as an indication. The search space of M-PDCCH may be used as an indication.

[0246] A WTRU may transmit PRACH in response to RA procedure initiation, for example, by PDCCH order.

[0247] A WTRU may monitor a search space such as M-PDCCH search space for DCI scrambled (*e.g.*, for DCI with CRC scrambled) with PDCCH order RNTI. A WTRU may receive and/or successfully decode DCI scrambled with PDCCH order RNTI.

[0248] A DCI scrambled with an RNTI may be the same as or may be used to represent a DCI with a CRC scrambled with an RNTI.

[0249] Upon receipt or in response to receipt of the DCI, the WTRU may initiate a RA or RA procedure.

[0250] The WTRU may transmit a PRACH based on information included in the PDCCH order carried by the DCI and/or configured information.

[0251] The WTRU may determine, for example from this information, one or more of (i) the PRACH preamble, (ii) the CE level and/or number of repetitions to use for the preamble transmission and/or the RA procedure, and/or (iii) the time and/or frequency resources for the preamble transmission.

[0252] The WTRU may transmit the determined preamble in the determined time and/or frequency resources with the determined CE level or number of repetitions. For example, the WTRU may transmit the PRACH (or preamble) with or using the CE level or number of repetitions indicated in or by the PDCCH order. The WTRU may transmit the PRACH (or preamble) with or using the CE level or number of repetitions configured via higher layer signaling, for example for contention-free or PDCCH order initiated RA.

[0253] The WTRU may transmit the PRACH (or preamble) with or using its current CE level, which may be the CE level of a recent (*e.g.*, its most recent) successful RA procedure.

[0254] The WTRU may transmit the PRACH (or preamble) with or using the CE level or number of repetitions corresponding to (or determined from or according to) the CE level or number of repetitions of a previous (*e.g.*, previous successful) RA procedure. The previous RA procedure may be a most recent (*e.g.*, most recent successful) contention-based (or contention-free) RA procedure. The previous RA procedure may be the most recent (*e.g.*, most recent successful) contention-based (or contention-free) RA procedure for RRC connection establishment or that was initiated by PDCCH order.

[0255] A successful RA procedure may be one for which the WTRU successfully received an RAR (*e.g.*, successfully received an RAR which it determined was intended for it).

[0256] The CE level that the WTRU may use for the PDCCH order indicated RA procedure may be determined, *e.g.*, by the WTRU, based on a prior RA (*e.g.*, a prior contention-based RA). For example, the CE level may be determined based on the PRACH resource associated with the latest (*e.g.*, most recent) RAR the WTRU received successfully.

[0257] The WTRU may transmit a preamble indicated in the PDCCH order. The WTRU may transmit a preamble configured by higher layers for contention-free or PDCCH order requested RA.

[0258] The WTRU may transmit the PRACH with the power level or type (*e.g.*, maximum power or based on DL measurement) indicated in or by the PDCCH order. The WTRU may transmit the PRACH with the power level or type configured by higher layers. If measurement based power is used, the WTRU may ramp the power and try again if an RAR is not successfully received.

[0259] The WTRU may transmit the PRACH in time and/or frequency resources according to the PRACH mask index indicated in or by the PDCCH order and/or a PRACH mask index configured by higher layers.

[0260] The WTRU may transmit the PRACH in time and/or frequency resources (*e.g.*, PRBs) indicated in or by the PDCCH order.

[0261] The WTRU may transmit the PRACH in time and/or frequency resources configured by higher layers for RACH or contention-free RACH, for example, for the CE level the WTRU may be using for the PRACH transmission.

[0262] A PDCCH order indicated or initiated RA or RA procedure may be an RA or RA procedure indicated, requested, and/or initiated by a DCI and/or PDCCH order, *e.g.*, by an eNB.

[0263] The CE level (or number of repetitions) that the WTRU may use for the PDCCH order indicated RA procedure may be or may be based on the CE level (or number of repetitions) used for the M-PDCCH carrying the PDCCH order. For example, the CE level (or number of repetitions) may be based on (*e.g.*, equal to) the number of repetitions used for M-PDCCH. The CE level (or number of repetitions) may be based on the number of total aggregation levels used for M-PDCCH, which may be referred to as the number of (E)CCEs used over subframes for repetitions.

[0264] If the WTRU does not successfully receive an RAR in response to a preamble it transmitted, the WTRU may try again, for example, until an RAR is successfully received or the maximum number of tries has been reached or exceeded.

[0265] The WTRU may use the same CE level for one or more (*e.g.*, all) preamble transmission attempts, for example for PDCCH order initiated RA. The WTRU may try different CE levels (*e.g.*, successively higher CE levels) and the starting CE level for the RA procedure may be or may be based on the CE level used for the M-PDCCH carrying the PDCCH order.

[0266] Starting CE level and CE level may be substituted for each other and still be consistent with this disclosure.

[0267] Techniques for handling DCI formats, *e.g.*, carrying PDCCH order, with coverage enhancement may be provided and/or used.

[0268] A PDCCH order (*e.g.*, a DCI carrying one or more PDCCH orders) may be transmitted repetitively. For example, a PDCCH order may be transmitted Nrep times (*e.g.*, in or in each of Nrep subframes or TTIs), where Nrep may be the number of repetitions. Nrep may be determined based on the CE level of the WTRU or WTRUs for which the PDCCH order or orders are intended. For example, Nrep may correspond to the CE level of the WTRU (*e.g.*, among the WTRUs for which the PDCCH order or orders may be intended) needing the most coverage enhancement. Nrep may be determined as a function of a group RNTI used for the DCI carrying one or more PDCCH orders. Nrep may be a value configured or provided by high layers and may be specific to a DCI carrying PDCCH order or may be common with the repetition number for other DCIs such as all DCIs

[0269] One or more (*e.g.*, all) DCI formats may have a repetition number, *e.g.*, a number of repetitions, associated with it or them. The repetition number may be configured, for example, in a WTRU-specific manner or cell-specific manner (*e.g.*, broadcast such as in system information). A WTRU may use a DCI format's repetition number (*e.g.*, configured repetition number) to receive or attempt to receive and/or decode that DCI format, for example, regardless of a CE level being used by a WTRU for other purposes, *e.g.*, for data transmission and/or reception. DCI and DCI format may be substituted for each other and still be consistent with this disclosure.

[0270] The number of repetitions of a DCI format may be a function of the maximum number of bits the DCI format may carry.

[0271] The number of repetitions of a DCI format may be a function of the maximum CE level supported by the eNB or cell that may transmit the DCI format.

[0272] The number of repetitions of a DCI format may be a function of the maximum CE level supported for the DCI format by the eNB or cell that may transmit the DCI format.

[0273] CE level use and/or support may be different for different DCI formats, *e.g.*, for an eNB or cell. Maximum CE level use and/or support may be different for different DCI formats, *e.g.*, for an eNB or cell.

[0274] If a WTRU receives a PDCCH order with repetitions and the last (or first) subframe of the repetitions is subframe n, the WTRU may transmit a PRACH preamble in the first PRACH resource (or the first PRACH resource available for the indicated PRACH preamble transmission) in subframe n+k3 or later where k3 may be at least one of following: (i) a fixed positive integer number such as 6, (ii) a positive integer number determined as a function of a CE level (or Nrep) such as the number of repetitions plus a fixed integer, and/or (iii) a configured number provided via higher layer signaling.

[0275] For a PDCCH order transmitted with Nrep repetitions, the WTRU may successfully receive the PDCCH order using fewer than Nrep repetitions, *e.g.*, Nue repetitions. The reference subframe n for determining the start of the preamble transmission may be the last subframe (or a subframe relative to the last subframe) of the Nrep repetitions or the Nue repetitions.

[0276] A PDCCH order to initiate a RA procedure may (or may only) be supported in a subset of CE levels. A WTRU and/or eNB may support two or more CE levels which may include normal coverage (*e.g.*, CE level-0) and one or more enhanced coverage levels (*e.g.*, CE level-1, 2, 3), for example for data transmission and reception. PDCCH order may (or may only) be used for a subset of the CE levels. For exemplary purposes, lower number CE levels may correspond to lower coverage enhancement, *e.g.*, fewer repetitions.

[0277] The PDCCH order may (or may only) be used for and/or by a WTRU in a normal coverage (*e.g.*, CE level-0). The PDCCH order may (or may only) be used for and/or by a WTRU in a normal coverage without bandwidth limitation.

[0278] The PDCCH order, *e.g.*, to initiate RA procedure, may be used for or by a WTRU in some coverage enhancement levels, but not in other coverage enhancement levels.

[0279] For example, the PDCCH order may be used for a WTRU in a low coverage enhancement level (*e.g.*, CE level-1 or CE level-1 and CE level-2). PDCCH order may not be used if a WTRU is in a high coverage enhancement level (*e.g.*, CE level-3 or CE level-2 and CE level-3). A WTRU in a low coverage enhancement level may monitor for and/or respond to a PDCCH order. A WTRU in a high coverage enhancement level may not monitor for and/or respond to a PDCCH order. Low coverage enhancement may be substituted for high coverage enhancement and vice versa and still be consistent with this disclosure.

[0280] The CE level or levels supported (*e.g.*, by the eNB and/or WTRU) for PDCCH order may be predefined, configured, or known. For example, configuration of the CE level, CE levels, or highest CE level supported by the eNB and/or expected to be supported by a WTRU for PDCCH order may be provided via higher layer signaling (*e.g.*, by the eNB) such as via system information, which may be broadcast. A WTRU may monitor for and/or respond to a PDCCH order while in or using a CE level supported or expected to be supported for PDCCH order. A WTRU may not monitor for and/or respond to a PDCCH order while in or using a CE level not supported or expected to be supported for PDCCH order.

[0281] The limit of PDCCH order to a subset of CE levels may be (or may only be) for PDCCH order which initiates contention-free RA. PDCCH order which initiates contention-based RA may be applicable at a larger set of (*e.g.*, all) CE levels supported, *e.g.*, by the eNB.

[0282] If a WTRU receives a PDCCH order indicating a contention-free RA procedure at a CE level not supported (*e.g.*, by the eNB or the WTRU) for contention-free RA, the WTRU may initiate a contention-based RA procedure.

[0283] A RA procedure may be used for CE level change.

[0284] An indication may be transmitted to initiate a RA procedure, which may be a contention-based or contention-free RA procedure. The indication may be transmitted in a PDCCH order. The PDCCH order may be used to change the CE level of the WTRU (*e.g.*, to a level such as a lower level which may need or use fewer repetitions or to a higher level which may need or use more repetitions).

[0285] In an example, a WTRU may receive a PDCCH order that may initiate a contention-based (or contention-free) RA procedure. In response, the WTRU may perform a contention-based (or contention-free) RA procedure.

[0286] The WTRU may perform the same (or a similar) RA procedure as for RRC connection establishment, *e.g.*, for initial access.

[0287] The WTRU may perform the same (or a similar) RA procedure as for RRC connection establishment, *e.g.*, for initial access, except for one or more aspects such as the starting CE level determination.

[0288] The starting CE level for a RA procedure (*e.g.*, a contention-based RA procedure) that may be initiated by a PDCCH order may be indicated in the PDCCH order.

[0289] The WTRU may begin with a starting CE level, and may transmit a preamble using that level (*e.g.*, with the repetitions corresponding to that level). If the WTRU does not successfully receive an RAR, the WTRU may try again using a higher (*e.g.*, next higher) CE level. The WTRU may try at each successively higher CE level until an RAR is successfully received or the RA procedure has failed at the highest CE level supported by the cell and/or the WTRU. Multiple tries at each level may be performed before going to the next higher level. Tries at the same level may be at increasingly higher power.

[0290] For the starting CE level, the WTRU may use the starting CE level provided in the PDCCH order or choose one autonomously, such as based on a DL measurement (*e.g.*, RSRP).

[0291] The WTRU may begin with a starting CE level corresponding to normal mode or to no coverage enhancement, for example based on an indication to do so included in the PDCCH order (*e.g.*, CE level or starting CE level set to a certain value such as 0) or a characteristic of the PDCCH order, such as the DCI format used or the RNTI used. A WTRU may begin with a starting CE level corresponding to normal mode or to no coverage enhancement for a contention-based RA initiated by PDCCH order, for example, always.

[0292] Normal coverage that, for example, may not use techniques such as repetition to enhance coverage, may be considered a CE level such as CE level-0.

[0293] A PDCCH order which may be used in initiate a RA procedure may include at least one of the following information: (i) a CE level or starting CE level, (ii) a PRACH preamble index, (iii) a PRACH preamble group index (*e.g.*, that may select a preconfigured group of preambles provided by higher layer signaling), (iv) a timing advance, (v) time and/or frequency resources (*e.g.*, subframes and/or PRBs) for the preamble transmission, and/or (vi) an indication of a group (*e.g.*, a group configured by higher layer signaling) of time and/or frequency resources (*e.g.*, subframes and/or PRBs) for the preamble transmission.

[0294] For contention-based RA, the PRACH preamble index may be a fixed known value, such as 0 or all zeros. This value may indicate to the WTRU that contention-based RA is requested or is to be performed. The value may indicate that the WTRU should choose the preamble.

[0295] The WTRU may choose the preamble to use from a set of preambles available for the CE level that the WTRU will use for the preamble transmission, for example, for contention-based RA.

[0296] A preamble or preamble group may be indicated in the PDCCH order. The WTRU may use the indicated preamble or select a preamble from the indicated group (*e.g.*, randomly), for example for contention-free RA.

[0297] The WTRU may choose time and/or frequency resources for the preamble transmission based on the time and/or frequency resources available for and/or corresponding to the CE level the WTRU will use for the preamble transmission. Correspondence may be configured and/or indicated in higher layer signaling. The WTRU may use resources indicated in the PDCCH order or select from a group of resources indicated in the PDCCH order.

[0298] After one or more attempts transmitting a preamble (*e.g.*, with repetitions for the CE level of the attempt), the WTRU may successfully receive an RAR. The WTRU may change the preamble for each attempt, for example, if one specific preamble was not indicated in the PDCCH order.

[0299] The WTRU may receive an UL grant, *e.g.*, in the RAR, to transmit a message to the eNB. The WTRU may send a message on the granted resources (*e.g.*, on a PUSCH). The message may indicate that the WTRU successfully received the RAR. The message may be used to perform contention resolution, *e.g.*, for a contention-based RA. For initial access, this message may be or may be referred to as msg3, which may be or include an RRC connection establishment request. For RA initiated by a PDCCH order, the WTRU may already be connected.

[0300] The WTRU may send a message or indication, *e.g.*, on the granted resources, which may indicate a successful RA procedure, RA procedure complete, successful reception of the RAR and/or other information which may indicate to the eNB (or may be interpreted by the eNB) that the RA procedure (*e.g.*, at least through RAR reception by the WTRU) was successful or completed. RA procedure msg3 or a modified version of msg3 may be used, for example, with a new establishment cause. A new message may be used. Message and msg may be used interchangeably.

[0301] The resources the WTRU may use for the PRACH transmission may be unique to a CE level and/or the eNB may be aware or informed that the RA procedure was successful. The eNB may know, *e.g.*, based on the PRACH resource used by the WTRU and/or the success of the RA procedure, what CE level the WTRU used or needed for achieving the successful RA procedure.

[0302] The CE level for the successful RA procedure (*e.g.*, the new CE level) may be lower (or higher) than the one the WTRU was using prior to the RA procedure.

[0303] The WTRU may change its current CE level to the CE level corresponding to the successful RA procedure (*e.g.*, the new CE level). The new CE level may correspond to normal coverage.

[0304] The WTRU may apply the timing advance included in the PDCCH order, for example, when or beginning when transmitting the UL message following successful reception of the RAR, *e.g.*, the UL message for which resources were granted in the RAR.

[0305] The WTRU may continue to use its current CE level until it completes the RA procedure. If the RA procedure results in a change of CE level, the WTRU may begin to use the new CE level when it completes the RA procedure.

[0306] Completion of the RA procedure may correspond to when the WTRU transmits the indication of the success of the RA procedure. The WTRU may use the new CE level when transmitting the indication.

[0307] In another example, a PDCCH order may be used to initiate one of contention-free RA or contention-based RA. An indication such as a bit field in the DCI associated with the PDCCH order may be used to indicate whether the PDCCH order is for contention-based RA or contention-free RA. A different RNTI may be used to indicate a PDCCH order for contention-based RA and a PDCCH order for contention-free RA. A different search space, *e.g.*, a different fallback M-PDCCH search space, may be used to indicate the type of RA indicated by the PDCCH order.

[0308] A search space that may be a fallback search space may be provided and/or used.

[0309] A search space, *e.g.*, of a cell, may have, use or be defined with a certain CE level, which may be a highest CE level which may be supported by the cell. An indication may be transmitted in this search space to a WTRU to initiate a RA procedure. The search space may be known or configured, *e.g.*, by higher layer signaling. The higher level signaling may be from the eNB, such as in system information, which may be broadcast.

[0310] The search space may be or may be used for a fallback control channel. The search space may be referred to as a fallback search space. A fallback control channel, a fallback search space, a common search space, and a fallback M-PDCCH may be used interchangeably.

[0311] A fallback M-PDCCH may be configured with at least one of: a subband or frequency location, a set of time locations, a CE level, and a number of repetitions.

[0312] A specific subband (*e.g.*, a subset of consecutive PRBs which may be within a system bandwidth such as a DL system bandwidth of a cell) and/or a specific time location or set of time locations (*e.g.*, a subset of subframes and/or radio frames) may be used for a fallback M-PDCCH.

[0313] The frequency and/or time locations of the subband may be indicated in higher layer signaling such as broadcast signaling or via a physical broadcasting channel (*e.g.*, MIB). The frequency and/or time locations of the subband may be determined (*e.g.*, by the WTRU) as a function of one or more system parameters. The system parameters may include DL system bandwidth, physical cell-ID, subframe number, SFN number, and MBSFN configuration. The frequency and/or time locations of the subband may change over time. For example, a frequency hopping pattern (*e.g.*, predefined or configured) may be used.

[0314] The number of repetitions for the fallback M-PDCCH may be the same as the maximum number of repetitions for M-PDCCH configured in the cell. The number of repetitions may be indicated via higher layer signaling such as broadcast signaling or via a physical broadcasting channel (*e.g.*, MIB).

[0315] A part of M-PDCCH WTRU-specific search space may be used as a fallback M-PDCCH. For example, M-PDCCH WTRU-specific search space may include one or more CE levels (*e.g.*, repetition numbers). One or more M-PDCCH candidates in the M-PDCCH WTRU-specific search space with a highest CE level may be used as fallback M-PDCCH.

[0316] A WTRU may determine one or more parameters (*e.g.*, transmission and/or reception parameters) for a fallback M-PDCCH which may include one or more of a subband or frequency location, a set of time locations, a CE level, and a number of repetitions. The WTRU may determine the one or more parameters based on at least one of received configuration, system parameters, and otherwise known information.

[0317] The WTRU may monitor fallback M-PDCCH according to at least the determined parameters. The WTRU may monitor fallback M-PDCCH for at least PDCCH order (or DCI format including a PDCCH order for the WTRU) that may indicate, initiate, or request an RA procedure. Upon or in response to successful receipt of a PDCCH order, the WTRU may initiate an RA procedure.

[0318] The fallback M-PDCCH may be used by the eNB to communicate with the WTRU at a certain CE level such as a highest CE level supported by the cell, for example, if communication with the WTRU may need a higher (or lower) CE level than what is currently being used. The eNB may indicate a CE level change to the WTRU in or using the fallback M-PDCCH. The eNB may transmit a PDCCH order and/or a request to initiate a RA procedure to a WTRU, for example to potentially change the CE level of the WTRU such as to a more appropriate or higher (or lower) CE level.

[0319] Paging may be provided and/or used. CE information may be used for paging. When an eNB may page or is to page a WTRU that may be in idle mode, the eNB may not know whether the WTRU may be in coverage enhanced (CE) mode and/or if it may be in CE mode, what the CE level may be. If the eNB may page a CE mode WTRU using normal paging procedures, the WTRU may not receive the page.

[0320] Idle mode may be or include one or more of (*e.g.*, the modes or states of) RRC Idle, ECM Idle, EMM Registered, and/or EMM Deregistered.

[0321] A WTRU may provide CE information that may be for or regarding the WTRU to an eNB and/or an MME. An eNB may provide CE information that may be for or regarding a WTRU to another eNB (*e.g.*, as part of a handover procedure) and/or to an MME. MME may be replaced by another network entity and still be consistent with this disclosure. WTRU and device (*e.g.*, which may be an MTC device or LC-MTC device) may be used interchangeably.

[0322] An MME may store CE information that may be for or regarding a WTRU. The MME may include CE information that may be for or regarding a WTRU in a message to an eNB, for example, when requesting the eNB to page the WTRU, such as when the WTRU may be in idle mode.

[0323] CE information that may be for or regarding a WTRU may include one or more of the mode of the WTRU with respect to coverage enhancements, *e.g.*, CE mode or not CE mode; the CE level of the WTRU; and/or the WTRU's capability to support CE mode. The information included in CE information may be different for different messages and/or purposes.

[0324] The mode of the WTRU with respect to coverage enhancements may be the current and/or last (or most recently) known or stored mode of the WTRU. The CE level of the WTRU may be the current and/or last (or most recently) known or stored CE level of the WTRU.

[0325] CE level may include an indication of CE mode. A certain value or level such as 0 may be used to indicate that the UE may not be in CE mode. For example, 0, 1, 2, and 3 may be used to indicate not in CE mode, and levels 1, 2, and 3 of CE mode, respectively.

[0326] In an example, a WTRU may provide CE information to an MME in a NAS message such as an attach (*e.g.*, ATTACH REQUEST) message and/or a tracking area update (TAU) message.

[0327] The WTRU may provide CE information to an MME during one or more of the network registration actions, such as an attach (*e.g.*, in the "ATTACH REQUEST" message) or during device or WTRU mobility management actions such as tracking area update (TAU) (*e.g.*, in the "TRACKING AREA UPDATE REQUEST" message). For example, the WTRU may include such CE information in one or more of the aforementioned messages itself, or in one or more of its WTRU or device capabilities or network support feature attribute IEs such as "WTRU network capabilities," "MS network capabilities," "MS Classmark 2," MS Classmark 3," "MS network feature support," and the like.

[0328] An eNB may receive CE information (*e.g.*, some CE information) from a WTRU and/or may determine CE information (*e.g.*, some or some other CE information) in one or more other ways (*e.g.*, from a PRACH resource a WTRU may have used which may indicate certain CE information). The WTRU may provide CE information, *e.g.*, to the eNB, in one or more capabilities information elements (IEs) or messages (*e.g.*, a WTRU capabilities IE or message and/or an IE or message that may be specific to CE information and/or or information relating to paging or paging capabilities). The WTRU may autonomously send the message. The eNB may provide CE information to an MME in an S1 (*e.g.*, S1AP) message.

[0329] An eNB may provide CE information to an MME for or regarding a WTRU following determination and/or receipt of this information. An eNB may provide CE information to an MME for or regarding a WTRU following a change or update of this information. An eNB may provide CE information to an MME for or regarding a WTRU when the eNB may release the WTRU (*e.g.*, from its connection such as an RRC connection with the eNB) and/or when the WTRU may go to idle mode.

[0330] An MME may provide CE information (*e.g.*, which it may have stored for a WTRU) to an eNB, for example, in support of certain procedures, for example certain procedures in which the eNB may not have this information. For example, the MME may provide CE information (*e.g.*, which may include one or more items of information that may be provided separately or in combinations such as in one or more IEs), to an eNB in association with paging (*e.g.*, with or in an S1 PAGING message) for a given WTRU or device that may be in idle mode or attached but not connected, or detached or unattached but known to be located in the paging area. The eNB may page the WTRU in a manner consistent with the CE information it may receive, *e.g.*, from the MME.

[0331] A WTRU may provide updated CE information to an eNB and/or MME, for example, when one or more of the components of its CE information may change or in other situations.

[0332] Under certain conditions, *e.g.*, when the WTRU may be in idle mode, the WTRU may perform a RA procedure to connect to an eNB for providing CE information or updated CE information. The WTRU may send an RRC connection request, and the reason may be indicated by the WTRU as mobile originated signaling (mo-signaling).

[0333] Change of CE mode and/or CE level (*e.g.*, in idle and/or connected mode) may be a reason for a WTRU to perform (*e.g.*, trigger) a TAU. Change of CE mode and/or CE level (*e.g.*, in idle and/or connected mode) may be a reason for a WTRU to perform a RA procedure and/or perform (or request) connection establishment and/or send a capabilities message to or with an eNB.

[0334] If a WTRU may change to or from CE mode and/or or may change its CE level, *e.g.*, while in idle mode (or connected mode), the WTRU may connect to an eNB (*e.g.*, RRC connection), *e.g.*, perform an RA procedure to request and/or establish an RRC connection with the eNB where the establishment cause may be mobile originated signaling (mo-signaling).

[0335] If a WTRU may change to or from CE mode and/or may change its CE level, *e.g.*, while in idle mode (or connected mode), the WTRU may perform an RA procedure with an eNB (which may be the same or similar procedure as the one for establishing the connection), which may enable the eNB to determine whether or not the WTRU may be in CE mode and/or what level of CE the WTRU may need or use.

[0336] If a WTRU may change to or from CE mode and/or or may change its CE level, *e.g.*, while in idle mode (or connected mode), and/or for other reasons, the WTRU may provide CE information (*e.g.*, updated CE information) regarding the WTRU to the eNB and/or MME, for example as part of a WTRU message to the eNB and/or a WTRU message (*e.g.*, NAS message) to the MME (*e.g.*, via the eNB). The WTRU may use one or more messages to convey the CE information to the eNB and/or MME. The WTRU may use a NAS procedure and/or message such as TAU (*e.g.*, in the "TRACKING AREA UPDATE REQUEST" message) to provide CE information or updated CE information to the MME. The WTRU may use a capabilities message to provide CE information or updated CE information to the eNB.

[0337] A WTRU may perform an RA procedure to establish a connection with an eNB.

[0338] Following connection establishment, the WTRU may send a NAS message to the MME which may be a TAU message. The message may include an indication of the mode (CE mode or not CE mode) and/or CE level of the WTRU. The WTRU may include the WTRU

capability of supporting CE mode in the TAU message. The CE mode support capability may (*e.g.*, may only) be included in an ATTACH message to the MME.

[0339] The WTRU may send CE information to the MME in a TAU message (*e.g.*, in the "TRACKING AREA UPDATE REQUEST" message). When the WTRU may send such a message, for example for a reason other than a change of CE information, the WTRU may include all or certain of its CE information, *e.g.*, the WTRU may or may only include the CE information that may have changed since the last time the WTRU may have sent CE information to the MME.

[0340] When CE information for a WTRU may change, an eNB may send a message (*e.g.*, an S1AP message) to provide certain (*e.g.*, some or all) of the CE information or at least (or only) the changed information to the MME.

[0341] During or after radio link failure (RLF) or recovery from RLF, a WTRU may provide CE information to an eNB and/or MME such as in accordance with one or more of the solutions or examples described herein, for example for a WTRU in idle mode which may have changed CE mode and/or CE level. The WTRU may act as if CE mode and/or CE level may have changed (*e.g.*, even if it or they have not changed), for example, since before RLF or conditions which may have resulted in RLF may have occurred.

[0342] Paging may be provided for and/or used by a WTRU or WTRUs that may be in CE mode. When an eNB may page or intend to page a WTRU which may support CE mode, the eNB may not know if the WTRU may currently be in CE mode and/or the eNB may not know the current CE level of the WTRU. This may happen, for example, if the CE information which may be stored by the MME may not include CE mode or CE level information or if such information may be stale.

[0343] An eNB may page a WTRU, such as one that may support CE mode, using non-CE paging or using both non-CE paging and CE paging (*e.g.*, simultaneously or sequentially). An eNB may page a WTRU, such as one that may support CE mode, using non-CE paging first and if unsuccessful, then using CE paging. An eNB may page a WTRU, such as one that may support CE mode, using CE paging or only CE paging. An eNB may page a WTRU, such as one that may support CE mode, using CE paging for the worst CE level (*e.g.*, the level which may use the most repetition), *e.g.*, only for the worst CE level. An eNB may page a WTRU, such as one that may support CE mode, using CE paging for one CE level, and if unsuccessful, using CE paging for another (*e.g.*, another higher) or the next (*e.g.*, the next higher) level. An eNB may page a WTRU, such as one that may support CE mode, using CE paging for one or more (*e.g.*, each of the) CE levels (*e.g.*, one at a time or simultaneously), for example, until successful or until the

worst level may have failed. An eNB may page a WTRU, such as one that may support CE mode, using CE paging for the last known or stored CE mode and/or CE level of the WTRU, which may be provided to the eNB in a message (*e.g.*, S1-Paging message), *e.g.*, from the MME. An eNB may page a WTRU, such as one that may support CE mode, using CE paging for the CE mode and/or CE level of the WTRU that may be provided to the eNB in a message (*e.g.*, S1-Paging message), *e.g.*, from the MME. Using non-CE paging may include using legacy paging techniques or paging techniques that may be used for WTRUs that may not need or use coverage enhancement. Using CE paging may include paging using coverage enhancement techniques such as repetition. The number of repetitions may be fixed, configured, or a function of the CE level. Using CE paging may include providing a PDSCH carrying PCH or paging without a DCI format.

[0344] An eNB that may page a WTRU using both non-CE paging and CE paging may cease the CE paging (*e.g.*, the repetitions of the CE paging) if and/or when it may receive (*e.g.*, successfully receive) a response from the WTRU to the non-CE paging. A response to a page from a WTRU may be or include the transmission of a PRACH preamble and/or at least part of an RA procedure. Successful reception of the response by the eNB may include being able to determine that the response was from the WTRU it may have paged.

[0345] An eNB that may page a WTRU using both non-CE paging and CE paging may cease the CE paging (*e.g.*, the repetitions of the CE paging) if and/or when the eNB may receive an indication, *e.g.*, from the MME that the page was successful. An indication that the page was successful may include a request to perform an operation for the WTRU, such as setting up a bearer.

[0346] An eNB that may page or intend to page a WTRU (*e.g.*, one that may support CE mode or that the eNB may know may support CE mode), where the eNB may, for example, not know or may be unsure of the (*e.g.*, the current) CE mode and/or CE level of the WTRU, may try paging the WTRU using non-CE paging (*e.g.*, first). If the eNB may not receive (or successfully receive) a response from the WTRU or an indication (*e.g.*, of paging success) from the MME, for example, within a certain amount of time, the eNB may try paging the WTRU using CE paging.

[0347] The eNB may try CE paging for one or more CE levels until successful or all fail, or may try the worst CE level (*e.g.*, only). A paging attempt by the eNB, *e.g.*, using non-CE mode or CE mode with a CE level (*e.g.*, a certain CE level), may be in response to a paging request from the MME. The paging request may be provided in an S1 paging message. An MME may provide an indication of lack of success of a paging attempt instead of an indication of success.

[0348] An eNB may page a connected mode CE mode WTRU, *e.g.*, using CE mode paging, to inform it of system information changes. The eNB may directly inform these WTRUs of the changes with dedicated signaling.

[0349] CE paging may be provided and/or used. A WTRU may monitor PDCCH and/or EPDCCH to determine if there may be PDSCH carrying PCH (or paging message) that may be intended for it. The WTRU may look for a paging RNTI (*e.g.*, P-RNTI) or DCI format masked with (*e.g.*, with a CRC scrambled with) a paging RNTI (*e.g.*, P-RNTI) that may indicate a PDSCH that may carry PCH or a paging message. PCH and paging message may be used interchangeably. Using a RNTI (*e.g.*, a DCI format using a RNTI) may be the same as being masked with (*e.g.*, the DCI format being masked with) the RNTI or having (*e.g.*, the DCI format having) a (or its) CRC scrambled with the RNTI.

[0350] A WTRU, such as a coverage limited WTRU, may use, need, and/or combine repetitions of a transmission (*e.g.*, PDCCH, EPDCCH, PDSCH, *etc.*) to be able to successfully receive and/or decode the transmission. Rules and/or procedures may be used for PDSCH that may carry PCH or a paging message and/or PDCCH (and/or EPDCCH) that may carry a DCI format that may indicate the presence of (or upcoming presence of) a PDSCH that may carry a PCH or paging message.

[0351] CE paging may use coverage enhancement techniques such as repetition of the PDCCH and/or EPDCCH that may carry a DCI format that may indicate the presence of (or upcoming presence of) a PDSCH that may carry a PCH or paging message and/or repetition of a PDSCH that may carry a PCH or paging message.

[0352] An eNB, such as one that may use CE paging, may transmit PCH in a coverage enhanced manner, for example, when transmitting PCH to a WTRU that may be coverage limited. A WTRU, such as a coverage limited WTRU that may use or respond to CE paging, may receive PCH in a coverage enhanced manner. CE paging may include transmission and/or reception of PCH in a coverage enhanced manner.

[0353] CE paging and/or transmission and/or reception of PCH in a coverage enhanced manner may include transmission of repetitions of PCH, which may include transmission of repetitions of a PDSCH that may carry PCH and/or transmission of repetitions of the associated PDCCH and/or EPDCCH. CE paging and/or transmission and/or reception of PCH in a coverage enhanced manner may include reception and/or combining of repetitions of PCH, which may include reception of and/or combining repetitions of the PDSCH that may carry PCH and/or reception of and/or combining repetitions of the associated PDCCH and/or EPDCCH. CE paging and/or transmission and/or reception of PCH in a coverage enhanced manner may include

transmission of an RNTI for the PCH PDCCH and/or EPDCCH, *e.g.*, legacy P-RNTI or an RNTI, *e.g.*, PCE-RNTI, which may be specific to coverage limited WTRUs, for example, of a coverage enhancement level (*e.g.*, of a certain CE level). CE paging and/or transmission and/or reception of PCH in a coverage enhanced manner may include monitoring and/or reception of an RNTI for the PCH PDCCH and/or EPDCCH, *e.g.*, legacy P-RNTI or an RNTI, *e.g.*, PCE-RNTI, which may be specific to coverage limited WTRUs, for example, of a coverage enhancement level (*e.g.*, of a certain CE level).

[0354] A WTRU and/or eNB (such as a WTRU and/or eNB that may use CE paging) may transmit repetitions of PCH, which may include transmitting repetitions of a PDSCH that may carry PCH and/or transmitting repetitions of the associated PDCCH and/or EPDCCH. A WTRU and/or eNB (such as a WTRU and/or eNB that may use CE paging) may receive and/or combine repetitions of PCH, which may include receiving and/or combining repetitions of the PDSCH that may carry PCH and/or receiving and/or combining repetitions of the associated PDCCH and/or EPDCCH. A WTRU and/or eNB (such as a WTRU and/or eNB that may use CE paging) may transmit an RNTI for the PCH PDCCH and/or EPDCCH, *e.g.*, legacy P-RNTI or an RNTI, *e.g.*, PCE-RNTI, which may be specific to coverage limited WTRUs, for example, of a coverage enhancement level (*e.g.*, of a certain CE level). A WTRU and/or eNB (such as a WTRU and/or eNB that may use CE paging) may monitor and/or receive an RNTI for the PCH PDCCH and/or EPDCCH, *e.g.*, legacy P-RNTI or an RNTI, *e.g.*, PCE-RNTI, which may be specific to coverage limited WTRUs, for example, of a coverage enhancement level (*e.g.*, of a certain CE level).

[0355] P-RNTI or another RNTI may be used for PDCCH and/or EPDCCH associated with PDSCH that may carry PCH, for example, for PCH intended for a WTRU that may be coverage limited and/or bandwidth limited.

[0356] PDCCH and/or EPDCCH associated with PDSCH that may carry PCH may be located in a common search space (*e.g.*, PDCCH common search space and/or EPDCCH common search space), for example, for PCH that may be intended for a WTRU that may be coverage limited and/or bandwidth limited.

[0357] A WTRU, such as one that may be coverage limited, may begin monitoring for the PDCCH and/or EPDCCH associated with PDSCH that may carry PCH at the start of its DRX cycle (*e.g.*, the first subframe of its DRX cycle). The WTRU may monitor for PDCCH and/or EPDCCH using P-RNTI or PCE-RNTI or a PCE-RNTI for its CE level (*e.g.*, current CE level).

[0358] An eNB may transmit a PCH PDSCH in a fixed, known, or determined location and/or with one or more fixed, known, or determined parameters (*e.g.*, transmission parameters such as MCS) such that a DCI format may not be required or used, *e.g.*, for a PCH PDSCH that

may be intended for a WTRU (or at least a WTRU) that may be bandwidth limited and/or coverage limited. The fixed, known, or determined location and/or parameters may be provided by the eNB in signaling, such as broadcast signaling (*e.g.*, in system information). PCH PDSCH may be used to represent a PDSCH which may carry PCH.

[0359] The location and/or one or more transmission parameters of a PCH PDSCH that may be intended for a WTRU (or at least a WTRU) that may be bandwidth limited and/or coverage limited may be a function of a capability (or reduced capability) of the WTRU. For example, PCH PDSCH location and/or one or more PCH PDSCH transmission parameters may be a function of one or more of CE mode, CE level, and/or BW limitation. The capability (or reduced capability) of the WTRU, such as the CE mode and/or CE level and/or BW limitation of the WTRU, may determine (or may be used by the WTRU and/or eNB to determine) the location (*e.g.*, subframes and/or RBs) and/or one or more transmission parameters (*e.g.*, MCS) for the PCH PDSCH that may be intended for a WTRU (or at least a WTRU) that may be bandwidth limited and/or coverage limited. The eNB may transmit and/or the WTRU may receive or attempt to receive the PCH PDSCH in the determined location.

[0360] Determination of the location and/or transmission parameter(s) of a PCH PDSCH that may be intended for a WTRU (or at least a WTRU) that may be bandwidth limited and/or coverage limited, *e.g.*, by the WTRU and/or eNB, may be based at least in part on configuration (*e.g.*, of PCH PDSCH location and/or parameters) for one or more capabilities (or reduced capabilities, such as CE mode or level), which may be provided by the eNB via signaling, such as broadcast signaling. Determination of the location and/or transmission parameter(s) of a PCH PDSCH that may be intended for a WTRU (or at least a WTRU) that may be bandwidth limited and/or coverage limited, *e.g.*, by the WTRU and/or eNB, may be based at least in part on a WTRU parameter or identifier, such as the WTRU IMSI or WTRU ID.

[0361] Location (*e.g.*, of a PCH PDSCH) may be or may include time (*e.g.*, subframe, set of subrames, or pattern of subframes) and/or frequency (*e.g.*, one or more RBs).

[0362] A PCH or PCH PDSCH may be or may represent an instance or repetition of a PCH or PCH PDSCH. Repetitions of a PCH or PCH PDSCH that may be combined by a WTRU, such as a WTRU that may be coverage limited, may be in the same or different locations (*e.g.*, subframes may be different and RBs may be the same or different) and/or may use the same or different parameters.

[0363] A WTRU, such as a bandwidth limited and/or coverage limited WTRU, may monitor for, receive, or attempt to receive PCH PDSCH, *e.g.*, from an eNB. The WTRU and/or the eNB may determine the location of an PCH PDSCH that may be intended for the WTRU (or at least

the WTRU) based at least in part on configuration, *e.g.*, of the relationship or correspondence between PCH PDSCH location and/or parameters and WTRU capability or reduced capability, which may be provided by the eNB via signaling, such as broadcast signaling.

[0364] One or more PCH (or PCH PDSCH) transport block sizes may be configured or fixed and may correspond to a certain number of pages (*e.g.*, to a certain number of WTRUs). Padding may be used, for example, when the number of pages (*e.g.*, actual pages) may be less than the number of pages (*e.g.*, the certain number of pages) that may correspond to a fixed or configured transport block size (TBS). TBS configuration may be by signaling, such as broadcast signaling, which may be from the eNB. There may be a separate PCH (or PCH PDSCH) TBS value (*e.g.*, fixed or configured) for one or more CE levels. There may be one or more PCH (or PCH PDSCH) TBS values for PCH (or PCH PDSCH) that may be intended for (*e.g.*, at least for) a coverage limited and/or bandwidth limited WTRU. A WTRU such as a WTRU that may be coverage limited and/or bandwidth limited may receive or may expect to receive a PCH (or PCH PDSCH) with a fixed or configured TBS. An eNB may transmit a PCH (or PCH PDSCH) that may be intended for (*e.g.*, at least for) a WTRU that may be coverage limited and/or bandwidth limited with a fixed or configured TBS.

[0365] There may be N CE levels, and there may be PCH PDSCH resources (*e.g.*, separate PCH PDSCH resources) for each of the N CE levels. An eNB may transmit and/or a WTRU may receive or may expect to receive a PCH PDSCH in certain time and/or frequency resources (*e.g.*, subframes and/or RBs) that may correspond to the CE mode or level of the WTRU.

[0366] One or more (*e.g.*, a set of) PCH (or PCH PDSCH) transport block (TB) sizes (*e.g.*, possible or candidate TB sizes) may be fixed or configured (*e.g.*, by the eNB) and/or determined (*e.g.*, by the WTRU). A WTRU may try one or more of the TB sizes (*e.g.*, in the set of TB sizes) to try to successfully receive the PCH (or PCH PDSCH), for example, when monitoring for and/or attempting to receive PCH (or PCH PDSCH).

[0367] One or more (*e.g.*, a set of) PCH (or PCH PDSCH) candidates may be fixed or configured (*e.g.*, by the eNB) and/or determined (*e.g.*, by the WTRU). The PCH (or PCH PDSCH) candidates may differ in one or more characteristics that may include time (*e.g.*, subframe), frequency (*e.g.*, RBs), TB size, and one or more transmission parameters, such as MCS. A WTRU may try one or more of the PCH (or PCH PDSCH) candidates to try to successfully receive the PCH (or PCH PDSCH), for example, when monitoring for and/or attempting to receive PCH (or PCH PDSCH).

[0368] PDCCH (and/or EPDCCH) may be repeated a number of times, *e.g.*, M times, for example, for CE paging. The same PDCCH may be repeated (*e.g.*, for one or more (*e.g.*, each) of

the M times) and one or more (*e.g.*, each of the) repetitions may be located in the same place in a search space such as a common search space (CSS), *e.g.*, a PDCCH and/or EPDCCH CSS.

[0369] There may be a gap of G (*e.g.*, 0 or greater) that may follow the PDCCH (and/or EPDCCH) repetitions. G may be or may include a number of subframes (or certain subframes such as POs) and/or frames (or certain frames, such as PFs). The corresponding PDSCH (*e.g.*, PCH PDSCH) may follow after the gap and/or may be repeated P times. M may or may not equal P. One or more of M, G, and P may be a function of a CE level (*e.g.*, the CE level determined for the WTRU to be paged or the worst case CE level). M and/or G may be zero, for example, if no DCI format may be used or needed for paging (*e.g.*, CE paging).

[0370] An eNB may transmit the repetitions of the PDCCH (and/or EPDCCH) and/or the PDSCH in certain subframes and/or frames such as POs and/or PFs.

[0371] An eNB may transmit the repetitions of the PDCCH (and/or EPDCCH) and/or the PDSCH in certain subframes such as designated or configured subframes and/or subframes which may be DL (*e.g.*, any DL) subframes and/or certain (*e.g.*, all) special subframes (*e.g.*, for TDD).

[0372] The subframe of the first PDSCH (*e.g.*, of a set of P repetitions of a PDSCH) that may carry a page (*e.g.*, PCH) for a WTRU, such as a CE mode WTRU, may align with POs and/or PFs and/or may be related to the timing of the PDCCH.

[0373] To page a WTRU, the eNB may transmit a first transmission (or repetition) of a PDCCH (and/or EPDCCH) and/or PDSCH (*e.g.*, PCH PDSCH) according to the starting PO of the WTRU, which may be determined in a same or similar manner to which a PO may be determined by or for a legacy WTRU or according to another rule or calculation.

[0374] Following the first transmission of a PDCCH (and/or EPDCCH) and/or PDSCH (*e.g.*, PCH PDSCH), which may be in a (*e.g.*, a certain) PO (*e.g.*, a starting PO) and/or a (*e.g.*, a certain) PF (*e.g.*, a starting PF), one or more (*e.g.*, each) of the next of the M or P repetitions may be transmitted by the eNB in the next PO (*e.g.*, each of the next M, M-1, P or P-1 POs). A next PO may be in the same or the next PF as a previous PO.

[0375] Following the first transmission of a PDCCH (and/or EPDCCH) and/or PDSCH (*e.g.*, PCH PDSCH), which may be in a (*e.g.*, a certain) PO (*e.g.*, a starting PO) and/or a (*e.g.*, a certain) PF (*e.g.*, a starting PF), one or more (*e.g.*, each) of the next of the M or P repetitions may be transmitted by the eNB in the same PO as the previous transmission in the next PF.

[0376] Following the first transmission of a PDCCH (and/or EPDCCH) and/or PDSCH (*e.g.*, PCH PDSCH), which may be in a (*e.g.*, a certain) PO (*e.g.*, a starting PO) and/or a (*e.g.*, a certain) PF (*e.g.*, a starting PF), one or more (*e.g.*, each) of the next of the M or P repetitions may

be transmitted by the eNB in the next subframe (*e.g.*, each of the next M, M-1, P or P-1 subframes) that may be DL.

[0377] Following the first transmission of a PDCCH (and/or EPDCCH) and/or PDSCH (*e.g.*, PCH PDSCH), which may be in a (*e.g.*, a certain) PO (*e.g.*, a starting PO) and/or a (*e.g.*, a certain) PF (*e.g.*, a starting PF), one or more (*e.g.*, each) of the next of the M or P repetitions may be transmitted by the eNB in the next subframe (*e.g.*, each of the next M, M-1, P or P-1 subframes) that may be either a DL or special subframe where special subframes may apply (*e.g.*, only apply) for TDD.

[0378] Following the first transmission of a PDCCH (and/or EPDCCH) and/or PDSCH (*e.g.*, PCH PDSCH), which may be in a (*e.g.*, a certain) PO (*e.g.*, a starting PO) and/or a (*e.g.*, a certain) PF (*e.g.*, a starting PF), one or more (*e.g.*, each) of the next of the M or P repetitions may be transmitted by the eNB in the next designated or configured subframe, which may be for this purpose. The subframe configuration may be provided via signaling, such as broadcast signaling, for example, in system information. System information may be provided in one or more SIBs.

[0379] Whether or not a subframe may be a DL subframe or a special subframe may be determined according to the cell specific TDD UL/DL configuration of the cell, which may be broadcast by the cell in system information (*e.g.*, in SIB 1).

[0380] The POs and/or PFs that may be used for CE paging and (*e.g.*, at least) non-CE paging (*e.g.*, legacy paging) may be the same or different. The POs and/or PFs that may be used for CE paging may be configured and/or determined separately from the POs and/or PFs that may be used for (*e.g.*, at least) non-CE (*e.g.*, legacy) paging.

[0381] A WTRU, such a WTRU that may be coverage limited, may look for a page using non-CE paging and may use CE paging if non-CE paging may not be successful. For example, the WTRU may monitor for PDCCH which may be masked by P-RNTI in a PO that may be determined according to a legacy calculation. If the WTRU may successfully receive a P-RNTI in this manner and/or a corresponding PDSCH in the PO subframe, the WTRU may not use CE paging, *e.g.*, it may not monitor for repeated PDCCH and/or EPDCCH and/or PDSCH. The WTRU may determine if a PCH it may have received in the PO may be intended for it and, if so, may respond to the page accordingly.

[0382] A WTRU, such a WTRU that may be coverage limited, may determine, *e.g.*, for its paging cycle, one or more of a starting subframe, a starting PF, and/or a starting PO. Such determination may be in a same or similar manner to which a PO may be determined by or for a legacy WTRU or according to a new rule or calculation.

[0383] The starting subframe or starting PO for a page or paging cycle for a CE mode WTRU may be the subframe or PO for or of the first transmission of the PDCCH (and/or EPDCCH) of the M repetitions of the channel. The starting subframe or starting PO for a page or paging cycle for a CE mode WTRU may be the subframe or PO for or of the first transmission of the PCH PDSCH of the P repetitions of the channel.

[0384] A WTRU, such as a WTRU that may be coverage limited, may look for a page using CE paging. According to the subframes in which the starting PO and the M repetitions of the PDCCH (and/or EPDCCH) may be (*e.g.*, as described for eNB transmission), the WTRU may monitor PDCCH (and/or EPDCCH) in those subframes and may combine the signals from those subframes or a subset of those subframes into one PDCCH (and/or EPDCCH) that it may attempt to decode and/or for which it may determine if it may be masked with a paging RNTI such as P-RNTI or PCE-RNTI.

[0385] If the WTRU may determine that there may be a page for the WTRU, for example, if the PDCCH (and/or EPDCCH) was or was determined by the WTRU to be masked with a paging RNTI (*e.g.*, P-RNTI or PCE-RNTI), the WTRU may begin to receive the corresponding P repetitions of PDSCH.

[0386] The WTRU may skip a certain number of subframes and/or frames from the last of the M repetitions to the first of the P repetitions, which may be according to G.

[0387] A WTRU may not monitor for PDCCH and/or EPDCCH in order to receive a PCH PDSCH. According to the subframes in which the starting PO and the P repetitions of the PCH PDSCH may be (*e.g.*, as described for eNB transmission), the WTRU may monitor for PDSCH (*e.g.*, PCH PDSCH) in those subframes and may combine the signals from those subframes or from a subset of those subframes into one PDSCH, which it may attempt to decode and/or receive. The WTRU may monitor for the PCH PDSCH in a known or determined location or locations and/or using one or more known and/or determined parameters of PCH PDSCH. The WTRU may monitor for one or more PCH PDSCH candidates.

[0388] The WTRU may receive the P repetitions or a subset of the P repetitions of the PDSCH or PDSCH candidates and may combine them (or one or more, *e.g.*, each set of repetitions) to a single PDSCH from which it may attempt to (*e.g.*, successfully) receive and/or decode a PCH. If the WTRU may (*e.g.*, successfully) receive and/or decode the PCH, the WTRU may determine if the PCH was intended for the WTRU and, if so, the WTRU may respond to the page.

[0389] One or more of M, G, and P may be a function of a CE level (*e.g.*, the CE level of the WTRU or the worst case CE level).

[0390] Worst case CE level may be the worst or highest CE level supported by the cell or eNB (e.g., the CE level with the highest number of repetitions) which may be indicated in cell-specific signaling, e.g., broadcast signaling such as via a physical broadcast channel (e.g., MIB) or higher layer signaled system information (e.g., SIB).

[0391] G and/or P may be indicated in the PDCCH (and/or EPDCCH), which may be masked by a paging RNTI such as P-RNTI or PCE-RNTI. G and/or P may be indicated in the PDCCH (and/or EPDCCH), which may correspond to the paging PDSCH, which may be repeated P times.

[0392] The subframes of the repetitions and/or the gap may not be consecutive subframes. The subframes of the repetitions and/or the gap may be PO subframes or other particular or designated subframes. The PO subframes may be the PO subframes of a WTRU, such as any WTRU or of a certain WTRU, such as a WTRU for which a page may be intended.

[0393] For example, the repeated PDCCHs (and/or EPDCCHs) and/or PDSCHs that may be used by CE mode WTRUs (and or eNBs for CE paging) may occur in subframes that may be possible paging occasions (POs). For FDD, PO subframes may be certain subframes, such as subframes 0, 4, 5, and 9, for example. Depending on configuration (*e.g.*, by the eNB), the subsets of subframes for POs may be certain subsets, such as [9], [4,9], or [0,4,5,9], for example. For TDD, the PO subframes may be certain subframes, such as subframes 0, 1, 5, and 6, for example. Depending on configuration (*e.g.*, by the eNB), the subsets of subframes for POs may be certain subsets, such as [0], [0,5], or [0,1,5,9], for example.

[0394] A starting subframe of a PO or a starting PO may be in a PF. One or more repetitions of an EPDCCH and/or PDSCH for paging may not be in a PF. One or more of the PDCCHs, EPDCCHs, and/or PDSCHs that may be used for paging may be transmitted and/or received in subframes that may be identified by configuration as subframes that may be used for paging. The configuration may be provided via signaling, such as broadcast signaling, for example, in system information. The system information may be provided, for example, in one or more system information blocks (SIBs).

[0395] A downlink (DL) control channel may be used for paging. For example, an (E)PDCCH common search space (CSS) may include one or more (E)PDCCH candidates and may be configured for paging. A WTRU, such as a WTRU that may be bandwidth limited and/or coverage limited, may decode and/or monitor one or more (E)PDCCH candidates in the (E)PDCCH CSS to receive a DCI that may be masked by a paging RNTI, such as P-RNTI or PCE-RNTI. One or more (E)PDCCH candidates may be transmitted in a time and/or frequency location known to a WTRU that may monitor or may need to monitor or receive the (E)PDCCH

candidates. CSS may be used as a non-limiting example of a search space. The time and/or frequency location of the (E)PDCCH CSS and/or (E)PDCCH candidate or candidates and/or one or more parameters that may enable monitoring and/or decoding of the (E)PDCCH CSS and/or (E)PDCCH candidate or candidates may be provided or configured via signaling, such as broadcast signaling that may be received and/or used by the WTRU. Another search space may be used and may be consistent with the disclosed subject matter.

[0396] Candidates, resources, and PRBs, such as (E)PDCCH candidates, (E)PDCCH resources, and (E)PDCCH PRBs may be used interchangeably or substituted for each other and still be consistent with this disclosure. PRBs and RBs may be used interchangeably.

[0397] The term (E)PDCCH may represent EPDCCH and/or PDCCH. The term (E)CCE may represent a control channel element (CCE) and/or an enhanced control channel element (ECCE).

[0398] An (E)PDCCH candidate may be, may have, and/or may include a combination of an (E)CCE aggregation level and a number of repetitions. For example, an (E)PDCCH candidate may include the (E)CCE aggregation level N_{AL} and the number of repetitions N_{REP}. A total aggregation level (TAL) may correspond to a total number of (E)CCEs that may belong to an (E)PDCCH candidate. The number of (E)CCEs for the total aggregation level N_{TAL} may be determined as a function of N_{AL} and N_{REP}. For example, N_{TAL} may be the product of N_{AL} and N_{REP}.

[0399] An (E)PDCCH candidate that may have a larger total aggregation level (N_{TAL}) may support a higher CE level than an (E)PDCCH candidate that may have a smaller total aggregation level. A higher CE level may provide more or better coverage enhancement than a lower CE level. For example, a higher CE level may provide better signal strength at a receiver than a lower CE level.

[0400] Two or more (E)PDCCH candidates may be configured with a different total aggregation level, for example, to support two or more CE levels. A WTRU may monitor and/or decode a subset of the (E)PDCCH candidates that may be configured. The subset may include one or more (*e.g.*, all) of the (E)PDCCH candidates that may be configured. A WTRU may monitor and/or decode an (E)PDCCH candidate to receive a DCI that may be masked with an RNTI, such as a paging RNTI.

[0401] A WTRU may monitor and/or decode one or more, *e.g.*, all, (E)PDCCH candidates that may be configured, regardless of a CE level used, configured, and/or determined for or by the WTRU.

[0402] For (E)PDCCH candidate monitoring, the WTRU may start from an (E)PDCCH candidate with a first, *e.g.*, smallest total aggregation level. The WTRU may move to an (E)PDCCH candidate with a second, *e.g.*, larger total aggregation level if the WTRU does not receive a DCI that may be masked with a paging RNTI in the first total aggregation level. The WTRU may move or continue to move to another, *e.g.*, larger total aggregation level until it reaches a maximum total aggregation level if the WTRU does not receive a DCI that may be masked with a paging RNTI in a total aggregation level (*e.g.*, a certain total aggregation level). The WTRU may stop monitoring (E)PDCCH candidates and may not move to a next or another total aggregation level if the WTRU receives a DCI that may be masked with a paging RNTI in a total aggregation level, *e.g.*, a certain total aggregation level.

[0403] A WTRU may monitor a subset of (E)PDCCH candidates configured based on the CE level used, configured, and/or determined for or by the WTRU. A paging RNTI that may be associated with a certain subset of (E)PDCCH candidates may be determined based on the CE level. A WTRU may monitor and/or decode one or more (E)PDCCH candidates in the subset of (E)PDCCH candidates to receive a DCI that may be masked with the paging RNTI associated with the CE level used, configured, and/or determined for or by the WTRU.

[0404] The WTRU may determine and/or use a first CE level or a number of repetitions for monitoring and/or decoding an (E)PDCCH candidate, for example, to receive a DCI that may be a paging DCI or a DCI that may be masked by a paging RNTI. The WTRU may determine and/or use a second CE level or number of repetitions for reception of a PDSCH that may carry a paging channel or paging message or paging information. A CE level may be associated with or configured to correspond to a number of repetitions, for example, via signaling from an eNB, such as via broadcast signaling. CE level and number of repetitions may be used interchangeably. The first and second CE levels may be the same or different. The first and/or second CE levels may be determined by the WTRU.

[0405] A WTRU may determine a CE level or CE levels (*e.g.*, the first and/or second CE levels), which may be used or configured for or by the WTRU, for example, for one or more aspects of paging reception. For example, a WTRU may determine one or more CE levels (*e.g.*, for one or more aspects of paging reception) based on a latest or most recent CE level used by or known to the WTRU and/or based on one or more of known, measured, and/or signaled values or information. The determined CE level (or levels) may be specific to paging (*e.g.*, to one or more aspects of paging reception) or may be applicable to other procedures or purposes rather than or in addition to paging (or paging reception). Paging reception aspects may include, but are not limited to, one or more of: monitoring and/or decoding one or more (E)PDCCH candidates,

receiving a paging DCI, and/or receiving a PDSCH carrying a paging channel or paging message or paging information.

[0406] A CE level that may be determined and/or used by the WTRU (*e.g.*, for at least one or more aspects of paging reception) may be or may be based on the latest CE level stored at an MME for the WTRU. The CE level for the WTRU may be signaled from an eNB, such as the serving eNB of the WTRU to the MME. The CE level that may be determined and/or used by the WTRU may be (or may be based on) the latest CE level used (*e.g.*, by the WTRU) for a successful reception of a DCI that may be masked with one or more of a paging RNTI, a system information RNTI, and/or a RA-RNTI, or the like. The CE level that may be determined and/or used by the WTRU may be (or may be based on) the latest CE level used (*e.g.*, by the WTRU) for a successful reception of a DL channel (*e.g.*, from its serving cell or the cell on which it is camped), such as a PDSCH carrying broadcast information (*e.g.*, a SIB), a PDSCH carrying a paging channel or paging message or paging information, a PDSCH carrying a RAR, and/or PBCH.

[0407] A CE level that may be determined and/or used by the WTRU (*e.g.*, for at least one or more aspects of paging reception) may be (or may be based on) the CE level associated with a downlink measurement (*e.g.*, RSRP and/or RSRQ), for example, made by the WTRU. The downlink measurement may be or correspond to a current or most recent downlink measurement. The measurement may be a filtered measurement.

[0408] A CE level that may be determined and/or used by the WTRU (*e.g.*, for at least one or more aspects of paging reception) may be (or may be based on) a CE level that may be indicated from broadcast signaling and/or a broadcasting channel, *e.g.*, SIB, MTC-SIB, LC-SIB, MIB, and/or PBCH. For example, the CE level that may be determined and/or used by the WTRU may be (or may be based on) a paging CE level (*e.g.*, a CE level for paging) that may, for example, be indicated from broadcast signaling and/or a broadcasting channel, *e.g.*, SIB, MTC-SIB, LC-SIB, MIB, and/or PBCH. The broadcast CE level may be used (*e.g.*, for paging) for and/or by some or all WTRUs. For example, the broadcast CE level may be used (*e.g.*, for paging) for and/or by one or more of: one or more (*e.g.*, all) WTRUs in CE mode, one or more (e.g., all) WTRUs that support CE mode, one or more (*e.g.*, all) WTRUs of a certain WTRU type or category (*e.g.*, low cost WTRU), and/or one or more (*e.g.*, all) WTRUs that have a certain capability or reduced capability (*e.g.*, reduced bandwidth WTRU).

[0409] A CE level that may be determined and/or used by the WTRU (*e.g.*, for at least one or more aspects of paging reception) may be (or may be based on) the maximum CE level supported by the cell from which the WTRU may receive paging (*e.g.*, the cell on which the

WTRU may be camped in idle mode). The maximum CE level supported by the cell may be provided in signaling, such as broadcast signaling (*e.g.*, SIB, MIB, and/or PBCH). The WTRU may receive and/or use the signaling to determine the maximum CE level and/or the CE level for paging.

[0410] The WTRU may use the determined CE level to determine the number of aggregation levels and/or the number of repetitions to use for one or more (E)PDCCH candidates that the WTRU may monitor and/or decode to receive a paging DCI. The WTRU may monitor and/or decode one or more (E)PDCCH candidates according to the determined number of aggregation levels and/or the number of repetitions, for example, to receive a paging DCI.

[0411] One or more (E)PDCCH candidates may be configured with a total aggregation level, *e.g.*, a same total aggregation level. The total aggregation level may correspond to a CE level, *e.g.*, a maximum CE level supported in the cell, such as the maximum CE level supported in the cell for paging.

[0412] The time and/or frequency location of the (E)PDCCH candidate or candidates may be known to a WTRU, such as a WTRU that may support enhanced coverage mode and/or that may be in enhanced coverage mode. For example, the configuration of the (E)PDCCH candidate or candidates may be signaled from broadcast signaling and/or a broadcasting channel (*e.g.*, MIB and/or MTC-SIB).

[0413] Enhanced coverage and coverage enhanced may be used interchangeably. Enhanced coverage mode and coverage enhanced mode may be used interchangeably. Enhanced coverage level and coverage enhanced level mode may be used interchangeably.

[0414] For an (E)PDCCH candidate or candidates with M repetitions, the (E)PDCCH candidate or candidates may be transmitted and/or received in M subframes. The M subframes may be M consecutive subframes or M consecutive DL subframes. The M subframes may be M consecutive subframes within the set of subframes that may be used for paging. The subframes that may be used for paging may be signaled (*e.g.*, via broadcast signaling such as via a SIB) or known. For a WTRU, the first of the M subframes may correspond to the WTRU's Paging Occasion, which may be a function of the WTRU-ID. The WTRU may combine the M repetitions to decode the (E)PDCCH candidate or candidates. The WTRU may combine a subset of the M repetitions, *e.g.*, S repetitions or the first S of the M repetitions, to decode the (E)PDCCH candidate or candidates. The WTRU may combine repetitions until it successfully decodes the (E)PDCCH candidate or candidates or until it combines all M repetitions. If the WTRU combines all M repetitions and does not successfully receive a DCI (*e.g.*, for paging), the WTRU may determine there is no page or no page for the WTRU, for example, for the current

paging cycle. If the WTRU successfully receives the DCI, the WTRU may receive or may attempt to receive the corresponding PDSCH, which may carry a paging message. Reception of a PDSCH may include receiving and/or combining repetitions of the PDSCH.

[0415] The frequency location of the (E)PDCCH candidate or candidates for paging may be determined as a function of one or more of a WTRU-ID (*e.g.*, IMSI) and/or a physical cell ID (PCI).

[0416] The frequency location of the (E)PDCCH candidate or candidates for paging may be determined as a function of the configuration of one or more downlink subbands, which may be configured for LC-MTC and/or enhanced coverage. A subband may correspond to a set of consecutive PRBs (*e.g.*, six consecutive PRBs) located within a system bandwidth. When multiple subbands are configured, the subbands may be partially or fully overlapped. The subbands may be mutually orthogonal in the frequency domain. One or more subbands may be used for an (E)PDCCH candidate or candidates for paging. The subband that may be used for or by a WTRU may be a function of one or more of WTRU-ID, PCI, and/or DL system bandwidth.

[0417] Subband configuration, *e.g.*, for an (E)PDCCH candidate or candidates and/or PDSCH for paging may be provided (*e.g.*, by a cell or eNB) in signaling such as broadcast signaling, for example in system information (*e.g.,* in one or more SIBs).

[0418] A WTRU may determine a subband to use for an (E)PDCCH candidate or candidates and/or PDSCH for paging from one or more of a subband configuration provided, a number of subbands configured, paging cycle, PF, PO, SFN, PCI, DL system bandwidth, and/or WTRU-ID. The WTRU may determine the subband to use for a PO, a starting subframe of a PO, and/or a subframe corresponding to a repetition of an (E)PDCCH candidate and/or PDSCH of a PO. The frequency location of the (E)PDCCH candidate or candidates for paging may be predefined or known. A certain subband index (*e.g.*, the first subband) may be used for an (E)PDCCH candidate or candidates for paging if one or more downlink subbands are configured. A starting PRB index for the paging subband may be defined or determined as a function of one or more of downlink system bandwidth, subframe number, frame number, physical cell ID, and/or WTRU-ID. WTRU-ID may be a WTRU IMSI.

[0419] For purposes of description and explanation, the terms paging channel, paging message, and paging information may be used interchangeably.

[0420] A PDSCH may carry a paging message. A PDSCH carrying a paging message (*e.g.*, PCH) for a WTRU that supports or that may be in enhanced coverage mode may be scheduled from an associated (E)PDCCH. A WTRU may monitor or decode a DCI that may be masked with a paging RNTI from the associated (E)PDCCH. The paging message may be intended for a

single WTRU or multiple WTRUs. The paging message may include a system information modification indication. The DCI may include the system information modification indication. For example, a bit or bit field in the DCI may indicate whether the system information has been changed or will be changed (*e.g.*, at the start of the next system information modification period). The bit or bit field may be or include an indication of yes or no or an indication of true or false. The bit field may be or may be used for a value tag, *e.g.*, systemInfoValueTag.

[0421] The DCI may carry one or more of the following information. The DCI may carry a frequency location of the PDSCH (*e.g.*, subband index or starting PRB). The DCI may carry a time location of the PDSCH (*e.g.*, a starting subframe location). The DCI may carry TBS or TBS candidates. The DCI may carry a modulation order. The DCI may carry the repetition number of the associated PDSCH (*e.g.*, P).

[0422] A WTRU may decode and/or receive the PDSCH if the WTRU receives a DCI that may be masked with a paging RNTI. The paging RNTI may be intended for the WTRU. A paging RNTI may be intended for a WTRU if it is intended for a WTRU or WTRUs of a certain type and the WTRU is of that type. For example, the paging RNTI may be intended for WTRUs supporting or in coverage enhanced mode.

[0423] A paging RNTI, for example, for a WTRU of a certain type, may be a function of one or more of a paging cycle, PF, PO, the number of POs per PF, SFN, WTRU-ID, and/or the number of repetitions that may be used for the (E)PDCCH candidates for paging. This may enable repetitions of a DCI beginning in the subframe of a first PO to be repeated in the subframe of a second PO (*e.g.*, in the same frame) without confusing WTRUs that may be looking for a DCI beginning in the second PO.

[0424] The PDSCH may be transmitted repetitively over multiple subframes (*e.g.*, P subframes). The P subframes may be continuous or consecutive within the subframes used for paging transmission. The P subframes may be discontinuous within the subframes used for paging transmission.

[0425] One or more P values may be used to support one or more CE levels. For example, P = {N1, N2, N3} may be used, where P values are positive integer numbers and $N1 < N2 < N3$. A different P value may be used according to the CE level. The P values may be predefined, *e.g.*, for each CE level supported by the cell. The P values, *e.g.*, for each CE level supported by the cell, may be indicated from a broadcasting channel (*e.g.*, SIB). The CE level or the P value that may be used for transmission of the PDSCH carrying a paging message may be indicated from (or by) the associated (E)PDCCH (*e.g.*, in the DCI). Three values of P are used for exemplary purposes. Another value may be used and still be consistent with this disclosure.

[0426] A starting subframe for a PDSCH carrying a paging message, for example, in a paging cycle or corresponding to a PO, may be the same regardless of the P value. For example, the PDSCH with P = N1 and the PDSCH with P = N2 may have the same starting subframe. The end subframe may be different.

[0427] A WTRU may start to receive the PDSCH with a smallest P value (*e.g.*, N1) and may move to a next level (*e.g.*, a next highest P value, N2) if the WTRU fails to receive the PDSCH carrying the paging message until it may reach a maximum P value (*e.g.*, N3). The WTRU may stop combining repetitions if it successfully receives the PDSCH prior to combining all P repetitions of a level (*e.g.*, N1, N2, or N3).

[0428] A WTRU may receive the PDSCH with a corresponding P value indicated from the associated (E)PDCCH. A WTRU may receive the PDSCH by combining repetitions up to the P value indicated from the associated (E)PDCCH. The WTRU may stop combining repetitions if it successfully receives the PDSCH prior to combining all P repetitions. A WTRU may receive the PDSCH with a P value associated with a current CE level, which may be determined based on a downlink measurement.

[0429] Each P value may be associated with a certain (*e.g.*, separate, unique, or different) paging RNTI. A WTRU may implicitly determine the P value from the paging RNTI when the WTRU receives a DCI that may be masked with a certain paging RNTI. For example, a first P-RNTI may be associated with a first P value (*e.g.*, N1) and a second P-RNTI may be associated with a second P value (*e.g.*, N2), and so on. When checking for a page, *e.g.*, in a PO or its PO, a WTRU may check for a CRC scrambled with one or more of the P-RNTIs. If such a CRC is found, the WTRU may use that P-RNTI to determine the P value with which the PDSCH may be transmitted. The association may be between a P-RNTI and a CE level. The CE level may be associated with the P value. One or more of the associations may be predefined, known, or provided in signaling, such as broadcast signaling. The paging RNTI for each CE level for paging may be a function of the number of CE levels (or the maximum CE level) supported by the eNB or cell. The WTRU may determine the paging RNTI for each CE level based on the number of CE levels (or the maximum CE level) supported by the eNB or cell which may be provided via broadcast signaling such as in a MIB (*e.g.*, PBCH) or SIB.

[0430] A starting subframe of a PDSCH carrying a paging message (*e.g.*, if the PDSCH is transmitted over P subframes repetitively) may be determined as a function of the last subframe of the associated (E)PDCCH. For example, if the last subframe of the associated (E)PDCCH is the subframe n, the starting subframe may be the subframe n+k, where k may be, for example, a gap value G. The subframe n may be the last subframe of a certain (E)PDCCH candidate. If a

different number of repetitions is used for two or more (E)PDCCH candidates, the subframe n may be different according to the (E)PDCCH candidate. The subframe n may be the last subframe of an (E)PDCCH candidate that may have a largest number of repetitions. The value of n may be the same regardless of the (E)PDCCH candidate in which a WTRU may receive a DCI that may be masked with a paging RNTI or that may carry a scheduling information of the PDSCH. The value of k may be determined based on the (E)PDCCH candidate and/or the number of repetitions for an (E)PDCCH candidate.

[0431] (E)PDCCH carrying a DCI masked or scrambled with a P-RNTI that may be intended for a WTRU that may be in CE mode may be transmitted with M repetitions. The value of M may be independent of the CE level of the WTRU. The WTRU may combine one or more repetitions of the EPDCCH up to the maximum of M repetitions to attempt to receive a DCI scrambled with a P-RNTI, *e.g.*, beginning in its PO. The DCI may implicitly or explicitly identify the number of repetitions, P, with which the PDSCH carrying the PCH may be transmitted. If the WTRU successfully receives the DCI, the WTRU may receive and/or may combine up to P repetitions of the PDSCH to receive the page. If the WTRU successfully receives the page and the page is intended for the WTRU (or the WTRU determines that a page intended for the WTRU is included in the paging message), the WTRU may respond, for example, by performing a random access procedure and/or requesting connection establishment for an incoming call. If the WTRU does not successfully receive the DCI, the WTRU may assume there is no page for the WTRU and the WTRU may sleep, for example, until its next PO. If the WTRU successfully receives the DCI and the value of P is lower than what the WTRU determines it needs to receive the PDSCH, the WTRU may not attempt to receive the PDSCH, for example, in order to save battery power. If the WTRU successfully receives the DCI and does not successfully receive the PDSCH after combining the P repetitions, the WTRU may determine its CE level to be higher than that which uses P repetitions and may save that information for use for a next or later PO.

[0432] A WTRU, such a WTRU in coverage enhancement mode, may receive (E)PDCCH carrying a DCI masked or scrambled with an RNTI such as a paging RNTI (*e.g.*, P-RNTI, PCE-RNTI, or another RNTI). The DCI may include an indication that system information (*e.g.*, one or more SIBs) has changed or will change. The indication may be in the form of a bit or bit field. The indication may have a value of True to indicate system information has changed or will change. The indication may be, for example, in the form of a value or a value tag that the WTRU may compare to a previously stored value or value tag. If the value or value tag is different from the previous or stored value tag, the WTRU may understand or infer that one or more SIBs has

changed or will change. If the DCI includes an indication (*e.g.*, a positive indication) regarding or related to system information change, there may not be a PDSCH associated with the DCI and/or the WTRU may not receive or attempt to receive a PDSCH that may be associated with the DCI. The WTRU may receive one or more SIBs (*e.g.*, after the start of the next SIB modification period) to acquire the updated system information, for example, if the indication indicates that system information has been or will be updated.

[0433] If the DCI (*e.g.*, DCI for paging and/or system information update) positively indicates a system information change (*e.g.*, has occurred or will occur), there may be no PDSCH associated with the DCI. If the DCI (*e.g.*, DCI for paging and/or system information update) does not indicate a (*e.g.*, any) system information change or indicates no system information change, there may be a PDSCH associated with the DCI.

[0434] A DCI or DCI format may be used to page or address one or more WTRUs and/or indicate that system information has been or will be updated. The update may occur at or before the start of the next system information modification period. The DCI format may be transmitted with or without an associated PDSCH that may carry a paging message or paging information. The DCI format may include an indication as to whether or not there may be an associated PCH or PDSCH. If the DCI format indicates that there is no associated PCH or PDSCH, one or more (*e.g.*, all) the parameters related to the PDSCH, *e.g.*, the scheduling parameters for the PDSCH, may not be included in the DCI or the parameters may be fixed values (*e.g.*, zeroes) or ignored. The DCI format may be carried by a PDCCH or EPDCCH which may be in CSS. For purposes of illustration and description, DCI and DCI format may be used interchangeably. The DCI format for system information update (*e.g.*, system information update without a paging message or WTRU-specific paging message or record) may be separate or different from the DCI format for paging (*e.g.*, for paging with an associated PCH or PDSCH).

[0435] A WTRU that receives the DCI format may receive or may attempt to receive an associated PDSCH if (*e.g.*, only if) the DCI format indicates an associated PDSCH (*e.g.*, that may carry a paging message) and/or the DCI format corresponds to a DCI format with an associated PDSCH (*e.g.*, that may carry a paging message).

[0436] The DCI format may be intended for use by and/or may be used by WTRUs in connected mode and/or idle mode. The DCI format may be intended for use by and/or may be used by WTRUs that may be in coverage enhanced mode and/or that may be reduced bandwidth WTRUs. The control channel (*e.g.*, PDCCH and/or EPDCCH) that may carry the DCI format and/or the DCI format may be repeated M-SI times or up to M-SI times. The value of M-SI may correspond to the maximum CE level supported by the cell. The value of M-SI may be provided

in broadcast signaling such as system information, *e.g.*, in a SIB which may be intended for use by and/or may be used by WTRUs which may be in coverage enhanced mode and or which may be reduced bandwidth WTRUs. The value of M-SI may be separate from and/or different from the number of repetitions that may be used for a DCI that may be for paging and/or may not indicate a system information update. The value of M-SI may be chosen by the eNB to correspond to the highest CE level (or number or repetitions) that may be needed by its connected mode WTRUs. A WTRU may combine up to M-SI repetitions to receive or successfully receive the DCI format.

[0437] The DCI format may include one or more system information update indications. A system information update indication may indicate update of one or more of: SIBs or system information that may be associated with a value tag; SIBs or system information that may be associated with ETWS; SIBs or system information that may be associated with CMAS; and/or SIBs or system information that may be associated with EAB parameters.

[0438] The CRC of a DCI format that may include one or more system information update indications (*e.g.*, one or more positive indications or one or more indications set to yes or true) may be scrambled with an RNTI that may be different from an RNTI that may be used to scramble the CRC of a DCI format that may not include a system information update indication (*e.g.*, a positive indication or an indication set to yes or true).

[0439] There may be a separate DCI format and/or RNTI for system information update indications to idle mode WTRUs and connected mode WTRUs.

[0440] The RNTI for a DCI format for system information update may be different from the RNTI for a DCI format for paging (*e.g.*, WTRU-specific paging). A separate or different RNTI may be provided and/or used for one or more of a DCI format for system information update, *e.g.*, only; a DCI format for positive system information update and paging (*e.g.*, indicating associated paging PDSCH); and/or a DCI format for paging (*e.g.*, indicating associated paging PDSCH) without a system information update or positive system information update. A WTRU may monitor for one or more of the RNTIs, *e.g.*, in or according to its PO.

[0441] The schedule for a PDCCH, EPDCCH, and/or DCI format that may carry a system information update indication may be separate from the schedule for a PDCCH, EPDCCH, and/or DCI format associated with paging messages. AWTRU may determine a PO per PC to monitor for paging messages. A WTRU may determine and/or may use another schedule for monitoring for system information updates. The occasions for system information updates may be referred to as system information update occasions (SIUOs). An idle mode WTRU may monitor its PO for paging messages (*e.g.*, for the PDCCH, EPDCCH, DCI format, and/or

PDSCH for paging messages). An idle mode and/or connected mode WTRU may monitor SIUOs for system information updates. SIUOs for idle and connected mode WTRUs may be different. A WTRU may monitor for an RNTI for paging in its PO. A WTRU may monitor for an RNTI for system information update in a SIUO. When a PO and SIUO coincide, a WTRU may monitor for a paging and/or a system information update RNTI.

[0442] Following receipt of a system information update indication, a WTRU may acquire the associated system information or one or more SIBs. For some SIBs, *e.g.*, value tag SIBs, the WTRU may wait until the start of the next system information modification period to acquire the SIBs.

[0443] A DCI format may be transmitted by the eNB and/or received by the WTRU in PDCCH or EPDCCH.

[0444] System information and/or a paging configuration may be updated. Configuration information for and/or related to paging may be carried in or at least in a broadcast signaling channel and/or system information, such as in a SIB, *e.g.*, MTC-SIB. Configuration information, for example, for paging, may include configuration information for an (E)PDCCH that may be used to carry a scheduling information of a PDSCH that may carry a paging message. Configuration information, for example, for paging, may include the number of repetitions M for an (E)PDCCH that may be used to carry a scheduling information of a PDSCH that may carry a paging message. Configuration information, for example for paging, may include one or more parameters that may be used for (E)PDCCH and/or PDSCH reception, for example, for paging. Configuration information may include, but is not limited to, a CE level, a maximum CE level, a number of repetitions, and/or a maximum number of repetitions. Configuration information, for example, for paging, may include PDSCH configuration and/or one or more P values that may be used for reception of PDSCH, which may carry a paging message.

[0445] An MTC-SIB may be transmitted and/or may be used if the PBCH or MIB indicates the support of low-cost WTRU and/or enhanced coverage WTRU. There may be one or more MTC-SIBs. An MTC-SIB may be intended for, received by, and/or used by one or more WTRUs that may be a certain type of WTRU. The certain type may be one or more of: MTC-WTRU, LC-MTC-WTRU, reduced BW WTRU, a WTRU supporting coverage enhancements, and/or a WTRU in coverage enhanced mode.

[0446] A first MTC-SIB (*e.g.*, MTC-SIB-0) may be transmitted in a known or determined time and/or frequency location. The time and/or frequency location may be determined, *e.g.*, by the WTRU, based on at least one or more of the system parameters acquired from MIB (*e.g.*, SFN, DL system bandwidth) and/or physical cell-ID.

[0447] The first MTC-SIB (*e.g.*, MTC-SIB-0) may carry an indication of system information modification (*e.g.*, systemInfoValueTag). The first MTC-SIB may carry one or more of the following for the second MTC-SIB (and/or subsequent MTC-SIB(s)): (i) scheduling information (*e.g.*, schedule in time), (ii) a TBS size, (iii) a modulation order, (iv) a repetition cycle (or CE level or repetition number), and/or (v) a frequency location.

[0448] The first MTC-SIB may have one or more properties, for example the first MTC-SIB may have a fixed TBS size. A zero-padding may be used if the actual payload size is smaller than the fixed TBS size. The first MTC-SIB may have a fixed modulation order. For example, QPSK may be used. The first MTC-SIB may be used for system information modification indication and scheduling information for the subsequent (*e.g.*, second) MTC-SIB. For example, the first MTC-SIB may only be used for system information modification indication and scheduling information for the subsequent MTC-SIB. The first MTC-SIB may be transmitted periodically.

[0449] A WTRU, such a WTRU in coverage enhancement mode, may receive the first MTC-SIB, for example, if the WTRU needs to check whether the system information has been or will be updated before it monitors or receives the paging signals. If the first MTC-SIB indicates that the system information has been updated or will be updated prior to the WTRU's PO, the WTRU may receive the subsequent MTC-SIBs (*e.g.*, after the start of the next SIB modification period) to acquire the updated system information, for example, at least related to the paging configuration. If the WTRU cannot acquire the SIBs, *e.g.*, at least the SIBs related to paging, prior to its PO, the WTRU may skip monitoring its PO for paging (*e.g.*, skip monitoring (E)PDCCH for paging), for example, until after it successfully receives the SIBs.

[0450] Techniques for reuse of the P-RNTI (*e.g.*, legacy P-RNTI) may be provided. For example, there may be limited space in CSS, which may make it difficult to page WTRUs (*e.g.*, legacy WTRUs and CE mode WTRUs).

[0451] P-RNTI may be used for CE paging and non-CE paging, for example, without overlap or collision when paging coverage limited WTRUs and non-coverage limited WTRUs.

[0452] PDCCH that may be associated with PDSCH that may carry PCH may be transmitted and/or received in a common search space (CSS). A WTRU may monitor for P-RNTI in CSS.

[0453] PDCCH for CE mode WTRUs may be repeated M times. The same PDCCH may be repeated for one or more of the M times. The same PDCCH may be repeated for each of the M times. One or more (*e.g.*, and possibly all) of the repetitions may be located in the same place, *e.g.*, the same place in the CSS. There may be a gap G that may follow the PDCCH repetitions.

The corresponding PDSCH may follow after the gap and may be repeated P times. P and M may be the same or different values.

[0454] A PDCCH may grant or point to one or more PDSCHs (*e.g.*, in a current or future subframe) which may carry PCH with a certain location and/or with certain parameters or properties (*e.g.*, MCS, *etc.*). A current subframe may be the same subframe as the PDCCH providing the grant. A future subframe may be a subframe after or later than the subframe of the PDCCH providing the grant.

[0455] In the M subframes in which the PDCCH may be transmitted, there may or may not be a corresponding PDSCH. A CE mode WTRU may not look for a PDSCH until after the M repetitions of the PDCCH and after it may successfully receive the PDCCH from combining the (*e.g.*, M) PDCCH repetitions. A non-CE mode and/or legacy WTRU, however, may look for a corresponding PDSCH in one or more (*e.g.*, each) of the M subframes in which there may be a P-RNTI. The PDSCH in these subframes may be used to page non-CE mode and/or legacy WTRUs according to non-CE mode and/or legacy rules. The PDSCHs (*e.g.*, all the PDSCHs) in these subframes may have the same location and parameters. The PDSCHs in these subframes may have the same location and parameters as the PDSCHs that may be repeated P times for a CE mode WTRU after the gap.

[0456] In the subframes of the gap and the P PDSCH subframes for the CE mode WTRU, the CE mode WTRU may not look for or expect a P-RNTI. P-RNTI may be used in those subframes for non-CE mode and/or legacy WTRUs. A PDCCH that may use P-RNTI in those subframes may be used in a non-CE mode and/or legacy manner. In those subframes, the PDCCH that may use P-RNTI may change from subframe to subframe and the PDCCH may point to a PDSCH in a different location and/or with different parameters. The PDCCH that may use P-RNTI in those subframes may not point to a PDSCH in a location that may overlap a PDSCH that may be used by or for CE mode WTRUs.

[0457] A DRX cycle may be provided and/or used. A DRX cycle may not be suitable or sufficient for CE mode WTRUs. DRX and paging cycle may be used interchangeably.

[0458] The DRX or paging cycle for a CE mode WTRU may be the longer of a WTRU specific signaled value and a default value such as the legacy default value. The DRX or paging cycle for a CE mode WTRU may be a CE mode DRX value, which may be cell-specific and may be provided in broadcast signaling, such as system information. The DRX or paging cycle for a CE mode WTRU may be the shorter or longer of a WTRU specific signaled value (*e.g.*, which may be specific to CE mode) and a cell specific value. The DRX or paging cycle for a CE mode WTRU may be independent of WTRU ID and/or IMSI.

[0459] The DRX or paging cycle for CE mode WTRUs may be a function of one or more of the default DRX or paging cycle (*e.g.*, a multiple of it); the legacy DRX or paging cycle (*e.g.*, a multiple of it); the CE level; and/or the number of repetitions of the paging PDCCH and/or PDSCH (*e.g.*, M and/or P) and or the gap (*e.g.*, G) between them.

[0460] Paging may be provided for and/or used by WTRUs that may be bandwidth limited. An eNB that may page or that may intend to page a WTRU may or may not know that the WTRU may be a limited bandwidth WTRU and may or may need to page the WTRU in a way in which the WTRU may receive the page.

[0461] An eNB that may support limited bandwidth WTRUs may or may always page certain WTRUs (*e.g.*, all WTRUs or limited bandwidth WTRUs) in a bandwidth in which limited bandwidth WTRUs may receive the PDSCH (*e.g.*, in or within N RBs such as the center N RBs, where N may be 6).

[0462] For paging a WTRU, such as one that may be a limited bandwidth WTRU, an eNB may use an EPDCCH for the control channel associated with a paging PDSCH (*e.g.*, a PDSCH that may carry PCH), for example, since a PDCCH may not (or may not be able to) be located in a limited bandwidth.

[0463] An eNB, for example one that may not know if a WTRU it may page or intend to page may be a limited bandwidth WTRU, may page the WTRU using PDCCH (*e.g.*, which may not be in a limited bandwidth) and EPDCCH (which may be in a limited bandwidth). The PDCCH and the EPDCCH may be associated with the same PDSCH and the grant that the PDCCH and/or EPDCCH may provide may be the same with respect to at least some (*e.g.*, all) parameters such as one or more of the grant size (*e.g.*, in RBs), grant location, and MCS, among others.

[0464] The PDCCH may be masked with P-RNTI or another paging RNTI that may be used by at least limited bandwidth WTRUs. The EPDCCH may be masked with P-RNTI or another paging RNTI that may be used by at least limited bandwidth WTRUs.

[0465] A WTRU that may be bandwidth limited may monitor EPDCCH in its PO. If the WTRU may receive (*e.g.*, successfully receive) an EPDCCH that may be masked with P-RNTI or a (*e.g.*, another) paging RNTI that may be used by at least limited BW WTRUs, the WTRU may receive or attempt to receive the associated (*e.g.*, granted) PDSCH that may carry PCH. If the PCH may include a page for the WTRU, the WTRU may respond to the page.

[0466] For a WTRU which may be both coverage limited and bandwidth limited, the eNB may apply one or more of the examples disclosed herein for paging a WTRU that may be coverage limited where the PDSCH repetitions which may carry the PCH and/or the associated

EPDCCH repetitions may be located within the limited bandwidth, which may be received by a limited bandwidth WTRU.

[0467] If an eNB may not know if a WTRU may be reduced BW, the eNB may try paging the WTRU as a full bandwidth WTRU one or more times and if unsuccessful may then try to page the WTRU as a limited bandwidth WTRU.

[0468] Paging a WTRU as a full bandwidth WTRU may include using PDCCH for the control channel (*e.g.*, which may be masked with P-RNTI or another paging RNTI), which may be associated with a PDSCH which may carry PCH.

[0469] Paging a WTRU as a limited bandwidth WTRU may include paging the WTRU in accordance with one or more of the examples disclosed herein for limited bandwidth WTRUs such as using EPDCCH and/or limiting the EPDCCH and/or paging PDSCH to locations within the limited bandwidth.

[0470] One or more examples described herein for RAR transmission and/or reception may be applied to PCH transmission and/or reception, for example, for PCH that may be or may be intended for a WTRU that may be bandwidth limited and/or coverage limited.

[0471] An eNB may page a WTRU that may be bandwidth limited and/or coverage limited without the use of a control channel, such as PDCCH or EPDCCH.

[0472] The POs and/or PFs in which a paging PDSCH (*e.g.*, one that may carry PCH) may be located may be known (*e.g.*, by calculations and/or parameters such as legacy and/or new calculations and/or parameters). The grant parameters for the paging PDSCH may be known (*e.g.*, fixed or signaled). Paging PDSCH for limited bandwidth WTRUs may be less often than paging PDSCH for full bandwidth WTRUs.

[0473] In a subframe or PO that may include a PCH intended for a WTRU that may be a bandwidth limited and/or coverage limited WTRU, the WTRU may attempt to receive a paging PDSCH using the known location and/or parameters. The WTRU may determine if it may receive the paging PDSCH successfully based on the CRC of the PDSCH. If the WTRU may successfully receive a PCH that it may determine to be intended for it, the WTRU may respond to the page.

[0474] For a WTRU that may be in CE mode, the WTRU may combine multiple repetitions of the paging PDSCH, which may be in the same location (*e.g.*, in at least frequency resources) and may use the same parameters for one or more (*e.g.*, each) of its repetitions, before attempting to successfully receive the PCH from the PDSCHs. For a WTRU that may be in CE mode but may not be bandwidth limited, the location of the PDSCHs may not be limited to being in or within the limited bandwidth. For a WTRU that may be bandwidth limited or that may behave

like a bandwidth limited WTRU, the location of the PDSCHs may be limited to being in or within the limited bandwidth.

[0475] A location (*e.g.*, time and/or frequency resources) of a PDSCH that may be used for paging and/or parameters (*e.g.*, coding/decoding parameters such as MCS) of the PDSCH may be signaled by the eNB to the WTRU using dedicated signaling and/or broadcast signaling (*e.g.*, in system information or in one or more SIBs). The location (*e.g.*, time and/or frequency resources) and/or certain parameters may be fixed or known (*e.g.*, by specification).

[0476] The processes and instrumentalities described herein may apply in any combination, may apply to other wireless technologies, and for other services.

[0477] A WTRU may refer to an identity of the physical device, or to the user's identity such as subscription related identities, *e.g.*, MSISDN, SIP URI, *etc.* WTRU may refer to application-based identities, *e.g.*, user names that may be used per application.

[0478] The processes described above may be implemented in a computer program, software, and/or firmware incorporated in a computer-readable medium for execution by a computer and/or processor. Examples of computer-readable media include, but are not limited to, electronic signals (transmitted over wired and/or wireless connections) and/or computer-readable storage media. Examples of computer-readable storage media include, but are not limited to, a read only memory (ROM), a random access memory (RAM), a register, cache memory, semiconductor memory devices, magnetic media such as, but not limited to, internal hard disks and removable disks, magneto-optical media, and/or optical media such as CD-ROM disks, and/or digital versatile disks (DVDs). A processor in association with software may be used to implement a radio frequency transceiver for use in a WTRU, UE, terminal, base station, RNC, and/or any host computer.

CLAIMS

What is Claimed:

1. A method for providing communication in a network, the method comprising:

transmitting a preamble using a physical random access channel (PRACH);

determining a location of a random access response (RAR) based on a parameter of the PRACH, the location comprising at least one of a subframe or a frequency resource on which the RAR is transmitted; and

receiving the RAR at the determined location.

2. The method of claim 1, further comprising selecting a PRACH resource based on a coverage enhancement (CE) level.

3. The method of claim 2, receiving the RAR being performed within a response window determined as a function of the CE level.

4. The method of claim 1, further comprising determining a number of repetitions of the RAR based on the parameter of the PRACH.

5. The method of claim 1, the parameter of the PRACH comprising at least one of a subframe, a frequency resource on which the PRACH is transmitted, or the preamble.

6. The method of claim 5, the frequency resource on which the PRACH is transmitted comprising at least one resource block (RB).

7. The method of claim 1, the frequency resource on which the RAR is transmitted comprising at least one resource block (RB).

8. The method of claim 1, further comprising:

receiving an indication to initiate a random access procedure; and

transmitting the preamble based on the received indication.

9. The method of claim 8, the indication comprising at least one of a physical downlink control channel (PDCCH) order or a coverage enhancement (CE) level.

10. The method of claim 9, further comprising selecting a PRACH resource based on the CE level, transmitting the preamble using the selected PRACH resource, and repeating the preamble transmission based on the CE level.

11. The method of claim 1, further comprising receiving a configuration that provides the relationship between the PRACH parameter and the RAR location.

12. The method of claim 11, the configuration being received in system information.

13. A method for providing communication in a network, the method comprising:

receiving a preamble using a physical random access channel (PRACH) associated with at least one of a coverage enhancement (CE) level or a CE mode of a wireless transmit/receive unit (WTRU) from which the preamble is received;

determining a location of a random access response (RAR) based on a parameter of the PRACH, the location comprising at least one of a subframe or a frequency resource on which the RAR is to be transmitted;

determining a number of repetitions of the RAR to transmit based on the CE level or CE mode; and

transmitting the RAR at the determined location with the determined number of repetitions.

14. The method of claim 13, further comprising providing CE information regarding the WTRU to at least one of an evolved node B (eNB) device or a mobility management entity (MME) device.

15. The method of claim 14, the CE information comprising at least one of the CE level, the CE mode, or a capability of the WTRU to support the CE mode.

16. The method of claim 13, further comprising receiving CE information from a mobile management entity (MME) device.

17. A wireless transmit/receive unit (WTRU) comprising:

a transceiver; and

a processor to execute instructions to cause the WTRU to

transmit a preamble using a physical random access channel (PRACH);

determine a location of a random access response (RAR) based on a parameter of the PRACH, the location comprising at least one of a subframe or a frequency resource on which the RAR is transmitted; and

receive the RAR at the determined location.

18. The WTRU of claim 17, the processor configured to select a PRACH resource based on a coverage enhancement (CE) level.

19. The WTRU of claim 17, the processor configured to determine a number of repetitions of the RAR based on the parameter of the PRACH.

20. The WTRU of claim 17, the parameter of the PRACH comprising at least one of a subframe, a frequency resource on which the PRACH is transmitted, or the preamble.

21. The WTRU of claim 20, the frequency resource on which the PRACH is transmitted comprising at least one resource block (RB).

22. The WTRU of claim 17, the frequency resource on which the RAR is transmitted comprising at least one resource block (RB).

23. An evolved node B (eNB) device comprising:

a transceiver; and

a processor to execute instructions to cause the eNB device to

receive a preamble using a physical random access channel (PRACH) associated with at least one of a coverage enhancement (CE) level or a CE mode of a wireless transmit/receive unit (WTRU) from which the preamble is received;

determine a location of a random access response (RAR) based on a parameter of the PRACH, the location comprising at least one of a subframe or a frequency resource on which the RAR is to be transmitted;

determine a number of repetitions of the RAR to transmit based on the CE level or CE mode; and

transmit the RAR at the determined location with the determined number of repetitions.

24. The eNB device of claim 23, the processor configured to cause the transceiver to provide CE information regarding the WTRU to at least one of an evolved node B (eNB) device or a mobile management entity (MME) device.

25. The eNB device of claim 24, the CE information comprising at least one of the CE level, the CE mode, or a capability of the WTRU to support the CE mode.

26. The eNB device of claim 23, the processor configured to cause the transceiver to receive CE information from a mobile management entity (MME) device.

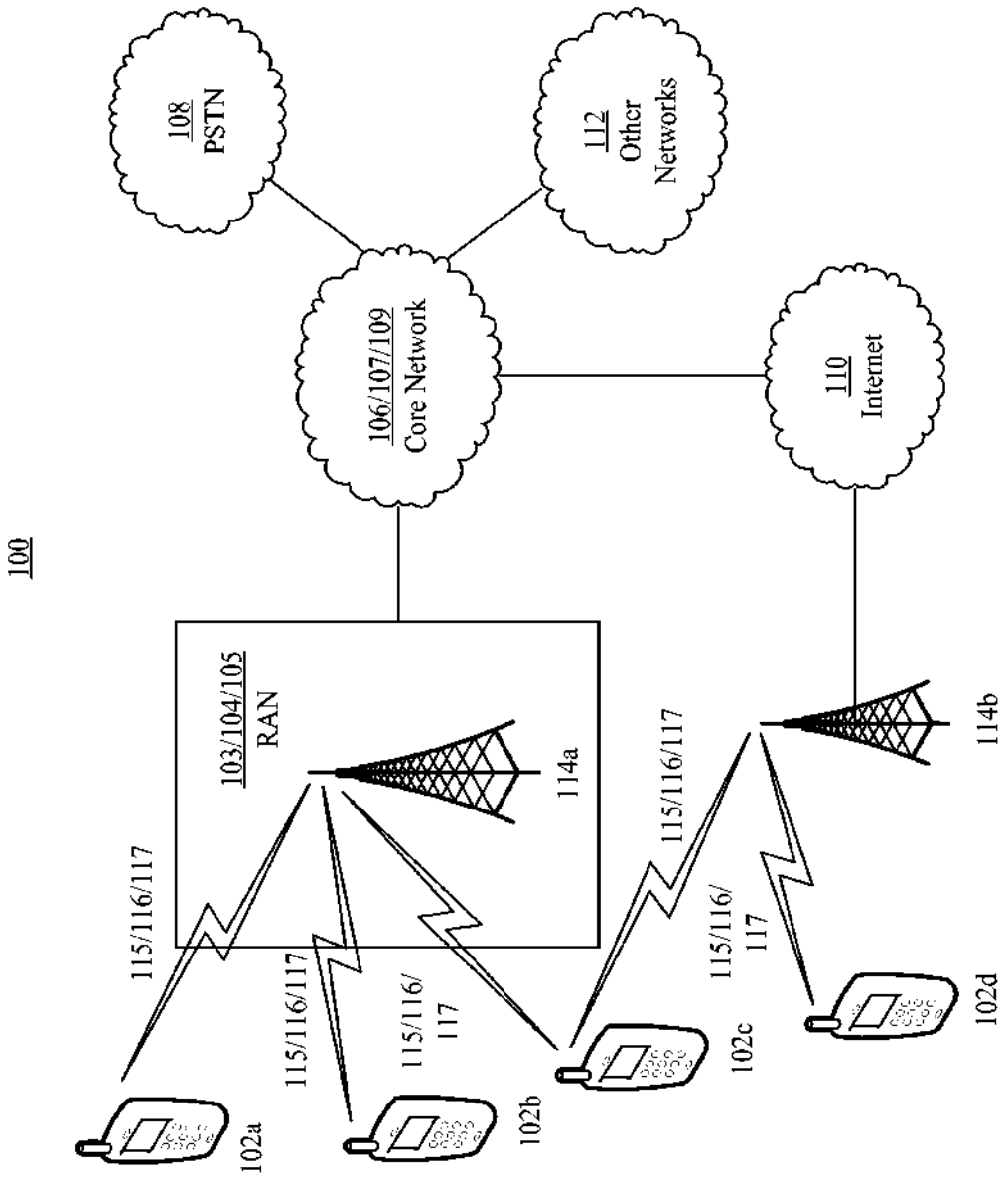

100
108
PSTN
112
Other
Networks
106/107/109
Core Network
110
Internet
103/104/105
RAN
114a
114b
115/116/117
115/116/
117
102a
102b
102c
102d

FIG. 1A

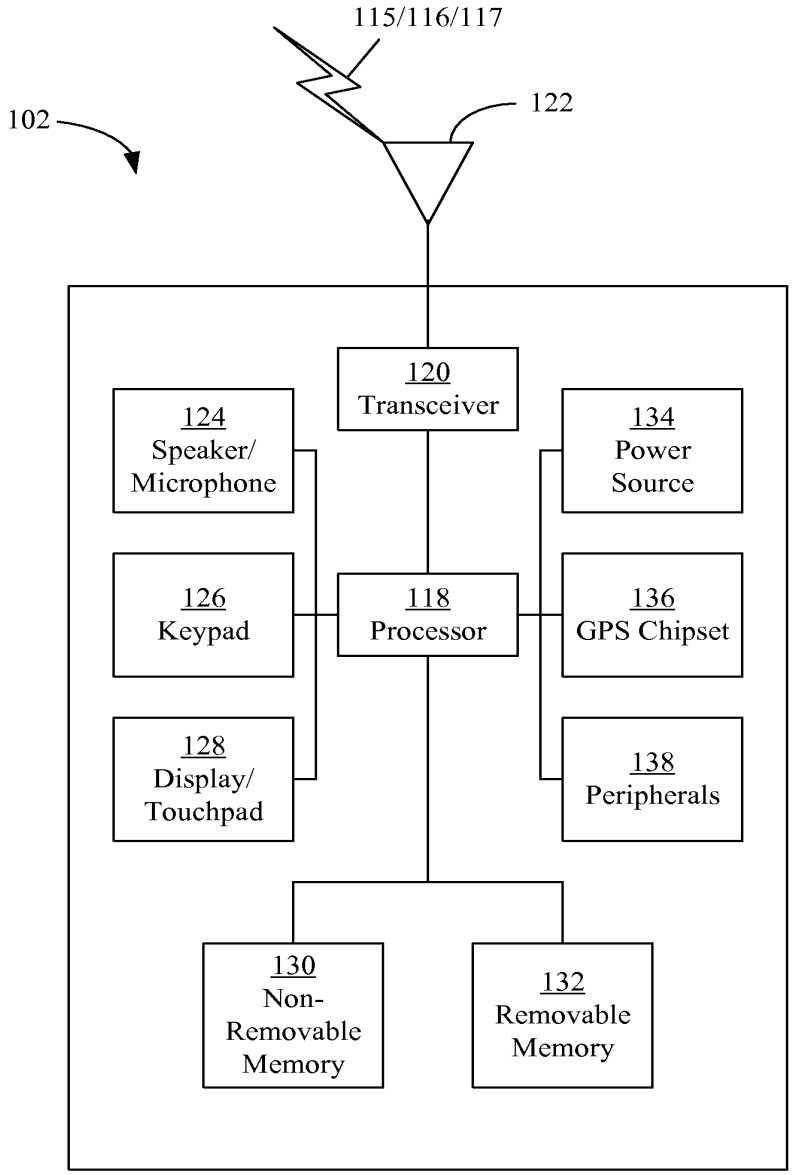

115/116/117
122
102
120
Transceiver
124
Speaker/
Microphone
134
Power
Source
126
Keypad
118
Processor
136
GPS Chipset
128
Display/
Touchpad
138
Peripherals
130
Non-
Removable
Memory
132
Removable
Memory

FIG. 1B

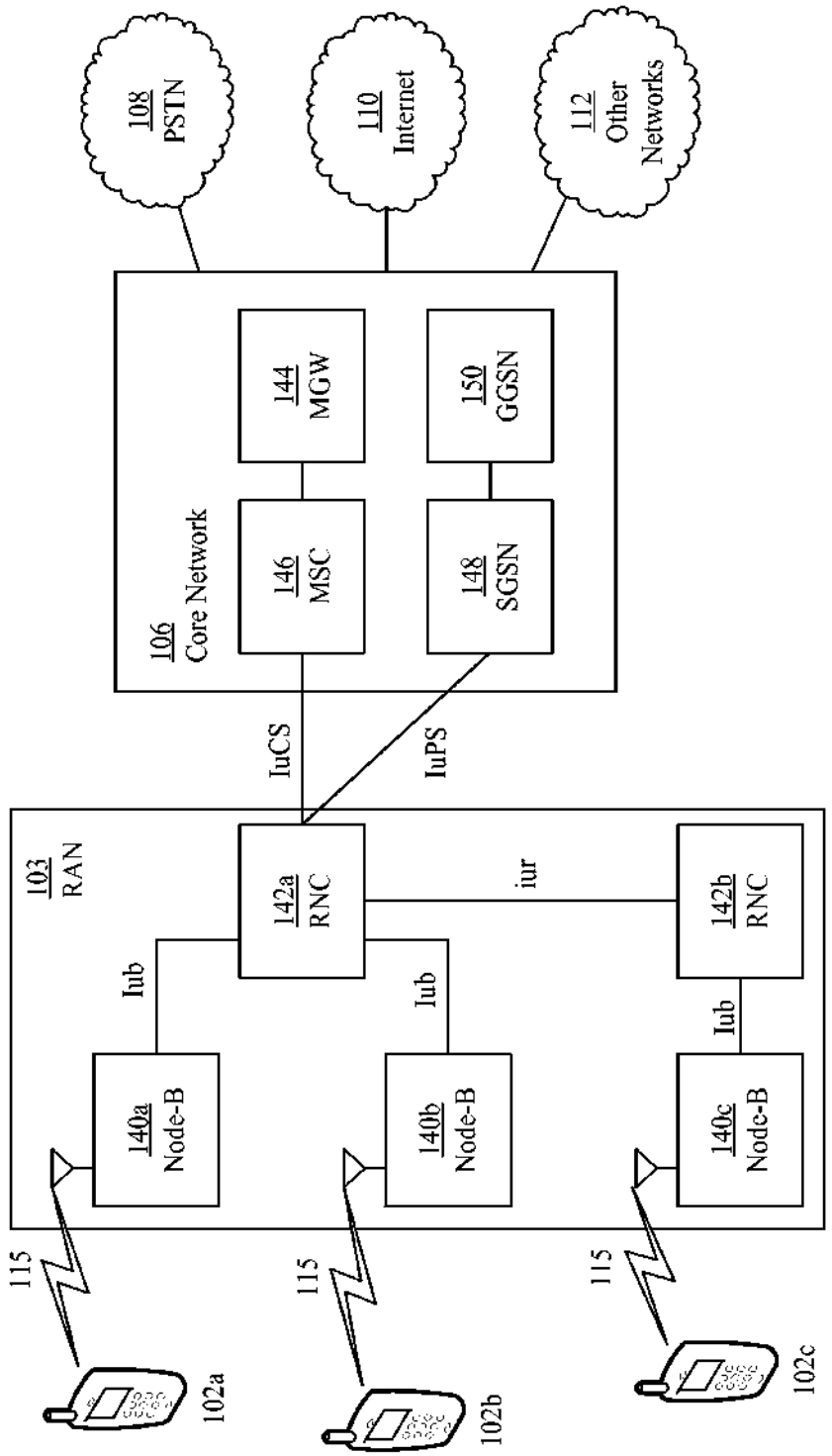

108 PSTN
110 Internet
112 Other Networks
106 Core Network
144 MGW
150 GGSN
146 MSC
148 SGSN
IuCS
IuPS
103 RAN
142a RNC
142b RNC
iur
Iub
Iub
Iub
140a Node-B
140b Node-B
140c Node-B
115
115
115
102a
102b
102c

FIG. 1C

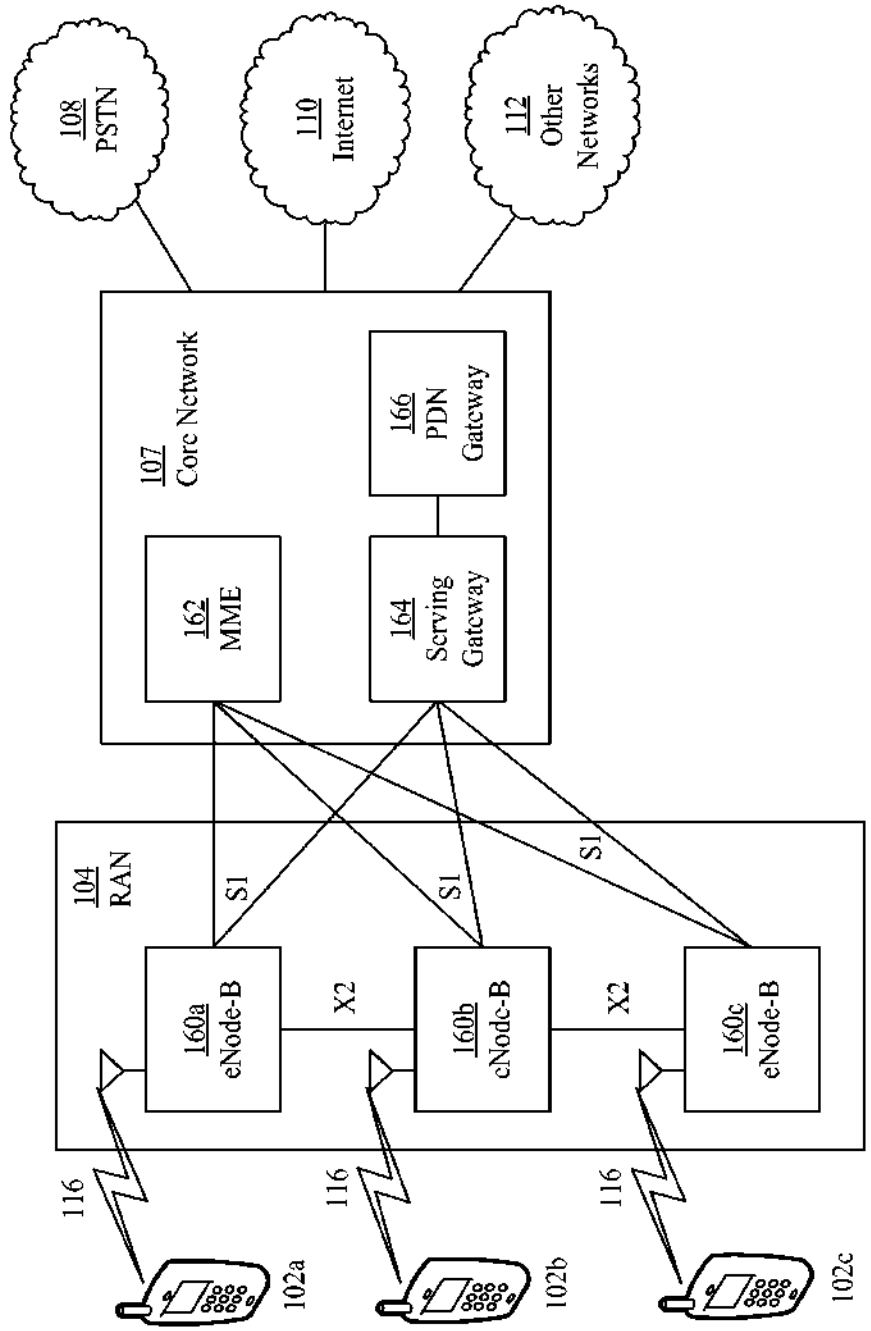

108 PSTN
110 Internet
112 Other Networks
107 Core Network
166 PDN Gateway
162 MME
164 Serving Gateway
104 RAN
S1
S1
S1
160a eNode-B
160b eNode-B
160c eNode-B
X2
X2
116
116
116
102a
102b
102c

FIG. 1D

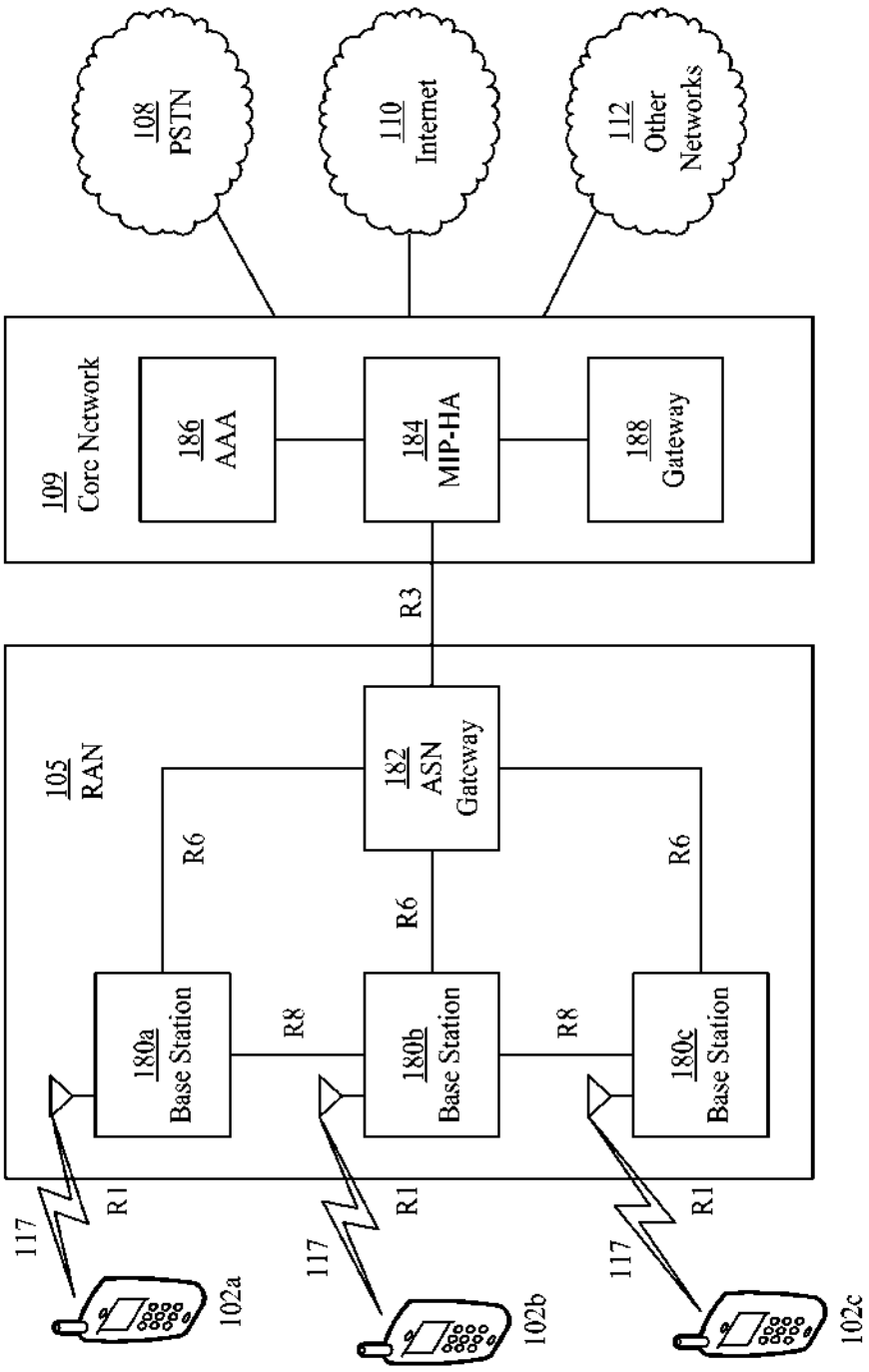

108
PSTN
110
Internet
112
Other
Networks
109
Core Network
186
AAA
184
MIP-HA
188
Gateway
R3
105
RAN
182
ASN
Gateway
R6
R6
R6
180a
Base Station
180b
Base Station
180c
Base Station
R8
R8
R1
R1
R1
117
117
117
102a
102b
102c

FIG. 1E

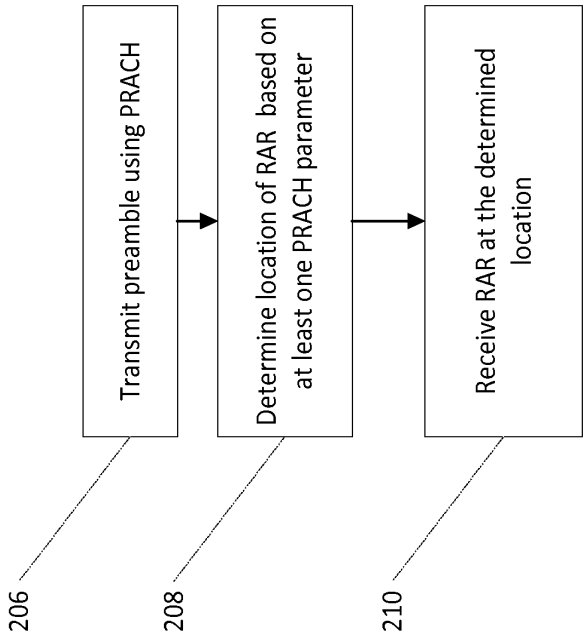

Transmit preamble using PRACH
Determine location of RAR based on at least one PRACH parameter
Receive RAR at the determined location
206
208
210

FIG. 2

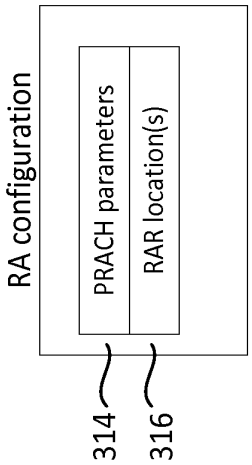

RA configuration
PRACH parameters
RAR location(s)
314
316

FIG. 3B

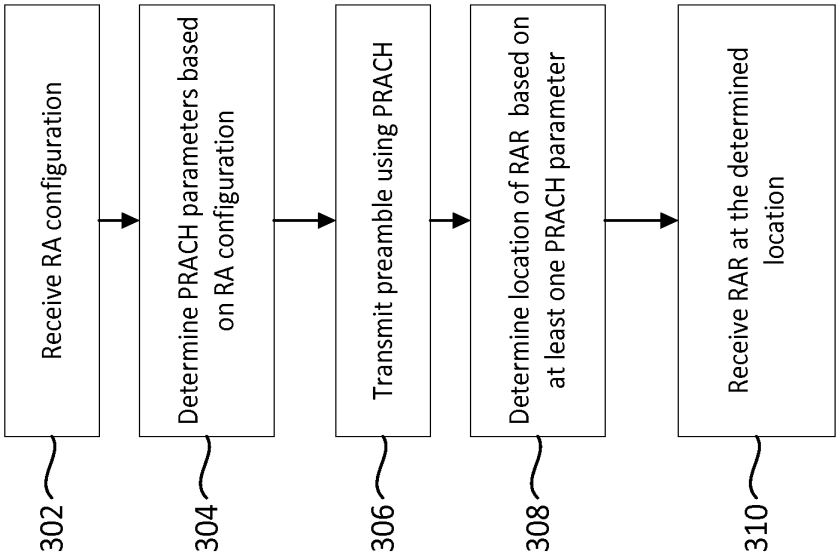

Receive RA configuration
Determine PRACH parameters based on RA configuration
Transmit preamble using PRACH
Determine location of RAR based on at least one PRACH parameter
Receive RAR at the determined location
302
304
306
308
310

FIG. 3A

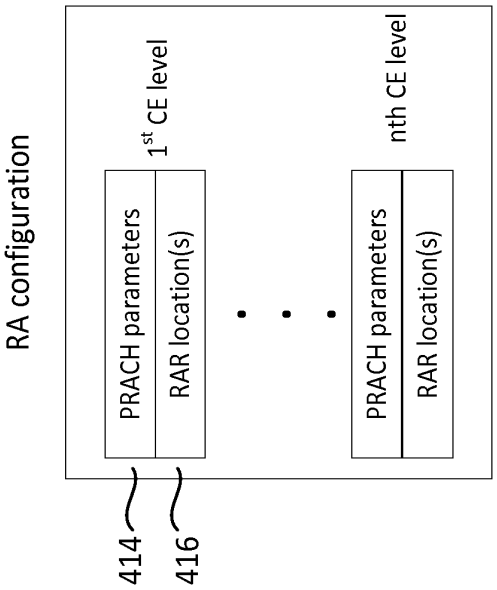

RA configuration
1st CE level
nth CE level
PRACH parameters
RAR location(s)
PRACH parameters
RAR location(s)
414
416

FIG. 4B

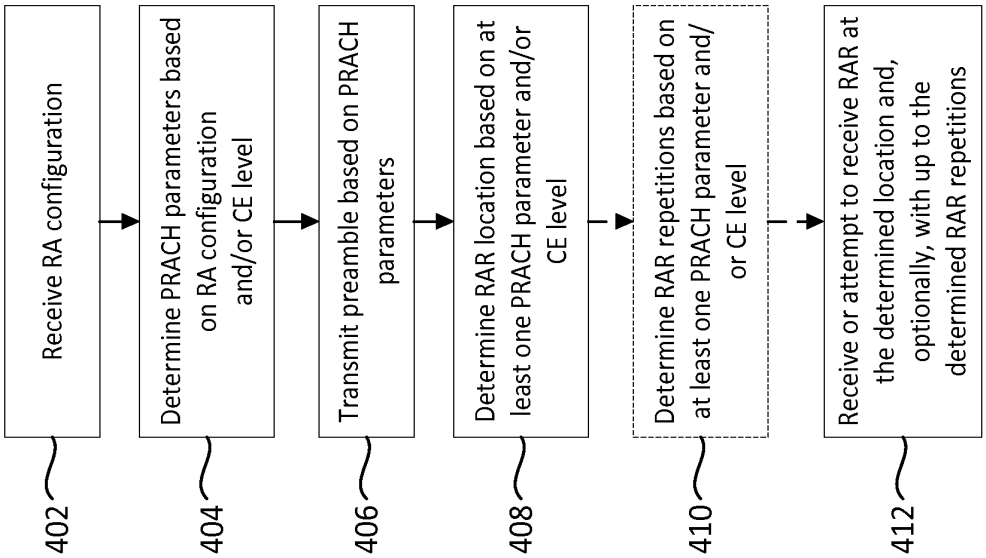

Receive RA configuration
Determine PRACH parameters based on RA configuration and/or CE level
Transmit preamble based on PRACH parameters
Determine RAR location based on at least one PRACH parameter and/or CE level
Determine RAR repetitions based on at least one PRACH parameter and/ or CE level
Receive or attempt to receive RAR at the determined location and, optionally, with up to the determined RAR repetitions
402
404
406
408
410
412

FIG. 4A

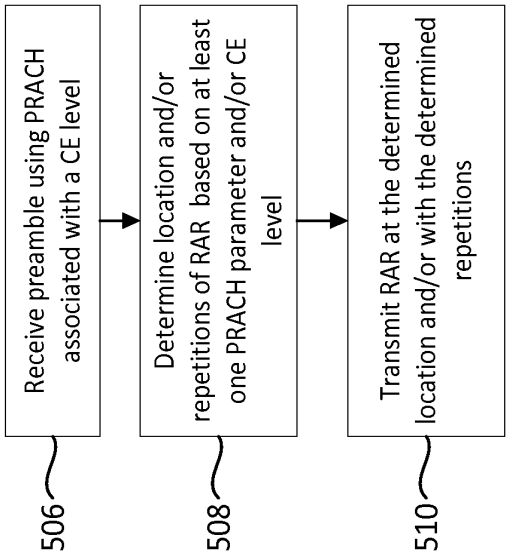

Receive preamble using PRACH associated with a CE level
Determine location and/or repetitions of RAR based on at least one PRACH parameter and/or CE level
Transmit RAR at the determined location and/or with the determined repetitions
506
508
510

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/045382

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W74/00 H04W74/08
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	NTT DOCOMO: "Discussion on Multi-level PRACH Coverage Enhancement", 3GPP DRAFT; R1-135509 PRACH_COVERAGE, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. San Francisco, USA; 20131111 - 20131115 13 November 2013 (2013-11-13), XP050735182, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN/RAN1/Docs/ [retrieved on 2013-11-13] page 2, paragraph 3 page 3, paragraphs 3.1, 3.2 page 4, paragraph 4 - page 5, paragraph 5 -/--	1-26

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents :

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 November 2015	20/11/2015

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Jurca, Dan

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/045382

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.

X	WO 2013/181808 A1 (HUAWEI TECH CO LTD [CN]; LI YUE [CN]; ZHU SONG [CN]; XIONG XIN [CN]; L) 12 December 2013 (2013-12-12) the whole document	1-26
X,P	& EP 2 849 483 A1 (HUAWEI TECH CO LTD [CN]) 18 March 2015 (2015-03-18) abstract page 5, paragraph 25-27 page 6, paragraphs 33,34,37,41,43 page 7, paragraph 55	1-26

X	US 2013/083749 A1 (XU HAO [US] ET AL) 4 April 2013 (2013-04-04)	1-12, 17-22
A	abstract page 5, paragraph 57 page 6, paragraphs 61,64-67, 69 page 7, paragraphs 72,73	13-16, 23-26

1

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2015/045382

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2013181808 A1	12-12-2013	CN 104170445 A	26-11-2014
		EP 2849483 A1	18-03-2015
		US 2015092740 A1	02-04-2015
		WO 2013181808 A1	12-12-2013
US 2013083749 A1	04-04-2013	CN 103828467 A	28-05-2014
		EP 2761962 A1	06-08-2014
		JP 5784840 B2	24-09-2015
		JP 2014531854 A	27-11-2014
		KR 20140071482 A	11-06-2014
		US 2013083749 A1	04-04-2013
		WO 2013049520 A1	04-04-2013

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13 November 2014 (13.11.2014)

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(72) Inventors: **WEBB, Matthew William**; c/o Sony European Intellectual Property, Department, Jays Close, Viables, Basingstoke Hampshire RG22 4SB (GB). **WAKABAYASHI, Hideji**; c/o Sony European Intellectual Property, Department, Jays Close, Viables, Basingstoke Hampshire RG22 4SB (GB).

(74) Agent: **LEWIS, Darren John**; D YOUNG & CO LLP, 120 Holborn, London EC1N 2DY (GB).

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[Continued on next page]

(54) Title: IDENTIFICATION OF DOWNLINK MESSAGES USING REPEATED TRANSMISSION

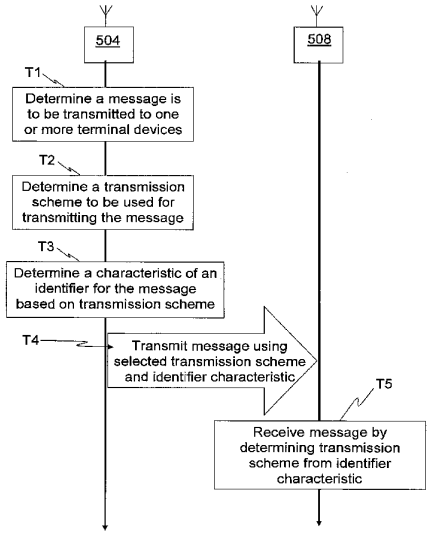


Fig. 9

(57) Abstract: A wireless telecommunication system comprises a base station arranged to communicate messages to one or more terminal devices over a radio interface. The radio interface has a radio frame structure comprising a plurality of subframes, wherein a message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes (e.g. one subframe) or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes (e.g. with repeat transmissions in a plurality of subframes). The message is transmitted in association with an identifier to indicate a terminal device to which the message is addressed. A characteristic for the identifier, for example a value or control region search space for the identifier, is dependent on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme. A terminal device to which the message is addressed determines the transmission scheme from the characteristic of the identifier and receives the message accordingly.

WO 2015/113664 A1

TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

IDENTIFICATION OF DOWNLINK MESSAGES USING REPEATED TRANSMISSION

BACKGROUND

Field

The present disclosure relates to telecommunications apparatus and methods. In particular, certain embodiments relate to schemes for communicating allocations of transmission resources of a shared channel in a wireless telecommunications system.

Description of Related Art

The "background" description provided herein is for the purpose of generally presenting the context of the disclosure. Work of the presently named inventors, to the extent it is described in this background section, as well as aspects of the description which may not otherwise qualify as prior art at the time of filing, are neither expressly or impliedly admitted as prior art against the present invention.

Mobile communication systems have evolved over the past ten years or so from the GSM System (Global System for Mobile communications) to the 3G system and now include packet data communications as well as circuit switched communications. The third generation partnership project (3GPP) is developing a fourth generation mobile communication system referred to as Long Term Evolution (LTE) in which a core network part has been evolved to form a more simplified architecture based on a merging of components of earlier mobile radio network architectures and a radio access interface which is based on Orthogonal Frequency Division Multiplexing (OFDM) on the downlink and Single Carrier Frequency Division Multiple Access (SC-FDMA) on the uplink.

Third and fourth generation mobile telecommunication systems, such as those based on the 3GPP defined UMTS and Long Term Evolution (LTE) architecture are becoming able to support more sophisticated services than simple voice and messaging services offered by previous generations of mobile telecommunication systems. For example, with the improved radio interface and enhanced data rates provided by LTE systems, a user is able to enjoy high data rate applications such as mobile video streaming and mobile video conferencing that would previously only have been available via a fixed line data connection. The demand to deploy third and fourth generation networks is therefore strong and there is a corresponding desire to extend the coverage available in such telecommunications systems (i.e. there is a desire to provide more reliable access to wireless telecommunications systems for terminal devices operating in coverage-limited locations).

A typical example of a coverage-limited terminal device might be a so-called machine type communication (MTC) device, such as a smart meter located in a customer's house and periodically transmitting information back to a central MTC server relating to the customer's consumption of a utility, such as gas, water, electricity and so on. Such a terminal device might operate in a coverage-limited location because, for example, it may be located in a basement or other location with relatively high penetration loss. Further information on characteristics of MTC-type devices can be found, for example, in the corresponding standards, such as ETSI TS 122 368 V10.530 (2011-07) / 3GPP TS 22.368 version 10.5.0 Release 10) [1]. Some typical characteristics of MTC type terminal devices / MTC type data might include, for example, characteristics such as low mobility, high delay tolerance, small data transmissions, infrequent transmission and group-based features, policing and addressing.

In some situations a terminal device in a coverage-limited situation in a particular communication cell served by a base station might be unable to receive communications from the base station unless specific provision is made for it to do so. One way to increase coverage in this situation would be for the base station to increase the power of its transmissions. However, a blanket increase in transmission power from a base station could be expected to give rise to increased interference in neighbouring communication cells. An alternative approach would be for the base station to in effect focus / concentrate its available transmission power budget into a subset of transmission resources (e.g. in terms of frequency) which are selected from within the base station's overall transmission resources and allocated for transmissions to coverage-limited terminal devices. However, this approach can again lead to increased interference in neighbouring cells and may in some cases require increased coordination among base stations to optimise performance.

Another approach for providing coverage extension is to rely on repeated transmissions of signalling in multiple subframes. A terminal device may then combine the signalling received for a plurality of repeated transmissions to increase the likelihood of successfully decoding the signalling, e.g. using chase combining / maximal ratio combining techniques. This repeated transmission approach may be applied for control signalling (e.g. sent on a physical downlink control channel such as PDCCH in LTE) and / or other signalling (e.g. sent on a physical downlink shared channel such as PDSCH in LTE).

One draw-back of a repeated transmission approach for providing coverage extension is a corresponding increase in the amount of transmission resources needed to communicate with terminal devices, particularly in the amount of transmission resources needed to provide control messages to the terminal devices, and the inventors have recognised how this issue can be especially significant for certain types of communications, as discussed further below. There is therefore a need for schemes which can allow for communications with terminal devices to be made over a number of subframes with a reduction in the overall amount of transmission resources needed to support this as compared to conventional techniques.

SUMMARY

According to a first aspect of the present disclosure, there is provided a method of operating a terminal device communicating with a base station in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the method comprises receiving a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel, determining a validity period for the control message, and receiving a plurality of other messages from the base station on the downlink data channel using the allocated transmission resources within the validity period for the control message.

According to a second aspect of the present disclosure, there is provided a terminal device for communicating with a base station in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the

downlink data channel, and wherein the terminal device comprises a controller unit and a transceiver unit configured to operate together to receive a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to receive a plurality of other messages from the base station on the downlink data channel using the allocated transmission resources within the validity period for the control message.

According to a third aspect of the present disclosure, there is provided circuitry for a terminal device communicating with a base station in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to cause the terminal device to receive a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to receive a plurality of other messages from the base station on the downlink data channel using the allocated transmission resources within the validity period for the control message

According to a forth aspect of the present disclosure, there is provided a method of operating a base station communicating with a terminal device in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the method comprises transmitting a control message to the terminal device conveying an indication of allocated transmission resources on the downlink data channel, determining a validity period for the control message, and transmitting a plurality of other messages to the terminal device on the downlink data channel using the allocated transmission resources within the validity period for the control message.

According to a fifth aspect of the present disclosure, there is provided a base station for communicating with a terminal device in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the base station comprises a controller unit and a transceiver unit configured to operate together to transmit a control message to the terminal device conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to transmit a plurality of other messages to the terminal device on the downlink data channel using the allocated transmission resources within the validity period for the control message.

According to a sixth aspect of the present disclosure, there is provided circuitry for a base station communicating with a terminal device in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the

downlink data channel, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to cause the base station to transmit a control message to the terminal device conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to transmit a plurality of other messages to the terminal device on the downlink data channel using the allocated transmission resources within the validity period for the control message.

According to a seventh aspect of the present disclosure, there is provided a method of operating a base station for communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein the method comprises selecting a characteristic for the identifier in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

According to an eighth aspect of the present disclosure, there is provided a base station for communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the base station comprises a controller unit and a transceiver unit configured to operate together such that the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein a characteristic for the identifier is selected in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

According to a ninth aspect of the present disclosure, there is provided circuitry for a base station communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the circuitry comprises a controller element and a transceiver element configured to operate together such that the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein a characteristic for the identifier is selected in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

According to a 10th aspect of the present disclosure, there is provided a method of operating a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission

resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the method comprises determining from an identifier associated with the message that the message is addressed to the terminal device, and further determining from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

According to an 11th aspect of the present disclosure, there is provided a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the terminal device comprises a controller unit and a transceiver unit configured to operate together to determine from an identifier associated with the message that the message is addressed to the terminal device, and to further determine from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

According to a twelfth aspect of the present disclosure, there is provided circuitry for a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to determine from an identifier associated with the message that the message is addressed to the terminal device, and to further determine from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

Further respective aspects and features are defined by the appended claims.

The foregoing paragraphs have been provided by way of general introduction, and are not intended to limit the scope of the following claims. The described embodiments, together with further advantages, will be best understood by reference to the following detailed description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the disclosure and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein like reference numerals designate identical or corresponding parts throughout the several views, and wherein:

Figure 1 provides a schematic diagram illustrating an example of a mobile telecommunication system;

Figure 2 provides a schematic diagram illustrating a LTE radio frame;

Figure 3 provides a schematic diagram illustrating an example of a LTE downlink radio subframe;

Figure 4 provides a schematic diagram illustrating a LTE "camp-on" procedure;

Figure 5 schematically represents a wireless telecommunications system according to an embodiment of the disclosure;

Figure 6 schematically represents a series of downlink subframes for communicating with a terminal device operating in the wireless telecommunications system of Figure 5;

Figure 7 schematically represents a series of downlink subframes for communicating with a terminal device operating in the wireless telecommunications system of Figure 5 in accordance with an embodiment of the disclosure;

Figure 8 is a signalling ladder diagram representing communications between a base station and a terminal device operating in accordance with an embodiment of the disclosure; and

Figure 9 is a signalling ladder diagram representing communications between a base station and a terminal device operating in accordance with another embodiment of the disclosure.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Figure 1 provides a schematic diagram illustrating some basic functionality of a mobile telecommunications network / system 100 operating in accordance with LTE principles and which may be adapted to implement embodiments of the disclosure as described further below. Various elements of Figure 1 and their respective modes of operation are well-known and defined in the relevant standards administered by the 3GPP (RTM) body and also described in many books on the subject, for example, Holma H. and Toskala A [2]. It will be appreciated that operational aspects of the telecommunications network which are not specifically described below may be implemented in accordance with any known techniques, for example according to the relevant standards.

The network 100 includes a plurality of base stations 101 connected to a core network 102. Each base station provides a coverage area 103 (i.e. a cell) within which data can be communicated to and from terminal devices 104. Data is transmitted from base stations 101 to terminal devices 104 within their respective coverage areas 103 via a radio downlink. Data is transmitted from terminal devices 104 to the base stations 101 via a radio uplink. The core network 102 routes data to and from the terminal devices 104 via the respective base stations 101 and provides functions such as authentication, mobility management, charging and so on. Terminal devices may also be referred to as mobile stations, user equipment (UE), user terminal, mobile radio, and so forth. Base stations may also be referred to as transceiver stations / nodeBs / e-nodeBs, and so forth.

Mobile telecommunications systems such as those arranged in accordance with the 3GPP defined Long Term Evolution (LTE) architecture use an orthogonal frequency division modulation (OFDM) based interface for the radio downlink (so-called OFDMA) and a single carrier frequency division multiple access scheme (SC-FDMA) on the radio uplink. Figure 2 shows a schematic diagram illustrating an OFDM based LTE downlink radio frame 201. The LTE downlink radio frame is transmitted from a LTE base station

(known as an enhanced Node B) and lasts 10 ms. The downlink radio frame comprises ten subframes, each subframe lasting 1 ms. A primary synchronisation signal (PSS) and a secondary synchronisation signal (SSS) are transmitted in the first and sixth subframes of the LTE frame. A physical broadcast channel (PBCH) is transmitted in the first subframe of the LTE frame.

Figure 3 is a schematic diagram of a grid which illustrates the structure of an example conventional downlink LTE subframe. The subframe comprises a predetermined number of symbols which are transmitted over a 1ms period. Each symbol comprises a predetermined number of orthogonal subcarriers distributed across the bandwidth of the downlink radio carrier.

The example subframe shown in Figure 3 comprises 14 symbols and 1200 subcarriers spread across a 20MHz bandwidth and in this example is the first subframe in a frame (hence it contains PBCH). The smallest allocation of physical resource for transmission in LTE is a resource block comprising twelve subcarriers transmitted over one subframe. For clarity, in Figure 3, each individual resource element is not shown, instead each individual box in the subframe grid corresponds to twelve subcarriers transmitted on one symbol.

Figure 3 shows in hatching resource allocations for four LTE terminals 340, 341, 342, 343. For example, the resource allocation 342 for a first LTE terminal (UE 1) extends over five blocks of twelve subcarriers (i.e. 60 subcarriers), the resource allocation 343 for a second LTE terminal (UE2) extends over six blocks of twelve subcarriers (i.e. 72 subcarriers), and so on.

Control channel data can be transmitted in a control region 300 (indicated by dotted-shading in Figure 3) of the subframe comprising the first "n" symbols of the subframe where "n" can vary between one and three symbols for channel bandwidths of 3MHz or greater and where "n" can vary between two and four symbols for a channel bandwidth of 1.4MHz. For the sake of providing a concrete example, the following description relates to host carriers with a channel bandwidth of 3MHz or greater so the maximum value of "n" will be 3 (as in the example of Figure 3). The data transmitted in the control region 300 includes data transmitted on the physical downlink control channel (PDCCH), the physical control format indicator channel (PCFICH) and the physical HARQ indicator channel (PHICH). These channels transmit physical layer control information. Control channel data can also or alternatively be transmitted in a second region of the subframe comprising a number of subcarriers for a time substantially equivalent to the duration of the subframe, or substantially equivalent to the duration of the subframe remaining after the "n" symbols. The data transmitted in this second region is transmitted on the enhanced physical downlink control channel (EPDCCH). This channel transmits physical layer control information which may be in addition to that transmitted on other physical layer control channels.

PDCCH and EPDCCH contain control data indicating which subcarriers of the subframe have been allocated to specific terminals (or all terminals or subset of terminals). This may be referred to as physical-layer control signalling / data. Thus, the PDCCH and/or EPDCCH data transmitted in the control region 300 of the subframe shown in Figure 3 would indicate that UE1 has been allocated the block of resources identified by reference numeral 342, that UE2 has been allocated the block of resources identified by reference numeral 343, and so on.

PCFICH contains control data indicating the size of the control region (i.e. between one and three symbols for channel bandwidths of 3 MHz or greater and between two and four symbols for channel bandwidths of 1.4 MHz).

PHICH contains HARQ (Hybrid Automatic Request) data indicating whether or not previously transmitted uplink data has been successfully received by the network.

Symbols in a central band 310 of the time-frequency resource grid are used for the transmission of information including the primary synchronisation signal (PSS), the secondary synchronisation signal (SSS) and the physical broadcast channel (PBCH). This central band 310 is typically 72 subcarriers wide (corresponding to a transmission bandwidth of 1.08 MHz). The PSS and SSS are synchronisation signals that once detected allow a LTE terminal device to achieve frame synchronisation and determine the physical layer cell identity of the enhanced Node B transmitting the downlink signal. The PBCH carries information about the cell, comprising a master information block (MIB) that includes parameters that LTE terminals use to properly access the cell. Data transmitted to terminals on the physical downlink shared channel (PDSCH), which may also be referred to as a downlink data channel, can be transmitted in other resource elements of the subframe. In general PDSCH conveys a combination of user-plane data and non-physical layer control-plane data (such as Radio Resource Control (RRC) and Non Access Stratum (NAS) signalling). The user-plane data and non-physical layer control-plane data conveyed on PDSCH may be referred to as higher layer data (i.e. data associated with a layer higher than the physical layer).

Figure 3 also shows a region of PDSCH containing system information and extending over a bandwidth of R344. A conventional LTE subframe will also include reference signals which are discussed further below but not shown in Figure 3 in the interests of clarity.

The number of subcarriers in a LTE channel can vary depending on the configuration of the transmission network. Typically this variation is from 72 sub carriers contained within a 1.4MHz channel bandwidth to 1200 subcarriers contained within a 20MHz channel bandwidth (as schematically shown in Figure 3). As is known in the art, data transmitted on the PDCCH, PCFICH and PHICH is typically distributed on the subcarriers across the entire bandwidth of the subframe to provide for frequency diversity. Therefore a conventional LTE terminal must be able to receive the entire channel bandwidth in order to receive and decode the control region.

Figure 4 illustrates a LTE “camp-on” process, that is, the process followed by a terminal so that it can decode downlink transmissions which are sent by a base station via a downlink channel. Using this process, the terminal can identify the parts of the transmissions that include system information for the cell and thus decode configuration information for the cell.

As can be seen in Figure 4, in a conventional LTE camp-on procedure, the terminal first synchronizes with the base station (step 400) using the PSS and SSS in the centre band and then decodes the PBCH (step 401). Once the terminal has performed steps 400 and 401, it is synchronized with the base station.

For each subframe, the terminal then decodes the PCFICH which is distributed across the entire bandwidth of carrier 320 (step 402). As discussed above, a LTE downlink carrier can be up to 20 MHz wide (1200 subcarriers) and a standard LTE-compliant terminal therefore has to have the capability to receive and decode transmissions on a 20 MHz bandwidth in order to decode the PCFICH. Accordingly, at the PCFICH decoding stage, with a 20MHz carrier band, the terminal operates at a larger bandwidth

(bandwidth of R320) than during steps 400 and 401 (bandwidth of R310) relating to synchronization and PBCH decoding.

The terminal then ascertains the PHICH locations (step 403) and decodes the PDCCH (step 404), in particular for identifying system information transmissions and for identifying its dedicated allocation grants. The allocation grants are used by the terminal to locate system information and to locate its data in the PDSCH. Both system information and dedicated allocations are transmitted on PDSCH and scheduled within the carrier band 320. Steps 403 and 404 also require a standard LTE-compliant terminal to operate on the entire bandwidth R320 of the carrier band. Allocation grants may also or alternatively be decoded from EPDCCH.

At steps 402 to 404, the terminal decodes information contained in the control region 300 of a subframe. As explained above, in LTE, the three control channels mentioned above (PCFICH, PHICH and PDCCH) can be found across the control region 300 of the carrier where the control region extends over the range R320 and occupies the first one, two or three OFDM symbols of each subframe as discussed above. In a subframe, typically the control channels do not use all the resource elements within the control region 300, but they are scattered across the entire region, such that a LTE terminal has to be able to simultaneously receive the entire control region 300 for decoding each of the three control channels.

The terminal can then decode the PDSCH (step 405) which contains system information or data transmitted for this terminal.

As explained above, in a LTE subframe the PDSCH generally occupies groups of resource elements which follow the control region. The data in the blocks of resource elements 340, 341, 342, 343 allocated to the different mobile communication terminals (UEs) and the system information data in the block of resources 344 shown in Figure 3 have a smaller bandwidth than the bandwidth of the entire carrier. To decode these blocks a terminal first receives the PDCCH spread across the frequency range R320 and/or the EPDCCH to determine if the (E)PDCCH indicates there are PDSCH resources in the subframe that need to be decoded by the UE. The intended recipient(s) for (E)PDCCH signalling in LTE is established through the use of radio network temporary identifiers (RNTI). (E)PDCCH signalling is addressed to a particular RNTI by using the RNTI to scramble cyclic redundancy check (CRC) bits associated with the (E)PDCCH signalling. Each connected UE in a cell is associated with a Cell RNTI (C-RNTI) that may be used to address PDCCH signalling to that particular UE. In addition there are other RNTIs defined and these may be used to simultaneously address groups of terminal devices. For example, a System Information RNTI (SI-RNTI) is defined and PDSCH transmissions comprising SI are allocated by (E)PDCCH signalling addressed to SI-RNTI. Various other RNTIs are defined for various other types of signalling. Some examples include a random-access RNTI (RA-RNTI), a Paging RNTI (P-RNTI), a Transmit Power Control Physical Uplink Control Channel RNTI (TPC-PUCCH-RNTI) and a Transmit Power Control Physical Uplink Shared Channel-RNTI (TPC-PUSCH-RNTI).

Thus, once a UE has received a downlink subframe, the UE searches for (E)PDCCH signalling associated with any RNTI that apply for the UE in the subframe to identify any corresponding allocations of transmission resources on PDSCH. If there is an allocation message addressed to the UE on (E)PDCCH the UE will proceed to decode the PDSCH in the relevant frequency range (if any) indicated by the PDCCH. So for example, UE 1 discussed above decodes the whole control region 300 to

determine its resource allocation and then extracts the relevant data from the corresponding resource block 342.

Figure 5 schematically shows a telecommunications system 500 according to an embodiment of the disclosure. The telecommunications system 500 in this example is based broadly on a LTE-type architecture. As such many aspects of the operation of the telecommunications system 500 are standard and well understood and not described here in detail in the interest of brevity. Operational aspects of the telecommunications system 500 which are not specifically described herein may be implemented in accordance with any known techniques, for example according to the established LTE-standards and known variations thereof.

The telecommunications system 500 comprises a core network part (evolved packet core) 502 coupled to a radio network part. The radio network part comprises a base station (evolved-nodeB) 504, a first terminal device 506 and a second terminal device 508. It will of course be appreciated that in practice the radio network part may comprise a plurality of base stations serving a larger number of terminal devices across various communication cells. However, only a single base station and two terminal devices are shown in Figure 5 in the interests of simplicity.

As with a conventional mobile radio network, the terminal devices 506, 508 are arranged to communicate data to and from the base station (transceiver station) 504. The base station is in turn communicatively connected to a serving gateway, S-GW, (not shown) in the core network part which is arranged to perform routing and management of mobile communications services to the terminal devices in the telecommunications system 500 via the base station 504. In order to maintain mobility management and connectivity, the core network part 502 also includes a mobility management entity (not shown) which manages the enhanced packet service, EPS, connections with the terminal devices 506, 508 operating in the communications system based on subscriber information stored in a home subscriber server, HSS. Other network components in the core network (also not shown for simplicity) include a policy charging and resource function, PCRF, and a packet data network gateway, PDN-GW, which provides a connection from the core network part 502 to an external packet data network, for example the Internet. As noted above, the operation of the various elements of the communications system 500 shown in Figure 5 may be broadly conventional apart from where modified to provide functionality in accordance with embodiments of the disclosure as discussed herein.

In this example, it is assumed the first terminal device 506 is a conventional smart-phone type terminal device communicating with the base station 504. Thus, and as is conventional, this first terminal device 506 comprises a transceiver unit 506a for transmission and reception of wireless signals and a controller unit 506b configured to control the smart phone 506. The controller unit 506b may comprise a processor unit which is suitably configured / programmed to provide the desired functionality using conventional programming / configuration techniques for equipment in wireless telecommunications systems. The transceiver unit 506a and the controller unit 506b are schematically shown in Figure 5 as separate elements. However, it will be appreciated that the functionality of these units can be provided in various different ways, for example using a single suitably programmed general purpose computer, or suitably configured application-specific integrated circuit(s) / circuitry. As will be appreciated the conventional terminal device 506 will in general comprise various other elements associated with its operating functionality.

In this example, it is assumed the second terminal device 508 is a machine-type communication (MTC) terminal device according to an embodiment of the disclosure and located in an area of restricted coverage. As discussed above, MTC devices may be typically characterised as semi-autonomous or autonomous wireless communication devices communicating small amounts of data. Examples include so-called smart meters which, for example, may be located in a customer's house and periodically transmit information back to a central MTC server data relating to the customer's consumption of a utility such as gas, water, electricity and so on. MTC devices may in some respects be seen as devices which can be supported by relatively low bandwidth communication channels having relatively low quality of service (QoS), for example in terms of latency. It is assumed here the MTC terminal device 508 in Figure 5 is such a device. It will, however, the appreciated that embodiments of the disclosure may also be implemented for other types of terminal device.

As with the smart phone 506, the MTC device 508 comprises a transceiver unit 508a for transmission and reception of wireless signals and a controller unit 508b configured to control the MTC device 508. The controller unit 508b may comprise a processor unit which is suitably configured / programmed to provide the desired functionality described herein using conventional programming / configuration techniques for equipment in wireless telecommunications systems. The transceiver unit 508a and the controller unit 508b are schematically shown in Figure 5 as separate elements for ease of representation. However, it will be appreciated that the functionality of these units can be provided in various different ways, for example using a single suitably programmed general purpose computer, or suitably configured application-specific integrated circuit(s) / circuitry, or using a plurality of discrete circuitry / processing elements for providing different elements of the desired functionality. It will be appreciated the MTC device 508 will in general comprise various other elements associated with its operating functionality in accordance with established wireless telecommunications techniques (e.g. a power source, possibly a user interface, and so forth).

The base station 504 comprises a transceiver unit 504a for transmission and reception of wireless signals and a controller unit 504b configured to control the base station 504. The controller unit 504b may comprise a processor unit which is suitably configured / programmed to provide the desired functionality described herein using conventional programming / configuration techniques for equipment in wireless telecommunications systems. The transceiver unit 504a and the controller unit 504b are schematically shown in Figure 5 as separate elements for ease of representation. However, it will be appreciated that the functionality of these units can be provided in various different ways, for example using a single suitably programmed general purpose computer, or suitably configured application-specific integrated circuit(s) / circuitry or using a plurality of discrete circuitry / processing elements for providing different elements of the desired functionality. It will be appreciated the base station 504 will in general comprise various other elements associated with its operating functionality. For example, the base station 504 will in general comprise a scheduling entity responsible for scheduling communications. The functionality of the scheduling entity may, for example, be subsumed by the controller unit 504b.

Thus, the base station 504 is configured to communicate data with the smart phone 506 over a first radio communication link 510 and communicate data with the MTC device 508 over a second radio communication link 512. Both radio links may be supported within a single radio frame structure associated with the base station 504. It is assumed here the base station 504 is configured to communicate with the smart phone 506 over the first radio communication link 510 in accordance with the

established principles of LTE-based communications and to communicate with the MTC-device 506 over the second radio communication link 512 in accordance with embodiments of the disclosure as described herein. It will be appreciated the base station may readily obtain information indicating the different classes of terminal device which are attached to the base station in accordance with conventional techniques. That is to say, the base station will be aware that the smart phone is of a device class that includes conventional smartphones and the MTC device is of a device class that includes MTC devices. Furthermore, the base station may establish using conventional techniques that the MTC device 508 is a device operating in a coverage limited situation such that steps are needed to increase the likelihood of the MTC device being able to decode downlink transmissions.

As noted above, in a LTE-based wireless telecommunications system some of the fundamental information required for a terminal device to operate in a cell is transmitted on PBCH in the Master Information Block (MIB). Other information regarding the system configuration is divided among System Information Blocks (SIBs) referred to as SIB1, SIB2, SIB3,...etc. (there are 16 SIBs defined as of Release 11 LTE). The SIBs are transmitted in system information (SI) messages, which, apart from SIB1, may contain multiple SIBs (termed first SI, second SI, etc.). There may be one or several SI messages transmitted at different periodicities. Each SI message may convey multiple SIBs suitable for scheduling with the same periodicity. The timings for SIB1 message transmissions are fixed on an 80 ms period and they occur in the fifth subframe of radio frames when System Frame Number (SFN) is a multiple of 8 (i.e. SFN mod 8 = 0). There are retransmissions of SIB1 messages provided in every other radio frame within the 80 ms period. The timings for other SIB transmission messages are configured in SIB1. The transmission resource allocations for the SI messages on PDSCH within a subframe are provided to terminal devices using PDCCH allocation messages addressed to SI-RNTI (System Information Radio Network Temporary Identifier - currently 0xFFFF in LTE). At higher layers, SI is carried on the logical broadcast control channel (BCCH).

In LTE the SI messages are transmitted within periodically occurring time domain windows (referred to as SI-windows) using dynamic scheduling. Each SI message is associated with a SI-window and the SI-windows of different SI messages do not overlap. That is, within one SI-window only the corresponding SI message is transmitted. The length of the SI-window is common for all SI messages, and is configurable. Within the SI-window, the corresponding SI message can be transmitted a number of times in any subframe other than MBSFN (multicast-broadcast single frequency network) subframes, uplink subframes in TDD (time division duplex), and subframe #5 of radio frames for which SFN (system frame number) mod 2 = 0. Terminal devices acquire the detailed time-domain scheduling (and other information, e.g. frequency-domain scheduling, transport format) from decoding SI-RNTI on PDCCH. A single SI-RNTI is used to address SystemInformationBlockType1 as well as all SI messages. SystemInformationBlockType1 configures the SI-window length and the transmission periodicity for the SI messages.

The system information in a cell may be changed, although typically this happens rarely with system information perhaps remaining unchanged for hours, days, or even weeks.

For changes of system information other than those related to EAB (Extended Access Barring), ETWS (Earthquake Tsunami Warning System) and CMAS (Commercial Mobile Alert System), there is a BCCH modification period defined (which may be referred to as a “SI modification period”). SI modification period boundaries are defined on radio frames for which SFN mod q = 0, for a cell-specific value of q.

When there is a change in system information, the new system information is transmitted from the start of a new SI modification period.

The general process for implementing a change in system information in a LTE-based network is described, for example, in Section 5.2.1.3 of ETSI TS 136 331 V11.4.0 (2013-07) / 3GPP TS 36.331 version 11.4.0 Release 11 [3]. In summary, a base station indicates a change of system information as follows.

1. When the network changes system information it notifies terminal devices about the change by transmitting a PDCCH resource allocation message addressed to the paging RNTI (P-RNTI). This directs the terminal devices to decode PDSCH resources containing a Paging message with a SystemInfoModification flag set to true. This may be done, for example, throughout one SI modification period. Both RRC_IDLE and RRC_CONNECTED terminal devices check for paging messages periodically. It may be noted that EAB alterations, ETWS and CMAS notifications may be separately modified with separate flags in a paging message (but can also be modified along with other SIBs).

2. In a following SI modification period, the network transmits the modified system information, and may increment a SystemInfoValueTag in SIB1. This value tag can indicate changes in any SIB, but it might not be used for EAB, ETWS, CMAS and some regularly changing SI parameters such as CDMA2000 system time. Terminal devices can use SystemInfoValueTag to verify if currently stored system information is still valid, for example on return from being out of coverage when the UE may have missed a system information change notification in paging.

More details on system information and changes in system information in a LTE-based system can be found in ETSI TS 136 331 V11.4.0 (2013-07) / 3GPP TS 36.331 version 11.4.0 Release 11 [3].

As discussed above, it has been proposed to improve coverage for terminal devices in a wireless telecommunications system by introducing repetitions of a transmission which a terminal device may combine to provide an increased likelihood of successful decoding.

Figure 6 schematically represents an approach for providing coverage extension through repeated transmissions for an SI message in accordance with existing techniques. Figure 6 schematically shows a sequence of LTE downlink subframes (labelled as subframes "A", "B", "C", …, "L" to aid explanation) with shading to schematically indicate which regions in which subframes are used to convey system information. The subframes represented in Figure 6 comprise four groups of three contiguous subframes with spaces between the groups as schematically indicated by dotted lines and discussed further below. Although not shown in Figure 6, the gaps between the groups comprise a continuing sequence of subframes used for other communications that are not relevant to the system information messaging considered here. As discussed above, each subframe comprises a control region 600 and a PDSCH region 602. The control regions 600 for the respective subframes are labelled in Figure 6 with the identification letter for the relevant subframe, i.e. as 600A, 600B, 600C, etc. The PDSCH regions for the respective subframes are similarly labelled in Figure 6 as 602A, 602B, 602C, etc. Each subframe represented in Figure 6 is in essence a simplified version of what is represented in Figure 3. Thus, the control regions 600 support the PCFICH, PHICH and PDCCH channels as discussed above while the PDSCH regions 602 support user-plane data and system information (among other things) and the EPDCCD if implemented. The most significant aspect of the control region 600 in the context of

embodiments of the present disclosure relate to the PDCCH and so for simplicity the control regions 600 may sometimes be referred to herein as PDCCH regions 600.

Before explaining the repeated transmissions approach to providing coverage extension represented in Figure 6 it is considered helpful to clarify some aspects of the terminology to be used herein. The term "repeat transmission" (and related terms) will be used to refer to a transmission in an individual subframe which is part of a sequence of transmissions that are being repeated for the purposes of providing coverage extension for a message being conveyed between a base station and a terminal device (such as a PDCCH message or a PDSCH message). Thus in a coverage extension context, the transmission of a (E)PDCCH message comprises a plurality of "repeat transmissions" on (E)PDCCH and the transmission of a PDSCH message comprises a plurality of "repeat transmissions" on PDSCH. The term "re-transmission" (and related terms) will be used to refer to the transmission of a message that has already been sent at least once before. These terms should be interpreted accordingly unless the context demands otherwise.

For the example repeat transmission approach to coverage extension represented in Figure 6 it is assumed for ease of representation the approach relies on providing only three repeat transmissions for each PDCCH message and each PDSCH message. It will, however, be appreciated that in practice larger numbers of repeat transmissions will typically be involved, for example there may be tens or hundreds of repeats comprising each message to provide a correspondingly higher degree of coverage extension. Furthermore, it will be appreciated that PDCCH messages and PDSCH messages may comprise different numbers of repeat transmissions (for example because different coding schemes are adopted meaning that different numbers of repeat transmissions are needed for a given probability of successful reception).

Thus, referring to Figure 6, subframes A, B and C are used to signal a PDCCH message addressed to SI-RNTI by sending three repeat PDCCH transmissions in the respective PDCCH regions 600A, 600B, 600C. Each PDCCH repeat transmission addressed to SI-RNTI in the PDCCH regions 600A, 600B, 600C in effect comprises a duplication of the same downlink control information which a terminal device can combine to seek to establish the content of the PDCCH message. For this example repeat-transmission based coverage extension scheme it is assumed a particular type of message subject to repeat transmissions is addressed to the same RNTI (e.g. SI-RNTI for a system information related type of messages) as if the same type of message were subject to conventional single-subframe transmission. However, as discussed further below, in accordance with certain embodiments of the disclosure identifiers having different characteristics (e.g. values) may be used for a given type of message depending on whether the messages to be sent in accordance with a first transmission scheme (e.g. using a conventional single subframe based transmission approach) or a second transmission scheme (e.g. using a repeat-transmission scheme for coverage extension). Furthermore, it will be appreciated the approach of using identifiers associated with a particular type of message having different characteristics according to what transmission scheme is to be used to transmit the message can be used in accordance with embodiments of the disclosure with or without the use of validity periods as disclosed herein.

The PDCCH message comprising the three repeat transmissions in the PDCCH regions of subframes A, B and C indicates resource blocks to be used for a subsequent PDSCH message comprising the transmission of system information. This PDSCH message itself comprises a plurality of repeat transmissions, and, in this example, are represented by shading in the PDSCH regions 602D, 602E and 602F of subframes D, E and F. The transmission resources, for example in terms of specific resource

elements, used to convey the repeat transmissions of the system information message in the PDSCH regions 602D, 602E and 602F are indicated in the corresponding PDCCH message addressed to SI-RNTI and comprising the repeat transmissions in PDCCH regions 600A, 600B, 600C in accordance with conventional resource allocation techniques in the context of coverage extension using repeat transmissions. Whilst the shading in Figure 6 schematically represents the same frequency resources being used for each repeat transmission in the respective PDSCH regions 602D, 602E and 602F of the subframes D, E, F, in principle the repeat-transmission approach may be configured to include frequency hopping for the different repeat transmissions comprising the PDSCH message sent in subframes D, E, F. The nature of any such frequency hopping may be pre-defined, for example it may be pre-specified according to an operating standard for the wireless telecommunications system, or it may be established in previous RRC (radio resource control) signalling, or it may be indicated in the PDCCH message.

As schematically represented in Figure 6 there is a gap between subframes C and D. This follows the currently-proposed approaches for repeat-transmission coverage extension whereby the transmission of a PDSCH message comprising a plurality of repeat transmissions does not start until after all repeat transmissions of the corresponding PDCCH message have been sent. This is to help reduce the buffering requirements at the terminal device. Furthermore, current proposals indicate there should be no overlap between the end of the repeat transmissions comprising the PDCCH message and the start of the repeat transmissions comprising the PDSCH message. It will, however, be appreciated the specific implementation of such aspects of a repeat transmission approach for providing coverage extension are not significant to the principles underlying the present disclosure. That is to say, the principles described herein may equally be implemented in association with other repeat transmission approaches (e.g. with repeat transmissions of PDCCH and its corresponding PDSCH occurring in the same subframe).

In subframes following the transmission of the system information message as schematically indicated in subframes D, E and F in Figure 6, the wireless telecommunications system continues to operate in accordance with its normal operating techniques until subframe G represented. Subframe G represents the beginning of another system information message. As noted above, system information messages can be regularly retransmitted in accordance with LTE techniques, and in this regard the system information message beginning at subframe G is considered in this example to be a re-transmission of the system information message transmitted using subframes A to F as discussed above. The specific timing of the re-transmission of system information (i.e. the timing of subframe G relative to subframe A) may follow any conventional system information re-transmission schedule. The principles underlying the re-transmission of the system information message starting from subframe G follow those described above. Thus, a PDCCH message addressed to SI-RNTI is sent using the PDCCH regions 600G, 600H and 600I of subframes G, H and I to allocate resources for a PDSCH message comprising three repeat transmissions in the PDSCH regions 602J, 602K and 602L in subframes J, K and L as indicated by shading in Figure 6. It may be noted in this example the frequencies of the resource elements for the re-transmission of the system information message on PDSCH in subframes J, K, L is different from that used in subframes D, E, F for the previous transmission, but this is not of any particular significance. Furthermore, the transmissions of the PDSCH message in subframes D, E, F, J, K, L may comprise different so-called redundancy versions of the PDSCH message comprising different combinations of information bits and redundancy bits arising from a forward error correction coding process.

It will be appreciated the transmission resources represented in Figure 6 which are not involved in the SI message signalling discussed above can be used for other communications in the network in the usual manner. In particular, it will be appreciated that although the entirety of the PDCCH regions associated with repeat transmissions of the PDCCH for the system information messages are shown shaded in Figure 6, this is merely to highlight those subframes in which a PDCCH for the system information messages is transmitted compared to those where it is not, and in practice these regions will comprise multiple PDCCH messages addressing different terminal devices for allocating resources for various different types of communication on PDSCH.

System information signalling in LTE is sent on what is approaching a more or less continuous basis. This means there is a considerable amount of PDSCH traffic for broadcasting system information messages comprising the SIBs. There is a corresponding requirement for PDCCH signalling to schedule the PDSCH resources for system information messages. The inventors have recognised that this can become a significant issue in a coverage extension scenario where a number of repetitions are expected, as illustrated in Figure 6. This is because for each PDSCH message comprising a plurality of PDSCH repeat transmissions (i.e. the PDSCH message sent using resources in subframes D, E and F and the PDSCH message sent using resources in subframes J, K and L) there is a corresponding SI-RNTI PDCCH message comprising a plurality of PDCCH repeat transmissions (i.e. the PDCCH message sent using resources in subframes A, B and C and the PDCCH message sent using resources in subframes G, H and I). With the potential for perhaps a hundred or more repeat transmissions to provide coverage extension to the edge of a base station's corresponding cell for system information messages a large fraction of the available control region resources will be needed to support this function following the approach of Figure 6. There is of course a corresponding increase in the use of PDSCH resources with the approach represented in Figure 6, but it is to be expected that in many situations it will be PDCCH resources that are more at a premium owing to the limited resources available in the control channel region for PDCCH and the priority typically given to PDSCH over EPDCCH in the PDSCH region. This is especially likely in networks supporting large numbers of MTC devices since these are likely to have a higher ratio of control signalling to data signalling as compared to the traffic profiles typically associated with conventional terminal devices. The increased PDCCH and/or EPDCCH resources needed to support repeat transmissions of system information messages could ultimately make it difficult to schedule unicast PDSCH transmissions to terminal devices operating within the system because of a lack an availability of control region resources to indicate the allocation of PDSCH resources and/or a lack of PDSCH region resource to indicate the allocation of PDSCH resources.

To address this type of issue there have been proposals to stop using PDCCH and EPDCCH messages resource allocations for PDSCH messages comprising system information (i.e. for system information messages). One proposal (described in the 3GPP document R1-135422, "On the need of PDCCH for SIB and other Common Channel", Mediatek, RAN1#75, San Francisco, November 2013 [4]) is to avoid providing any scheduling information in respect of system information-carrying PDSCH transmissions. Instead, a terminal device will be expected to perform blind searching of the PDSCH region to identify if there are any relevant system information transmissions. A drawback with this approach is a significant increase in the processing load required for terminal devices. To reduce the processing load required at the terminal device to a more manageable level the system information messages could be confined to a restricted subset of transmission resources comprising the PDSCH region. However, this approach still requires additional processing tasks to be performed by the terminal device and introduces reduced

scheduling flexibility. Another proposal (described in the 3GPP document R1-134207, "Coverage enhancement techniques for PBCH", Alcatel-Lucent, Alcatel-Lucent Shanghai Bell, RAN1#74bis, Guangzhou, October 2013 [5]) is to avoid using PDCCH messages to provide scheduling information in respect of system information-carrying PDSCH messages. Instead it is proposed that some of the spare bits currently available in the Master Information Block (MIB) in LTE are used for providing scheduling indications for system information messages. However, there are a limited number of spare bits available for this and so the approach does not allow for any significant degree of flexibility in scheduling system information messages, and furthermore the approach further reduces the number of spare bits available for other uses.

In view of these issues, the inventors have developed an alternative approach for reducing the amount of control signalling required to support resource allocations for higher-layer transmissions in a wireless telecommunications system. In particular, but not exclusively, the inventors have developed an approach which may be applied for reducing the amount of control-channel signalling required to support resource allocations for downlink messages, such as system information messages, and in particular for messages which may be subject to re-transmissions on a defined schedule and which may, in some cases, be sent using a repeat transmission approach to provide a degree of coverage extension.

Figure 7 is similar to, and represents various aspects that will be understood from, Figure 6, but shows an approach in accordance with certain embodiments of the present disclosure. Figure 8 is a signalling ladder diagram schematically representing modes of operation for the terminal device 508 and the base station 504 schematically represented in Figure 5 in accordance with some embodiments of the present disclosure for implementing an approach of the kind represented in Figure 7. In broad summary, some embodiments of the disclosure introduce the concept of a validity period for a PDCCH message to thereby indicate transmission resources that may be used for a plurality of PDSCH messages within the validity period. That is to say the control message transmitted on the PDCCH is considered valid for a period that is longer than the period needed to transmit a single PDSCH message (whether in one subframe or with repeat transmissions in a plurality of subframes to provide coverage extension). This means multiple PDSCH messages can in effect be scheduled using the control-region resources of only a single PDCCH message. There are various different ways in which the validity period may be established/determined, as discussed further below.

For the example represented in Figure 7, and as with Figure 6, it is assumed system information is being transmitted from a base station to a terminal device with a repeat transmission approach to providing coverage extension. Again the example approach to coverage extension represented in Figure 7 is assumed for ease of representation to rely on providing only three repeat transmissions for each PDCCH and PDSCH message. However, as noted above, it will be appreciated that in practice larger numbers of repeat transmissions will typically be involved, for example there may be tens or hundreds of repeats comprising each message to provide a correspondingly higher degree of coverage extension. Furthermore, it will be appreciated that PDCCH messages and PDSCH messages need not necessarily comprise the same number of repeat transmissions (for example different coding schemes may be adopted meaning that different numbers of repeat transmissions are appropriate to provide a desired probability of successful reception for each message).

Thus Figure 7 schematically represents an approach for providing coverage extension through repeated transmissions for a plurality of SI messages with reduced control signalling overhead in accordance with

an embodiment of the disclosure. Figure 7 schematically shows a sequence of LTE downlink subframes (labelled as subframes "O", "P", "Q", …, "Z" to aid explanation) with shading to schematically indicate which regions in which subframes are used to convey messages associated with the system information. The subframes represented in Figure 7 comprise four groups of three contiguous subframes with spaces between the groups as schematically indicated by dotted lines. Although not shown in Figure 7, the gaps between the groups comprise a continuing sequence of subframes used for other communications that are not relevant to the system information messaging considered here. As discussed above, each subframe comprises a control region 700 and a PDSCH region 702. The control regions 700 for the respective subframes are labelled in Figure 7 with the identification letter for the relevant subframe, i.e. as 700O, 700P, 700Q, etc. The PDSCH regions for the respective subframes are similarly labelled in Figure 6 as 702O, 702P, 702Q, etc.

As already noted above, aspects of the operation of a wireless telecommunications system in accordance with embodiments of the disclosure, for example as shown in Figure 7 and 8, which are not specifically described herein may be implemented in accordance with any conventional techniques. In this regard, insofar as the operation of embodiments of the disclosure follow conventional techniques the respective subframes represented in Figure 7 may be similar to that is represented in Figure 3. Thus, the control regions 700 support PCFICH, PHICH and PDCCH channels as discussed above while the PDSCH regions 702 support user-plane data and system information (among other things) and EPDCCH if implemented. The most significant aspect of the control region 700 in the context of embodiments of the present disclosure relate to the PDCCH and so for simplicity the control regions 700 may sometimes be referred to herein as PDCCH regions 700.

Thus referring to Figure 7 subframes O, P and Q are used to signal a PDCCH message addressed to SI-RNTI by sending three repeat PDCCH transmissions in the respective PDCCH regions 700O, 700P, 700Q. Each PDCCH repeat transmission addressed to SI-RNTI in the PDCCH regions 700O, 700P, 700Q in effect comprises a duplication of the same downlink control information which a terminal device can combine to seek to establish the content of the PDCCH message addressed to SI-RNTI in accordance with conventional techniques for coverage extension through repeat transmissions. For this example implementation of a repeat-transmission based coverage extension scheme it is again assumed a particular type of message subject to repeat transmissions is addressed to the same RNTI (e.g. SI-RNTI for a system information related type of messages) as if the same type of message were subject to conventional single-subframe transmission. However, as discussed further below, in accordance with certain embodiments of the disclosure identifiers having different characteristics (e.g. in terms of their value or control region search space) may be used for a given type of message depending on whether the messages to be sent in accordance with a first transmission scheme (e.g. using a conventional single subframe based transmission approach) or a second transmission scheme (e.g. using a repeat-transmission scheme for coverage extension). Furthermore, it will be appreciated the approach of using identifiers associated with a particular type of message having different characteristics according to the transmission scheme is to be used in accordance with embodiments of the disclosure may or may not also implement an approach using validity periods as disclosed herein.

The PDCCH message sent in subframes O, P and Q in Figure 7 differs from a conventional PDCCH message, for example of the kind transmitted in subframes A, B and C of Figure 6, in that it is associated with a validity period that is sufficient to span the transmission of a plurality of PDSCH messages. This is

different from the conventional approach in which a PDCCH message is simply associated with a single PDSCH message. The validity period for the PDCCH message is known to both the base station and the terminal device. For example, the validity period may be based on a defined standard for operations in accordance with an embodiment of the disclosure, whereby the base station and the terminal device can each determine the validity period from the defined standard. In other embodiments the base station may have flexibility to select the validity period, for example according to current scheduling requirements, and to communicate an indication of the validity period to the terminal device(s) to which the PDCCH message is addressed. Some example implementation of this approach are discussed further below.

The PDCCH message comprising the three repeat transmissions in the PDCCH regions of subframes O, P and Q indicate transmission resource blocks to be used for a subsequent PDSCH message comprising the transmission of system information. This PDSCH message itself comprises a plurality of repeat transmissions, and, in this example, are represented by shading in the PDSCH regions 702R, 702S and 702T of subframes D, E and F. The manner in which the PDCCH message indicates the corresponding PDSCH resources in subframes R, S and T may be in accordance with conventional techniques/signalling protocols. That is to say, the transmission resources, for example in terms of specific resource elements, used to convey the repeat transmissions of the system information message in the PDSCH regions 702R, 702S and 702T may be indicated in the corresponding PDCCH message addressed to SI-RNTI and comprising the repeat transmissions in PDCCH regions 700O, 700P, 700Q in accordance with conventional resource allocation techniques in the context of coverage extension using repeat transmissions. Whilst the shading in Figure 7 schematically represents the same frequency resources being used for each repeat transmission in the respective PDSCH regions 702R, 702S and 702T of the subframes R, S and T, in principle the repeat-transmission approach may be configured to include frequency hopping for the different repeat transmissions comprising the PDSCH message sent in subframes R, S and T. The nature of any such frequency hopping may be pre-defined, for example it may be pre-specified according to an operating standard for the wireless telecommunications system, or it may be established in previous RRC (radio resource control) signalling, or it may be indicated in the PDCCH message.

As schematically represented in Figure 7 there is a gap between subframes C and D. This again follows the currently-proposed approaches for repeat-transmission coverage extension whereby the transmission of a PDSCH message comprising a plurality of repeat transmissions does not start until after all repeat transmissions of the corresponding PDCCH message have been sent. Furthermore, some proposals indicate there should be no overlap between the end of the repeat transmissions comprising the PDCCH message and the start of the repeat transmissions comprising the PDSCH message. It will, however, be appreciated the specific implementation of such aspects of a repeat transmission approach for providing coverage extension are not significant to the principles underlying the present disclosure. That is to say, the principles described herein may equally be implemented in association with other repeat transmission approaches (e.g. with repeat transmissions of PDCCH and an associated PDSCH occurring in the same subframe).

Thus, the communication of the PDCCH message in subframes O, P and Q and the corresponding communication of the PDSCH message conveying system information in subframes R, S and T as represented in Figure 7 may follow the same general principles as the approach represented in Figure 6. Similarly, in subframes following the repeat-transmission approach for transmitting the system information

message as schematically indicated in subframes R, S and T in Figure 7, the wireless telecommunications system may continue to operate in accordance with its normal operating techniques for conveying other messages.

As noted above, system information messages are regularly retransmitted in accordance with LTE techniques, and the approach of Figure 7 differs from the approach of Figure 6 in respect of how a subsequent transmission of system information is scheduled on PDSCH in subframes X, Y and Z. In particular, the approach of Figure 7 differs from the approach of Figure 6 if the subsequent retransmission of system information occurs within the validity period associated with the previously-received PDCCH message in subframes O, P and Q initially sent in association with the previously-received system information message on PDSCH in subframes R, S and T. In LTE the transmission of system information follows a defined timing schedule, for example based on the system information window defined for the relevant system information. Thus, a base station and a terminal device are able to independently determine in which subframe a system information message will be transmitted on PDSCH (or which plurality of subframes in the case of coverage extension through repeat-transmissions as in this example). Thus, in the example of Figure 7, a terminal device to which the system information is addressed can determine that a system information message is to be transmitted in subframes X, Y and Z.

Referring back to Figure 6, the terminal device receiving the system information on PDSCH in subframes J, K and L can similarly determine in accordance with conventional techniques that the transmission will occur in these subframes. However, to determine the specific resources (e.g. in terms of specific OFDM carriers / resource blocks) on which the transmissions will occur within the relevant subframe(s) the terminal device must first receive the corresponding PDCCH allocation message sent in subframes G, H and I.

However, in the approach of Figure 7 in accordance with an embodiment of the present disclosure the resource allocation used for the PDSCH transmissions of the system information message on subframes X, Y and Z is determined from the previous resource allocation message sent on PDCCH in subframes O, P and Q. For example, in accordance with one approach the specific PDSCH resources (e.g. in terms of frequency) to be used for transmitting the subsequent system information message in subframes X,Y and Z are assumed to be the same as the specific PDSCH resources (e.g. in terms of frequency) used for transmitting the system information message in subframes R, S and T and indicated in the PDCCH message sent in subframes O, P and Q. However, it will be appreciated that other mappings can be adopted. For example, the frequencies to be used can be configured to shift in accordance with a predefined pattern for each retransmission within the validity period for the PDCCH message.

Thus, in accordance with an embodiment of the disclosure, and in contrast to the approach in the corresponding subframes in Figure 6, there is no PDCCH message sent in subframes U, V and W to support the system information message sent on PDSCH in subframes X, Y and Z. Instead it is determined that a previous PDCCH message remains valid (because its associated validity period has yet to expire), and the resources used for conveying the system information message on PDSCH in subframes X, Y and Z are derived from the previous PDCCH.

This approach has an advantage of freeing up the control-channel resources, in particular in subframes U, V and W for the example subframes represented in Figure 7. The approach can also help reduce the

amount of processing required by the terminal device (since the terminal device does not need to decode a separate PDCCH message for each and every PDSCH message). Furthermore the approach can reduce latency in situations that require high repetition numbers because there is no need to wait to receive a series of PDCCH repetitions before receiving each series of PDSCH repetitions.

It will be appreciated the transmission resources represented in Figure 7 that are not involved in the SI message signalling discussed above can be used for other communications in the network in the usual manner. In particular, it will be appreciated that although the entirety of the PDCCH regions associated with repeat transmissions of the PDCCH for the system information messages are shown shaded in Figure 7, this is merely to highlight those subframes in which a PDCCH for the system information messages is transmitted compared to those where it is not, and in practice these regions will comprise multiple PDCCH messages addressing different terminal devices for allocating resources for various different types of communication on PDSCH.

Thus, to summarise an approach in accordance with an embodiment of the disclosure as represented in Figure 7, and with reference to Figure 8, a base station 504 is transmitting system information messages to terminal devices, including terminal device 508, according to a pre-defined timing schedule. The predefined timing schedule may follow conventional LTE techniques for transmitting system information. It is assumed the processing represented in Figure 8 starts just prior to subframe O at the beginning of the series of subframes represented in Figure 7 and while there is no currently valid PDCCH message for the relevant system information. Thus, in a first step S1 in Figure 8 the base station determines a validity period that is to apply for an upcoming control-plane message that is to be transmitted to allocate resources for system information messages on PDSCH. The duration of a validity period for a given PDCCH message may be fixed / predetermined according to a specific implementation, for example by a network operator, or may be selectable by a base station according to current conditions. The validity period might be relatively short, for example it might only comprise the time required to transmit two PDSCH messages to provide a potential saving of one PDCCH message transmission. On the other hand, the validity period might be significant number, for example hundreds, thousands, tens of thousands, or even more subframes. In general a longer validity period may be preferred to reduce the number of PDCCH message transmissions, while an overly-long validity period may be considered to overly restrict scheduling flexibility. An appropriate validity period in a given situation may depend on current traffic conditions within a cell supported by a base station. For example, if a base station is currently supporting a large number of terminal devices it may be more appropriate to select a relatively long validity period to provide a correspondingly large saving in PDCCH message transmissions. However, if a base station is currently supporting only a small number of terminal devices with low traffic requirements (i.e. such that PDCCH congestion is not an overly significant concern), it may be more appropriate to select a relatively short validity period to provide a corresponding increase in scheduling flexibility (example to take better account of fluctuations in radio propagation conditions or traffic changes). In one example a current proportion of non-MTC traffic may be used to help determine an appropriate validity period for a repeated PDCCH. Generally speaking, the higher this proportion, the higher the proportion of non-delay-tolerant non-small-message terminal devices in the cell whose performance may be disrupted by a heavy use of control channel resources due to repeated PDCCH transmission. Therefore, as the proportion of relatively higher priority terminal devices (e.g. non-MTC terminal devices) increases, the base station may opt for longer PDCCH validity times, especially for use in association with SI-messages.

In step S2 the base station transmits a control-plane message, which can also be referred to as a control message (using repeat transmissions for coverage extension in this example) to allocate the resources for subsequent system information messages on PDSCH. This control message is received and decoded by the terminal device 508. This aspect of the operation may be based generally on conventional techniques, for example using a PDCCH message addressed to an SI-RNTI in LTE. Furthermore, the specific resources selected by the base station for allocation to the system information messages may be selected in accordance with established scheduling techniques in wireless communication systems. Thus, step S2 correspond with the transmissions made in subframes O, P and Q of Figure 7.

In step S3 the terminal device determines the validity period for the control-plane message received in step S2. There are various ways in which the terminal device may determine the validity period for the control-plane resource allocation message in accordance with various embodiments of the disclosure, and some examples are discussed further below.

In step S4 the base station proceeds to transmit a system information message (using repeat transmissions for coverage extension in this example) in accordance with the resource allocation identified by the control-plane (PDCCH) message of step S2. This aspect of the operation may be made broadly in accordance with conventional techniques. The terminal device seeks to receive and decode this system information message (SI message #1) in accordance with conventional techniques.

In step S5 the base station determines it is time to transmit another system information message (SI message #2) according to the predefined timing for periodic system information transmissions in the wireless telecommunications system. The base station further determines the validity period for the control-plane message sent in step S2 has not yet expired. Accordingly, the base station does not send any new control-plane message to support the new system information message that is about to be transmitted (SI message#2). Instead the base station proceeds to transmit the system information message (using repeat transmissions for coverage extension in this example) in accordance with resource allocations derived from the previously-sent control-plane (PDCCH) message of step S2. For example, the base station may be configured to simply use the same frequency resources for transmitting SI message #2 in step S5 as were used for transmitting SI message #1 in step S2. The terminal device likewise determines the expected transmission timing for the new system information message (SI message #2) from the predefined timing for system information transmissions and also determines the validity period for the previous control-plane message received in step S2 has not expired. Accordingly, the terminal device need not seek to receive a new control-plane message to indicate the PDSCH resources for the new system information message that is to be next transmitted (SI message#2). Instead the terminal device simply assumes the transmission is to be made in the relevant subframes (determined according to the predefined timing) on frequency resources derived from the previously-sent control-plane (PDCCH) message of step S2. Once the terminal device has determined the specific resources on which to expect the system information message in step S5 (SI message #2) it may proceed to receive and decode the system information message in accordance with conventional PDSCH transmission techniques.

As noted above the timing s for specific SI messages in LTE are based on SI windows. Conventionally it is the transmission of an associated PDCCH message addressed to the relevant system information RNTI which determines the precise subframe(s) in which the system information message PDSCH is transmitted. However, in accordance with certain embodiments of the disclosure there can be PDSCH

messages conveying system information in an SI windows without there being a corresponding PDCCH message in that SI window. There are a number of different ways in which a terminal device can determine the relevant subframe for a further PDSDH message transmitted within the validity period of a previously-received PDCCH message in accordance with embodiments of the disclosure. In one case, the base station may be configured to send the PDSCH message in a predefined subframe of the SI window. In principle this could be permanently fixed for all PDSCH system information messages at the cost of reduced scheduling flexibility. In another case the subframe(s) could be based on the subframe(s) used in association with the initial PDCCH message. For example, if the initial PDCCH indicates a system information message is to be sent in subframe number n (or starting in subframe n for repeat transitions for coverage extension) within a particular SI window, subsequent PDSCH messages within the validity period of the PDCCH might also be sent in (or start in) subframe n of the relevant SI window. In another example, the base station may retain the flexibility to send (or start sending when using repeat transmissions) the subsequent system information message in any subframe within the SI window. In this case a terminal device may check for a newly addressed PDCCH message in the subframes in the SI window in the normal way, and if a new PDCCH message is not found, the terminal device may decode the PDSCH resources indicated in accordance with a previously-received still valid PDCCH message in the same subframe(s) relative to the SI window as for the previous transmission. In principle, with sufficient processing power, the terminal device could simply seek to decode the relevant resources in all subframes of an SI window to see if an SI message can be decoded.

The process of the base station sending further system information messages, and the terminal device receiving the further information messages, based on transmission resource allocation information indicated in the control-plane message of step S2 may continue (as schematically indicated in step S6 for transmitting SI message #n) until the validity period for the control-plane message received in step S2 has expired, as schematically indicated in step S7.

Following step S7 the processing in effect cycles back to where it started prior to step S1. The base station may thus determine a new validity period for a new control message to be sent in a further step corresponding with step S2 (the base station determines that a new PDCCH message is required because the previous one has expired). Processing may then continue from this point in the manner discussed above.

Thus, the various example schemes represented in Figures 7 and 8, and described above, provide an approach in which control-plane messages, and in particular SI-messages, are associated with a validity period that extends for more than one message transmission of the associated PDSCH. For example, for SIBs in SI-messages, one SI-RNTI addressed PDCCH message can provide the control information for multiple transmissions of SIBs, and in general over multiple SI-windows. Similar operation for other types of message, for example messages addressed to other common search-space RNTIs, may be adopted in accordance with other examples. This kind of approach can help reduce control resource requirements, which can be especially important in the context of coverage extension where according to conventional techniques PDCCH (comprising multiple repeat transmissions) messages would have to be transmitted every time an SI-message (comprising multiple repeat transmissions) needed to be sent.

As noted above, SIBs in system information messages can in some cases remain unchanged for extended period, for example a few hours. A terminal device may thus combine system information message transmissions from across multiple SI-windows if it does not successfully decode an SI-

message at first attempt and with a sufficiently long validity period this can be achieved in accordance with the approaches described herein with reduced control signalling requirements than current schemes.

As noted above, there are various different ways in which the validity period for a PDCCH message may be established. In one simple example the period may be defined according to an operating standard of the wireless telecommunications system. Both the base station and the terminal device can in effect be hardwired with the validity period (or multiple validity periods associated with different types of messages). In another example the base station may have flexibility for determining a suitable validity period according to the implementation and traffic conditions at hand. In this case there are various different ways in which the validity period could be conveyed to a terminal device.

In one example the base station may be configured to convey a selected validity period to terminal devices by selecting a particular transmission characteristic, for example timing, for the PDCCH message with which the validity period is associated. According to current proposals for repeat transmission coverage extension in LTE, the starting subframe of a PDCCH message being transmitted in multiple subframes should be confined to a subset of subframes. This is because in some circumstances the terminal device may be required to blindly search over the possible numbers of repetitions the PDCCH might comprise. If it were allowed for a PDCCH messages comprising an arbitrary number of repeat transmissions to start in an arbitrary subframe this could be expected to give rise to significant complexity in the processing required of the terminal device. To address this there has been proposed an approach in which, for example, a PDCCH message comprising N repeats can only begin in subframes having a subframe number that is a multiple of N (i.e. 0, N, 2N, 3N,…). This reduces the set of possible repetition numbers the UE needs to consider per subframe. Thus, a similar approach could be used to convey information on PDCCH validity. This can be done by linking the validity period to the starting subframe number of the associated PDCCH message. For example, a PDCCH message commencing in subframe M might be taken to indicate a validity period corresponding to M SI-windows for the relevant system information. Thus, a terminal device can readily establish the relevant validity period from the timing of the relevant control-claim message. It may be noted that in some circumstances it may be preferable to assign longer PDCCH validity periods to PDSCH messages that comprise high numbers of repetitions.

In another example the base station may be configured to convey a selected validity period to terminal devices through explicit signalling, for example in the downlink control information (DCI) of the relevant PDCCH message. Thus, the DCI may comprise an indication of a number of subframes / radio frames corresponding to the validity period or may comprise an indication of a specific subframe / radio frame in which the validity period is to expire. In the application to the transmission of system information messages it may be preferable to indicate timings in respect of a number of SI-windows of validity.

In yet another example the terminal devices may be configured to simply assume the validity period for a given PDCCH message addressed to a given RNTI (e.g. SI-RNTI) extends until a subsequent PDCCH message addressed to the relevant RNTI is received. That is to say, the PDCCH message may be considered to remain valid until it is replaced by another PDCCH message. In this respect, in terms of the processing schematically represented in Figure 8, this corresponds with the terminal device determining the validity period for the control message (corresponding to step S3) at the same time at which the validity period expires (responding to step S7), with this being triggered by a new PDCCH message being received by the terminal device. In this approach a terminal device may thus monitor for a new PDCCH message addressed to the relevant RNTI in each subframe of each SI-window in the normal way until a

new PDCCH message is received to in effect define the end the validity period for the previous PDCCH message addressed to that RNTI.

Thus, one principle of the approaches described above in accordance with some embodiments of the disclosure is to associate a PDCCH message with a time defining its validity, that time being extensible beyond the time taken to convey a corresponding PDSCH message. A terminal device may thus assume the PDSCH resource allocation, MCS (modulation and coding scheme), TBS (transport block size), etc. in the DCI of the PDCCH message is valid for receiving multiple PDSCH messages during the PDCCH validity time. No further PDCCHs for multiple PDSCH messages need be sent during the validity time. Thus, in the case of SIB transmissions, the transmission of all SI-messages (including all transmissions within a SI-window of a particular SI-message), may be scheduled with a single transmission of SI-RNTI PDCCH with an appropriately configured validity period.

One particular situation in which approaches in accordance with the embodiments described above might be expected to be useful is where the transmissions are used to provide coverage extension on both PDCCH and PDSCH. However, similar principles can be applied where coverage extension is not being used, for example in respect of messages sent within single subframes.

Whilst the above-described embodiments have focused on system information messages, it will be appreciated that similar principles can be applied for other types of messages in wireless telecommunications systems, and especially for messages which rely on resource allocations occurring with some degree of predictable timing. For example, similar principles can be used for control signalling addressed to other common search space RNTIs, such as RA-RNTI and P-RNTI.

Thus a random access RNTI addressed PDCCH message received by a terminal device during an initial cell access may be associated with a validity period such that the transmission resources identified in association with the random access RNTI PDCCH message are taken to apply for later random access procedures in accordance with the principles set out above. The specific subframe of a RAR (random access response) window in which a subsequent RAR arrives can be established in a manner similar to that described above for system information within a predefined series of subframes comprising an SI-window

Similarly, a paging RNTI addressed PDCCH message may be associated with an extended validity in accordance with the principles described above. Thus a PDSCH resource allocation associated with a PDCCH message addressed to a paging RNTI transmitted in one subframe may be taken to indicate a PDSCH resource allocation in a subsequent subframe within a validity period associated with the PDCCH message. This may be especially appropriate for paging when a terminal device is in idle mode since there is a higher degree of predictability as to when paging messages may be sent according to a currently configured DRX, discontinuous reception, cycle. That is to say, the concept of PDDCH validity timers as discussed herein may be applied to the most recent P-RNTI PDCCH used to decode a paging message by an RRC_IDLE UE. An RRC_IDLE UE is only expected to monitor specific subframes for P-RNTI and is in DRX for other subframes. If the relevant PDCCH validity timer expires before a subsequent paging message is to be sent, the base station may provide a new P-RNTI PDCCH message to schedule the next paging message as normal. Otherwise the IDLE UE may assume the most recent such PDCCH is still valid. For an RRC_CONNECTED UE, there is less predictability as regards whether a particular subframe should contain P-RNTI PDCCH or not. For a connected mode terminal device the

principles described herein for paging messages might, for example, be used for subframes in which the UE would check for P-RNTI if it were in fact in IDLE mode. In other subframes the base station may send conventional paging signalling using PDCCH to page the UE in connected mode.

In a wireless telecommunications using repeat-transmissions for coverage extension there may be terminal devices which are not in coverage-limited locations and able to successfully decode individual ones of the PDCCH (or EPDCCH) repeat transmissions in each subframe. For example, and referring to Figure 7, a non-coverage-limited terminal device may be able to successfully decode the individual PDCCH repeat transmission in the control region 700O of subframe O. If this terminal device is not aware of the use of repeat-transmissions for coverage extension (for example because it is a legacy / conventional terminal device) it might be expected to assume the PDCCH information derived from the control region 700O subframe O applies to a system information transmission on PDSCH in the same subframe (i.e. in PDSCH region 702O). However, the terminal device would fail to receive the system information transmission (because it is not sent in accordance with this particular repeat-transmission protocol). Potentially this terminal device could seek to do this for each and every repeat transmission and so waste a considerable amount of processing effort needlessly decoding individual PDCCH repeat transmissions and associated PDSCH resources in the expectation of receiving system information messages which are not in fact being sent in those subframes. This is an issue which applies generally for repeat transmission approaches for coverage extension and is not specific to approaches based on validity periods as discussed herein.

Thus in accordance with certain embodiments of the disclosure an identifier (RNTI) having different characteristics (e.g. in terms of value or associated control region search space) may be associated with SI messages sent using a repeat transmission approach as compared to SI messages sent without using a repeat transmission approach. More generally, in a wireless telecommunications system supporting different transmission schemes for a given type (classification / category) of message (e.g. a message comprising a given radio resource control, RRC, information element, such as a system information related message or a paging request related message), a characteristic of an identifier associated with the message (i.e. an identifier to indicate which terminal device(s) the message is for) may be selected according to the transmission scheme used for the message. This approach may be implemented in accordance with certain embodiments of the disclosure regardless of whether the wireless telecommunications system also implements an approach using validity periods as described herein (i.e. the approach may be implemented in association with the principles of the repeat transmission scheme represented in Figure 6 as well as that represented in Figure 7). That is to say, the concept of associating a validity period with a control message and the concept of using different identifier characteristics according to a transmission scheme being used may be used together in combination or separately from one another in accordance with different embodiments of the disclosure.

A terminal device having the ability to receive transmissions using the repeat transmission approach can identify the transmissions as such directly from the associated identifier characteristic and receive the message accordingly. The characteristic for the identifier can be selected so that a terminal device not having the ability to receive transmissions using a repeat transmission approach, for example a legacy terminal device, does not recognise the message as being addressed to the terminal device, and so in effect ignores it. Such a terminal device may in effect ignore the message because, for example, the identifier has a value which is not recognised as a value relevant to the terminal device or because a search space for a control message conveying the identifier is not searched by the terminal device.

Thus, if in a particular implementation it is assumed that a repeat transmission approach to coverage extension is intended primarily for MTC-type devices, an MTC-specific system information radio network temporary identifier (MTC-SI-RNTI) may be established. PDCCH messages associated with repeat transmissions for conveying system information messages may thus be addressed to MTC-SI-RNTI instead of an SI-RNTI used for conveying system information that is not sent using repeat transmissions. More generally some embodiments of the disclosure propose introducing other repetition specific RNTIs to address messages that rely on repetitions for coverage extension to complement corresponding RNTIs in existing systems. Thus, system information messages to be sent in accordance with a non-repeat transmission technique may be associated with a conventional system information identifier (e.g. SI-RNTI) while system information messages to be sent in accordance with a repeat-transmission technique may be associated with a modified system information identifier (e.g. REPEAT-SI-RNTI).

Similar issues can arises for other common RNTIs associated with other types of message that may be sent using a repeat transmission approach. Thus corresponding RNTIs having different characteristics may also be established for these. For example, for each of SI-RNTI, P-RNTI, RA-RNTI, TPC-PUCCH-RNTI, TPC-PUSCH-RNTI and M-RNTI to be used for addressing non-repeat transmission messages, there may be established a corresponding RNTI having a different value to be used for addressing repeat-transmission messages (e.g. what might be generally referred to as REPEAT-RNTIs, such as REPEAT-SI-RNTI, REPEAT-P-RNTI, REPEAT-RA-RNTI, REPEAT-TPC-PUCCH-RNTI, REPEAT-TPC-PUSCH-RNTI and REPEAT-M-RNTI). Thus an approach in accordance with an embodiment of the disclosure may be used in association with messages selected from the group comprising: (i) a message associated with transmitting system information; (ii) a message associated with transmitting a paging message; (iii) a message associated with transmitting a random access response message; (iv) a message associated with transmitting power control information for an uplink control channel; (v) a message associated with transmitting power control information for an uplink data channel; and (vi) a message associated with a broadcast and / or multicast service. A similar approach can be taken for types of message associated with other common RNTIs which may be introduced in future.

In some implementations in which a message to be transmitted using a repeat-transmission approach in association with an identifier having a characteristic selected to indicate this, a component part of the message (e.g. a repeat transmission) may also be transmitted in one, or more, subframes in association with an identifier having a characteristic that would be used if the message were being transmitted using a conventional single-transmission approach. This will allow legacy terminal devices who are able to receive the message from only a single repeat transmission to in effect receive the message based on one of the repeat transmissions.

One advantage of associating identifiers for a given type of message with different characteristics based on the transmission scheme is the potential for more complete use of the available transmission resources. For example, referring to Figure 7, the initial SI-RNTI addressed PDCCH repeat transmission in the control region 700O of subframe O is part of a repeat transmission comprising three repeat transmissions in the respective control regions of subframes O, P and Q. This PDCCH message identifies resources (and other parameters) associated with a PDSCH message to be subsequently transmitted starting from subframe R as discussed above. As previously noted, it is expected for repeat-transmission based coverage extension there will be no PDSCH signalling associated with the PDCCH message until after the repeat transmissions comprising the PDCCH message had been made. In principle the PDSCH

transmission resources in the PDSCH regions 702O, 702P and 702Q of subframes O, P and Q corresponding to the resources allocated by the PDCCH message for use in subframe starting from subframe R could be used to support other transmissions. For example, the respective control regions 700O, 700P, 700R could include conventional single-subframe PDCCH messages allocating the relevant PDSCH transmission resources for another purpose, for example unicast data. However, it would be confusing for a legacy terminal device to decode a unicast PDCCH message and a SI PDCCH message resource allocation identifying the same resources in the same subframe. Thus by preventing the legacy terminal device from decoding the SI PDCCH signalling (through use of an appropriate distinguishing characteristic for the identifier as discussed herein), the legacy terminal device is free to receive unicast data on the relevant PDSCH resources (in association with an appropriately addressed PDCCH transmission indicating these resources).

In implementations in which the distinguishing characteristic for the identifier is its value (i.e. with one value, such as SI-RNTI, indicating conventional single-subframe transmission, and another value, such as REPEAT-SI-RNTI, indicating repeat-transmission coverage extension), the "new" REPEAT-RNTIs may be defined in accordance with an operating standard for the wireless telecommunications network in parallel with the corresponding RNTIs. For example, as noted above, in LTE the SI-RNTI has a fixed value 0xFFFF. In accordance with an embodiment of the disclosure a fixed value for a REPEAT-SI-RNTI may be selected from one of the currently reserved RNTIs in LTE (from 0xFFF4 to 0xFFC). Thus, if, for example, a value 0xFFF5 is allocated as REPEAT-SI-RNTI (i.e. an identifier for a system information related message sent using repeat transmissions), a PDCCH addressed to 0xFFFF can be identified as corresponding to a system information message sent without repetition whereas a PDCCH addressed to 0xFFF5 can be identified as corresponding to a system information message sent using repetition. A terminal device that is unaware of repetition will in effect ignore the PDCCH addressed to 0xFFF5 as this will not be recognised as a valid RNTI for the terminal device. Corresponding principles apply where EPDCCH is used.

In the above-described example the value of the RNTI is the characteristic used to distinguish between the different transmission schemes. However, in accordance with other embodiments of the disclosure, other characteristics can be used to distinguish identifiers to indicate different transmission schemes. For example, in LTE there are currently eight "spare" values that could be used as new REPEAT-RNTIs. This is a sufficient number of values to provide a corresponding RNTI to be used in association with a transmission scheme comprising repeat transmissions for all currently-existing common RNTIs. However, it may be considered preferable in some cases to avoid using these "spare" values so they remain free for other uses, or there may be a need for more REPEAT-RNTIs (for example, to provide multiple extra RNTI for a given type of message, e.g. a system information message, to indicate another aspect of the transmission scheme, for example the number of repeats). Thus, in accordance with some embodiments a REPEAT-RNTI may in fact have a value that is the same as its corresponding "conventional" RNTI (e.g. 0xFFFF for SI-RNTI and REPEAT-SI-RNTI) but be associated with a different search space. As is well known a terminal device will typically search a defined subset of control region resources to seek to identify any control messages associated with an identifier (RNTI) common to a plurality of terminal devices. The subset of control region resources is known as a search space and comprises a plurality of candidate PDCCH for the terminal device to check. This search space approach is taken to reduce the amount of processing required by the terminal device to seek to identify any relevant control messages. Thus, PDCCH signalling associated with the existing common RNTIs are constrained to a particular set of

candidate PDCCH comprising the common search space. In accordance with some embodiments of the disclosure the characteristic of the identifier which is used to distinguish the different potential transmission schemes may be based on the specific PDCCH resources used.

For example, a PDCCH message to be transmitted in accordance with a conventional single-subframe approach may be associated with an identifier, such as SI-RNTI, in the common search space in the usual way. However, a PDCCH message to be transmitted in accordance with a repeat-transmission approach may instead be associated with the same value of identifier, such as SI-RNTI, but transmitted on PDCCH resources outside the common search space. Thus in accordance with some implementations the distinguishing characteristic for the identifier based on the transmission scheme may be a search space with which the identifier is associated. Thus a PDCCH message addressed to SI-RNTI within a particular search space (e.g. the common search space in LTE) can be identified as corresponding to a system information message sent without repetition whereas a PDCCH transmission addressed to SI-RNTI outside the particular search space (e.g. outside the common search space in LTE) can be identified as corresponding to a system information message sent using repetition. A terminal device that is unaware of repetition will in effect ignore the PDCCH addressed to SI-RNTI outside the common search space as the terminal device will not search for the SI-RNTI outside the common search. Corresponding principles apply where EPDCCH is used. Thus in effect, identifiers associated with repeat transmissions may be associated with a newly-defined search space which is outside the search space used for the corresponding identifiers for conventional single-subframe transmissions. In some examples the new search space may support only a single aggregation level, for example an aggregation level 8 (the high aggregation level being appropriate in view of the coverage extension context). The new search space may be smaller (i.e. comprise fewer candidate PDCCH) than the search space for existing common RNTIs. This can help reduce the blind search load associated with the repeat transmissions comprising a message transmitted using a repeat transmission for coverage extension.

It will appreciated the advantages of establishing a new search space comprising a reduced number of candidate PDCCHs with a single relatively high aggregation level to be used in association with identifiers for repeat transmission messages can be applied even in circumstances where different identifier values are associated with the different transmission schemes. In such cases the repeat-specific identifier values may be selected from among the values that are available for use as identifiers in the wireless telecommunications system. In one example, as referred to above, a repeat-specific identifier values may simply match its corresponding non-repeat specific identify value (e.g. SI-RNTI) with the different search space in which a control message associated with the identifier is transmitted providing the distinguishing characteristic for the identifier for the selected transmission scheme. However, in another implementation the repeat-specific identifier values may be selected from, for example, identifiers available for other uses, for example in LTE from identifiers available for cell-specific RNTIs (which may range from 0x001 to 0xFFF3). This approach can in principle provide a relatively large number of repeat-specific identifiers. For example, one or more of the values normally used for C-RNTI can be in effect reserved as one or more repeat-specific RNTIs, such as REPEAT-SI-RNTI in the terminology used above, and likewise for types / classes / classifications of messages other than system information related messages, such as paging messages and random access a response messages etc. Thus a base station could in effect reserve (re-allocate) in its cell a number of RNTI values for one purpose as actually being for use as repeat-specific RNTIs. If any of the re-allocated subset of RNTIs comprising the repeat-specific RNTI is detected by a terminal device as addressing a PDCCH in the newly-defined search space, the terminal

device may be configured to interpret this as a repeat-specific RNTI. This may be based on the base station conveying in previous signalling to terminal devices that support repeat-transmission communications an indication of the relevant RNTI(s). Alternatively, or in addition, the relevant RNTI(s) may be defined in accordance with an operating standard of the network for reallocation within the new search space. If the PDCCH candidates comprising the new search space do not overlap with those of the pre-existing common search space and UE-specific search space used by legacy devices, then the RNTIs allocated as repeat-specific RNTIs within the new search space could continue to be used in the other search space without giving rise to the potential for confusion for legacy terminal devices. If, on the other hand, the PDCCH candidates comprising the new search space do overlap with those of the pre-existing common search space or UE-specific search space, then the base station may be configured to avoid allocating any of a currently re-allocated RNTI to terminal devices in accordance with the usual function for the RNTI (i.e. a C-RNTI reallocated for use as a repeat-specific identifier should not be allotted to a terminal device for use as a C-RNTI). This can be remedied as a straightforward matter of RNTI scheduling (for example, the base station can in effect simply treat the re-allocated RNTIs as being already allotted for use).

If multiple RNTI are made available for use for a given type of message, the particular RNTI selected for use in association with a particular message may be used to indicate a further characteristic of the message, for example a number of repeats or a specific PDCCH validity period where implemented. This can provide the base station with a simple mechanism for modifying the specific repeat and all validity period parameters associated with a particular message, thereby improving overall flexibility.

Determining which identifiers a terminal device should search for to seek to identify messages to be sent to the terminal device using a repeat transmission scheme can be done in accordance with the usual principles by linking it to transmission mode (TM) configuration. In one implementation the repeat-specific RNTIs provided in accordance with embodiments of the disclosure might apply in all transmission modes as the principles governing their use will in many respects be similar to conventional, search space RNTIs. There could also be a link with the category/type of the terminal device. For example, a new terminal device category identifier could be introduced (e.g. category 0) to indicate the terminal device is a particular type of terminal device, for example an MTC-based terminal device. The repeat-specific identifiers may then be considered to apply to all transmission modes for terminal devices of category 0 (if the repeat-transmission based scheme is limited to category 0 terminal devices), as well as for additional terminal device categories if the use of the repeat-transmission based scheme is more widely supported.

Figure 9 is a signalling ladder diagram schematically representing modes of operation for the terminal device 508 and the base station 504 schematically represented in Figure 5 in accordance with some embodiments of the present disclosure.

Processing begins in step T1 when the base station determines that a message is to be transmitted to one or more terminal devices. The message may, for example, be a broadcast message or a multicast message. The determination that a message is to be transmitted may be made in accordance with conventional operating procedures for the wireless communications system. For example, if the message is a system information message, step T1 may arise in accordance with a conventional timing schedule for transmitting system information messages. If the message is a paging message, step T1 may arise because an event has arisen which requires a terminal device to be paged. In this example it is assumed the message which is to be transmitted is a system information message which is relevant for (i.e.

address to an identifier associated with) terminal device 508. Furthermore, it is assumed the message may be transmitted in accordance with either one of a first transmission scheme using transmission resources in a first number of radio subframes (e.g. using conventional single-subframe transmission) or a second transmission scheme using transmission resources in a plurality radio subframes (e.g. using repeat-transmission for coverage extension).

In step T2 the base station determines which of the first and second transmission schemes are to be used for transmitting the message. That is to say, in this example, the base station determines whether or not a conventional single subframe approach or a repeat-transmission approach for coverage extension will be used for the message. There are a number of factors that may govern this determination, either individually or in combination. For example, the terminal devices in the wireless telecommunication system may comprise a first set of terminal devices and a second set of terminal devices step and T2 may be based on whether the one or more terminal devices to which the message is to be sent comprises terminal devices in the first or second sets. For example, the first set of terminal devices may comprise terminal devices that do not require coverage extension techniques to receive messages (or simply do not support coverage extension), whereas the second set of terminal devices may comprise terminal devices that do require coverage extension techniques to receive messages (and support repeat-transmission based coverage extension). Whether or not a specific terminal device requires coverage extension may, for example, be based on a measured radio propagation metric associated with the terminal device, for example a path loss, block error rate, a bit error rate, a packet error rate, a frame error rate, a symbol error rate, or negative or positive acknowledgement signalling rate (ACK/NACK) associated with communications with the terminal device. In another implementation the decision may take account of a specific identity or category for the one or more terminal devices to which the messages to be sent.

In step T3 the base station determines a characteristic of an identifier for the message based on the transmission scheme determined in step T2. This characteristic may be selected in accordance with any of the principles discussed above (e.g. use of different values for the identifier or different search spaces to be used with the identifier).

In step T4 the message is transmitted in accordance with the transmission scheme determined in step T2 and in association with an identifier, e.g. RNTI, having the characteristic determined in step T3. For example, the message may be transmitted in accordance with a repeat-transmission scheme as described herein with an identifier selected to have a characteristic to identify this, for example in accordance with any of the principles discussed above. In this regard the message may comprise one or other or both of a control message transmitted on a downlink control channel, e.g. a PDCCH message and another message transmitted on a downlink data channel, e.g. PDSCH (i.e. such that the identifier is transmitted separately from the message).

In step T5 the terminal device receives the transmitted signalling from the base station and determines the transmission scheme being used from the characteristic of the identifier. The terminal device may then proceed to receive and decode the message in accordance with the transmission scheme being used.

Thus, the process represented in Figure 9 demonstrates a mechanism by which a base station can readily indicates to terminal devices the transmission scheme being used for a given message. Once the terminal device has determined the transmission scheme, subsequent operation, for example in terms of

receiving the message, they be performed in accordance with conventional principles for receiving such messages. Furthermore, these techniques may be modified to incorporate a validity period approach such as discussed above.

Thus there has been described a wireless telecommunication system that comprises a base station and a terminal device communicating over a radio interface. The radio interface supports a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel (e.g. a physical downlink shared channel) for conveying other messages from the base station to the terminal device. The control messages convey information on resource allocations for the other messages on the downlink data channel. The other messages may comprise user-plane messages or control-plane messages. The terminal device is configured to receive a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel and determine a validity period for the control message. During the validity period for the control message the terminal device is configured to receive a plurality of the other messages from the base station on the downlink data channel using the allocated transmission resources.

There has also been described a wireless telecommunication system that comprises a base station arranged to communicate messages to one or more terminal devices over a radio interface. The radio interface has a radio frame structure comprising a plurality of subframes, wherein a message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes (e.g. one subframe) or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes (e.g. with repeat transmissions in a plurality of subframes). The message is transmitted in association with an identifier to indicate a terminal device to which the message is addressed. A characteristic for the identifier, for example a value or control region search space for the identifier, is dependent on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme. A terminal device to which the message is addressed determines the transmission scheme from the characteristic of the identifier and receives the message accordingly.

Further particular and preferred aspects of the present invention are set out in the accompanying independent and dependent claims. It will be appreciated that features of the dependent claims may be combined with features of the independent claims in combinations other than those explicitly set out in the claims.

Thus, the foregoing discussion discloses and describes merely exemplary embodiments of the present invention. As will be understood by those skilled in the art, the present invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. Accordingly, the disclosure of the present invention is intended to be illustrative, but not limiting of the scope of the invention, as well as other claims. The disclosure, including any readily discernible variants of the teachings herein, define, in part, the scope of the foregoing claim terminology such that no inventive subject matter is dedicated to the public.

Respective features of the present disclosure are defined by the following two groups of numbered paragraphs:

Group 1 of numbered paragraphs:

Paragraph 1. A method of operating a terminal device communicating with a base station in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the method comprises receiving a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel, determining a validity period for the control message, and receiving a plurality of other messages from the base station on the downlink data channel using the allocated transmission resources within the validity period for the control message.

Paragraph 2. The method of paragraph 1, wherein the other messages comprise system information messages.

Paragraph 3. The method of any preceding paragraph, wherein the system information messages comprise one or more system information blocks.

Paragraph 4. The method of any preceding paragraph, wherein the radio interface is based on a radio frame structure comprising a plurality of subframes, wherein each subframe comprises a control channel region for supporting the downlink control channel and a shared channel region for supporting the downlink data channel, and wherein respective ones of the control and / or the other messages comprise transmissions over a plurality of subframes.

Paragraph 5. The method of any preceding paragraph, wherein the validity period for the control message is determined in dependence on an identifier used in association with the control message.

Paragraph 6. The method of paragraph 5, wherein the identifier comprises an indication of one or more terminal devices to which the control message is addressed.

Paragraph 7. The method of any preceding paragraph, wherein the validity period for the control message is determined in dependence on a transmission characteristic of the control message.

Paragraph 8. The method of paragraph 7, wherein the transmission characteristic of the control message comprises a transmission time associated with the control message.

Paragraph 9. The method of any preceding paragraph, wherein the radio interface is based on a radio frame structure comprising a plurality of subframes, and wherein the timing of a subframe used to convey a first one of the plurality of other messages is used to determine the timing of a subframe used to convey a second one of the plurality of other messages within the validity period for the control message.

Paragraph 10. The method of any preceding paragraph, wherein the timing of a subframe used to convey the first one of the plurality of other messages relative to a first predefined range of subframes is used to determine the timing of a subframe used to convey the second one of the plurality of other messages relative to a second predefined range of subframes.

Paragraph 11. The method of any preceding paragraph, wherein the validity period is determined in dependence on a validity period indicator received in association with the control message.

Paragraph 12. The method of any preceding paragraph, wherein the validity period is determined in dependence on the time at which a subsequent control message is received.

Paragraph 13. The method of any preceding paragraph, wherein the other messages comprise random access response messages and / or paging messages..

Paragraph 14. A terminal device for communicating with a base station in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the terminal device comprises a controller unit and a transceiver unit configured to operate together to receive a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to receive a plurality of other messages from the base station on the downlink data channel using the allocated transmission resources within the validity period for the control message.

Paragraph 15. Circuitry for a terminal device communicating with a base station in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to cause the terminal device to receive a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to receive a plurality of other messages from the base station on the downlink data channel using the allocated transmission resources within the validity period for the control message

Paragraph 16. A method of operating a base station communicating with a terminal device in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the method comprises transmitting a control message to the terminal device conveying an indication of allocated transmission resources on the downlink data channel, determining a validity period for the control message, and transmitting a plurality of other messages to the terminal device on the downlink data channel using the allocated transmission resources within the validity period for the control message.

Paragraph 17. A base station for communicating with a terminal device in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the base station comprises a controller unit and a transceiver unit configured to operate together to transmit a control message to the terminal device conveying an indication of allocated transmission resources on the downlink data

channel, to determine a validity period for the control message, and to transmit a plurality of other messages to the terminal device on the downlink data channel using the allocated transmission resources within the validity period for the control message.

Paragraph 18. Circuitry for a base station communicating with a terminal device in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to cause the base station to transmit a control message to the terminal device conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to transmit a plurality of other messages to the terminal device on the downlink data channel using the allocated transmission resources within the validity period for the control message.

Group 2 of numbered paragraphs:

Paragraph 1. A method of operating a base station for communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein the method comprises selecting a characteristic for the identifier in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

Paragraph 2. The method of any preceding paragraph, wherein the first number of radio subframes comprises a single radio subframe and the second number of radio subframes comprises a plurality of radio subframes.

Paragraph 3. The method of any preceding paragraph, wherein terminal devices in the wireless telecommunications system comprise a first set of terminal devices and a second set of terminal devices, and wherein the method comprises determining whether to transmit the message in accordance with the first transmission scheme or the second transmission scheme in dependence on whether a terminal device to which the message is to be transmitted is a member of the first set of terminal devices or the second set of terminal devices.

Paragraph 4. The method of any preceding paragraph, wherein the method comprises determining whether to transmit the message in accordance with the first transmission scheme or the second transmission scheme in dependence on a radio propagation parameter associated with radio communications between the base station and a terminal device to which the message is to be transmitted.

Paragraph 5. The method of paragraph 4, wherein the radio propagation parameter is selected from the group comprising: a path loss; an error rate; a positive acknowledgment, ACK, signalling rate; and a negative acknowledgment signalling, NACK, rate.

Paragraph 6. The method of any preceding paragraph, wherein the method comprises determining whether to transmit the message in accordance with the first transmission scheme or the second transmission scheme in dependence on an identity and / or type of a terminal device to which the message is to be transmitted.

Paragraph 7. The method of any preceding paragraph, wherein the radio interface supports a downlink control channel for conveying control messages from the base station to terminal devices and a downlink data channel for conveying other messages from the base station to terminal devices, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the message comprises a control message transmitted on the downlink control channel.

Paragraph 8. The method of any preceding paragraph, wherein the radio interface supports a downlink control channel for conveying control messages from the base station to terminal devices and a downlink data channel for conveying other messages from the base station to terminal devices, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the message comprises one of the other messages transmitted on the downlink data channel.

Paragraph 9. The method of any preceding paragraph, wherein the identifier to indicate a terminal device to which the message is addressed is transmitted separately from the message.

1 Paragraph 0. The method of any preceding paragraph, wherein the identifier comprises a radio network temporary identifier, RNTI.

Paragraph 11. The method of any preceding paragraph, wherein the identifier is a common to a plurality of terminal devices.

Paragraph 12. The method of any preceding paragraph, wherein the message comprises a broadcast message.

Paragraph 13. The method of any preceding paragraph, wherein the message comprises a multicast message.

Paragraph 14. The method of any preceding paragraph, wherein for a given type of message the characteristic for the identifier is selected from a first predefined characteristic for the identifier associated with the given type of message and a second predefined characteristic for the identifier associated with the given type of message according to whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

Paragraph 15. The method of any preceding paragraph, wherein the message is selected from the group comprising: (i) a message associated with transmitting system information; (ii) a message associated with transmitting a paging message; (iii) a message associated with transmitting a random access response message; (iv) a message associated with transmitting power control information for an uplink control

channel; (v) a message associated with transmitting power control information for an uplink data channel; and (vi) a message associated with a broadcast and / or multicast service.

Paragraph 16. The method of any preceding paragraph, wherein for a message to be transmitted in accordance with the second transmission scheme, a component of the message transmitted in one of the second number of subframes is associated with a characteristic for the identifier corresponding to that which would be used if the message were to be transmitted in accordance with the first transmission scheme.

Paragraph 17. The method of any preceding paragraph, wherein the characteristic for the identifier comprises a value for the identifier.

Paragraph 18. The method of any preceding paragraph, wherein the characteristic for the identifier comprises a search space in which a terminal device searches using the identifier to determine if a message has been addressed to the terminal device.

Paragraph 19. The method of any preceding paragraph, wherein the method comprises selecting the characteristic for the identifier from a plurality of different characteristics associated with different types of message.

Paragraph 20. The method of any preceding paragraph, wherein the characteristic for the identifier to be selected for a message to be transmitted in accordance with the second transmission scheme is defined in accordance with an operating standard for the wireless telecommunications system.

Paragraph 21. The method of any preceding paragraph, further comprising the base station pre-defining the characteristic for the identifier to be selected for a message to be transmitted in accordance with the second transmission scheme.

Paragraph 22. The method of paragraph 21, wherein the pre-defining the characteristic for the identifier is a value for the identifier selected from among a plurality of values.

Paragraph 23. A base station for communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the base station comprises a controller unit and a transceiver unit configured to operate together such that the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein a characteristic for the identifier is selected in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

Paragraph 24. Circuitry for a base station communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the circuitry comprises a controller element and a transceiver element configured to operate together such that the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of

radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein a characteristic for the identifier is selected in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

Paragraph 25. A method of operating a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the method comprises determining from an identifier associated with the message that the message is addressed to the terminal device, and further determining from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

Paragraph 26. A terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the terminal device comprises a controller unit and a transceiver unit configured to operate together to determine from an identifier associated with the message that the message is addressed to the terminal device, and to further determine from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

Paragraph 27. Circuitry for a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to determine from an identifier associated with the message that the message is addressed to the terminal device, and to further determine from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

REFERENCES

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[3] ETSI TS 136 331 V11.4.0 (2013-07) / 3GPP TS 36.331 version 11.4.0 Release 11)

[4] 3GPP document R1-135422, “On the need of PDCCH for SIB and other Common Channel”, Mediatek, RAN1#75, San Francisco, November 2013

[5] 3GPP document R1-134207, “Coverage enhancement techniques for PBCH”, Alcatel-Lucent, Alcatel-Lucent Shanghai Bell, RAN1#74bis, Guangzhou, October 2013.

5

CLAIMS

What is claimed is:

1. A method of operating a base station for communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein the method comprises selecting a characteristic for the identifier in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

2. The method of claim 1, wherein the first number of radio subframes comprises a single radio subframe and the second number of radio subframes comprises a plurality of radio subframes.

3. The method of claim 1, wherein terminal devices in the wireless telecommunications system comprise a first set of terminal devices and a second set of terminal devices, and wherein the method comprises determining whether to transmit the message in accordance with the first transmission scheme or the second transmission scheme in dependence on whether a terminal device to which the message is to be transmitted is a member of the first set of terminal devices or the second set of terminal devices.

4. The method of claim 1, wherein the method comprises determining whether to transmit the message in accordance with the first transmission scheme or the second transmission scheme in dependence on a radio propagation parameter associated with radio communications between the base station and a terminal device to which the message is to be transmitted.

5. The method of claim 4, wherein the radio propagation parameter is selected from the group comprising: a path loss; an error rate; a positive acknowledgment, ACK, signalling rate; and a negative acknowledgment signalling, NACK, rate.

6. The method of claim 1, wherein the method comprises determining whether to transmit the message in accordance with the first transmission scheme or the second transmission scheme in dependence on an identity and / or type of a terminal device to which the message is to be transmitted.

7. The method of claim 1, wherein the radio interface supports a downlink control channel for conveying control messages from the base station to terminal devices and a downlink data channel for conveying other messages from the base station to terminal devices, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the message comprises a control message transmitted on the downlink control channel.

8. The method of claim 1, wherein the radio interface supports a downlink control channel for conveying control messages from the base station to terminal devices and a downlink data channel for conveying other messages from the base station to terminal devices, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the message comprises one of the other messages transmitted on the downlink data channel.

9. The method of claim 1, wherein the identifier to indicate a terminal device to which the message is addressed is transmitted separately from the message.

10. The method of claim 1, wherein the identifier comprises a radio network temporary identifier, RNTI.

11. The method of claim 1, wherein the identifier is a common to a plurality of terminal devices.

12. The method of claim 1, wherein the message comprises a broadcast message.

13. The method of claim 1, wherein the message comprises a multicast message.

14. The method of claim 1, wherein for a given type of message the characteristic for the identifier is selected from a first predefined characteristic for the identifier associated with the given type of message and a second predefined characteristic for the identifier associated with the given type of message according to whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

15. The method of claim 1, wherein the message is selected from the group comprising: (i) a message associated with transmitting system information; (ii) a message associated with transmitting a paging message; (iii) a message associated with transmitting a random access response message; (iv) a message associated with transmitting power control information for an uplink control channel; (v) a message associated with transmitting power control information for an uplink data channel; and (vi) a message associated with a broadcast and / or multicast service.

16. The method of claim 1, wherein for a message to be transmitted in accordance with the second transmission scheme, a component of the message transmitted in one of the second number of subframes is associated with a characteristic for the identifier corresponding to that which would be used if the message were to be transmitted in accordance with the first transmission scheme.

17. The method of claim 1, wherein the characteristic for the identifier comprises a value for the identifier.

18. The method of claim 1, wherein the characteristic for the identifier comprises a search space in which a terminal device searches using the identifier to determine if a message has been addressed to the terminal device.

19. The method of claim 1, wherein the method comprises selecting the characteristic for the identifier from a plurality of different characteristics associated with different types of message.

20. The method of claim 1, wherein the characteristic for the identifier to be selected for a message to be transmitted in accordance with the second transmission scheme is defined in accordance with an operating standard for the wireless telecommunications system.

21. The method of claim 1, further comprising the base station pre-defining the characteristic for the identifier to be selected for a message to be transmitted in accordance with the second transmission scheme.

22. The method of claim 21, wherein the pre-defining the characteristic for the identifier is a value for the identifier selected from among a plurality of values.

23. A base station for communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the base station comprises a controller unit and a transceiver unit configured to operate together such that the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein a characteristic for the identifier is selected in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

24. Circuitry for a base station communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the circuitry comprises a controller element and a transceiver element configured to operate together such that the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein a characteristic for the identifier is selected in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

25. A method of operating a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the method comprises determining from an identifier associated with the message that the message is addressed to the terminal device, and further determining from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

26. A terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the terminal device comprises a controller unit and a transceiver unit configured to operate together to determine from an identifier associated with the message that the message is addressed to the terminal device, and to further determine from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

27. Circuitry for a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to determine from an identifier associated with the message that the message is addressed to the terminal device, and to further determine from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

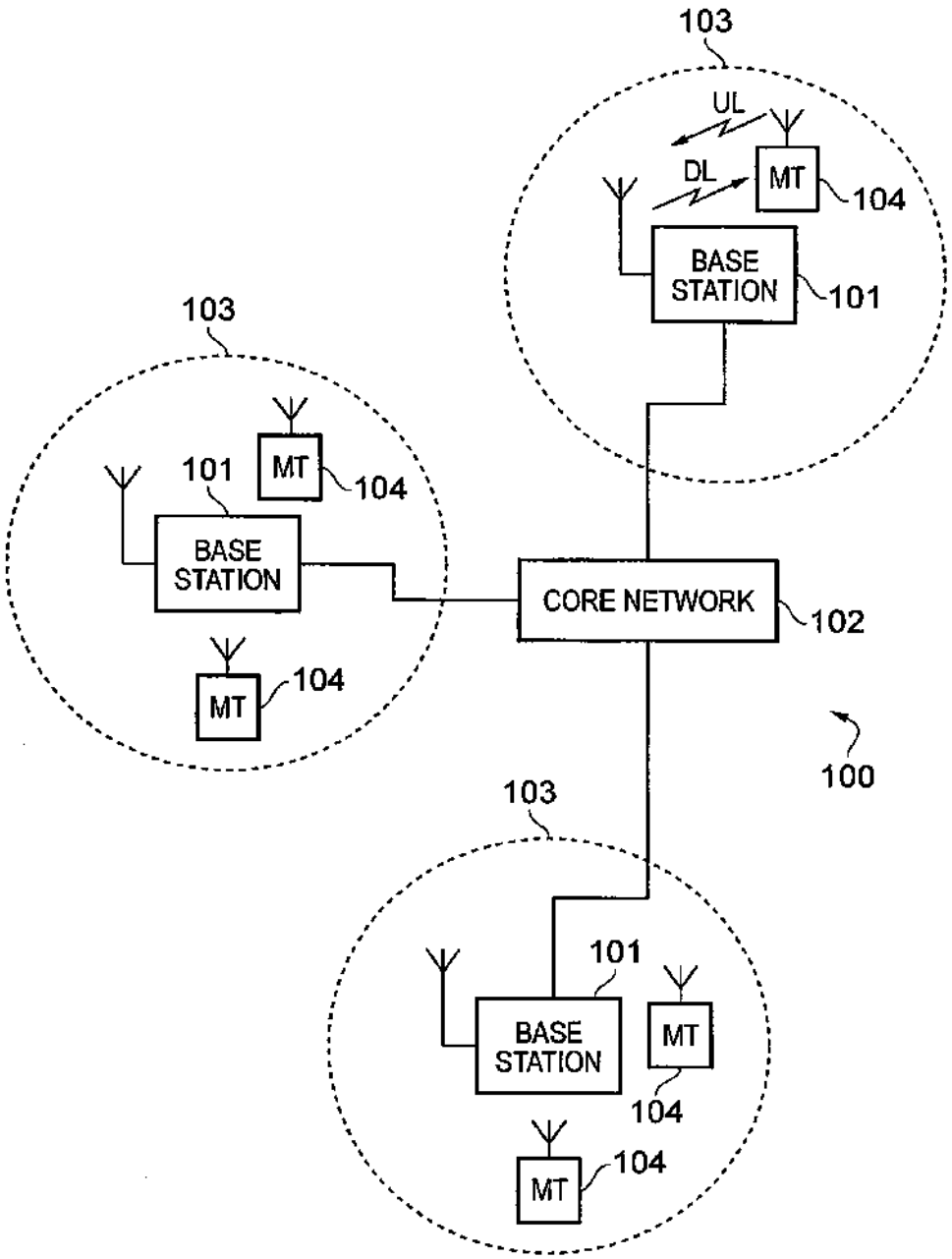

103
UL
DL
MT
104
BASE STATION
101
103
101
MT
104
BASE STATION
CORE NETWORK
102
MT
104
100
103
101
BASE STATION
MT
104
MT
104

FIG. 1

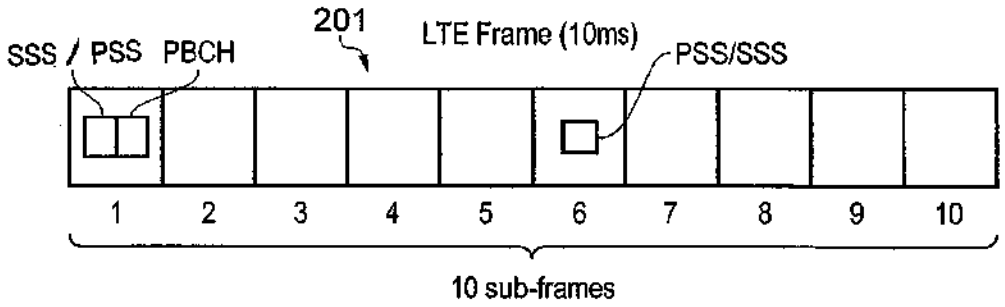

SSS / PSS
PBCH
201
LTE Frame (10ms)
PSS/SSS
1
2
3
4
5
6
7
8
9
10
10 sub-frames

FIG. 2

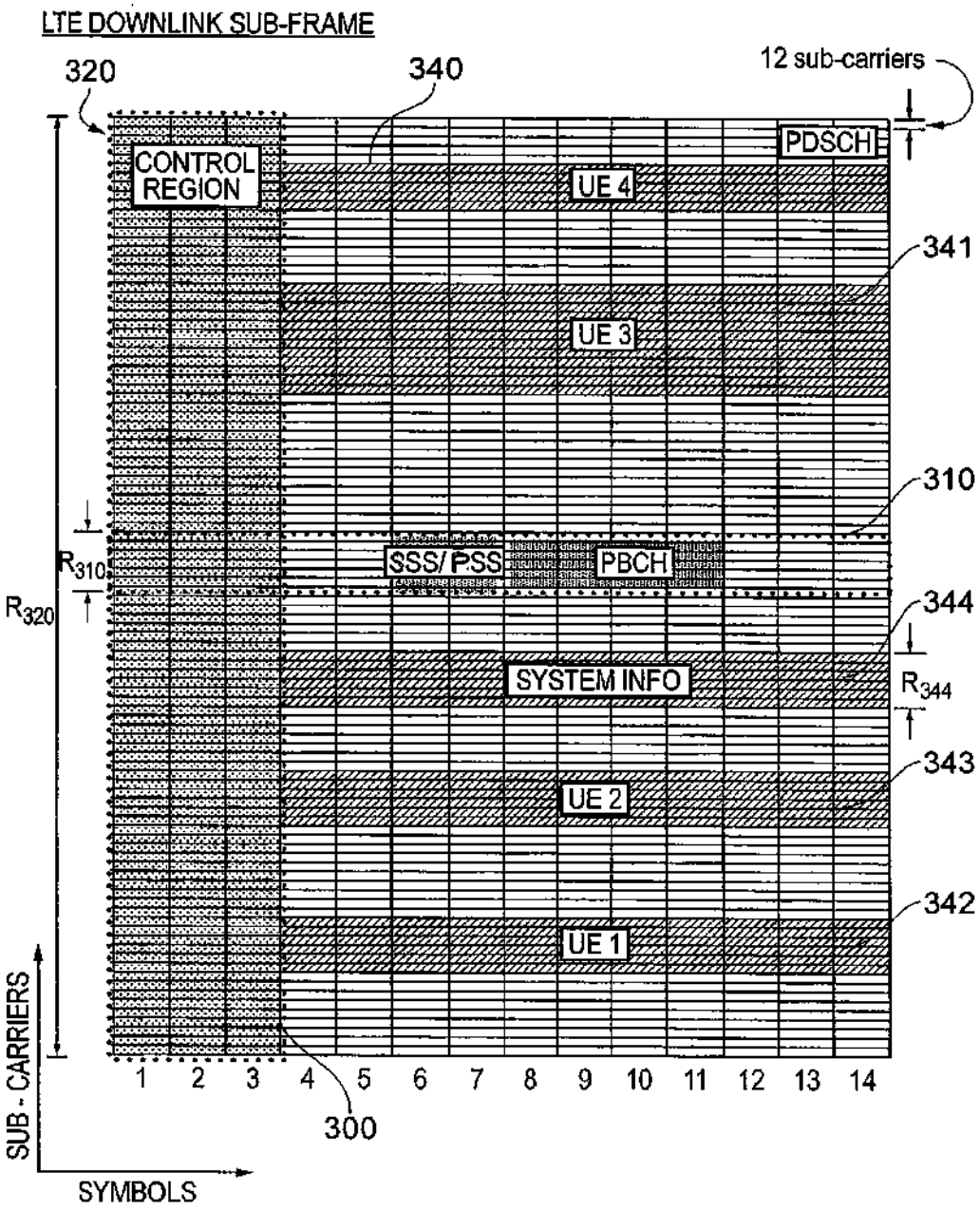

LTE DOWNLINK SUB-FRAME
320
340
12 sub-carriers
CONTROL REGION
PDSCH
UE 4
341
UE 3
310
R_{310}
SSS/ PSS
PBCH
R_{320}
344
SYSTEM INFO
R_{344}
343
UE 2
342
UE 1
SUB - CARRIERS
1 2 3 4 5 6 7 8 9 10 11 12 13 14
300
SYMBOLS

FIG. 3

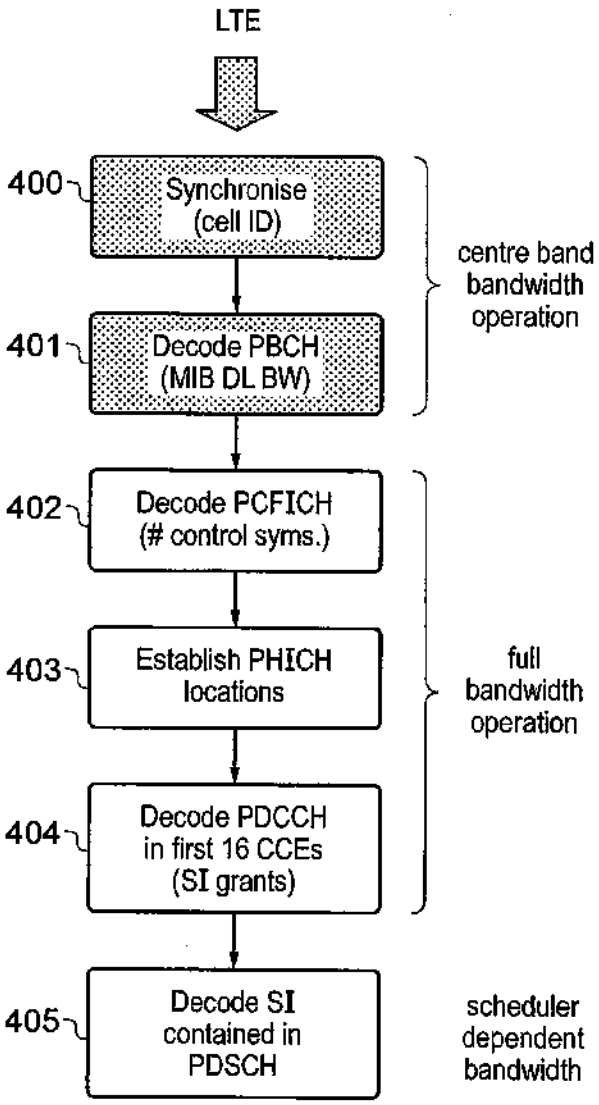

LTE
400
Synchronise (cell ID)
401
Decode PBCH (MIB DL BW)
centre band bandwidth operation
402
Decode PCFICH (# control syms.)
403
Establish PHICH locations
404
Decode PDCCH in first 16 CCEs (SI grants)
full bandwidth operation
405
Decode SI contained in PDSCH
scheduler dependent bandwidth

FIG. 4

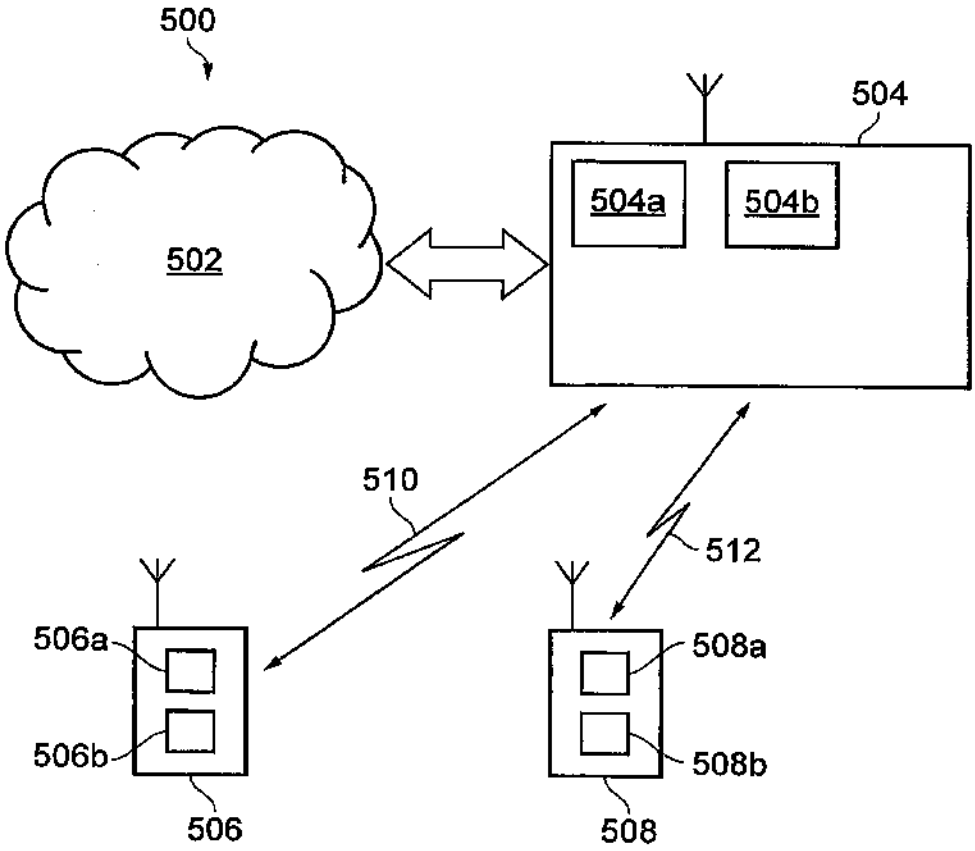


FIG. 5

Fig. 6

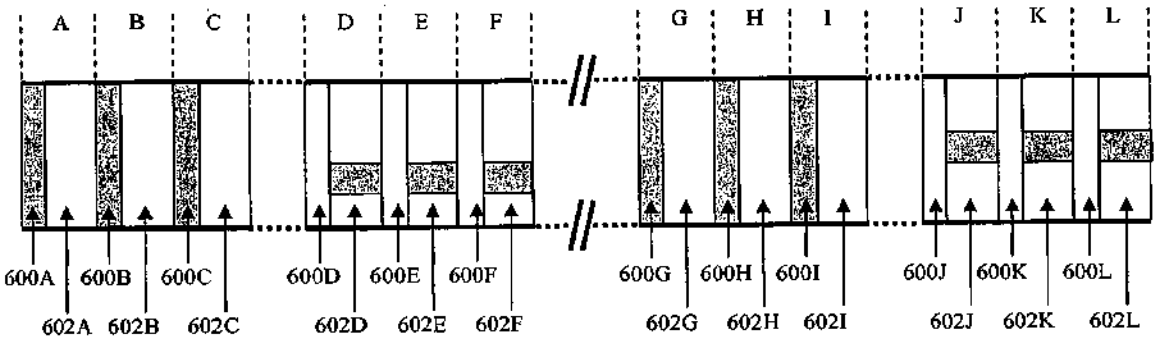
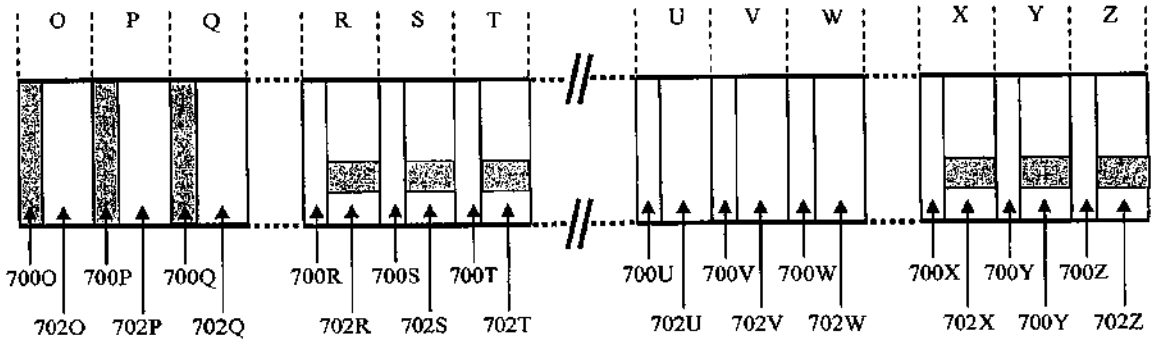

A
B
C
D
E
F
G
H
I
J
K
L
600A
600B
600C
600D
600E
600F
600G
600H
600I
600J
600K
600L
602A
602B
602C
602D
602E
602F
602G
602H
602I
602J
602K
602L

Fig. 7


O
P
Q
R
S
T
U
V
W
X
Y
Z
700O
700P
700Q
700R
700S
700T
700U
700V
700W
700X
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702V
702W
702X
702Y
702Z

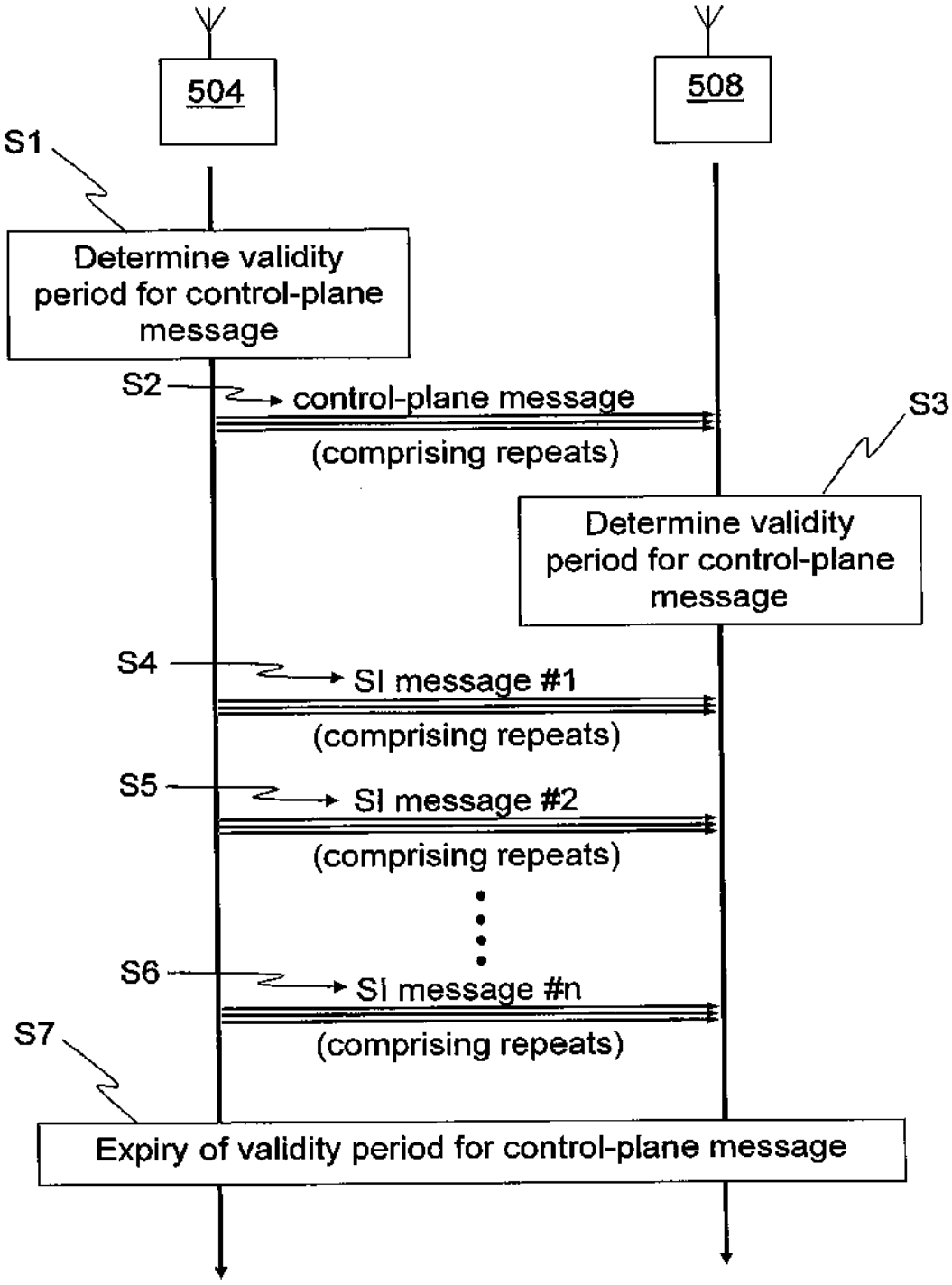

504
508
S1
Determine validity period for control-plane message
S2
control-plane message
(comprising repeats)
S3
Determine validity period for control-plane message
S4
SI message #1
(comprising repeats)
S5
SI message #2
(comprising repeats)
S6
SI message #n
(comprising repeats)
S7
Expiry of validity period for control-plane message

Fig. 8

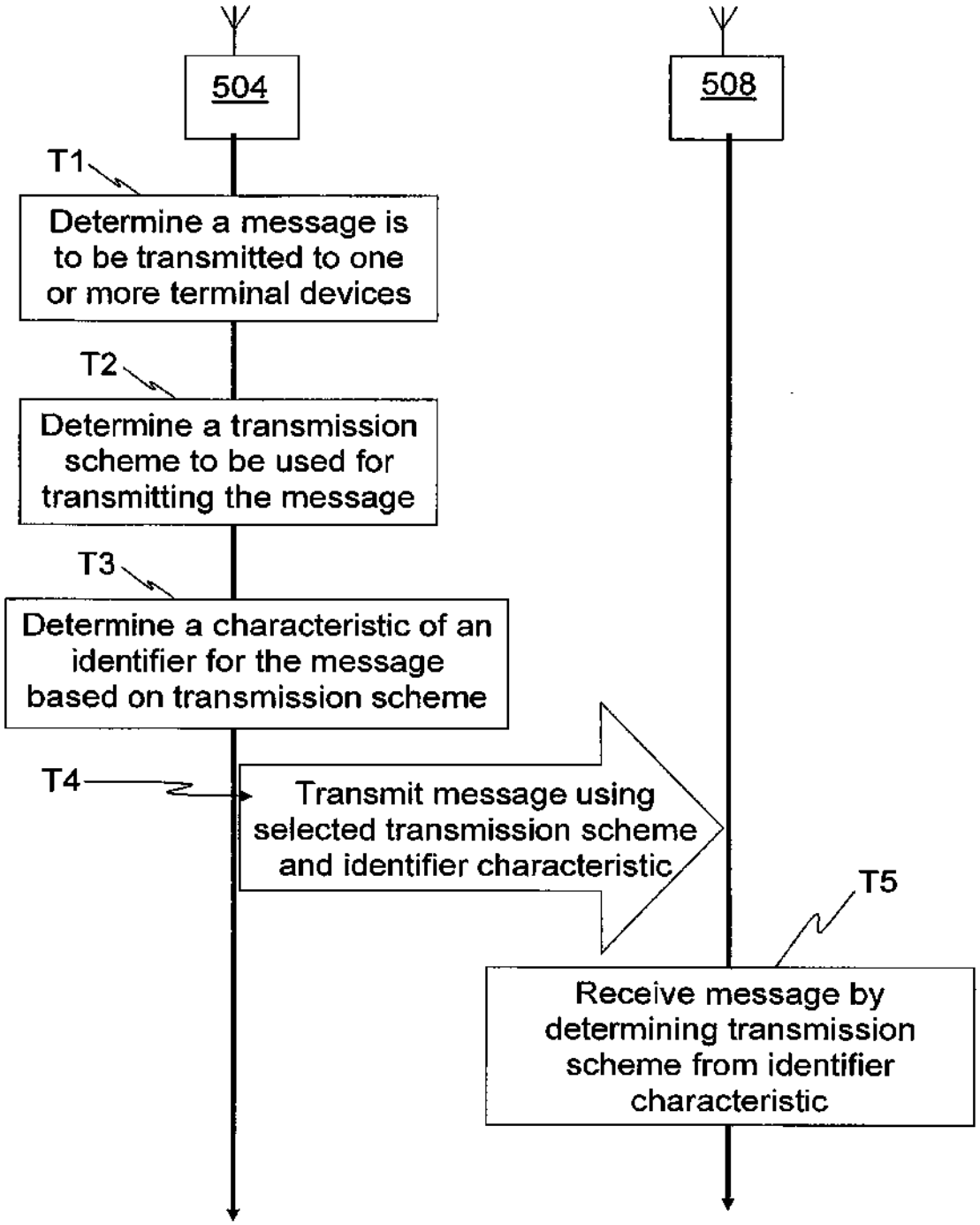

504
508
T1
Determine a message is to be transmitted to one or more terminal devices
T2
Determine a transmission scheme to be used for transmitting the message
T3
Determine a characteristic of an identifier for the message based on transmission scheme
T4
Transmit message using selected transmission scheme and identifier characteristic
T5
Receive message by determining transmission scheme from identifier characteristic

Fig. 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2014/074456

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W72/04
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W H04B H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2013/315159 A1 (XIA JINHUAN [CN] ET AL) 28 November 2013 (2013-11-28) paragraph [0005] - paragraph [0006] paragraph [0036]; figure 5 paragraph [0045]; figure 7 paragraph [0052] paragraph [0062]	1-27

X	EP 2 611 244 A2 (QUALCOMM INC [US]) 3 July 2013 (2013-07-03)	1,23-27
A	paragraph [0029]; figures 3,10 paragraph [0075]	2-22

	-/--	

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 February 2015	04/03/2015

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Cortés Gómez, F

1

Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
17/950,726	**11/19/2023 10:47:29 PM Z ET**	**ZL0205-0004-US-CON3**

Title of Invention

METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	6005	FILED BY	Jialin Zhong
PATENT CENTER #	63311403	FILING DATE	09/22/2022
CUSTOMER #	155075	FIRST NAMED INVENTOR	Xiaobo ZHANG
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	-

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R1-1704398 Discussions on DL beam management.pdf	CAA18A37FBE6A9A9F49E76ECD3158EB478B36F6160481FA574A6452F6E942218AAFEE1E3B8D147AD01DD6EFCF97D6760B20A855386877C052A13213CCC1DF833
R1-1704877 Discussion on DL beam management_v2.pdf	2DB8082D7D2495BFEFA1CBD983AE9F03DB1EDF241890E1FE3FE63EED11F026A9255EDAF267B3B0DDFF9E68AF3572B5234DA622B7F89301255360124A1335DC47
LTE UMTS Long Term	51A6E2EE1A688C0EB39B036288007B0058399224 3C1223667D

Evolution Sesia pp701-794.pdf	7F2AAC573BE36F2EF660B4DF2FEB4A7C8230834291D10E3F1A7DC931F75D8EB4DC5BBDFB2901D2
LTE UMTS Long Term Evolution Sesia pp581-700.pdf	C2B8B9B8361818CEF9814F5522944DDCE6AC30F01128C37B86AD6D0EBD4A7C133E6D5A35BB1A1A323A3D8B5C173F91DFE713054D1FAA66C7D119686319EAF229
LTE UMTS Long Term Evolution Sesia pp301-450.pdf	99ED66E70359E05D3321BBE708FA85E66DBD1B444CC726DF697C5A9244491E0DFA701A0542F516D10F746FE5FB60C31972659A4FC1821D08A22530974EA2B7F7
LTE UMTS Long Term Evolution Sesia pp1-150.pdf	D406238AF8E676E30E05533B633C10EE051C0AF6F7C79882364D8CF7F318F91E7AFB479DEEA0688D5D74C270A726DE6735E0200ADD6B5EE1E510BB88AD5F1003
LTE UMTS Long Term Evolution Sesia pp151-300.pdf	0DD4EE761D8F6D32BCEA4E269866F77353597CCBB7555F43232A32ED5052FE612237F40D428391477E9E5BB5F56AD5F872987F2118A5922CFDBA00EE3A7CA6E2
LTE UMTS Long Term Evolution Sesia pp451-580.pdf	C0878F224992F3E2E4375734C494D2B2DD9CF905B4F08A16F6F32505AAFE2F43D26CD1F74F21FE508B60B430CC5CBB47A8D20D6E8DD68D1DE4E8B2CE999689FB
3GPP TS 36.300 v14.3.0 2017-7 pp286-347.pdf	C6EE87381D86C97CE13CA32795E56811AE24AF4A09A16374FC04CCB08C9528A5547264AAF778B90E64E39A84292E2E204838016F016951390D6E93502174A44A
3GPP TS 36.300 v14.3.0 2017-7 pp126-180.pdf	5E7D01372F6B9ACB26EAB36D37FF95E4156FA996F824C083CE2D31D9BD6297F976DBAFB865ADE7703961E7C0608B902B05A4BBB3D8E9E6C1D0DC76B395791017
3GPP TS 36.300 v14.3.0 2017-7 pp1-70.pdf	454310D0421C9FD8FE05793AFB5128D742CAC2FFAEED155345A3B1182B26EFBB8B9CE473B9D67BF3C8660925002A50E93C86F0B4A51B83EB9416FF04775433ED
3GPP TS 36.300 v14.3.0 2017-7 pp71-125.pdf	94B54C44EFBDDB5328B70515E6D6AB65914742E21B57DA94AD872C7D1FC6BF03DCBFA72CE2519127F208CD9AF5F42233C07841CB6F20D1883395ACF5CE21B59A
3GPP TS 36.300 v14.3.0 2017-	6EA257367E2F21BABE31C39F7BE1ADCAE6D528BFE7BA8259

7 pp231-285.pdf	08AC99C97D17438B9DEDAA5B5CBC7287D226414FA16226EE82DE2502D0F9F7E6C226D66D06B3E9FE
3GPP TS 36.300 v14.3.0 2017-7 pp181-230.pdf	A3A49BFA369B0F9834E9350574C547D5C889CC5301DFEB6F69D894F0D339BD8775691EAE46596A7BAE4011116E8782865C6417BE2024F6D93F60C29683D2F3EF
4G LTE-LTE Advanced for Mobile Broadband Dahlman 2011 pp201-291.pdf	72B49DFACBF34A81175724043239E58DB30CCE1203F55AFF2FCDC43D3458362650A47197AB3FE72212DD73903BB3CFB0EBDEB9B6AC1257FC3989747B73E97097
4G LTE-LTE Advanced for Mobile Broadband Dahlman 2011 pp1-100.pdf	6EEA4CA4E13D04006F6E01024105166B08132B5DFB1C2609A95D4400629BC0BC8493B80660ECD35DE69C724CD8CADC0B82152D58173FED49972AC5F167C362C
4G LTE-LTE Advanced for Mobile Broadband Dahlman 2011 pp101-200.pdf	B14A584F7019A95256568A19C02B47D64AD1AE5C280E64AADA9F86E8B44509494D8CDF4D47C5662C7D3B9736DE69459D6D13BCA3C1473E6DFE2CFA449ACCB50E
3GPP TS 36.331 v13.5.0 2017-4 pp101-200.pdf	3F6E202001F2F4A3F1EE33E27DBB716FF1A7C5202D2444BF3AFFCB5B43A6276475F43ECC1E0865351C8E00206F82ED717E78A202981779BD8C16DBC1CD5FA69A
3GPP TS 36.331 v13.5.0 2017-4 pp201-300.pdf	4320F7A26492E8BFB1BB1F3C668269F822520DF9FAF53E52EE33CE6B0C088B730B030884E2767420CD3F5D9F7DE0397E7504BD40AF752ED2E35EAE5A9D13C4CD
3GPP TS 36.331 v13.5.0 2017-4 pp400-500.pdf	53869F4B87034C86DAE5AE4E3894A4F7F98F124614ACBA84CA427CEBA8162B4740015156261746A6D08AAEEE00EF57994D7808B54FDC319F5958874FDCFB5144
3GPP TS 36.331 v13.5.0 2017-4 201-399.pdf	DA9DE95902D6262A52438B33AE3C7A7C17DA6B8D84AA24148FF20E716A83B02E56FDCCC9F87AB5561023E35BDE9037A34AB6C7A7924958155BE02513663F8E28
3GPP TS 36.331 v13.5.0 2017-4 pp1-100.pdf	3BD43B5A53A296A6B304EFD1471F82C3929CDE71E782A9CEE89288737073A00CE2F67D2FE891918D8BEF1084EA9E849063048FEE0ACCCC253B0BA85369C14CB0
3GPP TS 36.331 v13.5.0 2017-	7353D9F6153100004E5D491B79FE174D69012543718 9BD98D5

4 pp501-645.pdf	D8A4A361178AA97F17A617422A3C43859FB8901801F6E05A1B7DB0E1FF4E9F8105AA7C7ECD35D0
3GPP TS 36.331 v13.3.0 2016-9 pp301-400.pdf	25A346E8C150D507C80923F90BE038352B13969ECF3A7D19D0D77A21C9B2932B8E0B39DBFADD66E39E5D7A8BEB83438940D97F8FA099F57D6952D12E04CA2FDC
3GPP TS 36.331 v13.3.0 2016-9 pp401-500.pdf	8A430C3B15964BBC4361DCF2B934553137D00DEF945252111BA88D0C51CA17B8CBF80C96D43C2483FF58AE37099C2970707B33A87E197AA386899E17661DFF34
3GPP TS 36.331 v13.3.0 2016-9 pp101-200.pdf	E14148A22E9607E0EF6C88CD68FCD5F7E0DFCF986F2CD5691188C9374BDE2B433A474EB9B3DB0D0D639C311888447E3F85E7617CA69B35DC6E2ABBB567E830D7
3GPP TS 36.331 v13.3.0 2016-9 pp501-600.pdf	16BB407BCCF4AB035A8AEDE3AC110E90EBE5B0B5A2834840EF6AB1E463A960A13E4C47C23B71C183BB2E2924D71EA1C28A6AE9936A4748CA140C6AE8100FE13B
3GPP TS 36.331 v13.3.0 2016-9 pp201-300.pdf	BA28442FA307CB0457B5318C435B3048C6094945D341E758E9B304B27425DC04AF2DAF5D59F6DCD5B204AD0A5CA8AAAE442FFD97BCB3955665FDC7E9480DB324
3GPP TS 36.331 v13.3.0 2016-9 pp1-100.pdf	C01F99E9B1C603B8C5A97CF2E8E41621BABBD3BD446B22B3EC6D3DDD9924BEC5887D975378BE8E7B6A2BEA55D455EF79FDE3C04659ACF7556ACB31720C194F57
3GPP TS 36.331 v13.0.0 2015-12 pp401-507.pdf	4982AAAA53751590301 3BDAC88F2E49D9A89EFFB3BD2FA2F916DF86C257BB5517ABE6D37ABAC5F01A13DD11BA79A6716C0C7BFD4513A33015520CBCFFCB92907
3GPP TS 36.331 v13.0.0 2015-12 pp301-400.pdf	AA4BD203D714B4A7A09BDDDD78F66B93AE63BC5BFD10B93DE7274719D37A8239BF2C2A3E0F3DB8AC6DF4D31DE3B6825624F7302F9E92E431BD97CC6F7FAB50EE
3GPP TS 36.331 v13.0.0 2015-12 pp201-300.pdf	CB84D73783CE25AC5FBF6664E54B6641C8475CD8276821A3251314B7A6C0B48ECF45103A8046D28705A67E0074D70C00F5D5B844D91424C7F2B6E77FB8203E86
3GPP TS 36.331 v13.0.0 2015-	862FA01D42774012D71AA4D1F6C67E94F53E84FE083866DEB

12 PP101-200.pdf	F03911EAC261C6B1FCA5EE58F827A2A16F2BDBFF494784BA9538703545A839E3AA57A7802D5B238
3GPP TS 36.331 v13.0.0 2015-12 pp1-100.pdf	4564515BF584DBF68AD1AD73FBB58974CB3F8E3D8E298490B649B2BC34108599B4C427FB73FA3EE6444A8A436853087F3932449CA4A9E00268F4D81E63FE62EF
3GPP TS 36.331 v12.8.0 2016-1 pp201-300.pdf	719526C533E742BD22449D4669D533546F852FFA3E81AD64255EB39B8E90DB71A87AF7A57A24E0EFAAF936F0EEBD1A2171CE66AC5A189E8FE9503F235AD08FB9
3GPP TS 36.331 v12.8.0 2016-1 pp401-500.pdf	7C996A2790F754063E77BD207EB791CFB2FDB0E7AE798782BAF3D79E4612C3DBDEFE60C1953146E9B27B5AC2B6DEFCC073A3764F82F93150F713EBE3575181AB
3GPP TS 36.331 v12.8.0 2016-1 pp501-593.pdf	DAEFE414490E7811E9DCB4AC86DEA119DC14236C7A39F7997C880C08C883BD5D70804A78ABC3A719AB996566A08110324C0D7EC2F1F7816A50C2F2CE76195945
3GPP TS 36.331 v12.8.0 2016-1 pp301-400.pdf	6A512E6A7B9A46381F561A07381CD86D9E3275F0C72256010FFBB925315A8FC14A397FF5C3D7A9776ACBA89B82C04E4A32A750B50D325786B300299C2FE03D49
3GPP TS 36.331 v12.8.0 2016-1 pp101-200.pdf	65F13FA9EDDEFC11DC97A74806A480F1779ADF50203ADB10F3165E80D6D04ACD7E7C04B038DA777D06FEBB479B14901F1899008507E2D61B510BD09A32A4E85E
3GPP TS 36.331 v12.8.0 2016-1 pp1-100.pdf	323D936FD30B0D20E7A890F3BDF0C20FC0C124811F30998DE17665A50AEC07F8436423F98802562DA0BDA7A9CFEFDDA36A60D59D059CCB69CBE63393CE642728
3GPP TS 36.331 v12.8.0 2015-12 pp401-456.pdf	ED80FA1886EF41947AABA160A90AE54567AACC837ACC38582C3D6A76B2E3DBF0C6026CD8E8C0F3E9B2128D95E4B765FD36DBCDBDF99F8922DA6961BCC397F3CB
3GPP TS 36.331 v12.8.0 2015-12 pp301-400.pdf	C421D0AF6BA689C7EFB973001B7765A1AB379D3BD282091B1614BFF6BB39EA86AC0A6F6A040DD15648E7776E27047C1DD5B100130BECAE37FF50F796284ECB2C
3GPP TS 36.331 v12.8.0 2015-	659283129256 7D8FA171727CDAA66A85B7060C4E2ADB8EF70

12 pp201-300.pdf	706719B961173F081885CFF51AF1989D4B545052737A059E7A28B9DA112B3A4EF17E13E9551F4FE
3GPP TS 36.331 v12.8.0 2015-12 pp101-200.pdf	3792B0D5302388AC3AC471BE8705EECF3242EEEEAB7B733D8F66B96B6D74F4CFEE0B023EB62CCD16FBCC9D089C12B37ADB8F255C6ADFEFC87A3FDAB0D5575EDF
3GPP TS 36.331 v12.8.0 2015-12 pp1-100.pdf	F3A8FE6BD05EBD9770FB72E5E06B7E6FAFCF7AAF431F3DFC2597BED34B92C303296312B4F286B2FA435B597A4C4BB17BC821F38DE02FB79ECB41295F7F4007C6
3GPP TS 36.331 v12.3.0 2014-9 pp301-383.pdf	5C5E2BD3B80CD69626C061D8DFCE45F77BAE975833E904C167D163A64B071BCEB41B98A482404D95A903B19D987D16E7909C69193DE00E57993496BEFD982D2A
3GPP TS 36.331 v12.3.0 2014-9 pp201-300.pdf	2C81E9FE2CA08AB5940182C35C47D4DFCA28848920E1241D898FD920B88258ED10E625F8C571B8D92125DA9C87DDA3B6475D4BE98553DDDBD8600DCD7134F08A
3GPP TS 36.331 v12.3.0 2014-9 pp101-200.pdf	76EC57BC4B78F777EE1D22005804D7459E8ABE81E04DD35EBF3A9AC6F54A46A775B8AB49F6679E65A27D5E94270692297E8DFD7ADB742F58EE0928F96BFC07D3
3GPP TS 36.331 v12.3.0 2014-9 pp1-100.pdf	2E19B21AF68369A350FD701D2DD2CE16710EE7C78F8C7F2DF914AA108BD6143BBEB748930311869CE374C9B317D25BCD85877E9D9EFB71820DEAB03C0D079B6A
3GPP TS 36.300 v12.8.0 2016-1 pp226-261.pdf	ADABA9F5FDDE111AE947F741C30C841A2B25D6A9FA8A1320285932B9EBA4684C40075F93B529F5B4997C98D9A02C180993F9C22F40E946213E9F3E5E49599FBB
3GPP TS 36.300 v12.8.0 2016-1 pp1-60.pdf	3A583BEF8A1B9C0B1B6EAB17D4B274D44144AD3A1C88951C3344C03698E7A104F053AF2CD07970EB394C54C0B2938547D267DB801871ED0CB19309A46AD71C57
3GPP TS 36.300 v12.8.0 2016-1 pp181-225.pdf	11BCF5522251012180 36F87D10ECA7290189C3A8C5043591E034CA9928E619B060546F62839BAB450B17DE1632CB74D4D7656759789829E2C49C6ACCD4E0C117
3GPP TS 36.300 v12.8.0 2016-	C15186B924D24D9255C3A8B9861353659E9F87067B14B6B65C

1 pp121-180.pdf	879A27B5B8027A1D270685958CC1B8605C13FE7EAB8C4FB11 2BB211FC761990037F951E9436B07
3GPP TS 36.300 v12.8.0 2016-1 pp61-120.pdf	874504874AD39BC488979A7E65DB2ACA71D31519647051EAB FA9A207F506F6175E54352620D6B44F675B700B4802DF337304 AAD99DD29001A09552E15EEAEB52

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(Not for submission under 37 CFR 1.99)

Application Number	17950726
Filing Date	2022-09-22
First Named Inventor	Xiaobo ZHANG
Art Unit	2471
Examiner Name	AHMED ELALLAM
Attorney Docket Number	ZL0205-0004-US-CON3

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	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

	1	R1-1610145, Qualcomm, October 1, 2016	☒
	2	R1-1610239, Nokia, Alcatel-Lucent Shanghai Bell, September 30, 2016	☒
	3	R1-1611385, China Academy of Telecommunications Technology (CATT), November 5, 2016	☒
	4	R1-1611415, ZTE, ZTE Microelectronics, November 5, 2016	☒
	5	R1-1611417, ZTE, ZTE Microelectronics, November 5, 2016	☒
	6	R1-1612056, Qualcomm, November 5, 2016	☒
	7	R1-1612493, Samsung, November 4, 2016	☒
	8	R1-1612862, Nokia, Alcatel-Lucent Shanghai Bell, November 4, 2016	☒
	9	R4-161779, Qualcomm Incorporated, April 26, 2016	☒
	10	3GPP TR 36.897 V13.0.0 Release 13, 3rd Generation Partnership Project (3GPP), June 2015	☒
	11	R1-1704867, LG Electronics, March 25, 2017	☒

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	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

	12	R1-1609662, Nokia, Alcatel-Lucent Shanghai Bell, September 30, 2016	☒
	13	R2-1703344, LG Electronics, March 24, 2017	☒
	14	3GPP R1-1704398, April 7, 2017	☒
	15	3GPP R1-1704877, April 7, 2017	☒
	16	R1-1609256, October 14, 2016	☒
	17	APEX BEAM TECHNOLOGIES LLC v. ONEPLUS TECHNOLOGY (SHENZHEN) CO., LTD., DEFENDANT'S INVALIDITY CONTENTIONS, Case No. 2:22-cv-00032-JRG, November 21, 2022	☒
	18	APEX BEAM TECHNOLOGIES LLC v. SAMSUNG ELECTRONICS CO., LTD., ET AL.,, DEFENDANT'S INVALIDITY CONTENTIONS, Case No. 2:22-cv-00188-JRG, March 2, 2023	☒
	19	APEX BEAM TECHNOLOGIES LLC v. ZTE CORPORATION, DEFENDANT'S INVALIDITY CONTENTIONS, Case No. 2:22-cv-00031-JRG-RSP, March 2, 2023	☒
	20	APEX BEAM TECHNOLOGIES LLC v. TCT MOBILE INTERNATIONAL LIMITED, DEFENDANTS' INITIAL INVALIDITY CONTENTIONS, Docket No. 2:21-cv-00438-JRG, November 9, 2023	☒
	21	SAMSUNG ELECTRONICS CO., LTD., AND SAMSUNG ELECTRONICS AMERICA, INC., v. APEX BEAM TECHNOLOGIES LLC, PETITION FOR INTER PARTES REVIEW, Case IPR2023-0059, February 28, 2023	☒

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	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

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☐ See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/JIALIN ZHONG/	Date (YYYY-MM-DD)	2023-11-19
Name/Print	JIALIN ZHONG	Registration Number	62937

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(54) METHOD, EQUIPMENT AND SYSTEM FOR COORDINATED MULTI-POINT TRANSMISSION/ RECEPTION

(57) A method, a device, and a system for CoMP coordinated multi-point transmission are disclosed, where the method includes: obtaining reference signal received power RSRP of a cell in a measurement set of a user equipment UE; determining that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold; and combining a cell whose RSRP is greater between the first cell and the second cell with the serving cell of the UE into a coordinated set of the UE, and performing coordinated multi-point transmission on the UE, thereby improving an effect of CoMP.

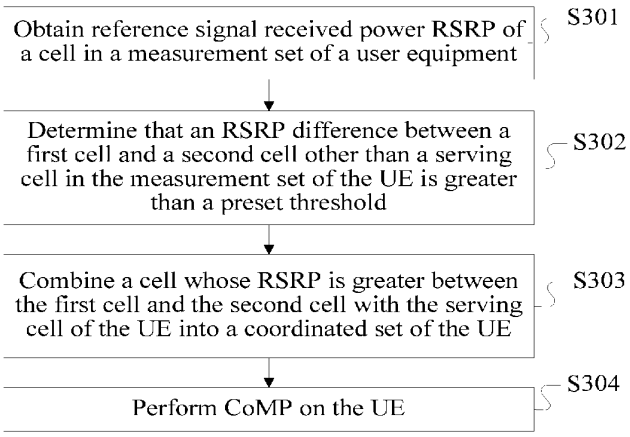


FIG. 3

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Description

TECHNICAL FIELD

[0001] The present invention relates to the field of network technologies, and in particular, to a method, a device, and a system for coordinated multi-point transmission.

BACKGROUND

[0002] CoMP (Coordinated Multi-point Transission/reception, coordinated multi-point transmission) is one of key technologies of LTE-A (Long Term Evolution-Advanced, long term evolution-advanced), and is used to expand coverage of a high data rate and increase average throughput of a system, thereby improving performance of a cell edge user.

[0003] FIG. 1 is a schematic diagram of a CoMP technology. CoMP is a cooperative sending and receiving technology, where one base station (for example, eNodeB x in FIG. 1) is connected to several access points (for example, Point x in FIG. 1), and one access point may include one or more antennas. Multiple users (User Equipment, UE for short) (UE x) may be served by one or more access points located at one same base station or different base stations. A coordination center controller may obtain information from a distributed access point, and allocate a resource to meet a QoS (Quality of Service, quality of service) requirement of a user, thereby maximizing performance of an entire network.

[0004] In the CoMP technology, signals of a serving cell and multiple coordination cells may be simultaneously sent or received, which is equivalent to increasing the number of antennas at a transmit end or a receive end, and demodulation performance is improved through a multiple input multiple output (Multiple Input Multiple Output, MIMO for short) receiver.

[0005] A main principle of uplink-based intra-eNodeB (Intra-eNodeB) CoMP is that, antennas in different cells of one same base station are used for receiving a signal of a certain user, and a combined gain and an interference suppression gain of the signal received by the multiple antennas may be obtained at the same time, and the combined gain of the signal is greater for a user closer to a boundary between two cells. By taking FIG. 2 as an example, a user is located at a boundary between cells, a Cell 0 and a Cell 1, and the Cell 1 is a serving cell for the user. When the user is closer to the boundary of the cell Cell 0, power of a signal of the user received by the cell Cell 0 is greater, and a combined gain of the signal is higher.

[0006] However, it is very complicated to implement CoMP for all users. Due to a limitation on a processing capability of a device at present, it is very difficult to implement this solution in practice. In a case of joint reception for some cells with excessively low signal to interference plus noise ratios (SINR), performance may decrease instead due to the influence of channel estimation. Therefore, how to select a CoMP coordinated set and which UEs are to be selected, where CoMP is performed on the UEs for optimization in terms of performance and complexity, become very important.

[0007] Currently, a mainstream solution in the prior art is to determine whether to perform CoMP on a UE by using whether a difference between RSRP (Reference Signal Receiving Power, reference signal received power) of a serving cell and RSRP of another neighboring cell is greater than a predetermined threshold. However, this selection manner does not take an interference factor into consideration, and in practice, interference on the serving cell and interference on another cell are usually very different. Therefore, a UE selected according to an RSRP difference between the serving cell and the another cell is usually not a UE for which a highest gain is obtained when CoMP is performed, which reduces an effect of CoMP.

SUMMARY

[0008] In view of this, embodiments of the present invention provide a method, a device, and a system for coordinated multi-point transmission, which can select a user equipment located at a cell overlapping area to perform coordinated multi-point transmission, thereby improving an effect of coordinated multi-point transmission.

[0009] To achieve the foregoing objectives, in one aspect, the present invention provides a method for CoMP coordinated multi-point transmission, where the method includes:

obtaining reference signal received power RSRP of a cell in a measurement set of a user equipment UE;
determining that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold; and
combining a cell whose RSRP is greater between the first cell and the second cell with the serving cell of the UE into a coordinated set of the UE, and performing coordinated multi-point transmission on the UE.

[0010] In another aspect, the present invention further provides a device for coordinated multi-point transmission, where the device includes:

an RSRP obtaining unit, configured to obtain reference signal received power RSRP of all cells in a measurement set of a user equipment UE;
a determining unit, configured to determine that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold;
a coordinated set joining unit, configured to combine a cell whose RSRP is greater between the first cell

and the second cell with the serving cell of the UE into a coordinated set of the UE; and

a transmitting unit, configured to perform coordinated multi-point transmission on the UE.

[0011] In still another aspect, the present invention further provides a system, including the device for coordinated multi-point transmission.

[0012] It can be seen that, in the method, the device, and the system for coordinated multi-point transmission provided by the embodiments of the present invention, whether to perform CoMP on a UE is determined based on whether two cells whose RSRP difference is greater than a threshold exist in a measurement set of the UE other than a serving cell. In the embodiments of the present invention, a UE near a cell overlapping area can be selected, and a relatively high gain can be obtained for such UE during CoMP, thereby improving an effect of CoMP.

BRIEF DESCRIPTION OF DRAWINGS

[0013] To describe the technical solutions in the embodiments of the present invention or in the prior art more clearly, the following briefly introduces accompanying drawings required for describing the embodiments or the prior art. Apparently, the accompanying drawings in the following description show merely some embodiments of the present invention, and a person of ordinary skill in the art may still derive other drawings according to these accompanying drawings without creative efforts.

FIG. 1 is a schematic diagram of a CoMP technology in the prior art;

FIG. 2 is a schematic diagram of a cell of an Intra-eNodeB CoMP technology;

FIG. 3 is a schematic flow chart of a method for coordinated multi-point transmission according to an embodiment of the present invention;

FIG. 4 is a schematic flow chart of a method for coordinated multi-point transmission according to another embodiment of the present invention;

FIG. 5 is a schematic diagram of an application scenario for a method for coordinated multi-point transmission according to an embodiment of the present invention;

FIG. 6 is a schematic structural diagram of a device for coordinated multi-point transmission according to an embodiment of the present invention; and

FIG. 7 is a schematic structural diagram of a device for coordinated multi-point transmission according to another embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

[0014] To make the objectives, technical solutions, and advantages of the embodiments of the present invention more comprehensible, the following clearly and completely describes the technical solutions in the embodiments of the present invention with reference to the accompanying drawings in the embodiments of the present invention. Apparently, the embodiments to be described are merely a part rather than all of the embodiments of the present invention. All other embodiments obtained by a person of ordinary skill in the art based on the embodiments of the present invention without creative efforts shall fall within the protection scope of the present invention.

[0015] FIG. 3 is a schematic flow chart of a method for coordinated multi-point transmission according to an embodiment of the present invention. An embodiment of the present invention provides a method for coordinated multi-point transmission, where, as shown in FIG. 3, the method includes:

Step S301: Obtain reference signal received power RSRP of a cell in a measurement set of a user equipment (UE).

[0016] Specific implementation of obtaining RSRP may adopt the prior art, for example, a method defined in the 3GPP 36.214 protocol. The present invention does not limit implementation of obtaining RSRP.

[0017] In addition, the measurement set may be determined by using the following method: A base station of a serving cell of the UE delivers a periodic measurement configuration to the UE. After receiving the periodic measurement configuration, the UE measures all available cells of a configured frequency to obtain signal quality, and reports the signal quality to the base station of the serving cell. The base station adds a cell whose signal quality exceeds a threshold set on a network to the measurement set of the UE. It may also be stipulated that cells whose signal quality ranks in the top several places are added to the measurement set of the UE, which is not limited by the present invention. Cells in the measurement set may belong to different base stations, or may belong to one same base station.

Step S302: Determine that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold. Subtraction may be performed on RSRP values of every two cells other than the serving cell in the measurement set of the UE to obtain an absolute value of an RSRP difference between two cells other than the serving cell in the measurement set, and the absolute value of the difference is compared with a threshold preset in advance.

[0018] For example, when there are two cells other than the serving cell of the UE in the measurement set, subtraction is performed on RSRP of the two cells for comparison with a preset threshold. It is assumed that there are three cells other than the serving cell of the UE

in the measurement set cell 1, cell 2, and cell 3. Subtraction is performed on RSRP values of every two cells of cell 1, cell 2, and cell 3 to obtain |RSRP cell 1 - RSRP cell 2|, |RSRP cell 1 - RSRP cell 3|, and |RSRP cell 3 - RSRP cell 2|, and the three values are compared with the preset threshold. As long as there is one of the three values which is greater than the preset threshold (or greater than or equal to the preset threshold, which is not limited in the present invention), CoMP may be performed on the UE.

When a first cell and a second cell that meet the foregoing condition exist, it indicates that the UE is located at an overlapping area of the serving cell and another cell, and a relatively high gain is obtained for the UE during CoMP.

Step S303: Combine a cell whose RSRP is greater between the first cell and the second cell with the serving cell of the UE into a coordinated set of the UE, and perform CoMP on the UE. A specific method for coordinated multi-point transmission may also be implemented through the prior art.

[0019] In the method provided by the embodiment, whether to perform CoMP on a UE is determined based on whether two cells whose RSRP difference is greater than a threshold exist in a measurement set of the UE other than a serving cell. Interference between cells other than the serving cell is usually close. Therefore, a UE near a cell overlapping area can be selected more accurately, and a relatively high gain can be obtained for such UE during CoMP, thereby improving an effect of CoMP.

[0020] FIG. 4 is a schematic flow chart of a method for coordinated multi-point transmission according to another embodiment of the present invention. As shown in FIG. 4, the method for coordinated multi-point transmission in embodiment 1 includes:

Step S401: Obtain reference signal received power (RSRP) of a cell in a measurement set of a UE.

[0021] For a specific method, reference may be similarly made to step S301 in the foregoing embodiment.

Step S402: Determine that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold.

For a specific method, reference may be similarly made to step S302 in the foregoing embodiment.

Step S403: Combine a cell whose RSRP is greater between the first cell and the second cell with the serving cell of the UE into a coordinated set of the UE.

For a specific method, reference may be similarly made to step S303 in the foregoing embodiment.

Step S404: After step S403, obtain a gain between a post-SINR (Posted-SINR) of the UE in the coordinated set and a post-SINR of the UE in the serving cell.

In a scenario where coverage is limited, a relative gain may be used as the gain in step S404. The relative gain may be determined according to the following formula:

$$\frac{\log_2(1+SINR_1)-\log_2(1+SINR_0)}{\log_2(1+SINR_0)},$$

where $SINR_0$ is the post-SINR of the UE in the serving cell of the UE, and $SINR_1$ is a post-SINR of the UE in a cell other than the serving cell in the coordinated set of the UE, where the cell other than the serving cell in the coordinated set of the UE may also be called a coordination cell of the UE; and

$\log_2(1+SINR_1)$ is throughput which is of the UE in the coordinated set of the UE and is determined according to the Shannon's formula, and $\log_2(1+SINR_0)$ is throughput which is of the UE in the serving cell of the UE and is determined according to the Shannon's formula.

[0022] In a scenario where a capacity is limited, an absolute gain may be used as the gain in step S404.

[0023] The absolute gain may be determined according to the following formula:

$$\log_2(1+SINR_1)-\log_2(1+SINR_0),$$

where $SINR_0$ is the post-SINR of the UE in the serving cell of the UE, and $SINR_1$ is the post-SINR of the UE in the cell other than the serving cell in the coordinated set of the UE; and

$\log_2(1+SINR_1)$ is the throughput which is of the UE in the coordinated set of the UE and is determined according to the Shannon's formula, and $\log_2(1+SINR_0)$ is the throughput which is of the UE in the serving cell of the UE and is determined according to the Shannon's formula.

Step S405: Perform CoMP on a UE whose gain is greater than the preset threshold.

In practice, alternatively, UEs may also be sorted according to gains obtained through calculation in step S404, and a UE with a highest gain is selected preferably for performing CoMP, until a processing resource is used up.

[0024] In the embodiment, by taking a case that a hardware resource is limited into consideration, it is possible that CoMP can be performed on only a part of UEs. After UEs near a cell overlapping area are selected through

step S401 to step S403, these UEs are sorted according to their gains, and CoMP is preferably performed on a UE with a highest gain, so that efficiency of CoMP may be fully improved with a limited resource.

[0025] It should be noted that, in the embodiment, the step for obtaining the gains of the UEs may be performed in each transmission time interval (TTI), or may be performed on each resource block (RB). Certainly, a granularity implemented in the step for obtaining the gains of the UEs may be divided according to another granularity.

[0026] In each of the foregoing embodiments, cells in the measurement set of the UE may belong to one same base station, or at least two cells may belong to different base stations.

[0027] If cells in the measurement set of the UE belong to one same base station, intra-eNodeB CoMP (Intra-eNodeB CoMP) is implemented when CoMP is performed on the UE.

[0028] If at least two cells in the measurement set of the UE belong to different base stations and the coordinated set of the UE also includes cells that belong to at least two base stations, inter-eNodeB CoMP is implemented when CoMP is performed on the UE.

[0029] Specific implementation of the method for coordinated multi-point transmission in the present invention is described in detail in the following through several specific examples.

[0030] Example 1: As shown in FIG. 5, it is assumed that a serving cell of a UE is Cell 0. In a measurement set of the UE, three cells are included, namely, a serving cell of the UE Cell0 and two other neighboring cells Cell 1 and Cell 2.

[0031] First, RSRP of Cell 0, Cell 1, and Cell 2 are obtained, and are marked as RSRP0, RSRP1, and RSRP2, respectively.

[0032] When it is determined that an absolute value of a difference between the RSRP1 and the RSRP2 is greater than a preset threshold, it indicates that the UE is located at a cell overlapping area. In FIG. 5, the UE is located at an overlapping area between cells Cell 0 and Cell 1, and a cell corresponding to a greater RSRP value between the RSRP1 and the RSRP2 and the serving cell Cell 0 are included in a coordinated set of the UE. For example, when the absolute value of the difference between the RSRP1 and the RSRP2 is greater than the preset threshold, and it may be measured that RSRP1> RSRP2 due to a fact the UE is closer to Cell1 than to Cell2, Cell 0 and Cell 1 are included in the coordinated set of the UE. Next, CoMP is performed on the UE.

[0033] Example 2: It is assumed that there are three UEs, which may be marked as UE1, UE2, and UE3 respectively, Cell0 is a serving cell of all the three UEs, and measurement sets all include Cell0 and other two neighboring cells Cell 1 and Cell 2.

[0034] First, a process as described in the foregoing example 1 for obtaining of RSPR and formation of a coordinated set of each UE is separately implemented for UE1, UE2, and UE3.

[0035] Next, a gain between a post-SINR of UE1 in the coordinated set of UE1 and a post-SINR of UE1 in the serving cell Cell0 of UE1 is calculated, and is marked as D1. A gain between a post-SINR of UE2 in the coordinated set of UE2 and a post-SINR of UE2 in the serving cell Cell0 of UE2 is calculated, and is marked as D2. A gain between a post-SINR of UE3 in the coordinated set of UE3 and a post-SINR of UE3 in the serving cell Cell0 of UE3 is calculated, and is marked as D3.

[0036] It is assumed that D2>D1>D3, and UE1, UE2, and UE3 are sorted according to order of their gains as follows: UE2, UE1, UE3.

[0037] CoMP is preferably performed on UE2, and then UE1. If a processing resource is used up after CoMP is performed on UE1, CoMP is not performed on UE3.

[0038] In addition, there may be multiple first cells and second cells that meet a condition in the foregoing embodiments, for example, in a scenario such as that a UE is located at a cell overlapping area between base stations, or a base station is divided into six cells. It is assumed that in a measurement set of a UE, five cells are included, namely, Cell 0, Cell 1, Cell 2, Cell 3, and Cell 4. Cell 0 is a serving cell of the UE. After measurement, RSRP of Cell 1, Cell 2, Cell 3, and Cell 4 are RSRP1, RSRP2, RSRP3, and RSRP4, respectively.

[0039] It is found through comparison that: An absolute value of a difference between the RSRP1 and the RSRP2 is greater than a preset threshold; an absolute value of a difference between the RSRP3 and the RSRP4 is also greater than the preset threshold. In a case that a hardware resource is sufficient, a cell whose RSRP is greater in each pair of cells whose RSRP difference is greater than the preset threshold and that meet a condition may be used as a coordination cell of the UE, and the coordination cell of the UE and the serving cell of the UE are included in a coordinated set of the UE. It is assumed that, in the foregoing example, there are two pairs of cells that meet the condition, namely, {cell1, cell2} and {cell3, cell4}, RSRP corresponding to the two pairs of cells may be respectively marked as {RSRP1, RSRP2} and {RSRP3, RSRP4}. It is assumed that, |RSRP1-RSRP2| and |RSRP3-RSRP4| are both greater than the preset threshold, and RSRP1>RSRP2 and RSRP3>RSRP4. In this case, RSRP1 and RSRP3 may both be used as coordination cells of the UE. In this way, the coordinated set of the UE includes Cell 0, Cell1, and Cell3.

[0040] However, sometimes, in a case that the hardware resource is insufficient, the number of coordination cells in the coordinated set of the UE is limited. In this case, cells whose RSRP is greater in each pair of the cells whose RSRP difference is greater than the preset threshold and that meet the condition need to be compared, and a cell whose RSRP is greater is preferably selected as the coordination cell of the UE. Alternatively, whether RSRP of a cell whose RSRP is greater among the cells whose RSRP difference is greater than the preset threshold is also greater than the preset threshold is determined through comparison, and then the cell whose

RSRP is greater is used as the coordination cell of the UE. For example, in the foregoing example, it is further assumed that, a difference between the RSRP1 and the RSRP3 of two first cells is also greater than the threshold. Then, only Cell1 whose RSRP is greater is used as the coordination cell of the UE. In this case, the coordinated set of the UE includes only Cell 0 and Cell1.

[0041] FIG. 6 is a schematic structural diagram of a device for coordinated multi-point transmission according to an embodiment of the present invention. As shown in FIG. 6, the device for coordinated multi-point transmission includes:

An RSRP obtaining unit 601 is configured to obtain reference signal received power RSRP of all cells in a measurement set of a user equipment UE.

[0042] A determining unit 602 is configured to determine that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold.

[0043] A transmitting unit 603 is configured to combine a cell whose RSRP is greater between the first cell and the second cell with the serving cell of the UE into a coordinated set of the UE, and perform coordinated multi-point transmission on the UE.

[0044] In practice, the device for coordinated multi-point transmission in the embodiment may be a base station.

[0045] Specific implementation of obtaining RSRP by the RSRP obtaining unit 601 may adopt the prior art, for example, a method defined in the 3GPP 36.214 protocol. The present invention does not limit implementation of obtaining RSRP. Cells in the measurement set may belong to different base stations or may belong to one same base station.

[0046] The determining unit 602 may perform subtraction on RSRP values of every two cells other than the serving cell in the measurement set of the UE to obtain an absolute value of an RSRP difference between two cells other than the serving cell in the measurement set, and compare the absolute value of the difference with the threshold preset in advance.

[0047] FIG. 7 is a schematic structural diagram of a device for coordinated multi-point transmission according to another embodiment of the present invention. As shown in FIG. 7, the device for coordinated multi-point transmission includes:

An RSRP obtaining unit 701 is configured to obtain reference signal received power RSRP of all cells in a measurement set of a user equipment UE. Specific implementation of obtaining RSRP by the RSRP obtaining unit 701 may adopt the prior art, for example, a method defined in the 3GPP 36.214 protocol. The present invention does not limit implementation of obtaining RSRP. Cells in the measurement set may belong to different base stations or may belong to one same base station.

[0048] A determining unit 702 is configured to determine that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold. The determining unit 702 may perform subtraction on RSRP values of every two cells other than the serving cell in the measurement set of the UE to obtain an absolute value of an RSRP difference between two cells other than the serving cell in the measurement set, and compare the absolute value of the difference with the threshold preset in advance.

[0049] A gain obtaining unit 703 is further included, where the gain obtaining unit 703 is configured to obtain a gain between a post-SINR of the UE in the coordinated set of the UE and a post-SINR of the UE in the serving cell of the UE.

[0050] Specifically, in a scenario where coverage is limited, the gain obtained by the gain obtaining unit 703 may be a relative gain, where the relative gain may be determined according to the following formula:

$$\frac{\log_2(1+SINR_1)-\log_2(1+SINR_0)}{\log_2(1+SINR_0)},$$

where $SINR_0$ is the post-SINR of the UE in the serving cell of the UE, and $SINR_1$ is a post-SINR of the UE in a cell other than the serving cell in the coordinated set of the UE, where the cell other than the serving cell in the coordinated set of the UE may also be called a coordination cell of the UE; and

$\log_2(1 + SINR_1)$ is throughput which is of the UE in the coordinated set of the UE and is determined according to the Shannon's formula, and $\log_2(1+SINR_0)$ is throughput which is of the UE in the serving cell of the UE and is determined according to the Shannon's formula.

[0051] In a scenario where a capacity is limited, the gain obtained by the gain obtaining unit 604 may be an absolute gain.

[0052] The absolute gain may be determined according to the following formula:

$$\log_2(1+SINR_1)-\log_2(1+SINR_0),$$

where $SINR_0$ is the post-SINR of the UE in the serving cell of the UE, and $SINR_1$ is the post-SINR of the UE in the cell other than the serving cell in the coordinated set of the UE; and

$\log_2(1 + SINR_1)$ is the throughput which is of the UE in the coordinated set of the UE and is determined according to the Shannon's formula, and

$\log_2(1+SINR_0)$ is the throughput which is of the UE in the serving cell of the UE and is determined according to the Shannon's formula.

[0053] A process of obtaining gains of UEs by the gain obtaining unit 703 may be performed in each transmission time interval (TTI), or may be performed on each resource block (RB). Certainly, a granularity implemented in the step for obtaining the gains of the UEs may be divided according to another granularity.

[0054] A transmitting unit 704 is specifically configured to select a UE whose gain is greater than a preset threshold to perform coordinated multi-point transmission.

[0055] The device for coordinated multi-point transmission in the embodiment may be a base station.

[0056] In addition, an embodiment of the present invention further provides a system, where the system includes the device for coordinated multi-point transmission in the foregoing device embodiments.

[0057] Exemplary implementation manners of the present invention are described in the foregoing. It should be noted that, a person of ordinary skill in the art may further make several modifications and variations without departing from the principle of the present invention, and these modifications and variations should also be construed as falling within the protection scope of the present invention.

Claims

1. A method for CoMP coordinated multi-point transmission, comprising:

   obtaining reference signal received power RSRP of a cell in a measurement set of a user equipment UE;
   determining that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold; and
   combining a cell whose RSRP is greater between the first cell and the second cell with the serving cell of the UE into a coordinated set of the UE, and performing coordinated multi-point transmission on the UE.

2. The method according to claim 1, further comprising:

   obtaining a gain between a post-SINR of the UE in the coordinated set and a post-SINR of the UE in the serving cell; wherein
   the performing coordinated multi-point transmission on the UE comprises:

   selecting the UE whose gain is greater than a preset threshold to perform coordinated multi-point transmission.

3. The method according to claim 2, wherein the gain is a relative gain or an absolute gain.

4. The method according to claim 2 or 3, wherein the obtaining a gain between a post-SINR of the UE in the coordinated set and a post-SINR of the UE in the serving cell comprises:

   obtaining, in each transmission time interval (TTI), the gain between the post-SINR of the UE in the coordinated set and the post-SINR of the UE in the serving cell.

5. The method according to claim 2 or 3, wherein the obtaining a gain between a post-SINR of the UE in the coordinated set and a post-SINR of the UE in the serving cell comprises:

   obtaining, on each resource block (RB), the gain between the post-SINR of the UE in the coordinated set and the post-SINR of the UE in the serving cell.

6. The method according to any one of claims 1 to 5, wherein,
   cells in the measurement set of the UE belong to one same base station, or
   at least two of cells in the measurement set of the UE belong to different base stations.

7. A device for coordinated multi-point transmission, comprising:

   an RSRP obtaining unit, configured to obtain reference signal received power RSRP of all cells in a measurement set of a user equipment UE;
   a determining unit, configured to determine that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold; and
   a transmitting unit, configured to combine a cell whose RSRP is greater between the first cell and the second cell with the serving cell of the UE into a coordinated set of the UE, and perform coordinated multi-point transmission on the UE.

8. The device according to claim 7, further comprising:

   a gain obtaining unit, configured to obtain a gain between a post-SINR of the UE in the coordinated set and a post-SINR of the UE in the serving cell; wherein
   the transmitting unit is specifically configured to select the UE whose gain is greater than a preset threshold to perform coordinated multi-point transmission.

9. The device according to claim 7, wherein the gain obtaining unit is specifically configured to obtain, in each transmission time interval (TTI), the gain between the post-SINR of the UE in the coordinated set and the post-SINR of the UE in the serving cell; or the gain obtaining unit is specifically configured to obtain, on each resource block (RB), the gain between the post-SINR of the UE in the coordinated set and the post-SINR of the UE in the serving cell.

10. The device according to any one of claims 7 to 9, wherein the device is a base station.

11. A system, comprising the device for coordinated multi-point transmission according to any one of claims 7 to 9.

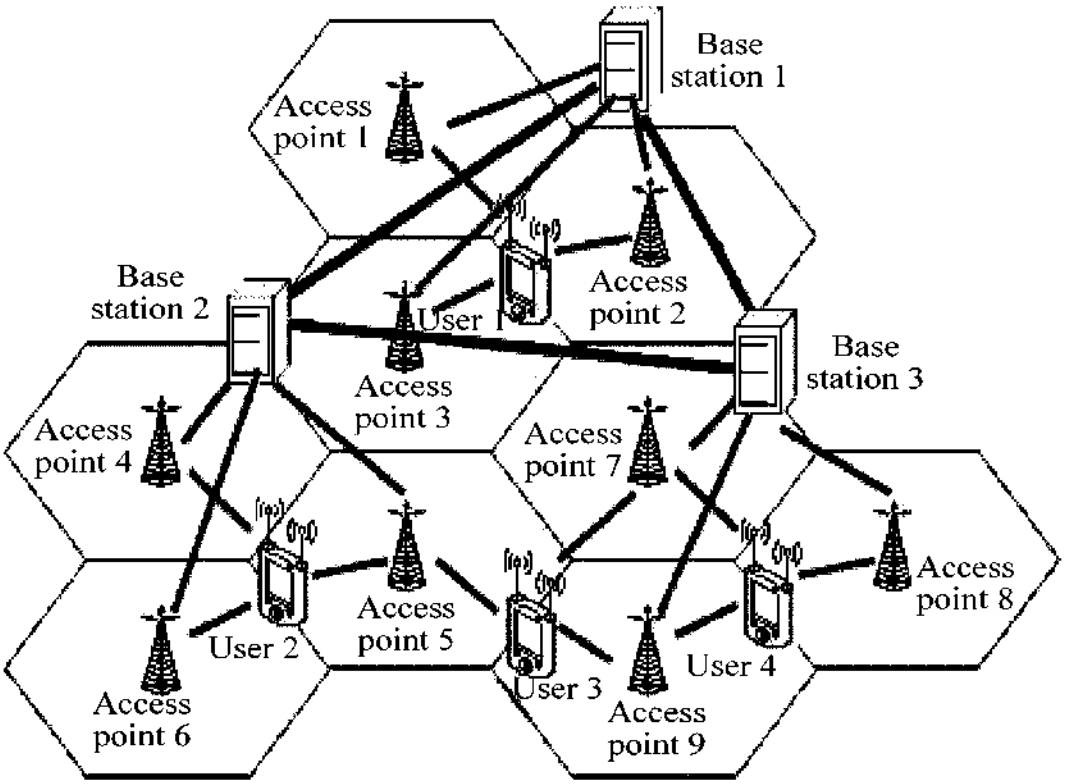

Base station 1
Access point 1
Base station 2
User 1
Access point 2
Base station 3
Access point 3
Access point 4
Access point 7
Access point 5
Access point 8
User 2
User 3
User 4
Access point 6
Access point 9

FIG. 1

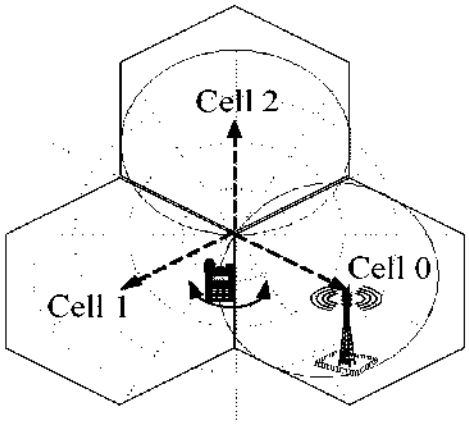

Cell 2
Cell 0
Cell 1

FIG. 2

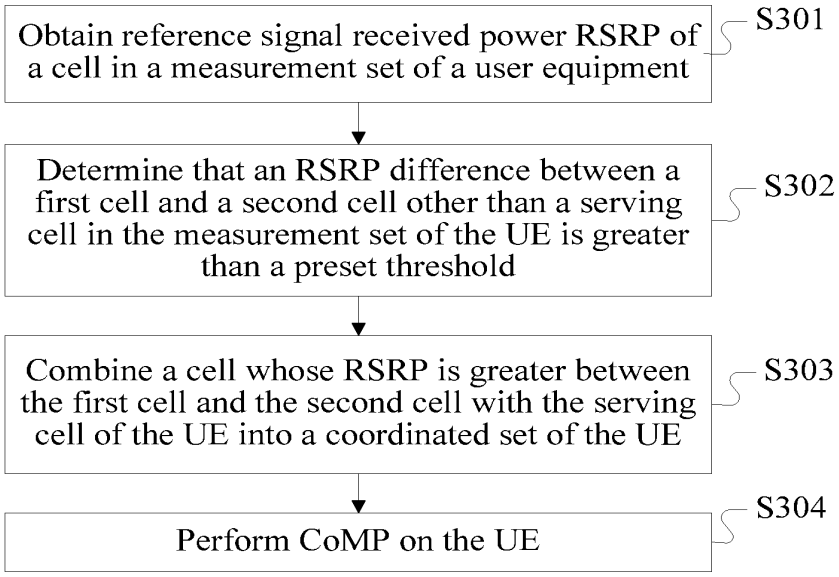

Obtain reference signal received power RSRP of a cell in a measurement set of a user equipment
S301
Determine that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold
S302
Combine a cell whose RSRP is greater between the first cell and the second cell with the serving cell of the UE into a coordinated set of the UE
S303
Perform CoMP on the UE
S304

FIG. 3

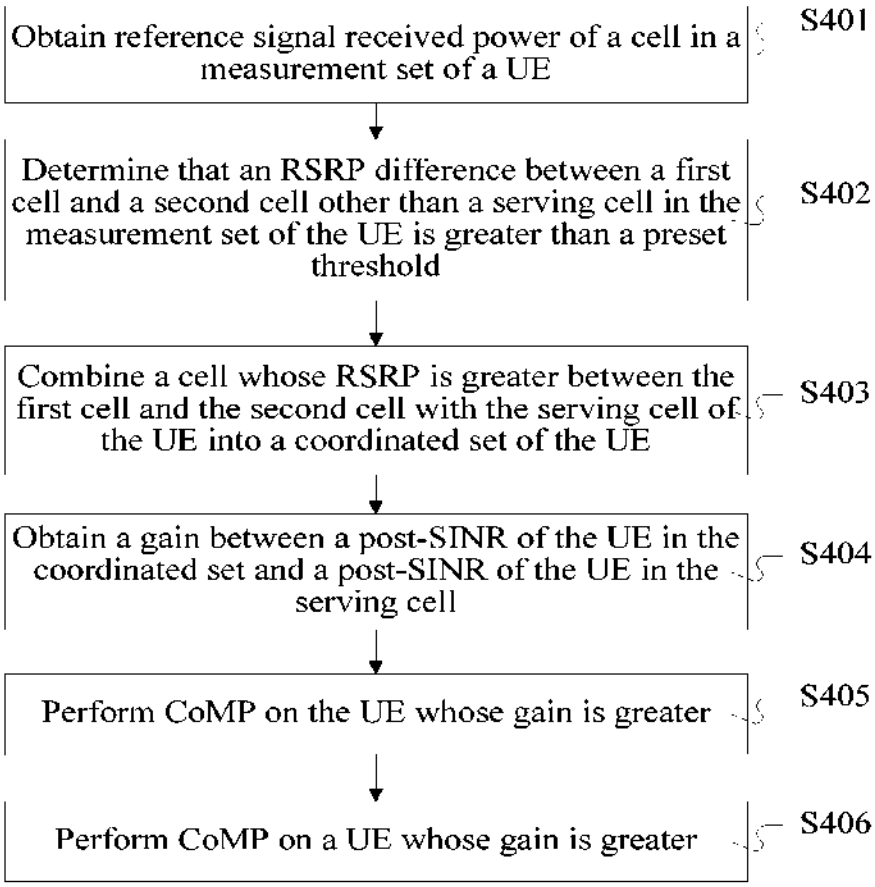

Obtain reference signal received power of a cell in a measurement set of a UE
S401
Determine that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold
S402
Combine a cell whose RSRP is greater between the first cell and the second cell with the serving cell of the UE into a coordinated set of the UE
S403
Obtain a gain between a post-SINR of the UE in the coordinated set and a post-SINR of the UE in the serving cell
S404
Perform CoMP on the UE whose gain is greater
S405
Perform CoMP on a UE whose gain is greater
S406

FIG. 4

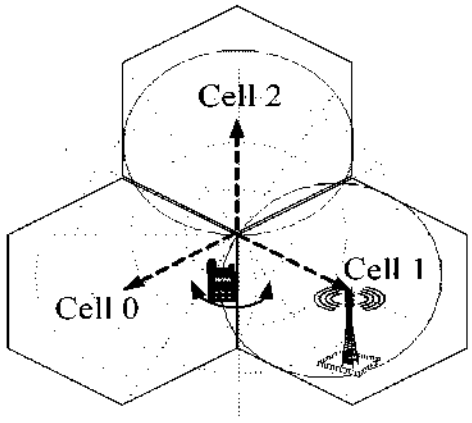

Cell 2
Cell 1
Cell 0

FIG. 5

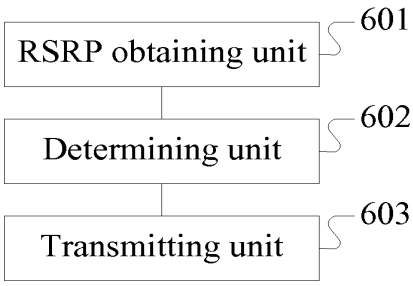

601
RSRP obtaining unit
602
Determining unit
603
Transmitting unit

FIG. 6

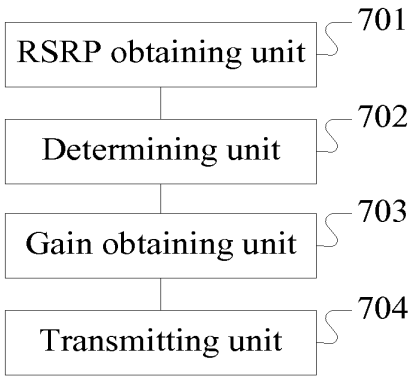

701
RSRP obtaining unit
702
Determining unit
703
Gain obtaining unit
704
Transmitting unit

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2011/077566

A. CLASSIFICATION OF SUBJECT MATTER

H04W 28/16 (2009.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: H04W, H04Q, H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNABS, CNTXT, CNKI: CoMP, coordinated multi-point, cell, transmission, reference signal received power, RSRP, quality, parameter, threshold, set

VEN, 3GPP: CoMP, coordinated multi-point transmission reception, cell?, RSRP, quality, parameter?, threshold?, set?

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 101895921 A (POTEVIO INSTITUTE OF TECHNOLOGY CO., LTD.), 24 November 2010 (24.11.2010), the whole document	1-11
A	CN 101873661 A (DATANG MOBILE COMMUNICATIONS EQUIPMENT CO., LTD.), 27 October 2010 (27.10.2010), the whole document	1-11
A	CN 102076096 A (SHANGHAI HUAWEI TECHNOLOGIES CO., LTD.), 25 May 2011 (25.05.2011), the whole document	1-11
A	CN 101815331 A (ZTE CORP.), 25 August 2010 (25.08.2010), the whole document	1-11

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 April 2012 (21.04.2012)	**03 May 2012 (03.05.2012)**
Name and mailing address of the ISA/CN: State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No.: (86-10) 62019451	Authorized officer **LV, Sihua** Telephone No.: (86-10) **62411386**

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
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Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 101895921 A	24.11.2010	None	
CN 101873661 A	27.10.2010	None	
CN 102076096 A	25.05.2011	None	
CN 101815331 A	25.08.2010	None	

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(74) Agents: **MOORE, Michael S.** et al.; 1211 SW 5th Avenue, Suite 1600, Portland, Oregon 97204 (US).

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[Continued on next page]

(54) Title: ENODEB REFERENCE SIGNAL REDUCTION

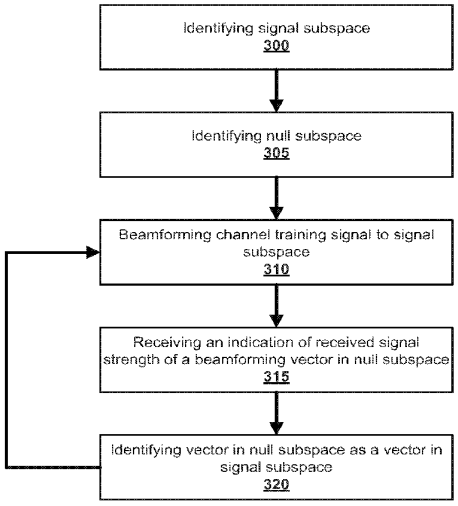


Figure 3

(57) Abstract: In embodiments, apparatuses, methods, and storage media may be described for reducing the overhead associated with the transmission of channel training signals from an eNodeB (eNB) of a wireless network. Specifically, the eNB may receive feedback from a user equipment (UE) regarding the received signal energy of a first and second beamformed signal produced with a first and second beamforming vector, respectively. The eNB may identify, based on the feedback of the received signal energy, a signal subspace and a null subspace. The eNB may then transmit a channel training signal to the signal subspace.

WO 2014/158255 A1

EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *of inventorship (Rule 4.17(iv))*

Published:

— *with international search report (Art. 21(3))*

— *with amended claims (Art. 19(1))*

ENODEB REFERENCE SIGNAL REDUCTION

Cross Reference to Related Application

The present application claims priority to U.S. Provisional Patent Application No. 61/806,821, filed March 29, 2013, entitled "Advanced Wireless Communication Systems and Techniques," the entire disclosure of which is hereby incorporated by reference in its entirety.

Field

Embodiments of the present invention relate generally to the technical field of channel training signals in wireless systems.

Background

The background description provided herein is for the purpose of generally presenting the context of the disclosure. Work of the presently named inventors, to the extent it is described in this background section, as well as aspects of the description that may not otherwise qualify as prior art at the time of filing, are neither expressly nor impliedly admitted as prior art against the present disclosure. Unless otherwise indicated herein, the approaches described in this section are not prior art to the claims in the present disclosure and are not admitted to be prior art by inclusion in this section.

Full dimension multiple-input-multiple-output (FD-MIMO) is a study item for the upcoming Release 12 of the third generation partnership project (3GPP) long term evolution (LTE) specifications. In FD-MIMO systems, the eNodeB (eNB) may have 16 or more different antenna elements that are configured for beamforming on one or more antenna ports to user equipment (UEs). Ideally, the throughput of the eNB in FD-MIMO systems may be expected to significantly increase with a large number of antenna elements.

However, in frequency division duplex (FDD) mode, beamforming may require channel training signals. Specifically, channel training signals may be reference signals that are sent by the eNB to each UE. The UE(s) may then respond with channel feedback based on the received channel training signals. This feedback may be used to identify the resources used to beamform one or more additional signals to the UE. Currently, the overhead associated with transmitting the channel training signals may increase linearly with the number of antenna elements. For large antenna arrays having, for example, 30 antenna elements, the overhead associated with transmitting the channel training signals may become prohibitive because the throughput gains realized through use of FD-MIMO

may be offset by the overhead incurred through transmission of the channel training signals.

Brief Description of the Drawings

Embodiments will be readily understood by the following detailed description in conjunction with the accompanying drawings. To facilitate this description, like reference numerals designate like structural elements. Embodiments are illustrated by way of example and not by way of limitation in the figures of the accompanying drawings.

Figure 1 schematically illustrates a high-level example of a network system comprising a UE and an eNB, in accordance with various embodiments.

Figure 2 depicts an example of different subspaces for FD-MIMO transmissions from an eNodeB (eNB) to a plurality of user equipment (UEs), in accordance with various embodiments.

Figure 3 depicts an example of a process flow for transmitting channel training signals, in accordance with various embodiments.

Figure 4 schematically illustrates an example system that may be used to practice various embodiments described herein.

Detailed Description

Apparatuses, methods, and storage media are described herein for reducing the overhead associated with the transmission of channel training signals such as the channel state information reference signal (CSI-RS). As described above, the number of antenna ports of an eNB may linearly increase with an increase in the number of antenna elements used by the eNB. This increase in antenna ports may increase transmissions of channel training signals, which in turn may increase resource overhead of the eNB.

The channel training signals may be shared between the antenna ports in order to reduce the resource overhead of the eNB. However, time sharing of the channel training signals may introduce latency or delay to transmissions of the eNB. As noted above, the channel training signals may be transmitted from the eNB, and the UE may feed back information related to the channel training signals, and more specifically the radio resources used to transmit the channel training signals. Based on the fed back information, the eNB may identify radio resources that should be used for further communication with the UE.

However, the latency introduced by time sharing of the channel training signals may be detrimental because the latency may be such that the radio resources in the cell may have changed significantly between the transmission of the channel training signal

and the identification of the channel resources to use to transmit further signals using the feedback based on the transmission of the channel training signal. In other words, the fed back information from a UE receiving the channel training signals may not necessarily correspond to the radio resources of the cell at the time of transmission of the additional signal(s) from the eNB. This change may be due to interference caused by multiple UEs, the UE moving, or other reasons. Therefore, time sharing of the channel training signals may reduce overall performance of the cell.

By contrast, the present disclosure may relate to selectively transmitting one or more channel training signals to particular signal subspaces. Specifically, the channel training signals may be beamformed to those signal subspaces. Typically, beamforming may include multiplying a signal by an antenna-specific or antenna-port specific weighting vector, which may be referred to as a beamforming vector. The beamforming vector may affect the phase of the signal, the amplitude of the signal, or some other characteristic of the signal. The weighted signal produced by this weighting may be referred to as a beamformed signal. By multiplying one or more antenna transmissions by the weighting vector, the beamformed signal may only be transmitted to a specific signal subspace.

Specifically, a signal subspace may be a vector space defined by a subset of the possible beamforming vectors. In other words, transmissions of the signal to the signal subspace may include weighting the signal by one or more beamforming vectors of the possible beamforming vectors to produce a beamformed signal, and transmitting the beamformed signal from the eNB. The signal subspace may be identified by identifying the beamforming vectors with which the UEs receive the signal with a relatively high signal energy. Specifically, as noted above, the eNB may initially transmit one or more training signals to one or more UEs, and receive feedback information from the UEs regarding the received signal. For example, the feedback may include information regarding strength or magnitude of the received signal energy, or the phase of the received signal. Based on that fedback information, the eNB may be able to identify the beamforming vectors that produce a relatively high amount of signal energy at the UEs. The identified beamforming vectors that produce a relatively high amount of signal energy at the UEs may then be used to identify the signal subspace on which the channel training signals should be transmitted. The eNB may then transmit the channel training signals to that signal subspace using the identified beamforming vectors.

The null subspace may then be identified as the remainder of the beamforming vectors that are not used for the beamforming signal transmission to the signal subspace.

In some embodiments an additional channel training signal may be beamformed to only a portion of the null subspace, as explained in greater detail below. In embodiments, the number of beamforming vectors used to generate a beamformed signal for the signal subspace may be significantly less than the number of beamforming vectors in the null subspace. Therefore, the transmission overhead of the eNB may be significantly reduced. For example, the dimension of the null space may be several times that of the signal subspace that is useful for data communications. Therefore, skipping the channel training in the entire null space may reduce the training overhead by multiple times. For example, simulations indicate that by not transmitting the channel training signal to the entire null subspace, the resource overhead of the cell may be reduced by up to 50% while the throughput of an FD-MIMO eNB with 16 antenna elements may only be reduced by 5%. The overhead reduction may be expected to increase significantly for eNBs with antenna arrays of 64 or 128 antenna elements. For example, an eNB with 128 antenna elements transmitting data to 10 UEs may need up to 128 antenna ports in legacy systems, while only needing up to 10 antennas ports (one antenna port per UE) in wireless cells of the present disclosure.

In some embodiments, and as described in further detail below, one or both of the signal and/or null subspaces may vary over time due to mobile channel variation. Because the eNB may identify or update the signal subspace and null subspace according to the feedback indications of training signals that were beamformed by the previous beamforming vectors, the currently updated signal subspace and null subspaces may not be exactly the same as the previous signal and null subspaces where the previous beamforming vectors are located. Therefore, in some embodiments, the newly identified subspace may not fully include the previous beamforming vector. However, since the channel variation may be relatively slow in many embodiments such that the subspaces are substantially correlated in time, i.e. very alike, the previous and the current signal and null subspace may be substantially the same.

In the following detailed description, reference is made to the accompanying drawings which form a part hereof wherein like numerals designate like parts throughout, and in which is shown by way of illustration embodiments that may be practiced. It is to be understood that other embodiments may be utilized and structural or logical changes may be made without departing from the scope of the present disclosure. Therefore, the following detailed description is not to be taken in a limiting sense.

Various operations may be described as multiple discrete actions or operations in

turn, in a manner that is most helpful in understanding the claimed subject matter. However, the order of description should not be construed as to imply that these operations are necessarily order dependent. In particular, these operations may not be performed in the order of presentation. Operations described may be performed in a different order than the described embodiment. Various additional operations may be performed and/or described operations may be omitted in additional embodiments.

For the purposes of the present disclosure, the phrases "A and/or B" and "A or B" mean (A), (B), or (A and B). For the purposes of the present disclosure, the phrase "A, B, and/or C" means (A), (B), (C), (A and B), (A and C), (B and C), or (A, B and C).

The description may use the phrases "in an embodiment," or "in embodiments," which may each refer to one or more of the same or different embodiments. Furthermore, the terms "comprising," "including," "having," and the like, as used with respect to embodiments of the present disclosure, are synonymous.

Figure 1 schematically illustrates a wireless communication network 100 in accordance with various embodiments. The wireless communication network 100 (hereinafter "network 100") may be an access network of a 3GPP LTE network such as evolved universal terrestrial radio access network (E-UTRAN). The network 100 may include an eNodeB (eNB, also referred to as an evolved NodeB) 105, configured to wirelessly communicate with a UE 110.

As shown in Figure 1, the UE 110 may include a transceiver module 120. The transceiver module 120 may be coupled with one or more of a plurality of antenna elements 125 of the UE 110 for communicating wirelessly with other components of the network 100, e.g., eNB 105 or another UE. The antenna elements 125 may be powered by a power amplifier 130 which may be a component of the transceiver module 120, as shown in Figure 1, or may be a separate component of the UE 110. In one embodiment, the power amplifier 130 provides the power for all transmissions on the antenna elements 125. In other embodiments, there may be multiple power amplifiers on the UE 110. The use of multiple antenna elements 125 may allow for the UE 110 to use transmit diversity techniques such as spatial orthogonal resource transmit diversity (SORTD), MIMO, or FD-MIMO. In certain embodiments the transceiver module 120 may contain both transmitter circuitry 155 and receiver circuitry 160. Specifically, the transmitter circuitry 155 may be configured to transmit a signal from the UE 110, for example using antenna elements 125. Similarly, the receiver circuitry 160 may be configured to receive a signal at the UE 110. Although Figure 1 depicts the transceiver module 120 including both the

transmitter circuitry 155 and the receiver circuitry 160, in other embodiments, the transceiver module 120 may be replaced by transmitter circuitry and receiver circuitry which are separate from one another (not shown). In other embodiments, the transceiver module 120 may be coupled with processor circuitry configured to alter, process, or transform signals or data received from, or sent to, the transceiver module 120 (not shown).

Similarly to the UE 110, the eNB 105 may include a transceiver module 140. The transceiver module 140 may be further coupled with one or more of a plurality of antenna elements 135 of the eNB 105 for communicating wirelessly with other components of the network 100, e.g., UE 110. The antenna elements 135 may be powered by a power amplifier 145 which may be a component of the transceiver module 140, as shown in Figure 1, or may be a separate component of the eNB 105. In one embodiment, the power amplifier 145 provides the power for all transmissions on the antenna elements 135. In other embodiments, there may be multiple power amplifiers on the eNB 105. The use of multiple antenna elements 135 may allow for the eNB 105 to use transmit diversity techniques such as SORTD, MIMO, or FD-MIMO. In certain embodiments the transceiver module 140 may contain both transmitter circuitry 165 and receiver circuitry 170 which may be similar to the transmitter circuitry 155 and receiver circuitry 160 described above. In other embodiments, the transceiver module 140 may be replaced by transmitter circuitry and receiver circuitry which are separate from one another (not shown). In other embodiments, the transceiver module 140 may be coupled with processor circuitry configured to alter, process, or transform signals or data received from, or sent to, the transceiver module 120 (not shown).

As noted above, an eNB such as eNB 105 may have a plurality of antenna ports, and each antenna port may correspond to one or more of the antenna elements 135. In embodiments the transceiver module 140 may additionally include, or otherwise be coupled with, a subspace identifier 150. As will be explained in additional detail below, the subspace identifier 150 may be configured to identify signal subspaces and/or null subspace(s) in the cell.

In embodiments, an antenna port may be perceived by a UE 110 over the air interface between the UE 110 and the eNB 105. In embodiments, one antenna port may be associated with one set of channel training symbols, for example the CSI-RS as described above. As will be described in further detail below, the UE 110 may measure the channel response of one or multiple antenna ports to generate feedback or make decisions. For

example, the UE 110 may measure the received power of antenna port 0 during a handover situation.

Therefore, in embodiments an antenna port may be the air interface perceived by UE 110. In embodiments herein, each antenna port may be formed by the eNB 105 using one or more (or all) antenna elements 135, with a beamforming weight assigned to each antenna element. In some embodiments, each antenna port may be associated with a set of beamforming weights, as described in further detail below. In embodiments described as examples below, the eNB 105 may form eight antenna ports using eight sets of weights, i.e. eight beamforming vectors. The eNB 105 may then let UEs in the cell know how the antenna ports are configured such that the UE can identify the resource in frequency and time allocated for the port.

In some embodiments, the eNB 105 may include a directional antenna with a narrow downtilt angle that uses multiple antenna elements with relatively fixed or constant beamforming weights. In the present disclosure, this directional antenna may be considered a single antenna element of the antenna elements 135 because the beamforming weights of the different antenna elements of the directional antenna may remain constant. Specifically, one or more of the antenna elements 135 may be omni-directional or unidirectional, and a directional antenna element of the antenna elements 135 may be physically implemented using multiple antenna elements with constant antenna weights.

Figure 2 depicts an example of a network 200 including an eNB 205, which may be similar to eNB 105, and UEs 210, 215, and 220, which may be similar to UE 110. Some of the UEs, for example UEs 210 and 220, may only include a single antenna element, while other UEs such as UE 215 may include two or more antenna elements. As can be seen, the eNB 205 may include a plurality of antenna elements 225 configured to transmit signals to, or receive signals from, UEs 210, 215, and 220. In the embodiment shown in Figure 2, the plurality of antenna elements 225 may include a first antenna element 230 through a sixteenth antenna element 235. In other embodiments, the eNB 205 may have more or less antenna elements in the plurality of antenna elements 225.

As used herein, "spaces" may refer to the vector spaces spanned by the antenna ports. For example, eNB 205 may have 16 antennas element in the plurality of antenna elements. If one antenna port is assigned to each antenna element in the plurality of antenna elements 225, then 16 antenna ports may be perceived by UEs 210, 215, and 220, and the dimension of the whole space may be 16. The 16 antenna ports may form a 16 by

1 vector space in linear algebra. The signal subspace may then be the "location" of the UEs in the whole space.

For example, the vector channel from the 16 antenna elements at the eNB to UE 210 may be denoted as $a = \begin{bmatrix} a_1 \\ \vdots \\ a_{16} \end{bmatrix}$, where a_i represents the channel response from the *i*th antenna element in the plurality of antenna elements 225 of eNB 205 to the receive antenna element of the UE 210. Similarly, the UE 215 may be equipped with two receive antenna elements and have two vector channels $b = \begin{bmatrix} b_1 \\ \vdots \\ b_{16} \end{bmatrix}$ and $c = \begin{bmatrix} c_1 \\ \vdots \\ c_{16} \end{bmatrix}$; and the UE 220 may have a vector channel $d = \begin{bmatrix} d_1 \\ \vdots \\ d_{16} \end{bmatrix}$. Because UE 215 has multiple vector channels, UE215 may have a matrix channel $\begin{bmatrix} b_1 & c_1 \\ \vdots & \vdots \\ b_{16} & c_{16} \end{bmatrix}$.

The signal subspace may be computed as follows as an example. Let the aggregated channel matrix of the active vector channels be $H = \begin{bmatrix} a_1 & b_1 & c_1 & d_1 \\ \vdots & \vdots & \vdots & \vdots \\ a_{16} & b_{16} & c_{16} & d_{16} \end{bmatrix}^T$. Let the singular value decomposition (SVD) of H be $H = U \begin{bmatrix} \sigma_1 & & & \\ & \sigma_2 & & \\ & & \sigma_3 & \\ & & & \sigma_4 \end{bmatrix} [v_1 \quad v_2 \quad v_3 \quad v_4]^H$, where σ_i represents the singular value of the ith eigen-mode; v_i is the corresponding beamforming vector of *i*th eigen-mode; and v_i is a 16 by 1 vector with complex values.

In this embodiment, the singular values may be ordered. Specifically, σ_i may be greater than or equal to σ_j for any $i < j$. If the eNB 205 is attempting to send a relatively high amount of signal to the aggregated UE side, which in this example may consist of the antenna elements of all three of the UEs 210, 215, and 220, using one antenna beam or one beamforming vector, then v_1 may be the beamforming vector because it corresponds to the largest singular value σ_1.

For this example, the dimension of the whole space may be 16 because there are 16 antenna elements in the plurality of antenna elements 225 of the eNB 200 and correspondingly 16 linearly independent channels to the receive antenna elements of each UE 210, 215, and 220. If the eNB 205 is configured to only use one antenna port for

channel training, then in this embodiment the eNB 205 may use the beamforming vector (or weight) v_1 for the antenna port. Namely, the *i*th entry of v_1 may be the beamforming weight for the *i*th antenna element of the eNB 205. Using v_1, the three UEs 210, 215, and 220 may receive the greatest amount of signal energy from the eNB 220 in total. Because in this example there may only be one beamformed signal, the three UEs 210, 215, and 220 may have to time share the beam. Similarly, if the eNB 205 is configured to use two antenna ports, then v_1 and v_2 or the linear combination of the two can be used as beamforming vectors for the two antenna ports for channel training.

The linear space spanned by vectors v_1 and v_2 within the whole space may be referred to as "subspace" or "signal subspace." If the eNB 205 sends two data streams over two beams, then there may exist two beamforming vectors within the signal subspace that can send the most energy to the aggregated UE side consisting of UEs 210, 215, and 220. The linear space within the whole space that is spanned by all the vectors orthogonal to the vectors in the signal subspace may be referred to as the null space (of the signal subspace). In this example, if eNB 205 uses two antenna ports, then the signal subspace may be spanned by v_1 and v_2 and any beamforming vectors orthogonal to v_1 and v_2 may be in the null space that may have 16-2=14 orthogonal vectors or dimensions. In other words, the null space may depend on the selection of the signal subspace. Note that in the example above v_3 and v_4 may be in the null space of v_1 and v_2 even though v_3 and v_4 may send energy to the aggregated UE side.

In the example above, the signal subspace is described with respect to beamforming vectors v_1 and v_2. However, as noted above in other embodiments the signal subspace may be described with respect to linear combinations of beamforming vectors v_1 and v_2. Specifically, as noted above beamforming vector v_1 may deliver the greatest amount of signal energy to UEs 210, 215, and 220. Beamforming vector v_2 may deliver the next greatest amount of signal energy to UEs 210, 215, and 220. In some embodiments, it may be desirable for one or more of UEs 210, 215, and 220 to perceive a relatively equal amount of signal energy from beamforming vectors v_1 and v_2. Therefore, in some embodiments beamforming vectors v_1 and v_2 may be added or subtracted from one another to produce one or more alternative beamforming vectors which may still be within the signal subspace defined by beamforming vectors v_1 and v_2, but produce a relatively equal amount of signal energy at one or more of UEs 210, 215, and 220.

Figure 3 depicts an example process 300 for identifying signal subspaces within a cell, and beamforming the channel training signal to the signal subspaces. Initially, the

signal subspace(s) may be identified at 300. In embodiments, and as described above, a signal subspace may be identified at 300 based on previous feedback(s) from the UEs 210, 215, and 220. Specifically, the eNB such as eNB 205 may transmit a pilot signal using each possible beamforming vector in the space. Each UE, for examples UEs 210, 215, and 220, may calculate the channel response of each beamforming vector as seen by the UE. The UE may then quantize the channel responses of all received beamforming vectors using vector or scalar quantization. To continue the example above with reference to Figure 2, four beamforming vectors (v_1, v_2, v_3, and v_4) may be selected by the eNB 205. Four pilot signals, one for each beamforming vector, may be transmitted from the eNB. If the UE has one receive antenna element, for example UEs 210 or 220, the channel response, which may indicate the received signal power of each beamformed pilot signal, of the eNB's four antenna ports may be a 4 by 1 vector with complex entries. The UE may then quantizes the 4 by 1 vector jointly using vector quantization i.e. codebook quantization. The index of the quantization codeword may then be fed back to the eNB.

If the UE has *m* receive antenna elements, for example UE 215 with two receive antenna elements, then the channel response of the four antenna ports may be a 4 by *m* matrix. The UE may select a desirable *k*-dimensional subspace of the 4 by *m* matrix, for example by using SVD. In embodiments, *k* may represent the number of spatial streams or rank that the UE desires. This *k*-dimensional subspace may in some embodiments be the best *k*-dimensional subspace, and may be based on the UE stepping through the available numbers of spatial streams for identifying the spatial stream that may maximize the throughput of the signal received by the UE from the eNB. The selected *k*-dimensional subspace may be quantized to produce a quantization index, and the quantization index may be fed back to the eNB. Additionally or alternatively, the eNB may be able to identify feedback information based on, for example, downlink or uplink sounding in time-division duplexing (TDD) mode. In some embodiments the feedback may be part of or associated with a rank indicator and/or precoding matrix indicator transmission of each UE.

In some embodiments the feedback may be based on an averaging function, a summation function, or some other mathematical function performed by the UE on a pilot or beamformed signal received from the eNB. As will be explained in greater detail below, in some embodiments the signal subspace may change based on changing conditions in the cell. Therefore, it may be desirable for the fedback information from the UE to be based only on one or more signals in a given time period such as a frame, a subframe, a plurality of frames, or some other time period in which the signal subspace is constant. Otherwise,

an averaging or summation function that spans a plurality of different signal subspaces may not be accurate.The combination of vectors received from the plurality of UEs may be used by the eNB to build the aggregated channel matrix *H* described above with respect to Figure 2.

The principal signal subspaces may be identified as corresponding to large singular values in the singular value decomposition of the fedback beamforming vectors. Specifically, as described above, the signal subspace may be identified as the signal subspace formed by the beamforming vectors that are capable of delivering the most signal power from the eNB to the UEs. A set of beamforming vectors that sufficiently covers the selected signal subspace may then be identified for additional transmissions of channel training signals from the eNB to the one or more UEs. In embodiments, each beamforming vector may be used for beamforming one channel training signal, for example a CSI-RS signal, using a given antenna port. In some embodiments, the beamforming vectors may or may not be orthogonal to one another. In some embodiments, set selection may be designed for feedback accuracy, a given feedback codebook, or based on the detection of channel variation.

Concurrently with, or subsequent to, the identification of the signal subspace at 300, the null subspace may be identified based on the singular value decomposition of the matrix formed by the fed back beamforming vectors received at the eNB from the UE. Specifically, the null subspace may be identified based on low singular values in the singular value decomposition formed by the fed back beamforming vectors received at the eNB from the UEs. Specifically, the null subspaces may correspond to beamforming vectors that produce relatively low signal power at the UEs. The eNB may then beamform one or more channel training signals, for example the CSI-RS, to the signal subspace at 310.

In some embodiments, after the signal subspace is identified at 300 and the null subspace is identified at 305, the strength of signals beamformed to the signal subspace may change. Specifically, a beamforming vector that produces a relatively high amount of signal energy at the UEs in the cell may instead begin to produce a relatively low amount of signal energy at the UEs. This may occur, for example, if a UE such as a mobile phone, personal digital assistant (PDA), laptop, or some other type of UE moves. Additionally or alternatively, the cell may experience a change in signal reflection, propagation, or interference. Based on this change in the strength of beamforming vectors, it may be desirable for the eNB to track variation in the channel or the cell. Specifically, UEs may

continuously provide feedback to the eNB, and it may be useful for the eNB to be able to dynamically modify this change in signal conditions in the cell based on the feedback from the UEs.

If the channel variation of a UE is within the signal subspace spanned by the current set of channel training signals, then the normal channel feedback procedures may be able to identify this change in the signal subspace. However, if a beamforming vector in the null subspace increases in strength, for example above the strength of a beamforming vector in the signal subspace, then there may be no feedback information from a UE that indicates this change in the beamforming vector of the null subspace because if the eNB is only beamforming signals to the signal subspace, then there may be no transmissions to the entire null subspace, or certain portions of the null subspace, by which the UE can feedback information to the eNB with regards to beamforming vectors in the null subspace.

In some embodiments it may therefore be desirable to identify whether the beamforming vectors of the signal subspace and the null subspace have changed. Therefore, in some embodiments, the eNB may receive an indication from a UE of a relatively high received signal strength of a beamforming vector in the null subspace at 315. Specifically, the eNB may occasionally beamform one or more channel training signals to the null subspace, and then analyze the singular values in the singular value decomposition formed by the fed back beamforming vectors received at the eNB from the UEs, as will be described in greater detail below. In some embodiments, because channel variation may usually be slow, the eNB may give processing priority to the beamforming feedback related to the signal subspace. Therefore, the channel training signals transmitted to the null subspace, for example by beamforming, may time share a single or a relatively low number of antenna ports so that the overhead that may result from the transmission of the channel training signals is reduced.

Based on the tracking the variation in the cell at 315, if the eNB receives feedback from one or more UEs that a transmission of a channel training signal using a beamforming vector in the null subspace has greater energy than a channel training signal beamformed using a beamforming vector in the signal subspace, then the eNB may identify the beamforming vector in the null subspace as part of the signal subspace at 320. The eNB may then return to beamforming the channel training signals in the signal subspace at 310.

To illustrate the process depicted in Figure 3 in more detail, the following specific

example may be useful. It will be understood that the following is merely an example and in other embodiments other values, equations, variables, or processes may be used. Generally, during the initial training phase, an eNB such as eNB 205 may receive feedback from one or more UEs in the cell. Based on that feedback, the signal subspace, which may contain almost all of the signal energy of the fed-back signals, and the null subspaces, which may contain a low amount or no signal energy of the fed-back signals, may be calculated at 300 and 305, respectively. The calculated information may then be used to configure future downlink training and reduce the signaling overhead by scanning the signal subspace for information from UEs with greater frequency than the null subspaces, as described above.

Initially, the variable k may represent the kth UE in a cell. t may represent a given orthogonal frequency division multiplexing (OFDM) symbol, and n may represent a subcarrier in the channel. Using this notation, the channel from an eNB to the kth UE may be written as $H_k[n,t] = \sum_{m=1}^{M} h_{k,m}[n,t]e_m = \sum_{m=1}^{M} g_{k,m}[n,t]w_m$. H_k may be, for example, a 16x1 vector in cells where the eNB includes 16 antenna elements, and there is only a single UE, and it may represent the spatial signature from the eNB to the UE that is obtained through uplink feedback. M may be the dimensionality of the channel, i.e. the number of subspaces in the cell. $h_{k,m}[n,t]$ may be the estimated channel, i.e. the channel response, for the kth UE on a given subcarrier n in OFDM symbol t. e_m may be a vector equal to, for example (0, 0, . . ., 0, 1, 0, 0, . . ., 0) with the 1 in the mth position and zeroes elsewhere, and represent the unit vector pointing to the mth direction. $g_{k,m}[n,t]$ may represent the channel coefficient for the kth UE in the mth dimension in OFDM symbol t and subcarrier n. w_m my represent the unit norm vector for the mth dimension, i.e. the normalization weighting factor.

As noted above, M may represent the dimensionality of the channel, i.e. the total number of subspaces in the cell. It may be desirable to compress the channel and reduce the dimensionality from M to $D < M$. In other words, all of the subspaces in the cell may have a dimensionality M, and the signal subspace may have a dimensionality $D < M$. In order to reduce the dimensionality of the channel, it may be desirable to find the optimal basis $w_1, \ldots, w_m$ such that $g_{k,m}[n]$ is approximately equal to 0 when $m > D$. Then, for $d = 1, 2, \ldots, D$, coefficients $g_{k,m}[n,t]$ may be given by $g_{k,d}[n,t] = w_d^H H_k[n,t]$.

One result of reducing the dimensionality from M to $D < M$ may be that, instead of

utilizing M reference signals to estimate the channel in the original M-dimensional space and feeding back that information, the eNB may only employ D reference signals. By beamforming these reference signals with the weights $w_1, \ldots, w_D$, each UE may estimate the coefficient $g_{k,m}[n]$ directly and send that information to the eNB.

By allowing the UE to estimate the coefficient $g_{k,m}[n]$ directly, the overhead of transmitting the channel training signals may be reduced by a factor of D/M. Additionally, because UEs may not need to actually know the beamforming vectors used to generate the beamformed signals in order to receive the beamformed signals, the process of reducing the dimensionality of the channel from M to D may be completely transparent to the UEs. In other words, the UEs may not receive an indication that channel training signals are being beamformed only to the signal subspace rather than to the full space of the cell. However, as described in further detail below, in some embodiments it may be useful for one or more of the UEs to receive an antenna port configuration schedule from the eNB so that the UE is able to identify, for feedback purposes, when the subspace configuration may remain relatively constant.

After receiving the feedback from the UE, the eNB may identify the signal and null subspaces in the cell. Specifically, the channel covariance matrix may be estimated at the end of the qth training phase (that is, the qth time that the channel training signals are transmitted from the eNB) as

$$R_q \approx \frac{1}{KTN}\sum_{k=1}^{K}\sum_{t=(q-1)T+1}^{qT}\sum_{n=1}^{N}\left(\frac{\hat{H}_k[t,n]}{\left\|\hat{H}_k[t,n]\right\|}\right)\left(\frac{\hat{H}_k[t,n]}{\left\|\hat{H}_k[t,n]\right\|}\right)^{H} = U_q \Lambda_q U_q^{H}$$

where R_q is the channel covariance matrix in the qth training phase. T may be the length of the training period for sample covariance matrix calculations at the eNB in terms of OFDM symbols. $\hat{H}_k$ may be the estimated channel for the kth UE. K may be the total number of UEs in the cell. N may be the total number of subcarriers used by the eNB. Superscript H may represent the transpose conjugate mathematical operation. U_q may be an M x M unitary matrix, and Λ_q may be a diagonal matrix of eigenvalues $\lambda_{q,1}, \ldots, \lambda_{q,D}$. In general, $U_q \Lambda_q U_q^{H}$ may be referred to as the SVD of the matrix formed by the fedback beamforming vectors received by the eNB from the UEs, and the eigenvalues may be the singular value corresponding to each eigenvector direction. An eigenvector may be a specific example of a beamforming vector. In other words, the eigenvalues from $\lambda_{q,1}$ to $\lambda_{q,D}$ may represent the strength of the signal received from signals beamformed using beamforming vectors in the signal subspaces, and the eigenvalues $\lambda_{q,D+1}$ to $\lambda_{q,M}$ may represent the strength of the

signals, or lack thereof, received from signals beamformed using beamforming vectors in the null subspaces. Without loss of generality, it may be assumed that $\lambda_{q,1} \geq \ldots \geq \lambda_{q,D} \geq \lambda_{q,D+1}$ which may be approximately equal to λ_M, which may be approximately equal to 0. Therefore, the basis for each signal subspace in the D-dimensional channel may be $\{u_{q,1}, \ldots, u_{q,D}\}$ where $u_{q,D}$ is the dth column of the unitary matrix U_q, that is the eigenvector corresponding to the dth strongest eigenvalue. These strongest eigenvectors may now be used to beamform reference signals to the signal subspace at 310.

However, as mentioned before, the signal subspace may change and one or more beamforming vectors in the null subspace may produce a better channel response than one or more beamforming vectors in the signal subspace. In order to track these movements, and the resultant changes in the channel, it may be desirable to occasionally scan at 315 one or more null subspaces that are orthogonal to the D-dimension signal subspace to identify new beamforming vector or vectors with components in the null subspaces that produce a better channel response than one or more beamforming vectors in the signal subspace. Specifically, the new beamforming vector may include two components. The first component may be in the existing subspace spanned by one or more vectors of the signal subspace. The other component may be in the null space, and may be viewed as a correction or adjustment to the component in the existing subspace. In embodiments, the correction component may be smaller than the component in the signal subspace. Because the basis for each signal subspace in the D-dimensional channel may be $\{u_{q,1}, \ldots, u_{q,D}\}$, the basis for each null subspace in the M-dimensional channel may be $\{u_{q,D+1}, \ldots, u_{q,M}\}$.

In order to scan the null subspaces, the eNB may beamform D-r reference signals with $u_{q,1}, \ldots, u_{q,D-r}$ and the remaining r reference signals may be beamformed with r vectors selected from $u_{q,D-r+1}, \ldots, u_{q,M}$ in order to cover the null subspaces of the M-dimensional space. UEs that receive one or more of the r reference signals may estimate and quantize their channel direction in the new space as $\tilde{g}_{k,d}[n,t] = \frac{u_{q,d}^{H} H_k[n,t]}{\left\| u_{q,d}^{H} H_k[n,t] \right\|}$ where $d = 1, 2, \ldots, D$. The estimated and quantized channel direction may be transmitted from the UE to the eNB along with a channel quality indicator (CQI) transmission (which may represent a signal to interference plus noise ratio (SINR)) to the eNB. The eNB may reconstruct the channel direction in the original M dimensional space as $\tilde{H}_k[t,n] \approx \sqrt{SINR_k[t,n]} \sum_{d=1}^{D-1} \tilde{g}_{k,d}[n,t] u_{k,d}$ to identify the relative strength of signals

received in the null subspace at 315. Based on these reconstructed channel directions, the eNB may be able to identify one or more of the beamforming vectors in the null subspaces as part of the signal subspace at 320.

Results of a simulated test using one embodiment of the present disclosure are presented below in Tables 1 and 2. In these simulations, it was assumed that an eNB such as eNB 205 included 16 antenna elements with eight antenna ports. The first seven antenna ports were selected to transmit channel training signals to the signal subspace, while the eighth antenna port was selected to periodically beamform a channel training signal to the null subspace. Specifically, the transmissions of the first seven channel training signals were weighted with the seven eigenvectors corresponding to the seven strongest eigenvalues to produce beamformed channel training signals. These seven eigenvectors may be considered to be in the signal subspace. The seven beamformed channel training signals were then respectively transmitted using the first seven antenna ports of the eNB. The eighth port was selected to time share the nine remaining eigenvectors, i.e. the beamforming vectors in the null subspace, that were orthogonal to the seven eigenvectors used to produce the beamformed channel training signals. Every five to ten frames, the eNB would update the first seven beamforming vectors, while the eighth eigenvector for tracking would be updated more often for time sharing the single port. In other words, while the first seven antenna ports transmitted the beamformed seven channel training signals produced by the seven strongest eigenvectors in each frame, the eighth port would sequentially transmit beamformed channel training signals produced using the ninth through sixteenth eigenvectors one at a time in respective frames (i.e. through time sharing of the eighth port).

Tables 1 and 2, below, depict simulated sample results for a 4x4 antenna configuration and a 16x1 antenna configuration, respectively. Specifically, Tables 1 and 2 depict the average cell throughput in Megabits per second (Mbps) and cell edge user throughput in kilobits per second per UE (kbps/UE). Tables 1 and 2 depicts results for a baseline measurement where the process of Figure 3 is not performed, a subspace tracking (SS) process with scalar quantization wherein the channel direction is quantized by a scalar quantizer with 3 bits per real dimension, an SS singular value decomposition (SVD) process wherein the channel direction is obtained by SVD, and a frequency division (FD) zero-forcing beamforming (ZFBF) process based on the instantaneous values of the effective channel where no channel compression is performed.

	Average Cell Throughput (Mbps)	Cell edge User Throughput (kbps/UE)
Baseline	19.57	671
SS, Scalar Quant.	23.29	757
SS, SVD	26.43	810
FD ZFBF, SVD	27.41	852

Table 1: Simulation Results for 4x4 Antenna Configuration

	Average Cell Throughput (Mbps)	Cell edge User Throughput (kbps/UE)
Baseline	19.57	671
SS, Scalar Quant.	31.46	1130
SS, SVD	36.76	1283
FD ZFBF, SVD	44.81	1591

Table 2: Simulation Results for 16x1 Antenna Configuration

In some embodiments, the process described above with respect to Figures 2 and 3 may cause the channel training signals to vary with time. For example, the channel reference signal (CRS) and CSI-RS may be beamformed on a vector that may vary with time. Therefore, in embodiments it may be useful for the UE to know the time boundary when the beamforming vectors of the channel training signals transmitted from the eNB in the signal subspace change. By knowing this time boundary, the UE may avoid providing feedback to the eNB regarding an average of the channel training signal across two different periods with two differently beamformed channel training signals.

Specifically, as noted above in some embodiments the signal subspace may change based on variations in the cell, positions of the UEs in the cell, or other factors.

Additionally, as described above the signal subspace may be constructed based on information fedback from UEs in the cell. However, if the signal conditions in the cell are changing, then based on this feedback the beamforming vectors in the signal subspace and the null subspace may change.

As noted above, in some embodiments the feedback may be based on one or more averaging, summation or some other mathematical operations of a UE of signals received from the eNB. However, in some embodiments if the beamforming vectors in the signal subspace and null subspace change, then information averaged over the change in signal subspace may not be desirable. Therefore, it may be useful for the UEs in the cell to not perform averaging or other mathematical operations that span two different signal subspace configurations. Specifically, in some embodiments the signal subspace may change with each radio frame, radio subframe, or plurality of radio frames, or according to some other time period. Therefore, an averaging, summation, or other mathematical operation of a UE may be limited to only a single time period rather than a plurality of time periods.

Therefore, in some embodiments the eNB may transmit an antenna port configuration schedule to one or more UEs. In some embodiments, the eNB may beamform the antenna port configuration schedule to one or more of the UEs, while in other embodiments the eNB may omnicast the antenna port configuration schedule to UEs in the cell. In some embodiments, the antenna port configuration schedule may include one or more of a start time at which the signal subspace configuration may remain constant, a duration at which the signal subspace configuration may remain constant, and/or an end time at which the signal subspace configuration may remain constant. In some embodiments the antenna port configuration schedule may be demarcated according to specific times, while in other embodiments the antenna port configuration schedule may indicate one or more known periods such as radio frames, subframes, etc. In some embodiments, the antenna port configuration schedule may include one or more of a start time at which the antenna port for the null space configuration may remain constant, a duration at which the null space configuration may remain constant, and/or an end time at which the null space may remain constant. In addition, the configuration information about how the large null space is stepped through by a small number of antenna ports may be sent by the eNB. By knowing the port scheduling of the null space, the UE may not average signals across two differently beamformed ports for the null space.

Embodiments of the present disclosure may be implemented into a system using

any suitable hardware and/or software to configure as desired. Figure 4 schematically illustrates an example system 400 that may be used to practice various embodiments described herein. Figure 4 illustrates, for one embodiment, an example system 400 having one or more processor(s) 405, system control module 410 coupled to at least one of the processor(s) 405, system memory 415 coupled to system control module 410, non-volatile memory (NVM)/storage 420 coupled to system control module 410, and one or more communications interface(s) 425 coupled to system control module 410.

In some embodiments, the system 400 may be capable of functioning as the UEs 110, 210, 215, or 220 as described herein. In other embodiments, the system 400 may be capable of functioning as the eNB 105 or 205 depicted in Figures 1 or 2 or any one of the other described embodiments. In some embodiments, the system 400 may include one or more computer-readable media (e.g., system memory or NVM/storage 420) having instructions and one or more processors (e.g., processor(s) 405) coupled with the one or more computer-readable media and configured to execute the instructions to implement a module to perform actions described herein.

System control module 410 for one embodiment may include any suitable interface controllers to provide for any suitable interface to at least one of the processor(s) 405 and/or to any suitable device or component in communication with system control module 410.

System control module 410 may include memory controller module 430 to provide an interface to system memory 415. The memory controller module 430 may be a hardware module, a software module, and/or a firmware module.

System memory 415 may be used to load and store data and/or instructions, for example, for system 400. System memory 415 for one embodiment may include any suitable volatile memory, such as suitable DRAM, for example. In some embodiments, the system memory 415 may include double data rate type four synchronous dynamic random-access memory (DDR4 SDRAM).

System control module 410 for one embodiment may include one or more input/output (I/O) controller(s) to provide an interface to NVM/storage 420 and communications interface(s) 425.

The NVM/storage 420 may be used to store data and/or instructions, for example. NVM/storage 420 may include any suitable non-volatile memory, such as flash memory, for example, and/or may include any suitable non-volatile storage device(s), such as one or more hard disk drive(s) (HDD(s)), one or more compact disc (CD) drive(s), and/or one or

more digital versatile disc (DVD) drive(s), for example.

The NVM/storage 420 may include a storage resource physically part of a device on which the system 400 may be installed or it may be accessible by, but not necessarily a part of, the device. For example, the NVM/storage 420 may be accessed over a network via the communications interface(s) 525.

Communications interface(s) 425 may provide an interface for system 400 to communicate over one or more network(s) and/or with any other suitable device. The system 400 may wirelessly communicate with the one or more components of the wireless network in accordance with any of one or more wireless network standards and/or protocols. In some embodiments the communications interface(s) 425 may include the transceiver module 140 and/or subspace identifier 150 of Figure 1.

For one embodiment, at least one of the processor(s) 405 may be packaged together with logic for one or more controller(s) of system control module 410, e.g., memory controller module 430. For one embodiment, at least one of the processor(s) 405 may be packaged together with logic for one or more controllers of system control module 410 to form a System in Package (SiP). For one embodiment, at least one of the processor(s) 405 may be integrated on the same die with logic for one or more controller(s) of system control module 410. For one embodiment, at least one of the processor(s) 405 may be integrated on the same die with logic for one or more controller(s) of system control module 410 to form a System on Chip (SoC).

In some embodiments the processor(s) 405 may include or otherwise be coupled with one or more of a graphics processor (GPU) (not shown), a digital signal processor (DSP) (not shown), wireless modem (not shown), digital camera or multimedia circuitry (not shown), sensor circuitry (not shown), display circuitry (not shown), and/or GPS circuitry (not shown).

In various embodiments, the system 400 may be, but is not limited to, a server, a workstation, a desktop computing device, or a mobile computing device (e.g., a laptop computing device, a handheld computing device, a tablet, a netbook, a smart phone, a gaming console, etc.). In various embodiments, the system 400 may have more or less components, and/or different architectures. For example, in some embodiments, the system 400 includes one or more of a camera, a keyboard, liquid crystal display (LCD) screen (including touch screen displays), non-volatile memory port, multiple antenna elements, graphics chip, application-specific integrated circuit (ASIC), and speakers.

Methods and apparatuses are provided herein for Example 1 may include an eNodeB (eNB) comprising: a plurality of antenna ports with a plurality of antenna elements; subspace identification circuitry coupled with the plurality of antenna elements, the subspace identification circuitry to: identify, based on feedback information, a plurality of beamforming weights for one or multiple antenna ports wherein a number of the antenna ports is less than a number of the plurality of antenna elements; and assign a beamforming weight in the plurality of beamforming weights to an antenna in the plurality of antenna elements; and transmitter circuitry coupled with the subspace identification circuitry, the transmitter circuitry to: beamform a channel training signal allocated for the antenna port with the beamforming weights; and transmit an antenna port configuration schedule from the plurality of antennas.

Example 2 may include the eNB of example 1, wherein the feedback information is based on downlink sounding, or uplink sounding, or a signal received from a user equipment (UE).

Example 3 may include the eNB of example 1, wherein the antenna port configuration schedule includes an indication of a time period where the beamforming weights will not change.

Example 4 may include the eNB of any of examples 1-3, wherein: the feedback information includes a first indication of a magnitude or phase of a first received signal of a first beamformed signal produced with a first beamforming vector and a second indication of a magnitude or phase of a second received signal of a second beamformed signal produced with a second beamforming vector; the subspace identification circuitry is further to identify a signal subspace that substantially includes the first beamforming vector based at least in part on the first indication, and a null subspace that substantially includes the second beamforming vector based at least in part on the second indication; and the transmitter circuitry is further to beamform the channel training signal to the signal subspace.

Example 5 may include the eNB of example 4, wherein the first received signal energy is higher than the second received signal energy.

Example 6 may include the eNB of example 4, wherein the channel training signal is a first channel training signal and the transmitter circuitry is further to beamform a second channel training signal to only a portion of the null subspace.

Example 7 may include the eNB of example 6, further comprising receiver circuitry coupled with the transmitter circuitry, the receiver circuitry to receive, in

response to the transmission of the additional training signal in the null subspace, a second feedback that includes a third indication of a magnitude or phase of a third received signal of a third beamformed signal produced with a third beamforming vector in the null subspace.

Example 8 may include the eNB of example 6, wherein the signal subspace is a first signal subspace and the subspace identification circuitry is further to identify a second signal subspace based at least in part on the third indication, wherein the second signal subspace includes the third beamforming vector.

Example 9 may include a method comprising: identifying, by an eNodeB (eNB), a first signal subspace in a space based at least in part on a first indication of a magnitude or a phase of a first received signal of a first beamforming signal using a first beamforming vector in the first signal subspace, the first signal subspace substantially including the first beamforming vector; identifying, by the eNB, a null subspace in the space based at least in part on a second indication of a magnitude or a phase of a second received signal of a second beamforming signal using a second beamforming vector in the null subspace, the null subspace substantially including the second beamforming vector; and beamforming, from an antenna port of the eNB, a channel training signal to the first signal subspace.

Example 10 may include the method of example 9, further comprising: receiving, by the eNB after the beamforming of the channel training signal, a third indication of a magnitude or a phase of a third received signal of a third beamforming signal using a third beamforming vector in the null subspace, the null subspace including a third beamforming vector; and identifying, by the eNB, a second signal subspace based at least in part on the third indication, the second signal subspace including the third beamforming vector.

Example 11 may include the method of example 10, wherein the channel training signal is a first channel training signal and the third indication is based at least in part on beamforming, by the eNB, a second channel training signal to at least a portion of the null subspace.

Example 12 may include the method of example 9, wherein the first signal subspace is based at least in part on a singular value decomposition of the first indication.

Example 13 may include the method of example 9, wherein the first received signal strength is greater than the second received signal strength.

Example 14 may include the method of any of examples 9-13, wherein the first indication, second indication, and third indication are received by the eNB from a user equipment (UE).

Example 15 may include the method of any of examples 9-13, wherein the antenna port includes a plurality of antenna elements of the eNB.

Example 16 may include the method of any of examples 9-13, wherein the channel training signal is a channel state information-reference signal (CSI-RS) signal.

Example 17 may include one or more computer readable media comprising instructions which, when executed by one or more processors of an eNodeB (eNB), cause the eNB to: identify a first signal subspace in a space based at least in part on a first indication of a magnitude or a phase of a first received signal of a first beamforming signal using a first beamforming vector in the signal subspace, the first signal subspace substantially including a first beamforming vector; identify a null subspace in the space based at least in part on a second indication of a magnitude or a phase of a second received signal of a second beamforming signal using a second beamforming vector in the null subspace, the null subspace substantially including the second beamforming vector; and beamform a channel training signal to the first signal subspace.

Example 18 may include the one or more computer readable media of example 17, further comprising instructions to: obtain, after the beamform of the channel training signal, a third indication of a magnitude or a phase of a third received signal of a third beamforming signal using a third beamforming vector in the null subspace, the null subspace including a third beamforming vector; and identify a second signal subspace based at least in part on the third indication, the second signal subspace including the third beamforming vector.

Example 19 may include the one or more computer readable media of examples 17 or 18, wherein the first received signal strength is greater than the second received signal strength.

Example 20 may include an eNodeB comprising: the one or more computer readable media of any of examples 17-19; and one or more processors coupled with the one or more computer-readable media and configured to execute the instructions.

Example 21 may include a method comprising: identifying, by an eNodeB (eNB) based on feedback information, a plurality of beamforming weights for one or multiple antenna ports, wherein the one or multiple antenna ports have a plurality of antenna elements, and a number of the antenna ports is less than a number of the plurality of antenna elements; assigning, by the eNB, a beamforming weight in the plurality of beamforming weights to an antenna in the plurality of antenna elements; beamforming, from the eNB, a channel training signal allocated for the antenna port with the

beamforming weights; and transmitting, from the eNB, an antenna port configuration schedule from the plurality of antennas.

Example 22 may include the method of example 21, wherein the feedback information is based on downlink sounding, or uplink sounding, or a signal received from a user equipment (UE).

Example 23 may include the method of example 21, wherein the antenna port configuration schedule includes an indication of a time period where the beamforming weights will not change.

Example 24 may include the method of any of examples 21-23, wherein the feedback information includes a first indication of a magnitude or phase of a first received signal of a first beamformed signal produced with a first beamforming vector and a second indication of a magnitude or phase of a second received signal of a second beamformed signal produced with a second beamforming vector and the method further comprises: identifying, by the eNB, a signal subspace that substantially includes the first beamforming vector based at least in part on the first indication, and a null subspace that substantially includes the second beamforming vector based at least in part on the second indication; and beamforming, from the eNB, the channel training signal to the signal subspace.

Example 25 may include the method of example 24, wherein the first received signal energy is higher than the second received signal energy.

Example 26 may include the method of example 24, wherein the channel training signal is a first channel training signal and the method further comprises beamforming, from the eNB, a second channel training signal to only a portion of the null subspace.

Example 27 may include the method of example 26, further comprising receiving, by the eNB and in response to the transmission of the additional training signal in the null subspace, a second feedback that includes a third indication of a magnitude or phase of a third received signal of a third beamformed signal produced with a third beamforming vector in the null subspace.

Example 28 may include the method of example 26, wherein the signal subspace is a first signal subspace and the method further comprising identifying, by the eNB, a second signal subspace based at least in part on the third indication, wherein the second signal subspace includes the third beamforming vector.

Example 29 may include an apparatus comprising: means to identify, based on feedback information, a plurality of beamforming weights for one or multiple antenna

ports, wherein the one or multiple antenna ports have a plurality of antenna elements, and a number of the antenna ports is less than a number of the plurality of antenna elements; means to assign a beamforming weight in the plurality of beamforming weights to an antenna in the plurality of antenna elements; means to beamform a channel training signal allocated for the antenna port with the beamforming weights; and means to transmit an antenna port configuration schedule from the plurality of antennas.

Example 30 may include the apparatus of example 29, wherein the feedback information is based on downlink sounding, or uplink sounding, or a signal received from a user equipment (UE).

Example 31 may include the apparatus of example 29, wherein the antenna port configuration schedule includes an indication of a time period where the beamforming weights will not change.

Example 32 may include the apparatus of any of examples 29-31, wherein the feedback information includes a first indication of a magnitude or phase of a first received signal of a first beamformed signal produced with a first beamforming vector and a second indication of a magnitude or phase of a second received signal of a second beamformed signal produced with a second beamforming vector and the apparatus further comprises: means to identify a signal subspace that substantially includes the first beamforming vector based at least in part on the first indication, and a null subspace that substantially includes the second beamforming vector based at least in part on the second indication; and means to beamform the channel training signal to the signal subspace.

Example 33 may include the apparatus of example 32, wherein the first received signal energy is higher than the second received signal energy.

Example 34 may include the apparatus of example 32, wherein the channel training signal is a first channel training signal and the apparatus further comprises means to beamform a second channel training signal to only a portion of the null subspace.

Example 35 may include the apparatus of example 34, further comprising means to receive, in response to the transmission of the additional training signal in the null subspace, a second feedback that includes a third indication of a magnitude or phase of a third received signal of a third beamformed signal produced with a third beamforming vector in the null subspace.

Example 36 may include the apparatus of example 34, wherein the signal subspace is a first signal subspace and the apparatus further comprises means to identify a second

signal subspace based at least in part on the third indication, wherein the second signal subspace includes the third beamforming vector.

Example 37 may include one or more computer readable media comprising instructions configured, upon execution of the instructions by a processor, to: identify, based on feedback information, a plurality of beamforming weights for one or multiple antenna ports, wherein the one or multiple antenna ports have a plurality of antenna elements, and a number of the antenna ports is less than a number of the plurality of antenna elements; assign a beamforming weight in the plurality of beamforming weights to an antenna in the plurality of antenna elements; beamform a channel training signal allocated for the antenna port with the beamforming weights; and transmit an antenna port configuration schedule from the plurality of antennas.

Example 38 may include the one or more computer readable media of example 37, wherein the feedback information is based on downlink sounding, or uplink sounding, or a signal received from a user equipment (UE).

Example 39 may include the one or more computer readable media of example 37, wherein the antenna port configuration schedule includes an indication of a time period where the beamforming weights will not change.

Example 40 may include the one or more computer readable media of any of examples 37-39, wherein the feedback information includes a first indication of a magnitude or phase of a first received signal of a first beamformed signal produced with a first beamforming vector and a second indication of a magnitude or phase of a second received signal of a second beamformed signal produced with a second beamforming vector and further comprising instructions to: identify a signal subspace that substantially includes the first beamforming vector based at least in part on the first indication, and a null subspace that substantially includes the second beamforming vector based at least in part on the second indication; and beamform the channel training signal to the signal subspace.

Example 41 may include the one or more computer readable media of example 40, wherein the first received signal energy is higher than the second received signal energy.

Example 42 may include the one or more computer readable media of example 40, wherein the channel training signal is a first channel training signal and further comprising instructions to beamform a second channel training signal to only a portion of the null subspace.

Example 43 may include the one or more computer readable media of example 42, further comprising instructions to receive, in response to the transmission of the additional training signal in the null subspace, a second feedback that includes a third indication of a magnitude or phase of a third received signal of a third beamformed signal produced with a third beamforming vector in the null subspace.

Example 44 may include the one or more computer readable media of example 42, wherein the signal subspace is a first signal subspace and further comprising instructions to identify a second signal subspace based at least in part on the third indication, wherein the second signal subspace includes the third beamforming vector.

Example 45 may include an apparatus comprising: means to identify a first signal subspace in a space based at least in part on a first indication of a magnitude or a phase of a first received signal of a first beamforming signal using a first beamforming vector in the first signal subspace, the first signal subspace substantially including the first beamforming vector; means to identify a null subspace in the space based at least in part on a second indication of a magnitude or a phase of a second received signal of a second beamforming signal using a second beamforming vector in the null subspace, the null subspace substantially including the second beamforming vector; and means to beamform, from an antenna port, a channel training signal to the first signal subspace.

Example 46 may include the apparatus of example 45, further comprising: means to receive, after the beamforming of the channel training signal, a third indication of a magnitude or a phase of a third received signal of a third beamforming signal using a third beamforming vector in the null subspace, the null subspace including a third beamforming vector; and means to identify a second signal subspace based at least in part on the third indication, the second signal subspace including the third beamforming vector.

Example 47 may include the apparatus of example 46, wherein the channel training signal is a first channel training signal and the third indication is based at least in part on a beamforming, by the eNB, of a second channel training signal to at least a portion of the null subspace.

Example 48 may include the apparatus of example 45, wherein the first signal subspace is based at least in part on a singular value decomposition of the first indication.

Example 49 may include the apparatus of example 45, wherein the first received signal strength is greater than the second received signal strength.

Example 50 may include the apparatus of any of examples 45-49, wherein the first indication, second indication, and third indication are received from a user equipment (UE).

Example 51 may include the apparatus of any of examples 45-49, wherein the antenna port includes a plurality of antenna elements of the eNB.

Example 52 may include the apparatus of any of examples 45-49, wherein the channel training signal is a channel state information-reference signal (CSI-RS) signal.

Example 53 may include an eNode B (eNB) comprising: subspace identification circuitry to: identify a first signal subspace in a space based at least in part on a first indication of a magnitude or a phase of a first received signal of a first beamforming signal using a first beamforming vector in the first signal subspace, the first signal subspace substantially including the first beamforming vector; and identify a null subspace in the space based at least in part on a second indication of a magnitude or a phase of a second received signal of a second beamforming signal using a second beamforming vector in the null subspace, the null subspace substantially including the second beamforming vector; and transmitter circuitry coupled with the subspace identification circuitry, the transmitter circuitry to beamform, from an antenna port of the eNB, a channel training signal to the first signal subspace.

Example 54 may include the eNB of example 53, further comprising: receiver circuitry coupled with the transmitter circuitry, the receiver circuitry to receive, after the beamforming of the channel training signal, a third indication of a magnitude or a phase of a third received signal of a third beamforming signal using a third beamforming vector in the null subspace, the null subspace including a third beamforming vector; and the subspace identification circuitry is further to identify a second signal subspace based at least in part on the third indication, the second signal subspace including the third beamforming vector.

Example 55 may include the eNB of example 54, wherein the channel training signal is a first channel training signal and the third indication is based at least in part on a beamforming, by the eNB, of a second channel training signal to at least a portion of the null subspace.

Example 56 may include the eNB of example 53, wherein the first signal subspace is based at least in part on a singular value decomposition of the first indication.

Example 57 may include the eNB of example 53, wherein the first received signal strength is greater than the second received signal strength.

Example 58 may include the eNB of any of examples 53-57, wherein the first indication, second indication, and third indication are received from a user equipment (UE).

Example 59 may include the eNB of any of examples 53-57, wherein the antenna port includes a plurality of antenna elements of the eNB.

Example 60 may include the eNB of any of examples 53-57, wherein the channel training signal is a channel state information-reference signal (CSI-RS) signal.

Although certain embodiments have been illustrated and described herein for purposes of description, this application is intended to cover any adaptations or variations of the embodiments discussed herein. Therefore, it is manifestly intended that embodiments described herein be limited only by the claims.

Where the disclosure recites "a" or "a first" element or the equivalent thereof, such disclosure includes one or more such elements, neither requiring nor excluding two or more such elements. Further, ordinal indicators (e.g., first, second or third) for identified elements are used to distinguish between the elements, and do not indicate or imply a required or limited number of such elements, nor do they indicate a particular position or order of such elements unless otherwise specifically stated.

Claims

What is claimed is:

1. An eNodeB (eNB) comprising:

a plurality of antenna ports with a plurality of antenna elements;

subspace identification circuitry coupled with the plurality of antenna elements, the subspace identification circuitry to:

identify, based on feedback information, a plurality of beamforming weights for one or multiple antenna ports wherein a number of the antenna ports is less than a number of the plurality of antenna elements; and

assign a beamforming weight in the plurality of beamforming weights to an antenna in the plurality of antenna elements; and

transmitter circuitry coupled with the subspace identification circuitry, the transmitter circuitry to:

beamform a channel training signal allocated for the antenna port with the beamforming weights; and

transmit an antenna port configuration schedule from the plurality of antennas.

2. The eNB of claim 1, wherein the feedback information is based on downlink sounding, or uplink sounding, or a signal received from a user equipment (UE).

3. The eNB of claim 1, wherein the antenna port configuration schedule includes an indication of a time period where the beamforming weights will not change.

4. The eNB of any of claims 1-3, wherein:

the feedback information includes a first indication of a magnitude or phase of a first received signal of a first beamformed signal produced with a first beamforming vector and a second indication of a magnitude or phase of a second received signal of a second beamformed signal produced with a second beamforming vector;

the subspace identification circuitry is further to identify a signal subspace that substantially includes the first beamforming vector based at least in part on the first indication, and a null subspace that substantially includes the second beamforming vector based at least in part on the second indication; and

the transmitter circuitry is further to beamform the channel training signal to the signal subspace.

5. The eNB of claim 4, wherein the first received signal energy is higher than the second received signal energy.

6. The eNB of claim 4, wherein the channel training signal is a first channel training signal and the transmitter circuitry is further to beamform a second channel training signal to only a portion of the null subspace.

7. The eNB of claim 6, further comprising receiver circuitry coupled with the transmitter circuitry, the receiver circuitry to receive, in response to the transmission of the additional training signal in the null subspace, a second feedback that includes a third indication of a magnitude or phase of a third received signal of a third beamformed signal produced with a third beamforming vector in the null subspace.

8. The eNB of claim 6, wherein the signal subspace is a first signal subspace and the subspace identification circuitry is further to identify a second signal subspace based at least in part on the third indication, wherein the second signal subspace includes the third beamforming vector.

9. A method comprising:

identifying, by an eNodeB (eNB), a first signal subspace in a space based at least in part on a first indication of a magnitude or a phase of a first received signal of a first beamforming signal using a first beamforming vector in the first signal subspace, the first signal subspace substantially including the first beamforming vector; and

identifying, by the eNB, a null subspace in the space based at least in part on a second indication of a magnitude or a phase of a second received signal of a second beamforming signal using a second beamforming vector in the null subspace, the null subspace substantially including the second beamforming vector; and

beamforming, from an antenna port of the eNB, a channel training signal to the first signal subspace.

10. The method of claim 9, further comprising:

receiving, by the eNB after the beamforming of the channel training signal, a third indication of a magnitude or a phase of a third received signal of a third beamforming signal using a third beamforming vector in the null subspace, the null subspace including a third beamforming vector; and

identifying, by the eNB, a second signal subspace based at least in part on the third indication, the second signal subspace including the third beamforming vector.

11. The method of claim 10, wherein the channel training signal is a first channel training signal and the third indication is based at least in part on beamforming, by the eNB, a second channel training signal to at least a portion of the null subspace.

12. The method of claim 9, wherein the first signal subspace is based at least in part on a singular value decomposition of the first indication.

13. The method of claim 9, wherein the first received signal strength is greater than the second received signal strength.

14. The method of any of claims 9-13, wherein the first indication, second indication, and third indication are received by the eNB from a user equipment (UE).

15. The method of any of claims 9-13, wherein the antenna port includes a plurality of antenna elements of the eNB.

16. The method of any of claims 9-13, wherein the channel training signal is a channel state information-reference signal (CSI-RS) signal.

17. One or more computer readable media comprising instructions which, when executed by one or more processors of an eNodeB (eNB), cause the eNB to:

identify a first signal subspace in a space based at least in part on a first indication of a magnitude or a phase of a first received signal of a first beamforming signal using a first beamforming vector in the signal subspace, the first signal subspace substantially including a first beamforming vector;

identify a null subspace in the space based at least in part on a second indication of a magnitude or a phase of a second received signal of a second beamforming signal using

a second beamforming vector in the null subspace, the null subspace substantially including the second beamforming vector; and

beamform a channel training signal to the first signal subspace.

18. The one or more computer readable media of claim 17, further comprising instructions to:

obtain, after the beamform of the channel training signal, a third indication of a magnitude or a phase of a third received signal of a third beamforming signal using a third beamforming vector in the null subspace, the null subspace including a third beamforming vector; and

identify a second signal subspace based at least in part on the third indication, the second signal subspace including the third beamforming vector.

19. The one or more computer readable media of claims 17 or 18, wherein the first received signal strength is greater than the second received signal strength.

20. An eNodeB comprising:

the one or more computer readable media of any of claims 17-19; and

one or more processors coupled with the one or more computer-readable media and configured to execute the instructions.

AMENDED CLAIMS
received by the International Bureau on 13 May 2014 (13.05.2014)

1. An eNodeB (eNB) comprising:

a plurality of antenna ports with a plurality of antenna elements;

subspace identification circuitry coupled with the plurality of antenna elements, the subspace identification circuitry to:

identify, based on feedback information, a plurality of beamforming weights for one or multiple antenna ports wherein a number of the antenna ports is less than a number of the plurality of antenna elements; and

assign a beamforming weight in the plurality of beamforming weights to an antenna in the plurality of antenna elements; and

transmitter circuitry coupled with the subspace identification circuitry, the transmitter circuitry to:

beamform a channel training signal allocated for the antenna port with the beamforming weights; and

transmit an antenna port configuration schedule from the plurality of antennas.

2. The eNB of claim 1, wherein the feedback information is based on downlink sounding, or uplink sounding, or a signal received from a user equipment (UE).

3. The eNB of claim 1, wherein the antenna port configuration schedule includes an indication of a time period where the beamforming weights will not change.

4. The eNB of any of claims 1-3, wherein:

the feedback information includes a first indication of a magnitude or phase of a first received signal of a first beamformed signal produced with a first beamforming vector and a second indication of a magnitude or phase of a second received signal of a second beamformed signal produced with a second beamforming vector;

the subspace identification circuitry is further to identify a signal subspace that includes the first beamforming vector based at least in part on the first indication, and a null subspace that includes the second beamforming vector based at least in part on the second indication; and

the transmitter circuitry is further to beamform the channel training signal to the signal subspace.

5. The eNB of claim 4, wherein the first received signal magnitude is higher than the second received signal magnitude.

AMENDED SHEET (ARTICLE 19)

6. The eNB of claim 4, wherein the channel training signal is a first channel training signal and the transmitter circuitry is further to beamform a second channel training signal to only a portion of the null subspace.

7. The eNB of claim 6, further comprising receiver circuitry coupled with the transmitter circuitry, the receiver circuitry to receive, in response to the transmission of the additional training signal in the null subspace, a second feedback that includes a third indication of a magnitude or phase of a third received signal of a third beamformed signal produced with a third beamforming vector in the null subspace.

8. The eNB of claim 6, wherein the signal subspace is a first signal subspace and the subspace identification circuitry is further to identify a second signal subspace based at least in part on the third indication, wherein the second signal subspace includes the third beamforming vector.

9. A method comprising:

identifying, by an eNodeB (eNB), a first signal subspace in a space based at least in part on a first indication of a magnitude or a phase of a first received signal of a first beamforming signal using a first beamforming vector in the first signal subspace, the first signal subspace including the first beamforming vector; and

identifying, by the eNB, a null subspace in the space based at least in part on a second indication of a magnitude or a phase of a second received signal of a second beamforming signal using a second beamforming vector in the null subspace, the null subspace including the second beamforming vector; and

beamforming, from an antenna port of the eNB, a channel training signal to the first signal subspace.

10. The method of claim 9, further comprising:

receiving, by the eNB after the beamforming of the channel training signal, a third indication of a magnitude or a phase of a third received signal of a third beamforming signal using a third beamforming vector in the null subspace, the null subspace including a third beamforming vector; and

identifying, by the eNB, a second signal subspace based at least in part on the third indication, the second signal subspace including the third beamforming vector.

11. The method of claim 10, wherein the channel training signal is a first channel training signal and the third indication is based at least in part on beamforming, by the eNB, a second channel training signal to at least a portion of the null subspace.

12. The method of claim 9, wherein the first signal subspace is based at least in part on a singular value decomposition of the first indication.

13. The method of claim 9, wherein the first received signal magnitude is greater than the second received signal magnitude.

14. The method of any of claims 9-13, wherein the first indication, second indication, and third indication are received by the eNB from a user equipment (UE).

15. The method of any of claims 9-13, wherein the antenna port includes a plurality of antenna elements of the eNB.

16. The method of any of claims 9-13, wherein the channel training signal is a channel state information-reference signal (CSI-RS) signal.

17. One or more computer readable media comprising instructions which, when executed by one or more processors of an eNodeB (eNB), cause the eNB to:

identify a first signal subspace in a space based at least in part on a first indication of a magnitude or a phase of a first received signal of a first beamforming signal using a first beamforming vector in the signal subspace, the first signal subspace including a first beamforming vector;

including the second beamforming vector; and

beamform a channel training signal to the first signal subspace.

18. The one or more computer readable media of claim 17, further comprising instructions to:

obtain, after the beamform of the channel training signal, a third indication of a magnitude or a phase of a third received signal of a third beamforming signal using a third beamforming vector in the null subspace, the null subspace including a third beamforming vector; and

identify a second signal subspace based at least in part on the third indication, the second signal subspace including the third beamforming vector.

19. The one or more computer readable media of claims 17 or 18, wherein the first received signal magnitude is greater than the second received signal magnitude.

20. An eNodeB comprising:

the one or more computer readable media of claims 17 or 18; and

one or more processors coupled with the one or more computer-readable media and configured to execute the instructions.

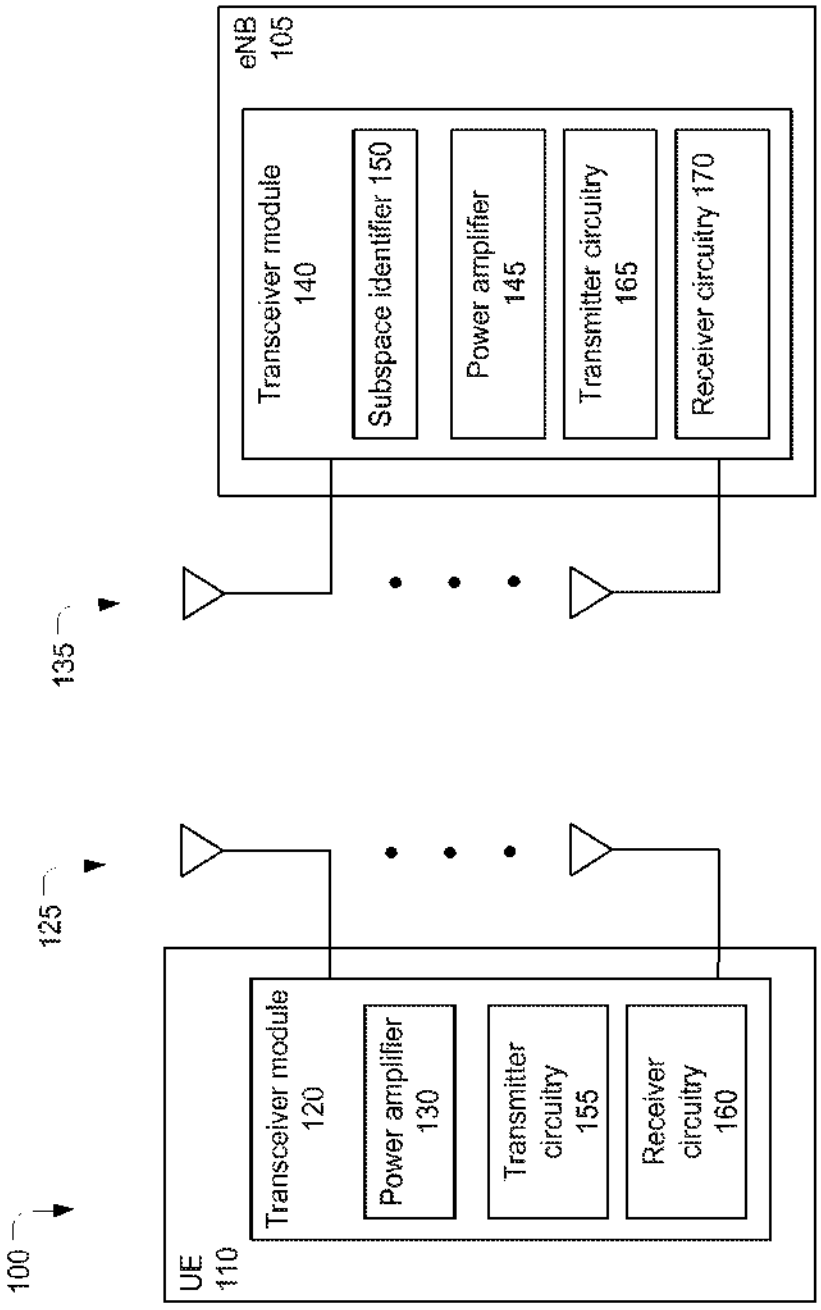

100
UE
110
Transceiver module
120
Power amplifier
130
Transmitter
circuitry
155
Receiver
circuitry
160
125
135
eNB
105
Transceiver module
140
Subspace identifier 150
Power amplifier
145
Transmitter circuitry
165
Receiver circuitry 170

Figure 1

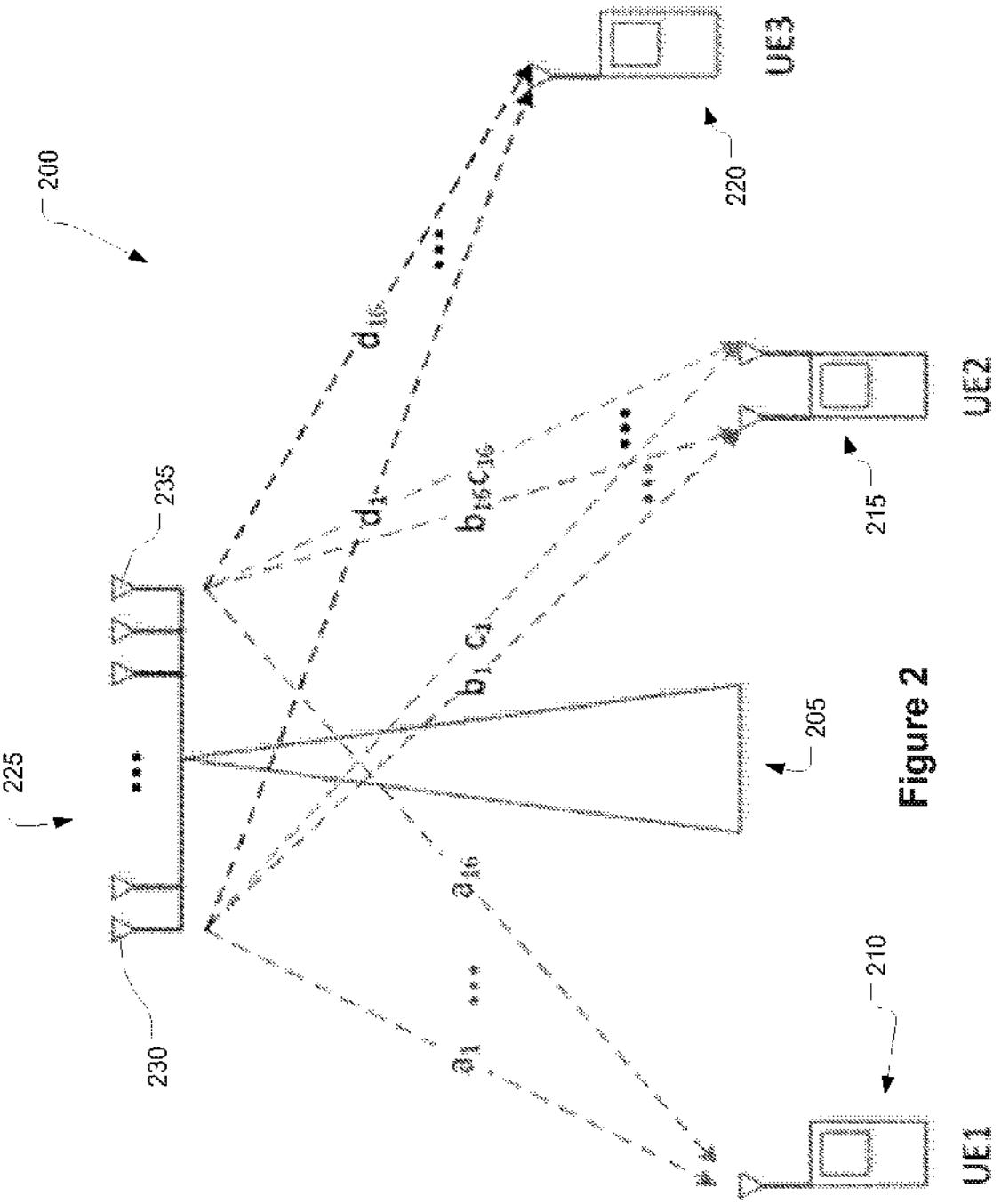


Figure 2

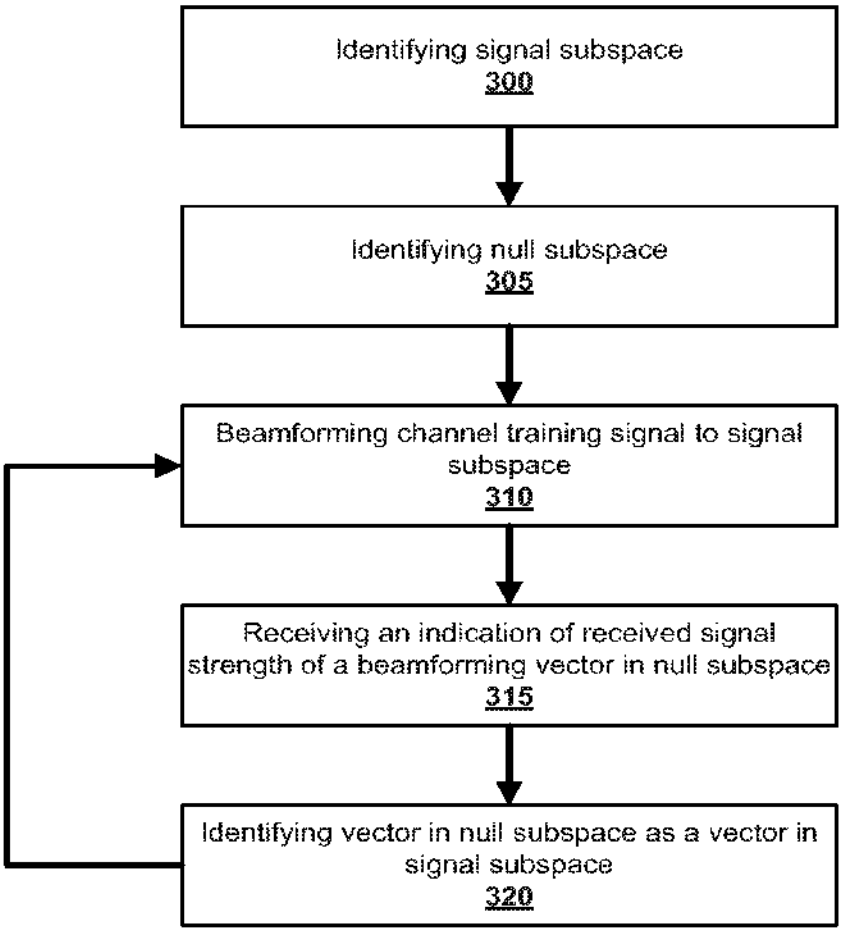

Identifying signal subspace
300
Identifying null subspace
305
Beamforming channel training signal to signal subspace
310
Receiving an indication of received signal strength of a beamforming vector in null subspace
315
Identifying vector in null subspace as a vector in signal subspace
320

Figure 3

4/4

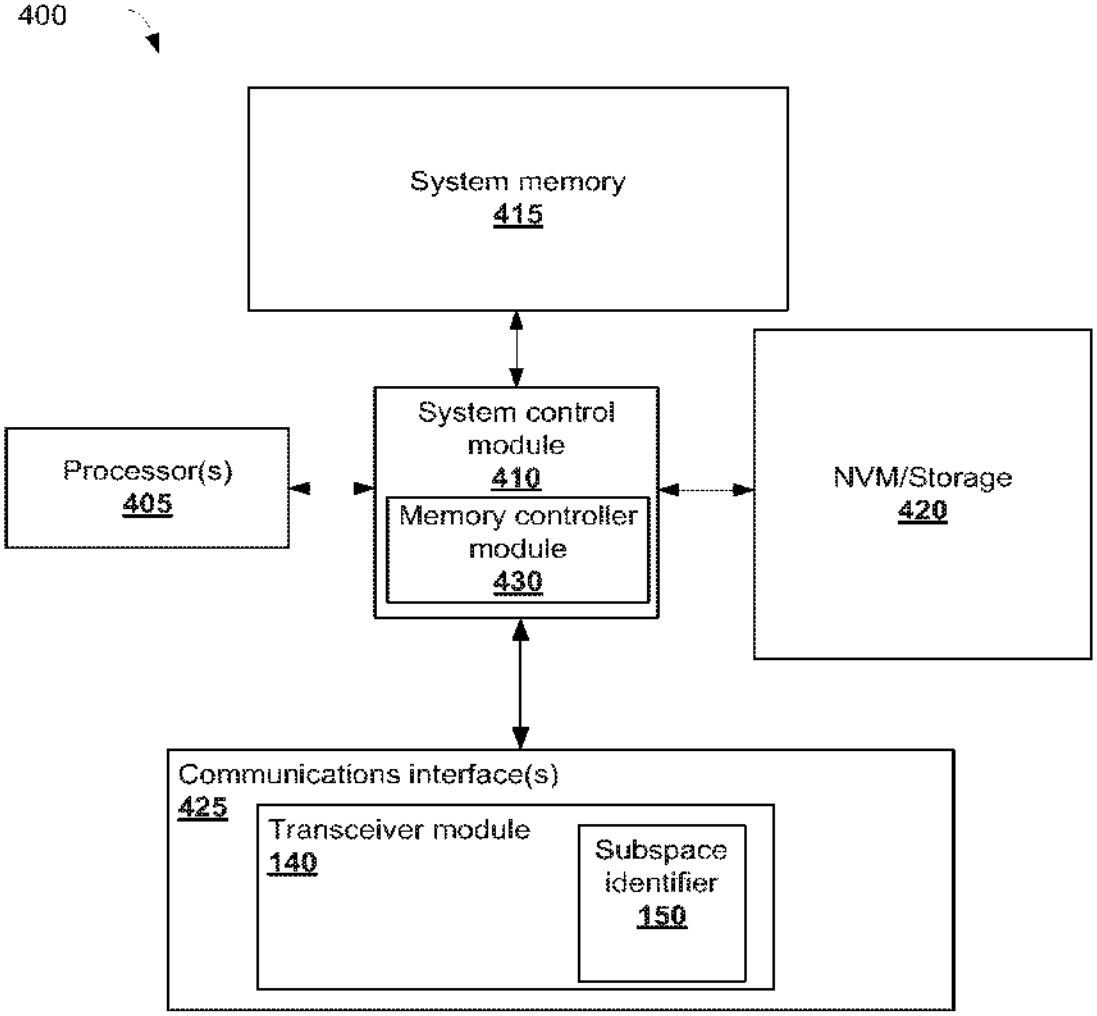

400
System memory
415
System control module
410
Memory controller module
430
Processor(s)
405
NVM/Storage
420
Communications interface(s)
425
Transceiver module
140
Subspace identifier
150

Figure 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/075463

A. CLASSIFICATION OF SUBJECT MATTER

H04B 7/06(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04B 7/06; H04B 7/00; H04B 7/02; H04B 17/00; H04M 1/00; H04Q 7/20; H04W 72/04; H04W 40/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: feedback, beamforming weight, channel training signal, beamform, antenna element, antenna port configuration schedule, signal subspace, null subspace, beamforming vector

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2009-0252250 A1 (ROBERT WENDELL HEATH, JR. et al.) 08 October 2009 See paragraphs 99-106, 115-125; and figs. 3, 5.	1-19
A	US 2009-0067375 A1 (WENDY C. WONG et al.) 12 March 2009 See paragraphs 31-99, 102-114; and figs. 2, 4.	1-19
A	US 2010-0075705 A1 (CORNELIUS VAN RENSBURG et al.) 25 March 2010 See paragraphs 50-67; and figs. 3, 4.	1-19
A	US 2013-0059619 A1 (TAE-YOUNG KIM et al.) 07 March 2013 See paragraphs 51-59, 83-91; and figs. 4, 7.	1-19
A	US 2011-0205963 A1 (YANG TANG et al.) 25 August 2011 See paragraphs 23-37, 50-58; and figs. 2a, 4.	1-19

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 March 2014 (18.03.2014)	**19 March 2014 (19.03.2014)**

Name and mailing address of the ISA/KR
International Application Division
Korean Intellectual Property Office
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Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/075463

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 20
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required addtional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of any additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2013/075463

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2009-0252250 A1	08/10/2009	KR 10-2009-0105299 A	07/10/2009
		US 8165533 B2	24/04/2012
US 2009-0067375 A1	12/03/2009	CN 101384023 A	11/03/2009
		CN 101384023 B	31/10/2012
		EP 2034626 A2	11/03/2009
		EP 2034626 A3	20/11/2013
		US 8085653 B2	27/12/2011
US 2010-0075705 A1	25/03/2010	EP 2311192 A1	20/04/2011
		EP 2311192 A4	17/08/2011
		US 8315657 B2	20/11/2012
		WO 2010-033989 A1	25/03/2010
US 2013-0059619 A1	07/03/2013	KR 10-2013-0025102 A	11/03/2013
		WO 2013-032188 A2	07/03/2013
		WO 2013-032188 A3	25/04/2013
US 2011-0205963 A1	25/08/2011	None	

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H04W 88/06 (2009.01)

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11 August 2015 (11.08.2015)

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(30) Priority Data:
62/114,733 11 February 2015 (11.02.2015) US

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to the identity of the inventor (Rule 4.17(i))*

Published:

— *with international search report (Art. 21(3))*

(54) **Title**: DEVICE, SYSTEM AND METHOD EMPLOYING UNIFIED FLEXIBLE 5G AIR INTERFACE

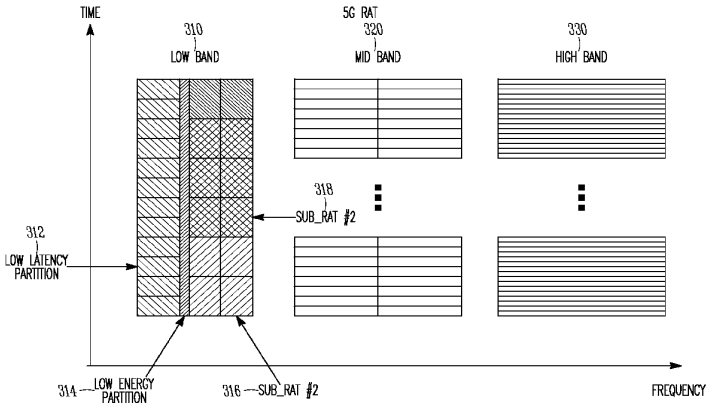


FIG. 3

(57) **Abstract**: An eNodeB (eNB), user equipment (UE) and method of providing a flexible Radio Access Technology (FRAT) are generally described. The information (resource allocation, partition information and numerology) of at least one of a plurality of RATs used by the eNB is provided to a UE. Each RAT has a flexible subcarrier spacing and symbol duration, which are integer multiples of a base subcarrier spacing and symbol duration, and is associated with at least one of different temporal and frequency resources. The symbol and/or frame structure of each RAT are independent. A Transmission Time Interval (TTI) boundary between the RATs is common, and the RATs comprise a common reference TTI duration. The information of the RATs is provided either via a different RAT than the RAT used by the UE for communication or via a dedicated carrier in the RAT used by the UE for communication.

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DEVICE, SYSTEM AND METHOD EMPLOYING UNIFIED FLEXIBLE 5G AIR INTERFACE

PRIORITY CLAIM

[0001] This application claims the benefit of priority to United States Provisional Patent Application Serial No. 62/114,733, filed February 11, 2015, and entitled "UNIFIED FLEXIBLE 5G NEW AIR INTERFACE DESIGN," which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] Embodiments pertain to radio access networks. Some embodiments relate to a unified communication framework using Radio Access Technologies (RAT) in 5th generation (5G) cellular networks.

BACKGROUND

[0003] The use of personal communication devices has increased astronomically over the last several decades. The penetration of mobile devices in modern society has continued to drive demand for a wide variety of networked devices in a number of disparate environments. The variety of available applications, especially video-related applications, has led to a concomitant increase in demand for increased bandwidth beyond that provided by Third Generation Partnership Project Long Term Evolution (3GPP LTE) and LTE advanced (LTE-A) systems.

[0004] The next generation wireless communication system, 5G, may provide access to information and sharing of data using a network that may be required to meet vastly different and sometimes conflicting performance dimensions and services driven by different services and use cases. It is therefore desirable that the next generation communication system be flexible and capable of providing high speed communications services for a wide ambit of devices under a multiplicity of circumstances.

BRIEF DESCRIPTION OF THE FIGURES

[0005] In the figures, which are not necessarily drawn to scale, like numerals may describe similar components in different views. Like numerals having different letter suffixes may represent different instances of similar components. The figures illustrate generally, by way of example, but not by way of limitation, various embodiments discussed in the present document.

[0006] FIG. 1 is a functional diagram of a 3GPP network in accordance with some embodiments.

[0007] FIG. 2 is a block diagram of a 3GPP device in accordance with some embodiments.

[0008] FIG. 3 illustrates one embodiment of a flexible Radio Access Technology (FRAT) of a 5G system in accordance with some embodiments.

[0009] FIG. 4 illustrates a unified frame structure in accordance with some embodiments.

[0010] FIG. 5 illustrates a Transmission Time Interval (TTI) boundary alignment in accordance with some embodiments.

[0011] FIG. 6 illustrates a symbol structure in accordance with some embodiments.

[0012] FIG. 7 illustrates frame structures within a TTI in accordance with some embodiments.

[0013] FIGS. 8A and 8B illustrate flowcharts of a uniform framework utilization method in accordance with some embodiments.

DETAILED DESCRIPTION OF THE INVENTION

[0014] The following description and the drawings sufficiently illustrate specific embodiments to enable those skilled in the art to practice them. Other embodiments may incorporate structural, logical, electrical, process, and other changes. Portions and features of some embodiments may be included in, or substituted for, those of other embodiments. Embodiments set forth in the claims encompass all available equivalents of those claims.

[0015] FIG. 1 is a functional diagram of a 3GPP network in accordance with some embodiments. The network may comprise a radio access network (RAN) (e.g., as depicted, the E-UTRAN or evolved universal terrestrial radio

access network) 100 and the core network 120 (e.g., shown as an evolved packet core (EPC)) coupled together through an S1 interface 115. For convenience and brevity sake, only a portion of the core network 120, as well as the RAN 100, is shown.

[0016] The core network 120 includes mobility management entity (MME) 122, serving gateway (serving GW) 124, and packet data network gateway (PDN GW) 126. The RAN 100 includes eNBs 104 (which may operate as base stations) for communicating with UE 102. The eNBs 104 may include macro eNBs and low power (LP) eNBs.

[0017] The MME is similar in function to the control plane of legacy Serving GPRS Support Nodes (SGSN). The MME manages mobility aspects in access such as gateway selection and tracking area list management. The serving GW 124 terminates the interface toward the RAN 100, and routes traffic packets (such as data packets or voice packets) between the RAN 100 and the core network 120. In addition, it may be a local mobility anchor point for inter-eNB handovers and also may provide an anchor for inter-3GPP mobility. Other responsibilities may include lawful intercept, charging, and some policy enforcement. The serving GW 124 and the MME 122 may be implemented in one physical node or separate physical nodes. The PDN GW 126 terminates a SGi interface toward the packet data network (PDN). The PDN GW 126 routes traffic packets between the EPC 120 and the external PDN, and may be a key node for policy enforcement and charging data collection. It may also provide an anchor point for mobility with non-LTE accesses. The external PDN can be any kind of IP network, as well as an IP Multimedia Subsystem (IMS) domain. The PDN GW 126 and the serving GW 124 may be implemented in one physical node or separated physical nodes.

[0018] The eNBs 104 (macro and micro) terminate the air interface protocol and may be the first point of contact for a UE 102. The eNBs 104 may communicate both with UEs 102 in a normal coverage mode and UEs 104 in one or more enhanced coverage modes. In some embodiments, an eNB 104 may fulfill various logical functions for the RAN 100 including but not limited to RNC (radio network controller functions) such as radio bearer management, uplink and downlink dynamic radio resource management and traffic packet

scheduling, and mobility management. In accordance with some embodiments, UEs 102 may be configured to communicate via orthogonal multiple access (OMA) communications such as Time Division Multiple Access (TDMA), Frequency Division Multiple Access (FDMA) Orthogonal FDMA (OFDMA), SC-FDMA or other communication signals with an eNB 104 over a multicarrier communication channel in accordance with the appropriate communication technique. The OFDM signals may comprise a plurality of orthogonal subcarriers. In accordance with some embodiments, UEs 102 may be configured to communicate via non-orthogonal multiple access (NOMA) signals.

[0019] The S1 interface 115 is the interface that separates the RAN 100 and the EPC 120. It is split into two parts: the S1-U, which carries traffic packets between the eNBs 104 and the serving GW 124, and the S1-MME, which is a signaling interface between the eNBs 104 and the MME 122.

[0020] With cellular networks, LP cells are typically used to extend coverage to indoor areas where outdoor signals do not reach well, or to add network capacity in areas with very dense phone usage, such as train stations. As used herein, the term low power (LP) eNB refers to any suitable relatively low power eNB for implementing a narrower cell (narrower than a macro cell) such as a femtocell, a picocell, or a micro cell. Femtocell eNBs are typically provided by a mobile network operator to its residential or enterprise customers. A femtocell is typically the size of a residential gateway or smaller and generally connects to the user's broadband line. Once plugged in, the femtocell connects to the mobile operator's mobile network and provides extra coverage in a range of typically 30 to 50 meters for residential femtocells. Thus, a LP eNB might be a femtocell eNB since it is coupled through the PDN GW 126. Similarly, a picocell is a wireless communication system typically covering a small area, such as in-building (offices, shopping malls, train stations, etc.), or more recently in-aircraft. A picocell eNB can generally connect through the X2 link to another eNB such as a macro eNB through its base station controller (BSC) functionality. Thus, LP eNB may be implemented with a picocell eNB since it is coupled to a macro eNB via an X2 interface. Picocell eNBs or other LP eNBs may incorporate some or all functionality of a macro eNB. In some cases, this may be referred to as an access point base station or enterprise femtocell.

[0021] As indicated in more detail below, communication over a 4G LTE network may be split up into 10ms frames, each of which may contain ten 1ms subframes. Each subframe of the frame, in turn, may contain two slots of 0.5ms. The eNB may schedule uplink and downlink transmissions over a variety of frequency bands. The allocation of resources in subframes used in one frequency band and may differ from those in another frequency band. Each slot of the subframe may contain 6-7 symbols, depending on the system used. In some embodiments, the subframe may contain 12 or 24 subcarriers. A resource grid may be used for downlink and uplink transmissions between an eNB and a UE. The resource grid may be a time-frequency grid, which is the physical resource in each slot. The smallest time-frequency unit in a resource grid may be denoted as a resource element (RE). Each column and each row of the resource grid may correspond to one OFDM symbol and one OFDM subcarrier, respectively. The resource grid may contain resource blocks (RBs) that describe the mapping of physical channels to resource elements and physical RBs (PRBs). A PRB may be the smallest unit of resources that can be allocated to a UE in the current 3GPP standard. A resource block may be 180 kHz wide in frequency and 1 slot long in time. In frequency, resource blocks may be either 12 x 15 kHz subcarriers or 24 x 7.5 kHz subcarriers wide. For most channels and signals, 12 subcarriers may be used per resource block, dependent on the system bandwidth. The duration of the resource grid in the time domain corresponds to one subframe or two resource blocks. Each resource grid may comprise 12 (subcarriers) *14 (symbols) =168 resource elements for normal cyclic prefix (CP) case. Several different physical channels may be conveyed using such resource blocks. As discussed in more detail below, in a 5G network, the sizes of the resource blocks, resource elements, and symbols, among others, may vary.

[0022] There may be several different physical downlink channels that are conveyed using such resource blocks, including the physical downlink control channel (PDCCH) and the physical downlink shared channel (PDSCH). Each subframe may contain a PDCCH, physical hybrid-ARQ indicator channel (PHICH), physical control format indicator channel (PCFICH) and the PDSCH. The PDCCH may normally occupy the first up to three symbols (four in the case

of narrow bandwidths of 1.4MHz) of each subframe and carry, among other things, information about the transport format and resource allocations related to the PDSCH channel and uplink scheduling grants for a physical uplink shared channel (PUSCH) transmission. The PHICH may be used to signal HARQ information in response to a PUSCH transmission. The PCFICH may inform the UE the control region size (e.g. one, two or three OFDM symbols) in each downlink subframe. The PDSCH may carry user data and higher layer signaling to a particular UE and occupy the remainder of the downlink subframe to avoid the resources in which downlink control channels (PDCCH/PHICH/PCFICH) are transmitted. Typically, downlink scheduling (assigning control and shared channel resource blocks to UEs within a cell) may be performed at the eNB based on channel quality information provided by the UEs, and then the downlink resource assignment information may be sent to a scheduled UE on the PDCCH used for (assigned to) PDSCH reception of the UE.

[0023] The PDCCH may contain downlink control information (DCI) in one of a number of formats that tell the UE where to find and how to decode the data, transmitted on PDSCH in the same subframe, from the resource grid. The DCI may provide details such as the number of resource blocks, resource allocation type, modulation scheme, transport block, redundancy version, coding rate etc. Each DCI format may have a cyclic redundancy code (CRC) and be scrambled with a Radio Network Temporary Identifier (RNTI) that identifies the target UE for which the PDSCH is intended. Use of the RNTI, which may be UE-specific, may limit decoding of the DCI information (and hence the corresponding PDSCH) to only the intended UE. The PDCCH may be located in any of a number of frequency/temporal regions, depending on whether the PDCCH is UE-Specific or common, as well as the aggregation level. The set of possible candidate locations for the PDCCH is defined in terms of search spaces. A search space is defined by a set of Control Channel Element (CCE) candidates with a number of aggregation level $L \in \{1,2,4,8\}$ where the UE may monitor to find its PDCCHs. A common search space may carry DCIs that are common for all UEs; for example, system information (using the SI-RNTI), paging (P-RNTI), PRACH responses (RA-RNTI), or UL TPC commands (TPC-PUCCH/PUSCH-RNTI). A UE-specific search space may carry DCIs for UE-

specific allocations using a Cell Radio-Network Temporary Identifier (C-RNTI) assigned to the UE, a semi-persistent scheduling (SPS C-RNTI), or an initial allocation (temporary C-RNTI). When configuring an SPS (either uplink or downlink), the SPS C-RNTI is provided by the eNB and the UE is configured by higher layers to decode a PDCCH with a CRC scrambled by the SPS C-RNTI. The UE may monitor the PDCCH having a CRC scrambled by the SPS C-RNTI in every subframe as the eNB can activate/re-activate/release the SPS at any time using a DCI format with a CRC scrambled by an SPS C-RNTI. The received DCI format with a CRC scrambled by the SPS C-RNTI can be a grant/assignment for a retransmission or for activation/re-activation/release of the SPS. 3GPP Technical Specification 36.213 has tabulated the validation procedure for activation/re-activation/release of SPS.

[0024] In addition to the PDCCH, an enhanced PDCCH (EPDCCH) may be used by the eNB and UE. The PDSCH may thus contain data in some of the resource blocks (RBs) and then EPDCCH contains the downlink control signals in others of the RBs of the bandwidth supported by the UE. Different UEs may have different EPDCCH configurations. The sets of RBs corresponding to EPDCCH may be configured, for example, by higher layer signaling such as Radio Resource Control (RRC) signaling for EPDCCH monitoring.

[0025] The Physical Uplink Control Channel (PUCCH) may be used by the UE to send Uplink Control Information (UCI) to the eNB. The PUCCH may be mapped to an UL control channel resource defined by an orthogonal cover code and two resource blocks (RBs), consecutive in time, with hopping potentially at the boundary between adjacent slots. The PUCCH may take several different formats, with the UCI containing information dependent on the format. Specifically, the PUCCH may contain a scheduling request (SR), acknowledgement responses/retransmission requests (ACK/NACK) or a Channel Quality Indication (CQI)/Channel State Information (CSI). The CQI/CSI may indicate to the eNB an estimate of the current downlink channel conditions as seen by the UE to aid channel-dependent scheduling and, if one MIMO transmission mode is configured to the UE, may include MIMO-related feedback (e.g. Precoder matrix indication, PMI).

[0026] FIG. 2 is a functional diagram of a 3GPP device in accordance with some embodiments. The device may be a UE or eNB, for example. In some embodiments, the eNB may be a stationary non-mobile device. The 3GPP device 200 may include physical layer circuitry 202 for transmitting and receiving signals using one or more antennas 201. The 3GPP device 200 may also include medium access control layer (MAC) circuitry 204 for controlling access to the wireless medium. The 3GPP device 200 may also include processing circuitry 206 and memory 208 arranged to perform the operations described herein.

[0027] In some embodiments, mobile devices or other devices described herein may be part of a portable wireless communication device, such as a personal digital assistant (PDA), a laptop or portable computer with wireless communication capability, a web tablet, a wireless telephone, a smartphone, a wireless headset, a pager, an instant messaging device, a digital camera, an access point, a television, a medical device (e.g., a heart rate monitor, a blood pressure monitor, etc.), or other device that may receive and/or transmit information wirelessly. In some embodiments, the mobile device or other device can be a UE 102 or eNB 104 configured to operate in accordance with 3GPP standards. In some embodiments, the mobile device or other device may be configured to operate according to other protocols or standards, including IEEE 802.11 or other IEEE standards. In some embodiments, the mobile device or other device may include one or more of a keyboard, a display, a non-volatile memory port, multiple antennas, a graphics processor, an application processor, speakers, and other mobile device elements. The display may be an LCD screen including a touch screen.

[0028] The antennas 201 may comprise one or more directional or omnidirectional antennas, including, for example, dipole antennas, monopole antennas, patch antennas, loop antennas, microstrip antennas or other types of antennas suitable for transmission of RF signals. In some multiple-input multiple-output (MIMO) embodiments, the antennas 201 may be effectively separated to take advantage of spatial diversity and the different channel characteristics that may result.

[0029] Although the 3GPP device 200 is illustrated as having several separate functional elements, one or more of the functional elements may be combined and may be implemented by combinations of software-configured elements, such as processing elements including digital signal processors (DSPs), and/or other hardware elements. For example, some elements may comprise one or more microprocessors, DSPs, field-programmable gate arrays (FPGAs), application specific integrated circuits (ASICs), radio-frequency integrated circuits (RFICs) and combinations of various hardware and logic circuitry for performing at least the functions described herein. In some embodiments, the functional elements may refer to one or more processes operating on one or more processing elements.

[0030] Embodiments may be implemented in one or a combination of hardware, firmware and software. Embodiments may also be implemented as instructions stored on a computer-readable storage device, which may be read and executed by at least one processor to perform the operations described herein. A computer-readable storage device may include any non-transitory mechanism for storing information in a form readable by a machine (e.g., a computer). For example, a computer-readable storage device may include read-only memory (ROM), random-access memory (RAM), magnetic disk storage media, optical storage media, flash-memory devices, and other storage devices and media. Some embodiments may include one or more processors and may be configured with instructions stored on a computer-readable storage device.

[0031] The term "machine readable medium" may include a single medium or multiple media (e.g., a centralized or distributed database, and/or associated caches and servers) configured to store one or more instructions. The term “machine readable medium” may include any medium that is capable of storing, encoding, or carrying instructions for execution by the 3GPP device 200 and that cause it to perform any one or more of the techniques of the present disclosure, or that is capable of storing, encoding or carrying data structures used by or associated with such instructions. The term “transmission medium” shall be taken to include any intangible medium that is capable of storing, encoding or carrying instructions for execution, and includes digital or analog

communications signals or other intangible medium to facilitate communication of such software.

[0032] As above, the upcoming 5G wireless communications technology systems may have a number of unique challenges, including carrying the inherent ability to provide different performances requirements for numerous different types of wireless devices. Higher data rates in particular may continue to drive network development and evolution for 5G system. It may be desirable for a 5G system to support a peak data rate of more than 10Gps and a minimum guaranteed user data rate of at least 100Mbps. In addition, it may be desirable for the 5G system to support the huge increase in variety and number of Internet of Things (IoT) and Machine-Type Communication (MTC)-type devices. MTC devices have been increasingly employed for different applications, using low operational power consumption and infrequent small burst transmissions. Moreover, it may be desirable for the 5G system to provide an extremely high level of reliable connectivity with guaranteed low latency, availability and reliability-of-service for mission critical MTC use cases.

[0033] In general, 5G systems may use a plurality of Radio Access Technologies (RATs), unlike previous 2G, 3G and 4G, systems. For example, an enormous amount of spectrum may be available through the use of higher frequency bands. In one example, the use of millimeter wave (mmWave) frequency bands ranging from 30 to 300GHz may provide the desired scalability, capacity and density for the 5G system. In this case, a new RAT may be defined for the mmWave band to achieve low latency and higher peak data rate. The RAT for mmWave band communications may differ from the RAT for one or more of the other frequency bands used to provide communication services. In some embodiments, the RATs may be used simultaneously by a single eNB for communications with different UEs.

[0034] In some embodiments, a 5G system may be provided that contains multiple RATs in a unified framework to support diverse applications, use cases and services and inter-networking in multiple frequency bands, including both licensed and unlicensed frequency bands. The RATs used in the licensed and unlicensed may be independent of each other. In some embodiments, flexible subcarrier spacing and symbol duration (i.e., configurable

numerology) may be provided across the frequency bands used in the 5G system. In addition, the 5G system may include mechanisms to multiplex multiple RATs, sub-RATs and other partitions in different or the same frequency resource or frequency bands.

[0035] The inter-networking in the unified frame structure may include, in some embodiments, a Transmission Time Interval (TTI) boundary alignment between multiple RATs may be provided to allow seamless scheduling, fallback and support of different RATs. In some embodiments, a TTI is the smallest unit of time in which the eNB is capable of scheduling any UE for uplink or downlink transmission. In some embodiments, the TTI boundary alignment may occur at a subframe or frame boundary. As used herein, a unified RAT with flexible air interface for the 5G system is referred to as a flexible Radio Access Technology (FRAT). A UE that communicates with an eNB operating using the FRAT may remain using a single air interface technology (i.e., RAT) or may switch between different RATs.

[0036] In some embodiments, a unified RAT with configurable numerologies may be used in the 5G system in which a base subcarrier spacing (Δf) and symbol duration (T) can be defined in the FRAT. In one example, to maintain the backward compatibility for existing LTE and LTE-Advanced systems, a base subcarrier spacing and symbol duration can be specified as Δf = 15KHz and T=66.7μs. Moreover, for convenience in some embodiments a single oscillator may be used, with the subcarrier spacing and symbol duration for different RATs specified as an integer number of the base subcarrier spacing and symbol duration, respectively.

[0037] Similarly, when a low latency use case and service is desired, a shortened symbol duration may be employed to reduce the latency by using larger subcarrier spacing. The subcarrier spacing and symbol duration may in this case be defined as $\Delta f_i = K*\Delta f$ and $T_i=(1/K)*T$. In one example, for frequency band between 6GHz and 30GHz, K can be chosen as 10, leading to a subcarrier spacing and symbol duration of 150KHz and 6.67μs, respectively. This may result in a 0.1ms TTI for low latency use case. In another example, for frequency bands below 6GHz, which includes the current LTE frequency range,

K can be selected by the network to be 2 or 4, and the corresponding subcarrier spacing and symbol duration changed proportional to the selected K value. Alternatively, the same subcarrier spacing and symbol duration can be defined for frequency bands below 6GHz (i.e., K =1), but a shorter TTI can be considered, e.g., with a fewer number of symbols, to support low latency use cases.

[0038] To efficiently support a massive number of MTC devices used in the 5G network, in other embodiments, the subcarrier spacing and symbol duration can be defined as $\Delta f_i = (1/K)*\Delta f$ and $T_i=K*T$. In such embodiments, K can be selected to be 10, and the subcarrier spacing and symbol duration 1.5KHz and 667μs, respectively. In this case, the subframe duration for MTC use cases can be defined to be 10ms, in the current generation LTE systems the length of a typical frame, rather than the typical 1ms. This may reduce the power consumption of MTC UEs by reducing the amount of time the MTC UE is active, thereby increasing the battery life of the MTC UEs.

[0039] A UE may be initially assigned the appropriate RAT by the eNB or other network device (such as the MME). In some embodiments, the UE may be configurable to communicate using any of the RATs, as indicated via the eNB, and can configure the subcarrier spacing and symbol duration accordingly. In some embodiments, the UE may be limited to communicating only using a subset of the RATs, and perhaps only a single RAT, e.g., when the UE is an MTC UE having a limited bandwidth and capabilities. The RAT may depend on the type of UE as well as the operating mode of the UE. For example, some UEs may change mode between a normal mode and an enhanced coverage mode in situations in which the link budget to the nearest serving eNB is worse than a typical link budget value in the network and additional link budget is to be obtained without increasing transmission power. Enhanced coverage mode may be employed by a variety of UEs, including a normal UE (e.g., a smartphone or the like), a machine-to-machine (M2M) UE or a stationary wireless UE (i.e., a UE that remains indefinitely in a single location) using MTC. The UE may determine whether additional link budget is desired, as well as how much additional link budget is desired, and enter an appropriate enhanced coverage mode (that provides the appropriate additional link budget). The different

enhanced coverage modes may correspond to different RATs. Some UEs, such as low cost, low complexity MTC UEs, further may be band limited and operate in a narrow bandwidth of e.g., to 1.4 MHz, for both control and data channels, leading to the ability to operate, e.g., in a single RAT unless the RAT is modified by the network.

[0040] FIG. 3 illustrates one embodiment of a FRAT of a 5G system in accordance with some embodiments. The FRAT 300 may contain one or more partitions in different frequency band regions 310, 320, 330. In one example, the low frequency band 310 may include frequencies used in 4G systems (up to 6 GHz), the mid-frequency band 320 may include higher frequencies (e.g., 6-30 GHz) and the high frequency band 330 may include the highest frequencies in the 5G system (e.g., mmWave, above 30 GHz). Although the RATs of only a low frequency band 310, a mid-frequency band 320, and a high frequency band 330 are shown, any number of RATs of different frequency bands may exist. The various RATs in frequency bands may each have a subcarrier spacing and symbol duration that is independent of the subcarrier spacing and symbol duration of another RAT in another frequency band (i.e., the RATs have configurable numerologies). Moreover, within each frequency band, one or more sub-RATs and partitions 312, 314, 316, 318 may be present with each sub-RAT or partition 312, 314, 316, 318 having a subcarrier spacing and symbol duration independent of the subcarrier spacing and symbol duration of another sub-RAT or partition 312, 314, 316, 318 and independent of the RAT in other frequency bands. As shown in FIG. 3, the sub_RATs 316, 318 in the low frequency band 310 may have the same subcarrier spacing and symbol duration and may be separated by frequency and/or time, while partitions 312, 314 may have different subcarrier spacings and symbol durations from each other and the sub_RATs 316, 318 and may be separated by frequency and/or time. Although the low frequency band 310 is shown as having multiple partitions 312, 314 and sub_RATs 316, 318, the mid frequency band 320 is shown as having two sub_RATs and the high frequency band 330 is shown as having no sub_RATs, the eNB may establish the number and type of RATs used within a particular frequency band differently.

[0041] In some embodiments, RATs and sub-RATs with same or different numerologies can be multiplexed. The multiplexing may be via Time-Division Multiplexing (TDM), Frequency-Division Multiplexing (FDM), code-division multiplex (CDM), spatial division multiplex (SDM), other possible orthogonal or non-orthogonal multiplexing schemes, or any combination thereof. For example, multiple RATs, sub-RATs or partitions with same or different numerologies can be multiplexed in a TDM manner. Each RAT, sub-RAT and partition may have a numerology, access scheme and modulation scheme that is independent of the numerology, access scheme and modulation scheme of the other RATs, sub-RATs and partitions. The numerologies, resource allocation and partition information in the time domain can be predefined or configured by higher layer signaling, e.g. via a Master Information Block (MIB), System Information Block (SIB) or UE-specific dedicated RRC signaling. If a MIB is used to indicate the partition configuration for multiple RATs, sub-RATs or partitions, the resource for the transmission physical broadcast channel (PBCH) used to carry the MIB may be predefined and known at the UEs. In some embodiments, the PBCH may be transmitted in a predetermined RAT, independent of the UE or number of RATs, sub-RATs or partitions supported. Once the UE receives the configuration information via the PBCH on the predetermined RAT, the UE may use a different RAT for further control and data communications; that is, the predetermined RAT and the RAT used by the UE to communicate may be independent.

[0042] In some embodiments, multiple RATs, sub-RATs or partitions with same or different numerologies can be multiplexed in a FDM manner. To minimize the interference between multiple RATs, sub-RATs or partitions with different numerologies, guard bands may be inserted at the edge of frequency resources allocated for the RATs, sub-RATs or partitions. Similar to the above, the numerologies and/or resource partition for multiple RATs, sub-RATs or partitions may be predefined or configured by high layer signaling via a MIB, SIB or UE-specific dedicated RRC signaling.

[0043] In embodiments in which numerologies and/or resource partition for multiple RATs, sub-RATs or partitions is predefined or dedicated carriers are allocated for different RATs, a dedicated downlink synchronization signal and

PBCHs may be transmitted on each RAT, sub-RAT or partition. In embodiments in which the numerologies and/or resource partition for multiple RATs, sub-RATs or partitions is configured using a MIB or SIB, a single MIB or SIB may be transmitted on one of the RAT, sub-RAT or partition. After successfully decoding the MIB or SIB, the UEs may be able to derive the resource information or numerologies for other RATs, sub-RATs or partitions. Thus, information provided from the eNB to the UE via a single transmission in a particular RAT, sub-RAT or partition may enable communications using different RATs, sub-RATs or partitions.

[0044] Particular RATs/sub-RATs/partitions may be used for different types of communications, with each having independently sized resource blocks. For example, as shown, the resources in a first partition 312 may be used for low-latency communications while the resources in a second partition 314 may be used for low energy communications. The first and second partitions 312, 314 may be multiplexed, as shown, using FDM such that the first and second partitions 312, 314 occupy the same time but different frequency resources. The first partition 312 may be associated with low latency communications in which the UE operates in a low latency mode and may have a short symbol duration and TTI, while the second partition 314 may be associated with low energy communications in which the UE operates in a low energy mode and may have a long symbol duration and TTI.

[0045] Other sub-RATs 316, 318 may similarly be FDM multiplexed with the first and second partitions 312, 314 and TDM multiplexed with each other. The sub-RATs 316, 318 may have a symbol duration and TTI between those associated with the first and second partitions 312, 314.

[0046] The RATs 320, 330 for the mid- and high- frequency band may be supported simultaneously with each other and the RAT 310 for low frequency band, while maintaining TTI boundary alignment between the different RATs 310, 320, 330. The RATs 320, 330 may similarly be FDM multiplexed with the first and second partitions 312, 314 and sub-RATs 316, 318. The RATs 320, 330 may have a symbol duration and TTI smaller than those associated with the first partition 312. As shown in FIG. 3, in some embodiments, the amount of temporal and/or frequency resources associated with the different RATs, sub-

RATs and partitions may differ among the different types, and the same type may be associated either with different amounts of temporal and/or frequency resources (e.g., as partitions 312, 314) or the same amount of temporal and/or frequency resources (e.g., as sub-RATs 316, 318). A given frequency and temporal range may be associated with a particular frame and symbol structure (as well as subcarrier spacing and symbol duration), with the frame and symbol structures of the frequency and temporal range independent of the frame and symbol structures of other frequency and temporal ranges.

[0047] FIG. 4 illustrates a unified frame structure in accordance with some embodiments. The unified frame structure contains frames 400, subframes 410, slots 420 and symbols 430. More specifically, each frame 400 may contain L subframes of equal duration and have an overall duration of X ms. Each subframe 410 may similarly comprise N slots of equal duration and have an overall duration of Y ms. Each slot may, in turn, comprise M symbols of equal duration. The slot and symbol durations may be different between subframes of different RATs depending on specific use cases, frequency bands and deployment scenarios. The frame structure of each of RAT may be independent of the frame structure of the other RATs. Thus, a particular RAT may have one or more of different L, N and/or M values, as well as different X and/or Y values, as the other RATs. This may also apply to the sub-RATs and partitions shown in FIG. 3.

[0048] FIG. 5 illustrates a Transmission Time Interval (TTI) boundary alignment in accordance with some embodiments. In some embodiments of the unified frame structure, it may be beneficial from a simplified design standpoint to periodically align the TTI boundary 530 between different RATs 510, 520, e.g., at a particular subframe or frame boundary after a predetermined number of subframes or frames. Thus, in some embodiments an integral number of TTIs 540 of a RAT 510 having a smaller TTI duration (low latency RAT) may be disposed within a single TTI 550 of a RAT 520 having a larger TTI duration. In the example shown in FIG. 5, the smaller TTI duration RAT 510 may have a TTI 540 of 0.1ms while the larger TTI RAT 520 may have a TTI 550 of 1ms. By implementing a TTI of 1ms, a low latency RAT TTI may align with the existing LTE specification TTI boundary. Having a common TTI boundary may support

cross-carrier/RAT scheduling for high frequency band RATs from low frequency band RATs based an anchor booster architecture. This is to say that, in some embodiments for cross-carrier/RAT scheduling, as shown a common PDCCH may be used to schedule other RATs, with the UE switching to a particular RAT to obtain the scheduling and then switching to another RAT to communicate and perhaps to obtain further scheduling information using that RAT. In some embodiments, the other RAT may contain a PDCCH for additional scheduling, while in other embodiments the other RAT may not contain a PDCCH, in which case the UE may periodically switch to the scheduling RAT to obtain scheduling information for the other RAT. In some embodiments, a UE may obtain initial scheduling information (e.g., when it initially powers on or otherwise accesses the eNB) from the initial RAT (e.g., a conventional 4G system RAT) and from then on, after switching to its assigned RAT, obtains scheduling information using that RAT. In other embodiments, each RAT may contain a PDCCH and scheduling is performed for the UE operating on the RAT. A licensed low frequency band RAT may provide reliable coverage for control signaling as an anchor cell, using the PDCCH shown in FIG. 5, while a high frequency band RAT may provide opportunistic boosting in data rate when channel conditions are favorable as booster cell.

[0049] FIG. 6 illustrates a symbol structure in accordance with some embodiments. FIG. 6 shows an OFDM symbol 610 and a unique word (UW) OFDM symbol 620. Each OFDM symbol 610 may contain a cyclic prefix (CP) 612 that comprises a replication of the initial portion of the OFDM symbol 610. The CP 612 may range in size from 1/4 to 1/32 of the symbol period 614. The CP 612 may be disposed at the end of the symbol or outside the symbol, depending on specific waveform, thereby creating a guard between the symbol and the adjacent symbol. In some embodiments, when OFDM downlink and SC-FDMA uplink waveforms are selected for a 5G RAT, the CP 612 may be inserted outside the symbol 610. In embodiments in which a UW OFDM symbol 620 or UW Discrete Fourier transform-Spread-Orthogonal Frequency Division Multiplexing (UW-DFT-s-OFDM) symbol is used, the UW 622 may be inserted within one symbol duration 624. The symbol structure may be independent for each of the RATs, such that whether or not a particular RAT a

CP or UW and whether the CP or UW is outside or within a symbol is independent of the symbol structure of any other RAT.

[0050] As shown in FIG. 6, the UW-OFDM 620 may be used to support different UW lengths based on different channel delay spreads while maintaining the same symbol duration (or FFT size). This enables both shorter UW 622 and longer UW 626 to be used in the same size symbol 624 as the UW 622, 624 is inserted within the FFT instead of being adding after the FFT size. The ability to maintain the same symbol duration may provide a greater flexibility to support a unified RAT design. In one example, using an OFDM symbol for a low frequency band (below 6GHz), a subcarrier spacing of 60KHz (i.e., K = 4, Δf =60KHz) may be used to achieve a 0.1ms TTI. This translates to OFDM symbols of T=16.7μs (66.7μs/K). Thus, 5 OFDM symbols may be able to be accommodated within one subframe (83.5μs) with a CP length of approximately 3.3μs (0.1ms - 83.5μs =16.5μs/5 CPs).

[0051] FIG. 7 illustrates frame structures within a TTI in accordance with some embodiments. In FIG. 7, various TTIs 710, 720, 730, 740 are illustrated in which the TTIs 710, 720, 730, 740 comprise UW-OFDM waveforms. The first TTI 710 shown in FIG. 7 may comprise a UW 712 and symbol 714 of typical length. In this example, the subcarrier spacing may be 15KHz and the symbol duration 716 may be 66.7μs. A total of 3 OFDM symbols 716 may be present in a TTI 710 of 200μs.

[0052] The second TTI 720 shown in FIG. 7 may comprise a low latency TTI 720 with short symbol duration. Such a TTI 720 can be used for use cases such as mission critical MTC applications and Vehicle–to-Vehicle applications, among others. The UW 722 and symbol 724 may each be smaller than the first TTI 710. In this example, the subcarrier spacing may be 30KHz and the symbol duration 726 may be 33.3μs. For a TTI 720 of the same length as the first TTI (e.g., 200μs), a total of 6 short OFDM symbols 726 may be present.

[0053] The third TTI 730 shown in FIG. 7 may comprise another low latency TTI 730 similar to the low latency TTI 720. The UW 732 and symbol 734 may each be smaller than the first TTI 710, the subcarrier spacing may be 30KHz and the symbol duration 736 may be 33.3μs. However, in this example

the TTI 730 may only be half the length as the first TTI (i.e., 100μs), corresponding to a total of 3 short OFDM symbols 736.

[0054] The fourth TTI 740 shown in FIG. 7 may comprise a low energy TTI 740, e.g., for use by MTC UEs. The UW 742 and symbol 744 may each have a longer duration smaller than the first TTI 710. In one example, the subcarrier spacing may be 5KHz and the symbol duration 746 may be 200μs. In this example, the TTI 740 may be 1ms, corresponding to a total of 5 long OFDM symbols 746.

[0055] The above TTIs 710, 720, 730, 740 may be FDM or TDM multiplexed based on the FRAT design. One or more of the UW-OFDM waveforms may be replaced by other waveforms so long as the same symbol duration is maintained. Other examples of OFDM waveforms may include ZT-OFDM and UW-DFTs-OFDM, among others. When different waveforms are used in the same carrier, multi-RATs can be supported where each RAT may have different waveform design. In some embodiments, existing LTE waveforms may be reused, i.e., OFDM waveforms may be used for downlink and SC-FDMA waveforms may be used for uplink communications. In some embodiments, OFDM may be used both downlink and uplink communications. In some embodiments, UW-based waveforms may be used both downlink and uplink communications. For example, UW-OFDM waveforms may be used for downlink communications and UW-DFT-s-OFDM waveforms may be used for uplink communications or either UW-OFDM or UW-DFT-s-OFDM waveforms may be used for both downlink and uplink communications. In some embodiment, filtered OFDM and filter-bank multiple carrier (FBMC) may be used. FBMC waveforms are produced using a nonrectangular sub-channel pulse shape in the time domain during OFDM-offset quadrature amplitude modulation (OQAM) transmission (in which the real part of QAM symbols are mapped to ½ of the multi-carrier symbols and the imaginary parts are mapped to an interlaced 1/2 of the multi-carrier symbols) and may lack a CP.

[0056] Tables 1-3 below illustrate various examples of 5G numerology.

Frequency Band	Subcarrier spacing	TTI	DL waveform	UL waveform

<3GHz (low power or MTC)	1.5KHz	10ms	OFDM	SC-FDMA
<3GHz	15KHz	1ms	OFDM	SC-FDMA
[3-6]GHz	75KHz	0.2ms	UW-OFDM	UW-DFT-s-OFDM
[6-30]GHz	480KHz	0.1ms	UW-OFDM	UW-DFT-s-OFDM
>30GHz	1.5MHz	0.1ms	DFT-s-OFDM	DFT-s-OFDM

Table 1: First 5G numerology example

Frequency Band	Subcarrier spacing	TTI	DL waveform	UL waveform
<3GHz (low power or MTC)	1.5KHz	10ms	UW-OFDM	UW-OFDM
<3GHz	15KHz	1ms	UW-OFDM	UW-OFDM
[3-6]GHz	75KHz	0.2ms	UW-OFDM	UW-OFDM
[6-30]GHz	480KHz	0.1ms	UW-DFT-s-OFDM	UW-DFT-s-OFDM
>30GHz	1.5MHz	0.1ms	OFDM	OFDM

Table 2: Second 5G numerology example

Frequency Band	Subcarrier spacing	TTI	DL waveform	UL waveform
<3GHz (low power or MTC)	1.5KHz	10ms	OFDM	OFDM
<3GHz	15KHz	1ms	OFDM	OFDM
[3,6]GHz	75KHz	0.2ms	OFDM	OFDM
[6,30]GHz	480KHz	0.1ms	UW-DFT-s-OFDM	UW-DFT-s-OFDM
>30GHz	1.5MHz	0.1ms	UW-DFT-s-OFDM	UW-DFT-s-OFDM

Table 3: Third 5G numerology example

[0057] FIGS. 8A and 8B illustrate flowcharts of a uniform framework utilization method in accordance with some embodiments. FIG. 8A in particular illustrates a flowchart of a uniform framework utilization method of an eNB such as the eNB shown in FIGS. 1 or 2 in accordance with some embodiments. As shown in FIG. 8A, the eNB may determine the unified framework at operation 802. The unified framework may include access scheme, modulation

scheme, frame structure, symbol structure, and configurable numerology including subcarrier spacing and symbol duration. The different frame and symbol structures may be associated with different temporal and/or frequency resources multiplexed respectively in a TDM or FDM manner.

[0058] At operation 804, the eNB may communicate specific unified framework configuration information of a particular RAT to one or more UEs serviced by the eNB. Different RAT information may be provided to different UEs attached to the eNB, in which different RATs may be associated with different frequency bands and/or time spans. The eNB may determine the configuration information to be provided to a particular UE based on the device type and/or data to be communicated between the UE and the eNB. The frequency bands may include both licensed and unlicensed frequency bands. The RAT information may include access and modulation scheme, frame and symbol structure, as well as numerology. The RAT information may also include resource allocation and partition information. The unified framework configuration information provided to each UE may be independent of the unified framework configuration information provided to any other UE. The RAT indicated by the eNB to the UE may be dependent on the type and/or operating mode of the UE.

[0059] The eNB may communicate with the UE at operation 806 using the RAT provided at operation 804. The information may include data and/or control information. For example, downlink communications from the eNB to the UE may include paging or control signals for channel estimation on the PDCCH and voice or video data from another UE on the PDSCH. The RAT information may be provided using a dedicated RAT that is different from the RAT used for communication with the UE or using a dedicated carrier on the RAT used for communication with the UE.

[0060] The eNB may, subsequent to communicating with the UE, receive an indication from the UE of a change of operating state of the UE at operation 808. The UE may, for example, be configured to operate in one or more of a normal mode, a low latency and low energy mode. The eNB may, at operation 804, assign the RAT to the UE based on the initial mode of the UE and

determine that an update of the operation mode of the UE has occurred at operation 808.

[0061] In response to determining at operation 808 that an update of the operation mode of the UE has occurred, the eNB may determine a new RAT and transmit the updated unified framework configuration information of the new RAT to the UE at operation 810. The new RAT may include a different frame and/or symbol structure and use a different frequency spectrum and/or time range. The eNB may then continue to communicate with the UE at operation 806.

[0062] FIG. 8B illustrates a uniform framework utilization method as performed by a UE in accordance with some embodiments. The UE may be the UE shown in FIGS. 1 or 2 and may attach to the eNB prior to communicating data. During the attachment, the UE may transmit the initial operation conditions to the eNB at operation 812. In particular, the UE may provide a UE type and/or operating mode during attachment. For example, the UE may be a MTC UE. The UE may moreover be configured to operate in a low latency and/or low energy mode. In some embodiments, a MTC UE may operate in an enhanced coverage, low energy mode.

[0063] In response to transmitting the operating conditions, unified framework configuration (RAT) information may be received by a particular UE at operation 814. The RAT information may be dependent on the type and/or operating mode of the UE. The RAT may be associated with a particular frequency band and/or time range. For example, when the UE operates in the low latency mode, a larger subcarrier spacing and shorter symbol duration may be indicated by the unified framework configuration information; while when the UE operates in the low energy mode, a smaller subcarrier spacing and longer symbol duration may be indicated by the unified framework configuration information.

[0064] Once the RAT received by the UE, the UE may then communicate using the RAT at operation 816. The UE may, for example, adjust FFT operating conditions and processing to meet the RAT information provided at operation 814. The UE may communicate with the eNB or may communicate directly with other UEs using device-to-device communication (D2D)

communication. The information may include uplink and downlink data and/or control information. For example, the information may include uplink communications of voice or video data for another UE or measurements of control signals for channel estimation.

[0065] The UE may, subsequent to communicating with the eNB, determine that a change of operating conditions is warranted at operation 818. For example, the UE may transition between the normal and enhanced coverage/low energy mode dependent on UE location, or between the normal and low latency mode dependent on the type of communication to transmit.

[0066] In response to determining that a change of operating conditions is warranted at operation 818, at operation 820 the UE may transmit an indication to the eNB indicating the change of operating state of the UE. The UE may instead determine that a change of operating conditions is desired at operation 820 and wait to change operating state until a new RAT is assigned to the UE.

[0067] In response to transmitting the indication at operation 820, the UE may return to operation 814 and receive a new RAT at operation 810. The new RAT may include a different frame and/or symbol structure and use a different frequency spectrum and/or time range. The eNB may then continue to communicate with the UE at operation 816.

[0068] Various examples of the disclosure are provided below. These examples are not intended to in any way limit the disclosure herein. In Example 1, user equipment (UE) may comprise processing circuitry configured to: configure a transceiver to receive a resource allocation from a network using a first Radio Access Technology (RAT), the first RAT selected from a plurality of RATs of a flexible RAT (FRAT) employed by the network, the plurality of RATs of the FRAT each comprising configurable numerology with flexible subcarrier spacing and symbol duration and associated with at least one of different temporal and frequency resources, the transceiver configurable to communicate using the plurality of RATs and configure the subcarrier spacing and symbol duration based on the numerology; and configure the transceiver to communicate using the first RAT.

[0069] In Example 2, the subject matter of Example 1 can optionally include that the processing circuitry is further configured to configure the transceiver to receive from an enhanced NodeB (eNB) higher layer signaling associated with the FRAT, the higher layer signaling indicating numerologies, resource allocation and partition information in at least one of a time and frequency domain.

[0070] In Example 3, the subject matter of one or any combination of Examples 1-2 can optionally include that the FRAT comprises a base subcarrier spacing and symbol duration, and at least one of the subcarrier spacing and symbol duration for different RATs of the FRAT is respectively specified as an integer number of the base subcarrier spacing or symbol duration.

[0071] In Example 4, the subject matter of one or any combination of Examples 1-3 can optionally include that the UE is a Machine-Type Communication (MTC) UE configured to operate in at least one of a low latency and low energy mode, and the first RAT comprises a larger subcarrier spacing and shorter symbol duration when the UE operates in the low latency mode and comprises a smaller subcarrier spacing and longer symbol duration when the UE operates in the low energy mode.

[0072] In Example 5, the subject matter of one or any combination of Examples 1-4 can optionally include that at least one of the plurality of RATs of the FRAT comprises at least one of a plurality of sub-RATs and partitions, each of the at least one of the plurality of sub-RATs and partitions comprising an independent configurable numerology with flexible subcarrier spacing and symbol duration and associated with at least one of different temporal and frequency resource, and the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are combined using at least one of a Time-Division Multiplexing (TDM), Frequency-Division Multiplexing (FDM), Code-Division Multiplexing (CDM), and Spatial Division Multiplexing (SDM).

[0073] In Example 6, the subject matter of one or any combination of Examples 1-6 can optionally include that the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are combined using TDM, and numerologies, resource allocation and partition information in a time domain are at least one of predefined or configured by higher-layer signaling via Master

Information Block (MIB), System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling, or the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are combined using FDM, guard bands are inserted at an edge of frequency resources allocated for the plurality of RATs and the at least one of the plurality of sub-RATs and partitions, and at least one of numerologies and resource partition for the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are at least one of predefined or configured by the higher-layer signaling.

[0074] In Example 7, the subject matter of one or any combination of Examples 1-6 can optionally include that a Transmission Time Interval (TTI) boundary between different RATs of the plurality of RATs is common, and the plurality of RATs comprise a common reference TTI duration.

[0075] In Example 8, the subject matter of one or any combination of Examples 1-7 can optionally include that a symbol structure of each of the plurality of RATs comprises a cyclic prefix (CP) or unique word (UW) outside or within a symbol, and the symbol structure of each of the plurality of RATs is independent of the symbol structure of the other RATs. ‘

[0076] In Example 9, the subject matter of one or any combination of Examples 1-8 can optionally include that the processing circuitry is further configured to configure the transceiver to communicate using Orthogonal Frequency-Division Multiplexing (OFDM) for downlink communications and one of Single Carrier Frequency-Division Multiple Access (SC-FDMA) and OFDM for uplink communications, and configure the transceiver to communicate using at least one of UW-OFDM and UW Discrete Fourier transform-Spread-Orthogonal Frequency Division Multiplexing (UW-DFT-s-OFDM).

[0077] In Example 10, the subject matter of one or any combination of Examples 1-9 can optionally include that a frame structure in each of the plurality of RATs comprises a frame comprising L subframes, each subframe comprising N slots, each slot comprising M symbols, and the frame structure of each of the plurality of RATs is independent of the frame structure of the other RATs.

[0078] In Example 11, the subject matter of one or any combination of Examples 1-10 can optionally include that the processing circuitry is further configured to configure the transceiver to receive numerologies, resource allocation and partition information via Master Information Block (MIB) carried by a physical broadcast channel (PBCH), a System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling in a second RAT, the first and second RATs being different.

[0079] In Example 12, the subject matter of one or any combination of Examples 1-11 can optionally include that the processing circuitry is configured to configure the transceiver to receive numerologies, resource allocation and partition information via a dedicated carrier in the first RAT, a dedicated carrier allocated for each of the plurality of RATs, and a dedicated downlink synchronization signal and physical broadcast channel (PBCH) is able to be received on each of the plurality of RATs.

[0080] In Example 13, the subject matter of one or any combination of Examples 1-12 can optionally include an antenna configured to transmit and receive communications between the transceiver and the eNB.

[0081] Example 14 comprises an apparatus of an eNode B (eNB) comprising processing circuitry configured to: configure a transceiver to transmit resource allocations for different Radio Access Technologies (RATs) to a plurality of user equipment (UE), at least two of the UEs associated with a different RAT, each RAT comprising an independent subcarrier spacing, symbol duration, frame structure and symbol structure; and configure the transceiver to communicate with each UE using the RAT associated with the UE.

[0082] In Example 15, the subject matter of Example 14 can optionally include that the processing circuitry is configured to configure the transceiver to transmit higher layer signaling indicating numerologies, resource allocation and partition information via Master Information Block (MIB) carried by a physical broadcast channel (PBCH), a System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling in a same RAT to each of the plurality of UEs.

[0083] In Example 16, the subject matter of one or any combination of Examples 14-15 can optionally include that the processing circuitry is

configured to configure the transceiver to transmit numerologies, resource allocation and partition information via a dedicated carrier allocated for each of the RATs, and a dedicated downlink synchronization signal and physical broadcast channel (PBCH) is able to be received on each of the RATs.

[0084] In Example 17, the subject matter of one or any combination of Examples 14-16 can optionally include that at least one of the subcarrier spacing and symbol duration for each of the RATs is respectively specified as an integer number of a base subcarrier spacing or symbol duration.

[0085] In Example 18, the subject matter of one or any combination of Examples 14-17 can optionally include that the RATs comprise a first RAT comprising a larger subcarrier spacing and shorter symbol duration configured for a UE operating in a low latency mode and a second RAT comprising a smaller subcarrier spacing and longer symbol duration configured for a UE operating in a low energy mode.

[0086] In Example 19, the subject matter of one or any combination of Examples 14-18 can optionally include that a Transmission Time Interval (TTI) boundary between the RATs is common, and the RATs comprise a common reference TTI duration.

[0087] In Example 20, the subject matter of one or any combination of Examples 14-19 can optionally include that a symbol structure of each of the RATs comprises a cyclic prefix (CP) or unique word (UW) outside or within a symbol, and the symbol structure of each of the RATs is independent of the symbol structure of the other RATs.

[0088] In Example 21, the subject matter of one or any combination of Examples 14-20 can optionally include that the processing circuitry is configured to at least one of: configure the transceiver to communicate using Orthogonal Frequency-Division Multiplexing (OFDM) for downlink communications and one of Single Carrier Frequency-Division Multiple Access (SC-FDMA) and OFDM for uplink communications, and configure the transceiver to communicate using at least one of UW-OFDM and UW Discrete Fourier transform-Spread-Orthogonal Frequency Division Multiplexing (UW-DFT-s-OFDM).

[0089] In Example 22 a non-transitory computer-readable storage medium that stores instructions for execution by one or more processors of a user equipment (UE) to configure the UE to communicate with an enhanced Node B (eNB), the one or more processors to configure the UE to: receive resource allocation, partition information and numerology, including subcarrier spacing and symbol duration, for a first Radio Access Technology (RAT) of a plurality of RATs used by the eNB, the UE configurable to configure the subcarrier spacing and symbol duration based on the numerology and to communicate using the plurality of RATs; and communicate using the first RAT.

[0090] In Example 23, the subject matter of Example 22 can optionally include that at least one of: a) at least one of the subcarrier spacing and symbol duration for the RATs is respectively specified as an integer number of a base subcarrier spacing or symbol duration, b) the UE is configured to operate in at least one of a low latency and low energy mode, and the first RAT comprises a larger subcarrier spacing and shorter symbol duration when the UE operates in the low latency mode and comprises a smaller subcarrier spacing and longer symbol duration when the UE operates in the low energy mode, and c) a Transmission Time Interval (TTI) boundary between the RATs is common, and the RATs comprise a common reference TTI duration.

[0091] In Example 24, the subject matter of one or any combination of Examples 22-23 can optionally include that at least one of: a) a symbol structure of each of the RATs comprises a cyclic prefix (CP) or unique word (UW) outside or within a symbol, and the symbol structure of each of the RATs is independent of the symbol structure of the other RATs, and b) a frame structure in each of the RATs comprises a frame comprising L subframes, each subframe comprising N slots, each slot comprising M symbols, and the frame structure of each of the RATs is independent of the frame structure of the other RATs.

[0092] In Example 25, the subject matter of one or any combination of Examples 22-24 can optionally include that the numerology, resource allocation and partition information is received via Master Information Block (MIB) carried by a physical broadcast channel (PBCH), a System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling in a second RAT, the first and second RATs being different.

[0093] Although an embodiment has been described with reference to specific example embodiments, it will be evident that various modifications and changes may be made to these embodiments without departing from the broader spirit and scope of the present disclosure. Accordingly, the specification and drawings are to be regarded in an illustrative rather than a restrictive sense. The accompanying drawings that form a part hereof show, by way of illustration, and not of limitation, specific embodiments in which the subject matter may be practiced. The embodiments illustrated are described in sufficient detail to enable those skilled in the art to practice the teachings disclosed herein. Other embodiments may be utilized and derived therefrom, such that structural and logical substitutions and changes may be made without departing from the scope of this disclosure. This Detailed Description, therefore, is not to be taken in a limiting sense, and the scope of various embodiments is defined only by the appended claims, along with the full range of equivalents to which such claims are entitled.

[0094] Such embodiments of the inventive subject matter may be referred to herein, individually and/or collectively, by the term “invention” merely for convenience and without intending to voluntarily limit the scope of this application to any single invention or inventive concept if more than one is in fact disclosed. Thus, although specific embodiments have been illustrated and described herein, it should be appreciated that any arrangement calculated to achieve the same purpose may be substituted for the specific embodiments shown. This disclosure is intended to cover any and all adaptations or variations of various embodiments. Combinations of the above embodiments, and other embodiments not specifically described herein, will be apparent to those of skill in the art upon reviewing the above description.

[0095] In this document, the terms "a" or "an" are used, as is common in patent documents, to include one or more than one, independent of any other instances or usages of "at least one" or "one or more." In this document, the term "or" is used to refer to a nonexclusive or, such that "A or B" includes "A but not B," "B but not A," and "A and B," unless otherwise indicated. In this document, the terms "including" and "in which" are used as the plain-English equivalents of the respective terms "comprising" and "wherein." Also, in the following claims, the

terms "including" and "comprising" are open-ended, that is, a system, UE, article, composition, formulation, or process that includes elements in addition to those listed after such a term in a claim are still deemed to fall within the scope of that claim. Moreover, in the following claims, the terms "first," "second," and "third," etc. are used merely as labels, and are not intended to impose numerical requirements on their objects.

[0096] The Abstract of the Disclosure is provided to comply with 37 C.F.R. §1.72(b), requiring an abstract that will allow the reader to quickly ascertain the nature of the technical disclosure. It is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims. In addition, in the foregoing Detailed Description, it can be seen that various features are grouped together in a single embodiment for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted as reflecting an intention that the claimed embodiments require more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive subject matter lies in less than all features of a single disclosed embodiment. Thus the following claims are hereby incorporated into the Detailed Description, with each claim standing on its own as a separate embodiment.

CLAIMS

What is claimed is:

1. User equipment (UE) comprising:

processing circuitry configured to:

configure a transceiver to receive a resource allocation from a network using a first Radio Access Technology (RAT), the first RAT selected from a plurality of RATs of a flexible RAT (FRAT) employed by the network, the plurality of RATs of the FRAT each comprising configurable numerology with flexible subcarrier spacing and symbol duration and associated with at least one of different temporal and frequency resources, the transceiver configurable to communicate using the plurality of RATs and configure the subcarrier spacing and symbol duration based on the numerology; and

configure the transceiver to communicate using the first RAT.

2. The UE of claim 1, wherein the processing circuitry is configured to:

configure the transceiver to receive from an enhanced NodeB (eNB) higher layer signaling associated with the FRAT, the higher layer signaling indicating numerologies, resource allocation and partition information in at least one of a time and frequency domain.

3. The UE of claim 1, wherein:

the FRAT comprises a base subcarrier spacing and symbol duration, and

at least one of the subcarrier spacing and symbol duration for different RATs of the FRAT is respectively specified as an integer number of the base subcarrier spacing or symbol duration.

4. The UE of claim 3, wherein:

the UE is a Machine-Type Communication (MTC) UE configured to operate in at least one of a low latency and low energy mode, and

the first RAT comprises a larger subcarrier spacing and shorter symbol duration when the UE operates in the low latency mode and comprises a smaller

subcarrier spacing and longer symbol duration when the UE operates in the low energy mode.

5. The UE of claim 1, wherein:

at least one of the plurality of RATs of the FRAT comprises at least one of a plurality of sub-RATs and partitions, each of the at least one of the plurality of sub-RATs and partitions comprising an independent configurable numerology with flexible subcarrier spacing and symbol duration and associated with at least one of different temporal and frequency resource, and

the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are combined using at least one of a Time-Division Multiplexing (TDM), Frequency-Division Multiplexing (FDM), Code-Division Multiplexing (CDM), and Spatial Division Multiplexing (SDM).

6. The UE of claim 5, wherein one of:

the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are combined using TDM, and numerologies, resource allocation and partition information in a time domain are at least one of predefined or configured by higher-layer signaling via Master Information Block (MIB), System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling, or

the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are combined using FDM, guard bands are inserted at an edge of frequency resources allocated for the plurality of RATs and the at least one of the plurality of sub-RATs and partitions, and at least one of numerologies and resource partition for the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are at least one of predefined or configured by the higher -layer signaling.

7. The UE of claim 1, wherein:

a Transmission Time Interval (TTI) boundary between different RATs of the plurality of RATs is common, and

the plurality of RATs comprise a common reference TTI duration.

8. The UE of claim 1, wherein:

a symbol structure of each of the plurality of RATs comprises a cyclic prefix (CP) or unique word (UW) outside or within a symbol, and

the symbol structure of each of the plurality of RATs is independent of the symbol structure of the other RATs.

9. The UE of claim 1, wherein the processing circuitry is configured to at least one of:

configure the transceiver to communicate using Orthogonal Frequency-Division Multiplexing (OFDM) for downlink communications and one of Single Carrier Frequency-Division Multiple Access (SC-FDMA) and OFDM for uplink communications, and

configure the transceiver to communicate using at least one of UW-OFDM and UW Discrete Fourier transform-Spread-Orthogonal Frequency Division Multiplexing (UW-DFT-s-OFDM).

10. The UE of claim 1, wherein:

a frame structure in each of the plurality of RATs comprises a frame comprising L subframes, each subframe comprising N slots, each slot comprising M symbols, and

the frame structure of each of the plurality of RATs is independent of the frame structure of the other RATs.

11. The UE of claim 1, wherein the processing circuitry is configured to:

configure the transceiver to receive numerologies, resource allocation and partition information via Master Information Block (MIB) carried by a physical broadcast channel (PBCH), a System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling in a second RAT, the first and second RATs being different.

12. The UE of claim 1, wherein:

the processing circuitry is configured to configure the transceiver to receive numerologies, resource allocation and partition information via a dedicated carrier in the first RAT, a dedicated carrier allocated for each of the plurality of RATs, and

a dedicated downlink synchronization signal and physical broadcast channel (PBCH) is able to be received on each of the plurality of RATs.

13. The UE of claim 1, further comprising an antenna configured to transmit and receive communications between the transceiver and the eNB.

14. An apparatus of an eNode B (eNB) comprising:

processing circuitry configured to:

configure a transceiver to transmit resource allocations for different Radio Access Technologies (RATs) to a plurality of user equipment (UE), at least two of the UEs associated with a different RAT, each RAT comprising an independent subcarrier spacing, symbol duration, frame structure and symbol structure; and

configure the transceiver to communicate with each UE using the RAT associated with the UE.

15. The apparatus of claim 14, wherein the processing circuitry is configured to:

configure the transceiver to transmit higher layer signaling indicating numerologies, resource allocation and partition information via Master Information Block (MIB) carried by a physical broadcast channel (PBCH), a System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling in a same RAT to each of the plurality of UEs.

16. The apparatus of claim 14, wherein the processing circuitry is configured to:

configure the transceiver to transmit numerologies, resource allocation and partition information via a dedicated carrier allocated for each of the RATs, and

a dedicated downlink synchronization signal and physical broadcast channel (PBCH) is able to be received on each of the RATs.

17. The apparatus of claim 14, wherein:

at least one of the subcarrier spacing and symbol duration for each of the RATs is respectively specified as an integer number of a base subcarrier spacing or symbol duration.

18. The apparatus of claim 14, wherein:

the RATs comprise a first RAT comprising a larger subcarrier spacing and shorter symbol duration configured for a UE operating in a low latency mode and a second RAT comprising a smaller subcarrier spacing and longer symbol duration configured for a UE operating in a low energy mode.

19. The apparatus of claim 14, wherein:

a Transmission Time Interval (TTI) boundary between the RATs is common, and

the RATs comprise a common reference TTI duration.

20. The apparatus of claim 14, wherein:

a symbol structure of each of the RATs comprises a cyclic prefix (CP) or unique word (UW) outside or within a symbol, and

the symbol structure of each of the RATs is independent of the symbol structure of the other RATs.

21. The apparatus of claim 14, wherein the processing circuitry is configured to at least one of:

configure the transceiver to communicate using Orthogonal Frequency-Division Multiplexing (OFDM) for downlink communications and one of Single Carrier Frequency-Division Multiple Access (SC-FDMA) and OFDM for uplink communications, and

configure the transceiver to communicate using at least one of UW-OFDM and UW Discrete Fourier transform-Spread-Orthogonal Frequency Division Multiplexing (UW-DFT-s-OFDM).

22. A non-transitory computer-readable storage medium that stores instructions for execution by one or more processors of a user equipment (UE) to configure the UE to communicate with an enhanced Node B (eNB), the one or more processors to configure the UE to:

receive resource allocation, partition information and numerology, including subcarrier spacing and symbol duration, for a first Radio Access Technology (RAT) of a plurality of RATs used by the eNB, the UE configurable to configure the subcarrier spacing and symbol duration based on the numerology and to communicate using the plurality of RATs; and

communicate using the first RAT.

23. The medium of claim 22, wherein at least one of:

a) at least one of the subcarrier spacing and symbol duration for the RATs is respectively specified as an integer number of a base subcarrier spacing or symbol duration,

b) the UE is configured to operate in at least one of a low latency and low energy mode, and

the first RAT comprises a larger subcarrier spacing and shorter symbol duration when the UE operates in the low latency mode and comprises a smaller subcarrier spacing and longer symbol duration when the UE operates in the low energy mode, and

c) a Transmission Time Interval (TTI) boundary between the RATs is common, and

the RATs comprise a common reference TTI duration.

24. The medium of claim 22, wherein at least one of:

a) a symbol structure of each of the RATs comprises a cyclic prefix (CP) or unique word (UW) outside or within a symbol, and

the symbol structure of each of the RATs is independent of the symbol structure of the other RATs, and

b) a frame structure in each of the RATs comprises a frame comprising L subframes, each subframe comprising N slots, each slot comprising M symbols, and

the frame structure of each of the RATs is independent of the frame structure of the other RATs.

25. The medium of claim 22, wherein:

the numerology, resource allocation and partition information is received via Master Information Block (MIB) carried by a physical broadcast channel (PBCH), a System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling in a second RAT, the first and second RATs being different.

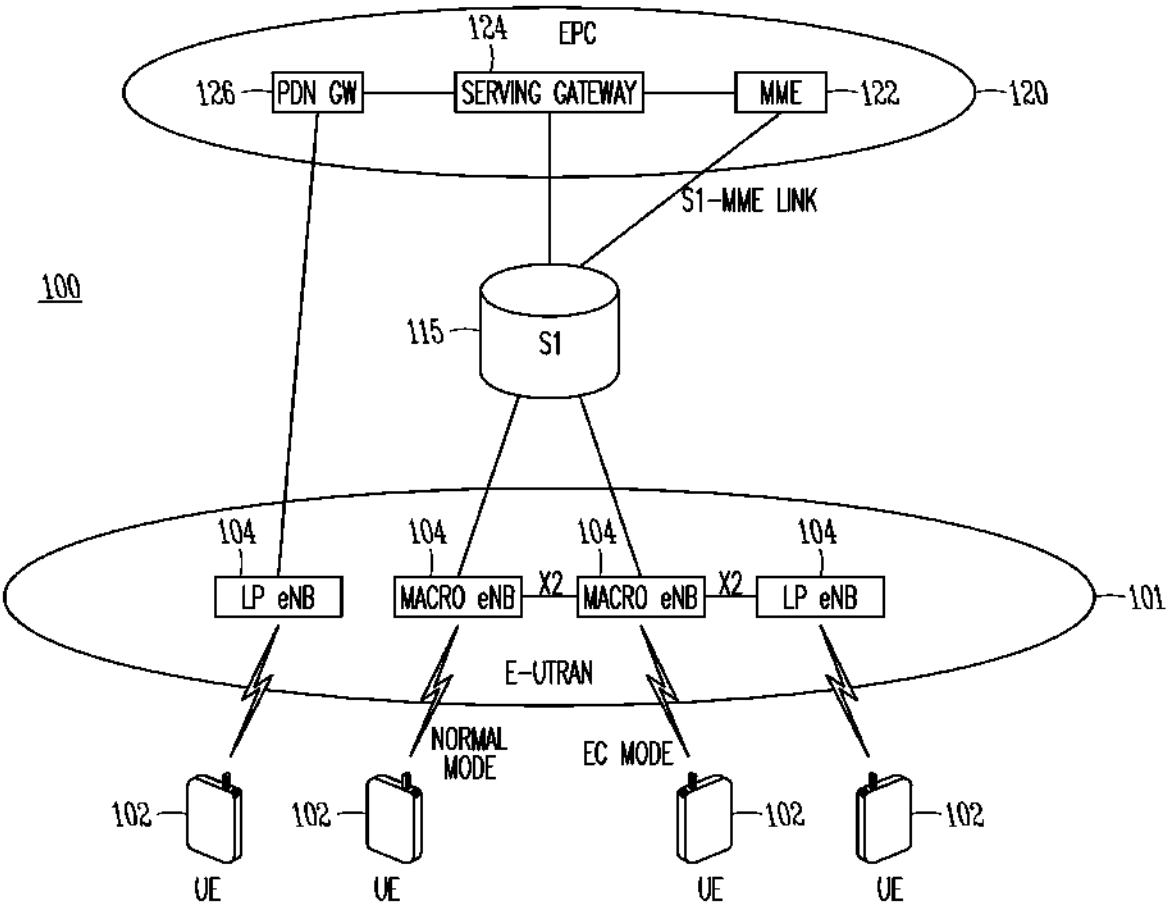

124
EPC
126
PDN GW
SERVING GATEWAY
MME
122
120
S1-MME LINK
100
115
S1
104
104
104
104
LP eNB
MACRO eNB
X2
MACRO eNB
X2
LP eNB
101
E-UTRAN
NORMAL MODE
EC MODE
102
102
102
102
UE
UE
UE
UE

FIG. 1

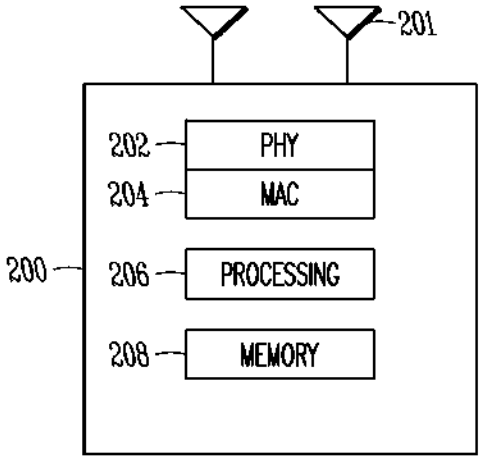


FIG. 2

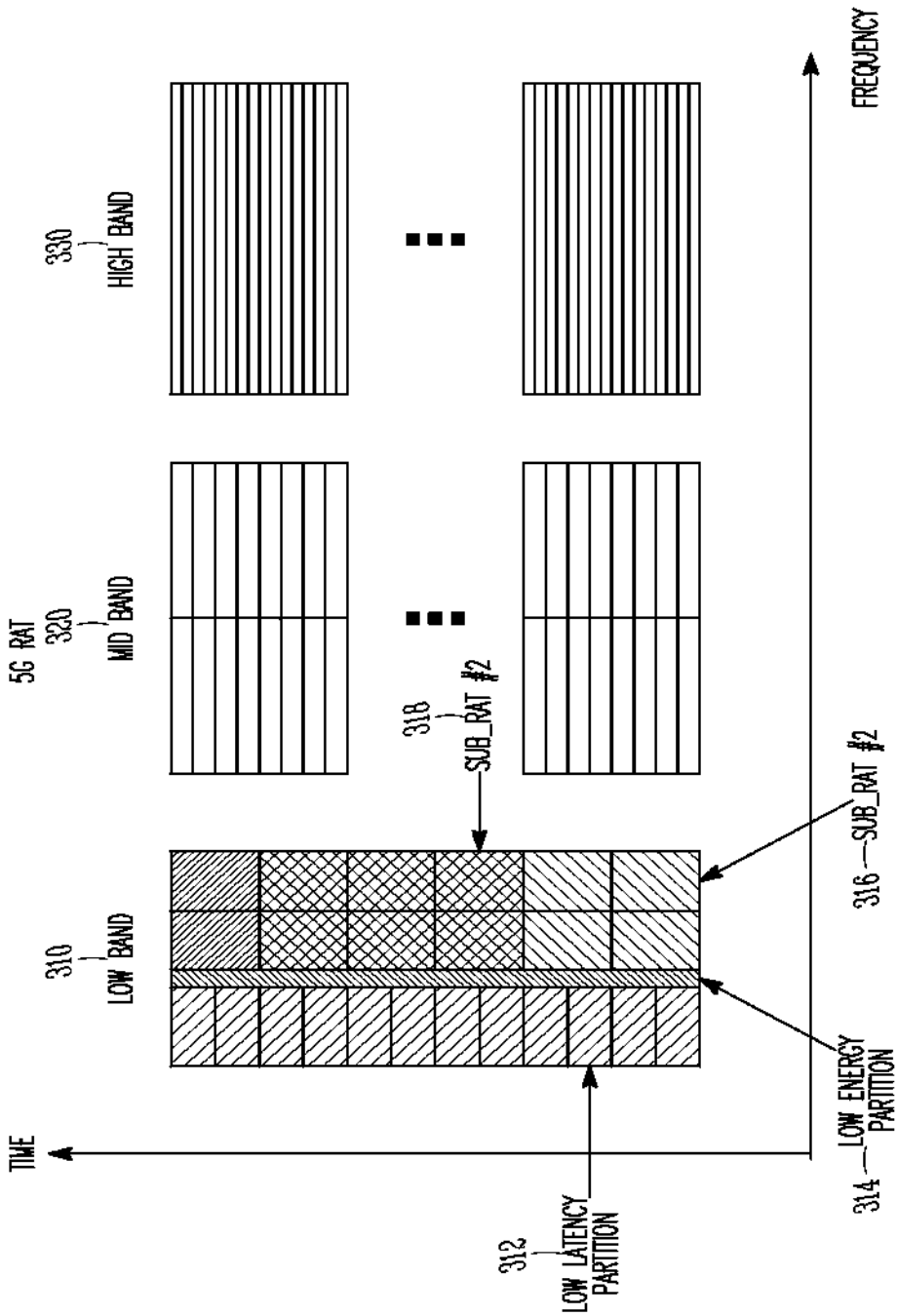

FREQUENCY
330
HIGH BAND
5G RAT
320
MID BAND
318
SUB_RAT #2
310
LOW BAND
316
SUB_RAT #2
TIME
314
LOW ENERGY PARTITION
312
LOW LATENCY PARTITION

FIG. 3

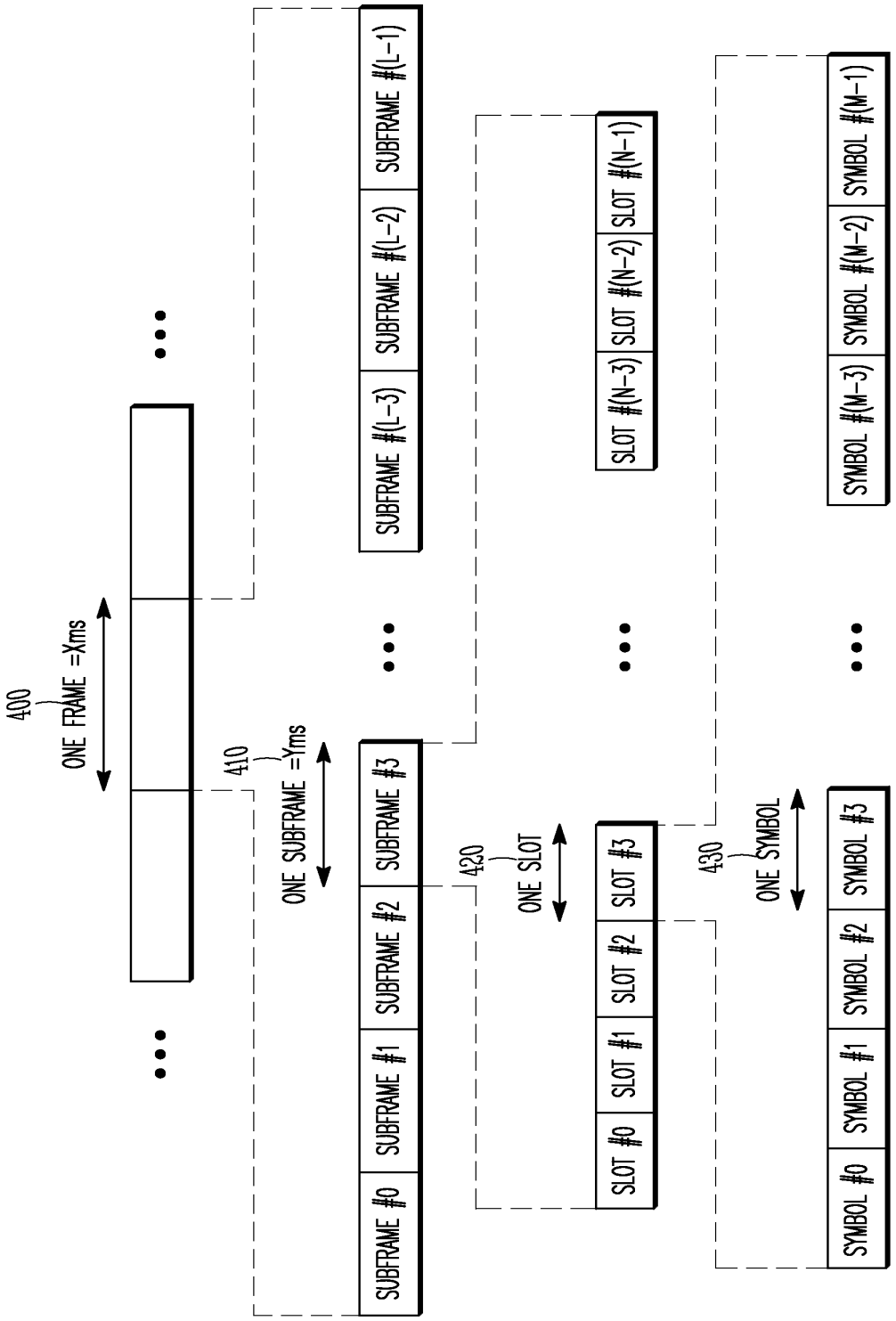

400
ONE FRAME =Xms
410
ONE SUBFRAME =Yms
SUBFRAME #0
SUBFRAME #1
SUBFRAME #2
SUBFRAME #3
SUBFRAME #(L-3)
SUBFRAME #(L-2)
SUBFRAME #(L-1)
420
ONE SLOT
SLOT #0
SLOT #1
SLOT #2
SLOT #3
SLOT #(N-3)
SLOT #(N-2)
SLOT #(N-1)
430
ONE SYMBOL
SYMBOL #0
SYMBOL #1
SYMBOL #2
SYMBOL #3
SYMBOL #(M-3)
SYMBOL #(M-2)
SYMBOL #(M-1)

FIG. 4

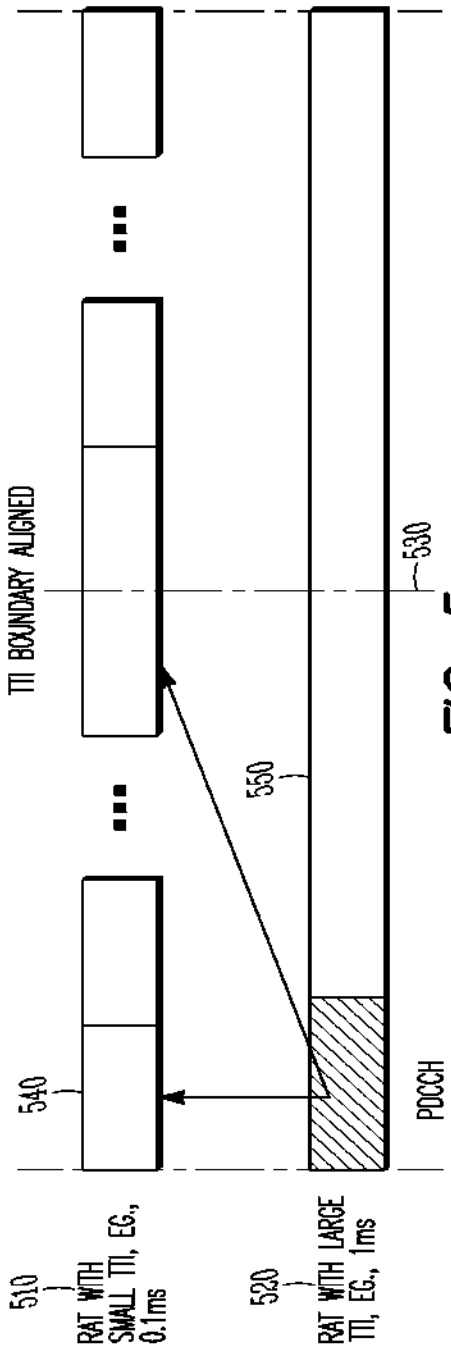

TTI BOUNDARY ALIGNED
530
550
540
PDCCH
510
RAT WITH SMALL TTI, EG., 0.1ms
520
RAT WITH LARGE TTI, EG., 1ms

FIG. 5

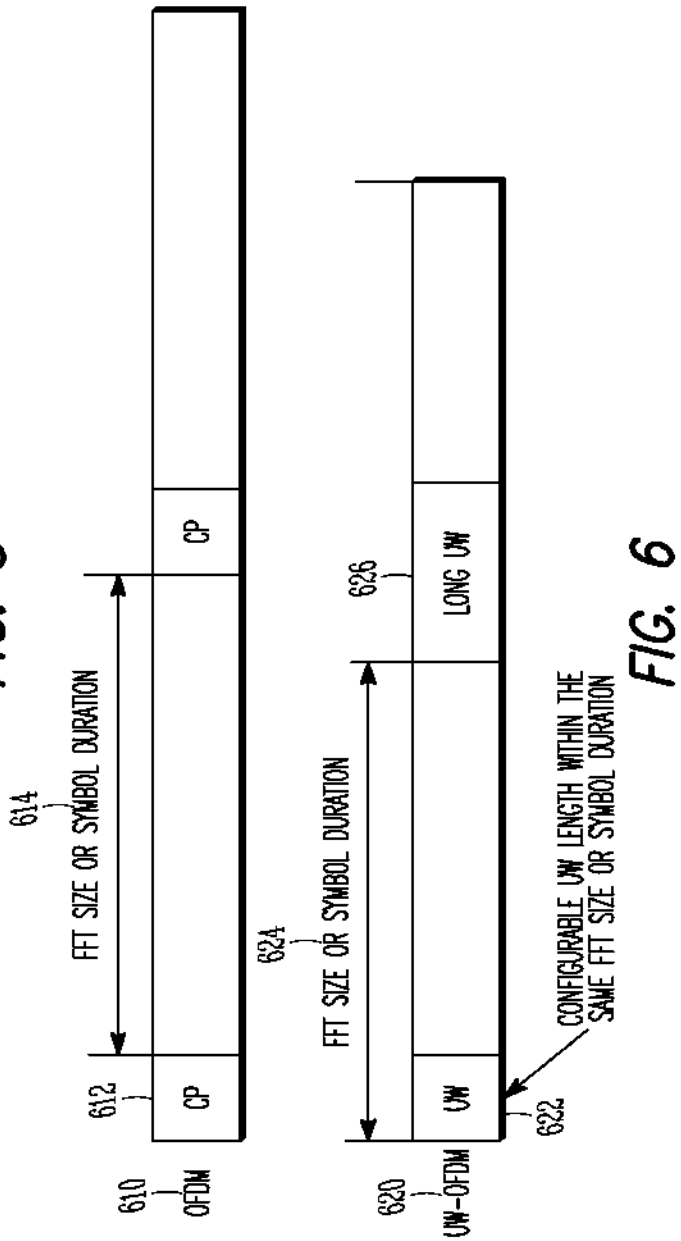

614
FFT SIZE OR SYMBOL DURATION
CP
612
610
OFDM
624
FFT SIZE OR SYMBOL DURATION
626
LONG UW
UW
622
620
UW-OFDM
CONFIGURABLE UW LENGTH WITHIN THE SAME FFT SIZE OR SYMBOL DURATION

FIG. 6

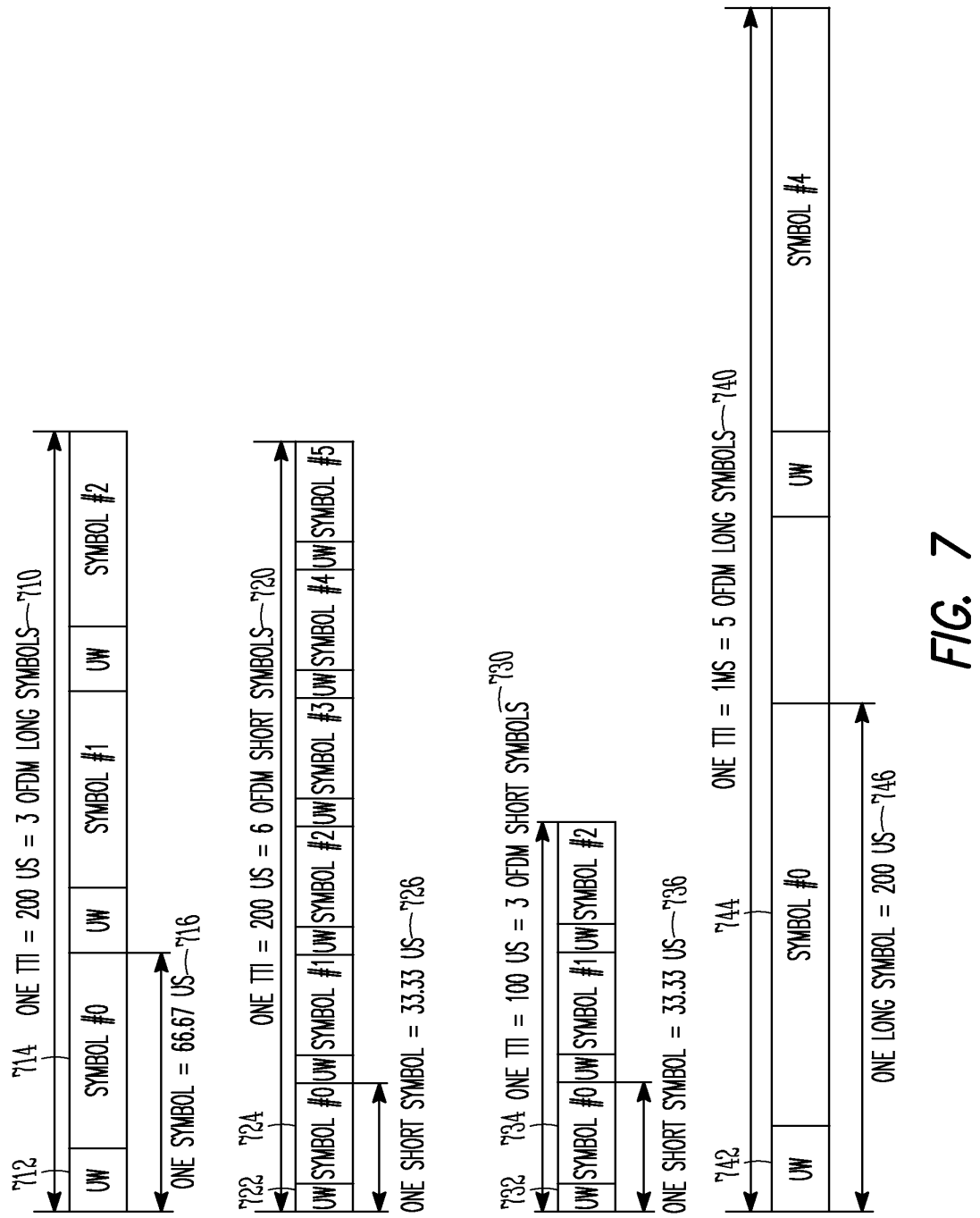

712
714
ONE TTI = 200 US = 3 OFDM LONG SYMBOLS
710
UW
SYMBOL #0
UW
SYMBOL #1
UW
SYMBOL #2
ONE SYMBOL = 66.67 US
716
722
724
ONE TTI = 200 US = 6 OFDM SHORT SYMBOLS
720
UW
SYMBOL #0
UW
SYMBOL #1
UW
SYMBOL #2
UW
SYMBOL #3
UW
SYMBOL #4
UW
SYMBOL #5
ONE SHORT SYMBOL = 33.33 US
726
732
734
ONE TTI = 100 US = 3 OFDM SHORT SYMBOLS
730
UW
SYMBOL #0
UW
SYMBOL #1
UW
SYMBOL #2
ONE SHORT SYMBOL = 33.33 US
736
742
744
ONE TTI = 1MS = 5 OFDM LONG SYMBOLS
740
UW
SYMBOL #0
UW
SYMBOL #4
ONE LONG SYMBOL = 200 US
746

FIG. 7

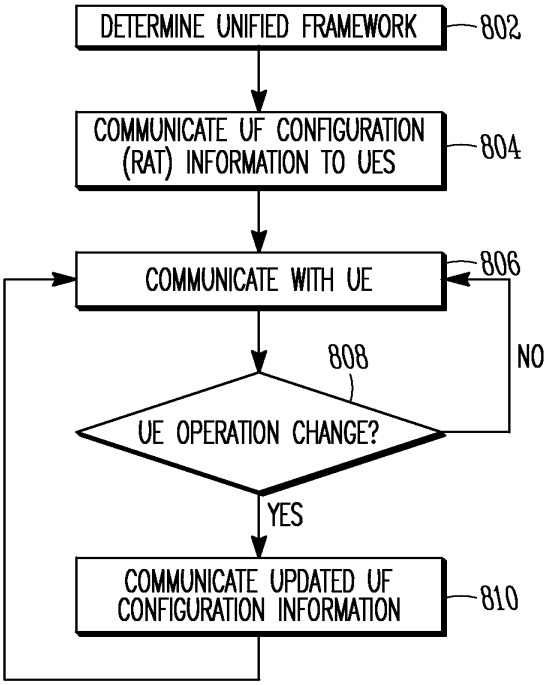

DETERMINE UNIFIED FRAMEWORK
802
COMMUNICATE UF CONFIGURATION (RAT) INFORMATION TO UES
804
COMMUNICATE WITH UE
806
808
UE OPERATION CHANGE?
NO
YES
COMMUNICATE UPDATED UF CONFIGURATION INFORMATION
810

FIG. 8A

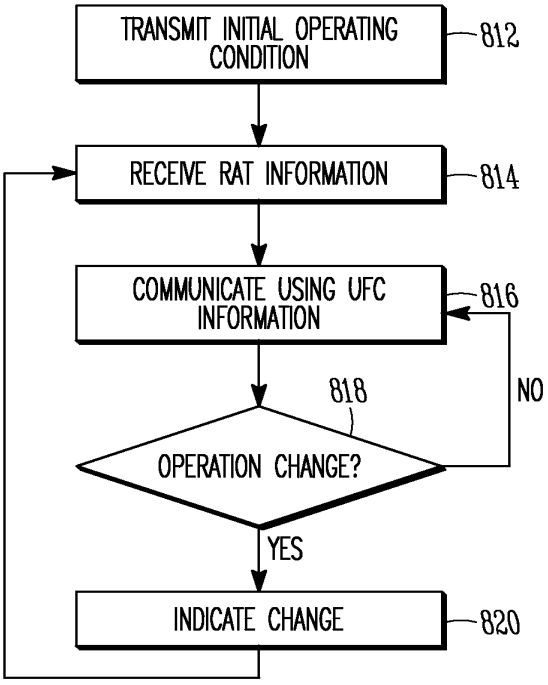

TRANSMIT INITIAL OPERATING CONDITION
812
RECEIVE RAT INFORMATION
814
COMMUNICATE USING UFC INFORMATION
816
818
OPERATION CHANGE?
NO
YES
INDICATE CHANGE
820

FIG. 8B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/044628

A. CLASSIFICATION OF SUBJECT MATTER

H04W 72/04(2009.01)i, H04W 92/10(2009.01)i, H04W 88/06(2009.01)i, H04W 88/08(2009.01)i, H04B 7/26(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W 72/04; H04L 5/00; H04Q 7/00; H04W 88/06; H04L 27/26; H04W 92/10; H04W 88/08; H04B 7/26

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: radio access technology (RAT), FRAT (flexible RAT), flexible subcarrier spacing and symbol duration, numerology, MTC, low latency, low energy, sub-RAT, partition, combination, TTI, unique word (UW), UW-OFDM, UW-DFT-s-OFDM, synchronization, broadcast

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2008-0130570 A1 (YOUNG-HO JUNG et al.) 5 June 2008 See paragraphs [0011], [0033]-[0045]; claims 1, 7; and figures 3-5.	1-25
Y	EEVA LAHETKANGAS et al., 'On the Flexible 5G Dense Deployment Air Interface for Mobile Broadband', In: 5G for Ubiquitous Connectivity (5GU), 2014 1st International Conference on, Page(s): 57-61, 26-28 November 2014 See pages 1-3; and figures 1, 4.	1-25
Y	US 2015-0029990 A1 (INTERDIGITAL PATENT HOLDINGS, INC.) 29 January 2015 See paragraphs [0066]-[0082]; and figure 1.	7,19
Y	US 2014-0140194 A1 (STEFAN FECHTEL) 22 May 2014 See paragraph [0024]; and figures 2A, 2B.	8,9,20,21
A	WO 2014-139562 A1 (NOKIA SOLUTIONS AND NETWORKS OY) 18 September 2014 See page 11, lines 19-32; claims 1, 8, 12; and figures 4, 5.	1-25

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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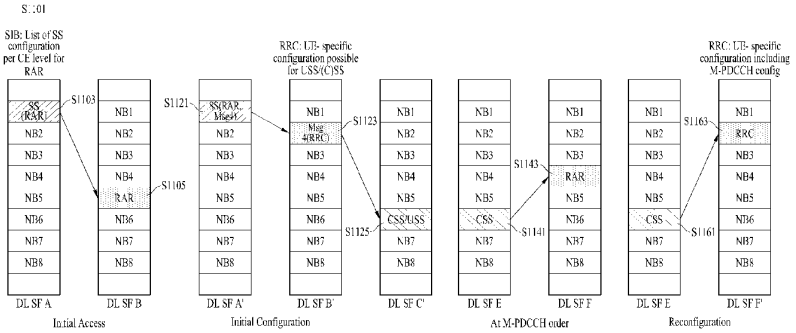
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(54) Title: METHOD AND USER EQUIPMENT FOR RECEIVING DOWNLINK CONTROL INFORMATION, AND METHOD AND BASE STATION FOR TRANSMITTING DOWNLINK CONTROL INFORMATION



(57) Abstract: A search space (hereinafter, CSS) for a control channel for scheduling a random access response may be configured by a system information block. A user equipment (UE) may attempt to receive a control channel for a random access response on the assumption that CSS is configured in accordance with a configuration based on the system information block. The UE may attempt to receive the control channel within a UE-specific search space (USS) by assuming that the USS is configured in accordance with the configuration of the CSS until a configuration for the USS is received.

Description

Title of Invention: METHOD AND USER EQUIPMENT FOR RECEIVING DOWNLINK CONTROL INFORMATION, AND METHOD AND BASE STATION FOR TRANSMITTING DOWNLINK CONTROL INFORMATION

Technical Field

[1] The present invention relates to a wireless communication system, and more particularly, to a method for transmitting or receiving downlink control information and a device therefor.

Background Art

[2] With appearance and spread of machine-to-machine (M2M) communication and a variety of devices such as smartphones and tablet PCs and technology demanding a large amount of data transmission, data throughput needed in a cellular network has rapidly increased. To satisfy such rapidly increasing data throughput, carrier aggregation technology, cognitive radio technology, etc. for efficiently employing more frequency bands and multiple input multiple output (MIMO) technology, multi-base station (BS) cooperation technology, etc. for raising data capacity transmitted on limited frequency resources have been developed.

[3] A general wireless communication system performs data transmission/reception through one downlink (DL) band and through one uplink (UL) band corresponding to the DL band (in case of a frequency division duplex (FDD) mode), or divides a prescribed radio frame into a UL time unit and a DL time unit in the time domain and then performs data transmission/reception through the UL/DL time unit (in case of a time division duplex (TDD) mode). A base station (BS) and a user equipment (UE) transmit and receive data and/or control information scheduled on a prescribed time unit basis, e.g. on a subframe basis. The data is transmitted and received through a data region configured in a UL/DL subframe and the control information is transmitted and received through a control region configured in the UL/DL subframe. To this end, various physical channels carrying radio signals are formed in the UL/DL subframe. In contrast, carrier aggregation technology serves to use a wider UL/DL bandwidth by aggregating a plurality of UL/DL frequency blocks in order to use a broader frequency band so that more signals relative to signals when a single carrier is used can be simultaneously processed.

[4] In addition, a communication environment has evolved into increasing density of nodes accessible by a user at the periphery of the nodes. A node refers to a fixed point

capable of transmitting/receiving a radio signal to/from the UE through one or more antennas. A communication system including high-density nodes may provide a better communication service to the UE through cooperation between the nodes.

Disclosure of Invention

Technical Problem

[5] Due to introduction of new radio communication technology, the number of user equipments (UEs) to which a BS should provide a service in a prescribed resource region increases and the amount of data and control information that the BS should transmit to the UEs increases. Since the amount of resources available to the BS for communication with the UE(s) is limited, a new method in which the BS efficiently receives/transmits uplink/downlink data and/or uplink/downlink control information using the limited radio resources is needed.

[6] The technical objects that can be achieved through the present invention are not limited to what has been particularly described hereinabove and other technical objects not described herein will be more clearly understood by persons skilled in the art from the following detailed description.

Solution to Problem

[7] A search space (hereinafter, CSS_RAR) for a control channel for scheduling a random access response may be configured by a system information block. A user equipment (UE) may attempt to receive a control channel for a random access response by assuming that CSS_RAR is configured in accordance with a configuration based on the system information block. If the UE receives the control channel for a random access response, the UE may receive the random access response to a random access preamble transmitted therefrom in accordance with control information carried by the control channel. The UE may attempt to receive a control channel within a UE-specific search space (hereinafter, USS) by assuming that the USS is configured in accordance with the configuration of the CSS until a configuration for the USS is received.

[8] In an aspect of the present invention, provided herein is a method for receiving, by a user equipment (UE), downlink control information (DCI) for the UE. The method comprises: receiving, by the UE, a common search space configuration for a common search space; receiving, by the UE, a first physical downlink control channel (PDCCH) scheduling a random access response; and receiving, by the UE, a second PDCCH carrying the DCI for the UE. The UE can monitor first PDCCH candidates of the common search space according to the common search space configuration in order to receive the first PDCCH. The UE can monitor second PDCCH candidates of a UE-specific search space in order to receive the second PDCCH. The UE can assume that configuration of the UE-specific search space is the same as that of the common search

space until the UE receives a UE-specific search space configuration.

[9] In another aspect of the present invention, provided herein is a method for transmitting, by a base station (BS), downlink control information (DCI) for a user equipment (UE). The method comprises: transmitting, by the BS, common search space configuration for a common search space; transmitting, by the BS to the UE, a first physical downlink control channel (PDCCH) scheduling a random access response; and transmitting, by the BS to the UE, a second PDCCH carrying the DCI for the UE. The BS can transmit the first PDCCH by using one of first PDCCH candidates of the common search space according to the common search space configuration. The BS can transmit the second PDCCH by using one of second PDCCH candidates of a UE-specific search space. The BS can configure the UE-specific search space according to the same configuration as the common search space configuration until the BS transmits a UE-specific search space configuration to the UE.

[10] In still another aspect of the present invention, provided herein a user equipment (UE) for receiving downlink control information (DCI) for the UE. The UE comprises a radio frequency (RF) unit and a processor connected to the RF unit. The processor can be configured to control the RF unit to receive common search space configuration for a common search space; control the RF unit to receive a first physical downlink control channel (PDCCH) scheduling a random access response; and control the RF unit to receive a second PDCCH carrying the DCI for the UE. The processor can be configured to monitor first PDCCH candidates of the common search space according to the common search space configuration in order to detect the firs PDCCH. The processor can be configured to monitor second PDCCH candidates of a UE-specific search space in order to detect the second PDCCH. The processor can be configured to assume that configuration of the UE-specific search space is the same as that of the common search space until the UE receives a UE-specific search space configuration.

[11] In a further aspect of the present invention, provided herein a base station (BS) for transmitting downlink control information (DCI) for a user equipment (UE). The BS comprises a radio frequency (RF) unit and a processor connected to the RF unit. The processor can be configured to control the RF unit to transmit common search space configuration for a common search space; control the RF unit to transmit a first physical downlink control channel (PDCCH) scheduling a random access response; and control the RF unit to transmit a second PDCCH carrying the DCI for the UE. The processor can be configured to control the RF unit to transmit the first PDCCH using one of first PDCCH candidates of the common search space according to the common search space configuration. The processor can be configured to control the RF unit to transmit the second PDCCH using one of second PDCCH candidates of a UE-specific search space. The processor can configure the UE-specific search space according to

the same as that of the common search space until the BS transmits a UE-specific search space configuration.

[12] In each aspect of the present invention, the common search space configuration can include information on a narrowband for the common search space. The second PDCCH candidates of the UE-specific search space can be configured on the same narrowband as the narrowband for the common search space until the UE-specific search space configuration is transmitted to the UE.

[13] In each aspect of the present invention, the common search space configuration can include information on a maximum number of repetitions for the first common search space. The second PDCCH candidates of the UE-specific search space can be configured based on the same number as the maximum number of repetitions for the common search space until the UE-specific search space configuration is transmitted to the UE.

[14] In each aspect of the present invention, the common search space configuration can include information on a first physical resource block (PRB) set for transmitting the first PDCCH. The same physical resource block set as the first PRB set can be used for the second PDCCH candidates until the UE-specific search space configuration is transmitted to the UE

[15] In each aspect of the present invention, the first PDCCH candidates of the common search space can be configured according to aggregation levels larger than or equal to 8 among a plurality of aggregation levels, whereas the second PDCCH candidates of the UE-specific search space can be configured according to the plurality of aggregation levels.

[16] In each aspect of the present invention, the UE can transmit a random access preamble using a physical random access channel (PRACH) resource. The UE can monitor the first PDCCH candidates in response to transmission of the random access preamble. The UE can receive the random access response according to control information carried by the first PDCCH. The BS can receive a random access preamble using a physical random access channel (PRACH) resource. The BS can transmit the first PDCCH in response to reception of the random access preamble. The BS can transmit the random access response according to control information carried by the first PDCCH.

[17] The above technical solutions are merely some parts of the embodiments of the present invention and various embodiments into which the technical features of the present invention are incorporated can be derived and understood by persons skilled in the art from the following detailed description of the present invention.

Advantageous Effects of Invention

[18] According to the present invention, uplink/downlink signals can be efficiently transmitted/received. Therefore, overall throughput of a radio communication system can be improved.

[19] According to one embodiment of the present invention, a low cost/complexity UE can perform communication with a BS at low cost while maintaining compatibility with a legacy system.

[20] According to one embodiment of the present invention, the UE can be implemented at low cost/complexity.

[21] According to one embodiment of the present invention, coverage can be enhanced.

[22] According to one embodiment of the present invention, the UE and the BS can perform communication with each other at a narrowband.

[23] It will be appreciated by persons skilled in the art that that the effects that can be achieved through the present invention are not limited to what has been particularly described hereinabove and other advantages of the present invention will be more clearly understood from the following detailed description.

Brief Description of Drawings

[24] The accompanying drawings, which are included to provide a further understanding of the invention, illustrate embodiments of the invention and together with the description serve to explain the principle of the invention.

[25] FIG. 1 illustrates the structure of a radio frame used in a wireless communication system.

[26] FIG. 2 illustrates the structure of a downlink (DL)/uplink (UL) slot in a wireless communication system.

[27] FIG. 3 illustrates a radio frame structure for transmission of a synchronization signal (SS).

[28] FIG. 4 illustrates the structure of a DL subframe used in a wireless communication system.

[29] FIG. 5 illustrates the structure of a UL subframe used in a wireless communication system.

[30] FIG. 6 illustrates an example of a signal band for MTC.

[31] FIG. 7 illustrates repeated transmission of a channel for coverage enhancement.

[32] FIG. 8 illustrates a configuration of a common search space (CSS) for paging according to the present invention.

[33] FIG. 9 illustrates a configuration of a common search space (CSS) for random access response (RAR) according to the present invention.

[34] FIG. 10 illustrates the example of the monitoring time region of USS and CSS.

[35] FIG. 11 illustrates a procedure of configuring a search space according to the present

invention.

[36] FIG. 12 illustrates a configuration of M-PDCCH repeated transmission according to the present invention.

[37] FIG. 13 is a block diagram illustrating elements of a transmitting device 10 and a receiving device 20 for implementing the present invention.

Mode for the Invention

[38] Reference will now be made in detail to the exemplary embodiments of the present invention, examples of which are illustrated in the accompanying drawings. The detailed description, which will be given below with reference to the accompanying drawings, is intended to explain exemplary embodiments of the present invention, rather than to show the only embodiments that can be implemented according to the invention. The following detailed description includes specific details in order to provide a thorough understanding of the present invention. However, it will be apparent to those skilled in the art that the present invention may be practiced without such specific details.

[39] In some instances, known structures and devices are omitted or are shown in block diagram form, focusing on important features of the structures and devices, so as not to obscure the concept of the present invention. The same reference numbers will be used throughout this specification to refer to the same or like parts.

[40] The following techniques, apparatuses, and systems may be applied to a variety of wireless multiple access systems. Examples of the multiple access systems include a code division multiple access (CDMA) system, a frequency division multiple access (FDMA) system, a time division multiple access (TDMA) system, an orthogonal frequency division multiple access (OFDMA) system, a single carrier frequency division multiple access (SC-FDMA) system, and a multicarrier frequency division multiple access (MC-FDMA) system. CDMA may be embodied through radio technology such as universal terrestrial radio access (UTRA) or CDMA2000. TDMA may be embodied through radio technology such as global system for mobile communications (GSM), general packet radio service (GPRS), or enhanced data rates for GSM evolution (EDGE). OFDMA may be embodied through radio technology such as institute of electrical and electronics engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20, or evolved UTRA (E-UTRA). UTRA is a part of a universal mobile telecommunications system (UMTS). 3rd generation partnership project (3GPP) long term evolution (LTE) is a part of evolved UMTS (E-UMTS) using E-UTRA. 3GPP LTE employs OFDMA in DL and SC-FDMA in UL. LTE-advanced (LTE-A) is an evolved version of 3GPP LTE. For convenience of description, it is assumed that the present invention is applied to 3GPP LTE/LTE-A. However, the

technical features of the present invention are not limited thereto. For example, although the following detailed description is given based on a mobile communication system corresponding to a 3GPP LTE/LTE-A system, aspects of the present invention that are not specific to 3GPP LTE/LTE-A are applicable to other mobile communication systems.

[41] For example, the present invention is applicable to contention based communication such as Wi-Fi as well as non-contention based communication as in the 3GPP LTE/LTE-A system in which an eNB allocates a DL/UL time/frequency resource to a UE and the UE receives a DL signal and transmits a UL signal according to resource allocation of the eNB. In a non-contention based communication scheme, an access point (AP) or a control node for controlling the AP allocates a resource for communication between the UE and the AP, whereas, in a contention based communication scheme, a communication resource is occupied through contention between UEs which desire to access the AP. The contention based communication scheme will now be described in brief. One type of the contention based communication scheme is carrier sense multiple access (CSMA). CSMA refers to a probabilistic media access control (MAC) protocol for confirming, before a node or a communication device transmits traffic on a shared transmission medium (also called a shared channel) such as a frequency band, that there is no other traffic on the same shared transmission medium. In CSMA, a transmitting device determines whether another transmission is being performed before attempting to transmit traffic to a receiving device. In other words, the transmitting device attempts to detect presence of a carrier from another transmitting device before attempting to perform transmission. Upon sensing the carrier, the transmitting device waits for another transmission device which is performing transmission to finish transmission, before performing transmission thereof. Consequently, CSMA can be a communication scheme based on the principle of "sense before transmit" or "listen before talk". A scheme for avoiding collision between transmitting devices in the contention based communication system using CSMA includes carrier sense multiple access with collision detection (CSMA/CD) and/or carrier sense multiple access with collision avoidance (CSMA/CA). CSMA/CD is a collision detection scheme in a wired local area network (LAN) environment. In CSMA/CD, a personal computer (PC) or a server which desires to perform communication in an Ethernet environment first confirms whether communication occurs on a network and, if another device carries data on the network, the PC or the server waits and then transmits data. That is, when two or more users (e.g. PCs, UEs, etc.) simultaneously transmit data, collision occurs between simultaneous transmission and CSMA/CD is a scheme for flexibly transmitting data by monitoring collision. A transmitting device using CSMA/CD adjusts data transmission thereof by sensing data transmission performed by another

device using a specific rule. CSMA/CA is a MAC protocol specified in IEEE 802.11 standards. A wireless LAN (WLAN) system conforming to IEEE 802.11 standards does not use CSMA/CD which has been used in IEEE 802.3 standards and uses CA, i.e. a collision avoidance scheme. Transmission devices always sense carrier of a network and, if the network is empty, the transmission devices wait for determined time according to locations thereof registered in a list and then transmit data. Various methods are used to determine priority of the transmission devices in the list and to re-configure priority. In a system according to some versions of IEEE 802.11 standards, collision may occur and, in this case, a collision sensing procedure is performed. A transmission device using CSMA/CA avoids collision between data transmission thereof and data transmission of another transmission device using a specific rule.

[42] In the present invention, a user equipment (UE) may be a fixed or mobile device. Examples of the UE include various devices that transmit and receive user data and/or various kinds of control information to and from a base station (BS). The UE may be referred to as a terminal equipment (TE), a mobile station (MS), a mobile terminal (MT), a user terminal (UT), a subscriber station (SS), a wireless device, a personal digital assistant (PDA), a wireless modem, a handheld device, etc. In addition, in the present invention, a BS generally refers to a fixed station that performs communication with a UE and/or another BS, and exchanges various kinds of data and control information with the UE and another BS. The BS may be referred to as an advanced base station (ABS), a node-B (NB), an evolved node-B (eNB), a base transceiver system (BTS), an access point (AP), a processing server (PS), etc. In describing the present invention, a BS will be referred to as an eNB.

[43] In the present invention, a node refers to a fixed point capable of transmitting/ receiving a radio signal through communication with a UE. Various types of eNBs may be used as nodes irrespective of the terms thereof. For example, a BS, a node B (NB), an e-node B (eNB), a pico-cell eNB (PeNB), a home eNB (HeNB), a relay, a repeater, etc. may be a node. In addition, the node may not be an eNB. For example, the node may be a radio remote head (RRH) or a radio remote unit (RRU). The RRH or RRU generally has a lower power level than a power level of an eNB. Since the RRH or RRU (hereinafter, RRH/RRU) is generally connected to the eNB through a dedicated line such as an optical cable, cooperative communication between RRH/ RRU and the eNB can be smoothly performed in comparison with cooperative communication between eNBs connected by a radio line. At least one antenna is installed per node. The antenna may mean a physical antenna or mean an antenna port, a virtual antennIn the present invention, a cell refers to a prescribed geographical area to which one or more nodes provide a communication service. Accordingly, in the present invention, communicating with a specific cell may mean communicating with an eNB

or a node which provides a communication service to the specific cell. In addition, a DL/UL signal of a specific cell refers to a DL/UL signal from/to an eNB or a node which provides a communication service to the specific cell. A node providing UL/DL communication services to a UE is called a serving node and a cell to which UL/DL communication services are provided by the serving node is especially called a serving cell. Furthermore, channel status/quality of a specific cell refers to channel status/ quality of a channel or communication link formed between an eNB or node which provides a communication service to the specific cell and a UE. The UE may measure DL channel state received from a specific node using cell-specific reference signal(s) (CRS(s)) transmitted on a CRS resource and/or channel state information reference signal(s) (CSI-RS(s)) transmitted on a CSI-RS resource, allocated by antenna port(s) of the specific node to the specific node. Detailed CSI-RS configuration may be understood with reference to 3GPP TS 36.211 and 3GPP TS 36.331 documents.

[44] Meanwhile, a 3GPP LTE/LTE-A system uses the concept of a cell in order to manage radio resources and a cell associated with the radio resources is distinguished from a cell of a geographic region.

[45] A "cell" of a geographic region may be understood as coverage within which a node can provide service using a carrier and a "cell" of a radio resource is associated with bandwidth (BW) which is a frequency range configured by the carrier. Since DL coverage, which is a range within which the node is capable of transmitting a valid signal, and UL coverage, which is a range within which the node is capable of receiving the valid signal from the UE, depends upon a carrier carrying the signal, the coverage of the node may be associated with coverage of the "cell" of a radio resource used by the node. Accordingly, the term "cell" may be used to indicate service coverage of the node sometimes, a radio resource at other times, or a range that a signal using a radio resource can reach with valid strength at other times. The "cell" of the radio resource will be described later in more detail.

[46] 3GPP LTE/LTE-A standards define DL physical channels corresponding to resource elements carrying information derived from a higher layer and DL physical signals corresponding to resource elements which are used by a physical layer but which do not carry information derived from a higher layer. For example, a physical downlink shared channel (PDSCH), a physical broadcast channel (PBCH), a physical multicast channel (PMCH), a physical control format indicator channel (PCFICH), a physical downlink control channel (PDCCH), and a physical hybrid ARQ indicator channel (PHICH) are defined as the DL physical channels, and a reference signal and a synchronization signal are defined as the DL physical signals. A reference signal (RS), also called a pilot, refers to a special waveform of a predefined signal known to both a BS and a UE. For example, a cell-specific RS (CRS), a UE-specific RS (UE-RS), a po-

sitioning RS (PRS), and channel state information RS (CSI-RS) may be defined as DL RSs. Meanwhile, the 3GPP LTE/LTE-A standards define UL physical channels corresponding to resource elements carrying information derived from a higher layer and UL physical signals corresponding to resource elements which are used by a physical layer but which do not carry information derived from a higher layer. For example, a physical uplink shared channel (PUSCH), a physical uplink control channel (PUCCH), and a physical random access channel (PRACH) are defined as the UL physical channels, and a demodulation reference signal (DM RS) for a UL control/data signal and a sounding reference signal (SRS) used for UL channel measurement are defined as the UL physical signals.

[47] In the present invention, a physical downlink control channel (PDCCH), a physical control format indicator channel (PCFICH), a physical hybrid automatic retransmit request indicator channel (PHICH), and a physical downlink shared channel (PDSCH) refer to a set of time-frequency resources or resource elements (REs) carrying downlink control information (DCI), a set of time-frequency resources or REs carrying a control format indicator (CFI), a set of time-frequency resources or REs carrying downlink acknowledgement (ACK)/negative ACK (NACK), and a set of time-frequency resources or REs carrying downlink data, respectively. In addition, a physical uplink control channel (PUCCH), a physical uplink shared channel (PUSCH) and a physical random access channel (PRACH) refer to a set of time-frequency resources or REs carrying uplink control information (UCI), a set of time-frequency resources or REs carrying uplink data and a set of time-frequency resources or REs carrying random access signals, respectively. In the present invention, in particular, a time-frequency resource or RE that is assigned to or belongs to PDCCH/PCFICH/PHICH/PDSCH/PUCCH/PUSCH/PRACH is referred to as PDCCH/PCFICH/PHICH/PDSCH/PUCCH/PUSCH/PRACH RE or PDCCH/PCFICH/PHICH/PDSCH/PUCCH/PUSCH/PRACH time-frequency resource, respectively. Therefore, in the present invention, PUCCH/PUSCH/PRACH transmission of a UE is conceptually identical to UCI/uplink data/random access signal transmission on PUSCH/PUCCH/PRACH, respectively. In addition, PDCCH/PCFICH/PHICH/PDSCH transmission of an eNB is conceptually identical to downlink data/DCI transmission on PDCCH/PCFICH/PHICH/PDSCH, respectively.

[48] Hereinafter, OFDM symbol/subcarrier/RE to or for which CRS/DMRS/CSI-RS/SRS/UE-RS/TRS is assigned or configured will be referred to as CRS/DMRS/CSI-RS/SRS/UE-RS/TRS symbol/carrier/subcarrier/RE. For example, an OFDM symbol to or for which a tracking RS (TRS) is assigned or configured is referred to as a TRS symbol, a subcarrier to or for which the TRS is assigned or configured is referred to as a TRS subcarrier, and an RE to or for which the TRS is

assigned or configured is referred to as a TRS RE. In addition, a subframe configured for transmission of the TRS is referred to as a TRS subframe. Moreover, a subframe in which a broadcast signal is transmitted is referred to as a broadcast subframe or a PBCH subframe and a subframe in which a synchronization signal (e.g. PSS and/or SSS) is transmitted is referred to a synchronization signal subframe or a PSS/SSS subframe. OFDM symbol/subcarrier/RE to or for which PSS/SSS is assigned or configured is referred to as PSS/SSS symbol/subcarrier/RE, respectively.

[49] In the present invention, a CRS port, a UE-RS port, a CSI-RS port, and a TRS port refer to an antenna port configured to transmit a CRS, an antenna port configured to transmit a UE-RS, an antenna port configured to transmit a CSI-RS, and an antenna port configured to transmit a TRS, respectively. Antenna ports configured to transmit CRSs may be distinguished from each other by the locations of REs occupied by the CRSs according to CRS ports, antenna ports configured to transmit UE-RSs may be distinguished from each other by the locations of REs occupied by the UE-RSs according to UE-RS ports, and antenna ports configured to transmit CSI-RSs may be distinguished from each other by the locations of REs occupied by the CSI-RSs according to CSI-RS ports. Therefore, the term CRS/UE-RS/CSI-RS/TRS ports may also be used to indicate a pattern of REs occupied by CRSs/UE-RSs/CSI-RSs/TRSs in a predetermined resource region. In the present invention, both a DMRS and a UE-RS refer to RSs for demodulation and, therefore, the terms DMRS and UE-RS are used to refer to RSs for demodulation.

[50] FIG. 1 illustrates the structure of a radio frame used in a wireless communication system.

[51] Specifically, FIG. 1(a) illustrates an exemplary structure of a radio frame which can be used in frequency division multiplexing (FDD) in 3GPP LTE/LTE-A and FIG. 1(b) illustrates an exemplary structure of a radio frame which can be used in time division multiplexing (TDD) in 3GPP LTE/LTE-A.

[52] Referring to FIG. 1, a 3GPP LTE/LTE-A radio frame is 10ms ($307,200T_s$) in duration. The radio frame is divided into 10 subframes of equal size. Subframe numbers may be assigned to the 10 subframes within one radio frame, respectively. Here, T_s denotes sampling time where T_s=1/(2048*15kHz). Each subframe is 1ms long and is further divided into two slots. 20 slots are sequentially numbered from 0 to 19 in one radio frame. Duration of each slot is 0.5ms. A time interval in which one subframe is transmitted is defined as a transmission time interval (TTI). Time resources may be distinguished by a radio frame number (or radio frame index), a subframe number (or subframe index), a slot number (or slot index), and the like.

[53] A radio frame may have different configurations according to duplex modes. In FDD mode for example, since DL transmission and UL transmission are discriminated

according to frequency, a radio frame for a specific frequency band operating on a carrier frequency includes either DL subframes or UL subframes. In TDD mode, since DL transmission and UL transmission are discriminated according to time, a radio frame for a specific frequency band operating on a carrier frequency includes both DL subframes and UL subframes.

[54] Table 1 shows an exemplary UL-DL configuration within a radio frame in TDD mode.

[55] [Table 1]

DL-UL configuration	Downlink-to-Uplink Switch-point periodicity	Subframe number									
		0	1	2	3	4	5	6	7	8	9
0	5ms	D	S	U	U	U	D	S	U	U	U
1	5ms	D	S	U	U	D	D	S	U	U	D
2	5ms	D	S	U	D	D	D	S	U	D	D
3	10ms	D	S	U	U	U	D	D	D	D	D
4	10ms	D	S	U	U	D	D	D	D	D	D
5	10ms	D	S	U	D	D	D	D	D	D	D
6	5ms	D	S	U	U	U	D	S	U	U	D

[56] In Table 1, D denotes a DL subframe, U denotes a UL subframe, and S denotes a special subframe. The special subframe includes three fields, i.e. downlink pilot time slot (DwPTS), guard period (GP), and uplink pilot time slot (UpPTS). DwPTS is a time slot reserved for DL transmission and UpPTS is a time slot reserved for UL transmission. Table 2 shows an example of the special subframe configuration.

[57] [Table 2]

Special subframe configuration	Normal cyclic prefix in downlink			Extended cyclic prefix in downlink		
	DwPTS	UpPTS		DwPTS	UpPTS	
		Normal cyclic prefix in uplink	Extended cyclic prefix in uplink		Normal cyclic prefix in uplink	Extended cyclic prefix in uplink
0	$6592 \cdot T_s$	$2192 \cdot T_s$	$2560 \cdot T_s$	$7680 \cdot T_s$	$2192 \cdot T_s$	$2560 \cdot T_s$
1	$19760 \cdot T_s$			$20480 \cdot T_s$		
2	$21952 \cdot T_s$			$23040 \cdot T_s$		
3	$24144 \cdot T_s$			$25600 \cdot T_s$		
4	$26336 \cdot T_s$			$7680 \cdot T_s$	$4384 \cdot T_s$	$5120 \cdot T_s$
5	$6592 \cdot T_s$	$4384 \cdot T_s$	$5120 \cdot T_s$	$20480 \cdot T_s$		
6	$19760 \cdot T_s$			$23040 \cdot T_s$		
7	$21952 \cdot T_s$			$12800 \cdot T_s$		
8	$24144 \cdot T_s$			-	-	-
9	$13168 \cdot T_s$			-	-	-

[58] FIG. 2 illustrates the structure of a DL/UL slot structure in a wireless communication system.

[59] Referring to FIG. 2, a slot includes a plurality of orthogonal frequency division multiplexing (OFDM) symbols in the time domain and includes a plurality of resource blocks (RBs) in the frequency domain. The OFDM symbol may refer to one symbol duration. Referring to FIG. 2, a signal transmitted in each slot may be expressed by a resource grid including $N^{DL/UL}_{RB} * N^{RB}_{sc}$ subcarriers and $N^{DL/UL}_{symb}$ OFDM symbols. N^{DL}_{RB} denotes the number of RBs in a DL slot and N^{UL}_{RB} denotes the number of RBs in a UL slot. N^{DL}_{RB} and N^{UL}_{RB} depend on a DL transmission bandwidth and a UL transmission bandwidth, respectively. N^{DL}_{symb} denotes the number of OFDM symbols in a DL slot, N^{UL}_{symb} denotes the number of OFDM symbols in a UL slot, and N^{RB}_{sc} denotes the number of subcarriers configuring one RB.

[60] An OFDM symbol may be referred to as an OFDM symbol, a single carrier frequency division multiplexing (SC-FDM) symbol, etc. according to multiple access schemes. The number of OFDM symbols included in one slot may be varied according to channel bandwidths and CP lengths. For example, in a normal cyclic prefix (CP) case, one slot includes 7 OFDM symbols. In an extended CP case, one slot includes 6

OFDM symbols. Although one slot of a subframe including 7 OFDM symbols is shown in FIG. 2 for convenience of description, embodiments of the present invention are similarly applicable to subframes having a different number of OFDM symbols. Referring to FIG. 2, each OFDM symbol includes $N^{DL/UL}_{RB} * N^{RB}_{sc}$ subcarriers in the frequency domain. The type of the subcarrier may be divided into a data subcarrier for data transmission, a reference signal (RS) subcarrier for RS transmission, and a null subcarrier for a guard band and a DC component. The null subcarrier for the DC component is unused and is mapped to a carrier frequency f_0 in a process of generating an OFDM signal or in a frequency up-conversion process. The carrier frequency is also called a center frequency f_c.

[61] One RB is defined as $N^{DL/UL}_{symb}$ (e.g. 7) consecutive OFDM symbols in the time domain and as N^{RB}_{sc} (e.g. 12) consecutive subcarriers in the frequency domain. For reference, a resource composed of one OFDM symbol and one subcarrier is referred to a resource element (RE) or tone. Accordingly, one RB includes $N^{DL/UL}_{symb} * N^{RB}_{sc}$ REs. Each RE within a resource grid may be uniquely defined by an index pair (k, l) within one slot. k is an index ranging from 0 to $N^{DL/UL}_{RB} * N^{RB}_{sc}$—1 in the frequency domain, and l is an index ranging from 0 to $N^{DL/UL}_{symb}$—1 in the time domain.

[62] Meanwhile, one RB is mapped to one physical resource block (PRB) and one virtual resource block (VRB). A PRB is defined as N^{DL}_{symb} (e.g. 7) consecutive OFDM or SC-FDM symbols in the time domain and N^{RB}_{sc} (e.g. 12) consecutive subcarriers in the frequency domain. Accordingly, one PRB is configured with $N^{DL/UL}_{symb} * N^{RB}_{sc}$ REs. In one subframe, two RBs each located in two slots of the subframe while occupying the same N^{RB}_{sc} consecutive subcarriers are referred to as a physical resource block (PRB) pair. Two RBs configuring a PRB pair have the same PRB number (or the same PRB index).

[63] FIG. 3 illustrates a radio frame structure for transmission of a synchronization signal (SS). Specifically, FIG. 3 illustrates a radio frame structure for transmission of an SS and a PBCH in frequency division duplex (FDD), wherein FIG. 3(a) illustrates transmission locations of an SS and a PBCH in a radio frame configured as a normal cyclic prefix (CP) and FIG. 3(b) illustrates transmission locations of an SS and a PBCH in a radio frame configured as an extended CP.

[64] If a UE is powered on or newly enters a cell, the UE performs an initial cell search procedure of acquiring time and frequency synchronization with the cell and detecting a physical cell identity N^{cell}_{ID} of the cell. To this end, the UE may establish synchronization with the eNB by receiving synchronization signals, e.g. a primary synchronization signal (PSS) and a secondary synchronization signal (SSS), from the eNB and obtain information such as a cell identity (ID).

[65] An SS will be described in more detail with reference to FIG. 3. An SS is categorized

into a PSS and an SSS. The PSS is used to acquire time-domain synchronization of OFDM symbol synchronization, slot synchronization, etc. and/or frequency-domain synchronization and the SSS is used to acquire frame synchronization, a cell group ID, and/or CP configuration of a cell (i.e. information as to whether a normal CP is used or an extended CP is used). Referring to FIG. 3, each of a PSS and an SSS is transmitted on two OFDM symbols of every radio frame. More specifically, SSs are transmitted in the first slot of subframe 0 and the first slot of subframe 5, in consideration of a global system for mobile communication (GSM) frame length of 4.6 ms for facilitation of inter-radio access technology (inter-RAT) measurement. Especially, a PSS is transmitted on the last OFDM symbol of the first slot of subframe 0 and on the last OFDM symbol of the first slot of subframe 5 and an SSS is transmitted on the second to last OFDM symbol of the first slot of subframe 0 and on the second to last OFDM symbol of the first slot of subframe 5. A boundary of a corresponding radio frame may be detected through the SSS. The PSS is transmitted on the last OFDM symbol of a corresponding slot and the SSS is transmitted on an OFDM symbol immediately before an OFDM symbol on which the PSS is transmitted. A transmit diversity scheme of an SS uses only a single antenna port and standards therefor are not separately defined. That is, a single antenna port transmission scheme or a transmission scheme transparent to a UE (e.g. precoding vector switching (PVS), time switched transmit diversity (TSTD), or cyclic delay diversity (CDD)) may be used for transmit diversity of an SS.

[66] Upon detecting a PSS, a UE may discern that a corresponding subframe is one of subframe 0 and subframe 5 because the PSS is transmitted every 5ms but the UE cannot discern whether the subframe is subframe 0 or subframe 5. Accordingly, the UE cannot recognize the boundary of a radio frame only by the PSS. That is, frame synchronization cannot be acquired only by the PSS. The UE detects the boundary of a radio frame by detecting an SSS which is transmitted twice in one radio frame with different sequences.

[67] The UE, which has determined time and frequency parameters necessary for demodulating a DL signal and transmitting a UL signal at an accurate time by performing a cell search procedure using PSS/SSS, can communicate with the eNB only after acquiring system information necessary for system configuration of the UE from the eNB.

[68] The system information is configured by a master information block (MIB) and system information blocks (SIBs). Each SIB includes a set of functionally associated parameters and is categorized into an MIB, SIB Type 1 (SIB 1), SIB Type 2 (SIB2), and SIB3 to SIB17 in accordance with the parameters.

[69] The MIB includes most frequently transmitted parameters which are essential for

initial access of the UE to a network of the eNB. The UE may receive the MIB through a broadcast channel (e.g. PBCH). The MIB includes a DL bandwidth (BW), PHICH configuration, and a system frame number (SFN). Accordingly, the UE may be explicitly aware of information about the DL BW, SFN, and PHICH configuration by receiving the MIB. Meanwhile, information which may be implicitly recognized by the UE through reception of the PBCH includes the number of transmit antenna ports of the eNB. Information about the number of transmit antennas of the eNB is implicitly signaled by masking (e.g. XOR operation) a sequence corresponding to the number of transmit antennas to a 16-bit cyclic redundancy check (CRC) used for error detection of the PBCH.

[70] The SIB1 includes parameters needed to determine if a specific cell is suitable for cell selection, as well as information about time-domain scheduling of the other SIBs. The SIB1 is received by the UE through broadcast signaling or dedicated signaling.

[71] DL carrier frequency and corresponding system bandwidth may be acquired by the MIB carried by the PBCH. UL carrier frequency and corresponding system bandwidth may be acquired by system information which is a DL signal. The UE which has received the MIB applies a DL BW value within the MIB to a UL-bandwidth (UL BW) until system information block type 2 (SystemInformationBlockType2, SIB2) is received if there is no valid system information stored in a corresponding cell. For example, the UE may identify a full UL system band, which may be used by itself for UL transmission, through UL-carrier frequency and UL-bandwidth information within the SIB2 by acquiring system information block type 2 (SystemInformationBlockType2, SIB2).

[72] In the frequency domain, a PSS/SSS and a PBCH are transmitted only in a total of 6 RBs, i.e. a total of 72 subcarriers, irrespective of actual system BW, wherein 3 RBs are in the left and the other 3 RBs are in the right centering on a DC subcarrier on corresponding OFDM symbols. Therefore, the UE is configured to detect or decode the SS and the PBCH irrespective of DL BW configured for the UE.

[73] After initial cell search, the UE may perform a random access procedure to complete access to the eNB. To this end, the UE may transmit a preamble through a physical random access channel (PRACH) and receive a response message to the preamble through a PDCCH and a PDSCH. In contention based random access, the UE may perform additional PRACH transmission and a contention resolution procedure of a PDCCH and a PDSCH corresponding to the PDCCH.

[74] After performing the aforementioned procedure, the UE may perform PDDCH/PDSCH reception and PUSCH/PUCCH transmission as general uplink/downlink transmission procedures.

[75] The random access procedure is also called RACH (random access channel)

procedure. The random access procedure is used for initial access, uplink synchronization adjustment, resource assignment, handover, etc. The random access procedure is classified into a contention-based process and a dedicated (i.e. non-contention-based) process. The contention-based random access procedure includes initial access and is normally used, whereas the dedicated random access procedure is limitedly used for handover. In the contention-based random access procedure, a UE randomly select a RACH preamble sequence. Accordingly, a plurality of UEs can simultaneously transmit the same RACH preamble sequence and thus a contention resolution procedure is not needed. In the dedicated random access procedure, a UE uses a RACH preamble sequence uniquely allocated thereto by an eNB. Accordingly, the UE can perform the random access procedure without colliding with other UEs.

[76] The contention-based random access procedure has the following four steps. Hereinafter, messages transmitted in steps 1 to 4 may be respectively referred to as Msg 1 to Msg 4.

[77] - Step 1: RACH preamble (via PRACH) (UE to eNB)

[78] - Step 2: Random access response (RAR) (via PDCCH and PDSCH) (eNB to UE)

[79] - Step 3: Layer 2/Layer 3 message (via PUSCH) (UE to eNB)

[80] - Step 4: Contention resolution message (eNB to UE)

[81] The dedicated random access procedure includes the following three steps. Hereinafter, uplink transmission (i.e. step 3) corresponding to a RAR may be performed as a part of the random access procedure. The dedicated random access procedure can be triggered using a PDCCH (hereinafter, referred to as PDCCH order) used for an eNB to command RACH preamble transmission.

[82] - Step 0: PACH preamble allocation through dedicated signaling (eNB to UE)

[83] - Step 1: RACH preamble (via PRACH) (UE to eNB)

[84] - Step 2: RAR (via PDCCH and PDSCH) (eNB to UE)

[85] After transmission of RACH preamble, the UE attempts to receive a random access response (RAR) within a predetermined time window. Specifically, the UE attempts to detect a PDCCH (hereinafter, referred to as RA-RNTI PDCCH) having an RA-RNTI (Random Access RNTI) (e.g., CRC is masked with RA-RNTI in the PDCCH) within the time window. The UE checks whether a RAR therefor is present in a PDSCH corresponding to the RA-RNTI PDCCH during RA-RNTI PDCCH detection. The RAR includes timing advance (TA) information indicating timing offset information for UL synchronization, UL resource allocation information (UL grant information), a temporary UE identifier (e.g., temporary cell-RNTI, TC-RNTI), etc. The UE can perform UL transmission (e.g., Msg3) in accordance with resource allocation information and TA value in the RAR. HARQ is applied to UL transmission corresponding to the RAR. Accordingly, the UE can receive acknowledgement information

(e.g., PHICH) corresponding to Msg 3 after transmission of Msg 3.

[86] The random access preamble, i.e., RACH preamble consists of a cyclic prefix of length T_{CP} and a sequence part of length T_{SEQ} in the physical layer. T_{CP} and T_{SEQ} depend on the frame structure and the random access configuration. The preamble format is controlled by higher layers. The following table shows examples of T_{CP} and T_{SEQ}.

[87] [Table 3]

Preamble format	T_{CP}	T_{SEQ}
0	$3168 \cdot T_s$	$24576 \cdot T_s$
1	$21024 \cdot T_s$	$24576 \cdot T_s$
2	$6240 \cdot T_s$	$2 \cdot 24576 \cdot T_s$
3	$21024 \cdot T_s$	$2 \cdot 24576 \cdot T_s$
4(see NOTE)	$448 \cdot T_s$	$4096 \cdot T_s$
NOTE: Frame structure type 2 and special subframe configuration with UpPTS lengths $4384 \cdot T_s$ and $5120 \cdot T_s$ only.		

[88] The random access preamble is transmitted in UL subframe(s). The transmission of a random access preamble is restricted to certain time and frequency resources. These resources are called PRACH resources. The PRACH resources, are enumerated in increasing order of the subframe number within the radio frame and the PRBs in the frequency domain such that index 0 correspond to the lowest numbered PRB and subframe within the radio frame. PRACH resources within the radio frame are indicated by a PRACH configuration index.

[89] For frame structure type 1 with preamble format 0-3, for each of the PRACH configurations there is at most one random access resource per subframe. The following table shows examples of the preamble formats and the subframes in which random access preamble transmission is allowed for a given configuration in frame structure type 1. The PRACH configuration index is given by a higher layer signal (transmitted by an eNB).

[90] [Table 4]

PRACH Configuration Index	Preamble Format	SFN	Subframe number	PRACH Configuration Index	Preamble Format	SFN	Subframe number
0	0	Even	1	32	2	Even	1
1	0	Even	4	33	2	Even	4
2	0	Even	7	34	2	Even	7
3	0	Any	1	35	2	Any	1
4	0	Any	4	36	2	Any	4
5	0	Any	7	37	2	Any	7
6	0	Any	1,6	38	2	Any	1,6
7	0	Any	2,7	39	2	Any	2,7
8	0	Any	3,8	40	2	Any	3,8
9	0	Any	1,4,7	41	2	Any	1,4,7
10	0	Any	2,5,8	42	2	Any	2,5,8
11	0	Any	3,6,9	43	2	Any	3,6,9
12	0	Any	0,2,4,6,8	44	2	Any	0,2,4,6,8
13	0	Any	1,3,5,7,9	45	2	Any	1,3,5,7,9
14	0	Any	0,1,2,3,4,5,6,7,8,9	46	N/A	N/A	N/A
15	0	Even	9	47	2	Even	9
16	1	Even	1	48	3	Even	1
17	1	Even	4	49	3	Even	4
18	1	Even	7	50	3	Even	7
19	1	Any	1	51	3	Any	1
20	1	Any	4	52	3	Any	4
21	1	Any	7	53	3	Any	7
22	1	Any	1,6	54	3	Any	1,6
23	1	Any	2,7	55	3	Any	2,7
24	1	Any	3,8	56	3	Any	3,8
25	1	Any	1,4,7	57	3	Any	1,4,7

26	1	Any	2,5,8	58	3	Any	2,5,8
27	1	Any	3,6,9	59	3	Any	3,6,9
28	1	Any	0,2,4,6,8	60	N/A	N/A	N/A
29	1	Any	1,3,5,7,9	61	N/A	N/A	N/A
30	N/A	N/A	N/A	62	N/A	N/A	N/A
31	1	Even	9	63	3	Even	9

[91] In Table 4, SFN denotes a system frame number.

[92] The first PRB, n^{RA}_{PRB}, allocated to the PRACH opportunity considered for preamble formats 0, 1, 2 and 3 is defined by $n^{RA}_{PRB}=n^{RA}_{PRBoffset}$, where the PRACH frequency offset $n^{RA}_{PRBoffset}$ is a PRB configured by higher layers and satisfies $0\leq n^{RA}_{PRBoffset}\leq N^{UL}_{RB}-6$.

[93] In case of frame structure type 2 with preamble formats 0 to 4, a plurality of random access resources may exist within UL subframe (or UpPTS for preamble format 4) in accordance with UL/DL configuration. The random access resources for the frame structure type 2 are defined in accordance with PRACH configuration index (see 3GPP TS 36.211 standard document).

[94] FIG. 4 illustrates the structure of a DL subframe used in a wireless communication system.

[95] Referring to FIG. 4, A DL subframe is divided into a control region and a data region in the time domain. Referring to FIG. 4, a maximum of 3 (or 4) OFDM symbols located in a front part of a first slot of a subframe corresponds to the control region. Hereinafter, a resource region for PDCCH transmission in a DL subframe is referred to as a PDCCH region. OFDM symbols other than the OFDM symbol(s) used in the control region correspond to the data region to which a physical downlink shared channel (PDSCH) is allocated. Hereinafter, a resource region available for PDSCH transmission in the DL subframe is referred to as a PDSCH region.

[96] Examples of a DL control channel used in 3GPP LTE include a physical control format indicator channel (PCFICH), a physical downlink control channel (PDCCH), a physical hybrid ARQ indicator channel (PHICH), etc.

[97] The PCFICH is transmitted in the first OFDM symbol of a subframe and carries information about the number of OFDM symbols available for transmission of a control channel within a subframe. The PCFICH notifies the UE of the number of OFDM symbols used for the corresponding subframe every subframe. The PCFICH is located at the first OFDM symbol. The PCFICH is configured by four resource element groups (REGs), each of which is distributed within a control region on the basis of cell ID. One REG includes four REs.

[98] A set of OFDM symbols available for the PDCCH at a subframe is given by the following Table.

[99] [Table 5]

Subframe	Number of OFDM symbols for PDCCH when $N^{DL}_{RB}>10$	Number of OFDM symbols for PDCCH when $N^{DL}_{RB}\leq 10$
Subframe 1 and 6 for frame structure type 2	1, 2	2
MBSFN subframes on a carrier supporting PDSCH, configured with 1 or 2 cell-specfic antenna ports	1, 2	2
MBSFN subframes on a carrier supporting PDSCH, configured with 4 cell-specific antenna ports	2	2
Subframes on a carrier not supporting PDSCH	0	0
Non-MBSFN subframes (except subframe 6 for frame structure type 2) configured with positioning reference signals	1, 2, 3	2, 3
All other cases	1, 2, 3	2, 3, 4

[100] A subset of downlink subframes within a radio frame on a carrier for supporting PDSCH transmission may be configured as MBSFN subframe(s) by a higher layer. Each MBSFN subframe is divided into a non-MBSFN region and an MBSFN region. The non-MBSFN region spans first one or two OFDM symbols, and its length is given by Table 5. The same CP as cyclic prefix (CP) used for subframe 0 is used for transmission within the non-MBSFN region of the MBSFN subframe. The MBSFN region within the MBSFN subframe is defined as OFDM symbols which are not used in the non-MBSFN region.

[101] The PCFICH carries a control format indicator (CFI), which indicates any one of values of 1 to 3. For a downlink system bandwidth $N^{DL}_{RB}>10$, the number 1, 2 or 3 of OFDM symbols which are spans of DCI carried by the PDCCH is given by the CFI. For a downlink system bandwidth $N^{DL}_{RB}\leq 10$, the number 2, 3 or 4 of OFDM symbols which are spans of DCI carried by the PDCCH is given by CFI+1. The CFI is coded in accordance with the following Table.

[102] [Table 6]

CFI	CFI code word<b_0, b_1, ..., b_{31}>
1	<0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1>
2	<1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0>
3	<1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1>
4(Reserved)	<0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0>

[103] The PHICH carries a HARQ (Hybrid Automatic Repeat Request) ACK/NACK (acknowledgment/negative-acknowledgment) signal as a response to UL transmission. The PHICH includes three REGs, and is scrambled cell-specifically. ACK/NACK is indicated by 1 bit, and the ACK/NACK of 1 bit is repeated three times. Each of the repeated ACK/NACK bits is spread with a spreading factor (SF) 4 or 2 and then mapped into a control region.

[104] The control information transmitted through the PDCCH will be referred to as downlink control information (DCI). The DCI includes resource allocation information for a UE or UE group and other control information. Transmit format and resource allocation information of a downlink shared channel (DL-SCH) are referred to as DL scheduling information or DL grant. Transmit format and resource allocation information of an uplink shared channel (UL-SCH) are referred to as UL scheduling information or UL grant. The size and usage of the DCI carried by one PDCCH are varied depending on DCI formats. The size of the DCI may be varied depending on a coding rate. In the current 3GPP LTE system, various formats are defined, wherein formats 0 and 4 are defined for a UL, and formats 1, 1A, 1B, 1C, 1D, 2, 2A, 2B, 2C, 3 and 3A are defined for a DL. Combination selected from control information such as a hopping flag, RB allocation, modulation coding scheme (MCS), redundancy version (RV), new data indicator (NDI), transmit power control (TPC), cyclic shift, cyclic shift demodulation reference signal (DM RS), UL index, channel quality information (CQI) request, DL assignment index, HARQ process number, transmitted precoding matrix indicator (TPMI), precoding matrix indicator (PMI) information is transmitted to the UE as the DCI. The following table shows examples of DCI formats.

[105] [Table 7]

DCI format	Description
0	Resource grants for the PUSCH transmissions (uplink)
1	Resource assignments for single codeword PDSCH transmissions
1A	Compact signaling of resource assignments for single codeword PDSCH
1B	Compact signaling of resource assignments for single codeword PDSCH
1C	Very compact resource assignments for PDSCH (e.g. paging/broadcast system information)
1D	Compact resource assignments for PDSCH using multi-user MIMO
2	Resource assignments for PDSCH for closed-loop MIMO operation
2A	Resource assignments for PDSCH for open-loop MIMO operation
2B	Resource assignments for PDSCH using up to 2 antenna ports with UE-specific reference signals
2C	Resource assignment for PDSCH using up to 8 antenna ports with UE-specific reference signals
3/3A	Power control commands for PUCCH and PUSCH with 2-bit/1-bit power adjustments
4	Scheduling of PUSCH in one UL Component Carrier with multi-antenna port transmission mode

[106] Other DCI formats in addition to the DCI formats defined in Table 7 may be defined.

[107] A plurality of PDCCHs may be transmitted within a control region. A UE may monitor the plurality of PDCCHs. An eNB determines a DCI format depending on the DCI to be transmitted to the UE, and attaches cyclic redundancy check (CRC) to the DCI. The CRC is masked (or scrambled) with an identifier (for example, a radio network temporary identifier (RNTI)) depending on usage of the PDCCH or owner of the PDCCH. For example, if the PDCCH is for a specific UE, the CRC may be masked with an identifier (for example, cell-RNTI (C-RNTI)) of the corresponding UE. If the PDCCH is for a paging message, the CRC may be masked with a paging identifier (for example, paging-RNTI (P-RNTI)). If the PDCCH is for system information (in more detail, system information block (SIB)), the CRC may be masked with system information RNTI (SI-RNTI). If the PDCCH is for a random access response, the CRC may be masked with a random access RNTI (RA-RNTI). For example, CRC masking

(or scrambling) includes XOR operation of CRC and RNTI at the bit level.

[108] Generally, a DCI format, which may be transmitted to the UE, is varied depending on a transmission mode configured for the UE. In other words, certain DCI format(s) corresponding to the specific transmission mode not all DCI formats may only be used for the UE configured to a specific transmission mode.

[109] For example, a transmission mode is semi-statically configured for the UE by a higher layer so that the UE may receive a PDSCH transmitted in accordance with one of a plurality of transmission modes which are previously defined. The UE attempts to decode a PDCCH using DCI formats only corresponding to its transmission mode. In other words, in order to maintain UE operation load according to blind decoding attempt, at a certain level or less, all DCI formats are not searched by the UE at the same time. Table 8 illustrates transmission modes for configuring multi-antenna technology and DCI formats for allowing a UE to perform blind decoding at the corresponding transmission mode. Particularly, Table 8 illustrates a relation between PDCCH and PDSCH configured by C-RNTI (Cell RNTI(Radio Network Temporary Identifier)).

[110] [Table 8]

Transmission mode	DCI format	Search Space	Transmission scheme of PDSCH corresponding to PDCCH
Mode 1	DCI format 1A	Common andUE specific by C-RNTI	Single-antenna port, port 0
	DCI format 1	UE specific by C-RNTI	Single-antenna port, port 0
Mode 2	DCI format 1A	Common andUE specific by C-RNTI	Transmit diversity
	DCI format 1	UE specific by C-RNTI	Transmit diversity
Mode 3	DCI format 1A	Common andUE specific by C-RNTI	Transmit diversity
	DCI format 2A	UE specific by C-RNTI	Large delay CDD or Transmit diversity
Mode 4	DCI format 1A	Common andUE specific by C-RNTI	Transmit diversity
	DCI format 2	UE specific by C-RNTI	Closed-loop spatial multiplexing or Transmit diversity
Mode 5	DCI format 1A	Common andUE specific by C-RNTI	Transmit diversity
	DCI format 1D	UE specific by C-RNTI	Multi-user MIMO
Mode 6	DCI format 1A	Common andUE specific by C-RNTI	Transmit diversity
	DCI format 1B	UE specific by C-RNTI	Closed-loop spatial multiplexing using a single transmission layer
Mode 7	DCI format	Common andUE	If the number of PBCH antenna ports

	1A	specific by C-RNTI	is one, Single-antenna port, port 0 is used, otherwise Transmit diversity
	DCI format 1	UE specific by C-RNTI	Single-antenna port, port 5
Mode 8	DCI format 1A	Common andUE specific by C-RNTI	If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used, otherwise Transmit diversity
	DCI format 2B	UE specific by C-RNTI	Dual layer transmission, port 7 and 8 or single-antenna port, port 7 or 8
Mode 9	DCI format 1A	Common andUE specific by C-RNTI	Non-MBSFN subframe: If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used, otherwise Transmit diversity.MBSFN subframe: Single-antenna port, port 7
	DCI format 2C	UE specific by C-RNTI	Up to 8 layer transmission, ports 7-14 or single-antenna port, port 7 or 8
Mode 10	DCI format 1A	Common andUE specific by C-RNTI	Non-MBSFN subframe: If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used, otherwise Transmit diversity.MBSFN subframe: Single-antenna port, port 7
	DCI format 2D	UE specific by C-RNTI	Up to 8 layer transmission, ports 7-14 or single antenna port, port 7 or 8

[111] Although transmission modes 1 to 10 are listed in Table 8, other transmission modes in addition to the transmission modes defined in Table 8 may be defined.

[112] Referring to Table 8, a UE configured to a transmission mode 9, for example, tries to decode PDCCH candidates of a UE-specific search space (USS) to a DCI format 1A, and tries to decode PDCCH candidates of a common search space (CSS) and the USS to a DCI format 2C. The UE may decode a PDSCH in accordance with DCI based on the DCI format successfully decoded. If DCI decoding from one of a plurality of PDCCH candidates to the DCI format 1A is successfully performed, the UE may decode the PDSCH by assuming that up to 8 layers from antenna ports 7 to 14 are transmitted thereto through the PDSCH, or may decode the PDSCH by assuming that a single layer from the antenna port 7 or 8 is transmitted thereto through the PDSCH.

[113] The PDCCH is allocated to first m number of OFDM symbol(s) within a subframe.

In this case, m is an integer equal to or greater than 1, and is indicated by the PCFICH.

[114] The PDCCH is transmitted on an aggregation of one or a plurality of continuous control channel elements (CCEs). The CCE is a logic allocation unit used to provide a coding rate based on the status of a radio channel to the PDCCH. The CCE corresponds to a plurality of resource element groups (REGs). For example, one CCE corresponds to nine resource element groups (REGs), and one REG corresponds to four REs. Four QPSK symbols are mapped to each REG. A resource element (RE) occupied by the reference signal (RS) is not included in the REG. Accordingly, the number of REGs within given OFDM symbols is varied depending on the presence of the RS. The REGs are also used for other downlink control channels (that is, PCFICH and PHICH).

[115] Assuming that the number of REGs not allocated to the PCFICH or the PHICH is N_{REG}, the number of available CCEs in a DL subframe for PDCCH(s) in a system is numbered from 0 to N_{CCE}—1, where $N_{CCE} = \text{floor}(N_{REG}/9)$.

[116] A PDCCH format and the number of DCI bits are determined in accordance with the number of CCEs. The CCEs are numbered and consecutively used. To simplify the decoding process, a PDCCH having a format including n CCEs may be initiated only on CCEs assigned numbers corresponding to multiples of n. The number of CCEs used for transmission of a specific PDCCH is determined by a network or the eNB in accordance with channel status. For example, one CCE may be required for a PDCCH for a UE (for example, adjacent to eNB) having a good downlink channel. However, in case of a PDCCH for a UE (for example, located near the cell edge) having a poor channel, eight CCEs may be required to obtain sufficient robustness. Additionally, a power level of the PDCCH may be adjusted to correspond to a channel status.

[117] In a 3GPP LTE/LTE-A system, a set of CCEs on which a PDCCH can be located for each UE is defined. A CCE set in which the UE can detect a PDCCH thereof is referred to as a PDCCH search space or simply as a search space (SS). An individual resource on which the PDCCH can be transmitted in the SS is called a PDCCH candidate. A set of PDCCH candidates that the UE is to monitor is defined in terms of SSs, where a search space $S^{(L)}_k$ at aggregation level $L \in \{1,2,4,8\}$ is defined by a set of PDCCH candidates. SSs for respective PDCCH formats may have different sizes and a dedicated SS and a common SS are defined. The dedicated SS is a UE-specific SS (USS) and is configured for each individual UE. The common SS (CSS) is configured for a plurality of UEs.

[118] The following table shows an example of aggregation levels for defining SS.

[119] [Table 9]

Search space $S^{(L)}_k$			Number of PDCCH candidates $M^{(L)}$
Type	Aggregation level L	Size [in CCEs]	
UE-specific	1	6	6
	2	12	6
	4	8	2
	8	16	2
Common	4	16	4
	8	16	2

[120] For each serving cell on which PDCCH is monitored, the CCEs corresponding to PDCCH candidates m of the search space $S^{(L)}_k$ are configured by "$L*\{Y_k+m'\}$ mod floor($N_{CCE,k}/L\}+i$", where i=0,...,L—1. For the common search space $m'=m$. For the PDCCH UE specific search space, for the serving cell on which PDCCH is monitored, if the monitorng UE is configured with carrier indicator field then $m'=m+M^{(L)}*n_{CI}$ where n_{CI} is the carrier indicator field (CIF) value, else if the monitoring UE is not configured with carrier indicator field then $m'=m$, where m=0,1,...,$M^{(L)}$—1. $M^{(L)}$ is the number of PDCCH candidates to monitor at aggregation level L in the given search space. The carrier indication field value can be the same as a serving cell index (*Serv-CellIndex*). For the common search space, Y_k is set to 0 for the two aggregation levels L=4 and L=8. For the UE-specific search space $S^{(L)}_k$ at aggregation level D, the variable Y_k is defined by "$Y_k = (A\cdot Y_{k-1})$ mod D", where $Y_{-1}=n_{RNTI}\neq 0$, A=39827, D=65537 and k =floor(n_s/2). n_s is the slot number within a radio frame.

[121] The eNB transmits an actual PDCCH (DCI) on a PDCCH candidate in a search space and the UE monitors the search space to detect the PDCCH (DCI). Here, monitoring implies attempting to decode each PDCCH in the corresponding SS according to all monitored DCI formats. The UE may detect a PDCCH thereof by monitoring a plurality of PDCCHs. Basically, the UE does not know the location at which a PDCCH thereof is transmitted. Therefore, the UE attempts to decode all PDCCHs of the corresponding DCI format for each subframe until a PDCCH having an ID thereof is detected and this process is referred to as blind detection (or blind decoding (BD)).

[122] For example, it is assumed that a specific PDCCH is CRC-masked with a radio network temporary identity (RNTI) 'A' and information about data transmitted using a radio resource 'B' (e.g. frequency location) and using transport format information 'C' (e.g. transmission block size, modulation scheme, coding information, etc.) is transmitted in a specific DL subframe. Then, the UE monitors the PDCCH using RNTI

information thereof. The UE having the RNTI 'A' receives the PDCCH and receives the PDSCH indicated by 'B' and 'C' through information of the received PDCCH.

[123] FIG. 5 illustrates the structure of a UL subframe used in a wireless communication system.

[124] Referring to FIG. 5, a UL subframe may be divided into a data region and a control region in the frequency domain. One or several PUCCHs may be allocated to the control region to deliver UCI. One or several PUSCHs may be allocated to the data region of the UE subframe to carry user data.

[125] In the UL subframe, subcarriers distant from a direct current (DC) subcarrier are used as the control region. In other words, subcarriers located at both ends of a UL transmission BW are allocated to transmit UCI. A DC subcarrier is a component unused for signal transmission and is mapped to a carrier frequency f_0 in a frequency up-conversion process. A PUCCH for one UE is allocated to an RB pair belonging to resources operating on one carrier frequency and RBs belonging to the RB pair occupy different subcarriers in two slots. The PUCCH allocated in this way is expressed by frequency hopping of the RB pair allocated to the PUCCH over a slot boundary. If frequency hopping is not applied, the RB pair occupies the same subcarriers.

[126] The PUCCH may be used to transmit the following control information.

[127] - Scheduling request (SR): SR is information used to request a UL-SCH resource and is transmitted using an on-off keying (OOK) scheme.

[128] - HARQ-ACK: HARQ-ACK is a response to a PDCCH and/or a response to a DL data packet (e.g. a codeword) on a PDSCH. HARQ-ACK indicates whether the PDCCH or PDSCH has been successfully received. 1-bit HARQ-ACK is transmitted in response to a single DL codeword and 2-bit HARQ-ACK is transmitted in response to two DL codewords. A HARQ-ACK response includes a positive ACK (simply, ACK), negative ACK (NACK), discontinuous transmission (DTX), or NACK/DRX. HARQ-ACK is used interchangeably with HARQ ACK/NACK and ACK/NACK.

[129] - Channel state information (CSI): CSI is feedback information for a DL channel. CSI may include channel quality information (CQI), a precoding matrix indicator (PMI), a precoding type indicator, and/or a rank indicator (RI). In the CSI, MIMO-related feedback information includes the RI and the PMI. The RI indicates the number of streams or the number of layers that the UE can receive through the same time-frequency resource. The PMI is a value reflecting a space characteristic of a channel, indicating an index of a preferred precoding matrix for DL signal transmission based on a metric such as an SINR. The CQI is a value of channel strength, indicating a received SINR that can be obtained by the UE generally when the eNB uses the PMI.

[130] A general wireless communication system performs data transmission/reception through one downlink (DL) band and through one uplink (UL) band corresponding to

the DL band (in case of a frequency division duplex (FDD) mode), or divides a prescribed radio frame into a UL time unit and a DL time unit in the time domain and then performs data transmission/reception through the UL/DL time unit (in case of a time division duplex (TDD) mode). Recently, to use a wider frequency band in recent wireless communication systems, introduction of carrier aggregation (or BW aggregation) technology that uses a wider UL/DL BW by aggregating a plurality of UL/DL frequency blocks has been discussed. A carrier aggregation (CA) is different from an orthogonal frequency division multiplexing (OFDM) system in that DL or UL communication is performed using a plurality of carrier frequencies, whereas the OFDM system carries a base frequency band divided into a plurality of orthogonal subcarriers on a single carrier frequency to perform DL or UL communication. Hereinbelow, each of carriers aggregated by carrier aggregation will be referred to as a component carrier (CC).

[131] For example, three 20MHz CCs may be aggregated on each of a UL and a DL to support a bandwidth of 60MHz. The respective CCs may be contiguous or non-contiguous in the frequency domain. For convenience, although it has been described that the bandwidth of UL CC and the bandwidth of DL CC are the same as each other and symmetric to each other, the bandwidth of each CC may be independently determined. Asymmetrical carrier aggregation in which the number of UL CCs is different from the number of DL CCs may be implemented. DL/UL CC limited to a specific UE may be referred to as a serving UL/DL CC configured for the specific UE.

[132] Meanwhile, the 3GPP LTE-A standard uses the concept of a cell to manage radio resources. The "cell" associated with the radio resources is defined by combination of downlink resources and uplink resources, that is, combination of DL CC and UL CC. The cell may be configured by downlink resources only, or may be configured by downlink resources and uplink resources. If carrier aggregation is supported, linkage between a carrier frequency of the downlink resources (or DL CC) and a carrier frequency of the uplink resources (or UL CC) may be indicated by system information. For example, combination of the DL resources and the UL resources may be indicated by linkage of system information block type 2 (SIB2). In this case, the carrier frequency means a center frequency of each cell or CC. A cell operating on a primary frequency may be referred to as a primary cell (Pcell) or PCC, and a cell operating on a secondary frequency may be referred to as a secondary cell (Scell) or SCC. The carrier corresponding to the Pcell on downlink will be referred to as a downlink primary CC (DL PCC), and the carrier corresponding to the Pcell on uplink will be referred to as an uplink primary CC (UL PCC). A Scell means a cell that may be configured after completion of radio resource control (RRC) connection establishment and used to provide additional radio resources. The Scell may form a set of serving cells for the UE

together with the Pcell in accordance with capabilities of the UE. The carrier corresponding to the Scell on the downlink will be referred to as downlink secondary CC (DL SCC), and the carrier corresponding to the Scell on the uplink will be referred to as uplink secondary CC (UL SCC). Although the UE is in RRC-CONNECTED state, if it is not configured by carrier aggregation or does not support carrier aggregation, a single serving cell configured by the Pcell only exists.

[133] The eNB may activate all or some of the serving cells configured in the UE or deactivate some of the serving cells for communication with the UE. The eNB may change the activated/deactivated cell, and may change the number of cells which is/are activated or deactivated. If the eNB allocates available cells to the UE cell-specifically or UE-specifically, at least one of the allocated cells is not deactivated unless cell allocation to the UE is fully reconfigured or unless the UE performs handover. Such a cell which is not deactivated unless CC allocation to the UE is fully reconfigured will be referred to as Pcell, and a cell which may be activated/deactivated freely by the eNB will be referred to as Scell. The Pcell and the Scell may be discriminated from each other on the basis of the control information. For example, specific control information may be set to be transmitted and received through a specific cell only. This specific cell may be referred to as the Pcell, and the other cell(s) may be referred to as Scell(s).

[134] A configured cell refers to a cell in which carrier aggregation is performed for a UE based on measurement report from another eNB or UE among cells of an eNB and is configured per UE. The cell configured for the UE may be a serving cell in terms of the UE. For the cell configured for the UE, i.e. the serving cell, resources for ACK/NACK transmission for PDSCH transmission are reserved in advance. An activated cell refers to a cell configured to be actually used for PDSCH/PUSCH transmission among cells configured for the UE and CSI reporting and SRS transmission for PDSCH/PUSCH transmission are performed in the activated cell. A deactivated cell refers to a cell configured not to be used for PDSCH/PUSCH transmission by the command of an eNB or the operation of a timer and, if a cell is deactivated, CSI reporting and SRS transmission are also stopped in the cell.

[135] For reference, a carrier indicator (CI) denots a serving cell index (*ServCellIndex*), CI=0 is applied to Pcell. The serving cell index is a short ID used to identify a serving cell. For example, any one of integers from 0 to 'maximum number of carrier frequencies which can be configured for the UE at a time - 1' may be allocated to one serving cell as the serving cell index. That is, the serving cell index may be a logical index used to identify a specific serving cell among cells allocated to the UE rather than a physical index used to identify a specific carrier frequency among all carrier frequencies.

[136] Meanwhile, the 3GPP LTE-A standard uses the concept of a cell to manage radio

resources.

[137] The cell mentioned in the present invention means a cell of carrier aggregation which is combination of UL CC and DL CC unless specifically noted.

[138] Meanwhile, since one serving cell is only present in case of communication based on a single carrier, a PDCCH carrying UL/DL grant and corresponding PUSCH/PDSCH are transmitted on one cell. In other words, in case of FDD under a single carrier environment, a PDCCH for a DL grant for a PDSCH, which will be transmitted on a specific DL CC, is transmitted on the specific CC, and a PDCCH for a UL grant for a PUSCH, which will be transmitted on a specific UL CC, is transmitted on a DL CC linked to the specific UL CC. In case of TDD under a single carrier environment, a PDCCH for a DL grant for a PDSCH, which will be transmitted on a specific DL CC, is transmitted on the specific CC, and a PDCCH for a UL grant for a PUSCH, which will be transmitted on a specific UL CC, is transmitted on the specific CC.

[139] On the contrary, since a plurality of serving cells may be configured in a multi-carrier system, transmission of UL/DL grant through a serving cell having a good channel status may be allowed. In this way, if a cell carrying UL/DL grant which is scheduling information is different from a cell where UL/DL transmission corresponding to the UL/DL grant is performed, this will be referred to as cross-carrier scheduling.

[140] Hereinafter, the case where the cell is scheduled from itself and the case where the cell is scheduled from another cell will be referred to as self-CC scheduling and cross-CC scheduling, respectively.

[141] For data transmission rate enhancement and stable control signaling, the 3GPP LTE/LTE-A may support aggregation of a plurality of CCs and a cross carrier-scheduling operation based on the aggregation.

[142] If cross-carrier scheduling (or cross-CC scheduling) is applied, a PDCCH for downlink allocation for a DL CC B or DL CC C, that is, carrying a DL grant may be transmitted through a DL CC A, and a corresponding PDSCH may be transmitted through the DL CC B or DL CC C. For cross-CC scheduling, a carrier indicator field (CIF) may be introduced. The presence or absence of the CIF within the PDCCH may be semi-statically and UE-specifically (or UE-group-specifically) configured by higher layer signaling (e.g., RRC signaling).

[143] Meanwhile, if RRH technology, cross-carrier scheduling technology, etc. are introduced, the amount of PDCCH which should be transmitted by the eNB is gradually increased. However, since a size of a control region within which the PDCCH may be transmitted is the same as before, PDCCH transmission acts as a bottleneck of system throughput. Although channel quality may be improved by the introduction of the aforementioned multi-node system, application of various communication schemes, etc., the introduction of a new control channel is required to apply the legacy commu-

nication scheme and the carrier aggregation technology to a multi-node environment. Due to the need, a configuration of a new control channel in a data region (hereinafter, referred to as PDSCH region) not the legacy control region (hereinafter, referred to as PDCCH region) has been discussed. Hereinafter, the new control channel will be referred to as an enhanced PDCCH (hereinafter, referred to as EPDCCH).

[144] The EPDCCH may be configured within rear OFDM symbols starting from a configured OFDM symbol, instead of front OFDM symbols of a subframe. The EPDCCH may be configured using continuous frequency resources, or may be configured using discontinuous frequency resources for frequency diversity. By using the EPDCCH, control information per node may be transmitted to a UE, and a problem that a legacy PDCCH region may not be sufficient may be solved. For reference, the PDCCH may be transmitted through the same antenna port(s) as that(those) configured for transmission of a CRS, and a UE configured to decode the PDCCH may demodulate or decode the PDCCH by using the CRS. Unlike the PDCCH transmitted based on the CRS, the EPDCCH is transmitted based on the demodulation RS (hereinafter, DMRS). Accordingly, the UE decodes/demodulates the PDCCH based on the CRS and decodes/demodulates the EPDCCH based on the DMRS. The DMRS associated with EPDCCH is transmitted on the same antenna port $p \in \{107,108,109,110\}$ as the associated EPDCCH physical resource, is present for EPDCCH demodulation only if the EPDCCH transmission is associated with the corresponding antenna port, and is transmitted only on the PRB(s) upon which the corresponding EPDCCH is mapped. For example, the REs occupied by the UE-RS(s) of the antenna port 7 or 8 may be occupied by the DMRS(s) of the antenna port 107 or 108 on the PRB to which the EPDCCH is mapped, and the REs occupied by the UE-RS(s) of antenna port 9 or 10 may be occupied by the DMRS(s) of the antenna port 109 or 110 on the PRB to which the EPDCCH is mapped. In other words, a certain number of REs are used on each RB pair for transmission of the DMRS for demodulation of the EPDCCH regardless of the UE or cell if the type of EPDCCH and the number of layers are the same as in the case of the UE-RS for demodulation of the PDSCH.

[145] For each serving cell, higher layer signalling can configure a UE with one or two EPDCCH-PRB-sets for EPDCCH monitoring. The PRB-pairs corresponding to an EPDCCH-PRB-set are indicated by higher layers. Each EPDCCH-PRB-set consists of set of ECCEs numbered from 0 to $N_{ECCE,p,k}$—1, where $N_{ECCE,p,k}$ is the number of ECCEs in EPDCCH-PRB-set p of subframe k. Each EPDCCH-PRB-set can be configured for either localized EPDCCH transmission or distributed EPDCCH transmission.

[146] The UE shall monitor a set of EPDCCH candidates on one or more activated serving cells as configured by higher layer signaling for control information.

[147] The set of EPDCCH candidates to monitor are defined in terms of EPDCCH UE-

specific search spaces. For each serving cell, the subframes in which the UE monitors EPDCCH UE-specific search spaces are configured by higher layers.

[148] An EPDCCH UE-specific search space $ES^{(L)}_k$ at aggregation level $L \in \{1,2,4,8,16,32\}$ is defined by a set of EPDCCH candidates.

[149] For an EPDCCH-PRB-set p, the ECCEs corresponding to EPDCCH candidate m of the search space $ES^{(L)}_k$ are given by the following equation.

[150] [Math.1]

$$L\left\{ (Y_{p,k} + \left\lfloor \frac{m \cdot N_{ECCE,p,k}}{L \cdot M_p^{(L)}} \right\rfloor + b) \bmod \lfloor N_{\mathrm{ECCE},p,k} / L \rfloor \right\} + i$$

[151] where $i=0,\ldots,L-1$. $b=n_{CI}$ if the UE is configured with a carrier indicator field for the serving cell on which EPDCCH is monitored, otherwise $b=0$. n_{CI} is the carrier indicator field (CIF) value, which is the same as a serving cell index (*ServCellIndex*). $m=0,1,\ldots,$ $M^{(L)}_p-1$, $M^{(L)}_p$ is the number of EPDCCH candidates to monitor at aggregation level L in EPDDCH-PRB-set p. The variable $Y_{p,k}$ is defined by '$Y_{p,k} = (A_p \cdot Y_{p,k-1}) \bmod D$', where $Y_{p,-1}=n_{RNTI} \neq 0$, $A_0=39827$, $A_0=39829$,$D=65537$ and $k=\mathrm{floor}(n_s/2)$. n_s is the slot number within a radio frame.

[152] A UE is not expected to monitor an EPDCCH candidate, if an ECCE corresponding to that EPDCCH candidate is mapped to a PRB pair that overlaps in frequency with a transmission of either PBCH or PSS/SSS in the same subframe.

[153] An EPDCCH is transmitted using an aggregation of one or several consecutive enhanced control channel elements (ECCEs). Each ECCE consists of multiple enhanced resource element groups (EREGs). EEREGs are used for defining the mapping of enhanced control channels to resource elements. There are 16 EREGs, numbered from 0 to 15, per physical resource block (PRB) pair. Number all resource elements (REs), except resource elements carrying DMRS (hereinafter EPDCCH DMRS) for demoduation of the EPDCCH, in a physical resource-block pair cyclically from 0 to 15 in an increasing order of first frequency, then time. Therefore all the REs, except REs carrying the EPDCCH DMRS, in the PRB pair has any one of numbers 0 to 15. All REs with number i in that PRB pair constitutes EREG number i.As described above, it is noted that EREGs are distributed on frequency and time axes within the PRB pair and an EPDCCH transmitted using aggregation of one or more ECCEs, each of which includes a plurality of EREGs, is also distributed on frequency and time axes within the PRB pair.

[154] The number of ECCEs used for one EPDCCH depends on the EPDCCH format as given by Table 10, the number of EREGs per ECCE is given by Table 11. Table 10 shows an example of supported EPDCCH formats, and Table 11 shows an example of

the number of EREGs per ECCE, N^{EREG}_{ECCE}. Both localized and distributed transmission is supported.

[155] [Table 10]

EPDCCH format	Number of ECCEs for one EPDCCH, N^{ECCE}_{EPDCCH}			
	Case A		Case B	
	Localized transmission	Distributed transmission	Localized transmission	Distributed transmission
0	2	2	1	1
1	4	4	2	2
2	8	8	4	4
3	16	16	8	8
4	-	32	-	16

[156] [Table 11]

Normal cyclic prefix			Extended cyclic prefix	
Normal subframe	Special subframe,configuration3, 4, 8	Special subframe,configuration1, 2, 6, 7, 9	Normal subframe	Special subframe,configuration1, 2, 3, 5, 6
4		8		

[157] An EPDCCH can use either localized or distributed transmission, differing in the mapping of ECCEs to EREGs and PRB pairs. One or two sets of PRB pairs which a UE shall monitor for EPDCCH transmissions can be configured. All EPDCCH candidates in EPDCCH set S_p (i.e., EPDCCH-PRB-set) use either only localized or only distributed transmission as configured by higher layers. Within EPDCCH set S_p in subframe k, the ECCEs available for transmission of EPDCCHs are numbered from 0 to $N_{ECCE,p,k}$—1. ECCE number n is corresponding to the following EREG(s):

[158] - EREGs numbered $(n \bmod N^{ECCE}_{RB})+jN^{ECCE}_{RB}$ in PRB index floor(n/N^{ECCE}_{RB}) for localized mapping, and

[159] - EREGs numbered floor $(n/N^{Sm}_{RB})+jN^{ECCE}_{RB}$ in PRB indices $(n+j\max(1,N^{Sp}_{RB}/N^{EREG}_{ECCE}))\bmod N^{Sp}_{RB}$ for distributed mapping,

[160] where $j=0,1,\ldots,N^{EREG}_{ECCE}-1$, N^{EREG}_{ECCE} is the number of EREGs per ECCE, and $N^{ECCE}_{RB}=16/N^{EREG}_{ECCE}$ is the number of ECCEs per RB pair. The PRB pairs constituting EPDCCH set S_p are assumed to be numbered in ascending order from 0 to $N^{Sp}_{RB}-1$.

[161] Case A in Table 10 applies when:

[162] - DCI formats 2, 2A, 2B, 2C or 2D is used and $N^{DL}_{RB}\geq 25$, or

[163] - any DCI format when n_{EPDCCH}<104 and normal cyclic prefix is used in normal subframes or special subframes with configuration 3, 4, 8.

[164] Otherwise case B is used. The quantity n_{EPDCCH} for a particular UE is defined as the number of downlink resource elements (k,l) in a PRB pair configured for possible EPDCCH transmission of EPDCCH set S_0 and and fulfilling all of the following criteria,

[165] - they are part of any one of the 16 EREGs in the physical resource-block pair,

[166] - they are assumed by the UE not to be used for CRSs or CSI-RSs,

[167] - the index l in a subframe fulfils $l \geq l_{EPDCCHStart}$.

[168] where $l_{EPDCCHStart}$ is given based on higher layer signaling '*epdcch*-StartSymbol-r11', higher layer signaling '*pdsch*-Start-r11', or CFI value carried by PCFICH.

[169] The mapping to resource elements (k,l) on antenna port p meeting the criteria above is in increasing order of first the index k and then the index l, starting with the first slot and ending with the second slot in a subframe.

[170] For localized transmission, the single antenna port p to use is given by Table 12 with $n' = n_{ECCE,low} \bmod N^{ECCE}_{RB} + n_{RNTI} \bmod \min(N^{ECCE}_{EPDCCH}, N^{ECCE}_{RB})$, where $n_{ECCE,low}$ is the lowest ECCE index used by this EPDCCH transmission in the EPDCCH set, n_{RNTI} corresponds to the RNTI associated with the EPDCCH transmission, and N^{ECCE}_{EPDCCH} is the number of ECCEs used for this EPDCCH.

[171] [Table 12]

n'	Normal cyclic prefix		Extended cyclic prefix
	Normal subframes,Special subframes,configurations3, 4, 8	Special subframes, configurations1, 2, 6, 7, 9	Any subframe
0	107	107	107
1	108	109	108
2	109	-	-
3	110	-	-

[172] For distributed transmission, each resource element in an EREG is associated with one out of two antenna ports in an alternating manner where $p \in \{107,109\}$ for normal cyclic prefix and $p \in \{107,108\}$ for extended cyclic prefix.

[173] Recently, machine type communication (MTC) has come to the fore as a significant communication standard issue. MTC refers to exchange of information between a machine and an eNB without involving persons or with minimal human intervention. For example, MTC may be used for data communication for measurement/

sensing/reporting such as meter reading, water level measurement, use of a surveillance camera, inventory reporting of a vending machine, etc. and may also be used for automatic application or firmware update processes for a plurality of UEs. In MTC, the amount of transmission data is small and UL/DL data transmission or reception (hereinafter, transmission/reception) occurs occasionally. In consideration of such properties of MTC, it would be better in terms of efficiency to reduce production cost and battery consumption of UEs for MTC (hereinafter, MTC UEs) according to data transmission rate. Since the MTC UE has low mobility, the channel environment thereof remains substantially the same. If an MTC UE is used for metering, reading of a meter, surveillance, and the like, the MTC UE is very likely to be located in a place such as a basement, a warehouse, and mountain regions which the coverage of a typical eNB does not reach. In consideration of the purposes of the MTC UE, it is better for a signal for the MTC UE to have wider coverage than the signal for the conventional UE (hereinafter, a legacy UE).

[174] When considering the usage of the MTC UE, there is a high probability that the MTC UE requires a signal of wide coverage compared with the legacy UE. Therefore, if the eNB transmits a PDCCH, a PDSCH, etc. to the MTC UE using the same scheme as a scheme of transmitting the PDCCH, the PDSCH, etc. to the legacy UE, the MTC UE has difficulty in receiving the PDCCH, the PDSCH, etc. Therefore, the present invention proposes that the eNB apply a coverage enhancement scheme such as subframe repetition (repetition of a subframe with a signal) or subframe bundling upon transmission of a signal to the MTC UE having a coverage issue so that the MTC UE can effectively receive a signal transmitted by the eNB. For example, the PDCCH and PDSCH may be transmitted to the MTC UE having the coverage issue in a plurality of subframes (e.g. about 100 subframes).

[175] FIG. 6 illustrates an example of signals band for MTC.

[176] As one method for reducing the cost of the MTC UE, an operation of the MTC UE may be performed at a reduced UE downlink and uplink bandwidth of 1.4 MHz, for example, regardless of an operating system bandwidth of a cell. At this time, a subband (narrowband) for operating the MTC UE may always be located at the center (e.g., 6 center PRBs) of a cell as shown in FIG. 6(a), or several subbands for MTC may be provided for one subframe to multiplex MTC UEs as shown in FIG. 6(b), whereby the UEs may use their respective subbands different from each other or the UEs use the same subband not the subband of 6 center PRBs.

[177] In this case, the MTC UE cannot receive a legacy PDCCH transmitted through a full system band normally, and transmission of PDCCH for the MTC UE from an OFDM symbol region within which the legacy PDCCH is transmitted may not be preferable due to multiplexing issue with a PDCCH transmitted to another UE. As one method for

solving this, it is required to introduce a control channel transmitted within a subband where MTC is operated for the MTC UE. As a downlink control channel for such a low-complexity MTC UE, the legacy EPDCCH may be used as it is. Or, M-PDCCH for the MTC UE which is a control channel of a modified type of the legacy PDCCH/ EPDCCH may be introduced. Hereinafter, in the present invention, the legacy EPDCCH or M-PDCCH for the low-complexity MTC UE or normal complexity MTC UE will be referred to as M-PDCCH. Also, MTC-EPDCCH is hereinafter used to refer to M-PDCCH.

[178] A data channel (e.g., PDSCH, PUSCH) and/or a control channel (e.g., M-PDCCH, PUCCH, PHICH) may be transmitted for coverage enhancement (CE) of the UE by using a repetition or TTI bundling scheme through multiple subframes. The control/ data channel may be transmitted by additionally using cross-subframe channel estimation and frequency (narrowband) hopping for CE. In this case, cross-subframe channel estimation means a channel estimation method means channel estimation using a reference signal within a subframe of a corresponding channel and a reference signal within neighboring subframe(s).

[179] The MTC UE may need CE of 15dB, for example. However, all MTC UEs do not exist in an environment that CE is needed. Also, the same requirements of QoS are not applied to all MTC UEs. For example, since devices such as sensor and meter have low mobility and are likely to be located in a shaded area even while having a small amount of data transmission and reception, the devices may need high CE. However, wearable devices such as smart watch may have mobility and are likely to be located in a place not a shaded area while having a relatively large amount of data transmission and reception. Therefore, all MTC UEs do not need CE of high level, and their requirement capability may be varied depending on their type.

[180] In the present invention, an operation for monitoring M-PDCCH by means of an MTC UE (which needs coverage enhancement (CE)) will be suggested. Hereinafter, M-PDCCH monitoring, search space monitoring, or M-PDCCH candidates monitoring may mean that reception or detection of M-PDCCH is attempted within a corresponding search space or from one of M-PDCCH candidates configuring the corresponding search space.

[181] In the following embodiments, the expression "assume" may mean that an entity for transmitting a channel transmits the channel to be suitable for the corresponding "assumption". An entity for receiving the channel may receive or decode the channel to be suitable for the corresponding "assumption" provided that the channel has been transmitted to be suitable for the corresponding "assumption".

[182] FIG. 7 illustrates repeated transmission of a channel for coverage enhancement.

[183] A search space for M-PDCCH may be configured over a plurality of downlink

subframes. For example, M-PDCCH search space having an aggregation level L and a repetition level R is defined by a set of M-PDCCH candidates. In this case, each M-PDCCH candidate may be repeated within a set of R number of consecutive downlink subframes. Referring to FIG. 7, in an example of maximum repetitions R_{max}=8 and a possible repetition level of $R \in \{1, 2, 4, 0\}$, a UE may attempt decoding of M-PDCCH by assuming that repetition of M-PDCCH (transmitted at an aggregation level L) exists in each of R number of consecutive downlink subframes. For example, the UE may attempt decoding of M-PDCCH by regarding signals received from each of 8 subframes as those of the same M-PDCCH in case of a repetition level $R = 8$ and attempt decoding of different M-PDCCHs in each of 8 subframes in case of a repetition level $R = 1$.

[184] In FIG. 7, repetition of a channel is performed over consecutive downlink subframes. However, a data channel and/or a control channel (hereinafter, data/control channel) transmitted to/from the MTC UE which needs CE may be transmitted by being repeated through non-consecutive subframes. For example, the control/data channel for a specific MTC UE may not be in all downlink subframes but may be restricted to some downlink subframes. Non-consecutive downlink subframes available at the MTC UE may be configured in such a manner that a downlink subframe group comprised of one or more consecutive downlink subframes is repeated with a periodicity greater than the number of subframes within the downlink subframe group. In other words, the data/control channel may be transmitted not in physically consecutive subframes, but transmitted in transmitted in each of physically non-consecutive subframes (excluding uplink subframes in case of downlink transmission, downlink subframes in case of uplink transmission, and/or subframes except subframe used for other purpose of use and cannot be used for data/control channel transmission). Use of non-consecutive (downlink or uplink) subframes for repeated transmission of the data/control channel of the MTC UE may increase transmission/reception latency. However, as time diversity effect is obtained in the time domain by use of non-consecutive subframes, the number of repetitions or the number of subframes used for channel transmission may be reduced as compared with transmission based on consecutive subframes. Therefore, overall system throughput may be increased. The embodiments of the present invention, which will be described later, suggest UE operation and transmission subframe during transmission/reception of a corresponding channel when a data/control channel transmitted from MTC UE is transmitted with repetition through consecutive subframes or non-consecutive subframes.

[185] In the following embodiments, each search space within an interval where a UE monitors M-PDCCH (CSS and/or USS) may be configured over one or more (consecutive or non-consecutive) downlink subframes. That is, a search space for

reception of the same M-PDCCH may be configured in each of one or more downlink subframes.

[186] For example, referring to FIG. 8, in case of no CE or CE having a repetition level = 1, each of CSSs of FIG. 8 may be CSS on which a respective M-PDCCH can be transmitted. At this time, a CSS starting subframe may mean a first subframe of paging occasions for allowing a UE to monitor M-PDCCH for a paging message. As another example, referring to FIG. 9, in case of no CE or CE having a repetition level = 1, each of CSSs of FIG. 9 may be CSS on which a respective M-PDCCH can be transmitted. At this time, a CSS starting subframe may mean a first subframe of a RAR window for allowing a UE to monitor M-PDCCH for scheduling RAR.

[187] In case of coverage enhancement (CE), M-PDCCH may be transmitted by being repeated once or multiple times. Therefore, a search space where M-PDCCH (hereinafter, paging M-PDCCH) will be monitored may be configured repeatedly over a plurality of downlink subframes, and a UE may attempt repeated reception of M-PDCCH within search spaces within the plurality of downlink subframes. If CE having a repetition level greater than 1 is applied, for example, each CSS shown in FIG. 8 may be a plurality of consecutive subframes that may have repetitions of M-PDCCH. If CE having a repetition level greater than 1 is applied, as another example, a plurality of CSSs within the same paging occasion shown in FIG. 8 may be CSSs for repetitions of the same M-PDCCH. If CE having a repetition level greater than 1 is applied, as still another example, a plurality of CSSs over a plurality of paging occasions shown in FIG. 8 may be CSSs for repetitions of the same M-PDCCH.

[188] ■ Section 1. M-PDCCH CSS for paging message scheduling

[189] In Section 1, details on M-PDCCH CSS for paging message scheduling are discussed.

[190] The paging message is used to notify UE(s) under RRC_IDLE and UE(s) under RRC_CONNECTED of system information modification.

[191] An eNB initiates a paging process by transmitting the paging message at a paging occasion of a UE. The eNB may address a plurality of UEs within the paging message by including a paging record (*PagingRecord*) per UE. The paging record may include information indicating NAS (non-access stratum) identifier of a UE which is paged and information indicating the origin of paging. One paging occasion means a subframe having P-RNTI transmitted on PDCCH/M-PDCCH addressing the paging message. A paging frame (PF) means one radio frame that includes one or a plurality of paging occasion(s).

[192] The UE may use discontinuous reception (DRX) in an idle mode to reduce power consumption. If DRX is used, the UE monitors only one paging occasion per DRX cycle.

[193] The paging message may be transmitted through a PDSCH, and the PDSCH carrying the paging message may be scheduled by PDCCH/M-PDCCH.

[194] For paging message scheduling, multiple narrowbands can be configured by eNB. Then, a narrowband location for a paging occasion monitoring of a UE is determined by at least UE ID at least for paging record(s). However, the narrowband location and paging occasion for common signal transmission (e.g., SI update, earthquake and tsunami warning system (ETWS), and/or commercial mobile alert system (CMAS)) is not determined yet. To reduce UE complexity, it would be beneficial to apply the same paging occasion and narrowband location for paging record(s) reception and other information reception such as SI update, ETWS, and CMAS. For example, the UE may attempt reception of M-PDCCH for scheduling the paging message on the same narrowband at the same paging occasion for SI update and reception of ETWS and CMAS instead of monitoring different paging occasions and/or different narrowbands for SI update and reception of ETWS and CMAS.

[195] FIG. 8 illustrates a configuration of a common search space (CSS) for paging according to the present invention.

[196] Under the assumption that a paging occasion is a time region for M-PDCCH monitoring for paging message scheduling, a UE can monitor a common search space (CSS) within a paging occasion to check paging message transmission. Depending on duration of paging occasion and period of CSS starting subframe, there can be multiple CSS monitoring opportunities within a paging occasion as shown in FIG. 8. The period and offset of CSS starting subframe location can be configured by eNB. In this case, offset k_{offset} of the CSS starting subframe may mean a difference from a reference subframe n (e.g., subframe 0) to a subframe $n+k_{offset}$ in which the CSS starting subframe is first applied.

[197] The composition of decoding candidates (i.e. M-PDCCH candidates) and a subset of $\{L, R\}$ for CSS for paging should be composed to supports all UEs with different CE levels. In this case, L indicates an aggregation level, and M-PDCCH of the aggregation level L is transmitted using aggregation of L number of M-CCEs. ECCE may be used as M-CCE, and CCE for MTC UE may newly be defined as M-CCE for MTC UE.

[198] To transmit paging message adapt to the target CE level, a subset of $\{L, R\}$ of CSS for paging needs to be composed to cover all range of CE levels or all range of repetition numbers. One simple configuration is $\{8, R1\}$, $\{16, R1\}$, $\{24, R1\}$, $\{24, R2\}$, $\{24, R3\}$, $\{24, R4\}$ where $R1 = 1$ and $R4$ is the maximum repetition level.

[199] In the present invention, a paging occasion may be defined as an interval where a UE monitors a paging M-PDCCH. For example, the UE may attempt reception of (same) paging M-PDCCH (or M-PDCCH scrambled by P-RNTI) within CSS(s) existing in the paging occasion or paging M-PDCCH search space(s) as shown in FIG. 8. Since the

paging M-PDCCH may be transmitted in any one of CSS(s) within the paging occasion, the UE continuously monitors the CSS(s) within the paging occasion. If the paging M-PDCCH (or M-PDCCH scrambled by P-RNTI) is received within the corresponding interval, the UE may receive a PDSCH carrying the corresponding paging message even though a paging message scheduled by the corresponding M-PDCCH, that is, a PDSCH carrying paging is transmitted outside a paging occasion interval.

[200] A duration of the paging occasion may be configured to be a multiple of the number of subframes configuring CSSs or search spaces on which the paging M-PDCCH is transmitted. For example, if the paging M-PDCCH search space is configured in each of R number of (consecutive or non-consecutive) downlink subframes, the paging occasion may be configured to have a duration of R*X number of subframes (where X is a positive integer).

[201] ■ Section 2. M-PDCCH CSS for RAR scheduling

[202] FIG. 9 illustrates a configuration of a common search space (CSS) for RAR according to the present invention.

[203] There would be multiple narrowbands for CSS for RAR scheduling, and the narrowband location of a UE for RAR monitoring is determined by PRACH resource set.

[204] After transmitting PRACH, a UE would try to receive RAR. Similar to paging occasion, there can be multiple CSS regions within a RAR window as depicted in Figure 9. So, the UE can monitor M-PDCCH scheduling RAR in CSS region(s) within the RAR window.

[205] A subset of $\{L, R\}$ and composition of decoding candidates of CSS for RAR can depend on CE level of corresponding PRACH resource set. For example, for each CE level, PRACH resource set(s) and available repetition level(s) may be configured. In this case, the UE may monitor a CSS, that is, M-PDCCH in accordance with a set of $\{L, R\}$ configured for a CE level associated with a PRACH resource used for a successful RACH procedure. Regardless of CSS and USS, same composition of decoding candidates and same subset of $\{L, R\}$ can be used for same CE level of the search space. For example, the UE may monitor a CSS and a USS in accordance with $\{L, R\}$ of the same set with respect to the same CE level.

[206] The present invention suggests that a RAR window interval should be defined as an interval where a UE monitor M-PDCCH (hereinafter, RAR M-PDCCH) for scheduling RAR. That is, as shown in FIG. 9, the UE may attempt reception of RAR M-PDCCH (e.g., M-PDCCH scheduled by RA-RNTI) on CSS(s) existing within a RAR window or a search space(s) (hereinafter, RAR M-PDCCH search space) on which RAR M-PDCCH is transmitted. If the UE receives RAR M-PDCCH within the corresponding interval, the UE may receive a PDSCH through which the corresponding RAR is

transmitted, even though RAR (e.g., PDSCH carrying RAR) scheduled by the corresponding M-PDCCH is transmitted outside the RAR window interval.

[207] A duration of the RAR window may be configured to become a multiple of the number of subframes configuring CSSs or RAR M-PDCCH search spaces. For example, if RAR M-PDCCH search space is configured in each of R number of (consecutive or non-consecutive) downlink subframes, the RAR window may be configured to have a duration of R*X number of subframes (in this case, X is a positive integer).

[208] ■ Section 3. M-PDCCH CSS for other purposes

[209] M-PDCCH CSS can be used to transmit DCIs for other purposes except paging message and RAR scheduling. For example, M-PDCCH CSS can be used for transmission of DCI for unicast data, DCI for TPC, DCI for enhanced interference management and traffic adaptation (eIMTA), and DCI for enhanced PHICH (EPHICH). If CSS is used to transmit these DCIs, the narrowband location, monitoring subframe location, and decoding candidates composition need to be specified. Hereinafter, the CSS will be referred to as CSS_regular or CSS_others.

[210] CSS for these purposes (i.e. CSS_regular) can be located in the same narrowband to USS. Then, a UE does not need to re-tune its operating frequency to monitor this CSS.

[211] To reconfigure CE level of a UE, the CSS needs to support the maximum CE level of the cell considering CE level reconfiguration message can be transmitted by this CSS. Therefore, CE level or a subset of $\{L, R\}$ composing the CSS should support all CE level of the cell.

[212] FIG. 10 illustrates the example of the monitoring time region of USS and CSS.

[213] Period of starting subframe for M-PDCCH USS monitoring and CSS monitoring can be configured independently. The period of CSS monitoring can be longer than the period of USS, since CE level of USS and CSS can be different and CSS can be occurred sparsely to reduce UE complexity.

[214] Referring to Math Figure 1 which is a hashing function, it is noted that $Y_{p,k}$ is varied depending on n_{RNTI} which is UE ID. In this way, CCE(s) or ECCE(s) configuring decoding candidates in the USS is(are) determined UE-specifically to be monitored by a specific UE. M-PDCCH CSS can be monitored by a group of MTC UEs. Therefore, for CSS, there should not be a hashing function to randomize the starting ECCE location composing a search space UE-specifically.

[215] ■ Section 4. Coverage enhancement level of CSS

[216] For transmission of a broadcast PDSCH (e.g., paging, RAR), CSSs for other purposes such as unicast data, TPC, eIMTA DCI and EPHICH may exist, and USS where a UE monitors unicast data may exist. Hereinafter, a coverage enhancement level of corresponding search spaces will be described.

[217] The present invention suggests that a plurality of SS types exist as follows in accordance with a coverage enhancement level supported by a search space or repetitions of M-PDCCH.

[218] - Method 1.

[219] In view of the UE, two types of search spaces (SSs) may exist as follows:

[220] * SS type 1: SS supporting all coverage enhancement levels or all repetitions of M-PDCCH, and

[221] * SS type 2: SS where the number of repetitions of M-PDCCH which is supported is varied depending on a coverage enhancement level of the UE.

[222] In this case, the UE may assume that CSS for paging and/or CSS_regular has SS type 1, and CSS and/or USS for RAR has SS type 2.

[223] Alternatively, as SS monitored by the UE, one SS having SS type 1 and one SS having SS type 2 may exist. CSS for paging and/or CSS_regular may be the same as SS having SS type 1, and CSS and/or USS for RAR may be the same as SS having SS type 2.

[224] - Method 2.

[225] When N number of coverage enhancement levels (or the number of repetitions of M-PDCCH) supported by a cell exist, in view of the cell, a plurality of SS types may exist as follows:

[226] * SS type 1: SS supporting coverage enhancement level 1 (or the number of repetitions R_1 of M-PDCCH),

[227] * SS type 2: SS supporting coverage enhancement level 2 (or the number of repetitions R_2 of M-PDCCH),

[228] ...

[229] * SS type N: SS supporting coverage enhancement level N (or the number of repetitions R_N of M-PDCCH),

[230] * SS type N+1: SS supporting all coverage enhancement levels (or all repetitions for M-PDCCH).

[231] In this case, SS supporting the coverage enhancement level n may mean SS supporting the coverage enhancement levels 1 to n or the maximum number of repetitions R_n of M-PDCCH.

[232] In this case, the UE may assume that the CSS for paging and CSS_regular has SS type N+1, and the CSS for RAR and/or USS has SS type k if the coverage enhancement level of the UE is k.

[233] ■ Section 5. Relationship between search spaces

[234] **CSS for paging (i.e., CSS_paging)**

[235] It is a CSS for paging monitoring in RRC_IDLE state. Since UEs in different CE levels monitor the same CSS for paging scheduling, it should be designed to cover all

the CE levels. CSS_paging are configured by SIB. In other words, the configuration of CSS_paging may be transmitted through SIB. The UE may identify the configuration of CSS_paging by reading SIB. The UE may monitor M-PDCCH candidates of CSS within subframe(s) and/or narrowband(s) according to the CSS_paging configuration.

[236] **CSS for** RAR corresponding to initial RACH procedure (i.e., CSS_RAR)

[237] Using CSS for RAR, a UE can monitor RAR, Msg3 (for retransmission), and Msg4. Though it can be considered to allow separate SS configurations for Msg3 re-transmission and Msg4 scheduling M-PDCCH from the SS configuration for RAR, given that those (i.e. RAR, Msg3 and Msg4) will be used only for initial access, the present invention proposes that the same configuration is used for initial RACH procedure. Required configurations for CSS_RAR can be configured by SIB per CE level. Then, in a UE perspective, configurations for CSS_RAR can be determined based on the CE level of PRACH resource set used for the latest PRACH transmission.

[238] **CSS for others (i.e., CSS_others or CSS_regular)**

[239] M-PDCCH CSS can be used to transmit DCIs for other purposes except paging message and initial RAR scheduling. For example, CSS is required to transmit TPC, unicast data for reconfiguration (such as CE level, transmission mode, USS recon-figuration), a DCI transmitting multiple HARQ-ACK corresponding to PUSCH to multiple UEs (if supported), transmit RAR corresponding to PRACH triggered by M-PDCCH order. CSS for these purposes can be located in the same narrowband to USS once a UE is connected to the network. Then, a UE does not need to re-tune its operating frequency to monitor this CSS. A UE can monitor CSS_others (i.e., CSS_regular) and USS simultaneously.

[240] If there is a complexity issue, TDM of CSS and USS monitoring can be considered. In other words, CSS and USS are time-division multiplexed, whereby the CSS and the USS may not be monitored at the same time.

[241] If CSS for other purposes are not defined, legacy PUCCH TPC via DCI format 3/3A cannot be supported. Then, if downlink traffic is occurred sparsely, it could be difficult to adopt PUCCH power since PUCCH TPC is accomplished by accumulated way. So, other way to handle this issue needs to be considered such as absolute PUCCH TPC via DL grant or unicast DCI for PUCCH TPC transmitted by USS. Thus, at least for CE mode A (for TCP and reconfiguration), CSS_others needs to be supported.

[242] **USS**

[243] USS is a search space for unicast data scheduling. Configurations for USS can be configured by SIB and Msg4. If necessary, reconfiguration can be utilized by radio resource control (RRC) layer (i.e. RRC signal). Configurations for USS also can be applied for CSS_others. In this case, individual configurations for CSS_others and USS may not be required.

[244] FIG. 11 illustrates a procedure of configuring a search space according to the present invention.

[245] Referring to FIG. 11, the UE may receive a list of search space (SS) configurations per CE level for RAR through SIB (S1101). The UE may transmit RACH preamble through PRACH by using a PRACH resource. PRACH resource(s) per CE level may be configured by SIB. The UE may monitor M-PDCCH for scheduling a response to the RACH preamble transmitted therefrom, that is, a response to transmission of the PRACH in a search space (S1103). The UE may assume that a search space for M-PDCCH scheduling the RAR depends on SS configuration (e.g., CSS_RAR configuration) received through the SIB. The UE which has received RAR M-PDCCH may receive RAR in accordance with DCI carried by the RAR M-PDCCH (S1105).

[246] Initial configuration for RAR, Msg3 and/or Msg4 may depend on SS configuration per CE level received (S1101) through SIB (S1121). The UE may monitor M-PDCCH for scheduling Msg4, which includes CSS configuration/reconfiguration and/or USS configuration/reconfiguration parameters, in the SS according to initial configuration through SIB (S1121). For example, the UE may monitor Msg4 M-PDCCH by assuming that the maximum number of repetitions, narrowband, PRB-set, etc. which are the same as those of CSS for RAR, are also applied to M-PDCCH (hereinafter, Msg4 M-PDCCH) for scheduling Msg4 (S1121). The UE which has received Msg4 M-PDCCH may receive Msg4 in accordance with DCI of the Msg4 M-PDCCH (S1123). The Msg4 may carry RRC message that includes UE-specific configuration for USS and/or CSS. In this case, the UE may monitor M-PDCCH by applying the UE-specific SS configuration instead of initial SS configuration (S1125).

[247] The UE may monitor M-PDCCH order within the CSS according to the UE-specific CSS configuration (S1141). The UE which has received the M-PDCCH order may receive RAR in accordance with scheduling information carried by the M-PDCCH order (S1143).

[248] The UE may monitor M-PDCCH for scheduling RRC message having UE-specific reconfiguration parameter(s) within the CSS according to the UE-specific CSS configuration (S1161). The UE-specific reconfiguration may include M-PDCCH configuration. The UE which has received the M-PDCCH may receive a PDSCH carrying the RRC message in accordance with scheduling information (that is, DCI) of the M-PDCCH (S1163). The UE may reconfigure M-PDCCH search space in accordance with the UE-specific reconfiguration.

[249] Table 13 illustrates parameters and configuration details required for search spaces. All or some of the parameters illustrated in Table 13 may be configured and/or reconfigured in accordance with Table 13.

[250] [Table 13]

Parameters	Configuration details				Description
	CSS_paging	CSS_RAR	CSS_others	USS	
Subset of L	Fixed to {8, 16, 24}			{1, 2, 4, 8, 16, 24}	
R_{max}	Configurable by SIB.	Configured by SIB per CE level (configuration can be shared for CSS_RAR, CSS_others, USS).For CSS_others/USS, it can be reconfigured by RRC.			Subset of repetition numbers is determined based on R_{max}. Details are described in Subsection 5.1.
PRB-sets	Configured by SIB.	Configured by SIB per CE level specific and cell-specific.	Alt 1. Configured by Msg4 per UE.Alt 2. Configured by SIB per CE level (in this case, same configuration for CSS_RAR, CSS_others, USS).It can be reconfigured by RRC.		This configuration includes the number of PRB-sets, PRB size/ location of each PRB-set.
Transmission type	Configured by SIB per PRB-set.	Configured by SIB per PRB-set.	Alt 1. Configured by Msg4 per UE (the network ensures the same type is used beween CSS_others and USS in case both are monitored at the same time).Alt 2. Configured by SIB per CE level (in this case, same configuration for CSS_RAR, CSS_others, USS).It can be reconfigured by RRC.		
Narrowband	Determined	Based on	Default value can be		

	by UE ID among paging narrowbands configured by SIB.	PRACH resource set where RAR narrowband corresponding to each PRACH resource set is configured by SIB.	CSS_RAR's narrowband location. Configurable by Msg 4 per UEIt can be reconfigured by RRC.	
M-PDCCH monitoring starting	Alt 1. Configured by SIB per CE level.Alt 2. Configured by SIB regardless of CE level (one maximum value to reset monitoring starting subframe).			See FIG. 7 and Subsection 5.1.
M-PDCCH starting subframe	Determined by repetition number R per repetition number R.	Alt 1. Determined by R_{max} for CE Mode A, determined by repetition number R per repetition number R for CE Mode B.Alt 2. Determined by repetition number R per repetition number R.		See FIG. 7 and Subsection 5.1.

[251] In Table 13, a merged cell means that the configuration can be shared by corresponding search spaces, so individual configuration is not needed for each search space. For example, referring to Table 13, "Fixed to {8, 16, 24}" which is the description of a subset of an aggregation level L exists within a cell merged for CSS_paging, CSS_RAR and CSS_others (i.e., CSS_regular), and thus means that a corresponding parameter is not required to be configured individually for CSS_paging, CSS_RAR and CSS_others(i.e. CSS_reguar) and a common parameter is applied to CSS_paging, CSS_RAR and CSS_others. According to Table 13, the UE may attempt reception of M-PDCCH at an aggregation level $L\in\{8, 16, 24\}$ for CSS_paging, CSS_RAR and CSS_others, and may attempt reception of M-PDCCH at $L\in\{1, 2, 4, 8, 16, 24\}$ for the USS.

[252] Reconfigurable parameters in Table 13 mean that the same value as initial configuration or default configuration is applied until a corresponding parameter is reconfigured, whereby search space(s) is(are) configured.

[253] For example, referring to Table 13, the maximum number of repetitions R_{max} of M-PDCCH may be provided through SIB as a configuration for CSS_RAR. The UE may monitor CSS_RAR, CSS_others and/or USS by assuming that R_{max} included in the SIB is applied to CSS_RAR, CSS_others, and USS. That is, the UE may monitor rep-

etitions of M-PDCCH in SS within maximum R_{max} number of subframes. According to Table 13, since R_{max} for CSS_others and/or USS (hereinafter, CSS_others/USS) may be reconfigured, if R_{max} for CSS_others/USS is reconfigured by RRC signal, the UE may monitor CSS_others/USS in accordance with the reconfigured R_{max}. In other words, the UE may monitor CSS_others/USS in accordance with R_{max} for CSS_RAR until R_{max} for CSS_others/USS is received.

[254] For another example, referring to parameters of PRB-sets in Table 13, PRBs on which PRB-set(s) for CSS_RAR, that is, RAR M-PDCCH may be transmitted may be configured CE level-specifically and cell-specifically by SIB. Referring to Alt 2, these PRB-sets configured per CE level may be applied to CSS_others and USS by SIB. Since PRB-set parameter for CSS_others and USS may be reconfigured by RRC, the UE may monitor CSS_others/USS by applying PRB-set(s) for CSS_RAR until reconfiguration PRB-set parameter for CSS_others/USS is received, and may monitor CSS_others/USS by applying the reconfiguration PRB-set parameter if the reconfiguration PRB-set parameter for CSS_others/USS is received. For example, if PRB-set(s) of CSS_RAR are fixed to 6, the UE may monitor M-PDCCH USS by assuming all PRBs within a narrowband according to CSS_RAR configuration as PRB-set(s) for USS until configuration of separate PRB-set(s) for USS is received.

[255] For still another example, referring to a narrowband parameter of Table 13, a narrowband (hereinafter, RAR narrowband) having CSS_RAR may be determined based on a PRACH resource set. In this case, a corresponding RAR narrowband per PRACH resource set is configured by SIB. A default narrowband location of CSS_others and/or USS may be a narrowband location of CSS_RAR. A narrowband for CSS_others/USS may be configured per UE by Msg4, and may be reconfigured by RRC. Therefore, the UE may monitor CSS_others/USS on the same narrowband as that for CSS_RAR until a narrowband parameter for CSS_others/USS is received, and if Msg4 for CSS_others/USS or reconfiguration RRC message is received, may monitor CSS_others/USS on a narrowband according to the Msg4 or the RRC message.

[256] □ Subsection 5.1. Aggregation levels and repetition numbers

[257] Search space configuration parameters of Table 13 may be applied as follows in view of an aggregation level and the number of repetitions. For example, a subset (and/or starting subframe of M-PDCCH SS and/or starting subframe of M-PDCCH) of the number of repetitions R based on R_{max} may be determined in accordance with the following description.

[258] **CSS for paging (i.e., CSS_paging)**

[259] - Aggregation levels:

[260] Since data transmission scheduled by CSS is targeted to multicast/broadcast, similar

to PDCCH CSS, some high aggregation levels can be supported. Aggregation levels (ALs) {8, 16, 24} can be supported for normal CP and ALs {4, 8, 12} can be supported for extended CP.

[261] - Repetition numbers:

[262] A subset of R for CSS for paging monitoring depends on the maximum R (i.e., R_{max}) where R_{max} is configured by SIB. To support wide range of repetition numbers, the subset of R monitored for CSS_paging can be {$R_{max}/64$, $R_{max}/16$, $R_{max}/4$, R_{max}}.

[263] **CSS for** RAR corresponding to initial RACH procedure (i.e., CSS_RAR)

[264] - Aggregation levels:

[265] Similar to CSS_paging, ALs $L \in \{8, 16, 24\}$ can be supported for normal CP and ALs $L \in \{4, 8, 12\}$ can be supported for extended CP.

[266] - Repetition numbers:

[267] For CSS scheduling RAR, the subset of R depends on the maximum R (i.e., R_{max}) where R_{max} is configured by SIB per CE level. The subset of R monitored for CSS_RAR can be {$R_{max}/4$, $R_{max}/2$, R_{max}}.

[268] **CSS for others (i.e., CSS_others)**

[269] - Aggregation levels:

[270] Similar to CSS_paging, ALs $L \in \{8, 16, 24\}$ can be supported for normal CP and ALs $L \in \{4, 8, 12\}$ can be supported for extended CP.

[271] - Repetition numbers:

[272] For CSS_others, the subset of R depends on the maximum R (i.e., R_{max}) where R_{max} is configured by SIB per CE level or Msg4. R_{max} can be reconfigured by RRC if necessary. The subset of R monitored for CSS_others can be {$R_{max}/4$, $R_{max}/2$, R_{max}}. Or, to reduce UE complexity, the subset of R monitored for CSS_others can be {$R_{max}/2$, R_{max}}.

[273] **USS**

[274] - Aggregation levels:

[275] For CE Mode A, ALs $L \in \{1, 2, 4, 8, 16, 24\}$ are supported for normal CP. ALs $L \in \{1, 2, 4, 8, 12\}$ are supported for extended CP. For CE Mode B, ALs $L \in \{8, 16, 24\}$ is supported for normal CP. ALs $L \in \{4, 8, 12\}$ are supported for extended CP.

[276] - Repetition numbers:

[277] For USS, the subset of R depends on the maximum R (i.e., R_{max}) where R_{max} is configured by SIB per CE level or Msg4. R_{max} can be reconfigured by RRC if necessary. The subset of R monitored for USS can be {$R_{max}/4$, $R_{max}/2$, R_{max}}. Or, to support higher R to CSS_others for CE level reconfiguration reliably, subset of R monitored for USS can be {$R_{max}/8$, $R_{max}/4$, $R_{max}/2$}.

[278] ■ Section 6. Collision of M-PDCCH(s)

[279] If there are some subframes not available for downlink transmission, M-

PDCCH/PDSCH transmission or repetitions can be postponed till the next available subframe. It can be applied in case unavailable subframes are aligned between eNB and UE.

[280] FIG. 12 illustrates a configuration of M-PDCCH repeated transmission according to the present invention.

[281] If a small interval (e.g., cycle of starting subframe of M-PDCCH search space) of M-PDCCH search space is configured or a large number of invalid subframes, which cannot have M-PDCCH, are provided between M-PDCCH search space starting subframes, M-PDCCH2 transmission may not end until next starting subframe of the search space, in the same manner as M-PDCCH2 transmission of FIG. 12. That is, the subframes configuring two search spaces may be overlapped with each other. In this case, the UE may be in the status that the UE should perform monitoring for M-PDCCH transmitted in a previous search space and monitoring for M-PDCCH transmitted in a next search space. However, this operation may not be preferable due to buffer size and complexity issue of the UE. In this case, the UE may perform reception of M-PDCCH as follows.

[282] - Method 1. If a starting time (hereinafter, subframe #n) of next search space occurs before reception of M-PDCCH is ended, the UE may assume that the M-PDCCH is transmitted up to subframe #n-1 and is not transmitted in subframe #n. In this case, the UE may attempt reception of the M-PDCCH by using repetitions smaller than the number of expected repetitions of M-PDCCH.

[283] - Method 2. If a starting time (hereinafter, subframe #n) of next search space occurs before reception of M-PDCCH is ended, the UE may determine that the M-PDCCH that the UE is receiving is invalid, and may not perform reception of the corresponding M-PDCCH.

[284] - Method 3. If subframe(s) configuring two search spaces are overlapped with each other, the UE may determine that a search space existing at an earlier time is invalid, and may not perform reception of M-PDCCH for one of the two search space, which is first started in a time domain.

[285] FIG. 13 is a block diagram illustrating elements of a transmitting device 10 and a receiving device 20 for implementing the present invention.

[286] The transmitting device 10 and the receiving device 20 respectively include Radio Frequency (RF) units 13 and 23 capable of transmitting and receiving radio signals carrying information, data, signals, and/or messages, memories 12 and 22 for storing information related to communication in a wireless communication system, and processors 11 and 21 operationally connected to elements such as the RF units 13 and 23 and the memories 12 and 22 to control the elements and configured to control the memories 12 and 22 and/or the RF units 13 and 23 so that a corresponding device may

perform at least one of the above-described embodiments of the present invention.

[287] The memories 12 and 22 may store programs for processing and controlling the processors 11 and 21 and may temporarily store input/output information. The memories 12 and 22 may be used as buffers.

[288] The processors 11 and 21 generally control the overall operation of various modules in the transmitting device and the receiving device. Especially, the processors 11 and 21 may perform various control functions to implement the present invention. The processors 11 and 21 may be referred to as controllers, microcontrollers, microprocessors, or microcomputers. The processors 11 and 21 may be implemented by hardware, firmware, software, or a combination thereof. In a hardware configuration, application specific integrated circuits (ASICs), digital signal processors (DSPs), digital signal processing devices (DSPDs), programmable logic devices (PLDs), or field programmable gate arrays (FPGAs) may be included in the processors 11 and 21. Meanwhile, if the present invention is implemented using firmware or software, the firmware or software may be configured to include modules, procedures, functions, etc. performing the functions or operations of the present invention. Firmware or software configured to perform the present invention may be included in the processors 11 and 21 or stored in the memories 12 and 22 so as to be driven by the processors 11 and 21.

[289] The processor 11 of the transmitting device 10 performs predetermined coding and modulation for a signal and/or data scheduled to be transmitted to the outside by the processor 11 or a scheduler connected with the processor 11, and then transfers the coded and modulated data to the RF unit 13. For example, the processor 11 converts a data stream to be transmitted into K layers through demultiplexing, channel coding, scrambling, and modulation. The coded data stream is also referred to as a codeword and is equivalent to a transport block which is a data block provided by a MAC layer. One transport block (TB) is coded into one codeword and each codeword is transmitted to the receiving device in the form of one or more layers. For frequency up-conversion, the RF unit 13 may include an oscillator. The RF unit 13 may include N_t (where N_t is a positive integer) transmit antennas.

[290] A signal processing process of the receiving device 20 is the reverse of the signal processing process of the transmitting device 10. Under control of the processor 21, the RF unit 23 of the receiving device 20 receives radio signals transmitted by the transmitting device 10. The RF unit 23 may include N_r (where N_r is a positive integer) receive antennas and frequency down-converts each signal received through receive antennas into a baseband signal. The processor 21 decodes and demodulates the radio signals received through the receive antennas and restores data that the transmitting device 10 intended to transmit.

[291] The RF units 13 and 23 include one or more antennas. An antenna performs a function for transmitting signals processed by the RF units 13 and 23 to the exterior or receiving radio signals from the exterior to transfer the radio signals to the RF units 13 and 23. The antenna may also be called an antenna port. Each antenna may correspond to one physical antenna or may be configured by a combination of more than one physical antenna element. The signal transmitted from each antenna cannot be further deconstructed by the receiving device 20. An RS transmitted through a corresponding antenna defines an antenna from the view point of the receiving device 20 and enables the receiving device 20 to derive channel estimation for the antenna, irrespective of whether the channel represents a single radio channel from one physical antenna or a composite channel from a plurality of physical antenna elements including the antenna. That is, an antenna is defined such that a channel carrying a symbol of the antenna can be obtained from a channel carrying another symbol of the same antenna. An RF unit supporting a MIMO function of transmitting and receiving data using a plurality of antennas may be connected to two or more antennas.

[292] In the embodiments of the present invention, a UE operates as the transmitting device 10 in UL and as the receiving device 20 in DL. In the embodiments of the present invention, an eNB operates as the receiving device 20 in UL and as the transmitting device 10 in DL. Hereinafter, a processor, an RF unit, and a memory included in the UE will be referred to as a UE processor, a UE RF unit, and a UE memory, respectively, and a processor, an RF unit, and a memory included in the eNB will be referred to as an eNB processor, an eNB RF unit, and an eNB memory, respectively.

[293] The eNB processor of the present invention may configure or reconfigure CSS_paging in accordance with section 1, section 5 and/or section 6. The eNB processor may control the eNB RF unit to transmit SIB or RRC message, which includes configuration for CSS_paging, to the UE in accordance with section 1, section 5 and/or section 6. The eNB processor may control the eNB RF unit to transmit M-PDCCH for scheduling a paging message within CSS_paging according to CSS_paging configuration. The UE processor of the present invention may control the UE RF unit to receive configuration or reconfiguration information on CSS_paging from the eNB in accordance with section 1, section 5 and/or section 6. The UE may attempt reception of paging M-PDCCH from CSS_paging according to the CSS_paging configuration.

[294] The eNB processor of the present invention may configure or reconfigure CSS_RAR in accordance with section 2, section 5 and/or section 6. The eNB processor may control the eNB RF unit to transmit SIB or RRC message, which includes configuration for CSS_RAR, to the UE in accordance with section 2, section 5 and/or section 6. The eNB processor may control the eNB RF unit to transmit M-PDCCH for

scheduling RAR, Msg3 and/or Msg4 within a CSS according to CSS_RAR configuration. The UE processor of the present invention may control the UE RF unit to receive configuration or reconfiguration information on CSS_RAR from the eNB in accordance with section 2, section 5 and/or section 6. The UE may attempt reception of RAR M-MPDCCH, Msg3 M-PDCCH and/or Msg4 M-PDCCH from the CSS according to the CSS_RAR configuration.

[295] The eNB processor of the present invention may configure or reconfigure CSS_others in accordance with section 3, section 5 and/or section 6. The eNB processor may control the eNB RF unit to transmit SIB or RRC message, which includes configuration for CSS_others, to the UE in accordance with section 3, section 5 and/or section 6. The eNB processor may control the eNB RF unit to transmit M-PDCCH for other purpose within a CSS according to CSS_others configuration. The UE processor of the present invention may control the UE RF unit to receive configuration or reconfiguration information on CSS_others from the eNB in accordance with section 3, section 5 and/or section 6. The UE may attempt reception of M-PDCCH for other purpose from the CSS according to the CSS_others configuration.

[296] The eNB processor of the present invention may transmit initial configuration for CSS through SIB in accordance with section 6. The eNB processor may configure CSS and/or USS in accordance with the initial configuration until the other configuration (e.g., UE-specific configuration/reconfiguration) for SS is transmitted. The initial configuration may include a configuration (e.g., narrowband, PRB-set(s), starting subframe and/or period, and the number of maximum repetitions of SS) of time-frequency resources of SS. The eNB processor may transmit M-PDCCH in accordance with the initial configuration until the other configuration for SS is transmitted. For example, the eNB processor may control the eNB RF unit to transmit M-PDCCH by applying the number of repetitions R based on maximum R_{max} according to the initial configuration within the PRB-set according to the initial configuration on a narrowband according to the initial configuration. If the other configuration for SS is transmitted, the eNB processor may control the eNB RF unit to transmit M-PDCCH on the SS configured in accordance with the other configuration. The UE processor may receive the initial configuration for CSS through SIB in accordance with section 6. The UE processor may assume that CSS and/or USS is configured in accordance with the initial configuration until the other configuration (e.g., UE-specific configuration/reconfiguration) for SS is received. The UE processor may monitor M-PDCCH in accordance with the initial configuration until the other configuration for SS is transmitted. For example, the UE processor may control the UE RF unit to receive or monitor M-PDCCH by applying the number of repetitions R based on maximum R_{max} according to the initial configuration within the PRB-set according to the initial con-

figuration on a narrowband according to the initial configuration. If the other configuration for SS is received, the UE processor may control the UE RF unit to receive or monitor M-PDCCH on the SS configured in accordance with the other configuration.

[297] As described above, the detailed description of the preferred embodiments of the present invention has been given to enable those skilled in the art to implement and practice the invention. Although the invention has been described with reference to exemplary embodiments, those skilled in the art will appreciate that various modifications and variations can be made in the present invention without departing from the spirit or scope of the invention described in the appended claims. Accordingly, the invention should not be limited to the specific embodiments described herein, but should be accorded the broadest scope consistent with the principles and novel features disclosed herein.

Industrial Applicability

[298] The embodiments of the present invention are applicable to a BS, a UE, or other devices in a wireless communication system.

Claims

[Claim 1] A method for receiving, by a user equipment (UE), downlink control information (DCI) for the UE, the method comprising:
receiving, by the UE, a common search space configuration for a common search space;
receiving, by the UE, a first physical downlink control channel (PDCCH) scheduling a random access response by monitoring first PDCCH candidates of the common search space according to the common search space configuration; and
receiving, by the UE, a second PDCCH carrying the DCI for the UE by monitoring second PDCCH candidates of a UE-specific search space,
wherein the second PDCCH candidates of the UE-specific search space are monitored according to the same configuration as the common search space configuration until the UE receives a UE-specific search space configuration.

[Claim 2] The method according to claim 1,
wherein the common search space configuration includes information on a narrowband for the common search space, and
wherein the second PDCCH candidates of the UE-specific search space are monitored on the same narrowband as the narrowband for the common search space until the UE receives a UE-specific search space configuration.

[Claim 3] The method according to claim 1 or 2,
wherein the common search space configuration includes information on a maximum number of repetitions for the common common search space, and
wherein the second PDCCH candidates of the UE-specific search space are monitored based on the same number as the maximum number of repetitions for the common search space until the UE receives a UE-specific search space configuration.

[Claim 4] The method according to any one of claims 1 to 3,
wherein the common search space configuration includes information on a first physical resource block (PRB) set for monitoring the first PDCCH, and
wherein the same physical resource block set as the first PRB set is used for monitoring the second PDCCH candidates until the UE receives a UE-specific search space configuration.

[Claim 5] The method according to any one of claims 1 to 4,
wherein the first PDCCH candidates of the common search space are monitored according to aggregation levels larger than or equal to 8 among a plurality of aggregation levels, and the second PDCCH candidates of the UE-specific search space are monitored according to the plurality of aggregation levels.

[Claim 6] A method for transmitting, by a base station (BS), downlink control information (DCI) for a user equipment (UE), the method comprising:
transmitting, by the BS, common search space configuration for a common search space;
transmitting, by the BS to the UE, a first physical downlink control channel (PDCCH) scheduling a random access response by using one of first PDCCH candidates of the common search space according to the common search space configuration; and
transmitting, by the BS to the UE, a second PDCCH carrying the DCI for the UE by using one of second PDCCH candidates of a UE-specific search space,
wherein the second PDCCH candidates of the UE-specific search space are configured according to the same configuration as the common search space configuration until a UE-specific search space configuration is transmitted to the UE.

[Claim 7] The method according to claim 6,
wherein the common search space configuration includes information on a narrowband for the common search space, and
wherein the second PDCCH candidates of the UE-specific search space are configured on the same narrowband as the narrowband for the common search space until the UE-specific search space configuration is transmitted to the UE.

[Claim 8] The method according to claim 6 or 7,
wherein the common search space configuration includes information on a maximum number of repetitions for the first common search space, and
wherein the second PDCCH candidates of the UE-specific search space are configured based on the same number as the maximum number of repetitions for the common search space until the UE-specific search space configuration is transmitted to the UE.

[Claim 9] The method according to any one of claims 6 to 8,
wherein the common search space configuration includes information

on a first physical resource block (PRB) set for transmitting the first PDCCH, and
wherein the same physical resource block set as the first PRB set is used for the second PDCCH candidates until the UE-specific search space configuration is transmitted to the UE.

[Claim 10] The method according to any one of claims 6 to 9,
wherein the first PDCCH candidates of the common search space are configured according to aggregation levels larger than or equal to 8 among a plurality of aggregation levels, and the second PDCCH candidates of the UE-specific search space are configured according to the plurality of aggregation levels.

[Claim 11] A user equipment (UE) for receiving downlink control information (DCI) for the UE, the UE comprising:
a radio frequency (RF) unit, and
a processor connected to the RF unit, the processor configured to:
control the RF unit to receive common search space configuration for a common search space;
control the RF unit to receive a first physical downlink control channel (PDCCH) scheduling a random access response by monitoring first PDCCH candidates of the common search space according to the common search space configuration; and
control the RF unit to receive a second PDCCH carrying the DCI for the UE by monitoring second PDCCH candidates of a UE-specific search space,
wherein the second PDCCH candidates of the UE-specific search space are monitored according to the same configuration as the common search space configuration until the UE receives a UE-specific search space configuration.

[Claim 12] The UE according to claim 11,
wherein the common search space configuration includes information on a narrowband for the common search space, and
wherein the second PDCCH candidates of the UE-specific search space are monitored on the same narrowband as the narrowband for the common search space until the UE receives a UE-specific search space configuration.

[Claim 13] The UE according to claim 11 or 12,
wherein the common search space configuration includes information on a maximum number of repetitions for the common common search

space, and
wherein the second PDCCH candidates of the UE-specific search space are monitored based on the same number as the maximum number of repetitions for the common search space until the UE receives a UE-specific search space configuration.

[Claim 14] The UE according to any one of claims 11 to 13,
wherein the common search space configuration includes information on a first physical resource block (PRB) set for monitoring the first PDCCH, and
wherein the same physical resource block set as the first PRB set is used for monitoring the second PDCCH candidates until the UE receives a UE-specific search space configuration.

[Claim 15] The UE according to any one of claims 11 to 14,
wherein the first PDCCH candidates of the common search space are monitored according to aggregation levels larger than or equal to 8 among a plurality of aggregation levels, and the second PDCCH candidates of the UE-specific search space are monitored according to the plurality of aggregation levels.

[Claim 16] A base station (BS) for transmitting downlink control information (DCI) to a user equipment (UE), the BS comprising:
a radio frequency (RF) unit, and
a processor connected to the RF unit, the processor configured to:
control the RF unit to transmit common search space configuration for a common search space;
control the RF unit to transmit, to the UE, a first physical downlink control channel (PDCCH) scheduling a random access response by using one of first PDCCH candidates of the common search space according to the common search space configuration; and
control the RF unit to transmit, to the UE, a second PDCCH carrying the DCI for the UE by using one of second PDCCH candidates of a UE-specific search space,
wherein the second PDCCH candidates of the UE-specific search space are configured according to the same configuration as the common search space configuration until a UE-specific search space configuration is transmitted to the UE.

[Claim 17] The BS according to claim 16,
wherein the common search space configuration includes information on a narrowband for the common search space, and

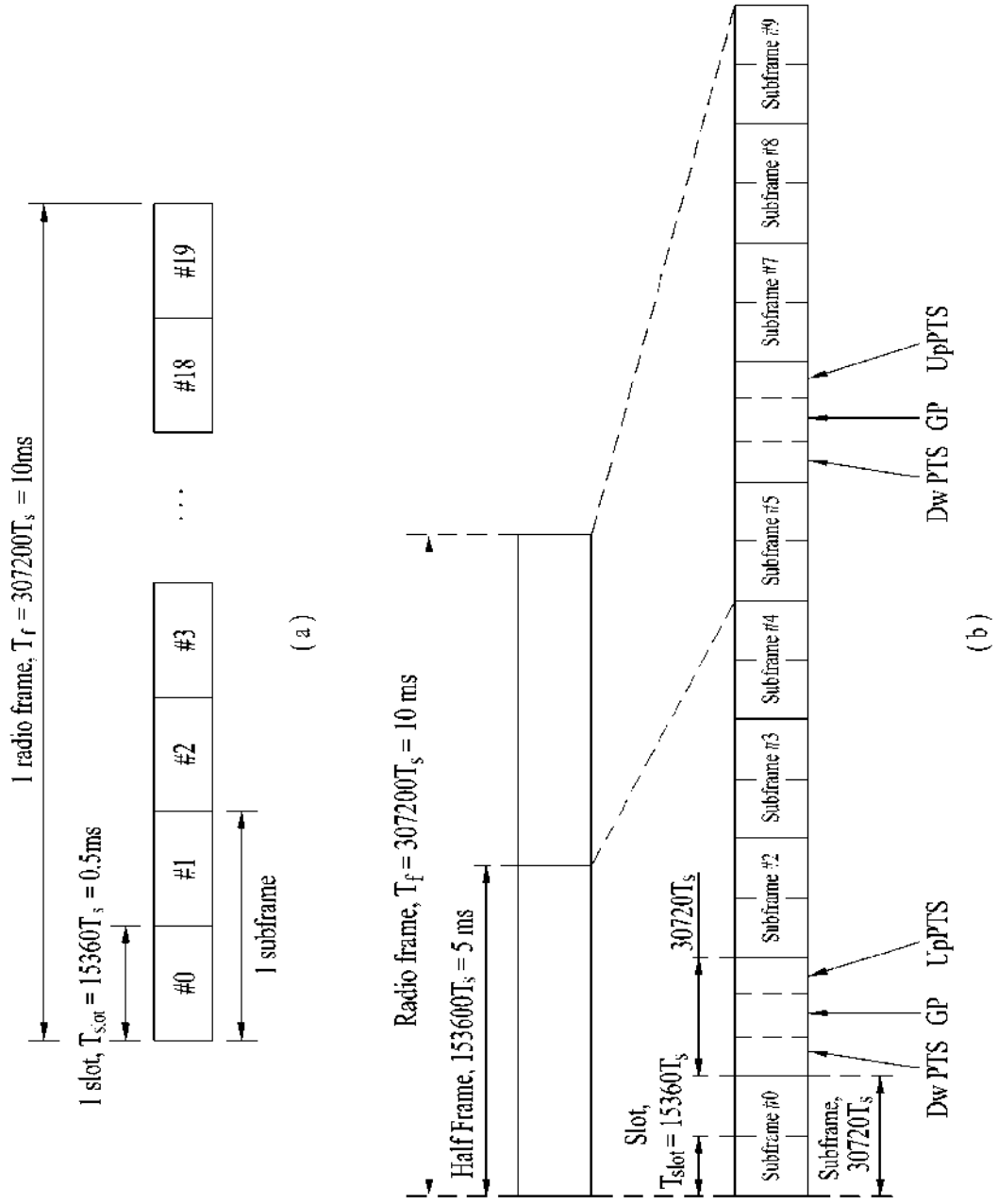
wherein the second PDCCH candidates of the UE-specific search space are configured on the same narrowband as the narrowband for the common search space until the UE-specific search space configuration is transmitted to the UE.

[Claim 18] The BS according to claim 16 or 17,
wherein the common search space configuration includes information on a maximum number of repetitions for the first common search space, and
wherein the second PDCCH candidates of the UE-specific search space are configured based on the same number as the maximum number of repetitions for the common search space until the UE-specific search space configuration is transmitted to the UE.

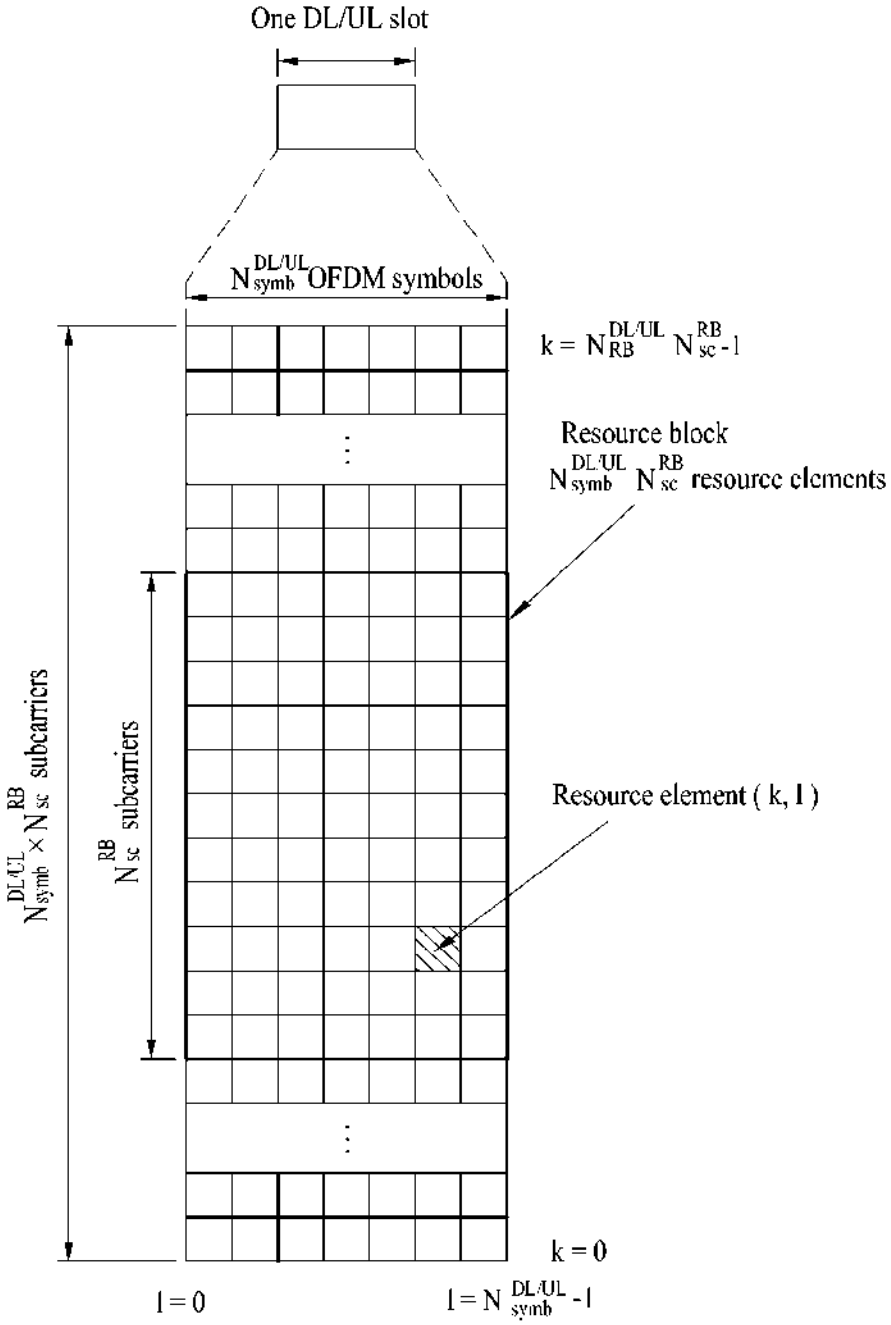
[Claim 19] The BS according to any one of claims 16 to 18,
wherein the common search space configuration includes information on a first physical resource block (PRB) set for transmitting the first PDCCH, and
wherein the same physical resource block set as the first PRB set is used for the second PDCCH candidates until the UE-specific search space configuration is transmitted to the UE.

[Claim 20] The BS according to any one of claims 16 to 19,
wherein the first PDCCH candidates of the common search space are configured according to aggregation levels larger than or equal to 8 among a plurality of aggregation levels, and the second PDCCH candidates of the UE-specific search space are configured according to the plurality of aggregation levels.

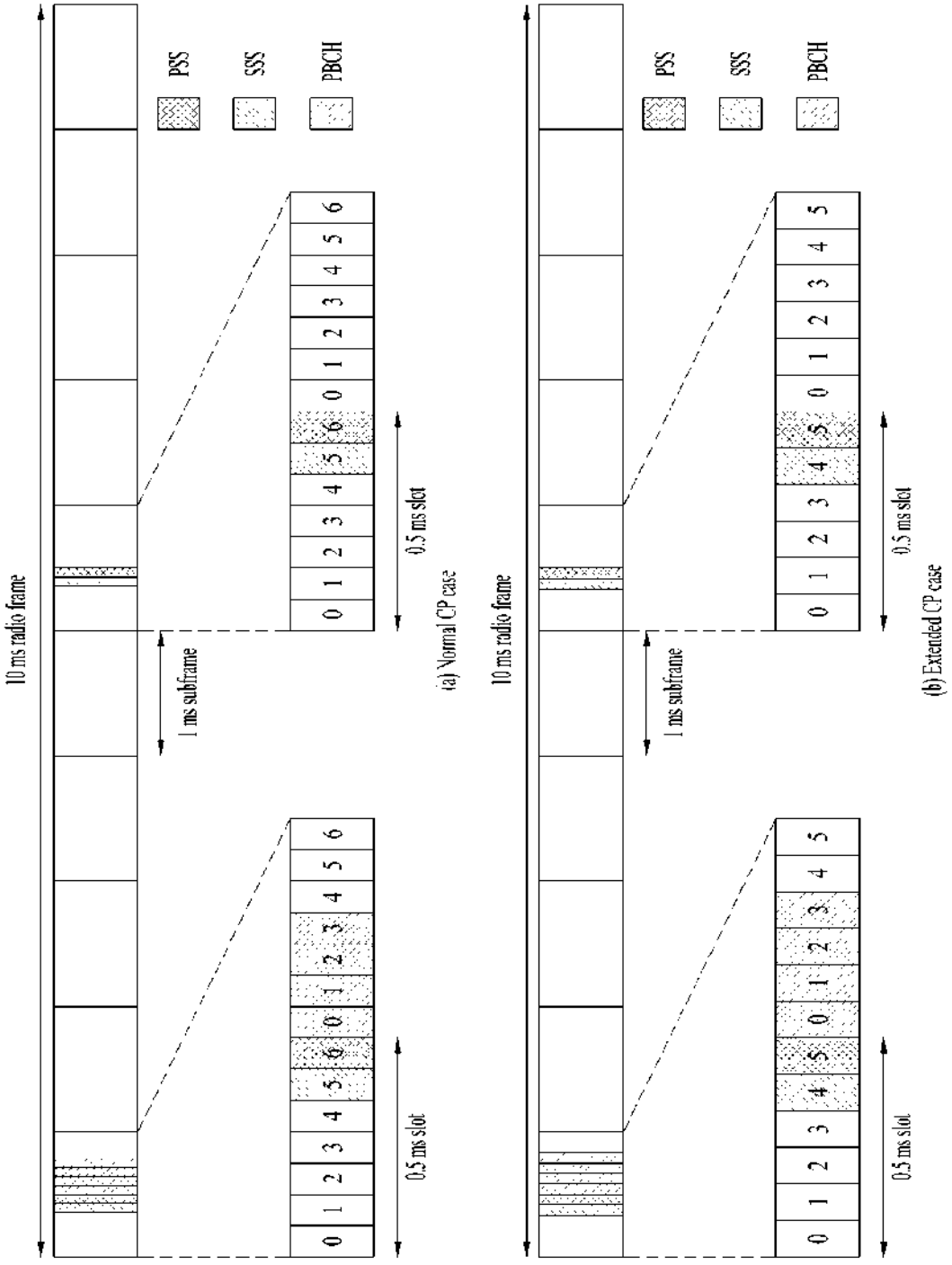
[Fig. 1]


1 radio frame, $T_f = 307200T_s = 10ms$
1 slot, $T_{slot} = 15360T_s = 0.5ms$
#0
#1
#2
#3
#18
#19
1 subframe
(a)
Radio frame, $T_f = 307200T_s = 10$ ms
Half Frame, $153600T_s = 5$ ms
Slot, $T_{slot} = 15360T_s$
$30720T_s$
Subframe, $30720T_s$
Subframe #0
Subframe #1
Subframe #2
Subframe #3
Subframe #4
Subframe #5
Subframe #6
Subframe #7
Subframe #8
Subframe #9
DwPTS
GP
UpPTS
DwPTS
GP
UpPTS
(b)

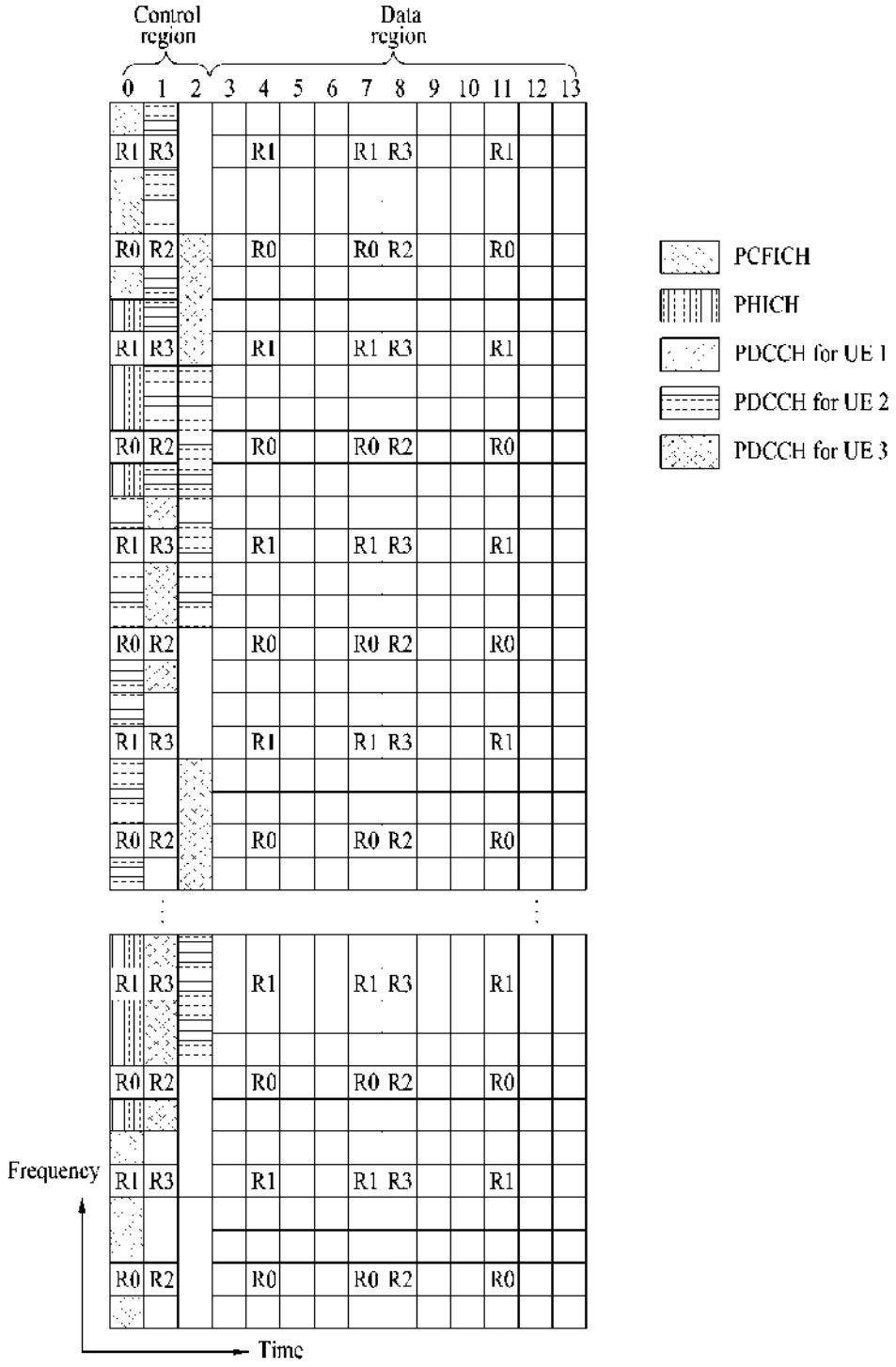
[Fig. 2]


One DL/UL slot
$N_{symb}^{DL/UL}$ OFDM symbols
$k = N_{RB}^{DL/UL} N_{sc}^{RB} - 1$
Resource block
$N_{symb}^{DL/UL} N_{sc}^{RB}$ resource elements
Resource element (k, l)
$N_{symb}^{DL/UL} \times N_{sc}^{RB}$ subcarriers
N_{sc}^{RB} subcarriers
k = 0
l = 0
$l = N_{symb}^{DL/UL} - 1$

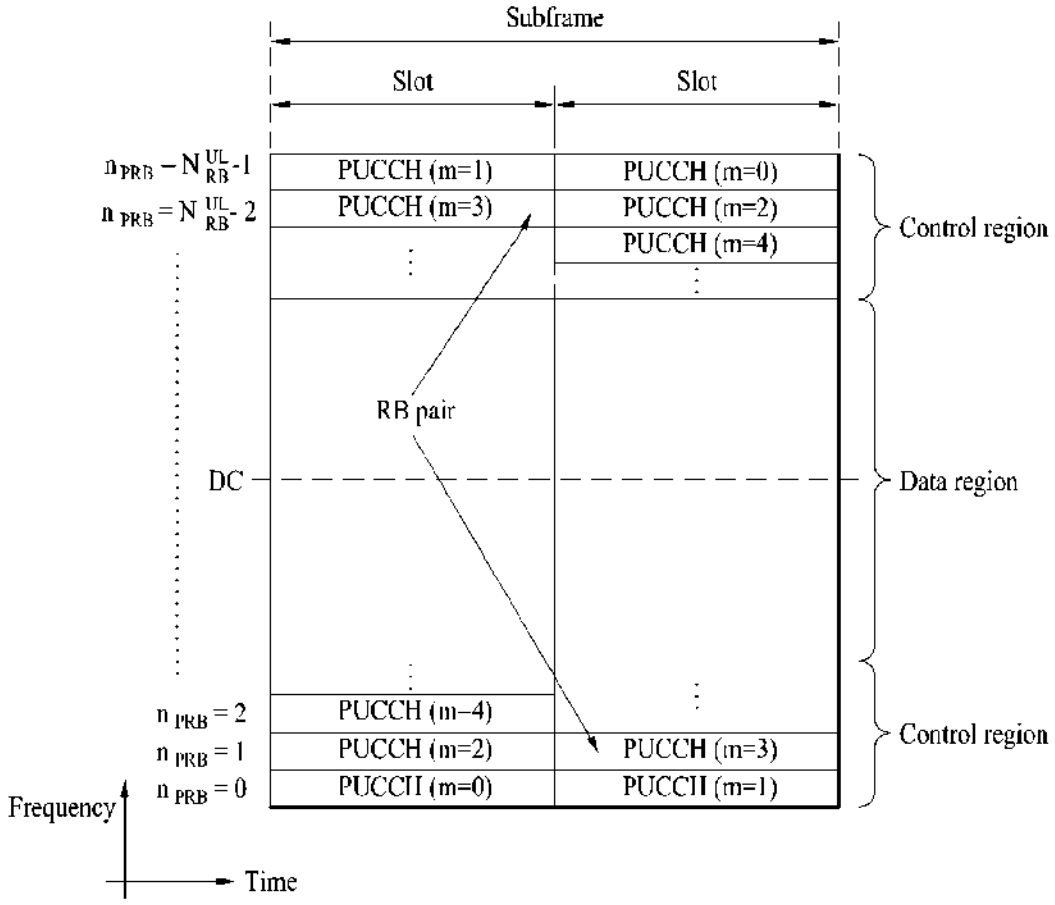
[Fig. 3]


PSS
SSS
PBCH
10 ms radio frame
1 ms subframe
0.5 ms slot
(a) Normal CP case
(b) Extended CP case

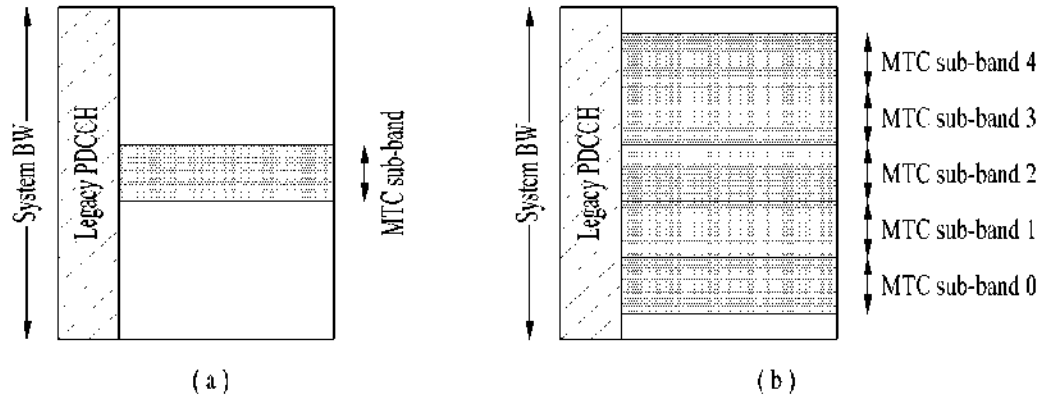
[Fig. 4]


Control region
Data region
0 1 2 3 4 5 6 7 8 9 10 11 12 13
R1 R3
R1
R1 R3
R1
R0 R2
R0
R0 R2
R0
PCFICH
PHICH
PDCCH for UE 1
PDCCH for UE 2
PDCCH for UE 3
Frequency
Time

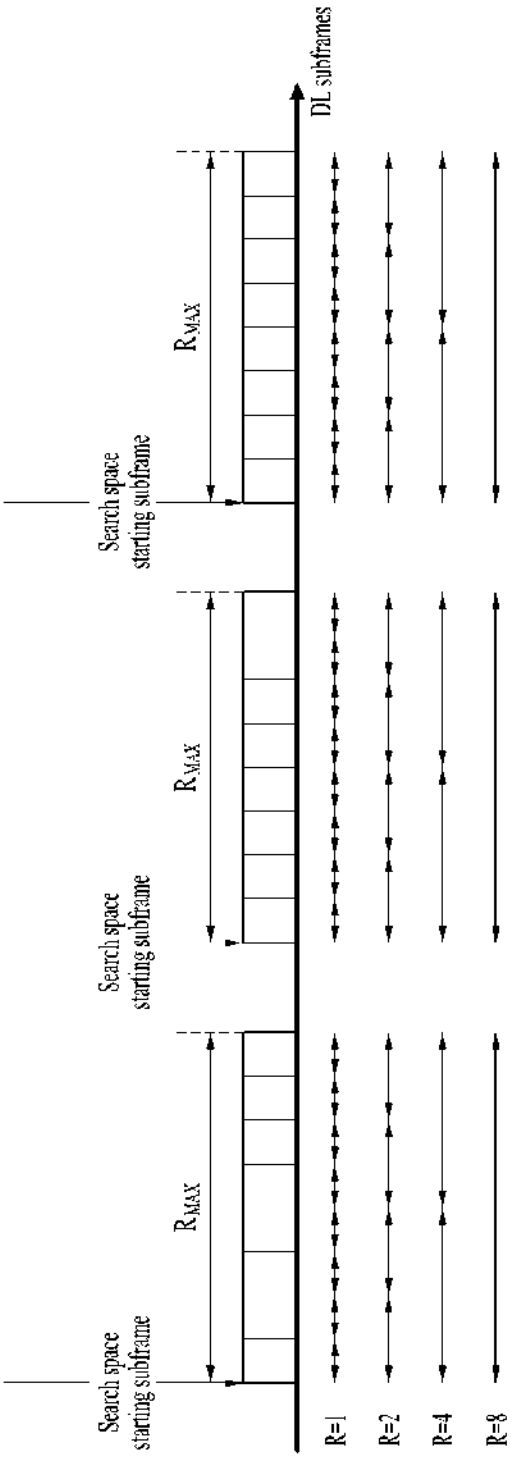
[Fig. 5]


Subframe
Slot
Slot
$n_{PRB} = N_{RB}^{UL} - 1$
$n_{PRB} = N_{RB}^{UL} - 2$
PUCCH (m=1)
PUCCH (m=0)
PUCCH (m=3)
PUCCH (m=2)
PUCCH (m=4)
Control region
RB pair
DC
Data region
$n_{PRB} = 2$
$n_{PRB} = 1$
$n_{PRB} = 0$
PUCCH (m=4)
PUCCH (m=2)
PUCCH (m=0)
PUCCH (m=3)
PUCCH (m=1)
Control region
Frequency
Time

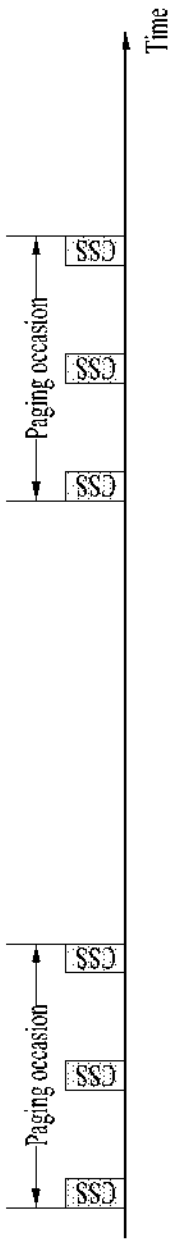
[Fig. 6]


System BW
Legacy PDCCH
MTC sub-band
(a)
System BW
Legacy PDCCH
MTC sub-band 4
MTC sub-band 3
MTC sub-band 2
MTC sub-band 1
MTC sub-band 0
(b)

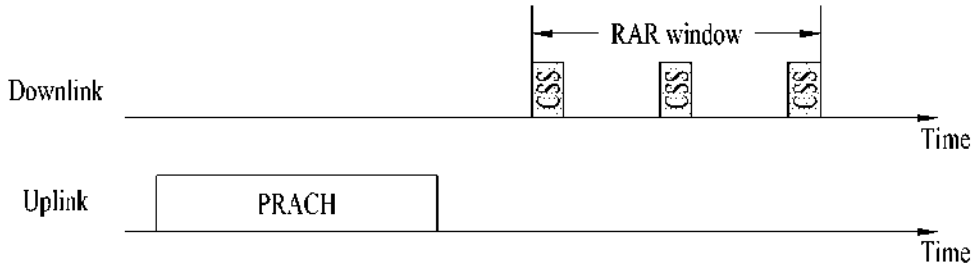
[Fig. 7]


DL subframes
Search space starting subframe
Search space starting subframe
Search space starting subframe
R_{MAX}
R_{MAX}
R_{MAX}
R=1
R=2
R=4
R=8

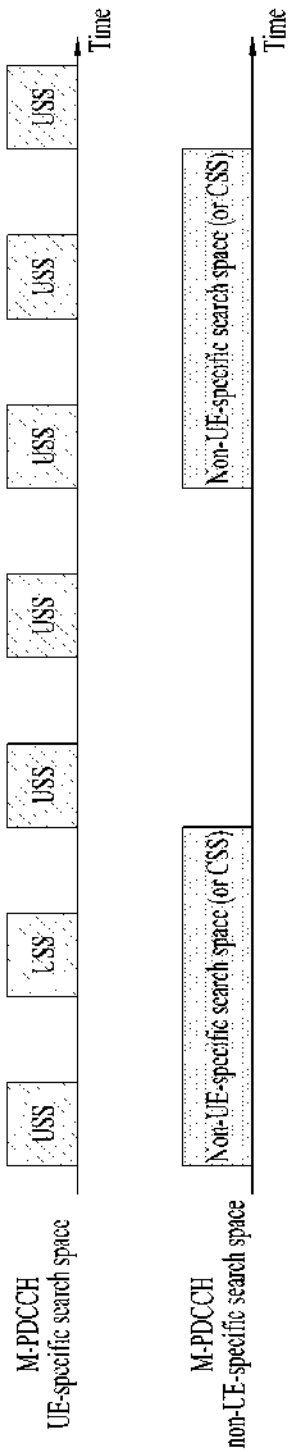
[Fig. 8]


Time
SSO
SSO
SSO
Paging occasion
SSO
SSO
SSO
Paging occasion

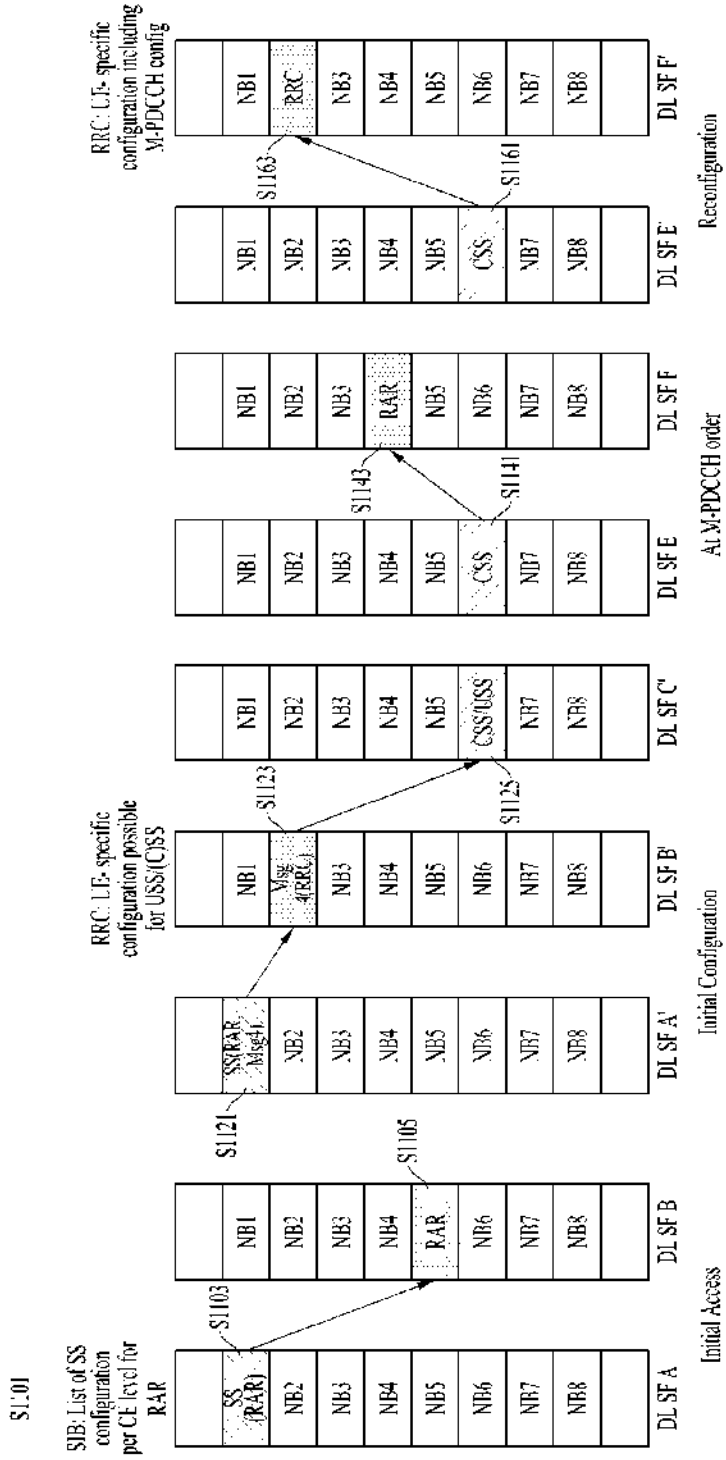
[Fig. 9]


RAR window
Downlink
CSS
CSS
CSS
Time
Uplink
PRACH
Time

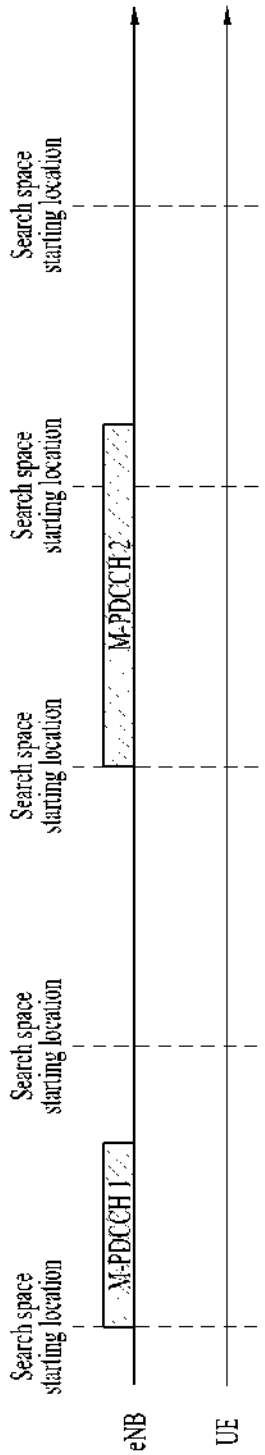
[Fig. 10]


M-PDCCH
UE-specific search space
USS
USS
USS
USS
USS
USS
Time
M-PDCCH
non-UE-specific search space
Non-UE-specific search space (or CSS)
Non-UE-specific search space (or CSS)
Time

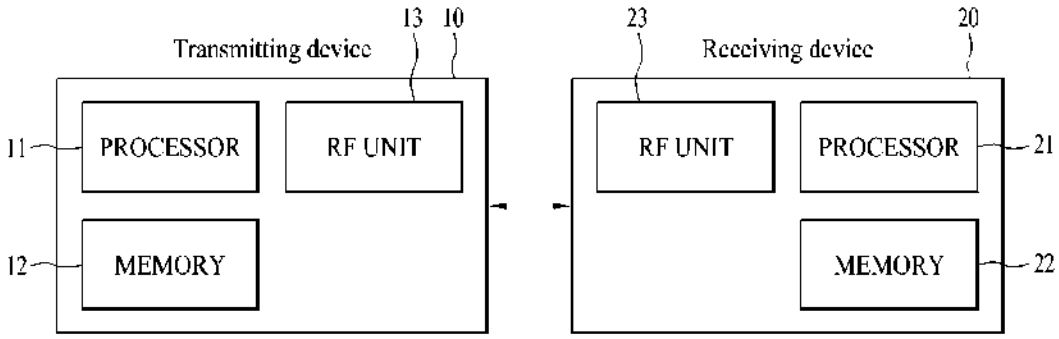
[Fig. 11]


S1101
SIB: List of SS configuration per CE level for RAR
SS (RAR)
NB1
NB2
NB3
NB4
NB5
NB6
NB7
NB8
DL SF A
S1103
RAR
DL SF B
Initial Access
S1105
S1121
SS/RAR Msg4
DL SF A'
RRC UE-specific configuration possible for USS/CSS
Msg 4(RRC)
DL SF B'
Initial Configuration
S1123
S1125
CSS/USS
DL SF C'
S1141
CSS
DL SF E
S1143
RAR
DL SF F
At M-PDCCH order
S1161
CSS
DL SF E'
S1163
RRC
DL SF F'
RRC UE-specific configuration including M-PDCCH config
Reconfiguration

[Fig. 12]


Search space starting location
Search space starting location
Search space starting location
Search space starting location
Search space starting location
M-PDCCH 1
M-PDCCH 2
eNB
UE

[Fig. 13]


Transmitting device
13
10
11
PROCESSOR
RF UNIT
12
MEMORY
23
Receiving device
20
RF UNIT
PROCESSOR
21
MEMORY
22

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2016/010542

A. CLASSIFICATION OF SUBJECT MATTER

H04L 5/00(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: common search space configuration, UE-specific search space, random access response, first PDCCH candidates, downlink control information, second PDCCH candidates, monitor, same configuration

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	ERICSSON, `EPDCCH initialization for MTC`, R1-153731, 3GPP TSG RAN WG1 Meeting #82, Beijing, China, 15 August 2015 See sections 2-3.1; and fig. 1.	1,2,6,7,11,12,16,17
A		3-5,8-10,13-15,18-20
Y	LG ELECTRONICS, `Discussion on Resource configuration for low complexity MTC UEs`, R1-154229, 3GPP TSG RAN WG1 Meeting #82, Beijing, China, 15 August 2015 See sections 2, 3; and figs. 2, 3.	1,2,6,7,11,12,16,17
A	ZTE, `Further considerations on M-PDCCH for MTC`, R1-154432, 3GPP TSG RAN WG1 Meeting #82, Beijing, China, 15 August 2015 See sections 2-3.3.	1-20
A	US 2014-0307560 A1 (LG ELECTRONICS INC.) 16 October 2014 See paragraphs [0102]-[0149]; and figs. 6, 7.	1-20
A	US 2015-0181577 A1 (FUJITSU LIMITED) 25 June 2015 See paragraphs [0145]-[0153]; and fig. 7.	1-20

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
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Information on patent family members

International application No.
PCT/KR2016/010542

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		JP 2015-527840 A	17/09/2015
		KR 10-2015-0024926 A	09/03/2015
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[Continued on next page]

(54) Title: TRANSMISSION SCHEMES AND MODES AND FALLBACK SCHEMES FOR THE ACCESS LINK OF SYSTEMS OPERATING IN HIGHER FREQUENCY BANDS

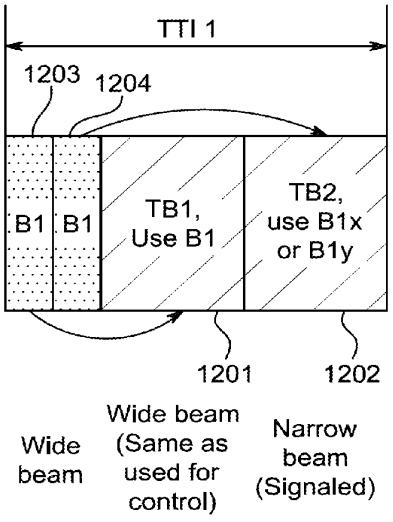


FIG. 12

(57) Abstract: A wireless transmit/receive unit (WTRU) configured to perform wireless communications in higher frequency bands (e.g., above 6 GHz) using a fallback scheme is provided. The WTRU includes a receiver configured to receive, in a time transmission interval (TTI), at least one control signal and a first data signal using a first beam associated with a first beam identifier (ID) and a second data signal, subsequent to the first data signal, using a second beam associated with a second beam ID different from the first beam ID, such that one of the at least one control signal indicates the second beam ID; and a processor configured to switch a receive beam of the receiver from the first beam to the second beam based on the second beam ID to receive the second data signal.

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TRANSMISSION SCHEMES AND MODES AND FALLBACK SCHEMES FOR THE ACCESS LINK OF SYSTEMS OPERATING IN HIGHER FREQUENCY BANDS

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of U.S. provisional application No. 62/253,473 filed November 10, 2015, the content of which is hereby incorporated by reference herein.

BACKGROUND

[0002] In order to meet the high data rate required for next generation of cellular communication systems, the wireless industry and academia have been exploring ways to leverage the large bandwidths available at above-6 GHz frequencies (e.g., centimeter wave (cmW) and millimeter wave (mmW) frequencies). One challenge of using these above-6 GHz frequencies may be issues with signal propagation, which has been considered unfavorable for wireless communication, especially in an outdoor environment.

[0003] The propagation of higher frequencies, such as these, may experience higher free space path loss. Rainfall and atmospheric gasses (e.g., oxygen, nitrogen, and hydrogen) may add further attenuation for above-6 GHz frequencies. In addition, foliage may cause attenuation and depolarization. Penetration and diffraction attenuation may also become more severe. As a result, Non Line-Of-Sight (NLOS) propagation path loss may be significant at above-6 GHz frequencies. For example, at mmW frequencies NLOS path loss may be more than 20 dB higher than Line-Of-Sight (LOS) path loss.

[0004] Outdoor mmW cellular networks may be feasible through the use of beamforming techniques. In addition, a large number of reflected and scattered multipath components (MPC) may be utilized to facilitate the mmW coverage in NLOS conditions.

SUMMARY

[0005] Embodiments provide a system, method, and apparatus for transmitting data between a wireless transmit/receive unit (WTRU) and a base station at a high carrier frequency.

[0006] According to an embodiment, a WTRU is configured to perform wireless communications in higher frequency bands using a fallback scheme. The WTRU includes a receiver configured to receive, in a time transmission interval (TTI), at least one control signal and a first data signal using a first beam associated with a first beam identifier (ID) and a second data signal, subsequent to the first data signal, using a second beam associated with a second beam ID different from the first beam ID. At least one of the control signal(s) indicates the second beam ID. The WTRU further includes a processor configured to switch a receive beam of the receiver from the first beam to the second beam based on the second beam ID to receive the second data signal.

[0007] According to an embodiment, a method implemented by a WTRU includes receiving, in a time transmission interval (TTI), at least one control signal and a first data signal using a first beam associated with a first beam identifier (ID) and a second data signal, subsequent to the first data signal, using a second beam associated with a second beam ID different from the first beam ID. At least one of the control signal(s) indicates the second beam ID. The method further includes switching a receive beam of the WTRU from the first beam to the second beam based on the second beam ID to receive the second data signal.

[0008] According to an embodiment, a wireless communication device is configured to perform wireless communications in higher frequency bands using a fallback scheme. The wireless communication device includes a transmitter configured to transmit, in a time transmission interval (TTI), at least one control signal and a first data signal using a first beam associated with a first beam identifier (ID) and a second data signal, subsequent to the first data signal, using a second beam associated with a second beam ID different from the first beam ID. At least one of the control signal(s) indicates the second beam ID. The wireless

communication device further includes a processor configured to switch a transmit beam of the transmitter from the first beam to the second beam based on the second beam ID to transmit the second data signal to a WTRU.

[0009] According to an embodiment, a method implemented in a wireless communication device includes a transmitting, in a time transmission interval (TTI), at least one control signal and a first data signal using a first beam associated with a first beam identifier (ID) and a second data signal, subsequent to the first data signal, using a second beam associated with a second beam ID different from the first beam ID. At least one of the control signal(s) indicates the second beam ID. The method further includes switching a transmit beam of the wireless communication device from the first beam to the second beam based on the second beam ID to transmit the second data signal to a WTRU.

[0010] According to an embodiment, a WTRU is configured to perform wireless communications in higher frequency bands using a fallback scheme. The WTRU includes a receiver configured to receive, in a time transmission interval (TTI), at least one control signal, a first transport block and a second transport block. The at least one control signal and the first transport block are received using a first beam, and the second transport block is received using a second beam that has a beam width that is more narrow than a beam width of the first beam. In addition, the first transport block and the second transport block are multiplexed using time division multiplexing such that the second transport block is received subsequent to the first transport block. The WTRU further includes a processor configured to switch a receive beam of the receiver from the first beam to the second beam, to receive the second transport block, based on beam information associated with the second beam received in one of the at least one control signal.

[0011] According to an embodiment, a method implemented by a WTRU includes receiving, in a time transmission interval (TTI), at least one control signal, a first transport block and a second transport block. The at least one control signal and the first transport block are received using a first beam, and

the second transport block is received using a second beam that has a beam width that is more narrow than a beam width of the first beam. In addition, the first transport block and the second transport block are multiplexed using time division multiplexing such that the second transport block is received subsequent to the first transport block. The method further includes switching a receive beam of the WTRU from the first beam to the second beam, to receive the second transport block, based on beam information associated with the second beam received in one of the at least one control signal.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] A more detailed understanding may be had from the following description, given by way of example in conjunction with the accompanying drawings wherein:

[0013] FIG. 1A is a system diagram of an example communications system in which one or more disclosed embodiments may be implemented;

[0014] FIG. 1B is a system diagram of an example wireless transmit/receive unit (WTRU) that may be used within the communications system illustrated in FIG. 1A;

[0015] FIG. 1C is a system diagram of an example radio access network and an example core network that may be used within the communications system illustrated in FIG. 1A;

[0016] FIG. 2 shows a diagram of an orthogonal frequency-division multiplexing (OFDM) frame structure over a 1-GHz system bandwidth according to one or more embodiments;

[0017] FIG. 3 shows a diagram of a single carrier frame structure over a 2-GHz system bandwidth according to one or more embodiments;

[0018] FIG. 4 shows a diagram illustrating a fully digitized beamforming system according to one or more embodiments;

[0019] FIG. 5 shows a diagram illustrating an analog beamforming system with one phase antenna array (PAA) and one radio frequency (RF) chain according to one or more embodiments;

[0020] FIGS. 6A and 6B show a diagram illustrating an analog beamforming system with one PAA and two RF chains according to one or more embodiments;

[0021] FIG. 7 shows a diagram illustrating an analog beamforming system with two PAAs and two RF chains according to one or more embodiments;

[0022] FIG. 8 shows a diagram illustrating an analog beamforming system with two PAAs and a single RF chain according to one or more embodiments;

[0023] FIG. 9 shows a diagram illustrating of a semi-static association between the control transmit (Tx) beam and data Tx beam according to one or more embodiments;

[0024] FIG. 10 shows a diagram illustrating an intra-transmission time interval (TTI) downlink (DL) assignment with a guard period according to one or more embodiments;

[0025] FIG. 11 shows a diagram illustrating a cross-TTI DL assignment with narrow beam indication according to one or more embodiments;

[0026] FIG. 12 shows a diagram for a dual transport block (TB) transmission scheme according to one or more embodiments;

[0027] FIG. 13 shows a diagram illustrating a use of a dual TB transmission scheme for data fallback according to one or more embodiments;

[0028] FIG. 14 shows a diagram illustrating another example of using a dual TB transmission scheme for data fallback according to one or more embodiments;

[0029] FIG. 15 shows a diagram illustrating an example of fallback TTI and linkage between fallback downlink control information (DCI) and fallback data, where the mB supports one RF chain according to one or more embodiments;

[0030] FIG. 16 shows a diagram illustrating an example of fallback TTI and linkage between fallback DCI and fallback data, where the mB supports multiple RF chains according to one or more embodiments;

[0031] FIG. 17 shows a diagram of fallback DCI mapped to the data region, and linkage to fallback data according to one or more embodiments;

[0032] FIG. 18 shows a diagram illustrating fallback DCI mapped to the data region using narrow beam transmission according to one or more embodiments;

[0033] FIG. 19 shows a flow diagram utilizing a dual TB transmission scheme according to one or more embodiments; and

[0034] FIG. 20 shows a flow diagram utilizing a dual TB transmission scheme according to one or more embodiments.

DETAILED DESCRIPTION

[0035] Embodiments described herein may define transmission modes (including reference signals and channel state information (CSI) feedback) and transmission schemes for operation of highly directional beamformed systems. In addition, embodiments may define how to mitigate control and/or data channel performance loss due to narrow beam misalignment, for systems operating in higher frequency bands (e.g. above-6 GHz frequencies).

[0036] The latter problem can further be broken down into two different scenarios. In the first scenario, a change in the wireless transmit/receive unit (WTRU) orientation may be such that the data channel performance using a narrow beam pair may be significantly degraded, while the downlink (DL) wide beam control channel may still be received by the WTRU. In the second scenario, the WTRU orientation change may be such that both the data and the control channels may not be received by the WTRU.

[0037] Embodiments may include downlink/uplink (DL/UL) transmission schemes for the access link of beamformed systems operating in the high frequency bands (e.g., above 6 GHz) using one or multiple radio frequency (RF) chains. In addition embodiments may define DL/UL transmission modes and modes of operations.

[0038] In addition to presenting transmission schemes and transmission modes for above 6 GHz systems, embodiments described herein may include

various scenarios where significant degradation of the control and/or data channel performance may occur due to transmit-receive (Tx-Rx) beam misalignment. Embodiments may addresses techniques for control and data fallback to maintain connectivity until a transmission mode change or a beam change is performed.

[0039] FIG. 1A is a diagram of an example communications system 100 in which one or more disclosed embodiments may be implemented. The communications system 100 may be a multiple access system that provides content, such as voice, data, video, messaging, broadcast, etc., to multiple wireless users. The communications system 100 may enable multiple wireless users to access such content through the sharing of system resources, including wireless bandwidth. For example, the communications systems 100 may employ one or more channel access methods, such as code division multiple access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), orthogonal FDMA (OFDMA), single-carrier FDMA (SC-FDMA), and the like.

[0040] As shown in FIG. 1A, the communications system 100 may include wireless transmit/receive units (WTRUs) 102a, 102b, 102c, 102d, a radio access network (RAN) 104, a core network 106, a public switched telephone network (PSTN) 108, the Internet 110, and other networks 112, though it will be appreciated that the disclosed embodiments contemplate any number of WTRUs, base stations, networks, and/or network elements. Each of the WTRUs 102a, 102b, 102c, 102d may be any type of device configured to operate and/or communicate in a wireless environment. By way of example, the WTRUs 102a, 102b, 102c, 102d may be configured to transmit and/or receive wireless signals and may include user equipment (UE), a mobile station, a fixed or mobile subscriber unit, a pager, a cellular telephone, a personal digital assistant (PDA), a smartphone, a laptop, a netbook, a personal computer, a wireless sensor, consumer electronics, and the like.

[0041] The communications systems 100 may also include a base station 114a and a base station 114b. Each of the base stations 114a, 114b may be any type of device configured to wirelessly interface with at least one of the WTRUs 102a, 102b, 102c, 102d to facilitate access to one or more communication networks, such as the core network 106, the Internet 110, and/or the other networks 112. By way of example, the base stations 114a, 114b may be a base transceiver station (BTS), a Node-B, an eNode B, a Home Node B, a Home eNode B, a site controller, an access point (AP), a wireless router, and the like. While the base stations 114a, 114b are each depicted as a single element, it will be appreciated that the base stations 114a, 114b may include any number of interconnected base stations and/or network elements.

[0042] The base station 114a may be part of the RAN 104, which may also include other base stations and/or network elements (not shown), such as a base station controller (BSC), a radio network controller (RNC), relay nodes, etc. The base station 114a and/or the base station 114b may be configured to transmit and/or receive wireless signals within a particular geographic region, which may be referred to as a cell (not shown). The cell may further be divided into cell sectors. For example, the cell associated with the base station 114a may be divided into three sectors. Thus, in one embodiment, the base station 114a may include three transceivers, i.e., one for each sector of the cell. In another embodiment, the base station 114a may employ multiple-input multiple-output (MIMO) technology and, therefore, may utilize multiple transceivers for each sector of the cell.

[0043] The base stations 114a, 114b may communicate with one or more of the WTRUs 102a, 102b, 102c, 102d over an air interface 116, which may be any suitable wireless communication link (e.g., radio frequency (RF), microwave, infrared (IR), ultraviolet (UV), visible light, etc.). The air interface 116 may be established using any suitable radio access technology (RAT).

[0044] More specifically, as noted above, the communications system 100 may be a multiple access system and may employ one or more channel access

schemes, such as CDMA, TDMA, FDMA, OFDMA, SC-FDMA, and the like. For example, the base station 114a in the RAN 104 and the WTRUs 102a, 102b, 102c may implement a radio technology such as Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access (UTRA), which may establish the air interface 116 using wideband CDMA (WCDMA). WCDMA may include communication protocols such as High-Speed Packet Access (HSPA) and/or Evolved HSPA (HSPA+). HSPA may include High-Speed Downlink Packet Access (HSDPA) and/or High-Speed Uplink Packet Access (HSUPA).

[0045] In another embodiment, the base station 114a and the WTRUs 102a, 102b, 102c may implement a radio technology such as Evolved UMTS Terrestrial Radio Access (E-UTRA), which may establish the air interface 116 using Long Term Evolution (LTE) and/or LTE-Advanced (LTE-A).

[0046] In other embodiments, the base station 114a and the WTRUs 102a, 102b, 102c may implement radio technologies such as IEEE 802.16 (i.e., Worldwide Interoperability for Microwave Access (WiMAX)), CDMA2000, CDMA2000 1X, CDMA2000 EV-DO, Interim Standard 2000 (IS-2000), Interim Standard 95 (IS-95), Interim Standard 856 (IS-856), Global System for Mobile communications (GSM), Enhanced Data rates for GSM Evolution (EDGE), GSM EDGE (GERAN), and the like.

[0047] The base station 114b in FIG. 1A may be a wireless router, Home Node B, Home eNode B, or access point, for example, and may utilize any suitable RAT for facilitating wireless connectivity in a localized area, such as a place of business, a home, a vehicle, a campus, and the like. In one embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.11 to establish a wireless local area network (WLAN). In another embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.15 to establish a wireless personal area network (WPAN). In yet another embodiment, the base station 114b and the WTRUs 102c, 102d may utilize a cellular-based RAT (e.g., WCDMA, CDMA2000, GSM, LTE, LTE-A, etc.) to establish a picocell or

femtocell. As shown in FIG. 1A, the base station 114b may have a direct connection to the Internet 110. Thus, the base station 114b may not be required to access the Internet 110 via the core network 106.

[0048] The RAN 104 may be in communication with the core network 106, which may be any type of network configured to provide voice, data, applications, and/or voice over internet protocol (VoIP) services to one or more of the WTRUs 102a, 102b, 102c, 102d. For example, the core network 106 may provide call control, billing services, mobile location-based services, pre-paid calling, Internet connectivity, video distribution, etc., and/or perform high-level security functions, such as user authentication. Although not shown in FIG. 1A, it will be appreciated that the RAN 104 and/or the core network 106 may be in direct or indirect communication with other RANs that employ the same RAT as the RAN 104 or a different RAT. For example, in addition to being connected to the RAN 104, which may be utilizing an E-UTRA radio technology, the core network 106 may also be in communication with another RAN (not shown) employing a GSM radio technology.

[0049] The core network 106 may also serve as a gateway for the WTRUs 102a, 102b, 102c, 102d to access the PSTN 108, the Internet 110, and/or other networks 112. The PSTN 108 may include circuit-switched telephone networks that provide plain old telephone service (POTS). The Internet 110 may include a global system of interconnected computer networks and devices that use common communication protocols, such as the transmission control protocol (TCP), user datagram protocol (UDP) and the internet protocol (IP) in the TCP/IP internet protocol suite. The networks 112 may include wired or wireless communications networks owned and/or operated by other service providers. For example, the networks 112 may include another core network connected to one or more RANs, which may employ the same RAT as the RAN 104 or a different RAT.

[0050] One or more of the WTRUs 102a, 102b, 102c, 102d in the communications system 100 may include multi-mode capabilities, i.e., the WTRUs 102a, 102b, 102c, 102d may include multiple transceivers for

communicating with different wireless networks over different wireless links. For example, the WTRU 102c shown in FIG. 1A may be configured to communicate with the base station 114a, which may employ a cellular-based radio technology, and with the base station 114b, which may employ an IEEE 802 radio technology.

[0051] FIG. 1B is a system diagram of an example WTRU 102. As shown in FIG. 1B, the WTRU 102 may include a processor 118, a transceiver 120, a transmit/receive element 122, a speaker/microphone 124, a keypad 126, a display/touchpad 128, non-removable memory 130, removable memory 132, a power source 134, a global positioning system (GPS) chipset 136, and other peripherals 138. It will be appreciated that the WTRU 102 may include any sub-combination of the foregoing elements while remaining consistent with an embodiment.

[0052] The processor 118 may be a general purpose processor, a special purpose processor, a conventional processor, a digital signal processor (DSP), a plurality of microprocessors, one or more microprocessors in association with a DSP core, a controller, a microcontroller, Application Specific Integrated Circuits (ASICs), Field Programmable Gate Array (FPGAs) circuits, any other type of integrated circuit (IC), a state machine, and the like. The processor 118 may perform signal coding, data processing, power control, input/output processing, and/or any other functionality that enables the WTRU 102 to operate in a wireless environment. The processor 118 may be coupled to the transceiver 120, which may be coupled to the transmit/receive element 122. While FIG. 1B depicts the processor 118 and the transceiver 120 as separate components, it will be appreciated that the processor 118 and the transceiver 120 may be integrated together in an electronic package or chip.

[0053] The transceiver 120, or any part thereof, may be configured to align its transmit beam, for transmitting an uplink transmission, with a receive beam of an eNode-B. Similarly, the transceiver 120, or any part thereof, may be configured to align its receive beam, for receiving a downlink transmission, with

a transmit beam of the eNode-B. The processor 118 may further be configured to determine a transmit beam and/or receive beam (e.g., based on received configuration or control information) for the transceiver 120 to use, and configure the transceiver 120 accordingly for communicating with the eNode-B.

[0054] The transmit/receive element 122 may be configured to transmit signals to, or receive signals from, a base station (e.g., the base station 114a) over the air interface 116. For example, in one embodiment, the transmit/receive element 122 may be an antenna configured to transmit and/or receive RF signals. In another embodiment, the transmit/receive element 122 may be an emitter/detector configured to transmit and/or receive IR, UV, or visible light signals, for example. In yet another embodiment, the transmit/receive element 122 may be configured to transmit and receive both RF and light signals. It will be appreciated that the transmit/receive element 122 may be configured to transmit and/or receive any combination of wireless signals.

[0055] In addition, although the transmit/receive element 122 is depicted in FIG. 1B as a single element, the WTRU 102 may include any number of transmit/receive elements 122. More specifically, the WTRU 102 may employ MIMO technology. Thus, in one embodiment, the WTRU 102 may include two or more transmit/receive elements 122 (e.g., multiple antennas) for transmitting and receiving wireless signals over the air interface 116.

[0056] The transceiver 120 may be configured to modulate the signals that are to be transmitted by the transmit/receive element 122 and to demodulate the signals that are received by the transmit/receive element 122. As noted above, the WTRU 102 may have multi-mode capabilities. Thus, the transceiver 120 may include multiple transceivers for enabling the WTRU 102 to communicate via multiple RATs, such as UTRA and IEEE 802.11, for example.

[0057] The processor 118 of the WTRU 102 may be coupled to, and may receive user input data from, the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128 (e.g., a liquid crystal display (LCD) display unit or organic light-emitting diode (OLED) display unit). The processor 118 may also

output user data to the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128. In addition, the processor 118 may access information from, and store data in, any type of suitable memory, such as the non-removable memory 130 and/or the removable memory 132. The non-removable memory 130 may include random-access memory (RAM), read-only memory (ROM), a hard disk, or any other type of memory storage device. The removable memory 132 may include a subscriber identity module (SIM) card, a memory stick, a secure digital (SD) memory card, and the like. In other embodiments, the processor 118 may access information from, and store data in, memory that is not physically located on the WTRU 102, such as on a server or a home computer (not shown).

[0058] The processor 118 may receive power from the power source 134, and may be configured to distribute and/or control the power to the other components in the WTRU 102. The power source 134 may be any suitable device for powering the WTRU 102. For example, the power source 134 may include one or more dry cell batteries (e.g., nickel-cadmium (NiCd), nickel-zinc (NiZn), nickel metal hydride (NiMH), lithium-ion (Li-ion), etc.), solar cells, fuel cells, and the like.

[0059] The processor 118 may also be coupled to the GPS chipset 136, which may be configured to provide location information (e.g., longitude and latitude) regarding the current location of the WTRU 102. In addition to, or in lieu of, the information from the GPS chipset 136, the WTRU 102 may receive location information over the air interface 116 from a base station (e.g., base stations 114a, 114b) and/or determine its location based on the timing of the signals being received from two or more nearby base stations. It will be appreciated that the WTRU 102 may acquire location information by way of any suitable location-determination method while remaining consistent with an embodiment.

[0060] The processor 118 may further be coupled to other peripherals 138, which may include one or more software and/or hardware modules that provide additional features, functionality and/or wired or wireless connectivity. For

example, the peripherals 138 may include an accelerometer, an e-compass, a satellite transceiver, a digital camera (for photographs or video), a universal serial bus (USB) port, a vibration device, a television transceiver, a hands free headset, a Bluetooth® module, a frequency modulated (FM) radio unit, a digital music player, a media player, a video game player module, an Internet browser, and the like.

[0061] FIG. 1C is a system diagram of the RAN 104 and the core network 106 according to an embodiment. As noted above, the RAN 104 may employ an E-UTRA radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 116. The RAN 104 may also be in communication with the core network 106.

[0062] The RAN 104 may include eNode-Bs 140a, 140b, 140c, though it will be appreciated that the RAN 104 may include any number of eNode-Bs while remaining consistent with an embodiment. The eNode-Bs 140a, 140b, 140c may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 116. In one embodiment, the eNode-Bs 140a, 140b, 140c may implement MIMO technology. Thus, the eNode-B 140a, for example, may use multiple antennas to transmit wireless signals to, and receive wireless signals from, the WTRU 102a.

[0063] Each of the eNode-Bs 140a, 140b, 140c may be associated with a particular cell (not shown) and may be configured to handle radio resource management decisions, handover decisions, scheduling of users in the uplink and/or downlink, and the like. As shown in FIG. 1C, the eNode-Bs 140a, 140b, 140c may communicate with one another over an X2 interface.

[0064] The core network 106 shown in FIG. 1C may include a mobility management entity gateway (MME) 142, a serving gateway 144, and a packet data network (PDN) gateway 146. While each of the foregoing elements are depicted as part of the core network 106, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

[0065] The MME 142 may be connected to each of the eNode-Bs 140a, 140b, 140c in the RAN 104 via an S1 interface and may serve as a control node. For example, the MME 142 may be responsible for authenticating users of the WTRUs 102a, 102b, 102c, bearer activation/deactivation, selecting a particular serving gateway during an initial attach of the WTRUs 102a, 102b, 102c, and the like. The MME 142 may also provide a control plane function for switching between the RAN 104 and other RANs (not shown) that employ other radio technologies, such as GSM or WCDMA.

[0066] The serving gateway 144 may be connected to each of the eNode Bs 140a, 140b, 140c in the RAN 104 via the S1 interface. The serving gateway 144 may generally route and forward user data packets to/from the WTRUs 102a, 102b, 102c. The serving gateway 144 may also perform other functions, such as anchoring user planes during inter-eNode B handovers, triggering paging when downlink data is available for the WTRUs 102a, 102b, 102c, managing and storing contexts of the WTRUs 102a, 102b, 102c, and the like.

[0067] The serving gateway 144 may also be connected to the PDN gateway 146, which may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, such as the Internet 110, to facilitate communications between the WTRUs 102a, 102b, 102c and IP-enabled devices.

[0068] The core network 106 may facilitate communications with other networks. For example, the core network 106 may provide the WTRUs 102a, 102b, 102c with access to circuit-switched networks, such as the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, 102c and traditional land-line communications devices. For example, the core network 106 may include, or may communicate with, an IP gateway (e.g., an IP multimedia subsystem (IMS) server) that serves as an interface between the core network 106 and the PSTN 108. In addition, the core network 106 may provide the WTRUs 102a, 102b, 102c with access to the networks 112, which may include other wired or wireless networks that are owned and/or operated by other service providers.

[0069] Other network 112 may further be connected to an IEEE 802.11 based wireless local area network (WLAN) 160. The WLAN 160 may include an access router 165. The access router may contain gateway functionality. The access router 165 may be in communication with a plurality of access points (APs) 170a, 170b. The communication between access router 165 and APs 170a, 170b may be via wired Ethernet (IEEE 802.3 standards), or any type of wireless communication protocol. AP 170a is in wireless communication over an air interface with WTRU 102d.

[0070] It should be noted that although 3GPP LTE may be used for example purposes, the techniques described herein may be applied to any other system.

[0071] The following list of definitions, although not intended to be limiting, may be helpful in understanding the following embodiments.

[0072] A "beam" may be one lobe (e.g. main/side/grating) of a transmit radiation pattern and receive gain pattern of an antenna array. The beam may also denote a spatial direction that may be represented with a set beamforming weights. The beam may be identified or associated with a reference signal, an antenna port, a beam identity (ID), and/or a scrambling sequence number. The beam may be transmitted and/or received at a specific time, frequency, code, and/or spatial resource. The beam may be formed digitally, in an analog manner, or both (i.e., hybrid beamforming). The analog beamforming may be based on fixed code-book or continuous phase shifting.

[0073] A "beam-specific reference signal" (BSRS) may be a sequence associated with a transmit beam used for beam acquisition, timing and/or frequency synchronization, channel estimation for a physical downlink directional control channel (PDDCCH), fine beam tracking, beam measurement, etc. BSRS may carry (e.g., implicitly carry) beam identity information. There may be different types of BSRS. For example, there may be BSRS for an mmW sector and its member segments. The segment may be referred as a beam direction (e.g., a narrow beam direction or a wide beam direction).

[0074] A “data channel beam” may be used to transmit a data channel, a Physical Downlink Shared Channel (PDSCH), a mPDSCH, a mmW PDSCH, a mmW data channel, a directional PDSCH, a beamformed data channel, a spatial data channel, a data channel slice, or a high frequency data channel. The data channel beam may be identified or associated with a reference signal, an antenna port, a beam identity (ID), and/or a scrambling sequence number. The data channel beam may be transmitted and/or received at a specific time, frequency, code, and/or spatial resource.

[0075] A “control channel beam” may be used to transmit a control channel, a control channel beam, a PDCCH, an mPDCCH, an mmW PDCCH, an mmW control channel, a directional PDCCH, a beamformed control channel, a spatial control channel, a control channel slice or a high frequency control channel. A control channel beam may be identified or associated with a reference signal, an antenna port, a beam identity (ID), a scrambling sequence number and may be transmitted and/or received at a specific time and/or frequency and/or code and/or spatial resources.

[0076] A “measurement beam” may be used to transmit a signal or channel for beam measurement. This may include a beam reference signal, a beam measurement reference signal, Cell Specific Reference Signal (CRS), Channel State Information-Reference Signal (CSI-RS), CSI-interference measurement (CSI-IM), etc. The measurement beam may be identified or associated with a reference signal, an antenna port, a beam identity (ID), and/or a scrambling sequence number. The measurement beam may be transmitted and/or received at a specific time, frequency, code, and/or spatial resource.

[0077] A “control channel beam duration” may be the length of time, which may be referred to in units of OFDM symbols, used within a scheduling interval for the transmission of one control channel beam.

[0078] A “control region” may be the length in theof time domain, which may be referred to in units of OFDM symbols, used within a scheduling interval for the transmission of all the control channel beams in that scheduling interval.

For example, a control region may be the number of OFDM symbols in a TTI occupied by all the control channel beams transmitted in the TTI.

[0079] A "data region" may be part of the scheduling interval in time domain, which may be referred to in units of OFDM symbols, used for the transmission of all data channel beams in that scheduling interval.

[0080] A "data fallback" may be an alternate scheme for data transmission, that may be used dynamically, irrespective of the transmission mode, to maintain the data communication between the base station and the WTRU. Data fallback schemes may be used in either downlink (DL), or uplink (UL), or both.

[0081] A "control fallback" may be an alternate scheme for signaling the control channel, that may be used dynamically, irrespective of the transmission mode, to maintain the control signaling between the base station and the WTRU.

[0082] In some embodiments described herein, the terms base station, eNode-B (eNB), mmW eNB (mB), Small Cell mmW eNB (SCmB), cell, small cell, primary cell (Pcell), and secondary cell (Scell) may be used interchangeably. In some embodiments, the term operate may be used interchangeably with transmit and/or receive. In some embodiments, the terms component carrier, mmW carrier may be used interchangeably with serving cell.

[0083] In some embodiments, the mB may transmit and/or receive one or more mmW channels and/or signals in a licensed band and/or an unlicensed band. In some embodiments, the WTRU may be substituted for eNB and/or vice versa and still be consistent with this disclosure. In some embodiments, UL may be substituted for DL and/or vice versa and still be consistent with this disclosure.

[0084] In some embodiments, a channel may refer to a frequency band that may have a center, or carrier frequency, and a bandwidth. Licensed and/or unlicensed spectrum may include one or more channels which may or may not overlap. Channel, frequency channel, wireless channel, and mmW channel may be used interchangeably. Accessing a channel may be the same as using (e.g., transmitting and/or receiving on or using) the channel.

[0085] In some embodiments, a channel refers to a mmW channel or signal, such as an uplink or downlink physical channel or signal. Downlink channels and signals may include one or more of the following: mmW synchronization signal, mmW broadcast channel, mmW cell reference signal, mmW beam reference signal, mmW beam control channel, mmW beam data channel, mmW hybrid automatic repeat request (ARQ) indicator channel, mmW demodulation reference signal, primary synchronization signal (PSS), secondary synchronization signal (SSS), demodulation reference signal (DMRS), CRS, CSI-RS, Physical Broadcast Channel (PBCH), Physical downlink Control Channel (PDCCH), Physical Hybrid ARQ Indicator Channel (PHICH), Enhanced Physical Downlink Control Channel (EPDCCH), and PDSCH. Uplink channels and signals may include one or more of the following: mmW Physical Random Access Channel (PRACH), mmW control channel, mmW data channel, mmW beam reference signal, mmW demodulation reference signal, PRACH, Physical Uplink Control Channel (PUCCH), sounding reference signal (SRS), DMRS and Physical Uplink Shared Channel (PUSCH). Channel and mmW channel may be used interchangeably. Channels and signals may be used interchangeably.

[0086] In some embodiments data/control may mean data and/or control signals and/or channels. Control may include synchronization. The data/control may be mmW data/control. Data/control and data/control channels and/or signals may be used interchangeably. Channels and signals may be used interchangeably. The terms control channel, control channel beam, PDCCH, mPDCCH, mmW PDCCH, mmW control channel, directional PDCCH, beamformed control channel, spatial control channel, control channel slice, high frequency control channel may be used interchangeably. The terms data channel, data channel beam, PDSCH, mPDSCH, mmW PDSCH, mmW data channel, directional PDSCH, beamformed data channel, spatial data channel, data channel slice, and high frequency data channel may be used interchangeably.

[0087] In some embodiments, channel resources may be resources (e.g., 3GPP LTE or LTE-A resources) such as time, frequency, code, and/or spatial

resources, which may, at least sometimes, carry one or more channels and/or signals. In some embodiments, channel resources may be used interchangeably with channels and/or signals.

[0088] The terms mmW beam reference signal, mmW reference resource for beam measurement, mmW measurement reference signal, mmW channel state measurement reference signal, mmW demodulation reference signal, mmW sounding reference signal, reference signal, CSI-RS, CRS, DM-RS, DRS, measurement reference signal, reference resource for measurement, CSI-IM, and measurement RS may be used interchangeably. mmW cell, mmW small cell, SCell, secondary cell, license-assisted cell, unlicensed cell, and Licensed Assisted Access (LAA) cell may be used interchangeably. The terms mmW cell, mmW small cell, PCell, primary cell, LTE cell, and licensed cell may be used interchangeably.

[0089] The terms interference and interference plus noise may be used interchangeably.

[0090] Multiple above-6 GHz frequency bands have been evaluated for next generation cellular networks. For example, 10 GHz and 15 GHz bands have been evaluated at the cmW frequency band. In addition, 28 GHz, 39 GHz, 60 GHz and 73 GHz bands have been evaluated at the mmW frequency band. These higher frequency bands may be allocated as licensed, lightly licensed, and unlicensed spectrums.

[0091] Depending on the allocation of the spectrum and its propagation characteristics, the above-6 GHz frequency bands may be deployed in various cellular network configurations. For example, mmW frequencies may be used for a homogenous network with mmW stand-alone Macro-, Micro- and Small Cell base stations. A heterogeneous network may consist of a mmW stand-alone small cell network overlaid with a LTE Macro- and/or Micro- network at sub-6 GHz frequencies. In such a network, a network node may be connected to both above-6 GHz frequencies (e.g., a mmW system) and below-6 GHz frequencies (e.g., a 2 GHz LTE system), which may be referred as Dual Connectivity. Carrier

aggregation may be applied to combine above-6 GHz carriers (e.g., mmW) and sub-6 GHz carriers (e.g., 2 GHz LTE carriers).

[0092] Embodiments described herein may apply to any above-6 GHz cellular deployment.

[0093] Waveforms, such as, for example, orthogonal frequency-division modulation (OFDM), broad-band Single Carrier (SC), SC-OFDM, Generalized OFDM, Filter Bank Multicarrier (FBMC), and Multi-Carrier Code Division Multiple Access (MC-CDMA) may be used for above-6 GHz systems. Waveforms may have different Peak to Average Power Ratio (PAPR) performance, sensitivity to transmitter non-linearity, Bit Error Rate (BER) performance, resource channelization, and implementation complexity.

[0094] While frame structure may depend on the applied waveform, it may also be dimensioned to meet the above-6 GHz system requirement. For example, in order to achieve very low latency, a higher-frequency cellular system may have a subframe length of 100 μs.

[0095] Referring to FIG. 2, FIG. 2 shows a diagram of an OFDM frame structure 200 over a 1-GHz system bandwidth. According to the OFDM-based frame structure 200 shown in FIG. 2, a frame 202 includes 10 sub-frames, each sub-frame includes 10 slots, and each slot includes 24 symbols. The OFDM-based frame structure 200 may have, for example, a sub-carrier spacing of 300 kHz with a corresponding symbol length (T_{symbol}) of 3.33 μs. Considering a cyclic prefix (CP) length may span over the entire length of the channel time dispersion in order to eliminate the inter-symbol-interference, one example of CP for a T_{symbol} of 3.33 μs may be selected at 1/4 of T_{symbol} (i.e., at 0.833 μs). This example numerology may be used for a range of above-6 GHz system bandwidths (e.g., from 50 MHz to 2 GHz) with corresponding Fast Fourier Transform (FFT) length.

[0096] Referring now to FIG. 3, FIG. 3 shows a diagram of a single carrier frame structure 300 over a 2-GHz system bandwidth. Another frame structure may be based on single carrier over an entire system bandwidth. The system bandwidth may range from 50 MHz to 2 GHz. One such example may be based

on 2 GHz bandwidth. The sampling frequency F_s may be 1.536 GHz with a 1024-FFT. A subframe 302 may include 10 time slots each of which may be 100 μs and may have 150 single carrier (FFT) blocks. Each single carrier block may have 1024 symbols that can be used for synchronization, reference, control, data, cyclic prefix or other system purposes.

[0097] An above-6 GHz system (e.g., cmW and mmW systems) may apply any waveform and frame structure or combination thereof as discussed above. Procedures described in this disclosure may apply to all these waveform and frame structure selections.

[0098] Above-6 GHz systems may use Frequency Division Duplex (FDD), Time Division Duplex (TDD), Spatial Division Duplex (SDD) or any combination of them in conjunction with either half-duplex or full-duplex mechanisms.

[0099] A full-duplex FDD system may use a duplex filter to allow simultaneous downlink and uplink operation at different frequencies separated by a duplex distance. A half-duplex FDD system may not use a duplex filter, as the downlink and uplink operation may take place at different time instance in its dedicated frequency. A TDD system may have the downlink and uplink operate at the same frequency at different time instances. A SDD system, for example, in a beamformed system, may enable a network node to transmit and receive at a same frequency and time instance but at different outgoing and incoming spatial directions.

[0100] An above-6 GHz network may use Frequency Division Multiple Access (FDMA), Time Division Multiple Access (TDMA), Spatial Division Multiple Access (SDMA), Code Division Multiple Access (CDMA), Non-Orthogonal Multiple Access (NOMA), or any combination thereof. FDMA, TDMA, SDMA and CDMA may be applied in an orthogonal manner to avoid interference.

[0101] Multiple network nodes may be assigned to use different frequency resources simultaneously in a FDMA system, or to access the system frequency resources at different time instances in a TDMA system. Moreover the network nodes may access the same frequency resources at the same time, but may use a

different code in a CDMA system. A SDMA system may assign a spatial resource to network nodes to operate at same frequency, time, and code resource. In a beamformed network, WTRUs may use different beams.

[0102] In a NOMA system, multiple network nodes may be assigned overlapping or identical resources in frequency, time, code or spatial domain, but may apply additional mechanisms to remove interference caused by the non-orthogonal use of the resource between users. For example, two WTRUs may be located relatively far from each other, and the difference of their path loss to the base station may be large. They may be assigned with the same frequency resource in the same subframe with very different transport formats. Superposition coding and a Successive Interference Rejection (SIC) receiver may be used for a WTRU to remove the received signal intended for the other.

[0103] An above-6 GHz system (e.g., cmW and mmW systems) may apply any duplex scheme and multiple access or combination of them as discussed above. Embodiments described herein may apply to all these duplex schemes and multiple access schemes.

[0104] An above-6 GHz system may have a number of physical channels and signals for various system purposes. Certain signals may be used for multiple system procedures.

[0105] The following are examples of downlink physical channels and signals.

[0106] A synchronization signal may be a pre-defined signal that may be used for cell timing/frequency synchronization. It may be transmitted according to pre-defined periodicity. In a beamformed system, the signal may provide beam timing and frequency acquisition.

[0107] A physical broadcast channel may carry broadcast information, such as cell specific system information.

[0108] A downlink reference signal may be a pre-defined sequence transmitted to enable various system procedures (e.g., channel estimation for control channel, channel statement measurement, timing and frequency fine-

tuning, system measurement, and the like). There may be different types of reference signals. In a beamformed system, a downlink reference signal may be used for beam acquisition, beam pairing, beam tracking, beam switch, beam measurement, and the like.

[0109] A physical downlink control channel may carry data related control information to identify, demodulate and decode the associated data channel properly.

[0110] A physical downlink data channel may carry payload information in the form of Medium Access Control (MAC) Protocol Data Unit (PDU) from the MAC layer. The resource allocation of this channel may be carried in the scheduling information in the physical downlink control channel.

[0111] A data demodulation reference signal may have symbols that may be transmitted for channel estimation of downlink control or data channel. The symbols may be placed together with the associated control or data symbols in the time and frequency domain according to pre-defined pattern. This may ensure correct interpolation and reconstruction of the channel.

[0112] The following are examples of uplink physical channels and signals.

[0113] An uplink reference signal may be used for uplink channel sounding, uplink system measurement, etc. In a beamformed system, an uplink reference signal may be used for uplink beam acquisition, beam pairing, beam tracking, beam switch, beam measurement, etc.

[0114] A physical random access channel (PRACH) may carry a pre-defined sequence in connection with a random access procedure.

[0115] A physical uplink control channel may carry uplink control information, such as channel state information, data acknowledgement, scheduling request, etc.

[0116] A physical uplink data channel may carry payload information in the form of MAC PDU from a UE MAC layer. The resource allocation of this channel may be conveyed in the downlink control channel.

[0117] A data demodulation reference signal may have symbols that may be transmitted for channel estimation of uplink control or data channel. The symbols may be placed together with the associated data symbols in the time and frequency domain according to pre-defined pattern to ensure correct interpolation and reconstruction of the channel.

[0118] An above-6 GHz system (e.g., cmW and mmW systems) may deploy the signals and channels discussed above. Embodiments described herein may apply to these physical signals and channels.

[0119] Beamforming may be important in above-6 GHz systems. Outage studies conducted at 28 GHz and 38 GHz in an urban area using a steerable 10°-beamwidth and a 24.5-dBi horn antenna have shown a consistent coverage may be achieved with a cell-radius of up to 200 meters. Currently, LTE WTRUs are assumed to have an Omni-directional beam pattern and may perceive a superimposed channel impulse response over the entire angular domain. Thus an aligned beam pair e.g., at mmW frequencies may provide an additional degree of freedom in the angular domain compared with the current LTE system.

[0120] Conventional LTE WTRUs may have an Omni-directional beam pattern and may perceive a superimposed channel impulse response over the entire angular domain. Thus, an aligned beam pair at, for example, mmW frequencies, may provide an additional degree of freedom in the angular domain compared with conventional LTE systems.

[0121] Referring now to FIG. 4, FIG. 4 shows a diagram illustrating fully digitized beamforming system 400 according to one or more embodiments. A phase antenna array (PAA) may be used for beamforming with element spacing, e.g., at 0.5λ. The phase antenna may apply different beamforming algorithms. A fully digitized beamforming approach may have a dedicated RF chain including an RF processor 401 and an analog-to-digital converter (ADC) 402 for each antenna element 403. The signal 404 processed by each antenna element 403 may be controlled independently in phase and amplitude to optimize the channel

capacity. A baseband (BB) processor 405 is configured to perform BB processing on each dedicated RF chain based on the signals received from each ADC 402.

[0122] Referring now to FIG. 5, FIG. 5 shows a diagram illustrating analog beamforming system 500 according to one or more embodiments. In this embodiment, the analog beamforming may be with one PAA and one RF chain. The analog beamforming may apply one RF chain for a number of antenna elements 503 that process the signal 504. Each antenna element 503 may be connected to a phase shifter 506 that may be used to set the weight for beamforming and steering. The RF chain further includes an RF processor 501 and an ADC 502 which provides an output to a BB processor 505. The implemented number of RF chains may be significantly reduced as well as the energy consumption.

[0123] The phase shifting and combining may be implemented in different stages (e.g., at RF state, at BB analog stage, or at Local Oscillator (LO) stage). One example is a single-beam analog configuration. It may operate one beam at a time and the single beam may be placed at, for example, the strongest angular direction such as a LOS path obtained from beam measurement. A broad beam pattern may cover a range of angular directions at the expense of reduced beamforming gain.

[0124] A hybrid beamforming may combine digital precoding and analog beamforming. The analog beamforming may be performed over the phase array antenna elements each associated with a phase shifter and all connected to one RF chain. The digital precoding may be applied on the baseband signal of each RF chain.

[0125] Examples of system parameters of the hybrid beamforming may be number of data streams (N_{DATA}), number of RF chains TRX (N_{TRX}), number of antenna ports (N_{AP}), number of antenna elements (N_{AE}), and number of phase antenna arrays (N_{PAA}). The configuration of these parameters may impact on the system function and performance as discussed below.

[0126] Referring now to FIGS. 6A and 6B, FIGS. 6A and 6B show a diagram illustrating analog beamforming system 600 with one PAA and two RF chains. One antenna port may carry a beamformed reference signal uniquely associated with this antenna port that may be used to identify the antenna port. One PAA may be connected to one RF chain or multiple RF chains depending on the system requirement and configuration. In FIGS. 6A and 6B, one PAA of size 4x4 with 16 antenna elements 603, for receiving a signal 604, may be connected to two RF chains and each RF chain may have a set of 16 phase shifters 606a and 606b. The PAA may form two narrow beam patterns within a $+45^{o}$ and -45° coverage in an azimuth plane. In this configuration, $N_{PAA} < N_{AP} = N_{TRX} < N_{AE}$. Each RF chain further includes an RF processor 601a or 601b and an ADC 602a or 602b which provide an output to a BB processor 605.

[0127] Referring now to FIG. 7, FIG. 7 shows a diagram illustrating analog beamforming system 700 with two PAAs and two RF chains. In an embodiment, there may two PAAs having a set of antenna elements 703a and 703b, respectively, for receiving signals 704a and 704b. Each antenna element 703a, 703b may be connected to a phase shifter 706a, 706b, respectively. Each PAA may have a dedicated RF chain, i.e., $N_{PAA} = N_{AP} = N_{TRX} \leq N_{AE}$, including an RF processor 701a, 701b and an ADC 702a, 702b which provide an output to a BB processor 705. This configuration may allow spatial independence between the two simultaneous signals 704a and 704b by placing the PAAs at different orientations (e.g., in an azimuth plane). An aligned PAA arrangement may provide an aggregated larger coverage.

[0128] Both abovementioned example configurations with two RF chains may apply MIMO with two data streams.

[0129] Referring now to FIG. 8, FIG. 8 shows a diagram illustrating analog beamforming system 800 with two PAAs having a set of antenna elements 803a and 803b, respectively, for receiving signals 804a and 804b. Each antenna element 803a, 803b may be connected to a phase shifter 806a, 806b, respectively. The PAAs are connected to a single RF chain that includes a switch 808, an RF

processor 801 and an ADC 802 that provides an output to a BB processor 805. Multiple PAAs may be connected to a single RF chain by using the switch 808 (i.e., $N_{AE} > N_{PAA} > N_{AP} = N_{TRX}$). Each PAA may form a narrow beam pattern covering from +45° to -45° in an azimuth plane. They may be oriented separately so a single-beam network node may have a good coverage by using a beam at different direction at different time instances.

[0130] An above-6 GHz system may apply different beamforming techniques, such as analogue, hybrid and digital beamforming. Embodiments described herein may apply to these beamforming techniques.

[0131] One or more embodiments may address the transmission schemes and transmission modes for highly directional antenna systems, and define the BRS association, the resource allocation and configuration for the fallback schemes, as well as the necessary CSI feedback.

[0132] Another embodiment may address the scenario where the data channel may exhibit a significant degradation, while the control channel may still be received. This scenario may occur for several reasons. For example, the scenario may be due to a change in orientation of the mobile device, which causes misalignment of the previously paired Tx-Rx narrow beams for data transmissions. Embodiments addressing this issue may be based on the fact that the control channel may still be received, and therefore it may be used for the data transmission at a lower rate. In other words, a main principle may be the use of the active control wide beam for data fallback, which may include both DL and UL data. The embodiments may include, but are not limited to: fallback to wide beam (both DL & UL data), and/or fallback to dual transport block (TB) transmission using wide and narrow beams for UE data in the same transmission time interval (TTI).

[0133] Another embodiment may address the scenario where both the control and the data channels are lost due to the beam misalignment. In this case, a two-step solution may be needed: the first step may identify a fallback for the control channel, and once the control channel can be decoded, a fallback may

be determined for the data channel. The embodiments may include: fallback for the DL control and the associated DL/UL data, using fallback TTI.

[0134] The following may provide details for embodiments of DL/UL transmission schemes for one and multiple RF chains.

[0135] Transmission schemes for a system operating at a high carrier frequency (e.g., above 6 GHz) may be defined as mapping of the modulated baseband symbols to the allocated space/time/frequency resources, individual transmit antenna(s), and the associated reference symbols.

[0136] As indicated above, systems operating at high carrier frequency (e.g., above 6 GHz) may need to use beamforming (analog, digital or hybrid) to compensate for a 20-30 dB pathloss since it becomes more significant as the carrier frequency becomes higher. The beamforming may be used at the transmitter and/or at the receiver. The highest beamforming may be achieved when both transmitter and receiver use beamforming and the beam directions are aligned (e.g., transmitter and receiver beams are paired). The transmit and receive beam widths may be determined as a function of the type, size and number of antenna elements of the phased array antenna (PAA).

[0137] A normal transmission scheme may be defined as a transmission scheme used when a transmitter and/or a receiver may control beams properly based on the current channel condition (e.g., wide or narrow transmit and/or receive beam pairing is complete). The system may operate within the expected SNR range. In a system, one or more normal transmission schemes may be defined.

[0138] A fallback transmission scheme may be defined as a transmission scheme used for one or more of following cases. A fallback transmission scheme may be used when the performance of the normal transmission scheme is significantly degraded. For example, a significant loss in SNR may occur due to a change of the WTRU orientation with respect to the mB or due to blocking. A fallback transmission scheme may be used when the channel status information (CSI) ages faster than a feedback cycle, so that a transmitter may not rely on the

reported CSI. A fallback transmission scheme may be used when a CSI is not available at the transmitter. Fallback transmission schemes may be defined for data channels, and for control channels. The transmission schemes in this disclosure may be not limited to a system with a high carrier frequency and may be used for a system with any carrier frequency.

[0139] A normal transmission scheme may use a single transmit RF chain or multiple transmit RF chains. If a single transmit RF chain is used, the normal transmission scheme may use analog beamforming. On the other hand, if multiple RF chains are used, the normal transmission scheme may use analog, digital, or hybrid beamforming. Although the beamforming capability is determined based on the number of RF chain and/or number of antenna element, embodiments described herein may be used for a system with any number of transmit/receive RF chains and/or antenna elements and still be consistent with this disclosure.

[0140] The beamforming capability described herein may include one or more of following: a number of beams supported, a beamwidth, a beam control ability (e.g., analog, digital, and hybrid), and a beam measurement/reporting. The number of beams may be interchangeably used as a number of beam steering vectors and a number of precoding vectors. The beamwidth may be interchangeably used as a beam steering vector and as a precoding vector.

[0141] A normal transmission scheme may use analog beamforming and may operate using either wide or narrow beams, with or without channel state information (CSI) feedback from the receiver (i.e., closed loop or open loop transmission schemes).

[0142] In an example, a WTRU may not have a receiver beamforming capability and an analog beamforming may be used only at the transmitter. Therefore, the beam pairing between transmitter beam and receiver beam may not be used. A transmission scheme may be defined without a beam pairing process. Therefore, a transmitter may not provide a transmit beam information

(e.g., the transmit beam ID) for a downlink transmission when a transmission scheme which may not support beam pairing process may be used.

[0143] In another example, a WTRU may have receiver beamforming capability and the analog beamforming may be used at both transmitter and receiver. A beam pairing scheme/process between transmitter beam and receiver beam may be used. A transmission scheme with beam pairing process may use one or more following methods. A downlink control channel may indicate the transmit beam information for the associated data channel. The downlink control channel may be, but is not limited to, a physical downlink control channel, MAC control message, higher layer radio resource control (RRC) signaling, or a broadcasting channel. A downlink control channel may indicate a receive beam information for the associated data channel. Therefore, a WTRU may use the receiver beam indicated from the downlink control channel. A transmitter may request a preferred transmit beam information from a receiver, or a receiver may be configured to report a preferred transmit beam information regularly.

[0144] The receiver beamforming may be indicated as a WTRU capability and a transmission scheme may be determined as a function of the receiver beamforming capability. For example, if a WTRU indicates no receiver beamforming support, a transmission scheme without beam pairing process may be used. On the other hand, if a WTRU indicates receiver beamforming support, a transmission scheme with beam pairing process may be used. For the transmission scheme determination according to the WTRU receiver beamforming capability, one or more of following operations may apply. Existence of a bit field in a downlink control channel may be used to indicate the transmit beamforming information may be determined as a function of the WTRU receiver beamforming capability. A downlink control information (DCI) format may be determined as a function of the WTRU receiver beamforming capability. A channel status information (CSI) reporting type may be determined as a function of the WTRU receiver beamforming capability. A downlink control type may be determined as a function of the WTRU receiver beamforming

capability. The relative timing between a downlink control channel and the associated data channel may be determined as a function of the WTRU beamforming capability.

[0145] Referring now to FIG. 9, FIG. 9 illustrates a diagram of a semi-static association between the control transmit (Tx) beam and data Tx beam. While the beams shown in FIG. 9 are described in the context of Tx beams used by a transmitter, it will be appreciated that a receiver uses a corresponding Rx beam in a similar manner. Therefore, Tx and Rx may be used interchangeably in the context of a transmitter or a receiver, respectively.

[0146] In FIG. 9, two TTIs 901 and 902 are shown. In TTI 901, a normal control Tx beam B1 (i.e., wide beam) is associated with a normal data Tx beam B1, which is a wide beam. In TTI 902, normal control Tx beams B1 and B2 (i.e., wide beams) are associated with normal data Tx beams B1 and B2, respectively, where the normal data Tx beams B1 and B2 are wide beams. A transmission scheme may use an implicit beam association between control channel and data channel, where a same transmit beam may be used for both the control channel and the associated data channel, as illustrated in FIG. 9. A WTRU or receiver may assume that a same transmit beam is used for the control channel and the associated data channel. A WTRU may use the same receiver beam for the control channel and the associated data channel as a WTRU may assume the same transmit beam is used. A WTRU may determine a preferred receiver beam during the control channel reception and use the determined receiver beam for the associated data channel.

[0147] For a transmission scheme which may use the same transmit beam for a control channel and the associated data channel, or may require the same receiver beam for a control channel and the associated data channel, the transmit beam information may not be indicated from the control channel. The transmit beam may be adapted either semi-statically or dynamically without the downlink beam indication. The beam may be changed semi-statically and the beam information may be transparent to a WTRU. The beam information for the

control channel and/or the associated data channel may be indicated via higher layer signaling. The beam may be changed dynamically without beam indication in the downlink control channel. The beam information for the control channel and/or the associated data channel may be determined based on the search space of the control channel. The beam information for the control channel and/or the associated data channel may be determined as a function of the location of the control channel within a search space. A beam index may be determined as a function of the starting control channel element (CCE) or enhanced control channel element (ECCE) index of the control channel. A beam index may be determined as a function of BRS used to demodulation the control channel.

[0148] A transmission scheme may use explicit beam association between control channel and the associated data channel, where the transmit beam for the control channel and the associated data channel may be determined independently (or separately). The transmit beam used for the data channel may be explicitly indicated from the corresponding control channel. The transmit beam described herein may include one or more of following parameters:, Tx or Rx beam width (e.g., beam subgroup), Tx or Rx beam direction (e.g., beam index) within the beam width, and a time-frequency resource associated with the beam. The beam index may be indicated as antenna port or reference signal sequence.

[0149] In an example, the transmission scheme using explicit beam association may dynamically switch the Tx beam within a TTI from the wide beam used for control channel to a narrow beam used for the associated data channel. The narrow beam may reside within the wide beam as a subset of the wide beam. As the transmit node dynamically switches from a wide to a narrow beam within a TTI, the receive node may need to also steer its receive beam to ensure that it can receive the narrow Tx beam correctly from the transmitter (e.g., mB). That is, the receiver configures its receive beam to be aligned with the narrow transmit beam. The DCI in the control channel may carry one or more of following parameters for the transmission scheme using explicit beam association: HARQ process number, transport block information, antenna

configuration (as needed), downlink assignment index (DAI), and/or power control indicator.

[0150] The DCI in the control channel may carry a beam ID or a beam index for the data channel. The beam ID or beam index may be interpreted differently according to the beam used for the control channel. For example, one or more wide beams may be used for the control channel. Additionally, a group of narrow beams, which may be associated with a wide beam, may be used for the associated data channel. Therefore, according to the wide beam used for the control channel, the narrow beam ID or beam index for the associated data channel may be different. The beam ID or beam index may be an index of a narrow beam within the group of narrow beams associated with the wide beam.

[0151] The wide beam for the control channel may be determined in a semi-static manner. For example, a higher layer signaling may be used to determine the wide beam and, based on the higher layer configured wide beam for control channel, the group of the narrow beam may be determined. The wide beam for the control channel may be determined as a function of the location of a WTRU-specific search space and/or location within the search space. The wide beam for the control channel may be determined during initial access procedure, random access procedure, and/or cell (re)selection procedure.

[0152] The DCI in the control channel may carry a bit field to request preferred beam reporting. If a WTRU receives an indication of preferred beam reporting, the WTRU may report a preferred narrow beam index in the corresponding uplink resource.

[0153] The DCI in the control channel may carry a bit field to request beam pairing.

[0154] Referring now to FIG. 10, FIG. 10 shows a diagram illustrating an intra-TTI DL assignment with a guard period to detect the Tx beam for data and switch the Rx beam. While the beams shown in 10 are described in the context of Tx beams used by a transmitter, it will be appreciated that a receiver uses a

corresponding Rx beam in a similar manner. Therefore, Tx and Rx may be used interchangeably in the context of a transmitter or a receiver, respectively.

[0155] In FIG. 10, two TTIs 1001 and 1002 are shown. In TTI 1001, a normal control Tx beam B1 (i.e., wide beam) is associated with a normal data Tx beam B1x, which is a narrow beam. A guard period G is present between the control Tx beam B1 and the normal data Tx beam B1x. In TTI 1002, normal control Tx beams B1 and B2 (i.e., wide beams) are associated with normal data Tx beams B1x and B2y, respectively, where the normal data Tx beams B1x and B2y are narrow beams. A guard period G is present between control Tx beam B2 and the data Tx beam B1x.

[0156] Spatially, narrow beams B2x, B2y, etc., are within the area of wide beam B2. Similarly, a number of narrow beams B1x, B1y, etc., reside within the area of wide beam B1. Thus, narrow beams B2x, B2y, etc., are associated with wide beam B2 and narrow beams B1x, B1y, etc., are associated with wide beam B1.

[0157] The WTRU may need to decode the control channel, and may extract from the DCI, the ID of the Tx beam (and thus information on the BRS) of the data channel. This may require a guard time G to be used between the end of the control region B1 and the start of the associated data Tx beam B1x, to allow the WTRU enough time to correctly steer its receive beam to receive the data channel (i.e., to align its (narrow) receive beam with the mB's transmit beam). Within a TTI, a guard period G may be achieved by creating a gap between the end of the control region and the start of the data region, as illustrated in FIG. 10. The length of the guard period may need to be set such that the WTRU may be able to decode the control channel and switch its receive beam before the start of the data region.

[0158] A guard period G may be present between the control channel and its associated data channel in a certain DCI format in which beam index is provided for the associated data channel. One or more of following parameters may apply.

[0159] A guard period G may be used for a WTRU with a certain receiver beamforming capability. For example, if a WTRU indicated that the WTRU has analog beamforming capability only at the receiver, the guard period G may be configured by the base station via higher layer signaling. Alternatively, a WTRU may indicate a required guard period for the receiver beamforming adaptation.

[0160] A guard period G may include the control channel reception time and receiver beam switching time. Therefore, the portion of control channel reception time may be used, depending on the WTRU receiver beamforming capabilities.

[0161] A guard period G may be present if the DCI in the control channel indicates that the beam index of the associated data channel is changed from the latest beam index. Alternatively, the guard period G may be present if the DCI in the control channel indicates that the beam index of the associated channel is different from the beam index of the control channel. A single bit or state in the DCI may indicate the beam index change confirmation, or guard period indication. Other bits or states may also indicate the beam index change.

[0162] If the length of the guard period G is smaller than the CP length, no explicit guard period may be used. If a system supports two or more CP lengths (e.g., a normal CP length and an extended CP length), the guard period G may be used in the normal CP case, while no guard period is used in the extended CP case. Therefore, the guard period G may be considered as '0' in FIG. 10 if the CP length is larger than beam switching time and the decoding time.

[0163] It should be noted that CP length and guard time can be interchangeably used. For example, CP length may be used in a certain waveform (e.g., OFDM) and guard time may be used in another waveform (e.g., single carrier modulation) but is not limited to a specific waveform. The CP may be used between modulation symbols and the guard period may be used between the control channel and the associated data channel.

[0164] Referring now to FIG. 11, FIG. 11 shows a diagram illustrating a cross-TTI DL assignment with narrow beam indication. Instead of creating guard

periods within a TTI, cross-TTI DL assignments may be used where a control Tx beam in one TTI is associated with a data Tx beam in a subsequent TTI. The subsequent TTI may immediately follow the corresponding TTI, or may follow by one or more TTIs. Suffixes "x", "y" and "z" are further used to identify different narrow data Tx beams associated with different wide control Tx beams. For example, B1x/B1y/B1z denote narrow beams associated to wide beam B1, B2x/B2y denote narrow beams associated to wide beam B2, and so on. In one or more instances, narrow data Tx beams (e.g., B1x and B2y) may be sequentially transmitted in the same TTI (e.g., TTI1). In other instances, narrow data Tx beams (e.g., B3x and B3y) may be transmitted in parallel in the same TTI (e.g., TTI3)

[0165] For the cross-TTI assignments, the control channel signaled during TTI "n" may point to DL data assignments for TTI "n+k". In this case, both the offset "k" and the narrow beam for data transmission may need to be signaled in the DCI in addition to the default information fields that may need to be carried in the DCI.

[0166] The above examples illustrate schemes using a single transport block (TB) per TTI. In another example, a transmission scheme may use two or more transport blocks (TBs) within a TTI.

[0167] Referring now to FIG. 12, FIG. 12 shows a diagram for a dual TB transmission scheme. Two or more transport blocks may be transmitted with a same beam as the control channel, or may be transmitted with different beams. For example, FIG. 12 illustrates two transport blocks 1201 and 1202 transmitted (multiplexed) in a TDM fashion within a single TTI (e.g., TTI1). The transmission of the individual transport blocks may use the same beam as the control channel (e.g., transport block 1201 which uses a wide beam), or may use a different beam (e.g., transport block 1202 which uses a narrow beam). In the latter case, the narrow beam ID may need to be signaled in the control region of the TTI.

[0168] In particular, as shown in FIG. 12, a first TB (TB1) may use the same wide beam or the same beam ID as the control channel, and a second TB

(TB2) may use a narrow beam or a beam ID that is different from the beam ID used by the control channel. The beam ID for TB2 may be signal in a DCI transmitted in control data B1 that is associated with TB2. In addition, the dual TB transmission scheme shown in FIG. 12 may be used to carry out a fallback transmission, to be described in more detail below. As a fallback mechanism, data carried by TB1 may be a subset of the data carried by TB2, and TB1 may use a lower modulation and coding scheme (MCS) value than TB2.

[0169] In an example which the two transport blocks may be transmitted in a TDM fashion, the control channel and the DL data assignment may be in the same TTI. For example, transport block 1201 may be associated with control Tx beam 1203 and transport block 1202 may be associated with control Tx beam 1204. The first transport block may be mapped on to a first codeword provided in the control Tx beam 1203 and the second transport block may be mapped on to a second codeword provided in control Tx beam 1204. The codeword may be associated with: a specific beam or beam ID, a BRS, and/or a time/frequency location. As used herein, a codeword represents user data before it is formatted for transmission.

[0170] There may be a one-to-one mapping between the transport block and the codeword. The mapping rule may be fixed. For instance, the first transport block may be mapped onto the first codeword and the second transport block may be mapped onto the second codeword. Alternatively, the mapping rule may be dynamically indicated. For instance, the first transport block may be mapped onto one of the codeword according to the indication. The number of codeword(s) could be equal to or smaller than the number of the transport block(s). If a single codeword is defined, irrespective of the number of transport block, the same beam may be used. Therefore, the transport blocks within a TTI may be mapped on to a single codeword.

[0171] Furthermore, the first codeword (codeword #1) may be transmitted on the same wide beam as the control channel, and the second codeword (codeword #2) may be transmitted on a narrow beam. In this case, mapping of

codeword #2 in the data region of the TTI may be done such that the WTRU has enough time to decode the control channel and switch its receive beam before it may start buffering and receiving the symbols corresponding to codeword #2.

[0172] In another example in which the two transport blocks are transmitted in a TDM fashion, the control channel and the DL data assignment may be in different TTIs. In this case, the network (e.g., mB) may include in the DCI the following information: the relative TTI offset of the DL data assignment and/or the Tx beam index (or beam ID) for both codewords. In this example, codeword #1 and codeword #2 may be mapped anywhere in the data region of the TTI (i.e., flexible mapping).

[0173] In an example, a normal transmission scheme in DL may use an open loop wide beam transmission with channel quality indication (CQI) only reporting for link adaptation purposes. For this scheme, the WTRU may use the BRS associated to the mB DL Tx wide beam, to perform channel estimation, receive the data channel and measure the CQI.

[0174] In another example, a normal Tx scheme may use closed loop narrow beam transmission. The WTRU may report, in addition to the CQI for the active beam, measurements on other detected narrow beams. For this scheme, the WTRU may use the BRS associated to the active narrow beam to perform channel estimation, receive the data channel, and report the CQI. Additionally, the WTRU may use BRS of other beams to perform and report other narrow beam measurements and report the beam ID of its preferred narrow beam.

[0175] One or more fallback transmission schemes are provided herein. The term “fallback transmission scheme” may be interchangeably used with the following: open-loop transmission scheme, coverage enhanced transmission scheme, beam diversity transmission scheme, beam sweeping transmission scheme, and transmit diversity scheme.

[0176] In one or more embodiments, a fallback transmission scheme may be defined as a transmission scheme which may not require a beam pairing process, WTRU reporting assistance for beam pairing, and/or beam ID indication

for the associated data channel. One or more of following parameters may apply for fallback transmission scheme. A certain DCI format may be used for fallback transmission scheme which may not include beam ID for the associated data channel. The control channel and/or data channel may be transmitted with one or more beams. A single wide beam may be used. Two or more wide beams may be used, where the two or more wide beams may be configured for a control channel and/or a data channel transmission. Two or more narrow beams associated with a wide beam which may be used in the normal transmission configured or used.

[0177] The control channel and/or data channel may be transmitted with repetitions. Two or more TTIs may be used for repetitions. A different beam may be used in each TTI. The beam ID in each TTI may be predefined or configured by higher layer signaling. Alternatively, the beam ID in each TTI may be determined as a function of the subframe number and/or SFN. The number of repetition of the fallback transmission scheme may be determined by one or more of following: configuration via higher layer signaling and/or broadcasting channel, a function of number of wide beams and/or number of narrow beams, an indication from the associated DCI, the time/frequency resource used during random access procedure, and/or system parameters.

[0178] In another example, a fallback transmission scheme may be defined as a transmission scheme which may be transmitted in a subset of the TTIs. A subset of TTIs may be defined or configured for the fallback transmission. A subset of TTIs may be defined or configured to monitor control channel associated with a fallback transmission. The subset of TTIs may be configured via higher layer signaling. The subset of TTIs may be determined as a function of the wide beam index associated with the control channel which is used for normal transmission. The subset of TTIs may be determined as a function of one or more of system parameters including physical cell ID, SFN number, and/or system bandwidth.

[0179] There may be a BRS association for normal and fallback transmission schemes. Each of two or more BRSs may be defined with a BRS

index associated with a beam. The BRS index may be defined according to the beam width. In an example, a BRS index associated with wide beam may be defined as W_x, where $x \in \{1,2,\ldots,N\}$, and a BRS index associated with narrow beam may be defined as N_y, where $y \in \{1,2,\ldots,M\}$. N wide beams and M narrow beams are used in the system with a BRS index. A WTRU may determine an associated receiver beam for each BRS index. The wide beams and the narrow beams may be independently defined. Alternatively, a wide beam may be associated with two or more narrow beams.

[0180] In another example, the BRS index may be defined in a hierarchical manner. For example, B_x, where $x \in \{1,2,\ldots,N\}$ may be defined as BRS index associated with a wide beam and each wide beam may be associated with two or more narrow beams B_xy, where $y \in \{1,2,\ldots,M\}$. Each wide beam may have two or more associated narrow beams. The number of narrow beam may be different according to the wide beam index.

[0181] According to the BRS index used, a WTRU may determine a receive beam to receive the signal and perform signal reception procedures. For example, the WTRU may form a receiver beam in analog, digital, or hybrid domain to receive the signal and buffer the signals before it starts demodulation.

[0182] In one or more embodiments, a first BRS index may be used to monitor and/or receive a control channel and a second BRS index may be used to receive an associated data channel. One or more of following parameters may apply.

[0183] The first BRS index may be associated with a wide beam and the second BRS index may be associated with a narrow beam. The first BRS index may be one of the beam indexes of wide beams. The second BRS index may be a narrow beam index associated with the first BRS index. For example, if the first BRS index is B_x, the narrow beam index may be B_xy, where the x is the same for both first BRS index and the second BRS index.

[0184] The first BRS index may be determined during random access procedures and the second BRS index may be determined by a transmitter (e.g., a

mB). For example, the first BRS index may be determined as a function of the PRACH resource used and the second BRS index may be indicated in the associated DCI.

[0185] The first BRS index may be determined during initial access procedures including cell selection/reselection procedures. The first BRS index may be determined as a function of the physical cell ID. The first BRS index may be determined based on the downlink measurement which may be used for cell selection/reselection. The first BRS index may be determined based on the time location of the synchronization signal received.

[0186] In one or more embodiments, a first BRS index may be used to monitor and/or receive a first type of control channel and a second BRS index may be used to monitor and/or receive a second type of control channel. One or more of following parameters may apply. The first BRS index and the second BRS index may be associated with a wide beam. The first BRS index may be associated with a wide beam and the second BRS index may be associated with a narrow beam. The second BRS index may be one of the narrow beams associated with the first BRS index. The second BRS index may be one of the narrow beams which may be independent from the wide beam index.

[0187] The first type of control channel may be a broadcasting/multi-casting channel and the second type of control channel may be a WTRU-specific control channel. For example, the first type of control channel may be defined as a common search space and the second type of the control channel may be defined as a WTRU-specific search space. A WTRU may monitor the first type of control channel in a common search space to receive a multi-casting and broadcasting channels including system information, group power control, paging, and MBMS. A WTRU may monitor the second type of control channel in a WTRU-specific search space to receive unicast traffic.

[0188] In one or more embodiments, the WTRU and the mB may operate using multiple transmission schemes. For example, both wide beams and narrow beams may be used in a first transmission scheme and wide beams may be only

used in a second transmission scheme. One or more of following parameters may apply. The first transmission scheme may be a normal transmission scheme and the second transmission may be a fallback transmission scheme.

[0189] The first transmission scheme may use one beam for a single transmission while the second transmission scheme may use beams available for a single transmission. The single transmission may be a control channel transmission or a data channel transmission. The single transmission may be a single transport block transmission for the data channel. In case of the control channel, the single transmission may be a single DCI transmission. The second transmission scheme may use beams available with repetitions. For example, N repetitions may be used with N beams. Therefore, one BRS index associated with a repetition transmission and all BRS indices are used with N repetitions, where N wide beams may be used in the system.

[0190] The first transmission scheme may use the BRS index indicated from a transmitter while the second transmission scheme may use a predefined BRS index. The predefined BRS index may be determined by one or more of following: a fixed number, a predefined sequence, a subframe number and/or frame number, time/frequency location, a WTRU ID, and/ or system parameters.

[0191] In one or more embodiments, a WTRU may report downlink reference signal received power (e.g., RSRP) for one or more BRS in order to provide physical layer (i.e., layer 1 (L1)) measurement and CSI feedback. For example, a hierarchical BRS structure may be used, wherein N wide beams may be used with M narrow beams for each N wide beams. It should be noted that the terms reference signal received power, downlink pathloss, pathloss, channel quality indicator, wideband channel quality indicator, RSRP and downlink measurement may be used interchangeably.

[0192] One or more of following parameters may apply for the downlink measurement reporting. A downlink measurement may be reported for the currently configured or used wide beam. A downlink measurement may be reported for a subset of N wide beams wherein the subset may be determined

based on currently configured or used wide beam. For example, adjacent wide beams of the currently configured or used wide beam may be determined as the subset. The downlink measurement reporting for a subset of N wide beams may include individual downlink measurement value for each wide beam within the subset. The downlink measurement reporting for a subset of N wide beams may include an index of the wide beam within the subset of N wide beams, which may provide the highest value and its associated downlink measurement value.

[0193] A downlink measurement may be reported for all N wide beams configured by mB. A WTRU may report one downlink measurement for a wide beam at a time. A reporting cycle (e.g., duty cycle) may be determined or configured for each wide beam. Therefore, each wide beam may have a same or a different reporting cycle. A time offset (e.g., TTIs) may be used for downlink measurement reporting for each wide beam.

[0194] In one or more embodiments, a WTRU may send a beam pairing, or beam re-pairing, request to a mB. For example, if a currently configured or used downlink transmit beam is below a predefined threshold, the WTRU may send a request of beam pairing between transmit and receive beams. The beam pairing request information may be transmitted in a higher layer configured uplink control resource. The higher layer configured uplink control resource may be the same as the uplink control resource configured for scheduling request. The beam pairing request information may be interchangeably used by a fallback transmission request.

[0195] The following provides a description of DL/UL transmission modes and modes of operation. In the current 3GPP specifications, the transmission modes may only be applicable to a downlink shared channel (DL-SCH) transmission, and may define the single or multi antenna transmission scheme, the specific antenna mapping, the reference symbols used for demodulation (e.g., CRS or DM-RS), and the associated CSI feedback. For systems operating at frequencies above 6 GHz, there may be a need to expand the concept of transmission mode to address aspects of the propagation channel specific to the

use of directional antennas (i.e., narrow and wide beams), such as: effects of change in the WTRU orientation, blocking effects, delay and angle spread, and so on.

[0196] One or more transmission modes may be used in a system and a transmission mode may use one or more transmission schemes. A WTRU may be configured with a transmission mode in a semi-static manner and the transmission schemes used within a transmission mode may be switched dynamically (e.g., according to a dynamic switching transmission mode). A transmission mode may be configured via higher layer signaling. A transmission mode may be determined as a function of at least one of the number of antenna ports, WTRU capability, and system parameters. A transmission mode may be determined based on the beamforming capability of a WTRU which may include the number of RF chains, number of receive beams, and/or beam switching time.

[0197] For example, a transmission mode may use two transmission schemes where a normal transmission scheme and a fallback transmission scheme may be used. One or more of following parameters may apply. Within a transmission mode, a transmission scheme used in a TTI may be determined by a DCI format received in the control region. A first transmission scheme may be used if a first DCI format (e.g., DCI format-A) is received in the control region and a second transmission scheme may be used if a second DCI format (e.g., DCI format-B) is received in the control region. The first transmission scheme may be a normal transmission scheme and the second transmission scheme may be a fallback transmission scheme.

[0198] The transmission scheme used in the TTI may be determined by a TTI type associated with a transmission. Each TTI may be associated with a transmission among the transmission schemes associated with the transmission mode. Therefore, the transmission scheme may be determined as a function of the subframe number and/or frame number.

[0199] The transmission scheme used in the TTI may be determined by a search space of the control channel. The control channel monitored by WTRU

may be split into multiple subsets and each subset may be associated with a certain transmission scheme.

[0200] The transmission scheme used in the TTI may be determined by an indication in the DCI.

[0201] A WTRU may monitor a control channel according to a first transmission scheme in all TTIs, while the WTRU may monitor a control channel according to a second transmission scheme in a subset of TTIs. The first transmission scheme may be a normal transmission scheme and the second transmission scheme may be a fallback transmission scheme. A WTRU may monitor the control channel for the second transmission scheme if one or more of the following applies: the WTRU is not scheduled for a certain number of consecutive TTIs, the WTRU sends a certain number of consecutive negative ACK corresponding to downlink transmissions, or a downlink measurement is below a predefined threshold.

[0202] A WTRU receiver may use a narrow beam in the first transmission scheme and the WTRU may use a wide beam in the second transmission.

[0203] A WTRU receiver may use a beam ID indicated in the associated control channel to receive the corresponding data channel for the first transmission scheme, and the WTRU may use a predefined beam to receive the corresponding data channel for the second transmission scheme. The predefined receiver beam for the second transmission scheme may be the same receiver beam used for the associated control channel. Alternatively, a sequence of beams may be predefined.

[0204] The following embodiments may include switching (in a semi-static or dynamic fashion) between fallback and normal transmission schemes and may address the following aspects: DCI and UE monitoring behavior, and WTRU behavior for switching between fallback and normal transmission schemes.

[0205] In one of more embodiments, it may be assumed that the WTRU may be connected to the mB via a narrow beam pair for the DL and UL data, and that the mB may use a wide beam for the DL control channel transmission. Thus,

an operation with data fallback to a wide beam is described such that, as the orientation of the WTRU may change, the paired narrow beams used for data transmission may become misaligned, and the data link may experience a sudden and significant drop in signal-to-noise ratio (SNR). If the change in the WTRU orientation does not exceed a certain value, the DL control channel transmissions using wide beams may still be received by the WTRU. This scenario may trigger the mB to dynamically switch the WTRU to a data fallback scheme that uses the same wide beam as for the DL control channel. The data fallback scheme may allow the WTRU to maintain connection using the current transmission mode, while the mB may perform a RRC reconfiguration of the transmission mode until the mB may perform a beam switch, or until the operating SNR using the current transmission mode may improve.

[0206] The following embodiments may address triggers that initiate the mB to use the data fallback, how the DL data fallback scheme is signaled to the WTRU, and how the WTRU data fallback scheme is signaled to the WTRU.

[0207] In one or more embodiments, signaling the DL data fallback to wide beam is described such that the mB may use the same wide beam as used for the control channel for the transmission of the DL fallback data. One or more of following parameters may apply. The WTRU may need to switch its receive beam for data to the beam used to receive the control channel. If control and fallback data are scheduled in the same TTI, a guard time may be needed between the control and the data regions of the TTI, as shown in FIG. 10. The fallback data may be scheduled for a subsequent TTI. The offset of the TTI carrying fallback data may be signaled in the DCI, may be pre-defined, or may be semi-statically configured.

[0208] A different DCI format may be used for fallback and normal transmission. For example, DCI-A may be used for normal transmission and DCI-B may be used for fallback transmissions. In the embodiment described above, the use of fallback DCI (DCI-B) may implicitly indicate the fallback data is

transmitted on the same wide beam as the control. In this case, the fallback DCI may not include the BRS and beam ID.

[0209] In another embodiment, the fallback DCI may explicitly indicate the data fallback beam. The fallback DCI may include at least one of the following pieces of information: BRS, beam ID, and the offset (in TTIs) of the DL data assignment. The fallback DCI may also include the preferred WTRU transmit beam for UL data fallback.

[0210] In another embodiment, the data fallback beam may be determined implicitly during the reception of the associated control channel. For example, a WTRU may perform a blind decoding of the associated control channel with one or more BRS candidates. The WTRU may determine one BRS for the associated control channel decoding. Based on the determined BRS for the associated control channel, the WTRU may determine the data fallback beam. In another example, a WTRU may perform a blind decoding of the associated control channel with one or more control channel candidates. The WTRU may determine the control fallback beam as a function of the control channel candidate. Based on the determined control fallback beam, the WTRU may determine the data fallback beam.

[0211] A WTRU may monitor for both a first DCI format (e.g. DCI-A) and a second DCI format (e.g., DCI-B) in each TTI. Alternatively, the WTRU may monitor for DCI-B only in configured TTIs. The use of DCI-A versus DCI-B may implicitly indicate a different timing rule for the associated data channel reception. In one example, the data channel associated to DCI-A may be transmitted in TTI n+k1 for a DCI-A signaled in TTI n, while the fallback data channel associated to DCI-B may be transmitted in TTI n+k2 for a DCI-B signaled in TTI n. The offset values k1 and k2 may be either explicitly included in the DCI, or the offset of the fallback data, k2, may be implicitly derived from the fallback DCI-B type.

[0212] Upon the detection of the fallback DCI-B on the control wide beam in TTI #n, the WTRU may configure its receive beam for DL data in TTI #n+k2,

where k2 may be explicitly signaled in DCI-B or implicitly derived from the fallback DCI-B type. This may be done using the appropriate BRS, which may be either the same BRS as used for the wide beam control, or determined based on the beam ID that may be signaled in DCI-B.

[0213] Additionally, the WTRU may transmit the UL Acknowledgment—Negative Acknowledgment (A/N) feedback using an UL beam that has the same orientation as the DL beam used for the data fallback reception. The timing for the transmission of the UL A/N feedback may be determined implicitly based on the TTI index (n+k2) of the fallback data transmission. For example, the UL A/N corresponding to the DL fallback data on TTI #n+k2 may be transmitted in TTI #n+k2+m. During TTI #n+k2+m, the mB may monitor the WTRU UL A/N feedback using an UL Rx beam with the same orientation as the DL Tx beam used for DL data fallback transmission during TTI #n+k2.

[0214] In an embodiment, a mB may indicate a fallback for UL data transmission. The fallback for UL data transmission may have at least one of the following parameters. First, a predefined wide beam may be used for uplink transmission. The predefined wide beam may be based on the beam used for UL control. The predefined wide beam may be a beam index. Second, a wider beam, which may be associated with the most recent narrow beam, may be used. For example, a wider beam may consist of one or more narrow beams that may be used for normal UL data transmission, and if a fallback UL transmission is triggered or indicated, the wider beam may be used for the UL fallback data transmission. Third, repetitions of the UL data transmission may be used. Fourth, the UL data transmission may be within a narrower bandwidth. Fifth, a higher transmission power may be used.

[0215] In an embodiment, the indication of a fallback UL data transmission may be transmitted in a DCI. For example, a reserved bit in a DCI, which may be used for uplink grant, may be used to indicate a fallback UL data transmission. In another example, a fallback DCI may be used and a WTRU may monitor for

the fallback DCI as well as for a normal DCI for normal UL data transmission (e.g., normal DCI). One or more of the following parameters may apply.

[0216] The fallback DCI may be monitored for in a subset of resources in which a WTRU may monitor for normal DCI. For example, if a WTRU monitors for normal DCI in every TTI, the WTRU may monitor for the fallback DCI in a subset of TTIs. A WTRU may monitor for both normal DCI and fallback DCI in a TTI, which may be a subset of TTIs determined for the fallback DCI.

[0217] The fallback DCI and the normal DCI may be monitored in a disjoint set of TTIs. For example, a first set of TTIs may be used for normal DCI and a second set of TTIs may be used for fallback DCI, and there may be no overlap between the first set and the second set. The first set of TTIs may be larger than the second set of TTIs. A transmission scheme for the associated UL data transmission may be different for the first set of TTIs and the second set of TTIs.

[0218] A fallback DCI may be received over multiple TTIs while a normal DCI may be received within a single TTI. For example, the fallback DCI may be transmitted with repetitions with multiple (e.g., consecutive) TTIs, while the normal DCI may be transmitted within a TTI.

[0219] When the fallback DCI is transmitted with repetitions, at least one of following parameters may apply. A different transmit beam (e.g., beam ID) may be used for each repetition. For example, if the number of repetitions (i.e., number of TTIs) is N, the transmit beam may change in each repetition. Therefore, N transmit beams may be used for a single fallback DCI transmission. If a total number of transmit beams at a transmitter is M and M is smaller than N, the M transmit beams may be cyclically used with N repetitions. Therefore, M transmit beams may be used for a single fallback DCI transmission with N repetitions. If a different transmit beam (e.g., beam ID) may be used for each repetition, a corresponding receiver beam may be used at a receiver.

[0220] The embodiments described herein may be used for the DCI that is used for normal and fallback downlink data transmissions, although an uplink

transmission beam may be replaced by a downlink receiver beam and still be consistent with the embodiments.

[0221] In one or more embodiments, the dual TB transmission scheme described above (see e.g., FIG. 12) may be used as a fallback transmission while operating in the dynamic switching transmission mode. Thus, an operation with dual TB based fallback Tx scheme is provided. As used herein, transport block and codeword may be used interchangeably.

[0222] When the mB detects that a particular WTRU needs data fallback, it may partition the transmission of the next transport block (MAC PDU) into two physical layer code words, which may be transmitted on a single spatial layer, in a TDM fashion within the TTI. The first codeword may use the same wide beam as the control channel, while the second codeword may use a narrow beam, with the beam ID or the beam index signaled by the mB in the DCI (see e.g., FIG. 12).

[0223] In an embodiment, the first codeword may use a robust coding and modulation scheme, and the data carried in the first codeword may be a subset of the data in the second codeword (current MAC PDU being transmitted). The WTRU may use the data that is correctly decoded in the first codeword to decode the second codeword.

[0224] Referring now to FIG. 13, FIG. 13 shows a diagram illustrating using a dual TB transmission scheme for data fallback. In an embodiment according to FIG. 13, the size of a MAC PDU 1301 to be transmitted may exceed a max Turbo coder block size and code block segmentation with M code blocks 1302 may be used. In this scenario, in a first transmission, the data transmitted by the first codeword may be a full code block of the MAC PDU carried in the second codeword, as illustrated in FIG. 13. The next (e.g., second) transmission of fallback data using this scheme may transmit, in the first codeword, the next code block of the current MAC PDU, and may re-transmit the full MAC PDU in the second codeword. This transmission scheme may continue (e.g., for M transmissions) until the WTRU correctly decodes the MAC PDU and the mB

receives an ACK for the current MAC PDU transmission. The A/N signaling for this scheme will be described in more detail below. Thus, a wide data Tx beam B1 may be used for transmitting TB1 (i.e., first codeword) of a transmission and a narrow data Tx beam B1x or B1y may be used for transmitting TB2 (i.e., second codeword).

[0225] Referring now to FIG. 14, FIG. 14 shows a diagram illustrating another example of using the dual TB transmission scheme for data fallback. In an embodiment according to FIG. 14, if a size of the MAC PDU does not exceed the max Turbo coder block size, the MAC PDU 1401 may be partitioned in M sub-blocks 1402. The first codeword may be used for sequential transmission of independently coded sub-blocks and the second codeword may be used for the transmission (and re-transmission) of the entire MAC PDU, as shown in FIG. 14. For example, for the first transmission of the fallback data, codeword #1 may transmit sub-block #1 of the MAC PDU, and codeword #2 may transmit the entire MAC PDU. For the first re-transmission (e.g., second transmission) of the fallback data, codeword #1 may carry sub-block #2, and codeword #2 may carry the full MAC PDU. The process may continue for a next transmission (e.g., third transmission) until the WTRU ACKs codeword #2. Thus, a wide data Tx beam B1 may be used for transmitting TB1 (i.e., first codeword) of a transmission and a narrow data Tx beam B1x or B1y may be used for transmitting TB2 (i.e., second codeword).

[0226] DL assignment for the dual TB transmission may be provided such that the dual TB transmission may be used as a normal transmission scheme, or as a fallback scheme. The DCI for the dual TB transmission scheme may include the default information: resource assignment information for each codeword (e.g., resource block allocation), HARQ process number, transport block information (modulation and coding scheme (MCS), redundancy version (RV), new data indicator (NDI), etc.), antenna configuration (as needed), DAI, power control indicator, and other flags as needed. Additionally, the DCI may include beam ID or beam index for each TB. In one or more embodiments, the beam ID or beam

index of the first codeword may implicitly be set to the beam ID or beam index used for the control channel transmission, and thus it may not be included in the DCI.

[0227] As the segmentation of the MAC PDU may be different for the fallback scheme as compared to the normal scheme, the segmentation configuration may be signaled to the WTRU. The type of segmentation may be indicated in the DCI, or may be included in the MAC header. For the case where the type of segmentation is included in the DCI, the DCI format for the dual TB scheme used for fallback may be different from the DCI format for the dual TB scheme used for normal transmission.

[0228] In one example, for the data fallback transmission, the DCI may include the following: a field indicating that a single MAC PDU is transmitted using the 2 CW scheme, a field indicating the number M of sub-blocks (or code blocks) the MAC PDU is partitioned in for mapping to codeword #1 (see e.g., FIG. 13 and FIG. 14), and the index (in the range 1 to M) of the sub-block (or code block) transmitted in the current TTI. The maximum value of M may be pre-defined. The choice for the maximum value of M may be a trade-off between the maximum transport block size to be transmitted with the fallback scheme, and the maximum number of TTIs the MAC PDU may be transmitted due to sub-block or code-block partitioning for transmission on codeword #1.

[0229] The dual TB transmission scheme may be used in all TTIs, or may be used in configured TTIs. When the scheme is used in all TTIs, the WTRU may need to monitor the normal DCI as well as the fallback DCI in all TTIs. When the scheme is used in configured TTIs, the WTRU may monitor the normal DCI and the fallback DCI during the configured TTIs, and may monitor the normal DCI only for the rest of the TTIs.

[0230] In one or more embodiments, HARQ retransmissions may be used when using the dual TB scheme. For example, when the dual TB scheme is used for fallback data, the mB may transmit in the first codeword, consecutive code blocks (or sub-blocks) of the original MAC PDU (as shown in FIG. 13 and FIG.

14). The WTRU may only transmit UL A/N signals for the second codeword. The mB may sequentially transmit code block (or sub-block) index 1, 2, ...M of the current MAC PDU on codeword #1 and the full MAC PDU on codeword #2. This may be done until the WTRU correctly decodes the MAC PDU on codeword #2. Due to HARQ processing latencies, and depending on how the DL fallback data transmissions are scheduled, it may happen that the mB transmits code block (or sub-block) k+1 after the WTRU has ACK-ed the MAC PDU after receiving code block (or sub-block) k. In this case, the WTRU may discard all the subsequent received buffers for the current MAC PDU.

[0231] In another embodiment, when the dual TB scheme is used for normal data transmission, the WTRU may transmit UL A/N signals for each codeword. In this case, if the WTRU correctly decodes codeword #1, but not codeword #2, the WTRU may send an ACK for codeword #1 and a NACK for codeword #2. When the mB receives an ACK for codeword #1 and a NACK for codeword #2, for the next transmission to the WTRU, the mB may transmit the next code block (or sub-block) of the sequence in codeword #1, and re-transmit the entire MAC PDU in codeword #2.

[0232] A control channel fallback operation is described such that fallback TTIs may be pre-defined TTIs within sub-frames, which may be used by the mB to transmit the control channel on multiple wide beams (i.e., perform wide beam sweeping) to WTRUs that may need control fallback. For example, for cases where the WTRU may change its orientation, or when blockage of an active beam pair may occur, the mB may determine the need to use a fallback transmission scheme for the control channel and the data channel of a specific WTRU. In this case, during the fallback TTIs, the mB may repeat the transmission of the control channel on several spatial beams, to enable the WTRU to correctly receive the control channel in one or more beams. The one or more beams may be different from the original active beam of the active beam pair. The mB may use a fallback DCI (e.g., DCI-B) to transmit the fallback control channel during the fallback TTIs.

[0233] To make efficient use of the spectrum resources, the fallback TTIs may be used for regular transmissions when fallback schemes are not used. Thus, the mB may use fallback schemes only if the mB determines it needs to. In this case, the mB may use normal DCI (e.g., DCI-A) for the control channel transmissions. During fallback TTIs, the WTRU may monitor for both the normal DCI (e.g., DCI-A) and the fallback DCI (e.g., DCI-B).

[0234] In one or more embodiments, when the mB determines the need for control fallback for a WTRU, it may use the same reference signal (BRS) for all control beams that it re-transmits to the WTRU. In this case, the WTRU may need knowledge of the number of repetitions of the control channel, as well as of the time and frequency resources that may be assigned to the fallback TTI. Accordingly, the WTRU may monitor the fallback TTIs using the same reference signals (BRS) as used for the normal transmission scheme.

[0235] In another embodiment, the mB may use different BRSs for each beam, which may enable the WTRU to perform beam measurements. In this case, a mapping of the mB Tx beam ID (or beam index, or BRS) to time-frequency resources within the fallback TTIs may need to be known at the WTRU. This mapping may be either cell-specific (in which case, it may be signaled on broadcast), or WTRU specific, which may be configured via RRC signaling.

[0236] Mapping of Tx beam for fallback DCI to resources (TTI/OFDM symbol) is provided according to one or more embodiments. As previously indicated, the first element that enables the control channel fallback operation may be the provisioning of fallback TTIs. The fallback TTIs may be either cell specific or WTRU specific.

[0237] In addition to provisioning the fallback TTIs, the WTRU may need to be able to find and decode the fallback control channel within the fallback TTIs. Therefore, a mapping between the mB transmit beam and the resources used for the fallback control channel may need to be defined. The mapping may be cell specific or WTRU specific and may be signaled to the WTRU via broadcast signals or RRC signaling. The signaling may include information on the number

of Tx wide beams supported by the mB, the number of fallback TTIs per sub-frame, the length of the control region in the fallback TTIs.

[0238] In one or more mapping embodiments, the number of mB Tx wide beams is denoted by Nwb, the size (in OFDM symbols) of the control region within a TTI is denoted by Lc, and the number of fallback TTIs per sub-frame is denoted by Nf. The mapping may be static, and pre-defined, as follows.

[0239] The sub-frame pattern periodicity, T, may be determined as the ratio between the number of mB wide beams (Nwb) and the number of OFDM symbols per sub-frame that may be used for fallback control signaling ($L_c N_f$).

[0240] The index of the fallback TTI (t_f) within a sub-frame may be fixed (pre-defined), or it may be WTRU specific. If the index of the fallback TTI is WTRU specific, in one example, the index may be set as: $t_f = mod\left(\frac{UE_{ID}}{N_f}\right)$. If more than one fallback TTIs per sub-frame are assigned to a WTRU, the index of the first fallback TTI may be calculated as indicated above. The indices of the subsequent fallback TTIs in the sub-frame may be at a fixed offset (pre-defined or signaled) with respect to the first fallback TTI.

[0241] The mapping between the mB Tx wide beam b, $(0 \le b \le N_{wb} - 1)$, the fallback TTI index $n, (0 \le n \le N_f - 1)$ within sub-frame k, $(0 \le k \le T - 1)$, and the OFDM symbol index (l), may be expressed as: $b = k \cdot N_f \cdot L_c + n \cdot L_c + l$.

[0242] In this example, the mB would transmit the fallback DCI on wide beam index b in sub-frame k, fallback TTI index n within sub-frame k, and OFDM index l within the fallback TTI. FIG. 15 shows a diagram of a mapping of Tx beams for fallback DCI to resources for a single RF chain mB. According to this mapping, Nwb = 6, Nf=1 and Lc = 3 and a WTRU and mB behavior during fallback TTI is provided according to such mapping.

[0243] In particular, FIG. 15 shows a diagram illustrating an example of fallback TTI and linkage between fallback DCI and fallback data, where the mB has one RF chain. In particular, a control channel fallback transmission scheme using fallback TTIs is shown such that a DL control channel in a fallback TTI

may be repeated for one or more beam identities in a TDM manner. A WTRU may monitor and/or attempt to decode one or more of the control channels. Furthermore, the WTRU may use one Rx beam or sweep its Rx beam over a set of predefined or configured beam indices for monitoring/decoding the control channels.

[0244] During the TTIs that the mB configures as fallback, the mB may sweep the wide beam control channel using fallback DCI (DCI-B) for the WTRUs that may need control fallback. During the TTIs configured for fallback, the WTRU may monitor for both the regular DCI (DCI-A) and the fallback DCI (DCI-B). During the TTIs not configured for fallback (i.e., non-fallback TTIs), the WTRU may monitor for the regular DCI (DCI-A). The WTRU may not monitor for the fallback DCI (DCI-B) during the non-fallback TTIs.

[0245] The fallback DCI (DCI-B) may point to the DL resource assignment (time, frequency and beam) for fallback data. The mB may schedule fallback data repeated on multiple wide beams (e.g., B1, B2, B3 in FIG. 15), using smaller TBs (i.e., a smaller TB size).

[0246] In one example, the association between the fallback control (DCI-B) and the fallback data is shown in FIG. 15. The fallback data may be assigned on the same wide beam as the wide beam used for signaling the fallback control (DCI-B). In this case, in addition to the regular information carried in the DCI, DCI-B may also signal the offset (in TTIs) of the TTI that carries the fallback data, with respect to the current TTI (the offset may also be set to zero). Alternatively, the DCI-B may signal the beam ID or the beam index, and correspondingly the BRS of the beam that carries the fallback data.

[0247] Referring now to FIG. 16, FIG. 16 shows a diagram illustrating an example of fallback TTI and linkage between fallback DCI and fallback data, where the mB supports multiple RF chains. Since the mB may support multiple Tx RF chains, the mB may simultaneously transmit multiple beams during either the control region of the TTI, or the data region, or both. For example, in FIG. 16, the mB may simultaneously transmit control channels on beams B1 and

B3 during the first time resource of the fallback TTI, followed by control channel on beams B2 and B3 during the second time resource of the fallback TTI, and so on. The time-frequency resources may be used across different beams in a SDM fashion. For this example, the mB may insert beam-specific reference signals (BRS) in the appropriate time-frequency resources to enable correct reception by the WTRU.

[0248] Uplink A/N feedback may be signaled by a WTRU that received fallback DCI-B using an UL Tx wide beam that matches the DL Rx beam that the fallback DCI-B was received on (as an example, use the same steering vector).

[0249] The WTRU may transmit UL A/N feedback for the fallback data that corresponds to the fallback DCI-Bs that the WTRU decoded. For example, if in FIG. 15, the UE successfully decoded DCI-B transmitted on beams B2 and B3 in the fallback TTI, but it did not decode DCI-B transmitted on beam B1, it may transmit UL A/N corresponding to the fallback data on Tx beam B2 in TTI4 and UL A/N corresponding to the fallback data on Tx beam B3 in TTI5.

[0250] The timing of the UL A/N feedback may be derived by the WTRU according to the duplexing mode that the system operates on. For example, if the system operates in a TDD mode (including dynamic or enhanced TDD operation), the UL A/N feedback for data received on Tx beam B2 in TTI4 may be transmitted in the UL transmission opportunity that meets the HARQ timing requirements. The mB may use the timing of the ACK transmitted by the WTRU, to determine the DL Tx beam ID of the successful reception of fallback control and data. Corresponding to that TTI, and in order to monitor for the UL A/N transmission from the WTRU, the mB may configure the UL Rx beam to match DL Tx beam B2.

[0251] The mB may continue transmitting fallback control (DCI-B) during the configured fallback TTIs, until either it receives a positive ACK for the current transport block, or a fallback timer expires.

[0252] If the WTRU correctly decodes a fallback DCI-B and its associated fallback data on a beam that is different from the current active beam, the mB

may issue a measurement request for that different beam, or the WTRU may send a measurement report of the (preferred) different beam. If a measurement (e.g., signal quality or strength) in the measurement report is above a threshold, the mB may issue a beam switch command to the WTRU, while maintaining the same transmission mode. In another solution, if the WTRU correctly decodes the fallback data on only one of the fallback beams used for re-transmission, the mB may directly issue a beam switch command to the WTRU for the ACK'ed beam, and maintain the same transmission mode.

[0253] Fallback DCI using wide beam sweeping in the PDSCH region may be provided in one or more embodiments. For example, FIG. 17 shows a diagram of fallback DCI mapped to the data region, and linkage to fallback data, where the mB supports one or more RF chains. Accordingly, the fallback TTIs may be still be defined and assigned as described above, but within the fallback TTIs, the fallback DCI (DCI-B) may be mapped to the data region. This approach may be used for scenarios that require control channel congestion mitigation. To enable the WTRU to decode the fallback DCI (DCI-B), the mapping between the transmitted beam and the specific time-frequency resources may need to be known by the WTRU. This mapping may be cell-specific or WTRU specific, and may be signaled to the WTRU via broadcast signaling (MIB or SIB) or via RRC signaling.

[0254] In the example illustrated in FIG. 17, the end of the data region (and the start of the region that may be used for the fallback control channel) may be indicated explicitly via signaling, implicitly to the WTRU, or may be pre-defined. For single Tx RF chain mBs, the mB may sweep the fallback DCI (DCI-B) on multiple beams in a TDM fashion, according to the beam to resource mapping. In this case, the mB may apply beam-specific reference signals (BRS) to the time-frequency resources used for each beam. In the fallback TTI (TTI2) of FIG. 17, fallback DCI-B may be transmitted on Beam B2 during the data region of the TTI. BRS specific to beam B2 may need to be inserted in the time-frequency resources used for the DCI-B transmission with beam B2.

Furthermore, BRS specific to beam B3 may need to be inserted in the time-frequency resources used for the DCI-B transmission with beam B3.

[0255] The mB may transmit fallback DCI in that data region if it determines the need to do so. If no WTRUs need fallback transmissions, the mB may reuse the time-frequency resources to schedule regular data. The WTRUs that may monitor for the fallback DCI during the fallback TTI may still attempt to blind decode the fallback control channel, but may not successfully detect the fallback control channel.

[0256] Referring now to FIG. 18, FIG. 18 shows a diagram illustrating fallback DCI mapped to the data region using narrow beam transmission. Accordingly, the fallback DCI may be transmitted in a narrow band within the assigned time-frequency resources in the data region of the TTI. This may allow the mB to use the rest of the frequency resource(s) for data transmission to the WTRUs operating in normal transmission mode. Mapping between the fallback TTI & time resource within a TTI and the mB DL beam for fallback DCI transmission may be done in a similar fashion as described above.

[0257] FIG. 19 shows a flow diagram utilizing a dual TB transmission scheme, for example, as shown in FIG. 12, according to one or more embodiments. While FIG. 12 may serve as an example of a dual TB transmission scheme, process 1900 shown in FIG. 19 can be applied to any dual TB transmission scheme.

[0258] The process 1900, implemented by a WTRU while operating in the high frequency bands (e.g., above 6 GHz), includes receiving multiple signals in a time transmission interval (TTI) (operations 1905, 1910 and 1920). In particular, the receiving of multiple signals includes receiving at least one control signal (operation 1905) using a first beam associated with a first beam identifier (ID), receiving a first data signal (operation 1910) using the first beam associated with the first beam ID, and receiving a second data signal (operation 1920), subsequent to the first data signal, using a second beam associated with a second beam ID different from the first beam ID. At least one of the control signal(s)

indicates the second beam ID. The process 1900 further includes switching a receive beam of the WTRU from the first beam to the second beam based on the second beam ID to receive the second data signal (operation 1915).

[0259] According to another embodiment, a method implemented by a WTRU includes receiving, in a time transmission interval (TTI), at least one control signal, a first transport block and a second transport block. The at least one control signal and the first transport block are received using a first beam, and the second transport block is received using a second beam that has a beam width that is more narrow than a beam width of the first beam. In addition, the first transport block and the second transport block are multiplexed using time division multiplexing such that the second transport block is received subsequent to the first transport block. The method further includes switching a receive beam of the WTRU from the first beam to the second beam, to receive the second transport block, based on beam information associated with the second beam received in one of the at least one control signal.

[0260] FIG. 20 shows a flow diagram utilizing a dual TB transmission scheme, for example, as shown in FIG. 12, according to one or more embodiments. While FIG. 12 may serve as an example of a dual TB transmission scheme, the process shown in FIG. 20 can be applied to any dual TB transmission scheme.

[0261] The process 2000, implemented by wireless communication device (e.g., a base station, eNB, mB, or the like) while operating in the high frequency bands (e.g., above 6 GHz), includes transmitting multiple signals in a time transmission interval (TTI) (operations 2005, 2010 and 2020). In particular, the transmitting of multiple signals includes transmitting at least one control signal (operation 2005) using a first beam associated with a first beam identifier (ID), transmitting a first data signal (operation 20910) using the first beam associated with the first beam ID, and transmitting a second data signal (operation 2020), subsequent to the first data signal, using a second beam associated with a second beam ID different from the first beam ID. At least one of the control signal(s)

indicates the second beam ID. The process 2000 further includes switching a transmit beam of the wireless communication device from the first beam to the second beam based on the second beam ID to transmit the second data signal (operation 2015).

[0262] According to another embodiment, a method implemented by a wireless communication device includes transmitting, in a time transmission interval (TTI), at least one control signal, a first transport block and a second transport block. The at least one control signal and the first transport block are transmitted using a first beam, and the second transport block is transmitted using a second beam that has a beam width that is more narrow than a beam width of the first beam. In addition, the first transport block and the second transport block are multiplexed using time division multiplexing such that the second transport block is transmitted subsequent to the first transport block. The method further includes switching a transmit beam of the wireless communication from the first beam to the second beam, to transmit the second transport block, based on beam information associated with the second beam transmitted in one of the at least one control signal.

[0263] Although features and elements are described above in particular combinations, one of ordinary skill in the art will appreciate that each feature or element can be used alone or in any combination with the other features and elements. In addition, the methods described herein may be implemented in a computer program, software, or firmware incorporated in a computer-readable medium for execution by a computer or processor. Examples of computer-readable media include electronic signals (transmitted over wired or wireless connections) and computer-readable storage media. Examples of computer-readable storage media include, but are not limited to, a read only memory (ROM), a random access memory (RAM), a register, cache memory, semiconductor memory devices, magnetic media such as internal hard disks and removable disks, magneto-optical media, and optical media such as CD-ROM disks, and digital versatile disks (DVDs). A processor in association with software

may be used to implement a radio frequency transceiver for use in a WTRU, UE, terminal, base station, RNC, or any host computer.

* * *

CLAIMS

What is claimed is:

1. A wireless transmit/receive unit (WTRU) configured to perform wireless communications in higher frequency bands using a fallback scheme, comprising:

a receiver configured to receive, in a time transmission interval (TTI), at least one control signal and a first data signal using a first beam associated with a first beam identifier (ID) and a second data signal, subsequent to the first data signal, using a second beam associated with a second beam ID different from the first beam ID, wherein one of the at least one control signal indicates the second beam ID; and

a processor configured to switch a receive beam of the receiver from the first beam to the second beam based on the second beam ID to receive the second data signal.

2. The WTRU of claim 1, wherein the first data signal is carried in a first transport block in the TTI and the second data signal is carried in a second transport block in the TTI.

3. The WTRU of claim 2, wherein the first transport block uses a lower modulation and coding scheme value than the second transport block.

4. The WTRU of claim 2, wherein the first transport block and the second transport block are multiplexed using time division multiplexing such that the second transport block is received subsequent to the first transport block.

5. The WTRU of claim 4, wherein the receiver is configured to receive the at least one control signal in a control region of the TTI that precedes the first and the second transport blocks.

6. The WTRU of claim 1, wherein the one of the at least one control signal includes downlink control information (DCI) that indicates the second beam ID.

7. The WTRU of claim 1, wherein the second beam is a subset of the first beam such that a beam width of the second beam is more narrow than a beam width of the first beam.

8. The WTRU of claim 1, wherein first data received in the first data signal is a subset of second data received in the second data signal.

9. The WTRU of claim 8, wherein the processor is configured to decode the second data using the received first data.

10. The WTRU of claim 1, wherein the at least one control signal includes a first control signal associated with the first data signal and a second control signal associated with the second data signal, wherein first control signal includes control information that indicates the first beam ID and the second control signal includes control information that indicates the second beam ID.

11. A method implemented by a wireless transmit/receive unit (WTRU) configured to perform wireless communications in higher frequency bands using a fallback scheme, the method comprising:

receiving, in a time transmission interval (TTI), at least one control signal and a first data signal using a first beam associated with a first beam identifier (ID) and a second data signal, subsequent to the first data signal, using a second

beam associated with a second beam ID different from the first beam ID, wherein one of the at least one control signal indicates the second beam ID; and

switching a receive beam of the WTRU from the first beam to the second beam based on the second beam ID to receive the second data signal.

12. The method of claim 11, wherein the first data signal is carried in a first transport block in the TTI and the second data signal is carried in a second transport block in the TTI.

13. The method of claim 12, wherein the first transport block uses a lower modulation and coding scheme value than the second transport block.

14. The method of claim 12, wherein the first transport block and the second transport block are multiplexed using time division multiplexing such that the second transport block is received subsequent to the first transport block.

15. The method of claim 14, further comprising:

receiving the at least one control signal in a control region of the TTI that precedes the first and the second transport blocks.

16. The method of claim 11, wherein the one of the at least one control signal includes downlink control information (DCI) that indicates the second beam ID.

17. The method of claim 11, wherein the second beam is a subset of the first beam such that a beam width of the second beam is more narrow than a beam width of the first beam.

18. The method of claim 11, wherein first data received in the first data signal is a subset of second data received in the second data signal.

19. The method of claim 18, further comprising:
decoding the second data using the received first data.

20. The method of claim 11, wherein the at least one control signal includes a first control signal associated with the first data signal and a second control signal associated with the second data signal, wherein first control signal includes control information that indicates the first beam ID and the second control signal includes control information that indicates the second beam ID.

21. A wireless transmit/receive unit (WTRU) configured to perform wireless communications in higher frequency bands using a fallback scheme, comprising:

a receiver configured to receive, in a time transmission interval (TTI), at least one control signal, a first transport block and a second transport block, wherein the at least one control signal and the first transport block are received using a first beam, and the second transport block is received using a second beam that has a beam width that is more narrow than a beam width of the first beam, and wherein the first transport block and the second transport block are multiplexed using time division multiplexing such that the second transport block is received subsequent to the first transport block; and

a processor configured to switch a receive beam of the WTRU from the first beam to the second beam, to receive the second transport block, based on beam information associated with the second beam received in one of the at least one control signal.

AMENDED CLAIMS
received by the International Bureau on 15 March 2017 (15.03.2017)

CLAIMS

What is claimed is:

1. A wireless transmit/receive unit (WTRU) configured to perform wireless communications, comprising:

a receiver configured to receive, in a time transmission interval (TTI), at least one control signal and a first data signal using a first beam associated with a first beam identifier (ID) and a second data signal, subsequent to the first data signal, using a second beam associated with a second beam ID different from the first beam ID, wherein one of the at least one control signal indicates the second beam ID; and

a processor configured to switch a receive beam of the receiver from the first beam to the second beam based on the second beam ID to receive the second data signal.

2. The WTRU of claim 1, wherein the first data signal is carried in a first transport block in the TTI and the second data signal is carried in a second transport block in the TTI.

3. The WTRU of claim 2, wherein the first transport block uses a lower modulation and coding scheme value than the second transport block.

4. The WTRU of claim 2, wherein the first transport block and the second transport block are multiplexed using time division multiplexing such that the second transport block is received subsequent to the first transport block.

5. The WTRU of claim 4, wherein the receiver is configured to receive the at least one control signal in a control region of the TTI that precedes the first and the second transport blocks.

6. The WTRU of claim 1, wherein the one of the at least one control signal includes downlink control information (DCI) that indicates the second beam ID.

7. The WTRU of claim 1, wherein the second beam is a subset of the first beam such that a beam width of the second beam is more narrow than a beam width of the first beam.

8. The WTRU of claim 1, wherein first data received in the first data signal is a subset of second data received in the second data signal.

9. The WTRU of claim 8, wherein the processor is configured to decode the second data using the received first data.

10. The WTRU of claim 1, wherein the at least one control signal includes a first control signal associated with the first data signal and a second control signal associated with the second data signal, wherein first control signal includes control information that indicates the first beam ID and the second control signal includes control information that indicates the second beam ID.

11. A method implemented by a wireless transmit/receive unit (WTRU) configured to perform wireless, the method comprising:

receiving, in a time transmission interval (TTI), at least one control signal and a first data signal using a first beam associated with a first beam identifier (ID) and a second data signal, subsequent to the first data signal, using a second beam associated with a second beam ID different from the first beam ID, wherein one of the at least one control signal indicates the second beam ID; and

switching a receive beam of the WTRU from the first beam to the second beam based on the second beam ID to receive the second data signal.

12. The method of claim 11, wherein the first data signal is carried in a first transport block in the TTI and the second data signal is carried in a second transport block in the TTI.

13. The method of claim 12, wherein the first transport block uses a lower modulation and coding scheme value than the second transport block.

14. The method of claim 12, wherein the first transport block and the second transport block are multiplexed using time division multiplexing such that the second transport block is received subsequent to the first transport block.

15. The method of claim 14, further comprising:

receiving the at least one control signal in a control region of the TTI that precedes the first and the second transport blocks.

16. The method of claim 11, wherein the one of the at least one control signal includes downlink control information (DCI) that indicates the second beam ID.

17. The method of claim 11, wherein the second beam is a subset of the first beam such that a beam width of the second beam is more narrow than a beam width of the first beam.

18. The method of claim 11, wherein first data received in the first data signal is a subset of second data received in the second data signal.

19. The method of claim 18, further comprising:

decoding the second data using the received first data.

20. The method of claim 11, wherein the at least one control signal includes a first control signal associated with the first data signal and a second

control signal associated with the second data signal, wherein first control signal includes control information that indicates the first beam ID and the second control signal includes control information that indicates the second beam ID.

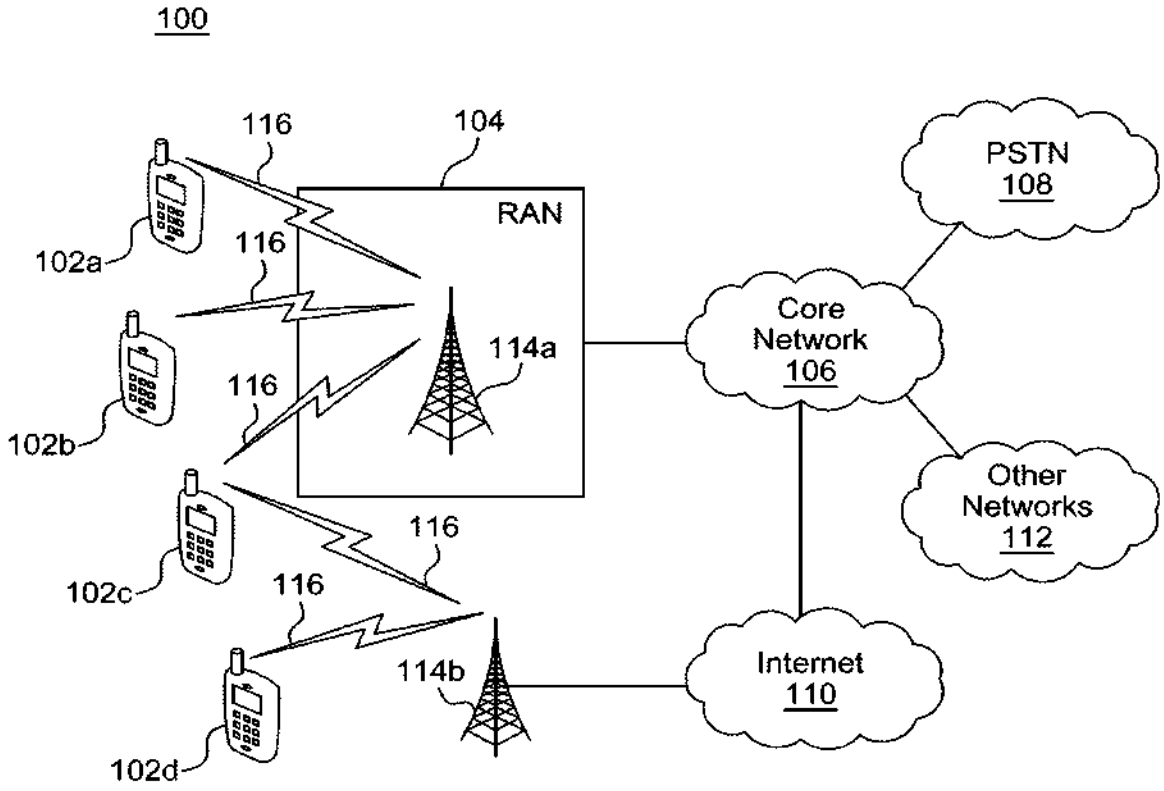

100
116
104
RAN
PSTN
108
102a
116
Core
Network
106
114a
102b
116
Other
Networks
112
116
102c
116
Internet
110
114b
102d

FIG. 1A

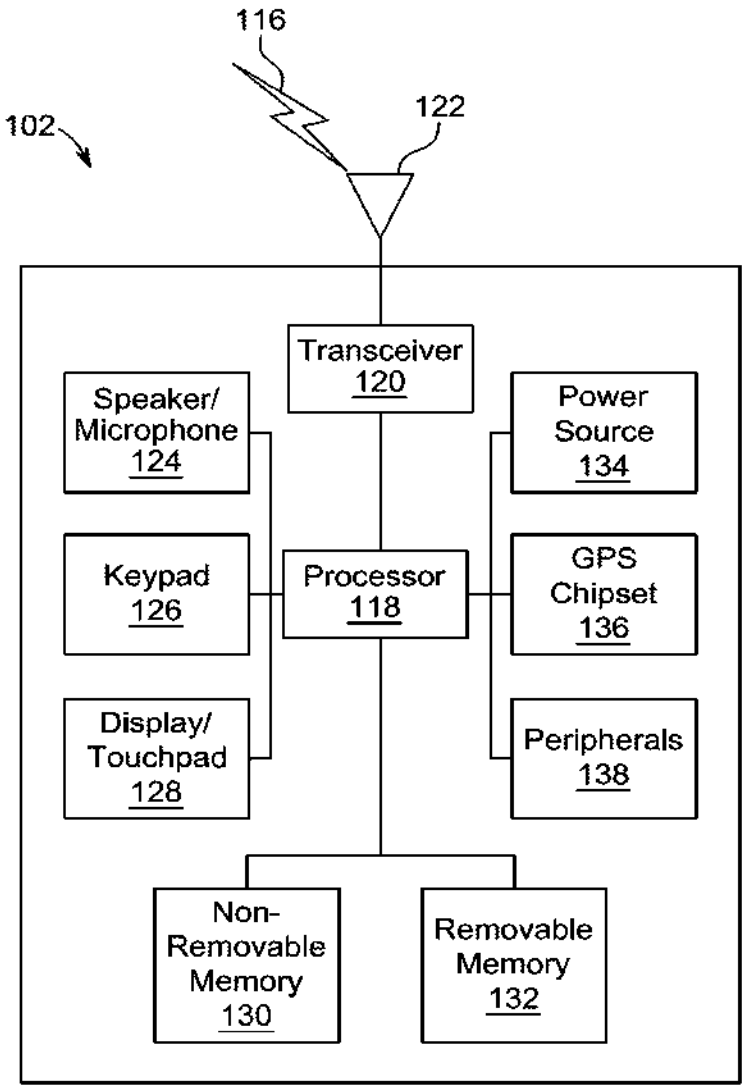

116
122
102
Transceiver
120
Speaker/
Microphone
124
Power
Source
134
Keypad
126
Processor
118
GPS
Chipset
136
Display/
Touchpad
128
Peripherals
138
Non-
Removable
Memory
130
Removable
Memory
132

FIG. 1B

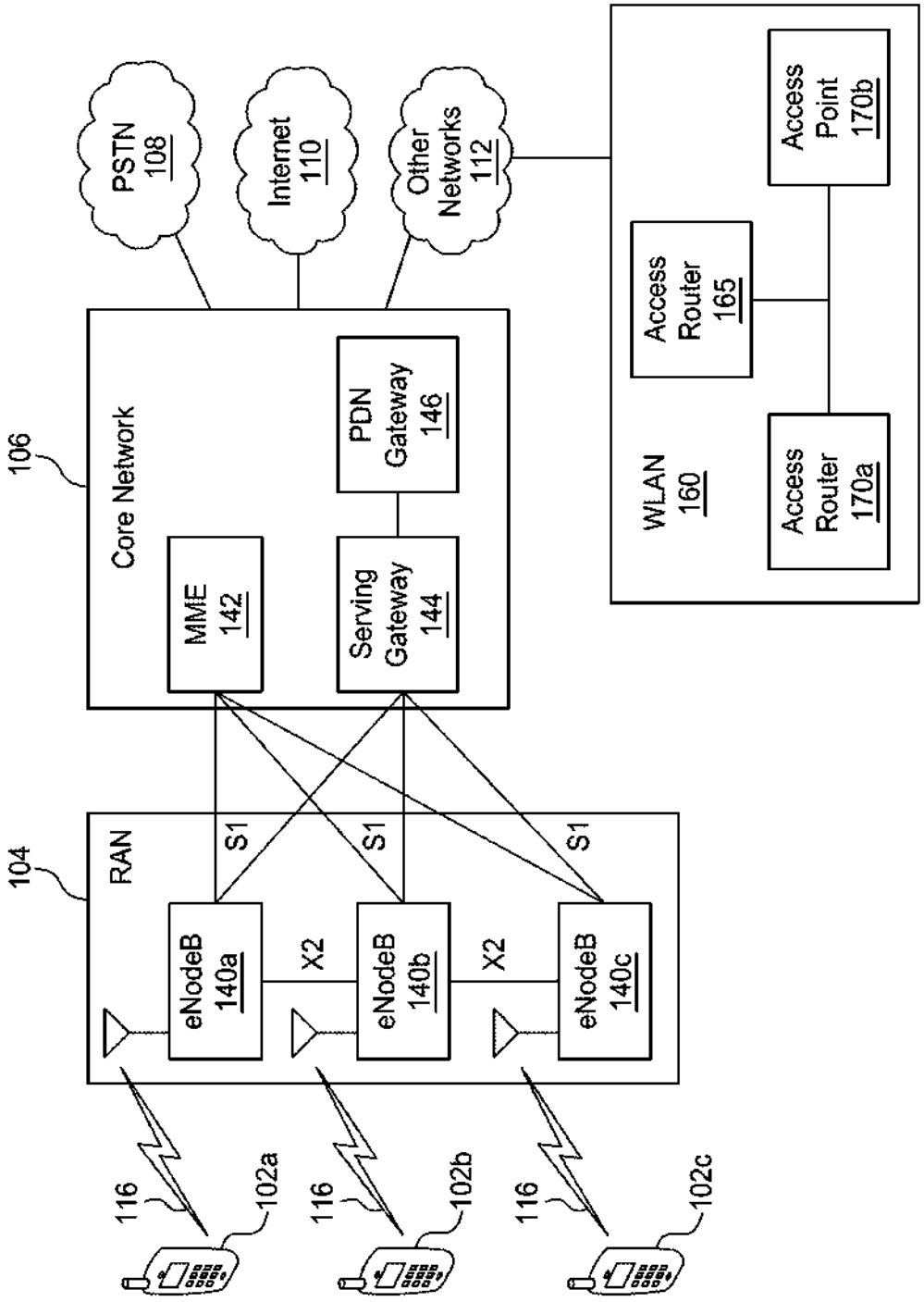

PSTN 108
Internet 110
Other Networks 112
106
Core Network
MME 142
PDN Gateway 146
Serving Gateway 144
WLAN 160
Access Router 165
Access Point 170b
Access Router 170a
104
RAN
S1
S1
S1
eNodeB 140a
eNodeB 140b
eNodeB 140c
X2
X2
116
116
116
102a
102b
102c

FIG. 1C

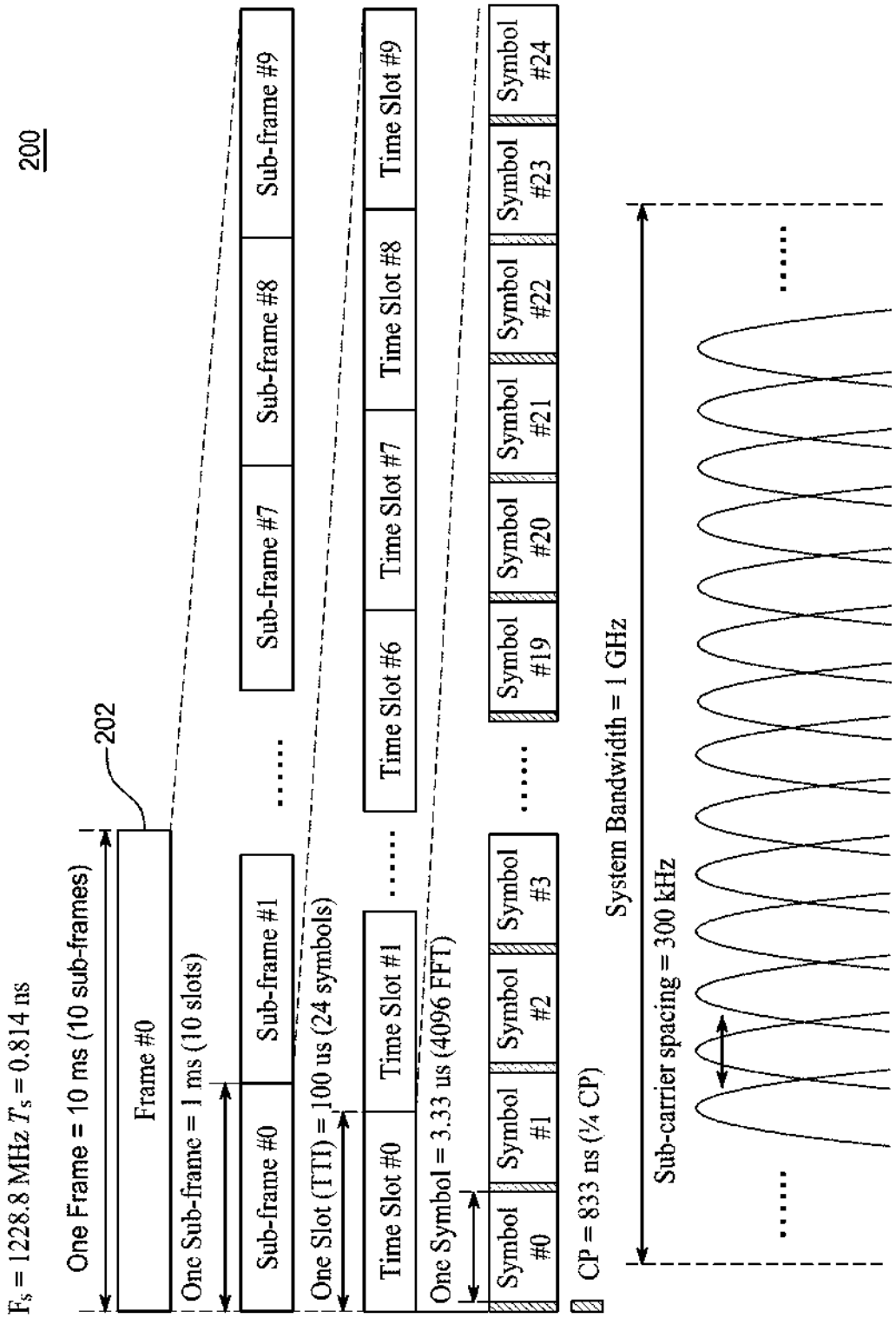

200
F_s = 1228.8 MHz T_s = 0.814 ns
One Frame = 10 ms (10 sub-frames)
202
Frame #0
One Sub-frame = 1 ms (10 slots)
Sub-frame #0
Sub-frame #1
Sub-frame #7
Sub-frame #8
Sub-frame #9
One Slot (TTI) = 100 us (24 symbols)
Time Slot #0
Time Slot #1
Time Slot #6
Time Slot #7
Time Slot #8
Time Slot #9
One Symbol = 3.33 us (4096 FFT)
Symbol #0
Symbol #1
Symbol #2
Symbol #3
Symbol #19
Symbol #20
Symbol #21
Symbol #22
Symbol #23
Symbol #24
CP = 833 ns (¼ CP)
System Bandwidth = 1 GHz
Sub-carrier spacing = 300 kHz

FIG. 2

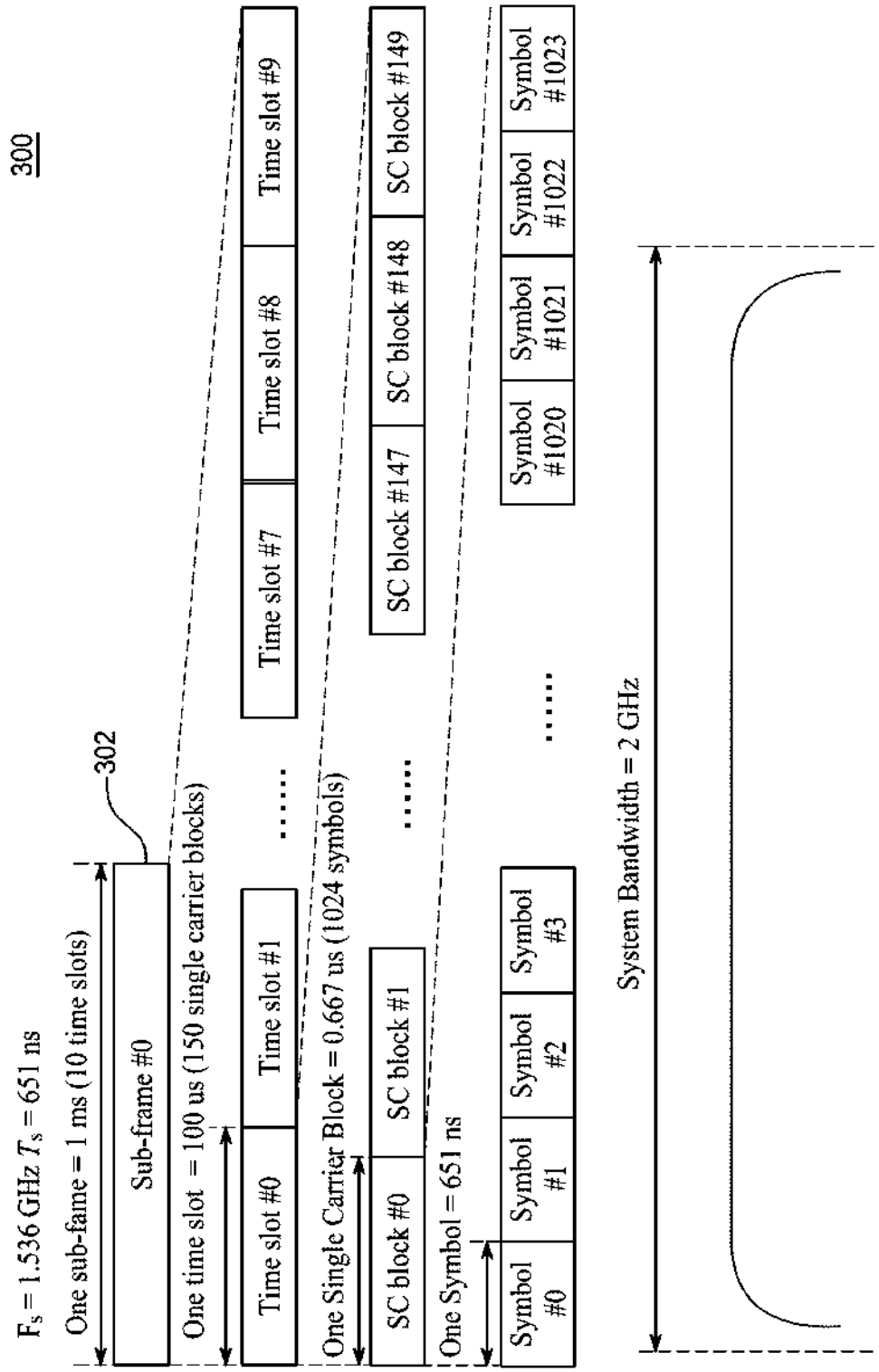

300
302
F_s = 1.536 GHz T_s = 651 ns
One sub-fame = 1 ms (10 time slots)
Sub-frame #0
One time slot = 100 us (150 single carrier blocks)
Time slot #0
Time slot #1
Time slot #7
Time slot #8
Time slot #9
One Single Carrier Block = 0.667 us (1024 symbols)
SC block #0
SC block #1
SC block #147
SC block #148
SC block #149
One Symbol = 651 ns
Symbol #0
Symbol #1
Symbol #2
Symbol #3
Symbol #1020
Symbol #1021
Symbol #1022
Symbol #1023
System Bandwidth = 2 GHz

FIG. 3

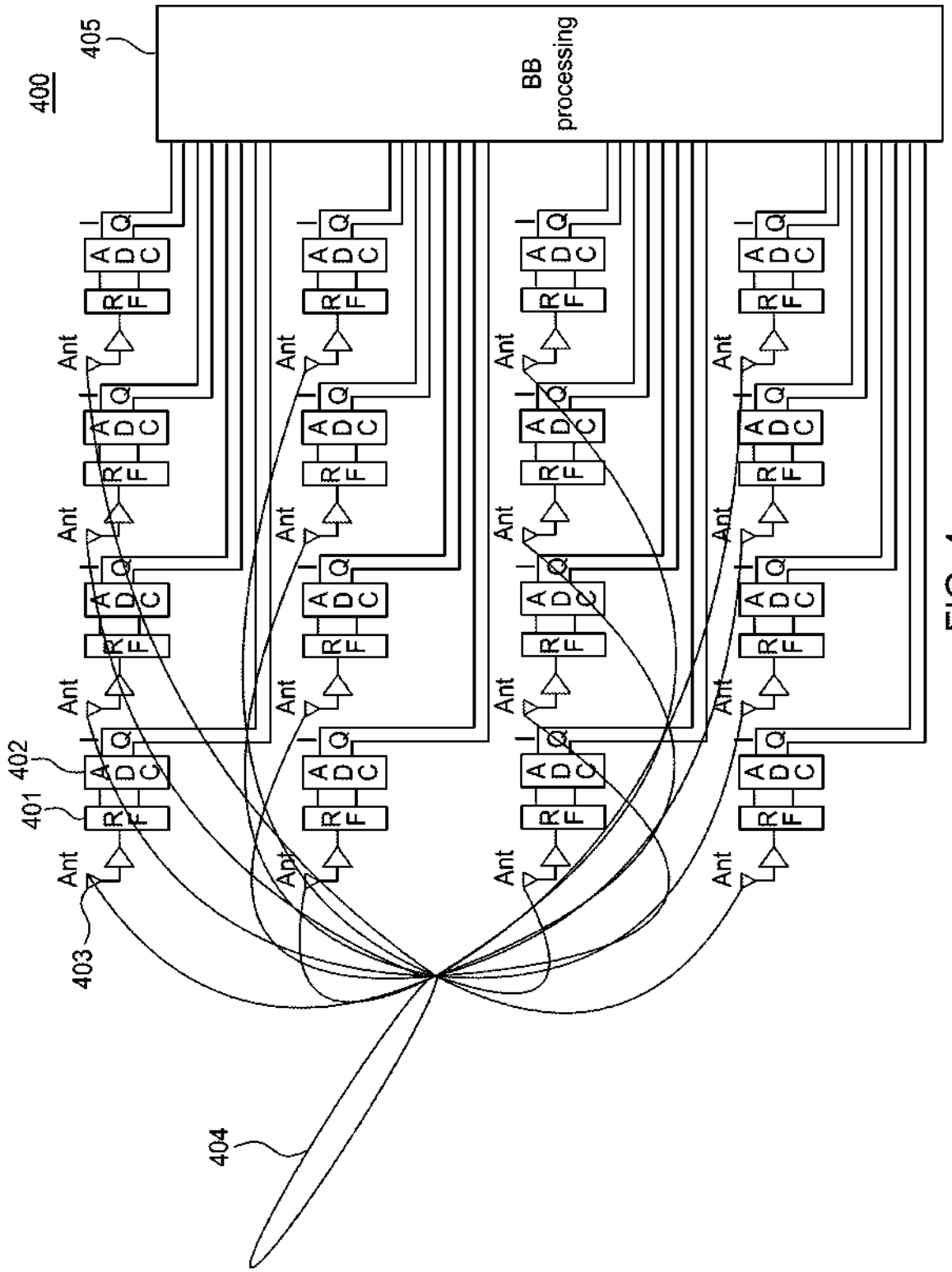


FIG. 4

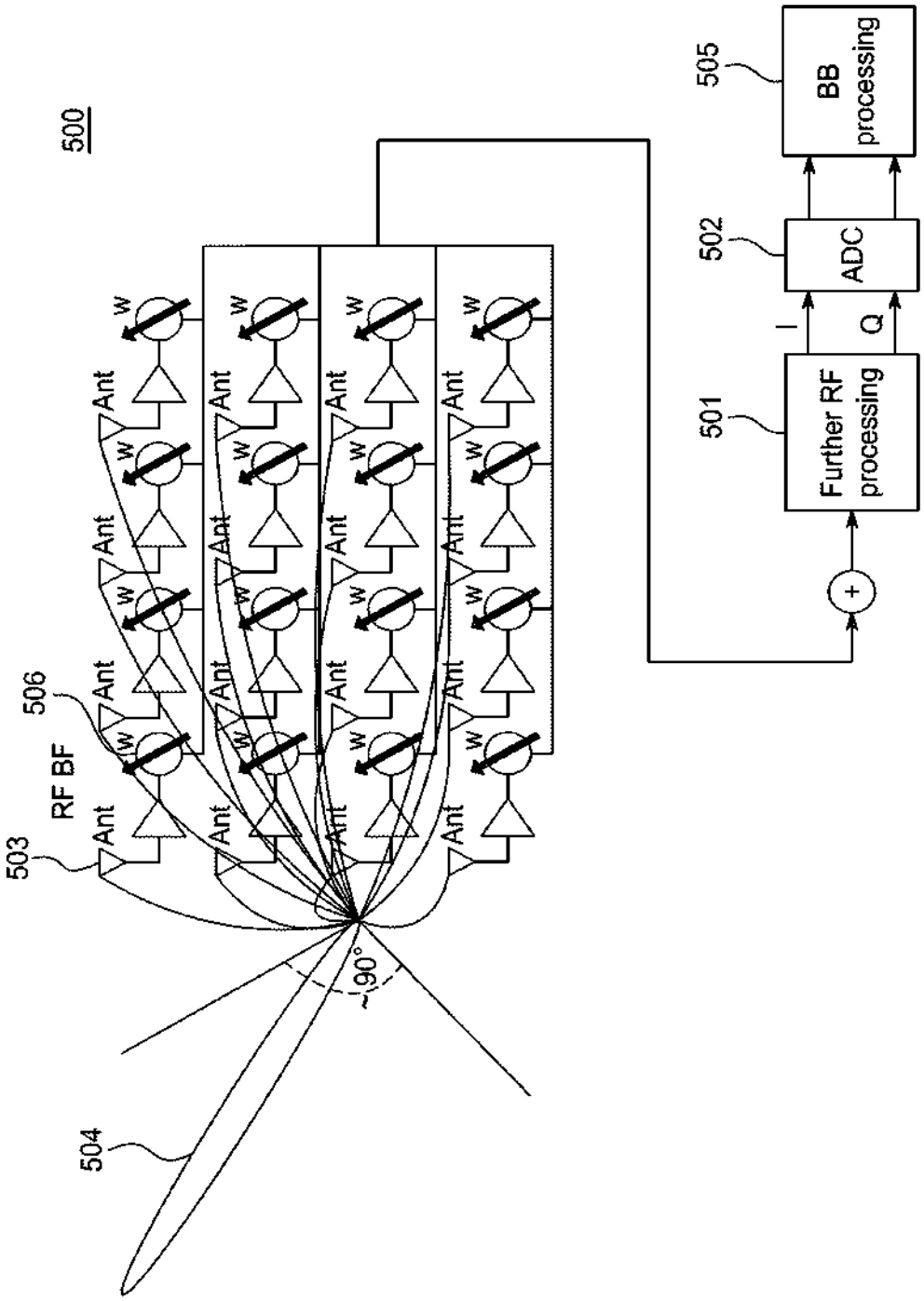

500
505
BB processing
502
ADC
I
Q
501
Further RF processing
+
506
RF BF
503
Ant
W
504
90°

FIG. 5

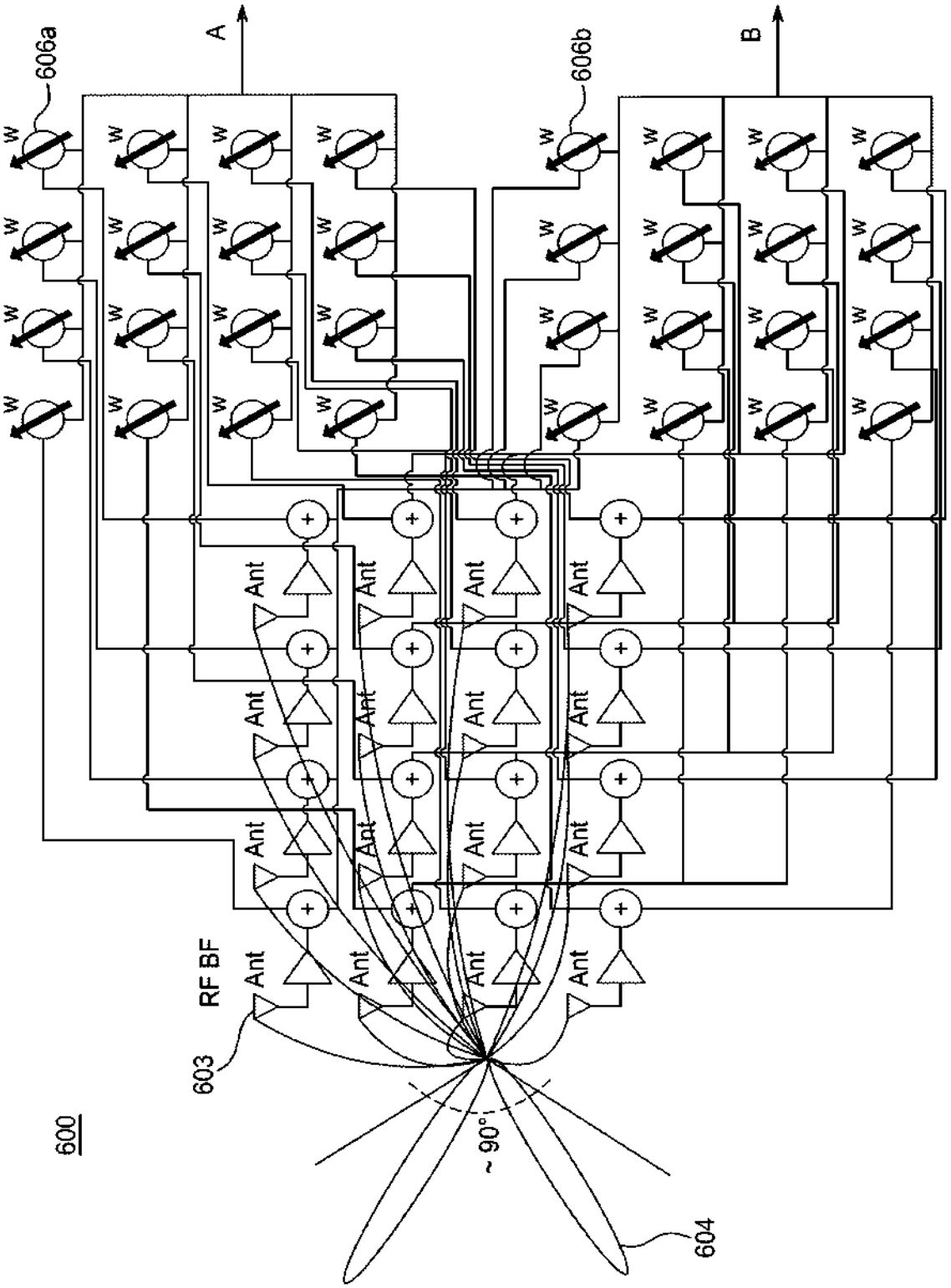


FIG. 6A

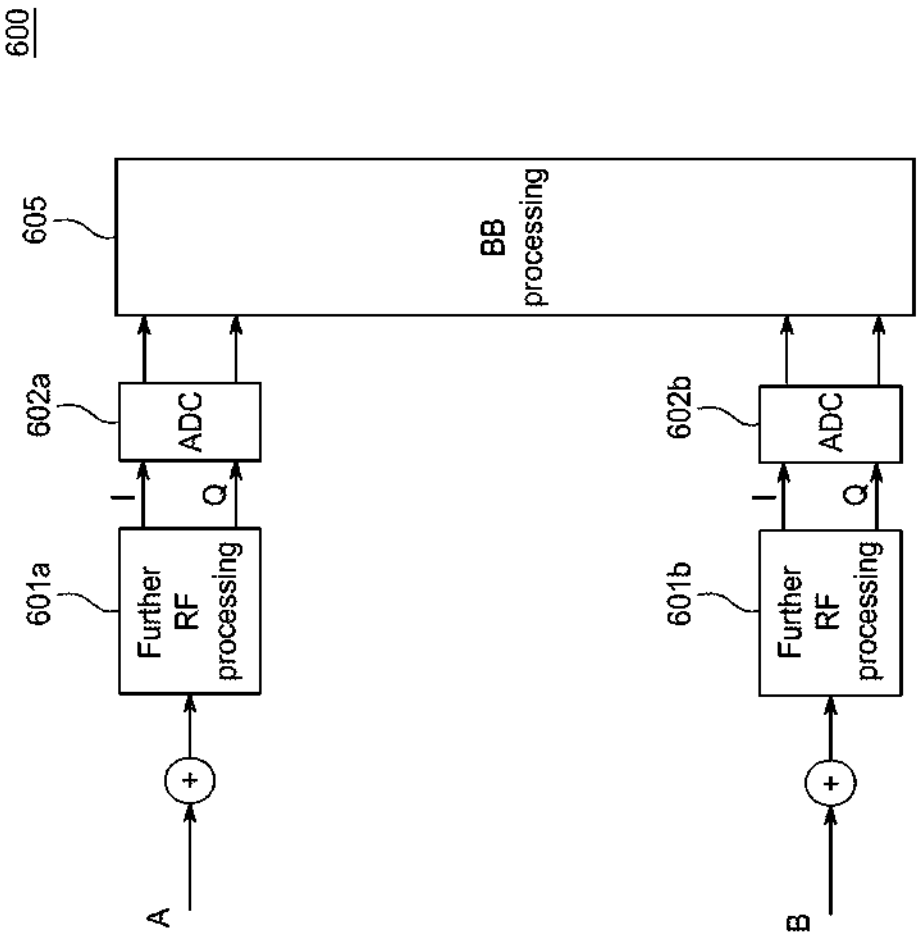

600
605
BB processing
602a
ADC
602b
ADC
I
Q
I
Q
601a
Further RF processing
601b
Further RF processing
A
B

FIG. 6B

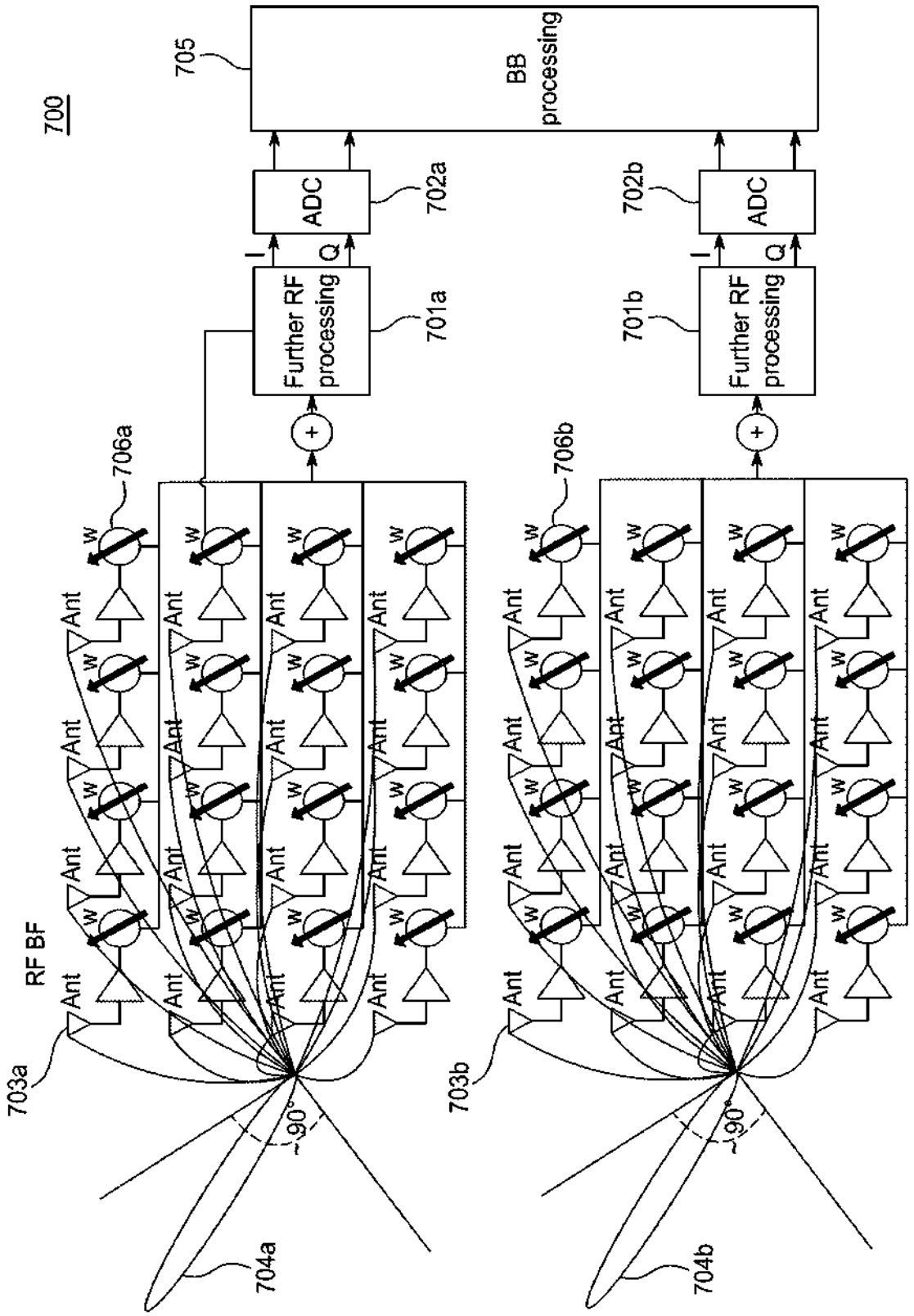

700
705
BB processing
ADC
702a
702b
I
Q
Further RF processing
701a
701b
706a
706b
RF BF
Ant
w
703a
703b
90°
704a
704b

FIG. 7

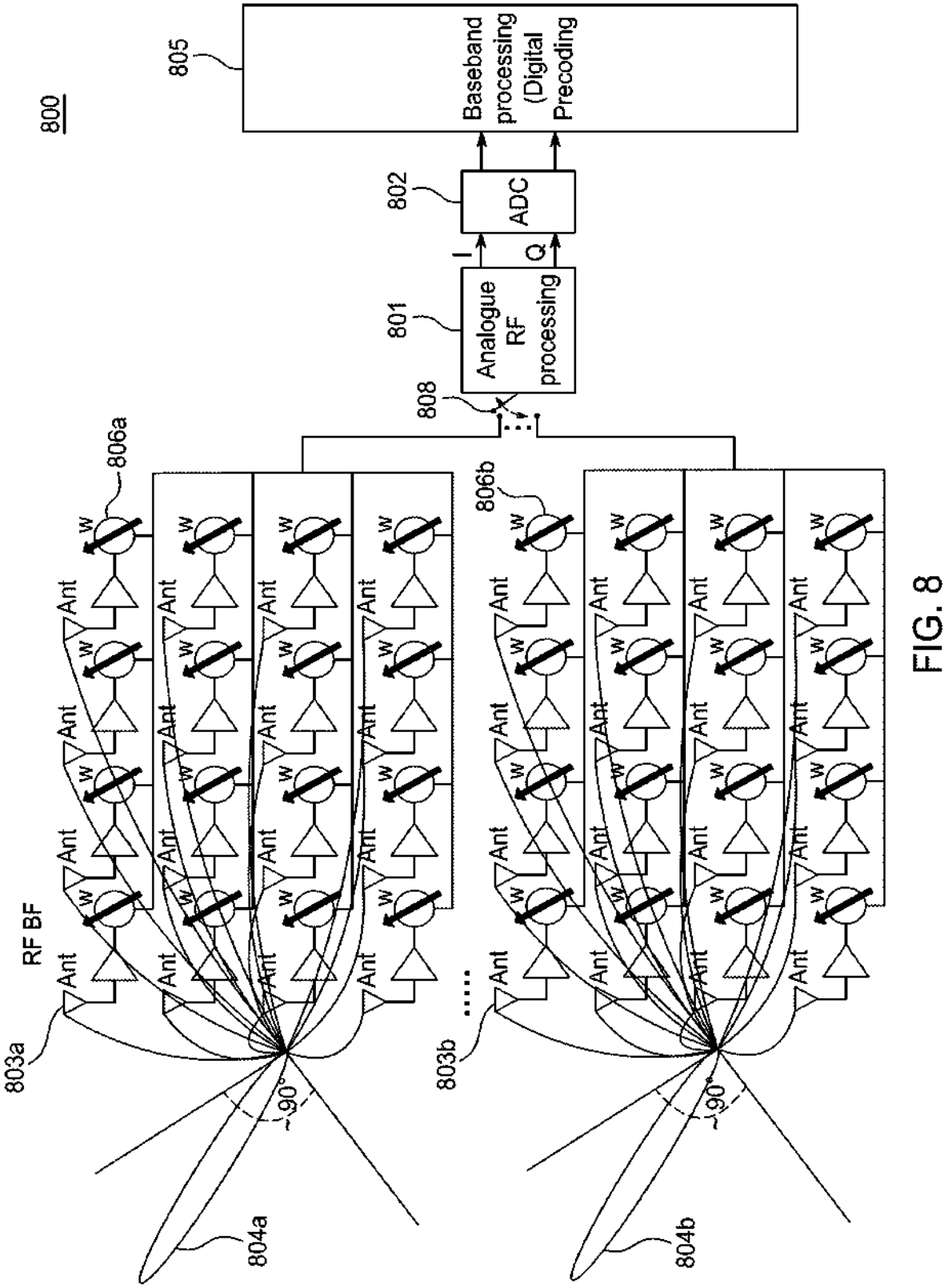

800
805
Baseband processing (Digital Precoding
802
ADC
I
Q
801
Analogue RF processing
808
806a
806b
RF BF
Ant
W
803a
803b
90°
804a
804b

FIG. 8

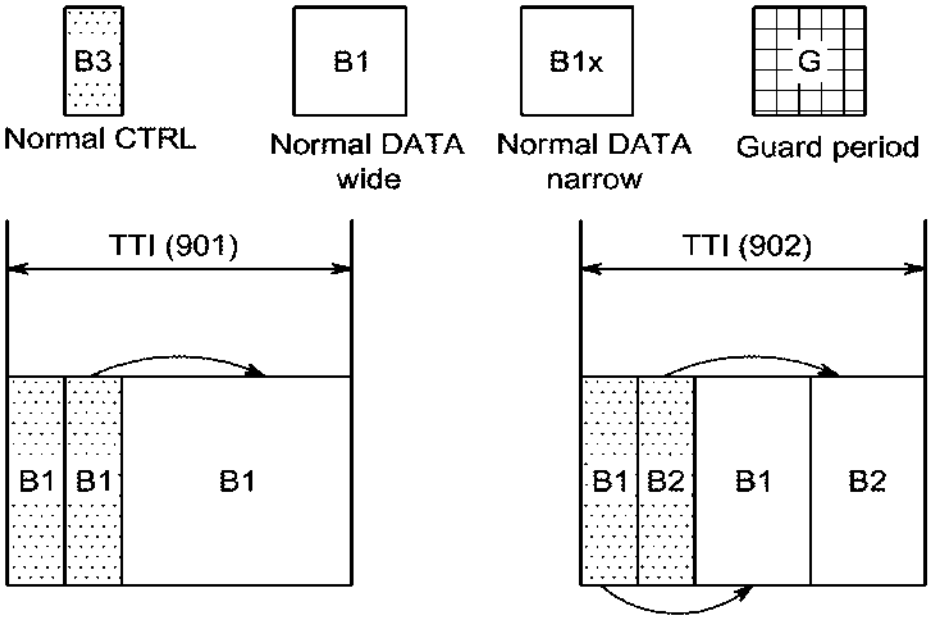

B3
Normal CTRL
B1
Normal DATA wide
B1x
Normal DATA narrow
G
Guard period
TTI (901)
B1
B1
B1
TTI (902)
B1
B2
B1
B2

FIG. 9

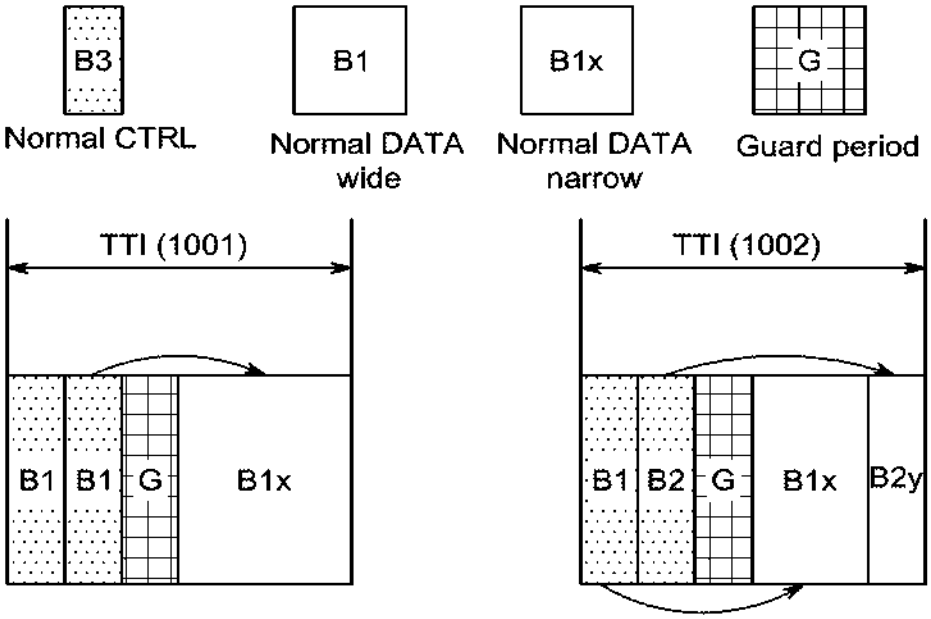

B3
Normal CTRL
B1
Normal DATA wide
B1x
Normal DATA narrow
G
Guard period
TTI (1001)
B1
B1
G
B1x
TTI (1002)
B1
B2
G
B1x
B2y

FIG. 10

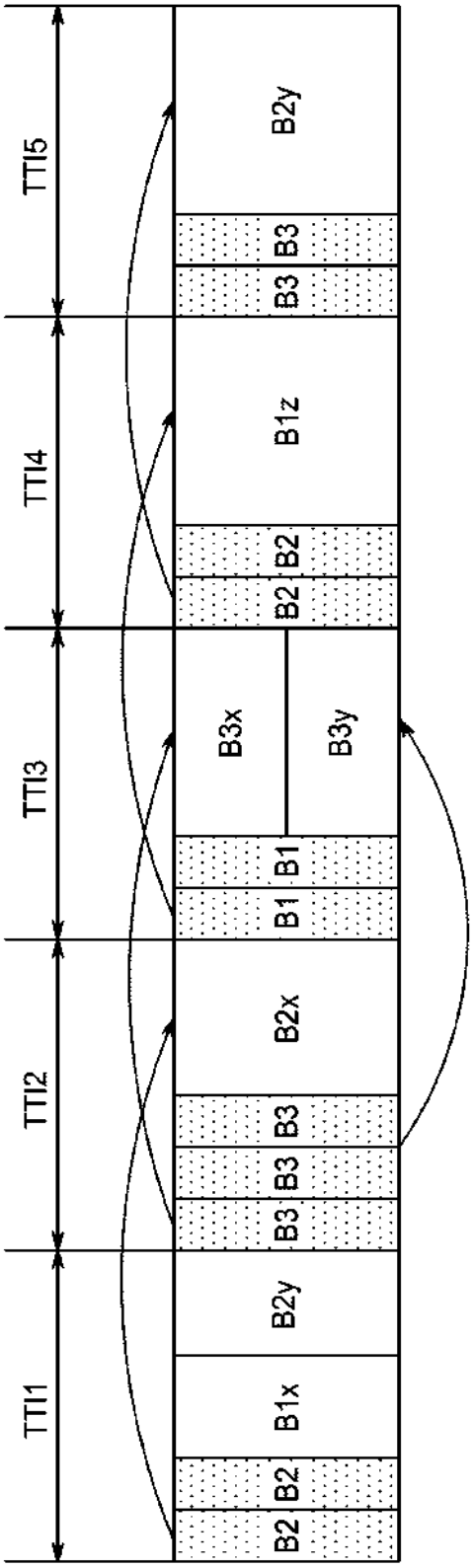

TTI5
TTI4
TTI3
TTI2
TTI1
B2y
B3
B3
B1z
B2
B2
B3x
B3y
B1
B1
B2x
B3
B3
B3
B2y
B1x
B2
B2

FIG. 11

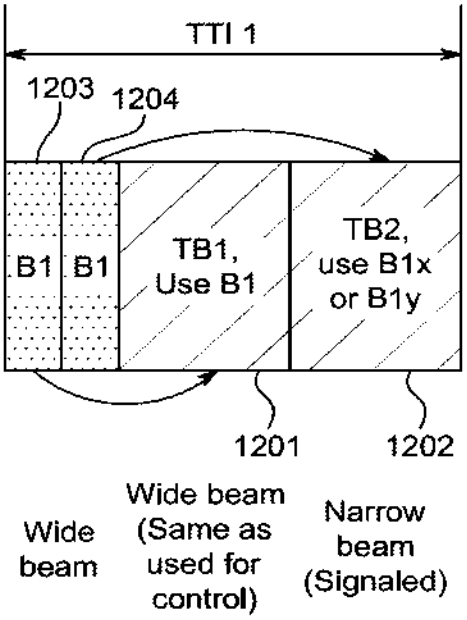

TTI 1
1203
1204
B1
B1
TB1,
Use B1
TB2,
use B1x
or B1y
1201
1202
Wide beam
Wide beam
(Same as
used for
control)
Narrow
beam
(Signaled)

FIG. 12

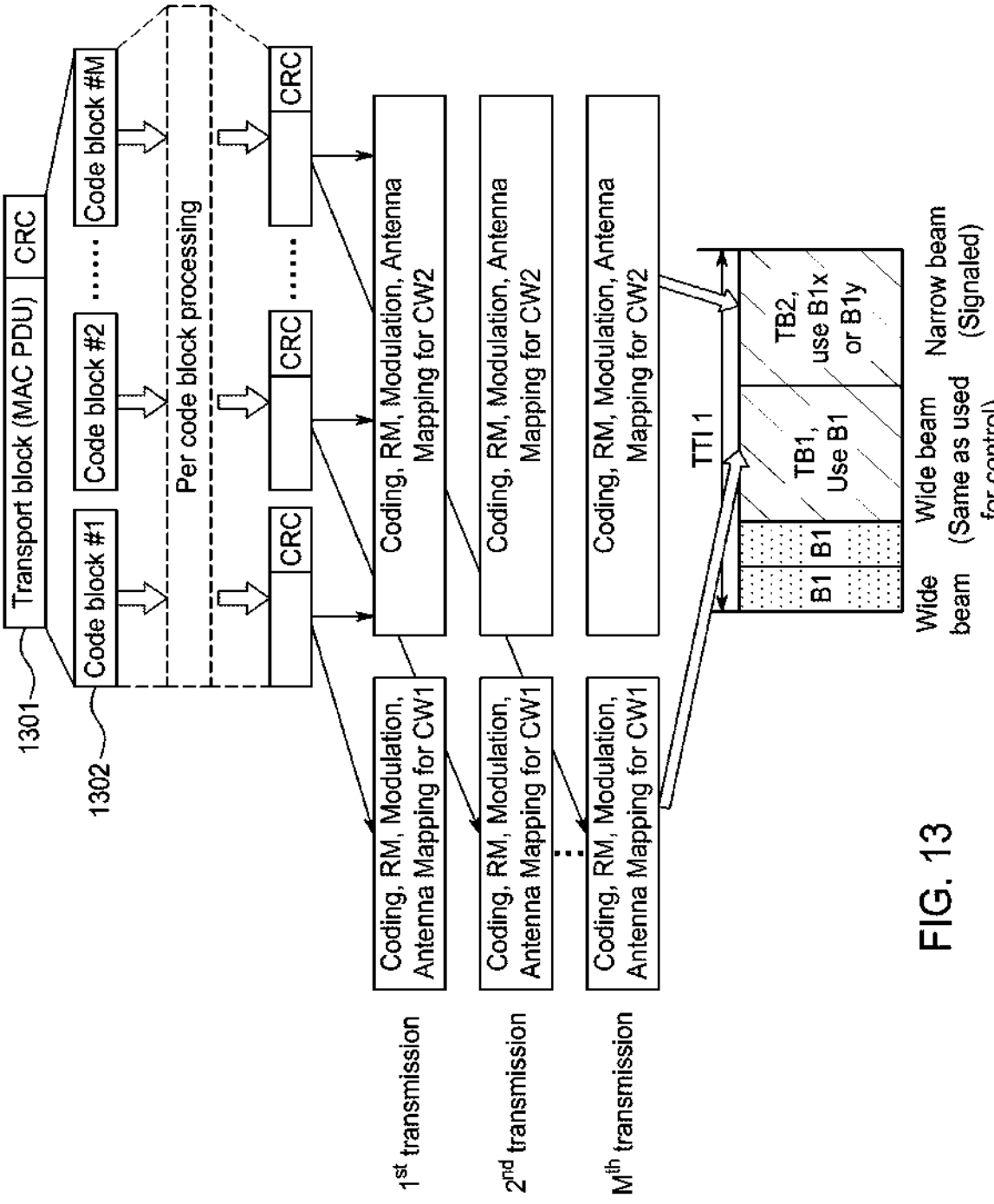

Transport block (MAC PDU)
CRC
1301
1302
Code block #1
Code block #2
Code block #M
Per code block processing
CRC
Coding, RM, Modulation, Antenna Mapping for CW1
Coding, RM, Modulation, Antenna Mapping for CW2
1st transmission
2nd transmission
Mth transmission
TTI 1
TB1, Use B1
TB2, use B1x or B1y
B1
Wide beam
Wide beam (Same as used for control)
Narrow beam (Signaled)

FIG. 13

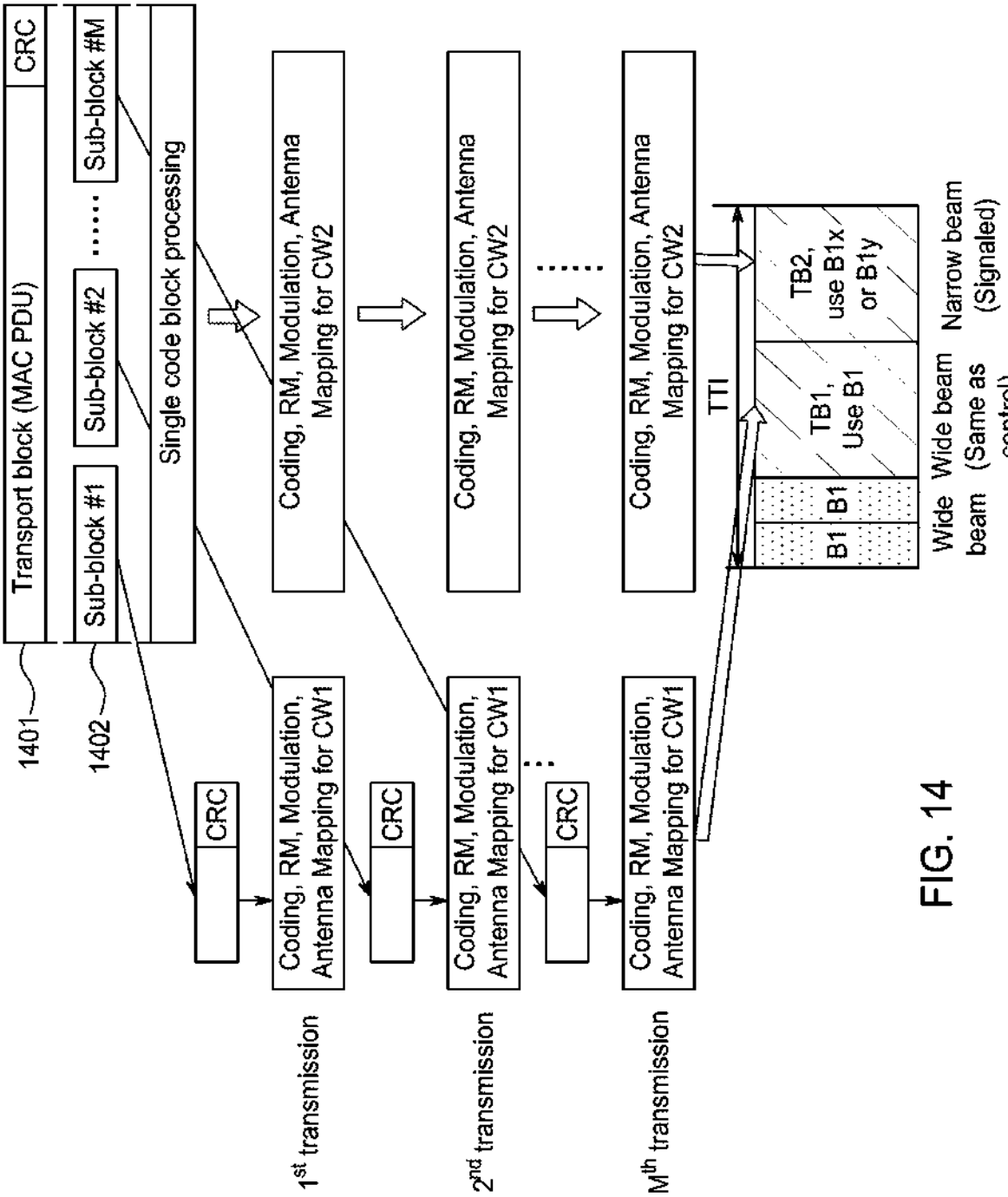

Transport block (MAC PDU)
CRC
Sub-block #1
Sub-block #2
.....
Sub-block #M
Single code block processing
1401
1402
CRC
Coding, RM, Modulation, Antenna Mapping for CW1
Coding, RM, Modulation, Antenna Mapping for CW2
1st transmission
2nd transmission
Mth transmission
TTI
TB1, Use B1
TB2, use B1x or B1y
B1
B1
Wide beam
Wide beam (Same as control)
Narrow beam (Signaled)

FIG. 14

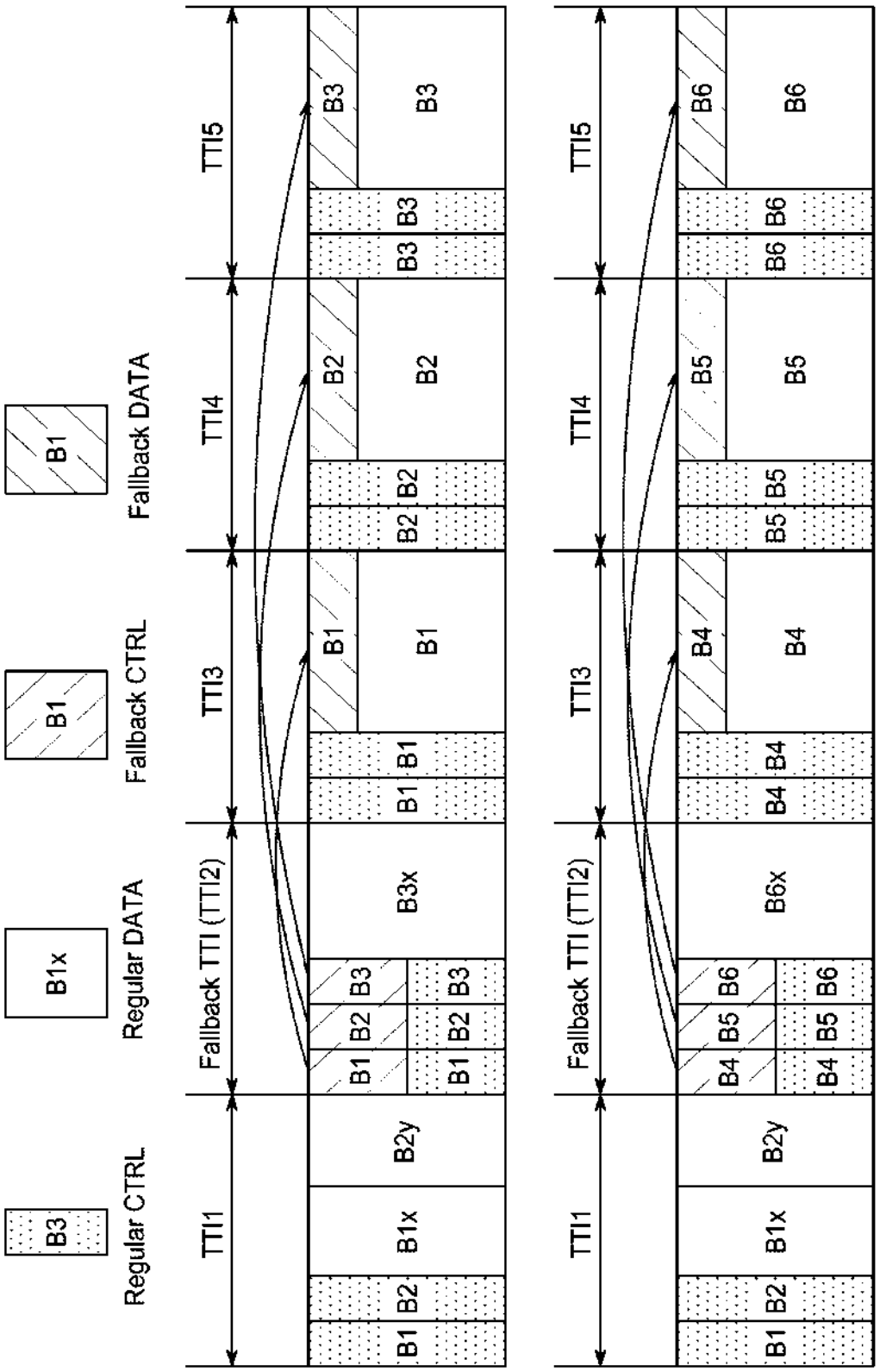

B3
Regular CTRL
B1x
Regular DATA
B1
Fallback CTRL
B1
Fallback DATA
TTI1
TTI3
TTI4
TTI5
Fallback TTI (TTI2)
B1x
B2y
B3x
B6x
B1
B2
B3
B4
B5
B6

FIG. 15

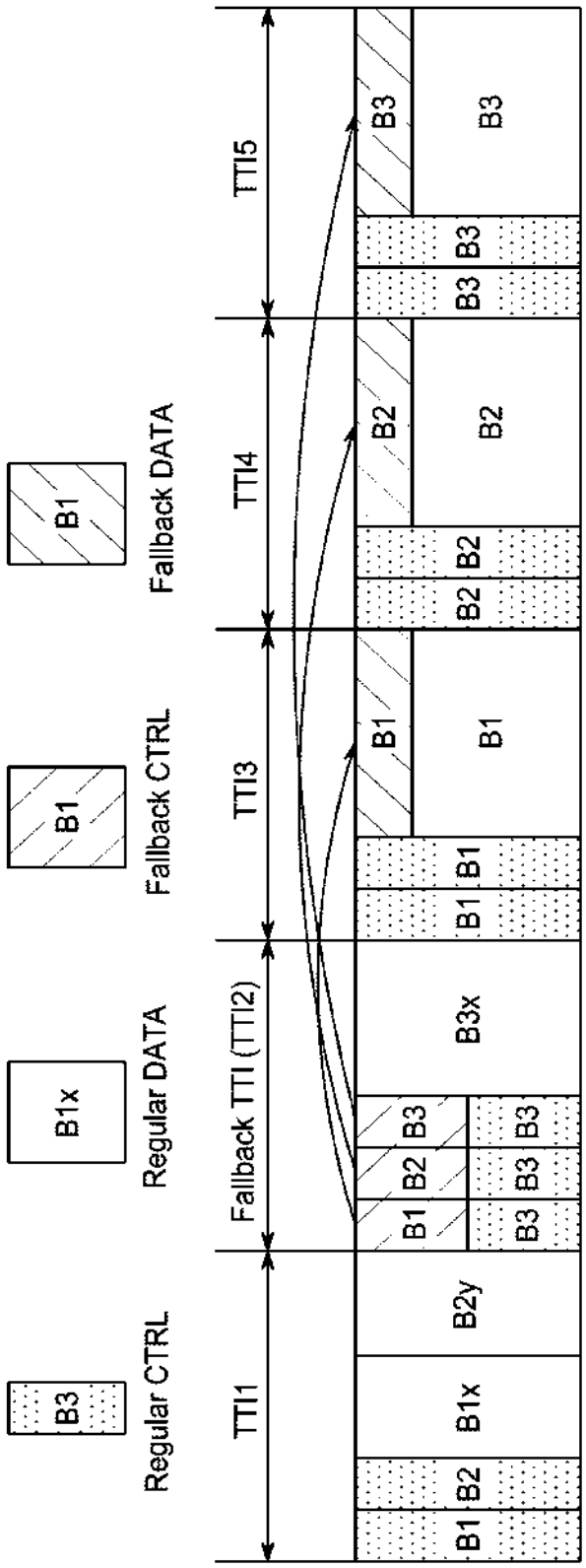

B3
Regular CTRL
B1x
Regular DATA
B1
Fallback CTRL
B1
Fallback DATA
TTI1
TTI2
TTI3
TTI4
TTI5
Fallback TTI (TTI2)
B1
B2
B1x
B2y
B3x
B1
B2
B3

FIG. 16

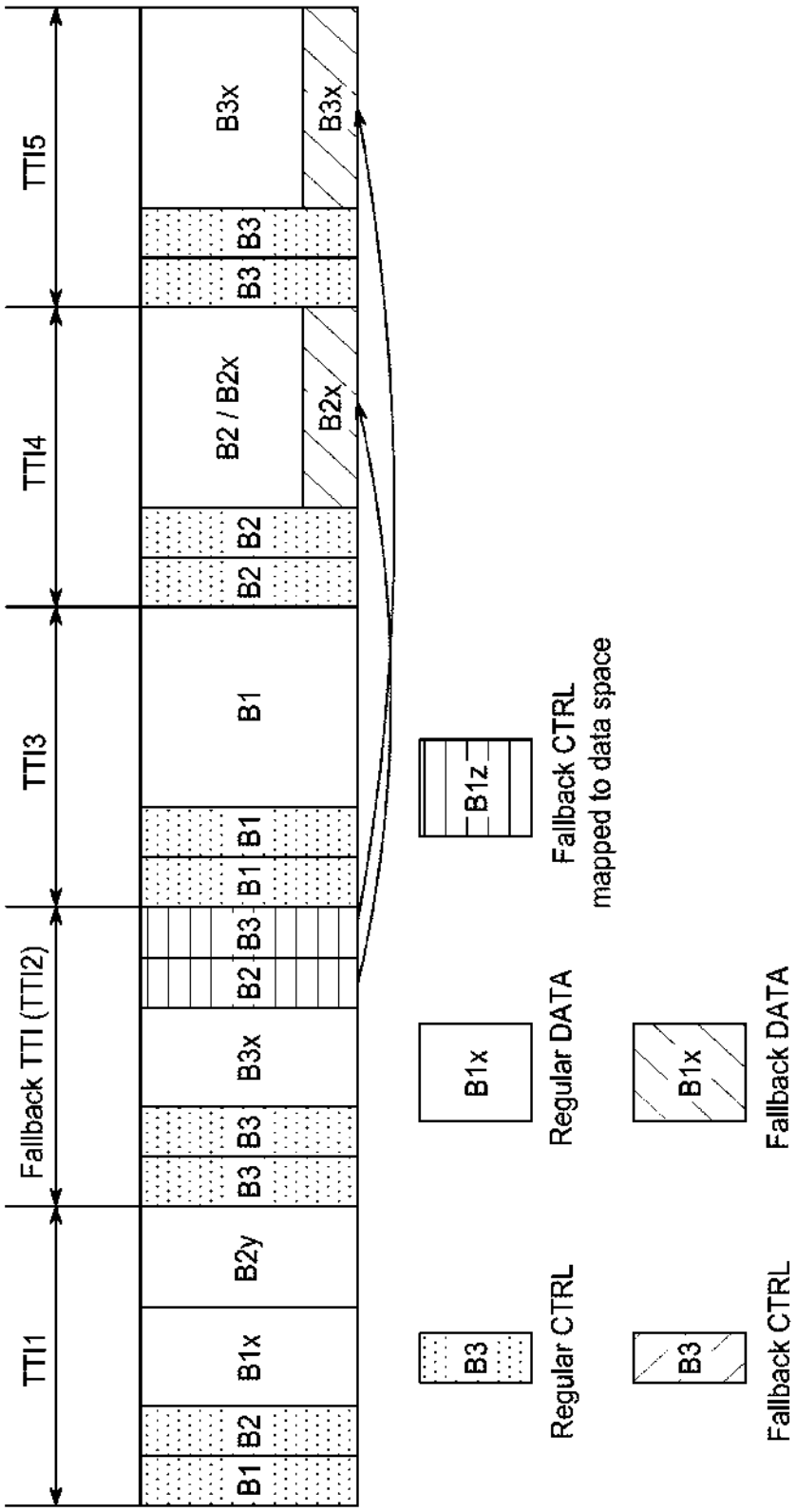

TTI1
TTI2
TTI3
TTI4
TTI5
Fallback TTI
B1
B2
B1x
B2y
B3
B3x
B1z
B2x
B2 / B2x
Regular CTRL
Regular DATA
Fallback CTRL
Fallback DATA
Fallback CTRL
mapped to data space

FIG. 17

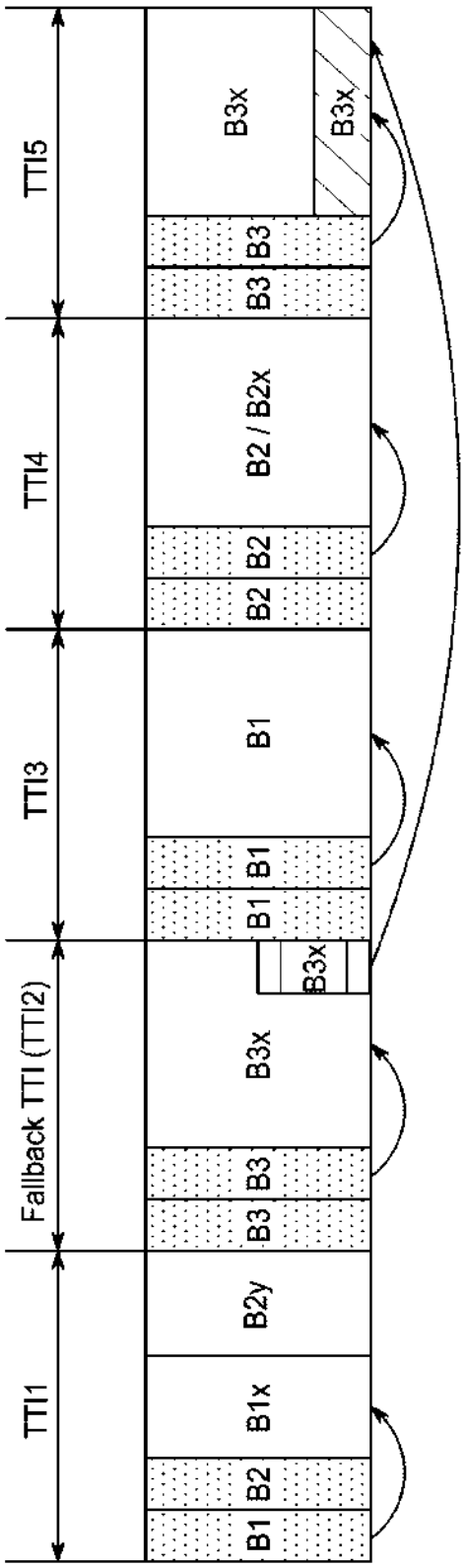

TTI1
TTI2
TTI3
TTI4
TTI5
Fallback TTI (TTI2)
B1
B2
B1x
B2y
B3
B3x
B1
B1
B2
B2 / B2x
B3
B3
B3x
B3x
B1x
B1z
B3
B1
Regular DATA
Narrow beam Fallback CTRL mapped to data space
Regular CTRL
Fallback DATA
Fallback CTRL

FIG. 18

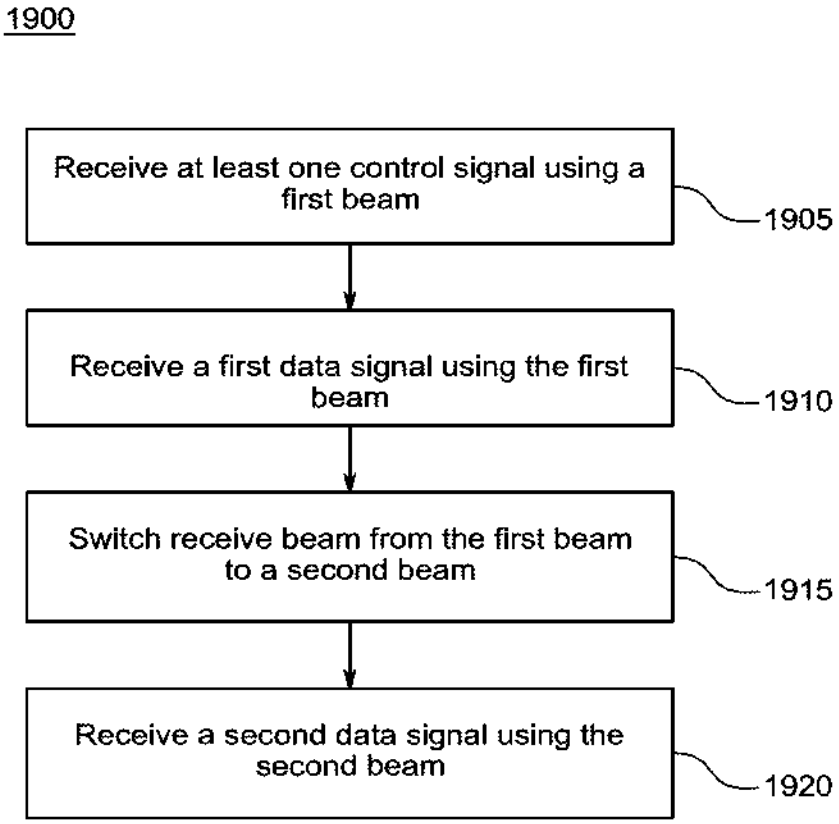

1900
Receive at least one control signal using a first beam
1905
Receive a first data signal using the first beam
1910
Switch receive beam from the first beam to a second beam
1915
Receive a second data signal using the second beam
1920

FIG. 19

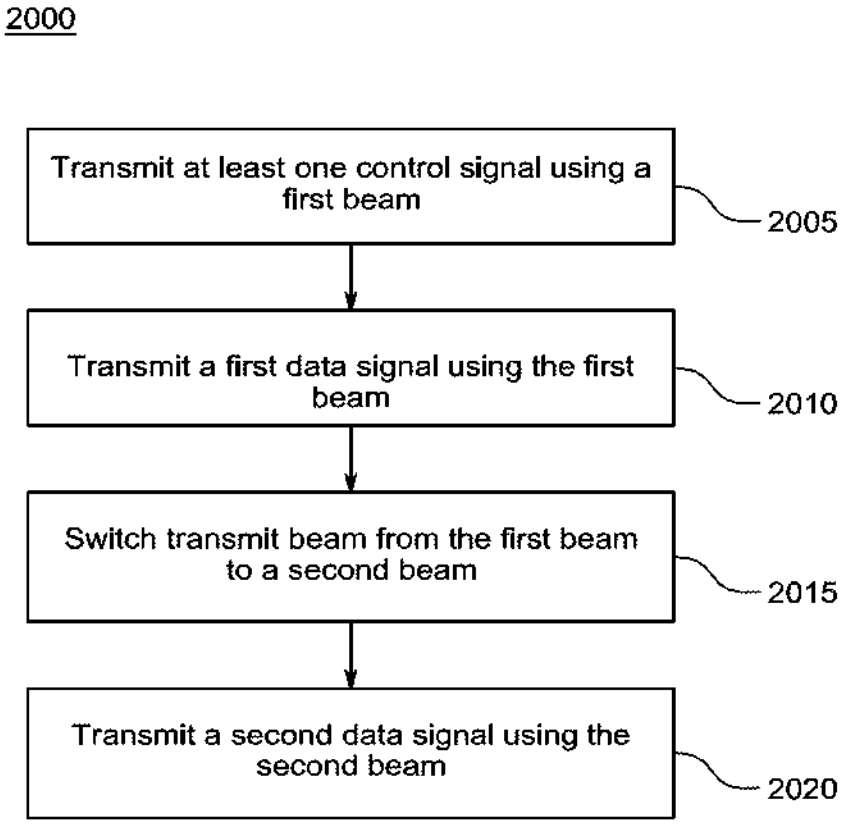

2000
Transmit at least one control signal using a first beam
2005
Transmit a first data signal using the first beam
2010
Switch transmit beam from the first beam to a second beam
2015
Transmit a second data signal using the second beam
2020

FIG. 20

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/061282

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04L5/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 1 562 306 A1 (CIT ALCATEL [FR]) 10 August 2005 (2005-08-10) paragraph [0014] - paragraph [0022] ----- -/--	1-21

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

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Date of the actual completion of the international search	Date of mailing of the international search report
10 January 2017	17/01/2017

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Koukourlis, Sotirios

1

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	INTEL CORPORATION: "On Cell Association in Phase Two Evaluation", 3GPP DRAFT; R1-144667_CELL_ASSOCIATION, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. San Francisco, USA; 20141117 - 20141121 17 November 2014 (2014-11-17), XP050875754, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN1/Docs/ [retrieved on 2014-11-17] the whole document -----	1-21
A	KYOCERA: "Dynamic Beamformed CSI-RS for Elevation Beamforming/FD-MIMO", 3GPP DRAFT; R1-151471, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. Belgrade, Serbia; 20150420 - 20150424 19 April 2015 (2015-04-19), XP050934343, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN1/Docs/ [retrieved on 2015-04-19] the whole document -----	1-21

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2016/061282

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 1562306 A1	10-08-2005	NONE	

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(71) Applicants: **SAMSUNG ELECTRONICS CO., LTD.** [KR/KR]; 129, Samsung-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do 16677 (KR). **BEIJING SAMSUNG TELECOM R&D CENTER** [CN/CN]; 1503, 15Floor, Building No.12, Taiyanggong Middle Road, Chaoyang district, Beijing 100125 (CN).

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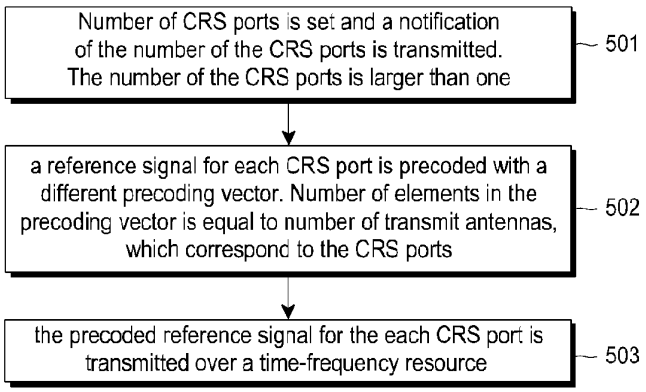
(74) Agents: **LEE, Keon-Joo** et al.; Mihwa Bldg., 16 Daehak-ro 9-gil, Chongro-gu, Seoul 110-524 (KR).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU,

[Continued on next page]

(54) Title: METHOD AND APPARATUS FOR REFERENCE SIGNAL TRANSMITTING AND RECEIVING IN ACTIVE ANTENNA SYSTEMS



(57) Abstract: Embodiments of the present disclosure provide reference signal transmitting and receiving methods and devices in an active antenna system. Port virtualization to a transmit antennas may be implemented for multiple cell-specific reference signal (CRS) antenna ports and applying different vertical beamforming vectors to implement port virtualization for the different CRS antenna ports. The User Equipment (UE) reports the maximum RSRP/RSRQ value measured based on multiple CRS ports, or the UE simultaneously reports multiple RSRP/RSRQ values and the information of the multiple CRS antenna ports. Therefore, the coverage problem of the CRS signal and Physical Broadcast Channel (PBCH)/Physical Downlink Control Channel (PDCCH)/Physical Downlink Shared Channel (PDSCH) demodulated based on CRS and the problem of measurement for Radio Resource Management (RRM) in the active antenna system may be avoided. Specifically, the following problems may be solved. 1) Coverage differences between CRS and PBCH/PDCCH/PDSCH demodulated based on CRS transmission and Enhanced PDCCH (E-PDCCH)/PDSCH signal transmission, which is measured based on the CSI-RS or demodulated based on the DMRS may be reduced or avoided. 2) The cell association problem due to the different vertical beamforming technologies adopted by the CSI-RS or DMRS and by the CRS may be avoided. 3) Deep spatial fading state may be avoided for CRS reception and PBCH/PDCCH/PDSCH demodulated based on the CRS.

WO 2015/199414 A1

TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

Description

Title of Invention: METHOD AND APPARATUS FOR REFERENCE SIGNAL TRANSMITTING AND RECEIVING IN ACTIVE ANTENNA SYSTEMS

Technical Field

[1] The present disclosure relates to a field of mobile communication systems, and more particularly to a method and apparatus for reference signal transmitting and receiving in active antenna systems.

Background Art

[2] In mobile communication systems, the wireless fading channels are time-varying. In order to effectively detect signals, channel information is needed to implement relevant detection. In order to obtain the channel information, the base station transmits the signals or sequences, which are known to the UE, via wireless channels. And the UE obtains the channel information via detecting the known signals or sequences. The known signals or sequences are called pilot signals or reference signals.

[3] A Long Term Evolution/ Long Term Evolution-Advanced (LTE/LTE-A) system is a typical correlation detection system. There are seven kinds of pilot signals or reference signals according to the purposes as described below.

[4] A Cell-specific Reference Signal (CRS) is used for data demodulation of PBCH, PDCCH, and some of PDSCHs, measurement of Channel State Information (CSI) of downlink shared channel (PDSCH) of transmission modes 1 to 8.

[5] A Multimedia Broadcast Multicast Service Single Frequency Network Reference Signal (MBSFN- RS) is used for data demodulation of a Multicast Channel (MCH).

[6] A downlink User Equipment-specific Reference Signal (DMRS) is used for data demodulation of PDSCH of transmission modes 7 to 10.

[7] A Channel State Information Reference Signal (CSI-RS) is used for measurement of the CSI for PDSCH of transmission modes 9 to 10.

[8] A Positioning Reference Signal (PRS) is used for performing positioning function.

[9] An uplink Demodulation Reference Signal (DMRS) is used for data demodulation of physical uplink shared channel (PUSCH) and physical uplink control channel (PUCCH).

[10] An uplink Sounding Reference Signal (SRS) is used for measurement of uplink CSI and obtaining downlink channel information via channel reciprocity for TDD systems.

[11] Besides CSI measurement, data demodulation and synchronization assistance, the CRS is further used for measurement of Reference Signal Receive Power (RSRP/RSRQ) to implement path loss estimation, cell association, etc.

[12] Reference signal received power (RSRP/RSRQ), is defined as the linear average over the power contributions (in [W]) of the resource elements that carry cell-specific reference signals within the considered measurement frequency bandwidth.

[13] For RSRP/RSRQ determination the cell-specific reference signals R0 according to TS 36.211 shall be used. If the UE can reliably detect that R1 is available it may use R1 in addition to R0 to determine RSRP/RSRQ, where R0 and R1 are reference signal of CRS port 0 and port 1, respectively.

[14] Reference Signal Received Quality (RSRQ) is defined as the ratio K×RSRP/RSRQ / (E-UTRA carrier RSSI), where K is the number of RB's of the E-UTRA carrier RSSI measurement bandwidth. The measurements in the numerator and denominator shall be made over the same set of resource blocks.

[15] E-UTRA Carrier Received Signal Strength Indicator (RSSI), comprises the linear average of the total received power (in [W]) observed only in OFDM symbols containing reference symbols for antenna port 0, in the measurement bandwidth, over K number of resource blocks by the UE from all sources, including co-channel serving and non-serving cells, adjacent channel interference, thermal noise etc. If higher-layer signalling indicates certain subframes for performing RSRQ measurements, then RSSI is measured over all OFDM symbols in the indicated subframes.

[16] An antenna port is defined such that the channel over which a symbol on the antenna port is conveyed can be inferred from the channel over which another symbol on the same antenna port is conveyed. There is not necessarily a one-to-one relationship between the antenna port and physical antenna. The signal of each antenna port may be transmitted by combining signals over one antenna or multiple antennas. This process is called port virtualization.

[17] With development of antenna technologies, particularly active antenna array technologies, physical antenna elements are not only distributed in a horizontal dimension, but also distributed in both the vertical dimension and the horizontal dimension to form a 2-Dimension (2-D) antenna array. As shown in Fig. 1 and Fig. 2, Fig. 1 is a schematic diagram illustrating structure of an active antenna cross-polarized 2-D antenna array in accordance with an embodiment of the prior art. Fig. 2 is a schematic diagram illustrating structure of a co-polarized 2-D antenna array in accordance with an embodiment of the prior art. N is the number of antennas in a horizontal co-polarized direction and M is the number of antennas in the vertical dimension.

[18] Using the 2-D antenna array, thevertical beamforming and/or dynamic vertical sectorization is possible. Narrow beams, which directly point to the UE or avoid interfere to the UE using the same time frequency resource, are generated in the vertical dimension via multiplexing different weighting factor to each antenna. Therefore, the received signal power may be improved or the interference to the other UEs using the

same time frequency resources may be avoided.

[19] At present, although the LTE/LTE-A system supports that different reference signals may adopt different port virtualization methods, in the LTE/LTE-A specification, only passive antenna array is only taken into consideration in standardization process, the characteristics of the active antenna array are not taken into consideration.

[20] For the convenience of description, the wireless communication system with the active antenna array is called an active antenna system hereinafter. In order to obtain a vertical beamforming gain, a UE-specific vertical beamforming technology may be adopted for PDSCH. In order to ensure that UE in anywhere of a cell can receive the CRS, a cell-specific vertical beamforming vector may be adopted in the vertical dimension. In this way, the transmission of the CRS and transmission of data, which is measured based on the CSI-RS or demodulated based on the DMRSDMRS, may have different beamforming gains in the vertical dimension, resulting in different received signal strength. Fig. 3 is a diagram illustrating that the CRS and the PDSCH, which is measured based on the CSI-RS or demodulated based on the DMRS, adopt different vertical beamforming in accordance with an embodiment in the prior art.

[21] In LTE/LTE-A systems, cell association is implemented based on a Reference Signal Receiving Power RSRP/RSRQ value reported measured based on CRS port 0. Since the CRS and PDSCH, which is measured based on the CSI-RS or demodulated based on the DMRS, are transmitted with different vertical beamforming technologies, the cell association may be not suitable for PDSCH, which is measured based on the CSI-RS or demodulated based on the DMRS.

[22] Fig. 4 is a diagram illustrating the transmission of the CRS in accordance with an embodiment in the prior art. As shown in Fig. 4, the CRS is virtualized with a fixed vertical beamforming vector. Generally, in order to control interference to the adjacent cells, a down-tilt angle may be to be formed. For instance, in the typical Urban Marco (UMa) scenario, the base station (BS) antenna height is 25m, and the inter-site distance is 500m. The UEs are distributed outdoor or in low buildings with height of 18~24m. The 90 degree represents the horizontal direction, the 0 degree represents vertically pointing to the sky, and the 180 degree presents vertically pointing to the ground. Then, electronic down-tilt of CRS is 102 degree. In that case, the CRS vertical antenna array gain received by the UE is much small if the UE antenna height is larger than or equal to the BS antenna height. The signal strength of the CRS received by the UE is relatively weak no matter of accessing which cell. The CRS receiving for these UEs are in deep spatial fading.

[23] On the other hand, the RSRP/RSRQ value measured based on the CRS port 0 is used to estimate the path loss value for the uplink power control. Inappropriate RSRP/RSRQ report may affect performance of the uplink control in the active antenna

systems. In LTE/LTE-A standardization with passive antennas, it is assumed that the uplink path loss and downlink path loss is approximately symmetrical. This is because in the passive antenna system, the uplink channel and downlink channel may experience the same large-scale fading and similar antenna array gain. However, in the active antenna systems adopting the vertical beamforming, if the CRS adopts the fixed vertical beamforming, while the Maximal Ratio Combining (MRC) detection is used in the uplink receiving, the antenna gains for the uplink and downlink are asymmetric. Therefore, the downlink path loss estimated with the RSRP/RSRQ value is significantly different from the actual uplink path loss and the uplink power control performance may be further affected.

Disclosure of Invention

Technical Problem

[24] In view of the above, embodiments of the present disclosure provide reference signal transmitting and receiving methods in the active antenna systems. With these methods, the coverage problem of CRS signal and physical broadcast channel (PBCH)/physical downlink control channel (PDCCH)/physical downlink shared channel (PDSCH) demodulated based on CRS and the problem of measurement for radio resource management (RRM) in the active antenna systems may be avoided.

[25] Embodiments of the present disclosure further provide reference signal transmitting and receiving devices in the active antenna system. With these devices, the coverage problem of CRS signal and physical broadcast channel (PBCH)/physical downlink control channel (PDCCH)/physical downlink shared channel (PDSCH) demodulated based on CRS and the problem of measurement for radio resource management (RRM) in the active antenna systems may be avoided.

Solution to Problem

[26] According to the above objectives, the present disclosure is implemented as follows.

[27] A reference signal transmitting method in an active antenna system includes:

[28] setting number of Cell-specific Reference Signal (CRS) ports and transmitting a notification of number of the CRS ports, wherein the number of the CRS ports is larger than 1;

[29] precoding a reference signal with a different precoding vector for each of the CRS ports, wherein number of elements in the precoding vector is equal to number of transmit antennas, which correspond to the CRS ports; and

[30] transmitting the precoded reference signal for the each of the CRS ports over a corresponding frequency-time resource.

[31] A reference signal receiving method in an active antenna system includes:

[32] receiving a notification of number of Cell-specific Reference Signal (CRS) ports,

wherein the number of the CRS ports is larger than 1; and

[33] receiving a reference signal over a time-frequency resource.

[34] A reference signal transmitting device in an active antenna system includes:

[35] a notification module, to set number of Cell-specific Reference Signal (CRS) ports and transmit a notification of number of the CRS ports, wherein the number of the CRS ports is larger than 1;

[36] a precoding module, to precode a reference signal with a different precoding vector for each of the CRS ports, wherein number of elements in the precoding vector is equal to number of transmit antennas, which correspond to the CRS ports; and

[37] a transmitting module, to transmit the precoded reference signal for the each of the CRS ports over a corresponding frequency-time resource.

[38] A reference signal receiving device in an active antenna system includes:

[39] a signaling receiving module, to receive a notification of number of Cell-specific Reference Signal (CRS) ports, wherein the number of the CRS ports is larger than 1; and

[40] a signal receiving module, to receive a reference signal over a time-frequency resource.

[41] It can be seen from the above technical scheme that embodiments of the present disclosure implement port virtualization to transmit antennas via using multiple CRS antenna ports and applying different vertical beamforming vectors to the different CRS antenna ports. When the UE reports the RSRP/RSRQ value, the UE simultaneously reports the information of the CRS antenna ports. Therefore, the problems of unsatisfactory CRS signal coverage and RSRP/RSRQ report in the active antenna system may be solved. Specifically, following problems may be solved. 1) Differences between transmission signal coverage of the CRS and transmission signal coverage of data, which is measured based on the CSI-RS or demodulated based on the DMRS may be reduced or avoided. 2) The problem that differences between the vertical beamforming technologies adopted by the CSI-RS or DMRS and that adopted by the CRS make it inappropriate for the UE to access a cell may be avoided. 3) It may be avoided that when the UE with a specific-height antenna receives the data signal and/or control signal, which are demodulated based on the CRS, the vertical antenna array gain is in a deep spatial fading state.

Brief Description of Drawings

[42] Fig. 1 is a schematic diagram illustrating structure of an active cross-polarized 2-D antenna array in accordance with an embodiment of the prior art;

[43] Fig. 2 is a schematic diagram illustrating structure of a co-polarized 2-D antenna array in accordance with an embodiment of the prior art;

[44] Fig. 3 is a diagram illustrating that the CRS and the PDSCH, which is measured based on the CSI-RS or demodulated based on the DMRS, adopt different vertical beamforming for port virtualization in accordance with an embodiment in the prior art;

[45] Fig. 4 is a diagram illustrating the transmission of the CRS in accordance with an embodiment in the prior art;

[46] Fig. 5 is a flow chart illustrating a reference signal transmitting method in an active antenna system in accordance with an embodiment of the present disclosure;

[47] Fig. 6 is a flow chart illustrating a reference signal receiving method in an active antenna system in accordance with an embodiment of the present disclosure;

[48] Fig. 7 is a schematic diagram illustrating structure of a reference signal transmitting device in an active antenna system in accordance with an embodiment of the present disclosure;

[49] Fig. 8 is a schematic diagram illustrating structure of a reference signal receiving device in an active antenna system in accordance with an embodiment of the present disclosure;

[50] Fig. 9 is a flow chart illustrating a reference signal transmitting method in an active antenna system in accordance with a first embodiment of the present disclosure;

[51] Fig. 10 is a schematic diagram illustrating a CRS transmitting process in the physical layer in accordance with a first embodiment of the present disclosure;

[52] Fig. 11 is a diagram illustrating a CRS time-frequency resource pattern in accordance with a first embodiment of the present disclosure;

[53] Fig. 12 is a flow chart illustrating a reference signal transmitting method in an active antenna system in accordance with a second embodiment of the present disclosure;

[54] Fig. 13 is a diagram illustrating the process of PBCH/PDCCH/PDSCH, which is de-modulated based on a CRS, in accordance with a second embodiment of the present disclosure;

[55] Fig. 14 is a flow chart illustrating a reference signal receiving method in an active antenna system in accordance with a third embodiment of the present disclosure;

[56] Fig. 15 is a diagram illustrating a CRS time-frequency resource pattern in accordance with a third embodiment of the present disclosure;

[57] Fig. 16 is a flow chart illustrating a reference signal transmitting method in an active antenna system in accordance with a fourth embodiment of the present disclosure;

[58] Fig. 17 is a flow chart illustrating a first method for determining specific UE-specific information/configuration in accordance with a fourth embodiment of the present disclosure;

[59] Fig. 18 is a flow chart illustrating a second method for determining the specific UE-specific information/configuration in accordance with a fourth embodiment of the present disclosure;

[60] Fig. 19 is a diagram illustrating determination of UE-specific CSI-RS resource configuration with RSRP/RSRQ values in accordance with a fourth embodiment of the present disclosure; and

[61] Fig. 20 is a flow chart illustrating a third method for determining the specific UE-specific information/configuration in accordance with a fourth embodiment of the present disclosure.

Mode for the Invention

[62] To make the objective and technical solution of the merits of the present disclosure more apparent, the present disclosure may be described in detail with reference to accompanying Fig.s.

[63] In the active antenna system, following problems are caused when the reference signal is transmitted or received. 1) Coverage differences between CRS and PBCH/PDCCH/PDSCH demodulated based on CRS transmission and Enhanced PDCCH (E-PDCCH)/PDSCH signal transmission, which is measured based on the CSI-RS or demodulated based on the DMRS may be occurred. 2) Cell association using RSRP/RSRQ measured from CRS may not guarantee the best performance in PDSCH/EPDCCH reception due to different beamforming gains between CRS and PDSCH/EPDCCH/DMRS for port virtualization. 3) A fixed vertical weighted vector is used by CRS while the UE is distributed in a large range of height, which leads to deep spatial fading for some UEs of CRS/PBCH/PDCCH/PDSCH demodulated based on the CRS. Therefore, in order to avoid the above problems, an embodiment of the present disclosure using multiple CRS ports. Port virtualization to transmit antennas may be implemented for multiple Cell-specific Reference Signal (CRS) antenna ports and applying different vertical beamforming vectors to implement port virtualization for the different CRS antenna ports. When the User Equipment (UE) reports the maximum RSRP/RSRQ values measured based on multiple CRS ports, or the UE simultaneously reports multiple RSRP/RSRQ values and the information of the multiple CRS antenna ports.

[64] Further, on the premise that a same channel measurement effect is obtained, the method and device provided by embodiments may reduce the resource of CSI-RS, which are used by the UE to perform CSI measurement, and may reduce the path loss estimation error RSRP/RSRQ for uplink power control.

[65] Fig. 5 is a flow chart illustrating a reference signal transmitting method in an active antenna system in accordance with an embodiment of the present disclosure. The blocks are as follows.

[66] AT block 501, number of CRS ports is set and a notification of the number of the CRS ports is transmitted. The number of the CRS ports is larger than one.

[67] At block 502, a reference signal for each CRS port is precoded with a different precoding vector. Number of elements in the precoding vector is equal to number of transmit antennas, which correspond to the CRS ports.

[68] At block 503, the precoded reference signal for the each CRS port is transmitted over a time-frequency resource.

[69] After block 503, the method further includes:

[70] receiving RSRP/RSRQ information and/or CRS port information. Number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than or equal to 1.

[71] After block 502 and before block 503, the method further includes:

[72] respectively precoding a data signal and/or control signal corresponding to the each CRS port based on the precoding vector adopted by the each CRS port.

[73] When block 503 is performed, the precoded data signal and/or control signal is transmitted over the time-frequency resource.

[74] Fig. 6 is a flow chart illustrating a reference signal receiving method in an active antenna system in accordance with an embodiment of the present disclosure. The blocks are as follows.

[75] At block 601, a notification of number of CRS ports is received. The number of the CRS ports is larger than 1.

[76] At block 602, a precoded reference signal is received over a time-frequency resource.

[77] This method further includes: obtaining RSRP/RSRQ information and/or CRS port information by measurement based on the CRS ports. Number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than 1 or equal to 1.

[78] The method further includes: receiving a precoded data signal and/or control signal over the time-frequency resource.

[79] Fig. 7 is a schematic diagram illustrating structure of a reference signal transmitting device in an active antenna system in accordance with an embodiment of the present disclosure. As shown in Fig. 7, the reference signal transmitting device includes: a notification module, a precoding module and a transmitting module.

[80] The notification module is to set number of CRS ports and transmit a notification of the number of the CRS ports. The number of the CRS ports is larger than 1.

[81] The precoding module is to precode a reference signal with a different precoding vector for each CRS port. Number of elements in the precoding vector is equal to number of transmit antennas, which correspond to the CRS ports.

[82] The transmitting module is to transmit the precoded reference signal for the each CRS port over a time-frequency resource.

[83] The reference signal transmitting device further includes a RSRP/RSRQ receiving module. The RSRP/RSRQ receiving module is to receive RSRP/RSRQ information and/or CRS port information. Number of RSRP/RSRQ values in the RSRP/RSRQ in-

formation is larger than or equal to 1.

[84] In this reference signal transmitting device, the precoding module is further to respectively precode a data signal and/or control signal corresponding to each CRS port based on the precoding vector adopted by the each CRS port.

[85] The transmitting module is further to transmit the precoded data signal and/or control over the time-frequency resource.

[86] In this reference signal transmitting device, the RSRP/RSRQ receiving module is further to determine specific UE-specific information/configuration according to the RSRP/RSRQ information and/or CRS port information.

[87] Fig. 8 is a schematic diagram illustrating structure of a reference signal receiving device in an active antenna system in accordance with an embodiment of the present disclosure. As shown in Fig. 8, the reference signal receiving device includes: a signaling receiving module and a signal receiving module.

[88] The signaling receiving module is to receive a notification of number of CRS ports. The number of the CRS port is larger than 1.

[89] The signal receiving module is to receive a precoded reference signal over a time-frequency resource.

[90] The reference signal receiving device further includes: a measurement report module. The measurement report module is to obtain RSRP/RSRQ information and/or CRS port information by measurement based on the CRS ports and transmit the RSRP/RSRQ information and/or CRS port information. Number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than or equal to 1.

[91] In the reference signal receiving device, the signal receiving module is further to receive a precoded data signal and/or control signal over the time-frequency resource.

[92] The present disclosure is described hereinafter in detail with reference to several specific embodiments.

[93] Embodiment one

[94] Fig. 9 is a flow chart illustrating a reference signal transmitting method in an active antenna system in accordance with a first embodiment of the present disclosure. Blocks are as follows.

[95] At block 901, the number of CRS ports is set and a notification of the number of the CRS ports is transmitted. The number of the CRS ports is larger than one.

[96] At this block, the notification of the number of the CRS ports may be performed in an implicit way. Specifically, the notification of the number of the CRS ports is implicitly performed by different Physical Broadcast Channel (PBCH) Cyclic Redundancy Check (CRC) scrambling codes. After the CRC attachment of PBCH, the CRC bits are scrambled according to the eNodeB transmit antenna configuration with the sequence as indicated in Table 1, Thus, the CRS port index can be determined

based on CRC mask at the UE side.

[97] Table 1

[Table 1]

Number of transmit antenna ports at eNodeB	PBCH CRC mask<$x_{ant,0}$, $x_{ant,1}$, ..., $x_{ant,15}$>
1	<0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0>
2	<1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1>
4	<0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1>

[98] In the active antenna systems, the number of the CRS ports is a positive integer, which is larger than 1. The base station may determine the number of CRS ports considering CRS overheads and the UE distribution of , d and transmit the notification of the number of the CRS ports. For instance, in typical UMa scenarios, the BS antenna height of a base station antenna is 25m. The inter-site distance is 500m. The UEs are distributed outdoor or distributed in low buildings with height of 18-24m. All vertical leaving angles of the UE are larger than 90 degree (The 90 degree represents a horizontal direction. The 0 degree represents vertically pointing to the sky. The 180 degree presents vertically pointing to the ground). Considering the CRS overhead and UE distribution, the number of the CRS ports may be set as 2.

[99] At block 902, a reference signal for each CRS port is precoded with a different precoding vector. Number of elements in the precoding vector is equal to number of transmit antennas, which correspond to the CRS ports.

[100] At this block, the CRS port adopts a different precoding vector to implement port virtualization to transmit antennas. Fig. 10 is a schematic diagram illustrating a CRS transmitting process in the physical layer in accordance with a first embodiment of the present disclosure. The port virtualization to transmit antennas refers to precoding the reference signal for the CRS port with a precoding vector. The number of elements in the precoding vector is equal to the number of transmit antennas, which transmitting the same CRS.

[101] Take the typical UMa for example, assuming a physical antenna configuration is cross-polarized 2-D antenna array, M=10 and N=1. Both the two polarization directions include M antenna groups distributed in the vertical dimension, i.e. antenna group 0 and antenna group 1. Suppose the distance between two transmit antennas is half-wavelength. The virtualization from signals of CRS port 0 to the antenna group 0 is implemented via the precoding vector $W_0 = \left[w_0^{(0)} w_1^{(0)} \cdots w_{M-1}^{(0)} \right]^T$. The virtualization from signals of CRS port 1 to the antenna group 1 is implemented via the

$W_1 = [\, w_0^{(1)} w_1^{(1)} \cdots w_{M-1}^{(1)} \,]^T$, $w_m^{(p)} = \frac{1}{\sqrt{M}} \exp(-j \frac{2\Pi}{\lambda} m \cdot d_v \cdot \cos\theta_p)$, dv denotes the distance between the vertical antennas, p denotes the index of CRS port, m denotes the m-th element of the precoding vectors, θ_p denotes the down-tilt angle corresponding to the p-th port. For instance, the electronic down-tilt angle corresponding to the port 0 is 102 degree, and the electronic down-tilt angle corresponding to port 1 is 95 degree.

[102] At block 903, the precoded reference signal for each CRS port is transmitted over the time-frequency resource.

[103] At this block, Fig. 11 is a diagram illustrating a CRS time-frequency resource pattern in accordance with a first embodiment of the present disclosure.

[104] At block 904, RSRP/RSRQ information and/or CRS port information is received. Number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than or equal to 1.

[105] At this block, the RSRP/RSRQ information and/or CRS port information may be an RSRP/RSRQ value measured by a CRS port with the maximum receiving power and the corresponding CRS port index. As shown in table 2, the reporting range of RSRP/RSRQ is defined from -140 dBm to -44 dBm with 1 dB resolution. The mapping of measured quantity and CRS port index may be mapped in Table 2. 4 RSRP/RSRQ states indicating the number of the CRS antenna ports may be reported RSRP/RSRQ simultaneously with RSRP/RSRQ value.

[106] Table 2

[Table 2]

Reported value	Measured quantity value	Unit
RSRP/RSRQ _00	RSRP/RSRQ -140	dBm
RSRP/RSRQ _01	-140 $\leq$ RSRP/RSRQ < -139	dBm
RSRP/RSRQ _02	-139 $\leq$ RSRP/RSRQ < -138	dBm
...	...	...
RSRP/RSRQ _95	-46 $\leq$ RSRP/RSRQ < -45	dBm
RSRP/RSRQ _96	-45 $\leq$ RSRP/RSRQ < -44	dBm
RSRP/RSRQ _97	-44 $\leq$ RSRP/RSRQ	dBm
RSRP/RSRQ _98	Port 0	
RSRP/RSRQ _99	Port 1	
RSRP/RSRQ _100	Port 2	
RSRP/RSRQ _101	Port 3	

[107] As shown in table 3, the RSRP/RSRQ information and/or CRS port information may further be the RSRP/RSRQ value measured by the port.

[108] Table 3

[Table 3]

Reported value	Measured quantity value	Unit
RSRP/RSRQ _00	Port 0 RSRP/RSRQ < -140	dBm
RSRP/RSRQ _01	Port 0 -140 $\leq$ RSRP/RSRQ < -139	dBm
RSRP/RSRQ _02	Port 0 -139 $\leq$ RSRP/RSRQ < -138	dBm
...	...	...
RSRP/RSRQ _95	Port 0 -46 $\leq$ RSRP/RSRQ < -45	dBm
RSRP/RSRQ _96	Port 0 -45 $\leq$ RSRP/RSRQ < -44	dBm
RSRP/RSRQ _97	Port 0 -44 $\leq$ RSRP/RSRQ	dBm
RSRP/RSRQ _98	Port 1 RSRP/RSRQ < -140	dBm
RSRP/RSRQ _99	Port 1 -140 $\leq$ RSRP/RSRQ < -139	dBm
RSRP/RSRQ _100	Port 1 -139 $\leq$ RSRP/RSRQ < -138	dBm
...	...	...
RSRP/RSRQ _183	Port 1 -46 $\leq$ RSRP/RSRQ < -45	dBm
RSRP/RSRQ _184	Port 1 -45 $\leq$ RSRP/RSRQ < -44	dBm
RSRP/RSRQ _185	Port 1 -44 $\leq$ RSRP/RSRQ	dBm
...	...	...

[109] The RSRP/RSRQ information and/or CRS port information may further be the RSRP/RSRQ value measured by the CRS port 0 or a relative RSRP/RSRQ value of another port to that of the CRS port 0.

[110] The RSRP/RSRQ information and/or CRS port information may further be the RSRP/RSRQ values measured by K CRS ports. K is larger than 1 and less than total number of the CRS antenna ports. Corresponding antenna port index is also reported.

[111] With the above processing, since different CRS ports adopt different vertical beamforming, UE which is not covered by the beam of the CRS port 0, may be covered by the beam of another CRS port. Therefore, it may be reduced or avoided that when the terminal with the specific-height antenna receives the CRS, the vertical antenna gain remains at the deep spatial fading state for a long time of given UE.

[112] In this embodiment, the received RSRP/RSRQ information and/or CRS port information provides not only the information of the RSRP/RSRQ value measured based on the CRS port with the maximum receiving power, but also the port information corresponding to the RSRP/RSRQ value measured based on the CRS port with the maximum receiving power. The BS may implement subsequent optimization for PBCH/PDCCH/PDSCH transmission, cell association, uplink power control, etc. with the above information.

[113] Embodiment two

[114] Fig. 12 is a flow chart illustrating a reference signal transmitting method in an active antenna system in accordance with a second embodiment of the present disclosure. Specific blocks are as follows.

[115] At block 1201, number of CRS ports is set and a notification of the number of the CRS ports is transmitted. The number of the CRS ports is larger than one.

[116] At block 1202, a reference signal for each CRS port is precoded with a different precoding vector. Number of elements in the precoding vector is equal to number of transmit antennas, which correspond to the CRS ports.

[117] At block 1203, a data signal and/or control signal corresponding to the each CRS port is respectively precoded based on the precoding vector adopted by the each CRS port. Number of elements in the precoding vector is equal to number of transmit antennas, which transmit the data signal and/or control signal.

[118] At this block, port virtualization to transmit antenna processing is performed for PBCH/PDCCH/PDSCH, which is demodulated based on the CRS, using the precoding vectors corresponding to the CRS ports. The physical layer processing process of PBCH/PDCCH/PDSCH, which is demodulated based on the CRS, is shown in Fig. 13. Fig. 13 is a diagram illustrating a physical layer processing of PBCH/PDCCH/PDSCH, which is demodulated based on CRS, in accordance with the second embodiment of the present disclosure. For instance, the CRS of port 0 adopts the precoding vector W0 to implement the port virtualization to transmit antennas. The PBCH/PDCCH/PDSCH over port 0 also implements the port virtualization to transmit antennas with the same precoding vector. Other ports adopt similar processing.

[119] At block 1204, the precoded reference signal for the each CRS port and the precoded data signal and/or control signal for the each CRS port are transmitted over the time-frequency resource.

[120] At block 1205, the RSRP/RSRQ information and/or CRS port information is received. Number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than or equal to 1.

[121] With the method shown in Fig. 12, since the reference signal and PBCH/PDCCH/PDSCH, which is demodulated based on the CRS of each CRS port adopt

different vertical beamforming, UE, which is not covered by the beam of the CRS port 0, may be covered by the beam of another CRS ports. Therefore, it may be reduced or avoided that the deep spatial fading problem may be reduced or avoided. Thus, the coverage of PBCH/PDCCH/PDSCH, which is demodulated based on the CRS, is improved.

[122] Embodiment three

[123] Fig. 14 is a flow chart illustrating a reference signal receiving method in an active antenna system in accordance with a third embodiment of the present disclosure. Specific blocks are as follows.

[124] At block 1401, a notification of number of CRS ports is received. The number of the CRS port is larger than 1.

[125] At this block, the number of antenna ports may be determined according to PBCH scrambling mask via decoding the signals of the PBCH over the CRS port 0.

[126] At block 1402, a precoded reference signal is received over a time-frequency resource.

[127] As exclusively used at this block, the precoded reference signal may be received according to the CRS time-frequency resource pattern shown in Fig. 15. Fig. 15 is a diagram illustrating a CRS time-frequency resource pattern in accordance with a third embodiment of the present disclosure.

[128] At block 1403, RSRP/RSRQ information and/or CRS port information is obtained by measurement based on the CRS ports. Number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than or equal to 1.

[129] At this block, the RSRP/RSRQ value measured based on the CRS port with maximum receiving power and the corresponding CRS antenna port index may be reported. For instance, as shown in table 2, four states indicating the CRS antenna port index are reported during the report of the RSRP/RSRQ value. Alternatively, as shown in table 3, the RSRP/RSRQ value of the each port is reported at the same time. Alternatively, the RSRP/RSRQ value of the CRS port 0 and a relative RSRP/RSRQ value of another port to that of the CRS port 0 are reported. Alternatively, the RSRP/RSRQ values of N CRS ports and corresponding antenna port number information are reported. N is larger than 1 and less than total number of the CRS antenna ports.

[130] With the above processing, the base station may obtain more RSRP/RSRQ information of the CRS port, which is convenient for the network side to make further processing to obtain the corresponding gain.

[131] Embodiment four

[132] Fig. 16 is a flow chart illustrating a reference signal transmitting method in an active antenna system in accordance with a fourth embodiment of the present disclosure. Specific blocks are as follows.

[133] At block 1601, number of CRS ports is set and a notification of the number of the CRS ports is transmitted. The number of the CRS ports is larger than one.

[134] At this block, in typical UMa scenarios, the BS antenna height is 10m. The inter-site distance is 200m. The UEs are distributed outdoor or distributed in low buildings with the height of 18-24m. Taking account of that vertical leaving angles of the UEs are in a large range and taking account of factors, such CRS overhead influence, the number of the CRS ports is set as 4.

[135] At block 1602, each CRS port adopts a different precoding vector to implement port virtualization to transmit antennas.

[136] At this block, four different precoding vectors are adopted to implement the port virtualization to transmit antennas of four CRS ports. The virtualization of the CRS port 0 to the antenna group 0 is implemented via the precoding vector $W_0 = [w_0^{(0)} w_1^{(0)} \dots w_{M-1}^{(0)}]^T$. The virtualization of the CRS port 1 to the antenna group 1 is implemented via the precoding vector $W_1 = [w_0^{(1)} w_1^{(1)} \dots w_{M-1}^{(1)}]^T$.

$w_m^{(p)} = \frac{1}{\sqrt{M}} \exp(-j\frac{2\Pi}{\lambda} m \cdot d_v \cdot \cos\theta_p)$, dv denotes the distance between the vertical antennas, p denotes the index of the CRS port, m denotes the m-th element of the precoding vectors, θ_p denotes a down-tilt angle corresponding to the p-th port. The down-tilt angle corresponding to the port 0 is 102 degree, the downward inclination angle corresponding to the port 1 is 95 degree, the down-tilt angle corresponding to the port 2 is 85 degree, the down-tilt angle corresponding to the port 3 is 75 degree.

[137] At block 1603, the precoded reference signal of each CRS port is transmitted over the time-frequency resource.

[138] At block 1604, the RSRP/RSRQ information and/or CRS port information is received. Number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than or equal to 1.

[139] At this block, the RSRP/RSRQ information may be the RSRP/RSRQ value measured by the CRS port with the maximum receiving power. The corresponding port information is the CRS port index corresponding to the RSRP/RSRQ value of measured by the CRS port with the maximum receiving power. The RSRP/RSRQ information may include the RSRP/RSRQ value of the each CRS port. The RSRP/RSRQ information may include the RSRP/RSRQ values of partial CRS ports and the number index information of the partial CRS ports.

[140] At block 1605, after the RSRP/RSRQ information and/or CRS port information is received, specific UE-specific information/configuration is determined.

[141] At this block, the specific UE-specific information/configuration includes: one or

combination of information of cell association, a path loss value for uplink power control and/or UE-specific CSI-RS resource configuration.

[142] Specifically speaking, Fig. 17 is a flow chart illustrating a first method for determining UE-specific information/configuration in accordance with a fourth embodiment of the present disclosure. Following blocks are included.

[143] At block 1701, RSRP/RSRQ information and/or CRS port information is received.

[144] At block 1702, a cell association is determined based on the RSRP/RSRQ information.

[145] At this block, each CRS port adopts a different vertical beam. The RSRP/RSRQ information includes the vertical beamforming gain of the best direction. Therefore, the difference between the RSRP/RSRQ and the beamforming gain of the CSI-RS and DMRS after the UE-specific vertical beamforming adopted is relatively reduced. Therefore, the selected cell is more suitable for the PDSCH/E-PDCCH transmission of the UE.

[146] Fig. 18 is a flow chart illustrating a second method for determining the specific UE-specific information/configuration in accordance with a fourth embodiment of the present disclosure. Following blocks are included.

[147] At block 1801, RSRP/RSRQ information and/or CRS port information is received.

[148] At block 1802, a UE-specific CSI-RS resource configuration is determined based on the RSRP/RSRQ information.

[149] At this block, the UE-specific CSI-RS resource configuration is determined based on the correlation of beamforming vectors used for the CSI-RS resources port virtualization and the CRS ports virtualization, RSRP/RSRQ information and CRS port information. The CSI-RS resources in the active antenna system are grouped according to the correlation of the vertical beamforming vectors used for CSI-RS port virtualization and CRS port virtualization. After the RSRP/RSRQ information and/or CRS port information is received, the CSI-RS resources in the CSI-RS resource group corresponding to the CRS port with RSRP/RSRQ value measured with the maximum receiving power, may be determined as the UE-specific CSI-RS resource configuration. Alternatively, CSI-RS resources in CSI-RS resource groups corresponding to the two CRS ports with the RSRP/RSRQ values with the maximum receiving power and second maximum receiving power may be determined as the UE-specific CSI-RS resource configurations.

[150] A specific example is given hereinafter for illustration, suppose two CRS ports adopt two different vertical beams. In the transmission mode using the CSI-RS measurement and DMRS demodulation, such as transmission mode 10 of LTE/LTE-A, the UE-specific vertical beamforming may be implemented via configuring multiple CSI-RS resources and multiple CSI processes for the UE. Fig. 19 is a diagram illustrating de-

termination of UE-specific CSI-RS resource configuration with RSRP/RSRQ reporting in accordance with a fourth embodiment of the present disclosure. As shown in Fig. 19, 9 CSI-RS resources are conFig.d in the active antenna systems. Each CSI-RS resource adopts different vertical beams to perform the beamforming. The 9 CSI-RS resources are divided into three groups. Each group includes 3 CSI-RS resources and the 3 CSI-RS resources adopt adjacent vertical beams to implement port virtualization to transmit antennas. The coverage of the first group of CSI-RS vertical beams in the vertical dimension is close to that of the CRS beam 0. The coverage of the third group of CSI-RS vertical beams in the vertical dimension is close to that of the CRS beam 1. And the coverage of the second group of CSI-RS vertical beams in the vertical dimension is between that of two CRS beams.

[151] If the RSRP/RSRQ CRS port with largest RSRP/RSRQ value is CRS port 0, the first group of CSI-RS resources is allocated to the UE. If the reported port with the largest RSRP/RSRQ value is port 01, the third group of CSI-RS resources is allocated to the UE. If the reported two ports, the RSRP/RSRQ values of which are close to each other, the second group of CSI-RS resources are allocated to the UE.

[152] The UE performs feedback of three CSI processes based three conFig.d CSI-RS resources in one group, such as CSI-RS resource 2-1, CSI-RS resource 2-2 and CSI-RS resource 2-3 in the second group. The base station selects the best vertical beamforming direction based on CSI feedback. For instance, the vertical beamforming direction corresponding to the CSI-RS resource 2-3 is taken as the beamforming direction used by the UE in the data transmission.

[153] In the above second embodiment, apparently, if the CRS port information is not reported, the UE needs to measure 9 different CSI-RS configurations to select the best beam from the nine vertical beams and simultaneously complete nine CSI report processes. Using the RSRP/RSRQ and CRS port information report, the best beam may be selected from the nine vertical beams via measuring only three CSI-RS configurations and completing three CSI report processes.

[154] Fig. 20 is a flow chart illustrating a method for determining the specific UE-specific information/configuration in accordance with a fourth embodiment of the present disclosure. Following blocks are included.

[155] At block 2001, RSRP/RSRQ information and/or CRS port information is received.

[156] At block 2002, the path loss value for uplink power control of a UE is determined based on the RSRP/RSRQ information.

[157] At this block, each CRS port adopts a different vertical beam. The RSRP/RSRQ information is measured based on the vertical beamforming in the best direction. Therefore, the difference between the RSRP/RSRQ value and an uplink antenna array gain of receiver is relatively reduced. Therefore, the difference between the path loss

estimation based on the RSRP/RSRQ and the uplink actual path loss is reduced and thus the uplink power control performance is improved.

[158] It can be seen from the methods and devices provided by embodiments of the present disclosure, coverage differences between CRS and PBCH/PDCCH/PDSCH demodulated based on CRS transmission and Enhanced PDCCH (E-PDCCH)/PDSCH signal transmission, which is measured based on the CSI-RS or demodulated based on the DMRS may be reduced or avoided. The cell association problem due to the different vertical beamforming technologies adopted by the CSI-RS or DMRS and by the CRS may be avoided. Deep spatial fading state may be avoided for CRS reception and PBCH/PDCCH/PDSCH demodulated based CRS. On the premise that a same channel measurement effect is obtained, embodiments of the present disclosure may reduce the number of CSI-RS configurations, which are used by the UE to perform channel estimation. Embodiments of the present disclosure may reduce the differences between the path loss of RSRP/RSRQ value estimation and the uplink actual path loss and may improve the uplink power control performance.

[159] The foregoing description only describes preferred embodiments of the present invention and may not be used for limiting the protection scope thereof. Any modification, equivalent substitution, or improvement made without departing from the spirit and principle of the present invention should be covered by the protection scope of the present invention.

Claims

[Claim 1] A reference signal transmitting method in an active antenna system, comprising:
setting number of Cell-specific Reference Signal (CRS) ports and transmitting a notification of number of the CRS ports, wherein the number of the CRS ports is larger than 1;
precoding a reference signal with a different precoding vector for each of the CRS ports, wherein number of elements in the precoding vector is equal to number of transmit antennas, which correspond to the CRS ports; and
transmitting the precoded reference signal for the each of the CRS ports over a corresponding frequency-time resource.

[Claim 2] The transmitting method according to claim 1, further comprising:
receiving Reference Signal Receive Power (RSRP)/Reference Signal Received Quality (RSRQ) information and/or CRS port information;
wherein number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than or equal to 1.

[Claim 3] The transmitting method according to claim 2, wherein the RSRP/RSRQ information and/or CRS port information comprises:
an RSRP/RSRQ value measured by a CRS port with the maximum receiving power and a corresponding CRS port index; or
RSRP/RSRQ values measured by the CRS ports; or
an RSRP/RSRQ value measured by CRS port 0 and a relative RSRP/RSRQ value of another port to that of the CRS port 0; or
RSRP/RSRQ values measured by N CRS ports and corresponding CRS port indexes, N is larger than 1 and less than total number of the CRS ports.

[Claim 4] The transmitting method according to claim 2, further comprising:
determining specific UE-specific information/configuration according to the RSRP/RSRQ information and/or the CRS port information.

[Claim 5] The transmitting method according to claim 4, wherein the specific UE-specific information/configuration comprises one or any combination of: information of cell association, a path loss value for uplink power control and Channel State Information Reference Signal (CSI-RS) resource configuration.

[Claim 6] The transmitting method according to claim 5, wherein when the specific UE-specific information/configuration is the information of

cell association, determining the specific UE-specific information/ configuration according to the RSRP/RSRQ information and/or the CRS port information comprises:
determining the cell association according to an RSRP/RSRQ value measured by the CRS port with maximum receiving power.

[Claim 7] The transmitting method according to claim 5, when the specific UE-specific information/configuration is the path loss value for uplink power control, determining the specific UE-specific information/configuration according to the RSRP/RSRQ information and/or the CRS port information comprises:
determining the path loss value for uplink power control based on an RSRP/RSRQ value measured by the CRS port with the maximum receiving power.

[Claim 8] The transmitting method according to claim 5, when the specific UE-specific information/configuration is the CSI-RS resource configuration, determining the specific UE-specific information/configuration according to the RSRP/RSRQ information and/or CRS port information comprises:
determining the UE-specific CSI-RS resource configuration based on correlation of beamforming vectors used for CSI-RS port virtualization and CRS port virtualization.

[Claim 9] The transmitting method according to claim 8, wherein determining the UE-specific CSI-RS resource configuration comprises:
grouping CSI-RS resources in an active antenna system according to the correlation of beamforming vectors used for the CSI-RS port virtualization and the CRS port virtualization;
after receiving the reported RSRP/RSRQ information and/or the CRS port information, determining CSI-RS resources in a CSI-RS resource group corresponding to a CRS port with an RSRP/RSRQ value measured by the CRS port with the maximum receiving power, as the UE-specific CSI-RS resource configuration; or
determining CSI-RS resources in CSI-RS resource groups corresponding to two CRS ports with RSRP/RSRQ values measured with the maximum receiving power and second maximum receiving power, as the UE-specific CSI-RS resource configurations.

[Claim 10] The transmitting method according to claim 1, wherein before transmitting the precoded reference signal for the each of the CRS ports over the corresponding frequency-time resource, the method further

comprises:
respectively precoding a data signal and/or control signal corresponding to the each of the CRS ports based on the precoding vector adopted by the each of the CRS ports;
when transmitting the precoded reference signal for the each of the CRS ports over corresponding frequency-time resource, the method further comprises:
transmitting the precoded data signal and/or control signal for the each of the CRS ports over the corresponding frequency-time resource.

[Claim 11] A reference signal receiving method in an active antenna system, comprising:
receiving a notification of number of Cell-specific Reference Signal (CRS) ports, wherein the number of the CRS ports is larger than 1; and
receiving a reference signal over a time-frequency resource.

[Claim 12] The receiving method according to claim 11, further comprising:
obtaining Reference Signal Receive Power (RSRP)/Reference Signal Received Quality (RSRQ) information and/ or CRS port information by measurement based on the CRS ports; wherein number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than or equal to 1.

[Claim 13] The receiving method according to claim 11, wherein the RSRP/RSRQ information and/or CRS port information comprises:
an RSRP/RSRQ value measured by a CRS port with the maximum receiving power and a corresponding CRS port index; or
RSRP/RSRQ values measured by the CRS ports; or
an RSRP/RSRQ value measured by CRS port 0 and a relative RSRP/RSRQ value of another port to that of the CRS port 0; or
RSRP/RSRQ values measured by N CRS ports and corresponding CRS port indexes, N is larger than 1 and less than total number of the CRS ports.

[Claim 14] The receiving method according to claim 11, further comprising:
receiving a precoded data signal and/or control signal, which are demodulated based on the CRS ports.

[Claim 15] A reference signal transmitting device in an active antenna system, comprising:
a notification module, to set number of Cell-specific Reference Signal (CRS) ports and transmit a notification of number of the CRS ports, wherein the number of the CRS ports is larger than 1;
a precoding module, to precode a reference signal with a different

precoding vector for each of the CRS ports, wherein number of elements in the precoding vector is equal to number of transmit antennas, which correspond to the CRS ports; and

a transmitting module, to transmit the precoded reference signal for the each of the CRS ports over a corresponding frequency-time resource.

[Claim 16] The transmitting device according to claim 15, further comprising:

a Reference Signal Receive Power (RSRP)/Reference Signal Received Quality (RSRQ) receiving module, to receive Reference Signal Receive Power (RSRP)/Reference Signal Received Quality (RSRQ) information and/or CRS port information; wherein number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than or equal to 1.

[Claim 17] The transmitting device according to claim 16, wherein the RSRP/ RSRQ receiving module is further to determine specific UE-specific information/configuration according to the RSRP/RSRQ information and/or CRS port information.

[Claim 18] The transmitting device according to claim 15, wherein

the precoding module is further to respectively precode a data signal and/or control signal corresponding to the each of the CRS ports based on the precoding vector adopted by the each of the CRS ports; and

the transmitting module is further to transmit the precoded data signal and/or control over the time-frequency resource.

[Claim 19] A reference signal receiving device in an active antenna system, comprising:

a signaling receiving module, to receive a notification of number of Cell-specific Reference Signal (CRS) ports, wherein the number of the CRS ports is larger than 1; and

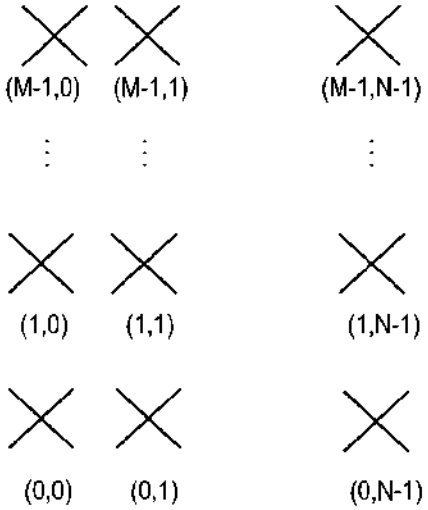
a signal receiving module, to receive a reference signal over a time-frequency resource.

[Claim 20] The receiving device according to claim 19, further comprising:

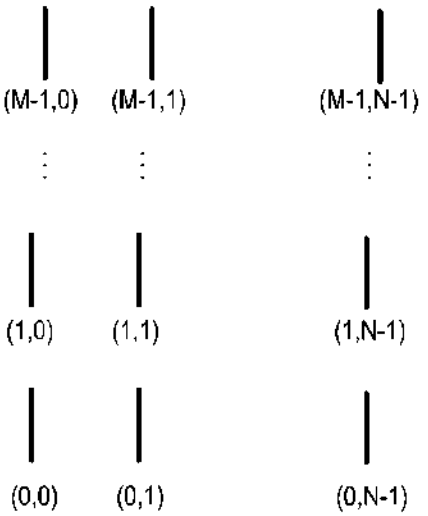
a measurement report module, to obtain Reference Signal Receive Power (RSRP)/ Reference Signal Received Quality (RSRQ) information and/or CRS port information by measurement based on the CRS ports; wherein number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than or equal to 1.

[Claim 21] The receiving device according to claim 19, wherein the signaling receiving module is further to receive a data signal and/or control signal over the time-frequency resource.

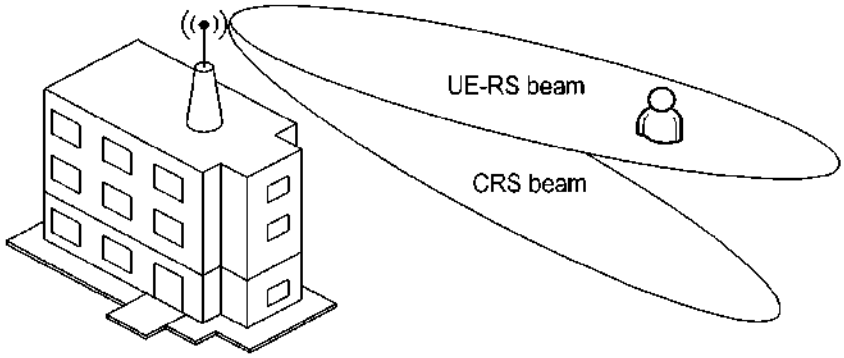
[Fig. 1]



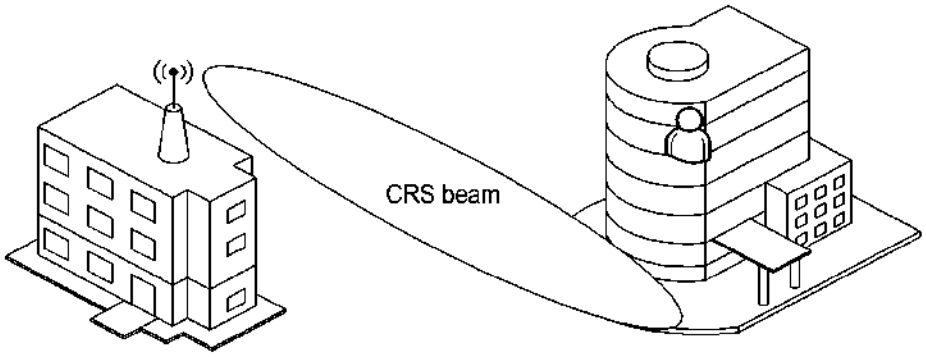
[Fig. 2]



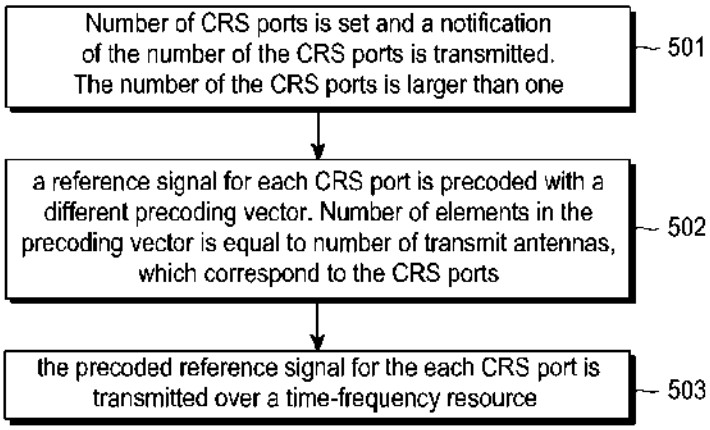
[Fig. 3]



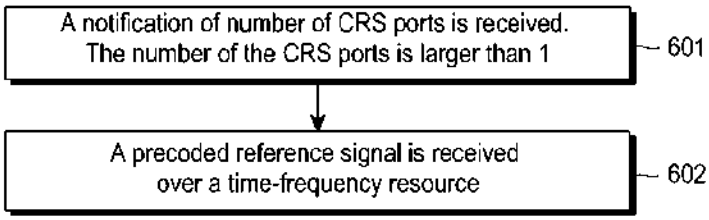
[Fig. 4]



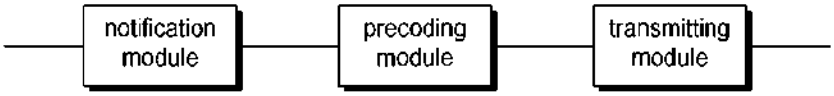
[Fig. 5]



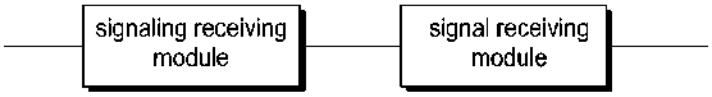
[Fig. 6]



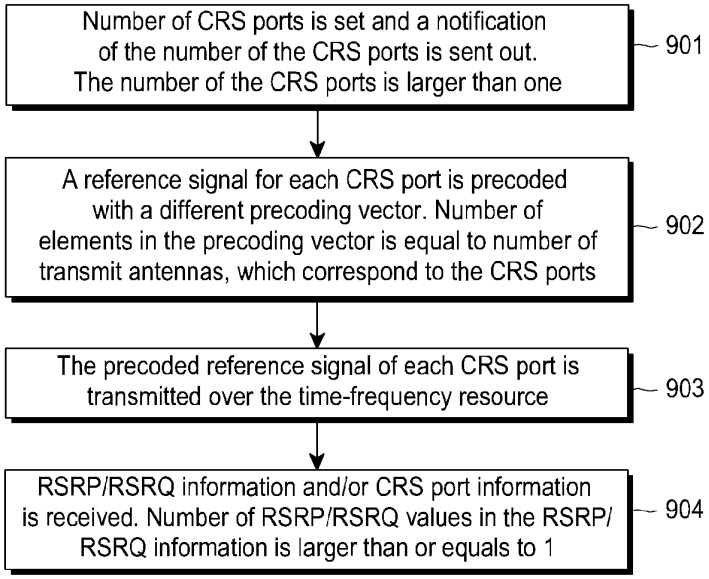
[Fig. 7]



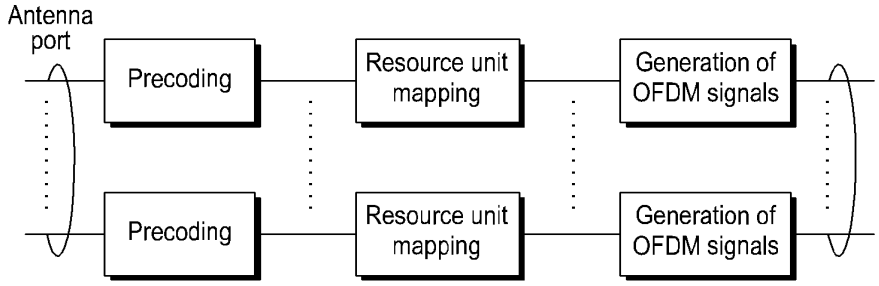
[Fig. 8]



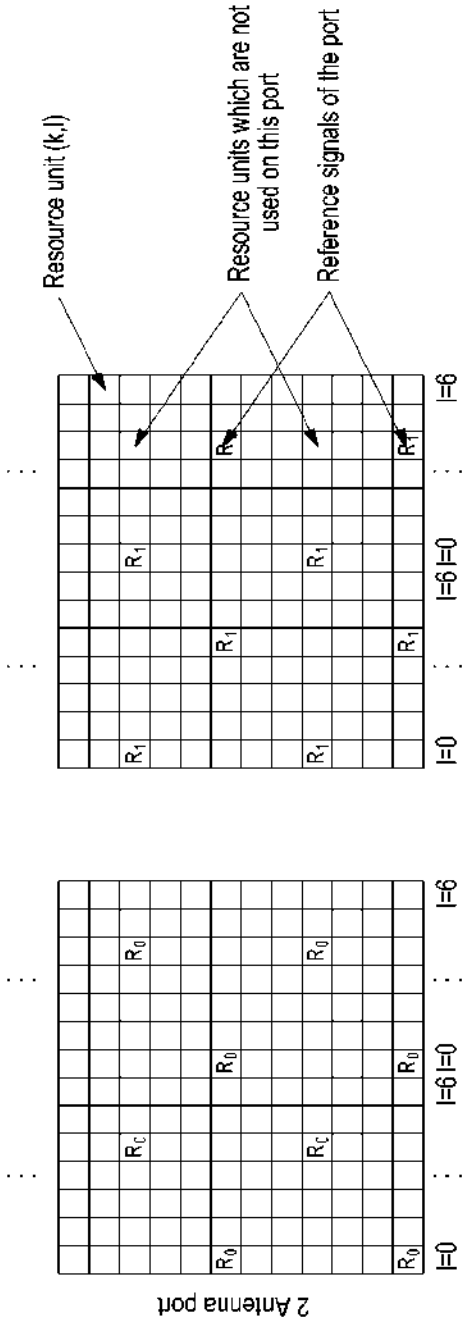
[Fig. 9]


Number of CRS ports is set and a notification of the number of the CRS ports is sent out. The number of the CRS ports is larger than one
901
A reference signal for each CRS port is precoded with a different precoding vector. Number of elements in the precoding vector is equal to number of transmit antennas, which correspond to the CRS ports
902
The precoded reference signal of each CRS port is transmitted over the time-frequency resource
903
RSRP/RSRQ information and/or CRS port information is received. Number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than or equals to 1
904

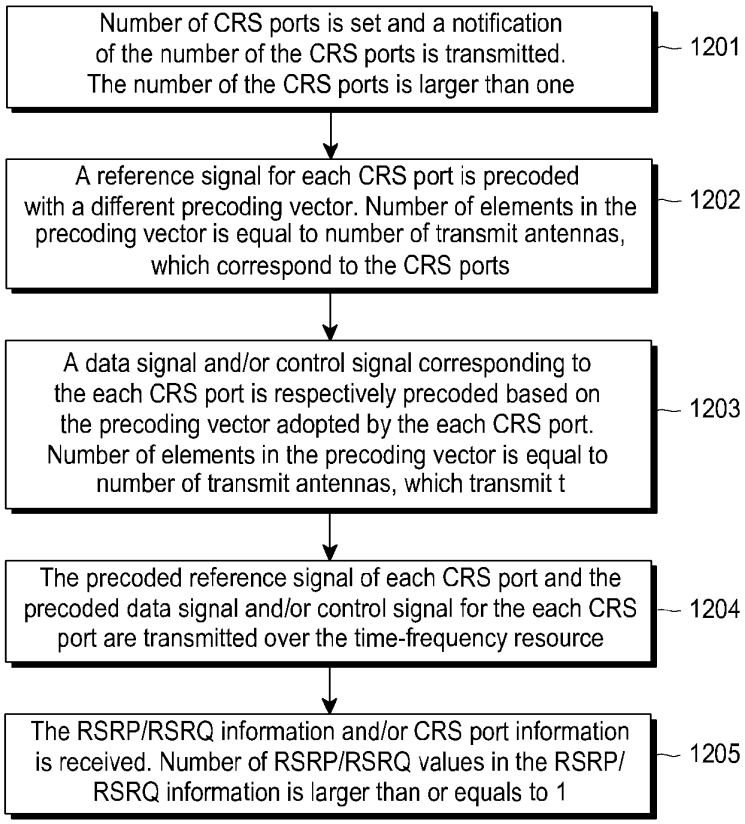
[Fig. 10]


Antenna port
Precoding
Precoding
Resource unit mapping
Resource unit mapping
Generation of OFDM signals
Generation of OFDM signals

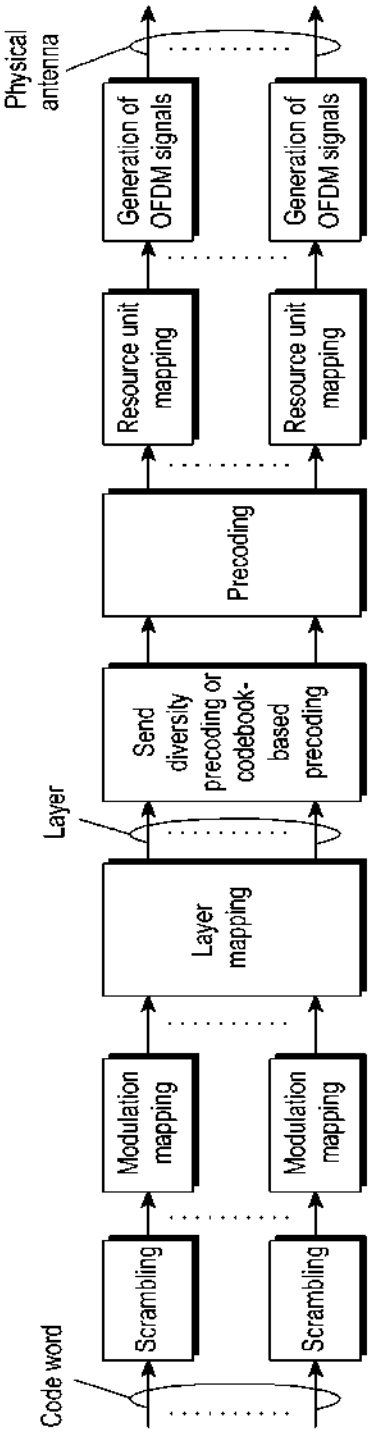
[Fig. 11]


Resource unit (k,l)
Resource units which are not used on this port
Reference signals of the port
l=6
l=6 l=0
l=0
2 Antenna port

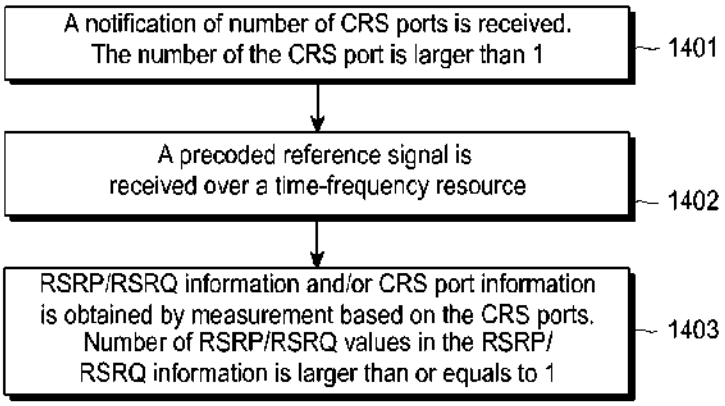
[Fig. 12]


Number of CRS ports is set and a notification of the number of the CRS ports is transmitted. The number of the CRS ports is larger than one
1201
A reference signal for each CRS port is precoded with a different precoding vector. Number of elements in the precoding vector is equal to number of transmit antennas, which correspond to the CRS ports
1202
A data signal and/or control signal corresponding to the each CRS port is respectively precoded based on the precoding vector adopted by the each CRS port. Number of elements in the precoding vector is equal to number of transmit antennas, which transmit t
1203
The precoded reference signal of each CRS port and the precoded data signal and/or control signal for the each CRS port are transmitted over the time-frequency resource
1204
The RSRP/RSRQ information and/or CRS port information is received. Number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than or equals to 1
1205

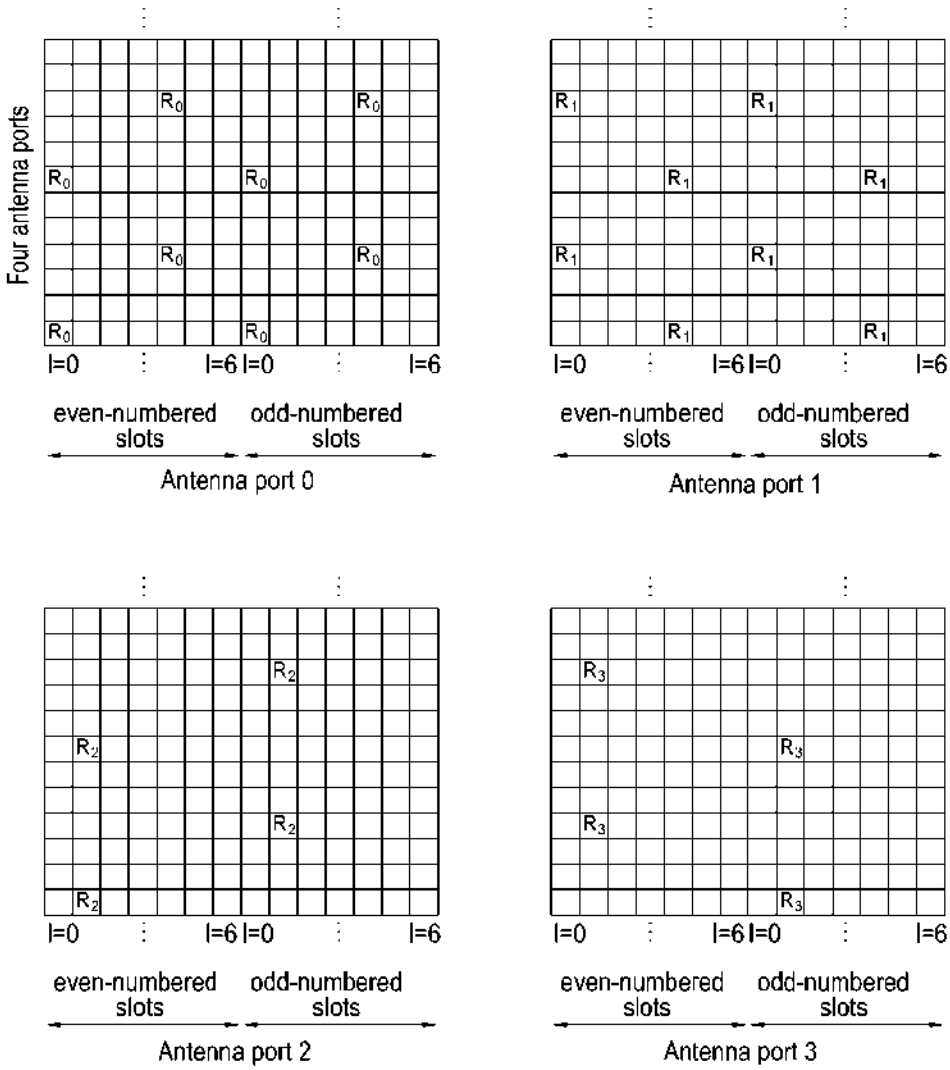
[Fig. 13]


Physical antenna
Generation of OFDM signals
Generation of OFDM signals
Resource unit mapping
Resource unit mapping
Precoding
Send diversity precoding or codebook-based precoding
Layer
Layer mapping
Modulation mapping
Modulation mapping
Scrambling
Scrambling
Code word

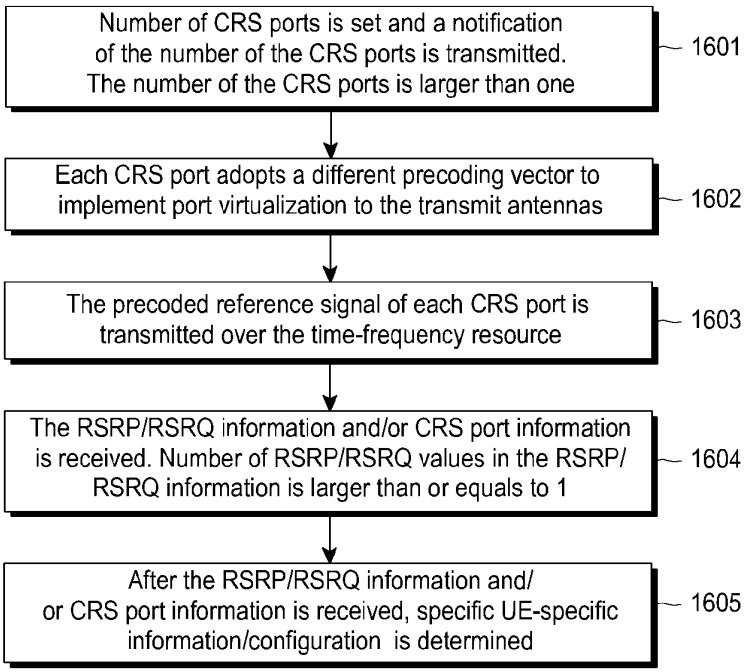
[Fig. 14]


A notification of number of CRS ports is received. The number of the CRS port is larger than 1
1401
A precoded reference signal is received over a time-frequency resource
1402
RSRP/RSRQ information and/or CRS port information is obtained by measurement based on the CRS ports. Number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than or equals to 1
1403

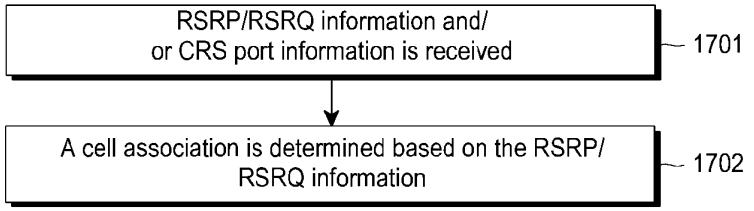
[Fig. 15]


Four antenna ports
l=0
l=6
even-numbered slots
odd-numbered slots
Antenna port 0
Antenna port 1
Antenna port 2
Antenna port 3

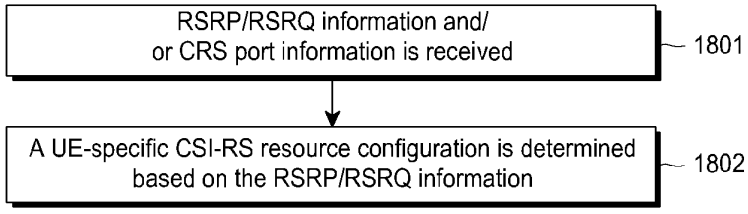
[Fig. 16]



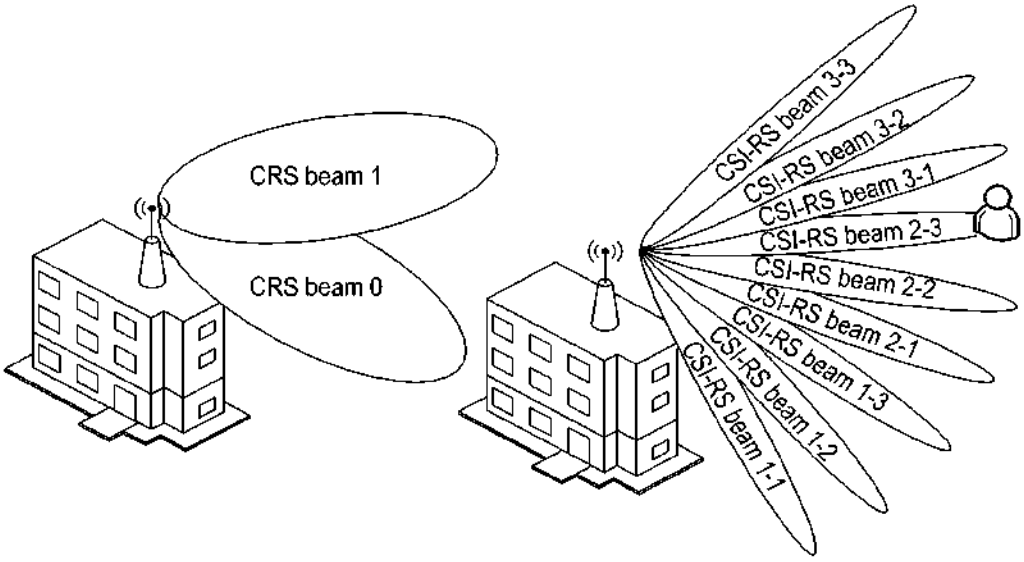
[Fig. 17]



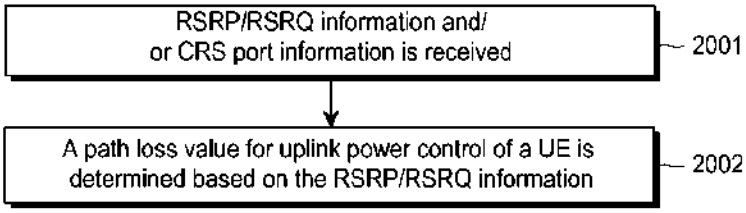
[Fig. 18]



[Fig. 19]


CRS beam 1
CRS beam 0
CSI-RS beam 3-3
CSI-RS beam 3-2
CSI-RS beam 3-1
CSI-RS beam 2-3
CSI-RS beam 2-2
CSI-RS beam 2-1
CSI-RS beam 1-3
CSI-RS beam 1-2
CSI-RS beam 1-1

[Fig. 20]


RSRP/RSRQ information and/
or CRS port information is received
2001
A path loss value for uplink power control of a UE is
determined based on the RSRP/RSRQ information
2002

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2015/006369

A. CLASSIFICATION OF SUBJECT MATTER

H04L 5/00(2006.01)i, H04L 1/06(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04L 5/00; H04L 1/06; H04B 7/06; H04W 72/00; H04B 7/04; H04W 24/08

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & keywords: CRS port, notify, precoding, RSRP/RSRQ(Reference Signal Receive Power/ Received Quality)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2013-0315191 A1 (TAKASHI YOSHIMOTO et al.) 28 November 2013 See paragraph [0099]; and figure 1.	1,11,14,15,19,21
A		2-10,12,13,16-18,20
Y	US 2103-0107746 A1 (FUJITSU LIMITED) 02 May 2013 See paragraphs [0089]-[0103]; claims 1, 5; and figures 1, 2.	1,11,14,15,19,21
A	US 2013-0329772 A1 (NIKLAS WERNERSSON et al.) 12 December 2013 See paragraphs [0093]-[0152]; and figures 6-9.	1-21
A	US 2014-0098689 A1 (INTERDIGITAL PATENT HOLDINGS, INC.) 10 April 2014 See paragraphs [0076]-[0079]; and figure 3.	1-21
A	WO 2014-073846 A1 (PANTECH CO., LTD.) 15 May 2014 See paragraphs [0252]-[0297]; and figures 28, 29.	1-21

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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Date of the actual completion of the international search	Date of mailing of the international search report
08 October 2015 (08.10.2015)	**08 October 2015 (08.10.2015)**

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Telephone No. +82-42-481-8264

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/KR2015/006369

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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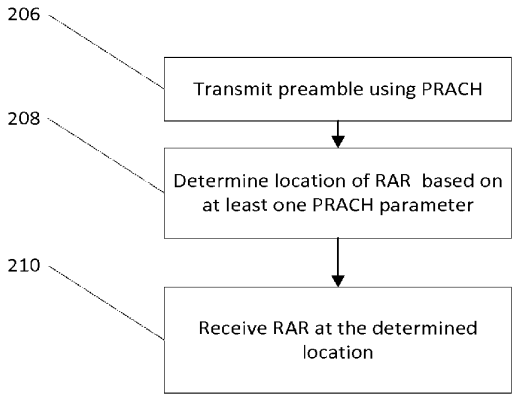


FIG. 2

(57) Abstract: A wireless transmit/receive unit (WTRU) may transmit a preamble using a physical random access channel (PRACH) and determine a location of a random access response (RAR) based on a parameter of the PRACH. The location may include a subframe and/or a frequency resource on which the RAR is transmitted. The RAR may be received at the location. A device may receive a preamble using a PRACH associated with a coverage enhancement (CE) level and/or a CE mode of a WTRU. The device may determine a location of an RAR based on a parameter of the PRACH. The location may include a subframe and/or a frequency resource on which the RAR is to be transmitted. The device may determine a number of repetitions of the RAR to transmit based on the CE level or CE mode. The RAR may be transmitted at the location with the determined number of repetitions.

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SUPPORTING RANDOM ACCESS AND PAGING PROCEDURES FOR REDUCED CAPABILITY WTRUS IN AN LTE SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of United States Provisional Patent Application 62/038,194, filed August 15, 2014; United States Provisional Patent Application 62/075,555, filed November 5, 2014; United States Provisional Patent Application 62/149,053, filed April 17, 2015; United States Provisional Patent Application 62/161,212, filed May 13, 2015; and United States Provisional Patent Application 62/204,341, filed August 12, 2015.

BACKGROUND

[0002] A coverage enhanced wireless transmit/receive unit (WTRU) may be a WTRU that may need or may use coverage enhancement or a WTRU that may support or use a coverage enhancement (CE) mode. A coverage limited WTRU may refer to a coverage enhanced WTRU, and *vice versa*.

[0003] A reduced bandwidth (BW) WTRU may be a WTRU that may support a certain limited bandwidth (*e.g.*, RF bandwidth) or a certain limited number of resource blocks (RBs) in the downlink (DL) and/or uplink (UL) that may be independent of the bandwidth of the eNB or cell with which the WTRU may communicate. For example, a limited bandwidth WTRU may support a certain number of RBs (*e.g.*, 6 RBs) or bandwidth (*e.g.*, 1.4 MHz) for transmission and/or reception. Such a WTRU may communicate with an eNB or cell for which the bandwidth may be larger (*e.g.*, 20 MHz or 100 RBs). This WTRU may use procedures to operate in a portion of the full bandwidth of the cell. Reduced bandwidth, limited bandwidth, and bandwidth limited may be used interchangeably.

SUMMARY

[0004] PRACH resource allocation and random access procedures may be provided for WTRUs that may be coverage limited and/or bandwidth limited. Some (*e.g.*, all) of the PRACH resources that may be allocated, *e.g.*, by an eNB, for coverage limited WTRUs may be located in

a bandwidth that may be supported by bandwidth limited WTRUs. WTRUs that may be both coverage limited and bandwidth limited may choose from and/or use one or more PRACH resources for PRACH transmission to an eNB. PRACH resources that may be allocated or designated for each of one or more (*e.g.*, all) levels of coverage limitation may include a subset that may be used by WTRUs that may be coverage limited and bandwidth limited.

[0005] PRACH resources may be allocated or designated for WTRUs that may be both coverage limited and bandwidth limited. WTRUs that may be both coverage limited and bandwidth limited may choose from and/or use these allocated or designated PRACH resources for PRACH transmission to an eNB. PRACH resources (which may be differentiated, for example, by one or more of preamble, time, and/or frequency) may be allocated and/or used for different levels of coverage limitation.

[0006] A WTRU may transmit a preamble using a PRACH and may determine a location of a random access response (RAR) based on a parameter of the PRACH, the location comprising at least one of a subframe or a frequency resource on which the RAR is transmitted. The WTRU may receive the RAR at the determined location.

[0007] A device may receive a preamble using a PRACH associated with at least one of a coverage enhancement (CE) level or a CE mode of a WTRU from which the preamble is received. The device may determine a location of an RAR based on a parameter of the PRACH. The location may comprise at least one of a subframe or a frequency resource on which the RAR is to be transmitted. The device may determine a number of repetitions of the RAR to transmit based on the CE level or CE mode. The device may transmit the RAR at the determined location with the determined number of repetitions.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. 1A is a system diagram of an example communications system in which one or more disclosed embodiments may be implemented.

[0009] FIG. 1B is a system diagram of an example wireless transmit/receive unit (WTRU) that may be used within the communications system illustrated in FIG. 1A.

[0010] FIG. 1C is a system diagram of an example radio access network and an example core network that may be used within the communications system illustrated in FIG. 1A.

[0011] FIG. 1D is a system diagram of another example radio access network and another example core network that may be used within the communications system illustrated in FIG. 1A.

[0012] FIG. 1E is a system diagram of another example radio access network and another example core network that may be used within the communications system illustrated in FIG. 1A.

[0013] FIG. 2 illustrates an example of preamble transmission and RAR reception by a WTRU.

[0014] FIG. 3A illustrates an example of preamble transmission and RAR reception by a WTRU.

[0015] FIG. 3B illustrates an example RA configuration.

[0016] FIG. 4A illustrates an example of preamble transmission and RAR reception by a WTRU.

[0017] FIG. 4B illustrates an example RA configuration.

[0018] FIG. 5 illustrates an example of preamble reception and RAR transmission.

DETAILED DESCRIPTION

[0019] A detailed description of illustrative embodiments will now be described with reference to the various Figures. Although this description provides a detailed example of possible implementations, it should be noted that the details are intended to be exemplary and in no way limit the scope of the application.

[0020] FIG. 1A is a diagram of an example communications system 100 in which one or more disclosed embodiments may be implemented. The communications system 100 may be a multiple access system that provides content, such as voice, data, video, messaging, broadcast, *etc.*, to multiple wireless users. The communications system 100 may enable multiple wireless users to access such content through the sharing of system resources, including wireless bandwidth. For example, the communications system 100 may employ one or more channel access methods, such as code division multiple access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), orthogonal FDMA (OFDMA), single-carrier FDMA (SC-FDMA), and the like.

[0021] As shown in FIG. 1A, the communications system 100 may include wireless transmit/receive units (WTRUs) 102a, 102b, 102c, and/or 102d (which generally or collectively may be referred to as WTRU 102), a radio access network (RAN) 103/104/105, a core network 106/107/109, a public switched telephone network (PSTN) 108, the Internet 110, and other networks 112, though it will be appreciated that the disclosed embodiments contemplate any

number of WTRUs, base stations, networks, and/or network elements. Each of the WTRUs 102a, 102b, 102c, 102d may be any type of device configured to operate and/or communicate in a wireless environment. By way of example, the WTRUs 102a, 102b, 102c, 102d may be configured to transmit and/or receive wireless signals and may include user equipment (UE), a mobile station, a fixed or mobile subscriber unit, a pager, a cellular telephone, a personal digital assistant (PDA), a smartphone, a laptop, a netbook, a personal computer, a wireless sensor, consumer electronics, and the like.

[0022] The communications system 100 may also include a base station 114a and a base station 114b. Each of the base stations 114a, 114b may be any type of device configured to wirelessly interface with at least one of the WTRUs 102a, 102b, 102c, 102d to facilitate access to one or more communication networks, such as the core network 106/107/109, the Internet 110, and/or the networks 112. By way of example, the base stations 114a, 114b may be a base transceiver station (BTS), a Node-B, an eNode B, a Home Node B, a Home eNode B, a site controller, an access point (AP), a wireless router, and the like. While the base stations 114a, 114b are each depicted as a single element, it will be appreciated that the base stations 114a, 114b may include any number of interconnected base stations and/or network elements.

[0023] The base station 114a may be part of the RAN 103/104/105, which may also include other base stations and/or network elements (not shown), such as a base station controller (BSC), a radio network controller (RNC), relay nodes, *etc.* The base station 114a and/or the base station 114b may be configured to transmit and/or receive wireless signals within a particular geographic region, which may be referred to as a cell (not shown). The cell may further be divided into cell sectors. For example, the cell associated with the base station 114a may be divided into three sectors. Thus, in one embodiment, the base station 114a may include three transceivers, *e.g.*, one for each sector of the cell. In another embodiment, the base station 114a may employ multiple-input multiple output (MIMO) technology and, therefore, may utilize multiple transceivers for each sector of the cell.

[0024] The base stations 114a, 114b may communicate with one or more of the WTRUs 102a, 102b, 102c, 102d over an air interface 115/116/117, which may be any suitable wireless communication link (*e.g.*, radio frequency (RF), microwave, infrared (IR), ultraviolet (UV), visible light, *etc.*). The air interface 115/116/117 may be established using any suitable radio access technology (RAT).

[0025] More specifically, as noted above, the communications system 100 may be a multiple access system and may employ one or more channel access schemes, such as CDMA, TDMA,

FDMA, OFDMA, SC-FDMA, and the like. For example, the base station 114a in the RAN 103/104/105 and the WTRUs 102a, 102b, 102c may implement a radio technology such as Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access (UTRA), which may establish the air interface 115/116/117 using wideband CDMA (WCDMA). WCDMA may include communication protocols such as High-Speed Packet Access (HSPA) and/or Evolved HSPA (HSPA+). HSPA may include High-Speed Downlink Packet Access (HSDPA) and/or High-Speed Uplink Packet Access (HSUPA).

[0026] In another embodiment, the base station 114a and the WTRUs 102a, 102b, 102c may implement a radio technology such as Evolved UMTS Terrestrial Radio Access (E-UTRA), which may establish the air interface 115/116/117 using Long Term Evolution (LTE) and/or LTE-Advanced (LTE-A).

[0027] In other embodiments, the base station 114a and the WTRUs 102a, 102b, 102c may implement radio technologies such as IEEE 802.16 (*e.g.*, Worldwide Interoperability for Microwave Access (WiMAX)), CDMA2000, CDMA2000 1X, CDMA2000 EV-DO, Interim Standard 2000 (IS-2000), Interim Standard 95 (IS-95), Interim Standard 856 (IS-856), Global System for Mobile communications (GSM), Enhanced Data rates for GSM Evolution (EDGE), GSM EDGE (GERAN), and the like.

[0028] The base station 114b in FIG. 1A may be a wireless router, Home Node B, Home eNode B, or access point, for example, and may utilize any suitable RAT for facilitating wireless connectivity in a localized area, such as a place of business, a home, a vehicle, a campus, and the like. In one embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.11 to establish a wireless local area network (WLAN). In another embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.15 to establish a wireless personal area network (WPAN). In yet another embodiment, the base station 114b and the WTRUs 102c, 102d may utilize a cellular-based RAT (*e.g.*, WCDMA, CDMA2000, GSM, LTE, LTE-A, *etc.*) to establish a picocell or femtocell. As shown in FIG. 1A, the base station 114b may have a direct connection to the Internet 110. Thus, the base station 114b may not be required to access the Internet 110 via the core network 106/107/109.

[0029] The RAN 103/104/105 may be in communication with the core network 106/107/109, which may be any type of network configured to provide voice, data, applications, and/or voice over internet protocol (VoIP) services to one or more of the WTRUs 102a, 102b, 102c, 102d. For example, the core network 106/107/109 may provide call control, billing services, mobile

location-based services, pre-paid calling, Internet connectivity, video distribution, *etc.*, and/or perform high-level security functions, such as user authentication. Although not shown in FIG. 1A, it will be appreciated that the RAN 103/104/105 and/or the core network 106/107/109 may be in direct or indirect communication with other RANs that employ the same RAT as the RAN 103/104/105 or a different RAT. For example, in addition to being connected to the RAN 103/104/105, which may be utilizing an E-UTRA radio technology, the core network 106/107/109 may also be in communication with another RAN (not shown) employing a GSM radio technology.

[0030] The core network 106/107/109 may also serve as a gateway for the WTRUs 102a, 102b, 102c, 102d to access the PSTN 108, the Internet 110, and/or other networks 112. The PSTN 108 may include circuit-switched telephone networks that provide plain old telephone service (POTS). The Internet 110 may include a global system of interconnected computer networks and devices that use common communication protocols, such as the transmission control protocol (TCP), user datagram protocol (UDP) and the internet protocol (IP) in the TCP/IP internet protocol suite. The networks 112 may include wired or wireless communications networks owned and/or operated by other service providers. For example, the networks 112 may include another core network connected to one or more RANs, which may employ the same RAT as the RAN 103/104/105 or a different RAT.

[0031] Some or all of the WTRUs 102a, 102b, 102c, 102d in the communications system 100 may include multi-mode capabilities, *e.g.*, the WTRUs 102a, 102b, 102c, 102d may include multiple transceivers for communicating with different wireless networks over different wireless links. For example, the WTRU 102c shown in FIG. 1A may be configured to communicate with the base station 114a, which may employ a cellular-based radio technology, and with the base station 114b, which may employ an IEEE 802 radio technology.

[0032] FIG. 1B is a system diagram of an example WTRU 102. As shown in FIG. 1B, the WTRU 102 may include a processor 118, a transceiver 120, a transmit/receive element 122, a speaker/microphone 124, a keypad 126, a display/touchpad 128, non-removable memory 130, removable memory 132, a power source 134, a global positioning system (GPS) chipset 136, and other peripherals 138. It will be appreciated that the WTRU 102 may include any sub-combination of the foregoing elements while remaining consistent with an embodiment. Also, embodiments contemplate that the base stations 114a and 114b, and/or the nodes that base stations 114a and 114b may represent, such as but not limited to transceiver station (BTS), a Node-B, a site controller, an access point (AP), a home node-B, an evolved home node-B

(eNodeB), a home evolved node-B (HeNB or HeNodeB), a home evolved node-B gateway, and proxy nodes, among others, may include some or all of the elements depicted in FIG. 1B and described herein.

[0033] The processor 118 may be a general purpose processor, a special purpose processor, a conventional processor, a digital signal processor (DSP), a plurality of microprocessors, one or more microprocessors in association with a DSP core, a controller, a microcontroller, Application Specific Integrated Circuits (ASICs), Field Programmable Gate Array (FPGAs) circuits, any other type of integrated circuit (IC), a state machine, and the like. The processor 118 may perform signal coding, data processing, power control, input/output processing, and/or any other functionality that enables the WTRU 102 to operate in a wireless environment. The processor 118 may be coupled to the transceiver 120, which may be coupled to the transmit/receive element 122. While FIG. 1B depicts the processor 118 and the transceiver 120 as separate components, it will be appreciated that the processor 118 and the transceiver 120 may be integrated together in an electronic package or chip. A processor, such as the processor 118, may include integrated memory (*e.g.*, WTRU 102 may include a chipset that includes a processor and associated memory). Memory may refer to memory that is integrated with a processor (*e.g.*, processor 118) or memory that is otherwise associated with a device (*e.g.*, WTRU 102). The memory may be non-transitory. The memory may include (*e.g.*, store) instructions that may be executed by the processor (*e.g.*, software and/or firmware instructions). For example, the memory may include instructions that when executed may cause the processor to implement one or more of the implementations described herein.

[0034] The transmit/receive element 122 may be configured to transmit signals to, or receive signals from, a base station (*e.g.*, the base station 114a) over the air interface 115/116/117. For example, in one embodiment, the transmit/receive element 122 may be an antenna configured to transmit and/or receive RF signals. In another embodiment, the transmit/receive element 122 may be an emitter/detector configured to transmit and/or receive IR, UV, or visible light signals, for example. In yet another embodiment, the transmit/receive element 122 may be configured to transmit and receive both RF and light signals. It will be appreciated that the transmit/receive element 122 may be configured to transmit and/or receive any combination of wireless signals.

[0035] In addition, although the transmit/receive element 122 is depicted in FIG. 1B as a single element, the WTRU 102 may include any number of transmit/receive elements 122. More specifically, the WTRU 102 may employ MIMO technology. Thus, in one embodiment, the

WTRU 102 may include two or more transmit/receive elements 122 (*e.g.*, multiple antennas) for transmitting and receiving wireless signals over the air interface 115/116/117.

[0036] The transceiver 120 may be configured to modulate the signals that are to be transmitted by the transmit/receive element 122 and to demodulate the signals that are received by the transmit/receive element 122. As noted above, the WTRU 102 may have multi-mode capabilities. Thus, the transceiver 120 may include multiple transceivers for enabling the WTRU 102 to communicate via multiple RATs, such as UTRA and IEEE 802.11, for example.

[0037] The processor 118 of the WTRU 102 may be coupled to, and may receive user input data from, the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128 (*e.g.*, a liquid crystal display (LCD) display unit or organic light-emitting diode (OLED) display unit). The processor 118 may also output user data to the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128. In addition, the processor 118 may access information from, and store data in, any type of suitable memory, such as the non-removable memory 130, the removable memory 132, and/or memory integrated with the processor 118. The non-removable memory 130 may include random-access memory (RAM), read-only memory (ROM), a hard disk, or any other type of memory storage device. The removable memory 132 may include a subscriber identity module (SIM) card, a memory stick, a secure digital (SD) memory card, and the like. In other embodiments, the processor 118 may access information from, and store data in, memory that is not physically located on the WTRU 102, such as on a server or a home computer (not shown).

[0038] The processor 118 may receive power from the power source 134, and may be configured to distribute and/or control the power to the other components in the WTRU 102. The power source 134 may be any suitable device for powering the WTRU 102. For example, the power source 134 may include one or more dry cell batteries (*e.g.*, nickel-cadmium (NiCd), nickel-zinc (NiZn), nickel metal hydride (NiMH), lithium-ion (Li-ion), *etc.*), solar cells, fuel cells, and the like.

[0039] The processor 118 may also be coupled to the GPS chipset 136, which may be configured to provide location information (*e.g.*, longitude and latitude) regarding the current location of the WTRU 102. In addition to, or in lieu of, the information from the GPS chipset 136, the WTRU 102 may receive location information over the air interface 115/116/117 from a base station (*e.g.*, base stations 114a, 114b) and/or determine its location based on the timing of the signals being received from two or more nearby base stations. It will be appreciated that the

WTRU 102 may acquire location information by way of any suitable location-determination implementation while remaining consistent with an embodiment.

[0040] The processor 118 may further be coupled to other peripherals 138, which may include one or more software and/or hardware modules that provide additional features, functionality and/or wired or wireless connectivity. For example, the peripherals 138 may include an accelerometer, an e-compass, a satellite transceiver, a digital camera (for photographs or video), a universal serial bus (USB) port, a vibration device, a television transceiver, a hands free headset, a Bluetooth® module, a frequency modulated (FM) radio unit, a digital music player, a media player, a video game player module, an Internet browser, and the like.

[0041] FIG. 1C is a system diagram of the RAN 103 and the core network 106 according to an embodiment. As noted above, the RAN 103 may employ a UTRA radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 115. The RAN 103 may also be in communication with the core network 106. As shown in FIG. 1C, the RAN 103 may include Node-Bs 140a, 140b, 140c, which may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 115. The Node-Bs 140a, 140b, 140c may each be associated with a particular cell (not shown) within the RAN 103. The RAN 103 may also include RNCs 142a, 142b. It will be appreciated that the RAN 103 may include any number of Node-Bs and RNCs while remaining consistent with an embodiment.

[0042] As shown in FIG. 1C, the Node-Bs 140a, 140b may be in communication with the RNC 142a. Additionally, the Node-B 140c may be in communication with the RNC 142b. The Node-Bs 140a, 140b, 140c may communicate with the respective RNCs 142a, 142b via an Iub interface. The RNCs 142a, 142b may be in communication with one another via an Iur interface. Each of the RNCs 142a, 142b may be configured to control the respective Node-Bs 140a, 140b, 140c to which it is connected. In addition, each of the RNCs 142a, 142b may be configured to carry out or support other functionality, such as outer loop power control, load control, admission control, packet scheduling, handover control, macrodiversity, security functions, data encryption, and the like.

[0043] The core network 106 shown in FIG. 1C may include a media gateway (MGW) 144, a mobile switching center (MSC) 146, a serving GPRS support node (SGSN) 148, and/or a gateway GPRS support node (GGSN) 150. While each of the foregoing elements are depicted as part of the core network 106, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

[0044] The RNC 142a in the RAN 103 may be connected to the MSC 146 in the core network 106 via an IuCS interface. The MSC 146 may be connected to the MGW 144. The MSC 146 and the MGW 144 may provide the WTRUs 102a, 102b, 102c with access to circuit-switched networks, such as the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, 102c and traditional land-line communications devices.

[0045] The RNC 142a in the RAN 103 may also be connected to the SGSN 148 in the core network 106 via an IuPS interface. The SGSN 148 may be connected to the GGSN 150. The SGSN 148 and the GGSN 150 may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, such as the Internet 110, to facilitate communications between and the WTRUs 102a, 102b, 102c and IP-enabled devices.

[0046] As noted above, the core network 106 may also be connected to the networks 112, which may include other wired or wireless networks that are owned and/or operated by other service providers.

[0047] FIG. 1D is a system diagram of the RAN 104 and the core network 107 according to an embodiment. As noted above, the RAN 104 may employ an E-UTRA radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 116. The RAN 104 may also be in communication with the core network 107.

[0048] The RAN 104 may include eNode-Bs 160a, 160b, 160c, though it will be appreciated that the RAN 104 may include any number of eNode-Bs while remaining consistent with an embodiment. The eNode-Bs 160a, 160b, 160c may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 116. In one embodiment, the eNode-Bs 160a, 160b, 160c may implement MIMO technology. Thus, the eNode-B 160a, for example, may use multiple antennas to transmit wireless signals to, and receive wireless signals from, the WTRU 102a.

[0049] Each of the eNode-Bs 160a, 160b, 160c may be associated with a particular cell (not shown) and may be configured to handle radio resource management decisions, handover decisions, scheduling of users in the uplink and/or downlink, and the like. As shown in FIG. 1D, the eNode-Bs 160a, 160b, 160c may communicate with one another over an X2 interface.

[0050] The core network 107 shown in FIG. 1D may include a mobility management gateway (MME) 162, a serving gateway 164, and a packet data network (PDN) gateway 166. While each of the foregoing elements are depicted as part of the core network 107, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

[0051] The MME 162 may be connected to each of the eNode-Bs 160a, 160b, 160c in the RAN 104 via an S1 interface and may serve as a control node. For example, the MME 162 may be responsible for authenticating users of the WTRUs 102a, 102b, 102c, bearer activation/deactivation, selecting a particular serving gateway during an initial attach of the WTRUs 102a, 102b, 102c, and the like. The MME 162 may also provide a control plane function for switching between the RAN 104 and other RANs (not shown) that employ other radio technologies, such as GSM or WCDMA.

[0052] The serving gateway 164 may be connected to each of the eNode-Bs 160a, 160b, 160c in the RAN 104 via the S1 interface. The serving gateway 164 may generally route and forward user data packets to/from the WTRUs 102a, 102b, 102c. The serving gateway 164 may also perform other functions, such as anchoring user planes during inter-eNode B handovers, triggering paging when downlink data is available for the WTRUs 102a, 102b, 102c, managing and storing contexts of the WTRUs 102a, 102b, 102c, and the like.

[0053] The serving gateway 164 may also be connected to the PDN gateway 166, which may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, such as the Internet 110, to facilitate communications between the WTRUs 102a, 102b, 102c and IP-enabled devices.

[0054] The core network 107 may facilitate communications with other networks. For example, the core network 107 may provide the WTRUs 102a, 102b, 102c with access to circuit-switched networks, such as the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, 102c and traditional land-line communications devices. For example, the core network 107 may include, or may communicate with, an IP gateway (*e.g.*, an IP multimedia subsystem (IMS) server) that serves as an interface between the core network 107 and the PSTN 108. In addition, the core network 107 may provide the WTRUs 102a, 102b, 102c with access to the networks 112, which may include other wired or wireless networks that are owned and/or operated by other service providers.

[0055] FIG. 1E is a system diagram of the RAN 105 and the core network 109 according to an embodiment. The RAN 105 may be an access service network (ASN) that employs IEEE 802.16 radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 117. As will be further discussed below, the communication links between the different functional entities of the WTRUs 102a, 102b, 102c, the RAN 105, and the core network 109 may be defined as reference points.

[0056] As shown in FIG. 1E, the RAN 105 may include base stations 180a, 180b, 180c, and an ASN gateway 182, though it will be appreciated that the RAN 105 may include any number of base stations and ASN gateways while remaining consistent with an embodiment. The base stations 180a, 180b, 180c may each be associated with a particular cell (not shown) in the RAN 105 and may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 117. In one embodiment, the base stations 180a, 180b, 180c may implement MIMO technology. Thus, the base station 180a, for example, may use multiple antennas to transmit wireless signals to, and receive wireless signals from, the WTRU 102a. The base stations 180a, 180b, 180c may also provide mobility management functions, such as handoff triggering, tunnel establishment, radio resource management, traffic classification, quality of service (QoS) policy enforcement, and the like. The ASN gateway 182 may serve as a traffic aggregation point and may be responsible for paging, caching of subscriber profiles, routing to the core network 109, and the like.

[0057] The air interface 117 between the WTRUs 102a, 102b, 102c and the RAN 105 may be defined as an R1 reference point that implements the IEEE 802.16 specification. In addition, each of the WTRUs 102a, 102b, 102c may establish a logical interface (not shown) with the core network 109. The logical interface between the WTRUs 102a, 102b, 102c and the core network 109 may be defined as an R2 reference point, which may be used for authentication, authorization, IP host configuration management, and/or mobility management.

[0058] The communication link between each of the base stations 180a, 180b, 180c may be defined as an R8 reference point that includes protocols for facilitating WTRU handovers and the transfer of data between base stations. The communication link between the base stations 180a, 180b, 180c and the ASN gateway 182 may be defined as an R6 reference point. The R6 reference point may include protocols for facilitating mobility management based on mobility events associated with each of the WTRUs 102a, 102b, 102c.

[0059] As shown in FIG. 1E, the RAN 105 may be connected to the core network 109. The communication link between the RAN 105 and the core network 109 may defined as an R3 reference point that includes protocols for facilitating data transfer and mobility management capabilities, for example. The core network 109 may include a mobile IP home agent (MIP-HA) 184, an authentication, authorization, accounting (AAA) server 186, and a gateway 188. While each of the foregoing elements are depicted as part of the core network 109, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

[0060] The MIP-HA may be responsible for IP address management, and may enable the WTRUs 102a, 102b, 102c to roam between different ASNs and/or different core networks. The MIP-HA 184 may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, such as the Internet 110, to facilitate communications between the WTRUs 102a, 102b, 102c and IP-enabled devices. The AAA server 186 may be responsible for user authentication and for supporting user services. The gateway 188 may facilitate interworking with other networks. For example, the gateway 188 may provide the WTRUs 102a, 102b, 102c with access to circuit-switched networks, such as the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, 102c and traditional land-line communications devices. In addition, the gateway 188 may provide the WTRUs 102a, 102b, 102c with access to the networks 112, which may include other wired or wireless networks that are owned and/or operated by other service providers.

[0061] Although not shown in FIG. 1E, it will be appreciated that the RAN 105 may be connected to other ASNs and the core network 109 may be connected to other core networks. The communication link between the RAN 105 the other ASNs may be defined as an R4 reference point, which may include protocols for coordinating the mobility of the WTRUs 102a, 102b, 102c between the RAN 105 and the other ASNs. The communication link between the core network 109 and the other core networks may be defined as an R5 reference, which may include protocols for facilitating interworking between home core networks and visited core networks.

[0062] A WTRU that may support the full bandwidth of a cell may be referred to as a full bandwidth WTRU. Bandwidth may include a number of RBs and/or a location in a band, such as the center of the band.

[0063] A WTRU may at least sometimes communicate, behave, or operate in a manner that may be consistent (*e.g.*, at least partially consistent) with that of a full bandwidth (BW) WTRU and may at least sometimes (*e.g.*, at other times) communicate, behave, or operate in a manner that may be consistent (*e.g.*, at least partially consistent) with that of a reduced BW WTRU. For example, a WTRU that may support the full bandwidth of a cell may communicate, behave, or operate in a manner that may be consistent (*e.g.*, at least partially consistent) with that of a reduced BW WTRU at certain times, such as when it may be coverage limited or when it may operate in coverage enhanced (CE) mode. A WTRU may be or may be considered a full BW WTRU and/or a reduced BW WTRU, for example, at least sometimes.

[0064] A WTRU may be or may be considered a reduced BW WTRU while it may (or may need to or may intend to) behave or operate like (*e.g.*, at least partially like) a reduced BW WTRU. A WTRU that may communicate (*e.g.*, with an eNB), behave, or operate in a manner that may be consistent (*e.g.*, at least partially consistent) with that of a reduced BW WTRU may be or may be considered to be a reduced BW WTRU, for example, at least sometimes, such as when the WTRU may communicate, behave, or operate in a manner that may be consistent (*e.g.*, at least partially consistent) with that of a reduced BW WTRU.

[0065] The examples disclosed herein may apply to eNBs and cells. The examples disclosed herein may apply to WTRUs such as coverage limited and reduced bandwidth (BW) WTRUs. The examples disclosed herein as being applicable to reduced BW WTRUs may apply to coverage limited WTRUs. The examples disclosed herein as being applicable to coverage limited WTRUs may apply to reduced BW WTRUs. The examples disclosed herein may apply to WTRUs of other types, with other capabilities, or with reduced capabilities.

[0066] For purposes of description and explanation, PDCCH may be replaced with EPDCCH, and *vice versa*, and may still be consistent with the examples disclosed herein. For purposes of description and explanation, PDCCH (or EPDCCH) may be replaced with a DL control channel or another DL control channel and may still be consistent with the examples disclosed herein. For purposes of description and explanation, component carrier (CC) and serving cell may be used interchangeably. For purposes of description and explanation, WTRU, WTRU MAC entity, and MAC entity may be used interchangeably. For purposes of description and explanation, eNB and cell may be used interchangeably. CE level may be replaced with number of repetitions, and *vice versa*, and may still be consistent with the examples disclosed herein. Repetition number, number of repetitions, and repetition level may be used interchangeably.

[0067] A WTRU or WTRUs may be replaced with at least a WTRU or at least WTRUs, and may still be consistent with the examples disclosed herein. Intended for may be replaced with at least intended for or with intended for at least and may still be consistent with the examples disclosed herein.

[0068] Examples disclosed herein may be disclosed for RAR, PCH, or for a physical downlink shared channel (PDSCH) that may carry RAR or PCH. Such examples are non-limiting. RAR may be replaced by PCH, PCH PDSCH, or PDSCH, and *vice versa*, and may still be consistent with the examples disclosed herein. The channel or other content that may be

carried by the PDSCH may be replaced by another channel or content and may still be consistent with the examples disclosed herein.

[0069] An eNB and/or a WTRU may use a random access procedure for WTRU initial access (for example, to a cell or eNB), reset of UL timing (for example, to reset or align WTRU UL timing with respect to a cell), and/or reset of timing during handover (for example, to reset or align WTRU timing with respect to the handover target cell). The WTRU may transmit a physical random access channel (PRACH) preamble sequence at a power P_{PRACH}, which may be based on configured parameters and/or measurements, and the WTRU may transmit the preamble using a time-frequency resource or resources. The configured parameters, which may be provided or configured by the eNB, may include one or more of initial preamble power (*e.g.*, preambleInitialReceivedTargetPower), a preamble format based offset (*e.g.*, deltaPreamble), a random access response window (*e.g.*, ra-ResponseWindowSize), a power ramping factor (*e.g.*, powerRampingStep), and/or a maximum number of retransmissions (*e.g.*, preambleTransMax). The PRACH resources (which may include preambles or sets of preambles and/or time/frequency resources that may be used for preamble transmission) may be provided or configured by the eNB. The measurements may include pathloss. The time-frequency resource or resources may be chosen by the WTRU from an allowed set or may be chosen by the eNB and signaled to the WTRU. Following WTRU transmission of a preamble, if the eNB may detect the preamble, it may respond with a random access response (RAR). If the WTRU may not or does not receive an RAR for the transmitted preamble (which may, for example, correspond to a certain preamble index and time/frequency resource), within an allotted time (for example, ra-ResponseWindowSize), the WTRU may send another preamble at a later time, at a higher power, (for example, higher than the previous preamble transmission by powerRampingStep) where the transmission power may be limited by a maximum power, for example, a WTRU-configured maximum power which may be for the WTRU as a whole (for example, P_{CMAX}) or for a serving cell of the WTRU (for example, $P_{CMAX,c}$). The WTRU may wait again for receipt of an RAR from the eNB. This sequence of transmitting and waiting may continue until the eNB may respond with an RAR or until the maximum number of random access preamble transmissions (for example, preambleTransMax) may have been reached. The eNB may transmit and the WTRU may receive the RAR in response to a single preamble transmission.

[0070] The term time/frequency or time-frequency may be used to represent time and/or frequency. The term time-frequency may be used to represent a specific time and frequency.

[0071] A random access procedure (*e.g.*, an instance of a random access procedure) may be contention-based or contention-free. A contention-free procedure may be initiated by a request, for example from an eNB, which may, for example, be via physical layer signaling such as a PDCCH order or by higher layer signaling such as an RRC reconfiguration message (*e.g.*, an RRC connection reconfiguration message) that may include mobility control information and may, for example, indicate or correspond to a handover request. For a contention-free procedure that may be initiated by PDCCH order in subframe n, the PRACH preamble may be transmitted in the first subframe (or the first subframe available for PRACH) $n+k_2$, where k_2 may be at least 6. When initiated by RRC command, there may be other delays that may be specified (for example, there may be minimum and/or maximum required or allowed delays). The WTRU may autonomously initiate a contention-based procedure for reasons that may include for example, initial access, restoration of UL synchronization, and/or recovering from radio link failure. For certain events, for example, events other than recovery from radio link failure, it may not be defined or specified as to how long after such an event the WTRU may send the PRACH preamble.

[0072] For a contention-free random access (RA) procedure, a network-signaled PRACH preamble may be used, *e.g.*, by a WTRU. For a contention-based random access procedure, the WTRU may autonomously choose a preamble where the preamble format and/or the time/frequency resource or resources available for preamble transmissions may be based on an indication or index (*e.g.*, prach configIndex) that may be provided or signaled by the eNB.

[0073] In an LTE system, one of the preambles transmitted at the progressively higher transmit powers may be detected by the eNB. An RAR may be sent by the eNB in response to that one detected preamble.

[0074] A WTRU may monitor (*e.g.*, periodically) the PDCCH for DL assignments on the PDCCH masked with a P-RNTI (Paging Radio Network Temporary Identifier (RNTI)) in idle mode and/or in connected mode. When such a DL assignment using the P-RNTI may be detected, the WTRU may demodulate the assigned PDSCH resource blocks (RBs) and may decode the paging channel (PCH) carried on that PDSCH. A PDSCH that may carry PCH may be a PCH PDSCH. Paging, paging message, paging information, and PCH may be used interchangeably.

[0075] In idle mode, the specific paging frame (PF) and subframe within that PF, for example, the paging occasion (PO) that a WTRU may monitor for the paging channel may be determined based on the WTRU ID (*e.g.*, WTRU_ID) and parameters that may be specified by

the network. The parameters may include the paging cycle (PC) length (*e.g.*, in frames), which may be the same as a DRX cycle and another parameter, *e.g.*, nB, which together may facilitate the determination of the number of PF per PC and the number of PO per PF that may be in the cell. The WTRU ID may be the WTRU IMSI or the WTRU IMSI modulo a number such as 1024. For example, the PO may be determined based on WTRU IMSI mod 1024.

[0076] There may be multiple PFs per paging cycle and multiple POs within a PF, for example, more than one subframe per paging cycle may carry PDCCH masked with a P-RNTI. A WTRU may monitor a (*e.g.*, one) PO per paging cycle, and such a PO may be determined based on WTRU ID and/or one or more of the parameters disclosed herein, which may be provided to the WTRU via system information, dedicated signaling information, and the like. POs may include pages for one or more specific WTRUs, or they may include system information change pages that may be directed to each of the WTRUs, some of the WTRUs, or all of the WTRUs. For WTRU-specific pages (*e.g.*, pages that may be specific to one or more WTRUs), a WTRU (*e.g.*, a WTRU in idle mode) may monitor one PO per PC that may be based on a WTRU ID. For pages that may indicate a system information change (*e.g.*, a change that has occurred or an upcoming system information change), a WTRU (*e.g.*, a WTRU in idle or connected mode) may monitor one or more POs in a system information modification period that may or may not be based on the WTRU ID.

[0077] In connected mode, a WTRU may receive pages related to a system information change, for example, and it may not receive WTRU-specific pages such as those that may be used for an incoming call. A WTRU in the connected mode may not monitor a specific PO (*e.g.*, a PO that may be based on its WTRU ID). For frequency division duplexing (FDD), the PO subframes may include certain subframes, such as subframes 0, 4, 5, and 9. For time division duplexing (TDD), the PO subframes may include certain subframes, such as subframes 0, 1, 5, and 6.

[0078] A number of repetitions, such as of a preamble, a control channel, a PDSCH (*e.g.*, an RAR PDSCH), a PUSCH, and/or a PUCCH may include the first transmission (or reception). A number of repetitions (*e.g.*, other repetitions) may exclude the first transmission (or reception). Inclusion may be substituted for exclusion and *vice versa* and still be consistent with the examples disclosed herein. Downlink control channel, downlink control channel for MTC WTRU, (E)PDCCH (*e.g.*, EPDCCH and/or PDCCH), PDCCH, and/or M-PDCCH may be used interchangeably. System information, system information for MTC WTRU, MTC-SIB, M-SIB, and/or SIB may be used interchangeably.

[0079] A random access (RA) procedure may be provided and/or used. An eNB or cell may support WTRUs with capabilities or limitations, such as coverage limited WTRUs and/or WTRUs with reduced capabilities, such as reduced bandwidth WTRUs. A WTRU may be coverage limited and/or reduced bandwidth. Reduced capabilities may or may also include reduced complexity, such as inclusion or use of (*e.g.*, only of) a single receive antenna and/or receiver chain and/or support for a reduced transport block size.

[0080] PRACH resources may be partitioned such that resources (*e.g.*, certain resources) which may be or include preambles and/or resources in time and/or frequency may be used by WTRUs such as coverage limited WTRUs and the use of the resources (*e.g.*, certain resources) may indicate to an eNB that the WTRU using the resources may be coverage limited and/or the coverage limitation of the WTRU using the resources may be of a certain level.

[0081] An eNB, for example, one that may support a bandwidth (BW) larger than that of a reduced bandwidth WTRU and/or that may support reduced bandwidth WTRUs, may allocate PRACH resources that may be used by at least certain WTRUs, such as reduced bandwidth WTRUs. The allocated resources may be located in a bandwidth (*e.g.*, number of RBs and/or band location such as a band center) in which a reduced bandwidth WTRU may or may be able to transmit. These resources may be the same as, separate from, or a subset of those which may be allocated for legacy or other WTRUs. The allocated resources may include preambles that may or may only be used by reduced bandwidth WTRUs.

[0082] PRACH resource allocation (*e.g.*, for resources that may be used by at least certain WTRUs) may include the designation of one or more of preambles (*e.g.*, certain preambles), times (*e.g.*, subframes or certain subframes), and/or frequencies (*e.g.*, RBs or certain RBs). PRACH resources (*e.g.*, for use by at least certain WTRUs) may be differentiated (*e.g.*, from resources that may not be used by the certain WTRUs) by at least one or more of preamble, time (*e.g.*, subframe allocation), and/or frequency (*e.g.*, RB allocation). Allocation and/or designation may be via signaling (*e.g.*, by the eNB), such as dedicated or broadcast signaling and/or system information.

[0083] PRACH resource allocation and random access procedures may be provided for WTRUs that may be coverage limited and/or bandwidth limited. Some (*e.g.*, all) of the PRACH resources that may be allocated, *e.g.*, by an eNB, for coverage limited WTRUs may be or may always be located in a bandwidth that may be supported by bandwidth limited WTRUs. WTRUs that may be coverage limited and/or bandwidth limited may choose from and/or use one or more PRACH resources (*e.g.*, from among the PRACH resources that may be allocated for coverage

limited WTRUs and/or may be located in a bandwidth that may be supported by bandwidth limited WTRUs) for PRACH transmission to an eNB. PRACH resources that may be allocated or designated for each of one or more (*e.g.*, all) levels of coverage limitation may include a subset (which may include the full set) that may be used by WTRUs that may be coverage limited and bandwidth limited.

[0084] An eNB may consider a coverage limited WTRU (*e.g.*, a WTRU that the eNB may determine to be coverage limited) as a bandwidth limited WTRU as well, for example, until informed or determined otherwise. The eNB may determine the WTRU to be coverage limited based on the PRACH resource the WTRU may have used (*e.g.*, transmitted) or the eNB may have received from the WTRU. The eNB may communicate with the WTRU accordingly.

[0085] An eNB that may receive a PRACH from a PRACH resource that may be designated or allocated for coverage limited WTRUs and that may be used by bandwidth limited WTRUs (*e.g.*, by designation or by location in the supportable bandwidth of the WTRU) may consider the WTRU that may have transmitted the PRACH as a bandwidth limited WTRU, for example, until informed or determined otherwise. The eNB may communicate with the WTRU accordingly.

[0086] PRACH resources may be specifically allocated or designated for WTRUs that may be both coverage limited and bandwidth limited. WTRUs that may be both coverage limited and bandwidth limited may choose from and/or use these allocated or designated PRACH resources for PRACH transmission to an eNB. Separate PRACH resources (which may be differentiated, for example, by one or more of preamble, time, and/or frequency) may be allocated and/or used for different levels of coverage limitation. For example, one level of coverage limitation, *e.g.*, the worst case level, may be used by WTRUs that may be both coverage limited and bandwidth limited.

[0087] An eNB that may receive a PRACH from a PRACH resource that may be designated or allocated for WTRUs that may be both coverage limited and bandwidth limited may consider the WTRU that may have transmitted the PRACH as both a coverage limited and bandwidth limited WTRU. Based on the PRACH resource, the eNB may also know the coverage limitation level. The eNB may communicate with the WTRU accordingly.

[0088] A random access response (RAR) may be provided and/or used. During a random access procedure with a WTRU, an eNB may not know if the WTRU is a reduced bandwidth WTRU, for example, until it may receive an indication or message from the WTRU, and may, for example, not know whether to respond to the WTRU in a reduced bandwidth.

[0089] An eNB may consider a WTRU that may have transmitted (or from which the eNB may have received) a PRACH in a certain bandwidth (*e.g.*, a certain number of RBs and/or a certain location such as a center set of RBs, such as the center 6 RBs) to be a reduced bandwidth WTRU, for example, until it receives an indication that the WTRU is not a reduced bandwidth WTRU. The indication may be provided by the WTRU in a message (*e.g.*, RRC message such as a RRC connection request or WTRU capabilities message, which may be from the WTRU).

[0090] When responding to PRACH from a WTRU such as one that may be or may be considered by an eNB to be a reduced bandwidth WTRU, the eNB may provide the random access response (RAR) in a way in which the WTRU may be able to receive it.

[0091] An eNB may, for example, until it knows or determines a WTRU is not a reduced bandwidth WTRU, limit transmissions intended for the WTRU to a maximum of a certain number R RBs (*e.g.*, 6) and/or location, such as a set (*e.g.*, a certain set) of R RBs (*e.g.*, the center R RBs). The eNB may or may also limit an UL grant (*e.g.*, the UL grant for msg3 of the RA procedure) size to a certain maximum number Y RBs (*e.g.*, 6 RBs) and/or location such as a set (*e.g.*, a certain set) of Y RBs (*e.g.*, the center Y RBs). R may be equal to Y. The RB location(s) may be provided (*e.g.*, by the eNB, in signaling such as broadcast signaling (*e.g.*, in system information). This may apply (*e.g.*, may only apply) for WTRUs that may or may be determined to be coverage limited (*e.g.*, based on the PRACH resource used by the WTRU).

[0092] An eNB that may receive a PRACH from a PRACH resource that may be allocated or designated for or used by at least certain, *e.g.*, bandwidth limited and/or coverage limited, WTRUs may do one or more of the following: provide RAR in a manner in which a WTRU, such as a bandwidth limited WTRU and/or a coverage limited WTRU, may receive the RAR, provide an UL grant for resources (*e.g.*, for message 3 of the RA procedure) in the bandwidth in which a bandwidth limited WTRU may transmit, and/or provide or continue to provide DL grants and/or UL grants for a limited bandwidth WTRU until, for example, it may receive an indication (explicit or otherwise) that the WTRU may not be a limited bandwidth WTRU. The indication may be included in an RRC message such as an RRC connection request message or a WTRU capabilities message, which may be from the WTRU.

[0093] Providing RAR in a manner in which a WTRU, such as a bandwidth limited WTRU and/or a coverage limited WTRU, may receive the RAR may include using EPDCCH (or both EPDCCH and PDCCH) to send the control information (*e.g.*, DCI format) that may indicate the location and/or parameters for the PDSCH that may carry the RAR. Providing RAR in a manner in which a WTRU, such as a bandwidth limited WTRU and/or a coverage limited WTRU, may

receive the RAR may include transmitting the PDSCH that may carry RAR in the bandwidth (*e.g.*, number of RBs and/or band location such as the center of the band) in which a limited bandwidth WTRU may receive it. Providing RAR in a manner in which a WTRU, such as a bandwidth limited WTRU and/or a coverage limited WTRU, may receive the RAR may include transmitting the RAR PDSCH in a fixed, known, or determined location and/or with one or more fixed, known, or determined parameters (*e.g.*, transmission parameters such as MCS) such that a DCI format may not be required or used (*e.g.*, for the RAR) by or for a WTRU, which may be a bandwidth limited WTRU or a coverage limited WTRU. The fixed, known, or determined location and/or parameters may be provided by the eNB in signaling, such as broadcast system information and/or may be a function of the PRACH or PRACH transmission to which the RAR may respond or may include a response.

[0094] A known location, parameter, or value may be determined by the WTRU and/or eNB. Known and determined may be used interchangeably.

[0095] Providing DL grants and/or UL grants for a limited bandwidth WTRU may include one or more of using EPDCCH (or both EPDCCH and PDCCH) to send the control information (*e.g.*, DCI format) associated with the grant, transmitting the granted PDSCH in the bandwidth (*e.g.*, number of RBs and/or band location such as the center of the band) in which a limited bandwidth WTRU may receive it, and/or granting UL resources in the bandwidth (*e.g.*, number of RBs and/or band location such as the center of the band) in which a limited bandwidth WTRU may transmit.

[0096] The location and/or transmission parameters of an RAR that may be intended for a WTRU (or at least a WTRU) that may be bandwidth limited and/or coverage limited may be a function of one or more parameters of the PRACH (*e.g.*, the PRACH resource) for which the RAR may provide or include a response. A location (*e.g.*, of an RAR) may be or may include time (*e.g.*, subframe) and/or frequency (*e.g.*, one or more RBs). A PRACH or PRACH resource parameter may be or may include time (*e.g.*, subframe or subframe set), frequency (*e.g.*, one or more RBs), and/or preamble.

[0097] An RAR may be or may represent a certain instance or repetition of an RAR. Repetitions of an RAR that may be combined by a WTRU, such as a WTRU that may be coverage limited, may be in the same or different locations (*e.g.*, subframes may be different and RBs may be the same or different) and/or may use the same or different parameters.

[0098] A WTRU, such as a bandwidth limited and/or coverage limited WTRU, may transmit a PRACH, *e.g.*, to an eNB. The WTRU and/or the eNB may determine the location of an RAR

that may be intended for the WTRU (or at least the WTRU), for example, in response to the PRACH transmission of the WTRU, based on one or more parameters of the PRACH (*e.g.*, the PRACH resource). For example, the RB or RBs in which a WTRU may transmit a PRACH may determine (or may be used by the WTRU and/or eNB to determine) the RB or RBs for the RAR that may correspond to the PRACH. The eNB may transmit and/or the WTRU may receive or attempt to receive the RAR in the determined location. Determination by the WTRU may be based on at least configuration, *e.g.*, of the relationship or correspondence between RAR location and/or parameters and PRACH parameters and/or PRACH resources, which may be provided by the eNB via signaling, such as broadcast signaling or in system information, which may be broadcast.

[0099] A location (*e.g.*, which may be fixed or known) and/or one or more transmission parameters (*e.g.*, which may be fixed or known) of an RAR that may be intended for a WTRU (or at least a WTRU), such as a WTRU that may be bandwidth limited and/or coverage limited, may be a function of a capability (or reduced capability) of the WTRU. For example, RAR location and/or one or more RAR transmission parameters may be a function of at least one of CE mode, CE level, and/or bandwidth limitation. The capability (or reduced capability) of the WTRU, such as the CE mode and/or CE level, and/or bandwidth limitation of the WTRU, may determine (or may be used by the WTRU and/or eNB to determine) the location (*e.g.*, subframes and/or RBs) and/or one or more transmission parameters (*e.g.*, MCS) for the RAR that may correspond to the PRACH. The eNB may transmit and/or the WTRU may receive or attempt to receive the RAR in the determined location. Determination by the WTRU may be based on at least configuration (*e.g.*, of RAR location and/or parameters) for one or more capabilities (or reduced capabilities, such as CE mode or level) that may be provided by the eNB via signaling such as broadcast signaling.

[0100] FIG. 2 illustrates an example of preamble transmission and RAR reception by a WTRU. The WTRU may transmit a preamble on or using a PRACH at 206. The WTRU may determine the location of the RAR based on at least one parameter of the PRACH at 208. The location of the RAR may comprise at least one of a subframe or a frequency resource on which the RAR may be or will be transmitted. A PRACH parameter may comprise at least one of a subframe, a frequency resource, *e.g.*, on which the preamble is transmitted, or the preamble. The WTRU may receive or may attempt to receive the RAR at the determined location at 210. The WTRU may transmit the preamble with repetitions, for example, when the WTRU is in CE mode, using CE, and/or using a CE level. The WTRU may receive and combine repetitions of an RAR to successfully receive and/or decode the RAR, for example, when the WTRU is in CE

mode, using CE, and/or using a CE level. The location of the RAR repetitions may be determined based on the at least one parameter of the PRACH and/or one or more other PRACH parameters. The association or correspondence between the one or more PRACH parameters and the RAR location (or locations, for example for repetitions) may be provided to and/or received by the WTRU via a configuration, *e.g.*, a random access (RA) configuration. The configuration may be provided and/or received in system information, which may be broadcast.

[0101] FIG. 3A illustrates another example of preamble transmission and RAR reception by a WTRU. The WTRU receives an RA configuration at 302. The WTRU determines one or more PRACH parameters based on the RA configuration at 304. The WTRU transmits a preamble on or using a PRACH at 306. The WTRU determines the location of the RAR based on at least one parameter of the PRACH at 308. The location of the RAR may comprise at least one of a subframe or a frequency resource on which the RAR may be or will be transmitted. A PRACH parameter may comprise at least one of a subframe, a frequency resource, *e.g.*, on which the preamble is transmitted, or the preamble. The WTRU may receive or may attempt to receive the RAR at the determined location at 310. The WTRU may transmit the preamble with repetitions, for example, when the WTRU is in CE mode, using CE, and/or using a CE level. The WTRU may receive and combine repetitions of an RAR to successfully receive and/or decode the RAR, for example, when the WTRU is in CE mode, using CE, and/or using a CE level. The location of the RAR repetitions may be determined based on the at least one parameter of the PRACH and/or one or more other PRACH parameters. The RA configuration may provide the WTRU with the association or correspondence between the one or more PRACH parameters and the RAR location (or locations, for example, for repetitions).

[0102] FIG. 3B illustrates an example RA configuration that includes one or more PRACH parameters 314 and one or more RAR locations 316. The RA configuration may provide the association or correspondence between one or more PRACH parameters and an RAR location or locations, for example for repetitions. The PRACH parameters and/or RAR locations may be associated with CE levels.

[0103] FIG. 4A illustrates an example of preamble transmission and RAR reception by a WTRU. The WTRU may receive an RA configuration at 402. The WTRU may determine PRACH parameters based on the RA configuration and/or CE level at 404. For example, the RA configuration may include one or more PRACH parameters or sets of PRACH parameters that may be associated with one or more CE levels. PRACH parameters may include one or more preambles and/or one or more PRACH time and/or frequency resources. The WTRU may

determine a preamble, *e.g.*, select a preamble from a set of one or more preambles. The WTRU may determine a subframe or set of subframes (*e.g.*, for repetition) from the one or more time resources. The WTRU may determine a frequency resource such as one or more (*e.g.*, a set of) PRBs from the one or more frequency resources. The CE level may be determined by the WTRU, for example, based on a measurement. The CE level may be determined by the WTRU according to a starting CE level and a number of prior failed random access attempts. For a WTRU that may be using a reduced BW but may not be in or using a CE mode, CE level may not be included in the determination of PRACH parameters at 404.

[0104] The WTRU may transmit a preamble based on the PRACH parameters at 406. For example, the WTRU may transmit the determined preamble on or using the determined PRACH. The WTRU may transmit the determined preamble in the determined subframe or set of subframes in the determined frequency resource (or frequency resources, *e.g.*, if frequency hopping is used for one or more repetitions).

[0105] The WTRU may determine the RAR location based on at least one PRACH parameter and/or CE level at 408. The RAR location may comprise at least one of a subframe and/or a frequency resource on which the RAR may be transmitted. For RAR with repetition, the location may comprise multiple (*e.g.*, a set of) subframes. For RAR with repetition, the location may comprise multiple (*e.g.*, a set of) frequency locations, *e.g.*, if frequency hopping is used.

[0106] The WTRU may determine the number of repetitions with which the RAR will be transmitted based on at least one PRACH parameter and/or CE level at 410. For some WTRUs, *e.g.*, a WTRU that may be using a reduced BW but may not be in or using a CE mode, this determination may not be made.

[0107] The WTRU may receive or may attempt to receive an RAR at the determined location and, optionally, with up to the determined number of repetitions at 412. The WTRU may receive a repetition of an RAR at one or more determined locations and may combine the repetitions to successfully receive and decode the RAR. The WTRU may receive and combine up to the determined number of repetitions at 412.

[0108] If the WTRU successfully receives an RAR within an RA response window, the WTRU may transmit a success message on resources which may be allocated or granted by the RAR. The success message may be a random access msg3 or another message. If the WTRU does not successfully receive an RAR within an RA response window, the WTRU may stop or may try again depending on the random access procedure and the number of attempts already made, *e.g.*, at one or more CE levels.

[0109] FIG. 4B illustrates another example RA configuration that includes one or more PRACH parameters 414 and one or more RAR locations 416. The RA configuration may provide the WTRU with the association or correspondence between one or more PRACH parameters and an RAR location or locations, for example for repetitions. The PRACH parameters and/or RAR locations may be associated with CE levels.

[0110] FIG. 5 illustrates an example of preamble reception and RAR transmission, for example by an eNB or cell. A preamble may be received on or using a PRACH associated with a CE level at 506. The location of the RAR and/or the number RAR repetitions may be determined based on at least one parameter of the PRACH at 508. The location of the RAR may comprise at least one of a subframe or a frequency resource on which the RAR may be or will be transmitted. A PRACH parameter may comprise at least one of a subframe, a frequency resource, *e.g.*, on which the preamble is transmitted or received, or the preamble. The RAR may be transmitted at the determined location and/or with the determined repetitions at 510.

[0111] RAR location may be used to represent the location of a PDSCH that may carry a (or at least one) RAR. RAR location may be used to represent the location of a control channel or control information, *e.g.*, one or more of a PDCCH, EPDCCH, M-PDCCH, a DCI, or a DCI format, that may include or carry a (or at least one) RAR or may indicate or be associated with a PDSCH that may carry a (or at least one) RAR.

[0112] RAR may be used to represent a PDSCH that may carry an RAR (or at least one RAR). RAR may be used to represent a control channel or control information, *e.g.*, one or more of a PDCCH, EPDCCH, M-PDCCH, a DCI, or a DCI format, that may include or carry a (or at least one) RAR or may indicate or be associated with a PDSCH that may carry a (or at least one) RAR.

[0113] At least one RAR transport block size (TBS) may be configured or fixed and may correspond to a number (*e.g.*, a certain number) of RA responses (*e.g.*, to a number or certain number of preambles). Padding may be used, for example, when the number of responses (*e.g.*, actual responses) may be less than the number (*e.g.*, the certain number) of RA responses or preambles to which the RAR TBS that may be configured or fixed may apply. TBS configuration may be by signaling, such as broadcast signaling, which may be from the eNB. There may be a separate RAR TBS value (*e.g.*, fixed or configured) for one or more CE levels. There may be at least one RAR TBS value for RAR that may be intended for (*e.g.*, at least for) a coverage limited and/or bandwidth limited WTRU. A WTRU, such as a WTRU that may be coverage limited and/or bandwidth limited, may receive or may expect to receive an RAR with a fixed or

configured TBS. An eNB may transmit an RAR that may be intended for (*e.g.*, at least for) a WTRU that may be coverage limited and/or bandwidth limited with a fixed or configured TBS.

[0114] There may be N CE levels and/or there may be PRACH resources (*e.g.*, separate PRACH resources) for one or more (*e.g.*, each) of the N CE levels. A WTRU that may transmit PRACH using the resources that may correspond to a certain CE level may receive or may expect to receive an RAR in time and/or frequency resources (*e.g.*, subframes and/or RBs) that may correspond to the CE level of the WTRU and/or the PRACH resources used by the WTRU. An eNB may transmit an RAR in time and/or frequency resources (*e.g.*, subframes and/or RBs) that may correspond to the resources in which the eNB may have received the PRACH that may correspond to a certain CE level. RAR for different CE levels may be in different frequency resources that may be in the same or different subframes.

[0115] A set of RAR transport block (TB) sizes (*e.g.*, possible or candidate TB sizes) may be fixed or configured (*e.g.*, by the eNB) and/or determined (*e.g.*, by the WTRU). A WTRU may try one or more of the TB sizes in the set to try to successfully receive the RAR, for example, when monitoring for and/or attempting to receive RAR.

[0116] A set of RAR candidates may be fixed or configured (*e.g.*, by the eNB) and/or determined (*e.g.*, by the WTRU). The RAR candidates may differ in one or more characteristics, which may include time (*e.g.*, subframe), frequency (*e.g.*, RBs), TBS, and/or one or more transmission parameters, such as MCS. A WTRU may try one or more of the RAR candidates to try to successfully receive the RAR, for example, when monitoring for and/or attempting to receive RAR.

[0117] An eNB, for example, one that may be unsure if a WTRU from which it may have received a PRACH transmission may be a limited bandwidth WTRU, may transmit RAR in a way in which a limited bandwidth WTRU may receive it and in a way in which a full bandwidth WTRU may receive it.

[0118] The eNB may transmit a PDSCH (which may be repeated in the case of coverage enhancement) that may carry a RAR that may be intended for (*e.g.*, at least) the WTRU. The eNB may transmit the DCI format for the PDSCH that may carry RAR in both PDCCH and EPDCCH. The PDCCH may indicate the location and/or parameters of the PDSCH to be the same as the location and/or parameters indicated by the EPDCCH. The PDSCH may be located in a bandwidth that may be received by a limited bandwidth WTRU. If a DCI format may not be needed for the RAR PDSCH (*e.g.*, for a coverage limited and/or limited bandwidth WTRU), then the EPDCCH may not be transmitted. The PDCCH may indicate the location and/or parameters

of the PDSCH to be the same as the configured or otherwise known or determined location and/or parameters. The PDSCH may provide a grant for UL resources in a bandwidth that a limited bandwidth WTRU may support.

[0119] The eNB may transmit two PDSCH (one or more of which may be repeated in the case of coverage enhancement), *e.g.*, in the same subframe. A PDSCH (*e.g.*, each of the two and/or the repetitions of the two) may carry a RAR that may be intended for (*e.g.*, at least for) the WTRU.

[0120] The eNB may transmit a DCI format for a first PDSCH in a PDCCH. The eNB may transmit a DCI format for a second PDSCH in an EPDCCH. The transmissions may be in the same subframe. The location of the first PDSCH may not be limited to a bandwidth that may be supported by a limited bandwidth WTRU. The location of the second PDSCH may be in (or limited to) a bandwidth that may be supported by a limited bandwidth WTRU. The eNB may not transmit a DCI format for the second PDSCH. The location and/or parameters for the second PDSCH may be configured (*e.g.*, by signaling from the eNB such as broadcast signaling and/or system information) and/or known or determined. One or more (*e.g.*, each) PDSCH may carry an RAR that may be intended for (*e.g.*, at least for) the WTRU from which it may have received the PRACH transmission.

[0121] The eNB may provide two UL grants (*e.g.*, each for a PUSCH transmission) that may be for WTRU transmission of a PUSCH which may carry RA procedure message 3. The two UL grants may be for resources in the same subframe. At least one UL grant may be for resources that a limited bandwidth WTRU may support (*e.g.*, be able to transmit in). The first and/or second (*e.g.*, at least the second) PDSCH may include an UL grant for resources which a limited bandwidth WTRU may support.

[0122] A full bandwidth WTRU (*e.g.*, that may have transmitted the PRACH that may have resulted in the eNB sending the RAR) may receive and/or decode the DCI format in the PDCCH and may receive the first PDSCH (*e.g.*, based on a DL grant in the PDCCH). The full bandwidth WTRU may transmit a PUSCH that may carry message 3 in UL resources granted by the first PDSCH. A limited bandwidth WTRU (*e.g.*, that may have transmitted the PRACH that may have resulted in the eNB sending the RAR) may receive and/or decode the DCI format in the EPDCCH and/or may receive the second PDSCH (*e.g.*, based on a DL grant in the EPDCCH or based on a known or determined location and/or known or determined parameters). The limited bandwidth WTRU may transmit message 3 in a PUSCH in UL resources granted by the second PDSCH.

[0123] The eNB may determine whether the WTRU may be a limited bandwidth WTRU based on the PUSCH in which the WTRU may transmit and/or the eNB may receive message 3 (*e.g.*, from the WTRU that may have been granted the UL resources).

[0124] One or more of a PRACH, PDCCH, EPDCCH, PDSCH, and/or PUSCH may be repeated, *e.g.*, in multiple subframes, for example, when coverage enhancement techniques may be used. Transmitting and/or receiving one of these channels may be replaced by transmitting or receiving one or more repetitions of the channel (*e.g.*, where the first instance of the channel may be considered a repetition of the channel) and still be consistent with this disclosure. For a WTRU or eNB to successfully receive a channel, one or more of the repetitions, which may include a first instance and one or more subsequent repetitions, may be combined.

[0125] An RAR may include an indication of a subframe (*e.g.*, a starting or ending subframe) and/or frequency (*e.g.*, RB or starting RB) of the PRACH transmission to which the RAR may correspond.

[0126] A WTRU may inform an eNB whether or not it is a limited bandwidth WTRU via a message, which may be, for example, an RRC message, such as an RRC connection request message or a WTRU capabilities message.

[0127] Non-receipt of an indication that a WTRU is a limited bandwidth WTRU in a message that may include such an indication (such as a RRC connection request or capabilities message) may be considered the same as receipt of an indication that the WTRU is not a reduced bandwidth WTRU. For example, if the eNB receives a message that may include a reduced bandwidth indication from a WTRU and a limited bandwidth indication is not included, the eNB may consider the WTRU to be a full bandwidth WTRU (*e.g.*, not a limited bandwidth WTRU).

[0128] The eNB may determine the bandwidth capability (*e.g.*, limited or non-limited) of a WTRU based on whether or not the eNB receives a limited bandwidth indication.

[0129] A RA response and/or RA-RNTI may be provided and/or used. After a WTRU may transmit a RA preamble, *e.g.*, regardless of a possible occurrence of a measurement gap, the WTRU may monitor a PDCCH, *e.g.*, of a serving cell such as the PCell, for random access response(s) (RARs) that may be identified by an RA-RNTI and that may arrive in an RA response window. The RA response window may start at a certain subframe, such as the subframe that may include the end of the preamble transmission plus a number of additional subframes, *e.g.*, three additional subframes. The RA response window may have a length in subframes, such as ra-ResponseWindowSize subframes, which may be configured or provided (*e.g.*, by the eNB) via signaling such as broadcast (*e.g.*, system information) signaling.

[0130] The RA-RNTI associated with the PRACH in which a preamble may be transmitted, may be computed, for example, as:

$$RA\text{-}RNTI = 1 + t_id + 10 * f_id$$

where t_id may be the index of the first subframe of the PRACH (*e.g.*, $0 \leq t_id < 10$), and/or f_id may be the index of the PRACH within that subframe, *e.g.*, in ascending order of frequency domain (*e.g.*, $0 \leq f_id < 6$). The WTRU may stop monitoring for RARs after successful reception of a RAR that may include a RA preamble identifier that may match the transmitted RA preamble.

[0131] For a coverage limited WTRU, preambles and/or RAR may be repeated. RA-RNTI for coverage limited WTRUs may collide with those for non-coverage limited WTRUs, and the RA response window definition may be insufficient for coverage limited WTRUs.

[0132] An eNB may transmit RAR in a coverage enhanced manner, for example when transmitting RAR to a UE which may be coverage limited. A WTRU, such as a coverage limited WTRU, may receive RAR in a coverage enhanced manner. Transmission and/or reception in a coverage enhanced manner may include at least one or more of the following, and/or a WTRU and/or eNB may perform transmission and/or reception in a coverage enhanced manner in accordance with at least one or more of the following.

[0133] Transmission and/or reception in a coverage enhanced manner may include transmission of repetitions of RAR, which may include repetitions of a PDSCH that may carry RAR and/or repetitions of the associated PDCCH and/or EPDCCH.

[0134] Transmission and/or reception in a coverage enhanced manner may include reception and/or combining of repetitions of RAR, which may include reception and/or combining repetitions of a PDSCH that may carry RAR and/or reception and/or combining repetitions of the associated PDCCH and/or EPDCCH.

[0135] Transmission and/or reception in a coverage enhanced manner may include use of a modified and/or extended RA response window (*e.g.*, with respect to the RA response window that may be used by or for a non-coverage limited WTRU or WTRUs that may not be in coverage enhanced (CE) mode).

[0136] Transmission and/or reception in a coverage enhanced manner may include transmission of an RNTI for the RAR PDCCH or EPDCCH, *e.g.*, CE-RA-RNTI, which may be specific to coverage limited WTRUs, for example, of a certain coverage enhancement level.

[0137] Transmission and/or reception in a coverage enhanced manner may include monitoring and/or reception of an RNTI for the RAR PDCCH or EPDCCH, *e.g.*, CE-RA-RNTI,

which may be specific to coverage limited WTRUs, for example, of a certain coverage enhancement level.

[0138] RA-RNTI or a new RNTI may be used for PDCCH and/or EPDCCH associated with PDSCH that may carry RAR, for example, for RAR intended for (*e.g.*, at least for) a WTRU that may be coverage limited and/or bandwidth limited.

[0139] PDCCH and/or EPDCCH associated with PDSCH that may carry RAR may be located in a common search space (*e.g.*, PDCCH common search space and/or EPDCCH common search space), for example, for RAR intended for (*e.g.*, at least for) a WTRU that may be coverage limited and/or bandwidth limited.

[0140] The eNB may transmit RAR in a coverage enhanced manner, for example, when responding to receipt of a PRACH preamble that may have been transmitted by a coverage limited WTRU and/or that may be considered or determined by the eNB to have been transmitted by a coverage limited WTRU.

[0141] The RA response window may start at a subframe, such as the subframe that may be or include the end of the preamble transmission (which may be the subframe of the last repetition of the preamble) plus a number of subframes (*e.g.*, three subframes). The start and/or length of the RA response window may be a function of at least one or more of the number of repetitions (or CE level) of the preamble (or PRACH transmission); the number of repetitions or expected repetitions of the RAR; the number of repetitions of the PDCCH and/or EPDCCH that may carry the control information for the RAR and/or that may use RA-RNTI (or CE-RA-RANTI); the gap (*e.g.*, in subframes) that may be between the last RA-RNTI (or CE-RA-RANTI) PDCCH (or EPDCCH) for the RAR and the first RAR; the ra-ResponseWindowSize; a value, *e.g.*, ce-ra-ResponseWindowSize, which may be a fixed value or a configured value (*e.g.*, by eNB signaling such as broadcast and/or system information signaling); a window offset value, which may be a fixed value or a configured value (*e.g.*, by eNB signaling such as broadcast and/or system information signaling); and/or the subframe allocation for the repetitions of the RAR.

[0142] The repetitions and/or expected repetitions of the preamble and/or associated PDCCH (or EPDCCH) and/or RAR may be based on the CE mode and/or level of the WTRU which may be indicated by the WTRU and/or understood by the eNB from the PRACH resource used by the WTRU for the random access. The gap may be a fixed value or a configured value (*e.g.*, by eNB signaling such as broadcast and/or system information signaling).

[0143] For example, if the WTRU may transmit the preamble Nrep times, the length of the window may be Nrep (or a multiple or Nrep such as 2) plus a fixed or configured (*e.g.*, by eNB signaling such as broadcast and/or system information signaling) value such as ra-

ResponseWindowSize or a value, *e.g.*, ce-ra-ResponseWindowSize, subframes. An offset may be added. For example, a CE response window size may be 2 x Nrep + ra-ResponseWindowSize + window offset.

[0144] If the number of times that the RAR may be (or may be expected to be) transmitted is Mrep, the length of the window may be Mrep (or a multiple of Mrep such as 2) plus a fixed or configured value such as ra-ResponseWindowSize or a value, *e.g.*, ce-ra-ResponseWindowSize, subframes. An offset may be added. For example, a CE response window size may be 2 x Mrep + ra-ResponseWindowSize + window offset. The window offset may be a gap of time in subframes between the last of the repetitions of the control channel that may indicate the grant for the RAR PDSCH and the first repetition (*e.g.*, first transmission) of the RAR PDSCH. If the number of repetitions of the control channel may be Crep and the number of repetitions of the RAR may be Rrep, the response window size may be a function of both and may be a function of the size of the gap between them, if any. For example, a CE response window size may be Crep + Rrep + ra-ResponseWindowSize + window offset. ra-ResponseWindowSize may be replaced by ce-ra-ResponseWindowSize or another parameter or value. The window offset may be 0 or a positive integer.

[0145] A subframe allocation for the repetitions of the RAR may be provided or configured by the eNB, for example, by signaling such as broadcast signaling. The subframe allocation may indicate in which subframes an RAR or a certain RAR may be transmitted and/or expected. For example, an RAR that may correspond to a certain CE mode, CE level, BW limitation, or PRACH resource may be transmitted or may only be transmitted in certain subframes. The subframes (*e.g.*, the certain subframes) may be indicated by at least one or more of a periodicity, an indication of the SFNs to which the periodicity may correspond (*e.g.*, x may be designated and periodicity may correspond to SFN mod x=0), and/or an offset (*e.g.*, from the start of the period). The response window start and/or length may be a function of the subframe allocation. For example, if the subframe allocation may have a periodicity of 4 subframes, the response window may be on the order of 4 times longer than if it may have a periodicity of 1 subframe.

[0146] The response window size, for example for TDD, may be a function of the number of DL (or non-UL) subframes in each frame, which may be based on the TDD UL/DL configuration that may be broadcast in a system information block (SIB, *e.g.*, SIB1) of the cell. When counting or considering subframes for RAR, for example for TDD, subframes may (or may only) refer to subframes in which RAR may be transmitted (*e.g.*, DL and/or non-UL subframes).

[0147] If some subframes may not include RAR (*e.g.*, UL subframes, some special subframes, and/or subframes that may include PBCH), then when counting or considering subframes for the RAR window, those subframes may be excluded from the count or consideration and the window may be longer in time than the count. For example, if the RAR response window may be 100 subframes, and 2 out of each 10 subframes in a frame may be excluded, the response window may use a span of 100/0.8 = 125 actual subframes for 100 counted subframes.

[0148] The length of the window may be or may be based on a new configured (*e.g.*, by eNB signaling such as broadcast and/or system information signaling) value, *e.g.*, ce-ra-ResponseWindowSize subframes, which may be a function of the CE level and which may take into account the repetitions of the RAR for the CE level.

[0149] The WTRU may monitor a control channel (*e.g.*, PDCCH and/or EPDCCH) for RA-RNTI and/or CE-RA-RNTI, for example, following transmission of the preamble repetitions that may be for the (*e.g.*, the current) coverage enhancement level of the WTRU. The WTRU may receive PDSCH carrying RAR. The WTRU may perform the monitoring in the response window. The WTRU may combine Crep repetitions (*e.g.*, a moving window of Crep repetitions) of the control channel until it may successfully receive the control channel. The WTRU may combine Rrep or up to Rrep (*e.g.*, a moving window of Rrep or up to Rrep repetitions of the RAR), for example, until it may successfully receive the RAR. A WTRU may or may only monitor a control channel for RA-RNTI and/or CE-RA-RNTI in subframes that may correspond to a subframe allocation that may correspond to a characteristic of the WTRU and/or the PRACH resource that the WTRU may have used for transmission. A WTRU characteristic may include one or more of CE mode, CE level, and/or bandwidth limitation.

[0150] The WTRU may monitor for (*e.g.*, receive or attempt to receive) PDSCH that may carry RAR in a fixed, known, and/or determined location, for example, following transmission of the preamble repetitions that may be for the current coverage enhancement level of the WTRU. The WTRU may perform the monitoring in the response window. The WTRU may combine Rrep or up to Rrep repetitions (*e.g.*, a moving window of Rrep or up to Rrep repetitions of the RAR), for example, until the WTRU may successfully receive an RAR that may include indication of the preamble that the WTRU may have transmitted.

[0151] A WTRU may or may only monitor the PDSCH that may carry RAR in subframes that may correspond to a subframe allocation that may correspond to a characteristic of the WTRU and/or the PRACH resource that the WTRU may have used for transmission.

[0152] A WTRU that may be both coverage limited and bandwidth limited may act at least in accordance with one or more examples disclosed herein for a coverage limited WTRU. For example, a WTRU, such as one that may be both coverage limited and bandwidth limited, may monitor a control channel for CE-RA-RNTI, transmit repeated preambles, combine repetitions of a control channel and/or PDSCH, transmit repeated PUSCH and/or PUCCH, and/or the like.

[0153] The RA-RNTI that may be used for RAR, *e.g.*, CE-RA-RNTI, which may be intended for (*e.g.*, at least for) a coverage limited WTRU, may be determined the same as for legacy WTRUs or may be different or offset from that calculation.

[0154] CE-RA-RNTI may be the same as or different from RA-RNTI. There may be a different CE-RA-RNTI or set of CE-RA-RNTIs for one or more CE levels (*e.g.*, each CE level) that may be supported by an eNB. A CE-RA-RNTI that may be intended (*e.g.*, at least intended) for or monitored for or expected by a certain WTRU may be a function of, for example, one or more of a CE mode (*e.g.*, the CE mode of the WTRU); a CE level (*e.g.*, the CE level of the WTRU); the first or last subframe (*e.g.*, the index of that subframe within a frame) of the preamble transmission (*e.g.*, of the WTRU); the SFN of the frame of the first or last subframe of the preamble transmission (*e.g.*, of the WTRU); the number of repetitions of the preamble (*e.g.*, by the WTRU or that may correspond to the CE mode or CE level of the WTRU); the frequency resource or the index of the frequency resource (*e.g.*, of the set of frequency resources that may be used by certain WTRUs, such as coverage limited WTRUs) of the PRACH or preamble transmission (*e.g.*, of the WTRU); and/or the set of RA-RNTIs.

[0155] For example, the first CE-RA-RNTI may be the first RNTI available after the last RA-RNTI. The first CE-RA-RNTI, *e.g.*, CE-RA-RNTI1, may be (11+10*f_id_max), where f_id_max may be the highest index PRACH in a subframe, *e.g.*, for legacy WTRUs. For example, for FDD, there may be one (*e.g.*, one legacy) PRACH in a subframe, so f_id_max may be 0. For TDD there may be up to six (*e.g.*, six legacy) PRACH configured by the eNB (*e.g.*, with indices 0-5), so f_id_max may be the number of PRACH configured minus 1.

[0156] A CE-RA-RNTI may be a function of the first CE-RA-RNTI, CE-RA-RNTI1, and the first subframe of the preamble transmission or the first PRACH transmission, *e.g.*, t_id where t_id may be an integer from 0 through 9. For example, CE-RA-RNTI may be CE-RA-RNTI1 + t_id.

[0157] CE-RA-RNTI may be CElevel x CE-RA-RNTI1 + t_id, where CElevel may be a value that may correspond to the coverage enhancement level (*e.g.*, a value of 0, 1, or 2 if there may be three coverage enhancement levels) of the WTRU for which the RAR may be intended. No coverage enhancement may or may not be considered a coverage enhancement level.

[0158] CE-RA-RNTI may be CElevel x (1 + t_id+10*f_id).

[0159] A DCI format may not be used for RAR. The PDSCH that may carry the RAR may indicate to the WTRU (*e.g.*, in the contents and/or one or more headers of the PDSCH) whether or not the RAR may include a response that may be intended (*e.g.*, at least intended) for the WTRU, for example, without the need for the WTRU to look for the preamble that it transmitted in the RAR.

[0160] The CRC of the PDSCH that may carry RAR may be scrambled with an RA-RNTI or CE-RA-RNTI or other indication that may correspond to the PRACH that may have been transmitted by a WTRU. The WTRU may discard PDSCH that may carry RAR if the RA-RNTI or CE-RA-RNTI or other indication with which its CRC may be scrambled may not match the one that may correspond to the PRACH transmission of the WTRU. The indication may be a function of one or more of the items described herein of which a CE-RA-RNTI may be a function.

[0161] An RAR may include an indication, such as an RA-RNTI or CE-RA-RNTI, that may assist the WTRU in determining if the RAR may include a response that may be intended for (*e.g.*, at least intended for) it. For example, the indication may be included in a fixed location in the RAR, such as in the MAC header or at the beginning of the RAR. The indication may be a function of one or more of the items described herein of which a CE-RA-RNTI may be a function.

[0162] The WTRU may use the indication to determine if an RAR may be intended (*e.g.*, at least intended) for it. If the WTRU may determine that the RAR may be intended (*e.g.*, at least intended) for it, the WTRU may look for an indication of the preamble that it may have transmitted in the RAR to find the response that may be intended for (*e.g.*, at least intended for) it. If the WTRU may determine that the RAR may not be intended for (*e.g.*, at least intended for) it, the WTRU may discard the RAR and/or may continue to look for an RAR that may include a response that may be intended for (*e.g.*, at least intended for) it.

[0163] A WTRU may monitor for PDSCH that may carry RAR that may be intended for (*e.g.*, at least intended for) the WTRU in a location and/or with one or more parameters that may be known or determined by the WTRU, for example, in accordance with one or more examples disclosed herein. If the WTRU may successfully receive and/or decode the PDSCH, the WTRU may determine whether (or that) the PDSCH may include an RAR and/or whether (or that) the PDSCH may include an RAR that may be intended for (*e.g.*, at least intended for) the WTRU and/or that may include a response (*e.g.*, at least a response) for the WTRU. The WTRU may make the determination based on at least one or more of: whether the RAR may include the

preamble or an indication of the preamble that the WTRU may have transmitted; whether the RAR may include a certain RA-RNTI or CE-RNTI or other indication that may indicate that the RAR may be intended for (or at least intended for) the WTRU. The WTRU may determine that the RAR may be intended for (or at least intended for) the WTRU if the RAR may include the preamble or an indication of the preamble that the WTRU may have transmitted, and/or if the RAR may include a certain RA-RNTI or CE-RNTI or other indication that may indicate that the RAR may be intended for (or at least intended for) the WTRU.

[0164] PRACH subframes may be provided and/or used. For coverage limited WTRUs, the WTRU may repeat the transmission of a preamble a number of times, such as 50 or 100. Given a set of PRACH resources in a (*e.g.*, each) subframe and the large number of repetitions, some rules for preamble selection may result in more collisions with, for example, preamble transmissions of other WTRUs, such as coverage limited or non-coverage limited WTRUs.

[0165] PRACH resources may be defined, for example, in a set of frames such as every frame or every other frame. Certain subframes in those frames may be designated as subframes for PRACH resources. A WTRU may transmit a PRACH preamble and/or may choose a PRACH preamble for transmission in a PRACH subframe.

[0166] A WTRU (*e.g.*, a coverage limited WTRU) may choose a preamble and a PRACH frequency resource, *e.g.*, from a set or pool of such preambles and frequency resources, in one subframe and may repeat that transmission in multiple subframes. If another WTRU may choose a preamble and PRACH frequency resource (*e.g.*, from the same set or pool) in one or more of the subframes in which the first WTRU may transmit its chosen preamble and frequency resource, the opportunities for collision may be increased by the number of repetitions.

[0167] The frames and/or subframes in which PRACH preamble transmission may start (*e.g.*, in which a WTRU may begin PRACH preamble transmission or send a first PRACH preamble transmission before repetitions) may be a reduced set (*e.g.*, a subset) of frames and/or subframes from the full set of frames and/or subframes in which PRACH preambles may be transmitted.

[0168] One or more frames and/or subframes may be designated, allocated, configured (*e.g.*, by an eNB such as by signaling, which may be dedicated or broadcast and/or system information signaling), and/or used as PRACH starting frames and/or subframes.

[0169] One or more PRACH starting frames and/or subframes may be defined, specified, configured (*e.g.*, by an eNB, such as by signaling, such as broadcast signaling and/or system information).

[0170] A starting frame and/or subframe may be a function of a system frame number (SFN).

[0171] A starting frame and/or subframe may be a function of at least one of a PRACH configuration index that may determine or identify one or more of the SFNs (*e.g.*, even or any) in which there may be PRACH resources (*e.g.*, PRACH SFNs), the subframes in each of the PRACH SFNs in which there may be PRACH resources, and/or the preamble format that may be used for transmission.

[0172] A starting frame and/or subframe may be a function of a CE level. A starting frame and/or subframe may be a function of the number of repetitions of the preamble, which may be a function of the CE level. A starting frame and/or subframe may be a function of a configured value (*e.g.*, signaled from the eNB), such as an offset, *e.g.*, a frame offset or subframe offset.

[0173] A starting frame and/or subframe may be a function of a FDD or TDD mode of operation and/or a TDD UL/DL configuration.

[0174] A PRACH starting frame may be a frame (*e.g.*, the first frame) in which a WTRU, such as a coverage limited WTRU, may transmit a certain PRACH preamble (or the first part of a certain PRACH preamble). The certain preamble may be the first preamble of a set of repeated preambles that the WTRU may transmit.

[0175] A PRACH starting subframe may be a subframe (*e.g.*, the first subframe) in which a WTRU such as a coverage limited WTRU, may transmit a PRACH preamble (or the first part of a PRACH preamble). The preamble may be the first preamble of a set of repeated preambles that the WTRU may transmit. A PRACH starting subframe may be in a PRACH starting frame. A PRACH starting subframe may be (or may be identified by) an offset (*e.g.*, in subframes) from the start (*e.g.*, subframe 0) of a PRACH starting frame.

[0176] For example, if a WTRU may (or may only) transmit a preamble beginning in subframe X1 and repeat that preamble in (or beginning in) subframes X2, X3, X4, … Xn, then X1 may be the PRACH starting subframe.

[0177] A WTRU, such as a coverage limited WTRU, may or may only transmit a preamble beginning in a starting PRACH subframe. The WTRU may repeat the preamble N times in (or beginning in) each of a certain N subframes which may be one or more of the next N subframes; the next N subframes that may be available or usable for PRACH transmission (*e.g.*, by the WTRU); the next N PRACH subframes; a designated, allocated, or configured set of N (*e.g.*, next N) subframes or PRACH subframes that may be based on the PRACH starting frame and/or subframe; and/or the same subframe as the starting subframe in one or more (*e.g.*, each) of the next N frames that may include PRACH resources.

[0178] PRACH subframes for CE mode may be the same or different from PRACH subframes for non CE mode use.

[0179] A WTRU that may transmit a preamble beginning in a certain starting PRACH frame and/or subframe, may repeat the preamble N times in (or beginning in) each of a certain N subframes, which may be the next N subframes or PRACH subframes that may be allocated, designated, or configured for the repetitions of a preamble that may have first been transmitted in the certain PRACH starting frame and/or subframe.

[0180] A WTRU, such as a coverage limited WTRU, may or may only select a PRACH resource from available PRACH resources (*e.g.*, preamble and/or frequency) in or for transmission in a PRACH starting frame and/or subframe. A frequency resource may be comprised of one or more RBs or PRBs. The WTRU may use the same resource (*e.g.*, preamble and/or frequency) for one or more (*e.g.*, each) of its (*e.g.*, subsequent N) repetitions of the preamble transmission. A WTRU may not (or may not be able or allowed) to choose a (*e.g.*, a new or another) PRACH resource in a subframe that may not be (or may not be considered to be) a PRACH starting frame and/or subframe. PRACH repetitions (*e.g.*, one or more repetitions) may have or may use different resources (*e.g.*, RBs or PRBs), for example, for frequency diversity. The resources that may be used for the repetitions may be identified (*e.g.*, explicitly), for example, by signaling or may be based on a pattern, such as a frequency hopping pattern.

[0181] A repetition rate of PRACH starting frames, *e,g.*, PFrep may be defined, allocated, or configured (*e.g.*, by an eNB such as by signaling such as dedicated or broadcast signaling and/or system information). A PFrep may be defined, allocated, or configured for CE mode and/or for one or more (*e.g.*, each) CE level, *e.g.*, PFrep(CE level). The PFrep(CE level) values may be the same or different. A PFrep(CE level) value may be a function of the CE level and/or the number repetitions (*e.g.*, preamble repetitions) that may be associated with the CE level.

[0182] PRACH starting frames, may satisfy the equation SFN mod (PFrep) = 0 or SFN mod (PFrep) = frame offset. PRACH starting frames for a CE level may satisfy the equation: SFN mod [PFrep (CE level)] = 0 or SFN mod [PFrep (CE level)] = frame offset.

[0183] PFrep may be a function of the number of repetitions of the PRACH that may be transmitted, for example, for a CE level. PFrep may be the next highest power of 2 from the number of repetitions of the PRACH that may be transmitted, for example for a CE level. For example, for a CE level that may use 50 repetitions, PFrep may be 64. PRrep may be a function of the number of PRACH resources (or available PRACH resources) in a subframe and/or which frames (*e.g.*, any or even) may include PRACH resources. If the number of repetitions may be a power of 2, PFrep may be the number of repetitions of the PRACH which may be transmitted.

[0184] Given a starting frame, starting subframes may be subframes (*e.g.*, certain subframes) within the starting frame and/or subframes (*e.g.*, certain subframes) offset from the start (*e.g.*,

subframe 0) of the starting frame. There may be multiple starting subframes associated with a starting frame. If there may be more than one starting subframe in or associated with a starting frame, a WTRU may choose one that may be designated or configured by the eNB (*e.g.*, for contention free RA) or may choose one randomly. If there may be multiple starting subframes to choose from in or associated with a starting frame, the PRACH resources in the multiple starting subframes may differ in some way such as by preamble(s) and/or frequency resources.

[0185] In an example, starting subframes may repeat every 64 frames and may be offset by 4 frames, *e.g.*, they may satisfy SFN mode 64 = 4. Available PRACH subframes in each frame may be subframes 1 and 3 (*e.g.*, according to a PRACH configuration). In frames that may satisfy SFN mode 64 = 4, a WTRU may select subframe 1 or 3 as a starting subframe, *e.g.*, randomly.

[0186] For a CE level with R repetitions (*e.g.*, preamble repetitions), PRACH starting subframes may be at least R subframes apart.

[0187] PRACH frames may be frames that may include PRACH resources. In an example, the number of repetitions (*e.g.*, preamble repetitions), for example for a CE level, may be R, PRACH frames may occur every F frames, and P subframes may be available per PRACH frame that may include PRACH. PRACH starting subframes, *e.g.*, for a CE level, may be based on or a function of at least one of R, F, and P. PRACH starting subframes may be at least CEIL [(R x F)/P] subframes apart. For example, for R = 100, P = 3, and F = 2, PRACH starting subframes may be at least CEIL [(R x F)/P] = CEIL [(100 x 2)/3] = 67 subframes apart. PRACH starting subframes may be apart by a function of CEIL [(R x F)/P]. For example, PRACH starting subframes may be apart by the next multiple of 10 subframes (*e.g.*, apart by the closest multiple of 10 greater than or equal to CEIL [(R x F)/P]) (*e.g.*, 70 subframes apart for R=100, P=3, and F=2). In another example, PRACH subframes may be apart by the next power of 2 subframes (e.g., apart by the closest power of 2 greater than or equal to CEIL [(R x F)/P]) (*e.g.*, 128 subframes apart for R=100, P=3, and F=2). In another example, PRACH subframes may be apart by the next multiple of a certain number of frames (e.g., apart by the closest multiple of the certain number greater than or equal to CEIL [(R x F)/P]). For example, the certain number of frames may be 4 frames or 40 ms and for R=100, P=3, and F=2, CEIL [(R x F)/P] = 67 and the PRACH subframes may be the next multiple of 40ms greater than 67 apart (*e.g.*, 80 ms apart).

[0188] A PRACH configuration index may indicate which frames and/or subframes may and/or may not include PRACH resources. One or more PRACH configuration indices may be provided for CE mode, *e.g.*, one may be provided for each CE level or one may be used for all

CE levels. The legacy PRACH configuration index may be used for CE mode or may be the default if a CE specific value may not be provided.

[0189] Certain preambles or sets of preambles may (*e.g.*, may only) be configured and/or used, *e.g.*, for PRACH transmission, in certain subframes or sets of subframes. Certain frequency resources or sets of frequency resources may (*e.g.*, may only) be configured and/or used, *e.g.*, for PRACH transmission, in certain subframes or sets of subframes. Allocations and/or usage such as these may enable or facilitate multiple starting subframes in the same frame.

[0190] RAR may be provided in reduced bandwidth, *e.g.*, for at least bandwidth limited WTRUs. For RAR that may be intended (or at least intended) for bandwidth limited WTRUs, if the PDSCH that may carry the RAR may be located in RBs, such as the center 6 RBs of the band, special handling may be used in some subframes, *e.g.*, subframes that may carry synchronization channels (*e.g.*, PSS and/or SSS) and/or a physical broadcast channel (PBCH).

[0191] In subframes that may carry PSS and/or SSS, transmission (*e.g.*, by the eNB) of a channel (*e.g.*, EPDCCH and/or PDSCH, for example, a PDSCH that may carry an RAR) that may be located in RBs that may include PSS and/or SSS, may not use the resource elements (REs) that may include the PSS and/or SSS signals. Not using certain REs may involve omitting transmitting in those REs. Not using certain REs may involve rate matching around those REs.

[0192] If the transmission of a channel (*e.g.*, a PDSCH that may carry RAR) may rate match around certain REs, such as REs that may include PSS and/or SSS, a WTRU that may receive or attempt to receive that channel may account for the rate matching in its reception and/or decoding of the channel.

[0193] Subframes that may carry PBCH may not be used for transmission and/or reception of PDSCH that may carry RAR for certain WTRUs, such as limited bandwidth WTRUs and/or coverage limited WTRUs. An eNB may not transmit RAR (and/or a repeated RAR) intended for a WTRU (*e.g.*, for a certain WTRU such as one that may be a limited bandwidth WTRU and/or a coverage limited WTRU) in a subframe that may carry PBCH. A WTRU (*e.g.*, one that may be bandwidth limited and/or coverage limited) may not monitor a subframe that may carry PBCH for EPDCCH. The RAR window size may exclude PBCH subframes from counting or consideration. A PBCH subframe may be a subframe that may not be used for RAR for at least some WTRUs, such as WTRUs that may be bandwidth limited and/or coverage limited.

[0194] An RAR message size may be reduced and/or limited in size (*e.g.*, compact RAR), for example, for RAR that may be intended for certain WTRUs such as bandwidth limited WTRUs and/or coverage limited WTRUs.

[0195] The size may be reduced by reducing or eliminating elements in the RAR that may relate to the UL grant for message 3 of the RA procedure.

[0196] A limited bandwidth WTRU and/or a coverage limited WTRU may or may only be able to transmit in (or within) a bandwidth that may include a certain RF bandwidth and/or a certain number of RBs. RA message 3, which may be in response to an RAR and/or which may include an RRC connection request message, may be or may need to be allocated resources and/or transmitted in (or within) that bandwidth (BW).

[0197] Since, for example, the possible locations for the transmission of message 3 may be limited (*e.g.*, to 6 RBs), one or more UL grant parameters may be reduced (*e.g.*, to fewer bits) or may be eliminated.

[0198] In an example, one or more UL resources may be predefined and/or configured. One or more of these UL resources may be dynamically selected (*e.g.*, by an index), *e.g.*, by the RAR, for use for UL transmission (*e.g.*, for message 3). This may enable reduction in the size of the UL grant. The WTRU may use this selected resource for UL transmission, *e.g.*, of message 3.

[0199] A WTRU may set its UL power, for example, after a random access (RA) procedure. WTRU transmit power for an UL channel, *e.g.*, a PUSCH, may include an open loop component and/or a closed loop component. The WTRU transmit power for the UL channel may be limited (*e.g.*, by the WTRU) to the WTRU maximum power, *e.g.*, the WTRU configured maximum output power. The open loop component may be at least a function of one or more of: the transmission bandwidth or number of resource blocks to be transmitted, pathloss, and/or one or more configured values. The closed loop component may be a function of transmit power control commands that may be received by the WTRU, *e.g.*, from an eNB. WTRU transmit power for an UL channel, *e.g.*, a PUSCH, may be or may also be a function of the power ramping performed by the WTRU during a random access (RA) procedure, such as an initial RA procedure (e.g., for RRC connection establishment) and/or a contention based RA procedure.

[0200] An example setting for WTRU transmit power for a UL channel, such as a PUSCH transmission, may be as follows for subframe i and serving cell c:

$$P_{PUSCH,c}(i) = min\begin{cases} P_{CMAX,c}(i), \\ 10\log_{10}\left(M_{PUSCH,c}(i)\right) + P_{O_PUSCH,c}(j) + \alpha_c(j)\cdot PL_c + \Delta_{TF,c}(i) + f_c(i) \end{cases}$$

and the value may be in dBm.

[0201] $P_{CMAX,c}$ may be the WTRU configured maximum output power. $M_{PUSCH,c}$ may be the number of resource blocks granted or allowed for the transmission. $P_{O_PUSCH,c}$ may be a configured value or a sum of configured values. α may be a configured value. PL may be the pathloss. $\Delta_{TF,c}$ may be an adjustment factor that may relate to the use of MIMO or the use of one

or more antennas. f_c may be a correction value, *e.g.*, a sum of a starting correction value, $f_c(0)$ and one or more other correction values that may correspond to transmit power control (TPC) commands that the WTRU may receive or may have received, *e.g.*, from an eNB. The starting correction value may be a function of an RA procedure power ramping. Inclusion of the effects of power ramping in the correction value that accumulates TPC commands may be by way of illustration and not limitation. The impact of RA power ramping on the power setting may be separate from the TPC commands. Adjustment for TPC commands may be omitted from the power setting.

[0202] If a WTRU does not perform power ramping during the RA procedure, *e.g.*, if the WTRU may transmit at maximum power or may always transmit at maximum power, *e.g.*, $P_{CMAX,c}$ for the PRACH power, the value to use for $f_c(0)$ and/or the initial power for an UL channel, such as PUSCH, may be undefined. An UL transmission may be or may include one or more of a PUSCH, PUCCH, and SRS. PUSCH may be a non-limiting example of an UL channel or transmission. Another UL channel or transmission, such as PUCCH or SRS, may be used consistently with the subject matter disclosed herein.

[0203] A random access response (RAR) may include one or more parameters that the WTRU may use to determine the value of $f_c(0)$ and/or its UL power setting for one or more channels, *e.g.*, for PUSCH. A UL transmission, *e.g.*, the first UL transmission, that a WTRU may make, *e.g.*, on a PUSCH, following PRACH preamble transmission may be message 3 of the RA procedure, which may be or may include an RRC connection (*e.g.*, RRC connection establishment) request. An RAR, *e.g.*, the RAR in which the WTRU may receive the grant for resources for message 3, may include an indication of an initial power to use for the PUSCH transmission. The RAR may include one or more parameters from which the initial power to use for the PUSCH transmission may be determined. The RAR may include the starting correction value $f_c(0)$ for the PUSCH transmission. The RAR may include a coverage enhancement (CE) level for PUSCH and/or one or more other subsequent UL and/or DL transmissions for the WTRU. The RAR may include a number of repetitions or a value or index that corresponds to a number of repetitions to use for PUSCH and/or one or more other subsequent UL and/or DL transmissions for the WTRU. The RAR may include a power offset or delta, *e.g.*, to subtract from the maximum power to determine the PUSCH power.

[0204] A WTRU may determine its UL power and/or UL repetitions, *e.g.*, PUSCH power and/or PUSCH repetitions, according to one or more of the parameters or values included in the RAR and may transmit according to the determined power and/or repetitions.

[0205] For example, the WTRU may determine its initial and/or subsequent PUSCH power based on a starting correction value $f_c(0)$ or a power offset that may be included in the RAR and may transmit PUSCH using the determined power.

[0206] The WTRU may determine UL power, for example, according to:

$$P_{PUSCH,c(i)} = min\left[P_{CMAX,c}(i), openlooppower(i) + f_c(i)\right]$$

[0207] The WTRU may use a value of $f_c(0)$ that it may have received in the RAR. The open loop power may be a function of the CE level, which may correspond to the CE level of the RA procedure for which the WTRU successfully received an RAR or the CE level that the WTRU received in the RAR. The open loop power may be a function of the number of PRACH repetitions for which the WTRU successfully received an RAR or the number of repetitions that the WTRU received in the RAR. A closed loop component may not be present, *e.g.*, $f_c(i)$ may be 0 or nonexistent for $i > 0$ or $i >= 0$. The closed loop component, if present, may be a function of the CE level or repetitions that may be updated, *e.g.*, dynamically.

[0208] The WTRU may transmit or may always transmit PUSCH at maximum power, *e.g.*, $P_{CMAX,c}$ or $P_{CMAX,c(i)}$. The WTRU may use a number of repetitions or a CE level that may be provided in the RAR for transmission of a channel such as PUSCH, for example, to account or compensate for the use of maximum power when the repetitions are combined at the receiver. For example, the open loop and/or closed loop part of the power control calculation may be a function of the CE level or the number of repetitions for the transmission of the UL channel, which may be included or indicated in the RAR.

[0209] The WTRU may set its PUSCH power (*e.g.*, initial PUSCH power) according to an initial value included in the RAR. The WTRU may reduce its power from maximum by at least a delta or offset provided in the RAR. The WTRU may determine UL power according to, for example:

$$P_{PUSCH,c}(i) = \min[P_{CMAX,c}(i), PUSCH_{initial} + closedlooppower(i)]$$

or

$$P_{PUSCH,c}(i) = \min[P_{CMAX,c}(i), P_{CMAX,c}(i) - \Delta + closedlooppower(i)]$$

[0210] There may be no closed loop component, *e.g.*, closedlooppower(i) may be 0. The initial closed loop value may be zero or the delta may be included in the closed loop value. The closed loop component may be a function of TPC commands, *e.g.*, accumulated TPC commands. The closed loop component may be a function of CE level or repetitions that may be the CE level or repetitions used for the RA procedure (*e.g.*, the successful RA procedure) and/or the CE level

or repetitions included in the RAR. The closed loop component and/or the CE level or repetitions that may impact the closed loop component may be updated, *e.g.*, dynamically.

[0211] One or more values not indicated as a function of subframe or TTI, *e.g.*, i, may be a function of subframe or TTI and may be consistent with the subject matter disclosed herein. For example, $P_{CMAX,c}$ and $P_{CMAX,c}(i)$ may be used interchangeably.

[0212] One or more values indicated as a function of subframe or TTI, *e.g.*, i, may not be a function of subframe or TTI and may be consistent with the subject matter disclosed herein.

[0213] The initial PUSCH power setting may be $P_{CMAX,c}$. The WTRU may determine the initial closed loop value or adjustment value, *e.g.*, $f_c(0)$, to be the value that may make the PUSCH value equal to $P_{CMAX,c}$.

[0214] For example, $P_{PUSCH,c}(i)$ may be determined by:

$$P_{PUSCH,c}(i) = openlooppower(i) + f_C(i)$$

or

$$P_{PUSCH,c}(i) = \min[P_{CMAX,c}(i), openlooppower(i) + f_c(i)]$$

[0215] The WTRU may determine (*e.g.*, may first determine) the initial PUSCH power based on no power ramp-up, *e.g.*, $P_{PUSCH\text{-}noramp}$. $P_{PUSCH\text{-}noramp}$ may be the value of openlooppower(0). The value of openlooppower(0) may be or may be set to $P_{PUSCH\text{-}noramp}$.. The WTRU may determine $f_c(0)$ according to the following: $f_c(0) = \max(0, P_{CMAX,c} - P_{PUSCH-noramp})$.

[0216] With this starting value of f_c, the starting value of the PUSCH power may be $P_{CMAX,c}$. The value of f_c may be adjusted by TPC commands and/or adjustments to CE level or repetitions. The value of $f_c(0)$ may be adjusted or may also be adjusted by a parameter provided in the RAR, such as a TPC command indicated in the RAR, *e.g.*, delta_msg2. $P_{PUSCH\text{-}noramp}$ may include the effects of a TPC command indicated in the RAR.

[0217] $f_c(0)$ may be determined according to the following:

$$f_c(0) = delta\ P_{rampup,c} + delta_msg2, c$$

where delta_msg2,c may be a TPC command indicated in the RAR.

[0218] The value of delta $P_{rampup,c}$ may be determined according to:

$$\begin{aligned} delta\ P_{rampup,c} \\ &= \max[0, P_{CMAX,c} - (10 \\ &\cdot log_{10}(M_{PUSCH,c}(0) + P0_{PUSCH,c}(2) + delta_{msg2}, c + alpha, c(2) \cdot PL \\ &+ deltaTF, c(0) + CL)] \end{aligned}$$

where $M_{PUSCH,c}(0)$ may be the bandwidth of the PUSCH resource assignment expressed as a number of resource blocks valid for the subframe of the first PUSCH transmission in the serving cell c, and deltaTF,c(0) may be a power adjustment of first PUSCH transmission in the serving cell c. $P0_{PUSCH,c}(2)$ may equal the initial preamble power, *e.g.*, preambleInitialReceivedTargetPower, which may be configured by higher layers plus a message3 delta power value that may be configured by higher layers. CL may be an adjustment to compensate for the CE level or the number of repetitions for the PUSCH transmission, which may be included or indicated in the RAR. One or more of the elements of the above equation may be 0 or not included. The message3 delta power may be 0 or not exist.

[0219] The equation above may (*e.g.*, in effect) correspond to a delta $P_{rampup,c}$ value that may result in the initial power being maximum power. $f_c(0)$ and/or delta $P_{rampup,c}$ may be zero.

[0220] The WTRU may use the CE level and/or number of repetitions that it uses for the successful PRACH preamble transmission or transmissions, *e.g.*, the CE level and/or number of repetitions for which the WTRU successfully receives an RAR, as the CE level and/or number of repetitions for a PUSCH transmission, *e.g.*, the first PUSCH transmission, which may correspond to message 3 of the RA procedure.

[0221] A transmission power, such as an initial power, may be associated with a CE level or number of repetitions. This transmission power may be configured, for example, by signaling such as broadcast or higher layer signaling. The WTRU may set the PUSCH power (*e.g.*, the initial PUSCH power or message 3 PUSCH power) to this value and/or may set the PUSCH using or at this power. The power may be a minimum power for a CE level.

[0222] A CE level or number of repetitions may be updated. UL grants and/or TPC commands may include adjustments that may be applied to future UL transmissions and/or to future UL transmit power determinations. For example, an UL grant or TPC command may include a CE level or number of repetitions to use for an upcoming UL transmission. The WTRU may transmit, *e.g.*, may always transmit, the PUSCH at maximum power or may adjust the transmit power based on an open loop component and/or a closed loop component. The WTRU may transmit the PUSCH with a number of repetitions that may be provided with or separately from an UL grant or a TPC command. The WTRU may transmit the PUSCH with a number of repetitions that may correspond to a CE level that may be provided with or separately from an UL grant or a TPC command.

[0223] If the grant or TPC command corresponds to an UL transmission in subframe X or an UL transmission that may begin in subframe X, the WTRU may use the indicated CE level, repetitions, or power adjustment (*e.g.*, to increase or decrease the power) for the UL transmission

in subframe X or for the UL transmission that may begin in subframe X. The TPC command or UL grant may be repeated (*e.g.*, by the eNB) and/or received (*e.g.*, by the WTRU) in a set of subframes that may correspond to UL transmission by the WTRU in subframe X or to UL transmission that may begin in subframe X.

[0224] PUSCH power may be ramped. For example, the WTRU may ramp its PUSCH power if it has not received an ACK from the eNB for a number of PUSCH transmissions. This number may be configured, for example, by the eNB. The WTRU may increase its power by a certain delta value based on a number of unsuccessful transmissions, which may be determined based on the lack of receipt of ACK for the transmissions. The delta value may be configured, for example, by the eNB. The number of unsuccessful transmissions and/or the delta value may be a function of the CE level and/or the number of repetitions. The power may be increased for one or more retransmissions, *e.g.*, each of the retransmissions. The transmission power may not be increased above the maximum power. Increases to the power may be stopped when the maximum power is reached or when an increase would cause the power to exceed the maximum power.

[0225] One or more of the examples disclosed herein for an UL channel or transmission may be applicable to a downlink (DL) channel or transmission. For example, the examples disclosed herein in the context of UL grants may be applicable to DL grants, consistent with the subject matter disclosed herein. For example, a CE level or a number of repetitions to use for PDSCH reception or PUCCH transmission may be included in a DL grant.

[0226] Successful reception of an RAR may be or may include reception of an RAR that may be intended for the WTRU. Transmission of a PRACH or preamble may include transmission of repetitions of a PRACH or preamble. For purposes of illustration and description, PRACH and preamble may be used interchangeably.

[0227] A random access (RA) or RA procedure may be requested or initiated, for example, by a PDCCH order. For example, a WTRU may receive a request or indication, *e.g.*, from an eNB, to perform or initiate an RA or RA procedure. The request or indication may be or may be included in a PDCCH order that may be transmitted in a PDCCH region, for example, in a downlink control information (DCI). A WTRU, such as a low cost or reduced capability WTRU, may not be able to receive a PDCCH in a PDCCH region, *e.g.*, due to a limited capability (*e.g.*, reduced bandwidth and/or limited coverage). PDCCH order in a PDCCH region may not be supported for or by some WTRUs, such as low cost or reduced capability WTRUs or WTRUs that may not be able to receive a PDCCH in a PDCCH region.

[0228] PDCCH order is disclosed by way of example only and not limitation. Another request to perform or initiate an RA or RA procedure may be used and may still be consistent with this disclosure. For example, an RA request may be substituted for a PDCCH order and may still be consistent with this disclosure.

[0229] PDCCH order, M-PDCCH carrying PDCCH order, a DCI that may request or initiate contention-free (or contention-based) RA, a DCI carrying one or more PDCCH orders, and a DCI that may request or initiate RA may be used interchangeably herein.

[0230] CE level, number of repetitions, and repetition number may be substituted for each other and may still be consistent with this disclosure.

[0231] An RA procedure may be initiated on an individual basis or on a group basis. A DCI or PDCCH order or RA request that may indicate (or initiate) an RA, *e.g.*, a contention-free or contention-based RA, may be transmitted via an M-PDCCH. An M-PDCCH may be a downlink control channel that may be monitored and/or received by a WTRU, such as a low cost or reduced capability WTRU.

[0232] For purposes of description and explanation, RA may be replaced with RA procedure, and *vice versa*, and may still be consistent with the examples disclosed herein.

[0233] A DCI, such as a group DCI, may be used to initiate RA for one or more WTRUs. A DCI may include one or more PDCCH orders that may request or initiate an RA or RA procedure for one or more WTRUs. A PDCCH order may be associated with a WTRU. A PDCCH order may be associated with multiple WTRUs. If a PDCCH order requests or initiates RA, WTRUs associated with that PDCCH order (*e.g.*, WTRUs that receive that PDCCH order) may transmit a PRACH preamble, *e.g.*, a selected or assigned PRACH preamble. The assigned PRACH preamble may be configured, *e.g.*, by the eNB, such as by higher layer signaling. For example, a WTRU may be configured with a PRACH preamble for a contention-free RA via higher layer signaling. The PRACH preamble configured via higher layer signaling may be considered as a WTRU-specific PRACH preamble for contention-free RA. The assigned PRACH preamble may be indicated in or with the PDCCH order. A separate PRACH preamble may be indicated for a WTRU (*e.g.*, each WTRU) for which the PDCCH order is intended (or may be intended).

[0234] A PDCCH order may be used to initiate random access for multiple WTRUs, *e.g.*, individually. An eNB may indicate the random access initiation for a WTRU in a WTRU group that may monitor the same PDCCH order. For example, a bit field may include N bits that may be associated with N WTRUs, *e.g.*, in a group. A bit (*e.g.*, each bit) may indicate random access (e.g., a request to initiate random access) or not (*e.g.*, 0 for no initiation of RA, 1 for initiation of

RA). A WTRU (*e.g.*, each WTRU) may be indicated or configured with a bit location (*e.g.*, in the bit field) associated with or in the PDCCH order. A PRACH preamble for the PDCCH order may be configured via higher layer signaling for a WTRU (*e.g.*, each WTRU). A PRACH preamble index corresponding to each bit in the bit field for RA initiation may be transmitted in the PDCCH order.

[0235] Two or more PDCCH orders may be transmitted in a DCI. A (*e.g.*, each) PDCCH order may be associated with a WTRU.

[0236] A DCI or PDCCH may include information for initiating an RA procedure for one or more WTRUs. At least some of the information may be included separately for a WTRU (*e.g.*, each WTRU) for which the PDCCH order may be intended. At least some of the information may be common to one or more WTRUs (*e.g.*, all of the WTRUs) for which the PDCCH order may be intended.

[0237] A DCI or PDCCH order that may initiate an RA procedure may include a PRACH preamble index. A DCI or PDCCH order that may initiate an RA procedure may include a PRACH mask index and/or time resources for the PRACH transmission. A DCI or PDCCH order that may initiate an RA procedure may include a CE level and/or repetition number. A DCI or PDCCH order that may initiate an RA procedure may include a transmission (e.g., power) level and/or power level type (*e.g.*, maximum power or based on DL measurement). A DCI or PDCCH order that may initiate an RA procedure may include frequency resources (*e.g.*, a set of PRBs) for the PRACH transmission.. A DCI or PDCCH order that may initiate an RA procedure may include an on/off indicator (*e.g.*, on to initiate RA, or off for no initiation of RA)..

[0238] A DCI that may carry one or more PDCCH orders may be scrambled with an RNTI, *e.g.*, its CRC may be scrambled with an RNTI. A WTRU may be configured with and/or use one or more RNTIs, such as a WTRU-specific RNTI (*e.g.*, a C-RNTI). The WTRU may use the one or more RNTIs to determine whether a DCI is intended for it.

[0239] An RNTI may be used for the DCI carrying one or more PDCCH orders. The RNTI may be WTRU-specific. The RNTI may be a group RNTI or a common RNTI, such as one that may be used by multiple WTRUs. The RNTI may be referred to as a PDCCH order RNTI. The RNTI may or may not be specific to DCIs carrying one or more PDCCH orders.

[0240] For a WTRU, the PDCCH order RNTI may be the WTRU's C-RNTI. A PDCCH order may be transmitted in a WTRU-specific DCI, which may use C-RNTI.

[0241] The PDCCH order RNTI may be or may be determined as a function of at least one of a WTRU-ID (*e.g.*, C-RNTI), a CE level, and/or a PRACH preamble index. One or more of a C-RNTI, a CE level, and/or a PRACH preamble index may be configured via higher layers.

[0242] The PDCCH order RNTI may be or may be determined as a function of the PRACH preamble and/or resource that may be used for a contention-based RA procedure. For example, the PDCCH order RNTI may be a function of a recent (*e.g.*, the most recent) PRACH preamble and/or PRACH resource that the WTRU used (*e.g.*, successfully) for RRC connection establishment. The PDCCH order RNTI may be a function of a recent (*e.g.*, the most recent) PRACH preamble and/or PRACH resource that the WTRU used (*e.g.*, successfully) for a PDCCH-initiated RA procedure (*e.g.*, a contention-based RA procedure).

[0243] The PDCCH order RNTI may be or may be determined as a function of the time and/or frequency location of the RAR associated with a recent (*e.g.*, the most recent) PRACH preamble and/or PRACH resource that the WTRU used (*e.g.*, successfully) for a contention-based RA procedure (*e.g.*, for RRC connection establishment or PDCCH order initiated). The PDCCH order RNTI may be indicated via higher layers.

[0244] The time and/or frequency location in which a WTRU may monitor PDCCH order may be determined as a function of the PDCCH order RNTI.

[0245] An indication may be used to determine whether a DCI is intended to be used for the scheduling of unicast traffic (*e.g.*, PUSCH/PDSCH) or whether the DCI is intended to be used for a PDCCH order. The indication may be a bit field in the DCI. The indication may be based on the RNTI used for the DCI. A combination of two or more bit field conditions may be used as an indication. The search space of M-PDCCH may be used as an indication.

[0246] A WTRU may transmit PRACH in response to RA procedure initiation, for example, by PDCCH order.

[0247] A WTRU may monitor a search space such as M-PDCCH search space for DCI scrambled (*e.g.*, for DCI with CRC scrambled) with PDCCH order RNTI. A WTRU may receive and/or successfully decode DCI scrambled with PDCCH order RNTI.

[0248] A DCI scrambled with an RNTI may be the same as or may be used to represent a DCI with a CRC scrambled with an RNTI.

[0249] Upon receipt or in response to receipt of the DCI, the WTRU may initiate a RA or RA procedure.

[0250] The WTRU may transmit a PRACH based on information included in the PDCCH order carried by the DCI and/or configured information.

[0251] The WTRU may determine, for example from this information, one or more of (i) the PRACH preamble, (ii) the CE level and/or number of repetitions to use for the preamble transmission and/or the RA procedure, and/or (iii) the time and/or frequency resources for the preamble transmission.

[0252] The WTRU may transmit the determined preamble in the determined time and/or frequency resources with the determined CE level or number of repetitions. For example, the WTRU may transmit the PRACH (or preamble) with or using the CE level or number of repetitions indicated in or by the PDCCH order. The WTRU may transmit the PRACH (or preamble) with or using the CE level or number of repetitions configured via higher layer signaling, for example for contention-free or PDCCH order initiated RA.

[0253] The WTRU may transmit the PRACH (or preamble) with or using its current CE level, which may be the CE level of a recent (*e.g.*, its most recent) successful RA procedure.

[0254] The WTRU may transmit the PRACH (or preamble) with or using the CE level or number of repetitions corresponding to (or determined from or according to) the CE level or number of repetitions of a previous (*e.g.*, previous successful) RA procedure. The previous RA procedure may be a most recent (*e.g.*, most recent successful) contention-based (or contention-free) RA procedure. The previous RA procedure may be the most recent (*e.g.*, most recent successful) contention-based (or contention-free) RA procedure for RRC connection establishment or that was initiated by PDCCH order.

[0255] A successful RA procedure may be one for which the WTRU successfully received an RAR (*e.g.*, successfully received an RAR which it determined was intended for it).

[0256] The CE level that the WTRU may use for the PDCCH order indicated RA procedure may be determined, *e.g.*, by the WTRU, based on a prior RA (*e.g.*, a prior contention-based RA). For example, the CE level may be determined based on the PRACH resource associated with the latest (*e.g.*, most recent) RAR the WTRU received successfully.

[0257] The WTRU may transmit a preamble indicated in the PDCCH order. The WTRU may transmit a preamble configured by higher layers for contention-free or PDCCH order requested RA.

[0258] The WTRU may transmit the PRACH with the power level or type (*e.g.*, maximum power or based on DL measurement) indicated in or by the PDCCH order. The WTRU may transmit the PRACH with the power level or type configured by higher layers. If measurement based power is used, the WTRU may ramp the power and try again if an RAR is not successfully received.

[0259] The WTRU may transmit the PRACH in time and/or frequency resources according to the PRACH mask index indicated in or by the PDCCH order and/or a PRACH mask index configured by higher layers.

[0260] The WTRU may transmit the PRACH in time and/or frequency resources (*e.g.*, PRBs) indicated in or by the PDCCH order.

[0261] The WTRU may transmit the PRACH in time and/or frequency resources configured by higher layers for RACH or contention-free RACH, for example, for the CE level the WTRU may be using for the PRACH transmission.

[0262] A PDCCH order indicated or initiated RA or RA procedure may be an RA or RA procedure indicated, requested, and/or initiated by a DCI and/or PDCCH order, *e.g.*, by an eNB.

[0263] The CE level (or number of repetitions) that the WTRU may use for the PDCCH order indicated RA procedure may be or may be based on the CE level (or number of repetitions) used for the M-PDCCH carrying the PDCCH order. For example, the CE level (or number of repetitions) may be based on (*e.g.*, equal to) the number of repetitions used for M-PDCCH. The CE level (or number of repetitions) may be based on the number of total aggregation levels used for M-PDCCH, which may be referred to as the number of (E)CCEs used over subframes for repetitions.

[0264] If the WTRU does not successfully receive an RAR in response to a preamble it transmitted, the WTRU may try again, for example, until an RAR is successfully received or the maximum number of tries has been reached or exceeded.

[0265] The WTRU may use the same CE level for one or more (*e.g.*, all) preamble transmission attempts, for example for PDCCH order initiated RA. The WTRU may try different CE levels (*e.g.*, successively higher CE levels) and the starting CE level for the RA procedure may be or may be based on the CE level used for the M-PDCCH carrying the PDCCH order.

[0266] Starting CE level and CE level may be substituted for each other and still be consistent with this disclosure.

[0267] Techniques for handling DCI formats, *e.g.*, carrying PDCCH order, with coverage enhancement may be provided and/or used.

[0268] A PDCCH order (*e.g.*, a DCI carrying one or more PDCCH orders) may be transmitted repetitively. For example, a PDCCH order may be transmitted Nrep times (*e.g.*, in or in each of Nrep subframes or TTIs), where Nrep may be the number of repetitions. Nrep may be determined based on the CE level of the WTRU or WTRUs for which the PDCCH order or orders are intended. For example, Nrep may correspond to the CE level of the WTRU (*e.g.*, among the WTRUs for which the PDCCH order or orders may be intended) needing the most coverage enhancement. Nrep may be determined as a function of a group RNTI used for the DCI carrying one or more PDCCH orders. Nrep may be a value configured or provided by high layers and may be specific to a DCI carrying PDCCH order or may be common with the repetition number for other DCIs such as all DCIs

[0269] One or more (*e.g.*, all) DCI formats may have a repetition number, *e.g.*, a number of repetitions, associated with it or them. The repetition number may be configured, for example, in a WTRU-specific manner or cell-specific manner (*e.g.*, broadcast such as in system information). A WTRU may use a DCI format's repetition number (*e.g.*, configured repetition number) to receive or attempt to receive and/or decode that DCI format, for example, regardless of a CE level being used by a WTRU for other purposes, *e.g.*, for data transmission and/or reception. DCI and DCI format may be substituted for each other and still be consistent with this disclosure.

[0270] The number of repetitions of a DCI format may be a function of the maximum number of bits the DCI format may carry.

[0271] The number of repetitions of a DCI format may be a function of the maximum CE level supported by the eNB or cell that may transmit the DCI format.

[0272] The number of repetitions of a DCI format may be a function of the maximum CE level supported for the DCI format by the eNB or cell that may transmit the DCI format.

[0273] CE level use and/or support may be different for different DCI formats, *e.g.*, for an eNB or cell. Maximum CE level use and/or support may be different for different DCI formats, *e.g.*, for an eNB or cell.

[0274] If a WTRU receives a PDCCH order with repetitions and the last (or first) subframe of the repetitions is subframe n, the WTRU may transmit a PRACH preamble in the first PRACH resource (or the first PRACH resource available for the indicated PRACH preamble transmission) in subframe n+k3 or later where k3 may be at least one of following: (i) a fixed positive integer number such as 6, (ii) a positive integer number determined as a function of a CE level (or Nrep) such as the number of repetitions plus a fixed integer, and/or (iii) a configured number provided via higher layer signaling.

[0275] For a PDCCH order transmitted with Nrep repetitions, the WTRU may successfully receive the PDCCH order using fewer than Nrep repetitions, *e.g.*, Nue repetitions. The reference subframe n for determining the start of the preamble transmission may be the last subframe (or a subframe relative to the last subframe) of the Nrep repetitions or the Nue repetitions.

[0276] A PDCCH order to initiate a RA procedure may (or may only) be supported in a subset of CE levels. A WTRU and/or eNB may support two or more CE levels which may include normal coverage (*e.g.*, CE level-0) and one or more enhanced coverage levels (*e.g.*, CE level-1, 2, 3), for example for data transmission and reception. PDCCH order may (or may only) be used for a subset of the CE levels. For exemplary purposes, lower number CE levels may correspond to lower coverage enhancement, *e.g.*, fewer repetitions.

[0277] The PDCCH order may (or may only) be used for and/or by a WTRU in a normal coverage (*e.g.*, CE level-0). The PDCCH order may (or may only) be used for and/or by a WTRU in a normal coverage without bandwidth limitation.

[0278] The PDCCH order, *e.g.*, to initiate RA procedure, may be used for or by a WTRU in some coverage enhancement levels, but not in other coverage enhancement levels.

[0279] For example, the PDCCH order may be used for a WTRU in a low coverage enhancement level (*e.g.*, CE level-1 or CE level-1 and CE level-2). PDCCH order may not be used if a WTRU is in a high coverage enhancement level (*e.g.*, CE level-3 or CE level-2 and CE level-3). A WTRU in a low coverage enhancement level may monitor for and/or respond to a PDCCH order. A WTRU in a high coverage enhancement level may not monitor for and/or respond to a PDCCH order. Low coverage enhancement may be substituted for high coverage enhancement and vice versa and still be consistent with this disclosure.

[0280] The CE level or levels supported (*e.g.*, by the eNB and/or WTRU) for PDCCH order may be predefined, configured, or known. For example, configuration of the CE level, CE levels, or highest CE level supported by the eNB and/or expected to be supported by a WTRU for PDCCH order may be provided via higher layer signaling (*e.g.*, by the eNB) such as via system information, which may be broadcast. A WTRU may monitor for and/or respond to a PDCCH order while in or using a CE level supported or expected to be supported for PDCCH order. A WTRU may not monitor for and/or respond to a PDCCH order while in or using a CE level not supported or expected to be supported for PDCCH order.

[0281] The limit of PDCCH order to a subset of CE levels may be (or may only be) for PDCCH order which initiates contention-free RA. PDCCH order which initiates contention-based RA may be applicable at a larger set of (*e.g.*, all) CE levels supported, *e.g.*, by the eNB.

[0282] If a WTRU receives a PDCCH order indicating a contention-free RA procedure at a CE level not supported (*e.g.*, by the eNB or the WTRU) for contention-free RA, the WTRU may initiate a contention-based RA procedure.

[0283] A RA procedure may be used for CE level change.

[0284] An indication may be transmitted to initiate a RA procedure, which may be a contention-based or contention-free RA procedure. The indication may be transmitted in a PDCCH order. The PDCCH order may be used to change the CE level of the WTRU (*e.g.*, to a level such as a lower level which may need or use fewer repetitions or to a higher level which may need or use more repetitions).

[0285] In an example, a WTRU may receive a PDCCH order that may initiate a contention-based (or contention-free) RA procedure. In response, the WTRU may perform a contention-based (or contention-free) RA procedure.

[0286] The WTRU may perform the same (or a similar) RA procedure as for RRC connection establishment, *e.g.*, for initial access.

[0287] The WTRU may perform the same (or a similar) RA procedure as for RRC connection establishment, *e.g.*, for initial access, except for one or more aspects such as the starting CE level determination.

[0288] The starting CE level for a RA procedure (*e.g.*, a contention-based RA procedure) that may be initiated by a PDCCH order may be indicated in the PDCCH order.

[0289] The WTRU may begin with a starting CE level, and may transmit a preamble using that level (*e.g.*, with the repetitions corresponding to that level). If the WTRU does not successfully receive an RAR, the WTRU may try again using a higher (*e.g.*, next higher) CE level. The WTRU may try at each successively higher CE level until an RAR is successfully received or the RA procedure has failed at the highest CE level supported by the cell and/or the WTRU. Multiple tries at each level may be performed before going to the next higher level. Tries at the same level may be at increasingly higher power.

[0290] For the starting CE level, the WTRU may use the starting CE level provided in the PDCCH order or choose one autonomously, such as based on a DL measurement (*e.g.*, RSRP).

[0291] The WTRU may begin with a starting CE level corresponding to normal mode or to no coverage enhancement, for example based on an indication to do so included in the PDCCH order (*e.g.*, CE level or starting CE level set to a certain value such as 0) or a characteristic of the PDCCH order, such as the DCI format used or the RNTI used. A WTRU may begin with a starting CE level corresponding to normal mode or to no coverage enhancement for a contention-based RA initiated by PDCCH order, for example, always.

[0292] Normal coverage that, for example, may not use techniques such as repetition to enhance coverage, may be considered a CE level such as CE level-0.

[0293] A PDCCH order which may be used in initiate a RA procedure may include at least one of the following information: (i) a CE level or starting CE level, (ii) a PRACH preamble index, (iii) a PRACH preamble group index (*e.g.*, that may select a preconfigured group of preambles provided by higher layer signaling), (iv) a timing advance, (v) time and/or frequency resources (*e.g.*, subframes and/or PRBs) for the preamble transmission, and/or (vi) an indication of a group (*e.g.*, a group configured by higher layer signaling) of time and/or frequency resources (*e.g.*, subframes and/or PRBs) for the preamble transmission.

[0294] For contention-based RA, the PRACH preamble index may be a fixed known value, such as 0 or all zeros. This value may indicate to the WTRU that contention-based RA is requested or is to be performed. The value may indicate that the WTRU should choose the preamble.

[0295] The WTRU may choose the preamble to use from a set of preambles available for the CE level that the WTRU will use for the preamble transmission, for example, for contention-based RA.

[0296] A preamble or preamble group may be indicated in the PDCCH order. The WTRU may use the indicated preamble or select a preamble from the indicated group (*e.g.*, randomly), for example for contention-free RA.

[0297] The WTRU may choose time and/or frequency resources for the preamble transmission based on the time and/or frequency resources available for and/or corresponding to the CE level the WTRU will use for the preamble transmission. Correspondence may be configured and/or indicated in higher layer signaling. The WTRU may use resources indicated in the PDCCH order or select from a group of resources indicated in the PDCCH order.

[0298] After one or more attempts transmitting a preamble (*e.g.*, with repetitions for the CE level of the attempt), the WTRU may successfully receive an RAR. The WTRU may change the preamble for each attempt, for example, if one specific preamble was not indicated in the PDCCH order.

[0299] The WTRU may receive an UL grant, *e.g.*, in the RAR, to transmit a message to the eNB. The WTRU may send a message on the granted resources (*e.g.*, on a PUSCH). The message may indicate that the WTRU successfully received the RAR. The message may be used to perform contention resolution, *e.g.*, for a contention-based RA. For initial access, this message may be or may be referred to as msg3, which may be or include an RRC connection establishment request. For RA initiated by a PDCCH order, the WTRU may already be connected.

[0300] The WTRU may send a message or indication, *e.g.*, on the granted resources, which may indicate a successful RA procedure, RA procedure complete, successful reception of the RAR and/or other information which may indicate to the eNB (or may be interpreted by the eNB) that the RA procedure (*e.g.*, at least through RAR reception by the WTRU) was successful or completed. RA procedure msg3 or a modified version of msg3 may be used, for example, with a new establishment cause. A new message may be used. Message and msg may be used interchangeably.

[0301] The resources the WTRU may use for the PRACH transmission may be unique to a CE level and/or the eNB may be aware or informed that the RA procedure was successful. The eNB may know, *e.g.*, based on the PRACH resource used by the WTRU and/or the success of the RA procedure, what CE level the WTRU used or needed for achieving the successful RA procedure.

[0302] The CE level for the successful RA procedure (*e.g.*, the new CE level) may be lower (or higher) than the one the WTRU was using prior to the RA procedure.

[0303] The WTRU may change its current CE level to the CE level corresponding to the successful RA procedure (*e.g.*, the new CE level). The new CE level may correspond to normal coverage.

[0304] The WTRU may apply the timing advance included in the PDCCH order, for example, when or beginning when transmitting the UL message following successful reception of the RAR, *e.g.*, the UL message for which resources were granted in the RAR.

[0305] The WTRU may continue to use its current CE level until it completes the RA procedure. If the RA procedure results in a change of CE level, the WTRU may begin to use the new CE level when it completes the RA procedure.

[0306] Completion of the RA procedure may correspond to when the WTRU transmits the indication of the success of the RA procedure. The WTRU may use the new CE level when transmitting the indication.

[0307] In another example, a PDCCH order may be used to initiate one of contention-free RA or contention-based RA. An indication such as a bit field in the DCI associated with the PDCCH order may be used to indicate whether the PDCCH order is for contention-based RA or contention-free RA. A different RNTI may be used to indicate a PDCCH order for contention-based RA and a PDCCH order for contention-free RA. A different search space, *e.g.*, a different fallback M-PDCCH search space, may be used to indicate the type of RA indicated by the PDCCH order.

[0308] A search space that may be a fallback search space may be provided and/or used.

[0309] A search space, *e.g.*, of a cell, may have, use or be defined with a certain CE level, which may be a highest CE level which may be supported by the cell. An indication may be transmitted in this search space to a WTRU to initiate a RA procedure. The search space may be known or configured, *e.g.*, by higher layer signaling. The higher level signaling may be from the eNB, such as in system information, which may be broadcast.

[0310] The search space may be or may be used for a fallback control channel. The search space may be referred to as a fallback search space. A fallback control channel, a fallback search space, a common search space, and a fallback M-PDCCH may be used interchangeably.

[0311] A fallback M-PDCCH may be configured with at least one of: a subband or frequency location, a set of time locations, a CE level, and a number of repetitions.

[0312] A specific subband (*e.g.*, a subset of consecutive PRBs which may be within a system bandwidth such as a DL system bandwidth of a cell) and/or a specific time location or set of time locations (*e.g.*, a subset of subframes and/or radio frames) may be used for a fallback M-PDCCH.

[0313] The frequency and/or time locations of the subband may be indicated in higher layer signaling such as broadcast signaling or via a physical broadcasting channel (*e.g.*, MIB). The frequency and/or time locations of the subband may be determined (*e.g.*, by the WTRU) as a function of one or more system parameters. The system parameters may include DL system bandwidth, physical cell-ID, subframe number, SFN number, and MBSFN configuration. The frequency and/or time locations of the subband may change over time. For example, a frequency hopping pattern (*e.g.*, predefined or configured) may be used.

[0314] The number of repetitions for the fallback M-PDCCH may be the same as the maximum number of repetitions for M-PDCCH configured in the cell. The number of repetitions may be indicated via higher layer signaling such as broadcast signaling or via a physical broadcasting channel (*e.g.*, MIB).

[0315] A part of M-PDCCH WTRU-specific search space may be used as a fallback M-PDCCH. For example, M-PDCCH WTRU-specific search space may include one or more CE levels (*e.g.*, repetition numbers). One or more M-PDCCH candidates in the M-PDCCH WTRU-specific search space with a highest CE level may be used as fallback M-PDCCH.

[0316] A WTRU may determine one or more parameters (*e.g.*, transmission and/or reception parameters) for a fallback M-PDCCH which may include one or more of a subband or frequency location, a set of time locations, a CE level, and a number of repetitions. The WTRU may determine the one or more parameters based on at least one of received configuration, system parameters, and otherwise known information.

[0317] The WTRU may monitor fallback M-PDCCH according to at least the determined parameters. The WTRU may monitor fallback M-PDCCH for at least PDCCH order (or DCI format including a PDCCH order for the WTRU) that may indicate, initiate, or request an RA procedure. Upon or in response to successful receipt of a PDCCH order, the WTRU may initiate an RA procedure.

[0318] The fallback M-PDCCH may be used by the eNB to communicate with the WTRU at a certain CE level such as a highest CE level supported by the cell, for example, if communication with the WTRU may need a higher (or lower) CE level than what is currently being used. The eNB may indicate a CE level change to the WTRU in or using the fallback M-PDCCH. The eNB may transmit a PDCCH order and/or a request to initiate a RA procedure to a WTRU, for example to potentially change the CE level of the WTRU such as to a more appropriate or higher (or lower) CE level.

[0319] Paging may be provided and/or used. CE information may be used for paging. When an eNB may page or is to page a WTRU that may be in idle mode, the eNB may not know whether the WTRU may be in coverage enhanced (CE) mode and/or if it may be in CE mode, what the CE level may be. If the eNB may page a CE mode WTRU using normal paging procedures, the WTRU may not receive the page.

[0320] Idle mode may be or include one or more of (*e.g.*, the modes or states of) RRC Idle, ECM Idle, EMM Registered, and/or EMM Deregistered.

[0321] A WTRU may provide CE information that may be for or regarding the WTRU to an eNB and/or an MME. An eNB may provide CE information that may be for or regarding a WTRU to another eNB (*e.g.*, as part of a handover procedure) and/or to an MME. MME may be replaced by another network entity and still be consistent with this disclosure. WTRU and device (*e.g.*, which may be an MTC device or LC-MTC device) may be used interchangeably.

[0322] An MME may store CE information that may be for or regarding a WTRU. The MME may include CE information that may be for or regarding a WTRU in a message to an eNB, for example, when requesting the eNB to page the WTRU, such as when the WTRU may be in idle mode.

[0323] CE information that may be for or regarding a WTRU may include one or more of the mode of the WTRU with respect to coverage enhancements, *e.g.*, CE mode or not CE mode; the CE level of the WTRU; and/or the WTRU's capability to support CE mode. The information included in CE information may be different for different messages and/or purposes.

[0324] The mode of the WTRU with respect to coverage enhancements may be the current and/or last (or most recently) known or stored mode of the WTRU. The CE level of the WTRU may be the current and/or last (or most recently) known or stored CE level of the WTRU.

[0325] CE level may include an indication of CE mode. A certain value or level such as 0 may be used to indicate that the UE may not be in CE mode. For example, 0, 1, 2, and 3 may be used to indicate not in CE mode, and levels 1, 2, and 3 of CE mode, respectively.

[0326] In an example, a WTRU may provide CE information to an MME in a NAS message such as an attach (*e.g.*, ATTACH REQUEST) message and/or a tracking area update (TAU) message.

[0327] The WTRU may provide CE information to an MME during one or more of the network registration actions, such as an attach (*e.g.*, in the "ATTACH REQUEST" message) or during device or WTRU mobility management actions such as tracking area update (TAU) (*e.g.*, in the "TRACKING AREA UPDATE REQUEST" message). For example, the WTRU may include such CE information in one or more of the aforementioned messages itself, or in one or more of its WTRU or device capabilities or network support feature attribute IEs such as "WTRU network capabilities," "MS network capabilities," "MS Classmark 2," MS Classmark 3," "MS network feature support," and the like.

[0328] An eNB may receive CE information (*e.g.*, some CE information) from a WTRU and/or may determine CE information (*e.g.*, some or some other CE information) in one or more other ways (*e.g.*, from a PRACH resource a WTRU may have used which may indicate certain CE information). The WTRU may provide CE information, *e.g.*, to the eNB, in one or more capabilities information elements (IEs) or messages (*e.g.*, a WTRU capabilities IE or message and/or an IE or message that may be specific to CE information and/or or information relating to paging or paging capabilities). The WTRU may autonomously send the message. The eNB may provide CE information to an MME in an S1 (*e.g.*, S1AP) message.

[0329] An eNB may provide CE information to an MME for or regarding a WTRU following determination and/or receipt of this information. An eNB may provide CE information to an MME for or regarding a WTRU following a change or update of this information. An eNB may provide CE information to an MME for or regarding a WTRU when the eNB may release the WTRU (*e.g.*, from its connection such as an RRC connection with the eNB) and/or when the WTRU may go to idle mode.

[0330] An MME may provide CE information (*e.g.*, which it may have stored for a WTRU) to an eNB, for example, in support of certain procedures, for example certain procedures in which the eNB may not have this information. For example, the MME may provide CE information (*e.g.*, which may include one or more items of information that may be provided separately or in combinations such as in one or more IEs), to an eNB in association with paging (*e.g.*, with or in an S1 PAGING message) for a given WTRU or device that may be in idle mode or attached but not connected, or detached or unattached but known to be located in the paging area. The eNB may page the WTRU in a manner consistent with the CE information it may receive, *e.g.*, from the MME.

[0331] A WTRU may provide updated CE information to an eNB and/or MME, for example, when one or more of the components of its CE information may change or in other situations.

[0332] Under certain conditions, *e.g.*, when the WTRU may be in idle mode, the WTRU may perform a RA procedure to connect to an eNB for providing CE information or updated CE information. The WTRU may send an RRC connection request, and the reason may be indicated by the WTRU as mobile originated signaling (mo-signaling).

[0333] Change of CE mode and/or CE level (*e.g.*, in idle and/or connected mode) may be a reason for a WTRU to perform (*e.g.*, trigger) a TAU. Change of CE mode and/or CE level (*e.g.*, in idle and/or connected mode) may be a reason for a WTRU to perform a RA procedure and/or perform (or request) connection establishment and/or send a capabilities message to or with an eNB.

[0334] If a WTRU may change to or from CE mode and/or or may change its CE level, *e.g.*, while in idle mode (or connected mode), the WTRU may connect to an eNB (*e.g.*, RRC connection), *e.g.*, perform an RA procedure to request and/or establish an RRC connection with the eNB where the establishment cause may be mobile originated signaling (mo-signaling).

[0335] If a WTRU may change to or from CE mode and/or may change its CE level, *e.g.*, while in idle mode (or connected mode), the WTRU may perform an RA procedure with an eNB (which may be the same or similar procedure as the one for establishing the connection), which may enable the eNB to determine whether or not the WTRU may be in CE mode and/or what level of CE the WTRU may need or use.

[0336] If a WTRU may change to or from CE mode and/or or may change its CE level, *e.g.*, while in idle mode (or connected mode), and/or for other reasons, the WTRU may provide CE information (*e.g.*, updated CE information) regarding the WTRU to the eNB and/or MME, for example as part of a WTRU message to the eNB and/or a WTRU message (*e.g.*, NAS message) to the MME (*e.g.*, via the eNB). The WTRU may use one or more messages to convey the CE information to the eNB and/or MME. The WTRU may use a NAS procedure and/or message such as TAU (*e.g.*, in the "TRACKING AREA UPDATE REQUEST" message) to provide CE information or updated CE information to the MME. The WTRU may use a capabilities message to provide CE information or updated CE information to the eNB.

[0337] A WTRU may perform an RA procedure to establish a connection with an eNB.

[0338] Following connection establishment, the WTRU may send a NAS message to the MME which may be a TAU message. The message may include an indication of the mode (CE mode or not CE mode) and/or CE level of the WTRU. The WTRU may include the WTRU

capability of supporting CE mode in the TAU message. The CE mode support capability may (*e.g.*, may only) be included in an ATTACH message to the MME.

[0339] The WTRU may send CE information to the MME in a TAU message (*e.g.*, in the "TRACKING AREA UPDATE REQUEST" message). When the WTRU may send such a message, for example for a reason other than a change of CE information, the WTRU may include all or certain of its CE information, *e.g.*, the WTRU may or may only include the CE information that may have changed since the last time the WTRU may have sent CE information to the MME.

[0340] When CE information for a WTRU may change, an eNB may send a message (*e.g.*, an S1AP message) to provide certain (*e.g.*, some or all) of the CE information or at least (or only) the changed information to the MME.

[0341] During or after radio link failure (RLF) or recovery from RLF, a WTRU may provide CE information to an eNB and/or MME such as in accordance with one or more of the solutions or examples described herein, for example for a WTRU in idle mode which may have changed CE mode and/or CE level. The WTRU may act as if CE mode and/or CE level may have changed (*e.g.*, even if it or they have not changed), for example, since before RLF or conditions which may have resulted in RLF may have occurred.

[0342] Paging may be provided for and/or used by a WTRU or WTRUs that may be in CE mode. When an eNB may page or intend to page a WTRU which may support CE mode, the eNB may not know if the WTRU may currently be in CE mode and/or the eNB may not know the current CE level of the WTRU. This may happen, for example, if the CE information which may be stored by the MME may not include CE mode or CE level information or if such information may be stale.

[0343] An eNB may page a WTRU, such as one that may support CE mode, using non-CE paging or using both non-CE paging and CE paging (*e.g.*, simultaneously or sequentially). An eNB may page a WTRU, such as one that may support CE mode, using non-CE paging first and if unsuccessful, then using CE paging. An eNB may page a WTRU, such as one that may support CE mode, using CE paging or only CE paging. An eNB may page a WTRU, such as one that may support CE mode, using CE paging for the worst CE level (*e.g.*, the level which may use the most repetition), *e.g.*, only for the worst CE level. An eNB may page a WTRU, such as one that may support CE mode, using CE paging for one CE level, and if unsuccessful, using CE paging for another (*e.g.*, another higher) or the next (*e.g.*, the next higher) level. An eNB may page a WTRU, such as one that may support CE mode, using CE paging for one or more (*e.g.*, each of the) CE levels (*e.g.*, one at a time or simultaneously), for example, until successful or until the

worst level may have failed. An eNB may page a WTRU, such as one that may support CE mode, using CE paging for the last known or stored CE mode and/or CE level of the WTRU, which may be provided to the eNB in a message (*e.g.*, S1-Paging message), *e.g.*, from the MME. An eNB may page a WTRU, such as one that may support CE mode, using CE paging for the CE mode and/or CE level of the WTRU that may be provided to the eNB in a message (*e.g.*, S1-Paging message), *e.g.*, from the MME. Using non-CE paging may include using legacy paging techniques or paging techniques that may be used for WTRUs that may not need or use coverage enhancement. Using CE paging may include paging using coverage enhancement techniques such as repetition. The number of repetitions may be fixed, configured, or a function of the CE level. Using CE paging may include providing a PDSCH carrying PCH or paging without a DCI format.

[0344] An eNB that may page a WTRU using both non-CE paging and CE paging may cease the CE paging (*e.g.*, the repetitions of the CE paging) if and/or when it may receive (*e.g.*, successfully receive) a response from the WTRU to the non-CE paging. A response to a page from a WTRU may be or include the transmission of a PRACH preamble and/or at least part of an RA procedure. Successful reception of the response by the eNB may include being able to determine that the response was from the WTRU it may have paged.

[0345] An eNB that may page a WTRU using both non-CE paging and CE paging may cease the CE paging (*e.g.*, the repetitions of the CE paging) if and/or when the eNB may receive an indication, *e.g.*, from the MME that the page was successful. An indication that the page was successful may include a request to perform an operation for the WTRU, such as setting up a bearer.

[0346] An eNB that may page or intend to page a WTRU (*e.g.*, one that may support CE mode or that the eNB may know may support CE mode), where the eNB may, for example, not know or may be unsure of the (*e.g.*, the current) CE mode and/or CE level of the WTRU, may try paging the WTRU using non-CE paging (*e.g.*, first). If the eNB may not receive (or successfully receive) a response from the WTRU or an indication (*e.g.*, of paging success) from the MME, for example, within a certain amount of time, the eNB may try paging the WTRU using CE paging.

[0347] The eNB may try CE paging for one or more CE levels until successful or all fail, or may try the worst CE level (*e.g.*, only). A paging attempt by the eNB, *e.g.*, using non-CE mode or CE mode with a CE level (*e.g.*, a certain CE level), may be in response to a paging request from the MME. The paging request may be provided in an S1 paging message. An MME may provide an indication of lack of success of a paging attempt instead of an indication of success.

[0348] An eNB may page a connected mode CE mode WTRU, *e.g.*, using CE mode paging, to inform it of system information changes. The eNB may directly inform these WTRUs of the changes with dedicated signaling.

[0349] CE paging may be provided and/or used. A WTRU may monitor PDCCH and/or EPDCCH to determine if there may be PDSCH carrying PCH (or paging message) that may be intended for it. The WTRU may look for a paging RNTI (*e.g.*, P-RNTI) or DCI format masked with (*e.g.*, with a CRC scrambled with) a paging RNTI (*e.g.*, P-RNTI) that may indicate a PDSCH that may carry PCH or a paging message. PCH and paging message may be used interchangeably. Using a RNTI (*e.g.*, a DCI format using a RNTI) may be the same as being masked with (*e.g.*, the DCI format being masked with) the RNTI or having (*e.g.*, the DCI format having) a (or its) CRC scrambled with the RNTI.

[0350] A WTRU, such as a coverage limited WTRU, may use, need, and/or combine repetitions of a transmission (*e.g.*, PDCCH, EPDCCH, PDSCH, *etc.*) to be able to successfully receive and/or decode the transmission. Rules and/or procedures may be used for PDSCH that may carry PCH or a paging message and/or PDCCH (and/or EPDCCH) that may carry a DCI format that may indicate the presence of (or upcoming presence of) a PDSCH that may carry a PCH or paging message.

[0351] CE paging may use coverage enhancement techniques such as repetition of the PDCCH and/or EPDCCH that may carry a DCI format that may indicate the presence of (or upcoming presence of) a PDSCH that may carry a PCH or paging message and/or repetition of a PDSCH that may carry a PCH or paging message.

[0352] An eNB, such as one that may use CE paging, may transmit PCH in a coverage enhanced manner, for example, when transmitting PCH to a WTRU that may be coverage limited. A WTRU, such as a coverage limited WTRU that may use or respond to CE paging, may receive PCH in a coverage enhanced manner. CE paging may include transmission and/or reception of PCH in a coverage enhanced manner.

[0353] CE paging and/or transmission and/or reception of PCH in a coverage enhanced manner may include transmission of repetitions of PCH, which may include transmission of repetitions of a PDSCH that may carry PCH and/or transmission of repetitions of the associated PDCCH and/or EPDCCH. CE paging and/or transmission and/or reception of PCH in a coverage enhanced manner may include reception and/or combining of repetitions of PCH, which may include reception of and/or combining repetitions of the PDSCH that may carry PCH and/or reception of and/or combining repetitions of the associated PDCCH and/or EPDCCH. CE paging and/or transmission and/or reception of PCH in a coverage enhanced manner may include

transmission of an RNTI for the PCH PDCCH and/or EPDCCH, *e.g.*, legacy P-RNTI or an RNTI, *e.g.*, PCE-RNTI, which may be specific to coverage limited WTRUs, for example, of a coverage enhancement level (*e.g.*, of a certain CE level). CE paging and/or transmission and/or reception of PCH in a coverage enhanced manner may include monitoring and/or reception of an RNTI for the PCH PDCCH and/or EPDCCH, *e.g.*, legacy P-RNTI or an RNTI, *e.g.*, PCE-RNTI, which may be specific to coverage limited WTRUs, for example, of a coverage enhancement level (*e.g.*, of a certain CE level).

[0354] A WTRU and/or eNB (such as a WTRU and/or eNB that may use CE paging) may transmit repetitions of PCH, which may include transmitting repetitions of a PDSCH that may carry PCH and/or transmitting repetitions of the associated PDCCH and/or EPDCCH. A WTRU and/or eNB (such as a WTRU and/or eNB that may use CE paging) may receive and/or combine repetitions of PCH, which may include receiving and/or combining repetitions of the PDSCH that may carry PCH and/or receiving and/or combining repetitions of the associated PDCCH and/or EPDCCH. A WTRU and/or eNB (such as a WTRU and/or eNB that may use CE paging) may transmit an RNTI for the PCH PDCCH and/or EPDCCH, *e.g.*, legacy P-RNTI or an RNTI, *e.g.*, PCE-RNTI, which may be specific to coverage limited WTRUs, for example, of a coverage enhancement level (*e.g.*, of a certain CE level). A WTRU and/or eNB (such as a WTRU and/or eNB that may use CE paging) may monitor and/or receive an RNTI for the PCH PDCCH and/or EPDCCH, *e.g.*, legacy P-RNTI or an RNTI, *e.g.*, PCE-RNTI, which may be specific to coverage limited WTRUs, for example, of a coverage enhancement level (*e.g.*, of a certain CE level).

[0355] P-RNTI or another RNTI may be used for PDCCH and/or EPDCCH associated with PDSCH that may carry PCH, for example, for PCH intended for a WTRU that may be coverage limited and/or bandwidth limited.

[0356] PDCCH and/or EPDCCH associated with PDSCH that may carry PCH may be located in a common search space (*e.g.*, PDCCH common search space and/or EPDCCH common search space), for example, for PCH that may be intended for a WTRU that may be coverage limited and/or bandwidth limited.

[0357] A WTRU, such as one that may be coverage limited, may begin monitoring for the PDCCH and/or EPDCCH associated with PDSCH that may carry PCH at the start of its DRX cycle (*e.g.*, the first subframe of its DRX cycle). The WTRU may monitor for PDCCH and/or EPDCCH using P-RNTI or PCE-RNTI or a PCE-RNTI for its CE level (*e.g.*, current CE level).

[0358] An eNB may transmit a PCH PDSCH in a fixed, known, or determined location and/or with one or more fixed, known, or determined parameters (*e.g.*, transmission parameters such as MCS) such that a DCI format may not be required or used, *e.g.*, for a PCH PDSCH that

may be intended for a WTRU (or at least a WTRU) that may be bandwidth limited and/or coverage limited. The fixed, known, or determined location and/or parameters may be provided by the eNB in signaling, such as broadcast signaling (*e.g.*, in system information). PCH PDSCH may be used to represent a PDSCH which may carry PCH.

[0359] The location and/or one or more transmission parameters of a PCH PDSCH that may be intended for a WTRU (or at least a WTRU) that may be bandwidth limited and/or coverage limited may be a function of a capability (or reduced capability) of the WTRU. For example, PCH PDSCH location and/or one or more PCH PDSCH transmission parameters may be a function of one or more of CE mode, CE level, and/or BW limitation. The capability (or reduced capability) of the WTRU, such as the CE mode and/or CE level and/or BW limitation of the WTRU, may determine (or may be used by the WTRU and/or eNB to determine) the location (*e.g.*, subframes and/or RBs) and/or one or more transmission parameters (*e.g.*, MCS) for the PCH PDSCH that may be intended for a WTRU (or at least a WTRU) that may be bandwidth limited and/or coverage limited. The eNB may transmit and/or the WTRU may receive or attempt to receive the PCH PDSCH in the determined location.

[0360] Determination of the location and/or transmission parameter(s) of a PCH PDSCH that may be intended for a WTRU (or at least a WTRU) that may be bandwidth limited and/or coverage limited, *e.g.*, by the WTRU and/or eNB, may be based at least in part on configuration (*e.g.*, of PCH PDSCH location and/or parameters) for one or more capabilities (or reduced capabilities, such as CE mode or level), which may be provided by the eNB via signaling, such as broadcast signaling. Determination of the location and/or transmission parameter(s) of a PCH PDSCH that may be intended for a WTRU (or at least a WTRU) that may be bandwidth limited and/or coverage limited, *e.g.*, by the WTRU and/or eNB, may be based at least in part on a WTRU parameter or identifier, such as the WTRU IMSI or WTRU ID.

[0361] Location (*e.g.*, of a PCH PDSCH) may be or may include time (*e.g.*, subframe, set of subrames, or pattern of subframes) and/or frequency (*e.g.*, one or more RBs).

[0362] A PCH or PCH PDSCH may be or may represent an instance or repetition of a PCH or PCH PDSCH. Repetitions of a PCH or PCH PDSCH that may be combined by a WTRU, such as a WTRU that may be coverage limited, may be in the same or different locations (*e.g.*, subframes may be different and RBs may be the same or different) and/or may use the same or different parameters.

[0363] A WTRU, such as a bandwidth limited and/or coverage limited WTRU, may monitor for, receive, or attempt to receive PCH PDSCH, *e.g.*, from an eNB. The WTRU and/or the eNB may determine the location of an PCH PDSCH that may be intended for the WTRU (or at least

the WTRU) based at least in part on configuration, *e.g.*, of the relationship or correspondence between PCH PDSCH location and/or parameters and WTRU capability or reduced capability, which may be provided by the eNB via signaling, such as broadcast signaling.

[0364] One or more PCH (or PCH PDSCH) transport block sizes may be configured or fixed and may correspond to a certain number of pages (*e.g.*, to a certain number of WTRUs). Padding may be used, for example, when the number of pages (*e.g.*, actual pages) may be less than the number of pages (*e.g.*, the certain number of pages) that may correspond to a fixed or configured transport block size (TBS). TBS configuration may be by signaling, such as broadcast signaling, which may be from the eNB. There may be a separate PCH (or PCH PDSCH) TBS value (*e.g.*, fixed or configured) for one or more CE levels. There may be one or more PCH (or PCH PDSCH) TBS values for PCH (or PCH PDSCH) that may be intended for (*e.g.*, at least for) a coverage limited and/or bandwidth limited WTRU. A WTRU such as a WTRU that may be coverage limited and/or bandwidth limited may receive or may expect to receive a PCH (or PCH PDSCH) with a fixed or configured TBS. An eNB may transmit a PCH (or PCH PDSCH) that may be intended for (*e.g.*, at least for) a WTRU that may be coverage limited and/or bandwidth limited with a fixed or configured TBS.

[0365] There may be N CE levels, and there may be PCH PDSCH resources (*e.g.*, separate PCH PDSCH resources) for each of the N CE levels. An eNB may transmit and/or a WTRU may receive or may expect to receive a PCH PDSCH in certain time and/or frequency resources (*e.g.*, subframes and/or RBs) that may correspond to the CE mode or level of the WTRU.

[0366] One or more (*e.g.*, a set of) PCH (or PCH PDSCH) transport block (TB) sizes (*e.g.*, possible or candidate TB sizes) may be fixed or configured (*e.g.*, by the eNB) and/or determined (*e.g.*, by the WTRU). A WTRU may try one or more of the TB sizes (*e.g.*, in the set of TB sizes) to try to successfully receive the PCH (or PCH PDSCH), for example, when monitoring for and/or attempting to receive PCH (or PCH PDSCH).

[0367] One or more (*e.g.*, a set of) PCH (or PCH PDSCH) candidates may be fixed or configured (*e.g.*, by the eNB) and/or determined (*e.g.*, by the WTRU). The PCH (or PCH PDSCH) candidates may differ in one or more characteristics that may include time (*e.g.*, subframe), frequency (*e.g.*, RBs), TB size, and one or more transmission parameters, such as MCS. A WTRU may try one or more of the PCH (or PCH PDSCH) candidates to try to successfully receive the PCH (or PCH PDSCH), for example, when monitoring for and/or attempting to receive PCH (or PCH PDSCH).

[0368] PDCCH (and/or EPDCCH) may be repeated a number of times, *e.g.*, M times, for example, for CE paging. The same PDCCH may be repeated (*e.g.*, for one or more (*e.g.*, each) of

the M times) and one or more (*e.g.*, each of the) repetitions may be located in the same place in a search space such as a common search space (CSS), *e.g.*, a PDCCH and/or EPDCCH CSS.

[0369] There may be a gap of G (*e.g.*, 0 or greater) that may follow the PDCCH (and/or EPDCCH) repetitions. G may be or may include a number of subframes (or certain subframes such as POs) and/or frames (or certain frames, such as PFs). The corresponding PDSCH (*e.g.*, PCH PDSCH) may follow after the gap and/or may be repeated P times. M may or may not equal P. One or more of M, G, and P may be a function of a CE level (*e.g.*, the CE level determined for the WTRU to be paged or the worst case CE level). M and/or G may be zero, for example, if no DCI format may be used or needed for paging (*e.g.*, CE paging).

[0370] An eNB may transmit the repetitions of the PDCCH (and/or EPDCCH) and/or the PDSCH in certain subframes and/or frames such as POs and/or PFs.

[0371] An eNB may transmit the repetitions of the PDCCH (and/or EPDCCH) and/or the PDSCH in certain subframes such as designated or configured subframes and/or subframes which may be DL (*e.g.*, any DL) subframes and/or certain (*e.g.*, all) special subframes (*e.g.*, for TDD).

[0372] The subframe of the first PDSCH (*e.g.*, of a set of P repetitions of a PDSCH) that may carry a page (*e.g.*, PCH) for a WTRU, such as a CE mode WTRU, may align with POs and/or PFs and/or may be related to the timing of the PDCCH.

[0373] To page a WTRU, the eNB may transmit a first transmission (or repetition) of a PDCCH (and/or EPDCCH) and/or PDSCH (*e.g.*, PCH PDSCH) according to the starting PO of the WTRU, which may be determined in a same or similar manner to which a PO may be determined by or for a legacy WTRU or according to another rule or calculation.

[0374] Following the first transmission of a PDCCH (and/or EPDCCH) and/or PDSCH (*e.g.*, PCH PDSCH), which may be in a (*e.g.*, a certain) PO (*e.g.*, a starting PO) and/or a (*e.g.*, a certain) PF (*e.g.*, a starting PF), one or more (*e.g.*, each) of the next of the M or P repetitions may be transmitted by the eNB in the next PO (*e.g.*, each of the next M, M-1, P or P-1 POs). A next PO may be in the same or the next PF as a previous PO.

[0375] Following the first transmission of a PDCCH (and/or EPDCCH) and/or PDSCH (*e.g.*, PCH PDSCH), which may be in a (*e.g.*, a certain) PO (*e.g.*, a starting PO) and/or a (*e.g.*, a certain) PF (*e.g.*, a starting PF), one or more (*e.g.*, each) of the next of the M or P repetitions may be transmitted by the eNB in the same PO as the previous transmission in the next PF.

[0376] Following the first transmission of a PDCCH (and/or EPDCCH) and/or PDSCH (*e.g.*, PCH PDSCH), which may be in a (*e.g.*, a certain) PO (*e.g.*, a starting PO) and/or a (*e.g.*, a certain) PF (*e.g.*, a starting PF), one or more (*e.g.*, each) of the next of the M or P repetitions may

be transmitted by the eNB in the next subframe (*e.g.*, each of the next M, M-1, P or P-1 subframes) that may be DL.

[0377] Following the first transmission of a PDCCH (and/or EPDCCH) and/or PDSCH (*e.g.*, PCH PDSCH), which may be in a (*e.g.*, a certain) PO (*e.g.*, a starting PO) and/or a (*e.g.*, a certain) PF (*e.g.*, a starting PF), one or more (*e.g.*, each) of the next of the M or P repetitions may be transmitted by the eNB in the next subframe (*e.g.*, each of the next M, M-1, P or P-1 subframes) that may be either a DL or special subframe where special subframes may apply (*e.g.*, only apply) for TDD.

[0378] Following the first transmission of a PDCCH (and/or EPDCCH) and/or PDSCH (*e.g.*, PCH PDSCH), which may be in a (*e.g.*, a certain) PO (*e.g.*, a starting PO) and/or a (*e.g.*, a certain) PF (*e.g.*, a starting PF), one or more (*e.g.*, each) of the next of the M or P repetitions may be transmitted by the eNB in the next designated or configured subframe, which may be for this purpose. The subframe configuration may be provided via signaling, such as broadcast signaling, for example, in system information. System information may be provided in one or more SIBs.

[0379] Whether or not a subframe may be a DL subframe or a special subframe may be determined according to the cell specific TDD UL/DL configuration of the cell, which may be broadcast by the cell in system information (*e.g.*, in SIB 1).

[0380] The POs and/or PFs that may be used for CE paging and (*e.g.*, at least) non-CE paging (*e.g.*, legacy paging) may be the same or different. The POs and/or PFs that may be used for CE paging may be configured and/or determined separately from the POs and/or PFs that may be used for (*e.g.*, at least) non-CE (*e.g.*, legacy) paging.

[0381] A WTRU, such a WTRU that may be coverage limited, may look for a page using non-CE paging and may use CE paging if non-CE paging may not be successful. For example, the WTRU may monitor for PDCCH which may be masked by P-RNTI in a PO that may be determined according to a legacy calculation. If the WTRU may successfully receive a P-RNTI in this manner and/or a corresponding PDSCH in the PO subframe, the WTRU may not use CE paging, *e.g.*, it may not monitor for repeated PDCCH and/or EPDCCH and/or PDSCH. The WTRU may determine if a PCH it may have received in the PO may be intended for it and, if so, may respond to the page accordingly.

[0382] A WTRU, such a WTRU that may be coverage limited, may determine, *e.g.*, for its paging cycle, one or more of a starting subframe, a starting PF, and/or a starting PO. Such determination may be in a same or similar manner to which a PO may be determined by or for a legacy WTRU or according to a new rule or calculation.

[0383] The starting subframe or starting PO for a page or paging cycle for a CE mode WTRU may be the subframe or PO for or of the first transmission of the PDCCH (and/or EPDCCH) of the M repetitions of the channel. The starting subframe or starting PO for a page or paging cycle for a CE mode WTRU may be the subframe or PO for or of the first transmission of the PCH PDSCH of the P repetitions of the channel.

[0384] A WTRU, such as a WTRU that may be coverage limited, may look for a page using CE paging. According to the subframes in which the starting PO and the M repetitions of the PDCCH (and/or EPDCCH) may be (*e.g.*, as described for eNB transmission), the WTRU may monitor PDCCH (and/or EPDCCH) in those subframes and may combine the signals from those subframes or a subset of those subframes into one PDCCH (and/or EPDCCH) that it may attempt to decode and/or for which it may determine if it may be masked with a paging RNTI such as P-RNTI or PCE-RNTI.

[0385] If the WTRU may determine that there may be a page for the WTRU, for example, if the PDCCH (and/or EPDCCH) was or was determined by the WTRU to be masked with a paging RNTI (*e.g.*, P-RNTI or PCE-RNTI), the WTRU may begin to receive the corresponding P repetitions of PDSCH.

[0386] The WTRU may skip a certain number of subframes and/or frames from the last of the M repetitions to the first of the P repetitions, which may be according to G.

[0387] A WTRU may not monitor for PDCCH and/or EPDCCH in order to receive a PCH PDSCH. According to the subframes in which the starting PO and the P repetitions of the PCH PDSCH may be (*e.g.*, as described for eNB transmission), the WTRU may monitor for PDSCH (*e.g.*, PCH PDSCH) in those subframes and may combine the signals from those subframes or from a subset of those subframes into one PDSCH, which it may attempt to decode and/or receive. The WTRU may monitor for the PCH PDSCH in a known or determined location or locations and/or using one or more known and/or determined parameters of PCH PDSCH. The WTRU may monitor for one or more PCH PDSCH candidates.

[0388] The WTRU may receive the P repetitions or a subset of the P repetitions of the PDSCH or PDSCH candidates and may combine them (or one or more, *e.g.*, each set of repetitions) to a single PDSCH from which it may attempt to (*e.g.*, successfully) receive and/or decode a PCH. If the WTRU may (*e.g.*, successfully) receive and/or decode the PCH, the WTRU may determine if the PCH was intended for the WTRU and, if so, the WTRU may respond to the page.

[0389] One or more of M, G, and P may be a function of a CE level (*e.g.*, the CE level of the WTRU or the worst case CE level).

[0390] Worst case CE level may be the worst or highest CE level supported by the cell or eNB (e.g., the CE level with the highest number of repetitions) which may be indicated in cell-specific signaling, e.g., broadcast signaling such as via a physical broadcast channel (e.g., MIB) or higher layer signaled system information (e.g., SIB).

[0391] G and/or P may be indicated in the PDCCH (and/or EPDCCH), which may be masked by a paging RNTI such as P-RNTI or PCE-RNTI. G and/or P may be indicated in the PDCCH (and/or EPDCCH), which may correspond to the paging PDSCH, which may be repeated P times.

[0392] The subframes of the repetitions and/or the gap may not be consecutive subframes. The subframes of the repetitions and/or the gap may be PO subframes or other particular or designated subframes. The PO subframes may be the PO subframes of a WTRU, such as any WTRU or of a certain WTRU, such as a WTRU for which a page may be intended.

[0393] For example, the repeated PDCCHs (and/or EPDCCHs) and/or PDSCHs that may be used by CE mode WTRUs (and or eNBs for CE paging) may occur in subframes that may be possible paging occasions (POs). For FDD, PO subframes may be certain subframes, such as subframes 0, 4, 5, and 9, for example. Depending on configuration (*e.g.*, by the eNB), the subsets of subframes for POs may be certain subsets, such as [9], [4,9], or [0,4,5,9], for example. For TDD, the PO subframes may be certain subframes, such as subframes 0, 1, 5, and 6, for example. Depending on configuration (*e.g.*, by the eNB), the subsets of subframes for POs may be certain subsets, such as [0], [0,5], or [0,1,5,9], for example.

[0394] A starting subframe of a PO or a starting PO may be in a PF. One or more repetitions of an EPDCCH and/or PDSCH for paging may not be in a PF. One or more of the PDCCHs, EPDCCHs, and/or PDSCHs that may be used for paging may be transmitted and/or received in subframes that may be identified by configuration as subframes that may be used for paging. The configuration may be provided via signaling, such as broadcast signaling, for example, in system information. The system information may be provided, for example, in one or more system information blocks (SIBs).

[0395] A downlink (DL) control channel may be used for paging. For example, an (E)PDCCH common search space (CSS) may include one or more (E)PDCCH candidates and may be configured for paging. A WTRU, such as a WTRU that may be bandwidth limited and/or coverage limited, may decode and/or monitor one or more (E)PDCCH candidates in the (E)PDCCH CSS to receive a DCI that may be masked by a paging RNTI, such as P-RNTI or PCE-RNTI. One or more (E)PDCCH candidates may be transmitted in a time and/or frequency location known to a WTRU that may monitor or may need to monitor or receive the (E)PDCCH

candidates. CSS may be used as a non-limiting example of a search space. The time and/or frequency location of the (E)PDCCH CSS and/or (E)PDCCH candidate or candidates and/or one or more parameters that may enable monitoring and/or decoding of the (E)PDCCH CSS and/or (E)PDCCH candidate or candidates may be provided or configured via signaling, such as broadcast signaling that may be received and/or used by the WTRU. Another search space may be used and may be consistent with the disclosed subject matter.

[0396] Candidates, resources, and PRBs, such as (E)PDCCH candidates, (E)PDCCH resources, and (E)PDCCH PRBs may be used interchangeably or substituted for each other and still be consistent with this disclosure. PRBs and RBs may be used interchangeably.

[0397] The term (E)PDCCH may represent EPDCCH and/or PDCCH. The term (E)CCE may represent a control channel element (CCE) and/or an enhanced control channel element (ECCE).

[0398] An (E)PDCCH candidate may be, may have, and/or may include a combination of an (E)CCE aggregation level and a number of repetitions. For example, an (E)PDCCH candidate may include the (E)CCE aggregation level N_{AL} and the number of repetitions N_{REP}. A total aggregation level (TAL) may correspond to a total number of (E)CCEs that may belong to an (E)PDCCH candidate. The number of (E)CCEs for the total aggregation level N_{TAL} may be determined as a function of N_{AL} and N_{REP}. For example, N_{TAL} may be the product of N_{AL} and N_{REP}.

[0399] An (E)PDCCH candidate that may have a larger total aggregation level (N_{TAL}) may support a higher CE level than an (E)PDCCH candidate that may have a smaller total aggregation level. A higher CE level may provide more or better coverage enhancement than a lower CE level. For example, a higher CE level may provide better signal strength at a receiver than a lower CE level.

[0400] Two or more (E)PDCCH candidates may be configured with a different total aggregation level, for example, to support two or more CE levels. A WTRU may monitor and/or decode a subset of the (E)PDCCH candidates that may be configured. The subset may include one or more (*e.g.*, all) of the (E)PDCCH candidates that may be configured. A WTRU may monitor and/or decode an (E)PDCCH candidate to receive a DCI that may be masked with an RNTI, such as a paging RNTI.

[0401] A WTRU may monitor and/or decode one or more, *e.g.*, all, (E)PDCCH candidates that may be configured, regardless of a CE level used, configured, and/or determined for or by the WTRU.

[0402] For (E)PDCCH candidate monitoring, the WTRU may start from an (E)PDCCH candidate with a first, *e.g.*, smallest total aggregation level. The WTRU may move to an (E)PDCCH candidate with a second, *e.g.*, larger total aggregation level if the WTRU does not receive a DCI that may be masked with a paging RNTI in the first total aggregation level. The WTRU may move or continue to move to another, *e.g.*, larger total aggregation level until it reaches a maximum total aggregation level if the WTRU does not receive a DCI that may be masked with a paging RNTI in a total aggregation level (*e.g.*, a certain total aggregation level). The WTRU may stop monitoring (E)PDCCH candidates and may not move to a next or another total aggregation level if the WTRU receives a DCI that may be masked with a paging RNTI in a total aggregation level, *e.g.*, a certain total aggregation level.

[0403] A WTRU may monitor a subset of (E)PDCCH candidates configured based on the CE level used, configured, and/or determined for or by the WTRU. A paging RNTI that may be associated with a certain subset of (E)PDCCH candidates may be determined based on the CE level. A WTRU may monitor and/or decode one or more (E)PDCCH candidates in the subset of (E)PDCCH candidates to receive a DCI that may be masked with the paging RNTI associated with the CE level used, configured, and/or determined for or by the WTRU.

[0404] The WTRU may determine and/or use a first CE level or a number of repetitions for monitoring and/or decoding an (E)PDCCH candidate, for example, to receive a DCI that may be a paging DCI or a DCI that may be masked by a paging RNTI. The WTRU may determine and/or use a second CE level or number of repetitions for reception of a PDSCH that may carry a paging channel or paging message or paging information. A CE level may be associated with or configured to correspond to a number of repetitions, for example, via signaling from an eNB, such as via broadcast signaling. CE level and number of repetitions may be used interchangeably. The first and second CE levels may be the same or different. The first and/or second CE levels may be determined by the WTRU.

[0405] A WTRU may determine a CE level or CE levels (*e.g.*, the first and/or second CE levels), which may be used or configured for or by the WTRU, for example, for one or more aspects of paging reception. For example, a WTRU may determine one or more CE levels (*e.g.*, for one or more aspects of paging reception) based on a latest or most recent CE level used by or known to the WTRU and/or based on one or more of known, measured, and/or signaled values or information. The determined CE level (or levels) may be specific to paging (*e.g.*, to one or more aspects of paging reception) or may be applicable to other procedures or purposes rather than or in addition to paging (or paging reception). Paging reception aspects may include, but are not limited to, one or more of: monitoring and/or decoding one or more (E)PDCCH candidates,

receiving a paging DCI, and/or receiving a PDSCH carrying a paging channel or paging message or paging information.

[0406] A CE level that may be determined and/or used by the WTRU (*e.g.*, for at least one or more aspects of paging reception) may be or may be based on the latest CE level stored at an MME for the WTRU. The CE level for the WTRU may be signaled from an eNB, such as the serving eNB of the WTRU to the MME. The CE level that may be determined and/or used by the WTRU may be (or may be based on) the latest CE level used (*e.g.*, by the WTRU) for a successful reception of a DCI that may be masked with one or more of a paging RNTI, a system information RNTI, and/or a RA-RNTI, or the like. The CE level that may be determined and/or used by the WTRU may be (or may be based on) the latest CE level used (*e.g.*, by the WTRU) for a successful reception of a DL channel (*e.g.*, from its serving cell or the cell on which it is camped), such as a PDSCH carrying broadcast information (*e.g.*, a SIB), a PDSCH carrying a paging channel or paging message or paging information, a PDSCH carrying a RAR, and/or PBCH.

[0407] A CE level that may be determined and/or used by the WTRU (*e.g.*, for at least one or more aspects of paging reception) may be (or may be based on) the CE level associated with a downlink measurement (*e.g.*, RSRP and/or RSRQ), for example, made by the WTRU. The downlink measurement may be or correspond to a current or most recent downlink measurement. The measurement may be a filtered measurement.

[0408] A CE level that may be determined and/or used by the WTRU (*e.g.*, for at least one or more aspects of paging reception) may be (or may be based on) a CE level that may be indicated from broadcast signaling and/or a broadcasting channel, *e.g.*, SIB, MTC-SIB, LC-SIB, MIB, and/or PBCH. For example, the CE level that may be determined and/or used by the WTRU may be (or may be based on) a paging CE level (*e.g.*, a CE level for paging) that may, for example, be indicated from broadcast signaling and/or a broadcasting channel, *e.g.*, SIB, MTC-SIB, LC-SIB, MIB, and/or PBCH. The broadcast CE level may be used (*e.g.*, for paging) for and/or by some or all WTRUs. For example, the broadcast CE level may be used (*e.g.*, for paging) for and/or by one or more of: one or more (*e.g.*, all) WTRUs in CE mode, one or more (e.g., all) WTRUs that support CE mode, one or more (*e.g.*, all) WTRUs of a certain WTRU type or category (*e.g.*, low cost WTRU), and/or one or more (*e.g.*, all) WTRUs that have a certain capability or reduced capability (*e.g.*, reduced bandwidth WTRU).

[0409] A CE level that may be determined and/or used by the WTRU (*e.g.*, for at least one or more aspects of paging reception) may be (or may be based on) the maximum CE level supported by the cell from which the WTRU may receive paging (*e.g.*, the cell on which the

WTRU may be camped in idle mode). The maximum CE level supported by the cell may be provided in signaling, such as broadcast signaling (*e.g.*, SIB, MIB, and/or PBCH). The WTRU may receive and/or use the signaling to determine the maximum CE level and/or the CE level for paging.

[0410] The WTRU may use the determined CE level to determine the number of aggregation levels and/or the number of repetitions to use for one or more (E)PDCCH candidates that the WTRU may monitor and/or decode to receive a paging DCI. The WTRU may monitor and/or decode one or more (E)PDCCH candidates according to the determined number of aggregation levels and/or the number of repetitions, for example, to receive a paging DCI.

[0411] One or more (E)PDCCH candidates may be configured with a total aggregation level, *e.g.*, a same total aggregation level. The total aggregation level may correspond to a CE level, *e.g.*, a maximum CE level supported in the cell, such as the maximum CE level supported in the cell for paging.

[0412] The time and/or frequency location of the (E)PDCCH candidate or candidates may be known to a WTRU, such as a WTRU that may support enhanced coverage mode and/or that may be in enhanced coverage mode. For example, the configuration of the (E)PDCCH candidate or candidates may be signaled from broadcast signaling and/or a broadcasting channel (*e.g.*, MIB and/or MTC-SIB).

[0413] Enhanced coverage and coverage enhanced may be used interchangeably. Enhanced coverage mode and coverage enhanced mode may be used interchangeably. Enhanced coverage level and coverage enhanced level mode may be used interchangeably.

[0414] For an (E)PDCCH candidate or candidates with M repetitions, the (E)PDCCH candidate or candidates may be transmitted and/or received in M subframes. The M subframes may be M consecutive subframes or M consecutive DL subframes. The M subframes may be M consecutive subframes within the set of subframes that may be used for paging. The subframes that may be used for paging may be signaled (*e.g.*, via broadcast signaling such as via a SIB) or known. For a WTRU, the first of the M subframes may correspond to the WTRU's Paging Occasion, which may be a function of the WTRU-ID. The WTRU may combine the M repetitions to decode the (E)PDCCH candidate or candidates. The WTRU may combine a subset of the M repetitions, *e.g.*, S repetitions or the first S of the M repetitions, to decode the (E)PDCCH candidate or candidates. The WTRU may combine repetitions until it successfully decodes the (E)PDCCH candidate or candidates or until it combines all M repetitions. If the WTRU combines all M repetitions and does not successfully receive a DCI (*e.g.*, for paging), the WTRU may determine there is no page or no page for the WTRU, for example, for the current

paging cycle. If the WTRU successfully receives the DCI, the WTRU may receive or may attempt to receive the corresponding PDSCH, which may carry a paging message. Reception of a PDSCH may include receiving and/or combining repetitions of the PDSCH.

[0415] The frequency location of the (E)PDCCH candidate or candidates for paging may be determined as a function of one or more of a WTRU-ID (*e.g.*, IMSI) and/or a physical cell ID (PCI).

[0416] The frequency location of the (E)PDCCH candidate or candidates for paging may be determined as a function of the configuration of one or more downlink subbands, which may be configured for LC-MTC and/or enhanced coverage. A subband may correspond to a set of consecutive PRBs (*e.g.*, six consecutive PRBs) located within a system bandwidth. When multiple subbands are configured, the subbands may be partially or fully overlapped. The subbands may be mutually orthogonal in the frequency domain. One or more subbands may be used for an (E)PDCCH candidate or candidates for paging. The subband that may be used for or by a WTRU may be a function of one or more of WTRU-ID, PCI, and/or DL system bandwidth.

[0417] Subband configuration, *e.g.*, for an (E)PDCCH candidate or candidates and/or PDSCH for paging may be provided (*e.g.*, by a cell or eNB) in signaling such as broadcast signaling, for example in system information (*e.g.,* in one or more SIBs).

[0418] A WTRU may determine a subband to use for an (E)PDCCH candidate or candidates and/or PDSCH for paging from one or more of a subband configuration provided, a number of subbands configured, paging cycle, PF, PO, SFN, PCI, DL system bandwidth, and/or WTRU-ID. The WTRU may determine the subband to use for a PO, a starting subframe of a PO, and/or a subframe corresponding to a repetition of an (E)PDCCH candidate and/or PDSCH of a PO. The frequency location of the (E)PDCCH candidate or candidates for paging may be predefined or known. A certain subband index (*e.g.*, the first subband) may be used for an (E)PDCCH candidate or candidates for paging if one or more downlink subbands are configured. A starting PRB index for the paging subband may be defined or determined as a function of one or more of downlink system bandwidth, subframe number, frame number, physical cell ID, and/or WTRU-ID. WTRU-ID may be a WTRU IMSI.

[0419] For purposes of description and explanation, the terms paging channel, paging message, and paging information may be used interchangeably.

[0420] A PDSCH may carry a paging message. A PDSCH carrying a paging message (*e.g.*, PCH) for a WTRU that supports or that may be in enhanced coverage mode may be scheduled from an associated (E)PDCCH. A WTRU may monitor or decode a DCI that may be masked with a paging RNTI from the associated (E)PDCCH. The paging message may be intended for a

single WTRU or multiple WTRUs. The paging message may include a system information modification indication. The DCI may include the system information modification indication. For example, a bit or bit field in the DCI may indicate whether the system information has been changed or will be changed (*e.g.*, at the start of the next system information modification period). The bit or bit field may be or include an indication of yes or no or an indication of true or false. The bit field may be or may be used for a value tag, *e.g.*, systemInfoValueTag.

[0421] The DCI may carry one or more of the following information. The DCI may carry a frequency location of the PDSCH (*e.g.*, subband index or starting PRB). The DCI may carry a time location of the PDSCH (*e.g.*, a starting subframe location). The DCI may carry TBS or TBS candidates. The DCI may carry a modulation order. The DCI may carry the repetition number of the associated PDSCH (*e.g.*, P).

[0422] A WTRU may decode and/or receive the PDSCH if the WTRU receives a DCI that may be masked with a paging RNTI. The paging RNTI may be intended for the WTRU. A paging RNTI may be intended for a WTRU if it is intended for a WTRU or WTRUs of a certain type and the WTRU is of that type. For example, the paging RNTI may be intended for WTRUs supporting or in coverage enhanced mode.

[0423] A paging RNTI, for example, for a WTRU of a certain type, may be a function of one or more of a paging cycle, PF, PO, the number of POs per PF, SFN, WTRU-ID, and/or the number of repetitions that may be used for the (E)PDCCH candidates for paging. This may enable repetitions of a DCI beginning in the subframe of a first PO to be repeated in the subframe of a second PO (*e.g.*, in the same frame) without confusing WTRUs that may be looking for a DCI beginning in the second PO.

[0424] The PDSCH may be transmitted repetitively over multiple subframes (*e.g.*, P subframes). The P subframes may be continuous or consecutive within the subframes used for paging transmission. The P subframes may be discontinuous within the subframes used for paging transmission.

[0425] One or more P values may be used to support one or more CE levels. For example, P = {N1, N2, N3} may be used, where P values are positive integer numbers and N1 < N2 < N3. A different P value may be used according to the CE level. The P values may be predefined, *e.g.*, for each CE level supported by the cell. The P values, *e.g.*, for each CE level supported by the cell, may be indicated from a broadcasting channel (*e.g.*, SIB). The CE level or the P value that may be used for transmission of the PDSCH carrying a paging message may be indicated from (or by) the associated (E)PDCCH (*e.g.*, in the DCI). Three values of P are used for exemplary purposes. Another value may be used and still be consistent with this disclosure.

[0426] A starting subframe for a PDSCH carrying a paging message, for example, in a paging cycle or corresponding to a PO, may be the same regardless of the P value. For example, the PDSCH with P = N1 and the PDSCH with P = N2 may have the same starting subframe. The end subframe may be different.

[0427] A WTRU may start to receive the PDSCH with a smallest P value (*e.g.*, N1) and may move to a next level (*e.g.*, a next highest P value, N2) if the WTRU fails to receive the PDSCH carrying the paging message until it may reach a maximum P value (*e.g.*, N3). The WTRU may stop combining repetitions if it successfully receives the PDSCH prior to combining all P repetitions of a level (*e.g.*, N1, N2, or N3).

[0428] A WTRU may receive the PDSCH with a corresponding P value indicated from the associated (E)PDCCH. A WTRU may receive the PDSCH by combining repetitions up to the P value indicated from the associated (E)PDCCH. The WTRU may stop combining repetitions if it successfully receives the PDSCH prior to combining all P repetitions. A WTRU may receive the PDSCH with a P value associated with a current CE level, which may be determined based on a downlink measurement.

[0429] Each P value may be associated with a certain (*e.g.*, separate, unique, or different) paging RNTI. A WTRU may implicitly determine the P value from the paging RNTI when the WTRU receives a DCI that may be masked with a certain paging RNTI. For example, a first P-RNTI may be associated with a first P value (*e.g.*, N1) and a second P-RNTI may be associated with a second P value (*e.g.*, N2), and so on. When checking for a page, *e.g.*, in a PO or its PO, a WTRU may check for a CRC scrambled with one or more of the P-RNTIs. If such a CRC is found, the WTRU may use that P-RNTI to determine the P value with which the PDSCH may be transmitted. The association may be between a P-RNTI and a CE level. The CE level may be associated with the P value. One or more of the associations may be predefined, known, or provided in signaling, such as broadcast signaling. The paging RNTI for each CE level for paging may be a function of the number of CE levels (or the maximum CE level) supported by the eNB or cell. The WTRU may determine the paging RNTI for each CE level based on the number of CE levels (or the maximum CE level) supported by the eNB or cell which may be provided via broadcast signaling such as in a MIB (*e.g.*, PBCH) or SIB.

[0430] A starting subframe of a PDSCH carrying a paging message (*e.g.*, if the PDSCH is transmitted over P subframes repetitively) may be determined as a function of the last subframe of the associated (E)PDCCH. For example, if the last subframe of the associated (E)PDCCH is the subframe n, the starting subframe may be the subframe n+k, where k may be, for example, a gap value G. The subframe n may be the last subframe of a certain (E)PDCCH candidate. If a

different number of repetitions is used for two or more (E)PDCCH candidates, the subframe n may be different according to the (E)PDCCH candidate. The subframe n may be the last subframe of an (E)PDCCH candidate that may have a largest number of repetitions. The value of n may be the same regardless of the (E)PDCCH candidate in which a WTRU may receive a DCI that may be masked with a paging RNTI or that may carry a scheduling information of the PDSCH. The value of k may be determined based on the (E)PDCCH candidate and/or the number of repetitions for an (E)PDCCH candidate.

[0431] (E)PDCCH carrying a DCI masked or scrambled with a P-RNTI that may be intended for a WTRU that may be in CE mode may be transmitted with M repetitions. The value of M may be independent of the CE level of the WTRU. The WTRU may combine one or more repetitions of the EPDCCH up to the maximum of M repetitions to attempt to receive a DCI scrambled with a P-RNTI, *e.g.*, beginning in its PO. The DCI may implicitly or explicitly identify the number of repetitions, P, with which the PDSCH carrying the PCH may be transmitted. If the WTRU successfully receives the DCI, the WTRU may receive and/or may combine up to P repetitions of the PDSCH to receive the page. If the WTRU successfully receives the page and the page is intended for the WTRU (or the WTRU determines that a page intended for the WTRU is included in the paging message), the WTRU may respond, for example, by performing a random access procedure and/or requesting connection establishment for an incoming call. If the WTRU does not successfully receive the DCI, the WTRU may assume there is no page for the WTRU and the WTRU may sleep, for example, until its next PO. If the WTRU successfully receives the DCI and the value of P is lower than what the WTRU determines it needs to receive the PDSCH, the WTRU may not attempt to receive the PDSCH, for example, in order to save battery power. If the WTRU successfully receives the DCI and does not successfully receive the PDSCH after combining the P repetitions, the WTRU may determine its CE level to be higher than that which uses P repetitions and may save that information for use for a next or later PO.

[0432] A WTRU, such a WTRU in coverage enhancement mode, may receive (E)PDCCH carrying a DCI masked or scrambled with an RNTI such as a paging RNTI (*e.g.*, P-RNTI, PCE-RNTI, or another RNTI). The DCI may include an indication that system information (*e.g.*, one or more SIBs) has changed or will change. The indication may be in the form of a bit or bit field. The indication may have a value of True to indicate system information has changed or will change. The indication may be, for example, in the form of a value or a value tag that the WTRU may compare to a previously stored value or value tag. If the value or value tag is different from the previous or stored value tag, the WTRU may understand or infer that one or more SIBs has

changed or will change. If the DCI includes an indication (*e.g.*, a positive indication) regarding or related to system information change, there may not be a PDSCH associated with the DCI and/or the WTRU may not receive or attempt to receive a PDSCH that may be associated with the DCI. The WTRU may receive one or more SIBs (*e.g.*, after the start of the next SIB modification period) to acquire the updated system information, for example, if the indication indicates that system information has been or will be updated.

[0433] If the DCI (*e.g.*, DCI for paging and/or system information update) positively indicates a system information change (*e.g.*, has occurred or will occur), there may be no PDSCH associated with the DCI. If the DCI (*e.g.*, DCI for paging and/or system information update) does not indicate a (*e.g.*, any) system information change or indicates no system information change, there may be a PDSCH associated with the DCI.

[0434] A DCI or DCI format may be used to page or address one or more WTRUs and/or indicate that system information has been or will be updated. The update may occur at or before the start of the next system information modification period. The DCI format may be transmitted with or without an associated PDSCH that may carry a paging message or paging information. The DCI format may include an indication as to whether or not there may be an associated PCH or PDSCH. If the DCI format indicates that there is no associated PCH or PDSCH, one or more (*e.g.*, all) the parameters related to the PDSCH, *e.g.*, the scheduling parameters for the PDSCH, may not be included in the DCI or the parameters may be fixed values (*e.g.*, zeroes) or ignored. The DCI format may be carried by a PDCCH or EPDCCH which may be in CSS. For purposes of illustration and description, DCI and DCI format may be used interchangeably. The DCI format for system information update (*e.g.*, system information update without a paging message or WTRU-specific paging message or record) may be separate or different from the DCI format for paging (*e.g.*, for paging with an associated PCH or PDSCH).

[0435] A WTRU that receives the DCI format may receive or may attempt to receive an associated PDSCH if (*e.g.*, only if) the DCI format indicates an associated PDSCH (*e.g.*, that may carry a paging message) and/or the DCI format corresponds to a DCI format with an associated PDSCH (*e.g.*, that may carry a paging message).

[0436] The DCI format may be intended for use by and/or may be used by WTRUs in connected mode and/or idle mode. The DCI format may be intended for use by and/or may be used by WTRUs that may be in coverage enhanced mode and/or that may be reduced bandwidth WTRUs. The control channel (*e.g.*, PDCCH and/or EPDCCH) that may carry the DCI format and/or the DCI format may be repeated M-SI times or up to M-SI times. The value of M-SI may correspond to the maximum CE level supported by the cell. The value of M-SI may be provided

in broadcast signaling such as system information, *e.g.*, in a SIB which may be intended for use by and/or may be used by WTRUs which may be in coverage enhanced mode and or which may be reduced bandwidth WTRUs. The value of M-SI may be separate from and/or different from the number of repetitions that may be used for a DCI that may be for paging and/or may not indicate a system information update. The value of M-SI may be chosen by the eNB to correspond to the highest CE level (or number or repetitions) that may be needed by its connected mode WTRUs. A WTRU may combine up to M-SI repetitions to receive or successfully receive the DCI format.

[0437] The DCI format may include one or more system information update indications. A system information update indication may indicate update of one or more of: SIBs or system information that may be associated with a value tag; SIBs or system information that may be associated with ETWS; SIBs or system information that may be associated with CMAS; and/or SIBs or system information that may be associated with EAB parameters.

[0438] The CRC of a DCI format that may include one or more system information update indications (*e.g.*, one or more positive indications or one or more indications set to yes or true) may be scrambled with an RNTI that may be different from an RNTI that may be used to scramble the CRC of a DCI format that may not include a system information update indication (*e.g.*, a positive indication or an indication set to yes or true).

[0439] There may be a separate DCI format and/or RNTI for system information update indications to idle mode WTRUs and connected mode WTRUs.

[0440] The RNTI for a DCI format for system information update may be different from the RNTI for a DCI format for paging (*e.g.*, WTRU-specific paging). A separate or different RNTI may be provided and/or used for one or more of a DCI format for system information update, *e.g.*, only; a DCI format for positive system information update and paging (*e.g.*, indicating associated paging PDSCH); and/or a DCI format for paging (*e.g.*, indicating associated paging PDSCH) without a system information update or positive system information update. A WTRU may monitor for one or more of the RNTIs, *e.g.*, in or according to its PO.

[0441] The schedule for a PDCCH, EPDCCH, and/or DCI format that may carry a system information update indication may be separate from the schedule for a PDCCH, EPDCCH, and/or DCI format associated with paging messages. AWTRU may determine a PO per PC to monitor for paging messages. A WTRU may determine and/or may use another schedule for monitoring for system information updates. The occasions for system information updates may be referred to as system information update occasions (SIUOs). An idle mode WTRU may monitor its PO for paging messages (*e.g.*, for the PDCCH, EPDCCH, DCI format, and/or

PDSCH for paging messages). An idle mode and/or connected mode WTRU may monitor SIUOs for system information updates. SIUOs for idle and connected mode WTRUs may be different. A WTRU may monitor for an RNTI for paging in its PO. A WTRU may monitor for an RNTI for system information update in a SIUO. When a PO and SIUO coincide, a WTRU may monitor for a paging and/or a system information update RNTI.

[0442] Following receipt of a system information update indication, a WTRU may acquire the associated system information or one or more SIBs. For some SIBs, *e.g.*, value tag SIBs, the WTRU may wait until the start of the next system information modification period to acquire the SIBs.

[0443] A DCI format may be transmitted by the eNB and/or received by the WTRU in PDCCH or EPDCCH.

[0444] System information and/or a paging configuration may be updated. Configuration information for and/or related to paging may be carried in or at least in a broadcast signaling channel and/or system information, such as in a SIB, *e.g.*, MTC-SIB. Configuration information, for example, for paging, may include configuration information for an (E)PDCCH that may be used to carry a scheduling information of a PDSCH that may carry a paging message. Configuration information, for example, for paging, may include the number of repetitions M for an (E)PDCCH that may be used to carry a scheduling information of a PDSCH that may carry a paging message. Configuration information, for example for paging, may include one or more parameters that may be used for (E)PDCCH and/or PDSCH reception, for example, for paging. Configuration information may include, but is not limited to, a CE level, a maximum CE level, a number of repetitions, and/or a maximum number of repetitions. Configuration information, for example, for paging, may include PDSCH configuration and/or one or more P values that may be used for reception of PDSCH, which may carry a paging message.

[0445] An MTC-SIB may be transmitted and/or may be used if the PBCH or MIB indicates the support of low-cost WTRU and/or enhanced coverage WTRU. There may be one or more MTC-SIBs. An MTC-SIB may be intended for, received by, and/or used by one or more WTRUs that may be a certain type of WTRU. The certain type may be one or more of: MTC-WTRU, LC-MTC-WTRU, reduced BW WTRU, a WTRU supporting coverage enhancements, and/or a WTRU in coverage enhanced mode.

[0446] A first MTC-SIB (*e.g.*, MTC-SIB-0) may be transmitted in a known or determined time and/or frequency location. The time and/or frequency location may be determined, *e.g.*, by the WTRU, based on at least one or more of the system parameters acquired from MIB (*e.g.*, SFN, DL system bandwidth) and/or physical cell-ID.

[0447] The first MTC-SIB (*e.g.*, MTC-SIB-0) may carry an indication of system information modification (*e.g.*, systemInfoValueTag). The first MTC-SIB may carry one or more of the following for the second MTC-SIB (and/or subsequent MTC-SIB(s)): (i) scheduling information (*e.g.*, schedule in time), (ii) a TBS size, (iii) a modulation order, (iv) a repetition cycle (or CE level or repetition number), and/or (v) a frequency location.

[0448] The first MTC-SIB may have one or more properties, for example the first MTC-SIB may have a fixed TBS size. A zero-padding may be used if the actual payload size is smaller than the fixed TBS size. The first MTC-SIB may have a fixed modulation order. For example, QPSK may be used. The first MTC-SIB may be used for system information modification indication and scheduling information for the subsequent (*e.g.*, second) MTC-SIB. For example, the first MTC-SIB may only be used for system information modification indication and scheduling information for the subsequent MTC-SIB. The first MTC-SIB may be transmitted periodically.

[0449] A WTRU, such a WTRU in coverage enhancement mode, may receive the first MTC-SIB, for example, if the WTRU needs to check whether the system information has been or will be updated before it monitors or receives the paging signals. If the first MTC-SIB indicates that the system information has been updated or will be updated prior to the WTRU's PO, the WTRU may receive the subsequent MTC-SIBs (*e.g.*, after the start of the next SIB modification period) to acquire the updated system information, for example, at least related to the paging configuration. If the WTRU cannot acquire the SIBs, *e.g.*, at least the SIBs related to paging, prior to its PO, the WTRU may skip monitoring its PO for paging (*e.g.*, skip monitoring (E)PDCCH for paging), for example, until after it successfully receives the SIBs.

[0450] Techniques for reuse of the P-RNTI (*e.g.*, legacy P-RNTI) may be provided. For example, there may be limited space in CSS, which may make it difficult to page WTRUs (*e.g.*, legacy WTRUs and CE mode WTRUs).

[0451] P-RNTI may be used for CE paging and non-CE paging, for example, without overlap or collision when paging coverage limited WTRUs and non-coverage limited WTRUs.

[0452] PDCCH that may be associated with PDSCH that may carry PCH may be transmitted and/or received in a common search space (CSS). A WTRU may monitor for P-RNTI in CSS.

[0453] PDCCH for CE mode WTRUs may be repeated M times. The same PDCCH may be repeated for one or more of the M times. The same PDCCH may be repeated for each of the M times. One or more (*e.g.*, and possibly all) of the repetitions may be located in the same place, *e.g.*, the same place in the CSS. There may be a gap G that may follow the PDCCH repetitions.

The corresponding PDSCH may follow after the gap and may be repeated P times. P and M may be the same or different values.

[0454] A PDCCH may grant or point to one or more PDSCHs (*e.g.*, in a current or future subframe) which may carry PCH with a certain location and/or with certain parameters or properties (*e.g.*, MCS, *etc.*). A current subframe may be the same subframe as the PDCCH providing the grant. A future subframe may be a subframe after or later than the subframe of the PDCCH providing the grant.

[0455] In the M subframes in which the PDCCH may be transmitted, there may or may not be a corresponding PDSCH. A CE mode WTRU may not look for a PDSCH until after the M repetitions of the PDCCH and after it may successfully receive the PDCCH from combining the (*e.g.*, M) PDCCH repetitions. A non-CE mode and/or legacy WTRU, however, may look for a corresponding PDSCH in one or more (*e.g.*, each) of the M subframes in which there may be a P-RNTI. The PDSCH in these subframes may be used to page non-CE mode and/or legacy WTRUs according to non-CE mode and/or legacy rules. The PDSCHs (*e.g.*, all the PDSCHs) in these subframes may have the same location and parameters. The PDSCHs in these subframes may have the same location and parameters as the PDSCHs that may be repeated P times for a CE mode WTRU after the gap.

[0456] In the subframes of the gap and the P PDSCH subframes for the CE mode WTRU, the CE mode WTRU may not look for or expect a P-RNTI. P-RNTI may be used in those subframes for non-CE mode and/or legacy WTRUs. A PDCCH that may use P-RNTI in those subframes may be used in a non-CE mode and/or legacy manner. In those subframes, the PDCCH that may use P-RNTI may change from subframe to subframe and the PDCCH may point to a PDSCH in a different location and/or with different parameters. The PDCCH that may use P-RNTI in those subframes may not point to a PDSCH in a location that may overlap a PDSCH that may be used by or for CE mode WTRUs.

[0457] A DRX cycle may be provided and/or used. A DRX cycle may not be suitable or sufficient for CE mode WTRUs. DRX and paging cycle may be used interchangeably.

[0458] The DRX or paging cycle for a CE mode WTRU may be the longer of a WTRU specific signaled value and a default value such as the legacy default value. The DRX or paging cycle for a CE mode WTRU may be a CE mode DRX value, which may be cell-specific and may be provided in broadcast signaling, such as system information. The DRX or paging cycle for a CE mode WTRU may be the shorter or longer of a WTRU specific signaled value (*e.g.*, which may be specific to CE mode) and a cell specific value. The DRX or paging cycle for a CE mode WTRU may be independent of WTRU ID and/or IMSI.

[0459] The DRX or paging cycle for CE mode WTRUs may be a function of one or more of the default DRX or paging cycle (*e.g.*, a multiple of it); the legacy DRX or paging cycle (*e.g.*, a multiple of it); the CE level; and/or the number of repetitions of the paging PDCCH and/or PDSCH (*e.g.*, M and/or P) and or the gap (*e.g.*, G) between them.

[0460] Paging may be provided for and/or used by WTRUs that may be bandwidth limited. An eNB that may page or that may intend to page a WTRU may or may not know that the WTRU may be a limited bandwidth WTRU and may or may need to page the WTRU in a way in which the WTRU may receive the page.

[0461] An eNB that may support limited bandwidth WTRUs may or may always page certain WTRUs (*e.g.*, all WTRUs or limited bandwidth WTRUs) in a bandwidth in which limited bandwidth WTRUs may receive the PDSCH (*e.g.*, in or within N RBs such as the center N RBs, where N may be 6).

[0462] For paging a WTRU, such as one that may be a limited bandwidth WTRU, an eNB may use an EPDCCH for the control channel associated with a paging PDSCH (*e.g.*, a PDSCH that may carry PCH), for example, since a PDCCH may not (or may not be able to) be located in a limited bandwidth.

[0463] An eNB, for example one that may not know if a WTRU it may page or intend to page may be a limited bandwidth WTRU, may page the WTRU using PDCCH (*e.g.*, which may not be in a limited bandwidth) and EPDCCH (which may be in a limited bandwidth). The PDCCH and the EPDCCH may be associated with the same PDSCH and the grant that the PDCCH and/or EPDCCH may provide may be the same with respect to at least some (*e.g.*, all) parameters such as one or more of the grant size (*e.g.*, in RBs), grant location, and MCS, among others.

[0464] The PDCCH may be masked with P-RNTI or another paging RNTI that may be used by at least limited bandwidth WTRUs. The EPDCCH may be masked with P-RNTI or another paging RNTI that may be used by at least limited bandwidth WTRUs.

[0465] A WTRU that may be bandwidth limited may monitor EPDCCH in its PO. If the WTRU may receive (*e.g.*, successfully receive) an EPDCCH that may be masked with P-RNTI or a (*e.g.*, another) paging RNTI that may be used by at least limited BW WTRUs, the WTRU may receive or attempt to receive the associated (*e.g.*, granted) PDSCH that may carry PCH. If the PCH may include a page for the WTRU, the WTRU may respond to the page.

[0466] For a WTRU which may be both coverage limited and bandwidth limited, the eNB may apply one or more of the examples disclosed herein for paging a WTRU that may be coverage limited where the PDSCH repetitions which may carry the PCH and/or the associated

EPDCCH repetitions may be located within the limited bandwidth, which may be received by a limited bandwidth WTRU.

[0467] If an eNB may not know if a WTRU may be reduced BW, the eNB may try paging the WTRU as a full bandwidth WTRU one or more times and if unsuccessful may then try to page the WTRU as a limited bandwidth WTRU.

[0468] Paging a WTRU as a full bandwidth WTRU may include using PDCCH for the control channel (*e.g.*, which may be masked with P-RNTI or another paging RNTI), which may be associated with a PDSCH which may carry PCH.

[0469] Paging a WTRU as a limited bandwidth WTRU may include paging the WTRU in accordance with one or more of the examples disclosed herein for limited bandwidth WTRUs such as using EPDCCH and/or limiting the EPDCCH and/or paging PDSCH to locations within the limited bandwidth.

[0470] One or more examples described herein for RAR transmission and/or reception may be applied to PCH transmission and/or reception, for example, for PCH that may be or may be intended for a WTRU that may be bandwidth limited and/or coverage limited.

[0471] An eNB may page a WTRU that may be bandwidth limited and/or coverage limited without the use of a control channel, such as PDCCH or EPDCCH.

[0472] The POs and/or PFs in which a paging PDSCH (*e.g.*, one that may carry PCH) may be located may be known (*e.g.*, by calculations and/or parameters such as legacy and/or new calculations and/or parameters). The grant parameters for the paging PDSCH may be known (*e.g.*, fixed or signaled). Paging PDSCH for limited bandwidth WTRUs may be less often than paging PDSCH for full bandwidth WTRUs.

[0473] In a subframe or PO that may include a PCH intended for a WTRU that may be a bandwidth limited and/or coverage limited WTRU, the WTRU may attempt to receive a paging PDSCH using the known location and/or parameters. The WTRU may determine if it may receive the paging PDSCH successfully based on the CRC of the PDSCH. If the WTRU may successfully receive a PCH that it may determine to be intended for it, the WTRU may respond to the page.

[0474] For a WTRU that may be in CE mode, the WTRU may combine multiple repetitions of the paging PDSCH, which may be in the same location (*e.g.*, in at least frequency resources) and may use the same parameters for one or more (*e.g.*, each) of its repetitions, before attempting to successfully receive the PCH from the PDSCHs. For a WTRU that may be in CE mode but may not be bandwidth limited, the location of the PDSCHs may not be limited to being in or within the limited bandwidth. For a WTRU that may be bandwidth limited or that may behave

like a bandwidth limited WTRU, the location of the PDSCHs may be limited to being in or within the limited bandwidth.

[0475] A location (*e.g.*, time and/or frequency resources) of a PDSCH that may be used for paging and/or parameters (*e.g.*, coding/decoding parameters such as MCS) of the PDSCH may be signaled by the eNB to the WTRU using dedicated signaling and/or broadcast signaling (*e.g.*, in system information or in one or more SIBs). The location (*e.g.*, time and/or frequency resources) and/or certain parameters may be fixed or known (*e.g.*, by specification).

[0476] The processes and instrumentalities described herein may apply in any combination, may apply to other wireless technologies, and for other services.

[0477] A WTRU may refer to an identity of the physical device, or to the user's identity such as subscription related identities, *e.g.*, MSISDN, SIP URI, *etc.* WTRU may refer to application-based identities, *e.g.*, user names that may be used per application.

[0478] The processes described above may be implemented in a computer program, software, and/or firmware incorporated in a computer-readable medium for execution by a computer and/or processor. Examples of computer-readable media include, but are not limited to, electronic signals (transmitted over wired and/or wireless connections) and/or computer-readable storage media. Examples of computer-readable storage media include, but are not limited to, a read only memory (ROM), a random access memory (RAM), a register, cache memory, semiconductor memory devices, magnetic media such as, but not limited to, internal hard disks and removable disks, magneto-optical media, and/or optical media such as CD-ROM disks, and/or digital versatile disks (DVDs). A processor in association with software may be used to implement a radio frequency transceiver for use in a WTRU, UE, terminal, base station, RNC, and/or any host computer.

CLAIMS

What is Claimed:

1. A method for providing communication in a network, the method comprising:

transmitting a preamble using a physical random access channel (PRACH);

determining a location of a random access response (RAR) based on a parameter of the PRACH, the location comprising at least one of a subframe or a frequency resource on which the RAR is transmitted; and

receiving the RAR at the determined location.

2. The method of claim 1, further comprising selecting a PRACH resource based on a coverage enhancement (CE) level.

3. The method of claim 2, receiving the RAR being performed within a response window determined as a function of the CE level.

4. The method of claim 1, further comprising determining a number of repetitions of the RAR based on the parameter of the PRACH.

5. The method of claim 1, the parameter of the PRACH comprising at least one of a subframe, a frequency resource on which the PRACH is transmitted, or the preamble.

6. The method of claim 5, the frequency resource on which the PRACH is transmitted comprising at least one resource block (RB).

7. The method of claim 1, the frequency resource on which the RAR is transmitted comprising at least one resource block (RB).

8. The method of claim 1, further comprising:

receiving an indication to initiate a random access procedure; and

transmitting the preamble based on the received indication.

9. The method of claim 8, the indication comprising at least one of a physical downlink control channel (PDCCH) order or a coverage enhancement (CE) level.

10. The method of claim 9, further comprising selecting a PRACH resource based on the CE level, transmitting the preamble using the selected PRACH resource, and repeating the preamble transmission based on the CE level.

11. The method of claim 1, further comprising receiving a configuration that provides the relationship between the PRACH parameter and the RAR location.

12. The method of claim 11, the configuration being received in system information.

13. A method for providing communication in a network, the method comprising:

receiving a preamble using a physical random access channel (PRACH) associated with at least one of a coverage enhancement (CE) level or a CE mode of a wireless transmit/receive unit (WTRU) from which the preamble is received;

determining a location of a random access response (RAR) based on a parameter of the PRACH, the location comprising at least one of a subframe or a frequency resource on which the RAR is to be transmitted;

determining a number of repetitions of the RAR to transmit based on the CE level or CE mode; and

transmitting the RAR at the determined location with the determined number of repetitions.

14. The method of claim 13, further comprising providing CE information regarding the WTRU to at least one of an evolved node B (eNB) device or a mobility management entity (MME) device.

15. The method of claim 14, the CE information comprising at least one of the CE level, the CE mode, or a capability of the WTRU to support the CE mode.

16. The method of claim 13, further comprising receiving CE information from a mobile management entity (MME) device.

17. A wireless transmit/receive unit (WTRU) comprising:

a transceiver; and

a processor to execute instructions to cause the WTRU to

transmit a preamble using a physical random access channel (PRACH);

determine a location of a random access response (RAR) based on a parameter of the PRACH, the location comprising at least one of a subframe or a frequency resource on which the RAR is transmitted; and

receive the RAR at the determined location.

18. The WTRU of claim 17, the processor configured to select a PRACH resource based on a coverage enhancement (CE) level.

19. The WTRU of claim 17, the processor configured to determine a number of repetitions of the RAR based on the parameter of the PRACH.

20. The WTRU of claim 17, the parameter of the PRACH comprising at least one of a subframe, a frequency resource on which the PRACH is transmitted, or the preamble.

21. The WTRU of claim 20, the frequency resource on which the PRACH is transmitted comprising at least one resource block (RB).

22. The WTRU of claim 17, the frequency resource on which the RAR is transmitted comprising at least one resource block (RB).

23. An evolved node B (eNB) device comprising:

a transceiver; and

a processor to execute instructions to cause the eNB device to

receive a preamble using a physical random access channel (PRACH) associated with at least one of a coverage enhancement (CE) level or a CE mode of a wireless transmit/receive unit (WTRU) from which the preamble is received;

determine a location of a random access response (RAR) based on a parameter of the PRACH, the location comprising at least one of a subframe or a frequency resource on which the RAR is to be transmitted;

determine a number of repetitions of the RAR to transmit based on the CE level or CE mode; and

transmit the RAR at the determined location with the determined number of repetitions.

24. The eNB device of claim 23, the processor configured to cause the transceiver to provide CE information regarding the WTRU to at least one of an evolved node B (eNB) device or a mobile management entity (MME) device.

25. The eNB device of claim 24, the CE information comprising at least one of the CE level, the CE mode, or a capability of the WTRU to support the CE mode.

26. The eNB device of claim 23, the processor configured to cause the transceiver to receive CE information from a mobile management entity (MME) device.

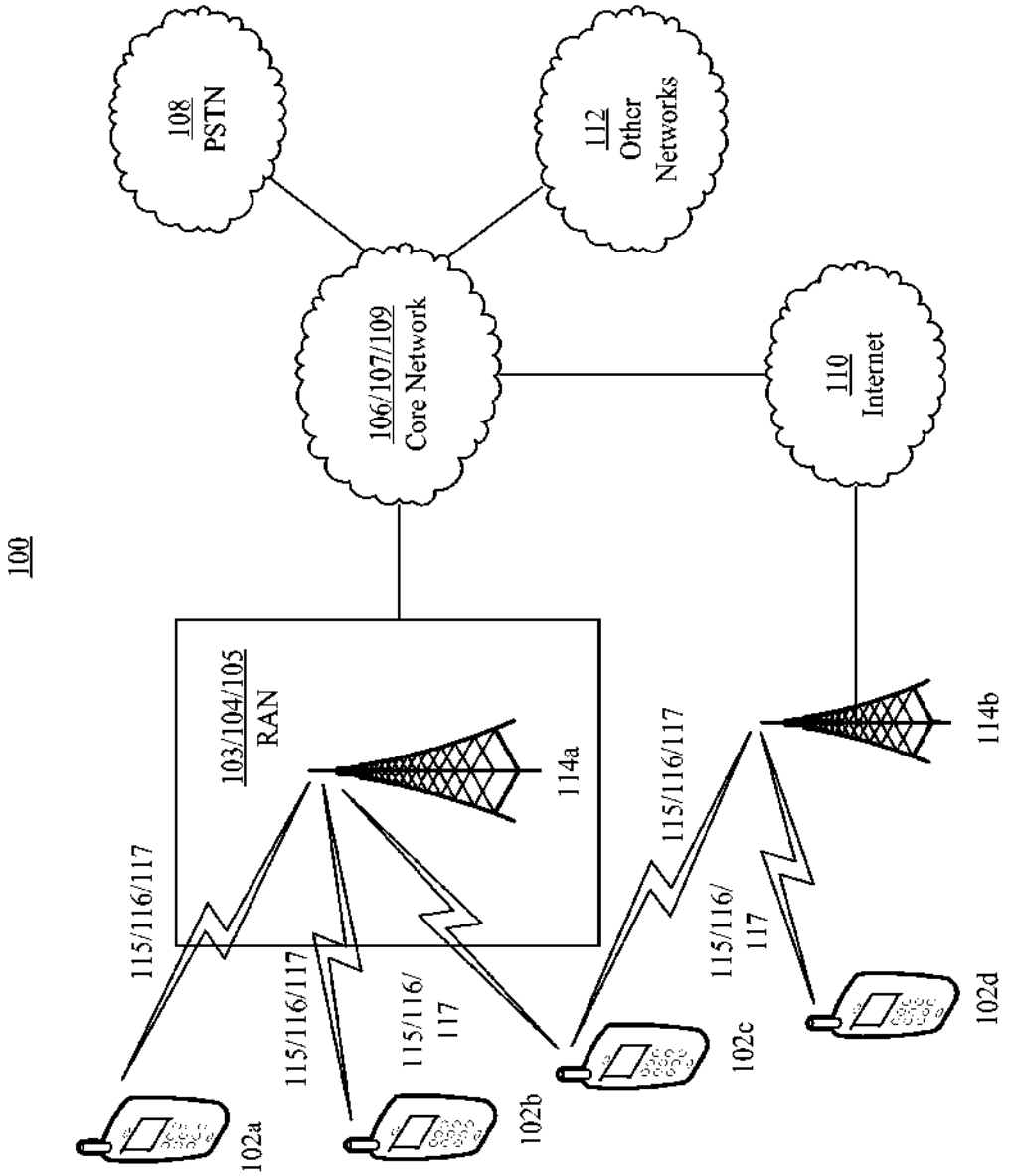

100
108
PSTN
112
Other
Networks
106/107/109
Core Network
110
Internet
103/104/105
RAN
114a
114b
115/116/117
115/116/
117
102a
102b
102c
102d

FIG. 1A

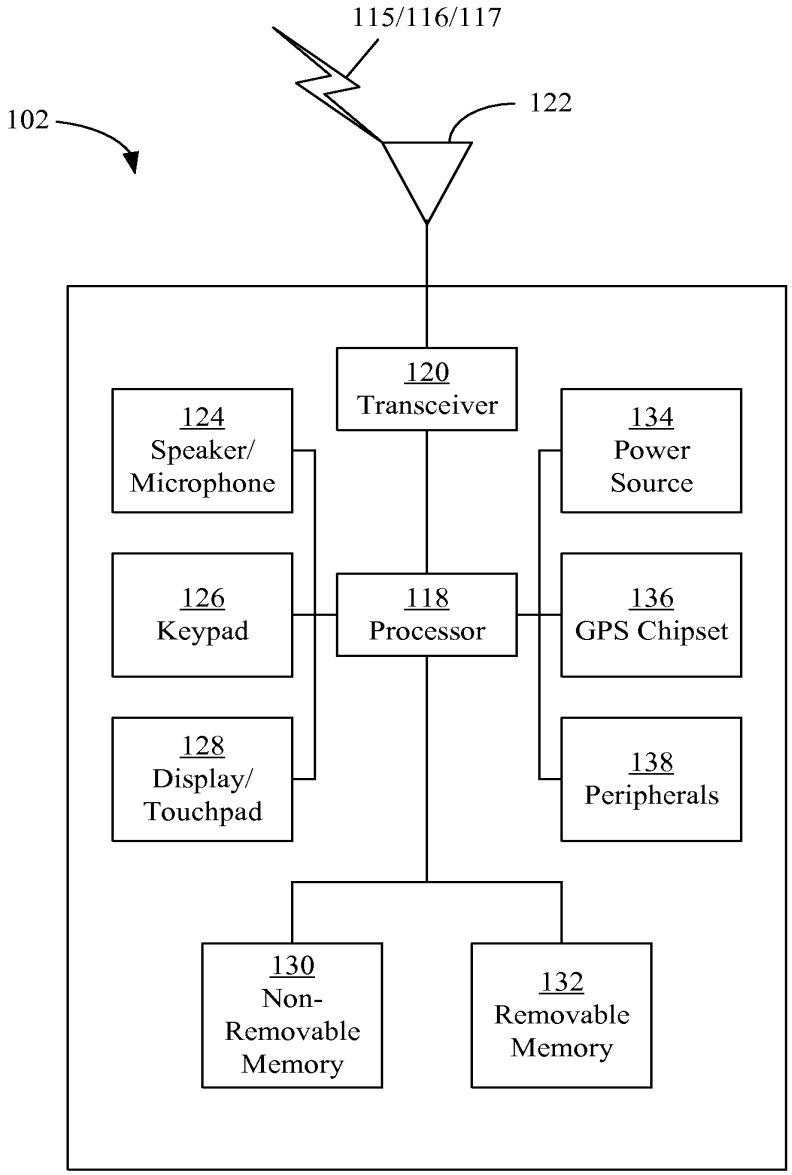

115/116/117
122
102
120
Transceiver
124
Speaker/
Microphone
134
Power
Source
126
Keypad
118
Processor
136
GPS Chipset
128
Display/
Touchpad
138
Peripherals
130
Non-
Removable
Memory
132
Removable
Memory

FIG. 1B

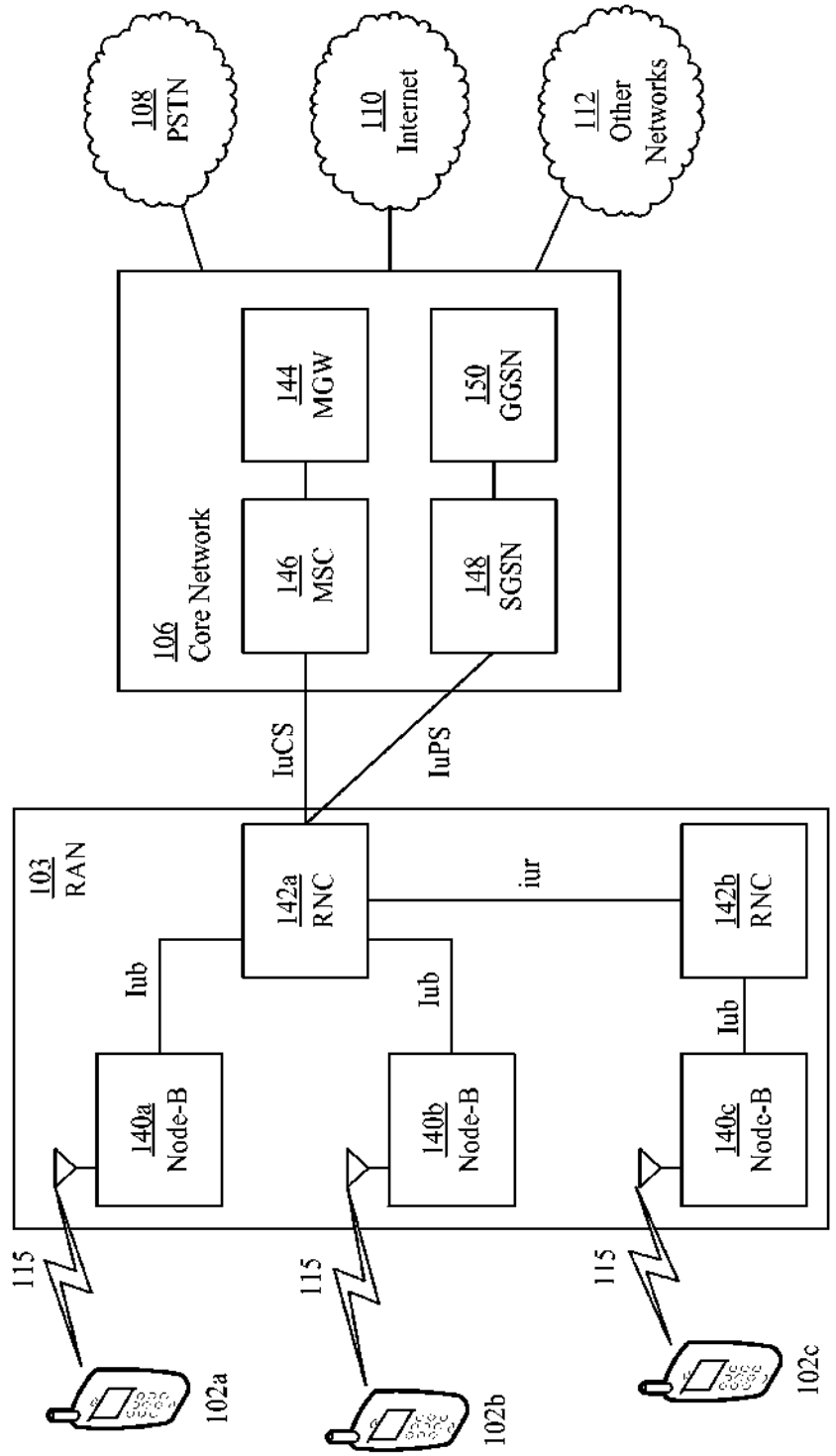

108 PSTN
110 Internet
112 Other Networks
106 Core Network
144 MGW
150 GGSN
146 MSC
148 SGSN
IuCS
IuPS
103 RAN
142a RNC
142b RNC
iur
Iub
Iub
Iub
140a Node-B
140b Node-B
140c Node-B
115
115
115
102a
102b
102c

FIG. 1C

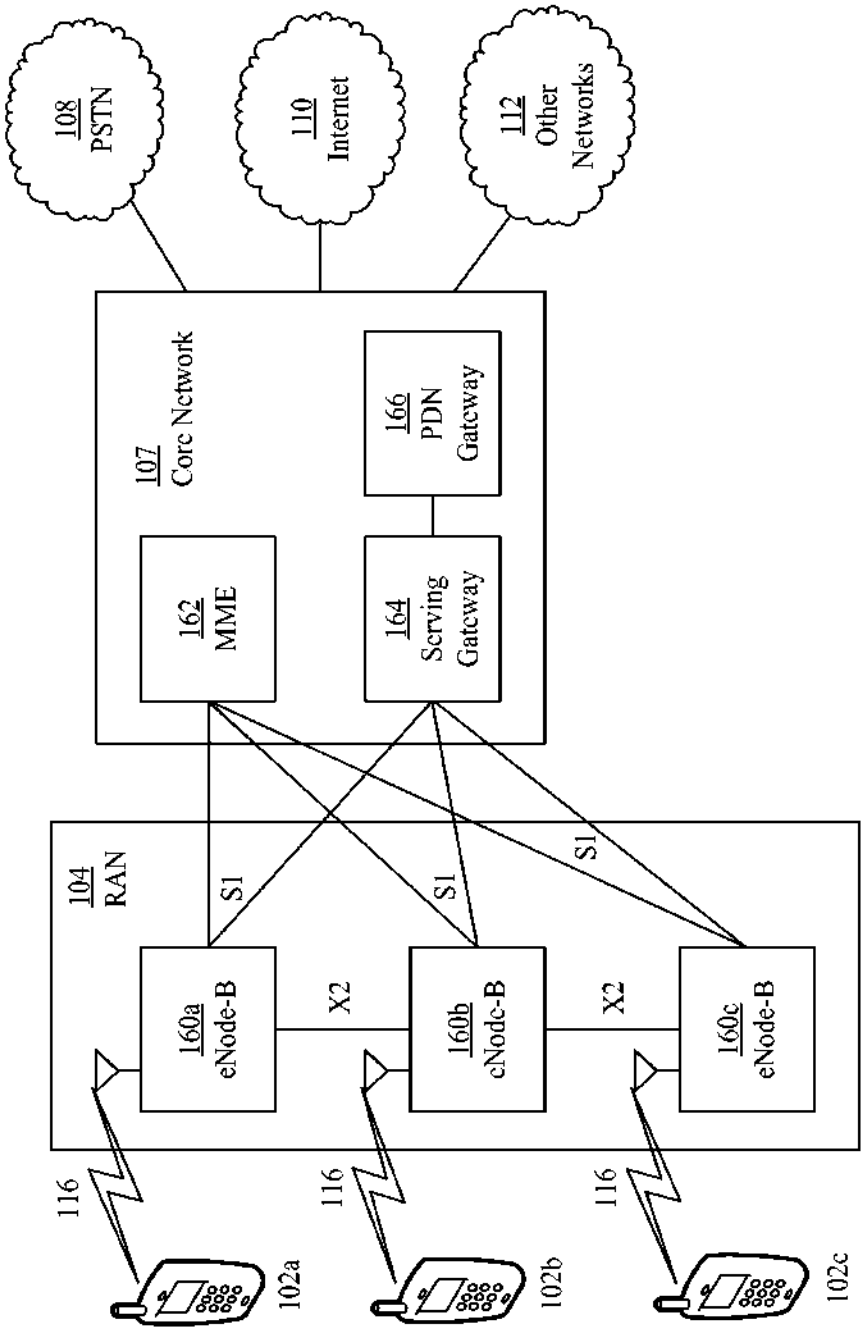

108 PSTN
110 Internet
112 Other Networks
107 Core Network
166 PDN Gateway
162 MME
164 Serving Gateway
104 RAN
S1
S1
S1
160a eNode-B
160b eNode-B
160c eNode-B
X2
X2
116
116
116
102a
102b
102c

FIG. 1D

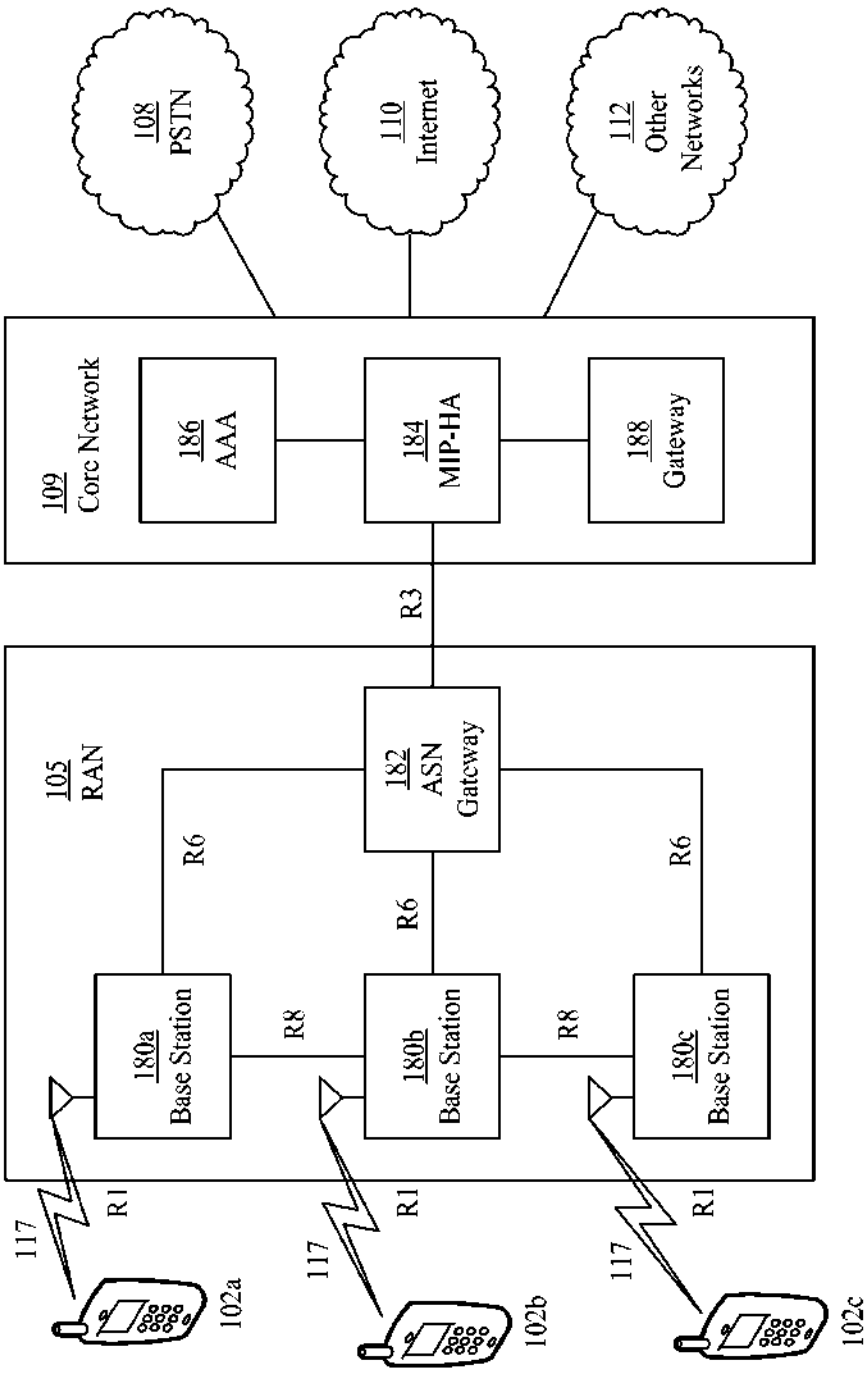

108
PSTN
110
Internet
112
Other
Networks
109
Core Network
186
AAA
184
MIP-HA
188
Gateway
R3
105
RAN
182
ASN
Gateway
R6
R6
R6
180a
Base Station
180b
Base Station
180c
Base Station
R8
R8
R1
R1
R1
117
117
117
102a
102b
102c

FIG. 1E

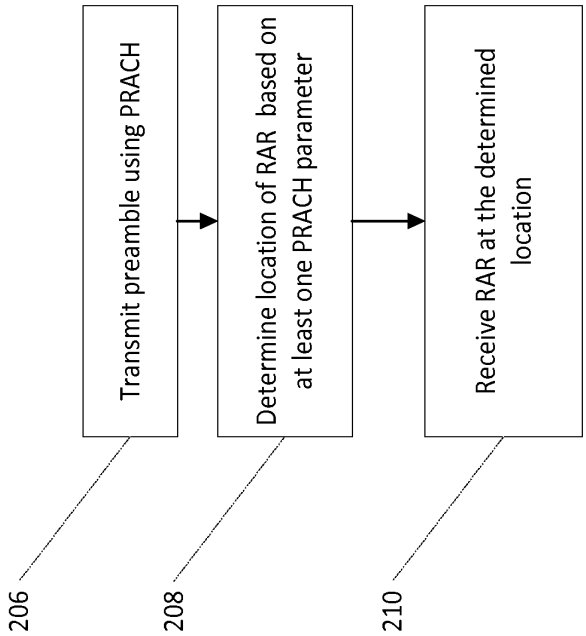

Transmit preamble using PRACH
Determine location of RAR based on at least one PRACH parameter
Receive RAR at the determined location
206
208
210

FIG. 2

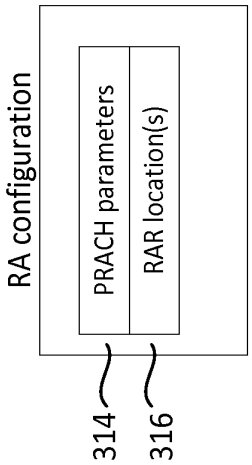

RA configuration
PRACH parameters
RAR location(s)
314
316

FIG. 3B

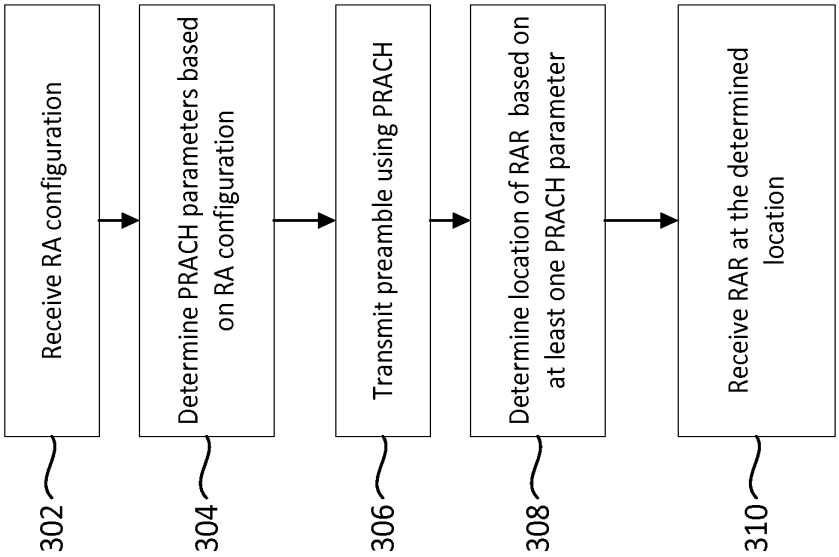

Receive RA configuration
Determine PRACH parameters based on RA configuration
Transmit preamble using PRACH
Determine location of RAR based on at least one PRACH parameter
Receive RAR at the determined location
302
304
306
308
310

FIG. 3A

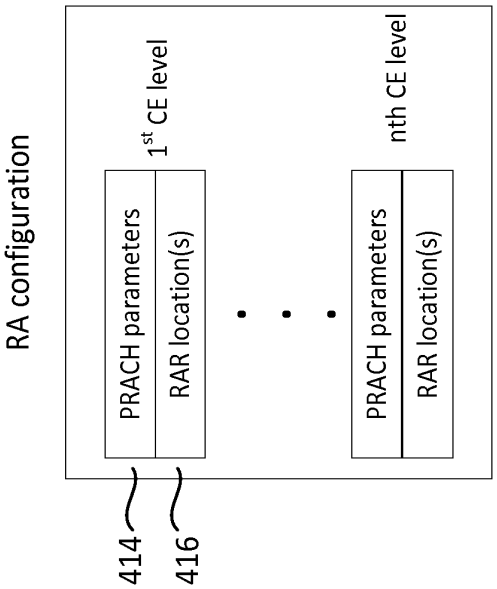

RA configuration
1st CE level
nth CE level
PRACH parameters
RAR location(s)
PRACH parameters
RAR location(s)
414
416

FIG. 4B

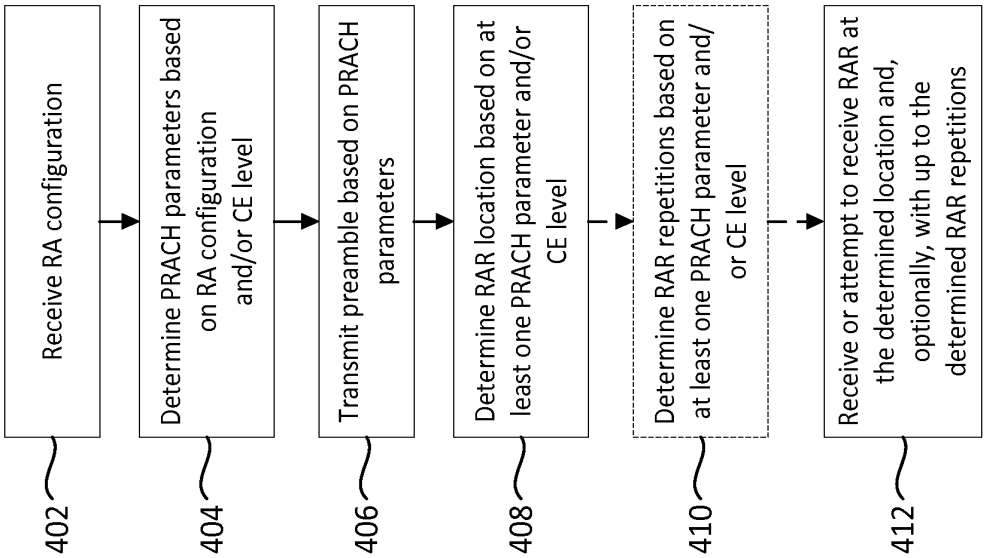

Receive RA configuration
Determine PRACH parameters based on RA configuration and/or CE level
Transmit preamble based on PRACH parameters
Determine RAR location based on at least one PRACH parameter and/or CE level
Determine RAR repetitions based on at least one PRACH parameter and/ or CE level
Receive or attempt to receive RAR at the determined location and, optionally, with up to the determined RAR repetitions
402
404
406
408
410
412

FIG. 4A

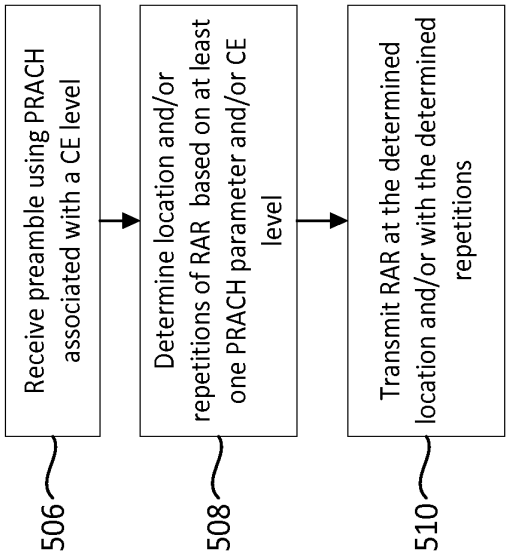

Receive preamble using PRACH associated with a CE level
Determine location and/or repetitions of RAR based on at least one PRACH parameter and/or CE level
Transmit RAR at the determined location and/or with the determined repetitions
506
508
510

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/045382

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W74/00 H04W74/08
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	NTT DOCOMO: "Discussion on Multi-level PRACH Coverage Enhancement", 3GPP DRAFT; R1-135509 PRACH_COVERAGE, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. San Francisco, USA; 20131111 - 20131115 13 November 2013 (2013-11-13), XP050735182, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN/RAN1/Docs/ [retrieved on 2013-11-13] page 2, paragraph 3 page 3, paragraphs 3.1, 3.2 page 4, paragraph 4 - page 5, paragraph 5 -/--	1-26

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 November 2015	20/11/2015

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Jurca, Dan

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Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/045382

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.

X	WO 2013/181808 A1 (HUAWEI TECH CO LTD [CN]; LI YUE [CN]; ZHU SONG [CN]; XIONG XIN [CN]; L) 12 December 2013 (2013-12-12) the whole document	1-26
X,P	& EP 2 849 483 A1 (HUAWEI TECH CO LTD [CN]) 18 March 2015 (2015-03-18) abstract page 5, paragraph 25-27 page 6, paragraphs 33,34,37,41,43 page 7, paragraph 55	1-26

X	US 2013/083749 A1 (XU HAO [US] ET AL) 4 April 2013 (2013-04-04)	1-12, 17-22
A	abstract page 5, paragraph 57 page 6, paragraphs 61,64-67, 69 page 7, paragraphs 72,73	13-16, 23-26

1

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2015/045382

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2013181808 A1	12-12-2013	CN 104170445 A	26-11-2014
		EP 2849483 A1	18-03-2015
		US 2015092740 A1	02-04-2015
		WO 2013181808 A1	12-12-2013
US 2013083749 A1	04-04-2013	CN 103828467 A	28-05-2014
		EP 2761962 A1	06-08-2014
		JP 5784840 B2	24-09-2015
		JP 2014531854 A	27-11-2014
		KR 20140071482 A	11-06-2014
		US 2013083749 A1	04-04-2013
		WO 2013049520 A1	04-04-2013

Form PCT/ISA/210 (patent family annex) (April 2005)

(12) 특허협력조약에 의하여 공개된 국제출원

(19) 세계지식재산권기구
국제사무국

(43) 국제공개일
2016 년 8 월 11 일 (11.08.2016)

WIPO | PCT

(10) 국제공개번호
WO 2016/126099 A1

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H04B 7/06 (2006.01) *H04L 5/00* (2006.01)
H04B 17/24 (2015.01)

(21) 국제출원번호: PCT/KR2016/001177

(22) 국제출원일: 2016 년 2 월 3 일 (03.02.2016)

(25) 출원언어: 한국어

(26) 공개언어: 한국어

(30) 우선권정보:
62/112,621 2015 년 2 월 5 일 (05.02.2015) US
62/131,221 2015 년 3 월 10 일 (10.03.2015) US

(71) 출원인: 엘지전자(주) (LG ELECTRONICS INC.) [KR/KR]; 07336 서울시 영등포구 여의대로 128, Seoul (KR).

(72) 발명자: 박종현 (PARK, Jonghyun); 06772 서울시 서초구 양재대로 11 길 19, LG 전자 특허센터, Seoul (KR). 김기준 (KIM, Kijun); 06772 서울시 서초구 양재대로 11 길 19, LG 전자 특허센터, Seoul (KR). 김형태 (KIM, Hyungtae); 06772 서울시 서초구 양재대로 11 길 19, LG 전자 특허센터, Seoul (KR). 김영태 (KIM, Youngtae); 06772 서울시 서초구 양재대로 11 길 19, LG 전자 특허센터, Seoul (KR). 염건일 (YUM, Kunil); 06772 서울시 서초구 양재대로 11 길 19, LG 전자 특허센터, Seoul (KR).

(74) 대리인: 특허법인 로얄 (ROYAL PATENT & LAW OFFICE); 08806 서울시 관악구 남부순환로 2072, 도원회관 빌딩 1 층, Seoul (KR).

(81) 지정국 (별도의 표시가 없는 한, 가능한 모든 종류의 국내 권리의 보호를 위하여): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

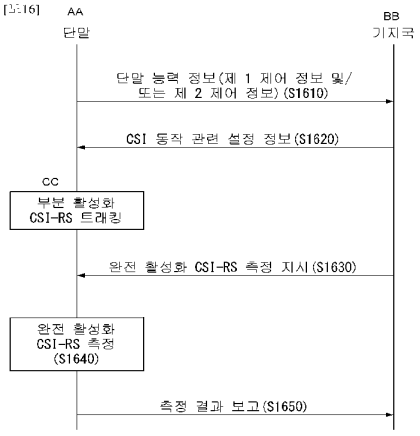
(84) 지정국 (별도의 표시가 없는 한, 가능한 모든 종류의 역내 권리의 보호를 위하여): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), 유라시아 (AM, AZ, BY, KG, KZ, RU, TJ, TM), 유럽 (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR),

[다음 쪽 계속]

(54) Title: METHOD FOR CSI FEEDBACK IN WIRELESS COMMUNICATION SYSTEM, AND APPARATUS THEREFOR

(54) 발명의 명칭 : 무선 통신 시스템에서 CSI를 피드백하기 위한 방법 및 이를 위한 장치

[도16]



S1610 ... Terminal capability information (first control information and/or second control information)
S1620 ... CSI action-related configuration information
S1630 ... Command measurement of fully activated CSI-RS
S1640 ... Measure fully activated CSI-RS
S1650 ... Report result of measurement
AA ... Terminal
BB ... Base station
CC ... Track partially activated CSI-RS

(57) Abstract: A method for feeding back channel state information (CSI) in a wireless communication system, carried out by a terminal, according to the present specification comprises the steps of: transmitting, to a base station, capability information of the terminal for CSI-related action; receiving configuration information for the CSI-related action from the base station; tracking partially activated CSI reference signal (RS); measuring fully activated CSI-RS; and reporting the results of the measurement to the base station.

(57) 요약서: 본 명세서는 무선 통신 시스템에서 CSI(Channel State Information) 피드백(feedback)을 수행하기 위한 방법에 있어서, 단말에 의해 수행되는 방법은, CSI 관련 동작에 대한 상기 단말의 능력(capability) 정보를 기지국으로 전송하는 단계; CSI 관련 동작 설정(configuration) 정보를 상기 기지국으로부터 수신하는 단계; 부분 활성화 CSI-RS(Reference Signal)를 트래킹(tracking)하는 단계; 완전 활성화 CSI-RS 를 측정하는 단계; 및 상기 측정 결과를 상기 기지국으로 보고(report)하는 단계를 포함하여 이루어지는 것을 특징으로 한다.

WO 2016/126099 A1

OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

공개:

— 국제조사보고서와 함께 (조약 제 21 조(3))

명세서

발명의 명칭: 무선 통신 시스템에서 CSI를 피드백하기 위한 방법 및 이를 위한 장치

기술분야

[1] 본 발명은 무선 통신 시스템에 관한 것으로서, 보다 상세하게 단말에서 참조 신호(reference signal)을 기반으로 CSI를 피드백하기 위한 방법 및 이를 지원하는 장치에 관한 것이다.

배경기술

[2] 이동 통신 시스템은 사용자의 활동성을 보장하면서 음성 서비스를 제공하기 위해 개발되었다. 그러나 이동통신 시스템은 음성뿐 아니라 데이터 서비스까지 영역을 확장하였으며, 현재에는 폭발적인 트래픽의 증가로 인하여 자원의 부족 현상이 야기되고 사용자들이 보다 고속의 서비스에 대한 요구하므로, 보다 발전된 이동 통신 시스템이 요구되고 있다.

[3] 차세대 이동 통신 시스템의 요구 조건은 크게 폭발적인 데이터 트래픽의 수용, 사용자 당 전송률의 획기적인 증가, 대폭 증가된 연결 디바이스 개수의 수용, 매우 낮은 단대단 지연(End-to-End Latency), 고에너지 효율을 지원할 수 있어야 한다. 이를 위하여 이중 연결성(Dual Connectivity), 대규모 다중 입출력(Massive MIMO: Massive Multiple Input Multiple Output), 전이중(In-band Full Duplex), 비직교 다중접속(NOMA: Non-Orthogonal Multiple Access), 초광대역(Super wideband) 지원, 단말 네트워킹(Device Networking) 등 다양한 기술들이 연구되고 있다.

발명의 상세한 설명

기술적 과제

[4] 본 명세서는 CSI 동작과 관련된 단말의 능력 정보를 송수신하는 방법을 제공함에 목적이 있다.

[5] 또한, 본 명세서는 CSI 피드백 절차에서 지연을 줄이기 위해 부분 활성화 CSI-RS를 트래킹하고, 완전 활성화 CSI-RS에 대해서만 측정 및 보고를 수행하는 방법을 제공함에 목적이 있다.

[6] 또한, 본 명세서는 CSI 측정 관련 윈도우를 초기화 또는 갱신하는 방법을 제공함에 목적이 있다.

[7] 본 발명에서 이루고자 하는 기술적 과제들은 이상에서 언급한 기술적 과제들로 제한되지 않으며, 언급하지 않은 또 다른 기술적 과제들은 아래의 기재로부터 본 발명이 속하는 기술분야에서 통상의 지식을 가진 자에게 명확하게 이해될 수 있을 것이다.

과제 해결 수단

[8] 본 명세서는 무선 통신 시스템에서 CSI(Channel State Information)

피드백(feedback)을 수행하기 위한 방법에 있어서, 단말에 의해 수행되는 방법은, CSI 관련 동작에 대한 상기 단말의 능력(capability) 정보를 기지국으로 전송하는 단계; CSI 관련 동작 설정(configuration) 정보를 상기 기지국으로부터 수신하는 단계, 상기 CSI 관련 동작 설정 정보는 부분 활성화(partial activation)를 수행하는 CSI 관련 동작을 나타내는 부분 활성화 CSI 관련 동작 인덱스(index) 정보 또는 완전 활성화(full activation)를 수행하는 CSI 관련 동작을 나타내는 완전 활성화 CSI 관련 동작 인덱스 정보 중 적어도 하나를 포함하며; 부분 활성화 CSI-RS(Reference Signal)를 트래킹(tracking)하는 단계; 완전 활성화 CSI-RS를 측정하는 단계; 및 상기 측정 결과를 상기 기지국으로 보고(report)하는 단계를 포함하여 이루어지는 것을 특징으로 한다.

[9] 또한, 본 명세서에서 상기 완전 활성화 CSI-RS를 측정하는 단계는, 상기 완전 활성화 CSI-RS에 대한 측정의 활성화를 지시하는 제 1 메시지를 상기 기지국으로부터 수신하는 단계; 및 상기 제 1 메시지에 의해 활성화된 완전 활성화 CSI-RS를 측정하는 단계를 포함하는 것을 특징으로 한다.

[10] 또한, 본 명세서에서 상기 CSI 관련 동작은 CSI-RS, CSI-IM(Interference Management) 또는 CSI process 중 적어도 하나와 관련 있는 것을 특징으로 한다.

[11] 또한, 본 명세서에서 상기 단말의 능력 정보는 동시에 완전 활성화(full activation) 가능한 상기 CSI 관련 동작의 최대 개수를 나타내는 제 1 제어 정보 및 동시에 부분 활성화(partial activation) 가능한 상기 CSI 관련 동작의 최대 개수를 나타내는 제 2 제어 정보를 포함하는 것을 특징으로 한다.

[12] 또한, 본 명세서에서 상기 부분 활성화 CSI-RS를 트래킹(tracking)하는 단계는, 상기 부분 활성화 CSI-RS에 대해 시간 및/또는 주파수에서 동기를 맞추는 단계를 포함하는 것을 특징으로 한다.

[13] 또한, 본 명세서에서 상기 트래킹은 상기 CSI 관련 동작 설정 정보에 포함된 특정 RS(Reference Signal)과 quasi co-location(QCL) 가정을 적용하여 수행하는 것을 특징으로 한다.

[14] 또한, 본 명세서에서 상기 완전 활성화 CSI-RS는 상기 부분 활성화 CSI-RS에서 선택되는 것을 특징으로 한다.

[15] 또한, 본 명세서에서 상기 제 1 메시지는 MAC(Media Access Control) CE(Control Element) 또는 DCI(Downlink Control Information)인 것을 특징으로 한다.

[16] 또한, 본 명세서는 상기 기지국으로부터 CSI-RS 측정 윈도우(measurement window)와 관련된 제 3 제어 정보를 수신하는 단계를 더 포함하며, 상기 CSI-RS를 측정하는 단계는, 상기 제 1 메시지를 수신하는 경우, 상기 CSI-RS 측정 윈도우를 초기화 또는 갱신하는 단계; 상기 CSI-RS 측정 윈도우가 초기화 또는 갱신되는 시점부터 특정 구간까지 CSI-RS의 측정을 반복적으로 수행하는 단계; 및 상기 측정 결과들을 평균하는(averaging) 단계를 포함하는 것을 특징으로 한다.

[17] 또한, 본 명세서에서 CSI 피드백이 주기적 CSI 피드백인 경우, 상기 CSI-RS 측정 윈도우를 초기화 또는 갱신하는 시점은 상기 특정 구간 이후에 최초로 발생하는 RI(Rank Indicator) 보고에 연관된 특정 기준 자원(reference resource) 시점인 것을 특징으로 한다.

[18] 또한, 본 명세서에서 상기 제 1 메시지는 각 CSI 프로세스 별로 상기 기지국으로부터 수신되는 것을 특징으로 한다.

[19] 또한, 본 명세서에서 상기 제 1 메시지는 빔포밍 관련 매트릭스의 변경을 알리는 빔-변경 지시자(Beam-Change Indicator:BCI) 시그널링(signaling)인 것을 특징으로 한다.

[20] 또한, 본 명세서는 무선 통신 시스템에서 CSI(Channel State Information)을 피드백하기 위한 단말에 있어서, 상기 단말은, 무선 신호를 송수신하기 위한 RF(Radio Frequency) 유닛; 및 상기 RF 유닛을 제어하는 프로세서를 포함하고, CSI 관련 동작에 대한 상기 단말의 능력(capability) 정보를 기지국으로 전송하고; CSI 관련 동작 설정(configuration) 정보를 상기 기지국으로부터 수신하고, 상기 CSI 관련 동작 설정 정보는 부분 활성화(partial activation)를 수행하는 CSI 관련 동작을 나타내는 부분 활성화 CSI 관련 동작 인덱스(index) 정보 또는 완전 활성화(full activation)를 수행하는 CSI 관련 동작을 나타내는 완전 활성화 CSI 관련 동작 인덱스 정보 중 적어도 하나를 포함하며; 부분 활성화 CSI-RS(Reference Signal)를 트래킹(tracking)하고; 완전 활성화 CSI-RS를 측정하며; 및 상기 측정 결과를 상기 기지국으로 보고(report)하도록 제어하는 것을 특징으로 한다.

발명의 효과

[21] 본 명세서는 MAC 레벨 또는 PHY 레벨에서 CSI 설정 관련 정보를 단말로 전송함으로써, CSI 피드백 절차에 있어 지연을 줄일 수 있는 효과가 있다.

[22] 또한, 본 명세서는 CSI 측정 관련 윈도우를 CSI 측정 활성화 지시 시점 또는 CSI 설정 변경 알림 시점에 초기화 또는 갱신하도록 함으로써, 불필요한 과거의 환경을 CSI 측정에 반영시키지 않도록 함으로써 보다 정확한 CSI 피드백을 수행할 수 있는 효과가 있다.

[23] 본 발명에서 얻을 수 있는 효과는 이상에서 언급한 효과로 제한되지 않으며, 언급하지 않은 또 다른 효과들은 아래의 기재로부터 본 발명이 속하는 기술분야에서 통상의 지식을 가진 자에게 명확하게 이해될 수 있을 것이다.

도면의 간단한 설명

[24] 본 발명에 관한 이해를 돕기 위해 상세한 설명의 일부로 포함되는, 첨부 도면은 본 발명에 대한 실시예를 제공하고, 상세한 설명과 함께 본 발명의 기술적 특징을 설명한다.

[25] 도 1은 본 발명이 적용될 수 있는 무선 통신 시스템에서 무선 프레임의 구조를 나타낸다.

[26] 도 2는 본 발명이 적용될 수 있는 무선 통신 시스템에서 하나의 하향링크 슬롯에 대한 자원 그리드(resource grid)를 예시한 도면이다.

[27] 도 3은 본 발명이 적용될 수 있는 무선 통신 시스템에서 하향링크 서브 프레임의 구조를 나타낸다.

[28] 도 4는 본 발명이 적용될 수 있는 무선 통신 시스템에서 상향링크 서브 프레임의 구조를 나타낸다.

[29] 도 5는 일반적인 다중 입출력 안테나(MIMO) 통신 시스템의 구성도이다.

[30] 도 6은 다수의 송신 안테나에서 하나의 수신 안테나로의 채널을 나타낸 도이다.

[31] 도 7은 본 발명이 적용될 수 있는 무선 통신 시스템에서 컴포넌트 캐리어 및 캐리어 병합의 일례를 나타낸다.

[32] 도 8은 본 발명이 적용될 수 있는 무선 통신 시스템에서 경쟁 기반 랜덤 액세스 절차를 설명하기 위한 도면이다.

[33] 도 9는 본 발명이 적용될 수 있는 무선 통신 시스템에서 하향링크 자원 블록 쌍에 매핑된 참조 신호 패턴을 예시한다.

[34] 도 10은 본 발명이 적용될 수 있는 무선 통신 시스템에서 CSI-RS 구성을 예시하는 도면이다.

[35] 도 11은 본 발명이 적용될 수 있는 무선 통신 시스템에서 기지국 또는 단말이 AAS 기반의 3D(3-Dimension) 빔 형성이 가능한 다수의 송/수신 안테나를 갖고 있는 시스템을 예시한다.

[36] 도 12는 본 발명의 일 실시예에 따른 RRM-RS의 안테나 포트 별 RSRP를 예시한다.

[37] 도 13은 본 발명의 일 실시예에 따른 RRM-RS 안테나 포트 그룹핑 레벨을 예시한다.

[38] 도 14는 본 발명의 일 실시예에 따른 이차원 인덱스로 배열된 RRM-RS의 안테나 포트와 안테나 포트 그룹을 예시하는 도면이다.

[39] 도 15 내지 17은 본 명세서에서 제안하는 CSI 측정 및 보고 방법의 일례들을 나타낸 도이다.

[40] 도 18은 본 발명의 일 실시예에 따른 무선 통신 장치의 블록 구성도를 예시한다.

발명의 실시를 위한 형태

[41] 이하, 본 발명에 따른 바람직한 실시 형태를 첨부된 도면을 참조하여 상세하게 설명한다. 첨부된 도면과 함께 이하에 개시될 상세한 설명은 본 발명의 예시적인 실시형태를 설명하고자 하는 것이며, 본 발명이 실시될 수 있는 유일한 실시형태를 나타내고자 하는 것이 아니다. 이하의 상세한 설명은 본 발명의 완전한 이해를 제공하기 위해서 구체적 세부사항을 포함한다. 그러나, 당업자는 본 발명이 이러한 구체적 세부사항 없이도 실시될 수 있음을 안다.

[42] 몇몇 경우, 본 발명의 개념이 모호해지는 것을 피하기 위하여 공지의 구조 및 장치는 생략되거나, 각 구조 및 장치의 핵심기능을 중심으로 한 블록도 형식으로

도시될 수 있다.

[43] 본 명세서에서 기지국은 단말과 직접적으로 통신을 수행하는 네트워크의 종단 노드(terminal node)로서의 의미를 갖는다. 본 문서에서 기지국에 의해 수행되는 것으로 설명된 특정 동작은 경우에 따라서는 기지국의 상위 노드(upper node)에 의해 수행될 수도 있다. 즉, 기지국을 포함하는 다수의 네트워크 노드들(network nodes)로 이루어지는 네트워크에서 단말과의 통신을 위해 수행되는 다양한 동작들은 기지국 또는 기지국 이외의 다른 네트워크 노드들에 의해 수행될 수 있음은 자명하다. '기지국(BS: Base Station)'은 고정국(fixed station), Node B, eNB(evolved-NodeB), BTS(base transceiver system), 액세스 포인트(AP: Access Point) 등의 용어에 의해 대체될 수 있다. 또한, '단말(Terminal)'은 고정되거나 이동성을 가질 수 있으며, UE(User Equipment), MS(Mobile Station), UT(user terminal), MSS(Mobile Subscriber Station), SS(Subscriber Station), AMS(Advanced Mobile Station), WT(Wireless terminal), MTC(Machine-Type Communication) 장치, M2M(Machine-to-Machine) 장치, D2D(Device-to-Device) 장치 등의 용어로 대체될 수 있다.

[44] 이하에서, 하향링크(DL: downlink)는 기지국에서 단말로의 통신을 의미하며, 상향링크(UL: uplink)는 단말에서 기지국으로의 통신을 의미한다. 하향링크에서 송신기는 기지국의 일부이고, 수신기는 단말의 일부일 수 있다. 상향링크에서 송신기는 단말의 일부이고, 수신기는 기지국의 일부일 수 있다.

[45] 이하의 설명에서 사용되는 특정 용어들은 본 발명의 이해를 돕기 위해서 제공된 것이며, 이러한 특정 용어의 사용은 본 발명의 기술적 사상을 벗어나지 않는 범위에서 다른 형태로 변경될 수 있다.

[46] 이하의 기술은 CDMA(code division multiple access), FDMA(frequency division multiple access), TDMA(time division multiple access), OFDMA(orthogonal frequency division multiple access), SC-FDMA(single carrier frequency division multiple access), NOMA(non-orthogonal multiple access) 등과 같은 다양한 무선 접속 시스템에 이용될 수 있다. CDMA는 UTRA(universal terrestrial radio access)나 CDMA2000과 같은 무선 기술(radio technology)로 구현될 수 있다. TDMA는 GSM(global system for mobile communications)/GPRS(general packet radio service)/EDGE(enhanced data rates for GSM evolution)와 같은 무선 기술로 구현될 수 있다. OFDMA는 IEEE 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802-20, E-UTRA(evolved UTRA) 등과 같은 무선 기술로 구현될 수 있다. UTRA는 UMTS(universal mobile telecommunications system)의 일부이다. 3GPP(3rd generation partnership project) LTE(long term evolution)은 E-UTRA를 사용하는 E-UMTS(evolved UMTS)의 일부로써, 하향링크에서 OFDMA를 채용하고 상향링크에서 SC-FDMA를 채용한다. LTE-A(advanced)는 3GPP LTE의 진화이다.

[47] 본 발명의 실시예들은 무선 접속 시스템들인 IEEE 802, 3GPP 및 3GPP2 중 적어도 하나에 개시된 표준 문서들에 의해 뒷받침될 수 있다. 즉, 본 발명의

실시예들 중 본 발명의 기술적 사상을 명확히 드러내기 위해 설명하지 않은 단계들 또는 부분들은 상기 문서들에 의해 뒷받침될 수 있다. 또한, 본 문서에서 개시하고 있는 모든 용어들은 상기 표준 문서에 의해 설명될 수 있다.

[48] 설명을 명확하게 하기 위해, 3GPP LTE/LTE-A를 위주로 기술하지만 본 발명의 기술적 특징이 이에 제한되는 것은 아니다.

[49]

[50] **본 발명이 적용될 수 있는 무선 통신 시스템 일반**

[51] 도 1은 본 발명이 적용될 수 있는 무선 통신 시스템에서 무선 프레임의 구조를 나타낸다.

[52] 3GPP LTE/LTE-A에서는 FDD(Frequency Division Duplex)에 적용 가능한 타입 1 무선 프레임(radio frame) 구조와 TDD(Time Division Duplex)에 적용 가능한 타입 2의 무선 프레임 구조를 지원한다.

[53] 도 1에서 무선 프레임의 시간 영역에서의 크기는 T_s=1/(15000*2048)의 시간 단위의 배수로 표현된다. 하향링크 및 상향링크 전송은 T_f=307200*T_s=10ms의 구간을 가지는 무선 프레임으로 구성된다.

[54] 도 1의 (a)는 타입 1 무선 프레임의 구조를 예시한다. 타입 1 무선 프레임은 전이중(full duplex) 및 반이중(half duplex) FDD에 모두 적용될 수 있다.

[55] 무선 프레임(radio frame)은 10개의 서브프레임(subframe)으로 구성된다. 하나의 무선 프레임은 T_slot=15360*T_s=0.5ms 길이의 20개의 슬롯으로 구성되고, 각 슬롯은 0부터 19까지의 인덱스가 부여된다. 하나의 서브프레임은 시간 영역(time domain)에서 연속적인 2개의 슬롯(slot)으로 구성되고, 서브프레임 i는 슬롯 2i 및 슬롯 2i+1로 구성된다. 하나의 서브프레임을 전송하는데 걸리는 시간을 TTI(transmission time interval)이라 한다. 예를 들어, 하나의 서브 프레임은 길이는 1ms이고, 하나의 슬롯의 길이는 0.5ms일 수 있다.

[56] FDD에서 상향링크 전송 및 하향링크 전송은 주파수 도메인에서 구분된다. 전이중 FDD에 제한이 없는 반면, 반이중 FDD 동작에서 단말은 동시에 전송 및 수신을 할 수 없다.

[57] 하나의 슬롯은 시간 영역에서 복수의 OFDM(orthogonal frequency division multiplexing) 심볼을 포함하고, 주파수 영역에서 다수의 자원블록(RB: Resource Block)을 포함한다. 3GPP LTE는 하향링크에서 OFDMA를 사용하므로 OFDM 심볼은 하나의 심볼 구간(symbol period)을 표현하기 위한 것이다. OFDM 심볼은 하나의 SC-FDMA 심볼 또는 심볼 구간이라고 할 수 있다. 자원 블록(resource block)은 자원 할당 단위이고, 하나의 슬롯에서 복수의 연속적인 부반송파(subcarrier)를 포함한다.

[58] 도 1의 (b)는 타입 2 프레임 구조(frame structure type 2)를 나타낸다.

[59] 타입 2 무선 프레임은 각 153600*T_s=5ms의 길이의 2개의 하프 프레임(half frame)으로 구성된다. 각 하프 프레임은 30720*T_s=1ms 길이의 5개의 서브프레임으로 구성된다.

[60] TDD 시스템의 타입 2 프레임 구조에서 상향링크-하향링크 구성(uplink-downlink configuration)은 모든 서브프레임에 대하여 상향링크와 하향링크가 할당(또는 예약)되는지 나타내는 규칙이다.

[61] 표 1은 상향링크-하향링크 구성을 나타낸다.

[62] [표1]

Uplink-Downlink configu-ration	Downlink-to-Uplink Switch-point periodicity	Subframe number									
		0	1	2	3	4	5	6	7	8	9
0	5ms	D	S	U	U	U	D	S	U	U	U
1	5ms	D	S	U	U	D	D	S	U	U	D
2	5ms	D	S	U	D	D	D	S	U	D	D
3	10ms	D	S	U	U	U	D	D	D	D	D
4	10ms	D	S	U	U	D	D	D	D	D	D
5	10ms	D	S	U	D	D	D	D	D	D	D
6	5ms	D	S	U	U	U	D	S	U	U	D

[63] 표 1을 참조하면, 무선 프레임의 각 서브프레임 별로, 'D'는 하향링크 전송을 위한 서브프레임을 나타내고, 'U'는 상향링크 전송을 위한 서브프레임을 나타내며, 'S'는 DwPTS(Downlink Pilot Time Slot), 보호구간(GP: Guard Period), UpPTS(Uplink Pilot Time Slot) 3가지의 필드로 구성되는 스페셜 서브프레임(special subframe)을 나타낸다.

[64] DwPTS는 단말에서의 초기 셀 탐색, 동기화 또는 채널 추정에 사용된다. UpPTS는 기지국에서의 채널 추정과 단말의 상향링크 전송 동기를 맞추는 데 사용된다. GP는 상향링크와 하향링크 사이에 하향링크 신호의 다중경로 지연으로 인해 상향링크에서 생기는 간섭을 제거하기 위한 구간이다.

[65] 각 서브프레임 i는 각 T_slot=15360*T_s=0.5ms 길이의 슬롯 2i 및 슬롯 2i+1로 구성된다.

[66] 상향링크-하향링크 구성은 7가지로 구분될 수 있으며, 각 구성 별로 하향링크 서브프레임, 스페셜 서브프레임, 상향링크 서브프레임의 위치 및/또는 개수가 다르다.

[67] 하향링크에서 상향링크로 변경되는 시점 또는 상향링크에서 하향링크로 전환되는 시점을 전환 시점(switching point)이라 한다. 전환 시점의 주기성(Switch-point periodicity)은 상향링크 서브프레임과 하향링크 서브프레임이 전환되는 양상이 동일하게 반복되는 주기를 의미하며, 5ms 또는 10ms가 모두 지원된다. 5ms 하향링크-상향링크 전환 시점의 주기를 가지는 경우에는 스페셜 서브프레임(S)은 하프-프레임 마다 존재하고, 5ms 하향링크-상향링크 전환 시점의 주기를 가지는 경우에는 첫번째 하프-프레임에만 존재한다.

[68] 모든 구성에 있어서, 0번, 5번 서브프레임 및 DwPTS는 하향링크 전송만을 위한 구간이다. UpPTS 및 서브프레임 서브프레임에 바로 이어지는 서브프레임은

항상 상향링크 전송을 위한 구간이다.

[69] 이러한, 상향링크-하향링크 구성은 시스템 정보로써 기지국과 단말이 모두 알고 있을 수 있다. 기지국은 상향링크-하향링크 구성 정보가 바뀔 때마다 구성 정보의 인덱스만을 전송함으로써 무선 프레임의 상향링크-하향링크 할당상태의 변경을 단말에 알려줄 수 있다. 또한, 구성 정보는 일종의 하향링크 제어정보로서 다른 스케줄링 정보와 마찬가지로 PDCCH(Physical Downlink Control Channel)를 통해 전송될 수 있으며, 방송 정보로서 브로드캐스트 채널(broadcast channel)을 통해 셀 내의 모든 단말에 공통으로 전송될 수도 있다.

[70] 표 2는 스페셜 서브프레임의 구성(DwPTS/GP/UpPTS의 길이)을 나타낸다.

[71] [표2]

Special subframe configuration	Normal cyclic prefix in downlink			Extended cyclic prefix in downlink		
	DwPTS	UpPTS		DwPTS	UpPTS	
		Normal cyclic prefix in uplink	Extended cyclic prefix in uplink		Normal cyclic prefix in uplink	Extended cyclic prefix in uplink
0	$6592 \cdot T_s$	$2192 \cdot T_s$	$2560 \cdot T_s$	$7680 \cdot T_s$	$2192 \cdot T_s$	$2560 \cdot T_s$
1	$19760 \cdot T_s$			$20480 \cdot T_s$		
2	$21952 \cdot T_s$			$23040 \cdot T_s$		
3	$24144 \cdot T_s$			$25600 \cdot T_s$		
4	$26336 \cdot T_s$			$7680 \cdot T_s$	$4384 \cdot T_s$	$5120 \cdot T_s$
5	$6592 \cdot T_s$	$4384 \cdot T_s$	$5120 \cdot T_s$	$20480 \cdot T_s$		
6	$19760 \cdot T_s$			$23040 \cdot T_s$		
7	$21952 \cdot T_s$			-	-	-
8	$24144 \cdot T_s$			-	-	-

[72] 도 1의 예시에 따른 무선 프레임의 구조는 하나의 예시에 불과하며, 무선 프레임에 포함되는 부 반송파의 수 또는 서브 프레임에 포함되는 슬롯의 수, 슬롯에 포함되는 OFDM 심볼의 수는 다양하게 변경될 수 있다.

[73] 도 2는 본 발명이 적용될 수 있는 무선 통신 시스템에서 하나의 하향링크 슬롯에 대한 자원 그리드(resource grid)를 예시한 도면이다.

[74] 도 2를 참조하면, 하나의 하향링크 슬롯은 시간 영역에서 복수의 OFDM 심볼을 포함한다. 여기서, 하나의 하향링크 슬롯은 7개의 OFDM 심볼을 포함하고, 하나의 자원 블록은 주파수 영역에서 12개의 부 반송파를 포함하는 것을 예시적으로 기술하나, 이에 한정되는 것은 아니다.

[75] 자원 그리드 상에서 각 요소(element)를 자원 요소(resource element)하고, 하나의 자원 블록(RB: resource block)은 12×7 개의 자원 요소를 포함한다. 하향링크 슬롯에 포함되는 자원 블록들의 수 N^DL은 하향링크 전송 대역폭(bandwidth)에 종속한다.

[76] 상향링크 슬롯의 구조는 하향링크 슬롯의 구조와 동일할 수 있다.

[77] 도 3은 본 발명이 적용될 수 있는 무선 통신 시스템에서 하향링크 서브

프레임의 구조를 나타낸다.

[78] 도 3을 참조하면, 서브 프레임내의 첫번째 슬롯에서 앞의 최대 3개의 OFDM 심볼들이 제어 채널들이 할당되는 제어 영역(control region)이고, 나머지 OFDM 심볼들은 PDSCH(Physical Downlink Shared Channel)이 할당되는 데이터 영역(data region)이다. 3GPP LTE에서 사용되는 하향링크 제어 채널의 일례로 PCFICH(Physical Control Format Indicator Channel), PDCCH(Physical Downlink Control Channel), PHICH(Physical Hybrid-ARQ Indicator Channel) 등이 있다.

[79] PCFICH는 서브 프레임의 첫번째 OFDM 심볼에서 전송되고, 서브 프레임 내에 제어 채널들의 전송을 위하여 사용되는 OFDM 심볼들의 수(즉, 제어 영역의 크기)에 관한 정보를 나른다. PHICH는 상향 링크에 대한 응답 채널이고, HARQ(Hybrid Automatic Repeat Request)에 대한 ACK(Acknowledgement)/NACK(Not-Acknowledgement) 신호를 나른다. PDCCH를 통해 전송되는 제어 정보를 하향링크 제어정보(DCI: downlink control information)라고 한다. 하향링크 제어정보는 상향링크 자원 할당 정보, 하향링크 자원 할당 정보 또는 임의의 단말 그룹에 대한 상향링크 전송(Tx) 파워 제어 명령을 포함한다.

[80] PDCCH는 DL-SCH(Downlink Shared Channel)의 자원 할당 및 전송 포맷(이를 하향링크 그랜트라고도 한다.), UL-SCH(Uplink Shared Channel)의 자원 할당 정보(이를 상향링크 그랜트라고도 한다.), PCH(Paging Channel)에서의 페이징(paging) 정보, DL-SCH에서의 시스템 정보, PDSCH에서 전송되는 랜덤 액세스 응답(random access response)과 같은 상위 레이어(upper-layer) 제어 메시지에 대한 자원 할당, 임의의 단말 그룹 내 개별 단말들에 대한 전송 파워 제어 명령들의 집합, VoIP(Voice over IP)의 활성화 등을 나를 수 있다. 복수의 PDCCH들은 제어 영역 내에서 전송될 수 있으며, 단말은 복수의 PDCCH들을 모니터링할 수 있다. PDCCH는 하나 또는 복수의 연속적인 CCE(control channel elements)의 집합으로 구성된다. CCE는 무선 채널의 상태에 따른 부호화율(coding rate)을 PDCCH에 제공하기 위하여 사용되는 논리적 할당 단위이다. CCE는 복수의 자원 요소 그룹(resource element group)들에 대응된다. PDCCH의 포맷 및 사용 가능한 PDCCH의 비트 수는 CCE들의 수와 CCE들에 의해 제공되는 부호화율 간의 연관 관계에 따라 결정된다.

[81] 기지국은 단말에게 전송하려는 DCI에 따라 PDCCH 포맷을 결정하고, 제어 정보에 CRC(Cyclic Redundancy Check)를 붙인다. CRC에는 PDCCH의 소유자(owner)나 용도에 따라 고유한 식별자(이를 RNTI(Radio Network Temporary Identifier)라고 한다.)가 마스킹된다. 특정의 단말을 위한 PDCCH라면 단말의 고유한 식별자, 예를 들어 C-RNTI(Cell-RNTI)가 CRC에 마스킹될 수 있다. 또는 페이징 메시지를 위한 PDCCH라면 페이징 지시 식별자, 예를 들어 P-RNTI(Paging-RNTI)가 CRC에 마스킹될 수 있다. 시스템 정보, 더욱 구체적으로 시스템 정보 블록(SIB: system information block)를 위한 PDCCH라면 시스템 정보

식별자, SI-RNTI(system information RNTI)가 CRC에 마스킹될 수 있다. 단말의 랜덤 액세스 프리앰블의 전송에 대한 응답인 랜덤 액세스 응답을 지시하기 위하여, RA-RNTI(random access-RNTI)가 CRC에 마스킹될 수 있다.

[82] EPDCCH(enhanced PDCCH)는 단말 특정(UE-specific) 시그널링을 나른다. EPDCCH는 단말 특정하게 설정된 물리 자원 블록(PRB: physical resource block)에 위치한다. 다시 말해, 상술한 바와 같이 PDCCH는 서브 프레임내의 첫번째 슬롯에서 앞의 최대 3개의 OFDM 심볼들에서 전송될 수 있으나, EPDCCH는 PDCCH 이외의 자원 영역에서 전송될 수 있다. 서브프레임 내 EPDCCH가 시작되는 시점(즉, 심볼)은 상위 계층 시그널링(예를 들어, RRC 시그널링 등)을 통해 단말에 설정될 수 있다.

[83] EPDCCH는 DL-SCH와 관련된 전송 포맷, 자원 할당 및 HARQ 정보, UL-SCH와 관련된 전송 포맷, 자원 할당 및 HARQ 정보, SL-SCH(Sidelink Shared Channel) 및 PSCCH(Physical Sidelink Control Channel)과 관련된 자원 할당 정보 등을 나를 수 있다. 다중의 EPDCCH가 지원될 수 있으며, 단말은 EPCCH의 세트를 모니터링할 수 있다.

[84] EPDCCH는 하나 또는 그 이상의 연속된 진보된 CCE(ECCE: enhanced CCE)를 이용하여 전송될 수 있으며, 각 EPDCCH 포맷 별로 단일의 EPDCCH 당 ECCE의 개수가 정해질 수 있다.

[85] 각 ECCE는 복수의 자원 요소 그룹(EREG: enhanced resource element group)으로 구성될 수 있다. EREG는 ECCE의 RE에의 매핑을 정의하기 위하여 사용된다. PRB 쌍 별로 16개의 EREG가 존재한다. 각 PRB 쌍 내에서 DMRS를 나르는 RE를 제외하고, 모든 RE는 주파수가 증가하는 순서대로 그 다음 시간이 증가하는 순서대로 0 내지 15까지의 번호가 부여된다.

[86] 단말은 복수의 EPDCCH를 모니터링할 수 있다. 예를 들어, 단말이 EPDCCH 전송을 모니터링하는 하나의 PRB 쌍 내 하나 또는 두 개의 EPDCCH 세트가 설정될 수 있다.

[87] 서로 다른 개수의 ECCE가 병합됨으로써 EPCCH를 위한 서로 다른 부호화율(coding rate)이 실현될 수 있다. EPCCH는 지역적 전송(localized transmission) 또는 분산적 전송(distributed transmission)을 사용할 수 있으며, 이에 따라 PRB 내 RE에 ECCE의 매핑이 달라질 수 있다.

[88] 도 4는 본 발명이 적용될 수 있는 무선 통신 시스템에서 상향링크 서브 프레임의 구조를 나타낸다.

[89] 도 4를 참조하면, 상향링크 서브 프레임은 주파수 영역에서 제어 영역과 데이터 영역으로 나눌 수 있다. 제어 영역에는 상향링크 제어 정보를 나르는 PUCCH(Physical Uplink Control Channel)이 할당된다. 데이터 영역은 사용자 데이터를 나르는 PUSCH(Physical Uplink Shared Channel)이 할당된다. 단일 반송파 특성을 유지하기 위해 하나의 단말은 PUCCH와 PUSCH을 동시에 전송하지 않는다.

[90] 하나의 단말에 대한 PUCCH에는 서브 프레임 내에 자원 블록(RB: Resource Block) 쌍이 할당된다. RB 쌍에 속하는 RB들은 2개의 슬롯들의 각각에서 서로 다른 부 반송파를 차지한다. 이를 PUCCH에 할당된 RB 쌍은 슬롯 경계(slot boundary)에서 주파수 도약(frequency hopping)된다고 한다.

[91]

[92] **MIMO**(Multi-Input Multi-Output)

[93] MIMO 기술은 지금까지 일반적으로 한 개의 송신안테나와 한 개의 수신안테나를 사용했던 것에서 탈피하여, 다중 송신(Tx) 안테나와 다중 수신(Rx) 안테나를 사용한다. 다시 말해서, MIMO 기술은 무선 통신 시스템의 송신단 또는 수신단에서 다중 입출력 안테나를 사용하여 용량 증대 또는 성능 개성을 꾀하기 위한 기술이다. 이하에서는 'MIMO'를 '다중 입출력 안테나'라 칭하기로 한다.

[94] 더 구체적으로, 다중 입출력 안테나 기술은 하나의 완전한 메시지(total message)를 수신하기 위하여 한 개의 안테나 경로에 의존하지 않으며, 여러 개의 안테나를 통해 수신한 복수의 데이터 조각을 수집하여 완전한 데이터를 완성시킨다. 결과적으로, 다중 입출력 안테나 기술은 특정 시스템 범위 내에서 데이터 전송율을 증가시킬 수 있으며, 또한 특정 데이터 전송율을 통해 시스템 범위를 증가시킬 수 있다.

[95] 차세대 이동통신은 기존 이동통신에 비해 훨씬 높은 데이터 전송률을 요구하므로 효율적인 다중 입출력 안테나 기술이 반드시 필요할 것으로 예상된다. 이와 같은 상황에서 MIMO 통신 기술은 이동통신 단말과 중계기 등에 폭넓게 사용할 수 있는 차세대 이동통신 기술이며, 데이터 통신 확대 등으로 인해 한계 상황에 따라 다른 이동통신의 전송량 한계를 극복할 수 있는 기술로서 관심을 모으고 있다.

[96] 한편, 현재 연구되고 있는 다양한 전송효율 향상 기술 중 다중 입출력 안테나(MIMO) 기술은 추가적인 주파수 할당이나 전력증가 없이도 통신 용량 및 송수신 성능을 획기적으로 향상시킬 수 있는 방법으로서 현재 가장 큰 주목을 받고 있다.

[97] 도 5는 일반적인 다중 입출력 안테나(MIMO) 통신 시스템의 구성도이다.

[98] 도 5를 참조하면, 송신 안테나의 수를 N_T개로, 수신 안테나의 수를 N_R개로 동시에 늘리게 되면, 송신기나 수신기에서만 다수의 안테나를 사용하게 되는 경우와 달리 안테나 수에 비례하여 이론적인 채널 전송 용량이 증가하므로, 전송 레이트(transfer rate)를 향상시키고, 주파수 효율을 획기적으로 향상시킬 수 있다. 이 경우, 채널 전송 용량의 증가에 따른 전송 레이트는 하나의 안테나를 이용하는 경우의 최대 전송 레이트(R_o)에 다음과 같은 레이트 증가율(R_i)이 곱해진 만큼으로 이론적으로 증가할 수 있다.

[99] [수식1]

$$R_i = \min\left(N_T, N_R\right)$$

[100] 즉, 예를 들어, 4개의 송신 안테나와 4개의 수신 안테나를 이용하는 MIMO 통신 시스템에서는 단일 안테나 시스템에 비해 이론상 4배의 전송 레이트를 획득할 수 있다.

[101] 이와 같은 다중 입출력 안테나의 기술은 다양한 채널 경로를 통과한 심볼들을 이용하여 전송 신뢰도를 높이는 공간 다이버시티(spatial diversity) 방식과, 다수의 송신 안테나를 이용하여 다수의 데이터 심볼을 동시에 송신하여 전송률을 향상시키는 공간 멀티플렉싱(spatial multiplexing) 방식으로 나눌 수 있다. 또한 이러한 두 가지 방식을 적절히 결합하여 각각의 장점을 적절히 얻고자 하는 방식에 대한 연구도 최근 많이 연구되고 있는 분야이다.

[102] 각각의 방식에 대해 좀더 구체적으로 살펴보면 다음과 같다.

[103] 첫째로, 공간 다이버시티 방식의 경우에는 시공간 블록 부호 계열과, 다이버시티 이득과 부호화 이득을 동시에 이용하는 시공간 트렐리스(Trelis) 부호 계열 방식이 있다. 일반적으로 비트 오류율 개선 성능과 부호 생성 자유도는 트렐리스 부호 방식이 우수하지만, 연산 복잡도는 시공간 블록 부호가 간단하다. 이와 같은 공간 다이버서티 이득은 송신 안테나 수(N_T)와 수신 안테나 수(N_R)의 곱(N_T × N_R)에 해당되는 양을 얻을 수 있다.

[104] 둘째로, 공간 멀티플렉싱 기법은 각 송신 안테나에서 서로 다른 데이터 열을 송신하는 방법인데, 이때 수신기에서는 송신기로부터 동시에 전송된 데이터 사이에 상호 간섭이 발생하게 된다. 수신기에서는 이 간섭을 적절한 신호처리 기법을 이용하여 제거한 후 수신한다. 여기에 사용되는 잡음 제거 방식은 MLD(maximum likelihood detection) 수신기, ZF(zero-forcing) 수신기, MMSE(minimum mean square error) 수신기, D-BLAST (Diagonal-Bell Laboratories Layered Space-Time), V-BLAST(Vertical-Bell Laboratories Layered Space-Time) 등이 있으며, 특히 송신단에서 채널 정보를 알 수 있는 경우에는 SVD(singular value decomposition) 방식 등을 사용할 수 있다.

[105] 셋째로, 공간 다이버시티와 공간 멀티플렉싱의 결합된 기법을 들 수 있다. 공간 다이버시티 이득만을 얻을 경우 다이버시티 차수의 증가에 따른 성능개선 이득이 점차 포화되며, 공간 멀티플렉싱 이득만을 취하면 무선 채널에서 전송 신뢰도가 떨어진다. 이를 해결하면서 두 가지 이득을 모두 얻는 방식들이 연구되어 왔으며, 이 중 시공간 블록 부호 (Double-STTD), 시공간 BICM(STBICM) 등의 방식이 있다.

[106] 상술한 바와 같은 다중 입출력 안테나 시스템에 있어서의 통신 방법을 보다 구체적인 방법으로 설명하기 위해 이를 수학적으로 모델링하는 경우 다음과 같이 나타낼 수 있다.

[107] 먼저, 도 5에 도시된 바와 같이 N_T개의 송신 안테나와 N_R개의 수신 안테나가 존재하는 것을 가정한다.

[108] 먼저, 송신 신호에 대해 살펴보면, 이와 같이 N_T개의 송신 안테나가 있는 경우 최대 전송 가능한 정보는 N_T개 이므로, 이를 다음과 같은 벡터로 나타낼 수

있다.

[109] [수식2]

$$\mathbf{s} = \left[s_1, s_2, \cdots, s_{N_T}\right]^T$$

[110] 한편, 각각의 전송 정보 s_1, s_2, ..., s_N_T에 있어 전송 전력을 달리 할 수 있으며, 이때 각각의 전송 전력을 P_1, P_2, ..., P_N_T라 하면, 전송 전력이 조정된 전송 정보는 다음과 같은 벡터로 나타낼 수 있다.

[111] [수식3]

$$\hat{\mathbf{s}} = \left[\hat{s}_1, \hat{s}_2, \cdots, \hat{s}_{N_T}\right]^T = \left[P_1 s_1, P_2 s_2, \cdots, P_{N_T} s_{N_T}\right]^T$$

[112] 또한, 수학식 3의 전송 전력이 조정된 전송 정보를 전송 전력의 대각 행렬 P로 다음과 같이 나타낼 수 있다.

[113] [수식4]

$$\hat{\mathbf{s}} = \begin{bmatrix} P_1 & & & 0 \\ & P_2 & & \\ & & \ddots & \\ 0 & & & P_{N_T} \end{bmatrix} \begin{bmatrix} s_1 \\ s_2 \\ \vdots \\ s_{N_T} \end{bmatrix} = \mathbf{Ps}$$

[114] 한편, 수학식 4의 전송 전력이 조정된 정보 벡터는 그 후 가중치 행렬 W가 곱해져 실제 전송되는 N_T개의 전송 신호 x_1, x_2, ..., x_N_T를 구성한다. 여기서, 가중치 행렬은 전송 채널 상황 등에 따라 전송 정보를 각 안테나에 적절히 분배해 주는 역할을 수행한다. 이와 같은 전송 신호 x_1, x_2, ..., x_N_T를 벡터 x를 이용하여 다음과 같이 나타낼 수 있다.

[115] [수식5]

$$\mathbf{x} = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_i \\ \vdots \\ x_{N_T} \end{bmatrix} = \begin{bmatrix} w_{11} & w_{12} & \cdots & w_{1N_T} \\ w_{21} & w_{22} & \cdots & w_{2N_T} \\ \vdots & & \ddots & \\ w_{i1} & w_{i2} & \cdots & w_{iN_T} \\ \vdots & & \ddots & \\ w_{N_T1} & w_{N_T2} & \cdots & w_{N_TN_T} \end{bmatrix} \begin{bmatrix} \hat{s}_1 \\ \hat{s}_2 \\ \vdots \\ \hat{s}_j \\ \vdots \\ \hat{s}_{N_T} \end{bmatrix} = \mathbf{W}\hat{\mathbf{s}} = \mathbf{WPs}$$

[116] 여기서, w_ij는 i번째 송신 안테나와 j번째 전송 정보간의 가중치를 나타내며, W는 이를 행렬로 나타낸 것이다. 이와 같은 행렬 W를 가중치 행렬(Weight Matrix) 또는 프리코딩 행렬(Precoding Matrix)라 부른다.

[117] 한편, 상술한 바와 같은 전송 신호(x)는 공간 다이버시티를 사용하는 경우와 공간 멀티플랙싱을 사용하는 경우로 나누어 생각해 볼 수 있다.

[118] 공간 멀티플랙싱을 사용하는 경우는 서로 다른 신호를 다중화하여 보내게 되므로, 정보 벡터 s의 원소들이 모두 다른 값을 가지게 되는 반면, 공간

다이버시티를 사용하게 되면 같은 신호를 여러 채널 경로를 통하여 보내게 되므로 정보 벡터 s의 원소들이 모두 같은 값을 갖게 된다.

[119] 물론, 공간 멀티플랙싱과 공간 다이버시티를 혼합하는 방법도 고려 가능하다. 즉, 예를 들어 3 개의 송신 안테나를 통하여 같은 신호를 공간 다이버시티를 이용하여 전송하고, 나머지는 각각 다른 신호를 공간 멀티플랙싱하여 보내는 경우도 고려할 수 있다.

[120] 다음으로, 수신신호는 N_R개의 수신 안테나가 있는 경우, 각 안테나의 수신신호 y_1, y_2, ..., y_N_R을 벡터 y로 다음과 같이 나타내기로 한다.

[121] [수식6]

$$\mathbf{y} = \left[y_1, y_2, \cdots, y_{N_R}\right]^{\mathrm{T}}$$

[122] 한편, 다중 입출력 안테나 통신 시스템에 있어서의 채널을 모델링하는 경우, 각각의 채널은 송수신 안테나 인덱스에 따라 구분할 수 있으며, 송신 안테나 j로부터 수신 안테나 i를 거치는 채널을 h_ij로 표시하기로 한다. 여기서, h_ij의 인덱스의 순서가 수신 안테나 인덱스가 먼저, 송신안테나의 인덱스가 나중임에 유의한다.

[123] 이러한 채널은 여러 개를 한데 묶어서 벡터 및 행렬 형태로도 표시 가능하다. 벡터 표시의 예를 들어 설명하면 다음과 같다.

[124] 도 6은 다수의 송신 안테나에서 하나의 수신 안테나로의 채널을 나타낸 도이다.

[125] 도 6에 도시된 바와 같이 총 N_T개의 송신 안테나로부터 수신안테나 i로 도착하는 채널은 다음과 같이 표현 가능하다.

[126] [수식7]

$$\mathbf{h}_i^T = \left[h_{i1}, h_{i2}, \cdots, h_{iN_T}\right]$$

[127] 또한, 상기 수학식 7과 같은 행렬 표현을 통해 N_T개의 송신 안테나로부터 N_R개의 수신 안테나를 거치는 채널을 모두 나타내는 경우 다음과 같이 나타낼 수 있다.

[128] [수식8]

$$\mathbf{H} = \begin{bmatrix} \mathbf{h}_1^{\mathrm{T}} \\ \mathbf{h}_2^{\mathrm{T}} \\ \vdots \\ \mathbf{h}_i^{\mathrm{T}} \\ \vdots \\ \mathbf{h}_{\mathbf{N_R}}^{\mathrm{T}} \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} & \cdots & h_{1N_T} \\ h_{21} & h_{22} & \cdots & h_{2N_T} \\ \vdots & & \ddots & \\ h_{i1} & h_{i2} & \cdots & h_{iN_T} \\ \vdots & & \ddots & \\ h_{N_R1} & h_{N_R2} & \cdots & h_{N_RN_T} \end{bmatrix}$$

[129] 한편, 실제 채널은 위와 같은 채널 행렬 H를 거친 후에 백색 잡음(AWGN: Additive White Gaussian Noise)가 더해지게 되므로, N_R개의 수신 안테나 각각에 더해지는 백색 잡음 n_1, n_2, ..., n_N_R을 백터로 표현하면 다음과 같다.

[130] [수식9]

$$\mathbf{n} = \left[n_1, n_2, \cdots, n_{N_R}\right]^{\mathrm{T}}$$

[131] 상술한 바와 같은 전송 신호, 수신 신호, 채널, 및 백색 잡음의 모델링을 통해 다중 입출력 안테나 통신 시스템에서의 각각은 다음과 같은 관계를 통해 나타낼 수 있다.

[132] [수식10]

$$\mathbf{y} = \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_i \\ \vdots \\ y_{N_R} \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} & \cdots & h_{1N_T} \\ h_{21} & h_{22} & \cdots & h_{2N_T} \\ \vdots & & \ddots & \\ h_{i1} & h_{i2} & \cdots & h_{iN_T} \\ \vdots & & \ddots & \\ h_{N_R1} & h_{N_R2} & \cdots & h_{N_RN_T} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_j \\ \vdots \\ x_{N_T} \end{bmatrix} + \begin{bmatrix} n_1 \\ n_2 \\ \vdots \\ n_i \\ \vdots \\ n_{N_R} \end{bmatrix} = \mathbf{Hx} + \mathbf{n}$$

[133] 한편, 채널의 상태를 나타내는 채널 행렬 H의 행과 열의 수는 송수신 안테나 수에 의해서 결정된다. 채널 행렬 H는 앞서 살펴본 바와 같이 행의 수는 수신 안테나의 수 N_R과 같아지고, 열의 수는 송신 안테나의 수 N_T와 같아 지게 된다. 즉, 채널 행렬 H는 N_R×N_T 행렬이 된다.

[134] 일반적으로, 행렬의 랭크(rank)는 서로 독립인(independent) 행 또는 열의 개수 중에서 최소 개수로 정의된다. 따라서, 행렬의 랭크는 행 또는 열의 개수보다 클 수 없게 된다. 수식적으로 예를 들면, 채널 행렬 H의 랭크(rank(H))는 다음과 같이 제한된다.

[135] [수식11]

$$rank(\mathbf{H}) \le \min(N_T, N_R)$$

[136] 또한, 행렬을 고유치 분해(Eigen value decomposition)를 하였을 때, 랭크는 고유치(eigen value)들 중에서 0이 아닌 고유치들의 개수로 정의할 수 있다. 비슷한 방법으로, 랭크를 SVD(singular value decomposition) 했을 때 0이 아닌 특이값(singular value)들의 개수로 정의할 수 있다. 따라서, 채널 행렬에서 랭크의 물리적인 의미는 주어진 채널에서 서로 다른 정보를 보낼 수 있는 최대 수라고 할 수 있다.

[137] 본 명세서에 있어, MIMO 전송에 대한 '랭크(Rank)'는 특정 시점 및 특정 주파수 자원에서 독립적으로 신호를 전송할 수 있는 경로의 수를 나타내며, '레이어(layer)의 개수'는 각 경로를 통해 전송되는 신호 스트림의 개수를 나타낸다. 일반적으로 송신단은 신호 전송에 이용되는 랭크 수에 대응하는 개수의 레이어를 전송하기 때문에 특별한 언급이 없는 한 랭크는 레이어 개수와 동일한 의미를 가진다.

[138]

[139] 캐리어 병합(Carrier Aggregation)

[140] 본 발명의 실시예들에서 고려하는 통신 환경은 멀티 캐리어(Multi-carrier) 지원 환경을 모두 포함한다. 즉, 본 발명에서 사용되는 멀티 캐리어 시스템 또는 캐리어 병합(CA: Carrier Aggregation) 시스템이라 함은 광대역을 지원하기 위해서, 목표로 하는 광대역을 구성할 때 목표 대역보다 작은 대역폭(bandwidth)을 가지는 1개 이상의 컴포넌트 캐리어(CC: Component Carrier)를 병합(aggregation)하여 사용하는 시스템을 말한다.

[141] 본 발명에서 멀티 캐리어는 캐리어의 병합(또는, 반송파 집성)을 의미하며, 이때 캐리어의 병합은 인접한(contiguous) 캐리어 간의 병합뿐 아니라 비 인접한(non-contiguous) 캐리어 간의 병합을 모두 의미한다. 또한, 하향링크와 상향링크 간에 집성되는 컴포넌트 캐리어들의 수는 다르게 설정될 수 있다. 하향링크 컴포넌트 캐리어(이하, 'DL CC'라 한다.) 수와 상향링크 컴포넌트 캐리어(이하, 'UL CC'라 한다.) 수가 동일한 경우를 대칭적(symmetric) 집성이라고 하고, 그 수가 다른 경우를 비대칭적(asymmetric) 집성이라고 한다. 이와 같은 캐리어 병합은 반송파 집성, 대역폭 집성(bandwidth aggregation), 스펙트럼 집성(spectrum aggregation) 등과 같은 용어와 혼용되어 사용될 수 있다.

[142] 두 개 이상의 컴포넌트 캐리어가 결합되어 구성되는 캐리어 병합은 LTE-A 시스템에서는 100MHz 대역폭까지 지원하는 것을 목표로 한다. 목표 대역보다 작은 대역폭을 가지는 1개 이상의 캐리어를 결합할 때, 결합하는 캐리어의 대역폭은 기존 IMT 시스템과의 호환성(backward compatibility) 유지를 위해서 기존 시스템에서 사용하는 대역폭으로 제한할 수 있다. 예를 들어서 기존의 3GPP LTE 시스템에서는 {1.4, 3, 5, 10, 15, 20}MHz 대역폭을 지원하며, 3GPP LTE-advanced 시스템(즉, LTE-A)에서는 기존 시스템과의 호환을 위해 상기의 대역폭들만을 이용하여 20MHz보다 큰 대역폭을 지원하도록 할 수 있다. 또한, 본 발명에서 사용되는 캐리어 병합 시스템은 기존 시스템에서 사용하는 대역폭과 상관없이 새로운 대역폭을 정의하여 캐리어 병합을 지원하도록 할 수도 있다.

[143] LTE-A 시스템은 무선 자원을 관리하기 위해 셀(cell)의 개념을 사용한다.

[144] 상술한 캐리어 병합 환경은 다중 셀(multiple cells) 환경으로 일컬을 수 있다. 셀은 하향링크 자원(DL CC)과 상향링크 자원(UL CC) 한 쌍의 조합으로 정의되나, 상향링크 자원은 필수 요소는 아니다. 따라서, 셀은 하향링크 자원 단독, 또는 하향링크 자원과 상향링크 자원으로 구성될 수 있다. 특정 단말이 단 하나의 설정된 서빙 셀(configured serving cell)을 가지는 경우 1개의 DL CC와 1개의 UL CC를 가질 수 있으나, 특정 단말이 2개 이상의 설정된 서빙 셀을 가지는 경우에는 셀의 수만큼의 DL CC를 가지며 UL CC의 수는 그와 같거나 그보다 작을 수 있다.

[145] 또는, 그 반대로 DL CC와 UL CC가 구성될 수도 있다. 즉, 특정 단말이 다수의 설정된 서빙 셀을 가지는 경우 DL CC의 수보다 UL CC가 더 많은 캐리어 병합

환경도 지원될 수 있다. 즉, 캐리어 병합(carrier aggregation)은 각각 캐리어 주파수(셀의 중심 주파수)가 서로 다른 둘 이상의 셀들의 병합으로 이해될 수 있다. 여기서, 말하는 '셀(Cell)'은 일반적으로 사용되는 기지국이 커버하는 영역으로서의 '셀'과는 구분되어야 한다.

[146] LTE-A 시스템에서 사용되는 셀은 프라이머리 셀(PCell: Primary Cell) 및 세컨더리 셀(SCell: Secondary Cell)을 포함한다. P셀과 S셀은 서빙 셀(Serving Cell)로 사용될 수 있다. RRC_CONNECTED 상태에 있지만 캐리어 병합이 설정되지 않았거나 캐리어 병합을 지원하지 않는 단말의 경우, P셀로만 구성된 서빙 셀이 단 하나 존재한다. 반면, RRC_CONNECTED 상태에 있고 캐리어 병합이 설정된 단말의 경우 하나 이상의 서빙 셀이 존재할 수 있으며, 전체 서빙 셀에는 P셀과 하나 이상의 S셀이 포함된다.

[147] 서빙 셀(P셀과 S셀)은 RRC 파라미터를 통해 설정될 수 있다. PhysCellId는 셀의 물리 계층 식별자로 0부터 503까지의 정수값을 가진다. SCellIndex는 S셀을 식별하기 위하여 사용되는 간략한(short) 식별자로 1부터 7까지의 정수값을 가진다. ServCellIndex는 서빙 셀(P셀 또는 S셀)을 식별하기 위하여 사용되는 간략한(short) 식별자로 0부터 7까지의 정수값을 가진다. 0값은 P셀에 적용되며, SCellIndex는 S셀에 적용하기 위하여 미리 부여된다. 즉, ServCellIndex에서 가장 작은 셀 ID (또는 셀 인덱스)을 가지는 셀이 P셀이 된다.

[148] P셀은 프라이머리 주파수(또는, primary CC) 상에서 동작하는 셀을 의미한다. 단말이 초기 연결 설정(initial connection establishment) 과정을 수행하거나 연결 재-설정 과정을 수행하는데 사용될 수 있으며, 핸드오버 과정에서 지시된 셀을 지칭할 수도 있다. 또한, P셀은 캐리어 병합 환경에서 설정된 서빙 셀 중 제어관련 통신의 중심이 되는 셀을 의미한다. 즉, 단말은 자신의 P셀에서만 PUCCH를 할당 받아 전송할 수 있으며, 시스템 정보를 획득하거나 모니터링 절차를 변경하는데 P셀만을 이용할 수 있다. E-UTRAN(Evolved Universal Terrestrial Radio Access)은 캐리어 병합 환경을 지원하는 단말에게 이동성 제어 정보(mobilityControlInfo)를 포함하는 상위 계층의 RRC 연결 재설정(RRCConnectionReconfigutaion) 메시지를 이용하여 핸드오버 절차를 위해 P셀만을 변경할 수도 있다.

[149] S셀은 세컨더리 주파수(또는, Secondary CC) 상에서 동작하는 셀을 의미할 수 있다. 특정 단말에 P셀은 하나만 할당되며, S셀은 하나 이상 할당될 수 있다. S셀은 RRC 연결이 설정이 이루어진 이후에 구성 가능하고 추가적인 무선 자원을 제공하는데 사용될 수 있다. 캐리어 병합 환경에서 설정된 서빙 셀 중에서 P셀을 제외한 나머지 셀들, 즉 S셀에는 PUCCH가 존재하지 않는다. E-UTRAN은 S셀을 캐리어 병합 환경을 지원하는 단말에게 추가할 때, RRC_CONNECTED 상태에 있는 관련된 셀의 동작과 관련된 모든 시스템 정보를 특정 시그널(dedicated signal)을 통해 제공할 수 있다. 시스템 정보의 변경은 관련된 S셀의 해제 및 추가에 의하여 제어될 수 있으며, 이 때 상위 계층의 RRC

연결 재설정 (RRCConnectionReconfigutaion) 메시지를 이용할 수 있다. E-UTRAN은 관련된 S셀 안에서 브로드캐스트하기 보다는 단말 별로 상이한 파라미터를 가지는 특정 시그널링(dedicated signaling) 할 수 있다.

[150] 초기 보안 활성화 과정이 시작된 이후에, E-UTRAN은 연결 설정 과정에서 초기에 구성되는 P셀에 부가하여 하나 이상의 S셀을 포함하는 네트워크를 구성할 수 있다. 캐리어 병합 환경에서 P셀 및 S셀은 각각의 컴포넌트 캐리어로서 동작할 수 있다. 이하의 실시 예에서는 프라이머리 컴포넌트 캐리어(PCC)는 P셀과 동일한 의미로 사용될 수 있으며, 세컨더리 컴포넌트 캐리어(SCC)는 S셀과 동일한 의미로 사용될 수 있다.

[151] 도 7은 본 발명이 적용될 수 있는 무선 통신 시스템에서 컴포넌트 캐리어 및 캐리어 병합의 일례를 나타낸다.

[152] 도 7의 (a)는 LTE 시스템에서 사용되는 단일 캐리어 구조를 나타낸다. 컴포넌트 캐리어에는 DL CC와 UL CC가 있다. 하나의 컴포넌트 캐리어는 20MHz의 주파수 범위를 가질 수 있다.

[153] 도 7의 (b)는 LTE_A 시스템에서 사용되는 캐리어 병합 구조를 나타낸다. 도 7의 (b)의 경우에 20MHz의 주파수 크기를 갖는 3 개의 컴포넌트 캐리어가 결합된 경우를 나타낸다. DL CC와 UL CC가 각각 3 개씩 있으나, DL CC와 UL CC의 개수에 제한이 있는 것은 아니다. 캐리어 병합의 경우 단말은 3개의 CC를 동시에 모니터링할 수 있고, 하향링크 신호/데이터를 수신할 수 있고 상향링크 신호/데이터를 송신할 수 있다.

[154] 만약, 특정 셀에서 N개의 DL CC가 관리되는 경우에는, 네트워크는 단말에 M (M≤N)개의 DL CC를 할당할 수 있다. 이때, 단말은 M 개의 제한된 DL CC 만을 모니터링하고 DL 신호를 수신할 수 있다. 또한, 네트워크는 L (L≤M≤N)개의 DL CC에 우선순위를 주어 주된 DL CC를 단말에 할당할 수 있으며, 이러한 경우 UE는 L 개의 DL CC는 반드시 모니터링해야 한다. 이러한 방식은 상향링크 전송에도 똑같이 적용될 수 있다.

[155] 하향링크 자원의 반송파 주파수(또는 DL CC)와 상향링크 자원의 반송파 주파수(또는, UL CC) 사이의 링키지(linkage)는 RRC 메시지와 같은 상위계층 메시지나 시스템 정보에 의해 지시될 수 있다. 예를 들어, SIB2(System Information Block Type2)에 의해서 정의되는 링키지에 의해서 DL 자원과 UL 자원의 조합이 구성될 수 있다. 구체적으로, 링키지는 UL 그랜트를 나르는 PDCCH가 전송되는 DL CC와 상기 UL 그랜트를 사용하는 UL CC간의 맵핑 관계를 의미할 수 있으며, HARQ를 위한 데이터가 전송되는 DL CC(또는 UL CC)와 HARQ ACK/NACK 신호가 전송되는 UL CC(또는 DL CC)간의 맵핑 관계를 의미할 수도 있다.

[156] 단말이 하나 이상의 S셀이 설정되면, 네트워크는 설정된 S셀(들)을 활성화(activate) 또는 비활성화(deactivate)할 수 있다. P셀은 항상 활성화된다. 네트워크는 활성/비활성(Activation/Deactivation) MAC 제어 요소(MAC control

element)를 전송함으로써 S셀(들)을 활성화 또는 비활성화한다.

[157] 활성/비활성 MAC 제어 요소는 고정된 크기를 가지고, 7개의 C 필드(C-field)와 1개의 R 필드(R-field)를 포함하는 단일의 옥텟(octet)으로 구성된다. C 필드는 각 S셀 인덱스(SCellIndex) 별로 구성되고, S셀의 활성/비활성 상태를 지시한다. C 필드 값이 '1'로 셋팅되면 해당 S셀 인덱스를 가지는 S셀의 활성화되는 것을 지시하고, '0'으로 셋팅되면 해당 S셀 인덱스를 가지는 S셀의 비활성화되는 것을 지시한다.

[158] 또한, 단말은 설정된 S셀 별로 타이머(sCellDeactivationTimer)를 유지하고, 타이머가 만료될 때 관련된 S셀을 비활성화한다. 동일한 초기 타이머 값이 타이머(sCellDeactivationTimer)의 각 인스턴스(instance)에 적용되며, RRC 시그널링에 의해 설정된다. S셀(들)이 추가될 때 또는 핸드오버 이후, 초기 S셀(들)은 비활성화 상태이다.

[159] 단말은 각 TTI에서 각각의 설정된 S셀(들)에 대하여 아래와 같은 동작을 수행한다.

[160] - 단말이 특정 TTI(서브프레임 n)에서 S셀을 활성화하는 활성/비활성 MAC 제어 요소를 수신하면, 단말은 정해진 타이밍에 해당하는 TTI(서브프레임 n+8 또는 그 이후)에서 S셀을 활성화하고, 해당 S셀과 관련된 타이머를 (재)시작시킨다. 단말이 S셀을 활성화한다는 것은 단말이 S셀 상에서 SRS(Sounding Reference Signal) 전송, S셀을 위한 CQI(Channel Quality Indicator)/PMI(Precoding Matrix Indicator)/RI(Rank Indication)/PTI(Precoding Type Indicator) 보고, S셀 상에서 PDCCH 모니터링, S셀을 위한 PDCCH 모니터링과 같은 일반 S셀 동작을 적용한다는 것을 의미한다.

[161] - 단말이 특정 TTI(서브프레임 n)에서 S셀을 비활성화하는 활성/비활성 MAC 제어 요소를 수신하거나 또는 특정 TTI(서브프레임 n) 활성화된 S셀과 관련된 타이머가 만료되면, 단말은 정해진 타이밍에 해당하는 TTI(서브프레임 n+8 또는 그 이후)에서 S셀을 비활성화하고, 해당 S셀의 타이머를 중단하며, 해당 S셀과 관련된 모든 HARQ 버퍼를 비운다(flush).

[162] - 활성화된 S셀 상의 PDCCH가 상향링크 그랜트(uplink grant) 또는 하향링크 승인(downlink assignment)을 지시하거나, 또는 활성화된 S셀을 스케줄링하는 서빙 셀 상의 PDCCH가 활성화된 S셀을 위한 상향링크 그랜트(uplink grant) 또는 하향링크 승인(downlink assignment)을 지시하면, 단말은 해당 S셀과 관련된 타이머를 재시작한다.

[163] - S셀이 비활성화되면, 단말은 S셀 상에서 SRS를 전송하지 않고, S셀을 위한 CQI/PMI/RI/PTI를 보고하지 않으며, S셀 상에서 UL-SCH를 전송하지 않으며, S셀 상에서 PDCCH를 모니터하지 않는다.

[164]

[165] **랜덤 액세스 절차(Random Access Procedure)**

[166] 이하에서는 LTE/LTE-A 시스템에서 제공하는 랜덤 액세스 절차(random access

procedure)에 대해 살펴본다.

[167] 랜덤 액세스 절차는 단말이 기지국과 상향링크 동기를 얻거나 상향링크 무선 자원을 할당 받기 위해 사용된다. 단말의 전원이 켜진 후, 단말은 초기 셀과의 하향링크 동기를 획득하고 시스템 정보를 수신한다. 시스템 정보로부터 사용 가능한 랜덤 액세스 프리앰블(random access preamble)의 집합과 랜덤 액세스 프리앰블의 전송에 사용되는 무선 자원에 관한 정보를 얻는다. 랜덤 액세스 프리앰블의 전송에 사용되는 무선 자원은 적어도 하나 이상의 서브프레임 인덱스와 주파수 영역 상의 인덱스의 조합으로 특정될 수 있다. 단말은 랜덤 액세스 프리앰블의 집합으로부터 임의로 선택한 랜덤 액세스 프리앰블을 전송하고, 상기 랜덤 액세스 프리앰블을 수신한 기지국은 상향링크 동기를 위한 타이밍 정렬(TA: timing alignment) 값을 랜덤 액세스 응답을 통해 단말로 보낸다. 이로써 단말은 상향링크 동기를 획득하는 것이다.

[168] 랜덤 액세스 절차는 FDD(frequency division duplex)와 TDD(time division duplex)에서 공통적인 절차이다. 랜덤 액세스 절차는 셀 사이즈에 무관하며, 캐리어 병합(CA: carrier aggregation)이 설정된 경우 서빙 셀(serving cell)의 개수와도 무관하다.

[169] 먼저, 단말이 랜덤 액세스 절차를 수행하는 경우로는 다음과 같은 경우가 있다.

[170] - 단말이 기지국과의 RRC 연결(RRC Connection)이 없어, RRC 아이들 상태에서 초기 접속 (initial access)을 수행하는 경우

[171] - RRC 연결 재-확립 절차(RRC connection re-establishment procedure)를 수행하는 경우

[172] - 단말이 핸드오버 과정에서, 타겟(target) 셀로 처음 접속하는 경우

[173] - 기지국의 명령에 의해 랜덤 액세스 절차가 요청되는 경우

[174] - RRC 연결 상태 중, 상향링크 시간 동기가 맞지 않은 상황에서(non-synchronized) 하향링크로 전송될 데이터가 발생하는 경우

[175] - RRC 연결 상태 중, 상향링크의 시간 동기가 맞지 않거나(non-synchronized), 무선자원을 요청하기 위해 사용되는 지정된 무선자원이 할당되지 않은 상황에서, 상향링크로 전송할 데이터가 발생하는 경우

[176] - RRC 연결 상태 중, 타이밍 어드밴스(timing advance)가 필요한 상황에서 단말의 위치 결정(positioning)을 수행하는 경우

[177] - 무선 연결 실패(radio link failure) 또는 핸드오버 실패(handover failure) 시 복구 과정을 수행하는 경우

[178] 3GPP Rel-10에서는 캐리어 병합을 지원하는 무선 접속 시스템에서 하나의 특정 셀(예를 들어, P셀)에 적용 가능한 TA(timing advance) 값을 복수의 셀에 공통으로 적용하는 것을 고려하였다. 다만, 단말이 서로 다른 주파수 밴드에 속한(즉, 주파수 상에서 크게 이격된) 복수의 셀들 혹은 전파(propagation) 특성이 다른 복수의 셀들을 병합할 수 있다. 또한 특정 셀의 경우 커버리지 확대 혹은 커버리지 홀의 제거를 위해 RRH(remote radio header)(즉, 리피터), 펨토 셀(femto

cell) 혹은 피코 셀(pico cell) 등과 같은 스몰 셀(small cell) 또는 세컨더리 기지국(SeNB: secondary eNB)이 셀 내에 배치되는 상황에서 단말은 하나의 셀을 통해 기지국(즉, 매크로 기지국(macro eNB))과 통신을 수행하고, 다른 셀을 통해 세컨더리 기지국과 통신을 수행하는 경우 복수의 셀들이 서로 다른 전파 지연 특성을 가지게 될 수 있다. 이 경우, 하나의 TA 값을 복수의 셀들에 공통으로 적용하는 방식으로 사용하는 상향링크 전송을 수행할 경우 복수의 셀들 상에서 전송되는 상향링크 신호의 동기에 심각한 영향을 끼칠 수 있다. 따라서, 복수의 셀들이 병합된 CA 상황에서 복수의 TA를 가지는 것이 바람직할 수 있으며, 3GPP Rel-11에서는 다중 TA(multiple TA)를 지원하기 위하여 특정 셀 그룹 단위로 TA를 독립적으로 할당하는 것을 고려한다. 이를 TA 그룹(TAG: TA group)이라 하며, TAG는 하나 이상의 셀들을 포함할 수 있으며, TAG 내 포함된 하나 이상의 셀에는 동일한 TA가 공통적으로 적용될 수 있다. 이러한 다중 TA를 지원하기 위하여, MAC TA 명령 제어 요소(element)는 2 비트의 TAG 식별자(TAG ID)와 6 비트의 TA 명령 필드로 구성된다.

[179] 캐리어 병합이 설정된 단말은 P셀과 관련되어 앞서 설명한 랜덤 액세스 절차를 수행하는 경우가 발생되면 랜덤 액세스 절차를 수행하게 된다. P셀이 속한 TAG(즉, pTAG: primary TAG)의 경우, 기존과 동일하게 P셀을 기준으로 결정되는, 혹은 P셀에 수반되는 랜덤 액세스 절차를 통해 조정되는 TA를 pTAG 내 모든 셀(들)에 적용할 수 있다. 반면, S셀로만 구성되는 TAG(즉, sTAG: secondary TAG)의 경우, sTAG 내 특정 S셀을 기준으로 결정되는 TA는 해당 sTAG 내 모든 셀(들)에 적용할 수 있으며, 이 때 TA는 기지국에 의해 개시되 랜덤 액세스 절차에 의해 획득될 수 있다. 구체적으로, sTAG 내에서 S셀은 RACH(Random Access Channel) 자원으로 설정되고, 기지국은 TA를 결정하기 위하여 S셀에서 RACH 접속을 요청한다. 즉, 기지국은 P셀에서 전송되는 PDCCH 오더에 의해 S셀들 상에서 RACH 전송을 개시시킨다. S셀 프리앰블에 대한 응답 메시지는 RA-RNTI를 사용하여 P셀을 통해 전송된다. 단말은 랜덤 액세스를 성공적으로 마친 S셀을 기준으로 결정되는 TA는 해당 sTAG 내 모든 셀(들)에 적용할 수 있다. 이와 같이, 랜덤 액세스 절차는 S셀에서도 해당 S셀이 속한 sTAG의 타이밍 정렬(timing alignment)을 획득하기 위하여 S셀에서도 수행될 수 있다.

[180] LTE/LTE-A 시스템에서는 랜덤 액세스 프리앰블(random access preamble, RACH preamble)을 선택하는 과정에서, 특정한 집합 안에서 단말이 임의로 하나의 프리앰블을 선택하여 사용하는 경쟁 기반 랜덤 액세스 절차(contention based random access procedure)과 기지국이 특정 단말에게만 할당해준 랜덤 액세스 프리앰블을 사용하는 비 경쟁 기반 랜덤 액세스 절차(non-contention based random access procedure)을 모두 제공한다. 다만, 비 경쟁 기반 랜덤 액세스 절차는, 상술한 핸드오버 과정, 기지국의 명령에 의해 요청되는 경우, 단말 위치 결정(positioning) 및/또는 sTAG을 위한 타이밍 어드밴스 정렬에 한하여 사용될

수 있다. 랜덤 액세스 절차가 완료된 후에 일반적인 상향링크/하향링크 전송이 발생된다.

[181] 한편, 릴레이 노드(RN: relay node) 또한 경쟁 기반 랜덤 액세스 절차와 비 경쟁 기반 랜덤 액세스 절차를 모두 지원한다. 릴레이 노드가 랜덤 액세스 절차를 수행할 때, 그 시점에서 RN 서브프레임 구성(configuration)을 중단시킨다(suspend). 즉, 이는 일시적으로 RN 서브프레임 구성을 폐기하는 것으로 의미한다. 이후, 성공적으로 랜덤 액세스 절차가 완료되는 시점에서 RN 서브프레임 구성이 재개된다.

[182] 도 8은 본 발명이 적용될 수 있는 무선 통신 시스템에서 경쟁 기반 랜덤 액세스 절차를 설명하기 위한 도면이다.

[183] (1) 제1 메시지(Msg 1, message 1)

[184] 먼저, 단말은 시스템 정보(system information) 또는 핸드오버 명령(handover command)을 통해 지시된 랜덤 액세스 프리앰블의 집합에서 임의로(randomly) 하나의 랜덤 액세스 프리앰블(random access preamble, RACH preamble)을 선택하고, 상기 랜덤 액세스 프리앰블을 전송할 수 있는 PRACH(physical RACH) 자원을 선택하여 전송한다.

[185] 랜덤 액세스 프리앰블은 RACH 전송 채널에서 6비트로 전송되고, 6비트는 RACH 전송한 단말을 식별하기 위한 5비트의 임의 식별자(radom identity)와, 추가 정보를 나타내기 위한 1비트(예를 들어, 제3 메시지(Msg 3)의 크기를 지시)로 구성된다.

[186] 단말로부터 랜덤 액세스 프리엠블을 수신한 기지국은 프리앰블을 디코딩하고, RA-RNTI를 획득한다. 랜덤 액세스 프리앰블이 전송된 PRACH와 관련된 RA-RNTI는 해당 단말이 전송한 랜덤 액세스 프리앰블의 시간-주파수 자원에 따라 결정된다.

[187] (2) 제2 메시지(Msg 2, message 2)

[188] 기지국은 제1 메시지 상의 프리앰블을 통해서 획득한 RA-RNTI로 지시(address)되는 랜덤 액세스 응답(random access response)을 단말로 전송한다. 랜덤 액세스 응답에는 랜덤 액세스 프리앰블 구분자/식별자(RA preamble index/identifier), 상향링크 무선자원을 알려주는 상향링크 승인(UL grant), 임시 셀 식별자(TC-RNTI: Temporary C-RNTI) 그리고 시간 동기 값(TAC: time alignment command)들이 포함될 수 있다. TAC는 기지국이 단말에게 상향링크 시간 정렬(time alignment)을 유지하기 위해 보내는 시간 동기 값을 지시하는 정보이다. 단말은 상기 시간 동기 값을 이용하여, 상향링크 전송 타이밍을 갱신한다. 단말이 시간 동기를 갱신하면, 시간 동기 타이머(time alignment timer)를 개시 또는 재시작한다. UL grant는 후술하는 스케줄링 메시지(제3 메시지)의 전송에 사용되는 상향링크 자원 할당 및 TPC(transmit power command)를 포함한다. TPC는 스케줄링된 PUSCH를 위한 전송 파워의 결정에 사용된다.

[189] 단말은 랜덤 액세스 프리앰블을 전송 후에, 기지국이 시스템 정보 또는 핸드오버 명령을 통해 지시된 랜덤 액세스 응답 윈도우(random access response window) 내에서 자신의 랜덤 액세스 응답(random access response)의 수신을 시도하며, PRACH에 대응되는 RA-RNTI로 마스킹된 PDCCH를 검출하고, 검출된 PDCCH에 의해 지시되는 PDSCH를 수신하게 된다. 랜덤 액세스 응답 정보는 MAC PDU(MAC packet data unit)의 형식으로 전송될 수 있으며, 상기 MAC PDU는 PDSCH을 통해 전달될 수 있다. PDCCH에는 상기 PDSCH를 수신해야 하는 단말의 정보와, 상기 PDSCH의 무선 자원의 주파수 그리고 시간 정보, 그리고 상기 PDSCH의 전송 형식 등이 포함되어 있는 것이 바람직하다. 상술한 바와 같이, 일단 단말이 자신에게 전송되는 PDCCH의 검출에 성공하면, 상기 PDCCH의 정보들에 따라 PDSCH로 전송되는 랜덤 액세스 응답을 적절히 수신할 수 있다.

[190] 랜덤 액세스 응답 윈도우는 프리앰블을 전송한 단말이 랜덤 액세스 응답 메시지를 수신하기 위해서 대기하는 최대 시구간을 의미한다. 랜덤 액세스 응답 윈도우는 프리앰블이 전송되는 마지막 서브프레임에서 3개의 서브프레임 이후의 서브프레임으로부터 시작하여 'ra-ResponseWindowSize'의 길이를 가진다. 즉, 단말은 프리앰블을 전송이 종료된 서브프레임으로부터 3개의 서브프레임 이후부터 확보한 랜덤 액세스 윈도우 동안 랜덤 액세스 응답을 수신하기 위해 대기한다. 단말은 시스템 정보(system information)을 통해 랜덤 액세스 윈도우 사이즈('ra-ResponseWindowsize') 파라미터 값을 획득할 수 있으며, 랜덤 액세스 윈도우 사이즈는 2부터 10 사이의 값으로 결정될 수 있다.

[191] 단말은 기지국에 전송하였던 랜덤 액세스 프리앰블과 동일한 랜덤 액세스 프리앰블 구분자/식별자를 가지는 랜덤 액세스 응답을 성공적으로 수신하면, 랜덤 액세스 응답의 모니터링을 중지한다. 반면, 랜덤 액세스 응답 윈도우가 종료될 때까지 랜덤 액세스 응답 메시지를 수신하지 못하거나, 기지국에 전송하였던 랜덤 액세스 프리앰블과 동일한 랜덤 액세스 프리앰블 구분자를 가지는 유효한 랜덤 액세스 응답을 수신하지 못한 경우 랜덤 액세스 응답의 수신은 실패하였다고 간주되고, 이후 단말은 프리앰블 재전송을 수행할 수 있다.

[192] 상술한 바와 같이 랜덤 액세스 응답에서 랜덤 액세스 프리앰블 구분자가 필요한 이유는, 하나의 랜덤 액세스 응답에는 하나 이상의 단말들을 위한 랜덤 액세스 응답 정보가 포함될 수 있기 때문에, 상기 UL grant, TC-RNTI 그리고 TAC가 어느 단말에게 유효한지를 알려주기 위는 것이 필요하기 때문이다.

[193] (3) 제3 메시지(Msg 3, message 3)

[194] 단말이 자신에게 유효한 랜덤 액세스 응답을 수신한 경우에는, 상기 랜덤 액세스 응답에 포함된 정보들을 각각 처리한다. 즉, 단말은 TAC을 적용시키고, TC-RNTI를 저장한다. 또한, UL grant를 이용하여, 단말의 버퍼에 저장된 데이터 또는 새롭게 생성된 데이터를 기지국으로 전송한다. 단말의 최초 접속의 경우, RRC 계층에서 생성되어 CCCH를 통해 전달된 RRC 연결 요청이 제3 메시지에

포함되어 전송될 수 있으며, RRC 연결 재확립 절차의 경우 RRC 계층에서 생성되어 CCCH를 통해 전달된 RRC 연결 재확립 요청이 제3 메시지에 포함되어 전송될 수 있다. 또한, NAS 접속 요청 메시지를 포함할 수도 있다.

[195] 제3 메시지는 단말의 식별자가 포함되어야 한다. 경쟁 기반 랜덤 액세스 절차에서는 기지국에서 어떠한 단말들이 상기 랜덤 액세스 절차를 수행하는지 판단할 수 없는데, 차후에 충돌 해결을 하기 위해서는 단말을 식별해야 하기 때문이다.

[196] 단말의 식별자를 포함시키는 방법으로는 두 가지 방법이 존재한다. 첫 번째 방법은 단말이 상기 랜덤 액세스 절차 이전에 이미 해당 셀에서 할당 받은 유효한 셀 식별자(C-RNTI)를 가지고 있었다면, 단말은 상기 UL grant에 대응하는 상향링크 전송 신호를 통해 자신의 셀 식별자를 전송한다. 반면에, 만약 랜덤 액세스 절차 이전에 유효한 셀 식별자를 할당 받지 못하였다면, 단말은 자신의 고유 식별자(예를 들면, S-TMSI 또는 임의 값(random number))를 포함하여 전송한다. 일반적으로 상기의 고유 식별자는 C-RNTI보다 길다. UL-SCH 상의 전송에서는 단말 특정 스크램블링이 사용된다. 다만, 단말이 아직 C-RNTI를 할당받지 못한 경우라면, 스크램블링은 C-RNTI에 기반할 수 없으며 대신 랜덤 액세스 응답에서 수신한 TC-RNTI가 사용된다. 단말은 상기 UL grant에 대응하는 데이터를 전송하였다면, 충돌 해결을 위한 타이머(contention resolution timer)를 개시한다.

[197] (4) 제4 메시지(Msg 4, message 4)

[198] 기지국은 단말로부터 제3 메시지를 통해 해당 단말의 C-RNTI를 수신한 경우 수신한 C-RNTI를 이용하여 단말에게 제4 메시지를 전송한다. 반면, 단말로부터 제3 메시지를 통해 상기 고유 식별자(즉, S-TMSI 또는 임의 값(random number))를 수신한 경우, 랜덤 액세스 응답에서 해당 단말에게 할당한 TC-RNTI를 이용하여 제4 메시지를 단말에게 전송한다. 여기서, 제4 메시지는 C-RNTI를 포함하는 RRC 연결 설정 메시지(RRC connection setup)가 해당될 수 있다.

[199] 단말은 랜덤 액세스 응답에 포함된 UL grant를 통해 자신의 식별자를 포함한 데이터를 전송한 이후, 충돌 해결을 위해 기지국의 지시를 기다린다. 즉, 특정 메시지를 수신하기 위해 PDCCH의 수신을 시도한다. 상기 PDCCH를 수신하는 방법에 있어서도 두 가지 방법이 존재한다. 앞에서 언급한 바와 같이 상기 UL grant에 대응하여 전송된 제3 메시지가 자신의 식별자가 C-RNTI인 경우, 자신의 C-RNTI를 이용하여 PDCCH의 수신을 시도하고, 상기 식별자가 고유 식별자(즉, S-TMSI 또는 임의 값(random number))인 경우에는, 랜덤 액세스 응답에 포함된 TC-RNTI를 이용하여 PDCCH의 수신을 시도한다. 그 후, 전자의 경우, 만약 상기 충돌 해결 타이머가 만료되기 전에 자신의 C-RNTI를 통해 PDCCH를 수신한 경우에, 단말은 정상적으로 랜덤 액세스 절차가 수행되었다고 판단하고, 랜덤 액세스 절차를 종료한다. 후자의 경우에는 상기 충돌 해결 타이머가 만료되기 전에 TC-RNTI를 통해 PDCCH를 수신하였다면, 상기 PDCCH가 지시하는

PDSCH이 전달하는 데이터를 확인한다. 만약 상기 데이터의 내용에 자신의 고유 식별자가 포함되어 있다면, 단말은 정상적으로 랜덤 액세스 절차가 수행되었다고 판단하고, 랜덤 액세스 절차를 종료한다. 제4 메시지를 통해 단말은 C-RNTI를 획득하고, 이후 단말과 네트워크는 C-RNTI를 이용하여 단말 특정 메시지(dedicated message)를 송수신하게 된다.

[200] 다음은 랜덤 액세스에서 충돌 해결을 위한 방법에 대하여 설명한다.

[201] 랜덤 액세스를 수행함에 있어서 충돌이 발생하는 이유는 기본적으로 랜덤 액세스 프리앰블의 수가 유한하기 때문이다. 즉, 기지국은 모든 단말들에게 단말 고유의 랜덤 액세스 프리앰블을 부여할 수 없기 때문에, 단말은 공통의 랜덤 액세스 프리앰블들 중에서 임의적으로 하나를 선택해서 전송하게 된다. 이에 따라 동일한 무선 자원(PRACH 자원)을 통해 둘 이상의 단말들이 같은 랜덤 액세스 프리앰블을 선택하여 전송하게 되는 경우가 발생하지만, 기지국에서는 하나의 단말에게서 전송되는 하나의 랜덤 액세스 프리앰블로 판단하게 된다. 이로 인해, 기지국은 랜덤 액세스 응답을 단말에게 전송하고 랜덤 액세스 응답은 하나의 단말이 수신할 것으로 예측한다. 하지만, 상술한 바와 같이 충돌이 발생할 수 있기 때문에, 둘 이상의 단말들이 하나의 랜덤 액세스 응답을 수신하게 되며, 이에 따라 단말마다 각각 랜덤 액세스 응답의 수신에 따른 동작을 수행하게 된다. 즉, 랜덤 액세스 응답에 포함된 하나의 UL Grant를 이용하여, 둘 이상의 단말들이 서로 다른 데이터를 동일한 무선자원에 전송하게 되는 문제점이 발생하게 된다. 이에 따라, 상기 데이터의 전송은 모두 실패할 수도 있고, 단말들의 위치 또는 전송파워에 따라 특정 단말의 데이터만을 기지국에서 수신할 수도 있다. 후자의 경우, 둘 이상의 단말들은 모두 자신의 데이터의 전송이 성공했다고 가정하기 때문에, 기지국은 경쟁에서 실패한 단말들에게 실패 사실에 대한 정보를 알려주어야 한다. 즉, 상기 경쟁의 실패 또는 성공에 대한 정보를 알려주는 것이 충돌 해결(contention resolution)라 한다.

[202] 충돌 해결 방법에는 두 가지 방법이 있는데 한 가지 방법은, 충돌 해결 타이머(contention resolution timer)를 이용하는 방법과, 다른 한가지 방법은 성공한 단말의 식별자를 단말들에게 전송하는 방법이다. 전자의 경우는, 단말이 랜덤 액세스 과정 전에 이미 고유의 C-RNTI를 가지고 있는 경우에 사용된다. 즉, 이미 C-RNTI를 가지고 있는 단말은 랜덤 액세스 응답에 따라 자신의 C-RNTI를 포함한 데이터를 기지국으로 전송하고, 충돌 해결 타이머를 작동한다. 그리고, 충돌 해결 타이머가 만료되기 전에, 자신의 C-RNTI에 의해 지시되는 PDCCH 정보가 수신되면, 단말은 자신이 경쟁에서 성공했다고 판단하고, 랜덤 액세스를 정상적으로 마치게 된다. 반대로, 만약 충돌 해결 타이머가 만료되기 전에, 자신의 C-RNTI에 의해 지시되는 PDCCH를 전송 받지 못한 경우는, 자신이 경쟁에서 실패했다고 판단하고, 랜덤 액세스 과정을 다시 수행하거나, 상위 계층으로 실패 사실을 통보할 수 있다. 충돌 해소 방법 중 후자의 경우, 즉 성공한 단말의 식별자를 전송하는 방법은, 단말이 랜덤 액세스 과정 전에 고유의 셀

식별자가 없는 경우에 사용된다. 즉, 단말 자신이 셀 식별자가 없는 경우, 랜덤 액세스 응답에 포함된 UL Grant 정보에 따라 데이터에 셀 식별자 보다 상위 식별자(S-TMSI 또는 random number)를 포함하여 전송하고, 단말은 충돌 해결 타이머를 작동시킨다. 충돌 해결 타이머가 만료되기 전에, 자신의 상위 식별자를 포함한 데이터가 DL-SCH로 전송된 경우, 단말은 랜덤 액세스 과정이 성공했다고 판단한다. 반면에, 충돌 해결 타이머가 만료되기 전에, 자신의 상위 식별자를 포함한 데이터를 DL-SCH로 전송 받지 못하는 경우에는, 단말은 랜덤 액세스 과정이 실패했다고 판단하게 되는 것이다.

[203] 한편, 비경쟁 기반 임의접속 과정에서의 동작은 도 8에 도시된 경쟁 기반 임의접속 과정과 달리 제1 메시지 전송 및 제2 메시지 전송만으로 임의접속 절차가 종료되게 된다. 다만, 제1 메시지로서 단말이 기지국에 임의접속 프리엠블을 전송하기 전에 단말은 기지국으로부터 임의접속 프리엠블을 할당받게 되며, 이 할당받은 임의접속 프리엠블을 기지국에 제1 메시지로서 전송하고, 기지국으로부터 임의접속 응답을 수신함으로써 임의접속 절차가 종료되게 된다.

[204]

[205] <u>참조 신호(RS: Reference Signal)</u>

[206] 무선 통신 시스템에서 데이터는 무선 채널을 통해 전송되기 때문에, 신호는 전송 중에 왜곡될 수 있다. 수신단에서 왜곡된 신호를 정확하게 수신하기 위하여, 수신된 신호의 왜곡은 채널 정보를 이용하여 보정되어야 한다. 채널 정보를 검출하기 위하여 송신측과 수신측 모두 알고 있는 신호 전송 방법과 신호가 채널을 통해 전송될 때 왜곡된 정도를 이용하여 채널 정보를 검출하는 방법을 주로 이용한다. 상술한 신호를 파일럿 신호 또는 참조 신호(RS: reference signal)라고 한다.

[207] 또한 최근 대부분의 이동통신 시스템에서 패킷을 전송할 때, 지금까지 한 개의 송신안테나와 한 개의 수신안테나를 사용했던 것에서 탈피, 다중송신안테나와 다중수신안테나를 채택해 송수신 데이터 효율을 향상시킬 수 있는 방법을 사용한다. 다중 입출력 안테나를 이용하여 데이터를 송수신할 때, 신호를 정확하게 수신하기 위하여 송신 안테나와 수신 안테나 간의 채널 상태가 검출되어야 한다. 따라서 각 송신 안테나는 개별적인 참조 신호를 가져야 한다.

[208] 이동 통신 시스템에서 RS는 그 목적에 따라 크게 두 가지로 구분될 수 있다. 채널 정보 획득을 위한 목적의 RS와 데이터 복조를 위해 사용되는 RS가 있다. 전자는 UE가 하향 링크로의 채널 정보를 획득하는데 그 목적이 있으므로, 광대역으로 전송되어야 하고, 특정 서브 프레임에서 하향 링크 데이터를 수신하지 않는 UE라도 그 RS를 수신하고 측정할 수 있어야 한다. 또한 이는 핸드오버 등의 측정 등을 위해서도 사용된다. 후자는 기지국이 하향링크를 보낼 때 해당 리소스에 함께 보내는 RS로서, UE는 해당 RS를 수신함으로써 채널 추정을 할 수 있고, 따라서 데이터를 복조할 수 있게 된다. 이 RS는 데이터가 전송되는

영역에 전송되어야 한다.

[209] 하향 참조 신호는 셀 내 모든 단말이 공유하는 채널 상태에 대한 정보 획득 및 핸드오버 등의 측정 등을 위한 하나의 공통 참조 신호(CRS: common RS)와 특정 단말만을 위하여 데이터 복조를 위해 사용되는 전용 참조 신호(dedicated RS)가 있다. 이와 같은 참조 신호들을 이용하여 복조(demodulation)와 채널 측정(channel measurement)을 위한 정보를 제공할 수 있다. 즉, DRS는 데이터 복조용으로만 사용되며 CRS는 채널 정보 획득 및 데이터 복조의 두 가지 목적으로 다 사용된다.

[210] 수신 측(즉, 단말)은 CRS로부터 채널 상태를 측정하고, CQI(Channel Quality Indicator), PMI(Precoding Matrix Index) 및/또는 RI(Rank Indicator)와 같은 채널 품질과 관련된 지시자를 송신 측(즉, 기지국)으로 피드백한다. CRS는 셀 특정 기준신호(cell-specific RS)라고도 한다. 반면, 채널 상태 정보(CSI: Channel State Information)의 피드백과 관련된 참조 신호를 CSI-RS라고 정의할 수 있다.

[211] DRS는 PDSCH 상의 데이터 복조가 필요한 경우 자원 요소들을 통해 전송될 수 있다. 단말은 상위 계층을 통하여 DRS의 존재 여부를 수신할 수 있으며, 상응하는 PDSCH가 매핑되었을 때만 유효하다. DRS를 단말 특정 참조 신호(UE-specific RS) 또는 복조 참조 신호(DMRS: Demodulation RS)라고 할 수 있다.

[212] 도 9는 본 발명이 적용될 수 있는 무선 통신 시스템에서 하향링크 자원 블록 쌍에 매핑된 참조 신호 패턴을 예시한다.

[213] 도 9를 참조하면, 참조 신호가 매핑되는 단위로 하향링크 자원 블록 쌍은 시간 영역에서 하나의 서브 프레임 × 주파수 영역에서 12개의 부 반송파로 나타낼 수 있다. 즉, 시간 축(x축) 상에서 하나의 자원 블록 쌍은 일반 순환 전치(normal CP: normal Cyclic Prefix) 인 경우 14개의 OFDM 심볼의 길이를 가지고(도 9(a)의 경우), 확장 순환 전치(extended CP: extended Cyclic Prefix)인 경우 12개의 OFDM 심볼의 길이를 가진다(도 9(b)의 경우). 자원 블록 격자에서 '0', '1', '2' 및 '3'으로 기재된 자원 요소들(REs)은 각각 안테나 포트 인덱스 '0', '1', '2' 및 '3'의 CRS의 위치를 의미하며, 'D'로 기재된 자원 요소들은 DRS의 위치를 의미한다.

[214] 이하 CRS에 대하여 좀 더 상세하게 기술하면, CRS는 물리적 안테나의 채널을 추정하기 위해 사용되고, 셀 내에 위치한 모든 단말에 공통적으로 수신될 수 있는 참조 신호로써 전체 주파수 대역에 분포된다. 즉, 이 CRS는 cell-specific한 시그널로, 광대역에 대해서 매 서브 프레임마다 전송된다. 또한, CRS는 채널 품질 정보(CSI) 및 데이터 복조를 위해 이용될 수 있다.

[215] CRS는 전송 측(기지국)에서의 안테나 배열에 따라 다양한 포맷으로 정의된다. 3GPP LTE 시스템(예를 들어, 릴리즈-8)에서는 기지국의 전송 안테나 개수에 따라서 최대 4개의 안테나 포트에 대한 RS가 전송된다. 하향링크 신호 송신 측은 단일의 송신 안테나, 2개의 송신 안테나 및 4개의 송신 안테나와 같이 3 종류의 안테나 배열을 가진다. 예를 들어 기지국의 송신 안테나의 개수가 두 개일 경우,

0번과 1번 안테나 포트에 대한 CRS가 전송되고, 네 개인 경우 0~3 번 안테나 포트에 대한 CRS가 각각 전송된다. 기지국의 송신 안테나가 4개일 경우 한 RB에서의 CRS 패턴은 도 9와 같다.

[216] 기지국이 단일의 송신 안테나를 사용하는 경우, 단일 안테나 포트를 위한 참조 신호가 배열된다.

[217] 기지국이 2개의 송신 안테나를 사용하는 경우, 2개의 송신 안테나 포트를 위한 참조 신호는 시분할 다중화(TDM: Time Division Multiplexing) 및/또는 주파수 분할 다중화(FDM Frequency Division Multiplexing) 방식을 이용하여 배열된다. 즉, 2개의 안테나 포트를 위한 참조 신호는 각각이 구별되기 위해 서로 다른 시간 자원 및/또는 서로 다른 주파수 자원이 할당된다.

[218] 게다가, 기지국이 4개의 송신 안테나를 사용하는 경우, 4개의 송신 안테나 포트를 위한 참조 신호는 TDM 및/또는 FDM 방식을 이용하여 배열된다. 하향링크 신호의 수신 측(단말)에 의하여 측정된 채널 정보는 단일의 송신 안테나 전송, 송신 다이버시티, 폐쇄 루프 공간 다중화(closed-loop spatial multiplexing), 개방 루프 공간 다중화(open-loop spatial multiplexing) 또는 다중 사용자-다중 입출력 안테나(Multi-User MIMO)와 같은 전송 방식을 이용하여 전송된 데이터를 복조하기 위하여 사용될 수 있다.

[219] 다중 입출력 안테나가 지원되는 경우 참조 신호가 특정의 안테나 포트로부터 전송될 때, 상기 참조 신호는 참조 신호의 패턴에 따라 특정된 자원 요소들의 위치에 전송되며, 다른 안테나 포트를 위해 특정된 자원 요소들의 위치에 전송되지 않는다. 즉, 서로 다른 안테나 사이의 참조 신호는 서로 겹치지 않는다.

[220] 이하 DRS에 대하여 좀 더 상세하게 기술하면, DRS는 데이터를 복조하기 위하여 사용된다. 다중 입출력 안테나 전송에서 특정의 단말을 위해 사용되는 선행 부호화(precoding) 가중치는 단말이 참조 신호를 수신하였을 때 각 송신 안테나에서 전송된 전송 채널과 결합되어 상응하는 채널을 추정하기 위하여 변경 없이 사용된다.

[221] 3GPP LTE 시스템(예를 들어, 릴리즈-8)은 최대로 4개의 전송 안테나를 지원하고, 랭크 1 빔포밍(beamforming)을 위한 DRS가 정의된다. 랭크 1 빔포밍을 위한 DRS는 또한 안테나 포트 인덱스 5 를 위한 참조 신호를 나타낸다.

[222] LTE 시스템의 진화 발전된 형태의 LTE-A 시스템에서 기지국의 하향 링크로 최대 8개의 송신 안테나를 지원할 수 있도록 디자인되어야 한다. 따라서 최대 8개 송신 안테나에 대한 RS 역시 지원되어야 한다. LTE 시스템에서 하향 링크 RS는 최대 4개의 안테나 포트에 대한 RS만 정의되어 있으므로, LTE-A 시스템에서 기지국이 4개 이상 최대 8개의 하향 링크 송신 안테나를 가질 경우 이들 안테나 포트에 대한 RS가 추가적으로 정의되고 디자인되어야 한다. 최대 8개의 송신 안테나 포트에 대한 RS는 위에서 설명한 채널 측정을 위한 RS와 데이터 복조를 위한 RS 두 가지가 모두 디자인되어야 한다.

[223] LTE-A 시스템을 디자인 함에 있어서 중요한 고려 사항 중 하나는 하위

호환성(backward compatibility), 즉 LTE 단말이 LTE-A 시스템에서도 아무 무리 없이 잘 동작해야 하고, 시스템 또한 이를 지원해야 한다는 것이다. RS 전송 관점에서 보았을 때, LTE에서 정의되어 있는 CRS가 전 대역으로 매 서브 프레임마다 전송되는 시간-주파수 영역에서 추가적으로 최대 8개의 송신 안테나 포트에 대한 RS가 추가적으로 정의되어야 한다. LTE-A 시스템에서 기존 LTE의 CRS와 같은 방식으로 최대 8개의 송신 안테나에 대한 RS 패턴을 매 서브 프레임마다 전 대역에 추가하게 되면 RS 오버헤드가 지나치게 커지게 된다.

[224] 따라서 LTE-A 시스템에서 새로이 디자인되는 RS는 크게 두 가지 분류로 나누게 되는데, MCS, PMI 등의 선택을 위한 채널 측정 목적의 RS (CSI-RS: Channel State Information-RS, Channel State Indication-RS 등)와 8개의 전송 안테나로 전송되는 데이터 복조를 위한 RS(DM-RS: Data Demodulation-RS)이다.

[225] 채널 측정 목적의 CSI-RS는 기존의 CRS가 채널 측정, 핸드 오버 등의 측정 등의 목적과 동시에 데이터 복조를 위해 사용되는 것과 달리 채널 측정 위주의 목적을 위해서 디자인되는 특징이 있다. 물론 이 또한 핸드 오버 등의 측정 등의 목적으로도 사용될 수도 있다. CSI-RS가 채널 상태에 대한 정보를 얻는 목적으로만 전송되므로 CRS와 달리 매 서브 프레임마다 전송되지 않아도 된다. CSI-RS의 오버헤드를 줄이기 위하여 CSI-RS는 시간 축 상에서 간헐적으로 전송된다.

[226] 데이터 복조를 위해서 해당 시간-주파수 영역에서 스케줄링 된 UE에게 전용적(dedicated)으로 DM-RS가 전송된다. 즉, 특정 UE의 DM-RS는 해당 UE가 스케줄링 된 영역, 즉 데이터를 수신 받는 시간-주파수 영역에만 전송되는 것이다.

[227] LTE-A 시스템에서 eNB는 모든 안테나 포트에 대한 CSI-RS를 전송해야 한다. 최대 8개의 송신 안테나 포트에 대한 CSI-RS를 매 서브 프레임마다 전송하는 것은 오버헤드가 너무 큰 단점이 있으므로, CSI-RS는 매 서브 프레임마다 전송되지 않고 시간 축에서 간헐적으로 전송되어야 그 오버헤드를 줄일 수 있다. 즉, CSI-RS는 한 서브 프레임의 정수 배의 주기를 가지고 주기적으로 전송되거나 특정 전송 패턴으로 전송될 수 있다. 이 때 CSI-RS가 전송되는 주기나 패턴은 eNB가 설정할 수 있다.

[228] CSI-RS를 측정하기 위해서 UE는 반드시 자신이 속한 셀의 각각의 CSI-RS 안테나 포트에 대한 CSI-RS의 전송 서브 프레임 인덱스, 전송 서브 프레임 내에서 CSI-RS 자원 요소(RE) 시간-주파수 위치, 그리고 CSI-RS 시퀀스 등에 대한 정보를 알고 있어야 한다.

[229] LTE-A 시스템에 eNB는 CSI-RS를 최대 8개의 안테나 포트에 대해서 각각 전송해야 한다. 서로 다른 안테나 포트의 CSI-RS 전송을 위해 사용되는 자원은 서로 직교(orthogonal)해야 한다. 한 eNB가 서로 다른 안테나 포트에 대한 CSI-RS를 전송할 때 각각의 안테나 포트에 대한 CSI-RS를 서로 다른 RE에 맵핑함으로써 FDM/TDM방식으로 이들 자원을 orthogonal하게 할당할 수 있다.

또는 서로 다른 안테나 포트에 대한 CSI-RS를 서로 orthogonal한 코드에 맵핑시키는 CDM방식으로 전송할 수 있다.

[230] CSI-RS에 관한 정보를 eNB가 자기 셀 UE에게 알려줄 때, 먼저 각 안테나 포트에 대한 CSI-RS가 매핑되는 시간-주파수에 대한 정보를 알려줘야 한다. 구체적으로, CSI-RS가 전송되는 서브 프레임 번호들, 또는 CSI-RS가 전송되는 주기, CSI-RS가 전송되는 서브 프레임 오프셋이며, 특정 안테나의 CSI-RS RE가 전송되는 OFDM 심볼 번호, 주파수 간격(spacing), 주파수 축에서의 RE의 오프셋 또는 쉬프트 값 등이 있다.

[231] CSI-RS는 1개, 2개, 4개 또는 8개의 안테나 포트를 통해 전송된다. 이때, 사용되는 안테나 포트는 각각 p=15, p=15,16, p=15,...,18, p=15,...,22이다. CSI-RS는 서브캐리어 간격 Δf=15kHz에 대해서만 정의될 수 있다.

[232] (k',l')(여기서, k'는 자원 블록 내 부반송파 인덱스이고, l'는 슬롯 내 OFDM 심볼 인덱스를 나타낸다.) 및 n_s의 조건은 아래 표 4 또는 표 5와 같은 CSI-RS 설정(configuration)에 따라 결정된다.

[233] 표 3은 일반 CP에서 CSI-RS 구성으로부터 (k',l')의 매핑을 예시한다.

[234] [표3]

	CSI reference signal configuration	Number of CSI reference signals configured					
		1 or 2		4		8	
		(k',l')	n_s mod 2	(k',l')	n_s mod 2	(k',l')	n_s mod 2
Frame structure type 1 and 2	0	(9,5)	0	(9,5)	0	(9,5)	0
	1	(11,2)	1	(11,2)	1	(11,2)	1
	2	(9,2)	1	(9,2)	1	(9,2)	1
	3	(7,2)	1	(7,2)	1	(7,2)	1
	4	(9,5)	1	(9,5)	1	(9,5)	1
	5	(8,5)	0	(8,5)	0		
	6	(10,2)	1	(10,2)	1		
	7	(8,2)	1	(8,2)	1		
	8	(6,2)	1	(6,2)	1		
	9	(8,5)	1	(8,5)	1		
	10	(3,5)	0				
	11	(2,5)	0				
	12	(5,2)	1				
	13	(4,2)	1				
	14	(3,2)	1				
	15	(2,2)	1				
	16	(1,2)	1				
	17	(0,2)	1				
	18	(3,5)	1				
	19	(2,5)	1				
Frame structure type 2 only	20	(11,1)	1	(11,1)	1	(11,1)	1
	21	(9,1)	1	(9,1)	1	(9,1)	1
	22	(7,1)	1	(7,1)	1	(7,1)	1
	23	(10,1)	1	(10,1)	1		
	24	(8,1)	1	(8,1)	1		
	25	(6,1)	1	(6,1)	1		
	26	(5,1)	1				
	27	(4,1)	1				
	28	(3,1)	1				
	29	(2,1)	1				
	30	(1,1)	1				
	31	(0,1)	1				

[235] 표 4는 확장 CP에서 CSI-RS 구성으로부터 (k',l')의 매핑을 예시한다.

[236] [표4]

	CSI reference signal configuration	Number of CSI reference signals configured 1 or 2		4		8	
		(k',l')	$n_s \bmod 2$	(k',l')	$n_s \bmod 2$	(k',l')	$n_s \bmod 2$
Frame structure type 1 and 2	0	(11,4)	0	(11,4)	0	(11,4)	0
	1	(9,4)	0	(9,4)	0	(9,4)	0
	2	(10,4)	1	(10,4)	1	(10,4)	1
	3	(9,4)	1	(9,4)	1	(9,4)	1
	4	(5,4)	0	(5,4)	0		
	5	(3,4)	0	(3,4)	0		
	6	(4,4)	1	(4,4)	1		
	7	(3,4)	1	(3,4)	1		
	8	(8,4)	0				
	9	(6,4)	0				
	10	(2,4)	0				
	11	(0,4)	0				
	12	(7,4)	1				
	13	(6,4)	1				
	14	(1,4)	1				
	15	(0,4)	1				
Frame structure type 2 only	16	(11,1)	1	(11,1)	1	(11,1)	1
	17	(10,1)	1	(10,1)	1	(10,1)	1
	18	(9,1)	1	(9,1)	1	(9,1)	1
	19	(5,1)	1	(5,1)	1		
	20	(4,1)	1	(4,1)	1		
	21	(3,1)	1	(3,1)	1		
	22	(8,1)	1				
	23	(7,1)	1				
	24	(6,1)	1				
	25	(2,1)	1				
	26	(1,1)	1				
	27	(0,1)	1				

[237] 표 3 및 표 4를 참조하면, CSI-RS의 전송에 있어서, 이종 네트워크(HetNet: heterogeneous network) 환경을 포함하여 멀티 셀 환경에서 셀간 간섭(ICI: inter-cell interference)을 줄이기 위하여 최대 32개(일반 CP 경우) 또는 최대 28개(확장 CP 경우)의 서로 다른 구성(configuration)이 정의된다.

[238] CSI-RS 구성은 셀 내의 안테나 포트의 개수 및 CP에 따라 서로 다르며, 인접한 셀은 최대한 서로 다른 구성을 가질 수 있다. 또한, CSI-RS 구성은 프레임 구조에 따라 FDD 프레임과 TDD 프레임에 모두 적용하는 경우와 TDD 프레임에만 적용하는 경우로 나눠질 수 있다.

[239] 표 3 및 표 4를 기반으로 CSI-RS 구성에 따라 (k',l') 및 n_s가 정해지고, 각 CSI-RS 안테나 포트가 CSI-RS 전송에 이용하는 시간-주파수 자원이 결정된다.

[240] 도 10은 본 발명이 적용될 수 있는 무선 통신 시스템에서 CSI-RS 구성을 예시하는 도면이다.

[241] 도 10(a)는 1개 또는 2개의 CSI-RS 안테나 포트들에 의한 CSI-RS 전송에 사용

가능한 20가지 CSI-RS 구성들을 나타낸 것이고, 도 10(b)는 4개의 CSI-RS 안테나 포트들에 의해 사용 가능한 10가지 CSI-RS 구성들을 나타낸 것이며, 도 10(c)는 8개의 CSI-RS 안테나 포트들에 의해 CSI-RS 전송에 사용 가능한 5가지 CSI-RS 구성들을 나타낸 것이다.

[242] 이와 같이, 각 CSI-RS 구성에 따라 CSI-RS가 전송되는 무선 자원(즉, RE 쌍)이 결정된다.

[243] 특정 셀에 대하여 CSI-RS 전송을 위해 1개 혹은 2개의 안테나 포트가 설정되면, 도 10(a)에 도시된 20가지 CSI-RS 구성들 중 설정된 CSI-RS 구성에 따른 무선 자원 상에서 CSI-RS가 전송된다.

[244] 마찬가지로, 특정 셀에 대하여 CSI-RS 전송을 위해 4개의 안테나 포트가 설정되면, 도 10(b)에 도시된 10가지 CSI-RS 구성들 중 설정된 CSI-RS 구성에 따른 무선 자원 상에서 CSI-RS가 전송된다. 또한, 특정 셀에 대하여 CSI-RS 전송을 위해 8개의 안테나 포트가 설정되면, 도 10(c)에 도시된 5가지 CSI-RS 구성들 중 설정된 CSI-RS 구성에 따른 무선 자원 상에서 CSI-RS가 전송된다.

[245] 2개의 안테나 포트 별(즉, {15,16}, {17,18}, {19,20}, {21,22})로 각각의 안테나 포트에 대한 CSI-RS는 동일한 무선 자원에 CDM되어 전송된다. 안테나 포트 15 및 16를 예를 들면, 안테나 포트 15 및 16에 대한 각각의 CSI-RS 복소 심볼은 동일하나, 서로 다른 직교 코드(예를 들어, 왈시 코드(walsh code)가 곱해져서 동일한 무선 자원에 매핑된다. 안테나 포트 15에 대한 CSI-RS의 복소 심볼에는 [1, 1]이 곱해지고, 안테나 포트 16에 대한 CSI-RS의 복소 심볼에는 [1 -1]이 곱해져서 동일한 무선 자원에 매핑된다. 이는 안테나 포트 {17,18}, {19,20}, {21,22}도 마찬가지이다.

[246] UE는 전송된 심볼에 곱해진 코드를 곱하여 특정 안테나 포트에 대한 CSI-RS를 검출할 수 있다. 즉, 안테나 포트 15에 대한 CSI-RS를 검출하기 위해서 곱해진 코드 [1 1]을 곱하고, 안테나 포트 16에 대한 CSI-RS를 검출하기 위해서 곱해진 코드 [1 -1]을 곱한다.

[247] 도 10(a) 내지 (c)를 참조하면, 동일한 CSI-RS 구성 인덱스에 해당하게 되면, 안테나 포트 수가 많은 CSI-RS 구성에 따른 무선 자원은 CSI-RS 안테나 포트 수가 적은 CSI-RS 구성에 따른 무선 자원을 포함한다. 예를 들어, CSI-RS 구성 0의 경우, 8개 안테나 포트 수에 대한 무선 자원은 4개 안테나 포트 수에 대한 무선 자원과 1 또는 2개의 안테나 포트 수에 대한 무선 자원을 모두 포함한다.

[248] 하나의 셀에서 복수의 CSI-RS 구성이 사용될 수 있다. 넌-제로 전력(NZP: non-zero power) CSI-RS는 0개 또는 1개 CSI-RS 구성만이 이용되고, 제로 전력(ZP: zero power) CSI-RS는 0개 또는 여러 개의 CSI-RS 구성이 이용될 수 있다.

[249] 상위 계층에 의해 설정되는 16 비트의 비트맵인 ZP CSI-RS(ZeroPowerCSI-RS)에서 1로 설정된 각 비트 별로, UE는 위의 표 3 및 표 4의 4개의 CSI-RS 열(column)에 해당하는 RE들에서(상위 계층에 의해 설정된

NZP CSI-RS를 가정하는 RE와 중복되는 경우를 제외) 제로 전송 전력을 가정한다. 최상위 비트(MSB: Most Significant Bit)는 가장 낮은 CSI-RS 구성 인덱스에 해당하고, 비트맵 내에서 그 다음의 비트는 순서대로 다음의 CSI-RS 구성 인덱스에 해당한다.

[250] CSI-RS는 위의 표 3 및 표 4에서 (n_s mod 2)의 조건을 만족하는 하향링크 슬롯 및 CSI-RS 서브프레임 구성을 만족하는 서브프레임에서만 전송된다.

[251] 프레임 구조 타입 2(TDD)의 경우, 스페셜 서브프레임, 동기 신호(SS), PBCH 또는 SIB 1(SystemInformationBlockType1) 메시지 전송과 충돌되는 서브프레임 또는 페이징 메시지 전송을 위해 설정된 서브프레임에서 CSI-RS는 전송되지 않는다.

[252] 또한, 안테나 포트 세트 S(S={15}, S={15,16}, S={17,18}, S={19,20} 또는 S={21,22}) 내 속하는 어떠한 안테나 포트에 대한 CSI-RS가 전송되는 RE는 PDSCH 또는 다른 안테나 포트의 CSI-RS 전송에 사용되지 않는다.

[253] CSI-RS 전송에 사용되는 시간-주파수 자원들은 데이터 전송에 사용될 수 없으므로, CSI-RS 오버헤드가 증가할수록 데이터 처리량(throughput)이 감소하게 된다. 이를 고려하여 CSI-RS는 매 서브프레임마다 전송되도록 구성되지 않고, 다수의 서브프레임에 해당하는 소정의 전송 주기마다 전송되도록 구성된다. 이 경우, 매 서브프레임마다 CSI-RS가 전송되는 경우에 비하여 CSI-RS 전송 오버헤드가 많이 낮아질 수 있다.

[254] CSI-RS 전송을 위한 서브프레임 주기(이하, 'CSI 전송 주기'로 지칭함)(T_CSI-RS) 및 서브프레임 오프셋(Δ_CSI-RS)은 아래 표 5과 같다.

[255] 표 5은 CSI-RS 서브프레임 구성을 예시한다.

[256] [표5]

CSI-RS-SubframeConfig I_{CSI-RS}	CSI-RS periodicity T_{CSI-RS} (subframes)	CSI-RS subframe offset Δ_{CSI-RS} (subframes)
0 - 4	5	I_{CSI-RS}
5 - 14	10	$I_{CSI\ RS}-5$
15 - 34	20	$I_{CSI-RS}-15$
35 - 74	40	$I_{CSI-RS}-35$
75 - 154	80	$I_{CSI-RS}-75$

[257] 표 5을 참조하면, CSI-RS 서브프레임 구성(I_CSI-RS)에 따라 CSI-RS 전송 주기(T_CSI-RS) 및 서브프레임 오프셋(Δ_CSI-RS)이 결정된다.

[258] 표 5의 CSI-RS 서브프레임 구성은 앞서 'SubframeConfig' 필드 및 'zeroTxPowerSubframeConfig' 필드 중 어느 하나로 설정될 수 있다. CSI-RS 서브프레임 구성은 NZP CSI-RS 및 ZP CSI-RS에 대하여 개별적으로(separately) 설정될 수 있다.

[259] CSI-RS를 포함하는 서브프레임은 아래 수학식 12를 만족한다.

[260] [수식12]

$$(10n_f + \lfloor n_s/2 \rfloor - \Delta_{CSI-RS}) \bmod T_{CSI-RS} = 0$$

[261] 수학식 12에서 T_CSI-RS는 CSI-RS 전송 주기, Δ_CSI-RS는 서브프레임 오프셋 값, n_f는 시스템 프레임 넘버, n_s는 슬롯 넘버를 의미한다.

[262] 서빙 셀에 대해 전송 모드 9(transmission mode 9)가 설정된 UE의 경우, UE는 하나의 CSI-RS 자원 구성이 설정될 수 있다. 서빙 셀에 대해 전송 모드 10(transmission mode 10)이 설정된 UE의 경우, UE는 하나 또는 그 이상의 CSI-RS 자원 구성(들)이 설정될 수 있다.

[263] 각 CSI-RS 자원 구성을 위한 아래와 같이 파라미터가 상위 계층 시그널링을 통해 설정된다.

[264] - 전송 모드 10이 설정된 경우, CSI-RS 자원 구성 식별자

[265] - CSI-RS 포트 개수

[266] - CSI-RS 구성 (표 3 및 표 4 참조)

[267] - CSI-RS 서브프레임 구성(I_CSI-RS) (표 5 참조)

[268] - 전송 모드 9가 설정된 경우, CSI 피드백을 위한 전송 파워(P_C)

[269] - 전송 모드 10이 설정된 경우, 각 CSI 프로세스에 대하여 CSI 피드백을 위한 전송 파워(P_C). CSI 프로세스에 대하여 CSI 서브프레임 세트들 C_CSI,0 및 C_CSI,1가 상위 계층에 의해 설정되면, P_C는 CSI 프로세스의 각 CSI 서브프레임 세트 별로 설정된다.

[270] - 임의 랜덤(pseudo-rnadom) 시퀀스 발생기 파라미터(n_ID)

[271] - 전송 모드 10이 설정된 경우, QCL(QuasiCo-Located) 타입 B UE 가정을 위한 QCL 스크램블링 식별자(qcl-ScramblingIdentity-r11), CRS 포트 카운트(crs-PortsCount-r11), MBSFN 서브프레임 설정 리스트(mbsfn-SubframeConfigList-r11) 파라미터를 포함하는 상위 계층 파라미터('qcl-CRS-Info-r11')

[272] UE가 도출한 CSI 피드백 값이 [-8, 15] dB 범위 내의 값을 가질 때, P_C는 CSI-RS EPRE에 대한 PDSCH EPRE의 비율로 가정된다. 여기서, PDSCH EPRE는 CRS EPRE에 대한 PDSCH EPRE의 비율이 ρ_A인 심볼에 해당한다.

[273] 서빙 셀의 동일한 서브프레임에서 CSI-RS와 PMCH이 함께 설정되지 않는다.

[274] 프레임 구조 타입 2에서 4개의 CRS 안테나 포트가 설정된 경우, UE는 일반 CP의 경우 [20-31] 세트(표 3 참조) 또는 확장 CP의 경우 [16-27] 세트(표 4 참조)에 속하는 CSI-RS 구성 인덱스가 설정되지 않는다.

[275] UE는 CSI-RS 자원 구성의 CSI-RS 안테나 포트가 지연 확산(delay spread), 도플러 확산(Doppler spread), 도플러 쉬프트(Doppler shift), 평균 이득(average gain) 및 평균 지연(average delay)에 대하여 QCL 관계를 가진다고 가정할 수 있다.

[276] 전송 모드 10 그리고 QCL 타입 B가 설정된 UE는 CSI-RS 자원 구성에 해당하는

안테나 포트 0-3과 CSI-RS 자원 구성에 해당하는 안테나 포트 15-22가 도플러 확산(Doppler spread), 도플러 쉬프트(Doppler shift)에 대하여 QCL 관계라고 가정할 수 있다.

[277] 전송 모드 10이 설정된 UE의 경우, 서빙 셀에 대하여 하나 또는 그 이상의 CSI-IM(Channel-State Information - Interference Measurement) 자원 구성이 설정될 수 있다.

[278] 상위 계층 시그널링을 통해 각 CSI-IM 자원 구성을 위한 아래와 같은 파라미터가 설정될 수 있다.

[279] - ZP CSI-RS 구성 (표 3 및 표 4 참조)

[280] - ZP CSI RS 서브프레임 구성(I_CSI-RS) (표 5 참조)

[281] CSI-IM 자원 구성은 설정된 ZP CSI-RS 자원 구성 중 어느 하나와 동일하다.

[282] 서빙 셀의 동일한 서브프레임 내 CSI-IM 자원과 PMCH가 동시에 설정되지 않는다.

[283] 전송 모드 1-9가 설정된 UE의 경우, 서빙 셀에 대하여 UE는 하나의 ZP CSI-RS 자원 구성이 설정될 수 있다. 전송 모드 10이 설정된 UE의 경우, 서빙 셀에 대하여 UE는 하나 또는 그 이상의 ZP CSI-RS 자원 구성이 설정될 수 있다.

[284] 상위 계층 시그널링을 통해 ZP CSI-RS 자원 구성을 위한 아래와 같은 파라미터가 설정될 수 있다.

[285] - ZP CSI-RS 구성 리스트 (표 3 및 표 4 참조)

[286] - ZP CSI-RS 서브프레임 구성(I_CSI-RS) (표 5 참조)

[287] 서빙 셀의 동일한 서브프레임에서 ZP CSI-RS와 PMCH가 동시에 설정되지 않는다.

[288]

[289] **셀 측정(Cell Measurement)/측정 보고(Measurement Report)**

[290] 단말의 이동성(mobility) 보장을 위한 여러 방법들(핸드오버, 랜덤 액세스, 셀 탐색 등) 중 하나 또는 그 여러 방법들을 위하여 UE는 셀 측정(cell measurement)한 결과를 기지국(혹은 네트워크)에 보고한다.

[291] 3GPP LTE/LTE-A 시스템에서 셀 특정 참조 신호(CRS)는 시간 축으로 각 서브프레임 내의 0, 4, 7, 11 번째 OFDM 심볼을 통해 전송되고, 이는 셀 측정(cell measurement)를 위해 기본적으로 사용된다. 즉, 단말은 서빙 셀(serving cell)과 이웃 셀(neighbor cell)로부터 각각 수신되는 CRS를 이용하여, 셀 측정을 수행한다.

[292] 셀 측정(cell measurement)은 서빙 셀 및 이웃 셀의 신호 세기 혹은 총 수신 전력 대비 신호 세기 등을 측정하는 참조 신호 수신 전력(RSRP: Reference signal receive power), 수신신호강도(RSSI: Received signal strength indicator), 참조신호수신품질(RSRQ: Reference signal received quality) 등의 RRM(Radio resource management) 측정과 서빙 셀과의 링크 품질을 측정하여 라디오 링크 실패(radio link failure) 여부를 평가할 수 있는 RLM(Radio Link Monitoring)

측정을 포함하는 개념이다.

[293] RSRP는 측정 주파수 대역 내에서 CRS가 전송되는 RE의 전력 분배의 선형 평균이다. RSRP 결정을 위해, 안테나 포트 '0'에 해당하는 CRS(R0)가 사용될 수 있다. 또한, RSRP 결정을 위해, 안테나 포트 '1'에 해당하는 CRS(R1)가 추가로 사용될 수도 있다. RSRP를 결정하기 위하여 UE에 의해 이용되는 측정 주파수 대역 및 측정 구간 내에서 이용하는 RE들의 수는 해당 측정 정확도 요구(accuracy requirements)가 만족되는 한도에서 UE가 결정할 수 있다. 또한, RE 당 전력은 순환 전치(CP)를 제외한 심볼의 나머지 부분 내에서 수신한 에너지로부터 결정될 수 있다.

[294] RSSI는 측정 대역 내에서 안테나 포트 '0'에 해당하는 RS를 포함하는 OFDM 심볼들에서 동일 채널(co-channel)의 서빙 셀(serving cell)과 넌-서빙 셀(non-serving cell), 인접 채널로부터의 간섭, 열 잡음(thermal noise) 등을 포함하는 해당 UE에 의해 모든 소스들로부터 감지된 총 수신 전력의 선형 평균으로 도출된다. 상위 계층 시그널링에 의하여 RSRQ 측정을 수행하기 위한 특정 서브프레임들이 지시되는 경우, RSSI는 지시된 서브프레임들 내의 모든 OFDM 심볼에 통해 측정된다.

[295] RSRQ는 N×RSRP/RSSI로 도출된다. 여기서, N은 RSSI 측정 대역폭의 RB 개수를 의미한다. 또한, 위의 식에서 분자 및 분모의 측정은 동일한 RB의 세트에서 구해질 수 있다.

[296] 기지국은 상위 계층 시그널링(예를 들어, RRC 연결 재구성(RRC Connection Reconfiguration) 메시지)을 통해 UE에게 측정(measurement)을 위한 설정 정보를 전달할 수 있다.

[297] RRC 연결 재구성 메시지는 무선 자원 구성 전용('radioResourceConfigDedicated') 정보 요소(IE: Information Element)와, 측정 설정('measConfig') IE를 포함한다.

[298] 'measConfig' IE는 UE에 의해 수행되어야 하는 측정을 특정하고, 측정 갭(measurement gap)의 구성 뿐만 아니라 인트라-주파수(intra-frequency) 이동성, 인터-주파수(inter-frequency) 이동성, 인터-RAT(inter-RAT) 이동성을 위한 설정 정보를 포함한다.

[299] 특히, 'measConfig' IE는 측정에서 제거될 측정 대상('measObject')의 리스트를 나타내는 'measObjectToRemoveList'와 새로이 추가되거나 수정될 리스트를 나타내는 'measObjectToAddModList'가 포함된다. 또한, 'measObject'에는 통신 기술에 따라 'MeasObjectCDMA2000', 'MeasObjctEUTRA', 'MeasObjectGERAN' 등이 포함된다.

[300] 'RadioResourceConfigDedicated' IE는 무선 베어러(Radio Bearer)를 설정/변경/해제(setup/modify/release) 하거나, MAC 메인 구성을 변경하거나, 반정적 스케줄링(SPS: Semi-Persistent Scheduling) 설정을 변경하거나 및 전용 물리적 설정(dedicated physical configuration)을 변경하기 위하여 사용된다.

[301] 'RadioResourceConfigDedicated' IE는 서빙 셀 측정을 위한 시간 영역 측정 자원 제한 패턴(time domain measurement resource restriction pattern)을 지시하는 'measSubframePattern-Serv' 필드를 포함한다. 또한, UE에 의해 측정될 이웃 셀을 지시하는 'measSubframeCellList' 와 이웃 셀 측정을 위한 시간 영역 측정 자원 제한 패턴을 지시하는 'measSubframePattern-Neigh'를 포함한다.

[302] 측정 셀(서빙 셀 및 이웃 셀 포함)을 위해 설정된 시간 영역 측정 자원 제한 패턴(time domain measurement resource restriction pattern)은 RSRQ 측정을 수행하기 위한 무선 프레임 당 적어도 하나의 서브프레임을 지시할 수 있다. 측정 셀을 위해 설정된 시간 영역 측정 자원 제한 패턴에 의하여 지시된 서브프레임 이외에서는 RSRQ 측정이 수행되지 않는다.

[303] 이와 같이, UE(예를 들어, 3GPP Rel-10)는 서빙 셀 측정을 위한 서브프레임 패턴('measSubframePattern-Serv') 및 이웃 셀 측정을 위한 서브프레임 패턴('measSubframePattern-Neigh')에 의해 설정된 구간에서만 RSRQ가 측정되어야 한다.

[304] 다만, RSRP는 이러한 패턴 내 측정이 제약되어 있지 않지만, 정확도 요구(accuracy requirement)를 위해서는 이러한 패턴 내에서만 측정되는 것이 바람직하다.

[305]

[306] <u>안테나 포트 간 QCL(quasi co-located)</u>

[307] QC/QCL(quasi co-located 혹은 quasi co-location)은 다음과 같이 정의될 수 있다.

[308] 두 개의 안테나 포트가 QC/QCL 관계에 있다(혹은 QC/QCL 되었다)고 하면, 하나의 안테나 포트를 통해 전달되는 신호의 광범위 특성(large-scale property)이 다른 하나의 안테나 포트를 통해 전달되는 신호로부터 암시(infer)될 수 있다고 단말이 가정할 수 있다. 여기서, 상기 광범위 특성은 지연 확산(Delay spread), 도플러 확산(Doppler spread), 주파수 쉬프트(Frequency shift), 평균 수신 파워(Average received power), 수신 타이밍(Received Timing) 중 하나 이상을 포함한다.

[309] 또한, 다음과 같이 정의될 수도 있다. 두 개의 안테나 포트가 QC/QCL 관계에 있다(혹은 QC/QCL 되었다)고 하면, 하나의 안테나 포트를 통해 일 심볼이 전달되는 채널의 광범위 특성(large-scale property)이 다른 하나의 안테나 포트를 통해 일 심볼이 전달되는 무선 채널로부터 암시(infer)될 수 있다고 단말이 가정할 수 있다. 여기서, 상기 광범위 특성은 지연 확산(delay spread), 도플러 확산(Doppler spread), 도플러 쉬프트(Doppler shift), 평균 이득(average gain) 및 평균 지연(average delay) 중 하나 이상을 포함한다.

[310] 즉, 두 개의 안테나 포트들이 QC/QCL 관계에 있다(혹은 QC/QCL 되었다)고 함은, 하나의 안테나 포트로부터의 무선 채널의 광범위 특성이 나머지 하나의 안테나 포트로부터의 무선 채널의 광범위 특성과 같음을 의미한다. RS가 전송되는 복수의 안테나 포트를 고려하면, 서로 다른 두 종류의 RS가 전송되는

안테나 포트들이 QCL 관계에 있으면, 한 종류의 안테나 포트로부터의 무선 채널의 광범위 특성을 다른 한 종류의 안테나 포트로부터의 무선 채널의 광범위 특성으로 대체할 수 있을 것이다.

[311] 본 명세서에서 위 QC/QCL 관련 정의들을 구분하지 않는다. 즉, QC/QCL 개념은 위 정의들 중에 하나를 따를 수 있다. 혹은 유사한 다른 형태로, QC/QCL 가정이 성립하는 안테나 포트 간에는 마치 동일 위치(co-location)에서 전송하는 것처럼 가정할 수 있다는 형태 (예를 들어, 동일 전송 포인트(transmission point)에서 전송하는 안테나 포트라고 단말이 가정할 수 있다는 등)으로 QC/QCL 개념 정의가 변형될 수도 있으며, 본 발명의 사상은 이와 같은 유사 변형예들을 포함한다. 본 발명에서는 설명의 편의상 위 QC/QCL 관련 정의들을 혼용하여 사용한다.

[312] 상기 QC/QCL의 개념에 따라, 단말은 비-QC/QCL(Non-QC/QCL) 안테나 포트들에 대해서는 해당 안테나 포트들로부터의 무선 채널 간에 동일한 상기 광범위 특성을 가정할 수 없다. 즉, 이 경우 단말은 타이밍 획득 및 트랙킹(tracking), 주파수 오프셋 추정 및 보상, 지연 추정 및 도플러 추정 등에 대하여 각각의 설정된 비-QC/QCL 안테나 포트 별로 독립적인 프로세싱을 수행하여야 한다.

[313] QC/QCL을 가정할 수 있는 안테나 포트들간에 대해서, 단말은 다음과 같은 동작을 수행할 수 있다는 장점이 있다:

[314] - 지연 확산 및 도플러 확산에 대하여, 단말은 어떤 하나의 안테나 포트로부터의 무선 채널에 대한 전력-지연-프로파일(power-delay profile), 지연 확산 및 도플러 스펙트럼(Doppler spectrum), 도플러 확산 추정 결과를, 다른 안테나 포트로부터의 무선 채널에 대한 채널 추정 시 사용되는 위너 필터(Wiener filter) 등에 동일하게 적용할 수 있다.

[315] - 주파수 쉬프트(shift) 및 수신된 타이밍에 대하여, 단말은 어떤 하나의 안테나 포트에 대한 시간 및 주파수 동기화 수행한 후, 동일한 동기화를 다른 안테나 포트의 복조에 적용할 수 있다.

[316] - 평균 수신 전력에 대하여, 단말은 둘 이상의 안테나 포트들에 대하여 RSRP(Reference Signal Received Power) 측정을 평균할 수 있다.

[317] 예를 들어, 단말이 하향링크 데이터 채널 복조를 위한 DMRS 안테나 포트가 서빙 셀의 CRS 안테나 포트와 QC/QCL 되었다면, 단말은 해당 DMRS 안테나 포트를 통한 채널 추정 시 자신의 CRS 안테나 포트로부터 추정했던 무선 채널의 광범위 특성들(large-scale properties)을 동일하게 적용하여 DMRS 기반 하향링크 데이터 채널 수신 성능을 향상시킬 수 있다.

[318] 왜냐하면, CRS는 매 서브프레임 그리고 전체 대역에 걸쳐 상대적으로 높은 밀도(density)로 브로드캐스팅되는 참조 신호이므로, 광범위 특성에 관한 추정치는 CRS로부터 보다 안정적으로 획득이 가능하기 때문이다. 반면, DMRS는 특정 스케줄링된 RB에 대해서는 단말 특정하게 전송되며, 또한

PRG(precoding resource block group) 단위가 기지국이 전송에 사용하는 프리코딩 행렬(precoding matrix)가 변할 수 있으므로 단말에게 수신되는 유효 채널은 PRG 단위로 달라질 수 있어 다수의 PRG를 스케줄링 받은 경우라고 하더라도 넓은 대역에 걸쳐 DMRS를 무선 채널의 광범위 특성 추정용으로 사용 시에 성능 열화가 발생할 수 있다. 또한, CSI-RS도 그 전송 주기가 수~수십 ms가 될 수 있고, 자원 블록 당 평균적으로 안테나 포트 당 1 자원 요소의 낮은 밀도를 가지므로 CSI-RS도 마찬가지로 무선 채널의 광범위 특성 추정용으로 사용할 경우 성능 열화가 발생할 수 있다.

[319] 즉, 안테나 포트 간의 QC/QCL 가정을 함으로써 단말은 하향링크 참조 신호의 검출/수신, 채널 추정, 채널 상태 보고 등에 활용할 수 있다.

[320]

[321] 제한된 RLM 및 RRM/CSI 측정

[322] 간섭 조정(Interference coordination)의 한 방법으로서, 공격 셀(aggressor cell)이 일부 물리 채널의 전송 파워(transmission power)/동작(activity)를 줄이는 (여기서, 전송 파워/동작을 줄이는 것은 제로 파워로 설정하는 동작까지 포함할 수 있음) 침묵 서브프레임(silent subframe)(또는, ABS(almost blank subframe)으로 지칭될 수 있음)을 사용하고, 희생 셀(victim cell)이 이를 고려하여 UE를 스케줄링하는 시간 도메인 셀 간 간섭 조정(scheduling하는 time domain inter-cell interference coordination)이 가능하다.

[323] 이 경우, 희생 셀(victim cell) UE의 입장에서는 간섭 레벨(interference level)이 서브프레임에 따라서 크게 변화할 수 있다.

[324] 이러한 상황에서 각 서브프레임에서의 보다 정확한 무선 링크 모니터링(RLM: radio link monitoring)이나 RSRP/RSRQ 등을 측정하는 무선 자원 관리(RRM: radio resource management) 동작을 수행하거나 링크 적응(link adaptation)을 위해서 채널 상태 정보(CSI: channel state information)를 측정하기 위해서, 상기 모니터링/측정은 균일한 간섭 특성을 지니는 서브프레임의 세트들로 제한되어야 한다. 3GPP LTE 시스템에서는 아래와 같이 제한된 RLM 및 RRM/CSI 측정을 정의한다.

[325] UE는 Pcell의 하향링크 무선 링크 품질(downlink link quality)을 감지하기 위하여 셀 특정 참조 신호(CRS)에 기반하여 하향링크 링크 품질을 모니터한다. 단말은 하향링크 무선 링크 품질을 추정하고, Pcell의 하향링크 무선 링크 품질을 모니터링하기 위하여 임계치 Q_out 및 Q_in와 추정치를 비교한다.

[326] 임계치 Q_out은 하향링크 무선 링크가 신뢰있게(reliably) 수신될 수 없는 레벨로 정의되고, 아래 표 6에서 명시된 전송 파라미터에 기반하여 PCFICH 에러를 고려한 가상의(hypothetical) PDCCH 전송의 10% 블록 에러율(BER: block error rate)에 해당한다.

[327] 임계치 Q_in는 하향링크 무선 링크 품질이 Q_out에서의 하향링크 무선 링크 품질 보다 현저하게 신뢰있게 수신될 수 있는 레벨로 정의되고, 아래 표 7에서

명시된 전송 파라미터에 기반하여 PCFICH 에러를 고려한 가상의(hypothetical) PDCCH 전송의 2% BER에 해당한다.

[328] 상위 계층 시그널링이 제한된 RLM을 위한 특정 서브프레임을 지시할 때, 무선 링크 품질이 모니터링된다.

[329] RLM 측정을 수행하기 위한 시간 도메인 측정 자원 제한 패턴이 상위 계층에 의해 설정될 때, 또한 측정되는 셀을 위해 설정된 시간 도메인 측정 자원 제한 패턴이 RLM 측정을 수행하기 위한 무선 프레임 당 적어도 하나의 서브프레임을 지시한다면, 일정한 요구 사항이 적용된다.

[330] CRS 지원(assistance) 정보가 제공되는 경우, CRS 지원 정보가 제공된 하나 또는 그 이상의 셀의 전송 안테나 포트(transmit antenna port)의 개수가 RLM이 수행되는 셀의 전송 안테나 포트의 개수와 상이할 때 상기 요구 사항이 만족될 수 있다.

[331] 만약, 단말이 CRS 지원 정보를 제공받지 않거나 CRS 지원 데이터가 전체 평가 기간 동안에 유효하지 않으면, CRS와 논-MBSFN(multicast broadcast single frequency network) 서브프레임 내에서 설정된 ABS의 충돌 하에 시간 도메인 측정 제한이 적용될 수 있다.

[332] 표 6은 동기가 맞지 않은 상태(out-of-sync)에 대한 PDCCH/PCFICH 전송 파라미터를 예시한다.

[333] [표6]

속성(Attribute)	값(Value)
DCI 포맷	1A
제어 OFDM 심볼의 수	2; 대역폭 ≥ 10 MHz 3; 3 MHz ≤ 대역폭 ≤ 10 MHz 4; 대역폭 = 1.4 MHz
병합 레벨(Aggregation level) (CCE)	4; 대역폭 = 1.4 MHz 8; 대역폭 ≥ 3 MHz
PDCCH RE 에너지 대 평균 RS RE 에너지의 비 (Ratio of PDCCH RE energy to average RS RE energy)	4 dB; Pcell에 의한 CRS 전송을 위해 단일 안테나 포트가 사용되는 경우 1 dB; Pcell에 의한 CRS 전송을 위해 2개 또는 4개 안테나 포트가 사용되는 경우
PCFICH RE 에너지 대 평균 RS RE 에너지의 비 (Ratio of PCFICH RE energy to average RS RE energy)	4 dB; Pcell에 의한 CRS 전송을 위해 단일 안테나 포트가 사용되는 경우 1 dB: Pcell에 의한 CRS 전송을 위해 2개 또는 4개 안테나 포트가 사용되는 경우

[334] 표 7은 동기가 맞는 상태(in-sync)에 대한 PDCCH/PCFICH 전송 파라미터를 예시한다.

[335] [표7]

속성(Attribute)	값(Value)
DCI 포맷	1C
제어 OFDM 심볼의 수	2; 대역폭 ≥ 10 MHz 3; 3 MHz ≤ 대역폭 ≤ 10 MHz 4; 대역폭 = 1.4 MHz
병합 레벨(Aggregation level) (CCE)	4
PDCCH RE 에너지와 평균 RS RE 에너지 간 비율 (Ratio of PDCCH RE energy to average RS RE energy)	0 dB; Pcell에 의한 CRS 전송을 위해 단일 안테나 포트가 사용되는 경우 -3 dB; Pcell에 의한 CRS 전송을 위해 2개 또는 4개 안테나 포트가 사용되는 경우
PCFICH RE 에너지 대 평균 RS RE 에너지의 비 (Ratio of PCFICH RE energy to average RS RE energy)	4 dB; Pcell에 의한 CRS 전송을 위해 단일 안테나 포트가 사용되는 경우 1 dB; Pcell에 의한 CRS 전송을 위해 2개 또는 4개 안테나 포트가 사용되는 경우

[336] Pcell에 대한 하향링크 무선 링크 품질은 UE에 의해 상위 계층에 동기가 맞지 않은 상태(out-of-sync status)/동기가 맞는 상태(in-sync status)를 지시하기 위하여 모니터된다.

[337] 비-DRX(non-DRX) 모드 동작에서, UE의 물리 계층은 매 무선 프레임에서 임계치(Q_out 및 Q_in)를 고려하여 이전 시간 구간 동안 평가된 무선 링크 품질을 측정(assess)한다.

[338] 상위 계층 시그널링이 제한된 RLM을 위한 특정 서브프레임을 지시하면, 무선 링크 품질의 측정은 상위 계층 시그널링에서 지시되지 않는 이외 다른 서브프레임에서 수행되지 않는다.

[339] 무선 링크 품질이 임계치 Q_out 보다 불량하면, UE의 물리 계층은 무선 링크 품질이 측정된 무선 프레임 내에서 상위 계층에게 out-of-sync를 지시한다. 무선 링크 품질이 임계치 Q_in 보다 양호하면, UE의 물리 계층은 무선 링크 품질이 측정된 무선 프레임 내에서 상위 계층에게 in-sync를 지시한다.

[340]

[341] <u>매시브 MIMO(Massive MIMO)</u>

[342] LTE 릴리즈(Rel: release)-12 이후의 무선 통신 시스템에서는 능동 안테나 시스템(AAS: Active Antenna System)의 도입이 고려되고 있다.

[343] 신호의 위상 및 크기를 조정할 수 있는 증폭기와 안테나가 분리되어 있는 기존의 수동 안테나 시스템과 달리, AAS는 각각의 안테나가 증폭기와 같은 능동 소자를 포함하도록 구성된 시스템을 의미한다.

[344] AAS는 능동 안테나 사용에 따라 증폭기와 안테나를 연결하기 위한 별도의 케이블, 커넥터, 기타 하드웨어 등이 필요하지 않고, 따라서 에너지 및 운용 비용 측면에서 효율성이 높은 특징을 갖는다. 특히, AAS는 각 안테나 별 전자식 빔 제어(electronic beam control) 방식을 지원하기 때문에 빔 방향 및 빔 폭을 고려한

정교한 빔 패턴 형성 또는 3차원 빔 패턴을 형성하는 등의 진보된 MIMO 기술을 가능하게 한다.

[345] AAS 등의 진보된 안테나 시스템의 도입으로 다수의 입출력 안테나와 다차원 안테나 구조를 갖는 대규모 MIMO 구조 또한 고려되고 있다. 일례로, 기존의 일자 형 안테나 배열과 달리 2차원 안테나 배열을 형성할 경우, AAS의 능동 안테나에 의해 3차원 빔 패턴을 형성할 수 있다. 송신 안테나 관점에서 상기 3차원 빔 패턴을 활용할 경우, 빔의 수평 방향뿐만 아니라 수직 방향으로의 준-정적 또는 동적인 빔 형성을 수행할 수 있으며 일례로 수직 방향의 섹터 형성 등의 응용을 고려할 수 있다.

[346] 또한, 수신 안테나 관점에서는 대규모 수신 안테나를 활용하여 수신 빔을 형성할 때, 안테나 배열 이득(antenna array gain)에 따른 신호 전력 상승 효과를 기대할 수 있다. 따라서, 상향링크의 경우, 기지국이 다수의 안테나를 통해 단말로부터 전송되는 신호를 수신할 수 있으며, 이때 단말은 간섭 영향을 줄이기 위해 대규모 수신 안테나의 이득을 고려하여 자신의 송신 전력을 매우 낮게 설정할 수 있는 장점이 있다.

[347] 도 11은 본 발명이 적용될 수 있는 무선 통신 시스템에서 기지국 또는 단말이 AAS 기반의 3D(3-Dimension) 빔 형성이 가능한 다수의 송/수신 안테나를 갖고 있는 시스템을 예시한다.

[348] 도 11은 앞서 설명한 예를 도식화한 것으로서, 2차원 안테나 배열(즉, 2D-AAS)를 이용한 3D MIMO 시스템을 예시한다.

[349]

[350] <u>매시브 MIMO의 셀 커버리지(Cell coverage of massive MIMO)</u>

[351] 다중 안테나 시스템, 일례로서 N개의 전송 안테나를 갖는 시스템은 단일 안테나 시스템에 비교해서 전체 전송 전력을 동일하게 전송한다고 가정하면, 특정 지점에 수신 파워가 최대 N배 높도록 빔포밍(beamforming) 해줄 수 있다.

[352] 다중 안테나를 갖는 기지국에서도 CRS, PSS/SSS, PBCH 및 브로드캐스트(broadcast) 정보를 전달하는 채널은 기지국 커버리지 영역내의 모든 UE들이 수신할 수 있도록 특정 방향으로 beamforming을 해주지는 않는다.

[353] 이와 달리, 특정 UE에게 유니캐스트(unicast) 정보를 전달하는 채널인 PDSCH는 해당 UE의 위치 및 링크 상황에 맞추어 beamforming을 해주어 전송 효율을 높이도록 한다. 즉, PDSCH의 전송 데이터 스트림은 특정 방향으로 빔을 형성하기 위하여 프로코딩(precoding)되어 다중의 안테나 포트를 통해 전송된다. 그러므로 대표적으로 CRS와 PDSCH의 전송 전력이 동일한 경우에, 특정 UE에게 CRS의 평균 수신 전력과 비교해서 해당 UE를 향해 beamforming 된 프로코딩된(precoded) PDSCH의 수신 전력은 최대 N배까지 높을 수 있다.

[354] 현재까지 LTE Rel-11 시스템에서 최대 8개의 전송 안테나를 갖는 기지국을 고려하는데, 이는 CRS 평균 수신 전력에 비해서 precoded PDSCH 수신 전력이 8배 클 수 있음을 의미한다. 그러나, 향후에 매시브 MIMO 시스템의 도입으로

기지국의 전송 안테나가 100개 이상 되는 경우에 CRS와 precoded PDSCH의 수신 전력은 100배 이상 차이를 나타낼 수 있다. 결론적으로 massive MIMO 시스템의 도입으로 특정 기지국에서 전송하는 CRS의 커버리지 영역과 DM-RS 기반 PDSCH의 커버리지 영역이 일치하지 않게 된다.

[355] 특히, 이러한 현상은 인접한 두 개의 기지국의 전송 안테나 개수의 차이가 많을 때 크게 나타날 수 있다. 대표적으로 64개의 전송 안테나를 갖는 매크로 셀(macro cell)과 단일 전송 안테나를 갖는 마이크로 셀(micro cell)(예를 들어, 피코 셀(pico cell))이 인접하고 있는 경우를 예로 들 수 있다. Massive MIMO의 초기 배치(deployment) 과정에서 서빙받는(served) UE가 많은 macro cell부터 먼저 안테나 개수를 늘릴 것으로 기대하고 있기 때문에 macro cell, micro cell 그리고 pico cell이 혼재되어 있는 이종의 네트워크(heterogeneous network)의 경우에 인접한 기지국간에 전송 안테나의 개수가 크게 차이 나게 된다.

[356] 예를 들어, 단일 전송 안테나를 갖는 pico cell의 경우에 CRS와 PDSCH의 커버리지 영역이 일치하게 된다. 그러나 64개의 전송 안테나를 갖는 macro cell의 경우에 CRS의 커버리지 영역보다 PDSCH의 커버리지 영역이 더 크게 된다. 그러므로 macro cell과 pico cell의 경계에서 CRS의 수신 품질인 RSRP 또는 RSRQ에만 의존하여 초기접속 및 핸드오버를 결정하게 되면 PDSCH의 최대 품질을 제공해 줄 기지국을 서빙 셀(serving cell)로 선택할 수 없게 된다. 이에 대한 단순한 해결책으로 N개의 전송 안테나를 갖는 기지국의 PDSCH 수신 전력은 N배 클 것으로 가정할 수 있으나, 기지국이 가능한 모든 방향으로 beamforming을 다 해줄 수 없는 경우를 고려할 때 최적 해결책은 아니다.

[357]

[358] **RRM-RS**

[359] 본 특허에서는 프리코딩된 RS(precoded RS)를 전송하고 이에 대한 RRM 측정(measurement)를 수행하는 방법을 제안한다. 이하, 본 명세서에서는 이러한 목적의 precoded RS를 'RRM-RS'라고 명칭하도록 한다. RRM-RS는 다수개의 안테나 포트로 구성되어 있으며 각 안테나 포트 별로 beamforming을 다르게 설정하여 각 전송 빔(beam) 별로 UE가 RSRP를 측정할 수 있도록 한다. 일례로, 기지국에서 M개의 방향으로 beamforming이 가능한 경우에 M 포트(M-port)로 구성된 RRM-RS를 설정하도록 한다.

[360]

[361] **RRM-RS의 주기 및 다중화(multiplexing)**

[362] M-port RRM-RS는 동일 서브프레임에서 CDM되거나 또는 FDM/TDM으로 구분되어 전송될 수 있다. 즉, M-port RRM-RS의 각 안테나 포트 별 전송 신호는 동일 서브프레임에서 다른 전송 RE를 사용하여 전송되거나, 또는 동일 RE를 사용하여 전송되는 경우에 안테나 포트 간에 직교 스크램블링 코드(orthogonal scrambling code)를 사용하여 상호간에 간섭 없이 구분할 수 있도록 한다.

[363] 이와 달리 하나의 서브프레임에서 동시에 전송 가능한 RRM-RS의 안테나 포트

수를 K로 설정하고 (M/K)개의 서브프레임에 나누어 전송할 수 있다.

[364] 이 경우, RRM-RS의 설정 파라미터는 전체 안테나 포트의 개수 M과 하나의 서브프레임에서 동시 전송되는 안테나 포트 수 K를 포함한다. RRM-RS의 설정 파라미터로써 RRM-RS 전송 주기 P와 오프셋 O를 포함한다. 여기서, RRM-RS 전송 주기는 RRM-RS가 전송되는 서브프레임의 간격으로 정의한다. 예로써 P=10, O=5, M=64, K=32인 경우에 RRM-RS는 서브프레임 인덱스(SFI: subframe index)가 5, 15, 25, 35, ... 인 서브프레임에서 전송되며, SFI=5인 서브프레임에서 안테나 포트 0에서 31의 RRM-RS가 전송되고, SFI=15인 서브프레임에서 안테나 포트 32에서 63의 RRM-RS가 전송되고, SFI=25인 서브프레임에서 안테나 포트 0에서 31의 RRM-RS가 또다시 전송된다.

[365] 이와 달리 RRM-RS 전송 주기를 동일 안테나 port의 RS가 전송되는 서브프레임의 간격으로 정의하고, (M/K)개의 서브프레임에 RRM-RS의 안테나 포트들을 나누어 전송하는 방식에서 (M/K)개의 연속된 서브프레임에 나누어 전송하도록 한다. 예로써 P=20, O=5, M=64, K=32인 경우에 RRM-RS는 SFI가 5, 6, 25, 26, 45, 46, ...인 서브프레임에서 전송되며, SFI=5인 서브프레임에서 안테나 포트 0에서 31의 RRM-RS가 전송되고, SFI=6인 서브프레임에서 안테나 포트 32에서 63의 RRM-RS가 전송되고, SFI=25인 서브프레임에서 안테나 포트 0에서 31의 RRM-RS가 또다시 전송된다.

[366]

[367] **RSRP** 측정 및 보고

[368] RRM-RS의 RSRP는 안테나 포트 별로 측정하여 보고하도록 한다. UE는 다수개의 RRM-RS를 설정 받을 수 있다.

[369] 각 셀에서 RRM-RS를 하나씩 전송하는 경우에, UE는 서빙 셀 및 인접 셀들이 전송하는 RRM-RS들의 설정을 지정 받을 수 있다. 하나의 셀이 다수개의 RRM-RS를 전송할 수도 있다. UE는 RRM-RS의 RSRP를 보고할 때 해당 RSRP가 몇 번째 RRM-RS의 몇 번째 안테나 포트의 RSRP 측정결과인지 함께 알려준다.

[370] RRM-RS의 RSRP를 계산하기 위하여 각 안테나 포트의 수신 신호 레벨의 평균을 취하는데, 평균을 취하는 시간 윈도우(window)를 기지국이 지정해 줄 수 있거나, 또는 미리 정해진 시간 (예를 들어, 200ms) 동안 RRM-RS의 각 안테나 포트 별 수신 신호 레벨의 평균을 취하여 RSRP를 얻도록 한다. 또는 각각의 시간 윈도우에서 얻은 평균 수신 파워를 다시 필터링하여 보고할 RSRP를 얻을 수 있다.

[371] 다수개의 RRM-RS를 설정 받은 UE는 각 RRM-RS의 각 안테나 포트별 RSRP를 측정한다. RRM-RS를 R개 설정 받고 r번째 RRM-RS의 안테나 포트 수가 M_r인 경우에, r번째 RRM-RS의 m번째 안테나 포트의 RSRP를 RSRP(r,m)로 정의한다. UE는 RSRP(r,m)을 정렬하고 그 중에서 강하게 수신되는 L개 안테나 포트의 RSRP를 선택하여 보고하도록 한다.

[372] 위 방식을 약간 변형하여 UE는 RSRP(r,m)을 정렬하고 그 중에서 가장 강하게

수신되는 안테나 port를 선택하고 선택된 안테나 포트의 RSRP, 즉 max(RSRP(r,m))와 대비하여 일정 차이 내로 들어오는 포트의 RSRP들로 보고를 한정시킨다. 즉, 다음과 같이 RSRP 비율(ratio) 또는 dB 스케일(scale) 표현에서 RSRP의 차이가 일정 임계치 보다 높은 최대 L개의 안테나 포트의 RSRP를 보고하도록 한다.

[373] [수식13]

```
RSRP(r,m) - max(RSRP(r,m)) > Threshold
```

[374] 다른 일례로, UE는 참조(reference) 안테나 포트를 지정 받을 수 있다. 참조 안테나 포트로써 해당 UE에게 설정된 프리코딩된(precoded) CSI-RS와 빔 방향이 유사한 서빙 셀이 전송하는 RRM-RS의 안테나 포트를 지정해 주는 것이 바람직하다. UE는 r_0번째 RRM-RS의 m_0번째 안테나 포트를 참조 안테나 포트로 지정 받은 경우에, 참조 안테나 포트의 RSRP에 비해 다른 안테나 포트의 RSRP가 일정 차이 내로 들어오는 경우에 보고하도록 한다. 즉 다음과 같이 RSRP 비율(ratio) 또는 dB 스케일(scale) 표현에서 RSRP의 차이가 일정 임계치를 넘는 경우에 보고하도록 한다.

[375] [수식14]

```
RSRP(r,m) - RSRP(r_0,m_0) > Threshold
```

[376] 도 12는 본 발명의 일 실시예에 따른 RRM-RS의 안테나 포트 별 RSRP를 예시한다.

[377] 도 12에서는 32 안테나 포트로 구성된 RRM-RS의 각 안테나 포트별 RSRP의 일 예시를 나타내고 있다.

[378] 최대 RSRP를 갖는 안테나 포트에 비교해서 5dB이내의 RSRP를 갖는 안테나 포트들의 RSRP를 보고하도록 설정된 경우, 도 12와 같이 안테나 포트 13이 최대 RSRP 40dB를 가지므로 RSRP가 35dB를 넘는 안테나 포트에 대해 보고하도록 한다. 즉, 안테나 포트 13을 포함하여 안테나 포트 24, 25, 26의 RSRP가 기지국에 보고된다.

[379]

[380] <u>안테나 포트 그룹핑(Antenna port grouping)</u>

[381] 안테나 포트 별로 빔 포밍을 다르게 설정할 수 있으므로, 이 경우 안테나 포트와 빔은 일대일 대응 관계를 갖는다.

[382] 그러므로 안테나 포트 인덱스 (i)는 빔 인덱스(beam index) (i)와 일대일로 매핑시킬 수 있다. (i)번째 빔과 (i+1)번째 빔의 방향이 서로 인접하도록 빔들을 인덱싱하는 경우, 앞서 도 12의 예시에서처럼 인접한 안테나 포트들간의 RSRP는 서로 유사한 특징을 보이게 된다. 이러한 유사도는 (i)번째 빔과 (i+c)번째 빔 사이에서도 나타나지만 c가 커질수록 유사도는 떨어진다. 몇 개의 연속된 인접 빔들 사이에서 높은 유사도가 나올지는, 빔의 간격 및 빔의 폭(width), 그리고 다중-경로(multipath)들의 분산(scattering) 정도에 따라서 좌우된다.

[383] RRM-RS에 기반한 RSRP 측정 결과를 보고 받은 기지국은 해당 UE의 대략적 위치를 파악하고 해당 지점으로 향하여 전송되는 프리코딩된(precoded) CSI-RS 설정을 UE에게 알려주어 UE가 CSI-RS를 측정하여 PDSCH 스케줄링을 위한 CSI(RI, PMI, CQI 등)를 피드백 할 수 있도록 한다. 또한, 다수의 셀에서 전송하는 RRM-RS들에 기반한 RSRP 측정 결과를 보고 받은 기지국은 RSRP 측정 결과에 기반하여 해당 UE를 어떤 셀로 핸드오버 시킬지 그리고 타겟 셀에서 어떤 프리코딩된(precoded) CSI-RS를 UE에게 설정해 줄지 결정한다. 즉, RRM-RS에 기반한 RSRP 측정 결과는 해당 UE에게 향후에 어떤 프리코딩된(precoded) CSI-RS를 설정해 줄지를 판단하는데 필요한 중요 정보를 기지국에 제공한다.

[384] 앞서 도 12의 예시와 같은 RSRP 측정 결과를 바탕으로 해당 UE에게 최대 4개의 데이터 스트림 전송이 가능하도록 하거나 또는 페이딩(fading)의 변화에 맞추어 빠르게 최상의 빔 스위칭(best beam switching)을 하기 위하여 4-포트 CSI-RS를 설정해주는 경우에, RSRP가 가장 큰 RRM-RS 포트 13, 24, 25, 26의 빔 방향과 동일한 4-포트 CSI-RS를 생성하여 설정해 주는 것이 최적일 것으로 예상된다. 하지만 CSI-RS가 UE 별로 최적화하여 생성하고 전송하기에는 오버헤드(overhead)가 너무 크다. 그러므로 동일 환경에 있는 많은 UE들이 CSI-RS를 공유하는 것이 CSI-RS 전송 오버헤드를 줄일 수 있는 방법이다. 이러한 목적을 달성하기 위하여 하나의 CSI-RS 설정내의 CSI-RS 안테나 포트들의 프리코딩은 인접 방향으로 전송되는 빔의 특징을 나타내도록 프리코딩되어야 한다. 즉, 다른 서빙 받는 UE(served UE)들을 고려하여 미리 RRM-RS 포트 12, 13, 14, 15의 빔 방향과 동일한 4-포트 CSI-RS1과 RRM-RS 포트 24, 25, 26, 27의 빔 방향과 동일한 4-포트 CSI-RS2가 미리 설정되어 있는 경우에, 해당 UE에게 어떤 CSI-RS를 설정해주는 것이 좋을지를 RRM-RS의 RSRP 보고를 통해 판단할 수 있어야 한다.

[385] 본 발명의 또 다른 실시예로서 안테나 포트 그룹(antenna port group)에 대해서 RSRP를 측정 보고하도록 한다. 제안 방식에서 안테나 포트들을 그룹핑하고 그룹에 속하는 안테나 포트의 RSRP들을 평균 취하여 해당 안테나 포트 그룹의 RSRP를 얻도록 한다. 그룹은 미리 정해져 있거나 또는 기지국이 정해서 알려 줄 수 있다. 또는 UE가 그룹핑 방식을 정하고 이를 보고 할 수 있다.

[386] 앞서 도 12의 예시에서처럼 32-포트로 구성된 RRM-RS의 경우에 4 포트 씩 그룹핑 될 수 있다. 각 그룹들간에 분리(disjoint)하여 8(=32/4)개의 그룹으로 그룹핑될 수 있다. 이 경우에 (i)번째 포트 그룹은 RRM-RS 포트 (4i), (4i+1), (4i+2), (4i+3)로 구성된다. (i)번째 포트 그룹의 RSRP는 안테나 포트 (4i), (4i+1), (4i+2), 그리고 (4i+3)의 RSRP의 평균으로 정의한다.

[387] 또 다른 실시예로서, 그룹간의 중첩을 허용하여 그룹핑할 수 있다. 32-포트로 구성된 RRM-RS을 4 포트씩 그룹핑하는 경우에 15개의 그룹으로 그룹핑하도록 한다. 이 경우에 (i)번째 포트 그룹은 RRM-RS 포트 (2i), (2i+1), (2i+2), (2i+3)로 구성된다. 제안 방식을 일반화하여 A 개의 포트씩 그룹핑하고, 인접 그룹간의

포트 간격을 B로 설정하면, (i)번째 포트 그룹은 RRM-RS 포트 (B*i), (B*i+1), ..., (B*i+A-1)로 구성된다. 파라미터 A와 B의 설정은 기지국이 UE에게 지정해 주거나, 또는 UE가 채널 환경 및 UE 능력(capability)을 고려하여 선정하여 보고할 수 있다.

[388] 제안 방식의 변형으로 UE는 보고할 안테나 포트 그룹을 선택하는 방식으로 RSRP보다 해당 안테나 포트 그룹으로 얻을 수 있는 능력(capability)을 고려할 수 있다. 이 경우에 UE는 안테나 포트 그룹내의 다수의 안테나로부터 다중-계층(multi-layer) 데이터 전송을 고려하여 능력을 계산하도록 한다.

[389]

[390] <u>안테나 포트 그룹핑 레벨(Antenna port grouping level)</u>

[391] 제안 방식에서 크기가 다른 다수개의 그룹핑 방법을 사용할 수 있다. 즉, A1 포트씩 그룹핑하는 방법과 A2 포트씩 그룹핑하는 방법을 동시에 사용할 수 있다. 이하, A_i 포트씩 그룹핑하는 방법을 그룹핑 레벨(grouping level) i로 명칭하도록 한다.

[392] 도 13은 본 발명의 일 실시예에 따른 RRM-RS 안테나 포트 그룹핑 레벨을 예시한다.

[393] 도 13에서는 16 포트 RRM-RS를 4단계의 그룹핑 레벨을 적용하여 그룹핑하는 방식의 일례를 보여주고 있다. 예시에서 그룹핑 레벨 1은 1 포트씩 그룹핑하는 방법으로 그룹핑을 하지 않지 않는 방식을 나타낸다. 그리고 그룹핑 레벨 2, 3, 4는 각각 2 포트, 4 포트, 8 포트씩 그룹핑하고 있다. 그림의 예시에서는 동일 레벨의 안테나 포트 그룹들이 분히(disjoint)하여 설정된 경우를 나타내고 있다.

[394] 이러한 다중 그룹핑 방식에서 UE는 그룹핑 레벨 별로 RSRP를 보고한다. 즉 각 그룹핑 레벨 별로 RSRP가 높은 안테나 그룹을 선택하여 보고하도록 한다. 또는 레벨이 다른 안테나 그룹간에 RSRP를 비교하여 최상의(best) 그룹과 그룹 레벨을 보고할 수 있다. 레벨1이 다른 안테나 그룹간의 RSRP를 비교하기 위하여 각 레벨의 그룹 RSRP에 일정 오프셋만큼 보정하고 비교하도록 한다. RRM-RS를 R개 설정 받은 경우에, (r)번째 RRM-RS의 (l)번째 그룹핑 레벨의 (g)번째 안테나 포트 그룹의 RSRP를 GRSRP(r,l,g)로 정의하면, 다음과 같이 기지국으로부터 (r)번째 RRM-RS의 (l)번째 그룹핑 레벨을 위해 지정 받은 offset(r,l)만큼을 보정하여 Adj_GRSRP(r,l,g)를 계산하고 이를 비교하도록 한다.

[395] [수식15]

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Adj_GRSRP(r,l,g) = GRSRP(r,l,g) + offset(r,l)
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[396] 추가적으로, 그룹핑 레벨 별로 또는 전체 그룹핑 방식에서 최상의(best) L개의 포트 그룹 RSRP를 보고하는 방식에서 보고되는 최상의(best) L에 대한 잦은 변동을 줄이기 위해 히스테리시스 파라미터(Hysteresis parameter), Hy를 추가하여 RSRP를 보정할 수 있다.

[397] [수식16]

$$Adj_GRSRP(r,l,g) = GRSRP(r,l,g) + offset(r,l) \pm Hy$$

[398] 여기서, Hy는 해당 포트 그룹이 이전 보고에서 최상의(best) L GRSRP에 포함되는지 여부에 따라서 Hy를 더할지 뺄지 결정된다. 해당 포트 그룹이 이전 보고에서 최상의(best) L GRSRP에 포함되어 있는 경우에 Hy를 더하여 높은 Adj_RSRP를 갖도록 바이어스를 줘서 최상의(best) L Adj_GRSRP를 갖는 포트 그룹이 자주 바뀌는 것을 줄여 주도록 한다.

[399] 제안 방식으로 UE는 참조(reference) 안테나 포트 그룹을 지정 받을 수 있다. 기지국은 해당 UE에게 설정된 프리코딩된(precoded) CSI-RS와 빔 방향이 동일한 서빙 셀이 전송하는 RRM-RS의 안테나 포트 그룹을 참조 안테나 포트 그룹으로 지정해 주는 것이 바람직하다. UE는 그룹핑 레벨 별로 참조 안테나 포트 그룹을 지정 받을 수 있다. 또는 전체 그룹핑 레벨에서 하나의 참조 안테나 포트 그룹을 지정 받을 수 있다. UE는 r_0번째 RRM-RS의 l_0번째 그룹핑 레벨의 m_0번째 안테나 포트 그룹을 참조 안테나 포트 그룹으로 지정 받은 경우에, 참조 안테나 포트 그룹의 Adj_GRSRP에 비해 다른 안테나 포트 그룹의 Adj_GRSRP가 일정 임계츠를 넘는 경우에 보고하도록 한다. 즉 다음과 같이 Adj_GRSRP 비율(ratio) 또는 dB 스케일(scale) 표현에서 RSRP의 차이가 일정 임계치를 넘는 경우에 보고하도록 한다.

[400] [수식17]

$$Adj_GRSRP(r,l,g) - Adj_GRSRP(r_0, l_0, m_0) > Threshold$$

[401] 또는 제안 방식의 변형으로 참조 RSRP를 현재 설정되어 있는 CSI-RS를 통해 특정하여 CSI-RS 기반 RSRP에 비해 RRM-RS 기반 RSRP 결과를 비교하여 선택 보고하도록 한다.

[402]

[403] **3차원(3D: 3-Dimension)을 위한 RRM-RS**

[404] 앞서 본 발명에서 제안하는 방식은 빔(beam)의 방향성이 2차원 공간에서 3차원 공간으로 확장되는 경우에도 변형하여 적용 가능하다. 3차원 공간상에서 빔의 방향성은 상하각(수직각)과 좌우각(수평각)의 두 개의 각도의 의해 조절된다. 그러므로 인접 빔 여부를 파악하기 위하여 빔들을 두 개의 인덱스, 즉 수평 인덱스와 수직 인덱스로 인덱스하는 것이 효율적이다. 본 발명의 특징에 따라 빔 인덱스와 RRM-RS 포트 인덱스와 일대일 대응 관계를 갖기 위하여 RRM-RS 포트도 수평 인덱스와 수직 인덱스로 인덱싱되는 것이 바람직하다.

[405] 수직 방향으로 M_v개의 빔을 갖고 수평 방향으로 M_h개의 빔을 갖는 3D MIMO 시스템의 경우에 전체 (M_v×M_h)개의 빔이 가능하다. 본 발명에서는 (M_v×M_h)-포트 RRM-RS를 설정하고 각 안테나 포트에 수평 인덱스 j_h(j_h=0, ..., M_h-1)와 수직 인덱스 j_v(j_v=0, ..., M_v-1)를 부여하도록 한다. (M_v×M_h)-포트 RRM-RS의 자원 매핑을 고려하여 각 안테나 포트들은 일차원

인덱스 i(i=0, ..., M_v×M_h-1)와 이차원 인덱스 j_h와 j_v를 부여 받게 되는데, (i) = f(j_h, j_v)의 관계를 갖게 된다.

[406] 도 14는 본 발명의 일 실시예에 따른 이차원 인덱스로 배열된 RRM-RS의 안테나 포트와 안테나 포트 그룹을 예시하는 도면이다.

[407] 도 14를 참조하면, 각 안테나 포트들은 (j_h, j_v)로 인덱싱되어 있다. 본 발명에서 제안하는 방식을 적용하여 A_h×A_v 개의 포트씩 그룹핑하고, 인접 그룹간의 포트 간격을 B_h와 B_v로 설정하면, (i_h, i_v)번째 포트 그룹은 RRM-RS port (B_h×i_h+j_h, B_v×i_v+j_v), (j_h=0, ..., A_h-1), (j_v=0, ..., A_v-1)로 구성된다. 파라미터 A_h, A_v와 B_h, B_v의 설정은 기지국이 UE에게 지정해 주거나, 또는 UE가 채널 환경 및 UE 능력(capability)를 고려하여 선정하여 보고할 수 있다.

[408]

[409] **RRM-RS과 CSI-RS의 차이점**

[410] 기존 LTE/LTE-A 시스템에서는 CSI 보고의 목적으로 CSI-RS를 전송한다. UE는 CSI로써 RI, PMI, CQI 등을 보고한다. 이와 달리 본 발명에서 제안하는 RRM-RS는 안테나 포트 별로 RSRP를 측정하기 위해 사용된다. RRM-RS의 전송 자원을 새롭게 정의하기 보다는 기존의 CSI-RS가 설정 가능한 자원을 사용하는 것이 바람직하다. 이는 레가시(legacy) UE들의 전송 효율을 떨어뜨리지 않기 때문이다. 새로운 자원에 RRM-RS를 전송하는 경우에 레가시(legacy) UE들은 이를 인식하지 못하므로, RRM-RS이 전송되는 서브프레임에서 전송 효율이 떨어지거나 또는 스케줄링하지 못하게 된다. 그러므로 기존의 CSI-RS가 설정 가능한 자원을 사용하여 RRM-RS를 전송하는 방식은 레가시(legacy) UE에게 해당 자원을 포함하여 CSI-RS 설정을 해주어 해당 자원에 데이터 매핑이 되지 않음을 알려줄 수 있다.

[411] UE에게 CSI 보고를 위해 설정된 다수개의 CSI-RS에는 데이터 매핑이 이루어지지 않는다. 즉 CSI-RS가 매핑되는 RE를 제외하고 PDSCH를 매핑한다. 본 발명의 제안 방식에서 RRM-RS는 CSI-RS 마찬가지로 RRM-RS가 매핑되는 RE를 제외하고 PDSCH를 매핑하도록 할 수 있다. 그러나 변형된 방식으로 RRM-RS와 무관하게 PDSCH를 매핑하도록 할 수 있다. 이 경우에 UE는 동일 RE에서 RRM-RS와 PDSCH를 동시에 수신할 수 있어야 한다. 또는 기지국이 RRM-RS의 안전한 수신을 보장하기 위하여 해당 자원을 ZP-CSI-RS로 설정하여 PDSCH가 매핑되지 않도록 할 수 있다.

[412]

[413] **RRM-RS의 QCL 설정**

[414] 각 셀에서 RRM-RS를 전송하는 경우에, UE는 서빙 셀 및 인접 셀들이 전송하는 RRM-RS들의 설정을 지정 받을 수 있다. 이를 통하여 UE는 서빙 셀의 빔포밍(beamforming)에 따른 이득 및 인접 셀의 beamforming에 따른 이득을 측정하여 네트워크에 보고하고 핸드오버의 판단 기준으로 활용하도록 해준다.

RRM-RS는 전송 밀도(density)가 매우 낮게 설정되므로 신호의 트래킹(tracking) 목적으로 부족할 수 있다. 그러므로 밀도(density)가 높아 신뢰(reliable)있게 수신되는 신호 대표적으로 CRS를 트래킹(tracking)하고 RRM-RS의 검출하는데 트래킹(tracking) 결과를 활용하도록 한다. 즉, 서빙 셀과 인접 셀의 반송파 주파수를 발생하는 오실레이터의 오차에 의하여 서빙 셀의 CRS에 의해 트래킹(tracking)된 결과를 인접 셀에서 전송된 RRM-RS를 위해 사용하기에는 부적합하다. 그러므로 각각의 RRM-RS 별로 RRM-RS를 검출할 때 사용할 QCL(Quasi Co-Located)된 CRS (혹은 CSI-RS 등 특정 다른 RS)를 알려주도록 한다. UE는 QCL된 CRS (혹은 CSI-RS 등 특정 다른 RS)로부터 추정된 채널의 광범위 특성(large-scale) 특성을 RRM-RS의 검출에 사용한다. 여기서 채널의 광범위 특성(large-scale) 특성은 지연 확산(Delay spread), 도플러 확산(Doppler spread), 도플러 쉬프트(Doppler shift), 평균 이득(average gain), 그리고 평균 지연(average delay) 중에 하나 이상을 포함할 수 있다.

[415]

[416] **RSRQ로 확장**

[417] 본 발명의 제안 방식들은 RRM-RS의 각 안테나 포트 별로 RSRQ를 측정하는 방식으로 확장 적용될 수 있다. RSRQ는 RSRP와 RSSI의 비율로 정의된다. 그러므로 추가적으로 RSSI의 측정이 추가된다. RSSI의 측정 자원은 동일 반송파 주파수를 갖는, 즉 동일 컴포넌트 캐리어(component carrier)에 설정된 모든 RRM-RS들에 있어서 동일하게 설정될 수 있다. 이 경우에 동일 컴포넌트 캐리어 내의 RRM-RS들의 포트들 간의 비교는 RSRP을 사용하나 RSRQ를 사용하나 동일하다. 그러나 이종 동일 컴포넌트 캐리어 내의 RRM-RS들의 포트들간의 비교는 RSRP을 사용할지 RSRQ를 사용할지에 따라 달라진다. 그러므로 기지국은 UE에게 RRM-RS에 기반한 RRM 보고를 수행함에 있어서 RSRP을 사용할지 RSRQ를 사용할지를 지정해 주도록 한다.

[418] 이와 달리 각각의 RRM-RS들 개별적으로 RSSI 측정 자원을 따로 설정해 줄 수 있다. 이 경우에는 동일 컴포넌트 캐리어 내에서도 RRM-RS들의 포트들간의 비교는 RSRP을 사용할지 RSRQ를 사용할지에 따라 달라진다. 그러므로 기지국은 UE에게 RRM-RS에 기반한 RRM 보고를 수행함에 있어서 RSRP을 사용할지 RSRQ를 사용할지를 지정해 주도록 한다.

[419]

[420] **RRM-RS RSRP와 CRS RSRP의 연관성**

[421] 본 발명의 RRM-RS에 기반한 RSRP는 다중 안테나를 가지고 있는 기지국의 beamforming 이득을 서빙 셀 선택에 반영함을 목적으로 하고 있다. RRM-RS의 RSRP에 근거하여 특정 인접 셀의 beamforing이 가장 좋다고 판단되어도, 해당 셀에서 브로드캐스트하는 채널들, 즉 CRS 기반 복조(demodulation)를 하는 채널이 안정적으로 수신되지 않으면 해당 인접 셀로 UE를 핸드오버 시킬 수 없다. 그러므로 UE에게 특정 기지국에서 전송하는 RRM-RM와 CRS 모두 좋은

품질을 갖는지 보고 받고 이를 근거를 핸드오버 결정 및 빔 선택(beam selection을 수행해야 한다. 이를 위하여 UE는 설정 받은 i번째 RRM-RS의 j번째 안테나 포트 또는 포트그룹의 RSRP를 보고하면서 i번째 RRM-RS과 연결된 CRS의 RSRP를 같이 보고 하도록 한다. 여기서 RRM-RS와 연결된 CRS는 RRM-RS와 QCL된 CRS일 수 있다.

[422]

[423] 이하, 본 명세서에서 제안하는 지연(latency)을 줄이기 위한 단말의 CSI 측정 및 보고 동작 방법에 대해 살펴본다.

[424] 본 명세서에서 제안하는 방법은 3D-MIMO, massive MIMO 등의 시스템뿐만 아니라 amorphous cell(비정형 셀) 환경 등에서도 확장되어 적용 가능할 수 있음은 물론이다.

[425] 먼저, 3D-MIMO 시스템에 대해 간략히 살펴본다.

[426] 3D-MIMO 시스템은 LTE 표준(Rel-12)을 기반으로 하여 앞서 살핀 도 11과 같은 single-cell 2D-AAS(Adaptive Antenna System) 기지국에 적합한 최적의 전송 방식 중 하나이며, 다음과 같은 동작을 고려할 수 있다.

[427] 도 11에 도시된 바와 같이, 8-by-8(8X8)의 antenna array로부터 CSI-RS ports를 구성하는 예를 들어 살펴보면, 세로로 각각 8개의 안테나에 대해서는 특정 target UE에게 최적화된 'UE-dedicated beam coefficients'를 적용한 precoded CSI-RS port 하나씩을 구성하도록 함으로써, 가로로 총 8-port (vertically precoded) CSI-RS를 설정/전송하도록 한다.

[428] 이를 통해, 단말은 종래와 같은 8-port에 대한 CSI feedback을 수행할 수 있게 된다.

[429] 결국, 기지국은 개별 단말 (또는 특정 단말 그룹)에 최적화된 수직 방향 beam gain이 이미 적용된 (precoded) CSI-RS 8 ports를 단말로 전송한다.

[430] 따라서, 상기 단말은 무선 채널을 겪은 CSI-RS를 측정(measure)하기 때문에, 상기 단말은 종래의 수평 방향 코드북에 의한 동일한 피드백 방식을 수행하더라도 상기 (vertically precoded) CSI-RS에 대한 CSI 측정 및 보고(measurement and reporting) 동작을 통해 이미 무선 채널의 수직 방향의 beam gain 효과를 얻을 수 있게 된다.

[431] 이 때, 개별 단말에 최적화된 수직 방향의 beam을 결정하기 위한 방법으로 (1) (vertically precoded) small-cell discovery RS (DRS)에 의한 RRM report 결과를 이용하는 방법, (2) 단말의 sounding RS (SRS)를 기지국이 최적의 수신 beam 방향으로 수신하고, 해당 수신 beam 방향을 채널 상호 관계(channel reciprocity)에 의해 DL 최적 beam 방향으로 변환하여 적용하는 방법 등이 있다.

[432] 만일 기지국이 단말의 이동성으로 인해 상기 UE-dedicated best V-beam 방향이 바뀌었다고 판단할 경우, 종래 동작에 의하면 기지국은 CSI-RS 및 연관 CSI process 등과 관련된 RRC 설정을 모두 재구성(re-configure)하였다.

[433] 이와 같이 RRC 재구성(reconfiguration) 과정을 수행해야 하는 경우, RRC

레벨의 지연(latency)(e.g., 수십 ~ 수백 ms단위) 발생은 불가피하다.

[434] 즉, 네트워크 차원에서는 사전에 타겟 V-beam 방향을 예를 들어, 4개로 분할해 놓고, 각각의 V-방향에 precoding이 걸린 별도의 8 port CSI-RS를 해당 별도의 전송 자원 위치에서 전송하게 된다.

[435] 또한, 각 UE는 8 port CSI-RS 중에서 특정 하나의 CSI-RS 설정에 대한 CSI 측정 및 보고(measurement and reporting)을 해야 하므로, 타겟 V-방향이 바뀔 때에는 변경될 CSI-RS 설정으로 네트워크와 RRC reconfiguration 절차를 수행할 수 밖에 없게 된다.

[436]

[437] 따라서, 이하에서는 본 명세서에서 제안하는 RRC 레벨의 지연(latency)를 없애거나 또는 대폭 줄이기 위한 CSI 측정 및 보고(measurement and reporting) 방법에 대해 구체적으로 살펴본다.

[438] 즉, 본 명세서에서 제안하는 방법은 UE에게 단일 CSI process와 단일 상향링크(UL) 피드백 자원만을 할당해 놓고, measure 대상이 되는 CSI-RS index (그리고/또는 CSI-IM index)가 무엇인지를 RRC 레벨이 아니 MAC 레벨 (또는 PHY 레벨)에서 지시하여 주는 방법에 관한 것이다.

[439] MAC 레벨 지시는 MAC CE를 이용할 수 있고, PHY 레벨 지시는 DCI를 이용할 수 있다.

[440] 즉, 본 명세서에서 제안하는 방법은 기지국(또는 네트워크)가 RRC signaling을 이용하여 다수의 후보 CSI-RS들에 대한 CSI-RS 설정들을 단말에게 설정해주고, 다수의 후보 CSI-RS들 중에 CSI-RS 측정 및 보고를 수행하는 적어도 하나의 CSI-RS에 대해 단말로 '활성화' 지시를 명시적 또는 암시적으로 알려준다.

[441] 예를 들어, CSI-RS 1이 활성화된 상태였을 때, CSI-RS 1에서 CSI-RS 2로 옮길지가 고려되는 상황인 경우, 기지국은 실제로 CSI-RS 2로 옮기라고 re-activate 명령을 지시하기 이전에, 단말에게 CSI-RS 2에 대한 트래킹(tracking)을 미리 하고 있을 수 있도록 사전 활성화(pre-activate)를 먼저 지시할 수 있다.

[442] 여기서, 상기 CSI-RS에 대한 트래킹(tracking)은 단말이 CSI-RS를 측정할 수 있도록 CSI-RS에 대해 시간 및/또는 주파수 동기를 맞추는 동작을 의미할 수 있다.

[443] 즉, 사전-활성화(pre-activate)된 CSI-RS x는 (특정 타이머 시간 이내에서) 실제로 활성화될 수도 있거나 또는 활성화가 되지 않을 수도 있다.

[444] 여기서, 상기 단말은 기지국으로부터 CSI-RS x의 활성화를 지시하는 활성화 메시지를 기지국으로부터 수신한 후, 특정 y ms 이후에 온전한 CSI reporting을 상기 기지국으로 피드백(feedback)할 수 있다.

[445] 여기서, 온전한 CSI reporting을 피드백한다는 의미는 단말이 기지국으로 의미 있는 CSI feedback을 수행하는 것으로 해석될 수 있다.

[446] 상기 CSI feedback은 측정되는 sample의 수에 따라 의미있는 것인지 아니면

의미없는 것인지 판단될 수 있다.

[447]

[448] **능력(capability) 정보 전송**

[449] 보다 구체적으로, 본 명세서에서는 먼저 단말이 특정 능력 시그널링(capability signaling)을 기지국으로 전송함으로써 사전에 (예:초기 접속 시) 상기 기지국으로 자신의 CSI 동작 관련 능력(capability) 정보를 알려준다.

[450] 상기 CSI 동작 관련 단말의 능력 정보는 아래 정보들 중 적어도 하나를 포함할 수 있다.

[451] 여기서, CSI 관련 동작은 CSI-RS, CSI-IM 및/또는 CSI process와 관련된 동작을 의미할 수 있다.

[452] 'A 및/또는 B'의 기재는 'A 또는 B 중 적어도 하나'로 해석될 수 있다.

[453] 1. 최대 몇 개까지의 CSI-RS (Nc개), CSI-IM(Interference Measurement) (Ni개), 및/또는 CSI process (Np개)가 동시에 '완전 활성화(full activation)'가 될 수 있는지에 대한 능력 정보

[454] 여기서, 'full activation (configuration)'으로 표현한 이유는 예를 들어 Nc=3, Ni=3, Np=4인 단말의 경우에는, 실제 기지국이 총 Nc=3 CSI-RSs, Ni=3 CSI-IMs, Np=4 CSI processes를 모두 동시에 설정 가능하다는 의미이며, 이 경우 종래의 Rel-11 표준에서의 CoMP 동작들이 모두 지원 가능하다.

[455] 즉, 단말은 Nc=3 CSI-RSs를 모두 channel measurement하여야 하고, Ni=3 CSI-IMs을 모두 간섭 측정(interference measurement:IM)하여야 하고, Np=4 CSI processes에 대한 CSI feedback을 모두 수행하여야 함을 의미한다.

[456] 2. 최대 몇 개까지의 CSI-RS (Nc'개), CSI-IM (Ni'개), 및/또는 CSI process (Np'개)가 동시에 '일부 활성화(partial activation)'가 될 수 있는지에 대한 능력 정보

[457] 여기서, '일부 활성화(partial activation)'으로 표현한 이유는 상기 'full activation'시에 단말이 수행할 수 있는 동작들 중에 특정 일부 동작(e.g., CSI-RS tracking)만으로 한정되거나 또는 별도의 추가 동작이 포함될 수도 있다.

[458] 예를 들어, 특정 단말은 상기 1.에서의 파라미터는 Nc=1, Ni=1, Np=1임과 동시에 2.에서의 파라미터는 Nc'=3, Ni'=1, Np'=1일 수 있다.

[459] 즉, Nc=1이고, Nc'=3이라는 차이만 가지고 있다.

[460] 이 의미는 상기 특정 단말은 Nc'=3개의 일부 활성화(partial activation)된 CSI-RS에 대해서는 time/frequency synchronization/tracking을 유지하고 있으며, 이 중에서 특정 Nc=1개의 '완전 활성화(full activation)'되는 CSI-RS를 지정받을 수 있다는 의미로 해석될 수 있다.

[461] 이와 같은 Nc=1개의 CSI-RS를 지정 받을 수 있는 대표적인 방법으로, (1) MAC CE command 등을 통해 MAC layer에서 지시를 받을 수 있는 방법, (2) DCI signaling을 통해 PHY layer에서 보다 dynamic indication을 받을 수 있는 방법 등이 있을 수 있다.

[462] 이와 같은 방법을 통해, 단말은 단일 Np=Np'=1개의 CSI process에 대한 (특정 CC에서) 단일 CSI feedback만 수행하면 되기 때문에, CSI feedback에 대한 복잡도 및 overhead는 항상 동일하게 유지될 수 있다.

[463] 그리고, 본 명세서에서 제안하는 방법을 통해 단말이 측정해야 하는 CSI-RS index만을 MAC layer 또는 PHY layer의 signaling을 통해 동적으로 스위칭(dynamic switching)해줄 수 있다는 장점이 있다.

[464] 즉, 본 명세서는 RRC signaling에 의한 즉, CSI-RS reconfiguration latency 보다 작은 latency를 갖는 signaling을 통해 measure 대상이 되는 자원만 switching해주는 방법을 제공한다.

[465] 본 명세서에서는 설명의 편의를 위해, CSI-RS를 중심으로 설명하나 본 명세서에서 제안하는 방법은 CSI-IM index (또는 CSI process index)를 dynamic switching하는 데에도 동일하게 확장 적용할 수 있음은 자명하다.

[466] 추가적으로, 앞의 1. 및 2.에서 파라미터들 간에 Nc <= Nc', Ni <= Ni', 및/또는 Np <= Np' 형태로 추가적인 제한이 있을 수도 있다.

[467] 이 경우, 단말은 이러한 조건을 만족하는 한에서 상기 능력 시그널링(capability signaling)을 전송해야 한다.

[468]

[469] 기지국이 상기 CSI 동작 관련 단말의 능력 정보를 포함하는 capability signaling을 단말로부터 수신하는 경우, 상기 기지국은 추후 해당 단말을 설정할 때, 앞서 살핀 capability 특성 조합에 위배되지 않는 형태로 상기 단말에게 RRC signaling을 전송해야 한다.

[470] 상기 단말은 상기 capability 특성에 위배되는 경우에 대해서는 기대하지 않으며, error case로 간주할 수 있다.

[471]

[472] 앞서 살핀 것처럼, 단말은 기지국으로부터 Nc'=3에 해당하는 CSI-RS 3개를 모두 RRC signaling을 통해 설정받을 수 있다고 가정한다.

[473] 다만, 이때 상기 단말은 각 CSI-RS index별로 'partical activation' 상태로 설정하는 것임을 식별할 수 있는 별도의 식별자 또는 특정 implicit indication에 의해 이를 인지할 수 있는 signaling을 상기 기지국으로부터 수신할 수 있다.

[474] 이 경우, 상기 단말은 상기 RRC signaling을 수신한 시점부터 상기 3개의 CSI-RS에 대해 각각 time/frequency synchronization/tracking을 수행하도록 한다.

[475] 이는 각 CSI-RS 설정에 포함되어 있는 quasi co-location(QCL) 가정을 적용하도록 하는 특정 RS(e.g., CRS)등의 정보에 입각하여 synchronization/tracking을 수행할 수 있다.

[476] 이 때, 상기 별도의 식별자 형태로 Nc'=3개의 CSI-RS 중에 특정 Nc=1개의 CSI-RS만 '완전 활성화(full activation)'임을 추가로 (또는 동시에) 설정 또는 지시 받을 수 있다.

[477] 또는, 암시적으로(implicit하게) 상기 Nc=1개의 CSI-RS는 항상 lowest(highest)

indexed CSI-RS로 규정되는 등 특정 index로 사전에 규정될 수도 있다.

[478] 그러면, 단말은 상기 Nc=1개의 'full activation'된 CSI-RS에 대해서만 CSI feedback을 위한 channel measurement를 수행하면 된다.

[479] 즉, 단말은 나머지 Nc'-Nc=2개의 CSI-RS에 대해서는 channel measurement를 수행하지 않고, tracking만 수행한다.

[480] 이와 같이, Nc=1개의 특정 CSI-RS에 대해서만 channel measurement를 수행하고, 상기 측정을 통해 feedback contents(e.g., RI/PMI/CQI)를 derive하는 방법은 이것과 함께 설정되는 특정 CSI process에 대해 상기 feedback contents를 계산하는 동작이 규정/설정될 수 있다.

[481] 예를 들어, 단말은 특정 Np=1개의 CSI process도 RRC signaling을 통해 기지국으로부터 수신하게 되고, 이러한 CSI process는 특정 개수의 CSI-RS와 CSI-IM 인덱스 간의 조합으로 정의된다.

[482] 하지만, 여기서의 CSI-RS는 상기 full activation되는 Nc=1개의 CSI-RS가 무엇이냐에 따라 상기 full activation되는 CSI-RS가 자동 반영되어 해당 CSI process의 채널 측정(channel measure)의 대상이 되는 CSI-RS로 인식되도록 하는 동작이 정의/설정될 수 있다.

[483] 또 다른 일례로서, CSI process도 예를 들어, Np'=3으로 partial activation 상태로 3가지를 설정 받고, 각각의 CSI process 내 상기 Nc'=3개의 CSI-RS 인덱스가 설정될 수 있다.

[484] 이후, 기지국은 Np=1개의 full activation되는 특정 CSI process를 상기 MAC 또는 PHY signaling을 통해 단말로 dynamic indication을 줄 수 있다.

[485] 그러면, 단말은 상기 full activation되는 특정 CSI process에 대한 CSI feedback을 기지국으로 전송할 수 있다.

[486] 결국, 특정 CSI process 별로 여기에 연동되어 지시되는 특정 CSI-RS 및/또는 CSI-IM 인덱스는 이것이 고정된 인덱스인지, 앞서 살핀 것처럼 자동으로 가변 가능한 인덱스인지를 식별할 수 있는 별도의 식별자 또는 특정 implicit signaling 방법이 정의될 수 있다.

[487] 만일 상기 특정 CSI-RS 및/또는 CSI-IM 인덱스가 특정 인덱스로 고정되어 지시되는 경우, 단말은 상기 고정된 CSI-RS 및/또는 CSI-IM 인덱스에 해당하는 자원에 대한 측정(measurement)를 수행한다.

[488] 만일 상기 특정 CSI-RS 및/또는 CSI-IM 인덱스가 가변 가능한 인덱스 형태로 설정되어 있는 경우, 앞서 살핀 것처럼 특정 Nc=1개의 CSI-RS가 별도의 MAC 또는 PHY signaling으로 'full activation'되는 경우, 해당 인덱스를 자동으로 적용하도록 하는 형태로 적용될 수 있다.

[489] 여기서, full activation되는 Nc개가 2개 이상일 수도 있다.

[490] 예를 들면, 2D-AAS 구조에서의 multiple CSI-RS resources를 Kronecker 연산 등을 통해 함께 measure하도록 하는 목적 등의 경우에 full activation되는 Nc개는 2개 이상일 수 있다.

[491] 이 경우에도 상기 full activation되는 Nc개가 무엇인지가 별도로 dynamic indication되는 경우, 이러한 인덱스들을 자동으로 적용되도록 할 수 있다.

[492] 결국, 이러한 CSI process 설정에 있어서는 해당 설정에서 지시될 수 있는 CSI-RS 및/또는 CSI-IM 인덱스가 어떠한 후보 set 중에서 설정될 수 있는지 RRC 설정 단계에서부터 규정되는 것이 바람직할 수 있다.

[493] 마찬가지로, 상기 CSI-IM에 대해서도 Ni' 및 Ni 개수에 따른 상기 설정 또는 지시 동작이 적용될 수 있음은 자명하다.

[494] 도 15는 본 명세서에서 제안하는 CSI 측정 및 보고 방법의 일례를 나타낸 도이다.

[495] 도 15를 참조하면, 단말은 기지국으로 CSI 동작 관련 상기 단말의 능력 정보를 포함하는 능력 시그널링(capability signaling)을 전송한다(S1510).

[496] 상기 단말의 능력 정보는 동시에 완전 활성화(full activation) 가능한 상기 CSI 관련 동작의 최대 개수를 나타내는 제 1 제어 정보 및 동시에 부분 활성화(partial activation) 가능한 상기 CSI 관련 동작의 최대 개수를 나타내는 제 2 제어 정보를 포함한다.

[497] 이후, 상기 기지국은 CSI 동작과 관련된 설정이 변경되는 경우, 상기 기지국은 상기 단말로 CSI 동작 관련 설정 정보(또는 CSI 관련 동작 설정 정보)를 전송한다(S1520).

[498] 상기 CSI 동작 관련 설정 정보는 부분 활성화(partial activation)를 수행하는 CSI 관련 동작을 나타내는 부분 활성화 CSI 관련 동작 인덱스(index) 정보 또는 완전 활성화(full activation)를 수행하는 CSI 관련 동작을 나타내는 완전 활성화 CSI 관련 동작 인덱스 정보 중 적어도 하나를 포함한다.

[499] 이후, 상기 단말은 상기 CSI 동작 관련 설정 정보에 기초하여 완전 활성화 CSI를 측정한다(S1530).

[500] S1530 단계 이전에 상기 단말은 부분 활성화 CSI-RS에 대해서는 트래킹을 수행한다.

[501] CSI-RS 트래킹에 대한 구체적인 설명은 앞의 내용을 참조한다.

[502] 이후, 상기 단말은 상기 측정 결과를 상기 기지국으로 보고한다(S1540).

[503]

[504] 도 16은 본 명세서에서 제안하는 CSI 측정 및 보고 방법의 또 다른 일례를 나타낸 도이다.

[505] S1610 및 S1620, S1640 및 S1650은 도 15의 S1510 내지 S1540과 동일하므로 구체적인 설명은 생략한다.

[506] S1620 단계 이후(CSI 동작 관련 설정 정보를 기지국이 단말로 전송한 이후), 기지국은 단말로 완전 활성화 CSI-RS에 대한 측정을 지시하는 지시 메시지를 전송한다(S1630).

[507] 상기 지시 메시지는 MAC CE 또는 DCI일 수 있다.

[508] 또한, 상기 완전 활성화 CSI-RS는 부분 활성화 CSI-RS에서 선택되는 것이

바람직할 수 있다.

[509]

[510] **CSI 측정** 윈도우(measurement window) 초기화/갱신 시점

[511] 단말이 MAC signaling 또는 PHY signaling을 통해, 기지국으로부터 특정 CSI-RS, CSI-IM, 및/또는 CSI process index(들)의 full activation되는 signaling을 SF(sufbrame) #n 시점에 수신한 경우, 상기 단말은 해당 시점(subframe #n)으로부터 특정 y ms부터 즉, SF #(n+y) 시점부터 CSI measurement 및 reporting을 하도록 적용할 수 있다.

[512] 만일 periodic CSI reporting의 경우, 상기 SF #(n+y) 시점 이후에 최초로 나오는 RI reporting instance에 연동된 특정 reference resource 시점부터 새롭게 full activation된 특정 CSI-RS, CSI-IM, 및/또는 CSI process index(들)에 대한 CSI measurement 및 reporting을 개시하도록 한다.

[513] 즉, SF #(n+y) 시점 이후에 존재하는 유효한 reference resource 시점들에 대해, 상기 reference resource 시점에 계산되는 CSI(e.g., RI/PMI/CQI)가 최초로 RI가 reporting되는 시점부터 이러한 새로운 CSI contents를 report하도록 정의할 수 있다.

[514] 즉, 상기 최초의 RI reporting 시점 이전에는 PMI/CQI reporting instance가 존재한다 하더라도 상기 새롭게 full activation된 설정에 입각하면 안되고, 그 직전에 따르고 있는 설정에 입각한 CSI feedback contents가 지속해서 reporting되어야 함을 의미한다.

[515] 결국, 새로운 RI reporting instance 시점부터 상기 full activation된 설정에 입각하여 단말의 CSI reporting을 수행하도록 한다.

[516]

[517] 위 동작들에 있어서, CSI measurement를 averaging하는 window와 관련된 설정 정보도 별도로 또는 함께 RRC signaling을 통해 제공되도록 규정될 수 있다.

[518] 또한 이와 같은 동작은 상기 full/partial activation과 같은 형태의 설정을 지원하는 enhanced 단말에 대해서만 규정될 수 있다.

[519] 즉, 종래의 unrestricted observation을 허용하는 것이 아닌, 특정 [d1, d2] ms 시간 구간 안에서만 measurement를 averaging하도록 한다.

[520] 이는 measure 대상이 되는 CSI-RS 및/또는 CSI-IM의 자원 설정 정보가 MAC 또는 PHY signaling을 통해 dynamic switching될 수 있기 때문에 특정 bounded된 구간 내에서만 measurement averaging을 수행하도록 규정하는 것이 바람직할 수 있기 때문이다.

[521] 일례로, 측정(measure) 대상이 되는 CSI-RS 그리고/또는 CSI-IM의 자원 설정 정보가 MAC 또는 PHY signaling(e.g., by DCI)을 통해 dynamic switching/indication되는 signaling을 단말이 기지국으로부터 수신한 경우, 단말은 이에 연동하여 상기 CSI-RS-based channel measurement의 measurement averaging window를 초기화 또는 갱신하도록 규정/설정될 수 있다.

[522] 또한, 단말은 상기 (dynamic switching/indication 되는) signaling에 연동하여 해당 CSI-IM-based interference measurement의 measurement averaging window를 초기화 또는 갱신할 수 있다.

[523] 여기서, measurement averaging window가 초기화 또는 갱신된다는 의미는, 현재 표준에 따른 CSI 측정을 위한 'unrestricted observation'에 의해 예를 들어, 과거 임의의 시점부터 현재까지 반복적으로 측정된 해당 CSI-RS ports로부터의 채널 측정치들을 단말 구현에 따라 averaging하는 종래 동작 대신에, 상기 '임의의 시점부터'라는 'measurement window의 시작점'을 상기 (dynamic switching/indication 되는) signaling을 수신한 시점 #n (또는 특정 설정/지시된 시점 후, e.g., #n+k)부터로 다시 초기화 또는 갱신하도록 하는 것이다.

[524] 또는, 상기 signaling을 통해 어느 시점부터 해당 measurement window가 초기화 또는 갱신되는지의 시점 정보를 (e.g., timestamp형태) 함께 explicit signaling해주는 방식도 적용 가능하다.

[525] 예를 들어, SFN, slot number 등 절대 시간 파라미터 값들에 대한 시간 정보 지시 방법, 또는 상기 signaling을 단말이 수신한 시점부터 특정 +/-Delta값 형태로 지시해주는 방식 등이 있을 수 있다.

[526] 다시 말해, 상기 signaling은 오직 measurement averaging window의 시작 시점만 갱신/리셋 해주는 역할을 하는 것으로 한정될 수 있다.

[527] 그러면, 해당 시점부터 시작하여 이후에 추가적인 상기 signaling이 수신되기 이전까지 단말은 CSI 측정치들을 (단말 구현에 따라) 평균화할 수 있다.

[528] 상기 signaling은 각 CSI process별로 별도로 (독립적으로) signaling될 수 있다. 이를 통해, 각 process별로 measurement window reset이 독립적으로 적용될 수 있도록 한다.

[529] 상기 signaling은 특정 CSI-IM 자원에 대한 interference measurement averaging window를 리셋하는 용도로도 함께 적용될 수도 있다.

[530] 이 경우에는, 특정 CSI process에 속한 CSI-RS 및 CSI-IM에 대한 measurement averaging window를 함께 초기화하는 역할을 하게 된다.

[531] 또는, CSI-IM 자원에 대한 interference measurement averaging window를 리셋하기 위한 별도의 (독립적인) indicator를 signaling하는 방식도 적용 가능하다.

[532] 이는, 간섭 환경의 변화가 존재하는 환경(e.g., eICIC, eIMTA, LAA 등)에서 예를 들어 기지국이 예측/감지 가능한 간섭 환경의 변화가 존재하는 경우, 단말에게 상기 특정 CSI process에 대한 measurement averaging window를 초기화하도록 알려줌으로써, 과거의 간섭 환경을 더 이상 현 시점부터 간섭 측정치에 반영하지 않도록 분리해줄 수 있다는 효과가 있다.

[533] 도 17은 본 명세서에서 제안하는 CSI 측정 및 보고 방법의 또 다른 일례를 나타낸 도이다.

[534] S1710 내지 S1730, S1750 및 S1760은 도 16의 S1610 내지 S1630, S1640 및

S1650과 동일하므로 구체적인 설명은 생략한다.

[535] 도 17을 참조하면, S1730 단계 이후, 단말은 CSI 측정 윈도우를 초기화 또는 갱신한다(S1740).

[536] 이후, 상기 단말은 초기화 또는 갱신된 CSI 측정 윈도우 구간에서 완전 활성화 CSI-RS를 반복적으로 측정하고, 상기 측정 결과를 평균하여, 상기 평균값을 기지국으로 보고한다(S1750~S1760).

[537] S1740 단계 이전에 기지국은 단말로 CSI 측정 윈도우 관련 설정 정보를 전송할 수 있다.

[538]

[539] 상기 (dynamic switching/indication 되는) signaling과 유사한 형태의 또 다른 실시예로서, 본 명세서는 아래와 같이 beamformed CSI-RS 기반의 방식에 대해서도 앞서 살핀 측정 윈도우(measurement window) 설정 관련 동작이 적용될 수 있다.

[540] Elevation beamforming 및 FD-MIMO 동작을 위해서 아래와 같은 PMI feedback scenario들이 고려될 수 있다.

[541] 1. EBF(Elevation Beamforming)/FD-MIMO에 대한 프리코딩 정의

[542] (1) 프리코딩 매트릭스/벡터(Precoding matrix/vector)

[543] - P_1: 와이드밴드(wideband); 자주 업데이트되지 않음(updated less frequently)

[544] - P_2: 서브밴드(subband) 또는 와이드밴드(wideband); 더 자주 업데이트됨(updated more frequently)

[545] - P is a function of P_1 and P_2, applied to 1D or 2D antenna array(P는 1D 또는 2D 안테나 어레이에 적용되는 P_1 및 P_2의 함수이다.)

[546] - PMI(s) are to be specified w.r.t. the above definition

[547] (2) CSI 피드백 시나리오들(Scenarios for CSI feedback)

[548] 1) 시나리오 1

[549] - UE measures CSI-RS ports beamformed with P_1(P_1 transparent to UE).

[550] - PMI report(s) for P_2

[551] 2) 시나리오 2

[552] - UE measures non-precoded 1-D or 2-D CSI-RS ports

[553] Note:P_1 not applied to CSI-RS at eNB

[554] - PMI report(s) for P_1 and P_2

[555] 3) 시나리오 3

[556] - UE measures both non-precoded 1- or 2-D CSI-RS ports (lower duty cycle) and CSI-RS beamformed with P_1

[557] - PMI report(s) for P_1 and P_2

[558] 4) 시나리오 4

[559] - UE measures non-precoded 1- or 2-D CSI-RS ports

[560] Note: P_1 not applied to CSI-RS at eNB(P_1 indicated to UE).

[561] - PMI report(s) for P_2

[562]

[563] 상기 시나리오 1 내지 시나리오 4 중에, 예를 들어 scenario 1 및 scenario 3과 같은 beamformed CSI-RS를 활용하는 방법은 단말이 행렬 P1 자체는 알 필요가 없다고 하더라도, 만일 해당 CSI-RS ports에 기지국이 beamforming을 적용한 P1이 변경된 경우, 상기 기지국은 상기 P1의 변경 시점 관련 정보를 단말로 사전에 알려주어야 한다.

[564] 그래야, 상기 단말은 CSI measurement and calculation 시에 적절한 measurement averaging window를 설정/적용할 수가 있다.

[565] 즉, 현재 표준에 따르면 단말이 해당 CSI-RS ports에 대한 channel measurement 시에는 'unrestricted observation'에 의해 과거 임의의 시점부터 현재까지 반복적으로 측정된 해당 CSI-RS ports로부터의 채널 측정치들을 단말 구현에 따라 averaging하여 신뢰도를 높일 수 있었다(e.g., noise suppression 효과).

[566] 하지만, 상기 시나리오 1 내지 4에서는 P1 자체가 단말에게 알려지지 않는 beamformed CSI-RS ports를 활용하므로, 기지국이 임의의 시점에 P1 자체를 변경할 수 있고, 기지국이 상기 P1이 변경되었음을 단말에게 알려주지 않으면 단말은 변경 이전의 P1과 변경 이후의 P1'에 대한 채널 측정치를 함께 averaging할 수 있으므로 해당 CSI measurement and reporting의 정확도에 문제가 발생할 수 있다.

[567] 따라서, 본 명세서는 이러한 문제점을 해결하기 위해, 기지국이 단말에게 일종의 'beam-change notification' 또는 'beam-change indicator (BCI) signaling을 전송하는 방법을 제공한다.

[568] 이하에서는 'beam-change indicator'를 간단히 'BCI'로 호칭하기로 한다.

[569] BCI signaling은 RRC signaling형태로 지시될 수도 있다.

[570] 그러나 보다 바람직하게는, MAC CE를 통한 signaling이나 DCI 등을 통한 dynamic indication으로 제공될 수 있다.

[571] 즉, 단말은 기지국으로부터 BCI signaling을 수신하는 경우, 해당 CSI process에서의 CSI derivation시에 적용하는 measurement averaging window의 시작점을 해당 BCI signaling 수신 시점(또는 이로부터 특정 지시된 시점, 또는 별도의 timestamp 등으로 explicit indication된 시점)으로 갱신한다.

[572] 즉, 상기 BCI 정보와 함께 (또는 연계된 정보로서), 어느 시점부터 해당 measurement window가 초기화 또는 갱신되는지의 시점 정보를(e.g., timestamp형태) 함께 explicit signaling해주는 방식도 적용 가능하다.

[573] 예를 들어, SFN, slot number등 절대 시간 파라미터 값들에 대한 시간 정보 지시 방법, 또는 상기 signaling을 단말이 수신한 시점부터 특정 +/-Delta값 형태로 지시해주는 방식 등이 있을 수 있다.

[574] 즉, 이러한 BCI signaling은 오직 measurement averaging window의 시작 시점만 갱신/리셋 해주는 역할을 하는 것으로 한정될 수 있다.

[575] 그러면, 이 시점(BCI signaling 수신 시점)부터 시작하여 이후에 추가적인 BCI가

수신되기 이전까지 단말은 CSI 측정치들을 (단말 구현에 따라) 평균화할 수 있다.

[576] 결국, 단말이 상기 갱신된 행렬 P1자체는 알지 못하지만, P1이 갱신되었음을 상기 BCI를 통해 지시받았으므로, 이 시점부터 다시 새롭게 CSI 측정치들을 평균화하도록 함으로써 갱신된 P1이 적용된 CSI-RS ports에 대해서만 해당 CSI process에 대한 CSI calculation and reporting(e.g., P1, P2, RI, CQI 등)을 수행할 수 있다.

[577] 상기 BCI는 각 CSI process별로 별도로 (독립적으로) signaling될 수 있다.

[578] 이를 통해, 각 process별로 measurement window reset이 독립적으로 적용될 수 있도록 한다.

[579] 상기 BCI는 특정 CSI-IM 자원에 대한 interference measurement averaging window를 리셋하는 용도로도 함께 적용될 수도 있다.

[580] 이 경우에는, 특정 CSI process에 속한 CSI-RS 및 CSI-IM에 대한 measurement averaging window를 함께 초기화하는 역할을 하게 된다.

[581] 또는, CSI-IM 자원에 대한 interference measurement averaging window를 리셋하기 위한 별도의 (독립적인) indicator를 signaling하는 방식도 적용 가능하다.

[582] 이는, 간섭 환경의 변화가 존재하는 환경(e.g., eICIC, eIMTA, LAA 등)에서 예를 들어 기지국이 예측/감지 가능한 간섭 환경의 변화가 존재하는 경우, 단말에게 상기 특정 CSI process에 대한 measurement averaging window를 초기화하도록 알려줌으로써, 과거의 간섭 환경을 더 이상 현 시점부터 간섭 측정치에 반영하지 않도록 분리해줄 수 있다는 효과가 있다.

[583]

[584] **본 발명이 적용될 수 있는 장치 일반**

[585] 도 18은 본 발명의 일 실시예에 따른 무선 통신 장치의 블록 구성도를 예시한다.

[586] 도 18를 참조하면, 무선 통신 시스템은 기지국(1810)과 기지국(1810) 영역 내에 위치한 다수의 단말(1820)을 포함한다.

[587] 기지국(1810)은 프로세서(processor, 1811), 메모리(memory, 1812) 및 RF부(radio frequency unit, 1813)을 포함한다. 프로세서(1811)는 앞서 도 1 내지 도 17에서 제안된 기능, 과정 및/또는 방법을 구현한다. 무선 인터페이스 프로토콜의 계층들은 프로세서(1811)에 의해 구현될 수 있다. 메모리(1812)는 프로세서(1811)와 연결되어, 프로세서(1811)를 구동하기 위한 다양한 정보를 저장한다. RF부(1813)는 프로세서(1811)와 연결되어, 무선 신호를 송신 및/또는 수신한다.

[588] 단말(1820)은 프로세서(1821), 메모리(1822) 및 RF부(1823)을 포함한다. 프로세서(1821)는 앞서 도 1 내지 도 17에서 제안된 기능, 과정 및/또는 방법을 구현한다. 무선 인터페이스 프로토콜의 계층들은 프로세서(1821)에 의해 구현될 수 있다. 메모리(1822)는 프로세서(1821)와 연결되어, 프로세서(1821)를

구동하기 위한 다양한 정보를 저장한다. RF부(1823)는 프로세서(1821)와 연결되어, 무선 신호를 송신 및/또는 수신한다.

[589] 메모리(1812, 1822)는 프로세서(1811, 1821) 내부 또는 외부에 있을 수 있고, 잘 알려진 다양한 수단으로 프로세서(1811, 1821)와 연결될 수 있다. 또한, 기지국(1810) 및/또는 단말(1820)은 한 개의 안테나(single antenna) 또는 다중 안테나(multiple antenna)를 가질 수 있다.

[590] 이상에서 설명된 실시예들은 본 발명의 구성요소들과 특징들이 소정 형태로 결합된 것들이다. 각 구성요소 또는 특징은 별도의 명시적 언급이 없는 한 선택적인 것으로 고려되어야 한다. 각 구성요소 또는 특징은 다른 구성요소나 특징과 결합되지 않은 형태로 실시될 수 있다. 또한, 일부 구성요소들 및/또는 특징들을 결합하여 본 발명의 실시예를 구성하는 것도 가능하다. 본 발명의 실시예들에서 설명되는 동작들의 순서는 변경될 수 있다. 어느 실시예의 일부 구성이나 특징은 다른 실시예에 포함될 수 있고, 또는 다른 실시예의 대응하는 구성 또는 특징과 교체될 수 있다. 특허청구범위에서 명시적인 인용 관계가 있지 않은 청구항들을 결합하여 실시예를 구성하거나 출원 후의 보정에 의해 새로운 청구항으로 포함시킬 수 있음은 자명하다.

[591] 본 발명에 따른 실시예는 다양한 수단, 예를 들어, 하드웨어, 펌웨어(firmware), 소프트웨어 또는 그것들의 결합 등에 의해 구현될 수 있다. 하드웨어에 의한 구현의 경우, 본 발명의 일 실시예는 하나 또는 그 이상의 ASICs(application specific integrated circuits), DSPs(digital signal processors), DSPDs(digital signal processing devices), PLDs(programmable logic devices), FPGAs(field programmable gate arrays), 프로세서, 콘트롤러, 마이크로 콘트롤러, 마이크로 프로세서 등에 의해 구현될 수 있다.

[592] 펌웨어나 소프트웨어에 의한 구현의 경우, 본 발명의 일 실시예는 이상에서 설명된 기능 또는 동작들을 수행하는 모듈, 절차, 함수 등의 형태로 구현될 수 있다. 소프트웨어 코드는 메모리에 저장되어 프로세서에 의해 구동될 수 있다. 상기 메모리는 상기 프로세서 내부 또는 외부에 위치하여, 이미 공지된 다양한 수단에 의해 상기 프로세서와 데이터를 주고 받을 수 있다.

[593] 본 발명은 본 발명의 필수적 특징을 벗어나지 않는 범위에서 다른 특정한 형태로 구체화될 수 있음은 당업자에게 자명하다. 따라서, 상술한 상세한 설명은 모든 면에서 제한적으로 해석되어서는 아니 되고 예시적인 것으로 고려되어야 한다. 본 발명의 범위는 첨부된 청구항의 합리적 해석에 의해 결정되어야 하고, 본 발명의 등가적 범위 내에서의 모든 변경은 본 발명의 범위에 포함된다.

산업상 이용가능성

[594] 본 발명의 무선 통신 시스템에서 CSI 피드백하는 방안은 3GPP LTE/LTE-A 시스템에 적용되는 예를 중심으로 설명하였으나, 3GPP LTE/LTE-A 시스템 이외에도 다양한 무선 통신 시스템에 적용하는 것이 가능하다.

청구범위

[청구항 1] 무선 통신 시스템에서 CSI(Channel State Information) 피드백(feedback)을 수행하기 위한 방법에 있어서, 단말에 의해 수행되는 방법은,
CSI 관련 동작에 대한 상기 단말의 능력(capability) 정보를 기지국으로 전송하는 단계;
CSI 관련 동작 설정(configuration) 정보를 상기 기지국으로부터 수신하는 단계,
상기 CSI 관련 동작 설정 정보는 부분 활성화(partial activation)를 수행하는 CSI 관련 동작을 나타내는 부분 활성화 CSI 관련 동작 인덱스(index) 정보 또는 완전 활성화(full activation)를 수행하는 CSI 관련 동작을 나타내는 완전 활성화 CSI 관련 동작 인덱스 정보 중 적어도 하나를 포함하며;
부분 활성화 CSI-RS(Reference Signal)를 트래킹(tracking)하는 단계;
완전 활성화 CSI-RS를 측정하는 단계; 및
상기 측정 결과를 상기 기지국으로 보고(report)하는 단계를 포함하여 이루어지는 것을 특징으로 하는 방법.

[청구항 2] 제 1항에 있어서,
상기 완전 활성화 CSI-RS를 측정하는 단계는,
상기 완전 활성화 CSI-RS에 대한 측정의 활성화를 지시하는 제 1 메시지를 상기 기지국으로부터 수신하는 단계; 및
상기 제 1 메시지에 의해 활성화된 완전 활성화 CSI-RS를 측정하는 단계를 포함하는 것을 특징으로 하는 방법.

[청구항 3] 제 1항에 있어서,
상기 CSI 관련 동작은 CSI-RS, CSI-IM(Interference Management) 또는 CSI process 중 적어도 하나와 관련 있는 것을 특징으로 하는 방법.

[청구항 4] 제 1항에 있어서,
상기 단말의 능력 정보는 동시에 완전 활성화(full activation) 가능한 상기 CSI 관련 동작의 최대 개수를 나타내는 제 1 제어 정보 및 동시에 부분 활성화(partial activation) 가능한 상기 CSI 관련 동작의 최대 개수를 나타내는 제 2 제어 정보를 포함하는 것을 특징으로 하는 방법.

[청구항 5] 제 1항에 있어서,
상기 부분 활성화 CSI-RS를 트래킹(tracking)하는 단계는,
상기 부분 활성화 CSI-RS에 대해 시간 및/또는 주파수에서 동기를 맞추는 단계를 포함하는 것을 특징으로 하는 방법.

[청구항 6] 제 1항에 있어서,
상기 트래킹은 상기 CSI 관련 동작 설정 정보에 포함된 특정 RS(Reference Signal)과 quasi co-location(QCL) 가정을 적용하여 수행하는 것을 특징으로

하는 방법.

[청구항 7] 제 1항에 있어서,
상기 완전 활성화 CSI-RS는 상기 부분 활성화 CSI-RS에서 선택되는 것을 특징으로 하는 방법.

[청구항 8] 제 2항에 있어서,
상기 제 1 메시지는 MAC(Media Access Control) CE(Control Element) 또는 DCI(Downlink Control Information)인 것을 특징으로 하는 방법.

[청구항 9] 제 2항에 있어서,
상기 기지국으로부터 CSI-RS 측정 윈도우(measurement window)와 관련된 제 3 제어 정보를 수신하는 단계를 더 포함하며,
상기 CSI-RS를 측정하는 단계는,
상기 제 1 메시지를 수신하는 경우, 상기 CSI-RS 측정 윈도우를 초기화 또는 갱신하는 단계;
상기 CSI-RS 측정 윈도우가 초기화 또는 갱신되는 시점부터 특정 구간까지 CSI-RS의 측정을 반복적으로 수행하는 단계; 및
상기 측정 결과들을 평균하는(averaging) 단계를 포함하는 것을 특징으로 하는 방법.

[청구항 10] 제 9항에 있어서,
CSI 피드백이 주기적 CSI 피드백인 경우, 상기 CSI-RS 측정 윈도우를 초기화 또는 갱신하는 시점은 상기 특정 구간 이후에 최초로 발생하는 RI(Rank Indicator) 보고에 연관된 특정 기준 자원(reference resource) 시점인 것을 특징으로 하는 방법.

[청구항 11] 제 2항에 있어서,
상기 제 1 메시지는 각 CSI 프로세스 별로 상기 기지국으로부터 수신되는 것을 특징으로 하는 방법.

[청구항 12] 제 2항에 있어서,
상기 제 1 메시지는 빔포밍 관련 매트릭스의 변경을 알리는 빔-변경 지시자(Beam-Change Indicator:BCI) 시그널링(signaling)인 것을 특징으로 하는 방법.

[청구항 13] 무선 통신 시스템에서 CSI(Channel State Information)을 피드백하기 위한 단말에 있어서, 상기 단말은,
무선 신호를 송수신하기 위한 RF(Radio Frequency) 유닛; 및
상기 RF 유닛을 제어하는 프로세서를 포함하고,
CSI 관련 동작에 대한 상기 단말의 능력(capability) 정보를 기지국으로 전송하고;
CSI 관련 동작 설정(configuration) 정보를 상기 기지국으로부터 수신하고,
상기 CSI 관련 동작 설정 정보는 부분 활성화(partial activation)를 수행하는 CSI 관련 동작을 나타내는 부분 활성화 CSI 관련 동작

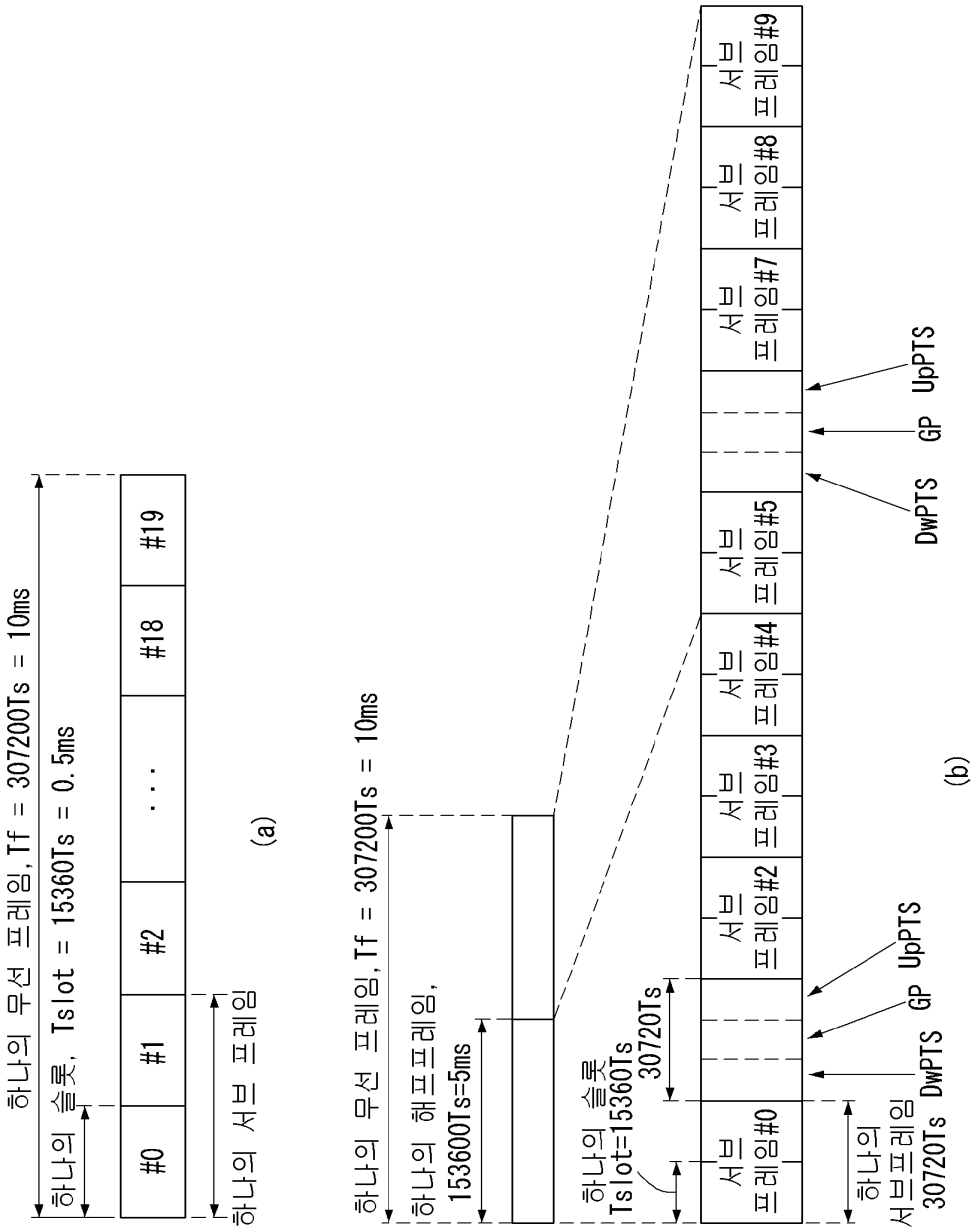
인덱스(index) 정보 또는 완전 활성화(full activation)를 수행하는 CSI 관련 동작을 나타내는 완전 활성화 CSI 관련 동작 인덱스 정보 중 적어도 하나를 포함하며;

부분 활성화 CSI-RS(Reference Signal)를 트래킹(tracking)하고;

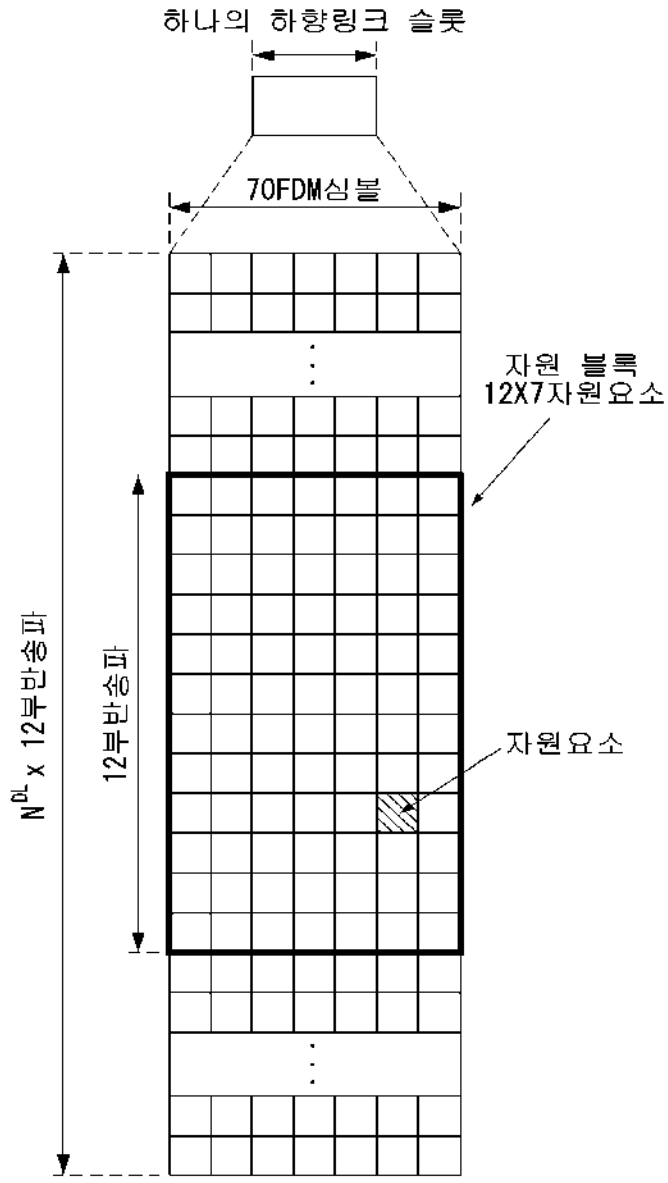
완전 활성화 CSI-RS를 측정하며; 및

상기 측정 결과를 상기 기지국으로 보고(report)하도록 제어하는 것을 특징으로 하는 단말.

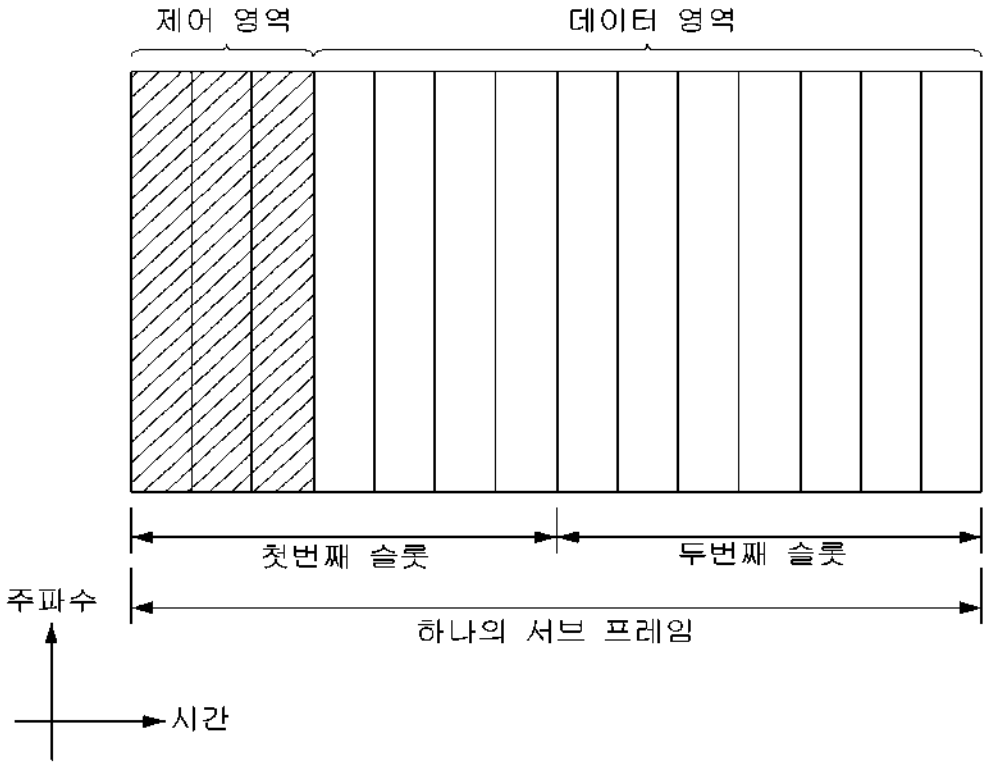
[도1]


하나의 무선 프레임, Tf = 307200Ts = 10ms
하나의 슬롯, Tslot = 15360Ts = 0.5ms
#0
#1
#2
...
#18
#19
하나의 서브 프레임
(a)
하나의 무선 프레임, Tf = 307200Ts = 10ms
하나의 해프프레임, 153600Ts=5ms
하나의 슬롯 Tslot=15360Ts
30720Ts
서브 프레임#0
서브 프레임#2
서브 프레임#3
서브 프레임#4
서브 프레임#5
서브 프레임#7
서브 프레임#8
서브 프레임#9
DwPTS
GP
UpPTS
하나의 서브프레임 30720Ts
(b)

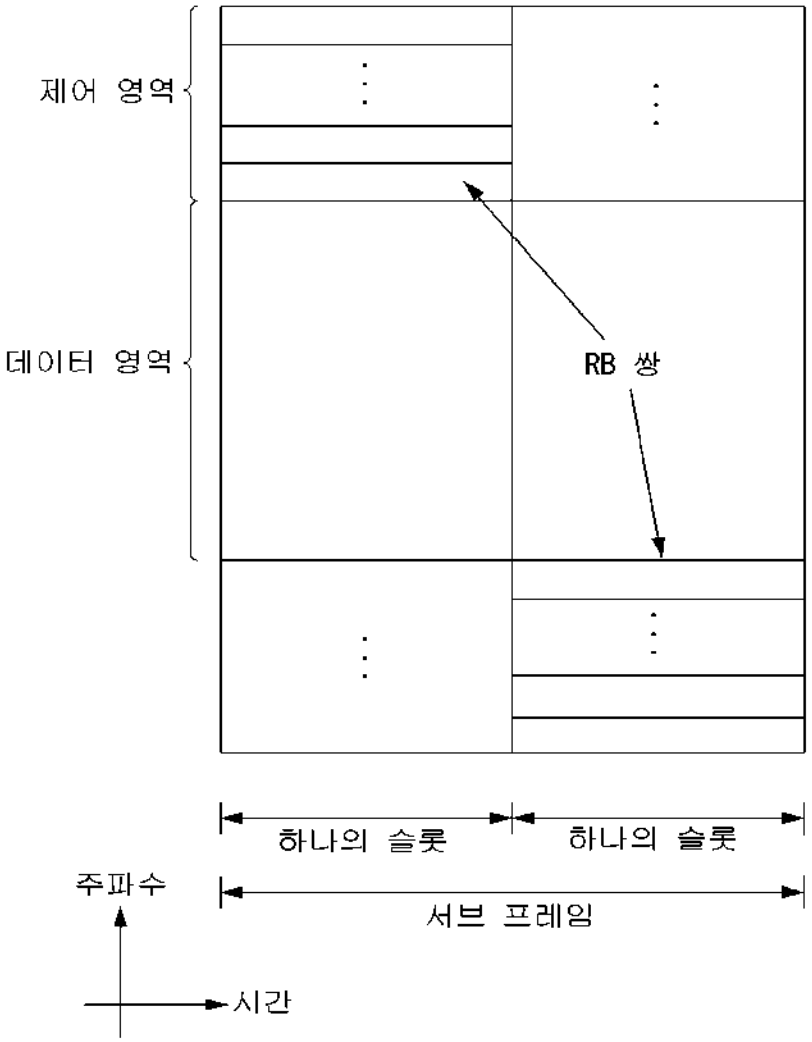
[도2]



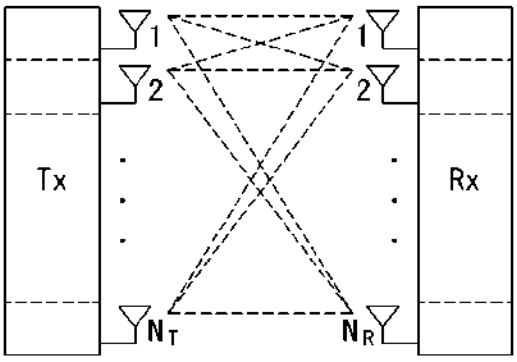
[도3]



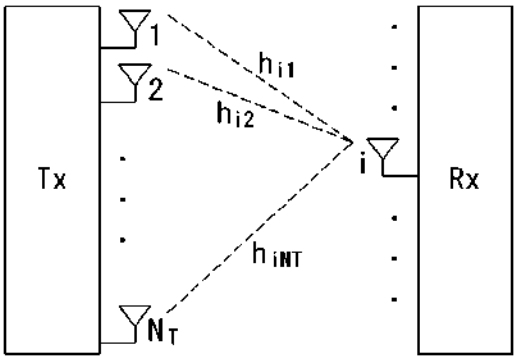
[도4]



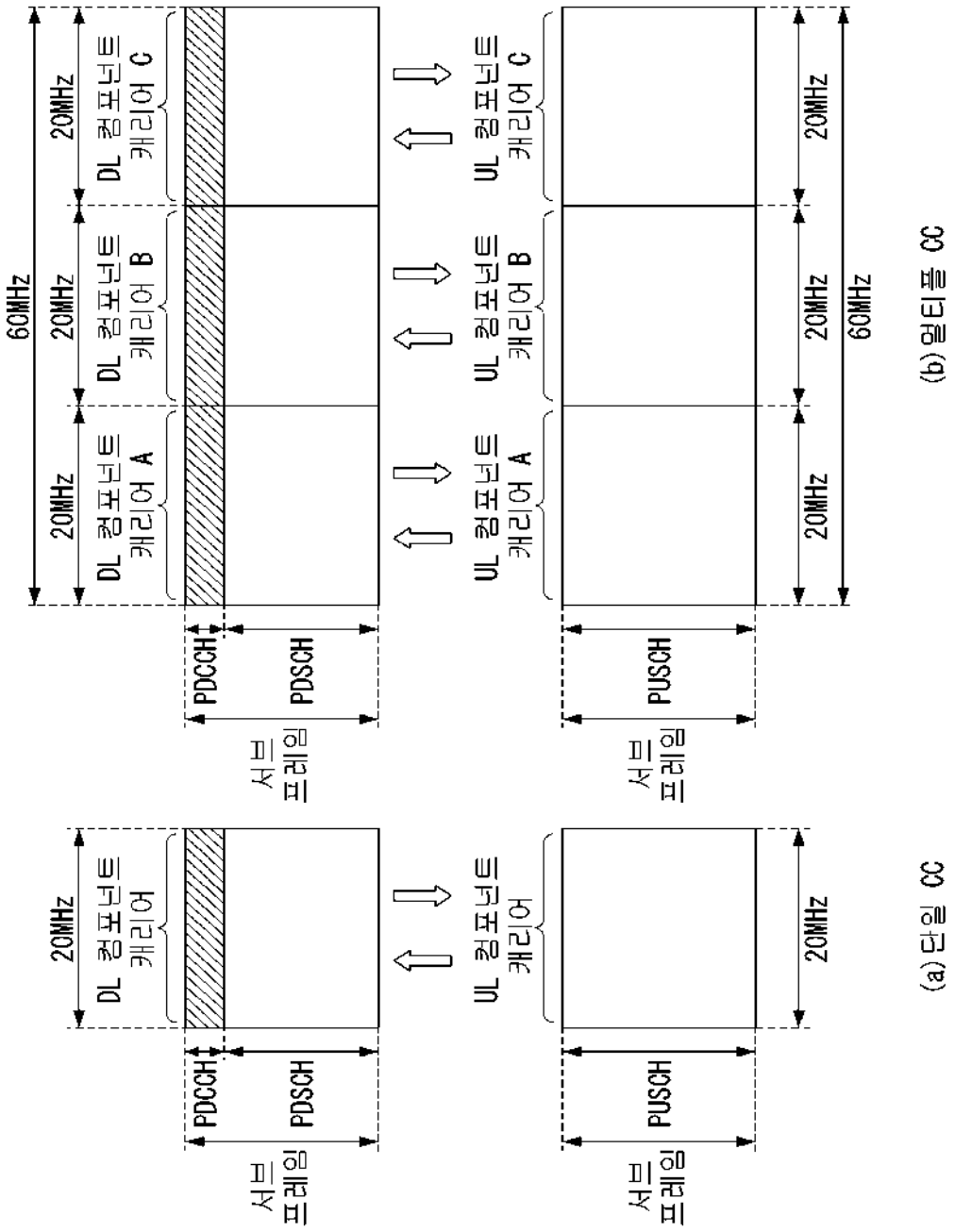
[도5]



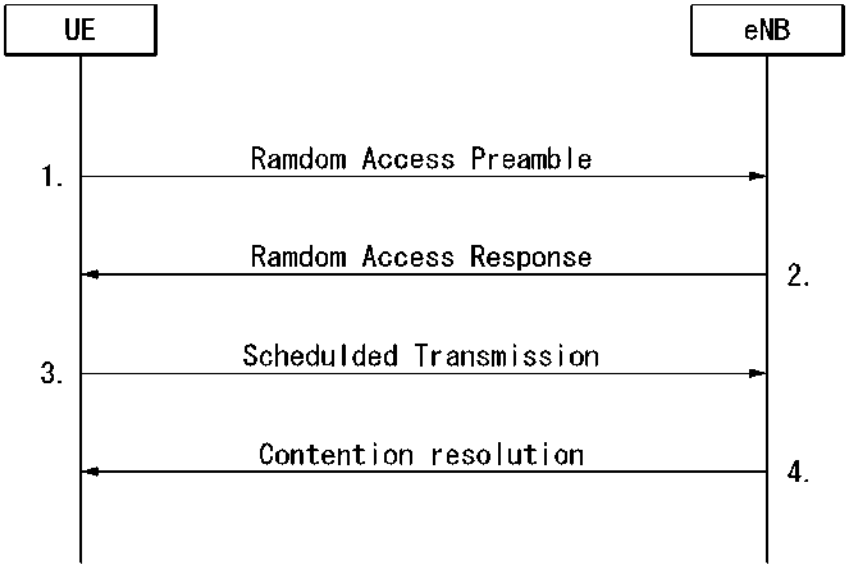
[도6]



[도7]

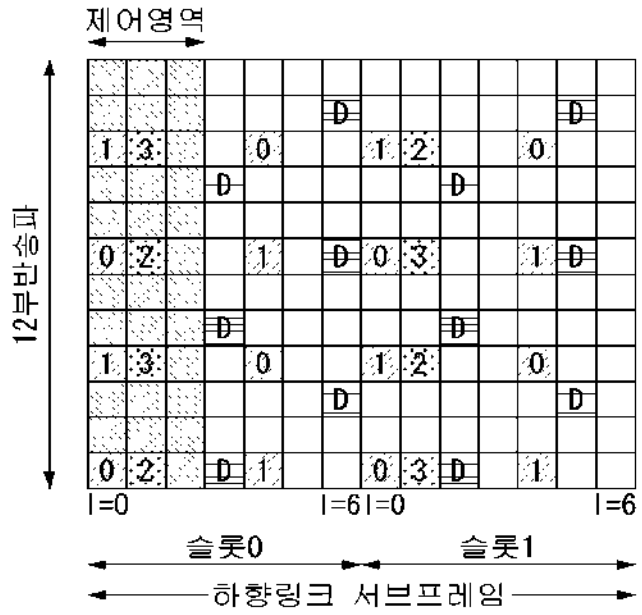

60MHz
20MHz
20MHz
20MHz
DL 컴포넌트 캐리어 A
DL 컴포넌트 캐리어 B
DL 컴포넌트 캐리어 C
PDCCH
PDSCH
서브프레임
UL 컴포넌트 캐리어 A
UL 컴포넌트 캐리어 B
UL 컴포넌트 캐리어 C
PUSCH
(b) 멀티플 CC
20MHz
DL 컴포넌트 캐리어
UL 컴포넌트 캐리어
(a) 단일 CC

[도8]

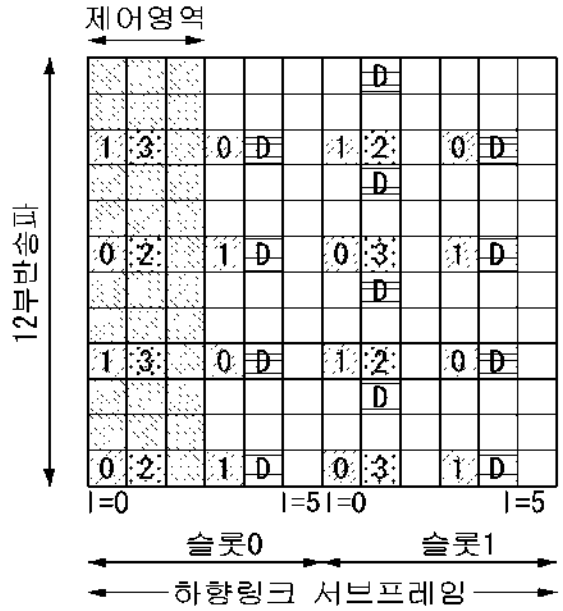

UE
eNB
1.
Ramdom Access Preamble
Ramdom Access Response
2.
3.
Schedulded Transmission
Contention resolution
4.

[도9]

(a)

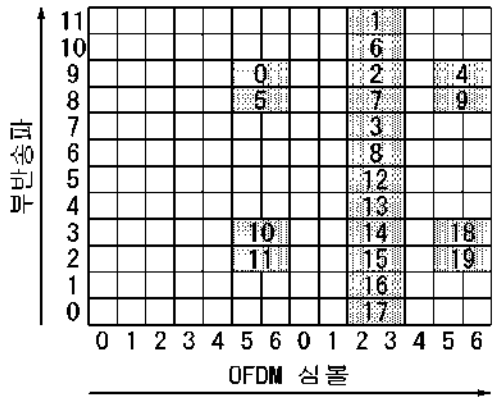

제어영역
12부반송파
l=0
l=6
l=0
l=6
슬롯0
슬롯1
하향링크 서브프레임

(b)


제어영역
12부반송파
l=0
l=5
l=0
l=5
슬롯0
슬롯1
하향링크 서브프레임

[도10]

(a) 1개 또는 2개 CSI-RS 포트



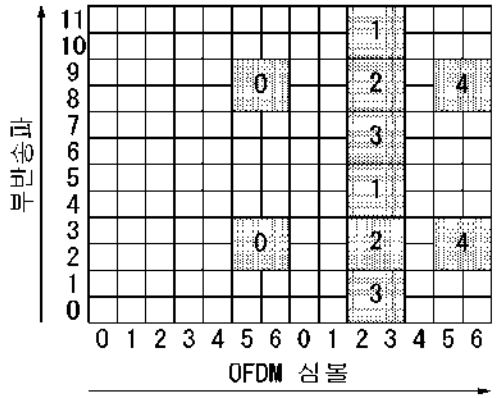
(b) 4개 CSI-RS 포트



[i] :1개 또는 2개 CSI-RS 포트를 위해 이용가능한 CSI-RS 구성 i

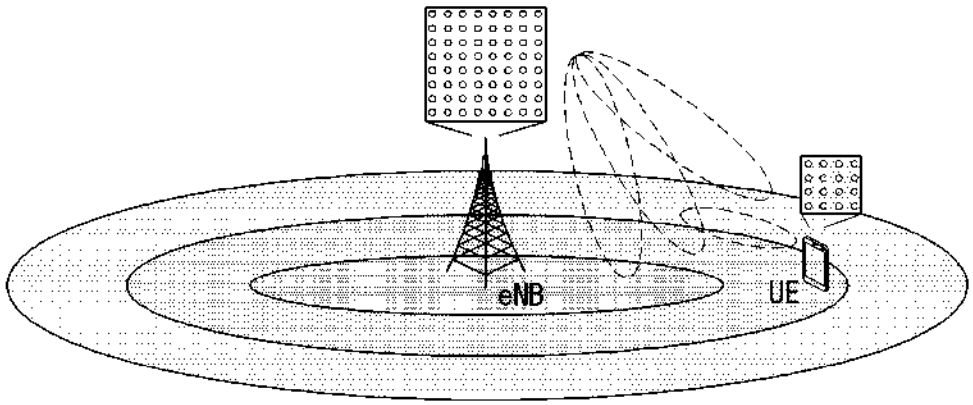
[i] :4개 CSI-RS 포트를 위해 이용가능한 CSI-RS 구성 i

(c) 8개 CSI-RS 포트

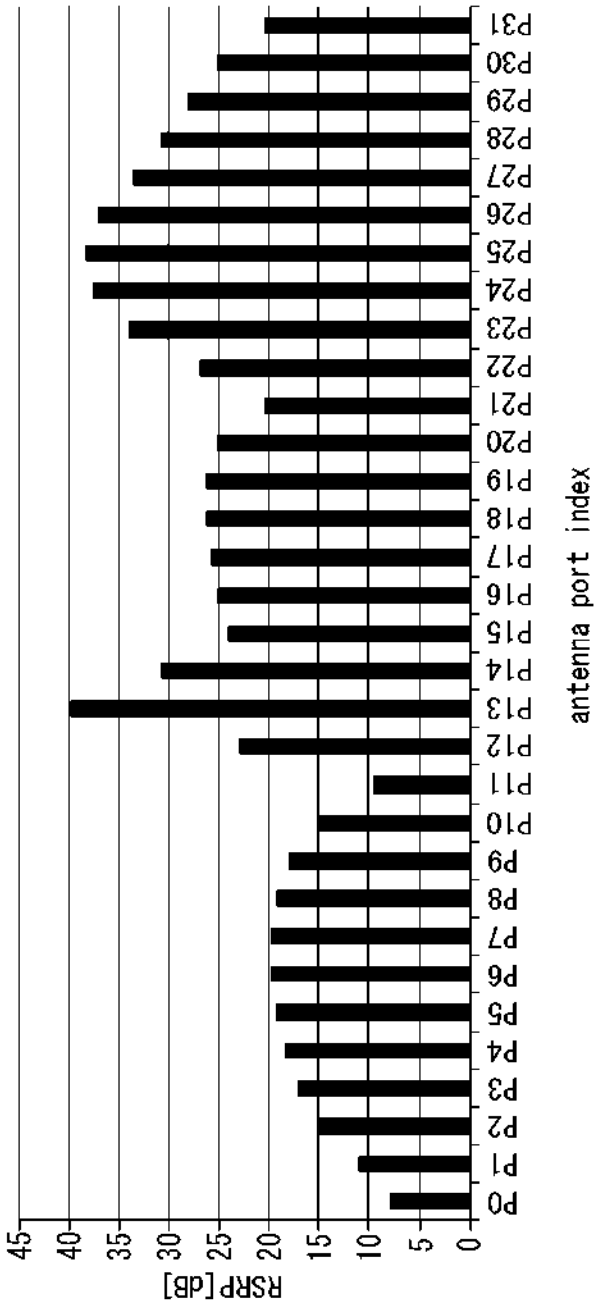


[i] :8개 CSI-RS 포트를 위해 이용가능한 CSI-RS 구성 i

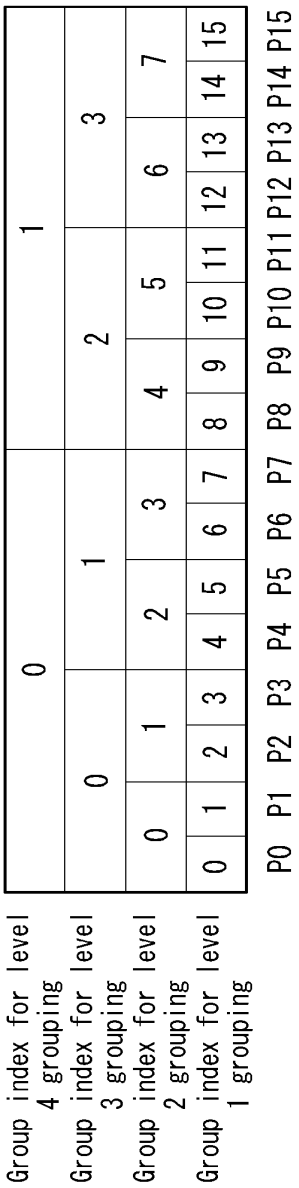
[도11]



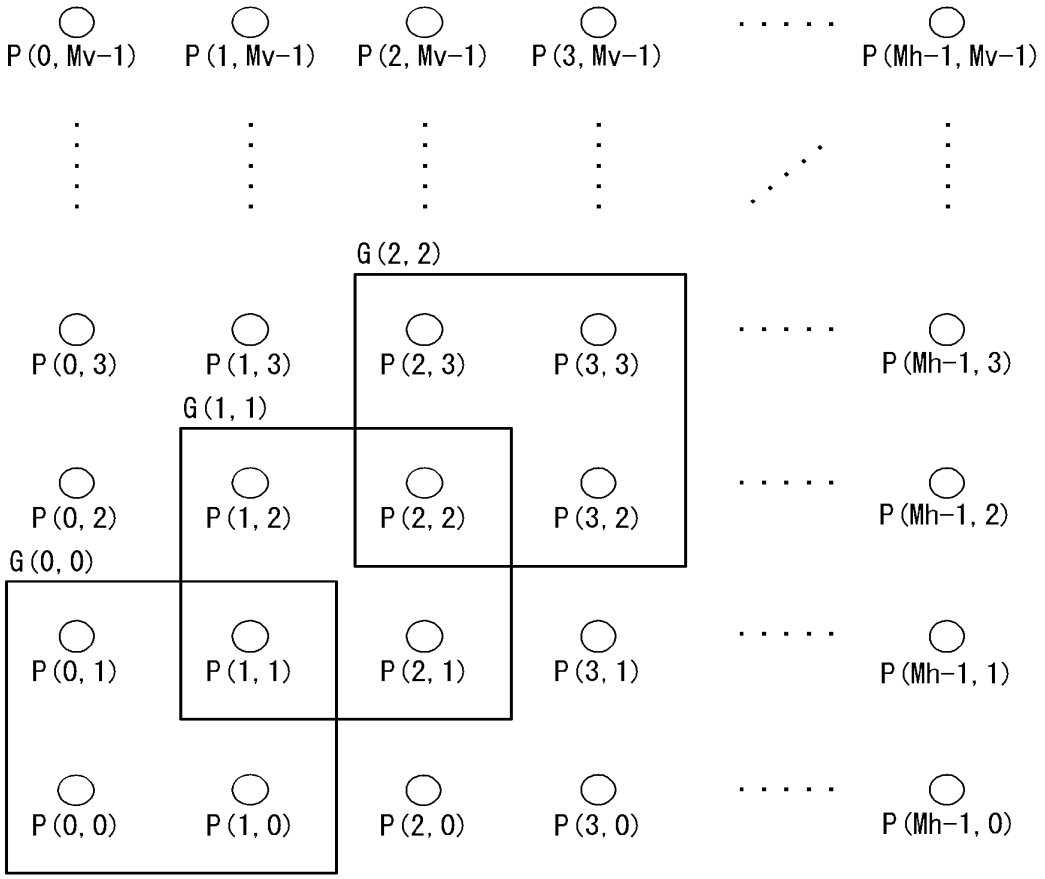
[도12]


RSRP[dB]
45
40
35
30
25
20
15
10
5
0
antenna port index
P0
P1
P2
P3
P4
P5
P6
P7
P8
P9
P10
P11
P12
P13
P14
P15
P16
P17
P18
P19
P20
P21
P22
P23
P24
P25
P26
P27
P28
P29
P30
P31

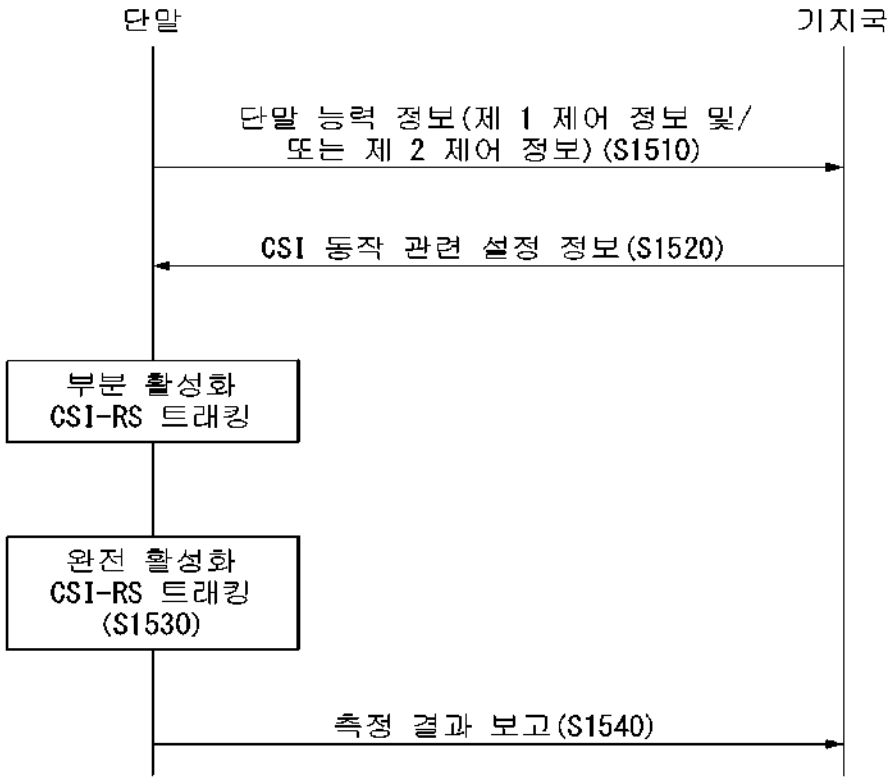
[도13]


Group index for level 4 grouping
Group index for level 3 grouping
Group index for level 2 grouping
Group index for level 1 grouping
0
1
0
1
2
3
0
1
2
3
4
5
6
7
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
P0 P1 P2 P3 P4 P5 P6 P7 P8 P9 P10 P11 P12 P13 P14 P15

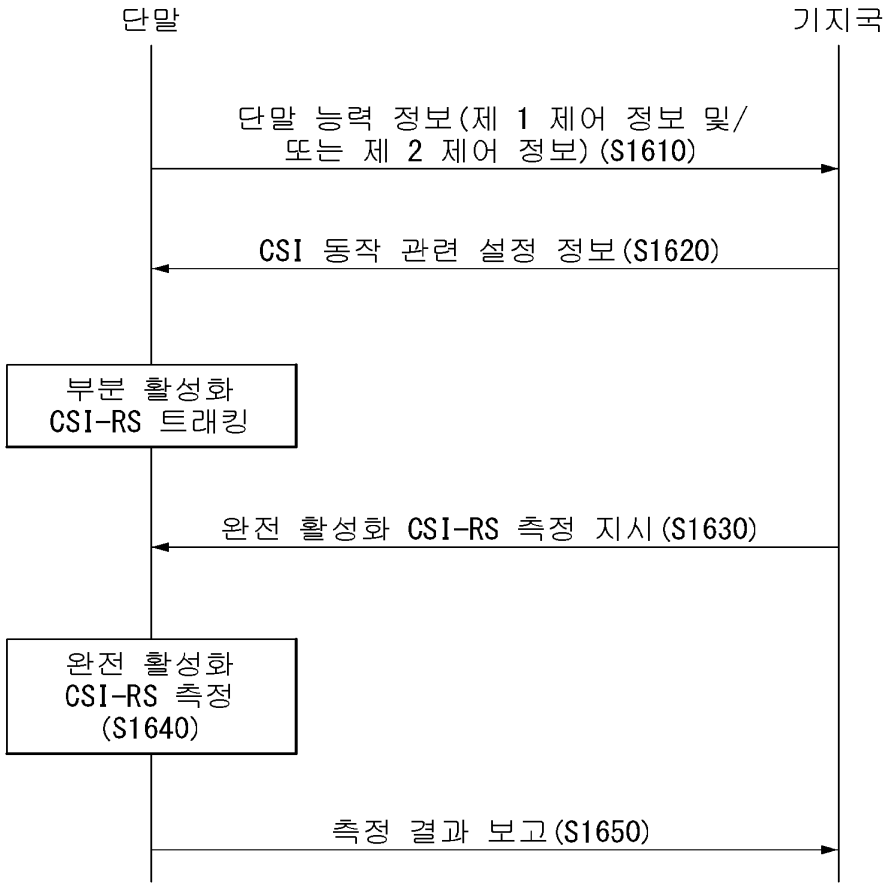
[도14]


P(0, Mv-1)
P(1, Mv-1)
P(2, Mv-1)
P(3, Mv-1)
P(Mh-1, Mv-1)
G(2, 2)
P(0, 3)
P(1, 3)
P(2, 3)
P(3, 3)
P(Mh-1, 3)
G(1, 1)
P(0, 2)
P(1, 2)
P(2, 2)
P(3, 2)
P(Mh-1, 2)
G(0, 0)
P(0, 1)
P(1, 1)
P(2, 1)
P(3, 1)
P(Mh-1, 1)
P(0, 0)
P(1, 0)
P(2, 0)
P(3, 0)
P(Mh-1, 0)

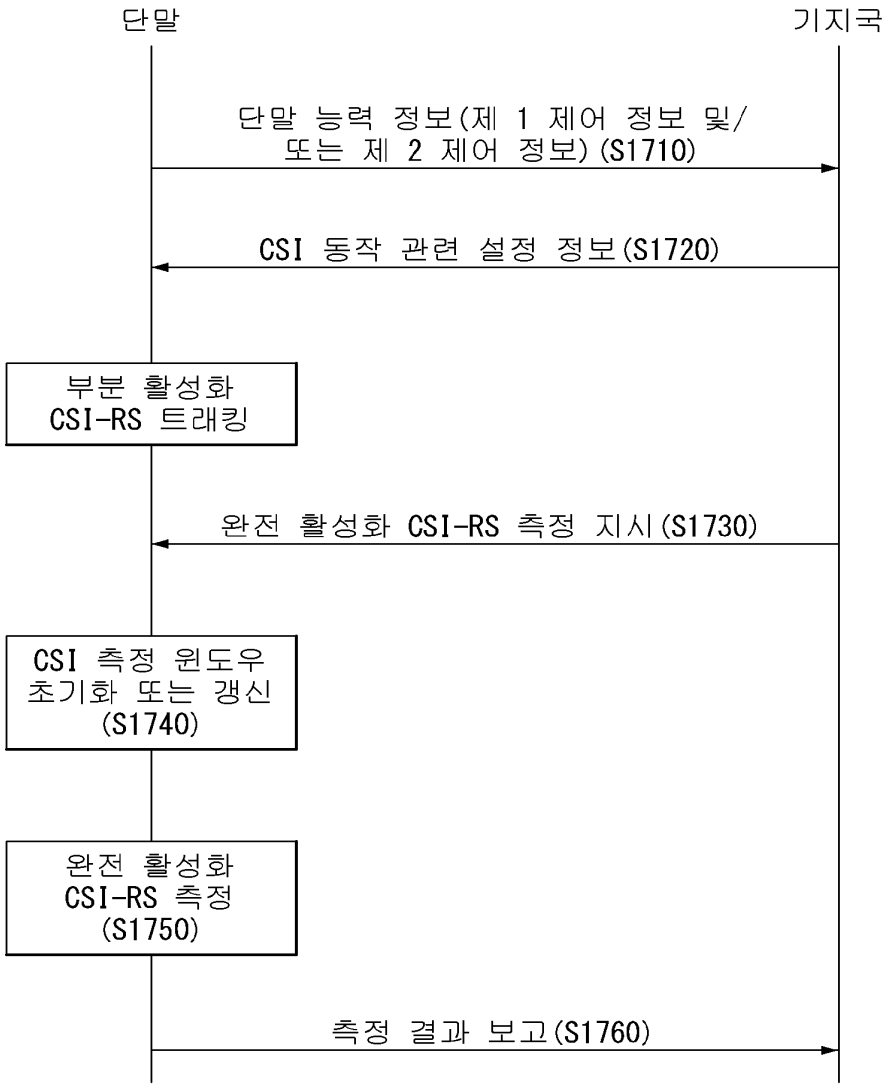
[도15]


단말
기지국
단말 능력 정보(제 1 제어 정보 및/
또는 제 2 제어 정보)(S1510)
CSI 동작 관련 설정 정보(S1520)
부분 활성화
CSI-RS 트래킹
완전 활성화
CSI-RS 트래킹
(S1530)
측정 결과 보고(S1540)

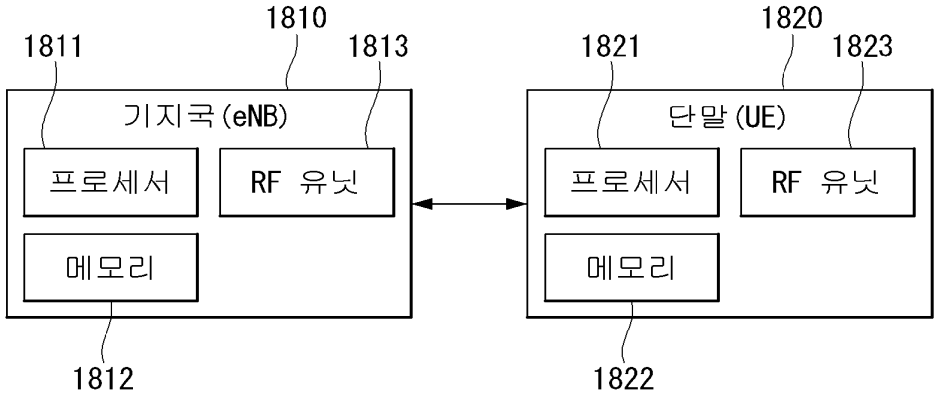
[도16]


단말
기지국
단말 능력 정보(제 1 제어 정보 및/
또는 제 2 제어 정보)(S1610)
CSI 동작 관련 설정 정보(S1620)
부분 활성화
CSI-RS 트래킹
완전 활성화 CSI-RS 측정 지시(S1630)
완전 활성화
CSI-RS 측정
(S1640)
측정 결과 보고(S1650)

[도17]


단말
기지국
단말 능력 정보(제 1 제어 정보 및/
또는 제 2 제어 정보)(S1710)
CSI 동작 관련 설정 정보(S1720)
부분 활성화
CSI-RS 트래킹
완전 활성화 CSI-RS 측정 지시(S1730)
CSI 측정 윈도우
초기화 또는 갱신
(S1740)
완전 활성화
CSI-RS 측정
(S1750)
측정 결과 보고(S1760)

[도18]


1810
1811
1813
1820
1821
1823
기지국(eNB)
프로세서
RF 유닛
메모리
단말(UE)
프로세서
RF 유닛
메모리
1812
1822

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2016/001177

A. CLASSIFICATION OF SUBJECT MATTER

H04B 7/06(2006.01)i, H04B 17/24(2014.01)i, H04L 5/00(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04B 7/06; H04B 7/26; H04W 72/12; H04B 7/02; H04W 56/00; H04W 24/10; H04B 17/24; H04L 5/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Utility models and applications for Utility models: IPC as above
Japanese Utility models and applications for Utility models: IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS (KIPO internal) & Keywords: partial activation, full activation, CSI, CSI-RS, motion configuration information, terminal capacity

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2014-081262 A1 (LG ELECTRONICS INC.) 30 May 2014 See paragraphs [0046], [0052]-[0061], [0072], [0111]-[0118], [0126]; claims 2-3; and figure 5.	1,3,5-6,13
A		2,4,7-12
Y	HUAWEI et al., "On the Support of TM10 with CA in Rel-11", R1-131154, 3GPP TSG RAN WG1 Meeting #72bis, Chicago, USA, 06 April 2013 See pages 1-3; and tables 1-2.	1,3,5-6,13
A	US 2014-0219115 A1 (ETEMAD, Kamran et al.) 07 August 2014 See paragraphs [0039], [0057], [0064]-[0068]; and figure 10.	1-13
A	US 2015-0030037 A1 (LG ELECTRONICS INC.) 29 January 2015 See paragraphs [0009]-[0010], [0085]-[0109]; claim 1; and figure 5.	1-13
A	KR 10-2014-0124356 A (LG ELECTRONICS INC.) 24 October 2014 See paragraphs [0104]-[0120]; and figures 14-15.	1-13

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 MAY 2016 (25.05.2016)	**25 MAY 2016 (25.05.2016)**
Name and mailing address of the ISA/KR Korean Intellectual Property Office Government Complex-Daejeon, 189 Seonsa-ro, Daejeon 302-701, Republic of Korea Facsimile No. 82-42-472-7140	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2016/001177

Patent document cited in search report	Publication date	Patent family member	Publication date
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		US 2015-0282036 A1	01/10/2015
US 2014-0219115 A1	07/08/2014	AU 2013-217503 A1	15/08/2013
		AU 2013-217503 B2	21/04/2016
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		EP 2813007 A4	28/10/2015
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		EP 2813038 A4	17/02/2016
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		KR 10-1606484 B1	25/03/2016
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		KR 10-2014-0116472 A	02/10/2014
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		US 2013-0272124 A1	17/10/2013
		US 2015-0381497 A1	31/12/2015
		US 9055477 B2	09/06/2015
		US 9071999 B2	30/06/2015
		US 9125103 B2	01/09/2015
		WO 2013-119267 A2	15/08/2013

Form PCT/ISA/210 (patent family annex) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2016/001177

Patent document cited in search report	Publication date	Patent family member	Publication date
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		WO 2013-119506 A1	15/08/2013
		WO 2013-119583 A1	15/08/2013
		WO 2013-119585 A1	15/08/2013
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KR 10-2014-0124356 A	24/10/2014	CN 104106223 A	15/10/2014
		CN 104137440 A	05/11/2014
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		CN 104641582 A	20/05/2015
		CN 104662984 A	27/05/2015
		CN 104685802 A	03/06/2015
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		CN 104704754 A	10/06/2015
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		EP 2897314 A1	22/07/2015
		EP 2899906 A1	29/07/2015
		EP 2905909 A1	12/08/2015
		EP 2905910 A1	12/08/2015
		EP 2905914 A1	12/08/2015
		EP 2905915 A1	12/08/2015
		EP 2905935 A1	12/08/2015
		EP 2914044 A1	02/09/2015
		JP 05902835 B2	13/04/2016
		JP 2015-511447 A	16/04/2015
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		JP 2015-533062 A	16/11/2015
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		JP 2015-534784 A	03/12/2015
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국 제 조 사 보 고 서

국제출원번호
PCT/KR2016/001177

A. 발명이 속하는 기술분류(국제특허분류(IPC))

H04B 7/06(2006.01)i, H04B 17/24(2014.01)i, H04L 5/00(2006.01)i

B. 조사된 분야

조사된 최소문헌(국제특허분류를 기재)

H04B 7/06; H04B 7/26; H04W 72/12; H04B 7/02; H04W 56/00; H04W 24/10; H04B 17/24; H04L 5/00

조사된 기술분야에 속하는 최소문헌 이외의 문헌

한국등록실용신안공보 및 한국공개실용신안공보: 조사된 최소문헌란에 기재된 IPC

일본등록실용신안공보 및 일본공개실용신안공보: 조사된 최소문헌란에 기재된 IPC

국제조사에 이용된 전산 데이터베이스(데이터베이스의 명칭 및 검색어(해당하는 경우))

eKOMPASS(특허청 내부 검색시스템) & 키워드: 부분 활성화, 완전 활성화, CSI, CSI-RS, 동작 설정 정보, 단말 능력

C. 관련 문헌

카테고리*	인용문헌명 및 관련 구절(해당하는 경우)의 기재	관련 청구항
Y	WO 2014-081262 A1 (LG ELECTRONICS INC.) 2014.05.30 단락 [0046], [0052]-[0061], [0072], [0111]-[0118], [0126]; 청구항 2-3; 및 도면 5 참조.	1,3,5-6,13
A		2,4,7-12
Y	HUAWEI 등, `On the support of TM10 with CA in Rel-11`, R1-131154, 3GPP TSG RAN WG1 Meeting #72bis, Chicago, USA, 2013.04.06 페이지 1-3; 및 테이블 1-2 참조.	1,3,5-6,13
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☐ 추가 문헌이 C(계속)이 기재되어 있습니다.

☒ 대응특허에 관한 별지를 참조하십시오.

* 인용된 문헌의 특별 카테고리

"A" 특별히 관련이 없는 것으로 보이는 일반적인 기술수준을 정의한 문헌

"B" 국제출원일보다 빠른 출원일 또는 우선일을 가지나 국제출원일 이후에 공개된 선출원 또는 특허 문헌

"L" 우선권 주장에 이문을 제기하는 문헌 또는 다른 인용문헌의 공개일 또는 다른 특별한 이유(이유를 명시)를 밝히기 위하여 인용된 문헌

"O" 구두 개시, 사용, 전시 또는 기타 수단을 언급하고 있는 문헌

"P" 우선일 이후에 공개되었으나 국제출원일 이전에 공개된 문헌

"T" 국제출원일 또는 우선일 후에 공개된 문헌으로, 출원과 상충하지 않으며 발명의 기초가 되는 원리나 이론을 이해하기 위해 인용된 문헌

"X" 특별한 관련이 있는 문헌. 해당 문헌 하나만으로 청구된 발명의 신규성 또는 진보성이 없는 것으로 본다.

"Y" 특별한 관련이 있는 문헌. 해당 문헌이 하나 이상의 다른 문헌과 조합하는 것으로 그 조합이 당업자에게 자명한 경우 청구된 발명은 진보성이 없는 것으로 본다.

"&" 동일한 대응특허문헌에 속하는 문헌

국제조사의 실제 완료일	국제조사보고서 발송일
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국 제 조 사 보 고 서
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(54) Title: PAGING FOR LOW COMPLEXITY USER EQUIPMENT AND/OR USER EQUIPMENT IN COVERAGE ENHANCEMENT MODE

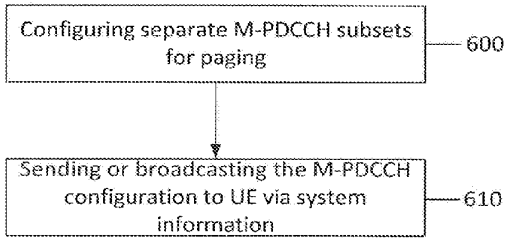


Fig. 6a

(57) Abstract: Systems, methods, apparatuses, and computer program products for paging of low complexity UE and/or UE in coverage enhancement mode are provided. One method includes producing a machine type communication (MTC) physical downlink control channel (M-PDCCH) configuration by configuring separate M-PDCCH subsets for paging. One of the subsets may be for low complexity user equipment, and another one of the subsets may be for user equipment operating in coverage enhancement mode.

PAGING FOR LOW COMPLEXITY USER EQUIPMENT AND/OR USER EQUIPMENT IN COVERAGE ENHANCEMENT MODE

BACKGROUND:

Field:

[0001] Embodiments of the invention generally relate to wireless or mobile communications networks, such as, but not limited to, the Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access Network (UTRAN), Long Term Evolution (LTE) Evolved UTRAN (E-UTRAN), LTE-Advanced (LTE-A), future 5G radio access technology, and/or High Speed Packet Access (HSPA). In particular, some embodiments may relate to paging.

Description of the Related Art:

[0002] Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access Network (UTRAN) refers to a communications network including base stations, or Node Bs, and for example radio network controllers (RNC). UTRAN allows for connectivity between the user equipment (UE) and the core network. The RNC provides control functionalities for one or more Node Bs. The RNC and its corresponding Node Bs are called the Radio Network Subsystem (RNS). In case of E-UTRAN (enhanced UTRAN), no RNC exists and radio access functionality is provided in the enhanced Node B (eNodeB or eNB) or many eNBs. Multiple eNBs are involved for a single UE connection, for example, in case of Coordinated Multipoint Transmission (CoMP) and in dual connectivity.

[0003] Long Term Evolution (LTE) or E-UTRAN provides a new radio access technology and refers to the improvements of UMTS through improved efficiency and services, lower costs, and use of new spectrum opportunities. In particular, LTE is a 3GPP standard that provides for uplink peak rates of at least, for example, 75 megabits per second (Mbps) per carrier and downlink peak rates of at least, for example, 300 Mbps per carrier. LTE supports scalable

carrier bandwidths from 20 MHz down to 1.4 MHz and supports both Frequency Division Duplexing (FDD) and Time Division Duplexing (TDD).

[0004] As mentioned above, LTE may also improve spectral efficiency in networks, allowing carriers to provide more data and voice services over a given bandwidth. Therefore, LTE is designed to fulfill the needs for high-speed data and media transport in addition to high-capacity voice support. Advantages of LTE include, for example, high throughput, low latency, FDD and TDD support in the same platform, an improved end-user experience, and a simple architecture resulting in low operating costs.

[0005] Certain releases of 3GPP LTE (e.g., LTE Rel-10, LTE Rel-11, LTE Rel-12, LTE Rel-13) are targeted towards international mobile telecommunications advanced (IMT-A) systems, referred to herein for convenience simply as LTE-Advanced (LTE-A).

[0006] LTE-A is directed toward extending and optimizing the 3GPP LTE radio access technologies. A goal of LTE-A is to provide significantly enhanced services by means of higher data rates and lower latency with reduced cost. LTE-A is a more optimized radio system fulfilling the international telecommunication union-radio (ITU-R) requirements for IMT-Advanced while keeping the backward compatibility. One of the key features of LTE-A, introduced in LTE Rel-10, is carrier aggregation, which allows for increasing the data rates through aggregation of two or more LTE carriers, e.g., to the transmission bandwidth of up to 100 MHz. LTE-A in later releases may include even wider bandwidths as specified so far. Further, aggregating or interworking on the radio access level with the wireless LAN (WLAN) access network is foreseen.

SUMMARY:

[0007] One embodiment is directed to a method, which may include configuring, by a network node, separate machine type communication (MTC)

physical downlink control channel (M-PDCCH) subsets for paging. One of the subsets is for low complexity user equipment and another one of the subsets is for user equipment operating in coverage enhancement mode.

[0008] Another embodiment is directed to an apparatus that includes at least one processor and at least one memory comprising computer program code. The at least one memory and the computer program code are configured, with the at least one processor, to cause the apparatus at least to configure separate machine type communication (MTC) physical downlink control channel (M-PDCCH) subsets for paging. One of the subsets is for low complexity user equipment and another one of the subsets is for user equipment operating in coverage enhancement mode.

[0009] Another embodiment is directed to an apparatus that may include configuring means for configuring separate machine type communication (MTC) physical downlink control channel (M-PDCCH) subsets for paging. One of the subsets is for low complexity user equipment and another one of the subsets is for user equipment operating in coverage enhancement mode.

[00010] Another embodiment is directed to a method, which may include calculating, by a user equipment, a paging occasion/paging frame (PO/PF). The method may also include deriving a machine type communication (MTC) physical downlink control channel (M-PDCCH) configuration. The M-PDCCH configuration comprises a starting subframe and repetition period of the M-PDCCH transmission.

[00011] Another embodiment is directed to an apparatus that includes at least one processor and at least one memory comprising computer program code. The at least one memory and the computer program code are configured, with the at least one processor, to cause the apparatus at least to calculate a paging occasion/paging frame (PO/PF), and derive a machine type communication (MTC) physical downlink control channel (M-PDCCH) configuration. The M-PDCCH configuration comprises a starting subframe and repetition period of the M-PDCCH transmission.

[00012] Another embodiment is directed to an apparatus that may include calculating means for calculating a paging occasion/paging frame (PO/PF), and deriving means for deriving a machine type communication (MTC) physical downlink control channel (M-PDCCH) configuration. The M-PDCCH configuration comprises a starting subframe and repetition period of the M-PDCCH transmission.

[00013] Another embodiment is directed to a method, which may include calculating a paging occasion/paging frame (PO/PF) according to a new paging cycle definition that links the PO/PF with a machine type communication (MTC) physical downlink control channel (M-PDCCH) configuration, and deriving a machine type communication (MTC) physical downlink control channel (M-PDCCH) configuration. The M-PDCCH configuration comprises a starting subframe and repetition period of the M-PDCCH transmission.

[00014] Another embodiment is directed to an apparatus that includes at least one processor and at least one memory comprising computer program code. The at least one memory and the computer program code are configured, with the at least one processor, to cause the apparatus at least to calculate a paging occasion/paging frame (PO/PF) according to a new paging cycle definition that links the PO/PF with a machine type communication (MTC) physical downlink control channel (M-PDCCH) configuration, and to derive a machine type communication (MTC) physical downlink control channel (M-PDCCH) configuration. The M-PDCCH configuration comprises a starting subframe and repetition period of the M-PDCCH transmission..

[00015] Another embodiment is directed to an apparatus that may include calculating means for calculating a paging occasion/paging frame (PO/PF) according to a new paging cycle definition that links the PO/PF with a machine type communication (MTC) physical downlink control channel (M-PDCCH) configuration, and deriving means for deriving a machine type communication (MTC) physical downlink control channel (M-PDCCH)

configuration. The M-PDCCH configuration comprises a starting subframe and repetition period of the M-PDCCH transmission.

BRIEF DESCRIPTION OF THE DRAWINGS:

[00016] For proper understanding of the invention, reference should be made to the accompanying drawings, wherein:

[00017] Fig. 1 illustrates an example M-PDCCH transmission and PO/PF, according to an embodiment;

[00018] Fig. 2 illustrates a M-PDCCH common search space configuration, according to an embodiment;

[00019] Fig. 3 illustrates an example M-PDCCH monitoring with paging cycle, according to an embodiment;

[00020] Fig. 4 illustrates an example of an enhanced paging cycle configuration, according to an embodiment;

[00021] Fig. 5a illustrates a block diagram of an apparatus, according to an embodiment;

[00022] Fig. 5b illustrates a block diagram of an apparatus, according to another embodiment;

[00023] Fig. 6a illustrates a flow diagram of a method, according to one embodiment;

[00024] Fig. 6b illustrates a flow diagram of a method, according to another embodiment;

[00025] Fig. 6c illustrates a flow diagram of a method, according to another embodiment;

[00026] Fig. 7a illustrates a block diagram of an apparatus, according to one embodiment; and

[00027] Fig. 7b illustrates a block diagram of an apparatus, according to another embodiment.

DETAILED DESCRIPTION:

[00028] It will be readily understood that the components of the invention, as generally described and illustrated in the figures herein, may be arranged and designed in a wide variety of different configurations. Thus, the following detailed description of embodiments of systems, methods, apparatuses, and computer program products for paging of low complexity UE and/or UE in coverage enhancement mode, as represented in the attached figures, is not intended to limit the scope of the invention, but is merely representative of some selected embodiments of the invention.

[00029] The features, structures, or characteristics of the invention described throughout this specification may be combined in any suitable manner in one or more embodiments. For example, the usage of the phrases "certain embodiments," "some embodiments," or other similar language, throughout this specification refers to the fact that a particular feature, structure, or characteristic described in connection with the embodiment may be included in at least one embodiment of the present invention. Thus, appearances of the phrases "in certain embodiments," "in some embodiments," "in other embodiments," or other similar language, throughout this specification do not necessarily all refer to the same group of embodiments, and the described features, structures, or characteristics may be combined in any suitable manner in one or more embodiments.

[00030] Additionally, if desired, the different functions discussed below may be performed in a different order and/or concurrently with each other. Furthermore, if desired, one or more of the described functions may be optional or may be combined. As such, the following description should be considered as merely illustrative of the principles, teachings and embodiments of this invention, and not in limitation thereof.

[00031] Certain embodiments of the invention relate to paging. Paging may be used to notify user equipment (UE) in idle state about incoming data connections. It may be transmitted on the physical downlink shared channel (PDSCH) which is scheduled by the physical downlink control channel

(PDCCH) over air interface. A UE in radio resource control (RRC) Idle mode uses discontinuous reception (DRX) to reduce power consumption, which determines how frequently the UE check for paging messages and wakes from specific paging occasion/paging frame (PO/PF) to monitor PDCCH for potential paging message.

[00032] 3GPP Rel-13 includes a work item entitled "Further LTE Physical Layer Enhancements for MTC" [RP-150492]. The purpose of this work item is to specify a new low-complexity UE for machine type communications (MTC) operation in LTE, to support coverage enhancement (CE) for both Rel-13 low-complexity UE and UE operating in CE compared to existing LTE networks. RAN1 #81 agreed that the paging message is scheduled by MTC PDCCH (M-PDCCH) and a starting subframe of an M-PDCCH UE-specific search space is configured at least for enhanced coverage.

[00033] More specifically, the work item looks at the issue whereby, for MTC, the M-PDCCH has to be repeated numerous times depending on the specific coverage enhancement requirements of UEs. However, if there is a misalignment between the paging cycle and the M-PDCCH, the M-PDCCH may be incorrectly decoded. For example, such incorrect decoding may occur when the PO is not the starting subframe of the M-PDCCH transmission and the UE starts detecting M-PDCCH for paging from the PO which happens in the middle of the M-PDCCH repetitions. Fig. 1 illustrates an example M-PDCCH transmission and PO/PF, where the PO is not the starting subframe of the M-PDCCH transmission and the UE starts detecting M-PDCCH for paging from the PO. Therefore, it would be desirable to match the M-PDCCH and paging cycle setting to the extent possible.

[00034] Thus, embodiments of the invention aim to match the settings of both the paging cycle and the M-PDCCH. One embodiment is for the eNB to configure the M-PDCCH common search space for paging so that separate search subset spaces are formed: one for low complexity UEs, and one for enhanced mode UEs and broadcasted to all UEs in the cell.

[00035] Certain embodiments are directed to solutions for configuring the M-PDCCH common searching space for paging message and enhanced paging monitoring procedure for low complexity UEs and UEs in coverage enhancement mode. The M-PDCCH common search space is made up of multiple search units from the beginning of each M-PDCCH repetition period. One search unit includes a group of subframes, the length of which is determined, for example, by the minimum of supported number of repetitions for transmitting an M-PDCCH downlink control information (DCI) for CE mode UEs.

[00036] The common search space and the UE specific search space can be overlapped in time domain. Fig. 2 illustrates a M-PDCCH common search space configuration, where M-PDCCH CSS is comprised of four search units. In the example of Fig. 2, four candidates (candidate 0-3) are defined with the same number of repetitions, with each mapped to one respective search unit. Candidates 4-6 are mapped to two or more search units respectively. That is to say, there are candidates mapped to different number of repetitions. The length of M-PDCCH CSS can be configured through broadcasting signaling.

[00037] In an embodiment, the eNB configures separate M-PDCCH subset {L,R} for paging, one {L,R} subset for low complexity UEs and another {L,R} subset for UE operating in coverage enhancement mode, where L is enhanced control channel element (eCCE) aggregation level and R is the number of repetitions. The eNB may also configure the starting subframe of a M-PDCCH UE-specific search space at least for UE in enhanced coverage. The M-PDCCH configuration may also be broadcast to UE via system information. In an embodiment, a subset may be considered to be equivalent to a UE search space (either UE-specific or common).

[00038] Therefore, according to certain embodiments, a subset may contain multiple {L,R} values that comprises the UE search space (e.g., {24,8}, {24,16}, {24,32}). As such, in this embodiment, a subset equals the UE search space.

[00039] According to an embodiment, a UE starts monitoring M-PDCCH from the nearest configured M-PDCCH allocation (starting subframe of this M-PDCCH repetitions) after the calculated PO/PF. For example, in this embodiment, the UE may calculate the PO/PF with the existing equation specified in 3GPP TS 36.304, and derive the M-PDCCH configuration (starting subframe and the repetition number of the M-PDCCH transmission) from system information. Unlike existing paging monitoring procedure, in this embodiment, the UE wakes up from the nearest M-PDCCH configuration (starting subframe of this M-PDCCH repetition) after the calculated PO/PF. Fig. 3 illustrates an example M-PDCCH monitoring with paging cycle, according to this embodiment. It is noted that the M-PDCCH starting subframes may be different for different coverage enhancement levels and also for different UEs (e.g., to provide load balancing and reduce blocking probability).

[00040] In addition, a window containing multiple M-PDCCH decoding opportunities (i.e., {L, R} search spaces) in time may be defined. This can help reduce blocking probability but may require the UE to perform additional blind decodings which may increase power consumption. This window size may be configured by the eNB.

[00041] According to another embodiment, a new paging cycle definition is introduced by using one M-PDCCH repetition period as the minimum unit. One example is the paging cycle being: {32pr, 64pr, 128pr, 256pr}, where pr represents the M-PDCCH repetition period. The existing paging cycle range is {32rf, 64rf, 128rf, 256rf}, where value 32rf corresponds to 32 radio frames, 64rf corresponds to 64 radio frames, and so on. However, the repetition of M-PDCCH may occupy 10rf (100 subframes) in the worst case (i.e., the M-PDCCH may need to repeat more than 100 subframes in the worst case), so the paging cycle may need to be extended accordingly to guarantee the desired power saving.

[00042] Therefore, considering the repetition requirement of M-PDCCH, in this embodiment, a new parameter is introduced to count the bundle of M-PDCCH repetitions (or the repetition period of M-PDCCH). This new parameter may be named, for example, as MPN. However, other naming conventions may be used, and MPN is used herein as one example for the sake of simplicity. The MPN could be derived from the system frame number (SFN). For example, where each repetition period of M-PDCCH has M system frame(s) (M could be 2, 4, 8, 16), then MPN = SFN/M.

[00043] An embodiment extends the paging cycle to {32pr, 64pr, 128pr, 256pr}, where pr refers to the M-PDCCH repetition period, such that 32pr equals 32 M-PDCCH repetition periods and so on. The UE may then derive the M-PDCCH repetition period from the existing equation with following update: MPN mod T= (T div N) × (UE_ID mod N), where T is the DRX cycle duration in the number of M-PDCCH repetition period, N is given by Min(T, nB), nB belongs to the set {4T, 2T, T, T/2, T/4, T/8, T/16, T/32}, and UE_ID = IMSI mod (1024/M) (M is the duration of the repetition period of M-PDCCH, could be 2,4, 8 ...). The paging occasion (PO) may be determined by the starting subframe of the M-PDCCH repetition period, and the UE starts receiving M-PDCCH for potential paging from this subframe.

[00044] Fig. 4 illustrates an example of an enhanced paging cycle configuration, where the paging cycle is configured as 32pr which means one paging cycle contains 32 M-PDCCH repetition periods and each modification period contains 4 system frames (which means M = 4). The MPN of the M-PDCCH repetition period for monitoring paging is 4, 36, ..., and the PO is the starting subframe within each M-PDCCH repetition period for paging. It is noted that the M-PDCCH repetition pattern is preconfigured and the starting subframe is not necessarily the subframe# 0 of a system frame, in Fig. 4, the PO of MPN #4 is subframe #5 of SFN #20.

[00045] Fig. 5a illustrates an example of an apparatus 10 according to an embodiment. In an embodiment, apparatus 10 may be a node, host, or server

in a communications network or serving such a network. For example, in certain embodiments, apparatus 10 may be a network node or access node for a radio access network, such as a base station in UMTS or eNB in LTE or LTE-A. However, in other embodiments, apparatus 10 may be other components within a radio access network. It should be noted that one of ordinary skill in the art would understand that apparatus 10 may include components or features not shown in Fig. 5a.

[00046] As illustrated in Fig. 5a, apparatus 10 includes a processor 22 for processing information and executing instructions or operations. Processor 22 may be any type of general or specific purpose processor. While a single processor 22 is shown in Fig. 5a, multiple processors may be utilized according to other embodiments. In fact, processor 22 may include one or more of general-purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs), field-programmable gate arrays (FPGAs), application-specific integrated circuits (ASICs), and processors based on a multi-core processor architecture, as examples.

[00047] Apparatus 10 may further include or be coupled to a memory 14 (internal or external), which may be coupled to processor 22, for storing information and instructions that may be executed by processor 22. Memory 14 may be one or more memories and of any type suitable to the local application environment, and may be implemented using any suitable volatile or nonvolatile data storage technology such as a semiconductor-based memory device, a magnetic memory device and system, an optical memory device and system, fixed memory, and removable memory. For example, memory 14 can be comprised of any combination of random access memory (RAM), read only memory (ROM), static storage such as a magnetic or optical disk, or any other type of non-transitory machine or computer readable media. The instructions stored in memory 14 may include program instructions or computer program code that, when executed by processor 22, enable the apparatus 10 to perform tasks as described herein.

[00048] In some embodiments, apparatus 10 may also include or be coupled to one or more antennas 25 for transmitting and receiving signals and/or data to and from apparatus 10. Apparatus 10 may further include or be coupled to a transceiver 28 configured to transmit and receive information. For instance, transceiver 28 may be configured to modulate information on to a carrier waveform for transmission by the antenna(s) 25 and demodulate information received via the antenna(s) 25 for further processing by other elements of apparatus 10. In other embodiments, transceiver 28 may be capable of transmitting and receiving signals or data directly.

[00049] Processor 22 may perform functions associated with the operation of apparatus 10 which may include, for example, precoding of antenna gain/phase parameters, encoding and decoding of individual bits forming a communication message, formatting of information, and overall control of the apparatus 10, including processes related to management of communication resources.

[00050] In an embodiment, memory 14 may store software modules that provide functionality when executed by processor 22. The modules may include, for example, an operating system that provides operating system functionality for apparatus 10. The memory may also store one or more functional modules, such as an application or program, to provide additional functionality for apparatus 10. The components of apparatus 10 may be implemented in hardware, or as any suitable combination of hardware and software.

[00051] In one embodiment, apparatus 10 may be a network node or access node, such as a base station in UMTS or an eNB in LTE or LTE-A, for example. According to certain embodiments, apparatus 10 may be controlled by memory 14 and processor 22 to produce or generate a M-PDCCH configuration by configuring separate M-PDCCH subsets for paging. In an embodiment, one of the subsets is for low complexity user equipment and

another one of the subsets is for user equipment operating in coverage enhancement mode.

[00052] According to one embodiment, each of the subsets may include an enhanced control channel element (eCCE) aggregation level and a number of repetitions. In some embodiments, apparatus 10 may be further controlled by memory 14 and processor 22 to broadcast the M-PDCCH configuration to UE(s) via system information. Also, in an embodiment, apparatus 10 may be further controlled by memory 14 and processor 22 to configure a starting subframe of the M-PDCCH UE-specific search space at least for UE(s) in enhanced coverage.

[00053] Fig. 5b illustrates an example of an apparatus 20 according to another embodiment. In an embodiment, apparatus 20 may be a node or element in a communications network or associated with such a network, such as a UE, mobile device, mobile unit, a machine type UE or other device. For instance, in some embodiments, apparatus 20 may be UE in LTE or LTE-A. It should be noted that one of ordinary skill in the art would understand that apparatus 20 may include components or features not shown in Fig. 5b.

[00054] As illustrated in Fig. 5b, apparatus 20 includes a processor 32 for processing information and executing instructions or operations. Processor 32 may be any type of general or specific purpose processor. While a single processor 32 is shown in Fig. 5b, multiple processors may be utilized according to other embodiments. In fact, processor 32 may include one or more of general-purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs), field-programmable gate arrays (FPGAs), application-specific integrated circuits (ASICs), and processors based on a multi-core processor architecture, as examples.

[00055] Apparatus 20 may further include or be coupled to a memory 34 (internal or external), which may be coupled to processor 32, for storing information and instructions that may be executed by processor 32. Memory 34 may be one or more memories and of any type suitable to the local

application environment, and may be implemented using any suitable volatile or nonvolatile data storage technology such as a semiconductor-based memory device, a magnetic memory device and system, an optical memory device and system, fixed memory, and removable memory. For example, memory 34 can be comprised of any combination of random access memory (RAM), read only memory (ROM), static storage such as a magnetic or optical disk, or any other type of non-transitory machine or computer readable media. The instructions stored in memory 34 may include program instructions or computer program code that, when executed by processor 32, enable the apparatus 20 to perform tasks as described herein.

[00056] In some embodiments, apparatus 20 may also include or be coupled to one or more antennas 35 for transmitting and receiving signals and/or data to and from apparatus 20. Apparatus 20 may further include a transceiver 38 configured to transmit and receive information. For instance, transceiver 38 may be configured to modulate information on to a carrier waveform for transmission by the antenna(s) 35 and demodulate information received via the antenna(s) 35 for further processing by other elements of apparatus 20. In other embodiments, transceiver 38 may be capable of transmitting and receiving signals or data directly.

[00057] Processor 32 may perform functions associated with the operation of apparatus 20 including, without limitation, precoding of antenna gain/phase parameters, encoding and decoding of individual bits forming a communication message, formatting of information, and overall control of the apparatus 20, including processes related to management of communication resources.

[00058] In an embodiment, memory 34 stores software modules that provide functionality when executed by processor 32. The modules may include, for example, an operating system that provides operating system functionality for apparatus 20. The memory may also store one or more functional modules, such as an application or program, to provide additional functionality for

apparatus 20. The components of apparatus 20 may be implemented in hardware, or as any suitable combination of hardware and software.

[00059] As mentioned above, according to one embodiment, apparatus 20 may be a mobile device, such as a UE in LTE or LTE-A. In one embodiment, apparatus 20 may be controlled by memory 34 and processor 32 to calculate a paging occasion/paging frame (PO/PF) according to legacy equations (e.g., the equations defined in TS 36.304), and to derive a M-PDCCH configuration. The M-PDCCH configuration may include a starting subframe and repetition period of the M-PDCCH transmission.

[00060] In an embodiment, apparatus 20 may be controlled to derive the M-PDCCH configuration from system information. In some embodiments, apparatus 20 may also be controlled by memory 34 and processor 32 to wake up from nearest M-PDCCH configuration after the calculated paging occasion/paging frame (PO/PF).

[00061] According to another embodiment, apparatus 20 may be controlled by memory 34 and processor 32 to calculate PO/PF according to a new paging cycle definition that links the PO/PF with M-PDCCH configuration (that is, the DRX cycle is associated with the M-PDCCH period and the PO is actually the starting subframe within a M-PDCCH period). Apparatus 20 may be controlled, for example, to derive the M-PDCCH repetition period for potential paging according to the following formula: MPN mod T = (T div N) x (UE_ID mod N), where MPN is a parameter for counting the repetition period of M-PDCCH, T is the discontinuous reception cycle duration in the number of M-PDCCH repetition period, N is given by Min(T, nB), nB belongs to the set {4T, 2T, T, T/2, T/4, T/8, T/16, T/32}, and UE_ID = International Mobile Subscriber Identity (IMSI) mod (1024/M), and where M is a duration of the repetition period of M-PDCCH. In one embodiment, MPN = SFN/M, where SFN is system frame number and M is the number of system frames.

[00062] According to certain embodiments, apparatus 20 may be controlled by memory 34 and processor 32 to extend a paging cycle range. In one

embodiment, the paging cycle may be extended to {32pr, 64pr, 128pr, 256pr}, where pr refers to the M-PDCCH repetition period.

[00063] According to certain embodiments, apparatus 20 may be controlled to determine the paging occasion (PO) by starting subframe of M-PDCCH repetition period. In an embodiment, apparatus 20 may then be controlled to start receiving M-PDCCH for potential paging from the starting subframe.

[00064] Fig. 6a illustrates an example flow diagram of a method for producing or generating a M-PDCCH configuration, according to one embodiment of the invention. In certain embodiments, the method of Fig. 6a may be performed by a network node, such as a base station or eNB. As illustrated in Fig. 6a, the method may include, at 600, configuring separate M-PDCCH subsets for paging. One of the subsets may be for low complexity user equipment and another one of the subsets may be for user equipment operating in coverage enhancement mode. According to some embodiments, each of the subsets may include an enhanced control channel element (eCCE) aggregation level and a number of repetitions. In an embodiment, the method may further include, at 610, sending or broadcasting the M-PDCCH configuration to UE via system information. In certain embodiments, the method may also include configuring a starting subframe of a M-PDCCH UE-specific search space at least for UE(s) in enhanced coverage.

[00065] Fig. 6b illustrates an example flow diagram of a method for producing or generating a M-PDCCH configuration, according to one embodiment of the invention. In certain embodiments, the method of Fig. 6b may be performed by a device, such as a UE in LTE or LTE-A. As illustrated in Fig. 6b, the method may include, at 620, calculating a paging occasion/paging frame (PO/PF) according to the legacy PO/PF calculation (e.g., as defined in TS 36.304) and, at 630, deriving a M-PDCCH configuration. The M-PDCCH configuration may include a starting subframe and repetition period of the M-PDCCH transmission.

[00066] In certain embodiments, the deriving step may further include deriving the M-PDCCH configuration from system information. In an embodiment, the method of Fig. 6b may also include, at 640, waking up at the nearest M-PDCCH configuration after the calculated paging occasion/paging frame (PO/PF).

[00067] Fig. 6c illustrates an example flow diagram of a method, according to another embodiment. In certain embodiments, the method of Fig. 6c may be performed by a device, such as a UE in LTE or LTE-A. As illustrated in Fig. 6c, the method may include, at 650, calculating PO/PF according to a new paging cycle definition that links the PO/PF with M-PDCCH configuration and, at 655, deriving a machine type communication (MTC) physical downlink control channel (M-PDCCH) configuration. The M-PDCCH configuration may include a starting subframe and repetition period of the M-PDCCH transmission.

[00068] In this embodiment, the DRX cycle is associated with the M-PDCCH period and the PO is actually the starting subframe within a M-PDCCH period. In one example, the M-PDCCH repetition period for potential paging may be derived according to the following formula: MPN mod T = (T div N) x (UE_ID mod N), where MPN is a parameter for counting the repetition period of M-PDCCH, T is the discontinuous reception cycle duration in the number of M-PDCCH repetition period, N is given by Min(T, nB), nB belongs to the set {4T, 2T, T, T/2, T/4, T/8, T/16, T/32}, and UE_ID = International Mobile Subscriber Identity (IMSI) mod (1024/M), and where M is a duration of the repetition period of M-PDCCH. According to some embodiments, the MPN may be equal to SFN/M, where SFN is system frame number and M is the number of system frames.

[00069] According to an embodiment, the method of Fig. 6c may also include extending a paging cycle range. In one embodiment, the extending of the paging cycle range may include extending the paging cycle to {32pr, 64pr, 128pr, 256pr}, where pr refers to the M-PDCCH repetition period.

[00070] According to some embodiments, the calculating step may further include determining the paging occasion (PO) by starting subframe of M-PDCCH repetition period. The method may then include, at 660, starting receiving M-PDCCH for potential paging from the starting subframe.

[00071] Fig. 7a illustrates an example block diagram of an apparatus 700, according to an embodiment. In certain embodiments, apparatus 700 may be a base station or eNB, for example. As illustrated in the example of Fig. 7a, apparatus 700 may include a configuring unit or means 710 and a transceiving unit or means 720 for receiving or transmitting information. In some embodiments, apparatus 700 may also include a storage unit or means, which is not shown.

[00072] According to an embodiment, configuring unit 710 may configure separate machine type communication (MTC) physical downlink control channel (M-PDCCH) subsets for paging. One of the subsets may be for low complexity UE and another one of the subsets may be for UE operating in coverage enhancement mode. Each of the subsets may include an enhanced control channel element (eCCE) aggregation level and a number of repetitions.

[00073] In an embodiment, transceiving unit 720 may send or broadcast M-PDCCH configuration to UE via system information. In some embodiments, configuring unit 710 may also configure a starting subframe of a M-PDCCH UE-specific search space at least for UE in enhanced coverage.

[00074] Fig. 7b illustrates an example block diagram of an apparatus 701, according to another embodiment. In certain embodiments, apparatus 701 may be a mobile device or UE, for example. As illustrated in the example of Fig. 7b, apparatus 701 may include a calculating unit or means 730, a deriving unit or means 740, an extending unit or means 750, a waking unit or means 760, and a transceiving unit or means 770 for receiving or transmitting information. In some embodiments, apparatus 701 may also include a storage unit or means, which is not shown.

[00075] According to an embodiment, calculating unit 730 may calculate a paging occasion/paging frame (PO/PF), for example, according to legacy equation(s), and deriving unit 740 may derive a M-PDCCH configuration. The M-PDCCH configuration may include a starting subframe and repetition period of the M-PDCCH transmission.

[00076] In one embodiment, deriving unit 740 may derive the M-PDCCH configuration from system information. According to some embodiments, waking unit 760 may wake up at the nearest M-PDCCH configuration after the calculated paging occasion/paging frame (PO/PF).

[00077] In another embodiment, calculating unit 730 may calculate a paging occasion/paging frame (PO/PF) according to a new paging cycle definition that links the PO/PF with M-PDCCH configuration, and deriving unit 740 may derive a M-PDCCH configuration. For example, in this embodiment, the DRX cycle is associated with the M-PDCCH period and the PO is actually the starting subframe within a M-PDCCH period. In this embodiment, deriving unit 740 may derive the M-PDCCH repetition period for potential paging according to the following formula: MPN mod T = (T div N) x (UE_ID mod N), where MPN is a parameter for counting the repetition period of M-PDCCH, T is the discontinuous reception cycle duration in the number of M-PDCCH repetition period, N is given by Min(T, nB), nB belongs to the set {4T, 2T, T, T/2, T/4, T/8, T/16, T/32}, and UE_ID = International Mobile Subscriber Identity (IMSI) mod (1024/M), and where M is a duration of the repetition period of M-PDCCH. In an embodiment, MPN may be equal to SFN/M, where SFN is system frame number and M is the number of system frames.

[00078] In certain embodiments, extending unit 750 may extend a paging cycle range. In one embodiment, the paging cycle may be extended to {32pr, 64pr, 128pr, 256pr}, where pr refers to the M-PDCCH repetition period. In one embodiment, calculating unit 730 may determine the paging occasion by starting subframe of M-PDCCH repetition period. Transceiving unit 770 may start receiving M-PDCCH for potential paging from the starting subframe.

[00079] In view of the above, embodiments of the invention may provide several advantages and technical improvements. For example, certain embodiments ensure the reliable M-PDCCH reception for detecting paging message for 3GPP Rel-13 low complexity UEs and UEs in coverage enhancement mode.

[00080] According to embodiments, programs, also called program products or computer programs, including software routines, applets and macros, may be stored in any apparatus-readable data storage medium and they include program instructions to perform particular tasks. A computer program product may comprise one or more computer-executable components which, when the program is run, are configured to carry out embodiments. The one or more computer-executable components may be at least one software code or portions of it. Modifications and configurations required for implementing functionality of an embodiment may be performed as routine(s), which may be implemented as added or updated software routine(s). Software routine(s) may be downloaded into the apparatus.

[00081] Software or a computer program code or portions of it may be in a source code form, object code form, or in some intermediate form, and it may be stored in some sort of carrier, distribution medium, or computer readable medium, which may be any entity or device capable of carrying the program. Such carriers include a record medium, computer memory, read-only memory, photoelectrical and/or electrical carrier signal, telecommunications signal, and software distribution package, for example. Depending on the processing power needed, the computer program may be executed in a single electronic digital computer or it may be distributed amongst a number of computers. The computer readable medium or computer readable storage medium may be a non-transitory medium.

[00082] In other embodiments, the functionality of any method or apparatus described herein may be performed by hardware, for example through the use of an application specific integrated circuit (ASIC), a programmable gate

array (PGA), a field programmable gate array (FPGA), or any other combination of hardware and software. In yet another embodiment, the functionality may be implemented as a signal, a non-tangible means that may be carried by an electromagnetic signal downloaded from the Internet or other network.

[00083] According to an embodiment, an apparatus, such as a node, device, or a corresponding component, may be configured as a computer or a microprocessor, such as single-chip computer element, or as a chipset, including at least a memory for providing storage capacity used for arithmetic operation and an operation processor for executing the arithmetic operation.

[00084] One having ordinary skill in the art will readily understand that the invention as discussed above may be practiced with steps in a different order, and/or with hardware elements in configurations which are different than those which are disclosed. Therefore, although the invention has been described based upon these preferred embodiments, it would be apparent to those of skill in the art that certain modifications, variations, and alternative constructions would be apparent, while remaining within the spirit and scope of the invention. In order to determine the metes and bounds of the invention, therefore, reference should be made to the appended claims.

WHAT IS CLAIMED IS:

1. A method, comprising:

configuring, by a network node, separate machine type communication (MTC) physical downlink control channel (M-PDCCH) subsets for paging,

wherein one of the subsets is for low complexity user equipment and another one of the subsets is for user equipment operating in coverage enhancement mode.

2. The method according to claim 1, wherein each of the subsets comprise a plurality of pairs that are each comprised of enhanced control channel element (eCCE) aggregation level and a number of repetitions.

3. The method according to any one of claims 1 or 2, further comprising broadcasting the machine type communication (MTC) physical downlink control channel (M-PDCCH) configuration to user equipment via system information.

4. The method according to any one of claims 1-3, further comprising configuring a starting subframe of a machine type communication (MTC) physical downlink control channel (M-PDCCH) user equipment-specific search space at least for user equipment in enhanced coverage.

5. An apparatus, comprising:

at least one processor; and

at least one memory comprising computer program code,

the at least one memory and the computer program code are configured, with the at least one processor, to cause the apparatus at least to

configure separate machine type communication (MTC) physical downlink control channel (M-PDCCH) subsets for paging,

wherein one of the subsets is for low complexity user equipment and another one of the subsets is for user equipment operating in coverage enhancement mode.

6. An apparatus, comprising:

configuring means for configuring separate machine type communication (MTC) physical downlink control channel (M-PDCCH) subsets for paging,

wherein one of the subsets is for low complexity user equipment and another one of the subsets is for user equipment operating in coverage enhancement mode.

7. The apparatus according to claim 6, wherein each of the subsets comprise an enhanced control channel element (eCCE) aggregation level and a number of repetitions.

8. The apparatus according to any one of claims 6 or 7, further comprising broadcasting means for broadcasting the machine type communication (MTC) physical downlink control channel (M-PDCCH) configuration to user equipment via system information.

9. The apparatus according to any one of claims 6-8, further comprising configuring means for configuring a starting subframe of a machine type communication (MTC) physical downlink control channel (M-PDCCH) user equipment-specific search space at least for user equipment in enhanced coverage.

10. A method, comprising:

calculating, by a user equipment, a paging occasion/paging frame (PO/PF); and

deriving a machine type communication (MTC) physical downlink control channel (M-PDCCH) configuration,

wherein the M-PDCCH configuration comprises at least one of a starting subframe or repetition period of the M-PDCCH transmission.

11. The method according to 10, further comprising waking up at nearest M-PDCCH configuration after the calculated paging occasion/paging frame (PO/PF).

12. The method according to claim 10, wherein the deriving comprises deriving the M-PDCCH configuration from system information.

13. A method, comprising:

calculating a paging occasion/paging frame (PO/PF) according to a paging cycle definition that links the PO/PF with a machine type communication (MTC) physical downlink control channel (M-PDCCH) configuration,

deriving a machine type communication (MTC) physical downlink control channel (M-PDCCH) configuration,

wherein the M-PDCCH configuration comprises a starting subframe and repetition period of the M-PDCCH transmission.

14. The method according to claim 13, wherein the deriving further comprises deriving the M-PDCCH repetition period for potential paging according to the following formula:

$$MPN \bmod T = (T \operatorname{div} N) \times (UE_ID \bmod N),$$

where MPN is a parameter for counting the repetition period of M-PDCCH, T is the discontinuous reception cycle duration in the number of M-PDCCH repetition period, N is given by Min(T, nB), nB belongs to the set {4T, 2T, T, T/2, T/4, T/8, T/16, T/32}, and UE_ID = International Mobile Subscriber

Identity (IMSI) mod (1024/M), where M is a duration of the repetition period of M-PDCCH.

15. The method according to claim 14, wherein MPN = SFN/M, where SFN is system frame number and M is the number of system frames contained in one repetition period of M-PDCCH.

16. The method according to claim 13, further comprising extending a paging cycle range.

17. The method according to claim 16, wherein the extending further comprises extending the paging cycle to {32pr, 64pr, 128pr, 256pr}, where pr refers to the M-PDCCH repetition period.

18. The method according to claim 13, wherein the calculating further comprises determining the paging occasion by starting subframe of M-PDCCH repetition period.

19. The method according to claim 18, further comprising starting receiving M-PDCCH for potential paging from the starting subframe.

20. An apparatus, comprising:

at least one processor; and

at least one memory comprising computer program code,

the at least one memory and the computer program code are configured, with the at least one processor, to cause the apparatus at least to

calculate a paging occasion/paging frame (PO/PF); and

derive a machine type communication (MTC) physical downlink control channel (M-PDCCH) configuration,

wherein the M-PDCCH configuration comprises a starting subframe and

repetition period of the M-PDCCH transmission.

21. An apparatus, comprising:

calculating means for calculating a paging occasion/paging frame (PO/PF); and

deriving means for deriving a machine type communication (MTC) physical downlink control channel (M-PDCCH) configuration,

wherein the M-PDCCH configuration comprises a starting subframe and repetition period of the M-PDCCH transmission.

22. The apparatus according to 21, further comprising waking means for waking up from nearest M-PDCCH configuration after the calculated paging occasion/paging frame (PO/PF).

23. The apparatus according to claim 20, wherein the deriving means comprises means for deriving the M-PDCCH configuration from system information.

24. An apparatus, comprising:

calculating means for calculating a paging occasion/paging frame (PO/PF) according to a paging cycle definition that links the PO/PF with a machine type communication (MTC) physical downlink control channel (M-PDCCH) configuration,

deriving means for deriving a machine type communication (MTC) physical downlink control channel (M-PDCCH) configuration,

wherein the M-PDCCH configuration comprises a starting subframe and repetition period of the M-PDCCH transmission.

25. The apparatus according to claim 24, further comprising deriving means for deriving the M-PDCCH repetition period for potential paging according to the following formula:

MPN mod T = (T div N) x (UE_ID mod N),

where MPN is a parameter for counting the repetition period of M-PDCCH, T is the discontinuous reception cycle duration in the number of M-PDCCH repetition period, N is given by Min(T, nB), nB belongs to the set {4T, 2T, T, T/2, T/4, T/8, T/16, T/32}, and UE_ID = International Mobile Subscriber Identity (IMSI) mod (1024/M), where M is a duration of the repetition period of M-PDCCH.

26. The apparatus according to claim 25, wherein MPN = SFN/M, where SFN is system frame number and M is the number of system frames.

27. The apparatus according to claim 24, further comprising extending means for extending a paging cycle range.

28. The apparatus according to claim 27, wherein the extending means further comprises means for extending the paging cycle to {32pr, 64pr, 128pr, 256pr}, where pr refers to the M-PDCCH repetition period.

29. The apparatus according to claim 24, wherein the calculating means further comprises means for determining the paging occasion by starting subframe of M-PDCCH repetition period.

30. The apparatus according to claim 29, further comprising receiving means for starting receiving M-PDCCH for potential paging from the starting subframe.

31. A computer program, embodied on a non-transitory computer readable medium, the computer program configured to control a processor to perform a process according to any one of claims 1-4 or 10-19.

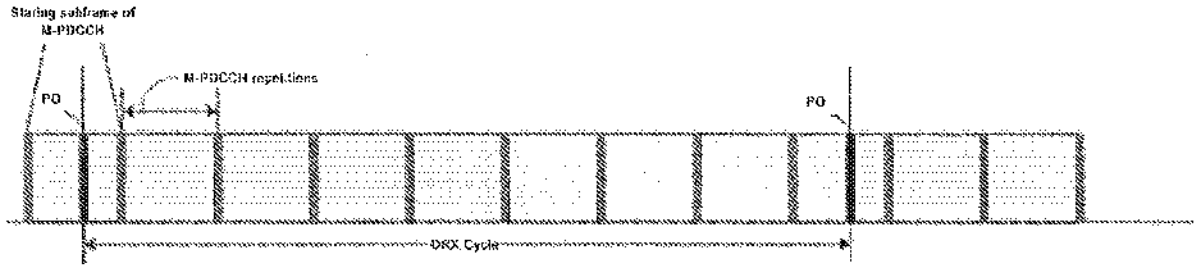

Starting subframe of M-PDCCH
PO
M-PDCCH repetitions
PO
DRX Cycle

Fig. 1

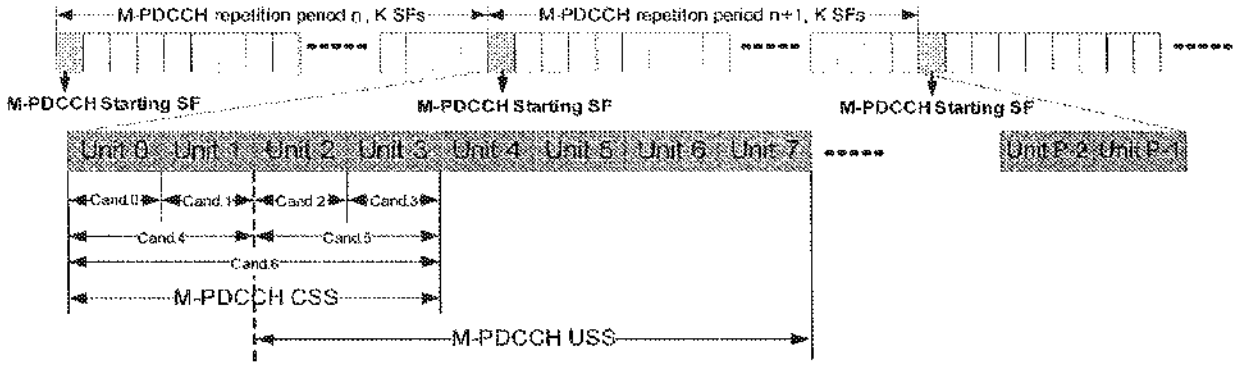

M-PDCCH repetition period n , K SFs
M-PDCCH repetition period n+1, K SFs
M-PDCCH Starting SF
M-PDCCH Starting SF
M-PDCCH Starting SF
Unit 0
Unit 1
Unit 2
Unit 3
Unit 4
Unit 5
Unit 6
Unit 7
Unit P-2
Unit P-1
Cand.0
Cand.1
Cand.2
Cand.3
Cand.4
Cand.5
Cand.6
M-PDCCH CSS
M-PDCCH USS

Fig. 2

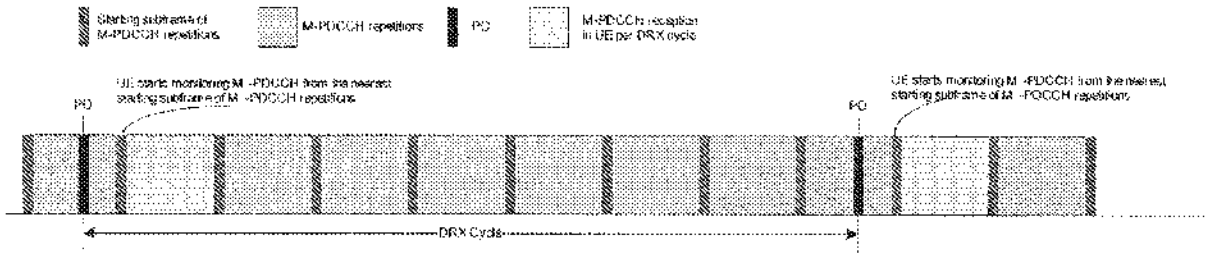

Starting subframe of M-PDCCH repetitions
M-PDCCH repetitions
PO
M-PDCCH reception in UE per DRX cycle
UE starts monitoring M -PDCCH from the nearest starting subframe of M -PDCCH repetitions
PO
UE starts monitoring M -PDCCH from the nearest starting subframe of M -PDCCH repetitions
DRX Cycle

Fig. 3

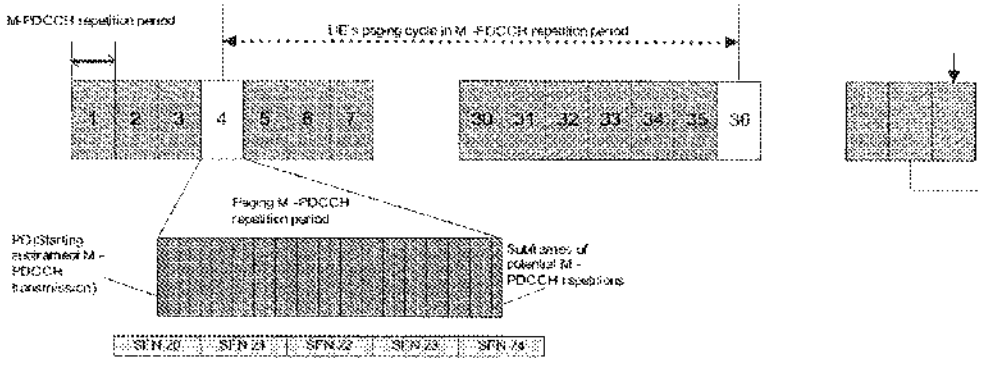

M-PDCCH repetition period
UE's paging cycle in M -PDCCH repetition period
1
2
3
4
5
6
7
30
31
32
33
34
35
36
Paging M -PDCCH repetition period
PO (Starting subframe of M -PDCCH transmission)
Subframes of potential M -PDCCH repetitions
SFN /0
SFN /1
SFN /2
SFN /3
SFN /4

Fig. 4

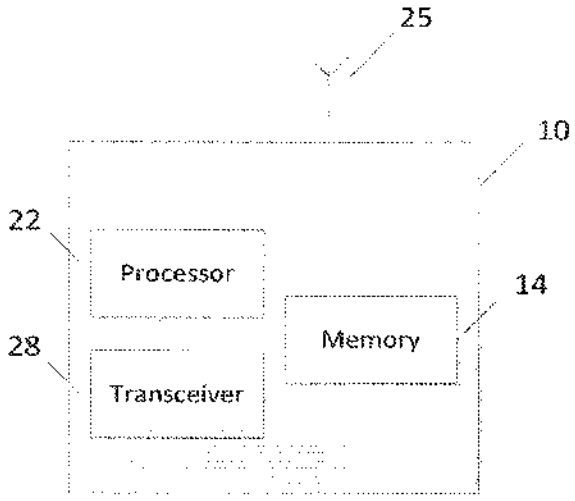

25
10
22
Processor
14
Memory
28
Transceiver

Fig. 5a

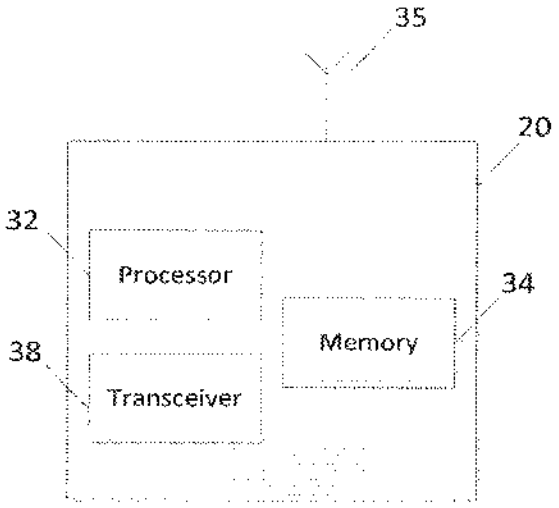

35
20
32
Processor
34
Memory
38
Transceiver

Fig. 5b

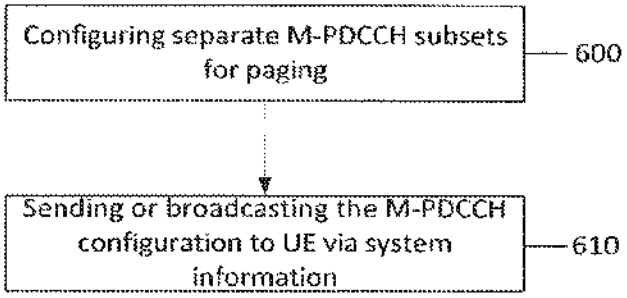


Fig. 6a

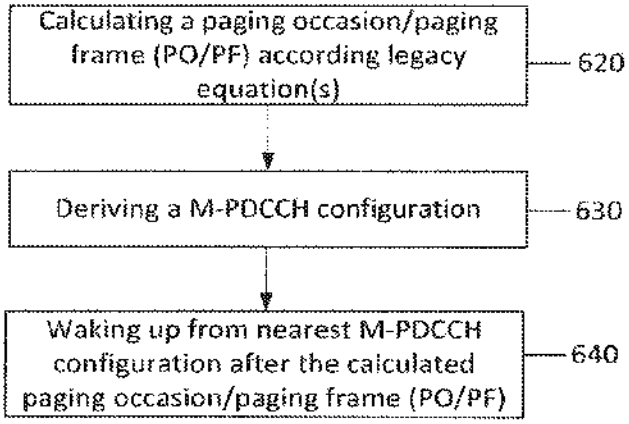


Fig. 6b

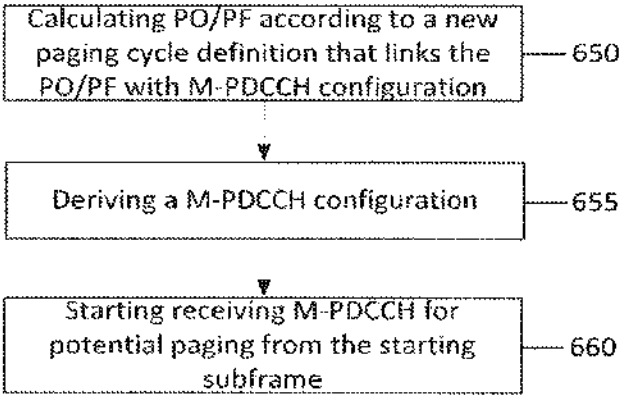


Fig. 6c

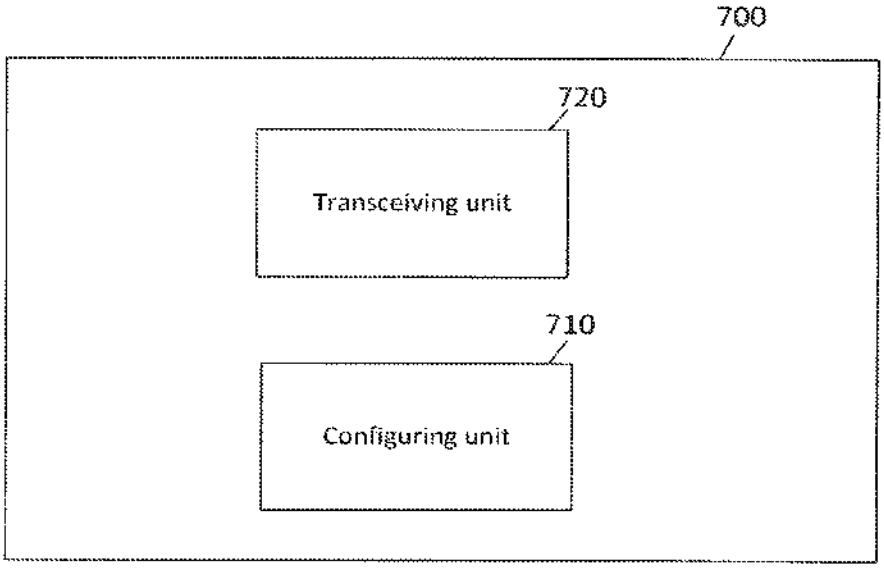

700
720
Transceiving unit
710
Configuring unit

Fig. 7a

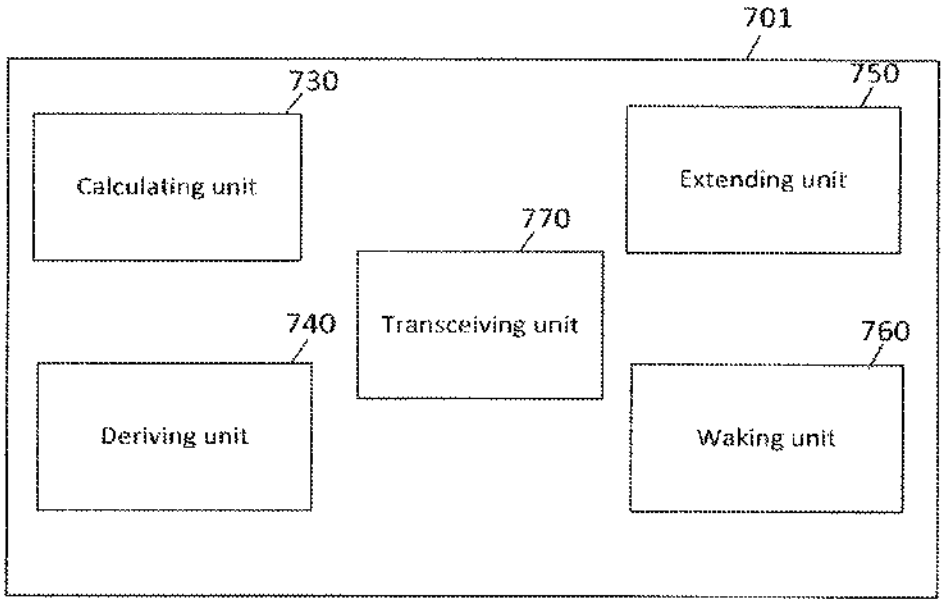

701
730
Calculating unit
750
Extending unit
770
Transceiving unit
740
Deriving unit
760
Waking unit

Fig. 7b

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2015/086797

A. CLASSIFICATION OF SUBJECT MATTER

H04W 48/12(2009.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04W; H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNPAT,WPI,EPODOC,CNKI,3GPP: machine type communication, machine to machine, MTC, M2M, physical downlink control channel, PDCCH, paging, configur+, low complexity, low cost, low specification, low performance, coverage, enhance+, paging occasion, paging frame, starting subframe, repetition, period, cycle

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2014055878 A1 (INTERDIGITAL PATENT HOLDINGS, INC.) 10 April 2014 (2014-04-10) description, paragraphs [0003]-[0005], [0081]-[0083], [0092], [0137]-[0140], [0145]-[0154], [0180]-[0186], [0194], [0202], [0218], [0278]-[0286], [0294]-[0295], [0304], [0319]	1-31
A	WO 2015019182 A2 (ALCATEL LUCENT) 12 February 2015 (2015-02-12) the whole document	1-31
A	CN 104137635 A (HUAWEI TECHNOLOGIES CO., LTD.) 05 November 2014 (2014-11-05) the whole document	1-31
A	CN 104811279 A (CHINA ACADEMY OF TELECOMMUNICATIONS TECHNOLOGY) 29 July 2015 (2015-07-29) the whole document	1-31
A	BERGMAN, Johan,. "Further LTE Physical Layer Enhancements for MTC," *3GPP TSG RAN meeting #68 RP-150583*, 18 June 2015 (2015-06-18), the whole document	1-31

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 April 2016	**13 May 2016**
Name and mailing address of the ISA/CN **STATE INTELLECTUAL PROPERTY OFFICE OF THE P.R.CHINA** **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088, China** Facsimile No. **(86-10)62019451**	Authorized officer **WANG,Manli** Telephone No. **(86-10)61648269**

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2015/086797

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
WO	2014055878	A1	10 April 2014	KR	20150064196	A	10 June 2015
				CN	104704884	A	10 June 2015
				EP	2904850	A1	12 August 2015
				TW	201429174	A	16 July 2014
				US	2014098761	A1	10 April 2014
				JP	2015537422	A	24 December 2015
WO	2015019182	A2	12 February 2015	CN	104349290	A	11 February 2015
				TW	201521399	A	01 June 2015
CN	104137635	A	05 November 2014	EP	2953409	A1	09 December 2015
				WO	2014131167	A1	04 September 2014
				US	2015365914	A1	17 December 2015
CN	104811279	A	29 July 2015	WO	2015110010	A1	30 July 2015

Form PCT/ISA/210 (patent family annex) (July 2009)

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

(54) Title: METHOD AND DEVICE FOR INDICATING NUMEROLOGY

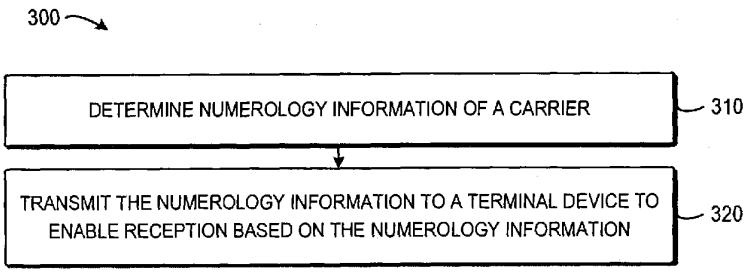


FIG. 3

(57) Abstract: Embodiments of the disclosure provide a method and device for indicating numerology. The method comprises: determining numerology information of a carrier, the numerology information indicating numerologies of one or more basic units for the carrier; and transmitting the numerology information to a terminal device to enable reception based on the numerology information.

WO 2018/081913 A1

METHOD AND DEVICE FOR INDICATING NUMEROLOGY

FIELD OF THE INVENTION

[0001] Embodiments of the present disclosure generally relate to communication techniques. More particularly, embodiments of the present disclosure relate to a method and device for indicating numerology.

BACKGROUND OF THE INVENTION

[0002] Newly-developed mobile standards call for higher data transfer speeds, greater numbers of connections, and better coverage, among other improvements. The 5G standard, according to the Next Generation Mobile Networks Alliance, is expected to provide data rates of several tens of megabits per second to each of tens of thousands of users, with 1 gigabit per second to tens of workers on an office floor. Several hundreds of thousands of simultaneous connections should be supported in order to support large sensor deployments. Consequently, the spectral efficiency is expected to be enhanced to meet more requirements of the new standards.

[0003] Conventionally, for a single carrier, there is one numerology. Therefore, terminal devices have to employ the same numerology in communication with a network device. This inevitably brings undesired, delays, low spectral efficiency for some kind of traffic.

[0004] Accordingly, there is a need for development of better transmission/processing techniques for wireless data transmission to meet different requirements of different applications/users at the same time.

SUMMARY OF THE INVENTION

[0005] The present disclosure proposes a solution for indicating numerology.

[0006] According to a first aspect of embodiments of the present disclosure, embodiments of the disclosure provide a method performed by a network device. The network device determines numerology information of a carrier. The numerology information indicates numerologies of one or more basic units for the

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carrier. Then the network device transmits the numerology information to a terminal device to enable reception based on the numerology information.

[0007] According to a second aspect of embodiments of the present disclosure, embodiments of the disclosure provide method performed by a terminal device. The terminal device receives numerology information of a carrier from a network device. The numerology information indicates numerologies of one or more basic units for the carrier. Then the terminal device decodes a signal based on the numerology information.

[0008] According to a third aspect of embodiments of the present disclosure, embodiments of the disclosure provide a network device. The network device comprises: a controller configured to determine numerology information of a carrier, the numerology information indicating numerologies of one or more basic units for the carrier; and a transmitter the numerology information to a terminal device to enable reception based on the numerology information.

[0009] According to a fourth aspect of embodiments of the present disclosure, embodiments of the disclosure provide a terminal device. The terminal device comprises: a receiver configured to receive numerology information of a carrier from a network device, the numerology information indicating numerologies of one or more basic units for the carrier; and a decoder configured to decode a signal based on the numerology information.

[0010] Other features and advantages of the embodiments of the present disclosure will also be apparent from the following description of specific embodiments when read in conjunction with the accompanying drawings, which illustrate, by way of example, the principles of embodiments of the disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Embodiments of the disclosure are presented in the sense of examples and their advantages are explained in greater detail below, with reference to the accompanying drawings, where

[0012] FIG. 1 illustrates a schematic diagram of a communication system 100 according to embodiments of the present disclosure;

[0013] FIG. 2A illustrates a diagram 200 of a basic unit in accordance with embodiments of the present disclosure;

[0014] FIG. 2B illustrates a diagram 260 of a basic unit in accordance with further embodiments of the present disclosure;

[0015] FIG. 3 illustrates a flow chart of a method 300 for performing communication according to embodiments of the present disclosure;

[0016] FIG. 4 illustrates a diagram 400 of the distributed indication according to embodiments of the present disclosure;

[0017] FIG. 5 illustrates a diagram 500 of the centralized indication according to embodiments of the present disclosure;

[0018] FIG. 6 illustrates a diagram 600 of a guard band 610 according to embodiments of the present disclosure;

[0019] FIG. 7 illustrates a diagram 700 of indication of a guard band according to embodiments of the present disclosure;

[0020] FIG. 8 illustrates a diagram 800 of indication of a guard band according to embodiments of the present disclosure;

[0021] FIG. 9 illustrates a diagram 900 of a resource unit 910 according to embodiments of the present disclosure;

[0022] FIG. 10 illustrates a diagram 1000 of information transmission according to embodiments of the present disclosure;

[0023] FIG. 11 illustrates a flow chart of a method 1100 for performing communication according to embodiments of the present disclosure;

[0024] FIG. 12 illustrates a schematic diagram of a network device 1200 according to an embodiment of the present disclosure; and

[0025] FIG. 13 illustrates a schematic diagram of a terminal device 1300 according to an embodiment of the present disclosure.

[0026] Throughout the figures, same or similar reference numbers indicate same or similar elements.

DETAILED DESCRIPTION OF EMBODIMENTS

[0027] The subject matter described herein will now be discussed with reference to several example embodiments. It should be understood these embodiments are discussed only for the purpose of enabling those skilled persons in the art to better understand and thus implement the subject matter described herein, rather than suggesting any limitations on the scope of the subject matter.

[0028] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of example embodiments. As used herein, the singular forms "a," "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises," "comprising," "includes" and/or "including," when used herein, specify the presence of stated features, integers, steps, operations, elements and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components and/or groups thereof.

[0029] It should also be noted that in some alternative implementations, the functions/acts noted may occur out of the order noted in the figures. For example, two functions or acts shown in succession may in fact be executed concurrently or may sometimes be executed in the reverse order, depending upon the functionality/acts involved.

[0030] As used herein, the term "communication network" refers to a network following any suitable communication standards, such as Long Term Evolution (LTE), LTE-Advanced (LTE-A), Wideband Code Division Multiple Access (WCDMA), High-Speed Packet Access (HSPA), and so on. Furthermore, the communications between a terminal device and a network device in the communication network may be performed according to any suitable generation communication protocols, including, but not limited to, the first generation (1G), the second generation (2G), 2.5G, 2.75G, the third generation (3G), the fourth generation (4G), 4.5G, the future fifth generation (5G) communication protocols, and/or any other protocols either currently known or to be developed in the future.

[0031] Embodiments of the present disclosure may be applied in various communication systems. Given the rapid development in communications, there

will of course also be future type communication technologies and systems with which the present disclosure may be embodied. It should not be seen as limiting the scope of the present disclosure to only the aforementioned system.

[0032] The term "network device" includes, but not limited to, a base station (BS), a gateway, a management entity, and other suitable device in a communication system. The term "base station" or "BS" represents a node B (NodeB or NB), an evolved NodeB (eNodeB or eNB), a Remote Radio Unit (RRU), a radio header (RH), a remote radio head (RRH), a relay, a low power node such as a femto, a pico, and so forth.

[0033] The term "terminal device" includes, but not limited to, "user equipment (UE)" and other suitable end device capable of communicating with the network device. By way of example, the "terminal device" may refer to a terminal, a Mobile Terminal (MT), a Subscriber Station (SS), a Portable Subscriber Station, a Mobile Station (MS), or an Access Terminal (AT).

[0034] Now some exemplary embodiments of the present disclosure will be described below with reference to the figures. Reference is first made to FIG. 1, which illustrates schematic diagram of a communication system 100 according to embodiments of the present disclosure.

[0035] In the communication system 100, there illustrate a network device (for example, an eNB) 110 that communicates with a terminal device (for example, a UE) 120 by using a certain transmission pattern. The network device 110 sends numerology information to the terminal device 120, wherein the numerology information indicates numerologies of one or more basic units for a carrier. As such, the terminal device 120 is enabled to receive signals from the network device 110 based on the numerology information.

[0036] In the context of the present disclosure, the term "numerology" refers to a set of parameters. In an Orthogonal Frequency Division Multiplexing (OFDM)-based system, the parameters include, for example, but not limited to, a subcarrier spacing, a symbol length, a length of a cyclic prefix (CP), and so on. For instance, a numerology for a subcarrier spacing of 15KHz may include 14 symbols in one subframe, a normal CP, and so on. A numerology for a subcarrier spacing of 30KHz may include 28 symbols in one subframe, a normal CP, and so on. Such a numerology is different from the numerology for the subcarrier spacing of 15KHz.

[0037] The term "basic unit" refers to a block of time-frequency resource. The size of a basic unit may depend on the employed numerology. The basic unit may be determined based on a subcarrier spacing and a symbol length used by subcarriers of the carrier. In a frequency domain, the basic unit may be decided by the largest subcarrier spacing. For example, a physical resource block (PRB) with the largest subcarrier spacing may be the frequency size of a basic unit, and/or the largest symbol length may be the time size of the basic unit.

[0038] FIG. 2A illustrates a diagram of a basic unit 240 in accordance with embodiments of the present disclosure. There are three subcarriers, Sc1-Sc3, illustrated in the example of FIG. 2A. In the frequency domain, the basic unit 240 is determined based on the largest subcarrier spacing, 60KHz. That is, the frequency size of the basic unit 240 equals to one PRB of the subcarrier Sc1 of 60KHz, 2 PRBs of the subcarrier Sc2 of 30KHz, and 4 PRBs of the subcarrier Sc3 of 15KHz.

[0039] In the time domain, the basic unit 240 is determined based on the largest symbol length. Thus, the time size of the basic unit 240 equals to a symbol of Sc3 of 15KHz, which has a largest symbol length among Sc1 to Sc3.

[0040] In addition to the above, the basic unit according embodiments of the present disclosure may be implemented in other suitable forms, for example, multiples of the largest symbol length in time domain, and/or multiples of the largest subcarrier spacing, multiples of a PRB, one or multiples of the smallest subcarrier spacing. FIG. 2B illustrates a diagram 200 of another basic unit 270 in accordance with further embodiments of the present disclosure. In the example shown in FIG. 2B, the basic unit 270 is defined based on the smallest subcarrier spacing in frequency domain. The time domain duration may be indicated by other ways explicitly or implicitly. For instance, the basic unit 270 may have the same duration as the basic unit 240 in the time domain, or the time duration may be multiples of the time duration of the basic unit 240.

[0041] It is to be understood that, the above examples are discussed for purpose of illustration, rather than limitation. Those skilled in the art would appreciate that the basic unit can be implemented other suitable forms with the scope of the subject matter of the present disclosure.

[0042] Conventionally, a carrier employs a single numerology, thus spectrum

utilization may be inefficient when terminal devices have different communication demands. To solve this problem, embodiments of the present disclosure propose a solution as discussed below to employ multiple numerologies in a single carrier. By receiving numerology information indicating numerologies of one or more basic units for the carrier, the terminal devices can receive signals based on the numerology information.

[0043] Now some exemplary embodiments of the present disclosure will be described below with reference to the following figures. FIG. 3 illustrates a flow chart of a method 300 for indicating numerology according to embodiments of the present disclosure. The method 300 may be implemented by the network device 110, for example, an eNB or other suitable device.

[0044] The method 300 is entered at 310, where the network device determines numerology information of a carrier. The numerology information indicates numerologies of one or more basic units for the carrier. At 320, the network device transmits the numerology information to a terminal device to enable reception based on the numerology information.

[0045] According to embodiments of the present disclosure, there may be a variety of ways to indicate numerology. In some embodiments, the numerology information may be indicated in a distributed way, which is also referred to as "distributed indication". In this case, the numerology of each basic unit is indicated. For purpose of illustration, the basic unit 240 of FIG. 2A is discussed in these embodiments. Thus, at 310, the network device may determine numerologies for all the basic units. In some implementations, a bitmap may be used to indicate the numerologies of the basic units, that is, one or more bits may be used to indicate the numerology for each basic unit. For example, two bits may be used to indicate subcarrier spacing 15KHz, 30KHz, 60KHz, and 120KHz, respectively. If the bits are "00", it means that the subcarrier of the numerology is 15KHz *1, and if the bits are "01", it means that the subcarrier of the numerology is 15KHz *2 = 30KHz. At 320, the network device may transmit information about the numerologies for all the basic units to the terminal device. FIG. 4 illustrates a diagram 400 of the distributed indication according to embodiments of the present disclosure. As shown in FIG. 4, there are six basic units in a carrier, namely, basic units 1 to 6, and there are 6

numerology indications are used for each of the basic units 1 to 6. In this way, the numerologies may be indicated in a flexible way.

[0046] In some other embodiments, if the basic unit is defined as the basic unit 270 as discussed with reference to FIG. 2B, when the numerology is changed from a small subcarrier spacing to a larger one, numerologies of at least multiple basic units need to be the same. For example, if the basic unit is based on 15KHz subcarrier spacing, and the numerology is changed from 15KHz to 30KHz, then numerology of at least two adjacent basic units should be same; if the numerology is changed to be 60KHz, then numerology of at least four adjacent basic units should be the same.

[0047] Alternatively, in some embodiments, the numerology information may be indicated in a centralized way, which is also referred to as "centralized indication." In this case, the carrier bandwidth may be divided into several groups, and each group may have a group-specific numerology. One group may include one or more basic units. Details of group division may be defined by a pattern, for example, referred to as a grouping pattern. The grouping pattern may be predefined in several ways, for example, according to the traffic characteristics, similar as Time Division Duplex (TDD) configuration. The grouping pattern may be alternatively defined in specification. In some implementations, the grouping pattern may be carried by system information and/or a Physical broadcast channel (PBCH). In the embodiments, the network device may inform the terminal device the grouping pattern and/or the group-specific numerology. The number of groups may be decided by the grouping pattern. The number may change due to different grouping patterns. The maximum group number may be reserved. In this case, the terminal device may need to firstly decode the grouping pattern, and then decode the corresponding numerology for each group based on the pattern.

[0048] In these embodiments, at 310, the network device may determine a grouping pattern indicating groups of the basic units, and then determine a numerology for each of the groups. At 320, the network device may transmit information about the grouping pattern and/or the numerology for each of the groups to the terminal device. FIG. 5 illustrates a diagram 500 of the centralized indication according to embodiments of the present disclosure. In the example of FIG. 5, there are six basic units in a carrier, namely, basic units 1 to 6, and they are divided into three groups,

namely, groups 1 to 3. As shown, group 1 includes basic units 1 and 2, group 2 includes basic unit 3, and group 3 includes basic units 4-6. A numerology is determined for each of the groups. As such, there are three numerology indications for groups 1, 2 and 3, respectively.

[0049] In some other embodiments, if the basic unit is defined as the basic unit 270 as discussed with reference to FIG. 2B, when the numerology is changed from a small subcarrier spacing to a larger one, the basic units may be divided into groups to guarantee basic units in each group have the same numerology. Still referring to FIG. 5, if basic units 1 to 6 are each defined as the basic unit 270, and basic units 1 and 2 correspond to numerology 1, basic unit 3 corresponds to numerology 2 and basic units 4, 5 and 6 correspond to numerology 3, then the basic units 1 to 6 may be divided into three groups to guarantee basic units in each group have the same numerology when the numerology is changed from 15KHz to 30KHz.

[0050] As a further alternative, the indication may be from a numerology perspective. That is to say, one or more basic units may be indicated for a specific numerology. The indication may be similar to a legacy approach of LTE resource allocation. The basic units corresponding to a numerology may be continuous or discontinuous. In some embodiments, the numerology information may be determined as below. At 310, the network device may determine numerologies for the basic units and determine an association between the numerologies and the basic units. Then, at 320, the network device may transmit information about the numerologies and/or the association to the terminal device. In an embodiment, the numerology information may be implemented in the form of the following table 1.

	NUMEROLOGY ID	BASIC UNIT ID
1	Numerology 1	Basic unit 1, 2
2	Numerology 2	Basic unit 3
3	Numerology 3	Basic unit 4, 5, 6

[0051] Upon receipt of the numerology information, the terminal device would understand that three numerologies (i.e., Numerology 1, 2 and 3) are designed for the carrier, Basic units 1 and 2 are associated with Numerology 1, Basic unit 3 is associated with Numerology 2, and Basic units 4, 5 and 6 are associated with

Numerology 3.

[0052] As a still further alternative, the bandwidth of the carrier may be divided into groups, and each group has the same numerology distribution pattern. A numerology distribution pattern indicating numerologies for basic units in one of the groups. For example, if in a group, the ith basic unit (also referred to as basic unit i, i=1,...M, and M indicates the total number of basic units in the group) has a numerology corresponding to 15KHz, and basic unit i+4 has a numerology corresponding to 60KHz, and basic units i and i+4 within another group share the same numerology 15KHz and 60KHz, respectively, then the numerology distribution patterns are the same for these two groups. In this case, the network device may indicate the numerology distribution pattern for a single group to the terminal device, and/or information about the group division, and/or the like. The numerology distribution pattern and/or information about the group division may be specified by specification, by RRC configuration, or in other suitable ways. The numerology distribution pattern for each group can also be indicated dynamically in downlink control information. In some embodiments, the numerology information may be determined as below. At 310, the network device may divide the basic units into groups and determine a numerology distribution pattern indicating numerologies for basic units in one of the groups. Then, at 320, the network device may transmit information about the numerology distribution pattern and/or information about the groups to the terminal device.

[0053] In accordance with embodiments of the present disclosure, for different adjacent numerologies, puncturing of one or more subcarriers may be used if a guard band is necessary. From efficiency point of view, the smaller subcarrier spacing may be punctured. In some embodiments, if new waveform design can mitigate the necessity of a guard band, then the puncturing may be unnecessary. According to embodiments of the present disclosure, the guard band may be indicated in a variety of ways. A size for a unit of the guard band (also referred to as a "guard band unit" hereafter) in the frequency domain may be a subcarrier, a PRB, or other suitable length, depending on the adjacent numerologies and/or numerology bandwidth and/or transmission direction. One or more guard band units may be indicated as a guard band.

[0054] FIG. 6 illustrates a diagram 600 of a guard band 610 according to embodiments of the present disclosure. As shown in FIG. 6, there is a guard band 610 between different subcarrier spacings, Sc2 of 30KHz and Sc3 of 15 KHz. The size of the guard band unit is a subcarrier/PRB, and the guard band in this example includes 3 guard band units.

[0055] According to embodiments of the present disclosure, optionally, after 320, the network device may further determines guard band information about a guard band between adjacent basic units based on numerologies of the adjacent basic units, and transmits the guard band information to the terminal device for each basic unit.

[0056] According to further embodiments of the present disclosure, optionally, after 320, the network device may further determine guard band information about a guard band between adjacent basic units based on transmission directions of the basic units. For example, a basic unit is used for downlink transmission and the adjacent basic unit is uplink transmission, then there will be a guard band between them. If the transmission direction is changed semi-statically, then the guard band information may be indicated to the terminal device in RRC signaling or PBCH. If the transmission direction, for example, downlink or uplink, is changed dynamically, then the guard band information may be indicated to a terminal device in downlink control information.

[0057] In the determination of the guard band information, the network device may detect whether there is a change between numerologies of the adjacent basic units and then determine occurrence of a guard band between the adjacent basic units based on the detection. In some embodiments, the guard band information may include: a number of subcarriers occupied by the guard band, a number of physical resource blocks occupied by the guard band, a basic unit where the guard band is located, and/or the like. The guard band information may indicate whether a guard band exists. From signaling point of view, even the guard band is to be decided not existent, it can be expressed by indicating the guard band to be 0.

[0058] After determining the guard band information, the network device may transmit the guard band information to the terminal device. In an embodiment, the guard band information may be transmitted together with the numerology information. Referring back to the embodiments of FIG. 4, the guard band information may be transmitted together with the numerology information for each basic unit. In another

embodiment, referring back to the embodiments of FIG. 5, the guard band information may be transmitted together with the numerology information for each group of basic units. More details about the indication of the guard band information will be discussed with the following embodiments with reference to FIGs. 7 and 8.

[0059] In some embodiments, the guard band may be defined by specification. In this case, the guard band may be impacted by adjacent numerology combination, and may be located in the side of the lower subcarrier spacing. For example, when a subcarrier spacing of 30KHz and a subcarrier spacing of 60KHz are located adjacently, no matter the detailed bandwidth for each subcarrier spacing, the guard band is the same and is always located in the 30KHz side. FIG. 7 illustrates a diagram 700 of indication of a guard band according to embodiments of the present disclosure. As shown in FIG. 7, there are two change points of numerologies of basic units 1-6, and two guard bands 710 and 720 defined by specification are located at the change points. In this case, the network device may inform the terminal device information about the numerology, and based on the derived numerology, the terminal device may deduce that there are guard bands 710 and 720.

[0060] Alternatively, in some embodiments, the guard band information and/or the numerology information may be transmitted or indicated by system information/PBCH or Dynamic Control Information (DCI). The indication of the guard band information may be according to the numerology distribution pattern, similar to the indication of the numerology information. In this case, the guard band may be impacted by both the adjacent numerology combination and the bandwidth of each numerology.

[0061] In an embodiment, there is a guard band for each basic unit. The guard band may be zero if no numerology change between adjacent basic units or new wave form adoption. Such guard band information may be transmitted together with the numerology information as discussed with reference to FIG. 4. For each basic unit, the numerology and the guard band are indicated. Both independent indication and joint encoding may be employed. FIG. 8 illustrates a diagram 800 of indication of a guard band according to such an embodiment.

[0062] In an alternative embodiment, there is a guard band for each numerology change. In this case, the guard band information may be transmitted together with

the numerology information as discussed with reference to FIG. 5. For example, the guard band information and/or the numerology information may indicate the numerology distribution pattern. Thus, upon receipt of the information, the terminal device may obtain a change point of numerologies based thereon, and then determine the position of the guard band according to the change point. In this embodiment, the guard band information is transmitted when numerologies of two adjacent basic units change. As such, overhead of transmitting the guard band information is reduced.

[0063] In accordance with embodiments of the present disclosure, the network device may further inform the terminal device information about resource allocation. The allocated resource may be indicated by a common index irrespectively of numerology. Thus, the terminal device may understand the resource allocated to it. In some embodiments, the network device may allocate a resource to one or more terminal devices, and then transmit information about the allocated resource to the terminal device. The information about the allocated resource may include one or more of: an index of a basic unit allocated to the terminal devices, an index of a physical resource block in a basic unit allocated to the terminal devices, and other suitable information.

[0064] In some embodiments, the basic units may be indexed from 0 to N-1, where N is a total number of the basic units. The total number may be determined in several ways. For example, if the carrier bandwidth is B and the bandwidth of the basic frequency variation units is W, then the total number may be calculated below:

$$N = \text{ceil}(B/W),$$

where "ceil" indicates an operation of rounding up.

[0065] The total PRB number (denoted as N_p) within a basic unit may be calculated as:

$$N_p = W/Sc/N_Sc$$

where Sc represents the subcarrier spacing for this basic unit, and N_Sc represents the subcarrier number within a PRB.

[0066] The network device may determine which PRB(s) and/or which basic unit(s) are allocated to terminal devices, and transmit the information about the allocated

resource to the terminal devices. The information may include index of the basic unit(s). A terminal device, for example, the terminal device 120, upon receipt of the information about the allocated resource, may identify the index of the basic unit(s) first. Then, the terminal device may determine which PRBs in the allocated basic unit(s) can be used.

[0067] In some implementations, one or more bits may be used to indicate the index of the basic unit(s). Then, one or more additional bits may be used to indicate PRBs within the basic unit. These bits may be used in both downlink and uplink to indicate the corresponding allocated frequency domain resource.

[0068] Alternatively, in some embodiments, the resource allocation information may be indicated by resource unit(s). The resource unit may be defined based on the smallest subcarrier spacing in frequency domain. For a larger subcarrier spacing, resources allocated to a single UE should consider the relationship between the smallest subcarrier spacing and the larger subcarrier spacing. By way of example, if the resource unit is based on 15KHz subcarrier spacing, and for a 60KHz resource allocation, the allocated resources may be multiple of 4, where 4 is obtained by dividing 60KHz by 15KHz. The time domain duration may be indicated by other ways explicitly or implicitly. For instance, the resource unit may have the same duration as the basic unit discussed above in the time domain, or the time duration may be multiples of the time duration of the basic unit.

[0069] FIG. 9 illustrates a diagram 900 of a resource unit 910 according to embodiments of the present disclosure. In the frequency domain, the resource unit 910 corresponds to the PRB of the smallest subcarrier spacing, namely, Sc3 of 15KHz. In the time domain, the resource unit 910 corresponds to a symbol of the smallest subcarrier spacing.

[0070] With respect the above embodiments, if different channel coding schemes are used for different information block sizes, or if the time domain transmission duration may change due to multi-subframe or mini-slot scheduling, the corresponding Modulation and Coding Scheme (MCS)/Transmission Block Size (TBS) table may change. The chosen of MCS/TBS table may be configured by Radio resource configuration (RRC) signaling.

[0071] In accordance with embodiments of the present disclosure, the network device may transmit the numerology information, and/or the guard band information, and/or the information about resource allocation in a variety of ways. In some embodiments, the network device may transmit the numerology information/guard band information in a region of the carrier corresponding to a reference numerology, and transmit the information about the allocated resource in one or more of the basic units, the region of the carrier for transmitting the reference numerology, and/or the like.

[0072] In some embodiments, the numerology information, the guard band information, and/or the information about resource allocation may be carried by PDCCH/Enhanced PDCCH (ePDCCH). The PDCCH carrying the numerology information and/or guard band information may be shared by a group of UEs, and may be scrambled by a cell specific/beam specific sequence. And the PDCCH carrying the resource allocation information may be scrambled in a UE-specific way. With respect to the terminal device, for example, a UE, it may decode received signals to obtain the numerology information and/or the guard band information. Then, the UE may decode the information about resource allocation to obtain allocated resources, MCS/TBS, transmission duration, and/or the like, which are collectively called as UE specific control information hereafter.

[0073] In some embodiments, the UE specific control information may be located at a time-frequency resource corresponding to a specific numerology. Alternatively, the UE specific control information may also be located at the time-frequency resource corresponding to the reference numerology, combined with the cell/beam-specific control information to be carried in a single PDCCH or scrambled independently to form an independent PDCCH. In some implementations, the PDCCH may occur in a periodical way or in aperiodical way. In the case of the aperiodical implementation, the UE may perform blind detection to identify the PDCCH.

[0074] In some alternative embodiments, the control information may also be carried by PBCH or RRC signaling. As a further alternative, the control information may be carried by a combination of RRC signaling and physical layer control information. In such a case, RRC signaling may be used to indicate a subset of possible

numerologies/guard band configurations, and physical layer control information may be used to indicate the numerology within the subset dynamically.

[0075] FIG. 10 illustrates a diagram 1000 of transmission of UE specific control information 1010 and numerology information/guard band 1020 according to embodiments of the present disclosure. As shown in the example of FIG. 10, the UE specific control information 1010 is transmitted via basic unit 1, and the numerology information/guard band information are transmitted in a region 1030 of the carrier corresponding to the reference numerology.

[0076] Reference is now made to FIG. 11, which illustrates a flow chart of a method 1100 for performing communication according to embodiments of the present disclosure. The method 1100 may be implemented by the terminal device 120, for example, a UE or other suitable device.

[0077] The method 1100 is entered at 1110, where the terminal device receives numerology information of a carrier from a network device. The numerology information may indicate numerologies of one or more basic units for the carrier. The basic unit may be determined based on a subcarrier spacing and a symbol length used by subcarriers of the carrier. For example, in the frequency domain, the basic unit may be determined based on the largest subcarrier spacing. In the time domain, the basic unit 240 may be determined based on the largest symbol length. In another example, the basic unit may also be determined based on the smallest subcarrier spacing in frequency domain, and/or determined based on the smallest symbol length in time domain.

[0078] In some embodiments, at 1110, the terminal device may receive information about numerologies for all the basic units. Alternatively, the terminal device may receive information about a grouping pattern indicating groups of the basic units and/or a numerology for each of the groups. As a further alternative, the terminal device may receive information about numerologies for the basic units and/or an association between the numerologies and the basic units. As a still further alternative, the basic units are divided into groups, and the basic units in each of the groups having the same numerology distribution pattern. In this case, the terminal device may receive at least one of information about a numerology distribution

pattern indicating numerologies for basic units in one of groups of basic units and/or information about the groups.

[0079] At 1120, the terminal device decodes a signal based on the numerology information.

[0080] In some embodiments, optionally, the terminal device may further receive guard band information about a guard band between adjacent basic units. In this case, at 1120, the terminal device may decode the signal based on the numerology information and the guard band information.

[0081] In some embodiments, optionally, the terminal device may further information about allocated resource of one or more terminal devices from the network device. The information about allocated resource may include an index of a basic unit allocated to the terminal devices, an index of a physical resource block in a basic unit allocated to the terminal devices, and/or the like. In this case, at 1120, the terminal device may decode the signal based on the numerology information and the information about allocated resource (also referred to as "information about resource allocation").

[0082] In some embodiments, the numerology information may be received in a region of the carrier for transmitting a reference numerology, and the information about the allocated resource may be received in one or more of the basic units, or in the region of the carrier for transmitting the reference numerology, or other suitable regions.

[0083] FIG. 12 illustrates a schematic diagram of a network device 1200 according to an embodiment of the present disclosure. According to embodiments of the present disclosure, the network device 1200 may be implemented as the network device 110 or other suitable device in the communication system.

[0084] As shown in FIG. 12, the network device 1200 comprises: a controller 1210 configured to determine numerology information of a carrier, the numerology information indicating numerologies of one or more basic units for the carrier; and a transmitter 1220 configured to transmit the numerology information to a terminal device to enable reception based on the numerology information.

[0085] In some embodiments, the basic unit may be determined based on a subcarrier spacing and a symbol length used by subcarriers of the carrier.

[0086] In some embodiments, the controller 1210 may be further configured to determine numerologies for all the basic units, and wherein the transmitter 1220 may be further configured to transmit information about the numerologies for all the basic units to the terminal device.

[0087] In some embodiments, the controller 1210 may be further configured to: determine a grouping pattern indicating groups of the basic units; and determine a numerology for each of the groups, and wherein the transmitter may be further configured to transmit information about the grouping pattern and/or the numerology for each of the groups to the terminal device.

[0088] In some embodiments, the controller 1210 may be further configured to: determine numerologies for the basic units; and determine an association between the numerologies and the basic units, and wherein the transmitter 1220 may be further configured to transmit information about the numerologies and/or the association to the terminal device.

[0089] In some embodiments, the controller 1210 may be further configured to: divide the basic units into groups; and determine a numerology distribution pattern indicating numerologies for basic units in one of the groups, and wherein the transmitter may be further configured to transmit information about the numerology distribution pattern and/or information about the groups to the terminal device.

[0090] In some embodiments, the controller 1210 may be further configured to: determine guard band information about a guard band between adjacent basic units based on numerologies of the adjacent basic units; and wherein the transmitter may be further configured to transmit the guard band information to the terminal device.

[0091] In some embodiments, the controller 1210 may be further configured to: detect whether there is a change between numerologies of the adjacent basic units; and determine occurrence of a guard band between the adjacent basic units based on the detection.

[0092] In some embodiments, the guard band information may further include one or more of: a number of subcarriers occupied by the guard band, a number of physical resource blocks occupied by the guard band, and a basic unit where the guard band is located.

[0093] In some embodiments, the transmitter 1220 may be further configured to transmit the guard band information to the terminal device based on the numerology information.

[0094] In some embodiments, the controller 1210 may be further configured to allocate a resource to one or more terminal devices, and wherein the transmitter 1220 may be further configured to transmit information about the allocated resource to the terminal device, wherein the information about the allocated resource includes at least one of: an index of a basic unit allocated to the terminal devices, and an index of a physical resource block in a basic unit allocated to the terminal devices.

[0095] In some embodiments, the transmitter 1220 may be further configured to: transmit the numerology information in a region of the carrier for transmitting a reference numerology; and transmit the information about the allocated resource in at least one of: one or more of the basic units, and the region of the carrier for transmitting the reference numerology.

[0096] FIG. 13 illustrates a schematic diagram of a terminal device 1300 according to an embodiment of the present disclosure. According to embodiments of the present disclosure, the terminal device 1300 may be implemented as the network device 120 or other suitable device in the communication system.

[0097] As shown in FIG. 13, the terminal device 1300 comprises: a receiver 1310 configured to receive numerology information of a carrier from a network device, the numerology information indicating numerologies of one or more basic units for the carrier; and a decoder 1320 configured to decode a signal based on the numerology information.

[0098] In some embodiments, the basic unit may be determined based on a subcarrier spacing and a symbol length used by subcarriers of the carrier.

[0099] In some embodiments, the receiver 1310 may be further configured to receive at least one of: information about numerologies for all the basic units; information about a grouping pattern indicating groups of the basic units and/or a numerology for each of the groups; information about numerologies for the basic units and/or an association between the numerologies and the basic units; and at least one of information about a numerology distribution pattern indicating numerologies for basic units in one of groups of basic units and/or information about the groups, the basic

units in the groups having the same numerology distribution pattern.

[00100] In some embodiments, the receiver 1310 may be further configured to receive guard band information about a guard band between adjacent basic units, wherein the decoder 1320 may be further configured to decode the signal based on the numerology information and the guard band information.

[00101] In some embodiments, the receiver 1310 may be further configured to receive information about allocated resource of one or more terminal devices from the network device, wherein the information about allocated resource includes at least one of: an index of a basic unit allocated to the terminal devices, and an index of a physical resource block in a basic unit allocated to the terminal devices.

[00102] In some embodiments, wherein the numerology information may be received in a region of the carrier for transmitting a reference numerology, and the information about the allocated resource may be received in at least one of: one or more of the basic units, and the region of the carrier for transmitting the reference numerology.

[00103] It is also to be noted that the device 1200 or 1300 may be respectively implemented by any suitable technique either known at present or developed in the future. Further, a single device shown in FIG. 12 or 13 may be alternatively implemented in multiple devices separately, and multiple separated devices may be implemented in a single device. The scope of the present disclosure is not limited in these regards.

[00104] It is noted that the device 1200 or 1300 may be configured to implement functionalities as described with reference to FIGs. 3-10 or FIG. 11. Therefore, the features discussed with respect to the method 300 may apply to the corresponding components of the device 1200, and the features discussed with respect to the method 1100 may apply to the corresponding components of the device 1300. It is further noted that the components of the device 1200 or 1300 may be embodied in hardware, software, firmware, and/or any combination thereof. For example, the components of the device 1200 or 1300may be respectively implemented by a circuit, a processor or any other appropriate device. Those skilled in the art will appreciate that the aforesaid examples are only for illustration not limitation.

[00105] In some embodiment of the present disclosure, the device 1200 or 1300 may

comprise at least one processor. The at least one processor suitable for use with embodiments of the present disclosure may include, by way of example, both general and special purpose processors already known or developed in the future. The device 1200 or 1300 may further comprise at least one memory. The at least one memory may include, for example, semiconductor memory devices, e.g., RAM, ROM, EPROM, EEPROM, and flash memory devices. The at least one memory may be used to store program of computer executable instructions. The program can be written in any high-level and/or low-level compliable or interpretable programming languages. In accordance with embodiments, the computer executable instructions may be configured, with the at least one processor, to cause the device 1200 to at least perform according to the method 300 as discussed above and to cause the device 1300 to at least perform according to the method 1100 as discussed above.

[00106] Based on the above description, the skilled in the art would appreciate that the present disclosure may be embodied in an apparatus, a method, or a computer program product. In general, the various exemplary embodiments may be implemented in hardware or special purpose circuits, software, logic or any combination thereof. For example, some aspects may be implemented in hardware, while other aspects may be implemented in firmware or software which may be executed by a controller, microprocessor or other computing device, although the disclosure is not limited thereto. While various aspects of the exemplary embodiments of this disclosure may be illustrated and described as block diagrams, flowcharts, or using some other pictorial representation, it is well understood that these blocks, apparatus, systems, techniques or methods described herein may be implemented in, as non-limiting examples, hardware, software, firmware, special purpose circuits or logic, general purpose hardware or controller or other computing devices, or some combination thereof.

[00107] The various blocks shown in FIG. 3 or 11 may be viewed as method steps, and/or as operations that result from operation of computer program code, and/or as a plurality of coupled logic circuit elements constructed to carry out the associated function(s). At least some aspects of the exemplary embodiments of the disclosures may be practiced in various components such as integrated circuit chips and modules, and that the exemplary embodiments of this disclosure may be realized in an apparatus that is embodied as an integrated circuit, FPGA or ASIC that is configurable

to operate in accordance with the exemplary embodiments of the present disclosure.

[00108] While this specification contains many specific implementation details, these should not be construed as limitations on the scope of any disclosure or of what may be claimed, but rather as descriptions of features that may be specific to particular embodiments of particular disclosures. Certain features that are described in this specification in the context of separate embodiments can also be implemented in combination in a single embodiment. Conversely, various features that are described in the context of a single embodiment can also be implemented in multiple embodiments separately or in any suitable sub-combination. Moreover, although features may be described above as acting in certain combinations and even initially claimed as such, one or more features from a claimed combination can in some cases be excised from the combination, and the claimed combination may be directed to a sub-combination or variation of a sub-combination.

[00109] Similarly, while operations are depicted in the drawings in a particular order, this should not be understood as requiring that such operations be performed in the particular order shown or in sequential order, or that all illustrated operations be performed, to achieve desirable results. In certain circumstances, multitasking and parallel processing may be advantageous. Moreover, the separation of various system components in the embodiments described above should not be understood as requiring such separation in all embodiments, and it should be understood that the described program components and systems can generally be integrated together in a single software product or packaged into multiple software products.

[00110] Various modifications, adaptations to the foregoing exemplary embodiments of this disclosure may become apparent to those skilled in the relevant arts in view of the foregoing description, when read in conjunction with the accompanying drawings. Any and all modifications will still fall within the scope of the non-limiting and exemplary embodiments of this disclosure. Furthermore, other embodiments of the disclosures set forth herein will come to mind to one skilled in the art to which these embodiments of the disclosure pertain having the benefit of the teachings presented in the foregoing descriptions and the associated drawings.

[00111] Therefore, it is to be understood that the embodiments of the disclosure are not to be limited to the specific embodiments disclosed and that modifications and

other embodiments are intended to be included within the scope of the appended claims. Although specific terms are used herein, they are used in a generic and descriptive sense only and not for purpose of limitation.

WHAT IS CLAIMED IS:

1. A method performed by a network device, comprising:

determining numerology information of a carrier, the numerology information indicating numerologies of one or more basic units for the carrier; and

transmitting the numerology information to a terminal device to enable reception based on the numerology information.

2. The method according to Claim 1, wherein the basic unit is determined based on a subcarrier spacing and a symbol length used by subcarriers of the carrier.

3. The method according to Claim 1, wherein determining the numerology information comprises: determining numerologies for all the basic units, and

wherein transmitting the numerology information comprises: transmitting information about the numerologies for all the basic units to the terminal device.

4. The method according to Claim 1, wherein determining the numerology information comprises:

determining a grouping pattern indicating groups of the basic units; and

determining a numerology for each of the groups, and

wherein transmitting the numerology information comprises: transmitting information about the grouping pattern and/or the numerology for each of the groups to the terminal device.

5. The method according to Claim 1, wherein determining the numerology information comprises:

determining numerologies for the basic units; and

determining an association between the numerologies and the basic units, and

wherein transmitting the numerology information comprises: transmitting information about the numerologies and/or the association to the terminal device.

6. The method according to Claim 1, wherein determining the numerology information comprises:

dividing the basic units into groups; and

determining a numerology distribution pattern indicating numerologies for basic units in one of the groups, and

wherein transmitting the numerology information comprises: transmitting information about the numerology distribution pattern and/or information about the groups to the terminal device.

7. The method according to Claim 1, further comprising:

determining guard band information about a guard band between adjacent basic units based on numerologies of the adjacent basic units; and

transmitting the guard band information to the terminal device.

8. The method according to Claim 7, wherein determining the guard band information comprises:

detecting whether there is a change between numerologies of the adjacent basic units; and

determining occurrence of a guard band between the adjacent basic units based on the detection.

9. The method according to Claim 7 or 8, wherein the guard band information further includes one or more of:

a number of subcarriers occupied by the guard band,

a number of physical resource blocks occupied by the guard band, and

a basic unit where the guard band is located.

10. The method according to Claim 7, wherein transmitting the guard band information to the terminal device comprises:

transmitting the guard band information to the terminal device based on the numerology information.

11. The method according to Claim 1, further comprising:

allocating a resource to one or more terminal devices; and

transmitting information about the allocated resource to the terminal device,

wherein the information about the allocated resource includes at least one of: an index of a basic unit allocated to the terminal devices, and an index of a physical resource block in a basic unit allocated to the terminal devices.

12. The method according to Claim 11, wherein transmitting the numerology information comprises:

transmitting the numerology information in a region of the carrier for transmitting a reference numerology; and

transmitting the information about the allocated resource in at least one of: one or more of the basic units, and the region of the carrier for transmitting the reference numerology.

13. A method performed by a terminal device, comprising:

receiving numerology information of a carrier from a network device, the numerology information indicating numerologies of one or more basic units for the carrier; and

decoding a signal based on the numerology information.

14. The method according to Claim 13, wherein the basic unit is determined based on a subcarrier spacing and a symbol length used by subcarriers of the carrier.

15. The method according to Claim 13, wherein receiving the numerology information comprises at least one of:

receiving information about numerologies for all the basic units;

receiving information about a grouping pattern indicating groups of the basic units and/or a numerology for each of the groups;

receiving information about numerologies for the basic units and/or an association between the numerologies and the basic units; and

receiving at least one of information about a numerology distribution pattern indicating numerologies for basic units in one of groups of basic units and/or information about the groups, the basic units in the groups having the same numerology distribution pattern.

16. The method according to Claim 13, further comprising:

receiving guard band information about a guard band between adjacent basic units,

wherein decoding the signal comprises: decoding the signal based on the numerology information and the guard band information.

17. The method according to Claim 13, further comprising:

receiving information about allocated resource of one or more terminal devices from the network device, wherein the information about allocated resource includes at least one of: an index of a basic unit allocated to the terminal devices, and an index of a physical resource block in a basic unit allocated to the terminal devices.

18. The method according to Claim 17, wherein the numerology information is received in a region of the carrier for transmitting a reference numerology, and the information about the allocated resource is received in at least one of: one or more of the basic units, and the region of the carrier for transmitting the reference numerology.

19. A network device, comprising:

a controller configured to determine numerology information of a carrier, the numerology information indicating numerologies of one or more basic units for the carrier; and

a transmitter configured to transmit the numerology information to a terminal device to enable reception based on the numerology information.

20. The network device according to Claim 19, wherein the basic unit is determined based on a subcarrier spacing and a symbol length used by subcarriers of the carrier.

21. The network device according to Claim 19, wherein the controller is further configured to determine numerologies for all the basic units, and

wherein the transmitter is further configured to transmit information about the numerologies for all the basic units to the terminal device.

22. The network device according to Claim 19, wherein the controller is further configured to:

determine a grouping pattern indicating groups of the basic units; and

determine a numerology for each of the groups, and

wherein the transmitter is further configured to transmit information about the grouping pattern and/or the numerology for each of the groups to the terminal device.

23. The network device according to Claim 19, wherein the controller is further configured to:

determine numerologies for the basic units; and

determine an association between the numerologies and the basic units, and

wherein the transmitter is further configured to transmit information about the numerologies and/or the association to the terminal device.

24. The network device according to Claim 19, wherein the controller is further configured to:

divide the basic units into groups; and

determine a numerology distribution pattern indicating numerologies for basic units in one of the groups, and

wherein the transmitter is further configured to transmit information about the numerology distribution pattern and/or information about the groups to the terminal device.

25. The network device according to Claim 19, wherein the controller is further configured to:

determine guard band information about a guard band between adjacent basic units based on numerologies of the adjacent basic units; and

wherein the transmitter is further configured to transmit the guard band information to the terminal device.

26. The network device according to Claim 25, wherein the controller is further configured to:

detect whether there is a change between numerologies of the adjacent basic units; and

determine occurrence of a guard band between the adjacent basic units based on the detection.

27. The network device according to Claim 25 or 26, wherein the guard band information further includes one or more of:

a number of subcarriers occupied by the guard band,

a number of physical resource blocks occupied by the guard band, and

a basic unit where the guard band is located.

28. The network device according to Claim 25, wherein the transmitter is further configured to transmit the guard band information to the terminal device based on the numerology information.

29. The network device according to Claim 19, wherein the controller is further configured to allocate a resource to one or more terminal devices, and wherein the transmitter is further configured to transmit information about the allocated resource to the terminal device,

wherein the information about the allocated resource includes at least one of: an index of a basic unit allocated to the terminal devices, and an index of a physical resource block in a basic unit allocated to the terminal devices.

30. The network device according to Claim 29, wherein the transmitter is further configured to:

transmit the numerology information in a region of the carrier for transmitting a reference numerology; and

transmit the information about the allocated resource in at least one of: one or more of the basic units, and the region of the carrier for transmitting the reference numerology.

31. A terminal device, comprising:

a receiver configured to receive numerology information of a carrier from a network device, the numerology information indicating numerologies of one or more basic units for the carrier; and

a decoder configured to decode a signal based on the numerology information.

32. The terminal device according to Claim 31, wherein the basic unit is determined based on a subcarrier spacing and a symbol length used by subcarriers of the carrier.

33. The terminal device according to Claim 31, wherein the receiver is further configured to receive at least one of:

information about numerologies for all the basic units;

information about a grouping pattern indicating groups of the basic units and/or a numerology for each of the groups;

information about numerologies for the basic units and/or an association between the numerologies and the basic units; and

at least one of information about a numerology distribution pattern indicating numerologies for basic units in one of groups of basic units and/or information about the groups, the basic units in the groups having the same numerology distribution pattern.

34. The terminal device according to Claim 31, wherein the receiver is further configured to receive guard band information about a guard band between adjacent basic units,

wherein the decoder is further configured to decode the signal based on the numerology information and the guard band information.

35. The terminal device according to Claim 31, wherein the receiver is further configured to receive information about allocated resource of one or more terminal devices from the network device, wherein the information about allocated resource includes at least one of: an index of a basic unit allocated to the terminal

devices, and an index of a physical resource block in a basic unit allocated to the terminal devices.

36. The terminal device according to Claim 35, wherein the numerology information is received in a region of the carrier for transmitting a reference numerology, and the information about the allocated resource is received in at least one of: one or more of the basic units, and the region of the carrier for transmitting the reference numerology.

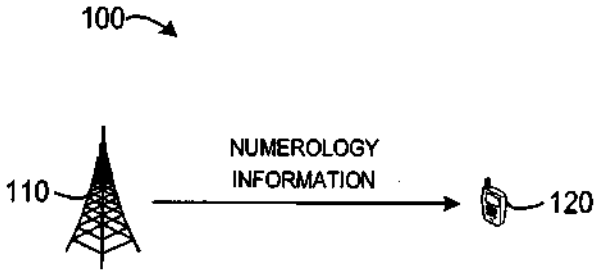

100
110
NUMEROLOGY
INFORMATION
120

FIG. 1

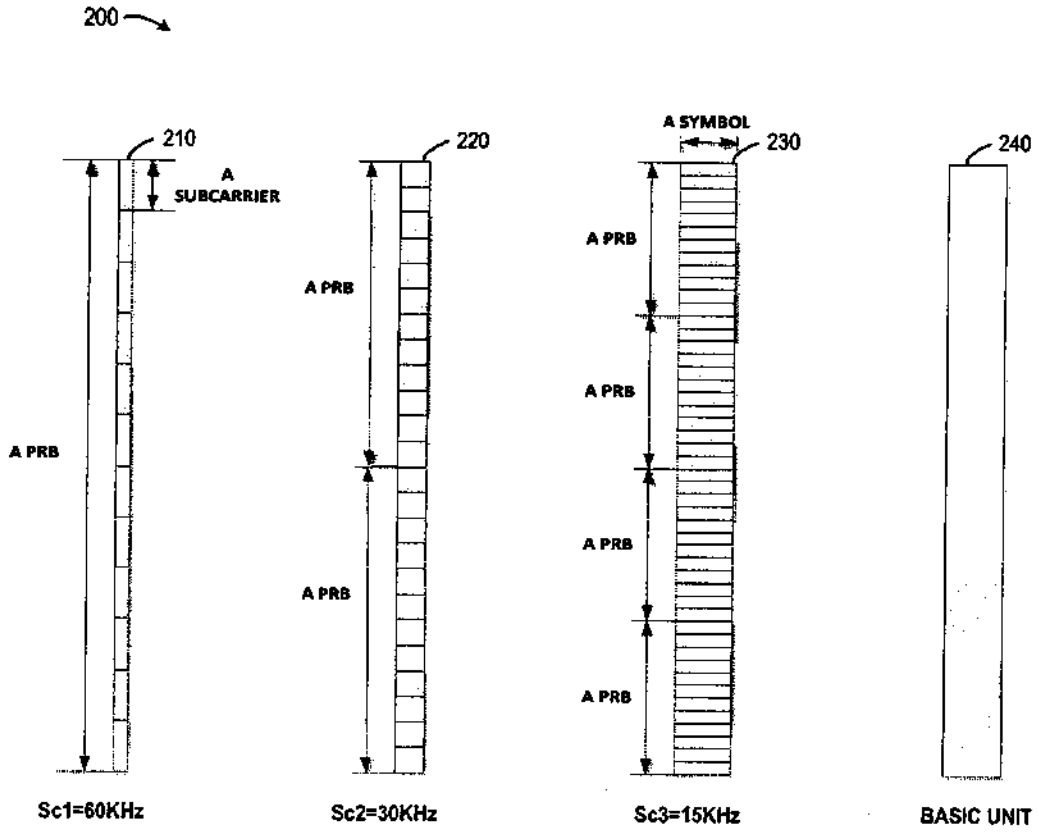

200
210
A
SUBCARRIER
A PRB
Sc1=60KHz
220
A PRB
A PRB
Sc2=30KHz
A SYMBOL
230
A PRB
A PRB
A PRB
A PRB
Sc3=15KHz
240
BASIC UNIT

FIG. 2A

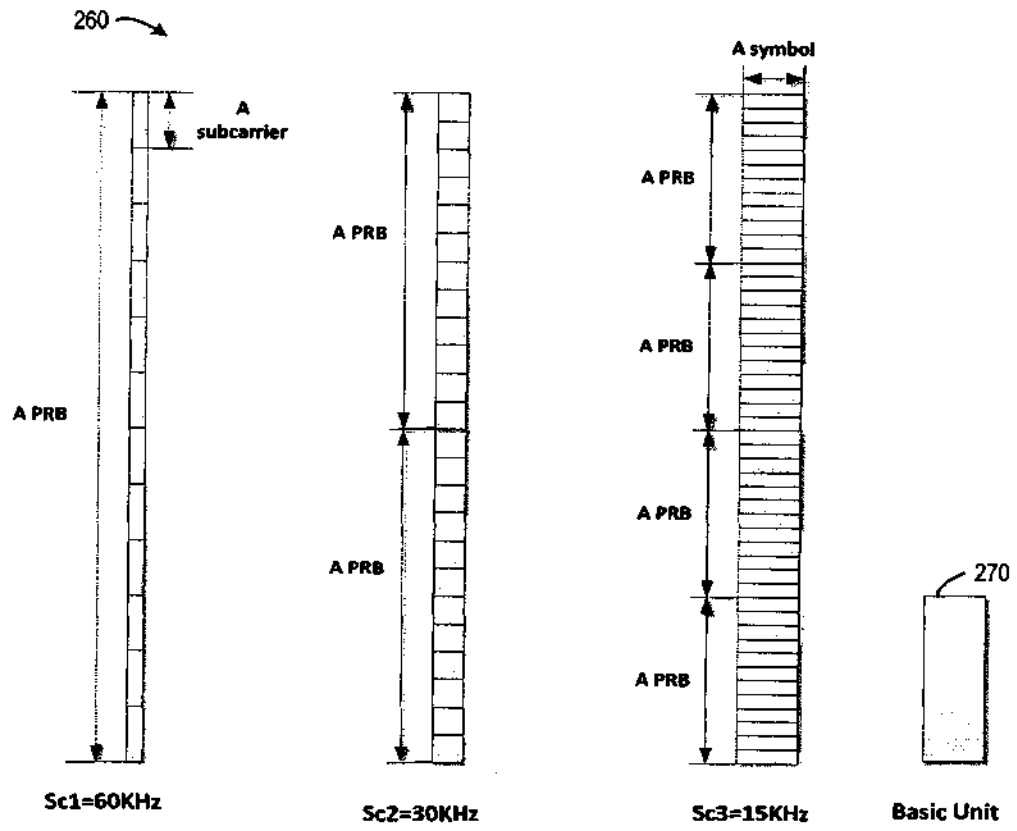

260
A subcarrier
A PRB
A PRB
A PRB
A symbol
A PRB
A PRB
A PRB
A PRB
270
Sc1=60KHz
Sc2=30KHz
Sc3=15KHz
Basic Unit

FIG. 2B

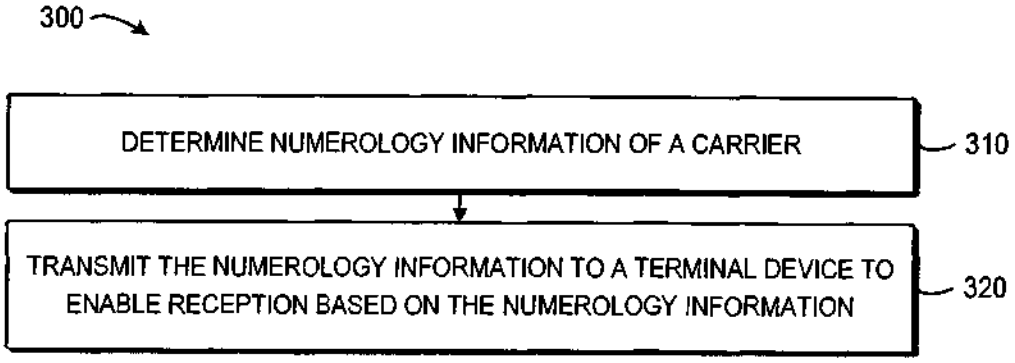

300
DETERMINE NUMEROLOGY INFORMATION OF A CARRIER
310
TRANSMIT THE NUMEROLOGY INFORMATION TO A TERMINAL DEVICE TO ENABLE RECEPTION BASED ON THE NUMEROLOGY INFORMATION
320

FIG. 3

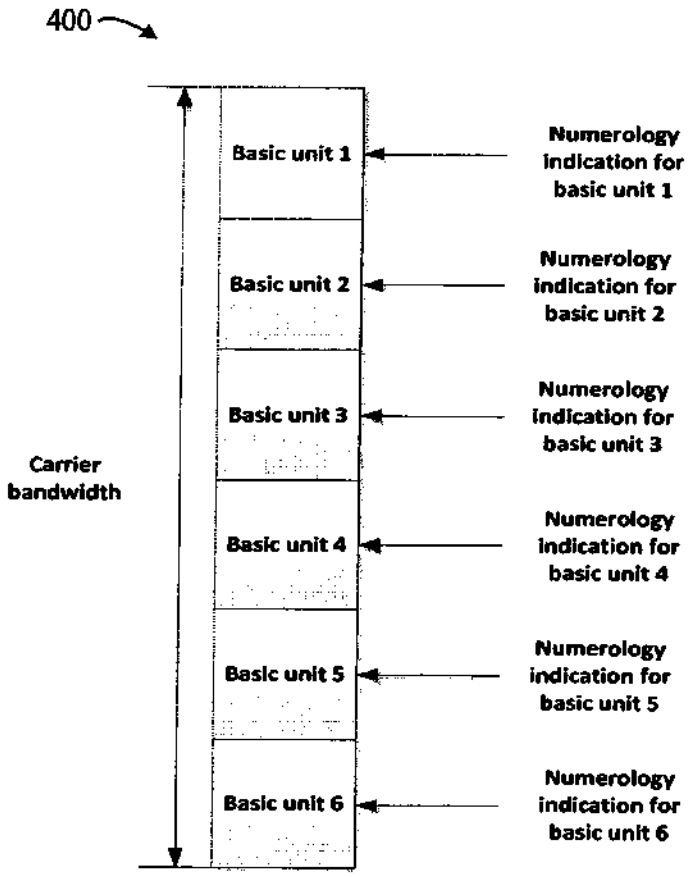

400
Carrier bandwidth
Basic unit 1
Basic unit 2
Basic unit 3
Basic unit 4
Basic unit 5
Basic unit 6
Numerology indication for basic unit 1
Numerology indication for basic unit 2
Numerology indication for basic unit 3
Numerology indication for basic unit 4
Numerology indication for basic unit 5
Numerology indication for basic unit 6

FIG. 4

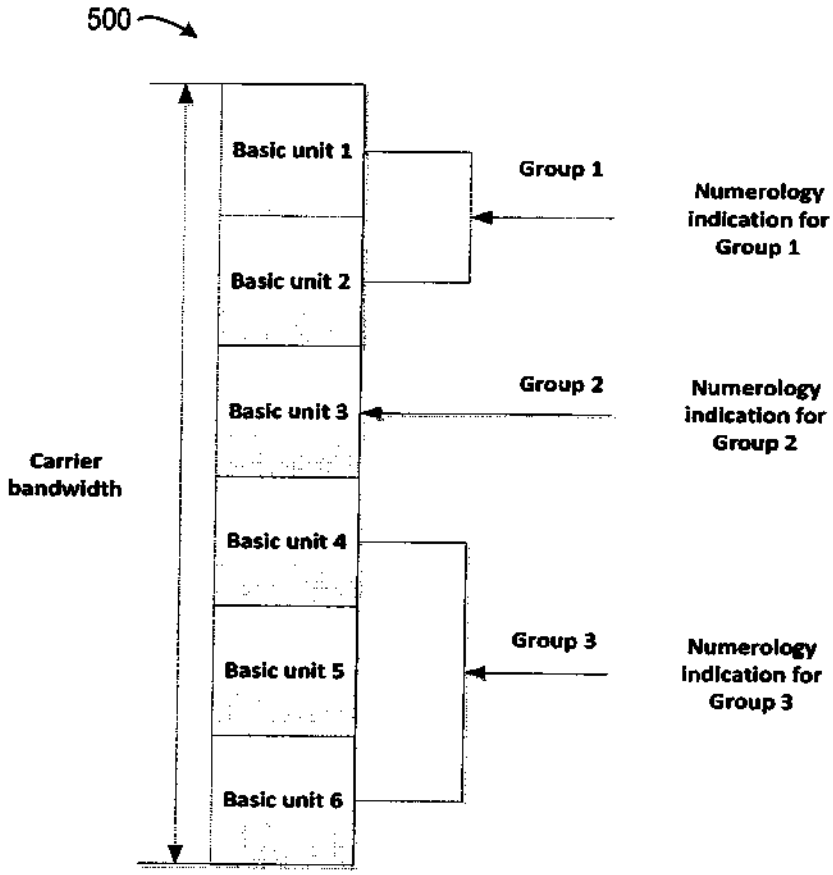

500
Basic unit 1
Basic unit 2
Basic unit 3
Basic unit 4
Basic unit 5
Basic unit 6
Carrier bandwidth
Group 1
Group 2
Group 3
Numerology indication for Group 1
Numerology indication for Group 2
Numerology indication for Group 3

FIG. 5

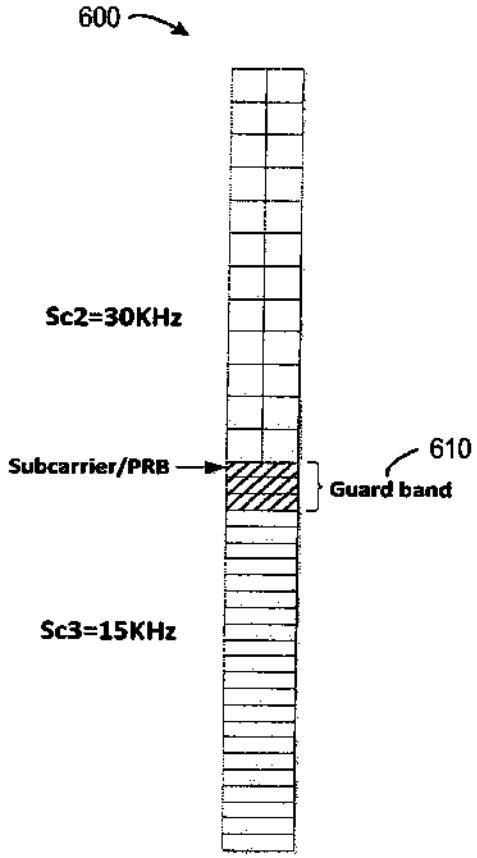


FIG. 6

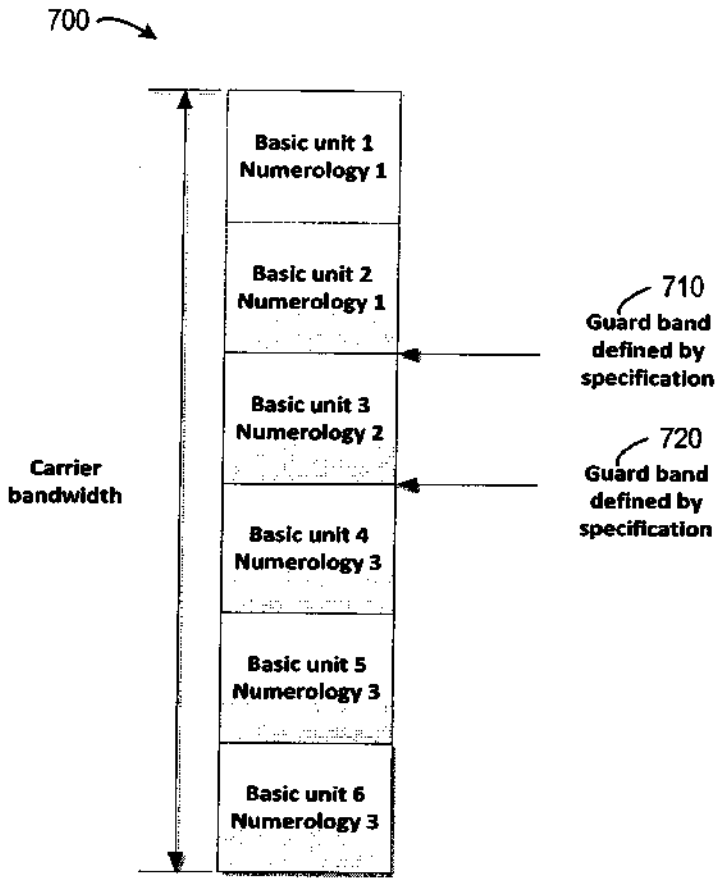

700
Basic unit 1
Numerology 1
Basic unit 2
Numerology 1
Basic unit 3
Numerology 2
Basic unit 4
Numerology 3
Basic unit 5
Numerology 3
Basic unit 6
Numerology 3
Carrier bandwidth
710
Guard band defined by specification
720
Guard band defined by specification

FIG. 7

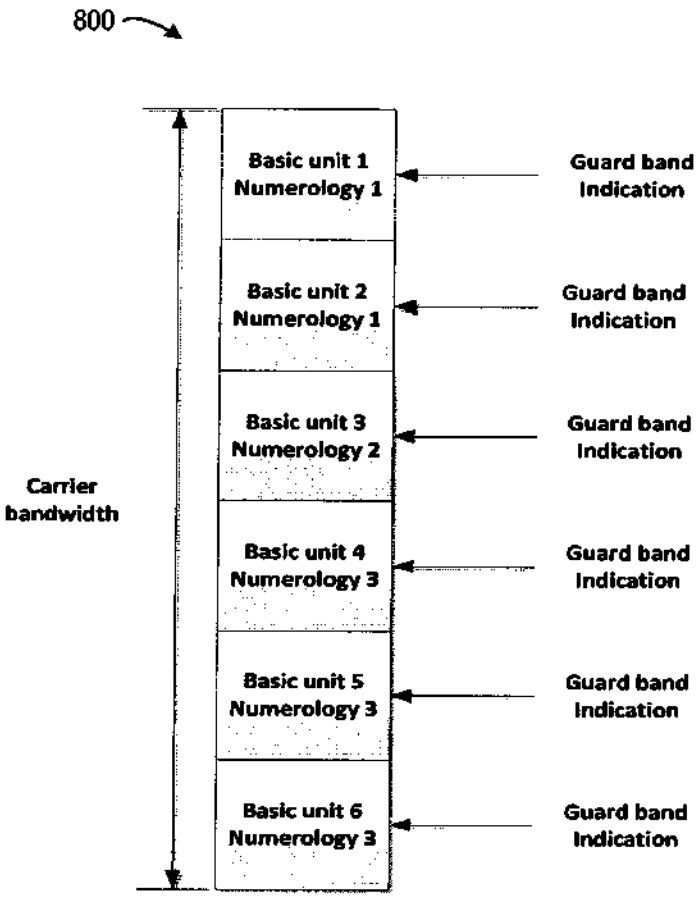

800
Carrier bandwidth
Basic unit 1 Numerology 1
Basic unit 2 Numerology 1
Basic unit 3 Numerology 2
Basic unit 4 Numerology 3
Basic unit 5 Numerology 3
Basic unit 6 Numerology 3
Guard band Indication
Guard band Indication
Guard band Indication
Guard band Indication
Guard band Indication
Guard band Indication

FIG. 8

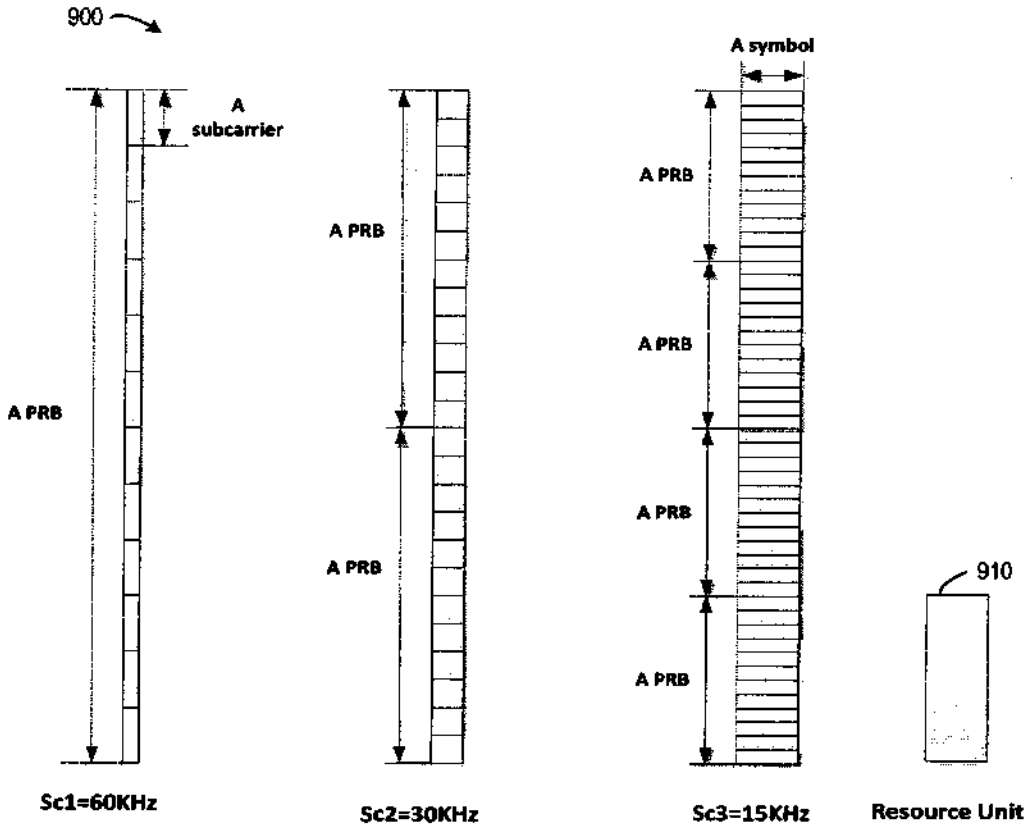

900
A subcarrier
A PRB
Sc1=60KHz
A PRB
A PRB
Sc2=30KHz
A symbol
A PRB
A PRB
A PRB
A PRB
Sc3=15KHz
910
Resource Unit

FIG. 9

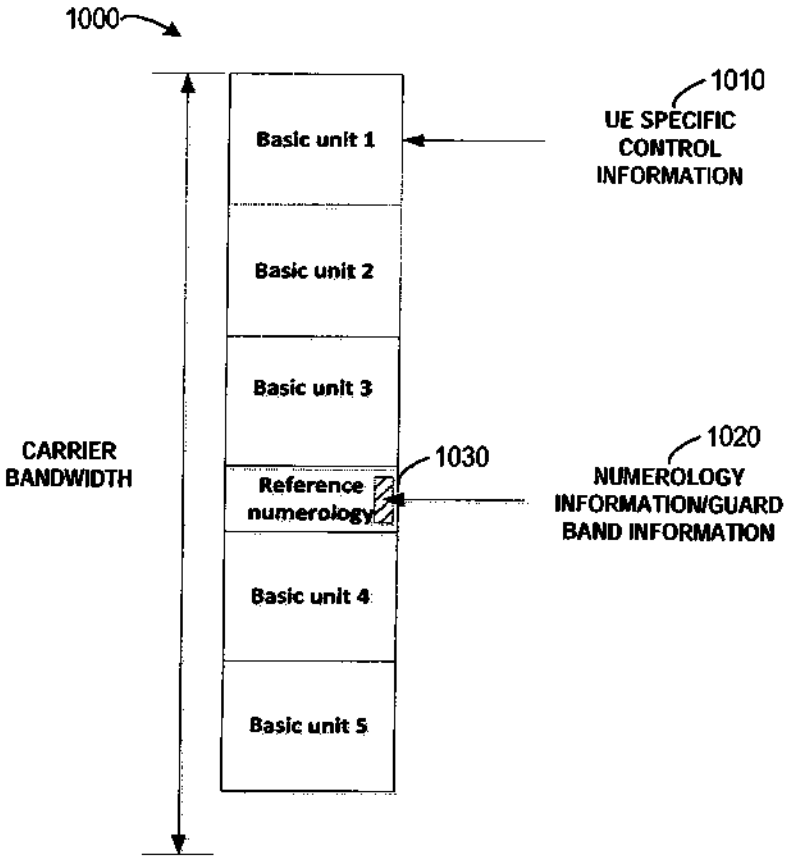

1000
Basic unit 1
Basic unit 2
Basic unit 3
Reference numerology
Basic unit 4
Basic unit 5
CARRIER BANDWIDTH
1010
UE SPECIFIC CONTROL INFORMATION
1020
1030
NUMEROLOGY INFORMATION/GUARD BAND INFORMATION

FIG. 10

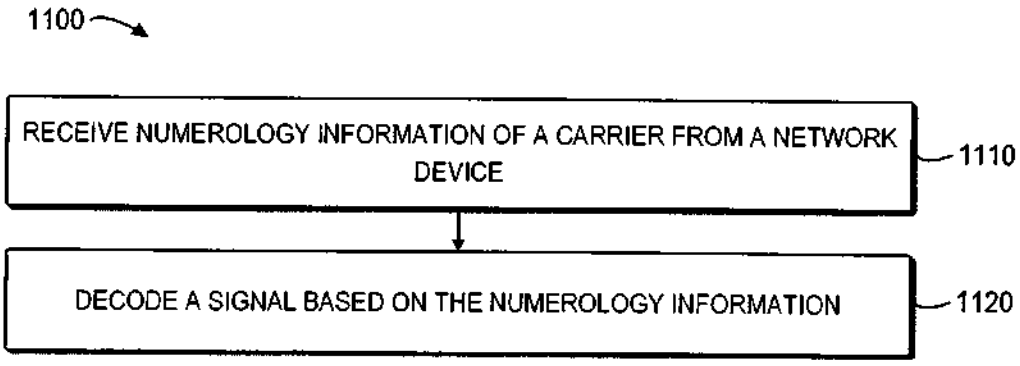

1100
RECEIVE NUMEROLOGY INFORMATION OF A CARRIER FROM A NETWORK DEVICE
1110
DECODE A SIGNAL BASED ON THE NUMEROLOGY INFORMATION
1120

FIG. 11

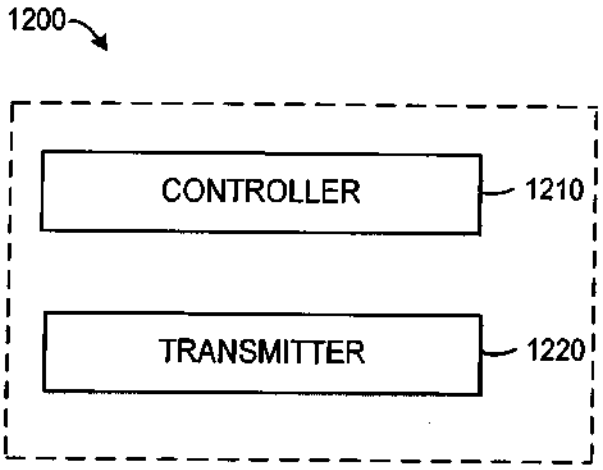

1200
CONTROLLER
1210
TRANSMITTER
1220

FIG. 12

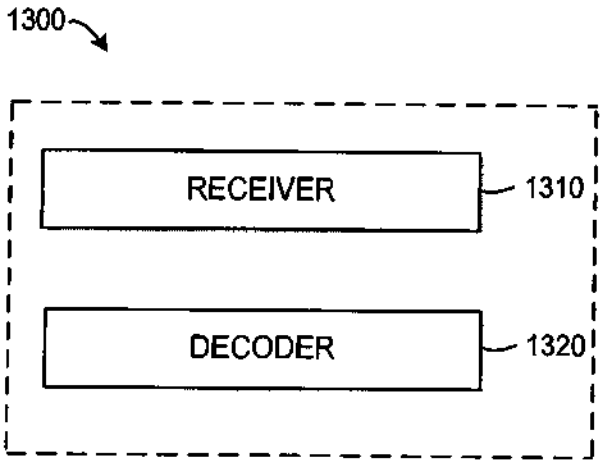

1300
RECEIVER
1310
DECODER
1320

FIG. 13

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2016/000597

A. CLASSIFICATION OF SUBJECT MATTER

H04W 72/04(2009.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04W; H04L; H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI; EPODOC; CNKI; CNPAT; 3GPP: numerology, parameter, carrier, subcarrier, basic unit, subcarrier spacing, symbol length, cyclic prefix, time frequency resource, physical resource block, nodeB, eNodeB, eNB, UE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	PANASONIC. "3GPP TSG-RAN WG1 Meeting #86bis R1-1610217" *Resource assignment for mixed numerologies,* 14 October 2016 (2016-10-14), the whole document	1-36
X	NEC. "3GPP TSG RAN WG1 Meeting #86bis R1-1609145" *Discussion on numerology multiplexing for supporting different service requirements,* 14 October 2016 (2016-10-14), the whole document	1-36
A	US 2015215148 A1 (SAMSUNG ELECTRONICS CO., LTD.) 30 July 2015 (2015-07-30) the whole document	1-36
A	CN 101932104 A (INDUSTRIAL TECHNOLOGY RESEARCH INSTITUTE) 29 December 2010 (2010-12-29) the whole document	1-36

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
06 July 2017	**27 July 2017**
Name and mailing address of the ISA/CN **STATE INTELLECTUAL PROPERTY OFFICE OF THE P.R.CHINA** **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088** **China** Facsimile No. **(86-10)62019451**	Authorized officer **LIU,Qingfeng** Telephone No. **(86-10)62413279**

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2016/000597

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
US	2015215148	A1	30 July 2015	US	2013051485	A1	28 February 2013
				KR	20130022523	A	07 March 2013
CN	101932104	A	29 December 2010	TW	201129188	A	16 August 2011
				CN	102932124	A	13 February 2013
				US	2010322175	A1	23 December 2010

Form PCT/ISA/210 (patent family annex) (July 2009)

(12) 특허협력조약에 의하여 공개된 국제출원

(19) 세계지식재산권기구
국제사무국

(43) 국제공개일
2016 년 8 월 4 일 (04.08.2016)

WIPO | PCT

(10) 국제공개번호
WO 2016/122232 A1

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(21) 국제출원번호: PCT/KR2016/000945

(22) 국제출원일: 2016 년 1 월 28 일 (28.01.2016)

(25) 출원언어: 한국어

(26) 공개언어: 한국어

(30) 우선권정보:
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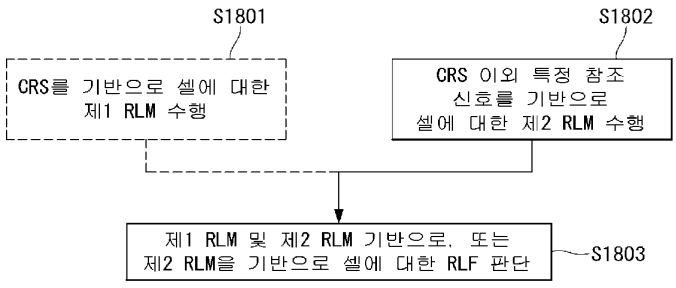
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공개:
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(54) Title: RADIO LINK MONITORING METHOD IN WIRELESS COMMUNICATION SYSTEM AND DEVICE THEREFOR

(54) 발명의 명칭 : 무선 통신 시스템에서 무선 링크 모니터링 방법 및 이를 위한 장치

[도18]



S1801 ... Perform first RLM for cell on basis of CRS
S1802 ... Perform second RLM for cell on basis of particular reference signal except for CRS
S1803 ... Determine RLM for cell, on basis of first RLM and second RLM or on basis of second RLM

(57) **Abstract**: Disclosed are a radio link monitoring method in a wireless communication system and a device therefor. Specifically, the method for performing radio link monitoring (RLM) by a terminal in a wireless communication system comprises the steps of: performing second RLM for a cell, on the basis of a reference signal except for a cell-specific reference signal (CRS); and determining a radio link failure (RLF) for the cell, on the basis of the second RLM, wherein a determination condition for RLF determination applied to the second RLM may be different from a determination condition for RLF determination applied to CRS-based first RLM.

(57) **요약서**: 무선 통신 시스템에서 무선 링크 모니터링 방법 및 이를 위한 장치가 개시된다. 구체적으로, 무선 통신 시스템에서 단말이 무선 링크 모니터링(RLM: radio link monitoring)을 수행하는 방법에 있어서, 셀 특정 참조 신호(CRS: cell-specific reference signal) 이외 참조 신호를 기반으로 셀에 대한 제 2 RLM 을 수행하는 단계 및 상기 제 2 RLM 을 기반으로 상기 셀에 대한 무선 링크 실패(RLF: radio link failure)를 판단하는 단계를 포함하고, 상기 제 2 RLM 에 적용되는 RLF 판단을 위한 판단 조건은 CRS 기반 제 1 RLM 에 적용되는 RLF 판단을 위한 판단 조건과 상이할 수 있다.

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명세서

발명의 명칭: 무선 통신 시스템에서 무선 링크 모니터링 방법 및 이를 위한 장치

기술분야

[1] 본 발명은 무선 통신 시스템에 관한 것으로서, 보다 상세하게 단말에서 참조 신호(reference signal)을 기반으로 무선 링크 모니터링을 수행하기 위한 방법 및 이를 지원하는 장치에 관한 것이다.

배경기술

[2] 이동 통신 시스템은 사용자의 활동성을 보장하면서 음성 서비스를 제공하기 위해 개발되었다. 그러나 이동통신 시스템은 음성뿐 아니라 데이터 서비스까지 영역을 확장하였으며, 현재에는 폭발적인 트래픽의 증가로 인하여 자원의 부족 현상이 야기되고 사용자들이 보다 고속의 서비스에 대한 요구하므로, 보다 발전된 이동 통신 시스템이 요구되고 있다.

[3] 차세대 이동 통신 시스템의 요구 조건은 크게 폭발적인 데이터 트래픽의 수용, 사용자 당 전송률의 획기적인 증가, 대폭 증가된 연결 디바이스 개수의 수용, 매우 낮은 단대단 지연(End-to-End Latency), 고에너지 효율을 지원할 수 있어야 한다. 이를 위하여 이중 연결성(Dual Connectivity), 대규모 다중 입출력(Massive MIMO: Massive Multiple Input Multiple Output), 전이중(In-band Full Duplex), 비직교 다중접속(NOMA: Non-Orthogonal Multiple Access), 초광대역(Super wideband) 지원, 단말 네트워킹(Device Networking) 등 다양한 기술들이 연구되고 있다.

발명의 상세한 설명

기술적 과제

[4] 본 발명의 목적은 무선 통신 시스템에서 단말이 셀 특정 참조 신호(CRS: Cell-specific Reference Signal)과는 별도로 설정되는 무선 자원 무선 자원 관리(RRM: Radio Resource Management) 측정을 위한 참조 신호(RRM-RS)를 기반으로 단말이 셀을 (재)선택하는 방법을 제안한다.

[5] 또한, 본 발명의 목적은 RRM-RS 기반으로 선택된 최적의 셀로 초기 접속(initial access) 과정을 수행하기 위한 방법을 제안한다.

[6] 또한, 본 발명의 목적은 CRS 이외의 참조 신호를 기반으로 무선 링크 모니터링(radio link monitoring)을 수행하는 방법을 제안한다.

[7] 본 발명에서 이루고자 하는 기술적 과제들은 이상에서 언급한 기술적 과제들로 제한되지 않으며, 언급하지 않은 또 다른 기술적 과제들은 아래의 기재로부터 본 발명이 속하는 기술분야에서 통상의 지식을 가진 자에게 명확하게 이해될 수 있을 것이다.

과제 해결 수단

[8] 본 발명의 일 양상은, 무선 통신 시스템에서 단말이 무선 링크 모니터링(RLM: radio link monitoring)을 수행하는 방법에 있어서, 셀 특정 참조 신호(CRS: cell-specific reference signal) 이외 참조 신호를 기반으로 셀에 대한 제2 RLM을 수행하는 단계 및 상기 제2 RLM을 기반으로 상기 셀에 대한 무선 링크 실패(RLF: radio link failure)를 판단하는 단계를 포함하고, 상기 제2 RLM에 적용되는 RLF 판단을 위한 판단 조건은 CRS 기반 제1 RLM에 적용되는 RLF 판단을 위한 판단 조건과 상이할 수 있다.

[9] 본 발명의 다른 일 양상은, 무선 통신 시스템에서 무선 링크 모니터링(RLM: radio link monitoring)을 수행하는 단말에 있어서, 무선 신호를 송수신하기 위한 RF(Radio Frequency) 유닛 및 상기 RF 유닛을 제어하는 프로세서를 포함하고, 상기 셀 특정 참조 신호(CRS: cell-specific reference signal) 이외 참조 신호를 기반으로 셀에 대한 제2 RLM을 수행하고, 상기 제2 RLM을 기반으로 상기 셀에 대한 무선 링크 실패(RLF: radio link failure)를 판단하도록 구성되고, 상기 제2 RLM에 적용되는 RLF 판단을 위한 판단 조건은 CRS 기반 제1 RLM에 적용되는 RLF 판단을 위한 판단 조건과 상이할 수 있다.

[10] 바람직하게, 상기 CRS 기반으로 상기 제1 RLM을 수행하는 단계를 더 포함하고, 상기 셀에 대한 RLF는 상기 제1 RLM 및 상기 제2 RLM을 기반으로 판단될 수 있다.

[11] 바람직하게, 상기 RLF 판단을 위한 판단 조건은 제어 채널 전송 파라미터, 비동기(out-of-sync)/동기(in-sync) 상태 판단을 위한 임계값 및 RLF 타이머 중 적어도 어느 하나를 포함할 수 있다.

[12] 바람직하게, 상기 제2 RLM의 경우, 상기 제2 모니터링을 위한 하향링크 제어 정보(DCI: Downlink Control Information)가 소정의 진보된 물리 하향링크 제어 채널(EPDCCH: Enhanced Physical Downlink Control Channel) 세트로부터 전송된다고 가정될 수 있다.

[13] 바람직하게, 상기 단말이 풀 차원 다중 입력 다중 출력(FD-MIMO: full dimension-Multi Input Multi Output) 지원 가능한 경우, 상기 제2 RLM이 수행될 수 있다.

[14] 바람직하게, 상기 단말이 FD-MIMO 지원 가능하고 상기 단말이 FD-MIMO 모드가 활성화된 경우, 상기 제2 RLM이 수행될 수 있다.

[15] 바람직하게, 상기 셀에 대한 RLF가 상기 제1 RLM 및 상기 제2 RLM을 기반으로 판단되는 경우, 상기 제1 RLM 및 상기 제2 RLM 중 적어도 어느 하나에 의해 상기 셀에 대한 RLF가 결정되면, 상기 셀에 대한 RLF가 결정될 수 있다.

[16] 바람직하게, 상기 제1 RLM 및 상기 제2 RLM 중 어느 하나가 상기 셀에 대한 RLF 판단에 있어서 높은 우선 순위를 가질 수 있다.

[17] 바람직하게, 상기 셀에 대한 RLF가 상기 제1 RLM 및 상기 제2 RLM을 기반으로 판단되는 경우, 상기 제1 RLM 및 상기 제2 RLM 모두에 의해 상기 셀에 대한 RLF가 결정되면, 상기 셀에 대한 RLF가 결정될 수 있다.

[18] 바람직하게, 상기 제2 RLM은 상기 제1 RLM에 의해 소정의 조건이 만족되는 경우 수행될 수 있다.

[19] 바람직하게, 상기 제1 RLM에 의한 RLF 타이머가 가동된 시점으로부터 소정의 오프셋 시간 이후 상기 제2 RLM이 개시될 수 있다.

[20] 바람직하게, 상기 제1 RLM에 의한 RLF 타이머가 가동된 시점으로부터 상기 단말에 의한 다른 셀의 선택(selection) 또는 재선택(reselection) 절차가 완료되기까지 구간 동안, 상기 제2 RLM과 연계된 EPDCCH 세트를 통해 DCI가 수신되고, 상기 DCI에 의해 스케줄링된 물리 하향링크 공유 채널(PDSCH: Physical Downlink Shared Channel)를 통해 하향링크 데이터가 수신될 수 있다.

[21] 바람직하게, 미리 정해진 무선 네트워크 임시 식별자(RNTI: Radio Network Temporary Identifier)로 마스킹된 DCI만 상기 EPDCCH 세트를 통해 수신될 수 있다.

[22] 바람직하게, 상기 CSI 이외 참조 신호는 채널 상태 정보 참조 신호(CSI-RS: Channel State Information-Reference Signal), 디스커버리 참조 신호(DRS: Discovery Reference Signal), 프리코딩된(precoded) 참조 신호 및 셀 (재)선택 관련 동작 시에 적용하도록 설정된 참조 서로 다른 셀 또는 전송 포인트(TP: Transmission Point)의 개수로 구성되는 무정형 셀(amorphous cell)에서 전송되는 참조 신호 중 어느 하나일 수 있다.

발명의 효과

[23] 본 발명의 실시예에 따르면, 무선 통신 시스템에서, 특히 풀-차원-MIMO(full-dimension MIMO)를 사용하거나 진보된 무정형 셀(amorphous cell)을 지원하는 환경에서, 단말에게 가장 효율이 좋은 최적의 셀이 선택될 수 있다.

[24] 또한, 본 발명의 실시예에 따르면, 단말에게 가장 효율이 좋은 최적의 셀로 초기 접속(initial access)함으로써 단말의 초기 셀 접속 과정에서의 지연(latency)을 최소화할 수 있다.

[25] 또한, 본 발명의 실시예에 따르면, 단말에게 가장 효율이 좋은 최적의 셀로 초기 접속(initial access)함으로써, 단말의 추가적인 핸드오버(hand-over)나 셀 재선택(cell re-selection) 과정 없이 빠르게 정상 동작 상태에 진입할 수 있도록 하는 장점이 있다.

[26] 또한, 본 발명의 실시예에 따르면, (CRS 기반 무선 링크 모니터링과 함께) CRS 이외 참조 신호 기반 무선 링크 모니터링에 의해 무선 링크 실패를 판단함으로써 빔포밍된 채널(예를 들어, 풀 차원 다중 입출력(FD-MIMO: Full Dimension Multi-Input Multi-Output) 등이 적용된 채널)에 따른 무선 링크 품질을 고려할 수 있다.

[27] 또한, 본 발명의 실시예에 따르면, 빔포밍된 채널에 따른 무선 링크 품질을 고려함으로써, 빔포밍된 채널 환경이 좋은 상태에서 통신 링크가 단절되는

현상을 줄이며, 또한 빔포밍된 채널을 통한 송수신 동작을 유지함에 따른 성능 이득을 얻을 수 있다.

[28] 본 발명에서 얻을 수 있는 효과는 이상에서 언급한 효과로 제한되지 않으며, 언급하지 않은 또 다른 효과들은 아래의 기재로부터 본 발명이 속하는 기술분야에서 통상의 지식을 가진 자에게 명확하게 이해될 수 있을 것이다.

도면의 간단한 설명

[29] 본 발명에 관한 이해를 돕기 위해 상세한 설명의 일부로 포함되는, 첨부 도면은 본 발명에 대한 실시예를 제공하고, 상세한 설명과 함께 본 발명의 기술적 특징을 설명한다.

[30] 도 1은 본 발명이 적용될 수 있는 무선 통신 시스템에서 무선 프레임의 구조를 나타낸다.

[31] 도 2는 본 발명이 적용될 수 있는 무선 통신 시스템에서 하나의 하향링크 슬롯에 대한 자원 그리드(resource grid)를 예시한 도면이다.

[32] 도 3은 본 발명이 적용될 수 있는 무선 통신 시스템에서 하향링크 서브 프레임의 구조를 나타낸다.

[33] 도 4는 본 발명이 적용될 수 있는 무선 통신 시스템에서 상향링크 서브 프레임의 구조를 나타낸다.

[34] 도 5는 일반적인 다중 입출력 안테나(MIMO) 통신 시스템의 구성도이다.

[35] 도 6은 다수의 송신 안테나에서 하나의 수신 안테나로의 채널을 나타낸 도이다.

[36] 도 7은 본 발명이 적용될 수 있는 무선 통신 시스템에서 컴포넌트 캐리어 및 캐리어 병합의 일례를 나타낸다.

[37] 도 8은 본 발명이 적용될 수 있는 무선 통신 시스템에서 경쟁 기반 랜덤 액세스 절차를 설명하기 위한 도면이다.

[38] 도 9는 본 발명이 적용될 수 있는 무선 통신 시스템에서 하향링크 자원 블록 쌍에 매핑된 참조 신호 패턴을 예시한다.

[39] 도 10은 본 발명이 적용될 수 있는 무선 통신 시스템에서 CSI-RS 구성을 예시하는 도면이다.

[40] 도 11은 본 발명이 적용될 수 있는 무선 통신 시스템에서 기지국 또는 단말이 AAS 기반의 3D(3-Dimension) 빔 형성이 가능한 다수의 송/수신 안테나를 갖고 있는 시스템을 예시한다.

[41] 도 12는 본 발명의 일 실시예에 따른 RRM-RS의 안테나 포트 별 RSRP를 예시한다.

[42] 도 13은 본 발명의 일 실시예에 따른 RRM-RS 안테나 포트 그룹핑 레벨을 예시한다.

[43] 도 14는 본 발명의 일 실시예에 따른 이차원 인덱스로 배열된 RRM-RS의 안테나 포트와 안테나 포트 그룹을 예시하는 도면이다.

[44] 도 15는 본 발명의 일 실시예에 따른 RRM-RS 기반 셀 선택 방법을 예시하는

도면이다.

[45] 도 16은 본 발명의 일 실시예에 따른 RRM 측정 방법을 예시하는 도면이다.

[46] 도 17은 본 발명의 일 실시예에 따른 랜덤 액세스 절차를 예시하는 도면이다.

[47] 도 18은 본 발명의 일 실시예에 따른 무선 링크 모니터링을 위한 방법을 예시하는 도면이다.

[48] 도 19는 본 발명의 일 실시예에 따른 무선 통신 장치의 블록 구성도를 예시한다.

발명의 실시를 위한 형태

[49] 이하, 본 발명에 따른 바람직한 실시 형태를 첨부된 도면을 참조하여 상세하게 설명한다. 첨부된 도면과 함께 이하에 개시될 상세한 설명은 본 발명의 예시적인 실시형태를 설명하고자 하는 것이며, 본 발명이 실시될 수 있는 유일한 실시형태를 나타내고자 하는 것이 아니다. 이하의 상세한 설명은 본 발명의 완전한 이해를 제공하기 위해서 구체적 세부사항을 포함한다. 그러나, 당업자는 본 발명이 이러한 구체적 세부사항 없이도 실시될 수 있음을 안다.

[50] 몇몇 경우, 본 발명의 개념이 모호해지는 것을 피하기 위하여 공지의 구조 및 장치는 생략되거나, 각 구조 및 장치의 핵심기능을 중심으로 한 블록도 형식으로 도시될 수 있다.

[51] 본 명세서에서 기지국은 단말과 직접적으로 통신을 수행하는 네트워크의 종단 노드(terminal node)로서의 의미를 갖는다. 본 문서에서 기지국에 의해 수행되는 것으로 설명된 특정 동작은 경우에 따라서는 기지국의 상위 노드(upper node)에 의해 수행될 수도 있다. 즉, 기지국을 포함하는 다수의 네트워크 노드들(network nodes)로 이루어지는 네트워크에서 단말과의 통신을 위해 수행되는 다양한 동작들은 기지국 또는 기지국 이외의 다른 네트워크 노드들에 의해 수행될 수 있음은 자명하다. '기지국(BS: Base Station)'은 고정국(fixed station), Node B, eNB(evolved-NodeB), BTS(base transceiver system), 액세스 포인트(AP: Access Point) 등의 용어에 의해 대체될 수 있다. 또한, '단말(Terminal)'은 고정되거나 이동성을 가질 수 있으며, UE(User Equipment), MS(Mobile Station), UT(user terminal), MSS(Mobile Subscriber Station), SS(Subscriber Station), AMS(Advanced Mobile Station), WT(Wireless terminal), MTC(Machine-Type Communication) 장치, M2M(Machine-to-Machine) 장치, D2D(Device-to-Device) 장치 등의 용어로 대체될 수 있다.

[52] 이하에서, 하향링크(DL: downlink)는 기지국에서 단말로의 통신을 의미하며, 상향링크(UL: uplink)는 단말에서 기지국으로의 통신을 의미한다. 하향링크에서 송신기는 기지국의 일부이고, 수신기는 단말의 일부일 수 있다. 상향링크에서 송신기는 단말의 일부이고, 수신기는 기지국의 일부일 수 있다.

[53] 이하의 설명에서 사용되는 특정 용어들은 본 발명의 이해를 돕기 위해서 제공된 것이며, 이러한 특정 용어의 사용은 본 발명의 기술적 사상을 벗어나지 않는 범위에서 다른 형태로 변경될 수 있다.

[54] 이하의 기술은 CDMA(code division multiple access), FDMA(frequency division multiple access), TDMA(time division multiple access), OFDMA(orthogonal frequency division multiple access), SC-FDMA(single carrier frequency division multiple access), NOMA(non-orthogonal multiple access) 등과 같은 다양한 무선 접속 시스템에 이용될 수 있다. CDMA는 UTRA(universal terrestrial radio access)나 CDMA2000과 같은 무선 기술(radio technology)로 구현될 수 있다. TDMA는 GSM(global system for mobile communications)/GPRS(general packet radio service)/EDGE(enhanced data rates for GSM evolution)와 같은 무선 기술로 구현될 수 있다. OFDMA는 IEEE 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802-20, E-UTRA(evolved UTRA) 등과 같은 무선 기술로 구현될 수 있다. UTRA는 UMTS(universal mobile telecommunications system)의 일부이다. 3GPP(3rd generation partnership project) LTE(long term evolution)은 E-UTRA를 사용하는 E-UMTS(evolved UMTS)의 일부로써, 하향링크에서 OFDMA를 채용하고 상향링크에서 SC-FDMA를 채용한다. LTE-A(advanced)는 3GPP LTE의 진화이다.

[55] 본 발명의 실시예들은 무선 접속 시스템들인 IEEE 802, 3GPP 및 3GPP2 중 적어도 하나에 개시된 표준 문서들에 의해 뒷받침될 수 있다. 즉, 본 발명의 실시예들 중 본 발명의 기술적 사상을 명확히 드러내기 위해 설명하지 않은 단계들 또는 부분들은 상기 문서들에 의해 뒷받침될 수 있다. 또한, 본 문서에서 개시하고 있는 모든 용어들은 상기 표준 문서에 의해 설명될 수 있다.

[56] 설명을 명확하게 하기 위해, 3GPP LTE/LTE-A를 위주로 기술하지만 본 발명의 기술적 특징이 이에 제한되는 것은 아니다.

[57]

[58] **본 발명이 적용될 수 있는 무선 통신 시스템 일반**

[59] 도 1은 본 발명이 적용될 수 있는 무선 통신 시스템에서 무선 프레임의 구조를 나타낸다.

[60] 3GPP LTE/LTE-A에서는 FDD(Frequency Division Duplex)에 적용 가능한 타입 1 무선 프레임(radio frame) 구조와 TDD(Time Division Duplex)에 적용 가능한 타입 2의 무선 프레임 구조를 지원한다.

[61] 도 1에서 무선 프레임의 시간 영역에서의 크기는 $T_s=1/(15000*2048)$의 시간 단위의 배수로 표현된다. 하향링크 및 상향링크 전송은 $T_f=307200*T_s=10ms$의 구간을 가지는 무선 프레임으로 구성된다.

[62] 도 1의 (a)는 타입 1 무선 프레임의 구조를 예시한다. 타입 1 무선 프레임은 전이중(full duplex) 및 반이중(half duplex) FDD에 모두 적용될 수 있다.

[63] 무선 프레임(radio frame)은 10개의 서브프레임(subframe)으로 구성된다. 하나의 무선 프레임은 $T_{slot}=15360*T_s=0.5ms$ 길이의 20개의 슬롯으로 구성되고, 각 슬롯은 0부터 19까지의 인덱스가 부여된다. 하나의 서브프레임은 시간 영역(time domain)에서 연속적인 2개의 슬롯(slot)으로 구성되고, 서브프레임 i는 슬롯 2i 및 슬롯 2i+1로 구성된다. 하나의 서브프레임을 전송하는데 걸리는 시간을

TTI(transmission time interval)이라 한다. 예를 들어, 하나의 서브 프레임은 길이는 1ms이고, 하나의 슬롯의 길이는 0.5ms일 수 있다.

[64] FDD에서 상향링크 전송 및 하향링크 전송은 주파수 도메인에서 구분된다. 전이중 FDD에 제한이 없는 반면, 반이중 FDD 동작에서 단말은 동시에 전송 및 수신을 할 수 없다.

[65] 하나의 슬롯은 시간 영역에서 복수의 OFDM(orthogonal frequency division multiplexing) 심볼을 포함하고, 주파수 영역에서 다수의 자원블록(RB: Resource Block)을 포함한다. 3GPP LTE는 하향링크에서 OFDMA를 사용하므로 OFDM 심볼은 하나의 심볼 구간(symbol period)을 표현하기 위한 것이다. OFDM 심볼은 하나의 SC-FDMA 심볼 또는 심볼 구간이라고 할 수 있다. 자원 블록(resource block)은 자원 할당 단위이고, 하나의 슬롯에서 복수의 연속적인 부반송파(subcarrier)를 포함한다.

[66] 도 1의 (b)는 타입 2 프레임 구조(frame structure type 2)를 나타낸다.

[67] 타입 2 무선 프레임은 각 153600*T_s=5ms의 길이의 2개의 하프 프레임(half frame)으로 구성된다. 각 하프 프레임은 30720*T_s=1ms 길이의 5개의 서브프레임으로 구성된다.

[68] TDD 시스템의 타입 2 프레임 구조에서 상향링크-하향링크 구성(uplink-downlink configuration)은 모든 서브프레임에 대하여 상향링크와 하향링크가 할당(또는 예약)되는지 나타내는 규칙이다.

[69] 표 1은 상향링크-하향링크 구성을 나타낸다.

[70] [표1]

Uplink-Downlink configu-ration	Downlink-to-Uplink Switch-point periodicity	Subframe number									
		0	1	2	3	4	5	6	7	8	9
0	5ms	D	S	U	U	U	D	S	U	U	U
1	5ms	D	S	U	U	D	D	S	U	U	D
2	5ms	D	S	U	D	D	D	S	U	D	D
3	10ms	D	S	U	U	U	D	D	D	D	D
4	10ms	D	S	U	U	D	D	D	D	D	D
5	10ms	D	S	U	D	D	D	D	D	D	D
6	5ms	D	S	U	U	U	D	S	U	U	D

[71] 표 1을 참조하면, 무선 프레임의 각 서브프레임 별로, 'D'는 하향링크 전송을 위한 서브프레임을 나타내고, 'U'는 상향링크 전송을 위한 서브프레임을 나타내며, 'S'는 DwPTS(Downlink Pilot Time Slot), 보호구간(GP: Guard Period), UpPTS(Uplink Pilot Time Slot) 3가지의 필드로 구성되는 스페셜 서브프레임(special subframe)을 나타낸다.

[72] DwPTS는 단말에서의 초기 셀 탐색, 동기화 또는 채널 추정에 사용된다. UpPTS는 기지국에서의 채널 추정과 단말의 상향링크 전송 동기를 맞추는 데 사용된다. GP는 상향링크와 하향링크 사이에 하향링크 신호의 다중경로

지연으로 인해 상향링크에서 생기는 간섭을 제거하기 위한 구간이다.

[73] 각 서브프레임 i는 각 T_slot=15360*T_s=0.5ms 길이의 슬롯 2i 및 슬롯 2i+1로 구성된다.

[74] 상향링크-하향링크 구성은 7가지로 구분될 수 있으며, 각 구성 별로 하향링크 서브프레임, 스페셜 서브프레임, 상향링크 서브프레임의 위치 및/또는 개수가 다르다.

[75] 하향링크에서 상향링크로 변경되는 시점 또는 상향링크에서 하향링크로 전환되는 시점을 전환 시점(switching point)이라 한다. 전환 시점의 주기성(Switch-point periodicity)은 상향링크 서브프레임과 하향링크 서브프레임이 전환되는 양상이 동일하게 반복되는 주기를 의미하며, 5ms 또는 10ms가 모두 지원된다. 5ms 하향링크-상향링크 전환 시점의 주기를 가지는 경우에는 스페셜 서브프레임(S)은 하프-프레임 마다 존재하고, 5ms 하향링크-상향링크 전환 시점의 주기를 가지는 경우에는 첫번째 하프-프레임에만 존재한다.

[76] 모든 구성에 있어서, 0번, 5번 서브프레임 및 DwPTS는 하향링크 전송만을 위한 구간이다. UpPTS 및 서브프레임 서브프레임에 바로 이어지는 서브프레임은 항상 상향링크 전송을 위한 구간이다.

[77] 이러한, 상향링크-하향링크 구성은 시스템 정보로써 기지국과 단말이 모두 알고 있을 수 있다. 기지국은 상향링크-하향링크 구성 정보가 바뀔 때마다 구성 정보의 인덱스만을 전송함으로써 무선 프레임의 상향링크-하향링크 할당상태의 변경을 단말에 알려줄 수 있다. 또한, 구성 정보는 일종의 하향링크 제어정보로서 다른 스케줄링 정보와 마찬가지로 PDCCH(Physical Downlink Control Channel)를 통해 전송될 수 있으며, 방송 정보로서 브로드캐스트 채널(broadcast channel)을 통해 셀 내의 모든 단말에 공통으로 전송될 수도 있다.

[78] 표 2는 스페셜 서브프레임의 구성(DwPTS/GP/UpPTS의 길이)을 나타낸다.

[79] [표2]

Special subframe configuration	Normal cyclic prefix in downlink			Extended cyclic prefix in downlink		
	DwPTS	UpPTS		DwPTS	UpPTS	
		Normal cyclic prefix in uplink	Extended cyclic prefix in uplink		Normal cyclic prefix in uplink	Extended cyclic prefix in uplink
0	$6592 \cdot T_s$	$2192 \cdot T_s$	$2560 \cdot T_s$	$7680 \cdot T_s$	$2192 \cdot T_s$	$2560 \cdot T_s$
1	$19760 \cdot T_s$			$20480 \cdot T_s$		
2	$21952 \cdot T_s$			$23040 \cdot T_s$		
3	$24144 \cdot T_s$			$25600 \cdot T_s$		
4	$26336 \cdot T_s$			$7680 \cdot T_s$	$4384 \cdot T_s$	$5120 \cdot T_s$
5	$6592 \cdot T_s$	$4384 \cdot T_s$	$5120 \cdot T_s$	$20480 \cdot T_s$		
6	$19760 \cdot T_s$			$23040 \cdot T_s$		
7	$21952 \cdot T_s$			-	-	-
8	$24144 \cdot T_s$			-	-	-

[80] 도 1의 예시에 따른 무선 프레임의 구조는 하나의 예시에 불과하며, 무선 프레임에 포함되는 부 반송파의 수 또는 서브 프레임에 포함되는 슬롯의 수, 슬롯에 포함되는 OFDM 심볼의 수는 다양하게 변경될 수 있다.

[81] 도 2는 본 발명이 적용될 수 있는 무선 통신 시스템에서 하나의 하향링크 슬롯에 대한 자원 그리드(resource grid)를 예시한 도면이다.

[82] 도 2를 참조하면, 하나의 하향링크 슬롯은 시간 영역에서 복수의 OFDM 심볼을 포함한다. 여기서, 하나의 하향링크 슬롯은 7개의 OFDM 심볼을 포함하고, 하나의 자원 블록은 주파수 영역에서 12개의 부 반송파를 포함하는 것을 예시적으로 기술하나, 이에 한정되는 것은 아니다.

[83] 자원 그리드 상에서 각 요소(element)를 자원 요소(resource element)하고, 하나의 자원 블록(RB: resource block)은 12×7 개의 자원 요소를 포함한다. 하향링크 슬롯에 포함되는 자원 블록들의 수 N^DL은 하향링크 전송 대역폭(bandwidth)에 종속한다.

[84] 상향링크 슬롯의 구조는 하향링크 슬롯의 구조와 동일할 수 있다.

[85] 도 3은 본 발명이 적용될 수 있는 무선 통신 시스템에서 하향링크 서브 프레임의 구조를 나타낸다.

[86] 도 3을 참조하면, 서브 프레임내의 첫번째 슬롯에서 앞의 최대 3개의 OFDM 심볼들이 제어 채널들이 할당되는 제어 영역(control region)이고, 나머지 OFDM 심볼들은 PDSCH(Physical Downlink Shared Channel)이 할당되는 데이터 영역(data region)이다. 3GPP LTE에서 사용되는 하향링크 제어 채널의 일례로 PCFICH(Physical Control Format Indicator Channel), PDCCH(Physical Downlink Control Channel), PHICH(Physical Hybrid-ARQ Indicator Channel) 등이 있다.

[87] PCFICH는 서브 프레임의 첫번째 OFDM 심볼에서 전송되고, 서브 프레임 내에 제어 채널들의 전송을 위하여 사용되는 OFDM 심볼들의 수(즉, 제어 영역의

크기)에 관한 정보를 나른다. PHICH는 상향 링크에 대한 응답 채널이고, HARQ(Hybrid Automatic Repeat Request)에 대한 ACK(Acknowledgement)/NACK(Not-Acknowledgement) 신호를 나른다. PDCCH를 통해 전송되는 제어 정보를 하향링크 제어정보(DCI: downlink control information)라고 한다. 하향링크 제어정보는 상향링크 자원 할당 정보, 하향링크 자원 할당 정보 또는 임의의 단말 그룹에 대한 상향링크 전송(Tx) 파워 제어 명령을 포함한다.

[88] PDCCH는 DL-SCH(Downlink Shared Channel)의 자원 할당 및 전송 포맷(이를 하향링크 그랜트라고도 한다.), UL-SCH(Uplink Shared Channel)의 자원 할당 정보(이를 상향링크 그랜트라고도 한다.), PCH(Paging Channel)에서의 페이징(paging) 정보, DL-SCH에서의 시스템 정보, PDSCH에서 전송되는 랜덤 액세스 응답(random access response)과 같은 상위 레이어(upper-layer) 제어 메시지에 대한 자원 할당, 임의의 단말 그룹 내 개별 단말들에 대한 전송 파워 제어 명령들의 집합, VoIP(Voice over IP)의 활성화 등을 나를 수 있다. 복수의 PDCCH들은 제어 영역 내에서 전송될 수 있으며, 단말은 복수의 PDCCH들을 모니터링할 수 있다. PDCCH는 하나 또는 복수의 연속적인 CCE(control channel elements)의 집합으로 구성된다. CCE는 무선 채널의 상태에 따른 부호화율(coding rate)을 PDCCH에 제공하기 위하여 사용되는 논리적 할당 단위이다. CCE는 복수의 자원 요소 그룹(resource element group)들에 대응된다. PDCCH의 포맷 및 사용 가능한 PDCCH의 비트 수는 CCE들의 수와 CCE들에 의해 제공되는 부호화율 간의 연관 관계에 따라 결정된다.

[89] 기지국은 단말에게 전송하려는 DCI에 따라 PDCCH 포맷을 결정하고, 제어 정보에 CRC(Cyclic Redundancy Check)를 붙인다. CRC에는 PDCCH의 소유자(owner)나 용도에 따라 고유한 식별자(이를 RNTI(Radio Network Temporary Identifier)라고 한다.)가 마스킹된다. 특정의 단말을 위한 PDCCH라면 단말의 고유한 식별자, 예를 들어 C-RNTI(Cell-RNTI)가 CRC에 마스킹될 수 있다. 또는 페이징 메시지를 위한 PDCCH라면 페이징 지시 식별자, 예를 들어 P-RNTI(Paging-RNTI)가 CRC에 마스킹될 수 있다. 시스템 정보, 더욱 구체적으로 시스템 정보 블록(SIB: system information block)를 위한 PDCCH라면 시스템 정보 식별자, SI-RNTI(system information RNTI)가 CRC에 마스킹될 수 있다. 단말의 랜덤 액세스 프리앰블의 전송에 대한 응답인 랜덤 액세스 응답을 지시하기 위하여, RA-RNTI(random access-RNTI)가 CRC에 마스킹될 수 있다.

[90] EPDCCH(enhanced PDCCH)는 단말 특정(UE-specific) 시그널링을 나른다. EPDCCH는 단말 특정하게 설정된 물리 자원 블록(PRB: physical resource block)에 위치한다. 다시 말해, 상술한 바와 같이 PDCCH는 서브 프레임내의 첫번째 슬롯에서 앞의 최대 3개의 OFDM 심볼들에서 전송될 수 있으나, EPDCCH는 PDCCH 이외의 자원 영역에서 전송될 수 있다. 서브프레임 내 EPDCCH가 시작되는 시점(즉, 심볼)은 상위 계층 시그널링(예를 들어, RRC 시그널링 등)을

통해 단말에 설정될 수 있다.

[91] EPDCCH는 DL-SCH와 관련된 전송 포맷, 자원 할당 및 HARQ 정보, UL-SCH와 관련된 전송 포맷, 자원 할당 및 HARQ 정보, SL-SCH(Sidelink Shared Channel) 및 PSCCH(Physical Sidelink Control Channel)과 관련된 자원 할당 정보 등을 나를 수 있다. 다중의 EPDCCH가 지원될 수 있으며, 단말은 EPCCH의 세트를 모니터링할 수 있다.

[92] EPDCCH는 하나 또는 그 이상의 연속된 진보된 CCE(ECCE: enhanced CCE)를 이용하여 전송될 수 있으며, 각 EPDCCH 포맷 별로 단일의 EPDCCH 당 ECCE의 개수가 정해질 수 있다.

[93] 각 ECCE는 복수의 자원 요소 그룹(EREG: enhanced resource element group)으로 구성될 수 있다. EREG는 ECCE의 RE에의 매핑을 정의하기 위하여 사용된다. PRB 쌍 별로 16개의 EREG가 존재한다. 각 PRB 쌍 내에서 DMRS를 나르는 RE를 제외하고, 모든 RE는 주파수가 증가하는 순서대로 그 다음 시간이 증가하는 순서대로 0 내지 15까지의 번호가 부여된다.

[94] 단말은 복수의 EPDCCH를 모니터링할 수 있다. 예를 들어, 단말이 EPDCCH 전송을 모니터링하는 하나의 PRB 쌍 내 하나 또는 두 개의 EPDCCH 세트가 설정될 수 있다.

[95] 서로 다른 개수의 ECCE가 병합됨으로써 EPCCH를 위한 서로 다른 부호화율(coding rate)이 실현될 수 있다. EPCCH는 지역적 전송(localized transmission) 또는 분산적 전송(distributed transmission)을 사용할 수 있으며, 이에 따라 PRB 내 RE에 ECCE의 매핑이 달라질 수 있다.

[96] 도 4는 본 발명이 적용될 수 있는 무선 통신 시스템에서 상향링크 서브 프레임의 구조를 나타낸다.

[97] 도 4를 참조하면, 상향링크 서브 프레임은 주파수 영역에서 제어 영역과 데이터 영역으로 나눌 수 있다. 제어 영역에는 상향링크 제어 정보를 나르는 PUCCH(Physical Uplink Control Channel)이 할당된다. 데이터 영역은 사용자 데이터를 나르는 PUSCH(Physical Uplink Shared Channel)이 할당된다. 단일 반송파 특성을 유지하기 위해 하나의 단말은 PUCCH와 PUSCH을 동시에 전송하지 않는다.

[98] 하나의 단말에 대한 PUCCH에는 서브 프레임 내에 자원 블록(RB: Resource Block) 쌍이 할당된다. RB 쌍에 속하는 RB들은 2개의 슬롯들의 각각에서 서로 다른 부 반송파를 차지한다. 이를 PUCCH에 할당된 RB 쌍은 슬롯 경계(slot boundary)에서 주파수 도약(frequency hopping)된다고 한다.

[99]

[100] **MIMO**(Multi-Input Multi-Output)

[101] MIMO 기술은 지금까지 일반적으로 한 개의 송신안테나와 한 개의 수신안테나를 사용했던 것에서 탈피하여, 다중 송신(Tx) 안테나와 다중 수신(Rx) 안테나를 사용한다. 다시 말해서, MIMO 기술은 무선 통신 시스템의 송신단 또는

수신단에서 다중 입출력 안테나를 사용하여 용량 증대 또는 성능 개성을 꾀하기 위한 기술이다. 이하에서는 'MIMO'를 '다중 입출력 안테나'라 칭하기로 한다.

[102] 더 구체적으로, 다중 입출력 안테나 기술은 하나의 완전한 메시지(total message)를 수신하기 위하여 한 개의 안테나 경로에 의존하지 않으며, 여러 개의 안테나를 통해 수신한 복수의 데이터 조각을 수집하여 완전한 데이터를 완성시킨다. 결과적으로, 다중 입출력 안테나 기술은 특정 시스템 범위 내에서 데이터 전송율을 증가시킬 수 있으며, 또한 특정 데이터 전송율을 통해 시스템 범위를 증가시킬 수 있다.

[103] 차세대 이동통신은 기존 이동통신에 비해 훨씬 높은 데이터 전송률을 요구하므로 효율적인 다중 입출력 안테나 기술이 반드시 필요할 것으로 예상된다. 이와 같은 상황에서 MIMO 통신 기술은 이동통신 단말과 중계기 등에 폭넓게 사용할 수 있는 차세대 이동통신 기술이며, 데이터 통신 확대 등으로 인해 한계 상황에 따라 다른 이동통신의 전송량 한계를 극복할 수 있는 기술로서 관심을 모으고 있다.

[104] 한편, 현재 연구되고 있는 다양한 전송효율 향상 기술 중 다중 입출력 안테나(MIMO) 기술은 추가적인 주파수 할당이나 전력증가 없이도 통신 용량 및 송수신 성능을 획기적으로 향상시킬 수 있는 방법으로서 현재 가장 큰 주목을 받고 있다.

[105] 도 5는 일반적인 다중 입출력 안테나(MIMO) 통신 시스템의 구성도이다.

[106] 도 5를 참조하면, 송신 안테나의 수를 N_T개로, 수신 안테나의 수를 N_R개로 동시에 늘리게 되면, 송신기나 수신기에서만 다수의 안테나를 사용하게 되는 경우와 달리 안테나 수에 비례하여 이론적인 채널 전송 용량이 증가하므로, 전송 레이트(transfer rate)를 향상시키고, 주파수 효율을 획기적으로 향상시킬 수 있다. 이 경우, 채널 전송 용량의 증가에 따른 전송 레이트는 하나의 안테나를 이용하는 경우의 최대 전송 레이트(R_o)에 다음과 같은 레이트 증가율(R_i)이 곱해진 만큼으로 이론적으로 증가할 수 있다.

[107] [수식1]

$$R_i = \min\left(N_T, N_R\right)$$

[108] 즉, 예를 들어, 4개의 송신 안테나와 4개의 수신 안테나를 이용하는 MIMO 통신 시스템에서는 단일 안테나 시스템에 비해 이론상 4배의 전송 레이트를 획득할 수 있다.

[109] 이와 같은 다중 입출력 안테나의 기술은 다양한 채널 경로를 통과한 심볼들을 이용하여 전송 신뢰도를 높이는 공간 다이버시티(spatial diversity) 방식과, 다수의 송신 안테나를 이용하여 다수의 데이터 심볼을 동시에 송신하여 전송률을 향상시키는 공간 멀티플렉싱(spatial multiplexing) 방식으로 나눌 수 있다. 또한 이러한 두 가지 방식을 적절히 결합하여 각각의 장점을 적절히 얻고자 하는 방식에 대한 연구도 최근 많이 연구되고 있는 분야이다.

[110] 각각의 방식에 대해 좀더 구체적으로 살펴보면 다음과 같다.

[111] 첫째로, 공간 다이버시티 방식의 경우에는 시공간 블록 부호 계열과, 다이버시티 이득과 부호화 이득을 동시에 이용하는 시공간 트렐리스(Trelis) 부호 계열 방식이 있다. 일반적으로 비트 오류율 개선 성능과 부호 생성 자유도는 트렐리스 부호 방식이 우수하지만, 연산 복잡도는 시공간 블록 부호가 간단하다. 이와 같은 공간 다이버서티 이득은 송신 안테나 수(N_T)와 수신 안테나 수(N_R)의 곱(N_T × N_R)에 해당되는 양을 얻을 수 있다.

[112] 둘째로, 공간 멀티플렉싱 기법은 각 송신 안테나에서 서로 다른 데이터 열을 송신하는 방법인데, 이때 수신기에서는 송신기로부터 동시에 전송된 데이터 사이에 상호 간섭이 발생하게 된다. 수신기에서는 이 간섭을 적절한 신호처리 기법을 이용하여 제거한 후 수신한다. 여기에 사용되는 잡음 제거 방식은 MLD(maximum likelihood detection) 수신기, ZF(zero-forcing) 수신기, MMSE(minimum mean square error) 수신기, D-BLAST (Diagonal-Bell Laboratories Layered Space-Time), V-BLAST(Vertical-Bell Laboratories Layered Space-Time) 등이 있으며, 특히 송신단에서 채널 정보를 알 수 있는 경우에는 SVD(singular value decomposition) 방식 등을 사용할 수 있다.

[113] 셋째로, 공간 다이버시티와 공간 멀티플렉싱의 결합된 기법을 들 수 있다. 공간 다이버시티 이득만을 얻을 경우 다이버시티 차수의 증가에 따른 성능개선 이득이 점차 포화되며, 공간 멀티플렉싱 이득만을 취하면 무선 채널에서 전송 신뢰도가 떨어진다. 이를 해결하면서 두 가지 이득을 모두 얻는 방식들이 연구되어 왔으며, 이 중 시공간 블록 부호 (Double-STTD), 시공간 BICM(STBICM) 등의 방식이 있다.

[114] 상술한 바와 같은 다중 입출력 안테나 시스템에 있어서의 통신 방법을 보다 구체적인 방법으로 설명하기 위해 이를 수학적으로 모델링하는 경우 다음과 같이 나타낼 수 있다.

[115] 먼저, 도 5에 도시된 바와 같이 N_T개의 송신 안테나와 N_R개의 수신 안테나가 존재하는 것을 가정한다.

[116] 먼저, 송신 신호에 대해 살펴보면, 이와 같이 N_T개의 송신 안테나가 있는 경우 최대 전송 가능한 정보는 N_T개 이므로, 이를 다음과 같은 벡터로 나타낼 수 있다.

[117] [수식2]

$$\mathbf{s} = \left[s_1, s_2, \cdots, s_{N_T}\right]^T$$

[118] 한편, 각각의 전송 정보 s_1, s_2, ..., s_N_T에 있어 전송 전력을 달리 할 수 있으며, 이때 각각의 전송 전력을 P_1, P_2, ..., P_N_T라 하면, 전송 전력이 조정된 전송 정보는 다음과 같은 벡터로 나타낼 수 있다.

[119] [수식3]

$$\hat{\mathbf{s}} = \left[\hat{s}_1, \hat{s}_2, \cdots, \hat{s}_{N_T}\right]^T = \left[P_1 s_1, P_2 s_2, \cdots, P_{N_T} s_{N_T}\right]^T$$

[120] 또한, 수학식 3의 전송 전력이 조정된 전송 정보를 전송 전력의 대각 행렬 P로 다음과 같이 나타낼 수 있다.

[121] [수식4]

$$\hat{\mathbf{s}} = \begin{bmatrix} P_1 & & & 0 \\ & P_2 & & \\ & & \ddots & \\ 0 & & & P_{N_T} \end{bmatrix} \begin{bmatrix} s_1 \\ s_2 \\ \vdots \\ s_{N_T} \end{bmatrix} = \mathbf{Ps}$$

[122] 한편, 수학식 4의 전송 전력이 조정된 정보 벡터는 그 후 가중치 행렬 W가 곱해져 실제 전송되는 N_T개의 전송 신호 x_1, x_2, ..., x_N_T를 구성한다. 여기서, 가중치 행렬은 전송 채널 상황 등에 따라 전송 정보를 각 안테나에 적절히 분배해 주는 역할을 수행한다. 이와 같은 전송 신호 x_1, x_2, ..., x_N_T를 벡터 x를 이용하여 다음과 같이 나타낼 수 있다.

[123] [수식5]

$$\mathbf{x} = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_i \\ \vdots \\ x_{N_T} \end{bmatrix} = \begin{bmatrix} w_{11} & w_{12} & \cdots & w_{1N_T} \\ w_{21} & w_{22} & \cdots & w_{2N_T} \\ \vdots & & \ddots & \\ w_{i1} & w_{i2} & \cdots & w_{iN_T} \\ \vdots & & \ddots & \\ w_{N_T1} & w_{N_T2} & \cdots & w_{N_TN_T} \end{bmatrix} \begin{bmatrix} \hat{s}_1 \\ \hat{s}_2 \\ \vdots \\ \hat{s}_j \\ \vdots \\ \hat{s}_{N_T} \end{bmatrix} = \mathbf{W}\hat{\mathbf{s}} = \mathbf{WPs}$$

[124] 여기서, w_ij는 i번째 송신 안테나와 j번째 전송 정보간의 가중치를 나타내며, W는 이를 행렬로 나타낸 것이다. 이와 같은 행렬 W를 가중치 행렬(Weight Matrix) 또는 프리코딩 행렬(Precoding Matrix)라 부른다.

[125] 한편, 상술한 바와 같은 전송 신호(x)는 공간 다이버시티를 사용하는 경우와 공간 멀티플랙싱을 사용하는 경우로 나누어 생각해 볼 수 있다.

[126] 공간 멀티플랙싱을 사용하는 경우는 서로 다른 신호를 다중화하여 보내게 되므로, 정보 벡터 s의 원소들이 모두 다른 값을 가지게 되는 반면, 공간 다이버시티를 사용하게 되면 같은 신호를 여러 채널 경로를 통하여 보내게 되므로 정보 벡터 s의 원소들이 모두 같은 값을 갖게 된다.

[127] 물론, 공간 멀티플랙싱과 공간 다이버시티를 혼합하는 방법도 고려 가능하다. 즉, 예를 들어 3 개의 송신 안테나를 통하여 같은 신호를 공간 다이버시티를 이용하여 전송하고, 나머지는 각각 다른 신호를 공간 멀티플랙싱하여 보내는 경우도 고려할 수 있다.

[128] 다음으로, 수신신호는 N_R개의 수신 안테나가 있는 경우, 각 안테나의 수신신호 y_1, y_2, ..., y_N_R을 벡터 y로 다음과 같이 나타내기로 한다.

[129] [수식6]

$$\mathbf{y} = \left[y_1, y_2, \cdots, y_{N_R} \right]^{\mathrm{T}}$$

[130] 한편, 다중 입출력 안테나 통신 시스템에 있어서의 채널을 모델링하는 경우, 각각의 채널은 송수신 안테나 인덱스에 따라 구분할 수 있으며, 송신 안테나 j로부터 수신 안테나 i를 거치는 채널을 h_ij로 표시하기로 한다. 여기서, h_ij의 인덱스의 순서가 수신 안테나 인덱스가 먼저, 송신안테나의 인덱스가 나중임에 유의한다.

[131] 이러한 채널은 여러 개를 한데 묶어서 벡터 및 행렬 형태로도 표시 가능하다. 벡터 표시의 예를 들어 설명하면 다음과 같다.

[132] 도 6은 다수의 송신 안테나에서 하나의 수신 안테나로의 채널을 나타낸 도이다.

[133] 도 6에 도시된 바와 같이 총 N_T개의 송신 안테나로부터 수신안테나 i로 도착하는 채널은 다음과 같이 표현 가능하다.

[134] [수식7]

$$\mathbf{h}_i^T = \left[h_{i1}, h_{i2}, \cdots, h_{iN_T} \right]$$

[135] 또한, 상기 수학식 7과 같은 행렬 표현을 통해 N_T개의 송신 안테나로부터 N_R개의 수신 안테나를 거치는 채널을 모두 나타내는 경우 다음과 같이 나타낼 수 있다.

[136] [수식8]

$$\mathbf{H} = \begin{bmatrix} \mathbf{h}_1^{\mathrm{T}} \\ \mathbf{h}_2^{\mathrm{T}} \\ \vdots \\ \mathbf{h}_i^{\mathrm{T}} \\ \vdots \\ \mathbf{h}_{\mathrm{N_R}}^{\mathrm{T}} \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} & \cdots & h_{1N_T} \\ h_{21} & h_{22} & \cdots & h_{2N_T} \\ \vdots & & \ddots & \\ h_{i1} & h_{i2} & \cdots & h_{iN_T} \\ \vdots & & \ddots & \\ h_{N_R1} & h_{N_R2} & \cdots & h_{N_RN_T} \end{bmatrix}$$

[137] 한편, 실제 채널은 위와 같은 채널 행렬 H를 거친 후에 백색 잡음(AWGN: Additive White Gaussian Noise)가 더해지게 되므로, N_R개의 수신 안테나 각각에 더해지는 백색 잡음 n_1, n_2, ..., n_N_R을 백터로 표현하면 다음과 같다.

[138] [수식9]

$$\mathbf{n} = \left[n_1, n_2, \cdots, n_{N_R} \right]^{\mathrm{T}}$$

[139] 상술한 바와 같은 전송 신호, 수신 신호, 채널, 및 백색 잡음의 모델링을 통해 다중 입출력 안테나 통신 시스템에서의 각각은 다음과 같은 관계를 통해 나타낼 수 있다.

[140] [수식10]

$$\mathbf{y} = \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_i \\ \vdots \\ y_{N_R} \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} & \cdots & h_{1N_T} \\ h_{21} & h_{22} & \cdots & h_{2N_T} \\ \vdots & & \ddots & \\ h_{i1} & h_{i2} & \cdots & h_{iN_T} \\ \vdots & & \ddots & \\ h_{N_R1} & h_{N_R2} & \cdots & h_{N_RN_T} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_j \\ \vdots \\ x_{N_T} \end{bmatrix} + \begin{bmatrix} n_1 \\ n_2 \\ \vdots \\ n_i \\ \vdots \\ n_{N_R} \end{bmatrix} = \mathbf{Hx} + \mathbf{n}$$

[141] 한편, 채널의 상태를 나타내는 채널 행렬 H의 행과 열의 수는 송수신 안테나 수에 의해서 결정된다. 채널 행렬 H는 앞서 살펴본 바와 같이 행의 수는 수신 안테나의 수 N_R과 같아지고, 열의 수는 송신 안테나의 수 N_T와 같아 지게 된다. 즉, 채널 행렬 H는 N_R×N_T 행렬이 된다.

[142] 일반적으로, 행렬의 랭크(rank)는 서로 독립인(independent) 행 또는 열의 개수 중에서 최소 개수로 정의된다. 따라서, 행렬의 랭크는 행 또는 열의 개수보다 클 수 없게 된다. 수식적으로 예를 들면, 채널 행렬 H의 랭크(rank(H))는 다음과 같이 제한된다.

[143] [수식11]

$$rank(\mathbf{H}) \le \min(N_T, N_R)$$

[144] 또한, 행렬을 고유치 분해(Eigen value decomposition)를 하였을 때, 랭크는 고유치(eigen value)들 중에서 0이 아닌 고유치들의 개수로 정의할 수 있다. 비슷한 방법으로, 랭크를 SVD(singular value decomposition) 했을 때 0이 아닌 특이값(singular value)들의 개수로 정의할 수 있다. 따라서, 채널 행렬에서 랭크의 물리적인 의미는 주어진 채널에서 서로 다른 정보를 보낼 수 있는 최대 수라고 할 수 있다.

[145] 본 명세서에 있어, MIMO 전송에 대한 '랭크(Rank)'는 특정 시점 및 특정 주파수 자원에서 독립적으로 신호를 전송할 수 있는 경로의 수를 나타내며, '레이어(layer)의 개수'는 각 경로를 통해 전송되는 신호 스트림의 개수를 나타낸다. 일반적으로 송신단은 신호 전송에 이용되는 랭크 수에 대응하는 개수의 레이어를 전송하기 때문에 특별한 언급이 없는 한 랭크는 레이어 개수와 동일한 의미를 가진다.

[146]

[147] <u>캐리어 병합(Carrier Aggregation)</u>

[148] 본 발명의 실시예들에서 고려하는 통신 환경은 멀티 캐리어(Multi-carrier) 지원 환경을 모두 포함한다. 즉, 본 발명에서 사용되는 멀티 캐리어 시스템 또는 캐리어 병합(CA: Carrier Aggregation) 시스템이라 함은 광대역을 지원하기 위해서, 목표로 하는 광대역을 구성할 때 목표 대역보다 작은 대역폭(bandwidth)을 가지는 1개 이상의 컴포넌트 캐리어(CC: Component

Carrier)를 병합(aggregation)하여 사용하는 시스템을 말한다.

[149] 본 발명에서 멀티 캐리어는 캐리어의 병합(또는, 반송파 집성)을 의미하며, 이때 캐리어의 병합은 인접한(contiguous) 캐리어 간의 병합뿐 아니라 비 인접한(non-contiguous) 캐리어 간의 병합을 모두 의미한다. 또한, 하향링크와 상향링크 간에 집성되는 컴포넌트 캐리어들의 수는 다르게 설정될 수 있다. 하향링크 컴포넌트 캐리어(이하, 'DL CC'라 한다.) 수와 상향링크 컴포넌트 캐리어(이하, 'UL CC'라 한다.) 수가 동일한 경우를 대칭적(symmetric) 집성이라고 하고, 그 수가 다른 경우를 비대칭적(asymmetric) 집성이라고 한다. 이와 같은 캐리어 병합은 반송파 집성, 대역폭 집성(bandwidth aggregation), 스펙트럼 집성(spectrum aggregation) 등과 같은 용어와 혼용되어 사용될 수 있다.

[150] 두 개 이상의 컴포넌트 캐리어가 결합되어 구성되는 캐리어 병합은 LTE-A 시스템에서는 100MHz 대역폭까지 지원하는 것을 목표로 한다. 목표 대역보다 작은 대역폭을 가지는 1개 이상의 캐리어를 결합할 때, 결합하는 캐리어의 대역폭은 기존 IMT 시스템과의 호환성(backward compatibility) 유지를 위해서 기존 시스템에서 사용하는 대역폭으로 제한할 수 있다. 예를 들어서 기존의 3GPP LTE 시스템에서는 {1.4, 3, 5, 10, 15, 20}MHz 대역폭을 지원하며, 3GPP LTE-advanced 시스템(즉, LTE-A)에서는 기존 시스템과의 호환을 위해 상기의 대역폭들만을 이용하여 20MHz보다 큰 대역폭을 지원하도록 할 수 있다. 또한, 본 발명에서 사용되는 캐리어 병합 시스템은 기존 시스템에서 사용하는 대역폭과 상관없이 새로운 대역폭을 정의하여 캐리어 병합을 지원하도록 할 수도 있다.

[151] LTE-A 시스템은 무선 자원을 관리하기 위해 셀(cell)의 개념을 사용한다.

[152] 상술한 캐리어 병합 환경은 다중 셀(multiple cells) 환경으로 일컬을 수 있다. 셀은 하향링크 자원(DL CC)과 상향링크 자원(UL CC) 한 쌍의 조합으로 정의되나, 상향링크 자원은 필수 요소는 아니다. 따라서, 셀은 하향링크 자원 단독, 또는 하향링크 자원과 상향링크 자원으로 구성될 수 있다. 특정 단말이 단 하나의 설정된 서빙 셀(configured serving cell)을 가지는 경우 1개의 DL CC와 1개의 UL CC를 가질 수 있으나, 특정 단말이 2개 이상의 설정된 서빙 셀을 가지는 경우에는 셀의 수만큼의 DL CC를 가지며 UL CC의 수는 그와 같거나 그보다 작을 수 있다.

[153] 또는, 그 반대로 DL CC와 UL CC가 구성될 수도 있다. 즉, 특정 단말이 다수의 설정된 서빙 셀을 가지는 경우 DL CC의 수보다 UL CC가 더 많은 캐리어 병합 환경도 지원될 수 있다. 즉, 캐리어 병합(carrier aggregation)은 각각 캐리어 주파수(셀의 중심 주파수)가 서로 다른 둘 이상의 셀들의 병합으로 이해될 수 있다. 여기서, 말하는 '셀(Cell)'은 일반적으로 사용되는 기지국이 커버하는 영역으로서의 '셀'과는 구분되어야 한다.

[154] LTE-A 시스템에서 사용되는 셀은 프라이머리 셀(PCell: Primary Cell) 및 세컨더리 셀(SCell: Secondary Cell)을 포함한다. P셀과 S셀은 서빙 셀(Serving

Cell)로 사용될 수 있다. RRC_CONNECTED 상태에 있지만 캐리어 병합이 설정되지 않았거나 캐리어 병합을 지원하지 않는 단말의 경우, P셀로만 구성된 서빙 셀이 단 하나 존재한다. 반면, RRC_CONNECTED 상태에 있고 캐리어 병합이 설정된 단말의 경우 하나 이상의 서빙 셀이 존재할 수 있으며, 전체 서빙 셀에는 P셀과 하나 이상의 S셀이 포함된다.

[155] 서빙 셀(P셀과 S셀)은 RRC 파라미터를 통해 설정될 수 있다. PhysCellId는 셀의 물리 계층 식별자로 0부터 503까지의 정수값을 가진다. SCellIndex는 S셀을 식별하기 위하여 사용되는 간략한(short) 식별자로 1부터 7까지의 정수값을 가진다. ServCellIndex는 서빙 셀(P셀 또는 S셀)을 식별하기 위하여 사용되는 간략한(short) 식별자로 0부터 7까지의 정수값을 가진다. 0값은 P셀에 적용되며, SCellIndex는 S셀에 적용하기 위하여 미리 부여된다. 즉, ServCellIndex에서 가장 작은 셀 ID (또는 셀 인덱스)을 가지는 셀이 P셀이 된다.

[156] P셀은 프라이머리 주파수(또는, primary CC) 상에서 동작하는 셀을 의미한다. 단말이 초기 연결 설정(initial connection establishment) 과정을 수행하거나 연결 재-설정 과정을 수행하는데 사용될 수 있으며, 핸드오버 과정에서 지시된 셀을 지칭할 수도 있다. 또한, P셀은 캐리어 병합 환경에서 설정된 서빙 셀 중 제어관련 통신의 중심이 되는 셀을 의미한다. 즉, 단말은 자신의 P셀에서만 PUCCH를 할당 받아 전송할 수 있으며, 시스템 정보를 획득하거나 모니터링 절차를 변경하는데 P셀만을 이용할 수 있다. E-UTRAN(Evolved Universal Terrestrial Radio Access)은 캐리어 병합 환경을 지원하는 단말에게 이동성 제어 정보(mobilityControlInfo)를 포함하는 상위 계층의 RRC 연결 재설정(RRCConnectionReconfigutaion) 메시지를 이용하여 핸드오버 절차를 위해 P셀만을 변경할 수도 있다.

[157] S셀은 세컨더리 주파수(또는, Secondary CC) 상에서 동작하는 셀을 의미할 수 있다. 특정 단말에 P셀은 하나만 할당되며, S셀은 하나 이상 할당될 수 있다. S셀은 RRC 연결이 설정이 이루어진 이후에 구성 가능하고 추가적인 무선 자원을 제공하는데 사용될 수 있다. 캐리어 병합 환경에서 설정된 서빙 셀 중에서 P셀을 제외한 나머지 셀들, 즉 S셀에는 PUCCH가 존재하지 않는다. E-UTRAN은 S셀을 캐리어 병합 환경을 지원하는 단말에게 추가할 때, RRC_CONNECTED 상태에 있는 관련된 셀의 동작과 관련된 모든 시스템 정보를 특정 시그널(dedicated signal)을 통해 제공할 수 있다. 시스템 정보의 변경은 관련된 S셀의 해제 및 추가에 의하여 제어될 수 있으며, 이 때 상위 계층의 RRC 연결 재설정 (RRCConnectionReconfigutaion) 메시지를 이용할 수 있다. E-UTRAN은 관련된 S셀 안에서 브로드캐스트하기 보다는 단말 별로 상이한 파라미터를 가지는 특정 시그널링(dedicated signaling) 할 수 있다.

[158] 초기 보안 활성화 과정이 시작된 이후에, E-UTRAN은 연결 설정 과정에서 초기에 구성되는 P셀에 부가하여 하나 이상의 S셀을 포함하는 네트워크를 구성할 수 있다. 캐리어 병합 환경에서 P셀 및 S셀은 각각의 컴포넌트

캐리어로서 동작할 수 있다. 이하의 실시 예에서는 프라이머리 컴포넌트 캐리어(PCC)는 P셀과 동일한 의미로 사용될 수 있으며, 세컨더리 컴포넌트 캐리어(SCC)는 S셀과 동일한 의미로 사용될 수 있다.

[159] 도 7은 본 발명이 적용될 수 있는 무선 통신 시스템에서 컴포넌트 캐리어 및 캐리어 병합의 일례를 나타낸다.

[160] 도 7의 (a)는 LTE 시스템에서 사용되는 단일 캐리어 구조를 나타낸다. 컴포넌트 캐리어에는 DL CC와 UL CC가 있다. 하나의 컴포넌트 캐리어는 20MHz의 주파수 범위를 가질 수 있다.

[161] 도 7의 (b)는 LTE_A 시스템에서 사용되는 캐리어 병합 구조를 나타낸다. 도 7의 (b)의 경우에 20MHz의 주파수 크기를 갖는 3 개의 컴포넌트 캐리어가 결합된 경우를 나타낸다. DL CC와 UL CC가 각각 3 개씩 있으나, DL CC와 UL CC의 개수에 제한이 있는 것은 아니다. 캐리어 병합의 경우 단말은 3개의 CC를 동시에 모니터링할 수 있고, 하향링크 신호/데이터를 수신할 수 있고 상향링크 신호/데이터를 송신할 수 있다.

[162] 만약, 특정 셀에서 N개의 DL CC가 관리되는 경우에는, 네트워크는 단말에 M (M≤N)개의 DL CC를 할당할 수 있다. 이때, 단말은 M 개의 제한된 DL CC 만을 모니터링하고 DL 신호를 수신할 수 있다. 또한, 네트워크는 L (L≤M≤N)개의 DL CC에 우선순위를 주어 주된 DL CC를 단말에 할당할 수 있으며, 이러한 경우 UE는 L 개의 DL CC는 반드시 모니터링해야 한다. 이러한 방식은 상향링크 전송에도 똑같이 적용될 수 있다.

[163] 하향링크 자원의 반송파 주파수(또는 DL CC)와 상향링크 자원의 반송파 주파수(또는, UL CC) 사이의 링키지(linkage)는 RRC 메시지와 같은 상위계층 메시지나 시스템 정보에 의해 지시될 수 있다. 예를 들어, SIB2(System Information Block Type2)에 의해서 정의되는 링키지에 의해서 DL 자원과 UL 자원의 조합이 구성될 수 있다. 구체적으로, 링키지는 UL 그랜트를 나르는 PDCCH가 전송되는 DL CC와 상기 UL 그랜트를 사용하는 UL CC간의 맵핑 관계를 의미할 수 있으며, HARQ를 위한 데이터가 전송되는 DL CC(또는 UL CC)와 HARQ ACK/NACK 신호가 전송되는 UL CC(또는 DL CC)간의 맵핑 관계를 의미할 수도 있다.

[164] 단말이 하나 이상의 S셀이 설정되면, 네트워크는 설정된 S셀(들)을 활성화(activate) 또는 비활성화(deactivate)할 수 있다. P셀은 항상 활성화된다. 네트워크는 활성/비활성(Activation/Deactivation) MAC 제어 요소(MAC control element)를 전송함으로써 S셀(들)을 활성화 또는 비활성화한다.

[165] 활성/비활성 MAC 제어 요소는 고정된 크기를 가지고, 7개의 C 필드(C-field)와 1개의 R 필드(R-field)를 포함하는 단일의 옥텟(octet)으로 구성된다. C 필드는 각 S셀 인덱스(SCellIndex) 별로 구성되고, S셀의 활성/비활성 상태를 지시한다. C 필드 값이 '1'로 셋팅되면 해당 S셀 인덱스를 가지는 S셀의 활성화되는 것을 지시하고, '0'으로 셋팅되면 해당 S셀 인덱스를 가지는 S셀의 비활성화되는 것을

지시한다.

[166] 또한, 단말은 설정된 S셀 별로 타이머(sCellDeactivationTimer)를 유지하고, 타이머가 만료될 때 관련된 S셀을 비활성화한다. 동일한 초기 타이머 값이 타이머(sCellDeactivationTimer)의 각 인스턴스(instance)에 적용되며, RRC 시그널링에 의해 설정된다. S셀(들)이 추가될 때 또는 핸드오버 이후, 초기 S셀(들)은 비활성화 상태이다.

[167] 단말은 각 TTI에서 각각의 설정된 S셀(들)에 대하여 아래와 같은 동작을 수행한다.

[168] - 단말이 특정 TTI(서브프레임 n)에서 S셀을 활성화하는 활성/비활성 MAC 제어 요소를 수신하면, 단말은 정해진 타이밍에 해당하는 TTI(서브프레임 n+8 또는 그 이후)에서 S셀을 활성화하고, 해당 S셀과 관련된 타이머를 (재)시작시킨다. 단말이 S셀을 활성화한다는 것은 단말이 S셀 상에서 SRS(Sounding Reference Signal) 전송, S셀을 위한 CQI(Channel Quality Indicator)/PMI(Precoding Matrix Indicator)/RI(Rank Indication)/PTI(Precoding Type Indicator) 보고, S셀 상에서 PDCCH 모니터링, S셀을 위한 PDCCH 모니터링과 같은 일반 S셀 동작을 적용한다는 것을 의미한다.

[169] - 단말이 특정 TTI(서브프레임 n)에서 S셀을 비활성화하는 활성/비활성 MAC 제어 요소를 수신하거나 또는 특정 TTI(서브프레임 n) 활성화된 S셀과 관련된 타이머가 만료되면, 단말은 정해진 타이밍에 해당하는 TTI(서브프레임 n+8 또는 그 이후)에서 S셀을 비활성화하고, 해당 S셀의 타이머를 중단하며, 해당 S셀과 관련된 모든 HARQ 버퍼를 비운다(flush).

[170] - 활성화된 S셀 상의 PDCCH가 상향링크 그랜트(uplink grant) 또는 하향링크 승인(downlink assignment)을 지시하거나, 또는 활성화된 S셀을 스케줄링하는 서빙 셀 상의 PDCCH가 활성화된 S셀을 위한 상향링크 그랜트(uplink grant) 또는 하향링크 승인(downlink assignment)을 지시하면, 단말은 해당 S셀과 관련된 타이머를 재시작한다.

[171] - S셀이 비활성화되면, 단말은 S셀 상에서 SRS를 전송하지 않고, S셀을 위한 CQI/PMI/RI/PTI를 보고하지 않으며, S셀 상에서 UL-SCH를 전송하지 않으며, S셀 상에서 PDCCH를 모니터하지 않는다.

[172]

[173] **랜덤 액세스 절차(Random Access Procedure)**

[174] 이하에서는 LTE/LTE-A 시스템에서 제공하는 랜덤 액세스 절차(random access procedure)에 대해 살펴본다.

[175] 랜덤 액세스 절차는 단말이 기지국과 상향링크 동기를 얻거나 상향링크 무선 자원을 할당 받기 위해 사용된다. 단말의 전원이 켜진 후, 단말은 초기 셀과의 하향링크 동기를 획득하고 시스템 정보를 수신한다. 시스템 정보로부터 사용 가능한 랜덤 액세스 프리앰블(random access preamble)의 집합과 랜덤 액세스 프리앰블의 전송에 사용되는 무선 자원에 관한 정보를 얻는다. 랜덤 액세스

프리앰블의 전송에 사용되는 무선 자원은 적어도 하나 이상의 서브프레임 인덱스와 주파수 영역 상의 인덱스의 조합으로 특정될 수 있다. 단말은 랜덤 액세스 프리앰블의 집합으로부터 임의로 선택한 랜덤 액세스 프리앰블을 전송하고, 상기 랜덤 액세스 프리앰블을 수신한 기지국은 상향링크 동기를 위한 타이밍 정렬(TA: timing alignment) 값을 랜덤 액세스 응답을 통해 단말로 보낸다. 이로써 단말은 상향링크 동기를 획득하는 것이다.

[176] 랜덤 액세스 절차는 FDD(frequency division duplex)와 TDD(time division duplex)에서 공통적인 절차이다. 랜덤 액세스 절차는 셀 사이즈에 무관하며, 캐리어 병합(CA: carrier aggregation)이 설정된 경우 서빙 셀(serving cell)의 개수와도 무관하다.

[177] 먼저, 단말이 랜덤 액세스 절차를 수행하는 경우로는 다음과 같은 경우가 있다.

[178] - 단말이 기지국과의 RRC 연결(RRC Connection)이 없어, RRC 아이들 상태에서 초기 접속 (initial access)을 수행하는 경우

[179] - RRC 연결 재-확립 절차(RRC connection re-establishment procedure)를 수행하는 경우

[180] - 단말이 핸드오버 과정에서, 타겟(target) 셀로 처음 접속하는 경우

[181] - 기지국의 명령에 의해 랜덤 액세스 절차가 요청되는 경우

[182] - RRC 연결 상태 중, 상향링크 시간 동기가 맞지 않은 상황에서(non-synchronized) 하향링크로 전송될 데이터가 발생하는 경우

[183] - RRC 연결 상태 중, 상향링크의 시간 동기가 맞지 않거나(non-synchronized), 무선자원을 요청하기 위해 사용되는 지정된 무선자원이 할당되지 않은 상황에서, 상향링크로 전송할 데이터가 발생하는 경우

[184] - RRC 연결 상태 중, 타이밍 어드밴스(timing advance)가 필요한 상황에서 단말의 위치 결정(positioning)을 수행하는 경우

[185] - 무선 연결 실패(radio link failure) 또는 핸드오버 실패(handover failure) 시 복구 과정을 수행하는 경우

[186] 3GPP Rel-10에서는 캐리어 병합을 지원하는 무선 접속 시스템에서 하나의 특정 셀(예를 들어, P셀)에 적용 가능한 TA(timing advance) 값을 복수의 셀에 공통으로 적용하는 것을 고려하였다. 다만, 단말이 서로 다른 주파수 밴드에 속한(즉, 주파수 상에서 크게 이격된) 복수의 셀들 혹은 전파(propagation) 특성이 다른 복수의 셀들을 병합할 수 있다. 또한 특정 셀의 경우 커버리지 확대 혹은 커버리지 홀의 제거를 위해 RRH(remote radio header)(즉, 리피터), 펨토 셀(femto cell) 혹은 피코 셀(pico cell) 등과 같은 스몰 셀(small cell) 또는 세컨더리 기지국(SeNB: secondary eNB)이 셀 내에 배치되는 상황에서 단말은 하나의 셀을 통해 기지국(즉, 매크로 기지국(macro eNB))과 통신을 수행하고, 다른 셀을 통해 세컨더리 기지국과 통신을 수행하는 경우 복수의 셀들이 서로 다른 전파 지연 특성을 가지게 될 수 있다. 이 경우, 하나의 TA 값을 복수의 셀들에 공통으로 적용하는 방식으로 사용하는 상향링크 전송을 수행할 경우 복수의 셀들 상에서

전송되는 상향링크 신호의 동기에 심각한 영향을 끼칠 수 있다. 따라서, 복수의 셀들이 병합된 CA 상황에서 복수의 TA를 가지는 것이 바람직할 수 있으며, 3GPP Rel-11에서는 다중 TA(multiple TA)를 지원하기 위하여 특정 셀 그룹 단위로 TA를 독립적으로 할당하는 것을 고려한다. 이를 TA 그룹(TAG: TA group)이라 하며, TAG는 하나 이상의 셀들을 포함할 수 있으며, TAG 내 포함된 하나 이상의 셀에는 동일한 TA가 공통적으로 적용될 수 있다. 이러한 다중 TA를 지원하기 위하여, MAC TA 명령 제어 요소(element)는 2 비트의 TAG 식별자(TAG ID)와 6 비트의 TA 명령 필드로 구성된다.

[187] 캐리어 병합이 설정된 단말은 P셀과 관련되어 앞서 설명한 랜덤 액세스 절차를 수행하는 경우가 발생되면 랜덤 액세스 절차를 수행하게 된다. P셀이 속한 TAG(즉, pTAG: primary TAG)의 경우, 기존과 동일하게 P셀을 기준으로 결정되는, 혹은 P셀에 수반되는 랜덤 액세스 절차를 통해 조정되는 TA를 pTAG 내 모든 셀(들)에 적용할 수 있다. 반면, S셀로만 구성되는 TAG(즉, sTAG: secondary TAG)의 경우, sTAG 내 특정 S셀을 기준으로 결정되는 TA는 해당 sTAG 내 모든 셀(들)에 적용할 수 있으며, 이 때 TA는 기지국에 의해 개시되 랜덤 액세스 절차에 의해 획득될 수 있다. 구체적으로, sTAG 내에서 S셀은 RACH(Random Access Channel) 자원으로 설정되고, 기지국은 TA를 결정하기 위하여 S셀에서 RACH 접속을 요청한다. 즉, 기지국은 P셀에서 전송되는 PDCCH 오더에 의해 S셀들 상에서 RACH 전송을 개시시킨다. S셀 프리앰블에 대한 응답 메시지는 RA-RNTI를 사용하여 P셀을 통해 전송된다. 단말은 랜덤 액세스를 성공적으로 마친 S셀을 기준으로 결정되는 TA는 해당 sTAG 내 모든 셀(들)에 적용할 수 있다. 이와 같이, 랜덤 액세스 절차는 S셀에서도 해당 S셀이 속한 sTAG의 타이밍 정렬(timing alignment)을 획득하기 위하여 S셀에서도 수행될 수 있다.

[188] LTE/LTE-A 시스템에서는 랜덤 액세스 프리앰블(random access preamble, RACH preamble)을 선택하는 과정에서, 특정한 집합 안에서 단말이 임의로 하나의 프리앰블을 선택하여 사용하는 경쟁 기반 랜덤 액세스 절차(contention based random access procedure)과 기지국이 특정 단말에게만 할당해준 랜덤 액세스 프리앰블을 사용하는 비 경쟁 기반 랜덤 액세스 절차(non-contention based random access procedure)을 모두 제공한다. 다만, 비 경쟁 기반 랜덤 액세스 절차는, 상술한 핸드오버 과정, 기지국의 명령에 의해 요청되는 경우, 단말 위치 결정(positioning) 및/또는 sTAG을 위한 타이밍 어드밴스 정렬에 한하여 사용될 수 있다. 랜덤 액세스 절차가 완료된 후에 일반적인 상향링크/하향링크 전송이 발생된다.

[189] 한편, 릴레이 노드(RN: relay node) 또한 경쟁 기반 랜덤 액세스 절차와 비 경쟁 기반 랜덤 액세스 절차를 모두 지원한다. 릴레이 노드가 랜덤 액세스 절차를 수행할 때, 그 시점에서 RN 서브프레임 구성(configuration)을 중단시킨다(suspend). 즉, 이는 일시적으로 RN 서브프레임 구성을 폐기하는

것으로 의미한다. 이후, 성공적으로 랜덤 액세스 절차가 완료되는 시점에서 RN 서브프레임 구성이 재개된다.

[190] 도 8은 본 발명이 적용될 수 있는 무선 통신 시스템에서 경쟁 기반 랜덤 액세스 절차를 설명하기 위한 도면이다.

[191] (1) 제1 메시지(Msg 1, message 1)

[192] 먼저, 단말은 시스템 정보(system information) 또는 핸드오버 명령(handover command)을 통해 지시된 랜덤 액세스 프리앰블의 집합에서 임의로(randomly) 하나의 랜덤 액세스 프리앰블(random access preamble, RACH preamble)을 선택하고, 상기 랜덤 액세스 프리앰블을 전송할 수 있는 PRACH(physical RACH) 자원을 선택하여 전송한다.

[193] 랜덤 액세스 프리앰블은 RACH 전송 채널에서 6비트로 전송되고, 6비트는 RACH 전송한 단말을 식별하기 위한 5비트의 임의 식별자(radom identity)와, 추가 정보를 나타내기 위한 1비트(예를 들어, 제3 메시지(Msg 3)의 크기를 지시)로 구성된다.

[194] 단말로부터 랜덤 액세스 프리앰블을 수신한 기지국은 프리앰블을 디코딩하고, RA-RNTI를 획득한다. 랜덤 액세스 프리앰블이 전송된 PRACH와 관련된 RA-RNTI는 해당 단말이 전송한 랜덤 액세스 프리앰블의 시간-주파수 자원에 따라 결정된다.

[195] (2) 제2 메시지(Msg 2, message 2)

[196] 기지국은 제1 메시지 상의 프리앰블을 통해서 획득한 RA-RNTI로 지시(address)되는 랜덤 액세스 응답(random access response)을 단말로 전송한다. 랜덤 액세스 응답에는 랜덤 액세스 프리앰블 구분자/식별자(RA preamble index/identifier), 상향링크 무선자원을 알려주는 상향링크 승인(UL grant), 임시 셀 식별자(TC-RNTI: Temporary C-RNTI) 그리고 시간 동기 값(TAC: time alignment command)들이 포함될 수 있다. TAC는 기지국이 단말에게 상향링크 시간 정렬(time alignment)을 유지하기 위해 보내는 시간 동기 값을 지시하는 정보이다. 단말은 상기 시간 동기 값을 이용하여, 상향링크 전송 타이밍을 갱신한다. 단말이 시간 동기를 갱신하면, 시간 동기 타이머(time alignment timer)를 개시 또는 재시작한다. UL grant는 후술하는 스케줄링 메시지(제3 메시지)의 전송에 사용되는 상향링크 자원 할당 및 TPC(transmit power command)를 포함한다. TPC는 스케줄링된 PUSCH를 위한 전송 파워의 결정에 사용된다.

[197] 단말은 랜덤 액세스 프리앰블을 전송 후에, 기지국이 시스템 정보 또는 핸드오버 명령을 통해 지시된 랜덤 액세스 응답 윈도우(random access response window) 내에서 자신의 랜덤 액세스 응답(random access response)의 수신을 시도하며, PRACH에 대응되는 RA-RNTI로 마스킹된 PDCCH를 검출하고, 검출된 PDCCH에 의해 지시되는 PDSCH를 수신하게 된다. 랜덤 액세스 응답 정보는 MAC PDU(MAC packet data unit)의 형식으로 전송될 수 있으며, 상기 MAC

PDU는 PDSCH을 통해 전달될 수 있다. PDCCH에는 상기 PDSCH를 수신해야 하는 단말의 정보와, 상기 PDSCH의 무선 자원의 주파수 그리고 시간 정보, 그리고 상기 PDSCH의 전송 형식 등이 포함되어 있는 것이 바람직하다. 상술한 바와 같이, 일단 단말이 자신에게 전송되는 PDCCH의 검출에 성공하면, 상기 PDCCH의 정보들에 따라 PDSCH로 전송되는 랜덤 액세스 응답을 적절히 수신할 수 있다.

[198] 랜덤 액세스 응답 윈도우는 프리앰블을 전송한 단말이 랜덤 액세스 응답 메시지를 수신하기 위해서 대기하는 최대 시구간을 의미한다. 랜덤 액세스 응답 윈도우는 프리앰블이 전송되는 마지막 서브프레임에서 3개의 서브프레임 이후의 서브프레임으로부터 시작하여 'ra-ResponseWindowSize'의 길이를 가진다. 즉, 단말은 프리앰블을 전송이 종료된 서브프레임으로부터 3개의 서브프레임 이후부터 확보한 랜덤 액세스 윈도우 동안 랜덤 액세스 응답을 수신하기 위해 대기한다. 단말은 시스템 정보(system information)을 통해 랜덤 액세스 윈도우 사이즈('ra-ResponseWindowsize') 파라미터 값을 획득할 수 있으며, 랜덤 액세스 윈도우 사이즈는 2부터 10 사이의 값으로 결정될 수 있다.

[199] 단말은 기지국에 전송하였던 랜덤 액세스 프리앰블과 동일한 랜덤 액세스 프리앰블 구분자/식별자를 가지는 랜덤 액세스 응답을 성공적으로 수신하면, 랜덤 액세스 응답의 모니터링을 중지한다. 반면, 랜덤 액세스 응답 윈도우가 종료될 때까지 랜덤 액세스 응답 메시지를 수신하지 못하거나, 기지국에 전송하였던 랜덤 액세스 프리앰블과 동일한 랜덤 액세스 프리앰블 구분자를 가지는 유효한 랜덤 액세스 응답을 수신하지 못한 경우 랜덤 액세스 응답의 수신은 실패하였다고 간주되고, 이후 단말은 프리앰블 재전송을 수행할 수 있다.

[200] 상술한 바와 같이 랜덤 액세스 응답에서 랜덤 액세스 프리앰블 구분자가 필요한 이유는, 하나의 랜덤 액세스 응답에는 하나 이상의 단말들을 위한 랜덤 액세스 응답 정보가 포함될 수 있기 때문에, 상기 UL grant, TC-RNTI 그리고 TAC가 어느 단말에게 유효한지를 알려주기 위는 것이 필요하기 때문이다.

[201] (3) 제3 메시지(Msg 3, message 3)

[202] 단말이 자신에게 유효한 랜덤 액세스 응답을 수신한 경우에는, 상기 랜덤 액세스 응답에 포함된 정보들을 각각 처리한다. 즉, 단말은 TAC을 적용시키고, TC-RNTI를 저장한다. 또한, UL grant를 이용하여, 단말의 버퍼에 저장된 데이터 또는 새롭게 생성된 데이터를 기지국으로 전송한다. 단말의 최초 접속의 경우, RRC 계층에서 생성되어 CCCH를 통해 전달된 RRC 연결 요청이 제3 메시지에 포함되어 전송될 수 있으며, RRC 연결 재확립 절차의 경우 RRC 계층에서 생성되어 CCCH를 통해 전달된 RRC 연결 재확립 요청이 제3 메시지에 포함되어 전송될 수 있다. 또한, NAS 접속 요청 메시지를 포함할 수도 있다.

[203] 제3 메시지는 단말의 식별자가 포함되어야 한다. 경쟁 기반 랜덤 액세스 절차에서는 기지국에서 어떠한 단말들이 상기 랜덤 액세스 절차를 수행하는지 판단할 수 없는데, 차후에 충돌 해결을 하기 위해서는 단말을 식별해야 하기

때문이다.

[204] 단말의 식별자를 포함시키는 방법으로는 두 가지 방법이 존재한다. 첫 번째 방법은 단말이 상기 랜덤 액세스 절차 이전에 이미 해당 셀에서 할당 받은 유효한 셀 식별자(C-RNTI)를 가지고 있었다면, 단말은 상기 UL grant에 대응하는 상향링크 전송 신호를 통해 자신의 셀 식별자를 전송한다. 반면에, 만약 랜덤 액세스 절차 이전에 유효한 셀 식별자를 할당 받지 못하였다면, 단말은 자신의 고유 식별자(예를 들면, S-TMSI 또는 임의 값(random number))를 포함하여 전송한다. 일반적으로 상기의 고유 식별자는 C-RNTI보다 길다. UL-SCH 상의 전송에서는 단말 특정 스크램블링이 사용된다. 다만, 단말이 아직 C-RNTI를 할당받지 못한 경우라면, 스크램블링은 C-RNTI에 기반할 수 없으며 대신 랜덤 액세스 응답에서 수신한 TC-RNTI가 사용된다. 단말은 상기 UL grant에 대응하는 데이터를 전송하였다면, 충돌 해결을 위한 타이머(contention resolution timer)를 개시한다.

[205] (4) 제4 메시지(Msg 4, message 4)

[206] 기지국은 단말로부터 제3 메시지를 통해 해당 단말의 C-RNTI를 수신한 경우 수신한 C-RNTI를 이용하여 단말에게 제4 메시지를 전송한다. 반면, 단말로부터 제3 메시지를 통해 상기 고유 식별자(즉, S-TMSI 또는 임의 값(random number))를 수신한 경우, 랜덤 액세스 응답에서 해당 단말에게 할당한 TC-RNTI를 이용하여 제4 메시지를 단말에게 전송한다. 여기서, 제4 메시지는 C-RNTI를 포함하는 RRC 연결 설정 메시지(RRC connection setup)가 해당될 수 있다.

[207] 단말은 랜덤 액세스 응답에 포함된 UL grant를 통해 자신의 식별자를 포함한 데이터를 전송한 이후, 충돌 해결을 위해 기지국의 지시를 기다린다. 즉, 특정 메시지를 수신하기 위해 PDCCH의 수신을 시도한다. 상기 PDCCH를 수신하는 방법에 있어서도 두 가지 방법이 존재한다. 앞에서 언급한 바와 같이 상기 UL grant에 대응하여 전송된 제3 메시지가 자신의 식별자가 C-RNTI인 경우, 자신의 C-RNTI를 이용하여 PDCCH의 수신을 시도하고, 상기 식별자가 고유 식별자(즉, S-TMSI 또는 임의 값(random number))인 경우에는, 랜덤 액세스 응답에 포함된 TC-RNTI를 이용하여 PDCCH의 수신을 시도한다. 그 후, 전자의 경우, 만약 상기 충돌 해결 타이머가 만료되기 전에 자신의 C-RNTI를 통해 PDCCH를 수신한 경우에, 단말은 정상적으로 랜덤 액세스 절차가 수행되었다고 판단하고, 랜덤 액세스 절차를 종료한다. 후자의 경우에는 상기 충돌 해결 타이머가 만료되기 전에 TC-RNTI를 통해 PDCCH를 수신하였다면, 상기 PDCCH가 지시하는 PDSCH이 전달하는 데이터를 확인한다. 만약 상기 데이터의 내용에 자신의 고유 식별자가 포함되어 있다면, 단말은 정상적으로 랜덤 액세스 절차가 수행되었다고 판단하고, 랜덤 액세스 절차를 종료한다. 제4 메시지를 통해 단말은 C-RNTI를 획득하고, 이후 단말과 네트워크는 C-RNTI를 이용하여 단말 특정 메시지(dedicated message)를 송수신하게 된다.

[208] 다음은 랜덤 액세스에서 충돌 해결을 위한 방법에 대하여 설명한다.

[209] 랜덤 액세스를 수행함에 있어서 충돌이 발생하는 이유는 기본적으로 랜덤 액세스 프리앰블의 수가 유한하기 때문이다. 즉, 기지국은 모든 단말들에게 단말 고유의 랜덤 액세스 프리앰블을 부여할 수 없기 때문에, 단말은 공통의 랜덤 액세스 프리앰블들 중에서 임의적으로 하나를 선택해서 전송하게 된다. 이에 따라 동일한 무선 자원(PRACH 자원)을 통해 둘 이상의 단말들이 같은 랜덤 액세스 프리앰블을 선택하여 전송하게 되는 경우가 발생하지만, 기지국에서는 하나의 단말에게서 전송되는 하나의 랜덤 액세스 프리앰블로 판단하게 된다. 이로 인해, 기지국은 랜덤 액세스 응답을 단말에게 전송하고 랜덤 액세스 응답은 하나의 단말이 수신할 것으로 예측한다. 하지만, 상술한 바와 같이 충돌이 발생할 수 있기 때문에, 둘 이상의 단말들이 하나의 랜덤 액세스 응답을 수신하게 되며, 이에 따라 단말마다 각각 랜덤 액세스 응답의 수신에 따른 동작을 수행하게 된다. 즉, 랜덤 액세스 응답에 포함된 하나의 UL Grant를 이용하여, 둘 이상의 단말들이 서로 다른 데이터를 동일한 무선자원에 전송하게 되는 문제점이 발생하게 된다. 이에 따라, 상기 데이터의 전송은 모두 실패할 수도 있고, 단말들의 위치 또는 전송파워에 따라 특정 단말의 데이터만을 기지국에서 수신할 수도 있다. 후자의 경우, 둘 이상의 단말들은 모두 자신의 데이터의 전송이 성공했다고 가정하기 때문에, 기지국은 경쟁에서 실패한 단말들에게 실패 사실에 대한 정보를 알려주어야 한다. 즉, 상기 경쟁의 실패 또는 성공에 대한 정보를 알려주는 것이 충돌 해결(contention resolution)라 한다.

[210] 충돌 해결 방법에는 두 가지 방법이 있는데 한 가지 방법은, 충돌 해결 타이머(contention resolution timer)를 이용하는 방법과, 다른 한가지 방법은 성공한 단말의 식별자를 단말들에게 전송하는 방법이다. 전자의 경우는, 단말이 랜덤 액세스 과정 전에 이미 고유의 C-RNTI를 가지고 있는 경우에 사용된다. 즉, 이미 C-RNTI를 가지고 있는 단말은 랜덤 액세스 응답에 따라 자신의 C-RNTI를 포함한 데이터를 기지국으로 전송하고, 충돌 해결 타이머를 작동한다. 그리고, 충돌 해결 타이머가 만료되기 전에, 자신의 C-RNTI에 의해 지시되는 PDCCH 정보가 수신되면, 단말은 자신이 경쟁에서 성공했다고 판단하고, 랜덤 액세스를 정상적으로 마치게 된다. 반대로, 만약 충돌 해결 타이머가 만료되기 전에, 자신의 C-RNTI에 의해 지시되는 PDCCH를 전송 받지 못한 경우는, 자신이 경쟁에서 실패했다고 판단하고, 랜덤 액세스 과정을 다시 수행하거나, 상위 계층으로 실패 사실을 통보할 수 있다. 충돌 해소 방법 중 후자의 경우, 즉 성공한 단말의 식별자를 전송하는 방법은, 단말이 랜덤 액세스 과정 전에 고유의 셀 식별자가 없는 경우에 사용된다. 즉, 단말 자신이 셀 식별자가 없는 경우, 랜덤 액세스 응답에 포함된 UL Grant 정보에 따라 데이터에 셀 식별자 보다 상위 식별자(S-TMSI 또는 random number)를 포함하여 전송하고, 단말은 충돌 해결 타이머를 작동시킨다. 충돌 해결 타이머가 만료되기 전에, 자신의 상위 식별자를 포함한 데이터가 DL-SCH로 전송된 경우, 단말은 랜덤 액세스 과정이 성공했다고 판단한다. 반면에, 충돌 해결 타이머가 만료되기 전에, 자신의 상위

식별자를 포함한 데이터를 DL-SCH로 전송 받지 못하는 경우에는, 단말은 랜덤 액세스 과정이 실패했다고 판단하게 되는 것이다.

[211] 한편, 비경쟁 기반 임의접속 과정에서의 동작은 도 8에 도시된 경쟁 기반 임의접속 과정과 달리 제1 메시지 전송 및 제2 메시지 전송만으로 임의접속 절차가 종료되게 된다. 다만, 제1 메시지로서 단말이 기지국에 임의접속 프리엠블을 전송하기 전에 단말은 기지국으로부터 임의접속 프리엠블을 할당받게 되며, 이 할당받은 임의접속 프리엠블을 기지국에 제1 메시지로서 전송하고, 기지국으로부터 임의접속 응답을 수신함으로써 임의접속 절차가 종료되게 된다.

[212]

[213] 참조 신호(RS: Reference Signal)

[214] 무선 통신 시스템에서 데이터는 무선 채널을 통해 전송되기 때문에, 신호는 전송 중에 왜곡될 수 있다. 수신단에서 왜곡된 신호를 정확하게 수신하기 위하여, 수신된 신호의 왜곡은 채널 정보를 이용하여 보정되어야 한다. 채널 정보를 검출하기 위하여 송신측과 수신측 모두 알고 있는 신호 전송 방법과 신호가 채널을 통해 전송될 때 왜곡된 정도를 이용하여 채널 정보를 검출하는 방법을 주로 이용한다. 상술한 신호를 파일럿 신호 또는 참조 신호(RS: reference signal)라고 한다.

[215] 또한 최근 대부분의 이동통신 시스템에서 패킷을 전송할 때, 지금까지 한 개의 송신안테나와 한 개의 수신안테나를 사용했던 것에서 탈피, 다중송신안테나와 다중수신안테나를 채택해 송수신 데이터 효율을 향상시킬 수 있는 방법을 사용한다. 다중 입출력 안테나를 이용하여 데이터를 송수신할 때, 신호를 정확하게 수신하기 위하여 송신 안테나와 수신 안테나 간의 채널 상태가 검출되어야 한다. 따라서 각 송신 안테나는 개별적인 참조 신호를 가져야 한다.

[216] 이동 통신 시스템에서 RS는 그 목적에 따라 크게 두 가지로 구분될 수 있다. 채널 정보 획득을 위한 목적의 RS와 데이터 복조를 위해 사용되는 RS가 있다. 전자는 UE가 하향 링크로의 채널 정보를 획득하는데 그 목적이 있으므로, 광대역으로 전송되어야 하고, 특정 서브 프레임에서 하향 링크 데이터를 수신하지 않는 UE라도 그 RS를 수신하고 측정할 수 있어야 한다. 또한 이는 핸드오버 등의 측정 등을 위해서도 사용된다. 후자는 기지국이 하향링크를 보낼 때 해당 리소스에 함께 보내는 RS로서, UE는 해당 RS를 수신함으로써 채널 추정을 할 수 있고, 따라서 데이터를 복조할 수 있게 된다. 이 RS는 데이터가 전송되는 영역에 전송되어야 한다.

[217] 하향 참조 신호는 셀 내 모든 단말이 공유하는 채널 상태에 대한 정보 획득 및 핸드오버 등의 측정 등을 위한 하나의 공통 참조 신호(CRS: common RS)와 특정 단말만을 위하여 데이터 복조를 위해 사용되는 전용 참조 신호(dedicated RS)가 있다. 이와 같은 참조 신호들을 이용하여 복조(demodulation)와 채널 측정(channel measurement)을 위한 정보를 제공할 수 있다. 즉, DRS는 데이터 복조용으로만

사용되며 CRS는 채널 정보 획득 및 데이터 복조의 두 가지 목적으로 다 사용된다.

[218] 수신 측(즉, 단말)은 CRS로부터 채널 상태를 측정하고, CQI(Channel Quality Indicator), PMI(Precoding Matrix Index) 및/또는 RI(Rank Indicator)와 같은 채널 품질과 관련된 지시자를 송신 측(즉, 기지국)으로 피드백한다. CRS는 셀 특정 기준신호(cell-specific RS)라고도 한다. 반면, 채널 상태 정보(CSI: Channel State Information)의 피드백과 관련된 참조 신호를 CSI-RS라고 정의할 수 있다.

[219] DRS는 PDSCH 상의 데이터 복조가 필요한 경우 자원 요소들을 통해 전송될 수 있다. 단말은 상위 계층을 통하여 DRS의 존재 여부를 수신할 수 있으며, 상응하는 PDSCH가 매핑되었을 때만 유효하다. DRS를 단말 특정 참조 신호(UE-specific RS) 또는 복조 참조 신호(DMRS: Demodulation RS)라고 할 수 있다.

[220] 도 9는 본 발명이 적용될 수 있는 무선 통신 시스템에서 하향링크 자원 블록 쌍에 매핑된 참조 신호 패턴을 예시한다.

[221] 도 9를 참조하면, 참조 신호가 매핑되는 단위로 하향링크 자원 블록 쌍은 시간 영역에서 하나의 서브 프레임 × 주파수 영역에서 12개의 부 반송파로 나타낼 수 있다. 즉, 시간 축(x축) 상에서 하나의 자원 블록 쌍은 일반 순환 전치(normal CP: normal Cyclic Prefix) 인 경우 14개의 OFDM 심볼의 길이를 가지고(도 9(a)의 경우), 확장 순환 전치(extended CP: extended Cyclic Prefix)인 경우 12개의 OFDM 심볼의 길이를 가진다(도 9(b)의 경우). 자원 블록 격자에서 '0', '1', '2' 및 '3'으로 기재된 자원 요소들(REs)은 각각 안테나 포트 인덱스 '0', '1', '2' 및 '3'의 CRS의 위치를 의미하며, 'D'로 기재된 자원 요소들은 DRS의 위치를 의미한다.

[222] 이하 CRS에 대하여 좀 더 상세하게 기술하면, CRS는 물리적 안테나의 채널을 추정하기 위해 사용되고, 셀 내에 위치한 모든 단말에 공통적으로 수신될 수 있는 참조 신호로써 전체 주파수 대역에 분포된다. 즉, 이 CRS는 cell-specific한 시그널로, 광대역에 대해서 매 서브 프레임마다 전송된다. 또한, CRS는 채널 품질 정보(CSI) 및 데이터 복조를 위해 이용될 수 있다.

[223] CRS는 전송 측(기지국)에서의 안테나 배열에 따라 다양한 포맷으로 정의된다. 3GPP LTE 시스템(예를 들어, 릴리즈-8)에서는 기지국의 전송 안테나 개수에 따라서 최대 4개의 안테나 포트에 대한 RS가 전송된다. 하향링크 신호 송신 측은 단일의 송신 안테나, 2개의 송신 안테나 및 4개의 송신 안테나와 같이 3 종류의 안테나 배열을 가진다. 예를 들어 기지국의 송신 안테나의 개수가 두 개일 경우, 0번과 1번 안테나 포트에 대한 CRS가 전송되고, 네 개인 경우 0~3 번 안테나 포트에 대한 CRS가 각각 전송된다. 기지국의 송신 안테나가 4개일 경우 한 RB에서의 CRS 패턴은 도 9와 같다.

[224] 기지국이 단일의 송신 안테나를 사용하는 경우, 단일 안테나 포트를 위한 참조 신호가 배열된다.

[225] 기지국이 2개의 송신 안테나를 사용하는 경우, 2개의 송신 안테나 포트를 위한

참조 신호는 시분할 다중화(TDM: Time Division Multiplexing) 및/또는 주파수 분할 다중화(FDM Frequency Division Multiplexing) 방식을 이용하여 배열된다. 즉, 2개의 안테나 포트를 위한 참조 신호는 각각이 구별되기 위해 서로 다른 시간 자원 및/또는 서로 다른 주파수 자원이 할당된다.

[226] 게다가, 기지국이 4개의 송신 안테나를 사용하는 경우, 4개의 송신 안테나 포트를 위한 참조 신호는 TDM 및/또는 FDM 방식을 이용하여 배열된다. 하향링크 신호의 수신 측(단말)에 의하여 측정된 채널 정보는 단일의 송신 안테나 전송, 송신 다이버시티, 폐쇄 루프 공간 다중화(closed-loop spatial multiplexing), 개방 루프 공간 다중화(open-loop spatial multiplexing) 또는 다중 사용자-다중 입출력 안테나(Multi-User MIMO)와 같은 전송 방식을 이용하여 전송된 데이터를 복조하기 위하여 사용될 수 있다.

[227] 다중 입출력 안테나가 지원되는 경우 참조 신호가 특정의 안테나 포트로부터 전송될 때, 상기 참조 신호는 참조 신호의 패턴에 따라 특정된 자원 요소들의 위치에 전송되며, 다른 안테나 포트를 위해 특정된 자원 요소들의 위치에 전송되지 않는다. 즉, 서로 다른 안테나 사이의 참조 신호는 서로 겹치지 않는다.

[228] 이하 DRS에 대하여 좀 더 상세하게 기술하면, DRS는 데이터를 복조하기 위하여 사용된다. 다중 입출력 안테나 전송에서 특정의 단말을 위해 사용되는 선행 부호화(precoding) 가중치는 단말이 참조 신호를 수신하였을 때 각 송신 안테나에서 전송된 전송 채널과 결합되어 상응하는 채널을 추정하기 위하여 변경 없이 사용된다.

[229] 3GPP LTE 시스템(예를 들어, 릴리즈-8)은 최대로 4개의 전송 안테나를 지원하고, 랭크 1 빔포밍(beamforming)을 위한 DRS가 정의된다. 랭크 1 빔포밍을 위한 DRS는 또한 안테나 포트 인덱스 5 를 위한 참조 신호를 나타낸다.

[230] LTE 시스템의 진화 발전된 형태의 LTE-A 시스템에서 기지국의 하향 링크로 최대 8개의 송신 안테나를 지원할 수 있도록 디자인되어야 한다. 따라서 최대 8개 송신 안테나에 대한 RS 역시 지원되어야 한다. LTE 시스템에서 하향 링크 RS는 최대 4개의 안테나 포트에 대한 RS만 정의되어 있으므로, LTE-A 시스템에서 기지국이 4개 이상 최대 8개의 하향 링크 송신 안테나를 가질 경우 이들 안테나 포트에 대한 RS가 추가적으로 정의되고 디자인되어야 한다. 최대 8개의 송신 안테나 포트에 대한 RS는 위에서 설명한 채널 측정을 위한 RS와 데이터 복조를 위한 RS 두 가지가 모두 디자인되어야 한다.

[231] LTE-A 시스템을 디자인 함에 있어서 중요한 고려 사항 중 하나는 하위 호환성(backward compatibility), 즉 LTE 단말이 LTE-A 시스템에서도 아무 무리 없이 잘 동작해야 하고, 시스템 또한 이를 지원해야 한다는 것이다. RS 전송 관점에서 보았을 때, LTE에서 정의되어 있는 CRS가 전 대역으로 매 서브 프레임마다 전송되는 시간-주파수 영역에서 추가적으로 최대 8개의 송신 안테나 포트에 대한 RS가 추가적으로 정의되어야 한다. LTE-A 시스템에서 기존 LTE의 CRS와 같은 방식으로 최대 8개의 송신 안테나에 대한 RS 패턴을 매 서브

프레임마다 전 대역에 추가하게 되면 RS 오버헤드가 지나치게 커지게 된다.

[232] 따라서 LTE-A 시스템에서 새로이 디자인되는 RS는 크게 두 가지 분류로 나누게 되는데, MCS, PMI 등의 선택을 위한 채널 측정 목적의 RS (CSI-RS: Channel State Information-RS, Channel State Indication-RS 등)와 8개의 전송 안테나로 전송되는 데이터 복조를 위한 RS(DM-RS: Data Demodulation-RS)이다.

[233] 채널 측정 목적의 CSI-RS는 기존의 CRS가 채널 측정, 핸드 오버 등의 측정 등의 목적과 동시에 데이터 복조를 위해 사용되는 것과 달리 채널 측정 위주의 목적을 위해서 디자인되는 특징이 있다. 물론 이 또한 핸드 오버 등의 측정 등의 목적으로도 사용될 수도 있다. CSI-RS가 채널 상태에 대한 정보를 얻는 목적으로만 전송되므로 CRS와 달리 매 서브 프레임마다 전송되지 않아도 된다. CSI-RS의 오버헤드를 줄이기 위하여 CSI-RS는 시간 축 상에서 간헐적으로 전송된다.

[234] 데이터 복조를 위해서 해당 시간-주파수 영역에서 스케줄링 된 UE에게 전용적(dedicated)으로 DM-RS가 전송된다. 즉, 특정 UE의 DM-RS는 해당 UE가 스케줄링 된 영역, 즉 데이터를 수신 받는 시간-주파수 영역에만 전송되는 것이다.

[235] LTE-A 시스템에서 eNB는 모든 안테나 포트에 대한 CSI-RS를 전송해야 한다. 최대 8개의 송신 안테나 포트에 대한 CSI-RS를 매 서브 프레임마다 전송하는 것은 오버헤드가 너무 큰 단점이 있으므로, CSI-RS는 매 서브 프레임마다 전송되지 않고 시간 축에서 간헐적으로 전송되어야 그 오버헤드를 줄일 수 있다. 즉, CSI-RS는 한 서브 프레임의 정수 배의 주기를 가지고 주기적으로 전송되거나 특정 전송 패턴으로 전송될 수 있다. 이 때 CSI-RS가 전송되는 주기나 패턴은 eNB가 설정할 수 있다.

[236] CSI-RS를 측정하기 위해서 UE는 반드시 자신이 속한 셀의 각각의 CSI-RS 안테나 포트에 대한 CSI-RS의 전송 서브 프레임 인덱스, 전송 서브 프레임 내에서 CSI-RS 자원 요소(RE) 시간-주파수 위치, 그리고 CSI-RS 시퀀스 등에 대한 정보를 알고 있어야 한다.

[237] LTE-A 시스템에 eNB는 CSI-RS를 최대 8개의 안테나 포트에 대해서 각각 전송해야 한다. 서로 다른 안테나 포트의 CSI-RS 전송을 위해 사용되는 자원은 서로 직교(orthogonal)해야 한다. 한 eNB가 서로 다른 안테나 포트에 대한 CSI-RS를 전송할 때 각각의 안테나 포트에 대한 CSI-RS를 서로 다른 RE에 맵핑함으로써 FDM/TDM방식으로 이들 자원을 orthogonal하게 할당할 수 있다. 또는 서로 다른 안테나 포트에 대한 CSI-RS를 서로 orthogonal한 코드에 맵핑시키는 CDM방식으로 전송할 수 있다.

[238] CSI-RS에 관한 정보를 eNB가 자기 셀 UE에게 알려줄 때, 먼저 각 안테나 포트에 대한 CSI-RS가 매핑되는 시간-주파수에 대한 정보를 알려줘야 한다. 구체적으로, CSI-RS가 전송되는 서브 프레임 번호들, 또는 CSI-RS가 전송되는 주기, CSI-RS가 전송되는 서브 프레임 오프셋이며, 특정 안테나의 CSI-RS RE가

전송되는 OFDM 심볼 번호, 주파수 간격(spacing), 주파수 축에서의 RE의 오프셋 또는 쉬프트 값 등이 있다.

[239] CSI-RS는 1개, 2개, 4개 또는 8개의 안테나 포트를 통해 전송된다. 이때, 사용되는 안테나 포트는 각각 p=15, p=15,16, p=15,...,18, p=15,...,22이다. CSI-RS는 서브캐리어 간격 Δf=15kHz에 대해서만 정의될 수 있다.

[240] (k',l')(여기서, k'는 자원 블록 내 부반송파 인덱스이고, l'는 슬롯 내 OFDM 심볼 인덱스를 나타낸다.) 및 n_s의 조건은 아래 표 4 또는 표 5와 같은 CSI-RS 설정(configuration)에 따라 결정된다.

[241] 표 3은 일반 CP에서 CSI-RS 구성으로부터 (k',l')의 매핑을 예시한다.

[242] [표3]

	CSI reference signal configuration	Number of CSI reference signals configured					
		1 or 2		4		8	
		(k',l')	$n_s \bmod 2$	(k',l')	$n_s \bmod 2$	(k',l')	$n_s \bmod 2$
Frame structure type 1 and 2	0	(9,5)	0	(9,5)	0	(9,5)	0
	1	(11,2)	1	(11,2)	1	(11,2)	1
	2	(9,2)	1	(9,2)	1	(9,2)	1
	3	(7,2)	1	(7,2)	1	(7,2)	1
	4	(9,5)	1	(9,5)	1	(9,5)	1
	5	(8,5)	0	(8,5)	0		
	6	(10,2)	1	(10,2)	1		
	7	(8,2)	1	(8,2)	1		
	8	(6,2)	1	(6,2)	1		
	9	(8,5)	1	(8,5)	1		
	10	(3,5)	0				
	11	(2,5)	0				
	12	(5,2)	1				
	13	(4,2)	1				
	14	(3,2)	1				
	15	(2,2)	1				
	16	(1,2)	1				
	17	(0,2)	1				
	18	(3,5)	1				
	19	(2,5)	1				
Frame structure type 2 only	20	(11,1)	1	(11,1)	1	(11,1)	1
	21	(9,1)	1	(9,1)	1	(9,1)	1
	22	(7,1)	1	(7,1)	1	(7,1)	1
	23	(10,1)	1	(10,1)	1		
	24	(8,1)	1	(8,1)	1		
	25	(6,1)	1	(6,1)	1		
	26	(5,1)	1				
	27	(4,1)	1				
	28	(3,1)	1				
	29	(2,1)	1				
	30	(1,1)	1				
	31	(0,1)	1				

[243] 표 4는 확장 CP에서 CSI-RS 구성으로부터 (k',l')의 매핑을 예시한다.

[244] [표4]

	CSI reference signal configuration	Number of CSI reference signals configured 1 or 2		4		8	
		(k',l')	$n_s \bmod 2$	(k',l')	$n_s \bmod 2$	(k',l')	$n_s \bmod 2$
Frame structure type 1 and 2	0	(11,4)	0	(11,4)	0	(11,4)	0
	1	(9,4)	0	(9,4)	0	(9,4)	0
	2	(10,4)	1	(10,4)	1	(10,4)	1
	3	(9,4)	1	(9,4)	1	(9,4)	1
	4	(5,4)	0	(5,4)	0		
	5	(3,4)	0	(3,4)	0		
	6	(4,4)	1	(4,4)	1		
	7	(3,4)	1	(3,4)	1		
	8	(8,4)	0				
	9	(6,4)	0				
	10	(2,4)	0				
	11	(0,4)	0				
	12	(7,4)	1				
	13	(6,4)	1				
	14	(1,4)	1				
	15	(0,4)	1				
Frame structure type 2 only	16	(11,1)	1	(11,1)	1	(11,1)	1
	17	(10,1)	1	(10,1)	1	(10,1)	1
	18	(9,1)	1	(9,1)	1	(9,1)	1
	19	(5,1)	1	(5,1)	1		
	20	(4,1)	1	(4,1)	1		
	21	(3,1)	1	(3,1)	1		
	22	(8,1)	1				
	23	(7,1)	1				
	24	(6,1)	1				
	25	(2,1)	1				
	26	(1,1)	1				
	27	(0,1)	1				

[245] 표 3 및 표 4를 참조하면, CSI-RS의 전송에 있어서, 이종 네트워크(HetNet: heterogeneous network) 환경을 포함하여 멀티 셀 환경에서 셀간 간섭(ICI: inter-cell interference)을 줄이기 위하여 최대 32개(일반 CP 경우) 또는 최대 28개(확장 CP 경우)의 서로 다른 구성(configuration)이 정의된다.

[246] CSI-RS 구성은 셀 내의 안테나 포트의 개수 및 CP에 따라 서로 다르며, 인접한 셀은 최대한 서로 다른 구성을 가질 수 있다. 또한, CSI-RS 구성은 프레임 구조에 따라 FDD 프레임과 TDD 프레임에 모두 적용하는 경우와 TDD 프레임에만 적용하는 경우로 나눠질 수 있다.

[247] 표 3 및 표 4를 기반으로 CSI-RS 구성에 따라 (k',l') 및 n_s가 정해지고, 각 CSI-RS 안테나 포트가 CSI-RS 전송에 이용하는 시간-주파수 자원이 결정된다.

[248] 도 10은 본 발명이 적용될 수 있는 무선 통신 시스템에서 CSI-RS 구성을 예시하는 도면이다.

[249] 도 10(a)는 1개 또는 2개의 CSI-RS 안테나 포트들에 의한 CSI-RS 전송에 사용

가능한 20가지 CSI-RS 구성들을 나타낸 것이고, 도 10(b)는 4개의 CSI-RS 안테나 포트들에 의해 사용 가능한 10가지 CSI-RS 구성들을 나타낸 것이며, 도 10(c)는 8개의 CSI-RS 안테나 포트들에 의해 CSI-RS 전송에 사용 가능한 5가지 CSI-RS 구성들을 나타낸 것이다.

[250] 이와 같이, 각 CSI-RS 구성에 따라 CSI-RS가 전송되는 무선 자원(즉, RE 쌍)이 결정된다.

[251] 특정 셀에 대하여 CSI-RS 전송을 위해 1개 혹은 2개의 안테나 포트가 설정되면, 도 10(a)에 도시된 20가지 CSI-RS 구성들 중 설정된 CSI-RS 구성에 따른 무선 자원 상에서 CSI-RS가 전송된다.

[252] 마찬가지로, 특정 셀에 대하여 CSI-RS 전송을 위해 4개의 안테나 포트가 설정되면, 도 10(b)에 도시된 10가지 CSI-RS 구성들 중 설정된 CSI-RS 구성에 따른 무선 자원 상에서 CSI-RS가 전송된다. 또한, 특정 셀에 대하여 CSI-RS 전송을 위해 8개의 안테나 포트가 설정되면, 도 10(c)에 도시된 5가지 CSI-RS 구성들 중 설정된 CSI-RS 구성에 따른 무선 자원 상에서 CSI-RS가 전송된다.

[253] 2개의 안테나 포트 별(즉, {15,16}, {17,18}, {19,20}, {21,22})로 각각의 안테나 포트에 대한 CSI-RS는 동일한 무선 자원에 CDM되어 전송된다. 안테나 포트 15 및 16를 예를 들면, 안테나 포트 15 및 16에 대한 각각의 CSI-RS 복소 심볼은 동일하나, 서로 다른 직교 코드(예를 들어, 왈시 코드(walsh code)가 곱해져서 동일한 무선 자원에 매핑된다. 안테나 포트 15에 대한 CSI-RS의 복소 심볼에는 [1, 1]이 곱해지고, 안테나 포트 16에 대한 CSI-RS의 복소 심볼에는 [1 -1]이 곱해져서 동일한 무선 자원에 매핑된다. 이는 안테나 포트 {17,18}, {19,20}, {21,22}도 마찬가지이다.

[254] UE는 전송된 심볼에 곱해진 코드를 곱하여 특정 안테나 포트에 대한 CSI-RS를 검출할 수 있다. 즉, 안테나 포트 15에 대한 CSI-RS를 검출하기 위해서 곱해진 코드 [1 1]을 곱하고, 안테나 포트 16에 대한 CSI-RS를 검출하기 위해서 곱해진 코드 [1 -1]을 곱한다.

[255] 도 10(a) 내지 (c)를 참조하면, 동일한 CSI-RS 구성 인덱스에 해당하게 되면, 안테나 포트 수가 많은 CSI-RS 구성에 따른 무선 자원은 CSI-RS 안테나 포트 수가 적은 CSI-RS 구성에 따른 무선 자원을 포함한다. 예를 들어, CSI-RS 구성 0의 경우, 8개 안테나 포트 수에 대한 무선 자원은 4개 안테나 포트 수에 대한 무선 자원과 1 또는 2개의 안테나 포트 수에 대한 무선 자원을 모두 포함한다.

[256] 하나의 셀에서 복수의 CSI-RS 구성이 사용될 수 있다. 넌-제로 전력(NZP: non-zero power) CSI-RS는 0개 또는 1개 CSI-RS 구성만이 이용되고, 제로 전력(ZP: zero power) CSI-RS는 0개 또는 여러 개의 CSI-RS 구성이 이용될 수 있다.

[257] 상위 계층에 의해 설정되는 16 비트의 비트맵인 ZP CSI-RS(ZeroPowerCSI-RS)에서 1로 설정된 각 비트 별로, UE는 위의 표 3 및 표 4의 4개의 CSI-RS 열(column)에 해당하는 RE들에서(상위 계층에 의해 설정된

NZP CSI-RS를 가정하는 RE와 중복되는 경우를 제외) 제로 전송 전력을 가정한다. 최상위 비트(MSB: Most Significant Bit)는 가장 낮은 CSI-RS 구성 인덱스에 해당하고, 비트맵 내에서 그 다음의 비트는 순서대로 다음의 CSI-RS 구성 인덱스에 해당한다.

[258] CSI-RS는 위의 표 3 및 표 4에서 (n_s mod 2)의 조건을 만족하는 하향링크 슬롯 및 CSI-RS 서브프레임 구성을 만족하는 서브프레임에서만 전송된다.

[259] 프레임 구조 타입 2(TDD)의 경우, 스페셜 서브프레임, 동기 신호(SS), PBCH 또는 SIB 1(SystemInformationBlockType1) 메시지 전송과 충돌되는 서브프레임 또는 페이징 메시지 전송을 위해 설정된 서브프레임에서 CSI-RS는 전송되지 않는다.

[260] 또한, 안테나 포트 세트 S(S={15}, S={15,16}, S={17,18}, S={19,20} 또는 S={21,22}) 내 속하는 어떠한 안테나 포트에 대한 CSI-RS가 전송되는 RE는 PDSCH 또는 다른 안테나 포트의 CSI-RS 전송에 사용되지 않는다.

[261] CSI-RS 전송에 사용되는 시간-주파수 자원들은 데이터 전송에 사용될 수 없으므로, CSI-RS 오버헤드가 증가할수록 데이터 처리량(throughput)이 감소하게 된다. 이를 고려하여 CSI-RS는 매 서브프레임마다 전송되도록 구성되지 않고, 다수의 서브프레임에 해당하는 소정의 전송 주기마다 전송되도록 구성된다. 이 경우, 매 서브프레임마다 CSI-RS가 전송되는 경우에 비하여 CSI-RS 전송 오버헤드가 많이 낮아질 수 있다.

[262] CSI-RS 전송을 위한 서브프레임 주기(이하, 'CSI 전송 주기'로 지칭함)(T_CSI-RS) 및 서브프레임 오프셋(Δ_CSI-RS)은 아래 표 5과 같다.

[263] 표 5은 CSI-RS 서브프레임 구성을 예시한다.

[264] [표5]

CSI-RS-SubframeConfig I_{CSI-RS}	CSI-RS periodicity T_{CSI-RS} (subframes)	CSI-RS subframe offset Δ_{CSI-RS} (subframes)
0 - 4	5	I_{CSI-RS}
5 - 14	10	$I_{CSI\ RS}-5$
15 - 34	20	$I_{CSI-RS}-15$
35 - 74	40	$I_{CSI-RS}-35$
75 - 154	80	$I_{CSI-RS}-75$

[265] 표 5을 참조하면, CSI-RS 서브프레임 구성(I_CSI-RS)에 따라 CSI-RS 전송 주기(T_CSI-RS) 및 서브프레임 오프셋(Δ_CSI-RS)이 결정된다.

[266] 표 5의 CSI-RS 서브프레임 구성은 앞서 'SubframeConfig' 필드 및 'zeroTxPowerSubframeConfig' 필드 중 어느 하나로 설정될 수 있다. CSI-RS 서브프레임 구성은 NZP CSI-RS 및 ZP CSI-RS에 대하여 개별적으로(separately) 설정될 수 있다.

[267] CSI-RS를 포함하는 서브프레임은 아래 수학식 12를 만족한다.

[268] [수식12]

$$(10n_f + \lfloor n_s/2 \rfloor - \Delta_{CSI-RS}) \bmod T_{CSI-RS} = 0$$

[269] 수학식 12에서 T_CSI-RS는 CSI-RS 전송 주기, Δ_CSI-RS는 서브프레임 오프셋 값, n_f는 시스템 프레임 넘버, n_s는 슬롯 넘버를 의미한다.

[270] 서빙 셀에 대해 전송 모드 9(transmission mode 9)가 설정된 UE의 경우, UE는 하나의 CSI-RS 자원 구성이 설정될 수 있다. 서빙 셀에 대해 전송 모드 10(transmission mode 10)이 설정된 UE의 경우, UE는 하나 또는 그 이상의 CSI-RS 자원 구성(들)이 설정될 수 있다.

[271] 각 CSI-RS 자원 구성을 위한 아래와 같이 파라미터가 상위 계층 시그널링을 통해 설정된다.

[272] - 전송 모드 10이 설정된 경우, CSI-RS 자원 구성 식별자

[273] - CSI-RS 포트 개수

[274] - CSI-RS 구성 (표 3 및 표 4 참조)

[275] - CSI-RS 서브프레임 구성(I_CSI-RS) (표 5 참조)

[276] - 전송 모드 9가 설정된 경우, CSI 피드백을 위한 전송 파워(P_C)

[277] - 전송 모드 10이 설정된 경우, 각 CSI 프로세스에 대하여 CSI 피드백을 위한 전송 파워(P_C). CSI 프로세스에 대하여 CSI 서브프레임 세트들 C_CSI,0 및 C_CSI,1가 상위 계층에 의해 설정되면, P_C는 CSI 프로세스의 각 CSI 서브프레임 세트 별로 설정된다.

[278] - 임의 랜덤(pseudo-rnadom) 시퀀스 발생기 파라미터(n_ID)

[279] - 전송 모드 10이 설정된 경우, QCL(QuasiCo-Located) 타입 B UE 가정을 위한 QCL 스크램블링 식별자(qcl-ScramblingIdentity-r11), CRS 포트 카운트(crs-PortsCount-r11), MBSFN 서브프레임 설정 리스트(mbsfn-SubframeConfigList-r11) 파라미터를 포함하는 상위 계층 파라미터('qcl-CRS-Info-r11')

[280] UE가 도출한 CSI 피드백 값이 [-8, 15] dB 범위 내의 값을 가질 때, P_C는 CSI-RS EPRE에 대한 PDSCH EPRE의 비율로 가정된다. 여기서, PDSCH EPRE는 CRS EPRE에 대한 PDSCH EPRE의 비율이 ρ_A인 심볼에 해당한다.

[281] 서빙 셀의 동일한 서브프레임에서 CSI-RS와 PMCH이 함께 설정되지 않는다.

[282] 프레임 구조 타입 2에서 4개의 CRS 안테나 포트가 설정된 경우, UE는 일반 CP의 경우 [20-31] 세트(표 3 참조) 또는 확장 CP의 경우 [16-27] 세트(표 4 참조)에 속하는 CSI-RS 구성 인덱스가 설정되지 않는다.

[283] UE는 CSI-RS 자원 구성의 CSI-RS 안테나 포트가 지연 확산(delay spread), 도플러 확산(Doppler spread), 도플러 쉬프트(Doppler shift), 평균 이득(average gain) 및 평균 지연(average delay)에 대하여 QCL 관계를 가진다고 가정할 수 있다.

[284] 전송 모드 10 그리고 QCL 타입 B가 설정된 UE는 CSI-RS 자원 구성에 해당하는

안테나 포트 0-3과 CSI-RS 자원 구성에 해당하는 안테나 포트 15-22가 도플러 확산(Doppler spread), 도플러 쉬프트(Doppler shift)에 대하여 QCL 관계라고 가정할 수 있다.

[285] 전송 모드 10이 설정된 UE의 경우, 서빙 셀에 대하여 하나 또는 그 이상의 CSI-IM(Channel-State Information - Interference Measurement) 자원 구성이 설정될 수 있다.

[286] 상위 계층 시그널링을 통해 각 CSI-IM 자원 구성을 위한 아래와 같은 파라미터가 설정될 수 있다.

[287] - ZP CSI-RS 구성 (표 3 및 표 4 참조)

[288] - ZP CSI RS 서브프레임 구성(I_CSI-RS) (표 5 참조)

[289] CSI-IM 자원 구성은 설정된 ZP CSI-RS 자원 구성 중 어느 하나와 동일하다.

[290] 서빙 셀의 동일한 서브프레임 내 CSI-IM 자원과 PMCH가 동시에 설정되지 않는다.

[291] 전송 모드 1-9가 설정된 UE의 경우, 서빙 셀에 대하여 UE는 하나의 ZP CSI-RS 자원 구성이 설정될 수 있다. 전송 모드 10이 설정된 UE의 경우, 서빙 셀에 대하여 UE는 하나 또는 그 이상의 ZP CSI-RS 자원 구성이 설정될 수 있다.

[292] 상위 계층 시그널링을 통해 ZP CSI-RS 자원 구성을 위한 아래와 같은 파라미터가 설정될 수 있다.

[293] - ZP CSI-RS 구성 리스트 (표 3 및 표 4 참조)

[294] - ZP CSI-RS 서브프레임 구성(I_CSI-RS) (표 5 참조)

[295] 서빙 셀의 동일한 서브프레임에서 ZP CSI-RS와 PMCH가 동시에 설정되지 않는다.

[296]

[297] **셀 측정(Cell Measurement)/측정 보고(Measurement Report)**

[298] 단말의 이동성(mobility) 보장을 위한 여러 방법들(핸드오버, 랜덤 액세스, 셀 탐색 등) 중 하나 또는 그 여러 방법들을 위하여 UE는 셀 측정(cell measurement)한 결과를 기지국(혹은 네트워크)에 보고한다.

[299] 3GPP LTE/LTE-A 시스템에서 셀 특정 참조 신호(CRS)는 시간 축으로 각 서브프레임 내의 0, 4, 7, 11 번째 OFDM 심볼을 통해 전송되고, 이는 셀 측정(cell measurement)를 위해 기본적으로 사용된다. 즉, 단말은 서빙 셀(serving cell)과 이웃 셀(neighbor cell)로부터 각각 수신되는 CRS를 이용하여, 셀 측정을 수행한다.

[300] 셀 측정(cell measurement)은 서빙 셀 및 이웃 셀의 신호 세기 혹은 총 수신 전력 대비 신호 세기 등을 측정하는 참조 신호 수신 전력(RSRP: Reference signal receive power), 수신신호강도(RSSI: Received signal strength indicator), 참조신호수신품질(RSRQ: Reference signal received quality) 등의 RRM(Radio resource management) 측정과 서빙 셀과의 링크 품질을 측정하여 라디오 링크 실패(radio link failure) 여부를 평가할 수 있는 RLM(Radio Link Monitoring)

측정을 포함하는 개념이다.

[301] RSRP는 측정 주파수 대역 내에서 CRS가 전송되는 RE의 전력 분배의 선형 평균이다. RSRP 결정을 위해, 안테나 포트 '0'에 해당하는 CRS(R0)가 사용될 수 있다. 또한, RSRP 결정을 위해, 안테나 포트 '1'에 해당하는 CRS(R1)가 추가로 사용될 수도 있다. RSRP를 결정하기 위하여 UE에 의해 이용되는 측정 주파수 대역 및 측정 구간 내에서 이용하는 RE들의 수는 해당 측정 정확도 요구(accuracy requirements)가 만족되는 한도에서 UE가 결정할 수 있다. 또한, RE 당 전력은 순환 전치(CP)를 제외한 심볼의 나머지 부분 내에서 수신한 에너지로부터 결정될 수 있다.

[302] RSSI는 측정 대역 내에서 안테나 포트 '0'에 해당하는 RS를 포함하는 OFDM 심볼들에서 동일 채널(co-channel)의 서빙 셀(serving cell)과 넌-서빙 셀(non-serving cell), 인접 채널로부터의 간섭, 열 잡음(thermal noise) 등을 포함하는 해당 UE에 의해 모든 소스들로부터 감지된 총 수신 전력의 선형 평균으로 도출된다. 상위 계층 시그널링에 의하여 RSRQ 측정을 수행하기 위한 특정 서브프레임들이 지시되는 경우, RSSI는 지시된 서브프레임들 내의 모든 OFDM 심볼에 통해 측정된다.

[303] RSRQ는 N×RSRP/RSSI로 도출된다. 여기서, N은 RSSI 측정 대역폭의 RB 개수를 의미한다. 또한, 위의 식에서 분자 및 분모의 측정은 동일한 RB의 세트에서 구해질 수 있다.

[304] 기지국은 상위 계층 시그널링(예를 들어, RRC 연결 재구성(RRC Connection Reconfiguration) 메시지)을 통해 UE에게 측정(measurement)을 위한 설정 정보를 전달할 수 있다.

[305] RRC 연결 재구성 메시지는 무선 자원 구성 전용('radioResourceConfigDedicated') 정보 요소(IE: Information Element)와, 측정 설정('measConfig') IE를 포함한다.

[306] 'measConfig' IE는 UE에 의해 수행되어야 하는 측정을 특정하고, 측정 갭(measurement gap)의 구성 뿐만 아니라 인트라-주파수(intra-frequency) 이동성, 인터-주파수(inter-frequency) 이동성, 인터-RAT(inter-RAT) 이동성을 위한 설정 정보를 포함한다.

[307] 특히, 'measConfig' IE는 측정에서 제거될 측정 대상('measObject')의 리스트를 나타내는 'measObjectToRemoveList'와 새로이 추가되거나 수정될 리스트를 나타내는 'measObjectToAddModList'가 포함된다. 또한, 'measObject'에는 통신 기술에 따라 'MeasObjectCDMA2000', 'MeasObjctEUTRA', 'MeasObjectGERAN' 등이 포함된다.

[308] 'RadioResourceConfigDedicated' IE는 무선 베어러(Radio Bearer)를 설정/변경/해제(setup/modify/release) 하거나, MAC 메인 구성을 변경하거나, 반정적 스케줄링(SPS: Semi-Persistent Scheduling) 설정을 변경하거나 및 전용 물리적 설정(dedicated physical configuration)을 변경하기 위하여 사용된다.

[309] 'RadioResourceConfigDedicated' IE는 서빙 셀 측정을 위한 시간 영역 측정 자원 제한 패턴(time domain measurement resource restriction pattern)을 지시하는 'measSubframePattern-Serv' 필드를 포함한다. 또한, UE에 의해 측정될 이웃 셀을 지시하는 'measSubframeCellList' 와 이웃 셀 측정을 위한 시간 영역 측정 자원 제한 패턴을 지시하는 'measSubframePattern-Neigh'를 포함한다.

[310] 측정 셀(서빙 셀 및 이웃 셀 포함)을 위해 설정된 시간 영역 측정 자원 제한 패턴(time domain measurement resource restriction pattern)은 RSRQ 측정을 수행하기 위한 무선 프레임 당 적어도 하나의 서브프레임을 지시할 수 있다. 측정 셀을 위해 설정된 시간 영역 측정 자원 제한 패턴에 의하여 지시된 서브프레임 이외에서는 RSRQ 측정이 수행되지 않는다.

[311] 이와 같이, UE(예를 들어, 3GPP Rel-10)는 서빙 셀 측정을 위한 서브프레임 패턴('measSubframePattern-Serv') 및 이웃 셀 측정을 위한 서브프레임 패턴('measSubframePattern-Neigh')에 의해 설정된 구간에서만 RSRQ가 측정되어야 한다.

[312] 다만, RSRP는 이러한 패턴 내 측정이 제약되어 있지 않지만, 정확도 요구(accuracy requirement)를 위해서는 이러한 패턴 내에서만 측정되는 것이 바람직하다.

[313]

[314] <u>안테나 포트 간 QCL(quasi co-located)</u>

[315] QC/QCL(quasi co-located 혹은 quasi co-location)은 다음과 같이 정의될 수 있다.

[316] 두 개의 안테나 포트가 QC/QCL 관계에 있다(혹은 QC/QCL 되었다)고 하면, 하나의 안테나 포트를 통해 전달되는 신호의 광범위 특성(large-scale property)이 다른 하나의 안테나 포트를 통해 전달되는 신호로부터 암시(infer)될 수 있다고 단말이 가정할 수 있다. 여기서, 상기 광범위 특성은 지연 확산(Delay spread), 도플러 확산(Doppler spread), 주파수 쉬프트(Frequency shift), 평균 수신 파워(Average received power), 수신 타이밍(Received Timing) 중 하나 이상을 포함한다.

[317] 또한, 다음과 같이 정의될 수도 있다. 두 개의 안테나 포트가 QC/QCL 관계에 있다(혹은 QC/QCL 되었다)고 하면, 하나의 안테나 포트를 통해 일 심볼이 전달되는 채널의 광범위 특성(large-scale property)이 다른 하나의 안테나 포트를 통해 일 심볼이 전달되는 무선 채널로부터 암시(infer)될 수 있다고 단말이 가정할 수 있다. 여기서, 상기 광범위 특성은 지연 확산(delay spread), 도플러 확산(Doppler spread), 도플러 쉬프트(Doppler shift), 평균 이득(average gain) 및 평균 지연(average delay) 중 하나 이상을 포함한다.

[318] 즉, 두 개의 안테나 포트들이 QC/QCL 관계에 있다(혹은 QC/QCL 되었다)고 함은, 하나의 안테나 포트로부터의 무선 채널의 광범위 특성이 나머지 하나의 안테나 포트로부터의 무선 채널의 광범위 특성과 같음을 의미한다. RS가 전송되는 복수의 안테나 포트를 고려하면, 서로 다른 두 종류의 RS가 전송되는

안테나 포트들이 QCL 관계에 있으면, 한 종류의 안테나 포트로부터의 무선 채널의 광범위 특성을 다른 한 종류의 안테나 포트로부터의 무선 채널의 광범위 특성으로 대체할 수 있을 것이다.

[319] 본 명세서에서 위 QC/QCL 관련 정의들을 구분하지 않는다. 즉, QC/QCL 개념은 위 정의들 중에 하나를 따를 수 있다. 혹은 유사한 다른 형태로, QC/QCL 가정이 성립하는 안테나 포트 간에는 마치 동일 위치(co-location)에서 전송하는 것처럼 가정할 수 있다는 형태 (예를 들어, 동일 전송 포인트(transmission point)에서 전송하는 안테나 포트라고 단말이 가정할 수 있다는 등)으로 QC/QCL 개념 정의가 변형될 수도 있으며, 본 발명의 사상은 이와 같은 유사 변형예들을 포함한다. 본 발명에서는 설명의 편의상 위 QC/QCL 관련 정의들을 혼용하여 사용한다.

[320] 상기 QC/QCL의 개념에 따라, 단말은 비-QC/QCL(Non-QC/QCL) 안테나 포트들에 대해서는 해당 안테나 포트들로부터의 무선 채널 간에 동일한 상기 광범위 특성을 가정할 수 없다. 즉, 이 경우 단말은 타이밍 획득 및 트랙킹(tracking), 주파수 오프셋 추정 및 보상, 지연 추정 및 도플러 추정 등에 대하여 각각의 설정된 비-QC/QCL 안테나 포트 별로 독립적인 프로세싱을 수행하여야 한다.

[321] QC/QCL을 가정할 수 있는 안테나 포트들간에 대해서, 단말은 다음과 같은 동작을 수행할 수 있다는 장점이 있다:

[322] - 지연 확산 및 도플러 확산에 대하여, 단말은 어떤 하나의 안테나 포트로부터의 무선 채널에 대한 전력-지연-프로파일(power-delay profile), 지연 확산 및 도플러 스펙트럼(Doppler spectrum), 도플러 확산 추정 결과를, 다른 안테나 포트로부터의 무선 채널에 대한 채널 추정 시 사용되는 위너 필터(Wiener filter) 등에 동일하게 적용할 수 있다.

[323] - 주파수 쉬프트(shift) 및 수신된 타이밍에 대하여, 단말은 어떤 하나의 안테나 포트에 대한 시간 및 주파수 동기화 수행한 후, 동일한 동기화를 다른 안테나 포트의 복조에 적용할 수 있다.

[324] - 평균 수신 전력에 대하여, 단말은 둘 이상의 안테나 포트들에 대하여 RSRP(Reference Signal Received Power) 측정을 평균할 수 있다.

[325] 예를 들어, 단말이 하향링크 데이터 채널 복조를 위한 DMRS 안테나 포트가 서빙 셀의 CRS 안테나 포트와 QC/QCL 되었다면, 단말은 해당 DMRS 안테나 포트를 통한 채널 추정 시 자신의 CRS 안테나 포트로부터 추정했던 무선 채널의 광범위 특성들(large-scale properties)을 동일하게 적용하여 DMRS 기반 하향링크 데이터 채널 수신 성능을 향상시킬 수 있다.

[326] 왜냐하면, CRS는 매 서브프레임 그리고 전체 대역에 걸쳐 상대적으로 높은 밀도(density)로 브로드캐스팅되는 참조 신호이므로, 광범위 특성에 관한 추정치는 CRS로부터 보다 안정적으로 획득이 가능하기 때문이다. 반면, DMRS는 특정 스케줄링된 RB에 대해서는 단말 특정하게 전송되며, 또한

PRG(precoding resource block group) 단위가 기지국이 전송에 사용하는 프리코딩 행렬(precoding matrix)가 변할 수 있으므로 단말에게 수신되는 유효 채널은 PRG 단위로 달라질 수 있어 다수의 PRG를 스케줄링 받은 경우라고 하더라도 넓은 대역에 걸쳐 DMRS를 무선 채널의 광범위 특성 추정용으로 사용 시에 성능 열화가 발생할 수 있다. 또한, CSI-RS도 그 전송 주기가 수~수십 ms가 될 수 있고, 자원 블록 당 평균적으로 안테나 포트 당 1 자원 요소의 낮은 밀도를 가지므로 CSI-RS도 마찬가지로 무선 채널의 광범위 특성 추정용으로 사용할 경우 성능 열화가 발생할 수 있다.

[327] 즉, 안테나 포트 간의 QC/QCL 가정을 함으로써 단말은 하향링크 참조 신호의 검출/수신, 채널 추정, 채널 상태 보고 등에 활용할 수 있다.

[328]

[329] <u>제한된 RLM 및 RRM/CSI 측정</u>

[330] 간섭 조정(Interference coordination)의 한 방법으로서, 공격 셀(aggressor cell)이 일부 물리 채널의 전송 파워(transmission power)/동작(activity)를 줄이는 (여기서, 전송 파워/동작을 줄이는 것은 제로 파워로 설정하는 동작까지 포함할 수 있음) 침묵 서브프레임(silent subframe)(또는, ABS(almost blank subframe)으로 지칭될 수 있음)을 사용하고, 희생 셀(victim cell)이 이를 고려하여 UE를 스케줄링하는 시간 도메인 셀 간 간섭 조정(scheduling하는 time domain inter-cell interference coordination)이 가능하다.

[331] 이 경우, 희생 셀(victim cell) UE의 입장에서는 간섭 레벨(interference level)이 서브프레임에 따라서 크게 변화할 수 있다.

[332] 이러한 상황에서 각 서브프레임에서의 보다 정확한 무선 링크 모니터링(RLM: radio link monitoring)이나 RSRP/RSRQ 등을 측정하는 무선 자원 관리(RRM: radio resource management) 동작을 수행하거나 링크 적응(link adaptation)을 위해서 채널 상태 정보(CSI: channel state information)를 측정하기 위해서, 상기 모니터링/측정은 균일한 간섭 특성을 지니는 서브프레임의 세트들로 제한되어야 한다. 3GPP LTE 시스템에서는 아래와 같이 제한된 RLM 및 RRM/CSI 측정을 정의한다.

[333] UE는 Pcell의 하향링크 무선 링크 품질(downlink link quality)을 감지하기 위하여 셀 특정 참조 신호(CRS)에 기반하여 하향링크 링크 품질을 모니터한다. 단말은 하향링크 무선 링크 품질을 추정하고, Pcell의 하향링크 무선 링크 품질을 모니터링하기 위하여 임계치 Q_out 및 Q_in와 추정치를 비교한다.

[334] 임계치 Q_out은 하향링크 무선 링크가 신뢰있게(reliably) 수신될 수 없는 레벨로 정의되고, 아래 표 6에서 명시된 전송 파라미터에 기반하여 PCFICH 에러를 고려한 가상의(hypothetical) PDCCH 전송의 10% 블록 에러율(BER: block error rate)에 해당한다.

[335] 임계치 Q_in는 하향링크 무선 링크 품질이 Q_out에서의 하향링크 무선 링크 품질 보다 현저하게 신뢰있게 수신될 수 있는 레벨로 정의되고, 아래 표 7에서

명시된 전송 파라미터에 기반하여 PCFICH 에러를 고려한 가상의(hypothetical) PDCCH 전송의 2% BER에 해당한다.

[336] 상위 계층 시그널링이 제한된 RLM을 위한 특정 서브프레임을 지시할 때, 무선 링크 품질이 모니터링된다.

[337] RLM 측정을 수행하기 위한 시간 도메인 측정 자원 제한 패턴이 상위 계층에 의해 설정될 때, 또한 측정되는 셀을 위해 설정된 시간 도메인 측정 자원 제한 패턴이 RLM 측정을 수행하기 위한 무선 프레임 당 적어도 하나의 서브프레임을 지시한다면, 일정한 요구 사항이 적용된다.

[338] CRS 지원(assistance) 정보가 제공되는 경우, CRS 지원 정보가 제공된 하나 또는 그 이상의 셀의 전송 안테나 포트(transmit antenna port)의 개수가 RLM이 수행되는 셀의 전송 안테나 포트의 개수와 상이할 때 상기 요구 사항이 만족될 수 있다.

[339] 만약, 단말이 CRS 지원 정보를 제공받지 않거나 CRS 지원 데이터가 전체 평가 기간 동안에 유효하지 않으면, CRS와 논-MBSFN(multicast broadcast single frequency network) 서브프레임 내에서 설정된 ABS의 충돌 하에 시간 도메인 측정 제한이 적용될 수 있다.

[340] 표 6은 동기가 맞지 않은 상태(out-of-sync)에 대한 PDCCH/PCFICH 전송 파라미터를 예시한다.

[341] [표6]

속성(Attribute)	값(Value)
DCI 포맷	1A
제어 OFDM 심볼의 수	2; 대역폭 ≥ 10 MHz 3; 3 MHz ≤ 대역폭 ≤ 10 MHz 4; 대역폭 = 1.4 MHz
병합 레벨(Aggregation level) (CCE)	4; 대역폭 = 1.4 MHz 8; 대역폭 ≥ 3 MHz
PDCCH RE 에너지 대 평균 RS RE 에너지의 비 (Ratio of PDCCH RE energy to average RS RE energy)	4 dB; Pcell에 의한 CRS 전송을 위해 단일 안테나 포트가 사용되는 경우 1 dB; Pcell에 의한 CRS 전송을 위해 2개 또는 4개 안테나 포트가 사용되는 경우
PCFICH RE 에너지 대 평균 RS RE 에너지의 비 (Ratio of PCFICH RE energy to average RS RE energy)	4 dB; Pcell에 의한 CRS 전송을 위해 단일 안테나 포트가 사용되는 경우 1 dB: Pcell에 의한 CRS 전송을 위해 2개 또는 4개 안테나 포트가 사용되는 경우

[342] 표 7은 동기가 맞는 상태(in-sync)에 대한 PDCCH/PCFICH 전송 파라미터를 예시한다.

[343] [표7]

속성(Attribute)	값(Value)
DCI 포맷	1C
제어 OFDM 심볼의 수	2; 대역폭 ≥ 10 MHz 3; 3 MHz ≤ 대역폭 ≤ 10 MHz 4; 대역폭 = 1.4 MHz
병합 레벨(Aggregation level) (CCE)	4
PDCCH RE 에너지와 평균 RS RE 에너지 간 비율 (Ratio of PDCCH RE energy to average RS RE energy)	0 dB; Pcell에 의한 CRS 전송을 위해 단일 안테나 포트가 사용되는 경우 -3 dB; Pcell에 의한 CRS 전송을 위해 2개 또는 4개 안테나 포트가 사용되는 경우
PCFICH RE 에너지 대 평균 RS RE 에너지의 비 (Ratio of PCFICH RE energy to average RS RE energy)	4 dB; Pcell에 의한 CRS 전송을 위해 단일 안테나 포트가 사용되는 경우 1 dB; Pcell에 의한 CRS 전송을 위해 2개 또는 4개 안테나 포트가 사용되는 경우

[344] Pcell에 대한 하향링크 무선 링크 품질은 UE에 의해 상위 계층에 동기가 맞지 않은 상태(out-of-sync status)/동기가 맞는 상태(in-sync status)를 지시하기 위하여 모니터된다.

[345] 비-DRX(non-DRX) 모드 동작에서, UE의 물리 계층은 매 무선 프레임에서 임계치(Q_out 및 Q_in)를 고려하여 이전 시간 구간 동안 평가된 무선 링크 품질을 측정(assess)한다.

[346] 상위 계층 시그널링이 제한된 RLM을 위한 특정 서브프레임을 지시하면, 무선 링크 품질의 측정은 상위 계층 시그널링에서 지시되지 않는 이외 다른 서브프레임에서 수행되지 않는다.

[347] 무선 링크 품질이 임계치 Q_out 보다 불량하면, UE의 물리 계층은 무선 링크 품질이 측정된 무선 프레임 내에서 상위 계층에게 out-of-sync를 지시한다. 무선 링크 품질이 임계치 Q_in 보다 양호하면, UE의 물리 계층은 무선 링크 품질이 측정된 무선 프레임 내에서 상위 계층에게 in-sync를 지시한다.

[348]

[349] <u>매시브 MIMO(Massive MIMO)</u>

[350] LTE 릴리즈(Rel: release)-12 이후의 무선 통신 시스템에서는 능동 안테나 시스템(AAS: Active Antenna System)의 도입이 고려되고 있다.

[351] 신호의 위상 및 크기를 조정할 수 있는 증폭기와 안테나가 분리되어 있는 기존의 수동 안테나 시스템과 달리, AAS는 각각의 안테나가 증폭기와 같은 능동 소자를 포함하도록 구성된 시스템을 의미한다.

[352] AAS는 능동 안테나 사용에 따라 증폭기와 안테나를 연결하기 위한 별도의 케이블, 커넥터, 기타 하드웨어 등이 필요하지 않고, 따라서 에너지 및 운용 비용 측면에서 효율성이 높은 특징을 갖는다. 특히, AAS는 각 안테나 별 전자식 빔 제어(electronic beam control) 방식을 지원하기 때문에 빔 방향 및 빔 폭을 고려한

정교한 빔 패턴 형성 또는 3차원 빔 패턴을 형성하는 등의 진보된 MIMO 기술을 가능하게 한다.

[353] AAS 등의 진보된 안테나 시스템의 도입으로 다수의 입출력 안테나와 다차원 안테나 구조를 갖는 대규모 MIMO 구조 또한 고려되고 있다. 일례로, 기존의 일자 형 안테나 배열과 달리 2차원 안테나 배열을 형성할 경우, AAS의 능동 안테나에 의해 3차원 빔 패턴을 형성할 수 있다. 송신 안테나 관점에서 상기 3차원 빔 패턴을 활용할 경우, 빔의 수평 방향뿐만 아니라 수직 방향으로의 준-정적 또는 동적인 빔 형성을 수행할 수 있으며 일례로 수직 방향의 섹터 형성 등의 응용을 고려할 수 있다.

[354] 또한, 수신 안테나 관점에서는 대규모 수신 안테나를 활용하여 수신 빔을 형성할 때, 안테나 배열 이득(antenna array gain)에 따른 신호 전력 상승 효과를 기대할 수 있다. 따라서, 상향링크의 경우, 기지국이 다수의 안테나를 통해 단말로부터 전송되는 신호를 수신할 수 있으며, 이때 단말은 간섭 영향을 줄이기 위해 대규모 수신 안테나의 이득을 고려하여 자신의 송신 전력을 매우 낮게 설정할 수 있는 장점이 있다.

[355] 도 11은 본 발명이 적용될 수 있는 무선 통신 시스템에서 기지국 또는 단말이 AAS 기반의 3D(3-Dimension) 빔 형성이 가능한 다수의 송/수신 안테나를 갖고 있는 시스템을 예시한다.

[356] 도 11은 앞서 설명한 예를 도식화한 것으로서, 2차원 안테나 배열(즉, 2D-AAS)를 이용한 3D MIMO 시스템을 예시한다.

[357]

[358] <u>매시브 MIMO의 셀 커버리지(Cell coverage of massive MIMO)</u>

[359] 다중 안테나 시스템, 일례로서 N개의 전송 안테나를 갖는 시스템은 단일 안테나 시스템에 비교해서 전체 전송 전력을 동일하게 전송한다고 가정하면, 특정 지점에 수신 파워가 최대 N배 높도록 빔포밍(beamforming) 해줄 수 있다.

[360] 다중 안테나를 갖는 기지국에서도 CRS, PSS/SSS, PBCH 및 브로드캐스트(broadcast) 정보를 전달하는 채널은 기지국 커버리지 영역내의 모든 UE들이 수신할 수 있도록 특정 방향으로 beamforming을 해주지는 않는다.

[361] 이와 달리, 특정 UE에게 유니캐스트(unicast) 정보를 전달하는 채널인 PDSCH는 해당 UE의 위치 및 링크 상황에 맞추어 beamforming을 해주어 전송 효율을 높이도록 한다. 즉, PDSCH의 전송 데이터 스트림은 특정 방향으로 빔을 형성하기 위하여 프로코딩(precoding)되어 다중의 안테나 포트를 통해 전송된다. 그러므로 대표적으로 CRS와 PDSCH의 전송 전력이 동일한 경우에, 특정 UE에게 CRS의 평균 수신 전력과 비교해서 해당 UE를 향해 beamforming 된 프로코딩된(precoded) PDSCH의 수신 전력은 최대 N배까지 높을 수 있다.

[362] 현재까지 LTE Rel-11 시스템에서 최대 8개의 전송 안테나를 갖는 기지국을 고려하는데, 이는 CRS 평균 수신 전력에 비해서 precoded PDSCH 수신 전력이 8배 클 수 있음을 의미한다. 그러나, 향후에 매시브 MIMO 시스템의 도입으로

기지국의 전송 안테나가 100개 이상 되는 경우에 CRS와 precoded PDSCH의 수신 전력은 100배 이상 차이를 나타낼 수 있다. 결론적으로 massive MIMO 시스템의 도입으로 특정 기지국에서 전송하는 CRS의 커버리지 영역과 DM-RS 기반 PDSCH의 커버리지 영역이 일치하지 않게 된다.

[363] 특히, 이러한 현상은 인접한 두 개의 기지국의 전송 안테나 개수의 차이가 많을 때 크게 나타날 수 있다. 대표적으로 64개의 전송 안테나를 갖는 매크로 셀(macro cell)과 단일 전송 안테나를 갖는 마이크로 셀(micro cell)(예를 들어, 피코 셀(pico cell))이 인접하고 있는 경우를 예로 들 수 있다. Massive MIMO의 초기 배치(deployment) 과정에서 서빙받는(served) UE가 많은 macro cell부터 먼저 안테나 개수를 늘릴 것으로 기대하고 있기 때문에 macro cell, micro cell 그리고 pico cell이 혼재되어 있는 이종의 네트워크(heterogeneous network)의 경우에 인접한 기지국간에 전송 안테나의 개수가 크게 차이 나게 된다.

[364] 예를 들어, 단일 전송 안테나를 갖는 pico cell의 경우에 CRS와 PDSCH의 커버리지 영역이 일치하게 된다. 그러나 64개의 전송 안테나를 갖는 macro cell의 경우에 CRS의 커버리지 영역보다 PDSCH의 커버리지 영역이 더 크게 된다. 그러므로 macro cell과 pico cell의 경계에서 CRS의 수신 품질인 RSRP 또는 RSRQ에만 의존하여 초기접속 및 핸드오버를 결정하게 되면 PDSCH의 최대 품질을 제공해 줄 기지국을 서빙 셀(serving cell)로 선택할 수 없게 된다. 이에 대한 단순한 해결책으로 N개의 전송 안테나를 갖는 기지국의 PDSCH 수신 전력은 N배 클 것으로 가정할 수 있으나, 기지국이 가능한 모든 방향으로 beamforming을 다 해줄 수 없는 경우를 고려할 때 최적 해결책은 아니다.

[365]

[366] **RRM-RS**

[367] 본 특허에서는 프리코딩된 RS(precoded RS)를 전송하고 이에 대한 RRM 측정(measurement)를 수행하는 방법을 제안한다. 이하, 본 명세서에서는 이러한 목적의 precoded RS를 'RRM-RS'라고 명칭하도록 한다. RRM-RS는 다수개의 안테나 포트로 구성되어 있으며 각 안테나 포트 별로 beamforming을 다르게 설정하여 각 전송 빔(beam) 별로 UE가 RSRP를 측정할 수 있도록 한다. 일례로, 기지국에서 M개의 방향으로 beamforming이 가능한 경우에 M 포트(M-port)로 구성된 RRM-RS를 설정하도록 한다.

[368]

[369] **RRM-RS의 주기 및 다중화(multiplexing)**

[370] M-port RRM-RS는 동일 서브프레임에서 CDM되거나 또는 FDM/TDM으로 구분되어 전송될 수 있다. 즉, M-port RRM-RS의 각 안테나 포트 별 전송 신호는 동일 서브프레임에서 다른 전송 RE를 사용하여 전송되거나, 또는 동일 RE를 사용하여 전송되는 경우에 안테나 포트 간에 직교 스크램블링 코드(orthogonal scrambling code)를 사용하여 상호간에 간섭 없이 구분할 수 있도록 한다.

[371] 이와 달리 하나의 서브프레임에서 동시에 전송 가능한 RRM-RS의 안테나 포트

수를 K로 설정하고 (M/K)개의 서브프레임에 나누어 전송할 수 있다.

[372] 이 경우, RRM-RS의 설정 파라미터는 전체 안테나 포트의 개수 M과 하나의 서브프레임에서 동시 전송되는 안테나 포트 수 K를 포함한다. RRM-RS의 설정 파라미터로써 RRM-RS 전송 주기 P와 오프셋 O를 포함한다. 여기서, RRM-RS 전송 주기는 RRM-RS가 전송되는 서브프레임의 간격으로 정의한다. 예로써 P=10, O=5, M=64, K=32인 경우에 RRM-RS는 서브프레임 인덱스(SFI: subframe index)가 5, 15, 25, 35, ... 인 서브프레임에서 전송되며, SFI=5인 서브프레임에서 안테나 포트 0에서 31의 RRM-RS가 전송되고, SFI=15인 서브프레임에서 안테나 포트 32에서 63의 RRM-RS가 전송되고, SFI=25인 서브프레임에서 안테나 포트 0에서 31의 RRM-RS가 또다시 전송된다.

[373] 이와 달리 RRM-RS 전송 주기를 동일 안테나 port의 RS가 전송되는 서브프레임의 간격으로 정의하고, (M/K)개의 서브프레임에 RRM-RS의 안테나 포트들을 나누어 전송하는 방식에서 (M/K)개의 연속된 서브프레임에 나누어 전송하도록 한다. 예로써 P=20, O=5, M=64, K=32인 경우에 RRM-RS는 SFI가 5, 6, 25, 26, 45, 46, ...인 서브프레임에서 전송되며, SFI=5인 서브프레임에서 안테나 포트 0에서 31의 RRM-RS가 전송되고, SFI=6인 서브프레임에서 안테나 포트 32에서 63의 RRM-RS가 전송되고, SFI=25인 서브프레임에서 안테나 포트 0에서 31의 RRM-RS가 또다시 전송된다.

[374]

[375] **RSRP** 측정 및 보고

[376] RRM-RS의 RSRP는 안테나 포트 별로 측정하여 보고하도록 한다. UE는 다수개의 RRM-RS를 설정 받을 수 있다.

[377] 각 셀에서 RRM-RS를 하나씩 전송하는 경우에, UE는 서빙 셀 및 인접 셀들이 전송하는 RRM-RS들의 설정을 지정 받을 수 있다. 하나의 셀이 다수개의 RRM-RS를 전송할 수도 있다. UE는 RRM-RS의 RSRP를 보고할 때 해당 RSRP가 몇 번째 RRM-RS의 몇 번째 안테나 포트의 RSRP 측정결과인지 함께 알려준다.

[378] RRM-RS의 RSRP를 계산하기 위하여 각 안테나 포트의 수신 신호 레벨의 평균을 취하는데, 평균을 취하는 시간 윈도우(window)를 기지국이 지정해 줄 수 있거나, 또는 미리 정해진 시간 (예를 들어, 200ms) 동안 RRM-RS의 각 안테나 포트 별 수신 신호 레벨의 평균을 취하여 RSRP를 얻도록 한다. 또는 각각의 시간 윈도우에서 얻은 평균 수신 파워를 다시 필터링하여 보고할 RSRP를 얻을 수 있다.

[379] 다수개의 RRM-RS를 설정 받은 UE는 각 RRM-RS의 각 안테나 포트별 RSRP를 측정한다. RRM-RS를 R개 설정 받고 r번째 RRM-RS의 안테나 포트 수가 M_r인 경우에, r번째 RRM-RS의 m번째 안테나 포트의 RSRP를 RSRP(r,m)로 정의한다. UE는 RSRP(r,m)을 정렬하고 그 중에서 강하게 수신되는 L개 안테나 포트의 RSRP를 선택하여 보고하도록 한다.

[380] 위 방식을 약간 변형하여 UE는 RSRP(r,m)을 정렬하고 그 중에서 가장 강하게

수신되는 안테나 port를 선택하고 선택된 안테나 포트의 RSRP, 즉 max(RSRP(r,m))와 대비하여 일정 차이 내로 들어오는 포트의 RSRP들로 보고를 한정시킨다. 즉, 다음과 같이 RSRP 비율(ratio) 또는 dB 스케일(scale) 표현에서 RSRP의 차이가 일정 임계치 보다 높은 최대 L개의 안테나 포트의 RSRP를 보고하도록 한다.

[381] [수식13]

```
RSRP(r,m) - max(RSRP(r,m)) > Threshold
```

[382] 다른 일례로, UE는 참조(reference) 안테나 포트를 지정 받을 수 있다. 참조 안테나 포트로써 해당 UE에게 설정된 프리코딩된(precoded) CSI-RS와 빔 방향이 유사한 서빙 셀이 전송하는 RRM-RS의 안테나 포트를 지정해 주는 것이 바람직하다. UE는 r_0번째 RRM-RS의 m_0번째 안테나 포트를 참조 안테나 포트로 지정 받은 경우에, 참조 안테나 포트의 RSRP에 비해 다른 안테나 포트의 RSRP가 일정 차이 내로 들어오는 경우에 보고하도록 한다. 즉 다음과 같이 RSRP 비율(ratio) 또는 dB 스케일(scale) 표현에서 RSRP의 차이가 일정 임계치를 넘는 경우에 보고하도록 한다.

[383] [수식14]

```
RSRP(r,m) - RSRP(r_0,m_0) > Threshold
```

[384] 도 12는 본 발명의 일 실시예에 따른 RRM-RS의 안테나 포트 별 RSRP를 예시한다.

[385] 도 12에서는 32 안테나 포트로 구성된 RRM-RS의 각 안테나 포트별 RSRP의 일 예시를 나타내고 있다.

[386] 최대 RSRP를 갖는 안테나 포트에 비교해서 5dB이내의 RSRP를 갖는 안테나 포트들의 RSRP를 보고하도록 설정된 경우, 도 12와 같이 안테나 포트 13이 최대 RSRP 40dB를 가지므로 RSRP가 35dB를 넘는 안테나 포트에 대해 보고하도록 한다. 즉, 안테나 포트 13을 포함하여 안테나 포트 24, 25, 26의 RSRP가 기지국에 보고된다.

[387]

[388] <u>안테나 포트 그룹핑(Antenna port grouping)</u>

[389] 안테나 포트 별로 빔 포밍을 다르게 설정할 수 있으므로, 이 경우 안테나 포트와 빔은 일대일 대응 관계를 갖는다.

[390] 그러므로 안테나 포트 인덱스 (i)는 빔 인덱스(beam index) (i)와 일대일로 매핑시킬 수 있다. (i)번째 빔과 (i+1)번째 빔의 방향이 서로 인접하도록 빔들을 인덱싱하는 경우, 앞서 도 12의 예시에서처럼 인접한 안테나 포트들간의 RSRP는 서로 유사한 특징을 보이게 된다. 이러한 유사도는 (i)번째 빔과 (i+c)번째 빔 사이에서도 나타나지만 c가 커질수록 유사도는 떨어진다. 몇 개의 연속된 인접 빔들 사이에서 높은 유사도가 나올지는, 빔의 간격 및 빔의 폭(width), 그리고 다중-경로(multipath)들의 분산(scattering) 정도에 따라서 좌우된다.

[391] RRM-RS에 기반한 RSRP 측정 결과를 보고 받은 기지국은 해당 UE의 대략적 위치를 파악하고 해당 지점으로 향하여 전송되는 프리코딩된(precoded) CSI-RS 설정을 UE에게 알려주어 UE가 CSI-RS를 측정하여 PDSCH 스케줄링을 위한 CSI(RI, PMI, CQI 등)를 피드백 할 수 있도록 한다. 또한, 다수의 셀에서 전송하는 RRM-RS들에 기반한 RSRP 측정 결과를 보고 받은 기지국은 RSRP 측정 결과에 기반하여 해당 UE를 어떤 셀로 핸드오버 시킬지 그리고 타겟 셀에서 어떤 프리코딩된(precoded) CSI-RS를 UE에게 설정해 줄지 결정한다. 즉, RRM-RS에 기반한 RSRP 측정 결과는 해당 UE에게 향후에 어떤 프리코딩된(precoded) CSI-RS를 설정해 줄지를 판단하는데 필요한 중요 정보를 기지국에 제공한다.

[392] 앞서 도 12의 예시와 같은 RSRP 측정 결과를 바탕으로 해당 UE에게 최대 4개의 데이터 스트림 전송이 가능하도록 하거나 또는 페이딩(fading)의 변화에 맞추어 빠르게 최상의 빔 스위칭(best beam switching)을 하기 위하여 4-포트 CSI-RS를 설정해주는 경우에, RSRP가 가장 큰 RRM-RS 포트 13, 24, 25, 26의 빔 방향과 동일한 4-포트 CSI-RS를 생성하여 설정해 주는 것이 최적일 것으로 예상된다. 하지만 CSI-RS가 UE 별로 최적화하여 생성하고 전송하기에는 오버헤드(overhead)가 너무 크다. 그러므로 동일 환경에 있는 많은 UE들이 CSI-RS를 공유하는 것이 CSI-RS 전송 오버헤드를 줄일 수 있는 방법이다. 이러한 목적을 달성하기 위하여 하나의 CSI-RS 설정내의 CSI-RS 안테나 포트들의 프리코딩은 인접 방향으로 전송되는 빔의 특징을 나타내도록 프리코딩되어야 한다. 즉, 다른 서빙 받는 UE(served UE)들을 고려하여 미리 RRM-RS 포트 12, 13, 14, 15의 빔 방향과 동일한 4-포트 CSI-RS1과 RRM-RS 포트 24, 25, 26, 27의 빔 방향과 동일한 4-포트 CSI-RS2가 미리 설정되어 있는 경우에, 해당 UE에게 어떤 CSI-RS를 설정해주는 것이 좋을지를 RRM-RS의 RSRP 보고를 통해 판단할 수 있어야 한다.

[393] 본 발명의 또 다른 실시예로서 안테나 포트 그룹(antenna port group)에 대해서 RSRP를 측정 보고하도록 한다. 제안 방식에서 안테나 포트들을 그룹핑하고 그룹에 속하는 안테나 포트의 RSRP들을 평균 취하여 해당 안테나 포트 그룹의 RSRP를 얻도록 한다. 그룹은 미리 정해져 있거나 또는 기지국이 정해서 알려 줄 수 있다. 또는 UE가 그룹핑 방식을 정하고 이를 보고 할 수 있다.

[394] 앞서 도 12의 예시에서처럼 32-포트로 구성된 RRM-RS의 경우에 4 포트 씩 그룹핑 될 수 있다. 각 그룹들간에 분리(disjoint)하여 8(=32/4)개의 그룹으로 그룹핑될 수 있다. 이 경우에 (i)번째 포트 그룹은 RRM-RS 포트 (4i), (4i+1), (4i+2), (4i+3)로 구성된다. (i)번째 포트 그룹의 RSRP는 안테나 포트 (4i), (4i+1), (4i+2), 그리고 (4i+3)의 RSRP의 평균으로 정의한다.

[395] 또 다른 실시예로서, 그룹간의 중첩을 허용하여 그룹핑할 수 있다. 32-포트로 구성된 RRM-RS을 4 포트씩 그룹핑하는 경우에 15개의 그룹으로 그룹핑하도록 한다. 이 경우에 (i)번째 포트 그룹은 RRM-RS 포트 (2i), (2i+1), (2i+2), (2i+3)로 구성된다. 제안 방식을 일반화하여 A 개의 포트씩 그룹핑하고, 인접 그룹간의

포트 간격을 B로 설정하면, (i)번째 포트 그룹은 RRM-RS 포트 (B*i), (B*i+1), ..., (B*i+A-1)로 구성된다. 파라미터 A와 B의 설정은 기지국이 UE에게 지정해 주거나, 또는 UE가 채널 환경 및 UE 능력(capability)을 고려하여 선정하여 보고할 수 있다.

[396] 제안 방식의 변형으로 UE는 보고할 안테나 포트 그룹을 선택하는 방식으로 RSRP보다 해당 안테나 포트 그룹으로 얻을 수 있는 능력(capability)을 고려할 수 있다. 이 경우에 UE는 안테나 포트 그룹내의 다수의 안테나로부터 다중-계층(multi-layer) 데이터 전송을 고려하여 능력을 계산하도록 한다.

[397]

[398] 안테나 포트 그룹핑 레벨(Antenna port grouping level)

[399] 제안 방식에서 크기가 다른 다수개의 그룹핑 방법을 사용할 수 있다. 즉, A1 포트씩 그룹핑하는 방법과 A2 포트씩 그룹핑하는 방법을 동시에 사용할 수 있다. 이하, A_i 포트씩 그룹핑하는 방법을 그룹핑 레벨(grouping level) i로 명칭하도록 한다.

[400] 도 13은 본 발명의 일 실시예에 따른 RRM-RS 안테나 포트 그룹핑 레벨을 예시한다.

[401] 도 13에서는 16 포트 RRM-RS를 4단계의 그룹핑 레벨을 적용하여 그룹핑하는 방식의 일례를 보여주고 있다. 예시에서 그룹핑 레벨 1은 1 포트씩 그룹핑하는 방법으로 그룹핑을 하지 않지 않는 방식을 나타낸다. 그리고 그룹핑 레벨 2, 3, 4는 각각 2 포트, 4 포트, 8 포트씩 그룹핑하고 있다. 그림의 예시에서는 동일 레벨의 안테나 포트 그룹들이 분히(disjoint)하여 설정된 경우를 나타내고 있다.

[402] 이러한 다중 그룹핑 방식에서 UE는 그룹핑 레벨 별로 RSRP를 보고한다. 즉 각 그룹핑 레벨 별로 RSRP가 높은 안테나 그룹을 선택하여 보고하도록 한다. 또는 레벨이 다른 안테나 그룹간에 RSRP를 비교하여 최상의(best) 그룹과 그룹 레벨을 보고할 수 있다. 레벨1이 다른 안테나 그룹간의 RSRP를 비교하기 위하여 각 레벨의 그룹 RSRP에 일정 오프셋만큼 보정하고 비교하도록 한다. RRM-RS를 R개 설정 받은 경우에, (r)번째 RRM-RS의 (l)번째 그룹핑 레벨의 (g)번째 안테나 포트 그룹의 RSRP를 GRSRP(r,l,g)로 정의하면, 다음과 같이 기지국으로부터 (r)번째 RRM-RS의 (l)번째 그룹핑 레벨을 위해 지정 받은 offset(r,l)만큼을 보정하여 Adj_GRSRP(r,l,g)를 계산하고 이를 비교하도록 한다.

[403] [수식15]

```
Adj_GRSRP(r,l,g) = GRSRP(r,l,g) + offset(r,l)
```

[404] 추가적으로, 그룹핑 레벨 별로 또는 전체 그룹핑 방식에서 최상의(best) L개의 포트 그룹 RSRP를 보고하는 방식에서 보고되는 최상의(best) L에 대한 잦은 변동을 줄이기 위해 히스테리시스 파라미터(Hysteresis parameter), Hy를 추가하여 RSRP를 보정할 수 있다.

[405] [수식16]

$$Adj_GRSRP(r,l,g) = GRSRP(r,l,g) + offset(r,l) \pm Hy$$

[406] 여기서, Hy는 해당 포트 그룹이 이전 보고에서 최상의(best) L GRSRP에 포함되는지 여부에 따라서 Hy를 더할지 뺄지 결정된다. 해당 포트 그룹이 이전 보고에서 최상의(best) L GRSRP에 포함되어 있는 경우에 Hy를 더하여 높은 Adj_RSRP를 갖도록 바이어스를 줘서 최상의(best) L Adj_GRSRP를 갖는 포트 그룹이 자주 바뀌는 것을 줄여 주도록 한다.

[407] 제안 방식으로 UE는 참조(reference) 안테나 포트 그룹을 지정 받을 수 있다. 기지국은 해당 UE에게 설정된 프리코딩된(precoded) CSI-RS와 빔 방향이 동일한 서빙 셀이 전송하는 RRM-RS의 안테나 포트 그룹을 참조 안테나 포트 그룹으로 지정해 주는 것이 바람직하다. UE는 그룹핑 레벨 별로 참조 안테나 포트 그룹을 지정 받을 수 있다. 또는 전체 그룹핑 레벨에서 하나의 참조 안테나 포트 그룹을 지정 받을 수 있다. UE는 r_0번째 RRM-RS의 l_0번째 그룹핑 레벨의 m_0번째 안테나 포트 그룹을 참조 안테나 포트 그룹으로 지정 받은 경우에, 참조 안테나 포트 그룹의 Adj_GRSRP에 비해 다른 안테나 포트 그룹의 Adj_GRSRP가 일정 임계츠를 넘는 경우에 보고하도록 한다. 즉 다음과 같이 Adj_GRSRP 비율(ratio) 또는 dB 스케일(scale) 표현에서 RSRP의 차이가 일정 임계치를 넘는 경우에 보고하도록 한다.

[408] [수식17]

$$Adj_GRSRP(r,l,g) - Adj_GRSRP(r_0, l_0, m_0) > Threshold$$

[409] 또는 제안 방식의 변형으로 참조 RSRP를 현재 설정되어 있는 CSI-RS를 통해 특정하여 CSI-RS 기반 RSRP에 비해 RRM-RS 기반 RSRP 결과를 비교하여 선택 보고하도록 한다.

[410]

[411] **3차원(3D: 3-Dimension)을 위한 RRM-RS**

[412] 앞서 본 발명에서 제안하는 방식은 빔(beam)의 방향성이 2차원 공간에서 3차원 공간으로 확장되는 경우에도 변형하여 적용 가능하다. 3차원 공간상에서 빔의 방향성은 상하각(수직각)과 좌우각(수평각)의 두 개의 각도의 의해 조절된다. 그러므로 인접 빔 여부를 파악하기 위하여 빔들을 두 개의 인덱스, 즉 수평 인덱스와 수직 인덱스로 인덱스하는 것이 효율적이다. 본 발명의 특징에 따라 빔 인덱스와 RRM-RS 포트 인덱스와 일대일 대응 관계를 갖기 위하여 RRM-RS 포트도 수평 인덱스와 수직 인덱스로 인덱싱되는 것이 바람직하다.

[413] 수직 방향으로 M_v개의 빔을 갖고 수평 방향으로 M_h개의 빔을 갖는 3D MIMO 시스템의 경우에 전체 (M_v×M_h)개의 빔이 가능하다. 본 발명에서는 (M_v×M_h)-포트 RRM-RS를 설정하고 각 안테나 포트에 수평 인덱스 j_h(j_h=0, ..., M_h-1)와 수직 인덱스 j_v(j_v=0, ..., M_v-1)를 부여하도록 한다. (M_v×M_h)-포트 RRM-RS의 자원 매핑을 고려하여 각 안테나 포트들은 일차원

인덱스 i(i=0, ..., M_v×M_h-1)와 이차원 인덱스 j_h와 j_v를 부여 받게 되는데, (i) = f(j_h, j_v)의 관계를 갖게 된다.

[414] 도 14는 본 발명의 일 실시예에 따른 이차원 인덱스로 배열된 RRM-RS의 안테나 포트와 안테나 포트 그룹을 예시하는 도면이다.

[415] 도 14를 참조하면, 각 안테나 포트들은 (j_h, j_v)로 인덱싱되어 있다. 본 발명에서 제안하는 방식을 적용하여 A_h×A_v 개의 포트씩 그룹핑하고, 인접 그룹간의 포트 간격을 B_h와 B_v로 설정하면, (i_h, i_v)번째 포트 그룹은 RRM-RS port (B_h×i_h+j_h, B_v×i_v+j_v), (j_h=0, ..., A_h-1), (j_v=0, ..., A_v-1)로 구성된다. 파라미터 A_h, A_v와 B_h, B_v의 설정은 기지국이 UE에게 지정해 주거나, 또는 UE가 채널 환경 및 UE 능력(capability)를 고려하여 선정하여 보고할 수 있다.

[416]

[417] **RRM**-RS과 CSI-RS의 차이점

[418] 기존 LTE/LTE-A 시스템에서는 CSI 보고의 목적으로 CSI-RS를 전송한다. UE는 CSI로써 RI, PMI, CQI 등을 보고한다. 이와 달리 본 발명에서 제안하는 RRM-RS는 안테나 포트 별로 RSRP를 측정하기 위해 사용된다. RRM-RS의 전송 자원을 새롭게 정의하기 보다는 기존의 CSI-RS가 설정 가능한 자원을 사용하는 것이 바람직하다. 이는 레가시(legacy) UE들의 전송 효율을 떨어뜨리지 않기 때문이다. 새로운 자원에 RRM-RS를 전송하는 경우에 레가시(legacy) UE들은 이를 인식하지 못하므로, RRM-RS이 전송되는 서브프레임에서 전송 효율이 떨어지거나 또는 스케줄링하지 못하게 된다. 그러므로 기존의 CSI-RS가 설정 가능한 자원을 사용하여 RRM-RS를 전송하는 방식은 레가시(legacy) UE에게 해당 자원을 포함하여 CSI-RS 설정을 해주어 해당 자원에 데이터 매핑이 되지 않음을 알려줄 수 있다.

[419] UE에게 CSI 보고를 위해 설정된 다수개의 CSI-RS에는 데이터 매핑이 이루어지지 않는다. 즉 CSI-RS가 매핑되는 RE를 제외하고 PDSCH를 매핑한다. 본 발명의 제안 방식에서 RRM-RS는 CSI-RS 마찬가지로 RRM-RS가 매핑되는 RE를 제외하고 PDSCH를 매핑하도록 할 수 있다. 그러나 변형된 방식으로 RRM-RS와 무관하게 PDSCH를 매핑하도록 할 수 있다. 이 경우에 UE는 동일 RE에서 RRM-RS와 PDSCH를 동시에 수신할 수 있어야 한다. 또는 기지국이 RRM-RS의 안전한 수신을 보장하기 위하여 해당 자원을 ZP-CSI-RS로 설정하여 PDSCH가 매핑되지 않도록 할 수 있다.

[420]

[421] **RRM**-RS의 QCL 설정

[422] 각 셀에서 RRM-RS를 전송하는 경우에, UE는 서빙 셀 및 인접 셀들이 전송하는 RRM-RS들의 설정을 지정 받을 수 있다. 이를 통하여 UE는 서빙 셀의 빔포밍(beamforming)에 따른 이득 및 인접 셀의 beamforming에 따른 이득을 측정하여 네트워크에 보고하고 핸드오버의 판단 기준으로 활용하도록 해준다.

RRM-RS는 전송 밀도(density)가 매우 낮게 설정되므로 신호의 트래킹(tracking) 목적으로 부족할 수 있다. 그러므로 밀도(density)가 높아 신뢰(reliable)있게 수신되는 신호 대표적으로 CRS를 트래킹(tracking)하고 RRM-RS의 검출하는데 트래킹(tracking) 결과를 활용하도록 한다. 즉, 서빙 셀과 인접 셀의 반송파 주파수를 발생하는 오실레이터의 오차에 의하여 서빙 셀의 CRS에 의해 트래킹(tracking)된 결과를 인접 셀에서 전송된 RRM-RS를 위해 사용하기에는 부적합하다. 그러므로 각각의 RRM-RS 별로 RRM-RS를 검출할 때 사용할 QCL(Quasi Co-Located)된 CRS (혹은 CSI-RS 등 특정 다른 RS)를 알려주도록 한다. UE는 QCL된 CRS (혹은 CSI-RS 등 특정 다른 RS)로부터 추정된 채널의 광범위 특성(large-scale) 특성을 RRM-RS의 검출에 사용한다. 여기서 채널의 광범위 특성(large-scale) 특성은 지연 확산(Delay spread), 도플러 확산(Doppler spread), 도플러 쉬프트(Doppler shift), 평균 이득(average gain), 그리고 평균 지연(average delay) 중에 하나 이상을 포함할 수 있다.

[423]

[424] **RSRQ로 확장**

[425] 본 발명의 제안 방식들은 RRM-RS의 각 안테나 포트 별로 RSRQ를 측정하는 방식으로 확장 적용될 수 있다. RSRQ는 RSRP와 RSSI의 비율로 정의된다. 그러므로 추가적으로 RSSI의 측정이 추가된다. RSSI의 측정 자원은 동일 반송파 주파수를 갖는, 즉 동일 컴포넌트 캐리어(component carrier)에 설정된 모든 RRM-RS들에 있어서 동일하게 설정될 수 있다. 이 경우에 동일 컴포넌트 캐리어 내의 RRM-RS들의 포트들 간의 비교는 RSRP을 사용하나 RSRQ를 사용하나 동일하다. 그러나 이종 동일 컴포넌트 캐리어 내의 RRM-RS들의 포트들간의 비교는 RSRP을 사용할지 RSRQ를 사용할지에 따라 달라진다. 그러므로 기지국은 UE에게 RRM-RS에 기반한 RRM 보고를 수행함에 있어서 RSRP을 사용할지 RSRQ를 사용할지를 지정해 주도록 한다.

[426] 이와 달리 각각의 RRM-RS들 개별적으로 RSSI 측정 자원을 따로 설정해 줄 수 있다. 이 경우에는 동일 컴포넌트 캐리어 내에서도 RRM-RS들의 포트들간의 비교는 RSRP을 사용할지 RSRQ를 사용할지에 따라 달라진다. 그러므로 기지국은 UE에게 RRM-RS에 기반한 RRM 보고를 수행함에 있어서 RSRP을 사용할지 RSRQ를 사용할지를 지정해 주도록 한다.

[427]

[428] **RRM-RS RSRP와 CRS RSRP의 연관성**

[429] 본 발명의 RRM-RS에 기반한 RSRP는 다중 안테나를 가지고 있는 기지국의 beamforming 이득을 서빙 셀 선택에 반영함을 목적으로 하고 있다. RRM-RS의 RSRP에 근거하여 특정 인접 셀의 beamforing이 가장 좋다고 판단되어도, 해당 셀에서 브로드캐스트하는 채널들, 즉 CRS 기반 복조(demodulation)를 하는 채널이 안정적으로 수신되지 않으면 해당 인접 셀로 UE를 핸드오버 시킬 수 없다. 그러므로 UE에게 특정 기지국에서 전송하는 RRM-RM와 CRS 모두 좋은

품질을 갖는지 보고 받고 이를 근거를 핸드오버 결정 및 빔 선택(beam selection을 수행해야 한다. 이를 위하여 UE는 설정 받은 i번째 RRM-RS의 j번째 안테나 포트 또는 포트그룹의 RSRP를 보고하면서 i번째 RRM-RS과 연결된 CRS의 RSRP를 같이 보고 하도록 한다. 여기서 RRM-RS와 연결된 CRS는 RRM-RS와 QCL된 CRS일 수 있다.

[430]

[431] 개선된 RRM 및 RLM 동작

[432] FD-MIMO가 사용될 때, 일반적인 셀 연관(conventional cell association) 방법으로 인하여 셀 경계(cell-edge) 사용자는 현저하게 성능 저하(degradation)가 유발될 수 있다. 또한, CRS/PDCCH의 수직 빔(vertical beam)의 폭(width)은, 폭이 좁은 수직 빔(narrow vertical beam)으로 인해 발생되는 CRS/PDCCH의 커버리지 홀(coverage hole) 때문에 성능 저하(degradation)가 유발되는 시스템의 수율(throughput)에 현저한 영향을 미칠 수 있다. 만약, FD-MIMO를 위해 CRS 가상화(virtualization)가 사용된다면, 시스템 성능 측면에서 특히, 셀 경계(cell edge) UE의 부적절한 셀 연관(cell association)을 야기시킬 수 있다. FD-MIMO 전송 방식은 일반적인 전송 방식에 비하여 더 높은 빔 이득으로 동작하기 때문에, UE는 해당 UE를 위한 PDSCH에 적용되는 최적인 수직 빔을 제공할 수 있는 셀에 어태치되어야 한다.

[433] 즉, FD-MIMO 동작에 있어서, UE는 해당 UE에 대한 PDSCH에 적용되는 최적의 수직 빔(best vertical beam)을 제공할 수 있는 셀에 어태치(attach)되어야 한다.

[434] UE가 셀에 미리 어태치(attach)되어 있는 상황에서는 CSI-RS(디스커버리 RS(DRS: Discovery RS)로서 이용되는 경우 DRS-CSI-RS) 기반 RRM 측정을 통해 이를 가능하게 할 수 있다. 더욱 구체적으로, (FD-MIMO를 지원하는) UE는 상술한 FD-MIMO 측면에서 최적의 셀(best cell)이 아니더라도 주로 RACH 절차를 포함하는 기존의 CRS 기반 셀 선택 절차에 따라 셀에 어태치된다. UE가 RRC-Connected 모드에 셋업되면, UE는 DRS 측정 타이밍 설정(DMTC: DRS measurement timing configuration), DRS-CSI-RS 설정 등을 포함하는 디스커버리 절차를 위하여 필요한 모든 상위 계층 시그널링이 설정될 필요가 있다. 이러한 설정에 따라, UE는 DMTC 내 설정된 주기(예를 들어, 40, 80 또는 160 ms)에 따라 주기적으로 DRS-CSI-RS를 측정한다.

[435] 특히, UE는 DRS-CSI-RS 기반 RRM 측정에 기반하여(예를 들어, FD-MIMO 사용 케이스에서 각각 서로 다른 수직 빔(vertical beam)이 적용되는 경우 등), 특수한 동작에 따라 CSI-RS 기반 RRM 보고를 수행할 수 있다. eNB에서 이러한 RRM 보고 결과를 취합하고, eNB가 해당 UE의 현재 서빙 셀이 FD-MIMO 모드에 의해 전송된 PDSCH에 적용되는 최적의 수직 빔을 UE에게 제공하지 않는다고 판단하면, UE는 eNB으로부터 다른 셀로 핸드오버하도록 지시 받을 수 있다. 다시 말해, 서빙 셀 이외 다른 셀로부터 전송되는 특정 DRS-CSI-RS에 기반하여

최적 RRM 결과가 도출되고, 보고될 수 있다.

[436] DRS와 같이 프리코딩된 CSI-RS는 FD-MIMO를 지원하는 UE를 위한 잠재적인 핸드오버 결정뿐만 아니라 최적의 수직 빔 선택을 포함하는 RRM을 위해 이용될 수 있다.

[437] 그러나, FD-MIMO를 더 효율적으로 지원하기 위하여, 순수하게 RRM 측정 목적의 RS를 설계하는 것이 고려될 수 있다.

[438] 현재 DRS-CSI-RS는 안테나 포트 15에서만 전송되기 때문에, 셀 별로 서로 다른 수직 빔 각각에 상응하는 개별적인 DRS-CSI-RS 설정이 단말에 설정되는 것이 필요하다. 다만, FD-MIMO를 지원하기 위한 RRM 목적을 고려하여, 자원 사용 효율을 높이기 위해 CSI-RS 설정 내 안테나 포트 간 CDM(예를 들어, 안테나 포트 15 및 16)이 여전히 적용되기 위하여, 동일 셀 내 서로 다른 수직 빔 방향에 각각 적용되는 다중의 CSI-RS 안테나 포트가 단일의 CSI-RS 설정 내 설정될 수 있다. 또한, 설정들과 관련된 DRS 시점(occasion) 등을 포함하여 디스커버리 절차를 위해 필요한 다른 설정 및 동작은 이러한 RRM 목적을 위해 생략될 수 있다.

[439] 따라서, FD-MIMO를 지원하기 위하여 RRM 목적을 위한 개별적인 RS가 요구된다.

[440] UE을 위한 PDSCH에 적용되는 최적의 수직 빔(best vertical beam)을 제공할 수 있는 셀에 적절히 연관(association)하는 중에 발생되는 상술한 지연(latency)을 고려하여, 그러한 지연을 감소시키는 방법 또한 UE이 최초 접속 단계(initial access stage)에서도 최적의 셀에 연관하는 방법이 요구된다.

[441] 더욱 구체적으로, 일반적인 셀 연관 동작(cell association behavior)에 따라, 최악의 경우에서 지연(worst-case latency)은 UE가 그러한 디스커버리 절차와 관련된 DMTC를 포함하는 RRC 시그널링을 수신하고, UE가 설정된 RRC 시그널링에 따라 장기(long-term) DRS-CSI-RS 측정 및 보고를 수행하고, UE가 FD-MIMO 측면에서 최적이 아닌 셀에 어태치되었음이 판명된 경우 또 다른 셀로 핸드오버하는 것일 수 있다.

[442] 이에 따라 UE가 아이들 모드(idle mode)일 때 최적의 셀(best cell)을 최초로 탐색할 수 있도록 FD-MIMO를 지원하는 UE를 위한 셀 선택/재선택 절차의 개선을 고려할 수 있다.

[443] 또한, FD-MIMO 전송에 의해 서비스받는 단말이 최적의 셀에 연관(association)하기 위한 측면에서 무선 링크 모니터링 동작에 대한 개선이 필요하다.

[444] 따라서, FD-MIMO를 지원하는 UE이 최적의 셀로 적절히 연관하는 중에 발생될 수 있는 잠재적인 지연을 감소시키는 방법이 요구된다.

[445]

[446] <u>RRM-RS 기반 셀 선택 방법</u>

[447] 상술한 RRM-RS 등과 같이 특정 방향 빔포밍된 RS 포트(beamformed RS ports)

또는, (서로 다른 TP(들)/셀(들)의 개수로 구성되는) 무정형 셀(amorphous cells) 환경에서의 서로 다른 RS 포트(different RS ports)에 기반하여 단말이 RRM 측정치(예를 들어, RSRP, RSRQ 등)들을 기지국에 보고함으로써 기지국의 단말 연관(association) 결정을 도울 수 있다.

[448] 여기서, 무정형 셀(amorphous cell)은 고정적인 셀 형태를 가지지 않고, 단말 중심으로 무정형하게 구성되는 셀을 의미한다. 즉, 고정적인 셀 형태 없이 밀집한 (스몰) 셀들 간의 협력을 통해 이동 단말에게 데이터를 전달함으로써 커버리지를 형성하게 된다. 따라서, 단말이 이동하면 이동한 위치의 셀이 고려가 되어 핸드오버를 최소화할 수 있다.

[449] 즉, 이러한 일련의 동작을 단말이 수행하기 위해서는 우선 종래의 랜덤 액세스 절차(즉, RACH(Random Access Channel) 절차) 등의 초기 접속(initial access) 과정을 통해 특정 셀에 접속을 하여야 하고, 단말은 RRC 연결(RRC-connected) 상태에서 상기 RRM-RS 관련 설정 정보 등 다양한 사전 정보를 RRC 시그널링에 의해 제공 받아야 한다. 그 후, 상기 설명된 다양한 RRM 보고 절차에 따라 기지국에 각종 RRM 측정치들을 보고하는 동작까지가 단말이 수행하게 된다. 그 후, 최적의 셀 선택/핸드오버(best cell selection/hand-over) 과정들은 기지국에서 수행/결정함으로써, 해당 단말을 필요 시에 핸드오버(hand-over)시키거나 최적의 전송 포인트(best TP(transmission point))를 결정하여 CSI-RS 설정 등에 반영하는 형태로 동작될 수 있다. 결국, 이러한 일련의 과정을 통해 단말의 최적의 서빙 셀(best serving-cell)이 초기 접속 과정에 의해 접속된 서빙 셀이 아닌 것으로 판명되는 경우, 불가피하게 핸드오버가 발생할 수 있다. 따라서, 만일 초기에 접속하자 마자 위와 같은 과정을 통해 다른 셀로 조기에 핸드오버되는 단말의 경우, 최적의 셀 연관(best cell association)에 있어서 불필요한 큰 지연(latency)이 발생한다는 한계가 있다.

[450] 또 다른 종래 기술의 활용의 한계점에 관한 예시로서, 릴리즈(Rel: release)-12 스몰 셀 향상(small-cell enhancement)에 따른 디스커버리 절차(discovery procedure)를 활용하여, 예를 들어 상기 RRM-RS의 역할을 하는 RS(예를 들어, 디스커버리 신호(discovery signal) 또는 디스커버리 참조 신호(DRS: discovery reference signal) 또는 DRS-CSI-RS)(이하, 편의상 DRS로 지칭함)가 설정되고, DRS 측정 타이밍 설정(DMTC: DRS measurement timing configuration)을 포함한 DRS 기반 측정 관련 제반 정보가 설정될 수 있다. 그리고, 이를 통해 상기 풀-차원-MIMO(FD-MIMO: full-dimension MIMO) 사용 케이스 또는 진보된 무정형 셀(amorphous cells) 환경에서의 최적의 UE 기준의 셀 선택(best UE-centric cell selection)에 활용할 수 있는 방법이 존재한다.

[451] DMTC는 상위 계층 메시지(예를 들어, RRC 메시지)를 통해 단말에 제공될 수 있다. DMTC는 DRS 전송 주기/오프셋, 측정 주파수 대역, 측정 구간(즉, 디스커버리 신호 시점(discovery signal occasion)), DRS 안테나 포트 정보 등을 포함할 수 있다.

[452] 보다 구체적으로 살펴보면, 스몰 셀 향상은 스몰 셀의 에너지 절감(saving) 및 인접 셀로의 간섭을 감소시키기 위하여 단말이 스몰 셀 커버리지 내 존재하는 경우에만 스몰 셀의 온 상태(on-state)를 유지하고, 그렇지 않으면 스몰 셀의 오프 상태(off-state)를 유지하는 스몰 셀 on/off 메커니즘을 지원한다. 이 경우, 단말에서 스몰 셀이 on/off-state를 판단할 수 있도록 디스커버리 절차(discovery procedure)가 필요하다. 이를 위해, on/off-state와 무관하게 스몰 셀은 항상 DRS를 전송(즉, 방송)한다. 즉, 스몰 셀이 off-state인 경우에도 일정 주기를 가지고 DRS를 방송한다. 일정 주기를 측정 주기(measurement period) 또는 DRS 측정 타이밍 설정(DMTC) 주기라고 지칭할 수 있으며, 일례로 40ms, 80ms, 160ms 등이 해당될 수 있다.

[453] 이때, 스몰 셀은 DRS를 방송하는 on-state를 일정 시간(예를 들어, 1개 내지 5개 서브프레임) 유지할 수 있다. 예를 들어, 측정 주기가 40ms인 경우, 6ms 동안 on-state를 유지하면서 DRS를 방송하고, 나머지 34ms 동안 off-state를 유지할 수 있다. 이처럼 DRS를 전송하는 구간을 측정 윈도우(measurement window) 또는 디스커버리 신호 시점(DRS occasion)라고 지칭할 수 있다. 즉, 디스커버리 신호 시점은 연속된 서브프레임의 구간(예를 들어, 1개(또는 2개) 내지 5개의 연속된 서브프레임 구간)으로 구성될 수 있으며, 하나의 디스커버리 신호 시점은 매 측정 주기(또는 DMTC 주기) 내에서 한 번씩 존재할 수 있다.

[454] 단말은 스몰 셀로부터 수신한 DRS를 기반으로 측정(measurement)를 수행하고, 기지국(또는 네트워크)에게 측정 보고(measurement report)를 전송한다. 이와 같이, 단말로 하여금 스몰 셀이 on/off-state인지 무관하게 항상 스몰셀에서 전송되는 DRS를 측정하여 기지국(또는 네트워크)에게 보고하도록 함으로써, 기지국(네트워크)은 해당 단말 주변에 가장 효율이 좋은 스몰 셀을 파악할 수 있다. 예를 들어, 기지국(네트워크)이 UE로부터 측정 결과를 보고 받은 결과, off-state인 스몰 셀이나 단말에서의 DRS 수신 파워가 큰 경우에 기지국은 해당 스몰 셀을 on-state로 전환시킬 수 있다.

[455] 그러나 이 경우도 마찬가지로, 우선 UE가 특정 서빙 셀에 종래 방식대로 어태치(attach)된 후 RRC-connected 상태에서 DMTC 등 스몰 셀 디스커버리 관련 설정 정보를 RRC 시그널링을 통해 수신한 후, (프리코딩된(precoded)) DRS들(각각이 별도의 FD-MIMO 빔 방향을 타겟하거나, 또는 서로 다른 무정형 셀을 구성하는 TP들로부터 전송됨)에 대한 다수개의 CSI-RS-RSRP 보고(즉, DRS 기반 RSRP 보고)를 수행하여야 하며, 이것들에 기반하여 기지국이 해당 단말이 CRS 기반 RSRP 관점에서는 최적(best)이 아니지만 FD-MIMO 또는 무정형 셀 관점에서 최적의 셀이 따로 있다면 해당 셀로 핸드오버 시켜야 한다. 결국, 이 방식도 마찬가지로, 최적의 셀(best cell)로 연관(association)되기까지 (예를 들어, RRC-connection → DMTC 관련 RRC 정보 수신 → 장기(long-term) DRS-CSI-RS 측정 및 보고 → 핸드오버 절차의 과정을 모두 거쳐야 하는 단말이 있을 수 있으므로) 지연이 크게 증가할 수 있다는 한계가 있다.

[456] 따라서, 본 발명에서는 상기 FD-MIMO 또는 무정형 셀(amorphous cell) 환경 등과 같이, 종래의 셀 특정(cell-specific)하게 전송되는 RS(예를 들어, CRS)와 다른 별도의 RS(예를 들어, RRM 측정을 위한 RS, 셀 선택/재선택을 위한 RS) 포트를 활용하여 특정 RRM 측정(예를 들어, RSRP, RSRQ 등)을 단말이 수행하는 방법 및/또는 RRM 측정치들을 기반으로 단말이 초기 접속 시 등의 RRC 아이들 모드(idle-mode)(예를 들어, RRC_IDLE) 상태에서도 자신이 설정 받을 최적의 전송 모드를 미리 고려하여 최적의 셀을 선택(selection) 또는 재선택(reselection)하는 방법 및/또는 선택된 최적의 셀로 초기 접속(initial access) 과정을 개시하는 방법을 제안한다. 또한, 단말은 본 발명에서 제안하는 방법들을 순차적으로 수행함으로써 단말의 초기 접속(initial access) 과정을 수행할 수 있다.

[457] 이하, 본 발명의 설명함에 있어서, RRM-RS는 앞서 설명한 바와 같이 FD-MIMO와 같이 날카로운 빔(sharp beam)을 통해 지역적으로 방향을 다르게 전송되는 RS, 지리적으로 분산되어 배치된 TP(또는 cell) 별로 서로 다른 안테나 포트를 통해 전송되는 RS, 그 외에도 셀 특정 참조 신호(CRS)와 다른 별도의 RRM 측정 및 보고를 위한 RS(예를 들어, CSI-RS, DRS 등)를 통칭한다.

[458]

[459] 1. 단말의 초기 셀 탐색 과정

[460] - 본 발명에 따른 초기 접속(initial access) 과정의 첫 번째 과정으로서 단말의 초기 셀 탐색 과정이 수행될 수 있다.

[461] 단말의 초기 셀 탐색(initial cell search) 과정에서, 단말은 종래와 동일하게 각 셀이 전송하는 1차 동기신호(PSS: Primary Synchronization Signal) 및 2차 동기신호(SSS: Secondary Synchronization Signal) 등의 특정 동기 신호를 검출함으로써 해당 셀이 사용하고 있는 물리 셀 식별자(PCI: physical (layer) cell-ID)를 획득할 수 있다.

[462] PSS와 SSS의 특정 시퀀스에 의하여 단말은 PCI를 획득할 수 있다. 즉, SS는 3개의 PSS와 168개의 SSS의 조합을 통해 총 504개의 고유한 PCI를 나타낼 수 있다.

[463] 다시 말해, 상기 PCI들은 각 PCI가 오직 하나의 PCI 그룹의 부분이 되도록 각 그룹이 3개의 고유한 식별자들을 포함하는 168개의 PCI 그룹들로 그룹핑된다. 따라서, 물리 계층 셀 식별자 N_ID^cell = 3N_ID^(1) + N_ID^(2)는 PCI 그룹을 나타내는 0부터 167까지의 범위 내 번호 N_ID^(1)와 상기 PCI 그룹 내 상기 PCI를 나타내는 0부터 2까지의 번호 N_ID^(2)에 의해 고유하게 정의된다.

[464] 단말은 PSS를 검출하여 특정 PCI 그룹 내 3개의 고유한 PCI 중 하나를 알 수 있고, SSS를 검출하여 상기 PCI에 연관된 168개의 PCI 그룹들 중 하나를 식별할 수 있다.

[465] 그리고, 단말은 검출된 해당 PCI를 사용하여, 전송되는 해당 셀의 CRS를 검출 시도함으로써, 셀 ID(cell-ID)의 검증(verification)을 수행할 수 있다.

[466]

[467] 2. 탐색된 셀에서 시스템 정보 획득 과정

[468] 단말은 셀이 전송하는 예를 들어, PBCH(Physical Broadcast Channel), PDSCH(Physical Downlink Shared Channel) 등을 읽어서 해당 채널 상에서 전달되는 각종 시스템 정보(system information)를 획득한다.

[469] 시스템 정보(system information)는 마스터 정보 블록(MIB: Master Information Block)과 복수의 시스템 정보 블록(SIB: System Information Block)으로 나뉠 수 있다. 이하, SIB 타입 x(SystemInformationBlockTypex)를 간단히 'SIB x'로 지칭한다.

[470] 단말은 네트워크에 의해 브로드캐스트되는 시스템 정보를 획득하기 위하여 시스템 정보 획득 절차를 이용한다. 시스템 정보 획득 절차는 RRC_IDLE 모드인 단말 및 RRC_CONNECTED 모드인 단말 모두에게 적용된다. 예를 들어, 셀 선택(예를 들어, 단말 전원이 켜질 때) 및 셀 재선택, 핸드오버 완료 후, 다른 무선 접속 기술(RAT: Radio Access Technology)에 진입할 때, 커버리지 밖에서 커버리지 내로 진입할 때, 시스템 정보가 변경되었다는 통지를 수신하였을 때, 최대 유효 지속 기간(maximum validity duration)을 경과하였을 때 등 단말은 시스템 정보 획득 절차를 개시할 수 있다.

[471] 먼저, 단말은 네트워크로부터 MIB를 수신한다. 이때, MIB는 물리 채널(physical channel) PBCH에서 전송된다. MIB는 시스템 프레임 번호(SFN: System Frame Number) mod 4 = 0 인 무선 프레임의 서브프레임 #0에서 스케줄되고, 해당 주기 내에서 다른 모든 무선 프레임의 서브프레임 #0에서 반복된다. 그리고, 무선 프레임의 서브프레임 #0의 두 번째 슬롯의 처음 4개의 OFDM 심볼 내에서 중심의 72 서브캐리어를 점유한다.

[472] 단말은 MIB로부터 수신한 파라미터를 사용하여 네트워크로부터 SIB 1을 수신한다. 그리고, 단말은 SIB 1으로부터 획득한 스케줄링 정보 리스트(schedulingInfoList)를 기반으로, 네트워크로부터 SIB 1 이외의 SIB x를 수신한다.

[473] SIB 1은 SFN mod 8 = 0 인 무선 프레임의 서브프레임 #5에서 스케줄되고, 80 ms 주기 내에서 SFN mod 2 = 0 인 다른 모든 무선 프레임의 서브프레임 #5에서 반복된다. 반면, SIB 1을 제외한 나머지 SIB는 동일한 전송 주기를 가지는 SIB 별로 시스템 정보(SI: System Information) 메시지에 매핑되어 전송된다.

[474] 모든 SIB는 물리 채널 PDSCH에서 전달된다. SIB을 위한 PDCCH는 SI-RNTI(system information-RNTI)에 의해 스크램블된 CRC가 부착된 DCI를 전달하고, PDCCH로부터 SIB를 전달하는 PDSCH가 식별된다.

[475] 단말은 PDCCH 상의 SI-RNTI를 디코딩함으로써 SI 메시지를 전달하는 PDSCH의 구체적인 시간/주파수 자원 영역 스케줄링 등을 획득할 수 있다. 하나의 SI-RNTI가 SIB 1뿐만 아니라 모든 SI 메시지를 어드레스하기 위하여 사용된다.

[476] 단말은 시스템 정보 획득 절차를 통해 획득한 시스템 정보를 이미 저장되어 있는 시스템 정보에 덮어쓸 수 있다(overwrite).

[477] 이하, 본 발명에서는 MIB 또는 특정 SIB X 등 시스템 정보에 다음과 같은 RRM-RS 설정 관련 정보 중 적어도 하나가 포함되어 단말에게 전송하는 방법을 제안한다. 이에 대하여 아래 도면을 참조하여 설명한다.

[478] 도 15는 본 발명의 일 실시예에 따른 RRM-RS 기반 셀 선택 방법을 예시하는 도면이다.

[479] 도 15를 참조하면, 기지국은 단말에게 RRM-RS 설정 정보를 포함하는 시스템 정보를 전송한다(S1501).

[480] 상술한 바와 같이 이하 RRM-RS는 설명의 편의상 부여된 명칭일 뿐, CSI-RS 등과 동일 혹은 유사한 포맷으로 설정될 수 있는 등 다양한 명칭/변형 형태로 정의될 수 있다.

[481] - PCI (및/또는 인접 셀(neighbor-cell) 리스트)를 수반한 RRM-RS 설정(RRM-RS configurations with PCI)

[482] 해당 셀에서 전송하는 RRM-RS 설정 정보뿐만 아니라 인접 셀들에서 전송하는 RRM-RS 설정 정보도 함께 시스템 정보로서 단말에게 제공될 수 있다. 즉, 특정 RRM-RS 설정(들)은 특정 PCI와 연동(또는 대응)되어 있고 이 연동 정보가 함께 제공될 수 있다. 이때, 하나의 PCI 당 하나 이상의 RRM-RS가 연동(또는 대응)될 수 있다.

[483] 여기서, 인접 셀(neighbor-cell) 리스트는 인접-셀의 PCI 리스트를 포함한다. 일례로, 인접 셀의 일례로 해당 셀 주변의 1-타이어(tier) 정도의 영역에 존재하는 eNB 위치(site)에 속하는 셀들이 대상이 될 수 있다.

[484] 이러한 RRM-RS 설정 정보를 통해, 단말은 시스템 정보를 읽음으로써 해당 셀이 전송하는 RRM-RS 안테나 포트 뿐만 아니라 주변의 셀들이 전송하는 RRM-RS 안테나 포트에 대한 정보도 함께 획득할 수 있으므로 인접 셀들을 포함하여 최상의 RRM 측정치를 찾는 과정에 도움이 될 수 있다.

[485] 또한, 단말은 이와 같이 제공된 상기 RRM-RS 별로 연동된 특정 PCI 정보를 통해, 해당 RRM-RS 포트와 해당 연동된 PCI로 생성되는 CRS 포트 간에 서로 QCL(quasi-co-location) 가정을 할 수 있다. 이때, QCL 가정이 가능한 무선 채널의 광범위 특성(large-scale properties)은 {도플러 쉬프트(Doppler shift), 도플러 확산(Doppler spread), 평균 지연(average delay), 지연 확산(delay spread), 평균 이득(average gain)} 중에 적어도 하나를 포함할 수 있다.

[486] 또는, 평균 이득(average gain)은 RS가 서로 다르므로 QCL 가정에서 제외하고, QCL 가정이 가능한 무선 채널의 광범위 특성(large-scale properties)은 {도플러 쉬프트(Doppler shift), 도플러 확산(Doppler spread), 평균 지연(average delay), 지연 확산(delay spread)} 중에 적어도 하나를 포함하도록 정의될 수 있다).

[487] 보다 특징적으로 QCL 가정이 가능한 무선 채널의 광범위 특성은 {도플러 쉬프트(Doppler shift), 도플러 확산(Doppler spread)}로만 제한되어, 단말이 해당

RRM-RS의 주파수 동기(frequency sync)를 해당 연동된 CRS를 통해 획득하도록 할 수 있다. 이 경우, 단말은 시간 동기(time sync)를 RRM-RS 자체적으로 획득할 수 있다고 간주할 수 있다.

[488] 또는, 오직 단말이 RRM-RS로 RRM 측정만을 수행한다고 정의되거나 또는 설정된다면, QCL 가정이 가능한 무선 채널의 광범위 특성은 {도플러 쉬프트(Doppler shift)}만 적용할 수도 있다.

[489] 또는, 단말이 시간 동기(time sync)를 획득하기 위하여 CRS의 도움을 받아야 하고, 또한 RRM-RS로 RRM 측정 목적만이 있다면, QCL 가정이 가능한 무선 채널의 광범위 특성은 {도플러 쉬프트(Doppler shift), 평균 지연(average delay)}을 포함할 수 있으며, RRM-RS의 복조에 CRS를 통해 획득된 동기를 적용할 수 있도록 한다.

[490] 앞서 RRM-RS의 QCL 가정에 관하여 설명된 문장에서, CRS 대신 "PSS 및/또는 SSS"가 대체되어 모든 문장 또는 일부 문장에 적용될 수도 있다. 다시 말해, RRM-RS 복조에 CRS로부터 획득된 주파수 및/또는 시간 동기를 적용할 수 있으며, 그리고/또는 (해당 PCI로 (함께) 연동된) PSS/SSS로부터 획득된 주파수 및/또는 시간 동기를 적용할 수도 있다. 즉, 해당 PCI로 연동된 상기 특정 {RRM-RS, CRS, PSS/SSS} 간에 전체 또는 일부에 대해 서로 QCL 가정이 성립함을 단말에게 설정하거나 사전에 정의될 수 있다.

[491] - RRM-RS 설정 당 RRM-RS 안테나 포트 수 정보, RRM-RS 안테나 포트 매핑 정보, 해당 RRM-RS 전송 주기/오프셋 관련 정보 및/또는 전송 (주파수/시간) 자원 관련 정보 등과 같은 단말이 해당 RRM-RS를 측정하기 위해 필요한 설정 정보들이 제공된다.

[492] 즉, 상술한 바와 같이, 하나의 PCI(즉, 셀) 당 하나 이상의 RRM-RS 설정이 연동(또는 대응)될 수 있으며, 하나의 RRM-RS 설정 당 해당 RRM-RS를 측정하기 위해 필요한 설정 정보들이 제공된다.

[493] 만일, 이러한 RRM-RS가 스몰 셀 디스커버리(discovery)에서의 DRS(또는 DRS-CSI-RS)를 재사용하는 형태 등으로 구성된다면, DMTC 등 DRS로서의 CSI-RS를 측정하기 위해 필요한 설정 정보도 해당 시스템 정보에 더 포함되어 전달될 수 있다.

[494] 위와 같은 형태로, 해당 RRM-RS 관련 설정 정보가 명시적인 시그널링(explicit signaling)될 수도 있지만, 앞서 설명한 "1. 단말의 초기 셀 탐색 과정"에서 검출된 해당 PCI에 연동되는 암묵적인 지시(implicit indication) 형태로 상술한 RRM-RS 관련 설정 정보 중 일부가 암묵적으로 제공되는 방식도 가능하다. 즉, 상기 시스템 정보는 RRM-RS 관련 설정 정보로서 PCI를 포함하지 않을 수 있으며, 단말은 시스템 정보에 포함된 RRM-RS 설정 정보를 초기 셀 탐색 과정에서 검출된 PCI와 연동(또는 대응)되는 RRM-RS 설정 정보로 판단(또는 간주)할 수 있다.

[495] 예를 들어, 상기 전송 (주파수/시간) 자원 관련 정보는 PCI에 따라 특정 참조

자원(reference resource) 위치가 사전에 고정적으로 정의되어 있을 수 있다. 물론, RRM-RS 안테나 포트 수 정보, RRM-RS 안테나 포트 매핑 정보, 해당 RRM-RS 전송 주기/오프셋 관련 정보 중 하나 이상도 해당 PCI에 따라 암묵적 매핑(즉, 고정)되어 있을 수도 있다.

[496] 그러나, RRM-RS 안테나 포트 수나 RRM-RS 전송 주기/오프셋 관련 정보는 상기 설명한 시스템 정보로서 개별적인 셀 별(즉, PCI 별)로 제공하는 것이 바람직할 수 있다. 이 경우, 예를 들어 32개의 안테나 포트 RRM-RS가 40ms 주기와 오프셋 5ms에 따라 전송된다는 설정 정보가 상기 시스템 정보로서 제공되었다면, 상기 "참조 자원(reference resource)" 위치는 특정 서브프레임 내에서의 특정 참조 RE 위치를 의미하는 형태로 사전에 정의될 수 있다. 즉, PCI에 의해 고정적으로 정의되어 있는 상기 참조 RE 위치를 시작점으로 하여 32개의 안테나 포트가 순차적으로 매핑되는 관계는 사전에 규칙이 정의될 수 있으며, 따라서 해당 참조 RE 위치로부터 32개의 안테나 포트에 대한 RS 매핑 위치가 모두 정해지게 된다. 이때, 만일 1-순환(cycle)의 RRM-RS 전송이 단일 서브프레임에서 모두 전송될 수 없고 다중 서브프레임에 걸쳐서 전송되는 형태라면, 그 중 첫 서브프레임에 상기 참조 RE 위치가 적용되는 것으로 정의될 수 있다.

[497] RRM-RS 설정 정보를 수신한 단말은 RRM-RS 설정 정보에 기초하여 RRM 측정을 수행하게 된다. 즉, 단말은 RRM-RS 설정 정보에 기초하여 RACH(즉, PRACH)를 전송하기 이전(즉, 랜덤 액세스 절차를 개시하기 전)에 다중 RRM-RS 포트에 대한 RRM 측정을 수행할 수 있다.

[498]

[499] 3. RRM-RS 등 기반 진보된(enhanced) RRM 측정의 수행에 따른 단말 관점에서의 선호 셀 결정

[500] 도 16은 본 발명의 일 실시예에 따른 RRM 측정 방법을 예시하는 도면이다.

[501] 도 16을 참조하면, 단말은 기지국으로부터 전송되는 셀 특정 참조 신호(CRS) 및/또는 RRM 참조 신호(RRM-RS)를 기반으로 RRM(예를 들어, RSRP, RSRQ 등)을 측정한다(S1601).

[502] 단말은 CRS 기반 RRM 측정값 및/또는 RRM-RS 기반 RRM 측정값을 기반으로 셀 선택한다(S1602).

[503] 단말은 초기 셀 탐색(initial cell search) 과정을 통해 탐색된 셀 또는 단말의 서빙 셀(또는 단말이 현재 캠핑(camping)하는 셀), 단말에 의해 탐색된 셀에 인접한 셀 또는 단말의 서빙 셀에 인접한 셀 중에서 CRS 기반 RRM 측정 값 및/또는 RRM-RS 기반 RRM 측정값을 기반으로 셀을 (재)선택한다. 이후, RRC_IDLE 단말의 경우 (재)선택된 셀로 초기 접속(initial access) 과정을 수행하거나 해당 셀에 캠핑(camping)한다. 또한, RRC_CONNECTED 단말의 경우 (재)선택된 셀로 핸드오버(handover) 과정을 수행할 수 있다.

[504] 보다 구체적으로 살펴보면, 앞서 설명된 RRM-RS 관련 설정 정보들을 토대로,

단말은 다중 RRM-RS 포트에 대한 별도의 RRM 측정을 수행한다. 상술한 바와 같이, 이러한 RRM 측정은 단일 타겟 셀에 국한된 것이 아닌 인접 후보 셀들이 전송하는 RRM-RS들도 포함하여 수행될 수 있다.

[505] 예를 들어, 단말은 셀 1(PCI 1) 및 셀 2(PCI 2)에서 전송하는 RRM-RS 세트 1 및 RRM-RS 세트 2에 대해 RRM-RS 기반 RRM 측정을 수행한 후, 각 세트 별로 최상의(best) RRM(예를 들어, RSRP, RSRQ 등) 측정치를 나타낸 RRM-RS 포트를 파악한다.

[506] 그리고, 단말은 이 중 가장 큰 RRM-RS 기반 RRM 값(즉, 최상의(best) 값)을 나타내는 RRM-RS를 전송한 셀로 초기 접속 (예를 들어, RACH 프리앰블(preamble) 전송에 의한 RACH 절차)를 개시할 수 있다. 즉, 단말은 해당 셀로 RACH 프리앰블을 송신함으로써 랜덤 액세스 절차(즉, RACH 절차)를 시작할 수 있다. 또는, RRC_IDLE 단말은 가장 큰 RRM-RS 기반 RRM 값(즉, 최상의(best) 값)을 나타내는 RRM-RS를 전송한 셀을 선택(selection)하거나 재선택(reselection)하여 해당 셀에서 캠핑(camping)할 수 있다. 또한, RRC_CONNECTED 단말은 가장 큰 RRM-RS 기반 RRM 값(즉, 최상의(best) 값)을 나타내는 RRM-RS를 전송한 셀로 핸드오버(handover)를 진행할 수 있다.

[507] RRC_IDLE 상태의 단말은 항상 적절한 품질의 셀을 선택하여 이 셀을 통해 서비스를 제공받기 위한 준비를 하고 있어야 한다. 예를 들어, 전원이 막 켜진 단말은 네트워크에 등록을 하기 위해 적절한 품질의 셀을 선택해야 한다. RRC_CONNECTED 상태에 있던 단말이 RRC_IDLE 상태에 진입하면, 상기 단말은 RRC_IDLE 상태에서 머무를 셀을 선택해야 한다. 이와 같이, 상기 단말이 RRC_IDLE 상태와 같은 서비스 대기 상태로 머물고 있기 위해서 어떤 조건을 만족하는 셀을 고르는 과정을 셀 선택(Cell Selection)이라고 한다.

[508] 그리고, 단말이 일단 셀 선택 과정을 통해 어떤 셀을 선택한 이후, 단말의 이동성 또는 무선 환경의 변화 등으로 단말과 기지국간의 신호의 세기나 품질이 바뀔 수 있다. 따라서 만약 선택한 셀의 품질이 저하되는 경우, 단말은 더 좋은 품질을 제공하는 다른 셀을 선택할 수 있다. 이렇게 셀을 다시 선택하는 경우, 일반적으로 현재 선택된 셀보다 더 좋은 신호 품질을 제공하는 셀을 선택한다. 이런 과정을 셀 재선택(Cell Reselection)이라고 한다.

[509] 이하, 설명의 편의를 위해 (초기 접속) 타겟 셀로 선택한다는 것은 단말이 RACH 절차를 개시하기 위한 셀을 선택하거나, 또는 RRC_IDLE 단말이 캠핑 셀(camping cell)을 선택 또는 재선택하거나, 또는 RRC_CONNECTED 단말이 핸드오버를 수행할 타겟 셀을 선택한다는 의미로 해석될 수 있다.

[510] 또는, 최상의(best) RRM-RS 기반 RRM 측정치를 보인 특정 RRM-RS를 전송한 셀로 RACH 프리앰블을 전송(즉, 랜덤 액세스 절차 개시)하는 방법 뿐만 아니라, RRM-RS 기반 RRM 측정치와 해당 셀이 전송하는 CRS 기반 RRM(CRS-based RRM) 측정 값도 함께 비교하여 최적의 초기 접속 타겟 셀을 결정하는 특정 함수(또는 규칙) 형태가 사전에 정의되거나 단말에 설정될 수 있다.

[511] 예를 들어, 최상의(best) RRM-RS 기반 RRM 측정치를 보인 특정 RRM-RS를 전송한 셀의 CRS 기반 RRM 측정값이, 다른 셀로부터의 CRS 기반 RRM 측정값(예를 들어, 가장 큰 CRS 기반 RRM 측정 값) 대비 임계값(즉, Y dB) 차이보다도 더 나쁜(작은) 경우에는 해당 셀은 타겟 셀이 될 수 없다는 등의 조건(또는 규칙)과 함께 특정 임계치 값 Y가 정의될 수도 있다. 이처럼 최상의(best) RRM-RS 기반 RRM 측정치를 보인 특정 RRM-RS를 전송한 셀이 타겟 셀에서 제외되는 경우, 단말은 그 다음으로 큰 큰 RRM-RS 기반 RRM 측정치를 가지는 셀을 선택할 수 있다. 이는 해당 셀의 기본적인 제어 채널(예를 들어, PDCCH) 전송에 대한 수신 품질이 지나치게 떨어질 경우 이 셀에 접속하는 것을 방지하기 위한 것이다.

[512] 또 다른 예시로는, 단말은 RRM-RS 기반 RRM(RRM-RS-based RRM) 측정치와 해당 셀이 전송하는 CRS 기반 RRM 측정치간에 특정 가중된 평균(weighted average)을 취하여 최적의(best) 타겟 셀을 결정할 수도 있다. 즉, 단말은 RRM-RS 기반 RRM 측정 값과 CRS 기반 RRM 측정 값의 가중 평균치가 가장 큰 셀을 타겟 셀로 선택할 수 있다.

[513] 이때, 가중된 평균(weighted average)에 관한 가중치(weights) 값은 사전에 정의될 수 있다. 또한, 가중치(weights) 값은 어느 정도 단말 구현의 범주로 허용하되 단말 테스트 시에 특정 테스트 벡터에 의해 성능에 대한 검증이 수행될 수 있다.

[514] 또 다른 예시로는, 각 검출된 셀 별로의 CRS 기반 RRM 측정치들을 크기 순서대로 나열했을 때, 예를 들어 가장 큰 측정치 값이 C1 (예를 들어, PCI 7에 대한)이고 그 다음 C2(예를 들어, PCI 9에 대한), C3(예를 들어, PCI 6에 대한), C4(예를 들어, PCI 5에 대한), ... 순서로 정렬되었을 때, C1-C4 > Y 로서 임계치 Y를 넘어가는 C4 이하의 RRM 측정치 값들은 타겟 셀 대상에서 제외할 수 있다. 즉, 가장 큰 CRS 기반 RRM 측정치와의 차이가 임계치 이하(또는 미만)인 셀을 타겟 셀 후보로 결정할 수 있다. 따라서, 위의 경우 C1, C2, C3의 CRS 기반 RRM 측정치에 해당하는 각 셀 (PCI 7, PCI 9, 또는 PCI 6를 가지는 셀)이 타겟 셀 후보로 고려될 수 있다. 그리고, 단말은 타겟 셀 후보 중에서 RRM-RS 기반 RRM 측정 값이 가장 큰 셀을 타겟 셀로 선택할 수 있다.

[515] 만약, 종래 동작에 따르면 단말은 C1값을 갖는 PCI 7 셀에 초기 접속을 개시하는 것이 바람직하다. 다만, 본 발명의 또 다른 실시예에 따르면 각 C1, C2, C3 값 각각에 대해 추가적으로 각 셀에서 전송하는 RRM-RS들 중에 최상의(best) RRM-RS 기반 RRM 측정치를 산출하여 추가 비교할 수 있다.

[516] 예를 들어, C1값을 나타낸 PCI 7 셀에서 전송하는 RRM-RS들 중에 최상의(best) RRM 측정치 값을 R1이라고 하고, C2값을 나타낸 PCI 9 셀에서 전송하는 RRM-RS들 중에 최상의(best) RRM 측정치 값을 R2이라고 하고, C3값을 나타낸 PCI 6 셀에서 전송하는 RRM-RS들 중에 최상의(best) RRM 측정치 값을 R3이라고 가정한다. 그리고, R2 = max{R1, R2, R3}라고 가정하고, 크기 순서로

정렬하자면 R2 > R3 > R1이었다고 가정한다.

[517] 이때, 결국 어떠한 셀에 초기 접속을 개시하도록 할 것인지에 관해 정형화된 규칙이 미리 정해지거나 단말에 설정될 수 있다.

[518] 이를 위해 사전에 상기 임계치 Y를 좀더 세분화 하여 0 < Y1 < Y2 < ... < Yn < Y 과 같은 형태로 세분화된 임계치가 사전에 정의되거나 단말에 설정될 수 있다. 예를 들어, 설명의 편의상 n=3으로 가정한다. 그러면, 0 < Y1 < Y2 < Y3 < Y 의 조건이 성립하는 세분화된 임계치 Y1, Y2, Y3가 미리 정의되거나 단말에 설정될 수 있다.

[519] 또한, 유사하게 상기 R1, R2, R3 값들에 대한 비교를 위해서도 사전에 0 < Z1 < Z2 < ... < Zm < Z 의 임계치 값들이 미리 정의되거나 단말에 설정될 수 있다. 예를 들어, 설명의 편의상 m=3으로 가정한다. 그러면, 0 < Z1 < Z2 < Z3 < Z 의 조건이 성립하는 세분화된 임계치 Z1, Z2, Z3가 미리 정의되거나 단말에 설정될 수 있다.

[520] 예를 들어 다음과 같은 형태의 규칙이 충족될 경우에만 상기 최상의(best) CRS 기반 RRM 측정치 C1을 나타낸 PCI7 셀이 아닌 다른 셀로 초기 접속을 개시할 수 있도록 하는 특정 명확한 동작이 정의될 수 있다.

[521] 이하, 상술한 규칙에 대하여 예시한다.

[522] (1) 특정 셀 i에 대한 Ci가 Y3 ≤ C1-Ci < Y 범위에 있는 경우, 해당 셀 i에 대한 Ri가 0 ≤ max_j{Rj} - Ri < Z1 인 경우에만 해당 셀 i를 초기 접속 타겟 셀로 선택할 수 있다.

[523] (2) 특정 셀 i에 대한 Ci가 Y2 ≤ C1-Ci < Y3 범위에 있는 경우, 해당 셀 i에 대한 Ri가 0 ≤ max_j{Rj} - Ri < Z2 인 경우에만 해당 셀 i를 초기 접속 타겟 셀로 선택할 수 있다.

[524] (3) 특정 셀 i에 대한 Ci가 Y1 ≤ C1-Ci < Y2 범위에 있는 경우, 해당 셀 i에 대한 Ri가 0 ≤ max_j{Rj} - Ri < Z3 인 경우에만 해당 셀 i를 초기 접속 타겟 셀로 선택할 수 있다.

[525] (4) 특정 셀 i에 대한 Ci가 0 ≤ C1-Ci < Y1 범위에 있는 경우, 해당 셀 i에 대한 Ri가 0 ≤ max_j{Rj} - Ri < Z 인 경우에만 해당 셀 i를 초기 접속 타겟 셀로 선택할 수 있다.

[526] 위의 수식을 살펴보면, 최상의 CRS 기반 RRM 측정값과 측정 대상 셀에 대한 CRS 기반 RRM 측정값의 차이와, 최상의 RRM-RS 기반 RRM 측정값과 측정 대상 셀의 최상의 RRM-RS 기반 측정값의 차이를 기반으로 초기 접속 타겟 셀이 선택될 수 있다. 다시 말해, 가장 큰 CRS 기반 RRM 측정 값과 특정 셀의 CRS 기반 RRM 측정 값의 차이가 상대적으로 크다면, 가장 큰 RRM-RS 기반 RRM 측정 값과 해당 특정 셀의 RRM-RS 기반 RRM 측정 값의 차이가 상대적으로 작은 경우에만 해당 특정 셀을 타겟 셀로 선택할 수 있다. 반대로, 가장 큰 CRS 기반 RRM 측정 값과 특정 셀의 CRS 기반 RRM 측정 값의 차이가 상대적으로 작다면, 가장 큰 RRM-RS 기반 RRM 측정 값과 해당 특정 셀의 RRM-RS 기반 RRM 측정 값의 차이가 상대적으로 크더라도 해당 특정 셀을 타겟 셀로 선택할

수 있다. 결국, 단말은 CRS 기반 RRM 측정 값과 RRM-RS 기반 RRM 측정 값 중 어느 하나라도 양호한 셀을 타겟 셀로 선택할 수 있다.

[527] 만일 상기 (1), (2), (3), (4) 조건들 중 다수가 충족되는 상황에서는, 그 중에서 가장 높은 Ri 값을 나타내는 셀을 초기 접속의 타겟 셀로 결정하여 RACH 프리앰블을 송신할 수 있다. 또한, RRC_IDLE 단말의 가장 높은 Ri 값을 나타내는 셀을 선택(selection)하거나 재선택(reselection)할 수 있다.

[528] 위 규칙은 하나의 예시에 불과하며, 본 발명이 이에 한정되는 것은 아니다. 즉, 이와 같이 CRS 기반 RRM 값(즉, C1, C2, C3,...)들과 RRM-RS 기반 RRM(즉, R1, R2, R3,...)들을 동시에 고려하여 초기 접속 타겟 셀을 결정하도록 하는 구체적인 조건 수식은 변형될 수 있다.

[529] 앞서 설명한 바와 같이, CRS 기반 RRM 측정치를 함께 고려하여 최적의(best) 타겟 셀을 정하지 않고, 오직 상기 RRM-RS 기반 RRM 측정치에 입각하여 최적의(best) 타겟 셀을 정하여 초기 접속을 개시하도록 하는 경우에는, 이후에 공통의 제어 채널(common control channel) 등 제어 채널의 경우 곧바로 단말 특정(UE-dedicated) 제어 채널 (예를 들어, EPDCCH)을 통해서만 제어가 이루어질 수 있는 시스템(예를 들어, CRS 및 PDCCH가 존재하지 않는 새로운 캐리어 타입(NCT: new-carrier type) 시스템)에서 활용될 수 있다.

[530] 이 경우, 상기 SIB X 등 시스템 정보에 (또는 RACH 절차 상의 초기에) EPDCCH 설정 관련 정보도 미리 단말들에게 알려 줄 수 있다. 예를 들어, 상기 시스템 정보를 통해 단말에게 분산 EPCCH(distributed EPDCCH) 관련 설정 정보만 우선 제공될 수 있다. 그 후에, 단말이 특정 RRM-RS가 최상의(best) RRM 측정치를 보이는 것으로 보고가 된다면, 이를 바탕으로 기지국이 해당 단말에게 보다 최적화된 지역 EPDCCH(localized EPDCCH) 관련 설정 정보를 제공하고 지역 EPDCCH(localized EPDCCH)에 의한 제어 정보가 전달되도록 할 수 있다.

[531]

[532] 4. RACH 절차 상에서의 추가 개선 동작

[533] 도 17은 본 발명의 일 실시예에 따른 랜덤 액세스 절차를 예시하는 도면이다.

[534] 이하, 설명의 편의를 위해 본 발명의 일 실시예에 따른 랜덤 액세스 절차는 앞서 도 8에 따른 랜덤 액세스 절차와 비교하여 차이가 있는 부분을 위주로 설명하며, 이하 설명되지 않은 내용은 앞서 도 8에 따른 랜덤 액세스 절차로 대체될 수 있다.

[535] 1) 1 단계 (단말의 RACH 프리앰블 송신)

[536] 단말은 RACH 프리앰블을 전송하는 타겟 셀은 앞서 설명한 "3. RRM-RS 등 기반 진보된(enhanced) RRM 측정의 수행에 따른 단말 관점에서의 선호 셀 결정"에서 설명한 방법들 중 적어도 어느 하나를 적용하여 결정하고, 해당 타겟 셀로 RACH 프리앰블(즉, 제1 메시지)을 송신한다(S1701).

[537] 이때, RRM 측정 값(예를 들어, RRM-RS 기반 RRM 측정 값 및/또는 CRS 기반 RRM 측정 값)을 RACH 절차 내에서 보고하는 단말은 그렇지 않은

레가시(legacy) 단말과 구분될 수 있도록, 레가시(legacy) 단말과 다른 RACH 프리앰블 집합에서 RACH 프리앰블을 선택할 수 있다. 이에 따라 기지국은 단말로부터 수신한 RACH 프리앰블이 속한 RACH 프리앰블 집합에 따라 해당 단말이 RACH 절차 내에서 RRM 측정 값을 보고하는 단말인지 여부를 판단할 수 있다. 이처럼 RACH 절차 내에서 RRM 측정 값을 보고하는 단말과 레가시(legacy) 단말이 서로 다른 RACH 프리앰블 집합을 이용하는 경우, 기지국은 시스템 정보에서 RACH 프리앰블 집합 정보를 전송할 수도 있다. 예를 들어, 앞서 도 15의 S1501 단계에서 RRM-RS 기반 RRM 측정을 수행한 단말 및/또는 레가시(legacy) 단말을 위한 RACH 프리앰블 집합 정보를 전송할 수 있다.

[538] 2) 2 단계 (기지국으로부터의 랜덤 액세스 응답(RAR: random access response) 수신)

[539] 기지국은 제2 메시지(message 2)(즉, RAR)를 통해 해당 단말이 전송한 RACH 프리앰블에 대한 응답을 전송한다(S1702).

[540] 현재 단계에서 기지국은 해당 단말이 상기 FD-MIMO 등을 지원할 수 있는 진보된(enhanced) 단말(즉, RRM-RS 기반 RRM 측정을 수행한 단말)에 대한 정보들을 알지 못하므로 레가시(legacy) 단말에 대한 동일한 형태의 제2 메시지(message 2) 응답을 제공할 수 있다.

[541] 또는, 상술한 바와 같이, RACH 절차 내에서 RRM 측정 값을 전송하는 단말과 레가시 단말이 서로 다른 RACH 프리앰블 집합에서 RACH 프리앰블을 선택하는 경우, RACH 절차 내에서 RRM 측정 값을 전송하는 단말과 레가시 단말에게 전송되는 제2 메시지는 서로 다른 포맷을 가질 수 있다. 예를 들어, 이와 같이 제2 메시지의 포맷이 구분되는 경우, RACH 절차 내에서 RRM 측정 값을 전송하는 단말에게 전송되는 제2 메시지에서만 후술하는 임계치 Z 값을 포함할 수 있다. 또한, 기지국은 RACH 절차 내에서 RRM 측정 값을 전송하는 단말에게는, 해당 단말이 후술하는 RRM 측정치를 포함하는 제3 메시지의 전송하는 점을 고려하여 시간/주파수 자원을 할당할 수 있다.

[542] 3 단계 (단말의 L2(layer 2)/L3(layer 3) 메시지 전송)

[543] 단말은 S1702 단계에서 기지국으로부터 수신한 RAR에 대한 응답으로 PUSCH를 통해 상향링크 메시지(즉, 제3 메시지(message 3))를 전송한다(S1703).

[544] 이때, S1702 단계에서 기지국으로부터 RAR을 통해 제공받은 (임시(temporal)) C-RNTI를 통해 PUSCH를 전송할 수 있다.

[545] 본 발명의 일 실시예에 따르면, 단말은 참조 신호 기반으로 측정된 RRM 측정치 값을 제3 메시지를 통해 기지국에 보고할 수 있다. 이때, RRM 측정 값은 앞서 설명한 RRM-RS 기반 측정치들이 해당되거나, 또는 CRS 기반 RRM 측정치들이 해당되거나, 또는 RRM-RS 기반 측정치와 CRS 기반 RRM 측정치가 모두 해당될 수도 있다.

[546] 예를 들어, 현재 제3 메시지(message 3)를 전송하는 타겟 셀이 전송하는

RRM-RS 설정들 및 모든 포트에 대한 RRM 측정치들을 모두 보고하도록 정의될 수 있다. 이를 통해 해당 셀은 이후 이 단말에게 적절한 CSI-RS 설정들을 할 때에 이 보고 정보에 기반하여 효과적으로 CSI-RS를 설정할 수 있다는 장점이 있다.

[547] 또는, 모든 RRM-RS 측정치들을 보고하는 것이 아니라, 최상의(best) RRM-RS 측정치 대비 Z dB 이내의 RRM-RS 측정치들을 보고하도록 정의될 수 있다.

[548] 이때, 임계치 Z 값은 사전에 고정적으로 정의되어 있거나, 앞서 S1702 단계의 RAR 메시지를 통해 기지국이 알려줄 수도 있다. 이 경우, 이 정보는 진보된 단말(enhanced UE)만 이해할 수 있는 정보로서 취급될 수 있다.

[549] 또한, 이와 같이 단말이 RRM-RS 측정치들을 보고할 때, 해당 RRM-RS를 전송하는 셀의 PCI를 함께 연동정보로서 보고할 수 있다.

[550] 이는 대상 셀 이외에도 인접 셀(neighbor cell)이 전송하고 있는 RRM-RS에 대한 RRM 측정값도 어느 수준 이상 높은 값을 보이고 있다면 (예를 들어, 임계치 Z' 이내), 해당 단말에게 가해지고 있는 인접 셀들로부터의 간섭 수준을 미리 파악할 수 있다는 장점이 있고 이를 통해 CSI 프로세스(CSI process) 관련 설정 등에 있어서 참고로 활용될 수 있다.

[551] 이와 같이 단말이 상기 RRM-RS 기반 RRM 측정치들 및/또는 CRS 기반 RRM 측정치 값들 자체를 기지국에 보고해주는 시점은 제3 메시지를 전송하는 단계(즉, S1703 단계)가 아니라 그 이후 다른 단계에서 보고될 수도 있다. 이 경우, 단말은 이후의 단계에서 상기 RRM-RS 기반 RRM 측정치들 및/또는 CRS 기반 RRM 측정치 값들을 보고한다는 것을 기지국에 알리기 위한 지시자(예를 들어, 1 비트 지시자)를 포함시켜 제3 메시지를 전송할 수도 있다.

[552] 예를 들어, 제4 메시지(message 4)를 단말이 기지국으로부터 수신한 후에 (그리고 제4 메시지에서 단말의 식별자를 포함함으로써 기지국이 충돌 해결을 확인(confirmation)을 해준 경우), 단말은 긍정 응답(positive ACKnowledgement)(즉, 'ACK')을 기지국에 전송하도록 종래 동작이 정의되어 있다. 이 시점과 연동되어 함께 상기 RRM-RS 기반 RRM 측정치들 및 CRS 기반 RRM 측정치 값들을 기지국에 보고하도록 전송 시점이 정의될 수 있다.

[553] 즉, 이러한 ACK을 보내는 시점이 서브프레임(SF: subframe) #n이라면, 단말이 상기 RRM-RS 기반 RRM 측정치들 및 CRS 기반 RRM 측정치 값들을 동일 SF #n에 전송하는 것으로 (예를 들어, PUSCH에 의해) 정의될 수 있다.

[554] 또는, 특정 SF 오프셋 k값이 사전에 정의되거나 기지국의 선행하는 메시지(예를 들어, 시스템 정보 또는 제2 메시지 등)를 통해 알려주는 경우 해당 k값을 적용하여 SF #n+k 시점에 상기 RRM-RS 기반 RRM 측정치들 및 CRS 기반 RRM 측정치 값들을 전송하는 것으로 미리 정의되거나 단말에 설정될 수 있다.

[555] 또는, 기지국으로부터 명시적인 트리거링(explicit triggering) (예를 들어, UL 그랜트(grant))에 따라 해당 시점에 전송하는 것으로 정의될 수도 있다. 다시 말해, 이 경우 모든 RACH 절차가 완료된 후 기지국으로부터 특정 UL 그랜트를 수신할 수 있고 (예를 들어, 해당 UL 그랜트 내에 특정 명시적(explicit) 또는

암묵적(implicit) 필드 지시가 포함되거나 별도의 RNTI로 마스킹(masking)되는 형태 등 특정 규약된 시그널링 형태를 따를 수 있음), 이와 같이 상기 RRM-RS 기반 RRM 측정치들 및 CRS 기반 RRM 측정치 값들을 기지국으로 전송하라는 특정 UL 그랜트를 수신한 시점(즉, UL 그랜트에 대한 응답으로)에 이 정보들을 기지국에 전송하도록 정의되거나 단말에 설정될 수 있다.

[556] Step 4 (기지국으로부터 충돌 해결 메시지(Contention resolution message) 수신)

[557] 기지국은 충돌 해결 메시지(즉, 제4 메시지)를 단말에게 전송할 수 있다. 이 단계 자체에 대해서는 도 8의 예시에 따른 방식을 그대로 사용할 수 있다.

[558] 또는, 본 발명의 또 다른 일 실시예에 따르면, 이 단계와 동시에 즉, 충돌 해결 메시지(즉, 제4 메시지) 내에서 기지국은 상기 제3 메시지(message 3) 단계에서의 RRM-RS 기반 RRM 보고 정보들을 고려하여 바로 해당 단말에게 전송 모드(transport mode) 설정 및 CSI 피드백 관련 설정 정보들을 제공할 수 있다.

[559] 이러한 과정을 통해, 본 발명에 따르면 단말의 정상적인 전송 모드 설정 및 CSI 피드백, 그리고 송/수신 동작을 위해 추가적인 핸드오버(hand-over)나 셀 재선택(cell re-selection) 과정 없이 빠르게 정상 동작 상태에 진입할 수 있도록 하는 장점이 있다.

[560] 앞서 본 발명에 대한 설명에 있어서, 설명의 편의상 FD-MIMO를 활용 사례를 위주로 설명을 하였으나, 상기 언급한 바와 같이 무정형 셀(amorphous cells) 환경에서의 다수의 RRM-RS 설정 (즉, 서로 다른 개수의 TP(들)들로 무정형 셀이 구성됨에 따라 서로 다른 개수의 TP(들)이 함께 각 RRM-RS를 전송하는 형태) 등 다양한 활용 사례에도 적용될 수 있음은 자명하다. 그 밖에도 종래의 셀 별로 단일 CRS 기반 RRM 측정치에 기반하여 초기 접속(initial access)을 위한 타겟 셀을 고려하는 방식이 아닌, 별도의 다른 RS(앞서 설명의 편의상 RRM-RS로 지칭하였음)들부터의 RRM 측정치에 기반하여 초기 접속(initial access)이 수행되도록 하는 또 다른 다양한 환경에서도 적용이 가능하다.

[561] 앞서 1. 내지 4.에서는 설명의 편의상 단말이 네트워크로의 초기 접속(initial access)하는 상황을 가정하여 설명하였으나, 반드시 1. 내지 4. 방법이 단말의 초기 접속(initial access) 과정에서만 순차적으로 적용될 필요는 없으며 각각의 방법이 독립적으로 수행될 수 있음은 물론이다.

[562] 앞서 2. 방법의 경우, 반드시 단말이 네트워크에 초기 접속 이전에 기지국으로부터 수신하는 시스템 정보로 한정될 필요는 없으며, 기지국으로부터 브로드캐스트되는 어떠한 시스템 정보를 통해서도 RRM-RS 설정 정보가 단말에게 제공될 수 있다.

[563] 또한, 앞서 3. 방법의 경우, 반드시 단말이 네트워크에 초기 접속 과정을 수행하기 전에 셀을 선택하는 경우로 한정될 필요는 없으며, 단말이 캠핑(camping)하는 셀을 (재)선택하거나 핸드오버(handover)하는 등 최적의 셀을 선택하기 위한 어떠한 상황에서든 이 방법이 적용될 수 있다.

[564] 또한, 앞서 4. 방법의 경우, 반드시 단말이 네트워크에 초기 접속하기 위한

RACH 절차로 한정될 필요는 없으며, 그 외에도 단말이 수행하는 어떠한 RACH 절차에서도 적용될 수 있다. 또한, 레가시(legacy) 단말에서도 CRS 기반 RRM 측정값을 기지국에 전송하기 위하여 4. 방법이 적용될 수 있다.

[565]

[566] 진보된 RLM(advanced RLM) 동작

[567] UE는 무선링크 상태 및 수신신호 품질에 대한 측정/보고/관리를 목적으로 상기 RRM 뿐만 아니라, 무선 링크 모니터링(RLM) 동작을 수행하여야 한다.

[568] RLM의 경우 구체적으로, UE는 주어진 시간 구간/주기(예를 들어, 특정 무선 프레임/서브프레임)에 대하여 참조 신호(예를 들어, CRS 등)를 기반으로 측정된 특정 시점(예를 들어, 서브프레임)에서 무선 링크 품질(예를 들어, 신호 대 잡음비(SNR: Signal-to-Noise Ratio) 또는 신호 대 간섭 및 잡음비(SINR: Signal-to-Interference plus Noise Ratio) 등)을 특정 임계치(즉, Q_out 및 Q_in)과 비교하고, 이를 토대로 무선 링크 상태(예를 들어, out-of sync 상태 또는 in-sync 상태)를 모니터링/평가할 수 있다.

[569] 이하, 본 발명의 설명에 있어서, 종래의 또는 통상적인 RLM 동작들을 통칭하여 편의상 "제1 RLM 동작(behaviors)"으로 지칭하기로 한다.

[570] UE 동작의 예를 들면, 제1 RLM 동작에 따라 UE는 자신이 접속해 있는 셀의 (CRS 기반의) 하향링크 링크 품질을 측정하고 이를 임계치 Q_out 및 Q_in와 비교하는 것을 포함하는 RLM 동작을 수행하게 된다. 만일, 해당 하향링크 무선 링크가 "신뢰있게 수신(reliably received)"되기 어렵다고 판정되는 경우(예를 들어, 3GPP TS 36.133에서 명시된 동작에 따라 무선 링크 품질이 임계치 Q_out 보다 불량한 경우)(또는 미리 정의된 횟수만큼 무선 링크 품질이 임계치 Q_out 보다 불량하다고 판단된 경우), UE는 특정 "무선 링크 실패(RLF: Radio Link Failure) 타이머(timer)" 관련 동작에 의해 무선 링크 실패(RLF)를 판정하기 위한 타이머를 가동시킨다. 그리고, UE는 해당 타이머가 만료(expire)되면 대상 셀과의 링크를 초기화하고, 새로운 셀을 탐색하는 등의 셀 (재)선택 과정을 수행할 수 있다. 만일, 상기 RLF 타이머가 만료되기 전에 다시 상기 Q_in 관련 조건을 충족하게 되면(즉, 무선 링크 품질이 임계치 Q_in 보다 양호한 경우)(또는 미리 정의된 횟수만큼 무선 링크 품질이 임계치 Q_in 보다 양호하다고 판단된 경우), UE는 해당 셀과의 링크를 유지할 수 있다. 이 경우 단말은 RLF 타이머를 중단할 수 있다.

[571] 이러한 동작이 상기 FD-MIMO 사용 케이스에 그대로 적용되는 상황을 고려하면, 단말이 상기 통상적인 (CRS 기반) RLM 동작에 따라 특정 셀에 대하여 무선 링크 품질이 매우 낮아져서 RLF를 판정하게 되는 상황이 발생할 경우라 하더라도, 만일 해당 단말에게 FD-MIMO 빔포밍이 적용되고 있는 PDSCH 그리고/또는 EPDCCH 전송의 무선 링크 품질이 여전히 안정적인 품질을 보이고 있다면, 해당 링크를 유지하도록 하는 것이 바람직할 수 있다.

[572] 즉, 이를 통해 통신 링크 단절 현상을 줄이고, 예를 들어 제어 채널은 FD-MIMO

빔포밍된 EPDCCH로부터 수신하고, 데이터 채널은 FD-MIMO 빔포밍된 PDSCH로부터 수신하는 동작을 유지함에 따른 성능 이득을 기대할 수 있다. 이는 FD-MIMO 전송 시 eNB단에서 많은 수의 안테나 요소를 활용하여 매우 높은 FD-MIMO 빔포밍 이득을 얻도록 할 수 있기 때문이다.

[573] 본 발명의 이하에서는 이러한 동작을 가능하게 하기 위해, 상기 "제1 RLM 동작"을 대체하여, 또는 상기 "제1 RLM 동작"에 추가하여 다음과 같은 요소들 중 적어도 하나를 포함하는 특정 "제2 RLM 동작"을 정의하거나 UE에 설정 UE에 설정(예를 들어, RRC 시그널링 등에 의해)하는 방법을 제안한다.

[574]

[575] (1) "제2 RLM 동작"은 상기 "제1 RLM 동작"에서 기반이 되는 CRS가 아닌, 별도의 특정 참조 신호(RS)를 기반으로 RLM 동작이 수행될 수 있다.

[576] 이러한 별도의 RS의 예시로는, 다음과 같은 RS 중 적어도 하나를 포함할 수 있다.

[577] 특정 CSI-RS(예를 들어, 단말에 설정된 가장 낮은 또는 가장 높은 CSI-RS 인덱스에 해당하는 CSI-RS)가 이용될 수 있다. 여기서, CSI-RS는 프리코딩된(pre-coded) CSI-RS일 수 있다.

[578] 또한, DRS-CSI-RS(즉, 디스커버리 참조 신호(DRS)로서 이용되는 CSI-RS)가 이용될 수 있다. 이때, 물리 셀 식별자(PCI 또는 PCID)는 상기 통상적인 "제1 RLM 동작"을 수행하는 대상이 되는 셀 ID일 수 있다. 즉, UE는 해당 PCI로 생성된 CRS를 기반으로 해당 셀에 대한 제1 RLM behaviors를 수행하고, 그리고/또는 해당 PCI에 연동된(또는 연관된) 특정 DRS-CSI-RS에 대하여 상기 제2 RLM 동작을 수행할 수 있다. 여기서, DRS-CSI-RS는 프리코딩된(pre-coded) DRS-CSI-RS일 수 있다.

[579] 또한, 앞서 설명한 별도의 RRM-RS가 이용될 수 있다. 여기서, 예를 들어, 이러한 RRM-RS는 상기 설명된 바와 같이 SIB 등 시스템 정보 관련 시그널링 메시지에 포함되어 단말의 초기 접속 시 그리고/또는 아이들 모드(idle mode)에서의 셀 (재)선택 관련 동작 시에 적용하도록 별도로 설정된 RRM-RS일 수 있다. 또 다른 일례로, RRM-RS는 앞서 설명한 바와 같이 FD-MIMO와 같이 날카로운 빔(sharp beam)을 통해 지역적으로 방향을 다르게 전송되는 RS에 해당될 수도 있으며 또는 서로 다른 셀 또는 전송 포인트(TP: Transmission Point)의 개수로 구성되는 무정형 셀(amorphous cell)에서 전송되는 RS에 해당될 수도 있다.

[580]

[581] (2) "제2 RLM 동작"과 관련하여, 제1 RLM 동작에 적용하는 RLF 판단을 위한 판정 조건(예를 들어, 전송 파라미터(앞서 표 6 및 표 7), out-of-sync/in-sync 판정을 위한 임계치 및/또는 RLF 타이머 등을 포함)과 별개의 독립적인 판정 조건들이 정의되거나 UE에 설정(예를 들어, RRC 시그널링 등에 의해)될 수 있다.

[582] 예를 들어, 제2 RLM 동작에 관한 DCI 포맷은 제1 RLM 동작에서의 DCI 1A (표 6 참조) 및 DCI 1C (표 7 참조)와 독립적인 특정 DCI 포맷으로 out-of-sync 및 in-sync를 각각 새롭게 정의하거나 UE에게 설정될 수 있다.

[583] 즉, UE는 제2 RLM 동작과 관련하여 사전에 정의되거나 UE에 설정된 DCI 포맷을 eNB로부터 수신할 때의 무선 링크 품질을 추정(또는 측정)하고, 추정(또는 측정)된 결과와 임계치(즉, Q'_out 및 Q'_in)를 비교하여 out-of-sync/in-sync 상태를 판단할 수 있다.

[584] 또한, 제2 RLM 동작에 관하여 정의/설정된 해당 DCI(예를 들어, out-of-sync 또는 in-sync에 대한)는 특정 EPDCCH 세트(예를 들어, 가장 낮은 또는 가장 높은 EPDCCH 세트)으로부터 전송되는 것을 UE가 가정하도록 정의되거나 UE에게 설정될 수 있다. 이는, 해당 특정 EPDCCH 세트로부터 전송되는 DCI가 FD-MIMO 빔포밍에 의해 전송되는 것(즉, FD-MIMO 빔포밍이 적용되는 것)을 고려하기 위함이다.

[585] - "제어 OFDM 심볼의 수(Number of control OFDM symbols)", "병합 레벨(CCE 또는 ECCE)", "(E)PDCCH RE 에너지 대 평균 RS RE 에너지의 비(Ratio of (E)PDCCH RE energy to average RS RE energy)" 등의 요소들 중 적어도 하나에 대해서도, out-of-sync 및 in-sync 각각에 대해 제1 RLM 동작에 적용하는 전송 파라미터와 독립적으로 (해당 EPDCCH 기반으로 계산될 수 있도록) 별도의 값들이 사전에 정의되거나 UE에게 설정될 수 있다.

[586] 이때, 예를 들어, 제2 RLM 동작에 적용되는 제어 OFDM 심볼의 수(Number of control OFDM symbols), (E)CCE 병합 레벨은 셀(또는 캐리어) 대역폭에 따라 상이하게 설정될 수 있다. 또한, (E)PDCCH RE 에너지 대 평균 RS RE 에너지의 비는 앞서 (1)에서 설명한 RS가 전송되는 안테나 포트의 개수에 따라 상이하게 설정될 수 있다.

[587] - 제1 RLM 동작과 별개로 제2 RLM 동작에서 RLF 관련 판정 조건에 사용되는 임계치가 독립적으로 정의되거나 UE에게 설정될 수 있다. 본 명세서에서는 설명의 편의상 이를 Q'_in 및 Q'_out으로 표기한다.

[588] - 임계치 Q'_out은 하향링크 무선 링크가 신뢰있게(reliably) 수신될 수 없는 레벨로 정의되고, 가상의(hypothetical) (E)PDCCH 전송(즉, EPDCCH 세트(예를 들어, 가장 낮은 EPDCCH 세트) 및 미리 정의된 관련 기준에 따른)의 X% 블록 에러율(BER)에 해당할 수 있다.

[589] - 임계치 Q'_in는 하향링크 무선 링크 품질이 Q'_out에서의 하향링크 무선 링크 품질 보다 현저하게 신뢰있게 수신될 수 있는 레벨로 정의되고, 가상의(hypothetical) (E)PDCCH 전송(즉, EPDCCH 세트(예를 들어, 가장 낮은 EPDCCH 세트) 및 미리 정의된 관련 기준에 따른)의 Y% BER에 해당할 수 있다.

[590]

[591] (3) 앞서 (1) 및/또는 (2)에서 설명한 "제2 RLM 동작"은 특정 상위 계층 신호(예를 들어, RRC 시그널링 등)에 의한 지시/설정에 따라, "제1 RLM 동작"을

대체하여 수행되도록 또는 병행하여 독립적인 조건에 따라 수행되도록 지시/설정될 수 있다.

[592] - 여기서, 특정 FD-MIMO 가능한(capable) UE(또는 보다 일반적으로, 본 발명에서 제안하는 제2 RLM 동작을 지원하는 UE 등)에게 상기 "제2 RLM 동작"은 항상 활성화될 수 있다. 즉, 특정 FD-MIMO 가능한(capable) UE의 경우 항상 제2 RLM 동작을 수행할 수 있다.

[593] 또는, 특정 FD-MIMO 가능한(capable) UE(또는 보다 일반적으로, 본 발명에서 제안하는 제2 RLM 동작을 지원하는 UE 등)라도 "제2 RLM 동작"이 항상 활성화되지는 않고, 해당 단말에게 FD-MIMO 관련 모드(또는 보다 일반적으로, 본 발명에서 제안하는 제2 RLM 동작을 지원하는 모드 등)가 설정된 경우에 "제2 RLM 동작"이 활성화될 수도 있다. 즉, 특정 FD-MIMO 가능한(capable) UE의 경우라도 항상 제2 RLM 동작을 수행하지 않고, FD-MIMO 관련 동작이 활성화(즉, FD-MIMO 관련 모드 설정)된 경우 제2 RLM 동작을 수행할 수 있다.

[594] 이 경우, 제1 RLM 동작을 대체하여 제2 RLM 동작을 수행하도록 정의 또는 UE에게 설정되거나, 제1 RLM 동작과 함께 제2 RLM 동작을 함께 병행하여 수행하도록 정의되거나 UE에게 설정될 수 있다.

[595] 후자와 같이, 제1 RLM 동작과 제2 RLM 동작의 병행하여 동작되는 경우, 제2 RLM 동작이 항상 별도의 동작 조건에 의해 제1 RLM 동작과 무관하게 동작될 수도 있다. 또는 제2 RLM 동작은 제1 RLM 동작에 종속되어, 제1 RLM 동작에 의해 특정 조건이 충족되는 경우, 여기에 연동되어 제2 RLM 동작의 동작 조건이 종속적으로 정의되거나 UE에게 설정될 수도 있다. 예를 들어, 후술하는 (4) 등의 실시예와 같이 제2 RLM 동작은 제1 RLM 동작에 종속되어 수행될 수 있다.

[596] 상술한, FD-MIMO 가능한(capable) UE는 UE가 네트워크에 초기 접속 시에 자신의 특정 능력 시그널링(즉, FD-MIMO 지원 가능한 능력)을 기지국에 전달할 수 있다. 이때, 이에 관한 특정 FD-MIMO 관련 능력 시그널링 포맷이 정의될 수 있다. 예를 들어, FD-MIMO 가능한(capable) UE(예를 들어, FD-MIMO 지원 가능한 능력을 시그널링한 UE)는 상기 제2 RLM 동작이 적용될 수 있다.

[597] 또는, 상기 제2 RLM 동작의 적용 가능 여부에 관한 능력 시그널링 형태로 세분화될 수도 있다. 즉, 특정 FD-MIMO 관련 능력 메시지는 제2 RLM 동작의 적용 가능 여부를 지시하는 정보를 포함할 수도 있다.

[598] 또한, 상기 RRM-RS 그리고/또는 연관된 최초 접속(initial access) 동작 방식에 관해서도 특정 능력 시그널링 형태로 유사하게 세분화될 수 있다. 즉, UE는 상술한 RRM-RS의 지원 가능 여부에 대한 능력 및/또는 이와 연관된 최초 접속(initial access) 동작 방식의 지원 가능 여부에 대한 능력 시그널링을 eNB에게 전송할 수 있다.

[599] - 만일, 상기 제2 RLM 동작이 제1 RLM 동작을 대체하는 형태로 정의되거나 UE에 설정된 경우라면, 이 UE의 RLF 판정 여부는 오직 상기 제2 RLM 동작 관련 판정 조건에 따라 정해진다. 즉, 앞서 (2)에서 설명한 제2 RLM 동작에 대한 판정

조건만으로 UE는 RLF를 판정할 수 있다.

[600] - 또한 만일, 상기 제2 RLM 동작이 제1 RLM 동작과 병행하여 둘 다 활성화되는 상태로 유지되는 형태로 정의되거나 UE에 설정된 경우라면, 이 UE의 RLF 판정 여부는 제1 RLM 동작과 제2 RLM 동작 관련 판정 조건을 모두 고려하여, 두 경우 모두에서 RLF 판정이 내려진 경우에만 해당 셀의 통신 링크를 끊을 수 있도록(즉, 해당 셀과의 링크를 초기화하도록) 정의되거나 UE에 설정될 수 있다.

[601] 또는, 제1 RLM 동작과 제2 RLM 동작 중 어느 하나라도 RLF 판정이 내려진 경우에는 해당 셀의 통신 링크를 끊을 수 있도록(즉, 해당 셀과의 링크를 초기화하도록) 정의되거나 UE에 설정될 수 있다. 그리고/또는, 제2(또는 제1) RLM 동작에 의해서 RLF 판정이 내려진 경우에는 제1(또는 제2) RLM 동작의 판정 결과와 무관하게 RLF 판정을 내리는 것으로 정해질 수도 있다. 즉, 제1 RLM 동작과 제2 RLM 동작 중 어느 하나가 RLF 판정에 있어서 다른 하나보다 높은 우선순위를 가질 수 있다.

[602]

[603] (4) 상술한 바와 같이 제2 RLM 동작은 제1 RLM 동작에 종속적으로 수행될 수 있다.

[604] 일례로, "제1 RLM 동작"에 의해 RLF 타이머가 작동 개시된 시점 t1으로부터 특정 오프셋 시간인 d1만큼의 시간(예를 들어, d1=0, 또는 d1은 특정 양수 값 등)이 지난 후부터, 상기 (1)에서 설명한 특정 RS에 대하여 "제2 RLM 동작"에 따른 RLF 판정 관련 동작이 개시될 수 있다.

[605] 또한, 상기 제1 RLM 동작에 의해 RLF 타이머가 작동 개시되고 만료되기 전까지, 상기 제2 RLM 동작에 의해 특정 Q'_in 조건이 충족하게 되는 경우(즉, 무선 링크 품질이 Q'_in 보다 양호한 경우), 해당 셀에 대해서는 RLF를 판정하지 않을 수 있다.

[606] 이러한 제안 동작에 의해, "제2 RLM 동작"은 오직 "제1 RLM 동작"의 RLF 타이머가 작동되는 시점과 연동된 특정 시간 구간 동안에만 활성화되는 것으로 제한함으로써, 단말의 불필요한 배터리 소모를 방지할 수 있다.

[607] 또한, UE가 새로운 셀을 (재)선택하여 정상적으로 (재)접속이 완료되기 까지(또는 (재)접속이 완료되어 해당 새로운 셀로부터 정상적인 "제1 RLM 동작"이 개시될 수 있는 상태가 되기까지)의 구간 동안에는, 반드시 이 UE에게는 해당 "제2 RLM 동작"과 연계된 특정 EPDCCH 세트(예를 들어, 가장 낮은 EPDCCH 세트)로부터의 DCI들을 통한 제어 시그널링만 수신이 가능한 것으로 정의되거나 설정될 수 있다. 그리고, EPDCCH에 의해 특정 PDSCH 수신 및 상향링크 송신 등의 동작이 지시될 수 있다.

[608] 또한, 새로운 셀을 (재)선택하여 정상적으로 (재)접속이 완료되기 까지(또는 (재)접속이 완료되어 해당 새로운 셀로부터 정상적인 "제1 RLM 동작"이 개시될 수 있는 상태가 되기까지)의 구간 동안에는 C-RNTI, SPS C-RNTI 등 특정 RNTI(들)로 마스킹된 DCI만 해당 EPDCCH 세트로부터 수신이 가능한 것으로

한정될 수도 있다. 즉, 이 경우 UE는 이러한 제한된 형태의 DCI들만 블라인드 검출(blind detection)을 시도하면 된다.

[609] 그리고/또는, UE는 이러한 상태에서 특정 정의되거나 UE에 설정된 동작 조건에 따라, 계속해서 새로운 셀 탐색 관련 동작을 수행해야 할 수 있다. 즉, 이와 같은 새로운 셀 탐색 관련 동작을 지속적으로 수행함과 동시에, 상기 "제2 RLM 동작"과 연계된 특정 EPDCCH 세트를 통한 특정 EPDCCH DCI(들)의 모니터링은 지속해야 한다. 이를 통해, FD-MIMO 빔포밍된 EPDCCH에 의해 스케줄링되는 FD-MIMO 빔포밍된 PDSCH는 (상기 "제1 RLM 동작"에 의해서는 RLF가 판정된 상태라 할지라도) 여전히 지속적으로 수행될 수 있도록 함으로써 통신 링크의 연결성을 크게 증대시킬 수 있다는 장점이 있다.

[610] 또 다른 일례로, "제1 RLM 동작"에 의한 RLF 판정 결과에 따라 "제2 RLM 동작"이 개시될 수도 있다.

[611] 예를 들어, "제1 RLM 동작"과 "제2 RLM 동작"의 판정 조건을 모두 고려하여, 두 경우 모두 RLF 판정이 내려진 경우에만 해당 셀의 통신 링크를 끊는(즉, 해당 셀과의 링크를 초기화) 경우를 가정한다. 이 경우, "제1 RLM 동작"에 의한 RLF 판정이 내려진 경우(즉, 무선 링크 품질이 임계치 Q_out 보다 불량하여 구동이 개시된 RLF 타이머가 만료된 경우)에만 "제2 RLM 동작"이 개시될 수도 있다. 반면, "제1 RLM 동작"에 의한 RLF 타이머가 작동 개시되었더라도 무선 링크 품질이 임계치 Q_in보다 양호한 경우에는 "제2 RLM 동작"이 개시되지 않을 수 있다.

[612] 또 다른 예로, "제1 RLM 동작"과 "제2 RLM 동작" 중 어느 하나라도 RLF 판정이 내려진 경우에는 해당 셀의 통신 링크를 끊을 수 있도록(즉, 해당 셀과의 링크를 초기화하도록) 정의되거나 UE에 설정된 경우를 가정한다. 또한, 제1 RLM 동작에 의해서 RLF 판정이 내려진 경우에는 제2 RLM 동작의 판정 결과와 무관하게 RLF 판정을 내리는 경우도 마찬가지이다. 이 경우, "제1 RLM 동작"에 의한 RLF 판정이 내려진 경우(즉, 무선 링크 품질이 임계치 Q_out 보다 불량하여 구동이 개시된 RLF 타이머가 만료된 경우)에는 해당 셀의 통신 링크를 끊게되며(즉, 해당 셀과의 링크를 초기화), "제2 RLM 동작"이 개시되지 않을 수 있다.

[613] 도 18은 본 발명의 일 실시예에 따른 무선 링크 모니터링을 위한 방법을 예시하는 도면이다.

[614] 도 18을 참조하면, UE는 CRS를 기반으로 셀(cell)에 대한 무선 링크 모니터링(이하, '제1 RLM')을 수행할 수 있다(S1801).

[615] UE는 CRS 이외 특정 참조 신호(RS)를 기반으로 셀(cell)에 대한 무선 링크 모니터링(이하, '제2 RLM')을 수행한다(S1802).

[616] 여기서, 특정 RS는 CRS 이외 앞서 (1)에서 설명한 RS를 의미할 수 있다. 예를 들어, (pre-coded) CSI-RS, (pre-coded) DRS-CSI-RS, 단말의 초기 접속 시 그리고/또는 아이들 모드(idle mode)에서의 셀 (재)선택 관련 동작 시에

적용하도록 별도로 설정된 RRM-RS, FD-MIMO와 같이 날카로운 빔(sharp beam)을 통해 지역적으로 방향을 다르게 전송되는 RS, 또는 서로 다른 셀 또는 전송 포인트(TP: Transmission Point)의 개수로 구성되는 무정형 셀(amorphous cell)에서 전송되는 RS가 해당될 수 있다.

[617] UE는 CRS 기반 제1 RLM 및 CRS 이외 참조 신호 기반 제2 RLM을 기반으로 또는 CRS 이외 참조 신호 기반 제2 RLM을 기반으로 셀에 대한 RLF를 판단한다(S1803).

[618] 여기서, S1803 단계에서 제2 RLM에 의해서만 해당 셀에 대한 RLF를 판단하는 경우, 앞서 S1801 단계는 수행되지 않을 수도 있다.

[619] 보다 구체적으로 살펴보면, UE는 해당 셀에 대한 하향링크 무선 링크 품질을 모니터링하고, 모니터링에 의한 측정치와 미리 정해진 임계치를 비교할 수 있다.

[620] 여기서, CRS 기반 제1 RLM의 경우, UE는 CRS 기반 모니터링에 의한 측정치를 Q_in 및 Q_out과 비교할 수 있다.

[621] 또한, CRS 이외 참조 신호 기반 제2 RLM의 경우, UE는 CRS 이외 참조 신호 기반 모니터링에 의한 측정치를 Q'_in 및 Q'_out과 비교할 수 있다. 이때, 상술한 바와 같이, Q'_in 및 Q'_out는 Q_in 및 Q_out와 독립적으로 미리 정의되거나, UE에게 설정될 수 있다.

[622] 여기서, 상술한 바와 같이, Q'_in 및 Q'_out은 각각 미리 정의된 전송 파라미터(즉, (E)PDCCH 전송 파라미터)를 이용한 가상의 (E)PDCCH 전송에 대한 BER에 해당할 수 있다. 즉, 가상의 (E)PDCCH 전송은 (E)PDCCH 전송 파라미터에 기반하여 전송된다고 가정되는 (E)PDCCH 전송을 의미한다. 이때, (E)PDCCH 전송 파라미터는 앞서 CRS 기반 제1 모니터링을 위한 전송 파라미터(즉, PDCCH/PCFICH 전송 파라미터)와 독립적으로 정의되거나 UE에게 설정될 수 있다.

[623] 그리고, UE는 모니터링에 의한 측정치와 미리 정해진 임계치를 비교한 결과에 기반하여 RLF 타이머를 구동시킬 수 있다. 그리고, RLF 타이머가 만료되면 상기 셀에 대한 RLF라고 결정할 수 있다.

[624] 예를 들어, CRS 기반 제1 RLM의 경우, 무선 링크 품질이 Q_out 보다 불량한 경우 out-of-sync 상태로 판단할 수 있으며, 무선 링크 품질이 Q_in 보다 양호한 경우 in-sync 상태로 판단할 수 있다. 이때, 무선 링크 품질이 Q_out 보다 불량한 경우(또는, 미리 정의된 횟수만큼 무선 링크 품질이 임계치 Q_out 보다 불량하다고 판단된 경우), UE는 제1 RLM에 대한 RLF 타이머를 구동시킬 수 있다. 그리고, 제1 RLM에 대한 RLF 타이머가 만료되면 상기 셀에 대한 RLF라고 결정할 수 있다. 이때, 제1 RLM에 대한 RLF 타이머 구동 중 무선 링크 품질이 Q_in 보다 양호한 경우(또는 미리 정의된 횟수만큼 무선 링크 품질이 임계치 Q_in 보다 양호하다고 판단된 경우), 제1 RLM에 대한 RLF 타이머를 중단시킬 수 있다.

[625] 또한, CRS 이외 참조 신호 기반 제2 RLM의 경우, 무선 링크 품질이 Q'_out 보다

불량한 경우 out-of-sync 상태로 판단할 수 있으며, 무선 링크 품질이 Q'_in 보다 양호한 경우 in-sync 상태로 판단할 수 있다. 이때, 무선 링크 품질이 Q'_out 보다 불량한 경우(또는, 미리 정의된 횟수만큼 무선 링크 품질이 임계치 Q'_out 보다 불량하다고 판단된 경우), UE는 제2 RLM에 대한 RLF 타이머를 구동시킬 수 있다. 그리고, 제2 RLM에 대한 RLF 타이머가 만료되면 상기 셀에 대한 RLF라고 결정할 수 있다. 이때, 제2 RLM에 대한 RLF 타이머 구동 중 무선 링크 품질이 Q'_in 보다 양호한 경우(또는 미리 정의된 횟수만큼 무선 링크 품질이 임계치 Q'_in 보다 양호하다고 판단된 경우), 제2 RLM에 대한 RLF 타이머를 중단시킬 수 있다.

[626] 상술한 바와 같이, UE는 제1 RLM 동작을 대체하여 제2 RLM 동작을 수행할 수도 있으나, 제1 RLM 동작과 함께 제2 RLM 동작을 수행할 수도 있다.

[627] 즉, 제1 RLM 동작을 대체하여 제2 RLM 동작을 수행하는 경우, UE는 제2 RLM 동작에 의해 해당 셀에 대한 RLF를 판단할 수 있다.

[628] 반면, 제1 RLM 동작과 함께 제2 RLM 동작을 수행하는 경우, UE는 제1 RLM 동작과 무관하게 제2 RLM 동작을 수행할 수도 있으나, 제1 RLM 동작에 의해 특정 조건이 만족되는 경우 제2 RLM 동작을 수행할 수도 있다.

[629] 예를 들어, 제1 RLM에 대한 RLF 타이머가 작동 개시된 시점으로부터 특정 오프셋 시간 이후부터 제2 RLM이 수행될 수 있다. 또는, 제1 RLM에 의해 해당 셀이 RLF라고 판단되면, 제2 RLM이 수행될 수도 있다.

[630] 이와 같이 제1 RLM 동작과 함께 제2 RLM 동작을 수행하는 경우, UE는 제1 RLM 동작 및 제2 RLM 동작에 의해 모두 해당 셀에 대한 RLF가 판정된 경우, 최종적으로 해당 셀에 대한 RLF라고 판단할 수 있다.

[631] 또는, 제1 RLM 동작과 함께 제2 RLM 동작을 수행하는 경우, UE는 제1 RLM 동작 또는 제2 RLM 동작에 의해 해당 셀에 대한 RLF가 판정된 경우, 최종적으로 해당 셀에 대한 RLF라고 판단할 수 있다. 이때, 제1 RLM 동작 및 제2 RLM 동작 중 어느 하나에 의해 RLF라고 판단된 경우, 이외 동작에 대한 판정 결과와 무관하게 최종적으로 해당 셀에 대한 RLF라고 판단할 수도 있다.

[632] 위와 같이, 제1 RLM 및/또는 제2 RLM에 의해 최종적으로 해당 셀에 대하여 RLF라고 판단된 경우, UE는 해당 셀과의 링크를 초기화하고, 새로운 셀을 탐색하는 등의 셀 (재)선택 과정을 수행할 수 있다.

[633]

[634] 앞서, 본 발명의 설명에 있어서, 설명의 편의상 FD-MIMO 사용 케이스를 위주로 설명하였으나, 앞서 설명한 바와 같이 무정형 셀(amorphous cells) 환경에서 다수의 RRM-RS 설정 (각 RRM-RS는 서로 다른 개수의 TP(들)/셀(들)이 함께 전송하는 형태) 등 다양한 사용 케이스에도 본 발명이 동일하게 적용될 수 있다. 즉, 앞서 통상적인 "제1 RLM 동작"과 상이하게 상기 앞서 본 발명에서 제안된 다양한 형태의 동작/적용 조건에 의해 별도의 "제2 RLM 동작"이 정의되거나 UE에게 설정될 수 있으며, 이에 따라 RLF 판정 조건 등이 상이하게

적용되도록 하는 형태로 일반화되어 확장 적용될 수 있음은 자명하다. 이러한 사용 케이스는 그 밖에도 다양하게 존재할 수 있으며, 본 발명의 제안 방식들은 특정 사용 케이스에 제한되지 않는다.

[635] 또한, 본 발명에서 "최초 접속(initial access) 관련 동작" 또는 "초기 접속 시에" 등의 표현은, 설명의 편의를 위한 것이고, 본 발명의 제안은 일반적으로 UE가 아이들 상태(예를 들어, RRC-connected 상태가 아닌 상태)에서 셀 선택/재선택을 수행할 때에 일반적으로 적용될 수 있는 것으로 이해되어야 한다. 즉, UE가 초기 턴-온(turn-on)되어 셀 선택을 해야 하는 상태 이외에도, 단말이 특정 셀에 접속된 후에라도 콜 드랍(call drop)이나, 휴지 기간 등의 여러 가지 이유로 아이들 상태에 있을 때, 지속적으로 최적의 셀을 탐색하고, 필요 시 다른 셀로 접속하여야 하므로 이러한 동작에 있어서도 일반적으로 적용될 수 있다.

[636] 구체적 예시로는, 이와 같이 단말이 아이들 상태에서 특정 셀에 접속하기 위해서는, 본 발명에서의 제안 방식이 우선 기존과 같이 CRS 기반으로 가장 평균 수신 파워가 강한 특정 셀의 시스템 정보를 획득하고 여기에 주변 인접 셀들의 상기 RRM-RS와 같은 목적의 RS 관련 정보가 제공되는 경우, 이에 따라 UE는 (아이들 상태에서) 인접 셀들의 RRM-RS 등을 함께 측정하여, 인접 셀이 (상기 "FD-MIMO" 관점에서) 더 최적의 셀(best cell)인 경우 해당 인접 셀로 (아이들 상태에서) 바로 셀-재선택(cell-reselection)을 수행 후 해당 인접 셀로 접속하는 방식이 적용될 수 있다.

[637]

[638] 본 발명이 적용될 수 있는 장치 일반

[639] 도 19는 본 발명의 일 실시예에 따른 무선 통신 장치의 블록 구성도를 예시한다.

[640] 도 19를 참조하면, 무선 통신 시스템은 기지국(1910)과 기지국(1910) 영역 내에 위치한 다수의 단말(1920)을 포함한다.

[641] 기지국(1910)은 프로세서(processor, 1911), 메모리(memory, 1912) 및 RF부(radio frequency unit, 1913)을 포함한다. 프로세서(1911)는 앞서 도 1 내지 도 18에서 제안된 기능, 과정 및/또는 방법을 구현한다. 무선 인터페이스 프로토콜의 계층들은 프로세서(1911)에 의해 구현될 수 있다. 메모리(1912)는 프로세서(1911)와 연결되어, 프로세서(1911)를 구동하기 위한 다양한 정보를 저장한다. RF부(1913)는 프로세서(1911)와 연결되어, 무선 신호를 송신 및/또는 수신한다.

[642] 단말(1920)은 프로세서(1921), 메모리(1922) 및 RF부(1923)을 포함한다. 프로세서(1921)는 앞서 도 1 내지 도 18에서 제안된 기능, 과정 및/또는 방법을 구현한다. 무선 인터페이스 프로토콜의 계층들은 프로세서(1921)에 의해 구현될 수 있다. 메모리(1922)는 프로세서(1921)와 연결되어, 프로세서(1921)를 구동하기 위한 다양한 정보를 저장한다. RF부(1923)는 프로세서(1921)와 연결되어, 무선 신호를 송신 및/또는 수신한다.

[643] 메모리(1912, 1922)는 프로세서(1911, 1921) 내부 또는 외부에 있을 수 있고, 잘

알려진 다양한 수단으로 프로세서(1911, 1921)와 연결될 수 있다. 또한, 기지국(1910) 및/또는 단말(1920)은 한 개의 안테나(single antenna) 또는 다중 안테나(multiple antenna)를 가질 수 있다.

[644] 이상에서 설명된 실시예들은 본 발명의 구성요소들과 특징들이 소정 형태로 결합된 것들이다. 각 구성요소 또는 특징은 별도의 명시적 언급이 없는 한 선택적인 것으로 고려되어야 한다. 각 구성요소 또는 특징은 다른 구성요소나 특징과 결합되지 않은 형태로 실시될 수 있다. 또한, 일부 구성요소들 및/또는 특징들을 결합하여 본 발명의 실시예를 구성하는 것도 가능하다. 본 발명의 실시예들에서 설명되는 동작들의 순서는 변경될 수 있다. 어느 실시예의 일부 구성이나 특징은 다른 실시예에 포함될 수 있고, 또는 다른 실시예의 대응하는 구성 또는 특징과 교체될 수 있다. 특허청구범위에서 명시적인 인용 관계가 있지 않은 청구항들을 결합하여 실시예를 구성하거나 출원 후의 보정에 의해 새로운 청구항으로 포함시킬 수 있음은 자명하다.

[645] 본 발명에 따른 실시예는 다양한 수단, 예를 들어, 하드웨어, 펌웨어(firmware), 소프트웨어 또는 그것들의 결합 등에 의해 구현될 수 있다. 하드웨어에 의한 구현의 경우, 본 발명의 일 실시예는 하나 또는 그 이상의 ASICs(application specific integrated circuits), DSPs(digital signal processors), DSPDs(digital signal processing devices), PLDs(programmable logic devices), FPGAs(field programmable gate arrays), 프로세서, 콘트롤러, 마이크로 콘트롤러, 마이크로 프로세서 등에 의해 구현될 수 있다.

[646] 펌웨어나 소프트웨어에 의한 구현의 경우, 본 발명의 일 실시예는 이상에서 설명된 기능 또는 동작들을 수행하는 모듈, 절차, 함수 등의 형태로 구현될 수 있다. 소프트웨어 코드는 메모리에 저장되어 프로세서에 의해 구동될 수 있다. 상기 메모리는 상기 프로세서 내부 또는 외부에 위치하여, 이미 공지된 다양한 수단에 의해 상기 프로세서와 데이터를 주고 받을 수 있다.

[647] 본 발명은 본 발명의 필수적 특징을 벗어나지 않는 범위에서 다른 특정한 형태로 구체화될 수 있음은 당업자에게 자명하다. 따라서, 상술한 상세한 설명은 모든 면에서 제한적으로 해석되어서는 아니 되고 예시적인 것으로 고려되어야 한다. 본 발명의 범위는 첨부된 청구항의 합리적 해석에 의해 결정되어야 하고, 본 발명의 등가적 범위 내에서의 모든 변경은 본 발명의 범위에 포함된다.

산업상 이용가능성

[648] 본 발명의 무선 통신 시스템에서 단말이 무선 링크 모니터링 방안은 3GPP LTE/LTE-A 시스템에 적용되는 예를 중심으로 설명하였으나, 3GPP LTE/LTE-A 시스템 이외에도 다양한 무선 통신 시스템에 적용하는 것이 가능하다.

청구범위

[청구항 1] 무선 통신 시스템에서 단말이 무선 링크 모니터링(RLM: radio link monitoring)을 수행하는 방법에 있어서,
셀 특정 참조 신호(CRS: cell-specific reference signal) 이외 참조 신호를 기반으로 셀에 대한 제2 RLM을 수행하는 단계; 및
상기 제2 RLM을 기반으로 상기 셀에 대한 무선 링크 실패(RLF: radio link failure)를 판단하는 단계를 포함하고,
상기 제2 RLM에 적용되는 RLF 판단을 위한 판단 조건은 CRS 기반 제1 RLM에 적용되는 RLF 판단을 위한 판단 조건과 상이한 무선 링크 모니터링 방법.

[청구항 2] 제1항에 있어서,
상기 CRS 기반으로 상기 제1 RLM을 수행하는 단계를 더 포함하고,
상기 셀에 대한 RLF는 상기 제1 RLM 및 상기 제2 RLM을 기반으로 판단되는 무선 링크 모니터링 방법.

[청구항 3] 제1항에 있어서,
상기 RLF 판단을 위한 판단 조건은 제어 채널 전송 파라미터, 비동기(out-of-sync)/동기(in-sync) 상태 판단을 위한 임계값 및 RLF 타이머 중 적어도 어느 하나를 포함하는 무선 링크 모니터링 방법.

[청구항 4] 제1항에 있어서,
상기 제2 RLM의 경우, 상기 제2 모니터링을 위한 하향링크 제어 정보(DCI: Downlink Control Information)가 소정의 진보된 물리 하향링크 제어 채널(EPDCCH: Enhanced Physical Downlink Control Channel) 세트로부터 전송된다고 가정되는 무선 링크 모니터링 방법.

[청구항 5] 제1항에 있어서,
상기 단말이 풀 차원 다중 입력 다중 출력(FD-MIMO: full dimension-Multi Input Multi Output) 지원 가능한 경우, 상기 제2 RLM이 수행되는 무선 링크 모니터링 방법.

[청구항 6] 제1항에 있어서,
상기 단말이 FD-MIMO 지원 가능하고 상기 단말이 FD-MIMO 모드가 활성화된 경우, 상기 제2 RLM이 수행되는 무선 링크 모니터링 방법.

[청구항 7] 제2항에 있어서,
상기 셀에 대한 RLF가 상기 제1 RLM 및 상기 제2 RLM을 기반으로 판단되는 경우,
상기 제1 RLM 및 상기 제2 RLM 중 적어도 어느 하나에 의해 상기 셀에 대한 RLF가 결정되면, 상기 셀에 대한 RLF가 결정되는 무선 링크 모니터링 방법.

[청구항 8] 제7항에 있어서,

상기 제1 RLM 및 상기 제2 RLM 중 어느 하나가 상기 셀에 대한 RLF 판단에 있어서 높은 우선 순위를 가지는 무선 링크 모니터링 방법.

[청구항 9] 제2항에 있어서,
상기 셀에 대한 RLF가 상기 제1 RLM 및 상기 제2 RLM을 기반으로 판단되는 경우,
상기 제1 RLM 및 상기 제2 RLM 모두에 의해 상기 셀에 대한 RLF가 결정되면, 상기 셀에 대한 RLF가 결정되는 무선 링크 모니터링 방법.

[청구항 10] 제2항에 있어서,
상기 제2 RLM은 상기 제1 RLM에 의해 소정의 조건이 만족되는 경우 수행되는 무선 링크 모니터링 방법.

[청구항 11] 제10항에 있어서,
상기 제1 RLM에 의한 RLF 타이머가 가동된 시점으로부터 소정의 오프셋 시간 이후 상기 제2 RLM이 개시되는 무선 링크 모니터링 방법.

[청구항 12] 제11항에 있어서,
상기 제1 RLM에 의한 RLF 타이머가 가동된 시점으로부터 상기 단말에 의한 다른 셀의 선택(selection) 또는 재선택(reselection) 절차가 완료되기까지 구간 동안, 상기 제2 RLM과 연계된 EPDCCH 세트를 통해 DCI가 수신되고, 상기 DCI에 의해 스케줄링된 물리 하향링크 공유 채널(PDSCH: Physical Downlink Shared Channel)를 통해 하향링크 데이터가 수신되는 무선 링크 모니터링 방법.

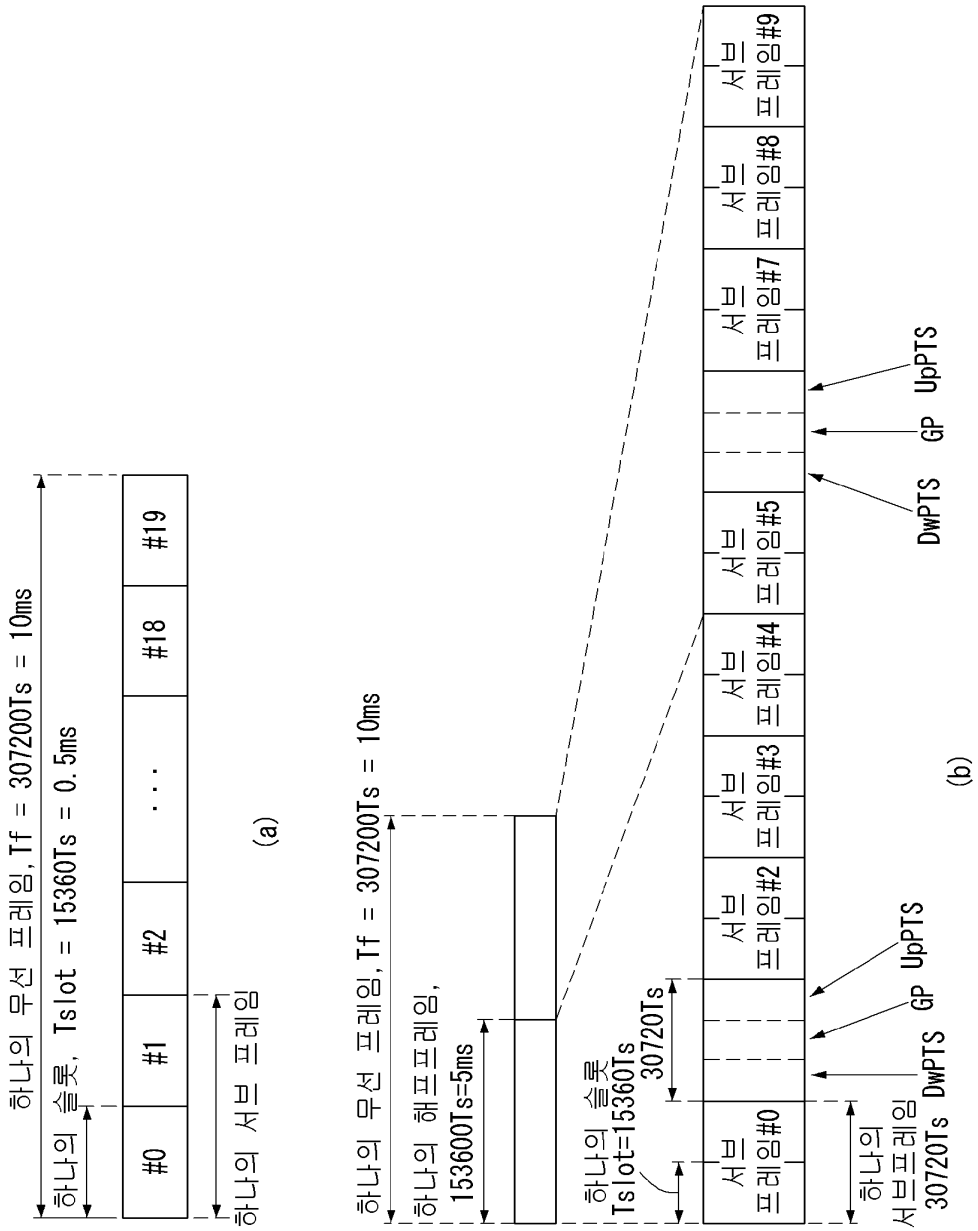
[청구항 13] 제12항에 있어서,
미리 정해진 무선 네트워크 임시 식별자(RNTI: Radio Network Temporary Identifier)로 마스킹된 DCI만 상기 EPDCCH 세트를 통해 수신되는 무선 링크 모니터링 방법.

[청구항 14] 제1항에 있어서,
상기 CSI 이외 참조 신호는 채널 상태 정보 참조 신호(CSI-RS: Channel State Information-Reference Signal), 디스커버리 참조 신호(DRS: Discovery Reference Signal), 프리코딩된(precoded) 참조 신호 및 셀 (재)선택 관련 동작 시에 적용하도록 설정된 참조 서로 다른 셀 또는 전송 포인트(TP: Transmission Point)의 개수로 구성되는 무정형 셀(amorphous cell)에서 전송되는 참조 신호 중 어느 하나인 무선 링크 모니터링 방법.

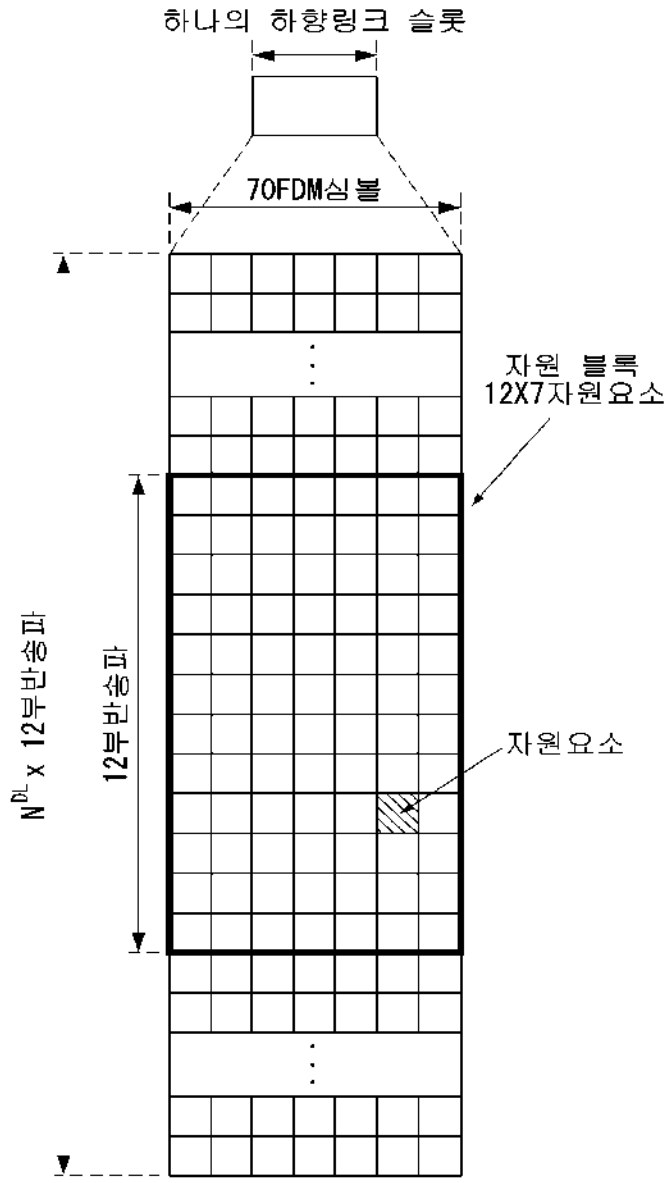
[청구항 15] 무선 통신 시스템에서 무선 링크 모니터링(RLM: radio link monitoring)을 수행하는 단말에 있어서,
무선 신호를 송수신하기 위한 RF(Radio Frequency) 유닛; 및
상기 RF 유닛을 제어하는 프로세서를 포함하고,
상기 셀 특정 참조 신호(CRS: cell-specific reference signal) 이외 참조 신호를 기반으로 셀에 대한 제2 RLM을 수행하고,
상기 제2 RLM을 기반으로 상기 셀에 대한 무선 링크 실패(RLF: radio link

failure)를 판단하도록 구성되고,
상기 제2 RLM에 적용되는 RLF 판단을 위한 판단 조건은 CRS 기반 제1 RLM에 적용되는 RLF 판단을 위한 판단 조건과 상이한 단말.

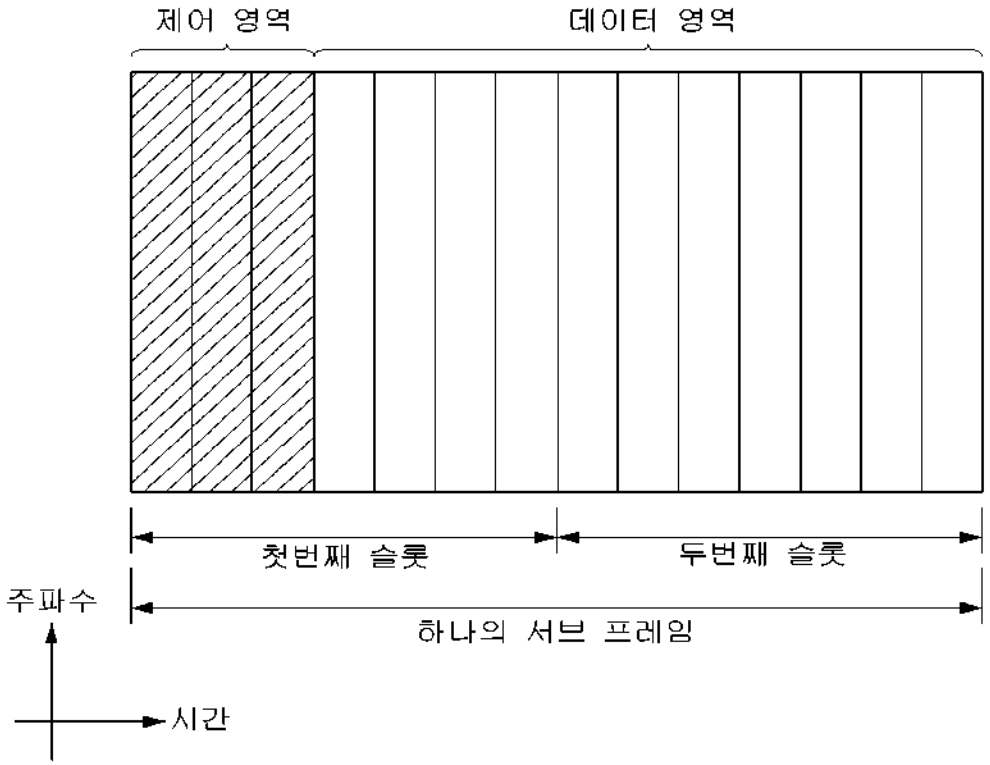
[도1]


하나의 무선 프레임, Tf = 307200Ts = 10ms
하나의 슬롯, Tslot = 15360Ts = 0.5ms
#0
#1
#2
...
#18
#19
하나의 서브 프레임
(a)
하나의 무선 프레임, Tf = 307200Ts = 10ms
하나의 해프프레임, 153600Ts=5ms
하나의 슬롯 Tslot=15360Ts
30720Ts
서브 프레임#0
서브 프레임#2
서브 프레임#3
서브 프레임#4
서브 프레임#5
서브 프레임#7
서브 프레임#8
서브 프레임#9
DwPTS
GP
UpPTS
하나의 서브프레임 30720Ts
(b)

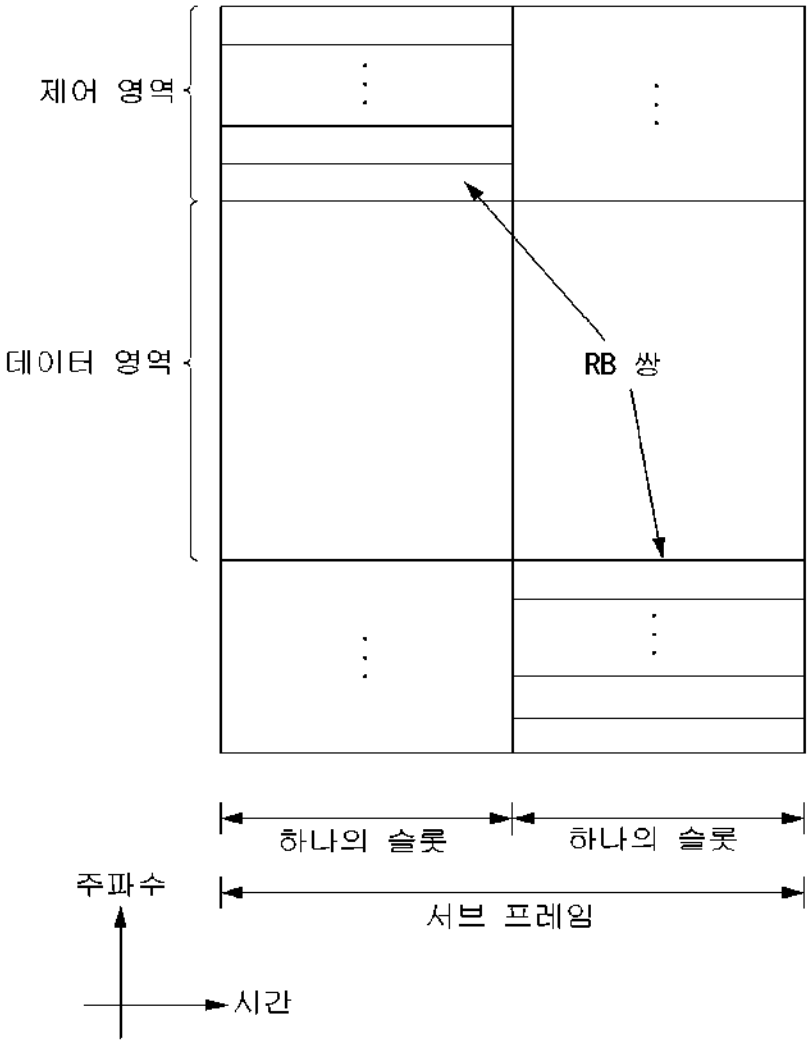
[도2]



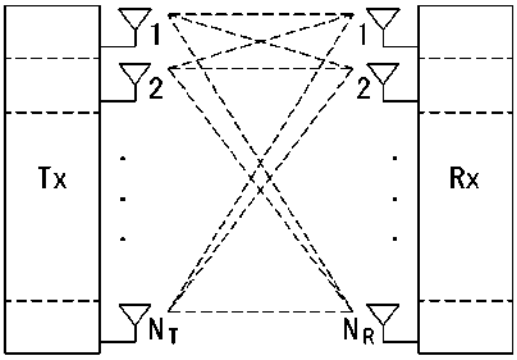
[도3]



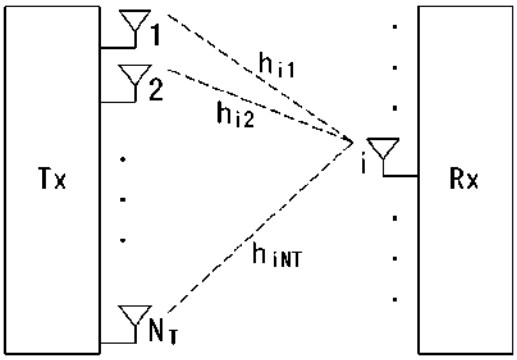
[도4]



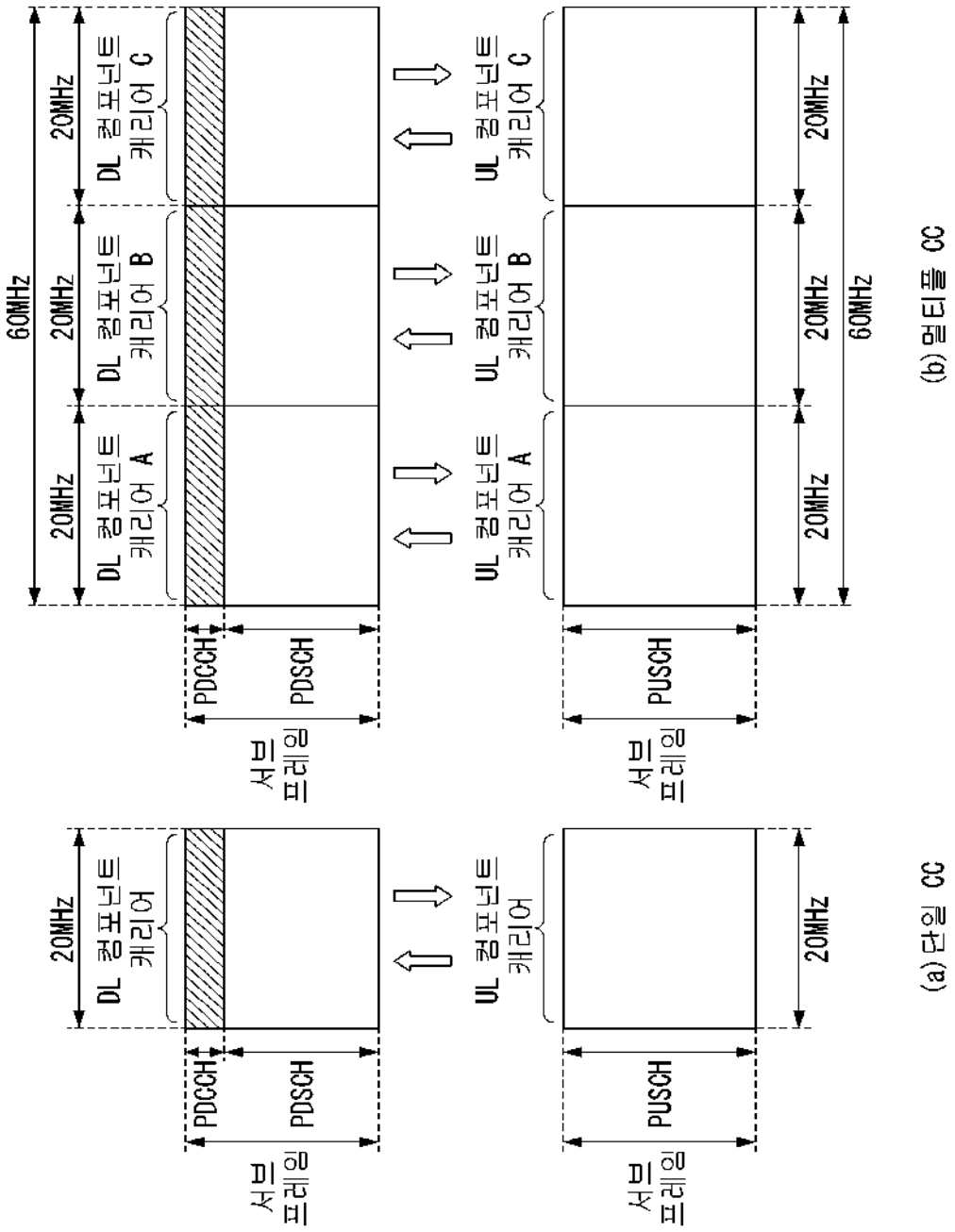
[도5]



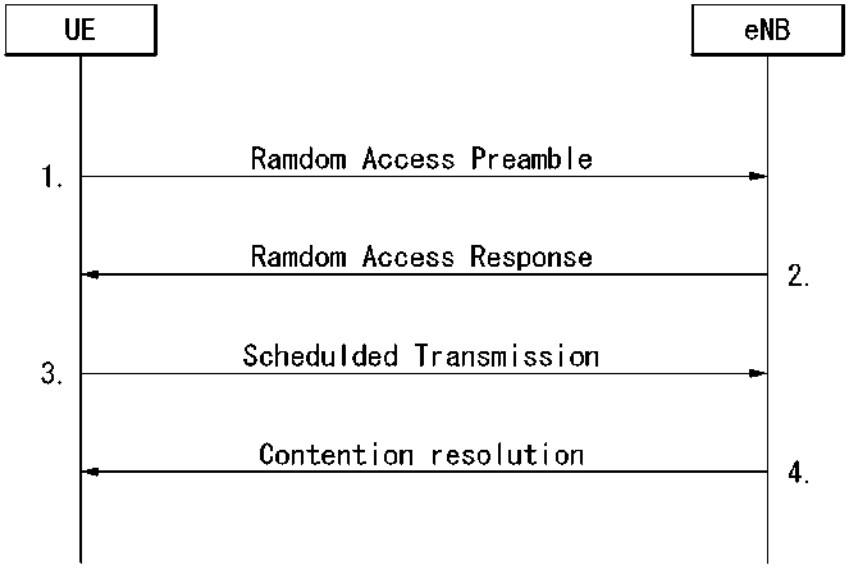
[도6]



[도7]

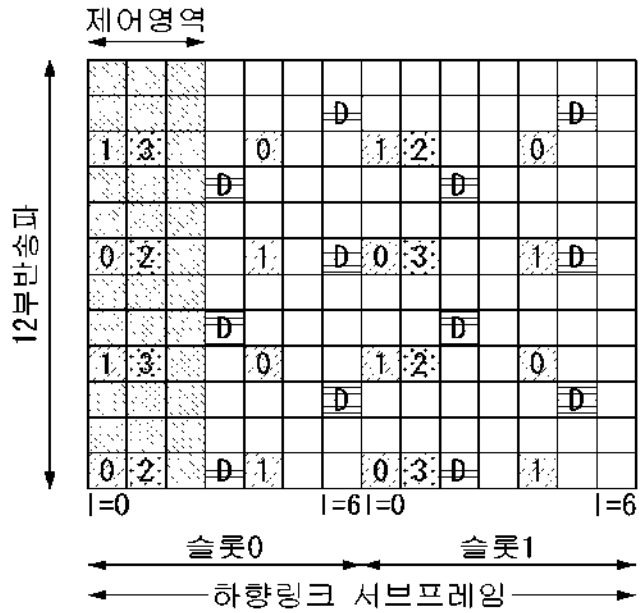

60MHz
20MHz
20MHz
20MHz
DL 컴포넌트 캐리어 A
DL 컴포넌트 캐리어 B
DL 컴포넌트 캐리어 C
PDCCH
PDSCH
서브프레임
UL 컴포넌트 캐리어 A
UL 컴포넌트 캐리어 B
UL 컴포넌트 캐리어 C
PUSCH
서브프레임
(b) 멀티플 CC
20MHz
DL 컴포넌트 캐리어
PDCCH
PDSCH
서브프레임
UL 컴포넌트 캐리어
PUSCH
서브프레임
(a) 단일 CC

[도8]

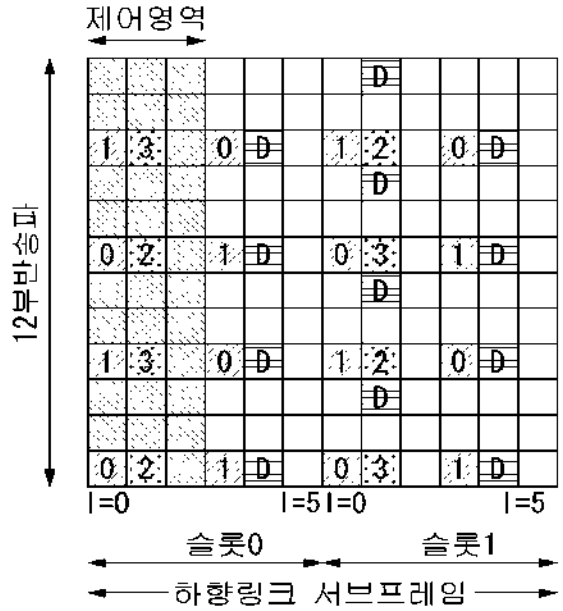

UE
eNB
1.
Ramdom Access Preamble
Ramdom Access Response
2.
3.
Schedulded Transmission
Contention resolution
4.

[도9]

(a)

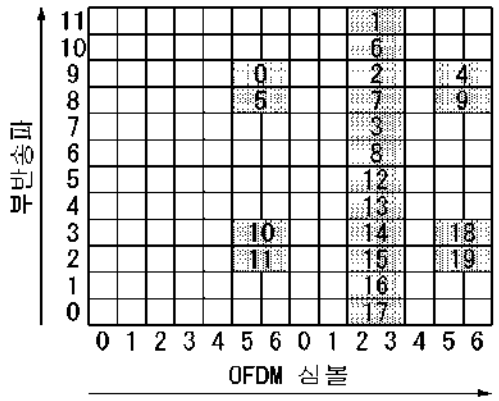

제어영역
12부반송파
l=0
l=6
l=0
l=6
슬롯0
슬롯1
하향링크 서브프레임

(b)

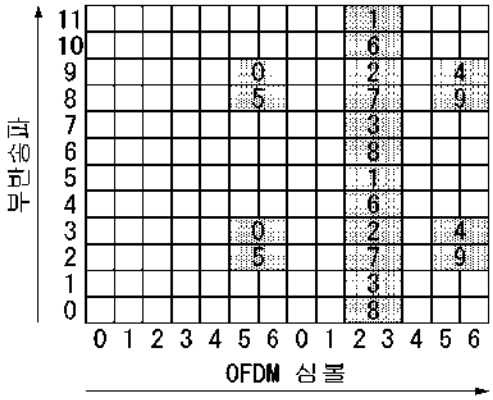

제어영역
12부반송파
l=0
l=5
l=0
l=5
슬롯0
슬롯1
하향링크 서브프레임

[도10]

(a) 1개 또는 2개 CSI-RS 포트



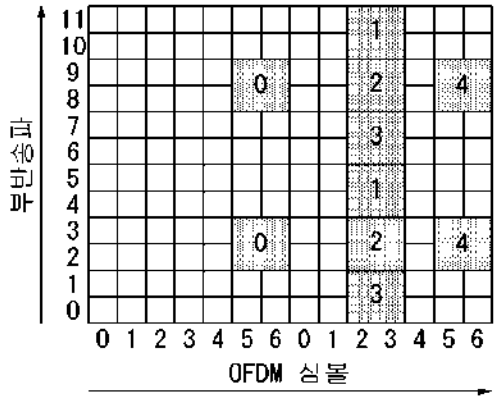
(b) 4개 CSI-RS 포트



ⓘ :1개 또는 2개 CSI-RS 포트를 위해 이용가능한 CSI-RS 구성 i

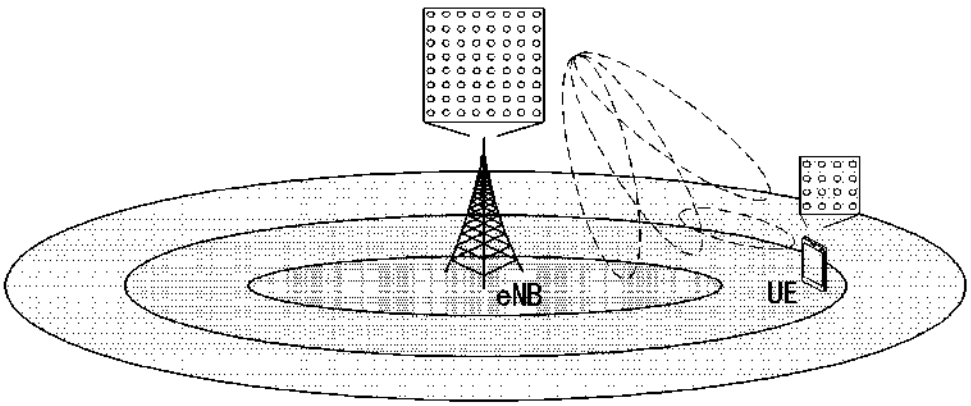
ⓘ :4개 CSI-RS 포트를 위해 이용가능한 CSI-RS 구성 i

(c) 8개 CSI-RS 포트

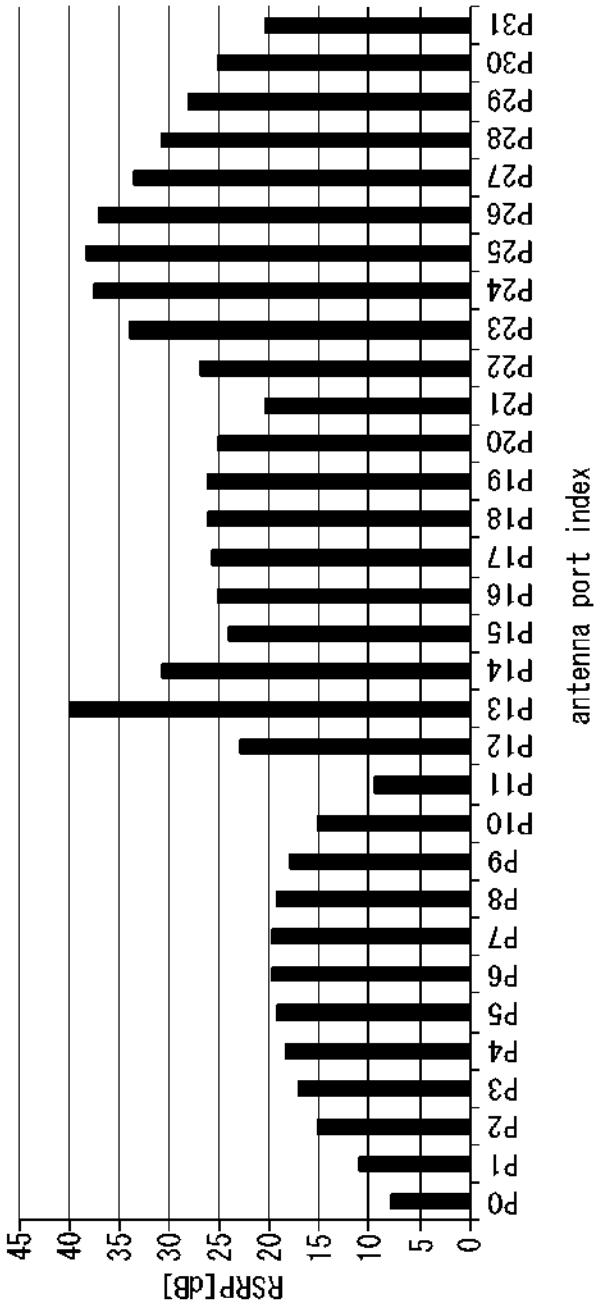


ⓘ :8개 CSI-RS 포트를 위해 이용가능한 CSI-RS 구성 i

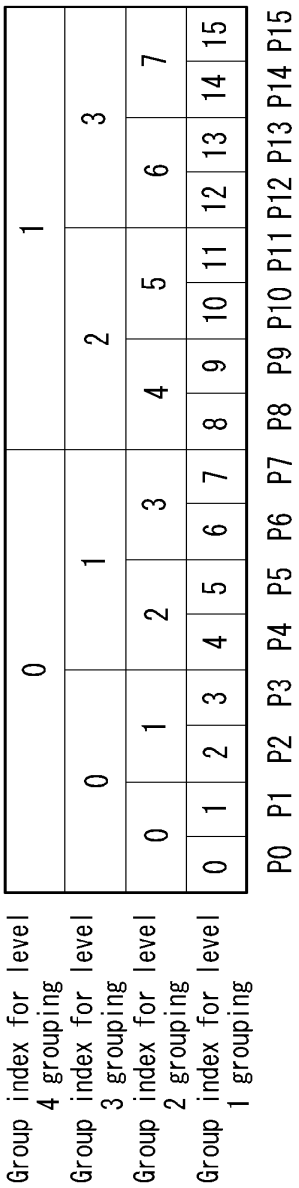
[도11]



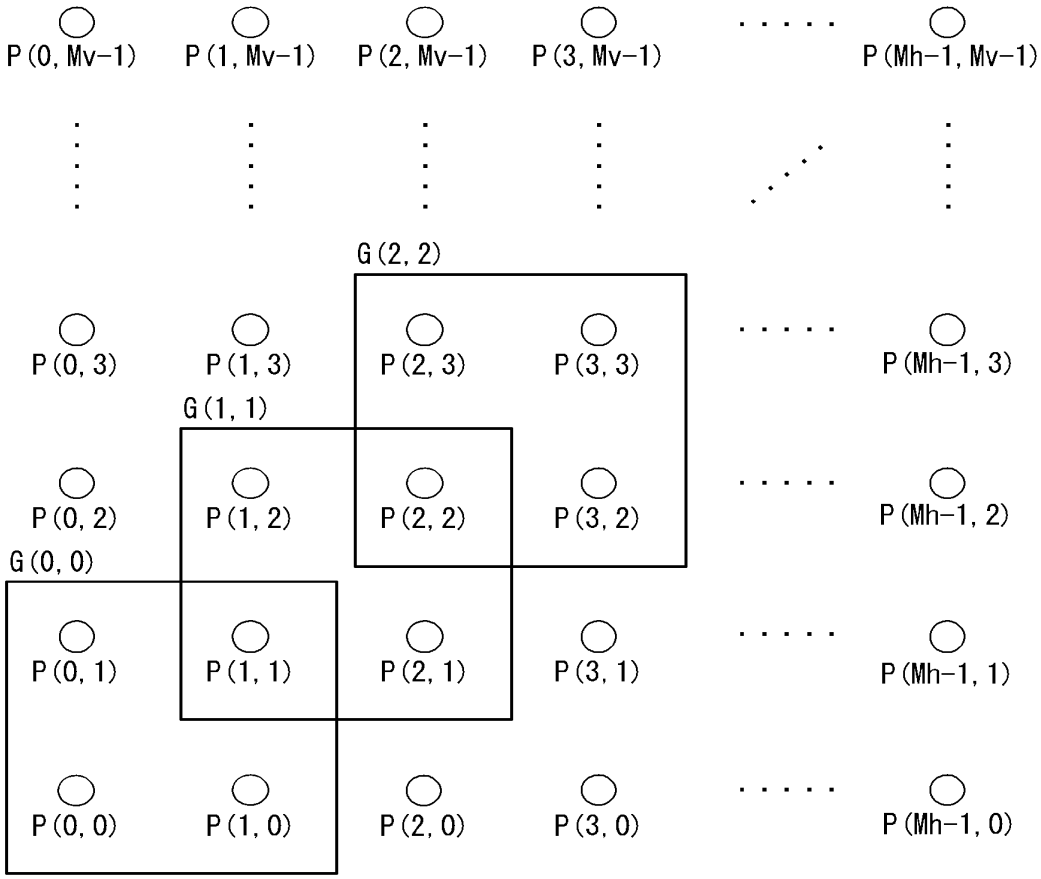
[도12]


RSRP[dB]
45
40
35
30
25
20
15
10
5
0
antenna port index
P0
P1
P2
P3
P4
P5
P6
P7
P8
P9
P10
P11
P12
P13
P14
P15
P16
P17
P18
P19
P20
P21
P22
P23
P24
P25
P26
P27
P28
P29
P30
P31

[도13]


Group index for level 4 grouping
Group index for level 3 grouping
Group index for level 2 grouping
Group index for level 1 grouping
0
1
0
1
2
3
0
1
2
3
4
5
6
7
0
1
2
3
4
5
6
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15
P0 P1 P2 P3 P4 P5 P6 P7 P8 P9 P10 P11 P12 P13 P14 P15

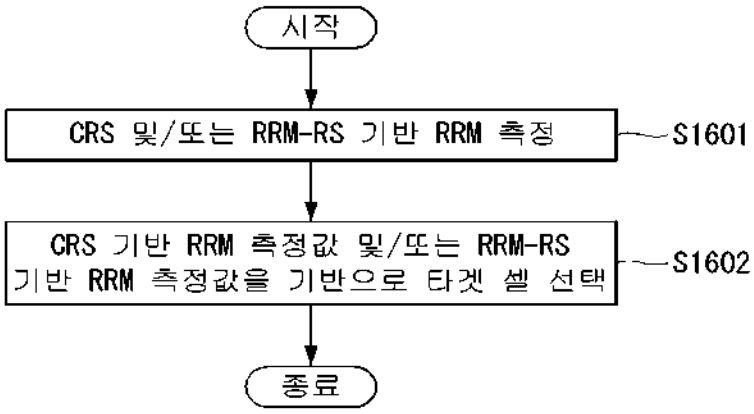
[도14]


P(0, Mv-1)
P(1, Mv-1)
P(2, Mv-1)
P(3, Mv-1)
P(Mh-1, Mv-1)
G(2, 2)
P(0, 3)
P(1, 3)
P(2, 3)
P(3, 3)
P(Mh-1, 3)
G(1, 1)
P(0, 2)
P(1, 2)
P(2, 2)
P(3, 2)
P(Mh-1, 2)
G(0, 0)
P(0, 1)
P(1, 1)
P(2, 1)
P(3, 1)
P(Mh-1, 1)
P(0, 0)
P(1, 0)
P(2, 0)
P(3, 0)
P(Mh-1, 0)

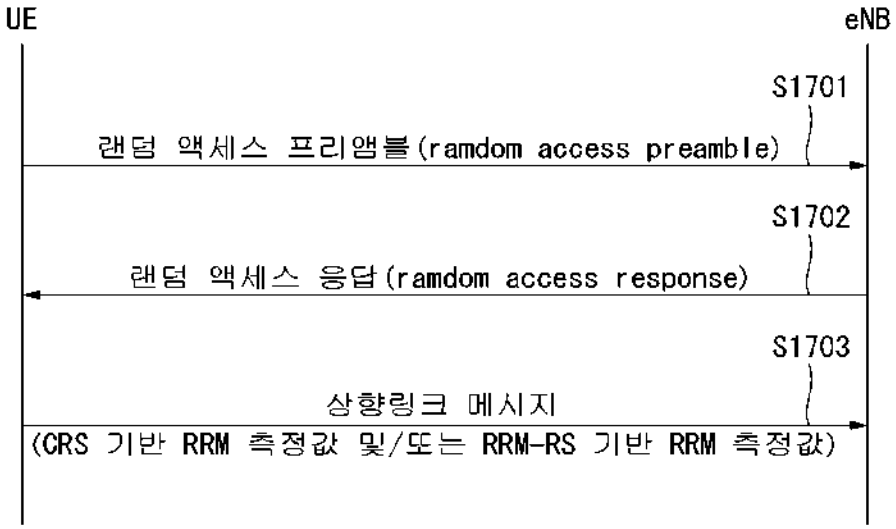
[도15]


UE
eNB
S1501
시스템 정보 (RRM-RS 설정 정보)

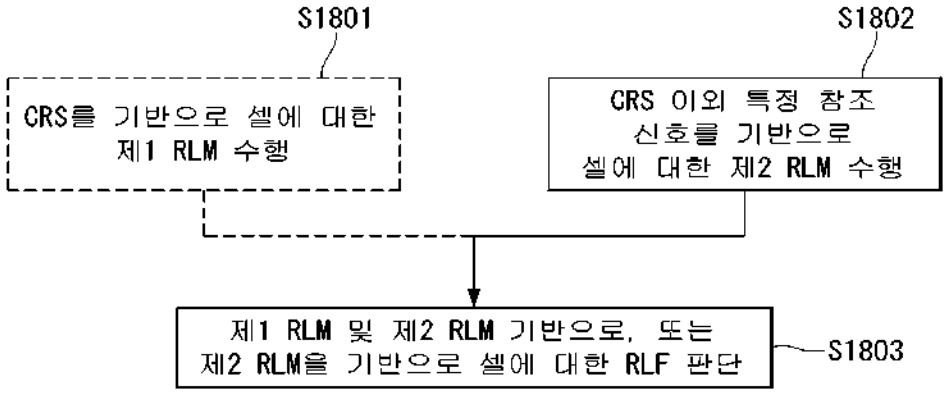
[도16]


시작
CRS 및/또는 RRM-RS 기반 RRM 측정
S1601
CRS 기반 RRM 측정값 및/또는 RRM-RS 기반 RRM 측정값을 기반으로 타겟 셀 선택
S1602
종료

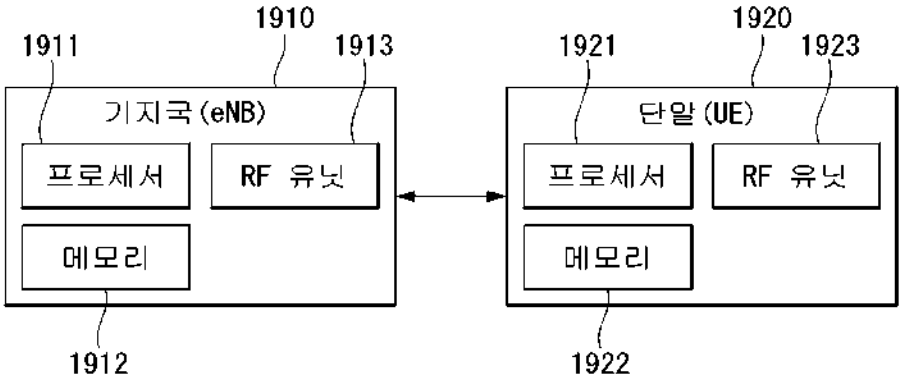
[도17]


UE
eNB
S1701
랜덤 액세스 프리앰블(ramdom access preamble)
S1702
랜덤 액세스 응답(ramdom access response)
S1703
상향링크 메시지
(CRS 기반 RRM 측정값 및/또는 RRM-RS 기반 RRM 측정값)

[도18]


S1801
CRS를 기반으로 셀에 대한 제1 RLM 수행
S1802
CRS 이외 특정 참조 신호를 기반으로 셀에 대한 제2 RLM 수행
제1 RLM 및 제2 RLM 기반으로, 또는 제2 RLM을 기반으로 셀에 대한 RLF 판단
S1803

[도19]


1910
1911
1913
기지국(eNB)
프로세서
RF 유닛
메모리
1912
1920
1921
1923
단말(UE)
프로세서
RF 유닛
메모리
1922

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2016/000945

A. CLASSIFICATION OF SUBJECT MATTER

H04B 17/382(2014.01)i, H04B 7/04(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04B 17/382; H04W 24/00; H04W 56/00; H04W 24/10; **H**04W 24/08; **H**04B 7/04

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Utility models and applications for Utility models: IPC as above
Japanese Utility models and applications for Utility models: IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS (KIPO internal) & Keywords: radio link monitoring(RLM: radio link monitoring), CRS, primary RLM, secondary RLM, radio link failure (RLF: radio link failure), determination condition, different, control channel transmission parameter, out-of-sync (out-of-sync)/in-sync(in-sync), RLF timer, DCI, EPDCCH, FD-MIMO, cell section, cell resection, RNTI, CSI-RS, DRS, amorphous cell

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2014-093659 A (NTT DOCOMO, INC.) 19 May 2014 See paragraphs [0020]-[0063]; and figures 4-8.	1-4,7,9,14,15
Y		5,6
A		8,10-13
Y	SONY, "On Reference Signals from RRM Measurements in FD-MIMO", R1-145022, 3GPP TSG RAN WG1 #79, San Francisco, USA, 08 November 2014 See pages 1, 2.	5,6
A	US 2014-0043988 A1 (QUALCOMM INCORPORATED) 13 February 2014 See paragraphs [0056]-[0065]; claims 1, 12, 16-20; and figure 5.	1-15
A	WO 2014-068535 A2 (RENESAS MOBILE CORPORATION) 08 May 2014 See page 10, line 20-page 16, line 11; and figures 3, 4.	1-15
A	US 2013-0252606 A1 (NIMBALKER, Ajit et al.) 26 September 2013 See paragraphs [0048]-[0065]; and figures 4, 5.	1-15

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
04 MAY 2016 (04.05.2016)	**04 MAY 2016 (04.05.2016)**
Name and mailing address of the ISA/KR Korean Intellectual Property Office Government Complex-Daejeon, 189 Seonsa-ro, Daejeon 302-701, Republic of Korea Facsimile No. 82-42-472-7140	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2016/000945

Patent document cited in search report	Publication date	Patent family member	Publication date
JP 2014-093659 A	19/05/2014	EP 2916581 A1	09/09/2015
		US 2015-0296487 A1	15/10/2015
		WO 2014-069382 A1	08/05/2014
US 2014-0043988 A1	13/02/2014	CN 104509018 A	08/04/2015
		KR 10-1551743 B1	09/09/2015
		KR 10-2015-0041007 A	15/04/2015
		US 8976698 B2	10/03/2015
		WO 2014-025380 A1	13/02/2014
WO 2014-068535 A2	08/05/2014	GB 201219885 D0	19/12/2012
		GB 2507570 A	07/05/2014
		WO 2014-068535 A3	24/07/2014
US 2013-0252606 A1	26/09/2013	CN 104303562 A	21/01/2015
		EP 2829130 A1	28/01/2015
		US 8971881 B2	03/03/2015
		WO 2013-142222 A1	26/09/2013
		WO 2013-142222 A8	16/10/2014

Form PCT/ISA/210 (patent family annex) (January 2015)

국 제 조 사 보 고 서

국제출원번호
PCT/KR2016/000945

A. 발명이 속하는 기술분류(국제특허분류(IPC))

H04B 17/382(2014.01)i, H04B 7/04(2006.01)i

B. 조사된 분야

조사된 최소문헌(국제특허분류를 기재)

H04B 17/382; H04W 24/00; H04W 56/00; H04W 24/10; H04W 24/08; H04B 7/04

조사된 기술분야에 속하는 최소문헌 이외의 문헌

한국등록실용신안공보 및 한국공개실용신안공보: 조사된 최소문헌란에 기재된 IPC

일본등록실용신안공보 및 일본공개실용신안공보: 조사된 최소문헌란에 기재된 IPC

국제조사에 이용된 전산 데이터베이스(데이터베이스의 명칭 및 검색어(해당하는 경우))

eKOMPASS(특허청 내부 검색시스템) & 키워드: 무선 링크 모니터링 (RLM: radio link monitoring), 셀 특정 참조 신호 (CRS), 제1 RLM, 제2 RLM, 무선 링크 실패 (RLF: radio link failure), 판단 조건, 상이, 싱크 체넌 전송 파라미터, 비동기(out of sync)/동기(in sync), RLF 타이머, DCI, EPDCCH, FD-MIMO, 셀 선택, 셀 재선택, RNTI, CSI-RS, DRS, 무정형 셀

C. 관련 문헌

카테고리*	인용문헌명 및 관련 구절(해당하는 경우)의 기재	관련 청구항
X	JP 2014-093659 A (NTT DOCOMO, INC.) 2014.05.19 단락 [0020]-[0063]; 및 도면 4-8 참조.	1-4,7,9,14,15
Y		5,6
A		8,10-13
Y	SONY, 'On reference signals from RRM measurements in FD-MIMO', R1-145022, 3GPP TSG RAN WG1 #79, San Francisco, USA, 2014.11.08 페이지 1, 2 참조.	5,6
A	US 2014-0043988 A1 (QUALCOMM INCORPORATED) 2014.02.13 단락 [0056]-[0065]; 청구항 1, 12, 16-20; 및 도면 5 참조.	1-15
A	WO 2014-068535 A2 (RENESAS MOBILE CORPORATION) 2014.05.08 페이지 10, 라인 20 - 페이지 16, 라인 11; 및 도면 3, 4 참조.	1-15
A	US 2013-0252606 A1 (AJIT NIMBALKER 등) 2013.09.26 단락 [0048]-[0065]; 및 도면 1, 5 참조.	1-15

☐ 추가 문헌이 C(계속)이 기재되어 있습니다.

☒ 대응특허에 관한 별지를 참조하십시오.

* 인용된 문헌의 특별 카테고리

"A" 특별히 관련이 없는 것으로 보이는 일반적인 기술수준을 정의한 문헌

"B" 국제출원일보다 빠른 출원일 또는 우선일을 가지나 국제출원일 이후에 공개된 선출원 또는 특허 문헌

"L" 우선권 주장에 의문을 제기하는 문헌 또는 다른 인용문헌의 공개일 또는 다른 특별한 이유(이유를 명시)를 밝히기 위하여 인용된 문헌

"O" 구두 개시, 사용, 전시 또는 기타 수단을 언급하고 있는 문헌

"P" 우선일 이후에 공개되었으나 국제출원일 이전에 공개된 문헌

"T" 국제출원일 또는 우선일 후에 공개된 문헌으로, 출원과 상충하지 않으며 발명의 기초가 되는 원리나 이론을 이해하기 위해 인용된 문헌

"X" 특별한 관련이 있는 문헌. 해당 문헌 하나만으로 청구된 발명의 신규성 또는 진보성이 없는 것으로 본다.

"Y" 특별한 관련이 있는 문헌. 해당 문헌이 하나 이상의 다른 문헌과 조합하는 것으로 그 조합이 당업자에게 자명한 경우 청구된 발명은 진보성이 없는 것으로 본다.

"&" 동일한 대응특허문헌에 속하는 문헌

국제조사의 실제 완료일	국제조사보고서 발송일
2016년 05월 04일 (04.05.2016)	2016년 05월 04일 (04.05.2016)

ISA/KR의 명칭 및 우편주소
대한민국 특허청
(35208) 대전광역시 서구 청사로 189,
4동 (둔산동, 정부대전청사)
팩스 번호 +82-42-481-8578

심사관
김희곡
전화번호 +82-42-481-8264

서식 PCT/ISA/210 (두 번째 용지) (2015년 1월)

국 제 조 사 보 고 서
대응특허에 관한 정보

국제출원번호
PCT/KR2016/000945

국제조사보고서에서 인용된 특허문헌	공개일	대응특허문헌	공개일
JP 2014-093659 A	2014/05/19	EP 2916581 A1	2015/09/09
		US 2015-0296487 A1	2015/10/15
		WO 2014-069382 A1	2014/05/08
US 2014-0043988 A1	2014/02/13	CN 104509018 A	2015/04/08
		KR 10-1551743 B1	2015/09/09
		KR 10-2015-0041007 A	2015/04/15
		US 8976698 B2	2015/03/10
		WO 2014-025380 A1	2014/02/13
WO 2014-068535 A2	2014/05/08	GB 201219885 D0	2012/12/19
		GB 2507570 A	2014/05/07
		WO 2014-068535 A3	2014/07/24
US 2013-0252606 A1	2013/09/26	CN 104303562 A	2015/01/21
		EP 2829130 A1	2015/01/28
		US 8971881 B2	2015/03/03
		WO 2013-142222 A1	2013/09/26
		WO 2013-142222 A8	2014/10/16

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
16 February 2017 (16.02.2017)

WIPO | PCT

(10) International Publication Number
WO 2017/026983 A1

(51) International Patent Classification:
H04L 5/00 (2006.01) *H04W 88/06* (2009.01)
H04L 27/26 (2006.01) *H04W 84/00* (2009.01)

(21) International Application Number:
PCT/US2015/000466

(22) International Filing Date:
26 December 2015 (26.12.2015)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/203,301 10 August 2015 (10.08.2015) US

(71) Applicant: **INTEL CORPORATION** [US/US]; 2200 Mission College Boulevard, Santa Clara, CA 95054 (US).

(72) Inventors: **KHORYAEV, Alexey**; Rybinskaya Street 75-34, Nizhny Novgo, 603105 (RU). **CHERVYAKOV, Andrey**; Volodarskogo Str. 7-47, Nizhny Novgorod, Niz, 603006 (RU). **BELOV, Dmitry**; Mechnikov Str. 73, Apt. 134, Nizhny Novgorod, Niz, 603148 (RU). **SHILOV, Mikhail**; N. Rybakova Str 16-59, Nizhny Novgorod, Niz, 603054 (RU).

(74) Agent: **OLSON, Jared**; Ledell Ansari, LLP, c/o Cpa Global, P.O. Box 52050, Minneapolis, MN 55402 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

(54) **Title**: ENHANCED PHYSICAL SIGNAL STRUCTURE FOR LTE V2V COMMUNICATIONS

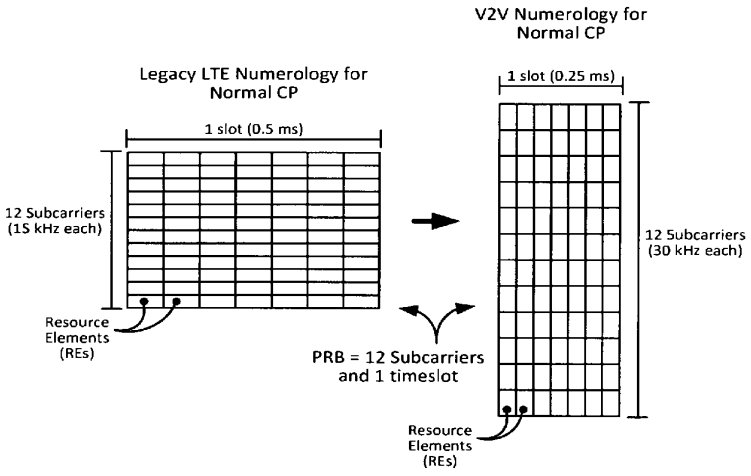


Fig. 4

(57) **Abstract**: A vehicle may wirelessly communicate with another vehicle via a physical channel (a vehicle-to-vehicle (V2V) channel) that is robust and reliable under high mobility propagation conditions. The physical channel may be created by modifying an existing long-term evolution (LTE) physical channel, such as an LTE sidelink (SL) channel. For instance, the V2V physical channel may be created by increasing, by a particular factor, the subcarrier spacing of legacy LTE channels (e.g., from 15 kilohertz (kHz) to 30 kHz). Additionally, a symbol duration and a fast Fourier transform (FFT) size for the V2V physical channel may each be reduced by the same factor. Doing so may enable the V2V physical channel to be implemented without significant modifications to other aspects of the LTE standard.

WO 2017/026983 A1

ENHANCED PHYSICAL SIGNAL STRUCTURE FOR LTE V2V COMMUNICATIONS

RELATED APPLICATIONS

The present application claims the benefit of U.S. Provisional Patent Application No. 62/203,301, which was filed on August 10, 2015, the contents of which are hereby incorporated by reference as though fully set forth herein.

BACKGROUND

The so-called "connected car concept" includes the idea that vehicles may be enabled to communicate wirelessly with one another. The 3GPP (3rd Generation Partnership Project) Long Term Evolution (LTE) communications standard has been proposed as the communication standard for implementing the connected car concept (also referred to as vehicle-to-vehicle (V2V) communications). V2V communications include one vehicle establishing a direct connection with one or multiple other vehicles.

Examples of such connections may include an LTE sidelink connection (also referred as direct connection, a proximity services (ProSe) connection, a device-to-device (D2D) connection, etc.). Once connected, vehicles may communicate a variety of information to each other, such as location information, velocity information, acceleration information, directional information, performance information, and more. Such information may be used to provide a variety of functionalities, such as preventing car accidents, determining driving conditions (e.g., traffic jams, icy roads, car accidents, etc.), determining optimal routes for driving from one location to another, etc.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments described herein will be readily understood by the following detailed description in conjunction with the accompanying drawings. To facilitate this description, like reference numerals may designate like structural elements. Embodiments are illustrated by way of example and not by way of limitation in the figures of the accompanying drawings.

Fig. 1 is a diagram of an example environment in which systems and/or methods described herein may be implemented;

Fig. 2 is a diagram illustrating an example process for sending information to another vehicle;

Fig. 3 is a diagram illustrating an example process for receiving information from another vehicle;

Fig. 4 is a diagram of an example physical resource block (PRB) of a legacy long term evolution (LTE) numerology and an example PRB of a vehicle-to-vehicle (V2V) numerology, under normal cyclic prefix (CP) conditions;

Fig. 5 is a diagram of an example PRB of a legacy LTE numerology and an example PRB of a V2V numerology, under extended CP conditions;

Fig. 6 is a diagram of example PRB pairs of a legacy LTE numerology and example PRB pairs of a V2V numerology, under normal CP conditions;

Fig. 7 is a diagram of example PRB pairs of a legacy LTE numerology and PRB pairs of a V2V numerology, under extended CP conditions;

Figs. 8A-8D are diagrams of example PRBs according to one or more embodiments described herein;

Figs. 9A-9D are diagrams of example PRBs according to one or more embodiments described herein;

Fig. 10 is a table of example characteristics of a legacy LTE numerology and a V2V numerology with 30 kilohertz (kHz) subcarrier spacing;

Fig. 11 is a table of example characteristics of a legacy LTE numerology and a V2V numerology with 60 kHz subcarrier spacing;

Fig. 12 is a table representing an example of legacy LTE and V2V transmission multiplexing; and

Fig. 13 illustrates, for one embodiment, example components of an electronic device.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The following detailed description refers to the accompanying drawings. The same reference numbers in different drawings may identify the same or similar elements. It is to be understood that other embodiments may be utilized and structural or logical changes may be made without departing from the scope of the present disclosure. Therefore, the following detailed description is not to be taken in a limiting sense, and the scope of embodiments defined by the appended claims and their equivalents.

As mentioned above, the 3GPP (3rd Generation Partnership Project) Long Term Evolution (LTE) communications standard has been proposed as the communication standard for vehicle-to-vehicle (V2V) communications. One reason behind the proposal is the reliability and high data rate capabilities of LTE technology. However, the current LTE standard includes

certain limitations when it comes to enabling vehicles to communicate with one another directly. For example, legacy LTE sidelink (SL) physical channels (also referred to as PC5 channels or device-to-device (D2D) channels) are considered to be used or enable V2V communications. At the same time, the legacy SL physical channels were designed with an assumption of substantially lower mobility conditions than the ones considered to be used for V2V communication (e.g., a scenario in which two vehicles are driving toward one another at 140 kilometers per hour (km/h) each). As a result, when subjected to wireless propagation in high mobility conditions (that may cause high Doppler fading and/or frequency shifts), legacy LTE physical channels may experience an unacceptably high block error rate (BLER) performance and/or use an unacceptably high signal-to-interference-noise ratio (SINR) to achieve reliable performance for V2V wireless communication.

Techniques described herein may be used to provide a physical channel (referred to herein as "V2V physical channel") of greater robustness and reliability when subjected to the high mobility conditions of V2V communications. For example, a V2V physical channel may have increased subcarrier spacing (e.g., 30 kilohertz (kHz) subcarriers) instead of the 15 kHz subcarrier spacing used in legacy LTE SL physical channels. The increased subcarrier spacing may improve physical channel robustness (particularly under high mobility wireless propagation effects) via a reduction of the impacts of frequency offset errors on the subcarriers orthogonality, reduced channel variations on the packet transmission duration, etc.

In some embodiments, the V2V physical channel may include additional alterations from current LTE SL physical channels. For example, the V2V physical channel may include a reduced symbol duration (e.g., a single-carrier frequency-division multiple access (SC-FDMA) symbol duration, etc.). The decrease in symbol duration may be proportional to the increased subcarrier spacing. For instance, if the subcarrier spacing of the V2V physical channel is twice as large as subcarrier spacing of a legacy LTE SL physical channel (e.g., 30 kHz instead of 15 kHz), the symbol duration for the V2V physical channel may be halved. Additionally, the decrease in symbol duration may be accompanied by a similar decrease (e.g., half) to a fast Fourier transform (FTT) size.

Additionally, since LTE air interfaces currently implement physical resource blocks (PRBs) as a fundamental unit of allocation for air interface resources, the techniques described herein may include one or more PRB formats for implementing the enhancements described above regarding modified subcarrier spacing and symbol duration of the V2V physical channels. For instance, a PRB of the V2V physical channel may

include time-domain changes, such as a change in the duration of each PRB and/or the number of slots per PRB. Similarly, a PRB of the V2V channel may include frequency-domain changes, such as the number of subcarriers per PRB, the PRB size in terms of frequency, etc. PRB formats may be discussed herein in terms of numerologies (e.g., legacy LTE numerologies and V2V numerologies), which may include a representation of subcarriers, slot durations, and resource elements (REs) of a PRB or PRB pair.

In some embodiments, the techniques described herein may be implemented within the context of cyclic prefixing (CP). For example, in the 3GPP LTE communication standard, CP may include copying a portion of one symbol (e.g., an end portion of the symbol) and adding the copied portion to a beginning portion of the symbol, such that the symbol begins and ends with the same portion. Doing so may, for example, reduce inter-symbol interference.

Fig. 1 is a diagram of an example environment 100 in which systems and/or methods described herein may be implemented. Environment 100 may include one or more vehicles with vehicle-to-X (V2X) devices 110, user equipment devices (UEs) 120, and network 130.

V2X device 110 may include a computing and communication device installed in a vehicle, such as a car, a truck, a sports utility vehicle (SUV), etc. V2X device 110 may be capable of gathering, processing, and communicating information regarding the vehicle in which V2X device 110 is installed. Examples of such information may include vehicle performance information, vehicle location information, vehicle usage information, vehicle status information, vehicle diagnostic information, etc. In some embodiments, V2X device 110 may be capable over gathering, processing, and communicating other types of information, such as information relating to a driver or passenger of the vehicle. V2X device 110 may be an example of user equipment device (UE) or another type of end terminal.

As shown, V2X device 110 may be capable of communicating with one or more networks or devices, such as UE 120, the V2X device of another vehicle, network 130, etc. In some embodiments, V2X device 110 may do so by establishing a connection that is based on a particular communications standard, such as the 3GPP LTE communication standard. For instance, V2X device 110 may establish a vehicle-to-pedestrian (V2P) connection with UE 120, which may include a D2D connection, an LTE SL connection, or other type of direct connection. V2X device 110 may also, or alternatively, establish a vehicle-to-infrastructure/network (V2I) connection with network 130. The V2I connection may include a standard connection with a base station (e.g., an evolved Node B (eNB)), a wireless access point (AP), or another device capable of enabling V2X device 110 to communicate with network 130.

As such, the "X" in "V2X device," may represent an ability of V2X device 110 to communicate with one or more types of devices (e.g., other V2X devices, UEs 120, a base station, a network access point (AP), etc.).

Additionally, or alternatively, V2X device 110 may establish a V2V connection with the V2X device of another vehicle. The V2V connection may include a D2D connection, an LTE SL connection, or other type of direct connection between UEs (e.g., a connection that does not, for example, include network 130). In some embodiments, V2X device 110 may be capable of communicating with other V2X devices using one or more of the techniques described herein. For example, V2X device 110 may be capable of using a V2V physical channel that ensure improved robustness and reliability when subjected to the high mobility conditions of V2V communications. The V2V physical channel may, for example, include greater subcarrier spacing and reduced symbol durations to, for example, improve demodulation performance including BLER reduction but still operating within the framework of an established communications standard (such as the 3GPP LTE communications standard).

UE 120 may include a portable computing and communication device, such as a personal digital assistant (PDA), a smart phone, a cellular phone, a laptop computer with connectivity to a cellular wireless network, a tablet computer, etc. UE 120 may also include non-portable computing devices, such as a desktop computer, a consumer or business appliance, or other devices that have the ability to connect to network 130. UE 120 may also include a computing and communication device that may be worn by a user (also referred to as wearable devices) as a watch, a fitness band, a necklace, glasses, an eyeglass, a ring, a belt, a headset, or another type of wearable device. As shown, UE 120 may establish a direct connection (e.g., a D2D connection) with V2X device 110. Additionally, UE 120 may communicate with V2X device 110 regarding the vehicle of V2X device 110, a driver or passenger of the vehicle, a user of UE 120, a location of the vehicle with respect to the user of UE 120, etc.

Network 130 may include one or more wired and/or wireless networks. For example, network 130 may include an LTE network. In some embodiments, network 130 may include one or more additional networks, such as a cellular network (e.g., a second generation (2G) network, a third generation (3G) network, a fourth generation (4G) network, a fifth generation (5G) network, a global system for mobile (GSM) network, a code division multiple access (CDMA) network, an evolution-data optimized (EVDO) network, or the like), a public land mobile network (PLMN), and/or another network. Additionally, or alternatively, network 150 may include a local area network (LAN), a wireless LAN (WLAN), a wide area network (WAN), a metropolitan network (MAN), the Public Switched Telephone Network (PSTN), an

ad hoc network, a managed IP network, a virtual private network (VPN), an intranet, the Internet, a fiber optic-based network, and/or a combination of these or other types of networks.

The quantity of devices and/or networks, illustrated in Fig. 1, is provided for explanatory purposes only. In practice, there may be additional devices and/or networks; fewer devices and/or networks; different devices and/or networks; or differently arranged devices and/or networks than illustrated in Fig. 1. Alternatively, or additionally, one or more of the devices of environment 100 may perform one or more functions described as being performed by another one or more of the devices of system 100. Furthermore, while "direct" connections are shown in Fig. 1, these connections should be interpreted as logical communication pathways, and in practice, one or more intervening devices (e.g., routers, gateways, modems, switches, hubs, etc.) may be present.

Additionally, while some of the techniques described herein may involve V2V communications as an example, the techniques described herein may be applied to various scenarios and/or other types of communications. For example, techniques described herein may be applicable to time division duplexing (TDD) or frequency division duplexing (FDD) communications. In some embodiments, techniques described herein may be applied to all of downlink (DL), uplink (UL), and sidelink (SL) communications, while other embodiments may only apply the techniques described herein to DL or UL or SL communications. Additionally, while the techniques described herein may be described within the context of the 3GPP LTE communications standard, the techniques may also be applied to other communication standards. Additionally, while examples provided herein may include enabling vehicles to communicate with one another more reliably, the techniques described herein may be applied to other scenarios as well (such as another system or device that may experience significant Doppler fading conditions when attempting to communicate wirelessly).

Fig. 2 is a diagram illustrating an example process 200 for sending information to another vehicle. Process 200 may be particularly appropriate for devices capable of wireless communications that may be subjected to high mobility propagation conditions (e.g., wireless propagation in high mobility conditions characterized by high Doppler fading and/or frequency shifts that may jeopardize the integrity or reliability of the wireless communications). Process 200 may be implemented by, for example, V2X device 110. Additionally, process 200 provides an example of how a V2V physical channel may be used; however, it should be noted that the V2V physical channel, as described herein, may

be used in additional and alternative ways, which may include fewer, additional, and/or alternative operations than the operations described below with reference to Fig. 2.

As shown, process 200 may include identifying a physical channel that is appropriate for communicating with another vehicle (block 210). For example, in some embodiments, V2X device 110 may be capable of using multiple physical channels for communicating with another vehicle. As described above, examples of such channels may include an LTE SL physical channel, a V2V physical channel (as described herein), etc. In some embodiments, V2X device 110 may identify the appropriate physical channel based on one or more factors.

Examples of such factors may include whether the physical channel will likely be subjected to high mobility propagation conditions. For instance, if the vehicle of the V2X device 110 and/or the other vehicle are traveling at a high speed, V2X device 110 may determine that communications between the vehicles are likely to be subjected to such conditions. As such, a V2V physical channel (as opposed to, for example, a legacy LTE SL channel) may be appropriate for communicating with the other vehicle.

Another example of a factor that may be considered by V2X device 110 may include the communication capabilities of the other vehicle. For example, V2X device 110 may determine the types of physical channels that the other vehicle is capable of using and select the most appropriate physical channel from on the physical channels that the other vehicle is capable of using. In some embodiments, determining the communication capabilities of the other vehicle may include determining what type of communications device is being implemented by the other vehicle (e.g., a V2X device or another type of communications device).

Additional examples of factors that may be used to identify an appropriate physical channel may include physical channel availability (e.g., whether V2X device is already using one or more physical channels), a measure of importance regarding the information (or type of information) that is to be sent to the other vehicle (e.g., less important information may be allocated with less reliable physical channels), a measure of importance of other information that is to communicated to a different vehicle, etc. In yet another example, V2X device may implement one or more rules for prioritizing which type of physical channel (e.g., an LTE SL channel, a V2V physical channel, etc.) should be implemented in light of one or more of the factors described above.

Process 200 may include generating information to communicate to the vehicle (block 220). For example, V2X device 110 may generate the information that is to be

transmitted to the other vehicle. Examples of such information may include vehicle performance information, vehicle location information, vehicle usage information, vehicle status information, vehicle diagnostic information, information relating to a driver or passenger of the vehicle, etc.

Process 200 may include processing the information based on the physical channel identified for communicating with the other vehicle (block 230). For example, V2X device 110 may arrange the information in accordance with a particular PRB format, which may be particular to the type of physical channel identified as the suitable for communicating with the other vehicle. For instance, if the identified physical channel corresponds to a currently available physical channel (such as an LTE LS physical channel), the information may be allocated to accommodate a format where a PRB includes 12 subcarriers (also referred to herein as frequency REs) with 15 kHz subcarrier spacing and 1 slot of 0.5 ms duration in time. However, if the identified physical channel corresponds to a V2V physical channel, the information may be allocated to accommodate a format where a PRB includes 12 subcarriers with 30 kHz subcarrier spacing and 1 slot of 0.25 ms duration in time. Alternatively, for V2V physical channel, the information may be allocated to accommodate a format where a PRB includes 12 subcarriers with 60 kHz subcarrier spacing and 1 slot of 0.125 ms duration in time. Additional examples of PRB formats are discussed below with reference to Figs. 4-9.

Process 200 may include using the physical channel to communicate information to vehicle (block 240). For example, V2X device 110 may use the physical channel identified as being appropriate for communicating with the vehicle to transmit the information to the vehicle. As described above, the physical channel may include a legacy channel (such as an LTE SL channel) or a V2V physical channel, and the information may be formatted in accordance with a format (e.g., a PRB format) that is particular to the physical channel used to transmit the information.

Fig. 3 is a diagram illustrating an example process 300 for receiving information from another vehicle. Process 300 may be particularly appropriate for devices capable of wireless communications that may be subjected to high mobility conditions (e.g., that may cause high Doppler fading and/or frequency shifts) during V2V communications. Process 300 may be implemented by, for example, V2X device 110.

As shown, process 300 may include receiving information from another vehicle via a physical channel (block 310). For example, V2X device 110 may be capable of using physical channels for communicating with another vehicle. As described above, examples

of such channels may include an LTE SL channel, a V2V physical channel, etc. The information sent and received between vehicles may include vehicle performance information, vehicle location information, vehicle usage information, vehicle status information, vehicle diagnostic information, information relating to a driver or passenger of the vehicle, etc.

Process 300 may include determining a physical channel type corresponding to the physical channel (block 320). For example, V2X device 110 may identify the type of physical channel (e.g., an LTE SL channel, a V2V channel, etc.) used to receive the information. In some embodiments, V2X device 110 may determine the manner in which the information is arranged in the physical channel based on the physical channel type may include. For example, if the physical channel corresponds to an LTE SL physical channel, the information may be formatted into PRBs that include 12 subcarriers with 15 kHz subcarrier spacing and 1 slot of 0.5 ms duration in time. In another example, if the physical channel corresponds to a V2V physical channel, the information may be formatted into PRBs that include 12 subcarriers with 30 kHz subcarrier spacing and 1 slot of 0.25 ms duration in time. Alternatively, for a V2V physical channel, the information may be allocated to accommodate a format where a PRB includes 12 subcarriers with 60 kHz subcarrier spacing and 1 slot of 0.125 ms duration in time. Additional examples of PRB formats are discussed below with reference to Figs. 4-9.

Process 300 may include interpreting the information based on the physical channel type of the physical channel (block 330). For example, V2X device 110 may interpret the information, received from another vehicle, based on a type of physical channel used to communicate the information. For instance, if the physical channel corresponds to an LTE LS physical channel, the information may be interpreted based on the assumption that the information was formatted into PRBs that include 12 subcarriers with 15 kHz subcarrier spacing and 1 slot of 0.5 ms duration in time. By contrast, if the physical channel corresponds to a V2V physical channel, the information may be interpreted based on the assumption that the information was formatted into PRBs that include 12 subcarriers with 30 kHz subcarrier spacing and 1 slot of 0.25 ms duration in time. Alternatively, for V2V physical channel, the information may be interpreted based on the assumption that the information was formatted into PRBs that include 12 subcarriers with 60 kHz subcarrier spacing and 1 slot of 0.125 ms duration in time.

Fig. 4 is a diagram of an example PRB of a legacy LTE numerology and an example PRB of a V2V numerology, under normal CP conditions. The legacy LTE numerology may correspond to a legacy LTE physical channel (e.g., an LTE SL channel), while the V2V

numerology may correspond to a V2V physical channel. A numerology, as discussed herein, may include parameters and characteristics of a physical channel (e.g., a legacy LTE SL channel or a V2V physical channel).

Such parameters and characteristics may include a bandwidth supported by the physical channel, a number of subcarriers per channel, a subcarrier spacing, a fast Fourier transform (FFT) size, a symbol duration, a slot duration, a subframe duration. Additional examples of numerological parameters and characteristics may include a direct, or indirect, description of a PRB and/or PRB pair of the physical channel, such as a number of subcarriers per PRB, a PRB duration (e.g., a number of slots per PRB), a number of resource elements (REs) per PRB, a number of symbols per PRB, etc.

Additionally, in the 3GPP LTE communication standard, CP may include copying a small portion of one symbol (e.g., an end portion of the symbol) and adding the copied portion to a beginning portion of the symbol, such that the symbol begins and ends with the same portion. Normal CP (as depicted in Figs. 4 and 6) may be implemented for wireless communications over shorter distances, while extended CP (as depicted in Figs. 5 and 7) may be implemented for wireless communications over longer distances. As such, normal CP may include a PRB of more symbols (or REs) per slot in time domain (e.g., 7), while extended CP may include a PRB of fewer symbols (or REs) per slot in time domain (e.g., 6).

As shown in Fig. 4, a PRB of the legacy LTE numerology for normal CP may include 12 subcarriers with 15 kHz subcarrier spacing, a slot of 0.5 ms in time domain comprising 7 consecutive symbols, and 84 REs in total. By contrast, the PRB of the V2V numerology for normal CP may include 12 subcarriers with 30 kHz subcarrier spacing, 1 slot of 0.25 ms in the time domain, comprising 7 consecutive symbols, and 84 REs in total. As such, each subcarrier of a V2V physical channel PRB may have twice as much subcarrier spacing as the subcarriers of the legacy LTE channel PRB; however, the duration of the slot of the V2V physical channel may be half the duration of the slot of the legacy LTE physical channel. As mentioned above, the decrease in slot duration may be accompanied by a similar decrease (e.g., a factor of 2, 4, etc.) to the FTT size associated with the V2V physical channel. Doing so may help ensure that the sampling time and/or sampling frequency of the V2V physical channel remains the same as the sampling time and sampling frequency of the legacy LTE channel.

For example, sampling time, as described herein, may include the basic time unit for the corresponding physical channel. For instance, in the 3GPP LTE communication standard, sampling time may be represented by "Ts" and may be equal to 1/(subcarrier spacing x FFT

size) (e.g., 1/(1500Hz x 2048)). By contrast, sampling frequency, as described herein, may include the basic frequency unit for a particular physical channel. For example, in the 3GPP LTE communication standard, sampling frequency may be represented by "Fs" and may be equal to subcarrier spacing (e.g., 15 kHz) multiplied by the number of FFT time samples (e.g., 2048).

As described above, a V2V channel may have increased subcarrier spacing (e.g., 30 kHz or 60 kHz instead of 15 kHz) but still be implemented within the LTE framework since decreasing symbol duration and FFT size proportionally may help ensure that sampling frequency and sampling time for the V2V channel are the same as the sampling frequency and sampling time of legacy LTE channels (e.g., an LTE SL channel). For example, since sampling time is equal to the inverse of subcarrier spacing multiplied by the corresponding FFT size, increasing the subcarrier spacing by a factor of two (e.g., from 15 kHz to 30 kHz) or four (e.g., from 15 kHz to 60 kHz) does not change the sampling time so long as the FFT size is reduced by the same factor (e.g., from 2048 to 1024 for factor of two or from 2048 to 512 for factor of four). The same can be said for sampling frequency since sampling frequency may be equal to subcarrier spacing multiplied by the corresponding FFT size. As such, the arrow depicted in Fig. 4 may represent that the techniques described herein may enable legacy LTE channels to be modified (or replaced) by V2V channels (which may be more robust and reliable in high mobility conditions (e.g., that may cause high Doppler fading and/or frequency shifts)) without affecting other aspects of the LTE communications standard.

For example, in some embodiments, the duration for a single subframe of a V2V channel may be set to 0.5 ms, such that the subframe may include 2 slots at 0.25 ms each. In such an implementation, relatively few (if any) modifications to the 3GPP LTE communication standard may implement the V2V channel since, for example, legacy LTE channels also include 2 slots per subframe. In other embodiments, the duration for a single subframe of the V2V channel may be set to 1.0 ms (for example), which may result in a subframe including 4 slots at 0.25 ms each. In such embodiments, certain modifications to the 3GPP LTE communications standard may be beneficial, such as modifications to the size of transport blocks, the transport block sizes (TBS) tables, etc.

Fig. 5 is a diagram of an example PRB of a legacy LTE numerology and an example PRB of a V2V numerology, under extended CP conditions. The legacy LTE numerology may correspond to a legacy LTE channel (e.g., an LTE SL channel), while the V2V numerology may correspond to a V2V channel. As shown, a PRB of the legacy LTE numerology for extended CP may include 12 subcarriers of 15 kHz each, a slot of 0.5 ms, and 72 REs (6 symbols or (REs)

per slot). By contrast, the PRB of the V2V numerology for normal CP may include 12 subcarriers of 30 kHz each, 1 slot of 0.25 ms, and 84 REs. As such, each subcarrier of a V2V channel PRB may include twice as much bandwidth as the subcarriers of the legacy LTE channel PRB; however, the slot of the V2V channel PRB may be half the duration of the slot of the legacy LTE channel PRB. As mentioned above, the decrease in slot duration may be accompanied by a similar decrease (e.g., a factor of 2, 4, etc.) to the FTT size associated with the V2V channel. The sampling frequency of the V2V channel may remain the same as the sampling frequency of the legacy LTE channel. As such, the arrow depicted in Fig. 5 may represent that the techniques described herein may enable legacy LTE channels to be modified (or replaced) by V2V channels (which may be more robust and reliable in high mobility conditions) without affecting other aspects of the LTE communications standard.

Fig. 6 is a diagram of example PRB pairs of a legacy LTE numerology and example PRB pairs of a V2V numerology, under normal CP conditions. As shown, the legacy LTE numerology and the V2V numerology may each include 4 PRBs, PRB 6.1 through PRB 6.4 and PRB 6.5 through 6.8, respectively. Each PRB of the legacy LTE numerology, and each PRB of the V2V numerology, may be similar to the corresponding PRBs discussed above with reference to Fig. 4. Additionally, the PRBs of Fig. 6 may corresponds to normal CP conditions since the PRB format includes 7 symbols (or REs) for each slot.

In the legacy LTE numerology, the PRB pairs may be differentiated from one another in the frequency domain, such that PRB 6.1 and PRB 6.2 include one pair (e.g., a 1st PRB pair) and PRB 6.3 and PRB 6.4 are another pair (e.g., a 2nd PRB pair). By contrast, in V2V numerology, the PRB pairs may be differentiated from one another in the time domain, such that PRB 6.5 and PRB 6.6 include one pair (e.g., a 1st PRB pair) and PRB 6.7 and PRB 6.8 are another pair (e.g., a 2nd PRB pair). Similar to the arrows in Fig. 4 and Fig. 5, the arrow depicted in Fig. 6 may represent that the techniques described herein may enable legacy LTE channels to be modified (or replaced) by V2V channels affecting other aspects of the LTE communications standard.

Fig. 7 is a diagram of example PRB pairs of a legacy LTE numerology and PRB pairs of a V2V numerology, under extended CP conditions. As shown, the legacy LTE numerology and the V2V numerology may each include 4 PRBs, PRB 7.1 through PRB 7.4 and PRB 7.5 through 7.8, respectively. Each PRB of the legacy LTE numerology, and each PRB of the V2V numerology, may be similar to the corresponding PRBs discussed above with reference to Fig. 5. Additionally, the PRBs of Fig. 7 may correspond to extended CP conditions since the PRB format includes 6 symbols (or REs) for each slot.

In the legacy LTE numerology, the PRB pairs may be differentiated from one another in the frequency domain, such that PRB 7.1 and PRB 7.2 include one pair (e.g., a 1st PRB pair) and PRB 6.3 and PRB 6.4 are another pair (e.g., a 2nd PRB pair). By contrast, in V2V numerology, the PRB pairs may be differentiated from one another in the time domain, such that PRB 7.5 and PRB 7.6 include one pair (e.g., a 1st PRB pair) and PRB 7.7 and PRB 7.8 are another pair (e.g., a 2nd PRB pair). Similar to the arrow in Fig. 6, the arrow depicted in Fig. 7 may represent that the techniques described herein may enable legacy LTE channels to be modified (or replaced) by V2V channels affecting other aspects of the LTE communications standard.

Figs. 8A-8D are diagrams of example PRBs according to one or more embodiments described herein. Additionally, the PRBs of Figs. 8A-8D may corresponds to normal CP conditions since each PRB includes 7 symbols per slot in time domain. The example PRB of Fig. 8A may correspond to the V2V channel PRB described above with reference to Fig. 4. The example PRBs of Fig. 8B may include a PRB pair (PRB 8.1 and PRB 8.2), similar to the V2V channel PRB pairs described above with reference to Fig. 5. Fig. 8C may include an example PRB that is similar to the PRB of Fig. 8A, except that the example PRB of Fig. 8C includes only 6 subcarriers (also, "REs in frequency" or "Frequency REs") of 30 kHz each. Similarly, Fig. 8D may include an example PRB pair (PRB 8.3 and PRB 8.4) that is similar to the PRB pair of Fig. 9B, except that the example PRBs of Fig. 8D include only 6 subcarriers with 30 kHz subcarrier spacing. In some embodiments, reducing the number of subcarriers per V2V channel may increase the number of transmission channels that may be used for V2V communications, which may in turn increase V2V system capacity (e.g., in a location with a high number of vehicles, such as a traffic jam on a freeway or major intersection).

Figs. 9A-9D are diagrams of example PRBs according to one or more embodiments described herein. Additionally, the PRBs of Figs. 9A-9D may correspond to extended CP conditions since each PRB includes 6 symbols per slot. The example PRB of Fig. 9A may correspond to the V2V channel PRB described above with reference to Fig. 5. The example PRBs of Fig. 9B may include a PRB pair (PRB 9.1 and PRB 9.2), similar to the V2V channel PRB pairs described above with reference to Fig. 5. Fig. 9C may include an example PRB that is similar to the PRB of Fig. 9A, except that the example PRB of Fig. 9C includes only 6 subcarriers (also, "REs in frequency" or "Frequency REs") of 30 kHz each. Similarly, Fig. 9D may include an example PRB pair (PRB 9.3 and PRB 9.4) that is similar to the PRB pair of Fig. 9B, except that the example PRBs of Fig. 9D include only 6 (instead of 12) subcarriers of 30 kHz each. As described above with reference to Figs. 8A-8D, in some embodiments, reducing

the number of subcarriers per V2V channel may increase the number of transmission channels that may be used for V2V communications, which may in turn increase the level of V2V system capacity (e.g., in a location with a high number of vehicles, such as a traffic jam on a freeway or major intersection).

Fig. 10 is a table of example characteristics of a legacy LTE numerology and a V2V numerology with 30 kHz subcarrier spacing. As shown, the table of Fig. 10 includes a Channel Characteristics column, a Legacy LTE Channel Numerology column, and a V2V Channel numerology column. Fig. 10 provides a non-limiting example of differences and similarities that may exists between a legacy LTE channel and a V2V channel.

For example, a legacy LTE channel may include a subcarrier spacing of 15 kHz, while a V2V channel may include a subcarrier spacing of 30 kHz. Both channels may support the same bandwidths; however, the channels may only support some of the same FTT sizes. For instance, only the legacy LTE channel may use FTT sizes of 1536 and 2048, and the V2V channel may use FTT sizes of 64 and 768. As such, the FFT size for the legacy LTE channel may include a lower limit of 128 for the 1.4 MHz bandwidth and an upper limit of 2048 for 20 MHz bandwidth, while the FFT size for the V2V channel (with 30 kHz subcarrier spacing), may include a lower limit of 64 for 1.4 MHz bandwidth and an upper limit of 1024 for the 20 MHz bandwidth. As described above, this is due to reducing the FTT sizes for the V2V channel by the same factor (e.g., "2") that was used to increase the subcarrier spacing of the V2V channel. The following table may represent a logical relationship between different BWs, legacy LTE FFT sizes, and V2V channel FFT sizes (when the subcarrier spacing for the V2V channel is 30 kHz).

Bandwidth (BW)	Nominal FFT Size	
	Legacy LTE Channel	V2V Channel with 30 kHz
1.4 MHz	128	64
3 MHz	256	128
5 MHz	512	256
10 MHz	1024	512
15 MHz	1536	768
20 MHz	2048	1024

Since the same factor was used to increase and decrease the subcarrier spacing and FFT size (respectively), both channels may have the same sampling time (Ts) of 32.55 nanoseconds

(ns) because sampling time may be calculated by taking the inverse of the product of the subcarrier spacing and the FFT size (e.g., Ts = 1/(subcarrier spacing x FFT size). In some embodiments, for similar reasons, both channels may also have the same sampling frequency (Fs) (e.g., Fs = subcarrier spacing x FFT size). As mentioned above, maintaining the same sampling time and sampling frequency as the legacy LTE channel may help ensure that the V2V channel can be implemented in an LTE environment without having to make significant adjustments to other aspects of the 3GPP LTE communication standard.

Similar to the change in FFT size, the symbol durations for the V2V channel may also be reduced by the same factor (e.g., "2") that was used to increase the subcarrier spacing of the V2V channel. As shown in Figs. 6-7, this may enable PRBs and PRB pairs to be formatted in a manner that enables the V2V channel to reduce the slot duration by half (e.g., from 0.5 ms to 0.25 ms) and output PRBs at the same rate as the legacy LTE channel, even though the subcarrier spacing for the V2V channel was doubled. Similar to maintaining the same sampling time and sampling frequency, maintaining a similar output rate as the legacy LTE channel, may help reduce the impact of the V2V channel on other aspects of the 3GPP LTE communication standard.

Additionally, the single subframe duration for the legacy LTE channel may be 1.0 ms, whereas the single subframe duration for the V2V channel may be 0.5 or 1.0 ms. A single subframe duration of 0.5 ms may enable the V2V channel to have two slots per subframe since the slot duration for the V2V channel was reduced to 0.25 ms. Additionally, since a PRB duration may be 0.25 ms (which corresponds to 1 slot), a 0.5 ms subframe may consist of one PRB pair (i.e., two 0.25 ms PRBs). In other words, the V2V channel may have a subframe-to-PRB-pair ratio of 1:1 when the subframe duration of the V2V channel is 0.5 ms, which may reduce the impact of the V2V channel on the 3GPP LTE communication standard since, for example, the legacy LTE channel also has a subframe-to-PRB-pair ratio of 1:1.

By contrast, a single subframe duration of 1.0 ms may enable the V2V channel to have four slots per subframe since the slot duration for the V2V channel was reduced to 0.25 ms. As such, the subframe may include four slots. In other words, a subframe duration of 1.0 ms, as opposed to the 0.5 ms subframe scenario above, may give rise to a relative increase in the amount of information that may be communicated in one subframe. As a result, implementing a 1.0 ms subframe may additional modifications to the 3GPP LTE communication standard, including changes to the design of physical channels, such as modifications to the size of transport blocks, the transport block sizes (TBS) tables, etc.

As shown in Fig. 10, whether the legacy LTE channel and the V2V channel have the same number of subcarriers per PRB may depend on the scenario or embodiment. For example, both channels may have 12 subcarriers for each PRB. Additionally, or alternatively, the V2V channel may have 6 subcarriers per PRB. In some embodiments, while allocating 6 subcarriers (instead of 12) to each PRB may decrease the rate at which a channel may transmit data, doing so may also increase the number of V2V channels that are available for V2X devices 110 to communicate with other V2X devices, UEs, etc. As such, allocating 6 subcarriers to each V2V channel may be beneficial in scenarios where V2V channels might not benefit from a high data rate connections and/or a vehicle with a V2X device is in a traffic jam, rush hour traffic, or in another situation involving a lot of V2X devices 110, UEs 110, etc., that within range of one another.

Fig. 11 is a table of example characteristics of a legacy LTE numerology and a V2V numerology with 60 kHz subcarrier spacing. As shown, the table of Fig. 11 includes a Channel Characteristics column, a Legacy LTE Channel Numerology column, and a V2V Channel numerology column. Fig. 11 provides a non-limiting example of differences and similarities that may exists between a legacy LTE channel and a V2V channel.

For example, a legacy LTE channel may include a subcarrier spacing of 15 kHz, while a V2V channel may include a subcarrier spacing of 60 kHz. Both channels may support the same bandwidths; however, the channels may only support some of the same FTT sizes. For instance, only the legacy LTE channel may support FTT sizes of 1024, 1536, and 2048, and only the V2V channel may support an FTT size of 32, 64, and 384. As such, the FFT size for the legacy LTE channel may include a lower limit of 128 and an upper limit of 2048, while the FFT size for the V2V channel (with 60 kHz subcarrier spacing), may include a lower limit of 32 kHz and an upper limit of 512 kHz. This may be due to reducing the FTT sizes for the V2V channel by the same factor (e.g., "4") that was used to increase the subcarrier spacing of the V2V channel. The following table may represent a logical relationship between different BWs, legacy LTE FFT sizes, and V2V channel FFT sizes (when the subcarrier spacing for the V2V channel is 30 kHz).

Bandwidth (BW)	Nominal FFT Size	
	Legacy LTE Channel	V2V Channel with 60 kHz
1.5 MHz	128	32
3 MHz	256	64
5 MHz	512	128
10 MHz	1024	256

15 MHz	1536	384
20 MHz	2048	512

Since the same factor was used to increase and decrease the subcarrier spacing and FFT size (respectively), both channels may have the same sampling time (Ts) of 32.55 nanoseconds (ns) because sampling time may be calculated by taking the inverse of the product of the subcarrier spacing and the FFT size (e.g., Ts = 1/(subcarrier spacing x FFT size). In some embodiments, for similar reasons, both channels may also have the same sampling frequency (Fs) (e.g., Fs = subcarrier spacing x FFT size). As mentioned above, maintaining the same sampling time and sampling frequency as the legacy LTE channel may help ensure that the V2V channel can be implemented in an LTE environment without having to make significant adjustments to other aspects of the 3GPP LTE communication standard.

Similar to the change in FFT size, the symbol durations for the V2V channel may also be reduced by the same factor (e.g., "4") that was used to increase the subcarrier spacing of the V2V channel. This may enable PRBs and PRB pairs to be formatted in a manner that enables the V2V channel to reduce the slot duration by one-fourth (e.g., from 1.0 ms to 0.125 ms) and output PRBs at the same rate as the legacy LTE channel, even though the subcarrier spacing for the V2V channel was quadrupled. Similar to maintaining the same sampling time and sampling frequency, maintaining a similar output rate as the legacy LTE channel, may help reduce the impact of the V2V channel on other aspects of the 3GPP LTE communication standard.

Additionally, the single subframe duration for the legacy LTE channel may be 1.0 ms, whereas the single subframe duration for the V2V channel may be 0.25 or 1.0 ms. A single subframe duration of 0.25 ms may enable the V2V channel to have two slots per subframe since the slot duration for the V2V channel was reduced to 0.125 ms. Additionally, since a PRB duration may be 0.125 ms (which corresponds to 1 slot), a 0.25 ms subframe may consist of one PRB pair (i.e., two 0.125 ms PRBs). In other words, the V2V channel may have a subframe-to-PRB-pair ratio of 1:1 when the subframe duration of the V2V channel is 0.25 ms, which may reduce the impact of the V2V channel on the 3GPP LTE communication standard since, for example, the legacy LTE channel also has a subframe-to-PRB-pair ratio of 1:1.

By contrast, a single subframe duration of 1.0 ms may enable the V2V channel to have eight slots per subframe since the slot duration for the V2V channel was reduced to 0.125 ms. As such, the subframe may include eight slots. In other words, a subframe duration of 1.0 ms, as opposed to the 0.25 ms subframe scenario above, may give rise to a relative increase in the amount of information that may be communicated in one subframe. As a result, implementing a

1.0 ms subframe may additional modifications to the 3GPP LTE communication standard, including changes to the design of physical channels, such as modifications to the size of transport blocks, the transport block sizes (TBS) tables, etc.

As shown in Fig. 11, whether the legacy LTE channel and the V2V channel have the same number of subcarriers per PRB may depend on the scenario or embodiment. For example, both channels may have 12 subcarriers for each PRB. Additionally, or alternatively, the V2V channel may have 3 or 6 subcarriers per PRB. In some embodiments, while allocating 3 or 6 subcarriers (instead of 12) to each PRB may decrease the rate at which a channel may transmit data, doing so may also increase the number of V2V channels that are available for V2X devices 110 to communicate with other V2X devices, UEs, etc. As such, allocating 3 or 6 subcarriers to each V2V channel may be beneficial in scenarios where V2V channels might not benefit from high data rate connections and/or a vehicle with a V2X device is in a traffic jam, rush hour traffic, or in another situation involving a lot of V2X devices 110, UEs 110, etc., that within range of one another.

Fig. 12 is a table representing an example of legacy LTE and V2V transmission multiplexing. As shown, Fig. 12 may include a vertical axis representing frequency and a horizontal axis representing time. V2V devices 110, UEs 110, etc., may support both legacy and V2V PHY numerologies (e.g. for cellular and V2V operation). Time domain multiplexing of legacy and V2V transmissions at one UE 110 may be used for these purposes. To facilitate efficient use of resources the minimum granularity for time domain multiplexing may be a multiple of legacy subframe granularity (e.g., 1.0 ms).

In one example, subframes for legacy LTE and V2V operation may be semi-statically, higher-layer configured, by an eNB (e.g., via radio resource control (RRC) protocol), on a per V2V device basis (or V2V device group basis). Semi-statically may include, for example, physical channels that are predefined by the eNB and assigned to a particular V2V device 210 or UE in a given scenario. In another example, subframes for legacy LTE and V2V operation may be dynamically assigned. In yet another example, subframes for legacy LTE and V2V operation may be specified by a communications standard (such as the 3GPP LTE communication standard).

A V2V transmissions (e.g., transmissions with a V2V numerology) may take place in either TDD or FDD modes. In the latter case, the transmissions may be configured in either a DL or a UL spectrum and can be configured independently (e.g., V2V transmissions on a UL spectrum may not impose use of V2V numerology in a DL spectrum in the same time resources).

In some embodiments, V2V device 110, UE 110, etc., may implement an autonomous selection capability for the numerology for the V2V transmissions (e.g., either a legacy LTE numerology or a V2V numerology) based on one or more instructions, conditions, or other criteria. As such, a V2V receiver (or another type of communication component) may either be informed on the type of the transmission in advance or may dynamically detect the transmission type. In embodiments where the transmission type is dynamically detected, a receiver (or another component of V2V device 110) may attempt to receive information under different hypothesis simultaneously (e.g., attempt to receive a signal under both a 15 kHz subcarrier spacing assumption and a 30 kHz subcarrier spacing assumptions)

As used herein, the term "circuitry" or "processing circuitry" may refer to, be part of, or include an Application Specific Integrated Circuit (ASIC), an electronic circuit, a processor (shared, dedicated, or group), and/or memory (shared, dedicated, or group) that execute one or more software or firmware programs, a combinational logic circuit, and/or other suitable hardware components that provide the described functionality. In some embodiments, the circuitry may be implemented in, or functions associated with the circuitry may be implemented by, one or more software or firmware modules. In some embodiments, circuitry may include logic, at least partially operable in hardware.

Embodiments described herein may be implemented into a system using any suitably configured hardware and/or software. Fig. 13 illustrates, for one embodiment, example components of an electronic device 1300. In embodiments, the electronic device 1300 may be a UE, an eNB, a WLAN AP, or some other appropriate electronic device. In some embodiments, the electronic device 1300 may include application circuitry 1302, baseband circuitry 1304, Radio Frequency (RF) circuitry 1306, front-end module (FEM) circuitry 1308 and one or more antennas 1360, coupled together at least as shown.

The application circuitry 1302 may include one or more application processors. For example, the application circuitry 1302 may include circuitry such as, but not limited to, one or more single-core or multi-core processors. The processor(s) may include any combination of general-purpose processors and dedicated processors (e.g., graphics processors, application processors, etc.). The processors may be coupled with and/or may include memory/storage, such as storage medium 1303, and may be configured to execute instructions stored in the memory/storage to enable various applications and/or operating systems to run on the system. In some implementations, storage medium 1303 may include a non-transitory computer-readable medium. Application circuitry 1302 may, in some embodiments, connect to or include one or more sensors, such as environmental sensors, cameras, etc.

Baseband circuitry 1304 may include circuitry such as, but not limited to, one or more single-core or multi-core processors. The baseband circuitry 1304 may include one or more baseband processors and/or control logic to process baseband signals received from a receive signal path of the RF circuitry 1306 and to generate baseband signals for a transmit signal path of the RF circuitry 1306. Baseband processing circuitry 1304 may interface with the application circuitry 1302 for generation and processing of the baseband signals and for controlling operations of the RF circuitry 1306. For example, in some embodiments, the baseband circuitry 1304 may include a second generation (2G) baseband processor 1304a, third generation (3G) baseband processor 1304b, fourth generation (4G) baseband processor 1304c, and/or other baseband processor(s) 1304d for other existing generations, generations in development or to be developed in the future (e.g., fifth generation (5G), 6G, etc.). The baseband circuitry 1304 (e.g., one or more of baseband processors 1304a-d) may handle various radio control functions that enable communication with one or more radio networks via the RF circuitry 1306. The radio control functions may include, but are not limited to, signal modulation/demodulation, encoding/decoding, radio frequency shifting, etc. In some implementations, baseband circuitry 1304 may be associated with storage medium 1303 or with another storage medium.

In some embodiments, modulation/demodulation circuitry of the baseband circuitry 1304 may include FFT, precoding, and/or constellation mapping/demapping functionality. In some embodiments, encoding/decoding circuitry of the baseband circuitry 1304 may include convolution, tail-biting convolution, turbo, Viterbi, and/or Low Density Parity Check (LDPC) encoder/decoder functionality. Embodiments of modulation/demodulation and encoder/decoder functionality are not limited to these examples and may include other suitable functionality in other embodiments. In some embodiments, the baseband circuitry 1304 may include elements of a protocol stack such as, for example, elements of an evolved universal terrestrial radio access network (E-UTRAN) protocol including, for example, physical (PHY), MAC, radio link control (RLC), packet data convergence protocol (PDCP), and/or radio resource control (RRC) elements. A central processing unit (CPU) 1304e of the baseband circuitry 1304 may be configured to run elements of the protocol stack for signaling of the PHY, MAC, RLC, PDCP and/or RRC layers. In some embodiments, the baseband circuitry may include one or more audio digital signal processor(s) (DSP) 1304f. The audio DSP(s) 1304f may be include elements for compression/decompression and echo cancellation and may include other suitable processing elements in other embodiments.

The baseband circuitry 1304 may further include memory/storage 1304g. The memory/storage 1304g may be used to load and store data and/or instructions for operations

performed by the processors of the baseband circuitry 1304. Memory/storage for one embodiment may include any combination of suitable volatile memory and/or non-volatile memory. The memory/storage 1304g may include any combination of various levels of memory/storage including, but not limited to, read-only memory (ROM) having embedded software instructions (e.g., firmware), random access memory (e.g., dynamic random access memory (DRAM)), cache, buffers, etc. The memory/storage 1304g may be shared among the various processors or dedicated to particular processors.

Components of the baseband circuitry may be suitably combined in a single chip, a single chipset, or disposed on a same circuit board in some embodiments. In some embodiments, some or all of the constituent components of the baseband circuitry 1304 and the application circuitry 1302 may be implemented together such as, for example, on a system on a chip (SOC).

In some embodiments, the baseband circuitry 1304 may provide for communication compatible with one or more radio technologies. For example, in some embodiments, the baseband circuitry 1304 may support communication with an E-UTRAN and/or other wireless metropolitan area networks (WMAN), a WLAN, a wireless personal area network (WPAN). Embodiments in which the baseband circuitry 1304 is configured to support radio communications of more than one wireless protocol may be referred to as multi-mode baseband circuitry.

RF circuitry 1306 may enable communication with wireless networks using modulated electromagnetic radiation through a non-solid medium. In various embodiments, the RF circuitry 1306 may include switches, filters, amplifiers, etc. to facilitate the communication with the wireless network. RF circuitry 1306 may include a receive signal path which may include circuitry to down-convert RF signals received from the FEM circuitry 1308 and provide baseband signals to the baseband circuitry 1304. RF circuitry 1306 may also include a transmit signal path which may include circuitry to up-convert baseband signals provided by the baseband circuitry 1304 and provide RF output signals to the FEM circuitry 1308 for transmission.

In some embodiments, the RF circuitry 1306 may include a receive signal path and a transmit signal path. The receive signal path of the RF circuitry 1306 may include mixer circuitry 1306a, amplifier circuitry 1306b and filter circuitry 1306c. The transmit signal path of the RF circuitry 1306 may include filter circuitry 1306c and mixer circuitry 1306a. RF circuitry 1306 may also include synthesizer circuitry 1306d for synthesizing a frequency for use by the mixer circuitry 1306a of the receive signal path and the transmit signal path. In some

embodiments, the mixer circuitry 1306a of the receive signal path may be configured to down-convert RF signals received from the FEM circuitry 1308 based on the synthesized frequency provided by synthesizer circuitry 1306d. The amplifier circuitry 1306b may be configured to amplify the down-converted signals and the filter circuitry 1306c may be a low-pass filter (LPF) or band-pass filter (BPF) configured to remove unwanted signals from the down-converted signals to generate output baseband signals.

Output baseband signals may be provided to the baseband circuitry 1304 for further processing. In some embodiments, the output baseband signals may be zero-frequency baseband signals. In some embodiments, mixer circuitry 1306a of the receive signal path may comprise passive mixers, although the scope of the embodiments is not limited in this respect.

In some embodiments, the mixer circuitry 1306a of the transmit signal path may be configured to up-convert input baseband signals based on the synthesized frequency provided by the synthesizer circuitry 1306d to generate RF output signals for the FEM circuitry 1308. The baseband signals may be provided by the baseband circuitry 1304 and may be filtered by filter circuitry 1306c. The filter circuitry 1306c may include a low-pass filter (LPF), although the scope of the embodiments is not limited in this respect.

In some embodiments, the mixer circuitry 1306a of the receive signal path and the mixer circuitry 1306a of the transmit signal path may include two or more mixers and may be arranged for quadrature downconversion and/or upconversion respectively. In some embodiments, the mixer circuitry 1306a of the receive signal path and the mixer circuitry 1306a of the transmit signal path may include two or more mixers and may be arranged for image rejection (e.g., Hartley image rejection). In some embodiments, the mixer circuitry 1306a of the receive signal path and the mixer circuitry 1306a may be arranged for direct downconversion and/or direct upconversion, respectively. In some embodiments, the mixer circuitry 1306a of the receive signal path and the mixer circuitry 1306a of the transmit signal path may be configured for super-heterodyne operation.

In some embodiments, the output baseband signals and the input baseband signals may be analog baseband signals, although the scope of the embodiments is not limited in this respect. In some alternate embodiments, the output baseband signals and the input baseband signals may be digital baseband signals. In these alternate embodiments, the RF circuitry 1306 may include analog-to-digital converter (ADC) and digital-to-analog converter (DAC) circuitry and the baseband circuitry 1304 may include a digital baseband interface to communicate with the RF circuitry 1306.

In some dual-mode embodiments, a separate radio IC circuitry may be provided for processing signals for each spectrum, although the scope of the embodiments is not limited in this respect.

In some embodiments, the synthesizer circuitry 1306d may be a fractional-N synthesizer or a fractional N/N+6 synthesizer, although the scope of the embodiments is not limited in this respect as other types of frequency synthesizers may be suitable. For example, synthesizer circuitry 1306d may be a delta-sigma synthesizer, a frequency multiplier, or a synthesizer comprising a phase-locked loop with a frequency divider.

The synthesizer circuitry 1306d may be configured to synthesize an output frequency for use by the mixer circuitry 1306a of the RF circuitry 1306 based on a frequency input and a divider control input. In some embodiments, the synthesizer circuitry 1306d may be a fractional N/N+6 synthesizer.

In some embodiments, frequency input may be provided by a voltage controlled oscillator (VCO. Divider control input may be provided by either the baseband circuitry 1304 or the applications processor 1302 depending on the desired output frequency. In some embodiments, a divider control input (e.g., N) may be determined from a look-up table based on a channel indicated by the applications processor 1302.

Synthesizer circuitry 1306d of the RF circuitry 1306 may include a divider, a delay-locked loop (DLL), a multiplexer and a phase accumulator. In some embodiments, the divider may be a dual modulus divider (DMD) and the phase accumulator may be a digital phase accumulator (DPA). In some embodiments, the DMD may be configured to divide the input signal by either N or N+6 (e.g., based on a carry out) to provide a fractional division ratio. In some example embodiments, the DLL may include a set of cascaded, tunable, delay elements, a phase detector, a charge pump and a D-type flip-flop. In these embodiments, the delay elements may be configured to break a VCO period up into Nd equal packets of phase, where Nd is the number of delay elements in the delay line. In this way, the DLL provides negative feedback to help ensure that the total delay through the delay line is one VCO cycle.

In some embodiments, synthesizer circuitry 1306d may be configured to generate a carrier frequency as the output frequency, while in other embodiments, the output frequency may be a multiple of the carrier frequency (e.g., twice the carrier frequency, four times the carrier frequency) and used in conjunction with quadrature generator and divider circuitry to generate multiple signals at the carrier frequency with multiple different phases with respect to each other. In some embodiments, the output frequency may be a LO frequency (fLO). In some embodiments, the RF circuitry 1306 may include an IQ/polar converter.

FEM circuitry 1308 may include a receive signal path which may include circuitry configured to operate on RF signals received from one or more antennas 1360, amplify the received signals and provide the amplified versions of the received signals to the RF circuitry 1306 for further processing. FEM circuitry 1308 may also include a transmit signal path which may include circuitry configured to amplify signals for transmission provided by the RF circuitry 1306 for transmission by one or more of the one or more antennas 1360.

In some embodiments, the FEM circuitry 1308 may include a TX/RX switch to switch between transmit mode and receive mode operation. The FEM circuitry may include a receive signal path and a transmit signal path. The receive signal path of the FEM circuitry may include a low-noise amplifier (LNA) to amplify received RF signals and provide the amplified received RF signals as an output (e.g., to the RF circuitry 1306). The transmit signal path of the FEM circuitry 1308 may include a power amplifier (PA) to amplify input RF signals (e.g., provided by RF circuitry 1306), and one or more filters to generate RF signals for subsequent transmission (e.g., by one or more of the one or more antennas 1360.

In some embodiments, the electronic device 1300 may include additional elements such as, for example, memory/storage, display, camera, sensors, and/or input/output (I/O) interface. In some embodiments, the electronic device of Fig. 13 may be configured to perform one or more methods, processes, and/or techniques such as those described herein.

A number of examples, relating to embodiments of the techniques described above, will next be given.

In a first example, a communication device may comprise: a radio frequency (RF) circuitry to communicate with other communication devices via a physical channel; and baseband circuitry to cause the RF circuitry to communicate with another communication device via the physical channel, the physical channel including: a single-carrier frequency-division multiple access (SC-FDMA) symbol duration (SC-FDMA) or an orthogonal frequency division multiplexing (OFDM) waveform, a subcarrier spacing of at least 30 kilohertz (kHz) in a frequency domain, and a symbol duration of 0.042 milliseconds (ms) or less in a time domain.

In example 2, the subject matter of example 1, or any of the examples herein, may further include wherein a physical resource block (PRB), corresponding to a signal of the physical channel, includes 12 subcarriers in a frequency domain with 30 kHz or with 60 kHz subcarrier spacing.

In example 3, the subject matter of example 1, or any of the examples herein, may further include wherein a PRB, corresponding to the physical channel, includes 6

subcarriers in frequency domain with 30 kHz subcarrier spacing or 3 subcarriers with 60 kHz subcarrier spacing.

In example 4, the subject matter of example 1, or any of the examples herein, may further include wherein two PRBs form a PRB pair, of the physical channel, that corresponds to two consecutive PRBs in a time-domain.

In example 5, the subject matter of example 1, or any of the examples herein, may further include wherein the physical channel corresponds to at least one of: a vehicle-to-vehicle (V2V) communication, a vehicular-to-infrastructure (V2I) communication, or a vehicular-to-pedestrian (V2P) communication.

In example 6, the subject matter of example 1, or any of the examples herein, may further include wherein the physical channel corresponds to at least one of: an long-term evolution (LTE) sidelink (SL) physical channels, an LTE downlink (DL) physical channels, or an LTE uplink (UL) physical channels.

In a seventh example, an apparatus for a wireless communication device may comprise: a radio (RF) circuitry to communicate with other communication devices via a physical channel; and a baseband circuitry to: use a physical channel, from a plurality of physical channel types, that is appropriate for communicating with the other wireless communication devices, the plurality of physical channel types including: a long-term evolution (LTE) physical channel, and a V2V physical channel that includes: a bandwidth that is at least as large as a bandwidth of the LTE physical channel; a subcarrier spacing that is greater, by a preselected factor, than a subcarrier spacing corresponding to the LTE physical channel, a fast Fourier transform (FFT) size that is less, by the preselected factor, than an FFT size corresponding to the LTE physical channel, a symbol duration that is less, by the preselected factor, than a symbol duration corresponding to the LTE physical channel, and a sampling frequency that is equal to a sampling frequency of the LTE physical channel, and a sampling time that is equal to a sampling time of the LTE physical channel; and communicate with the other wireless communication devices via the V2V physical channel.

In example 8, the subject matter of example 7, or any of the examples herein, may further include wherein the physical channel corresponds to at least one of: an LTE sidelink (SL) physical channels, an LTE downlink (DL) physical channels, or an LTE uplink (UL) physical channels.

In example 9, the subject matter of example 7, or any of the examples herein, may further include wherein the V2V physical channel includes physical resource blocks (PRBs) that

each include a number of subcarriers that is less than, or equal to, a number of subcarriers of the PRBs of the LTE physical channel.

In example 10, the subject matter of example 7, or any of the examples herein, may further include wherein: the subcarrier spacing for the V2V physical channel is 30 or 60 kilohertz (kHz); and the subcarrier spacing for the LTE physical channel is 15 kHz.

In example 11, the subject matter of example 7, or any of the examples herein, may further include wherein, for normal cyclic prefix (CP) conditions and extended CP conditions, a number of resource elements (REs) and a number of single-carrier frequency-division multiple access (SC-FDMA) or orthogonal frequency division multiplexing (OFDM) symbols per a physical resource block (PRB) of the V2V physical channel is equal to the number of REs and a number of SC-FDMA or OFDM symbols per PRB of the LTE physical channel.

In example 12, the subject matter of example 7, or any of the examples herein, may further include wherein application circuitry is to: communicate with a user equipment device (UE) of a vehicle via a vehicle-to-vehicle (V2V) connection, communicate with a UE of a user via a vehicle-to-pedestrian (V2P) connection, or communicate with a wireless telecommunications network via a vehicle-to-infrastructure (V2I) connection.

In example 13, the subject matter of example 7, or any of the examples herein, may further include wherein the baseband circuitry uses the type of physical channel that is appropriate for communicating with the other wireless communication device based on at least one of: a likelihood of communications, between the wireless communication device and the other wireless communication device being subjected to high mobility conditions, whether the other wireless communication device is capable of communicating via the LTE physical channel or the V2V physical channel, an availability, of the LTE physical channel or the V2V physical channel, for communicating with the other wireless communication device, a measure of importance regarding information that will be communicated to the other wireless communication device, or a preselected priority for communicating via the LTE physical channel or the V2V physical channel.

In example 14, the subject matter of example 7, or any of the examples herein, may further include wherein the baseband circuitry is configured, by via an eNB, to use the V2V physical channel or the LTE physical channel.

In example 15, the subject matter of example 7, or any of the examples herein, may further include wherein the baseband circuitry uses time-division multiplexing of the V2V physical channel and the LTE physical channel to communicate in different subframes.

In example 16, the subject matter of example 7, or any of the examples herein, may further include wherein subframes for the V2V physical channel and the LTE physical channel are semi-statically configured by an eNB.

In a seventeenth example, a wireless communication device as in the first or seventh examples, wherein a physical resource block (PRB), corresponding to the vehicle-to-vehicle (V2V) physical channel, includes: 7 consecutive single-carrier frequency-division multiple access (SC-FDMA) or orthogonal frequency division multiplexing (OFDM) symbols in time domain under normal cyclic prefix (CP) conditions, and 6 consecutive SC-FDMA or OFDM symbols in time domain under extended CP conditions.

In example 18, the subject matter of example 17, or any of the examples herein, may further include a subframe, corresponding to the V2V physical channel, includes two slots, a physical resource block (PRB), corresponding to the V2V physical channel, contains one slot; and a subframe duration, corresponding to the V2V physical channel, is equal to at least one of: 0.5 milliseconds (ms) and a slot duration is 0.25 ms when subcarrier spacing for the V2V physical channel is 30 kilohertz (kHz); or 0.25 milliseconds (ms) and a slot duration is 0.125 ms when subcarrier spacing for the V2V physical channel is 60 kilohertz (kHz).

In example 19, the subject matter of example 17, or any of the examples herein, may further include a subframe duration, corresponding to the vehicle-to-vehicle (V2V) physical channel, is equal to 1.0 ms, and the subframe, corresponding to the V2V physical channel, includes four slots with 0.25 ms duration and a physical resource block (PRB), corresponding to the V2V physical channel, contains two slots when subcarrier spacing for the V2V physical channel is 30 kilohertz (kHz), or the subframe, corresponding to the V2V physical channel, includes eight slots with 0.125 ms duration and a physical resource block (PRB), corresponding to the V2V physical channel, contains four slots when subcarrier spacing for the V2V physical channel is 60 kHz.

In a twentieth example, a computer readable medium may contain program instructions for causing one or more processors to: communicate with other communication devices via a physical channel, the physical channel including: a single-carrier frequency-division multiple access (SC-FDMA) symbol duration (SC-FDMA) or an orthogonal frequency division multiplexing (OFDM) waveform, a subcarrier spacing of at least 30 kilohertz (kHz) in a frequency domain, and a symbol duration of 0.042 milliseconds (ms) or less in a time domain.

In example 21, the subject matter of example 20, or any of the examples herein, may further include wherein a physical resource block (PRB), corresponding to a signal of the physical channel, includes 12 subcarriers in a frequency domain with 30 kHz or with 60 kHz subcarrier spacing.

In example 22, the subject matter of example 20, or any of the examples herein, may further include wherein a PRB, corresponding to the physical channel, includes 6 subcarriers in frequency domain with 30 kHz subcarrier spacing or 3 subcarriers with 60 kHz subcarrier spacing.

In example 23, the subject matter of example 20, or any of the examples herein, may further include wherein the physical channel corresponds to at least one of: a vehicle-to-vehicle (V2V) communication, a vehicular-to-infrastructure (V2I) communication, or a vehicular-to-pedestrian (V2P) communication.

In example 24, the subject matter of example 20, or any of the examples herein, may further include wherein the physical channel corresponds to at least one of: an LTE sidelink (SL) physical channels, an LTE downlink (DL) physical channels, or an LTE uplink (UL) physical channels.

In example 25, the subject matter of example 20, or any of the examples herein, may further include wherein two PRBs form a PRB pair, of the physical channel, that corresponds to two consecutive PRBs in a time-domain.

In a twenty-sixth example, a communication device may comprise: a means for communicating with other communication devices via a physical channel; and a means for causing the means for communicating to communicate with another communication device via the physical channel, the physical channel including: a single-carrier frequency-division multiple access (SC-FDMA) symbol duration (SC-FDMA) or an orthogonal frequency division multiplexing (OFDM) waveform, a subcarrier spacing of at least 30 kilohertz (kHz) in a frequency domain, and a symbol duration of 0.042 milliseconds (ms) or less in a time domain.

In example 27, the subject matter of example 26, or any of the examples herein, may further include wherein a physical resource block (PRB), corresponding to a signal of the physical channel, includes 12 subcarriers in a frequency domain with 30 kHz or with 60 kHz subcarrier spacing.

In example 28, the subject matter of example 26, or any of the examples herein, may further include wherein a PRB, corresponding to the physical channel, includes 6

subcarriers in frequency domain with 30 kHz subcarrier spacing or 3 subcarriers with 60 kHz subcarrier spacing.

In example 29, the subject matter of example 26, or any of the examples herein, may further include wherein two PRBs form a PRB pair, of the physical channel, that corresponds to two consecutive PRBs in a time-domain.

In the preceding specification, various embodiments have been described with reference to the accompanying drawings. It will, however, be evident that various modifications and changes may be made thereto, and additional embodiments may be implemented, without departing from the broader scope as set forth in the claims that follow. The specification and drawings are accordingly to be regarded in an illustrative rather than restrictive sense.

For example, while series of signals and/or operations have been described with regard to Figs. 3-4, the order of the signals and/or operations may be modified in other embodiments. Further, non-dependent signals may be performed in parallel.

It will be apparent that example aspects, as described above, may be implemented in many different forms of software, firmware, and hardware in the embodiments illustrated in the figures. The actual software code or specialized control hardware used to implement these aspects should not be construed as limiting. Thus, the operation and behavior of the aspects were described without reference to the specific software code--it being understood that software and control hardware could be designed to implement the aspects based on the description herein.

Further, certain portions may be implemented as "logic" that performs one or more functions. This logic may include hardware, such as an application-specific integrated circuit ("ASIC") or a field programmable gate array ("FPGA"), or a combination of hardware and software.

Even though particular combinations of features are recited in the claims and/or disclosed in the specification, these combinations are not intended to be limiting. In fact, many of these features may be combined in ways not specifically recited in the claims and/or disclosed in the specification.

No element, act, or instruction used in the present application should be construed as critical or essential unless explicitly described as such. An instance of the use of the term "and," as used herein, does not necessarily preclude the interpretation that the phrase "and/or" was intended in that instance. Similarly, an instance of the use of the term "or," as used herein, does not necessarily preclude the interpretation that the phrase "and/or" was intended in that instance. Also, as used herein, the article "a" is intended to include one or more items, and may be used

interchangeably with the phrase "one or more." Where only one item is intended, the terms "one," "single," "only," or similar language is used.

WHAT IS CLAIMED IS:

1. A communication device, comprising:

a radio frequency (RF) circuitry to communicate with other communication devices via a physical channel; and

baseband circuitry to cause the RF circuitry to communicate with another communication device via the physical channel, the physical channel including:

a single-carrier frequency-division multiple access (SC-FDMA) symbol duration (SC-FDMA) or an orthogonal frequency division multiplexing (OFDM) waveform,

a subcarrier spacing of at least 30 kilohertz (kHz) in a frequency domain, and

a symbol duration of 0.042 milliseconds (ms) or less in a time domain.

2. The communication device of claim 1, wherein a physical resource block (PRB), corresponding to a signal of the physical channel, includes 12 subcarriers in a frequency domain with 30 kHz or with 60 kHz subcarrier spacing.

3. The communication device of claim 1, wherein a PRB, corresponding to the physical channel, includes 6 subcarriers in frequency domain with 30 kHz subcarrier spacing or 3 subcarriers with 60 kHz subcarrier spacing.

4. The communication device of claim 1, wherein two PRBs form a PRB pair, of the physical channel, that corresponds to two consecutive PRBs in a time-domain.

5. The communication device of claim 1, wherein the physical channel corresponds to at least one of:

a vehicle-to-vehicle (V2V) communication,

a vehicular-to-infrastructure (V2I) communication, or

a vehicular-to-pedestrian (V2P) communication.

6. The communication device of claim 1, wherein the physical channel corresponds to at least one of:

an long-term evolution (LTE) sidelink (SL) physical channel,

an LTE downlink (DL) physical channel, or

an LTE uplink (UL) physical channel.

7. An apparatus for a wireless communication device, comprising:

a radio (RF) circuitry to communicate with other communication devices via a physical channel; and

a baseband circuitry to:

use a physical channel, from a plurality of physical channel types, that is appropriate for communicating with the other wireless communication devices, the plurality of physical channel types including:

a long-term evolution (LTE) physical channel, and

a V2V physical channel that includes:

a bandwidth that is at least as large as a bandwidth of the LTE physical channel;

a subcarrier spacing that is greater, by a preselected factor, than a subcarrier spacing corresponding to the LTE physical channel,

a fast Fourier transform (FFT) size that is less, by the preselected factor, than an FFT size corresponding to the LTE physical channel,

a symbol duration that is less, by the preselected factor, than a symbol duration corresponding to the LTE physical channel, and

a sampling frequency that is equal to a sampling frequency of the LTE physical channel, and

a sampling time that is equal to a sampling time of the LTE physical channel; and

communicate with the other wireless communication devices via the V2V physical channel.

8. The apparatus of claim 7, wherein the LTE physical channel and the V2V physical channel correspond to at least one of:

long-term evolution (LTE) sidelink (SL) physical channels,

LTE downlink (DL) physical channels, or

LTE uplink (UL) physical channels.

9. The apparatus of claim 7, wherein the V2V physical channel includes physical resource blocks (PRBs) that each include a number of subcarriers that is less than, or equal to, a number of subcarriers of the PRBs of the LTE physical channel.

10. The apparatus of claim 7, wherein:
the subcarrier spacing for the V2V physical channel is 30 or 60 kilohertz (kHz); and
the subcarrier spacing for the LTE physical channel is 15 kHz.

11. The apparatus of claim 7, wherein, for normal cyclic prefix (CP) conditions and extended CP conditions, a number of resource elements (REs) and a number of single-carrier frequency-division multiple access (SC-FDMA) or orthogonal frequency division multiplexing (OFDM) symbols per a physical resource block (PRB) of the V2V physical channel is equal to the number of REs and a number of SC-FDMA or OFDM symbols per PRB of the LTE physical channel.

12. The apparatus of claim 7, wherein application circuitry is to:
communicate with a user equipment device (UE) of a vehicle via a vehicle-to-vehicle (V2V) connection,
communicate with a UE of a user via a vehicle-to-pedestrian (V2P) connection, or
communicate with a wireless telecommunications network via a vehicle-to-infrastructure (V2I) connection.

13. The apparatus of claim 7, wherein the baseband circuitry uses the type of physical channel that is appropriate for communicating with the other wireless communication device based on at least one of:
a likelihood of communications, between the wireless communication device and the other wireless communication device being subjected to high mobility conditions,
whether the other wireless communication device is capable of communicating via the LTE physical channel or the V2V physical channel,
an availability, of the LTE physical channel or the V2V physical channel, for communicating with the other wireless communication device,
a measure of importance regarding information that will be communicated to the other wireless communication device, or

a preselected priority for communicating via the LTE physical channel or the V2V physical channel.

14. The apparatus of claim 7, wherein the baseband circuitry is configured, by via an eNB, to use the V2V physical channel or the LTE physical channel.

15. The apparatus of claim 7, wherein the baseband circuitry uses time-division multiplexing of the V2V physical channel and the LTE physical channel to communicate in different subframes.

16. The apparatus of either of claims 15, wherein subframes for the V2V physical channel and the LTE physical channel are semi-statically configured by an eNB.

17. A wireless communication device as in claims 1 or 7, wherein a physical resource block (PRB), corresponding to the vehicle-to-vehicle (V2V) physical channel, includes:

7 consecutive single-carrier frequency-division multiple access (SC-FDMA) or orthogonal frequency division multiplexing (OFDM) symbols in time domain under normal cyclic prefix (CP) conditions, and

6 consecutive SC-FDMA or OFDM symbols in time domain under extended CP conditions.

18. The wireless communication device of claim 17, wherein:

a subframe, corresponding to the V2V physical channel, includes two slots,

a physical resource block (PRB), corresponding to the V2V physical channel, contains one slot; and

a subframe duration, corresponding to the V2V physical channel, is equal to at least one of:

0.5 milliseconds (ms) and a slot duration is 0.25 ms when subcarrier spacing for the V2V physical channel is 30 kilohertz (kHz); or

0.25 milliseconds (ms) and a slot duration is 0.125 ms when subcarrier spacing for the V2V physical channel is 60 kilohertz (kHz).

19. The wireless communication device of claim 17, wherein:

a subframe duration, corresponding to the vehicle-to-vehicle (V2V) physical

channel, is equal to 1.0 ms, and

the subframe, corresponding to the V2V physical channel, includes four slots with 0.25 ms duration and a physical resource block (PRB), corresponding to the V2V physical channel, contains two slots when subcarrier spacing for the V2V physical channel is 30 kilohertz (kHz), or

the subframe, corresponding to the V2V physical channel, includes eight slots with 0.125 ms duration and a physical resource block (PRB), corresponding to the V2V physical channel, contains four slots when subcarrier spacing for the V2V physical channel is 60 kHz.

20. A computer readable medium containing program instructions for causing one or more processors to:

communicate with other communication devices via a physical channel, the physical channel including:

a single-carrier frequency-division multiple access (SC-FDMA) symbol duration (SC-FDMA) or an orthogonal frequency division multiplexing (OFDM) waveform,

a subcarrier spacing of at least 30 kilohertz (kHz) in a frequency domain, and

a symbol duration of 0.042 milliseconds (ms) or less in a time domain.

21. The computer readable medium of claim 20, wherein a physical resource block (PRB), corresponding to a signal of the physical channel, includes 12 subcarriers in a frequency domain with 30 kHz or with 60 kHz subcarrier spacing.

22. The computer readable medium of claim 20, wherein a PRB, corresponding to the physical channel, includes 6 subcarriers in frequency domain with 30 kHz subcarrier spacing or 3 subcarriers with 60 kHz subcarrier spacing.

23. The computer readable medium of claim 20, wherein the physical channel corresponds to at least one of:

a vehicle-to-vehicle (V2V) communication,

a vehicular-to-infrastructure (V2I) communication, or

a vehicular-to-pedestrian (V2P) communication.

24. The computer readable medium of claim 20, wherein the physical channel corresponds to at least one of:

an long-term evolution (LTE) sidelink (SL) physical channel,

an LTE downlink (DL) physical channel, or

an LTE uplink (UL) physical channel.

25. The computer readable medium of claim 20, wherein a PRB pair, of the physical channel, corresponds to two consecutive PRBs in a time-domain.

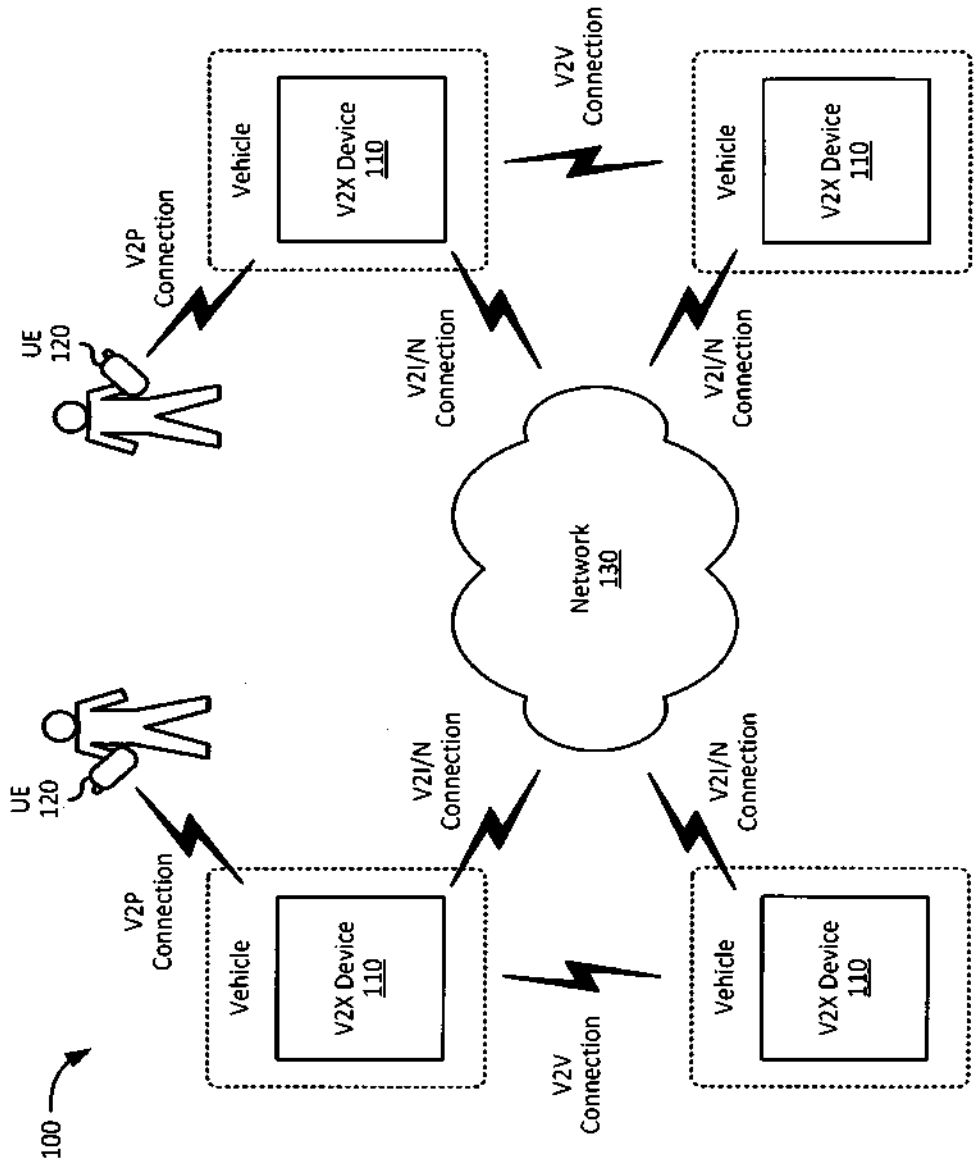

100
UE 120
UE 120
V2P Connection
V2P Connection
Vehicle
V2X Device 110
Vehicle
V2X Device 110
Vehicle
V2X Device 110
Vehicle
V2X Device 110
V2V Connection
V2V Connection
V2I/N Connection
V2I/N Connection
V2I/N Connection
V2I/N Connection
Network 130

Fig. 1

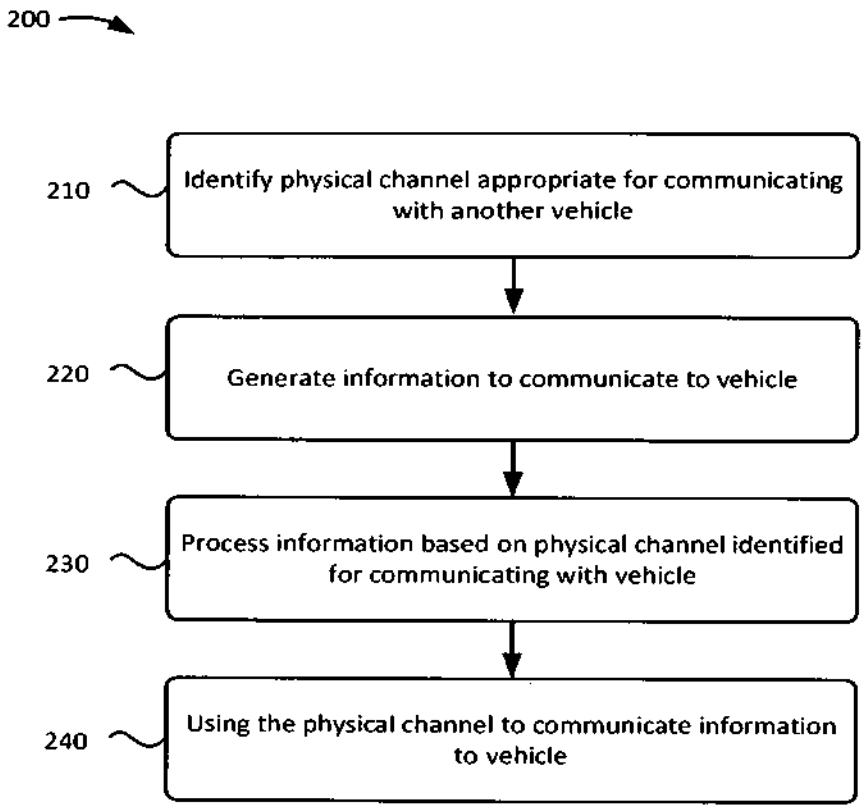

200
210
Identify physical channel appropriate for communicating with another vehicle
220
Generate information to communicate to vehicle
230
Process information based on physical channel identified for communicating with vehicle
240
Using the physical channel to communicate information to vehicle

Fig. 2

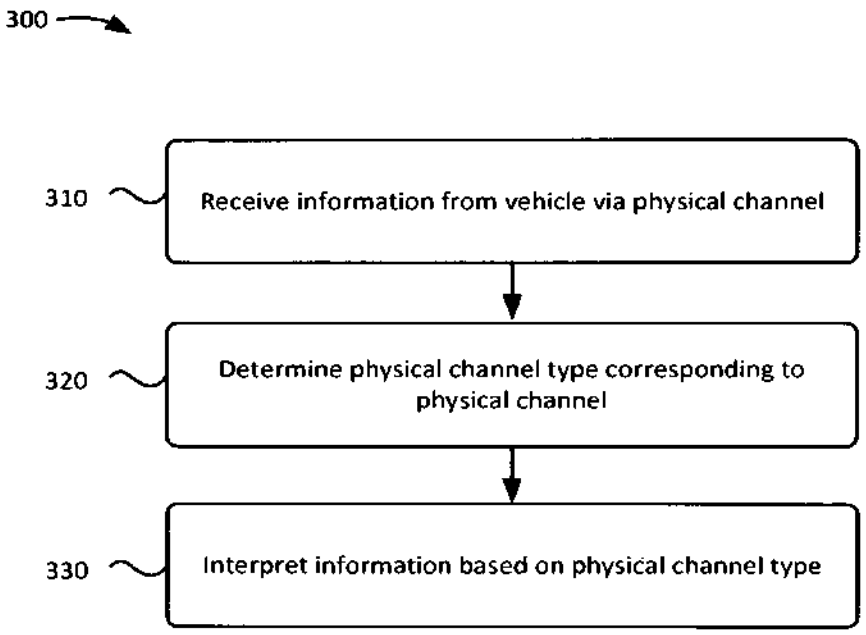

300
310
Receive information from vehicle via physical channel
320
Determine physical channel type corresponding to physical channel
330
Interpret information based on physical channel type

Fig. 3

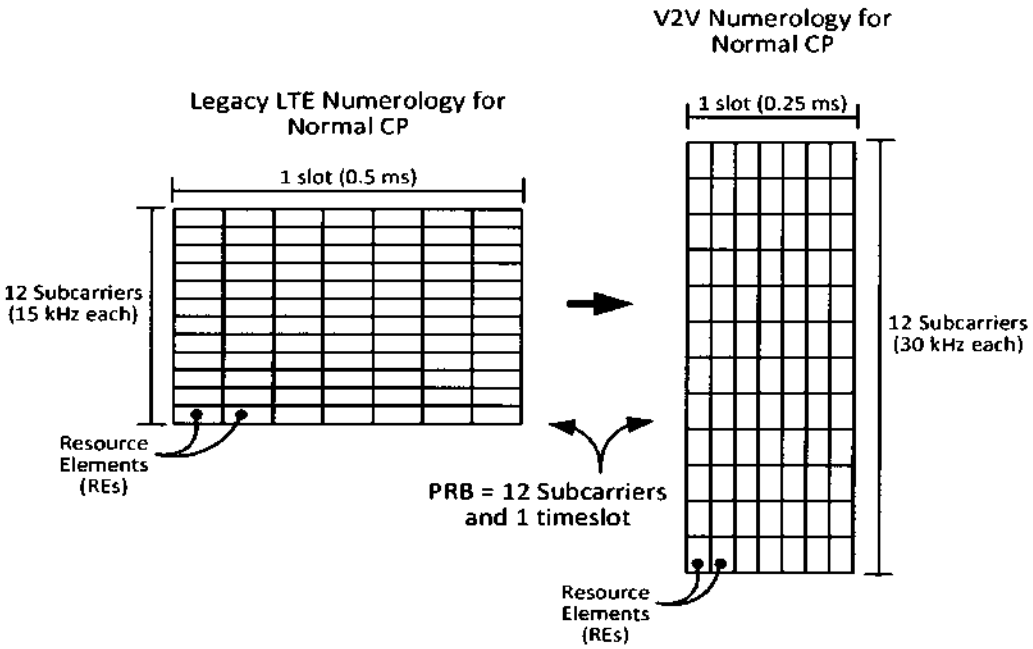

V2V Numerology for Normal CP
Legacy LTE Numerology for Normal CP
1 slot (0.25 ms)
1 slot (0.5 ms)
12 Subcarriers (15 kHz each)
12 Subcarriers (30 kHz each)
Resource Elements (REs)
PRB = 12 Subcarriers and 1 timeslot
Resource Elements (REs)

Fig. 4

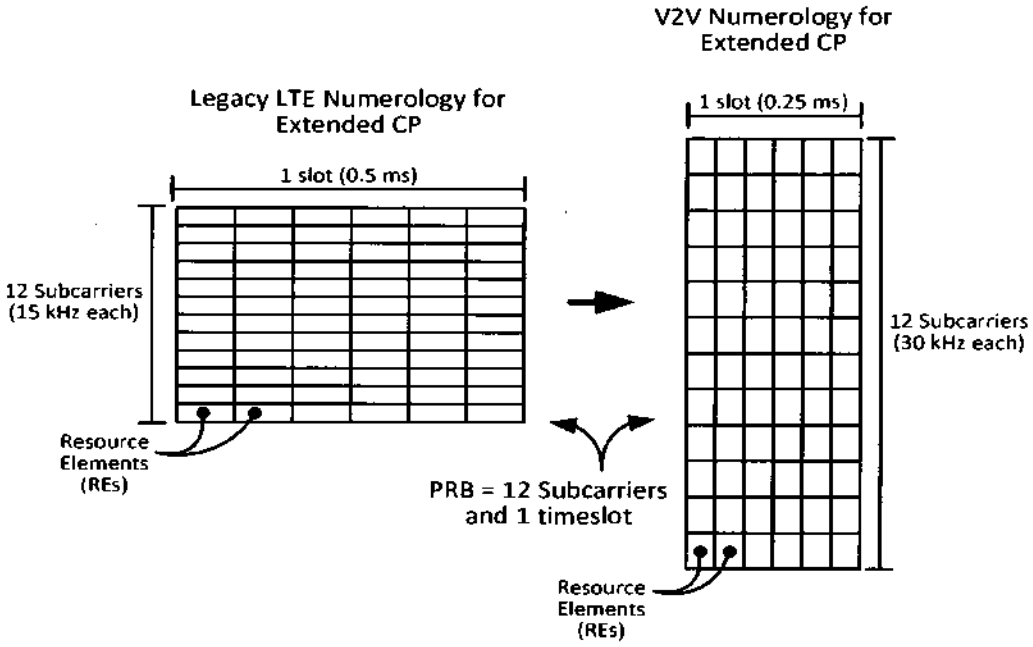

V2V Numerology for Extended CP
Legacy LTE Numerology for Extended CP
1 slot (0.25 ms)
1 slot (0.5 ms)
12 Subcarriers (15 kHz each)
12 Subcarriers (30 kHz each)
Resource Elements (REs)
PRB = 12 Subcarriers and 1 timeslot
Resource Elements (REs)

Fig. 5

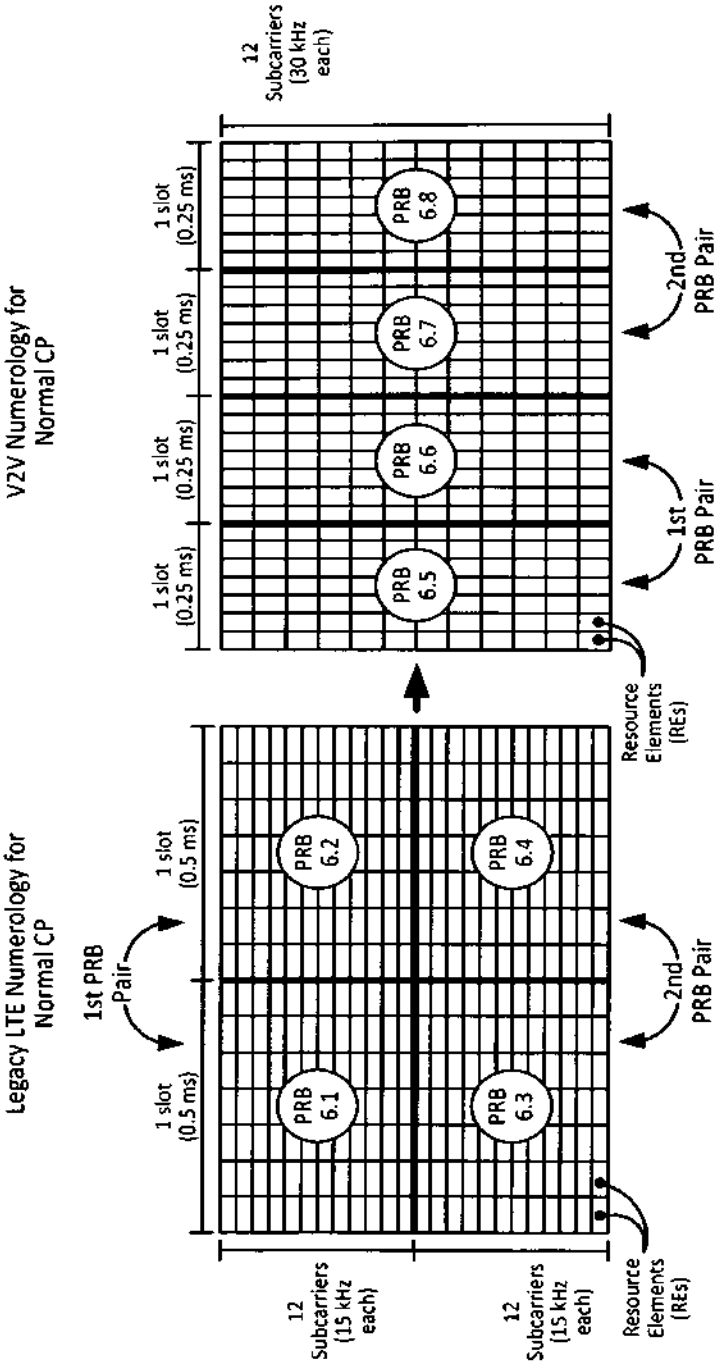

Legacy LTE Numerology for Normal CP
1st PRB Pair
1 slot (0.5 ms)
1 slot (0.5 ms)
PRB 6.1
PRB 6.2
PRB 6.3
PRB 6.4
2nd PRB Pair
12 Subcarriers (15 kHz each)
12 Subcarriers (15 kHz each)
Resource Elements (REs)
V2V Numerology for Normal CP
1 slot (0.25 ms)
1 slot (0.25 ms)
1 slot (0.25 ms)
1 slot (0.25 ms)
PRB 6.5
PRB 6.6
PRB 6.7
PRB 6.8
1st PRB Pair
2nd PRB Pair
12 Subcarriers (30 kHz each)
Resource Elements (REs)

Fig. 6

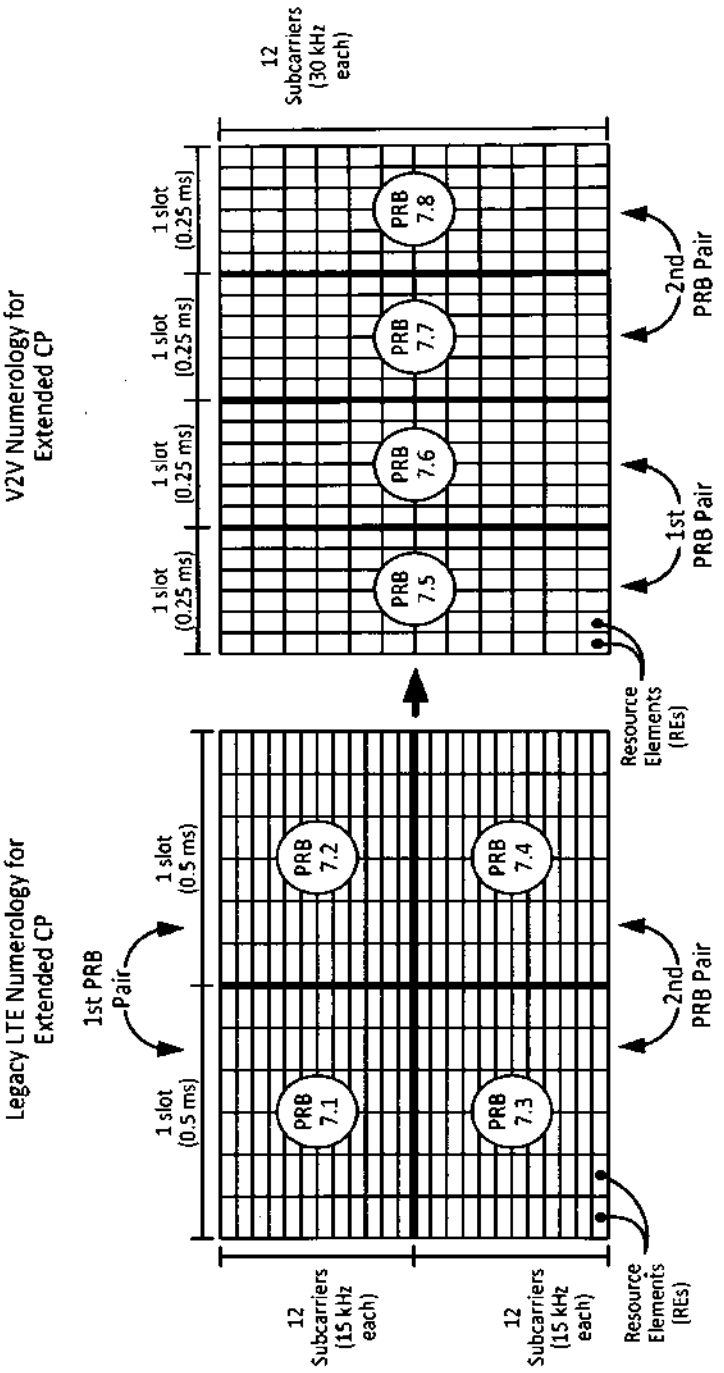

Legacy LTE Numerology for Extended CP
1st PRB Pair
1 slot (0.5 ms)
1 slot (0.5 ms)
PRB 7.1
PRB 7.2
PRB 7.3
PRB 7.4
2nd PRB Pair
12 Subcarriers (15 kHz each)
12 Subcarriers (15 kHz each)
Resource Elements (REs)
V2V Numerology for Extended CP
1 slot (0.25 ms)
1 slot (0.25 ms)
1 slot (0.25 ms)
1 slot (0.25 ms)
PRB 7.5
PRB 7.6
PRB 7.7
PRB 7.8
1st PRB Pair
2nd PRB Pair
12 Subcarriers (30 kHz each)
Resource Elements (REs)

Fig. 7

V2V Numerology for Normal CP

1 PRB = 12 Frequency REs and 1 timeslot

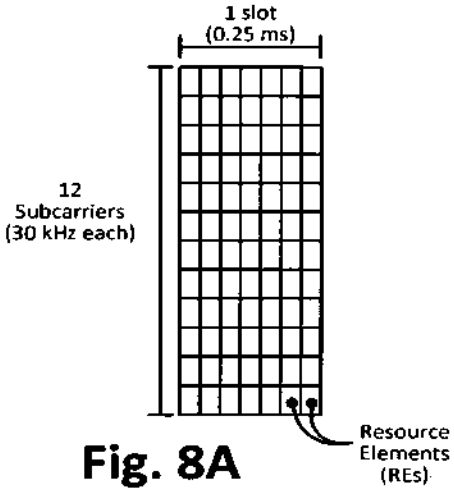


Fig. 8A

1 PRB Pair = 12 Frequency REs and 2 timeslots

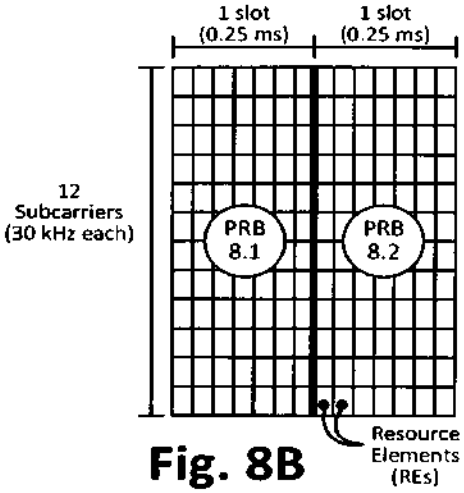


Fig. 8B

1 PRB = 6 Frequency REs and 1 timeslot

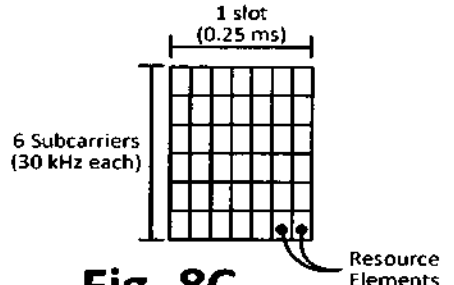


Fig. 8C

1 PRB Pair = 6 Frequency REs and 2 timeslots

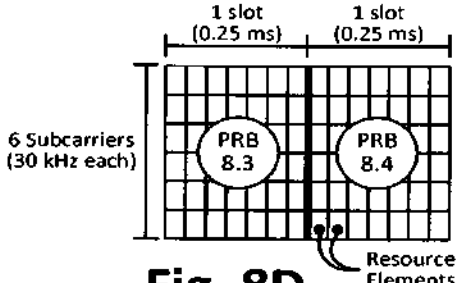


Fig. 8D

V2V Numerology for Extended CP

1 PRB = 12 Frequency Res and 1 timeslot

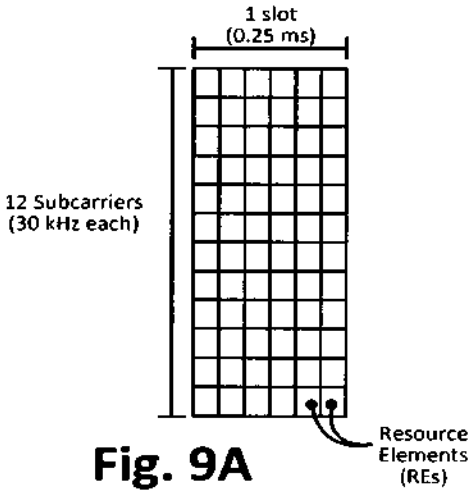


Fig. 9A

1 PRB Pair = 12 Frequency Res and 2 timeslots

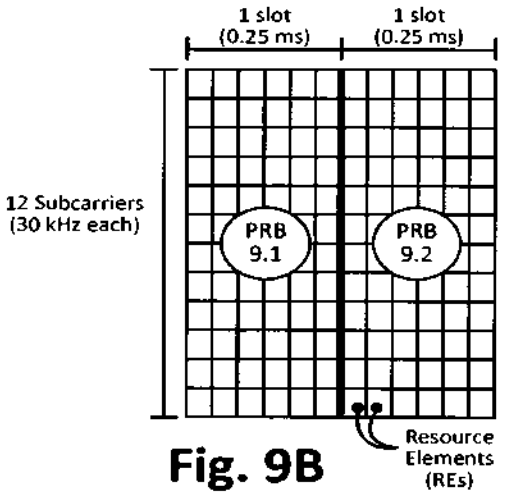


Fig. 9B

1 PRB = 6 Frequency REs and 1 timeslot

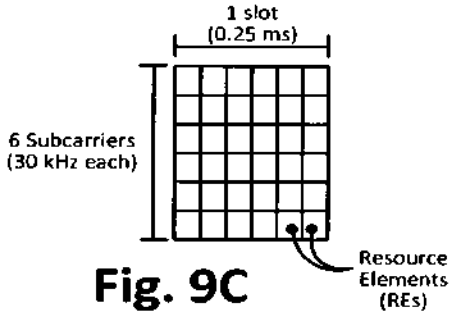


Fig. 9C

1 PRB Pair = 6 Frequency REs and 2 timeslots

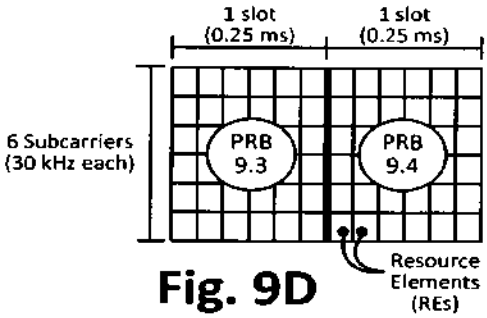


Fig. 9D

Channel Characteristic	Legacy LTE Channel Numerology	V2V Channel Numerology
Subcarrier Spacing	15 kHz	30 kHz
Supported Bandwidths	1.4, 3, 5, 10, 15, and 20 MHz	1.4, 3, 5, 10, 15, and 20 MHz
FFT Size	128, 256, 512, 1024, 1536, and 2048 MHz	64, 128, 256, 512, 768, and 1024 MHz
Sampling Time (Ts)	32.55 ns	32.55 ns
Symbol Duration (OFDM / SC-FDMA)	Normal CP, symbol 0: {(160+2048) x Ts) Normal CP, symbols 1-6: {(144+2048) x Ts) Extended CP: {(512+2048) x Ts)	Normal CP, symbol 0: {(160+2048) x Ts)/2 Normal CP, symbols 1-6: {(144+2048) x Ts)/2 Extended CP: {(512+2048) x Ts)/2
Single Timeslot Duration	0.5 ms (7 symbols for Normal CP) (6 symbols for Extended CP)	0.25 ms (7 symbols for Normal CP) (6 symbols for Extended CP
Single Subframe Duration	1.0 ms	0.5 or 1.0 ms
Subcarriers per PRB (Frequency REs)	12 subcarriers per PRB	6 or 12 subcarriers per PRB

Fig. 10

Channel Characteristic	Legacy LTE Channel Numerology	V2V Channel Numerology
Subcarrier Spacing	15 kHz	60 kHz
Supported Bandwidths	1.4, 3, 5, 10, 15, and 20 MHz	1.4, 3, 5, 10, 15, and 20 MHz
FFT Size	128, 256, 512, 1024, 1536, and 2048 MHz	64, 128, 256, 512, 768, and 1024 MHz
Sampling Time (Ts)	32.55 ns	32.55 ns
Symbol Duration (OFDM / SC-FDMA)	Normal CP, symbol 0: ((160+2048) x Ts) Normal CP, symbols 1-6: ((144+2048) x Ts) Extended CP: ((512+2048) x Ts)	Normal CP, symbol 0: ((160+2048) x Ts)/4 Normal CP, symbols 1-6: ((144+2048) x Ts)/4 Extended CP: ((512+2048) x Ts)/4
Single Timeslot Duration	0.5 ms (7 symbols for Normal CP) (6 symbols for Extended CP)	0.125 ms (7 symbols for Normal CP) (6 symbols for Extended CP
Single Subframe Duration	1.0 ms	0.5 or 1.0 ms
Subcarriers per PRB (Frequency REs)	12 subcarriers per PRB	3, 6, or 12 subcarriers per PRB

Fig. 11

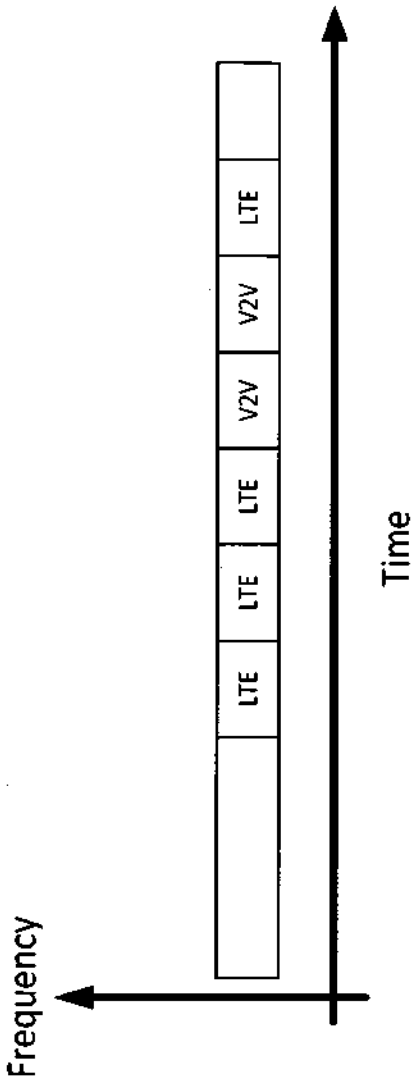


Fig. 12

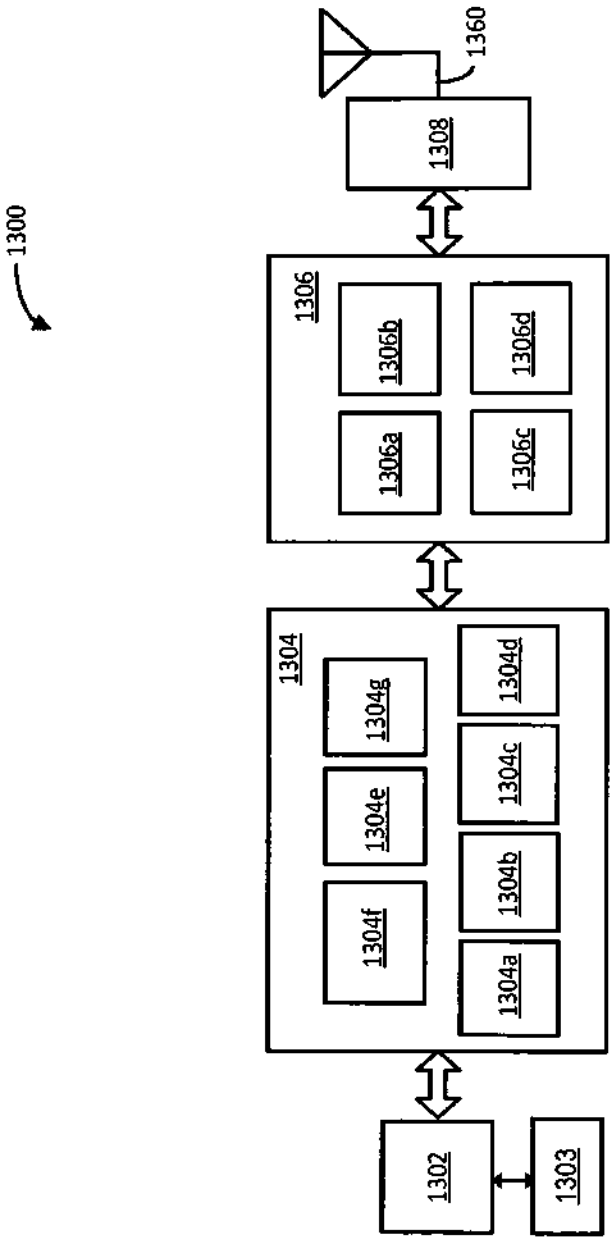

1300
1360
1308
1306
1306b
1306d
1306a
1306c
1304
1304g
1304d
1304e
1304c
1304f
1304b
1304a
1302
1303

Fig. 13

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/000466

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04L5/00 H04L27/26 H04W88/06 H04W84/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04L H04W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2014/065563 A1 (LG ELECTRONICS INC) 1 May 2014 (2014-05-01) the whole document -& US 2015/282178 A1 (KIM KITAE [KR] ET AL) 1 October 2015 (2015-10-01) paragraph [0010] paragraph [0023] paragraph [0045] - paragraph [0046] paragraph [0061] - paragraph [0065] paragraph [0082] paragraph [0094] paragraph [0110] - paragraph [0111] paragraph [0131] paragraph [0156] paragraph [0166] - paragraph [0177] figures 6,13,18 tables 1,4,6,8 ----- -/--	1-12,14, 17-25

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/000466

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2015/180622 A1 (YOO TAESANG [US] ET AL) 25 June 2015 (2015-06-25) paragraph [0007] paragraph [0012] paragraph [0054] - paragraph [0062] paragraph [0068] - paragraph [0080] paragraph [0140] - paragraph [0141] figures 2,3a,3c,8-10,12,13	1-25
A	Erik Dahlman ET AL: "Physical Transmission Resources (Chapter 9)" In: "4G: LTE/LTE-Advanced for Mobile Broadband (second edition) [Kindle Edition]", 7 October 2013 (2013-10-07), Academic Press, XP055167425, ISBN: 978-0-12-419997-2 pages 141-159, the whole document	1-25
A	Deliverable D2: "Document Number: ICT-317669-METIS/D2.4 Project Name: Mobile and wireless communications Enablers for the Twenty-twenty Information Society (METIS)", , 28 February 2015 (2015-02-28), XP055248907, Retrieved from the Internet: URL:https://www.metis2020.com/wp-content/uploads/deliverables/METIS_D2.4_v1.pdf [retrieved on 2016-02-10] Chapters 3 and 6	1-25

3

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2015/000466

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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(54) Title: RANDOM ACCESS PROCESS IN NEW RADIO

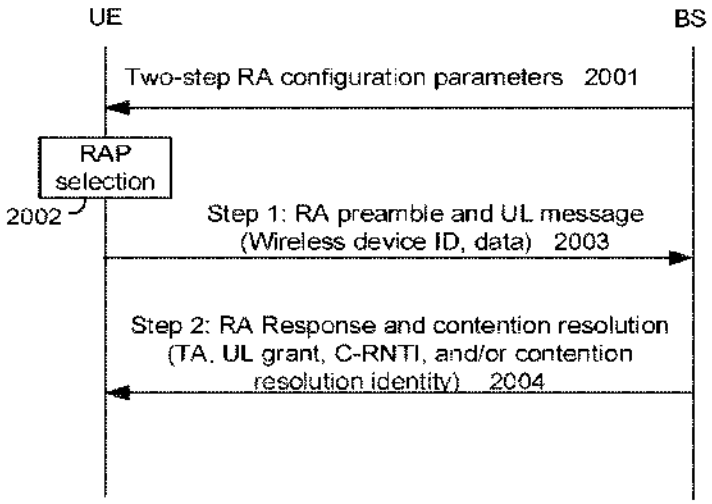


FIG. 20

(57) Abstract: Systems, apparatuses, and methods are described for wireless communications. Random access procedures may include various types of procedures, such as four-step or two-step random access procedures. One or more indicators may be included in one or more messages for a handover to indicate a type of a random access procedure. Additionally or alternatively, one or more indicators for transmission power may be used to determine a random access procedure.

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RANDOM ACCESS PROCESS IN NEW RADIO

CROSS-REFERENCE TO RELATED APPLICATIONS

[01] This application claims the benefit of U.S. Provisional Application No. 62/475,028, titled "Random Access Process in New Radio" and filed on March 22, 2017, U.S. Provisional Application No. 62/475,033, titled "Handover Random Access" and filed on March 22, 2017, U.S. Provisional Application No. 62/475,039, titled "RAR in New Radio" and filed on March 22, 2017, U.S. Provisional Application No. 62/475,045, titled "2-Stage RACH in New Radio" and filed on March 22, 2017, and U.S. Provisional Application No. 62/475,537, titled "Power Control For 2-Step RACH, filed March 23, 2017, each of the above of which is hereby incorporated by reference in its entirety.

BACKGROUND

[02] In wireless communications, such as between a wireless device and a base station, a four-step random access (RA) procedure may be performed. A first step may include a random access preamble (RAP) transmission. A second step may include a random access response (RAR) transmission. A third step may include scheduled transmissions of one or more transport blocks (TBs). And, a fourth step may include contention resolution. While different RA procedures may be performed, difficulties may arise in determining and/or indicating a particular RA procedure among a plurality of RA procedures.

[03] In wireless communications, such as between a wireless device and a base station, an RA procedure may be performed to initiate the communications. A wireless device may handover from a source base station to a target base station, e.g., if the wireless device moves from a location in a first cell served by the source base station to a location in a second cell served by the target base station. The source base station and the target base station may perform different RA procedures to initiate communications with wireless devices. Difficulties may arise in determining a type of RA procedure to perform when a handover occurs.

[04] In wireless communications, such as between a wireless device and a base station, a random access procedure may be performed to initiate the communications. As a wireless device travels further from a base station, and as transmissions may comprise

more overlapping signals, the wireless device may require increasingly more power for communication transmissions to be successful. A wireless device may additionally have a maximum amount of power at which the wireless device may be allowed to transmit. Difficulties may arise for transmissions that may require more than a maximum amount of power to be successful.

SUMMARY

[05] The following summary presents a simplified summary of certain features. The summary is not an extensive overview and is not intended to identify key or critical elements.

[06] Systems, apparatuses, and methods are described for performing and indicating various RA procedures. RA procedures may comprise different steps. For example, a two-step RA procedure or a four-step RA procedure may be performed. A type of RA procedure may be indicated by one or more indicators. Such indicators may be used, for example, to indicate random access successes, random access failures, random access response size information, various steps for random access procedures, and/or other information about one or more RA procedures. One or more timers may be used to determine, e.g., whether an RA procedure fails (such as a failure of a 2-step RA procedure) and/or whether a different RA procedure should be performed (such as a fallback to a 4-step RA procedure).

[07] Systems, apparatuses, and methods are described for determining a type of RA procedure to perform when a handover occurs. RA procedures may comprise different steps. For example, a two-step RA procedure or a four-step RA procedure may be performed. The type of RA procedure may be identified by one or more indicators. The one or more indicators may be included in messages sent to or from devices involved in a handover, such as a wireless device, a source base station, a target base station, and/or one or more core network devices.

[08] Systems, apparatuses, and methods are described for performing and identifying various RA procedures. RA procedures may comprise different steps. For example, a four-step RA procedure or a two-step RA procedure, comprising overlapping signals, may be performed. The type of RA procedure may be determined based on, e.g., power demands for transmissions and a power threshold. The type of RA procedure may be indicated by one or more indicators in one or more messages. The one or more indicators may correspond with transmission power levels associated with random access procedure parameters.

[09] These and other features and advantages are described in greater detail below.

BRIEF DESCRIPTION OF THE DRAWINGS

[10] Some features are shown by way of example, and not by limitation, in the accompanying drawings. In the drawings, like numerals reference similar elements.

[11] FIG. 1 shows example sets of orthogonal frequency division multiplexing (OFDM) subcarriers.

[12] FIG. 2 shows example transmission time and reception time for two carriers in a carrier group.

[13] FIG. 3 shows example OFDM radio resources.

[14] FIG. 4 shows hardware elements of a base station and a wireless device.

[15] FIG. 5A, FIG. 5B, FIG. 5C and FIG. 5D show examples for uplink and downlink signal transmission.

[16] FIG. 6 shows an example protocol structure with multi-connectivity.

[17] FIG. 7 shows an example protocol structure with carrier aggregation (CA) and dual connectivity (DC).

[18] FIG. 8 shows example timing advance group (TAG) configurations.

[19] FIG. 9 shows example message flow in a random access process in a secondary TAG.

[20] FIG. 10A and FIG. 10B show examples for interfaces between a 5G core network and base stations.

[21] FIG. 11A, FIG. 11B, FIG. 11C, FIG. 11D, FIG. 11E, and FIG. 11F show examples for architectures of tight interworking between 5G RAN and long term evolution (LTE) radio access network (RAN).

[22] FIG. 12A, FIG. 12B, and FIG. 12C show examples for radio protocol structures of tight interworking bearers.

[23] FIG. 13A and FIG.13B show examples for gNodeB (gNB) deployment scenarios.

[24] FIG. 14 functional split option examples of a centralized gNB deployment scenario.

[25] FIG. 15 shows examples of contention-based and contention free random access procedures.

[26] FIG. 16 shows an example of a random access preamble selection procedure.

[27] FIG. 17 shows an example media access control (MAC) packet data unit (PDU) format of an example of MAC PDU comprising a MAC header and MAC random access responses (RARs) for a four-step RA procedure.

[28] FIG. 18 shows an example of shows an example of an uplink resource for a transmission in a first step of a two-step RA procedure.

[29] FIG. 19 shows an example MAC RAR format of an example of MAC RAR comprising a timing advance command, Uplink (UL) Grant, and Temporary Cell-Radio Network Temporary Identifier for a four-step RA procedure.

[30] FIG. 20 shows an example of a two-step RA procedure.

[31] FIG. 21 shows an example of contention resolution for a two-step RA procedure.

[32] FIG. 22 shows an example of a two-step RA procedure of an example failure of UL transmission for n times.

[33] FIG. 23 shows example RARs with a fixed size 8 bytes for example RAR formats for two-step RA procedures and for a four-step RA procedure.

[34] FIG. 24 shows an example RAR with a fixed size 12 bytes for example RAR formats for two-step and four-step RA procedures.

[35] FIG. 25 shows an example for hybrid automatic repeat request (HARQ) retransmission, such as when a cell detects a random access preamble identifier but fails to decode data.

[36] FIG. 26 shows an example of a two-step RA procedure failure as the number of HARQ retransmission reaches a threshold.

[37] FIG. 27 shows an example of a two-step RA procedure when a base station decodes a RAP and UL data and responds with an RAR to a wireless device.

[38] FIG. 28 shows an example of a handover of a wireless device from a source base station to a target base station.

[39] FIG. 29 shows an example of a handover of a wireless device from a source base station to a target base station that is facilitated by a core network entity.

[40] FIG. 30 shows an example of handover procedures for a wireless device.

[41] FIG. 31 shows an example of handover procedures for a source base station.

[42] FIG. 32 shows an example of handover procedures for a target base station.

[43] FIG. 33 shows an example of handover procedures for a core network device.

[44] FIG. 34 shows an example of handover procedures with different types of RA procedures for a wireless device.

[45] FIG. 35 shows an example network with a base station, a first wireless device, and a second wireless device.

[46] FIG. 36 shows an example of a process for determining whether to initiate a two-step or four-step random access procedure.

[47] FIG. 37 shows an example of a process for determining whether to drop data transmissions

[48] FIG. 38 shows an example of a process for determining whether to adjust transmission power for preamble and/or data transmissions.

[49] FIG. 39 shows an example of a process for recalculating transmission power for preamble and/or data transmissions, adjusting transmission power for data transmissions, and/or determining whether to perform a four-step random access procedure based on the transmission power for the data transmissions.

DETAILED DESCRIPTION

[50] The accompanying drawings, which form a part hereof, show examples of the disclosure. It is to be understood that the examples shown in the drawings and/or discussed herein are non-exclusive and that there are other examples of how the disclosure may be practiced.

[51] Examples may enable operation of carrier aggregation and may be employed in the technical field of multicarrier communication systems. Examples may relate to signal timing in a multicarrier communication systems.

[52] The following Acronyms are used throughout the present disclosure:

3GPP	3rd Generation Partnership Project
5G	5th generation wireless systems
5GC	5G Core Network
ACK	Acknowledgement
AMF	Access and Mobility Management Function
ASIC	application-specific integrated circuit
BPSK	binary phase shift keying
CA	carrier aggregation
CC	component carrier
CDMA	code division multiple access
CP	cyclic prefix
CPLD	complex programmable logic devices
CSI	channel state information
CSS	common search space
CU	central unit
DC	dual connectivity
DCI	downlink control information
DFTS-OFDM	discrete fourier transform spreading OFDM
DL	downlink
DU	distributed unit
eLTE	enhanced LTE
eMBB	enhanced mobile broadband
eNB	evolved Node B
EPC	evolved packet core
E-UTRAN	evolved-universal terrestrial radio access network
FDD	frequency division multiplexing
FPGA	field programmable gate arrays
Fs-C	Fs-control plane
Fs-U	Fs-user plane
gNB	next generation node B

HARQ	hybrid automatic repeat request
HDL	hardware description languages
ID	identifier
IE	information element
LTE	long term evolution
MAC	media access control
MCG	master cell group
MeNB	master evolved node B
MIB	master information block
MME	mobility management entity
mMTC	massive machine type communications
NACK	Negative Acknowledgement
NAS	non-access stratum
NG CP	next generation control plane core
NGC	next generation core
NG-C	NG-control plane
NG-U	NG-user plane
NR MAC	new radio MAC
NR PDCP	new radio PDCP
NR PHY	new radio physical
NR RLC	new radio RLC
NR RRC	new radio RRC
NR	new radio
NR	new radio
NSSAI	network slice selection assistance information
OFDM	orthogonal frequency division multiplexing
PCC	primary component carrier
PCell	primary cell
PDCCH	physical downlink control channel
PDCP	packet data convergence protocol
PDU	packet data unit
PHICH	physical HARQ indicator channel
PHY	physical
PLMN	public land mobile network
PSCell	primary secondary cell

pTAG	primary timing advance group
PUCCH	physical uplink control channel
PUSCH	physical uplink shared channel
QAM	quadrature amplitude modulation
QPSK	quadrature phase shift keying
RA	random access
RACH	random access channel
RAN	radio access network
RAP	random access preamble
RAPID / RAP ID	random access preamble identifier
RAR	random access response
RB	resource blocks
RBG	resource block groups
RLC	radio link control
RRC	radio resource control
RRM	radio resource management
RV	redundancy version
SCC	secondary component carrier
SCell	secondary cell
SCG	secondary cell group
SC-OFDM	single carrier-OFDM
SDU	service data unit
SeNB	secondary evolved node B
SFN	system frame number
S-GW	serving gateway
SIB	system information block
SC-OFDM	single carrier orthogonal frequency division multiplexing
SRB	signaling radio bearer
sTAG(s)	secondary timing advance group(s)
TA	timing advance
TAG	timing advance group
TAI	tracking area identifier
TAT	time alignment timer
TDD	time division duplexing
TDMA	time division multiple access

TTI	transmission time interval
TB	transport block
UE	user equipment
UL	uplink
UPGW	user plane gateway
URLLC	ultra-reliable low-latency communications
VHDL	VHSIC hardware description language
Xn-C	Xn-control plane
Xn-U	Xn-user plane
Xx-C	Xx-control plane
Xx-U	Xx-user plane

[53] Examples may be implemented using various physical layer modulation and transmission mechanisms. Example transmission mechanisms may include, but are not limited to: CDMA, OFDM, TDMA, Wavelet technologies, and/or the like. Hybrid transmission mechanisms such as TDMA/CDMA, and OFDM/CDMA may also be employed. Various modulation schemes may be applied for signal transmission in the physical layer. Examples of modulation schemes include, but are not limited to: phase, amplitude, code, a combination of these, and/or the like. An example radio transmission method may implement QAM using BPSK, QPSK, 16-QAM, 64-QAM, 256-QAM, and/or the like. Physical radio transmission may be enhanced by dynamically or semi-dynamically changing the modulation and coding scheme depending on transmission requirements and radio conditions.

[54] FIG. 1 shows example sets of OFDM subcarriers. As shown in this example, arrow(s) in the diagram may depict a subcarrier in a multicarrier OFDM system. The OFDM system may use technology such as OFDM technology, DFTS-OFDM, SC-OFDM technology, or the like. For example, arrow 101 shows a subcarrier transmitting information symbols. FIG. 1 is shown as an example, and a typical multicarrier OFDM system may include more subcarriers in a carrier. For example, the number of subcarriers in a carrier may be in the range of 10 to 10,000 subcarriers. FIG. 1 shows two guard bands 106 and 107 in a transmission band. As shown in FIG. 1, guard band 106 is between subcarriers 103 and subcarriers 104. The example set of subcarriers A 102 includes subcarriers 103 and subcarriers 104. FIG. 1 also shows an example set of subcarriers B 105. As shown, there is no guard band between any two subcarriers in the example set of subcarriers B

105. Carriers in a multicarrier OFDM communication system may be contiguous carriers, non-contiguous carriers, or a combination of both contiguous and non-contiguous carriers.

[55] FIG. 2 shows an example with transmission time and reception time for two carriers. A multicarrier OFDM communication system may include one or more carriers, for example, ranging from 1 to 10 carriers. Carrier A 204 and carrier B 205 may have the same or different timing structures. Although FIG. 2 shows two synchronized carriers, carrier A 204 and carrier B 205 may or may not be synchronized with each other. Different radio frame structures may be supported for FDD and TDD duplex mechanisms. FIG. 2 shows an example FDD frame timing. Downlink and uplink transmissions may be organized into radio frames 201. In this example, radio frame duration is 10 milliseconds (msec). Other frame durations, for example, in the range of 1 to 100 msec may also be supported. In this example, each 10 msec radio frame 201 may be divided into ten equally sized subframes 202. Other subframe durations such as including 0.5 msec, 1 msec, 2 msec, and 5 msec may also be supported. Subframe(s) may consist of two or more slots (e.g., slots 206 and 207). For the example of FDD, 10 subframes may be available for downlink transmission and 10 subframes may be available for uplink transmissions in each 10 msec interval. Uplink and downlink transmissions may be separated in the frequency domain. A slot may be 7 or 14 OFDM symbols for the same subcarrier spacing of up to 60kHz with normal CP. A slot may be 14 OFDM symbols for the same subcarrier spacing higher than 60kHz with normal CP. A slot may contain all downlink, all uplink, or a downlink part and an uplink part, and/or alike. Slot aggregation may be supported, e.g., data transmission may be scheduled to span one or multiple slots. In an example, a mini-slot may start at an OFDM symbol in a subframe. A mini-slot may have a duration of one or more OFDM symbols. Slot(s) may include a plurality of OFDM symbols 203. The number of OFDM symbols 203 in a slot 206 may depend on the cyclic prefix length and subcarrier spacing.

[56] FIG. 3 shows an example of OFDM radio resources. The resource grid structure in time 304 and frequency 305 is shown in FIG. 3. The quantity of downlink subcarriers or RBs may depend, at least in part, on the downlink transmission bandwidth 306 configured in the cell. The smallest radio resource unit may be called a resource element (e.g., 301). Resource elements may be grouped into resource blocks (e.g., 302). Resource blocks may be grouped into larger radio resources called Resource Block Groups (RBG) (e.g., 303). The transmitted signal in slot 206 may be described by one or several resource

grids of a plurality of subcarriers and a plurality of OFDM symbols. Resource blocks may be used to describe the mapping of certain physical channels to resource elements. Other pre-defined groupings of physical resource elements may be implemented in the system depending on the radio technology. For example, 24 subcarriers may be grouped as a radio block for a duration of 5 msec. A resource block may correspond to one slot in the time domain and 180 kHz in the frequency domain (for 15 kHz subcarrier bandwidth and 12 subcarriers).

[57] Multiple numerologies may be supported. A numerology may be derived by scaling a basic subcarrier spacing by an integer N. Scalable numerology may allow at least from 15kHz to 480kHz subcarrier spacing. The numerology with 15 kHz and scaled numerology with different subcarrier spacing with the same CP overhead may align at a symbol boundary every 1 msec in a NR carrier.

[58] FIG. 4 shows hardware elements of a base station 401 and a wireless device 406. A communication network 400 may include at least one base station 401 and at least one wireless device 406. The base station 401 may include at least one communication interface 402, one or more processors 403, and at least one set of program code instructions 405 stored in non-transitory memory 404 and executable by the one or more processors 403. The wireless device 406 may include at least one communication interface 407, one or more processors 408, and at least one set of program code instructions 410 stored in non-transitory memory 409 and executable by the one or more processors 408. A communication interface 402 in the base station 401 may be configured to engage in communication with a communication interface 407 in the wireless device 406, such as via a communication path that includes at least one wireless link 411. The wireless link 411 may be a bi-directional link. The communication interface 407 in the wireless device 406 may also be configured to engage in communication with the communication interface 402 in the base station 401. The base station 401 and the wireless device 406 may be configured to send and receive data over the wireless link 411 using multiple frequency carriers. Base stations, wireless devices, and other communication devices may include structure and operations of transceiver(s). A transceiver is a device that includes both a transmitter and receiver. Transceivers may be employed in devices such as wireless devices, base stations, relay nodes, and/or the like. Examples for radio technology implemented in the communication interfaces 402, 407 and the wireless link 411 are shown in FIG. 1, FIG. 2, FIG. 3, FIG. 5, and associated text. The communication network 400 may comprise any number and/or type of devices,

such as, for example, wireless devices, mobile devices, handsets, tablets, laptops, internet of things (IoT) devices, hotspots, cellular repeaters, computing devices, and/or, more generally, user equipment (e.g., UE). Although one or more of the above types of devices may be referenced herein (e.g., UE, wireless device, etc.), it should be understood that any device herein may comprise any one or more of the above types of devices or similar devices. The communication network 400, and any other network referenced herein, may comprise an LTE network, a 5G network, or any other network for wireless communications. Apparatuses, systems, and/or methods described herein may generally be described as implemented on one or more devices (e.g., wireless device, base station, eNB, gNB, computing device, etc.), in one or more networks, but it will be understood that one or more features and steps may be implemented on any device and/or in any network. As an example, any reference to a base station may comprise an eNB, a gNB, a computing device, or any other device, and any reference to a wireless device may comprise a UE, a handset, a mobile device, a computing device or any other device.

[59] The communications network 400 may comprise Radio Access Network (RAN) architecture. The RAN architecture may comprise one or more RAN nodes that may be a next generation Node B (gNB) (e.g., 401) providing New Radio (NR) user plane and control plane protocol terminations towards a first wireless device (*e.g.* 406). A RAN node may be a next generation evolved Node B (ng-eNB), providing Evolved UMTS Terrestrial Radio Access (E-UTRA) user plane and control plane protocol terminations towards a second wireless device. The first wireless device may communicate with a gNB over a Uu interface. The second wireless device may communicate with a ng-eNB over a Uu interface. Base station 401 may comprise at least one of a gNB, ng-eNB, and or the like.

[60] A gNB or an ng-eNB may host functions such as: radio resource management and scheduling, IP header compression, encryption and integrity protection of data, selection of Access and Mobility Management Function (AMF) at User Equipment (UE) attachment, routing of user plane and control plane data, connection setup and release, scheduling and transmission of paging messages (originated from the AMF), scheduling and transmission of system broadcast information (originated from the AMF or Operation and Maintenance (O&M)), measurement and measurement reporting configuration, transport level packet marking in the uplink, session management, support of network slicing, Quality of Service (QoS) flow management and mapping to data radio bearers,

support of UEs in RRC_INACTIVE state, distribution function for Non-Access Stratum (NAS) messages, RAN sharing, and dual connectivity or tight interworking between NR and E-UTRA.

[61] One or more gNBs and/or one or more ng-eNBs may be interconnected with each other by means of Xn interface. A gNB or an ng-eNB may be connected by means of NG interfaces to 5G Core Network (5GC). 5GC may comprise one or more AMF/User Plan Function (UPF) functions. A gNB or an ng-eNB may be connected to a UPF by means of an NG-User plane (NG-U) interface. The NG-U interface may provide delivery (*e.g.* non-guaranteed delivery) of user plane Protocol Data Units (PDUs) between a RAN node and the UPF. A gNB or an ng-eNB may be connected to an AMF by means of an NG-Control plane (NG-C) interface. The NG-C interface may provide functions such as NG interface management, UE context management, UE mobility management, transport of NAS messages, paging, PDU session management, configuration transfer or warning message transmission.

[62] A UPF may host functions such as anchor point for intra-/inter-Radio Access Technology (RAT) mobility (when applicable), external PDU session point of interconnect to data network, packet routing and forwarding, packet inspection and user plane part of policy rule enforcement, traffic usage reporting, uplink classifier to support routing traffic flows to a data network, branching point to support multi-homed PDU session, QoS handling for user plane, *e.g.* packet filtering, gating, Uplink (UL)/Downlink (DL) rate enforcement, uplink traffic verification (*e.g.* Service Data Flow (SDF) to QoS flow mapping), downlink packet buffering and/or downlink data notification triggering.

[63] An AMF may host functions such as NAS signaling termination, NAS signaling security, Access Stratum (AS) security control, inter Core Network (CN) node signaling for mobility between 3rd Generation Partnership Project (3GPP) access networks, idle mode UE reachability (*e.g.*, control and execution of paging retransmission), registration area management, support of intra-system and inter-system mobility, access authentication, access authorization including check of roaming rights, mobility management control (subscription and policies), support of network slicing and/or Session Management Function (SMF) selection

[64] An interface may be a hardware interface, a firmware interface, a software interface, and/or a combination thereof. The hardware interface may include connectors, wires,

electronic devices such as drivers, amplifiers, and/or the like. A software interface may include code stored in a memory device to implement protocol(s), protocol layers, communication drivers, device drivers, combinations thereof, and/or the like. A firmware interface may include a combination of embedded hardware and code stored in and/or in communication with a memory device to implement connections, electronic device operations, protocol(s), protocol layers, communication drivers, device drivers, hardware operations, combinations thereof, and/or the like.

[65] The term configured may relate to the capacity of a device whether the device is in an operational or a non-operational state. Configured may also refer to specific settings in a device that effect the operational characteristics of the device whether the device is in an operational or a non-operational state. In other words, the hardware, software, firmware, registers, memory values, and/or the like may be "configured" within a device, whether the device is in an operational or a nonoperational state, to provide the device with specific characteristics. Terms such as "a control message to cause in a device" may mean that a control message has parameters that may be used to configure specific characteristics in the device, whether the device is in an operational or a non-operational state.

[66] A 5G network may include a multitude of base stations, providing a user plane NR PDCP/NR RLC/NR MAC/NR PHY and control plane (NR RRC) protocol terminations towards the wireless device. The base station(s) may be interconnected with other base station(s) (e.g., employing an Xn interface). The base stations may also be connected employing, for example, an NG interface to an NGC. FIG. 10A and FIG. 10B show examples for interfaces between a 5G core network (e.g., NGC) and base stations (e.g., gNB and eLTE eNB). For example, the base stations may be interconnected to the NGC control plane (e.g., NG CP) employing the NG-C interface and to the NGC user plane (e.g., UPGW) employing the NG-U interface. The NG interface may support a many-to-many relation between 5G core networks and base stations.

[67] A base station may include many sectors, for example: 1, 2, 3, 4, or 6 sectors. A base station may include many cells, for example, ranging from 1 to 50 cells or more. A cell may be categorized, for example, as a primary cell or secondary cell. At RRC connection establishment/re-establishment/handover, one serving cell may provide the NAS (non-access stratum) mobility information (e.g., TAI), and at RRC connection re-establishment/handover, one serving cell may provide the security input. This cell may

be referred to as the Primary Cell (PCell). In the downlink, the carrier corresponding to the PCell may be the Downlink Primary Component Carrier (DL PCC), while in the uplink, it may be the Uplink Primary Component Carrier (UL PCC). Depending on wireless device capabilities, Secondary Cells (SCells) may be configured to form together with the PCell a set of serving cells. In the downlink, the carrier corresponding to an SCell may be a Downlink Secondary Component Carrier (DL SCC), while in the uplink, it may be an Uplink Secondary Component Carrier (UL SCC). An SCell may or may not have an uplink carrier.

[68] A cell, comprising a downlink carrier and optionally an uplink carrier, may be assigned a physical cell ID and a cell index. A carrier (downlink or uplink) may belong to only one cell. The cell ID or cell index may also identify the downlink carrier or uplink carrier of the cell (depending on the context it is used). The cell ID may be equally referred to a carrier ID, and cell index may be referred to carrier index. In implementation, the physical cell ID or cell index may be assigned to a cell. A cell ID may be determined using a synchronization signal transmitted on a downlink carrier. A cell index may be determined using RRC messages. For example, reference to a first physical cell ID for a first downlink carrier may indicate that the first physical cell ID is for a cell comprising the first downlink carrier. The same concept may apply to, for example, carrier activation. Reference to a first carrier that is activated may indicate that the cell comprising the first carrier is activated.

[69] Examples may be configured to operate as needed. The disclosed mechanisms may be performed when certain criteria are met, for example, in a wireless device, a base station, a radio environment, a network, a combination of the above, and/or the like. Example criteria may be based, at least in part, on for example, traffic load, initial system set up, packet sizes, traffic characteristics, a combination of the above, and/or the like. When the one or more criteria are met, various examples may be applied. Therefore, it may be possible to implement examples that selectively implement disclosed protocols.

[70] A base station may communicate with a mix of wireless devices. Wireless devices may support multiple technologies, and/or multiple releases of the same technology. Wireless devices may have some specific capability(ies) depending on its wireless device category and/or capability(ies). A base station may comprise multiple sectors. Reference to a base station communicating with a plurality of wireless devices may indicate that a subset of the total wireless devices in a coverage area. A plurality of wireless devices of a given

LTE or 5G release, with a given capability and in a given sector of the base station, may be used. The plurality of wireless devices may refer to a selected plurality of wireless devices, and/or a subset of total wireless devices in a coverage area which perform according to disclosed methods, and/or the like. There may be a plurality of wireless devices in a coverage area that may not comply with the disclosed methods, for example, because those wireless devices perform based on older releases of LTE or 5G technology.

[71] A base station may transmit (e.g., to a wireless device) one or more messages (*e.g.* RRC messages) that may comprise a plurality of configuration parameters for one or more cells. One or more cells may comprise at least one primary cell and at least one secondary cell. In an example, an RRC message may be broadcasted or unicasted to the wireless device. In an example, configuration parameters may comprise common parameters and dedicated parameters.

[72] Services and/or functions of an RRC sublayer may comprise at least one of: broadcast of system information related to AS and NAS; paging initiated by 5GC and/or NG-RAN; establishment, maintenance, and/or release of an RRC connection between a wireless device and NG-RAN, which may comprise at least one of addition, modification and release of carrier aggregation; or addition, modification, and/or release of dual connectivity in NR or between E-UTRA and NR. Services and/or functions of an RRC sublayer may further comprise at least one of security functions comprising key management; establishment, configuration, maintenance, and/or release of Signaling Radio Bearers (SRBs) and/or Data Radio Bearers (DRBs); mobility functions which may comprise at least one of a handover (*e.g.* intra NR mobility or inter-RAT mobility) and a context transfer; or a wireless device cell selection and reselection and control of cell selection and reselection. Services and/or functions of an RRC sublayer may further comprise at least one of QoS management functions; a wireless device measurement configuration/reporting; detection of and/or recovery from radio link failure; or NAS message transfer to/from a core network entity (*e.g.* AMF, Mobility Management Entity (MME)) from/to the wireless device.

[73] An RRC sublayer may support an RRC_Idle state, an RRC_Inactive state and/or an RRC_Connected state for a wireless device. In an RRC_Idle state, a wireless device may perform at least one of: Public Land Mobile Network (PLMN) selection; receiving broadcasted system information; cell selection/re-selection; monitoring/receiving a paging for mobile terminated data initiated by 5GC; paging for mobile terminated data

area managed by 5GC; or DRX for CN paging configured via NAS. In an RRC_Inactive state, a wireless device may perform at least one of: receiving broadcasted system information; cell selection/re-selection; monitoring/receiving a RAN/CN paging initiated by NG-RAN/5GC; RAN-based notification area (RNA) managed by NG-RAN; or DRX for RAN/CN paging configured by NG-RAN/NAS. In an RRC_Idle state of a wireless device, a base station (*e.g.* NG-RAN) may keep a 5GC-NG-RAN connection (both C/U-planes) for the wireless device; and/or store a UE AS context for the wireless device. In an RRC_Connected state of a wireless device, a base station (*e.g.* NG-RAN) may perform at least one of: establishment of 5GC-NG-RAN connection (both C/U-planes) for the wireless device; storing a UE AS context for the wireless device; transmit/receive of unicast data to/from the wireless device; or network-controlled mobility based on measurement results received from the wireless device. In an RRC_Connected state of a wireless device, an NG-RAN may know a cell that the wireless device belongs to.

[74] System information (SI) may be divided into minimum SI and other SI. The minimum SI may be periodically broadcast. The minimum SI may comprise basic information required for initial access and information for acquiring any other SI broadcast periodically or provisioned on-demand, i.e. scheduling information. The other SI may either be broadcast, or be provisioned in a dedicated manner, either triggered by a network or upon request from a wireless device. A minimum SI may be transmitted via two different downlink channels using different messages (*e.g. MasterInformationBlock* and *SystemInformationBlockType1*). The other SI may be transmitted via *SystemInformationBlockType2*. For a wireless device in an RRC_Connected state, dedicated RRC signaling may be employed for the request and delivery of the other SI. For the wireless device in the RRC_Idle state and/or the RRC_Inactive state, the request may trigger a random-access procedure.

[75] A wireless device may report its radio access capability information which may be static. A base station may request what capabilities for a wireless device to report based on band information. When allowed by a network, a temporary capability restriction request may be sent by the wireless device to signal the limited availability of some capabilities (*e.g.* due to hardware sharing, interference or overheating) to the base station. The base station may confirm or reject the request. The temporary capability restriction may be transparent to 5GC (*e.g.*, static capabilities may be stored in 5GC).

[76] When CA is configured, a wireless device may have an RRC connection with a network. At RRC connection establishment/re-establishment/handover procedure, one serving cell may provide NAS mobility information, and at RRC connection re-establishment/handover, one serving cell may provide a security input. This cell may be referred to as the PCell. Depending on the capabilities of the wireless device, SCells may be configured to form together with the PCell a set of serving cells. The configured set of serving cells for the wireless device may comprise one PCell and one or more SCells.

[77] The reconfiguration, addition and removal of SCells may be performed by RRC. At intra-NR handover, RRC may also add, remove, or reconfigure SCells for usage with the target PCell. When adding a new SCell, dedicated RRC signaling may be employed to send all required system information of the SCell. While in connected mode, wireless devices may not need to acquire broadcasted system information directly from the SCells.

[78] The purpose of an RRC connection reconfiguration procedure may be to modify an RRC connection, (*e.g.* to establish, modify and/or release RBs, to perform handover, to setup, modify, and/or release measurements, to add, modify, and/or release SCells and cell groups). As part of the RRC connection reconfiguration procedure, NAS dedicated information may be transferred from the network to the wireless device. The *RRCConnectionReconfiguration* message may be a command to modify an RRC connection. It may convey information for measurement configuration, mobility control, radio resource configuration (*e.g.* RBs, MAC main configuration and physical channel configuration) comprising any associated dedicated NAS information and security configuration. If the received RRC Connection Reconfiguration message includes the *sCellToReleaseList*, the wireless device may perform an SCell release. If the received RRC Connection Reconfiguration message includes the *sCellToAddModList*, the wireless device may perform SCell additions or modification.

[79] An RRC connection establishment (or reestablishment, resume) procedure may be to establish (or reestablish, resume) an RRC connection. an RRC connection establishment procedure may comprise SRB1 establishment. The RRC connection establishment procedure may be used to transfer the initial NAS dedicated information message from a wireless device to E-UTRAN. The *RRCConnectionReestablishment* message may be used to re-establish SRB1.

[80] A measurement report procedure may be to transfer measurement results from a wireless device to NG-RAN. The wireless device may initiate a measurement report procedure after successful security activation. A measurement report message may be employed to transmit measurement results.

[81] FIG. 5A, FIG. 5B, FIG. 5C, and FIG. 5D show examples for uplink and downlink signal transmission. FIG. 5A shows an example for an uplink physical channel. The baseband signal representing the physical uplink shared channel may be processed according to the following processes, which may be performed by structures described below. While these structures and corresponding functions are shown as examples, it is anticipated that other structures and/or functions may be implemented in various examples. The structures and corresponding functions may comprise, e.g., one or more scrambling devices 501A and 501B configured to perform scrambling of coded bits in each of the codewords to be transmitted on a physical channel; one or more modulation mappers 502A and 502B configured to perform modulation of scrambled bits to generate complex-valued symbols; a layer mapper 503 configured to perform mapping of the complex-valued modulation symbols onto one or several transmission layers; one or more transform precoders 504A and 504B to generate complex-valued symbols; a precoding device 505 configured to perform precoding of the complex-valued symbols; one or more resource element mappers 506A and 506B configured to perform mapping of precoded complex-valued symbols to resource elements; one or more signal generators 507A and 507B configured to perform the generation of a complex-valued time-domain DFTS-OFDM/SC-FDMA signal for each antenna port; and/or the like.

[82] Example modulation and up-conversion to the carrier frequency of the complex-valued DFTS-OFDM/SC-FDMA baseband signal for each antenna port and/or the complex-valued physical random access channel (PRACH) baseband signal is shown in FIG. 5B. For example, the baseband signal, represented as $s_l(t)$, may be split, by a signal splitter 510, into real and imaginary components, $\mathrm{Re}\{s_l(t)\}$ and $\mathrm{Im}\{s_l(t)\}$, respectively. The real component may be modulated by a modulator 511A, and the imaginary component may be modulated by a modulator 511B. The output signal of the modulator 511A and the output signal of the modulator 511B may be mixed by a mixer 512. The output signal of the mixer 512 may be input to a filtering device 513, and filtering may be employed by the filtering device 513 prior to transmission.

[83] An example structure for downlink transmissions is shown in FIG. 5C. The baseband signal representing a downlink physical channel may be processed by the following processes, which may be performed by structures described below. While these structures and corresponding functions are shown as examples, it is anticipated that other structures and/or functions may be implemented in various examples. The structures and corresponding functions may comprise, e.g., one or more scrambling devices 531A and 531B configured to perform scrambling of coded bits in each of the codewords to be transmitted on a physical channel; one or more modulation mappers 532A and 532B configured to perform modulation of scrambled bits to generate complex-valued modulation symbols; a layer mapper 533 configured to perform mapping of the complex-valued modulation symbols onto one or several transmission layers; a precoding device 534 configured to perform precoding of the complex-valued modulation symbols on each layer for transmission on the antenna ports; one or more resource element mappers 535A and 535B configured to perform mapping of complex-valued modulation symbols for each antenna port to resource elements; one or more OFDM signal generators 536A and 536B configured to perform the generation of complex-valued time-domain OFDM signal for each antenna port; and/or the like.

[84] Example modulation and up-conversion to the carrier frequency of the complex-valued OFDM baseband signal for each antenna port is shown in FIG. 5D. For example, the baseband signal, represented as $s_l^{(p)}(t)$, may be split, by a signal splitter 520, into real and imaginary components, $\mathrm{Re}\{s_l^{(p)}(t)\}$ and $\mathrm{Im}\{s_l^{(p)}(t)\}$, respectively. The real component may be modulated by a modulator 521A, and the imaginary component may be modulated by a modulator 521B. The output signal of the modulator 521A and the output signal of the modulator 521B may be mixed by a mixer 522. The output signal of the mixer 522 may be input to a filtering device 523, and filtering may be employed by the filtering device 523 prior to transmission.

[85] FIG. 6 and FIG. 7 show examples for protocol structures with CA and multi-connectivity. In FIG. 6, NR may support multi-connectivity operation, whereby a multiple receiver/transmitter (RX/TX) UE in RRC_CONNECTED may be configured to utilize radio resources provided by multiple schedulers located in multiple gNBs connected via a non-ideal or ideal backhaul over the Xn interface. gNBs involved in multi-connectivity for a certain UE may assume two different roles: a gNB may either act as a master gNB (e.g., 600) or as a secondary gNB (e.g., 610 or 620). In multi-connectivity, a UE may be connected to one master gNB (e.g., 600) and one or more secondary gNBs (e.g., 610

and/or 620). Any one or more of the Master gNB 600 and/or the secondary gNBs 610 and 620 may be a Next Generation (NG) NodeB. The master gNB 600 may comprise protocol layers NR MAC 601, NR RLC 602 and 603, and NR PDCP 604 and 605. The secondary gNB may comprise protocol layers NR MAC 611, NR RLC 612 and 613, and NR PDCP 614. The secondary gNB may comprise protocol layers NR MAC 621, NR RLC 622 and 623, and NR PDCP 624. The master gNB 600 may communicate via an interface 606 and/or via an interface 607, the secondary gNB 610 may communicate via an interface 615, and the secondary gNB 620 may communicate via an interface 625. The master gNB 600 may also communicate with the secondary gNB 610 and the secondary gNB 621 via interfaces 608 and 609, respectively, which may include Xn interfaces. For example, the master gNB 600 may communicate via the interface 608, at layer NR PDCP 605, with the secondary gNB 610 at layer NR RLC 612. The master gNB 600 may communicate via the interface 609, at layer NR PDCP 605, with the secondary gNB 620 at layer NR RLC 622.

[86] FIG. 7 shows an example structure for the UE side MAC entities, e.g., if a Master Cell Group (MCG) and a Secondary Cell Group (SCG) are configured. Media Broadcast Multicast Service (MBMS) reception may be included but is not shown in this figure for simplicity.

[87] In multi-connectivity, the radio protocol architecture that a particular bearer uses may depend on how the bearer is set up. As an example, three alternatives may exist, an MCG bearer, an SCG bearer, and a split bearer, such as shown in FIG. 6. NR RRC may be located in a master gNB and SRBs may be configured as a MCG bearer type and may use the radio resources of the master gNB. Multi-connectivity may have at least one bearer configured to use radio resources provided by the secondary gNB. Multi-connectivity may or may not be configured or implemented.

[88] In the case of multi-connectivity, the UE may be configured with multiple NR MAC entities: e.g., one NR MAC entity for a master gNB, and other NR MAC entities for secondary gNBs. In multi-connectivity, the configured set of serving cells for a UE may comprise two subsets: e.g., the Master Cell Group (MCG) containing the serving cells of the master gNB, and the Secondary Cell Groups (SCGs) containing the serving cells of the secondary gNBs.

[89] For an SCG, one or more of the following may be applied. At least one cell in the SCG may have a configured UL component carrier (CC) and one of the UL CCs, e.g., named PSCell (or PCell of SCG, or sometimes called PCell), may be configured with PUCCH resources. If the SCG is configured, there may be at least one SCG bearer or one split bearer. If a physical layer problem or a random access problem on a PSCell occurs or is detected, if the maximum number of NR RLC retransmissions has been reached associated with the SCG, or if an access problem on a PSCell during a SCG addition or a SCG change occurs or is detected, then an RRC connection re-establishment procedure may not be triggered, UL transmissions towards cells of the SCG may be stopped, a master gNB may be informed by the UE of a SCG failure type, and for a split bearer the DL data transfer over the master gNB may be maintained. The NR RLC Acknowledge Mode (AM) bearer may be configured for the split bearer. Like the PCell, a PSCell may not be de-activated. The PSCell may be changed with an SCG change (e.g., with a security key change and a RACH procedure). A direct bearer type may change between a split bearer and an SCG bearer, or a simultaneous configuration of an SCG and a split bearer may or may not be supported.

[90] With respect to the interaction between a master gNB and secondary gNBs for multi-connectivity, one or more of the following principles may be applied. The master gNB may maintain the RRM measurement configuration of the UE, and the master gNB may, (e.g., based on received measurement reports, and/or based on traffic conditions and/or bearer types), decide to ask a secondary gNB to provide additional resources (e.g., serving cells) for a UE. If a request from the master gNB is received, a secondary gNB may create a container that may result in the configuration of additional serving cells for the UE (or the secondary gNB decide that it has no resource available to do so). For UE capability coordination, the master gNB may provide some or all of the Active Set (AS) configuration and the UE capabilities to the secondary gNB. The master gNB and the secondary gNB may exchange information about a UE configuration, such as by employing NR RRC containers (e.g., inter-node messages) carried in Xn messages. The secondary gNB may initiate a reconfiguration of its existing serving cells (e.g., PUCCH towards the secondary gNB). The secondary gNB may decide which cell is the PSCell within the SCG. The master gNB may or may not change the content of the NR RRC configuration provided by the secondary gNB. In the case of an SCG addition and an SCG SCell addition, the master gNB may provide the latest measurement results for the SCG cell(s). Both a master gNB and a secondary gNBs may know the system frame

number (SFN) and subframe offset of each other by operations, administration, and maintenance (OAM) (e.g., for the purpose of discontinuous reception (DRX) alignment and identification of a measurement gap). In an example, when adding a new SCG SCell, dedicated NR RRC signaling may be used for sending required system information of the cell for CA, except, e.g., for the SFN acquired from an MIB of the PSCell of an SCG.

[91] FIG. 7 shows an example of dual-connectivity (DC) for two MAC entities at a UE side. A first MAC entity may comprise a lower layer of an MCG 700, an upper layer of an MCG 718, and one or more intermediate layers of an MCG 719. The lower layer of the MCG 700 may comprise, e.g., a paging channel (PCH) 701, a broadcast channel (BCH) 702, a downlink shared channel (DL-SCH) 703, an uplink shared channel (UL-SCH) 704, and a random access channel (RACH) 705. The one or more intermediate layers of the MCG 719 may comprise, e.g., one or more hybrid automatic repeat request (HARQ) processes 706, one or more random access control processes 707, multiplexing and/or de-multiplexing processes 709, logical channel prioritization on the uplink processes 710, and a control processes 708 providing control for the above processes in the one or more intermediate layers of the MCG 719. The upper layer of the MCG 718 may comprise, e.g., a paging control channel (PCCH) 711, a broadcast control channel (BCCH) 712, a common control channel (CCCH) 713, a dedicated control channel (DCCH) 714, a dedicated traffic channel (DTCH) 715, and a MAC control 716.

[92] A second MAC entity may comprise a lower layer of an SCG 720, an upper layer of an SCG 738, and one or more intermediate layers of an SCG 739. The lower layer of the SCG 720 may comprise, e.g., a BCH 722, a DL-SCH 723, an UL-SCH 724, and a RACH 725. The one or more intermediate layers of the SCG 739 may comprise, e.g., one or more HARQ processes 726, one or more random access control processes 727, multiplexing and/or de-multiplexing processes 729, logical channel prioritization on the uplink processes 730, and a control processes 728 providing control for the above processes in the one or more intermediate layers of the SCG 739. The upper layer of the SCG 738 may comprise, e.g., a BCCH 732, a DCCH 714, a DTCH 735, and a MAC control 736.

[93] Serving cells may be grouped in a TA group (TAG). Serving cells in one TAG may use the same timing reference. For a given TAG, user equipment (UE) may use at least one downlink carrier as a timing reference. For a given TAG, a UE may synchronize uplink

subframe and frame transmission timing of uplink carriers belonging to the same TAG. In an example, serving cells having an uplink to which the same TA applies may correspond to serving cells hosted by the same receiver. A UE supporting multiple TAs may support two or more TA groups. One TA group may contain the PCell and may be called a primary TAG (pTAG). In a multiple TAG configuration, at least one TA group may not contain the PCell and may be called a secondary TAG (sTAG). In an example, carriers within the same TA group may use the same TA value and/or the same timing reference. When DC is configured, cells belonging to a cell group (e.g., MCG or SCG) may be grouped into multiple TAGs including a pTAG and one or more sTAGs.

[94] FIG. 8 shows example TAG configurations. In Example 1, a pTAG comprises a PCell, and an sTAG comprises an SCell1. In Example 2, a pTAG comprises a PCell and an SCell1, and an sTAG comprises an SCell2 and an SCell3. In Example 3, a pTAG comprises a PCell and an SCell1, and an sTAG1 comprises an SCell2 and an SCell3, and an sTAG2 comprises a SCell4. Up to four TAGs may be supported in a cell group (MCG or SCG), and other example TAG configurations may also be provided. In various examples, structures and operations are described for use with a pTAG and an sTAG. Some of the examples may be applied to configurations with multiple sTAGs.

[95] In an example, an eNB may initiate an RA procedure, via a PDCCH order, for an activated SCell. The PDCCH order may be sent on a scheduling cell of this SCell. When cross carrier scheduling is configured for a cell, the scheduling cell may be different than the cell that is employed for preamble transmission, and the PDCCH order may include an SCell index. At least a non-contention based RA procedure may be supported for SCell(s) assigned to sTAG(s).

[96] FIG. 9 shows an example of random access processes, and a corresponding message flow, in a secondary TAG. A base station, such as an eNB, may transmit an activation command 900 to a wireless device, such as a UE. The activation command 900 may be transmitted to activate an SCell. The base station may also transmit a PDDCH order 901 to the wireless device, which may be transmitted after the activation command 900. The wireless device may begin to perform a RACH process for the SCell, which may be initiated after receiving the PDDCH order 901. The RACH process may include the wireless device transmitting to the base station a preamble 902 (e.g., Msg1), such as a random access preamble (RAP). The preamble 902 may be transmitted in response to the PDCCH order 901. The wireless device may transmit the preamble 902 via an SCell

belonging to an sTAG. In an example, preamble transmission for SCells may be controlled by a network using PDCCH format 1A. The base station may send a random access response (RAR) 903 (e.g., Msg2 message) to the wireless device. The RAR 903 may be in response to the preamble 902 transmission via the SCell. The RAR 903 may be addressed to a random access radio network temporary identifier (RA-RNTI) in a PCell common search space (CSS). If the wireless device receives the RAR 903, the RACH process may conclude. The RACH process may conclude after or in response to the wireless device receiving the RAR 903 from the base station. After the RACH process, the wireless device may transmit an uplink transmission 904. The uplink transmission 904 may comprise uplink packets transmitted via the same SCell used for the preamble 902 transmission.

[97] Initial timing alignment for communications between the wireless device and the base station may be achieved through a random access procedure, such as described above regarding FIG. 9. The random access procedure may involve a wireless device, such as a UE, transmitting a random access preamble and a base station, such as an eNB, responding with an initial TA command NTA (amount of timing advance) within a random access response window. The start of the random access preamble may be aligned with the start of a corresponding uplink subframe at the UE assuming NTA=0. The eNB may estimate the uplink timing from the random access preamble transmitted by the UE. The TA command may be derived by the eNB based on the estimation of the difference between the desired UL timing and the actual UL timing. The UE may determine the initial uplink transmission timing relative to the corresponding downlink of the sTAG on which the preamble is transmitted.

[98] The mapping of a serving cell to a TAG may be configured by a serving eNB with RRC signaling. The mechanism for TAG configuration and reconfiguration may be based on RRC signaling. If an eNB performs an SCell addition configuration, the related TAG configuration may be configured for the SCell. An eNB may modify the TAG configuration of an SCell by removing (e.g., releasing) the SCell and adding (e.g., configuring) a new SCell (with the same physical cell ID and frequency) with an updated TAG ID. The new SCell with the updated TAG ID may initially be inactive subsequent to being assigned the updated TAG ID. The eNB may activate the updated new SCell and start scheduling packets on the activated SCell. In some examples, it may not be possible to change the TAG associated with an SCell, but rather, the SCell may need to be removed and a new SCell may need to be added with another TAG. For example, if

there is a need to move an SCell from an sTAG to a pTAG, at least one RRC message, such as at least one RRC reconfiguration message, may be sent to the UE. The at least one RRC message may be sent to the UE to reconfigure TAG configurations, e.g., by releasing the SCell and then configuring the SCell as a part of the pTAG. If, e.g., an SCell is added or configured without a TAG index, the SCell may be explicitly assigned to the pTAG. The PCell may not change its TA group and may be a member of the pTAG.

[99] In LTE Release-10 and Release-11 CA, a PUCCH transmission is only transmitted on a PCell (e.g., a PSCell) to an eNB. In LTE-Release 12 and earlier, a UE may transmit PUCCH information on one cell (e.g., a PCell or a PSCell) to a given eNB. As the number of CA capable UEs increase, and as the number of aggregated carriers increase, the number of PUCCHs and the PUCCH payload size may increase. Accommodating the PUCCH transmissions on the PCell may lead to a high PUCCH load on the PCell. A PUCCH on an SCell may be introduced to offload the PUCCH resource from the PCell. More than one PUCCH may be configured. For example, a PUCCH on a PCell may be configured and another PUCCH on an SCell may be configured. One, two, or more cells may be configured with PUCCH resources for transmitting CSI, acknowledgment (ACK), and/or non-acknowledgment (NACK) to a base station. Cells may be grouped into multiple PUCCH groups, and one or more cell within a group may be configured with a PUCCH. In some examples, one SCell may belong to one PUCCH group. SCells with a configured PUCCH transmitted to a base station may be called a PUCCH SCell, and a cell group with a common PUCCH resource transmitted to the same base station may be called a PUCCH group.

[100] A MAC entity may have a configurable timer, e.g., timeAlignmentTimer, per TAG. The timeAlignmentTimer may be used to control how long the MAC entity considers the serving cells belonging to the associated TAG to be uplink time aligned. If a Timing Advance Command MAC control element is received, the MAC entity may apply the Timing Advance Command for the indicated TAG; and/or the MAC entity may start or restart the timeAlignmentTimer associated with a TAG that may be indicated by the Timing Advance Command MAC control element. If a Timing Advance Command is received in a Random Access Response message for a serving cell belonging to a TAG, the MAC entity may apply the Timing Advance Command for this TAG and/or start or restart the timeAlignmentTimer associated with this TAG. Additionally or alternatively, if the Random Access Preamble is not selected by the MAC entity, the MAC entity may

apply the Timing Advance Command for this TAG and/or start or restart the timeAlignmentTimer associated with this TAG. If the timeAlignmentTimer associated with this TAG is not running, the Timing Advance Command for this TAG may be applied, and the timeAlignmentTimer associated with this TAG may be started. If the contention resolution is not successful, a timeAlignmentTimer associated with this TAG may be stopped. If the contention resolution is successful, the MAC entity may ignore the received Timing Advance Command. The MAC entity may determine whether the contention resolution is successful or whether the contention resolution is not successful.

[101] FIG. 10A and FIG. 10B show examples for interfaces between a 5G core network (e.g., NGC) and base stations (e.g., gNB and eLTE eNB). For example, in FIG. 10A, a base station, such as a gNB 1020, may be interconnected to an NGC 1010 control plane employing an NG-C interface. The base station, e.g., the gNB 1020, may also be interconnected to an NGC 1010 user plane (e.g., UPGW) employing an NG-U interface. As another example, in FIG. 10B, a base station, such as an eLTE eNB 1040, may be interconnected to an NGC 1030 control plane employing an NG-C interface. The base station, e.g., the eLTE eNB 1040, may also be interconnected to an NGC 1030 user plane (e.g., UPGW) employing an NG-U interface. An NG interface may support a many-to-many relation between 5G core networks and base stations.

[102] FIG. 11A, FIG. 11B, FIG. 11C, FIG. 11D, FIG. 11E, and FIG. 11F are examples for architectures of tight interworking between a 5G RAN and an LTE RAN. The tight interworking may enable a multiple receiver/transmitter (RX/TX) UE in an RRC_CONNECTED state to be configured to utilize radio resources provided by two schedulers located in two base stations (e.g., an eLTE eNB and a gNB). The two base stations may be connected via a non-ideal or ideal backhaul over the Xx interface between an LTE eNB and a gNB, or over the Xn interface between an eLTE eNB and a gNB. Base stations involved in tight interworking for a certain UE may assume different roles. For example, a base station may act as a master base station or a base station may act as a secondary base station. In tight interworking, a UE may be connected to both a master base station and a secondary base station. Mechanisms implemented in tight interworking may be extended to cover more than two base stations.

[103] In FIG. 11A and FIG. 11B, a master base station may be an LTE eNB 1102A or an LTE eNB 1102B, which may be connected to EPC nodes 1101A or 1101B, respectively. This connection to EPC nodes may be, e.g., to an MME via the S1-C interface and/or to an S-

GW via the S1-U interface. A secondary base station may be a gNB 1103A or a gNB 1103B, either or both of which may be a non-standalone node having a control plane connection via an Xx-C interface to an LTE eNB (e.g., the LTE eNB 1102A or the LTE eNB 1102B). In the tight interworking architecture of FIG. 11A, a user plane for a gNB (e.g., the gNB 1103A) may be connected to an S-GW (e.g., the EPC 1101A) through an LTE eNB (e.g., the LTE eNB 1102A), via an Xx-U interface between the LTE eNB and the gNB, and via an S1-U interface between the LTE eNB and the S-GW. In the architecture of FIG. 11B, a user plane for a gNB (e.g., the gNB 1103B) may be connected directly to an S-GW (e.g., the EPC 1101B) via an S1-U interface between the gNB and the S-GW.

[104] In FIG. 11C and FIG. 11D, a master base station may be a gNB 1103C or a gNB 1103D, which may be connected to NGC nodes 1101C or 1101D, respectively. This connection to NGC nodes may be, e.g., to a control plane core node via the NG-C interface and/or to a user plane core node via the NG-U interface. A secondary base station may be an eLTE eNB 1102C or an eLTE eNB 1102D, either or both of which may be a non-standalone node having a control plane connection via an Xn-C interface to a gNB (e.g., the gNB 1103C or the gNB 1103D). In the tight interworking architecture of FIG. 11C, a user plane for an eLTE eNB (e.g., the eLTE eNB 1102C) may be connected to a user plane core node (e.g., the NGC 1101C) through a gNB (e.g., the gNB 1103C), via an Xn-U interface between the eLTE eNB and the gNB, and via an NG-U interface between the gNB and the user plane core node. In the architecture of FIG. 11D, a user plane for an eLTE eNB (e.g., the eLTE eNB 1102D) may be connected directly to a user plane core node (e.g., the NGC 1101D) via an NG-U interface between the eLTE eNB and the user plane core node.

[105] In FIG. 11E and FIG. 11F, a master base station may be an eLTE eNB 1102E or an eLTE eNB 1102F, which may be connected to NGC nodes 1101E or 1101F, respectively. This connection to NGC nodes may be, e.g., to a control plane core node via the NG-C interface and/or to a user plane core node via the NG-U interface. A secondary base station may be a gNB 1103E or a gNB 1103F, either or both of which may be a non-standalone node having a control plane connection via an Xn-C interface to an eLTE eNB (e.g., the eLTE eNB 1102E or the eLTE eNB 1102F). In the tight interworking architecture of FIG. 11E, a user plane for a gNB (e.g., the gNB 1103E) may be connected to a user plane core node (e.g., the NGC 1101E) through an eLTE eNB (e.g., the eLTE eNB 1102E), via an Xn-U interface between the eLTE eNB and the gNB, and via an NG-

U interface between the eLTE eNB and the user plane core node. In the architecture of FIG. 11F, a user plane for a gNB (e.g., the gNB 1103F) may be connected directly to a user plane core node (e.g., the NGC 1101F) via an NG-U interface between the gNB and the user plane core node.

[106] FIG. 12A, FIG. 12B, and FIG. 12C are examples for radio protocol structures of tight interworking bearers.

[107] In FIG. 12A, an LTE eNB 1201A may be an S1 master base station, and a gNB 1210A may be an S1 secondary base station. An example for a radio protocol architecture for a split bearer and an SCG bearer is shown. The LTE eNB 1201A may be connected to an EPC with a non-standalone gNB 1210A, via an Xx interface between the PDCP 1206A and an NR RLC 1212A. The LTE eNB 1201A may include protocol layers MAC 1202A, RLC 1203A and RLC 1204A, and PDCP 1205A and PDCP 1206A. An MCG bearer type may interface with the PDCP 1205A, and a split bearer type may interface with the PDCP 1206A. The gNB 1210A may include protocol layers NR MAC 1211A, NR RLC 1212A and NR RLC 1213A, and NR PDCP 1214A. An SCG bearer type may interface with the NR PDCP 1214A.

[108] In FIG. 12B, a gNB 1201B may be an NG master base station, and an eLTE eNB 1210B may be an NG secondary base station. An example for a radio protocol architecture for a split bearer and an SCG bearer is shown. The gNB 1201B may be connected to an NGC with a non-standalone eLTE eNB 1210B, via an Xn interface between the NR PDCP 1206B and an RLC 1212B. The gNB 1201B may include protocol layers NR MAC 1202B, NR RLC 1203B and NR RLC 1204B, and NR PDCP 1205B and NR PDCP 1206B. An MCG bearer type may interface with the NR PDCP 1205B, and a split bearer type may interface with the NR PDCP 1206B. The eLTE eNB 1210B may include protocol layers MAC 1211B, RLC 1212B and RLC 1213B, and PDCP 1214B. An SCG bearer type may interface with the PDCP 1214B.

[109] In FIG. 12C, an eLTE eNB 1201C may be an NG master base station, and a gNB 1210C may be an NG secondary base station. An example for a radio protocol architecture for a split bearer and an SCG bearer is shown. The eLTE eNB 1201C may be connected to an NGC with a non-standalone gNB 1210C, via an Xn interface between the PDCP 1206C and an NR RLC 1212C. The eLTE eNB 1201C may include protocol layers MAC 1202C, RLC 1203C and RLC 1204C, and PDCP 1205C and PDCP 1206C. An MCG

bearer type may interface with the PDCP 1205C, and a split bearer type may interface with the PDCP 1206C. The gNB 1210C may include protocol layers NR MAC 1211C, NR RLC 1212C and NR RLC 1213C, and NR PDCP 1214C. An SCG bearer type may interface with the NR PDCP 1214C.

[110] In a 5G network, the radio protocol architecture that a particular bearer uses may depend on how the bearer is setup. At least three alternatives may exist, e.g., an MCG bearer, an SCG bearer, and a split bearer, such as shown in FIG. 12A, FIG. 12B, and FIG. 12C. The NR RRC may be located in a master base station, and the SRBs may be configured as an MCG bearer type and may use the radio resources of the master base station. Tight interworking may have at least one bearer configured to use radio resources provided by the secondary base station. Tight interworking may or may not be configured or implemented.

[111] In the case of tight interworking, the UE may be configured with two MAC entities: e.g., one MAC entity for a master base station, and one MAC entity for a secondary base station. In tight interworking, the configured set of serving cells for a UE may comprise of two subsets: e.g., the Master Cell Group (MCG) containing the serving cells of the master base station, and the Secondary Cell Group (SCG) containing the serving cells of the secondary base station.

[112] For an SCG, one or more of the following may be applied. At least one cell in the SCG may have a configured UL CC and one of them, e.g., a PSCell (or the PCell of the SCG, which may also be called a PCell), is configured with PUCCH resources. If the SCG is configured, there may be at least one SCG bearer or one split bearer. If one or more of a physical layer problem or a random access problem is detected on a PSCell, if the maximum number of (NR) RLC retransmissions associated with the SCG has been reached, and/or if an access problem on a PSCell during an SCG addition or during an SCG change is detected, then: an RRC connection re-establishment procedure may not be triggered, UL transmissions towards cells of the SCG may be stopped, a master base station may be informed by the UE of a SCG failure type, and/or for a split bearer the DL data transfer over the master base station may be maintained. The RLC AM bearer may be configured for the split bearer. Like the PCell, a PSCell may not be de-activated. A PSCell may be changed with an SCG change, e.g., with security key change and a RACH procedure. A direct bearer type change, between a split bearer and an SCG bearer, may

not be supported. Simultaneous configuration of an SCG and a split bearer may not be supported.

[113] With respect to the interaction between a master base station and a secondary base station, one or more of the following principles may be applied. The master base station may maintain the RRM measurement configuration of the UE. The master base station may determine to ask a secondary base station to provide additional resources (e.g., serving cells) for a UE. This determination may be based on, e.g., received measurement reports, traffic conditions, and/or bearer types. If a request from the master base station is received, a secondary base station may create a container that may result in the configuration of additional serving cells for the UE, or the secondary base station may determine that it has no resource available to do so. The master base station may provide at least part of the AS configuration and the UE capabilities to the secondary base station, e.g., for UE capability coordination. The master base station and the secondary base station may exchange information about a UE configuration such as by using RRC containers (e.g., inter-node messages) carried in Xn or Xx messages. The secondary base station may initiate a reconfiguration of its existing serving cells (e.g., PUCCH towards the secondary base station). The secondary base station may determine which cell is the PSCell within the SCG. The master base station may not change the content of the RRC configuration provided by the secondary base station. If an SCG is added and/or an SCG SCell is added, the master base station may provide the latest measurement results for the SCG cell(s). Either or both of a master base station and a secondary base station may know the SFN and subframe offset of each other by OAM, (e.g., for the purpose of DRX alignment and identification of a measurement gap). If a new SCG SCell is added, dedicated RRC signaling may be used for sending required system information of the cell, such as for CA, except, e.g., for the SFN acquired from an MIB of the PSCell of an SCG.

[114] FIG. 13A and FIG.13B show examples for gNB deployment scenarios. A core 1301 and a core 1310, in FIG. 13A and FIG. 13B, respectively, may interface with other nodes via RAN-CN interfaces. In a non-centralized deployment scenario in FIG. 13A, the full protocol stack (e.g., NR RRC, NR PDCP, NR RLC, NR MAC, and NR PHY) may be supported at one node, such as a gNB 1302, a gNB 1303, and/or an eLTE eNB or LTE eNB 1304. These nodes (e.g., the gNB 1302, the gNB 1303, and the eLTE eNB or LTE eNB 1304) may interface with one of more of each other via a respective inter-BS interface. In the centralized deployment scenario in FIG. 13B, upper layers of a gNB

may be located in a Central Unit (CU) 1311, and lower layers of the gNB may be located in Distributed Units (DU) 1312, 1313, and 1314. The CU-DU interface (e.g., Fs interface) connecting CU 1311 and DUs 1312, 1312, and 1314 may be ideal or non-ideal. The Fs-C may provide a control plane connection over the Fs interface, and the Fs-U may provide a user plane connection over the Fs interface. In the centralized deployment, different functional split options between the CU 1311 and the DUs 1312, 1313, and 1314 may be possible by locating different protocol layers (e.g., RAN functions) in the CU 1311 and in the DU 1312, 1313, and 1314. The functional split may support flexibility to move the RAN functions between the CU 1311 and the DUs 1312, 1313, and 1314 depending on service requirements and/or network environments. The functional split option may change during operation after the Fs interface setup procedure, or the functional split option may change only in the Fs setup procedure (e.g., the functional split option may be static during operation after Fs setup procedure).

[115] FIG. 14 shows examples for different functional split options of a centralized gNB deployment scenario. Element numerals that are followed by "A" or "B" designations in FIG. 14 may represent the same elements in different traffic flows, e.g., either receiving data (e.g., data 1402A) or sending data (e.g., 1402B). In the split option example 1, an NR RRC 1401 may be in a CU, and an NR PDCP 1403, an NR RLC (e.g., comprising a High NR RLC 1404 and/or a Low NR RLC 1405), an NR MAC (e.g., comprising a High NR MAC 1406 and/or a Low NR MAC 1407), an NR PHY (e.g., comprising a High NR PHY 1408 and/or a LOW NR PHY 1409), and an RF 1410 may be in a DU. In the split option example 2, the NR RRC 1401 and the NR PDCP 1403 may be in a CU, and the NR RLC, the NR MAC, the NR PHY, and the RF 1410 may be in a DU. In the split option example 3, the NR RRC 1401, the NR PDCP 1403, and a partial function of the NR RLC (e.g., the High NR RLC 1404) may be in a CU, and the other partial function of the NR RLC (e.g., the Low NR RLC 1405), the NR MAC, the NR PHY, and the RF 1410 may be in a DU. In the split option example 4, the NR RRC 1401, the NR PDCP 1403, and the NR RLC may be in a CU, and the NR MAC, the NR PHY, and the RF 1410 may be in a DU. In the split option example 5, the NR RRC 1401, the NR PDCP 1403, the NR RLC, and a partial function of the NR MAC (e.g., the High NR MAC 1406) may be in a CU, and the other partial function of the NR MAC (e.g., the Low NR MAC 1407), the NR PHY, and the RF 1410 may be in a DU. In the split option example 6, the NR RRC 1401, the NR PDCP 1403, the NR RLC, and the NR MAC may be in CU, and the NR PHY and the RF 1410 may be in a DU. In the split option example 7, the NR RRC

1401, the NR PDCP 1403, the NR RLC, the NR MAC, and a partial function of the NR PHY (e.g., the High NR PHY 1408) may be in a CU, and the other partial function of the NR PHY (e.g., the Low NR PHY 1409) and the RF 1410 may be in a DU. In the split option example 8, the NR RRC 1401, the NR PDCP 1403, the NR RLC, the NR MAC, and the NR PHY may be in a CU, and the RF 1410 may be in a DU.

[116] The functional split may be configured per CU, per DU, per UE, per bearer, per slice, and/or with other granularities. In a per CU split, a CU may have a fixed split, and DUs may be configured to match the split option of the CU. In a per DU split, each DU may be configured with a different split, and a CU may provide different split options for different DUs. In a per UE split, a gNB (e.g., a CU and a DU) may provide different split options for different UEs. In a per bearer split, different split options may be utilized for different bearer types. In a per slice splice, different split options may be applied for different slices.

[117] A new radio access network (new RAN) may support different network slices, which may allow differentiated treatment customized to support different service requirements with end to end scope. The new RAN may provide a differentiated handling of traffic for different network slices that may be pre-configured, and the new RAN may allow a single RAN node to support multiple slices. The new RAN may support selection of a RAN part for a given network slice, e.g., by one or more slice ID(s) or NSSAI(s) provided by a UE or provided by an NGC (e.g., an NG CP). The slice ID(s) or NSSAI(s) may identify one or more of pre-configured network slices in a PLMN. For an initial attach, a UE may provide a slice ID and/or an NSSAI, and a RAN node (e.g., a gNB) may use the slice ID or the NSSAI for routing an initial NAS signaling to an NGC control plane function (e.g., an NG CP). If a UE does not provide any slice ID or NSSAI, a RAN node may send a NAS signaling to a default NGC control plane function. For subsequent accesses, the UE may provide a temporary ID for a slice identification, which may be assigned by the NGC control plane function, to enable a RAN node to route the NAS message to a relevant NGC control plane function. The new RAN may support resource isolation between slices. When the RAN resource isolation is implemented, shortage of shared resources in one slice does not cause a break in a service level agreement for another slice.

[118] The amount of data traffic carried over networks is expected to increase for many years to come. The number of users/devices is increasing and each user/device accesses an

increasing number and variety of services, e.g., video delivery, large files, and images. This requires not only high capacity in the network, but also provisioning very high data rates to meet customers' expectations on interactivity and responsiveness. More spectrum may be required for network operators to meet the increasing demand. Considering user expectations of high data rates along with seamless mobility, it is beneficial that more spectrum be made available for deploying macro cells as well as small cells for communication systems.

[119] Striving to meet the market demands, there has been increasing interest from operators in deploying some complementary access utilizing unlicensed spectrum to meet the traffic growth. This is exemplified by the large number of operator-deployed Wi-Fi networks and the 3GPP standardization of LTE/WLAN interworking solutions. This interest indicates that unlicensed spectrum, when present, may be an effective complement to licensed spectrum for network operators, e.g., to help address the traffic explosion in some scenarios, such as hotspot areas. Licensed Assisted Access (LAA) offers an alternative for operators to make use of unlicensed spectrum while managing one radio network, offering new possibilities for optimizing the network's efficiency.

[120] Listen-before-talk (clear channel assessment) may be implemented for transmission in an LAA cell. In a listen-before-talk (LBT) procedure, equipment may apply a clear channel assessment (CCA) check before using the channel. For example, the CCA may utilize at least energy detection to determine the presence or absence of other signals on a channel in order to determine if a channel is occupied or clear, respectively. For example, European and Japanese regulations mandate the usage of LBT in the unlicensed bands. Apart from regulatory requirements, carrier sensing via LBT may be one way for fair sharing of the unlicensed spectrum.

[121] Discontinuous transmission on an unlicensed carrier with limited maximum transmission duration may be enabled. Some of these functions may be supported by one or more signals to be transmitted from the beginning of a discontinuous LAA downlink transmission. Channel reservation may be enabled by the transmission of signals, by an LAA node, after gaining channel access, e.g., via a successful LBT operation, so that other nodes that receive the transmitted signal with energy above a certain threshold sense the channel to be occupied. Functions that may need to be supported by one or more signals for LAA operation with discontinuous downlink transmission may include one or more of the following: detection of the LAA downlink transmission (including cell

identification) by UEs, time synchronization of UEs, and frequency synchronization of UEs.

[122] DL LAA design may employ subframe boundary alignment according to LTE-A carrier aggregation timing relationships across serving cells aggregated by CA. This may not indicate that the eNB transmissions may start only at the subframe boundary. LAA may support transmitting PDSCH when not all OFDM symbols are available for transmission in a subframe according to LBT. Delivery of necessary control information for the PDSCH may also be supported.

[123] LBT procedures may be employed for fair and friendly coexistence of LAA with other operators and technologies operating in unlicensed spectrum. LBT procedures on a node attempting to transmit on a carrier in unlicensed spectrum may require the node to perform a clear channel assessment to determine if the channel is free for use. An LBT procedure may involve at least energy detection to determine if the channel is being used. For example, regulatory requirements in some regions, e.g., in Europe, specify an energy detection threshold such that if a node receives energy greater than this threshold, the node assumes that the channel is not free. While nodes may follow such regulatory requirements, a node may optionally use a lower threshold for energy detection than that specified by regulatory requirements. In an example, LAA may employ a mechanism to adaptively change the energy detection threshold, e.g., LAA may employ a mechanism to adaptively lower the energy detection threshold from an upper bound. Adaptation mechanism may not preclude static or semi-static setting of the threshold. A Category 4 LBT mechanism or other type of LBT mechanisms may be implemented.

[124] Various example LBT mechanisms may be implemented. For some signals, in some implementation scenarios, in some situations, and/or in some frequencies, no LBT procedure may performed by the transmitting entity. For example, Category 2 (e.g., LBT without random back-off) may be implemented. The duration of time that the channel is sensed to be idle before the transmitting entity transmits may be deterministic. For example, Category 3 (e.g., LBT with random back-off with a contention window of fixed size) may be implemented. The LBT procedure may have the following procedure as one of its components. The transmitting entity may draw a random number N within a contention window. The size of the contention window may be specified by the minimum and maximum value of N. The size of the contention window may be fixed. The random number N may be employed in the LBT procedure to determine the duration

of time that the channel is sensed to be idle before the transmitting entity transmits on the channel. In an example, Category 4 (e.g., LBT with random back-off with a contention window of variable size) may be implemented. The transmitting entity may draw a random number N within a contention window. The size of contention window may be specified by the minimum and maximum value of N. The transmitting entity may vary the size of the contention window when drawing the random number N. The random number N may be used in the LBT procedure to determine the duration of time that the channel is sensed to be idle before the transmitting entity transmits on the channel.

[125] LAA may employ uplink LBT at the UE. The UL LBT scheme may be different from the DL LBT scheme, e.g., by using different LBT mechanisms or parameters. These differences in schemes may be due to the LAA UL being based on scheduled access, which may affect a UE's channel contention opportunities. Other considerations motivating a different UL LBT scheme may include, but are not limited to, multiplexing of multiple UEs in a single subframe.

[126] A DL transmission burst may be a continuous transmission from a DL transmitting node, e.g., with no transmission immediately before or after from the same node on the same CC. An UL transmission burst from a UE perspective may be a continuous transmission from a UE, e.g., with no transmission immediately before or after from the same UE on the same CC. A UL transmission burst may be defined from a UE perspective or from an eNB perspective. If an eNB is operating DL and UL LAA over the same unlicensed carrier, DL transmission burst(s) and UL transmission burst(s) on LAA may be scheduled in a TDM manner over the same unlicensed carrier. An instant in time may be part of a DL transmission burst or part of an UL transmission burst.

[127] Random access (RA) procedures may be used to establish communications between a wireless device and a base station in a cell. A four-step RA procedure may include, e.g., a first step comprising a wireless device sending, to a base station, a request to establish communications with the base station. A second step may include, e.g., the base station sending, to the wireless device, a response indicating that the wireless device may send additional information for establishing the requested communications. A third step may include, e.g., the wireless device sending, to the base station, the additional information for establishing the requested communications. A fourth step may include, e.g., the base station sending, to the wireless device, information confirming the establishing of the requested communications. A four-step RA procedure may have an associated latency,

e.g., which may be a minimum of fourteen transmission time intervals (TTI). As an example, 3GPP TR 38.804 v14.0.0 indicates a minimum latency of fourteen TTIs comprising, e.g., 3 TTIs after a message from step 1 of a four-step RA procedure, 1 TTI for a message from step 2 of a four-step RA procedure, 5 TTIs after the message from step 2, 1 TTI for a message from step 3 of a four-step RA procedure, 3 TTIs after the message from step 3, and 1 TTI for a message from step 4 of a four-step procedure (e.g., 3 + 1 + 5 + 1 + 3 + 1 = 14). Reducing the number of steps in an RA procedure may reduce latency. By using parallel transmissions, a four-step RA procedure may be reduced to a two-step RA procedure. A two-step RA procedure may have an associated latency, e.g., which may be a minimum of four TTIs and which may be less than an associated latency for a four-step RA procedure. As an example, 3GPP TR 38.804 v14.0.0 indicates a minimum latency of four TTIs comprising, e.g., 3 TTIs after a message from step 1 of a two-step RA procedure and 1 TTI for a message from step 2 of a two-step RA procedure.

[128] FIG. 15 shows examples of (a) a contention-based four-step RA procedure, (b) a contention free three-step RA procedure, (c) descriptions of a contention-based four-step RA procedure, and (d) a contention free two-step RA procedure. A four-step RA procedure may comprise a RAP transmission in a first step, an RAR transmission in a second step, a scheduled transmission of one or more transport blocks (TBs) in a third step, and contention resolution in a fourth step.

[129] In step 1501, a base station may transmit four-step RA configuration parameters to a wireless device (e.g., a UE). The base station may generate and transmit RA configuration parameters periodically, e.g., based on a timer. The base station may broadcast RA configuration parameters in one or more messages. The wireless device may perform a RAP selection process at step 1502, e.g., after receiving the four-step RA configuration parameters. In a contention-based RA procedure, such as shown in part (a) of FIG. 15, the RA configuration parameters may comprise a root sequence that may be used by the wireless device to generate a RAP. The RAP may be randomly selected by the wireless device, among various RAP candidates generated by the root sequence, during the RAP selection process. The wireless device may perform the RAP selection using, e.g., the procedure described below regarding FIG. 16, and/or one or more RAP selections procedures described herein.

[130] During a first step of the RA procedure, at step 1503, a wireless device may transmit a RAP, e.g., using a configured RA preamble format with a single particular transmission (Tx) beam. A random access channel (RACH) resource may be defined as a time-frequency resource to transmit a RAP. Broadcast system information may indicate whether wireless device should transmit one preamble, or multiple or repeated preambles, within a subset of RACH resources.

[131] In the second step of the four-step RA procedure, at step 1504, a base station may transmit a random access response (RAR) to the wireless device. The base station may transmit the RAR in response to an RAP that the wireless device may transmit. A wireless device may monitor the physical-layer downlink control channel for RARs identified by the RA-RNTI in an RA response window. The RA response window may start at a subframe that contains the end of an RAP transmission, plus three subframes, and the RA response window may have the length *ra-ResponseWindowSize*. A wireless device may determine the RA-RNTI associated with the PRACH in which the wireless device transmits an RAP by the following operation:

$$\text{RA-RNTI} = 1 + t_id + 10 * f_id$$

[132] where t_id is the index of the first subframe of the specified PRACH ($0 \leq t_id < 10$), and f_id is the index of the specified PRACH within that subframe, in ascending order of frequency domain ($0 \leq f_id < 6$). Different types of UEs, e.g., narrow band-Internet of Things (NB-IoT), bandwidth limited (BL)-UE, and/or UE-Extended Coverage (UE-EC), may use different formulas or operations for determining RA-RNTI. A base station may configure an association between a DL signal or channel, a subset of RACH resources, and/or a subset of RAP indexes. Such an association may be for determining the DL transmission in the second step of the RA procedure, at step 1504 of FIG. 15. Based on the DL measurement and the corresponding association, a wireless device may select the subset of RACH resources and/or the subset of RAP indexes.

[133] In the third step of the four-step RA procedure (e.g., step 1505 in FIG. 15), a wireless device may adjust an UL time alignment by using the TA value corresponding to the TA command in the received RAR in the second step (e.g., step 1504 in FIG. 15). A wireless device may transmit one or more TBs to a base station using the UL resources assigned in the UL grant in the received RAR. One or more TBs that a wireless device may transmit in the third step (e.g., step 1505 in FIG. 15) may comprise RRC signaling, such

as an RRC connection request, an RRC connection Re-establishment request, or an RRC connection resume request. The one or more TBs may also comprise a wireless device identity, e.g., which may be used as part of the contention-resolution mechanism in the fourth step (e.g., step 1506 in FIG. 15).

[134] The fourth step in the four-step RA procedure (e.g., step 1506 in FIG. 15) may comprise a DL message for contention resolution. Based on the second step (e.g., step 1504 in FIG. 15), one or more wireless devices may perform simultaneous RA attempts using the same RAP in the first step (e.g., step 1503 in FIG. 15), and/or receive the same RAR with the same TC-RNTI in the second step (e.g., step 1504 in FIG. 15). The contention resolution in the fourth step may be to ensure that a wireless device does not incorrectly use another wireless device identity. The contention resolution mechanism may be based on either a C-RNTI on a PDCCH, or a UE Contention Resolution Identity on a DL-SCH, e.g., depending on whether or not a wireless device has a C-RNTI. If a wireless device has a C-RNTI, e.g., if the wireless device detects the C-RNTI on the PDCCH, the wireless device may determine the success of RA procedure. If the wireless device does not have a C-RNTI (e.g., if a C-RNTI is not pre-assigned), the wireless device may monitor a DL-SCH associated with a TC-RNTI, e.g., that a base station may transmit in an RAR of the second step. In the fourth step (e.g., step 1506 in FIG. 15), the wireless device may compare the identity in the data transmitted by the base station on the DL-SCH with the identity that the wireless device transmits in the third step (e.g., step 1505 in FIG. 15). If the wireless determines that two identities are the same or satisfy a threshold similarity, the wireless device may determine that the RA procedure is successful. If the wireless device determines that the RA is successful, the wireless device may promote the TC-RNTI to the C-RNTI. A TC-RNTI may be an identifier initially assigned to a wireless device when the wireless device first attempts to access a base station. A TC-RNTI may be used for a wireless device in an idle state. After access is allowed by the base station, a C-RNTI may be used for identifying the wireless device. A C-RNTI may be used for a wireless device in an inactive or an active state.

[135] The fourth step in the four-step RA procedure (e.g., step 1506 in FIG. 15) may allow HARQ retransmission. A wireless device may start a *mac-ContentionResolutionTimer* when the wireless device transmits one or more TBs to a base station in the third step (e.g., step 1505 in FIG. 15). The wireless may restart the *mac-ContentionResolutionTimer* at each HARQ retransmission. When a wireless device receives data on the DL resources identified by C-RNTI or TC-RNTI in the fourth step

(e.g., step 1506 in FIG. 15), the wireless device may stop the *mac-ContentionResolutionTimer*. If the wireless device does not detect the contention resolution identity that matches the identity transmitted by the wireless device in the third step (e.g., step 1505 in FIG. 15), the wireless device may determine that the RA procedure has failed and the wireless device may discard the TC-RNTI. Additionally or alternatively, if the *mac-ContentionResolutionTimer* expires, the wireless device may determine that the RA procedure has failed and the wireless device may discard the TC-RNTI. If the wireless device determines that the contention resolution has failed, the wireless device may flush the HARQ buffer used for transmission of the MAC PDU and the wireless device may restart the four-step RA procedure from the first step (e.g., step 1503 in FIG. 15). The wireless device may delay subsequent RAP transmission, e.g., by a backoff time. The backoff time may be randomly selected, e.g., according to a uniform distribution between 0 and the backoff parameter value corresponding to the BI in the MAC PDU for RAR.

[136] In a four-step RA procedure, the usage of the first two steps may be, e.g., to obtain a UL time alignment for a wireless device and/or to obtain an uplink grant. The UL time alignment may not be necessary in one or more scenarios. For example, in small cells, or for stationary wireless devices, the process for acquiring the UL time alignment may not be necessary if either a TA equal to zero may be sufficient (e.g., for small cells), or if a stored TA value from the last RA may be able to serve for the current RA (e.g., a stationary wireless device). If a wireless device is in an RRC connected state, e.g., with a valid TA value and no resource configured for UL transmission, the UL time alignment may not be necessary when the wireless device attempts to obtain an UL grant.

[137] Part (b) of FIG. 15 shows a three-step contention free RA procedure. A base station may transmit RA configuration parameters to a wireless device, e.g., a UE, in step 1510. In a contention-free RA procedure, such as shown in part (b) of FIG. 15, the configuration parameters may indicate to the wireless device what preamble to send to the base station and when to send the preamble. The base station may also transmit a control command to the wireless device at step 1511. The control command may comprise, e.g., downlink control information. In a first step of the RA procedure, the wireless device may transmit a random access preamble transmission to the base station at step 1512. The RAP transmission may be based on the RA configuration parameters and the control command. In a second step of the RA procedure, the base station may transmit to the wireless device a random access response at step 1513. In a third step of the RA

procedure, the wireless device may transmit scheduled transmissions at step 1514. The scheduled transmissions may be based on the RAR. The contention free RA procedure may end with the third step. Thereafter, the base station may transmit a downlink transmission to the wireless device at step 1515. This downlink transmission may comprise, e.g., an acknowledgement (ACK) indication, a non-acknowledgement (NACK) indication, data, or other information. Contention-free RA procedures such as described above may have reduced latency compared with contention-based RA procedures. Contention-based RA procedures may involve collisions, such as when more than one wireless device is attempting to communicate with the same base station at the same time.

[138] Part (c) of FIG. 15 shows an example of common language descriptions that may facilitate an understanding of some of the messaging involved in the contention-based four-step RA procedure described above regarding part (a) of FIG. 15. In step 1 of the RA procedure, a wireless device may send a communication to a base station similar to a request such as, "Hello, can I camp on?" (step 1520). If the base station can accommodate the wireless device request, the base station may respond to the wireless device with a message similar to an instruction such as "Send your info & data here" (step 1521). Based on the base station's response, the wireless device may send a message similar to a response such as "Here you are" (step 1522). Based on the information received by the base station, the base station may respond with a message similar to a grant such as "You are now in" (step 1523).

[139] Part (d) of FIG. 15 shows an example of a two-step contention free random access procedure of a wireless device. At step 1530, the wireless device may receive RA configuration parameters from a base station (e.g., from a handover source base station, and/or from a handover target base station via the handover source base station). The RA configuration parameters may comprise one or more parameters indicating a type of a random access process. The type of the random access process may indicate a two-step random access process. At step 1531, the wireless device may transmit an RA preamble and one or more transport blocks as a first step of the procedure, e.g., overlapping in time with each other. In response to the RA preamble and/or the one or more transport blocks, at step 1532, the wireless device may receive an RA response from a base station (e.g., a handover target base station).

[140] FIG. 16 shows an example of a RAP selection procedure for preamble groups that may be used as the RAP selection process at step 1502 of FIG. 15. A base station may broadcast the RAP grouping information, along with one or more thresholds, in system information. At step 1601, a wireless device may select a preamble group comprising preambles. Two or more RAP groups may be indicated by broadcast system information, and one or more of the RAP groups may be optional. At step 1602, the wireless device may select a RAP group among a plurality of RAP groups, based on, e.g., a size of data that the wireless may have to transmit, a measured pathloss, and/or other information. At step 1603, the wireless device may generate a RAP from the selected RAP group. If a base station configures two groups, e.g., in a four-step RA procedure, a wireless device may use the pathloss and a size of the message transmitted by the wireless device in the third step of the RA procedure, to determine from which group the wireless device selects an RAP. A base station may use a group type to which a RAP belongs as an indication of the message size in the third step and/or the radio conditions at a wireless device. The process may end at step 1603.

[141] FIG. 17 shows an example of a MAC PDU comprising a MAC header and MAC RARs. A four-step RA procedure may use the arrangement shown in FIG. 17. A two-step RA procedure may also use the arrangement shown in FIG. 17. Additionally or alternatively, a two-step RA procedure may use a variation of the arrangement shown in FIG. 17, e.g., with additional or fewer fields, and/or with longer or shorter fields. If an RAR comprises a RAPID corresponding to a RAP that a wireless device transmits, the wireless device may process the data in the RAR. The data in the RAR may comprise, e.g., one or more of a timing advance (TA) command, a UL grant, and/or a Temporary C-RNTI (TC-RNTI). The MAC header may comprise subheaders, such as an E/T/R/R/BI subheader (described further below) and up to n number of E/T/RAPID subheaders (described further below). The E/T/R/R/BI subheader may comprise an octet of bits comprising 1 bit each of E, T, R, and R, and four bits of BI. Each of n E/T/RAPID subheaders may comprise an octet comprising 1 bit each of E and T, and 6 bits of an RAPID.

[142] FIG. 18 shows an example of an uplink resource 1801 that may be used, e.g., for a transmission of a random access preamble and data in a first step of a two-step RA procedure. A transmission may comprise a random access preamble 1803, e.g., via a physical random access channel (PRACH), and data 1802. The data 1802 may comprise one or more transport blocks, an identifier of a wireless device, and/or other information. The data may be included in, e.g., an RRC connection request. The RRC connection

request may comprise one or more of, e.g., the data 1802, an identifier of a wireless device, an indication of a type of data (e.g., emergency, high priority access, standard access, signaling, etc.), and/or other information. The RAP 1803 may comprise a preamble sequence, e.g., bits arranged in octets 1804. A guard time and/or a cyclic prefix may be inserted, e.g., at either end of the preamble sequence. Additionally or alternatively, a guard band may be inserted above the preamble sequence and/or below the preamble sequence.

[143] FIG. 19 shows examples of MAC RAR formats comprising a TA command, a UL Grant, and a TC-RNTI for a four-step RA procedure. Part (a) shows an example MAC RAR format, part (b) shows an example MAC RAR for a PRACH enhanced coverage level 2 or level 3, and part (c) shows an example MAC RAR for NB-IoT UEs.

[144] In FIG. 19 part (a), a first octet comprises 1 bit of R, and 7 bits of the TA command. The second octet comprises an additional 4 bits of the TA command as well as 4 bits of the UL grant. The third and fourth octet each comprise 8 additional bits of the UL grant. And, the fifth and sixth octet each comprise 8 bits of the TC-RNTI. In FIG. 19 part (b), the MAC RAR for PRACH enhanced coverage level 2 or level 3 comprises a MAC RAR similar to the MAC RAR example in FIG. 19 part (a), except that in part (b) the UL grant comprises 8 bits in the third octet and the TC-RNTI is included in the fourth and fifth octets. In FIG. 19 part (c), a MAC RAR example for NB-IoT UEs comprises a MAC RAR similar to the MAC RAR in FIG. 19 part (a), except that the fourth octet in part (c) comprises 3 bits of the UL grant and 5 bits of R. As shown in FIG. 19 parts (a), (b), and (c), a MAC RAR may comprise one or more reserved bits (R bits). One or more of the R bits in the MAC RAR may indicate whether a RA procedure is a 2-step RA procedure or a 4-step RA procedure.

[145] FIG. 20 shows a two-step RA procedure that may comprise an uplink (UL) transmission of an RAP and data, followed by a downlink (DL) transmission of an RAR and contention resolution information. A two-step RA procedure may reduce RA latency compared with a four-step RA process, e.g., by integrating a process to obtain a timing advance (TA) value with a data transmission. In the UL transmission of a two-step RA procedure at step 2003, a wireless device may transmit, via a cell and to a base station, a RAP for UL time alignment and/or an UL message. The UL message may comprise, e.g., an UL grant, a wireless device ID, one or more TBs, a C-RNTI, and/or other information. In the DL transmission at step 2004, a base station may transmit an RAR

and contention resolution information. The DL transmission may identify an assignment of dedicated resources for the wireless to transmit data, e.g., which may include an assignment of one or more transport blocks. The DL transmission may be in response to the UL transmission. The RAR may comprise an acknowledgement of a reception of the one or more transport blocks, and/or an indication of a successful decoding of the one or more transport blocks. The contention resolution may comprise, e.g., TA information, an UL grant, a C-RNTI, and/or a contention resolution identity.

[146] In the UL transmission of a two-step RA procedure, a wireless device, may transmit, via a cell and to a base station, an RAP in parallel with one or more TBs. The wireless device may acquire one or more configuration parameters for the UL transmission before the wireless device starts a two-step RA procedure, e.g., at step 2001. In a contention-based RA procedure such as shown in FIG. 20, the one or more configuration parameters may comprise a root sequence that may be used by the wireless device to generate an RAP. The wireless device may determine an RAP at step 2002. An RAP selection by the wireless device may be based on the RA configuration parameters received at step 2001, e.g., comprising one or more RAP selections procedures described herein. The wireless device may use the root sequence to generate one or more candidate preambles, and the wireless device may randomly select one of the candidate preambles as the RAP. The one or more candidate preambles may be organized into groups that may indicate an amount of data for transmission. For example a first group may comprise RAPs indicated for small data transmissions, and a second group may comprise RAPs indicated for larger data transmissions. By transmitting an RAP from a specific group of RAPs, the wireless device may be able to indicate a size of data it may have for transmission. The wireless device may transmit the RAP via a RACH resource. The wireless device may transmit the one or more TBs via an UL resource associated with the RAP. The UL transmissions may occur, e.g., in the same subframe, in consecutive subframes, or in the same burst. A two-step RA procedure may be on a contention basis. The contention may occur for the RAP and/or data transmission.

[147] In the UL transmission, the RAP may be used to adjust UL time alignment for a cell and/or to aid in channel estimation for one or more TBs. A portion of the UL transmission for one or more TBs may comprise, e.g., a wireless device ID, a C-RNTI, a service request such as buffer state reporting (e.g., a buffer status report) (BSR), one or more user data packets, and/or other information. A wireless device in an RRC connected state may use a C-RNTI as an identifier of the wireless device (e.g., a wireless

device ID). A wireless device in an RRC inactive state may use a C-RNTI (if available), a resume ID, or a short MAC-ID as an identifier of the wireless device. A wireless device in an RRC idle state may use a C-RNTI (if available), a resume ID, a short MAC-ID, an IMSI (International Mobile Subscriber Identifier), a T-IMSI (Temporary-IMSI), and/or a random number as an identifier of the wireless device.

[148] The UL transmission may comprise one or more TBs that may be transmitted using a two-step RA procedure different ways. User data packet(s) may be multiplexed in the first step of a two-step RA procedure. A base station may configure one or more resources reserved for the UL transmission that may be indicated to a wireless device before the UL transmission. If the wireless device transmits one or more TBs in the first step of the two-step RA procedure, a base station may transmit in a DL transmission an RAR that may comprise a contention resolution message and/or an acknowledgement/non-acknowledgement message of the UL data transmission. The DL transmission may be in response to the UL transmission. A wireless device may transmit one or more TBs after the reception of an RAR. The wireless device may transmit an indicator, such as buffer state reporting, in the UL transmission. The indicator may indicate to a base station an amount of data the wireless device may attempt to transmit. The base station may assign a UL grant based on the indicator. The base station may transmit the UL grant to the wireless device via an RAR. If UL data transmission, based on the UL grant via an RAR, occurs after the reception of RAR, the UL data transmission may occur on a contention-based channel. The UL data transmission may occur after a wireless device receives the RAR, e.g., in a subframe x+5, or x+n, where x is a subframe in which the RAR is received by the wireless device and n is any whole number greater than zero.

[149] A wireless device may provide, to a base station, an indication of a required UL grant size. The wireless device may provide this indication, e.g., by determining a RAP selection (e.g., at step 2002), as opposed to transmitting a BSR, e.g., comprising one or more RAP selections procedures described herein. A base station may partition RAPs available to the base station into one or more RAP groups such that each partition may indicate a particular UL grant size. A wireless device may indicate a request, to a base station, of a small or large grant by selecting a RAP from a designated group. The base station may determine the requested grant size based on a RAP that the base station receives. A base station may configure an association between RAP groups and a UL

grant size. The base station may broadcast one or more parameters via system information to indicate the association between RAP groups and a UL grant size.

[150] A wireless device may provide, to a base station, an indication of a required UL grant size by transmitting an RAP on a partitioned radio resource. A base station may partition radio resources used for RAP transmission into one or more groups such that one or more resources in a group carrying an RAP may indicate a UL grant size that a wireless device may request. The base station may determine the requested grant size based on a RAP received by the base station via resources in a group. When a high granularity is required, a base station may configure a large number of radio resources for the RAP transmission. A base station may configure an association between radio resource groups and a UL grant size. The base station may broadcast one or more parameters via system information to indicate the association between radio resource groups and a UL grant size.

[151] In the second step of the two-step RA procedure (e.g., step 2004), a base station may transmit an RAR to a wireless device. The base station may transmit the RAR in response to receiving the RAP and data from the wireless device. The RAR may comprise TA information, a contention resolution identity, a UL grant, and/or a C-RNTI. A MAC PDU may comprise one or more of an RAR MAC subheader and a corresponding RAR. The TA may be used by the wireless device for a two-step RA procedure, e.g., when a TA timer has expired.

[152] A base station may or may not transmit the contention resolution identity to a wireless device. If a wireless device transmits a C-RNTI (e.g., as a wireless device ID) in a UL transmission, the wireless device may complete contention resolution based on a C-RNTI in an RAR. If a wireless device transmits a shared RNTI, that may be monitored by more than one wireless device as a wireless device ID in a UL transmission, the wireless device may complete contention resolution based on a contention resolution identity in an RAR. Other identifiers for a wireless device, such as a random number, resume ID, T-IMSI, and/or IMSI may be used to complete the contention resolution.

[153] The UL grant may be for a wireless device that may have subsequent UL data to transmit. BSR may be transmitted by a wireless device in the UL transmission. A base station may use the BSR for determining a UL grant.

[154] A wireless device may not have a C-RNTI, such as a wireless device in an RRC inactive state. If a two-step RA procedure is used for state transition from inactive to connected, a base station may assign a C-RNTI to a wireless device that lacks a C-RNTI.

[155] A wireless device may acquire one or more two-step RA configuration parameters (e.g., in step 2001 of FIG. 20) from one or more messages broadcast and/or unicast by a cell. A base station may broadcast or multicast, via a cell, one or more two-step RA configuration parameters comprised in one or more system information blocks. The base station may transmit configuration parameters to a wireless device via dedicated resource(s) and signaling, such as via a unicast to a wireless device in an RRC connected state.

[156] A base station may configure or restrict the usage of the two-step RA procedure to one or more case-based procedures, services, or radio conditions. If a cell is small such that there may be no need for a TA, a base station in the cell may use broadcast signaling to configure all wireless devices under its coverage to use a two-step RA procedure. A wireless device may acquire the configuration, via one or more system information blocks, and/or via L1 control signaling used to initiate a two-step RA procedure for downlink data arrival.

[157] If a base station has macro coverage, a wireless device having a stored and/or persisted TA value, e.g., a stationary or near stationary wireless device such as a sensor-type wireless device, may perform a two-step RA procedure. A base station having macro coverage may use dedicated signaling to configure a two-step RA procedure with one or more wireless devices having stored and/or persisted TA values under the coverage.

[158] A wireless device in an RRC connected state may perform a two-step RA procedure, e.g., when performing a network initiated handover, and/or when the wireless device requires or requests a UL grant within a required delay and there are no physical-layer uplink control channel resources available to transmit a scheduling request. A wireless device in an RRC inactive state may perform a two-step RA procedure, e.g., for a small data transmission while remaining in the inactive state or for resuming a connection. A wireless device may initiate a two-step RA procedure, for example, for initial access such as establishing a radio link, re-establishment of a radio link, handover, establishment of UL synchronization, and/or a scheduling request when there is no UL grant.

[159] Determining a type of RA procedure may comprise determining whether to do a 2-step or a 4-step RA procedure. An indicator may be provided in a MAC PDU subheader. Such an indicator may be included in a RAP identifier (RAPID), such as shown in FIG. 17. A RAPID may identify a specific RAP, where up to 2^n unique RAPs are possible for an n-bit wide RAPID. Multiple wireless devices may transmit their own RAPs to a base station. A base station may receive RAPs from a plurality of wireless devices. Each RAPID may indicate one of the plurality of RAPs transmitted to a base station. A wireless device may determine a RAP. This determination may be performed by the wireless device using a random process. The wireless device may transmit the RAP. If a base station detects the RAP from the wireless device, the base station may use bits in a RAPID field to identify that RAP. The base station may transmit the RAPID in a MAC subheader within a MAC header of a MAC PDU, such as shown in FIG. 17. The wireless device that transmits the RAP may receive a MAC PDU comprising the RAPID in a MAC subheader. The wireless device may determine, based on the RAPID, that the RAP was successfully received by the base station.

[160] The number of n bits in a RAPID may be 6 bits, such as in the RAPID shown in FIG. 17, or any number of bits greater or smaller than 6. The base station may determine an estimate of a number of wireless devices supported in a cell. The base station may also determine, based on the estimated number of wireless devices in a cell, a total number of RAPs that may be used for the cell. The base station may also determine, based on the number of RAPs that may be used for the cell, the number of bits to be used in the RAPID for identifying a RAP. The base station may reduce the number of bits used in the RAPID for identifying unique RAPs, which in turn, may allow one or more bits of the RAPID shown in FIG. 17, to be used for other information, such as a type of RA procedure to be used. Using fewer than n bits for identifying RAPs, may allow use of one or more unused RAPID bits as an indicator for other information such as whether a random access procedure uses a 2-step procedure or a 4-step procedure. The indication of whether a RA procedure is 2-steps or 4-steps may be in the form of a single bit, where "0" indicates one of the two possible RA procedures, such as a 2-step procedure, and "1" indicates the other, such as a 4-step procedure. Additionally or alternatively, more than one bit of a RAPID may be used, e.g., 2 or 3 bits, to indicate additional information, such as information specific to one or more steps in a RA procedure.

[161] One or more bits of the E and/or T fields, such as in a MAC subheader comprising a RAPID shown in FIG. 17, may be used as an indication of a type of RA procedure, such

as a 2-step RA procedure or a 4-step RA procedure. The E field may be an extension field. A MAC subheader with an E field set to 1 may indicate the presence of a backoff indicator (BI) in the subheader and the presence of an additional MAC subheader. A MAC subheader with an E field set to 0 may indicate the presence of a RAPID in the subheader. The T field may be an indication of a presence of additional MAC subheaders. A MAC subheader with a T field set to 1 may indicate the presence of an additional MAC subheader, and a MAC subheader with a T field set to 0 may indicate that the MAC subheader is the last MAC subheader in the MAC header. One or more of these E and/or T fields may be used to indicate a type of RA procedure, such as a 2-step RA procedure or a 4-step RA procedure.

[162] A wireless device may perform a method for determining whether to perform a 2-step RA procedure or a 4-step RA procedure. The wireless device may transmit, to a base station, a RAP comprising a RAP identifier (e.g., RAPID / RAP ID) and one or more transport blocks. Additionally or alternatively, the wireless device may transmit, to a base station, one or more preambles in parallel with one or more transport blocks. Any of the above transmissions by the wireless device may be based on a determination, by the wireless device, that the type of the RA procedure is a two-step RA procedure. The wireless device may receive, from the base station, a MAC PDU comprising one or more MAC subheaders and one or more MAC RARs, such as shown in FIG. 17. This transmission by base station may be based on the first transmission by the wireless device. Each of the RARs may be associated with one of the one or more MAC subheaders. The wireless device may determine, based on a first field in a particular MAC subheader of the one or more MAC subheaders, a type of an RA procedure. Additionally or alternatively, based on the type of RA procedure (e.g., based on the first field in the particular MAC subheader), the wireless device may determine a size of an RAR that is associated with the particular MAC subheader comprising the field (e.g., a first MAC subheader, a second MAC subheader, etc.). The type of RA procedure may be, e.g., either a 2-step RA procedure or a 4-step RA procedure. Additionally or alternatively, the RA procedure may be a 3-step RA procedure, or some other number of steps. This particular MAC subheader may comprise a second field comprising the first field and/or one or more bits of an RAP identifier (e.g., a RAPID / RAP ID). This particular MAC subheader may also comprise an extension field, a type field, and/or a reserved bit. The wireless device may determine, based on a comparison of the field in the particular MAC subheader with the RAPID of the RAP transmitted by the wireless

device, whether the RAP in the first transmission by the wireless device is successfully received by the base station. The wireless device may determine the type of RA procedure (e.g., a two-step RA procedure) based on whether an initial attempt of the particular RA procedure is successful. If the wireless device determines that the first attempt at the RA procedure is not successful, the wireless device may retransmit the first transmission and/or the wireless device may determine to perform a four-step RA procedure, such as shown in FIG. 15 part (a) and described above. The wireless device may determine whether a random process has completed. This determining whether a random access has completed may be based on, e.g., the first MAC subheader comprising a random access preamble identifier of the one or more preambles, and/or a second field in the first RAR that indicates that the one or more transport blocks have been successfully received by the base station. Additionally or alternatively, the determining that the random access procedure has completed may be based on the type of the random access procedure of the first RAR being a two-step random access procedure. The wireless device may transmit, based on a second field in the first RAR that indicates that at least one of the one or more transport blocks have not been successfully received by the base station, one or more messages using a four-step random access procedure. The wireless device may receive, from a base station, one or more messages comprising configuration parameters of a two-step random access procedure and/or configuration parameters of a four-step random access procedure. The wireless device may receive, from the base station, an RAR that may comprise an uplink grant. The wireless device may retransmit, in response to a field of the RAR (e.g., a first field, a second field, etc.) indicating that one or more transport blocks have not been successfully received by the base station, the one or more transport blocks. A wireless device may perform any combination of one or more of the above steps. A base station, or any other device, may perform any combination of a step, or a complementary step, of one or more of the above steps.

[163] A base station may perform a method for determining whether to perform a two-step RA procedure or a four-step RA procedure. The base station may receive, from a wireless device, an RAP. The base station may also receive, in this first transmission from the wireless device, one or more transport blocks. The base station may determine, based on the RAP, a type of RA procedure. The type of RA procedure may be, e.g., either a two-step RA procedure or a four-step RA procedure. Additionally or alternatively, the RA procedure may be a 3-step RA procedure, or some other number of steps. The base

station may transmit, to the wireless device and based on the RAP, a MAC PDU comprising one or more MAC subheaders and one or more MAC RARs, such as shown in FIG. 17. A particular MAC subheader may comprise a field indicating the type of the RA procedure. This particular MAC subheader may comprise one or more bits of an RAP identifier (e.g., a RAPID / RAP ID). This particular subheader may also comprise an extension field, a type field, and/or a reserved bit. Each of the one or more RARs may be associated with one of the one or more MAC subheaders. The RAR may comprise the same size or one of a plurality of different sizes. An indication of the type of the RA procedure may be based on a RAPID in the RAP. Additionally or alternatively, an indication of the type of the RA procedure may be based on one or more of the extension field, the type field, and/or a reserved bit. A base station may perform any combination of one or more of the above steps. A wireless device, or any other device, may perform any combination of a step, or a complementary step, of one or more of the above steps.

[164] A base station may determine a first MAC PDU for a two-step RA procedure comprising RARs only for two-step RA procedures, and a base station may determine a second and different MAC PDU for a 4-step RA procedure comprising RARs only for 4-step RA procedures, wherein each RAR in a MAC PDU is for the same type of RA procedure. The base station may provide an indicator as to which type of RA procedure the MAC PDU corresponds. Such an indicator may be included in any location of the MAC PDU, e.g., within a MAC header or within MAC RARs (e.g., within an R field comprising reserved bits). By including the indicator in the MAC header, a wireless device may be able to determine the type of RA procedure, as well as the size of the MAC RARs, prior to receiving or decoding the MAC RARs of the MAC PDU.

[165] A base station may multiplex different type of RA responses (RARs) into one MAC PDU. A wireless device may require or request resources for both two-step RA and four-step RA procedures, and these resources for difference types of RA procedures may be independent of each other. A base station may require or request to use additional resources to accommodate a MAC PDU for 2-step RA procedures that may be different from a MAC PDU for 4-step procedures. If a base station multiplexes two types of RARs (e.g., RARs for 2-step RA procedures and RARs for 4-step RA procedures) into one MAC PDU, the base station may only be able to assign common RACH resources, where a UE can transmit a 2-step RAP or a 4-step RAP. Resources in the uplink and the downlink may be conserved by identifying an RA type without allocating separate resources for different MAC PDUs. If a base station multiplexes two types of RARs in

the same MAC PDU, e.g., if the length of a two-step RAR may be different than the length of a four-step RAR, one or more indicators may be required to indicate one or more RAR boundaries in the same MAC PDU.

[166] A base station may determine a type of RA procedure, such as a two-step RA procedure or a four-step RA procedure, for communications with one or more wireless devices. A base station may monitor RACH resources to determine whether one or more RAPs are received. If a RAP is received, the base station may determine a type of RA procedure for the RAP, such as a two-step RA procedure or a four-step RA procedure. The base station may determine, based on the type of the RA procedure for the RAP, a corresponding type of RA procedure for communications with the wireless device that transmitted the RAP. The base station may make the above determinations for a plurality of RAPs, and each of the plurality of RAPs may be associated with one of a plurality of wireless devices. The base station may multiplex a plurality of MAC PDUs. Each of the MAC PDUs may comprise a one or more MAC subheaders. At least one of the one or more MAC subheaders may comprise an indication of a type of an RA procedure, such as a two-step RA procedure or a four-step RA procedure. The base station may transmit the multiplexed plurality of MAC PDUs. One or more of the plurality of wireless devices may receive the multiplexed MAC PDUs and determine whether to perform one or more steps of an RA procedure with the base station. The one or more of the plurality of wireless devices may determine, based on one or more indications in a MAC subheader of at least one of the MAC PDUs, a type of the RA procedure for communications with the base station.

[167] A base station and/or a wireless device may determine whether an attempt for an RA procedure is successful. If an attempt for an RA procedure is successful, the base station and the wireless device may communicate using the type of RA procedure of the successful attempt. If the attempt for an RA procedure is not successful, the base station and/or the wireless device may make another attempt for an RA procedure of the same type as the prior attempt. If one or more attempts (e.g., up to a threshold number) for an RA procedure of a particular type of RA procedure (e.g., a two-step RA procedure) are not successful, the base station and/or the wireless device may attempt an RA procedure of a different type (e.g., a four-step RA procedure). A base station may perform any combination of one or more of the above steps. A wireless device, or any other device, may perform any combination of a step, or a complementary step, of one or more of the above steps.

[168] A two-step RA procedure may be attempted by a wireless device. The wireless device may transmit, to a base station, an RAP in parallel with data. The data may be an uplink message that may comprise, e.g., an identifier of the wireless device and other data such as one or more transport blocks. A base station may receive the transmission from the wireless device and the base station may decode one or more transport blocks received from the wireless device. The base station may transmit, to the wireless device, a random access response (RAR). The base station may include the RAR in a MAC PDU. The base station may also include one or more additional RARs in the MAC PDU. The base station may multiplex the MAC PDU with other MAC PDUs. The base station may transmit the multiplexed MAC PDUs. The base station may include in the RAR, which may be responsive to the first transmission of the wireless device, one or more indications of whether the one or more transport blocks were successfully received by the base station. The one or more indications may be included in one or more R fields of one or more reserved bits of the RAR. Examples of R fields are shown, e.g., as "R" in FIG. 19 parts (a), (b), and (c). The wireless device may receive the multiplexed MAC PDUs. The wireless device may demultiplex the multiplexed MAC PDUs. The wireless device may determine, based on a RAPID or other indication in a MAC subheader of a MAC PDU, that a particular RAR associated with that MAC subheader is intended for the wireless device. For example, if a RAPID in a MAC subheader of a MAC PDU corresponds to an RAP that a wireless device transmitted to a base station, the wireless device may determine that a particular RAR associated with that MAC subheader comprising the RAPID is intended for the wireless device. The RAPID or other indication in the MAC subheader may include an indication of the identifier of the wireless device that was previously included in the uplink message of the transmission by the wireless device. The wireless device may determine, based on the indication in the RAR associated with the MAC subheader, whether the one or more transport blocks were successfully received by the base station. As described above, the indication may comprise one or more bits in one or more R fields in the RAR. R fields may comprise remainder bits of an octet comprising fields designated for other purposes, and these remainder bits may be reserved for future use or for one or more indications such as described above. An indication whether one or more transport blocks were successfully received by the base station may comprise a single bit. The indication may also comprise one or more additional bits to provide additional information to the wireless device. The additional information provided by one or more additional bits may comprise, e.g., a

redundancy version for a retransmission of one or more transport blocks by the wireless device.

[169] A wireless device may perform a method for determining whether a 2-step RA procedure is successful. A wireless device may receive, from a base station, one or more messages comprising configuration parameters for a RACH of a cell. The configuration parameters may comprise one or more RA parameters. The wireless device may transmit, to the base station, an RAP in parallel with: one or more first TBs with a first redundancy version (RV) associated with a HARQ process. This first transmission by the wireless device may be based on the one or more RA parameters. The one or more first TBs may comprise an identifier associated with the wireless device (e.g., UE ID). The wireless device may receive, from the base station, an RAR MAC PDU comprising, e.g., a preamble identifier (e.g., RAPID), an uplink grant, a field indicating whether the one or more first TBs are successfully received by a base station, and/or an RNTI. The RNTI may comprise, e.g., one or more of a C-RNTI or a TC-RNTI. The uplink grant may comprise an indication of uplink resources. The field indicating whether the one or more first TBs are successfully received by the base station may comprise: one or more of the identifier associated with the wireless device or a C-RNTI, if the one or more first TBs are received successfully by the base station; or one or more of a fixed value or a TC-RNTI, if the one or more first TBs are not received successfully by the base station. One or more transport blocks may be considered successfully received by the base station if the base station is able to decode information contained in the one or more transport blocks. Additionally or alternatively, the RAR MAC PDU may comprise at least one MAC subheader that comprises one or more of a TC-RNTI or an indication of a decoding failure. The wireless device may transmit, to the base station, one or more first TBs with a second RV associated with the HARQ process, wherein the second RV may be the same as /or different from the first RV. The wireless device may receive, from the base station, a downlink packet comprising the identifier associated with the wireless device, if the one or more first TBs with the first RV or the second RV are received successfully by the base station. The wireless device may receive, from the base station, an indication of a NACK, if TBs are not received successfully. The wireless device may transmit, based on the indication of the NACK, a HARQ comprising retransmitted TBs with another RV different from the prior first and second RVs. The wireless device may receive, from the base station, an indication of an ACK, if TBs are successfully received. If the one or more first TBs are not received successfully by the base station, the wireless

device may determine that the RA procedure has failed and/or the wireless device may fall back to a four-step RA procedure, such as described above regarding FIG. 15 part (a). A wireless device may perform any combination of one or more of the above steps. A base station, or any other device, may perform any combination of a step, or a complementary step, of one or more of the above steps.

[170] A base station may perform a method for determining whether a two-step RA procedure is successful. A base station may transmit, to a wireless device, one or more messages comprising configuration parameters for a RACH of a cell. The configuration parameters may comprise one or more RA parameters. The base station may receive, from the wireless device, an RAP in parallel with: one or more first TBs with a first redundancy version (RV) associated with a HARQ process. This first transmission by the wireless device may be based on the one or more RA parameters. The one or more first TBs may comprise an identifier associated with the wireless device (e.g., UE ID). The base station may transmit, to the wireless device, an RAR MAC PDU comprising, e.g., a preamble identifier (e.g., RAPID), an uplink grant, a field indicating whether the one or more first TBs are received successfully, and/or an RNTI. The RNTI may comprise, e.g., one or more of a C-RNTI or a TC-RNTI. The uplink grant may comprise an indication of uplink resources. The field indicating whether the one or more first TBs are received successfully may comprise: one or more of the identifier associated with the wireless device or a C-RNTI, if the one or more first TBs are received successfully by the base station; or one or more of a fixed value or a TC-RNTI, if the one or more first TBs are not received successfully by the base station. One or more transport blocks may be considered successfully received by the base station if the base station is able to decode information contained in the one or more transport blocks. Additionally or alternatively, the RAR MAC PDU may comprise at least one MAC subheader that comprises one or more of a TC-RNTI or an indication of a decoding failure. The base station may receive, from the wireless device, one or more first TBs with a second RV associated with the HARQ process, wherein the second RV may be the same as or different from the first RV. The base station may transmit, to the wireless device, a downlink packet comprising the identifier associated with the wireless device, if the one or more first TBs with the first RV or the second RV are received successfully by the base station. The base station may transmit, to the wireless device, an indication of a NACK, if TBs are not received successfully. The base station may receive, based on the indication of the NACK, a HARQ comprising retransmitted TBs with another RV different from the prior first and

second RVs. The base station may transmit, to the wireless device, an indication of an ACK, if TBs are successfully received. If the one or more first TBs are not received successfully by the base station, the base station may determine that the RA procedure has failed and/or that a four-step RA procedure, such as described above regarding FIG. 15 part (a), should be attempted. The base station may transmit, to the wireless device, an indication that the RA procedure has failed and/or an indication to fall back to a four-step RA procedure. A base station may perform any combination of one or more of the above steps. A wireless device, or any other device, may perform any combination of a step, or a complementary step, of one or more of the above steps.

[171] Because a two-step RA procedure may reduce latency of UL data transfer compared with a four-step RA procedure, two-step RA procedures may be advantageous for UL data transfer such as UL data arrival for a wireless device in an RRC connected state or UL data arrival for a wireless device in an RRC inactive state. If a wireless device is in an RRC connected state, using two-step RA procedure may improve the latency of receiving an uplink grant for UL data arrival. The two-step RA procedure may be used, e.g., if a TA timer expires or a physical-layer uplink control channel resource for the SR is not configured for a wireless device. If a wireless device is in an RRC inactive state, the wireless device may transmit a UL data arrival using a two-step RA procedure without a state transition to the RRC connected state.

[172] If a base station configures four-step and two-step RA procedures, the base station may use separate preamble signature groups and/or separate time-frequency resources for each of four-step and two-step RA preamble transmissions. Using separate preamble signature groups and/or separate time-frequency resources for different types of RA procedures may help the base station determine whether a wireless device attempts to initiate a two-step RA procedure or a four-step RA procedure. A base station may broadcast and/or unicast one or more configuration parameters that indicate separate preamble signature groups, and/or that use separate time-frequency resources, for four-step and two-step RA preamble transmissions.

[173] One or more RAP groups may be configured for a two-step RA procedure via broadcast system information. If a base station configures one or more groups in the two-step RA procedure, a wireless device may use a size of the message transmitted by the wireless device in the third step, and/or the pathloss, to determine for which group the wireless device selects an RAP. A base station may use a group type to which an RAP belongs as

an indication of the message size in the third step and/or as an indication of the radio conditions at a wireless device. A base station may broadcast the RAP grouping information along with one or more thresholds on system information.

[174] A process for generating a RAP may be predetermined, or may be determined, e.g., using two-step RA configuration parameters. A type of sequence for RAP generation, e.g., a Zadoff-Chu sequence, the number of samples in a sequence, a sub-carrier spacing for a RAP transmission, and a format of a RAP transmission in a subframe (e.g., guard time/frequency, cyclic prefix length for a RAP transmission, and/or a resource block size allocated for an RAP and data transmission) may be predetermined. A cell may broadcast one or more parameters, such as a root sequence index and cyclic shift interval (e.g., rootSequenceindex, highspeedflag, and/or zeroCorrelationZoneConfig in LTE), required for a wireless device to generate a set of RAPs.

[175] The resources used for a RAP and data transmission may be pre-determined or indicated by RA configuration parameters. A table or other form of memory may indicate possible pairs of system frame number (SFN) and subframe number. A wireless device may attempt the first step of a two-step RA procedure, e.g., transmission of an RAP and data, based on such a table. A base station may broadcast one or more pairs of SFN and subframe used in the cell for the RAP and data transmission of a two-step RA procedure. A frequency offset with which a wireless device transmits an RAP and data within a subframe may be configured by two-step RA configuration parameters. A resource via which a data part is transmitted during the UL transmission may be pre-determined or configured by two-step RA configuration parameters. Such a resource may be associated with a selected RAP ID, such that a wireless devices that select different RAPs transmit data via different resources in the UL transmission.

[176] One or more wireless devices may perform the first step of a two-step RA procedure using the same cell in the same subframe. The cell may respond to one or more wireless devices' UL transmissions by multiplexing one or more RARs into a single MAC PDU as shown in FIG. 17. FIG. 17 is an example MAC PDU format. Other fields may be added, e.g., to the subheader and/or to the RARs. A MAC PDU may comprise a MAC header and MAC RARs. The MAC header may comprise one or more MAC subheaders, at least one of which may comprise a BI. Other MAC subheaders may comprise a RAPID that may indicate an index number of one of available RAPs in a cell. Each MAC RAR may comprise a wireless device ID, a C-RNTI, a TA command, an UL grant,

and/or other parameters. A wireless device may identify an RAR corresponding to the wireless device in a MAC PDU by first identifying a subheader having a RAPID that matches the RAP that the wireless device transmitted during the UL transmission. The wireless device may decode an RAR that is paired with the identified subheader.

[177] The MAC PDU may comprise a subheader that may comprise a bit string, e.g., including a special bit string comprising zeros, that may be pre-defined to indicate the failure of RAP detection but success of data decoding at a cell. The bit string may be indicated by a field of the RAPID or by a dedicated field for the bit string in the subheader. An RAR that is a pair of the subheader having the special bit string may include the wireless device ID (and/or other IDs) that a wireless device transmits in the UL transmission. The wireless device may decode the RAR having a corresponding subheader that has the special bit string, to determine whether the RAR is intended for the wireless device. The MAC subheader may comprise a field that may be a RAP identifier associated with the RAP if the RAP is detected. If the RAP is not detected, the field may comprise a pre-defined format. Additionally or alternatively, a second field in the MAC PDU subheader may indicate that a RAP is not detected.

[178] An RAR response timer may be configured using two-step RA configuration parameters. A wireless device may reset and/or start the RAR response timer in response to the wireless device transmitting a UL RAP and data transmission. The wireless device may monitor a downlink channel for an RAR on a cell until the RAR response timer is expired. A base station may transmit a MAC PDU that comprises one or more RARs, one or multiple times, in a DL transmission before the RAR response timer expires. The presence of an RAR may be indicated via a specific channel (e.g., a PDCCH in LTE) using an identity (e.g., RA-RNTI in LTE) created based on UL transmission time (e.g., as a combination of SFN and/or subframe number) and/or frequency offset. A wireless device may stop an RAR response timer when at least one of the following conditions are satisfied: the wireless device detects a MAC PDU that comprises a RAPID matching the RAP that the wireless device transmitted (and/or satisfying a threshold of similarity), the wireless device determines an RAR has a wireless device ID that the wireless device transmitted, and/or the RAR response timer is expired.

[179] A wireless device may monitor RARs for unique identifiers associated with the wireless device to determine whether information transmitted by the base station is intended for the wireless device. A base station may assign a unique identifier to each wireless device

of a plurality of wireless devices in a cell. The unique identifier may be associated with a radio network temporary identifier (RNTI). For a particular cell, the RNTI may be a cell radio network temporary identifier (C-RNTI). A wireless device may have a plurality of RNTIs associated with it, each of which may be for a different purpose. A wireless device may monitor resources in a time and frequency resource map by identifying a C-RNTI corresponding to the wireless device. If a base station transmits information in these resources, the information may be scrambled by the unique identifier of the wireless device, e.g., C-RNTI, to which the information is intended. If the wireless device receives a transmission from a base station, the wireless device may attempt to decode packets with the unique identifier assigned to the wireless device by the base station. The wireless device may determine, using its unique identifier, whether there is any data for the particular wireless device. The wireless device may monitor one or more channels, such as downlink control channels, with its unique identifier, e.g., at least one of RNTI assigned to the wireless device, to determine whether information is intended for that particular wireless device. If the wireless device uses its unique identifier to attempt to decode information but is not successful, then the wireless device may determine that the information is intended for a different wireless device. The wireless device that was unsuccessful in its attempt to decode information may continue to monitor the one or more channels.

[180] A two-step RA procedure may comprise two pairs of transmission, e.g., a first pair for a preamble transmission and a second pair for data transmission. Four overall outcomes may be possible from these pairs of transmission: both pairs succeed, both pairs fail, the first pair succeeds but the second pair fails, or the second pair succeeds but the first pair fails. A wireless device may determine, based on an indication in a MAC subheader such as described above, whether one or more preamble transmissions are successfully received by a base station. A wireless may determine, based on an indication in a MAC RAR such as described above, whether one or more data transmissions are successfully received by a base station. If either one or more preamble transmissions are not successfully received by a base station, and/or if either one or more data transmissions are not successfully received by a base station, a wireless device may determine whether to perform a retransmission of at least one of the first pair and/or the second pair of transmissions. If a wireless device determines to perform a retransmission, the wireless device may determine when to perform the retransmission.

[181] A contention resolution may be completed based on, e.g., either a C-RNTI or a wireless device contention resolution identity in an RAR. If a base station detects an RAP and decodes one or more TBs or portion thereof that a wireless device transmits, the base station may respond with an RAR that comprises the C-RNTI and/or other wireless device identifiers that the wireless device transmits in the first step of a two-step RA procedure. By detecting the C-RNTI and/or other wireless device identifiers in the received RAR, the wireless device may determine the success of the two-step RA procedure. The wireless device may start monitoring the downlink control channel associated with the C-RNTI (or Temporary C-RNTI) from the time the wireless device detects the C-RNTI (or Temporary C-RNTI) in the RAR such as shown in FIG. 21.

[182] If a base station detects an RAP but fails to decode one or more TBs or portion thereof that a wireless device transmits in the UL transmission of the two-step RA procedure, the base station may indicate such a failure. The base may transmit a MAC PDU that comprises a TC-RNTI, and/or one or more indicators in a MAC subheader and/or in an RAR, that may indicate a decoding failure to the wireless device of the RAP that the base station detected but failed to decode. A wireless device may determine, based on the one or more indicators, that the RAP was not successfully received or decoded by the base station. The wireless device may re-transmit the one or more transport blocks, e.g., by performing HARQ retransmission. The wireless device may start a *mac-ContentionResolutionTimer* when the wireless device retransmits, based on uplink grant in the RAR, the one or more transport blocks. The wireless device may not start a *mac-ContentionResolutionTimer* when the wireless device transmits one or more transport blocks based on uplink grant in the RAR, if the RAR indicates that one or more transport blocks are received and decoded successfully by the base station.

[183] A wireless device may restart the *mac-ContentionResolutionTimer* at a HARQ retransmission. If a wireless device starts or restarts the *mac-ContentionResolutionTimer*, the wireless device may start monitoring a downlink control channel using the C-RNTI or TC-RNTI. The wireless device may start this monitoring at a subframe and/or at a time offset from a start or restart of the *mac-ContentionResolutionTimer*. If an RAR indicates that one or more transport blocks are received successfully by a base station, the wireless device may monitor the C-RNTI and/or TC-RNTI. The wireless device may start this monitoring at a subframe and/or at a time offset from receiving the RAR.

[184] If a wireless device transmits a C-RNTI in the first step of a two-step RA procedure, the wireless device may monitor a downlink control channel using the C-RNTI. If a wireless device does not transmit a C-RNTI in the first step of a two-step RA procedure, the wireless device may monitor a downlink control channel using the TC-RNTI. If the *mac-ContentionResolutionTimer* expires, a wireless device may determine that the two-step RA procedure has failed.

[185] FIG. 21 shows an example of contention resolution for a two-step RA procedure. At step 2101, a wireless device may transmit, to a base station and via a cell, a random access preamble (RAP) and data. The base station associated with the cell may receive the RAP and the data. The RAP may include an identifier (e.g., RAPID = xxx). The data may comprise UL data and a redundancy version (e.g., RV = aa). The data may comprise an identifier of the wireless device (e.g., UE ID = yyy). The wireless device may start an RAR response timer (e.g., *mac-ContentionResolutionTimer*) at or near the time the wireless device transmits the RAP and data. At step 2102, the base station may transmit, and the wireless device may receive, a MAC PDU comprising a subheader that includes a RAP identifier of the RAP (e.g., RAPID = xxx). The MAC PDU may also comprise an RAR that may correspond to the subheader comprising an uplink grant. The RAR may include one or more indications of a decoding failure by the base station of the UL data. If an indication of a decoding failure is turned off, the wireless device may start monitoring a downlink control channel with a C-RNTI of the wireless device. At step 2103, if an indication of a decoding failure is turned on, the wireless device may perform a HARQ retransmission of the RAP and data, the wireless device may start monitoring the downlink control channel with the C-RNTI of the wireless device, and/or the wireless device may start and/or restart a timer (e.g., the *mac-ContentionResolutionTimer*).

[186] The wireless device may transmit one or more transport blocks in a first subframe and via radio resources indicated in an uplink grant. The wireless device may start a contention resolution timer in the first subframe depending on whether the RAR comprises the identifier of the wireless device. The wireless device may stop monitoring for RAR(s), e.g., after decoding a MAC packet data unit for an RAR and determining that the RAP identifier matches the RAP transmitted by the wireless device. The MAC PDU may comprise one or more MAC RARs and a MAC header. The MAC header may comprise a subheader having a backoff indicator and one or more subheaders that comprises RAPIDs.

[187] If one or more data transmissions are successfully received by a base station, the base station may transmit a MAC PDU comprising one or more corresponding RARs that each comprise an uplink grant. The uplink grant may indicate a particular subframe for a wireless device to transmit uplink data. The wireless device may start monitoring a downlink control channel from a second subframe. The wireless device may determine the second subframe based on, e.g.: a third subframe in which an RAR is received, if the RAR comprises the wireless device identifier; and/or the first subframe in which the wireless device transmits uplink resources based on the uplink grant. The wireless device may monitor the data for a C-RNTI, if the data comprises a C-RNTI; and/or the wireless device may monitor the RAR for a Temporary C-RNTI (TC-RNTI), if the data does not comprise a C-RNTI.

[188] If a wireless device does not receive any MAC PDU that comprises the RAPID and/or the wireless device identifier associated with the RAP, and if an RAR response timer has expired, the wireless device may retry the first step of a two-step RA procedure. The wireless device may retransmit the RAP and the data on the same cell.

[189] If the wireless device receives a MAC PDU that comprises a BI, the wireless device may select a backoff time. The backoff time may be random, and it may be determined according to a uniform distribution, e.g., between 0 and a BI value. The wireless device may delay the subsequent re-transmission of the RAP and the data by the selected backoff time. If the wireless device receives a MAC PDU that does not comprise any backoff indicator until an RAR response timer has expired, the backoff time may be set to zero. The wireless device may have a counter for counting the number of retransmissions of RAP and data. The wireless device may set the counter to zero (or 1) in the initial RAP transmission, and the wireless device may increase the counter by one whenever the wireless device re-tries the first step of a two-step RA procedure. The wireless device may reset the counter to zero (or 1) when the wireless device receives any MAC PDU that comprises the RAP ID or the wireless device ID, and/or when an RAR response timer expires. Two-step RA configuration parameters may have a parameter limiting an allowed maximum number of the retransmissions of RAP and data. If the counter reaches the maximum number, the wireless device may stop retransmission. The wireless device may perform a new RA on another cell with two-step or four-step RA procedure depending on two-step RA configuration parameters of a cell associated with the another cell.

[190] FIG. 22 shows an example of a two-step RA procedure and the failure of UL transmission for n times. At step 2201, a first base station (e.g., base station A) may transmit, via a first cell (e.g., cell A_a), two-step RA configuration parameters to a wireless device. The wireless device may determine a RAP selection, at step 2202, e.g., comprising one or more RAP selections procedures described herein. At step 2203, the wireless device may transmit a RAP and data (e.g. one or more transport blocks) of a two-step RA procedure to a base station. The RAP may comprise an identifier (RAP ID = xxx), and the data may comprise a wireless device identifier (UE ID = yyy). At or near the time the wireless device transmits the RAP and the data, the wireless device may start an RAR response timer. The base station may successfully decode and identify a RAP ID associated with the RAP, but the base station may fail to decode the data. Failure to decode the data may result from, e.g., collision or low signal quality. The base station may not transmit an RAR to the wireless in response to the RAP and data, or the base station may transmit an RAR comprising an indication of a decoding failure of the data. If the RAR response timer expires, and if the wireless device has not received an RAR indicating that the RAP and the data were successfully received by the base station, at step 2204, the wireless device may retransmit the RAP and the data after a time period corresponding to a backoff time. The wireless device may perform the above steps 2203 through 2204, to retransmit the RAP and the data, n number of times, where n may be any whole number. After the nth retransmission at step 2205, and after the RAR response timer expires with the wireless device not receiving an RAR indicating that the RAP and the data were successfully received by the base station, the wireless device may receive RA configuration parameters from a second base station (e.g., base station B) via a second cell (e.g., cell B_a), at step 2206. The RA configuration parameters from the second base station may be for a two-step RA procedure or for a four-step RA procedure. At step 2207, the wireless device may determine, based on the RA configuration parameters from the second base station, a RAP selection, e.g., comprising one or more RAP selections procedures described herein. The wireless device may transmit, to the second base station, a new RAP (e.g., comprising RAP ID = zzz) and the data (e.g., comprising the UE ID = yyy). The wireless device may repeat any of the above steps until the wireless device determines that a RA procedure is successful.

[191] The wireless device may receive a MAC PDU comprising a subheader that includes a RAP ID that the wireless device transmitted, but that also includes a decoding failure indicator in the subheader or in the RAR associated with the subheader. The decoding

failure indicator may be implemented in different ways depending on a MAC PDU format. If RARs for data decoding failures and successes have the same size, a MAC PDU may have a dedicated field inserted in a subheader or in an RAR to indicate the data decoding success or failure. This field may comprise one bit, such that either zero or one may indicate data decoding success or failure. A special bit string may be also used in an existing field in an RAR to indicate data decoding success or failure. This special bit string may comprise, e.g., all zeros or a detectable pattern of ones and zeros in the field of a wireless device ID in an RAR to indicate data decoding failure, or to indicate data decoding success. If RARs for data decoding failure and success have the same size, a wireless device may determine, based on a pre-determined RAR size information, the boundary of an RAR in a MAC PDU. If RARs for data decoding failure and success have different sizes, the base station may insert a field, to indicate RAR size information, in a MAC subheader or in an RAR. A wireless device may determine the boundary of an RAR in a MAC PDU based on the field. If RARs for data decoding failure and successes have different sizes, the RARs may have different formats. For example, an RAR for a data decoding failure may comprise a field of Temporary Cell Radio Network Temporary Identity instead of a field of a contention resolution wireless device ID, and an RAR for a data decoding success may comprise a contention resolution wireless device ID instead of a TC-RNTI.

[192] A wireless device may transmit, to a base station and as a part of a two-step RA process, a random access preamble and one or more transport blocks. The wireless device may receive a MAC PDU comprising: one or more MAC PDU subheaders, wherein a subheader comprises an RAP identifier; and one or more RARs, wherein each RAR corresponds to a MAC PDU subheader in the one or more MAC PDU sub-headers. The wireless device may determine whether the one or more transport blocks are received successfully based on one or more of: a first field in the subheader (e.g., a bit in the subheader indicating a fall back to a four-step RA procedure); a second field in an RAR associated with a first sub-header comprising an RAR identifier associated with the RAR (e.g., a bit in the RAR indicating a fall back to a four-step RA procedure). The wireless device may retransmit one or more transport blocks, if the one or more transport blocks are not received successfully by a base station. The wireless device may determine a size of the RAR based on one or more indications in the first field and/or in the second field. The wireless device may determine whether to fall back to a four-step RA procedure based on one or more indications in the first field and/or in the second field.

[193] A wireless device may perform a method for determining whether a two-step RA procedure has failed based on one or more timers. A wireless device may receive, from a base station, RA configuration parameters. The wireless device may transmit, to a base station, an RAP and one or more first transport blocks. The one or more first transport blocks may comprise an identifier of the wireless device (e.g., UE ID). The wireless device may receive, from the base station, a MAC PDU comprising one or more MAC subheaders and one or more RARs. At least one of the one or more MAC subheaders may comprise a RAPID of the RAP transmitted by the wireless device. Each RAR of the one or more RARs may be associated with a MAC subheader of the one or more MAC subheaders. A first RAR may be associated with a first MAC header comprising an uplink grant for a first subframe. The wireless device may transmit, to the base station, in a first subframe, and via radio resources indicated by the uplink grant, one or more transport blocks. The wireless device may start, in response to transmitting one or more transport blocks, and based on whether the RAR comprises the identifier of the wireless device, a contention resolution timer. The contention resolution timer may be for determining whether a random access procedure is successful. The wireless device may stop, based on a determination that the RAPID of the MAC subheader matches the identifier of the wireless device, an RAR response timer that started in response to transmitting the RAP. The wireless device may stop, based on a determination that a downlink control information detected from a downlink control channel comprises the identifier of the wireless device, the contention resolution timer. The wireless device may perform one or more operations regarding the contention timer one or more times, and/or using one or more timers. The wireless device may restart, based on a retransmission of the one or more TBs, the contention resolution timer. The wireless device may determine that, based on an expiration of the contention resolution timer, a first RA procedure has failed. The wireless device may initiate, at a time period after determining that the first RA procedure has failed, a second RA procedure. The wireless device may determine, based on a backoff indicator in the RAR, the time period. The wireless device may monitor a downlink control channel associated with an RNTI. The wireless device may start the monitoring from a second subframe. The monitoring by the wireless device may comprise monitoring the downlink control channel for a downlink control information associated with the RNTI. The wireless device may determine the second subframe based on one or more of: a subframe in which an additional RAR is received that comprises the identifier of the wireless device; and/or a subframe in which the wireless device transmits uplink resources based on the uplink grant. The monitoring

may be performed after detecting the RAR comprising the RNTI. The RNTI may comprise one or more of a C-RNTI or a TC-RNTI. The wireless device may determine that an RAR associated with the RAP has not been received. The wireless device may perform the following one or more times: retransmitting the RAP and the one or more transport blocks; starting, based on the retransmitting the RAP and the one or more transport blocks, a second timer; and determining that an RAR associated with the retransmitted RAP has not been received. This determining may occur at a second time period after the starting of the second timer. The wireless device may determine, based on a determination that an RAR associated with one or more retransmissions of the RAP has not been received, that an RA procedure with the base station has failed. The wireless device may receive, from a second base station, RA parameters. The wireless device may transmit, to the second base station, the RAP and the one or more transport blocks. A wireless device may perform any combination of one or more of the above steps. A base station, or any other device, may perform any combination of a step, or a complementary step, of one or more of the above steps.

[194] A base station may multiplex, in a MAC PDU, RARs for two-step and four-step RA procedures. If RARs for two-step and four-step RA procedure have the same size, a wireless device may not require an RAR length indicator field and/or the wireless device may determine the boundary of each RAR in the MAC PDU based on pre-determined RAR size information. The RAR may have a field to indicate a type of RAR (e.g., comprising one or bits in a reserved "R" field as shown in FIG. 23). An RAR may comprise different formats for two-step and four-step RARs with a fixed size. Some examples for different RAR formats are shown in FIG. 23 parts (a), (b), and (c). By using RARs with different formats, the size of the sub-header may be reduced and/or additional bits may be available for other fields. Encoding RARs with an indication of an RAR type may reduce downlink signaling overhead.

[195] FIG. 24 shows an example RAR format that may or may not comprise a field to indicate a type of RAR. The RAR shown in FIG. 24 may comprise a fixed size using the same format for two-step and four-step RA. If RARs for two-step and four-step RA procedures have different sizes, a field for indicating an RAR type may be included in a subheader (such as a MAC subheader) or in an RAR. An RAR may comprise different types of fields that may correspond with an indicator in a subheader or in an RAR. A wireless device may determine the boundary of one or more RARs in a MAC PDU based on one or more indicators.

[196] Different message formats may be used based on the type of device for communication. If a wireless device comprises, e.g., an IoT device, such as a smart appliance or other electronics equipment that may not require a large amount of data transmission, the format may include a small message space for transmissions by the device instead of including an uplink grant. If the wireless device comprises, e.g., a phone, tablet, or other device that requires a large amount of data transmissions, the format may include an uplink grant for larger transmissions.

[197] A wireless device may determine whether an RAR is a two-step RAR or a four-step RAR, at least based on the RAP identifier in the corresponding MAC PDU sub-header. Two-step and four-step RA preamble identifiers may be selected from two different preamble groups. The wireless device may determine whether an RAR is a two-step RAR or a four-step RAR, at least based on a field indicating an RAR type. The MAC PDU subheader may comprise the field indicating an RAR type. The field may comprise one bit indicating a two-step or a four-step RAR type. The RAR length may be predetermined for each RAR type. A wireless device may determine a size of an RAR based on a determination of whether the RAR is a two-step RAR or a four-step RAR.

[198] A wireless device may transmit, to a base station, a random access preamble via a random access channel in a subframe and using a frequency offset. A wireless device may determine an RA-RNTI based on one or more of a subframe number and/or a frequency index. A wireless device may monitor a control channel for a control packet associated with an RA-RNTI. A wireless device may receive a MAC PDU, associated with RA-RNTI, comprising: one or more MAC PDU subheaders, wherein a subheader may comprise an RAP identifier; one or more RARs, wherein each RAR of the one or more RARs may correspond to a MAC PDU subheader of the one or more MAC PDU sub-headers; and an uplink grant. The wireless device may transmit one or more transport blocks based on the uplink grant.

[199] Example RAR formats are shown in FIGS 19, 23, and 24. An RAR may include one or more fields, such as a timing advance command, an uplink grant, a TC-RNTI, a C-RNTI, a wireless device (e.g., a UE) contention resolution identity, and/or other parameters. An RAR format may be determined based on the fields that are needed in the RAR. A present bit may be used for a field to indicate whether the field is included in the RAR. For example, a presence field may indicate whether or not an RAR includes an uplink grant. Other fields may be associated with a presence field. Multiple RAR types may

include different fields that may be pre-defined. A field in the MAC subheader or in an RAR may determine the RAR type and a corresponding RAR length. A two bit field may indicate which of four or three RAR types are transmitted. Other fields, comprising any number of its, may be included in the MAC subheader and/or in an RAR to indicate information about an RA procedure.

[200] FIG. 19 shows example RAR formats with a fixed size (e.g., 6 bytes) for various RA procedures (e.g., two-step and four-step RA procedures). FIG. 23 parts (c) and (a) show example RAR formats with a fixed size (e.g., 6 bytes) for two-step and four-step RA procedures, respectively. FIG. 23 part (b) shows an example RAR format with a fixed size (e.g., 8 bytes) for a two-step RA procedure. FIG. 24 shows an example RAR format with a fixed size (e.g., 12 bytes) for two-step and four-step RA procedures. As shown in FIGS. 23 parts (a)-(c) and FIG. 24, an RAR format may comprise, e.g., one or more: reserved fields (e.g., "R"), timing advance command, uplink grant, temporary C-RNTI (TC-RNTI), and/or wireless device (e.g., UE) contention resolution identity.

[201] A two-step RA procedure may comprise a hybrid automatic repeat request (HARQ), including, e.g., HARQ with soft combining, if a data decoding failure occurs. If a wireless device receives a MAC PDU that comprises a subheader with a RAP ID that matches or indicates the RAP that was transmitted by the wireless device, but a decoding failure indicator indicates a failure has occurred, the wireless device may perform HARQ. The wireless device may perform HARQ, e.g., by transmitting another redundancy version to the cell from which the wireless device received the MAC PDU. The HARQ transmission may occur at an a priori known subframe or time period, such as every eight subframes, after a prior HARQ transmission in the same HARQ process. The HARQ may predetermine a sequence of redundancy version numbers that the wireless device may transmit in a HARQ transmission in the same process. An RV number may start, e.g., from zero or one in an initial UL data transmission, and the next RV in the sequence may be transmitted if a wireless device determines that an RAR comprises an indicator requesting a next RV.

[202] FIG. 25 shows an example of an RA procedure using HARQ retransmission. A HARQ retransmission may occur if a wireless device detects a RAPID in a cell but determines that the base station failed to decode data transmitted by the wireless device. At step 2501, a wireless device may receive, from a base station and via a cell, RA configuration parameters. At step 2502, the wireless device may determine an RAP selection, e.g.,

comprising one or more RAP selections procedures described herein. At step 2503, the wireless device may transmit an RAP (e.g., comprising an RAP ID = xxx) and UL data (e.g., comprising a first RV = aa, and UE ID = yyy). At or near step 2503, the wireless device may start or restart an RAR response timer. At step 2504, the base station may transmit, and the wireless device may receive, a MAC PDU comprising a subheader (e.g., comprising RAP ID = xxx), such as a MAC subheader, with a TC-RNTI and a decoding failure indicator. Based on receiving the decoding failure indicator, the wireless device may stop the RAR response timer. At step 2505, the wireless device may transmit a HARQ retransmission of the RAP and the UL data. The HARQ retransmission may comprise a second RV (e.g., RV = bb). The wireless device may transmit the HARQ retransmission based on a determination that a decoding failure has occurred (e.g., which may be indicated by the decoding failure indicator). At or near step 2505, the wireless device may start a contention resolution timer. At step 2506, the base station may transmit, to the wireless device, a NACK. The base station may transmit the NACK transmission based on receiving the HARQ retransmission. Based on receiving the NACK, the wireless device may stop the contention resolution timer. At step 2507, the wireless device may transmit a second HARQ retransmission of the RAP and the UL data. The second HARQ retransmission may comprise a third RV (e.g., RV = cc). The wireless device may transmit the second HARQ retransmission based on the wireless device receiving the NACK. At or near step 2507, the wireless device may start or restart a contention resolution timer. At step 2508, the base station may transmit, to the wireless device, an ACK. The wireless device may receive the ACK. Based on receiving the ACK, the wireless device may determine that the second HARQ retransmission was successful. Based on receiving the ACK, the wireless device may stop the contention resolution timer.

[203] For RA procedures using HARQ retransmission, each RV may be transmitted in an adaptive or in a non-adaptive manner. A base station may transmit, to a wireless device and via a cell, one or more indicators of a HARQ transmission type. For example, the base station may transmit, to the wireless device and via a downlink control channel, a new data indicator (NDI) with downlink control information (DCI). Additionally or alternatively, the base station may transmit, to the wireless device and via a downlink HARQ indicator channel, a one-bit HARQ acknowledgement (ACK) or non-acknowledgement (NACK). The wireless device may determine, based on the ACK or NACK, whether to transmit, to the base station and via the cell, another RV. If the

wireless device detects an NDI that differs from a previously received NDI (e.g., an NDI bit has changed), the wireless device may, regardless of a HARQ ACK or NACK, transmit another RV specified in the DCI. The wireless device may transmit this RV using a resource and modulation and coding scheme (MCS) specified in the same DCI. If the wireless device detects a NDI non-toggled but receives a HARQ NACK message, the wireless device may transmit a predefined RV with the same resource and MCS as the previous HARQ transmission.

[204] The maximum number of HARQ transmissions may be determined for a two-step RA procedure, e.g., by maxHARQ-Msg3Tx in LTE. A wireless device may have a counter for counting the number of HARQ transmissions. A wireless device may set the counter to one based on transmitting the first RV. The wireless device may increase the counter by one based on transmitting a next RV in the cell. If the counter reaches the maximum number of HARQ transmissions configured in a cell (or a retransmission threshold and/or a HARQ transmission threshold), a wireless device may determine that the two-step RA procedure has failed. If the wireless determines that the two-step RA procedure has failed, the wireless device may perform a new RA procedure on a different cell, the same RA procedure but on a different cell, or a new RA procedure on the same cell. The new RA procedure may comprise a two-step or a four-step RA procedure.

[205] FIG. 26 shows an example of a two-step RA procedure failure as the number of HARQ retransmission reaches a threshold. Each of FIG. 26 steps 2601 through 2607 correspond to FIG. 25 steps 2501 through 2607, respectively, the descriptions of which are incorporated by reference here for FIG. 26 steps 2601 through 2607. At step 2608, the base station may transmit, and the wireless device may receive, a second NACK. Steps 2607 and 2608 may be repeated any number of times, wherein each HARQ retransmission may include a different RV, up to a final HARQ retransmission and NACK at steps 2609 and 2610, respectively. The final HARQ retransmission may be based on the total number of HARQ retransmissions reaching a threshold value, such as indicated by *maxHARQ-Msg3Tx*. At step 2611, if the threshold value for HARQ retransmissions is reached, and if a wireless device receives a NACK (e.g., at step 2610) and/or the contention resolution timer expires without the wireless device receiving an ACK, then the wireless device may determine that the RA procedure has failed. A base station may determine that an RA procedure has failed, e.g., if the base station is unsuccessful in decoding a threshold number of HARQ retransmissions, and/or if the

base station does not receive a HARQ retransmission from the wireless device after a threshold period of time.

[206] A wireless device may determine that a two-step RA procedure is successful, e.g., if, prior to the expiration of an RAR response timer, the wireless device receives a MAC PDU that comprises the same RAP ID and wireless device ID that a wireless device transmitted in the UL transmission. An RA procedure may be successful if a base station identifies the wireless device's transmitted RAP, decodes the wireless device's transmitted data, and transmits, to the wireless device and before the wireless device's RAR timer expires, a MAC PDU comprising the RAP ID and wireless device ID. A base station may identify an RAP ID based on a peak detector. The peak detector may detect a peak from correlation outputs between a received signal and a set of RAPs available to a cell. If the resource block, over which the data or portion thereof is transmitted during the UL transmission, is associated with an RAP, an RAP ID may also be detectable based on an energy detector. The energy detector may measure an energy level of the resource block for a UL data transmission.

[207] FIG. 27 shows an example of a successful two-step RA procedure, e.g., wherein a base station decodes an RAP and UL data, and a base station responds by transmitting an RAR to a wireless device. Each of FIG. 27 steps 2701 through 2703 correspond to FIG. 20 steps 2001 through 2003, respectively, the descriptions of which are incorporated by reference here for FIG. 27 steps 2701 through 2703. At or near step 2703, the wireless device may start or restart an RAR response timer. At step 2704, the base station may transmit, to the wireless device, a MAC PDU comprising one or more MAC subheaders and one of more RARs. At least one of the MAC subheaders in the MAC PDU may comprise a RAP ID (e.g., RAP ID = xxx) that may correspond to the RAP ID included in the RAP that was transmitted by the wireless device in step 2703. At least one of the RARs in the MAC PDU may comprise an identifier associated with the wireless device (e.g., UE ID = yyy) that may correspond to the identifier transmitted by the wireless device in step 2703. If the wireless device determines that the RAP ID included in at least one of the MAC subheaders corresponds to the wireless device's RAP IP; if the wireless device determines that an RAP, corresponding to the MAC subheader with the wireless device's RAP ID, comprises the wireless device's identifier; and if the RAR response time has not expired; then the wireless device may determine that the two-step RA procedure was successful.

[208] A wireless device may transmit in parallel, to a base station and via a first cell, a random access preamble, and one or more transport blocks with a first RV associated with a HARQ process, wherein the one or more TBs comprise the wireless device ID. The wireless device may receive an RAR MAC PDU comprising one or more of: a preamble identifier; an uplink grant; a field indicating whether the one or more TBs are received successfully; and/or an RNTI. The wireless device may transmit, using uplink resources, the one or more TBs with a second RV different from the first RV associated with the HARQ process. The uplink resources may be identified in the uplink grant. The wireless device may receive a downlink packet comprising the wireless device ID, if the one or more TBs are decoded successfully. The wireless device may receive one or more messages comprising configuration parameters of a RACH of a first cell.

[209] A wireless device may handover from a source base station to a target base station. A handover may occur, e.g., if the wireless device moves from a location in a first cell served by the source base station to a location in a second cell served by the target base station, if the source base station is unable to accommodate communications with the wireless device, if it is determined that a different base station is a better candidate for accommodating communications with the wireless device than the source base station, or for various other reasons.

[210] A random access procedure may be optimized for a handover of a wireless device from a source base station to a target base station. Such optimization may provide a faster handover, with reduced latency, and may provide a handover without suffering from collisions with other transmissions. A wireless device may perform, with a target base station, a contention-based four-step random access procedure that may take, e.g., 20 ms, a contention-free three-step random access procedure that may take, e.g., 14 ms, and/or a contention-based two-step random access procedure that may take, e.g., 4 ms. By communicating random access information from a target base station to a wireless device (e.g., via a source base station), prior to performing random access, the wireless device may employ a contention-free two-step random access procedure that may take, e.g., 1 ms. A contention-free, two-step random access procedure for handover with the above advantages may be achieved by communicating random access information with handover messaging described below.

[211] A source base station and a target base station for a possible handover may perform different operations for RA procedures to initiate communications with the wireless

device. Additionally or alternatively, a wireless device that is a candidate for a handover may be capable or incapable of one or more types of RA procedures, and/or conditions in a cell of the source base station may differ from conditions in a cell of a target base station. For one or more reasons, prior to initiating a handover of a wireless device from a source base station (e.g., an eNB, a gNB, etc.) to a target base station (e.g., an eNB, a gNB, etc.), a device may determine a type of random access procedure to use to perform the handover. The type of RA procedure may include, e.g., a two-step RA procedure or a 4-step RA procedure. Additionally or alternative, the type of RA procedure may include, e.g., whether the RA procedure is contention-based (such as a contention-based four-step RA procedure described above regarding FIG. 15 part (a)) or contention-free (such as a three-step contention-free RA procedure described above regarding FIG. 15 part (b), or a two-step contention-free RA procedure available that may be used for handover). The device that may determine the type of the RA procedure may be a target base station, a source base station, and/or a core network device (e.g., located at a Next Generation Core (NGC) network entity). Additionally or alternatively, a wireless device may determine the type of the RA procedure, e.g., based on random access information received in one or more messages. As an example, a source base station may send to a target base station information about the type of RA procedure (e.g., a contention-free two-step RA procedure) to perform for a wireless device that may be a candidate for a handover from the source base station to a target base station. Information about the type of RA procedure may also be sent by the target base station to the source base station, and by the source base station to the wireless device.

[212] A wireless device may receive random access information from a source base station for accessing a target cell. The random access information may comprise, e.g., an indication of a type of random access procedure, such as a two-step random access procedure or a four-step random access procedure, for the wireless device. The random access information may also comprise timing advance information for uplink transmissions and/or downlink transmissions for the wireless device in the target cell, such as for a random access preamble, a random access response, and/or one or more transport blocks. The timing advance information may indicate, e.g., whether the timing advance value is zero or not, and/or an estimated time advance value. Receiving the random access information from a source base station, as opposed to waiting to receive system information comprising random access information for a target base station, may enable a wireless device to reduce handover delay. The wireless device may perform a random

access procedure as part of a handover to a target cell based on one or more elements of received random access information.

[213] FIG. 28 shows an example of a random access procedure for handover, such as via a direct interface. At step 2810, a wireless device 2801 (e.g., a UE, or any device capable of communicating with a network) may send, to a source base station 2802 (e.g., a source gNB), a first message comprising a measurement report for one or more cells. The measurement report may be based on one or more attributes of the one or more cells. The measurement report may comprise, e.g., at least one of a list of cells, an RSRP (Reference Signal Received Power) for a cell or for each of a plurality of cells included in a list of cells, an RSRQ (Reference Signal Received Quality) for a cell or for each of a plurality of cells in a list of cells, cell priority of one or more base stations including a cell priority of the target base station 2803, or other information that may be used in a handover decision. The wireless device 2801 may generate the measurement report from measurements of neighboring cells, and the measurement report may indicate one or more base stations, of a plurality of neighboring base station, that may be candidates for a handover of the wireless device 2801 from the source base station 2802 based on power measurements for each base station. The wireless device 2801 may generate the measurement report using the procedures described below regarding FIG. 30.

[214] The source base station 2802 may determine a handover decision at step 2820. The handover decision may be based on the measurement report. The source base station 2802 may determine a target base station 2803, from among a plurality of potential target base stations. The source base station 2802 may determine, based on one or more elements of the measurement report, whether or not to initiate a handover procedure for the wireless device 2801. If the base station 2802 determines that a handover should be performed, the base station 2802 may send a second message, at step 2830, to a target base station 2803 (e.g., a target gNB). The second message may comprise a handover request message. The second message may also comprise one or more of the measurement report from the first message, an identifier of the wireless device 2801, a wireless device context (e.g., one or more bearers, one or more slices, subscriber information, security information, etc.), capability information of the wireless device 2801 (e.g., one or more types of RA procedures the wireless device 2801 is capable of performing), one or more cell identifiers of a cell or of a plurality of cells served by the target base station 2803, one or more elements of the measurement report received from the wireless device 2801, or other information that may be used for performing a

handover. The source base station 2802 may perform the handover decision in step 2820, and the source base station 2802 may receive and send the first and second messages in steps 2810 and 2830, respectively, using the procedures described below regarding FIG. 31.

[215] The target base station 2803 may receive the second message, at step 2830. The target base station 2803 may process the handover request. The target base station 2803 may determine, based on the second message, whether or not to accept the handover request for the wireless device 2801. The target base station 2803 may provide an acknowledgement of the handover request, e.g., by sending, at step 2840, a third message to the source base station 2802. The target base station 2803 may process the handover request, and the target base station 2803 may receive and send the second and third messages in steps 2830 and 2840, respectively, using the procedures described below regarding FIG. 32.

[216] The third message, that may be sent by the target base station 2803 to the source base station 2802, may comprise a handover request acknowledgement and random access information, including, e.g., an indication of a type of a random access procedure. The handover request acknowledgement may comprise an ACK that may be in response to the handover request. The target base station 2803 may determine random access information for inclusion in the handover request acknowledgement. The target base station 2803 may send the third message based on determining to accept the handover request. The target base station 2803 may include in the third message a handover request acknowledge message as well as random access information.

[217] In a handover procedure, the handover related information may be transmitted by an upper layer message, such as an RRC message. A type of a random access procedure, such as a two-step random access procedure or a four-step random access procedure, may be indicated, e.g., by one or more RACH type indication parameters in an RRC connection reconfiguration message. The RRC reconfiguration message may be included with a handover command. Additionally or alternatively, one or more RACH type indication parameters may comprise one or more indications of a capability (e.g., configured for a contention-free two-step RA procedure) or an incapability (e.g., not configured for a contention-free two-step RA procedure). With respect to one or more indications of incapability, one or more default RA procedures may be indicated in the random access information of the third message (e.g., instructing a wireless device to

default to a contention-based four-step RA procedure). Mobility control information (e.g., *mobilityControlInfo*) in an RRC connection reconfiguration message (e.g., *RRCConnectionReconfiguration*) may comprise one or more of the RACH type indication parameters. A target NG-RAN node to a source NG-RAN node transparent container may comprise RRC parameters comprising a handover command and/or one or more of the RACH type indication parameters. The handover command may comprise, e.g., an RRC E-UTRA handover command message, such as *handoverCommandMessage*. Additionally or alternatively, a type of a random access procedure may be indicated by one or more parameters in a mobility control information. The mobility control information may further indicate one or more of: *mobilityControlInfoV2X*, *handoverWithoutWT-Change*, *makeBeforeBreak*, *rach-Skip*, or *sameSFN-Indication*.

[218] The random access information may comprise, e.g., at least one of a first indication indicating that a random access procedure for handover execution should be performed with one of a two-step random access procedure or a four-step random access procedure, a second indication for performing a two-step random access process, a preamble identifier for a two-step random access procedure, and/or a preamble identifier for a four-step random access procedure. The preamble identifier for a two-step random access procedure and/or a four-step random access procedure may be used to determine radio resources, e.g., for channel access by the wireless device 2801. The preamble identifier may comprise one or more of a preamble index, PRACH mask index, root sequence, and/or the preamble, each of which may be used by the wireless device 2801 for a random access procedure. The random access information may further comprise a random access channel configuration information for a two-step random access procedure and/or radio resource configuration parameters for a two-step random access procedure. Additionally or alternatively, the third message may comprise, e.g., one or more of: a handover request acknowledgment, one or more bearers admitted, one or more slices admitted, one or more cells served by the target base station 2803, radio resource configuration information (e.g., RACH configuration, channel configuration information, etc.) for the wireless device 2801, one or more types of random access procedures, and/or mobility control information for the wireless device 2801. The third message may further comprise timing advance information, e.g., for transmission of uplink data. The timing advance information may comprise at least one of an indication of a zero timing advance and/or a first value for the timing advance. The first value for the timing

advance may be estimated by, e.g., the source base station 2802, the second base station 2803, and/or another device, such as a core network device described further below regarding FIG. 29.

[219] The second message and/or the third message may be exchanged directly, e.g., via a direct interface such as an Xn interface, between the source base station 2802 and the target base station 2803. Additionally or alternatively, one or more elements of the second message and/or one or more elements of the third message may be exchanged indirectly, e.g., via one or more core network entities.

[220] At step, 2840, the source base station 2802 may receive the third message. The source base station 2802 may send, to the wireless device 2801 and based on the third message, a fourth message, at step 2850. The fourth message may comprise, e.g., a handover command and random access information. The handover command may comprise a command for the wireless device 2801 to execute a handover towards a cell of the target base station 2803. The handover command may be based on one or more elements of the third message. The fourth message may comprise some or all of the information in the third message. The fourth message may be an RRC connection reconfiguration message. The fourth message may comprise, e.g., information associated with one or more cells served by a respective one or more base stations of a plurality of base stations that may comprise the target base station. Additionally or alternatively, the fourth message may comprise radio resource configuration information (e.g., RACH configuration, channel configuration information, etc.) for the wireless device 2801, and/or a mobility control information for the wireless device 2801. One or more elements of the fourth message may be based on an acknowledgement received by the source base station from the target base station for the handover request. The fourth message may comprise an indication indicating that a random access for a handover execution is performed with one of a two-step random access procedure and/or a four-step random access procedure. The wireless device 2801 may receive and process the fourth message using the procedures described below regarding FIG. 34.

[221] The wireless device 2801 may send, based on the random access information in the fourth message, a fifth message that may be part of a random access procedure with the target base station 2803, at step 2860. The wireless device 2801 may send a fifth message, e.g., comprising a random access preamble, to the target base station 2803, e.g., via a cell associated with the target base station 2803. The message comprising the

random access preamble may be part of a random access procedure that may be performed with, e.g., two messages (e.g., for two-step random access) or four messages (e.g., for four-step random access). The random access preamble may be transmitted in a first step of one of a two-step random access procedure and/or a four-step random access procedure. Timing advance information may be included in the fourth message. Timing advance information may comprise at least one of an indication of a zero timing advance and/or a first value for a timing advance. The first value of the timing advance may be estimated by the source base station and/or the target base station. The fifth message may comprise, e.g., one or more transport blocks that may comprise at least one of a handover complete message (e.g., an RRC connection reconfiguration complete message), uplink data, a buffer status report, and/or an identifier of the wireless device (e.g., C-RNTI). The fourth message may comprise, e.g., a preamble identifier. Radio resources for transmissions may be determined by the preamble identifier. The fourth message may comprise a random access channel configuration for a two-step random access procedure and/or radio resource configuration parameters for a two-step random access procedure. The random access preamble may be transmitted in a first step of one of a two-step random access procedure or a four-step random access procedure. The transmitting of the random access preamble message may be based on one or more elements of the random access information included in the third message and/or the fourth message from steps 2840 and/or 2850, respectively. The type of random access procedure may be, e.g., a two-step random access procedure or a four-step random access procedure described further herein. The type of random access procedure may be indicated by the random access information in the fourth message, including, e.g., in a handover command. The random access information in the fourth message may be the same as the random access information in the third message. Additionally or alternatively, the random access information in the fourth message may comprise additional information provided by the source base station 2802 and/or less than all of the random access information included in the third message.

[222] In a two-step random access procedure, a first random access message may be transmitted by the wireless device 2801 to the target base station 2803. The first random access message may comprise at least one of a random access preamble, a radio resource control message, and/or one or more uplink packets. A second random access message of a two-step random access procedure may be transmitted to the wireless device 2801 by the target base station 2803, e.g., if the target base station 2803 receives the first random

access message. The second random access message may comprise, e.g., an acknowledgement of a reception of the first random access message. The second random access message of the two-step random access procedure may further comprise a resource grant for uplink message transmission.

[223] In a four-step random access procedure, a first random access message may be transmitted by the wireless device 2801 to the target base station 2803, and the first random access message may comprise a random access preamble. A second random access message of a four-step random access procedure may be transmitted to the wireless device 2801 by the target base station 2803, e.g., if the target base station 2803 receives the first message. The second random access message may comprise a resource grant for uplink message transmission. A third random access message of the four-step random access procedure may be transmitted by the wireless device 2801 to the target base station 2803, at least based on the resource grant in the second random access message. The third random access message may comprise a radio resource control message and/or one or more uplink packets. A fourth random access message may be transmitted by the target base station 2803 to the wireless device 2801, and the fourth random access message may comprise an acknowledgement of a reception of the third random access message. The fourth random access message of the four-step random access procedure may further comprise a resource grant for uplink message transmission.

[224] After completing the random access procedure initiated by the wireless device 2801, the target base station 2803 may send a sixth message to network device. The network device may comprise a core network entity. The sixth message may be transmitted to the network device, e.g., to update downlink packet destination information such as a tunnel endpoint identifier and/or an IP address and/or another address. The sixth message may comprise a path switch request message and/or a downlink packet destination information for one or more bearers for the wireless device 2801. The network device may send a seventh message to the target base station 2803 that may be in response to the sixth message. The seventh message may comprise a path switch request acknowledge message. Additionally or alternatively, the seventh message may comprise an uplink packet destination information, such as a tunnel endpoint identifier and/or an IP address and/or another address, for one or more bearers for the wireless device 2801, and/or a list of bearers to be released.

[225] After completing a random access procedure initiated by the wireless device 2801, the target base station 2803 may notify the source base station 2802 that the handover has completed. The target base station 2803 may notify the source base station 2802, e.g., by sending an eighth message to the source base station 2802. The eighth message may comprise a UE context release message and/or an identifier of the wireless device 2801. The eighth message may be sent, e.g., via a direct interface between the target base station 2803 and the source base station 2802. Additionally or alternatively, one or more elements of the eighth message may be sent to the source base station 2802 indirectly, e.g., via one or more core network entities. In response to receiving the eighth message and/or the one or more elements of the eighth message, the source base station 2802 may release a wireless device context for the wireless device 2801. Any one or more of the above described messages may be exchanged among one or more communication nodes between one or more of the wireless device 2801, the source base station 2802, and/or the target base station 2803.

[226] FIG. 29 shows an example of a random access procedure for handover, e.g., using a core network device 2904. The core network device 2904 may be located at a Next Generation Core (NGC) network entity that may be configured to communicate, e.g., via an NG interface, with one or both of the source base station 2902 and the target base station 2903. One or more of a wireless device 2901, a source base station 2902 (e.g., an eNB, a gNB, etc.), and/or a target base station 2903 (e.g., an eNB, a gNB, etc.), and operations thereof, may correspond to the wireless device 2801, the source base station 2802, and/or the target base station 2803, respectively, described above regarding FIG. 28, descriptions of which are incorporated herein with respect to FIG. 29. The messages sent in steps 2810, 2830, 2840, 2850, and 2860 of FIG. 28 may correspond to messages sent in similarly numbered steps 2910, 2930, 2940, 2950, and 2960, respectively, of FIG. 29. The handover decision in step 2820 of FIG. 28 may also correspond to the handover decision in step 2920 of FIG. 29.

[227] The core network device 2904 may communicate with the source base station 2902 and the target base station 2903. The core network device 2904 may comprise one or more devices located at a core network entity, such as an NGC, one or more devices at an access and mobility management function (AMF) network entity, one or more devices at a mobility management entity (MME), or one or more devices at any other location. The core network device 2904 may determine an availability of base stations, including a determining whether a target base station, such as the target base station 2903, is

available. The core network device 2904 may communicate with the source base station 2902 and the target base station 2903 via an NG interface and/or via an S1 interface (e.g., for an MME), and the core network device 2904 may operate as an intermediary for communications between the source base station 2902 and the target base station 2903. Processing in the core network device 2904, and potential latency in communicating information to and from the core network device 2904, may not delay a handover when, e.g., some or all of such processes and communications may occur prior to a handover.

[228] At step 2910 the wireless device 2901 may send, to a source base station 2902, a first message comprising a measurement report for one or more cells, including, e.g., a cell for the target base station 2903. The first message in step 2910 may comprise some or all of the information in the first message in step 2810 described above. The wireless device may generate the measurement report using the procedures described below regarding FIG. 30.

[229] The source base station 2902 may receive the first message at step 2910. At step 2920, the source base station 2902 may make a handover decision. The handover decision may be based on the measurement report in the first message. The handover decision may also be based on a determination whether to use a core network device 2904 for a handover. As an example, if an Xn connection is established between the source base station 2902 and the target base station 2903, the source base station 2902 may determine to send a second message, e.g., comprising a handover request, to the target base station 2903 without involving the core network device 2904; and if an Xn connection is not established between the source base station 2902 and the target base station 2903, then the source base station 2902 may send a second message, e.g., comprising a handover required message, to the core network device 2904 at step 2925. The second message may be based on the measurement report. The second message (e.g., a handover request message and/or a handover required message) may further comprise one or more measurements results of a measurement report (e.g., that may be provided by the wireless device step 2810) and/or one or more of: timing advance information for transmission of uplink data, a random access preamble, and/or random access information. The second message in step 2925 may comprise some or all of the information in the second message in step 2830 described above. The source base station 2902 may perform the handover decision in step 2920, and receive and send the first and second messages in steps 2910 and 2925, respectively, using the procedures described below regarding FIG. 31.

[230] The core network device 2904 may receive the second message at step 2925. The core network device 2904 may process the second message, including, e.g., to determine whether the wireless device may require latency sensitive service. The core network device 2904 may determine whether the wireless device may require latency sensitive service based on, e.g., packet data unit session information of the wireless device. At step 2930, the core network device 2904 may send, to the target base station 2903, a third message comprising a handover request. The third message in step 2930 may comprise some or all of the information in the second message in step 2830 described above. The core network device 2904 may receive and process the second message in step 2925, and determine and send the third message in step 2930, using the procedures described below regarding FIG. 33.

[231] The target base station 2903 may receive the third message at step 2930. The target base station 2903 may determine whether the handover request is acceptable. The target base station 2903 may process a handover request in a direct handover from a source base station 2902, e.g., via an Xn interface, using one or more of the same procedures as the target base station 2903 uses to process a handover request from a core network device 2904, e.g., via an NG interface. The target base station 2903 may also determine characteristics that may be relevant for a handover, such as power, latency sensitive service type, cell size, and/or availability of one or more types of random access procedures. Based on one or more determinations, at step 2940, the target base station 2903 may send, to the core network device 2904, a fourth message comprising a handover request acknowledgement and random access information. The fourth message in step 2940 may comprise some or all of the information in the third message in step 2840 described above. The target base station 2903 may receive and process the third message in step 2930, and determine and send the fourth message in step 2940, using the procedures described below regarding FIG. 32.

[232] The core network device 2904 may receive the fourth message at step 2940. The core network device 2904 may process the fourth message to generate a fifth message comprising a handover request acknowledgement and random access information. At step 2945, the core network device 2904 may send the fourth message to the source base station 2902. The fifth message in step 2945 may comprise some or all of the information in the third message in step 2840 described above. The core network device 2904 may receive and process the fourth message in step 2940, and determine and send the fifth message in step 2945, using the procedures described below regarding FIG. 33.

[233] The source base station 2902 may receive the fifth message at step 2945. The source base station 2902 may process the fifth message to determine a sixth message, e.g., comprising a handover command and random access information. At step 2950, the source base station may send, to the wireless device 2901, the sixth message. The sixth message in step 2950 may comprise some or all of the information in the fourth message in step 2850 described above. The source base station 2902 may receive and process the fifth message in step 2945, and determine and send the sixth message in step 2950, using procedures described below regarding FIG. 31.

[234] The wireless device 2901 may receive, from the source base station 2902, the sixth message at step 2950. The sixth message may comprise a handover command and random access information. The handover command may comprise a command for a handover a cell of the source base station 2902 to a cell of the target base station 2903. At step 2960, the wireless device 2901 may obtain channel access by proceeding with a random access procedure with the target base station 2903. The wireless device 2901 may initiate the random access procedure by sending, to the target base station 2903, a seventh message comprising a random access preamble and data. The wireless device may transmit, to the target base station 2903, one or more transport blocks via radio resources of the cell of the target base station 2903, wherein the radio resources may be determined at least based on one or more elements of the sixth message. The transmitting, by the wireless device 2901, may further comprise transmitting a random access preamble overlapping in time with transmission of the one or more transport blocks. The sixth message may comprise, e.g., an indication for performing a two-step random access procedure, and/or a preamble identifier for a two-step random access procedure. The seventh message may comprise some or all of the information in step 2003 of the two-step random access procedure described above regarding FIG. 20. The wireless device 2901 may receive and process the sixth message in step 2950, and determine and send the seventh message in step 2960, using the procedures described below regarding FIG. 34.

[235] FIG. 30 shows an example of handover procedures 3000 for a wireless device. The procedures may start with step 3001 during which a wireless device, such as the wireless device 2801 and/or the wireless device 2901, measures target cell quality and serving cell quality. The wireless device may also measure cell quality of one or more neighboring cells that may become a target cell. The wireless device may make measurements to determine power of transmissions from one or more base stations in a respective one or

more neighboring cells. The wireless device may also measure the power of transmissions by a source base station, such as the source base station 2802 and/or the source base station 2902, that may be serving the wireless device. At step 3002, the wireless device may determine whether one or more measurement events have occurred. A measurement event may be an indication that a target cell quality may exceed a serving cell quality and/or may exceed a serving cell quality by an offset value. A measurement event may comprise, e.g., one or more of a determination that an RSRP and/or an RSRQ of a target cell (e.g., a cell of a target base station) is greater than a first threshold; a determination that an RSRP and/or an RSRQ of a source cell (e.g., a cell of a source base station) is less than a second threshold; a determination that an RSRP and/or an RSRQ of a target cell exceeds a an RSRP and/or RSRQ of a source cell and/or exceeds an RSRP and/or RSRQ of a source cell by an offset power value; and/or a determination that a time duration of maintaining a condition, such as one or more of the above conditions, is greater than or equal to a time threshold value. If the wireless device determines that one or more measurement events have not occurred, the wireless device may return to step 3001. If the wireless device determines that one or more measurement events have occurred, then the wireless device may send a measurement report to the source base station at step 3003, such as described above regarding step 2810 in FIG. 28 and/or step 2910 in FIG. 29. The wireless device may receive a handover command and RA information from a source base station at step 3004, such as described above regarding step 2850 in FIG. 28 and/or step 2950 in FIG. 29. The handover command and/or RA information may comprise an indication of a type of RA procedure that the wireless device is to perform for a handover to a target base station. The wireless device may proceed with a RA procedure for channel access with the target base station. The RA procedure may be based on the handover command and RA information received from the source base station. The process 3000 may end after step 3005, or the process 3000 may repeat after a time period or after an event that may trigger a measurement of target cell quality and/or serving cell quality, such as one or more indications of a transmission failure and/or one or more indications of a neighbor cell transmission.

[236] One or more additional steps (not shown) may also be performed by the wireless device, in between, before, or after, any of steps 3001-3005, e.g., to determine whether to initiate a handover, and/or to determine a type of RA procedure to use. Such additional steps may include power measurements, distance measurements, traffic measurements, moving speed of the wireless devices, determination of other cells available to the wireless

device, and any other network condition that may be used to determine a handover and/or a type of RA procedure.

[237] FIG. 31 shows an example of handover procedures 3100 for a source base station. The procedures may start with step 3101 during which a source base station, such as the source base station 2802 and/or the source base station 2902, receives a measurement report from a wireless device. Based on the measurement report, the source base station may determine, at step 3102, whether one or more handover triggering condition have been satisfied. The one or more handover triggering conditions may comprise some or all of the measurement events described above in step 3002 of FIG. 30. Additionally or alternatively, the one or more handover triggering conditions may comprise a determination that an RSRP and/or RSRQ of a target cell indicates better performance for a wireless device than an RSRP and/or RSRQ of other candidate target cells; a determination that a moving speed of a wireless device is slower than a threshold speed value; and/or a cell identifier of a target cell is, or is not, among one or more cells in a handover restriction. If the source base station determines that one or more handover triggering conditions have not occurred, the source base station may end the process 3100. If the source base station determines that one or more handover triggering conditions have occurred, then the source base station may proceed to step 3103.

[238] The source base station may determine, at step 3103, whether to proceed with handover procedures via direct communications (e.g., employing an Xn interface) with a target base station, or via indirect communications with a target base station, e.g., using a core network device such as 2904 as an intermediary. The source base station may base its determination of direct or indirect communications with the target base station on the type of connection it may have with the target base station. If the source base station and the target base station are capable of sufficiently timely direct communications with each other, such as via an Xn interface, then the source base station may determine to proceed with direct communications with the target base station, e.g., via steps 3104 and 3105, and/or via the process described above regarding FIG. 28. If the source base station and the target base station are not capable of sufficiently timely direct communications with each other, such as via an Xn interface (e.g., if these two base stations only communicate with each other via an X2 interface or if an X2 interface between these two base stations is not operating sufficiently to accommodate sufficiently timely communications), then the source base station may determine to proceed with indirect communications with the

target base station, e.g., via steps 3106 and 3107, and/or via the process described above regarding FIG. 29.

[239] At step 3104, a source base station may send a handover request message to a target base station, as described above regarding step 2830. At step 3105, the source base station may receive a handover request acknowledgement and RA information, as described above regarding step 2840. At step 3106, a source base station may send a handover required message to a core network device, such as core network device 2904, as described above regarding step 2925. At step 3107, the source base station may receive a handover required acknowledgement and RA information, as described above regarding step 2945. After step 3105 and/or after step 3107, the process may continue to step 3108. At step 3108, the source base station may process the handover request acknowledgement and/or RA information, and the source base station may send a handover command and RA information to the wireless device for handover to the target base station, as described above regarding step 2850. The process 3100 may end after step 3108.

[240] One or more of steps 3102-3103 may be omitted, or performed before or after other steps. Additional steps (not shown) may also be performed by the source base station, in between, before, or after, any of steps 3102-3103, e.g., to determine whether to initiate a handover of the wireless device, to determine whether to send one or more handover-related messages to a target base station and/or to a core network device, and/or to determine a type of RA procedure. Such additional steps may include power measurements, distance measurements, service type measurements (e.g., slice type, packet data unit session type, QoS flow type, bearer type, and/or QoS requirement), traffic measurements, moving speed of the wireless devices, determination of other cells available to the wireless device, and any other network condition that may be used to determine a handover and/or a type of RA procedure.

[241] FIG. 32 shows an example of handover procedures 3200 for a target base station. The procedures may start with step 3201 during which a target base station, such as the target base station 2803 and/or the target base station 2903, receives a handover request message for a wireless device. Based on the handover request message, the target base station may determine, at step 3202, whether the handover request is acceptable. The determination of whether the handover request is acceptable may be based on one or more of: whether radio resources are available for at least a default packet data unit session of the wireless device; whether a particular one or more service type are

supported at the target cell; whether an RSRP and/or an RSRQ satisfies a threshold; whether a moving speed of the wireless device is below a speed threshold; and/or whether a cause for the handover is reasonable, such as to provide emergency service or to reduce traffic load of a source cell (e.g., if an RSRP and/or RSRQ does not satisfy a threshold). If a determination is made that the handover request is not acceptable, then the process may continue to step 3203 and the target base station may send a handover failure message, after which the process 3200 may end. If a determination is made that the handover request is acceptable, then the process may continue to step 3204.

[242] At step 3204, the target base station may determine whether RSRP exceeds a power threshold. If RSRP exceeds a power threshold, the process may continue to step 3205, in which case the target base station may send a handover request acknowledgement message indicating a four-step random access procedure for handover. A four-step random access procedure may use less power per transmission than a two-step random access procedure, e.g., because a two-step random access procedure may transmit more information in each step relative to a four-step random access procedure. If RSRP does not exceed a power threshold, the process may continue to step 3206.

[243] At step 3206, the target base station may determine whether the wireless device requires latency sensitive service, such as for emergency or other time-sensitive messages. If the target base station determines that the wireless device does not require latency sensitive service, the target base station may determine, at step 3207, whether the size of the handover target cell is small, or below a threshold size (e.g., a time alignment may less (or not) affect communication between the target base station and the wireless device). If the target base station determines that the size of the target cell is below a threshold size, the target base station may determine, at step 3208, whether the wireless device supports a two-step RA procedure (e.g., based on UE capability information of the wireless device in the handover request message). If the target base station determines that the wireless device supports a two-step RA procedure, the target base station may determine, at step 3209, whether one or more random access resources for two-step RA are available at the target cell. If the target base station determines that each condition in steps 3204-3209 is satisfied, the target base station may send, at step 3210, a handover request acknowledgement message (e.g., to the source base station 2802 in step 2840 FIG. 28 and/or to the core network device 2904 in step 2940 FIG. 29) indicating a two-step RA procedure for the handover. If the target base station determines any one or more of the conditions in steps 32094-3209 are not satisfied, the target base station may send, at step

3205, a handover request acknowledgement (e.g., to the source base station 2802 in step 2840 FIG. 28 and/or to the core network device 2904 in step 2940 FIG. 29) indicating a four-step RA procedure for the handover. After sending a handover request acknowledgement message, in step 3205 or in step 3210, the target base station may proceed with a RA procedure (e.g., as in step 2860 in FIG. 28 and/or as in step 2960 in FIG. 29) with the wireless device for channel access, in step 3211 (e.g., by receiving a corresponding RA preamble from the wireless device). The process 3200 may end after step 3211.

[244] One or more of steps 3204-3209 may be omitted, or performed before or after any of the other steps 3204-3209. Additional steps (not shown) may also be performed by the target base station, in between, before, or after, any of steps 3204-3209, to determine whether to indicate, in a handover request acknowledgement, a four-step RA procedure or a two-step RA procedure. Such additional steps may include power measurements, distance measurements, traffic measurements, moving speed of the wireless devices, determination of other cells available to the wireless device, and any other network condition that may be used to determine a handover and/or a type of RA procedure.

[245] FIG. 33 shows an example of handover procedures 3300 for a core network device. The procedures may start with step 3301 during which a core network device, such as the core network device 2904 in FIG. 29, receives a handover required message from a source base station (e.g., a message in step 2925 in FIG. 29). At step 3302, the core network device may determine whether the wireless device requires latency sensitive service, such as for emergency or other time-sensitive messages. The core network device 2904 may determine whether the wireless device requires latency sensitive service based on, e.g., packet data unit session information of the wireless device. If latency services are not required, the process may continue to step 3304. If latency services are required by the wireless device, then at step 3303, the core network device may include a latency sensitive service indication in a handover request message, before continuing to step 3304. At step 3304, the core network device may send a handover request message to a target base station (e.g., as in step 2930 in FIG. 29). At step 3305, the core network device may receive a handover request acknowledgement and random access information from the target base station (e.g., as in step 2940 in FIG. 29). At step 3306, the core network device may send a handover required acknowledgement and random access information to the source base station (e.g., as in step 2945). The process 3300 may end after step 3306.

[246] One or more additional steps (not shown) may also be performed by the core network device, in between, before, or after, any of steps 3301-3305, e.g., to determine whether to send one or more handover messages, to determine what to include in one or more handover messages, and/or to determine a type of RA procedure to indicate in one or more handover messages. Such additional steps may include power measurements, distance measurements, traffic measurements, moving speed of the wireless devices, determination of other cells available to the wireless device, and any other network condition that may be used to determine a handover and/or a type of RA procedure.

[247] FIG. 34 shows an example of handover procedures 3400 for a wireless device. The procedures may start with step 3401 during which a wireless device, such as the wireless device 2801 and or the wireless device 2901, receives a handover command message from a source base station (e.g., as in step 2850 in FIG. 28 and/or as in step 2950 in FIG. 29). The handover command message may comprise random access information. At step 3402, the wireless device may determine, based on the random access information, whether the handover command message indicates a two-step random access procedure. If the wireless device determines that a two-step random access procedure is indicated, the wireless device, at step 3404, may send to a target base station a random access preamble for a two-step RA procedure. If the wireless device determines that a two-step random access procedure is not indicated in the handover command message, then the wireless device, at step 3403, may send to the target base station a random access preamble for a four-step RA procedure. After sending a random access preamble, the wireless device may continue with the particular random access procedure (e.g., a two-step RA procedure or a four-step RA procedure) at step 3405 (e.g., as in step 2860 in FIG. 28 and/or as in step 2960 in FIG. 29). The process 3400 may end after step 3405.

[248] One or more additional steps (not shown) may also be performed by the wireless device, in between, before, or after, any of steps 3401-3405, e.g., to determine whether to proceed with a handover, to determine one or more RA transmissions, and/or to determine a type of RA procedure to use. Such additional steps may include power measurements, distance measurements, traffic measurements, moving speed of the wireless devices, determination of other cells available to the wireless device, and any other network condition that may be used to determine a handover and/or a type of RA procedure.

[249] A wireless device may perform a method for determining a type of random access procedure to use for a handover from a source base station to a target base station. The wireless device may receive, from one or more cells, a plurality of messages comprising one or more of an indication of a power associated with a cell, an indication of a quality associated with a cell, and/or an indication of a cell priority. The wireless device may determine, based on the plurality of messages, a measurement report. The wireless device may transmit, to a first base station, a first message comprising a measurement report based on one or more second cells. The wireless device may receive, from the first base station, a second message comprising a command for a handover from the first cell to a second cell of the one or more second cells. The first cell may be a source cell for the wireless device, and the second cell may be a target cell. The second message may comprise one or more parameters indicating a type of a random access procedure for the handover. Additionally or alternatively, the second message may comprise timing advance information, e.g., for transmission of one or more uplink data and/or a random access preamble. The timing advance information may comprise one or more of an indication of a zero timing advance, or a value for a timing advance. The value for the timing advance may be estimated by the first base station and/or the second base station. One or more elements of the second message may be based on an acknowledgement received by the first base station, from the second base station, for the handover request. For a two-step random access procedure, the second message may comprise one or more of a preamble identifier for the RA procedure, random access channel configuration information for the RA procedure, random access resource information for the RA procedure, or radio resource configuration parameters. The wireless device may determine, based on the preamble identifier, radio resources to use for the RA procedure. For a four-step random access procedure, the second message may comprise a root sequence that the wireless may use to generate a random access preamble that the wireless device may transmit in a first step of the four-step RA procedure. The type of the random access procedure may comprise a two-step random access procedure or a four-step random access procedure. The wireless device may transmit, to the second base station, a random access preamble employing the type of random access procedure indicated in the second message. The wireless device may transmit, to the second base station, one or more transport blocks. The one or more transport blocks may comprise one or more of a handover complete message, uplink data, a buffer status report, or an identifier of the wireless device. The wireless device may transmit, to the second base station, a random access preamble overlapping in time with the one or more transport

blocks. The wireless device may transmit, in a first step of a four-step random access procedure, a second random access preamble. A wireless device may perform any combination of one or more of the above steps. A base station, or any other device, may perform any combination of a step, or a complementary step, of one or more of the above steps.

[250] A first base station may perform a method for indicating a type of random access procedure in a handover from the first base station (e.g., a source base station) to a second base station (e.g., a target base station). The first base station may receive, from a wireless device, a first message comprising a measurement report based on one or more second cells. The first base station may be associated with a first cell. The first base station may determine, based on the measurement report, to handover the wireless device from the first cell to a second cell of the one or more second cells. The first cell may be a source cell for the wireless device, and the second cell may be a target cell. The first base station may transmit, to a third device, a second message comprising an indication for the handover. The third device may comprise the second base station that may be associated with the second cell. Additionally or alternatively, the third device may comprise a core network device. The third device may determine the second cell from a plurality of cells. The second message may comprise a handover request and/or an indication that a handover is requested. The first base station may receive, from the third device, a third message indicating a type of a random access procedure for the handover. The type of the random access procedure may comprise a two-step random access procedure or a four-step random access procedure. The first base station may transmit, to the wireless device, a fourth message. The fourth message may comprise one or more parameters indicating the type of the random access procedure for the handover and/or the fourth message may comprise a command to proceed with the handover. The fourth message may comprise timing advance information, e.g., for transmission of one or more uplink data or a random access preamble. The timing advance information may comprise one or more of an indication of a zero timing advance, or a value for a timing advance. The value for the timing advance may be estimated by the first base station and/or the third device. For a two-step random access procedure, the fourth message may comprise a preamble identifier for the RA procedure. The third device may transmit, to a second base station and based on the second message, a fifth message comprising a handover request. The third device may receive, from the second base station, a sixth message indicating the type of the random access procedure for the handover and comprising an

acknowledgement of the handover request. One or more base stations (e.g., a source base station, a target base station, etc.) may perform any combination of one or more of the above steps. A wireless device, a core network device, or any other device, may perform any combination of a step, or a complementary step, of one or more of the above steps.

[251] A network device may perform a method for indicating a type of random access procedure in a handover from a first base station (e.g., a source base station 2902) to a second base station (e.g., a target base station 2903). The network device may comprise a core network device (e.g., core network device 2904). Additionally or alternatively, the network device may comprise the second base station. The network device may receive, from a first base station, a first message comprising an indication for a handover of a wireless device from a first cell associated with the first base station to a second cell of one or more second cells. The second base station may be associated with the second cell. The first cell may be a source cell for the wireless device, and the second cell may be a target cell. The network device may determine the second cell from a plurality of cells. The network device may determine, based on the first message, to proceed with the handover. The network device may transmit, to the first base station a second message. The second message may comprise one or more of an acknowledgement for the handover, a handover request, an indication that a handover is required, or an indication of a type of a random access procedure for the handover. The type of the random access procedure may comprise a two-step random access procedure or a four-step random access procedure. The network device may transmit, to a second base station and based on the first message, a third message comprising a handover request. The network device may receive, from the second base station, a fourth message. The fourth message may indicate the type of the random access procedure for the handover. The fourth message may comprise an acknowledgement of the handover request. One or more network devices may perform any combination of one or more of the above steps. A wireless device, a base station, or any other device, may perform any combination of a step, or a complementary step, of one or more of the above steps.

[252] One or more of the messages described herein may be exchanged among one or more devices at a communication node in a network. One or more of the processes described herein may be performed in one or more devices in a network. For example, if an interface between a target base station (e.g., the target base station 2903) and a source base station (e.g., the source base station 2902) cannot accommodate sufficiently timely communications, such as if the interface between these base stations is not an Xn

interface of if an X2 interface between them is not operative, a core network device (e.g., the core network device 2904) may be used to perform handover processes and send and receive handover related messages described herein with respect to a target base station and/or a source base station. As another example, if a wireless device (e.g., the wireless device 2801 and/or the wireless device 2901) is a fast moving device, a source base station (e.g., the source base station 2801 and/or the source base station 2902) may be used to perform handover processes and send and receive handover related messages described herein with respect to a target base station and/or a core network device. As another example, if a wireless device (e.g., the wireless device 2801 and/or the wireless device 2901) has latency sensitive information, such as emergency information, and if a source base station cannot accommodate the wireless device transmissions and cannot perform a handover decision in a sufficiently timely manner, the wireless device may perform handover processes and send and receive handover related messages described herein with respect to a source base station, a target base station, and/or a core network device.

[253] A wireless device within a network may utilize power demands for transmissions and a power threshold to determine a type of random access (RA) procedure with which to communicate with a base station of the network. The type of RA procedure may be indicated by one or more indicators in one or more messages sent from the base station. The one or more indicators may correspond with transmission power levels associated with random access procedure parameters.

[254] FIG. 35 shows an example of a network 3500 comprising a base station 3502, a first wireless device 3504, and a second wireless device 3506. The network 3500 may comprise any number and/or type of devices, such as, for example, wireless devices, mobile devices, handsets, tablets, laptops, Internet-of-Things (IoT) devices, hotspots, cellular repeaters, computing devices, and/or, more generally, user equipment (UE). Although one or more of the above types of devices may be referenced herein (e.g., UE, wireless device, etc.), it should be understood that any device herein may comprise one or more of the above types of devices or similar devices.

[255] The first wireless device 3504 may be a first distance D1 from the base station 3502. The second wireless device 3506 may be a second distance D2 from the base station 3502. The second wireless device 3506 may be farther from the base station 3502 than the first wireless device 3504. The second wireless device 3506 may be at or near an edge of a

cell 3508, which may be a maximum range at which the wireless device 3506 may be able to communicate, via the cell 3508, with the base station 3502. As the distance between a wireless device (e.g., the first wireless device 3504 or the second wireless device 3506) and the base station 3502 increases, the power required by a wireless device to transmit messages, via the cell 3508, to the base station 3502 may increase. Larger distances may require additional power due to path loss. Wireless devices (e.g., the first wireless device 3504 and/or the second wireless device 3506) may have a maximum transmission power that may not be exceeded for transmissions, via a cell (e.g., the cell 3508), to a base station (e.g., the base station 3502). The maximum transmission power may not be exceeded by the wireless device when transmitting, e.g., a preamble and data at the same time and/or within a same transmission, such as during a two-step random access procedure.

[256] The base station 3502 may initially send configuration parameters to one or more wireless devices 3504, 3506. The configuration parameters may comprise, e.g., one or more target power levels requested by the base station 3502 to ensure preamble and/or data transmissions are successfully received and decoded by the base station 3502 (e.g., preamble_received_target_power for preamble transmissions and/or $P_{\text{O_PUSCH},c}(j)$ for PUSCH data transmissions), a reference signal that allows each of the one or more wireless devices 3504, 3506 to determine its estimated path loss (e.g., a reduction of power of a transmission as it travels through space), a maximum power level that the one or more wireless devices 3504, 3506 may not exceed during a transmission, and/or offset data. The one or more wireless devices 3504, 3506 may utilize one or more of these configuration parameters to determine, e.g., one or more of a type of random access procedure, a power level for a transmission, a power priority for a transmission, a power adjustment, and/or whether to drop a configured transmission.

[257] Power control mechanisms may be used by a wireless device and/or a base station, e.g., when the wireless device transmission power nears a maximum threshold. The following processes may be implemented in technologies such as LTE, 5G or New Radio, and/or other technologies, each of which may have its own specific parameters. Physical layer power control mechanisms may be enhanced, such as when layer 2 parameters are taken into account. Downlink power control may determine, e.g., an Energy Per Resource Element (EPRE). The term resource element energy may correspond to the energy prior to CP insertion. The term resource element energy may correspond to an average energy

taken over all constellation points for an applied modulation scheme. Uplink power control may determine e.g., the average power over a SC-FDMA symbol in which the physical channel may be transmitted. Uplink power control may control the transmit power of different uplink physical channels.

[258] If a UE (e.g., one of the one or more wireless devices 3504, 3506) is configured with an LAA SCell for uplink transmissions, the UE may apply the procedures described for a Physical Uplink Shared Channel (PUSCH) transmission and/or a Sounding Reference Signal (SRS) transmission, e.g., based on a frame structure type 1 for the LAA SCell. For PUSCH data, the transmit power, $\hat{P}_{\mathrm{PUSCH},c}(i)$, may be first scaled by the ratio of the number of antennas ports with a non-zero PUSCH transmission to the number of configured antenna ports for the transmission scheme. The resulting scaled power may be split equally across the antenna ports on which the non-zero PUSCH is transmitted. For Physical Uplink Control Channel (PUCCH) and/or SRS, the transmit power, $\hat{P}_{\mathrm{PUCCH}}(i)$ and/or $\hat{P}_{\mathrm{SRS},c}(i)$, may be split equally across the configured antenna ports. $\hat{P}_{\mathrm{SRS},c}(i)$ may correspond to a linear value of $P_{\mathrm{SRS},c}(i)$. A cell wide overload indicator and a High Interference Indicator to control UL interference may be parameters used, e.g., in LTE technology, for making power determinations.

[259] For a serving cell with frame structure type 1, a UE may not be configured with *UplinkPowerControlDedicated-v12x0*. If the UE is configured with a secondary cell group (SCG), the UE may apply the procedures described for both a master cell group (MCG) and the SCG. When the procedures are applied for MCG, the terms secondary cell(s) and/or serving cell(s) may refer to secondary cell(s) and/or serving cell(s) belonging to the MCG respectively. When the procedures are applied for a SCG, the terms secondary cell(s) and/or serving cell(s) may refer to secondary cell(s) (not including PSCell) and/or serving cell(s) belonging to the SCG, respectively. The term primary cell may refer to the PSCell of the SCG.

[260] If the UE is configured with a PUCCH-SCell, the UE may apply the procedures described for both the primary PUCCH group and the secondary PUCCH group. When the procedures are applied for the primary PUCCH group, the terms secondary cell(s) and/or serving cell(s) may refer to secondary cell(s) and/or serving cell(s) belonging to the primary PUCCH group, respectively. When the procedures are applied for the secondary PUCCH group, the terms secondary cell(s) and/or serving cell(s) may refer to

secondary cell(s) and/or serving cell(s) belonging to the secondary PUCCH group, respectively.

[261] The setting of the UE Transmit power for a PUSCH transmission may be determined as follows. If the UE transmits a PUSCH transmission without a simultaneous or overlapping Physical Uplink Control Channel (PUCCH) transmission, for the serving cell c and with a PRACH transmission ($\hat{P}_{\text{PRACH}}$=0 if no PRACH transmission), then the UE transmit power $P_{\text{PUSCH},c}(i)$ for a PUSCH transmission in subframe i for the serving cell c may be determined by:

$$P_{\text{PUSCH},c}(i) = \min\begin{Bmatrix} 10\log_{10}\left(\hat{P}_{\text{CMAX},c}(i) - \hat{P}_{\text{PRACH}}(i)\right), \\ 10\log_{10}(M_{\text{PUSCH},c}(i)) + P_{\text{O_PUSCH},c}(j) + \alpha_c(j)\cdot PL_c + \Delta_{\text{TF},c}(i) + f_c(i) \end{Bmatrix} \text{ [dBm]}$$

wherein $\hat{P}_{\text{CMAX},c}(i)$ may correspond to the UE maximum transmit power, $\hat{P}_{\text{PRACH}}(i)$ may correspond to the preamble transmission power, $P_{\text{O_PUSCH},c}(j)$ may correspond to a target power required by the base station for decoding a message sent by a UE, PL_c may correspond to an estimated path loss based on a distance that the UE is from a base station, $M_{\text{PUSCH},c}(i)$ may correspond to the bandwidth of the PUSCH resource assignment (e.g., expressed in number of resource blocks valid for subframe i and serving cell c), and $\Delta_{\text{TF},c}(i) + f_c(i)$ may correspond to offset data. The path loss may increase exponentially based on the distance that the UE is from a corresponding base station.

[262] If the UE transmits a PUSCH transmission simultaneously with or at least partially overlapping with a PUCCH transmission and a PRACH transmission, for the serving cell c, then the UE transmit power $P_{\text{PUSCH},c}(i)$ for the PUSCH transmission in subframe i for the serving cell c may be determined by:

$$P_{\text{PUSCH},c}(i) = \min\begin{Bmatrix} 10\log_{10}\left(\hat{P}_{\text{CMAX},c}(i) - \hat{P}_{\text{PUCCH}}(i) - \hat{P}_{\text{PRACH}}(i)\right), \\ 10\log_{10}(M_{\text{PUSCH},c}(i)) + P_{\text{O_PUSCH},c}(j) + \alpha_c(j)\cdot PL_c + \Delta_{\text{TF},c}(i) + f_c(i) \end{Bmatrix} \text{ [dBm]}$$

where $\hat{P}_{\text{PUCCH}}(i)$ may correspond to a linear value of $P_{\text{PUCCH}}(i)$.

[263] If the UE is not transmitting a PUSCH transmission for the serving cell c, then for the accumulation of a transmit power control (TPC) command received with DCI format 3 or

format 3A for PUSCH, the UE may determine a virtual transmit power $P_{\text{PUSCH},c}(i)$ for the PUSCH transmission in subframe i for the serving cell c according to:

$$P_{\text{PUSCH}c}(i) = \min\left\{P_{\text{CMAX}c}(i),\ P_{\text{O_PUSCH}c}(1) + \alpha_c(1)\cdot PL_c + f_c(i)\right\} \quad \text{[dBm]}$$

[264] One or more transmission powers may be prioritized, e.g., when simultaneous or at least partially overlapping transmissions may otherwise cause a UE to reach or exceed a maximum allowable transmission power. For a two-step random access procedure, a PRACH transmission power may be assigned a higher priority than a PUSCH transmission power. A PRACH transmission power and a PUCCH transmission power may both have a higher priority than a PUSCH transmission power. A UE may not have enough power for overlapping transmissions (e.g., simultaneous or at least partially overlapping transmissions) of a PRACH transmission, a PUCCH transmission, and a PUSCH transmission. The UE may change a type of RA procedure used, adjust power (e.g., scale, decrease, and/or increase), re-transmit, and/or drop one or more transmissions to satisfy a transmission power threshold and/or to conserve power.

[265] If a UE does not have enough power to transmit both a PUSCH transmission and a PRACH transmission, e.g., in an overlapping transmission during a first step of a two-step RA procedure (e.g., $\hat{P}_{\text{CMAX},c}(i) \le \hat{P}_{\text{PUSCH}}(i) + \hat{P}_{\text{PRACH}}(i)$), the UE may fall back to a four-step random access procedure and transmit or retransmit the PRACH transmission (e.g., a random access preamble and/or a UE identifier) prior to a transmission or retransmission of the PUSCH transmission. Additionally or alternatively, the UE may determine resources for a four-step RA procedure (e.g., preamble, random access resource, subframe, etc.) to initiate a four-step RA procedure instead of a two-step RA procedure, e.g., based on a power determination. A bandwidth reduced low complexity or coverage enhanced (BL/CE) UE may set $\hat{P}_{\text{PRACH}}(i) = \hat{P}_{\text{CMAX},c}(i)$, and if so, the UE may not start the two-step RA procedure.

[266] The UE may perform one or more measurements to determine whether to use a two-step RA procedure or a 4-step RA procedure. The UE may measure, e.g., link signal strength and/or a quality of one or more cells, and use such measurements (that may be in addition to other parameters, e.g., logical channel, etc.) to make a decision on whether to use a two-step RA procedure or a four-step RA procedure. The base station may transmit one or more parameters, such as link quality and/or a power parameter, for use by the

wireless device in determining a type of RA procedure to use. The wireless device may use the parameters in making a decision on whether start a two-step RA procedure or a four-step RA procedure.

[267] FIG. 36 shows an example of a process 3600 that may be performed by one or more of the wireless devices (e.g., the second wireless device 3506) for determining whether to initiate a two-step or four-step random access procedure. While examples herein reference the second wireless device 3506, the methods, systems, and apparatuses disclosed herein may be applicable to all devices capable of communication with a base station. Additionally or alternatively, some or all of the steps in the process 3600 may be performed by a base station (e.g., the base station 3502) and/or one or more other devices (e.g., at a node in a 5G core network). The process 3600 may begin, at step 3602, with configuration of devices (e.g., the base station 3502, the first wireless device 3504, and/or the second wireless device 3506). At step 3604, the second wireless device 3506 may receive first parameters transmitted from the base station 3502 (3604). At step 3606, the second wireless device 3506 may perform one or more measurements for one or more cells to obtain second parameters, such as link signal strength and/or quality of the cell 3508 and/or of one or more neighbouring cells. After receiving the first and/or second parameters, the second wireless device 3506 may determine to perform a two-step random access procedure and, at step 3608, the second wireless device 3506 may initiate the two-step random access procedure.

[268] Based on the parameters received at step 3604 and/or the measurements determined at step 3606, the second wireless device 3506 may select resources for the two-step random access procedure at step 3610. The second wireless device 3506 may determine, at step 3612, whether current parameters (e.g., link signal strength, quality of one or more cells, transmission power for selected resources, etc.) are sufficient for sending messages via the two-step random access procedure. For example, the second wireless device 3506 may compare a transmission power for selected resources (e.g., preamble transmission power $\hat{P}_{\mathrm{PRACH}}(i)$, data transmission power, $P_{\mathrm{PUSCH},c}(i)$ and/or $\hat{P}_{\mathrm{PUCCH}}(i)$, etc.) to a maximum transmission power of the second wireless device 3506 in the cell 3508 (e.g., $P_{\mathrm{CMAX},c}$). If the current parameters are sufficient for sending messages via the two-step random access procedure (e.g., 3612: YES), the process may proceed to step 3618. If the current parameters are not sufficient for sending messages via the two-step random access procedure (e.g., 3612: NO), then the second wireless device 3506 may initiate a

four-step random access procedure at step 3614. The second wireless device 3506 may select resources for the four-step random access procedure, at step 3616. At step 3618, the second wireless device 3506 may transmit one or more messages based on the selected resources (e.g., two-step RA resource or four-step RA resources) and parameters of the second wireless device 3506 (e.g., link signal strength, quality of one or more cells, transmission power for selected resources, etc.). Thereafter, the process 3600 may end. Process 3600 may be repeated, looped, combined, paused, or performed in parallel with other processes.

[269] If $\hat{P}_{\text{CMAX},c}(i) \leq \hat{P}_{\text{PRACH}}(i)$, then PUSCH (e.g. at least one data transport block) may be dropped and may not be transmitted. If $\hat{P}_{\text{CMAX},c}(i) \leq \hat{P}_{\text{PUCCH}}(i) + \hat{P}_{\text{PRACH}}(i)$, then PUSCH may be dropped and may not be transmitted.

[270] FIG. 37 shows an example of a process 3700 that may be performed by one or more of the wireless devices (e.g., the second wireless device 3506) for determining whether to drop data transmissions, e.g., in order to successfully perform a two-step random access procedure. While examples herein reference the second wireless device 3506, the methods, systems, and apparatuses disclosed herein may be applicable to all devices capable of communication with a base station. Additionally or alternatively, some or all of the steps in the process 3700 may be performed by a base station (e.g., the base station 3502) and/or one or more other devices (e.g., at a node in a 5G core network). The process 3700 may begin, at step 3702, with configuration of devices (e.g., the base station 3502, the first wireless device 3504, and/or the second wireless device 3506). The second wireless device 3506 may receive first parameters transmitted from the base station 3502 (3704). The second wireless device AA06 may measure second parameters such as, for example, link signal strength and/or quality of the cell 3508 (3706). After receiving the first and/or second parameters, the second wireless device 3506 may initiate a two-step random access procedure (3708).

[271] Based on the first and/or second parameters, the second wireless device 3506 may select resources for the two-step random access procedure (3710). The second wireless device 3506 may determine whether the current (e.g., first and/or second) parameters (e.g., link signal strength, quality of cell, transmission power for selected resources, etc.) are sufficient for sending messages via the two-step random access procedure (3712). If the current parameters are sufficient for sending messages via the two-step random access

procedure (3712: YES), the process 3700 may proceeds to step 3722. If the current parameters are not sufficient for sending messages via the two-step random access procedure (3712: NO), then the second wireless device 3506 may determine whether a PUCCH transmission is scheduled (3714). At step 3714, if it is determined that there are no PUCCH transmissions scheduled (3714: NO), then the second wireless device 3506 may drop a configured PUSCH transmission, at step 3716, and the process 3700 may return to step 3712.

[272] If there is a PUCCH transmission scheduled (3714: YES), then, at step 3718, the second wireless device 3506 may determine whether a PUSCH transmission is scheduled for a transmission overlapping with the PUCCH transmission. If there is a PUSCH transmission scheduled (3718: YES), then the process 3700 may return to step 3716. If there are no PUSCH transmissions scheduled (3718: NO), then the second wireless device 3506 may drop the configured PUCCH transmission (3720), and the process 3700 may return to step 3712. At step 3722, the second wireless device 3506 may transmit, via the two-step random access procedure, one or more messages based on the selected resources and first and/or second parameters. Thereafter, the process 3700 may end. Process 3700 may be repeated, looped, combined, paused, or performed in parallel with other processes.

[273] If the preamble and data transmitted by a UE are not successfully decoded by the base station, the UE may ramp up a preamble power and/or a data power. The UE may retransmit the preamble and/or the data (e.g., with the same HARQ RV or different HARQ RV depending on UE implementation) to the base station. The base station may transmit, to the wireless device (e.g., via a broadcast such as a SIB message, and/or via dedicated RRC signalling), a first ramp up power for the preamble and a second ramp up power for the data. The UE may employ the ramp up power parameters to calculate one or more re-transmission powers.

[274] FIG. 38 shows an example of a process 3800 that may be performed by one or more of the wireless devices (e.g., the second wireless device 3506) for determining whether to adjust transmission power for preamble and/or data transmissions, e.g., in order to successfully perform a two-step random access procedure. While examples herein reference the second wireless device 3506, the methods, systems, and apparatuses disclosed herein may be applicable to all devices capable of communication with a base station. Additionally or alternatively, some or all of the steps in the process 3800 may be

performed by a base station (e.g., the base station 3502) and/or one or more other devices (e.g., at a node in a 5G core network). The process 3800 may begin with configuration of devices (e.g., the base station 3502, the first wireless device 3504, and/or the second wireless device 3506) (3802). The second wireless device 3506 may receive first parameters transmitted from the base station 3502 (3804). The received first parameters may comprise a first ramp-up power value associated with a preamble transmission power and a second ramp-up power value associated with a data transmission power. The second wireless device 3506 may measure second parameters such as, for example, link signal strength and/or quality of the cell 3508 (3806). After receiving the first and/or second parameters, the second wireless device 3506 may initiate a two-step random access procedure (3808).

[275] Based on the first and/or parameters, the second wireless device 3506 may select resources for the two-step random access procedure (3810). At step 3812, the second wireless device 3506 may transmit, via the two-step random access procedure, one or more messages based on the selected resources and first and/or second parameters. At step 3814, the second wireless device 3506 may wait a threshold amount of time for a response to the one or more transmitted messages. If the second wireless device 3506 receives a response to the one or more transmitted messages within the threshold amount of time (3814: YES), the process 3800 may end. At step 3816, if the second wireless device 3506 does not receive a response to the one or more transmitted messages within the threshold amount of time (3814: NO), or if the second wireless device 3506 receives one or more messages indicating a failure of the base station receiving and/or decoding the one or more transmitted messages, the second wireless device may adjust (e.g., scale, increase, etc.), based on the first ramp-up power value, the transmission power for the preamble transmission, and/or adjust, based on the second ramp-up power value, the transmission power for the data transmission. The process 3800 may return to step 3812, and the second wireless device 3506 may retransmit the one or more messages using an adjusted transmission power determined from step 3816. Steps 3812-3816 may be repeated one or more times, and/or the process may end after a threshold number of times step 3814 is performed. The process 3800 may be repeated, looped, combined, paused or performed in parallel with other processes.

[276] The UE may fall back to a four-step random access procedure if a total calculated power of at least the preamble and/or data exceeds a predetermined value (e.g. a maximum allowable transmission power of the UE). If the preamble power and/or a data power in a

re-transmission exceeds a predetermine value (e.g., a maximum allowable transmission power of the UE), the UE may adjust (e.g., scale, decrease, etc.) the data transmission power such that the total transmission power of the UE may be below the predetermined value. The UE may fall back to a four-step RA procedure, e.g., if a calculated data power is below a threshold value (e.g. a minimum transmission power level indicated by the base station).

[277] FIG. 39 shows an example of a process 3900 that may be performed by one or more of the wireless devices (e.g., the second wireless device 3506) for recalculating transmission power for preamble and/or data transmissions, adjusting transmission power for data transmissions, and/or determining whether to perform a four-step random access procedure based on the transmission power for the data transmissions. While examples herein reference the second wireless device 3506, the methods, systems, and apparatuses disclosed herein may be applicable to all devices capable of communication with a base station. Additionally or alternatively, some or all of the steps in the process 3900 may be performed by a base station (e.g., the base station 3502) and/or one or more other devices (e.g., at a node in a 5G core network). At step 3902, the process 3900 may begin with configuration of devices (e.g., the base station 3502, the first wireless device 3504, and/or the second wireless device 3506). The second wireless device 3506 may receive first parameters transmitted from the base station 3502 (3904). The second wireless device 3506 may measure second parameters, such as, for example, link signal strength and/or quality of the cell (3906). After receiving the first and/or second parameters, the second wireless device 3506 may initiate a two-step random access procedure (3908).

[278] Based on the parameters received at 3904, the second wireless device 3506 may select resources for the two-step random access procedure (3910). The second wireless device 3506 may transmit, via the two-step random access procedure, one or more messages based on the selected resources and first and/or second parameters (3912). The second wireless device 3506 may wait a threshold amount of time for a response to the one or more transmitted messages from a base station. If the second wireless device 3506 receives a response to the one or more transmitted messages within the threshold amount of time (3914: YES), the process 3900 may cease.

[279] At step 3916, if the second wireless device 3506 does not receive a response to the one or more transmitted messages within the threshold amount of time (3914: NO), or if the second wireless device 3506 receives one or more messages indicating a failure of the

base station receiving and/or decoding the one or more transmitted messages, the second wireless device may recalculate total transmission power for the second wireless device 3506. The total transmission power may comprise a first power for the preamble transmission and a second power for the data transmission. At step 3918, the second wireless device 3506 may determine whether the recalculated total transmission power exceeds a first threshold power value (e.g., $P_{CMAX,c}(i)$). If the recalculated total transmission power does not exceed the first threshold power value (3918: NO), the process 3900 may return to step 3912. If the recalculated total transmission power exceeds the first threshold power value (3918: YES), then, at step 3920, the second wireless device 3506 may adjust (e.g., scale, decrease, etc.) the second power for the data transmission. At step 3922, the second wireless device 3506 may determine whether the scaled second power is below a second threshold value (e.g., a minimum power for a successful transmission).

[280] If the scaled second power is not below the second threshold value (3922: NO), then the process 3900 may return to step 3912. If the scaled second power is below the second threshold value (3922: YES), then, at step 3924, the second wireless device may initiate a four-step random access procedure. At step 3926, the second wireless device 3506 may select resources for the four-step random access procedure. Thereafter, at step 3928, the second wireless device 3506 may transmit, via the four-step random access procedure, one or more messages based on the selected resources and first and/or second parameters. After step 3928, the process 3900 may end. Process 3900 may be repeated, looped, combined, paused, or performed in parallel with other processes.

[281] The base station 3502 may communicate with the wireless devices 3504, 3506. For example, with reference to FIG. 20, the base station 3502 may send parameters to one or more of the wireless devices 3504, 3506. The parameters may include one or more parameters for a two-step random access procedure and one or more parameters for a four-step random access procedure. The base station 3502 may receive, from one of the one or more wireless devices 3504, 3506, a message indicating one of the two-step random access procedure or the four-step random access procedure. Based on the message, the base station 3502 may determine that further communications with that particular wireless device may continue or default to the random access procedure indicated in the message. The base station may communicate with other base stations to

provide such information as a wireless device preferences such as, for example, during a handover procedure.

[282] Various equations are set forth below for determining the parameters discussed above in a variety of examples. For example, $\hat{P}_{\text{PRACH}}(i)$ may correspond to a linear value of a preamble transmission power, $P_{\text{PRACH}}(i)$. For a BL/CE UE, a number of PRACH repetitions for a preamble transmission attempt may be indicated by higher layers, e.g., as part of the request. For a non-BL/CE UE, or for a BL/CE UE with the PRACH coverage enhancement level 0/1/2, a preamble transmission power P_{PRACH} may be determined by:

$$P_{\text{PRACH}}(i) = \min\{ P_{\text{CMAX},c}(i),\ \text{PREAMBLE_RECEIVED_TARGET_POWER} + PL_c \}\ \text{[dBm]},$$

where $P_{\text{CMAX},c}(i)$ may correspond to a configured UE transmit power for subframe i of serving cell c, PL_c may correspond to a downlink path loss estimate that may be calculated (e.g., based on a distance the UE is from a base station) by the UE for serving cell c, and PREAMBLE_RECEIVED_TARGET_POWER may correspond to a target preamble received power that may be indicated by higher layers (e.g., via broadcast system information) as part of the request. For a BL/CE UE, P_{PRACH} may be set to $P_{\text{CMAX},c}(i)$ for the highest PRACH coverage enhancement level 3. The downlink path loss may increase exponentially based on the distance of the wireless device from a corresponding base station.

[283] PREAMBLE_RECEIVED_TARGET_POWER may be determined by:

preambleInitialReceivedTargetPower + DELTA_PREAMBLE +
(PREAMBLE_TRANSMISSION_COUNTER – 1) * powerRampingStep;

[284] If the UE is a BL/CE UE, then the PREAMBLE_RECEIVED_TARGET_POWER may be determined by:

PREAMBLE_RECEIVED_TARGET_POWER - 10 *
log10(numRepetitionPerPreambleAttempt)

[285] If the UE is an narrowband Internet-of-Things (NB-IoT) device in enhanced coverage level 0, the PREAMBLE_RECEIVED_TARGET_POWER may be determined by:

PREAMBLE_RECEIVED_TARGET_POWER - 10 *
log10(numRepetitionPerPreambleAttempt)

For other enhanced coverage levels (e.g., not enhanced coverage level 0), the PREAMBLE_RECEIVED_TARGET_POWER for an NB-IoT UE may be determined based on the maximum allowable UE transmission power.

[286] If the UE is an NB-IoT UE or a BL/CE UE, the UE may select a preamble from a preamble group and instruct the physical layer to transmit the selected preamble according to a number of repetitions for preamble transmission (e.g., numRepetitionPerPreambleAttempt). numRepetitionPerPreambleAttempt may correspond to the preamble group. The UE may instruct the physical lay to transmit the selected preamble using the selected PRACH corresponding to a selected enhanced coverage level, corresponding RA-RNTI, preamble index or for NB-IoT subcarrier index, and PREAMBLE_RECEIVED_TARGET_POWER.

[287] If the UE is not an NB-IoT UE or a BL/CE UE, the UE may instruct the physical layer to transmit a preamble using the selected PRACH, corresponding RA-RNTI, preamble index and PREAMBLE_RECEIVED_TARGET_POWER.

[288] The DELTA_PREAMBLE preamble format based power offset values may correspond to one or more values in Table 1, which may be determined by *prach-ConfigIndex*.

Preamble Format	DELTA_PREAMBLE value
0	0 dB
1	0 dB
2	-3 dB
3	-3 dB
4	8 dB

Table 1: DELTA_PREAMBLE values.

[289] The UE may acquire *preambleInitialReceivedTargetPower*, *powerRampingStep* and/or *prach-ConfigIndex* via a system information broadcast by a base station.

[290] $P_{\mathrm{CMAX},c}(i)$ may correspond to a configured UE transmit power in subframe i for serving cell c, and $\hat{P}_{\mathrm{CMAX}c}(i)$ may correspond to a linear value of $P_{\mathrm{CMAX},c}(i)$. If the UE transmits a PUCCH transmission without an overlapping PUSCH transmission, in subframe i for the serving cell c, then for the accumulation of TPC command received with DCI format 3 or format 3A for PUSCH, the UE may assume the value of $P_{\mathrm{CMAX},c}(i)$, based on a standards document. If the UE does not transmit a PUCCH transmission and an

overlapping PUSCH transmission, in subframe i for the serving cell c, then for the accumulation of TPC command received with DCI format 3 or format 3A for PUSCH, the UE may determine $P_{CMAX,c}(i)$ based on MPR=0dB, A-MPR=0dB, P-MPR=0dB and ΔT_C =0dB, where MPR, A-MPR, P-MPR and ΔT_C may be pre-defined in LTE technology.

[291] If the UE is configured with a higher layer parameter, e.g., *UplinkPowerControlDedicated-v12x0* for serving cell c, and if subframe i belongs to uplink power control subframe set 2, such as may be indicated by the higher layer parameter *tpc-SubframeSet-r12*, then: for j=2, $\alpha_c(j) = 1$; for j=0 or 1, $\alpha_c(j) = \alpha_{c,2} \in \{0, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1\}$. $\alpha_{c,2}$ may correspond to the parameter *alpha-SubframeSet2-r12* that may be provided by higher layers for each serving cell c.

[292] If the UE is not configured with a higher layer parameter, e.g., *UplinkPowerControlDedicated-v12x0* for serving cell c, or if subframe i belongs to uplink power control subframe set 2, then, for j=2, $\alpha_c(j) = 1$.; for j =0 or 1, $\alpha_c \in \{0, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1\}$ may correspond to a 3-bit parameter provided by higher layers for serving cell c.

[293] PL_c may correspond to the downlink path loss estimate that may be calculated by the UE for serving cell c, e.g., in dB. The downlink path loss estimate may be determined by PL_c = *referenceSignalPower*–higher layer filtered reference signal received power (RSRP). *referenceSignalPower* may be provided by higher layers and may correspond to an initial power level that the base station may use to transmit a reference signal. The base station may send the *referenceSignalPower* as a configuration parameter. The higher layer filtered RSRP may correspond to a power level of the reference signal as received by UE. By subtracting the received power level (e.g., higher layer filtered RSRP) from the initial power level (*referenceSignalPower*), the UE may determine the power lost during transmission (e.g., the downlink path loss PL_c).

[294] If serving cell c belongs to a TAG containing the primary cell, then, for the uplink of the primary cell, the primary cell may be used as the reference serving cell for determining *referenceSignalPower* and higher layer filtered RSRP. For the uplink of the secondary cell, the serving cell configured by the higher layer parameter *pathlossReferenceLinking*

may be used as the reference serving cell for determining *referenceSignalPower* and higher layer filtered RSRP.

[295] If serving cell c belongs to a TAG comprising the PSCell, then, for the uplink of the PSCell, the PSCell may be used as the reference serving cell for determining *referenceSignalPower* and higher layer filtered RSRP; and for the uplink of the secondary cell other than PSCell, the serving cell configured by the higher layer parameter *pathlossReferenceLinking* may be used as the reference serving cell for determining *referenceSignalPower* and higher layer filtered RSRP. If serving cell c belongs to a TAG that does not comprise the primary cell or the PSCell, then serving cell c may be used as the reference serving cell for determining *referenceSignalPower* and higher layer filtered RSRP.

[296] If the UE is configured with a higher layer parameter, e.g., *UplinkPowerControlDedicated-v12x0*, for serving cell c, and if subframe i belongs to uplink power control subframe set 2, as may be indicated by the higher layer parameter *tpc-SubframeSet-r12*, then:

[297] When j=0, $P_{O_PUSCH,c}(0) = P_{O_UE_PUSCH,c,2}(0) + P_{O_NOMINAL_PUSCH,c,2}(0)$, where j=0 may be used for PUSCH (re)transmissions corresponding to a semi-persistent grant. $P_{O_UE_PUSCH,c,2}(0)$ and $P_{O_NOMINAL_PUSCH,c,2}(0)$ may correspond to parameters *p0-UE-PUSCH-Persistent-SubframeSet2-r12* and *p0-NominalPUSCH-Persistent-SubframeSet2-r12* respectively provided by higher layers, for each serving cell c.

[298] When j=1, $P_{O_PUSCH,c}(1) = P_{O_UE_PUSCH,c,2}(1) + P_{O_NOMINAL_PUSCH,c,2}(1)$, where j=1 may be used for PUSCH (re)transmissions corresponding to a dynamic scheduled grant. $P_{O_UE_PUSCH,c,2}(1)$ and $P_{O_NOMINAL_PUSCH,c,2}(1)$ may correspond to parameters *p0-UE-PUSCH-SubframeSet2-r12* and *p0-NominalPUSCH-SubframeSet2-r12* respectively, provided by higher layers for serving cell c.

[299] When j=2, $P_{O_PUSCH,c}(2) = P_{O_UE_PUSCH,c}(2) + P_{O_NOMINAL_PUSCH,c}(2)$ where $P_{O_UE_PUSCH,c}(2) = 0$ and $P_{O_NOMINAL_PUSCH,c}(2) = P_{O_PRE} + \Delta_{PREAMBLE_Msg3}$, where the parameter *preambleInitialReceivedTargetPower* (P_{O_PR}) and $\Delta_{PREAMBLE_Msg3}$ may be

signalled from higher layers for serving cell c, where j=2 may be used for PUSCH transmissions and/or PUSCH retransmissions corresponding to the random access response grant.

[300] When j ≠0, 1, or 2, $P_{O_PUSCH,c}(j)$ may be a parameter composed of the sum of a component $P_{O_NOMINAL_PUSCH,c}(j)$ provided from higher layers for $j=0$ and 1 and a component $P_{O_UE_PUSCH,c}(j)$ provided by higher layers for $j=0$ and 1 for serving cell c. For PUSCH transmissions and/or PUSCH retransmissions corresponding to a semi-persistent grant then $j=0$, for PUSCH transmissions and/or PUSCH retransmissions corresponding to a dynamic scheduled grant then $j=1$ and for PUSCH transmissions and/or PUSCH retransmissions corresponding to the random access response grant then $j=2$. $P_{O_UE_PUSCH,c}(2)=0$ and $P_{O_NOMINAL_PUSCH,c}(2)=P_{O_PRE}+\Delta_{PREAMBLE_Msg3}$, where the parameter *preambleInitialReceivedTargetPower* (P_{O_PR}) and $\Delta_{PREAMBLE_Msg3}$ may be signalled from higher layers for serving cell c.

[301] $\Delta_{TF,c}(i)=10\log_{10}\left(\left(2^{BPRE\cdot K_s}-1\right)\cdot\beta_{offset}^{PUSCH}\right)$ for $K_S=1.25$ and 0 for $K_S=0$ where K_S may be determined based on the parameter *deltaMCS-Enabled* provided by higher layers for each serving cell c. $BPRE$ and β_{offset}^{PUSCH}, for each serving cell c, may be determined as below. $K_S=0$ for transmission mode 2.

[302] $BPRE=O_{CQI}/N_{RE}$ for control data sent via PUSCH without UL-SCH data and $\sum_{r=0}^{C-1}K_r/N_{RE}$ for other cases. C may correspond to a number of code blocks, K_r may correspond to a size for code block r, O_{CQI} may correspond to a number of CQI/PMI bits including CRC bits and N_{RE} may correspond to a number of resource elements determined as $N_{RE}=M_{sc}^{PUSCH-initial}\cdot N_{symb}^{PUSCH-initial}$, where C, K_r, $M_{sc}^{PUSCH-initial}$ and $N_{symb}^{PUSCH-initial}$ may be pre-defined in a standards document. $\beta_{offset}^{PUSCH}=\beta_{offset}^{CQI}$ for control data sent via PUSCH without UL-SCH data and 1 for other cases.

[303] $\delta_{PUSCH,c}$ may correspond to a correction value, also referred to as a TPC command and may be included in PDCCH/EPDCCH with DCI format 0, 0A, 0B, 4, 4A, or 4B or in MPDCCH with DCI format 6-0A for serving cell c or jointly coded with other TPC commands in PDCCH/MPDCCH with DCI format 3 or format 3A whose CRC parity bits

may be scrambled with TPC-PUSCH-RNTI. If the UE may be configured with higher layer parameter *UplinkPowerControlDedicated-v12x0* for serving cell c and if subframe i belongs to uplink power control subframe set 2 as indicated by the higher layer parameter *tpc-SubframeSet-r12*, the current PUSCH power control adjustment state for serving cell c may be determined based on $f_{c,2}(i)$, and the UE may use $f_{c,2}(i)$ instead of $f_c(i)$ to determine $P_{\mathrm{PUSCH},c}(i)$. Otherwise, the current PUSCH power control adjustment state for serving cell c may be determined by $f_c(i)$.

[304] $f_{c,2}(i)$ and $f_c(i)$ may be defined by: $f_c(i) = f_c(i-1) + \delta_{\mathrm{PUSCH},c}(i - K_{\mathrm{PUSCH}})$ and $f_{c,2}(i) = f_{c,2}(i-1) + \delta_{\mathrm{PUSCH},c}(i - K_{\mathrm{PUSCH}})$ if accumulation may be enabled based on the parameter *Accumulation-enabled* provided by higher layers or if the TPC command $\delta_{\mathrm{PUSCH},c}$ may be included in a PDCCH/EPDCCH with DCI format 0 or in a MPDCCH with DCI format 6-0A for serving cell c where the CRC may be scrambled by the Temporary C-RNTI. $\delta_{\mathrm{PUSCH},c}(i - K_{\mathrm{PUSCH}})$ may be signalled on PDCCH/EPDCCH with DCI format 0, 0A, 0B, 4, 4A, or 4B or MPDCCH with DCI format 6-0A or PDCCH/MPDCCH with DCI format 3 or format 3A on subframe $i - K_{PUSCH}$. $f_c(0)$ may correspond to a first value after reset of accumulation. For a BL/CE UE configured with CEModeA, subframe $i - K_{PUSCH}$ may correspond to a last subframe in which the MPDCCH with DCI format 6-0A or MPDCCH with DCI format 3 or format 3A may be transmitted. The value of K_{PUSCH} may be predetermined based on frame structure and/or link parameters.

[305] $f_c(i)$ may equal zero when no power control data is available. For example, when a UE starts a 2-step random access process in RRC inactive state, the UE may consider that the closed loop power control factor for data transmission is zero. The base station may transmit an offset value for calculating (offsetting) the UE calculated transmission power (in addition to power values in the power control formula) for transmission of data in the two-stage random access process.

[306] For serving cell c and a non-BL/CE UE, the UE may attempt to decode a PDCCH/EPDCCH of DCI format 0, 0A, 0B, 4, 4A, or 4B with the UE's C-RNTI or DCI format 0 for SPS C-RNTI or DCI format 0 for UL-V-SPS-RNTI and a PDCCH of DCI format 3 or format 3A with this UE's TPC-PUSCH-RNTI in every subframe except when

in DRX or where serving cell c may be deactivated. For serving cell c and a BL/CE UE configured with CEModeA, the UE may attempt to decode a MPDCCH of DCI format 6-0A with the UE's C-RNTI or SPS C-RNTI and a MPDCCH of DCI format 3 or format 3A with this UE's TPC-PUSCH-RNTI in every BL/CE downlink subframe except when in DRX

[307] For a non-BL/CE UE, if DCI format 0, 0A, 0B, 4, 4A, or 4B for serving cell c and DCI format 3 or3A may be both detected in the same subframe, then the UE may use the $\delta_{\mathrm{PUSCH},c}$ provided in DCI format 0, 0A, 0B, 4, 4A, or 4B. For a BL/CE UE configured with CEModeA, if DCI format 6-0A for serving cell c and DCI format 3 or format 3A may be both detected in the same subframe, then the UE may use the $\delta_{\mathrm{PUSCH},c}$ provided in DCI format 6-0A.

[308] $\delta_{\mathrm{PUSCH},c} = 0$ dB for a subframe where no TPC command may be decoded for serving cell c or where DRX occurs or i may be not an uplink subframe in TDD or FDD-TDD and serving cell c frame structure type 2. $\delta_{\mathrm{PUSCH},c} = 0$ dB if the subframe i may be not the first subframe scheduled by a PDCCH/EPDCCH of DCI format 0B or format 4B. The $\delta_{\mathrm{PUSCH},c}$ dB accumulated values signalled on PDCCH/EPDCCH with DCI format 0, 0A, 0B, 4, 4A, or 4B or MPDCCH with DCI format 6-0A may be as shown in Table 2. If the PDCCH/EPDCCH with DCI format 0 or MPDCCH with DCI format 6-0A may be validated as a SPS activation or release PDCCH/EPDCCH/MPDCCH, then $\delta_{\mathrm{PUSCH},c}$ may be 0dB.

[309] The δ_{PUSCH} dB accumulated values signalled on PDCCH/MPDCCH with DCI format 3 or format 3A may be one of SET1 as shown in Table 2 or SET2 as shown in Table 3,which may be determined by the parameter *TPC-Index* provided by higher layers. If UE has reached $P_{\mathrm{CMAX},c}(i)$ for serving cell c, positive TPC commands for serving cell c may not be accumulated. If UE has reached minimum power, negative TPC commands may not be accumulated.

[310] If the UE may be not configured with higher layer parameter *UplinkPowerControlDedicated-v12x0* for serving cell c, the UE may reset accumulation when $P_{\mathrm{O_UE_PUSCH},c}$ value may be changed by higher layers or when the UE receives random access response message for serving cell c.

[311] If the UE is configured with higher layer parameter *UplinkPowerControlDedicated-v12x0* for serving cell c, the UE may reset accumulation corresponding to $f_c(*)$ for serving cell c, when $P_{O_UE_PUSCH,c}$ value may be changed by higher layers, when the UE receives random access response message for serving cell c, the UE may reset accumulation corresponding to $f_{c,2}(*)$ for serving cell c, when $P_{O_UE_PUSCH,c,2}$ value may be changed by higher layers.

[312] If the UE is configured with higher layer parameter *UplinkPowerControlDedicated-v12x0* for serving cell c and if subframe i belongs to uplink power control subframe set 2 as indicated by the higher layer parameter *tpc-SubframeSet-r12*, then $f_c(i) = f_c(i-1)$. If the UE is configured with higher layer parameter *UplinkPowerControlDedicated-v12x0* for serving cell c and if subframe i does not belong to uplink power control subframe set 2 as indicated by the higher layer parameter *tpc-SubframeSet-r12*, then $f_{c,2}(i) = f_{c,2}(i-1)$.

[313] $f_c(i) = \delta_{\mathrm{PUSCH},c}(i - K_{\mathrm{PUSCH}})$ and $f_{c,2}(i) = \delta_{\mathrm{PUSCH},c}(i - K_{\mathrm{PUSCH}})$ if accumulation may be not enabled for serving cell c based on the parameter *Accumulation-enabled* provided by higher layers, where $\delta_{\mathrm{PUSCH},c}(i - K_{\mathrm{PUSCH}})$ was signalled on PDCCH/EPDCCH with DCI format 0, 0A, 0B, 4, 4A, or 4B or MPDCCH with DCI format 6-0A for serving cell c on subframe $i - K_{PUSCH}$. For a BL/CE UE configured with CEModeA, subframe $i - K_{PUSCH}$ may correspond to a last subframe in which the MPDCCH with DCI format 6-0A or MPDCCH with DCI format 3 or format 3A may be transmitted.

[314] The value of K_{PUSCH} may be predetermined based on frame structure and other link parameters. The $\delta_{\mathrm{PUSCH},c}$ dB absolute values signalled on PDCCH/EPDCCH with DCI format 0, 0A, 0B, 4, 4A, or 4B or a MPDCCH with DCI format 6-0A may be as shown in Table 2. If the PDCCH/EPDCCH with DCI format 0 or a MPDCCH with DCI format 6-0A may be validated as a SPS activation or release PDCCH/EPDCCH/MPDCCH, then $\delta_{\mathrm{PUSCH},c}$ may be 0dB.

[315] For a non-BL/CE UE, $f_c(i) = f_c(i-1)$ and $f_{c,2}(i) = f_{c,2}(i-1)$ for a subframe where no PDCCH/EPDCCH with DCI format 0, 0A, 0B, 4, 4A, or 4B may be decoded for serving

cell c or where DRX may occur or i may be not an uplink subframe in TDD or FDD-TDD and serving cell c frame structure type 2.

[316] For a BL/CE UE configured with CEModeA, $f_c(i) = f_c(i-1)$ and $f_{c,2}(i) = f_{c,2}(i-1)$ for a subframe where no MPDCCH with DCI format 6-0A may be decoded for serving cell c or where DRX occurs or i may be not an uplink subframe in TDD.

[317] If the UE is configured with higher layer parameter *UplinkPowerControlDedicated-v12x0* for serving cell c and if subframe i belongs to uplink power control subframe set 2 as indicated by the higher layer parameter *tpc-SubframeSet-r12*, then $f_c(i) = f_c(i-1)$. If the UE is configured with higher layer parameter *UplinkPowerControlDedicated-v12x0* for serving cell c and if subframe i does not belong to uplink power control subframe set 2 as indicated by the higher layer parameter *tpc-SubframeSet-r12*, then $f_{c,2}(i) = f_{c,2}(i-1)$.

[318] For both types of $f_c(*)$ (accumulation or current absolute) the first value may be set as follows: if $P_{O_UE_PUSCH,c}$ value is changed by higher layers and serving cell c is the primary cell or, if $P_{O_UE_PUSCH,c}$ value may be received by higher layers and serving cell c may be a Secondary cell, then $f_c(0) = 0$, otherwise if the UE receives the random access response message for a serving cell c, then $f_c(0) = \Delta P_{rampup,c} + \delta_{msg2,c}$. $\delta_{msg2,c}$ may correspond to a TPC command indicated in the random access response corresponding to the random access preamble transmitted in the serving cell c. $\Delta P_{rampup,c}$ and $\Delta P_{rampuprequested,c}$ may be provided by higher layers and may correspond to the total power ramp-up requested by higher layers from the first to the last preamble in the serving cell c. $M_{PUSCH,c}(0)$ may correspond to a bandwidth of the PUSCH resource assignment expressed in number of resource blocks valid for the subframe of first PUSCH transmission in the serving cell c. $\Delta_{TF,c}(0)$ may correspond to a power adjustment of first PUSCH transmission in the serving cell c. If $P_{O_UE_PUSCH,c,2}$ value is received by higher layers for a serving cell c, then $f_{c,2}(0) = 0$.

TPC Command Field in DCI format 0, 0A, 0B, 3, 4, 4A, 4B, 6-0A, 3B	Accumulated $\delta_{PUSCH,c}$ [dB]	Absolute $\delta_{PUSCH,c}$ [dB] only DCI format 0, 0A, 0B, 4, 4A, 4B, 6-0A
0	-1	-4
1	0	-1
2	1	1
3	3	4

Table 2: Example mapping of TPC Command Field in DCI format 0, 0A, 0B, 3, 4, 4A, 4B, 6-0A, or 3B to absolute and accumulated $\delta_{PUSCH,c}$ values

TPC Command Field in DCI format 3A or 3B	Accumulated $\delta_{PUSCH,c}$ [dB]
0	-1
1	1

Table 3: Example mapping of TPC Command Field in DCI format 3A/3B to accumulated $\delta_{PUSCH,c}$ values

[319] If the UE is not configured with an SCG or a PUCCH-SCell, and if the total transmit power of the UE would exceed $\hat{P}_{CMAX}(i)$, then the UE may scale $\hat{P}_{PUSCH,c}(i)$ for the serving cell c in subframe i such that $\sum_{c} w(i) \cdot \hat{P}_{PUSCH,c}(i) \leq \left(\hat{P}_{CMAX}(i) - \hat{P}_{PUCCH}(i)\right)$ is satisfied. $\hat{P}_{PUCCH}(i)$ may correspond to a linear value of $P_{PUCCH}(i)$, $\hat{P}_{PUSCH,c}(i)$ may correspond to a linear value of $P_{PUSCH,c}(i)$, $\hat{P}_{CMAX}(i)$ may correspond to a linear value of the UE total configured maximum output power P_{CMAX} in subframe i, and $w(i)$ may correspond to a scaling factor of $\hat{P}_{PUSCH,c}(i)$ for serving cell c where $0 \leq w(i) \leq 1$. In case there may be no PUCCH transmission in subframe i, $\hat{P}_{PUCCH}(i) = 0$.

[320] If the UE is not configured with an SCG or a PUCCH-Scell, and if the UE has PUSCH transmission with UCI on serving cell j and PUSCH without UCI in any of the remaining serving cells, and the total transmit power of the UE would exceed $\hat{P}_{CMAX}(i)$, the UE may scale $\hat{P}_{PUSCH,c}(i)$ for the serving cells without UCI in subframe i such that $\sum_{c \neq j} w(i) \cdot \hat{P}_{PUSCH,c}(i) \leq \left(\hat{P}_{CMAX}(i) - \hat{P}_{PUSCH,j}(i)\right)$ is satisfied. $\hat{P}_{PUSCH,j}(i)$ may correspond to

a PUSCH transmit power for the cell with UCI and $w(i)$ may be a scaling factor of $\hat{P}_{\text{PUSCH},c}(i)$ for serving cell c without UCI. Power scaling may be applied to $\hat{P}_{\text{PUSCH},j}(i)$ if $\sum_{c \neq j} w(i) \cdot \hat{P}_{\text{PUSCH},c}(i) = 0$ and the total transmit power of the UE still would exceed $\hat{P}_{CMAX}(i)$.

[321] For a UE not configured with a SCG or a PUCCH-SCell, note that $w(i)$ values may be the same across serving cells when $w(i) > 0$, but $w(i)$ may be zero for certain serving cells. If the UE is not configured with an SCG or a PUCCH-SCell, and if the UE has simultaneous or at least partially overlapping PUCCH and PUSCH transmissions with UCI on serving cell j and PUSCH transmission without UCI in any of the remaining serving cells, and the total transmit power of the UE would exceed $\hat{P}_{CMAX}(i)$, the UE may obtain $\hat{P}_{\text{PUSCH},c}(i)$ according to:

$$\hat{P}_{\text{PUSCH},j}(i) = \min\left(\hat{P}_{\text{PUSCH},j}(i), \left(\hat{P}_{\text{CMAX}}(i) - \hat{P}_{\text{PUCCH}}(i)\right)\right) \text{ ; and}$$

$$\sum_{c \neq j} w(i) \cdot \hat{P}_{\text{PUSCH},c}(i) \leq \left(\hat{P}_{\text{CMAX}}(i) - \hat{P}_{\text{PUCCH}}(i) - \hat{P}_{\text{PUSCH},j}(i)\right)$$

[322] If the UE is not configured with a SCG or a PUCCH-SCell,, if the UE is configured with multiple TAGs, and if the PUCCH/PUSCH transmission of the UE on subframe i for a serving cell in a TAG overlaps some portion of the first symbol of the PUSCH transmission on subframe $i + 1$ for a different serving cell in another TAG, then the UE may adjust its total transmission power to not exceed P_{CMAX} on any overlapped portion.

[323] If the UE is not configured with a SCG or a PUCCH-SCell, if the UE is configured with multiple TAGs, and if the PUSCH transmission of the UE on subframe i for a serving cell in a TAG overlaps some portion of the first symbol of the PUCCH transmission on subframe $i + 1$ for a different serving cell in another TAG, then the UE may adjust its total transmission power to not exceed P_{CMAX} on any overlapped portion.

[324] If the UE is not configured with a SCG or a PUCCH-SCell, if the UE is configured with multiple TAGs, and if the SRS transmission of the UE in a symbol on subframe i for a serving cell in a TAG overlaps with the PUCCH/PUSCH transmission on subframe i or

subframe $i + 1$ for a different serving cell in the same or another TAG, then the UE may drop SRS if its total transmission power exceeds P_{CMAX} on any overlapped portion of the symbol.

[325] If the UE is not configured with a SCG or a PUCCH-SCell, if the UE is configured with multiple TAGs and more than 2 serving cells, and if the SRS transmission of the UE in a symbol on subframe i for a serving cell overlaps with the SRS transmission on subframe i for a different serving cell(s) and with PUSCH/PUCCH transmission on subframe i or subframe $i + 1$ for another serving cell(s), then the UE may drop the SRS transmissions if the total transmission power exceeds P_{CMAX} on any overlapped portion of the symbol.

[326] If the UE is not configured with a SCG or a PUCCH-SCell, and if the UE is configured with multiple TAGs, the UE may, when requested by higher layers to transmit PRACH in a secondary serving cell in parallel with SRS transmission in a symbol on a subframe of a different serving cell belonging to a different TAG, drop SRS if the total transmission power exceeds P_{CMAX} on any overlapped portion in the symbol.

[327] If the UE is not configured with a SCG or a PUCCH-SCell, and if the UE is configured with multiple TAGs, the UE may, when requested by higher layers to transmit PRACH in a secondary serving cell in parallel with PUSCH/PUCCH in a different serving cell belonging to a different TAG, adjust the transmission power of PUSCH/PUCCH so that its total transmission power does not exceed P_{CMAX} on the overlapped portion.

[328] If the UE is configured with a LAA SCell for uplink transmissions, the UE may compute the scaling factor $w(i)$ under the assumption that the UE may perform a PUSCH transmission on the LAA SCell in subframe i irrespective of whether the UE may access the LAA SCell for the PUSCH transmission in subframe i according to the channel access procedures.

[329] For a BL/CE UE configured with CEModeA, if the PUSCH is transmitted in more than one subframe i_0, i_1, ..., i_{N-1} where $i_0 < i_1 < \ldots < i_{N-1}$, then the PUSCH transmit power in subframe i_k, k=0, 1, ..., N-1, may be determined by $P_{\mathrm{PUSCH},c}(i_k) = P_{\mathrm{PUSCH},c}(i_0)$. For a BL/CE UE configured with CEModeB, the PUSCH transmit power in subframe i_k may be determined by $P_{\mathrm{PUSCH},c}(i_k) = P_{\mathrm{CMAX},c}(i_0)$.

[330] A wireless device may perform a method for determining a type of random access procedure. The wireless device may receive, from a base station, one or more first messages comprising one or more first parameters for a two-step random access procedure, one or more second parameters for a four-step random access procedure, and a first threshold power level. The one or more first messages may comprise a ramp up power parameter. The one or more first parameters for the two-step random access procedure may indicate at least one first preamble for the two-step random access procedure and at least one first random access procedure resource for the two-step random access procedure. The one or more second parameters for the four-step random access procedure indicate at least one second preamble for the four-step random access procedure and at least one second random access procedure resource for the four-step random access procedure. The wireless device may determine, based on the one or more first parameters for a two-step random access procedure, a first transmission power associated with the two-step random access procedure. The first transmission power associated with the two-step random access procedure may be proportional to a distance or a path loss between the wireless device and the base station. A wireless device may perform any combination of one or more of the above steps. A base station, or any other device, may perform any combination of a step, or a complementary step, of one or more of the above steps.

[331] The wireless device may determine, based on a comparison of the first transmission power and the first threshold power level, a type of random access procedure. The wireless device may determine, based on the first transmission power not exceeding the first threshold power level, the type of random access procedure comprises the two-step random access procedure. The wireless device may determine, based on the first transmission power exceeding the first threshold power level, the type of random access procedure comprises the four-step random access procedure. A wireless device may perform any combination of one or more of the above steps. A base station, or any other device, may perform any combination of a step, or a complementary step, of one or more of the above steps.

[332] The wireless device may transmit, to the base station, a second message employing the determined type of random access procedure. Additionally or alternatively, the wireless device may drop, based on the first transmission power associated with the two-step random access procedure exceeding the first threshold power level, at least one transport block from the second message. Transmitting the second message may comprise

transmitting, using the at least one first random access procedure resource for the two-step random access procedure, the at least one first preamble for the two-step random access procedure or transmitting, using the at least one second random access procedure resource for the four-step random access procedure, the at least one second preamble for the four-step random access procedure. The determined type may be the four-step random access procedure, and the second message may comprise a random access preamble indicated by the one or more second parameters for the four-step random access procedure. A wireless device may perform any combination of one or more of the above steps. A base station, or any other device, may perform any combination of a step, or a complementary step, of one or more of the above steps.

[333] The wireless device may determine, based on the ramp up power parameter and after a response to the second message has not been received within a threshold amount of time, a second transmission power for re-transmitting the second message. The wireless device may adjust, based on the second transmission power for the wireless device exceeding the first threshold power level, a third transmission power for at least one transport block of the second message. The wireless device may compare the third transmission power with a second threshold power level. The wireless device may re-transmit, based on the third transmission power being below the second threshold power level, the second message via the four-step random access procedure. A wireless device may perform any combination of one or more of the above steps. A base station, or any other device, may perform any combination of a step, or a complementary step, of one or more of the above steps.

[334] A wireless device may receive, from a base station, one or more first messages comprising one or more first parameters for a two-step random access procedure, and one or more second parameters for a four-step random access procedure. The one or more first messages may comprise a ramp up power parameter. The one or more first parameters for the two-step random access procedure may indicate at least one first preamble for the two-step random access procedure, and at least one first random access procedure resource for the two-step random access procedure. The one or more second parameters for the four-step random access procedure may indicate at least one second preamble for the four-step random access procedure, and at least one second random access procedure resource for the four-step random access procedure. A wireless device may perform any combination of one or more of the above steps. A base station, or any

other device, may perform any combination of a step, or a complementary step, of one or more of the above steps.

[335] The wireless device may determine, during a first time period, a first transmission power for transmitting a second message, wherein the second message is based on the one or more first parameters for the two-step random access procedure. The first transmission power may be proportional to a distance or a path loss between the wireless device and the base station. The wireless device may compare the first transmission power to a threshold to determine whether the first transmission power exceeds the threshold. The wireless device may transmit, to the base station and based on determining that the first transmission power exceeds the threshold, a third message, wherein the third message is based on the one or more second parameters for the four-step random access procedure. A wireless device may perform any combination of one or more of the above steps. A base station, or any other device, may perform any combination of a step, or a complementary step, of one or more of the above steps.

[336] The wireless device may determine, based on the ramp up power parameter and after a response to the third message has not been received within a threshold amount of time, a second transmission power for re-transmitting the third message. The wireless device may adjust, based on the second transmission power exceeding the threshold, a third transmission power for at least one transport block of the third message. The wireless device may re-transmit, via the four-step random access procedure and after determining the third transmission power for the at least one transport block is below a minimum threshold power level, the third message. The wireless device may determine, during a second time period, a second transmission power for transmitting a fourth message, wherein the fourth message is based on the one or more first parameters for the two-step random access procedure. Additionally or alternatively, the wireless device may drop, based on the second transmission power exceeding the threshold, at least one transport block from the fourth message. A wireless device may perform any combination of one or more of the above steps. A base station, or any other device, may perform any combination of a step, or a complementary step, of one or more of the above steps.

[337] A wireless device may receive, from a base station, one or more first messages comprising one or more parameters indicating at least one first preamble for a two-step random access procedure, one or more second parameters indicating at least one resource for the two-step random access procedure, one or more third parameters indicating at

least one preamble for a four-step random access procedure, one or more fourth parameters indicating at least one resource for the four-step random access procedure, and one or more fifth parameters indicating a first threshold. The one or more first messages may comprise a ramp up power parameter. The first threshold may correspond to a maximum transmission power of the wireless device. The wireless device may determine, during a first time period, a first transmission power comprising at least a second transmission power for a first preamble of the at least one first preamble for the two-step random access procedure and a third transmission power for at least one first transport block. The first transmission power for the first preamble of the at least one preamble for the two-step random access procedure may be proportional to a distance or a path loss between the wireless device and a base station. The wireless device may select, based on the first transmission power being higher than the first threshold, a first preamble of the at least one preamble for the four-step random access procedure and a first resource of the at least one resource for the four-step random access procedure. The wireless device may transmit, via the first resource of the at least one resource for the four-step random access procedure, a second message comprising the first preamble of the at least one preamble for the four-step random access procedure and the at least one transport block. A wireless device may perform any combination of one or more of the above steps. A base station, or any other device, may perform any combination of a step, or a complementary step, of one or more of the above steps.

[338] The wireless device may determine, during a second time period, a fourth transmission power comprising a fifth transmission power for a second preamble of the at least one preamble for the two-step random access procedure and a sixth transmission power for at least one second transport block. The wireless device may select, based on the fourth transmission power being lower than or equal to the first threshold, the second preamble of the at least one preamble for the two-step random access procedure and a second resource of the at least one resource for the two-step random access procedure. The wireless device may transmit, via the second resource of the at least one resource for the two-step random access procedure, the second preamble of the at least one preamble for the two-step random access procedure. A wireless device may perform any combination of one or more of the above steps. A base station, or any other device, may perform any combination of a step, or a complementary step, of one or more of the above steps.

[339] The wireless device may determine, based on the ramp up power parameter and after a response to the second message has not been received within a threshold amount of time,

a seventh transmission power for re-transmitting the second message. The wireless device may adjust, based on the seventh transmission power exceeding the first threshold, an eighth transmission power for the at least one transport block of the second message. Additionally or alternatively, the wireless device may drop, based on the seventh transmission power exceeding the first threshold, the at least one transport block of the second message. A wireless device may perform any combination of one or more of the above steps. A base station, or any other device, may perform any combination of a step, or a complementary step, of one or more of the above steps.

[340] Many of the elements in examples may be implemented as modules. A module may be an isolatable element that performs a defined function and has a defined interface to other elements. The modules may be implemented in hardware, software in combination with hardware, firmware, wetware (i.e., hardware with a biological element) or a combination thereof, all of which may be behaviorally equivalent. For example, modules may be implemented as a software routine written in a computer language configured to be executed by a hardware machine (such as C, C++, Fortran, Java, Basic, Matlab or the like) or a modeling/simulation program such as Simulink, Stateflow, GNU Octave, or LabVIEWMathScript. Additionally or alternatively, it may be possible to implement modules using physical hardware that incorporates discrete or programmable analog, digital and/or quantum hardware. Examples of programmable hardware may comprise: computers, microcontrollers, microprocessors, application-specific integrated circuits (ASICs); field programmable gate arrays (FPGAs); and complex programmable logic devices (CPLDs). Computers, microcontrollers, and microprocessors may be programmed using languages such as assembly, C, C++ or the like. FPGAs, ASICs, and CPLDs may be programmed using hardware description languages (HDL), such as VHSIC hardware description language (VHDL) or Verilog, that may configure connections between internal hardware modules with lesser functionality on a programmable device. The above mentioned technologies may be used in combination to achieve the result of a functional module.

[341] Systems, apparatuses, and methods may perform operations of multi-carrier communications described herein. Additionally or alternatively, a non-transitory tangible computer readable media may comprise instructions executable by one or more processors configured to cause operations of multi-carrier communications described herein. An article of manufacture may comprise a non-transitory tangible computer readable machine-accessible medium having instructions encoded thereon for enabling

programmable hardware to cause a device (e.g., a wireless communicator, a UE, a base station, and the like) to enable operation of multi-carrier communications described herein. The device, or one or more devices such as in a system, may include one or more processors, memory, interfaces, and/or the like. Other examples may comprise communication networks comprising devices such as base stations, wireless devices or user equipment (UE), servers, switches, antennas, and/or the like. Any device (e.g., a wireless device, a base station, or any other device) or combination of devices may be used to perform any combination of one or more of steps described herein, including, e.g., any complementary step or steps of one or more of the above steps.

[342] Although examples are described above, features and/or steps of those examples may be combined, divided, omitted, rearranged, revised, and/or augmented in any desired manner. Various alterations, modifications, and improvements will readily occur to those skilled in the art. Such alterations, modifications, and improvements are intended to be part of this description, though not expressly stated herein, and are intended to be within the spirit and scope of the disclosure. Accordingly, the foregoing description is by way of example only, and is not limiting.

CLAIMS

1. A method comprising:

transmitting, by a wireless device and to a base station, one or more preambles in parallel with one or more transport blocks;

receiving, by the wireless device, a media access control (MAC) packet data unit comprising:

one or more MAC subheaders; and

one or more random access responses (RARs), wherein each RAR of the one or more RARs is associated with a MAC subheader of the one or more MAC subheaders;

determining, based on a first field in a first MAC subheader of the one or more MAC subheaders, a type of a random access procedure of a first RAR of the one or more RARs, wherein the first RAR is associated with the first MAC subheader, and wherein the type of the random access procedure is determined from among a plurality of types of random access procedures comprising at least a two-step random access procedure and a four-step random access procedure; and

determining, based on the first field, that the random access procedure has completed.

2. The method of claim 1, wherein the determining that the random access procedure has completed is based on:

the first MAC subheader comprising a random access preamble identifier of the one or more preambles; and

a second field in the first RAR that indicates that the one or more transport blocks have been successfully received by the base station.

3. The method of claim 1, wherein the determining that the random access procedure has completed is based on the type of the random access procedure of the first RAR being a two-step random access procedure.

4. The method of claim 1 further comprising:

transmitting, based on a second field in the first RAR that indicates that at least one of the one or more transport blocks have not been successfully received by the base station, one or more messages using a four-step random access procedure.

5. The method of claim 1, further comprising determining, based on the first field, a size of the first RAR.

6. The method of claim 1, further comprising receiving, by the wireless device, one or more messages comprising configuration parameters of the two-step random access procedure.

7. The method of claim 1, wherein the first RAR further comprises an uplink grant, and wherein the method further comprises:

retransmitting, in response to a second field of the first RAR indicating that the one or more transport blocks have not been successfully received by the base station, the one or more transport blocks.

8. A method comprising:

transmitting, by a wireless device and to a base station, a first transmission comprising:

a first random access preamble (RAP) comprising a first random access preamble identifier (RAPID); and

one or more transport blocks;

receiving a media access control (MAC) packet data unit comprising:

one or more MAC subheaders; and

one or more random access responses (RARs), wherein each RAR of the one or more RARs is associated with a MAC subheader of the one or more MAC subheaders;

determining, based on a first field in a first MAC subheader of the one or more MAC subheaders, a type of a random access procedure of a first RAR of the one or more RARs, wherein the first RAR is associated with the first MAC subheader, and wherein the type of the random access procedure is determined from among a plurality of types of random access procedures comprising at least a two-step random access procedure and a four-step random access procedure;

determining, based on the type of the random access procedure of the first RAR and based on the first RAPID of the first RAP, whether the first transmission was successful in delivering the one or more transport blocks to the base station; and

transmitting, to the base station and based on the type of the random access procedure of the first RAR, one or more messages.

9. The method of claim 8, further comprising determining, based on the type of the random access procedure of the first RAR being a two-step random access procedure, that the random access procedure was successful in delivering the one or more transport blocks to the base station.

10. The method of claim 8, wherein the determining whether the first transmission was successful in delivering the one or more transport blocks to the base station is based on:

the first MAC subheader comprising a random access preamble identifier of the first RAP; and

a second field in the first RAR that indicates whether the one or more transport blocks have been successfully received by the base station.

11. The method of claim 8, further comprising:

transmitting, based on a second field in the first RAR that indicates that at least one of the one or more transport blocks have not been successfully received by the base station, one or more messages using a four-step random access procedure.

12. The method of claim 8, further comprising determining, based on the first field, a size of the first RAR.

13. The method of claim 8, further comprising receiving, by the wireless device, one or more messages comprising configuration parameters of the two-step random access procedure.

14. The method of claim 8, wherein the first RAR further comprises an uplink grant, and wherein the method further comprises:

retransmitting, in response to the first field indicating that the one or more transport blocks have not been successfully received by the base station, the one or more transport blocks.

15. A method comprising:

receiving, by a base station and from a wireless device, a random access preamble (RAP);

determining a type of a random access procedure, from among a plurality of types of random access procedures comprising at least a two-step random access procedure and a four-step random access procedure, for communicating with the wireless device; and

transmitting, based on the RAP, a media access control (MAC) packet data unit comprising:

one or more MAC subheaders, wherein a first field in a first MAC subheader of the one or more MAC subheaders comprises an indication of the type of the random access procedure; and

one or more random access responses (RARs), wherein each RAR of the one or more RARs is associated with a MAC subheader of the one or more MAC subheaders.

16. The method of claim 15, wherein a second field in the MAC subheader comprises:

the first field; and

the first RAPID.

17. The method of claim 15, further comprising:

receiving, by the base station and based on the indication of the type of the random access procedure indicating the two-step random access procedure, a first transmission comprising a second RAP and one or more transport blocks.

18. The method of claim 15, further comprising:

receiving, by the base station and based on the indication of the type of the random access procedure indicating the four-step random access procedure, a first transmission comprising a second RAP;

transmitting, by the base station and based on the first transmission, a second transmission comprising a first random access response;

receiving, by the base station and based on the second transmission, a third transmission comprising one or more transport blocks; and

transmitting, by the base station and based on the third transmission, a fourth transmission comprising contention resolution information.

19. The method of claim 15, determining, based on the type of a random access procedure, a size of a first RAR of the one or more RARs.

20. The method of claim 15, wherein the indication of the type of the random access procedure is based on a random access preamble identifier (RAPID) in the RAP.

21. A method comprising:

transmitting, by a wireless device and to a first base station associated with a first cell, a first message comprising a measurement report based on one or more second cells;

receiving, by the wireless device and from the first base station, a second message comprising a command for a handover from the first cell to a second cell of the one or more second cells, wherein the second message comprises one or more parameters indicating a type of a random access procedure for the handover, and wherein the type of the random access procedure comprises a two-step random access procedure or a four-step random access procedure; and

transmitting, by the wireless device and to a second base station associated with the second cell, a random access preamble employing the type of the random access procedure indicated in the second message.

22. The method of claim 21, further comprising transmitting, by the wireless device, one or more transport blocks overlapping in time with the random access preamble.

23. The method of claim 22, wherein the one or more transport blocks comprise one or more of:

a handover complete message;

uplink data;

a buffer status report; or

an identifier of the wireless device.

24. The method of claim 21, wherein the one or more parameters of the second message comprise, for the random access procedure, one or more of:

a preamble identifier; or

random access resource information.

25. The method of claim 21, wherein the second message further comprises:

timing advance information for transmission of one or more of the random access preamble or one or more transport blocks.

26. The method of claim 25, further comprising:

receiving, from the one or more second cells, a plurality of third messages comprising one or more of:

an indication of a power associated with a cell;

an indication of a quality associated with a cell; or

an indication of a cell priority.

27. The method of claim 21, further comprising transmitting, by the wireless device and in a first step of a four-step random access procedure, a second random access preamble.

28. The method of claim 21, wherein the second message comprises a preamble identifier, and wherein the method further comprises:

determining, based on the preamble identifier, radio resources associated with the random access procedure.

29. The method of claim 21, wherein the second message comprises:

random access channel configuration information for a two-step random access procedure; and

radio resource configuration parameters for the two-step random access procedure.

30. A method comprising:

receiving, by a first base station associated with a first cell and from a wireless device, a first message comprising a measurement report based on one or more second cells;

determining, based on the measurement report, to handover the wireless device from the first cell to a second cell of the one or more second cells;

transmitting, by the first base station and to a third device, a second message comprising an indication for the handover;

receiving, by the first base station and from the third device, a third message indicating a type of a random access procedure for the handover, wherein the type of the random access procedure comprises a two-step random access procedure or a four-step random access procedure; and

transmitting, by the first base station and to the wireless device, a fourth message comprising:

one or more parameters indicating the type of the random access procedure for the handover; and

a command to proceed with the handover.

31. The method of claim 30, wherein:

the third device comprises a second base station associated with the second cell; and

the second message comprises a handover request.

32. The method of claim 30, wherein:

the third device comprises a core network device; and

the second message indicates that the handover is requested.

33. The method of claim 32, further comprising:

transmitting, by the core network device, to a second base station, and based on the second message, a fifth message comprising a handover request; and

receiving, by the core network device and from the second base station, a sixth message indicating the type of the random access procedure for the handover and comprising an acknowledgement of the handover request.

34. The method of claim 30, wherein the one or more parameters of the fourth message comprise, for the random access procedure, one or more of:

a preamble identifier; or

random access resource information.

35. The method of claim 30, wherein the fourth message further comprises timing advance information for transmission, by the wireless device, of one or more of a random access preamble or one or more transport blocks.

36. The method of claim 35, wherein the timing advance information comprises one or more of:

an indication of a zero timing advance; or

a value for a timing advance, wherein the value is estimated by the first base station or the third device.

37. A method comprising:

receiving, by a network device and from a first base station associated with a first cell, a first message comprising an indication for a handover of a wireless device from the first cell to a second cell of one or more second cells;

determining, by the network device and based on the first message, to proceed with the handover; and

transmitting, by the network device and to the first base station, a second message comprising:

an acknowledgement for the handover; and

one or more parameters indicating a type of a random access procedure for the handover, wherein the type of the random access procedure comprises a two-step random access procedure or a four-step random access procedure.

38. The method of claim 37, wherein:

the network device comprises a second base station that is associated with the second cell; and

the second message comprises a handover request.

39. The method of claim 37, wherein:

the network device comprises a core network device; and

the second message comprises an indication that the handover is required.

40. The method of claim 39, further comprising:

transmitting, by the core network device, to a second base station, and based on the first message, a third message comprising a handover request; and

receiving, by the core network device and from the second base station, a fourth message indicating the type of the random access procedure for the handover and comprising an acknowledgement of a request for a handover request.

41. A method comprising:

receiving, by a wireless device and from a base station, one or more first messages comprising:

one or more first parameters for a two-step random access procedure;

one or more second parameters for a four-step random access procedure; and

a first threshold power level;

determining, based on the one or more first parameters for the two-step random access procedure, a first transmission power associated with the two-step random access procedure;

determining, based on a comparison of the first transmission power and the first threshold power level, a type of random access procedure, wherein the type of random access procedure comprises the two-step random access procedure or the four-step random access procedure; and

transmitting, by the wireless device and to the base station, a second message employing the determined type of random access procedure.

42. The method of claim 41, wherein determining the type of random access procedure comprises:

determining, based on the first transmission power exceeding the first threshold power level, the type of random access procedure to be the four-step random access procedure.

43. The method of claim 41, wherein determining the type of random access procedure comprises:

determining, based on the first transmission power not exceeding the first threshold power level, the type of random access procedure to be the two-step random access procedure.

44. The method of claim 41, wherein the one or more first messages comprise a ramp up power parameter, the method further comprising:

determining, by the wireless device, that a response to the second message has not been received within a threshold amount of time;

determining, based on the ramp up power parameter, a second transmission power for re-transmitting the second message; and

adjusting, based on the second transmission power for the wireless device exceeding the first threshold power level, a third transmission power for at least one transport block of the second message.

45. The method of claim 44, further comprising:

comparing the third transmission power with a second threshold power level; and

re-transmitting, based on the third transmission power being below the second threshold power level, the second message via the four-step random access procedure.

46. The method of claim 41, wherein:

the one or more first parameters for the two-step random access procedure indicate:

at least one first preamble for the two-step random access procedure; and

at least one first random access procedure resource for the two-step random access procedure; and

the one or more second parameters for the four-step random access procedure indicate:

at least one second preamble for the four-step random access procedure; and

at least one second random access procedure resource for the four-step random access procedure,

wherein the transmitting the second message comprises:

transmitting, using the at least one first random access procedure resource for the two-step random access procedure, the at least one first preamble for the two-step random access procedure; or

transmitting, using the at least one second random access procedure resource for the four-step random access procedure, the at least one second preamble for the four-step random access procedure.

47. The method of claim 41, further comprising:

dropping, based on the first transmission power associated with the two-step random access procedure exceeding the first threshold power level, at least one transport block from the second message.

48. A method comprising:

receiving, by a wireless device and from a base station, one or more first messages comprising:

one or more first parameters for a two-step random access procedure; and

one or more second parameters for a four-step random access procedure;

determining, during a first time period, a first transmission power for transmitting a second message, wherein the second message is based on the one or more first parameters for the two-step random access procedure;

comparing the first transmission power to a threshold to determine whether the first transmission power exceeds the threshold; and

transmitting, to the base station and based on determining that the first transmission power exceeds the threshold, a third message, wherein the third message is based on the one or more second parameters for the four-step random access procedure.

49. The method of claim 48, further comprising:

determining, during a second time period, a second transmission power for transmitting a fourth message, wherein the fourth message is based on the one or more first parameters for the two-step random access procedure; and

transmitting, to the base station and based on determining that the second transmission power does not exceed the threshold, the fourth message.

50. The method of claim 49, further comprising:

dropping, based on the second transmission power exceeding the threshold, at least one transport block from the fourth message.

51. The method of claim 48, wherein the one or more first messages comprise a ramp up power parameter, the method further comprising:

determining by the wireless device, that a response to the third message has not been received within a threshold amount of time;

determining, based on the ramp up power parameter, a second transmission power for re-transmitting the third message; and

adjusting, based on the second transmission power exceeding the threshold, a third transmission power for at least one transport block of the third message.

52. The method of claim 51, further comprising:

comparing the third transmission power with a minimum threshold power level; and re-transmitting, via the four-step random access procedure and after determining the third transmission power for the at least one transport block is below the minimum threshold power level, the third message.

53. The method of claim 48, wherein:

the one or more first parameters for the two-step random access procedure indicate:

at least one first preamble for the two-step random access procedure; and

at least one first random access procedure resource for the two-step random access procedure; and

the one or more second parameters for the four-step random access procedure indicate:

at least one second preamble for the four-step random access procedure; and

at least one second random access procedure resource for the four-step random access procedure,

wherein the transmitting the third message comprises:

transmitting, using the at least one second random access procedure resource for the four-step random access procedure, the at least one second preamble for the four-step random access procedure.

54. The method of claim 48, wherein the first transmission power is proportional to a path loss between the wireless device and the base station.

55. A method comprising:

receiving, by a wireless device and from a base station, one or more first messages comprising:

one or more first parameters for a two-step random access procedure;

one or more second parameters for a four-step random access procedure; and

one or more third parameters indicating a first threshold;

determining, during a first time period, a first transmission power comprising at least a second transmission power for a first preamble for the two-step random access procedure and a third transmission power for at least one first transport block;

selecting, based on the first transmission power being higher than the first threshold:

a second preamble for the four-step random access procedure; and

a first resource for the four-step random access procedure; and

transmitting, by the wireless device and via the first resource for the four-step random access procedure, a second message comprising:

the second preamble for the four-step random access procedure; and

the at least one first transport block.

56. The method of claim 55, wherein:

the one or more first parameters for the two-step random access procedure indicate:

at least one preamble for the two-step random access procedure; and

at least one resource for the two-step random access procedure; and

the one or more second parameters for the four-step random access procedure indicate:

at least one preamble for the four-step random access procedure; and

at least one resource for the four-step random access procedure.

57. The method of claim 55, further comprising:

determining, during a second time period, a fourth transmission power comprising:

a fifth transmission power for a second preamble for the two-step random access procedure; and

a sixth transmission power for at least one second transport block;

selecting, based on the fourth transmission power being lower than or equal to the first threshold:

the second preamble for the two-step random access procedure; and

a second resource for the two-step random access procedure; and

transmitting, by the wireless device and via the second resource for the two-step random access procedure, the second preamble for the two-step random access procedure.

58. The method of claim 55, wherein the first transmission power for the first preamble for the two-step random access procedure is proportional to a path loss between the wireless device and the base station.

59. The method of claim 55, wherein the one or more first messages comprise a ramp up power parameter, the method further comprising:

determining, by the wireless device, that a response to the second message has not been received within a threshold amount of time;

determining, based on the ramp up power parameter, a fourth transmission power for re-transmitting the second message; and

adjusting, based on the fourth transmission power exceeding the first threshold, a fifth transmission power for the at least one first transport block of the second message.

60. The method of claim 55, wherein the first threshold corresponds to a maximum transmission power of the wireless device.

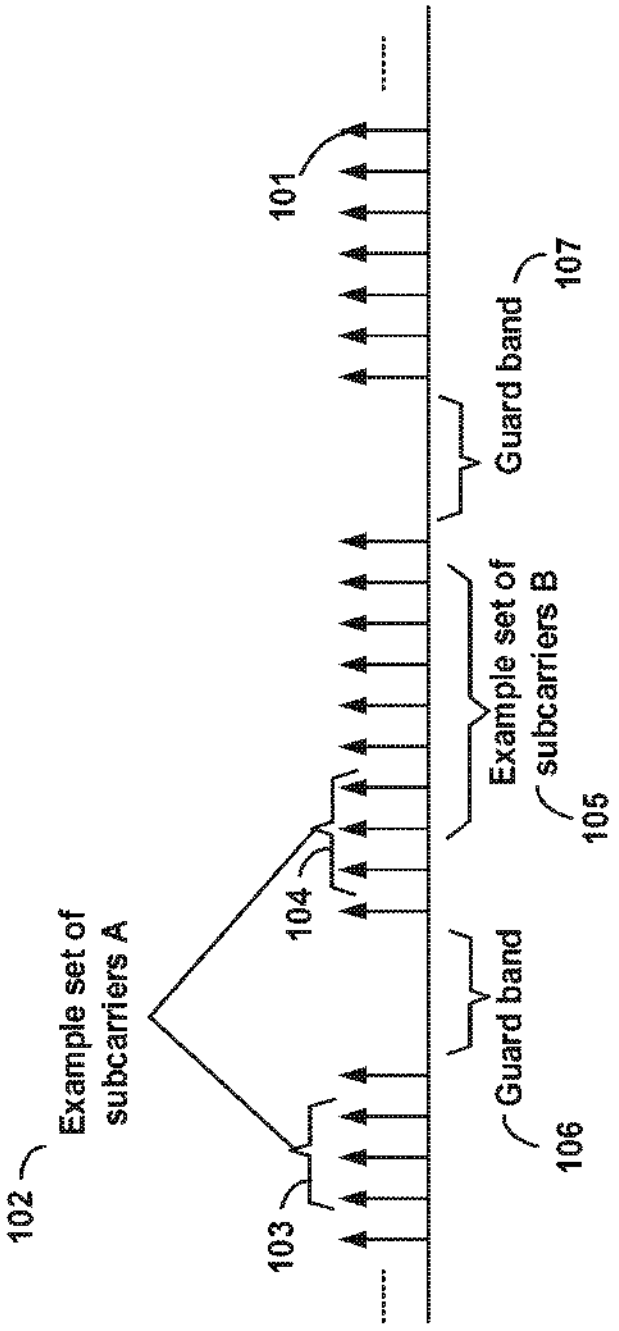

101
Guard band
107
Example set of subcarriers B
105
104
Guard band
106
Example set of subcarriers A
102
103

FIG. 1

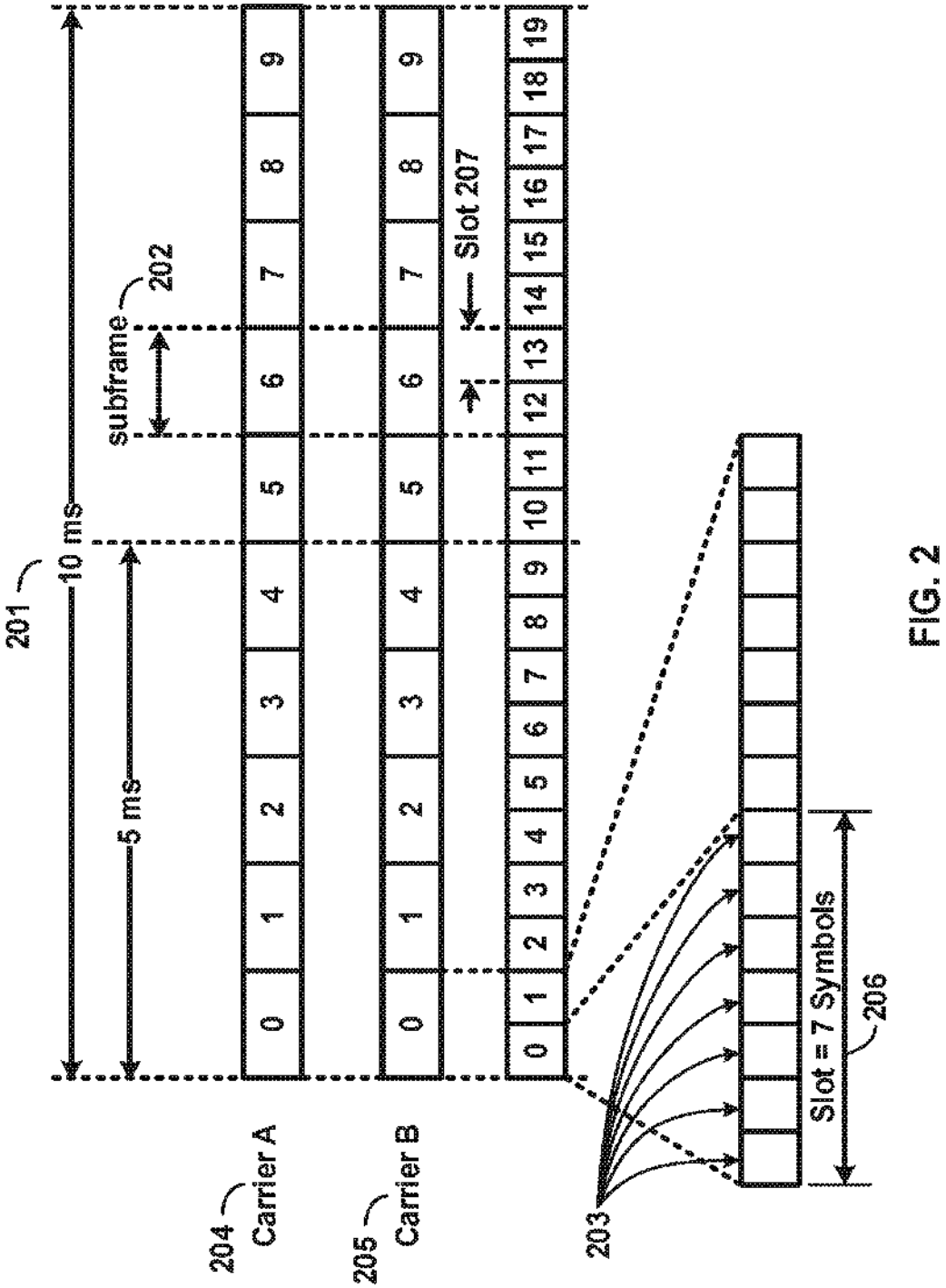

201
10 ms
5 ms
subframe
202
Slot 207
0 1 2 3 4 5 6 7 8 9
0 1 2 3 4 5 6 7 8 9
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
204
Carrier A
205
Carrier B
203
Slot = 7 Symbols
206

FIG. 2

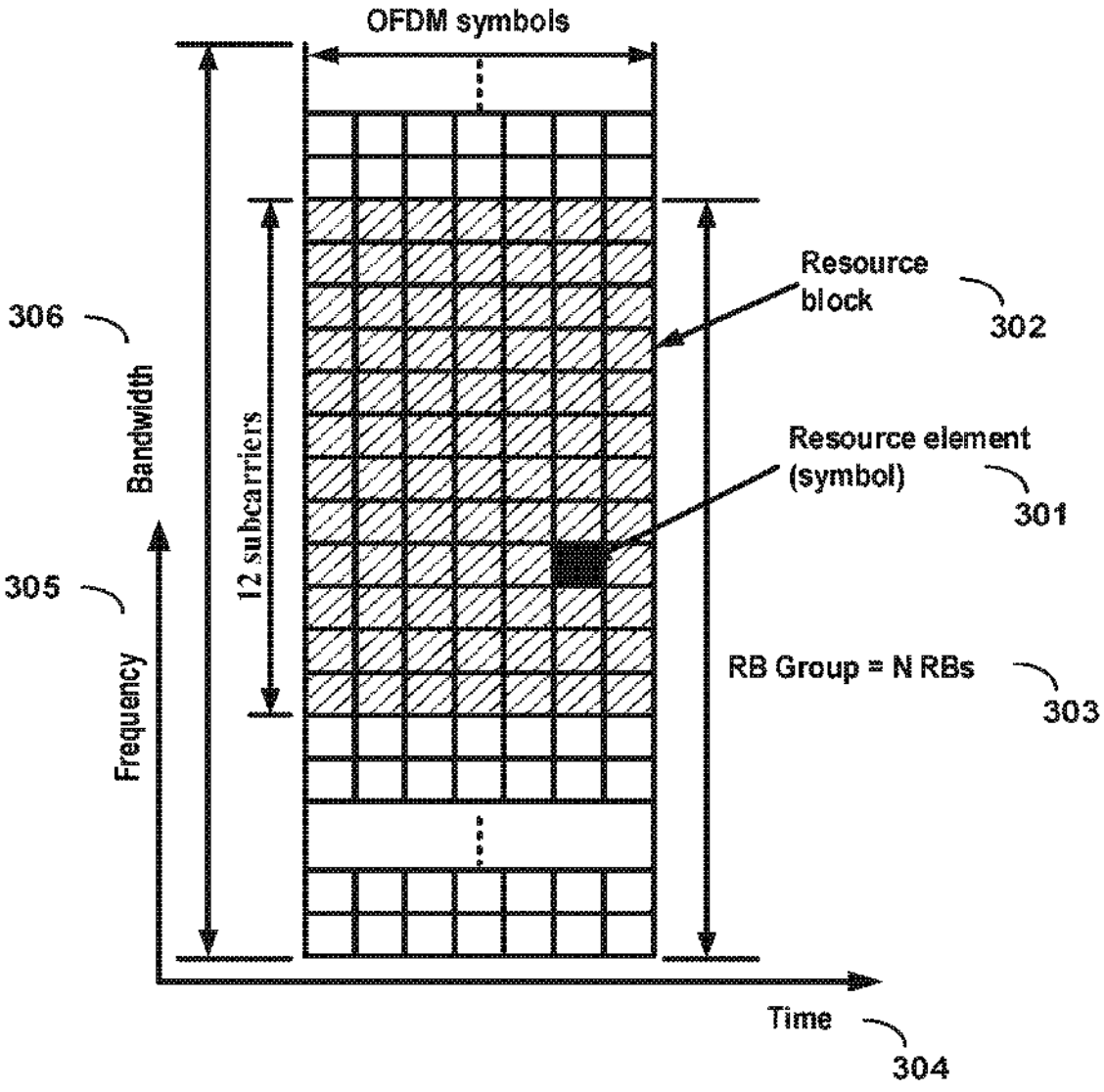

OFDM symbols
Resource block
302
306
Bandwidth
12 subcarriers
Resource element (symbol)
301
305
Frequency
RB Group = N RBs
303
Time
304

FIG. 3

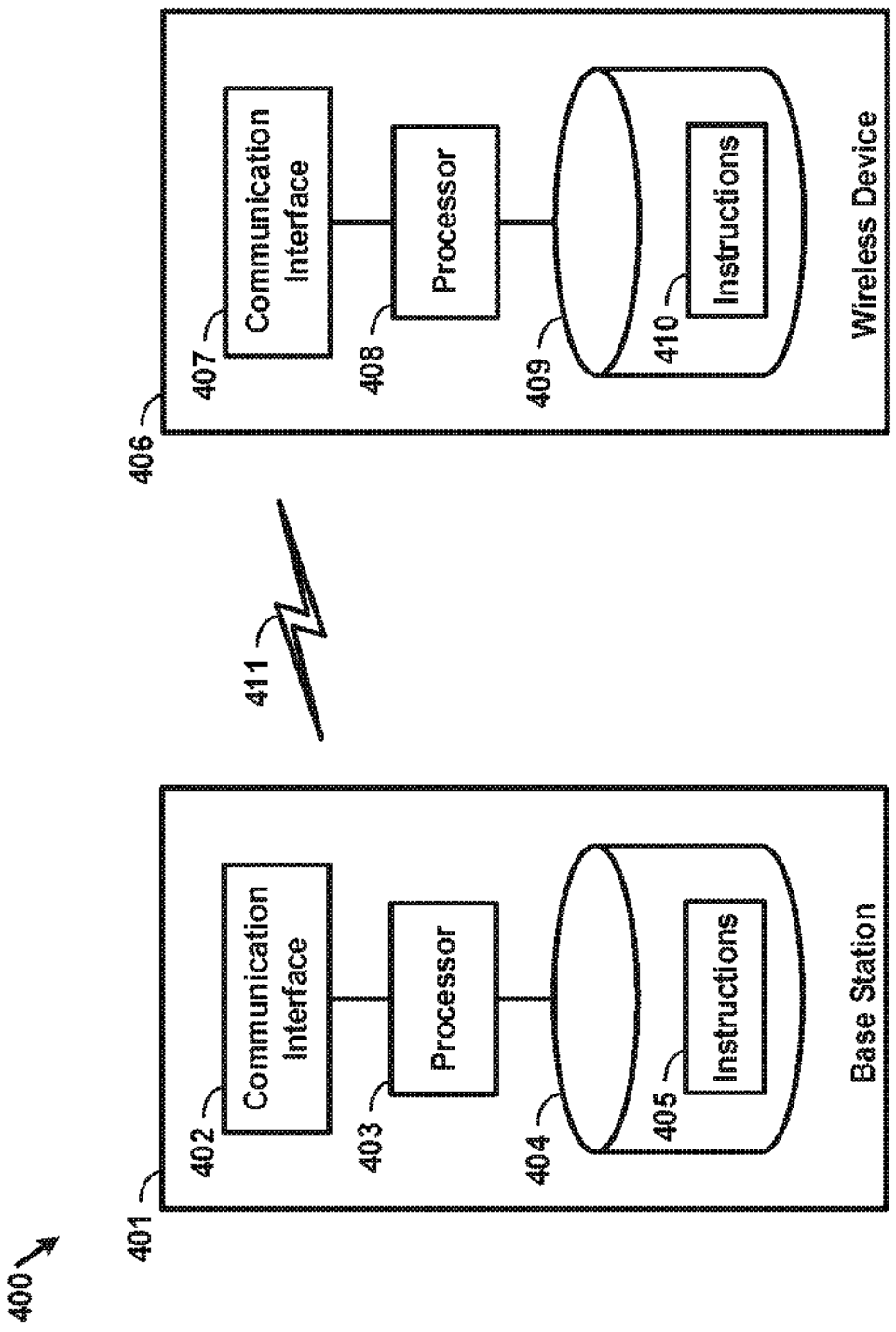

400
401
Base Station
402
Communication Interface
403
Processor
404
405
Instructions
411
406
Wireless Device
407
Communication Interface
408
Processor
409
410
Instructions

FIG. 4

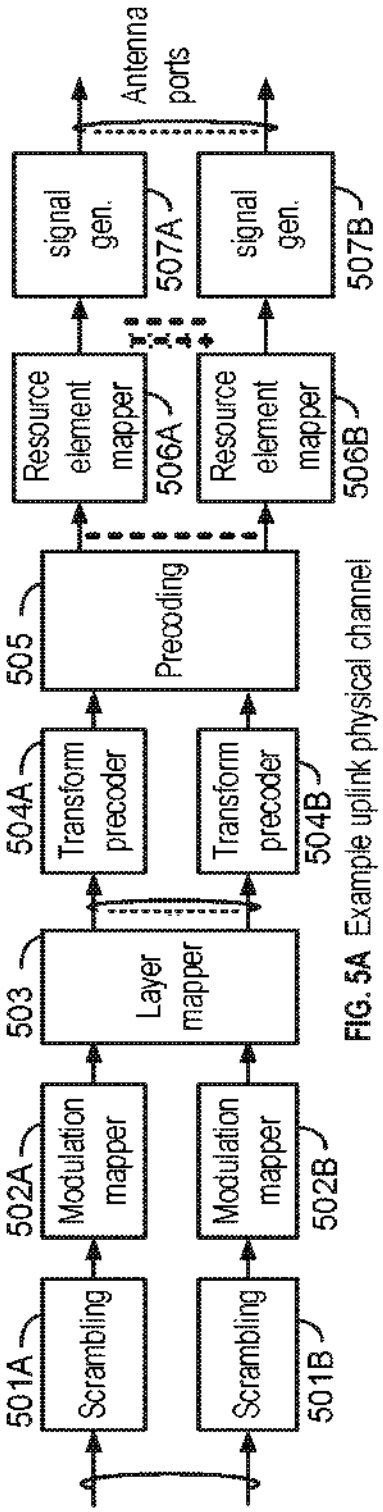


FIG. 5A Example uplink physical channel

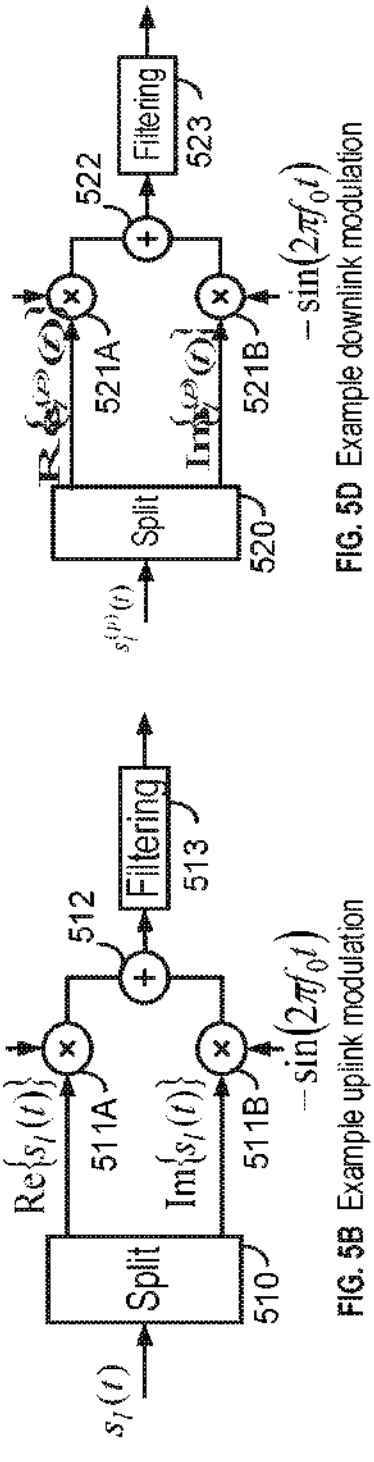


FIG. 5B Example uplink modulation

FIG. 5D Example downlink modulation

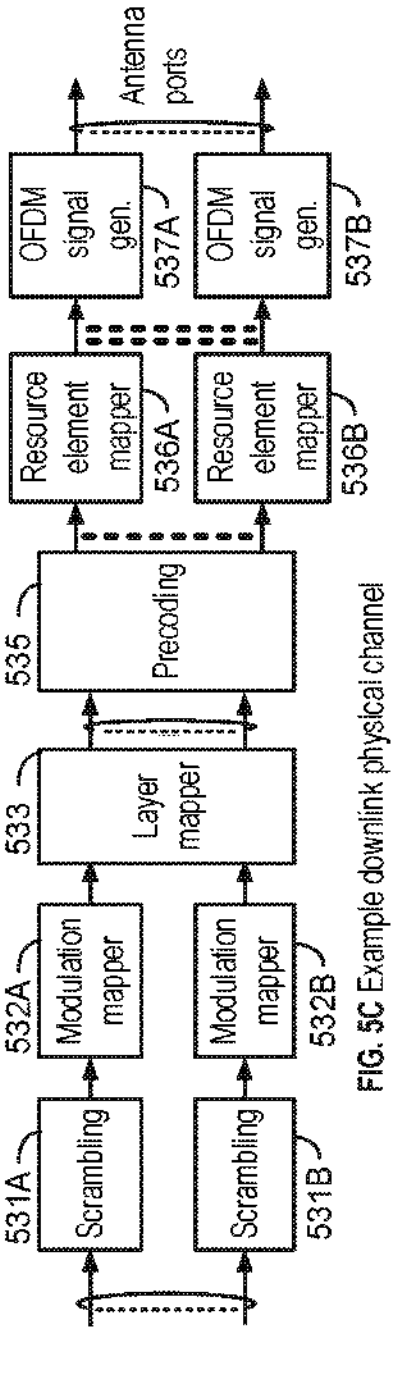


FIG. 5C Example downlink physical channel

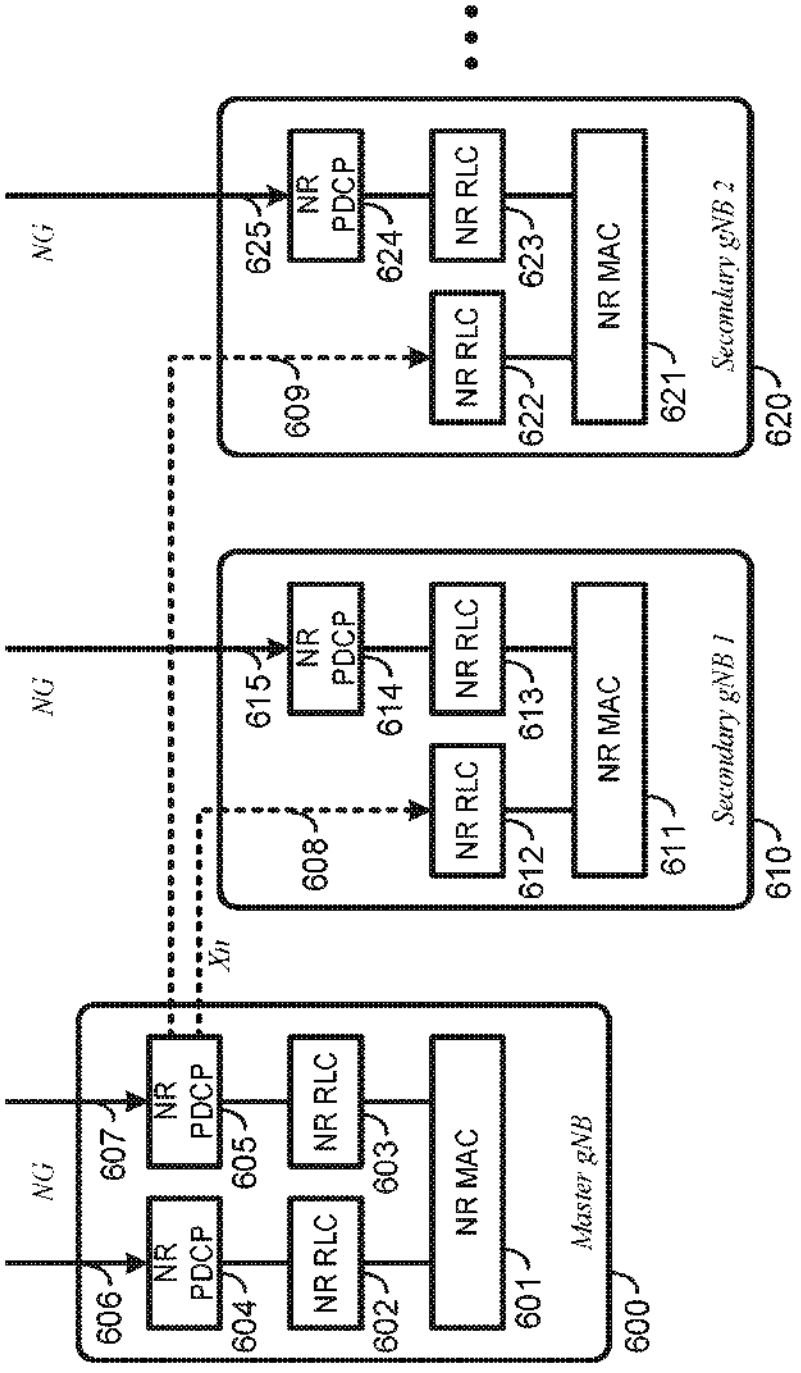

NG
NG
NG
Xn
Master gNB
600
NR MAC
601
NR RLC
602
NR RLC
603
NR PDCP
604
NR PDCP
605
606
607
Secondary gNB 1
610
NR MAC
611
NR RLC
612
NR RLC
613
NR PDCP
614
NR PDCP
615
608
Secondary gNB 2
620
NR MAC
621
NR RLC
622
NR RLC
623
NR PDCP
624
NR PDCP
625
609

FIG. 6

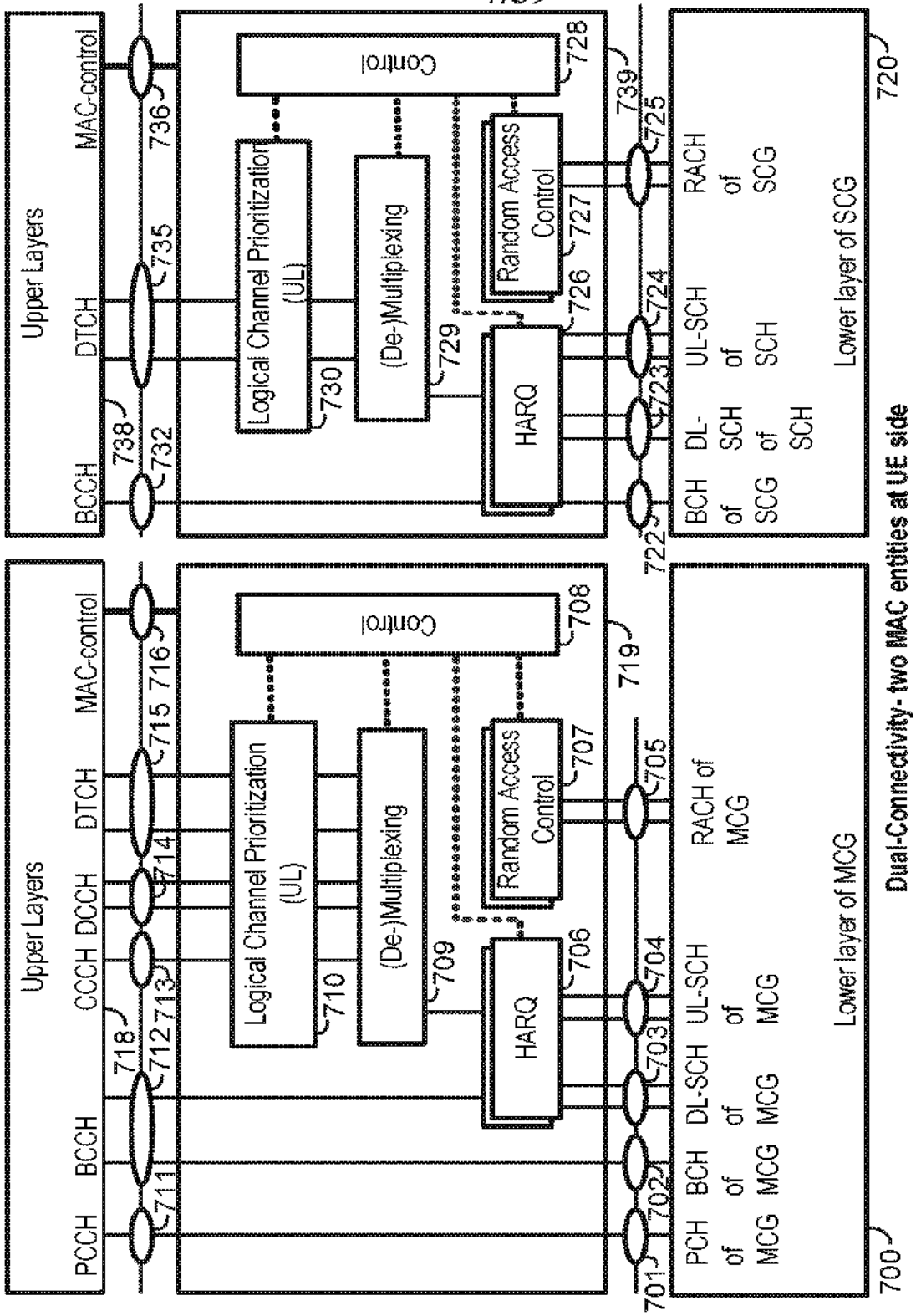

Upper Layers
PCCH
BCCH
CCCH
DCCH
DTCH
MAC-control
711
712
713
714
715
716
718
Logical Channel Prioritization (UL)
(De-)Multiplexing
HARQ
Random Access Control
Control
708
709
710
719
706
707
704
705
703
702
701
PCH of MCG
BCH of MCG
DL-SCH of MCG
UL-SCH of MCG
RACH of MCG
Lower layer of MCG
700
Upper Layers
BCCH
DTCH
MAC-control
732
735
736
738
Logical Channel Prioritization (UL)
(De-)Multiplexing
HARQ
Random Access Control
Control
728
729
730
726
727
739
725
724
723
722
BCH of SCG
DL-SCH of SCH of SCG
UL-SCH of SCH of SCG
RACH of SCG
Lower layer of SCG
720
Dual-Connectivity- two MAC entities at UE side

FIG. 7

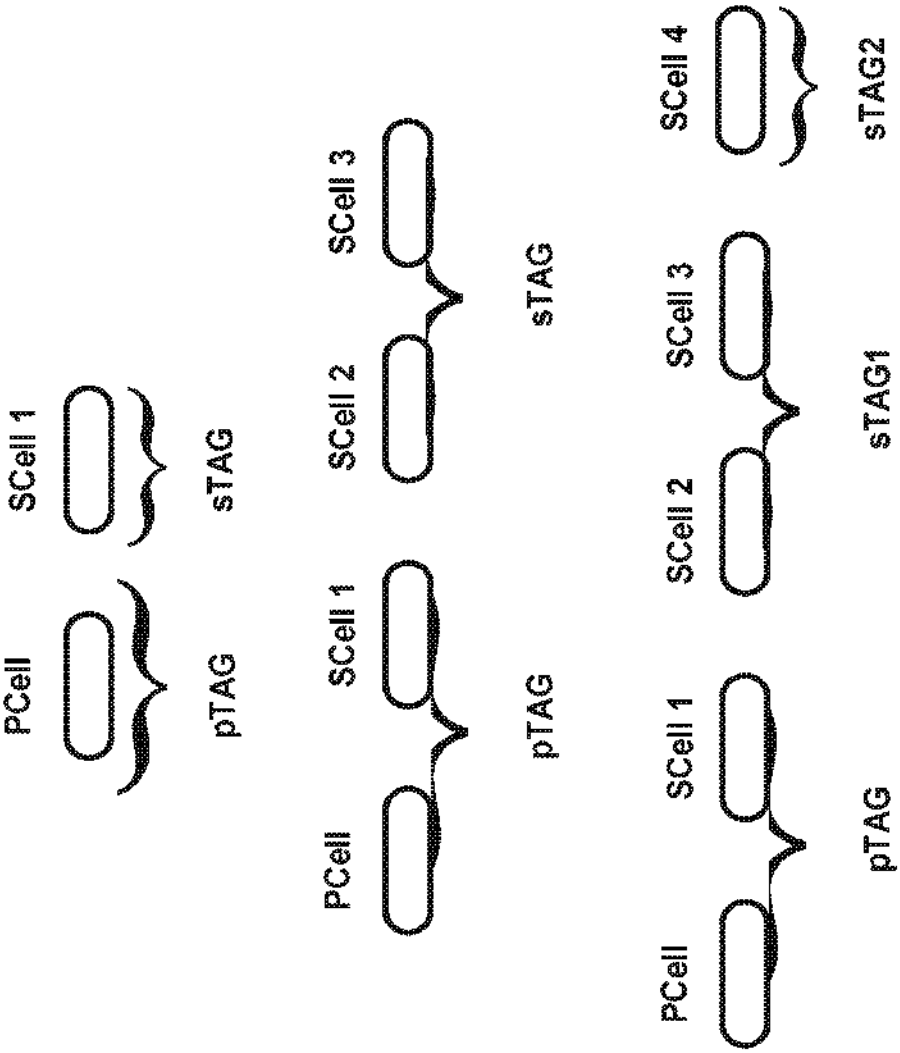

Example 1:
PCell
SCell 1
pTAG
sTAG
Example 2:
PCell
SCell 1
SCell 2
SCell 3
pTAG
sTAG
Example 3:
PCell
SCell 1
SCell 2
SCell 3
SCell 4
pTAG
sTAG1
sTAG2

FIG. 8

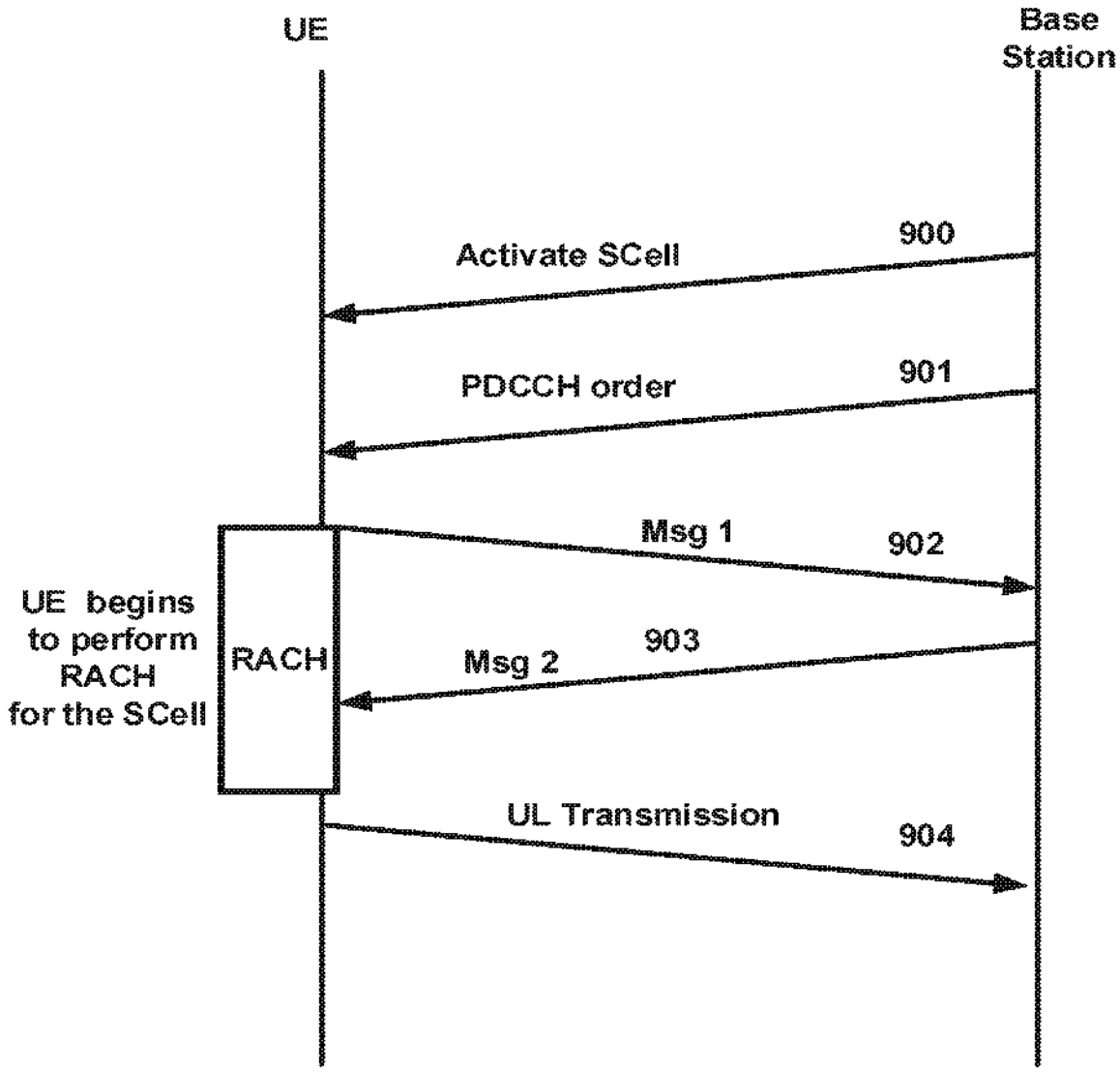

UE
Base Station
Activate SCell
900
PDCCH order
901
Msg 1
902
UE begins to perform RACH for the SCell
RACH
Msg 2
903
UL Transmission
904

FIG. 9

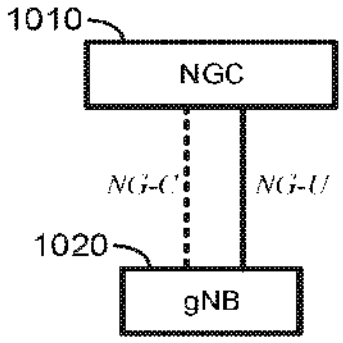


FIG. 10A gNB connected to NGC

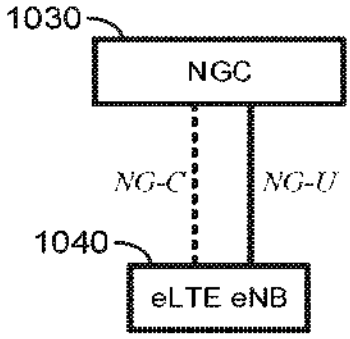


FIG. 10B eLTE eNB connected to NGC

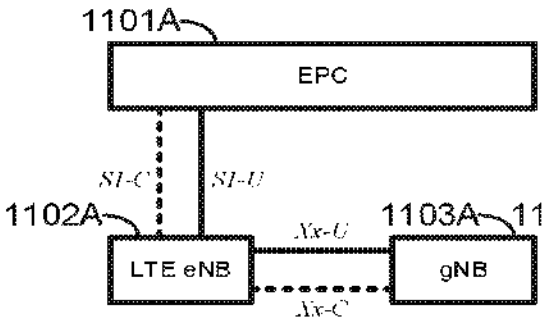


FIG. 11A LTE eNB connected to EPC with non-standalone gNB. gNB user plane connected to EPC via LTE eNB.

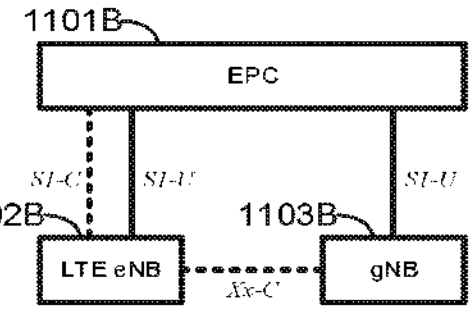


FIG. 11B LTE eNB connected to EPC with non-standalone gNB. gNB user plane connected to EPC directly.

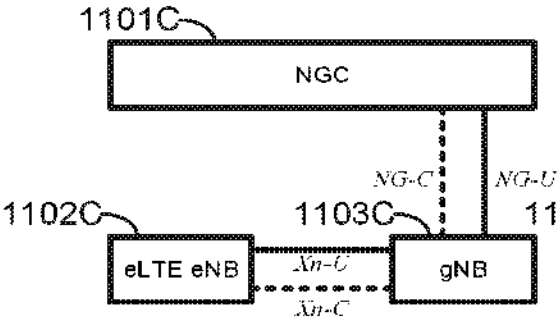


FIG. 11C gNB connected to NGC with non-standalone eLTE eNB. eLTE eNB user plane connected to NGC via gNB.

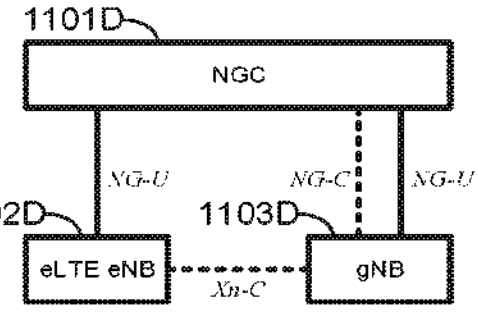


FIG. 11D gNB connected to NGC with non-standalone eLTE eNB. eLTE eNB user plane connected to NGC directly.

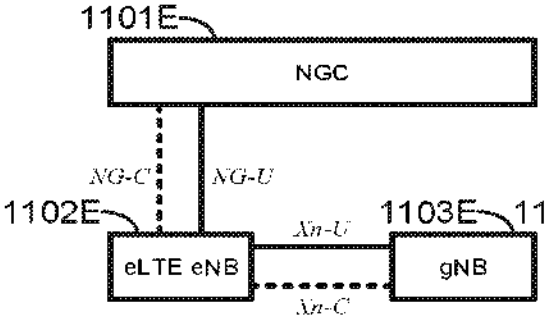


FIG. 11E eLTE eNB connected to NGC with non-standalone gNB. gNB user plane connected to NGC via eLTE eNB.

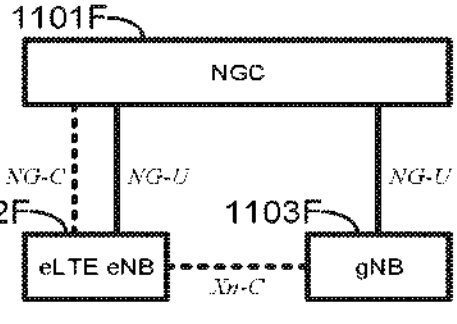


FIG. 11F eLTE eNB connected to NGC with non-standalone gNB. gNB user plane connected to NGC directly.

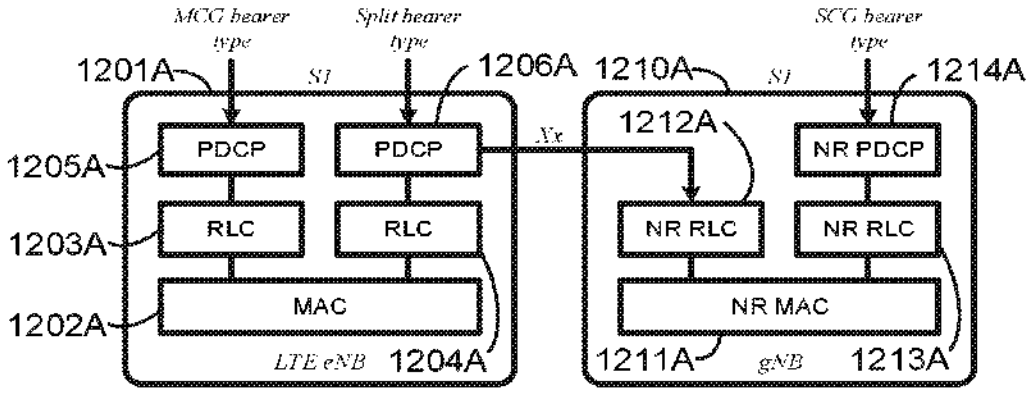


FIG. 12A Radio protocol architecture for split bearer and SCG bearer. LTE eNB connected to EPC with non-standalone gNB.

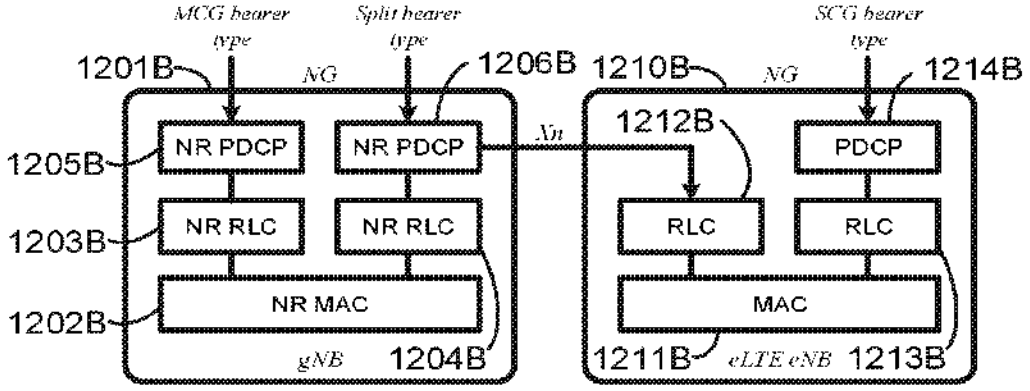


FIG. 12B Radio protocol architecture for split bearer and SCG bearer. gNB connected to NGC with non-standalone eLTE eNB.

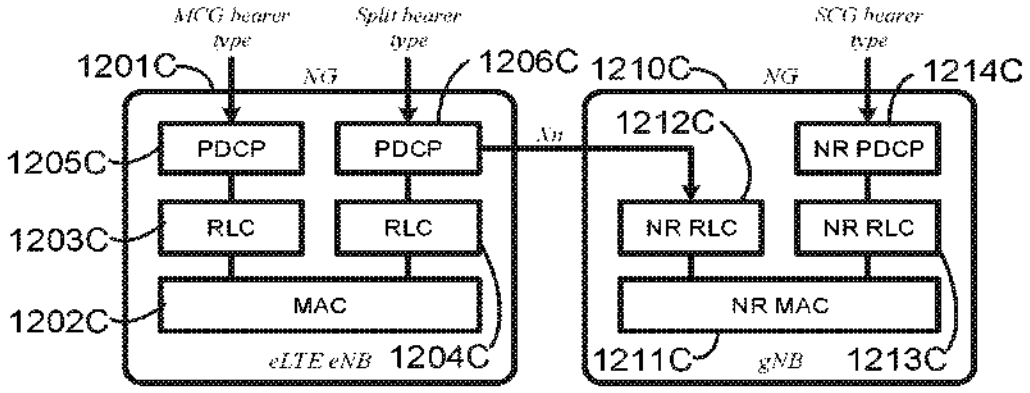


FIG. 12C Radio protocol architecture for split bearer and SCG bearer. eLTE eNB connected to NGC with non-standalone gNB.

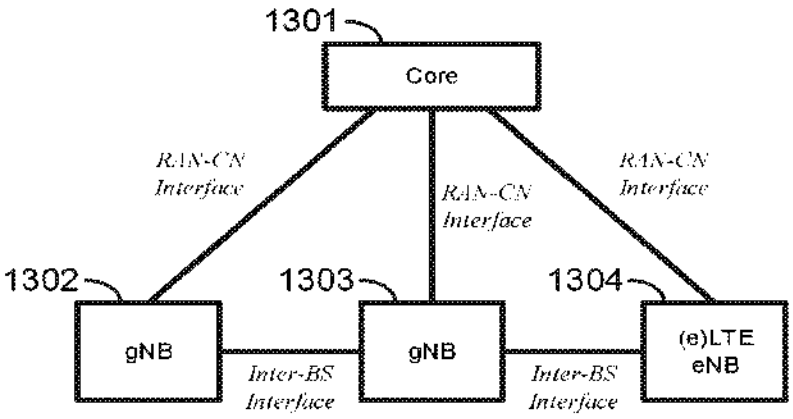


FIG. 13A Non-centralized deployment

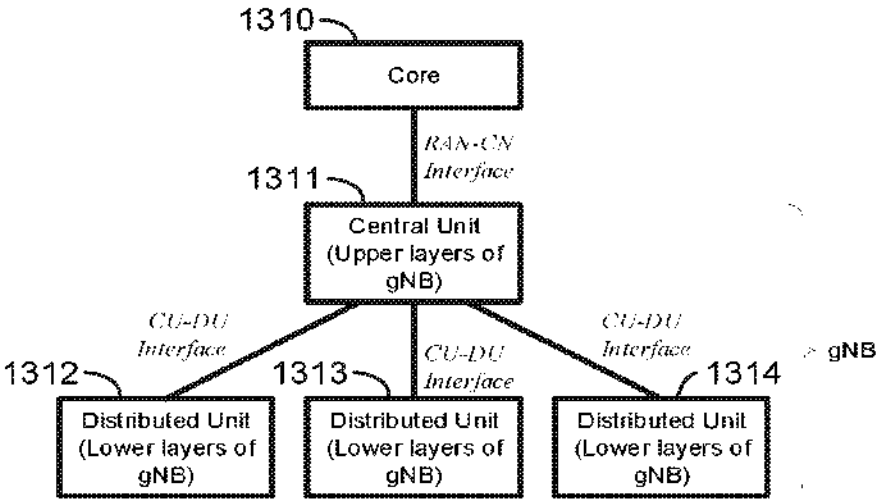


FIG. 13B Centralized deployment

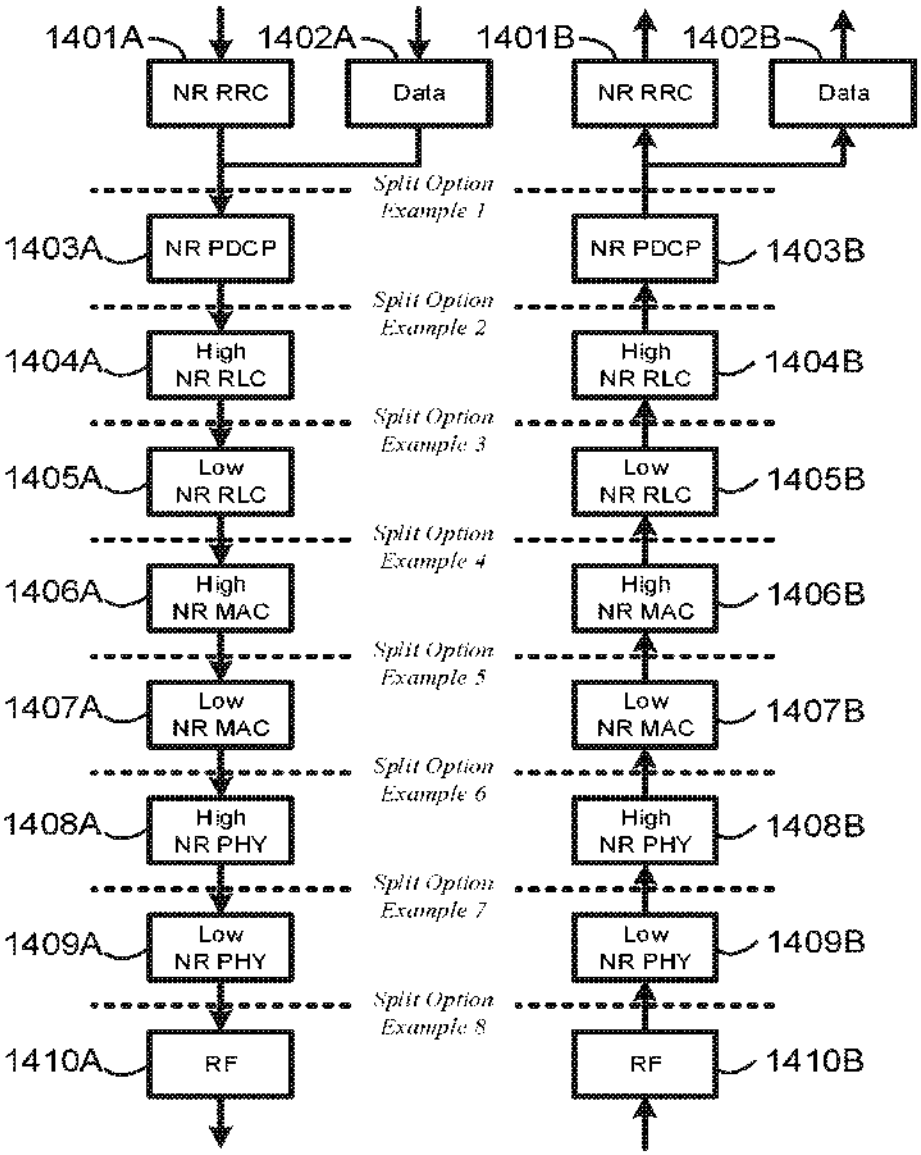

1401A
1402A
1401B
1402B
NR RRC
Data
NR RRC
Data
Split Option Example 1
1403A
NR PDCP
NR PDCP
1403B
Split Option Example 2
1404A
High NR RLC
High NR RLC
1404B
Split Option Example 3
1405A
Low NR RLC
Low NR RLC
1405B
Split Option Example 4
1406A
High NR MAC
High NR MAC
1406B
Split Option Example 5
1407A
Low NR MAC
Low NR MAC
1407B
Split Option Example 6
1408A
High NR PHY
High NR PHY
1408B
Split Option Example 7
1409A
Low NR PHY
Low NR PHY
1409B
Split Option Example 8
1410A
RF
RF
1410B

FIG. 14

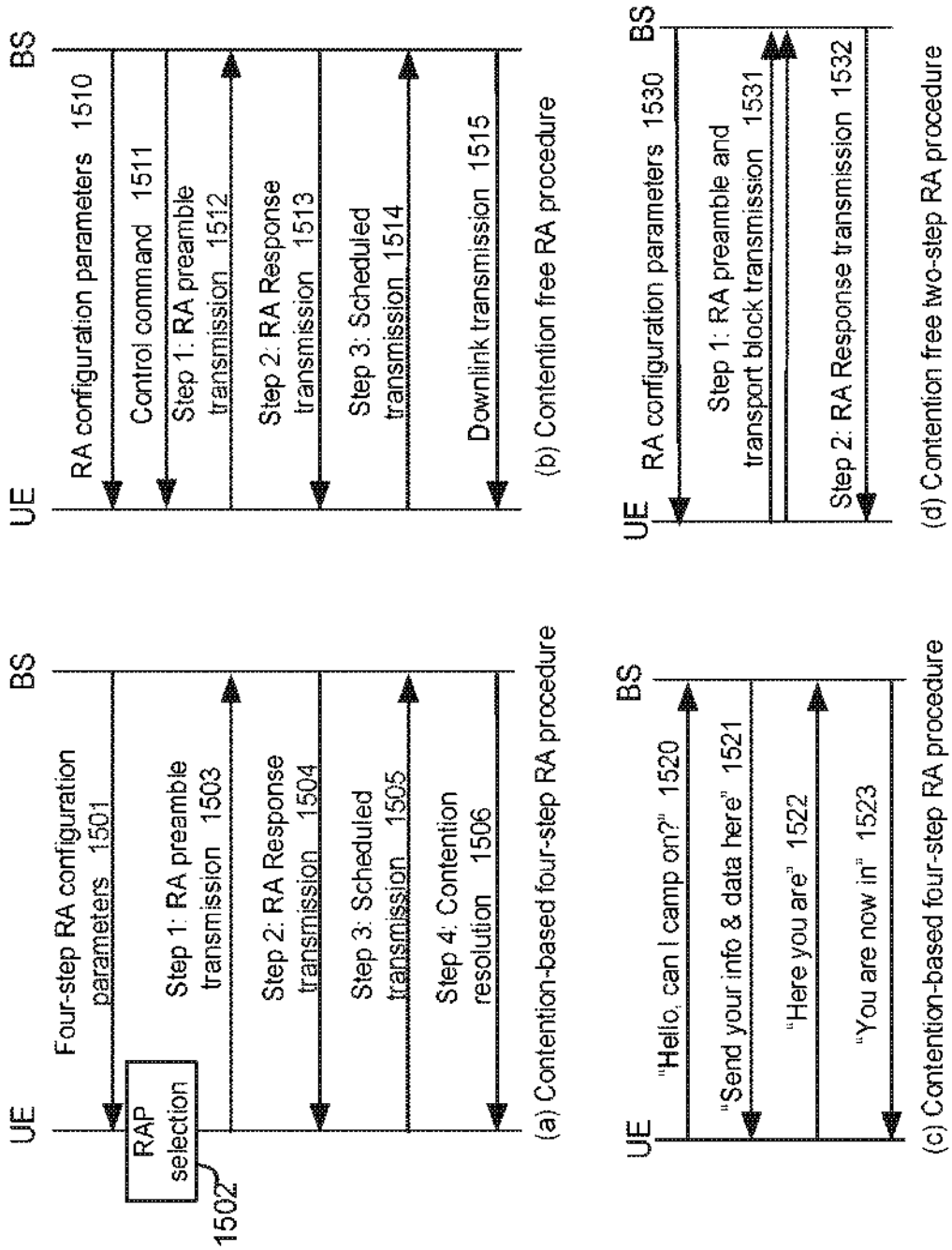

UE
BS
Four-step RA configuration parameters 1501
RAP selection
1502
Step 1: RA preamble transmission 1503
Step 2: RA Response transmission 1504
Step 3: Scheduled transmission 1505
Step 4: Contention resolution 1506
(a) Contention-based four-step RA procedure
UE
BS
RA configuration parameters 1510
Control command 1511
Step 1: RA preamble transmission 1512
Step 2: RA Response transmission 1513
Step 3: Scheduled transmission 1514
Downlink transmission 1515
(b) Contention free RA procedure
UE
BS
"Hello, can I camp on?" 1520
"Send your info & data here" 1521
"Here you are" 1522
"You are now in" 1523
(c) Contention-based four-step RA procedure
UE
BS
RA configuration parameters 1530
Step 1: RA preamble and transport block transmission 1531
Step 2: RA Response transmission 1532
(d) Contention free two-step RA procedure

FIG. 15

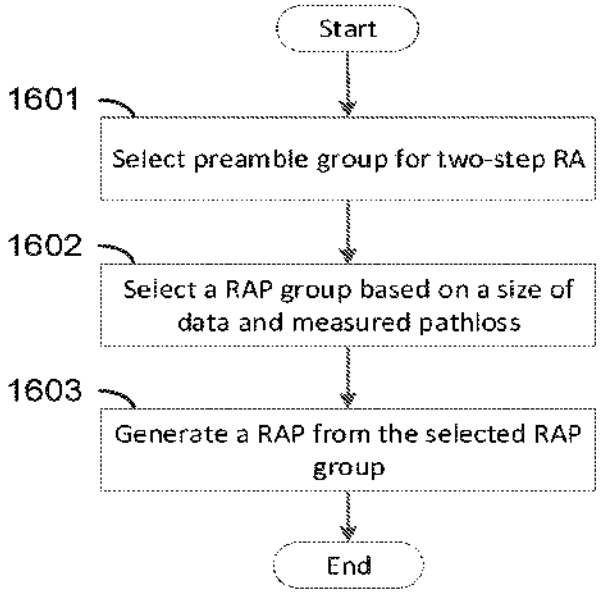

Start
1601
Select preamble group for two-step RA
1602
Select a RAP group based on a size of data and measured pathloss
1603
Generate a RAP from the selected RAP group
End

FIG. 16

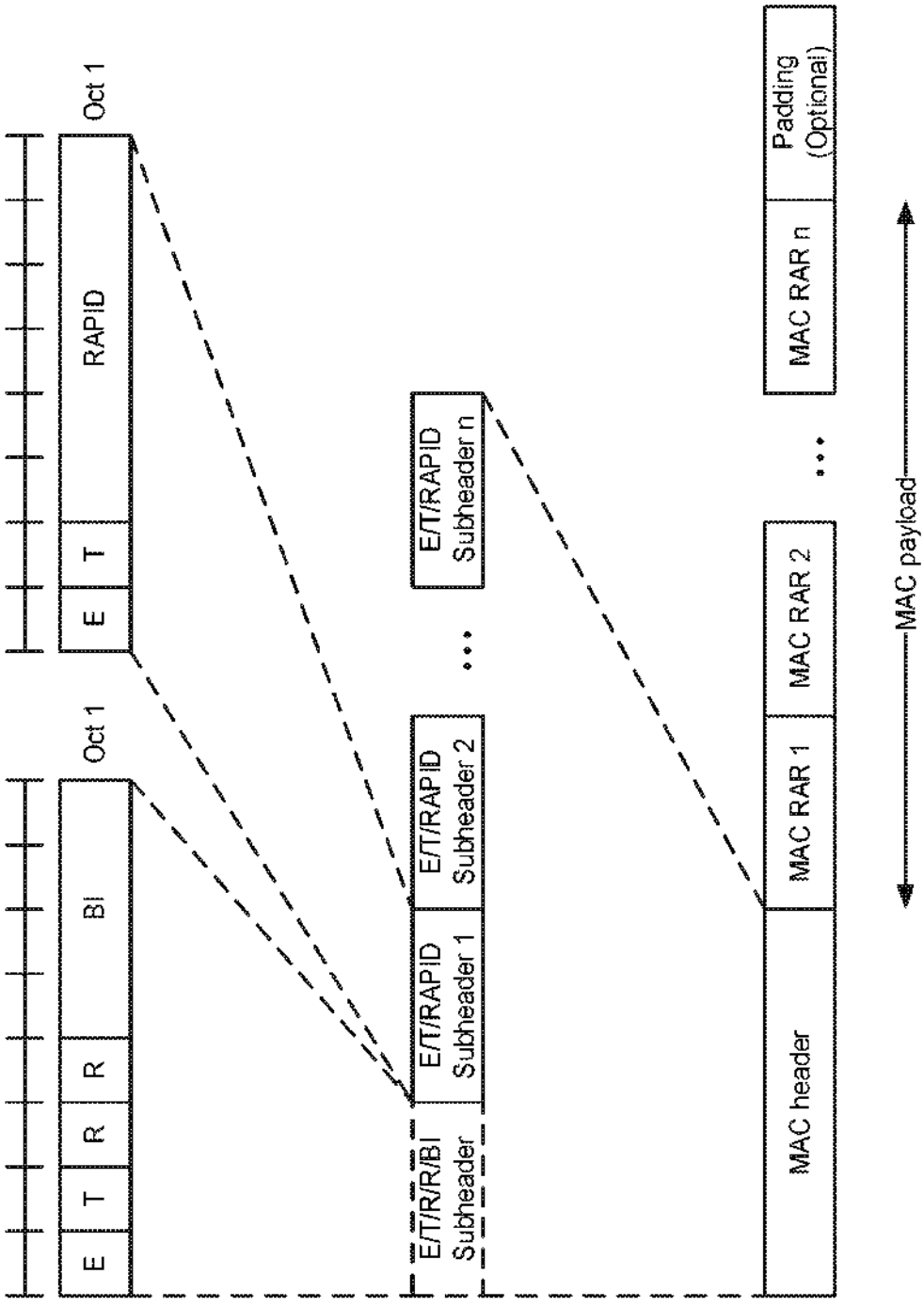

E
T
R
R
BI
Oct 1
E
T
RAPID
Oct 1
E/T/R/R/BI Subheader
E/T/RAPID Subheader 1
E/T/RAPID Subheader 2
E/T/RAPID Subheader n
MAC header
MAC RAR 1
MAC RAR 2
MAC RAR n
Padding (Optional)
MAC payload

FIG. 17

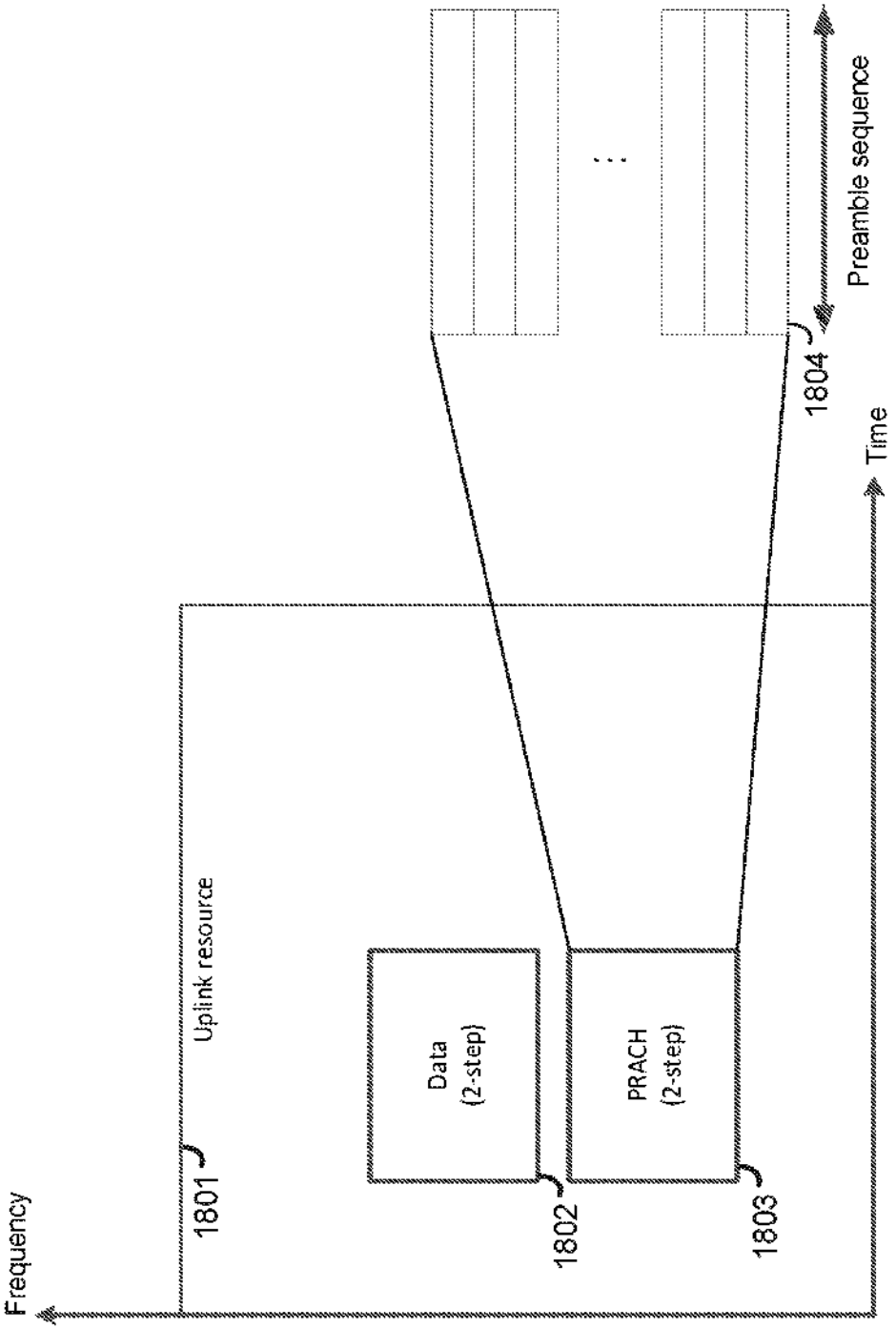

Frequency
Uplink resource
1801
Data
(2-step)
1802
PRACH
(2-step)
1803
Time
1804
Preamble sequence

FIG. 18

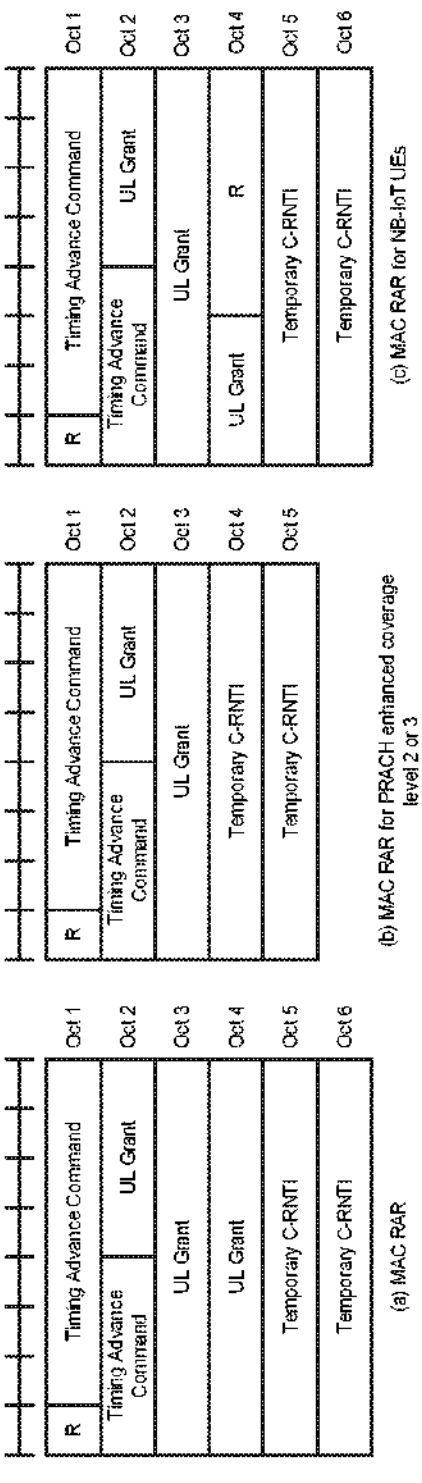

R
Timing Advance Command
Timing Advance Command
UL Grant
UL Grant
UL Grant
Temporary C-RNTI
Temporary C-RNTI
Oct 1
Oct 2
Oct 3
Oct 4
Oct 5
Oct 6
(a) MAC RAR
(b) MAC RAR for PRACH enhanced coverage level 2 or 3
(c) MAC RAR for NB-IoT UEs

FIG. 19

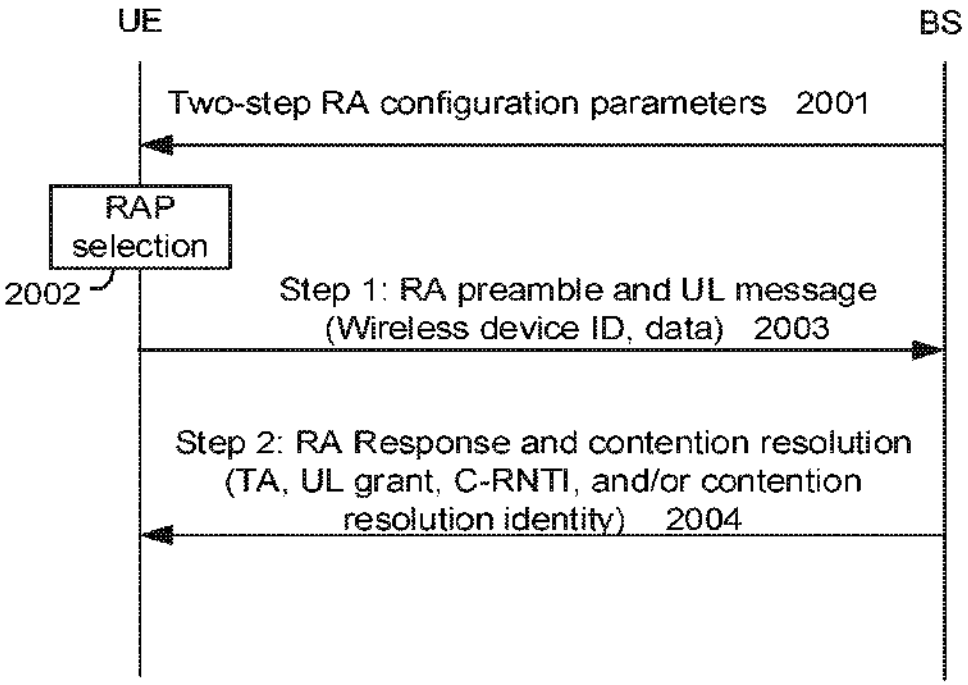

UE
BS
Two-step RA configuration parameters 2001
RAP selection
2002
Step 1: RA preamble and UL message (Wireless device ID, data) 2003
Step 2: RA Response and contention resolution (TA, UL grant, C-RNTI, and/or contention resolution identity) 2004

FIG. 20

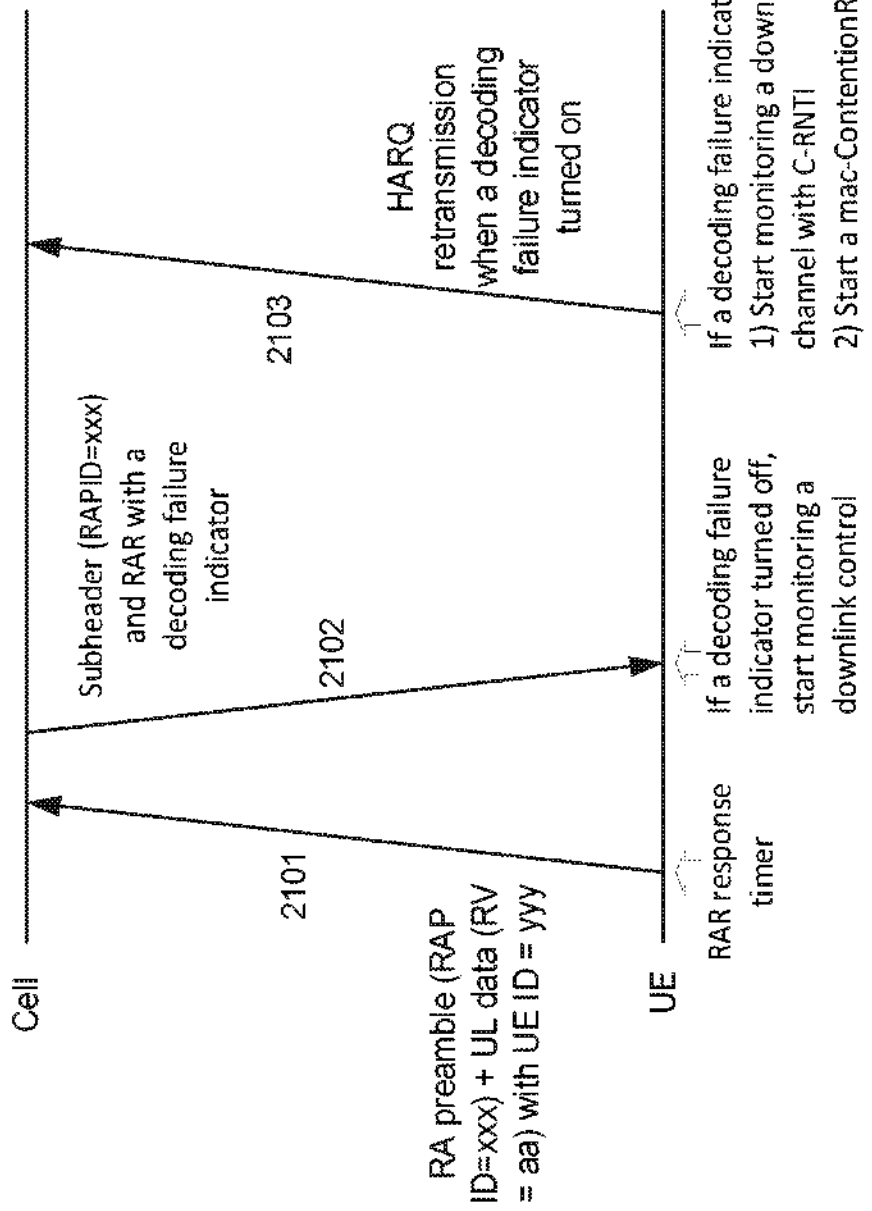

Cell
UE
2101
RA preamble (RAP ID=xxx) + UL data (RV = aa) with UE ID = yyy
RAR response timer
2102
Subheader (RAPID=xxx) and RAR with a decoding failure indicator
If a decoding failure indicator turned off, start monitoring a downlink control channel with C-RNTI
2103
HARQ retransmission when a decoding failure indicator turned on
If a decoding failure indicator turned on,
1) Start monitoring a downlink control channel with C-RNTI
2) Start a mac-ContentionResolutionTimer

FIG. 21

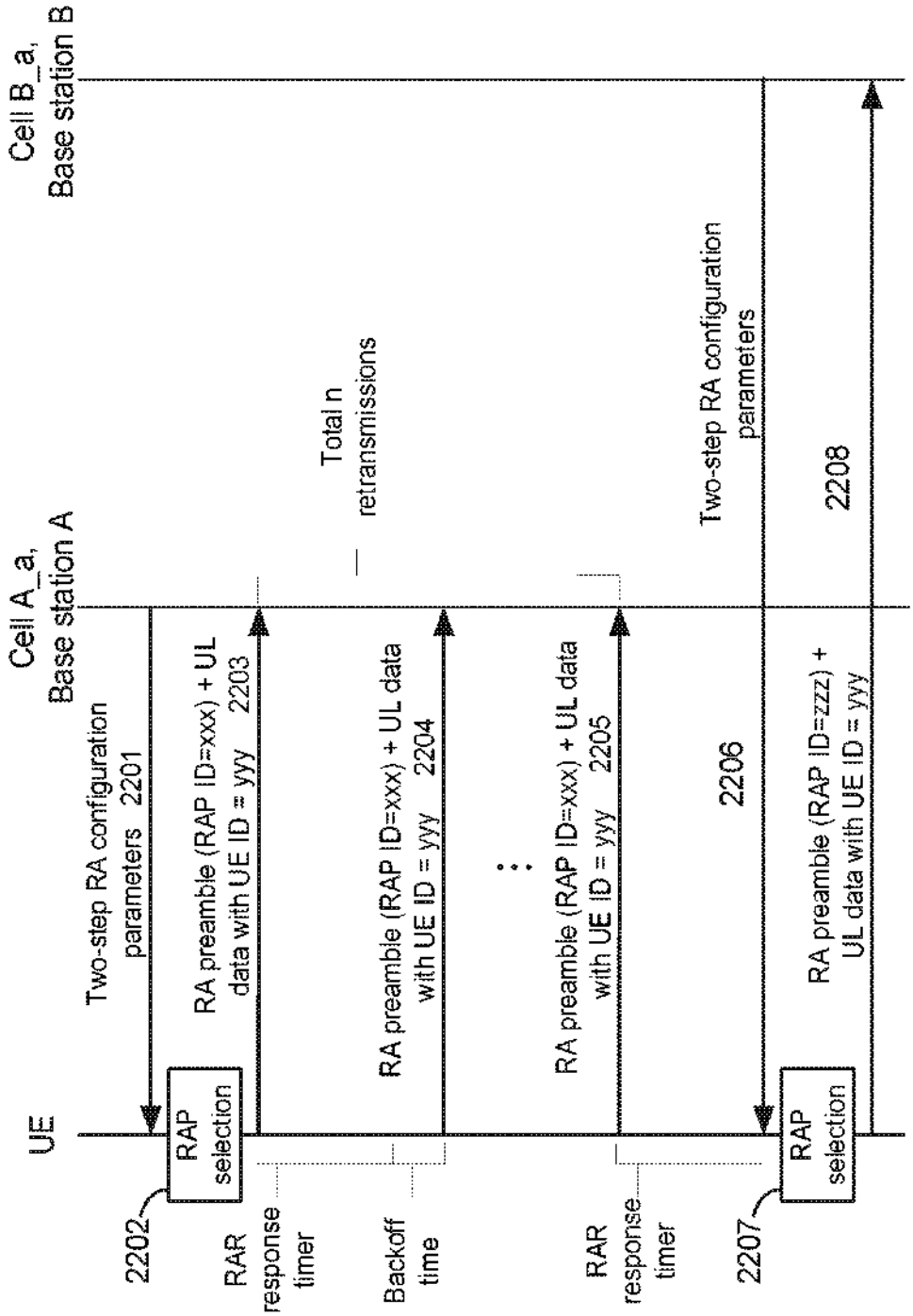

UE
Cell A_a,
Base station A
Cell B_a,
Base station B
Two-step RA configuration parameters 2201
RAP selection
2202
RA preamble (RAP ID=xx) + UL data with UE ID = yyy 2203
RAR response timer
Backoff time
RA preamble (RAP ID=xxx) + UL data with UE ID = yyy 2204
RA preamble (RAP ID=xxx) + UL data with UE ID = yyy 2205
Total n retransmissions
2206
Two-step RA configuration parameters
2208
RAP selection
2207
RA preamble (RAP ID=zzz) + UL data with UE ID = yyy

FIG. 22

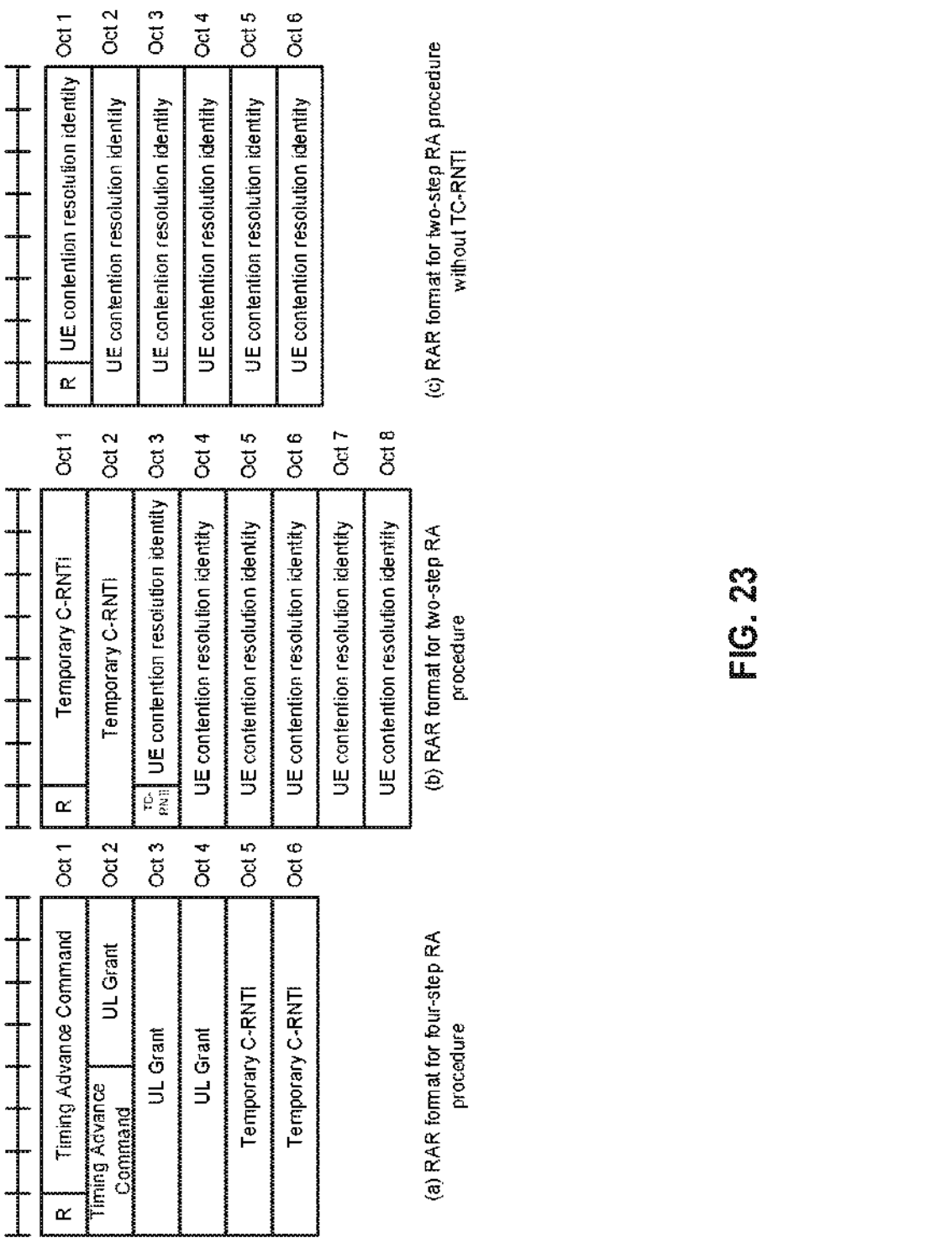

R
Timing Advance Command
Timing Advance Command
UL Grant
UL Grant
UL Grant
Temporary C-RNTI
Temporary C-RNTI
Oct 1
Oct 2
Oct 3
Oct 4
Oct 5
Oct 6
(a) RAR format for four-step RA procedure
R
Temporary C-RNTI
Temporary C-RNTI
TC-RNTI
UE contention resolution identity
UE contention resolution identity
UE contention resolution identity
UE contention resolution identity
UE contention resolution identity
UE contention resolution identity
Oct 1
Oct 2
Oct 3
Oct 4
Oct 5
Oct 6
Oct 7
Oct 8
(b) RAR format for two-step RA procedure
R
UE contention resolution identity
UE contention resolution identity
UE contention resolution identity
UE contention resolution identity
UE contention resolution identity
UE contention resolution identity
Oct 1
Oct 2
Oct 3
Oct 4
Oct 5
Oct 6
(c) RAR format for two-step RA procedure without TC-RNTI

FIG. 23

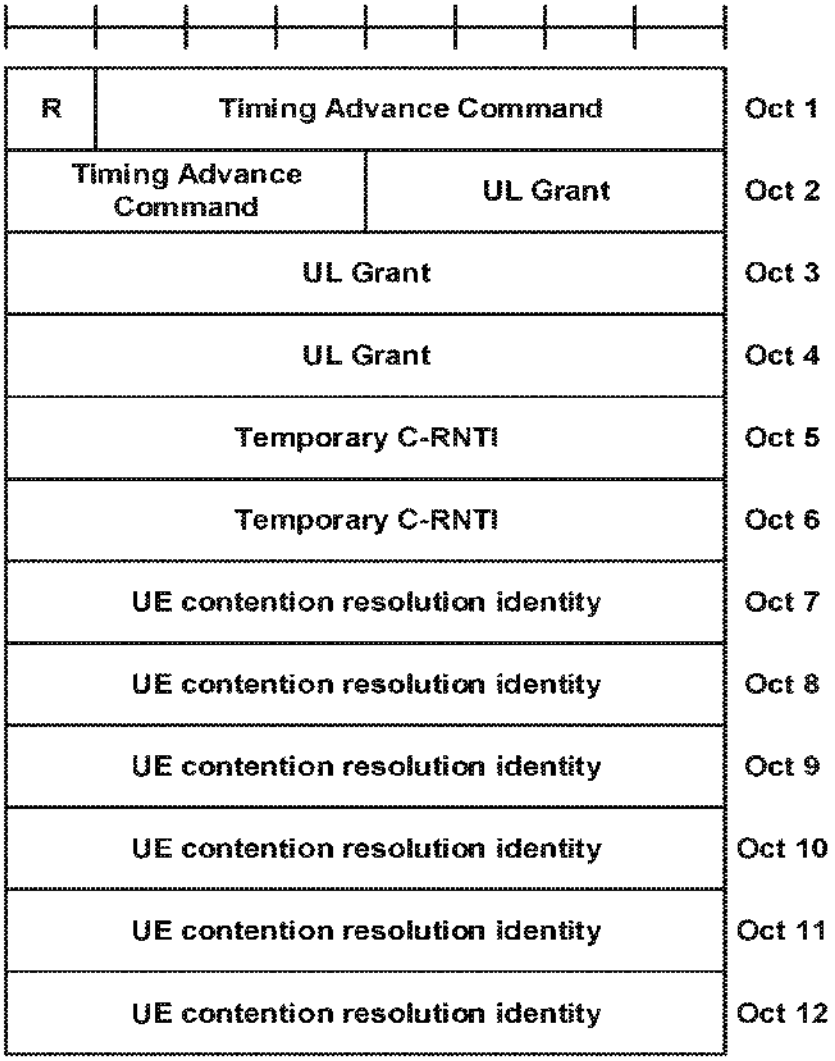

R
Timing Advance Command
Oct 1
Timing Advance Command
UL Grant
Oct 2
UL Grant
Oct 3
UL Grant
Oct 4
Temporary C-RNTI
Oct 5
Temporary C-RNTI
Oct 6
UE contention resolution identity
Oct 7
UE contention resolution identity
Oct 8
UE contention resolution identity
Oct 9
UE contention resolution identity
Oct 10
UE contention resolution identity
Oct 11
UE contention resolution identity
Oct 12

FIG. 24

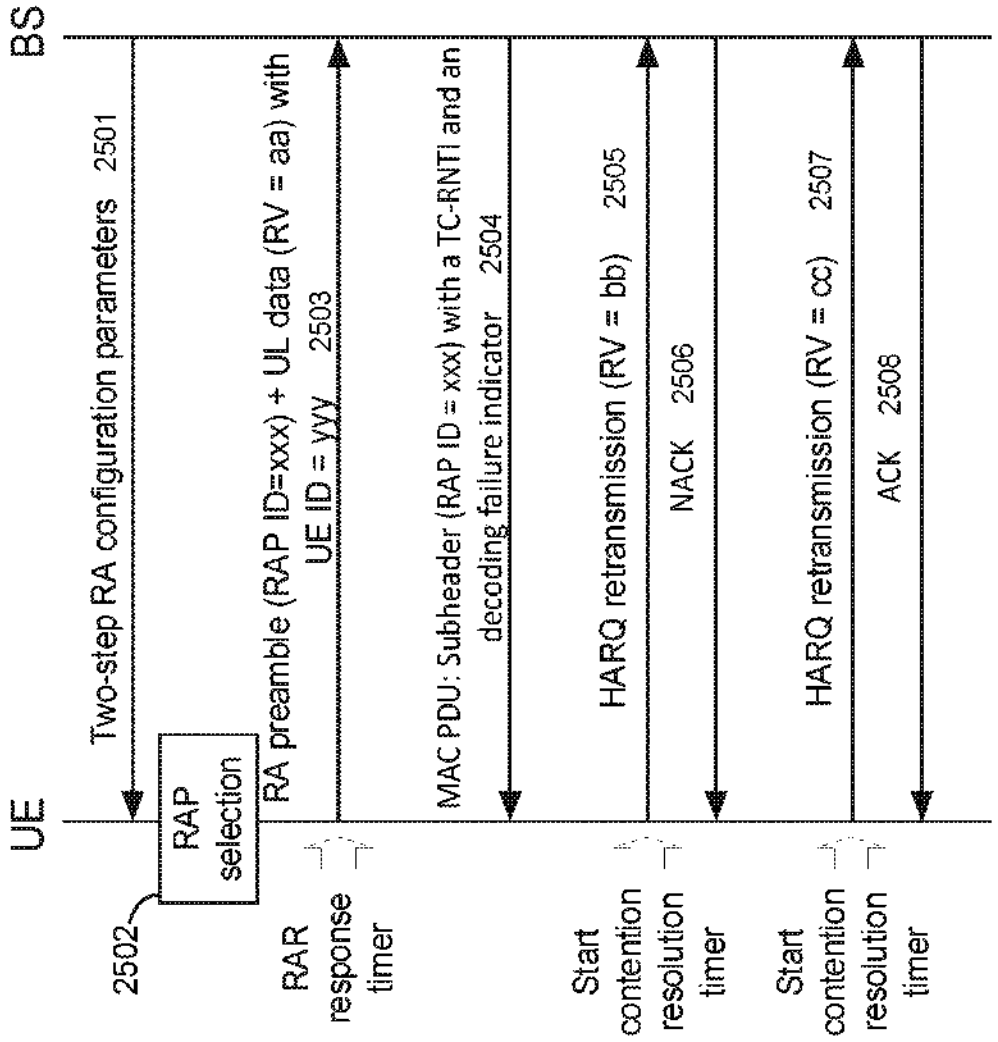

UE
BS
Two-step RA configuration parameters 2501
RAP selection
2502
RA preamble (RAP ID=xxx) + UL data (RV = aa) with UE ID = yyy 2503
RAR response timer
MAC PDU: Subheader (RAP ID = xxx) with a TC-RNTI and an decoding failure indicator 2504
HARQ retransmission (RV = bb) 2505
Start contention resolution timer
NACK 2506
HARQ retransmission (RV = cc) 2507
Start contention resolution timer
ACK 2508

FIG. 25

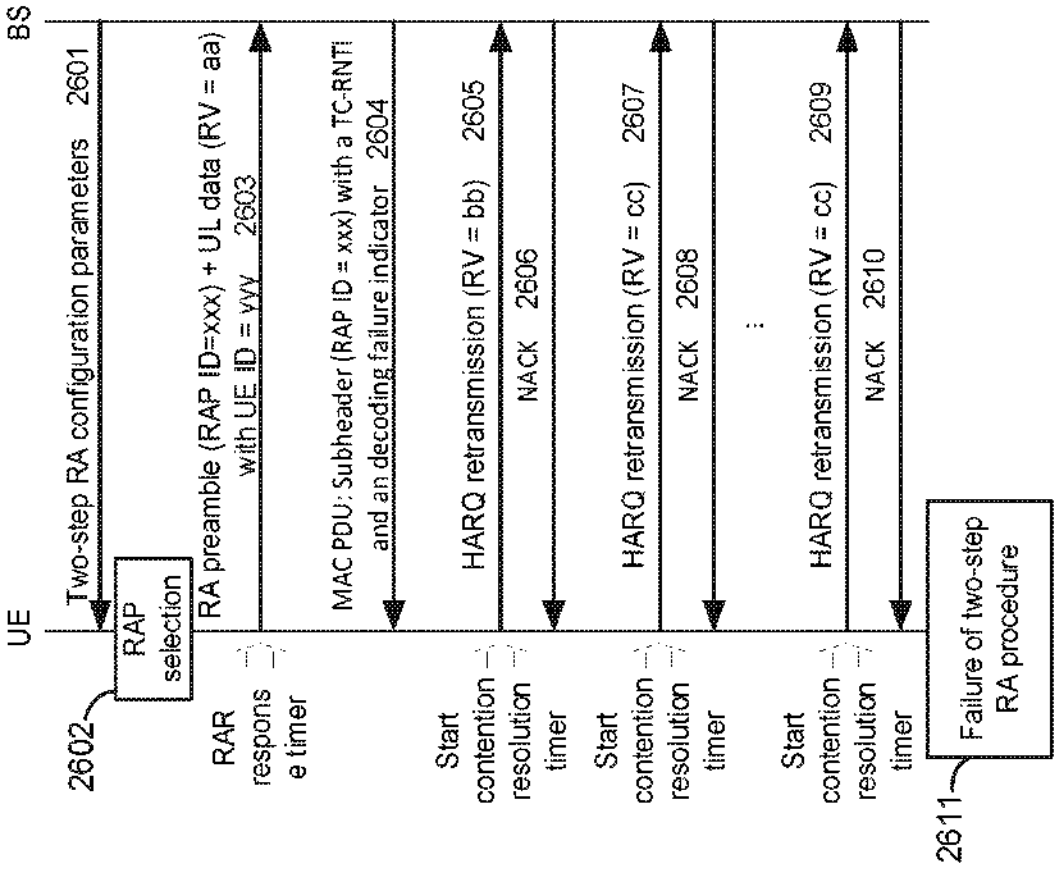

UE
BS
Two-step RA configuration parameters 2601
2602
RAP selection
RA preamble (RAP ID=xxx) + UL data (RV = aa) with UE ID = yyy 2603
RAR respons e timer
MAC PDU: Subheader (RAP ID = xxx) with a TC-RNTI and an decoding failure indicator 2604
HARQ retransmission (RV = bb) 2605
Start contention resolution timer
NACK 2606
HARQ retransmission (RV = cc) 2607
Start contention resolution timer
NACK 2608
HARQ retransmission (RV = cc) 2609
Start contention resolution timer
NACK 2610
Total n (=maxHARQ-Msg3Tx) retransmissions
2611
Failure of two-step RA procedure

FIG. 26

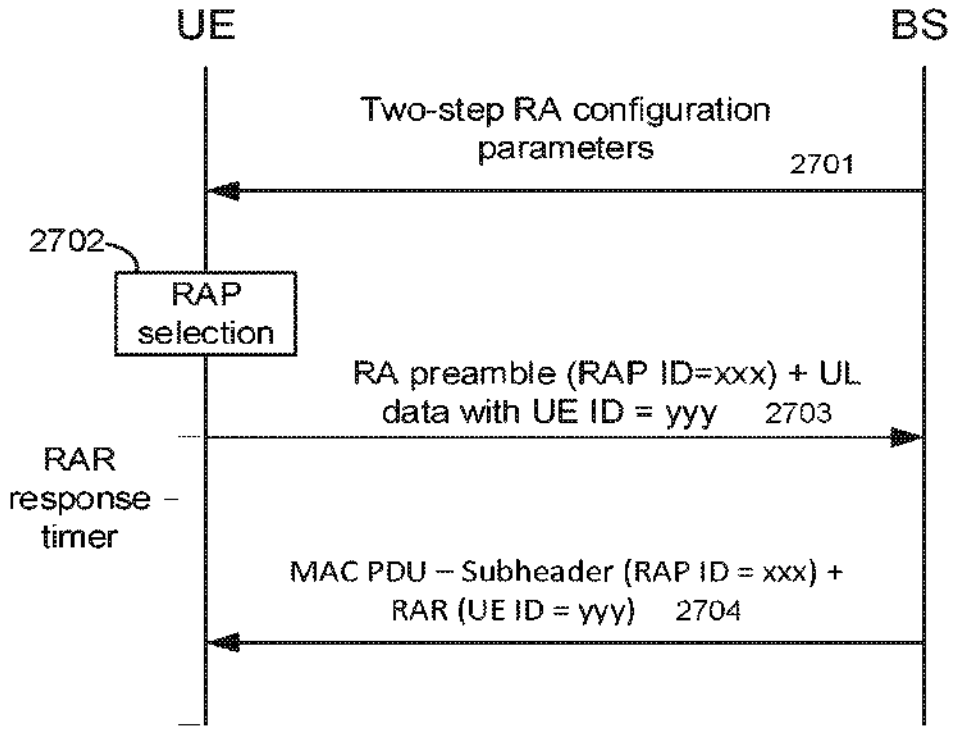

UE
BS
Two-step RA configuration parameters
2701
2702
RAP selection
RA preamble (RAP ID=xxx) + UL data with UE ID = yyy
2703
RAR response timer
MAC PDU – Subheader (RAP ID = xxx) + RAR (UE ID = yyy)
2704

FIG. 27

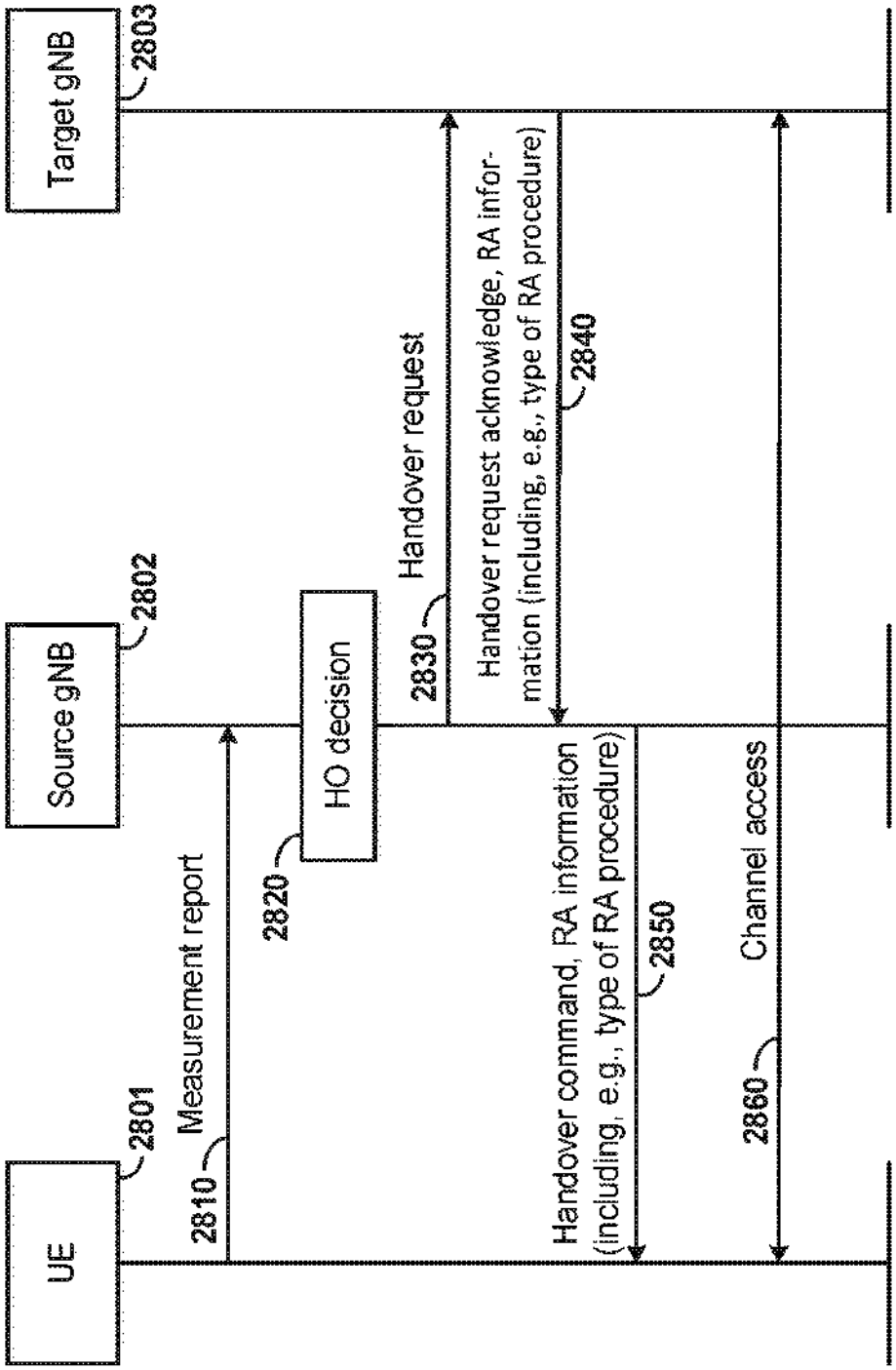

UE
2801
Source gNB
2802
Target gNB
2803
Measurement report
2810
HO decision
2820
Handover request
2830
Handover request acknowledge, RA information (including, e.g., type of RA procedure)
2840
Handover command, RA information (including, e.g., type of RA procedure)
2850
Channel access
2860

FIG. 28

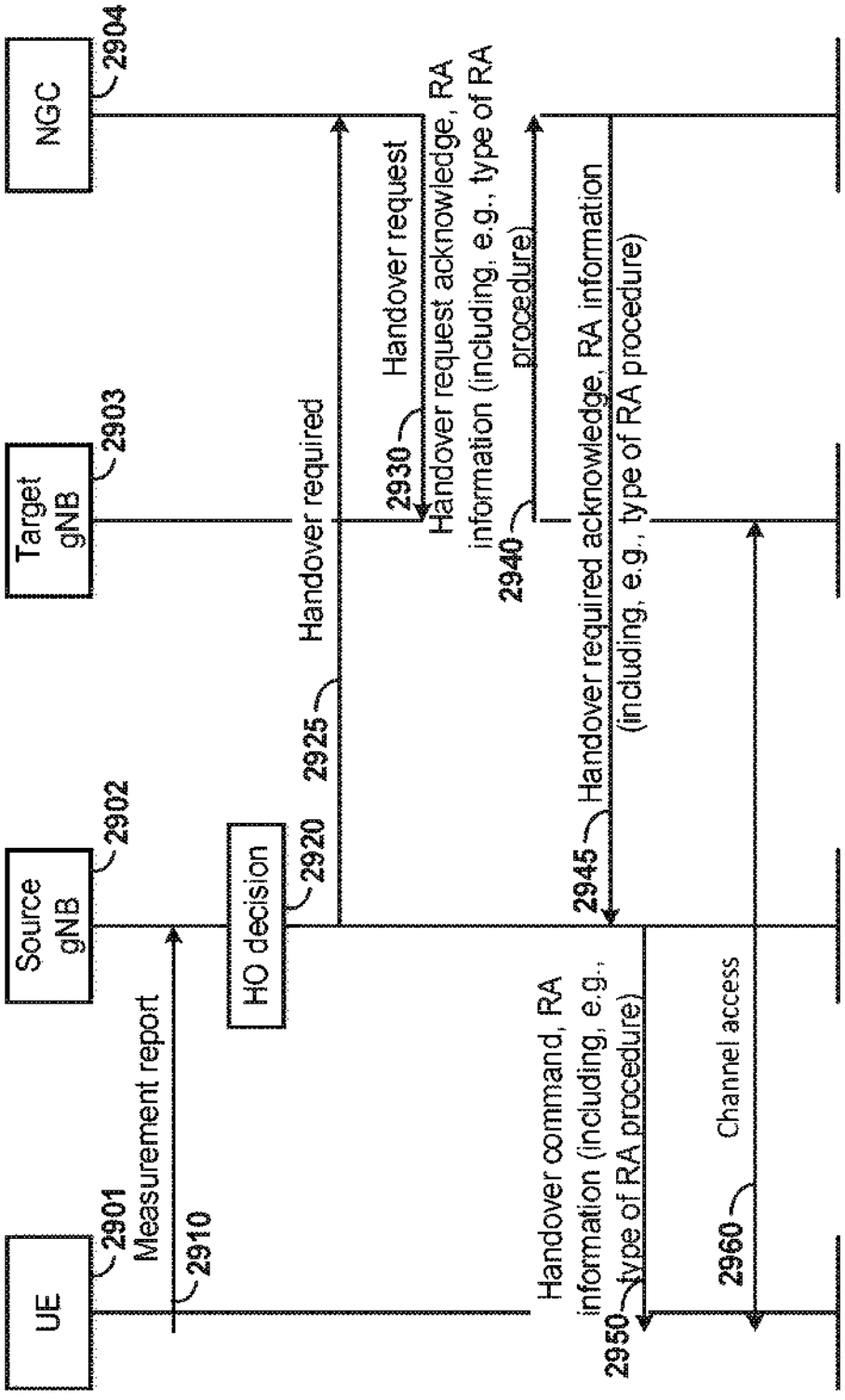

UE
2901
Source gNB
2902
Target gNB
2903
NGC
2904
Measurement report
2910
HO decision
2920
Handover required
2925
Handover request
2930
Handover request acknowledge, RA information (including, e.g., type of RA procedure)
2940
Handover required acknowledge, RA information (including, e.g., type of RA procedure)
2945
Handover command, RA information (including, e.g., type of RA procedure)
2950
Channel access
2960

FIG. 29

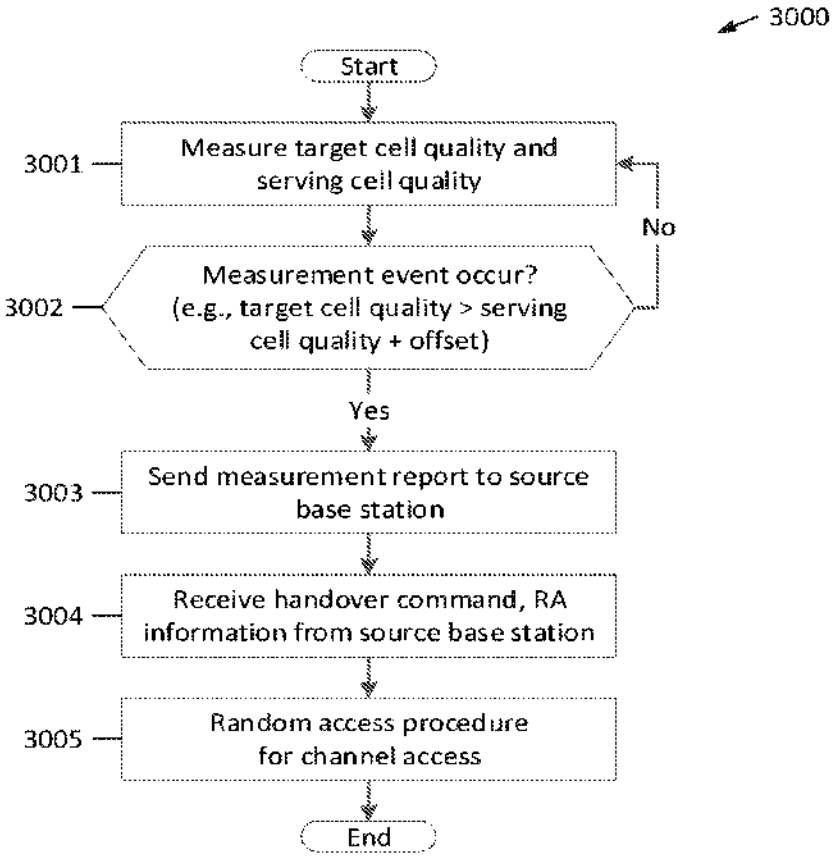

3000
Start
3001
Measure target cell quality and serving cell quality
No
3002
Measurement event occur? (e.g., target cell quality > serving cell quality + offset)
Yes
3003
Send measurement report to source base station
3004
Receive handover command, RA information from source base station
3005
Random access procedure for channel access
End

FIG. 30

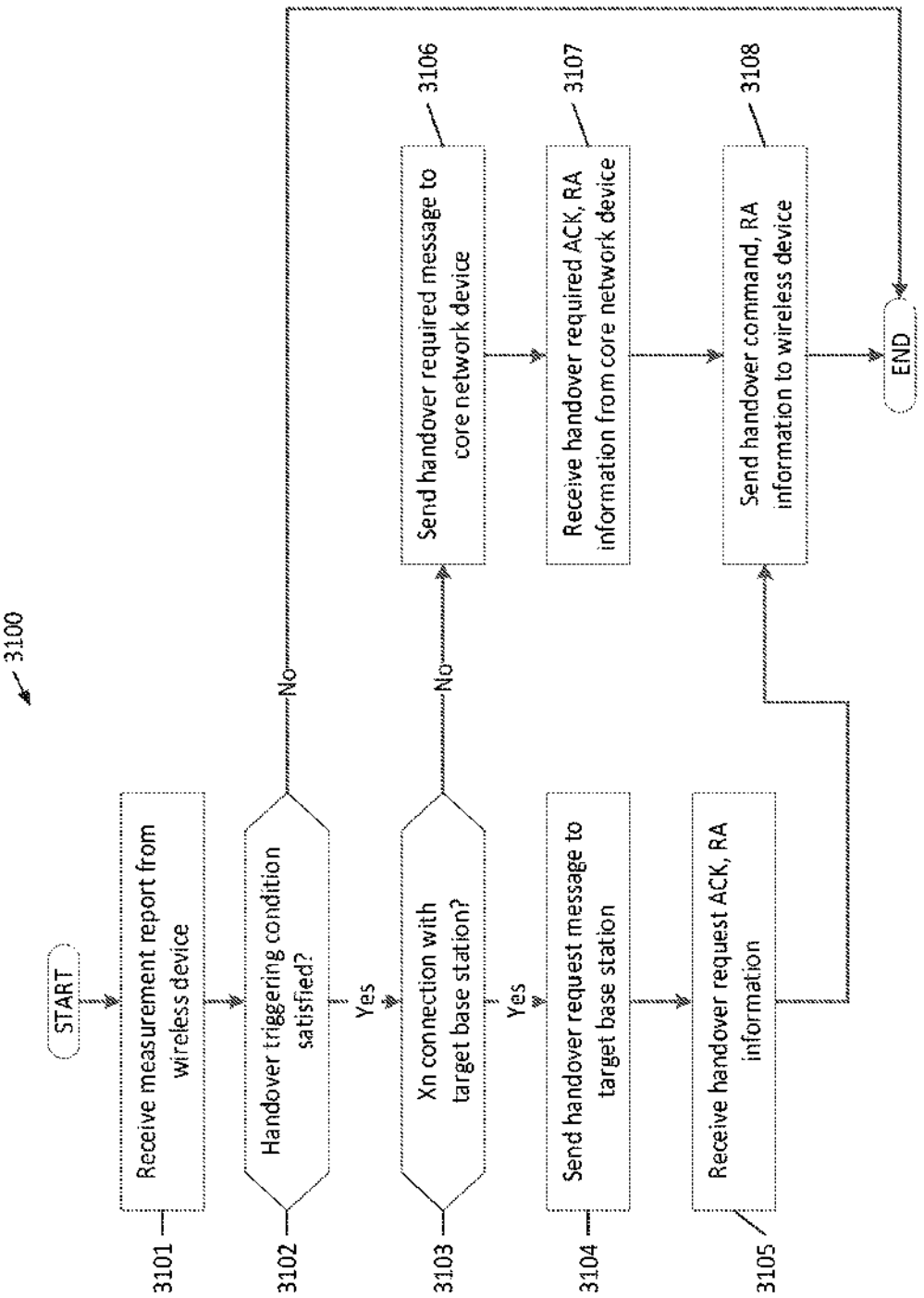

3100
START
Receive measurement report from wireless device
3101
Handover triggering condition satisfied?
3102
No
Yes
Xn connection with target base station?
3103
No
Yes
Send handover required message to core network device
3106
Receive handover required ACK, RA information from core network device
3107
Send handover command, RA information to wireless device
3108
END
Send handover request message to target base station
3104
Receive handover request ACK, RA information
3105

FIG. 31

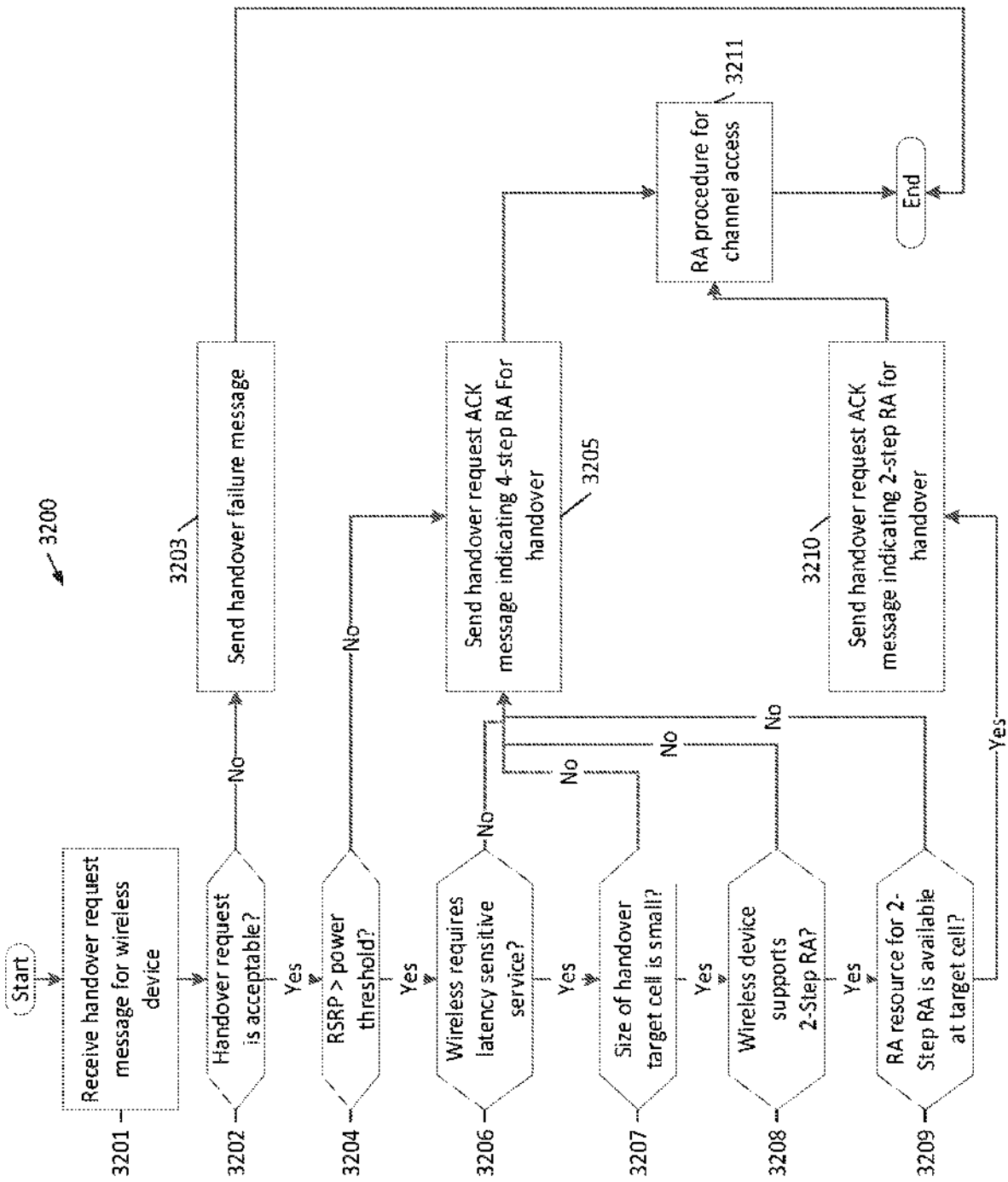

3200
Start
Receive handover request message for wireless device
3201
Handover request is acceptable?
3202
No
Send handover failure message
3203
Yes
RSRP > power threshold?
3204
No
Send handover request ACK message indicating 4-step RA For handover
3205
Yes
Wireless requires latency sensitive service?
3206
No
Yes
Size of handover target cell is small?
3207
No
Yes
Wireless device supports 2-Step RA?
3208
No
Yes
RA resource for 2-Step RA is available at target cell?
3209
No
Yes
Send handover request ACK message indicating 2-step RA for handover
3210
RA procedure for channel access
3211
End

FIG. 32

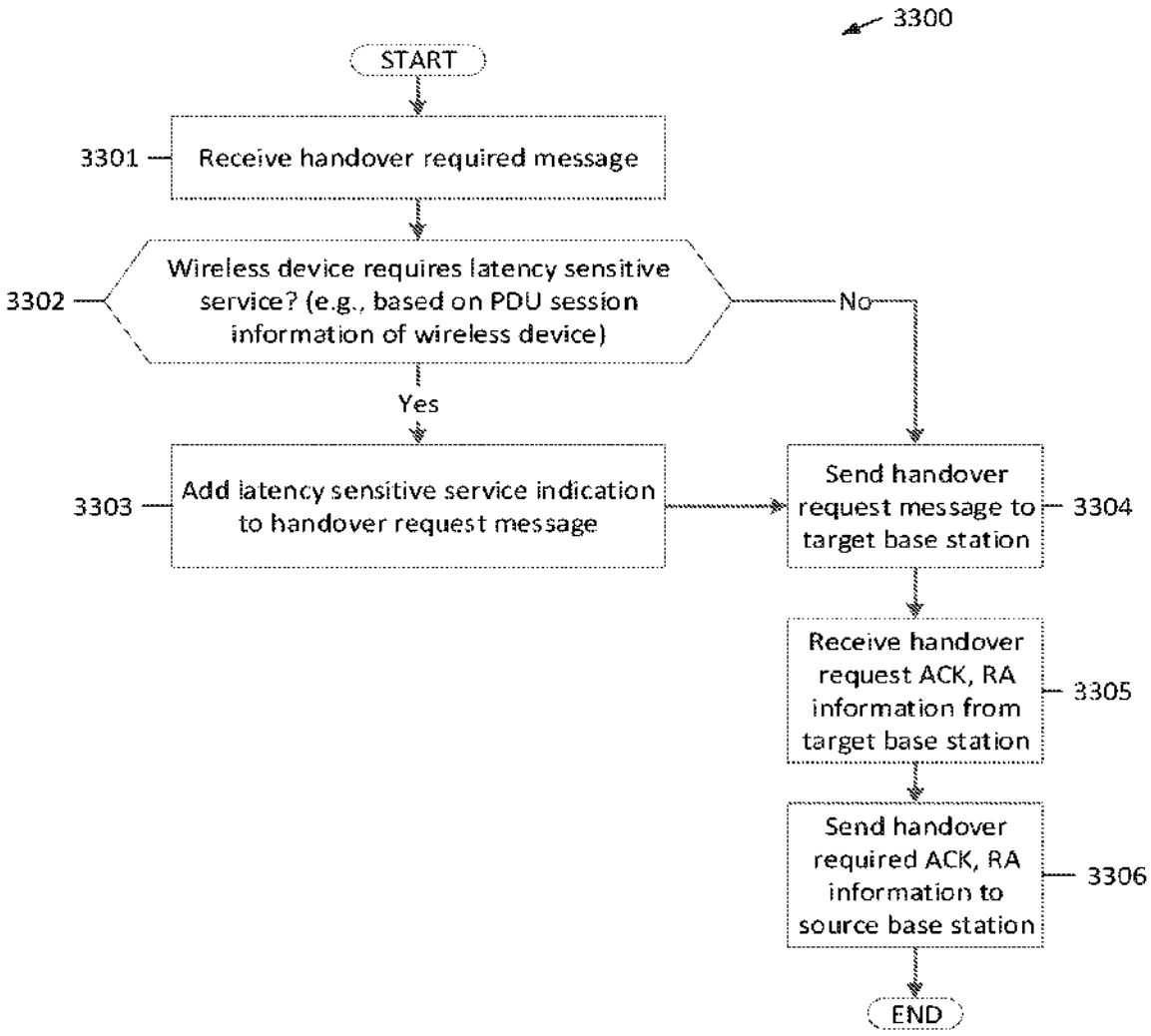

3300
START
3301
Receive handover required message
3302
Wireless device requires latency sensitive service? (e.g., based on PDU session information of wireless device)
No
Yes
3303
Add latency sensitive service indication to handover request message
Send handover request message to target base station
3304
Receive handover request ACK, RA information from target base station
3305
Send handover required ACK, RA information to source base station
3306
END

FIG. 33

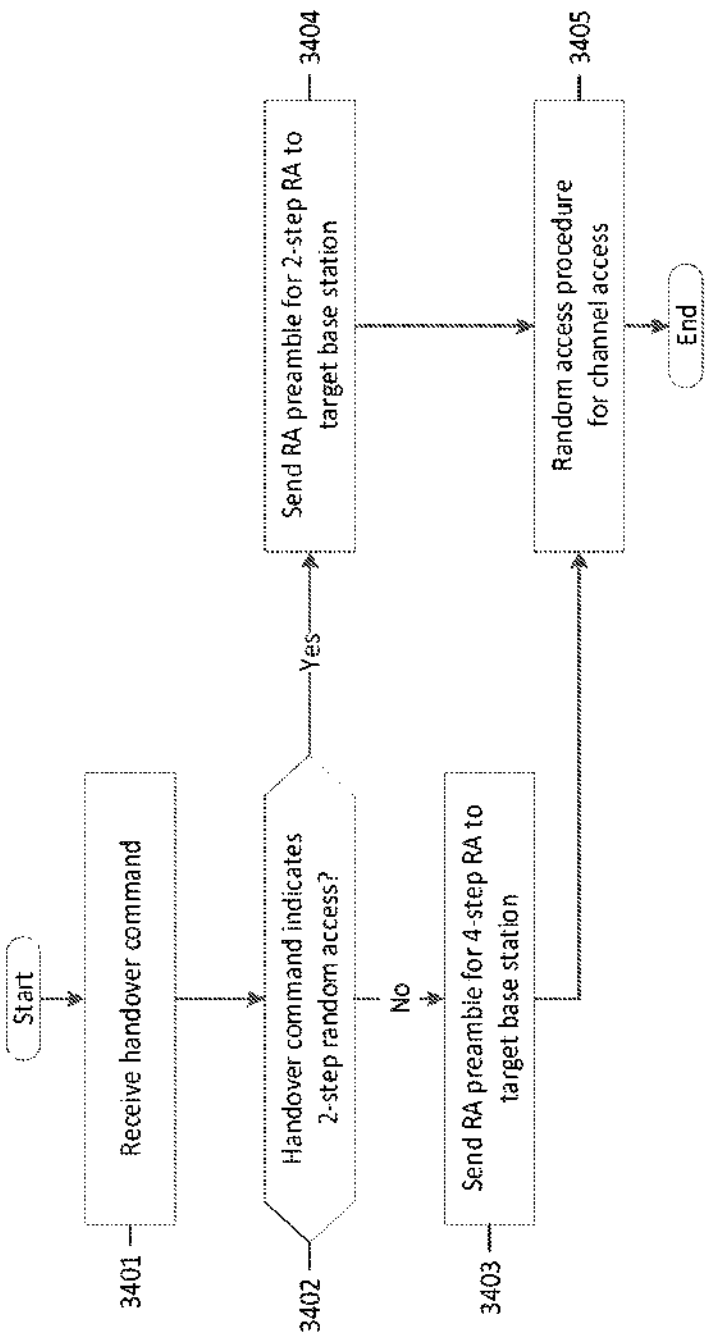

3400
Start
Receive handover command
3401
Handover command indicates 2-step random access?
3402
Yes
No
Send RA preamble for 2-step RA to target base station
3404
Send RA preamble for 4-step RA to target base station
3403
Random access procedure for channel access
3405
End

FIG. 34

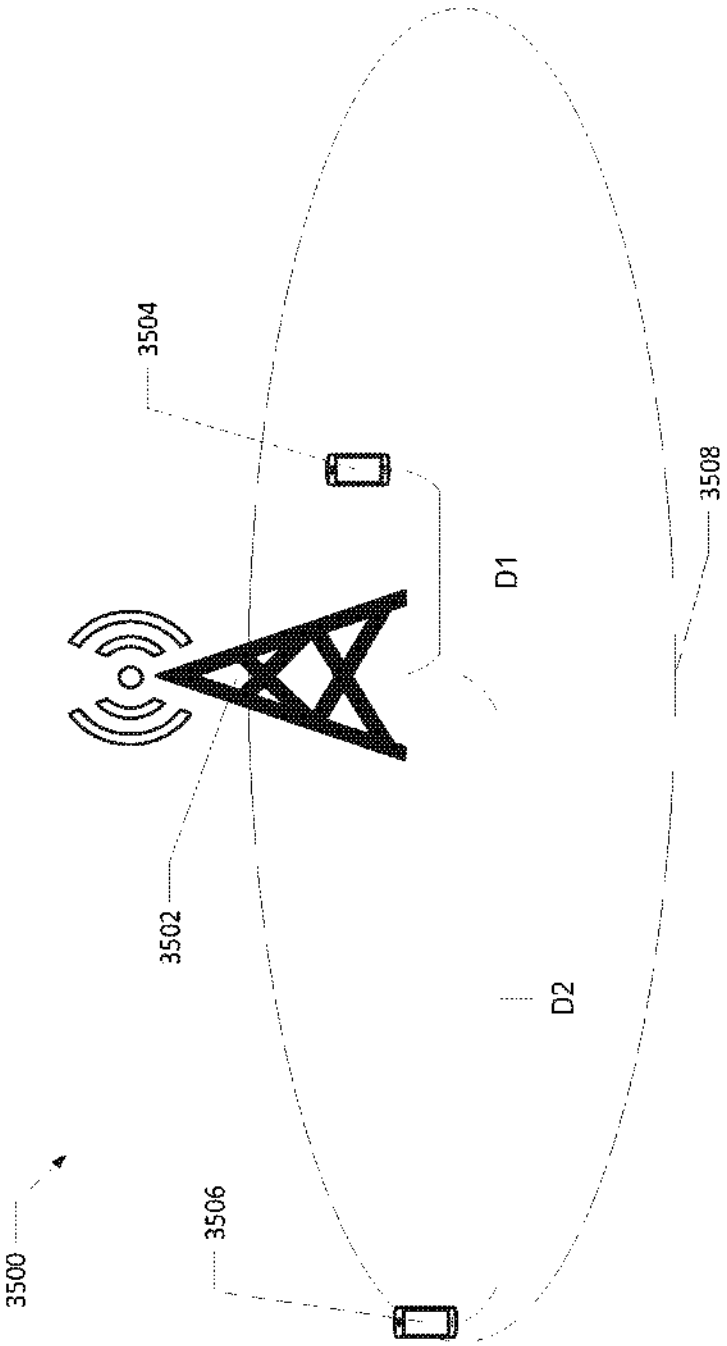


FIG. 35

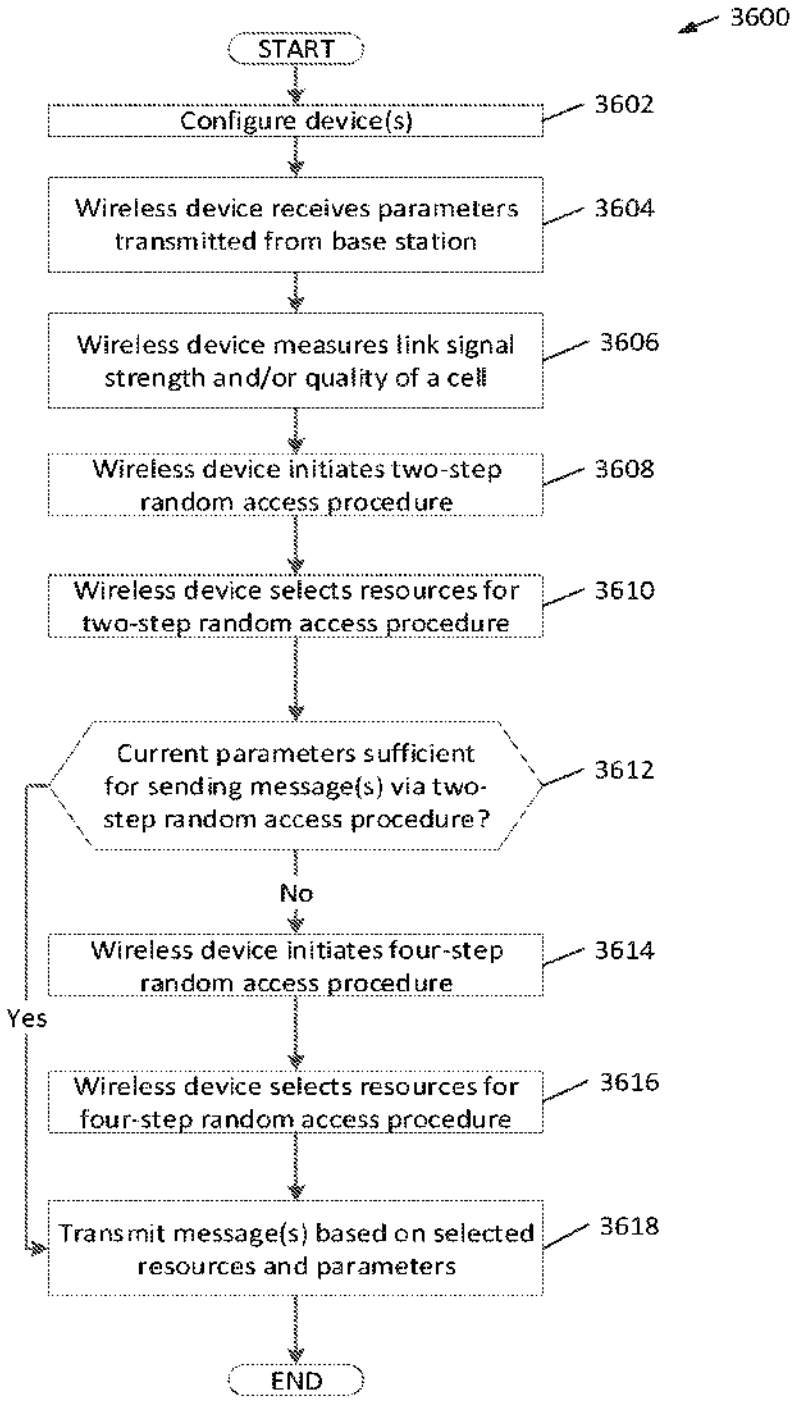

3600
START
Configure device(s)
3602
Wireless device receives parameters transmitted from base station
3604
Wireless device measures link signal strength and/or quality of a cell
3606
Wireless device initiates two-step random access procedure
3608
Wireless device selects resources for two-step random access procedure
3610
Current parameters sufficient for sending message(s) via two-step random access procedure?
3612
No
Yes
Wireless device initiates four-step random access procedure
3614
Wireless device selects resources for four-step random access procedure
3616
Transmit message(s) based on selected resources and parameters
3618
END

FIG. 36

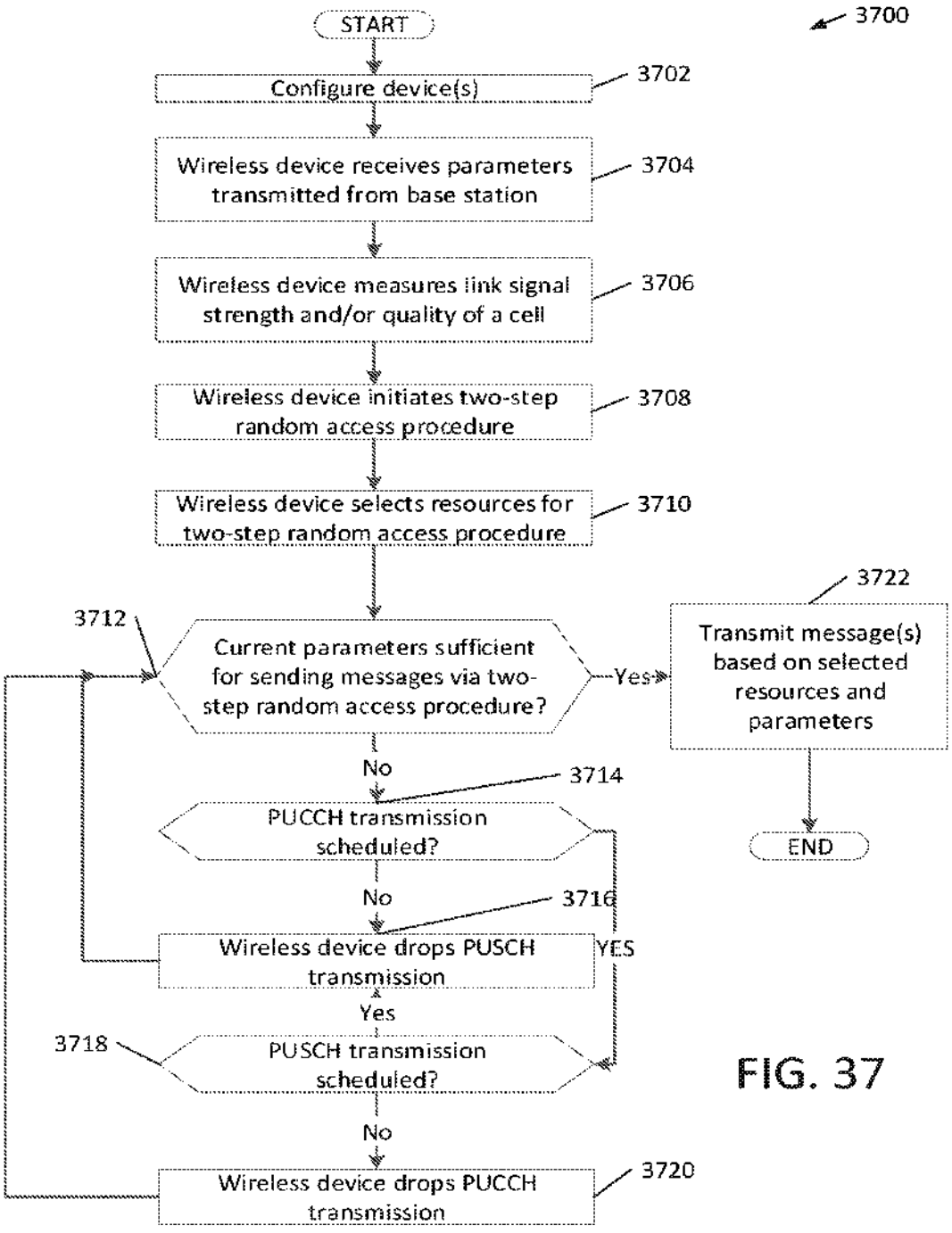

3700
START
Configure device(s)
3702
Wireless device receives parameters transmitted from base station
3704
Wireless device measures link signal strength and/or quality of a cell
3706
Wireless device initiates two-step random access procedure
3708
Wireless device selects resources for two-step random access procedure
3710
3712
Current parameters sufficient for sending messages via two-step random access procedure?
Yes
3722
Transmit message(s) based on selected resources and parameters
END
No
3714
PUCCH transmission scheduled?
No
3716
Wireless device drops PUSCH transmission
YES
Yes
3718
PUSCH transmission scheduled?
No
Wireless device drops PUCCH transmission
3720

FIG. 37

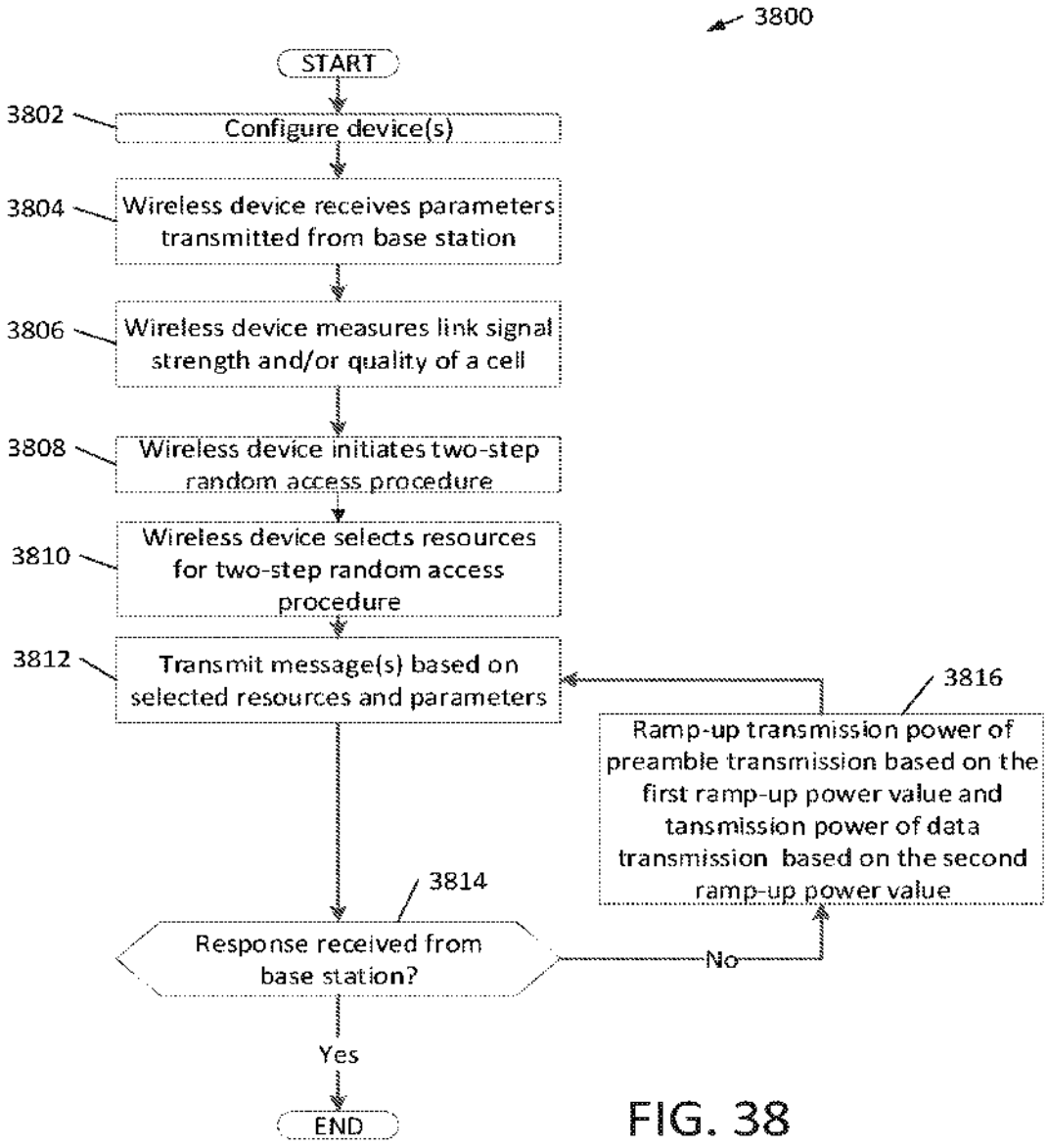

3800
START
3802
Configure device(s)
3804
Wireless device receives parameters transmitted from base station
3806
Wireless device measures link signal strength and/or quality of a cell
3808
Wireless device initiates two-step random access procedure
3810
Wireless device selects resources for two-step random access procedure
3812
Transmit message(s) based on selected resources and parameters
3816
Ramp-up transmission power of preamble transmission based on the first ramp-up power value and tansmission power of data transmission based on the second ramp-up power value
3814
Response received from base station?
No
Yes
END

FIG. 38

39/39

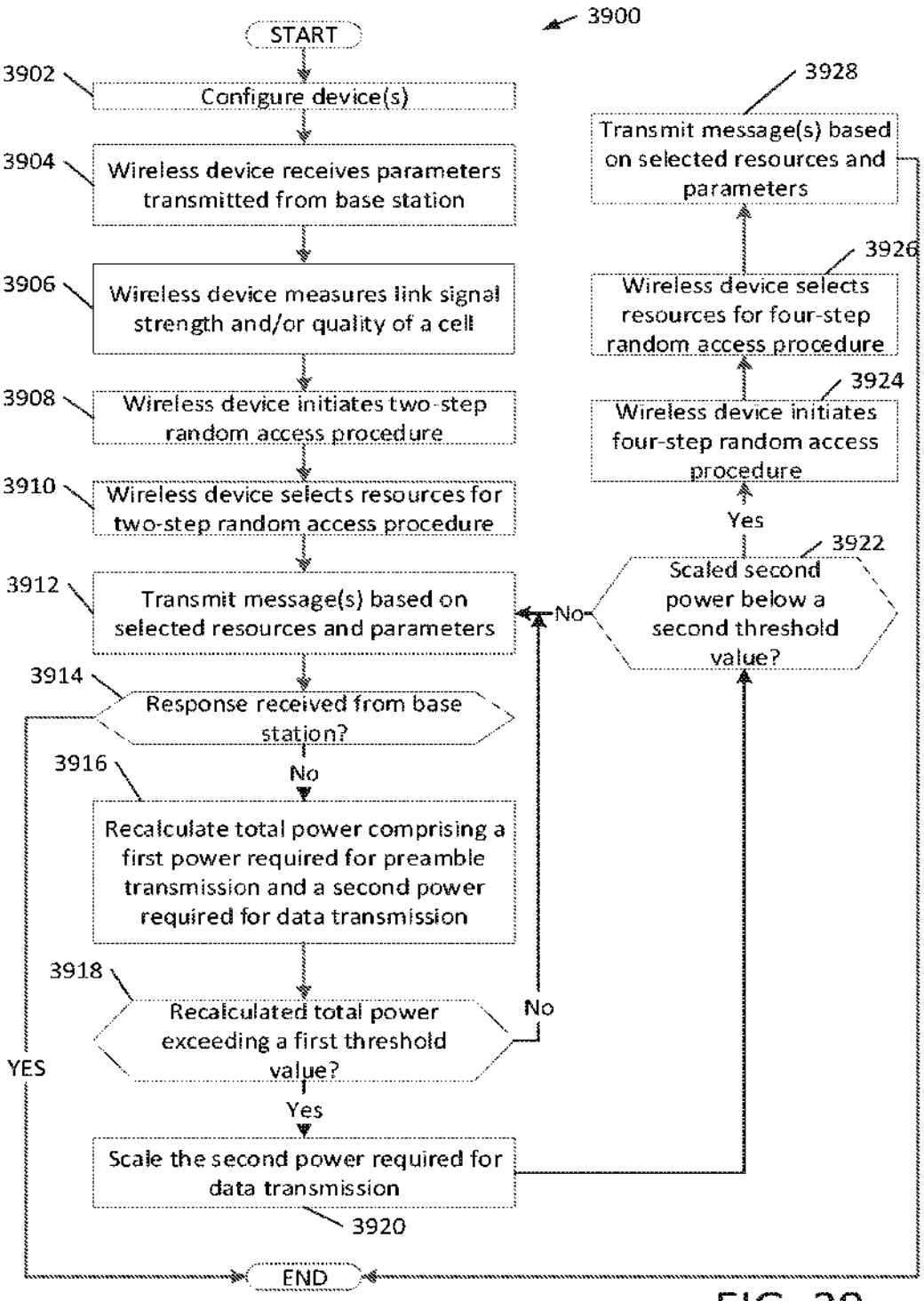

3900
START
3902
Configure device(s)
3904
Wireless device receives parameters transmitted from base station
3906
Wireless device measures link signal strength and/or quality of a cell
3908
Wireless device initiates two-step random access procedure
3910
Wireless device selects resources for two-step random access procedure
3912
Transmit message(s) based on selected resources and parameters
3914
Response received from base station?
No
3916
Recalculate total power comprising a first power required for preamble transmission and a second power required for data transmission
3918
Recalculated total power exceeding a first threshold value?
No
YES
Yes
Scale the second power required for data transmission
3920
Scaled second power below a second threshold value?
No
3922
Yes
Wireless device initiates four-step random access procedure
3924
Wireless device selects resources for four-step random access procedure
3926
Transmit message(s) based on selected resources and parameters
3928
END

FIG. 39

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2018/023886

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W74/08
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, INSPEC, IBM-TDB, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CATT: "Consideration on 2-step RA", 3GPP DRAFT; R2-1700205 2-STEP RA, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG2, no. Spokane, USA; 20170117 - 20170119 17 January 2017 (2017-01-17), XP051210789, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN2/Docs/ [retrieved on 2017-01-17]	1-3,5,8, 9,12, 14-20
Y	section 2.1 - section 2.4; figures 1, 2, 5, 6	4,6,7, 10,11,13

-/--

[X] Further documents are listed in the continuation of Box C.

[ ] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 June 2018	13/08/2018

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Vercauteren, Steven

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Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2018/023886

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-20

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-20

   Methods comprising transmitting resp. receiving a MAC PDU comprising one or more MAC sub-headers and one or more Random Access Responses, RARs, a field in a MAC sub-header indicating a type of random access procedure.

   ---

2. claims: 21-40

   Methods comprising transmitting resp. receiving a message indicating a type of random access procedure for a handover.

   ---

3. claims: 41-60

   Methods comprising determining a type of random access procedure based on the transmission power associated therewith.

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	INTERDIGITAL COMMUNICATIONS: "2-Step Random Access Procedure in NR", 3GPP DRAFT; R2-1700237 (NR SI AI3214 2-STEP RACH), 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG2, no. Spokane, USA; 20170117 - 20170119 17 January 2017 (2017-01-17), XP051210819, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN2/Docs/ [retrieved on 2017-01-17] figure 1 page 2, "Proposal 1" and "Proposal 5" figure 2 -----	6,13
Y	SAMSUNG: "NR 2-step random access procedure", 3GPP DRAFT; R1-1700892, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. Spokane, Wa; 20170116 - 20170120 16 January 2017 (2017-01-16), XP051208408, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN1/Docs/ [retrieved on 2017-01-16] page 2, last line - page 3, line 6 -----	4,7,10, 11
A	INTEL CORPORATION: "2-Step random access procedure in NR", 3GPP DRAFT; R2-168520_5G_2-STEP RA_V00, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG2, no. Reno, Nevada, USA; 20161114 - 20161118 5 November 2016 (2016-11-05), XP051193073, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_96/Docs/ [retrieved on 2016-11-05] section 2.1 - section 2.3 -----	1-20

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PTO/SB/08a (01-10)
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	17950726
Filing Date	2022-09-22
First Named Inventor	Xiaobo ZHANG
Art Unit	2471
Examiner Name	AHMED ELALLAM
Attorney Docket Number	ZL0205-0004-US-CON3

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Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
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	7	9236992	B2	2016-01-12	Jae Hoon Chung	
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	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

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	Art Unit	2471
	Examiner Name	AHMED ELALLAM
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	Examiner Name	AHMED ELALLAM
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	Art Unit	2471
	Examiner Name	AHMED ELALLAM
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	First Named Inventor	Xiaobo ZHANG
	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

	1	R1-1609080, Samsung, dated October 10-14, 2016 (Meeting dates) September 30, 2016 (Publication)	☒
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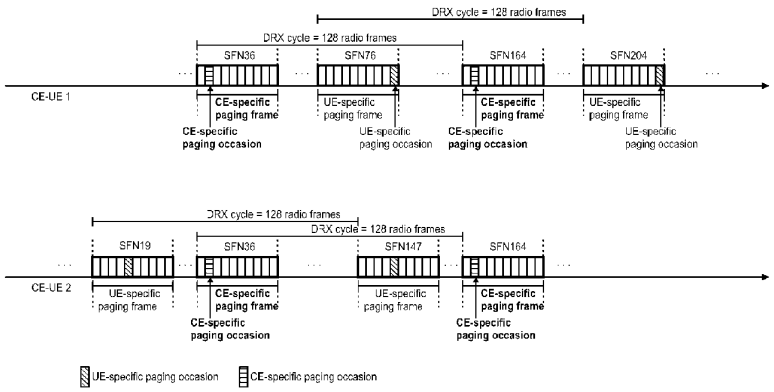
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(54) **Title**: IMPROVED PAGING PROCEDURES FOR USER EQUIPMENTS REQUIRING COVERAGE EXTENSION



(57) **Abstract**: The present disclosure relates to a method for paging coverage extension UEs in a cell controlled by a radio base station. At least one regularly-occurring coverage-extension-specific paging possibility (CE-specific paging possibility), is defined for paging CE UEs. The CE-UEs in the cell regularly monitor the at least one CE-specific paging possibility. When the radio base station determines to page all the user equipments in the cell, it pages the CE user equipments in the cell at the CE-specific paging possibility, using a coverage extension technique. The present disclosure also relates to a method for paging a CE UE, which performs radio measurements by the CE-capable user equipment to determine whether coverage extension is necessary. The radio base station is informed about whether the CE-capable user equipment needs coverage extension or not and then pages the CE UEs applying or not applying a CE technique depending on whether coverage extension is necessary or not.

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Description

Title of Invention: IMPROVED PAGING PROCEDURES FOR USER EQUIPMENTS REQUIRING COVERAGE EXTENSION

Technical Field

[0001] The present disclosure relates to methods for paging one or several user equipments in a cell of a radio base station, where the user equipment(s) do require coverage extension to be reliably paged. The present disclosure is also providing the user equipment and radio base station for participating in the methods described herein.

Background

[0002] Long Term Evolution (LTE)

Third-generation mobile systems (3G) based on WCDMA radio-access technology are being deployed on a broad scale all around the world. A first step in enhancing or evolving this technology entails introducing High-Speed Downlink Packet Access (HSDPA) and an enhanced uplink, also referred to as High Speed Uplink Packet Access (HSUPA), giving a radio access technology that is highly competitive.

[0003] In order to be prepared for further increasing user demands and to be competitive against new radio access technologies, 3GPP introduced a new mobile communication system which is called Long Term Evolution (LTE). LTE is designed to meet the carrier needs for high speed data and media transport as well as high capacity voice support for the next decade. The ability to provide high bit rates is a key measure for LTE.

[0004] The work item (WI) specification on Long-Term Evolution (LTE) called Evolved UMTS Terrestrial Radio Access (UTRA) and UMTS Terrestrial Radio Access Network (UTRAN) is finalized as Release 8 (LTE Rel. 8). The LTE system represents efficient packet-based radio access and radio access networks that provide full IP-based functionalities with low latency and low cost. In LTE, scalable multiple transmission bandwidths are specified such as 1.4, 3.0, 5.0, 10.0, 15.0, and 20.0 MHz, in order to achieve flexible system deployment using a given spectrum. In the downlink, Orthogonal Frequency Division Multiplexing (OFDM) based radio access was adopted because of its inherent immunity to multipath interference (MPI) due to a low symbol rate, the use of a cyclic prefix (CP) and its affinity to different transmission bandwidth arrangements. Single-carrier frequency division multiple access (SC-FDMA) based radio access was adopted in the uplink, since provisioning of wide area coverage was prioritized over improvement in the peak data rate considering the restricted transmit power of the user equipment (UE). Many key packet radio access techniques are employed including multiple-input multiple-output

(MIMO) channel transmission techniques and a highly efficient control signaling structure is achieved in LTE Rel. 8/9.

[0005] LTE architecture

The overall architecture is shown in Fig. 1 and a more detailed representation of the E-UTRAN architecture is given in Fig. 2. The E-UTRAN consists of an eNodeB, providing the E-UTRA user plane (PDCP/RLC/MAC/PHY) and control plane (RRC) protocol terminations towards the user equipment (UE). The eNodeB (eNB) hosts the Physical (PHY), Medium Access Control (MAC), Radio Link Control (RLC) and Packet Data Control Protocol (PDCP) layers that include the functionality of user-plane header-compression and encryption. It also offers Radio Resource Control (RRC) functionality corresponding to the control plane. It performs many functions including radio resource management, admission control, scheduling, enforcement of negotiated uplink Quality of Service (QoS), cell information broadcast, ciphering/ deciphering of user and control plane data, and compression/ decompression of downlink/uplink user plane packet headers. The eNodeBs are interconnected with each other by means of the X2 interface.

[0006] The eNodeBs are also connected by means of the S1 interface to the EPC (Evolved Packet Core), more specifically to the MME (Mobility Management Entity) by means of the S1-MME and to the Serving Gateway (SGW) by means of the S1-U. The S1 interface supports a many-to-many relation between MMEs/Serving Gateways and eNodeBs. The SGW routes and forwards user data packets, while also acting as the mobility anchor for the user plane during inter-eNodeB handovers and as the anchor for mobility between LTE and other 3GPP technologies (terminating S4 interface and relaying the traffic between 2G/3G systems and PDN GW). For idle state user equipments, the SGW terminates the downlink data path and triggers paging when downlink data arrives for the user equipment. It manages and stores user equipment contexts, e.g. parameters of the IP bearer service, network internal routing information. It also performs replication of the user traffic in case of lawful interception.

[0007] The MME is the key control-node for the LTE access-network. It is responsible for idle mode user equipment tracking and paging procedure including retransmissions. It is involved in the bearer activation/deactivation process and is also responsible for choosing the SGW for a user equipment at the initial attach and at time of intra-LTE handover involving Core Network (CN) node relocation. It is responsible for authenticating the user (by interacting with the HSS). The Non-Access Stratum (NAS) signaling terminates at the MME and it is also responsible for generation and allocation of temporary identities to user equipments. It checks the authorization of the user equipment to camp on the service provider's Public Land Mobile Network (PLMN) and enforces user equipment roaming restrictions. The MME is the ter-

mination point in the network for ciphering/integrity protection for NAS signaling and handles the security key management. Lawful interception of signaling is also supported by the MME. The MME also provides the control plane function for mobility between LTE and 2G/3G access networks with the S3 interface terminating at the MME from the SGSN. The MME also terminates the S6a interface towards the home HSS for roaming user equipments.

[0008] LTE RRC states

LTE is based on only two main states: "RRC_IDLE" and "RRC_CONNECTED".

[0009] In RRC_IDLE the radio is not active, but an ID is assigned and tracked by the core network. More specifically, a mobile terminal in RRC_IDLE performs cell selection and reselection — in other words, it decides on which cell to camp. The cell (re)selection process takes into account the priority of each applicable frequency of each applicable Radio Access Technology (RAT), the radio link quality and the cell status (i.e. whether a cell is barred or reserved). An RRC_IDLE mobile terminal monitors a paging channel to detect incoming calls, and also acquires system information. The system information mainly consists of parameters by which the network (E-UTRAN) can control the cell (re)selection process and also how the mobile terminal accesses the network. RRC specifies the control signalling applicable for a mobile terminal in RRC_IDLE, namely paging and system information. The mobile terminal behaviour in RRC_IDLE is specified in more detail e.g. in TS 36.304, current version 12.0.0(NPL 1), chapter 4 "General description of Idle mode" incorporated herein by reference.

[0010] In RRC_CONNECTED the mobile terminal has an active radio operation with contexts in the eNodeB. The E-UTRAN allocates radio resources to the mobile terminal to facilitate the transfer of (unicast) data via shared data channels. To support this operation, the mobile terminal monitors an associated control channel which is used to indicate the dynamic allocation of the shared transmission resources in time and frequency. The mobile terminal provides the network with reports of its buffer status and of the downlink channel quality, as well as neighbouring cell measurement information to enable E-UTRAN to select the most appropriate cell for the mobile terminal. These measurement reports include cells using other frequencies or RATs. The UE also receives system information, consisting mainly of information required to use the transmission channels. To extend its battery lifetime, a UE in RRC_CONNECTED may be configured with a Discontinuous Reception (DRX) cycle. RRC is the protocol by which the E-UTRAN controls the UE behaviour in RRC_CONNECTED.

[0011] The various functions of the mobile terminal in RRC Protocol for and including Connected Mode are described in 3GPP TS 36.331, current version 12.4.1(NPL 2), in

Ch. 4 "Functions", incorporated herein by reference.

[0012] Paging

The present application will differentiate between two types of paging, namely the paging initiated from the non-access stratum (NAS) (termed exemplarily in the following "Paging-NAS") and the paging initiated from the eNodeB (termed exemplarily in the following "Paging-eNB"). Paging-NAS relates to the paging of a particular UE e.g. when paging a UE in connection with an incoming data connection e.g. a mobile-terminating (MT) call. On the other hand, paging-eNB relates to the paging of all the UEs in the cell, and e.g. is used to inform them about a system information change, ETWS message (Earthquake and Tsunami Warning System), CMAS message (Commercial Mobile Alert System) etc. Furthermore, depending on whether the UE is in RRC idle or connected state, the actual paging messages are transmitted differently to the UE. However, the two paging procedures have a lot in common too.

[0013] In general, the UE in RRC_Idle state monitors for paging to detect incoming calls, system information change, for ETWS capable UEs, ETWS notification, and for CMAS capable UEs, CMAS notification. The UE in RRC_Connected state monitors for paging and/or System Information Block Type 1 contents to detect system information change, for ETWS capable UEs, ETWS notification, and for CMAS capable UEs, CMAS notification (see 3GPP TS 36.331, current version v12.4.1, subclause 4.2.1, incorporated herein by reference).

The general paging procedure for transmitting the paging message from EUTRAN to the UE is defined in TS 36.331, current version 12.4.1, subclause 5.3.2 incorporated herein by reference, describing that the purpose of the paging procedure is:

[0014] - to transmit paging information to a UE in RRC_IDLE (Paging-NAS) and/ or;

- to inform UEs in RRC_IDLE and UEs in RRC_CONNECTED about a system information change (Paging-eNB) and/ or;

- to inform about an ETWS primary notification and/ or ETWS secondary notification (Paging-eNB) and/ or;

- to inform about a CMAS notification (Paging-eNB).

[0015] The paging information received in the UE is provided to upper layers, which in response e.g. may the initiate RRC connection establishment to receive an incoming call.

[0016] E-UTRAN performs the paging procedure by transmitting the Paging message at the UE's paging occasion as specified in TS 36.304. E-UTRAN may address multiple UEs within a Paging message by including one PagingRecord for each UE.

[0017] To receive paging messages from E-UTRAN, UEs in idle mode monitor the PDCCH channel for an RNTI value used to indicate paging: the P-RNTI (Paging radio network

temporary identity) which is a common RNTI, i.e. not allocated to any UE explicitly. The UE only needs to monitor the PDCCH channel at certain UE-specific paging possibilities, i.e. at specific subframes within specific radio frames as will be discussed in more detail in the following. The E-UTRAN configures which of the radio frames and subframes can be used for paging in its cell. Each cell broadcasts a default paging cycle Tc, and in addition, upper layers may use dedicated signaling to configure a UE-specific paging cycle TUE; if both are configured, the UE applies the lowest value for the DRX cycle T of the UE.

[0018] In order to explain the procedure for paging as currently defined for LTE-A, the following exemplary cases A, B, and C are defined, as taken from the book LTE – The UMTS Long Term Evolution – From Theory to Practice, Edited by: Stefania Sesia, Issam Toufik, and Matthew Baker, Second Edition, ISBN 9780470660256, section 3.4(NPL 3).

[0019] [Table 1]

Case	UE_ID	T_C	T_{UE}	T	nB	N	Ns	PF	i_s	PO
A	147	256	256	256	64	64	1	76	0	9
B	147	256	128	128	32	32	1	76	0	9
C	147	256	128	128	256	128	2	19	1	4

[0020] The following parameters are used in said respect:

- "TC" is the cell-specific default paging cycle, and can be 32, 64, 128, or 256 radio frames,
- "TUE" is the UE-specific paging cycle of the UE, and can be 32, 64, 128, or 256 radio frames,
- "N" is the number of paging frames within the paging cycle of the UE, and is min (T, nB),
- Ns is the number of paging subframes in a radio frame that may be used for paging, and is max (1, nB/T),

[0021] - nB is the number of paging subframes per paging cycle (across all UEs in the cell), and can be 4T, 2T, T, T/2, T/4, T/8, T/16, T/32; the parameter determines to a large extent the paging capability of the eNB across all UEs in the cell. In general, if nB is set equal to or larger than T, all radio frames may be used for paging (see also parameter N), and there are nB/T POs per PF (see also parameter Ns). In turn, if nB is set lower than T, only a fraction nB/T of the radio frames may be used for paging (see also parameter N), and there is one PO per PF (see also parameter Ns).

[0022] - "T" is the DRX cycle of the UE (also termed paging cycle), is min of TC and TUE,

and specifies how frequently a UE monitors for paging, where a shorter DRX cycle decreases the time for paging but increases battery consumption.

[0023] For example, for cases A and B E-UTRAN has configured one out of every four radio frames and specifically one subframe in each of those radio frames, to be used for paging (see T, Ns, respectively). For case C, there are two subframes in each radio frame that can be used for paging, i.e. Ns=2, and 128 paging frames within the UE's paging cycle, i.e. N=128, available for paging the UEs in the cell. Furthermore, for case B, there are 32 paging frames within the UE's paging cycle (N=32). Across these generally-available paging opportunities configured by the eNB, the paging possibilities for paging the UEs are distributed based on the UE identity.

[0024] In said respect, the particular radio frame and subframe used for paging a particular UE is calculated as follows. A Paging Occasion (PO) is a subframe where there may be a P-RNTI (Paging radio network temporary identity) transmitted on PDCCH addressing the paging message. A Paging Frame (PF) is a radio frame, which may contain one or multiple Paging Occasion(s). In the context of this patent application, the term paging possibility shall refer to the combination of the paging frame and paging subframe.

[0025] The paging frames and paging occasions are defined for example in 3GPP TS 36.304, current version 12.0.0, subclause 7, incorporated herein by reference. Accordingly, the paging frame number (SFN) is calculated according to the following formula:

SFN mod T = (T div N)*(UE_ID mod N)

where UE_ID is IMSI mod 1024.

[0026] When assuming an UE_ID of 147 for all three cases A, B, and C, calculating the above formula results in the paging frame 76 for cases A and B, and paging frame 19 for case C. Furthermore, i_s would be calculated to be 0 for cases A and B, and be 1 for case C.

[0027] The paging occasion has values in the range of [0, 1, ... 9], as in LTE there are 10 subframes within one radio frame. The paging occasion number is selected from a preconfigured table based on the parameters Ns and i_s calculated according to the following formula:

i_s= floor(UE_ID / N) mod Ns.

[0028] The following table is taken from TS 36.304, current version 12.0.0, and is used to determine the Paging Occasion for a particular UE, based on the above parameters Ns and i_s. The following table is intended for FDD.

[0029]

[Table 2]

	PO when i_s=0	PO when i_s=1	PO when i_s=2	PO when i_s=3
1	9	N/A	N/A	N/A
2	4	9	N/A	N/A
4	0	4	5	9

[0030] Therefore, for case A and B, with Ns=1 and i_s=0, the table would yield the subframe number 9, such that the UE for cases A and B would be paged regularly in subframe 9 of radio frame 76 of every paging cycle; i.e. for case A next radio frame 332 and for case B next radio frame 204 etc. For case C, the UE would be paged regularly in subframe 4 of radio frame 19 of every paging cycle, i.e. next radio frame 147 etc.

[0031] The paging frame and paging occasion for the above-discussed cases B and C, is exemplarily depicted in Fig. 3.

[0032] Paging-NAS

For instance, in order to re-establish a connection towards a UE in idle mode, the MME - having been informed e.g. by the UE's P/SGW - sends a paging request message to all eNBs that are part of the so-called tracking area(s) to which the UE belongs and within which the UE can move without having to perform the Tracking Area Update (TAU) procedure (except the periodic TAU procedure).

[0033] When receiving the paging request, the eNodeB(s) of the tracking area(s) then broadcast(s) another paging message over the radio interface in the cells The UE is notified about the paging based on the P-RNTI on the PDCCH and then receives the paging message transmitted over the PDSCH, in the radio resources as indicated by the PDCCH paging notification. When the UE in RRC idle receives the paging message/ signal, it transfers from IDLE to CONNECTED state and establishes an RRC connection with that eNB where it is camped in IDLE mode (e.g. the UE initiates the RRC connection establishment procedure).

[0034] A system overview and message exchange is exemplarily illustrated in Fig. 4, assuming that the UE to be paged by the MME (as triggered by the SGW) is registered at tracking areas TAC1 and TAC3. Consequently, the MME will provide the S1AP paging request to the eNBs of those tracking areas, which in turn will transmit a page at the UE-specific paging possibility (i.e. the PDCCH notification) and then the paging message on the PDSCH resources. The UE is consequently notified about the paging, receives the paging message on the PDSCH, and after confirming its own identity in the paging message, processes the paging message and responds to the paging by e.g. by sending a service request to the MME.

[0035] In the current LTE system, the paging message transmitted from the MME to the eNB, and its content, are defined e.g. by 3GPP TS 36.413, current version 12.4.0(NPL 4), in sub-clauses 8.5 and 9.1.6, incorporated herein by reference. The paging message from the MME to the eNB contains amongst other the following information:

[0036] - UE_ID Index Value: known as UE_ID, which is calculated by (IMSI mod 1024). Correspondingly, the UE_ID may have values in the range of [0, 1 ... 1023].

[0037] - UE Paging Identity: can be the IMSI (as stored on the SIM card) or the SAE-Temporary Mobile subscriber ID (S-TMSI) assigned to the UE during the attach procedure. The UE Paging Identity is transmitted from the eNB to the UE in a paging message over the radio interface (i.e. Uu interface).

[0038] - Paging DRX cycle: is the Discontinuous Reception (DRX) cycle configured in the UE (using NAS signalling) or the default DRX cycle broadcast in the System Information Block (SIB). The default DRX cycle is also known as Paging Cycle in the RadioResourceConfigCommon SIB. The UE may use discontinued reception in IDLE mode in order to reduce power consumption. The DRX cycle is a time interval between monitoring Paging Occurrences for a specific UE. The values of the default DRX/paging cycle broadcast in the SIB are 32, 64, 128 or 256 radio frames.

- UE radio Capability for paging: including the radio access capabilities of the UE, including the coverage extension capability.

[0039] The paging message transmitted from the eNodeB is broadcast in a defined paging possibility as explained above. Paging possibilities are known to the eNodeB and the UE so that they send/listen to the paging message at the same time.

[0040] When Discontinues Reception (DRX) is used, the UE needs only to monitor one PO per DRX cycle.

[0041] As mentioned before, the paging initiated by the non-access stratum (NAS) is UE specific. Consequently, the UE is paged by using the IMSI (or S-TMSI) of the UE as paging identity in the paging message sent in the PDSCH. Therefore, for each UE a separate paging message has to be transmitted from the MME to the eNB(s), which has then to be broadcast from the corresponding eNB(s).

[0042] The paging message transmitted from the eNodeB to the UE is defined in TS 36.331, current version 12.4.1, subclause 6.2.2 Message definition, section "Paging", incorporated herein by reference. This message may contain the following:

[0043] - cmas-Indication: if present, indication of a CMAS notification

- cn-Domain: indicates the origin of paging

- eab-ParamModification: if present, indication of an EAB parameter (SIB14) modification

- etws-Indication: if present, indication often ETWS primary/secondary notification

- imsi: The International Mobile Subscriber Identity, a globally unique permanent

subscriber identity; can also be part of the Paging UE-Identity below
- systemInfoModification: if present, indication of a BCCH modification, other than SIB10-SIB12, SIB14
- ue-Identity: provides the NAS identity of the UE that is being paged

[0044] In the above description, it has been assumed that the UE is in an idle state when receiving the paging, such that the paging message is sent to the UE addressed to the P-RNTI on PDCCH at the UE-specific paging possibilities (based on IMSI of this UE) where the UE verifies that the paging message is indeed intended for it by checking the IDs in the included paging records.

[0045] However, also UEs in RRC connected state may be paged. In this case a downlink information transfer (DLInformationTransfer), containing the paging related information from the NAS, is sent to the UE addressed to the C-RNTI (Cell-RNTI, a unique ID used for identifying RRC connection and scheduling dedicated to a particular UE) on the PDCCH. The DLInformationTransfer message is used for the downlink transfer of NAS or non-3GPP dedicated information. The RRC layer is transparent for this information. For more information, reference is made to TS 36.331, current version 12.4.1, subclause 5.6.1 "DL information transfer" and 6.2.2 "Message definitions" section DLInformationTransfer, incorporate herein by reference.

[0046] Paging from eNB

One of the reasons for an eNodeB to page the UE is a change of system information. In general a change of system information only occurs at specific radio frames, thus implementing the concept of a modification period. System information may be transmitted a number of times with the same content within a modification period. When the network changes (some of) the system information, it first notifies the UEs about this change, which may be done throughout a modification period. In the next modification period, the network then transmits the updated system information. Upon receiving a change notification, the UE acquires the new system information immediately from the start of the next modification period. A paging message is used to inform the UEs in RRC idle and UEs in RRC connected state about a system information change (as mentioned e.g. in TS 36.304, current version 12.0.0, subclause 6.1). If the UE receives a paging message including the systemInfoModification, it knows that the system information will change at the next modification period and boundary. In said case, the UE does not need to check for the UE_ID (not included in the paging message), in view of the presence of the systemInfoModification. Further information in said respect can be found in TS 36.331, current version 12.4.1, subclause 5.2.1.3, incorporated herein by reference.

[0047] Another reason for the eNodeB to page the UEs is an ETWS (Earthquake and Tsunami Warning system) notification, where the paging message is used to inform

ETWS-capable UEs in RRC idle and in RRC connected state about the presence of an ETWS primary/secondary notification. Further information in said respect can be found in TS 36.331, current version 12.4.1, subclause 5.2.1.4, incorporated herein by reference. The paging message may also be used to inform CMAS-capable UEs in RRC idle and RRC connected state about the presence of one or more CMAS (Commercial Mobile Alert System) notifications. Further information in said respect can be found in TS 36.331, current version 12.4.1, subclause 5.2.1.5, incorporated herein by reference. Still another reason for the eNB to page UEs in its cell relates e.g. to Enhanced Access Barring for MTC devices, EAB, as explained for example in TS 36.331, current version 12.4.1, subclause 5.2.1.6 incorporated herein by reference.

[0048] For UEs in both RRC connected and idle state the eNB sends a paging notification to the UE(s) addressed to the P-RNTI on the PDCCH at all possible paging occasions (e.g. at subframes 0, 4, 5, and 9) and at all possible paging frames (e.g. N different radio frames in total, calculated according to SFN mod T=T/N (UE_ID mod N) for every possible "UE_ID mod N" value) irrespective of the IMSI of a particular UE in the cell. By transmitting the paging message at all possible paging possibilities within a paging cycle, the eNB ensures that all the UEs receive the paging message. The detailed definitions for determining the paging occasions and paging frames are given above.

[0049] Machine Type Communication (MTC)

As LTE deployments evolve, operators strive to reduce the cost of overall network maintenance by minimizing the number of RATs. In this respect, Machine-Type Communications (MTC) devices is a market that is likely to continue expanding in the future.

[0050] Many MTC devices are targeting low-end (low cost, low data rate) applications that can be handled adequately by GSM/GPRS. Owing to the low cost of these devices and good coverage of GSM/GPRS, there is very little motivation for MTC device suppliers to use modules supporting the LTE radio interface.

[0051] As more and more MTC devices are deployed in the field, this naturally increases the reliance on GSM/GPRS networks. This will cost operators not only in terms of maintaining multiple RATs, but also prevent operators reaping the maximum benefit out of their spectrum (given the non-optimal spectrum efficiency of GSM/GPRS). With users and traffic becoming denser, using more spectral-efficient technologies, such as Long Term Evolution (LTE), allow the operators to utilize their spectrum in a much more efficient way.

[0052] Given the likely high number of MTC devices, the overall resource they will need for service provision may be correspondingly significant, and inefficiently assigned (for further details on objectives for MTC, see for example 3GPP, RP-111112, Vodafone:

"Provision of low-cost MTC UEs based on LTE"(NPL 5), section 4, available at http://www.3gpp.org and incorporated herein by reference).

[0053] Approaches to lower the cost of LTE presently regard the volume of products as the primary reason. The impact of volume can be seen in two possible ways, depending on how low-cost MTC is developed. Firstly, if low-cost MTC may be very similar to mainline LTE and included in LTE chipsets, MTC has the benefit of the volume of LTE. Secondly, a low-cost MTC based on LTE may have significantly lower cost than mainline LTE. Although it appears not to have the volume benefit of LTE, the volume of MTC devices can be even larger due to a potentially greater number of supported MTC applications and scenarios.

[0054] In this respect, the following approaches to lower the cost of LTE, i.e. defining low-cost MTC are discussed and found to have significant UE cost impact (for further details on low-cost MTC devices, see for example 3GPP, R1-112912, Huawei, HiSilicon, CMCC: "Overview on low-cost MTC UEs based on LTE"(NPL 6), section 4, available at http://www.3gpp.org and incorporated herein by reference):

[0055] - Reduction in supported bandwidth for the low-cost LTE: The low cost of 1.4 MHz (6 RB) downlink bandwidth could cover most application scenarios of MTC. However, 3 MHz (15 RB) or 5 MHz (25 RB) could be considered given that the complexity does not increase much. Given that the uplink may have a larger requirement for MTC services, the possibility of reduced transmit power, and small baseband complexity (relative to downlink reception), any reduction in minimum transmission bandwidth in the UE should be carefully justified.

[0056] - Modified PDCCH-related design for the low-cost LTE to simplify the PDCCH blind decoding and give efficient channel access for a large number of MTC devices. A reduction in maximum bandwidth (e.g., 1.4MHz) decreases PDCCH blind decoding naturally.

[0057] - Protocol simplification including HARQ consideration, MAC, RLC and RRC protocol. Signaling reduction between low duty cycle MTC devices and the base station.

- Transmission modes down-selection to maintain coverage and balance complexity.

[0058] Further considerations on low-cost MTC devices relate to an improved indoor coverage. A number of applications require indoor deployment of Machine Type Communication, MTC, devices, e.g. in an apartment basement, or on indoor equipment that may be close to the ground floor etc. These UEs would experience significantly greater penetration losses on the radio interface than normal LTE devices. This effectively means that indoor coverage should be readily available and reliable: i.e. should provide a significant improvement on existing coverage.

[0059] Additionally, regarding the power consumption of low-cost MTC devices it is noted

that many applications require devices to have up to ten years of battery life. In this respect, presently available Power Save Modes appear not sufficient to achieve the envisaged battery life. In this respect, it is anticipated that further techniques are proposed to significantly cut down the power usage of MTC devices e.g. by optimizing signaling exchanges in the system, in order to realize battery life of up to ten years.

[0060] Enhanced Coverage mode (EC mode)

For improving indoor coverage (for low-cost MTC devices), recent developments have focused on an Enhanced Coverage, EC, mode that is applicable to UEs e.g. operating delay tolerant MTC applications. Another term is "Coverage Extension". The corresponding Work Item in 3GPP Release 12 "Low cost & enhanced coverage MTC UE for LTE" came to the conclusion that further complexity reduction of LTE devices for MTC can be achieved if additional complexity reduction techniques are supported, as apparent from the study report TR 36.888. The study report TR 36.888 concluded that a coverage improvement target of 15-20 dB for both FDD and TDD in comparison to a normal LTE footprint could be achieved to support the use cases where MTC devices are deployed in challenging locations, e.g. deep inside buildings, and to compensate for gain loss caused by complexity-reduction techniques. MTC coverage enhancements are now expected to be introduced in 3GPP Release 13.

[0061] The general objective is to specify a new UE for MTC operation in LTE that allows for enhanced coverage and lower power consumption. Some of the additional objectives are given below:

- Reduced UE bandwidth of 1.4 MHz in downlink and uplink.

-- Bandwidth reduced UEs should be able to operate within any system bandwidth.

-- Frequency multiplexing of bandwidth reduced UEs and non-MTC UEs should be supported.

-- The UE only needs to support 1.4 MHz RF bandwidth in downlink and uplink.

-- The allowed re-tuning time supported by specification (e.g. ~0 ms, 1 ms) should be determined by RAN4.

[0062] - Reduced maximum transmit power.

-- The maximum transmit power of the new UE power class should be determined by RAN4 and should support an integrated PA implementation.

[0063] - Reduced support for downlink transmission modes.

[0064] - The following further UE processing relaxations can also be considered within this work item:

-- Reduced maximum transport block size for unicast and/or broadcast signalling.

-- Reduced support for simultaneous reception of multiple transmissions.

-- Relaxed transmit and/or receive EVM requirement including restricted modulation scheme. Reduced physical control channel processing (e.g. reduced number of blind

decoding attempts).

-- Reduced physical data channel processing (e.g. relaxed downlink HARQ time line or reduced number of HARQ processes).

-- Reduced support for CQI/CSI reporting modes.

[0065] A relative LTE coverage improvement - corresponding to 15 dB for FDD - for the UE category/type defined above and other UEs operating delay-tolerant MTC applications with respect to their respective normal coverage shall be possible. At least some of the following techniques, which shall be applicable for both FDD and TDD, can be considered to achieve this:

[0066] - Subframe bundling techniques with HARQ for physical data channels (e.g. PDSCH, PUSCH)

- Elimination of use of control channels (e.g. PCFICH, PDCCH)
- Repetition techniques for control channels (e.g. PBCH, PRACH, (E)PDCCH)
- Either elimination or repetition techniques (e.g. PBCH, PHICH, PUCCH)
- Uplink PSD boosting with smaller granularity than 1 PRB
- Resource allocation using EPDCCH with cross-subframe scheduling and repetition (EPDCCH-less operation can also be considered)

[0067] - New physical channel formats with repetition for SIB/RAR/Paging

- A new SIB for bandwidth reduced and/or coverage enhanced UEs
- Increased reference symbol density and frequency hopping techniques
- Relaxed "probability of missed detection" for PRACH and initial UE system acquisition time for PSS/SSS/PBCH/SIBs can be considered as long as the UE power consumption impact can be kept on a reasonable level.
- Spreading: Spreading refers to spreading of information across resources including time-frequency domain resources or even spreading using Scrambling (or Channelization) codes.

[0068] There can be also other techniques than those listed above.

The amount of coverage enhancement should be configurable per cell and/or per UE and/or per channel and/or group of channels, such that different levels of coverage enhancements exist. The different levels of coverage enhancement could mean different level of CE techniques being applied to support the CE-device transmission and reception. Relevant UE measurements and reporting to support this functionality should be defined.

[0069] For more details, see for example 3GPP RP-141865 "Revised WI: Further LTE Physical Layer Enhancements for MTC"(NPL 7) sourced by Ericsson, available at http://www.3gpp.org and incorporated herein by reference.

[0070] Notably, coverage enhancements of 15/ 20 dB for UEs in the Enhanced Coverage mode with respect to their nominal coverage means that the UEs have to be capable of

receiving extremely low signal strengths. This applies not only to the initial scanning operation, the cell search and the cell selection operation but also the subsequent communication scheme to be performed by the UE.

[0071] Early attempts to define the Enhanced Coverage mode have focused on modifications of the radio transmissions. In this respect, discussions have focused on repeated transmissions as being the main technique to improve the coverage. Repetitions can be applied to every channel for coverage improvement.

[0072] An exemplary implementation of these repeated transmissions prescribes that the same data is transmitted across multiple sub-frames. Yet, it will become immediately apparent that these repeated transmissions will use more resource blocks (time-frequency) resources than required for normal coverage UEs.

Citation List

Non Patent Literature

[0073] NPL 1: 3GPP TS 36.304, "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) procedures in idle mode", version 12.0.0

NPL 2: 3GPP TS 36.331, "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification", version 12.4.1

NPL 3: Theory to Practice, Edited by: Stefania Sesia, Issam Toufik, and Matthew Baker, Second Edition, ISBN 9780470660256, section 3.4

NPL 4: 3GPP TS 36.413, "Evolved Universal Terrestrial Radio Access Network (E-UTRAN); S1 Application Protocol (S1AP) ", version 12.4.0

NPL 5: 3GPP, RP-111112, Vodafone: "Provision of low-cost MTC UEs based on LTE"

NPL 6: 3GPP, R1-112912, Huawei, HiSilicon, CMCC: "Overview on low-cost MTC UEs based on LTE"

NPL 7: 3GPP RP-141865 "Revised WI: Further LTE Physical Layer Enhancements for MTC"

NPL 8: 3GPP TS 36.214, "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer; Measurements", version 10.1.0

Summary

[0074] One non-limiting and exemplary embodiment provides an improved method for paging all user equipments in a cell, particularly involving user equipments which need coverage extension. Another non-limiting and exemplary embodiment provides an improved method for paging one user equipment in a cell, particularly a user equipment which needs coverage extension.

The independent claims provide non-limiting and exemplary embodiments. Advantageous embodiments are subject to the dependent claims.

According to a first aspect, the present disclosure improves the paging procedure by which a radio base station can page the user equipments in its cell, particularly for the case where the paging shall also reach user equipments which require coverage extension, i.e. user equipments that are in poor radio conditions but support coverage extension techniques as explained in the background section. The first aspect refers to the case were paging is initiated by the radio base station and shall reach all user equipments in the cell of the radio base station; in other words, the paging is not UE specific but cell specific, and can be for example used so as to broadcast a warning message or to inform UEs about an imminent system information change.

[0075] Consequently, the paging must reach user equipments that require coverage extension as well as "normal" user equipments which do not require coverage extension. One main idea of the first aspect is the definition of a coverage-extension-specific paging possibility, which is specifically defined for those user equipments that support coverage extension techniques, and more precisely which need coverage extension to be reliably reached. Correspondingly, the CE-UEs not only monitor the UE-specific paging possibility, calculated based on their identities, but additionally monitor a (at least one) different paging possibility dedicated to achieve coverage extension paging. Both CE-user equipments in idle and connected state can be configured to monitor this CE-specific paging possibility. Consequently, in order to reach those CE-UEs, the radio base station pages the CE-UEs at said CE-specific paging possibility, and uses one of the plurality of available techniques (e.g. repetition or increased transmission power) for extending the coverage of the paging and thus to reliably reach the CE-UE.

[0076] Like a usual UE-specific paging possibility, this CE-specific paging possibility is defined by a particular radio frame number and subframe number, and occurs regularly e.g. at every paging cycle.

[0077] Since the CE-specific paging possibility shall preferably only be monitored by CE-UEs, the radio base station still needs to reach the other non-CE-UEs and can thus, as described in the background section, perform the paging at all possible paging possibilities of a paging cycle, so as to reach all UEs in the cell. In this case the radio base station would not use a coverage extension technique, since the radio base station can be sure that the CE-UEs will be reached by the paging at the CE-specific paging possibility and not for all possible.

[0078] One advantage of the above-described first aspect is that, by providing one dedicated paging possibility for CE-UEs, downlink resources can be saved. The coverage extension techniques, which can be a heavy burden to the radio base station(s) are applied in a very limited manner, namely for just one paging possibility.

[0079] One set of variants of the first aspect differs as to how this CE-specific paging pos-

sibility is defined. In general, it can be said that the CE-specific paging possibility must be known to both the CE-UE(s) and the radio base station(s), so as to ensure that the paging can be successful. However, how exactly the CE-specific paging possibility is defined can vary. One solution is that the radio frame number and the subframe number of the CE-specific paging possibility is fixed beforehand such that corresponding information can be e.g. pre-stored at the radio base station and the CE-UE (e.g. in the USIM), or the radio base station can broadcast same in its cell. Another possible solution is that a plurality of possible paging subframes, generally configured for the system by the radio base station, is divided to be used either as a UE-specific paging subframe or as a CE-specific paging subframe. By correspondingly configuring the paging parameter(s) (e.g. nB) of normal UEs and CE-UEs it is possible that CE-UEs are assigned e.g. one normal UE-specific paging subframe and one CE-specific paging subframe. Still another solution is based on an additional CE-specific UE identity that is assigned exclusively to CE-UEs and which can be used for calculating the CE-specific paging possibility; in addition, as in the prior art, the UE-specific paging possibility is calculated based on the usual identity of the CE-UE (e.g. IMSI).

[0080] According to a second aspect, the paging procedure by which a radio base station pages a user equipment which requires coverage extension in its cell is improved. This second aspect refers to the case where the paging is initiated in the core network (NAS) and is destined to a single UE (or a very limited number of UEs), in contrast to the first aspect dealing with cell-wide paging initiated by the eNB. The paging which is directed at a particular CE-UE shall reliably reach the CE-UE, and thus the radio base station shall use one appropriate coverage extension technique for the CE paging. In order to avoid unnecessary CE paging from the radio base station, the CE-capable UEs will implement a measurement and reporting procedure according to which the radio base station is informed as to the current CE status of the UE. The radio base station will thus only perform a CE paging for a CE-capable UE that is indeed currently in the CE status, i.e. currently requiring coverage extension. CE-UEs, although CE capable, will not be paged with a coverage extension technique, if the status of the CE-capable UE, informed to the radio base station, indicates that no coverage extension is actually required by this CE-capable UE at the moment.

[0081] Appropriate radio measurements are regularly performed by the CE-capable UE(s) to determine whether coverage extension is necessary or not at the moment. The measurements could also be triggered by the radio base station or a core network entity when being interested in the current CE status. These measurements could include e.g. at least one of RSRQ, RSRP, channel quality, block error rate, or any other suitable measurement parameter. Appropriate threshold(s) can be defined to which the CE-capable UE(s) compare(s) the measurement results to determine whether it requires or

not coverage extension.

[0082] Consequently, a particular CE-capable UE can change it CE-status, i.e. toggle between being a CE-UE (i.e. indeed requiring coverage extension) and a non-CE-UE (i.e. supporting CE but not requiring CE at the moment).

[0083] The radio base station is kept updated on the current CE status of the CE-capable UE and thus (should) knows at the time of paging whether coverage extension is indeed necessary or not for the paging. In order to limit uplink traffic, the informing of the radio base station could be limited to the cases where the CE status of the CE-capable UE is changed, i.e. from non-CE-UE to CE-UE and vice versa. Of course it should also be possible for the CE-capable UE to measure and report such information/ measurements periodically even in the absence of said toggling. In this case, the eNB could, based on its implementation, perform some averaging of the received information including measurement reports and determine that a toggling of CE state is indeed helpful. The step of informing may be done, e.g. directly between the CE-capable UE and the radio base station, e.g. for CE-capable UEs that are in connected state and thus may provide the corresponding CE status to the radio base station. Alternatively, the CE-capable UE may report to a core network entity, which in turn may inform the radio base station, at the latest when triggering for paging; this may be done e.g. for those cases where the CE-capable UE is in idle state and thus has no active connection with the radio base station.

[0084] Correspondingly, the paging for CE-UE is performed by the radio base station by using a CE technique, whereas paging for a non-CE-UE is performed without using a CE technique. The CE-capable UE appropriately receives the CE paging or normal paging.

[0085] Correspondingly, in one general first aspect, the techniques disclosed here feature a method for paging all user equipments in a cell controlled by a radio base station in a mobile communication system. At least one regularly-occurring coverage-extension-specific paging possibility, in short CE-specific paging possibility, is defined for paging user equipments that require coverage extension, in short CE user equipments. The radio base station is capable to use one of a plurality of techniques for achieving a coverage extension for a CE user equipment. The CE user equipments in the cell regularly monitor the at least one CE-specific paging possibility. When the radio base station determines to page all the user equipments in the cell, the radio base station pages the CE user equipments in the cell at the CE-specific paging possibility, using one of the plurality of techniques for achieving the coverage extension.

[0086] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, a plurality of UE-specific paging possibilities is defined for paging a specific user equipment in the cell of the radio base station. The

CE user equipments and non-CE user equipments each monitor a respective UE-specific paging possibility out of the plurality of UE-specific paging possibilities. The radio base station — upon determining to page all the user equipments in the cell - additionally performs paging at all of the plurality of UE-specific paging possibilities without using one of the plurality of techniques for achieving coverage extension. According to a further example, each of the plurality of UE-specific paging possibilities is different from the at least one CE-specific paging possibility.

[0087] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, each of the at least one CE-specific paging possibility refers to radio resources of a control channel defined by a radio frame number and subframe number and is repeated every paging cycle. The at least one CE-specific paging possibility is only monitored by CE user equipments. For example, the at least one CE-specific paging possibility is monitored by CE user equipments in idle state and CE user equipments in connected state.

[0088] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, the step of paging includes transmitting by the radio base station a first paging notification at radio resources of a control channel specified by the at least one CE-specific paging possibility, and includes transmitting by the radio base station a second paging message at radio resources of another channel specified by the first paging notification. For example, the technique for achieving the coverage extension is applied to both steps of transmitting the first paging notification and of transmitting the second paging message.

[0089] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, the plurality of techniques for achieving the coverage extension comprise at least one of a repetition technique where a message is repeated by the radio base station for a pre-configured number of times, an increase in transmission power, where a message is transmitted by the radio base station with an increased transmission power, a bundling technique where a .same message is transmitted in a plurality of consecutive subframes, and a spreading technique where a message is transmitted by a larger resource, e.g. via a larger frequency-time resource or channelization code.

[0090] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, the step of determining by the radio base station to page all user equipments in the cell is triggered by a change of system information applicable to the cell controlled by the radio base station or by the presence of a message, e.g. a warning message, to be broadcast in the cell controlled by the radio base station.

[0091] According to an advantageous variant of the first aspect which can be used in

addition or alternatively to the above, each of the at least one CE-specific paging possibility refers to radio resources of a control channel defined by a radio frame number and a subframe number which are pre-configured such that the radio frame number and the subframe number are fixed for the CE-specific paging possibility. For example, information to determine the pre-configured radio frame number and the pre-configured subframe number is stored in a Universal Subscriber Identity Module, USIM, of the CE user equipment, or broadcast by the radio base station in the cell. Further exemplary, the pre-configured subframe number is 1, 2, 3, 6, 7, or 8.

[0092] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, a plurality of paging possibilities are defined for paging in the cell of the radio base station, wherein a first value of at least one parameter for calculating the UE-specific paging possibility is different from a second value of the at least one parameter for calculating a CE-specific paging possibility such that the plurality of paging possibilities are divided to be used either as the CE-specific paging possibility or the UE-specific paging possibility. CE user equipments are configured to use the first value of the at least one parameter for calculating the UE-specific paging possibility and to use the second value of the at least one parameter for calculating the CE-specific paging possibility. Non-CE user equipments are configured to use the first value of the at least one parameter for calculating the UE-specific paging possibility and to not calculate the CE-specific paging possibility.

[0093] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, 6, wherein CE user equipments are assigned a CE-specific user equipment identity based on which the CE-specific paging possibility is calculated by the radio base station and the CE user equipments. For example, the CE-specific user equipment identity is the same for all CE-configured user equipments, and the CE-specific user equipment identity is stored in a Universal Subscriber Identity Module, USIM, of the CE user equipment or broadcast by the radio base station in the cell. Further for example, a plurality of different levels of coverage extension is defined, and wherein for each level of coverage extension a different CE-specific user equipment identity is defined.

[0094] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, wherein a plurality of different levels of coverage extension is defined, and wherein for each level of coverage extension a different CE-specific paging possibility is defined for paging the CE user equipments configured for that level of coverage extension.

[0095] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, the radio base station determines whether there are CE user equipments in idle state in its cell by performing a counting procedure

where the CE user equipments in idle state inform the radio base station about their presence in the cell controlled by the radio base station. For example, the determination is only performed in case there are no CE user equipments in connected state in the cell.

[0096] Correspondingly, in one general first aspect, the techniques disclosed here feature a user equipment located in a cell controlled by a radio base station in a mobile communication system. The user equipment, in short CE user equipment, requires coverage extension, wherein at least one regularly-occurring coverage-extension-specific paging possibility, in short CE-specific paging possibility, is defined for the CE user equipment. The radio base station is capable to use one of a plurality of techniques for achieving a coverage extension for the CE user equipment. A processor of the CE user equipment regularly monitors the at least one CE-specific paging possibility. A receiver of the CE user equipment receives a paging from the radio base station at the CE-specific paging possibility, using one of the plurality of techniques for achieving the coverage extension.

[0097] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, a plurality of UE-specific paging possibilities is defined for paging a specific user equipment in the cell of the radio base station. The processor of the CE user equipment monitors a respective UE-specific paging possibility out of the plurality of UE-specific paging possibilities. In a further example, each of the plurality of UE-specific paging possibilities is different from the at least one CE-specific paging possibility.

[0098] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, wherein each of the at least one CE-specific paging possibility refers to radio resources of a control channel defined by a radio frame number and subframe number and is repeated every paging cycle. In a further example, the at least one CE-specific paging possibility is monitored by the CE user equipment when in idle state and when in connected state.

[0099] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, the receiver receiving the paging includes: receiving a first paging notification at radio resources of a control channel specific by the at least one CE-specific paging possibility, and includes receiving a second paging message at radio resources of another channel specific by the first paging notification. In a further example, the technique for achieving the coverage extension is used by the CE user equipment to both receive the first paging notification and receive the second paging message.

[0100] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, each of the at least one CE-specific paging pos-

sibility refers to radio resources of a control channel defined by a radio frame number and a subframe number which are pre-configured such that the radio frame number and the subframe number are fixed for the CE-specific paging possibility. In a further example, a memory of the CE user equipment is adapted to store information to determine the pre-configured radio frame number and the pre-configured subframe number. Exemplarily, the memory is a Universal Subscriber Identity Module, USIM, of the CE user equipment. Or, the receiver of the CE user equipment receives information to determine the pre-configured radio frame number and the pre-configured subframe number, broadcast by the radio base station in the cell.

[0101] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, the CE user equipment is assigned a CE-specific user equipment identity, wherein the processor of the CE user equipment is adapted to calculate the CE-specific paging possibility based on the CE-specific user equipment identity. Exemplarily, the CE-specific user equipment identity is the same for all CE-configured user equipments. In a further example, a plurality of different levels of coverage extension is defined. For each level of coverage extension a different CE-specific user equipment identity is defined.

[0102] Correspondingly, in one general first aspect, the techniques disclosed here feature a radio base station for paging all user equipments in a cell controlled by the radio base station in a mobile communication system. At least one regularly-occurring coverage-extension-specific paging possibility, in short CE-specific paging possibility, is defined for paging user equipments that require coverage extension, in short CE user equipments. The radio base station is capable to use one of a plurality of techniques for achieving a coverage extension for a CE user equipment. A processor of the radio base station determines whether to page all the user equipments in the cell. A transmitter of the radio base station pages the CE user equipments in the cell at the CE-specific paging possibility, using one of the plurality of techniques for achieving the coverage extension.

[0103] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, a plurality of UE-specific paging possibilities are defined for paging a specific user equipment in the cell of the radio base station, wherein transmitter of the radio base station — upon the processor determining to page all the user equipments in the cell —additionally pages at all of the plurality of UE-specific paging possibilities without using one of the plurality of techniques for achieving coverage extension. For example, each of the plurality of UE-specific paging possibilities is different from the at least one CE-specific paging possibility.

[0104] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, the transmitter of the radio base station is

adapted to transmit a first paging notification at radio resources of a control channel specified by the at least one CE-specific paging possibility, and to transmit a second paging message at radio resources of another channel specified by the first paging notification. Exemplarily, the technique for achieving the coverage extension is applied to both the transmitting of the first paging notification and the transmitting of the second paging message.

[0105] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, the processor determines to page all the user equipments in the cell when being triggered by a change of system information applicable to the cell controlled by the radio base station or by the presence of a message, e.g. a warning message, to be broadcast in the cell controlled by the radio base station.

[0106] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, each of the at least one CE-specific paging possibility refers to radio resources of a control channel defined by a radio frame number and a subframe number which are pre-configured such that the radio frame number and the subframe number are fixed for the CE-specific paging possibility. Exemplarily, information to determine the pre-configured radio frame number and the pre-configured subframe number is stored in the radio base station, wherein the transmitter of the radio base station broadcasts the information to determine the pre-configured radio frame number and subframe number.

[0107] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, a CE-specific user equipment identity is assigned to the CE user equipments, wherein the processor of the radio base station is adapted to calculate the CE-specific paging possibility based on the CE-specific user equipment identity. Exemplarily, the transmitter of the radio base station is adapted to broadcast the CE-specific user equipment identity in the cell.

[0108] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, the processor of the radio base station determines whether there are CE user equipments in idle state in its cell by performing a counting procedure. Exemplarily, the determination is only performed in case there are no CE user equipments in connected state in the cell.

[0109] Correspondingly, in one general second aspect, the techniques disclosed here feature a method for paging a user equipment in a cell controlled by a radio base station in a mobile communication system. The user equipment supports coverage extension techniques, wherein the radio base station is capable to use one of a plurality of techniques for achieving a coverage extension for the CE-capable user equipment. Radio measurements are performed by the CE-capable user equipment, which determines whether coverage extension is necessary or not, based on the results of the

radio measurements. The radio base station is informed about whether the CE-capable user equipment needs coverage extension or not, based on the determination result. When paging the CE-capable user equipment, the radio base station applies or not applies one of the plurality of techniques for achieving coverage extension depending on whether coverage extension is necessary or not for the CE-capable user equipment.

[0110] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the radio measurements performed by the CE-capable user equipment include measurements of a Reference Signal Received Power, RSRP, and/or Reference Signal Received Quality, RSRQ, and/or a channel quality, and/or a block error rate and/ or HARQ operating point.

[0111] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the step of determining whether coverage extension is necessary comprises the step of comparing by the CE-capable user equipment the result of the radio measurements with a first threshold to determine whether coverage extension is necessary. For example, the comparison determines that coverage extension is necessary when the result of the radio measurements falls below the first threshold. The step further comprises comparing by the CE-capable user equipment the result of the radio measurements with a second threshold to determine whether coverage extension is not necessary. For example, the comparison determines that coverage extension is not necessary when the result of the radio measurement exceeds the second threshold.

[0112] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the step of informing the radio base station about the CE-capable user equipment needing coverage extension or not, includes the steps of either transmitting by the CE-capable user equipment information about whether the CE-capable user equipment needs coverage extension or not to the radio base station. In this case, for example the CE-capable user equipment is in a connected state. In a further example, it is avoided that the CE-capable user equipment is changing into the idle state by keeping it in the connected state. Alternatively, the step of informing includes the steps of transmitting by the CE-capable user equipment information about whether the CE-capable user equipment needs coverage extension or not to a core network entity. In this case, the core network entity provides the received information to the radio base station. For example, the CE-capable user equipment is in a connected state or in an idle state. In a further example, the core network entity is a mobility management entity.

[0113] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the radio base station is triggered to page the CE-capable user equipment by a core network entity that initiates and controls the paging,

preferably wherein the core network entity initiating the paging is a mobility management entity.

[0114] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the steps of performing the radio measurements and of determining whether coverage extension is necessary or not is performed regularly at a pre-configured time interval and/or triggered by the radio base station.

[0115] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the step of informing the radio base station is only performed when the result of the determination is different from the result of the determination previously informed to the radio base station.

[0116] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the radio base station determines whether the CE-capable user equipment needs coverage extension or not based on the radio resources selected by the CE-capable user equipment for initially attaching to the radio base station; for example, based on the selected preamble or access slot used for a random access procedure performed by the CE-capable user equipment when initially attaching to the radio base station.

[0117] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the step of paging the CE-capable user equipment comprises the steps of transmitting by the radio base station a first paging notification at radio resources of a control channel specified by a paging possibility specific to the CE-capable user equipment, and transmitting by the radio base station a second paging message at radio resources of another channel specified by the first paging notification. In a further example, the technique for achieving the coverage extension is applied to both steps of transmitting the first paging notification and of transmitting the second paging message.

[0118] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, upon successfully being paged by the radio base station, the CE-capable user equipment informs the radio base station about the successful paging, and the radio base station can inform a core network entity responsible for initiating the paging about the successful paging.

[0119] Correspondingly, in one general second aspect, the techniques disclosed here feature a user equipment located in a cell controlled by a radio base station in a mobile communication system. The user equipment, in short CE user equipment, supports coverage extension techniques. The radio base station is capable to use one of a plurality of techniques for achieving a coverage extension for the CE-capable user equipment. A processor of the CE user equipment performs radio measurements, and determines whether coverage extension is necessary or not, based on the results of the

radio measurements. A transmitter of the CE user equipment informs the radio base station about whether the CE-capable user equipment needs coverage extension or not, based on the determination result. A receiver of the CE user equipment receives paging from the radio base station, applying or not applying one of the plurality of techniques for achieving coverage extension depending on whether coverage extension is necessary or not.

[0120] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the radio measurements performed by the CE-capable user equipment include measurements of a Reference Signal Received Power, RSRP, and/or Reference Signal Received Quality, RSRQ, and/or a channel quality, and/or a block error rate and/ or HARQ operating point.

[0121] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the processor determines whether coverage extension is necessary or not by comparing the result of the radio measurements with a first threshold to determine whether coverage extension is necessary. For example, the comparison determines that coverage extension is necessary when the result of the radio measurements falls below the first threshold. Furthermore, the result of the radio measurements is compared with a second threshold to determine whether coverage extension is not necessary. For example, the comparison determines that coverage extension is not necessary when the result of the radio measurement exceeds the second threshold.

[0122] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the transmitter informs the radio base station by transmitting information about whether the CE-capable user equipment needs coverage extension or not to the radio base station. For example, the CE-capable user equipment is in a connected state, and furthermore it is avoided that the CE-capable user equipment is changing into the idle state by keeping it in the connected state. Alternatively, information about whether the CE-capable user equipment needs coverage extension or not is transmitted to a core network entity. The core network entity provides the received information to the radio base station, preferably wherein the CE-capable user equipment is in a connected state or in an idle state.

[0123] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the processor performing the radio measurements and determining whether coverage extension is necessary or not is performed regularly at a pre-configured time interval and/or triggered by the radio base station.

[0124] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the transmitter informs the radio base station

only when the result of the determination is different from the result of the determination previously informed to the radio base station.

[0125] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the receiver receiving the paging includes receiving a first paging notification at radio resources of a control channel specific by a paging possibility specific to the CE-capable user equipment, and receiving a second paging message at radio resources of another channel specific by the first paging notification. For example, the technique for achieving the coverage extension is used by the CE user equipment to both receive the first paging notification and receive the second paging message.

[0126] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the transmitter is further adapted to inform the radio base station about the successful paging.

[0127] Correspondingly, in one general second aspect, the techniques disclosed here feature a radio base station for paging a user equipment in a cell controlled by the radio base station in a mobile communication system. The user equipment supports coverage extension techniques. The radio base station is capable to use one of a plurality of techniques for achieving a coverage extension for the CE-capable user equipment. A receiver of the radio base station receives information about whether the CE-capable user equipment needs coverage extension or not. A transmitter of the radio base station, when paging the CE-capable user equipment, applies or not applies one of the plurality of techniques for achieving coverage extension depending on whether coverage extension is necessary or not for the CE-capable user equipment.

[0128] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the receiver receiving the information includes receiving from the CE-capable user equipment or from a core network entity the information about whether the CE-capable user equipment needs coverage extension or not.

According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the transmitter of the radio base station transmit a first paging notification at radio resources of a control channel specified by a paging possibility specific to the CE user equipment, and transmit a second paging message at radio resources of another channel specified by the first paging notification. For example, the technique for achieving the coverage extension is applied to both the transmitting of the first paging notification and the transmitting of the second paging message.

[0129] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, a receiver of the radio base station receives in-

formation about the successful paging of the CE user equipment, and the transmitter of the radio base station informs a core network entity responsible for initiating the paging about the successful paging.

[0130] Additional benefits and advantages of the disclosed embodiments will be apparent from the specification and Figures. The benefits and/or advantages may be individually provided by the various embodiments and features of the specification and drawings disclosure, and need not all be provided in order to obtain one or more of the same.

[0131] These general and specific aspects may be implemented using a system, a method, and a computer program, and any combination of systems, methods, and computer programs.

Brief Description of Drawings

[0132] [fig.1]Fig.1 shows an exemplary architecture of a 3GPP LTE system.

[fig.2]Fig. 2 shows an exemplary overview of the overall E-UTRAN architecture of 3GPP LTE.

[fig.3]Fig. 3 illustrates cyclical paging frames and paging occasions for two different cases.

[fig.4]Fig. 4 shows a system overview and message exchange for a paging which is initiated by the MME and spread across the different tracking areas at which the UE is registered.

[fig.5]Fig. 5 illustrates the UE-specific paging possibilities and CE-specific paging possibilities of two CE-UEs according to one exemplary first embodiment.

[fig.6]Fig. 6 shows a sequence diagram for the UE behavior according to one exemplary first embodiment.

[fig.7]Fig. 7 shows a sequence diagram for the eNB behavior according to one exemplary first embodiment.

[fig.8]Fig. 8 shows a message sequence diagram for a message exchange for measurement reporting and paging according to one exemplary second embodiment.

[fig.9]Fig. 9 shows a sequence diagram for the UE behavior according to one exemplary second embodiment.

[fig.10]Fig. 10 shows a sequence diagram for the eNB behavior according to one exemplary second embodiment.

Description of Embodiments

[0133] A mobile station or mobile node or user terminal or user equipment is a physical entity within a communication network. One node may have several functional entities. A functional entity refers to a software or hardware module that implements and/or offers a predetermined set of functions to other functional entities of a node or the network. Nodes may have one or more interfaces that attach the node to a commu-

nication facility or medium over which nodes can communicate. Similarly, a network entity may have a logical interface attaching the functional entity to a communication facility or medium over which it may communicate with other functional entities or correspondent nodes.

[0134] The term "radio resources" as used in the set of claims and in the application is to be broadly understood as referring to physical radio resources, such as time-frequency resources.

The term "paging possibility" as used in the set of claims and in the application is to be broadly understood as referring to physical radio resources (frequency-time resources) of a control channel (e.g. the PDCCH), which are defined by a radio frame number (also termed paging frame, PF) and a subframe number (also termed paging occasion, PO).

[0135] The expression "coverage-extension UE" (or "CE UE") as used in the set of claims and in the application is to be broadly understood as referring to a UE which requires coverage extension, e.g. because it is in a bad radio condition. The expression "CE-capable UE" shall be used for a UE supporting the coverage extension techniques, irrespective of whether or not the UE indeed requires coverage extension, i.e. a UE can support coverage extension techniques but can still be understood as a "non-CE UE" in case that no coverage extension is currently necessary. From eNB-perspective, it may be unclear at any particular point in time whether a CE-capable UE indeed requires coverage extension or not. The second embodiment is directed at said drawback.

[0136] Correspondingly, the expression "non-CE-UE" as used in the set of claims and in the application is to be broadly understood as referring to a UE which either does not require coverage extension (even when actually supporting the corresponding CE techniques) or does not support coverage extension techniques.

[0137] The expression "UE-specific paging possibility" as used in the set of claims and in the application is to be broadly understood as that paging possibility which is calculated based on the UE-ID (e.g. IMSI), and should be understood in the context of the CE-specific paging possibility which is specific to only coverage extension. As described in the background section, there is only a limited amount of paging possibilities available, across which the UEs are then disposed depending on their IDs. Although a particular paging possibility may be monitored by several UEs, the paging possibilities are UE-specific in the sense that the paging possibility to be monitored by a UE is determined based on the respective UE-ID.

[0138] The terms "paging notification" and "paging message" are distinguished in the set of claims and in the application to respectively refer to the first PDCCH message (which is basically an indication notifying about a paging message e.g. by use of the common P-RNTI) and the subsequent PDSCH message with the actual paging information. The

term "paging" does not make this distinction and shall cover both.

[0139] The term "CE-page" or "CE-paging" as used in the application shall refer broadly to a paging where one out of a plurality of coverage extension techniques is used. For example, when considering the repetition technique as the CE-technique used by an eNB, the "CE-page" will involve repeating the transmission of both paging messages, i.e. the paging notification on the PDCCH and the actual paging message on the PDSCH, for a pre-configured number of times as defined for the repetition technique.

[0140] As explained in the background section, coverage extension techniques are to be implemented for (MTC) devices, and it is unclear how the coverage extension shall be achieved for the paging procedure. However, expenditure is quite high for any of these techniques, such that they should be only used when necessary. For the paging which is initiated by the eNB, and is directed to all UEs in the cell, the currently-implemented paging is applied to all possible paging possibilities so as to reach all UEs. In order to reach also the CE-UEs, a coverage extension technique may be applied to the paging at all possible paging possibilities, which however results in a high expenditure of resources.

[0141] For the paging which is initiated by the NAS, and is directed to one UE only (or a very limited number of UEs), the MME inform the eNB over the S1 interface about the capability of a RRC_Connected UE to allow coverage extension and thus to support the coverage enhancement techniques mentioned above. However, it is unclear whether the UE is actually requiring coverage extension at the time of the page, (e.g. the UE, e.g. MTC device, moved from the cellar to open terrain). Consequently, the eNB might page the UE at the UE-specific paging possibility by using one of the CE techniques, even though the UE is in a good radio condition and would not have needed a coverage extension page. Again, resources are wasted.

[0142] The following exemplary embodiments are conceived by the inventors to mitigate the problems explained above.

[0143] Some of these are to be implemented in the wide specification as given by the 3GPP standards and explained partly in the background section, with the particular key features as explained in the following pertaining to the various embodiments. It should be noted that the embodiments may be advantageously used for example in a mobile communication system, such as 3GPP LTE-A (Release 10/11/12/13) communication systems as described in the Technical Background section above, but the embodiments are not limited to its use in this particular exemplary communication networks.

[0144] The explanations should not be understood as limiting the scope of the disclosure, but as a mere example of embodiments to better understand the present disclosure. A skilled person should be aware that the general principles of the present disclosure as laid out in the claims can be applied to different scenarios and in ways that are not ex-

plicitly described herein. Correspondingly, the following scenarios assumed for explanatory purposes of the various embodiments shall not limit the present disclosure and its embodiments as such.

[0145] In the following a set of embodiments will be explained. Although in the following embodiment, the broad expressions UE, CE-UE, CE-capable UE, are used, the embodiments may be equally applied for MTC devices, i.e. a CE-MTC device or CE-capable MTC device etc.

[0146] First embodiment

According to a first exemplary embodiment, a paging procedure according to which the eNB can page all the UEs in its cell, including those UEs which require coverage extension (and of course also support coverage extension), is presented.

[0147] For this first embodiment it is assumed that the paging is initiated (i.e. triggered) by the eNB itself; in contrast to paging being initiated by the Non-Access-Stratum for which the second embodiment provides an improved paging procedure. As already explained in the background section, paging may be initiated by the eNB for several reasons. For example, system information applicable to the cell may change, and the eNB wants to notify the UEs in its cell such that the UEs may acquire the updated system information immediately from the start of the next modification period. Another reason is that a warning message shall be broadcast in the cell, such as a message from the ETWS or CMAS system, or a message in relation to EAB (Enhanced Access Barring for MTC devices). More detailed information is omitted here, and reference is made to the corresponding passages in the background section which equally apply to the first embodiment.

[0148] Consequently, due to nature of those reasons, the eNB wants to make sure that the paging reaches all UEs in the cell, including those UEs which need coverage extension to be successfully reached. According to the first embodiment, a paging possibility is established for specifically paging those CE-UEs, termed in the following CE-specific paging possibility. More precisely, a CE-specific paging frame and a CE-specific subframe are defined referring to radio resources of the PDCCH that can be used for the CE-paging. In a similarly manner as for the UE-specific paging possibilities defined in the current systems, the CE-specific paging possibility shall occur regularly, e.g. in a cyclic manner according to the paging cycle followed by the UE. The CE-specific paging possibility can be defined in addition to the normal UE-specific paging possibilities already established by the prior art, as discussed in the background section. The CE-specific paging possibility is independent from the UE's identity and shall be the same for a plurality of CE-UEs, e.g. CE-UEs of a particular cell or all CE-UEs in general (or at least all CE-UEs of a specific CE level as will be explained later); this is different from the normal UE-specific paging possibility which – even though

several UEs may monitor the same paging possibility - is specific to the UE due to being calculating based on the ID of the UE(s). This CE-specific paging possibility is known at least to the eNB and the CE-UEs; non-CE-UEs may or may not be informed about this CE-specific paging possibility; however, these non-CE-UEs shall not monitor the CE-specific paging possibility since they may be reached by "normal", i.e. non-CE, paging.

[0149] Furthermore, the paging initiated by the eNB shall reach both UEs in RRC-idle state as well as UEs in RRC-connected state. Consequently, the CE-specific paging possibility shall be monitored by UEs in RRC-idle state and UEs in RRC-connected state.

[0150] The CE-UEs regularly monitor the CE-specific paging possibility to receive the CE-paging, thereby ensuring that they can be successfully paged.

[0151] From the perspective of the eNB, when a page is triggered (e.g. by a system information change), in order to reach the CE-UEs, the eNB will wait for the corresponding paging opportunity given by the CE-specific paging possibility and will then perform a CE page at the CE-specific paging possibility which is monitored by all the CE-UEs in its cell. In a similar manner as for the UE-specific paging possibility, this particularly involves the transmission of the paging notification on the PDCCH at that radio frame and subframe of the CE-specific paging possibility and the corresponding transmission of the paging message on resources of the PDSCH as indicated by the paging notification on the PDCCH. This transmission of the two messages of the CE page is performed by using one appropriate technique of the plurality of CE techniques which are foreseen for achieving the coverage extension, e.g. a repetition technique or a technique where a significantly increased power is used for the transmission.

[0152] The CE-UE(s) in the cell of the eNB monitor the CE-specific paging possibility and thus will receive the paging notification on the PDCCH and subsequently the paging message on the PDSCH. Furthermore, since the eNB will use a coverage extension technique for the paging, which is known to the CE-UE(s), the CE-UE(s) will correspondingly react to the CE-paging by e.g. additionally receiving the repetitions of the paging notification and paging message.

[0153] The paging message will inform the CE-UE(s) about e.g. the system information change or a warning message etc. Depending on the content of the paging message on the PDSCH, the CE-UE will react accordingly, e.g. by acquiring the system information at the next modification period or by providing the warning message to the user of the CE-UE.

[0154] Of course, in a preferred first embodiment the eNB will also want to page the other (non-CE) UEs and for said purpose will page them at all possible paging possibilities, as discussed in the background section, i.e. this will be done without using any CE technique. The non-CE-UEs will each monitor their UE-specific paging possibility and

will thus receive one of the paging performed by the eNB.

[0155] In general, the CE-specific paging possibility may be different from any of the UE-specific paging possibilities, assignable for the UEs, although this is not strictly necessary for the functioning of the first embodiment. For example, only subframes 1, 2, 3, 6, 7, and 8 might be possible for the CE-specific paging possibility, considering that the other subframes 0, 4, 5, 9 are candidates for being selected/calculated as the UE-specific paging possibilities.

[0156] In one possible embodiment, the CE-UEs may keep on regularly monitoring their UE-specific paging possibility, calculated based on their identity as explained in the background section, in addition to the CE-specific paging possibility. Alternatively, the CE-UEs may not monitor the CE-specific paging possibility and the UE-specific paging possibility at the same time, but may only monitor the CE-specific paging possibility.

[0157] Fig. 5 shows, in a similar manner as Fig. 3, the paging possibilities monitored by two different CE-UEs, UE1 and UE2. As apparent from Fig. 5, it is assumed that CE-UE1 monitors a UE-specific paging possibility at radio frame number 76 and number 204 (76+128) etc., respectively at subframe 9 (see also Fig. 3, case B), and that CE-UE2 monitors a UE-specific paging possibility at radio frame number 19 and 147 (19+128) etc., respectively at subframe 4 (see also Fig. 3, case C). In addition, both CE-UE1 and CE-UE2 monitor the same CE-specific paging possibility, which in this exemplary illustration, is assumed to occur at CE-specific paging frames 36, 164 (36+128) etc. and at respective CE-specific subframe 1.

[0158] Fig. 6 shows a sequence diagram for the behavior of a CE-UE for an exemplary variant of the first embodiment. Particularly, it is assumed, in concordance with Fig. 5, that the CE-UE monitors both the CE-specific paging possibility as well as the UE-specific paging possibility, and when it receives the paging notification, the CE-UE will proceed to receive the corresponding paging message at the PDSCH resources indicated by the PDCCH paging notification, either applying or not applying a CE technique. Depending on the content of the paging message, the CE-UE will then react accordingly.

[0159] Fig. 7 shows a sequence diagram for the corresponding behavior of an eNB which wants to perform a paging. After the eNB decides to perform a paging of all UEs in its cell (e.g. due to system information change), it will proceed to perform the usual page at all possible UE-specific paging possibilities to reach all non-CE-UEs, without using any CE technique. On the other hand, to also reach the CE-UEs, the eNB will perform the CE paging at the CE-specific paging possibility, by using one appropriate CE-technique (e.g. repetition or increased transmission power).

[0160] The first embodiment as explained above has the advantage that the use of the

coverage extension technique(s) is limited to one particular CE-specific paging possibility, instead of having to be applied to all possible UE-specific paging possibilities. By using one paging possibility, all (or at least a plurality) of CE-UEs can be paged at the same time. Corresponding downlink resources can thus be saved. Furthermore, the CE-specific paging possibility is independent from the real IMSI of any CE-UE.

[0161] The CE-specific paging possibility can be defined in a number of different ways, but must always provide a CE-specific paging radio frame number and CE-specific paging subframe number, known to both the CE-UE(s) and the eNB(s).

[0162] According to a first variant of the first embodiment, the CE-specific paging possibility is fixed beforehand, e.g. not calculated but directly indicated. In one example, the numbers for the CE-specific paging radio frame and subframe are directly defined e.g. in the CE-UE (e.g. in its USIM, UICC etc) and the eNB; in other words, the CE-UE and the eNB would have information indicating particular radio frame and subframe numbers (such as radio frame number 36 and subframe number 1, as for the example of Fig. 4) for the CE-specific paging possibility. This information need not be pre-stored in the CE-UE (e.g. by use of the USIM) but could also be broadcast by the eNB in its cell, e.g. as part of the system information or indicated with a dedicated message when possible, such that the CE-UE(s) learn about the CE-specific paging possibility to be used for CE-paging from the eNB. This would allow different CE-specific paging possibilities to be used by different eNBs.

[0163] Alternatively, instead of directly indicating the CE-specific subframe number, the parameters Ns and i_s (already known from the calculation of the UE-specific paging possibility) could be reused in said respect. In particular, the following exemplary extended table can be used, which, in comparison with the table available from TS 36.304 as explained in the background section, includes at least one additional row for e.g. Ns= 5 (any other unused Ns number can be used of course) with the possible POs at subframes 1, 2, 3, and 6.

[0164] [Table 3]

Ns	PO when i_s=0	PO when i_s=1	PO when i_s=2	PO when i_s=3
1	9	N/A	N/A	N/A
2	4	9	N/A	N/A
4	0	4	5	9
5	1	2	3	6

[0165] For this alternative, Ns and i_s values would be pre-configured for the CE-specific paging possibility such that the CE-UE and eNB could determine, based on the exemplary table above, which CE-specific paging subframe to use. The CE-specific

paging radio frame would in this example still be directly indicated by a corresponding radio frame number.

[0166] The advantage of this first variant is that the CE-UE(s) would not need to calculate Ns and i_s, but may directly use the indicated numbers for the radio frame and subframe of the CE-specific paging possibility.

[0167] According to a second variant of the first embodiment to define the CE-specific paging possibility vis-a-vis the UE-specific paging possibility, the CE-specific paging possibilities are defined by providing different parameter values to the CE-UE(s) than to the non-CE-UEs. It is assumed, that the CE-specific paging subframe is calculated following the equations and principles explained for the UE-specific paging possibility in the background section. By using different parameter values for the same UE, the calculation of the UE-specific paging subframe yields different subframe numbers than the corresponding subframe numbers of the CE-specific paging possibility. As with the first variant explained above, the radio frame number for the CE-specific paging possibility is fixed.

[0168] In one example, the parameter with the different value is "nB", i.e. indicating the number of paging subframes per paging cycle (across all UEs in the cell), where one value is defined for CE-UEs and another value is defined for non-CE-UEs. There could however be another parameter broadcasted by the network for indicating rather directly the segregation of paging subframes between CE-UEs and non-CE-UEs.

[0169] According to a third variant of the first embodiment to define the CE-specific paging possibility, a CE-specific UE identity (e.g. CE-IMSI) is introduced. When considering the various CE levels a CE-UE can be configured for, a CE-level-specific UE identity can be introduced for each CE level. In any case, the CE-IMSI(s) is known to both the eNB and the CE-UE(s). The CE-specific UE identity(ies) can be provided to the CE-UEs beforehand, e.g. broadcast in the cell, or pre-stored in the SIM/ USIM or UICC or even in the Mobile Device, ME. A particular CE-UE and the network will use one of these identities corresponding to the required level of coverage extension support required e.g. one CE-UE deep down in bad radio and the network will use UE-identity1; whereas the same UE when coming back in relatively better radio, but still requiring CE support, will rather use UE-identity2 which is the corresponding use UE-identity for this level of Coverage Extension required. For this to work, it is important that the UE-identity to be used and the corresponding coverage extension required is known to both the network and the CE-UE e.g. by way of specification, or broadcasting etc. and there is a hand-shake between the CE-UE and the network about what level applies to the particular CE-UE at any given point in time. The hand-shake includes the measurement configuration and reporting as described previously.

[0170] It is assumed that basically the same calculation and principles are applied when cal-

culating the CE-specific paging possibility as explained for the UE-specific paging possibility in the background section. Both the eNB and the CE-UE(s) can calculate the same CE-(level)-specific paging possibility by the CE-(level)-specific IMSI instead of using the CE-UE's real IMSI.

[0171] As already mentioned in the background section, different coverage extension levels can be defined (e.g. 15dB, 13 dB etc.), where the respective coverage extension technique can be adapted appropriately to ensure achieving the corresponding coverage extension level. When e.g. considering the repetition CE technique, a coverage extension level to ensure 15dB might require 100 repetitions, whereas less or more repetitions may be necessary to ensure a different CE level. Similarly considerations apply to the other CE-techniques.

[0172] A particular CE-UE is configured for one of those coverage extension levels. Correspondingly, according to further examples of the first embodiment, one CE-specific paging possibility is defined per CE level, i.e. a CE-level-specific paging possibility, such that a CE-UE will only monitor the CE-level-specific paging possibility of the CE-level for which it is configured but not other CE-level-specific paging possibilities that are defined for other CE-levels.

[0173] A further improvement to the first embodiment is that CE-UEs which are in RRC-connected mode may try to read and receive paging at the UE-specific paging possibilities of other UEs. The UE_ID, which is IMSI mod 1024, can only take up to 1024 different values, and the radio frame is calculated based on "UE_ID mod N" such that only N different radio frames are used in each paging cycle. Consequently, a CE-UE could be configured to monitor some or all of the possible radio frames and subframes available for other UEs. This allows the network to not make as many repetitions as would otherwise be required if the UE was not receiving paging other than the UE-specific paging possibilities.

[0174] A further improvement to the first embodiment focuses on when to actually perform a CE page. Until now it has been (silently) assumed that there would be always a CE-UE in a cell, such that any eNB, at any time when paging is triggered, would perform the CE-paging at the CE-specific paging possibility(ies). The eNB is aware of all (CE-)UEs that are in RRC-Connected mode, since these have an active connection with the eNB, and thus the eNB determines whether a CE-UE that require coverage extension is in its cell or not. However, the eNB is not aware of which CE-UEs in RRC-Idle mode are currently in its cell. Consequently, assuming that no CE-UEs in RRC-Connected mode are in the cell of the eNB, the eNB is unaware of whether there is at least one CE-UE in RRC-Idle mode in its cell. To make sure that any possible CE-UEs in Idle mode are reached too, in these cases, the eNB will always have to performing the CE paging. This however may result in a waste of resources for the

case where no CE-UE(s) in RRC-Idle mode were in its cell either.

[0175] According to this improvement, this waste of resources shall be avoided by providing a procedure that allows the eNB to determine whether any CE-UEs are in its cell, be it in RRC-Idle or RRC-Connected state. To said end, the eNB might first determine whether there are any CE-UEs in RRC-Connected mode, which could be done e.g. by maintaining a table with UE-capability information received from the MME or UE. Subsequently, in case the eNB determines that there are no CE-UEs in RRC-Connected mode, a counting procedure is initiated which allows the eNB to determine/ estimate the number of CE-UEs in RRC-idle state in its cell. In one example of a counting procedure the UEs in RRC-Idle on a more or less round robin fashion go to RRC-Connected state and inform the network about the presence of the CE UE in RRC-Idle mode (i.e. about itself). The round robin method can e.g. be implemented using a persistence check method wherein the Idle UEs compare a randomly drawn number against a number broadcasted by the network. Only the one(s) drawing a smaller value will transit to RRC Connected to inform the network. The network can keep the broadcasted value to be small enough so that only a very small percentage of UEs should really pass this test at a given time. This is similar to what is done in MBMS Counting procedure as depicted in RRC specification 3GPP TS 36.331, current version 12.4.1 incorporated herein by reference.

[0176] In consequence, the eNB will only perform the CE page when it has determined that there is at least one CE-UE in its cell, be it in RRC-Idle or RRC-Connected state. As a result, the additional resources for a CE-page are not used in vain.

[0177] Second embodiment

As explained above, the first embodiment relates to an improvement for a paging procedure initiated by the eNB, which then shall page all UEs in its cell. The second embodiment to be presented relates to an improvement for a paging procedure that is initiated by the NAS (Non-Access-Stratum), e.g. the MME, and which is dedicated to just a single UE, or a rather limited number of UEs.

[0178] In particular, for this second embodiment it is assumed that the paging is initiated by the NAS, for instance in order to establish a call with a particular CE-UE; details in said respect have already been provided in the background section (see also Fig. 4) and apply equally to the second embodiment. In this respect the "call" need not be just a voice call but can also refer to other terminating service like SMS, MMS or Pager etc. For instance, the MME — in response to a corresponding trigger from the SGW in the core network — sends a paging message to all eNBs that belong to the tracking area(s) for which the CE-UE is currently registered. Particularly, the MME does not know where a CE-UE in RRC idle is located. Each eNB belonging to one of the TAs in an associated TA-list, in turn, then has to perform paging so as to page this CE-UE to

which the call is destined. Finally, the CE-UE being paged can then establish a connection with the eNB where it is camped and then proceed to accept the incoming call (see also Fig. 4).

[0179] In the above-described scenario, the MME informs the eNBs (over the S1 interface) about the capability(ies) of a (CE-)UE, e.g. whether the UE is capable of supporting coverage extension (and optionally which level of coverage extension). As explained before, this general capability information however gives no information on whether a particular CE-capable UE indeed requires coverage extension at the moment or not; e.g. while a CE-capable UE might have been in a basement for a long time, i.e. thus requiring coverage extension for compensating the bad radio conditions, this very same CE-capable UE might in mean time have emerged from the basement and thus might no longer require coverage extension or still require coverage extension but corresponding to a less demanding coverage extension level.

[0180] Consequently, according to the second embodiment, a procedure is implemented according to which the eNB can learn whether a CE-capable UE is indeed requiring coverage extension or not at the time of paging. To said end, a new measurement and reporting procedure is implemented between the UE and the eNB as will be explained in detail below.

[0181] The CE-capable UE is configured to perform radio measurements that allow determining whether the CE-capable UE is currently indeed requiring coverage extension or not. The radio measurements could refer for example to one or more of the following: Reference Signal Received Power (RSRP), Reference Signal Received Quality (RSRQ), channel quality etc. e.g. as defined in Chapter 5 of 3GPP TS36.214 v10.1.0(NPL 8), or even current Block Error Rate (BLER) estimates or HARQ operating point and any other suitable measurement target. In any case, a skilled person is well aware of how to determine the current radio conditions of a CE-capable UE that allow, in a subsequent step, to determine whether coverage extension is indeed necessary or not.

[0182] After performing the appropriate radio measurements, the CE-capable UE shall then determine whether coverage extension is necessary based on the results of the measurements. In one example, two appropriate thresholds can be defined, to which the measurements results are compared by the CE-capable UE so as to determine the current CE status of the CE-capable UE. For example, an upper threshold can be defined, where if the measurements results (e.g. RSRP or RSRQ) exceed the upper threshold, the CE-capable UE would determine that it does not require coverage extension, i.e. that it currently is a non-CE-UE. Conversely, a different lower threshold can be defined, where if the measurement results (e.g. again RSRP or RSRQ) fall below the lower threshold, the CE-capable would conclude that it does require

coverage extension, i.e. that is currently is a CE-UE. Instead of using two thresholds, the determination of whether CE is required or not, could of course also be determined by simply using one threshold, where measurements results exceeding the threshold would mean that coverage extension is not necessary, and measurements results falling below the threshold would mean that coverage extension is necessary. The same technique can also be used for other measurement possibility like for HARQ operating point i.e. where HARQ operating point exceeding the corresponding HARQ operating point-threshold would mean that coverage extension is not necessary, and HARQ operating point falling below the HARQ operating point-threshold would mean that coverage extension is necessary.

[0183] The radio measurements and CE status determination can be performed regularly by the CE-capable UE, i.e. at specific, pre-configured, intervals, and/or event triggered (one even for exceeding the threshold in either direction as described above), e.g. , and/or triggered by the eNB. In addition to the absolute threshold for the corresponding measurement, the network might also provide the corresponding Hysteresis and Time to Trigger values as described in 3GPP TS 36.331, current version 12.4.1. Hysteresis basically gives a margin or allowance in breaching the threshold in either direction, and the Time to Trigger (TTT) indicates at least how long the said threshold should remain breached/ exceeded for the UE to trigger the corresponding event.

[0184] Which radio measurements shall be performed, at which intervals, against which threshold(s) the measurement results should be compared, and any other necessary information can be pre-configured in the CE-capable UE or provided to the CE-capable UEs from the eNB, e.g. within a corresponding control message which could be signaled by RRC or Layer2 (MAC) or Layer1 (Physical layer signal) and may contain additional parameters including Hysteresis, TTT and the target object like current/ serving and neighbor cell list.

[0185] The CE-capable UE has to make sure that the eNB is kept updated on the current CE status, i.e. on whether the CE-capable UE needs coverage extension or not. This may be done e.g. by reporting every change of CE status to the eNB, such that the eNB knows at the time of paging whether a coverage extension technique shall be applied to the paging or not. Of course the same information can be used for DL messages other than paging and also to UL messages including paging response and other non-paging related messages. Depending on whether the CE-capable UE is in idle mode or connected mode, the reporting of the CE status to the eNB may be different. If the CE-capable UE is in RRC connected state and thus has an active connection with the eNB, the CE-capable UE can directly transmit a CE-status report, e.g. RRC Measurement Report, to the eNB.

[0186] Since such a direct report is not possible for CE-capable UEs in RRC-IDLE (since no

active connection with the eNB is available), the CE-capable UE in idle will report the CE status to the MME, which thus knows whether coverage extension is indeed required or not (independent from the CE-capability of a UE). The MME may either keep the eNB(s) regularly up to date in said respect, or might only provide the corresponding information to the eNB(s) when also triggering the eNB for paging. Of course, also CE-capable UEs in RRC connected could inform the MME, instead of or in addition to the eNB.

[0187] In another alternative, the CE-capable UE in idle will report the CE status and UE NAS identity directly to the serving eNB where the UE is camped in currently e.g. upon cell Selection and Reselection(s), which thus knows whether coverage extension is indeed required or not by maintaining a new Table including the UE NAS identity and CE-requirement.

[0188] Alternatively, another improvement provides that the CE-capable UEs do not change into RRC-idle state and thus remain all the time in RRC-connected state, such that the CE-capable UE can always transmit the measurement report directly to the eNB. The eNB can ensure that the UE remains in connected state by never sending the RRC Connection Release message to the UE i.e. basically ignoring any inactivity timer in the eNB for this UE.

[0189] In any case, the eNB, when being triggered to page a particular CE-capable UE, will be informed about and will consider whether said CE-capable UE indeed requires coverage extension or not. Based on the thus known current CE status of the UE, the eNB will or will not apply an appropriate CE technique to the paging of the CE-capable UE. As explained in detail for the first embodiment already, applying the CE technique to paging involves applying the CE technique to both the paging notification transmitted on the PDCCH and the actual paging message transmitted on the PDSCH as addressed by the PDCCH.

[0190] In other words, two measurement events are defined, one referring to the case where the radio measurements indicate that coverage extension is required, and the other referring to the case where the radio measurements indicate that coverage extension is not required. When any of the two events occur, this is reported to the eNB (either directly or via the core network entity, e.g. MME).

[0191] Fig. 8 shows a message sequence diagram for an exemplary paging procedure according to the second embodiment. As apparent therefrom, a measurement control message is provided from the eNB to the UE, which is assumed to include all information necessary to configure the UE to perform the radio measurements and to determine the CE-status based on the measurement results. Fig. 8 also shows the measurement report message from the UE to the eNB, which is transmitted to the eNB to allow the eNB to update the CE status of the UE. This allows in consequence that the

eNB performs the paging of the UE by using or not using a CE technique depending on the CE status of the UE.

[0192] Fig. 9 shows a simplified sequence process diagram for the CE-capable UE for one particular exemplary second embodiment as explained above where the measurement and reporting procedure is depicted in parallel to the page monitoring procedure.

[0193] Fig. 10 shows a simplified sequence process diagram for the eNB as explained above including the reception and update procedure for the CE status of the UE, and the parallel paging procedure which depends on the CE status.

[0194] Fig. 8 additionally shows an optional determination of the initial coverage extension status of the UE, which can be done directly upon the initial access of the UE to the eNB (see dashed box). In particular, the UE when initially attaching to a cell (and to the corresponding eNB) usually performs a RACH procedure, which involves e.g. the selection of an appropriate preamble, access slot etc. The CE-capable UE would, during initial access, determine its CE status in order to appropriately select the RACH resources (e.g. preamble, access slot, etc). Now, the eNB can estimate the radio conditions of the UE, and thus the CE status of the UE, based on the parameters, like preambles, preamble format or even the physical resources that the UE selected to perform the RACH procedure.

[0195] Another improvement of the second embodiment, which is also illustrated in Fig. 8 by use of a dashed arrow, refers to a feedback message transmitted from the eNB to the UE about the successful reception of the measurement report, i.e. CE status update, and confirmation that the toggling (between CE and non-CE) is successfully applied at the network side and therefore the UE should also toggle and transmit/ receive according to the new toggled state. By e.g. sending back information on the current CE status, the eNB can make sure that the CE-capable UE and the eNB have the same understanding of the CE status, and behave accordingly in a same manner. For instance, if the measurement report is lost, or decoded incorrectly at the eNB, the eNB would not change the CE status, and the UE and eNB would have different CE status (e.g. until the next, successful, measurement report is received by the eNB). Also, even successful reception of the measurement report is not a guarantee that eNB is fine with the toggling for reasons like admission control or for independent toggling evaluation at the eNB side. In this respect, the triggering of a measurement event is just one of the input parameter for the eNB to decide about the said toggling of CE state, and eNB may take the final decision based on cell and System specific considerations. In absence of the feedback message transmitted from the eNB to the UE about the successful reception of the measurement report and confirming that the toggling (between CE and non-CE) is successfully applied at the network side, obviously, different CE status might lead to a waste of radio resources or to an unsuccessful

paging, which is avoided by providing a feedback on the successful CE status update.

[0196] Still a further improvement of the second embodiment is also illustrated in Fig. 8. As indicated by the dashed arrow, the UE can inform the eNB immediately when a CE page was successful. In particular, instead of waiting to receive e.g. all repetitions of the CE page, as soon as the CE page is successfully received (e.g. the actual paging message was successfully decoded/delivered to the higher layer), the CE-capable UE informs the eNB in said respect. In turn, the eNB can inform the MME in the core network, which may then abort the page in the other eNBs of all the tracking areas (not shown in Fig. 8) pertaining to a corresponding TA-list. Radio resources are thus not wasted by other eNBs.

[0197] Third embodiment

According to a third embodiment, the first embodiment and the second embodiments are combined such that CE devices can be paged both at the NAS level and the AS level (i.e. initiated by NAS and initiated by eNB). Thus, the separation of NAS and AS is maintained as in legacy systems. Furthermore, the first and second embodiments are simple to implement and have no impact on legacy procedures.

[0198] Hardware and Software Implementation of the present disclosure

Other exemplary embodiments relate to the implementation of the above described various embodiments using hardware and software. In this connection a user terminal (mobile terminal) and an eNodeB (base station) are provided. The user terminal and base station is adapted to perform the methods described herein, including corresponding entities to participate appropriately in the methods, such as receiver, transmitter, processors.

[0199] It is further recognized that the various embodiments may be implemented or performed using computing devices (processors). A computing device or processor may for example be general purpose processors, digital signal processors (DSP), application specific integrated circuits (ASIC), field programmable gate arrays (FPGA) or other programmable logic devices, etc. The various embodiments may also be performed or embodied by a combination of these devices.

[0200] Further, the various embodiments may also be implemented by means of software modules, which are executed by a processor or directly in hardware. Also a combination of software modules and a hardware implementation may be possible. The software modules may be stored on any kind of computer readable storage media, for example RAM, EPROM, EEPROM, flash memory, registers, hard disks, CD-ROM, DVD, etc.

[0201] It should be further noted that the individual features of the different embodiments may individually or in arbitrary combination be subject matter to another embodiment.

[0202] It would be appreciated by a person skilled in the art that numerous variations and/or

modifications may be made to the present disclosure as shown in the specific embodiments. The present embodiments are, therefore, to be considered in all respects to be illustrative and not restrictive.

Claims

[Claim 1] A method for paging all user equipments in a cell controlled by a radio base station in a mobile communication system, wherein at least one regularly-occurring coverage-extension-specific paging possibility, in short CE-specific paging possibility, is defined for paging user equipments that require coverage extension, in short CE user equipments, wherein the radio base station is capable to use one of a plurality of techniques for achieving a coverage extension for a CE user equipment, the method comprising the steps of:
regularly monitoring by the CE user equipments in the cell the at least one CE-specific paging possibility,
determining by the radio base station to page all the user equipments in the cell, and
paging by the radio base station the CE user equipments in the cell at the CE-specific paging possibility, using one of the plurality of techniques for achieving the coverage extension.

[Claim 2] The method according to claim 1, wherein a plurality of UE-specific paging possibilities are defined for paging a specific user equipment in the cell of the radio base station, wherein the CE user equipments and non-CE user equipments each monitor a respective UE-specific paging possibility out of the plurality of UE-specific paging possibilities,
wherein the radio base station — upon determining to page all the user equipments in the cell - additionally performs paging at all of the plurality of UE-specific paging possibilities without using one of the plurality of techniques for achieving coverage extension,
preferably wherein each of the plurality of UE-specific paging possibilities is different from the at least one CE-specific paging possibility.

[Claim 3] The method according to claim 1 or 2, wherein the step of paging includes:
transmitting by the radio base station a first paging notification at radio resources of a control channel specified by the at least one CE-specific paging possibility, and
transmitting by the radio base station a second paging message at radio resources of another channel specified by the first paging notification,
preferably wherein the technique for achieving the coverage extension is applied to both steps of transmitting the first paging notification and of transmitting the second paging message.

[Claim 4] The method according to one of claims 1 to 3, wherein each of the at least one CE-specific paging possibility refers to radio resources of a control channel defined by a radio frame number and a subframe number which are pre-configured such that the radio frame number and the subframe number are fixed for the CE-specific paging possibility, preferably wherein information to determine the pre-configured radio frame number and the pre-configured subframe number is stored in a Universal Subscriber Identity Module, USIM, of the CE user equipment, or broadcast by the radio base station in the cell, and preferably wherein the pre-configured subframe number is 1, 2, 3, 6, 7, or 8.

[Claim 5] The method according to one of claims 1 to 3, wherein CE user equipments are assigned a CE-specific user equipment identity based on which the CE-specific paging possibility is calculated by the radio base station and the CE user equipments,
preferably wherein the CE-specific user equipment identity is the same for all CE-configured user equipments,
preferably wherein the CE-specific user equipment identity is stored in a Universal Subscriber Identity Module, USIM, of the CE user equipment or broadcast by the radio base station in the cell;
preferably wherein a plurality of different levels of coverage extension is defined, and wherein for each level of coverage extension a different CE-specific user equipment identity is defined.

[Claim 6] A user equipment located in a cell controlled by a radio base station in a mobile communication system, the user equipment, in short CE user equipment, requiring coverage extension, wherein at least one regularly-occurring coverage-extension-specific paging possibility, in short CE-specific paging possibility, is defined for the CE user equipment, wherein the radio base station is capable to use one of a plurality of techniques for achieving a coverage extension for the CE user equipment, the CE user equipment comprising:
a processor adapted to regularly monitor the at least one CE-specific paging possibility,
a receiver adapted to receive a paging from the radio base station at the CE-specific paging possibility, using one of the plurality of techniques for achieving the coverage extension.

[Claim 7] The user equipment according to claim 6, wherein each of the at least one CE-specific paging possibility refers to radio resources of a control

channel defined by a radio frame number and a subframe number which are pre-configured such that the radio frame number and the subframe number are fixed for the CE-specific paging possibility, preferably wherein a memory of the CE user equipment is adapted to store information to determine the pre-configured radio frame number and the pre-configured subframe number, preferably wherein the memory is a Universal Subscriber Identity Module, USIM, of the CE user equipment, or
preferably wherein the receiver of the CE user equipment is further adapted to receive information to determine the pre-configured radio frame number and the pre-configured subframe number, broadcast by the radio base station in the cell.

[Claim 8] A radio base station for paging all user equipments in a cell controlled by the radio base station in a mobile communication system, wherein at least one regularly-occurring coverage-extension-specific paging possibility, in short CE-specific paging possibility, is defined for paging user equipments that require coverage extension, in short CE user equipments, wherein the radio base station is capable to use one of a plurality of techniques for achieving a coverage extension for a CE user equipment, the radio base station comprising:
a processor adapted to determine whether to page all the user equipments in the cell, and
a transmitter adapted to page the CE user equipments in the cell at the CE-specific paging possibility, using one of the plurality of techniques for achieving the coverage extension.

[Claim 9] A method for paging a user equipment in a cell controlled by a radio base station in a mobile communication system, wherein the user equipment supports coverage extension techniques, wherein the radio base station is capable to use one of a plurality of techniques for achieving a coverage extension for the CE-capable user equipment, the method comprising the steps of:
performing radio measurements by the CE-capable user equipment,
determining by the CE-capable user equipment whether coverage extension is necessary or not, based on the results of the radio measurements,
wherein the radio base station is informed about whether the CE-capable user equipment needs coverage extension or not, based on the determination result,

when paging the CE-capable user equipment, applying or not applying by the radio base station one of the plurality of techniques for achieving coverage extension depending on whether coverage extension is necessary or not for the CE-capable user equipment.

[Claim 10] The method according to claim 9, wherein the radio measurements performed by the CE-capable user equipment include measurements of a Reference Signal Received Power, RSRP, and/or Reference Signal Received Quality, RSRQ, and/or a channel quality, and/or a block error rate and/ or HARQ operating point.

[Claim 11] The method according to claim 9 or 10, wherein the step of determining whether coverage extension is necessary comprises the steps of:
comparing by the CE-capable user equipment the result of the radio measurements with a first threshold to determine whether coverage extension is necessary, preferably wherein the comparison determines that coverage extension is necessary when the result of the radio measurements falls below the first threshold,
comparing by the CE-capable user equipment the result of the radio measurements with a second threshold to determine whether coverage extension is not necessary, preferably wherein the comparison determines that coverage extension is not necessary when the result of the radio measurement exceeds the second threshold.

[Claim 12] The method according to one of claims 9 to 11, wherein the step of paging the CE-capable user equipment comprises the steps of:
transmitting by the radio base station a first paging notification at radio resources of a control channel specified by a paging possibility specific to the CE-capable user equipment, and
transmitting by the radio base station a second paging message at radio resources of another channel specified by the first paging notification, preferably wherein the technique for achieving the coverage extension is applied to both steps of transmitting the first paging notification and of transmitting the second paging message.

[Claim 13] A user equipment located in a cell controlled by a radio base station in a mobile communication system, the user equipment, in short CE user equipment, supporting coverage extension techniques, wherein the radio base station is capable to use one of a plurality of techniques for achieving a coverage extension for the CE-capable user equipment, the user equipment comprising:
a processor adapted to perform radio measurements,

the processor being further adapted to determine whether coverage extension is necessary or not, based on the results of the radio measurements,

a transmitter adapted to inform the radio base station about whether the CE-capable user equipment needs coverage extension or not, based on the determination result,

a receiver adapted to receive paging from the radio base station, applying or not applying one of the plurality of techniques for achieving coverage extension depending on whether coverage extension is necessary or not.

[Claim 14] The user equipment according to claim 13, wherein the transmitter informs the radio base station by:

transmitting information about whether the CE-capable user equipment needs coverage extension or not to the radio base station, preferably wherein the CE-capable user equipment is in a connected state, preferably wherein it is avoided that the CE-capable user equipment is changing into the idle state by keeping it in the connected state, or

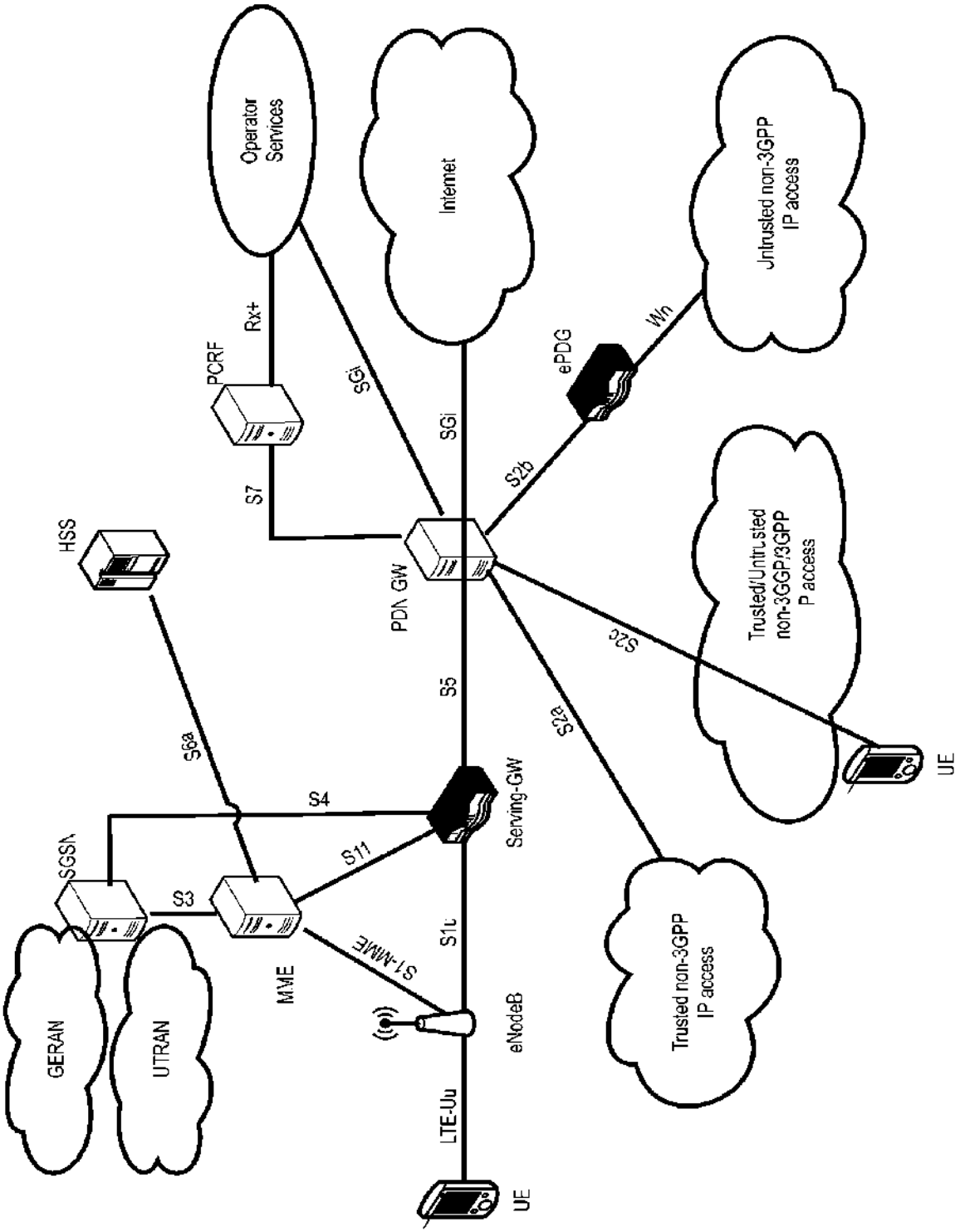
transmitting information about whether the CE-capable user equipment needs coverage extension or not to a core network entity, and wherein the core network entity provides the received information to the radio base station, preferably wherein the CE-capable user equipment is in a connected state or in an idle state.

[Claim 15] A radio base station for paging a user equipment in a cell controlled by the radio base station in a mobile communication system, wherein the user equipment supports coverage extension techniques, wherein the radio base station is capable to use one of a plurality of techniques for achieving a coverage extension for the CE-capable user equipment, the radio base station comprising:

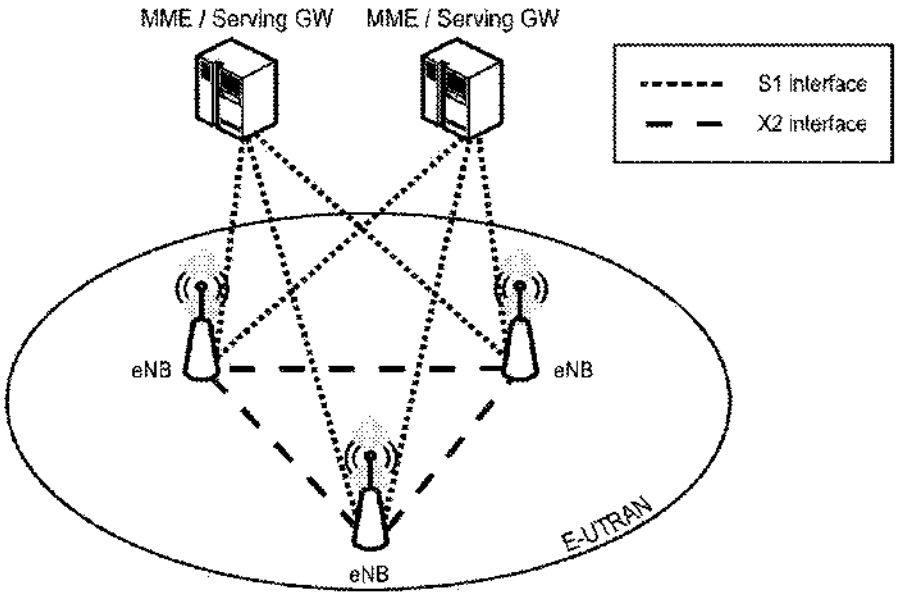
a receiver adapted to receive information about whether the CE-capable user equipment needs coverage extension or not,

a transmitter being adapted to, when paging the CE-capable user equipment, apply or not apply one of the plurality of techniques for achieving coverage extension depending on whether coverage extension is necessary or not for the CE-capable user equipment.

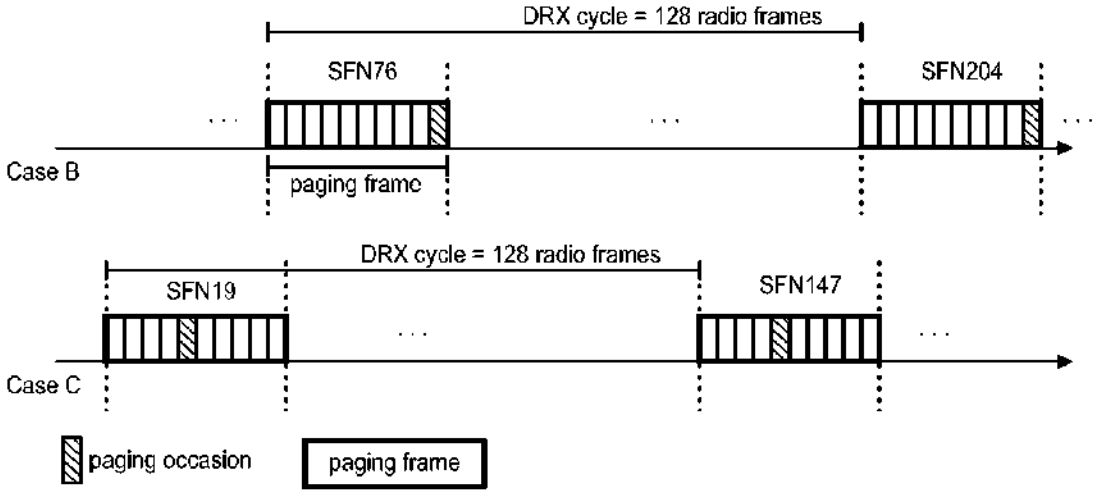
[Fig. 1]


Operator Services
Internet
Untrusted non-3GPP IP access
Rx+
PCRF
SGi
ePDG
Wn
S7
S2b
HSS
PDN GW
Trusted/Untrusted non-3GPP/3GPP P access
S2c
S5
S6a
S2a
UE
S4
Serving-GW
SGSN
S11
S3
S1u
S1-MME
GERAN
UTRAN
MME
eNodeB
Trusted non-3GPP IP access
LTE-Uu
UE

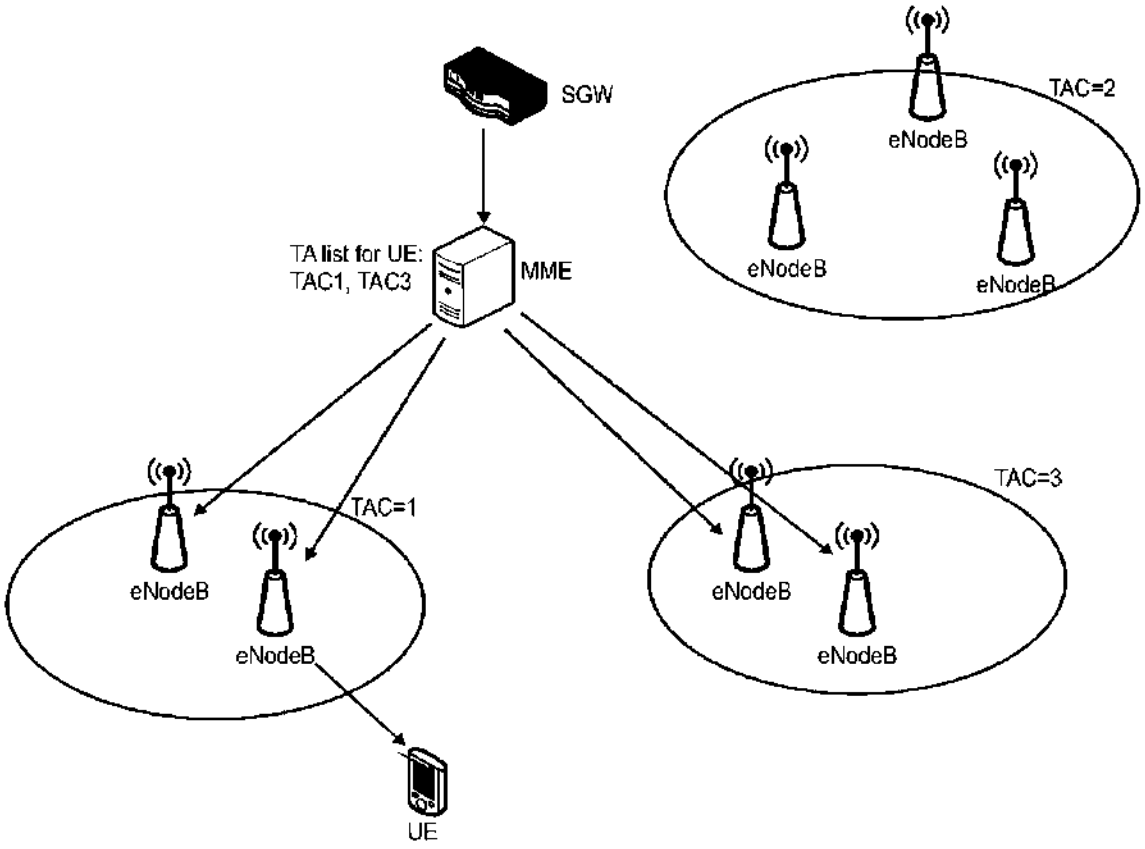
[Fig. 2]


MME / Serving GW
MME / Serving GW
S1 interface
X2 interface
eNB
eNB
eNB
E-UTRAN

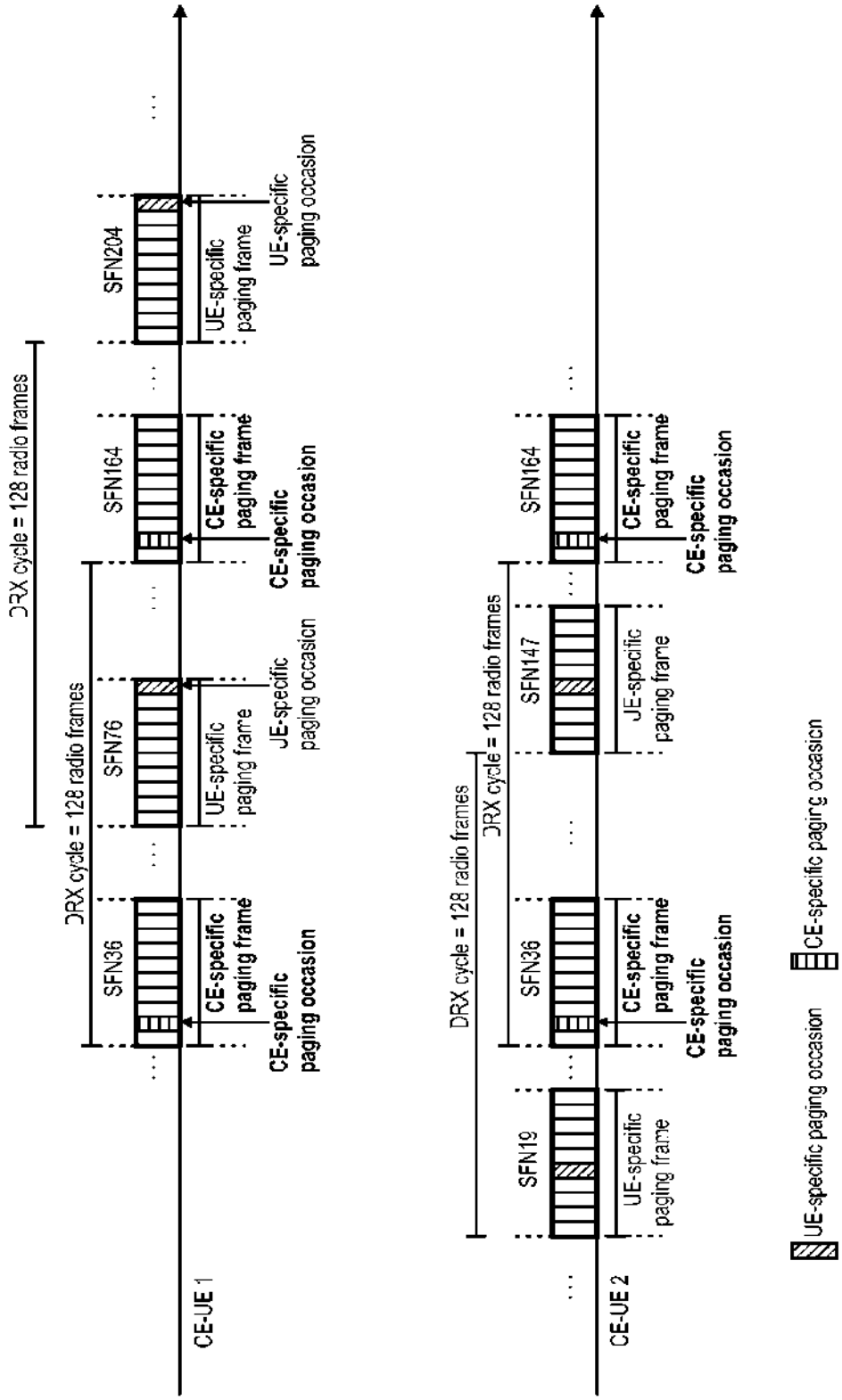
[Fig. 3]


DRX cycle = 128 radio frames
SFN76
SFN204
Case B
paging frame
DRX cycle = 128 radio frames
SFN19
SFN147
Case C
paging occasion
paging frame

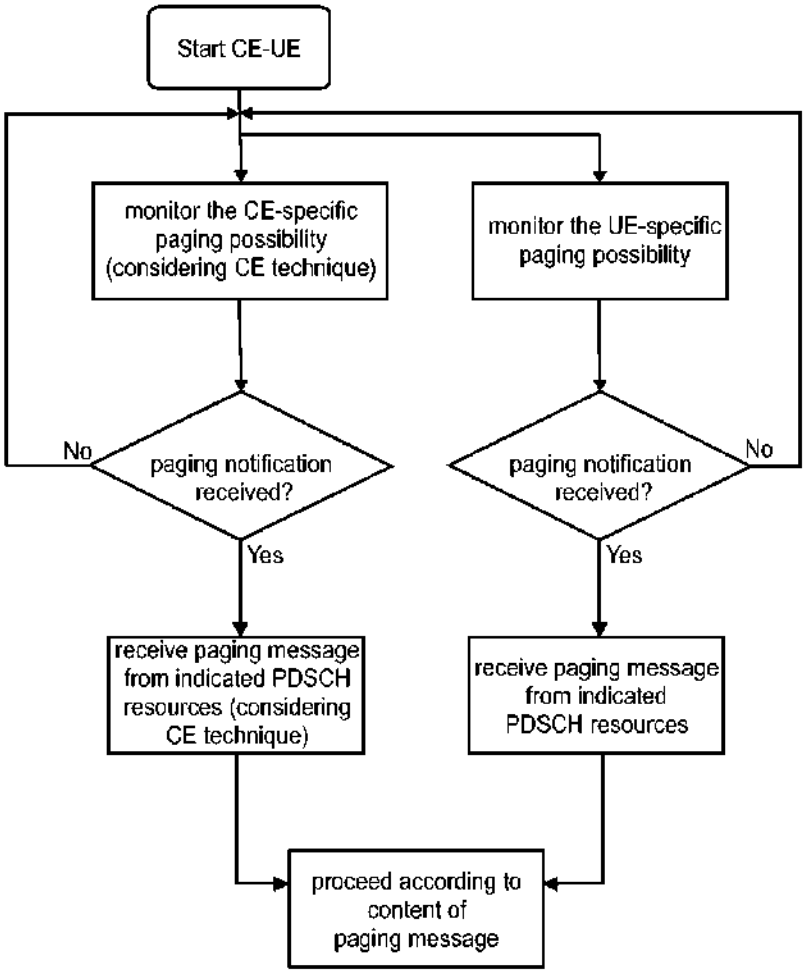
[Fig. 4]


SGW
TA list for UE:
TAC1, TAC3
MME
TAC=1
eNodeB
eNodeB
TAC=2
eNodeB
eNodeB
eNodeB
TAC=3
eNodeB
eNodeB
UE

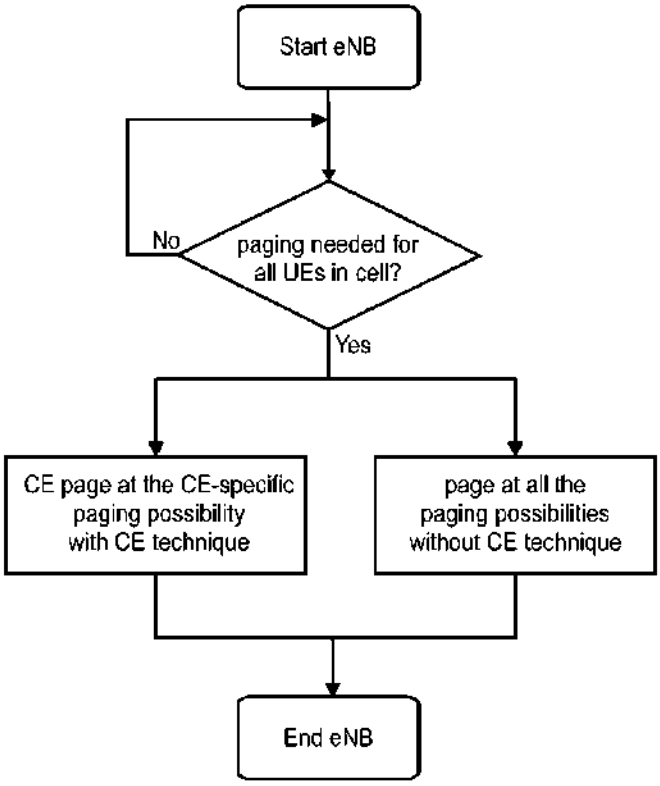
[Fig. 5]


DRX cycle = 128 radio frames
DRX cycle = 128 radio frames
SFN36
SFN76
SFN164
SFN204
CE-specific paging frame
UE-specific paging frame
CE-specific paging occasion
UE-specific paging occasion
CE-UE 1
DRX cycle = 128 radio frames
DRX cycle = 128 radio frames
SFN19
SFN36
SFN147
SFN164
UE-specific paging frame
CE-specific paging frame
CE-specific paging occasion
CE-UE 2
UE-specific paging occasion
CE-specific paging occasion

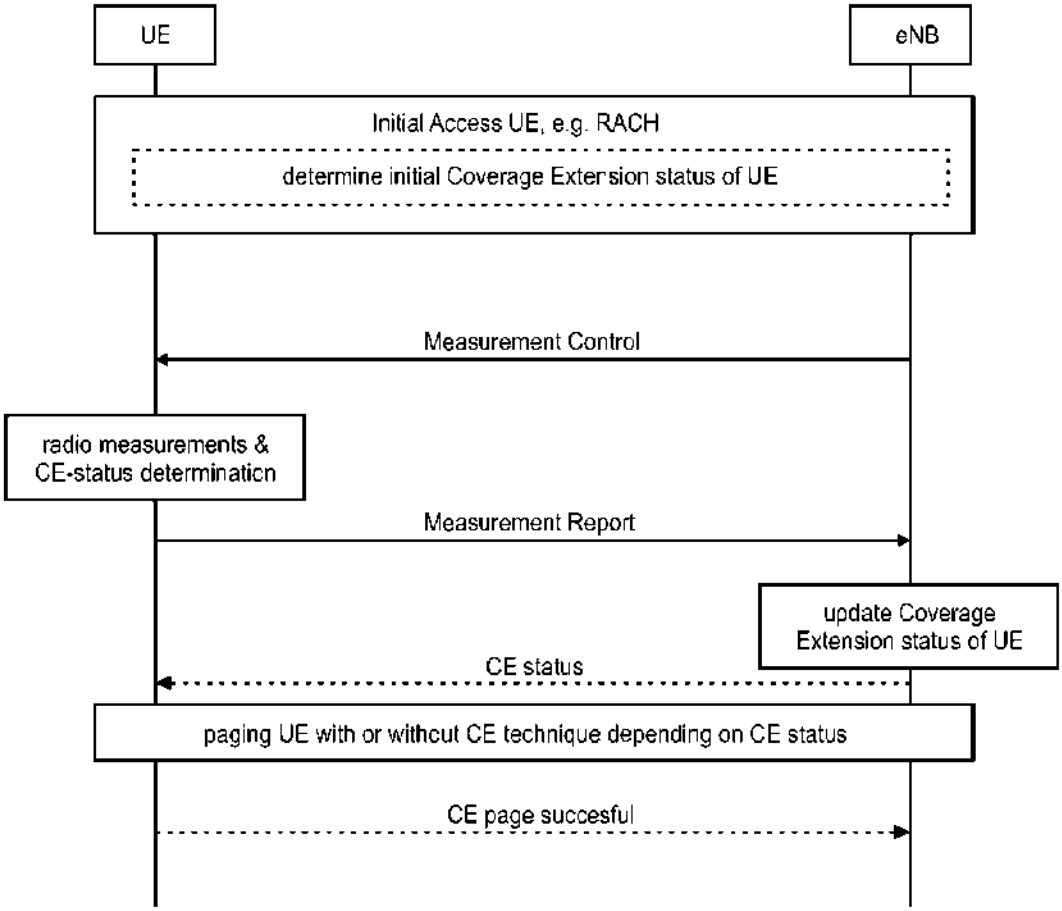
[Fig. 6]


Start CE-UE
monitor the CE-specific paging possibility (considering CE technique)
monitor the UE-specific paging possibility
paging notification received?
No
Yes
paging notification received?
No
Yes
receive paging message from indicated PDSCH resources (considering CE technique)
receive paging message from indicated PDSCH resources
proceed according to content of paging message

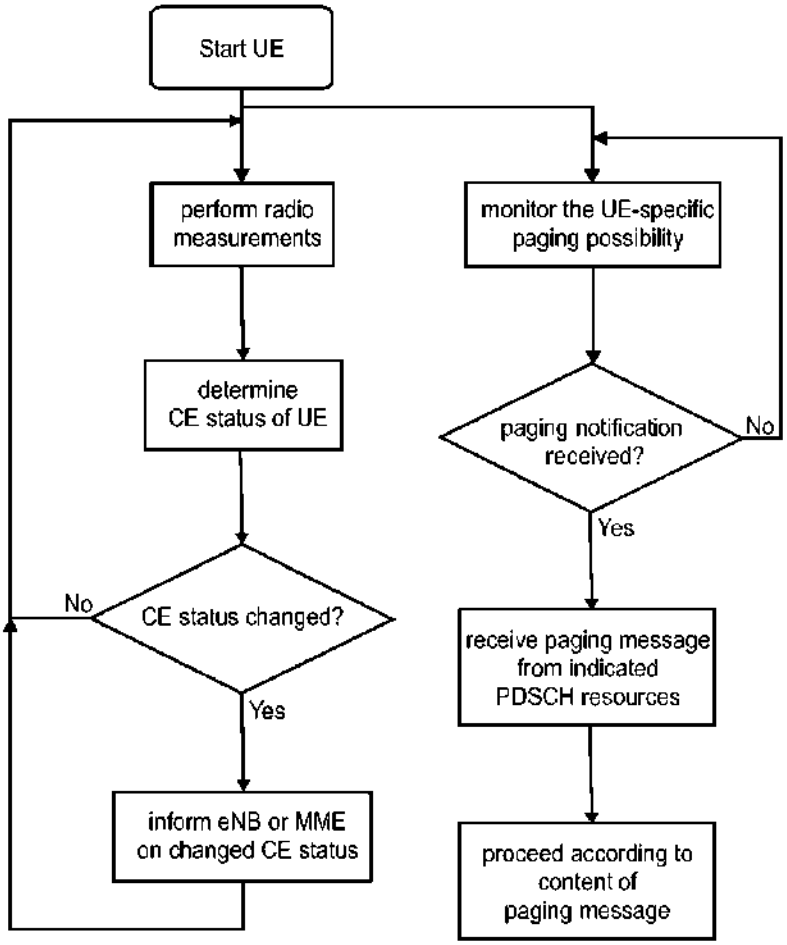
[Fig. 7]


Start eNB
No
paging needed for all UEs in cell?
Yes
CE page at the CE-specific paging possibility with CE technique
page at all the paging possibilities without CE technique
End eNB

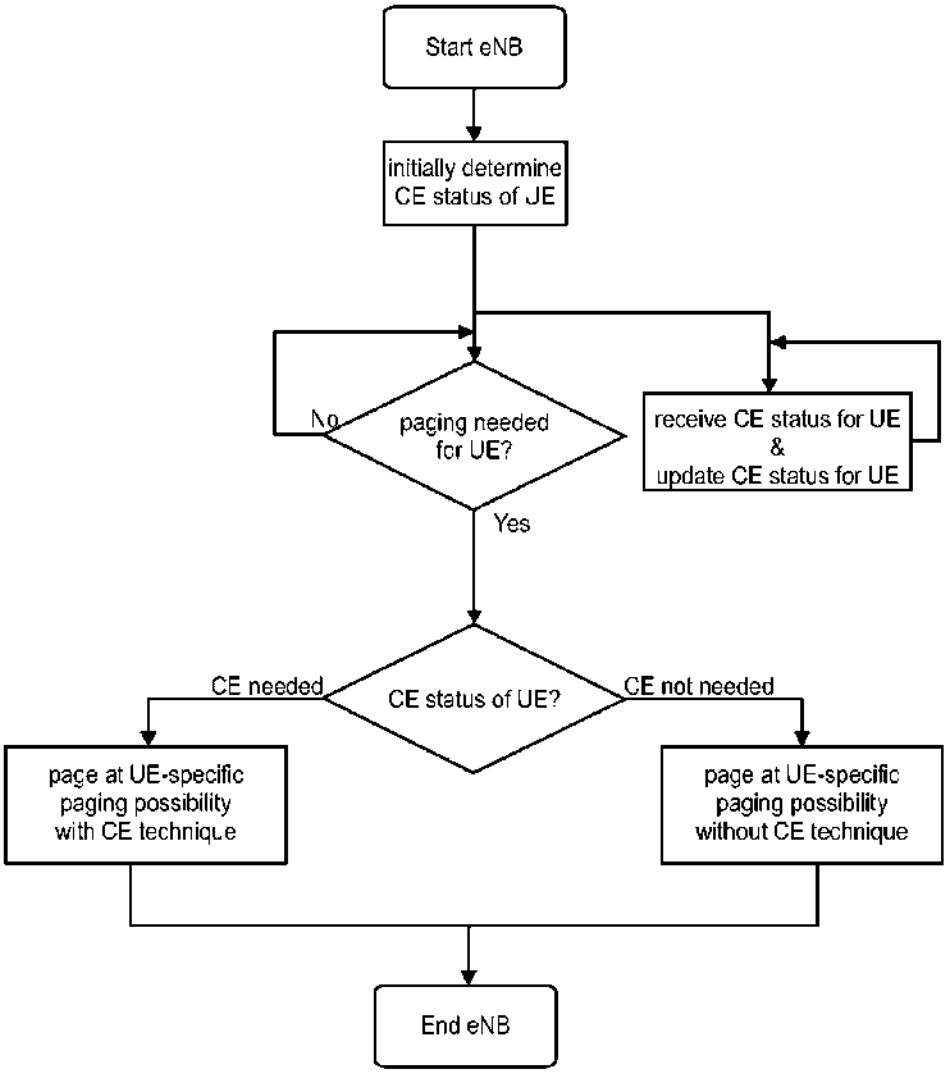
[Fig. 8]


UE
eNB
Initial Access UE, e.g. RACH
determine initial Coverage Extension status of UE
Measurement Control
radio measurements &
CE-status determination
Measurement Report
update Coverage
Extension status of UE
CE status
paging UE with or without CE technique depending on CE status
CE page succesful

[Fig. 9]


Start UE
perform radio measurements
determine CE status of UE
CE status changed?
No
Yes
inform eNB or MME on changed CE status
monitor the UE-specific paging possibility
paging notification received?
No
Yes
receive paging message from indicated PDSCH resources
proceed according to content of paging message

[Fig. 10]


Start eNB
initially determine CE status of JE
No
paging needed for UE?
receive CE status for UE & update CE status for UE
Yes
CE needed
CE status of UE?
CE not needed
page at UE-specific paging possibility with CE technique
page at UE-specific paging possibility without CE technique
End eNB

INTERNATIONAL SEARCH REPORT

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PCT/JP2016/000417

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According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2016
Registered utility model specifications of Japan 1996-2016
Published registered utility model applications of Japan 1994-2016

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2014/0098761 A1 (INTERDIGITAL PATENT HOLDINGS, INC.) 2014.04.10, whole document & JP 2015-537422 A & EP 2904850 A1 & TW 201429174 A & CN 104704884 A & KR 10-2015-0064196 A	1-15
A	Alcatel-Lucent, Alcatel-Lucent Shanghai Bell, Capability signaling for Low Complexity MTC UE[online], 3GPP TSG-RAN WG2#85 R2-140727, URL:http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_85/Docs/R2-140727.zip, 2014.02.01	1-15

☑ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/000417

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Alcatel-Lucent, Alcatel-Lucent Shanghai Bell, Coverage enhancement for common control messages[online], 3GPP TSG-RAN WG1#78b R1-144077, URL:http://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_78b/Docs/R1-144077.zip, 2014.09.27	1-15

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(54) **Title**: RECOVERY FROM BEAM FAILURE

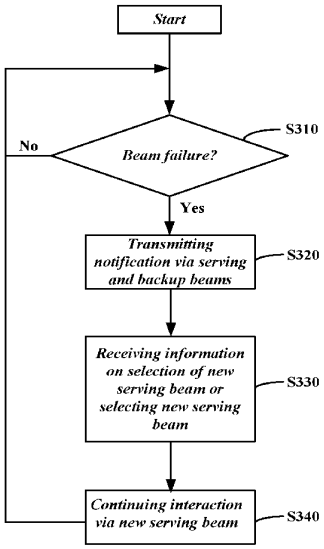


Fig. 3

(57) **Abstract**: The present invention generally relates to wireless communication, more particularly, relates to recovery from beam failure in a wireless access network where beamforming technique is used in communication between network elements. According to one aspect of the present invention, there is provided a method for recovery from beam failure in a wireless access network accessed by a user equipment (UE). The method comprises: at the wireless access network, determining whether the beam failure occurs on the basis of presence of a response from the UE during communicating between the wireless access network and the UE via a first beam; and if it is determined that the beam failure occurs, communicating with the UE via an available beam selected from the first beam and one or more second beams.

WO 2017/024516 A1

RECOVERY FROM BEAM FAILURE

TECHNICAL FIELD

[001] The present invention generally relates to wireless communication, more particularly, relates to recovery from beam failure in a wireless access network where beamforming technique is used in communication between network elements.

BACKGROUND

[002] The ultimate goal of mobile broadband should be the ubiquitous and sustainable provision of non-limiting data rates to everyone and everything at every time. Along this path, Ultra-Dense Network (UDN) is an important next step following the successful introduction of LTE for wide-area and local-area access.

[003] Ultra-dense network (UDN) is envisioned to provide ubiquitous mobile broadband with access-node densities considerably higher than the current densest cellular networks. UDN can be deployed in areas with high traffic consumption. Through overprovision and related low average loads in an access network, UDN creates ubiquitous access opportunities which – even under realistic assumptions on user density and traffic – provide users with the desired data rates.

[004] Overprovisioning is achieved by an extremely dense grid of access nodes; inter-access-node distances in the order of tens of meters and below are envisioned. For in-indoor deployments, one or even multiple access nodes are conceivable in each room. Additionally, in order to increase network capacity, densification – via reduced transmit powers – also offers access to vast spectrum holdings in the millimeter-wave bands and thus higher data rates.

[005] Beamforming for concentrating transmitted energy on an intended receiver plays a critical role for UDN. However, using more narrow transmission beams also makes a wireless system more susceptible to sudden coverage loss due to beam failure. In light of the above, an

efficient and reliable recovery from the beam failure constitutes an urgent issue to be addressed.

SUMMARY OF THE INVENTION

[006] According to one aspect of the present invention, there is provided a method for recovery from beam failure in a wireless access network accessed by a user equipment (UE). The method comprises: at the wireless access network, determining whether the beam failure occurs on the basis of presence of a response from the UE during communication between the wireless access network and the UE via a first beam; and if it is determined that the beam failure occurs, communicating with the UE via an available beam selected from the first beam and one or more second beams.

[007] According to the above aspect of the present invention, the beam failure can be effectively detected by a feedback-based determination without always-on reference signal. This is especially advantageous for a UE specific beam-based system such as UDN.

[008] In an embodiment according to the present invention, the response is one selected from a group consisting of: an acknowledgment(ACK) message or a negative Acknowledgment(NACK) message responding to a data message transmitted from an AN of the wireless access network on a downlink associated with the first beam, and a data message responding to a grant message transmitted from an AN of the wireless access network on a downlink associated with the first beam.

[009] In an embodiment according to the present invention, the selection of the available beam is on the basis of radio link quality for downlinks associated with the first beam and the one or more second beams.

[010] In an embodiment according to the present invention, the step of communicating with the UE via the available beam comprises: upon determining that the beam failure occurs, transmitting to the UE a message from one or more ANs of the wireless access network via the first beam and the one or more second beams; receiving information on the selection of the available beam from the UE; and using the selected available beam

during communication with the UE.

[011] In an embodiment according to the present invention, the step of communicating with the UE via the available beam comprises: upon determining that the beam failure occurs, transmitting to the UE a message from a first AN and a second AN of the wireless access network, wherein the message from the first AN is transmitted via the first beam and the message from the second AN is transmitted via the one or more second beams; receiving information on the selection of the available beam from the UE; and using the selected available beam during communication with the UE.

[012] In an embodiment according to the present invention, the step of communicating with the UE via the available beam comprises: upon determining that the beam failure occurs, transmitting a message from a first AN and second AN of the wireless access network, wherein the message from the first AN is transmitted via the first beam and at least one of the second beams and the message from the second AN is transmitted via the other of the second beams; receiving information on the selection of the available beam from the UE; and using the selected available beam during communication with the UE.

[013] According to another aspect of the present invention, there is provided a method for recovery from beam failure for a user equipment (UE) accessing a wireless access network. The method comprises: at the UE, determining whether the beam failure occurs on the basis of presence of a response from the wireless access network during communication between the wireless access network and the UE via a first beam; and if it is determined that the beam failure occurs, communicating with the wireless access network via an available beam selected from the first beam and one or more second beams.

[014] In an embodiment according to the present invention, the response is one selected from a group consisting of: a grant message responding to a service request transmitted from the UE on an uplink associated with the first beam and an random access response message responding to a random access request transmitted from the UE on an uplink associated with the first beam.

[015] In an embodiment according to the present invention, the selection of the available beam is on the basis of radio link quality for uplinks associated with the first beam and the one or more second beams.

[016] In an embodiment according to the present invention, the step of communicating with the wireless access network via the available beam comprises: upon determining that the beam failure occurs, transmitting to one or more ANs of the wireless access network a message from the UE via the first beam and the one or more second beams; receiving information on the selection of the available beam from the one or more ANs of the wireless access network; and using the selected available beam during communication with the wireless access network.

[017] According to another aspect of the present invention, there is provided an access node (AN) capable of communicating with a user equipment (UE). The AN is configured to: determine whether beam failure occurs on the basis of presence of a response from the UE during communication between the AN and the UE via a first beam; and if it is determined that the beam failure occurs, communicate with the UE via an available beam selected from the first beam and one or more second beams, or transfer to another AN communication with the UE, the communication being made via the available beam.

[018] According to another aspect of the present invention, there is provided a user equipment (UE) capable of communicating with a wireless access network. The UE is configured to: determine whether the beam failure occurs on the basis of presence of a response from the wireless access network during commnication between the wireless access network and the UE via a first beam; and if it is determined that the beam failure occurs, communicate with the wireless access network via an available beam selected from the first beam and one or more second beams.

[019] According to another aspect of the present invention, there is provided a user equipment (UE) capable of interacting with a wireless access network. The UE comprises: a determining unit configured to determine whether the beam failure occurs on the basis of presence of a response from the wireless access network during communication between the wireless access network and the UE via a first beam; and a transceiver configured to communicate with the wireless access network via an available beam selected from the first beam and one or more second beams if determining that the beam failure occurs.

[020] In an embodiment according to the present invention, for communicating with the wireless access network via the available beam, the transceiver is configured to: transmit to one or more ANs of the wireless access network a message from the UE via the first beam and the one or more second beams if determining that the beam failure occurs; receive information on the selection of the available beam from the one or more ANs of the wireless access network; and use the selected available beam to communicate with the wireless access network.

[021] According to another aspect of the present invention, there is provided an access node (AN) capable of communicating with a user equipment (UE). The AN comprises: a determining unit configured to determine whether beam failure occurs on the basis of presence of a response from the UE during communication between the AN and the UE via a first beam; and a transceiver configured to, if the determining unit determines that the beam failure occurs, communicate with the UE via an available beam selected from the first beam and one or more second beams, or transfer to another AN communication with the UE, the communication being made via the available beam.

BRIEF DESCRIPTION OF THE DRAWINGS

[022] The invention is herein described, by way of example only, with reference to the accompanying drawings. With specific reference now to the drawings in detail, it is stressed that the particulars shown are by way of example and for purposes of illustrative discussion of the preferred embodiments of the present invention only, and are presented in order to provide what is believed to be the most useful and readily understood description of the principles and conceptual aspects of the invention. In this regard, no attempt is made to show structural details of the invention in more detail than is necessary for a fundamental understanding of the invention, the description taken with the drawings making apparent to those skilled in the art how the several forms of the invention may be embodied in practice.

[023] In the drawings:

[024] Fig. 1 is a schematic diagram depicting an Ultra-dense network (UDN) architecture.

[025] Fig. 2 is a process flow diagram of a method for reaching pre-agreement on backup beam(s) according to one exemplary embodiment of the present invention.

[026] Fig. 3 is a process flow diagram of a method for recovery from beam failure in a wireless access network according to another exemplary embodiment of the present invention.

[027] Fig. 4 is a process flow diagram of a method for recovery from beam failure in a wireless access network according to another exemplary embodiment of the present invention.

[028] Fig. 5 is a block diagram illustrating a user equipment (UE) having recovery capability from beam failure according to another exemplary embodiment of the present invention.

[029] Fig. 6 is a block diagram illustrating an access node (AN) having recovery capability from beam failure according to another exemplary embodiment of the present invention.

DETAILED DESCRIPTION

[030] The principles and operation of the present invention may be better understood with reference to the drawings and accompanying description.

[031] Before explaining at least one embodiment of the invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of the components set forth in the following description or illustrated in the drawings. The invention is capable of being implemented by other embodiments or of being practiced or carried out in various ways. Also, it is to be understood that the phraseology and terminology employed herein is for the purpose of description and should not be regarded as limiting.

[032] All references to "a/an/the element, apparatus, component, means, step, etc." are to be interpreted as referring to at least one instance of the element, apparatus, component, means, step, etc., unless explicitly stated otherwise. The steps of any method disclosed herein do not have to be performed in the exact order disclosed, unless explicitly stated. The

discussion above and below in respect of any of the aspects of the present disclosure is also in applicable parts relevant to any other aspect of the present disclosure.

[033] Generally, all terms used in the claims and the description are to be interpreted according to their ordinary meaning in the technical field, unless explicitly defined otherwise herein. For example, the term "user equipment (UE)" may refer to any suitable terminal capable of wireless communication, such as a mobile phone or a portable computer. Likewise, the term "access node (AN)" may refer to any suitable intermediary devices providing wireless communication, such as a relay node, a router, an access point, a base station or a base site, which is capable of connecting a user equipment to another wireless access node or connecting a user equipment to a core network. The term "wireless link" or "radio link" may refer to a radio channel connecting wireless communication devices such as UEs and ANs with each other, and thus may refer to anyone of an uplink (UL), a downlink (DL), a forward link (FL) and a reverse link (RL).

[034] Beamforming is a signal processing technique used for directional signal transmission or reception. Beamforming can be used at both transmitting and receiving sides in order to achieve spatial selectivity. In a typical beamforming configuration, a transmitter with an antenna array amplifies a signal by different "weights" at the respective antennas, and thus the signal experiences constructive interference at particular directions or sectors and destructive interference at other directions or sectors. As a result, it can have a desired sensitivity pattern where a main lobe, serving as a beam for transmitting the signal to a receiver, is produced together with nulls and side lobes. By adjusting the main lobe width and the side lobe levels, the position of a null can be controlled. This is useful to ignore noise or jammers in one particular direction, while listening for events in other directions. A similar result can be obtained on reception. The details on beamforming are described in, e.g., IEEE 802.11ad, which is incorporated herein by reference in its entirety.

[035] Beam failure, as discussed throughout the present disclosure, refers

to such a situation where a beam currently being used for communication between a transceiver and a receiver becomes unavailable due to e.g., deteriorative radio link quality. A variety of events such as UE mobility, appearance of obstacle and orientation change for a UE may deteriorate the radio link quality.

[036] Fig. 1 is a schematic diagram depicting an Ultra-dense network (UDN) architecture. Referring to Fig. 1, a wireless network, e.g., UDN 110 herein, comprises ANs 111A-111G, which are configured to provide UEs 112A-112B with wireless access within their respective coverages by beamforming technique. For illustrative purpose, UEs 112A and 112B are communicatively coupled to ANs 111E and 111G, respectively. On the other hand, ANs 111A-111G are communicatively coupled with each other. In particular, as shown in Fig. 1, ANs 111A and 111C are connected together via a fixed backhaul link, and other ANs 111B, 111D-111G are connected to AN 111A or 111C via wireless links. As a result, ANs 111A-111G are either directly connected to fixed transport backhaul or wirelessly backhauled by other ANs. Moreover, these ANs are coupled to a transport aggregation node 113, over which they can communicate with an operator core network 120 or an external data network 130, e.g., internet.

[037] As stated above, it has a correlation between the beam failure and the deteriorated radio link quality. Therefore, one can determine whether the beam failure occurs on the basis of the radio link quality. However, this heavily relies on an always-on common reference signal on uplinks or downlinks and thus is not attainable for a typical UDN radio access configuration where beamforming is used widely to compensate the limited link budget in high-frequency spectrum and thus transmission is UE specific rather than UE common, i.e., reference signals are transmitted only when a UE is expected to receive them.

[038] According to one aspect of the present invention, a transmitter utilizes a feedback or response from a receiver to determine the occurrence of the beam failure. For example, in the UDN as shown Fig. 1, assuming that AN 111E and UE 112A communicate with each other via beam E1. In

a session, AN 111E transmits to UE 112A a data message via beam E1 and then waits for an acknowledgment(ACK) message or a negative Acknowledgment(NACK) message from UE 112A. If AN 111E receives neither the ACK message nor the NACK message via beam E1 within a predetermined time interval, it will determine the occurrence of the beam failure for beam E1. As another example, UE 112A transmits a service request to AN 111E via beam E1 and then waits for a grant message from AN 111E. If UE 112A fails to receive the grant message via beam E1 within a predetermined time interval, it will determine the occurrence of the beam failure for beam E1.

[039] It shall be noted that the feedback-based determination as described above is also applicable to other message types. For example, at AN side, the determination may be established on a data message responding to a grant message transmitted from AN 111E; and at UE side, one can make the determination on the basis of an random access response message responding to a random access request transmitted from UE 112A.

[040] With the feedback-based determination, the always-on reference signal is not necessary and thus the beam failure can be effectively detected in a UE specific beam-based system such as UDN.

[041] Typically, for communication between a UE and a wireless access network, two or more beams are available and one of them may be selected for serving the communication. For example, in the UDN as shown in Fig. 1, UE 112A and AN 111E can communicate with each other via beams E1, E2 and E4. These beams are collectively referred to be "candidate beam" hereinafter. Among the candidate beams, one currently serving the communication or interaction is referred to as "serving beam" or "first beam" hereinafter; and other candidate beam(s) are referred to as "backup beam" or "second beam" hereinafter. One way to recover from beam failure is to use one of the backup beams to take over the coverage in case of the sudden beam loss of the serving beam. Note that the candidate beams is unnecessarily limited to only a pair of a UE and a specific AN. As described below, for the candidate beams, some of them

may belong to the UE and one AN and the others may belong to the UE and another AN.

[042] According to another aspect of the present invention, a UE (UE side) and a wireless access network (network side) reach pre-agreement on which beams qualify as the backup beams for a serving beam. The pre-agreement may be periodically carried out between these participators, or carried out at the beginning of establishing connection between them. In one embodiment, the UE side or the network side as a transmitter side (Tx side), transmits to the network side or the UE side as a receiver side (Rx side) a reference signal in different directions or via different beams associated with uplinks or downlinks. The receiver side reports the beam(s) via which the reference signal is received, preferably along with radio link quality associated with them. Therefore, for each beam being as a serving beam, one or more backup beams are identified by the participators. For example, assuming the Tx side transmits the reference signal to the Rx side via beams X1, ... Xn, wherein n represents the number of the transmitting beams. If the Rx side receives the reference signal via beams X1, X3 and Xi, beams X3 and Xi are identified as the backup beams for beam X1, beams X1 and Xi are identified as the backup beams for beam X3, and beams X1 and X3 are identified as the backup beams for beam Xi.

[043] Preferably, in case of a plurality of backup beams for a serving beam, one is designated as a primary backup beam, which will be firstly selected as a new serving beam if the beam failure occurs. More preferably, the designation is made at the receiver side and is based on the radio link quality of the forward links associated with the backup beams. The radio link quality may be obtained from RSRP or SINR measurements at the receiver side. More preferably, the primary backup beam corresponds to one forward link having the best radio link quality.

[044] In case of the network or AN side being as the transmitter side, the designation is made at the UE side. Since the network side does not dominate the designation of the primary backup beam associated with the downlink, it takes a risk that no radio resources are available when the beam failure occurs or the utilization of radio resources is not optimum. In

one embodiment, the designation is always dominated at the network side so as to avoid the above defects. Particularly, the network side designates the primary backup beam based on, e.g., the radio link quality measurement made by the UE side and the current load distribution around the UE side. In one embodiment, the network side indicates the primary backup beam in each downlink transmission, e.g., as additional information in a Scheduling Assignment (SA) or as a MAC Control Element (MAC CE) in a MAC Protocol Data Unit (MAC PDU) carrying data. Alternatively, the network side may send a separate indicator on the primary backup beams by using a MAC CE, e.g., in a MAC PDU without higher layer data, or Radio Resources Control (RRC) signaling. In another embodiment, the primary backup beam is determined in a hybrid mode. As described above, the pre-agreement is periodically carried out between a UE side and a network side. At the beginning of the current pre-agreement cycle, the UE side, being as a receiver side, designates the backup beam corresponding to one forward link having the best radio link quality as the primary backup beam. However, the designation is changeable by the network side during the current pre-agreement cycle. For example, the network side may send a command for changing the primary backup beam in a downlink transmission, either in conjunction with data transmission or as a separate signaling message. Alternatively, the changed primary backup beam is valid until the next sending of the command. In other words, whatever measurements for radio link quality vary from one cycle to another cycle, the primary backup beam will be kept unchanged until the network side sends the command again.

[045] According to another aspect of the present invention, the identified backup beams are mapped into specific downlink and uplink resources. The specific uplink resources may be UL PHY resources, e.g., random access channel resources or scheduling request resources, and the specific downlink resources may be DL PHY resources, e.g., downlink control channel resources according to a Discontinuous Reception (DRX) pattern.

[046] As a result, a transmitter side (e.g., network or AN side in case of DL and UE side in case of UL) will notify the occurrence of beam failure

for a serving beam via both of the current serving beam and the backup beam(s), or only via the backup beam(s), and a receiver side (e.g., network side in case of UL and UE side in case of DL) will recognize the beam failure by monitoring the mapped radio link resources. For UL, the AN side is ready for uplink reception on the mapped resources associated with the backup beams. If the AN side receives a request for transmission resources through a Scheduling Request (SR), e.g., on Physical Downlink Control Channel (PDCCH) resources or through a random access procedure initiated on a Random Access Channel (RACH) mapped to the resources associated with one of the backup beams, it recognizes that this backup beam is in use for the reselection of the serving beam. On the other hand, for DL, the UE side is ready for downlink reception on the mapped resources associated with the backup beams. If the UE receives SA on PDCCH of the mapped downlink resources associated with one of the backup beam, it recognizes that this backup beam is in use for the reselection of the serving beam.

[047] According to another aspect of the present invention, if, at the transmitter side, e.g., at the network or UE side, it determines that the beam failure for the current serving beam occurs, a new serving beam needs to be reselected from the candidate beams, including the current serving beam and the backup beam(s), or only from the backup beam(s). Note that at this time, it has no knowledge on which link (forward link, reverse link, or both) causes the beam failure. Therefore, a transmitter will notify a receiver of the occurrence of the beam failure via the current serving beam and the backup beam(s), or only via the backup beam(s). The notification may be transmitted in a forward link transmission, either in conjunction with data transmission or as a separate signaling message. Note that the explicit notification is unnecessary and the receiver side can recognize the beam failure only from the event that the data transmission is performed via the backup beam(s). At the receiver side, e.g., the network side or UE side, it monitors the forward links associated with the candidate beams. Upon receiving the notification or the data transmission via the backup beams, the receiver side utilizes an available beam as a new

serving beam to communicate with the transmitter side. The available beam is selected from the serving beam and the backup beam(s), or only from the backup beam(s).

[048] In one embodiment, the selection is made on the basis of the radio link quality. For example, assuming the transmitter side transmits the notification or the data transmission via beams X1, X2, X3 and X4, and at the receiver side, the notification or the data transmission is received via beams X1, X2 and X3. If the forward link associated with beam X2 has the highest link quality, beam X2 is selected as the new serving beam.

[049] Alternatively, in case of the receiver side being the UE side, the new serving beam is selected by the network side. Particularly, upon receiving the notification or the data transmission via beams X1, X2 and X3, the receiver reports the radio link quality for the forward links. Then, at the transmitter, the new serving beam is selected on the basis of the radio link quality measurement made by the UE side and the current load distribution around the UE side.

[050] Preferably, upon receiving the notification or the data transmission via beams X1, X2 and X3, the receiver reports to the transmitter the receipt of the notification or the data transmission via beams X1, X2 and X3. Then, in response to the report from the receiver, the transmitter selects the new serving beam on the basis of the radio link quality for the reverse links associated with beams X1, X2 and X3, and optionally along with the current load distribution around the UE side. In another embodiment, the new serving beam may be the primary backup beam designated in the manner as described above.

[051] As a result, the communication continues between the transmitter side and the receiver side via the new serving beam. The new serving beam may be the serving beam previously in use or a backup beam.

[052] Fig. 2 is a process flow diagram of a method for reaching pre-agreement on backup beam(s) according to one exemplary embodiment of the present invention. For illustrative purpose, the following depiction is made in the context of the above architecture as

shown in Fig. 1. However, one skilled artisan in the art would recognize that the present invention is applicable to other architectures. Moreover, one skilled artisan will recognize that all of the aspects of the present invention as described above are applicable to the present exemplary embodiment.

[053] With reference to Fig. 2, at step S210, it determines whether a routine for reaching pre-agreement on backup beams for the current serving beams shall be initiated. Note that the routine may be triggered periodically or by the occurrence of a predefined event, e.g., establishment of connection between UE 112A and AN 111E. If the routine shall be initiated, the process proceeds to step S220; otherwise, the process continues to determine whether the routine shall be initiated at step S210.

[054] At step S220, the routine for reaching pre-agreement on backup beams for the current serving beam is initiated. The initiator for the routine may be either UE 112A or AN 111E. For example, as a initiator, AN 111E initiates the routine by transmitting to UE 112A a reference signal via beams E1, E2, E3 and E4 associated with downlinks.

[055] Assuming UE 112A receives the reference signal via downlinks associated with beams E1, E2 and E4. Thus, at step S230, UE112A will respond to AN 111E via uplinks associated with beams E1, E2 and E4. Preferably, the response to AN 111E may include radio link quality for the downlinks associated with these beams. As a result, the participants will identify backup beams for each beam. In particular, beams E2 and E4 are identified as the backup beams for beam E1, beams E1 and E4 as the backup beams for beam E2, and beams E1 and E2 as the backup beams for beam E4. The identified backup beams are mapped into specific downlink and uplink resources and thus the receiver side can recognize the beam failure by monitoring the mapped specific radio link resources.

[056] At UE 112A, one of beams E2 and E4 may be designated as a primary backup beam based on the radio link quality of the downlinks associated with these backup beams. Alternatively, the designation is performed by UE 111E on the basis of the radio link quality and the current load distribution around UE 112A.

[057] After step S230, the process proceeds to step S210.

[058] Fig. 3 is a process flow diagram of a method for recovery from beam failure in a wireless access network according to another exemplary embodiment of the present invention. For illustrative purpose, the following depiction is made in the context of the above architecture as shown in Fig. 1. However, one skilled artisan in the art would recognize that the present invention is applicable to other architectures. Moreover, one skilled artisan will recognize that all of the aspects of the present invention as described above are applicable to the present exemplary embodiment.

[059] For illustrative purpose, in the present exemplary embodiment, it assumes that UE 112A accesses to UDN 110 through AN 111E via beam E1, which is taken as the current serving beam at the beginning of the process, and under pre-agreement, beams E2 and E4 are taken as the backup beams for beam E1.

[060] At step S310, UE 112A or AN 111E determines whether beam failure for the current serving beam, i.e., beam E1, occurs. The determination may be the feedback-based determination as described above. In particular, UE 112A or AN 111E may utilize a feedback or response from a receiver to determine the occurrence of the beam failure. If it determines the beam failure occurs, the process proceeds to step S320; otherwise, the process continues to determine whether the beam failure occurs at step S310.

[061] For illustrative purpose, it assumes that the beam failure is determined at AN 111E. Then at step S320, AN 111E transmits notification of the occurrence of the beam failure to UE 112A via the current serving beam E1 and the backup beams E2 and E4. Alternatively, the notification may be transmitted only via the backup beams E2 and E4. Likewise, the notification may be transmitted either in conjunction with data transmission or as a separate signaling message.

[062] As described above, upon receiving the notification or the data transmission via the backup beams, the receiver side utilizes an available

beam as a new serving beam to communicate with the transmitter side. The available beam is selected from the serving beam and the backup beams, or only from the backup beams. Therefore, at step S330, AN 111E receives from UE 112A information on the selection of the available beam or the new serving beam. For illustrative purpose, assuming beam E4 is selected as the new serving beam.

[063] Alternatively, instead of selecting a new serving beam, the receiver side may send to the transmitter side a report on the beams via which the notification or the data transmission is received. For example, it assumes the notification or the data transmission is received via beams E1 and E4 at the receiver side. Thus, it will be reported that the notification or the data transmission is received via beams E1 and E4. Accordingly, at step S330, upon receiving the report from the receiver side, the transmitter side selects a new serving beam based on the radio link quality for the forward links associated with the reported beams, i.e., beams E1 and E4. For illustrative purpose, assuming that the forward link associated with beam E4 has the best radio link quality, As a result, beam E4 is selected as the new serving beam at the transmitter side.

[064] At step S340, AN 111E continues the interaction or communication with UE 112A via beam E4 and then returns step S310.

[065] In case the beam failure is determined at UE 112A, UE 112A transmits notification of the occurrence of the beam failure to AN 111E via beams E1, E2 and E4 or only via beams E2 and E4 at step S320. Then at step S330, UE 112A receives from AN 111E information on the selection of the available beam or the new serving beam. The process proceeds to step S340, where UE 112A continues the communication with AN 111E via beam E4 and then returns step S310.

[066] In the above embodiments, it assumes that the backup beams belong to the same AN. However, this assumption is not necessary and the present invention may be extended to such a scenario where, for a serving beam, some or all of the backup beams belong to an AN different from the AN of the serving beam. For example, as shown in Fig. 1, UE 112B can access to AN 111G via beams G1 or G2, or to AN 111F via beam F2.

Therefore, for serving beam G1(G2), besides backup beam G2(G1) in AN 111G, beam F2 in AN 111F can be also used as a backup beam; likewise, for serving beam F2, beams G1 and G2 can be used as backup beams. The above configuration enhances recovery capability from beam failure, especially when all of the beams within an AN are unavailable.

[067] In case the backup beams involve with multiple ANs, it is advantageous to introduce inter-AN coordination between the involved ANs in the pre-agreement on the backup beams and the selection of the new serving beam. Preferably, the inter-AN coordination is performed via an intermediate node, e.g., a control node acting as a cluster head for controlling a cluster comprising the involved ANs. Alternatively, the inter-AN coordination may be performed directly between the involved ANs.

[068] Fig. 4 is a process flow diagram of a method for recovery from beam failure in a wireless access network according to another exemplary embodiment of the present invention. For illustrative purpose, the following depiction is made in the context of the above architecture as shown in Fig. 1. However, one skilled artisan in the art would recognize that the present invention is applicable to other architectures. Moreover, one skilled artisan will recognize that all of the aspects of the present invention as described above are applicable to the present exemplary embodiment.

[069] For illustrative purpose, in the present exemplary embodiment, it assumes that UE 112B access to UDN 110 through AN 111G (referred to be "serving node" hereinafter) via beam G1, which is taken as the current serving beam at the beginning of the process, and between AN 111G, AN 111F (referring to as "neighboring node" hereinafter) and UE 112B, it reaches pre-agreement that beams G2 and F2 are backup beams for beam G1. As described above, an intermediate node such as a cluster head, e.g., transport aggregation node 113 as shown in Fig. 1, coordinates the pre-agreement on the backup beams. Likewise, the pre-agreement may be updated periodically or by the occurrence of a predefined event, e.g., establishment of connection between UE 112B and AN 111E. The

identified backup beams G2 and F2 are mapped into specific downlink and uplink resources and thus the receiver side can recognize the beam failure by monitoring the mapped specific radio link resources.

[070] With reference to Fig. 4, at step S410, UE 112B determines that beam failure for the current serving beam, i.e., beam G1, occurs. Likewise, the determination may be the feedback-based determination as described above. For example, if UE 112B fails to receive a follow-up DL signaling after an UL transmission, e.g., an Ack/Nack feedback, it determines the beam failure for beam G1 occurs.

[071] Then at step S420, UE 112B initiates multiple transmission e.g., by sending a backup beam activation command via uplinks associated with both of the serving and backup beams, i.e., beams G2 and F2. The backup beam activation command may be in the form of a SR.

[072] The serving and neighboring nodes, i.e., AN 111G and AN 111F, keep on monitoring the mapped specific uplink resources, e.g., the SR resources. Assuming that beam F2 is designated as a primary backup beam for beam G1, or the radio link quality for beam F2 is superior to G2, or beams failure for beam G2 also occurs. Thus, with the inter-AN coordination by the cluster head, beam F2 is selected as the new serving beam. As a result, at step S430, the neighboring node returns a UL grant to UE 112B to confirm the activation of the backup beam, i.e., beam F2. Then at step S440, AN 111F and UE 112B start to communicate with each other.

[073] At step S450, with the inter-AN coordination by the cluster head, the serving node notifies the neighboring node of the deactivation of beam G1, which was previously taken as the serving beam. Afterwards, at step S460, the neighboring node transmits DL signaling, e.g., a beam deactivation command to UE 112B to confirm the deactivation of previous serving beam G1.

[074] In the above embodiment, a third node such as a cluster head participates in the inter-AN coordination. As described above, however, the inter-AN coordination may be performed directly between the serving

node and the neighboring node.

[075] Fig. 5 is a block diagram illustrating a user equipment (UE) having recovery capability from beam failure according to another exemplary embodiment of the present invention. For illustrative purpose, the present embodiment is described in the context of the UDN architecture as discussed with reference to Fig1. However, one skilled artisan in the art would recognize that the present invention is applicable to other wireless access networks. Moreover, one skilled artisan will recognize that the aspects of the present invention as described above are applicable to the present exemplary embodiment.

[076] With reference to Fig. 5, in the present embodiment, a UE 500 comprises a transceiver 510 and a determining unit 520 coupled to each other.

[077] The transceiver 510 is configured to interact with one or more ANs in a wireless access network, e.g., ANs 111A-111G in UDN 110 as shown in Fig. 1. For example, the transceiver 510 is able to communicate or interact with AN 111E via beams E1, E2 and E4. Assuming beam E1 is selected as a current serving beam and beams E2 and E4 are selected as backup beams. As an example, the transceiver 510 transmits a service request or a random access request on an uplink associated with beam E1 and waits for a response responding to the service request or the random access request on a downlink associated with beam E1. Meanwhile, the transceiver 510 monitors the mapped specific radio link resources associated with beams E2 and E4.

[078] The determining unit 520 is configured to determine whether beam failure for the current serving beam, i.e., beam E1, occurs. The determination may be the feedback-based determination as described above. If determining the beam failure occurs, the determining unit 520 instructs the transceiver 510 to transmit notification of the occurrence of the beam failure to AN 111E via uplinks associated with the current serving beam E1 and the backup beams E2 and E4. Alternatively, the notification may be transmitted only via uplinks associated with the backup beams E2 and E4.

[079] When the transceiver 510 receives from AN 111E information on the selection of the available beam or the new serving beam, e.g., beam E2, the determining unit 520 will instruct the transceiver 510 to continue the communication or interaction with AN 111E via the new serving beam. Note that the information may be sent via downlinks associated with the new serving beam only, or associated with all of the beams linked to the mapped specific radio link resources.

[080] Note that in case the backup beams involve with multiple ANs, the determining unit 520 is further configured to instruct the transceiver 510 to transmit the notification to all involved ANs, and the transceiver 510 is configured to communicate or interact with the wireless access network via the new serving beam selected with an inter-AN coordination.

[081] Fig. 6 is a block diagram illustrating an access node (AN) having recovery capability from beam failure according to another exemplary embodiment of the present invention. For illustrative purpose, the present embodiment is described in the context of the UDN architecture as discussed with reference to Fig 1. However, one skilled artisan in the art would recognize that the present invention is applicable to other wireless access networks. Moreover, one skilled artisan will recognize that the aspects of the present invention as described above are applicable to the present exemplary embodiment.

[082] With reference to Fig. 6, in the present embodiment, an AN 600, e.g., anyone of ANs 111A-111G as shown in Fig.1, comprises a transceiver 610 and a determining unit 620 coupled to each other.

[083] The transceiver 610 is configured to interact with a UE, e.g., UE 112A or 112B as shown in Fig. 1, and other ANs in a wireless access network, e.g., UDN 110 as shown in Fig. 1. For example, the transceiver 610, e.g., in AN 111G, is able to interact with UE 112B via beams G1 and G2, and is connected to AN 111F directly or via a third node(s). Assuming beam G1 is selected as a current serving beam and beams G2 and F2 are selected as backup beams. As an example, the transceiver 610, e.g., in AN 111G transmits a data message or a grant message on a downlink associated with beam G1, and then waits for an acknowledgment(ACK)

message or a negative Acknowledgment(NACK) message to the data message, or a data message to the grant message on a downlink associated with beam G1. Meanwhile, with a pre-agreement, the transceivers 610, e.g., in AN 111G and AN 111F monitor the mapped specific radio link resources associated with beams G2 and F2, respectively.

[084] The determining unit 620, e.g., in AN 111G is configured to determine whether beam failure for the current serving beam, i.e., beam G1, occurs. The determination may be also the feedback-based determination as described above. If determining the beam failure occurs, in AN 111G, the determining unit 620 instructs the transceiver 610 to transmit notification of the occurrence of the beam failure to UE 112B via uplinks associated with the current serving beam G1 and the backup beams G2. Moreover, with an inter-AN coordination, the transceiver 610 in AN 111F transmits the notification to UE 112B via an uplink associated with beams F2. Alternatively, the notification may be transmitted only via uplinks associated with the backup beams G2 and F2.

[085] Assuming beam F2 is the primary backup beam as designated or is selected as a new serving beam by UE 112B. Thus, UE 112B will send information on the new serving beam, e.g., beam F2. At AN 111F, if the transceiver 610 receives the information from UE 112B, the determining unit 620 will instruct the transceiver 610 to communicate or interact with UE 112B via the new serving beam.

[086] In the exemplary embodiment described with reference to Figs. 5 and 6, the determining unit can be implemented as a processor or part of the processor to perform various tasks as discussed above. The processor can include a microprocessor, microcontroller, processor module or subsystem, programmable integrated circuit, programmable gate array, or another control or computing device.

[087] It should be noted that the aforesaid embodiments are illustrative of this invention instead of restricting this invention, substitute embodiments may be designed by those skilled in the art without departing from the scope of the claims enclosed. The wordings such as “include”, “including”, “comprise” and “comprising” do not exclude elements or

steps which are present but not listed in the description and the claims. It also shall be noted that as used herein and in the appended claims, the singular forms “a”, “an”, and “the” include plural referents unless the context clearly dictates otherwise. This invention can be achieved by means of hardware including several different elements or by means of a suitably programmed computer. In the unit claims that list several means, several ones among these means can be specifically embodied in the same hardware item. The use of such words as first, second, third does not represent any order, which can be simply explained as names.

What is claimed is:

1. A user equipment (UE) capable of communicating with a wireless access network, comprising:

a determining unit configured to determine whether beam failure occurs on the basis of presence of a response from the wireless access network during communication between the wireless access network and the UE via a first beam; and

a transceiver configured to communicate with the wireless access network via an available beam selected from the first beam and one or more second beams if the determined unit determines that the beam failure occurs.

2. The UE according to claim 1, wherein the response is one selected from a group consisting of: a grant message responding to a service request transmitted from the UE on an uplink associated with the first beam and an random access response message responding to a random access request transmitted from the UE on an uplink associated with the first beam.

3. The UE according to claim 1 or 2, wherein the selection of the available beam is on the basis of radio link quality for uplinks associated with the first beam and the one or more second beams.

4. The UE according to claim 1, wherein for communicating with the wireless access network via the available beam, the transceiver is configured to:

transmit to one or more ANs of the wireless access network a message from the UE via the first beam and the one or more second beams if determining that the beam failure occurs;

receive information on the selection of the available beam from the one or more ANs of the wireless access network; and

use the selected available beam during communication with the wireless access network.

5. An access node (AN) capable of communicating with a user equipment (UE), comprising:

a determining unit configured to determine whether beam failure occurs on the basis of presence of a response from the UE during an interaction between the AN and the UE via a first beam; and

a transceiver configured to, if the determining unit determines that the beam failure occurs, communicatewith the UE via an available beam selected from the first beam and one or more second beams, or transfer to another AN communication with the UE, the communication being made via the available beam.

6. The AN according to claim 5, wherein the response is one selected from a group consisting of: an acknowledgment(ACK) message or a negative Acknowledgment(NACK) message responding to a data message transmitted from the AN on a downlink associated with the first beam, and a data message responding to a grant message transmitted from the AN on a downlink associated with the first beam.

7. The AN according to claim 5 or 6, wherein the selection of the available beam is on the basis of radio link quality for downlinks associated with the first beam and the one or more second beams.

8. A user equipment (UE) capable of communicating with a wireless access network, configured to:

determine whether beam failure occurs on the basis of presence of a response from the wireless access network during communication between the wireless access network and the UE via a first beam; and

if it is determined that the beam failure occurs, communicate with the wireless access network via an available beam selected from the first beam and one or more second beams.

9. An access node (AN) capable of communicating with a user equipment (UE), configured to:

determine whether beam failure occurs on the basis of presence of a response from the UE during an interaction between the AN and the UE via a first beam; and

if it is determined that the beam failure occurs, communicate with the UE via an available beam selected from the first beam and one or more second beams, or transfer to another AN communication with the UE, the communication being made via the available beam.

10. A method for recovery from beam failure in a wireless access network accessed by a user equipment (UE), comprising:

at the wireless access network, determining whether beam failure occurs on the basis of presence of a response from the UE during communication between the wireless access network and the UE via a first beam; and

if it is determined that the beam failure occurs, communicating with the UE via an available beam selected from the first beam and one or more second beams.

11. The method according to claim 10, wherein the response is one selected from a group consisting of: an acknowledgment(ACK) message or a negative Acknowledgment(NACK) message responding to a data message transmitted from an AN of the wireless access network on a downlink associated with the first beam, and a data message responding to a grant message transmitted from an AN of the wireless access network on a downlink associated with the first beam.

12. The method according to claim 10 or 11, wherein the selection of the available beam is on the basis of radio link quality for downlinks associated with the first beam and the one or more second beams.

13. The method according to claim 10, wherein the step of communicating with the UE via the available beam comprising:

upon determining that the beam failure occurs, transmitting to the UE a message from one or more ANs of the wireless access network via the first beam and the one or more second beams;

receiving information on the selection of the available beam from the UE; and

using the selected available beam during communication with the UE.

14. The method according to claim 10, wherein the step of communicating with the UE via the available beam comprising:

upon determining that the beam failure occurs, transmitting to the UE a message from a first AN and a second AN of the wireless access network, wherein the message from the first AN is transmitted via the first beam and the message from the second AN is transmitted via the one or more second beams;

receiving information on the selection of the available beam from the UE; and

using the selected available beam during communication with the UE.

15. The method according to claim 10, wherein the step of communicating with the UE via the available beam comprising:

upon determining that the beam failure occurs, transmitting a message from a first AN and second AN of the wireless access network, wherein the message from the first AN is transmitted via the first beam and at least one of the second beams and the message from the second AN is transmitted via the other of the second beams;

receiving information on the selection of the available beam from the UE; and

using the selected available beam during communication with the UE.

16. A method for recovery from beam failure for a user equipment (UE) accessing a wireless access network, comprising:

at the UE, determining whether beam failure occurs on the basis of presence of a response from the wireless access network during communication between the wireless access network and the UE via a first beam; and

if it is determined that the beam failure occurs, communicating with the wireless access network via an available beam selected from the first beam and one or more second beams.

17. The method according to claim 15, wherein the response is one selected from a group consisting of: a grant message responding to a service request transmitted from the UE on an uplink associated with the first beam and an random access response message responding to a random access request transmitted from the UE on an uplink associated with the first beam.

18. The method according to claim 16 or 17, wherein the selection of the available beam is on the basis of radio link quality for uplinks associated with the first beam and the one or more second beams.

19. The method according to claim 16, wherein the step of communicating with the wireless access network via the available beam comprising:

upon determining that the beam failure occurs, transmitting to one or more ANs of the wireless access network a message from the UE via the first beam and the one or more second beams;

receiving information on the selection of the available beam from the one or more ANs of the wireless access network; and

using the selected available beam during communication with the wireless access network.

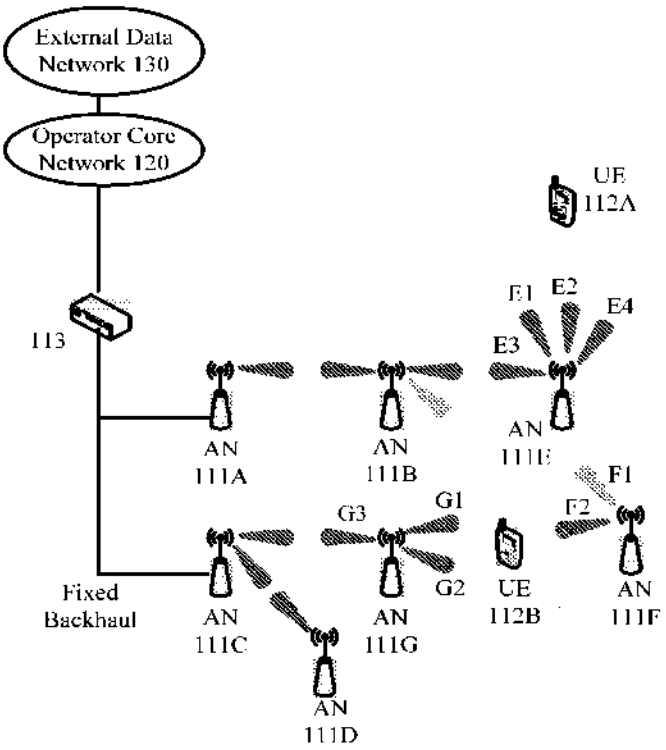

External Data Network 130
Operator Core Network 120
113
Fixed Backhaul
AN 111A
AN 111B
AN 111C
AN 111D
AN 111E
AN 111F
AN 111G
UE 112A
UE 112B
E1
E2
E3
E4
F1
F2
G1
G2
G3

Fig. 1

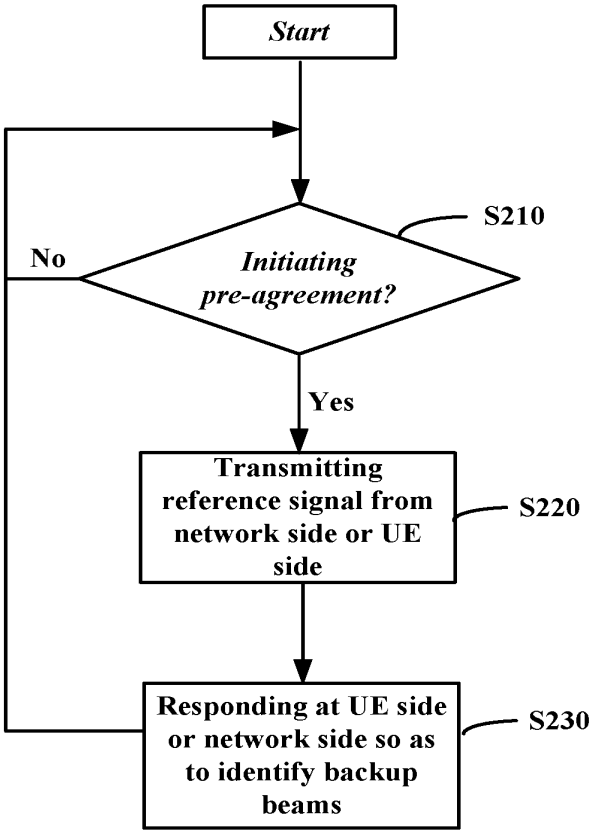

Start
S210
No
Initiating pre-agreement?
Yes
Transmitting reference signal from network side or UE side
S220
Responding at UE side or network side so as to identify backup beams
S230

Fig. 2

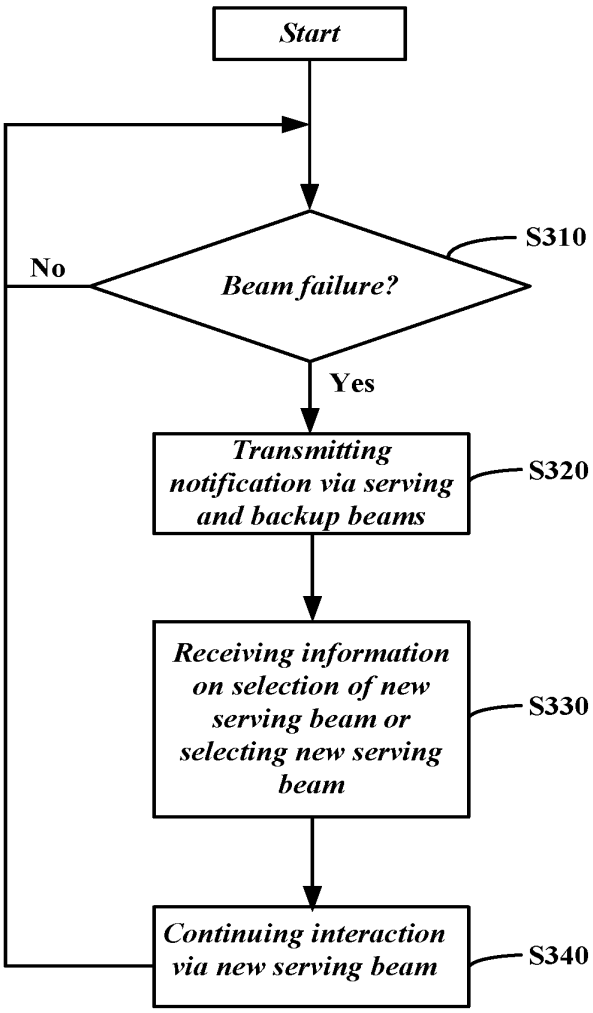

Start
S310
Beam failure?
No
Yes
Transmitting notification via serving and backup beams
S320
Receiving information on selection of new serving beam or selecting new serving beam
S330
Continuing interaction via new serving beam
S340

Fig. 3

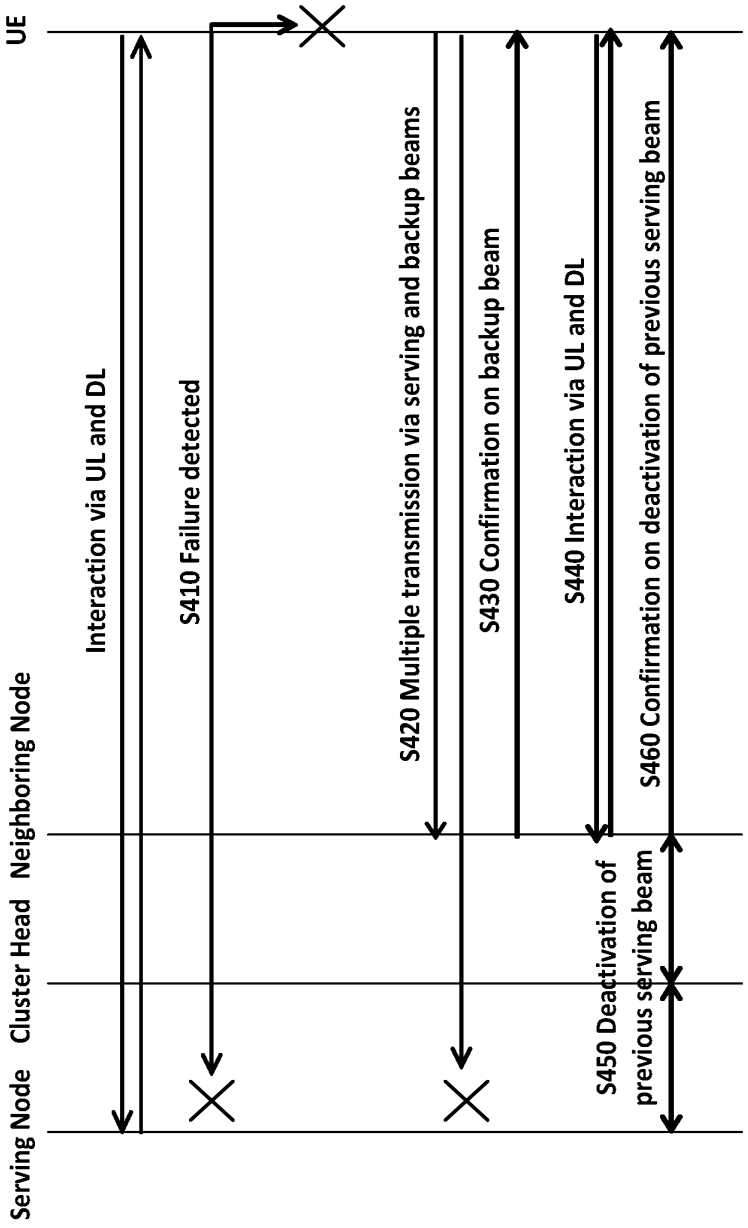

UE
Serving Node
Cluster Head
Neighboring Node
Interaction via UL and DL
S410 Failure detected
S420 Multiple transmission via serving and backup beams
S430 Confirmation on backup beam
S440 Interaction via UL and DL
S450 Deactivation of previous serving beam
S460 Confirmation on deactivation of previous serving beam

Fig. 4

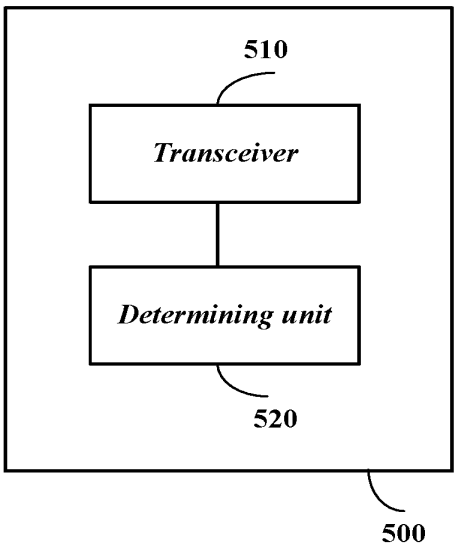

510
Transceiver
Determining unit
520
500

Fig. 5

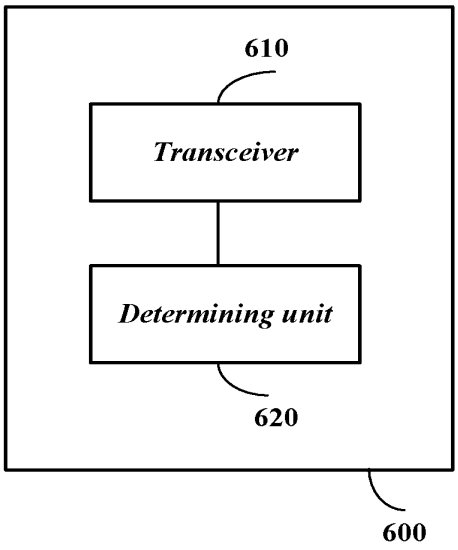

610
Transceiver
Determining unit
620
600

Fig. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2015/086611

A. CLASSIFICATION OF SUBJECT MATTER

H04W 72/08(2009.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04W; H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNPAT,CNKI,WPI,EPODOC,3GPP:beam, form+, beam?form+, fail+, error, fault, quality, disconnect+, low, lost+, miss+, receiv+, recept+, reselect+, chang+, switch+, backup

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2013039345 A1 (SAMSUNG ELECTRONICS CO., LTD.) 14 February 2013 (2013-02-14) description, paragraphs [0036]-[0066]	1-19
Y	WO 2013039331 A2 (SAMSUNG ELECTRONICS CO., LTD.) 21 March 2013 (2013-03-21) description, paragraphs [51]-[52]	1-19
A	US 2006098580 A1 (LI, QINGHUA ET AL.) 11 May 2006 (2006-05-11) the whole document	1-19
A	US 2015223222 A1 (PANASONIC INTELLECTUAL PROPERTY MANAGEMENT CO., LTD.) 06 August 2015 (2015-08-06) the whole document	1-19

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 April 2016	**28 April 2016**
Name and mailing address of the ISA/CN **STATE INTELLECTUAL PROPERTY OFFICE OF THE P.R.CHINA** **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088, China**	Authorized officer **YAO,Yaqian**
Facsimile No. (**86-10**)**62019451**	Telephone No. (**86-10**)**62413297**

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2015/086611

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
US	2013039345	A1	14 February 2013	EP	2742604	A1	18 June 2014
				WO	2013024942	A1	21 February 2013
				US	2014056256	A1	27 February 2014
				CN	103875191	A	18 June 2014
				JP	2014526217	A	02 October 2014
				KR	20130017932	A	20 February 2013
				AU	2011375057	A1	20 February 2014
				CA	2844372	A1	21 February 2013
				IN	KOLNP201400186	E	28 March 2014
WO	2013039331	A2	21 March 2013	WO	2013039331	A2	21 March 2013
				KR	20130029204	A	22 March 2013
				JP	2014530534	A	17 November 2014
				US	2013065622	A1	14 March 2013
				EP	2756607	A2	23 July 2014
				CN	103931109	A	16 July 2014
US	2006098580	A1	11 May 2006	None			
US	2015223222	A1	06 August 2015	WO	2014199610	A1	18 December 2014

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(81) 指定国 (除另有指明, 要求每一种可提供的国家保护): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB,

(54) Title: BEAM RECOVERY METHOD AND DEVICE

(54) 发明名称: 波束恢复方法及装置

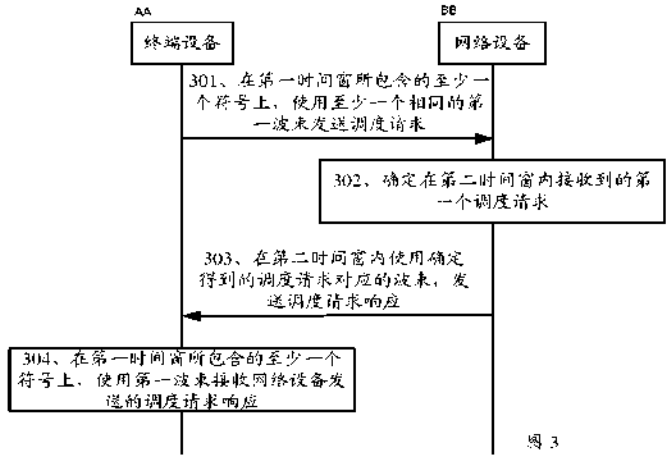


图 3

301 On at least one symbol comprised in a first time window, use at least one identical first beam to send a scheduling reques;
302 Determine a first scheduling request which is received within a second time window
303 Send a scheduling request response within the second time window by using a beam corresponding to the determined scheduling request
304 On at least one symbol comprised in the first time window, use the first beam to receive the scheduling request response which is sent by the network device
AA Terminal device
BB Network device

(57) Abstract: Disclosed in an embodiment of the present invention are a beam recovery method and device, the method comprising: a terminal device using at least one beam within a first time window to send to a network device a request which is used for recovering a beam, the request which is used for recovering a beam being a scheduling request or a beam failure recovery request; the terminal device using at least one beam within the first time window to receive a response to the request which is used for recovering a beam that is sent by the network device, the response to the request which is used for recovering a beam being a scheduling request response

[见续页]

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GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW。

(84) 指定国(除另有指明，要求每一种可提供的地区保护)：ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), 欧亚 (AM, AZ, BY, KG, KZ, RU, TJ, TM), 欧洲 (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG)。

本国际公布：

— 包括国际检索报告(条约第21条(3))。

— 包括经修改的权利要求(条约第19条(1))。

or a beam failure recovery request response. By using the embodiment of the present invention, the network device may perform beam recovery processing on multiple requests which are used for recovering a beam that are sent by the same terminal device, and beam recovery efficiency is increased.

(57) 摘要：本发明实施例公开了波束恢复方法及装置，所述方法包括：终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，用于恢复波束的请求为调度请求或者波束失败恢复请求；终端设备在第一时间窗内使用至少一个波束接收网络设备发送的用于波束恢复请求的响应，用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。采用本发明实施例，可实现网络设备针对同一终端设备发送的多个用于恢复波束的请求的波束恢复处理，提高波束恢复效率。

波束恢复方法及装置

技术领域

本申请涉及通信技术领域，尤其涉及波束恢复方法及装置。

背景技术

波束(beam)是一种通信资源，不同的波束可以认为是不同的通信资源。在移动通信系统中使用波束进行信息传输，即通过在空间上朝向特定的方向发送信号，可以实现更高的天线阵列增益。发射波束可以是指信号经天线发射出去后在空间不同方向上形成的信号强度的分布，接收波束可以是指从天线上接收到的无线信号在空间不同方向上的信号强度分布。一个波束对通常包括一个发送端的发射波束和一个接收端的接收波束。当下行控制信道关联的波束的性能下降到某个门限值时，该波束失效，即无法使用该波束进行信息传输，一旦波束失效，将触发波束恢复机制。

在长期演进（Long Term Evolution，LTE）系统中，在建立无线链路过程中的初始接入、在无线链路建立失败之后的链路重建或者采用基于上行测量的定位方法以进行定位等过程中可以采用随机接入方案，具体可以为：终端设备向网络设备发送调度请求（Scheduling Request，SR），以通知网络设备有终端设备试图接入；终端设备在预先配置的时间窗内监测控制信道，以接收网络设备下发的随机接入响应（Random Access Response，RAR）。上述随机接入方案仅针对网络设备接收到同一终端设备发送的一个 SR 的场景。

当下行链路（Down Link，DL）的波束对（Beam Pair Link，BPL）失效时，为了充分利用现有的资源，以及波束失效的持续时间远小于无线链路失效（Radio Link Failure，RLF）的时间窗长度，终端设备可以利用随机接入信道（Random Access Channel，RACH）资源在不同方向的多个波束上发射 SR，则网络设备在时间窗内可以接收到来自同一终端设备的多个 SR。而传统 LTE 中随机接入的处理流程仅针对网络设备收到同一终端设备发送的一个 SR 的场景，在网络设备收到同一终端设备发送的多个 SR 时如何进行随机接入处理，是目前亟需解决的问题。

发明内容

本发明实施例所要解决的技术问题在于，提供波束恢复方法及装置，可实现网络设备针对同一终端设备发送的多个用于恢复波束的请求的波束恢复处理，提高波束恢复效率。

第一方面，本发明实施例提供了一种波束恢复方法，终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求；终端设备在第一时间窗内使用至少一个波束接收网络设备发送的用于波束恢复请求的响应。

其中，用于恢复波束的请求可以为调度请求或者波束失败恢复请求（beam failure recovery request）。

其中，用于波束恢复请求的响应可以为调度请求响应或者波束失败恢复请求响应。

例如，当用于恢复波束的请求为调度请求时，用于波束恢复请求的响应可以为调度请求响应；当用于恢复波束的请求为波束失败恢复请求时，用于波束恢复请求的响应可以为

波束失败恢复请求响应。

其中，第一时间窗可以是网络设备对终端设备配置的时间窗，示例性的，第一时间窗可以包括 3 个符号或者 7 个符号等。

可选的，第一时间窗所包含的第一个符号可以为第一个配置有随机接入信道（Random Access Channel，RACH）资源的符号。

在该技术方案中，终端设备可以使用至少一个波束向网络设备发送用于恢复波束的请求，终端设备还可以在第一时间窗内使用上述至少一个波束接收网络设备发送的用于波束恢复请求的响应，则终端设备向网络设备发送的用于恢复波束的请求可以包括多个，以便提高波束恢复效率。

可选的，终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，具体可以为：终端设备在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送用于恢复波束的请求。

其中，第一波束可以是网络设备对终端设备配置的一个波束。

例如，终端设备可以在第一时间窗所包含的一个符号上，使用一个第一波束向网络设备发送用于恢复波束的请求。示例性的，第一时间窗包括 3 个符号，分别为第一符号、第二符号以及第三符号，若终端设备在第一时间窗中确定的一个符号为第一符号，则终端设备可以在第一时间窗所包含的第一符号上，使用第一波束向网络设备发送用于恢复波束的请求。

又如，终端设备可以在第一时间窗所包含的一个符号上，使用多个相同的第一波束向网络设备发送用于恢复波束的请求。示例性的，第一时间窗包括 3 个符号，分别为第一符号、第二符号以及第三符号，若终端设备在第一时间窗中确定的一个符号为第一符号，则终端设备可以在第一时间窗所包含的第一符号上，在不同方向上使用第一波束向网络设备发送用于恢复波束的请求。

又如，终端设备可以在第一时间窗所包含的多个符号上，使用一个第一波束向网络设备发送用于恢复波束的请求。示例性的，第一时间窗包括 3 个符号，分别为第一符号、第二符号以及第三符号，若终端设备在第一时间窗中确定的多个符号包括第二符号和第三符号，则终端设备可以在第一时间窗所包含的第二符号上，使用第一波束向网络设备发送用于恢复波束的请求，且在第一时间窗所包含的第三符号上，使用第一波束向网络设备发送用于恢复波束的请求。

又如，终端设备可以在第一时间窗所包含的多个符号上，使用多个相同的第一波束向网络设备发送用于恢复波束的请求。示例性的，第一时间窗包括 3 个符号，分别为第一符号、第二符号以及第三符号，若终端设备在第一时间窗中确定的多个符号包括第二符号和第三符号，则终端设备可以在第一时间窗所包含的第二符号上，使用第一波束向网络设备发送用于恢复波束的请求，且在第一时间窗所包含的第三符号上，使用第一波束向网络设备发送用于恢复波束的请求。

在该技术方案中，终端设备可以在一个符号上使用多个相同的第一波束向网络设备发送用于恢复波束的请求，或者在多个符号上使用一个或者多个相同的第一波束向网络设备发送用于恢复波束的请求，以实现同一终端设备向网络设备发送多个用于恢复波束的请求。

可选的，终端设备在第一时间窗内使用至少一个波束接收网络设备发送的用于波束恢复请求的响应，具体可以为：终端设备在第一时间窗所包含的至少一个符号上，使用第一波束接收用于波束恢复请求的响应。

在该技术方案中，终端设备在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送用于恢复波束的请求之后，可以在第一时间窗所包含的至少一个符号上，使用第一波束接收用于波束恢复请求的响应，可确保发送用于波束恢复的请求的波束和接收用于波束恢复请求的响应的波束为同一波束。

可选的，第一时间窗可以包括第一单元时间窗和第二单元时间窗，则终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，具体可以为：终端设备在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送用于恢复波束的请求。

其中，第一单元时间窗可以是网络设备对终端设备配置的时间窗，示例性的，第一单元时间窗可以包括 3 个符号或者 4 个符号等。

其中，第二单元时间窗可以是网络设备对终端设备配置的时间窗，示例性的，第二单元时间窗可以包括 4 个符号或者 5 个符号等。

其中，第二单元时间窗所包含的第一个符号为第一单元时间窗所包含的最后一个符号之后的第一个符号。例如第一单元时间窗包括 4 个符号，分别为符号 0、符号 1、符号 2 以及符号 3，符号 3 之后的第一个符号为符号 4，则终端设备可以确定第二单元时间窗所包含的第一个符号为符号 4。需要说明的是，本发明实施例中的第一单元时间窗包含但不限定 4 个符号，第一单元时间窗的长度和第二单元时间窗的长度可以相同，也可以不相同，具体不受本发明实施例的限定。

可选的，终端设备在第一时间窗内使用至少一个波束接收网络设备发送的用于波束恢复请求的响应，具体可以为：终端设备在第二单元时间窗所包含的至少一个符号上，使用第一波束接收用于波束恢复请求的响应。

在该技术方案中，终端设备在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送用于恢复波束的请求之后，终端设备可以在第二单元时间窗所包含的至少一个符号上，使用第一波束接收用于波束恢复请求的响应，可确保发送用于波束恢复的请求的波束和接收用于波束恢复请求的响应的波束为同一波束。

可选的，当在第一时间窗内未接收到用于波束恢复请求的响应时，终端设备可以确定网络设备对终端设备配置的第三时间窗，并在第三时间窗所包含的至少一个符号上，使用至少一个相同的第二波束向网络设备发送用于恢复波束的请求。

其中，第三时间窗可以是网络设备对终端设备配置的时间窗，示例性的，第三时间窗可以包括 3 个符号或者 5 个符号等。

在该技术方案中，终端设备在第一时间窗未检测到用于波束恢复请求的响应时，终端设备可以在第三时间窗使用第一波束以外的其他波束重新向网络设备发送用于恢复波束的请求，若终端设备在第三时间窗所包含的至少一个符号上使用第二波束接收到网络设备发送的用于波束恢复请求的响应，则可实现波束恢复，可提高波束恢复的可靠性。

可选的，第一时间窗可以包括第三单元时间窗和第四单元时间窗，则终端设备在第一

时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，具体可以为：终端设备在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备发送用于恢复波束的请求。

其中，第三单元时间窗可以是网络设备对终端设备配置的时间窗，示例性的，第一单元时间窗可以包括 3 个符号或者 5 个符号等。

其中，第四单元时间窗可以是网络设备对终端设备配置的时间窗，示例性的，第二单元时间窗可以包括 4 个符号或者 5 个符号等。

其中，第四单元时间窗所包含的第一个符号可以为第三单元时间窗所包含的最后一个符号之后的第一个符号。例如第三单元时间窗包括 4 个符号，分别为符号 0、符号 1、符号 2 以及符号 3，符号 3 之后的第一个符号为符号 4，则终端设备可以确定第四单元时间窗所包含的第一个符号为符号 4。需要说明的是，本发明实施例中的第三单元时间窗包含但不限定 4 个符号，第三单元时间窗的长度和第四单元时间窗的长度可以相同，也可以不相同，具体不受本发明实施例的限定。

其中，网络设备可以对终端设备配置最大波束数量，例如允许终端设备发送用于恢复波束的请求时所使用的波束的数量可以小于等于 5。需要说明的是，本发明实施例中的最大波束数量包含但不限于 5，例如，最大波束数量可以为 3，等等，具体不受本发明实施例的限制。

其中，第三单元时间窗所包含的符号的数量总和可以是根据网络设备对终端设备配置的最大波束数量确定的。例如，第三单元时间窗所包含的符号的数量总和与最大波束数量之间可以呈正比例关系。示例性的，最大波束数量为 5，则第三单元时间窗所包含的符号的数量总和可以为 5，即第三单元时间窗包含 5 个符号。

例如，终端设备可以在第三单元时间窗所包含的一个符号上，使用一个波束向网络设备发送用于恢复波束的请求。示例性的，第三单元时间窗包括 5 个符号，分别为第一符号、第二符号、第三符号、第四符号以及第五符号，若终端设备在第三单元时间窗中确定的一个符号为第一符号，则终端设备可以在第三单元时间窗所包含的第一符号上，使用波束 1 向网络设备发送用于恢复波束的请求。波束 1 可以为终端设备确定得到的一个波束，其中该波束可以是网络设备对终端设备配置的。

又如，终端设备可以在第三单元时间窗所包含的一个符号上，使用多个不同波束向网络设备发送用于恢复波束的请求。示例性的，第三单元时间窗包括 5 个符号，分别为第一符号、第二符号、第三符号、第四符号以及第五符号，若终端设备在第三单元时间窗中确定的一个符号为第一符号，则终端设备可以在第三单元时间窗所包含的第一符号上，在不同方向上分别使用波束 1~波束 5 中的多个波束向网络设备发送用于恢复波束的请求。其中，若网络设备对终端设备配置的最大波束数量为 5，则终端设备在第三单元时间窗所包含的第一符号上，可以使用大于等于 2 个且小于等于 5 个波束向网络设备发送用于恢复波束的请求。

又如，终端设备可以在第三单元时间窗所包含的多个符号上，使用一个波束向网络设备发送用于恢复波束的请求。示例性的，第三单元时间窗包括 5 个符号，分别为第一符号、第二符号、第三符号、第四符号以及第五符号，若终端设备在第三单元时间窗中确定的多

个符号包括第二符号和第三符号，则终端设备可以在第三单元时间窗所包含的第二符号上，使用波束 1 向网络设备发送用于恢复波束的请求，且在第三单元时间窗所包含的第三符号上，使用波束 1 向网络设备发送用于恢复波束的请求。

又如，终端设备可以在第三单元时间窗所包含的多个符号上，使用多个不同波束向网络设备发送用于恢复波束的请求。示例性的，第三单元时间窗包括 5 个符号，分别为第一符号、第二符号、第三符号、第四符号以及第五符号，若终端设备在第三单元时间窗中确定的多个符号包括第二符号和第三符号，则终端设备可以在第三单元时间窗所包含的第二符号上，在不同方向上分别使用波束 1~波束 5 中的多个波束向网络设备发送用于恢复波束的请求，且在第三单元时间窗所包含的第三符号上，在不同方向上分别使用波束 1~波束 5 中的多个波束向网络设备发送用于恢复波束的请求。

在该技术方案中，终端设备可以在一个符号上使用多个不同波束向网络设备发送用于恢复波束的请求，或者在多个符号上使用一个或者多个不同波束向网络设备发送用于恢复波束的请求，以实现同一终端设备向网络设备发送多个用于恢复波束的请求。

可选的，终端设备在第一时间窗内使用至少一个波束接收网络设备发送的用于波束恢复请求的响应，具体可以为：终端设备在第四单元时间窗所包含的至少一个符号上，使用至少一个不同的波束接收用于波束恢复请求的响应。

在该技术方案中，终端设备在第三单元时间窗所包含的至少一个符号上，使用至少一个不同波束向网络设备发送用于恢复波束的请求之后，终端设备可以在第四单元时间窗所包含的至少一个符号上，使用上述至少一个不同的波束接收用于波束恢复请求的响应，可确保发送用于波束恢复的请求的波束和接收用于波束恢复请求的响应的波束为同一波束。

可选的，终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，具体可以为：终端设备基于网络设备对终端设备配置的波束请求指示信息，在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，波束请求指示信息用于指示用于恢复波束的请求的发送方式。

例如，当波束请求指示信息用于指示用于恢复波束的请求的发送方式为在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束发送时，终端设备可以在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送用于恢复波束的请求，并在第一时间窗所包含的至少一个符号上，使用第一波束接收用于波束恢复请求的响应。

又如，当波束请求指示信息用于指示用于恢复波束的请求的发送方式为在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束发送时，终端设备可以在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送用于恢复波束的请求，并在第二单元时间窗所包含的至少一个符号上，使用第一波束接收用于波束恢复请求的响应。

又如，当波束请求指示信息用于指示用于恢复波束的请求的发送方式为在第三单元时间窗所包含的至少一个符号上，使用至少一个不同波束发送时，终端设备可以在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备发送用于恢复波束的请求，并在第四单元时间窗所包含的至少一个符号上，使用至少一个不同的波束接收用

于波束恢复请求的响应。

第二方面，本发明实施例提供了一种波束恢复方法，网络设备接收终端设备在第一时间窗内使用至少一个波束发送的用于恢复波束的请求，在第二时间窗内，在接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，并使用确定得到的用于恢复波束的请求对应的波束，向终端发送用于波束恢复请求的响应。

在该技术方案中，网络设备可以接收终端设备发送的多个用于恢复波束的请求，在接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，并使用确定得到的用于恢复波束的请求对应的波束，向终端发送用于波束恢复请求的响应，可实现网络设备针对同一终端设备发送的多个用于恢复波束的请求的波束恢复处理，提高波束恢复效率。

可选的，网络设备在接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，具体可以为：网络设备响应在第二时间窗内接收到的质量最好的波束所承载的用于恢复波束的请求。

例如，若终端设备在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备发送用于恢复波束的请求，则网络设备可以在第二时间窗内接收到的用于恢复波束的请求中确定质量最好的波束所承载的用于恢复波束的请求，并对确定得到的用于恢复波束的请求进行响应。

又如，若终端设备在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送用于恢复波束的请求，则网络设备可以在第二时间窗内接收到的用于恢复波束的请求中确定质量最好的波束所承载的用于恢复波束的请求，并对确定得到的用于恢复波束的请求进行响应。

可选的，网络设备在接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，具体可以为：网络设备响应在第二时间窗内接收到的第一个用于恢复波束的请求。

例如，若终端设备在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送用于恢复波束的请求，则网络设备可以在第二时间窗内接收到的用于恢复波束的请求中确定最先接收到的用于恢复波束的请求，并对确定得到的用于恢复波束的请求进行响应。

又如，若终端设备在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送用于恢复波束的请求，则网络设备可以在第二时间窗内接收到的用于恢复波束的请求中确定最先接收到的用于恢复波束的请求，并对确定得到的用于恢复波束的请求进行响应。

又如，若终端设备在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备发送用于恢复波束的请求，则网络设备可以在第二时间窗内接收到的用于恢复波束的请求中确定最先接收到的用于恢复波束的请求，并对确定得到的用于恢复波束的请求进行响应。

可选的，网络设备使用确定得到的用于恢复波束的请求对应的波束，向终端发送用于波束恢复请求的响应，具体可以为：网络设备在第二时间窗内使用确定得到的用于恢复波束的请求对应的波束，向终端设备发送用于波束恢复请求的响应。

可选的，网络设备使用确定得到的用于恢复波束的请求对应的波束，向终端发送用于波束恢复请求的响应，具体可以为：网络设备在第二时间窗之外使用确定得到的用于恢复波束的请求对应的波束，向终端设备发送用于波束恢复请求的响应。

第三方面，本发明实施例提供一种计算机存储介质，所述计算机存储介质存储有程序，所述程序执行时包括本发明实施例第一方面提供的波束恢复方法中全部或部分的步骤。

第四方面，本发明实施例提供一种计算机存储介质，所述计算机存储介质存储有程序，所述程序执行时包括本发明实施例第二方面提供的波束恢复方法中全部或部分的步骤。

第五方面，本发明实施例提供一种波束恢复装置，该波束恢复装置包括用于执行本发明实施例第一方面公开的波束恢复方法的模块。

第六方面，本发明实施例提供一种波束恢复装置，该波束恢复装置包括用于执行本发明实施例第二方面公开的波束恢复方法的模块。

第七方面，本发明实施例提供一种终端设备，其特征在于，包括处理器、存储器以及收发器，存储器中存储一组程序代码，且处理器调用存储器中存储的程序代码，用于执行以下操作：

在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求；在第一时间窗内使用至少一个波束接收网络设备发送的用于波束恢复请求的响应。

第八方面，本发明实施例提供一种网络设备，其特征在于，包括处理器、存储器以及收发器，存储器中存储一组程序代码，且处理器调用存储器中存储的程序代码，用于执行以下操作：

接收终端设备在第一时间窗内使用至少一个波束发送的用于恢复波束的请求；在第二时间窗内，在接收到的用于恢复波束的请求中确定一个用于恢复波束的请求；使用确定得到的用于恢复波束的请求对应的波束，向终端设备发送用于波束恢复请求的响应。

第九方面，本发明实施例提供一种波束恢复系统，包括本发明实施例第七方面公开的终端设备和本发明实施例第八方面公开的网络设备。

第十方面，本申请实施例提供了一种通信芯片，其中存储有指令，当其在终端设备上运行时，使得所述通信芯片执行上述第一方面的方法。

第十一方面，本申请实施例提供了一种通信芯片，其中存储有指令，当其在网络设备上运行时，使得所述通信芯片执行上述第二方面的方法。

附图说明

为了更清楚地说明本发明实施例或背景技术中的技术方案，下面将对本发明实施例或背景技术中所需要使用的附图进行说明。

图 1 是本发明实施例提供的一种波束恢复系统的架构示意图；

图 2A 是本发明实施例提供的一种信息传输的示意图；

图 2B 是本发明另一实施例提供的一种信息传输的示意图；

图 3 是本发明实施例提供的一种波束恢复方法的流程示意图；

图 4 是本发明另一实施例提供的一种信息传输的示意图；

图 5 是本发明另一实施例提供的一种波束恢复方法的流程示意图；

图 6 是本发明另一实施例提供的一种波束恢复方法的流程示意图；

图 7 是本发明另一实施例提供的一种信息传输的示意图；

图 8 是本发明另一实施例提供的一种波束恢复方法的流程示意图；

图 9 是本发明另一实施例提供的一种波束恢复方法的流程示意图；

图 10 是本发明另一实施例提供的一种信息传输的示意图；

图 11 是本发明另一实施例提供的一种波束恢复方法的流程示意图；

图 12 是本发明实施例提供的一种波束恢复装置的结构示意图；

图 13 是本发明实施例提供的一种终端设备的结构示意图；

图 14 是本发明另一实施例提供的一种波束恢复装置的结构示意图；

图 15 是本发明实施例提供的一种网络设备的结构示意图；

图 16 是本发明实施例提供的一种波束恢复系统的结构示意图。

具体实施方式

下面结合本发明实施例中的附图对本发明实施例进行描述。

为了更好的理解本发明实施例公开的一种波束恢复方法及装置，下面首先对本发明实施例适用的网络架构进行描述。请参见图 1，图 1 是本发明实施例公开的一种波束恢复系统的架构示意图。如图 1 所示，该波束恢复系统可以包括终端设备 10 以及网络设备 20。其中，终端设备 10 与网络设备 20 之间可以通过通信连接进行数据传输。

本发明实施例中的终端设备 10 可以称为用户设备（User Equipment，UE）、移动台、接入终端、用户单元、用户站、移动站、远方站、远程终端、移动设备、终端、无线通信设备、用户代理或用户装置等，其具体可以是 WLAN 中的站点（Station，ST）、蜂窝电话、无绳电话、会话启动协议（Session Initiation Protocol，SIP）电话、无线本地环路（Wireless Local Loop，WLL）站、个人数字处理（Personal Digital Assistant，PDA）、具有无线通信功能的手持设备、计算设备、连接到无线调制解调器的其它处理设备、车载设备、可穿戴设备、未来 5G 网络中的移动台以及未来演进的公共陆地移动网络（Public Land Mobile Network，PLMN）网络中的终端设备等中的任意一种。

本发明实施例中的网络设备 20 可以是能和终端设备 10 通信的设备。网络设备 20 可以是基站、中继站或接入点。基站可以是全球移动通信系统（Global System for Mobile Communication，GSM）或码分多址（Code Division Multiple Access，CDMA）网络中的基

站收发信台（Base Transceiver Station，BTS），也可以是宽带码分多址（Wideband Code Division Multiple Access，WCDMA）中的NB（NodeB），还可以是长期演进（Long Term Evolution，LTE）中的eNB或eNodeB（Evolutional NodeB）。网络设备20还可以是云无线接入网络（Cloud Radio Access Network，CRAN)场景下的无线控制器。网络设备20还可以是未来5G网络中的网络设备或者未来演进的PLMN网络中的网络设备。网络设备20还可以是可穿戴设备或车载设备。

应理解，本发明实施例的技术方案可以应用于各种通信系统，例如：GSM系统、CDMA系统、WCDMA系统、通用分组无线业务（General Packet Radio Service，GPRS）、LTE系统、LTE频分双工（Frequency Division Duplex，FDD）系统、LTE时分双工（Time Division Duplex，TDD）、通用移动通信系统（Universal Mobile Telecommunication System，UMTS）或全球互联微波接入（Worldwide Interoperability for Microwave Access，WiMAX）通信系统等。

本发明实施例中，能够和基站进行数据通信的设备均可以理解为终端设备10，本发明实施例将以一般意义上的终端设备来介绍；本发明实施例中，网络设备20可以通过信令对终端设备10配置允许的最大波束数量，则终端设备10可以使用小于等于最大波束数量的波束向网络设备20发送用于波束恢复的请求；本发明实施例中，网络设备20可以对终端设备10配置第一时间窗，其中第一时间窗可以包括一个子帧、一个时隙以及一个或多个符号中的任意一种，则终端设备10可以在第一时间窗使用至少一个波束向网络设备20发送用于波束恢复的请求；本发明实施例中，网络设备20可以对终端设备10配置第三时间窗，其中第三时间窗可以包括一个子帧、一个时隙以及一个或多个符号中的任意一种，则终端设备10在第一时间窗使用至少一个第一波束向网络设备20发送用于波束恢复的请求之后，当在第一时间窗内未接收到网络设备20发送的用于波束恢复请求的响应时，终端设备10可以在第三时间窗使用至少一个第二波束向网络设备发送用于恢复波束的请求；本发明实施例中，网络设备20可以配置网络设备20侧的第二时间窗，其中第二时间窗可以包括一个子帧、一个时隙以及一个或多个符号中的任意一种，则网络设备20接收到终端设备10在第一时间窗使用至少一个波束发送的用于波束恢复的请求之后，可以在第二时间窗，在接收到的用于波束恢复的请求中确定一个用于波束恢复的请求。

本发明实施例中，终端设备10至少有两种发送方式向网络设备20发送用于波束恢复的请求，以实现波束恢复。

第一种发送方式可以为：终端设备10在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备20发送用于恢复波束的请求，并在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备20发送的用于波束恢复请求的响应。

以图2A所示的信息传输的示意图为例，终端设备10在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束B4'向网络设备20发送用于恢复波束的请求。网络设备20按照接收RACH波束扫描方式检测终端设备10发送的用于恢复波束的请求，当网络设备20在第二时间窗内接收到终端设备10发送的用于波束恢复的请求时，网络设备20可以通过物理下行控制信道（Physical Downlink Control Channel，PDCCH）对该用于波束恢复的请求进行响应。当终端设备10在第一时间窗内未接收到网络设备20发送的用于恢

复波束请求的响应时，终端设备 10 可以在第二时间窗所包含的至少一个符号上，使用至少一个相同的第二波束 B5'向网络设备发送用于恢复波束的请求，当终端设备 10 在第二时间窗接收到网络设备 20 发送的用于波束恢复请求的响应时，终端设备 10 可以确定实现了波束恢复。

第二种发送方式可以为：若第一时间窗包括第三单元时间窗和第四单元时间窗，终端设备 10 可以在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备 20 发送用于恢复波束的请求，并在第四单元时间窗所包含的至少一个符号上，使用至少一个不同的波束接收网络设备 20 发送的用于波束恢复请求的响应。

以图 2B 所示的信息传输的示意图为例，终端设备 10 在第三单元时间窗所包含的至少一个符号上，使用多个不同的波束向网络设备 20 发送用于恢复波束的请求，网络设备 20 在第二时间窗内接收到终端设备 10 发送的多个用于恢复波束的请求之后，可以在多个用于恢复波束的请求中确定一个用于恢复波束的请求，网络设备 20 可以使用确定得到的一个用于恢复波束的请求对应的波束，向终端设备 10 发送用于波束恢复请求的响应。终端设备 10 可以按照波束扫描方式检测网络设备 20 发送的用于波束恢复请求的响应，当终端设备 10 接收到网络设备 20 发送的用于波束恢复请求的响应时，终端设备 10 可以确定实现了波束恢复。

相对第一种发送方式，本发明实施例通过第二种发送方式可以使用多个不同的波束向网络设备 20 发送用于恢复波束的请求，可减小时延，提高波束恢复效率。

基于图 1 所示的波束恢复系统的架构示意图，请参见图 3，图 3 是本发明实施例提供的一种波束恢复方法的流程示意图，该方法包括但不限于如下步骤：

步骤 S301：终端设备在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送调度请求。

具体地，当下行链路（Down Link，DL）的波束失效时，终端设备可以在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送调度请求。其中，第一波束可以是网络设备对终端设备配置的波束，例如波束 1。

例如，终端设备可以在第一时间窗中选取一个符号（例如符号 3），并在符号 3 上使用一个波束 1 向网络设备发送调度请求。又如，终端设备可以在第一时间窗中选取一个符号（例如符号 3），并在符号 3 上使用多个波束 1 向网络设备发送调度请求，即终端设备在符号 3 上，在不同方向上使用波束 1 向网络设备发送调度请求。又如，以图 4 所示的信息传输的示意图为例，终端设备可以在第一时间窗中选取多个符号（例如符号 3，符号 4），在符号 3 上使用一个波束 1 向网络设备发送调度请求，并在符号 4 上使用一个波束 1 向网络设备发送调度请求。又如，终端设备可以在第一时间窗中选取多个符号（例如符号 3，符号 4），在符号 3 上使用多个波束 1 向网络设备发送调度请求，并在符号 4 上使用多个波束 1 向网络设备发送调度请求。

本发明实施例中，终端设备在第一时间窗所包含的至少一个符号上，使用多个相同的第一波束向网络设备发送调度请求，可加大子载波间隔。

本发明实施例中，网络设备可以对终端设备配置第一时间窗。其中，第一时间窗的起

始时刻可以是配置有RACH资源的第一个符号，以图4所示的信息传输的示意图为例，配置有RACH资源的第一个符号为符号3，则终端设备可以确定第一时间窗的起始时刻为符号3。

其中，第一时间窗的长度可以是固定长度，例如7个符号，可选的，第一时间窗的长度也可以是网络设备配置的，例如3个符号或者5个符号等。

其中，网络设备可以向终端设备发送长度指示信息，以指示第一时间窗的长度。可选的，可以通过直接法指示第一时间窗的长度，例如长度指示信息为5，则终端设备可以确定第一时间窗的长度为5个符号。可选的，可以通过映射方式描述第一时间窗的长度，例如长度指示信息和第一时间窗的映射关系如表一所示：

表一

长度指示信息	第一时间窗的长度
00	3个符号
01	4个符号
10	5个符号
11	7个符号

通过表一可知，当长度指示信息为二进制00时，终端设备可以确定第一时间窗的长度为3个符号；当长度指示信息为二进制11时，终端设备可以确定第一时间窗的长度为7个符号。需要说明的是，本发明实施例中的长度指示信息和第一时间长度的映射关系包含但不局限于上述方式，研发人员可以结合不同场景进行修改，具体不受本发明实施例的限制。

其中，网络设备可以通过信令对终端设备配置第一时间窗，例如无线资源控制协议（Radio Resource Control，RRC）、媒体介入控制-控制元素协议（Media Access Control-Control Element，MAC-CE）或者下行控制信息协议（Downlink Control Information，DCI）等。

其中，网络设备可以通过向终端设备发送长度指示信息的方式，通知终端设备配置了第一时间窗。

步骤S302：网络设备确定在第二时间窗内接收到的第一个调度请求。

具体地，网络设备可以按照接收RACH波束扫描方式在第二时间窗内接收终端设备发送的调度请求，并确定在第二时间窗内接收到的第一个调度请求。

其中，网络设备可以配置网络设备侧的第二时间窗，第二时间窗所包含的第一个符号可以和第一单元时间窗所包含的第一个符号相同。

其中，第二时间窗的长度可以是固定长度，例如4个符号，可选的，第二时间窗的长度也可以是网络设备配置的，例如3个符号或者5个符号等。

步骤S303：网络设备在第二时间窗内使用确定得到的调度请求对应的波束，向终端设备发送调度请求响应。

具体实现中，网络设备可以获取承载确定得到的调度请求的波束，确定该波束所属波束对所包含的另一波束，在第二时间窗内使用确定得到的波束向终端设备发送调度请求响应。其中，波束对可以包括一个发送端的发射波束和一个接收端的接收波束。例如承载确

定得到的调度请求的波束为波束 1，波束 1 与波束 3 构成一个波束对，则网络设备可以在第二时间窗内使用波束 3 向终端设备发送调度请求响应。

以图 4 所示的信息传输的示意图为例，网络设备可以在第二时间窗所包含的符号 0 上，使用第一波束所属波束对所包含的另一波束向终端设备发送调度请求响应。

可选的，网络设备可以通过 PDCCH 向终端设备发送调度请求响应。例如，终端设备可以在同一子帧接收多个承载在不同 PDCCH 上的 DCI 消息。对于一个 PDCCH 所承载的 DCI 消息，每个 DCI 消息上可以附着一个 CRC。终端设备的 C-RNTI 可以被包含在 CRC 计算之中并隐式传输。则网络设备可以根据该终端设备的 C-RNTI，确定包含该 C-RNTI 的 CRC 所属的 DCI，进而确定承载该 DCI 的 PDCCH，通过确定得到的 PDCCH 向终端设备发送调度请求响应。其中，DCI 可以包括下行调度分配、上行调度请求、功率控制等。

可选的，网络设备可以通过 MAC-CE 向终端设备发送调度请求响应。例如，网络设备可以定义一个新的 MAC-CE，将该 MAC-CE 发送给终端设备，其中该 MAC-CE 可以携带调度请求响应。

可选的，网络设备可以通过 RRC 向终端设备发送调度请求响应。例如，网络设备可以定义一个新的 RRC IE，将该 RRC IE 发送给终端设备，其中该 RRC IE 可以携带调度请求响应。

可选的，网络设备可以通过物理下行共享信道（Physical Downlink Shared Channel，PDSCH）向终端设备发送调度请求响应。

步骤 S304：终端设备在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备发送的调度请求响应。

终端设备可以在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备发送的调度请求响应。例如，若终端设备在第一时间窗所包含的至少一个符号上，使用波束 1 向网络设备发送调度请求，则终端设备可以在第一时间窗所包含的至少一个符号上，使用波束 1 接收网络设备发送的调度请求响应。

相对传统的波束恢复方法中终端设备接收调度请求响应的接收时间与发送调度请求的发送时间间隔至少两个子帧，本发明实施例中终端设备接收调度请求响应的接收时间与发送调度请求的发送时间间隔最多第一时间窗，例如 7 个符号，可降低延迟，提高波束恢复的效率。

在图 3 所描述的方法中，终端设备在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送调度请求，网络设备确定在第二时间窗内接收到的第一个调度请求，网络设备在第二时间窗内使用确定得到的调度请求对应的波束，向终端设备发送调度请求响应，则终端设备在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备发送的调度请求响应，可实现网络设备针对同一终端设备发送的多个调度请求的波束恢复处理，提高波束恢复效率。

基于图 1 所示的波束恢复系统的架构示意图，请参见图 5，图 5 是本发明实施例提供的一种波束恢复方法的流程示意图，该方法包括但不限于如下步骤：

步骤 S501：终端设备在第一时间窗所包含的至少一个符号上，使用至少一个相同的第

一波束向网络设备发送波束失败恢复请求。

具体地，当 DL 波束失效时，终端设备可以在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送波束失败恢复请求。其中，第一波束可以是网络设备对终端设备配置的波束，例如波束 1。

例如，终端设备可以在第一时间窗中选取一个符号（例如符号 3），并在符号 3 上使用一个波束 1 向网络设备发送波束失败恢复请求。又如，终端设备可以在第一时间窗中选取一个符号（例如符号 3），并在符号 3 上使用多个波束 1 向网络设备发送波束失败恢复请求，即终端设备在符号 3 上，在不同方向上使用波束 1 向网络设备发送波束失败恢复请求。又如，以图 4 所示的信息传输的示意图为例，终端设备可以在第一时间窗中选取多个符号（例如符号 3，符号 4），在符号 3 上使用一个波束 1 向网络设备发送波束失败恢复请求，并在符号 4 上使用一个波束 1 向网络设备发送波束失败恢复请求。又如，终端设备可以在第一时间窗中选取多个符号（例如符号 3，符号 4），在符号 3 上使用多个波束 1 向网络设备发送波束失败恢复请求，并在符号 4 上使用多个波束 1 向网络设备发送波束失败恢复请求。

本发明实施例中，终端设备在第一时间窗所包含的至少一个符号上，使用多个相同的第一波束向网络设备发送波束失败恢复请求，可加大子载波间隔。

本发明实施例中，网络设备可以对终端设备配置第一时间窗。其中，第一时间窗的起始时刻可以是配置有 RACH 资源的第一个符号，以图 4 所示的信息传输的示意图为例，配置有 RACH 资源的第一个符号为符号 3，则终端设备可以确定第一时间窗的起始时刻为符号 3。

其中，第一时间窗的长度可以是固定长度，例如 7 个符号，可选的，第一时间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

其中，网络设备可以向终端设备发送长度指示信息，以指示第一时间窗的长度。可选的，可以通过直接法指示第一时间窗的长度，例如长度指示信息为 5，则终端设备可以确定第一时间窗的长度为 5 个符号。可选的，可以通过映射方式描述第一时间窗的长度，例如长度指示信息和第一时间窗的映射关系如表一所示。通过表一可知，当长度指示信息为二进制 00 时，终端设备可以确定第一时间窗的长度为 3 个符号；当长度指示信息为二进制 11 时，终端设备可以确定第一时间窗的长度为 7 个符号。需要说明的是，本发明实施例中的长度指示信息和第一时间长度的映射关系包含但不局限于上述方式，研发人员可以结合不同场景进行修改，具体不受本发明实施例的限制。

其中，网络设备可以通过信令对终端设备配置第一时间窗，例如无线资源控制协议（Radio Resource Control，RRC）、媒体介入控制-控制元素协议（Media Access Control-Control Element，MAC-CE）或者下行控制信息协议（Downlink Control Information，DCI）等。

其中，网络设备可以通过向终端设备发送长度指示信息的方式，通知终端设备配置了第一时间窗。

步骤 S502：网络设备确定在第二时间窗内接收到的第一个波束失败恢复请求。

具体地，网络设备可以按照接收 RACH 波束扫描方式在第二时间窗内接收终端设备发送的波束失败恢复请求，并确定在第二时间窗内接收到的第一个波束失败恢复请求。

其中，网络设备可以配置网络设备侧的第二时间窗，第二时间窗所包含的第一个符号可以和第一单元时间窗所包含的第一个符号相同。

其中，第二时间窗的长度可以是固定长度，例如 4 个符号，可选的，第二时间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

步骤 S503：网络设备在第二时间窗内使用确定得到的波束失败恢复请求对应的波束，向终端设备发送波束失败恢复请求响应。

具体实现中，网络设备可以获取承载确定得到的波束失败恢复请求的波束，确定该波束所属波束对所包含的另一波束，在第二时间窗内使用确定得到的波束向终端设备发送波束失败恢复请求响应。例如承载确定得到的波束失败恢复请求的波束为波束 1，波束 1 与波束 3 构成一个波束对，则网络设备可以在第二时间窗内使用波束 3 向终端设备发送波束失败恢复请求响应。

以图 4 所示的信息传输的示意图为例，网络设备可以在第二时间窗所包含的符号 0 上，使用第一波束所属波束对所包含的另一波束向终端设备发送波束失败恢复请求响应。

可选的，网络设备可以通过 PDCCH 向终端设备发送波束失败恢复请求响应。

可选的，网络设备可以通过 MAC-CE 向终端设备发送波束失败恢复请求响应。

可选的，网络设备可以通过 RRC 向终端设备发送波束失败恢复请求响应。

可选的，网络设备可以通过 PDSCH 向终端设备发送波束失败恢复请求响应。

步骤 S504：终端设备在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备发送的波束失败恢复请求响应。

终端设备可以在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备发送的波束失败恢复请求响应。例如，若终端设备在第一时间窗所包含的至少一个符号上，使用波束 1 向网络设备发送波束失败恢复请求，则终端设备可以在第一时间窗所包含的至少一个符号上，使用波束 1 接收网络设备发送的波束失败恢复请求响应。

相对传统的波束恢复方法中终端设备接收波束失败恢复请求响应的接收时间与发送波束失败恢复请求的发送时间间隔至少两个子帧，本发明实施例中终端设备接收波束失败恢复请求响应的接收时间与发送波束失败恢复请求的发送时间间隔最多第一时间窗，例如 7 个符号，可降低延迟，提高波束恢复的效率。

在图 5 所描述的方法中，终端设备在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送波束失败恢复请求，网络设备确定在第二时间窗内接收到的第一个波束失败恢复请求，网络设备在第二时间窗内使用确定得到的波束失败恢复请求对应的波束，向终端设备发送波束失败恢复请求响应，则终端设备在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备发送的波束失败恢复请求响应，可实现网络设备针对同一终端设备发送的多个波束失败恢复请求的波束恢复处理，提高波束恢复效率。

基于图 1 所示的波束恢复系统的架构示意图，请参见图 6，图 6 是本发明实施例提供的一种波束恢复方法的流程示意图，该方法包括但不限于如下步骤：

步骤 S601：终端设备在第一单元时间窗所包含的至少一个符号上，使用至少一个相同

的第一波束向网络设备发送调度请求。

具体地，当 DL 波束失效时，终端设备可以在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送调度请求。其中，第一波束可以是网络设备对终端设备配置的波束，例如波束 1。

例如，终端设备可以在第一单元时间窗中选取一个符号（例如符号 3），并在符号 3 上使用一个波束 1 向网络设备发送调度请求。又如，终端设备可以在第一单元时间窗中选取一个符号（例如符号 3），并在符号 3 上使用多个波束 1 向网络设备发送调度请求，即终端设备在符号 3 上，在不同方向上使用波束 1 向网络设备发送调度请求。又如，以图 7 所示的信息传输的示意图为例，终端设备可以在第一单元时间窗中选取多个符号（例如符号 3，符号 4），在符号 3 上使用一个波束 1 向网络设备发送调度请求，并在符号 4 上使用一个波束 1 向网络设备发送调度请求。又如，终端设备可以在第一单元时间窗中选取多个符号（例如符号 3，符号 4），在符号 3 上使用多个波束 1 向网络设备发送调度请求，并在符号 4 上使用多个波束 1 向网络设备发送调度请求。

本发明实施例中，终端设备在第一单元时间窗所包含的至少一个符号上，使用多个相同的第一波束向网络设备发送调度请求，可加大子载波间隔。

本发明实施例中，网络设备可以对终端设备配置第一单元时间窗。其中，第一单元时间窗的起始时刻可以是配置有 RACH 资源的第一个符号，以图 7 所示的信息传输的示意图为例，配置有 RACH 资源的第一个符号为符号 3，则终端设备可以确定第一单元时间窗的起始时刻为符号 3。

本发明实施例中，网络设备可以对终端设备配置第二单元时间窗。其中，第二单元时间窗所包含的第一个符号为第一单元时间窗所包含的最后一个符号之后的第一个符号，以图 7 所示的信息传输的示意图为例，第一单元时间窗所包含的最后一个符号为符号 6，则终端设备可以确定第二单元时间窗所包含的第一个符号为符号 0。

其中，第一单元时间窗的长度可以是固定长度，例如 4 个符号，可选的，第一单元时间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

其中，第二单元时间窗的长度可以是固定长度，例如 4 个符号，可选的，第二单元时间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

其中，网络设备可以向终端设备发送第一长度指示信息，以指示第一单元时间窗的长度。可选的，可以通过直接法指示第一单元时间窗的长度。可选的，可以通过映射方式描述第一单元时间窗的长度。

其中，网络设备可以向终端设备发送第二长度指示信息，以指示第二单元时间窗的长度。可选的，可以通过直接法指示第二单元时间窗的长度。可选的，可以通过映射方式描述第二单元时间窗的长度。

其中，网络设备可以通过信令对终端设备配置第一单元时间窗，例如 RRC、MAC-CE 或者 DCI 等。

其中，网络设备可以通过信令对终端设备配置第二单元时间窗，例如 RRC、MAC-CE 或者 DCI 等。

其中，网络设备可以通过向终端设备发送第一长度指示信息的方式，通知终端设备配

置了第一单元时间窗。

其中，网络设备可以通过向终端设备发送第二长度指示信息的方式，通知终端设备配置了第二单元时间窗。

步骤 S602：网络设备在第二时间窗内，在接收到的调度请求中确定一个调度请求。

具体地，网络设备可以按照接收 RACH 波束扫描方式在第二时间窗内接收终端设备发送的调度请求，并在接收到的调度请求中确定一个调度请求。

可选的，网络设备可以确定在第二时间窗内接收到的第一个调度请求。

可选的，网络设备可以确定在第二时间窗内接收到的质量大于预设质量阈值的波束所承载的调度请求。

可选的，网络设备可以确定在第二时间窗内接收到的质量最好的波束所承载的调度请求。

其中，网络设备可以配置网络设备侧的第二时间窗，第二时间窗所包含的第一个符号可以和第一单元时间窗所包含的第一个符号相同。

其中，第二时间窗的长度可以是固定长度，例如 4 个符号，可选的，第二时间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

步骤 S603：网络设备在第二时间窗之后使用确定得到的调度请求对应的波束，向终端设备发送调度请求响应。

具体实现中，网络设备可以获取承载确定得到的调度请求的波束，确定该波束所属波束对所包含的另一波束，在第二时间窗之后使用确定得到的波束向终端设备发送调度请求响应。例如承载确定得到的调度请求的波束为波束 1，波束 1 与波束 3 构成一个波束对，则网络设备可以在第二时间窗之后使用波束 3 向终端设备发送调度请求响应。

以图 7 所示的信息传输的示意图为例，终端设备可以在第二时间窗之后的第一个符号，即符号 0，使用第一波束所属波束对所包含的另一波束向终端设备发送调度请求响应。

可选的，网络设备可以通过 PDCCH 向终端设备发送调度请求响应。

可选的，网络设备可以通过 MAC-CE 向终端设备发送调度请求响应。

可选的，网络设备可以通过 RRC 向终端设备发送调度请求响应。

可选的，网络设备可以通过 PDSCH 向终端设备发送调度请求响应。

步骤 S604：终端设备在第二单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束接收网络设备发送的调度请求响应。

终端设备可以在第二单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束接收网络设备发送的调度请求响应。例如，若终端设备在第一单元时间窗所包含的至少一个符号上，使用波束 1 向网络设备发送调度请求，则终端设备可以在第二单元时间窗所包含的至少一个符号上，使用波束 1 接收网络设备发送的调度请求响应。

相对传统的波束恢复方法中终端设备接收调度请求响应的接收时间与发送调度请求的发送时间间隔至少两个子帧，本发明实施例中终端设备接收调度请求响应的接收时间与发送调度请求的发送时间间隔最多第一时间窗，例如 7 个符号，可降低延迟，提高波束恢复的效率。

在图 6 所描述的方法中，终端设备在第一时间窗所包含的至少一个符号上，使用至少

一个相同的第一波束向网络设备发送调度请求，网络设备确定在第一时间窗内接收到的第一个调度请求，网络设备在第一时间窗内使用确定得到的调度请求对应的波束，向终端设备发送调度请求响应，则终端设备在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备发送的调度请求响应，可实现网络设备针对同一终端设备发送的多个调度请求的波束恢复处理，提高波束恢复效率。

基于图 1 所示的波束恢复系统的架构示意图，请参见图 8，图 8 是本发明实施例提供的一种波束恢复方法的流程示意图，该方法包括但不限于如下步骤：

步骤 S801：终端设备在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送波束失败恢复请求。

具体地，当 DL 波束失效时，终端设备可以在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送波束失败恢复请求。其中，第一波束可以是网络设备对终端设备配置的波束，例如波束 1。

例如，终端设备可以在第一单元时间窗中选取一个符号（例如符号 3），并在符号 3 上使用一个波束 1 向网络设备发送波束失败恢复请求。又如，终端设备可以在第一单元时间窗中选取一个符号（例如符号 3），并在符号 3 上使用多个波束 1 向网络设备发送波束失败恢复请求，即终端设备在符号 3 上，在不同方向上使用波束 1 向网络设备发送波束失败恢复请求。又如，以图 7 所示的信息传输的示意图为例，终端设备可以在第一单元时间窗中选取多个符号（例如符号 3，符号 4），在符号 3 上使用一个波束 1 向网络设备发送波束失败恢复请求，并在符号 4 上使用一个波束 1 向网络设备发送波束失败恢复请求。又如，终端设备可以在第一单元时间窗中选取多个符号（例如符号 3，符号 4），在符号 3 上使用多个波束 1 向网络设备发送波束失败恢复请求，并在符号 4 上使用多个波束 1 向网络设备发送波束失败恢复请求。

本发明实施例中，终端设备在第一单元时间窗所包含的至少一个符号上，使用多个相同的第一波束向网络设备发送波束失败恢复请求，可加大子载波间隔。

本发明实施例中，网络设备可以对终端设备配置第一单元时间窗。其中，第一单元时间窗的起始时刻可以是配置有 RACH 资源的第一个符号，以图 7 所示的信息传输的示意图为例，配置有 RACH 资源的第一个符号为符号 3，则终端设备可以确定第一单元时间窗的起始时刻为符号 3。

本发明实施例中，网络设备可以对终端设备配置第二单元时间窗。其中，第二单元时间窗所包含的第一个符号为第一单元时间窗所包含的最后一个符号之后的第一个符号，以图 7 所示的信息传输的示意图为例，第一单元时间窗所包含的最后一个符号为符号 8，则终端设备可以确定第二单元时间窗所包含的第一个符号为符号 0。

其中，第一单元时间窗的长度可以是固定长度，例如 4 个符号，可选的，第一单元时间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

其中，第二单元时间窗的长度可以是固定长度，例如 4 个符号，可选的，第二单元时间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

其中，网络设备可以向终端设备发送第一长度指示信息，以指示第一单元时间窗的长

度。可选的，可以通过直接法指示第一单元时间窗的长度。可选的，可以通过映射方式描述第一单元时间窗的长度。

其中，网络设备可以向终端设备发送第二长度指示信息，以指示第二单元时间窗的长度。可选的，可以通过直接法指示第二单元时间窗的长度。可选的，可以通过映射方式描述第二单元时间窗的长度。

其中，网络设备可以通过信令对终端设备配置第一单元时间窗，例如 RRC、MAC-CE 或者 DCI 等。

其中，网络设备可以通过信令对终端设备配置第二单元时间窗，例如 RRC、MAC-CE 或者 DCI 等。

其中，网络设备可以通过向终端设备发送第一长度指示信息的方式，通知终端设备配置了第一单元时间窗。

其中，网络设备可以通过向终端设备发送第二长度指示信息的方式，通知终端设备配置了第二单元时间窗。

步骤 S802：网络设备在第二时间窗内，在接收到的波束失败恢复请求中确定一个波束失败恢复请求。

具体地，网络设备可以按照接收 RACH 波束扫描方式在第二时间窗内接收终端设备发送的波束失败恢复请求，并在接收到的波束失败恢复请求中确定一个波束失败恢复请求。

可选的，网络设备可以确定在第二时间窗内接收到的第一个波束失败恢复请求。

可选的，网络设备可以确定在第二时间窗内接收到的质量大于预设质量阈值的波束所承载的波束失败恢复请求。

可选的，网络设备可以确定在第二时间窗内接收到的质量最好的波束所承载的波束失败恢复请求。

其中，网络设备可以配置网络设备侧的第二时间窗，第二时间窗所包含的第一个符号可以和第一时间窗所包含的第一个符号相同。

其中，第二时间窗的长度可以是固定长度，例如 4 个符号，可选的，第二时间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

步骤 S803：网络设备在第二时间窗之后使用确定得到的波束失败恢复请求对应的波束，向终端设备发送波束失败恢复请求响应。

具体实现中，网络设备可以获取承载确定得到的波束失败恢复请求的波束，确定该波束所属波束对所包含的另一波束，在第二时间窗之后使用确定得到的波束向终端设备发送波束失败恢复请求响应。例如承载确定得到的波束失败恢复请求的波束为波束 1，波束 1 与波束 3 构成一个波束对，则网络设备可以在第二时间窗之后使用波束 3 向终端设备发送波束失败恢复请求响应。

以图 7 所示的信息传输的示意图为例，终端设备可以在第二时间窗之后的第一个符号上，使用第一波束所属波束对所包含的另一波束向终端设备发送波束失败恢复请求响应。

可选的，网络设备可以通过 PDCCH 向终端设备发送波束失败恢复请求响应。

可选的，网络设备可以通过 MAC-CE 向终端设备发送波束失败恢复请求响应。

可选的，网络设备可以通过 RRC 向终端设备发送波束失败恢复请求响应。

可选的，网络设备可以通过 PDSCH 向终端设备发送波束失败恢复请求响应。

步骤 S804：终端设备在第二单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束接收网络设备发送的波束失败恢复请求响应。

终端设备可以在第二单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束接收网络设备发送的波束失败恢复请求响应。例如，若终端设备在第一单元时间窗所包含的至少一个符号上，使用波束 1 向网络设备发送波束失败恢复请求，则终端设备可以在第二单元时间窗所包含的至少一个符号上，使用波束 1 接收网络设备发送的波束失败恢复请求响应。

相对传统的波束恢复方法中终端设备接收波束失败恢复请求响应的接收时间与发送波束失败恢复请求的发送时间间隔至少两个子帧，本发明实施例中终端设备接收波束失败恢复请求响应的接收时间与发送波束失败恢复请求的发送时间间隔最多第一时间窗，例如 7 个符号，可降低延迟，提高波束恢复的效率。

在图 8 所描述的方法中，终端设备在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送波束失败恢复请求，网络设备确定在第一时间窗内接收到的第一个波束失败恢复请求，网络设备在第一时间窗内使用确定得到的波束失败恢复请求对应的波束，向终端设备发送波束失败恢复请求响应，则终端设备在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备发送的波束失败恢复请求响应，可实现网络设备针对同一终端设备发送的多个波束失败恢复请求的波束恢复处理，提高波束恢复效率。

基于图 1 所示的波束恢复系统的架构示意图，请参见图 9，图 9 是本发明实施例提供的一种波束恢复方法的流程示意图，该方法包括但不限于如下步骤：

步骤 S901：终端设备在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备发送调度请求。

具体地，当 DL 波束失效时，终端设备可以在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备发送调度请求。其中，网络设备可以对终端设备配置允许的最大波束数量，则终端设备可以使用小于等于最大波束数量的波束向网络设备发送调度请求。

例如，终端设备可以在第三单元时间窗中选取一个符号（例如符号 3），并在符号 3 上使用一个波束 1 向网络设备发送调度请求。又如，终端设备可以在第三单元时间窗中选取一个符号（例如符号 3），并在符号 3 上使用多个不同波束向网络设备发送调度请求，示例性的，终端设备在符号 3 上，分别使用波束 1 和波束 2 向网络设备发送调度请求。又如，以图 10 所示的信息传输的示意图为例，终端设备可以在第三单元时间窗中选取多个符号（例如符号 3，符号 4），在符号 3 上使用一个波束 1 向网络设备发送调度请求，并在符号 4 上使用一个波束 1 向网络设备发送调度请求。又如，终端设备可以在第三单元时间窗中选取多个符号（例如符号 3，符号 4），在符号 3 上使用多个不同波束向网络设备发送调度请求，并在符号 4 上使用多个不同波束向网络设备发送调度请求。

本发明实施例中，终端设备在第三单元时间窗所包含的至少一个符号上，使用多个不

同波束向网络设备发送调度请求，可加大子载波间隔。

本发明实施例中，网络设备可通过 RRC、MAC-CE 或者 DCI 等信令对终端设备配置允许的最大波束数量。其中，同一小区所有终端设备可以配置相同的最大波束数量，或者终端设备集群所包含的所有终端设备可以配置相同的最大波束数量，或者不同终端设备可配置不同的最大波束数量，当不同终端设备配置不同的最大波束数量时，该终端设备需要向网络设备上报该终端设备的能力。其中，可以通过直接法指示最大波束数量。可选的，可以通过映射方法描述最大波束数量。

本发明实施例中，网络设备可以对终端设备配置第三单元时间窗。其中，第三单元时间窗的起始时刻可以是配置有 RACH 资源的第一个符号，以图 10 所示的信息传输的示意图为例，配置有 RACH 资源的第一个符号为符号 3，则终端设备可以确定第三单元时间窗的起始时刻为符号 3。

本发明实施例中，网络设备可以对终端设备配置第四单元时间窗。其中，第四单元时间窗所包含的第一个符号为第三单元时间窗所包含的最后一个符号之后的第一个符号，以图 10 所示的信息传输的示意图为例，第三单元时间窗所包含的最后一个符号为符号 6，则终端设备可以确定第四单元时间窗所包含的第一个符号为符号 0。

其中，第三单元时间窗的长度可以是固定长度，例如 4 个符号，可选的，第三单元时间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

其中，第四单元时间窗的长度可以是固定长度，例如 4 个符号，可选的，第四单元时间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

其中，网络设备可以向终端设备发送第三长度指示信息，以指示第三单元时间窗的长度。可选的，可以通过直接法指示第三单元时间窗的长度。可选的，可以通过映射方式描述第三单元时间窗的长度。

其中，网络设备可以向终端设备发送第四长度指示信息，以指示第四单元时间窗的长度。可选的，可以通过直接法指示第四单元时间窗的长度。可选的，可以通过映射方式描述第四单元时间窗的长度。

其中，网络设备可以通过信令对终端设备配置第三单元时间窗，例如 RRC、MAC-CE 或者 DCI 等。

其中，网络设备可以通过信令对终端设备配置第四单元时间窗，例如 RRC、MAC-CE 或者 DCI 等。

其中，网络设备可以通过向终端设备发送第三长度指示信息的方式，通知终端设备配置了第三单元时间窗。

其中，网络设备可以通过向终端设备发送第四长度指示信息的方式，通知终端设备配置了第四单元时间窗。

步骤 S902：网络设备在第二时间窗内，在接收到的调度请求中确定一个调度请求。

具体地，网络设备可以按照接收 RACH 波束扫描方式在第二时间窗内接收终端设备发送的调度请求，并在接收到的调度请求中确定一个调度请求。

可选的，网络设备可以确定在第二时间窗内接收到的第一个调度请求。

可选的，网络设备可以确定在第二时间窗内接收到的质量大于预设质量阈值的波束所

承载的调度请求。

可选的，网络设备可以确定在第二时间窗内接收到的质量最好的波束所承载的调度请求。

其中，网络设备可以配置网络设备侧的第二时间窗，第二时间窗所包含的第一个符号可以和第三单元时间窗所包含的第一个符号相同。

其中，第二时间窗的长度可以是固定长度，例如 4 个符号，可选的，第二时间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

步骤 S903：网络设备在第二时间窗之后使用确定得到的调度请求对应的波束，向终端设备发送调度请求响应。

具体实现中，网络设备可以获取承载确定得到的调度请求的波束，确定该波束所属波束对所包含的另一波束，在第二时间窗之后使用确定得到的波束向终端设备发送调度请求响应。例如承载确定得到的调度请求的波束为波束 1，波束 1 与波束 3 构成一个波束对，则网络设备可以在第二时间窗之后使用波束 3 向终端设备发送调度请求响应。

以图 10 所示的信息传输的示意图为例，终端设备可以在第二时间窗之后的第一个符号，即符号 0，使用第一波束所属波束对所包含的另一波束向终端设备发送调度请求响应，终端设备还可以在第二时间窗之后的第二个符号，即符号 1，使用第一波束所属波束对所包含的另一波束向终端设备发送调度请求响应。

可选的，网络设备可以通过 PDCCH 向终端设备发送调度请求响应。

可选的，网络设备可以通过 MAC-CE 向终端设备发送调度请求响应。

可选的，网络设备可以通过 RRC 向终端设备发送调度请求响应。

可选的，网络设备可以通过 PDSCH 向终端设备发送调度请求响应。

步骤 S904：终端设备在第四单元时间窗所包含的至少一个符号上，使用至少一个不同的波束接收网络设备发送的调度请求响应。

终端设备可以在第四单元时间窗所包含的至少一个符号上，使用至少一个不同的波束接收网络设备发送的调度请求响应。例如，若终端设备在第三单元时间窗所包含的至少一个符号上，分别使用波束 1 和波束 2 向网络设备发送调度请求，则终端设备可以在第四单元时间窗所包含的至少一个符号上，分别使用波束 1 和波束 2 接收网络设备发送的调度请求响应。

相对传统的波束恢复方法中终端设备接收调度请求响应的接收时间与发送调度请求的发送时间间隔至少两个子帧，本发明实施例中终端设备接收调度请求响应的接收时间与发送调度请求的发送时间间隔最多第一时间窗，例如 7 个符号，可降低延迟，提高波束恢复的效率。

在图 9 所描述的方法中，终端设备在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备发送调度请求，网络设备在第二时间窗内，在接收到的调度请求中确定一个调度请求，网络设备在第二时间窗之后使用确定得到的调度请求对应的波束，向终端设备发送调度请求响应，终端设备在第四单元时间窗所包含的至少一个符号上，使用至少一个不同的波束接收网络设备发送的调度请求响应，可实现网络设备针对同一终端设备发送的多个波束失败恢复请求的波束恢复处理，提高波束恢复效率。

基于图 1 所示的波束恢复系统的架构示意图，请参见图 11，图 11 是本发明实施例提供的一种波束恢复方法的流程示意图，该方法包括但不限于如下步骤：

步骤 S1101：终端设备在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备发送波束失败恢复请求。

具体地，当 DL 波束失效时，终端设备可以在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备发送波束失败恢复请求。其中，网络设备可以对终端设备配置允许的最大波束数量，则终端设备可以使用小于等于最大波束数量的波束向网络设备发送波束失败恢复请求。

例如，终端设备可以在第三单元时间窗中选取一个符号（例如符号 3），并在符号 3 上使用一个波束 1 向网络设备发送波束失败恢复请求。又如，终端设备可以在第三单元时间窗中选取一个符号（例如符号 3），并在符号 3 上使用多个不同波束向网络设备发送波束失败恢复请求，示例性的，终端设备在符号 3 上，分别使用波束 1 和波束 2 向网络设备发送波束失败恢复请求。又如，以图 10 所示的信息传输的示意图为例，终端设备可以在第三单元时间窗中选取多个符号（例如符号 3，符号 4），在符号 3 上使用一个波束 1 向网络设备发送波束失败恢复请求，并在符号 4 上使用一个波束 1 向网络设备发送波束失败恢复请求。又如，终端设备可以在第三单元时间窗中选取多个符号（例如符号 3，符号 4），在符号 3 上使用多个不同波束向网络设备发送波束失败恢复请求，并在符号 4 上使用多个不同波束向网络设备发送波束失败恢复请求。

本发明实施例中，终端设备在第三单元时间窗所包含的至少一个符号上，使用多个不同波束向网络设备发送波束失败恢复请求，可加大子载波间隔。

本发明实施例中，网络设备可通过 RRC、MAC-CE 或者 DCI 等信令对终端设备配置允许的最大波束数量。其中，同一小区所有终端设备可以配置相同的最大波束数量，或者终端设备集群所包含的所有终端设备可以配置相同的最大波束数量，或者不同终端设备可配置不同的最大波束数量，当不同终端设备配置不同的最大波束数量时，该终端设备需要向网络设备上报该终端设备的能力。其中，可以通过直接法指示最大波束数量。可选的，可以通过映射方法描述最大波束数量。

本发明实施例中，网络设备可以对终端设备配置第三单元时间窗。其中，第三单元时间窗的起始时刻可以是配置有 RACH 资源的第一个符号，以图 10 所示的信息传输的示意图为例，配置有 RACH 资源的第一个符号为符号 3，则终端设备可以确定第三单元时间窗的起始时刻为符号 3。

本发明实施例中，网络设备可以对终端设备配置第四单元时间窗。其中，第四单元时间窗所包含的第一个符号为第三单元时间窗所包含的最后一个符号之后的第一个符号，以图 10 所示的信息传输的示意图为例，第三单元时间窗所包含的最后一个符号为符号 6，则终端设备可以确定第四单元时间窗所包含的第一个符号为符号 0。

其中，第三单元时间窗的长度可以是固定长度，例如 4 个符号，可选的，第三单元时间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

其中，第四单元时间窗的长度可以是固定长度，例如 4 个符号，可选的，第四单元时

间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

其中，网络设备可以向终端设备发送第三长度指示信息，以指示第三单元时间窗的长度。可选的，可以通过直接法指示第三单元时间窗的长度。可选的，可以通过映射方式描述第三单元时间窗的长度。

其中，网络设备可以向终端设备发送第四长度指示信息，以指示第四单元时间窗的长度。可选的，可以通过直接法指示第四单元时间窗的长度。可选的，可以通过映射方式描述第四单元时间窗的长度。

其中，网络设备可以通过信令对终端设备配置第三单元时间窗，例如 RRC、MAC-CE 或者 DCI 等。

其中，网络设备可以通过信令对终端设备配置第四单元时间窗，例如 RRC、MAC-CE 或者 DCI 等。

其中，网络设备可以通过向终端设备发送第三长度指示信息的方式，通知终端设备配置了第三单元时间窗。

其中，网络设备可以通过向终端设备发送第四长度指示信息的方式，通知终端设备配置了第四单元时间窗。

步骤 S1102：网络设备在第二时间窗内，在接收到的波束失败恢复请求中确定一个波束失败恢复请求。

具体地，网络设备可以按照接收 RACH 波束扫描方式在第二时间窗内接收终端设备发送的波束失败恢复请求，并在接收到的波束失败恢复请求中确定一个波束失败恢复请求。

可选的，网络设备可以确定在第二时间窗内接收到的第一个波束失败恢复请求。

可选的，网络设备可以确定在第二时间窗内接收到的质量大于预设质量阈值的波束所承载的波束失败恢复请求。

可选的，网络设备可以确定在第二时间窗内接收到的质量最好的波束所承载的波束失败恢复请求。

其中，网络设备可以配置网络设备侧的第二时间窗，第二时间窗所包含的第一个符号可以和第三单元时间窗所包含的第一个符号相同。

其中，第二时间窗的长度可以是固定长度，例如 4 个符号，可选的，第二时间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

步骤 S1103：网络设备在第二时间窗之后使用确定得到的波束失败恢复请求对应的波束，向终端设备发送波束失败恢复请求响应。

具体实现中，网络设备可以获取承载确定得到的波束失败恢复请求的波束，确定该波束所属波束对所包含的另一波束，在第二时间窗之后使用确定得到的波束向终端设备发送波束失败恢复请求响应。例如承载确定得到的波束失败恢复请求的波束为波束 1，波束 1 与波束 3 构成一个波束对，则网络设备可以在第二时间窗之后使用波束 3 向终端设备发送波束失败恢复请求响应。

以图 10 所示的信息传输的示意图为例，终端设备可以在第二时间窗之后的第一个符号，即符号 0，使用第一波束所属波束对所包含的另一波束向终端设备发送波束失败恢复请求响应，终端设备还可以在第二时间窗之后的第二个符号，即符号 1，使用第一波束所

属波束对所包含的另一波束向终端设备发送波束失败恢复请求响应。

可选的，网络设备可以通过 PDCCH 向终端设备发送波束失败恢复请求响应。

可选的，网络设备可以通过 MAC-CE 向终端设备发送波束失败恢复请求响应。

可选的，网络设备可以通过 RRC 向终端设备发送波束失败恢复请求响应。

可选的，网络设备可以通过 PDSCH 向终端设备发送波束失败恢复请求响应。

步骤 S1104：终端设备在第四单元时间窗所包含的至少一个符号上，使用至少一个不同的波束接收网络设备发送的波束失败恢复请求响应。

终端设备可以在第四单元时间窗所包含的至少一个符号上，使用至少一个不同的波束接收网络设备发送的波束失败恢复请求响应。例如，若终端设备在第三单元时间窗所包含的至少一个符号上，分别使用波束 1 和波束 2 向网络设备发送波束失败恢复请求，则终端设备可以在第四单元时间窗所包含的至少一个符号上，分别使用波束 1 和波束 2 接收网络设备发送的波束失败恢复请求响应。

相对传统的波束恢复方法中终端设备接收波束失败恢复请求响应的接收时间与发送波束失败恢复请求的发送时间间隔至少两个子帧，本发明实施例中终端设备接收波束失败恢复请求响应的接收时间与发送波束失败恢复请求的发送时间间隔最多第一时间窗，例如 7 个符号，可降低延迟，提高波束恢复的效率。

在图 11 所描述的方法中，终端设备在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备发送波束失败恢复请求，网络设备在第二时间窗内，在接收到的波束失败恢复请求中确定一个波束失败恢复请求，网络设备在第二时间窗之后使用确定得到的波束失败恢复请求对应的波束，向终端设备发送波束失败恢复请求响应，终端设备在第四单元时间窗所包含的至少一个符号上，使用至少一个不同的波束接收网络设备发送的波束失败恢复请求响应，可实现网络设备针对同一终端设备发送的多个波束失败恢复请求的波束恢复处理，提高波束恢复效率。

上述详细阐述了本发明实施例的方法，下面提供了本发明实施例的装置。

请参见图 12，图 12 是本发明实施例提供的一种波束恢复装置的结构示意图，该波束恢复装置可以包括发送模块 1201 以及接收模块 1202，其中，各个模块的详细描述如下。

发送模块 1201，用于在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

接收模块 1202，用于在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

可选的，所述发送模块 1201，具体用于在所述第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

可选的，所述接收模块 1202，具体用于在所述第一时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

可选的，所述第一时间窗包括第一单元时间窗和第二单元时间窗，所述第二单元时间窗所包含的第一个符号为所述第一单元时间窗所包含的最后一个符号之后的第一个符号；

所述发送模块 1201，具体用于在所述第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

可选的，所述接收模块 1202，具体用于在所述第二单元时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

可选的，本发明实施例中的波束恢复装置还可以包括：

确定模块 1203，用于当在所述第一时间窗内未接收到所述用于波束恢复请求的响应时，所述波束恢复装置确定所述网络设备对所述波束恢复装置配置的第三时间窗；

所述发送模块 1201，还用于在所述第三时间窗所包含的至少一个符号上，使用至少一个相同的第二波束向所述网络设备发送所述用于恢复波束的请求。

可选的，所述第一时间窗包括第三单元时间窗和第四单元时间窗，所述第四单元时间窗所包含的第一个符号为所述第三单元时间窗所包含的最后一个符号之后的第一个符号；

所述发送模块 1201，具体用于在所述第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向所述网络设备发送所述用于恢复波束的请求。

可选的，所述接收模块 1202，具体用于在所述第四单元时间窗所包含的至少一个符号上，使用所述至少一个不同的波束接收所述用于波束恢复请求的响应。

可选的，所述发送模块 1201，具体用于基于所述网络设备对所述波束恢复装置配置的波束请求指示信息，在所述第一时间窗内使用所述至少一个波束向所述网络设备发送所述用于恢复波束的请求，所述波束请求指示信息用于指示所述用于恢复波束的请求的发送方式。

可选的，所述第一时间窗所包含的第一个符号为第一个配置有 RACH 资源的符号。

可选的，所述第一时间窗的长度是所述网络设备配置的。

可选的，所述第一时间窗所包含的符号的数量总和是根据所述网络设备对所述波束恢复装置配置的最大波束数量确定的。

需要说明的是，本发明实施例可具体参见图 3、5、6、8、9、11 所示实施例的相关描述，不再赘述。

本发明实施例中的波束恢复装置和方法实施例中的终端设备完全对应，由相应的模块执行相应的步骤，例如发送模块 1201 执行方法实施例中发送的步骤，接收模块 1202 执行方法实施例中接收的步骤，除发送接收外的其它步骤可以由确定模块 1203 或处理器执行。具体模块的功能可以参考相应的方法实施例，不再详述。

在图 12 所描述的波束恢复装置中，发送模块 1201 在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，接收模块 1202 在第一时间窗内使用至少一个波束接收网络设备发送的用于波束恢复请求的响应，可实现网络设备针对同一波束恢复装置发送的多个用于恢复波束的请求的波束恢复处理，提高波束恢复效率。

请参见图 13，图 13 是本发明实施例提供的一种终端设备，该终端设备包括处理器 1301、存储器 1302 以及收发器 1303，所述处理器 1301、存储器 1302 以及收发器 1303 通过总线相互连接。

存储器 1302 包括但不限于是随机存储记忆体（Random Access Memory，RAM）、只读

存储器（Read-Only Memory，ROM）、可擦除可编程只读存储器（Erasable Programmable Read Only Memory，EPROM）、或便携式只读存储器（Compact Disc Read-Only Memory，CD-ROM），该存储器 1302 用于存储相关指令及数据，例如用于恢复波束的请求等。收发器 1303 用于接收和发送数据，例如使用至少一个波束向网络设备发送用于恢复波束的请求，或者使用至少一个波束接收网络设备发送的用于波束恢复请求的响应等。存储器 1302 可以是一个单独的器件，也可以集成在处理器 1301 中。

处理器 1301 可以是一个或多个中央处理器（Central Processing Unit，CPU），或者一个或多个微控制单元（Microcontroller Unit，MCU）。在处理器 1301 是一个 CPU 的情况下，该 CPU 可以是单核 CPU，也可以是多核 CPU。其中，处理器 1301 可结合图 12 所示的波束恢复装置。

应理解，上述的收发器 1303 可以包括发射机和接收机。收发器 1303 还可以进一步包括天线，天线的数量可以为一个或多个。

上述的各个器件或部分器件可以集成到芯片中实现，如集成到基带芯片中实现。

该终端设备中的处理器 1301 用于读取所述存储器 1302 中存储的程序代码，执行以下操作：

通过收发器 1303 在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

通过收发器 1303 在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

可选的，处理器 1301 在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，具体可以为：

在所述第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

可选的，处理器 1301 在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，具体可以为：

在所述第一时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

可选的，所述第一时间窗包括第一单元时间窗和第二单元时间窗，所述第二单元时间窗所包含的第一个符号为所述第一单元时间窗所包含的最后一个符号之后的第一个符号；

处理器 1301 在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，具体可以为：

在所述第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

可选的，处理器 1301 在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，具体可以为：

在所述第二单元时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

可选的，处理器 1301 还可以执行以下操作：

当在所述第一时间窗内未接收到所述用于波束恢复请求的响应时，确定所述网络设备对所述终端设备配置的第三时间窗；

在所述第三时间窗所包含的至少一个符号上，使用至少一个相同的第二波束向所述网络设备发送所述用于恢复波束的请求。

可选的，所述第一时间窗包括第三单元时间窗和第四单元时间窗，所述第四单元时间窗所包含的第一个符号为所述第三单元时间窗所包含的最后一个符号之后的第一个符号；

处理器 1301 在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，具体可以为：

在所述第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向所述网络设备发送所述用于恢复波束的请求。

可选的，处理器 1301 在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，具体可以为：

在所述第四单元时间窗所包含的至少一个符号上，使用所述至少一个不同的波束接收所述用于波束恢复请求的响应。

可选的，处理器 1301 在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，具体可以为：

基于所述网络设备对所述终端设备配置的波束请求指示信息，在所述第一时间窗内使用所述至少一个波束向所述网络设备发送所述用于恢复波束的请求，所述波束请求指示信息用于指示所述用于恢复波束的请求的发送方式。

可选的，所述第一时间窗所包含的第一个符号为第一个配置有 RACH 资源的符号。

可选的，所述第一时间窗的长度是所述网络设备配置的。

可选的，所述第一时间窗所包含的符号的数量总和是根据所述网络设备对所述终端设备配置的最大波束数量确定的。

需要说明的是，本发明实施例可具体参见图 3、5、6、8、9、11 所示实施例的相关描述，不再赘述。

在图 13 所描述的终端设备中，处理器 1301 在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，并在第一时间窗内使用至少一个波束接收网络设备发送的用于波束恢复请求的响应，可实现网络设备针对同一终端设备发送的多个用于恢复波束的请求的波束恢复处理，提高波束恢复效率。

请参见图 14，图 14 是本发明实施例提供的一种波束恢复装置的结构示意图，该波束恢复装置可以包括接收模块 1401、确定模块 1402 以及发送模块 1403，其中，各个模块的详细描述如下。

接收模块 1401，用于接收终端设备在第一时间窗内使用至少一个波束发送的用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

确定模块 1402，用于在第二时间窗内，在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求；

发送模块 1403，用于使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

可选的，所述确定模块 1402，具体用于响应在所述第二时间窗内接收到的质量最好的波束所承载的用于恢复波束的请求，所述第二时间窗所包含的第一个符号与所述第一时间窗所包含的第一个符号相同。

可选的，所述确定模块 1402，具体用于响应在所述第二时间窗内接收到的第一个用于恢复波束的请求。

可选的，所述发送模块 1403，具体用于在所述第二时间窗内使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应。

可选的，所述发送模块 1403，具体用于在所述第二时间窗之外使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应。

需要说明的是，本发明实施例可具体参见图 3、5、6、8、9、11 所示实施例的相关描述，不再赘述。

本发明实施例中的波束恢复装置和方法实施例中的终端设备完全对应，由相应的模块执行相应的步骤，例如发送模块 1403 执行方法实施例中发送的步骤，接收模块 1401 执行方法实施例中接收的步骤，除发送接收外的其它步骤可以由确定模块 1402 或处理器执行。具体模块的功能可以参考相应的方法实施例，不再详述。

在图 14 所描述的波束恢复装置中，接收模块 1401 接收终端设备在第一时间窗内使用至少一个波束发送的用于恢复波束的请求，确定模块 1402 在第二时间窗内，在接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，发送模块 1403 使用确定得到的用于恢复波束的请求对应的波束，向终端设备发送用于波束恢复请求的响应，可实现网络设备针对同一波束恢复装置发送的多个用于恢复波束的请求的波束恢复处理，提高波束恢复效率。

请参见图 15，图 15 是本发明实施例提供的一种网络设备，该网络设备包括处理器 1501、存储器 1502 以及收发器 1503，所述处理器 1501、存储器 1502 以及收发器 1503 通过总线相互连接。

存储器 1502 包括但不限于是 RAM、ROM、EPROM、或 CD-ROM，该存储器 1502 用于存储相关指令及数据，例如用于恢复波束的请求等。收发器 1503 用于接收和发送数据，例如接收终端设备使用至少一个波束发送的用于恢复波束的请求，或者使用确定得到的用于恢复波束的请求对应的波束，向终端设备发送用于波束恢复请求的响应等。存储器 1502 可以是一个单独的器件，也可以集成在处理器 1501 中。

处理器 1501 可以是一个或多个 CPU，或者一个或多个 MCU。在处理器 1501 是一个 CPU 的情况下，该 CPU 可以是单核 CPU，也可以是多核 CPU。其中，处理器 1501 可结合图 14 所示的波束恢复装置。

应理解，上述的收发器 1503 可以包括发射机和接收机。收发器 1503 还可以进一步包括天线，天线的数量可以为一个或多个。

该网络设备中的处理器 1501 用于读取所述存储器 1502 中存储的程序代码，执行以下

操作：

通过收发器 1503 接收终端设备在第一时间窗内使用至少一个波束发送的用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

在第二时间窗内，在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求；

通过收发器 1503 使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

可选的，处理器 1501 在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，具体可以为：

响应在所述第二时间窗内接收到的质量最好的波束所承载的用于恢复波束的请求，所述第二时间窗所包含的第一个符号与所述第一时间窗所包含的第一个符号相同。

可选的，处理器 1501 在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，具体可以为：

响应在所述第二时间窗内接收到的第一个用于恢复波束的请求。

可选的，处理器 1501 使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，具体可以为：

在所述第二时间窗内使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应。

可选的，处理器 1501 使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，具体可以为：

在所述第二时间窗之外使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应。

在图 15 所描述的网络设备中，处理器 1501 接收终端设备在第一时间窗内使用至少一个波束发送的用于恢复波束的请求，在第二时间窗内，在接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，并使用确定得到的用于恢复波束的请求对应的波束，向终端设备发送用于波束恢复请求的响应，可实现网络设备针对同一终端设备发送的多个用于恢复波束的请求的波束恢复处理，提高波束恢复效率。

请参见图 16，图 16 是本发明实施例提供的一种波束恢复系统，该波束恢复系统可以包括图 13 所示的终端设备 1601 和图 15 所示的网络设备 1602，具体可以参见图 15、16 的描述，本发明实施例不再赘述。

本申请实施例还提供了一种通信芯片，其中存储有指令，当其在终端设备 1601 上运行时，使得所述通信芯片执行上述图 13 中的各种实现方式中终端设备对应的方法。

本申请实施例还提供了一种通信芯片，其中存储有指令，当其在网络设备 1602 上运行时，使得所述通信芯片执行上述图 15 中的各种实现方式中终端设备对应的方法。

上述各个方案的网络设备及终端设备具有实现上述方法中网络设备及终端设备执行的相应步骤的功能；所述功能可以通过硬件实现，也可以通过硬件执行相应的软件实现。所

述硬件或软件包括一个或多个与上述功能相对应的模块；例如发送模块可以由发射机替代，接收模块可以由接收机替代，其它模块，如处理模块等可以由处理器替代，分别执行各个方法实施例中的发送操作、接收操作以及相关的处理操作。

本领域普通技术人员可以理解实现上述实施例方法中的全部或部分流程，该流程可以由计算机程序来指令相关的硬件完成，该程序可存储于计算机可读取存储介质中，该程序在执行时，可包括如上述各方法实施例的流程。而前述的存储介质包括：ROM 或随机存储记忆体 RAM、磁碟或者光盘等各种可存储程序代码的介质。

在上述实施例中，可以全部或部分地通过软件、硬件、固件或者其任意组合来实现。当使用软件实现时，可以全部或部分地以计算机程序产品的形式实现。所述计算机程序产品包括一个或多个计算机指令。在计算机上加载和执行所述计算机程序指令时，全部或部分地产生按照本申请实施例所述的流程或功能。所述计算机可以是通用计算机、专用计算机、计算机网络、或者其他可编程装置。所述计算机指令可以存储在计算机可读存储介质中，或者从一个计算机可读存储介质向另一个计算机可读存储介质传输，例如，所述计算机指令可以从一个网站站点、计算机、服务器或数据中心通过有线（例如同轴电缆、光纤、数字用户线（DSL））或无线（例如红外、无线、微波等）方式向另一个网站站点、计算机、服务器或数据中心进行传输。所述计算机可读存储介质可以是计算机能够存取的任何可用介质或者是包含一个或多个可用介质集成的服务器、数据中心等数据存储设备。所述可用介质可以是磁性介质，(例如，软盘、硬盘、磁带)、光介质(例如，DVD)、或者半导体介质（例如固态硬盘 Solid State Disk (SSD)）等。

权 利 要 求

1、一种波束恢复方法，其特征在于，所述方法包括：

终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

所述终端设备在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

2、如权利要求 1 所述的方法，其特征在于，所述终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，包括：

所述终端设备在所述第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

3、如权利要求 2 所述的方法，其特征在于，所述终端设备在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，包括：

所述终端设备在所述第一时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

4、如权利要求 1 所述的方法，其特征在于，所述第一时间窗包括第一单元时间窗和第二单元时间窗，所述第二单元时间窗所包含的第一个符号为所述第一单元时间窗所包含的最后一个符号之后的第一个符号；

所述终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，包括：

所述终端设备在所述第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

5、如权利要求 4 所述的方法，其特征在于，所述终端设备在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，包括：

所述终端设备在所述第二单元时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

6、如权利要求 2~5 任一项所述的方法，其特征在于，所述方法还包括：

当在所述第一时间窗内未接收到所述用于波束恢复请求的响应时，所述终端设备确定所述网络设备对所述终端设备配置的第三时间窗；

所述终端设备在所述第三时间窗所包含的至少一个符号上，使用至少一个相同的第二波束向所述网络设备发送所述用于恢复波束的请求。

7、如权利要求 1 所述的方法，其特征在于，所述第一时间窗包括第三单元时间窗和第四单元时间窗，所述第四单元时间窗所包含的第一个符号为所述第三单元时间窗所包含的最后一个符号之后的第一个符号；

所述终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，包括：

所述终端设备在所述第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向所述网络设备发送所述用于恢复波束的请求。

8、如权利要求 7 所述的方法，其特征在于，所述终端设备在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，包括：

所述终端设备在所述第四单元时间窗所包含的至少一个符号上，使用所述至少一个不同的波束接收所述用于波束恢复请求的响应。

9、如权利要求 1~8 任一项所述的方法，其特征在于，所述终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，包括：

所述终端设备基于所述网络设备对所述终端设备配置的波束请求指示信息，在所述第一时间窗内使用所述至少一个波束向所述网络设备发送所述用于恢复波束的请求，所述波束请求指示信息用于指示所述用于恢复波束的请求的发送方式。

10、一种波束恢复方法，其特征在于，所述方法包括：

网络设备接收终端设备在第一时间窗内使用至少一个波束发送的用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

所述网络设备在第二时间窗内，在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求；

所述网络设备使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

11、如权利要求 10 所述的方法，其特征在于，所述网络设备在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，包括：

所述网络设备响应在所述第二时间窗内接收到的质量最好的波束所承载的用于恢复波束的请求，所述第二时间窗所包含的第一个符号与所述第一时间窗所包含的第一个符号相同。

12、如权利要求 10 所述的方法，其特征在于，所述网络设备在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，包括：

所述网络设备响应在所述第二时间窗内接收到的第一个用于恢复波束的请求。

13、如权利要求 10~12 任一项所述的方法，其特征在于，所述网络设备使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，包括：

所述网络设备在所述第二时间窗内使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应。

14、如权利要求 10~12 任一项所述的方法，其特征在于，所述网络设备使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，包括：

所述网络设备在所述第二时间窗之外使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应。

15、一种波束恢复装置，其特征在于，所述装置包括：

发送模块，用于在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

接收模块，用于在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

16、如权利要求 15 所述的装置，其特征在于，所述发送模块，具体用于：

在所述第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

17、如权利要求 16 所述的装置，其特征在于，

所述接收模块，具体用于在所述第一时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

18、如权利要求 15 所述的装置，其特征在于，所述第一时间窗包括第一单元时间窗和第二单元时间窗，所述第二单元时间窗所包含的第一个符号为所述第一单元时间窗所包含的最后一个符号之后的第一个符号；

所述发送模块，具体用于在所述第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

19、如权利要求 18 所述的装置，其特征在于，

所述接收模块，具体用于在所述第二单元时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

20、如权利要求 16~19 任一项所述的装置，其特征在于，所述装置还包括：

确定模块，用于当在所述第一时间窗内未接收到所述用于波束恢复请求的响应时，所述终端设备确定所述网络设备对所述终端设备配置的第三时间窗；

所述发送模块，还用于在所述第三时间窗所包含的至少一个符号上，使用至少一个相同的第二波束向所述网络设备发送所述用于恢复波束的请求。

21、如权利要求 15 所述的装置，其特征在于，所述第一时间窗包括第三单元时间窗和第四单元时间窗，所述第四单元时间窗所包含的第一个符号为所述第三单元时间窗所包含的最后一个符号之后的第一个符号；

所述发送模块，具体用于在所述第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向所述网络设备发送所述用于恢复波束的请求。

22、如权利要求 21 所述的装置，其特征在于，

所述接收模块，具体用于在所述第四单元时间窗所包含的至少一个符号上，使用所述至少一个不同的波束接收所述用于波束恢复请求的响应。

23、如权利要求 15~22 任一项所述的装置，其特征在于，

所述发送模块，具体用于基于所述网络设备对所述终端设备配置的波束请求指示信息，在所述第一时间窗内使用所述至少一个波束向所述网络设备发送所述用于恢复波束的请求，所述波束请求指示信息用于指示所述用于恢复波束的请求的发送方式。

24、一种波束恢复装置，其特征在于，所述装置包括：

接收模块，用于接收终端设备在第一时间窗内使用至少一个波束发送的用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

确定模块，用于在第二时间窗内，在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求；

发送模块，用于使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

25、如权利要求 24 所述的装置，其特征在于，

所述确定模块，具体用于响应在所述第二时间窗内接收到的质量最好的波束所承载的用于恢复波束的请求，所述第二时间窗所包含的第一个符号与所述第一时间窗所包含的第一个符号相同。

26、如权利要求 24 所述的装置，其特征在于，

所述确定模块，具体用于响应在所述第二时间窗内接收到的第一个用于恢复波束的请求。

27、如权利要求 24~26 任一项所述的装置，其特征在于，

所述发送模块，具体用于在所述第二时间窗内使用确定得到的用于恢复波束的请求对

应的波束，向所述终端设备发送用于波束恢复请求的响应。

28、如权利要求 24~26 任一项所述的装置，其特征在于，

所述发送模块，具体用于在所述第二时间窗之外使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应。

经修改的权利要求
国际局收到日：2018年08月17日（17.08.2018）

1、一种波束恢复方法，其特征在于，所述方法包括：

终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

所述终端设备在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

2、如权利要求 1 所述的方法，其特征在于，所述终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，包括：

所述终端设备在所述第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

3、如权利要求 2 所述的方法，其特征在于，所述终端设备在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，包括：

所述终端设备在所述第一时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

4、如权利要求 1 所述的方法，其特征在于，所述第一时间窗包括第一单元时间窗和第二单元时间窗，所述第二单元时间窗所包含的第一个符号为所述第一单元时间窗所包含的最后一个符号之后的第一个符号；

所述终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，包括：

所述终端设备在所述第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

5、如权利要求 4 所述的方法，其特征在于，所述终端设备在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，包括：

所述终端设备在所述第二单元时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

6、如权利要求 2~5 任一项所述的方法，其特征在于，所述方法还包括：

当在所述第一时间窗内未接收到所述用于波束恢复请求的响应时，所述终端设备确定所述网络设备对所述终端设备配置的第三时间窗；

所述终端设备在所述第三时间窗所包含的至少一个符号上，使用至少一个相同的第二波束向所述网络设备发送所述用于恢复波束的请求。

7、如权利要求 1 所述的方法，其特征在于，所述第一时间窗包括第三单元时间窗和第四单元时间窗，所述第四单元时间窗所包含的第一个符号为所述第三单元时间窗所包含的最后一个符号之后的第一个符号；

所述终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，包括：

所述终端设备在所述第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向所述网络设备发送所述用于恢复波束的请求。

8、如权利要求 7 所述的方法，其特征在于，所述终端设备在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，包括：

所述终端设备在所述第四单元时间窗所包含的至少一个符号上，使用所述至少一个不同的波束接收所述用于波束恢复请求的响应。

9、如权利要求 1~8 任一项所述的方法，其特征在于，所述终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，包括：

所述终端设备基于所述网络设备对所述终端设备配置的波束请求指示信息，在所述第一时间窗内使用所述至少一个波束向所述网络设备发送所述用于恢复波束的请求，所述波束请求指示信息用于指示所述用于恢复波束的请求的发送方式。

10、一种波束恢复方法，其特征在于，所述方法包括：

网络设备接收终端设备在第一时间窗内使用至少一个波束发送的用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

所述网络设备在第二时间窗内，在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求；

所述网络设备使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

11、如权利要求 10 所述的方法，其特征在于，所述网络设备在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，包括：

所述网络设备响应在所述第二时间窗内接收到的质量最好的波束所承载的用于恢复波束的请求，所述第二时间窗所包含的第一个符号与所述第一时间窗所包含的第一个符号相同。

12、如权利要求 10 所述的方法，其特征在于，所述网络设备在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，包括：

所述网络设备响应在所述第二时间窗内接收到的第一个用于恢复波束的请求。

13、如权利要求 10~12 任一项所述的方法，其特征在于，所述网络设备使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，包括：

所述网络设备在所述第二时间窗内使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应。

14、如权利要求 10~12 任一项所述的方法，其特征在于，所述网络设备使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，包括：

所述网络设备在所述第二时间窗之外使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应。

15、一种波束恢复装置，其特征在于，所述装置包括：

发送模块，用于在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

接收模块，用于在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

16、如权利要求 15 所述的装置，其特征在于，所述发送模块，具体用于：

在所述第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

17、如权利要求 16 所述的装置，其特征在于，

所述接收模块，具体用于在所述第一时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

18、如权利要求 15 所述的装置，其特征在于，所述第一时间窗包括第一单元时间窗和第二单元时间窗，所述第二单元时间窗所包含的第一个符号为所述第一单元时间窗所包含的最后一个符号之后的第一个符号；

所述发送模块，具体用于在所述第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

19、如权利要求 18 所述的装置，其特征在于，

所述接收模块，具体用于在所述第二单元时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

20、如权利要求 16~19 任一项所述的装置，其特征在于，所述装置还包括：

确定模块，用于当在所述第一时间窗内未接收到所述用于波束恢复请求的响应时，所述终端设备确定所述网络设备对所述终端设备配置的第三时间窗；

所述发送模块，还用于在所述第三时间窗所包含的至少一个符号上，使用至少一个相同的第二波束向所述网络设备发送所述用于恢复波束的请求。

21、如权利要求 15 所述的装置，其特征在于，所述第一时间窗包括第三单元时间窗和第四单元时间窗，所述第四单元时间窗所包含的第一个符号为所述第三单元时间窗所包含的最后一个符号之后的第一个符号；

所述发送模块，具体用于在所述第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向所述网络设备发送所述用于恢复波束的请求。

22、如权利要求 21 所述的装置，其特征在于，

所述接收模块，具体用于在所述第四单元时间窗所包含的至少一个符号上，使用所述至少一个不同的波束接收所述用于波束恢复请求的响应。

23、如权利要求 15~22 任一项所述的装置，其特征在于，

所述发送模块，具体用于基于所述网络设备对所述终端设备配置的波束请求指示信息，在所述第一时间窗内使用所述至少一个波束向所述网络设备发送所述用于恢复波束的请求，所述波束请求指示信息用于指示所述用于恢复波束的请求的发送方式。

24、一种波束恢复装置，其特征在于，所述装置包括：

接收模块，用于接收终端设备在第一时间窗内使用至少一个波束发送的用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

确定模块，用于在第二时间窗内，在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求；

发送模块，用于使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

25、如权利要求 24 所述的装置，其特征在于，

所述确定模块，具体用于响应在所述第二时间窗内接收到的质量最好的波束所承载的用于恢复波束的请求，所述第二时间窗所包含的第一个符号与所述第一时间窗所包含的第一个符号相同。

26、如权利要求 24 所述的装置，其特征在于，

所述确定模块，具体用于响应在所述第二时间窗内接收到的第一个用于恢复波束的请求。

27、如权利要求 24~26 任一项所述的装置，其特征在于，

所述发送模块，具体用于在所述第二时间窗内使用确定得到的用于恢复波束的请求对

应的波束，向所述终端设备发送用于波束恢复请求的响应。

28、如权利要求 24~26 任一项所述的装置，其特征在于，

所述发送模块，具体用于在所述第二时间窗之外使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应。

29、如权利要求 1 至 9 任一项所述的方法，其特征在于，所述用于恢复波束的请求通过随机接入信道 RACH 资源发送。

30、如权利要求 1 至 9 任一项所述的方法，其特征在于，所述用于波束恢复请求的响应通过物理下行控制信道 PDCCH 发送，所述 PDCCH 的循环冗余校验 CRC 由小区无线网络临时标识 C-RNTI 加扰。

31、如权利要求 4 或 5 所述的方法，其特征在于，所述第一单元时间窗的起始时刻是配置有 RACH 资源的第一个符号。

32、如权利要求 1 至 9 任一项所述的方法，其特征在于，该方法之前还包括：终端设备获取网络设备配置的用于发送恢复波束的请求时所使用的最大波束数量。

33、如权利要求 10 至 14 任一项所述的方法，其特征在于，该方法之前还包括：网络设备为终端设备配置用于发送恢复波束的请求时所使用的最大波束数量。

34、如权利要求 10 至 14 任一项所述的方法，其特征在于，所述用于恢复波束的请求通过随机接入信道 RACH 资源发送。

35、如权利要求 10 至 14 任一项所述的方法，其特征在于，所述用于波束恢复请求的响应通过物理下行控制信道 PDCCH 发送，所述 PDCCH 的循环冗余校验 CRC 由小区无线网络临时标识 C-RNTI 加扰。

36、如权利要求 15 至 23 任一项所述的装置，其特征在于，所述用于恢复波束的请求通过随机接入信道 RACH 资源发送。

37、如权利要求 15 至 23 任一项所述的装置，其特征在于，所述用于波束恢复请求的响应通过物理下行控制信道 PDCCH 发送，所述 PDCCH 的循环冗余校验 CRC 由小区无线网络临时标识 C-RNTI 加扰。

38、如权利要求 18 或 19 所述的装置，其特征在于，所述第一单元时间窗的起始时刻是配置有 RACH 资源的第一个符号。

39、如权利要求 15 至 13 任一项所述的装置，其特征在于，所述接收模块还用于：获取网络设备配置的用于发送恢复波束的请求时所使用的最大波束数量。

40、如权利要求 24 至 28 任一项所述的装置，其特征在于，所述确定模块还用于：为终端设备配置用于发送恢复波束的请求时所使用的最大波束数量。

41、如权利要求 24 至 28 任一项所述的装置，其特征在于，所述用于恢复波束的请求通过随机接入信道 RACH 资源发送。

42、如权利要求 24 至 28 任一项所述的装置，其特征在于，所述用于波束恢复请求的响应通过物理下行控制信道 PDCCH 发送，所述 PDCCH 的循环冗余校验 CRC 由小区无线网络临时标识 C-RNTI 加扰。

43、一种波束恢复装置，其特征在于，包括：存储器和处理器；所述处理器被配置为支持所述装置执行如权利要求 1 至 9 或 29-32 任一项所述的方法的功能，所述存储器用于保存所述装置的程序和数据。

44、一种波束恢复装置，其特征在于，包括：存储器和处理器；所述处理器被配置为支持所述装置执行如权利要求 10 至 14 或 33-35 任一项所述的方法的功能，所述存储器用于保存所述装置的程序和数据。

45、一种芯片系统，其特征在于，包括：处理器，所述处理器被配置为支持终端设备执行如权利要求 1 至 9 或 29-32 任一项所述的方法的功能。

46、如权利要求 45 所述的芯片系统，其特征在于，所述芯片系统还包括存储器，所述存储器用于保存所述终端设备的程序指令和数据。

47、一种芯片系统，其特征在于，包括：处理器，所述处理器被配置为支持网络设备执行如权利要求 10 至 14 或 33-35 任一项所述的方法的功能。

48、如权利要求 47 所述的芯片系统，其特征在于，所述芯片系统还包括存储器，所述存储器用于保存所述网络设备的程序指令和数据。

49、一种计算机存储介质，其特征在于，用于存储计算机程序，当所述计算机程序在终端设备上运行时，使得所述终端设备执行如权利要求 1 至 9 或 29-32 任一项所述的方法。

50、一种计算机存储介质，其特征在于，用于存储计算机程序，当所述计算机程序在

网络设备上运行时，使得所述网络设备执行如权利要求 10 至 14 或 33-35 任一项所述的方法。

51、一种计算机程序产品，其特征在于，当所述计算机程序产品在终端设备上运行时，使得所述终端设备执行如权利要求 1 至 9 或 29-32 任一项所述的方法。

52、一种计算机程序产品，其特征在于，当所述计算机程序产品在网络设备上运行时，使得所述网络设备执行如权利要求 10 至 14 或 33-35 任一项所述的方法。

53、一种波束恢复系统，其特征在于，所述波束恢复系统包括如权利要求 43 所述的波束恢复装置和如权利要求 44 所述的波束恢复装置。

54、一种波束恢复装置，用于实现如权利要求 1 至 9 或 29-32 任一项所述的方法步骤。

55、一种波束恢复装置，用于实现如权利要求 10 至 14 或 33-35 任一项所述的方法步骤。

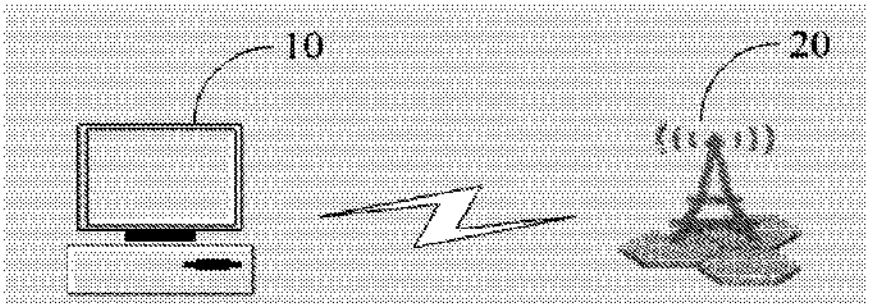

10
20

图 1

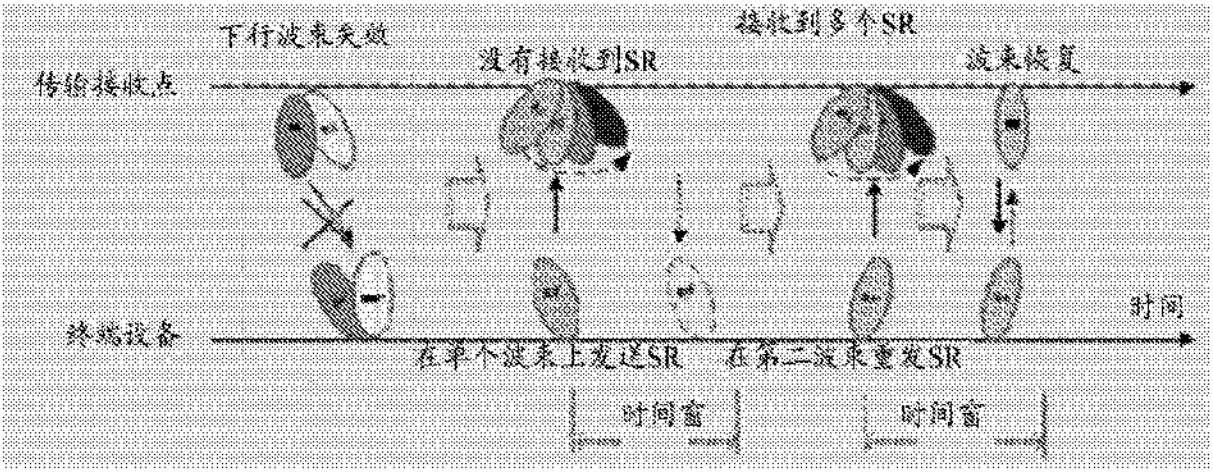

下行波束失效
接收到多个SR
传输接收点
没有接收到SR
波束恢复
时间
终端设备
在单个波束上发送SR
在第二波束重发SR
时间窗
时间窗

图 2A

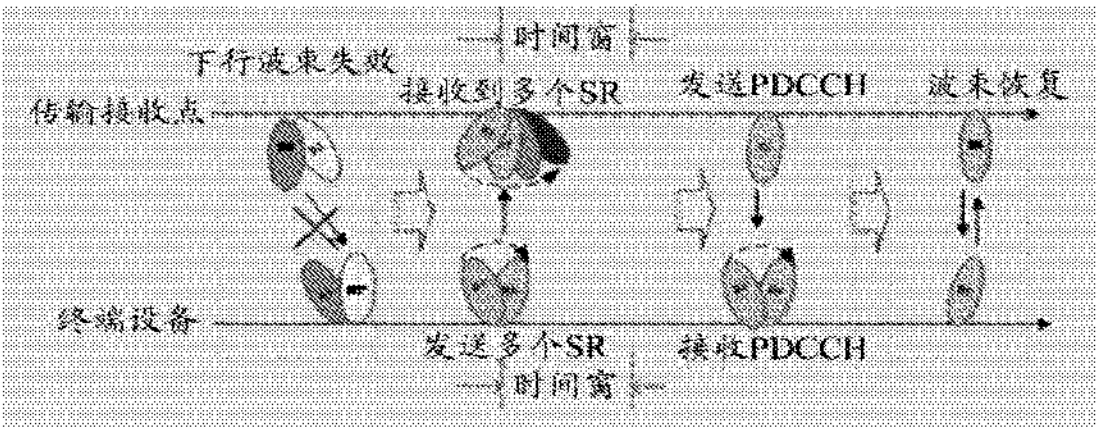

时间窗
下行波束失效
接收到多个SR
发送PDCCH
波束恢复
传输接收点
终端设备
发送多个SR
接收PDCCH
时间窗

图 2B

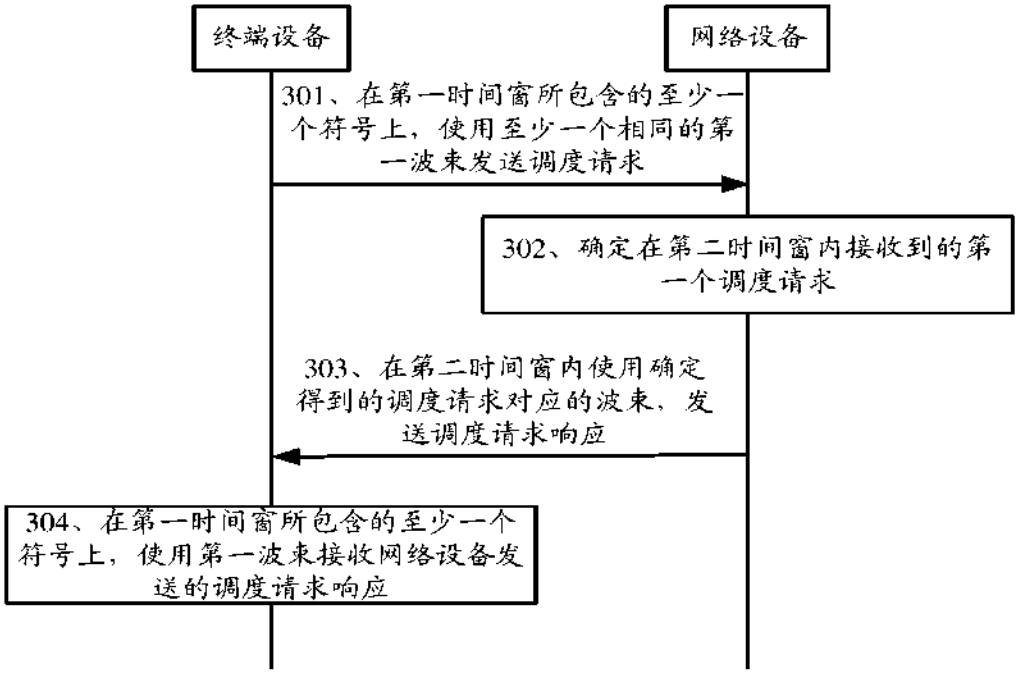

终端设备
网络设备
301、在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束发送调度请求
302、确定在第二时间窗内接收到的第一个调度请求
303、在第二时间窗内使用确定得到的调度请求对应的波束，发送调度请求响应
304、在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备发送的调度请求响应

图 3

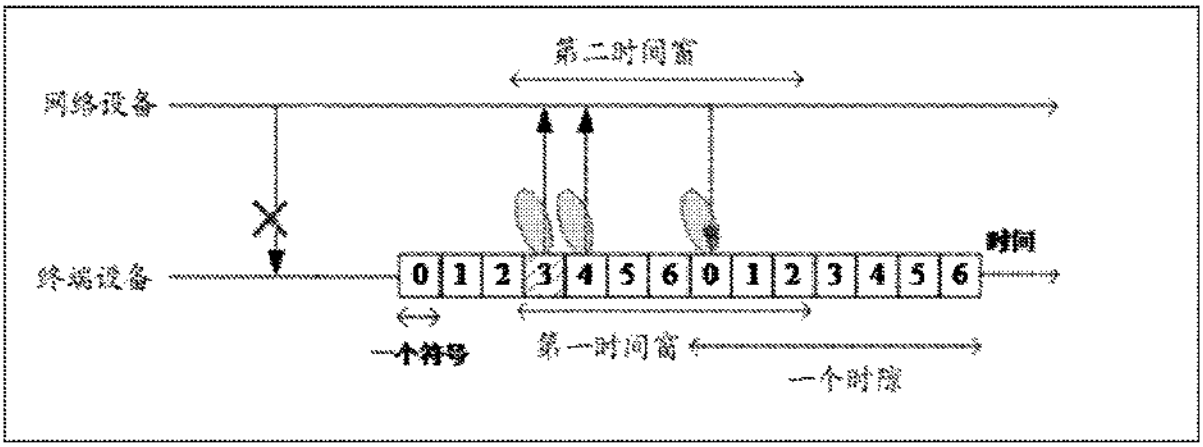

第二时间窗
网络设备
终端设备
时间
0 1 2 3 4 5 6 0 1 2 3 4 5 6
一个符号
第一时间窗
一个时隙

图 4

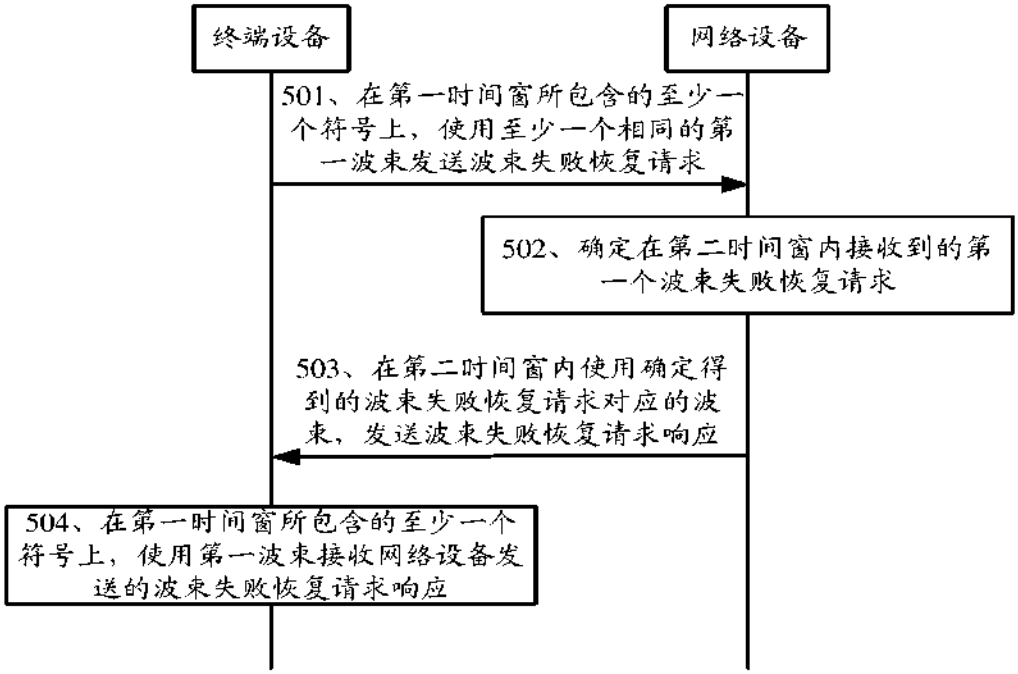

终端设备
网络设备
501、在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束发送波束失败恢复请求
502、确定在第二时间窗内接收到的第一个波束失败恢复请求
503、在第二时间窗内使用确定得到的波束失败恢复请求对应的波束，发送波束失败恢复请求响应
504、在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备发送的波束失败恢复请求响应

图 5

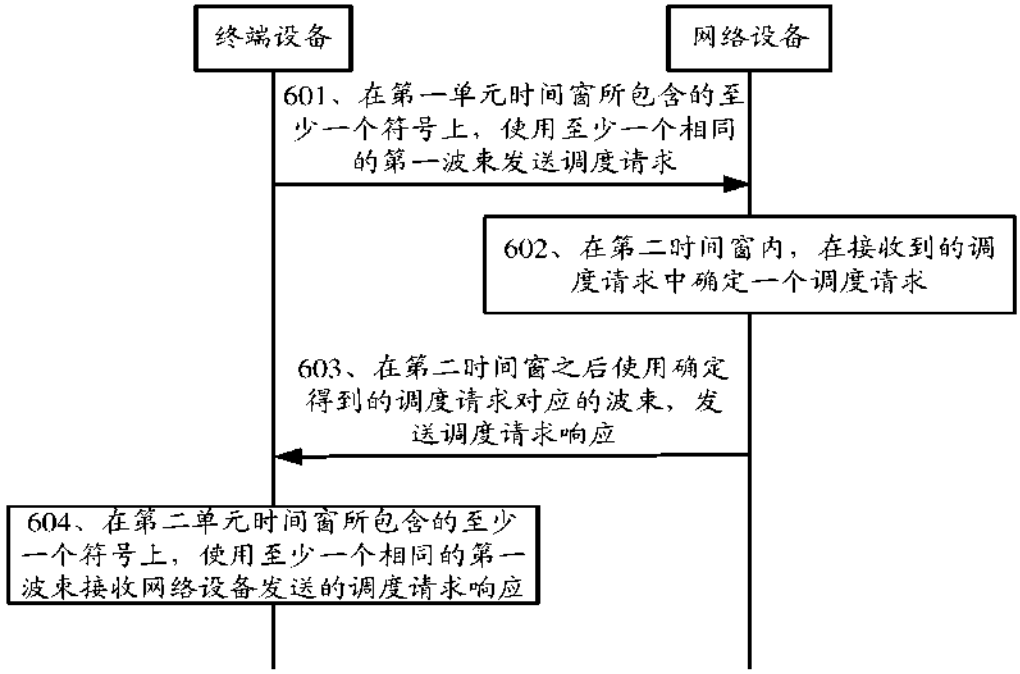

终端设备
网络设备
601、在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束发送调度请求
602、在第二时间窗内，在接收到的调度请求中确定一个调度请求
603、在第二时间窗之后使用确定得到的调度请求对应的波束，发送调度请求响应
604、在第二单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束接收网络设备发送的调度请求响应

图 6

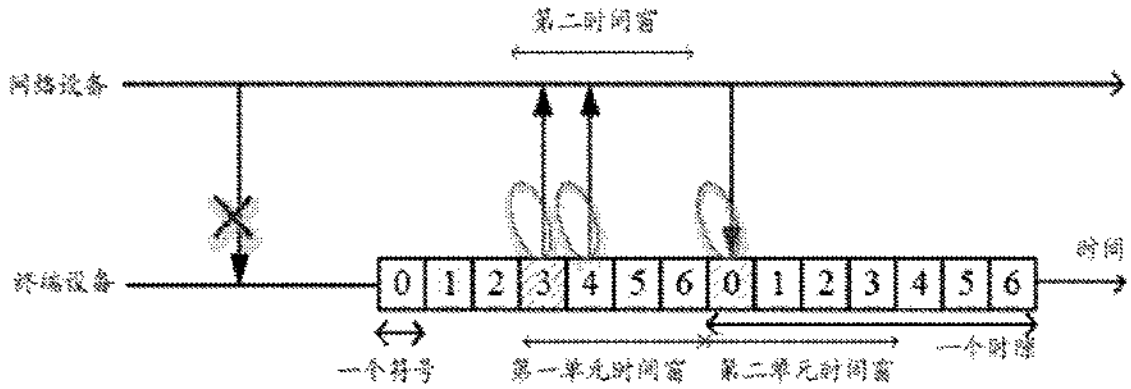

第二时间窗
网络设备
终端设备
0 1 2 3 4 5 6 0 1 2 3 4 5 6
时间
一个符号
第一单元时间窗
第二单元时间窗
一个时隙

图 7

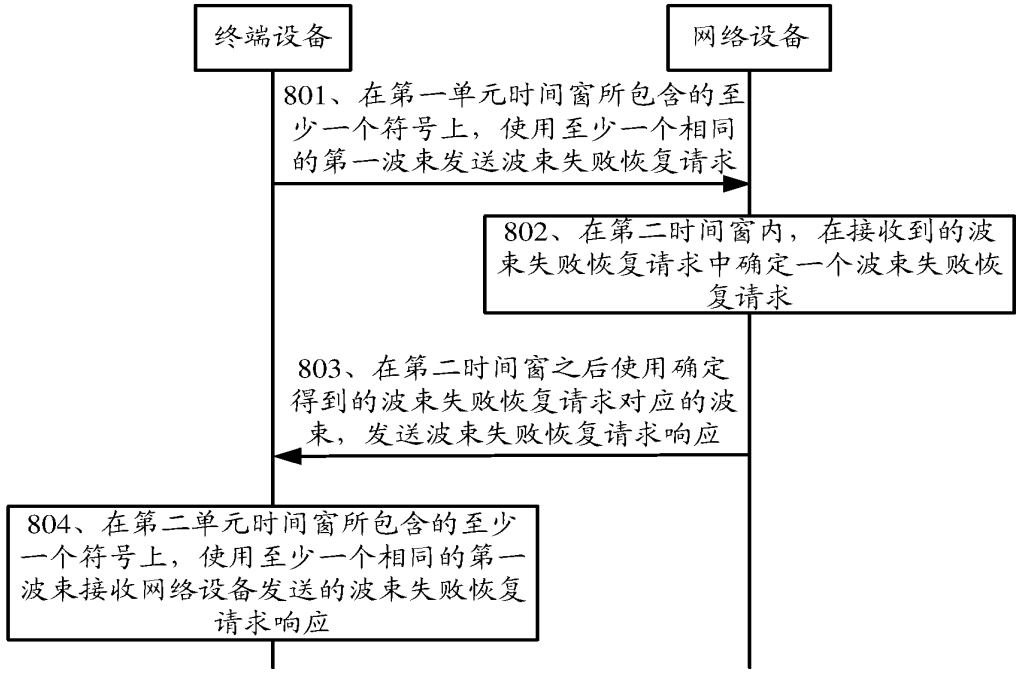

终端设备
网络设备
801、在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束发送波束失败恢复请求
802、在第二时间窗内，在接收到的波束失败恢复请求中确定一个波束失败恢复请求
803、在第二时间窗之后使用确定得到的波束失败恢复请求对应的波束，发送波束失败恢复请求响应
804、在第二单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束接收网络设备发送的波束失败恢复请求响应

图 8

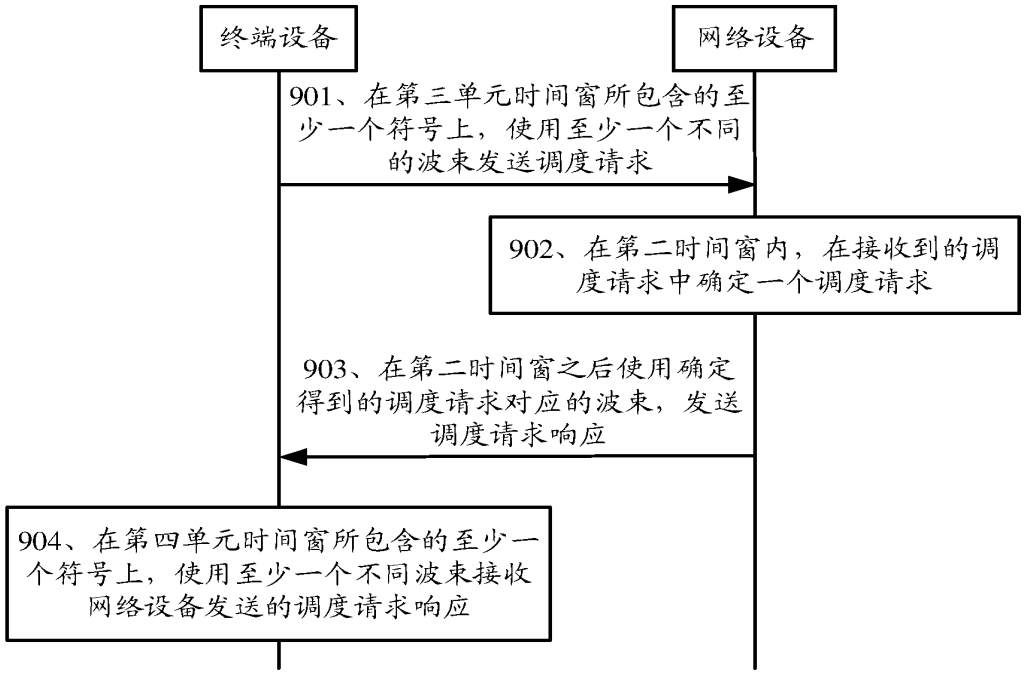

终端设备
网络设备
901、在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束发送调度请求
902、在第二时间窗内，在接收到的调度请求中确定一个调度请求
903、在第二时间窗之后使用确定得到的调度请求对应的波束，发送调度请求响应
904、在第四单元时间窗所包含的至少一个符号上，使用至少一个不同波束接收网络设备发送的调度请求响应

图 9

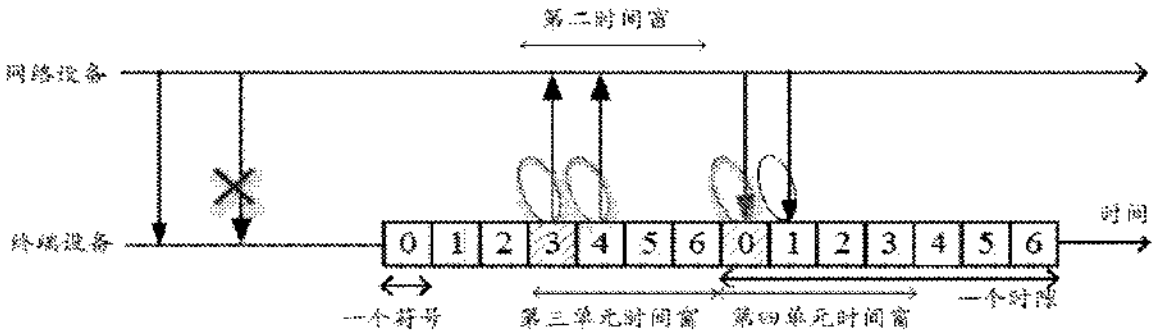

第二时间窗
网络设备
终端设备
时间
0 1 2 3 4 5 6 0 1 2 3 4 5 6
一个符号
第三单元时间窗
第四单元时间窗
一个时隙

图 10

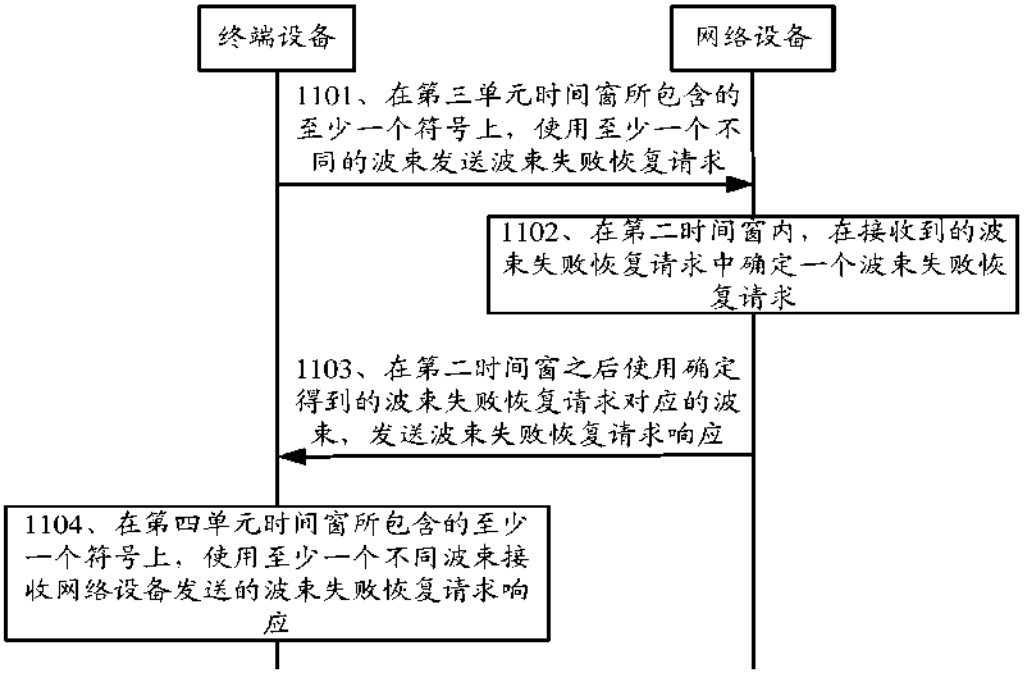

终端设备
网络设备
1101、在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束发送波束失败恢复请求
1102、在第二时间窗内，在接收到的波束失败恢复请求中确定一个波束失败恢复请求
1103、在第二时间窗之后使用确定得到的波束失败恢复请求对应的波束，发送波束失败恢复请求响应
1104、在第四单元时间窗所包含的至少一个符号上，使用至少一个不同波束接收网络设备发送的波束失败恢复请求响应

图 11

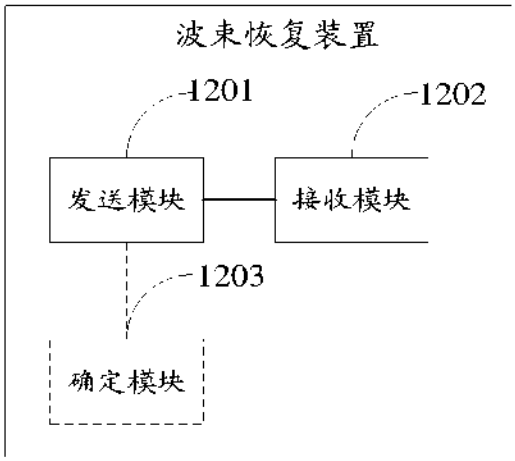

波束恢复装置
1201
1202
发送模块
接收模块
1203
确定模块

图 12

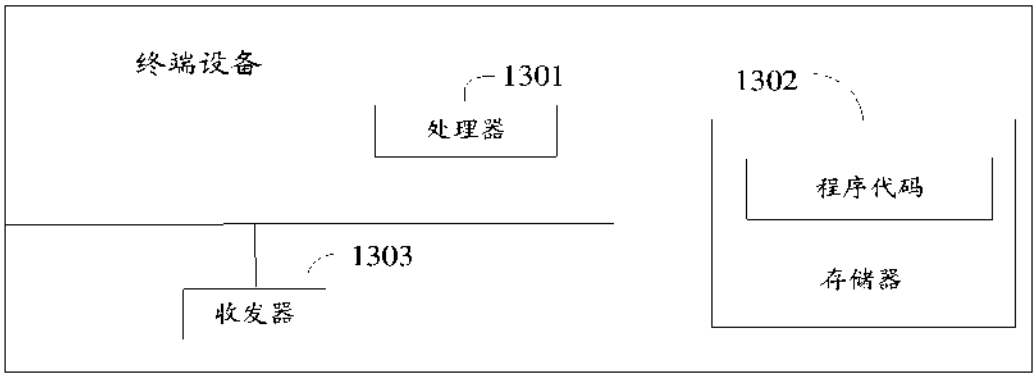


图 13

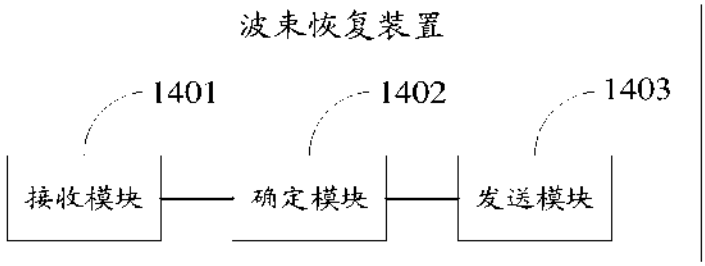


图 14

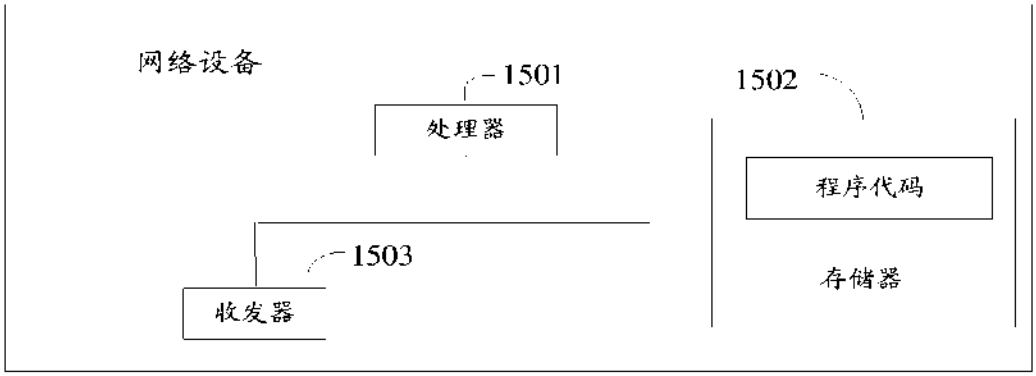


图 15

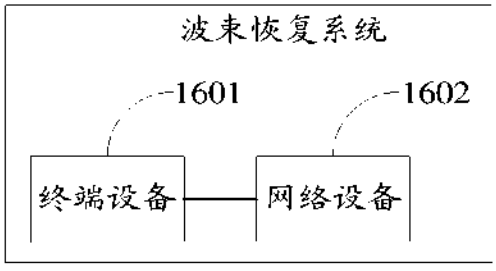


图 16

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2018/085733

A. CLASSIFICATION OF SUBJECT MATTER

H04B 7/0408 (2017.01) i; H04W 72/04 (2009.01) i; H04L 5/00 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04B, H04W, H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNABS; CNTXT; CNKI; VEN; USTXT; WOTXT; EPTXT; XP3GPP: 波束, 恢复, 时间窗, 调度请求, 响应; beam, recover, time 1w window, scheduling 1w request, SR, response

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	QUALCOMM INCORPORATED, Beam Recovery Request, 3GPP TSG-RAN WG 2 Meeting #97bis, R2-1703562, 07 April 2017 (07.04.2017), sections 1-2	1-28
Y	QUALCOM INCORPORATED, Beam Management, 3GPP TSG-RAN WG 2 Meeting #97bis, R2-1703564, 07 April 2017 (07.04.2017), sections 2.1-2.2	1-28
A	INTEL CORPORATION, Radio Link Monitoring, Beam Failure and Radio Link Failure, 3GPP TSG RAN WG 2 Meeting #97bis, R2-1703423, 07 April 2017 (07.04.2017), entire document	1-28
A	WO 2017022902 A1 (SAMSUNG ELECTRONICS CO., LTD.), 09 February 2017 (09.02.2017), entire document	1-28

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 July 2018	26 July 2018
Name and mailing address of the ISA State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No. (86-10) 62019451	Authorized officer LIU, Xin Telephone No. 86-010-62089141

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2018/085733

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
WO 2017022902 A1	09 February 2017	WO 2017022870 A1	09 February 2017
		EP 3332597 A1	13 June 2018
		CN 108141749 A	08 June 2018
		KR 20180036995 A	10 April 2018

Form PCT/ISA/210 (patent family annex) (January 2015)

国际检索报告

国际申请号
PCT/CN2018/085733

A. 主题的分类

H04B 7/0408(2017.01)i; H04W 72/04(2009.01)i; H04L 5/00(2006.01)i

按照国际专利分类(IPC)或者同时按照国家分类和IPC两种分类

B. 检索领域

检索的最低限度文献(标明分类系统和分类号)

H04B H04W H04L

包含在检索领域中的除最低限度文献以外的检索文献

在国际检索时查阅的电子数据库(数据库的名称，和使用的检索词（如使用）)

CNABS;CNTXT;CNKI,VEN;USTXT;WOTXT;EPTXT;XP3GPP:波束，恢复，时间窗，调度请求，响应; beam, recover, time lw window, scheduling lw request, SR, response

C. 相关文件

类 型*	引用文件，必要时，指明相关段落	相关的权利要求
Y	QUALCOMM INCORPORATED, "Beam recovery request" 3GPP TSG RAN WG2 Meeting #97bis, R2 1703562, 2017年 4月 7日 (2017-04-07), 第1 2节	1 28
Y	QUALCOMM INCORPORATED, "Beam management" 3GPP TSG-RAN WG2 Meeting #97bis, R2-1703564, 2017年 4月 7日 (2017-04-07), 第2.1-2.2节	1-28
A	INTEL CORPORATION, "Radio link monitoring, beam failure and radio link failure" 3GPP TSG RAN WG2 Meeting #97bis, R2-1703423, 2017年 4月 7日 (2017-04-07), 全文	1-28
A	WO 2017022902 A1 (SAMSUNG ELECTRONICS CO LTD) 2017年 2月 9日 (2017-02-09) 全文	1 28

☐ 其余文件在C栏的续页中列出。

☑ 见同族专利附件。

* 引用文件的具体类型:

"A" 认为不特别相关的表示了现有技术一般状态的文件

"E" 在国际申请日的当天或之后公布的在先申请或专利

"L" 可能对优先权要求构成怀疑的文件，或为确定另一篇引用文件的公布日而引用的或者因其他特殊理由而引用的文件(如具体说明的)

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"Y" 特别相关的文件，当该文件与另一篇或者多篇该类文件结合并且这种结合对于本领域技术人员为显而易见时，要求保护的发明不具有创造性

"&" 同族专利的文件

国际检索实际完成的日期	国际检索报告邮寄日期
2018年 7月 11日	2018年 7月 26日
ISA/CN的名称和邮寄地址 中华人民共和国国家知识产权局(ISA/CN) 中国北京市海淀区蓟门桥西上城路6号 100088 传真号 (86-10)62019451	受权官员 刘欣 电话号码 86-010-62089141

表 PCT/ISA/210 (第2页) (2015年1月)

国际检索报告
关于同族专利的信息

国际申请号
PCT/CN2018/085733

检索报告引用的专利文件			公布日（年/月/日）	同族专利			公布日（年/月/日）
WO	2017022902	A1	2017年 2月 9日	WO	2017022870	A1	2017年 2月 9日
				EP	3332597	A1	2018年 6月 13日
				CN	108141749	A	2018年 6月 8日
				KR	20180036995	A	2018年 4月 10日

表 PCT/ISA/210（同族专利附件）（2015年1月）

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	17950726
	Filing Date	2022-09-22
	First Named Inventor	Xiaobo ZHANG
	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

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	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

	1	R1-1710596, Lenovo, Motorola Mobility, dated June 27-30, 2017 (Meeting dates) June 16, 2017 (Publication)	☒
	2	R1-1710810, MediaTek Inc., dated June 27-30, 2017 (Meeting dates) June 17, 2017 (Publication)	☒
	3	R1-1710871, InterDigital Inc., dated June 20-27, 2017 (Meeting date) June 16, 2017 (Publication)	☒
	4	R1-1711161, Qualcomm Incorporated, dated June 27-30, 2017 (Meeting dates) June 17, 2017 (Publication)	☒
	5	R2-1700902, Ericsson, dated February 13-17, 2017 (Meeting date) February 4, 2017 (Publication)	☒
	6	R2-1701727, Intel Corporation, dated February 13-17, 2017 (Meeting date) February 4, 2017 (Publication)	☒
	7	R2-1702662, Ericsson, dated April 3-7, 2017 (Meeting dates) March 25, 2017 (Publication)	☒
	8	R2-1703344, LG Electronics, dated April 3-7, 2017 (Meeting date) March 24, 2017 (Publication)	☒
	9	R2-1703561, Qualcomm Incorporated, dated April 3-7, 2017 (Meeting dates) March 25, 2017 (Publication)	☒
	10	R2-1706926, Qualcomm Incorporated, dated June 27-29, 2017 (Meeting dates) June 17, 2017 (Publication)	☒
	11	R4-161779, Qualcomm Incorporated, dated April 11-15, 2016 (Meeting date) April 26, 2016 (Publication)	☒

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	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

	12	SINR, RSRP, RSSI and RSRQ Measurements in Long Term Evolution Networks, Farhana Afroz, dated August 2015	☒
	13	Subcarrier Spacing - How to Make Use of This Degree of Freedom, Frank Schaich, dated July 7, 2016	☒
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	15	Waveform and Numerology to Support 5G Services and Requirements, Ali A. Zaidi, dated November 1, 2016	☒
	16	Weight Control Scheme for MIMO System with Multiple Transmit and Receive Beamforming, Yoshitaka Hara, dated 2003	☒
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	18	R1-1701979, NEC Corporation, February 6, 2017	☒
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	20	3GPP TR 38.802 V14.0.0 to Radio Access Technology, 3rd Generation Partnership Project, March 2017	☒
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	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

	23	R1-1704465, MediaTek Inc., March 25, 2017	☒
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	26	R1-1707475, China Academy of Telecommunications Technology (CATT), May 6, 2017	☒
	27	R1-1700539, Panasonic, January 10, 2017	☒
	28	R1-1704618, Guangdong OPPO Mobile Telecom, March 25, 2017	☒
	29	R1-1707830, MediaTek Inc., May 7, 2017	☒
	30	R1-1708334, InterDigital, Inc., May 6, 2017	☒
	31	3GPP TS 36.211 version 14.2.0 Release 14 (“TS 36.211”), 3rd Generation Partnership Project (3GPP), April 2017	☒
	32	3GPP TS 36.212 version 14.2.0 Release 14 (“TS 36.212”), 3rd Generation Partnership Project (3GPP), April 2017	☒
	33	3GPP TS 36.306 version 14.2.0 Release 14 (“TS 36.306”), 3rd Generation Partnership Project (3GPP), April 2017	☒

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	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

	34	3GPP TS 36.331 version 13.5.0 Release 13 ("TS 36.331"), 3rd Generation Partnership Project (3GPP), April 2017	☒
	35	3G Evolution: HSPA and LTE for Mobile Broadband ("Dahlman 2007"), Dahlman et al., 2007	☒
	36	4G: LTE / LTE-Advanced for Mobil Broadband ("Dahlman 2011"), Dahlman et al., 2011	☒
	37	R1-1611421, ZTE, ZTE Microelectronics, November 5, 2016	☒
	38	R1-1613589, Samsung, Ericsson, NTT DOCOMO, Intel, Verizon, KT, November 19, 2016	☒
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	40	R1-1609080, Samsung, September 30, 2016	☒
	41	R1-1702676, Ericsson, February 7, 2017	☒
	42	R1-1704456, MediaTek Inc., March 25, 2017	☒
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	First Named Inventor	Xiaobo ZHANG
	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

	45	R1-1707954, Samsung, May 6, 2017	☒
	46	R1-1710871, InterDigital Inc., June 16, 2017	☒
	47	R1-151535, LG Electronics, April 11, 2015	☒
	48	R1-153175, Ericsson, May 16, 2015	☒
	49	R1-154127, Samsung, August 14, 2015	☒
	50	R1-1609525, Intel Corporation, October 1, 2016	☒

If you wish to add additional non-patent literature document citation information please click the Add button Add

EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
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	Filing Date	2022-09-22
	First Named Inventor	Xiaobo ZHANG
	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/JIALIN ZHONG/	Date (YYYY-MM-DD)	2023-11-19
Name/Print	JIALIN ZHONG	Registration Number	62937

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

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6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

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(19) Europäisches Patentamt
European Patent Office
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(11) EP 2 996 378 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
30.01.2019 Bulletin 2019/05

(21) Application number: **13887171.0**

(22) Date of filing: **19.06.2013**

(51) Int Cl.:
H04L 5/00 *(2006.01)* ***H04L 1/00*** *(2006.01)*
H04B 17/309 *(2015.01)*

(86) International application number:
PCT/CN2013/077477

(87) International publication number:
WO 2014/201638 (24.12.2014 Gazette 2014/52)

(54) **COMMUNICATION QUALITY MEASUREMENT METHOD**
KOMMUNIKATIONSQUALITÄTSMESSVERFAHREN
PROCÉDÉ DE MESURE DE QUALITÉ DE COMMUNICATION

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(43) Date of publication of application:
16.03.2016 Bulletin 2016/11

(73) Proprietor: **Huawei Technologies Co., Ltd.**
Longgang District
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(74) Representative: **Körber, Martin Hans**
Mitscherlich PartmbB
Patent- und Rechtsanwälte
Sonnenstrasse 33
80331 München (DE)

(56) References cited:
WO-A1-2013/081368
CN-A- 102 255 689
CN-A- 102 378 114
CN-A- 102 687 438
CN-A- 102 958 147
US-A1- 2012 176 939

- **HUAWEI ET AL: "Discussion on 3D antenna model", 3GPP DRAFT; R1-130897, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. Chicago, USA; 20130415 - 20130419 6 April 2013 (2013-04-06), XP050696899, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_72b/Docs/ [retrieved on 2013-04-06]**
- **ALCATEL-LUCENT SHANGHAI BELL ET AL: "Considerations on CSI feedback enhancements for high-priority antenna configurations", 3GPP DRAFT; R1-112420 CONSIDERATIONS ON CSI FEEDBACK ENHANCEMENTS FOR HIGH-PRIORITY ANTENNA CONFIGURATIONS_CLEAN, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG1, no. Athens, Greece; 20110822, 18 August 2011 (2011-08-18), XP050537814, [retrieved on 2011-08-18]**

Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

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EP 2 996 378 B1

Description

TECHNICAL FIELD

[0001] The present invention relates to the field of communications technologies, and in particular, to a method and an apparatus for measuring communication quality.

BACKGROUND

[0002] In the field of communications technologies, signals may usually be classified into two types: one type of signal carries information from a higher layer; the other type of signal does not carry information from a higher layer, and this type of signal is usually used for assisting in or indicating reception of the former type of signal. A transmit power of a signal is a very important parameter for both types of signals above. For example, a power of a reference signal may be used for deriving a path loss estimation value, and the path loss estimation value may be used as a part of open-loop control to implement uplink power control, or may be used as a basis for selecting a cell (or a transmit node, or a receive node). A power ratio of a physical downlink shared channel (PDSCH) signal to a reference signal (for example, a cell-specific reference signal (CRS) or a channel state information reference signal (CSI-RS)) may be used for deriving channel state information (CSI), thereby facilitating implementation of scheduling and link adaptation.

[0003] In existing Long Term Evolution (LTE) Releases R8-R11, a power-related parameter is determined on a base station side or a network side, and is notified to user equipment (UE) by using higher layer signaling. Because a conventional base station antenna configuration has a fixed downtilt, and an uplink and a downlink undergo similar path losses, so that a downlink path loss can be desirably used for estimating an uplink path loss. Therefore, distinguishing of antenna ports can be omitted in the power-related parameter sent by the base station side or the network side, and especially in a case of multiple antenna ports. If antenna ports are not distinguished, a downlink path loss can be desirably used for estimating an uplink path loss. The technology is desirably applicable to the conventional base station antenna configuration, especially if transmit powers of antenna ports are the same. In another aspect, a reference signal received power (RSRP), of a current cell/node or an adjacent cell/node, reported by user equipment (UE) may be used by a base station or an evolved node B (eNB) to select a serving cell or node for the UE. In the prior art, the RSRP is an estimation obtained by performing averaging on different antenna ports.

[0004] To lower a system cost and at the same time reach a higher system capacity and coverage requirement, active antenna systems (AAS) have been widely deployed in practice. At present, the LTE R12 standard that is about to be launched is considering enhancement of communication performance after introduction of an AAS system. Different from a conventional base station antenna, an AAS further provides design flexibility in a vertical direction of an antenna, where independent downtilts may be used in an uplink and a downlink, and powers of different antenna ports may be different. In addition, for AAS base stations, even if the AAS base stations have a same quantity of antenna ports, antenna array structures of the AAS base stations may also be different. Therefore, antenna ports having a same sequence number may also have different transmit powers in different array structures. In such a case, in the prior art, power control is implemented based on a downlink reference signal received power, or a method for selecting a cell/node is no longer effective. In the prior art, correct distinguishing cannot be performed if transmit powers of antenna ports are different, and a technical solution that accurately and effectively estimates an uplink path loss and estimates channel state information cannot be provided.

[0005] US 2012/176939 A1 discloses a communications system and a method for performing communications, wherein User Equipments (UEs) are provided with UE-specific configuration information, such as CSI-RS (Channel Status Indication-Reference Signal) patterns, antenna port groupings, reference signal configurations, subframe configurations, and/or scrambling codes.

[0006] WO 2013/081368 A1 discloses a method and apparatus for transmitting a reference signal and discloses an uplink transmission method and apparatus using the same. The method of transmitting a reference signal in a Cooperative Multi-Point (CoMP) system includes sending configuration information on the reference signal and sending the reference signal based on the configuration information on the reference signal, wherein the configuration information on the reference signal indicates Energy Per Resource Element (EPRE), used to transmit the reference signal, for each of transmission points that participate in the transmission of the reference signal.

SUMMARY

[0007] Embodiments of the present invention provide methods for measuring communication quality, thereby overcoming a problem in the prior art that accurate signal quality measurement information cannot be acquired in a multi-antenna system.

[0008] An aspect provides a method for measuring communication quality, including:

receiving reference signal resource configuration information sent by a base station, where the reference signal resource configuration information includes reference signal port configuration information, where the reference signal port configuration information is used for indicating a mapping relationship between a reference signal port and a port group;

obtaining reference signal port information in at least one port group according to the reference signal port configuration information; and

acquiring signal quality measurement information according to the reference signal port information in the at least one port group;

wherein the reference signal resource configuration information further includes: reference signal power information of at least two port groups that is used by the user equipment to acquire the signal quality measurement information according to the reference signal port configuration information and in combination with the reference signal power information of the at least two port groups,

wherein the acquiring the signal quality measurement information according to the reference signal port configuration information and in combination with the reference signal power information of the at least two port groups includes:

obtaining, according to the reference signal port configuration information, signal quality measurement information corresponding to the at least two port groups;

performing, according to the reference signal power information of the at least two port groups, weighted averaging on the obtained signal quality measurement information corresponding to the at least two port groups in accordance with a port group power, to obtain the signal quality measurement information, wherein the performing, according to the reference signal power information of the at least two port groups, weighted averaging on the obtained signal quality measurement information corresponding to the at least two port groups in accordance with a port group power, to obtain the signal quality measurement information includes:

obtaining the signal quality measurement information according to a formula

$$SQ = \left(\sum_{g=0}^{n-1} p_g \cdot SQ_g \right) \Big/ \left(\sum_{g=0}^{n-1} p_g \right),$$

where

SQ_g is signal quality measurement information of a specified port group, g is a sequence number of a specified port group, n is a quantity of specified port groups, $n \geq 2$, and p_g is a reference signal power of a specified port group, where the reference signal power of the specified port group is obtained according to the reference signal power information of the at least two port groups.

[0009] In a first possible implementation manner with reference to the above aspect, the reference signal power information of the at least two port groups includes:

a reference signal power of a first port group, and a ratio of a reference signal power of each port group among the rest port groups to the reference signal power of the first port group; or

a reference signal power of a first port group, and a differential between a reference signal power of each port group among the rest port groups and the reference signal power of the first port group.

[0010] According to the method for measuring communication quality provided in the embodiments of the present invention, reference signal resource configuration information is sent to UE on a user side, and the UE may perform processing according to reference signal quality, of one port group or multiple port groups, in the reference signal resource configuration information to obtain final signal quality measurement information, so that a UE side can distinguish ports according to different port groups, which differs from a case in which transmit powers of different ports cannot be distinguished in the prior art. Therefore, UE is enabled to acquire signal quality measurement information, so that the UE can perform more accurate cell selection and uplink power control.

BRIEF DESCRIPTION OF DRAWINGS

[0011] To describe the technical solutions in the embodiments of the present invention or in the prior art more clearly, the following briefly introduces the accompanying drawings required for describing the embodiments or the prior art. Apparently, the accompanying drawings in the following description show merely some embodiments of the present invention, and a person of ordinary skill in the art may still derive other drawings from these accompanying drawings

without creative efforts. It has to be noted that Embodiment 2 described below is an embodiment of the present invention as defined in the claims, while Embodiment 1 and 3-12 are examples not covered by the claims.

FIG. 1 is a flowchart of a method for measuring communication quality according to Embodiment 1 of the present invention;
FIG. 2 is a flowchart of a method for measuring communication quality according to Embodiment 2 of the present invention;
FIG. 3 is a brief schematic diagram of different uniform linear array antenna array configurations;
FIG. 4 is a brief schematic diagram of different cross-polarization antenna array configurations;
FIG. 5 is a flowchart of a method for measuring communication quality according to Embodiment 3 of the present invention;
FIG. 6 is a flowchart of a method for measuring communication quality according to Embodiment 4 of the present invention;
FIG. 7 is a brief schematic diagram of a network side apparatus according to Embodiment 5 of the present invention;
FIG. 8 is a brief schematic diagram of user equipment according to Embodiment 6 of the present invention;
FIG. 9 is a brief schematic diagram of a network side apparatus according to Embodiment 7 of the present invention;
FIG. 10 is a brief schematic diagram of user equipment according to Embodiment 8 of the present invention;
FIG. 11 is a brief schematic diagram of a network side apparatus according to Embodiment 9 of the present invention;
FIG. 12 is a brief schematic diagram of user equipment according to Embodiment 10 of the present invention;
FIG. 13 is a brief schematic diagram of a network side apparatus according to Embodiment 11 of the present invention; and
FIG. 14 is a brief schematic diagram of user equipment according to Embodiment 12 of the present invention.

DESCRIPTION OF EMBODIMENTS

[0012] The following clearly and completely describes the technical solutions in the embodiments of the present invention with reference to the accompanying drawings in the embodiments of the present invention. Apparently, the described embodiments are merely some but not all of the embodiments of the present invention. All other embodiments obtained by a person of ordinary skill in the art based on the embodiments of the present invention without creative efforts shall fall within the protection scope of the present invention.

Embodiment 1

[0013] An embodiment of the present invention provides a method for measuring communication quality. As shown in FIG. 1, the method includes:

Step S01: Determine reference signal resource configuration information, where the reference signal resource configuration information includes: reference signal port configuration information, where the reference signal port configuration information is used for indicating a mapping between the reference signal port and a port group.

[0014] The operation may specifically be executed on a base station side or a network side (for example, a Universal Terrestrial Radio Access Network (UTRAN)), or an evolved UTRAN, or an evolved node B.

[0015] When the reference signal resource configuration information includes the reference signal port configuration information, and optionally, the reference signal resource configuration information may further include reference signal power information of at least one port group, the reference signal resource configuration information is sent to user equipment (UE), so that the user equipment acquires signal quality measurement information according to the reference signal resource configuration information. Because reference signal ports are allocated to multiple groups, the UE may perform processing according to reference signal quality, of one port group or multiple port groups, in the reference signal resource configuration information to obtain final signal quality measurement information, so that a UE side can distinguish ports according to different port groups, which differs from a case in which transmit powers of different ports cannot be distinguished in the prior art. Therefore, the signal quality measurement information acquired in the solution enables the UE to perform more accurate cell selection and uplink power control.

[0016] It should be further understood that for detailed description of the reference signal port configuration information included in the reference signal resource configuration information, reference may be made to the description of step 101 in Embodiment 2.

[0017] Further, the reference signal resource configuration information may further include: any one of a reference signal configuration and a reference signal subframe configuration. Therefore, the UE can receive a reference signal according to the information. It should be understood that, however, this embodiment of the present invention does not limit that any one of the reference signal configuration and the reference signal subframe configuration is necessarily delivered to the UE by using the reference signal resource configuration information, and may also be delivered to the

UE in a form of other information. It should be pointed out that the reference signal configuration or the reference signal subframe configuration may also be predefined, or is implicitly derived according to a parameter, for example, a cell ID or a UE ID, that is known in advance, and is known to both a base station and the UE, which is not limited in this embodiment of the present invention.

[0018] Step S02: Send the determined reference signal resource configuration information to user equipment, so that the user equipment acquires signal quality measurement information according to the reference signal port configuration information.

[0019] Specifically, the foregoing signal quality measurement information may include:
any one or any combination of a reference signal received power RSRP, a reference signal received quality RSRQ, and a reference signal strength indicator RSSI.

[0020] According to the method described in Embodiment 1 above, in the method, reference signal resource configuration information is determined on a network side, and the reference signal resource configuration information is sent to a user side, where the reference signal resource configuration information includes reference signal port configuration information, where the reference signal port configuration information is used for indicating a mapping between the reference signal port and a port group. In the method, it can be avoided that reference signal power related information is indicated port by port, so as to reduce a signaling overhead; further, a uniform power indicator is used for ports in a port group, and for different port groups, power related information of the port groups may be indicated independently, so that full use of an antenna configuration or an antenna array structure is made, thereby enabling a system to flexibly select reference signal power related information according to the antenna configuration or the antenna array structure; because an antenna array may have symmetric weights, by means of the symmetry of the weights, design complexity in beamforming or side lobe suppression can be reduced.

[0021] Further, the reference signal resource configuration information is sent to UE on the user side, and the UE may perform processing according to reference signal quality of at least one port group in the reference signal resource configuration information to obtain final signal quality measurement information, so that a UE side can distinguish ports according to different port groups, which differs from a case in which transmit powers of different ports cannot be distinguished in the prior art. The UE is enabled to acquire signal quality measurement information, so that the UE can perform more accurate cell selection and uplink power control.

[0022] Optionally, the method further includes:
Step S03: Receive the signal quality measurement information sent by the user equipment.

[0023] Optionally, when the signal quality measurement information is a reference signal received power RSRP, the method further includes:
Step S04: Send, to the user equipment, filter coefficient information that is used by the user equipment to perform, based on the filter coefficient information, filtering on the reference signal received power RSRP and obtain a path loss estimation value.

[0024] Specifically, the filter coefficient information may be sent to the user equipment at a same time when the determined reference signal resource configuration information is sent to the user equipment in step S02, for example, the filter coefficient information and the determined reference signal resource configuration information are sent in a same subframe; or may be sent before or after the determined reference signal resource configuration information is sent to the user equipment in step S02. The filter coefficient information and the reference signal resource configuration information may be sent in an information element (IE) of same or different higher layer signaling such as RRC signaling, or same or different downlink control information (DCI).

[0025] Optionally, the method further includes:
Step S05: Receive an uplink physical channel or an uplink physical signal sent by the user equipment, where a transmit power of the uplink physical channel or the uplink physical signal is obtained by means of calculation by the user equipment according to the path loss estimation value.

[0026] Optionally, the reference signal resource configuration information further includes: reference signal power information of at least two port groups that is used by the user equipment to acquire the signal quality measurement information according to the reference signal port configuration information and in combination with the reference signal power information of the at least two port groups; and
the reference signal power information of the at least two port groups includes:

a reference signal power of a first port group, and a ratio of a reference signal power of each port group among the rest port groups to the reference signal power of the first port group; or
a reference signal power of a first port group, and a differential between a reference signal power of each port group among the rest port groups and the reference signal power of the first port group.

[0027] Optionally, the reference signal port configuration information is a single index, or is a double index, or is an index after combined coding.

[0028] Optionally, the reference signal power information of the port group at least includes: reference signal powers of ports in one port group are the same.

[0029] The first port group is one port group among the at least one port group.

Embodiment 2

[0030] This embodiment of the present invention provides a method for measuring communication quality. As shown in FIG. 2, the method includes:

Step 101: Receive reference signal resource configuration information sent by a base station, where the reference signal resource configuration information includes reference signal port configuration information, where the reference signal port configuration information is used for indicating a mapping relationship between a reference signal port and a port group.

[0031] Specifically, UE receives the reference signal resource configuration information, which may be that the UE receives, by using higher layer signaling (for example, radio resource control (RRC) signaling) or dynamic signaling (for example, downlink control information (DCI), the reference signal resource configuration information notified by an eNB, or obtains, based on a cell identity (ID), the reference signal resource configuration information. The higher layer signaling may be sent by using a data channel such as a physical downlink shared channel (PDSCH for short). The dynamic signaling, for example, the DCI, is sent by using a control channel such as a physical downlink control channel (PDCCH) or an enhanced PDCCH (ePDCCH).

[0032] It should be understood that the reference signal port configuration information is used for indicating a mapping between a reference signal port and a port group. The mapping relationship between a reference signal port and a port group may be predefined, and is known to both the base station and the user equipment. Therefore, a base station side and a user equipment side can both find the reference signal port configuration message by means of identification.

[0033] It should be further understood that according to information about a mapping relationship between a reference signal port group and a corresponding port, and a mapping index of the port group, a port included in the port group may be uniquely determined. As shown in Tables 1 to 3, after learning the information about the mapping relationship between a reference signal port group and a corresponding port, and the mapping index of the port group, a device can learn a port in the corresponding port group. Ports included in the port group may be predefined, and for a different index, a predefined port group may be obtained according to planning. It should be noted that one reference signal port corresponds to one antenna port, and one antenna port corresponds to one reference signal port. Channel information of an antenna signal port is obtained by means of measurement of a reference signal port. Therefore, usually the predefined port group may be obtained according to planning of an antenna port array configuration.

[0034] One reference signal port or antenna port usually corresponds to one physical antenna or one virtual antenna, where the virtual antenna may be obtained by means of weighted combination of multiple physical antennas. An actual antenna deployment may have a different antenna configuration and antenna port array form. For example, FIG. 3 shows different uniform linear array (ULA) antenna port array configurations. An antenna port array A is a 2-row 4-column uniform linear array, an antenna port array B is a 2-row 8-column uniform linear array, and an antenna port array C is a 4-row 4-column uniform linear array. Although both the antenna port array B and the antenna port array C have 16 ports, array forms of the antenna port array B and the antenna port array C are also different. For another example, FIG. 4 shows different cross-polarization (XPO) antenna array configurations. An antenna port array A is a 2-row 2-column cross-polarization antenna array, an antenna port array B is a 2-row 4-column uniform linear array, and an antenna port array C is a 4-row 2-column uniform linear array. Different polarization antennas may be located in a same column. Although both the antenna port array B and the antenna port array C have 16 ports, array forms of the antenna port array B and the antenna port array C are also different. The antenna port array is referred to as an antenna array for short below.

[0035] Optionally, as another embodiment, the reference signal port configuration information includes a quantity of reference signal ports and a mapping index, where the mapping index is used for indicating a mapping between a reference signal port group and a corresponding port. 8-antenna arrays represented by the antenna array A shown in FIG. 3 and the antenna array A shown in FIG. 4 are used as examples. The reference signal port configuration information includes: a quantity of reference signal ports is 8 and a mapping index is 0 or 1. The predefined mapping relationship between a reference signal port and a port group may be defined by using a function, or may be regulated by using a predefined table. For example, as shown in Table 1, the first row may be the reference signal port configuration information of the antenna array A in FIG. 3, and the mapping indication information includes: a quantity of reference signal ports is 8, a mapping index is 0, and two port groups are a port group 0 and a port group 1. The second row in Table 1 may be the reference signal port configuration information of the antenna array A in FIG. 4, and the mapping indication information includes: a quantity of reference signal ports is 8, a mapping index is 1, and two port groups are a port group 0 and a port group 1. It should be pointed out that, in this embodiment, a reference signal port and a reference signal port group may be interchangeable with an antenna port and an antenna port group.

Table 1-Mapping between a port and a port group

Index	Mapping between a port and a port group	
	0	1
0	0, 3, 4, 7	1, 2, 5, 6
1	0, 1, 4, 5	2, 3, 6, 7

[0036] Further, when a mapping index value is 0, the port group 0 includes reference signal ports (or antenna ports) 0, 3, 4, and 7, the port group 1 includes reference signal ports (or antenna ports) 1, 2, 5, and 6; when a mapping index value is 1, the port group 0 includes reference signal ports (or antenna ports) 0, 1, 4, and 5, the port group 1 includes reference signal ports (or antenna ports) 2, 3, 6, and 7.

[0037] 16-antenna arrays represented by the antenna array B or the antenna array C shown in FIG. 3 and the antenna array B or the antenna array C shown in FIG. 4 are used as examples. The reference signal port configuration information includes: a quantity of reference signal ports is 16, and a mapping index is 0 or 1 or 2 or 3. The predefined mapping relationship between a reference signal port and a port group may be defined by using a function, or may be regulated by using a predefined table, for example, as shown in Table 2:

Table 2-Mapping between a port and a port group

Index	Mapping between a port and a port group			
	0	1	2	3
0	0, 3, 8, 11	4, 7, 12, 15	1, 2, 9, 10	5, 6, 13, 14
1	0, 1, 12, 13	2,3, 14, 15	4, 5, 8, 9	6, 7, 10, 11
2	0, 7, 8, 15	1, 6, 9, 14	2, 5, 10, 13	3, 4, 11, 12
3	0, 3, 12, 15	1,2, 13, 14	4, 7, 8, 11	5, 6, 9, 10

[0038] It may be assumed that the antenna array B in FIG. 3 is the first row in Table 2, that is, a mapping index value is 0, a port group 0 includes reference signal ports (or antenna ports) 0, 3, 8, and 11, a port group 1 includes reference signal ports (or antenna ports) 4, 7, 12, and 15, a port group 2 includes reference signal ports (or antenna ports) 1, 2, 9, and 10, and a port group 3 includes reference signal ports (or antenna ports) 5, 6, 13, and 14. When the mapping index value is 1 or 2 or 3, reference signal ports included in each port group may be sequentially obtained by analogy from the foregoing Table.

[0039] Optionally, as another embodiment, the reference signal port configuration information may include a port group mapping double index (m, n). In this case, the predefined mapping relationship between a reference signal port and a port group may be defined by using a function, or may be regulated by using a predefined table, for example, as shown in Table 3:

Table 3-Mapping between a port and a port group

Double index (m, n)	Mapping between a port and a port group			
	0	1	2	3
(2, 4)	0, 1, 4, 5	2, 3, 6, 7	-	-
(2, 8)	0, 3, 8, 11	4, 7, 12, 15	1, 2, 9, 10	6, 7, 10, 11
(4, 4)	0, 1, 12, 13	2, 3, 14, 15	4, 5, 8, 9	6, 7, 10, 11

[0040] Optionally, the double index (m, n) may indicate that a quantity of reference signal ports is a product of m and n.

[0041] Further, combined coding may be performed on the double index information. For example, combined coding of the double index in Table 3 above is shown in Table 3a or 3b.

Table 3a-Mapping between a port and a port group

Combined coding of a double index (m, n)	Double index (m, n)	Mapping between a port and a port group			
		0	1	2	3
0	(2, 4)	0, 1, 4, 5	2, 3, 6, 7	-	-
1	(2, 8)	0, 3, 8, 11	4, 7, 12, 15	1, 2, 9, 10	6, 7, 10, 11
2	(4, 4)	0, 1, 12, 13	2, 3, 14, 15	4, 5, 8, 9	6, 7, 10, 11

or

Table 3b-Mapping between a port and a port group

Mapping index	Double index (m, n)	Mapping between a port and a port group			
		0	1	2	3
0	(2, 4)	0, 1, 4, 5	2, 3, 6, 7	-	-
1	(2, 8)	0, 3, 8, 11	4, 7, 12, 15	1, 2, 9, 10	6, 7, 10, 11
2	(4, 4)	0, 1, 12, 13	2, 3, 14, 15	4, 5, 8, 9	6, 7, 10, 11

[0042] Optionally, grouping of port groups may be that 4 reference signal ports (or antenna ports) are used as one port group.

[0043] It should be further pointed out that grouping of port groups may also be not limited to a port group including 4 reference signal ports, or may be a port group having 2 or 8 ports or in another formation. In addition, a number of a reference signal port included in each port group is also not limited to the foregoing value, and may be flexibly selected according to an actual antenna configuration or deployment. The foregoing predefined port group mapping and mapping indication information may enable a system to adapt to more antenna configurations and antenna array deployments.

[0044] Optionally, the reference signal resource configuration information may further include: any one of a reference signal configuration and a reference signal subframe configuration. The reference signal configuration may include: any one of a subcarrier used by a reference signal port, an orthogonal frequency division multiplexing (OFDM) symbol, and a code resource. The reference signal subframe configuration may include: any one of a subframe position occupied by a reference signal port, a subframe period, and a subframe offset. It should be pointed out that the reference signal configuration or the reference signal subframe configuration may also be predefined, or is implicitly derived according to a parameter, for example, a cell ID or a UE ID, that is known in advance, and is known to both the base station and the UE, which is not limited in this embodiment of the present invention.

[0045] Step 102: Obtain reference signal port information in at least one port group according to the reference signal port configuration information.

[0046] Step 103: Acquire signal quality measurement information according to the reference signal port information in the at least one port group.

[0047] Specifically, the reference signal or signal may specifically include a cell-specific reference signal CSR, or a channel state information reference signal (CSI-RS), or a demodulation reference signal (DMRS), but is not limited to current examples.

[0048] The signal quality measurement information may be a reference signal received power (RSRP) or a reference signal received quality (RSRQ) or a reference signal strength indicator (RSSI), or may also be other signal quality measurement information defined based on a reference signal.

[0049] In this embodiment, a reference signal received power RSRP is used as an example and one implementation is described in detail. This solution is not limited to another implementation solution, and a solution of acquiring other signal quality measurement information is also not limited.

[0050] Optionally, the obtaining reference signal port information in at least one port group according to the reference signal port configuration information in step 102 may include:

obtaining reference signal port information in one specified port group according to the reference signal port configuration information; and

the acquiring signal quality measurement information according to the reference signal port information in the at least one port group in step 103 includes:

acquiring the signal quality measurement information according to the reference signal port information in the one

specified port group.

[0051] For example, a mapping index in Table 2 is 0, and in this case, reference signal ports included in a port group 0 are 0, 3, 8, and 11. Complex RSRP measurement of each antenna port may be correlation between two adjacent reference signal resource elements (RE, Resource Element). The two adjacent REs herein may refer to two adjacent REs in a frequency domain, or two adjacent REs in a time domain, or two adjacent REs in a time-frequency domain.

$$RSRP(r,p)=\frac{1}{K_s-1}\sum_{m=0}^{K_s-1}\hat{h}_p(m)\cdot\hat{h}_p(m+1),p=0,3,8,11 \quad (1)$$

where $\hat{h}_p(m)$ is a channel estimation on a reference signal RE whose label number is m, K_s is a total sample quantity of usable reference signal REs in measurement bandwidth, p is a number of a reference signal port in the one specified port group, and r is an index of a receive antenna. An RSRP corresponding to the antenna port group 0 may be obtained by combining (combine) *RSRP*(*r*,*p*). Specifically, a reference signal received power *RSRP*(*r*,*p*) of a pth port of an rth receive antenna is obtained and the RSRP is obtained by combining *RSRP*(*r*,*p*). For example, for *RSRP*(*r*,*p*) above, linear (correlated or uncorrelated) averaging is performed on ports p and receive antennas, and then an absolute value is taken, to obtain the RSRP corresponding to the port group 0. Alternatively, for *RSRP*(*r*,*p*) above, linear (correlated or uncorrelated) averaging is performed on one port p and receive antennas, and then an absolute value is taken, to obtain the RSRP corresponding to the port group 0. By means of sequential analogy, the RSRP may also be obtained by using reference signals of another port group.

[0052] In step 103 in this embodiment, the port group used for obtaining an RSRP and a port in the port group may be predefined (for example, the port group 0, and the port 0 in the port group 0, or the ports 0 and 3 in the port group 0, or all the ports in the port group 0, or others) or notified by a base station eNB by using higher layer signaling such as RRC signaling or by using downlink control information. In the foregoing, an RSRP is obtained based on one port group or some or all ports in one port group, and RSRPs do not need to be measured port by port, so that implementation complexity in measuring an RSRP by UE can be reduced; at the same time, a port group is predefined or notified, so that the UE and the eNB have consistent understanding of measurement, thereby ensuring consistency in measurement of RSRPs. At the same time, for different port groups, powers of the port groups may be independently indicated, and full use of antenna configurations and antenna array structures shown in FIG. 3 and FIG. 4 is made, so as to adapt to changes in an antenna structure to perform flexible indication, thereby ensuring that the base station eNB can adapt to multiple antenna configurations and antenna arrays.

[0053] Optionally, reference signal power information, of one or more port groups, included in the reference signal resource configuration information received by the UE in step 101 is used for indicating a reference signal power of ports in a corresponding port group.

[0054] 16 reference signal ports are used as an example, and reference signal powers of 4 port groups may be shown in Table 4:

Table 4-Table of reference signal powers of port groups

Port group number	0	1	2	3
Reference signal power	p0	p1	p2	p3

[0055] In this case, a power of a reference signal port included in a port group 0 is p0, and powers of reference signal ports included in port groups 1, 2, and 3 may be sequentially obtained by analogy, which are respectively p1, p2, and p3.

[0056] Alternatively, reference signal power information of the foregoing one or more port groups may also be jointly represented by using a reference signal power of one port group (for example, the port group 0) among the one or more port groups and a ratio of a reference signal power of another port group (for example, the port group 1) to the reference signal power of the port group (for example, the port group 0) or ratios of reference signal powers of multiple port groups (for example, the port groups 1, 2, and 3) to the reference signal power of the port group (for example, the port group 0). For example, the reference signal power of the port group 0 is p0, the ratios of the reference signal powers of the port groups 1, 2, and 3 to the reference signal power of the port group 0 are respectively ρ1, ρ2, and ρ3. In this case, the UE may obtain that the reference signal powers of the port groups 1, 2, and 3 are respectively p0*ρ1, p0*ρ2, and p0*ρ3.

[0057] In addition, reference signal power information of the one or more port groups may also be represented by using a reference signal power of one port group (for example, the port group 0) among the one or more port groups and a differential between a reference signal power of another port group (for example, the port group 1) and the reference signal power of the port group (for example, the port group 0) or differentials between reference signal powers of multiple

port groups (for example, the port groups 1, 2, and 3) and the reference signal power of the port group (for example, the port group 0). For example, the reference signal power of the port group 0 is p0, the differentials between the reference signal powers of the port groups 1, 2, and 3 and the reference signal power of the port group 0 are respectively d1, d2, and d3. In this case, the UE may obtain that the reference signal powers of the port groups 1, 2, and 3 are respectively p0+d1, p0+d2, and p0+d3.

[0058] It is used above that reference signal power information is separately indicated for port groups, and it can be avoided that reference signal powers are indicated port by port, so as to reduce a signaling overhead; further, a uniform power indicator is used for ports in a port group, and for different port groups, different port groups powers may be independently indicated, so that full use of an antenna configuration or an antenna array structure is made, thereby enabling a system to flexibly select a reference signal power according to the antenna configuration or the antenna array structure. In addition, it should be further pointed that that grouping of port groups is not limited to a port group including 4 reference signal ports, and the grouping of port groups and the formation of the ports in Tables 1, 2, and 3 above may further enable the antenna arrays in FIG. 3 or FIG. 4 to have powers symmetric about array structures, that is, the ports may have symmetric weights relative to the array, and by means of the symmetry of the weights, design complexity in beamforming or side lobe suppression can be reduced.

[0059] Further, the reference signal power above may also be represented by using an energy per resource element (EPRE).

[0060] Optionally, reference signal power information of at least two port groups includes:

a reference signal power of a first port group, and a ratio of a reference signal power of each port group among the rest port groups to the reference signal power of the first port group; or
a reference signal power of a first port group, and a differential between a reference signal power of each port group among the rest port groups and the reference signal power of the first port group.

[0061] Optionally, the foregoing acquiring the signal quality measurement information according to the reference signal port configuration information and in combination with the reference signal power information of the at least two port groups includes:

obtaining, according to the reference signal port configuration information, signal quality measurement information corresponding to the at least two port groups; and
performing, according to the reference signal power information of the at least two port groups, weighted averaging on the obtained signal quality measurement information corresponding to the at least two port groups in accordance with a port group power, to obtain the signal quality measurement information.

[0062] Specifically, the signal quality measurement information may be obtained by combining reference signal received powers of more than one port group.

[0063] For example, there are 4 port groups in total: port groups 0, 1, 2, and 3. Based on the foregoing method for obtaining an RSRP of one port group, reference signal received powers $RSRP_g$ corresponding to the port groups 0, 1, 2, and 3 may be separately obtained, where $g = 0,1,2,3$. The reference signal resource configuration information received according to step 101 further includes: reference signal power information of at least two port groups that is used by the user equipment to acquire the signal quality measurement information according to the reference signal port configuration information and in combination with the reference signal power information of the at least two port groups.

[0064] The performing, according to the reference signal power information of the at least two port groups, weighted averaging on the obtained signal quality measurement information corresponding to the at least two port groups in accordance with a port group power, to obtain the signal quality measurement information includes:

according to a formula

$$SQ = \left(\sum_{g=0}^{n-1} p_g \cdot SQ_g \right) \Big/ \left(\sum_{g=0}^{n-1} p_g \right) \quad (2)$$

obtaining the signal quality measurement information, where
SQ_g is signal quality measurement information of a specified port group, g is a sequence number of a specified port group, n is a quantity of specified port groups, $n \geq 2$, and p_g is a reference signal power of a specified port group, where the reference signal power of the specified port group is obtained according to the reference signal power information of the at least two port groups.

[0065] The multiple port groups above may be all port groups, or may be some port groups. Therefore, preset port information may be information about all port groups, or may be information about some port groups. The some port groups may be agreed in advance (for example, the port group 0 and the port group 1) or notified by the base station eNB by using higher layer signaling such as RRC signaling or by using downlink control information. In the foregoing, RSRPs of the multiple port groups are obtained, and processing such as smoothing or filtering may be performed on the RSRP obtained for each port group, so as to further increase precision of measuring an RSRP; at the same time, it is avoided that the UE performs calculation port by port, thereby lowering implementation complexity. In addition, a configuration of a port group can ensure that the base station eNB can adapt to multiple antenna configurations and antenna arrays.

[0066] Likewise, a similar method is used. Based on the reference signal port configuration information in the reference signal resource configuration information and a reference signal configuration or a subframe configuration, a reference signal sent by the base station is received, and the UE may further obtain signal quality measurement information, such as a reference signal received quality (RSRQ) or a reference signal strength indicator (RSSI), of one or more port groups. The RSSI is a received total wideband power, including a power of interference and a power of thermal noise, and the RSRQ is a ratio of an RSRP to the RSSI.

[0067] Further, the method for measuring communication quality may further include:

[0068] Step 104: The UE reports, to a base station eNB, the channel quality measurement information, for example, an RSRP, so as to help implement cell selection or cell handover.

[0069] Optionally, when the signal quality measurement information is the reference signal received power RSRP, the method for measuring communication quality may further include:

Step 105: Receive filter coefficient information sent by the base station.

[0070] Step 106: Perform, based on the filter coefficient information, filtering on the reference signal received power RSRP, and obtain a path loss estimation value.

[0071] Specifically, the user equipment may receive filter coefficient information sent by the base station at the same time when the reference signal resource configuration information is received in step 101, for example, the filter coefficient information and the reference signal resource configuration information are received in a same subframe. The filter coefficient information sent by the base station may also be received before or after the reference signal resource configuration information is received in step 101. The filter coefficient information and the reference signal resource configuration information may be received in an information element (IE) of same or different higher layer signaling such as RRC signaling, or same or different downlink control information (DCI).

[0072] Specifically, for the method in step 103, a reference signal received power of one or more port groups may be obtained, for example, reference signal received powers $RSRP_g$ corresponding to port groups 0, 1, 2, and 3 maybe obtained, where g = 0,1,2,3.

[0073] The path loss estimation may be obtained based on a reference signal received power of one port group and a corresponding reference signal power:

$$PL(g) = \text{a reference signal power of a port group g} - \text{a higher layer filtered RSRP of the port group g.}$$

where $PL(g)$ represents the PL estimation obtained based on the port group g, where a higher layer filtering parameter is notified by using higher layer signaling. A PL estimation may be obtained by using a PL of one port group, for example, the port group 0. The higher layer filtered RSRP of the port group g is obtained by performing filtering on the RSRP of the port group g by using the higher layer filter parameter notified by using the higher layer signaling.

[0074] The foregoing port group for obtaining a PL estimation may be predefined (for example, the port group 0) or notified by the base station eNB by using higher layer signaling such as RRC signaling or by using downlink control information. A PL estimation is obtained above based on one port group, which can reduce implementation complexity of PL estimation by UE, and ensure consistency of PL estimation. In addition, a configuration of a port group can ensure that the base station eNB can adapt to multiple antenna configurations and antenna arrays.

[0075] The path loss estimation may also be obtained based on reference signal received powers of multiple port groups and corresponding reference signal powers. Specifically, the PL estimation may be a linear average of PL estimations obtained for the multiple port groups.

[0076] The multiple port groups above may be all port groups, or may be some port groups. The some port groups may be agreed in advance (for example, the port group 0 and the port group 1) or notified by the base station eNB by using higher layer signaling such as RRC signaling or by using downlink control information. In the foregoing, PL estimations are obtained for multiple port groups, which can further increase precision of PL estimation, and avoid excessively high complexity of implementation by UE. In addition, a configuration of a port group can ensure that the base station

eNB can adapt to multiple antenna configurations and antenna arrays.

[0077] Further, the method for measuring communication quality may further include:

Step 107: Send an uplink physical channel or an uplink physical signal to the base station, where a transmit power of the uplink physical channel or the uplink physical signal is obtained by means of calculation according to the path loss estimation value.

[0078] The physical channel may be a physical uplink control channel PUCCH, a physical uplink shared channel PUSCH, or the like. The physical signal may be a sounding reference signal (SRS) or a demodulation reference signal (DMRS) that is used for the uplink physical channel.

[0079] Specifically, according to the foregoing obtained path loss estimation, a setting of the transmit power of the physical uplink control channel PUCCH may be defined as the following formula (3):

$$P_{\mathrm{PUCCH}}(i) = \min\left\{P_{\mathrm{CMAX,c}}(i), P_{\mathrm{O_PUCCH}} + PL_c + h\left(n_{CQI}, n_{HARQ}, n_{SR}\right) + \Delta_{\mathrm{F_PUCCH}}(F) + \Delta_{TxD}(F') + g(i)\right\}$$

where $P_{\mathrm{CMAX,c}}(i)$ is a maximum transmit power configured on UE in a subframe i of a serving cell c, and $P_{\mathrm{O_PUCCH}}$ is a parameter formed by the sum of a cell-specific parameter $P_{\mathrm{O_NOMINAL_PUCCH}}$ provided by a higher layer and a UE specific parameter $P_{\mathrm{O_UE_PUCCH}}$. $h(n_{CQI},n_{HARQ},n_{SR})$ is a value dependent on a PUCCH format, where n_{CQI} corresponds to a quantity of information bits of a CQI. For the parameter n_{SR}, n_{SR} = 1 if subframe i is configured for SR for the UE not having any associated transport block for UL-SCH, or otherwise n_{SR} = 0. The parameter n_{HARQ} is a quantity of HARQ-ACK bits sent in the subframe i. The parameter $\Delta_{\mathrm{F_PUCCH}}(F)$ is provided by a higher layer, and a value of each $\Delta_{\mathrm{F_PUCCH}}(F)$ corresponds to a PUCCH format (F). For the parameter $\Delta_{TxD}(F')$, if the UE is configured by a higher layer to transmit a PUCCH on two antenna ports, a value of $\Delta_{TxD}(F')$ is provided by a higher layer, where each PUCCH format F' is predefined; otherwise, $\Delta_{TxD}(F') = 0$. $g(i)$ is a current PUCCH power control state of the UE. PL_c is an estimation value, of a path loss, obtained for the cell C by the UE by using the method in step 104.

[0080] For another example, according to the foregoing obtained path loss estimation, a setting of the transmit power of the physical uplink shared channel PUSCH may be defined as the following formula (4):

$$P_{\mathrm{PUSCH,c}}(i) = \min\left\{P_{\mathrm{CMAX,c}}(i), 10\log_{10}\left(M_{\mathrm{PUSCH,c}}(i)\right) + P_{\mathrm{O_PUSCH,c}}(j) + \alpha_c(j)\cdot PL_c + \Delta_{\mathrm{TF,c}}(i) + f_c(i)\right\}$$

where $P_{\mathrm{CMAX,c}}(i)$ is a maximum transmit power configured on UE in a subframe i of a serving cell c; $M_{\mathrm{PUSCH,c}}(i)$ is the bandwidth of the PUSCH resource assignment expressed in number of resource blocks valid for subframe i and serving cell c. $P_{\mathrm{O_PUSCH,c}}(j)$ is a parameter formed by a component $P_{\mathrm{O_NOMINAL_PUSCH,c}}(j)$ and a component $P_{\mathrm{O_UE_PUSCH,c}}(j)$ that are provided by a higher layer, where j=0, 1. $\alpha_c \in \{0,0.4,0.5,0.6,0.7,0.8,0.9,1\}$ is a 3-bit parameter, and is provided by a higher layer. $\Delta_{TF,c}(i)$ is a parameter that is determined by using higher layer signaling and related to a transmission format. $f_c(i)$ is a current PUSCH power control adjustment state of the UE. PL_c is an estimation value, of a path loss, obtained for the cell C by the UE by using the method in step 104.

[0081] For still another example, according to the foregoing obtained path loss estimation, a setting of a transmit power of a sounding reference signal SRS may be defined as the following formula:

$$P_{\mathrm{SRS,c}}(i) = \min\left\{P_{\mathrm{CMAX,c}}(i), P_{\mathrm{SRS_OFFSET,c}}(m) + 10\log_{10}\left(M_{\mathrm{SRS,c}}\right) + P_{\mathrm{O_PUSCH,c}}(j) + \alpha_c(j)\cdot PL_c + f_c(i)\right\} \quad ,$$

where $P_{\mathrm{SRS_OFFSET,c}}(m)$ is a parameter semi-statically configured by a higher layer for a serving cell c, where m=0 and m=1. For SRS transmission, if a trigger type is 0, m=0; if a trigger type 1, m=1. $M_{\mathrm{SRS,c}}$ is bandwidth of SRS transmission of a subframe i of the serving cell c. $f_c(i)$ is a current PUSCH power control adjustment state of the serving cell c. $P_{\mathrm{O_PUSCH,c}}(j)$ and $\alpha_c(j)$ are predefined parameters, for example, it is defined in Section 5.1.1.1 in LTE 36.213 that j=1. PL_c is an estimation value, of a path loss, obtained for the cell C by the UE by using the method in step 104.

[0082] The above path loss estimation is used for open-loop control of an uplink channel, which can further improve reliability of power control, and ensure that the base station eNB can adapt to multiple antenna configurations and antenna arrays.

Embodiment 3

[0083] This embodiment of the present invention provides a method for measuring communication quality. As shown in FIG. 5, the method includes:

Step S21: Determine reference signal resource configuration information, and send the reference signal resource configuration information to user equipment, where the reference signal resource configuration information includes: refer-

ence signal port configuration information and power ratio information, where the reference signal port configuration information is used for indicating a mapping between the reference signal port and a port group, and the power ratio information is used for indicating a power ratio of a data channel of at least one port group to a reference signal.

[0084] When the reference signal resource configuration information includes: the reference signal port configuration information and the power ratio information, the reference signal resource configuration information is sent to the user equipment (UE), so that the user equipment acquires channel state information CSI according to the reference signal resource configuration information. Because reference signal ports are allocated to multiple groups, the UE may perform processing according to reference signal quality, of one port group or multiple port groups, in the reference signal resource configuration information to obtain final signal quality measurement information, so that a UE side can distinguish ports according to different port groups, which differs from a case in which transmit powers of different ports cannot be distinguished in the prior art. Therefore, channel state information acquired in the solution may enable the UE to perform more accurate modulation and coding scheme (MCS) selection or scheduling, thereby increasing a throughput of a system.

[0085] Step S22: Receive channel state information CSI sent by the user equipment, where the CSI is obtained by the user equipment according to the reference signal port configuration information and the power ratio information.

[0086] The channel state information CSI includes: any one or any combination of a channel quality indicator CQI, a precoding matrix indicator PMI, and a rank indicator RI.

[0087] According to the method described in Embodiment 3 above, in the method, reference signal resource configuration information is determined on a network side, and the reference signal resource configuration information is sent to a user side, where the reference signal resource configuration information at least includes: reference signal power related information of a port group, and reference signal port configuration information, where the reference signal port configuration information is used for indicating a mapping between the reference signal port and a port group. In the method, it can be avoided that reference signal power related information is indicated port by port, so as to reduce a signaling overhead; further, a uniform power indicator is used for ports in a port group, and for different port groups, power related information of the port groups may be indicated independently, so that full use of an antenna configuration or an antenna array structure is made, thereby enabling a system to flexibly select reference signal power related information according to the antenna configuration or the antenna array structure; because an antenna array may have symmetric weights, by means of the symmetry of the weights, design complexity in beamforming or side lobe suppression can be reduced.

[0088] Further, the reference signal resource configuration information is sent to UE on the user side, and the UE may perform processing according to reference signal quality, of one port group or multiple port groups, in the reference signal resource configuration information to obtain final signal quality measurement information, so that a UE side can distinguish ports according to different port groups, which differs from a case in which transmit powers of different ports cannot be distinguished in the prior art. The UE is enabled to acquire channel state information, so that the UE can perform more accurate modulation and coding scheme (MCS) selection or scheduling, thereby increasing a throughput of a system.

[0089] Optionally, the reference signal port configuration information is a single index, or is a double index, or is an index after combined coding. Refer to Embodiment 1 for the detailed description, which is no longer repeated herein.

[0090] Optionally, in step S21, in the power ratio information:

power ratios of data channels on antenna ports in each port group among the at least one port group to a reference signal are the same; or

power ratios of data channels on ports in one port group among the at least one port group and data channels on ports in another port group to a reference signal are the same.

[0091] Optionally, the power ratio information is used for indicating multiple sets of power ratios of data channels of the at least one port group to a reference signal; and

the receiving channel state information CSI sent by the user equipment includes: receiving multiple sets of channel state information CSI that are sent by the user equipment, where each set of channel state information CSI is obtained by the user equipment according to one set of power ratios among the multiple sets of power ratios.

[0092] The "multiple sets" in this embodiment refers to use of multiple sets of values. For the multiple sets of values, multiple sets of signaling having a same format may be used. For example,

a signaling format is: power ratios of data channels on ports in at least one port group to a reference signal are the same, that is, powers of ports in a port group are the same; and

another signaling format is: power ratios of data channels on ports in one port group and data channels on ports in another port group to a reference signal are the same; however, powers of ports in a port group are different.

[0093] Two different signaling formats are listed as examples in the foregoing, and they may be understood as specific examples of this embodiment, and should not be construed as limitations to this embodiment.

Embodiment 4

[0094] This embodiment of the present invention provides a method for measuring communication quality. The method is similar to Embodiment 2 above, and a difference lies in that, after receiving reference signal resource configuration information sent by a network side, UE on a user side uses the information to acquire channel state information, so that the UE can perform corresponding modulation and coding scheme MCS selection or resource scheduling according to the channel state information.

[0095] As shown in FIG. 6, the method includes:

Step 201: Receive reference signal resource configuration information sent by a base station, where the reference signal resource configuration information includes: reference signal port configuration information and power ratio information, where the reference signal port configuration information is used for indicating a mapping between the reference signal port and a port group, and the power ratio information is used for indicating a power ratio of a data channel of at least one port group to a reference signal.

[0096] For detailed description of the reference signal port configuration information included in the reference signal resource configuration information, reference may be made to the description of the reference signal port configuration information in step 101. That is, the reference signal port configuration information is used for indicating the mapping between a reference signal port and a port group, and the mapping relationship between a reference signal port and a port group is predefined.

[0097] The data channel may be a physical downlink shared channel (PDSCH), or may be a channel used for transmitting control information. A power of a data channel may be an energy per resource element (EPRE).

[0098] Specifically, the UE receives a reference signal resource configuration, which may be that the UE receives, by using higher layer signaling such as radio resource control (RRC) signaling or dynamic signaling such as downlink control information (DCI), the reference signal resource configuration notified by an eNB, or obtains, based on a cell identity ID, the reference signal resource configuration.

[0099] Specifically, the reference signal port configuration information is used for indicating the mapping between the reference signal port and a port group.

[0100] One reference signal port usually corresponds to one physical antenna or one virtual antenna, where the virtual antenna may be obtained by means of weighted combination of multiple physical antennas. An actual antenna deployment may have a different antenna configuration and an antenna array form. It should be pointed out that, in this embodiment, a reference signal port and a reference signal port group may be interchangeable with an antenna port and an antenna port group.

[0101] Optionally, the reference signal port configuration information is used for indicating the mapping relationship between the reference signal port and a port group, and may include a quantity of reference signal ports and a mapping index, where the mapping index is used for indicating a mapping between a reference signal port group and a corresponding port. 8-antenna arrays represented by an antenna array A shown in FIG. 3 and an antenna array A shown in FIG. 4 are used as examples, and the reference signal port configuration information includes: a quantity of reference signal ports is 8 and a mapping index is 0 or 1. The predefined mapping relationship between a reference signal port and a port group may be defined by using a function, or may be regulated by using a predefined table, as shown in Table 1.

[0102] 16-antenna arrays represented by an antenna array B or an antenna array C shown in FIG. 3 and an antenna array B or an antenna array C shown in FIG. 4 are used as examples, and the reference signal port configuration information includes: a quantity of reference signal ports is 16 and a mapping index is 0 or 1 or 2 or 3. The predefined mapping relationship between a reference signal port and a port group may be defined by using a function, or may be regulated by using a predefined table, as shown in Table 2.

[0103] Specifically, the reference signal port configuration information may include a double index (m, n). In this case, the predefined mapping relationship between a reference signal port and a port group may be defined by using a function, or may be regulated by using a predefined table, as shown in Table 3.

[0104] Further, the double index (m, n) may indicate that a quantity of reference signal ports is a product of m and n.

[0105] Further, for the double index information, combined coding may be performed, for example, combined coding of the double index in Table 3 above is shown in Table 3a or 3b.

[0106] Optionally, grouping of port groups may be that 4 reference signal ports/antenna ports form one port group.

[0107] It should be further pointed out that grouping of port groups is not limited to a port group including 4 reference signal ports, or may be a port group having 2 or 8 ports or in another formation. In addition, a number of a reference signal port included in each port group is also not limited to the foregoing value, and may be flexibly selected according to an actual antenna configuration or deployment. The foregoing predefined port group mapping and mapping indication information may enable a system to adapt to more antenna configurations and antenna array deployments.

[0108] In the power ratio information in step 201, power ratios of data channels on antenna ports in each port group among the at least one port group to a reference signal are the same. 16 reference signal ports are used as an example, and it is assumed that a data channel is a PDSCH, and a power corresponds to an EPRE, so that a signal power ratio

of a 4-port group may be:

Table 4-Power ratio

Port group number	0	1	2	3
A ratio of an EPRE of a PDSCH to an EPRE of a reference signal	$\rho 0$	$\rho 1$	$\rho 2$	$\rho 3$

[0109] Further, power ratios of data channels on each antenna port in the at least one port group to a reference signal are equal. Table 4 is used as an example, where power ratios of data channels on ports in a port group 0 to a reference signal may be equal.

[0110] Optionally, as another embodiment, in the power ratio information in step 201, power ratios of data channels on ports in one port group among the at least one port group and data channels on ports in another port group to a reference signal are the same.

[0111] Specifically, a port group having 4 ports is used as an example. For example, ports of a port group 0 are 0, 1, 4, and 5, and ports of a port group 1 are 2, 3, 6, and 7. Power ratios of data channels in the port group 0 to a reference signal are shown in Table 4a.

Table 4a-Power ratio of a port group 0

Port number	0	1	4	5
A ratio of an EPRE of a PDSCH to an EPRE of a reference signal	$\rho 0$	$\rho 1$	$\rho 2$	$\rho 3$

[0112] The power ratios of data channels, corresponding to the ports in the port group 0 and the ports in the port group 1, to a reference signal are the same; that is, power ratios of data channels, corresponding to the ports 2, 3, 6, and 7 in the port group 1, to a reference signal are respectively $\rho 0$, $\rho 1$, $\rho 2$, and $\rho 3$.

[0113] Optionally, as another embodiment, the power ratio of the data channel in the one or more port groups to the reference signal in step 201 may include multiple sets of values. The sets of values may be values shown in Table 4 or 4a.

[0114] In addition, the reference signal resource configuration information may further include: any one of a reference signal configuration and a reference signal subframe configuration. The reference signal configuration may include a subcarrier used by a reference signal port or an OFDM symbol or a code resource. The reference signal subframe configuration may include a subframe position occupied by a reference signal port, a subframe period or a subframe offset. It should be pointed out that the reference signal configuration or the reference signal subframe configuration may also be predefined, or is implicitly derived according to a parameter, for example, a cell ID or a UE ID, that is known in advance, and is known to both the base station and the UE, which is not limited in this embodiment of the present invention.

[0115] Step 202: Obtain a power ratio of a data channel on each antenna port in the at least one port group to a reference signal according to the reference signal port configuration information and the power ratio information.

[0116] Step 203: Obtain channel state information CSI according to the power ratio of the data channel on each antenna port to the reference signal.

[0117] Specifically, the obtaining channel state information CSI according to the power ratio of the data channel on each antenna port to the reference signal may include:

obtaining, according to the reference signal on each antenna port, a channel measurement value corresponding to each antenna port;

obtaining a channel estimation value of the data channel on each antenna port according to the channel measurement value corresponding to each antenna port and the power ratio of the data channel on each antenna port to the reference signal; and

obtaining the channel state information CSI according to the channel estimation value of the data channel on each antenna port.

[0118] It should be pointed out that the present invention does not limit an execution sequence of obtaining a channel measurement value corresponding to each reference signal port in the at least one port group and obtaining a power ratio of a data channel, corresponding to each antenna port in the at least one port group, to a reference signal.

[0119] Specifically, the reference signal may specifically include a cell-specific reference signal CSR, or a received channel state information reference signal (CSI-RS), or a demodulation reference signal (DMRS).

[0120] The channel state information (CSI) may be a channel quality indicator (CQI) or a precoding matrix indicator (PMI) or a rank indicator (RI); or may be other channel state information such as a precoding type indicator (PTI).

[0121] Specifically, when calculating channel state information based on a ratio of an EPRE of a PDSCH signal to an EPRE of a channel state information reference signal (CSI-RS), the UE obtains a transmit power of a corresponding PDSCH on an antenna port.

[0122] 16 reference signal ports are used as an example, and it is assumed that the reference signal port configuration information notified in step 201 includes: a quantity of reference signal ports is 16 and a mapping index is 1; a mapping relationship is shown in Table 2, and power ratios are shown in Table 4. It can be known according to Table 2 and Table 4 that:

EPRE or power ratios of PDSCHs, corresponding to reference signal ports 0, 1, 12, and 13, to a reference signal are $\rho 0$;
EPRE or power ratios of PDSCHs, corresponding to reference signal ports 2,3,14, and 15, to a reference signal are $\rho 1$;
EPRE or power ratios of PDSCHs, corresponding to reference signal ports 4, 5, 8, and 9, to a reference signal are $\rho 2$; and
EPRE or power ratios of PDSCHs, corresponding to reference signal ports 6, 7, 10, and 11, to a reference signal are $\rho 3$.

[0123] It should be noted that the reference signal ports correspond to the antenna ports on a one-to-one basis.

[0124] In addition, the UE receives a reference signal according to the reference signal resource configuration information, and a channel measurement value corresponding to each antenna port may be obtained as follows:

$$\mathbf{H} = \begin{bmatrix} \mathbf{h}_0 & \mathbf{h}_1 & \cdots & \mathbf{h}_{15} \end{bmatrix}$$

where $\mathbf{h}_p$,p= 0,...,15 is a channel measurement value corresponding to an antenna port p, and the measurement value may be obtained based on a manner such as the least square method according to a specific reference signal such as a CSI RS, which is the prior art and is not further elaborated.

[0125] According to the foregoing channel measurement value corresponding to each antenna port, the UE may obtain a channel measurement value or channel estimation value of a data channel PDSCH on each antenna port according to an EPRE or power ratio of the PDSCH to a reference signal, as follows:

$$\hat{\mathbf{H}} = \begin{bmatrix} \hat{\mathbf{h}}_0 & \hat{\mathbf{h}}_1 & \cdots & \hat{\mathbf{h}}_{15} \end{bmatrix}$$

where a channel measurement value or channel estimation value $\hat{\mathbf{h}}_p$ of a data channel PDSCH on the antenna port p is:

$$\hat{\mathbf{h}}_p = \sqrt{\rho_p}\mathbf{h}_p$$

where p is an index of the antenna port, ρ_p is a power ratio of the data channel on the antenna port p to a reference signal, $\mathbf{h}_p$ is a channel measurement value corresponding to the antenna port p, and $\hat{\mathbf{h}}_p$ is a channel estimation value of the data channel on the antenna port p; that is,

$$\hat{\mathbf{h}}_p = \begin{cases} \sqrt{\rho 0}\mathbf{h}_p, p = 0,1,12,13 \\ \sqrt{\rho 1}\mathbf{h}_p, p = 2,3,14,15 \\ \sqrt{\rho 2}\mathbf{h}_p, p = 4,5,8,9 \\ \sqrt{\rho 3}\mathbf{h}_p, p = 6,7,10,11 \end{cases}$$

the UE may calculate channel state information CSI based on the following equation (5):

$$\mathrm{y} = \hat{\mathrm{H}}\mathrm{Ps} + \mathrm{n} \qquad (5)$$

where **P** is a precoding matrix, and for a non-precoding system, P is a unit array; **S** is a sent information symbol, for example, a modulation symbol; **n** is interference and noise vectors; and **y** is a received signal.

[0126] The channel state information, for example, any one or any combination of a channel quality indicator (CQI) or a precoding matrix indicator (PMI)/a rank indicator (RI) is obtained according to the equation (5) above. A specific process of obtaining channel state information, for example, a CQI or a PMI or an RI according to the equation (5) above is the prior art, which is no longer further elaborated herein.

[0127] Optionally, as another embodiment, the power ratio information is used for indicating multiple sets of power ratios of data channels of the at least one port group to a reference signal.

[0128] 16 reference signal ports are used as an example, and it is assumed that the reference signal port configuration information notified in step 201 includes: a quantity of reference signal ports is 16 and a mapping index is 1; a mapping relationship is shown in Table 2, and power ratios are shown in Table 4b. It can be known according to Table 2 and Table 4b that:

EPRE ratios or a first set of power ratios of PDSCHs, corresponding to reference signal ports 0, 1, 12, and 13, to a reference signal are x0;
EPRE ratios or a first set of power ratios of PDSCHs, corresponding to reference signal ports 2, 3, 14, and 15, to a reference signal are x1;
EPRE ratios or a first set of power ratios of PDSCHs, corresponding to reference signal ports 4, 5, 8, and 9, to a reference signal are x2;
EPRE ratios or a first set of power ratios of PDSCHs, corresponding to reference signal ports 6, 7, 10, and 11, to a reference signal are x3;
EPRE ratios or a second set of power ratios of PDSCHs, corresponding to reference signal ports 0, 1, 12, and 13, to a reference signal are y0;
EPRE ratios or a second set of power ratios of PDSCHs, corresponding to reference signal ports 2, 3, 14, and 15, to a reference signal are y1;
EPRE ratios or a second set of power ratios of PDSCHs, corresponding to reference signal ports 4, 5, 8, and 9, to a reference signal are y2; and
EPRE ratios or a second set of power ratios of PDSCHs, corresponding to reference signal ports 6, 7, 10, and 11, to a reference signal are y3.

Table 4b-Multiple sets of power ratios of a port group 0

Port number	0	1	4	5
A first ratio of an EPRE of a PDSCH to an EPRE of a reference signal	x0	x1	x2	x3
A second ratio of an EPRE of a PDSCH to an EPRE of a reference signal	y0	y1	y2	y3

[0129] Step 204: Send the channel state information CSI to the base station.

[0130] Specifically, the channel state information may be sent to the base station by using a physical uplink control channel PUCCH or a physical uplink shared channel PUSCH.

[0131] Optionally, the sending the channel state information CSI to the base station includes: sending multiple sets of channel state information CSI to the base station, where each set of channel state information CSI is obtained according to one set of power ratios among the multiple sets of power ratios.

[0132] 16 reference signal ports are used as an example, and it is assumed that the reference signal port configuration information notified in step 201 includes: a quantity of reference signal ports is 16 and a mapping index is 1; a mapping relationship is shown in Table 2, and power ratios are shown in Table 4b. It can be known according to Table 2 and Table 4b that UE sends two sets of channel state information CSI to the base station. The first set of CSI is calculated according to a first set of power ratios in Table 4c below:

Table 4c-First set of power ratios of a port group 0

Port number	0	1	4	5
A ratio of an EPRE of a PDSCH to an EPRE of a reference signal	x0	x1	x2	x3

[0133] The second set of CSI is calculated according to a second set of power ratios in Table 4d:

Table 4d-Second set of power ratios of a port group 0

Port number	0	1	4	5
A ratio of an EPRE of a PDSCH to an EPRE of a reference signal	y0	y1	y2	y3

[0134] In the foregoing, a port group is used to separately indicate a ratio of a power of a data channel to a power of a reference signal, which can reduce a signaling overhead and enable a system to flexibly configure a signal power according to an antenna configuration or an antenna array structure. In addition, it should be further pointed out that although grouping of a port group is not limited to a port group including 4 reference signal ports, grouping of port groups and formation of ports in Tables 1, 2, and 3 above may further enable the antenna arrays in FIG. 3 or FIG. 4 to have powers symmetric about array structures, that is, the ports may have symmetric weights relative to the array, so as to implement beamforming or side lobe suppression.

Embodiment 5

[0135] This embodiment of the present invention provides a network side apparatus. As shown in FIG. 7, the apparatus includes: a determining unit 601 and a first sending unit 602.

[0136] The determining unit 601 is configured to determine reference signal resource configuration information, where the reference signal resource configuration information includes reference signal port configuration information, where the reference signal port configuration information is used for indicating a mapping relationship between a reference signal port and a port group.

[0137] The first sending unit 602 is configured to send, to user equipment, the reference signal resource configuration information determined by the determining unit 601, so that the user equipment acquires signal quality measurement information according to the reference signal port configuration information.

[0138] The network side apparatus described in this embodiment may be a base station on a network side, and reference may be made to the description of the corresponding steps in Embodiment 1 for implementation of functions of units of the network side apparatus, which is no longer repeated herein.

[0139] In the apparatus described in Embodiment 5 above, reference signal resource configuration information is determined on a network side, and the reference signal resource configuration information is sent to a user side, where the reference signal resource configuration information includes reference signal port configuration information, where the reference signal port configuration information is used for indicating a mapping relationship between a reference signal port and a port group. The apparatus can avoid that reference signal power related information is indicated port by port, so as to reduce a signaling overhead; further, a uniform power indicator is used for ports in a port group, and for different port groups, power related information of the port groups may be indicated independently, so that full use of an antenna configuration or an antenna array structure is made, thereby enabling a system to flexibly select reference signal power related information according to the antenna configuration or the antenna array structure; because an antenna array may have symmetric weights, by means of the symmetry of the weights, design complexity in beamforming or side lobe suppression can be reduced.

[0140] Further, the reference signal resource configuration information is sent to UE on the user side, and the UE may perform processing according to reference signal quality, of at least one port group, in the reference signal resource configuration information to obtain final signal quality measurement information, so that a UE side can distinguish ports according to different port groups, which differs from a case in which transmit powers of different ports cannot be distinguished in the prior art. The UE is enabled to acquire signal quality measurement information, so that the UE can perform more accurate cell selection and uplink power control.

[0141] Optionally, the reference signal resource configuration information determined by the determining unit 601 further includes: reference signal power information of at least two port groups that is used by the user equipment to acquire the signal quality measurement information according to the reference signal port configuration information and in combination with the reference signal power information of the at least two port groups; and
the reference signal power information of the at least two port groups includes:

a reference signal power of a first port group, and a ratio of a reference signal power of each port group among the rest port groups to the reference signal power of the first port group; or
a reference signal power of a first port group, and a differential between a reference signal power of each port group among the rest port groups and the reference signal power of the first port group.

[0142] Optionally, when the signal quality measurement information is a reference signal received power RSRP, the

first sending unit 602 is further configured to send, to the user equipment, filter coefficient information that is used by the user equipment to perform, based on the filter coefficient information, filtering on the reference signal received power RSRP and obtain a path loss estimation value.

[0143] Optionally, the apparatus further includes:

a first receiving unit 603, configured to receive an uplink physical channel or an uplink physical signal sent by the user equipment, where a transmit power of the uplink physical channel or the uplink physical signal is obtained by means of calculation by the user equipment according to the path loss estimation value.

[0144] Optionally, the signal quality measurement information includes:

any one or any combination of a reference signal received power RSRP, a reference signal received quality RSRQ, and a reference signal strength indicator RSSI.

[0145] Optionally, the apparatus further includes: a second receiving unit 604, where

the second receiving unit 604 is configured to receive the signal quality measurement information sent by the user equipment.

[0146] The first receiving unit 603 and the second receiving unit 604 may be integrated in a same physical module, or may be regarded as being implemented by using a same module; the description of the first receiving unit and the second receiving unit is used for better understanding of connection relationships among modules in the network side apparatus.

Embodiment 6

[0147] This embodiment of the present invention provides user equipment. As shown in FIG. 8, the user equipment includes: a third receiving unit 701, a first acquiring unit 702, and a second acquiring unit 703.

[0148] The third receiving unit 701 is configured to receive reference signal resource configuration information sent by a base station, where the reference signal resource configuration information includes reference signal port configuration information, where the reference signal port configuration information is used for indicating a mapping relationship between a reference signal port and a port group.

[0149] The first acquiring unit 702 is configured to obtain reference signal port information in at least one port group according to the reference signal port configuration information received by the third receiving unit 701.

[0150] The second acquiring unit 703 is configured to acquire signal quality measurement information according to the reference signal port information, in the at least one port group, obtained by the first acquiring unit 702.

[0151] For the user equipment described in this embodiment, reference may be made to the description of the corresponding steps in Embodiment 2 for implementation of functions of units of the user equipment, which is no longer repeated herein.

[0152] The apparatus described in Embodiment 6 above receives reference signal resource configuration information determined on a network side, where the reference signal resource configuration information includes reference signal port configuration information, where the reference signal port configuration information is used for indicating a mapping relationship between a reference signal port and a port group. The apparatus can avoid that reference signal power related information is indicated port by port, so as to reduce a signaling overhead; further, a uniform power indicator is used for ports in a port group, and for different port groups, power related information of the port groups may be indicated independently, so that full use of an antenna configuration or an antenna array structure is made, thereby enabling a system to flexibly select reference signal power related information according to the antenna configuration or the antenna array structure; because an antenna array may have symmetric weights, by means of the symmetry of the weights, design complexity in beamforming or side lobe suppression can be reduced.

[0153] Further, the reference signal resource configuration information is sent to UE on a user side, and the UE may perform processing according to reference signal quality, of at least one port group, in the reference signal resource configuration information to obtain final signal quality measurement information, so that a UE side can distinguish ports according to different port groups, which differs from a case in which transmit powers of different ports cannot be distinguished in the prior art. The UE is enabled to acquire signal quality measurement information, so that the UE can perform more accurate cell selection and uplink power control.

[0154] Optionally, the first acquiring unit 702 is specifically configured to obtain reference signal port information in one specified port group according to the reference signal port configuration information received by the third receiving unit 701.

[0155] The second acquiring unit 703 is specifically configured to acquire the signal quality measurement information according to the reference signal port information, in the one specified port group, obtained by the first acquiring unit 702.

[0156] Optionally, when the signal quality measurement information is a reference signal received power RSRP, the second acquiring unit 703 is specifically configured to:

obtain reference signal received power $RSRP(r,p)$ of a pth port of an rth receive antenna according to a formula

$$RSRP(r,p)=\frac{1}{K_s-1}\sum_{m=0}^{K_s-1}\hat{h}_p(m)\cdot\hat{h}_p(m+1)$$ and obtain the RSRP by combining $RSRP(r,p)$, where $\hat{h}_p(m)$ is a channel estimation on a reference signal RE whose label number is m, K_s is a total sample quantity of usable reference signal REs in measurement bandwidth, p is a number of a reference signal port in the one specified port group, and r is an index of a receive antenna.

[0157] Optionally, the reference signal resource configuration information received by the third receiving unit 701 further includes: reference signal power information of at least two port groups.

[0158] The second acquiring unit 703 is further configured to acquire the signal quality measurement information according to the reference signal port configuration information and in combination with the reference signal power information of the at least two port groups.

[0159] Optionally, the second acquiring unit 703 is specifically configured to:

obtain, according to the reference signal port configuration information, signal quality measurement information corresponding to the at least two port groups; and
perform, according to the reference signal power information of the at least two port groups, weighted averaging on the obtained signal quality measurement information corresponding to the at least two port groups in accordance with a port group power, to obtain the signal quality measurement information.

[0160] Optionally, the performing, by the second acquiring unit 703, according to the reference signal power information of the at least two port groups, weighted averaging on the obtained signal quality measurement information corresponding to the at least two port groups in accordance with a port group power, to obtain the signal quality measurement information includes:

obtaining the signal quality measurement information according to a formula

$$SQ=\left(\sum_{g=0}^{n-1}p_g\cdot SQ_g\right)\Big/\left(\sum_{g=0}^{n-1}p_g\right),$$

where
SQ_g is signal quality measurement information of a specified port group, g is a sequence number of a specified port group, n is a quantity of specified port groups, $n \geq 2$, and p_g is a reference signal power of a specified port group, where the reference signal power of the specified port group is obtained according to the reference signal power information of the at least two port groups.

[0161] Optionally, the reference signal power information, of the at least two port groups, received by the third receiving unit 701 includes:

a reference signal power of a first port group, and a ratio of a reference signal power of each port group among the rest port groups to the reference signal power of the first port group; or
a reference signal power of a first port group, and a differential between a reference signal power of each port group among the rest port groups and the reference signal power of the first port group.

[0162] Optionally, the user equipment further includes: a second sending unit 704, configured to send the signal quality measurement information to the base station.

[0163] Optionally,
the third receiving unit 701 is further configured to: when the signal quality measurement information is a reference signal received power RSRP, receive filter coefficient information sent by the base station; and
the user equipment further includes: a third acquiring unit 705, where
the third acquiring unit 705 is configured to perform, based on the filter coefficient information received by the third receiving unit 701, filtering on the reference signal received power RSRP, and obtain a path loss estimation value.

[0164] Optionally, the user equipment further includes: a third sending unit 706, where
the third sending unit 706 is further configured to send an uplink physical channel or an uplink physical signal to the base station, where a transmit power of the uplink physical channel or the uplink physical signal is obtained by means of calculation according to the path loss estimation value.

[0165] The third sending unit 706 and the second sending unit 704 may be implemented by using a same physical module, and this time are described separately for ease of understanding.

[0166] Optionally, the signal quality measurement information includes: a reference signal received power RSRP, a reference signal strength indicator RSSI, or a reference signal received quality RSRQ.

Embodiment 7

[0167] This embodiment of the present invention provides a network side apparatus. As shown in FIG. 9, the apparatus includes: a fourth sending unit 801 and a fourth receiving unit 802.

[0168] The fourth sending unit 801 is configured to send reference signal resource configuration information to user equipment, where the reference signal resource configuration information includes: reference signal port configuration information and power ratio information, where the reference signal port configuration information is used for indicating a mapping relationship between the reference signal port and a port group, and the power ratio information is used for indicating a power ratio of a data channel of at least one port group to a reference signal.

[0169] The fourth receiving unit 802 is configured to receive channel state information CSI sent by the user equipment, where the CSI is obtained by the user equipment according to the reference signal port configuration information and the power ratio information.

[0170] The network side apparatus described in Embodiment 7 above determines reference signal resource configuration information by using a network side, and sends the reference signal resource configuration information to a user side, where the reference signal resource configuration information includes reference signal port configuration information and power ratio information, where the reference signal port configuration information is used for indicating a mapping relationship between the reference signal port and a port group, and the power ratio information is used for indicating a power ratio of a data channel of at least one port group to a reference signal. The apparatus can avoid that reference signal power related information is indicated port by port, so as to reduce a signaling overhead; further, a uniform power indicator is used for ports in a port group, and for different port groups, power related information of the port groups may be indicated independently, so that full use of an antenna configuration or an antenna array structure is made, thereby enabling a system to flexibly select reference signal power related information according to the antenna configuration or the antenna array structure; because an antenna array may have symmetric weights, by means of the symmetry of the weights, design complexity in beamforming or side lobe suppression can be reduced.

[0171] Further, the reference signal resource configuration information is sent to UE on the user side, and the UE may perform processing according to reference signal quality, of one port group or multiple port groups, in the reference signal resource configuration information to obtain final signal quality measurement information, so that a UE side can distinguish ports according to different port groups, which differs from a case in which transmit powers of different ports cannot be distinguished in the prior art. The UE is enabled to acquire channel state information, so that the UE can perform more accurate modulation and coding scheme (MCS) selection or scheduling, thereby increasing a throughput of a system.

[0172] Optionally, in the power ratio information:

power ratios of data channels on antenna ports in each port group among the at least one port group to a reference signal are the same; or

power ratios of data channels on ports in one port group among the at least one port group and data channels on ports in another port group to a reference signal are the same.

[0173] Optionally, the power ratio information is used for indicating multiple sets of power ratios of data channels of the at least one port group to a reference signal; and

the fourth receiving unit 802 is specifically configured to receive multiple sets of channel state information CSI that are sent by the user equipment, where each set of channel state information CSI is obtained by the user equipment according to one set of power ratios among the multiple sets of power ratios.

[0174] Optionally, the channel state information CSI received by the fourth receiving unit 802 includes: any one or any combination of a channel quality indicator CQI, a precoding matrix indicator PMI, and a rank indicator RI.

[0175] The network side apparatus provided in this embodiment may be a base station on a network side, and reference may be made to the description of the corresponding steps in Embodiment 3 for implementation of functions of units of the network side apparatus, which is no longer repeated herein.

Embodiment 8

[0176] This embodiment of the present invention provides user equipment. As shown in FIG. 10, the user equipment includes: a fifth receiving unit 901, a fourth acquiring unit 902, a fifth acquiring unit 903, and a fifth sending unit 904.

[0177] The fifth receiving unit 901 is configured to receive reference signal resource configuration information sent by a base station, where the reference signal resource configuration information includes: reference signal port configuration information and power ratio information, where the reference signal port configuration information is used for indicating a mapping relationship between the reference signal port and a port group, and the power ratio information is used for indicating a power ratio of a data channel of at least one port group to a reference signal.

[0178] The fourth acquiring unit 902 is configured to obtain a power ratio of a data channel on each antenna port in the at least one port group to a reference signal according to the reference signal port configuration information and the power ratio information that are received by the fifth receiving unit 901.

[0179] The fifth acquiring unit 903 is configured to obtain channel state information CSI according to the power ratio, of the data channel on each antenna port to the reference signal, obtained by the fourth acquiring unit 902.

[0180] The fifth sending unit 904 is configured to send, to the base station, the channel state information CSI obtained by the fifth acquiring unit 903.

[0181] This embodiment of the present invention provides user equipment. The apparatus may perform processing according to reference signal quality of one port group or multiple port groups to obtain final signal quality measurement information, so that a UE side can distinguish ports according to different port groups, which differs from a case in which transmit powers of different ports cannot be distinguished in the prior art. The UE is enabled to acquire channel state information, so that the UE can perform more accurate modulation and coding scheme (MCS) selection or scheduling, thereby increasing a throughput of a system.

[0182] Optionally, the fifth acquiring unit 903 is specifically configured to:

obtain, according to the reference signal on each antenna port, a channel measurement value corresponding to each antenna port;
obtain a channel estimation value of the data channel on each antenna port according to the channel measurement value corresponding to each antenna port and the power ratio of the data channel on each antenna port to the reference signal; and
obtain the channel state information CSI according to the channel estimation value of the data channel on each antenna port.

[0183] Optionally, the obtaining, by the fifth acquiring unit 903, a channel estimation value of the data channel on each antenna port according to the channel measurement value corresponding to each antenna port and the power ratio of the data channel on each antenna port to the reference signal includes:
obtaining a channel estimation value of a data channel on an antenna port p according to a formula

$$\hat{\mathbf{h}}_p = \sqrt{\rho_p}\mathbf{h}_p,$$

where
p is an index of the antenna port, ρ_p is a power ratio of the data channel on the antenna port p to a reference signal, $\mathbf{h}_p$ is a channel measurement value corresponding to the antenna port p, and $\hat{\mathbf{h}}_p$ is a channel estimation value of the data channel on the antenna port p.

[0184] Optionally, in the power ratio information:

power ratios of data channels on antenna ports in each port group among the at least one port group to a reference signal are the same; or
power ratios of data channels on ports in one port group among the at least one port group and data channels on ports in another port group to a reference signal are the same.

[0185] Optionally, the reference signal resource configuration information received by the fifth receiving unit 901 includes: the reference signal port configuration information and the power ratio information.

[0186] The power ratio information is used for indicating multiple sets of power ratios of data channels of the at least one port group to a reference signal; and
the fifth sending unit 904 is specifically configured to:
send multiple sets of channel state information CSI to the base station, where each set of channel state information CSI is obtained according to one set of power ratios among the multiple sets of power ratios.

[0187] Optionally, the channel state information CSI obtained by the fifth acquiring unit 903 includes: any one or any combination of a channel quality indicator CQI, a precoding matrix indicator PMI, and a rank indicator RI.

[0188] For the user equipment provided in this embodiment, reference may be made to the description of the corre-

sponding steps in Embodiment 4 for implementation of functions of units of the user equipment, which is no longer repeated herein.

Embodiment 9

[0189] A network side apparatus is provided and can support a radio communications technology. Transmission of a data packet can be performed based on the method described in Embodiment 1 among units in a communications device in this embodiment. A schematic structural diagram is shown in FIG. 11, and the network side apparatus includes: a processor 21, a receiver 23, and a transmitter 24 that are separately connected to a bus.

[0190] Optionally, the shown network side apparatus may further include: a memory 20.

[0191] Where:

the memory 20 is configured to store data input from the receiver 23, and may further store information such as a necessary file for the processor 21 to process data; and the receiver 23 and the transmitter 24 are ports by using which a communications device communicates with another device.

[0192] The processor 21 is configured to determine reference signal resource configuration information, where the reference signal resource configuration information includes reference signal port configuration information, where the reference signal port configuration information is used for indicating a mapping relationship between a reference signal port and a port group.

[0193] The transmitter 24 is configured to send the reference signal resource configuration information to user equipment, so that the user equipment acquires signal quality measurement information according to the reference signal port configuration information.

[0194] Optionally, the reference signal resource configuration information determined by the processor 21 further includes: reference signal power information of at least two port groups that is used by the user equipment to acquire the signal quality measurement information according to the reference signal port configuration information and in combination with the reference signal power information of the at least two port groups.

[0195] The reference signal power information of the at least two port groups includes:

a reference signal power of a first port group, and a ratio of a reference signal power of each port group among the rest port groups to the reference signal power of the first port group; or

a reference signal power of a first port group, and a differential between a reference signal power of each port group among the rest port groups and the reference signal power of the first port group.

[0196] Optionally, when the signal quality measurement information is a reference signal received power RSRP, the transmitter 24 is further configured to send, to the user equipment, filter coefficient information that is used by the user equipment to perform, based on the filter coefficient information, filtering on the reference signal received power RSRP and obtain a path loss estimation value.

[0197] Optionally, the receiver 23 is configured to receive an uplink physical channel or an uplink physical signal sent by the user equipment, where a transmit power of the uplink physical channel or the uplink physical signal is obtained by means of calculation by the user equipment according to the path loss estimation value.

[0198] Optionally, the signal quality measurement information includes:

any one or any combination of a reference signal received power RSRP, a reference signal received quality RSRQ, and a reference signal strength indicator RSSI.

[0199] Optionally, the receiver 23 is further configured to receive the signal quality measurement information sent by the user equipment.

[0200] The network side apparatus described in this embodiment may be a base station on a network side, and reference may be made to the description of the corresponding steps in Embodiment 1 for implementation of functions of units of the network side apparatus, which is no longer repeated herein.

Embodiment 10

[0201] This embodiment provides user equipment, which can support a radio communications technology. Transmission of a data packet can be performed based on the method described in Embodiment 2 among units in a communications device in this embodiment. A schematic structural diagram is shown in FIG. 12, and the user equipment includes: a processor 31, a receiver 33, and a transmitter 34 that are separately connected to a bus.

[0202] Optionally, the shown network side apparatus may further include: a memory 30.

[0203] The memory 30 is configured to store data input from the receiver 33, and may further store information such as a necessary file for the processor 31 to process data; and the receiver 33 and the transmitter 34 are ports by using which a communications device communicates with another device.

[0204] The receiver 33 is configured to receive reference signal resource configuration information sent by a base station, where the reference signal resource configuration information includes reference signal port configuration information, where the reference signal port configuration information is used for indicating a mapping relationship between a reference signal port and a port group.

[0205] The processor 31 is configured to obtain reference signal port information in at least one port group according to the reference signal port configuration information; and acquire signal quality measurement information according to the reference signal port information in the at least one port group.

[0206] Optionally, the processor 31 is specifically configured to:

obtain reference signal port information in one specified port group according to the reference signal port configuration information; and
acquire the signal quality measurement information according to the reference signal port information in the one specified port group.

[0207] Optionally, when the signal quality measurement information is a reference signal received power RSRP, the acquiring, by the processor 31, the signal quality measurement information according to the reference signal port information in the one specified port group includes:
obtaining a reference signal received power $RSRP(r,p)$ of a pth port of an rth receive antenna according to a formula

$$RSRP(r,p)=\frac{1}{K_s-1}\sum_{m=0}^{K_s-1}\hat{h}_p(m)\cdot\hat{h}_p(m+1)$$

and obtaining the RSRP by combining $RSRP(r,p)$, where $\hat{h}_p(m)$ is a channel estimation on a reference signal RE whose label number is m, K_s is a total sample quantity of usable reference signal REs in measurement bandwidth, p is a number of a reference signal port in the one specified port group, and r is an index of a receive antenna.

[0208] Optionally, the reference signal resource configuration information received by the receiver 33 further includes: reference signal power information of at least two port groups that is used by the user equipment to acquire the signal quality measurement information according to the reference signal port configuration information and in combination with the reference signal power information of the at least two port groups.

[0209] Optionally, the acquiring, by the processor 31, the signal quality measurement information according to the reference signal port configuration information and in combination with the reference signal power information of the at least two port groups includes:

obtaining, according to the reference signal port configuration information, signal quality measurement information corresponding to the at least two port groups; and
performing, according to the reference signal power information of the at least two port groups, weighted averaging on the obtained signal quality measurement information corresponding to the at least two port groups in accordance with a port group power, to obtain the signal quality measurement information.

[0210] Optionally, the performing, by the processor 31, according to the reference signal power information of the at least two port groups, weighted averaging on the obtained signal quality measurement information corresponding to the at least two port groups in accordance with a port group power, to obtain the signal quality measurement information includes:
obtaining the signal quality measurement information according to a formula

$$SQ=\left(\sum_{g=0}^{n-1}p_g\cdot SQ_g\right)\Big/\left(\sum_{g=0}^{n-1}p_g\right),$$

where
SQ_g is signal quality measurement information of a specified port group, g is a sequence number of a specified port group, n is a quantity of specified port groups, $n\geq 2$, and p_g is a reference signal power of a specified port group, where the reference signal power of the specified port group is obtained according to the reference signal power information of the at least two port groups.

[0211] Optionally, the reference signal power information, of the at least two port groups, received by the receiver 33 includes:

a reference signal power of a first port group, and a ratio of a reference signal power of each port group among the rest port groups to the reference signal power of the first port group; or
a reference signal power of a first port group, and a differential between a reference signal power of each port group among the rest port groups and the reference signal power of the first port group.

[0212] Optionally, the transmitter 34 is configured to send the signal quality measurement information to the base station.

[0213] Optionally, when the signal quality measurement information is a reference signal received power RSRP, the receiver 33 is further configured to receive filter coefficient information sent by the base station; and
the processor 31 is further configured to perform, based on the filter coefficient information, filtering on the reference signal received power RSRP, and obtain a path loss estimation value.

[0214] Optionally, the transmitter 34 is further configured to send an uplink physical channel or an uplink physical signal to the base station, where a transmit power of the uplink physical channel or the uplink physical signal is obtained by means of calculation according to the path loss estimation value.

[0215] Optionally, the signal quality measurement information includes: a reference signal received power RSRP, a reference signal strength indicator RSSI, or a reference signal received quality RSRQ.

Embodiment 11

[0216] A network side apparatus is provided and can support a radio communications technology. Transmission of a data packet can be performed based on the method described in Embodiment 3 among units in a communications device in this embodiment. A schematic structural diagram is shown in FIG. 13, and the network side apparatus includes: a processor 41, a receiver 43, and a transmitter 44 that are separately connected to a bus.

[0217] Optionally, the shown network side apparatus may further include: a memory 40.

[0218] The memory 40 is configured to store data input from the receiver 43, and may further store information such as a necessary file for the processor 41 to process data; and the receiver 43 and the transmitter 44 are ports by using which a communications device communicates with another device.

[0219] The transmitter 44 is configured to send reference signal resource configuration information to user equipment, where the reference signal resource configuration information includes: reference signal port configuration information and power ratio information, where the reference signal port configuration information is used for indicating a mapping relationship between the reference signal port and a port group, and the power ratio information is used for indicating a power ratio of a data channel of at least one port group to a reference signal; and
the receiver 43 is configured to receive channel state information CSI sent by the user equipment, where the CSI is obtained by the user equipment according to the reference signal port configuration information and the power ratio information.

[0220] Optionally, in the power ratio information:

power ratios of data channels on antenna ports in each port group among the at least one port group to a reference signal are the same; or
power ratios of data channels on ports in one port group among the at least one port group and data channels on ports in another port group to a reference signal are the same.

[0221] Optionally, the power ratio information is used for indicating multiple sets of power ratios of data channels of the at least one port group to a reference signal; and
the receiving, by the receiver 33, channel state information CSI sent by the user equipment includes: receiving multiple sets of channel state information CSI that are sent by the user equipment, where each set of channel state information CSI is obtained by the user equipment according to one set of power ratios among the multiple sets of power ratios.

[0222] Optionally, the channel state information CSI received by the receiver 33 includes: any one or any combination of a channel quality indicator CQI, a precoding matrix indicator PMI, and a rank indicator RI.

[0223] The network side apparatus provided in this embodiment may be a base station on a network side, and reference may be made to the description of the corresponding steps in Embodiment 3 for implementation of functions of units of the network side apparatus, which is no longer repeated herein.

Embodiment 12

[0224] This embodiment provides user equipment, which can support a radio communications technology. Transmission of a data packet can be performed based on the method described in Embodiment 4 among units in a communications device in this embodiment. A schematic structural diagram is shown in FIG. 14, and the user equipment includes: a

processor 51, a receiver 53, and a transmitter 54 that are separately connected to a bus.

[0225] Optionally, the shown network side apparatus may further include: a memory 50.

[0226] The memory 50 is configured to store data input from the receiver 53, and may further store information such as a necessary file for the processor 51 to process data; and the receiver 53 and the transmitter 54 are ports by using which a communications device communicates with another device.

[0227] The receiver 53 is configured to receive reference signal resource configuration information sent by a base station, where the reference signal resource configuration information includes: reference signal port configuration information and power ratio information, where the reference signal port configuration information is used for indicating a mapping relationship between the reference signal port and a port group, and the power ratio information is used for indicating a power ratio of a data channel of at least one port group to a reference signal.

[0228] The processor 51 is configured to obtain a power ratio of a data channel on each antenna port in the at least one port group to a reference signal according to the reference signal port configuration information and the power ratio information, and obtain channel state information CSI according to the power ratio of the data channel on each antenna port to the reference signal.

[0229] The transmitter 54 is configured to send the channel state information CSI to the base station.

[0230] Optionally, the obtaining, by the processor 51, channel state information CSI according to the power ratio of the data channel on each antenna port to the reference signal includes:

obtaining, according to the reference signal on each antenna port, a channel measurement value corresponding to each antenna port;
obtaining a channel estimation value of the data channel on each antenna port according to the channel measurement value corresponding to each antenna port and the power ratio of the data channel on each antenna port to the reference signal; and
obtaining the channel state information CSI according to the channel estimation value of the data channel on each antenna port.

[0231] Optionally, the obtaining, by the processor 51, a channel estimation value of the data channel on each antenna port according to the channel measurement value corresponding to each antenna port and the power ratio of the data channel on each antenna port to the reference signal includes:
obtaining a channel estimation value of a data channel on an antenna port p according to a formula

$$\hat{\mathbf{h}}_p = \sqrt{\rho_p}\mathbf{h}_p,$$

where
p is an index of the antenna port, ρ_p is a power ratio of the data channel on the antenna port p to a reference signal, $\mathbf{h}_p$ is a channel measurement value corresponding to the antenna port p, and $\hat{\mathbf{h}}_p$ is a channel estimation value of the data channel on the antenna port p.

[0232] Optionally, in the power ratio information:

power ratios of data channels on antenna ports in each port group among the at least one port group to a reference signal are the same; or
power ratios of data channels on ports in one port group among the at least one port group and data channels on ports in another port group to a reference signal are the same.

[0233] Optionally, the power ratio information is used for indicating multiple sets of power ratios of data channels of the at least one port group to a reference signal; and
the transmitter 54 is specifically configured to:
send multiple sets of channel state information CSI to the base station, where each set of channel state information CSI is obtained according to one set of power ratios among the multiple sets of power ratios.

[0234] Optionally, the channel state information CSI obtained by the processor 51 includes: any one or any combination of a channel quality indicator CQI, a precoding matrix indicator PMI, and a rank indicator RI.

[0235] A person of ordinary skill in the art may understand that all or a part of the steps of the methods in the embodiments may be implemented by a program instructing relevant hardware. The program may be stored in a computer readable storage medium. The storage medium may include: a ROM, a RAM, a magnetic disk, or an optical disc.

[0236] The method and the apparatus for measuring communication quality provided in the embodiments of the present invention are introduced above in detail. In this specification, specific examples are used to describe the principle and

implementation manners of the present invention, and the description of the embodiments is only intended to help understand the method and core idea of the present invention defined by the scope of the appended claims. Meanwhile, a person of ordinary skill in the art may, based on the idea of the present invention, make modifications with respect to the specific implementation manners. Therefore, the content of this specification shall not be construed as a limitation to the present invention, which is defined by the scope of the appended claims.

Claims

1. A method for measuring communication quality in an active antenna system performed by a user equipment, comprising:

receiving (101) reference signal resource configuration information sent by a base station, wherein the reference signal resource configuration information comprises reference signal port configuration information, wherein the reference signal port configuration information is used for indicating a mapping relationship between a reference signal port and a port group, wherein the port group is a group of ports of an antenna port array;
obtaining (102) reference signal port information in at least one port group according to the reference signal port configuration information; and
acquiring (103) signal quality measurement information according to the reference signal port information in the at least one port group; wherein the reference signal resource configuration information further comprises: reference signal power information of at least two port groups that is used by the user equipment to acquire the signal quality measurement information according to the reference signal port configuration information and in combination with the reference signal power information of the at least two port groups,
characterized in,
that the acquiring the signal quality measurement information according to the reference signal port configuration information and in combination with the reference signal power information of the at least two port groups comprises:

obtaining, according to the reference signal port configuration information, signal quality measurement information corresponding to the at least two port groups; and
performing, according to the reference signal power information of the at least two port groups, weighted averaging on the obtained signal quality measurement information corresponding to the at least two port groups in accordance with a port group power, to obtain the signal quality measurement information,

wherein the performing, according to the reference signal power information of the at least two port groups, weighted averaging on the obtained signal quality measurement information corresponding to the at least two port groups in accordance with a port group power, to obtain the signal quality measurement information comprises:
obtaining the signal quality measurement information according to a formula

$$SQ = \left(\sum_{g=0}^{n-1} p_g \cdot SQ_g \right) \Big/ \left(\sum_{g=0}^{n-1} p_g \right),$$

wherein
SQ_g is signal quality measurement information of a specified port group, g is a sequence number of a specified port group, n is a quantity of specified port groups, $n \geq 2$, and p_g is a reference signal power of a specified port group, wherein the reference signal power of the specified port group is obtained according to the reference signal power information of the at least two port groups.

2. The method according to claim 1, wherein the reference signal power information of the at least two port groups comprises:

a reference signal power of a first port group, and a ratio of a reference signal power of each port group among the rest port groups to the reference signal power of the first port group; or
a reference signal power of a first port group, and a differential between a reference signal power of each port group among the rest port groups and the reference signal power of the first port group.

Patentansprüche

1. Verfahren zum Messen der Kommunikationsqualität in einem aktiven Antennensystem, durchgeführt von einem Benutzergerät, das Folgendes umfasst:

   Empfangen (101) der von einer Basisstation gesendeten Referenzsignal-Ressourcenkonfigurationsinformationen, wobei die Referenzsignal-Ressourcenkonfigurationsinformationen Referenzsignal-Anschlusskonfigurationsinformationen umfassen, wobei die Referenzsignal-Anschlusskonfigurationsinformationen zum Angeben einer Zuordnungsbeziehung zwischen einem Referenzsignalanschluss und einer Anschlussgruppe verwendet werden, wobei die Anschlussgruppe eine Gruppe von Anschlüssen eines Antennenanschlussarrays ist;
   Erhalten (102) von Referenzsignal-Anschlussinformationen in mindestens einer Anschlussgruppe gemäß den Referenzsignal-Anschlusskonfigurationsinformationen; und
   Erfassen (103) von Signalqualitätsmessungsinformationen gemäß den Referenzsignal-Anschlussinformationen in der mindestens einen Anschlussgruppe; wobei die Referenzsignal-Ressourcenkonfigurationsinformationen ferner Folgendes umfassen: Referenzsignal-Leistungsinformationen von mindestens zwei Anschlussgruppen, die von dem Benutzergerät verwendet werden, um die Signalqualitätsmessungsinformationen gemäß den Referenzsignal-Anschlusskonfigurationsinformationen und in Kombination mit den Referenzsignal-Leistungsinformationen der mindestens zwei Anschlussgruppen zu erfassen,
   gekennzeichnet dadurch,
   dass das Erfassen der Signalqualitätsmessungsinformationen gemäß den Referenzsignal-Anschlusskonfigurationsinformationen und in Kombination mit den Referenzsignal-Leistungsinformationen der mindestens zwei Anschlussgruppen Folgendes umfasst:

      Erhalten, gemäß den Referenzsignal-Anschlusskonfigurationsinformationen, von Signalqualitätsmessungsinformationen, die den mindestens zwei Anschlussgruppen entsprechen; und
      Durchführen, gemäß den Referenzsignal-Leistungsinformationen der mindestens zwei Anschlussgruppen, einer gewichteten Mittelung an den erhaltenen Signalqualitätsmessungsinformationen, die den mindestens zwei Anschlussgruppen entsprechen, im Einklang mit einer Anschlussgruppenleistung, um die Signalqualitätsmessungsinformationen zu erhalten,

   wobei das Durchführen, gemäß den Referenzsignal-Leistungsinformationen der mindestens zwei Anschlussgruppen, einer gewichteten Mittelung an den erhaltenen Signalqualitätsmessungsinformationen, die den mindestens zwei Anschlussgruppen entsprechen, im Einklang mit einer Anschlussgruppenleistung, um die Signalqualitätsmessungsinformationen zu erhalten, Folgendes umfasst:
   Erhalten der Signalqualitätsmessungsinformationen gemäß einer Formel

$$= (\sum_{g=0}^{n-1} Pg \cdot SQg)/(\sum_{g=0}^{n-1} Pg),$$

   wobei
   SQg die Signalqualitätsmessungsinformationen einer angegebenen Anschlussgruppe sind, g eine Folgenummer einer angegebenen Anschlussgruppe ist, n eine Menge von angegebenen Anschlussgruppen ist, $n \geq 2$ ist, und Pg eine Referenzsignalleistung einer angegebenen Anschlussgruppe ist, wobei die Referenzsignalleistung der angegebenen Anschlussgruppe gemäß den Referenzsignal-Leistungsinformationen der mindestens zwei Anschlussgruppen erhalten wird.

2. Verfahren gemäß Anspruch 1, wobei die Referenzsignal-Leistungsinformationen der mindestens zwei Anschlussgruppen Folgendes umfassen:

   eine Referenzsignalleistung einer ersten Anschlussgruppe und ein Verhältnis einer Referenzsignalleistung jeder Anschlussgruppe unter den restlichen Anschlussgruppen zu der Referenzsignalleistung der ersten Anschlussgruppe; oder
   eine Referenzsignalleistung einer ersten Anschlussgruppe und eine Differenz zwischen einer Referenzsignalleistung jeder Anschlussgruppe unter den restlichen Anschlussgruppen und der Referenzsignalleistung der ersten Anschlussgruppe.

Revendications

1. Procédé de mesure d'une qualité de communication dans un système d'antenne actif exécuté par un équipement utilisateur, consistant à :

recevoir (101) des informations de configuration de ressources de signal de référence envoyées par une station de base, dans lequel les informations de configuration de ressources de signal de référence comprennent des informations de configuration de ports de signal de référence, dans lequel les informations de configuration de ports de signal de référence sont utilisées pour indiquer un rapport de mappage entre un port de signal de référence et un groupe de ports, le groupe de ports étant un groupe de ports d'un ensemble de ports d'antennes ;
obtenir (102) des informations de ports de signal de référence dans au moins un groupe de ports en fonction des informations de configuration de ports de signal de référence ; et
acquérir (103) des informations de mesures de qualité de signal en fonction des informations de ports de signal de référence dans l'au moins un groupe de ports ; les informations de configuration de ressources de signal de référence comprenant en outre : des informations de puissance de signal de référence d'au moins deux groupes de ports qui sont utilisées par l'équipement utilisateur pour acquérir les informations de mesures de qualité de signal en fonction des informations de configuration de ports de signal de référence et en combinaison avec les informations de puissance de signal de référence des au moins deux groupes de ports,
caractérisé en ce que
l'acquisition des informations de mesures de qualité de signal en fonction des informations de configuration de ports de signal de référence et en combinaison avec les informations de puissance de signal de référence des au moins deux groupes de ports consiste à :

obtenir, en fonction des informations de configuration de ports de signal de référence, des informations de mesures de qualité de signal correspondant aux au moins deux groupes de ports ; et
exécuter, en fonction des informations de puissance de signal de référence des au moins deux groupes de ports, un moyennage pondéré sur les informations de mesures de qualité de signal obtenues correspondant aux au moins deux groupes de ports en fonction d'une puissance des groupes de ports, pour obtenir les informations de mesures de qualité de signal,

dans lequel l'exécution, en fonction des informations de puissance de signal de référence des au moins deux groupes de ports, du moyennage pondéré sur les informations de mesures de qualité de signal obtenues correspondant aux au moins deux groupes de ports en fonction d'une puissance des groupes de ports, pour obtenir les informations de mesures de qualité de signal consiste à :
obtenir les informations de mesures de qualité de signal selon une formule

$$SQ = \left(\sum_{g=0}^{n-1} p_g \cdot SQ_g \right) \Big/ \left(\sum_{g=0}^{n-1} p_g \right),$$

dans laquelle
SQg représente les informations de mesures de qualité de signal d'un groupe de ports spécifié, g est un numéro de séquence d'un groupe de ports spécifié, n est une quantité de groupes de ports spécifiés, $n \geq 2$, et Pg représente une puissance de signal de référence d'un groupe de ports spécifiés, la puissance de signal de référence du groupe de ports spécifié étant obtenue en fonction des informations de puissance de signal de référence des au moins deux groupes de ports.

2. Procédé selon la revendication 1, dans lequel les informations de puissance de signal de référence des au moins deux groupes de ports comprennent :

une puissance de signal de référence d'un premier groupe de ports, et un rapport d'une puissance de signal de référence de chaque groupe de ports parmi les groupes de ports restants par rapport à la puissance de signal de référence du premier groupe de ports ; ou
une puissance de signal de référence d'un premier groupe de ports, et un différentiel entre une puissance de signal de référence de chaque groupe de ports parmi les groupes de ports restants et la puissance de signal de référence du premier groupe de ports.

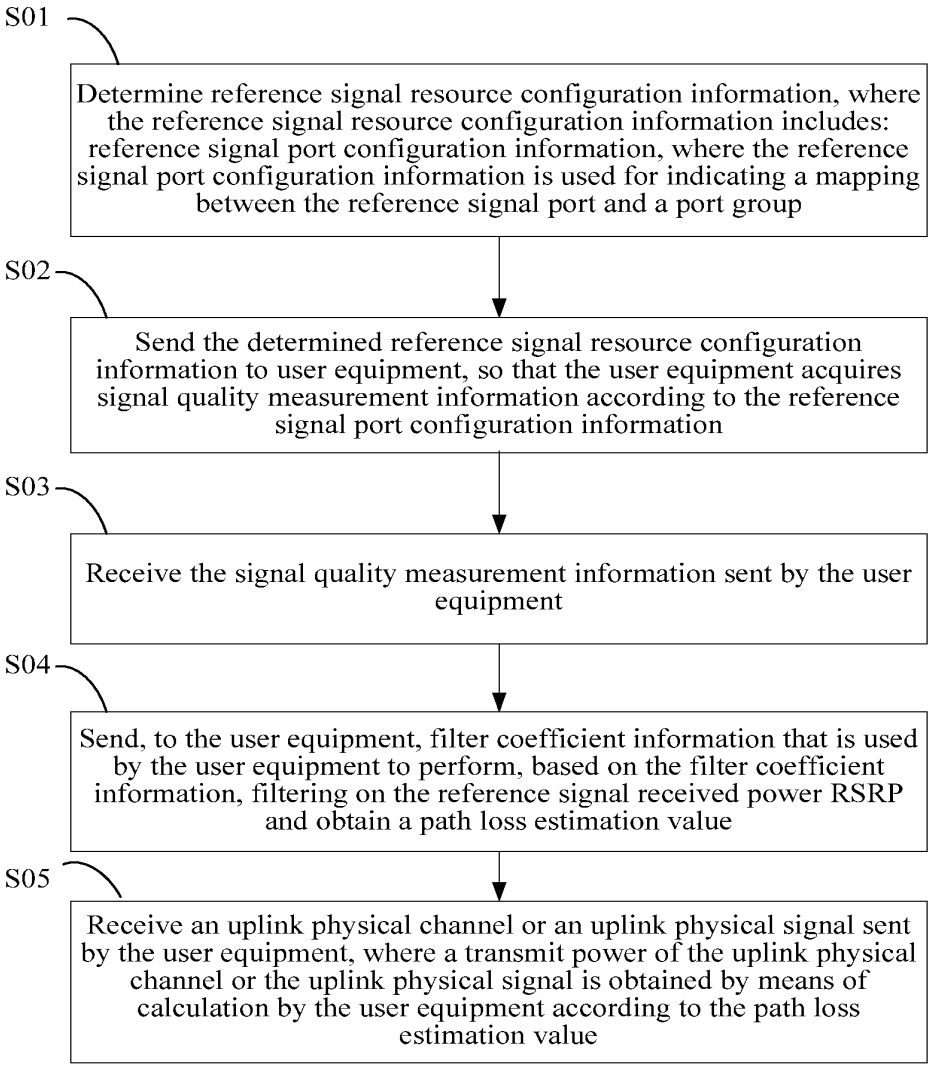

S01
Determine reference signal resource configuration information, where the reference signal resource configuration information includes: reference signal port configuration information, where the reference signal port configuration information is used for indicating a mapping between the reference signal port and a port group
S02
Send the determined reference signal resource configuration information to user equipment, so that the user equipment acquires signal quality measurement information according to the reference signal port configuration information
S03
Receive the signal quality measurement information sent by the user equipment
S04
Send, to the user equipment, filter coefficient information that is used by the user equipment to perform, based on the filter coefficient information, filtering on the reference signal received power RSRP and obtain a path loss estimation value
S05
Receive an uplink physical channel or an uplink physical signal sent by the user equipment, where a transmit power of the uplink physical channel or the uplink physical signal is obtained by means of calculation by the user equipment according to the path loss estimation value

FIG. 1

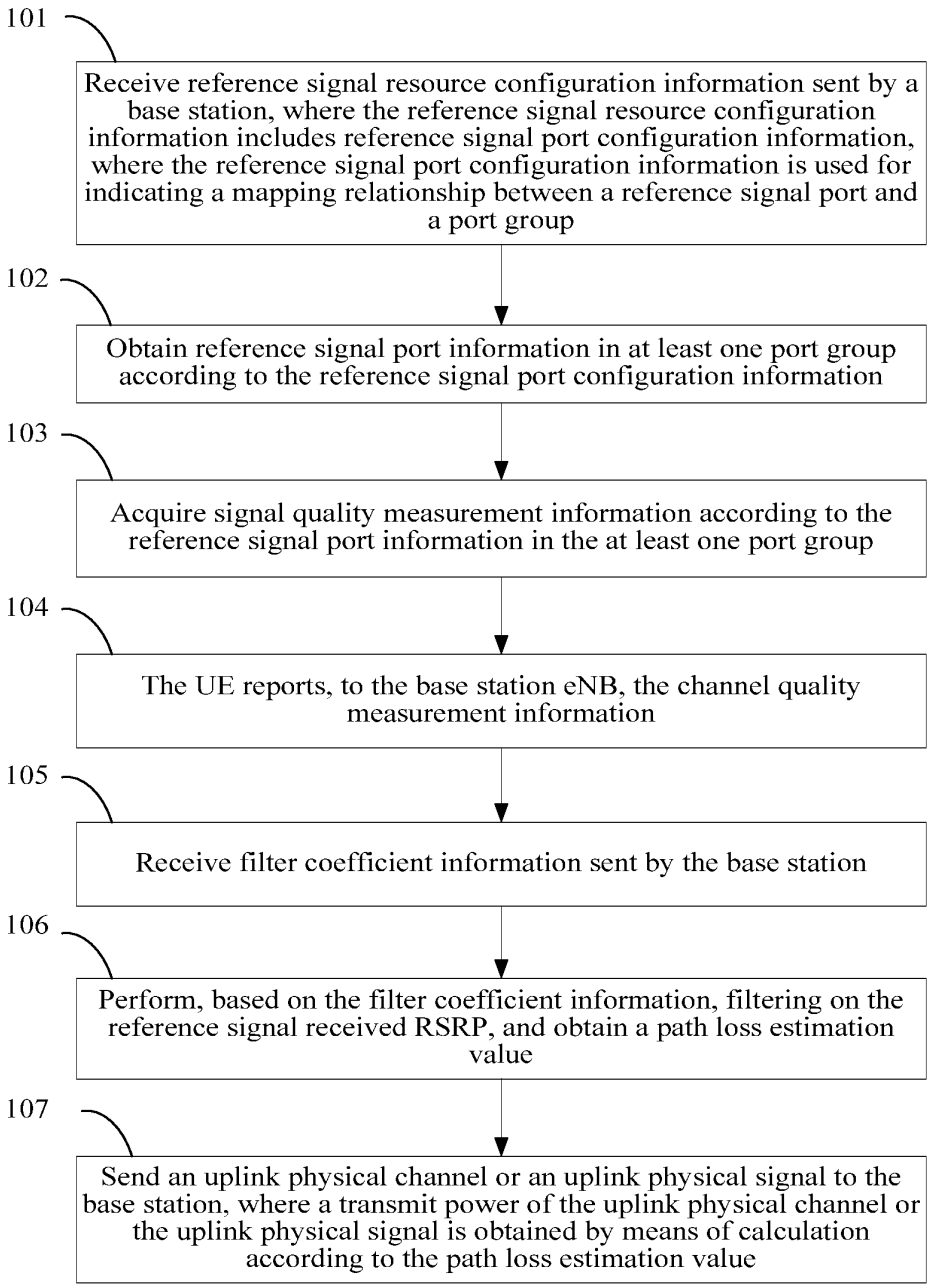

101
Receive reference signal resource configuration information sent by a base station, where the reference signal resource configuration information includes reference signal port configuration information, where the reference signal port configuration information is used for indicating a mapping relationship between a reference signal port and a port group
102
Obtain reference signal port information in at least one port group according to the reference signal port configuration information
103
Acquire signal quality measurement information according to the reference signal port information in the at least one port group
104
The UE reports, to the base station eNB, the channel quality measurement information
105
Receive filter coefficient information sent by the base station
106
Perform, based on the filter coefficient information, filtering on the reference signal received RSRP, and obtain a path loss estimation value
107
Send an uplink physical channel or an uplink physical signal to the base station, where a transmit power of the uplink physical channel or the uplink physical signal is obtained by means of calculation according to the path loss estimation value

FIG. 2

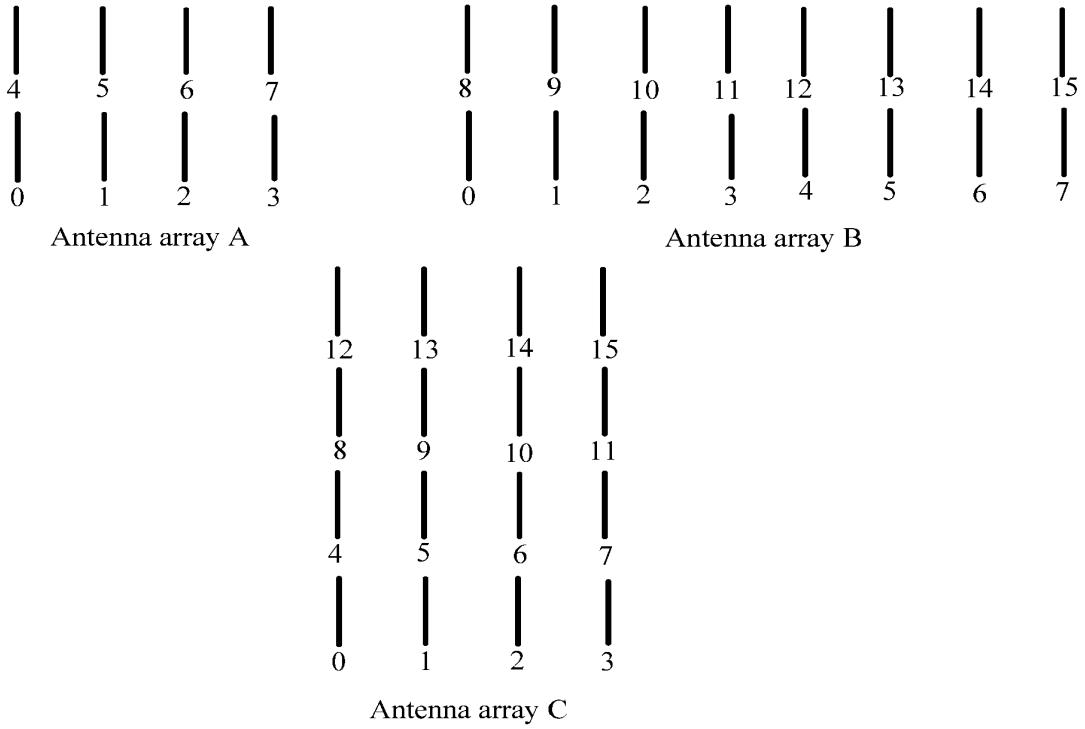

4 5 6 7
0 1 2 3
Antenna array A
8 9 10 11 12 13 14 15
0 1 2 3 4 5 6 7
Antenna array B
12 13 14 15
8 9 10 11
4 5 6 7
0 1 2 3
Antenna array C

FIG. 3

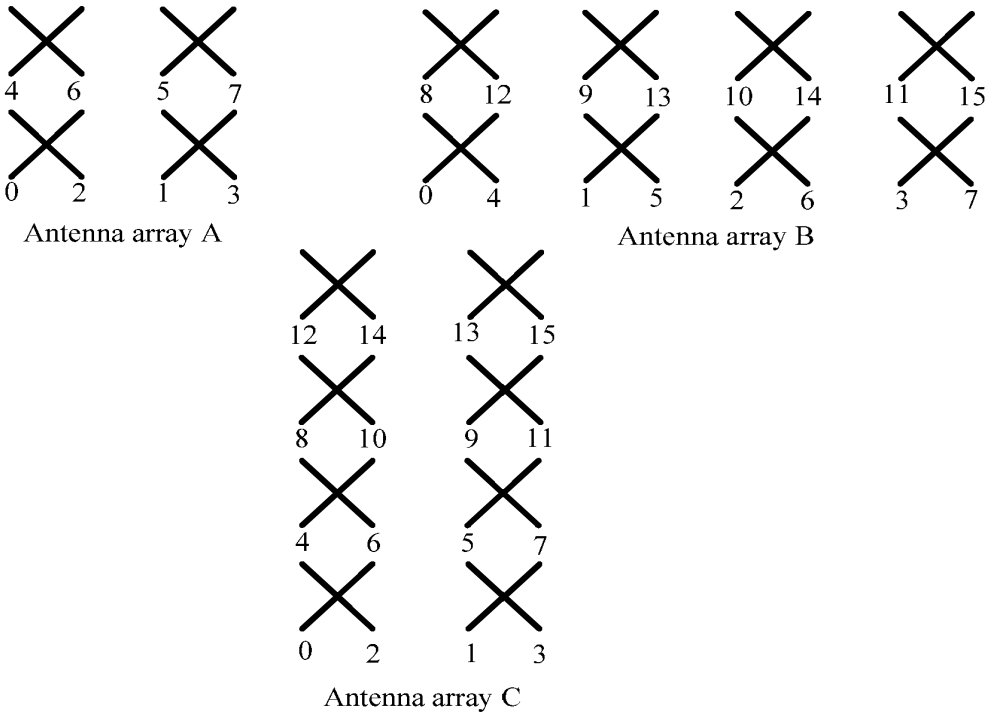

4 6
5 7
0 2
1 3
Antenna array A
8 12
9 13
10 14
11 15
0 4
1 5
2 6
3 7
Antenna array B
12 14
13 15
8 10
9 11
4 6
5 7
0 2
1 3
Antenna array C

FIG. 4

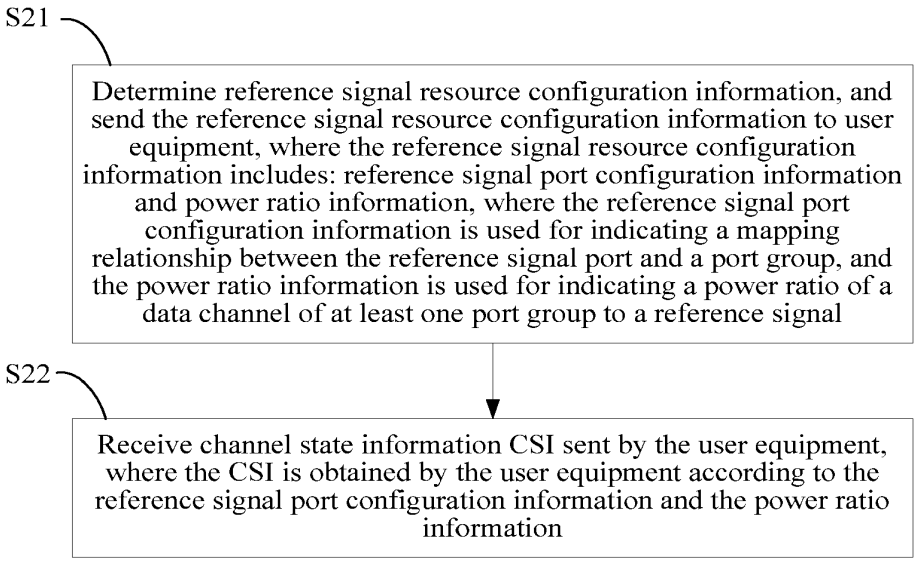

S21
Determine reference signal resource configuration information, and send the reference signal resource configuration information to user equipment, where the reference signal resource configuration information includes: reference signal port configuration information and power ratio information, where the reference signal port configuration information is used for indicating a mapping relationship between the reference signal port and a port group, and the power ratio information is used for indicating a power ratio of a data channel of at least one port group to a reference signal
S22
Receive channel state information CSI sent by the user equipment, where the CSI is obtained by the user equipment according to the reference signal port configuration information and the power ratio information

FIG. 5

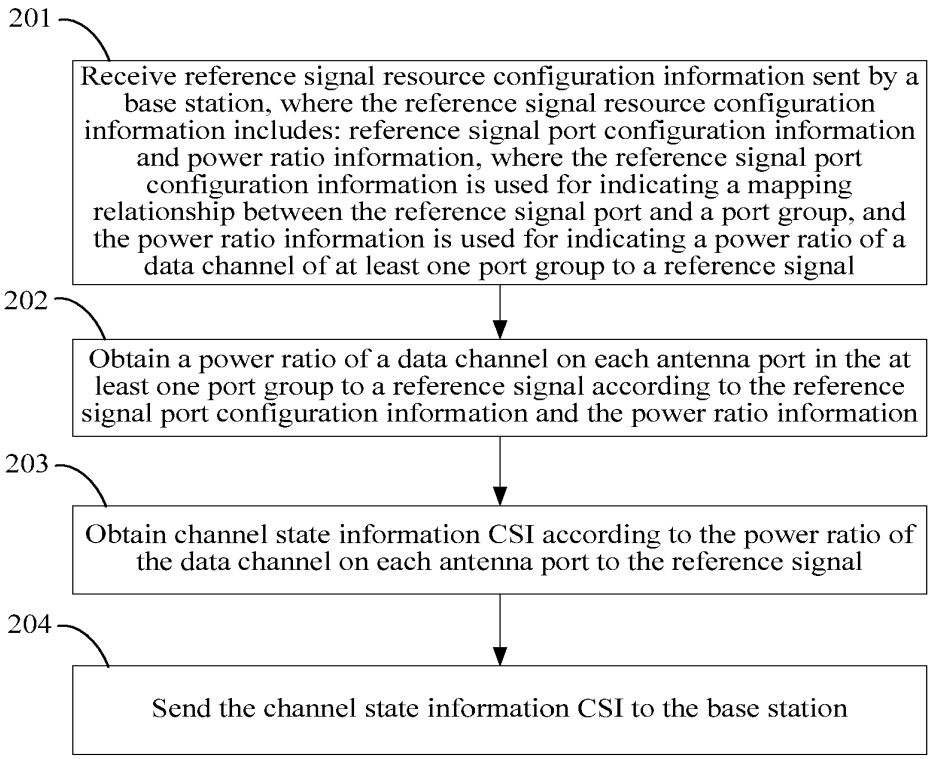

201
Receive reference signal resource configuration information sent by a base station, where the reference signal resource configuration information includes: reference signal port configuration information and power ratio information, where the reference signal port configuration information is used for indicating a mapping relationship between the reference signal port and a port group, and the power ratio information is used for indicating a power ratio of a data channel of at least one port group to a reference signal
202
Obtain a power ratio of a data channel on each antenna port in the at least one port group to a reference signal according to the reference signal port configuration information and the power ratio information
203
Obtain channel state information CSI according to the power ratio of the data channel on each antenna port to the reference signal
204
Send the channel state information CSI to the base station

FIG. 6

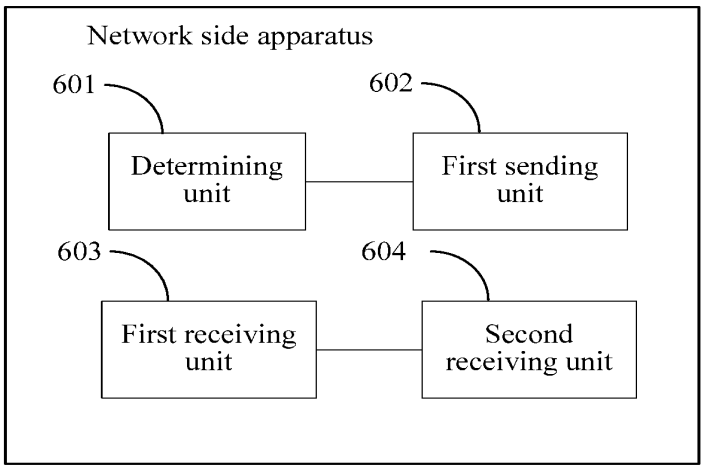

Network side apparatus
601
Determining unit
602
First sending unit
603
First receiving unit
604
Second receiving unit

FIG. 7

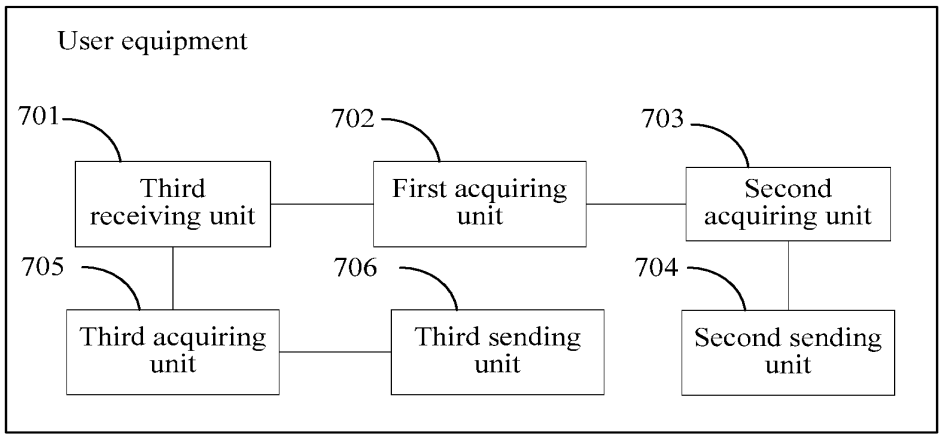


FIG. 8

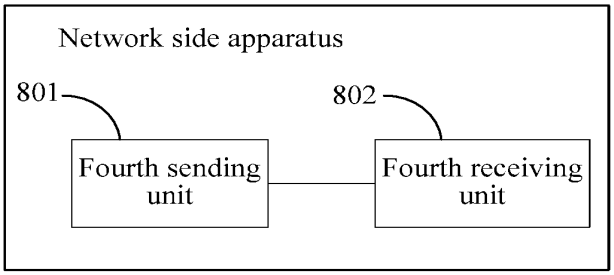


FIG. 9

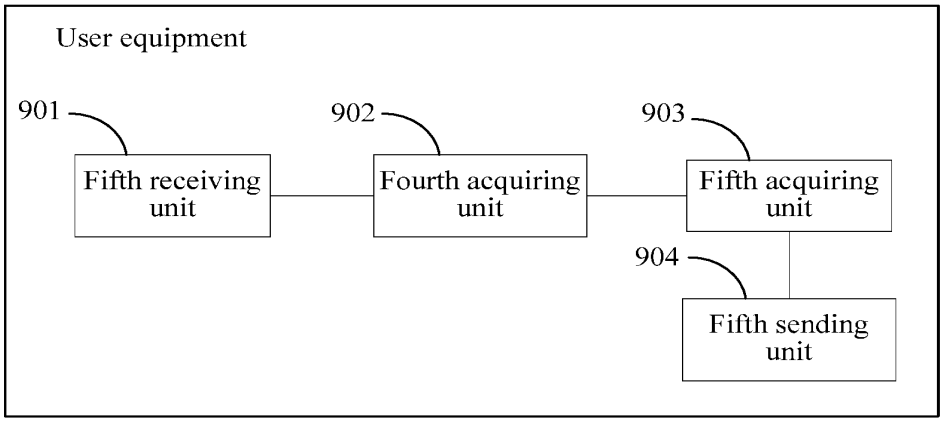


FIG. 10

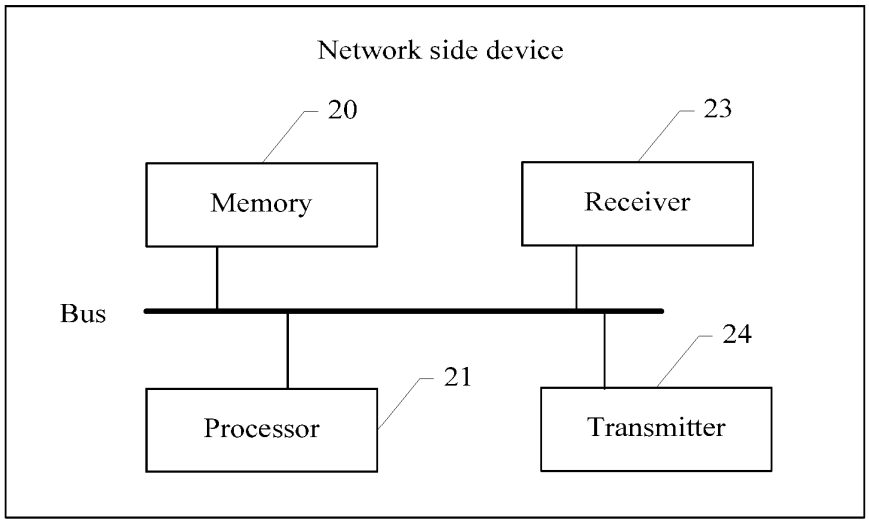

Network side device
20
23
Memory
Receiver
Bus
24
21
Processor
Transmitter

FIG. 11

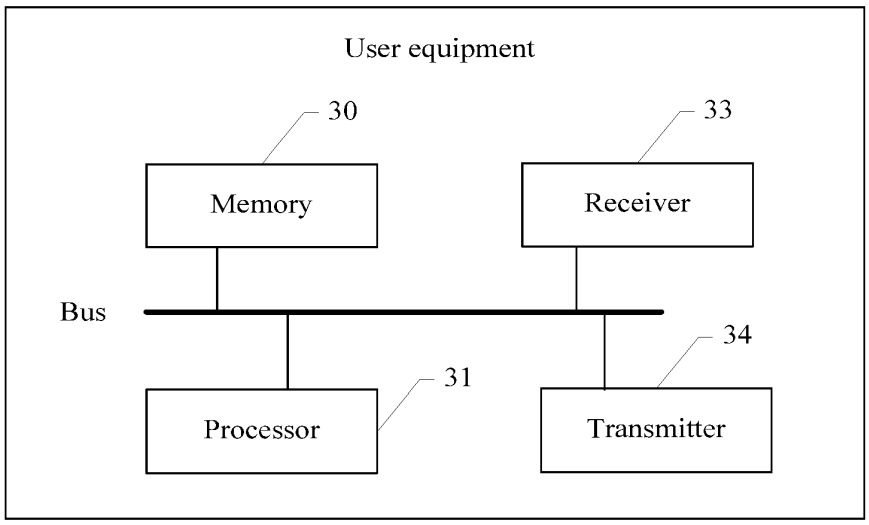

User equipment
30
33
Memory
Receiver
Bus
34
31
Processor
Transmitter

FIG. 12

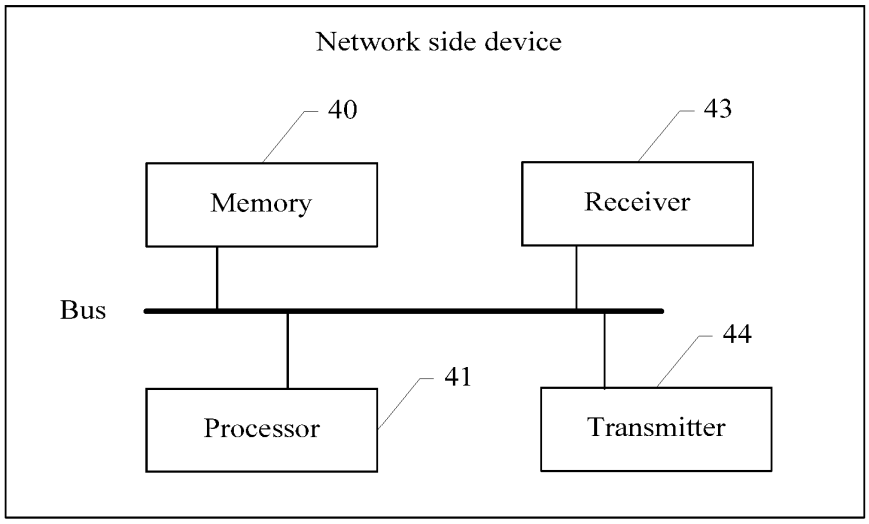

Network side device
40
43
Memory
Receiver
Bus
44
41
Processor
Transmitter

FIG. 13

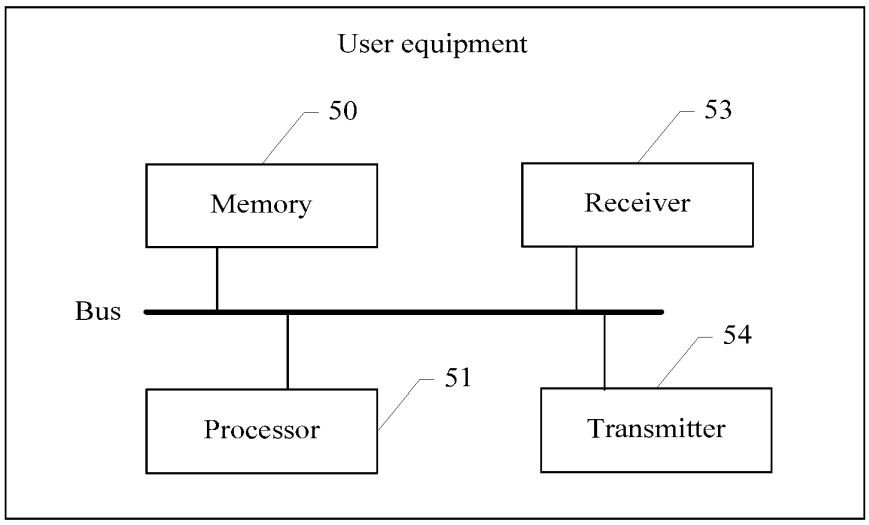

User equipment
50
53
Memory
Receiver
Bus
54
51
Processor
Transmitter

FIG. 14

REFERENCES CITED IN THE DESCRIPTION

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- WO 2013081368 A1 **[0006]**

Espacenet

CN110062398A Beam recovery method and device

Applicants: HUAWEI TECH CO LTD

Inventors: GUAN PENG,ZHANG XI,SUN YING

Classifications:

IPC ***H04W24/02; H04W72/04; H04W72/12;***

CPC **H04B7/0408 (US); H04B7/0695 (EP); H04L5/00 (US); H04W24/02 (CN,US); H04W72/04 (US); H04W72/046 (CN,US); H04W72/12 (CN,US); H04W72/21 (EP);**

Priorities: CN201710315436A 2017-05-05; CN201910246567A 2017-05-05

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Beam recovery method and device

Abstract

The embodiment of the invention discloses a beam recovery method and device, and the method comprises the steps that terminal device uses at least one beam in a first time window to send a request forrecovering a beam to network equipment, and the request for recovering the beam is a scheduling request or a beam failure recovery request; and the terminal device uses at least one beam in the firsttime window to receive a response for the beam recovery request sent by the network device, wherein the response for the beam recovery request is a scheduling request response or a beam failure recovery request response. By adopting the embodiment of the invention, the wave beam recovery processing of a plurality of wave beam recovery requests sent by the same terminal equipment by the network equipment can be realized, and the wave beam recovery efficiency is improved.

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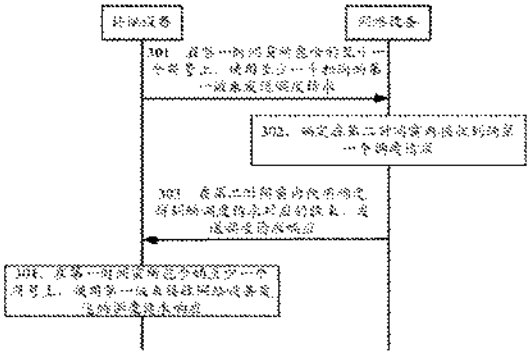
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(54)发明名称

波束恢复方法及装置

(57)摘要

本发明实施例公开了波束恢复方法及装置，所述方法包括：终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，用于恢复波束的请求为调度请求或者波束失败恢复请求；终端设备在第一时间窗内使用至少一个波束接收网络设备发送的用于波束恢复请求的响应，用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。采用本发明实施例，可实现网络设备针对同一终端设备发送的多个用于恢复波束的请求的波束恢复处理，提高波束恢复效率。



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1.一种波束恢复方法,其特征在于,所述方法包括:

终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求,所述用于恢复波束的请求为调度请求或者波束失败恢复请求;

所述终端设备在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应,所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

2.如权利要求1所述的方法,其特征在于,所述终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求,包括:

所述终端设备在所述第一时间窗所包含的至少一个符号上,使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

3.如权利要求2所述的方法,其特征在于,所述终端设备在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应,包括:

所述终端设备在所述第一时间窗所包含的至少一个符号上,使用所述第一波束接收所述用于波束恢复请求的响应。

4.如权利要求1所述的方法,其特征在于,所述第一时间窗包括第一单元时间窗和第二单元时间窗,所述第二单元时间窗所包含的第一个符号为所述第一单元时间窗所包含的最后一个符号之后的第一个符号;

所述终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求,包括:

所述终端设备在所述第一单元时间窗所包含的至少一个符号上,使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

5.如权利要求4所述的方法,其特征在于,所述终端设备在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应,包括:

所述终端设备在所述第二单元时间窗所包含的至少一个符号上,使用所述第一波束接收所述用于波束恢复请求的响应。

6.如权利要求2～5任一项所述的方法,其特征在于,所述方法还包括:

当在所述第一时间窗内未接收到所述用于波束恢复请求的响应时,所述终端设备确定所述网络设备对所述终端设备配置的第三时间窗;

所述终端设备在所述第三时间窗所包含的至少一个符号上,使用至少一个相同的第二波束向所述网络设备发送所述用于恢复波束的请求。

7.如权利要求1～6任一项所述的方法,其特征在于,所述终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求,包括:

所述终端设备基于所述网络设备对所述终端设备配置的波束请求指示信息,在所述第一时间窗内使用所述至少一个波束向所述网络设备发送所述用于恢复波束的请求,所述波束请求指示信息用于指示所述用于恢复波束的请求的发送方式。

8.如权利要求1～7任一项所述的方法,其特征在于,所述用于恢复波束的请求通过随机接入信道RACH资源发送。

9.如权利要求1-7任一项所述的方法,其特征在于,所述用于波束恢复请求的响应通过物理下行控制信道PDCCH发送,所述PDCCH的循环冗余校验CRC由小区无线网络临时标识C-

RNTI加扰。

10.一种波束恢复装置，其特征在于，所述装置包括：

发送模块，用于在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

接收模块，用于在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

11.如权利要求10所述的装置，其特征在于，所述发送模块，具体用于：

在所述第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

12.如权利要求11所述的装置，其特征在于，

所述接收模块，具体用于在所述第一时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

13.如权利要求10所述的装置，其特征在于，所述第一时间窗包括第一单元时间窗和第二单元时间窗，所述第二单元时间窗所包含的第一个符号为所述第一单元时间窗所包含的最后一个符号之后的第一个符号；

所述发送模块，具体用于在所述第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

14.如权利要求13所述的装置，其特征在于，

所述接收模块，具体用于在所述第二单元时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

15.如权利要求10～14任一项所述的装置，其特征在于，所述装置还包括：

确定模块，用于当在所述第一时间窗内未接收到所述用于波束恢复请求的响应时，所述终端设备确定所述网络设备对所述终端设备配置的第三时间窗；

所述发送模块，还用于在所述第三时间窗所包含的至少一个符号上，使用至少一个相同的第二波束向所述网络设备发送所述用于恢复波束的请求。

16.如权利要求10～15任一项所述的装置，其特征在于，

所述发送模块，具体用于基于所述网络设备对所述终端设备配置的波束请求指示信息，在所述第一时间窗内使用所述至少一个波束向所述网络设备发送所述用于恢复波束的请求，所述波束请求指示信息用于指示所述用于恢复波束的请求的发送方式。

17.如权利要求10～16任一项所述的装置，其特征在于，所述用于恢复波束的请求通过随机接入信道RACH资源发送。

18.如权利要求10～16任一项所述的装置，其特征在于，所述用于波束恢复请求的响应通过物理下行控制信道PDCCH发送，所述PDCCH的循环冗余校验CRC由小区无线网络临时标识C-RNTI加扰。

19.一种计算机存储介质，所述计算机存储介质存储有程序，所述程序被执行时实现如权利要求1-9任意一项的方法。

20.一种波束恢复装置，其特征在于，包括处理器、存储器，所述存储器中存储有程序代码，所述处理器调用存储器中存储的程序代码，实现如权利要求1-9任意一项的方法。

波束恢复方法及装置

技术领域

[0001] 本申请涉及通信技术领域，尤其涉及波束恢复方法及装置。

背景技术

[0002] 波束(beam)是一种通信资源，不同的波束可以认为是不同的通信资源。在移动通信系统中使用波束进行信息传输，即通过在空间上朝向特定的方向发送信号，可以实现更高的天线阵列增益。发射波束可以是指信号经天线发射出去后在空间不同方向上形成的信号强度的分布，接收波束可以是指从天线上接收到的无线信号在空间不同方向上的信号强度分布。一个波束对通常包括一个发送端的发射波束和一个接收端的接收波束。当下行控制信道关联的波束的性能下降到某个门限值时，该波束失效，即无法使用该波束进行信息传输，一旦波束失效，将触发波束恢复机制。

[0003] 在长期演进(Long Term Evolution，LTE)系统中，在建立无线链路过程中的初始接入、在无线链路建立失败之后的链路重建或者采用基于上行测量的定位方法以进行定位等过程中可以采用随机接入方案，具体可以为：终端设备向网络设备发送调度请求(Scheduling Request，SR)，以通知网络设备有终端设备试图接入；终端设备在预先配置的时间窗内监测控制信道，以接收网络设备下发的随机接入响应(Random Access Response，RAR)。上述随机接入方案仅针对网络设备接收到同一终端设备发送的一个SR的场景。

[0004] 当下行链路(Down Link，DL)的波束对(Beam Pair Link，BPL)失效时，为了充分利用现有的资源，以及波束失效的持续时间远小于无线链路失效(Radio Link Failure，RLF)的时间窗长度，终端设备可以利用随机接入信道(Random Access Channel，RACH)资源在不同方向的多个波束上发射SR，则网络设备在时间窗内可以接收到来自同一终端设备的多个SR。而传统LTE中随机接入的处理流程仅针对网络设备收到同一终端设备发送的一个SR的场景，在网络设备收到同一终端设备发送的多个SR时如何进行随机接入处理，是目前亟需解决的问题。

发明内容

[0005] 本发明实施例所要解决的技术问题在于，提供波束恢复方法及装置，可实现网络设备针对同一终端设备发送的多个用于恢复波束的请求的波束恢复处理，提高波束恢复效率。

[0006] 第一方面，本发明实施例提供了一种波束恢复方法，终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求；终端设备在第一时间窗内使用至少一个波束接收网络设备发送的用于波束恢复请求的响应。

[0007] 其中，用于恢复波束的请求可以为调度请求或者波束失败恢复请求(beam failure recovery request)。

[0008] 其中，用于波束恢复请求的响应可以为调度请求响应或者波束失败恢复请求响应。

[0009] 例如，当用于恢复波束的请求为调度请求时，用于波束恢复请求的响应可以为调度请求响应；当用于恢复波束的请求为波束失败恢复请求时，用于波束恢复请求的响应可以为波束失败恢复请求响应。

[0010] 其中，第一时间窗可以是网络设备对终端设备配置的时间窗，示例性的，第一时间窗可以包括3个符号或者7个符号等。

[0011] 可选的，第一时间窗所包含的第一个符号可以为第一个配置有随机接入信道(Random Access Channel，RACH)资源的符号。

[0012] 在该技术方案中，终端设备可以使用至少一个波束向网络设备发送用于恢复波束的请求，终端设备还可以在第一时间窗内使用上述至少一个波束接收网络设备发送的用于波束恢复请求的响应，则终端设备向网络设备发送的用于恢复波束的请求可以包括多个，以便提高波束恢复效率。

[0013] 可选的，终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，具体可以为：终端设备在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送用于恢复波束的请求。

[0014] 其中，第一波束可以是网络设备对终端设备配置的一个波束。

[0015] 例如，终端设备可以在第一时间窗所包含的一个符号上，使用一个第一波束向网络设备发送用于恢复波束的请求。示例性的，第一时间窗包括3个符号，分别为第一符号、第二符号以及第三符号，若终端设备在第一时间窗中确定的一个符号为第一符号，则终端设备可以在第一时间窗所包含的第一符号上，使用第一波束向网络设备发送用于恢复波束的请求。

[0016] 又如，终端设备可以在第一时间窗所包含的一个符号上，使用多个相同的第一波束向网络设备发送用于恢复波束的请求。示例性的，第一时间窗包括3个符号，分别为第一符号、第二符号以及第三符号，若终端设备在第一时间窗中确定的一个符号为第一符号，则终端设备可以在第一时间窗所包含的第一符号上，在不同方向上使用第一波束向网络设备发送用于恢复波束的请求。

[0017] 又如，终端设备可以在第一时间窗所包含的多个符号上，使用一个第一波束向网络设备发送用于恢复波束的请求。示例性的，第一时间窗包括3个符号，分别为第一符号、第二符号以及第三符号，若终端设备在第一时间窗中确定的多个符号包括第二符号和第三符号，则终端设备可以在第一时间窗所包含的第二符号上，使用第一波束向网络设备发送用于恢复波束的请求，且在第一时间窗所包含的第三符号上，使用第一波束向网络设备发送用于恢复波束的请求。

[0018] 又如，终端设备可以在第一时间窗所包含的多个符号上，使用多个相同的第一波束向网络设备发送用于恢复波束的请求。示例性的，第一时间窗包括3个符号，分别为第一符号、第二符号以及第三符号，若终端设备在第一时间窗中确定的多个符号包括第二符号和第三符号，则终端设备可以在第一时间窗所包含的第二符号上，使用第一波束向网络设备发送用于恢复波束的请求，且在第一时间窗所包含的第三符号上，使用第一波束向网络设备发送用于恢复波束的请求。

[0019] 在该技术方案中，终端设备可以在一个符号上使用多个相同的第一波束向网络设备发送用于恢复波束的请求，或者在多个符号上使用一个或者多个相同的第一波束向网络

设备发送用于恢复波束的请求，以实现同一终端设备向网络设备发送多个用于恢复波束的请求。

[0020] 可选的，终端设备在第一时间窗内使用至少一个波束接收网络设备发送的用于波束恢复请求的响应，具体可以为：终端设备在第一时间窗所包含的至少一个符号上，使用第一波束接收用于波束恢复请求的响应。

[0021] 在该技术方案中，终端设备在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送用于恢复波束的请求之后，可以在第一时间窗所包含的至少一个符号上，使用第一波束接收用于波束恢复请求的响应，可确保发送用于波束恢复的请求的波束和接收用于波束恢复请求的响应的波束为同一波束。

[0022] 可选的，第一时间窗可以包括第一单元时间窗和第二单元时间窗，则终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，具体可以为：终端设备在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送用于恢复波束的请求。

[0023] 其中，第一单元时间窗可以是网络设备对终端设备配置的时间窗，示例性的，第一单元时间窗可以包括3个符号或者4个符号等。

[0024] 其中，第二单元时间窗可以是网络设备对终端设备配置的时间窗，示例性的，第二单元时间窗可以包括4个符号或者5个符号等。

[0025] 其中，第二单元时间窗所包含的第一个符号为第一单元时间窗所包含的最后一个符号之后的第一个符号。例如第一单元时间窗包括4个符号，分别为符号0、符号1、符号2以及符号3，符号3之后的第一个符号为符号4，则终端设备可以确定第二单元时间窗所包含的第一个符号为符号4。需要说明的是，本发明实施例中的第一单元时间窗包含但不限定4个符号，第一单元时间窗的长度和第二单元时间窗的长度可以相同，也可以不相同，具体不受本发明实施例的限定。

[0026] 可选的，终端设备在第一时间窗内使用至少一个波束接收网络设备发送的用于波束恢复请求的响应，具体可以为：终端设备在第二单元时间窗所包含的至少一个符号上，使用第一波束接收用于波束恢复请求的响应。

[0027] 在该技术方案中，终端设备在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送用于恢复波束的请求之后，终端设备可以在第二单元时间窗所包含的至少一个符号上，使用第一波束接收用于波束恢复请求的响应，可确保发送用于波束恢复的请求的波束和接收用于波束恢复请求的响应的波束为同一波束。

[0028] 可选的，当在第一时间窗内未接收到用于波束恢复请求的响应时，终端设备可以确定网络设备对终端设备配置的第三时间窗，并在第三时间窗所包含的至少一个符号上，使用至少一个相同的第二波束向网络设备发送用于恢复波束的请求。

[0029] 其中，第三时间窗可以是网络设备对终端设备配置的时间窗，示例性的，第三时间窗可以包括3个符号或者5个符号等。

[0030] 在该技术方案中，终端设备在第一时间窗未检测到用于波束恢复请求的响应时，终端设备可以在第三时间窗使用第一波束以外的其他波束重新向网络设备发送用于恢复波束的请求，若终端设备在第三时间窗所包含的至少一个符号上使用第二波束接收到网络设备发送的用于波束恢复请求的响应，则可实现波束恢复，可提高波束恢复的可靠性。

[0031] 可选的，第一时间窗可以包括第三单元时间窗和第四单元时间窗，则终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，具体可以为：终端设备在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备发送用于恢复波束的请求。

[0032] 其中，第三单元时间窗可以是网络设备对终端设备配置的时间窗，示例性的，第三单元时间窗可以包括3个符号或者5个符号等。

[0033] 其中，第四单元时间窗可以是网络设备对终端设备配置的时间窗，示例性的，第四单元时间窗可以包括4个符号或者5个符号等。

[0034] 其中，第四单元时间窗所包含的第一个符号可以为第三单元时间窗所包含的最后一个符号之后的第一个符号。例如第三单元时间窗包括4个符号，分别为符号0、符号1、符号2以及符号3，符号3之后的第一个符号为符号4，则终端设备可以确定第四单元时间窗所包含的第一个符号为符号4。需要说明的是，本发明实施例中的第三单元时间窗包含但不限定4个符号，第三单元时间窗的长度和第四单元时间窗的长度可以相同，也可以不相同，具体不受本发明实施例的限定。

[0035] 其中，网络设备可以对终端设备配置最大波束数量，例如允许终端设备发送用于恢复波束的请求时所使用的波束的数量可以小于等于5。需要说明的是，本发明实施例中的最大波束数量包含但不限于5，例如，最大波束数量可以为3，等等，具体不受本发明实施例的限制。

[0036] 其中，第三单元时间窗所包含的符号的数量总和可以是根据网络设备对终端设备配置的最大波束数量确定的。例如，第三单元时间窗所包含的符号的数量总和与最大波束数量之间可以呈正比例关系。示例性的，最大波束数量为5，则第三单元时间窗所包含的符号的数量总和可以为5，即第三单元时间窗包含5个符号。

[0037] 例如，终端设备可以在第三单元时间窗所包含的一个符号上，使用一个波束向网络设备发送用于恢复波束的请求。示例性的，第三单元时间窗包括5个符号，分别为第一符号、第二符号、第三符号、第四符号以及第五符号，若终端设备在第三单元时间窗中确定的一个符号为第一符号，则终端设备可以在第三单元时间窗所包含的第一符号上，使用波束1向网络设备发送用于恢复波束的请求。波束1可以为终端设备确定得到的一个波束，其中该波束可以是网络设备对终端设备配置的。

[0038] 又如，终端设备可以在第三单元时间窗所包含的一个符号上，使用多个不同波束向网络设备发送用于恢复波束的请求。示例性的，第三单元时间窗包括5个符号，分别为第一符号、第二符号、第三符号、第四符号以及第五符号，若终端设备在第三单元时间窗中确定的一个符号为第一符号，则终端设备可以在第三单元时间窗所包含的第一符号上，在不同方向上分别使用波束1～波束5中的多个波束向网络设备发送用于恢复波束的请求。其中，若网络设备对终端设备配置的最大波束数量为5，则终端设备在第三单元时间窗所包含的第一符号上，可以使用大于等于2个且小于等于5个波束向网络设备发送用于恢复波束的请求。

[0039] 又如，终端设备可以在第三单元时间窗所包含的多个符号上，使用一个波束向网络设备发送用于恢复波束的请求。示例性的，第三单元时间窗包括5个符号，分别为第一符号、第二符号、第三符号、第四符号以及第五符号，若终端设备在第三单元时间窗中确定的

多个符号包括第二符号和第三符号，则终端设备可以在第三单元时间窗所包含的第二符号上，使用波束1向网络设备发送用于恢复波束的请求，且在第三单元时间窗所包含的第三符号上，使用波束1向网络设备发送用于恢复波束的请求。

[0040] 又如，终端设备可以在第三单元时间窗所包含的多个符号上，使用多个不同波束向网络设备发送用于恢复波束的请求。示例性的，第三单元时间窗包括5个符号，分别为第一符号、第二符号、第三符号、第四符号以及第五符号，若终端设备在第三单元时间窗中确定的多个符号包括第二符号和第三符号，则终端设备可以在第三单元时间窗所包含的第二符号上，在不同方向上分别使用波束1～波束5中的多个波束向网络设备发送用于恢复波束的请求，且在第三单元时间窗所包含的第三符号上，在不同方向上分别使用波束1～波束5中的多个波束向网络设备发送用于恢复波束的请求。

[0041] 在该技术方案中，终端设备可以在一个符号上使用多个不同波束向网络设备发送用于恢复波束的请求，或者在多个符号上使用一个或者多个不同波束向网络设备发送用于恢复波束的请求，以实现同一终端设备向网络设备发送多个用于恢复波束的请求。

[0042] 可选的，终端设备在第一时间窗内使用至少一个波束接收网络设备发送的用于波束恢复请求的响应，具体可以为：终端设备在第四单元时间窗所包含的至少一个符号上，使用至少一个不同的波束接收用于波束恢复请求的响应。

[0043] 在该技术方案中，终端设备在第三单元时间窗所包含的至少一个符号上，使用至少一个不同波束向网络设备发送用于恢复波束的请求之后，终端设备可以在第四单元时间窗所包含的至少一个符号上，使用上述至少一个不同的波束接收用于波束恢复请求的响应，可确保发送用于波束恢复的请求的波束和接收用于波束恢复请求的响应的波束为同一波束。

[0044] 可选的，终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，具体可以为：终端设备基于网络设备对终端设备配置的波束请求指示信息，在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，波束请求指示信息用于指示用于恢复波束的请求的发送方式。

[0045] 例如，当波束请求指示信息用于指示用于恢复波束的请求的发送方式为在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束发送时，终端设备可以在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送用于恢复波束的请求，并在第一时间窗所包含的至少一个符号上，使用第一波束接收用于波束恢复请求的响应。

[0046] 又如，当波束请求指示信息用于指示用于恢复波束的请求的发送方式为在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束发送时，终端设备可以在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送用于恢复波束的请求，并在第二单元时间窗所包含的至少一个符号上，使用第一波束接收用于波束恢复请求的响应。

[0047] 又如，当波束请求指示信息用于指示用于恢复波束的请求的发送方式为在第三单元时间窗所包含的至少一个符号上，使用至少一个不同波束发送时，终端设备可以在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备发送用于恢复波束的请求，并在第四单元时间窗所包含的至少一个符号上，使用至少一个不同的波束接

收用于波束恢复请求的响应。

[0048] 第二方面，本发明实施例提供了一种波束恢复方法，网络设备接收终端设备在第一时间窗内使用至少一个波束发送的用于恢复波束的请求，在第二时间窗内，在接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，并使用确定得到的用于恢复波束的请求对应的波束，向终端发送用于波束恢复请求的响应。

[0049] 在该技术方案中，网络设备可以接收终端设备发送的多个用于恢复波束的请求，在接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，并使用确定得到的用于恢复波束的请求对应的波束，向终端发送用于波束恢复请求的响应，可实现网络设备针对同一终端设备发送的多个用于恢复波束的请求的波束恢复处理，提高波束恢复效率。

[0050] 可选的，网络设备在接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，具体可以为：网络设备响应在第二时间窗内接收到的质量最好的波束所承载的用于恢复波束的请求。

[0051] 例如，若终端设备在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备发送用于恢复波束的请求，则网络设备可以在第二时间窗内接收到的用于恢复波束的请求中确定质量最好的波束所承载的用于恢复波束的请求，并对确定得到的用于恢复波束的请求进行响应。

[0052] 又如，若终端设备在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送用于恢复波束的请求，则网络设备可以在第二时间窗内接收到的用于恢复波束的请求中确定质量最好的波束所承载的用于恢复波束的请求，并对确定得到的用于恢复波束的请求进行响应。

[0053] 可选的，网络设备在接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，具体可以为：网络设备响应在第二时间窗内接收到的第一个用于恢复波束的请求。

[0054] 例如，若终端设备在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送用于恢复波束的请求，则网络设备可以在第二时间窗内接收到的用于恢复波束的请求中确定最先接收到的用于恢复波束的请求，并对确定得到的用于恢复波束的请求进行响应。

[0055] 又如，若终端设备在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送用于恢复波束的请求，则网络设备可以在第二时间窗内接收到的用于恢复波束的请求中确定最先接收到的用于恢复波束的请求，并对确定得到的用于恢复波束的请求进行响应。

[0056] 又如，若终端设备在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备发送用于恢复波束的请求，则网络设备可以在第二时间窗内接收到的用于恢复波束的请求中确定最先接收到的用于恢复波束的请求，并对确定得到的用于恢复波束的请求进行响应。

[0057] 可选的，网络设备使用确定得到的用于恢复波束的请求对应的波束，向终端发送用于波束恢复请求的响应，具体可以为：网络设备在第二时间窗内使用确定得到的用于恢复波束的请求对应的波束，向终端设备发送用于波束恢复请求的响应。

[0058] 可选的，网络设备使用确定得到的用于恢复波束的请求对应的波束，向终端发送用于波束恢复请求的响应，具体可以为：网络设备在第二时间窗之外使用确定得到的用于

恢复波束的请求对应的波束，向终端设备发送用于波束恢复请求的响应。

[0059] 第三方面，本发明实施例提供一种计算机存储介质，所述计算机存储介质存储有程序，所述程序执行时包括本发明实施例第一方面提供的波束恢复方法中全部或部分的步骤。

[0060] 第四方面，本发明实施例提供一种计算机存储介质，所述计算机存储介质存储有程序，所述程序执行时包括本发明实施例第二方面提供的波束恢复方法中全部或部分的步骤。

[0061] 第五方面，本发明实施例提供一种波束恢复装置，该波束恢复装置包括用于执行本发明实施例第一方面公开的波束恢复方法的模块。

[0062] 第六方面，本发明实施例提供一种波束恢复装置，该波束恢复装置包括用于执行本发明实施例第二方面公开的波束恢复方法的模块。

[0063] 第七方面，本发明实施例提供一种终端设备，其特征在于，包括处理器、存储器以及收发器，存储器中存储一组程序代码，且处理器调用存储器中存储的程序代码，用于执行以下操作：

[0064] 在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求；在第一时间窗内使用至少一个波束接收网络设备发送的用于波束恢复请求的响应。

[0065] 第八方面，本发明实施例提供一种网络设备，其特征在于，包括处理器、存储器以及收发器，存储器中存储一组程序代码，且处理器调用存储器中存储的程序代码，用于执行以下操作：

[0066] 接收终端设备在第一时间窗内使用至少一个波束发送的用于恢复波束的请求；在第二时间窗内，在接收到的用于恢复波束的请求中确定一个用于恢复波束的请求；使用确定得到的用于恢复波束的请求对应的波束，向终端设备发送用于波束恢复请求的响应。

[0067] 第九方面，本发明实施例提供一种波束恢复系统，包括本发明实施例第七方面公开的终端设备和本发明实施例第八方面公开的网络设备。

[0068] 第十方面，本申请实施例提供了一种通信芯片，其中存储有指令，当其在终端设备上运行时，使得所述通信芯片执行上述第一方面的方法。

[0069] 第十一方面，本申请实施例提供了一种通信芯片，其中存储有指令，当其在网络设备上运行时，使得所述通信芯片执行上述第二方面的方法。

附图说明

[0070] 为了更清楚地说明本发明实施例或背景技术中的技术方案，下面将对本发明实施例或背景技术中所需要使用的附图进行说明。

[0071] 图1是本发明实施例提供的一种波束恢复系统的架构示意图；

[0072] 图2A是本发明实施例提供的一种信息传输的示意图；

[0073] 图2B是本发明另一实施例提供的一种信息传输的示意图；

[0074] 图3是本发明实施例提供的一种波束恢复方法的流程示意图；

[0075] 图4是本发明另一实施例提供的一种信息传输的示意图；

[0076] 图5是本发明另一实施例提供的一种波束恢复方法的流程示意图；

[0077] 图6是本发明另一实施例提供的一种波束恢复方法的流程示意图；

[0078] 图7是本发明另一实施例提供的一种信息传输的示意图；

[0079] 图8是本发明另一实施例提供的一种波束恢复方法的流程示意图；

[0080] 图9是本发明另一实施例提供的一种波束恢复方法的流程示意图；

[0081] 图10是本发明另一实施例提供的一种信息传输的示意图；

[0082] 图11是本发明另一实施例提供的一种波束恢复方法的流程示意图；

[0083] 图12是本发明实施例提供的一种波束恢复装置的结构示意图；

[0084] 图13是本发明实施例提供的一种终端设备的结构示意图；

[0085] 图14是本发明另一实施例提供的一种波束恢复装置的结构示意图；

[0086] 图15是本发明实施例提供的一种网络设备的结构示意图；

[0087] 图16是本发明实施例提供的一种波束恢复系统的结构示意图。

具体实施方式

[0088] 下面结合本发明实施例中的附图对本发明实施例进行描述。

[0089] 为了更好的理解本发明实施例公开的一种波束恢复方法及装置，下面首先对本发明实施例适用的网络架构进行描述。请参见图1，图1是本发明实施例公开的一种波束恢复系统的架构示意图。如图1所示，该波束恢复系统可以包括终端设备10以及网络设备20。其中，终端设备10与网络设备20之间可以通过通信连接进行数据传输。

[0090] 本发明实施例中的终端设备10可以称为用户设备(User Equipment，UE)、移动台、接入终端、用户单元、用户站、移动站、远方站、远程终端、移动设备、终端、无线通信设备、用户代理或用户装置等，其具体可以是WLAN中的站点(Station，ST)、蜂窝电话、无绳电话、会话启动协议(Session Initiation Protocol，SIP)电话、无线本地环路(Wireless Local Loop，WLL)站、个人数字处理(Personal Digital Assistant，PDA)、具有无线通信功能的手持设备、计算设备、连接到无线调制解调器的其它处理设备、车载设备、可穿戴设备、未来5G网络中的移动台以及未来演进的公共陆地移动网络(Public Land Mobile Network，PLMN)网络中的终端设备等中的任意一种。

[0091] 本发明实施例中的网络设备20可以是能和终端设备10通信的设备。网络设备20可以是基站、中继站或接入点。基站可以是全球移动通信系统(Global System for Mobile Communication，GSM)或码分多址(Code Division Multiple Access，CDMA)网络中的基站收发信台(Base Transceiver Station，BTS)，也可以是宽带码分多址(Wideband Code Division Multiple Access，WCDMA)中的NB(NodeB)，还可以是长期演进(Long Term Evolution，LTE)中的eNB或eNodeB(Evolutional NodeB)。网络设备20还可以是云无线接入网络(Cloud Radio Access Network，CRAN)场景下的无线控制器。网络设备20还可以是未来5G网络中的网络设备或者未来演进的PLMN网络中的网络设备。网络设备20还可以是可穿戴设备或车载设备。

[0092] 应理解，本发明实施例的技术方案可以应用于各种通信系统，例如：GSM系统、CDMA系统、WCDMA系统、通用分组无线业务(General Packet Radio Service，GPRS)、LTE系统、LTE频分双工(Frequency Division Duplex，FDD)系统、LTE时分双工(Time Division Duplex，TDD)、通用移动通信系统(Universal Mobile Telecommunication System，UMTS)或全球互联微波接入(Worldwide Interoperability for Microwave Access，WiMAX)通信

系统等。

[0093] 本发明实施例中，能够和基站进行数据通信的设备均可以理解为终端设备10，本发明实施例将以一般意义上的终端设备来介绍；本发明实施例中，网络设备20可以通过信令对终端设备10配置允许的最大波束数量，则终端设备10可以使用小于等于最大波束数量的波束向网络设备20发送用于波束恢复的请求；本发明实施例中，网络设备20可以对终端设备10配置第一时间窗，其中第一时间窗可以包括一个子帧、一个时隙以及一个或多个符号中的任意一种，则终端设备10可以在第一时间窗使用至少一个波束向网络设备20发送用于波束恢复的请求；本发明实施例中，网络设备20可以对终端设备10配置第三时间窗，其中第三时间窗可以包括一个子帧、一个时隙以及一个或多个符号中的任意一种，则终端设备10在第一时间窗使用至少一个第一波束向网络设备20发送用于波束恢复的请求之后，当在第一时间窗内未接收到网络设备20发送的用于波束恢复请求的响应时，终端设备10可以在第三时间窗使用至少一个第二波束向网络设备发送用于恢复波束的请求；本发明实施例中，网络设备20可以配置网络设备20侧的第二时间窗，其中第二时间窗可以包括一个子帧、一个时隙以及一个或多个符号中的任意一种，则网络设备20接收到终端设备10在第一时间窗使用至少一个波束发送的用于波束恢复的请求之后，可以在第二时间窗，在接收到的用于波束恢复的请求中确定一个用于波束恢复的请求。

[0094] 本发明实施例中，终端设备10至少有两种发送方式向网络设备20发送用于波束恢复的请求，以实现波束恢复。

[0095] 第一种发送方式可以为：终端设备10在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备20发送用于恢复波束的请求，并在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备20发送的用于波束恢复请求的响应。

[0096] 以图2A所示的信息传输的示意图为例，终端设备10在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束B4'向网络设备20发送用于恢复波束的请求。网络设备20按照接收RACH波束扫描方式检测终端设备10发送的用于恢复波束的请求，当网络设备20在第二时间窗内接收到终端设备10发送的用于波束恢复的请求时，网络设备20可以通过物理下行控制信道(Physical Downlink Control Channel，PDCCH)对该用于波束恢复的请求进行响应。当终端设备10在第一时间窗内未接收到网络设备20发送的用于恢复波束请求的响应时，终端设备10可以在第三时间窗所包含的至少一个符号上，使用至少一个相同的第二波束B5'向网络设备发送用于恢复波束的请求，当终端设备10在第三时间窗接收到网络设备20发送的用于波束恢复请求的响应时，终端设备10可以确定实现了波束恢复。

[0097] 第二种发送方式可以为：若第一时间窗包括第三单元时间窗和第四单元时间窗，终端设备10可以在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备20发送用于恢复波束的请求，并在第四单元时间窗所包含的至少一个符号上，使用至少一个不同的波束接收网络设备20发送的用于波束恢复请求的响应。

[0098] 以图2B所示的信息传输的示意图为例，终端设备10在第三单元时间窗所包含的至少一个符号上，使用多个不同的波束向网络设备20发送用于恢复波束的请求，网络设备20在第二时间窗内接收到终端设备10发送的多个用于恢复波束的请求之后，可以在多个用于恢复波束的请求中确定一个用于恢复波束的请求，网络设备20可以使用确定得到的一个用于恢复波束的请求对应的波束，向终端设备10发送用于波束恢复请求的响应。终端设备10

可以按照波束扫描方式检测网络设备20发送的用于波束恢复请求的响应，当终端设备10接收到网络设备20发送的用于波束恢复请求的响应时，终端设备10可以确定实现了波束恢复。

[0099] 相对第一种发送方式，本发明实施例通过第二种发送方式可以使用多个不同的波束向网络设备20发送用于恢复波束的请求，可减小时延，提高波束恢复效率。

[0100] 基于图1所示的波束恢复系统的架构示意图，请参见图3，图3是本发明实施例提供的一种波束恢复方法的流程示意图，该方法包括但不限于如下步骤：

[0101] 步骤S301：终端设备在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送调度请求。

[0102] 具体地，当下行链路(Down Link，DL)的波束失效时，终端设备可以在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送调度请求。其中，第一波束可以是网络设备对终端设备配置的波束，例如波束1。

[0103] 例如，终端设备可以在第一时间窗中选取一个符号(例如符号3)，并在符号3上使用一个波束1向网络设备发送调度请求。又如，终端设备可以在第一时间窗中选取一个符号(例如符号3)，并在符号3上使用多个波束1向网络设备发送调度请求，例如：终端设备在符号3上，在不同方向上使用波束1向网络设备发送调度请求。又如，以图4所示的信息传输的示意图为例，终端设备可以在第一时间窗中选取多个符号(例如符号3，符号4)，在符号3上使用一个波束1向网络设备发送调度请求，并在符号4上使用一个波束1向网络设备发送调度请求。又如，终端设备可以在第一时间窗中选取多个符号(例如符号3，符号4)，在符号3上使用多个波束1向网络设备发送调度请求，并在符号4上使用多个波束1向网络设备发送调度请求。

[0104] 本发明实施例中，终端设备在第一时间窗所包含的至少一个符号上，使用多个相同的第一波束向网络设备发送调度请求，可加大子载波间隔。

[0105] 本发明实施例中，网络设备可以对终端设备配置第一时间窗。其中，第一时间窗的起始时刻可以是配置有RACH资源的第一个符号，以图4所示的信息传输的示意图为例，配置有RACH资源的第一个符号为符号3，则终端设备可以确定第一时间窗的起始时刻为符号3。

[0106] 其中，第一时间窗的长度可以是固定长度，例如7个符号，可选的，第一时间窗的长度也可以是网络设备配置的，例如3个符号或者5个符号等。

[0107] 其中，网络设备可以向终端设备发送长度指示信息，以指示第一时间窗的长度。可选的，可以通过直接法指示第一时间窗的长度，例如长度指示信息为5，则终端设备可以确定第一时间窗的长度为5个符号。可选的，可以通过映射方式描述第一时间窗的长度，例如长度指示信息和第一时间窗的映射关系如表一所示：

[0108] 表一

[0109]

长度指示信息	第一时间窗的长度
00	3个符号
01	4个符号
10	5个符号
11	7个符号

[0110] 通过表一可知，当长度指示信息为二进制00时，终端设备可以确定第一时间窗的长度为3个符号；当长度指示信息为二进制11时，终端设备可以确定第一时间窗的长度为7个符号。需要说明的是，本发明实施例中的长度指示信息和第一时间窗长度的映射关系包含但不局限于上述方式，研发人员可以结合不同场景进行修改，具体不受本发明实施例的限制。

[0111] 其中，网络设备可以通过信令对终端设备配置第一时间窗，例如无线资源控制协议(Radio Resource Control，RRC)、媒体介入控制-控制元素协议(Media Access Control-Control Element，MAC-CE)或者下行控制信息协议(Downlink Control Information，DCI)等。

[0112] 其中，网络设备可以通过向终端设备发送长度指示信息的方式，通知终端设备配置了第一时间窗。

[0113] 步骤S302：网络设备确定在第二时间窗内接收到的第一个调度请求。

[0114] 具体地，网络设备可以按照接收RACH波束扫描方式在第二时间窗内接收终端设备发送的调度请求，并确定在第二时间窗内接收到的第一个调度请求。

[0115] 其中，网络设备可以配置网络设备侧的第二时间窗，第二时间窗所包含的第一个符号可以和第一单元时间窗所包含的第一个符号相同。

[0116] 其中，第二时间窗的长度可以是固定长度，例如4个符号，可选的，第二时间窗的长度也可以是网络设备配置的，例如3个符号或者5个符号等。

[0117] 步骤S303：网络设备在第二时间窗内使用确定得到的调度请求对应的波束，向终端设备发送调度请求响应。

[0118] 具体实现中，网络设备可以获取承载确定得到的调度请求的波束，确定该波束所属波束对所包含的另一波束，在第二时间窗内使用确定得到的波束向终端设备发送调度请求响应。其中，波束对可以包括一个发送端的发射波束和一个接收端的接收波束。例如承载确定得到的调度请求的波束为波束1，波束1与波束3构成一个波束对，则网络设备可以在第二时间窗内使用波束3向终端设备发送调度请求响应。

[0119] 以图4所示的信息传输的示意图为例，网络设备可以在第二时间窗所包含的符号0上，使用第一波束所属波束对所包含的另一波束向终端设备发送调度请求响应。

[0120] 可选的，网络设备可以通过PDCCH向终端设备发送调度请求响应。例如，终端设备可以在同一子帧接收多个承载在不同PDCCH上的DCI消息。对于一个PDCCH所承载的DCI消息，每个DCI消息上可以附着一个CRC。终端设备的C-RNTI可以被包含在CRC计算之中并隐式传输。则网络设备可以根据该终端设备的C-RNTI，确定包含该C-RNTI的CRC所属的DCI，进而确定承载该DCI的PDCCH，通过确定得到的PDCCH向终端设备发送调度请求响应。其中，DCI可以包括下行调度分配、上行调度请求、功率控制等。

[0121] 可选的，网络设备可以通过MAC-CE向终端设备发送调度请求响应。例如，网络设备可以定义一个新的MAC-CE，将该MAC-CE发送给终端设备，其中该MAC-CE可以携带调度请求响应。

[0122] 可选的，网络设备可以通过RRC向终端设备发送调度请求响应。例如，网络设备可以定义一个新的RRC IE，将该RRC IE发送给终端设备，其中该RRC IE可以携带调度请求响应。

[0123] 可选的，网络设备可以通过物理下行共享信道(Physical Downlink Shared Channel，PDSCH)向终端设备发送调度请求响应。

[0124] 步骤S304：终端设备在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备发送的调度请求响应。

[0125] 终端设备可以在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备发送的调度请求响应。例如，若终端设备在第一时间窗所包含的至少一个符号上，使用波束1向网络设备发送调度请求，则终端设备可以在第一时间窗所包含的至少一个符号上，使用波束1接收网络设备发送的调度请求响应。

[0126] 相对传统的波束恢复方法中终端设备接收调度请求响应的接收时间与发送调度请求的发送时间间隔至少两个子帧，本发明实施例中终端设备接收调度请求响应的接收时间与发送调度请求的发送时间间隔最多第一时间窗，例如7个符号，可降低延迟，提高波束恢复的效率。

[0127] 在图3所描述的方法中，终端设备在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送调度请求，网络设备确定在第二时间窗内接收到的第一个调度请求，网络设备在第二时间窗内使用确定得到的调度请求对应的波束，向终端设备发送调度请求响应，则终端设备在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备发送的调度请求响应，可实现网络设备针对同一终端设备发送的多个调度请求的波束恢复处理，提高波束恢复效率。

[0128] 基于图1所示的波束恢复系统的架构示意图，请参见图5，图5是本发明实施例提供的一种波束恢复方法的流程示意图，该方法包括但不限于如下步骤：

[0129] 步骤S501：终端设备在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送波束失败恢复请求。

[0130] 具体地，当DL波束失效时，终端设备可以在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送波束失败恢复请求。其中，第一波束可以是网络设备对终端设备配置的波束，例如波束1。

[0131] 例如，终端设备可以在第一时间窗中选取一个符号(例如符号3)，并在符号3上使用一个波束1向网络设备发送波束失败恢复请求。又如，终端设备可以在第一时间窗中选取一个符号(例如符号3)，并在符号3上使用多个波束1向网络设备发送波束失败恢复请求，例如：终端设备在符号3上，在不同方向上使用波束1向网络设备发送波束失败恢复请求。又如，以图4所示的信息传输的示意图为例，终端设备可以在第一时间窗中选取多个符号(例如符号3，符号4)，在符号3上使用一个波束1向网络设备发送波束失败恢复请求，并在符号4上使用一个波束1向网络设备发送波束失败恢复请求。又如，终端设备可以在第一时间窗中选取多个符号(例如符号3，符号4)，在符号3上使用多个波束1向网络设备发送波束失败恢复请求，并在符号4上使用多个波束1向网络设备发送波束失败恢复请求。

[0132] 本发明实施例中，终端设备在第一时间窗所包含的至少一个符号上，使用多个相同的第一波束向网络设备发送波束失败恢复请求，可加大子载波间隔。

[0133] 本发明实施例中，网络设备可以对终端设备配置第一时间窗。其中，第一时间窗的起始时刻可以是配置有RACH资源的第一个符号，以图4所示的信息传输的示意图为例，配置有RACH资源的第一个符号为符号3，则终端设备可以确定第一时间窗的起始时刻为符号3。

[0134] 其中，第一时间窗的长度可以是固定长度，例如7个符号，可选的，第一时间窗的长度也可以是网络设备配置的，例如3个符号或者5个符号等。

[0135] 其中，网络设备可以向终端设备发送长度指示信息，以指示第一时间窗的长度。可选的，可以通过直接法指示第一时间窗的长度，例如长度指示信息为5，则终端设备可以确定第一时间窗的长度为5个符号。可选的，可以通过映射方式描述第一时间窗的长度，例如长度指示信息和第一时间窗的映射关系如表一所示。通过表一可知，当长度指示信息为二进制00时，终端设备可以确定第一时间窗的长度为3个符号；当长度指示信息为二进制11时，终端设备可以确定第一时间窗的长度为7个符号。需要说明的是，本发明实施例中的长度指示信息和第一时间窗长度的映射关系包含但不局限于上述方式，研发人员可以结合不同场景进行修改，具体不受本发明实施例的限制。

[0136] 其中，网络设备可以通过信令对终端设备配置第一时间窗，例如无线资源控制协议(Radio Resource Control，RRC)、媒体介入控制-控制元素协议(Media Access Control-Control Element，MAC-CE)或者下行控制信息协议(Downlink Control Information，DCI)等。

[0137] 其中，网络设备可以通过向终端设备发送长度指示信息的方式，通知终端设备配置了第一时间窗。

[0138] 步骤S502：网络设备确定在第二时间窗内接收到的第一个波束失败恢复请求。

[0139] 具体地，网络设备可以按照接收RACH波束扫描方式在第二时间窗内接收终端设备发送的波束失败恢复请求，并确定在第二时间窗内接收到的第一个波束失败恢复请求。

[0140] 其中，网络设备可以配置网络设备侧的第二时间窗，第二时间窗所包含的第一个符号可以和第一单元时间窗所包含的第一个符号相同。

[0141] 其中，第二时间窗的长度可以是固定长度，例如4个符号，可选的，第二时间窗的长度也可以是网络设备配置的，例如3个符号或者5个符号等。

[0142] 步骤S503：网络设备在第二时间窗内使用确定得到的波束失败恢复请求对应的波束，向终端设备发送波束失败恢复请求响应。

[0143] 具体实现中，网络设备可以获取承载确定得到的波束失败恢复请求的波束，确定该波束所属波束对所包含的另一波束，在第二时间窗内使用确定得到的波束向终端设备发送波束失败恢复请求响应。例如承载确定得到的波束失败恢复请求的波束为波束1，波束1与波束3构成一个波束对，则网络设备可以在第二时间窗内使用波束3向终端设备发送波束失败恢复请求响应。

[0144] 以图4所示的信息传输的示意图为例，网络设备可以在第二时间窗所包含的符号0上，使用第一波束所属波束对所包含的另一波束向终端设备发送波束失败恢复请求响应。

[0145] 可选的，网络设备可以通过PDCCH向终端设备发送波束失败恢复请求响应。

[0146] 可选的，网络设备可以通过MAC-CE向终端设备发送波束失败恢复请求响应。

[0147] 可选的，网络设备可以通过RRC向终端设备发送波束失败恢复请求响应。

[0148] 可选的，网络设备可以通过PDSCH向终端设备发送波束失败恢复请求响应。

[0149] 步骤S504：终端设备在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备发送的波束失败恢复请求响应。

[0150] 终端设备可以在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设

备发送的波束失败恢复请求响应。例如，若终端设备在第一时间窗所包含的至少一个符号上，使用波束1向网络设备发送波束失败恢复请求，则终端设备可以在第一时间窗所包含的至少一个符号上，使用波束1接收网络设备发送的波束失败恢复请求响应。

[0151] 相对传统的波束恢复方法中终端设备接收波束失败恢复请求响应的接收时间与发送波束失败恢复请求的发送时间间隔至少两个子帧，本发明实施例中终端设备接收波束失败恢复请求响应的接收时间与发送波束失败恢复请求的发送时间间隔最多第一时间窗，例如7个符号，可降低延迟，提高波束恢复的效率。

[0152] 在图5所描述的方法中，终端设备在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送波束失败恢复请求，网络设备确定在第二时间窗内接收到的第一个波束失败恢复请求，网络设备在第二时间窗内使用确定得到的波束失败恢复请求对应的波束，向终端设备发送波束失败恢复请求响应，则终端设备在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备发送的波束失败恢复请求响应，可实现网络设备针对同一终端设备发送的多个波束失败恢复请求的波束恢复处理，提高波束恢复效率。

[0153] 基于图1所示的波束恢复系统的架构示意图，请参见图6，图6是本发明实施例提供的一种波束恢复方法的流程示意图，该方法包括但不限于如下步骤：

[0154] 步骤S601：终端设备在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送调度请求。

[0155] 具体地，当DL波束失效时，终端设备可以在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送调度请求。其中，第一波束可以是网络设备对终端设备配置的波束，例如波束1。

[0156] 例如，终端设备可以在第一单元时间窗中选取一个符号(例如符号3)，并在符号3上使用一个波束1向网络设备发送调度请求。又如，终端设备可以在第一单元时间窗中选取一个符号(例如符号3)，并在符号3上使用多个波束1向网络设备发送调度请求，例如：终端设备在符号3上，在不同方向上使用波束1向网络设备发送调度请求。又如，以图7所示的信息传输的示意图为例，终端设备可以在第一单元时间窗中选取多个符号(例如符号3，符号4)，在符号3上使用一个波束1向网络设备发送调度请求，并在符号4上使用一个波束1向网络设备发送调度请求。又如，终端设备可以在第一单元时间窗中选取多个符号(例如符号3，符号4)，在符号3上使用多个波束1向网络设备发送调度请求，并在符号4上使用多个波束1向网络设备发送调度请求。

[0157] 本发明实施例中，终端设备在第一单元时间窗所包含的至少一个符号上，使用多个相同的第一波束向网络设备发送调度请求，可加大子载波间隔。

[0158] 本发明实施例中，网络设备可以对终端设备配置第一单元时间窗。其中，第一单元时间窗的起始时刻可以是配置有RACH资源的第一个符号，以图7所示的信息传输的示意图为例，配置有RACH资源的第一个符号为符号3，则终端设备可以确定第一单元时间窗的起始时刻为符号3。

[0159] 本发明实施例中，网络设备可以对终端设备配置第二单元时间窗。其中，第二单元时间窗所包含的第一个符号为第一单元时间窗所包含的最后一个符号之后的第一个符号，以图7所示的信息传输的示意图为例，第一单元时间窗所包含的最后一个符号为符号6，则

终端设备可以确定第二单元时间窗所包含的第一个符号为符号0。

[0160] 其中，第一单元时间窗的长度可以是固定长度，例如4个符号，可选的，第一单元时间窗的长度也可以是网络设备配置的，例如3个符号或者5个符号等。

[0161] 其中，第二单元时间窗的长度可以是固定长度，例如4个符号，可选的，第二单元时间窗的长度也可以是网络设备配置的，例如3个符号或者5个符号等。

[0162] 其中，网络设备可以向终端设备发送第一长度指示信息，以指示第一单元时间窗的长度。可选的，可以通过直接法指示第一单元时间窗的长度。可选的，可以通过映射方式描述第一单元时间窗的长度。

[0163] 其中，网络设备可以向终端设备发送第二长度指示信息，以指示第二单元时间窗的长度。可选的，可以通过直接法指示第二单元时间窗的长度。可选的，可以通过映射方式描述第二单元时间窗的长度。

[0164] 其中，网络设备可以通过信令对终端设备配置第一单元时间窗，例如RRC、MAC-CE或者DCI等。

[0165] 其中，网络设备可以通过信令对终端设备配置第二单元时间窗，例如RRC、MAC-CE或者DCI等。

[0166] 其中，网络设备可以通过向终端设备发送第一长度指示信息的方式，通知终端设备配置了第一单元时间窗。

[0167] 其中，网络设备可以通过向终端设备发送第二长度指示信息的方式，通知终端设备配置了第二单元时间窗。

[0168] 步骤S602：网络设备在第二时间窗内，在接收到的调度请求中确定一个调度请求。

[0169] 具体地，网络设备可以按照接收RACH波束扫描方式在第二时间窗内接收终端设备发送的调度请求，并在接收到的调度请求中确定一个调度请求。

[0170] 可选的，网络设备可以确定在第二时间窗内接收到的第一个调度请求。

[0171] 可选的，网络设备可以确定在第二时间窗内接收到的质量大于预设质量阈值的波束所承载的调度请求。

[0172] 可选的，网络设备可以确定在第二时间窗内接收到的质量最好的波束所承载的调度请求。

[0173] 其中，网络设备可以配置网络设备侧的第二时间窗，第二时间窗所包含的第一个符号可以和第一单元时间窗所包含的第一个符号相同。

[0174] 其中，第二时间窗的长度可以是固定长度，例如4个符号，可选的，第二时间窗的长度也可以是网络设备配置的，例如3个符号或者5个符号等。

[0175] 步骤S603：网络设备在第二时间窗之后使用确定得到的调度请求对应的波束，向终端设备发送调度请求响应。

[0176] 具体实现中，网络设备可以获取承载确定得到的调度请求的波束，确定该波束所属波束对所包含的另一波束，在第二时间窗之后使用确定得到的波束向终端设备发送调度请求响应。例如承载确定得到的调度请求的波束为波束1，波束1与波束3构成一个波束对，则网络设备可以在第二时间窗之后使用波束3向终端设备发送调度请求响应。

[0177] 以图7所示的信息传输的示意图为例，网络设备可以在第二时间窗之后的第一个符号，即符号0，使用第一波束所属波束对所包含的另一波束向终端设备发送调度请求响

应。

[0178] 可选的，网络设备可以通过PDCCH向终端设备发送调度请求响应。

[0179] 可选的，网络设备可以通过MAC-CE向终端设备发送调度请求响应。

[0180] 可选的，网络设备可以通过RRC向终端设备发送调度请求响应。

[0181] 可选的，网络设备可以通过PDSCH向终端设备发送调度请求响应。

[0182] 步骤S604：终端设备在第二单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束接收网络设备发送的调度请求响应。

[0183] 终端设备可以在第二单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束接收网络设备发送的调度请求响应。例如，若终端设备在第一单元时间窗所包含的至少一个符号上，使用波束1向网络设备发送调度请求，则终端设备可以在第二单元时间窗所包含的至少一个符号上，使用波束1接收网络设备发送的调度请求响应。

[0184] 相对传统的波束恢复方法中终端设备接收调度请求响应的接收时间与发送调度请求的发送时间间隔至少两个子帧，本发明实施例中终端设备接收调度请求响应的接收时间与发送调度请求的发送时间间隔最多第一时间窗，例如7个符号，可降低延迟，提高波束恢复的效率。

[0185] 在图6所描述的方法中，终端设备在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送调度请求，网络设备确定在第二时间窗内接收到的第一个调度请求，网络设备在第二时间窗之后使用确定得到的调度请求对应的波束，向终端设备发送调度请求响应，则终端设备在第二单元时间窗所包含的至少一个符号上，使用第一波束接收网络设备发送的调度请求响应，可实现网络设备针对同一终端设备发送的多个调度请求的波束恢复处理，提高波束恢复效率。

[0186] 基于图1所示的波束恢复系统的架构示意图，请参见图8，图8是本发明实施例提供的一种波束恢复方法的流程示意图，该方法包括但不限于如下步骤：

[0187] 步骤S801：终端设备在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送波束失败恢复请求。

[0188] 具体地，当DL波束失效时，终端设备可以在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送波束失败恢复请求。其中，第一波束可以是网络设备对终端设备配置的波束，例如波束1。

[0189] 例如，终端设备可以在第一单元时间窗中选取一个符号(例如符号3)，并在符号3上使用一个波束1向网络设备发送波束失败恢复请求。又如，终端设备可以在第一单元时间窗中选取一个符号(例如符号3)，并在符号3上使用多个波束1向网络设备发送波束失败恢复请求，例如：终端设备在符号3上，在不同方向上使用波束1向网络设备发送波束失败恢复请求。又如，以图7所示的信息传输的示意图为例，终端设备可以在第一单元时间窗中选取多个符号(例如符号3，符号4)，在符号3上使用一个波束1向网络设备发送波束失败恢复请求，并在符号4上使用一个波束1向网络设备发送波束失败恢复请求。又如，终端设备可以在第一单元时间窗中选取多个符号(例如符号3，符号4)，在符号3上使用多个波束1向网络设备发送波束失败恢复请求，并在符号4上使用多个波束1向网络设备发送波束失败恢复请求。

[0190] 本发明实施例中，终端设备在第一单元时间窗所包含的至少一个符号上，使用多

个相同的第一波束向网络设备发送波束失败恢复请求，可加大子载波间隔。

[0191] 本发明实施例中，网络设备可以对终端设备配置第一单元时间窗。其中，第一单元时间窗的起始时刻可以是配置有RACH资源的第一个符号，以图7所示的信息传输的示意图为例，配置有RACH资源的第一个符号为符号3，则终端设备可以确定第一单元时间窗的起始时刻为符号3。

[0192] 本发明实施例中，网络设备可以对终端设备配置第二单元时间窗。其中，第二单元时间窗所包含的第一个符号为第一单元时间窗所包含的最后一个符号之后的第一个符号，以图7所示的信息传输的示意图为例，第一单元时间窗所包含的最后一个符号为符号8，则终端设备可以确定第二单元时间窗所包含的第一个符号为符号0。

[0193] 其中，第一单元时间窗的长度可以是固定长度，例如4个符号，可选的，第一单元时间窗的长度也可以是网络设备配置的，例如3个符号或者5个符号等。

[0194] 其中，第二单元时间窗的长度可以是固定长度，例如4个符号，可选的，第二单元时间窗的长度也可以是网络设备配置的，例如3个符号或者5个符号等。

[0195] 其中，网络设备可以向终端设备发送第一长度指示信息，以指示第一单元时间窗的长度。可选的，可以通过直接法指示第一单元时间窗的长度。可选的，可以通过映射方式描述第一单元时间窗的长度。

[0196] 其中，网络设备可以向终端设备发送第二长度指示信息，以指示第二单元时间窗的长度。可选的，可以通过直接法指示第二单元时间窗的长度。可选的，可以通过映射方式描述第二单元时间窗的长度。

[0197] 其中，网络设备可以通过信令对终端设备配置第一单元时间窗，例如RRC、MAC-CE或者DCI等。

[0198] 其中，网络设备可以通过信令对终端设备配置第二单元时间窗，例如RRC、MAC-CE或者DCI等。

[0199] 其中，网络设备可以通过向终端设备发送第一长度指示信息的方式，通知终端设备配置了第一单元时间窗。

[0200] 其中，网络设备可以通过向终端设备发送第二长度指示信息的方式，通知终端设备配置了第二单元时间窗。

[0201] 步骤S802：网络设备在第二时间窗内，在接收到的波束失败恢复请求中确定一个波束失败恢复请求。

[0202] 具体地，网络设备可以按照接收RACH波束扫描方式在第二时间窗内接收终端设备发送的波束失败恢复请求，并在接收到的波束失败恢复请求中确定一个波束失败恢复请求。

[0203] 可选的，网络设备可以确定在第二时间窗内接收到的第一个波束失败恢复请求。

[0204] 可选的，网络设备可以确定在第二时间窗内接收到的质量大于预设质量阈值的波束所承载的波束失败恢复请求。

[0205] 可选的，网络设备可以确定在第二时间窗内接收到的质量最好的波束所承载的波束失败恢复请求。

[0206] 其中，网络设备可以配置网络设备侧的第二时间窗，第二时间窗所包含的第一个符号可以和第一时间窗所包含的第一个符号相同。

[0207] 其中，第二时间窗的长度可以是固定长度，例如4个符号，可选的，第二时间窗的长度也可以是网络设备配置的，例如3个符号或者5个符号等。

[0208] 步骤S803：网络设备在第二时间窗之后使用确定得到的波束失败恢复请求对应的波束，向终端设备发送波束失败恢复请求响应。

[0209] 具体实现中，网络设备可以获取承载确定得到的波束失败恢复请求的波束，确定该波束所属波束对所包含的另一波束，在第二时间窗之后使用确定得到的波束向终端设备发送波束失败恢复请求响应。例如承载确定得到的波束失败恢复请求的波束为波束1，波束1与波束3构成一个波束对，则网络设备可以在第二时间窗之后使用波束3向终端设备发送波束失败恢复请求响应。

[0210] 以图7所示的信息传输的示意图为例，网络设备可以在第二时间窗之后的第一个符号上，使用第一波束所属波束对所包含的另一波束向终端设备发送波束失败恢复请求响应。

[0211] 可选的，网络设备可以通过PDCCH向终端设备发送波束失败恢复请求响应。

[0212] 可选的，网络设备可以通过MAC-CE向终端设备发送波束失败恢复请求响应。

[0213] 可选的，网络设备可以通过RRC向终端设备发送波束失败恢复请求响应。

[0214] 可选的，网络设备可以通过PDSCH向终端设备发送波束失败恢复请求响应。

[0215] 步骤S804：终端设备在第二单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束接收网络设备发送的波束失败恢复请求响应。

[0216] 终端设备可以在第二单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束接收网络设备发送的波束失败恢复请求响应。例如，若终端设备在第一单元时间窗所包含的至少一个符号上，使用波束1向网络设备发送波束失败恢复请求，则终端设备可以在第二单元时间窗所包含的至少一个符号上，使用波束1接收网络设备发送的波束失败恢复请求响应。

[0217] 相对传统的波束恢复方法中终端设备接收波束失败恢复请求响应的接收时间与发送波束失败恢复请求的发送时间间隔至少两个子帧，本发明实施例中终端设备接收波束失败恢复请求响应的接收时间与发送波束失败恢复请求的发送时间间隔最多第一时间窗，例如7个符号，可降低延迟，提高波束恢复的效率。

[0218] 在图8所描述的方法中，终端设备在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送波束失败恢复请求，网络设备确定在第二时间窗内接收到的第一个波束失败恢复请求，网络设备在第二时间窗之后使用确定得到的波束失败恢复请求对应的波束，向终端设备发送波束失败恢复请求响应，则终端设备在第二单元时间窗所包含的至少一个符号上，使用第一波束接收网络设备发送的波束失败恢复请求响应，可实现网络设备针对同一终端设备发送的多个波束失败恢复请求的波束恢复处理，提高波束恢复效率。

[0219] 基于图1所示的波束恢复系统的架构示意图，请参见图9，图9是本发明实施例提供的一种波束恢复方法的流程示意图，该方法包括但不限于如下步骤：

[0220] 步骤S901：终端设备在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备发送调度请求。

[0221] 具体地，当DL波束失效时，终端设备可以在第三单元时间窗所包含的至少一个符

号上，使用至少一个不同的波束向网络设备发送调度请求。其中，网络设备可以对终端设备配置允许的最大波束数量，则终端设备可以使用小于等于最大波束数量的波束向网络设备发送调度请求。

[0222] 例如，终端设备可以在第三单元时间窗中选取一个符号(例如符号3)，并在符号3上使用一个波束1向网络设备发送调度请求。又如，终端设备可以在第三单元时间窗中选取一个符号(例如符号3)，并在符号3上使用多个不同波束向网络设备发送调度请求，示例性的，终端设备在符号3上，分别使用波束1和波束2向网络设备发送调度请求。又如，以图10所示的信息传输的示意图为例，终端设备可以在第三单元时间窗中选取多个符号(例如符号3，符号4)，在符号3上使用一个波束1向网络设备发送调度请求，并在符号4上使用一个波束2向网络设备发送调度请求。又如，终端设备可以在第三单元时间窗中选取多个符号(例如符号3，符号4)，在符号3上使用多个不同波束向网络设备发送调度请求，并在符号4上使用多个不同波束向网络设备发送调度请求。

[0223] 本发明实施例中，终端设备在第三单元时间窗所包含的至少一个符号上，使用多个不同波束向网络设备发送调度请求，可加大子载波间隔。

[0224] 本发明实施例中，网络设备可通过RRC、MAC-CE或者DCI等信令对终端设备配置允许的最大波束数量。其中，同一小区所有终端设备可以配置相同的最大波束数量，或者终端设备集群所包含的所有终端设备可以配置相同的最大波束数量，或者不同终端设备可配置不同的最大波束数量，当不同终端设备配置不同的最大波束数量时，该终端设备需要向网络设备上报该终端设备的能力。其中，可以通过直接法指示最大波束数量。可选的，可以通过映射方法描述最大波束数量。

[0225] 本发明实施例中，网络设备可以对终端设备配置第三单元时间窗。其中，第三单元时间窗的起始时刻可以是配置有RACH资源的第一个符号，以图10所示的信息传输的示意图为例，配置有RACH资源的第一个符号为符号3，则终端设备可以确定第三单元时间窗的起始时刻为符号3。

[0226] 本发明实施例中，网络设备可以对终端设备配置第四单元时间窗。其中，第四单元时间窗所包含的第一个符号为第三单元时间窗所包含的最后一个符号之后的第一个符号，以图10所示的信息传输的示意图为例，第三单元时间窗所包含的最后一个符号为符号6，则终端设备可以确定第四单元时间窗所包含的第一个符号为符号0。

[0227] 其中，第三单元时间窗的长度可以是固定长度，例如4个符号，可选的，第三单元时间窗的长度也可以是网络设备配置的，例如3个符号或者5个符号等。

[0228] 其中，第四单元时间窗的长度可以是固定长度，例如4个符号，可选的，第四单元时间窗的长度也可以是网络设备配置的，例如3个符号或者5个符号等。

[0229] 其中，网络设备可以向终端设备发送第三长度指示信息，以指示第三单元时间窗的长度。可选的，可以通过直接法指示第三单元时间窗的长度。可选的，可以通过映射方式描述第三单元时间窗的长度。

[0230] 其中，网络设备可以向终端设备发送第四长度指示信息，以指示第四单元时间窗的长度。可选的，可以通过直接法指示第四单元时间窗的长度。可选的，可以通过映射方式描述第四单元时间窗的长度。

[0231] 其中，网络设备可以通过信令对终端设备配置第三单元时间窗，例如RRC、MAC-CE

或者DCI等。

[0232] 其中，网络设备可以通过信令对终端设备配置第四单元时间窗，例如RRC、MAC-CE或者DCI等。

[0233] 其中，网络设备可以通过向终端设备发送第三长度指示信息的方式，通知终端设备配置了第三单元时间窗。

[0234] 其中，网络设备可以通过向终端设备发送第四长度指示信息的方式，通知终端设备配置了第四单元时间窗。

[0235] 步骤S902：网络设备在第二时间窗内，在接收到的调度请求中确定一个调度请求。

[0236] 具体地，网络设备可以按照接收RACH波束扫描方式在第二时间窗内接收终端设备发送的调度请求，并在接收到的调度请求中确定一个调度请求。

[0237] 可选的，网络设备可以确定在第二时间窗内接收到的第一个调度请求。

[0238] 可选的，网络设备可以确定在第二时间窗内接收到的质量大于预设质量阈值的波束所承载的调度请求。

[0239] 可选的，网络设备可以确定在第二时间窗内接收到的质量最好的波束所承载的调度请求。

[0240] 其中，网络设备可以配置网络设备侧的第二时间窗，第二时间窗所包含的第一个符号可以和第三单元时间窗所包含的第一个符号相同。

[0241] 其中，第二时间窗的长度可以是固定长度，例如4个符号，可选的，第二时间窗的长度也可以是网络设备配置的，例如3个符号或者5个符号等。

[0242] 步骤S903：网络设备在第二时间窗之后使用确定得到的调度请求对应的波束，向终端设备发送调度请求响应。

[0243] 具体实现中，网络设备可以获取承载确定得到的调度请求的波束，确定该波束所属波束对所包含的另一波束，在第二时间窗之后使用确定得到的波束向终端设备发送调度请求响应。例如承载确定得到的调度请求的波束为波束1，波束1与波束3构成一个波束对，则网络设备可以在第二时间窗之后使用波束3向终端设备发送调度请求响应。

[0244] 以图10所示的信息传输的示意图为例，网络设备可以在第二时间窗之后的第一个符号，即符号0，使用第一波束所属波束对所包含的另一波束向终端设备发送调度请求响应，网络设备还可以在第二时间窗之后的第二个符号，即符号1，使用第一波束所属波束对所包含的另一波束向终端设备发送调度请求响应。

[0245] 可选的，网络设备可以通过PDCCH向终端设备发送调度请求响应。

[0246] 可选的，网络设备可以通过MAC-CE向终端设备发送调度请求响应。

[0247] 可选的，网络设备可以通过RRC向终端设备发送调度请求响应。

[0248] 可选的，网络设备可以通过PDSCH向终端设备发送调度请求响应。

[0249] 步骤S904：终端设备在第四单元时间窗所包含的至少一个符号上，使用至少一个不同的波束接收网络设备发送的调度请求响应。

[0250] 终端设备可以在第四单元时间窗所包含的至少一个符号上，使用至少一个不同的波束接收网络设备发送的调度请求响应。例如，若终端设备在第三单元时间窗所包含的至少一个符号上，分别使用波束1和波束2向网络设备发送调度请求，则终端设备可以在第四单元时间窗所包含的至少一个符号上，分别使用波束1和波束2接收网络设备发送的调度请

求响应。

[0251] 相对传统的波束恢复方法中终端设备接收调度请求响应的接收时间与发送调度请求的发送时间间隔至少两个子帧，本发明实施例中终端设备接收调度请求响应的接收时间与发送调度请求的发送时间间隔最多第一时间窗，例如7个符号，可降低延迟，提高波束恢复的效率。

[0252] 在图9所描述的方法中，终端设备在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备发送调度请求，网络设备在第二时间窗内，在接收到的调度请求中确定一个调度请求，网络设备在第二时间窗之后使用确定得到的调度请求对应的波束，向终端设备发送调度请求响应，终端设备在第四单元时间窗所包含的至少一个符号上，使用至少一个不同的波束接收网络设备发送的调度请求响应，可实现网络设备针对同一终端设备发送的多个调度请求的波束恢复处理，提高波束恢复效率。

[0253] 基于图1所示的波束恢复系统的架构示意图，请参见图11，图11是本发明实施例提供的一种波束恢复方法的流程示意图，该方法包括但不限于如下步骤：

[0254] 步骤S1101：终端设备在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备发送波束失败恢复请求。

[0255] 具体地，当DL波束失效时，终端设备可以在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备发送波束失败恢复请求。其中，网络设备可以对终端设备配置允许的最大波束数量，则终端设备可以使用小于等于最大波束数量的波束向网络设备发送波束失败恢复请求。

[0256] 例如，终端设备可以在第三单元时间窗中选取一个符号(例如符号3)，并在符号3上使用一个波束1向网络设备发送波束失败恢复请求。又如，终端设备可以在第三单元时间窗中选取一个符号(例如符号3)，并在符号3上使用多个不同波束向网络设备发送波束失败恢复请求，示例性的，终端设备在符号3上，分别使用波束1和波束2向网络设备发送波束失败恢复请求。又如，以图10所示的信息传输的示意图为例，终端设备可以在第三单元时间窗中选取多个符号(例如符号3，符号4)，在符号3上使用一个波束1向网络设备发送波束失败恢复请求，并在符号4上使用一个波束2向网络设备发送波束失败恢复请求。又如，终端设备可以在第三单元时间窗中选取多个符号(例如符号3，符号4)，在符号3上使用多个不同波束向网络设备发送波束失败恢复请求，并在符号4上使用多个不同波束向网络设备发送波束失败恢复请求。

[0257] 本发明实施例中，终端设备在第三单元时间窗所包含的至少一个符号上，使用多个不同波束向网络设备发送波束失败恢复请求，可加大子载波间隔。

[0258] 本发明实施例中，网络设备可通过RRC、MAC-CE或者DCI等信令对终端设备配置允许的最大波束数量。其中，同一小区所有终端设备可以配置相同的最大波束数量，或者终端设备集群所包含的所有终端设备可以配置相同的最大波束数量，或者不同终端设备可配置不同的最大波束数量，当不同终端设备配置不同的最大波束数量时，该终端设备需要向网络设备上报该终端设备的能力。其中，可以通过直接法指示最大波束数量。可选的，可以通过映射方法描述最大波束数量。

[0259] 本发明实施例中，网络设备可以对终端设备配置第三单元时间窗。其中，第三单元时间窗的起始时刻可以是配置有RACH资源的第一个符号，以图10所示的信息传输的示意图

为例，配置有RACH资源的第一个符号为符号3，则终端设备可以确定第三单元时间窗的起始时刻为符号3。

[0260] 本发明实施例中，网络设备可以对终端设备配置第四单元时间窗。其中，第四单元时间窗所包含的第一个符号为第三单元时间窗所包含的最后一个符号之后的第一个符号，以图10所示的信息传输的示意图为例，第三单元时间窗所包含的最后一个符号为符号6，则终端设备可以确定第四单元时间窗所包含的第一个符号为符号0。

[0261] 其中，第三单元时间窗的长度可以是固定长度，例如4个符号，可选的，第三单元时间窗的长度也可以是网络设备配置的，例如3个符号或者5个符号等。

[0262] 其中，第四单元时间窗的长度可以是固定长度，例如4个符号，可选的，第四单元时间窗的长度也可以是网络设备配置的，例如3个符号或者5个符号等。

[0263] 其中，网络设备可以向终端设备发送第三长度指示信息，以指示第三单元时间窗的长度。可选的，可以通过直接法指示第三单元时间窗的长度。可选的，可以通过映射方式描述第三单元时间窗的长度。

[0264] 其中，网络设备可以向终端设备发送第四长度指示信息，以指示第四单元时间窗的长度。可选的，可以通过直接法指示第四单元时间窗的长度。可选的，可以通过映射方式描述第四单元时间窗的长度。

[0265] 其中，网络设备可以通过信令对终端设备配置第三单元时间窗，例如RRC、MAC-CE或者DCI等。

[0266] 其中，网络设备可以通过信令对终端设备配置第四单元时间窗，例如RRC、MAC-CE或者DCI等。

[0267] 其中，网络设备可以通过向终端设备发送第三长度指示信息的方式，通知终端设备配置了第三单元时间窗。

[0268] 其中，网络设备可以通过向终端设备发送第四长度指示信息的方式，通知终端设备配置了第四单元时间窗。

[0269] 步骤S1102：网络设备在第二时间窗内，在接收到的波束失败恢复请求中确定一个波束失败恢复请求。

[0270] 具体地，网络设备可以按照接收RACH波束扫描方式在第二时间窗内接收终端设备发送的波束失败恢复请求，并在接收到的波束失败恢复请求中确定一个波束失败恢复请求。

[0271] 可选的，网络设备可以确定在第二时间窗内接收到的第一个波束失败恢复请求。

[0272] 可选的，网络设备可以确定在第二时间窗内接收到的质量大于预设质量阈值的波束所承载的波束失败恢复请求。

[0273] 可选的，网络设备可以确定在第二时间窗内接收到的质量最好的波束所承载的波束失败恢复请求。

[0274] 其中，网络设备可以配置网络设备侧的第二时间窗，第二时间窗所包含的第一个符号可以和第三单元时间窗所包含的第一个符号相同。

[0275] 其中，第二时间窗的长度可以是固定长度，例如4个符号，可选的，第二时间窗的长度也可以是网络设备配置的，例如3个符号或者5个符号等。

[0276] 步骤S1103：网络设备在第二时间窗之后使用确定得到的波束失败恢复请求对应

的波束，向终端设备发送波束失败恢复请求响应。

[0277] 具体实现中，网络设备可以获取承载确定得到的波束失败恢复请求的波束，确定该波束所属波束对所包含的另一波束，在第二时间窗之后使用确定得到的波束向终端设备发送波束失败恢复请求响应。例如承载确定得到的波束失败恢复请求的波束为波束1，波束1与波束3构成一个波束对，则网络设备可以在第二时间窗之后使用波束3向终端设备发送波束失败恢复请求响应。

[0278] 以图10所示的信息传输的示意图为例，网络设备可以在第二时间窗之后的第一个符号，即符号0，使用第一波束所属波束对所包含的另一波束向终端设备发送波束失败恢复请求响应，网络设备还可以在第二时间窗之后的第二个符号，即符号1，使用第一波束所属波束对所包含的另一波束向终端设备发送波束失败恢复请求响应。

[0279] 可选的，网络设备可以通过PDCCH向终端设备发送波束失败恢复请求响应。

[0280] 可选的，网络设备可以通过MAC-CE向终端设备发送波束失败恢复请求响应。

[0281] 可选的，网络设备可以通过RRC向终端设备发送波束失败恢复请求响应。

[0282] 可选的，网络设备可以通过PDSCH向终端设备发送波束失败恢复请求响应。

[0283] 步骤S1104：终端设备在第四单元时间窗所包含的至少一个符号上，使用至少一个不同的波束接收网络设备发送的波束失败恢复请求响应。

[0284] 终端设备可以在第四单元时间窗所包含的至少一个符号上，使用至少一个不同的波束接收网络设备发送的波束失败恢复请求响应。例如，若终端设备在第三单元时间窗所包含的至少一个符号上，分别使用波束1和波束2向网络设备发送波束失败恢复请求，则终端设备可以在第四单元时间窗所包含的至少一个符号上，分别使用波束1和波束2接收网络设备发送的波束失败恢复请求响应。

[0285] 相对传统的波束恢复方法中终端设备接收波束失败恢复请求响应的接收时间与发送波束失败恢复请求的发送时间间隔至少两个子帧，本发明实施例中终端设备接收波束失败恢复请求响应的接收时间与发送波束失败恢复请求的发送时间间隔最多第一时间窗，例如7个符号，可降低延迟，提高波束恢复的效率。

[0286] 在图11所描述的方法中，终端设备在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备发送波束失败恢复请求，网络设备在第二时间窗内，在接收到的波束失败恢复请求中确定一个波束失败恢复请求，网络设备在第二时间窗之后使用确定得到的波束失败恢复请求对应的波束，向终端设备发送波束失败恢复请求响应，终端设备在第四单元时间窗所包含的至少一个符号上，使用至少一个不同的波束接收网络设备发送的波束失败恢复请求响应，可实现网络设备针对同一终端设备发送的多个波束失败恢复请求的波束恢复处理，提高波束恢复效率。

[0287] 上述详细阐述了本发明实施例的方法，下面提供了本发明实施例的装置。

[0288] 请参见图12，图12是本发明实施例提供的一种波束恢复装置的结构示意图，该波束恢复装置可以包括发送模块1201以及接收模块1202，其中，各个模块的详细描述如下。

[0289] 发送模块1201，用于在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

[0290] 接收模块1202，用于在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波

束失败恢复请求响应。

[0291] 可选的，所述发送模块1201，具体用于在所述第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

[0292] 可选的，所述接收模块1202，具体用于在所述第一时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

[0293] 可选的，所述第一时间窗包括第一单元时间窗和第二单元时间窗，所述第二单元时间窗所包含的第一个符号为所述第一单元时间窗所包含的最后一个符号之后的第一个符号；

[0294] 所述发送模块1201，具体用于在所述第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

[0295] 可选的，所述接收模块1202，具体用于在所述第二单元时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

[0296] 可选的，本发明实施例中的波束恢复装置还可以包括：

[0297] 确定模块1203，用于当在所述第一时间窗内未接收到所述用于波束恢复请求的响应时，所述波束恢复装置确定所述网络设备对所述波束恢复装置配置的第三时间窗；

[0298] 所述发送模块1201，还用于在所述第三时间窗所包含的至少一个符号上，使用至少一个相同的第二波束向所述网络设备发送所述用于恢复波束的请求。

[0299] 可选的，所述第一时间窗包括第三单元时间窗和第四单元时间窗，所述第四单元时间窗所包含的第一个符号为所述第三单元时间窗所包含的最后一个符号之后的第一个符号；

[0300] 所述发送模块1201，具体用于在所述第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向所述网络设备发送所述用于恢复波束的请求。

[0301] 可选的，所述接收模块1202，具体用于在所述第四单元时间窗所包含的至少一个符号上，使用所述至少一个不同的波束接收所述用于波束恢复请求的响应。

[0302] 可选的，所述发送模块1201，具体用于基于所述网络设备对所述波束恢复装置配置的波束请求指示信息，在所述第一时间窗内使用所述至少一个波束向所述网络设备发送所述用于恢复波束的请求，所述波束请求指示信息用于指示所述用于恢复波束的请求的发送方式。

[0303] 可选的，所述第一时间窗所包含的第一个符号为第一个配置有RACH资源的符号。

[0304] 可选的，所述第一时间窗的长度是所述网络设备配置的。

[0305] 可选的，所述第一时间窗所包含的符号的数量总和是根据所述网络设备对所述波束恢复装置配置的最大波束数量确定的。

[0306] 需要说明的是，本发明实施例可具体参见图3、5、6、8、9、11所示实施例的相关描述，不再赘述。

[0307] 本发明实施例中的波束恢复装置和方法实施例中的终端设备完全对应，由相应的模块执行相应的步骤，例如发送模块1201执行方法实施例中发送的步骤，接收模块1202执行方法实施例中接收的步骤，除发送接收外的其它步骤可以由确定模块1203或处理器执行。具体模块的功能可以参考相应的方法实施例，不再详述。

[0308] 在图12所描述的波束恢复装置中，发送模块1201在第一时间窗内使用至少一个波

束向网络设备发送用于恢复波束的请求，接收模块1202在第一时间窗内使用至少一个波束接收网络设备发送的用于波束恢复请求的响应，可实现网络设备针对同一波束恢复装置发送的多个用于恢复波束的请求的波束恢复处理，提高波束恢复效率。

[0309] 请参见图13，图13是本发明实施例提供的一种终端设备，该终端设备包括处理器1301、存储器1302以及收发器1303，所述处理器1301、存储器1302以及收发器1303通过总线相互连接。

[0310] 存储器1302包括但不限于是随机存储记忆体(Random Access Memory，RAM)、只读存储器(Read-Only Memory，ROM)、可擦除可编程只读存储器(Erasable Programmable Read Only Memory，EPROM)、或便携式只读存储器(Compact Disc Read-Only Memory，CD-ROM)，该存储器1302用于存储相关指令及数据，例如用于恢复波束的请求等。收发器1303用于接收和发送数据，例如使用至少一个波束向网络设备发送用于恢复波束的请求，或者使用至少一个波束接收网络设备发送的用于波束恢复请求的响应等。存储器1302可以是一个单独的器件，也可以集成在处理器1301中。

[0311] 处理器1301可以是一个或多个中央处理器(Central Processing Unit，CPU)，或者一个或多个微控制单元(Microcontroller Unit，MCU)。在处理器1301是一个CPU的情况下，该CPU可以是单核CPU，也可以是多核CPU。其中，处理器1301可结合图12所示的波束恢复装置。

[0312] 应理解，上述的收发器1303可以包括发射机和接收机。收发器1303还可以进一步包括天线，天线的数量可以为一个或多个。

[0313] 上述的各个器件或部分器件可以集成到芯片中实现，如集成到基带芯片中实现。

[0314] 该终端设备中的处理器1301用于读取所述存储器1302中存储的程序代码，执行以下操作：

[0315] 通过收发器1303在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

[0316] 通过收发器1303在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

[0317] 可选的，处理器1301在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，具体可以为：

[0318] 在所述第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

[0319] 可选的，处理器1301在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，具体可以为：

[0320] 在所述第一时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

[0321] 可选的，所述第一时间窗包括第一单元时间窗和第二单元时间窗，所述第二单元时间窗所包含的第一个符号为所述第一单元时间窗所包含的最后一个符号之后的第一个符号；

[0322] 处理器1301在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的

请求，具体可以为：

[0323] 在所述第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

[0324] 可选的，处理器1301在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，具体可以为：

[0325] 在所述第二单元时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

[0326] 可选的，处理器1301还可以执行以下操作：

[0327] 当在所述第一时间窗内未接收到所述用于波束恢复请求的响应时，确定所述网络设备对所述终端设备配置的第三时间窗；

[0328] 在所述第三时间窗所包含的至少一个符号上，使用至少一个相同的第二波束向所述网络设备发送所述用于恢复波束的请求。

[0329] 可选的，所述第一时间窗包括第三单元时间窗和第四单元时间窗，所述第四单元时间窗所包含的第一个符号为所述第三单元时间窗所包含的最后一个符号之后的第一个符号；

[0330] 处理器1301在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，具体可以为：

[0331] 在所述第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向所述网络设备发送所述用于恢复波束的请求。

[0332] 可选的，处理器1301在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，具体可以为：

[0333] 在所述第四单元时间窗所包含的至少一个符号上，使用所述至少一个不同的波束接收所述用于波束恢复请求的响应。

[0334] 可选的，处理器1301在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，具体可以为：

[0335] 基于所述网络设备对所述终端设备配置的波束请求指示信息，在所述第一时间窗内使用所述至少一个波束向所述网络设备发送所述用于恢复波束的请求，所述波束请求指示信息用于指示所述用于恢复波束的请求的发送方式。

[0336] 可选的，所述第一时间窗所包含的第一个符号为第一个配置有RACH资源的符号。

[0337] 可选的，所述第一时间窗的长度是所述网络设备配置的。

[0338] 可选的，所述第一时间窗所包含的符号的数量总和是根据所述网络设备对所述终端设备配置的最大波束数量确定的。

[0339] 需要说明的是，本发明实施例可具体参见图3、5、6、8、9、11所示实施例的相关描述，不再赘述。

[0340] 在图13所描述的终端设备中，处理器1301在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，并在第一时间窗内使用至少一个波束接收网络设备发送的用于波束恢复请求的响应，可实现网络设备针对同一终端设备发送的多个用于恢复波束的请求的波束恢复处理，提高波束恢复效率。

[0341] 请参见图14，图14是本发明实施例提供的一种波束恢复装置的结构示意图，该波

束恢复装置可以包括接收模块1401、确定模块1402以及发送模块1403，其中，各个模块的详细描述如下。

[0342] 接收模块1401，用于接收终端设备在第一时间窗内使用至少一个波束发送的用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

[0343] 确定模块1402，用于在第二时间窗内，在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求；

[0344] 发送模块1403，用于使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

[0345] 可选的，所述确定模块1402，具体用于响应在所述第二时间窗内接收到的质量最好的波束所承载的用于恢复波束的请求，所述第二时间窗所包含的第一个符号与所述第一时间窗所包含的第一个符号相同。

[0346] 可选的，所述确定模块1402，具体用于响应在所述第二时间窗内接收到的第一个用于恢复波束的请求。

[0347] 可选的，所述发送模块1403，具体用于在所述第二时间窗内使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应。

[0348] 可选的，所述发送模块1403，具体用于在所述第二时间窗之外使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应。

[0349] 需要说明的是，本发明实施例可具体参见图3、5、6、8、9、11所示实施例的相关描述，不再赘述。

[0350] 本发明实施例中的波束恢复装置和方法实施例中的终端设备完全对应，由相应的模块执行相应的步骤，例如发送模块1403执行方法实施例中发送的步骤，接收模块1401执行方法实施例中接收的步骤，除发送接收外的其它步骤可以由确定模块1402或处理器执行。具体模块的功能可以参考相应的方法实施例，不再详述。

[0351] 在图14所描述的波束恢复装置中，接收模块1401接收终端设备在第一时间窗内使用至少一个波束发送的用于恢复波束的请求，确定模块1402在第二时间窗内，在接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，发送模块1403使用确定得到的用于恢复波束的请求对应的波束，向终端设备发送用于波束恢复请求的响应，可实现网络设备针对同一波束恢复装置发送的多个用于恢复波束的请求的波束恢复处理，提高波束恢复效率。

[0352] 请参见图15，图15是本发明实施例提供的一种网络设备，该网络设备包括处理器1501、存储器1502以及收发器1503，所述处理器1501、存储器1502以及收发器1503通过总线相互连接。

[0353] 存储器1502包括但不限于是RAM、ROM、EPROM、或CD-ROM，该存储器1502用于存储相关指令及数据，例如用于恢复波束的请求等。收发器1503用于接收和发送数据，例如接收终端设备使用至少一个波束发送的用于恢复波束的请求，或者使用确定得到的用于恢复波束的请求对应的波束，向终端设备发送用于波束恢复请求的响应等。存储器1502可以是一个单独的器件，也可以集成在处理器1501中。

[0354] 处理器1501可以是一个或多个CPU，或者一个或多个MCU。在处理器1501是一个CPU

的情况下，该CPU可以是单核CPU，也可以是多核CPU。其中，处理器1501可结合图14所示的波束恢复装置。

[0355] 应理解，上述的收发器1503可以包括发射机和接收机。收发器1503还可以进一步包括天线，天线的数量可以为一个或多个。

[0356] 该网络设备中的处理器1501用于读取所述存储器1502中存储的程序代码，执行以下操作：

[0357] 通过收发器1503接收终端设备在第一时间窗内使用至少一个波束发送的用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

[0358] 在第二时间窗内，在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求；

[0359] 通过收发器1503使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

[0360] 可选的，处理器1501在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，具体可以为：

[0361] 响应在所述第二时间窗内接收到的质量最好的波束所承载的用于恢复波束的请求，所述第二时间窗所包含的第一个符号与所述第一时间窗所包含的第一个符号相同。

[0362] 可选的，处理器1501在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，具体可以为：

[0363] 响应在所述第二时间窗内接收到的第一个用于恢复波束的请求。

[0364] 可选的，处理器1501使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，具体可以为：

[0365] 在所述第二时间窗内使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应。

[0366] 可选的，处理器1501使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，具体可以为：

[0367] 在所述第二时间窗之外使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应。

[0368] 在图15所描述的网络设备中，处理器1501接收终端设备在第一时间窗内使用至少一个波束发送的用于恢复波束的请求，在第二时间窗内，在接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，并使用确定得到的用于恢复波束的请求对应的波束，向终端设备发送用于波束恢复请求的响应，可实现网络设备针对同一终端设备发送的多个用于恢复波束的请求的波束恢复处理，提高波束恢复效率。

[0369] 请参见图16，图16是本发明实施例提供的一种波束恢复系统，该波束恢复系统可以包括图13所示的终端设备1601和图15所示的网络设备1602，具体可以参见图13、15的描述，本发明实施例不再赘述。

[0370] 本申请实施例还提供了一种通信芯片，其中存储有指令，当其在终端设备1601上运行时，使得所述通信芯片执行上述图13中的各种实现方式中终端设备对应的方法。

[0371] 本申请实施例还提供了一种通信芯片，其中存储有指令，当其在网络设备1602上

运行时，使得所述通信芯片执行上述图15中的各种实现方式中终端设备对应的方法。

[0372] 上述各个方案的网络设备及终端设备具有实现上述方法中网络设备及终端设备执行的相应步骤的功能；所述功能可以通过硬件实现，也可以通过硬件执行相应的软件实现。所述硬件或软件包括一个或多个与上述功能相对应的模块；例如发送模块可以由发射机替代，接收模块可以由接收机替代，其它模块，如处理模块等可以由处理器替代，分别执行各个方法实施例中的发送操作、接收操作以及相关的处理操作。

[0373] 本领域普通技术人员可以理解实现上述实施例方法中的全部或部分流程，该流程可以由计算机程序来指令相关的硬件完成，该程序可存储于计算机可读取存储介质中，该程序在执行时，可包括如上述各方法实施例的流程。而前述的存储介质包括：ROM或随机存储记忆体RAM、磁碟或者光盘等各种可存储程序代码的介质。

[0374] 在上述实施例中，可以全部或部分地通过软件、硬件、固件或者其任意组合来实现。当使用软件实现时，可以全部或部分地以计算机程序产品的形式实现。所述计算机程序产品包括一个或多个计算机指令。在计算机上加载和执行所述计算机程序指令时，全部或部分地产生按照本申请实施例所述的流程或功能。所述计算机可以是通用计算机、专用计算机、计算机网络、或者其他可编程装置。所述计算机指令可以存储在计算机可读存储介质中，或者从一个计算机可读存储介质向另一个计算机可读存储介质传输，例如，所述计算机指令可以从一个网站站点、计算机、服务器或数据中心通过有线(例如同轴电缆、光纤、数字用户线(DSL))或无线(例如红外、无线、微波等)方式向另一个网站站点、计算机、服务器或数据中心进行传输。所述计算机可读存储介质可以是计算机能够存取的任何可用介质或者是包含一个或多个可用介质集成的服务器、数据中心等数据存储设备。所述可用介质可以是磁性介质，(例如，软盘、硬盘、磁带)、光介质(例如，DVD)、或者半导体介质(例如固态硬盘Solid State Disk(SSD))等。

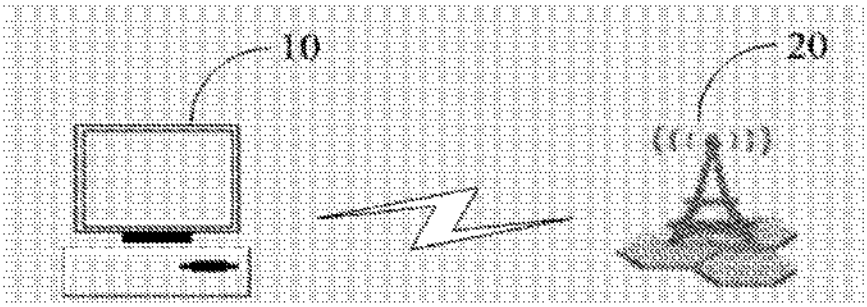

10
20

图1

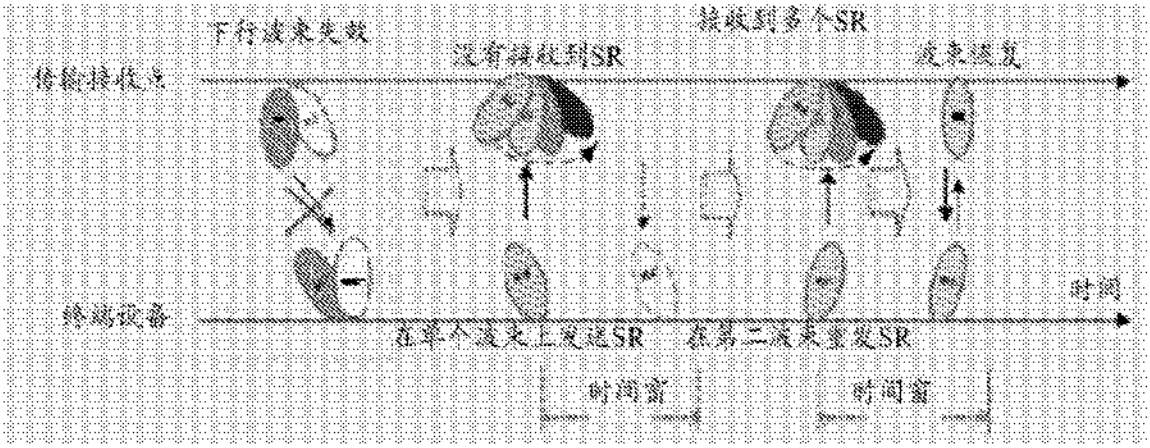

下行波束失效
没有接收到SR
接收到多个SR
波束恢复
传输接收点
终端设备
时间
在单个波束上发送SR
在第二波束重发SR
时间窗
时间窗

图2A

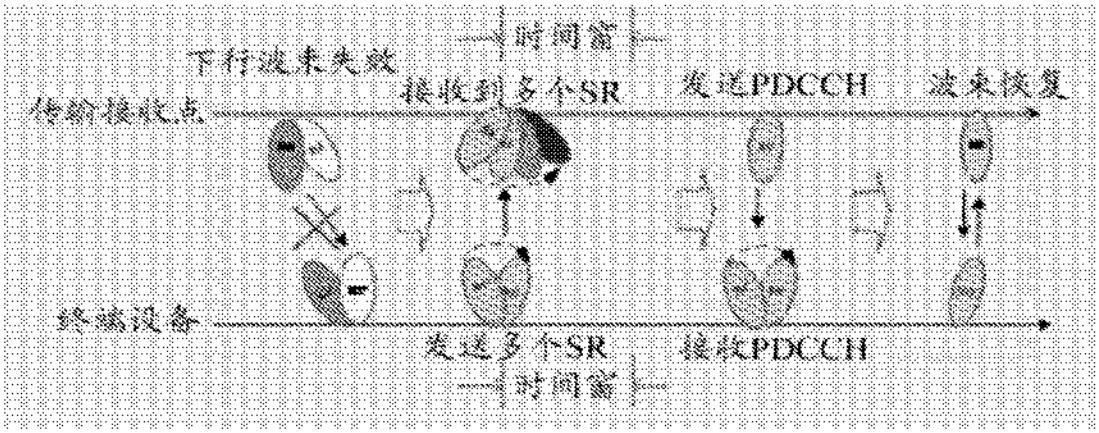

时间窗
下行波束失效
接收到多个SR
发送PDCCH
波束恢复
传输接收点
终端设备
发送多个SR
接收PDCCH
时间窗

图2B

33

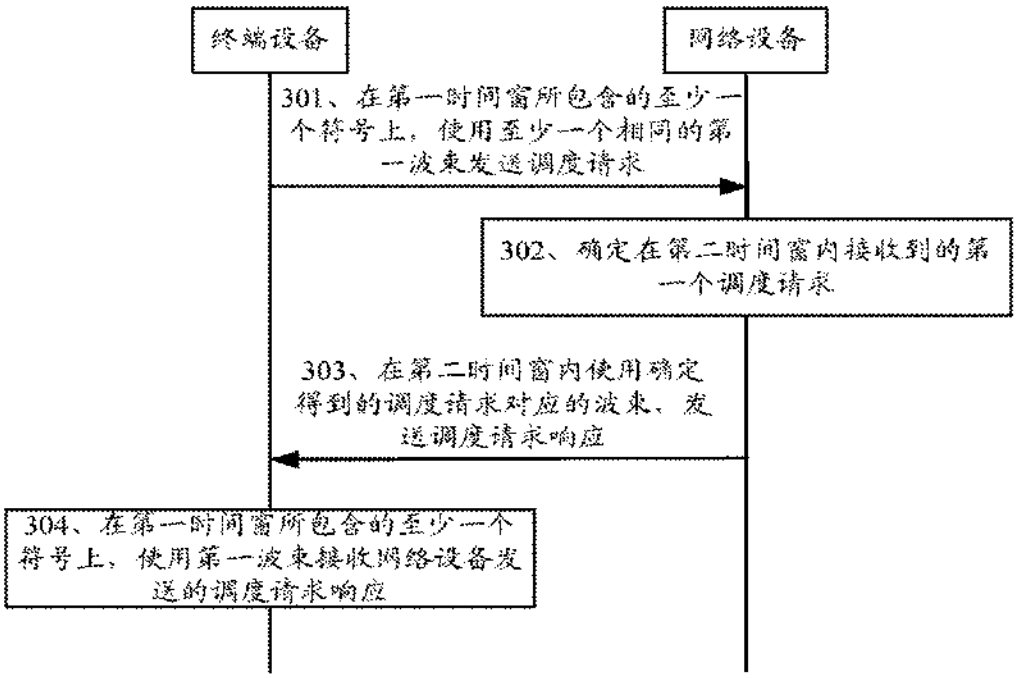

终端设备
网络设备
301、在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束发送调度请求
302、确定在第二时间窗内接收到的第一个调度请求
303、在第二时间窗内使用确定得到的调度请求对应的波束、发送调度请求响应
304、在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备发送的调度请求响应

图3

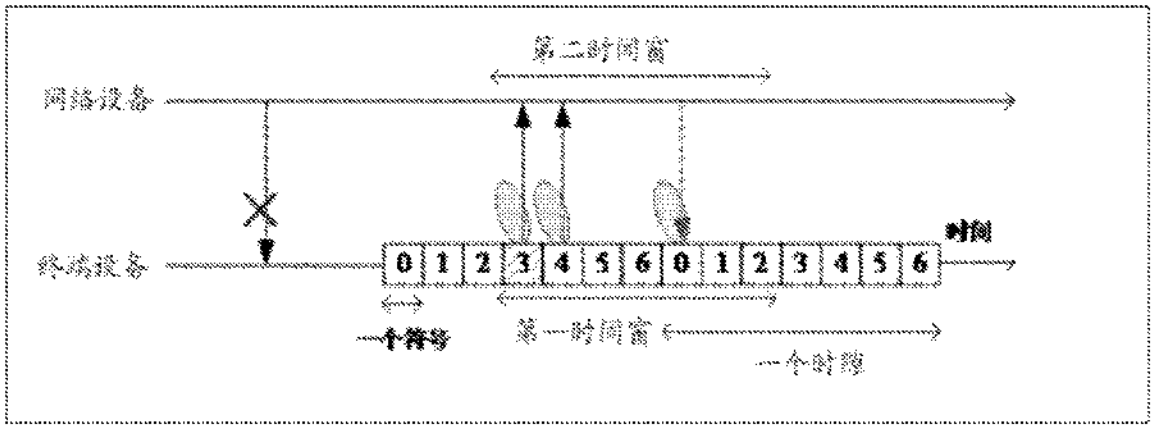

第二时间窗
网络设备
终端设备
0 1 2 3 4 5 6 0 1 2 3 4 5 6
时间
一个符号
第一时间窗
一个时隙

图4

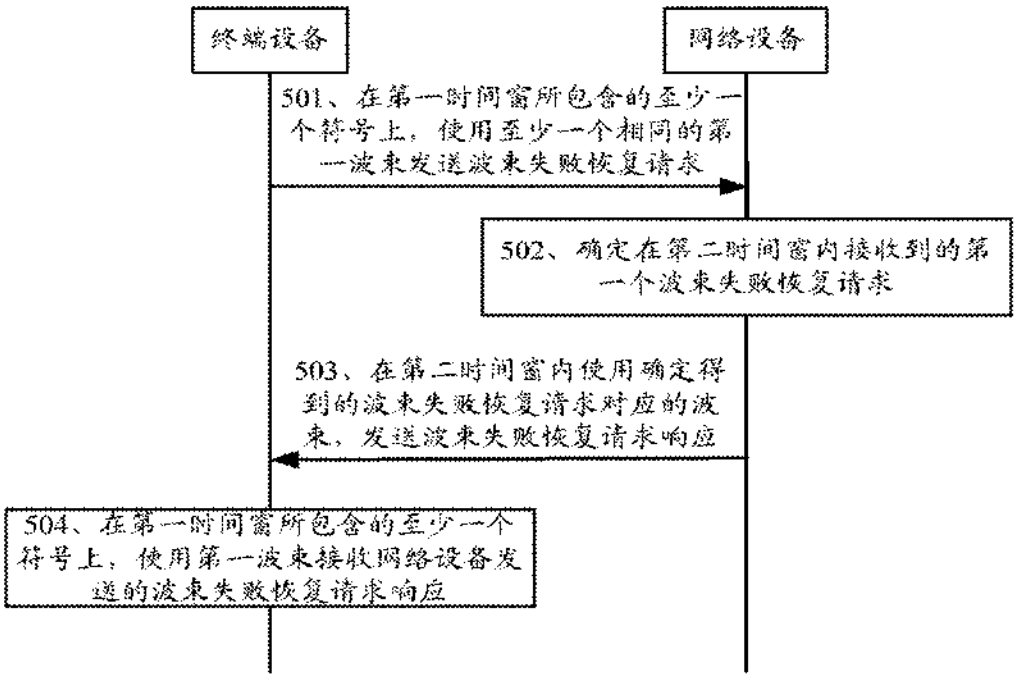

终端设备
网络设备
501、在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束发送波束失败恢复请求
502、确定在第二时间窗内接收到的第一个波束失败恢复请求
503、在第二时间窗内使用确定得到的波束失败恢复请求对应的波束，发送波束失败恢复请求响应
504、在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备发送的波束失败恢复请求响应

图5

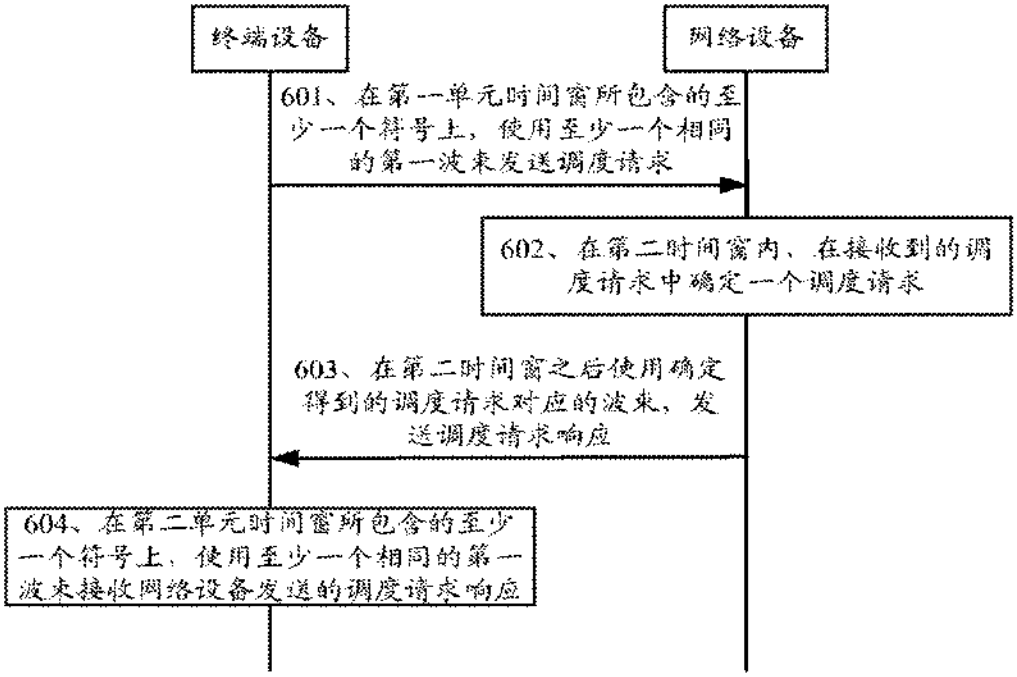

终端设备
网络设备
601、在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束发送调度请求
602、在第二时间窗内、在接收到的调度请求中确定一个调度请求
603、在第二时间窗之后使用确定得到的调度请求对应的波束，发送调度请求响应
604、在第二单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束接收网络设备发送的调度请求响应

图6

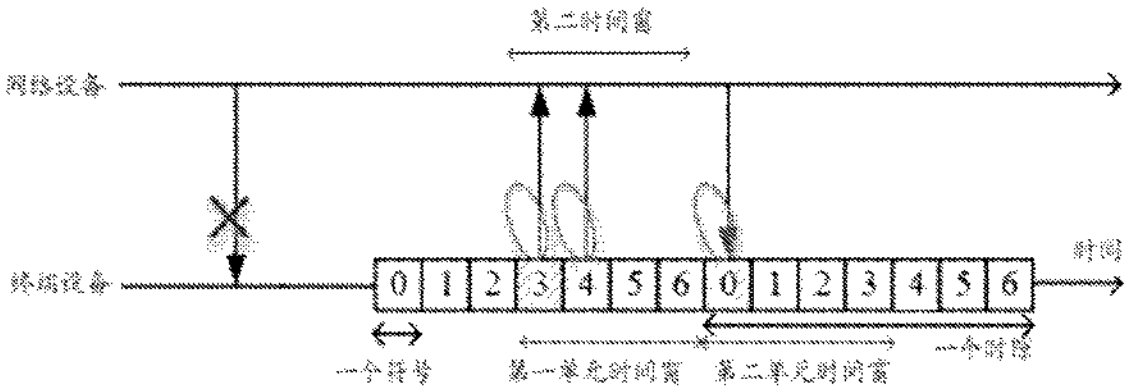

第二时间窗
网络设备
终端设备
0 1 2 3 4 5 6 0 1 2 3 4 5 6
时间
一个符号
第一单元时间窗
第二单元时间窗
一个时隙

图7

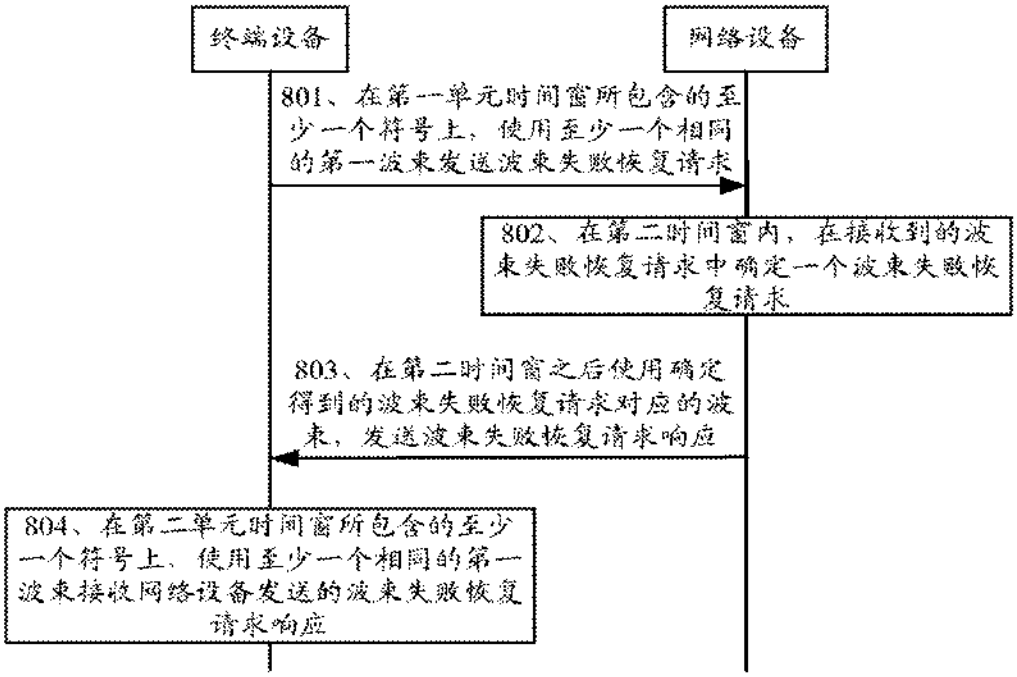

终端设备
网络设备
801、在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束发送波束失败恢复请求
802、在第二时间窗内，在接收到的波束失败恢复请求中确定一个波束失败恢复请求
803、在第二时间窗之后使用确定得到的波束失败恢复请求对应的波束，发送波束失败恢复请求响应
804、在第二单元时间窗所包含的至少一个符号上、使用至少一个相同的第一波束接收网络设备发送的波束失败恢复请求响应

图8

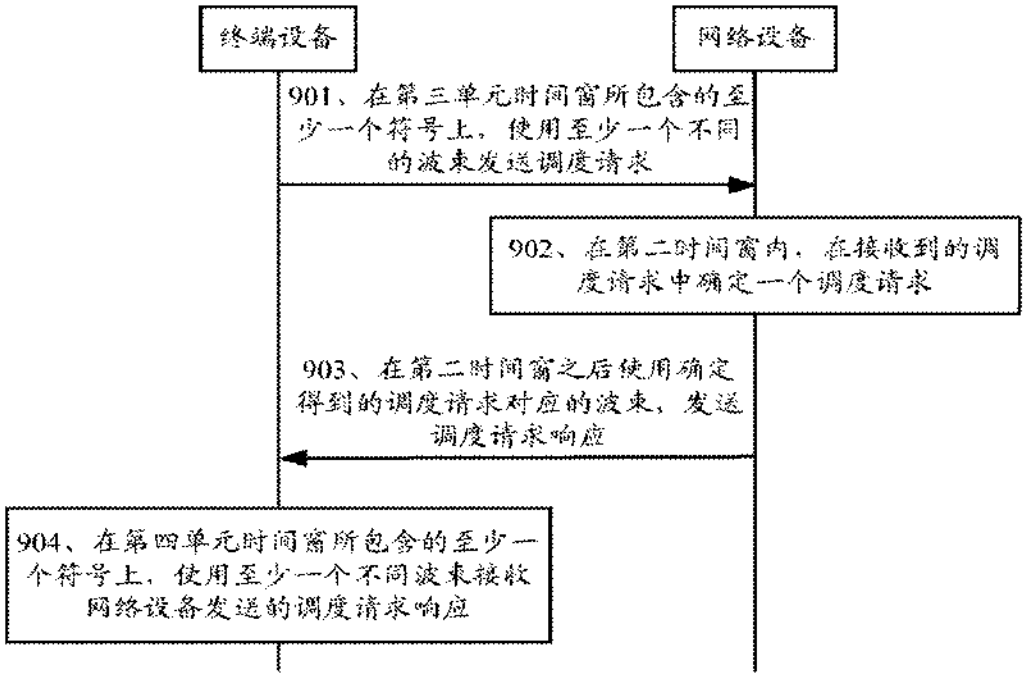

终端设备
网络设备
901、在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束发送调度请求
902、在第二时间窗内，在接收到的调度请求中确定一个调度请求
903、在第二时间窗之后使用确定得到的调度请求对应的波束，发送调度请求响应
904、在第四单元时间窗所包含的至少一个符号上，使用至少一个不同波束接收网络设备发送的调度请求响应

图9

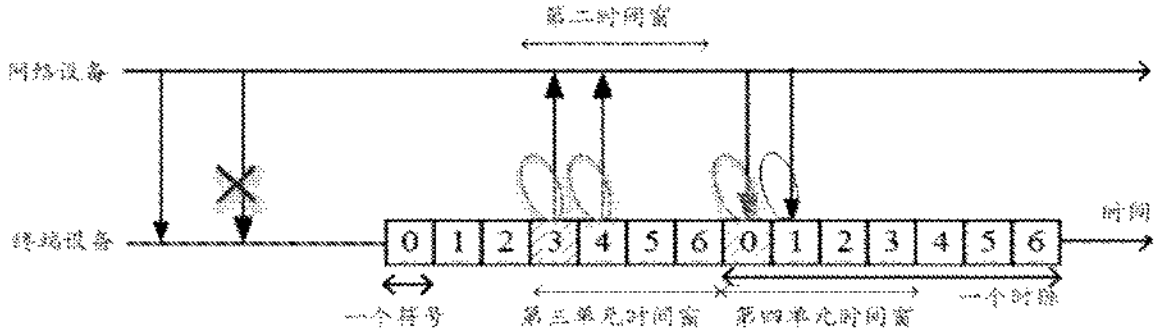

第二时间窗
网络设备
终端设备
0 1 2 3 4 5 6 0 1 2 3 4 5 6
时间
一个符号
第三单元时间窗
第四单元时间窗
一个时隙

图10

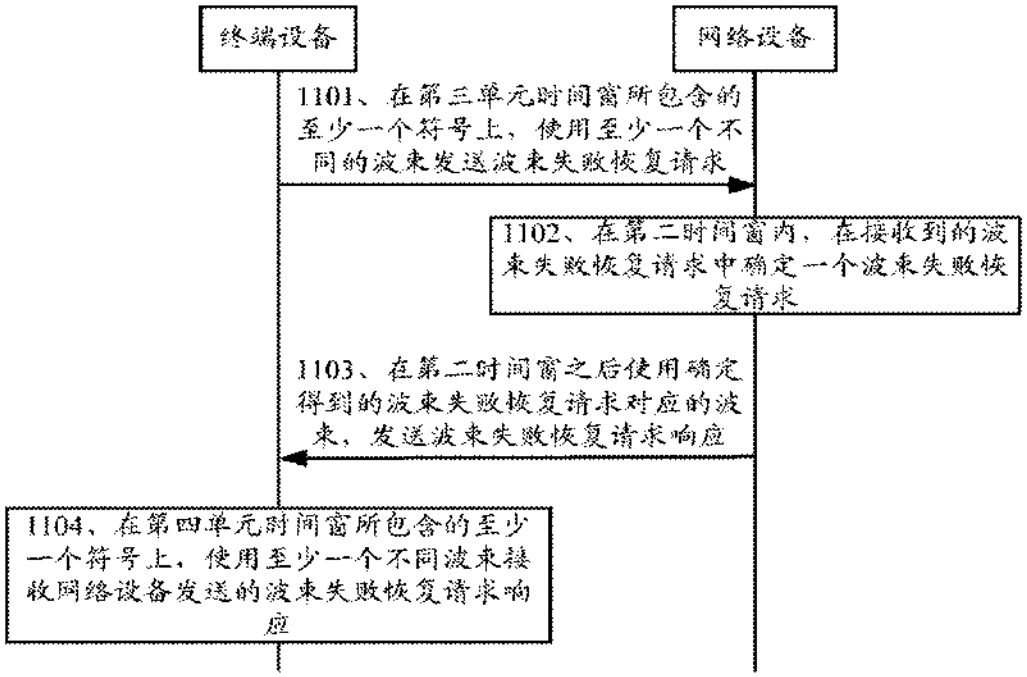

终端设备
网络设备
1101、在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束发送波束失败恢复请求
1102、在第二时间窗内，在接收到的波束失败恢复请求中确定一个波束失败恢复请求
1103、在第二时间窗之后使用确定得到的波束失败恢复请求对应的波束，发送波束失败恢复请求响应
1104、在第四单元时间窗所包含的至少一个符号上，使用至少一个不同波束接收网络设备发送的波束失败恢复请求响应

图11

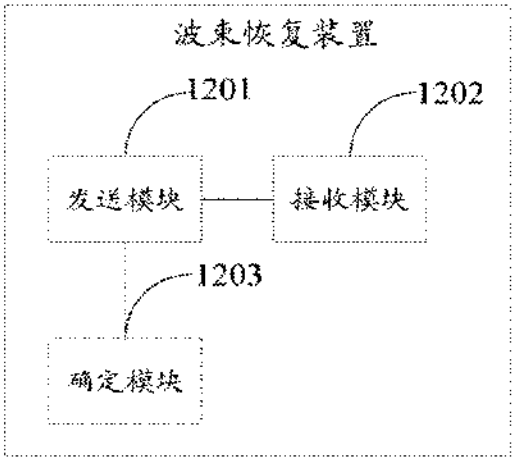

波束恢复装置
1201
1202
发送模块
接收模块
1203
确定模块

图12

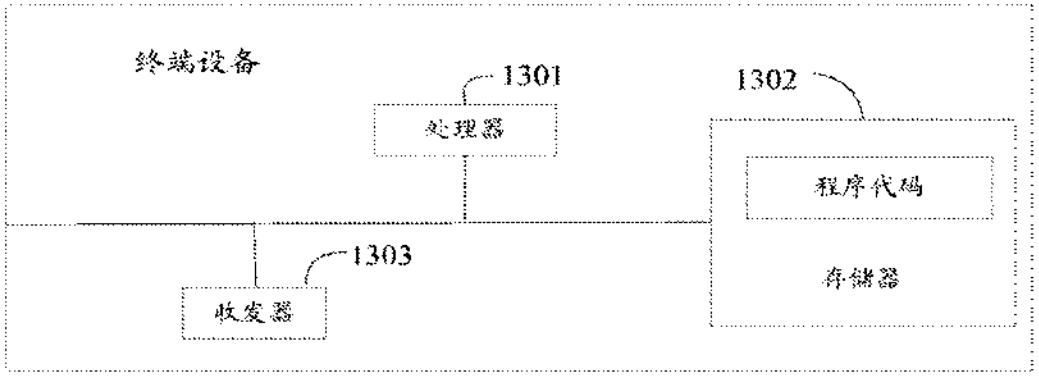

终端设备
1301
处理器
1302
程序代码
存储器
1303
收发器

图13

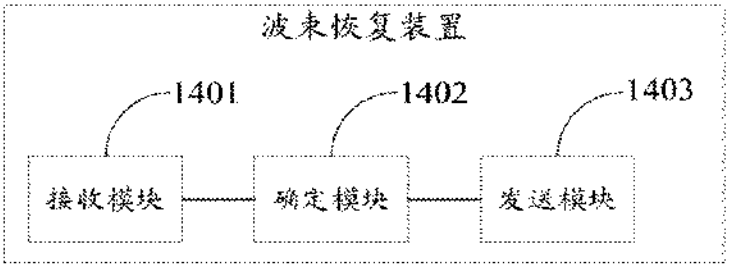

波束恢复装置
1401
1402
1403
接收模块
确定模块
发送模块

图14

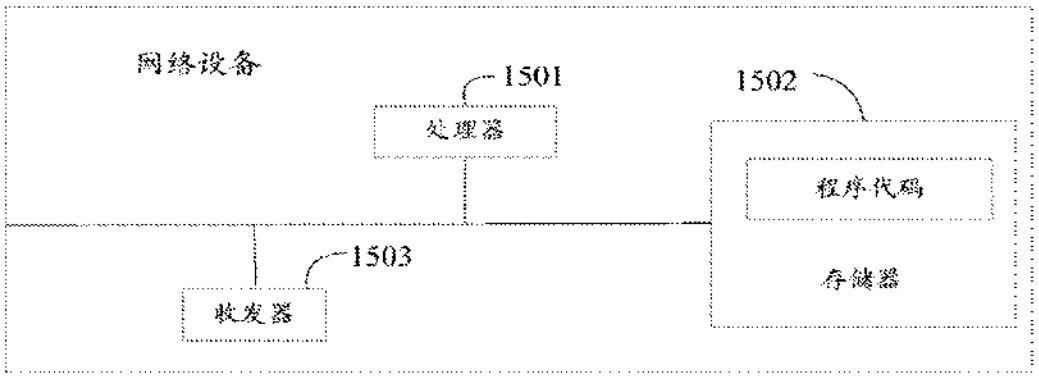

网络设备
1501
处理器
1502
程序代码
存储器
1503
收发器

图15

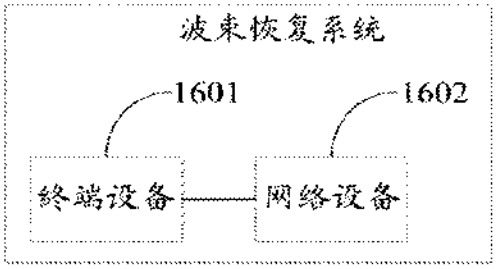


图16

Espacenet

CN108809488A Message decoding method, sending end and receiving end

Applicants: CHINA ACADEMY TELECOMMUNICATIONS TECHNOLOGY

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Message decoding method, sending end and receiving end

Abstract

The invention provides a message decoding method, a sending end and a receiving end. The method comprises the following steps: a receiving end receives a second message sent by a sending end and associated with the first message; the receiving end determines a target receiver parameter for decoding the first message according to the second message; and the receiving end decodes the first message sent by the sending end according to the target receiver parameter. Through the message decoding method provided by the embodiment of the invention, the receiving end can determine the receiver parameter according to the second message associated with the first message, and the message transmission performance can be improved.

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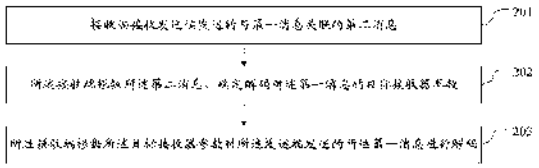
权利要求书5页 说明书20页 附图5页

(54)发明名称

一种消息解码方法、发送端和接收端

(57)摘要

本发明提供一种消息解码方法、发送端和接收端，该方法可包括：接收端接收发送端发送的与第一消息关联的第二消息；所述接收端根据所述第二消息，确定解码所述第一消息的目标接收器参数；所述接收端根据所述目标接收器参数对所述发送端发送的所述第一消息进行解码。这样本发明实施例可以实现接收端根据与第一消息关联的第二消息确定接收器参数，且还可以提高消息传输性能。



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1.一种消息解码方法，其特征在于，包括：

接收端接收发送端发送的与第一消息关联的第二消息；

所述接收端根据所述第二消息，确定解码所述第一消息的目标接收器参数；

所述接收端根据所述目标接收器参数对所述发送端发送的所述第一消息进行解码。

2.如权利要求1所述的方法，其特征在于，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端默认的接收器参数。

3.如权利要求2所述的方法，其特征在于，所述接收端默认的接收器参数包括：

所述接收端当前使用的接收器参数、所述接收端接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端向所述发送端上报时间最近的发送器参数对应的接收器参数。

4.如权利要求2所述的方法，其特征在于，所述参数指示信息显式或者隐式指示所述目标接收器参数。

5.如权利要求4所述的方法，其特征在于，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端选择的发送器参数，所述接收端将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

6.如权利要求1-5中任一项所述的方法，其特征在于，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

7.如权利要求6所述的方法，其特征在于，所述参数切换指示集对应的调度时间单位在时域上周期存在；和\或

所述参数切换指示集对应的调度时间单位由所述发送端半静态或半持续配置，并通知所述接收端。

8.如权利要求1-5中任一项所述的方法，其特征在于，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前，所述接收端根据所述目标接收器参数对所述第一消息进行解码，包括：

若所述第二消息包括参数指示信息，则所述接收端根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示信息，则所述接收端丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示信息，则所述接收端根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息不包括波束指示信息，则所述接收端根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段指示没有参数指示信息或者没有参数改变，则所述接收端根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

9.如权利要求1-5中任一项所述的方法，其特征在于，所述方法还包括：

所述接收端接收所述发送端发送的第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

10.如权利要求9所述的方法，其特征在于，所述第三消息用于指示M个时间单位内的第二消息是否包括参数指示信息，所述M为大于或者等于1的整数，所述M个时间单位连续或者不连续。

11.如权利要求1-5中任一项所述的方法，其特征在于，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

12.如权利要求11所述的方法，其特征在于，所述空域的接收器参数包括所述接收端的接收波束。

13.一种消息解码方法，其特征在于，包括：

发送端向接收端发送与第一消息关联的第二消息，所述第二消息用于所述接收端确定解码所述第一消息的目标接收器参数；

所述发送端向所述接收端发送所述第一消息。

14.如权利要求13所述的方法，其特征在于，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端默认的接收器参数。

15.如权利要求14所述的方法，其特征在于，所述接收端默认的接收器参数包括：

所述接收端当前使用的接收器参数、所述接收端接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端向所述发送端上报时间最近的发送器参数对应的接收器参数。

16.如权利要求14所述的方法，其特征在于，所述参数指示信息显式或者隐式指示所述目标接收器参数。

17.如权利要求16所述的方法，其特征在于，若所述参数指示信息隐式指示所述目标接

收器参数，则所述参数指示信息包括所述发送端选择的发送器参数，所述接收端将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

18.如权利要求13-17中任一项所述的方法，其特征在于，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

19.如权利要求18所述的方法，其特征在于，所述参数切换指示集对应的调度时间单位在时域上周期存在；和\或

所述参数切换指示集对应的调度时间单位由所述发送端半静态或半持续配置，并通知所述接收端。

20.如权利要求13-17中任一项所述的方法，其特征在于，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前。

21.如权利要求13-17中任一项所述的方法，其特征在于，所述方法还包括：

所述发送端向所述接收端发送第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

22.如权利要求21所述的方法，其特征在于，所述第三消息用于指示M个时间单位内的第二消息是否包括参数指示信息，所述M为大于或者等于1的整数，所述M个时间单位连续或者不连续。

23.如权利要求13-17中任一项所述的方法，其特征在于，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

24.如权利要求23所述的方法，其特征在于，所述空域的接收器参数包括所述接收端的接收波束。

25.一种接收端，其特征在于，包括：

第一接收模块，用于接收发送端发送的与第一消息关联的第二消息；

确定模块，用于根据所述第二消息，确定解码所述第一消息的目标接收器参数；

解码模块，用于根据所述目标接收器参数对所述发送端发送的所述第一消息进行解码。

26.如权利要求25所述的接收端，其特征在于，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端默认的接收器参数。

27.如权利要求25或26所述的接收端，其特征在于，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

28.如权利要求25或26所述的接收端，其特征在于，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前；

所述解码模块用于若所述第二消息包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示信息，则根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息不包括波束指示信息，则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示字段，且所述参数指示字段指示没有参数指示信息或者没有参数改变，则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

29.如权利要求25或26所述的接收端，其特征在于，所述接收端还包括：

第二接收模块，用于接收所述发送端发送的第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

30.一种发送端，其特征在于，包括：

第一发送模块，用于发送端向接收端发送与第一消息关联的第二消息，所述第二消息用于所述接收端确定解码所述第一消息的目标接收器参数；

第二发送模块，用于向所述接收端发送所述第一消息。

31.如权利要求30所述的发送端，其特征在于，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端默认的接收器参数。

32.如权利要求30或31所述的发送端，其特征在于，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

33.如权利要求30或31所述的发送端，其特征在于，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前。

34.如权利要求30或31所述的发送端，其特征在于，所述发送端还包括：

第二发送模块，用于向所述接收端发送第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

一种消息解码方法、发送端和接收端

技术领域

[0001] 本发明涉及通信技术领域，特别涉及一种消息解码方法、发送端和接收端。

背景技术

[0002] 随着通信技术的发展，目前通信设备均支持多天线系统，例如：支持高达128、256或者512个天线单元，以及高达128、256或者512个收发单元，每个天线单元连接一个收发单元。且目前通信设备还支持多波束，不同的波束的覆盖范围可以不同。这样发送端(例如：网络侧设备)在发送消息时，就可以在多个发送器参数(例如：发送波束)中选择相应的发送器参数进行发送，以提高通信性能。而接收端(例如：用户终端)如何选择相应的接收器参数(例如：接收波束)对发送端发送的消息进行解码目前还未明确。可见，接收端如何选择相应的接收器参数对发送端发送的消息进行解码是当前急需解决的技术问题。

发明内容

[0003] 本发明的目的在于提供一种消息解码方法、发送端和接收端，以解决接收端如何选择相应的接收器参数对发送端发送的消息进行解码的问题。

[0004] 为了达到上述目的，本发明实施例提供一种消息解码方法，包括：

[0005] 接收端接收发送端发送的与第一消息关联的第二消息；

[0006] 所述接收端根据所述第二消息，确定解码所述第一消息的目标接收器参数；

[0007] 所述接收端根据所述目标接收器参数对所述发送端发送的所述第一消息进行解码。

[0008] 可选的，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

[0009] 若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端默认的接收器参数。

[0010] 可选的，所述接收端默认的接收器参数包括：

[0011] 所述接收端当前使用的接收器参数、所述接收端接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端向所述发送端上报时间最近的发送器参数对应的接收器参数。

[0012] 可选的，所述参数指示信息显式或者隐式指示所述目标接收器参数。

[0013] 可选的，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端选择的发送器参数，所述接收端将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

[0014] 可选的，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

[0015] 若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所

述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

[0016] 可选的，所述参数切换指示集对应的调度时间单位在时域上周期存在；和\或

[0017] 所述参数切换指示集对应的调度时间单位由所述发送端半静态或半持续配置，并通知所述接收端。

[0018] 可选的，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前，所述接收端根据所述目标接收器参数对所述第一消息进行解码，包括：

[0019] 若所述第二消息包括参数指示信息，则所述接收端根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0020] 若所述第二消息包括参数指示信息，则所述接收端丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0021] 若所述第二消息包括参数指示信息，则所述接收端根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0022] 若所述第二消息不包括波束指示信息，则所述接收端根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码；或者

[0023] 若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0024] 若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0025] 若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0026] 若所述第二消息包括参数指示字段，且所述参数指示字段指示没有参数指示信息或者没有参数改变，则所述接收端根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

[0027] 可选的，所述方法还包括：

[0028] 所述接收端接收所述发送端发送的第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

[0029] 可选的，所述第三消息用于指示M个时间单位内的第二消息是否包括参数指示信息，所述M为大于或者等于1的整数，所述M个时间单位连续或者不连续。

[0030] 可选的，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

[0031] 可选的，所述空域的接收器参数包括所述接收端的接收波束。

[0032] 本发明实施例还提供一种消息解码方法，包括：

[0033] 发送端向接收端发送与第一消息关联的第二消息，所述第二消息用于所述接收端确定解码所述第一消息的目标接收器参数；

[0034] 所述发送端向所述接收端发送所述第一消息。

[0035] 可选的，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

[0036] 若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端默认的接收器参数。

[0037] 可选的，所述接收端默认的接收器参数包括：

[0038] 所述接收端当前使用的接收器参数、所述接收端接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端向所述发送端上报时间最近的发送器参数对应的接收器参数。

[0039] 可选的，所述参数指示信息显式或者隐式指示所述目标接收器参数。

[0040] 可选的，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端选择的发送器参数，所述接收端将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

[0041] 可选的，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

[0042] 若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

[0043] 可选的，所述参数切换指示集对应的调度时间单位在时域上周期存在；和\或

[0044] 所述参数切换指示集对应的调度时间单位由所述发送端半静态或半持续配置，并通知所述接收端。

[0045] 可选的，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前。

[0046] 可选的，所述方法还包括：

[0047] 所述发送端向所述接收端发送第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

[0048] 可选的，所述第三消息用于指示M个时间单位内的第二消息是否包括参数指示信息，所述M为大于或者等于1的整数，所述M个时间单位连续或者不连续。

[0049] 可选的，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

[0050] 可选的，所述空域的接收器参数包括所述接收端的接收波束。

[0051] 本发明实施例还提供一种接收端，包括：

[0052] 第一接收模块，用于接收发送端发送的与第一消息关联的第二消息；

[0053] 确定模块，用于根据所述第二消息，确定解码所述第一消息的目标接收器参数；

[0054] 解码模块，用于根据所述目标接收器参数对所述发送端发送的所述第一消息进行

解码。

[0055] 可选的，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

[0056] 若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端默认的接收器参数。

[0057] 可选的，所述接收端默认的接收器参数包括：

[0058] 所述接收端当前使用的接收器参数、所述接收端接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端向所述发送端上报时间最近的发送器参数对应的接收器参数。

[0059] 可选的，所述参数指示信息显式或者隐式指示所述目标接收器参数。

[0060] 可选的，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端选择的发送器参数，所述接收端将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

[0061] 可选的，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

[0062] 若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

[0063] 可选的，所述参数切换指示集对应的调度时间单位在时域上周期存在；和\或

[0064] 所述参数切换指示集对应的调度时间单位由所述发送端半静态或半持续配置，并通知所述接收端。

[0065] 可选的，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前；

[0066] 所述解码模块用于若所述第二消息包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0067] 所述解码模块用于若所述第二消息包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0068] 所述解码模块用于若所述第二消息包括参数指示信息，则根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0069] 所述解码模块用于若所述第二消息不包括波束指示信息，则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码；或者

[0070] 所述解码模块用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0071] 所述解码模块用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接

收器参数对所述第二部分内容进行解码;或者

[0072] 所述解码模块用于若所述第二消息包括参数指示字段,且所述参数指示字段包括参数指示信息,则根据默认的接收器参数对所述第一部分内容进行解码,以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码;或者

[0073] 所述解码模块用于若所述第二消息包括参数指示字段,且所述参数指示字段指示没有参数指示信息或者没有参数改变,则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

[0074] 可选的,所述接收端还包括:

[0075] 第二接收模块,用于接收所述发送端发送的第三消息,所述第三消息用于指示所述第二消息是否包括参数指示信息,且若所述第三消息指示所述第二消息包括参数指示信息,则所述第二消息与所述第一消息之间存在间隙,若所述第三消息指示所述第二消息不包括参数指示信息,则所述第二消息与所述第一消息之间不存在间隙。

[0076] 可选的,所述第三消息用于指示M个时间单位内的第二消息是否包括参数指示信息,所述M为大于或者等于1的整数,所述M个时间单位连续或者不连续。

[0077] 可选的,所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

[0078] 可选的,所述空域的接收器参数包括所述接收端的接收波束。

[0079] 本发明实施例还提供一种发送端,包括:

[0080] 第一发送模块,用于发送端向接收端发送与第一消息关联的第二消息,所述第二消息用于所述接收端确定解码所述第一消息的目标接收器参数;

[0081] 第二发送模块,用于向所述接收端发送所述第一消息。

[0082] 可选的,若所述第二消息包括参数指示信息,则所述目标接收器参数为所述参数指示信息指示的接收器参数;

[0083] 若所述第二消息不包括参数指示信息,则所述目标接收器参数为所述接收端默认的接收器参数。

[0084] 可选的,所述接收端默认的接收器参数包括:

[0085] 所述接收端当前使用的接收器参数、所述接收端接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端向所述发送端上报时间最近的发送器参数对应的接收器参数。

[0086] 可选的,所述参数指示信息显式或者隐式指示所述目标接收器参数。

[0087] 可选的,若所述参数指示信息隐式指示所述目标接收器参数,则所述参数指示信息包括所述发送端选择的发送器参数,所述接收端将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

[0088] 可选的,若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的,则所述第二消息包括参数指示信息,且所述第二消息与所述第一消息之间存在间隙;

[0089] 若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的,则所述第二消息不包括参数指示信息,且所述第二消息与所述第一消息之间不存在间隙。

[0090] 可选的,所述参数切换指示集对应的调度时间单位在时域上周期存在;和\或

[0091] 所述参数切换指示集对应的调度时间单位由所述发送端半静态或半持续配置,并

通知所述接收端。

[0092] 可选的，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前。

[0093] 可选的，所述发送端还包括：

[0094] 第二发送模块，用于向所述接收端发送第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

[0095] 可选的，所述第三消息用于指示M个时间单位内的第二消息是否包括参数指示信息，所述M为大于或者等于1的整数，所述M个时间单位连续或者不连续。

[0096] 可选的，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

[0097] 可选的，所述空域的接收器参数包括所述接收端的接收波束。

[0098] 本发明实施例还提供一种接收端，其特征在于，包括：处理器、收发机、存储器、用户接口和总线接口，其中：

[0099] 所述处理器，用于读取所述存储器中的程序，执行本发明实施例提供的接收端侧对应的消息解码方法中的步骤。

[0100] 本发明实施例还提供一种发送端，其特征在于，包括：处理器、收发机、存储器、用户接口和总线接口，其中：

[0101] 所述处理器，用于读取所述存储器中的程序，执行本发明实施例提供的发送侧对应的消息解码方法的步骤。

[0102] 本发明的上述技术方案至少具有如下有益效果：

[0103] 本发明实施例，接收端接收发送端发送的与第一消息关联的第二消息；所述接收端根据所述第二消息，确定解码所述第一消息的目标接收器参数；所述接收端根据所述目标接收器参数对所述发送端发送的所述第一消息进行解码。这样可以实现接收端根据与第一消息关联的第二消息确定接收器参数，且还可以提高消息传输性能。

附图说明

[0104] 图1为本发明实施例可应用的网络结构示意图；

[0105] 图2为本发明实施例提供的一种消息解码方法的流程图；

[0106] 图3为本发明实施例提供的一种消息发送的示意图；

[0107] 图4为本发明实施例提供的另一种消息发送的示意图；

[0108] 图5为本发明实施例提供的另一种消息发送的示意图；

[0109] 图6为本发明实施例提供的另一种消息发送的示意图；

[0110] 图7为本发明实施例提供的另一种消息解码方法的流程图；

[0111] 图8为本发明实施例提供的一种接收端的结构示意图；

[0112] 图9为本发明实施例提供的另一种接收端的结构示意图；

[0113] 图10为本发明实施例提供的一种发送端的结构示意图；

[0114] 图11为本发明实施例提供的另一种发送端的结构示意图；

[0115] 图12为本发明实施例提供的另一种接收端的结构示意图；

[0116] 图13为本发明实施例提供的另一种发送端的结构示意图。

具体实施方式

[0117] 为使本发明要解决的技术问题、技术方案和优点更加清楚，下面将结合附图及具体实施例进行详细描述。

[0118] 参见图1，图1为本发明实施例可应用的网络结构示意图，如图1所示，包括发送端11和接收端12，其中，发送端11可以是基站或者终端，而接收端12也可以是终端或者基站，例如：发送端11为基站，接收端12为终端，则可以实现终端与基站之间的通信，又或者发送端11为终端，则接收端12为基站，也可以实现终端与基站之间的通信，又或者发送端11为基站，接收端12也为基站，则可以实现基站与基站之间的通信，又或者发送端11为终端，接收端12也为终端，则可以实现终端与终端之间的通信。当然，本发明实施例中，并不限定发送端11只能是终端或者基站，例如：发送端11还可以是其他的网络侧设备，同理，接收端12也并不限定只是终端或者设备，例如：接收端12还可以是其他的网络侧设备，对此本发明实施例不作限定。其中，附图1，以发送端11为基站，接收端12为终端进行举例示意。终端可以是用户终端(User Equipment，UE)，例如：可以是手机、平板电脑(Tablet Personal Computer)、膝上型电脑(Laptop Computer)、个人数字助理(personal digital assistant，简称PDA)、移动上网装置(Mobile Internet Device，MID)或可穿戴式设备(Wearable Device)等终端侧设备，需要说明的是，在本发明实施例中并不限定终端的具体类型。基站可以是宏站，如LTE eNB、5G NR NB等；也可以是小站，如低功率节点(LPN：low power node)pico、femto等小站，或者可以是接入点(AP，access point)；基站也可以是中央单元(CU，central unit)与其管理和控制的多个传输接收点(TRP，Transmission Reception Point)共同组成的网络节点。另外，一个基站下有一个或多个小区(例如：不同的频点或扇区分裂)。需要说明的是，在本发明实施例中并不限定基站的具体类型。

[0119] 请参考图2，图2是本本发明实施例提供一种消息解码方法的流程图，如图2所示，包括以下步骤：

[0120] 201、接收端接收发送端发送的与第一消息关联的第二消息；

[0121] 202、所述接收端根据所述第二消息，确定解码所述第一消息的目标接收器参数；

[0122] 203、所述接收端根据所述目标接收器参数对所述发送端发送的所述第一消息进行解码。

[0123] 其中，上述第一消息可以是发送端需要向接收端发送的信号，例如：数据和/或控制消息等等，如上述第一消息可以是下行链路信号。另外，本发明实施例中，可以将第一消息定义为msg1。而上述第二消息可以理解为用于通知接收端接收器参考的消息，例如：控制消息或者调度消息等等，另外，本发明实施例中第二消息可以定义为msg2。

[0124] 上述根据所述第二消息，确定解码所述第一消息的目标接收器参数可以是，若上述第二消息中包括了参数指示信息，则确定该参数指示信息指示的接收器参数作为上述目标器参数，若上述第二消息中不包括参数指示信息，则确定默认的接收器参数作为上述目标器参数。即本发明实施例中，上述第二消息可以存在两种情况，一种是存在参数指示信息，该情况下接收端可能需要进行接收器参数切换，再对发送端发送的消息进行解码。另一

种是不存在参数指示信息，该情况下接收端可能不需要进行波束接收器参数切换，直接对接收端发送的消息进行解码。另外，目标接收器参数可以是接收端中接收器的相关参数，例如：接收波束、均衡器和接收滤波器等参数中的至少一项，对此本发明实施例不作限定。例如：以目标接收器参数为目标接收波束为例，上述确定解码所述第一消息的目标接收波束还可以是在接收端的多个接收波束(Rx波束)中选择一个或者多个接收波束。且接收端的多个接收器参数可以是与发送端无关的，或者接收端的多个接收器参数对于发送端来说也可以是已知的，例如：通过预配置或反馈通知发送端，对此本发明实施例不作限定。

[0125] 本发明实施例中，通过上述步骤就可以实现通过专门的第二消息向接收端通知发送端发送的第一消息的接收波束，从使接收端和发送端获得更准确的波束组合信息，支持多波束传输，以及提高波束传输性能。另外，本发明实施例可以用于在无线通信系统中的接收端的模拟波束切换，以及还可以用于接收端的数字波束切换等，对此本发明实施例不作限定。

[0126] 可选的，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

[0127] 若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端默认的接收器参数。

[0128] 该实施方式中，可以实现上述第二消息中包括或者不包括参数指示信息，若包括，则将参数指示信息指示的接收器参数作为上述目标接收器参数。其中，参数指示信息指示接收波束可以是与接收端当前使用的接收器参数为不同的接收器参数，这时接收端需要进行接收器参数切换。而使用默认的接收器参数，可以不进行切换，例如：默认的接收器参数就可以是接收端当前使用的接收器参数，以快速对发送端发送的消息进行解码。另外，本发明实施例中，第二消息中的参数指示信息可以是，第二消息中的参数指示字段，即第二消息中可以存在或者不存在该参数指示字段。

[0129] 例如：所述接收端默认的接收器参数包括：

[0130] 所述接收端当前使用的接收器参数、所述接收端接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端向所述发送端上报时间最近的发送器参数对应的接收器参数。

[0131] 该实施方式中，通过上述默认波束可以减少接收器参数的切换，例如：减少接收波束的切换，以提高传输性能，例如：第二消息与第一消息之间可以不存在间隙。

[0132] 另外，本发明实施例中，上述参数指示信息可以显式或者隐式指示所述目标接收器参数。例如：显式或者隐式指示所述目标接收波束。

[0133] 其中，显式指示可以理解为直接指示，例如：以接收波束举例，接收端具有一组L个预配置的接收波束，这些对于发送端可以是已知的。这样上述参数指示信息就式携带Log_2(L)位的字段，以指示接收端的推荐接收波束。在接收到第二消息后，接收端就可以机确定对应的接收波束用于解码msg1。而上述隐式指示可以理解为间接指示，例如：上述参数指示信息可以是指示发送波束(Tx波束)，通过指示的发送波束隐式指示该发送波束对应的接收波束。该实施方式中，通过上述显式或者隐式的方式可以实现灵活地向接收端指示接收波束，以提高系统的灵活性。

[0134] 可选的，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信

息包括所述发送端选择的发送器参数，所述接收端将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

[0135] 该实施方式中，可以实现通过发送器参数来隐式指示接收器参数，例如：以目标接收器参数为目标波束举例，发送端可以具有用于下行链路传输的M个候选发送波束。发送端配置M个参考符号(RS)资源，并将每个发送波束应用于相应的RS资源。对于每个RS资源，接收端可以测试一组候选接收波束，并确定每个RS资源(例如发送波束)的最佳接收波束。优选的，接收端可以将至少推荐的发送波束的信息反馈给发送端，例如，以推荐的RS资源的形式，但这一步是可选的。在发送第一消息之前，发送端以第二消息的方式发送其选定的发送波束的指示。接收端接收到第二消息后，获得所使用的发送波束的信息，并获得最佳的接收波束作为上述目标接收波束，该最佳的接收波束可以是从先前的测量已知并保存在接收端中。

[0136] 该实施方式中，可以实现通过发送器参数来隐式指示接收器参数，从而有利于接收端与发送端之间的传输。当然，在一些实施方式中，发送端可以是根据接收端返回的推荐信息自主选择相应的发送器参数，例如：发送波束。

[0137] 可选的，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

[0138] 若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

[0139] 该实施方式中，上述参数切换指示集(BSIS)对应的调度时间单位可以是子帧或者时隙(slots)等时间单位。且发送端和接收端对BSIS可以具有一致的认识。只有在BSIS对应的slot(这里以slot为例)中，第二消息才可能会携带参数指示信息，否则第二消息不携带波束指示信息。这意味着在BSIS对应的时隙之外的所有时隙中可以不执行接收器参数切换，例如：接收波束切换，而仅在周期性的选定时隙(例如BSIS中的时隙)中执行接收器参数切换。

[0140] 另外，由于第二消息包括参数指示信息时，所述第二消息与所述第一消息之间存在间隙，这样接收端可以是在该间隙切换进行接收器参数切换，例如：接收波束切换，从而不影响消息的传输。而所述第二消息不包括参数指示信息时，所述第二消息与所述第一消息之间可以不存在间隙，这样可以节约传输资源，因为该情况下，接收端可能是不需要进行接收器参数切换，例如：接收波束切换，进而第二消息和第一消息连续传输也不会影响接收端的解码。且上述第二消息和第一消息可以采用相同的频域资源发送的，或者采用相同的信道发送等，对此本发明实施例不作限定。

[0141] 例如：对于在BSIS中的时隙中发送的第二消息，携带波束指示信息。在这种情况下，同一时隙中的第一消息和第二消息之间有切换时间。否则对于BSIS外的时隙中的第二消息传输，发送端发送第二消息，而不携带波束指示字段。在这种情况下，接收端可以准备在第二消息之后立即接收第一消息(没有间隙)。例如：图3所示的第二个slot。另外，当尝试在每个时隙中接收到第二消息或者第一消息时，接收端可以根据假定存在或者不存在波束指示信息来解码第二消息。换句话说，在BSIS中的时隙中，第二消息可以携带参数指示信息，接收端尝试解码第二消息，假设有一个参数指示信息。在其他时隙中，接收器解码第二

消息，假设没有参数指示信息。在第二消息不携带参数指示信息的时隙中，接收端仍然可以选择一个接收器参数(例如：接收波束)来解码第一消息。接收端可以使用在最新的携带参数指示字段的第二消息中指示的接收器参数。如果没有接收到参数指示信息，则接收机可以使用默认的接收器参数来解码第一消息。

[0142] 可选的，所述参数切换指示集对应的调度时间单位在时域上周期存在；和\或

[0143] 所述参数切换指示集对应的调度时间单位由所述发送端半静态或半持续(semi-persistent)配置，并通知所述接收端。

[0144] 其中，上述参数切换指示集对应的调度时间单位在时域上周期存在可以是，上述参数切换指示集对应的调度时间单位具有周期性，例如：参数切换指示集在时域中可以周期性地具有预配置的周期和定时偏移，其中，该定时偏移可以是相对于另一个定时参考的偏移，如帧边界。例如，参数切换指示集可以具有10ms的周期，其指示在10个slots中的1个中发送的第二消息可能会携带参数指示信息，而其他9个slots中的第二消息不携带参数指示信息。上述参数切换指示集对应的调度时间单位由所述发送端半静态或半持续配置，并通知所述接收端可以是，发送端半静态或半持续配置，并通知接收端参数切换指示集的集合，即指示多个参数切换指示集。或者上述参数切换指示集可以由接收端获得，并作为推荐被反馈给发送端。发送端可以使用接收端推荐的参数切换指示集，或覆盖接收端推荐的参数切换指示集，并选择一个新的参数切换指示集。发送端可以需要向接收端指示是否确认接收端推荐的参数切换指示集，或者将其选择的参数切换指示集指示给接收端。

[0145] 可选的，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前，所述接收端根据所述目标接收器参数对所述第一消息进行解码，包括：

[0146] 若所述第二消息包括参数指示信息，则所述接收端根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0147] 若所述第二消息包括参数指示信息，则所述接收端丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0148] 若所述第二消息包括参数指示信息，则所述接收端根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0149] 若所述第二消息不包括波束指示信息，则所述接收端根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

[0150] 该实施方式中，所述第一消息分为时域上连续的第一部分内容和第二部分内容可以是接收端将第一消息分为两个部分，这里分为可以理解为将第一消息看作两个部分，因为，此时接收端还未接收到第一消息，不能对其进行拆分。

[0151] 例如：发送端可以发送携带与接收第一消息有关的下行调度信息的第二消息。第二消息可以携带或不携带参数指示信息，对此接收端可以没有先验知识。如果第二消息没有参数指示信息，则第二消息的有效载荷较小(表示为A位)。如果第二消息具有参数指示信息，则第二消息的有效载荷较大(表示为B位，其中B>A)。在发送端发送第二消息后，接收端可以尝试用盲解码第二消息。因为，接收端没有关于第二消息的有效载荷的先验信息，因此

需要基于不同的可能的第二消息有效载荷来执行盲解码。例如，接收端将执行假设有效载荷A位的第二消息的一次盲解码，以及假设B位的有效载荷的另一个第二消息的盲解码。这样根据第二消息的实际有效负载，两个盲解码之一将成功解码第二消息。之后，接收端就可以将第一消息分为第一部分内容和第二部分内容(part1and part 2)，第一部分内容在第二部分内容前面，并且在时域中为时分复用(TDM)。第一消息的第一部分部分紧随着第二消息，即两者没有间隙，第一消息的第二部分内容紧邻第一部分内容，例如：图4所示的第二个slot。

[0152] 另外，由于第一部分内容和第二部分内容属于同一消息，从而接收端可以分别对第一部分内容和第二部分内容执行符号级处理。

[0153] 该实施方式中，由于若所述第二消息包括参数指示信息时，则所述接收端使用所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码，其中，所述发送端未发送所述第一部分内容。例如：图4所示的第一个slot。这样可以提高接收端解码的准确性。

[0154] 另外，由于第二消息包括参数指示信息时，可以丢弃所述第一部分内容，以及使用所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码。即可以丢弃图4所示的第二个slot的第一部分内容，同样能够保证发送端与接收端之间的性能，因为，在该情况下发送端可以在第一部分内容中传输非重要信息，而在第二部分内容中传输重要信息。

[0155] 另外，由于第二消息包括参数指示信息时，可以使用默认的接收器参数对所述第一部分内容进行解码，以及使用所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码。这样可以实现接收到准备地解码第一部分部分和第二部分内容。

[0156] 另外，由于第二消息不包括参数指示信息，可以实现使用默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。即图4所示的第三个slot。

[0157] 另外，发送端和接收端可以将其对接收端上确切的第一消息解码行为的理解对齐。这可以由网络半静态地或半持续地配置给接收端，或者使用另一个动态控制消息动态地指示给接收端。

[0158] 可选的，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前，所述接收端根据所述目标接收器参数对所述发送端发送的所述第一消息进行解码，包括：

[0159] 若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0160] 若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0161] 若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0162] 若所述第二消息包括参数指示字段，且所述参数指示字段指示没有参数指示信息或者没有参数改变，则所述接收端根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

[0163] 该实施方式中，可以实现第二消息终具有参数指示字段，例如：波束指示字段，例如S比特位。且参数指示字段具有至少一个状态指示，即没有参数指示信息或者没有参数改变的状态指示，以及还可以指示用于解码第一消息的接收器参数的其他状态。因此，第二消息的有效载荷预先已知到发送端和接收端。例如对应于4个可能的接收器参数指示状态的S＝2。一个状态向接收机指示存在“没有参数指示信息或者没有参数改变”，而其他3个状态指示到接收机的接收器参数。

[0164] 另外，该实施方式中，关于第一消息的第一部分内容和第二部分内容可以参考上一实施方式中的相应描述，此处不作赘述。

[0165] 且关于第二消息中是否包括参数指示信息的情况，如何对第一部分内容和第二部分内容的解码，可以参见上述实施方式的相应描述，此处不作赘述，且可以达到相同的有益效率。

[0166] 可选的，所述方法还包括：

[0167] 所述接收端接收所述发送端发送的第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

[0168] 其中，上述第三消息可以定义为msg3，该实施方式中，通过第三消息通知接收端第二消息是否包括参数指示信息，更为具体的可以指示第二消息指示的接收器参数对于接收端是否存在接收器参数改变，这样可以实现当不存在接收器参数改变或者不包括参数指示信息时，接收端甚至可以不接收第二消息，直接使用当前的接收器参数对第一消息进行解码。另外，在一些实施方式中，第三消息可以具有固定有效载荷，其中第二消息中的参数指示信息的存在或者不存在对应于第三消息中的两个不同状态。例如，第三消息有1位表示第二消息是否携带参数指示信息。

[0169] 另外，本发明实施例中，上述第三消息可以对应于一个第二消息，即一个第三消息指示一个第二消息，例如：如图5所示。且第三消息、第二消息可以是以相同的调度时间单位(例如，时隙)发送，其中图5给出了一个示例。可以以不同的调度时间单位发送的第三消息和第二消息。如果第二消息有参数指示信息，第一消息和第二消息之间可以有一个间隙。如果第二消息没有参数指示，第一消息和第二消息之间可以没有间隙。

[0170] 可选的，所述第三消息用于指示M个时间单位内的第二消息是否包括参数指示信息，所述M为大于或者等于1的整数，所述M个时间单位连续或者不连续。

[0171] 该实施方式中，可以实现通过第三消息指示多个第二消息，例如：第三消息用于指示M个时隙中的M个第二消息是否包括参数指示信息，这样可以节省消息开销。另外，上述M的值和M个第二消息的时间位置可以预定义的半静态或半持续配置的，并且对发送端和接收端均是已知的。其中，图6示出了一个例子，其中M＝3。一旦接收到第三消息，该第三消息就向接收端指示相应的M个时隙中的第二消息是否携带参数指示信息。

[0172] 另外，第三消息可以是可以在每个调度时间单位(例如slots)或在由发送端预配

置的时隙的子集(例如,具有预先配置的传输周期和偏移)中被发送。对于后一种情况,发送端可以事先向接收端指示第三消息的发生。

[0173] 可选的,本发明实施例中,目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

[0174] 这样可以实现根据发送端的第二消息灵活选择时域、频域和空域中的至少一项的接收器参数,对第一消息进行解码。优先的,所述空域的接收器参数包括所述接收端的接收波束。这样可以实现接收端根据与第一消息关联的第二消息确定接收波束,且还可以提高波束传输性能。

[0175] 需要说明的是,本发明实施例介绍的多种可选的实施方式均可以相互结合实现,也可以单独实现,对此本发明实施例不作限定。

[0176] 本发明实施例,接收端接收发送端发送的与第一消息关联的第二消息;所述接收端根据所述第二消息,确定解码所述第一消息的目标接收器参数;所述接收端根据所述目标接收器参数对所述发送端发送的所述第一消息进行解码。这样可以实现接收端根据与第一消息关联的第二消息确定接收器参数,且还可以提高消息传输性能。

[0177] 请参阅图7,图7是本发明实施例提供的另一种消息解码方法的流程图,如图7所示,包括以下步骤:

[0178] 701、发送端向接收端发送与第一消息关联的第二消息,所述第二消息用于所述接收端确定解码所述第一消息的目标接收器参数;

[0179] 702、所述发送端向所述接收端发送所述第一消息。

[0180] 可选的,若所述第二消息包括参数指示信息,则所述目标接收器参数为所述参数指示信息指示的接收器参数;

[0181] 若所述第二消息不包括参数指示信息,则所述目标接收器参数为所述接收端默认的接收器参数。

[0182] 可选的,所述接收端默认的接收器参数包括:

[0183] 所述接收端当前使用的接收器参数、所述接收端接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端向所述发送端上报时间最近的发送器参数对应的接收器参数。

[0184] 可选的,所述参数指示信息显式或者隐式指示所述目标接收器参数。

[0185] 可选的,若所述参数指示信息隐式指示所述目标接收器参数,则所述参数指示信息包括所述发送端选择的发送器参数,所述接收端将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

[0186] 可选的,若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的,则所述第二消息包括参数指示信息,且所述第二消息与所述第一消息之间存在间隙;

[0187] 若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的,则所述第二消息不包括参数指示信息,且所述第二消息与所述第一消息之间不存在间隙。

[0188] 可选的,所述参数切换指示集对应的调度时间单位在时域上周期存在;和\或

[0189] 所述参数切换指示集对应的调度时间单位由所述发送端半静态或半持续配置,并通知所述接收端。

[0190] 可选的，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前。

[0191] 可选的，所述方法还包括：

[0192] 所述发送端向所述接收端发送第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

[0193] 可选的，所述第三消息用于指示M个时间单位内的第二消息是否包括参数指示信息，所述M为大于或者等于1的整数，所述M个时间单位连续或者不连续。

[0194] 可选的，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

[0195] 可选的，所述空域的接收器参数包括所述接收端的接收波束。

[0196] 需要说明的是，本实施例作为与图2所示的实施例中对应的发送端的实施方式，其具体的实施方式可以参见图2所示的实施例的相关说明，为了避免重复说明，本实施例不再赘述，且还可以达到相同有益效果。

[0197] 请参考图8，图8是本发明实施例提供一种接收端的结构图，如图8所示，接收端800包括：

[0198] 第一接收模块801，用于接收发送端发送的与第一消息关联的第二消息；

[0199] 确定模块802，用于根据所述第二消息，确定解码所述第一消息的目标接收器参数；

[0200] 解码模块803，用于根据所述目标接收器参数对所述发送端发送的所述第一消息进行解码。

[0201] 可选的，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

[0202] 若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端默认的接收器参数。

[0203] 可选的，所述接收端默认的接收器参数包括：

[0204] 所述接收端当前使用的接收器参数、所述接收端接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端向所述发送端上报时间最近的发送器参数对应的接收器参数。

[0205] 可选的，所述参数指示信息显式或者隐式指示所述目标接收器参数。

[0206] 可选的，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端选择的发送器参数，所述接收端将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

[0207] 可选的，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

[0208] 若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

[0209] 可选的，所述参数切换指示集对应的调度时间单位在时域上周期存在；和\或

[0210] 所述参数切换指示集对应的调度时间单位由所述发送端半静态或半持续配置，并通知所述接收端。

[0211] 可选的，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前；

[0212] 所述解码模块803用于若所述第二消息包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0213] 所述解码模块803用于若所述第二消息包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0214] 所述解码模块803用于若所述第二消息包括参数指示信息，则根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0215] 所述解码模块803用于若所述第二消息不包括波束指示信息，则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码；或者

[0216] 所述解码模块803用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0217] 所述解码模块803用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0218] 所述解码模块803用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0219] 所述解码模块803用于若所述第二消息包括参数指示字段，且所述参数指示字段指示没有参数指示信息或者没有参数改变，则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

[0220] 可选的，如图9所示，所述接收端800还包括：

[0221] 第二接收模块804，用于接收所述发送端发送的第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

[0222] 可选的，所述第三消息用于指示M个时间单位内的第二消息是否包括参数指示信息，所述M为大于或者等于1的整数，所述M个时间单位连续或者不连续。

[0223] 可选的，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

[0224] 可选的，所述空域的接收器参数包括所述接收端的接收波束。

[0225] 需要说明的是，本实施例中上述接收端800可以是本发明实施例中方法实施例中任意实施方式的接收端，本发明实施例中方法实施例中接收端的任意实施方式都可以被本

实施例中的上述接收端800所实现，以及达到相同的有益效果，此处不再赘述。

[0226] 请参阅图10，图10是本发明实施例提供的一种发送端的结构图，如图10所示，发送端1000包括：

[0227] 第一发送模块1001，用于发送端向接收端发送与第一消息关联的第二消息，所述第二消息用于所述接收端确定解码所述第一消息的目标接收器参数；

[0228] 第二发送模块1002，用于向所述接收端发送所述第一消息。

[0229] 可选的，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

[0230] 若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端默认的接收器参数。

[0231] 可选的，所述接收端默认的接收器参数包括：

[0232] 所述接收端当前使用的接收器参数、所述接收端接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端向所述发送端上报时间最近的发送器参数对应的接收器参数。

[0233] 可选的，所述参数指示信息显式或者隐式指示所述目标接收器参数。

[0234] 可选的，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端选择的发送器参数，所述接收端将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

[0235] 可选的，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

[0236] 若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

[0237] 可选的，所述参数切换指示集对应的调度时间单位在时域上周期存在；和\或

[0238] 所述参数切换指示集对应的调度时间单位由所述发送端半静态或半持续配置，并通知所述接收端。

[0239] 可选的，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前。

[0240] 可选的，如图11所示，所述发送端还包括：

[0241] 第二发送模块1003，用于向所述接收端发送第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

[0242] 可选的，所述第三消息用于指示M个时间单位内的第二消息是否包括参数指示信息，所述M为大于或者等于1的整数，所述M个时间单位连续或者不连续。

[0243] 可选的，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

[0244] 可选的，所述空域的接收器参数包括所述接收端的接收波束。

[0245] 需要说明的是，本实施例中上述发送端1000可以是本发明实施例中方法实施例中

任意实施方式的发送端，本发明实施例中方法实施例中发送端的任意实施方式都可以被本实施例中的上述发送端1000所实现，以及达到相同的有益效果，此处不再赘述。

[0246] 请参考图12，图12是本发明实施例提供的另一种接收端的结构图，如图12所示，该接收端包括：处理器1200、收发机1210、存储器1220、用户接口1230和总线接口，其中：

[0247] 处理器1200，用于读取存储器1220中的程序，执行下列过程：

[0248] 通过收发机1210接收端接收发送端发送的与第一消息关联的第二消息；

[0249] 根据所述第二消息，确定解码所述第一消息的目标接收器参数；

[0250] 根据所述目标接收器参数对所述发送端发送的所述第一消息进行解码。

[0251] 其中，收发机1210，用于在处理器1200的控制下接收和发送数据。

[0252] 在图12中，总线架构可以包括任意数量的互联的总线和桥，具体由处理器1200代表的一个或多个处理器和存储器1220代表的存储器的各种电路链接在一起。总线架构还可以将诸如外围设备、稳压器和功率管理电路等之类的各种其他电路链接在一起，这些都是本领域所公知的，因此，本文不再对其进行进一步描述。总线接口提供接口。收发机1210可以是多个元件，即包括发送机和接收机，提供用于在传输介质上与各种其他装置通信的单元。针对不同的用户设备，用户接口1230还可以是能够外接内接需要设备的接口，连接的设备包括但不限于小键盘、显示器、扬声器、麦克风、操纵杆等。

[0253] 处理器1200负责管理总线架构和通常的处理，存储器1220可以存储处理器1200在执行操作时所使用的数据。

[0254] 可选的，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

[0255] 若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端默认的接收器参数。

[0256] 可选的，所述接收端默认的接收器参数包括：

[0257] 所述接收端当前使用的接收器参数、所述接收端接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端向所述发送端上报时间最近的发送器参数对应的接收器参数。

[0258] 可选的，所述参数指示信息显式或者隐式指示所述目标接收器参数。

[0259] 可选的，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端选择的发送器参数，所述接收端将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

[0260] 可选的，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

[0261] 若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

[0262] 可选的，所述参数切换指示集对应的调度时间单位在时域上周期存在；和\或

[0263] 所述参数切换指示集对应的调度时间单位由所述发送端半静态或半持续配置，并通知所述接收端。

[0264] 可选的，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述

第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前，所述根据所述目标接收器参数对所述第一消息进行解码，包括：

[0265] 若所述第二消息包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0266] 若所述第二消息包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0267] 若所述第二消息包括参数指示信息，则根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0268] 若所述第二消息不包括波束指示信息，则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码；或者

[0269] 若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0270] 若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0271] 若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0272] 若所述第二消息包括参数指示字段，且所述参数指示字段指示没有参数指示信息或者没有参数改变，则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

[0273] 可选的，处理器1200还用于：

[0274] 通过收发机1210接收所述发送端发送的第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

[0275] 可选的，所述第三消息用于指示M个时间单位内的第二消息是否包括参数指示信息，所述M为大于或者等于1的整数，所述M个时间单位连续或者不连续。

[0276] 可选的，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

[0277] 可选的，所述空域的接收器参数包括所述接收端的接收波束。

[0278] 需要说明的是，本实施例中上述接收端可以是图1-图7所示的实施例中的终端，图1-图7所示实施例中接收端的任意实施方式都可以被本实施例中的上述接收所实现，以及达到相同的有益效果，此处不再赘述。

[0279] 请参考图13，图13是本发明实施提供的另一种发送端的结构图，如图13所示，该发送端包括：处理器1300、收发机1310、存储器1320、用户接口1330和总线接口，其中：

[0280] 处理器1300，用于读取存储器1320中的程序，执行下列过程：

[0281] 通过收发机1310向接收端发送与第一消息关联的第二消息，所述第二消息用于所

述接收端确定解码所述第一消息的目标接收器参数；

[0282] 通过收发机1310向所述接收端发送所述第一消息。

[0283] 其中，收发机1310，用于在处理器1300的控制下接收和发送数据。

[0284] 在图13中，总线架构可以包括任意数量的互联的总线和桥，具体由处理器1300代表的一个或多个处理器和存储器1320代表的存储器的各种电路链接在一起。总线架构还可以将诸如外围设备、稳压器和功率管理电路等之类的各种其他电路链接在一起，这些都是本领域所公知的，因此，本文不再对其进行进一步描述。总线接口提供接口。收发机1310可以是多个元件，即包括发送机和接收机，提供用于在传输介质上与各种其他装置通信的单元。针对不同的用户设备，用户接口1330还可以是能够外接内接需要设备的接口，连接的设备包括但不限于小键盘、显示器、扬声器、麦克风、操纵杆等。

[0285] 处理器1300负责管理总线架构和通常的处理，存储器1320可以存储处理器1300在执行操作时所使用的数据。

[0286] 可选的，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

[0287] 若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端默认的接收器参数。

[0288] 可选的，所述接收端默认的接收器参数包括：

[0289] 所述接收端当前使用的接收器参数、所述接收端接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端向所述发送端上报时间最近的发送器参数对应的接收器参数。

[0290] 可选的，所述参数指示信息显式或者隐式指示所述目标接收器参数。

[0291] 可选的，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端选择的发送器参数，所述接收端将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

[0292] 可选的，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

[0293] 若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

[0294] 可选的，所述参数切换指示集对应的调度时间单位在时域上周期存在；和\或

[0295] 所述参数切换指示集对应的调度时间单位由所述发送端半静态或半持续配置，并通知所述接收端。

[0296] 可选的，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前。

[0297] 可选的，处理器1300还用于：

[0298] 通过收发机1310向所述接收端发送第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数

指示信息，则所述第二消息与所述第一消息之间不存在间隙。

[0299] 可选的，所述第三消息用于指示M个时间单位内的第二消息是否包括参数指示信息，所述M为大于或者等于1的整数，所述M个时间单位连续或者不连续。

[0300] 可选的，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

[0301] 可选的，所述空域的接收器参数包括所述接收端的接收波束。

[0302] 需要说明的是，本实施例中上述发送端可以是图1-图7所示的实施例中的发送端，图1-图7所示实施例中发送端的任意实施方式都可以被本实施例中的上述发送端所实现，以及达到相同的有益效果，此处不再赘述。

[0303] 在本申请所提供的几个实施例中，应该理解到，所揭露方法和装置，可以通过其它的方式实现。例如，以上所描述的装置实施例仅仅是示意性的，例如，所述单元的划分，仅仅为一种逻辑功能划分，实际实现时可以有另外的划分方式，例如多个单元或组件可以结合或者可以集成到另一个系统，或一些特征可以忽略，或不执行。另一点，所显示或讨论的相互之间的耦合或直接耦合或通信连接可以是通过一些接口，装置或单元的间接耦合或通信连接，可以是电性，机械或其它的形式。

[0304] 另外，在本发明各个实施例中的各功能单元可以集成在一个处理单元中，也可以是各个单元单独物理包括，也可以两个或两个以上单元集成在一个单元中。上述集成的单元既可以采用硬件的形式实现，也可以采用硬件加软件功能单元的形式实现。

[0305] 上述以软件功能单元的形式实现的集成的单元，可以存储在一个计算机可读取存储介质中。上述软件功能单元存储在一个存储介质中，包括若干指令用以使得一台计算机设备(可以是个人计算机，服务器，或者网络设备等)执行本发明各个实施例所述收发方法的部分步骤。而前述的存储介质包括：U盘、移动硬盘、只读存储器(Read-Only Memory，简称ROM)、随机存取存储器(Random Access Memory，简称RAM)、磁碟或者光盘等各种可以存储程序代码的介质。

[0306] 以上所述是本发明的优选实施方式，应当指出，对于本技术领域的普通技术人员来说，在不脱离本发明所述原理的前提下，还可以作出若干改进和润饰，这些改进和润饰也应视为本发明的保护范围。

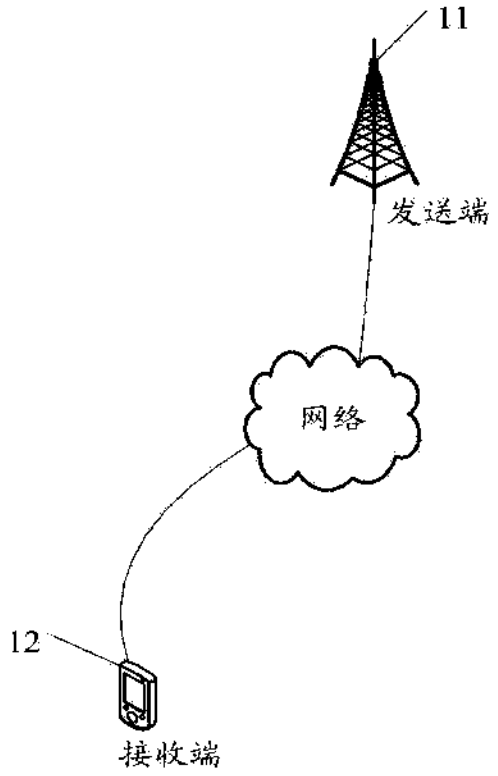

11
发送端
网络
12
接收端

图1

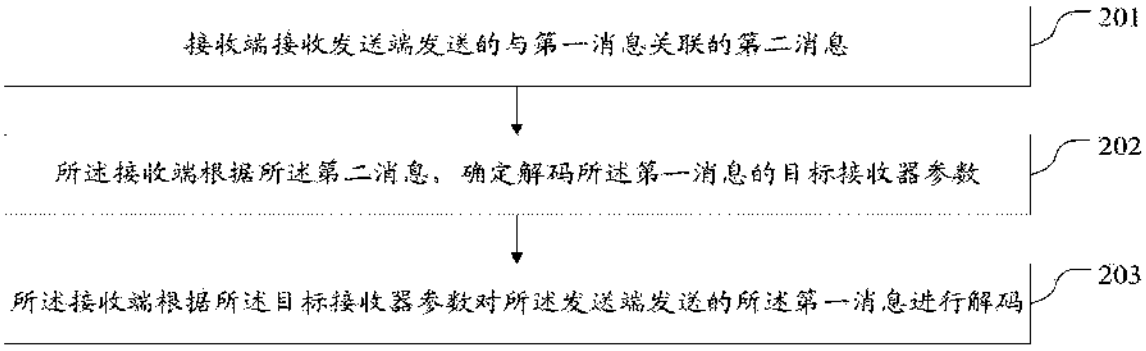

接收端接收发送端发送的与第一消息关联的第二消息
201
所述接收端根据所述第二消息，确定解码所述第一消息的目标接收器参数
202
所述接收端根据所述目标接收器参数对所述发送端发送的所述第一消息进行解码
203

图2

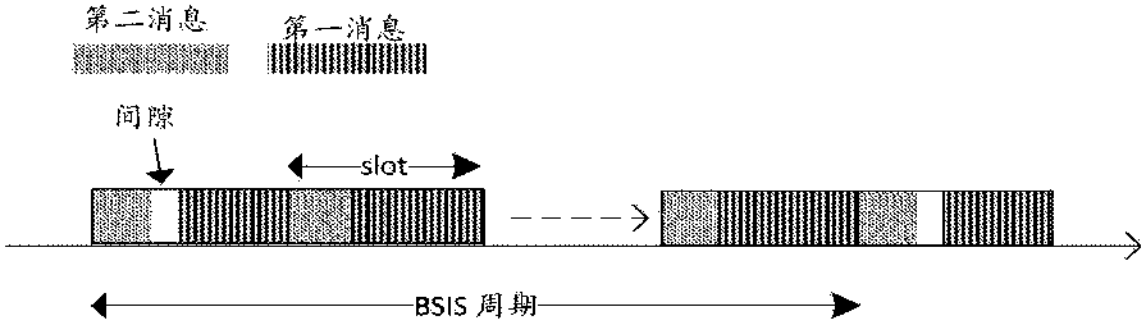

第二消息
第一消息
间隙
slot
BSIS 周期

图3

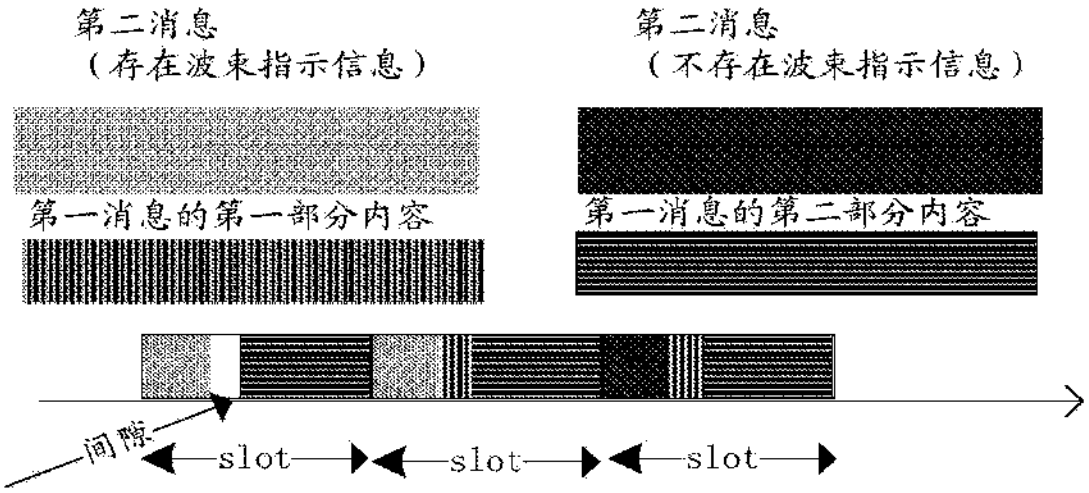

第二消息
（存在波束指示信息）
第二消息
（不存在波束指示信息）
第一消息的第一部分内容
第一消息的第二部分内容
间隙
slot
slot
slot

图4

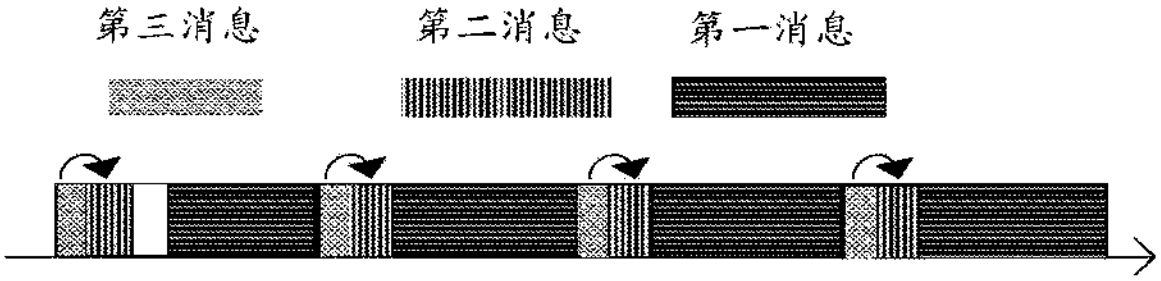

第三消息
第二消息
第一消息

图5

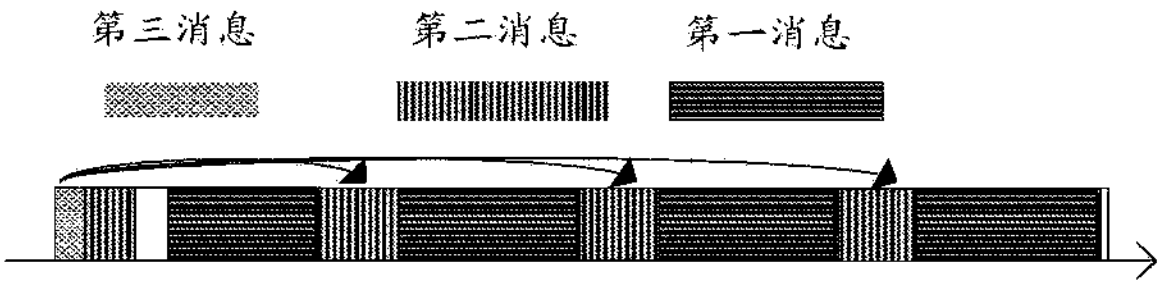

第三消息
第二消息
第一消息

图6

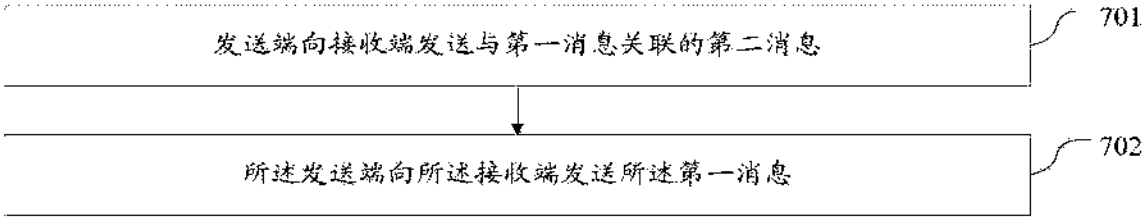

发送端向接收端发送与第一消息关联的第二消息
701
所述发送端向所述接收端发送所述第一消息
702

图7

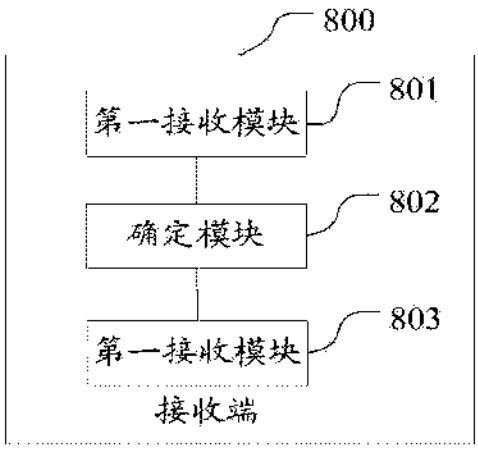

800
第一接收模块
801
确定模块
802
第一接收模块
803
接收端

图8

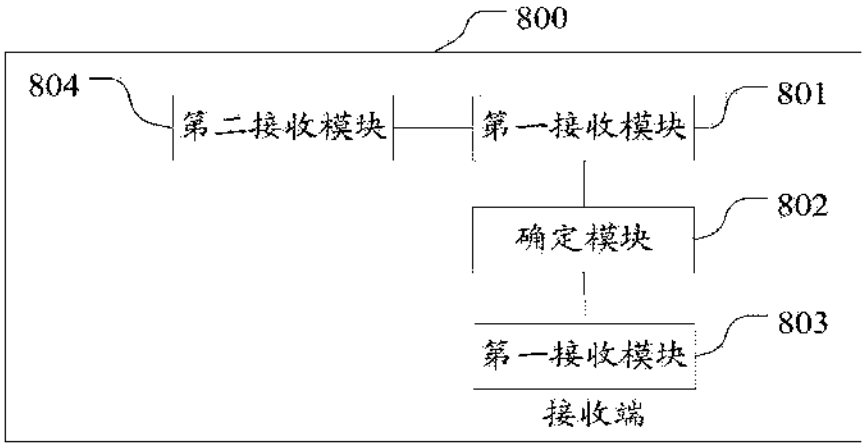

800
804
第二接收模块
第一接收模块
801
确定模块
802
第一接收模块
803
接收端

图9

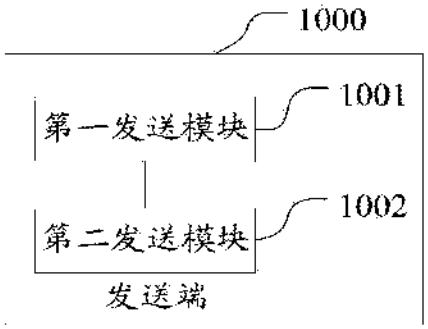

1000
第一发送模块
1001
第二发送模块
1002
发送端

图10

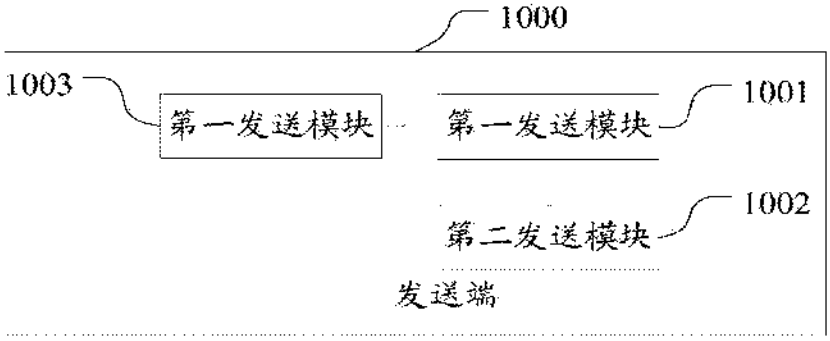

1000
1003
第一发送模块
第一发送模块
1001
第二发送模块
1002
发送端

图11

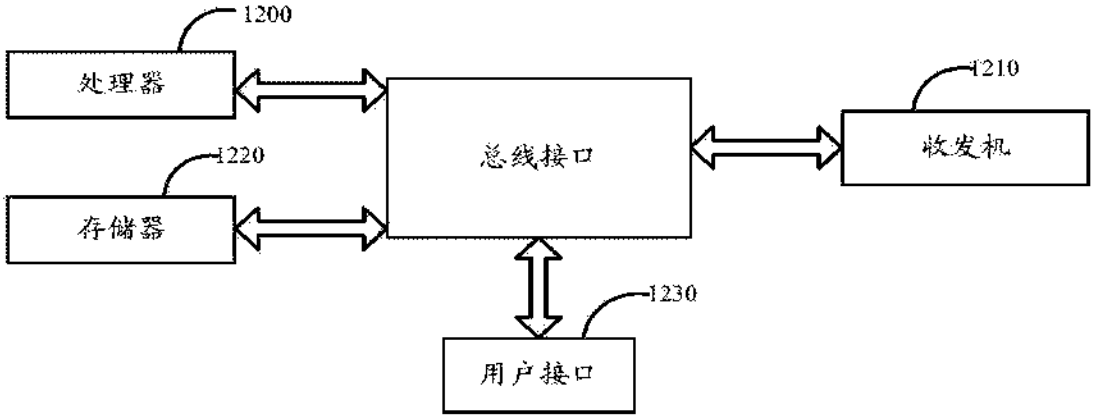

1200
处理器
1210
总线接口
收发机
1220
存储器
1230
用户接口

图12

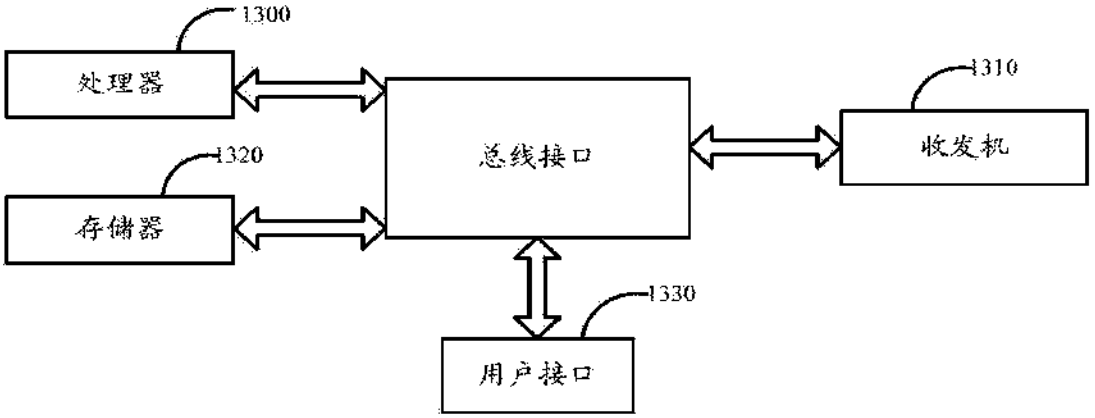
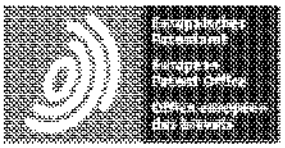

1300
处理器
1310
总线接口
收发机
1320
存储器
1330
用户接口

图13



Espacenet

CN108633047A Channel transmission method and network device

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Channel transmission method and network device

Abstract

Embodiments of the invention disclose a channel transmission method and a network device. The method includes steps: a first network device determines a search space of at least two downlink control channels; the first network device respectively determines resources occupied by the at least two downlink control channels in the search space, wherein the resources scheduled by the at least two downlink control channels belong to one carrier; and the first network device obtains the at least two downlink control channels by employing the resources. By adopting the method and the device, data ofone carrier can be scheduled through a plurality of downlink control channels so that the efficiency and the reliability of information transmission are improved.

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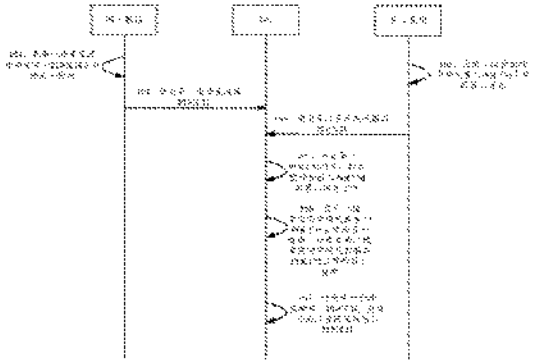
权利要求书6页 说明书32页 附图14页

(54)发明名称

一种信道传输方法及网络设备

(57)摘要

本发明实施例公开了一种信道传输方法及网络设备。其中，该方法包括：第一网络设备确定至少两个下行控制信道的搜索空间；所述第一网络设备在所述搜索空间中分别确定出所述至少两个下行控制信道占用的资源，所述至少两个下行控制信道调度的资源属于一个载波；所述第一网络设备使用所述资源获取所述至少两个下行控制信道。采用本发明实施例，能够实现通过多个下行控制信道调度一个载波的数据，从而提升了信息传输的效率及可靠性。



CN 108633047 B

1.一种信道传输方法,其特征在于,包括:

用户设备确定至少两个下行控制信道的搜索空间;

所述用户设备在所述搜索空间中分别确定出所述至少两个下行控制信道占用的资源,所述至少两个下行控制信道调度的数据所占的资源属于一个载波;

所述用户设备使用所述至少两个下行控制信道占用的资源,获取所述至少两个下行控制信道。

2.根据权利要求1所述的方法,其特征在于,所述至少两个下行控制信道的搜索空间相同;所述用户设备确定至少两个下行控制信道的搜索空间,包括:

所述用户设备基于第一参数确定至少两个下行控制信道的搜索空间;其中,所述第一参数包括控制信道元素CCE个数、第一时间单元的标识以及下行控制信道的候选位置中的至少一项;

所述至少两个下行控制信道的搜索空间的CCE的个数相同;或,

所述至少两个下行控制信道的第一时间单元的标识是基于所述至少两个下行控制信道占用的资源的子载波间隔确定的;或,

所述至少两个下行控制信道的第一时间单元的标识是根据预设子载波间隔下的时间单元中与所述至少两个下行控制信道的第一时间单元对应的时间单元的标识确定的;或,

所述至少两个下行控制信道的候选位置不同,所述至少两个下行控制信道的候选位置是基于第二参数确定的,所述第二参数包括设备类型、设备标识、聚合等级中的至少一项。

3.根据权利要求1所述的方法,其特征在于,所述至少两个下行控制信道的搜索空间不同;所述用户设备确定至少两个下行控制信道的搜索空间,包括:

所述用户设备分别确定至少两个下行控制信道的搜索空间占用的资源,所述至少两个下行控制信道的搜索空间占用的资源不同,其中,所述至少两个下行控制信道的搜索空间占用的资源包括频域资源或时域资源;

所述用户设备基于所述至少两个下行控制信道的搜索空间占用的资源分别确定所述至少两个下行控制信道的搜索空间。

4.根据权利要求3所述的方法,其特征在于,所述用户设备分别确定至少两个下行控制信道的搜索空间占用的资源,包括:

所述用户设备确定第一资源配置信息,并基于所述第一资源配置信息确定至少两个下行控制信道的搜索空间占用的资源;

其中,所述第一资源配置信息包括所述至少两个下行控制信道的搜索空间所在的控制信道资源集合占用的资源信息,且所述至少两个下行控制信道对应的搜索空间的个数与控制信道资源集合的个数相同。

5.根据权利要求3所述的方法,其特征在于,所述用户设备分别确定至少两个下行控制信道的搜索空间占用的资源,包括:

所述用户设备确定第二资源配置信息,并基于所述第二资源配置信息确定至少两个下行控制信道的搜索空间占用的资源;

其中,所述第二资源配置信息包括所述至少两个下行控制信道的搜索空间所在的至少两个控制信道资源集合占用的资源信息、所述至少两个控制信道资源集合的标识以及第一偏移值中的至少一项,所述第一偏移值是基于所述至少两个控制信道资源集合的标识确定

出的，且所述至少两个控制信道资源集合占用的资源相重叠。

6.根据权利要求3所述的方法，其特征在于，所述用户设备分别确定至少两个下行控制信道的搜索空间占用的资源，包括：

所述用户设备确定第三资源配置信息，并基于所述第三资源配置信息确定至少两个下行控制信道的搜索空间占用的资源；

其中，所述第三资源配置信息包括所述至少两个下行控制信道的搜索空间所在的控制信道资源集合占用的资源信息、所述至少两个下行控制信道的搜索空间的标识以及第二偏移值中的至少一项，所述第二偏移值是基于所述至少两个下行控制信道的搜索空间的标识确定出的，且所述至少两个下行控制信道对应的搜索空间所在的控制信道资源集合相同。

7.根据权利要求3所述的方法，其特征在于，所述至少两个下行控制信道的搜索空间占用的资源包括时域资源；所述方法还包括：

所述用户设备接收至少一个第二网络设备发送的通知消息，所述通知消息包括所述至少两个下行控制信道的搜索空间占用的第二时间单元的标识。

8.一种信道传输方法，其特征在于，包括：

第一网络设备在第一搜索空间中确定第一下行控制信道占用的第一资源；

第二网络设备在第二搜索空间中确定第二下行控制信道占用的第二资源，所述第一下行控制信道调度的资源和所述第二下行控制信道调度的数据所占的资源属于一个载波；

所述第一网络设备使用所述第一资源向用户设备发送所述第一下行控制信道；

所述第二网络设备使用所述第二资源向所述用户设备发送所述第二下行控制信道。

9.根据权利要求8所述的方法，其特征在于，所述第一搜索空间和所述第二搜索空间相同；所述方法还包括：

所述第一网络设备或所述第二网络设备基于第一参数确定所述第一搜索空间；

其中，所述第一参数包括控制信道元素CCE的个数、第一时间单元的标识以及下行控制信道的候选位置中的至少一项；

所述第一网络设备对应的第一参数包括的CCE的个数和所述第二网络设备对应的第一参数包括的CCE的个数相同；或，

所述第一下行控制信道的第一时间单元的标识或所述第二下行控制信道的第一时间单元的标识是基于所述第一资源和第二资源的子载波间隔确定的；或，

所述第一下行控制信道的第一时间单元的标识是根据预设子载波间隔下的时间单元中与所述第一下行控制信道的第一时间单元对应的时间单元的标识确定的，所述第二下行控制信道的第一时间单元的标识是根据所述预设子载波间隔下的时间单元中与所述第二下行控制信道的第一时间单元对应的时间单元的标识确定出的；或，

所述第一下行控制信道的候选位置与所述第二下行控制信道的候选位置不同，所述第一下行控制信道或所述第二下行控制信道的候选位置是基于第二参数确定的，所述第二参数包括设备类型、设备标识、聚合等级中的至少一项。

10.根据权利要求8所述的方法，其特征在于，所述第一搜索空间和所述第二搜索空间不同；所述方法还包括：

所述第一网络设备确定第一搜索空间占用的第三资源；其中，所述第三资源包括频域资源或时域资源；

所述第一网络设备基于所述第三资源确定所述第一搜索空间。

11.根据权利要求10所述的方法，其特征在于，所述第一网络设备基于所述第三资源确定所述第一搜索空间，包括：

所述第一网络设备确定第一资源配置信息，并基于所述第一资源配置信息确定所述第一搜索空间，所述第一资源配置信息包括所述第一搜索空间所在的控制信道资源集合占用的资源信息。

12.根据权利要求10所述的方法，其特征在于，所述第一网络设备基于所述第三资源确定所述第一搜索空间，包括：

所述第一网络设备确定第二资源配置信息，并基于所述第二资源配置信息确定所述第一搜索空间，所述第二资源配置信息包括所述第一搜索空间所在的控制信道资源集合占用的资源信息、所述控制信道资源集合的标识以及第一偏移值中的至少一项，所述第一偏移值是基于所述控制信道资源集合的标识确定出的。

13.根据权利要求10所述的方法，其特征在于，所述第一网络设备基于所述第三资源确定所述第一搜索空间，包括：

所述第一网络设备确定第三资源配置信息，并基于所述第三资源配置信息确定所述第一搜索空间，所述第三资源配置信息包括所述第一搜索空间所在的控制信道资源集合占用的资源信息、所述第一搜索空间的标识以及第二偏移值中的至少一项，所述第二偏移值是基于所述第一搜索空间的标识确定出的。

14.根据权利要求10所述的方法，其特征在于，所述第三资源包括时域资源；所述方法还包括：

所述第一网络设备向所述用户设备发送通知消息，所述通知消息包括所述第一搜索空间占用的第二时间单元的标识。

15.根据权利要求8所述的方法，其特征在于，所述方法还包括：

所述第一网络设备基于第三参数确定所述第一搜索空间，其中，所述第一搜索空间包括至少一个控制信道元素CCE，所述第三参数包括CCE的个数或CCE的标识。

16.一种用户设备，其特征在于，包括：

确定模块，用于确定至少两个下行控制信道的搜索空间；

所述确定模块，还用于在所述搜索空间中分别确定出所述至少两个下行控制信道占用的资源，所述至少两个下行控制信道调度的数据所占的资源属于一个载波；

通信模块，用于使用所述至少两个下行控制信道占用的资源获取所述至少两个下行控制信道。

17.根据权利要求16所述的用户设备，其特征在于，所述至少两个下行控制信道的搜索空间相同；所述确定模块在确定至少两个下行控制信道的搜索空间时，具体用于：

基于第一参数确定至少两个下行控制信道的搜索空间；其中，所述第一参数包括控制信道元素CCE个数、第一时间单元的标识以及下行控制信道的候选位置中的至少一项；

所述至少两个下行控制信道的搜索空间的CCE的个数相同；或，

所述至少两个下行控制信道的第一时间单元的标识是基于所述至少两个下行控制信道占用的资源的子载波间隔确定的；或，

所述至少两个下行控制信道的第一时间单元的标识是根据预设子载波间隔下的时间

单元中与所述至少两个下行控制信道的第一时间单元对应的时间单元的标识确定的；或，

所述至少两个下行控制信道的候选位置不同，所述至少两个下行控制信道的候选位置是基于第二参数确定的，所述第二参数包括设备类型、设备标识、聚合等级中的至少一项。

18.根据权利要求16所述的用户设备，其特征在于，所述至少两个下行控制信道的搜索空间不同；所述确定模块在确定至少两个下行控制信道的搜索空间时，具体用于：

分别确定至少两个下行控制信道的搜索空间占用的资源，所述至少两个下行控制信道的搜索空间占用的资源不同，其中，所述至少两个下行控制信道的搜索空间占用的资源包括频域资源或时域资源；

基于所述至少两个下行控制信道的搜索空间占用的资源分别确定所述至少两个下行控制信道的搜索空间。

19.根据权利要求18所述的用户设备，其特征在于，所述确定模块在分别确定至少两个下行控制信道的搜索空间占用的资源时，具体用于：

确定第一资源配置信息，并基于所述第一资源配置信息确定至少两个下行控制信道的搜索空间占用的资源；

其中，所述第一资源配置信息包括所述至少两个下行控制信道的搜索空间所在的控制信道资源集合占用的资源信息，且所述至少两个下行控制信道对应的搜索空间的个数与控制信道资源集合的个数相同。

20.根据权利要求18所述的用户设备，其特征在于，所述确定模块在分别确定至少两个下行控制信道的搜索空间占用的资源时，具体用于：

确定第二资源配置信息，并基于所述第二资源配置信息确定至少两个下行控制信道的搜索空间占用的资源；

其中，所述第二资源配置信息包括所述至少两个下行控制信道的搜索空间所在的至少两个控制信道资源集合占用的资源信息、所述至少两个控制信道资源集合的标识以及第一偏移值中的至少一项，所述第一偏移值是基于所述至少两个控制信道资源集合的标识确定出的，且所述至少两个控制信道资源集合占用的资源相重叠。

21.根据权利要求18所述的用户设备，其特征在于，所述确定模块在分别确定至少两个下行控制信道的搜索空间占用的资源时，具体用于：

确定第三资源配置信息，并基于所述第三资源配置信息确定至少两个下行控制信道的搜索空间占用的资源；

其中，所述第三资源配置信息包括所述至少两个下行控制信道的搜索空间所在的控制信道资源集合占用的资源信息、所述至少两个下行控制信道的搜索空间的标识以及第二偏移值中的至少一项，所述第二偏移值是基于所述至少两个下行控制信道的搜索空间的标识确定出的，且所述至少两个下行控制信道对应的搜索空间所在的控制信道资源集合相同。

22.根据权利要求18所述的用户设备，其特征在于，所述至少两个下行控制信道的搜索空间占用的资源包括时域资源；

所述通信模块，还用于接收至少一个另一网络设备发送的通知消息，所述通知消息包括所述至少两个下行控制信道的搜索空间占用的第二时间单元的标识。

23.一种网络设备，其特征在于，包括：

第一确定模块，用于在第一搜索空间中确定第一下行控制信道占用的第一资源；

第二确定模块，用于在第二搜索空间中确定第二下行控制信道占用的第二资源，所述第一下行控制信道调度的资源和所述第二下行控制信道调度的数据所占的资源属于一个载波；

第一通信模块，用于使用所述第一资源向用户设备发送所述第一下行控制信道；

第二通信模块，用于使用所述第二资源向所述用户设备发送所述第二下行控制信道。

24.根据权利要求23所述的网络设备，其特征在于，所述第一搜索空间和所述第二搜索空间相同；

所述第一确定模块，还用于基于第一参数确定所述第一搜索空间；

所述第二确定模块，还用于基于第一参数确定所述第一搜索空间；其中，所述第一参数包括控制信道元素CCE的个数、第一时间单元的标识以及下行控制信道的候选位置中的至少一项；

所述第一确定模块确定出的第一参数包括的CCE的个数和所述第二确定模块确定出的第一参数包括的CCE的个数相同；或，

所述第一下行控制信道的第一时间单元的标识或所述第二下行控制信道的第一时间单元的标识是基于所述第一资源和第二资源的子载波间隔确定的；或，

所述第一下行控制信道的第一时间单元的标识是根据预设子载波间隔下的时间单元中与所述第一下行控制信道的第一时间单元对应的时间单元的标识确定的，所述第二下行控制信道的第一时间单元的标识是根据所述预设子载波间隔下的时间单元中与所述第二下行控制信道的第一时间单元对应的时间单元的标识确定出的；或，

所述第一下行控制信道的候选位置与所述第二下行控制信道的候选位置不同，所述第一下行控制信道或所述第二下行控制信道的候选位置是基于第二参数确定的，所述第二参数包括设备类型、设备标识、聚合等级中的至少一项。

25.根据权利要求23所述的网络设备，其特征在于，所述第一搜索空间和所述第二搜索空间不同；

所述第一确定模块，还用于确定第一搜索空间占用的第三资源，并基于所述第三资源确定所述第一搜索空间；其中，所述第三资源包括频域资源或时域资源。

26.根据权利要求25所述的网络设备，其特征在于，所述第一确定模块在基于所述第三资源确定所述第一搜索空间时，具体用于：

确定第一资源配置信息，并基于所述第一资源配置信息确定所述第一搜索空间，所述第一资源配置信息包括所述第一搜索空间所在的控制信道资源集合占用的资源信息。

27.根据权利要求25所述的网络设备，其特征在于，所述第一确定模块在基于所述第三资源确定所述第一搜索空间时，具体用于：

确定第二资源配置信息，并基于所述第二资源配置信息确定所述第一搜索空间，所述第二资源配置信息包括所述第一搜索空间所在的控制信道资源集合占用的资源信息、所述控制信道资源集合的标识以及第一偏移值中的至少一项，所述第一偏移值是基于所述控制信道资源集合的标识确定出的。

28.根据权利要求25所述的网络设备，其特征在于，所述第一确定模块在基于所述第三资源确定所述第一搜索空间时，具体用于：

确定第三资源配置信息，并基于所述第三资源配置信息确定所述第一搜索空间，所述

第三资源配置信息包括所述第一搜索空间所在的控制信道资源集合占用的资源信息、所述第一搜索空间的标识以及第二偏移值中的至少一项，所述第二偏移值是基于所述第一搜索空间的标识确定出的。

29.根据权利要求25所述的网络设备，其特征在于，所述第三资源包括时域资源；

所述第一通信模块，还用于向所述用户设备发送通知消息，所述通知消息包括所述第一搜索空间占用的第二时间单元的标识。

30.根据权利要求23所述的网络设备，其特征在于，

所述第一确定模块，还用于基于第三参数确定所述第一搜索空间，其中，所述第一搜索空间包括至少一个控制信道元素CCE，所述第三参数包括CCE的个数或CCE的标识。

一种信道传输方法及网络设备

技术领域

[0001] 本申请涉及通信技术领域，尤其涉及一种信道传输方法及网络设备。

背景技术

[0002] 目前，基站和用户设备(英文:User Equipment，缩写:UE)之间可采用多点协作传输(英文:Coordinated Multiple Points Transmission/Reception，缩写:CoMP)技术进行信息传输，CoMP主要是指使用地理位置上分离的多个基站，协同参与为一个UE的物理下行共享信道(英文:Physical Downlink Sharing Channel，缩写:PDSCH)数据进行传输，或者联合接收一个UE发送的物理上行共享信道(英文:Physical Uplink Sharing Channel，缩写:PUSCH)数据，以提升UE的覆盖性能。现有的长期演进(英文:Long Term Evolution，缩写:LTE)系统中一个小区中的物理下行控制信道(英文:Physical Downlink Control Channel，缩写:PDCCH)的发送是采用全带宽的方式，在一个子帧中通过不同的载波协作传输一个UE的多个PDCCH，不同的PDCCH用于调度不同载波的数据。从而UE能够使用自身的无线网络临时标识(英文:RNTI Radio Network Tempory Identity，缩写:RNTI)对该子帧包括的所有PDCCH进行尝试解码，基于该RNTI解码得到属于自己的PDCCH，并基于该PDCCH进行信息发送或者接收。然而，对于同一个UE，目前一个子帧中只能携带该UE调度的一个载波的一个PDCCH，传输效率较低。而且，在协作传输的场景下，多基站是可以进行独立调度的，仅发送一个PDCCH往往会存在时延问题，导致发送该PDCCH前获知的信道状态信息(英文:Channel State Information，缩写:CSI)可能失效，进而导致导致PDCCH携带的信息不能适用于真正的信道状况，使得基于该PDCCH的信息传输不可靠。

发明内容

[0003] 本发明实施例提供了一种信道传输方法及网络设备，能够实现在通过多个下行控制信道调度一个载波的数据，从而提升了信息传输的效率及可靠性。

[0004] 第一方面，本发明实施例提供了一种信道传输方法，包括：

[0005] 第一网络设备确定至少两个下行控制信道的搜索空间，在该搜索空间中分别确定出该至少两个下行控制信道占用的资源，并使用该资源获取该至少两个下行控制信道。

[0006] 其中，该至少两个下行控制信道调度的资源属于一个载波。该下行控制信道可以包括下行调度信息，也可以包括上行调度信息。

[0007] 可选的，该至少两个下行控制信道可以是一个网络设备发送给该第一网络设备的，也可以是多个网络设备发送给该第一网络设备的。该第一网络设备可以为基站，也可以为用户设备。

[0008] 进一步可选的，该至少两个下行控制信道的搜索空间可以相同也可以不同。

[0009] 在一些可能的实现中，该至少两个下行控制信道的搜索空间可以相同，该第一网络设备确定至少两个下行控制信道的搜索空间时，可基于第一参数确定至少两个下行控制信道的搜索空间。

[0010] 其中，该第一参数可包括控制信道元素(英文：Control Channel Element，缩写：CCE)个数、第一时间单元的标识以及下行控制信道的候选位置中的至少一项。可选的，该第一参数可以是该第一网络设备确定出的；该第一参数也可以是发送该至少两个下行控制信道的网络设备发送给该第一网络设备的，从而该第一网络设备可接收至少一个网络设备发送的该第一参数，以基于该第一参数确定出该至少两个下行控制信道的搜索空间。

[0011] 在一些可能的实现中，该至少两个下行控制信道的搜索空间的CCE的个数相同；或，该至少两个下行控制信道的第一时间单元的标识是基于该至少两个下行控制信道占用的资源的子载波间隔确定的；或，该至少两个下行控制信道的第一时间单元的标识是根据预设子载波间隔下的时间单元中与该至少两个下行控制信道的第一时间单元对应的时间单元的标识确定的；或，该至少两个下行控制信道的候选位置不同，该至少两个下行控制信道的候选位置是基于第二参数确定的，该第二参数包括设备类型、设备标识、聚合等级中的至少一项。

[0012] 在一些可能的实现中，该第一网络设备还可基于至少两个下行控制信道的时间单元信息确定该至少两个下行控制信道的搜索空间对应的CCE的个数；其中，该时间单元信息包括第二时间单元的个数或第二时间单元的标识。也就是说，该第一网络设备还可以基于该至少两个下行控制信道(或其搜索空间)所在的第二时间单元的个数或标识确定出该至少两个下行控制信道的搜索空间的CCE个数，或该至少两个下行控制信道的搜索空间所在的控制信道资源集合的CCE个数，以确定出该至少两个下行控制信道的搜索空间。可选的，该第二时间单元对应的时间单位和该第一时间单元对应的时间单位可以相同也可以不同。

[0013] 在一些可能的实现中，该至少两个下行控制信道的搜索空间也可以不同；该第一网络设备确定至少两个下行控制信道的搜索空间时，可以具体为：第一网络设备分别确定至少两个下行控制信道的搜索空间占用的资源，该至少两个下行控制信道的搜索空间占用的资源不同，并基于该资源分别确定该至少两个下行控制信道的搜索空间。其中，该资源可以包括频域资源或时域资源。

[0014] 也就是说，当第一网络设备接收的多个下行控制信道的搜索空间不同时，该第一网络设备在确定该多个下行控制信道的搜索空间时，可分别确定该多个下行控制信道的搜索空间占用的时域资源和/或频域资源，并基于该资源分别确定该多个下行控制信道的搜索空间。

[0015] 在一些可能的实现中，该第一网络设备分别确定至少两个下行控制信道的搜索空间占用的资源，可以具体为：第一网络设备确定第一资源配置信息，并基于该第一资源配置信息确定至少两个下行控制信道的搜索空间占用的资源。其中，该第一资源配置信息包括该至少两个下行控制信道的搜索空间所在的控制信道资源集合占用的资源信息，且该至少两个下行控制信道对应的搜索空间的个数与控制信道资源集合的个数相同。也就是说，该至少两个下行控制信道对应的至少两个搜索空间可以处于至少两个控制信道资源集合中，该至少两个控制信道资源集合的频域资源不重叠，也即该至少两个下行控制信道的搜索空间所在的控制信道资源集合不同。

[0016] 在一些可能的实现中，该第一网络设备分别确定至少两个下行控制信道的搜索空间占用的资源，可以具体为：第一网络设备确定第二资源配置信息，并基于该第二资源配置信息确定至少两个下行控制信道的搜索空间占用的资源。其中，该第二资源配置信息包括

该至少两个下行控制信道的搜索空间所在的至少两个控制信道资源集合占用的资源信息、该至少两个控制信道资源集合的标识以及第一偏移值中的至少一项，该第一偏移值是基于该至少两个控制信道资源集合的标识确定出的，且该至少两个控制信道资源集合占用的资源相重叠。也就是说，该至少两个下行控制信道对应的至少两个搜索空间可以处于至少两个控制信道资源集合中，该至少两个控制信道资源集合的频域资源可以完全重叠，且该至少两个下行控制信道对应的搜索空间的个数与该控制信道资源集合的个数相同。

[0017] 在一些可能的实现中，该第一网络设备分别确定至少两个下行控制信道的搜索空间占用的资源，可以具体为：第一网络设备确定第三资源配置信息，并基于该第三资源配置信息确定至少两个下行控制信道的搜索空间占用的资源。其中，该第三资源配置信息包括该至少两个下行控制信道的搜索空间所在的控制信道资源集合占用的资源信息、该至少两个下行控制信道的搜索空间的标识以及第二偏移值中的至少一项，该第二偏移值是基于该至少两个下行控制信道的搜索空间的标识确定出的，且该至少两个下行控制信道对应的搜索空间所在的控制信道资源集合相同。也就是说，该至少两个下行控制信道对应的搜索空间可以处于一个控制信道资源集合中。

[0018] 可选的，该第一资源配置信息或该第二资源配置信息或该第三资源配置信息中还可携带CCE标识等信息，以结合该CCE标识进一步确定该搜索空间。

[0019] 进一步可选的，该第一资源配置信息或该第二资源配置信息或该第三资源配置信息还可以是至少一个第二网络设备发送给该第一网络设备的，比如通过某一通知消息指示该第一资源配置信息或该第二资源配置信息或该第三资源配置信息。其中，该第二网络设备可以是发送该至少两个下行控制信道中的一个或多个下行控制信道的网络设备。

[0020] 在一些可能的实现中，该资源可包括时域资源；则该第一网络设备还可接收该至少一个第二网络设备发送的通知消息，该通知消息可用于指示该至少两个下行控制信道的搜索空间占用的第三时间单元的标识，比如该通知消息中可以携带该第三时间单元的标识。可选的，该第三时间单元对应的时间单位可以与该第一时间单元对应的时间单位相同，也可以不同；该第三时间单元对应的时间单位可以与该第二时间单元对应的时间单位相同，也可以不同，本申请不做限定。

[0021] 在一些可能的实现中，第一网络设备确定至少两个下行控制信道的搜索空间，可以具体为：第一网络设备基于第三参数确定该至少两个下行控制信道的搜索空间。其中，该搜索空间包括至少一个CCE，该第三参数包括CCE的个数或CCE的标识。从而第一网络设备可基于该CCE个数或CCE标识确定出该搜索空间。

[0022] 进一步可选的，该第一网络设备还可接收该至少一个第二网络设备发送的第一消息，该第一消息用于指示发送的下行控制信道的个数，从而该第一网络设备可基于该个数获取下行控制信道，在获取的下行控制信道的个数达到该第一消息指示的个数之后即可停止盲检，从而减少了盲检次数，降低了设备开销。或者，该第一网络设备还可以向该至少一个第二网络设备发送第二消息，该第二消息用于指示第一网络设备支持接收的下行控制信道的个数，从而第二网络设备可以基于该第二消息指示的个数进行下行控制信道的发送，其发送的下行控制信道的个数不超过该第二消息指示的个数。可选的，该第一消息或第二消息指示的个数的值可以与该第一网络设备的接收能力相关，或者与当前的信道条件相关，接收能力越强，个数越大，信道条件越好，个数越大，等等，本申请不做限定。进一步可选

的，该搜索空间还可以是基于聚合级别、控制信息的格式、控制信息的大小以及搜索空间的个数中的至少一项确定出的。从而能够减少盲检次数，降低系统开销。

[0023] 第二方面，本发明实施例提供了一种信道传输方法，包括：

[0024] 第一网络设备在第一搜索空间中确定第一下行控制信道占用的第一资源；

[0025] 第二网络设备在第二搜索空间中确定第二下行控制信道占用的第二资源；

[0026] 第一网络设备使用该第一资源向发送该第一下行控制信道；

[0027] 第二网络设备使用该第二资源向该第三网络设备发送该第二下行控制信道。

[0028] 其中，该第一下行控制信道调度的资源和该第二下行控制信道调度的资源属于一个载波。

[0029] 在一些可能的实现中，该第一网络设备可确定该第一搜索空间；该第二网络设备确定该第二搜索空间。可选的，该第一网络设备和第二网络设备可以是相同的网络设备，即通过同一个网络设备给第三网络设备即其他网络设备发送多个下行控制信道；或者，该第一网络设备和第二网络设备还可以是不同的网络设备，即实现通过一个或多个网络设备向第三网络设备发送多个下行控制信道。其中，该第一网络设备和第二网络设备可以是基站，也可以是用户设备；该第三网络设备可以是用户设备，也可以是基站。该第一网络设备和第二网络设备可以和上述第一方面的信道传输方法中的至少一个第二网络设备相对应，该第三网络设备可以和上述第一方面的信道传输方法中的第一网络设备相对应。

[0030] 可选的，该至少两个下行控制信道的搜索空间可以相同也可以不同。

[0031] 在一些可能的实现中，该第一搜索空间和该第二搜索空间可以相同，则该第一网络设备可基于第一参数确定该第一搜索空间。进一步可选的，该第二网络设备可基于第二参数确定该第二搜索空间。其中，该第一参数或该第二参数可包括CCE的个数、第一时间单元的标识以及下行控制信道的候选位置中的至少一项。

[0032] 可选的，该第一参数包括的CCE的个数和该第二参数包括的CCE的个数相同；或，该第一下行控制信道的第一时间单元的标识或该第二下行控制信道的第一时间单元的标识是基于该第一资源和第二资源的子载波间隔确定的；或，该第一下行控制信道的第一时间单元的标识是根据预设子载波间隔下的时间单元中与该第一下行控制信道的第一时间单元对应的时间单元的标识确定的，该第二下行控制信道的第一时间单元的标识是根据该预设子载波间隔下的时间单元中与该第二下行控制信道的第一时间单元对应的时间单元的标识确定出的；或，该第一下行控制信道的候选位置与该第二下行控制信道的候选位置不同，该第一下行控制信道或该第二下行控制信道的候选位置是基于第三参数确定的，该第三参数可包括设备类型、设备标识、聚合等级中的至少一项。

[0033] 在一些可能的实现中，该第一网络设备或该第二网络设备还可向该第三网络设备发送该第一参数和/或第二参数和/或第三参数。

[0034] 在一些可能的实现中，该第一搜索空间和该第二搜索空间不同；该第一网络设备确定该第一搜索空间，可以具体为：第一网络设备确定第一搜索空间占用的第三资源，并基于该第三资源确定该第一搜索空间。其中，该第三资源可包括频域资源或时域资源。

[0035] 在一些可能的实现中，该第二网络设备确定该第二搜索空间，可以具体为：该第二网络设备确定第二搜索空间占用的第四资源，并基于该第四资源确定该第二搜索空间。其中，该第四资源可包括频域资源或时域资源；

[0036] 在一些可能的实现中，该第一网络设备基于该第三资源确定该第一搜索空间，可以具体为：第一网络设备确定第一资源配置信息，并基于该第一资源配置信息确定该第一搜索空间，该第一资源配置信息包括该第一搜索空间所在的控制信道资源集合占用的资源信息。相应的，该第二网络设备基于该第四资源确定该第二搜索空间，可以具体为：第二网络设备确定第四资源配置信息，并基于该第四资源配置信息确定该第二搜索空间，该第四资源配置信息包括该第二搜索空间所在的控制信道资源集合占用的资源信息。

[0037] 在一些可能的实现中，该第一网络设备基于该第三资源确定该第一搜索空间，可以具体为：该第一网络设备确定第二资源配置信息，并基于该第二资源配置信息确定该第一搜索空间，该第二资源配置信息包括该第一搜索空间所在的控制信道资源集合占用的资源信息、该控制信道资源集合的标识以及第一偏移值中的至少一项，该第一偏移值是基于该控制信道资源集合的标识确定出的。相应的，该第二网络设备基于该第四资源确定该第一搜索空间，可以具体为：该第二网络设备确定第五资源配置信息，并基于该第五资源配置信息确定该第二搜索空间，该第五资源配置信息包括该第二搜索空间所在的控制信道资源集合占用的资源信息、该控制信道资源集合的标识以及第一偏移值中的至少一项，该第一偏移值是基于该控制信道资源集合的标识确定出的。

[0038] 在一些可能的实现中，该第一网络设备基于该第三资源确定该第一搜索空间，可以具体为：该第一网络设备确定第三资源配置信息，并基于该第三资源配置信息确定该第一搜索空间，该第三资源配置信息包括该第一搜索空间所在的控制信道资源集合占用的资源信息、该第一搜索空间的标识以及第二偏移值中的至少一项，该第二偏移值是基于该第一搜索空间的标识确定出的。相应的，该第二网络设备基于该第四资源确定该第一搜索空间，可以具体为：该第二网络设备确定第六资源配置信息，并基于该第六资源配置信息确定该第二搜索空间，该第六资源配置信息包括该第二搜索空间所在的控制信道资源集合占用的资源信息、该第二搜索空间的标识以及第二偏移值中的至少一项，该第二偏移值是基于该第二搜索空间的标识确定出的。

[0039] 在一些可能的实现中，该第一网络设备还可向该第三网络设备发送通知消息，该通知消息用于指示第一资源配置信息或第二资源配置信息或第三资源配置信息。也就是说，第一网络设备在确定出第一资源配置信息之后，还可向第三网络设备发送用于指示该第一资源配置信息的通知消息，以告知第三网络设备该第一资源配置信息，以使该第三网络设备基于该第一资源配置信息确定搜索空间以获取下行控制信道。进一步的，该第一网络设备还可在确定出第二资源配置信息之后，还可向第三网络设备发送用于指示该第二资源配置信息的通知消息，在确定出第三资源配置信息之后，还可向第三网络设备发送用于指示该第三资源配置信息的通知消息，此处不赘述。进一步的，该第二网络设备还可向该第三网络设备发送通知消息，该通知消息用于指示第四资源配置信息或第五资源配置信息或第六资源配置信息。

[0040] 在一些可能的实现中，该第三资源可包括时域资源；则该第一网络设备还可向第三网络设备发送通知消息，该通知消息包括该第一搜索空间占用的第二时间单元的标识。相应的，该第二网络设备还可向第三网络设备发送通知消息，该通知消息包括该第二搜索空间占用的第二时间单元的标识。

[0041] 在一些可能的实现中，该第一网络设备还可以向该第三网络设备发送第一消息，

该第一消息用于指示发送的下行控制信道的个数(还可以指示搜索空间的个数),从而第三网络设备可以基于该第一消息指示的个数进行下行控制信道的接收,在接收的下行控制信道的个数达到该第一消息指示的个数之后即可停止盲检,从而减少了盲检次数,降低了设备开销。该第一网络设备还可接收该第三网络设备发送的第二消息,该第二消息用于指示第三网络设备支持接收的下行控制信道的个数(还可以指示搜索空间的个数),从而该第一网络设备可基于该个数发送下行控制信道,其发送的下行控制信道的个数可不超过该第二消息指示的个数。可选的,该第一消息或第二消息指示的个数的值可以与该第三网络设备的接收能力相关,或者与当前的信道条件相关,接收能力越强,个数越大,信道条件越好,个数越大,等等,本申请不做限定。进一步可选的,该搜索空间可以是基于聚合级别、控制信息的格式、控制信息的大小以及搜索空间的个数中的至少一项确定出的。从而能够减少盲检次数,降低系统开销。

[0042] 在一些可能的实现中,该第一网络设备还可基于第四参数确定该第一搜索空间,其中,该第一搜索空间包括至少一个控制信道元素CCE,该第四参数可包括CCE的个数或CCE的标识等等。相应的,该第二网络设备还可基于第五参数确定该第二搜索空间,其中,该第二搜索空间包括至少一个CCE,该第五参数可包括CCE的个数或CCE的标识等等。

[0043] 第三方面,本申请还提供了一种网络设备,该网络设备包括:确定模块和通信模块,该网络设备通过上述模块实现上述第一方面的信道传输方法中的第一网络设备的部分或全部步骤。所述模块可以是软件和/或是硬件。

[0044] 第四方面,本申请还提供了一种网络设备,该网络设备包括:第一确定模块、第二确定模块、第一通信模块和第二通信模块,该网络设备通过上述模块实现上述第二方面的信道传输方法中的第一网络设备或第二网络设备的部分或全部步骤。该模块可以是软件和/或是硬件。

[0045] 第五方面,本申请还提供了一种计算机存储介质,该计算机存储介质存储有程序,该程序执行时包括上述第一方面的信道传输方法的部分或全部的步骤。

[0046] 第六方面,本申请还提供了一种计算机存储介质,该计算机存储介质存储有程序,该程序执行时包括上述第二方面的信道传输方法的部分或全部的步骤。

[0047] 第七方面,本申请还提供了一种网络设备,包括:通信接口、存储器和处理器,该处理器分别与该通信接口及该存储器连接;其中,

[0048] 该存储器用于存储程序指令;

[0049] 该处理器用于调用该存储器中的程序指令执行上述第一方面的信道传输方法的部分或全部的步骤。

[0050] 第八方面,本申请还提供了一种网络设备,包括:通信接口、存储器和处理器,该处理器分别与该通信接口及该存储器连接;其中,

[0051] 该存储器用于存储程序指令;

[0052] 该处理器用于调用该存储器中的程序指令执行上述第二方面的信道传输方法的部分或全部步骤。

[0053] 第九方面,本申请还提供了一种信道传输系统,包括第一网络设备和至少一个第二网络设备;其中,该第一网络设备用于执行上述第一方面的信道传输方法的部分或全部步骤;该第二网络设备用于执行上述第二方面的信道传输方法的部分或全部步骤。

[0054] 本申请的又一方面提供了一种包含指令的计算机程序产品，当其在计算机上运行时，使得计算机执行上述各方面所述的方法。

[0055] 在本申请提供的技术方案中，网络设备能够通过确定调度的资源属于一个载波的多个下行控制信道如PDCCH的搜索空间，并进一步在该搜索空间中分别确定出该多个PDCCH占用的资源，以使用该资源传输该多个PDCCH，从而使得一个网络设备能够接收一个或多个其他网络设备发送的多个PDCCH，并通过该多个PDCCH调度一个载波的数据，这就提升了信息传输的效率，并提升了信息传输的可靠性。

附图说明

[0056] 为了更清楚地说明本发明实施例或背景技术中的技术方案，下面将对本发明实施例或背景技术中所需要使用的附图进行说明。

[0057] 图1是本发明实施例提供的一种通信系统的架构图；

[0058] 图2是本发明实施例提供的一种信道传输方法的交互示意图；

[0059] 图3是本发明实施例提供的一种RS配置示意图；

[0060] 图4是本发明实施例提供的一种基于不同子载波间隔的子帧示意图；

[0061] 图5a是本发明实施例提供的一种候选位置的结构示意图；

[0062] 图5b是本发明实施例提供的另一种候选位置的结构示意图；

[0063] 图5c是本发明实施例提供的又一种候选位置的结构示意图；

[0064] 图6是本发明实施例提供的另一种信道传输方法的交互示意图；

[0065] 图7是本发明实施例提供的一种基于频分方式的搜索空间的配置示意图；

[0066] 图8a是本发明实施例提供的一种控制信道资源集合和搜索空间的结构示意图；

[0067] 图8b是本发明实施例提供的另一种控制信道资源集合和搜索空间的结构示意图；

[0068] 图8c是本发明实施例提供的又一种控制信道资源集合和搜索空间的结构示意图；

[0069] 图9是本发明实施例提供的一种基于时分方式的搜索空间的配置示意图；

[0070] 图10a是本发明实施例提供的一种搜索空间的CCE结构示意图；

[0071] 图10b是本发明实施例提供的另一种搜索空间的CCE结构示意图；

[0072] 图11是本发明实施例提供的又一种信道传输方法的交互示意图；

[0073] 图12是本发明实施例提供的一种网络设备的结构示意图；

[0074] 图13是本发明实施例提供的另一种网络设备的结构示意图；

[0075] 图14是本发明实施例提供的一种信道传输系统的结构示意图；

[0076] 图15是本发明实施例提供的又一种网络设备的结构示意图；

[0077] 图16是本发明实施例提供的又一种网络设备的结构示意图。

具体实施方式

[0078] 下面结合本发明实施例中的附图对本发明实施例进行描述。

[0079] 应理解，本申请的技术方案可具体应用于各种通信系统中，例如：全球移动通讯系统(Global System of Mobile communication，缩写：GSM)，码分多址(英文：Code Division Multiple Access，缩写：CDMA)、宽带码分多址(英文：Wideband Code Division Multiple Access，缩写：WCDMA)、时分同步码分多址(英文：Time Division-Synchronous

Code Division Multiple Access,缩写:TD-SCDMA)、通用移动通信系统(英文:Universal Mobile Telecommunication System,缩写:UMTS)、长期演进(英文:Long Term Evolution,缩写:LTE)系统等,随着通信技术的不断发展,本申请的技术方案还可用于未来网络,如第五代移动通信技术(英文:The Fifth Generation Mobile Communication Technology,缩写:5G)系统,也可以称为NR(英文:New Radio,缩写:NR)系统,或者可用于D2D(device to device)系统,M2M(machine to machine)系统等等。

[0080] 本申请结合网络设备进行描述,其中,网络设备可以是基站,也可以是用户设备。示例的,本申请中涉及的通信既可以是基站和用户设备之间的,也可以是基站和基站之间的,比如宏基站和小基站之间的,还可以是用户设备和用户设备之间的,比如D2D网络中的通信。

[0081] 在本申请中,用户设备(英文:User Equipment,缩写:UE)还可称之为终端(terminal)、移动台(英文:Mobile Station,缩写:MS)、移动终端(mobile terminal)、订户单元(英文:Subscriber Unit;缩写:SU)、订户站(英文:Subscriber Station;缩写:SS),移动站(英文:Mobile Station;缩写:MB)、远程站(英文:Remote Station;缩写:RS)、接入点(英文:Access Point;缩写:AP)、远程终端(英文:Remote Terminal;缩写:RT)、接入终端(英文:Access Terminal;缩写:AT)、用户终端(英文:User Terminal;缩写:UT)、用户代理(英文:User Agent;缩写:UA)、终端设备(英文:User Device;缩写:UD)或用户装备(英文:User Equipment;缩写:UE)等,本申请不做限定。该用户设备可以是指无线终端、有线终端。该无线终端可以是指向用户提供语音和/或数据连通性的设备,具有无线连接功能的手持式设备、或连接到无线调制解调器的其他处理设备,其可以经无线接入网(如RAN,radio access network)与一个或多个核心网进行通信。例如,该用户设备可以是移动终端,如移动电话(或称为"蜂窝"电话)和具有移动终端的计算机,还可以是便携式、袖珍式、手持式、计算机内置的或者车载的移动装置,如个人通信业务(英文:Personal Communication Service;缩写:PCS)电话、无绳电话、会话发起协议(英文:Session Initiation Protocol;缩写:SIP)话机、无线本地环路(英文:Wireless Local Loop;缩写:WLL)站、个人数字助理(英文:Personal Digital Assistant;缩写:PDA)等,它们与无线接入网交换语言和/或数据。

[0082] 在本申请中,基站可以是指接入网中在空中接口上通过一个或多个扇区与用户设备通信的设备,其可协调对空中接口的属性管理。例如,该基站可以是如GSM或CDMA中的基站,如基站收发台(base transceiver station,缩写:BTS),也可以是WCDMA中的基站,如NodeB,还可以是LTE中的演进型基站,如eNB或e-NodeB(evolutional Node B),还可以是5G系统中的基站,如gNB,或未来网络中的基站,或者可以是传输点(英文:Transmission point,缩写:TP)、收发点(英文:transmission and receiver point,缩写:TRP)、中继设备,或者具备基站功能的其他网络设备等等,本申请不做限定。

[0083] 本申请中涉及的控制信道主要用于承载资源调度信息和其他控制信息,例如该控制信道可以是物理下行控制信道(英文:Physical Downlink Control Channel,缩写:PDCCH)、增强物理下行控制信道(英文:Enhanced Physical Downlink Control Channel,缩写:EPDCCH)、新空口物理下行控制信道(英文:New Radio Physical Downlink Control Channel,缩写:NR-PDCCH)以及随着网络演变而定义的具有上述功能的其他下行信道,或者

可以为上行控制信道，比如物理上行控制信道为(Physical Uplink Control CHannel，缩写：PUCCH)等等，本申请以PDCCH为例进行说明。在本申请中，信道也可以叫做信号或者其余名称，本申请不做限定。

[0084] 在本申请中，时间单元是指一种时间单位对应的一个单元。该时间单位是指用于进行信息传输的时域内的时间单位或者调度单位，该时间单元时域内包含整数个符号，如该时间单位可以是指子帧，也可以是指时隙(slot)，还可是指无线帧、微时隙(mini slot或sub slot)、多个聚合的时隙、多个聚合的子帧、符号等等，还可以是指传输时间间隔(英文：Transmission Time Interval，缩写：TTI)，本申请不做限定。其中，一种时间单位的一个或多个时间单元时域内可包含整数个另一种时间单位的时间单元，或者，一种时间单位的一个或多个时间单元时域内长度等于整数个另一种时间单位的时间单元长度和，例如，一个微时隙/时隙/子帧/无线帧内包含整数个符号，一个时隙/子帧/无线帧内包含整数个微时隙，一个子帧/无线帧内包含整数个时隙，一个无线帧包含整数个子帧等，也可以存在其余包含举例，本申请不做限定。

[0085] 下面对本申请的应用场景进行介绍，本申请以基站和UE之间的通信为例进行描述。请参见图1，图1是本发明实施例提供的一种通信系统的架构图。具体的，如图1所示，该通信系统中包括至少一个基站(图1中示出2个基站)和UE，基站与UE之间可采用各种通信系统进行通信，如上述无线通信系统中的5G系统，也可以称为NR系统，又如LTE系统等，从而实现信息传输。

[0086] 在基站和UE进行信息传输时，UE需要监听并尝试解码一个时间单元如子帧中的所有PDCCH候选位置(候选资源)，该候选资源上包括需要监听的一个或多个PDCCH。本申请能够通过在一个时间单元上通过不同的PDCCH搜索空间(Search Space)配置同一UE的多个PDCCH，或者通过相同的PDCCH搜索空间配置同一UE的多个PDCCH。可选的，该多个PDCCH可以通过相同的波束发送(即通过一个波束发送)，也可以通过不同的波束发送。使得一个UE能够接收到多个PDCCH，并基于接收的多个PDCCH调度一个载波的数据，以进行信息传输。其中，该多个PDCCH中的每个PDCCH可包括下行调度信息，也可以包括上行调度信息。在本申请中，PDCCH搜索空间由至少一个CCE组成，具体可包括一个时间单元如子帧中的控制区域的CCE的总数。CCE是控制信道资源的基本单位，CCE可由一个或者多个资源元素组(英文：Resource Element Group，缩写：REG)组成，REG是由一个或者多个资源元素RE组成，RE为基本的资源单位，比如LTE中一个RE为频域上的一个子载波和时域上的一个符号。进一步的，搜索空间中可以包括一个或者多个PDCCH候选资源，该候选资源可以与聚合级别有关，聚合级别可以是指一个PDCCH是由几个CCE传输，或者承载在几个CCE资源上。

[0087] 本申请公开了一种信道传输方法、网络设备及系统，能够实现通过多个下行控制信道调度一个载波的数据，从而提升了信息传输的效率及可靠性。在本申请中，UE可通过分别确定调度的资源属于一个载波的至少两个PDCCH在PDCCH搜索空间占用的资源，以使用该资源获取该至少两个PDCCH，从而实现一个UE对多个PDCCH的接收。其中，该调度的资源可以是指下行控制信道中调度的数据所占的资源。下面以UE接收两个PDCCH，如接收第一基站发送的第一PDCCH和第二基站发送的第二PDCCH为例进行详细说明。

[0088] 请参见图2，图2是本发明实施例提供的一种信道传输方法的交互示意图。具体的，如图2所示，本发明实施例的所述信道传输方法包括以下步骤：

[0089] 101、第一基站在第一搜索空间中确定第一PDCCH占用的第一资源。

[0090] 102、第二基站在第二搜索空间中确定第二PDCCH占用的第二资源，该第一搜索空间和该第二搜索空间相同。

[0091] 其中，该第一PDCCH调度的资源和第二PDCCH调度的资源属于一个载波，该调度的资源可以是指PDCCH中调度的数据所占的资源。可选的，传输该第一PDCCH和第二PDCCH的资源可以在一个载波上，即在相同的载波，也可以是在不同的载波。

[0092] 可选的，该第一基站和第二基站可以是相同的基站，即通过同一个基站给一个UE发送多个PDCCH；或者，该第一基站和第二基站还可以是不同的基站。进一步可选的，系统中还可存在第三基站、第四基站等等，每个基站可向同一个UE发送一个或多个PDCCH，即实现通过一个或多个基站向一个UE发送多个PDCCH，本发明实施例不做限定。

[0093] 可选的，系统中的多个基站向UE发送多个PDCCH时，可先确定出发送的PDCCH的搜索空间（又称“PDCCH搜索空间”），进而在该搜索空间中确定PDCCH占用的资源。也即，在本发明实施例中，该第一基站可确定该第一PDCCH搜索空间（即第一搜索空间），该第二基站可确定该第二PDCCH搜索空间（即第二搜索空间）。

[0094] 其中，该多个PDCCH的搜索空间可以相同也可以不同。也即，该第一PDCCH搜索空间和该第二PDCCH搜索空间可以相同，也可以不同。

[0095] 可选的，当该第一PDCCH搜索空间和该第二PDCCH搜索空间相同时，该第一基站在确定该第一PDCCH搜索空间时，可基于第一参数确定该第一PDCCH搜索空间；其中，该第一参数可包括CCE的个数、第一时间单元的标识以及PDCCH候选位置中的至少一项。相应的，该第二基站确定该第二PDCCH搜索空间时，也可基于第一参数确定该第一PDCCH搜索空间，该第一基站对应的第一参数和第二基站对应的第一参数的参数值可以相同也可以不同。也就是说，基站在确定PDCCH搜索空间时，可以是基于CCE的个数、第一时间单元的标识以及PDCCH候选位置等参数确定出的。进一步可选的，该CCE的个数可以是指PDCCH搜索空间的CCE的个数或该PDCCH搜索空间所在的控制信道资源集合（control resource set）包括的CCE的个数。

[0096] 具体的，基站在UE相同的搜索空间中发送PDCCH时，可先确定出control resource set，即PDCCH的搜索空间的所在的资源位置，包括时频资源位置。比如频域可以是一段带宽，也可以是连续的资源块（英文：Resource Block，缩写：RB）资源或者不连续的RB资源，或者一个或者多个子带，或者子带部分等；时域可以是时间单元的个数，如子帧或者时隙或者微时隙中的符号个数（比如可默认前几个符号），或者可以是时间单元的标识，如具体的一个或者多个符号位置。其中，RB是时频资源大小的一种衡量单位，比如LTE中的一个RB在频域上为12个子载波以及在时域上为一个时隙。随着系统的不断发展，RB资源块可以重新定义，本发明实施例不做限定。从而UE可在control resource set中进行PDCCH搜索空间的确定以及盲检。该确定方式有多种，本发明实施例按照如下方式进行举例说明。

[0097] 基站或UE在确定PDCCH搜索空间$S_k^{(L)}$时，可以按照以下公式确定出该搜索空间$S_k^{(L)}$：

[0098] $$L\left\{(Y_k+m')\bmod\left\lfloor N_{CCE,k}/L\right\rfloor\right\}+i$$

[0099] 其中，L为聚合级别（Aggregation level）的大小，其取值可以为1、2、4或8，或者还可以取其他值，L可表示用于传输该PDCCH的资源CCE个数。$N_{CCE,k}$为时间单元k如子帧k时包含

的控制区域(即控制信道资源集合)的CCE个数(Size),i=,0,…L1-且m=0,…,$M^{(L)}$-1。$M^{(L)}$为给定的搜索空间内需要监听的PDCCH candidate数目,即需要监听的PDCCH候选数目。例如,该L、$N_{CCE,k}$和$M^{(L)}$的对应关系可以如下表一所示。

[0100] 表一

[0101]

Search space $S_k^{(L)}$			Number of PDCCH candidates $M^{(L)}$
Type	Aggregation level L	Size [in CCEs]	
UE-specific	1	6	6
	2	12	6
	4	8	2
	8	16	2
Common	4	16	4
	8	16	2

[0102] 具体的,PDCCH搜索空间可分为公共搜索空间(Common)和用户搜索空间(UE-specific,即UE特定的搜索空间)。对于公共搜索空间,m′=m,Y_k为0。对于用户搜索空间,Y_k定义为:$Y_k=(A\cdot Y_{k-1})\ \mathrm{mod}D$,其中,$Y_{-1}=n_{RNTI}\neq 0$,A=39827,D=65537,$k=\lfloor n_s/2\rfloor$,$n_s$为一个无线帧中的时隙(slot)编号(取值范围可以为0～19)。可选的,该搜索空间还可以基于其他方式确定出,本发明实施例不做限定。

[0103] 也就是说,为了确保第一基站和第二基站也即多个基站在UE相同的PDCCH搜索空间中发送PDCCH,则该多个基站需确保该PDCCH搜索空间对应的时间单位(比如子帧,时隙,微时隙)上总的CCE个数相同,即搜索空间的CCE个数相同;和/或,还需该多个基站对于相同时域上的时间单元的标识相同;和/或,需要确保该发送的多个PDCCH在不同的PDCCH候选位置。

[0104] 具体的,该第一基站对应的第一参数包括的CCE的个数和该第二基站对应的第一参数包括的CCE的个数相同。假设分配频域资源为全带宽或者部分带宽或者子带等等,为第一基站和第二基站的分配的频域资源相同,当第一基站和第二基站的PDCCH搜索空间(控制区域)的时间单元如符号数相同时,若控制区域的符号上没有参考信号(英文:Reference Signal,缩写:RS),则可以确保PDCCH搜索空间对应的CCE个数相同;若该控制区域的符号上有RS,但该控制区域的导频图案(pattern)或者RE相同,则可以保证CCE相同。例如,第一基站和第二基站的该RS可以码分,此时第一基站和第二基站需要分别通知UE具体的导频序列,也即,针对一个PDCCH搜索空间所在的control resource set通知2种导频序列,使得UE能够根据该两种导频序列估计到两个基站的信道情况,进而进行信道估计以解码得到该PDCCH搜索空间中的多个PDCCH。若该控制区域的符号上有RS,且该控制区域的pattern或者RE不同,也可以保证CCE相同。例如,该第一基站和第二基站的该RS可以时分或者频分,此时需要通知UE具体的RS位置,也即,针对一个PDCCH搜索空间所在的control resource set通知2种RS的pattern或者RE,使得UE能够根据每种RS pattern确定出参考信号位置,进而进

行信道估计以解码得到该PDCCH搜索空间中的多个PDCCH。如图3所示，左图为时分方案，右图为频分方案，每个基站的RS占用不同的符号位置。可选的，对于不同基站的RS的位置按照以下两种处理方法：在第一基站的RS位置，第二基站不发送任何信号，该方式保证了基站间导频没有任何干扰，提高了解调性能；或者，在第一基站的RS位置，第二基站正常发送信号，这就使得UE可以在RS的位置先解RS，后续消除RS，再解有用信号，从而提升了信息传输的可靠性。

[0105] 进一步可选的，该第一基站还可向第二基站发送指示消息，该指示消息用于指示该第一PDCCH对应的第一时间单元信息；第二基站还可向第一基站发送指示消息，以指示该第二PDCCH对应的第二时间单元信息；该第一基站接收该第二基站发送的第二时间单元信息，该第二时间单元信息为该第二PDCCH对应的时间单元信息；该第一基站可基于该第一时间单元信息和该第二时间单元信息确定第一PDCCH搜索空间对应的CCE的个数；第二基站可基于该第一时间单元信息和该第二时间单元信息确定第二PDCCH搜索空间对应的CCE的个数。其中，该第一时间单元信息或该第二时间单元信息包括第二时间单元的个数或第二时间单元的标识。

[0106] 可选的，本发明实施例涉及的消息如该指示消息可以为高层信息，比如系统消息，或者无线资源控制(英文：Radio Resource Control，缩写：RRC)信令，或者媒体接入控制(英文：Medium Access Control，缩写：MAC)信令。或者，可选的，该指示消息还可以为物理层信令，比如物理层下行控制信息(英文：Downlink Control Information，缩写：DCI)信息，等等，本发明实施例不做限定。

[0107] 也就是说，当第一基站和第二基站的PDCCH搜索空间(控制区域)的符号数不同时，基站间可交互各自的符号数或符号标识等时间单元信息，以确保对于为UE分配的总体CCE相同。例如，该第一基站和该第二基站可以取两个基站符号数较小者作为确定CCE个数的符号数。

[0108] 可选的，在统一多个基站对于时间单元的标识的规则的理解时，该第一PDCCH的时间单元的标识或该第二PDCCH的时间单元的标识可以是基于该第一资源和第二资源的子载波间隔确定的。或者，该第一PDCCH的时间单元的标识还可以是根据预设子载波间隔下的时间单元中与该第一PDCCH的时间单元对应的时间单元的标识确定的，该第二PDCCH的时间单元的标识是根据该预设子载波间隔下的时间单元中与该第二PDCCH的时间单元对应的时间单元的标识确定出的。从而确保信道传输系统中的多个基站即协作的多个基站在相同时域上的时间单元的标识相同。

[0109] 具体的，由于不同的基站在不同的子帧上采用的帧结构可能是不同的，其结构与子载波间隔有关。如图4所示，分别为15kHz，30kHz，60kHz子载波间隔下子帧示意图。由此，在确定控制区域的时间单元的标识如时隙的编号时，可采用各自子载波间隔下的时隙号，因不同的子载波间隔下的时域长度成比例关系，因此，针对不同的子载波间隔下的时隙号，可以进行同样的处理：比如子载波间隔15kHz时，时间变量为$k=\lfloor n_s/2 \rfloor$；若子载波间隔为15*2nkHz，则时间变量为$k=\lfloor n_s/(2n) \rfloor$；若子载波间隔为$15*2^n$kHz，则时间变量为$k=\lfloor n_s/2^n \rfloor$，其中，$n_s$可以为时隙号或者微时隙号。或者，在确定时隙号时，可直接采用预设子载波间隔比如15kHz子载波间隔下的时隙编号，若一个时隙中有多个微时隙，则可按照15kHz子载波

间隔下的微时隙号(n_{mini_s})来确定搜索搜索空间。

[0110] 进一步可选的，该第一基站还可以向该UE发送该第一参数，该第二基站还可以向该UE发送该第一参数，以使UE快速确定出需要接收的PDCCH的搜索空间。

[0111] 可选的，该第一PDCCH的候选位置与该第二PDCCH的候选位置不同，该第一PDCCH或该第二PDCCH的候选位置是基于候选位置参数即第二参数确定的，该第二参数可包括基站类型、基站标识、聚合等级中的至少一项。

[0112] 具体的，在确保不同的基站在UE相同的PDCCH搜索空间中发送PDCCH时，第一基站和第二基站在决策时还需确保不在同一候选位置发送PDCCH。可选的，该第一基站和第二基站之间可交互或者预定义REG到CCE的映射，以及CCE到搜索空间候选的映射。其中，每个CCE可以包括4～8个REG，或者其他数目，REG到CCE可以是集中式映射也可以是分布式映射，REG到CCE的映射可以是先频域再时域，也可以先时域再频域，CCE到搜索空间的映射可以是先频域再时域，也可以先时域再频域，本发明实施例不做限定。

[0113] 进一步的，该第一PDCCH和该第二PDCCH的聚合级别可以相同也可以不同。当两个PDCCH的聚合级别相同时，基站之间可按照预定义或者基站交互的方式确定各自占用的候选空间(候选位置)。例如，可预定义为：第一基站(TP1，如服务基站)占前半部分，第二基站(TP2，如协作基站)占后半部分，如图5a所示；或者，可预定义为：交叉的方式，第一基站占候选1、3、5，第二基站占候选2、4、6等等，如图5b所示。或者，可按照基站编号(比如第一基站编号0，第二基站编号1)，编号小的用前半部分，编号大的用后半部分。或者，基站之间可以交互所使用的候选空间。当两个PDCCH的聚合级别不同时，可以预定义低聚合级别(Lower L)采用前半部分候选空间，高聚合级别(Higher L)采用后半部分候选空间，如图5c所示；或者预定义为低聚合级别采用后半部分候选空间，高聚合级别采用前半部分候选空间，或者基站间可交互各自采用的候选空间，等等。其中，该聚合级别L的高低可以是基站间交互或者预定义得到的，比如可定义L＝1，2代表低聚合级别，L＝4，8代表高聚合级别；或者可定义L＝1，2，4代表低聚合级别，L＝8，16，32为高聚合级别等。进一步可选的，若2个基站的信道特性差异比较大，则基站可以提前通知UE，2个PDCCH的聚合级别不同。其中，图5a或图5b或图5c中的方框可代表一个CCE。

[0114] 进一步可选的，该第一基站和第二基站还可以向该UE发送第二参数，即告知UE该第一基站和第二基站的基站类型、基站标识、聚合等级等参数。从而UE在基于该基站类型、基站标识、聚合等级等参数行盲检时，UE检测到一个PDCCH后，另一个PDCCH的盲检范围可以减小，进而减小盲检次数，降低UE开销。

[0115] 103、第一基站使用第一资源向UE发送所述第一PDCCH。

[0116] 104、第二基站使用第二资源向该UE发送所述第二PDCCH。

[0117] 其中，该第一资源可以是指时频域资源(时域资源和/或频域资源)，也可以是指码分资源。可选的，该第一PDCCH和第二PDCCH可以通过相同的波束发送，或者可以通过不同的波束发送，本发明实施例不做限定。

[0118] 进一步可选的，该一个或多个基站还可以分别通知UE需要接收的PDCCH的个数或搜索空间的个数，以便于UE基于该个数接收PDCCH(接收的PDCCH的个数不超过该通知的个数)；或者，该多个基站可接收用于指示UE发送的能够接收的PDCCH的个数或检查的搜索空间的个数的消息，以使基站基于该个数进行PDCCH的发送(发送的PDCCH的个数不超过该消

息指示的个数)。进一步的,该多个基站还可基于该个数进行交互,以确定各基站发送的PDCCH的个数,进而进行PDCCH的搜索空间配置,从而减小UE的盲检次数,降低UE开销,并提升PDCCH传输的可靠性。

[0119] 105、UE确定第一PDCCH的第一搜索空间和第二PDCCH的第二搜索空间。

[0120] 106、UE在该第一搜索空间中确定出该第一PDCCH占用的第一资源,以及在该第二搜索空间中确定出该第二PDCCH占用的第二资源。

[0121] 具体的,UE在确定PDCCH搜索空间时,UE可确定PDCCH搜索空间所在的控制信道资源集合control resource set,即传输控制信道的资源位置,包括时频资源位置。比如频域可以是整个带宽,也可以是连续的RB资源或者不连续的RB资源,或者一个或者多个子带,或者子带部分等;时域可以是时间单元如子帧或者时隙或者微时隙中的符号个数(如默认前几个符号),或者具体的一个或者多个符号位置。进而UE可在control resource set中进行PDCCH的搜索空间的确定以及盲检。可选的,基站在确定出control resource set之后,还可向UE发送该control resource set的配置信息,以指示该control resource set的位置。UE可接收该配置信息以确定该control resource set,或者,该control resource set可以是预定义得到的。

[0122] 可选的,UE在确定至少两个PDCCH的PDCCH搜索空间如该第一PDCCH搜索空间和该第二PDCCH搜索空间时,该UE可基于第一参数确定该第一PDCCH搜索空间和该第二PDCCH搜索空间;其中,该第一参数可包括CCE个数、第一时间单元的标识以及PDCCH的候选位置中的至少一项。可选的,该第一参数可以是至少一个基站发送给UE的,比如UE可接收第一基站发送的用于指示该第一PDCCH搜索空间的第一参数,UE还可接收第二基站发送的用于指示该第二PDCCH搜索空间的第一参数;或者,该第一参数也可以是UE按照预设规则确定的;或者,该第一参数还可以是基站和UE预先协商确定的,本发明实施例不做限定。

[0123] 可选的,为了确保该第一PDCCH搜索空间和该第二PDCCH搜索空间相同,则该第一PDCCH搜索空间的CCE的个数和该第二PDCCH搜索空间的CCE个数相同;或,该第一PDCCH的时间单元的标识和该第二PDCCH的时间单元的标识分别是基于该第一PDCCH和该第二PDCCH占用的资源的子载波间隔确定的;或,该第一PDCCH的时间单元的标识还可以是根据预设子载波间隔下的时间单元中与该第一PDCCH的时间单元对应的时间单元的标识确定的,该第二PDCCH的时间单元的标识是根据该预设子载波间隔下的时间单元中与该第二PDCCH的时间单元对应的时间单元的标识确定出的;或,该第一PDCCH和该第二PDCCH的候选位置不同,该候选位置可以是基于候选位置参数即第二参数确定的,该第二参数可包括基站类型、基站标识、聚合等级中的至少一项。

[0124] 具体的,该第一PDCCH的候选位置与该第二PDCCH的候选位置不同,从而UE可以根据各PDCCH的候选位置来进行盲检。例如,针对如图5a或5c所示的对半分的方案,如果UE在前半部分检测到一个PDCCH,接下来UE可以仅检测后半部分候选区域即可;如果UE在后半部分检测到一个PDCCH,接下来可以仅检测前半部分候选区域即可。再如,针对如图5b交叉分的方案,如果在第1、3、5...个候选区域检测到一个PDCCH,则接下来可以仅检测第2、4、6...个候选区域即可。又如,对于低聚合级别,UE可仅检测前半部分搜索空间候选;对于高聚合级别下,UE可仅检测后半部分搜索空间候选;再如,两个PDCCH搜索空间的聚合级别相同的情况下,UE可再按照基站的编号(比如第一基站编号0,第二基站编号1),编号小的检测前半

部分，编号大的检测后半部分，等等。从而UE在进行盲检时，UE在检测到一个PDCCH后，另一个PDCCH的盲检范围可以减小，进而可以减小盲检次数，降低UE开销。

[0125] 107、UE使用该第一资源获取第一PDCCH，并使用该第二资源获取第二PDCCH。

[0126] 可选的，可以设置一个最大盲检次数，当UE达到最大盲检次数停止盲检。从而能够进一步减小盲检次数，降低UE开销。可选的，该最大盲检次数可以协议预定义的，或者是由UE自定义设置得到，或者由基站通知得到，等等，本发明实施例不做限定。

[0127] 进一步可选的，该搜索空间可以是基于聚合级别、PDCCH的个数、控制信息的格式、控制信息的大小以及搜索空间的个数中的至少一项确定出的。比如该聚合级别、PDCCH的个数、控制信息格式、控制信息大小以及搜索空间的个数可以是基站通知给UE的，如在基站确定control resource set时通知给UE的(如可携带于control resource set的配置信息中)。其中，该控制信息可以是指下行控制信道如本发明实施例中的PDCCH承载的控制信息，如DCI。

[0128] 举例来说，第一基站或第二基站可以是在配置(确定)control resource set时可通知UE一个或者多个聚合级别。比如第一基站或第二基站可以配置聚合级别为4，则UE在监测时仅检测聚合级别为4的候选即可；或者第一基站或第二基站可以配置为4、8、16等多个聚合级别，则UE在监测时仅检测指示的聚合级别对应的候选即可，从而能够降低盲检次数。

[0129] 又例如，第一基站或第二基站可以通知UE针对该control resource set需要监测的PDCCH的个数。比如如果配置UE监测1个PDCCH，则UE监测到一个PDCCH或者到达最大盲检次数后停止监测；如果配置UE监测2个PDCCH，则UE监测到2个PDCCH或者到达最大盲检次数后停止监测。

[0130] 再例如，第一基站或第二基站可以通知UE针对该control resource set需要监测的PDCCH的个数以及对应的聚合级别。比如配置UE检测1个PDCCH而且对应的聚合级别为4，则UE仅针对聚合级别为4的候选进行监测，而且当UE监测到一个PDCCH或者到达最大盲检次数后停止监测；或者配置UE检测1个PDCCH而且对应的聚合级别为4、8、16等多个聚合级别，则UE仅针对指示的聚合级别的候选进行监测，当UE监测到一个PDCCH或者到达最大盲检次数后停止监测；或者，第一基站或第二基站可配置UE检测2个PDCCH，且两个对应的聚合级别相同，比如分别对应的聚合级别为4，则UE可仅针对聚合级别为4的候选进行监测，而且当UE监测到2个PDCCH或者到达最大盲检次数后停止监测；或者配置UE检测2个PDCCH而且两个对应的聚合级别相同，比如分别对应的聚合级别为4、8、16等多个聚合级别，则UE仅针对指示的聚合级别的候选进行监测，而且当UE监测到2个PDCCH或者到达最大盲检次数后停止监测；或者，第一基站或第二基站可配置UE检测2个PDCCH而且两个对应的聚合级别不同，比如第一个PDCCH对应的聚合级别为4，第二个PDCCH对应的聚合级别为8，则UE对于第一个PDCCH仅针对聚合级别为4的候选进行监测，而且当UE监测到1个PDCCH或者到达最大盲检次数后再进行第二个PDCCH的监测，针对第二个PDCCH，则UE仅针对聚合级别为8的候选进行监测，当UE检测到1个PDCCH或者达到最大盲检次数后停止监测；其中，第一PDCCH和第二PDCCH的检测顺序可以不分先后。或者，第一基站或第二基站可配置UE检测2个PDCCH，且两个对应的聚合级别不同，比如第一PDCCH对应的聚合级别为4、8、16等多个聚合级别，第二PDCCH对应的聚合级别为8、16、32等多个聚合级别，则UE可对于第一PDCCH仅针对指示的聚合级别比如4、8、16等的候选进行监测，而且当UE监测到1个PDCCH或者到达最大盲检次数后再进行第二

个PDCCH的监测，针对第二PDCCH，则UE仅针对指示的聚合级别比如8、16、32等的候选进行监测，当UE检测到1个PDCCH或者达到最大盲检次数后停止监测；其中，第一PDCCH和第二PDCCH的检测顺序可以不分先后，或者可以同时进行检测，比如在两者的聚合级别相同时，可以同时进行2个PDCCH的检测，本发明实施例不做限定。

[0131] 进一步可选的，第一基站或第二基站还可以通知UE针对该control resource set的控制信息格式或者控制信息大小中的至少一项。比如配置UE检测控制信息格式DCI format 2D或者检测控制信息大小为A的PDCCH，A的取值可以为20bit或者40bit或者其他数值。可选的，第一基站或第二基站可以针对多个搜索空间或者多个PDCCH配置多个控制信息个数或者控制信息大小的信息，或者可以针对多个搜索空间或者多个PDCCH配置一个控制信息个数或者控制信息大小的信息，或者可以针对一个搜索空间或者一个PDCCH配置多个控制信息个数或者控制信息大小的信息，或者该控制信息个数或者控制信息大小为预定义的，本发明实施例不做限定。从而UE能够快速进行PDCCH的检测和解码。

[0132] 进一步可选的，第一基站或第二基站还可以通知UE针对该control resource set的搜索空间个数，该一个搜索空间可以包括一个或者多个PDCCH。进一步的，第一基站或第二基站还可以通知针对搜索空间的PDCCH的个数以及对应的聚合级别、控制信息格式、控制信息大小，等等，具体请参考上述描述，此处不赘述。

[0133] 也就是说，UE在确定出每个PDCCH的搜索空间之后，即可在该搜索空间进行盲检，进一步在该搜索空间中确定出该PDCCH占用的资源，从而能够使用该资源获取该PDCCH。

[0134] 在本发明实施例中，多个基站能够在UE相同的PDCCH搜索空间中向UE发送多个PDCCH，从而UE能够接收多个PDCCH，并通过该多个PDCCH调度一个载波的数据，这就提升了信息传输的效率，并提升了信息传输的可靠性。本发明实施例通过设计多个PDCCH的搜索空间候选，设计多个PDCCH的CCE不重叠，解决了现有技术无法支持多个PDCCH传输的问题，并降低了UE盲检次数，提升了UE盲检效率。

[0135] 请参见图6，图6是本发明实施例提供的另一种信道传输方法的交互示意图。具体的，如图6所示，本发明实施例的所述信道传输方法包括以下步骤：

[0136] 201、第一基站在第一搜索空间中确定第一PDCCH占用的第一资源。

[0137] 202、第二基站在第二搜索空间中确定第二PDCCH占用的第二资源，该第一搜索空间和该第二搜索空间不同。

[0138] 其中，该第一PDCCH调度的资源和第二PDCCH调度的资源属于一个载波，该调度的资源可以是指PDCCH中调度的数据所占的资源。可选的，传输第一PDCCH和第二PDCCH的资源可以在一个载波上，即在相同的载波，也可以是在不同的载波。

[0139] 可选的，通信系统中的多个基站向UE发送多个PDCCH时，可先确定出发送的PDCCH的搜索空间，进而在该搜索空间中确定PDCCH占用的资源。也即，在本发明实施例中，该第一基站可确定该第一PDCCH搜索空间(即第一搜索空间)，该第二基站可确定该第二PDCCH搜索空间(即第二搜索空间)。

[0140] 其中，该多个PDCCH的搜索空间可以相同也可以不同。也即，该第一PDCCH搜索空间和该第二PDCCH搜索空间可以相同，也可以不同。

[0141] 可选的，当该第一PDCCH搜索空间和该第二PDCCH搜索空间不同时，该第一基站确定该第一PDCCH搜索空间时，可确定第一PDCCH搜索空间占用的第三资源，并基于该第三资

源确定该第一PDCCH搜索空间。相应的，该第二基站确定该第二PDCCH搜索空间时，可确定第二PDCCH搜索空间占用的第四资源，并基于该第四资源确定该第二PDCCH搜索空间。其中，该PDCCH搜索空间占用的资源即上述的第三资源和/或第四资源可包括频域资源或时域资源。从而能够在不同的时域资源或频域资源上发送不同的PDCCH，以实现UE进行多PDCCH的接收。

[0142] 进一步可选的，当该第一PDCCH搜索空间和该第二PDCCH搜索空间不同时，第一PDCCH和第二PDCCH可以从频域资源区分，如第一PDCCH搜索空间和第二PDCCH搜索空间可分别为不同的频域资源，如图7所示。

[0143] 作为一种可选的实施方式，该第一基站基于该第三资源确定该第一PDCCH搜索空间时，可确定第一资源配置信息，并基于该第一资源配置信息确定该第一PDCCH搜索空间，该第一资源配置信息可包括该第一PDCCH搜索空间所在的控制信道资源集合占用的资源信息。相应的，该第二基站基于该第四资源确定该第二PDCCH搜索空间时，也可确定第四资源配置信息，并基于该第四资源配置信息确定该第二PDCCH搜索空间，该第四资源配置信息包括该第二PDCCH搜索空间所在的控制信道资源集合占用的资源信息。进一步可选的，该第一资源配置信息和/或该第四资源配置信息中还可包括该CCE标识如CCE编号信息。

[0144] 进一步可选的，该第一基站还可向UE发送该第一通知消息，该第一通知消息用于指示该第一资源配置信息，该第二基站还可向UE发送该第四通知消息，该第四通知消息用于指示第四资源配置信息。从而UE能够根据该第一资源配置信息和该第四资源配置信息确定出两个PDCCH搜索空间。进一步的，该第一通知消息或第四通知消息可以是第一基站或第二基站在配置control resource set时发送给UE的，比如该第一资源配置信息或第四资源配置信息可以携带在control resource set的配置信息中发送给UE。该control resource set的配置信息还可包括PDCCH的个数、搜索空间的个数、聚合等级、控制信息格式、控制信息大小等信息。具体的配置方法如上述实施例所述，在此不做赘述。

[0145] 具体的，该第一PDCCH搜索空间和第二PDCCH搜索空间可以处于两个control resource set，两个set的频域资源不重叠，即两个PDCCH搜索空间所在的control resource set不同。进一步的，各自set的CCE编号可以分别编号，比如从0开始，如图8a所示，第一基站在control resource set1(控制信道资源集合1)中发送PDCCH(搜索空间1)，第二基站在control resource set2(控制信道资源集合2)中发送PDCCH(搜索空间2)。从而UE可基于该编号计算搜索空间位置，进行搜索空间候选的盲检测。或者，该两个control resource set中的CCE编号也可以是联合编号的，对于该control resource set的个数和CCE编号方式，本发明实施例不做限定。

[0146] 作为一种可选的实施方式，该第一基站基于该第三资源确定该第一PDCCH搜索空间时，可确定第二资源配置信息，并基于该第二资源配置信息确定该第一PDCCH搜索空间，该第二资源配置信息可包括该第一PDCCH搜索空间所在的控制信道资源集合占用的资源信息、该控制信道资源集合的标识以及第一偏移值中的至少一项，该第一偏移值可以是基于该控制信道资源集合的标识确定出的。相应的，该第二基站基于该第四资源确定该第二PDCCH搜索空间时，也可确定第五资源配置信息，并基于该第五资源配置信息确定该第二PDCCH搜索空间，该第五资源配置信息包括该第二PDCCH搜索空间所在的控制信道资源集合占用的资源信息、该控制信道资源集合的标识以及第一偏移值中的至少一项，该第一偏移

值可以是基于该控制信道资源集合的标识确定出的。进一步可选的，该第二资源配置信息和/或该第五资源配置信息中还可包括该CCE标识如CCE编号信息。

[0147] 进一步可选的，该第一基站还可向UE发送该第二通知消息，该第二通知消息用于指示第二资源配置信息，该第二基站还可向UE发送该第五通知消息，该第五通知消息用于指示第五资源配置信息。从而UE能够根据该第二资源配置信息和该第五资源配置信息确定出两个PDCCH搜索空间。进一步的，该第二通知消息或第五通知消息可以是第一基站或第二基站在配置control resource set时发送给UE的，比如该第二资源配置信息或第五资源配置信息可以携带在control resource set的配置信息中发送给UE。该control resource set的配置信息还可包括PDCCH的个数、搜索空间的个数、聚合等级、控制信息格式、控制信息大小等信息。具体的配置方法如上述实施例所述，在此不做赘述。

[0148] 具体的，该第一PDCCH搜索空间和第二PDCCH搜索空间可以处于两个control resource set，即control resource set1(控制信道资源集合1)和control resource set2(控制信道资源集合2)，两个set的资源可以完全重叠。进一步的，PDCCH搜索空间的CCE编号可以与set编号相关，比如可以配置一个第一偏移值offset1，则第一个set对应的第一PDCCH搜索空间的CCE编号可按公式确定出，第二个set对应的PDCCH搜索空间的CCE编号可增加offset1值。比如第一个set的某个CCE编号为1，则第二个set计算的CCE编号可以为1+offset1。其中，offset1可以为固定的值或者基站信令通知给UE，比如该offset1可以为8、16、32、64或其他整数。进一步的，offset1也可以是根据set编号确定的，比如offset1＝N*M，其中，N为set编号，M为偏移差值，比如8、16、32、64或其他整数。如图8b所示，最大圆圈指示了control resource set1的资源位置，也即control resource set2的资源位置，上面的圆圈指示了control resource set1的搜索空间(搜索空间1)即第一PDCCH搜索空间的CCE位置，下面的圆圈指示了control resource set2的搜索空间(搜索空间1)即第二PDCCH搜索空间的CCE的位置，其CCE编号增加了offset1值。

[0149] 作为一种可选的实施方式，该第一基站基于该第三资源确定该第一PDCCH搜索空间时，可确定第三资源配置信息，并基于该第三资源配置信息确定该第一PDCCH搜索空间，该第三资源配置信息包括该第一PDCCH搜索空间所在的控制信道资源集合占用的资源信息、该第一PDCCH搜索空间的标识以及第二偏移值中的至少一项，该第二偏移值是基于该第一PDCCH搜索空间的标识确定出的。相应的，该第二基站基于该第四资源确定该第二PDCCH搜索空间时，也可确定第六资源配置信息，并基于该第六资源配置信息确定该第二PDCCH搜索空间，该第六资源配置信息包括该第二PDCCH搜索空间所在的控制信道资源集合占用的资源信息、该第二PDCCH搜索空间的标识以及第二偏移值中的至少一项，该第二偏移值是基于该第二PDCCH搜索空间的标识确定出的。进一步可选的，该第三资源配置信息和/或该第六资源配置信息中还可包括该CCE标识如CCE编号信息。

[0150] 进一步可选的，该第一基站还可向UE发送该第三通知消息，该第三通知消息用于指示第三资源配置信息，该第二基站还可向UE发送该第六通知消息，该第六通知消息用于指示第六资源配置信息。从而UE能够根据该第三资源配置信息和该第六资源配置信息确定出该两个PDCCH搜索空间。进一步的，该第三通知消息或第六通知消息可以是第一基站或第二基站在配置control resource set时发送给UE的，比如该第三资源配置信息或第六资源配置信息可以携带在control resource set的配置信息中发送给UE，或者，该第三资源配

置信息或第六资源配置信息可以携带搜索空间的配置信息中(如第一搜索空间的配置信息携带该第三资源配置信息,第二搜索空间的配置信息携带该第六资源配置信息)。进一步可选的,该control resource set的配置信息或搜索空间的配置信息还可包括PDCCH的个数、搜索空间的个数、搜索空间的编号、聚合等级、控制信息格式、控制信息大小等信息。具体的配置方法如上述实施例所述,在此不做赘述。

[0151] 具体的,该第一PDCCH搜索空间(search space 1,即搜索空间1)和第二PDCCH搜索空间(search space 2,即搜索空间2)可以处于一个control resource set(control resource set1,即控制信道资源集合1)中。进一步的,PDCCH搜索空间的CCE编号可以与搜索空间的编号相关,比如针对搜索空间配置信息中可以配置一个第二偏移值offset2,具体的比如针对第一个搜索空间的offset2配置为0,的针对第二个搜索空间的offset2配置为offset2的值,则第一PDCCH搜索空间的CCE编号可按公式确定出,第二PDCCH搜索空间的CCE编号可增加offset2值。比如第一PDCCH搜索空间计算的某个CCE编号为1,则第二PDCCH搜索空间的CCE编号可以为1+offset2。其中,offset2可以为固定的值或者基站信令通知给UE,比如该offset2可以为8、16、32、64或其他整数,offset2可与PDCCH搜索空间编号相关,比如offset2=N*M,其中N为搜索空间search space的编号,M为偏移差值,比如8、16、32、64或其他整数。如图8c所示,最大圆圈指示了control resource set1的资源位置,上面的圆圈指示了control resource set1的search space 1的CCE位置,下面的圆圈指示了control resource set1的search space 2的CCE的位置,其CCE编号增加了offset2值。

[0152] 进一步可选的,针对不同的control resource set,第一基站或第二基站可以进行REG到CCE的映射,以及CCE到搜索空间候选的映射,该映射可以是集中式映射或者分布式映射。

[0153] 可选的,则该第一基站还可向UE发送第七通知消息,该第七通知消息包括该第一PDCCH搜索空间占用的第三时间单元的标识,该第二基站还可向UE发送第八通知消息,该第八通知消息包括该第二PDCCH搜索空间占用的第四时间单元的标识。

[0154] 也就是说,该第三资源可包括时域资源;当该第一PDCCH搜索空间和该第二PDCCH搜索空间不同时,第一PDCCH搜索空间和第二PDCCH搜索空间还可以从时域资源区分,如第一PDCCH搜索空间和第二PDCCH搜索空间可分别为不同的时域资源。如图9所示,可以将第一PDCCH搜索空间或第一PDCCH(PDCCH1)使用的时间单元的位置和第二PDCCH搜索空间或第二PDCCH(PDCCH2)使用的时间单元位置区分开,该时间单元对应的时间单位可以是子帧、时隙、微时隙、符号等等,图9中以时间单位为符号为例,比如第一PDCCH搜索空间占用第一个符号的资源,第二PDCCH搜索空间占用第二和第三个符号的资源。可选的,针对不同的时域资源,第一基站或第二基站可以进行REG到CCE的映射,以及CCE到搜索空间候选的映射,该映射可以是集中式映射或者分布式映射。

[0155] 举例来说,第一基站和第二基站可分别指示PDCCH1和PDCCH2的时间单元的标识如符号编号信息,比如在control resource set中指示PDCCH1和PDCCH2的符号编号信息。可选的,该符号编号信息可以用2个bit表示,比如00代表第一个符号,01代表第二个符号,10代表第三个符号,11代表第四个符号;或者,该符号编号信息可以采用bitmap的形式,用4个bit表示,比如1100代表使用第一个和第二个符号,0011代表使用第三个和第四个符号,1010代表使用第一个和第三个符号,0101代表使用第二个和第四个符号,等等;或者,该符

号编号信息也可以使用其他的bit个数或者bit含义指示，此处不一一列举；或者，该符号编号信息还可以直接指示，比如符号#0，#1可以表示使用符号编号为0和1的符号位置等等，本发明实施例不做限定。

[0156] 又例如，该第一基站和第二基站也可以先指示小区级的符号个数，再指示UE级的符号位置。从而第一基站和第二基站可通知各自小区内所有UE的可用符号个数，比如第一基站通知小区内UE的可用符号个数为2个，第二基站通知小区内UE的可用符号个数为3个，并能够进一步通知UE可用的符号编号，比如第一基站通知该UE该PDCCH1的可用符号编号为0，第二基站通知该UE该PDCCH2的可用符号编号为2。或者，第一基站和第二基站也可直接指示UE级的符号位置，比如第一基站和第二基站可通知UE可用的符号编号，如第一基站通知该UE该PDCCH1的可用符号编号为0，第二基站通知该UE该PDCCH2的可用符号编号为2。

[0157] 可选的，若PDCCH1和PDCCH2分别为不同的时域资源，在进行CCE编号时，CCE编号可以都从0开始。如图10a所示，假设针对两个control resource set，符号0代表第一个control resource set，符号1和2代表第二个control resource set，两个control resource set都从0开始编号。此时，若其他UE分配的也是1个符号或者2个符号，则可以将每个control resource set进行独立CCE编号，UE检索时按照每个Control resource set的总的N_{CCE}计算的盲检的CCE。从而能够避免不同符号间的交织情况。其中，该符号编号可在指示control resource set时携带。

[0158] 可选的，若PDCCH1和PDCCH2分别为不同的时域资源，在进行CCE编号时，可以根据符号所在位置，进行连续编号。如图10b所示，假设针对两个control resource set，符号0代表第一个control resource set，符号1和2代表第二个control resource set时，两个control resource set的编号与所在符号位置相关，比如位于符号0的control resource set的CCE可以从0开始编号，而位于符号1的control resource set的CCE从N开始编号。其中，N为第一个符号上包含的总的CCE个数。

[0159] 进一步可选的，该符号位置的信息可以携带于control resource set的配置信息发送给UE。比如第一基站或第二基站还可以配置一个control resource set，并且在该control resource set的配置信息中携带2种符号位置(符号位置可以是符号个数及符号编号的至少一项)的信息，该2种符号位置可分别对应2个搜索空间。或者，第一基站或第二基站可以配置2个control resource set，每个control resource set中可以携带一个符号位置的信息，等等，本发明实施例不做限定。

[0160] 203、第一基站使用第一资源向UE发送所述第一PDCCH。

[0161] 204、第二基站使用第二资源向该UE发送所述第二PDCCH。

[0162] 进一步的，第一基站和第二基站在确定PDCCH的资源位置之后，即可在该资源位置发送该PDCCH。其中，该第一资源可以是时频域资源，也可以是码分资源。

[0163] 进一步的，在可选的实施例中，该步骤203和204可以均执行或者仅执行一项，比如第一基站和第二基站都为UE的协作基站时，在不同的时刻传输数据的基站可以不同，如在时刻1第一基站和第二基站都需要发送下行控制信息(信道)对该UE进行数据调度时，则步骤203和步骤204可以都执行。又如在时刻2仅有第一基站需要发送下行控制信息对该UE进行数据调度时，则仅需要执行步骤203。又如在时刻3仅有第二基站需要发送下行控制信息对该UE进行数据调度时，则仅需要执行步骤204。具体哪一个或者哪几个基站对该UE进行数

据调度，可以取决于信道状况以及基站的调度决策等调度相关信息。其中时刻1、2、3可以是具体的时间单元的标识，比如该时间单元对应的时间单位可以是无线帧、子帧、时隙、微时隙、符号等等。

[0164] 205、UE确定第一PDCCH的第一搜索空间和第二PDCCH的第二搜索空间。

[0165] 具体的，当UE接收的多个PDCCH的PDCCH搜索空间不同时，该UE在确定该多个PDCCH的PDCCH搜索空间时，可分别确定该多个PDCCH的PDCCH搜索空间占用的资源，并基于该资源分别确定该多个PDCCH的PDCCH搜索空间。其中，该资源可包括频域资源，也可以包括时域资源。

[0166] 可选的，该UE分别确定该多个PDCCH的PDCCH搜索空间占用的资源时，可按照一定的规则确定该多个PDCCH的PDCCH搜索空间占用的资源，或者多个基站发送的通知消息来确定该多个PDCCH的PDCCH搜索空间占用的资源。比如UE可接收至少一个基站如该第一基站发送的用于指示第一资源配置信息的第一通知消息以及第二基站发送的用于指示第四资源配置信息的第四通知消息，并可基于该第一资源配置信息和第四资源配置信息确定该多个PDCCH的PDCCH搜索空间占用的资源。其中，该第一资源配置信息和第四资源配置信息可包括该多个PDCCH的PDCCH搜索空间所在的控制信道资源集合占用的资源信息。在本发明实施例中，该第一资源配置信息和第四资源配置信息可以是第一基站和第二基站分别发送的各自的资源配置信息，即该第一资源配置信息可包括该第一PDCCH搜索空间所在的控制信道资源集合占用的资源信息，该第四资源配置信息可包括该第二PDCCH搜索空间所在的控制信道资源集合占用的资源信息，即该控制信道集合的个数为2，即该多个PDCCH对应的PDCCH搜索空间的个数与控制信道资源集合的个数相同。进一步可选的，该第一资源配置信息和/或该第四资源配置信息中还可包括该CCE标识如CCE编号信息。UE可通过接收第一基站或第二基站发送的control resource set的配置信息获取该第一资源配置信息或第四资源配置信息。也即，该第一资源配置信息或该第四资源配置信息可以为基站发送的control resource set的配置信息。

[0167] 具体的，该第一PDCCH搜索空间和第二PDCCH搜索空间可以处于两个control resource set，两个set的频域资源不重叠，即两个PDCCH搜索空间所在的control resource set不同。进一步的，各自set的CCE编号可以从0开始，如图8a所示，从而UE可在control resource set1和control resource set2中基于该CCE编号计算搜索空间位置，进行搜索空间候选的盲检测。

[0168] 可选的，该UE分别确定该多个PDCCH的PDCCH搜索空间占用的资源时，还可接收第一基站发送的用于指示第二资源配置信息的第二通知消息以及第二基站发送的用于指示第五资源配置信息的第五通知消息，并基于该第二资源配置信息和第五资源配置信息确定第一PDCCH搜索空间和第二PDCCH搜索空间占用的资源。其中，该第二资源配置信息和该第五资源配置信息可包括该第一PDCCH搜索空间和该第二PDCCH所在的两个控制信道资源集合占用的资源信息，该两个控制信道资源集合的标识以及第一偏移值中的至少一项，该第一偏移值可以是基于该两个控制信道资源集合的标识确定出的(或者该第一偏移值还可由UE确定出，或者偏移值是预定义的)，且该两个控制信道资源集合占用的资源相重叠。进一步可选的，该第二资源配置信息和/或该第五资源配置信息中还可包括该CCE标识如CCE编号信息。UE可通过接收第一基站或第二基站发送的control resource set的配置信息获取

该第二资源配置信息或第五资源配置信息。也即，该第二资源配置信息或该第五资源配置信息可以为基站发送的control resource set的配置信息。

[0169] 具体的，该第一PDCCH搜索空间和第二PDCCH搜索空间可以处于两个control resource set，即control resource set1和control resource set2，两个set的资源可以完全重叠。进一步的，PDCCH搜索空间的CCE编号可以与set编号相关，比如可以配置一个第一偏移值offset1，则第一个set对应的第一PDCCH搜索空间的CCE编号可按公式确定出，第二个set对应的PDCCH搜索空间的CCE编号可增加offset1值。比如第一个set的某个CCE编号为1，则第二个set计算的CCE编号可以为1+offset1。其中，offset1可以为固定的值或者基站信令通知给UE，此处不赘述。如图8b所示，UE即可在control resource set1和control resource set2中基于该CCE编号计算搜索空间位置，进行搜索空间候选的盲检测。

[0170] 可选的，该UE分别确定该多个PDCCH的PDCCH搜索空间占用的资源时，还可接收第一基站发送的用于指示第三资源配置信息的第三通知消息以及第二基站发送的用于指示第六资源配置信息的第六通知消息，并基于该第三资源配置信息和第六资源配置信息确定第一PDCCH搜索空间和第二PDCCH搜索空间占用的资源。其中，该第三资源配置信息和该第六资源配置信息可以是第一基站和第二基站分别发送的各自的资源配置信息，该第三资源配置信息可包括该第一PDCCH搜索空间所在的控制信道资源集合占用的资源信息，该第一PDCCH搜索空间的标识以及第二偏移值中的至少一项，该第六资源配置信息可包括该第二PDCCH搜索空间所在的控制信道资源集合占用的资源信息，该第二PDCCH搜索空间的标识以及第二偏移值中的至少一项。该第二偏移值是基于该第一PDCCH搜索空间的标识和该第二PDCCH搜索空间的标识确定出的(该第二偏移值还可由UE确定出)，且该第一PDCCH搜索空间和该第二PDCCH搜索空间所在的控制信道资源集合相同。进一步可选的，该第三资源配置信息和/或该第六资源配置信息中还可包括该CCE标识如CCE编号信息。UE可通过接收第一基站或第二基站发送的control resource set的配置信息或搜索空间的配置信息以获取该第三资源配置信息或第六资源配置信息。也即，该第三资源配置信息或该第六资源配置信息可以为基站发送的control resource set的配置信息或搜索空间的配置信息。

[0171] 具体的，该第一PDCCH搜索空间(search space 1)和第二PDCCH搜索空间(search space 2)可以处于一个control resource set(control resource set1)中。进一步的，PDCCH搜索空间的CCE编号可以与搜索空间的编号相关，比如可以配置一个第二偏移值offset2，则第一PDCCH搜索空间的CCE编号可按公式确定出，第二PDCCH搜索空间的CCE编号可增加offset2值。比如第一PDCCH搜索空间计算的某个CCE编号为1，则第二PDCCH搜索空间的CCE编号可以为1+offset2。其中，offset2可以为固定的值或者基站信令通知给UE，此处不赘述。如图8c所示，UE即可在control resource set1和control resource set2中基于该CCE编号计算搜索空间位置，进行搜索空间候选的盲检测。

[0172] 进一步可选的，该资源可包括时域资源；则UE还可接收该第一基站和该第二基站发送的通知消息，如上述的第七通知消息和第八通知消息。该通知消息分别包括该第一PDCCH搜索空间占用的第三时间单元的标识和该第二PDCCH搜索空间占用的第四时间单元的标识。从而第一PDCCH搜索空间和第二PDCCH搜索空间可以从时域资源区分，如图9所示。UE即可基于各PDCCH搜索空间占用的时间单元的标识如符号编号去确定搜索空间并进行盲检。

[0173] 也就是说，该搜索空间可以是基于聚合级别、PDCCH的个数、控制信息的格式、控制信息的大小以及搜索空间的个数中的至少一项确定出的。比如该聚合级别、PDCCH的个数、控制信息的格式、控制信息的大小以及搜索空间的个数可以是基站通知给UE的，如在基站确定control resource set时通知给UE的。

[0174] 举例来说，第一基站或第二基站可以是在配置(确定)control resource set时可通知UE一个或者多个聚合级别。比如第一基站或第二基站可以配置聚合级别为4，则UE在监测时仅检测聚合级别为4的候选即可；或者第一基站或第二基站可以配置为4、8、16等多个聚合级别，则UE在监测时仅检测指示的聚合级别对应的候选即可，从而能够降低盲检次数。或者，第一基站或第二基站可以通知UE针对该control resource set需要监测的PDCCH的个数。比如如果配置UE监测1个PDCCH，则UE监测到一个PDCCH或者到达最大盲检次数后停止监测；如果配置UE监测2个PDCCH，则UE监测到2个PDCCH或者到达最大盲检次数后停止监测。

[0175] 又例如，第一基站或第二基站可以通知UE针对该control resource set需要监测的PDCCH的个数以及对应的聚合级别。比如配置UE检测1个PDCCH而且对应的聚合级别为4，则UE仅针对聚合级别为4的候选进行监测，而且当UE监测到一个PDCCH或者到达最大盲检次数后停止监测；或者配置UE检测1个PDCCH而且对应的聚合级别为4、8、16等多个聚合级别，则UE仅针对指示的聚合级别的候选进行监测，当UE监测到一个PDCCH或者到达最大盲检次数后停止监测；或者，第一基站或第二基站可配置UE检测2个PDCCH而且两个对应的聚合级别相同，比如分别对应的聚合级别为4，则UE可仅针对聚合级别为4的候选进行监测，而且当UE监测到2个PDCCH或者到达最大盲检次数后停止监测；或者配置UE检测2个PDCCH而且两个对应的聚合级别相同，比如分别对应的聚合级别为4、8、16等多个聚合级别，则UE仅针对指示的聚合级别的候选进行监测，而且当UE监测到2个PDCCH或者到达最大盲检次数后停止监测；或者，第一基站或第二基站可配置UE检测2个PDCCH而且两个对应的聚合级别不同，比如第一个PDCCH对应的聚合级别为4，第二个PDCCH对应的聚合级别为8，则UE对于第一个PDCCH仅针对聚合级别为4的候选进行监测，而且当UE监测到1个PDCCH或者到达最大盲检次数后再进行第二个PDCCH的监测，针对第二个PDCCH，则UE仅针对聚合级别为8的候选进行监测，当UE检测到1个PDCCH或者达到最大盲检次数后停止监测；其中，第一PDCCH和第二PDCCH的检测顺序可以不分先后。或者，第一基站或第二基站可配置UE检测2个PDCCH而且两个对应的聚合级别不同，比如第一PDCCH对应的聚合级别为4、8、16等多个聚合级别，第二PDCCH对应的聚合级别为8、16、32等多个聚合级别，则UE可对于第一PDCCH仅针对指示的聚合级别比如4、8、16等的候选进行监测，而且当UE监测到1个PDCCH或者到达最大盲检次数后再进行第二个PDCCH的监测，针对第二PDCCH，则UE仅针对指示的聚合级别比如8、16、32等的候选进行监测，当UE检测到1个PDCCH或者达到最大盲检次数后停止监测；其中，第一PDCCH和第二PDCCH的检测顺序可以不分先后，或者可以同时进行检测，比如在两者的聚合级别相同时，可以同时进行2个PDCCH的检测，本发明实施例不做限定。

[0176] 进一步可选的，第一基站或第二基站可以通知UE针对该control resource set的控制信息格式或者控制信息大小中的至少一项。比如配置UE检测控制信息格式DCI format 2D或者检测控制信息大小为A的PDCCH，A的取值为20bit或者40bit或者其他数值。可以针对多个搜索空间或者多个PDCCH配置多个控制信息个数或者控制信息大小的信息。或者可以针对多个搜索空间或者多个PDCCH配置一个控制信息个数或者控制信息大小的信息。或者

可以针对一个搜索空间或者一个PDCCH配置多个个控制信息个数或者控制信息大小的信息。或者控制信息个数或者控制信息大小为预定义。采用该方案，便于UE进行PDCCH的正确检测和解码。

[0177] 进一步可选的，第一基站或第二基站可以通知UE针对该control resource set的搜索空间个数，一个搜索空间可以包括一个或者多个PDCCH，进一步还可以通知针对搜索空间的PDCCH的个数以及对应的聚合级别、控制信息的格式、控制信息的大小，此处不赘述。

[0178] 206、UE在该第一搜索空间中确定出该第一PDCCH占用的第一资源，以及在该第二搜索空间中确定出该第二PDCCH占用的第二资源。

[0179] 207、该UE使用该第一资源获取第一PDCCH，并使用该第二资源获取第二PDCCH。

[0180] 进一步的，UE在确定出每个PDCCH的搜索空间之后，即可确定出每个PDCCH在该PDCCH搜索空间中占用的资源，并使用该资源获取该PDCCH，该资源包括时频资源或码分得到的资源，从而UE可在确定出的时频资源上获取该PDCCH，或者在确定出的码分资源上获取该PDCCH。

[0181] 在本发明实施例中，多个基站能够在UE不同的PDCCH搜索空间中向UE发送多个PDCCH，从而UE能够接收多个PDCCH，并通过该多个PDCCH调度一个载波的数据，这就提升了信息传输的效率，并提升了信息传输的可靠性。本发明实施例能够根据时频资源配置不同的control resource set及search space，并通过设计多个PDCCH的搜索空间候选，确保了多个PDCCH的CCE不重叠，从而解决了现有技术无法支持多个PDCCH传输的问题，并能够提升协作传输下分布式MIMO多流传输的性能，且降低了UE盲检次数，提升了UE盲检效率。

[0182] 请参见图11，图11是本发明实施例提供的又一种信道传输方法的交互示意图。具体的，如图11所示，本发明实施例的所述信道传输方法包括以下步骤：

[0183] 301、第一基站确定协作的第一搜索空间。

[0184] 302、第二基站确定协作的第二搜索空间。

[0185] 可选的，该第一基站确定该第一PDCCH搜索空间(即第一搜索空间)时，还可以是基于第三参数确定该第一PDCCH搜索空间。相应的，该第二基站在确定该第二PDCCH搜索空间(即第二搜索空间)时，还可以是基于第三参数确定该第二PDCCH搜索空间，其中，该第一PDCCH搜索空间或第二PDCCH搜索空间可包括至少一个CCE，该第三参数包括CCE的个数或CCE的标识。进一步可选的，该第一PDCCH搜索空间对应的第三参数和该第二PDCCH搜索空间对应的第三参数包括的CCE个数(或标识)可以相同，也可以不同。

[0186] 也就是说，该协作的第一PDCCH搜索空间或第二PDCCH搜索空间是指用于协作传输的专用搜索空间(又称“协作的搜索空间”)，该第一PDCCH搜索空间和该第二PDCCH搜索空间可以是预定义得到的。可选的，该协作的第一PDCCH搜索空间和该第二PDCCH搜索空间可以是为UE配置的搜索空间，也可以是为基站统一配置的搜索空间，也可以是为不同的基站分别配置的搜索空间，等等，本发明实施例不做限定。

[0187] 例如，对于为UE配置协作的搜索空间的方式，可以预定义该协作的搜索空间的大小和位置，并将该协作的搜索空间与UE的标识相关联。比如将时隙的前16个CCE作为该UE的协作搜索空间，该方式下，该第一PDCCH搜索空间和该第二PDCCH搜索空间相同。可选的，对于配置了协作的搜索空间的UE，可以按照一定的规则盲检PDCCH，比如搜索空间的确定与是否为协作控制信道相关，如果是协作控制信道，则将用于确定搜索空间的Y_k取值为固定的

值，比如将Y_k取值1或2等。或者令$Y_k'=Y_k+ID_{TP}$，并可将该Y_k'作为Y_k代入到上面的公式来确定搜索空间。其中，ID_{TP}可以表示协作的小区的标识，该标识可以是小区编号或者其他标识。进一步的，如果协作的搜索空间有空余，则正常UE的搜索空间与协作UE的搜索空间可以重叠，即正常UE也可以使用该协作的搜索空间，以避免资源浪费。例如，某个UE的RNTI模$\lfloor N_{CCE,k}/L \rfloor$等于1时，则该UE的搜索空间可以与协作的搜索空间全部或部分重叠，在该协作的搜索空间存在空余时可以传输该UE的PDCCH。

[0188] 又例如，协作的搜索空间可以由基站统一配置，如基站可通过RRC或MAC层信令配置第一配置信息，以基于该第一配置信息确定共用的协作搜索空间。可选的，该第一配置信息可包括以下至少一项：coordinated search space-config，用于指示协作的搜索空间的配置，也可以是协作的控制信道资源集合的配置；subframe pattern，用于指示时域资源的配置信息，比如可以是子帧、时隙、微时隙等等；symbol number，用于指示协作控制信道资源占用的符号个数；symbol Index，用于指示协作控制信道资源（该协作控制信道资源可以是协作的搜索空间或协作的控制信道资源集合）占用的符号所在的编号信息；CCE_number，用于指示协作的搜索空间占用的CCE的个数，或者是CCE的位置信息，比如可默认为某个时间单元中的前面几个CCE等；Yk_value，用于指示协作的搜索空间计算相关的变量值；frequencyResource，用于指示协作控制信道资源占用的频域资源位置信息。该方式下，不同基站共用一个协作的搜索空间，基站可以按照上述搜索空间相同的场景进行不同基站间的CCE的分配，此处不赘述。例如，该第一配置信息可以按照如下所示：

[0189]

```
Coordinated search space-Config ::=        SEQUENCE{
        subframePattern          MeasSubframePattern          OPTIONAL, -- Need ON
        SymbolNumber-r11         INTEGER (1..4)               OPTIONAL, -- Need OP
        SymbolIndex-r11          BIT STRING (size(4)) or INTEGER (1..4)
                                                              OPTIONAL, -- Need OP
        CCE_number               ENUMERATED {16,32,64}        OPTIONAL,-- Need ON
        Yk_value                 INTEGER (0,1..4)             OPTIONAL-- Need ON
        frequencyResource        ENUMERATED {16,32,64} or BIT STRING
                                     (size(4))or INTEGER (1..4)  OPTIONAL,-- Need ON
        }
    }
}
```

[0190] 又例如，不同的基站可以配置不同的协作搜索空间，此时，一个基站或者不同的基站可通过RRC或MAC层信令配置至少两个第二配置信息，每个第二配置信息可携带协作的搜索空间标识。可选的，该第二配置信息包括以下至少一项：coordinated search space-config，用于指示协作的搜索空间的配置，也可以是协作的控制信道资源集合配置；Coordinated search space_ID，用于指示协作的搜索空间的配置标识，也可以是协作的控制信道资源集合的配置标识；subframe pattern，用于指示时域资源的配置信息，比如可以是子帧，时隙，微时隙等等；symbol number，用于指示协作控制信道资源占用的符号个数；symbol Index，用于指示协作控制信道资源占用的符号所在的编号信息；CCE_number，用于指示协作的搜索空间占用的CCE的个数，或者是CCE的位置信息，比如可默认前面的CCE等；

Yk_value，用于指示协作的搜索空间计算相关的变量值；frequencyResource，用于指示协作控制信道资源占用的频域资源位置信息；Coordinated search space_ID，用于指示协作的搜索空间配置标识，也可以是协作控制信道资源集合配置标识；Coordinated search space_ID_List，用于指示协作的搜索空间的配置标识列表，也可以是协作的控制信道资源集合的配置标识列表；symbol Index_List，用于指示协作控制信道资源占用的符号所在的编号信息列表；CCE_index_List，用于指示协作的搜索空间占用的CCE的情况列表，或者是CCE个数列表，或者是CCE的位置信息列表；frequencyResource_List，用于指示协作控制信道资源占用的频域资源位置信息列表。从而UE能够通过该第二配置信息区分出多个基站的协作的搜索空间的CCE，以进行PDCCH盲检，而且不影响正常UE的接收。例如，该第二配置信息可以按照如下所示：

[0191]

```
Coordinated search space_ID      INTEGER (1..4)
subframePattern                  MeasSubframePattern-r10      OPTIONAL, -- Need ON
SymbolNumber                     INTEGER (1..4)               OPTIONAL, -- Need OP
SymbolIndex                      BIT STRING (size(4))    or INTEGER (1..4)
                                                              OPTIONAL, -- Need OP
CCE_index                        ENUMERATED {0~16,16~32,32~64}
                                                              OPTIONAL, -- Need ON
Yk_value                         INTEGER (0,1..4)             OPTIONAL, -- Need ON
frequencyResource                ENUMERATED {16,32,64}or BIT STRING (size(4))or
                                 INTEGER (1..4)               OPTIONAL, -- Need ON
        }
    }
}
```

[0192] 又如，该第二配置信息还可以按照如下所示：

[0193]

```
Coordinated search space-Config::=      SEQUENCE{
    Coordinated search space_ID_LIST    INTEGER (1..4)
    symbol Index_List                   SEQUENCE{ SIZE OF ENUMERATED
                                        {0,0~1,0~2,1~2,,1,2}} OPTIONAL -- Need ON
    CCE_index_List                      SEQUENCE{ SIZE OF ENUMERATED
                                        {0~16,16~32,32~64}} OPTIONAL -- Need ON
  frequencyResource_List                SEQUENCE{ ENUMERATED {16,32,64}or BIT
                                        STRING (size(4))or INTEGER (1..4) }
                                                              OPTIONAL, -- Need ON
```

[0194]

```
}
```

[0195] 303、第一基站在第一搜索空间中的第一资源向该UE发送第一PDCCH。

[0196] 304、第二基站在第二搜索空间中的第二资源向该UE发送第二PDCCH。

[0197] 305、UE确定该第一搜索空间和该第二搜索空间。

[0198] 306、UE使用该第一搜索空间中的第一资源获取该第一PDCCH，以及使用该第二搜索空间中的第二资源获取该第二PDCCH。

[0199] 具体的，该UE在确定第一PDCCH搜索空间和第二PDCCH搜索空间时，仍可基于第一

基站和第二基站发送的包括CCE的个数或CCE的标识的参数信息，或者预定义的CCE的个数或CCE的标识等参数信息，来确定该协作的第一PDCCH搜索空间和第二PDCCH搜索空间，从而在该确定出的PDCCH搜索空间上进行盲检，以获取得到第一PDCCH和第二PDCCH。

[0200] 可选的，该第一搜索空间和该第二搜索空间可以相同，也可以不同。该第一基站或第二基站确定PDCCH占用的资源，以及UE获取PDCCH的方式可以参照上述实施例中的描述，此处不赘述。

[0201] 进一步可选的，该第一基站或第二基站还可通知UE聚合级别和/或PDCCH的个数和/或搜索空间的个数和/或控制信息格式和/或控制信息大小，从而UE可基于该聚合级别和/或PDCCH的个数和/或搜索空间的个数和/或控制信息格式和/或控制信息大小来进行搜索空间的确定，具体可参照上述实施例中的描述，此处不赘述。

[0202] 在本发明实施例中，多个基站能够通过设计的协作的搜索空间向UE发送属于多个PDCCH，从而UE能够接收多个PDCCH，并通过该多个PDCCH调度一个载波的数据，本发明实施例通过设计多个PDCCH的搜索空间候选，确保了多个PDCCH的CCE不重叠，从而解决了现有技术无法支持多个PDCCH传输以调度一个载波的数据的问题，从而提升了信息传输的效率，并提升了信息传输的可靠性，且降低了UE盲检次数，提升了UE盲检效率。

[0203] 请参见图12，图12是本发明实施例提供的一种网络设备的结构示意图。具体的，如图12所示，本发明实施例的该网络设备可包括确定模块11和通信模块模块12。其中，

[0204] 确定模块11，用于确定至少两个下行控制信道的搜索空间；

[0205] 该确定模块11，还用于在该搜索空间中分别确定出该至少两个下行控制信道占用的资源，该至少两个下行控制信道调度的资源属于一个载波；

[0206] 通信模块12，用于使用该资源获取该至少两个下行控制信道。

[0207] 可选的，该至少两个下行控制信道的搜索空间可以相同，则该确定模块11在确定至少两个下行控制信道的搜索空间时，可具体用于：

[0208] 基于第一参数确定至少两个下行控制信道的搜索空间；其中，该第一参数包括控制信道元素CCE个数、第一时间单元的标识以及下行控制信道的候选位置中的至少一项。

[0209] 进一步可选的，该至少两个下行控制信道的搜索空间的CCE的个数相同；或，该至少两个下行控制信道的第一时间单元的标识是基于该至少两个下行控制信道占用的资源的子载波间隔确定的；或，该至少两个下行控制信道的第一时间单元的标识是根据预设子载波间隔下的时间单元中与该至少两个下行控制信道的第一时间单元对应的时间单元的标识确定的；或，该至少两个下行控制信道的候选位置不同，该至少两个下行控制信道的候选位置是基于第二参数确定的，该第二参数包括设备类型、设备标识、聚合等级中的至少一项。

[0210] 可选的，该至少两个下行控制信道的搜索空间也可以不同，则该确定模块11在确定至少两个下行控制信道的搜索空间时，可具体用于：

[0211] 分别确定至少两个下行控制信道的搜索空间占用的资源，该至少两个下行控制信道的搜索空间占用的资源不同，并基于该资源分别确定该至少两个下行控制信道的搜索空间。其中，该确定的资源可包括频域资源或时域资源。

[0212] 进一步可选的，该确定模块11在分别确定至少两个下行控制信道的搜索空间占用的资源时，可具体用于：

[0213] 确定第一资源配置信息，并基于该第一资源配置信息确定至少两个下行控制信道的搜索空间占用的资源。其中，该第一资源配置信息可包括该至少两个下行控制信道的搜索空间所在的控制信道资源集合占用的资源信息，且该至少两个下行控制信道对应的搜索空间的个数与控制信道资源集合的个数相同。

[0214] 进一步可选的，该确定模块11在分别确定至少两个下行控制信道的搜索空间占用的资源时，可具体用于：

[0215] 确定第二资源配置信息，并基于该第二资源配置信息确定至少两个下行控制信道的搜索空间占用的资源。其中，该第二资源配置信息可包括该至少两个下行控制信道的搜索空间所在的至少两个控制信道资源集合占用的资源信息、该至少两个控制信道资源集合的标识以及第一偏移值中的至少一项，该第一偏移值是基于该至少两个控制信道资源集合的标识确定出的，且该至少两个控制信道资源集合占用的资源相重叠。

[0216] 进一步可选的，该确定模块11在分别确定至少两个下行控制信道的搜索空间占用的资源时，可具体用于：

[0217] 确定第三资源配置信息，并基于该第三资源配置信息确定至少两个下行控制信道的搜索空间占用的资源。其中，该第三资源配置信息包括该至少两个下行控制信道的搜索空间所在的控制信道资源集合占用的资源信息、该至少两个下行控制信道的搜索空间的标识以及第二偏移值中的至少一项，该第二偏移值是基于该至少两个下行控制信道的搜索空间的标识确定出的，且该至少两个下行控制信道对应的搜索空间所在的控制信道资源集合相同。

[0218] 进一步可选的，该资源可包括时域资源；

[0219] 该通信模块11，还可用于接收至少一个另一网络设备发送的通知消息，该通知消息包括该至少两个下行控制信道的搜索空间占用的第二时间单元的标识。

[0220] 可选的，该网络设备可通过上述模块实现上述图2至图11对应实施例中的信道传输方法中用户设备执行的部分或全部步骤。应理解，本发明实施例是对应方法实施例的装置实施例，对方法实施例的描述，也适用于本发明实施例。

[0221] 请参见图13，图13是本发明实施例提供的另一种网络设备的结构示意图。具体的，如图13所示，本发明实施例的该网络设备包括第一确定模块21、第二确定模块22、第一通信模块23和第二通信模块24。其中，

[0222] 第一确定模块21，用于在第一搜索空间中确定第一下行控制信道占用的第一资源；

[0223] 第二确定模块22，用于在第二搜索空间中确定第二下行控制信道占用的第二资源，该第一下行控制信道调度的资源和该第二下行控制信道调度的资源属于一个载波；

[0224] 第一通信模块23，用于使用该第一资源向另一网络设备发送该第一下行控制信道；

[0225] 第二通信模块24，用于使用该第二资源向该另一网络设备发送该第二下行控制信道。

[0226] 可选的，该第一确定模块21、第一通信模块23和该第二确定模块22、第二通信模块24可以设置于同一网络设备中，也可以设置于不同的网络设备中，本发明实施例不做限定。

[0227] 其中，该第一搜索空间和该第二搜索空间可以相同也可以不同。

[0228] 可选的，该第一搜索空间和该第二搜索空间可以相同；

[0229] 第一确定模块21，还用于基于第一参数确定该第一搜索空间；

[0230] 第二确定模块22，还用于基于第一参数确定该第一搜索空间；其中，该第一参数包括CCE的个数、第一时间单元的标识以及下行控制信道的候选位置中的至少一项。

[0231] 进一步可选的，该第一确定模块21确定出的第一参数包括的CCE的个数和该第二确定模块22确定出的第一参数包括的CCE的个数相同；或，该第一下行控制信道的第一时间单元的标识或该第二下行控制信道的第一时间单元的标识是基于该第一资源和第二资源的子载波间隔确定的；或，该第一下行控制信道的第一时间单元的标识是根据预设子载波间隔下的时间单元中与该第一下行控制信道的第一时间单元对应的时间单元的标识确定的，该第二下行控制信道的第一时间单元的标识是根据该预设子载波间隔下的时间单元中与该第二下行控制信道的第一时间单元对应的时间单元的标识确定出的；或，该第一下行控制信道的候选位置与该第二下行控制信道的候选位置不同，该第一下行控制信道或该第二下行控制信道的候选位置是基于第二参数确定的，该第二参数包括设备类型、设备标识、聚合等级中的至少一项。

[0232] 可选的，该第一搜索空间和该第二搜索空间也可以不同；

[0233] 第一确定模块21，还可用于确定第一搜索空间占用的第三资源，并基于该第三资源确定该第一搜索空间。其中，该第三资源可包括频域资源或时域资源。

[0234] 进一步可选的，该第一确定模块21在基于该第三资源确定该第一搜索空间时，可具体用于：

[0235] 确定第一资源配置信息，并基于该第一资源配置信息确定该第一搜索空间。其中，该第一资源配置信息包括该第一搜索空间所在的控制信道资源集合占用的资源信息。

[0236] 进一步可选的，该第一确定模块21在基于该第三资源确定该第一搜索空间时，可具体用于：

[0237] 确定第二资源配置信息，并基于该第二资源配置信息确定该第一搜索空间。其中，该第二资源配置信息包括该第一搜索空间所在的控制信道资源集合占用的资源信息、该控制信道资源集合的标识以及第一偏移值中的至少一项，该第一偏移值是基于该控制信道资源集合的标识确定出的。

[0238] 进一步可选的，该第一确定模块21在基于该第三资源确定该第一搜索空间时，可具体用于：

[0239] 确定第三资源配置信息，并基于该第三资源配置信息确定该第一搜索空间。其中，该第三资源配置信息包括该第一搜索空间所在的控制信道资源集合占用的资源信息、该第一搜索空间的标识以及第二偏移值中的至少一项，该第二偏移值是基于该第一搜索空间的标识确定出的。

[0240] 进一步可选的，该第一搜索空间和该第二搜索空间也可以不同；第二确定模块22，还可用于确定第二搜索空间占用的第四资源，并基于该第四资源确定该第一搜索空间。具体的，该第二确定模块22基于该第四资源确定该第二搜索空间与该第一确定模块21基于该第三资源确定该第一搜索空间的方式相同，此处不赘述。

[0241] 可选的，该第三资源可包括时域资源；

[0242] 该第一通信模块23，还用于向该另一网络设备发送通知消息，该通知消息包括该

第一搜索空间占用的第二时间单元的标识。

[0243] 可选的，该第一确定模块21，还用于基于第三参数确定该第一搜索空间。其中，该第一搜索空间包括至少一个CCE，该第三参数包括CCE的个数或CCE的标识。

[0244] 具体的，该第一通信模块23和第二通信模块24在第二搜索空间中确定第二下行控制信道占用的第二资源的方式以及发送第二下行控制信道的方式与该第一确定模块21和第二确定模块22在第一搜索空间中确定第一下行控制信道占用的第一资源的方式以及发送第一下行控制信道的方式类似，此处不赘述。

[0245] 可选的，该网络设备可通过上述模块实现上述图2至图11对应实施例中的信道传输方法中基站执行的部分或全部步骤。应理解，本发明实施例是对应方法实施例的装置实施例，对方法实施例的描述，也适用于本发明实施例。

[0246] 在本发明实施例中，能够通过设计多个下行控制信道的搜索空间候选，实现多个下行控制信道的CCE不重叠，从而解决了现有技术无法支持多个PDCCH传输以调度一个载波的数据的问题，并降低了用户设备盲检次数，提升了盲检效率。

[0247] 请参见图14，图14是本发明实施例提供的一种信道传输系统的结构示意图。具体的，如图14所示，本发明实施例的信息传输系统可包括第一网络设备1、第二网络设备2和第三网络设备3。其中，

[0248] 第一网络设备1，用于在第一搜索空间中确定第一下行控制信道占用的第一资源，并使用该第一资源向第三网络设备3发送该第一下行控制信道；

[0249] 第二网络设备2，用于在第二搜索空间中确定第二下行控制信道占用的第二资源，并使用该第二资源向该第三网络设备3发送该第二下行控制信道；其中，该第一下行控制信道调度的资源和该第二下行控制信道调度的资源属于一个载波；

[0250] 第三网络设备3，用于确定该第一下行控制信道的第一搜索空间和该第二下行控制信道的第二搜索空间，在第一搜索空间中确定该第一下行控制信道占用的第一资源，在第二搜索空间中确定该第二下行控制信道占用的第二资源，使用该第一资源获取该第一下行控制信道以及使用该第二资源获取该第二下行控制信道。

[0251] 可选的，该第一搜索空间和第二搜索空间可以相同也可以不同。该网络设备如上述的第一网络设备、第二网络设备或第三网络设备可以是基站，也可以是用户设备。该第一网络设备和第二网络设备可以是相同的网络设备，即通过同一个网络设备如基站给另一个网络设备如用户设备发送多个下行控制信道；或者，该第一网络设备和第二网络设备还可以是不同的网络设备，本发明实施例不做限定。

[0252] 具体的，该第一网络设备和该第二网络设备可参照上述图2至图11对应实施例中的基站的相关描述，该第三网络设备可参照上述图2至图11对应实施例中的用户设备的相关描述，此处不赘述。

[0253] 请参见图15，图15是本发明实施例提供的又一种网络设备的结构示意图。具体的，如图15所示，本发明实施例的所述网络设备可包括：通信接口300、存储器200和处理器100，所述处理器100分别与所述通信接口300及所述存储器200连接。

[0254] 所述通信接口300、存储器200以及处理器100之间可以通过总线进行数据连接，也可以通过其他方式数据连接。本实施例中以总线连接进行说明。

[0255] 所述处理器100可以是中央处理器(英文：Central Processing Unit，缩写：CPU)，

网络处理器(英文:Network Processor,缩写:NP)或CPU和NP的组合。

[0256] 所述处理器100还可以进一步包括硬件芯片。上述硬件芯片可以是专用集成电路(英文:Application-Specific Integrated Circuit,缩写:ASIC),可编程逻辑器件(英文:Programmable Logic Device,缩写:PLD)或其组合。上述PLD可以是复杂可编程逻辑器件(英文:Complex Programmable Logic Device,缩写:CPLD),现场可编程逻辑门阵列(英文:Field-Programmable Gate Array,缩写:FPGA),通用阵列逻辑(英文:Generic Array Logic,缩写:GAL)或其任意组合。

[0257] 所述存储器200可以包括易失性存储器(英文:Volatile Memory),例如随机存取存储器(英文:Random-Access Memory,缩写:RAM);存储器也可以包括非易失性存储器(英文:non-volatile memory),例如快闪存储器(英文:flash memory),硬盘(英文:Hard Disk Drive,缩写:HDD)或固态硬盘(英文:Solid-State Drive,缩写:SSD);存储器200还可以包括上述种类的存储器的组合。

[0258] 其中,该网络设备可以是用户设备,也可以是基站。可选的,存储器200可以用于存储程序指令,该处理器100调用该存储器200中存储的程序指令,可以执行图2至图11所示实施例中的一个或多个步骤,或其中可选的实施方式,使得该网络设备实现上述方法中的功能。例如,该网络设备可通过上述模块实现上述图2至图11对应实施例中的信道传输方法中的网络设备如用户设备执行的部分或全部步骤。

[0259] 请参见图16,图16是本发明实施例提供的又一种网络设备的结构示意图。具体的,如图16所示,本发明实施例的网络设备可包括:通信接口600、存储器500和处理器400,该处理器400分别与通信接口600及存储器500连接。

[0260] 所述通信接口600、存储器500以及处理器400之间可以通过总线进行数据连接,也可以通过其他方式数据连接。本实施例中以总线连接进行说明。

[0261] 所述处理器400可以是CPU,NP或CPU和NP的组合。

[0262] 所述处理器400还可以进一步包括硬件芯片。上述硬件芯片可以是ASIC,PLD或其组合。上述PLD可以是CPLD,FPGA,GAL或其任意组合。

[0263] 所述存储器500可以包括易失性存储器(英文:Volatile Memory),例如RAM;存储器也可以包括非易失性存储器(英文:non-volatile memory),例如快闪存储器(英文:flash memory),HDD或SSD;存储器500还可以包括上述种类的存储器的组合。

[0264] 其中,该网络设备可以是基站,也可以是用户设备。可选的,存储器500可以用于存储程序指令,该处理器400调用该存储器500中存储的程序指令,可以执行图2至图11所示实施例中的一个或多个步骤,或其中可选的实施方式,使得该网络设备实现上述方法中的功能。例如,该网络设备可通过上述模块实现上述图2至图11对应实施例中的信道传输方法中的网络设备如基站执行的部分或全部步骤。

[0265] 在上述实施例中,可以全部或部分地通过软件、硬件、固件或者其任意组合来实现。当使用软件实现时,可以全部或部分地以计算机程序产品的形式实现。所述计算机程序产品包括一个或多个计算机指令。在计算机上加载和执行所述计算机程序指令时,全部或部分地产生按照本发明实施例所述的流程或功能。所述计算机可以是通用计算机、专用计算机、计算机网络、或者其他可编程装置。所述计算机指令可以存储在计算机可读存储介质中,或者从一个计算机可读存储介质向另一个计算机可读存储介质传输,例如,所述计算机

指令可以从一个网站站点、计算机、服务器或数据中心通过有线(例如同轴电缆、光纤、数字用户线(DSL))或无线(例如红外、无线、微波等)方式向另一个网站站点、计算机、服务器或数据中心进行传输。所述计算机可读存储介质可以是计算机能够存取的任何可用介质或者是包含一个或多个可用介质集成的服务器、数据中心等数据存储设备。所述可用介质可以是磁性介质,(例如,软盘、硬盘、磁带)、光介质(例如,DVD)、或者半导体介质(例如固态硬盘Solid State Disk(SSD))等。

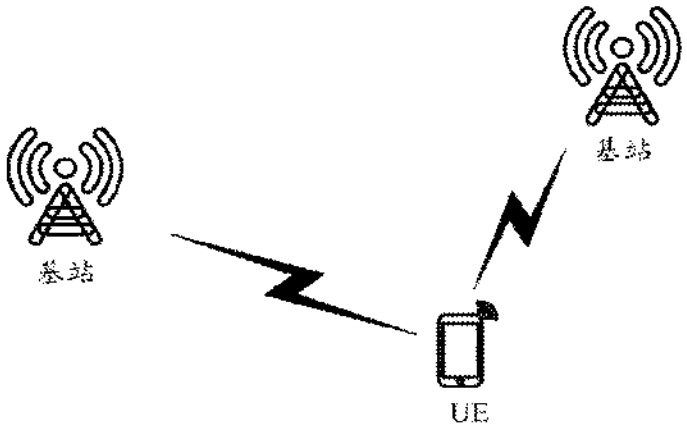

基站
基站
UE

图1

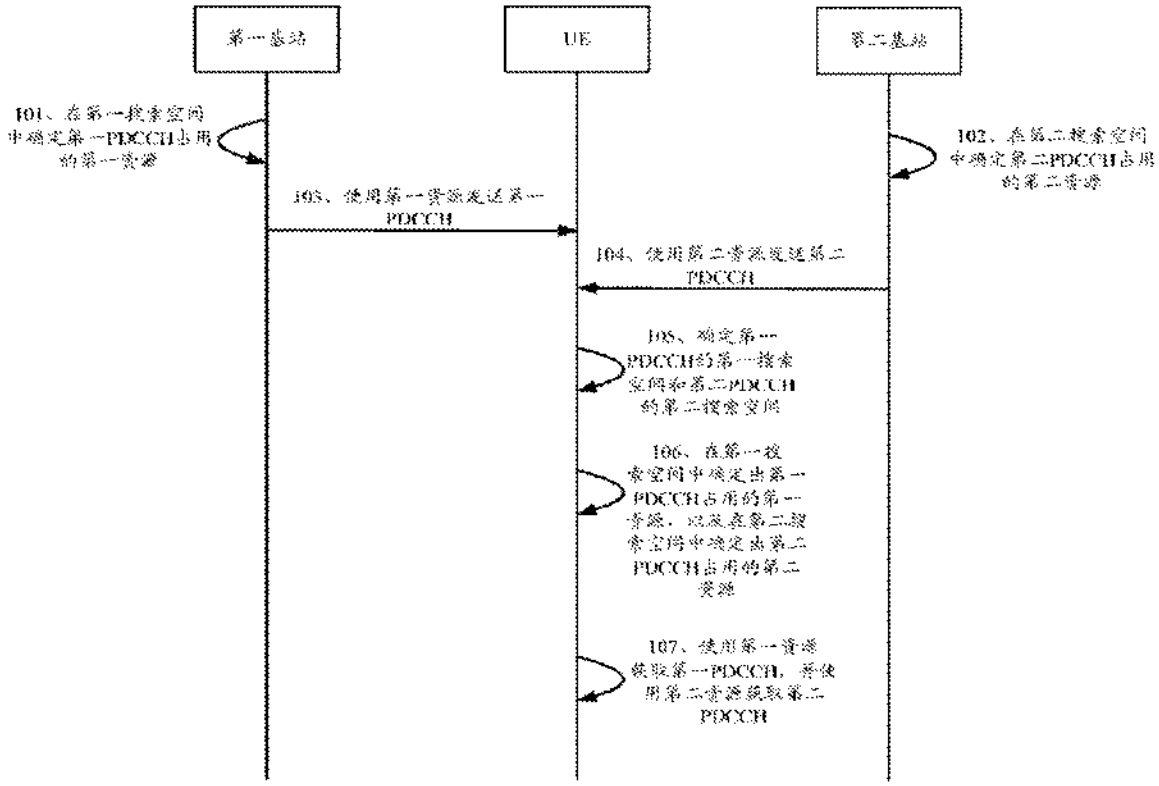

第一基站
UE
第二基站
101、在第一搜索空间中确定第一PDCCH占用的第一资源
102、在第二搜索空间中确定第二PDCCH占用的第二资源
103、使用第一资源发送第一PDCCH
104、使用第二资源发送第二PDCCH
105、确定第一PDCCH的第一搜索空间和第二PDCCH的第二搜索空间
106、在第一搜索空间中确定出第一PDCCH占用的第一资源，以及在第二搜索空间中确定出第二PDCCH占用的第二资源
107、使用第一资源获取第一PDCCH，并使用第二资源获取第二PDCCH

图2

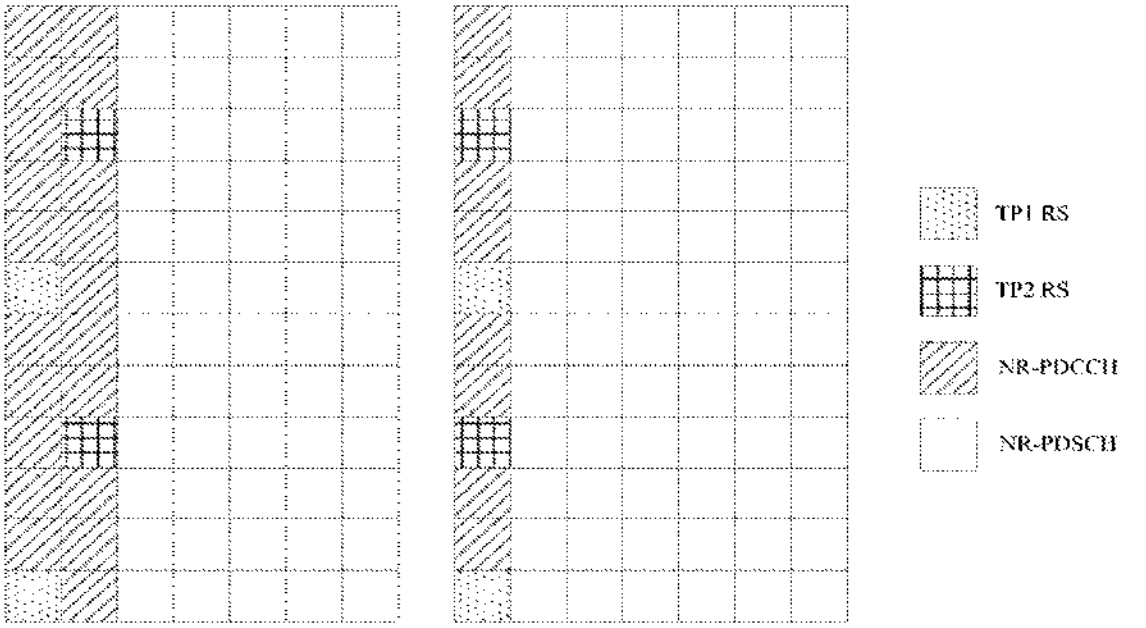


图3

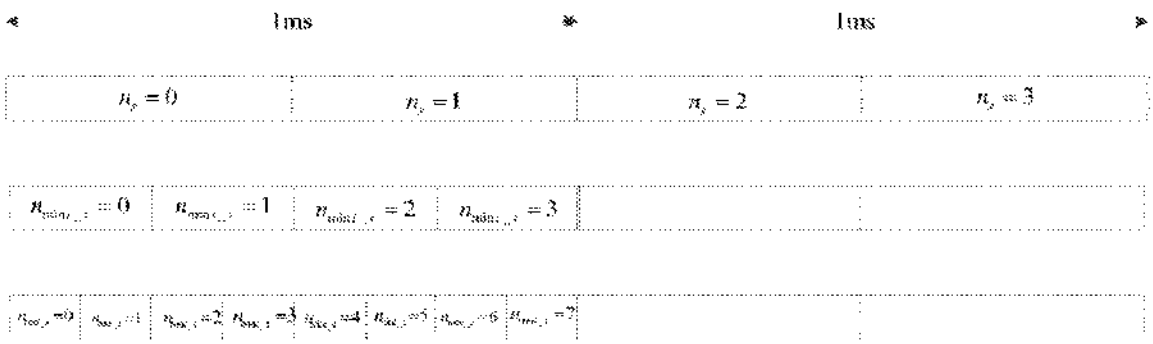


图4

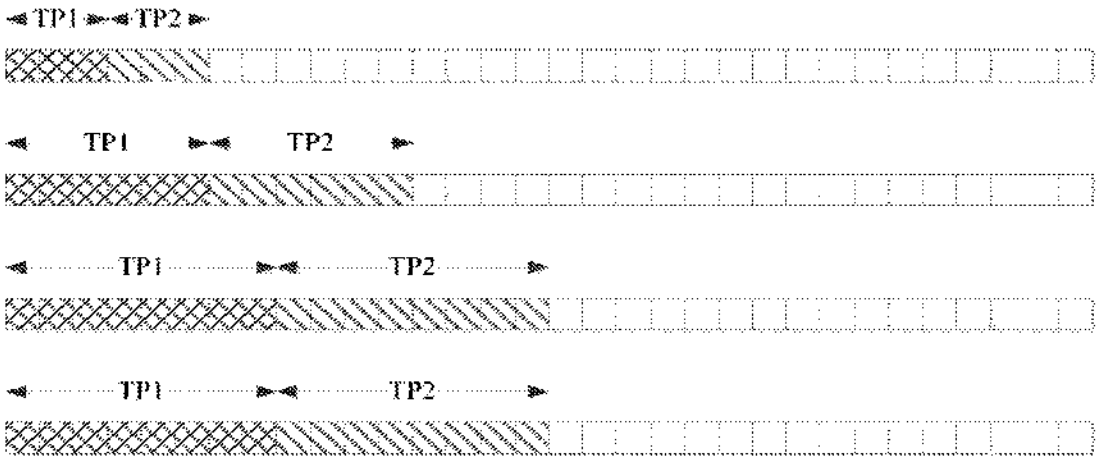


图5a

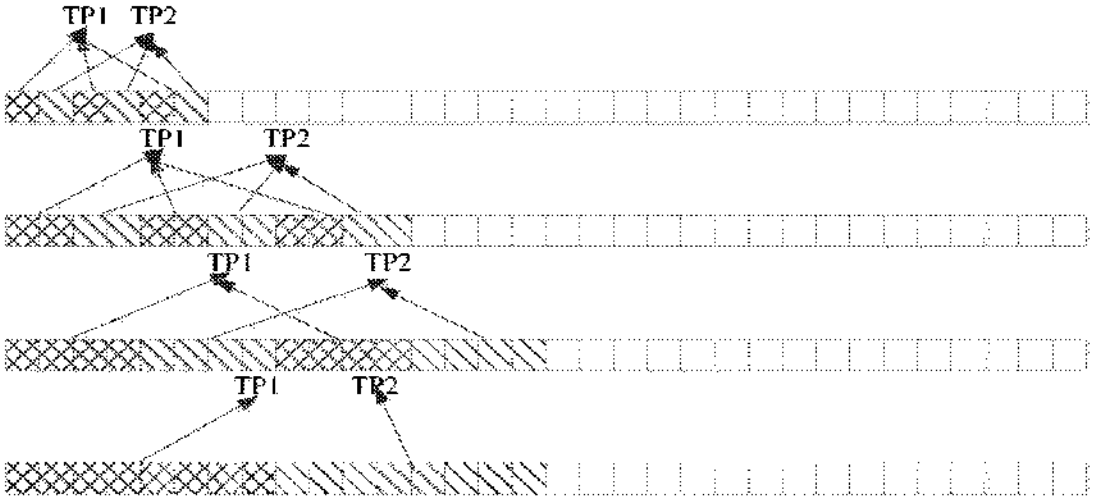


图5b

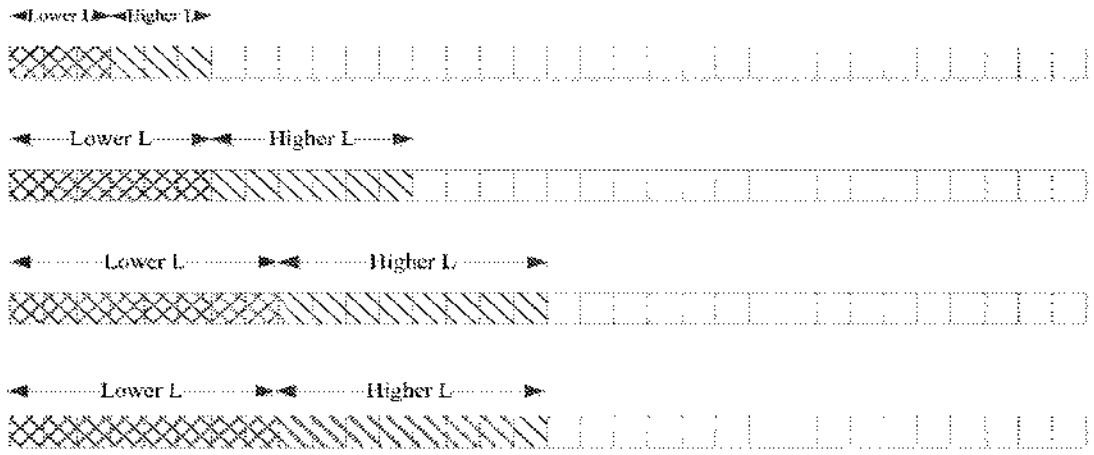

Lower L
Higher L
Lower L
Higher L
Lower L
Higher L
Lower L
Higher L

图5c

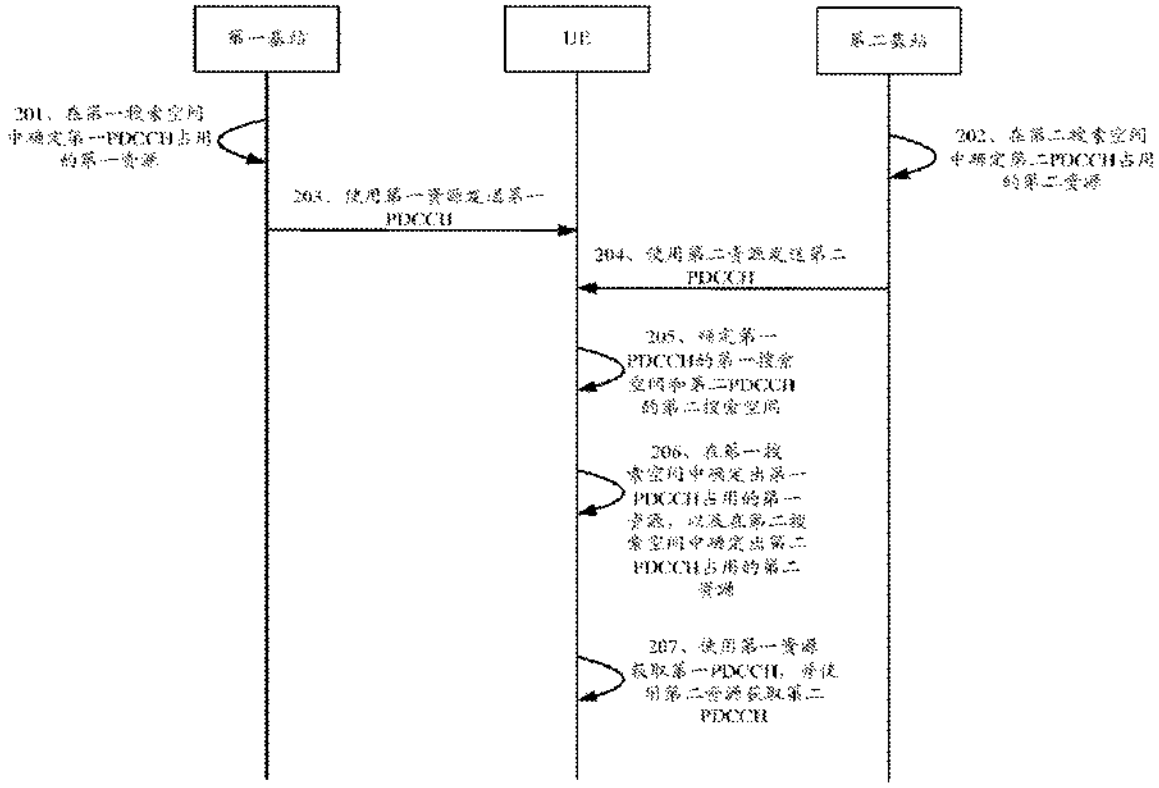

第一基站
UE
第二基站
201、在第一搜索空间中确定第一PDCCH占用的第一资源
202、在第二搜索空间中确定第二PDCCH占用的第二资源
203、使用第一资源发送第一PDCCH
204、使用第二资源发送第二PDCCH
205、确定第一PDCCH的第一搜索空间和第二PDCCH的第二搜索空间
206、在第一搜索空间中确定出第一PDCCH占用的第一资源，以及在第二搜索空间中确定出第二PDCCH占用的第二资源
207、使用第一资源获取第一PDCCH，并使用第二资源获取第二PDCCH

图6

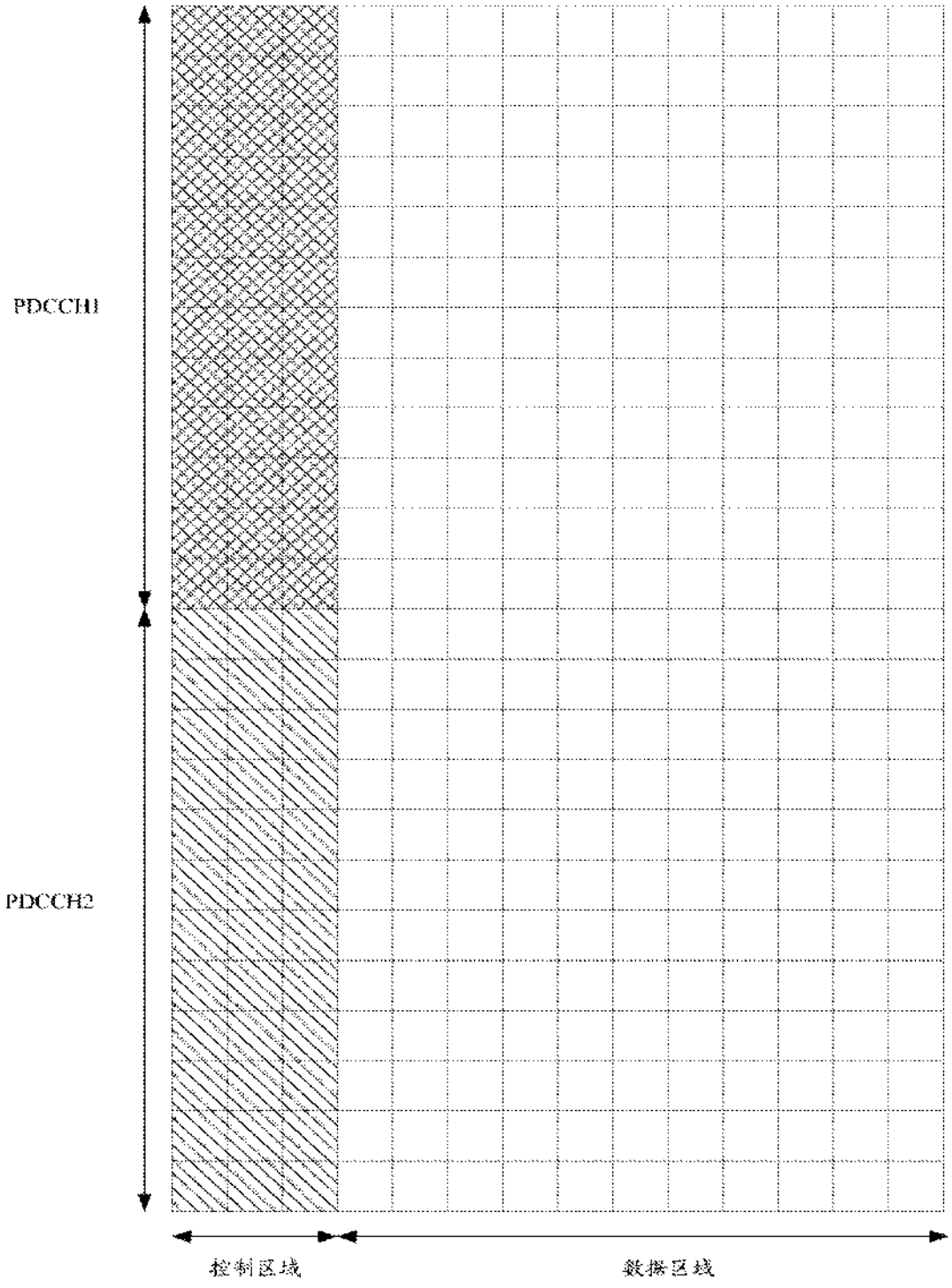


图7

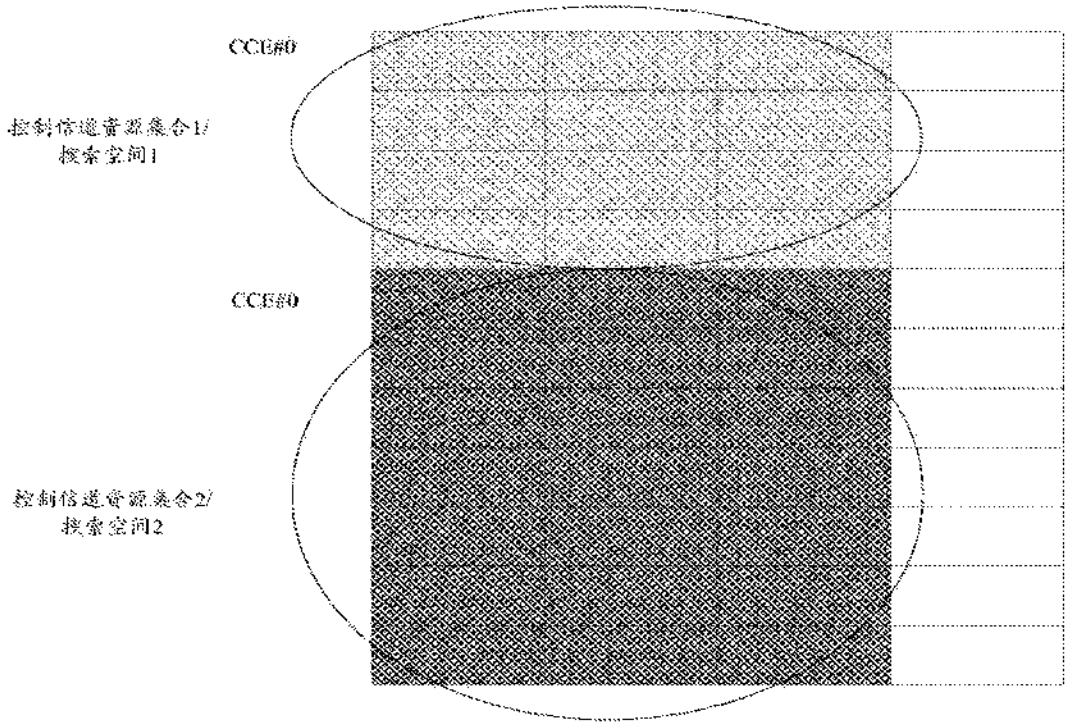


图8a

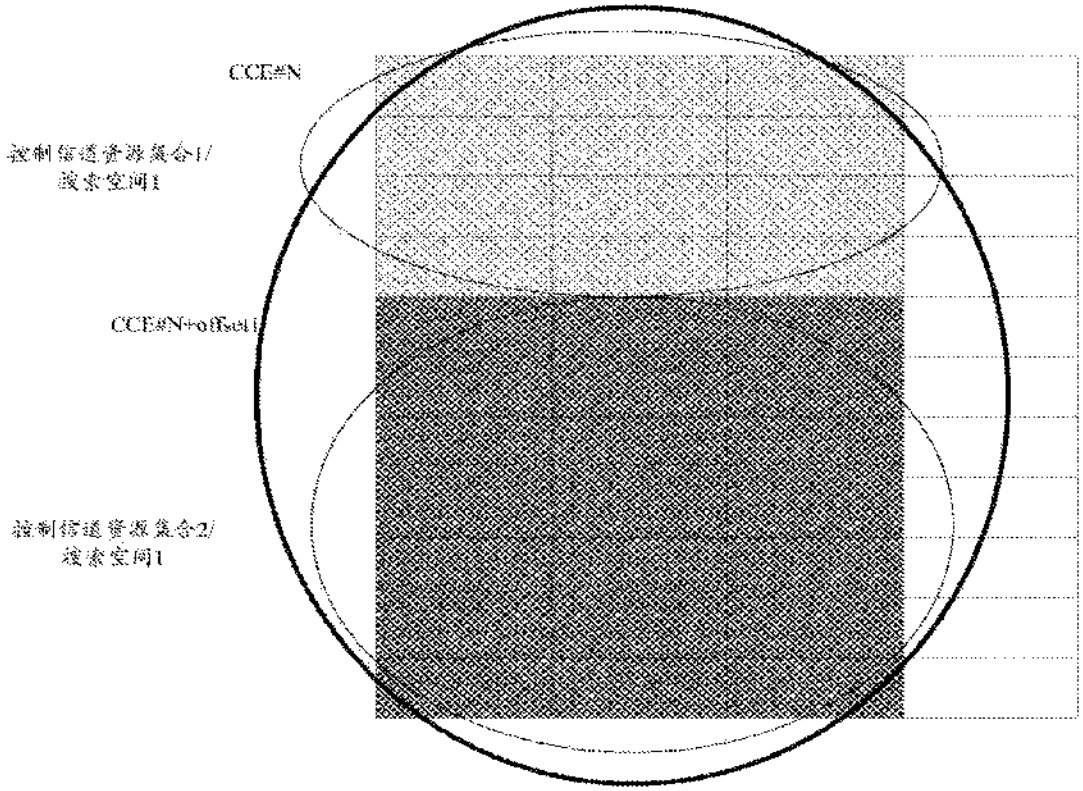


图8b

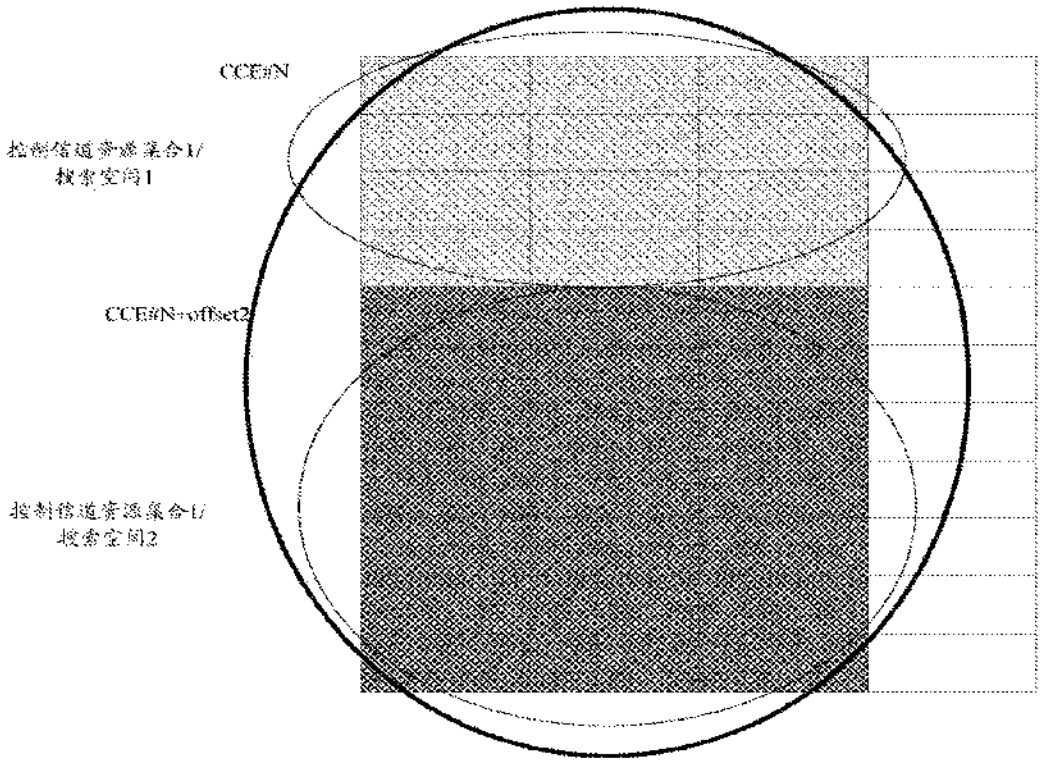


图8c

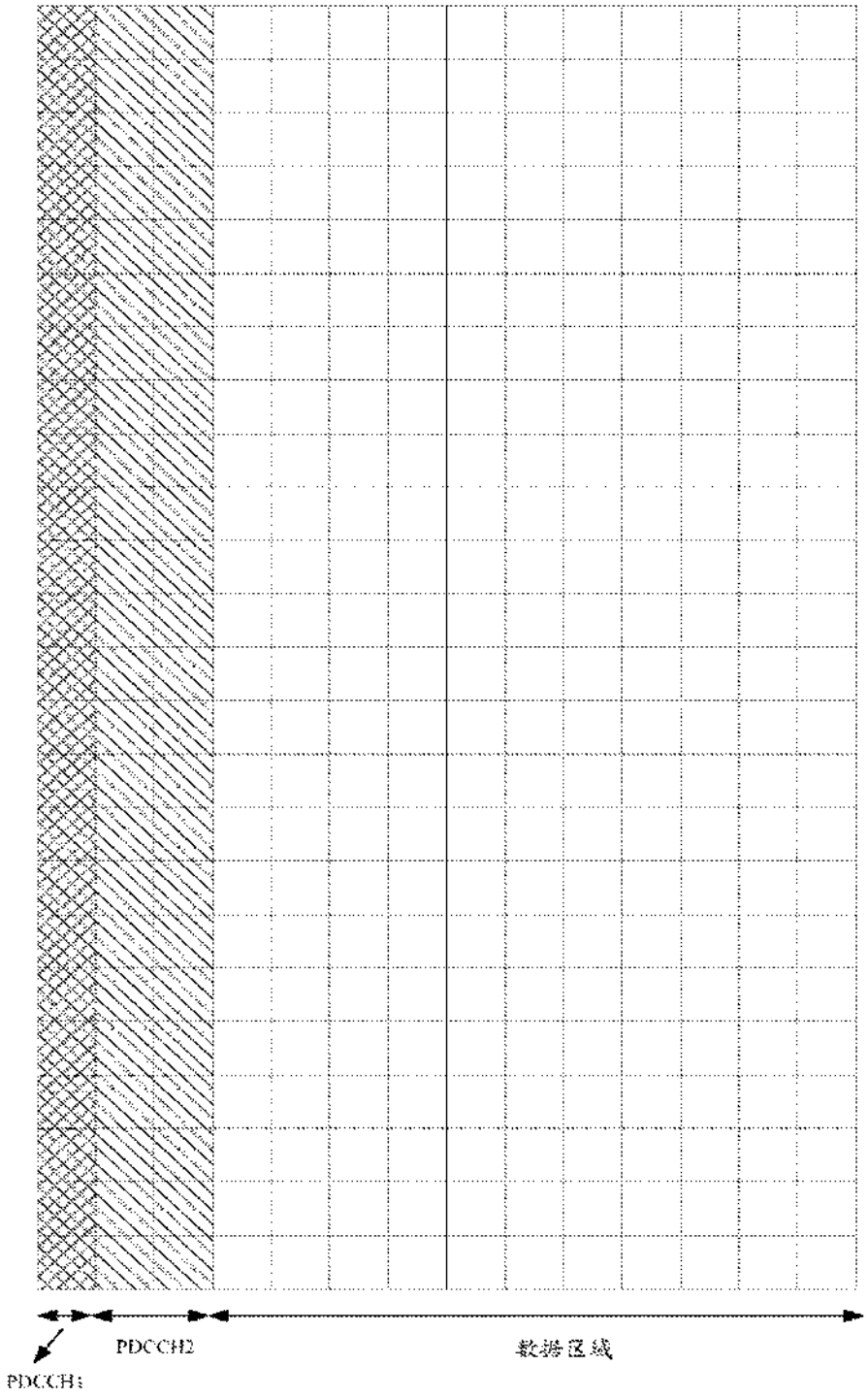


图9

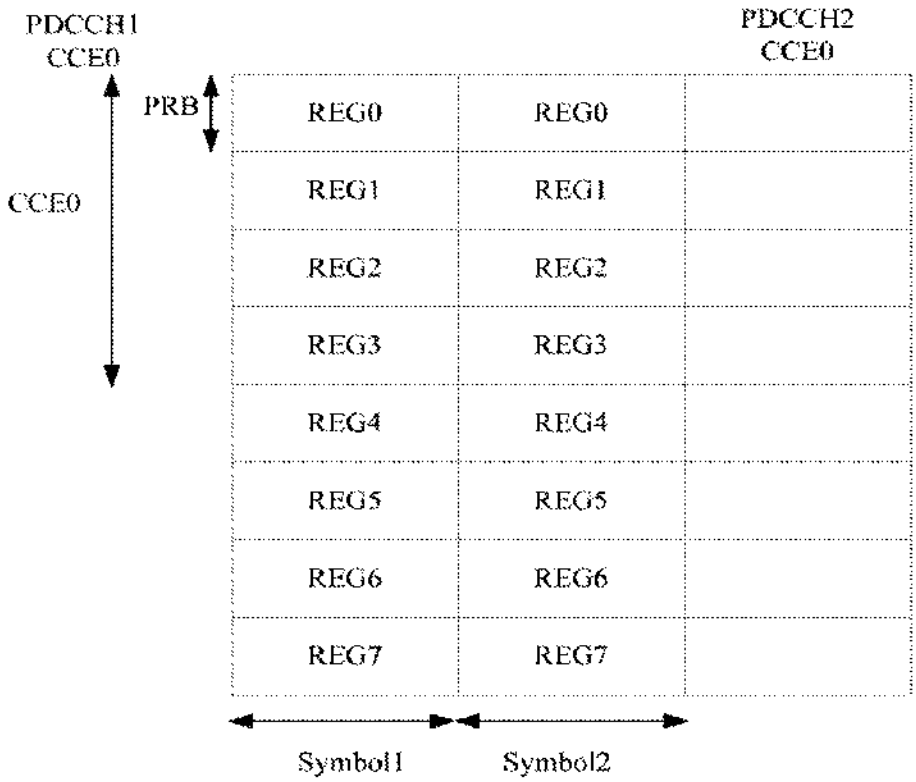

PDCCH1
CCE0
PRB
CCE0
PDCCH2
CCE0
REG0
REG0
REG1
REG1
REG2
REG2
REG3
REG3
REG4
REG4
REG5
REG5
REG6
REG6
REG7
REG7
Symbol1
Symbol2

图10a

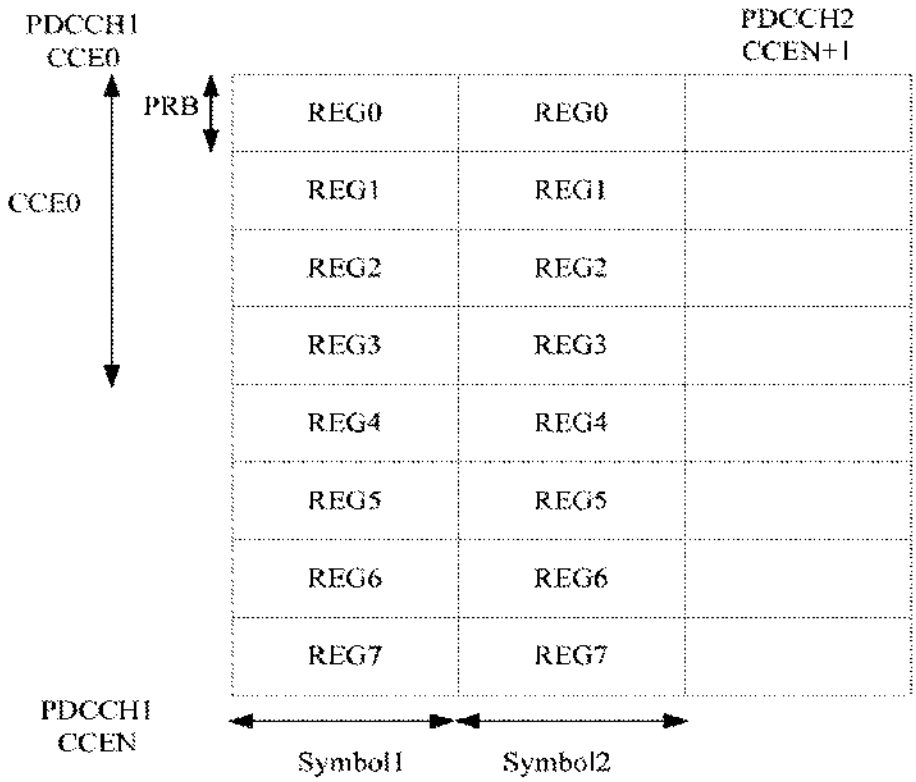

PDCCH1
CCE0
PRB
CCE0
PDCCH2
CCEN+1
REG0
REG1
REG2
REG3
REG4
REG5
REG6
REG7
REG0
REG1
REG2
REG3
REG4
REG5
REG6
REG7
PDCCH1
CCEN
Symbol1
Symbol2

图10b

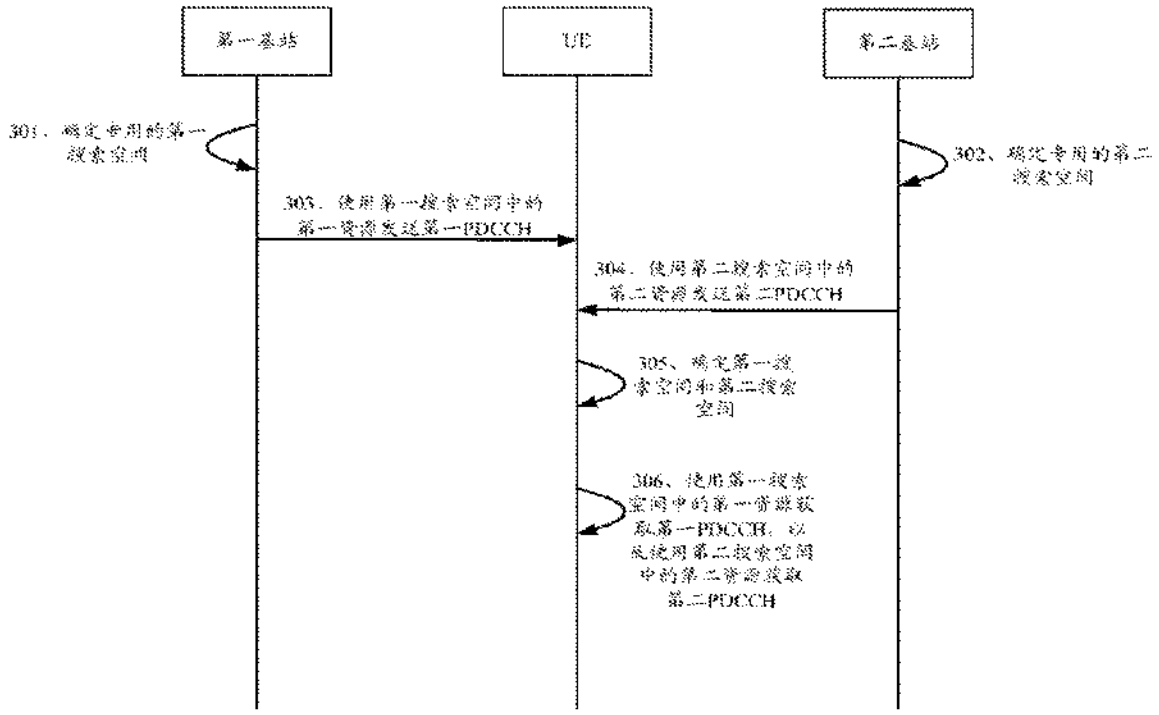

第一基站
UE
第二基站
301、确定专用的第一搜索空间
302、确定专用的第二搜索空间
303、使用第一搜索空间中的第一资源发送第一PDCCH
304、使用第二搜索空间中的第二资源发送第二PDCCH
305、确定第一搜索空间和第二搜索空间
306、使用第一搜索空间中的第一资源获取第一PDCCH，以及使用第二搜索空间中的第二资源获取第二PDCCH

图11

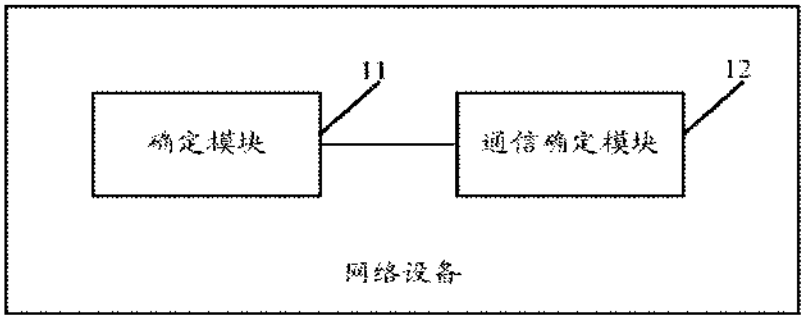

11
12
确定模块
通信确定模块
网络设备

图12

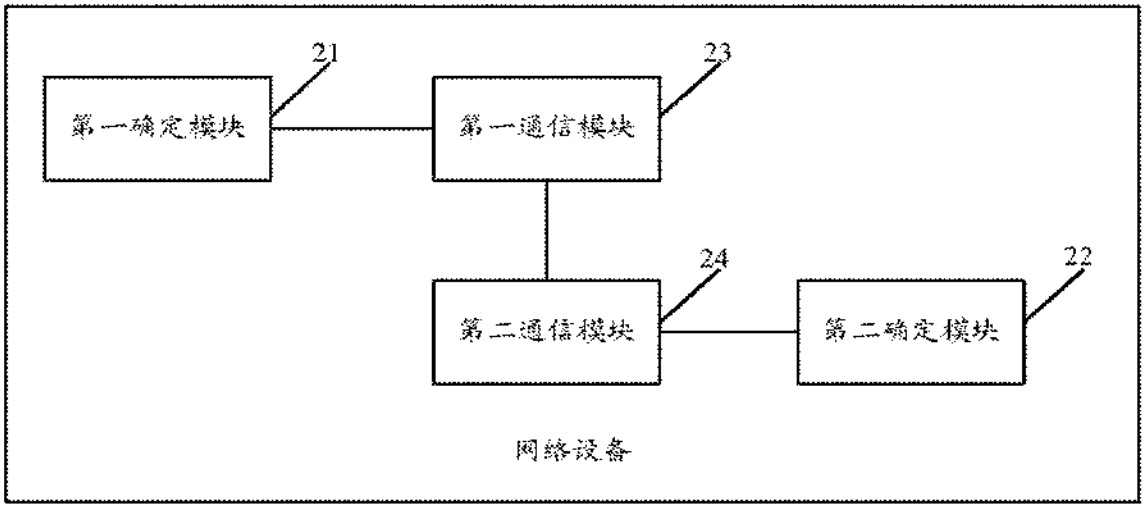

21
第一确定模块
23
第一通信模块
24
第二通信模块
22
第二确定模块
网络设备

图13

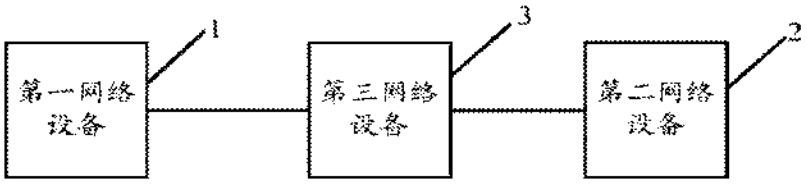

1
第一网络设备
3
第三网络设备
2
第二网络设备

图14

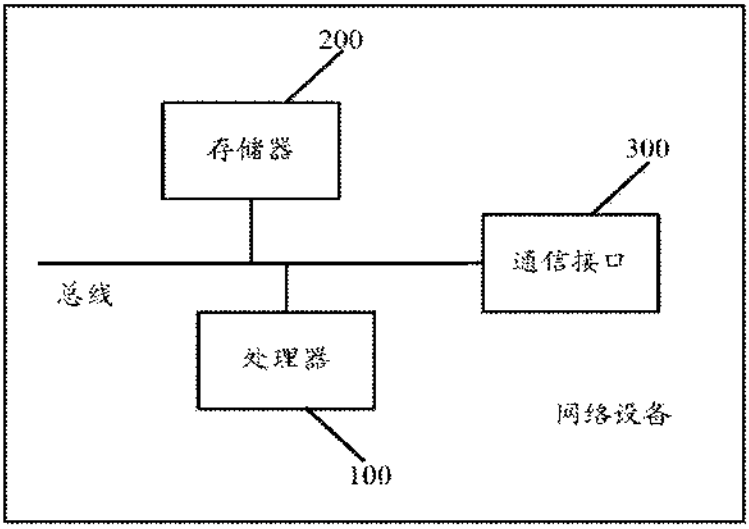

200
存储器
300
通信接口
总线
处理器
网络设备
100

图15

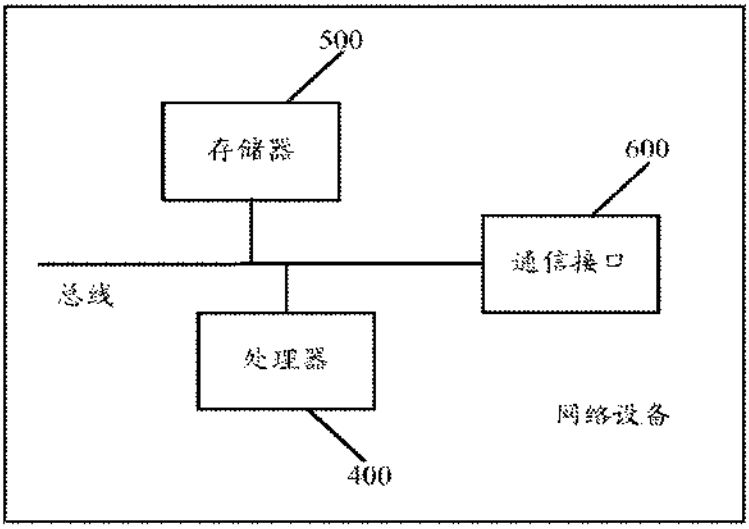

500
存储器
600
通信接口
总线
处理器
网络设备
400

图16

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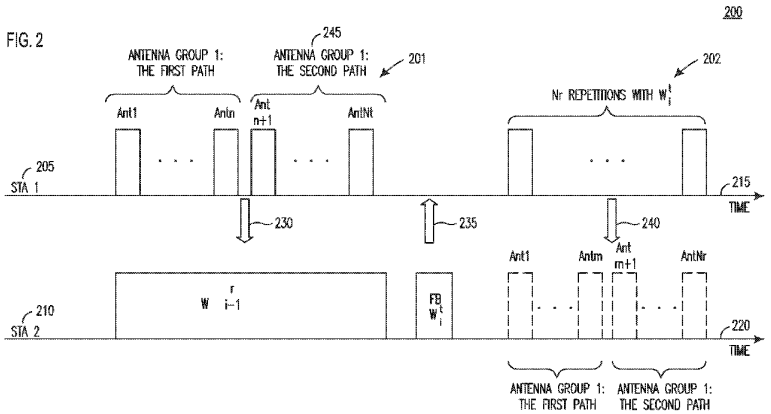
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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Published:

— *with international search report (Art. 21(3))*

(54) Title: BEAMFORMING METHODS AND METHODS FOR USING BEAMS



(57) Abstract: A method, apparatus, system, and computer readable medium may be used to perform beamforming. The method may include a first communication device sending a first plurality of beamforming training frames to a second communication device using a first beamforming weight vector; the first communication device receiving from the second communication device a second beamforming weight vector; and the first communication device sending a second plurality of beamforming training frames to the second communication device using the second beamforming weight vector. The apparatus, method, system, and computer readable media may use spatial diversity with beam switching, spatial diversity with a single beam, weighted multipath beamforming training, single user spatial multiplexing, and beamforming training for beam division multiple access (BDMA).

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BEAMFORMING METHODS AND METHODS FOR USING BEAMS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 61/724,679 filed on November 9, 2012, the contents of which are hereby incorporated by reference.

BACKGROUND

[0002] Some wireless communication networks support operation at very high and even extremely high carrier frequencies such as 60 GHz and millimeter wave (mmW) frequency bands. These extremely high carrier frequencies may support very high throughput such as up to 6 gigabits per second (Gbps). One of the challenges for wireless communication at very high or extremely high carrier frequencies is that a significant propagation loss may occur due to the high carrier frequency. As the carrier frequency increases, the carrier wavelength may decrease, and the propagation loss may increase as well.

[0003] At mmW frequency bands, the propagation loss may be severe. For example, the propagation loss may be on the order of 22 to 27 dB, relative to that observed in either the 2.4 GHz, or 5 GHz bands. Since the available spectrum is limited, however, and since users continue to demand more bandwidth, there is a need for effectively using very high and extremely high carrier frequencies for communication networks.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] FIG. 1A is a system diagram of an example communications system in which one or more disclosed embodiments may be implemented;

[0005] FIG. 1B is a system diagram of an example wireless transmit/receive unit (WTRU) that may be used within the communications system illustrated in FIG. 1A;

[0006] FIG. 1C is a system diagram of an example radio access network and an example core network that may be used within the communications system illustrated in FIG. 1A;

[0007] FIG. 1D is a diagram of an example WLAN with an AP and STA forming a BSS, and beamforming with multipath channels;

[0008] FIG. 1E is a diagram of another example WLAN with an AP and STA forming a BSS, and beamforming with multiple channels;

[0009] FIG. 2 is a diagram of an example of a method using two STAs to perform a multi-path beamforming method;

[0010] FIG. 3 is a diagram of an example of one iteration of the multi-path beamforming method using BRP transactions;

[0011] FIG. 4 is a diagram of an example frame format of a BRP packet;

[0012] FIG. 5 is a diagram of an example format of a BRP frame Action field;

[0013] FIG. 6 is a diagram of an example modified channel measurement feedback element;

[0014] FIG. 7 is a diagram of an example AP configured to perform a transmission using full size beamforming with STBC;

[0015] FIG. 8 is a diagram of an example AP configured to perform a transmission using partial size beamforming with STBC;

[0016] FIG. 9 is a diagram of an example transceiver architecture;

[0017] FIG. 10 is a diagram of another example transceiver architecture;

[0018] FIG. 11 is a diagram of an example beam division multiple access (BDMA) architecture;

[0019] FIG. 12 is a diagram of an example beamforming training method for BDMA;

[0020] FIG. 13 is a diagram of an example modified BRP procedure to implement a multi-stage iterative beamforming training method for BDMA;

[0021] FIG. 14 is a diagram of an example PHY layer frame format;

[0022] FIG. 15 is a diagram of an example beamforming training procedure using Eigen-beamforming based spatial multiplexing where the

communication devices may be configured to calibrate multiple transmit RF chains;

[0023] FIG. 16 is a diagram of an example beamforming training method for Type I devices and for Type II devices without calibration;

[0024] FIG. 17 is a diagram of an example beamforming training method for beam sweep based spatial multiplexing for Type I devices with calibration between two TX chains;

[0025] FIG. 18 is a diagram of an example beamforming training method for beam sweep based spatial multiplexing Type II devices and Type I devices without calibration;

[0026] FIG. 19 is a diagram of an example modified FBCK-TYPE subfield;

[0027] FIG. 20A is a diagram of an example PHY layer frame format;

[0028] FIG. 20B is a diagram of another example PHY layer frame format;

[0029] FIG. 20C is a diagram of another example PHY layer frame format;

[0030] FIG. 21 is a diagram of an example modified SSW training frames and sequence;

[0031] FIG. 22 is a diagram of an example SSWA frame format;

[0032] FIG. 23 is a diagram of an example early termination of the SLS training procedure; and

[0033] FIG. 24 is a diagram of an example multi-beam multi-DMG antenna SLS feedback method.

SUMMARY

[0034] A first communication device for beamforming may include a plurality of antennas and a processor. The processor may be configured to partition the antenna into at least a first group of antennas and a second group of antennas. The processor may be further configured to send a plurality of beamforming training frames to a second communication device using the

first group of antennas and the second group of antennas. The processor and/or a receiver may be configured to receive, from the second communication device, a first beamforming weight vector for sending signals on the first group of antennas and to receive a second beamforming weight vector for sending signals on the second group of antennas.

[0035] A method of beamforming training for beam division multiple access (BDMA) may include an AP transmitting Nt sequences modulated using Nt beamforming vectors. A first station may use a first previous beamforming vector to receive the Nt sequences and determine a first transmit beamforming weight from the AP to the first station based on the first previous beamforming vector and the received Nt sequences. The first station may send the determined first transmit beamforming weight to the AP. A second station may use a second previous beamforming vector to receive the Nt sequences and determine a second transmit beamforming weight from the AP to the first station based on the second previous beamforming vector and the received Nt sequences. The second station may send the determined second transmit beamforming weight to the AP, and the AP may transmit one or more sequences modulated based on the first transmit beamforming weight and the second transmit beamforming weight.

[0036] A method and apparatus may be used for spatial diversity with beam switching, spatial diversity with a single beam, weighted multipath beamforming training, single user spatial multiplexing, and for reduced beamforming training overhead.

DETAILED DESCRIPTION

[0037] FIG. 1A is a diagram of an example communications system 100 in which one or more disclosed embodiments may be implemented. The communications system 100 may be a multiple access system that provides content, such as voice, data, video, messaging, broadcast, etc., to multiple wireless users. The communications system 100 may enable multiple wireless users to access such content through the sharing of system resources,

including wireless bandwidth. For example, the communications systems 100 may employ one or more channel access methods, such as code division multiple access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), orthogonal FDMA (OFDMA), single-carrier FDMA (SC-FDMA), and the like.

[0038] As shown in FIG. 1A, the communications system 100 may include wireless transmit/receive units (WTRUs) 102a, 102b, 102c, 102d, a radio access network (RAN) 104, a core network 106, a public switched telephone network (PSTN) 108, the Internet 110, and other networks 112, though it will be appreciated that the disclosed embodiments contemplate any number of WTRUs, base stations, networks, and/or network elements. Each of the WTRUs 102a, 102b, 102c, 102d may be any type of device configured to operate and/or communicate in a wireless environment. By way of example, the WTRUs 102a, 102b, 102c, 102d may be configured to transmit and/or receive wireless signals and may include user equipment (UE), a mobile station, a fixed or mobile subscriber unit, a pager, a cellular telephone, a personal digital assistant (PDA), a smartphone, a laptop, a netbook, a personal computer, a wireless sensor, consumer electronics, and the like.

[0039] The communications systems 100 may also include a base station 114a and a base station 114b. Each of the base stations 114a, 114b may be any type of device configured to wirelessly interface with at least one of the WTRUs 102a, 102b, 102c, 102d to facilitate access to one or more communication networks, such as the core network 106, the Internet 110, and/or the networks 112. By way of example, the base stations 114a, 114b may be a base transceiver station (BTS), a Node-B, an eNode B, a Home Node B, a Home eNode B, a site controller, an access point (AP), a wireless router, and the like. While the base stations 114a, 114b are each depicted as a single element, it will be appreciated that the base stations 114a, 114b may include any number of interconnected base stations and/or network elements.

[0040] The base station 114a may be part of the RAN 104, which may also include other base stations and/or network elements (not shown), such as

a base station controller (BSC), a radio network controller (RNC), relay nodes, etc. The base station 114a and/or the base station 114b may be configured to transmit and/or receive wireless signals within a particular geographic region, which may be referred to as a cell (not shown). The cell may further be divided into cell sectors. For example, the cell associated with the base station 114a may be divided into three sectors. Thus, in one embodiment, the base station 114a may include three transceivers, i.e., one for each sector of the cell. In another embodiment, the base station 114a may employ multiple-input multiple output (MIMO) technology and, therefore, may utilize multiple transceivers for each sector of the cell.

[0041] The base stations 114a, 114b may communicate with one or more of the WTRUs 102a, 102b, 102c, 102d over an air interface 116, which may be any suitable wireless communication link (e.g., radio frequency (RF), microwave, infrared (IR), ultraviolet (UV), visible light, etc.). The air interface 116 may be established using any suitable radio access technology (RAT).

[0042] More specifically, as noted above, the communications system 100 may be a multiple access system and may employ one or more channel access schemes, such as CDMA, TDMA, FDMA, OFDMA, SC-FDMA, and the like. For example, the base station 114a in the RAN 104 and the WTRUs 102a, 102b, 102c may implement a radio technology such as Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access (UTRA), which may establish the air interface 116 using wideband CDMA (WCDMA). WCDMA may include communication protocols such as High-Speed Packet Access (HSPA) and/or Evolved HSPA (HSPA+). HSPA may include High-Speed Downlink Packet Access (HSDPA) and/or High-Speed Uplink Packet Access (HSUPA).

[0043] In another embodiment, the base station 114a and the WTRUs 102a, 102b, 102c may implement a radio technology such as Evolved UMTS Terrestrial Radio Access (E-UTRA), which may establish the air interface 116 using Long Term Evolution (LTE) and/or LTE-Advanced (LTE-A).

[0044] In other embodiments, the base station 114a and the WTRUs 102a, 102b, 102c may implement radio technologies such as IEEE 802.16 (i.e., Worldwide Interoperability for Microwave Access (WiMAX)), CDMA2000, CDMA2000 1X, CDMA2000 EV-DO, Interim Standard 2000 (IS-2000), Interim Standard 95 (IS-95), Interim Standard 856 (IS-856), Global System for Mobile communications (GSM), Enhanced Data rates for GSM Evolution (EDGE), GSM EDGE (GERAN), and the like.

[0045] The base station 114b in FIG. 1A may be a wireless router, Home Node B, Home eNode B, or access point, for example, and may utilize any suitable RAT for facilitating wireless connectivity in a localized area, such as a place of business, a home, a vehicle, a campus, and the like. In one embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.11 to establish a wireless local area network (WLAN). In another embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.15 to establish a wireless personal area network (WPAN). In yet another embodiment, the base station 114b and the WTRUs 102c, 102d may utilize a cellular-based RAT (e.g., WCDMA, CDMA2000, GSM, LTE, LTE-A, etc.) to establish a picocell or femtocell. As shown in FIG. 1A, the base station 114b may have a direct connection to the Internet 110. Thus, the base station 114b may not be required to access the Internet 110 via the core network 106.

[0046] The RAN 104 may be in communication with the core network 106, which may be any type of network configured to provide voice, data, applications, and/or voice over internet protocol (VoIP) services to one or more of the WTRUs 102a, 102b, 102c, 102d. For example, the core network 106 may provide call control, billing services, mobile location-based services, pre-paid calling, Internet connectivity, video distribution, etc., and/or perform high-level security functions, such as user authentication. Although not shown in FIG. 1A, it will be appreciated that the RAN 104 and/or the core network 106 may be in direct or indirect communication with other RANs that employ the same RAT as the RAN 104 or a different RAT. For example, in addition to

being connected to the RAN 104, which may be utilizing an E-UTRA radio technology, the core network 106 may also be in communication with another RAN (not shown) employing a GSM radio technology.

[0047] The core network 106 may also serve as a gateway for the WTRUs 102a, 102b, 102c, 102d to access the PSTN 108, the Internet 110, and/or other networks 112. The PSTN 108 may include circuit-switched telephone networks that provide plain old telephone service (POTS). The Internet 110 may include a global system of interconnected computer networks and devices that use common communication protocols, such as the transmission control protocol (TCP), user datagram protocol (UDP) and the internet protocol (IP) in the TCP/IP internet protocol suite. The networks 112 may include wired or wireless communications networks owned and/or operated by other service providers. For example, the networks 112 may include another core network connected to one or more RANs, which may employ the same RAT as the RAN 104 or a different RAT.

[0048] Some or all of the WTRUs 102a, 102b, 102c, 102d in the communications system 100 may include multi-mode capabilities, i.e., the WTRUs 102a, 102b, 102c, 102d may include multiple transceivers for communicating with different wireless networks over different wireless links. For example, the WTRU 102c shown in FIG. 1A may be configured to communicate with the base station 114a, which may employ a cellular-based radio technology, and with the base station 114b, which may employ an IEEE 802 radio technology.

[0049] FIG. 1B is a system diagram of an example WTRU 102. As shown in FIG. 1B, the WTRU 102 may include a processor 118, a transceiver 120, a transmit/receive element 122, a speaker/microphone 124, a keypad 126, a display/touchpad 128, non-removable memory 106, removable memory 132, a power source 134, a global positioning system (GPS) chipset 136, and other peripherals 138. It will be appreciated that the WTRU 102 may include any sub-combination of the foregoing elements while remaining consistent with an embodiment.

[0050] The processor 118 may be a general purpose processor, a special purpose processor, a conventional processor, a digital signal processor (DSP), a plurality of microprocessors, one or more microprocessors in association with a DSP core, a controller, a microcontroller, Application Specific Integrated Circuits (ASICs), Field Programmable Gate Array (FPGAs) circuits, any other type of integrated circuit (IC), a state machine, and the like. The processor 118 may perform signal coding, data processing, power control, input/output processing, and/or any other functionality that enables the WTRU 102 to operate in a wireless environment. The processor 118 may be coupled to the transceiver 120, which may be coupled to the transmit/receive element 122. While FIG. 1B depicts the processor 118 and the transceiver 120 as separate components, it will be appreciated that the processor 118 and the transceiver 120 may be integrated together in an electronic package or chip.

[0051] The transmit/receive element 122 may be configured to transmit signals to, or receive signals from, a base station (e.g., the base station 114a) over the air interface 116. For example, in one embodiment, the transmit/receive element 122 may be an antenna configured to transmit and/or receive RF signals. In another embodiment, the transmit/receive element 122 may be an emitter/detector configured to transmit and/or receive IR, UV, or visible light signals, for example. In yet another embodiment, the transmit/receive element 122 may be configured to transmit and receive both RF and light signals. It will be appreciated that the transmit/receive element 122 may be configured to transmit and/or receive any combination of wireless signals.

[0052] In addition, although the transmit/receive element 122 is depicted in FIG. 1B as a single element, the WTRU 102 may include any number of transmit/receive elements 122. More specifically, the WTRU 102 may employ MIMO technology. Thus, in one embodiment, the WTRU 102 may include two or more transmit/receive elements 122 (e.g., multiple antennas) for transmitting and receiving wireless signals over the air interface 116.

[0053] The transceiver 120 may be configured to modulate the signals that are to be transmitted by the transmit/receive element 122 and to demodulate the signals that are received by the transmit/receive element 122. As noted above, the WTRU 102 may have multi-mode capabilities. Thus, the transceiver 120 may include multiple transceivers for enabling the WTRU 102 to communicate via multiple RATs, such as UTRA and IEEE 802.11, for example.

[0054] The processor 118 of the WTRU 102 may be coupled to, and may receive user input data from, the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128 (e.g., a liquid crystal display (LCD) display unit or organic light-emitting diode (OLED) display unit). The processor 118 may also output user data to the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128. In addition, the processor 118 may access information from, and store data in, any type of suitable memory, such as the non-removable memory 106 and/or the removable memory 132. The non-removable memory 106 may include random-access memory (RAM), read-only memory (ROM), a hard disk, or any other type of memory storage device. The removable memory 132 may include a subscriber identity module (SIM) card, a memory stick, a secure digital (SD) memory card, and the like. In other embodiments, the processor 118 may access information from, and store data in, memory that is not physically located on the WTRU 102, such as on a server or a home computer (not shown).

[0055] The processor 118 may receive power from the power source 134, and may be configured to distribute and/or control the power to the other components in the WTRU 102. The power source 134 may be any suitable device for powering the WTRU 102. For example, the power source 134 may include one or more dry cell batteries (e.g., nickel-cadmium (NiCd), nickel-zinc (NiZn), nickel metal hydride (NiMH), lithium-ion (Li-ion), etc.), solar cells, fuel cells, and the like.

[0056] The processor 118 may also be coupled to the GPS chipset 136, which may be configured to provide location information (e.g., longitude and

latitude) regarding the current location of the WTRU 102. In addition to, or in lieu of, the information from the GPS chipset 136, the WTRU 102 may receive location information over the air interface 116 from a base station (e.g., base stations 114a, 114b) and/or determine its location based on the timing of the signals being received from two or more nearby base stations. It will be appreciated that the WTRU 102 may acquire location information by way of any suitable location-determination method while remaining consistent with an embodiment.

[0057] The processor 118 may further be coupled to other peripherals 138, which may include one or more software and/or hardware modules that provide additional features, functionality and/or wired or wireless connectivity. For example, the peripherals 138 may include an accelerometer, an e-compass, a satellite transceiver, a digital camera (for photographs or video), a universal serial bus (USB) port, a vibration device, a television transceiver, a hands free headset, a Bluetooth® module, a frequency modulated (FM) radio unit, a digital music player, a media player, a video game player module, an Internet browser, and the like.

[0058] FIG. 1C is a system diagram of the RAN 104 and the core network 106 according to an embodiment. As noted above, the RAN 104 may employ an E-UTRA radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 116. The RAN 104 may also be in communication with the core network 106.

[0059] The RAN 104 may include eNode-Bs 140a, 140b, 140c, though it will be appreciated that the RAN 104 may include any number of eNode-Bs while remaining consistent with an embodiment. The eNode-Bs 140a, 140b, 140c may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 116. In one embodiment, the eNode-Bs 140a, 140b, 140c may implement MIMO technology. Thus, the eNode-B 140a, for example, may use multiple antennas to transmit wireless signals to, and receive wireless signals from, the WTRU 102a.

[0060] Each of the eNode-Bs 140a, 140b, 140c may be associated with a particular cell (not shown) and may be configured to handle radio resource management decisions, handover decisions, scheduling of users in the uplink and/or downlink, and the like. As shown in FIG. 1C, the eNode-Bs 140a, 140b, 140c may communicate with one another over an X2 interface.

[0061] The core network 106 shown in FIG. 1C may include a mobility management gateway (MME) 142, a serving gateway 144, and a packet data network (PDN) gateway 146. While each of the foregoing elements are depicted as part of the core network 106, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

[0062] The MME 142 may be connected to each of the eNode-Bs 142a, 142b, 142c in the RAN 104 via an S1 interface and may serve as a control node. For example, the MME 142 may be responsible for authenticating users of the WTRUs 102a, 102b, 102c, bearer activation/deactivation, selecting a particular serving gateway during an initial attach of the WTRUs 102a, 102b, 102c, and the like. The MME 142 may also provide a control plane function for switching between the RAN 104 and other RANs (not shown) that employ other radio technologies, such as GSM or WCDMA.

[0063] The serving gateway 144 may be connected to each of the eNode Bs 140a, 140b, 140c in the RAN 104 via the S1 interface. The serving gateway 144 may generally route and forward user data packets to/from the WTRUs 102a, 102b, 102c. The serving gateway 144 may also perform other functions, such as anchoring user planes during inter-eNode B handovers, triggering paging when downlink data is available for the WTRUs 102a, 102b, 102c, managing and storing contexts of the WTRUs 102a, 102b, 102c, and the like.

[0064] The serving gateway 144 may also be connected to the PDN gateway 146, which may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, such as the Internet 110, to facilitate communications between the WTRUs 102a, 102b, 102c and IP-enabled devices. An access router (AR) 150 of a wireless local area network (WLAN)

155 may be in communication with the Internet 110. The AR 150 may facilitate communications between APs 160a, 160b, and 160c. The APs 160a, 160b, and 160c may be in communication with STAs 170a, 170b, and 170c.

[0065] The core network 106 may facilitate communications with other networks. For example, the core network 106 may provide the WTRUs 102a, 102b, 102c with access to circuit-switched networks, such as the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, 102c and traditional land-line communications devices. For example, the core network 106 may include, or may communicate with, an IP gateway (e.g., an IP multimedia subsystem (IMS) server) that serves as an interface between the core network 106 and the PSTN 108. In addition, the core network 106 may provide the WTRUs 102a, 102b, 102c with access to the networks 112, which may include other wired or wireless networks that are owned and/or operated by other service providers.

[0066] Fig. 1D is a diagram of an example use of beamforming in a WLAN 185. The WLAN 185 may include an AP 190 and an STA 192 forming a BSS. Fig. 1E is a diagram of an example use of beamforming using spatial diversity or multipath diversity in the WLAN 185. The WLAN 185 may include an AP 190 and an STA 192 forming a BSS. A WLAN in a Infrastructure Basic Service Set (BSS) mode has an Access Point (AP) 190 for the BSS and one or more stations (STAs) 192 associated with the AP. The AP 190 may have an access, or interface, to a Distribution System (DS) 195, or another type of wired/wireless network that carries traffic in and out of the BSS. Traffic to STAs that originates from outside the BSS may arrive through the AP to be delivered to the STAs. Traffic originating from STAs to destinations outside the BSS may be sent to the AP to be delivered to the respective destinations. Traffic between STAs within the BSS may also be sent through the AP where the source STA may send traffic to the AP and the AP may deliver the traffic to the destination STA. Such traffic between STAs within a BSS may be peer-to-peer traffic. Such peer-to-peer traffic may also be sent directly between the source and destination STAs with a direct link setup

(DLS) using an 802.11e DLS or an 802.11z tunneled DLS (TDLS). A WLAN using an Independent BSS (IBSS) mode has no AP, and/or STAs, communicating directly with each other. This mode of communication may be referred to as an "ad-hoc" mode of communication.

[0067] As used herein an STA 192 may include, but is not limited to, a WTRU 102, an AP, or a communication device. Using the 802.11 infrastructure mode of operation, the AP 190 may transmit a beacon on a fixed channel, usually the primary channel. This channel may be 20 MHz wide, and may be the operating channel of the BSS. This channel may also be used by the STAs to establish a connection with the AP. The fundamental channel access mechanism in an 802.11 system may be Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA). In this mode of operation, every STA, including the AP, may sense the primary channel. If the channel is detected to be busy, the STA may back off. Hence only one STA may transmit at any given time in a given BSS.

[0068] In an 802.11n example, High Throughput (HT) STAs may also use a 40 MHz wide channel for communication. This 40 MHz wide channel may be achieved by combining the primary 20 MHz channel, with an adjacent 20 MHz channel to form a 40 MHz wide contiguous channel. 802.11n may operate on the 2.4 GHz, and 5 GHz ISM bands.

[0069] In an 802.11ac example, Very High Throughput (VHT) STAs may support 20 MHz, 40 MHz, 80 MHz, and 160 MHz wide channels. The 40 MHz, and 80 MHz, channels may be formed by combining contiguous 20 MHz channels similar to 802.11n described above. A 160 MHz channel may be formed either by combining 8 contiguous 20 MHz channels, or by combining two non-contiguous 80 MHz channels, this may also be referred to as an 80+80 configuration. For the 80+80 configuration, the data, after channel encoding, is passed through a segment parser that may divide it into two streams. IFFT and time domain processing are done on each stream separately. The streams may then be mapped on two channels, and the data may be transmitted. At the receiver, this process may be reversed, and the combined data may be sent

to the MAC. 802.11ac may operate only on the 5 GHz ISM band, and consequently may not be backward compatible with 802.11n modes of operation in the 2.4 GHz ISM band. For the examples described herein, any combination of channels may be used, and should not be limited to contiguous and non-contiguous channels.

[0070] Sub 1 GHz modes of operation may be supported by 802.11af, and 802.11ah. For these specifications the channel operating bandwidths may be reduced relative to those used in 802.11n, and 802.11ac. 802.11af may support 5 MHz, 10 MHz and 20 MHz bandwidths in the TV White Space (TVWS) spectrum, and 802.11ah may support 1 MHz, 2 MHz, 4 MHz, 8 MHz, and 16 MHz bandwidths using a non-TVWS spectrum. A possible use case for 802.11ah may support Meter Type Control (MTC) devices in a macro coverage area. MTC devices may have limited capabilities including only support for limited bandwidths, but also may include a requirement for a very long battery life. 802.11ah may also be used for macro coverage as support for cellular offload to WiFi.

[0071] In 802.11ad, wide bandwidth spectrum at 60 GHz may be available, thus enabling very high throughput operation. 802.11ad may support up to 2 GHz operating bandwidths and the data rate may reach up to 6 Gbps. Since the propagation loss at 60 GHz may be more significant than at the 2.4 GHz, and 5 GHz bands, beamforming may be adopted in 802.11ad as a means to extend the coverage range. To support the receiver requirements for this band, the 802.11ac MAC layer may be modified in several areas. An important modification for the 802.11ad MAC layer may include procedures that allow channel estimation and training. These procedures may include omni, and beamformed modes of operation which do not exist in 802.11ac.

[0072] WLAN systems that support multiple channels and channel widths, such as 802.11n, 802.11ac, 802.11af, and 802.11ah, may include a channel designated as the primary channel. The primary channel may, but not necessarily, have a bandwidth equal to the largest common operating bandwidth supported by all STAs in the BSS. The bandwidth of the primary

channel may therefore be limited by the STA, of all the STAs operating in a BSS, which supports or enables the use of the smallest bandwidth operating mode. In the example of 802.11ah, the primary channel may be 1 MHz wide if there are STAs, for example, MTC type devices that only support a 1 MHz mode, even if the AP, and other STAs in the BSS, may support a 2 MHz, 4 MHz, 8 MHz, 16 MHz, or other channel bandwidth operating modes. All carrier sensing and NAV settings may depend on the status of the primary channel. For example, if the primary channel is busy due to a STA supporting only a 1 MHz operating mode, then the entire available frequency bands may be considered busy even though a majority of the frequency bands remain idle and available.

[0073] In the United States, for example, the available frequency bands that may be used by 802.11ah are from 902 MHz to 928 MHz. In Korea, for example, the available frequency bands may be from 917.5 MHz to 923.5 MHz, and in Japan, it may be from 916.5 MHz to 927.5 MHz. The total bandwidth available for 802.11ah may be 6 MHz to 26 MHz depending on the country.

[0074] One of the challenges for wireless communication over 60 GHz may include significant propagation loss due to the high frequency. As the wavelength decreases, the free space propagation loss may increase. To address the range limitation due to this propagation loss, 802.11ad may use beamforming to increase the Effective Radiated Power (ERP) of the transmissions. Since the wavelength is small, it may be possible to use a large antenna array to get a very high beamformed antenna gain. The beam in 802.11ad may be electronically steered to a particular STA, or group of STAs, during association with the STAs.

[0075] In order to support beamforming, the 802.11ad PHY and MAC specifications may be modified to support directional transmissions, and millimeter wave (mmW) antenna training procedures. A comprehensive beamforming training protocol may be defined in 802.11ad. The beamforming training protocol may include two components, for example a sector level sweep (SLS) procedure and a beam refinement protocol (BRP) procedure. The

SLS procedure may be used for transmit beamforming training. The BRP procedure may enable receive beamforming training and iterative refinement of both the transmit and receive beams.

[0076] In order to reduce implementation complexity, 802.11ad may support beam switching at both the AP and the STA. The beam switching at both the AP and the STA may be in contrast to more advanced multi-antenna schemes, and may assume that a single RF front-end is available at both ends. Problems related to link robustness and spectral efficiency may be of importance for enabling 802.11ad+ to address the current trend for a Carrier Grade WiFi service. A Carrier Grade WiFi service may be referred to as 5G Carrier Grade WiFi, may provide high air interference efficiency for multiple users, and a stable "cellular-like" quality. A 5G Carrier Grade WiFi system may support robust and dynamic deployments, for example dense deployments and flash crowds.

[0077] Although 802.11ad may address the need for a very high peak throughput, limitations due to the propagation environment are not adequately addressed in 802.11ad.

[0078] For mmW communications it may be necessary to handle a propagation loss due in part to the high free space propagation loss which may occur at mmW frequencies. For example, blockage of transmissions by the human body may attenuate a signal by 15 to 25 dB for hundreds of milliseconds.

[0079] While propagation loss of walls and other indoor obstacles may prevent the propagation of mmW through them, indoor Line of Site (LOS) propagation may occur indoors. LOS propagation may occur indoors either due to a direct line of sight transmission, or due to reflections off walls and other obstacles. It should be noted that non-negligible propagation loss at mmW frequencies may occur due to walls and other environmental factors. Beam switching may be used in 802.11ad to utilize signal diversity due to these reflections.

[0080] Some mmW communications may utilize a single beam for communications, for example, in 802.11ad. MIMO techniques, such as spatial multiplexing, may be employed to improve the spectral efficiency of the system, however it may be difficult to use these techniques in mmW systems due to the need for multiple symbol generation. Methods that improve the spectral efficiency of mmW systems, such as methods that enable the use of spatial multiplexing, may be needed in future mmW specifications which for example may be based on 802.11ad, and/or in mmW systems in general.

[0081] Beamforming training protocols, such as SLS and BRP, may be used to perform transmit/receive beamforming training and iterative beam refinement training. The beamforming training overhead and latency of these procedures, however, may be significant. For example, with the transmit beamforming training defined in SLS, the transmitter may need to transmit multiple sector sweep (SSW) frames that may be modulated by different beamforming sectors. Each device may have up to 64 different beam sectors. Each SSW frame may include a full PLCP header, which may include a preamble, one or more header blocks, and a MAC frame. In order to fully exploit the beamforming gain, transmit and receive training procedures at both peer devices may be required, and an iterative beam refinement may also be needed. These procedures may represent a significant overhead and hence methods that reduce this overhead may be needed in part to allow for a better user experience in mmW systems.

[0082] Referring back to FIGS. 1D and 1E, multipath propagation may be common in indoor communications links. Beam switching based beamforming algorithms utilized in the current 802.11ad specification may attempt to point the beam to the strongest path. As shown in FIG. 1D, a LOS path and a strong reflection path may exist between AP 190 and STA 192. After the beamforming training procedure, the beam with the best channel gain may be selected. This beam may be formed towards the strongest path among multiple propagation paths. However, human blockage may introduce an average 20 dB loss for 230 ms, which may prevent the 60GHz radio to

provide multi-Gigabit/sec data transmissions. It is therefore highly likely that the beamformed link may be dropped, and hence the transmitted packet during this period would be lost. Moreover, due to the loss of the packet, the system may have to repeat the beamforming training and then retransmit the packet over a potentially new beam.

[0083] Example beamforming schemes may exploit the spatial diversity such that the transmission is not dependent on only the strongest path. As shown in FIG. 1E, with two strong propagation paths, for example, a LOS path and a strong reflection path, a number of solutions may be possible including fast beam switching, wider beam and multi-beam methods.

[0084] Spatial diversity may be achieved with fast beam switching. In order to accomplish fast beam switching when the channel condition changes, it may be necessary that both AP and STA have an available list of weight vectors/beam identifiers. Example methods for obtaining a list of weight vectors/beam identifiers are disclosed below. There may be two possibilities for fast-beam switching including in-band signaling and out-of-band signaling. In-band beam switching may be used in some examples.

[0085] In an in-band beam switching example, the AP may be communicating with the STA using a beam set (Tx and Rx beams) B1. The AP and STA may have prioritized the beam sets according to the received SNR, or SINR, during the SLS and BRP phases. The STA may monitor one or more of the received SNR, SINR, Bit-Error-Rate (BER) or Packet Error Rate (PER), acknowledgement (ACK) statistics or a combination of these parameters. If, at the end of a packet reception, the STA determines that the channel quality is deteriorating, it may append a message to the ACK packet requesting the AP to switch to the next best beam set, for example B2, for the next transmitted packet. The assumption here is that the channel condition may be deteriorating, but not to the point that the data packet cannot be decoded correctly and hence an ACK may be sent.

[0086] In another example, alternative beam retransmission methods may be used. In 802.11 systems, and mmW systems in particular, if no ACK

is received, the data packet may be retransmitted. This retransmission may use the same beam that was used in the prior transmission. An example for an alternative procedure may be that if the AP does not receive an ACK, the AP may retransmit the data packet using the beam set B2 instead of the beam set B1. Since these beam sets may have been defined prior to this procedure, possibly during association of the STA with the AP, the procedure at the STA may use the corresponding receive beam set B2 for reception of the retransmission from the AP. In an example procedure, the AP and the STA may define an association of indices to beam sets, and subsequently use the beam set indices for identification of beam sets in the aforementioned procedures.

[0087] In an alternative, or additional example, the AP may cycle the data packet through the N best beam-sets. The STA may then perform a procedure wherein it receives N packets from the AP, and perform maximum-ratio-combining, selection combining, or a similar receive algorithm, on these packets. An ACK may then be determined and sent to the AP, for example, after all N transmissions have occurred, or as soon as the packet has been successfully received and decoded.

[0088] In an alternative, or additional example, the AP may also transmit the data packet through all of, or a subset of, the N beam-sets simultaneously. The remainder of the procedure described in the previous paragraph may then follow in a similar way.

[0089] A beam set may include the identification of a primary beam within the beam set. The primary beam may be used by transmission procedures at the AP, STA, or both, as the beam to be used for initial attempts at wireless communication. Alternatively, the primary beam may be used exclusively for transmission of control or scheduling information. More than one primary beam may be used for more than one STA wherein each primary beam may be associated with a particular STA.

[0090] In an alternative, or in addition to, the AP may also cycle through different modes of MIMO operation for each beam set, prior to

proceeding to the next beam set. For example, if the AP does not receive an ACK on beam set B1 it may select a more robust form of operation such as Space Time Block Coding (STBC), Space Frequency Block Coding (SFBC), or Cyclic Delay Diversity (CDD), before proceeding to transmit on the remaining beam sets B2 through BN.

[0091] In some examples, a first and second best beam transmission method may be used. For example, the STA may determine the two best beams, B1, B2, using a procedure similar to the above, and recommend these beam indices to the AP. In this example, for the remainder of the communication interval, the AP and the STA may assume that either, or both, beam indices may be used for wireless communication.

[0092] The AP may then determine to transmit on either beam during a particular transmission time interval (TTI) based on one or more criteria determined by the AP. Example criteria may include one or more of the received SNR, or SINR, Bit-Error-Rate (BER), or Packet Error Rate (PER), acknowledgement (ACK) statistics, or a combination of these criteria. The STA may respond to a message from the AP with an indication of the reception quality, or similar metric, for the beam that it used to receive the message from the AP. This indication or metric may be indicated in the response by the beam index.

[0093] Alternatively, if the STA does not provide an indication of the reception quality in its ACK and/or any other packet to the AP, the AP may determine that the reception quality was acceptable for one or more associated beams. If the STA indicates a poor reception quality to the AP for B1, it may assume that the next transmission from the AP will use the second best beam B2.

[0094] During communication with the STA, the AP may store the packet reception quality for each transmission, on each beam, in a memory, while using either beam. If a particular beam in the pair becomes unusable for further communication, the AP may identify a new first, or a second best beam for communication with the STA, while at the same time continuing

communication on the remaining beam of the original beam pair. Other combinations of the procedures described in this example may be possible. The above example is not limited to a pair of beams and may be extended to support any number of beams greater than one that the system may simultaneously support.

[0095] Some examples may use out of band beam switching. For example, the AP and STA may both have multi-band capability. In this example, the AP and the STA may communicate over either a 2.4 GHz or a 5 GHz link in addition to a directional 60 GHz link. The AP and the STA may use one or more of the sub-6 GHz links as an alternate link to signal to each other that the beam set needs to switch to the next best beam set at the beginning of the next data packet. This example procedure may allow for a fast beam switch to occur even if the packet currently being transmitted is not decoded correctly.

[0096] Some examples may implement spatial diversity using a single beam. For example, it may be possible that only one RF chain is available at both transmitter and receiver, such that only one data stream may be transmitted and received at the same time. This RF chain arrangement may be used in mmW systems. With one RF chain, devices may form one beam and transmit the data stream toward the direction specified by the beam. In this example, the devices may forming a beam pointing to a propagation path with the strongest channel gain. Multipath wireless channels, however, may introduce frequency selectivity. A beamforming weight may benefit some frequency tones, however, it may have a detrimental effect for one or more of the other set of frequency tones. Accordingly, there may be no guarantee that the weight pointing to the strongest propagation path will introduce the maximum beamforming gain for the entire frequency channel. Moreover, pointing in one beam direction may increase the system sensitivity to small changes in the multipath environment and may fail to provide robust communication.

[0097] FIG. 2 is a diagram of an example method 200 using two STAs to perform multi-path beamforming. The method may be a multi-stage iterative beamforming method as discussed below, and may include grouping two or more antennas. For example, FIG. 2 shows a first iteration 201 of the method and a second iteration 202 of the method.

[0098] The following articles disclose methods for beamforming. P. Xia, S. K. Yong, J. Oh and C. Ngo, "A practical SDMA protocol for 60GHz millimeter wave communications", Asilomar, 2008; and, P. Xia, S. K. Yong, J. Oh and C. Ngo, "Mulit-stage iterative antenna training for millimeter wave communications", Globecom, 2008, the entire contents of both are incorporated herein by reference.

[0099] Referring to FIG. 2, STA_1 205 and STA_2 210 are respectively shown on two time axes 215 and 220. In this example, STA_1 205 may transmit one or more training beamforming weights, and STA_2 210 may receive training beamforming weights 230, 240, and transmit beamforming weights 235 to STA_1 205. STA_1 205 and STA_2 210 may be, for example, WTRU, stations, electronic communication devices, or access points. The example in FIG. 2 shows STA_1 205 transmitting 230, 240 to only STA_2 210, however there may be more than one STA, which are not shown. STA_1 205 may be an AP or a non-AP STA. STA_2 210 may be an AP or a non-AP STA.

[0100] In each iteration of the method 201, 202, the AP, here STA_1 205, may transmit one or more training sequences over multiple time slots 230 and sweep the transmit beamforming weights. For example, STA_1 205 may be an AP or a non-AP STA. Note that only two iterations of the method 201, 202 are illustrated, but the method may have more than two iterations of the method 201, 202. STA_2 210 may calculate the best transmit beamforming weight vector according to an estimate of the received channel state. Note that the calculated transmit beamforming weight may not be one of the weights the transmitter STA_1 205 originally utilized. The method at STA_2 210 may then feedback this beamforming weight vector 235, or the estimated channel state vector, to the AP, here STA_1 205. The AP, here STA_1 205, may, or may not,

update the transmit beamforming weight it utilizes for a subsequent transmission to STA_2 210. The method may continue until packet transmissions are completed for the associated STAs, STA_2 210.

[0101] The AP, here STA_1 205, may group the antenna array into multiple sub-groups to point the beamforming weight to multiple paths. For example, if there are 36 antenna units and only the two strongest paths are used, then each sub-group may have 18 antenna units. Alternatively, if more antenna gain is anticipated from the strongest path, more antenna units may be assigned to the strongest path. The AP, here STA_1 205, may assign other antenna sub-group partitions depending on the requirements of the system. For example, more than two strongest paths may be used. The method in this example may steer the antenna array in the first sub-group to the strongest path, while the second sub-group may be steered to the second strongest path, and so on. This antenna group partition procedure may be performed by the AP, here STA_1 205, or STA_2 210, or both.

[0102] In another example, antenna group based multi-path beamforming may be performed. In this example, STA_1 205 may have Nt transmit antennas and STA_2 210 may have Nr receive antennas, and only the two strongest paths may be considered.

[0103] The transmitter, for example STA_1 205, may transmit Nt sequences 230. The Nt sequences 230 may be modulated using Nt orthogonal beamforming vectors. STA_1 205 may include a precoder, for example an identity precoder, and may be configured to transmit the first sequence using the first antenna, and transmit the second sequence using the second antenna, and so on. Other orthogonal precoding matrices may be utilized by STA_1 205.

[0104] The receiver, for example STA2 210, may receive the Nt sequences using the receive beamforming vector calculated in the last iteration, W_{i-1}^{r}. In some examples, W_{i-1}^{r} may be set to an initial value. STA2 210 may be configured to determine that the first n time slots correspond to transmit antenna 1 to antenna n, which may correspond to antenna group 1.

STA2 210 may utilize the training sequence transmitted in each time slot to estimate the strongest path of the propagation channel, and may denote the strongest channel path as H1. The received signal from the first n time slots may be expressed as $y_i^{11} = W_{i-1}^r(1:n)Hs + N$, where y may be the received symbol, s may be the sent symbol, N may be the additive Gaussian noise having a variance, and H may be the channel matrix between the transmitter STA1 205 and the receiver STA2 210. The receiver STA2 210 may use the correlation property of the training sequence to estimate the channel corresponding to the strongest propagation path, $\hat{H}_1^1$. Thus, the receiver STA2 210 may determine the best transmit beamforming weight corresponding to antenna group 1 and the strongest path, and may be represented as $(\hat{H}_1^1)'$. The size of the beamforming weight may be $n \times 1$.

[0105] The receiver, STA2 210, may be configured to determine that time slots n+1 to Nt correspond to transmit antenna n+1 to antenna Nt, and may correspond to antenna group 2 of STA1 205. The receiver, STA2 210, may utilize the training sequence transmitted in each time slot to estimate the second strongest path of the propagation channel, and may be denoted as H2. The received signal 245 from the Nt-(n+1)+1 time slots may be expressed as $y_i^{12} = W_{i-1}^r(n+1:Nt)Hs + N$. Since the signal may be transmitted using a sequence with a zero auto correlation (ZAC) property, STA2 210 may use a Rake receiver like method, where the strongest path may be removed, and the channel of the second strongest path may be determined. The second strongest path may be represented by $\hat{H}_2^1$. Thus the best transmit beamforming weight corresponding to antenna group 2 and the second strongest path may be $(\hat{H}_2^1)'$. The size of the transmit beamforming weight may be $(Nt - n) \times 1$.

[0106] The updated transmit beamforming weight for iteration i may be expressed as $W_i^t = [\hat{H}_1^1, \hat{H}_2^1]'$. STA2 210 may transmit W_i^t back to STA1 205 at 235. STA1 205 may use the received W_i^t to transmit 240 another set of beamforming training frames. STA1 205 may transmit Nr repetition of

training frames, where Nr may be the number of antenna(s) at STA2 205. STA2 205 may be configured to use this set of training frames to update the received beamforming weight. STA2 210 may use Nr antennas to receive the training frames sequentially. STA2 210 may also use other orthogonal beamforming weights to receive the Nr training frames. In this example, at STA2 210, antenna 1 to m may belong to the first antenna group, and may be used to point to the strongest propagation path, while antenna m+1 to Nr may belong to antenna group 2, and may correspond to the second strongest propagation path.

[0107] In one example, STA1 205 may use a mixed mode to transmit Nr repetitions of training frames with weight W_i^t. This example mixed mode method is shown in FIG. 2 as 202. The received signal through the Nr time slot may be expressed as $y_i = HW_i^t s + n$. The received signal from antenna group 1 may be $y_i^{21} = y_i(1:m)$. STA2 210 may use the correlation property of the training sequence to estimate the channel with the strongest propagation path, $\hat{H}_1^2$. The received signal from antenna group 2 may be $y_i^{22} = y_i(m+1:Nr)$, and STA2 210 may use correlation detection to remove the strongest path. STA2 210 may accordingly determine the estimated channel for the second strongest path, $\hat{H}_2^2$. STA2 210 may update the receive beamforming weight, which may be represented as $W_i^r = [\hat{H}_1^2, \hat{H}_2^2]'$. In FIG. 2, the reception of the signals is shown in dashed lines as an example illustration of the receiver operation while receiving a packet.

[0108] Alternatively, or in addition to, STA1 205 may use a sequential mode. STA1 205 may transmit m repetitions of training frames with antenna group 1, i.e., $W_1^{t1} = [\hat{H}_1^1, 0]'$. During the m training time slot, the receiver, for example STA2 210, may utilize antenna group 1 to receive the training frames. For example, STA2 210 may utilize antenna 1 to receive the first training frame, and antenna m to receive the mth training frame. The

received signal from these m frames may be expressed as $y_i^{21} = HW_i^{t1}s + n$. STA2 210 may estimate the channel corresponding to the strongest propagation path $\hat{H}_1^2$. STA1 205 may transmit Nr-m repetitions of training frames with antenna group 2 only, for example, $W_1^{t2} = [0, \hat{H}_2^1]'$. STA2 210 may utilize its antenna group 2 to receive the training frames. The received signal may be $y_i^{22} = HW_i^{t2}s + n$. STA2 210 may use a correlation method to determine the channel corresponding to the second strongest path, $\hat{H}_2^2$. STA2 210 may update the receive beamforming weight $W_i^r = [\hat{H}_1^2, \hat{H}_2^2]'$. In some examples, feedback channels corresponding to the strongest paths may be used directly by STA2 210 or STA1 205. Note that this mode is not illustrated in FIG. 2.

[0109] STA2 210 may send $W_i^r = [\hat{H}_1^2, \hat{H}_2^2]'$ to STA1 205 (not illustrated). In addition, the method may repeat for a number of times up to a threshold or until the method converges which may be determined by comparing a next value of the beamforming weights with a previous value of the beamforming weights and determining if the difference is less than a threshold value.

[0110] The initial beamforming weights for STA1 205 and STA2 210 may be set to initial values prior to beginning the method. STA1 205 and STA2 210 may determine the initial values in order to reduce the number iterations needed for the method to converge. The example method shown in FIG. 2 may be used for determining the two strongest paths. However, in other example embodiments, more than two paths may be determined by the STA1 205 and STA2 210.

[0111] Existing protocols may be modified to perform multi-path beamforming methods. For example, a multi-path beamforming method may be used in 802.11 and 802.11ad. For example, the multi-path beamforming method may be used in 802.11ad by using a modification of the beam refinement protocol (BRP) as disclosed in IEEE P802.11ad™/D9.0: Part 11, "Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications," the entire contents of which are herein incorporated by

reference. The multi-path beamforming method may be a multi-iteration multi-path beamforming training method.

[0112] A beam refinement transaction may be a set of BRP frames that include one or more beam refinement requests and responses. The multi-path beamforming method may be implemented by modifying current beamforming refinement protocols.

[0113] FIG. 3 is a diagram of an example of one iteration of the multi-path beamforming method 300 using BRP transactions. The beamforming initiator, STA1 305, may transmit a BRP frame 315 that indicates that the BRP frame 315 is a Transmit BRP Request frame. This indication may be performed by setting a field, for example, TX-TRN-REQ=1. A BRP frame with TX-TRN-REQ=1 315 may include a transmit training subfield (TRN-T) 320 appended to it. The responder, STA2 310 may reply with a Transmit BRP Feedback 325, for example, by setting TX-TRN-RSP=1. Moreover, STA2 310 may request a receive beamforming training by indicating Receive BRP Request frame in the same BRP frame, for example, by setting L_RX>0. In this example, the Receive BRP Request frame may be piggybacked on the Transmit BRP Response frame. L_RX may be a signal field used to indicate that the receiver requests a receive BRP training, and the transmitter may respond with a BRP train response followed by a TRN-R training field. STA1 305 may transmit a BRP frame 330 with a BRP train response, for example, by setting RX-TRN-RSP to 1. A BRP frame that includes an RX-Train-response that equals 1 may include a receive training subfield (TRN-R) 335 appended to it.

[0114] FIG. 4 is a diagram of an example frame format for a BRP packet 402. The BRP packet 402 may include a short training field (STF) 404, a channel estimation (CE) field 406, a Header field 408 and a data field 410. A training field 416 may be appended/prepended to the BRP packet 402 and may include an AGC training field 412 and a receiver/transmitter training subfield (TRN-R/T) 414. A BRP packet 402 may be transmitted using control PHY. Prior to the RTN-R/T training, there may be a signaling exchange to aid the

training procedure. This is the purpose of field 404, 406, 408, 410. A Packet Type field may be included in the PHY header, and it may indicate whether a TRN-R or a TRN-T subfield 414 is appended to the frame 402. A BRP frame 402 with a TRN-R/T 414 field appended may be referred to as a BRP-RX/TX packet 402. In a BRP-TX packet 402, the transmitter may change the TX beamforming weight configuration at the beginning of each AGC subfield 412. The set of beamforming weights used for the AGC subfields 412 may be the same as that used for the TRN-T subfield 414. In a BRP-RX packet 402, the transmitter may use the same transmit beamforming weight as in the preamble and data fields of the transmission data packet. The BRP frame may be an Action No ACK frame.

[0115] FIG. 5 is a diagram of an example format of a BRP frame Action field. The BRP frame Action field 500 may include a Category field 510, an Unprotected DMG Action field 520, a Dialog Token field 530, a BRP Request field 540, a DMG Beam Refinement element 550, and one or more Channel Measurement Feedback elements 5601…560n.

[0116] An 802.11ad beam refinement protocol may be modified as follows in order to accommodate a multi-path beamforming algorithm. For example, an initiator may determine the capabilities of the responder prior to initiating beamforming training with the responder. The multi-path multi-stage iterative beamforming training capability may be indicated in a DMG Capabilities element. A DMG Capabilities element may be present in Association Request, Association Response, Reassociation Request, Reassociation Response, Probe Request and Probe Response frames and may be present in DMG Beacon and Information request and response frames. A DMG Antenna Array Support field may include one or more bits that indicate that the STA is capable of forming sub-antenna groups and capable of performing the multi-path multi-stage beamforming training method.

[0117] Partitioning of antenna sub-groups at both initiator and responder may be signaled. Depending on the antenna grouping method, the

signaling may be different. For example, the antenna grouping may be performed uniformly or non-uniformly.

[0118] In a uniform antenna grouping example, assuming the total number of antennas is even, each antenna sub-group may have the same number of antenna elements, and hence only the number of antenna groups is required to indicate the partition of antenna sub-groups. For example if there are four antennas, and two groups, the number of groups, in this example two, may be sent back since the number of antennas per group will be known. The mapping between antenna element indices and sub-group indices may be predetermined and transmitted explicitly in a field of the BRP frame, for example, a BRP Request field. If the mapping is explicitly indicated in the BRP frame, the antenna sub-group index may be assigned to each antenna element.

[0119] In a non-uniform antenna grouping example, each antenna sub-group may have a different number of antenna elements. For example, the system may assign more antenna elements for the strongest path, so that the antenna gain from this sub-group may be larger. The mapping between antenna element indices and sub-group indices may be predetermined and transmitted explicitly in a field of the BRP frame, for example, in a BRP Request field.

[0120] Mapping between antenna sub-groups and channel propagation paths/taps may be predetermined. For example, antenna sub-group 1 may always map to the strongest path, and so on. Alternatively, the mapping may be defined in the BRP Request field.

[0121] The precoding matrix used by the initiator, for example, STA1 205, in the first part of each iteration may be predetermined and agreed by both initiator and responder. The first part of each iteration may be referred to as the transmit beamforming training part. In one example, a set of unitary precoding matrices may be predetermined. In this example, the initiator and responder may negotiate which matrix is utilized before performing the

beamforming training. For example, the precoding matrix index may be predetermined and transmitted in the BRP Request field.

[0122] The number of antennas at both initiator and responder side may be signaled. Number of antennas may be signaled, for example, in the PHY header, MAC header or BRP Request field.

[0123] FIG. 6 is a diagram of an example modified channel measurement feedback element 600. The channel measurement feedback element may include a signal-to-noise ratio (SNR) subfield 610, a channel measurement subfield 620, a tap delay subfield 630, and a sector ID order subfield 640. The presence of these subfields may depend on the values defined in the DMG Beam Refinement element. For example, the channel measurement subfield may be used to feed back up to Ntap channel measurements that correspond to a common set of relative tap delays defined in the tap delay subfield. Without the presence of the tap delay subfield, for example, the Ntaps channel taps may be interpreted as contiguous time samples, separated by Tc, where Tc may be the SC PHY chip time, and may be 0.57ns. In these exemplary multi-path beamforming methods, the channel measurements of the strongest propagation paths may be sent to STA1. In the example shown in FIG. 2, the strongest path/tap may be assigned for the first antenna sub-group, and the second strongest path/tap may be assigned for the second antenna sub-group and so on. If the multi-path beamforming method is indicated in the PHY header, MAC header or MAC body, the interpretation of the channel measurement may be modified when the tap delay subfield is not present. Therefore, protocols may be modified to accommodate examples of the multi-path beamforming method disclosed herein.

[0124] Weighted multi-path beamforming training methods may be performed. For example, a beamforming method for steering the beam towards multiple propagation paths may be performed. The strongest propagation paths/taps may be determined by a STA, and one or more beamforming weights may be determined to point to one or more of the propagation paths/taps. The beamforming weight for the kth strongest

propagation path may be represented as Wk, and the final beamforming weight may be expressed as $W = \sum_{k=1}^{K} \alpha_k W_k$, where K may be the number of channel propagation paths and α_k may be the weight, with $\sum \alpha_k = 1$.

[0125] Different methods may be used by the STA selecting α_k in one of the following ways. For example, propagation path selection may be based on: $\alpha_k = \begin{cases} 1 & k = m \\ 0 & k \neq m \end{cases}$. By this selection, the final beamforming weight vector may equal the weight vector directed towards the mth propagation path.

[0126] In an 802.11ad example, the channel propagation taps may be measured and fed back to the beamforming initiator, which may be STA1 205. According to the channel measurement of each tap, a channel gain may be estimated by the STA. Channel gain of the kth propagation path/tap may be represented as β_k. α_k may be represented as $\alpha_k = \lambda - \frac{1}{\beta_k}$, so that $\sum \alpha_k = 1$, $\lambda = \frac{1 + \sum 1/\beta_k}{K}$ may be satisfied. The propagation path with the larger channel gain may have a larger weight and may be determined by the STA to be the strongest propagation path.

[0127] A single data stream transmission may be performed with multi-beam capability devices. For example, multiple RF chains may be available at the AP. Accordingly, the AP may form multiple beams simultaneously. In this example, the STA may form only one RF chain. The AP and the STA may be configured to use an Nx1 virtual MIMO channel. The AP and the STA may be configured to use diversity methods, such as, for example, STBC, SFBC and CDD. These example methods may be performed by more than one AP and more than one STA. In addition, a STA may be an AP.

[0128] There may be at least two possible transmission procedures that implement RF front-end beamforming with digital domain STBC. One example transmission procedure may use full size beamforming with STBC.

Another example transmission procedure may use partial size beamforming with STBC.

[0129] FIG. 7 is a diagram of an example AP 700 configured to perform a transmission using full size beamforming with STBC. The AP 700 may include a coding/modulation unit 702, an STBC encoder 706, a plurality of DAC/upconverters 708, 710, and a plurality of antennas 716. In this example, the coding/modulation unit 702 may perform modulation and coding and pass the modulation symbols 704 to the STBC encoder 706. The STBC encoder 706 may generate two data streams 718, 720. The two data streams 718, 720 then be processed through two RF chains at the plurality of DAC/upconverters 708, 710, which may separately perform DAC and up conversion to the operating frequency band. At the RF front-end, two beamforming weight vectors W1 712 and W2 714 may be generated by AP. Each weight-vector may be of size Nt x 1. The first data stream 718 may be multiplied with the first weight vector W1 712, and the second data stream 720 may be multiplied with the second weight vector W2 514. The two data streams 718, 720 may then be summed together and transmitted through the Nt antennas 716. In some embodiments, the AP may be configured with more than two RF chains.

[0130] FIG. 8 is a diagram of an example AP 800 configured to perform a transmission using partial size beamforming with STBC. The AP 800 may include a coding/modulation unit 802, an STBC encoder 806, a plurality of DAC/upconverters 808, 810, and a plurality of sets of antennas 816, 817. In this example, the coding/modulation unit 802 may perform modulation and coding and pass the modulation symbols 804 to the STBC encoder 806. The STBC encoder 806 may generate two data streams 818, 820. The two data streams 818, 820 may then be processed through two RF chains at the plurality of DAC/upconverters 808, 810, which may separately perform DAC and up conversion to the operating frequency band. At the RF front-end, two beamforming weight vectors W1 812 and W2 814 may be generated. Each weight vector may be of size Nt/2 x 1. The first data stream 818 may be multiplied with the first weight vector W1 812, and the second data stream

820 may be multiplied with the second weight vector W2 814. The first data stream 818 may be transmitted through the first set of Nt/2 antennas 816 and the second data stream may be transmitted through the second set of Nt/2 antennas 817. In embodiments, AP may be configured with more than two RF chains.

[0131] The AP and/or the STA may be configured to send and receive multiple data streams. For example, the AP and/or the STA may be configured with multiple RF chains. In these examples, the AP may be configured to communicate with multiple STAs simultaneously. The AP may be configured to distinguish the multiple STAs by spatial domain beams, thus the method may be referred to as Beam Division Multiple Access (BDMA). The AP may need multiple RF chains to perform BDMA. For example, the AP may be configured to use spatial multiplexing methods for single STA transmission. The AP and STA may be configured to send more than one data stream at a time, which may increase the spectral efficiency of the system. Multiple RF chains may be needed at both AP and STA side.

[0132] FIG. 9 is a diagram of an example of transceiver architecture 900. The AP and/or STA may be configured as follows. The transceiver architecture 900 may include a transmitter side 902 and a receiver side 904. The transmitter side 902 may include one or more coding/modulation units 903, a plurality of DAC/upconverters 912, 914, a digital controller 917, one or more power amplifiers (PA)s 920, and a plurality of Nt antennas 925. Multiple data streams may be modulated and coded at baseband, and then converted from a digital domain to an analog domain through the digital controller 917. The streams 908, 910 may be upconverted to operation frequency band by the DAC/upconverters 912, 914. Two sets of DACs and upconverters are illustrated here, which implies that up to two data streams may be supported by the transmitter. Beamforming weights 915, 916 may be applied prior to applying the streams to the PAs 920. The beamforming weights 915, 916 may be prepared in a digital domain.

[0133] The transmitter 902, may be an AP or STA, an may be configured with Nt antennas 925. The Nt antennas 925 may be shared by two or more RF chains. When the transmitter 902 has two data streams $\{s_1, s_2\}$ to transmit, it may generate two beamforming weights $V^1 = (V_1^1, V_2^1, ..., V_{Nt}^1)^T$ 916 and $V^2 = (V_1^2, V_2^2, ..., V_{Nt}^2)^T$ 915. The two signal streams may be combined and transmitted through Nt transmit antennas 925, $s = V^1 s_1 + V^2 s_2$. The AP and STA may be similarly configured on the receiver side if multiple RF chains are presented. The receiver 904 may generate two sets of receive beamforming weights $U^1 = (U_1^1, U_2^1, ..., U_{Nr}^1)^T$ 936 and $U^2 = (U_1^2, U_2^2, ..., U_{Nr}^2)^T$ 935 and apply them in an analog domain. The weighted streams may be applied to a respective ADC/downconverter. The downconverted streams 908', 910' may be decoded and demodulated.

[0134] Communication devices, which may be, for example, APs or STAs, with the transceiver embodiment illustrated in FIG. 9 may be referred to as Type I. In some embodiments, the AP and/or STA may be configured with more than two RF chains where FIG. 9 may be extended to accommodate the more than two RF chains.

[0135] FIG. 10 is a diagram of another example transceiver architecture 1000. The transceiver architecture 1000 may include a transmitter side 1002 and a receiver side 1004. In this example, the AP and or the STA may be configured as follows. Each RF chain may have its own set of antennas 1048, 1050, respectively. The antennas may be deemed to have been partitioned or split into sub-groups based on the number of RF chains. Compared to Type I devices, in order to achieve the same antenna gain, N antenna elements may be required. Here N may be the number of RF chains. Communication devices, which may be, for example, APs or STA, with the transceiver architecture illustrated in FIG. 10 may be referred to as Type II. The beamforming weights in FIG. 10, may be tuned as a group by the digital controller logic, as indicated by the dashed lines.

[0136] FIG. 11 is a diagram of an example of beam division multiple access (BDMA) architecture 1100. The AP 1102 may be configured to transmit two packets to STA1 1106 and STA2 1104 simultaneously. The STAs 1106, 1104 may be configured to share the time-frequency resource by different RF front-end beams.

[0137] The AP 1102 may be configured to prepare MAC packets for both STA1 1106 and STA2 1104. The AP 1102 may encode and modulate the MAC packets and form separate PHY packets and up convert them to 60 GHz through separate RF chains. At the RF front-end, the AP 1102 may apply beamforming weight vector W1 to the first data stream and W2 to the second data stream. The AP transmits a combination of the two data streams. In this way, multiple RF chains may share the same set of antennas as shown in FIG. 9. Alternatively, the AP 1102 may be configured to implementation BDMA by dividing, grouping, or partitioning the set of antennas to sub-groups, and each RF chain control may be sent by the AP 1102 on one antenna sub-group as shown in FIG. 10.

[0138] The AP and STA may be configured to perform a beamforming training method for BDMA. The AP and/or STA may be configured to perform the beamforming training method sequentially with one or more STAs in communication with one another. The example beamforming training methods may be standardized, for example, and may be used in 802.11ad. The AP and/or STA may be configured to use orthogonality between training beams.

[0139] FIG. 12 is a diagram of an example beamforming training method 1200 for BDMA. This example may use a multi-stage iterative beamforming training algorithm for BDMA. In the example illustrated, the AP 1202 has Nt antennas, STA1 1204 has M1 antennas and STA2 1206 has M2 antennas.

[0140] The beamforming training method for BDMA may be performed iteratively. The AP 1202 may transmit Nt sequences 1208. The Nt sequences 1208 maybe modulated using Nt orthogonal beamforming vectors. The

example shown in FIG. 12 may be performed using a precoder, for example, an identity precoder. In this example, the first sequence may be transmitted using a first antenna ("Ant 1") 1208, and a second sequence may be transmitted using the second antenna, and so on until the Nt antenna ("Ant Nt") 1210. The AP 1202 may be configured to use other orthogonal precoding matrices, such as, for example, the Walsh Hadamard matrix or FFT matrix.

[0141] STA1 1204 may be configured to utilize the best receive beamforming vector 1212 calculated through the last iteration, W_{i-1}^{r1}, to receive the signals. In FIG. 12, the reception of the signals is shown in dashed lines as an example illustration of the receiver operation while receiving a packet. For example, the dashed box W_{i-1}^{r1} may indicate that the STA1 1204 should use receive beamforming vector W_{i-1}^{r1} to perform receive beamforming. Since the AP 1202 may have transmitted the signal through each antenna sequentially, STA1 1204 may receive a Nt x 1 effective MISO channel between AP 1202 and STA1 1204, $W_{i-1}^{r1}H_1$ at the end of the transmission due to the use of the receive beamformer. Equivalently, the received signal may be expressed in a matrix format: $y_{11} = W_{i-1}^{r1}H_1 s + n$, where y may be the received signal, s may be the sent signal, n may be Gaussian noise, W may be the weight used by STA1 1204, and H may be the channel matrix between AP 1202 and STA1 1204. Based on the received signal, STA1 1204 may calculate or determine the best transmit beamforming weight from AP 1202 to STA1 1204 which may be represented as $V_i^{r1} = \frac{y_{11}s'}{\|y_{11}s'\|}$.

[0142] Similarly, STA2 1206 may be configured to utilize W_{i-1}^{r2} to receive the signals, and the received signal may be expressed as $y_{12} = W_{i-1}^{r2}H_2 s + n$. The best transmit beamforming weight from AP 1202 to STA2 1206 may be represented as $V_i^{r2} = \frac{y_{12}s'}{\|y_{12}s'\|}$, which STA2 1206 may be configured to determine.

[0143] The method may continue with STA1 1204 sending V_i^{r1} 1222 to the AP 1202. STA2 1206 may send V_i^{r2} 1220 to the AP 1202. STA2 1206 may transmit the packet immediately after the transmission of STA1 1204, or STA2 1206 may wait for a polling frame transmitted from the AP 1202 (not illustrated) before transmitting the packet.

[0144] The method may continue with the AP 1202 calculating MU-MIMO weight W_i^{t1} and W_i^{t2} based on V_i^{r1} and V_i^{r2}. The AP 1202 may then implement a linear or non-linear MU-MIMO precoding algorithm for this weight update 1209.

[0145] The method may continue with the AP 1202 transmitting 1230 again with the best beamforming weights and each STA 1204, 1206 receiving with multiple receive antennas.

[0146] The method may continue with one of the following alternatives. In a first alternative, as illustrated in FIG. 12, the AP 1202 may transmit $W_i^{t1}s_1 + W_i^{t2}s_2$ for Max(M1,M2) times 1230. s_1 and s_2 may be orthogonal sequences, and may be known at AP 1202, STA1 1204 and STA2 1206. The AP 1202 may signal STA1 1204 and STA2 1206 about the assignment of s_1 and s_2. STA1 1204 may be configured to switch receive antennas to train the best receive beamforming weight W_i^{r1}. Similarly, STA2 1206 may train the best receive beamforming weight W_i^{r2}. STA1 1204 may use the orthogonal sequences to estimate the current signal (via cross correlation with s_1) and the current interference (via cross correlation with s_2). Thus, STA1 1204 may train its receive beamforming vectors by nulling the interference. Similarly, STA2 1206 may use the orthogonal sequences to estimate the current signal (via cross correlation with s_2) and the current interference (via cross correlation with s_1). Then, STA2 1206 may train its receive beamforming vectors by nulling the interference.

[0147] In a second alternative, the AP 1202 may transmit $W_i^{t1}s$ for M1 repetitions. STA1 1204 may switch between its M1 antennas to receive $W_i^{t1}s$, and at the same time, STA2 may monitor the transmission of $W_i^{t1}s$. AP 1202 may transmit $W_i^{t2}s$ for M2 repetitions and STA2 may switch between its M2 antennas to receive $W_i^{t2}s$ while STA1 1204 monitors the transmission of $W_i^{t2}s$.

[0148] The example beamforming training method for BDMA may not be successful. If the correlation between two STAs 1204, 1206 is high, the two STAs 1204, 1206 may not be distinguished by beams. This may lead to an unsuccessful beamforming training for BDMA. In this example, the AP 1202, and or STAs 1204, 1206, may be configured to provide information if BDMA may or may not be supported with the current configuration. The STAs 1204, 1206 may include the report of beamforming gain when they report V_i^{r1} and V_i^{r2} to the AP 1002. The beamforming gain may be defined as $\|y_{11}s'\|^2$ and $\|y_{12}s'\|^2$. Alternatively, or in addition, the STAs 1204, 1206 may report signal to interference ratio (SIR) during or at the end of the method. The STAs 1004, 1006 may determine or calculate the desired signal strength and interference signal strength with both example alternatives.

[0149] The BDMA training method may include performing BDMA training on each STA 1204, 1206 sequentially. This example method may be extended for more than two STAs.

[0150] Examples of the BDMA training method may be standardized. For example, the BDMA training method may be used with IEEE 802.11ad. In these examples, a service period (SP) may be a time period scheduled for service from one device to another device. The transmission during an SP duration may be scheduled by an AP. The BDMA training method may be scheduled by the AP if it is allocated in an SP duration. Examples of the BDMA training method may be used by modifying the BRP procedures.

[0151] FIG. 13 is a diagram of an example modified BRP procedure to implement a multi-stage iterative beamforming training method for BDMA 1300. In this example, AP 1302 may transmit a BRP frame 1320 that indicates a Transmit BDMA BRP Request. A Transmit BDMA BRP Request subfield may be defined in BRP Request field, and may indicate that the BRP frame is for transmit BDMA BRP training. Alternatively, a Transmit BRP Request may be used with TX-TRN-REQ=1 to indicate that the BRP frame is for transmit BRP training. A frame that is utilized for single user beamforming training or BDMA training may be indicated implicitly or explicitly in the MAC frame or PHY header.

[0152] STA1 1304 may reply with a Transmit BRP Feedback frame 1322 by setting TX-train-response=1. STA1 1304 may also request a receive beamforming training by indicating Receive BRP Request in the same Transmit BRP Feedback frame 1322 by setting L_RX>0.

[0153] AP 1302 may transmit a Polling frame 1324 to STA2 1304 to request BRP feedback. This step may be skipped if the frame length of BRP feedback frame is fixed and known by all the devices.

[0154] STA2 1306 may reply with a Transmit BRP Feedback frame 1326 by setting TX-train-response=1. STA2 1306 may also request a receive beamforming training by indicating Receive BRP Request in the same Transmit BRP Feedback frame 1326 by setting L_RX>0.

[0155] AP 1302 may transmit a BDMA BRP frame 1328 indicating a BRP train response by setting RX-Train-response to 1. A BRP frame with RX-Train-response equal to 1 may include a receive training subfield TRN-R 1330 appended to it. A BDMA BRP frame 1328 may indicate multiple receivers explicitly or implicitly in PHY header or MAC body.

[0156] The example in FIG. 13 shows that one AP 1302 may transmit to two STAs 1304, 1306. However, the BDMA transmission may be from one device to two devices irrespective of whether they are APs or STAs. Moreover, the AP 1302 may transmit to two or more STAs.

[0157] Examples of the method in FIG. 13 may include BDMA protection mechanisms. The feedback frame 1322 may include not only the best beam, but also the achievable SINR. If after a certain number of iterations, the achievable SINR is less than the target SNR, the BDMA method may be aborted. The number of iterations may be predetermined, determined statically, dynamically determined based on previous methods running, or in another way.

[0158] BDMA grouping may be indicated in some examples. The following examples may enable an indication of BDMA grouping by one or more communication devices. Using an SP, the BDMA grouping information may be indicated in an allocation field in an Extended Schedule Element. The Extended Schedule Element may be transmitted in a Beacon frame. The tuple, Source AID, Destination AID and Allocation ID may uniquely identify the allocation. The Source AID field may be set to the AID of the STA an may initiate channel access during the SP. The Destination AID field may indicate the AID of a STA that may be expected to communicate with the source STA during the allocation. The Allocation ID may identify an airtime allocation from a Source AID to a Destination AID. With BDMA transmission, more than one receiver may be indicated. One method may be to group BDMA transmitters and receivers, and assign each group a unique BDMA ID. Each STA corresponding to a BDMA ID may be assigned a User Position Array that may be used to distinguish the role of the STA. Therefore, the Destination AID may be replaced by the BDMA ID for BDMA transmissions. Alternatively, more than one Destination AID may be included in the allocation field. In this way, the order of the Destination AIDs may imply the role of one or more STAs in the BDMA transmission.

[0159] Since the BDMA transmission may be within the SP time slot, the communication device may not need to signal the BDMA transmission in the PHY header or MAC header. The MCS levels and Length field for each BDMA receiver may be signaled in PHY Header.

[0160] FIG. 14 is a diagram of an example PHY layer frame format 1400 that may be used in a BDMA transmission. N may represent the number of BDMA communication devices that may be signaled in the allocation field in Extended Schedule Element. The example PHY layer frame format 1400 may include an STF field 1410, one or more CE fields 1420, a header 1430, and a data field 1440. The one or more CE fields 1420 may be transmitted with a weight and a P matrix. The weight for the one or more CE fields may range from W1 to WN, for example, the first field may be transmitted with a weight W1, and the last CE field may be transmitted with a weight WN. The header 1430 and data field 1440 may be transmitted using BDMA and with all of the weights from W1 to WN.

[0161] Example embodiments may include performing BDMA in a contention based access period. For example, BDMA transmission protocols may be used by the communication device. Performing a BDMA transmission in a contention based access period may utilize the NDP announcement (NDPA) and NDP sequences for beamforming training. BDMA transmission may be performed after the NDP sequence exchanges. Alternatively, or in addition, the BDMA transmission may be delayed until the BDMA initiator, which may be a STA or an AP, acquires the media again.

[0162] In one example BDMA transmission procedure, one or more of the communication devices may be configured to use an NDPA period. In this example, an AP may transmit a message that indicates which STAs should participate in BDMA training. The NDPA frame may contain a STA info field to indicate the individual STA information. The NDPA frame may reserve a TXOP until the end of BDMA beamforming training by setting the duration period accordingly. Alternatively, the NDPA frame may reserve a TXOP until the end of the BDMA transmission.

[0163] In another example, an NDP period may be configured to allow training of transmit antennas at the AP. In this example, the STAs may perform measurements. In another example, a feedback period may be configured to allow STAs to take turns to feedback the best beam vectors as

well as the achievable SINRs. Moreover, STAs may also feedback the measured channels or the calculated transmit beamforming weight vectors.

[0164] In another example, a receiver training period may be configured to allow an AP to set its beamforming vectors. In this example, STAs may train their receive antennas.

[0165] In another example, the NDP period, feedback period, and receiver training period may be repeated for a number of iterations. A number of stopping criteria may be applied in this example. For example, if the achievable SINR meets expectation, the iteration may stop early. In these examples, BDMA transmissions may begin a certain inter-frame spacing after training is performed. ACK1 and ACK 2 may each be followed by a SIFs duration after BDMA transmission is performed.

[0166] In another example, one or more communication devices may be configured to indicate BDMA grouping. The following is an example of indicating grouping. BDMA grouping with contention based access period (CBAP) may be performed by using a BDMA ID. A BDMA ID management frame may be transmitted from an AP to a STA to indicate whether the STA belongs to one of the BDMA groups and the user position of the STA. The BDMA ID management frame may contain a Membership Status Array field and a User Position Array field. The BDMA ID may be included in BDMA related frames, such as BDMA training frames, BDMA transmission frames, or other similar frames.

[0167] One or more communication devices may be configured to perform a BDMA transmission method for CBAP that may be similar to that defined for SP. The BDMA transmission may be performed after the BDMA initiator, for example the AP, acquires a TXOP in the CBAP. The PHY layer frame format may be the same as illustrated FIG. 14. The transmission of BDMA in CBAP may not be scheduled by the AP. Accordingly, the BDMA ID may be included in the PHY header. The number of users or communication devices, N, may be indicated in the sequence exchange to acquire the TXOP

before a BDMA transmission. Alternatively, it may be implicitly indicated using a short training field (STF) and/or a channel estimation (CE) field.

[0168] In some examples, the communication devices may be configured to perform single user spatial multiplexing. In order to perform spatial multiplexing, both transmitter and receiver may have multiple RF chains. FIG. 9 and FIG. 10 are example transceiver configurations to perform single user spatial multiplexing. A communication device with the transceiver configuration shown in FIG. 9 may be referred to as a Type I device, i.e., where multiple RF chains share the same set of antenna elements. A communication device with the transceiver configuration shown in FIG. 10 may be referred to as a Type II communication device, i.e., where the antenna elements may be split into sub-groups, and each sub-group may correspond to one RF chain.

[0169] The communication devices may be configured to perform beamforming methods for spatial multiplexing. In this example, several beamforming methods may be used to perform spatial multiplexing transmission between a pair of communication devices. Two types of example beamforming methods may be used. The first example method may be referred to as Eigen-Beamforming based spatial multiplexing. In this example, the initiator/responder may estimate the channel over the air and calculate beamforming weights accordingly. The second example method may be referred to as beam sweep based spatial multiplexing. With this method, both initiator and responder may transmit and receive using pre-defined beam sectors. The beamforming beams may then be selected from these beam sectors.

[0170] The communication devices may be configured to perform an Eigen-Beamforming based spatial multiplexing method, where the communication devices may be configured as Type I devices with calibration. Type I devices may have multiple RF chains sharing the same set of antennas as discussed in conjunction with FIG. 9. If the communication devices are configured to calibrate the multiple transmit RF chains, the communication

devices may determine that the multiple RF chains are identical. Examples of non-calibrated or identical RF chains are discussed below.

[0171] FIG. 15 is a diagram of an example beamforming training procedure 1500 using Eigen-beamforming based spatial multiplexing where the Type I communication devices may be configured to calibrate the multiple transmit RF chains. An iterative example with two RF chains at both initiator and responder is shown in FIG. 15, however, the method may be extended to any number of RF chains. In this example, the transmitter (STA1) 1502 may have Nt antenna elements, and the receiver side (STA2) 1504 may have Nr antenna elements.

[0172] The beamforming training method may be performed iteratively. In each iteration, the transmit beamforming training may be performed and then the receive beamforming training may be performed. An example of a detailed method for Type I devices with calibration is described below.

[0173] For iteration i, STA1 1502 may act as an initiator, and may transmit Nt training sequences 1506 sweeping all the transmit antenna elements. The transmission may be performed using the first transmit RF chain (TX1) or the second transmit RF chain (TX2) of STA1 1502. In some examples, the two RF chains may be identical or differ by a scalar, or, in other examples, the two TX chains may be calibrated. Alternatively, STA1 1502 may also use an orthogonal precoding matrix to transmit the Nt training sequences.

[0174] STA2 (responder) 1504 may have two receive beamforming weights trained from previous iterations, and may be represented by W_{i-1}^{r1} and W_{i-1}^{r2}. If this is the first iteration of the method, STA2 1504 may randomly select two beamforming weights, or use Omni weights, or may determine the two beamforming weights in an alternate method. The first RF chain (RX1) may receive a signal that is the weighted combination of signals received from all the receive antenna elements. This weight may be the first receive beamforming weight W_{i-1}^{r1}. Similarly, the second RF chain (RX2) may receive a

signal that is the weighted combination of signals received from all the receive antenna elements. This weight may be the second receive beamforming weight W_{i-1}^{r2}. In FIG. 15, the reception of the signals is shown in dashed lines as an example illustration of the receiver operation while receiving a packet. For example, the dashed box W_{i-1}^{r1} may indicate that the STA1 1504 should use receive beamforming vector W_{i-1}^{r1} to perform receive beamforming. After conversion to the digital domain, STA2 1504 may estimate the effective channel by comparing the received sequence with the known transmitted sequence. For time slot k, STA2 1504 may estimate two channels using two RF chains $\begin{bmatrix} G_{k1} \\ G_{k2} \end{bmatrix}$. With Nt time slots, STA2 1504 may receive $\begin{bmatrix} G_{11} & \dots & G_{Nt1} \\ G_{12} & \dots & G_{Nt2} \end{bmatrix}$. Applying the inverse of the orthorgonal precoding matrix, STA2 1504 may obtain the channel from Nt transmit antenna elements to two RF chains as $H = \begin{bmatrix} H_{11} & \dots & H_{Nt1} \\ H_{12} & \dots & H_{Nt2} \end{bmatrix}$.

[0175] STA2 1504 may feedback the channel information or beamforming weights for multiple data streams to STA1 1502. STA2 1504 may calculate the transmit beamforming weights for spatial multiplexing and feedback 1508 the weights to STA1 1502. STA2 1504 may feedback the channel H to STA1 1502, and STA1 1502 then may determine or calculate the transmit beamforming weights 1510.

[0176] In some examples, the transmit beamforming weight method may be implementation dependent. For example, STA1 1502 and/or STA2 1504 may use linear or non-linear procoding algorithms.

[0177] The updated transmit beamforming weights for the ith iteration may be denoted as (W_i^{t1}, W_i^{t2}). STA1 1502 may transmit a training sequence Nr times with beamforming weight W_i^{t1} 1512. STA2 1504 may sweep through Nr receive antennas 1514, or apply an orthorgonal matrix. STA2 1504 then passes the received signal through the two RF chains. STA1 1502 may

transmit training sequences again Nr times with beamforming weight W_i^{t2} 1516. STA2 1504 may repeat a similar procedure with both RF chains 1518. The sweeping of the Nr receive antennas 1514 and 1518 is shown in dashed lines as an example illustration of receiver operation. For example, to receive Nr packets from the transmitter, the receiver may receive a first packet with the first receive antenna, a second packet with the second receive antenna, and so on, until it receives a last packet with the last receive antenna. STA2 1504 may estimate the channel and update the receive beamforming weight accordingly (not shown). The receive beamforming weight method may be implementation dependent.

[0178] The above method may be repeated until the method converges or certain criteria have been met that indicate that spatial multiplexing is not suitable for the pair of devices, for example, a set of failure criteria). There may be several ways to define failure criteria that indicate that the pair of devices are not suitable for spatial multiplexing. A first example of failure criteria may be that STA2 monitors the rank or condition number of a channel matrix while selecting a beamforming weight, and may feedback this information to STA1. A second example of failure criteria may be that STA2 monitors the rank or condition number of channel matrix while sweeping through Nr receive antennas or applying an orthogonal matrix, and feeds back this information to STA1. If the rank is less than the number of data streams expected to be supported, or the condition number is greater than a certain threshold, both STA1 and STA2 may determine that the maximum number of data streams supported may not meet the desired number. In this example, the pair of devices may determine to complete the training procedure, and perform RF selection at both transmitter and receiver later. For example, the pair of devices may terminate the training with a full set of RF chains, and return to perform beamforming training with a lesser number of RF chains. For example, after training, the devices may transmit with a lesser number of spatial streams.

[0179] A method of Eigen-beamforming for spatial multiplexing may be performed. The method may be for communication devices that are of Type I or Type II as discussed in conjunction with FIG. 9.

[0180] Type I devices may perform transmit RF chain training sequentially if the RF chains are not calibrated. Even though the RF chains share the same set of antenna elements and the physical channels over the air may be the same, the effective channels, which may be the combination of channel over the air and transmit/receive RF chains, may be measured and estimated.

[0181] Type II devices may split the antenna elements into sub-groups, and each sub-group has an RF chain. In these examples, there may be two RF chains and two sub-groups of antennas. The physical channel corresponding to RF chain 1 may be transmitted with antenna sub-group I, which may be different from that corresponding to RF chain 2 that may be transmitted with the other antenna sub-group. Because of this, the training for multiple transmit RF chains may be performed sequentially.

[0182] FIG. 16 is a diagram of an example beamforming training method 1600 for Eigen-beamforming based spatial multiplexing for Type I devices and for Type II devices without calibration. For iteration i, STA1 1602 (initiator) may transmit Nt repetitions of training sequences sweeping all the transmit antenna elements in a first antenna sub-group using the first transmit RF chain (TX1) 1606. Then STA1 1602 may transmit Nt repetitions of training sequences sweeping all the transmit antenna elements in the second antenna sub-group using the first transmit RF chain (TX2) 1608. STA1 1602 may also use an orthorgonal precoding matrix to transmit the Nt repetitions of training sequences. The first antenna sub-group may be the same as the second antenna sub-group for Type I devices, STA1 1602; while for Type II devices, STA1 1602, they may correspond to different antenna elements.

[0183] STA2 (responder) 1604 may have the two receive beamforming weights trained from the previous iterations. If this is the first iteration,

STA2 1604 may randomly select two beamforming weights, use Omni weights, or select the weights in an alternate manner. The first receive RF chain (RX1) may obtain a signal as the weighted combination of signals received from all antenna elements. The weight may be the first receive beamforming weight W_{i-1}^{r1}. Similarly, the second receive RF chain (RX2) may obtain a signal as the weighted combination of signals received from all the antenna elements. The weight may be the second receive beamforming weight W_{i-1}^{r2}. The sweeping of the Nr receive antennas 1616 and 1618 is shown in dashed lines as an example illustration of receiver operation. For example, to receive Nr packets from the transmitter, the receiver may receive a first packet with the first receive antenna, a second packet with the second receive antenna, and so on, until it receives a last packet with the last receive antenna. After converting them to baseband and digital domain, STA2 1604 may estimate the effective channel by comparing the received sequence with the known transmitted sequence. For time slot k, STA2 1604 may estimate two channels using two RF chains $\begin{bmatrix} G_{k1} \\ G_{k2} \end{bmatrix}$. With 2Nt time slot, STA2 may receive $\begin{bmatrix} G_{11} & \dots & G_{2Nt1} \\ G_{12} & \dots & G_{2Nt2} \end{bmatrix}$. The first half of the G matrix, $G_{TX1} = \begin{bmatrix} G_{11} & \dots & G_{Nt1} \\ G_{12} & \dots & G_{Nt2} \end{bmatrix}$, may correspond to TX1, and the second half of the G matrix, $G_{TX2} = \begin{bmatrix} G_{(Nt+1)1} & \dots & G_{2Nt1} \\ G_{(Nt+1)2} & \dots & G_{2Nt2} \end{bmatrix}$, may correspond to TX2. Applying the inverse of the orthorgonal precoding matrix to the first half and second half of G matrix respectively, STA2 1604 may obtain the channel from Nt transmit antenna elements with two transmit RF chains to two receive RF chains $H = \begin{bmatrix} H_{11} & \dots & H_{2Nt1} \\ H_{12} & \dots & H_{2Nt2} \end{bmatrix}$.

[0184] STA2 1604 may transmit channel information or beamforming weights for multiple data streams 1610 to STA1 1602. STA2 1604 may calculate the transmit beamforming weights to perform spatial multiplexing for STA1 1602, and transmit the weights 1610 to STA1 1602. STA2 1604 may

transmit the channel H 1610 to STA1 1602, and STA1 1602 then may determine or calculate the transmit beamforming weights for itself 1620.

[0185] For example, the transmit beamforming weight method may be implementation dependent, and linear or non-linear procoding methods may be used. The updated transmit beamforming weights for ith iteration may be denoted as (W_i^{t1}, W_i^{t2}). STA1 1602 may transmit training sequences Nr times with beamforming weight W_i^{t1} 1612. STA2 1604 may sweep through Nr receive antennas 1616, or apply an orthorgonal matrix. STA2 1604 may pass the received signal to two RF chains. STA1 1602 may transmit training sequences 1614 again for Nr times with beamforming weight W_i^{t2}. STA2 1604 may repeat the same procedure with both RF chains 1618. The sweeping of the Nr receive antennas 1616 and 1618 is shown in dashed lines as an example illustration of receiver operation. For example, to receive Nr packets from the transmitter, the receiver may receive a first packet with the first receive antenna, a second packet with the second receive antenna, and so on, until it receives a last packet with the last receive antenna. STA2 1604 may estimate the channel and update the receive beamforming weight 1622 accordingly.

[0186] For example, the receive beamforming weight method may be implementation dependent, and may be repeated for several iterations until the algorithm converges or certain criteria have been met that indicate that spatial multiplexing is not suitable for the pair of devices, STA1 1602 and STA2 1604.

[0187] There may be several ways to define failure criteria to indicate that the pair of devices are not suitable for spatial multiplexing. For example, the failure criteria may include STA2 monitoring the rank or condition number of channel matrix when selecting beamforming weights, and feeding back this information to STA1. A second example of a failure criteria may include STA2 monitoring the rank or condition number of channel matrix

while sweeping through Nr receive antennas or applying an orthogonal matrix, and feeding back this information to STA1.

[0188] If the rank is less than the number of data streams expected to be supported, or the condition number is greater than a certain threshold, both STA1 and STA2 may determine that the maximum number of data streams that may be supported does not meet the requirements. In this example, the pair of devices may determine to complete the training procedure, and perform RF selection at both transmitter and receiver later. Alternatively, the pair of devices may terminate the training with full set of RF chains, and return to performing beamforming training with a fewer number of RF chains. After training, they may transmit with a fewer number of spatial streams.

[0189] In some examples, methods for beam sweep based spatial multiplexing for Type I devices with calibration may be performed. For example, the method of beam sweep based spatial multiplexing may be similar to Eigen-Beamforming based spatial multiplexing. Examples using Eigen-Beamforming based spatial multiplexing may require that the channel estimate and the transmit/receive weights for spatial multiplexing may be determined based on the estimated channel, which may not necessarily be the same as one of the beams used for beamforming training. In beam sweep based spatial multiplexing, there may be no requirement for channel estimation. The device may select one or multiple beams from the set of beams used for beam sweep training. For example, implementation of beam sweep based beamforming may be easier than Eigen-Beamforming based beamforming. The performance of the beam sweep based methods may be sub-optimum compared to the Eigen-beamforming based methods.

[0190] FIG. 17 is a diagram of an example beamforming training method 1700 for beam sweep based spatial multiplexing for Type I devices with calibration between two TX chains. Referring to FIG. 17, for iteration i, STA1 (initiator) 1702 may transmit N repetitions of training sequences 1706 sweeping the transmit beams it intends to train. In these examples, N may

not necessarily be related to the number of transmit antennas. The transmission 1706 may be performed using the first transmit RF chain (TX1) or the second transmit RF chain (TX2). The two RF chains may be identical or different by a scalar. In some examples, the two TX chains may have been calibrated.

[0191] STA2 (responder) 1704 may have the two receive beams trained from the previous iterations. If this is the first iteration, STA2 1704 may randomly select two beams, use Omni weights, or select initial values in an alternate manner. The first receive RF chain (RX1) of STA2 1704 may obtain a signal as the weighted combination of signals received from all antenna elements. The weight may be the first receive beamforming weight W_{i-1}^{r1}. Similarly, the second receive RF chain (RX2) of STA2 1704 may obtain a signal as the weighted combination of signals received from all the antenna elements. The weight may be the second receive beamforming weight W_{i-1}^{r2}. $\{W_{i-1}^{r1}, W_{i-1}^{r2}\}$ may be the weights corresponding to beam indices $\{ID_{i-1}^{r1}, ID_{i-1}^{r2}\}$. After converting them to baseband and digital domain, STA2 1704 may measure the effective SNR or equivalent parameters. For time slot k, STA2 1704 may perform SNR measurements using two receive RF chains $\begin{bmatrix} SNR_{k1} \\ SNR_{k2} \end{bmatrix}$. With N time slots, STA2 1704 may receive $\begin{bmatrix} SNR_{11} & \dots & SNR_{N1} \\ SNR_{12} & \dots & SNR_{N2} \end{bmatrix}$. In FIG. 17, the reception of the signals is shown in dashed lines as an example illustration of the receiver operation while receiving a packet.

[0192] STA2 1704 may feedback two beam indices to STA1 1702. The beam selection method may be implementation dependent. For example, the STA2 1704 may choose the pair of indices (ID_i^{t1}, ID_i^{t2}) which may satisfy $ID_i^{t1} = \arg\max_k (SNR_{k1}^{TX} - SNR_{k2}^{TX})$, and $ID_i^{t2} = \arg\max_k (SNR_{k2}^{TX} - SNR_{k1}^{TX})$.

[0193] The updated transmit beam indices for the ith iteration may be (ID_i^{t1}, ID_i^{t2}). STA1 1702 may transmit a training sequence for M times with

beam ID_i^{t1} 1720. STA2 1704 may sweep through M receive beams with both receive RF chains (RX1 and RX2) 1722. STA1 1702 may transmits a training sequence again for M times with beamforming weight ID_i^{t2} 1724. STA2 1704 may repeat the similar procedure with both RF chains 1726. The sweeping of the receive antennas 1722 and 1726 is shown in dashed lines as an example illustration of receiver operation. For example, to receive packets from the transmitter, the receiver may receive a first packet with the first receive antenna, a second packet with the second receive antenna, and so on, until it receives a last packet with the last receive antenna. STA2 1704 may measure the SNR or equivalent parameters and update the receive beam index accordingly. The receive beam selection method may be implementation dependent. For example, M may be the number of receive beams STA2 1704 intends to train and it may not necessarily be related to a number of receive antennas at STA2 1704. The method may be repeated until the method converges or certain criteria have been met that indicates that spatial multiplexing is not suitable for the pair of devices.

[0194] Failure criteria may be defined in several different ways. For example, failure criteria may indicate that the pair of devices is not suitable for spatial multiplexing. In one example, the failure criteria may be defined as when STA2 1704 may record $\Delta_{11}^{SNR} = \max_k (SNR_{k1}^{TX} - SNR_{k2}^{TX})$ and $\Delta_{12}^{SNR} = \max_k (SNR_{k2}^{TX} - SNR_{k1}^{TX})$ when selecting beams, and feedback this information to STA1 1702. In another example, STA2 1704 may record $\Delta_{21}^{SNR} = \max_{1 \le k \le N} (SNR_{k1}^{RX} - SNR_{k2}^{RX})$ and $\Delta_{22}^{SNR} = \max_{N < k \le 2N} (SNR_{k2}^{RX} - SNR_{k1}^{RX})$ when sweeping beams, and feedback this information to STA1 1702.

[0195] If Δ_{ij}^{SNR} is smaller than a certain threshold, both STA1 1702 and STA2 1704 may determine that the channel cannot provide enough spatial diversity to support two data streams. In this example, STA1 1702 and STA2 1704 may determine to complete the training procedure, and perform RF selection at both transmitter and receiver. STA1 1702 and STA2 1704 may

terminate the training with two RF chains, and return to performing beamforming training with one RF chain. After training, they may transmit with a fewer number of spatial streams. For example, more than two data streams may be determined.

[0196] Beam sweep based spatial multiplexing for Type II devices and Type I devices without calibration may be performed. FIG. 18 is a diagram of an example beamforming training method 1800 for beam sweep based spatial multiplexing Type II devices and Type I devices without calibration.

[0197] For iteration i, STA1 (initiator) 1802 may transmit N repetition of training sequences sweeping all the transmit beams it intends to train using the first transmit RF chain (TX1) 1806. Then STA1 1802 may repeat the same procedure with the second RF chain (TX2) 1808. N may not necessarily be related to the number of transmit antennas. For example, the beam pattern used for TX1 may not be the same as that for TX2.

[0198] STA2 (responder) 1804 may have the two receive beams trained from the previous iterations. If this is the first iteration, STA2 1804 may randomly select two beams, use Omni weights, or select the two beams in a different way. The first receive RF chain (RX1) 1810 may obtain a signal as the weighted combination of signals received from all antenna elements. The weight may be the first receive beamforming weight W_{i-1}^{r1}. The second receive RF chain (RX2) 1812 may obtain a signal as the weighted combination of signals received from all the antenna elements. The weight may be the second receive beamforming weight W_{i-1}^{r2}. For example, $\{W_{i-1}^{r1}, W_{i-1}^{r2}\}$ may be the weights that correspond to beam indices $\{ID_{i-1}^{r1}, ID_{i-1}^{r2}\}$. After converting them to baseband and digital domain, STA2 1804 may measure the effective SNR or equivalent parameters. For time slot k, STA2 1804 may perform SNR measurements using two receive RF chains $\begin{bmatrix} SNR_{k1} \\ SNR_{k2} \end{bmatrix}$. With the first N time slot, STA2 1804 may receive $\begin{bmatrix} SNR_{11} & \dots & SNR_{N1} \\ SNR_{12} & \dots & SNR_{N2} \end{bmatrix}$, which may correspond to

TX1 of STA1 1802. With the last N time slots, STA2 1804 may receive $\begin{bmatrix} SNR_{(N+1)1} & \dots & SNR_{2N1} \\ SNR_{(N+1)2} & \dots & SNR_{2N2} \end{bmatrix}$, which may correspond to TX2 of STA1 1802. In FIG. 18, the reception of the signals is shown in dashed lines as an example illustration of the receiver operation while receiving a packet.

[0199] STA2 1804 may feedback two beam indices 1814 to STA1 1802. The beam selection method may be implementation dependent. For example, the STA2 1804 may select the pair of indices (ID_i^{t1}, ID_i^{t2}) which may satisfy $ID_i^{t1} = \arg\max_{1 \le k \le N} (SNR_{k1}^{TX} - SNR_{k2}^{TX})$ and $ID_i^{t2} = \arg\max_{N < k \le 2N} (SNR_{k2}^{TX} - SNR_{k1}^{TX})$.

[0200] The updated transmit beam indices for ith iteration may be (ID_i^{t1}, ID_i^{t2}). STA1 1802 may transmit a training sequence M times with beam ID_i^{t1} 1816. STA2 1804 may sweep through M receive beams with both receive RF chains (RX1 and RX2) 1818. STA1 1802 may transmit a training sequence again M times with beamforming weight ID_i^{t2} 1820. STA2 1804 may repeat the same procedure with both RF chains 1822. The sweeping of the receive antennas 1818 and 1822 is shown in dashed lines as an example illustration of receiver operation. For example, to receive packets from the transmitter, the receiver may receive a first packet with the first receive antenna, a second packet with the second receive antenna, and so on, until it receives a last packet with the last receive antenna. STA2 1804 may measure the SNR or equivalent parameters and update the receive beam index accordingly. The receive beam selection method may be implementation dependent. For example, M may be the number of receive beams STA2 1804 intends to train and may not necessarily be related to the number of receive antennas at STA2 1804.

[0201] The procedure may be repeated for several iterations until the method converges or certain criteria have been met that indicates that spatial multiplexing is not suitable for STA1 1802 and STA2 1804.

[0202] There may be several ways to define failure criteria that indicate that the pair of devices are not suitable for spatial multiplexing. For example, the failure criteria may be defined as when STA2 1804 may record $\Delta_{11}^{SNR} = \max_{1 \le k \le N}(SNR_{k1}^{TX} - SNR_{k2}^{TX})$ and $\Delta_{12}^{SNR} = \max_{N < k \le 2N}(SNR_{k2}^{TX} - SNR_{k1}^{TX})$ in when selecting beams, and feedback this information to STA1 1802. In another example failure criteria, STA2 1804 may record $\Delta_{21}^{SNR} = \max_{1 \le k \le N}(SNR_{k1}^{RX} - SNR_{k2}^{RX})$ and $\Delta_{22}^{SNR} = \max_{N < k \le 2N}(SNR_{k2}^{RX} - SNR_{k1}^{RX})$ in when sweeping beams, and feedback this information to STA1 1802.

[0203] If Δ_{ij}^{SNR} is smaller than a threshold, both STA1 1802 and STA2 1804 may determine that the channel cannot provide enough spatial diversity to support two data streams. In this example, the pair of devices may determine to complete the training procedure, and perform RF selection at both transmitter and receiver. Alternatively, the pair of devices may terminate the training with two RF chains, and return to performing beamforming training with one RF chain. After training, the pair of devices may transmit with a fewer number of spatial streams.

[0204] The beam refinement transaction discussed in conjunction with FIG. 3 may be used for Eigen-beamforming based spatial multiplexing methods disclosed above. Modifications may be applied to support spatial multiplexing. For example, a number of spatial streams may be defined. The number of data streams may be defined in a DMG beam refinement element. The FBCK-TYPE subfield in the DMG beam refinement element may be modified.

[0205] FIG. 19 is a diagram of an example modified FBCK-TYPE subfield 1900. The modified FBCK-TYPE subfield 1900 may be included in a DMG refinement element. The modified FBCK-TYPE subfield 1900 may include a SNR present field 1910, a channel measurement present field 1920, a tap delay present field 1930, a number of taps present field 1940, a number of measurement field 1950, a number of spatial streams field 1960, a sector ID order present field 1970, and a number of beams field 1980.

[0206] An initiator may determine the capabilities of the responder prior to initiating beamforming training with the responder by using an Eigen-beamforming based spatial multiplexing capability. The Beam sweep based spatial multiplexing capability may be indicated in a DMG capabilities element. The DMG capabilities element may be present in an association request, association response, re-association request, re-association response, probe request and probe response frames and may be present in DMG beacon and information request and response frames. One bit of Eigen-beamforming based spatial multiplexing indication and one bit of beam sweep spatial multiplexing capability may be used to indicate that the STA is capable of performing Eigen-beamforming based spatial multiplexing.

[0207] The type of beamforming training algorithm, such as Eigen-beamforming based and beam sweep based, may be indicated in DMG beam refinement element. In addition, transceiver architecture type, such as Type I and Type II may be indicated in a DMG capabilities element.

[0208] A precoding matrix utilized by the initiator in the first part of each iteration may be predefined and agreed on by both initiator and responder if Eigen-beamforming based spatial multiplexing is implemented. In this example, the initiator and responder may negotiate which matrix to utilize before the beamforming training. For example, the precoding matrix index may be defined and transmitted in a BRP request field. In addition, a set of unitary precoding matrices may be predetermined.

[0209] A number of antennas at both initiator and responder may be signaled if Eigen-beamforming based spatial multiplexing is implemented. The number of antennas may be signaled in the PHY header, MAC header or a BRP Request field.

[0210] A spatial multiplexing frame format may be implemented. For example, when a packet is transmitted using spatial multiplexing, an indication may be sent to inform the packet recipients that multiple streams were transmitted. The MCS may be redefined for a modulation/coding scheme and the number of spatial streams. In 802.11ad, for example, MCS 0 may be

the Control PHY; MCS 1-12 may be utilized for single carrier (SC) PHY; MCS 13-24 may be for OFDM PHY; and MCS 25-31 may be for low power SC PHY.

[0211] In examples with two data stream transmissions, the following may be defined for use by the communication devices. For example, MCS 32-43 may be for SC PHY, MCS 44-55 may be for OFDM PHY, and 56-62 may be for low power SC PHY. In some examples, the MCS mapping may not be the same as defined above.

[0212] Alternatively, the number of spatial streams may be indicated in a PHY header. In order to support multiple data streams, the PHY layer frame format may need to be modified.

[0213] FIGS. 20A, 20B, and 20C are diagrams of example PHY layer frame formats. With SC PHY, the data field may be composed of symbol blocks, while with OFDM PHY, the data field may be composed of OFDM symbols. The frame may be appended with TRN-T/R subfields, and may be utilized for beam refinement protocol.

[0214] Referring to FIG. 20A, short training field (STF) 2010, channel estimation field (CE) 2020 and PHY headers 2030 may be transmitted with a weight, W1 2040. The number of data streams supported, N, may be indicated in the PHY header. If more than one data stream will be transmitted, additional CE field(s) may be included. With N data streams, an extra N-1 CE field 2050 may be transmitted and weights W2 2060, ..., WN 2070 may be applied to each CE field. An orthogonal mapping matrix, such as the P matrix defined in 802.11n/ac, may be applied. If a cyclic shift delay (CSD) scheme is applied to spatial multiplexing, the same CSD parameters may be applied to the CE fields. The data field 2080 that follows may be transmitted using the spatial multiplexing scheme, and all of the weights (W1,...,WN) 2090 may be applied.

[0215] FIG. 20B is a diagram of another example preamble format for spatial multiplexing transmissions. This format is similar to FIG. 20A except that an AGC field 2015 may be inserted after additional CE fields and before the data field 2080. The AGC field 2015 may use the same sequence as an LTF

field, or it may be redesigned. The purpose of this AGC field 2015 may be for automatic gain control. The transmission of the AGC field 2015 may be in the same format as the data field 2080, i.e., weights (W1,...,WN) 2090 may be applied. The same CSD parameters may be applied to AGC field 2015 if CSD is utilized for data transmissions.

[0216] FIG. 20C is a diagram of another example preamble format for spatial multiplexing transmissions in which the number of data streams may be signaled implicitly. STF 2010 may be transmitted using all the weights (W1,...,WN) 2025. The first CE field 2020 following STF 2010 may be transmitted using the first weight W1 2040. The number of data streams may be implicitly indicated by using STF 2010 and the first CE field 2020. For example, several CE sequences may be defined, and each sequence may correspond to a certain number of data streams. Additional N-1 CE fields 2050 may follow the first CE field 2020 and transmitted with weights W2 2060 to WN 2070. The header 2035 may be transmitted with one of the weights or a combination of the weights similar to STF 2010. The spatial multiplexing transmission may be transmitted following the additional CE fields.

[0217] Beamforming training overhead and latency may be reduced. For example, sector sweep (SSW) frames and related training methods may be modified.

[0218] In the SLS procedures, SSW frames may be utilized for transmit and receive beamforming training. For example, the SSW frames may be transmitted in N time slots. For transmit beamforming training, SSW frames may be transmitted and multiple antenna sectors may be swept. The receiver may receive the SSW frames with the same antenna sector and feedback the best transmit sector ID to the transmitter. For example, for receive beamforming training, the same SSW frames may be repeated N times, and the receiver may sweep over multiple antenna sectors to receive. After the receive beamforming training, the receiver may select the best receive sector.

[0219] Each SSW frame may comprise a full PLCP header that may include a preamble, one or more header blocks, and a MAC frame. Since the

SSW frames may be utilized for beamforming training, they may be transmitted using the lowest data rate, for example, control PHY or MCS0 in 802.11ad. SSW frames may not contain data traffic, therefore SSW frame sequences may be beamforming training overhead.

[0220] FIG. 21 is a diagram of an example modified SSW training frames and sequence 2100. In this example, modified SSW training sequences may be utilized. A SSW announcement (SSWA) frame 2110 may be transmitted at the beginning of the SSW training sequences. The SSWA frame 2110 may contain all the information used to transmit by SSW frames. One or more N null SSW (NSSW) frames 2120 may follow the SSWA frame 2110 with a certain inter-frame spacing. NSSW frames 2120 may contain only preamble and PHY headers, and no MAC frame.

[0221] Figure 22 is a diagram of an example SSWA frame format 2200. The SSWA frame format 2200 may include a frame control field 2205, a duration field 2210, an RA field 2215, a TA field 2220, an SSW field 2225, an SSW feedback (FB) field 2230, and an FCS field 2235. The SSW field 2225 may include a direction subfield 2240, a DMG antenna ID 1 subfield 2245, a sector ID 1 subfield 2250, a sector ID N subfield 2255, a DMG antenna ID 2 subfield 2260, a sector ID 1 subfield 2265, a sector ID N2 subfield 2270, and an RXSS length subfield 2275. In this example, sector ID 1 subfield 2250 may be for DMG antenna ID 1, and sector ID 1 subfield 2265 may be for DMG antenna ID 2.

[0222] The direction subfield 2240 and the RXSS length subfield 2275 may be the same as in IEEE 802.11ad. The direction subfield 2240 may be set to 0 to indicate that the frame is transmitted by the beamforming initiator and set to 1 to indicate that the frame is transmitted by the beamforming responder. The RXSS Length subfield 2275 may be valid only when transmitted in a CBAP and may be reserved otherwise. The RXSS Length subfield 2275 may specify the length of a receive sector sweep as required by the transmitting STA, and may be defined in units of an SSW frame. The value of this field is in the range 0–62, with odd values being reserved.

[0223] DMG Antenna IDs and Sector IDs may be utilized to indicate the antenna pattern for the following NSSW frames. For example, the first NSSW frame may utilize DMG Antenna ID 1 and Sector ID 1 to transmit, and the second NSSW frame may utilize DMG Antenna ID 1 and Sector ID 2 to transmit, and so on. With DMG antenna ID k, there may be Nk sectors swept for this round of beamforming training. The total number of NSSW frames following this SSWA frame may be $\sum_{k=1}^{K} N_k$. K may be the number of DMG antennas trained with these SSWA-NSSW sequences.

[0224] The SSWA may be transmitted as follows. For example, the SSWA frame may carry all the MAC information necessary for beamforming training. It may be important that the receiver decodes the SSWA frame correctly. The SSWA frame may be transmitted using one of the following methods. For example, if the beamforming training is between two non-AP/PCP devices, the SSWA frame may be transmitted from AP to the two devices. In another example, if both the beamforming initiator and responder are multi-band capable, they may operate on multiple frequency bands simultaneously, and the SSWA frame may be transmitted on another frequency band. The SSWA frame may be transmitted with low data rate, spreading codes, or repetition schemes.

[0225] Some examples may use sub-optimum SLS training methods. In these examples, SLS training methods may be terminated early.

[0226] FIG. 23 is a diagram of an example early termination of the SLS training procedure. In this example, the initiator 2302 may have 4 beam sectors to train, and the countdown (CDOWN) number may equal 3 in the first training frame. In this example, sector 3 is shaded to illustrate that the initiator may use sector 3 for transmission in a first period, and sector 4 is shaded to illustrate that the initiator may use sector 4 for transmission in the second period. The initiator 2302 may continue transmitting training frames which are separated by inter-frame space duration 2T, for example. The responder 2304 may monitor the received training frames 2306. The dashed

"omni" circles in FIG. 23 are shown to illustrate that the receiver/responder may be in an omni-receiving mode. An omni-receiving mode may be enabled by an omni-directional receiving antenna. The first two "omni" circles are shown in dashed lines to illustrate that they are example receiver operations. The last "omni" circle is shown in indicating solid line to illustrate that this is an example transmitter operation, i.e., the feedback packet may be transmitted in an omni-transmitting mode, which may be enabled by an omni-directional transmitting antenna. Once the received SNR (or other parameters) is greater than a certain threshold, the responder 2304 may determine to terminate the training procedure by transmitting a feedback frame 2308. The feedback frame 2308 may be transmitted after a T duration from the end of a training frame transmitted by the initiator 2302. Thus the initiator 2302 may detect the transmission of this feedback and stop transmitting more training frames. This example may be used for both transmit and receive beamforming training.

[0227] A group based SLS training method may be performed. In this example, a STA may divide its sectors to groups. The partition of sectors may be implementation dependent. For example, the partition may be based on the direction of the sectors. The beamforming initiator may select one group to perform SLS training and wait for the feedback from the responder. Once the feedback from responder meets the expectation of the initiator, the beamforming initiator may determine to stop the beamforming training. Otherwise, the initiator may select another group to perform SLS training until one beam is selected or all the beams are swept.

[0228] Multi-beam, multi-DMG antenna sector level sweep feedback may be performed. In examples of the sector level sweep method, the receiver STA may report back the best beam only, for example, one sector of one DMG antenna. For example, a list of the best beams, such as multiple beams of multiple antennas may be reported. This may enable the communication link to track the relative performance of the beams over time and, if necessary, switch to a better beam without the need for retraining.

[0229] FIG. 24 is a diagram of an example multi-beam multi-DMG antenna SLS feedback method 2400. The following method 2400 may use a sector level sweep method that may report a list of best beams. In this example, the DMG transmitting STA1 2402 and receiving STA2 2404 may indicate their capability to support multi-sector, multi-DMG antenna Sector Sweep (SSW) feedback. This capability may be indicated by a bit in the DMG STA Capability Information field. STAs that do not have the capability may fall back to legacy transmission.

[0230] The STA initiating the sector sweep, for example STA1 2402, may transmit information to the responder STA, for example STA2 2404, indicating the number of beams to be fed back. The responder STA 2404 may also transmit information to initiator STA 2402 on the number of beams to be fed back. The metric to decide on the best beams may be implementation dependent. One signaling method may use a Transmit Sector Sweep frame for both the initiator and the responder may contain the number of beams to be fed back. A second signaling method may use a DMG beacon that may contain a field that indicates the number of beams to be fed back for all SSW feedback 2420. In a third signaling method, before a Sector Level Sweep procedure, the initiator and responder may exchange SLS setup frames indicating the number of beams to feed back. Quasi-omni may refer to a near omni-directional transmission or reception. For example, quasi-omni transmissions may be enabled by repeatedly transmitting the same information using multiple directional transmissions, as if it were transmitted using an omni-directional transmit antenna. Similarly, quasi-omni receptions may be enabled by repeatedly receiving the same packet using multiple directional receptions, as if it were received using an omni-directional receiving antenna.

[0231] Both STAs may implement the legacy initiator and responder sector level sweep procedures. The transmitter may feedback the best N beams. This may be by one of the following example methods. In a first example method, multiple SSW Feedback fields may be aggregated within an SSW feedback frame 2420. In a second example, a single SSW Feedback field

may be modified to enable feedback of multiple beams and DMG antennas and corresponding SNR Reports. In a third example, the best beam/antenna may be fed back during the SLS procedure and subsequent feedback of the additional N-1 beams with other transmissions, for example an ACK. In these examples, the number of antenna may be larger than the number radio frequency (RF) chains. In some examples, the number of antenna may be much larger than the number of RF chains.

EMBODIMENTS

1. A first communication device comprising:

a plurality of antennas;

a processor configured to partition the plurality of antennas;

a transmitter configured to transmit a plurality of frames to a second communication device;

and a receiver.

2. The first communication device of embodiment 1, wherein the processor is configured to partition the plurality of antennas into at least a first group of antennas and a second group of antennas.

3. The first communication device of embodiment 2, wherein the first group of antennas is associated with a first beam to a first station (STA).

4. The first communication device of embodiment 2 or 3, wherein the second group of antennas is associated with a second beam to a second station (STA).

5. The first communication device of any one of embodiments 2-4, wherein the first group of antennas is associated with a first beam to a first plurality of stations (STAs).

6. The first communication device of any one of embodiments 2-5, wherein the second group of antennas is associated with a second beam to a second plurality of stations (STAs).

7. The first communication device of any preceding embodiment, wherein the plurality of frames transmitted are beamforming training frames.

8. The first communication device of any preceding embodiment, wherein the plurality of frames are transmitted using the first group of antennas.

9. The first communication device of any preceding embodiment, wherein the plurality of frames are transmitted using the second group of antennas.

10. The first communication device of any preceding embodiment, wherein the receiver is configured to receive a first beamforming weight vector from the second communication device.

11. The first communication device of embodiment 10, wherein the first beamforming weight vector is for sending signals on the first group of antennas.

12. The first communication device of any preceding embodiment, wherein the receiver is configured to receive a second beamforming weight vector from the second communication device.

13. The first communication device of embodiment 12, wherein the second beamforming weight vector is for sending signals on the second group of antennas.

14. The first communication device of any one of embodiments 10-13, wherein the first beamforming weight vector is a strongest beam between the first communication device and the second communication device.

15. The first communication device of any one of embodiments 12-14, wherein the second beamforming weight vector is for a second strongest beam between the first communication device and the second communication device.

16. The first communication device of any preceding embodiment, wherein the first communication device is a wireless transmit/receive unit (WTRU).

17. The first communication device of any one of embodiments 1-15, wherein the first communication device is a station (STA).

18. The first communication device of any one of embodiments 1-15, wherein the first communication device is an access point (AP).

19. The first communication device of any one of embodiments 1-15, wherein the first communication device is a base station.

20. The first communication device of any preceding embodiment, wherein the second communication device is a wireless transmit/receive unit (WTRU).

21. The first communication device of any one of embodiments 1-19, wherein the second communication device is a station (STA).

22. The first communication device of any one of embodiments 1-19, wherein the second communication device is an access point (AP).

23. The first communication device of any one of embodiments 1-19, wherein the second communication device is a base station.

24. The first communication device of any one of embodiments 7-23, wherein the beamforming training frames are orthogonal beamforming vectors.

25. The first communication device of any preceding embodiment, wherein the transmitter is further configured to transmit a second set of beamforming training frames.

26. The first communication device of embodiment 25, wherein the second set of beamforming training frames is transmitted using the received first beamforming weight vector.

27. The first communication device of embodiment 25 or 26, wherein the second set of beamforming training frames is transmitted using the received second beamforming weight vector.

28. The first communication device of any preceding embodiment, wherein the receiver is further configured to receive a modified first beamforming weight vector.

29. The first communication device of embodiment 28, wherein the modified first weight vector is for sending signals on the first group of antenna.

30. The first communication device of any preceding embodiment, wherein the receiver is further configured to receive a modified second beamforming weight vector.

31. The first communication device of embodiment 30, wherein the modified second weight vector is for sending signals on the second group of antenna.

32. The first communication device of any preceding embodiment, wherein the first communication device comprises one or more radio frequency (RF) chains.

33. The first communication device of any preceding embodiment, wherein a number of the antenna is larger than a number of one or more radio frequency (RF) chains.

34. A first communication device comprising:

a plurality of antennas;

a receiver configured to receive a set of beamforming training frames;

a processor; and

a transmitter.

35. The first communication device of embodiment 34, wherein the processor is configured to determine a first transmit beamforming weight vector.

36. The first communication device of embodiment 35, wherein the first transmit beamforming weight vector corresponds to a first antenna group.

37. The first communication device of embodiment 36, wherein the first antenna group is for a second communication device.

38. The first communication device of any one of embodiments 34-37, wherein the processor is configured to determine a second transmit beamforming weight vector.

39. The first communication device of embodiment 38, wherein the second transmit beamforming weight vector corresponds to a second antenna group.

40. The first communication device of embodiment 39, wherein the second antenna group is for a second communication device.

41. The first communication device of any one of embodiments 34-40, wherein the transmitter is configured to transmit data using the first transmit beamforming weight vector to the second communication device to the second communication device.

42. The first communication device of any one of embodiments 34-41, wherein the transmitter is configured to transmit data using the second transmit data using the second transmit beamforming weight vector to the second communication device.

43. The first communication device of any one of embodiments 34-42, wherein the first communication device is a wireless transmit/receive unit (WTRU).

44. The first communication device of any one of embodiments 34-42, wherein the first communication device is a station (STA).

45. The first communication device of any one of embodiments 34-42, wherein the first communication device is an access point (AP).

46. The first communication device of any one of embodiments 34-42, wherein the first communication device is a base station.

47. The first communication device of any one of embodiments 34-46, wherein the second communication device is a wireless transmit/receive unit (WTRU).

48. The first communication device of any one of embodiments 34-46, wherein the second communication device is a station (STA).

49. The first communication device of any one of embodiments 34-46, wherein the second communication device is an access point (AP).

50. The first communication device of any one of embodiments 34-46, wherein the second communication device is a base station.

51. The first communication device of any one of embodiments 34-50, wherein the received beamforming training frames are orthogonal beamforming vectors.

52. The first communication device of any one of embodiments 34-51, wherein the transmitted beamforming weight vectors are orthogonal beamforming vectors.

53. A method for beamforming training for beam division multiple access (BDMA), the method comprising:

receiving a first transmit beamforming weight from a first station (STA), and receiving a second transmit beamforming weight from a second (STA);

transmitting Nt sequences modulated using Nt beamforming vectors, wherein the Nt sequences are modulated based on the first transmit beamforming weight and the second transmit beamforming weight.

54. The method of embodiment 53, wherein the Nt beamforming vectors are orthogonal.

55. A method for beamforming training for beam division multiple access (BDMA), the method comprising:

receiving a plurality of Nt sequences using a first previous beamforming vector;

determining a first transmit beamforming weight from an access point (AP) based on the first previous beamforming vector and the received plurality of Nt sequences; and

transmitting the determined first transmit beamforming weight to the AP.

56. A method for beamforming training for spatial multiplexing, the method comprising:

an initiator station having two radio frequency (RF) chains and having transmit antenna elements, the initiator station transmitting Nt known training sequences sweeping the transmit antenna elements;

a responder station having a first and a second RF chain and having receive antenna elements, and having a first and a second receive beamforming weight, the responder station receiving the first RF chain and receiving the second RF chain; and

the responder station estimating at least two channels by comparing the received first RF chain and the second RF chain to the Nt known training sequences.

57. The method of embodiment 56, wherein the first RF chain is the combination of signals received from the receive antenna elements weighted by the first receive beamforming weights

58. The method of embodiment 57, wherein the second RF chain is the combination of signals received from the receive antenna elements weighted by the second receive beamforming weights.

59. The method of any one of embodiments 56-58, wherein the transmitting Nt training sequences further comprises transmitting Nt training sequences over a first RF chain of the initiator.

60. The method of any one of embodiments 56-58, wherein the transmitting Nt training sequences further comprises transmitting Nt training sequences over a second RF chain of the initiator.

61. The method of any one of embodiments 56-58, wherein the transmitting Nt training sequences further comprises transmitting Nt training sequences over the first RF chain and the second RF chain.

62. The method of embodiment 61, wherein the first RF chain and the second RF chain are calibrated.

63. The method of any one of embodiments 56-62, wherein the transmitting Nt known training sequences sweeping the transmit antenna elements comprises the initiator station having two RF chains and having transmit antenna elements, transmitting Nt known training sequences sweeping the transmit antenna elements, wherein a number of the transmit antenna elements is larger than a number of RF chains.

64. The method of any one of embodiments 56-63, wherein the number of transmit antenna elements is at least six times larger than a number of RF chains.

65. The method of any one of embodiments 56-64 further comprising the responder transmitting the estimated two channels to the initiator.

66. A method for beamforming training for spatial multiplexing, the method comprising:

an initiator station having two or more radio frequency (RF) chains and having transmit antenna elements, the initiator station transmitting Nt known sequences sweeping the transmit antenna elements;

a responder station having a first and a second RF chain and having receive antenna elements, and having a first and a second receive beamforming weight, the responder station receiving the first RF chain and receiving the second RF chain; and

the responder estimating at least two channels by comparing the received first RF chain and the second RF chain to the known Nt training sequences.

67. The method of embodiment 66, wherein the first RF chain is a combination of signals received from the receive antenna elements weighted by the first receive beamforming weights.

68. The method of embodiment 66 or 67, wherein the second RF chain is the combination of signals received from the receive antenna elements weighted by the second receive beamforming weights.

69. A method for performing beamforming, the method comprising:

a first communication device transmitting a first plurality of beamforming training frames to a second communication device using a first beamforming vector;

the first communication device receiving from the second communication device a second beamforming weight vector; and

the first communication device transmitting a second plurality of beamforming training frames to the second communication device using the second beamforming vector.

70. The method of embodiment 69, wherein the first communication device transmits the first plurality of beamforming training frames to the second communication device using a first beamforming weight vector.

71. The method of embodiment 69 or 70, wherein the first communication device transmits a first portion of the first plurality of beamforming training frames using a first group of antenna and a first portion of the beamforming weights.

72. The method of any one of embodiments 69-71, wherein the first communication device transmits a second portion of the first plurality of beamforming training frames using a second group of antenna and a second portion of the beamforming weights.

73. A base station configured to perform any one of embodiments 53-72.

74. A base station configured to perform any portion of embodiments 53-72.

75. An integrated circuit configured to perform any one of embodiments 53-72.

76. An integrated circuit configured to perform any portion of embodiments 53-72.

77. A station (STA) configured to perform any one of embodiments 53-72.

78. A station (STA) configured to perform any portion of embodiments 53-72.

79. An access point (AP) configured to perform any one of embodiments 53-72.

80. An access point (AP) configured to perform any portion of embodiments 53-72.

81. A wireless transmit/receive unit (WTRU) configured to perform any one of embodiments 53-72.

82. A wireless transmit/receive unit (WTRU) configured to perform any portion of embodiments 53-72.

[0232] Although features and elements are described above in particular combinations, one of ordinary skill in the art will appreciate that each feature or element can be used alone or in any combination with the other features and elements. In addition, the methods described herein may be implemented in a computer program, software, or firmware incorporated in a computer-readable medium for execution by a computer or processor. Examples of computer-readable media include electronic signals (transmitted over wired or wireless connections) and computer-readable storage media. Examples of computer-readable storage media include, but are not limited to, a read only memory (ROM), a random access memory (RAM), a register, cache memory, semiconductor memory devices, magnetic media such as internal hard disks and removable disks, magneto-optical media, and optical media such as CD-ROM disks, and digital versatile disks (DVDs). A processor in association with software may be used to implement a radio frequency transceiver for use in a WTRU, UE, terminal, base station, RNC, or any host computer.

* * *

CLAIMS

What is claimed is:

1. A first communication device, the first communication device comprising:

a plurality of antennas;

a processor, wherein the processor is configured to partition the plurality of antennas into at least a first group of antennas and a second group of antennas, wherein the first group of antennas is associated with a first beam to a first station (STA) or a first plurality of STAs, and the second group of antennas is associated with a second beam to a second STA or a second plurality of STAs;

a transmitter configured to transmit, to a second communication device, a plurality of beamforming training frames using the first group of antennas and the second group of antennas; and

a receiver configured to receive from the second communication device a first beamforming weight vector for sending signals on the first group of antennas and to receive a second beamforming weight vector for sending signals on the second group of antennas.

2. The first communication device of claim 1, wherein the first beamforming weight vector is a strongest beam between the first communication device and the second communication device, and wherein the second beamforming weight vector is for a second strongest beam between the first communication device and the second communication device.

3. The first communication device of claim 1, wherein the first communication device and the second communication device are one of: a wireless transmit receive unit, a station, an access point, or a base station.

4. The first communication device of claim 1, wherein the beamforming training frames are orthogonal beamforming vectors.

5. The first communication device of claim 1, wherein the transmitter is further configured to transmit a second set of beamforming training frames using the received first beamforming weight vector and the second beamforming weight vector; and wherein the receiver is further configured to receive from the second communication device a modified first beamforming weight vector for sending signals on the first group of antenna and to receive a modified second beamforming weight vector for sending signals on the second group of antenna.

6. The first communication device of claim 1, wherein the first communication device comprises one or more radio frequency (RF) chains and wherein a number of the antenna is larger than a number of the one or more RF chains.

7. A first communication device, the first communication device comprising:

a plurality of antennas; and

a processor, wherein the plurality of antennas are configured to receive a set of beamforming training frames, and wherein the processor is configured to determine a first transmit beamforming weight vector corresponding to a first antenna group of a second communication device, and to determine a second transmit beamforming weight vector corresponding to a second antenna group of the second communication device; and

a transmitter configured to transmit data using the first transmit beamforming weight vector and to send data using the second transmit beamforming weight vector to the second communication device.

8. The first communication device of claim 7, wherein the first communication device and the second communication device are one of: a wireless transmit receive unit, a station, an access point, or a base station.

9. The first communication device of claim 7, wherein the received beamforming training frames are orthogonal beamforming vectors.

10. The first communication device of claim 7, wherein the transmitted beamforming weight vectors are orthogonal beamforming vectors.

11. A method for use in a first communication device, the method comprising:

partitioning, at the first communication device, a plurality of antennas into at least a first group of antennas and a second group of antennas, wherein the first group of antennas is associated with a first beam to a first station (STA) or a first plurality of STAs, and the second group of antennas is associated with a second beam to a second STA or a second plurality of STAs;

transmitting, to a second communication device, a plurality of beamforming training frames using the first group of antennas and the second group of antennas; and

receiving, from the second communication device, a first beamforming weight vector for transmitting signals on the first group of antennas and receiving a second beamforming weight vector for transmitting signals on the second group of antennas.

12. The method of claim 11, wherein the first beamforming weight vector is a strongest beam between the first communication device and the second communication device, and wherein the second beamforming weight vector is for a second strongest beam between the first communication device and the second communication device.

13. The method of claim 11, wherein the first communication device and the second communication device are one of: a wireless transmit receive unit, a STA, an access point (AP), or a base station.

14. The method of claim 11, wherein the beamforming training frames are orthogonal beamforming vectors.

15. The method of claim 11 further comprising:

transmitting a second set of beamforming training frames using the received first beamforming weight vector and the second beamforming weight vector; and

receiving from the second communication device a modified first beamforming weight vector for transmitting signals on the first group of antenna and receiving a modified second beamforming weight vector for transmitting signals on the second group of antenna.

16. The method of claim 11, wherein the first communication device comprises one or more radio frequency (RF) chains and wherein a number of the antenna is larger than a number of the one or more RF chains.

17. A method for use in a first communication device, the method comprising:

receiving a set of beamforming training frames;

determining a first transmit beamforming weight vector corresponding to a first antenna group of a second communication device, and to determining a second transmit beamforming weight vector corresponding to a second antenna group of the second communication device; and

transmitting data using the first transmit beamforming weight vector and transmitting data using the second transmit beamforming weight vector to the second communication device.

18. The method of claim 17, wherein the first communication device and the second communication device are one of: a wireless transmit receive unit, a station (STA), an access point (AP), or a base station.

19. The method of claim 17, wherein the received beamforming training frames are orthogonal beamforming vectors.

20. The method of claim 17, wherein the received beamforming training frames are orthogonal beamforming vectors.

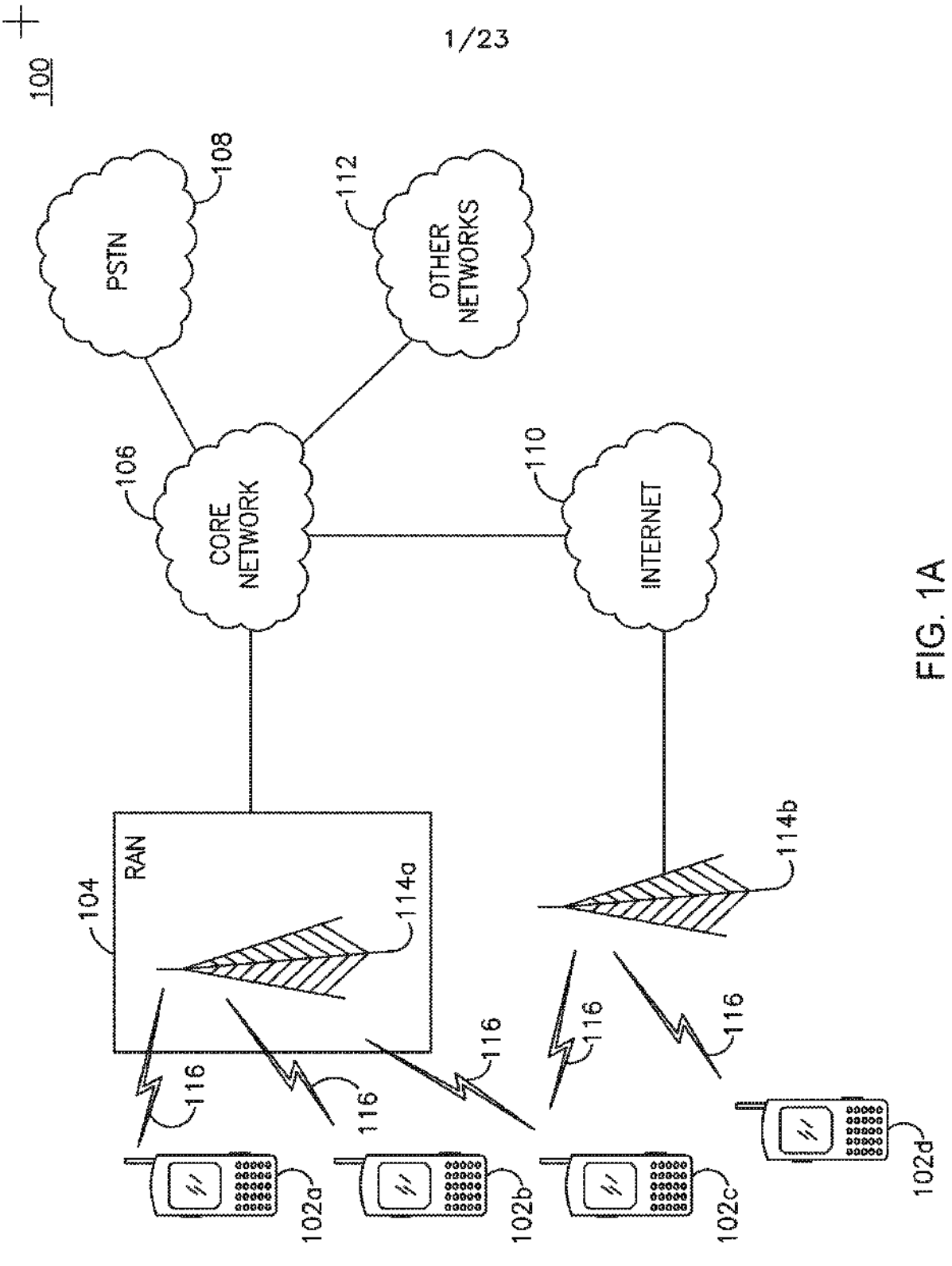

100
PSTN
108
OTHER NETWORKS
112
CORE NETWORK
106
INTERNET
110
RAN
104
114a
114b
116
116
116
116
116
102a
102b
102c
102d

FIG. 1A

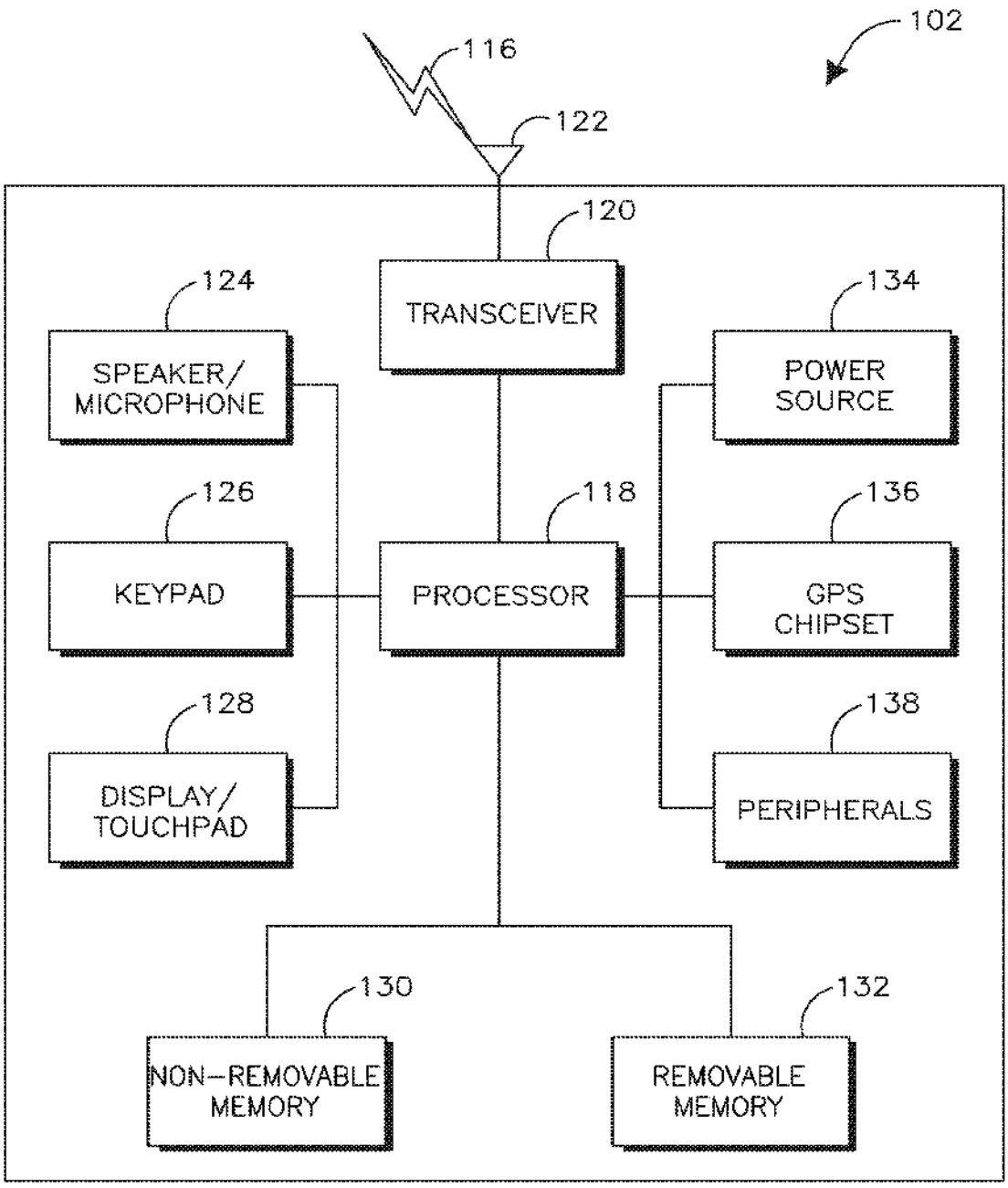

102
116
122
120
TRANSCEIVER
124
SPEAKER/
MICROPHONE
134
POWER
SOURCE
126
KEYPAD
118
PROCESSOR
136
GPS
CHIPSET
128
DISPLAY/
TOUCHPAD
138
PERIPHERALS
130
NON-REMOVABLE
MEMORY
132
REMOVABLE
MEMORY

FIG. 1B

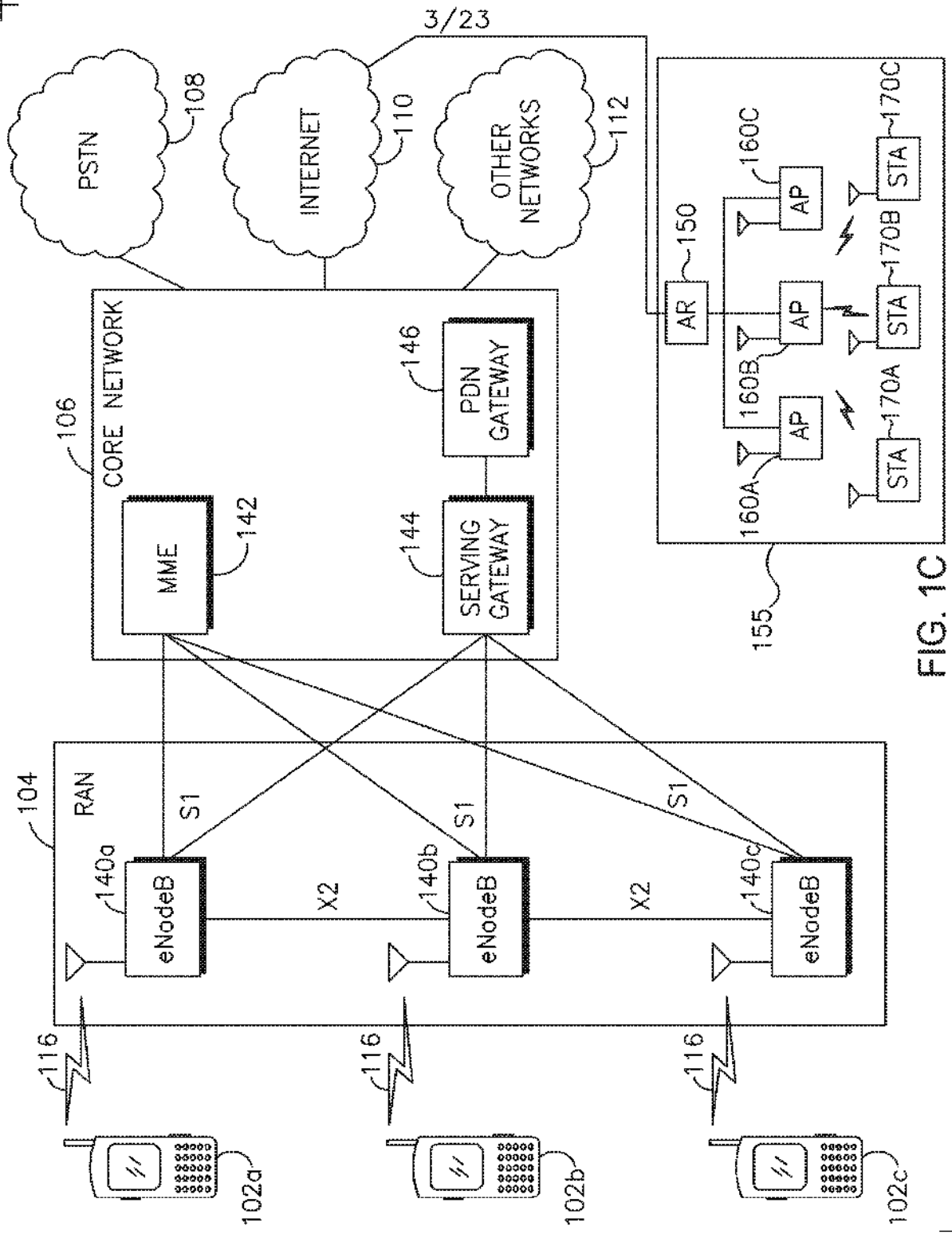

3/23
PSTN
108
INTERNET
110
OTHER NETWORKS
112
CORE NETWORK
106
MME
142
PDN GATEWAY
146
SERVING GATEWAY
144
104
RAN
S1
S1
S1
X2
X2
140a
eNodeB
140b
eNodeB
140c
eNodeB
116
116
116
102a
102b
102c
AR
150
AP
160A
AP
160B
AP
160C
STA
170A
STA
170B
STA
170C
155

FIG. 1C

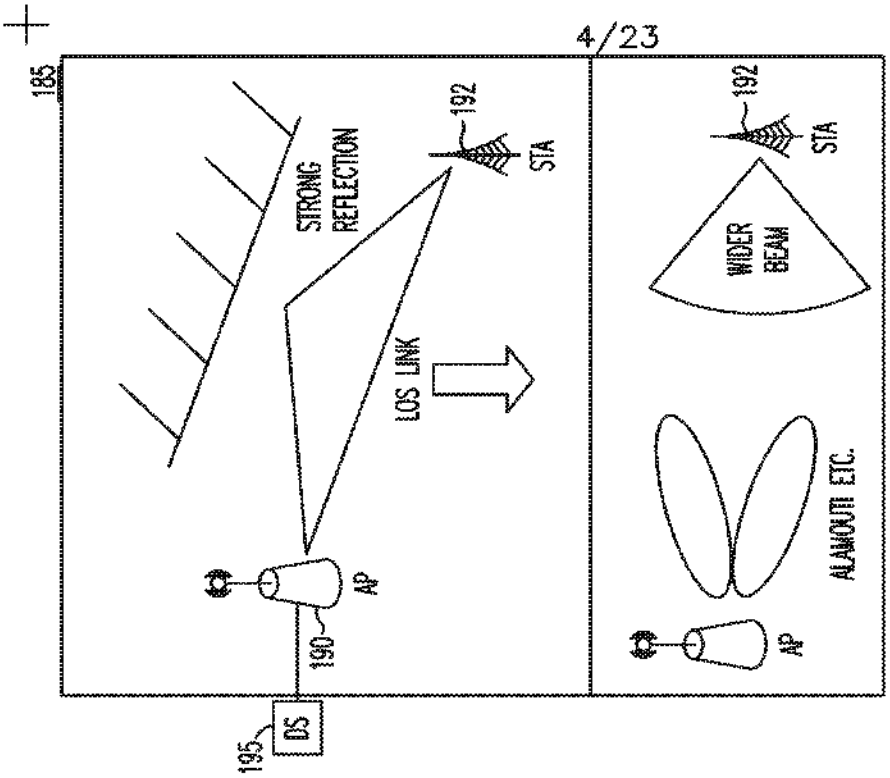

185
STRONG REFLECTION
192
STA
LOS LINK
AP
190
195
DS
WIDER BEAM
ALAMOUTI ETC.

FIG. 1E

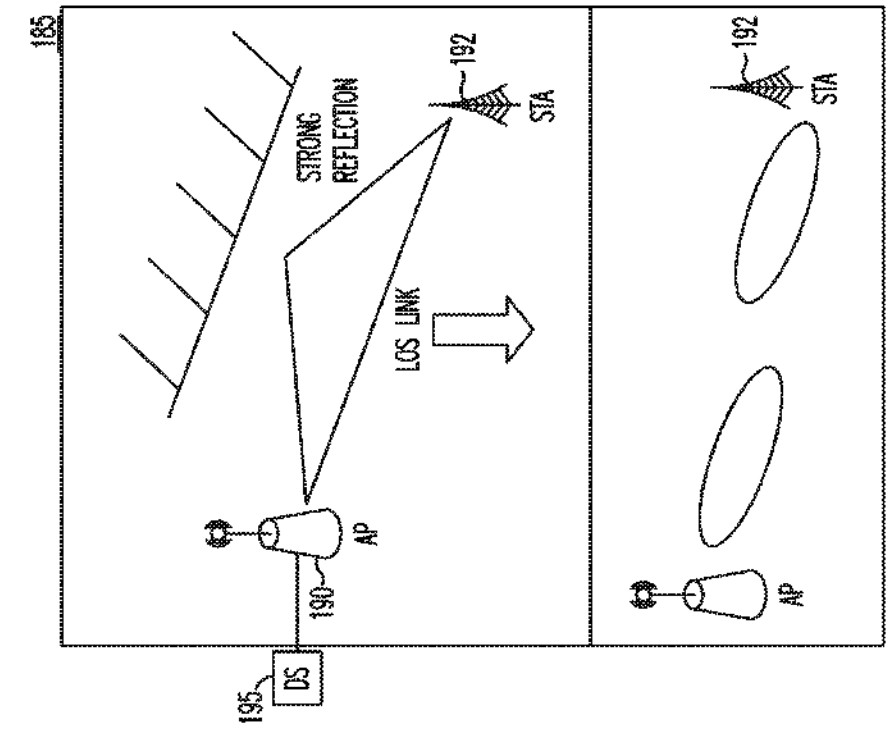

185
STRONG REFLECTION
192
STA
LOS LINK
AP
190
195
DS

FIG. 1D

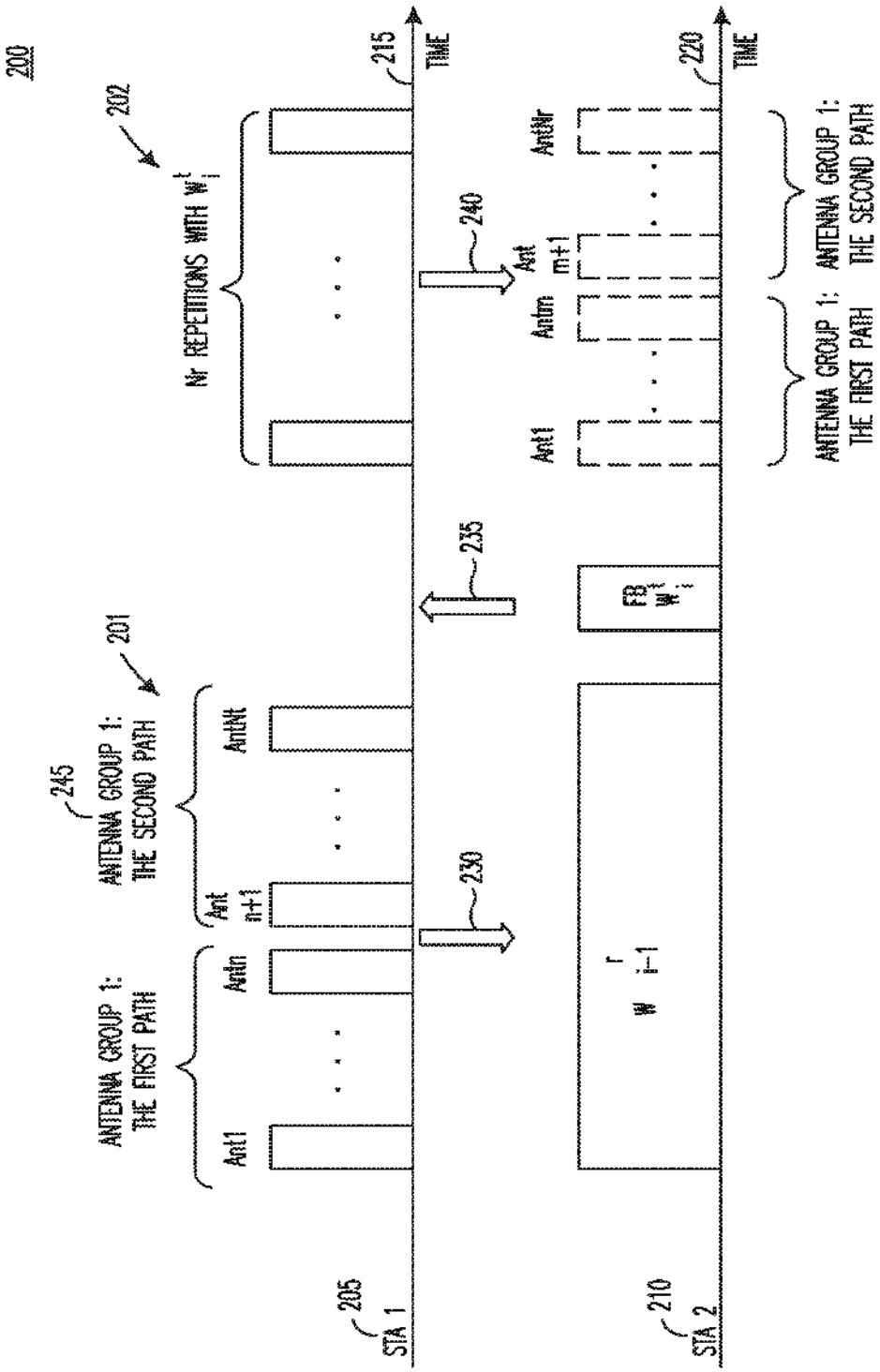

200
202
Nr REPETITIONS WITH W_i^1
215
TIME
240
Ant m+1
Antm
Ant1
AntNr
ANTENNA GROUP 1: THE FIRST PATH
ANTENNA GROUP 1: THE SECOND PATH
235
FB W_{i-1}^r
245
201
Ant n+1
AntN1
230
W_{i-1}^r
205
STA 1
210
STA 2
220
TIME

FIG. 2

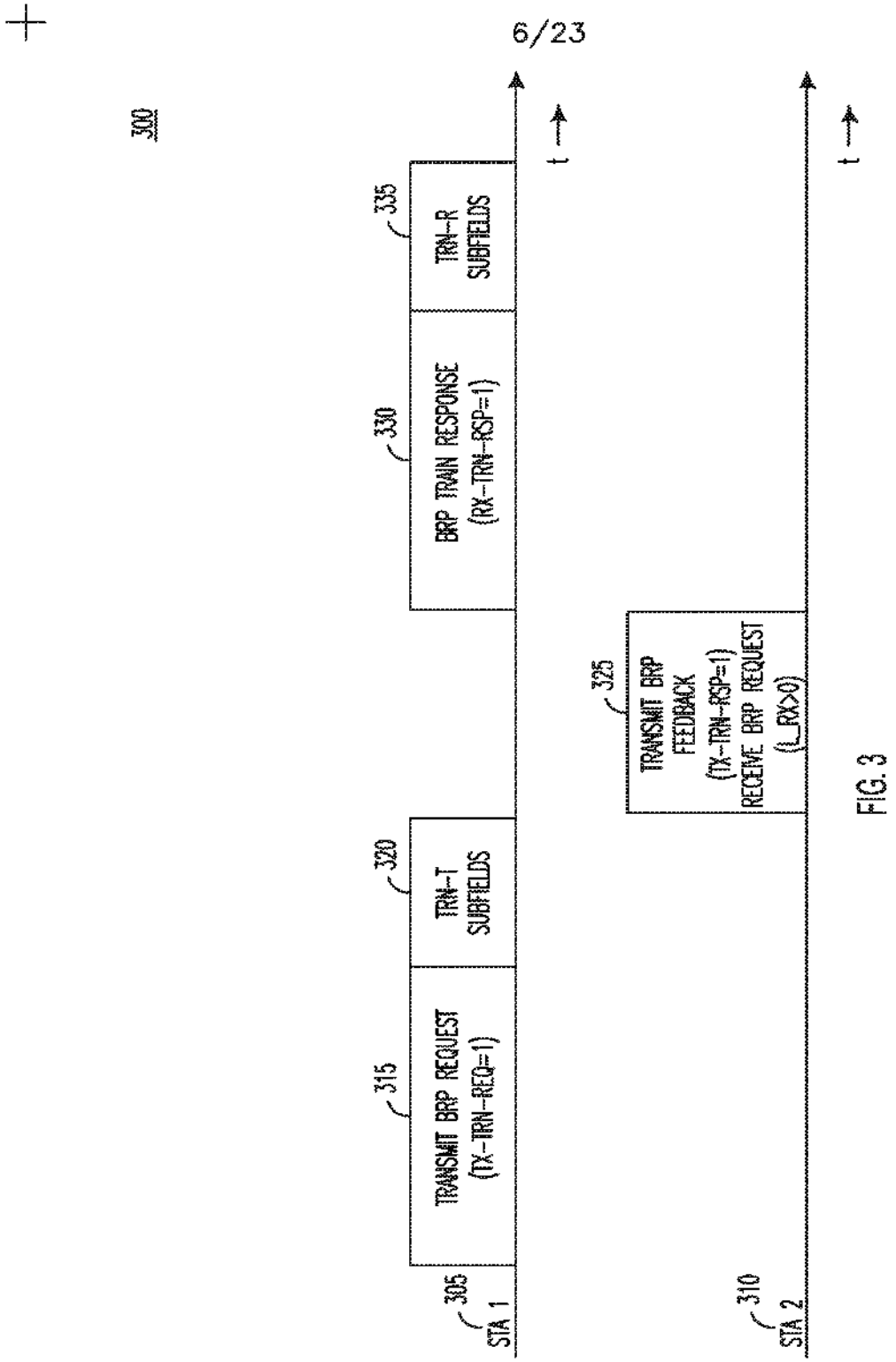

300
305
STA 1
310
STA 2
315
TRANSMIT BRP REQUEST
(TX-TRN-REQ=1)
320
TRN-T
SUBFIELDS
325
TRANSMIT BRP
FEEDBACK
(TX-TRN-RSP=1)
RECEIVE BRP REQUEST
(L_RX>0)
330
BRP TRAIN RESPONSE
(RX-TRN-RSP=1)
335
TRN-R
SUBFIELDS
t
t

FIG. 3

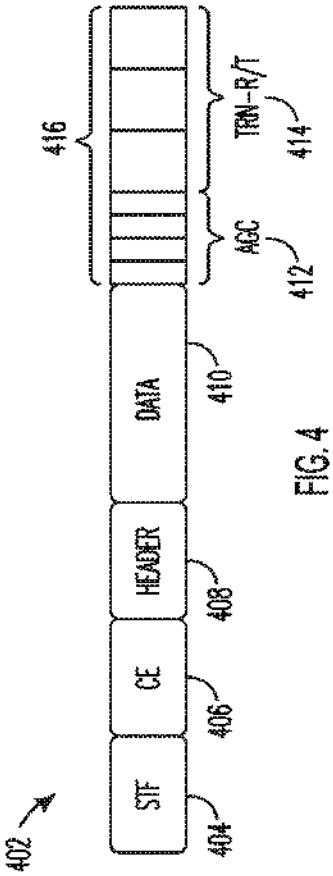


FIG. 4

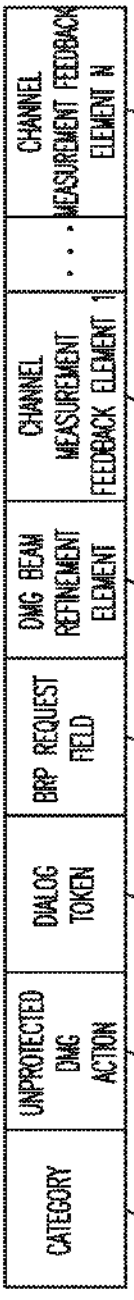


FIG. 5

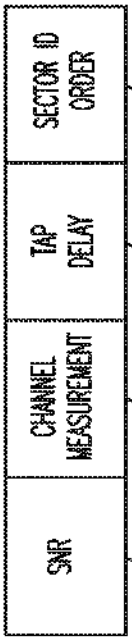


FIG. 6

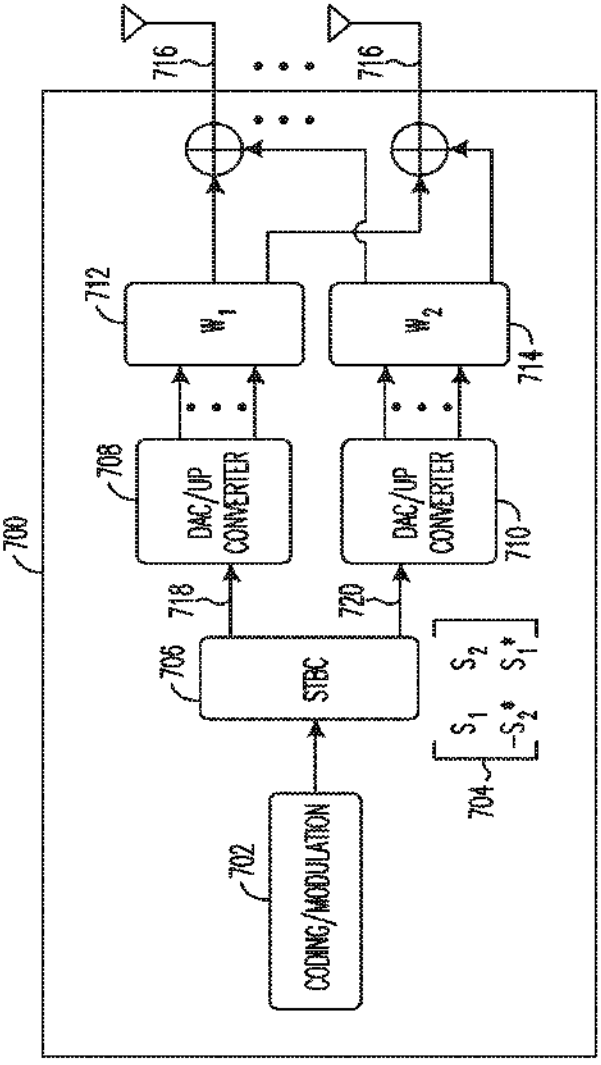

700
716
716
712
W_1
W_2
714
708
DAC/UP CONVERTER
DAC/UP CONVERTER
710
718
720
706
STBC
$\begin{bmatrix} S_1 & S_2 \\ -S_2^* & S_1^* \end{bmatrix}$
704
702
CODING/MODULATION

FIG. 7

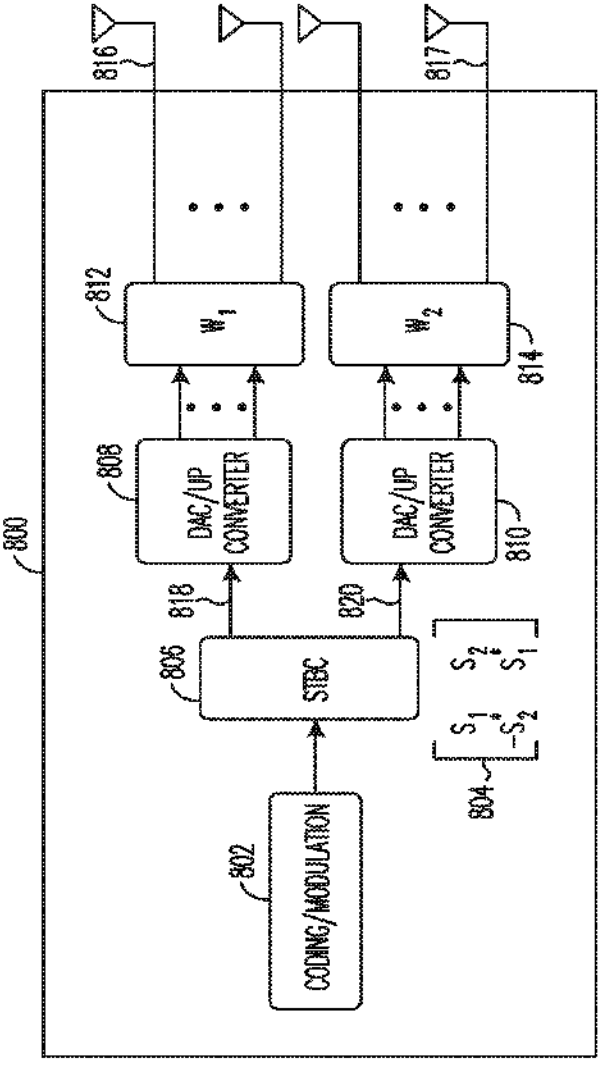

800
816
817
812
W_1
W_2
814
808
DAC/UP CONVERTER
DAC/UP CONVERTER
810
818
820
806
STBC
$\begin{bmatrix} s_1 & s_2 \\ -s_2^* & s_1^* \end{bmatrix}$
804
802
CODING/MODULATION

FIG. 8

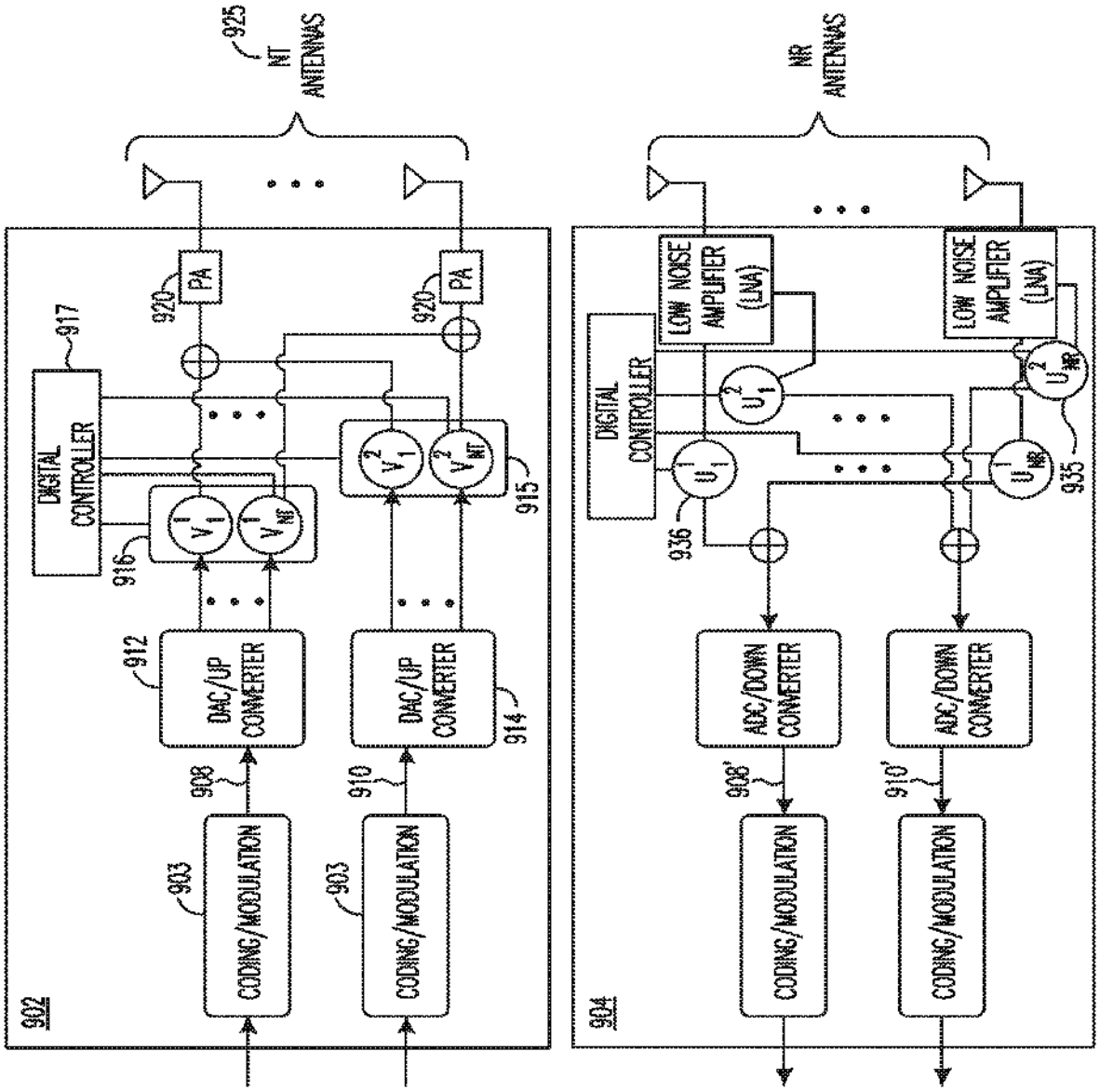

925
NT
ANTENNAS
NR
ANTENNAS
902
904
DIGITAL
CONTROLLER
917
916
915
920
PA
912
DAC/UP
CONVERTER
914
908
910
903
CODING/MODULATION
LOW NOISE
AMPLIFIER
(LNA)
936
935
ADC/DOWN
CONVERTER
908'
910'

FIG. 9

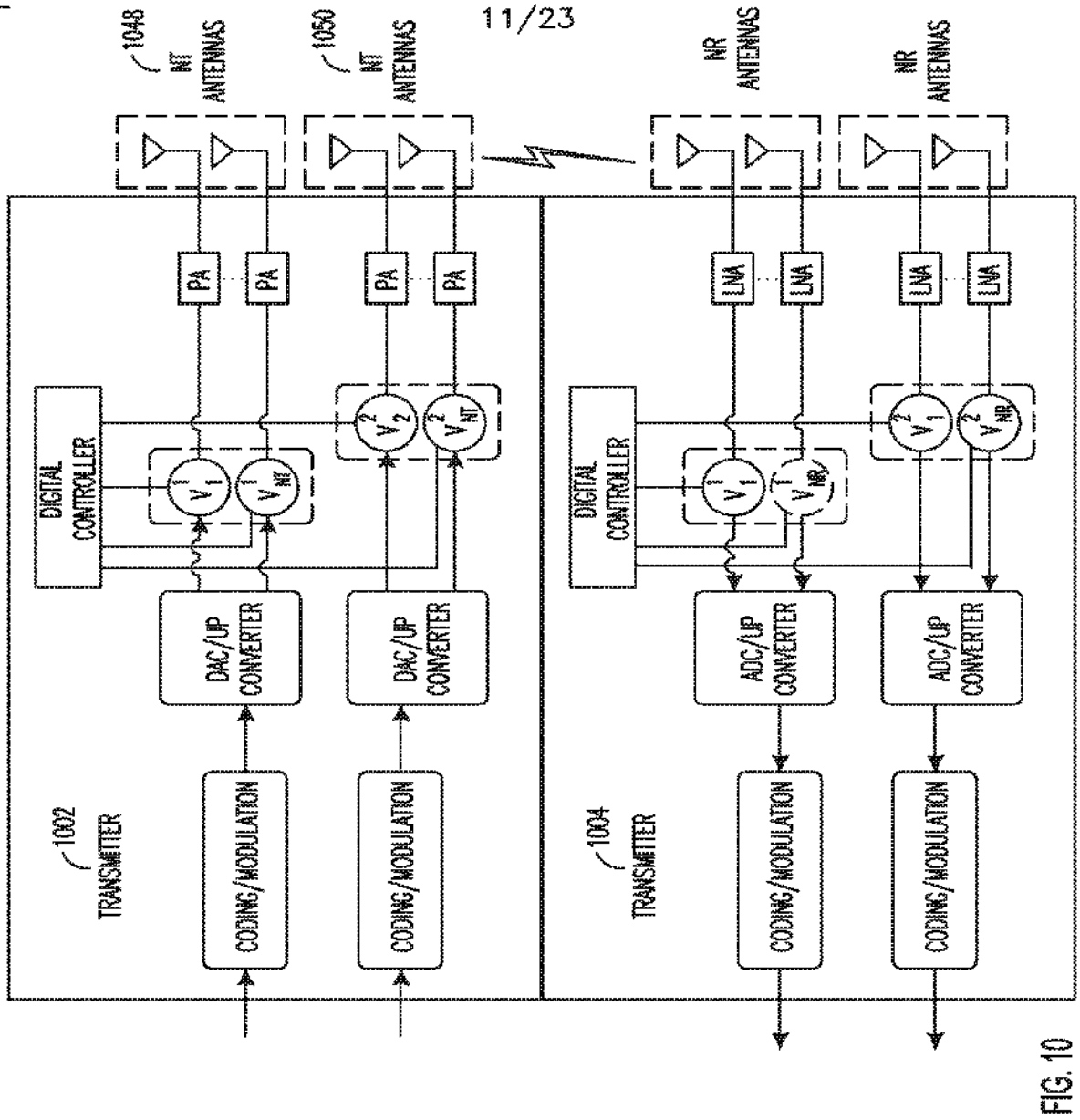

1048
NT ANTENNAS
1050
NT ANTENNAS
NR ANTENNAS
NR ANTENNAS
PA
LNA
DIGITAL CONTROLLER
DAC/UP CONVERTER
ADC/UP CONVERTER
CODING/MODULATION
1002
TRANSMITTER
1004
TRANSMITTER

FIG. 10

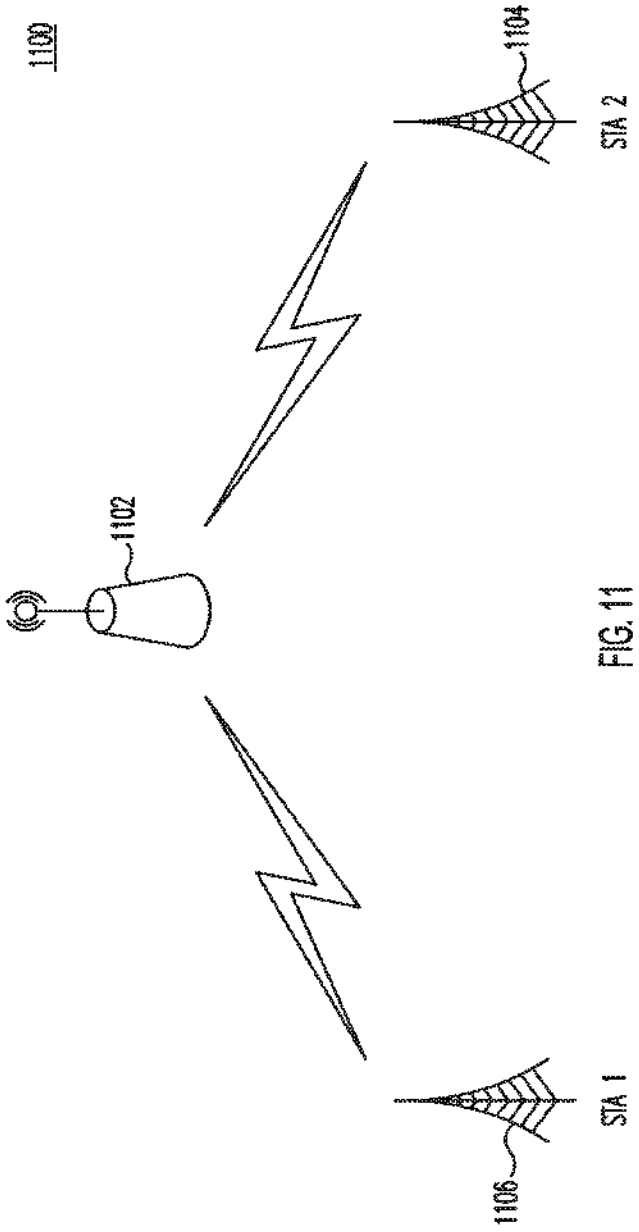


FIG. 11

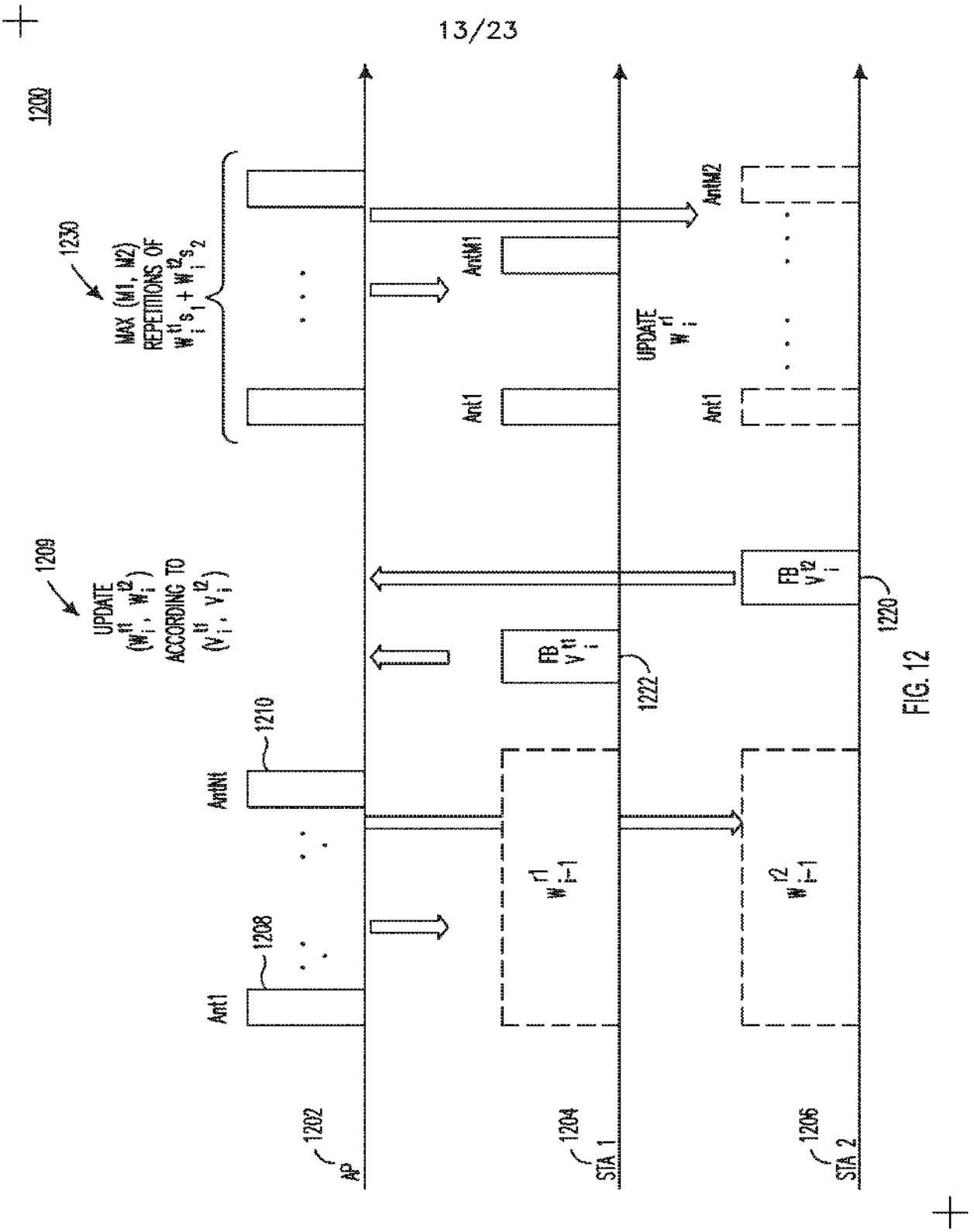

1200
1230
MAX (M1, M2)
REPETITIONS OF
$W_i^{t1} s_1 + W_i^{t2} s_2$
1209
UPDATE
(W_i^{t1}, W_i^{t2})
ACCORDING TO
(V_i^{t1}, V_i^{t2})
AntNt
1210
Ant1
1208
$r1\ W_{i-1}$
$FB\ V_i^{t1}$
1222
UPDATE
W_i^{r1}
AntM1
Ant1
$r2\ W_{i-1}$
$FB\ V_i^{t2}$
1220
AntM2
Ant1
1202
AP
1204
STA 1
1206
STA 2

FIG. 12

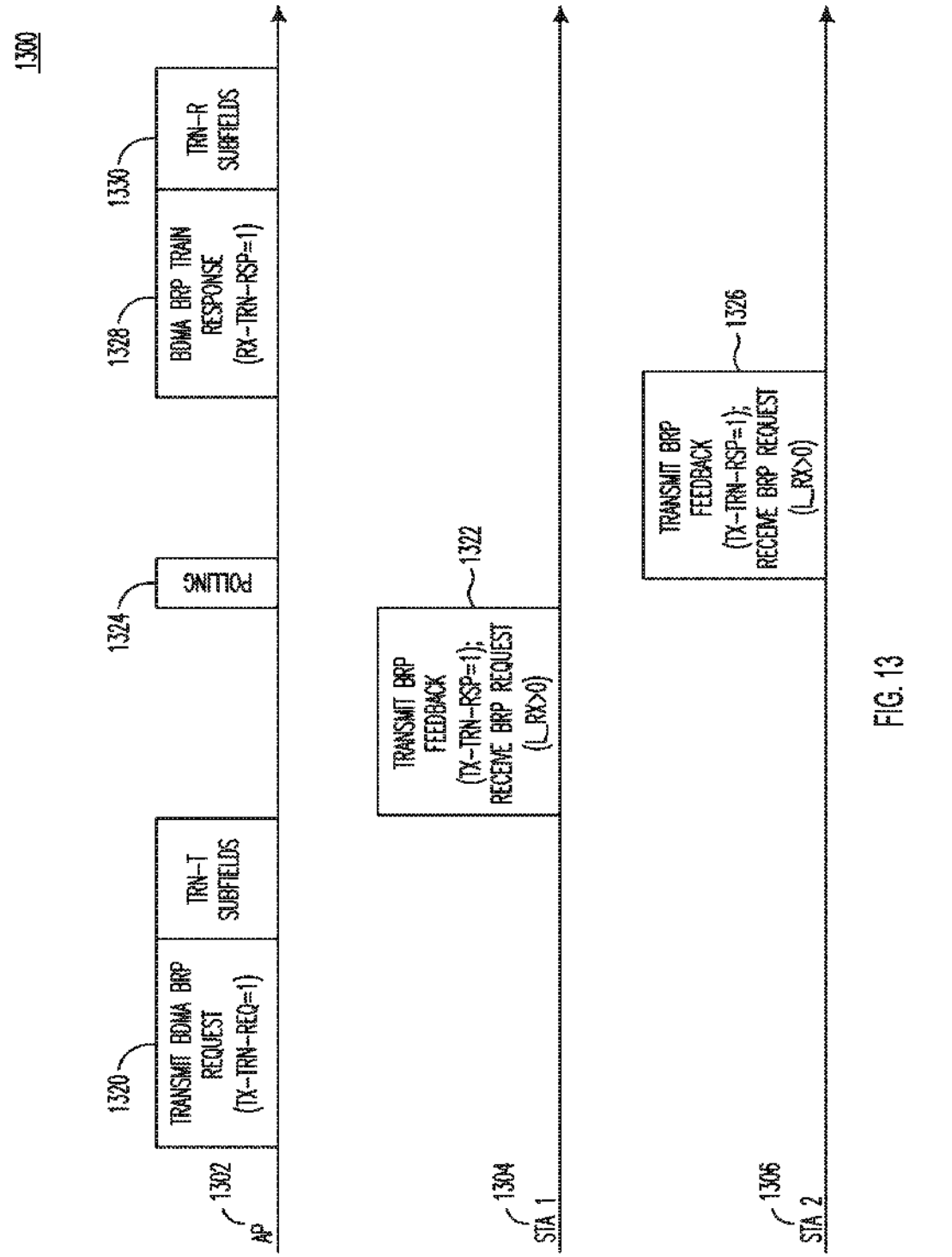

1300
AP
1302
STA 1
1304
STA 2
1306
TRANSMIT BDMA BRP REQUEST (TX-TRN-REQ=1)
1320
TRN-T SUBFIELDS
SIFS
1324
TRANSMIT BRP FEEDBACK (TX-TRN-RSP=1); RECEIVE BRP REQUEST (L_RX>0)
1322
BDMA BRP TRAIN RESPONSE (RX-TRN-RSP=1)
1328
TRN-R SUBFIELDS
1330
TRANSMIT BRP FEEDBACK (TX-TRN-RSP=1); RECEIVE BRP REQUEST (L_RX>0)
1326

FIG. 13

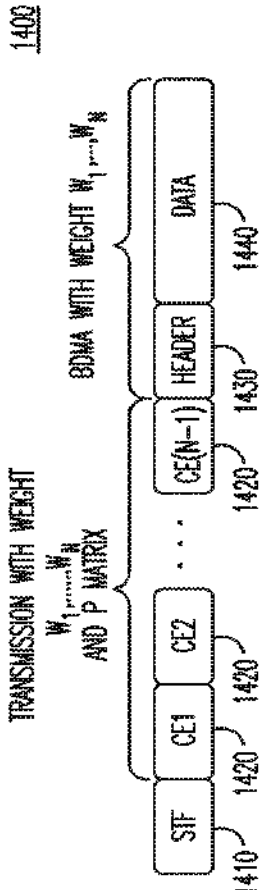

1400
TRANSMISSION WITH WEIGHT
$W_1,\ldots,W_N$
AND P MATRIX
BDMA WITH WEIGHT $W_1,\ldots,W_N$
STF
CE1
CE2
CE(N-1)
HEADER
DATA
1410
1420
1420
1420
1430
1440

FIG. 14

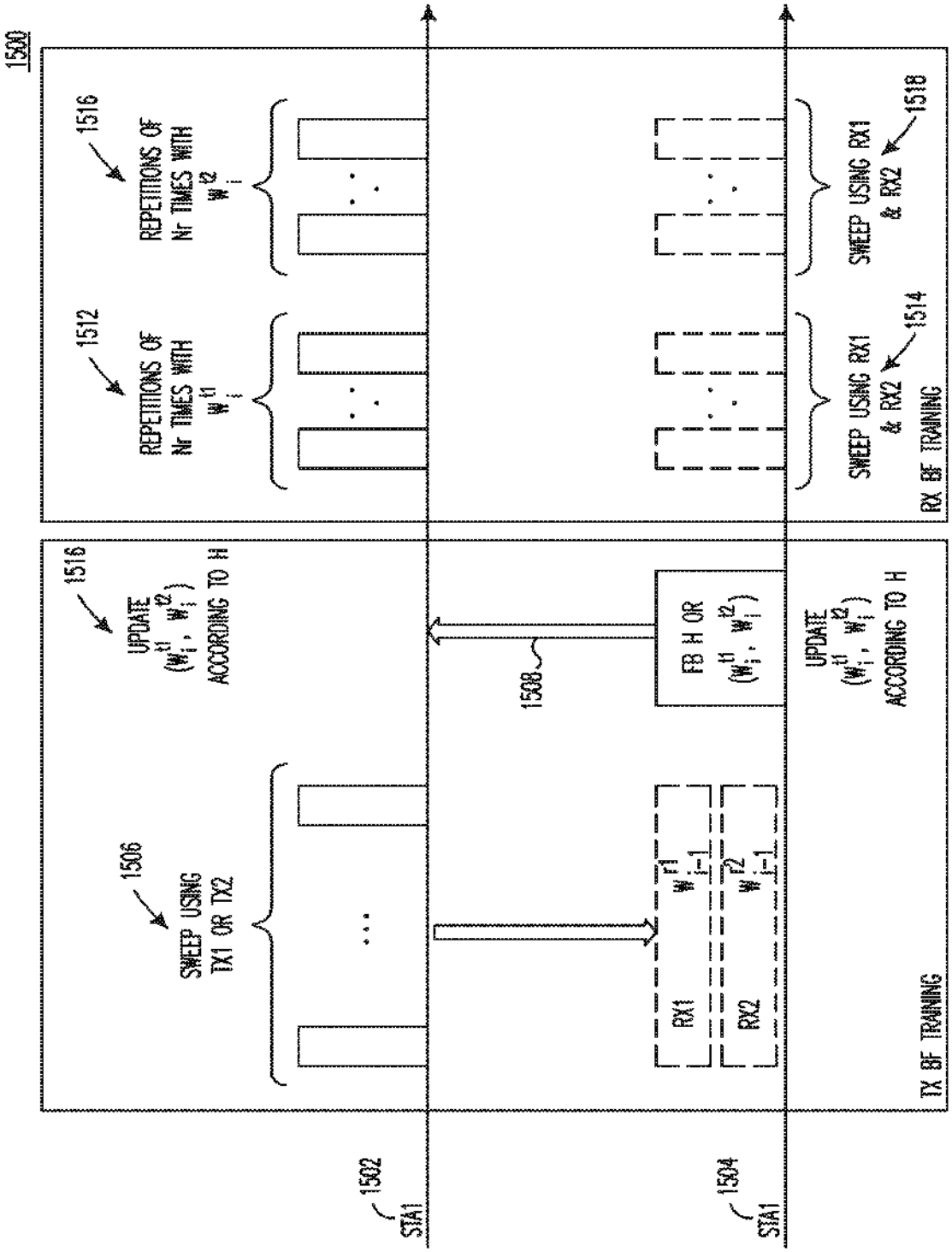

1500
1516
REPETITIONS OF Nr TIMES WITH W_i^{t2}
1512
REPETITIONS OF Nr TIMES WITH W_i^{t1}
SWEEP USING RX1 & RX2
1518
1514
RX BF TRAINING
1516
UPDATE (W_i^{t1}, W_i^{t2}) ACCORDING TO H
1506
SWEEP USING TX1 OR TX2
1508
FB H OR (W_i^{t1}, W_i^{t2})
RX1 W_{i-1}^{r1}
RX2 W_{i-1}^{r2}
UPDATE (W_i^{t1}, W_i^{t2}) ACCORDING TO H
TX BF TRAINING
1502
STA1
1504
STA1

FIG. 15

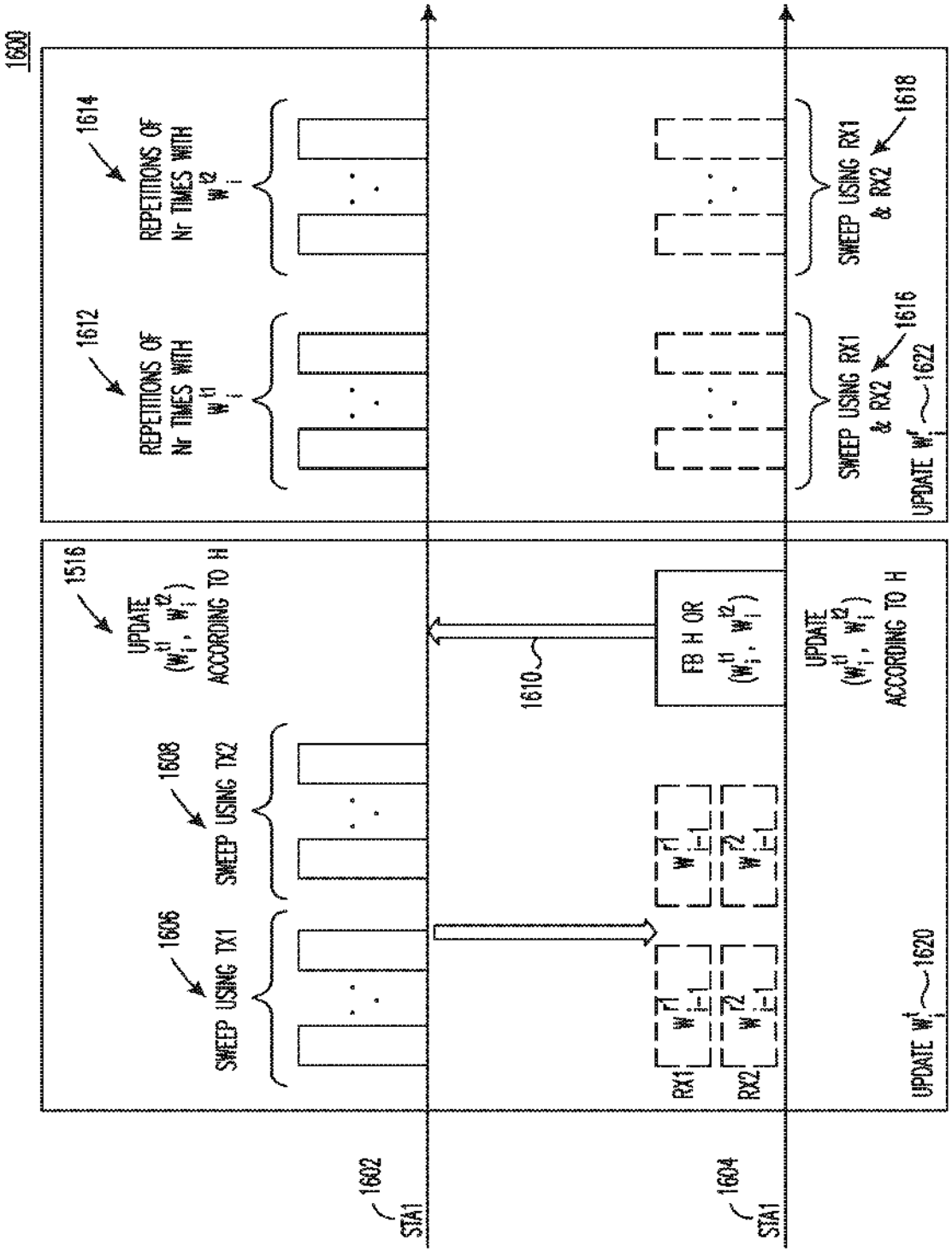

1600
1602
STA1
1604
STA1
1606
SWEEP USING TX1
1608
SWEEP USING TX2
1610
1612
REPETITIONS OF Nr TIMES WITH
1614
REPETITIONS OF Nr TIMES WITH
1516
UPDATE
ACCORDING TO H
FB H OR
RX1
RX2
1616
SWEEP USING RX1 & RX2
1618
SWEEP USING RX1 & RX2
1620
UPDATE
1622
UPDATE

FIG. 16

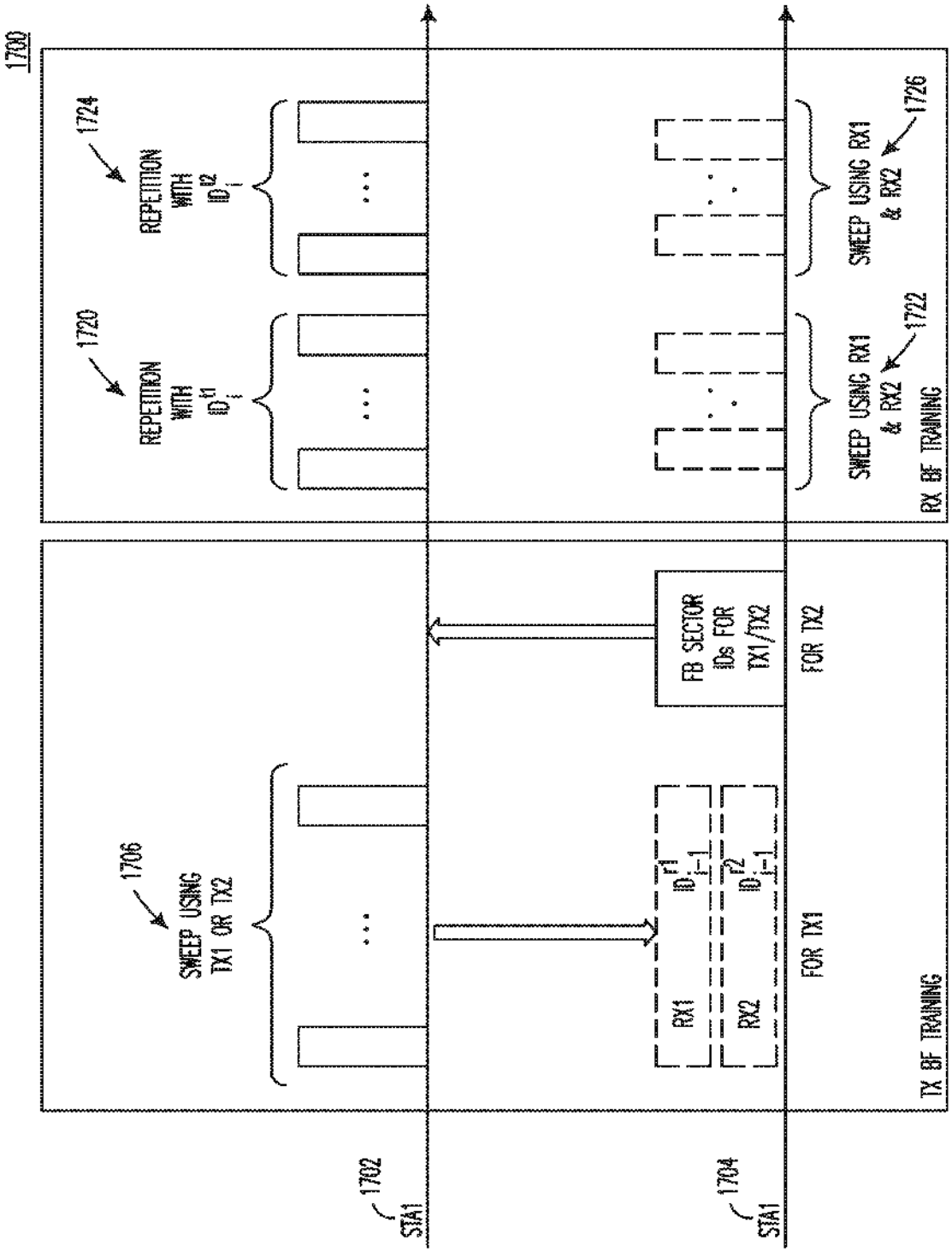

1700
1724
REPETITION WITH ID_i^{I2}
1720
REPETITION WITH ID_i^{I1}
SWEEP USING RX1 & RX2
1722
SWEEP USING RX1 & RX2
1726
RX BF TRAINING
1706
SWEEP USING TX1 OR TX2
RX1
RX2
ID_{i-1}^{r1}
ID_{i-1}^{r2}
FB SECTOR IDs FOR TX1/TX2
FOR TX1
FOR TX2
TX BF TRAINING
1702
STA1
1704
STA1

FIG. 17

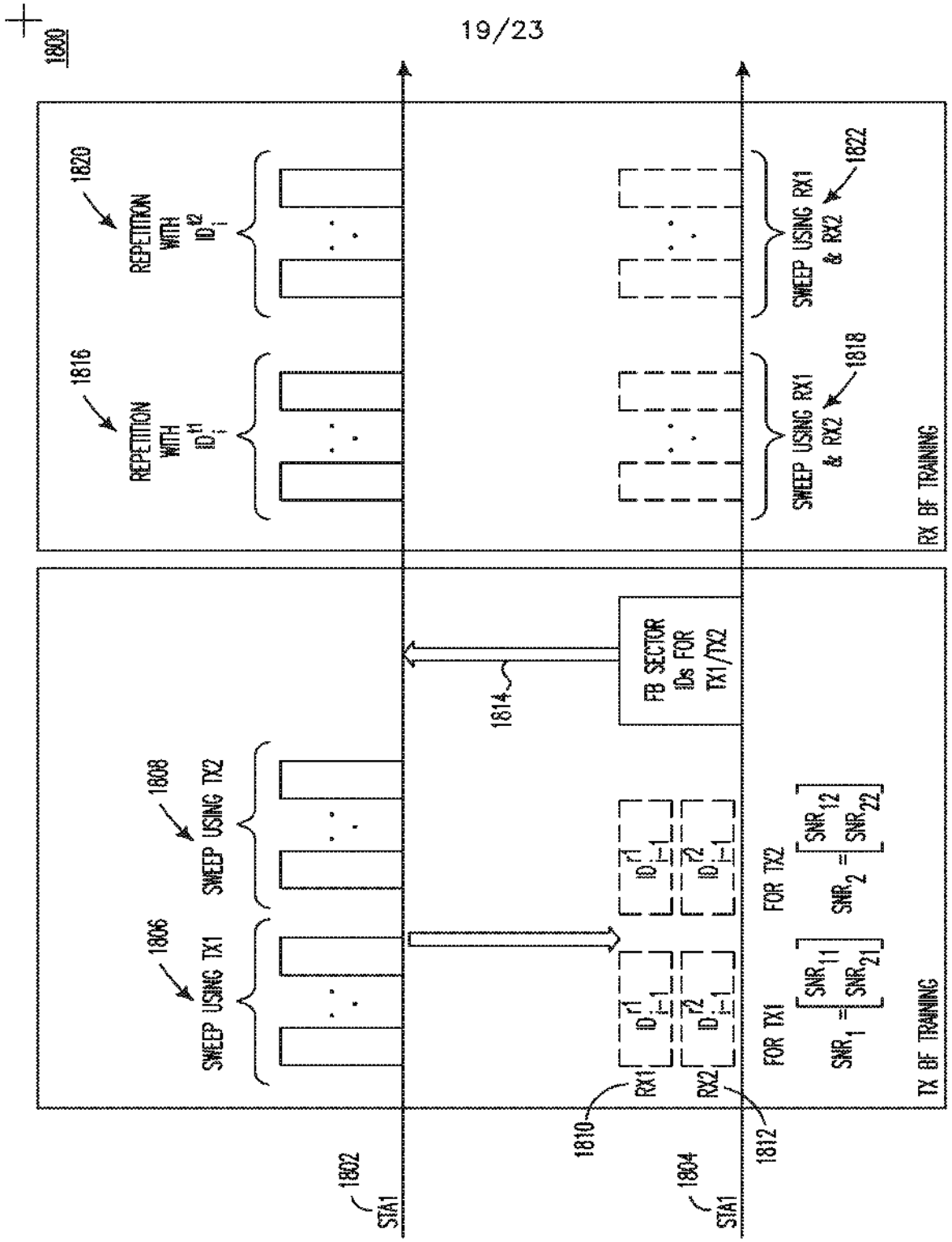

1800
1820
REPETITION WITH ID_i^{12}
1816
REPETITION WITH ID_i^{11}
SWEEP USING RX1 & RX2
1822
1818
RX BF TRAINING
1806
SWEEP USING TX1
1808
SWEEP USING TX2
1814
FB SECTOR IDs FOR TX1/TX2
ID_{i-1}^{r1}
ID_{i-1}^{r2}
RX1
RX2
1810
1812
FOR TX1
$SNR_1 = \begin{bmatrix} SNR_{11} \\ SNR_{21} \end{bmatrix}$
FOR TX2
$SNR_2 = \begin{bmatrix} SNR_{12} \\ SNR_{22} \end{bmatrix}$
TX BF TRAINING
1802
STA1
1804
STA1

FIG. 18

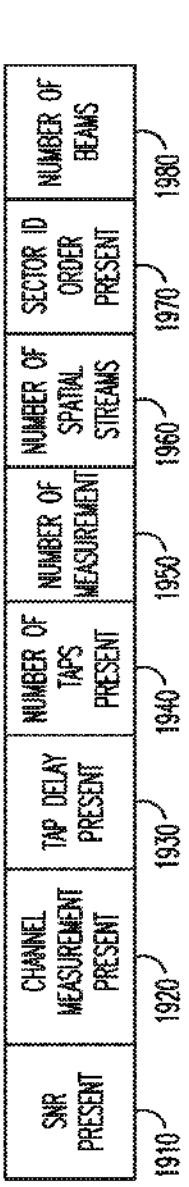


FIG. 19

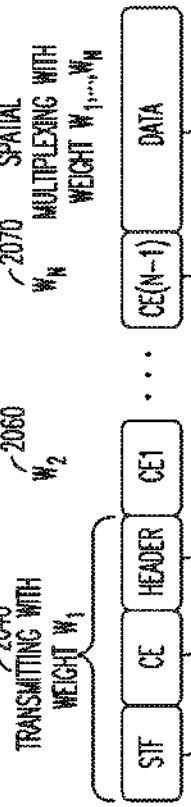


FIG. 20A

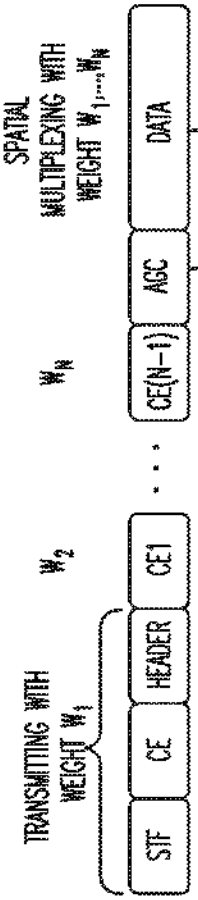


FIG. 20B

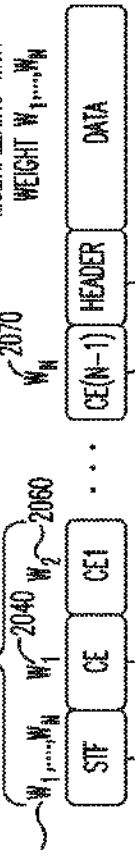


FIG. 20C

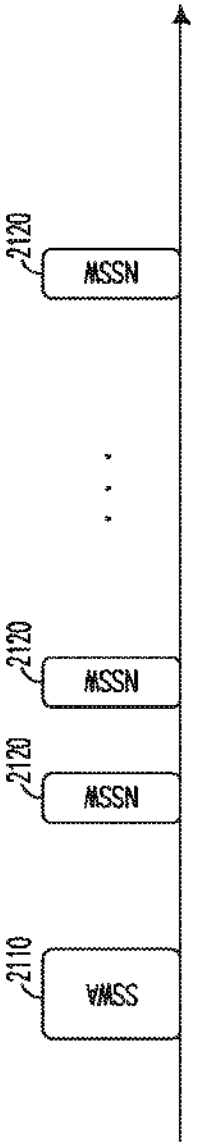

2100
2110
VMSS
2120
MSSN
2120
MSSN
2120
MSSN

FIG. 21

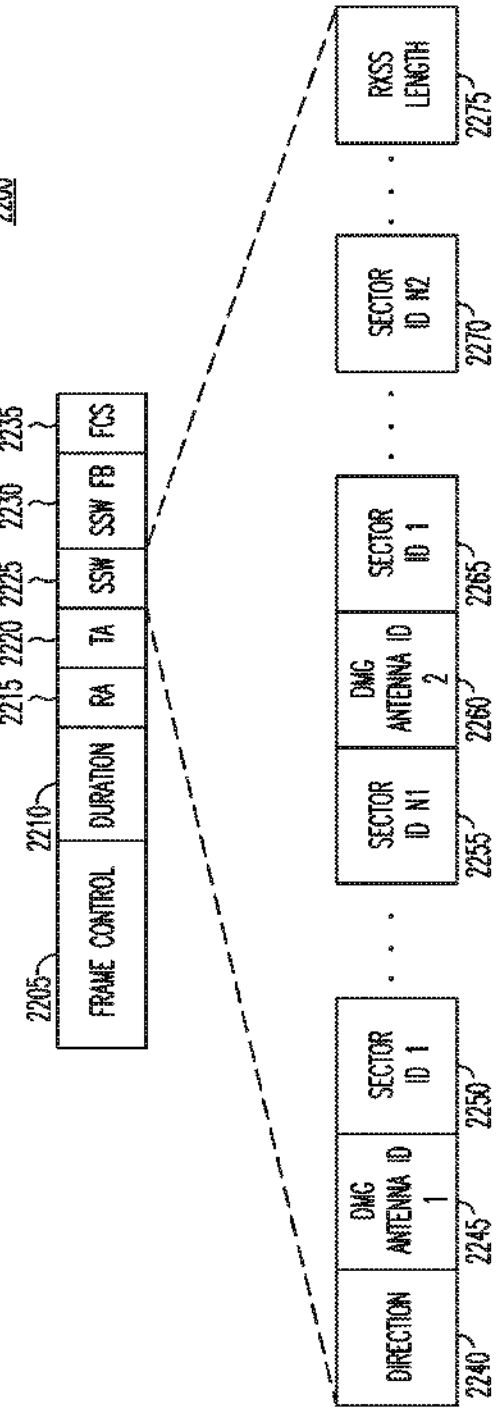

2200
2205
FRAME CONTROL
2210
DURATION
2215
RA
2220
TA
2225
SSW
2230
SSW FB
2235
FCS
2240
DIRECTION
2245
DMG ANTENNA ID 1
2250
SECTOR ID 1
2255
SECTOR ID N1
2260
DMG ANTENNA ID 2
2265
SECTOR ID 1
2270
SECTOR ID N2
2275
RXSS LENGTH

FIG. 22

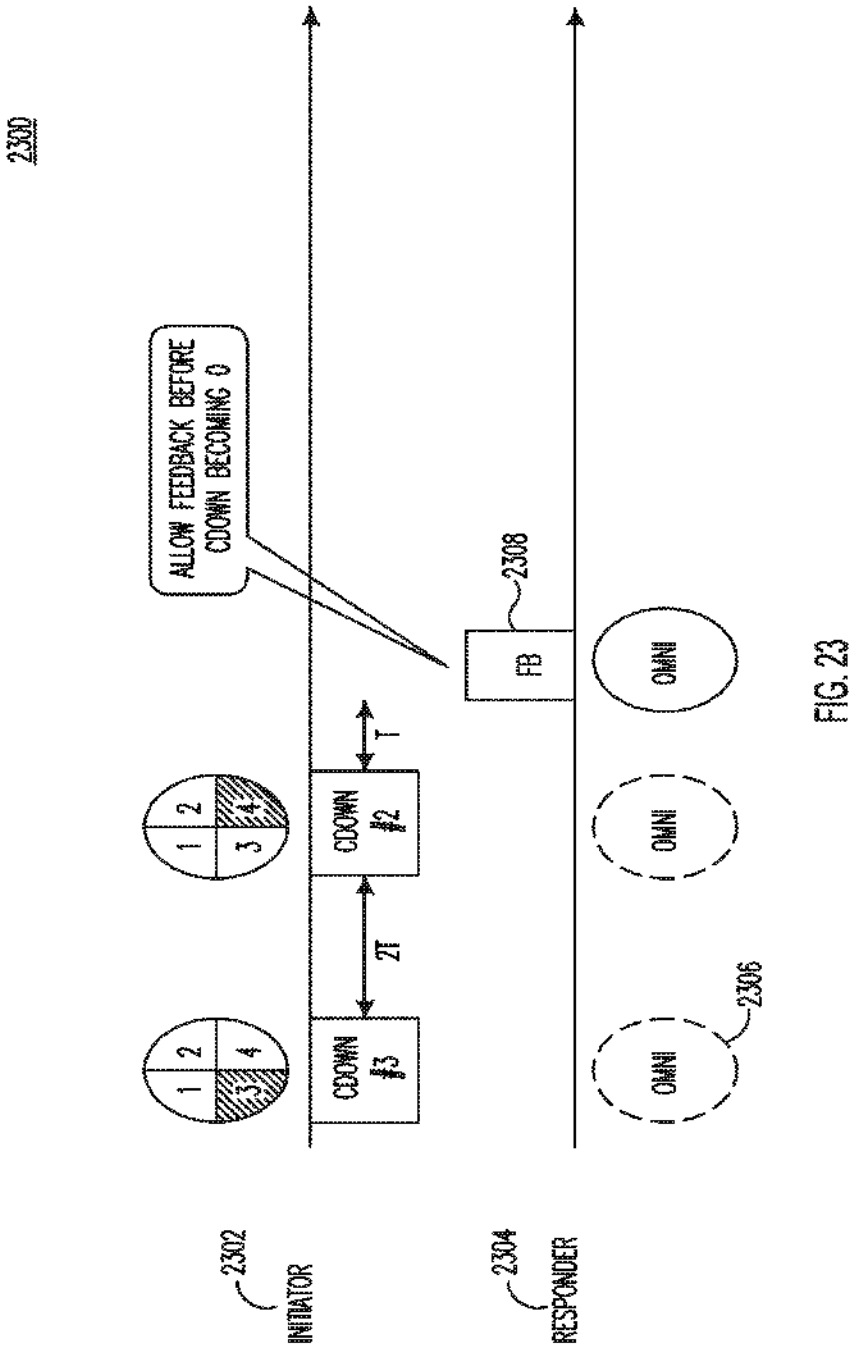

2300
ALLOW FEEDBACK BEFORE CDOWN BECOMING 0
2308
FB
OMNI
T
CDOWN #2
1 2 3 4
2T
CDOWN #3
1 2 3 4
OMNI
OMNI
2306
2302
INITIATOR
2304
RESPONDER

FIG. 23

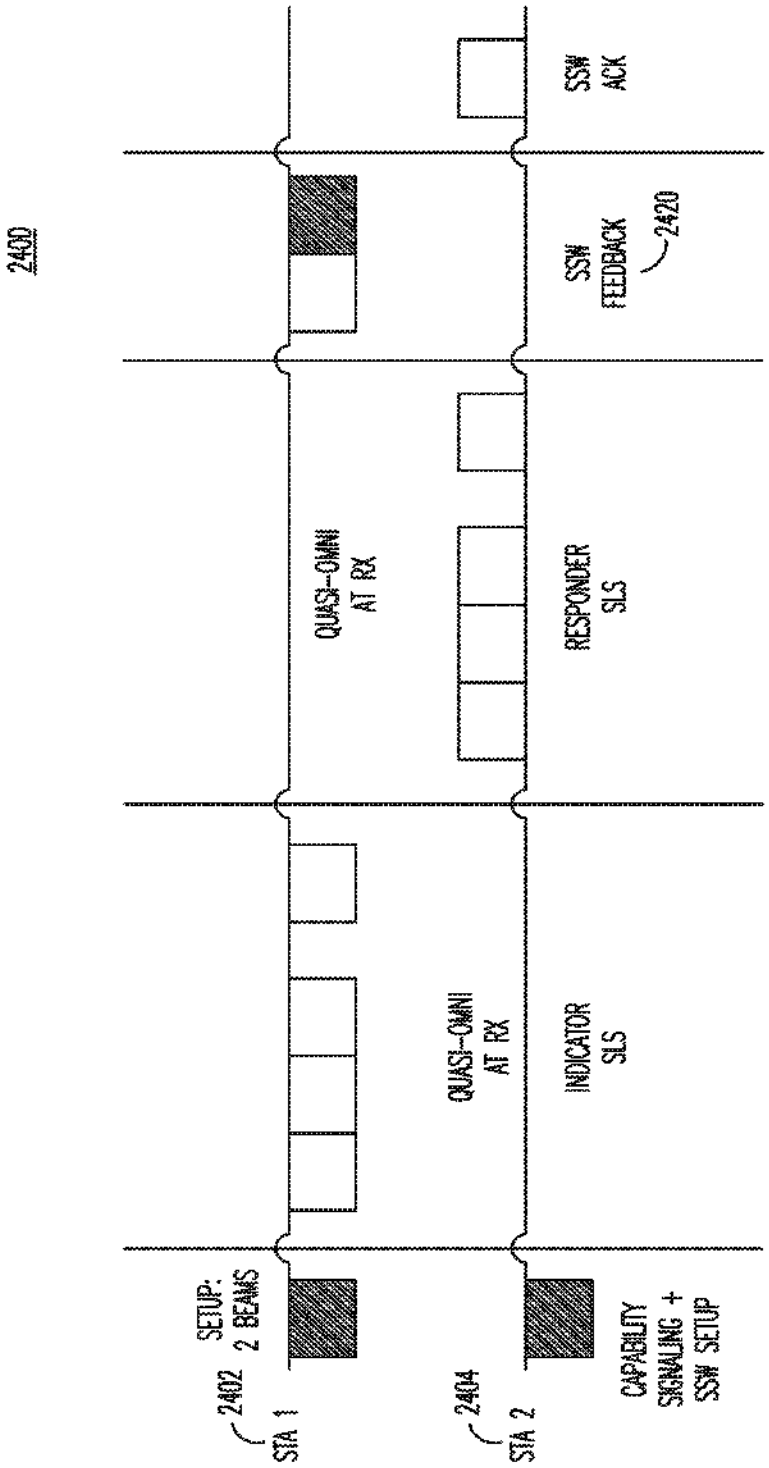

2400
SETUP: 2 BEAMS
2402
STA 1
QUASI-OMNI AT RX
QUASI-OMNI AT RX
2404
STA 2
INDICATOR SLS
CAPABILITY SIGNALING + SSW SETUP
RESPONDER SLS
SSW FEEDBACK
2420
SSW ACK

FIG. 24

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2013/069265

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04B7/04 H04B7/06
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2010/050874 A1 (ERICSSON TELEFON AB L M [SE]; RAHMAN MUHAMMAD IMADUR [SE]; JOENGREN GE) 6 May 2010 (2010-05-06) figures 1,5 page 9, line 1 - page 4, line 20 -----	1-20
X	WO 2009/093870 A2 (LG ELECTRONICS INC [KR]; JEON BEOM JIN [KR]) 30 July 2009 (2009-07-30) abstract paragraph [0001] - paragraph [0022] -----	1-20
X	WO 2009/102124 A2 (SAMSUNG ELECTRONICS CO LTD [KR]) 20 August 2009 (2009-08-20) abstract paragraph [0030] - paragraph [0057] ----- -/--	1-20

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 February 2014	27/02/2014

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Neeb, Christoph

3

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 2 211 483 A1 (SONY CORP [JP]) 28 July 2010 (2010-07-28) paragraph [0026] - paragraph [0080] -----	1-20
A	US 2009/232010 A1 (LI GUOQING [US] ET AL) 17 September 2009 (2009-09-17) the whole document -----	1-20
A	ELDAD PERAHIA ET AL: "Gigabit wireless LANs", ACM SIGMOBILE MOBILE COMPUTING AND COMMUNICATIONS REVIEW, vol. 15, no. 3, 29 November 2011 (2011-11-29), page 23, XP055015658, ISSN: 1559-1662, DOI: 10.1145/2073290.2073294 section III -----	1-20
A	EP 1 266 463 B1 (NOKIA CORP [FI]) 21 June 2006 (2006-06-21) paragraph [0030] - paragraph [0050] -----	1-20

3

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2013/069265

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		EP 2351246 A1	03-08-2011
		US 2011205930 A1	25-08-2011
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		KR 20090081064 A	28-07-2009
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		US 7200368 B1	03-04-2007
		WO 0169814 A1	20-09-2001

Form PCT/ISA/210 (patent family annex) (April 2005)

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62/107,504	26 January 2015 (26.01.2015)	US
62/235,585	1 October 2015 (01.10.2015)	US

(71) Applicant: **LG ELECTRONICS INC.** [KR/KR]; 128, Yeoui-daero,Yeongdeungpo-gu, Seoul 07336 (KR).

(72) Inventors: **YI, Yunjung**; IP Center, LG Electronics Inc., 19, Yangjae-daero 11-gil, Seocho-gu, Seoul 06772 (KR). **AHN, Joonkui**; IP Center, LG Electronics Inc., 19, Yangjae-daero 11-gil, Seocho-gu, Seoul 06772 (KR). **YOU, Hyangsun**; IP Center, LG Electronics Inc., 19, Yangjae-daero 11-gil, Seocho-gu, Seoul 06772 (KR).

(74) Agent: **S&IP PATENT & LAW FIRM**; (2F. Samheung Yeoksam Bldg., Yeoksam-dong), 5 Teheran-ro 14-gil, Gangnam-gu, Seoul 06235 (KR).

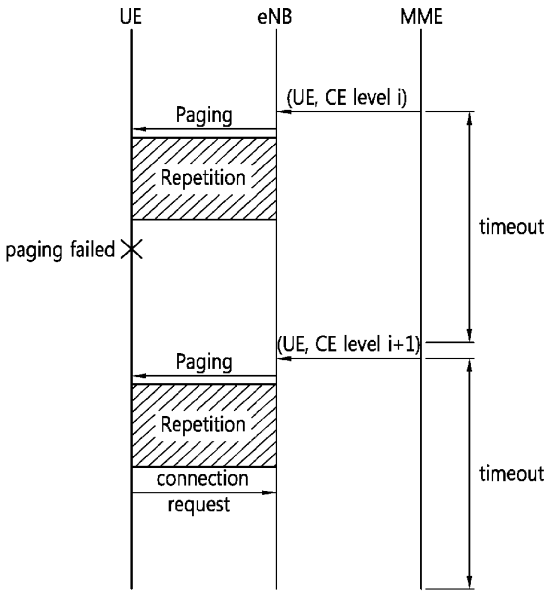
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE,

[Continued on next page]

(54) Title: METHOD AND APPARATUS FOR TRANSMITTING PAGING FOR MACHINE TYPE COMMUNICATION USER EQUIPMENT IN WIRELESS COMMUNICATION SYSTEM

[Fig. 7]



(57) Abstract: A method and apparatus for monitoring a paging in a wireless communication system is provided. A user equipment (UE) monitors multiple paging instances at one paging occasion. Specifically, the UE monitors a first paging instance with a first repetition level in a paging occasion, and monitors a second paging instance with a second repetition level, which is higher than the first repetition level, in the paging occasion.

WO 2016/072770 A1

DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

Description

Title of Invention: METHOD AND APPARATUS FOR TRANSMITTING PAGING FOR MACHINE TYPE COMMUNICATION USER EQUIPMENT IN WIRELESS COMMUNICATION SYSTEM

Technical Field

[1] The present invention relates to wireless communications, and more particularly, to a method and apparatus for transmitting a paging for a machine type communication user equipment (MTC UE) in a wireless communication system.

Background Art

[2] 3rd generation partnership project (3GPP) long-term evolution (LTE) is a technology for enabling high-speed packet communications. Many schemes have been proposed for the LTE objective including those that aim to reduce user and provider costs, improve service quality, and expand and improve coverage and system capacity. The 3GPP LTE requires reduced cost per bit, increased service availability, flexible use of a frequency band, a simple structure, an open interface, and adequate power consumption of a terminal as an upper-level requirement.

[3] In the future versions of the LTE-A, it has been considered to configure low-cost/low-end (or, low-complexity) user equipments (UEs) focusing on the data communication, such as meter reading, water level measurement, use of security camera, vending machine inventory report, etc. For convenience, these UEs may be called machine type communication (MTC) UEs. Since MTC UEs have small amount of transmission data and have occasional uplink data transmission/downlink data reception, it is efficient to reduce the cost and battery consumption of the UE according to a low data rate. Specifically, the cost and battery consumption of the UE may be reduced by decreasing radio frequency (RF)/baseband complexity of the MTC UE significantly by making the operating frequency bandwidth of the MTC UE smaller.

[4] Paging is the mechanism in which the network tells UE saying "I have something for you". Then the UE decode the content (paging cause) of the paging message and the UE has to initiate the appropriate procedure. In most cases, this paging process happens while the UE is in idle mode. This means that the UE has to monitor whether the network transmits any paging message to the UE and the UE has to spend some energy (battery) to run this monitoring process. Accordingly, a method for transmitting a paging for MTC UEs efficiently may be required.

Disclosure of Invention

Technical Problem

[5] The present invention provides a method and apparatus for transmitting a paging for a machine type communication user equipment (MTC UE) in a wireless communication system. The present invention provides a method and apparatus for performing periodic reporting triggered by paging for low complexity MTC UEs. The present invention provides a method and apparatus for addressing a paging mechanism for low complexity MTC UEs requiring coverage enhancement via such as repetition.

Solution to Problem

[6] In an aspect, a method for monitoring, by a user equipment (UE), a paging in a wireless communication system is provided. The method includes monitoring a first paging instance with a first repetition level in a paging occasion, and monitoring a second paging instance with a second repetition level, which is higher than the first repetition level, in the paging occasion.

[7] In another aspect, a user equipment (UE) is provided. The UE includes a memory, a transceiver, and a processor coupled to the memory and the transceiver, and configured to monitor a first paging instance with a first repetition level, and monitor a second paging instance with a second repetition level which is higher than the first repetition level.

Advantageous Effects of Invention

[8] MTC UEs can be paged efficiently.

Brief Description of Drawings

[9] FIG. 1 shows a wireless communication system.

[10] FIG. 2 shows structure of a radio frame of 3GPP LTE.

[11] FIG. 3 shows a resource grid for one downlink slot.

[12] FIG. 4 shows structure of a downlink subframe.

[13] FIG. 5 shows structure of an uplink subframe.

[14] FIG. 6 shows an overall paging timing to support coverage enhancement for MTC UEs according to an embodiment of the present invention.

[15] FIG. 7 shows increase of coverage enhancement levels or repetition levels according to an embodiment of the present invention.

[16] FIG. 8 shows a method for monitoring a paging according to an embodiment of the present invention.

[17] FIG. 9 shows a wireless communication system to implement an embodiment of the present invention.

Mode for the Invention

[18] Techniques, apparatus and systems described herein may be used in various wireless

access technologies such as code division multiple access (CDMA), frequency division multiple access (FDMA), time division multiple access (TDMA), orthogonal frequency division multiple access (OFDMA), single carrier frequency division multiple access (SC-FDMA), etc. The CDMA may be implemented with a radio technology such as universal terrestrial radio access (UTRA) or CDMA2000. The TDMA may be implemented with a radio technology such as global system for mobile communications (GSM)/general packet radio service (GPRS)/enhanced data rates for GSM evolution (EDGE). The OFDMA may be implemented with a radio technology such as institute of electrical and electronics engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802-20, evolved-UTRA (E-UTRA) etc. The UTRA is a part of a universal mobile telecommunication system (UMTS). 3rd generation partnership project (3GPP) long term evolution (LTE) is a part of an evolved-UMTS (E-UMTS) using the E-UTRA. The 3GPP LTE employs the OFDMA in downlink (DL) and employs the SC-FDMA in uplink (UL). LTE-advance (LTE-A) is an evolution of the 3GPP LTE. For clarity, this application focuses on the 3GPP LTE/LTE-A. However, technical features of the present invention are not limited thereto.

[19] FIG. 1 shows a wireless communication system. The wireless communication system 10 includes at least one evolved NodeB (eNB) 11. Respective eNBs 11 provide a communication service to particular geographical areas 15a, 15b, and 15c (which are generally called cells). Each cell may be divided into a plurality of areas (which are called sectors). A user equipment (UE) 12 may be fixed or mobile and may be referred to by other names such as mobile station (MS), mobile terminal (MT), user terminal (UT), subscriber station (SS), wireless device, personal digital assistant (PDA), wireless modem, handheld device. The eNB 11 generally refers to a fixed station that communicates with the UE 12 and may be called by other names such as base station (BS), base transceiver system (BTS), access point (AP), etc.

[20] In general, a UE belongs to one cell, and the cell to which a UE belongs is called a serving cell. An eNB providing a communication service to the serving cell is called a serving eNB. The wireless communication system is a cellular system, so a different cell adjacent to the serving cell exists. The different cell adjacent to the serving cell is called a neighbor cell. An eNB providing a communication service to the neighbor cell is called a neighbor eNB. The serving cell and the neighbor cell are relatively determined based on a UE.

[21] This technique can be used for DL or UL. In general, DL refers to communication from the eNB 11 to the UE 12, and UL refers to communication from the UE 12 to the eNB 11. In DL, a transmitter may be part of the eNB 11 and a receiver may be part of the UE 12. In UL, a transmitter may be part of the UE 12 and a receiver may be part of the eNB 11.

[22] The wireless communication system may be any one of a multiple-input multiple-output (MIMO) system, a multiple-input single-output (MISO) system, a single-input single-output (SISO) system, and a single-input multiple-output (SIMO) system. The MIMO system uses a plurality of transmission antennas and a plurality of reception antennas. The MISO system uses a plurality of transmission antennas and a single reception antenna. The SISO system uses a single transmission antenna and a single reception antenna. The SIMO system uses a single transmission antenna and a plurality of reception antennas. Hereinafter, a transmission antenna refers to a physical or logical antenna used for transmitting a signal or a stream, and a reception antenna refers to a physical or logical antenna used for receiving a signal or a stream.

[23] FIG. 2 shows structure of a radio frame of 3GPP LTE. Referring to FIG. 2, a radio frame includes 10 subframes. A subframe includes two slots in time domain. A time for transmitting one subframe is defined as a transmission time interval (TTI). For example, one subframe may have a length of 1ms, and one slot may have a length of 0.5ms. One slot includes a plurality of orthogonal frequency division multiplexing (OFDM) symbols in time domain. Since the 3GPP LTE uses the OFDMA in the DL, the OFDM symbol is for representing one symbol period. The OFDM symbols may be called by other names depending on a multiple-access scheme. For example, when SC-FDMA is in use as a UL multi-access scheme, the OFDM symbols may be called SC-FDMA symbols. A resource block (RB) is a resource allocation unit, and includes a plurality of contiguous subcarriers in one slot. The structure of the radio frame is shown for exemplary purposes only. Thus, the number of subframes included in the radio frame or the number of slots included in the subframe or the number of OFDM symbols included in the slot may be modified in various manners.

[24] The wireless communication system may be divided into a frequency division duplex (FDD) scheme and a time division duplex (TDD) scheme. According to the FDD scheme, UL transmission and DL transmission are made at different frequency bands. According to the TDD scheme, UL transmission and DL transmission are made during different periods of time at the same frequency band. A channel response of the TDD scheme is substantially reciprocal. This means that a DL channel response and a UL channel response are almost the same in a given frequency band. Thus, the TDD-based wireless communication system is advantageous in that the DL channel response can be obtained from the UL channel response. In the TDD scheme, the entire frequency band is time-divided for UL and DL transmissions, so a DL transmission by the eNB and a UL transmission by the UE cannot be simultaneously performed. In a TDD system in which a UL transmission and a DL transmission are discriminated in units of subframes, the UL transmission and the DL transmission are performed in different subframes.

[25] FIG. 3 shows a resource grid for one downlink slot. Referring to FIG. 3, a DL slot includes a plurality of OFDM symbols in time domain. It is described herein that one DL slot includes 7 OFDM symbols, and one RB includes 12 subcarriers in frequency domain as an example. However, the present invention is not limited thereto. Each element on the resource grid is referred to as a resource element (RE). One RB includes 12×7 resource elements. The number N^{DL} of RBs included in the DL slot depends on a DL transmit bandwidth. The structure of a UL slot may be same as that of the DL slot. The number of OFDM symbols and the number of subcarriers may vary depending on the length of a CP, frequency spacing, etc. For example, in case of a normal cyclic prefix (CP), the number of OFDM symbols is 7, and in case of an extended CP, the number of OFDM symbols is 6. One of 128, 256, 512, 1024, 1536, and 2048 may be selectively used as the number of subcarriers in one OFDM symbol.

[26] FIG. 4 shows structure of a downlink subframe. Referring to FIG. 4, a maximum of three OFDM symbols located in a front portion of a first slot within a subframe correspond to a control region to be assigned with a control channel. The remaining OFDM symbols correspond to a data region to be assigned with a physical downlink shared chancel (PDSCH). Examples of DL control channels used in the 3GPP LTE includes a physical control format indicator channel (PCFICH), a physical downlink control channel (PDCCH), a physical hybrid automatic repeat request (HARQ) indicator channel (PHICH), etc. The PCFICH is transmitted at a first OFDM symbol of a subframe and carries information regarding the number of OFDM symbols used for transmission of control channels within the subframe. The PHICH is a response of UL transmission and carries a HARQ acknowledgment (ACK)/non-acknowledgment (NACK) signal. Control information transmitted through the PDCCH is referred to as downlink control information (DCI). The DCI includes UL or DL scheduling information or includes a UL transmit (TX) power control command for arbitrary UE groups.

[27] The PDCCH may carry a transport format and a resource allocation of a downlink shared channel (DL-SCH), resource allocation information of an uplink shared channel (UL-SCH), paging information on a paging channel (PCH), system information on the DL-SCH, a resource allocation of an upper-layer control message such as a random access response transmitted on the PDSCH, a set of TX power control commands on individual UEs within an arbitrary UE group, a TX power control command, activation of a voice over IP (VoIP), etc. A plurality of PDCCHs can be transmitted within a control region. The UE can monitor the plurality of PDCCHs. The PDCCH is transmitted on an aggregation of one or several consecutive control channel elements (CCEs). The CCE is a logical allocation unit used to provide the PDCCH with a coding rate based on a state of a radio channel. The CCE corresponds to a plurality of resource

element groups.

[28] A format of the PDCCH and the number of bits of the available PDCCH are determined according to a correlation between the number of CCEs and the coding rate provided by the CCEs. The eNB determines a PDCCH format according to a DCI to be transmitted to the UE, and attaches a cyclic redundancy check (CRC) to control information. The CRC is scrambled with a unique identifier (referred to as a radio network temporary identifier (RNTI)) according to an owner or usage of the PDCCH. If the PDCCH is for a specific UE, a unique identifier (e.g., cell-RNTI (C-RNTI)) of the UE may be scrambled to the CRC. Alternatively, if the PDCCH is for a paging message, a paging indicator identifier (e.g., paging-RNTI (P-RNTI)) may be scrambled to the CRC. If the PDCCH is for system information (more specifically, a system information block (SIB) to be described below), a system information identifier and a system information RNTI (SI-RNTI) may be scrambled to the CRC. To indicate a random access response that is a response for transmission of a random access preamble of the UE, a random access-RNTI (RA-RNTI) may be scrambled to the CRC.

[29] FIG. 5 shows structure of an uplink subframe. Referring to FIG. 5, a UL subframe can be divided in a frequency domain into a control region and a data region. The control region is allocated with a physical uplink control channel (PUCCH) for carrying UL control information. The data region is allocated with a physical uplink shared channel (PUSCH) for carrying user data. When indicated by a higher layer, the UE may support a simultaneous transmission of the PUSCH and the PUCCH. The PUCCH for one UE is allocated to an RB pair in a subframe. RBs belonging to the RB pair occupy different subcarriers in respective two slots. This is called that the RB pair allocated to the PUCCH is frequency-hopped in a slot boundary. This is said that the pair of RBs allocated to the PUCCH is frequency-hopped at the slot boundary. The UE can obtain a frequency diversity gain by transmitting UL control information through different subcarriers according to time.

[30] UL control information transmitted on the PUCCH may include a HARQ ACK/NACK, a channel quality indicator (CQI) indicating the state of a DL channel, a scheduling request (SR), and the like. The PUSCH is mapped to a UL-SCH, a transport channel. UL data transmitted on the PUSCH may be a transport block, a data block for the UL-SCH transmitted during the TTI. The transport block may be user information. Or, the UL data may be multiplexed data. The multiplexed data may be data obtained by multiplexing the transport block for the UL-SCH and control information. For example, control information multiplexed to data may include a CQI, a precoding matrix indicator (PMI), an HARQ, a rank indicator (RI), or the like. Or the UL data may include only control information.

[31] A radio resource control (RRC) state indicates whether an RRC layer of the UE is logically connected to an RRC layer of the evolved universal terrestrial radio access network (E-UTRAN). The RRC state may be divided into two different states such as an RRC idle state (RRC_IDLE) and an RRC connected state (RRC_CONNECTED). In RRC_IDLE, the UE may receive broadcasts of system information and paging information while the UE specifies a discontinuous reception (DRX) configured by non-access stratum (NAS), and the UE has been allocated an identification (ID) which uniquely identifies the UE in a tracking area and may perform public land mobile network (PLMN) selection and cell re-selection. Also, in RRC_IDLE, no RRC context is stored in the eNB.

[32] In RRC_CONNECTED, the UE has an E-UTRAN RRC connection and a context in the E-UTRAN, such that transmitting and/or receiving data to/from the eNB becomes possible. Also, the UE can report channel quality information and feedback information to the eNB. In RRC_CONNECTED, the E-UTRAN knows the cell to which the UE belongs. Therefore, the network can transmit and/or receive data to/from UE, the network can control mobility (handover and inter-radio access technologies (RAT) cell change order to GSM EDGE radio access network (GERAN) with network assisted cell change (NACC)) of the UE, and the network can perform cell measurements for a neighboring cell.

[33] In RRC_IDLE, the UE specifies the paging DRX cycle. Specifically, the UE monitors a paging signal at a specific paging occasion of every UE specific paging DRX cycle. The paging occasion is a time interval during which a paging signal is transmitted. The UE has its own paging occasion. A paging message is transmitted over all cells belonging to the same tracking area. If the UE moves from one tracking area (TA) to another TA, the UE will send a tracking area update (TAU) message to the network to update its location.

[34] Discontinuous reception for paging is further described. The UE may use DRX in idle mode in order to reduce power consumption. One paging occasion (PO) is a subframe in which there may be P-RNTI transmitted on PDCCH addressing the paging message. One paging frame (PF) is one radio Frame, which may contain one or multiple PO(s). When DRX is used, the UE needs only to monitor one PO per DRX cycle.

[35] The PF and PO is determined by following equations using the DRX parameters provided in system Information. PF is given by Equation 1 below.

[36] <Equation 1>

[37] SFN mod T = (T div N)*(UE_ID mod N)

[38] Index i_s pointing to PO from subframe pattern is derived from Equation 2 below.

[39] <Equation 2>

[40] i_s = floor(UE_ID/N) mod Ns

[41] System information DRX parameters stored in the UE shall be updated locally in the UE whenever the DRX parameter values are changed in system information. If the UE has no international mobile subscriber identity (IMSI), for instance when making an emergency call without universal subscriber identity module (USIM), the UE shall use as default identity UE_ID = 0 in the PF and i_s equations above.

[42] The following parameters are used for the calculation of the PF and i_s, shown in Equation 1 and Equation 2.

[43] - T: DRX cycle of the UE. T is determined by the shortest of the UE specific DRX value, if allocated by upper layers, and a default DRX value broadcast in system information. If UE specific DRX is not configured by upper layers, the default value is applied.

[44] - nB: 4T, 2T, T, T/2, T/4, T/8, T/16, T/32

[45] - N: min(T, nB)

[46] - Ns: max(1, nB/T)

[47] - UE_ID: IMSI mod 1024.

[48] IMSI is given as sequence of digits of type Integer (0..9), and IMSI in the equations above shall be interpreted as a decimal integer number, where the first digit given in the sequence represents the highest order digit. For example, when IMSI = 12 (digit1=1, digit2=2), in the calculations, this shall be interpreted as the decimal integer "12", not "1x16+2 = 18".

[49] Table 1 shows paging subframe patterns for FDD.

[50] [Table 1]

Ns	PO when i_s=0	PO when i_s=1	PO when i_s=2	PO when i_s=3
1	9	N/A	N/A	N/A
2	4	9	N/A	N/A
4	0	4	5	9

[51] Table 2 shows paging subframe patterns for TDD (all UL/DL configurations).

[52] [Table 2]

Ns	PO when i_s=0	PO when i_s=1	PO when i_s=2	PO when i_s=3
1	0	N/A	N/A	N/A
2	0	5	N/A	N/A
4	0	1	5	6

[53] In the current LTE specification, all UEs shall support maximum 20MHz system bandwidth, which requires baseband processing capability to support 20MHz

bandwidth. To reduce hardware cost and battery power of the UE used for machine type communication (MTC), reducing bandwidth is a very attractive option. To enable narrow-band MTC UEs, the current LTE specification shall be changed to allow narrow-band UE category. If the serving cell has small system bandwidth (smaller than or equal to bandwidth that narrow-band UE can support), the UE can attach based on the current LTE specification.

[54] In normal MTC, it is expected that UL heavy traffic such as periodic reporting of sensor data is typical. To support a long-battery-life, it is also expected that a UE sleeps a long time and wakes up only for either event-triggered reporting or periodic reporting or sending keep-alive messages. When the UE wakes up, due to a rather long-time sleep, time/frequency tracking of the UE may be inaccurate. Thus, re-synchronization may be necessary. This is also true for UL transmission as well. Thus, transmitting necessary tracking signals such as cell-specific reference signal (CRS) is essential along with any DL data such as paging or wake-up signals. When the UE wakes up from paging or based on event/timer, before it transmits UL data, the UE also needs to transmit physical random access channel (PRACH)-like signals to align UL timing/frequency. To allow multiplexing of UEs, a mechanism to trigger periodic report based on paging may be considered. For example, the eNB may transmit paging to a set of UEs periodically which will be used for UL grants. Further, when a UE experiences limited coverage, it is also necessary to transmit repeated paging (paging re-transmission or repetition) for coverage enhancement (CE). In this case, paging occasion and paging frame definition for a MTC UE needs to be changed. Furthermore, how to repeat paging also need to be clarified.

[55] In order to solve the problem described above, a method for transmitting a paging for MTC UEs according to an embodiment of the present invention may be proposed. Hereinafter, all of a MTC UE, a low cost UE, a low end UE, a low complexity UE, a narrow(er) band UE, a small(er) band UE, or a new category UE may be used mixed with each other. Or, just UE may refer one of UEs described above. In the description below, a case where system bandwidth of available cells is larger than bandwidth that new category narrow-band UEs can support may be assumed. For the new category UE, it may be assumed that only one narrow-band is defined. In other words, all narrow-band UE shall support the same narrow bandwidth smaller than 20MHz. It may be assumed that the narrow bandwidth is larger than 1.4MHz (6 PRBs). However, the present invention may be applied to narrower bandwidth less than 1.4MHz as well (e.g. 200 kHz), without loss of generality. More generally, the present invention may apply to a case where the system has large bandwidth such as 160MHz, whereas the UE may support smaller bandwidth size such as 20MHz as well.

[56] FIG. 6 shows an overall paging timing to support coverage enhancement for MTC

UEs according to an embodiment of the present invention. Referring to FIG. 6, for MTC UEs in coverage enhancement mode, T_{MTC} may be defined in a predetermined value or signaled by SIB/master information block (MIB), which may contain the cycle duration of paging instance to MTC UEs in coverage enhancement mode. This is different from no coverage enhancement where paging frame can occur in every T where T is the default DRX cycle in RRC_IDLE broadcasted by SIB or minimum DRX cycle in RRC_CONNECTED. The cycle duration of paging instance may be defined as overall periodicity of MTC UE reporting such as for smart meter applications. T_{MTC} may be defined in consideration of both periodicity of wake-up or paging and the maximum coverage enhancement level that the network supports. If the network supports e.g. 15dB enhancement and thus may support up to 100 times of repetition of paging, one paging frame occasion for a MTC UE may be larger than 100 subframes. PF_{MTC} may define the number of subframes or the number of radio frames where one paging instance may require. PF_{MTC} may be defined based on the maximum coverage level that the network supports. Within a PF_{MTC}, a set of subframe/radio frames may be allocated for paging purpose in a predetermined or via higher layer signaling such as SIB.

[57] In terms of determining the location of paging/paging frame, the current function may be reused. Since the network may not know the coverage enhancement level that a UE may require, the network may transmit the maximum repetition that the network supports for every UE. Alternatively, the network may use previous coverage enhancement level that the specific UE has been configured/used (which was successful), and if the transmission fails (i.e. no feedback has been received from the UE), the network may increase the coverage enhancement level. However, given that paging may not occur so often particularly for MTC UEs in coverage enhancement mode, it is desirable to always use maximum coverage enhancement mode to support successful transmission. However, a MTC UE may stop monitoring/receiving repletion of paging once it succeeds the reception.

[58] Starting subframe of paging repetition according to an embodiment of the present invention is described. To determine the starting subframe of repeated paging, according to an embodiment of the present invention, paging may be transmitted without PDCCH with preconfigured modulation and coding scheme (MCS) and resource allocation. In this case, the starting position/subframe of the repeated paging may start at PF_{MTC} and the repetition may continue every PO_{MTC} opportunity (i.e. paging occasion configured not only for the given UE as well for other UEs) in each PF_{MTC}. Further, in order to indicate starting set of PF_{MTC} or set of PO_{MTC} where a UE may expect the repeated paging may start. In terms of determining PF_{MTC}, UE-specific or P-RNTI-based function, which is similar to the current function, may be used. In

this case, the first PO within a PF may be used as a starting subframe for the repeated paging transmission. In this case, to determine the paging location for a UE, the following function may be used. PF may be given by Equation 3. Further, PO_{MTC}=0.

[59] <Equation 3>

[60] SFN*M mod T*M = (T*M div N*M)*(UE_ID mod N)

[61] In Equation 3, the following parameters may be used.

[62] - T: Size of one paging cycle (e.g. the number of UEs or the number of P-RNTIs supported in one paging cycle), which is predetermined or higher layer signaled

[63] - M: The number of radio frames within one PF_{MTC}. For example, M=4 may mean that 40 subframes consist one PF_{MTC}.

[64] - nB: 4T, 2T, T, T/2, T/4, T/8, T/16, T/32

[65] - N: min(T, nB)

[66] - Ns: max(1, nB/T)

[67] - UE_ID: IMSI mod 1024.

[68] Alternatively, the starting position/subframe of the repeated paging may start at PF_{MTC}/PO_{MTC} and the repetition may continue in successive DL subframes. In this case, it is desirable that the size of PF_{MTC} is larger than the required number of subframes to transmit repeated/retransmitted paging. One example may be to set the size of PF_{MTC} = 2 * maximum number of repetition (e.g. 100) and PO_{MTC} may be placed only in first half of PF_{MTC} duration such that all UEs can be scheduled with the maximum repetition number within one PF_{MTC}. For this, PF_{MTC} may be determined as the same as the first approach, i.e. by Equation 3 described above. Paging occasion may be determined by Equation 4, which distributes UEs uniformly within one half of PF_{MTC}.

[69] <Equation 4>

[70] i_s = UE_ID mod M*10/2

[71] The set of subframes/radio frames used for paging repetition may be determined based on UE ID or P-RNTI. For example, one PF_{MTC} = PO_{MTC} size * number of UE IDs (or number of P-RNTIs), where the size of PO_{MTC} may be larger than the maximum repetition number for paging. In that case, the starting subframe of repetition may be the first subframe within a PO_{MTC}. This approach is similar to the first approach. The difference is that the paging occasion frame may be determined solely by UE ID or P-RNTI such as K = (UE_ID mod N), where K is the index of PF_{MTC} and N is the maximum number of UE IDs (or number of P-RNTIs) that the system supports.

[72] According to another embodiment of the present invention, paging may be transmitted with PDCCH. In this case, approaches described above for paging without PDCCH may be applied similarly. Once PDCCH is transmitted, in terms of PDSCH, the following options may be considered.

[73] - PDSCH repetition may start at K subframe (e.g. K = 1 or 2) after end of the

PDCCH repetition

[74] - Two separate PF_{MTC}/PO_{MTC} for PDCCH/PDSCH may be defined where the repetition of PDCCH/PDSCH occurs in each set respectively.

[75] - PDCCH may indicate a set of subframes where PDSCH are transmitted.

[76] - Other options used for repeating PDCCH and PDSCH may be also applicable to paging retransmission.

[77] Meanwhile, PDCCH for MTC UEs (hereinafter, M-PDCCH) is used to schedule paging transmission, paging occasion may be configured in consideration of repetition number or aligned with repetition number. The network may configure at least one of the followings via SIB.

[78] - Periodicity of M-PDCCH (the largest repetition number of M-PDCCH): It is generally desirable to have multiple of radio frame for this periodicity, and also, it is desirable that the maximum number of system frame number (SFN) can divide this repetition number.

[79] - (optionally) offset indicating when the period starts

[80] - Repetition number of M-PDCCH

[81] For M-PDCCH used for paging, the repetition may occur only valid subframe configured by SIB1. Further, a set of paging subframe where M-PDCCH and/or paging PDSCH may be transmitted. In terms of paging occasion configuration, the following may be considered. PF may be given by Equation 5.

[82] <Equation 5>

[83] SFN*M mod T*M = (T*M div N*M)*(UE_ID mod floor (N/P)*P)

[84] In Equation 5, the following parameters may be used.

[85] - T: Size of one paging cycle (e.g. the number of UEs or the number of P-RNTIs supported in one paging cycle), which is predetermined or higher layer signaled

[86] - M: The number of radio frames within one PF_{MTC}. For example, M=4 may mean that 40 subframes consist one PF_{MTC}.

[87] - nB: 4T, 2T, T, T/2, T/4, T/8, T/16, T/32

[88] - N: min(T, nB)

[89] - Ns: max(1, nB/T)

[90] - UE_ID: IMSI mod 1024.

[91] - P: the periodicity in radio frame unit.

[92] By this way, paging occasion may be aligned with the starting subframes of M-PDCCH monitoring for paging transmission. Other configuration may be also considered which aligns the starting subframe of M-PDCCH with paging occasion. If paging occasion and starting subframe of M-PDCCH is not aligned, a UE may start monitoring of M-PDCCH monitoring occasions within paging occasion.

[93] In addition to the above configuration, paging duration may be configured in SIB via

some signaling. For example, the paging duration may be multiple of M-PDCCH monitoring window. If a UE is monitoring multiple repetition levels, it will be based on the largest repetition number. Or, separate configuration per each repetition level may be also considered. Further, for PDSCH where paging is transmitted, the PDSH may be scheduled outside of paging occasion. The starting offset of PDSCH may be signaled from M-PDCCH or via SIB.

[94] Handling of dynamic/variable CE/repetition level according to an embodiment of the present invention is described. For a MTC UE in coverage enhancement mode, it is likely that CE/repetition level for paging message may change even though the UE may be static due to channel/environments change. Since paging generally occurs for a UE in RRC_IDLE, tight management of CE/repetition level does not seem to be feasible or feedback from UE regarding CE/repetition level may not be easily assumed. In this case, overall change of CE/repetition level may be performed as described below.

[95] If it is assumed that a mobility management entity (MME) may increase CE/ repetition level in case of retransmission, since the UE may not know whether there is a retransmission or not, the UE may have to monitor multiple resource candidates where paging can be transmitted at one time. Or, multiple resource candidates may be configured such that a UE may monitor different resources with different repetition level at each time. For example, at each paging occasion, instead of a UE monitoring one instance of paging, the UE may monitor multiple paging instances with potentially different repetition level. Specifically, since the UE does not know the CE/repetition level, the UE may monitor paging instances, from the minimum CE/repetition level to the maximum CE/repetition level.

[96] FIG. 7 shows increase of coverage enhancement levels or repetition levels according to an embodiment of the present invention. Referring to FIG. 7, at first, the MME initiates paging with CE level i. The eNB transmits the paging message to the UE with CE level i. However, in spite of repetition, the UE cannot receive the paging message. Accordingly, the MME increases CE level. The eNB transmits the paging message to the UE with CE level i+1. In this case, the UE can receive the paging message via repetition, and can transmit a connection request to the eNB.

[97] As one approach, in order to transmit the paging message with different repetition levels, the paging message may be transmitted by utilizing a control channel format, such as PDCCH or enhanced PDCCH (EPDCCH) or a new control channel format, which allows multiplexing of different aggregation levels where different aggregation levels may be mapped to different CE/repetition levels. In this example, the number of repeated subframes may be fixed where different aggregation levels are used for different CE/repetition levels. In this case, to cover multiple CE/repetition levels, more

aggregation levels may be used, or different aggregation levels may be used. For example, instead that aggregation levels of 1, 2, 4 and 8 is used, aggregation levels of 1, 4, 16, 256, and so on, may be used. The number of repeated PDSCH may be indicated by PDCCH or implicitly mapped to the aggregation level used for control channel or CE/repetition level used for control channel.

[98] As another approach, repetition/CE level may be mapped to a subband or frequency location such that control channel may indirectly indicate CE/repetition level of PDSCH depending on resource allocation or subband allocation. Another approach is to configure the maximum number of repetitions based on the maximum CE/repetition level that the system supports or system supports for the paging, and the network may transmit the paging message with smaller number of repetition if the CE/repetition level used for paging is smaller than the maximum CE/repetition level. In this case, a UE needs to blindly search the end of repetition (e.g. by detecting discontinuous transmission (DTX), etc.). CE/repetition level change/determination mechanisms described here may be applied to other channels such unicast PDSCH or random access response (RAR).

[99] Alternatively, multiple PO and/or PF may be configure for different CE/repetition levels. For example, m different number of PF_{MTC} and/or PO_{MTC} may be configured such that in one instance of paging, the UE may need to monitor multiple occasions with different CE/repetition levels. However, this approach leads higher latency to be able to receive paging with the appropriate CE/repetition level.

[100] FIG. 8 shows a method for monitoring a paging according to an embodiment of the present invention. In step S100, the UE monitors a first paging instance with a first repetition level in a paging occasion. Paging in the first paging instance with the first paging repetition level may be failed. In step S110, the UE monitors a second paging instance with a second repetition level, which is higher than the first repetition level, in the paging occasion. Paging in the second paging instance with the second paging repetition level may be succeed. The first repetition level and the second repetition level may be provided by the MME to the eNB. In this case, the UE may transmit a connection request message to the eNB. The UE may be a low cost machine-type communication UE.

[101] The first repetition level may correspond to a minimum repetition level. The second repetition level may correspond to a maximum repetition level. Monitoring the first paging instance or the second paging instance may comprise monitoring transmission of a paging message from an eNB in the first paging instance or the second paging instance. The paging message may be transmitted with a first aggregation level in the first paging instance, and the paging message may be transmitted with a second aggregation level in the second paging instance. The first repetition level may be mapped

to the first aggregation level, and the second repetition level may be mapped to the second aggregation level.

[102] FIG. 9 shows a wireless communication system to implement an embodiment of the present invention.

[103] An eNB 800 may include a processor 810, a memory 820 and a transceiver 830. The processor 810 may be configured to implement proposed functions, procedures and/or methods described in this description. Layers of the radio interface protocol may be implemented in the processor 810. The memory 820 is operatively coupled with the processor 810 and stores a variety of information to operate the processor 810. The transceiver 830 is operatively coupled with the processor 810, and transmits and/or receives a radio signal.

[104] A MTC UE 900 may include a processor 910, a memory 920 and a transceiver 930. The processor 910 may be configured to implement proposed functions, procedures and/or methods described in this description. Layers of the radio interface protocol may be implemented in the processor 910. The memory 920 is operatively coupled with the processor 910 and stores a variety of information to operate the processor 910. The transceiver 930 is operatively coupled with the processor 910, and transmits and/or receives a radio signal.

[105] The processors 810, 910 may include application-specific integrated circuit (ASIC), other chipset, logic circuit and/or data processing device. The memories 820, 920 may include read-only memory (ROM), random access memory (RAM), flash memory, memory card, storage medium and/or other storage device. The transceivers 830, 930 may include baseband circuitry to process radio frequency signals. When the embodiments are implemented in software, the techniques described herein can be implemented with modules (e.g., procedures, functions, and so on) that perform the functions described herein. The modules can be stored in memories 820, 920 and executed by processors 810, 910. The memories 820, 920 can be implemented within the processors 810, 910 or external to the processors 810, 910 in which case those can be communicatively coupled to the processors 810, 910 via various means as is known in the art.

[106] In view of the exemplary systems described herein, methodologies that may be implemented in accordance with the disclosed subject matter have been described with reference to several flow diagrams. While for purposed of simplicity, the methodologies are shown and described as a series of steps or blocks, it is to be understood and appreciated that the claimed subject matter is not limited by the order of the steps or blocks, as some steps may occur in different orders or concurrently with other steps from what is depicted and described herein. Moreover, one skilled in the art would understand that the steps illustrated in the flow diagram are not exclusive and

other steps may be included or one or more of the steps in the example flow diagram may be deleted without affecting the scope and spirit of the present disclosure.

Claims

[Claim 1] A method for monitoring, by a user equipment (UE), a paging in a wireless communication system, the method comprising:
monitoring a first paging instance with a first repetition level in a paging occasion; and
monitoring a second paging instance with a second repetition level, which is higher than the first repetition level, in the paging occasion.

[Claim 2] The method of claim 1, wherein paging in the first paging instance with the first paging repetition level is failed.

[Claim 3] The method of claim 1, wherein paging in the second paging instance with the second paging repetition level is succeed.

[Claim 4] The method of claim 3, further comprising transmitting a connection request message to an evolved NodeB (eNB).

[Claim 5] The method of claim 1, wherein the first repetition level or the second repetition level is provided by a mobility management entity (MME) to an eNB.

[Claim 6] The method of claim 1, wherein the first repetition level corresponds to a minimum repetition level.

[Claim 7] The method of claim 1, wherein the second repetition level corresponds to a maximum repetition level.

[Claim 8] The method of claim 1, wherein monitoring the first paging instance or the second paging instance comprises monitoring transmission of a paging message from an eNB in the first paging instance or the second paging instance.

[Claim 9] The method of claim 8, wherein the paging message is transmitted with a first aggregation level in the first paging instance, and
wherein the paging message is transmitted with a second aggregation level in the second paging instance.

[Claim 10] The method of claim 9, wherein the first repetition level is mapped to the first aggregation level, and
wherein the second repetition level is mapped to the second aggregation level.

[Claim 11] The method of claim 1, wherein the UE is a low cost machine-type communication UE.

[Claim 12] A user equipment (UE) comprising:
a memory;
a transceiver; and

a processor coupled to the memory and the transceiver, and configured to:

monitor a first paging instance with a first repetition level; and

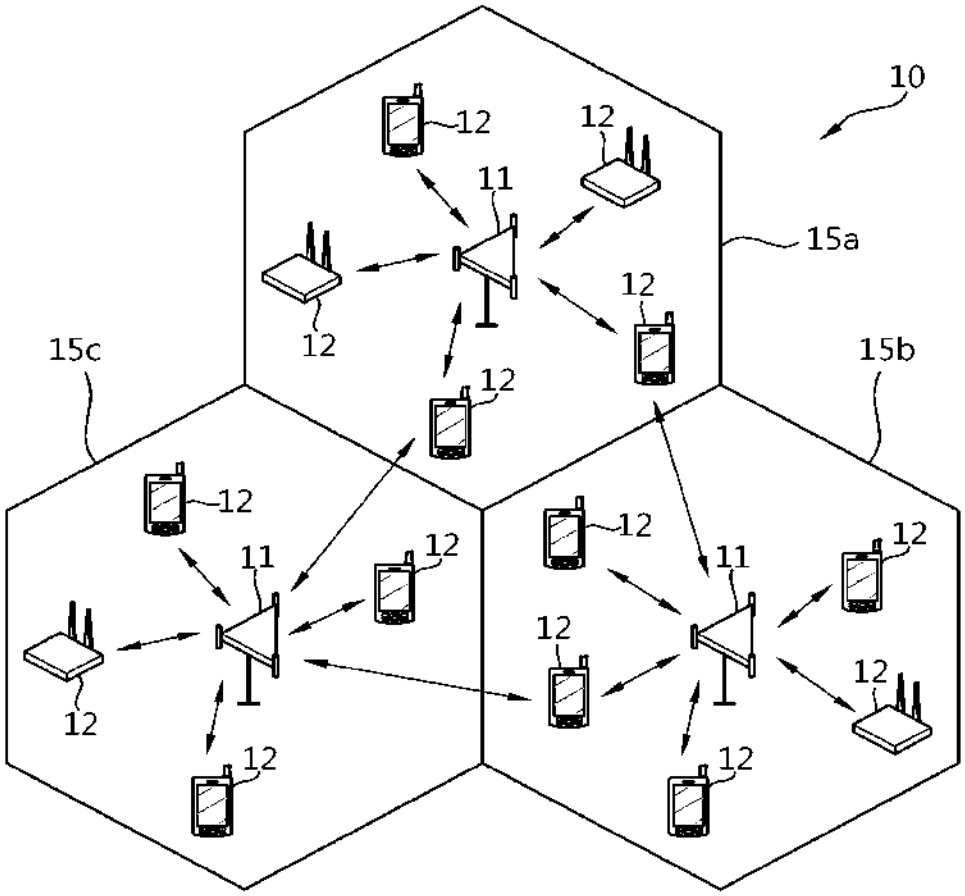
monitor a second paging instance with a second repetition level which is higher than the first repetition level.

[Claim 13] The UE of claim 12, wherein paging in the first paging instance with the first paging repetition level is failed.

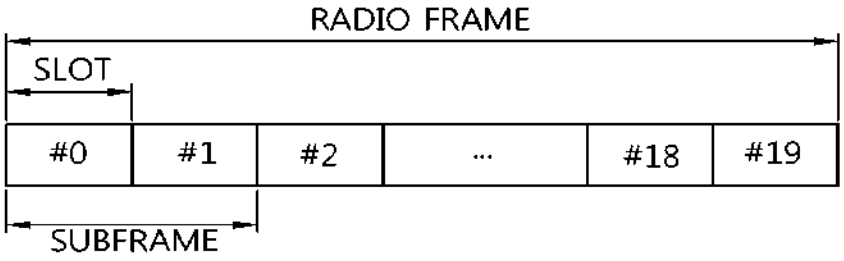
[Claim 14] The UE of claim 12, wherein paging in the second paging instance with the second paging repetition level is succeed.

[Claim 15] The UE of claim 12, wherein the first repetition level or the second repetition level is provided by a mobility management entity (MME) to an eNB.

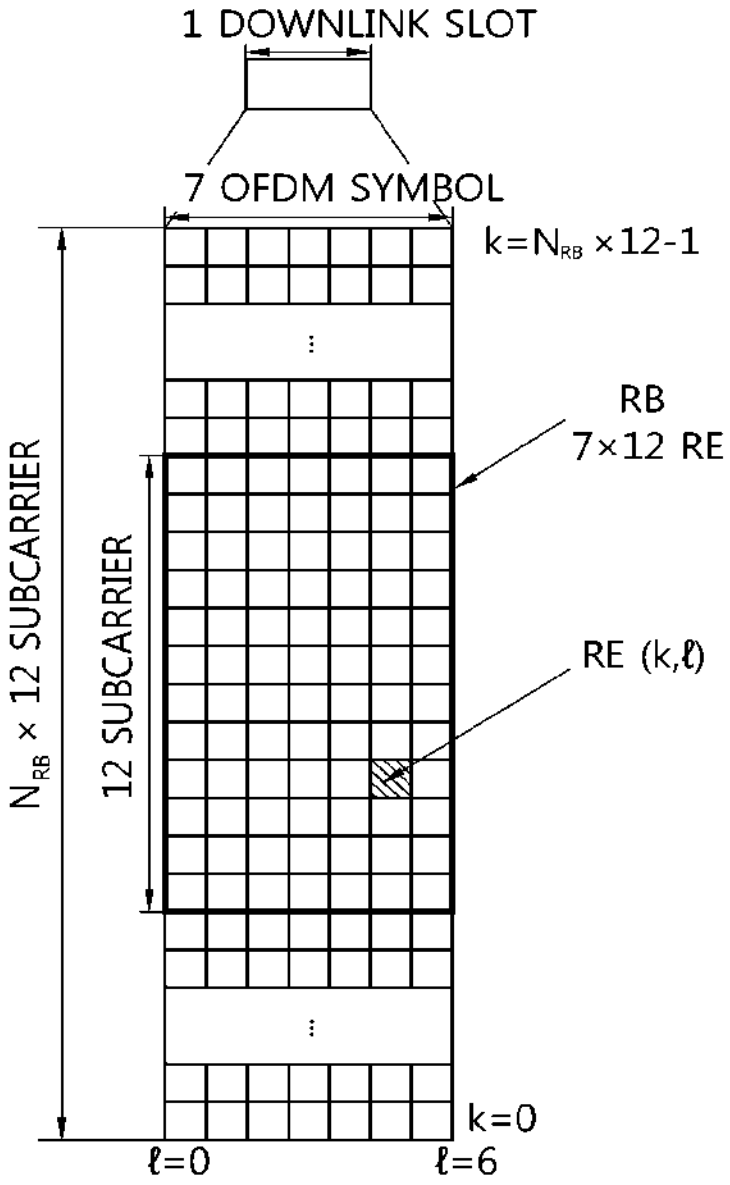
[Fig. 1]



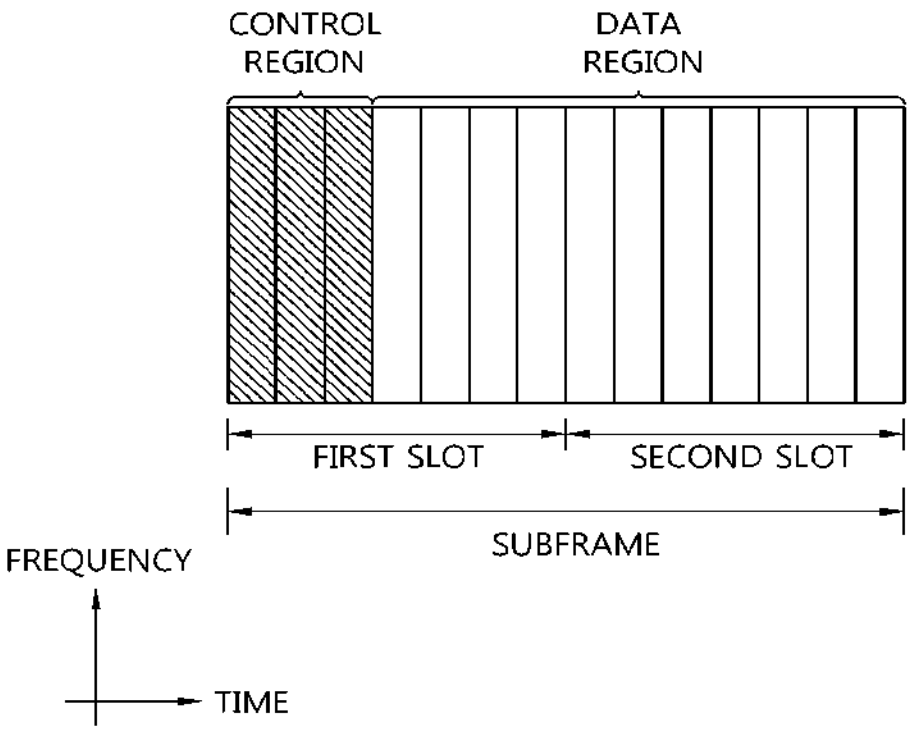
[Fig. 2]



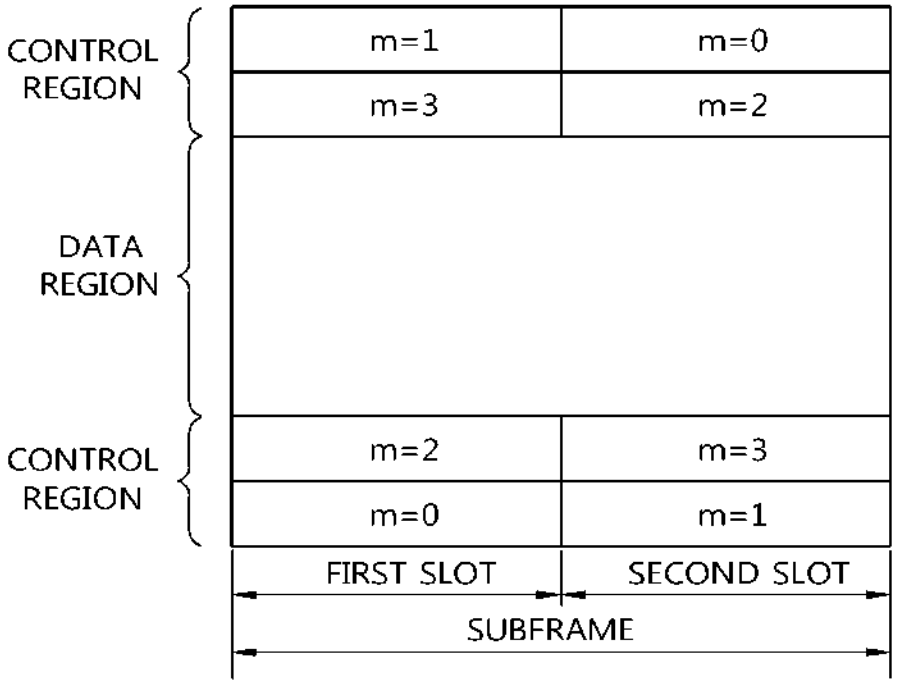
[Fig. 3]

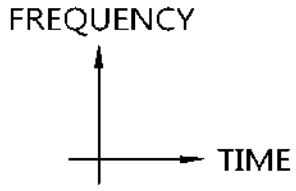

1 DOWNLINK SLOT
7 OFDM SYMBOL
k=N_RB ×12-1
RB
7×12 RE
RE (k,ℓ)
N_RB × 12 SUBCARRIER
12 SUBCARRIER
k=0
ℓ=0
ℓ=6

[Fig. 4]

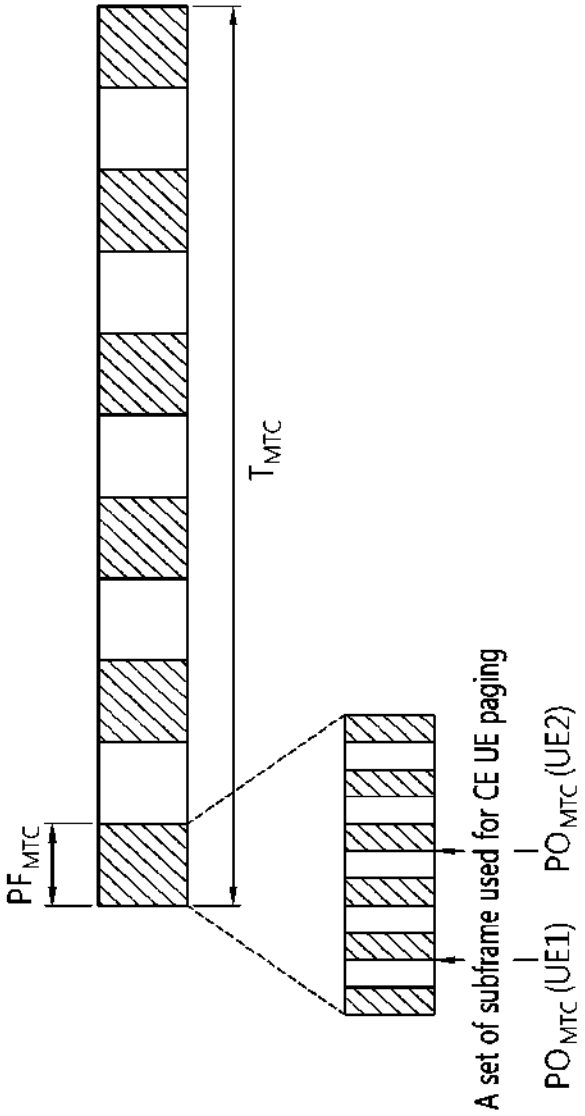

CONTROL REGION
DATA REGION
FIRST SLOT
SECOND SLOT
SUBFRAME
FREQUENCY
TIME

[Fig. 5]

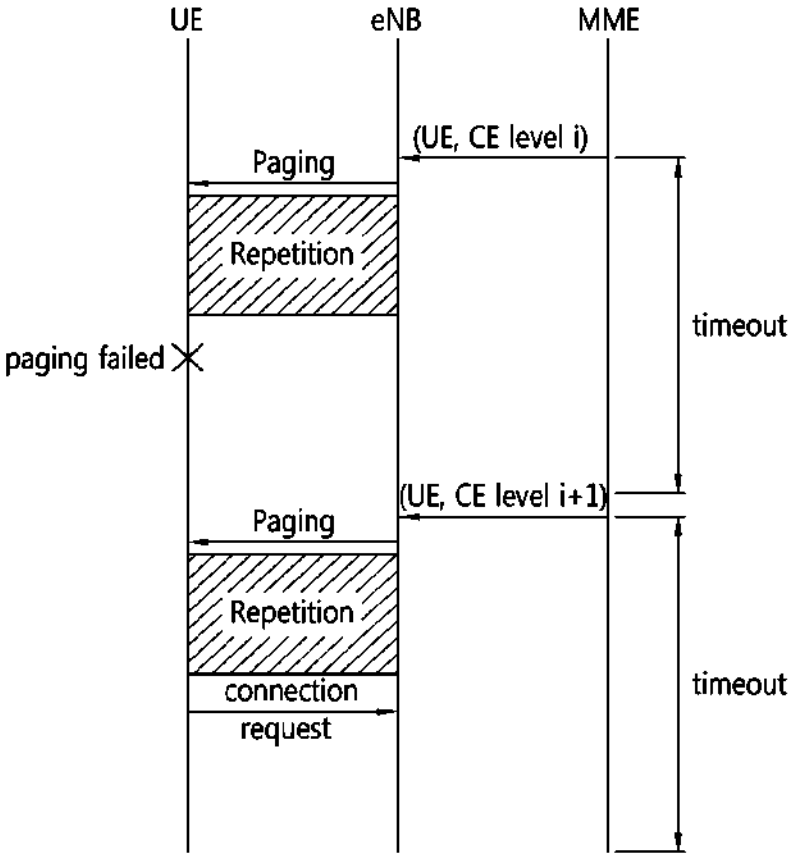

CONTROL REGION
DATA REGION
CONTROL REGION
m=1
m=0
m=3
m=2
m=2
m=3
m=0
m=1
FIRST SLOT
SECOND SLOT
SUBFRAME


FREQUENCY
TIME

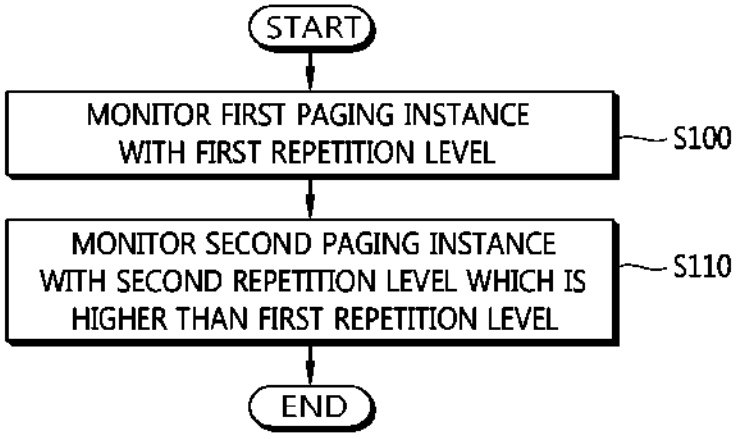
[Fig. 6]


T_{MTC}
PF_{MTC}
A set of subframe used for CE UE paging
PO_{MTC} (UE1)
PO_{MTC} (UE2)

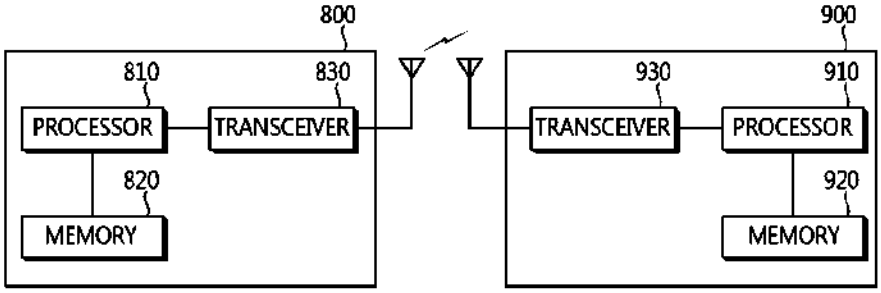
[Fig. 7]


UE
eNB
MME
(UE, CE level i)
Paging
Repetition
timeout
paging failed
(UE, CE level i+1)
Paging
Repetition
connection
request
timeout

[Fig. 8]


START
MONITOR FIRST PAGING INSTANCE WITH FIRST REPETITION LEVEL
S100
MONITOR SECOND PAGING INSTANCE WITH SECOND REPETITION LEVEL WHICH IS HIGHER THAN FIRST REPETITION LEVEL
S110
END

[Fig. 9]


800
810
830
PROCESSOR
TRANSCEIVER
820
MEMORY
900
930
910
TRANSCEIVER
PROCESSOR
920
MEMORY

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2015/011863

A. CLASSIFICATION OF SUBJECT MATTER

H04W 68/02(2009.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W 68/02; H04L 5/00; H04W 74/08; G08B 5/22; H04W 68/00; H04J 11/00; H04W 72/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: higher repetition level, paging occasion, paging instance, monitor, MTC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2014-111693 A1 (SONY CORPORATION) 24 July 2014 See page 53, line 21 - page 55, line 26; and fig. 22.	1-15
Y	ERICSSON, `Common control messages for MTC', R1-143789, 3GPP TSG-RAN WG1 Meeting #78bis, Ljubljana, Slovenia, 27 September 2014 See pages 1-6; and fig. 3.	1-15
A	US 2012-0076085 A1 (CHIE-MING CHOU) 29 March 2012 See paragraphs [0063]-[0090]; and figs. 1, 4B-4D.	1-15
A	US 2013-0015953 A1 (CHIA-CHUN HSU et al.) 17 January 2013 See paragraphs [0034]-[0062]; and figs. 3-11.	1-15
A	US 2014-0098761 A1 (INTERDIGITAL PATENT HOLDINGS, INC.) 10 April 2014 See paragraphs [0278]-[0286].	1-15

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
05 February 2016 (05.02.2016)	**05 February 2016 (05.02.2016)**

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/KR2015/011863

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		KR 10-2015-0064196 A	10/06/2015
		TW 201429174 A	16/07/2014
		WO 2014-055878 A1	10/04/2014

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(25) 申请语言: 中文

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(81) 指定国 (除另有指明, 要求每一种可提供的国家保护): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW。

(84) 指定国 (除另有指明, 要求每一种可提供的地区保护): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), 欧亚 (AM, AZ, BY, KG, KZ, RU, TJ, TM), 欧洲 (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO,

[见续页]

(54) Title: SIGNAL TRANSMISSION METHOD AND ASSOCIATED DEVICE

(54) 发明名称 : 一种信号发送方法及相关设备

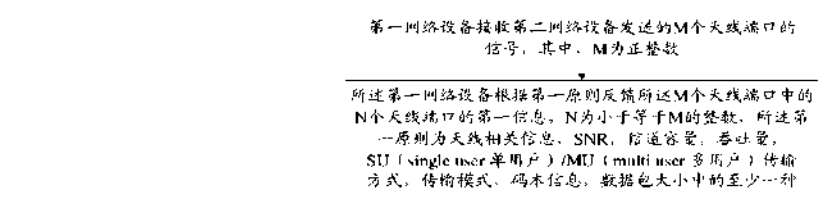


图 1 / Fig. 1

S101 A FIRST NETWORK DEVICE RECEIVES SIGNALS OF M ANTENNA PORTS SENT BY A SECOND NETWORK DEVICE, WHERE M IS A POSITIVE INTEGER

S102 THE FIRST NETWORK DEVICE FEEDS BACK FIRST INFORMATION OF N ANTENNA PORTS IN THE M ANTENNA PORTS ACCORDING TO A FIRST RULE, WHERE N IS AN INTEGER SMALLER THAN OR EQUAL TO M, AND THE FIRST RULE IS AT LEAST ONE OF ANTENNA ASSOCIATED INFORMATION, SNR, CHANNEL CAPACITY, THROUGHPUT, AN SU (SINGLE-USER)/MU (MULTI-USER) TRANSMISSION MANNER, A TRANSMISSION MODE, CODEBOOK INFORMATION AND A DATA PACKET SIZE

(57) Abstract: A signal transmission method and an associated device. The method comprises: a first network device receives signals of M antenna ports sent by a second network device, where M is a positive integer; the first network device feeds back first information of N antenna ports in the M antenna ports according to a first rule, where N is an integer smaller than or equal to M, and the first rule is at least one of antenna associated information, SNR, channel capacity, throughput, an SU (single-user)/MU (multi-user) transmission manner, a transmission mode, codebook information and a data packet size. The present invention performs the optimum antenna configuration according to at least one of antenna associated information, SNR, channel capacity, throughput, an SU/MU transmission manner, a transmission mode, codebook information or a data packet size and carries out more effective antenna selection.

(57) 摘要: 一种信号发送方法及相关设备。其中的方法包括：第一网络设备接收第二网络设备发送的 M 个天线端口的信号，其中，M 为正整数；所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，N 为小于等于 M 的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU(single user 单用户)/MU(multi user 多用户)传输方式，传输模式，码本信息，数据包大小中的至少一种。本发明实施例通过根据天线相关信息、SNR、信道容量、吞吐量、单用户/多用户传输方式、传输模式、码本信息或数据包大小中的至少一种进行最优天线配置，进行了更有效的天线选择。

WO 2016/015307 A1

RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG)。

本国际公布:

— 包括国际检索报告(条约第 21 条(3))。

一种信号发送方法及相关设备

技术领域

本发明涉及通信技术领域，尤其涉及一种信号发送方法及相关设备。

背景技术

通过发射波束赋形(Beam Forming，BF)/预编码和接收合并，多输入多输出(Multiple-Input Multiple-Output，MIMO)无线系统可以得到分集和阵列增益。利用 BF 或者预编码的典型系统通常可以表示为：

$$\mathbf{y}=\mathbf{HVs}+\mathbf{n}$$

其中 $\mathbf{y}$ 是接收信号矢量，$\mathbf{H}$ 是信道矩阵，$\mathbf{V}$ 是预编码矩阵，$\mathbf{s}$ 是发射的符号矢量，$\mathbf{n}$ 是测量噪声。最优预编码通常需要发射机完全已知信道状态信息（Channel State Information，CSI）。常用的方法是用户设备对瞬时 CSI 进行量化并反馈给基站设备。现有 LTE R8 系统反馈的 CSI 信息包括秩指示（RI）、预编码矩阵指示（PMI）和信道质量指示（CQI）信息等，其中 RI 和 PMI 分别指示使用的层数和预编码矩阵。

现在为了进一步提高小区用户总吞吐率和平均吞吐率，使用动态三维(3 Dimensions，3D)波束赋形技术等 3D 多天线技术。但在现有蜂窝系统中，基站发射端波束仅能在水平维进行调整，而垂直维对每个用户都是固定的下倾角，因此各种波束赋形/预编码技术等均是基于水平维信道信息的。事实上，由于信道是 3D 的，固定下倾角的方法往往不能使系统的吞吐量达到最优。因此在 3D 天线可以通过不同的驱动网络形成对应于不同下倾角的天线端口，即不同的天线端口的天线方向图不同。同时，随着高频技术的演进，将会引入 massive MIMO 技术，massive MIMO 采用大规模天线，不同的天线间的信道特性不会完全相同。

综上所述，3D 多天线，或者大规模天线技术中需要有更有效的天线选择方法。

发明内容

本发明实施例提供一种信号发送方法及相关设备，以进行更有效的天线选择。

第一方面，提供了一种信号发送方法，包括:

第一网络设备接收第二网络设备发送的 M 个天线端口的信号，其中，M 为正整数;

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，N 为小于等于 M 的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种。

在第一种可能的实现方式中，所述第一准则为天线相关信息;

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为:

所述第一网络设备根据测量的所述 M 个天线端口的天线相关信息，进行小区选择，其中 M 个天线端口对应至少两个小区或者两个传输节点，每个所述小区或传输节点对应至少两个天线端口。

结合第一方面的第一种可能的实现方式，在第二种可能的实现方式中，所述第一网络设备根据测量的所述 M 个天线端口的天线相关信息，进行小区选择，具体为:

所述第一网络设备根据测量的所述 M 个天线端口的天线相关信息与第一阈值的比较结果，选择所述 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第一方面，在第三种可能的实现方式中，所述第一准则为信噪比 SNR;

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为:

所述第一网络设备在 M 个天线端口中选择使得波束赋型或者发射分集后的 SNR 小于等于或大于等于第二阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第一方面，在第四种可能的实现方式中，第一准则为信道容量;

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为:

所述第一网络设备在 M 个天线端口中选择使得信道容量小于等于或大于等于第三阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天

线端口的第一信息并进行反馈。

结合第一方面，在第五种可能的实现方式中，第一准则为吞吐量；

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备在 M 个天线端口中选择使得吞吐量小于等于或大于等于第四阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第一方面，在第六种可能的实现方式中，第一准则为 SU/MU 传输方式；

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备在 M 个天线端口中选择 SU 传输最优的第一组天线端口，所述的第一组天线端口包含 N1 个天线端口，得到所述 N1 个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在 M 个天线端口中选择 MU 传输最优的第二组天线端口，所述的第二组天线端口包含 N2 个天线端口，得到所述 N2 个天线端口的第一信息并进行反馈。

结合第一方面，在第七种可能的实现方式中，第一准则为传输模式；所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备在 M 个天线端口中选择传输模式是发射分集传输的最优的第一组天线端口，所述的第一组天线端口包含 N1 个天线端口，得到所述 N1 个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在 M 个天线端口中选择传输模式是波束赋型传输的最优的第二组天线端口，所述的第一组天线端口包含 N2 个天线端口，得到所述 N2 个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在 M 个天线端口中选择传输模式是空间复用传输的最优的第三组天线端口，所述的第三组天线端口包含 N3 个天线端口，得到所述 N3 个天线端口的第一信息并进行反馈。

结合第一方面，在第八种可能的实现方式中，所述第一准则为码本信息；

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备在 M 个天线端口中选择采用其对应的第一码本信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第一方面，在第九种可能的实现方式中，所述第一准则为码本信息；

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备在 M 个天线端口中选择轮询第一码本中的所有码字使得平均信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第一方面，在第十种可能的实现方式中，所述第一准则为码本信息；

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备在 M 个天线端口中选择轮询第一码本中的所有码字使得其中最好的信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第一方面，在第十一种可能的实现方式中，所述第一准则为数据包信息；

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备在 M 个天线端口中选择传输第一数据包传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在 M 个天线端口中选择传输第一数据包最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在 M 个天线端口中选择传输第一数据包达到一定性能要求的最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第一方面或第一方面的第一种可能的实现方式或第一方面的第二种可能的实现方式或第一方面的第三种可能的实现方式或第一方面的第四种可能的实现方式或第一方面的第五种可能的实现方式或第一方面的第六种可能的实现方式或第一方面的第七种可能的实现方式或第一方面的第八种可能的

实现方式或第一方面的第九种可能的实现方式或第一方面的第十种可能的实现方式或第一方面的第十一种可能的实现方式，在第十二种可能的实现方式中，所述第一准则或者所述第一阈值，第二阈值，第三阈值和第四阈值为所述第二网络设备通过广播信息，高层信令或者动态信令配置的。

结合第一方面或第一方面的第一种可能的实现方式或第一方面的第二种可能的实现方式或第一方面的第三种可能的实现方式或第一方面的第四种可能的实现方式或第一方面的第五种可能的实现方式或第一方面的第六种可能的实现方式或第一方面的第七种可能的实现方式或第一方面的第八种可能的实现方式或第一方面的第九种可能的实现方式或第一方面的第十种可能的实现方式或第一方面的第十一种可能的实现方式或第一方面的第十二种可能的实现方式，在第十三种可能的实现方式中，所述 M 个天线端口对应于 X 个信道状态信息处理进程 CSI process，N 个天线端口对应于所述 X 个 CSI process 中的一个 CSI process，其中，X 为正整数。

结合第一方面或第一方面的第一种可能的实现方式或第一方面的第二种可能的实现方式或第一方面的第三种可能的实现方式或第一方面的第四种可能的实现方式或第一方面的第五种可能的实现方式或第一方面的第六种可能的实现方式或第一方面的第七种可能的实现方式或第一方面的第八种可能的实现方式或第一方面的第九种可能的实现方式或第一方面的第十种可能的实现方式或第一方面的第十一种可能的实现方式或第一方面的第十二种可能的实现方式或第一方面的第十三种可能的实现方式，在第十四种可能的实现方式中，所述第一信息包括天线相关信息，或者所述 N 个天线端口对应的信道状态信息 CSI，或者所述 N 个天线端口的索引信息。

第二方面，提供了一种信号发送方法，包括:

第二网络设备向第一网络设备发送 M 个天线端口的信号，其中，M 为正整数;

所述第二网络设备接收所述第一网络设备根据第一准则反馈的所述 M 个天线端口中的 N 个天线端口的第一信息，N 为小于等于 M 的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少

一种。

在第一种可能的实现方式中，所述第一信息包括天线相关信息；

所述方法，还包括：

所述第二网络设备根据所述天线相关信息确定所述 N 个天线端口为所选择的天线端口。

结合第二方面，在第二种可能的实现方式中，所述第一信息包括所述 N 个天线端口对应的信道状态信息 CSI，或者所述 N 个天线端口的索引信息。

结合第二方面或第二方面的第一种可能的实现方式或第二方面的第二种可能的实现方式，在第三种可能的实现方式中，所述第二网络设备通过广播信息、高层信令或动态信令配置所述第一准则，第一阈值，第二阈值，第三阈值或者第四阈值。

第三方面，提供了一种第一网络设备，包括：

接收单元，用于接收第二网络设备发送的 M 个天线端口的信号，其中，M 为正整数；

反馈单元，用于根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，N 为小于等于 M 的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种。

在第一种可能的实现方式中，所述第一准则为天线相关信息；

所述反馈单元具体用于：

根据测量的所述 M 个天线端口的天线相关信息，进行小区选择，其中 M 个天线端口对应至少两个小区或者两个传输节点，每个所述小区或传输节点对应至少两个天线端口。

结合第三方面的第一种可能的实现方式，在第二种可能的实现方式中，所述反馈单元执行所述根据测量的所述 M 个天线端口的天线相关信息，进行小区选择，的步骤，具体为：

所述第一网络设备根据测量的所述 M 个天线端口的天线相关信息与第一阈值的比较结果，选择所述 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第三方面，在第三种可能的实现方式中，所述第一准则为信噪比 SNR;

所述反馈单元具体用于:

在 M 个天线端口中选择使得波束赋型或者发射分集后的 SNR 小于等于或大于等于第二阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第三方面，在第四种可能的实现方式中，第一准则为信道容量;

所述反馈单元具体用于:

在 M 个天线端口中选择使得信道容量小于等于或大于等于第三阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第三方面，在第五种可能的实现方式中，第一准则为吞吐量;

所述反馈单元具体用于:

在 M 个天线端口中选择使得吞吐量小于等于或大于等于第四阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第三方面，在第六种可能的实现方式中，第一准则为 SU/MU 传输方式;

所述反馈单元具体用于:

在 M 个天线端口中选择 SU 传输最优的第一组天线端口，所述的第一组天线端口包含 N1 个天线端口，得到所述 N1 个天线端口的第一信息并进行反馈; 和/或

在 M 个天线端口中选择 MU 传输最优的第二组天线端口，所述的第二组天线端口包含 N2 个天线端口，得到所述 N2 个天线端口的第一信息并进行反馈。

结合第三方面，在第七种可能的实现方式中，第一准则为传输模式;

所述反馈单元具体用于:

在 M 个天线端口中选择传输模式是发射分集传输的最优的第一组天线端口，所述的第一组天线端口包含 N1 个天线端口，得到所述 N1 个天线端口的第一信息并进行反馈; 和/或

在 M 个天线端口中选择传输模式是波束赋型传输的最优的第二组天线端

口，所述的第一组天线端口包含 N2 个天线端口，得到所述 N2 个天线端口的第一信息并进行反馈；和/或

在 M 个天线端口中选择传输模式是空间复用传输的最优的第三组天线端口，所述的第三组天线端口包含 N3 个天线端口，得到所述 N3 个天线端口的第一信息并进行反馈。

结合第三方面，在第八种可能的实现方式中，所述第一准则为码本信息；

所述反馈单元具体用于：

在 M 个天线端口中选择采用其对应的第一码本信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第三方面，在第九种可能的实现方式中，所述第一准则为码本信息；

所述反馈单元具体用于：

在 M 个天线端口中选择轮询第一码本中的所有码字使得平均信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第三方面，在第十种可能的实现方式中，所述第一准则为码本信息；

所述反馈单元具体用于：

在 M 个天线端口中选择轮询第一码本中的所有码字使得其中最好的信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第三方面，在第十一种可能的实现方式中，所述第一准则为数据包信息；

所述反馈单元具体用于：

在 M 个天线端口中选择传输第一数据包传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈；和/或

在 M 个天线端口中选择传输第一数据包最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在 M 个天线端口中选择传输第一数据包达到一定性能要求的最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第三方面或第三方面的第一种可能的实现方式或第三方面的第二种可能的实现方式或第三方面的第三种可能的实现方式或第三方面的第四种可能的实现方式或第三方面的第五种可能的实现方式或第三方面的第六种可能

的实现方式或第三方面的第七种可能的实现方式或第三方面的第八种可能的实现方式或第三方面的第九种可能的实现方式或第三方面的第十种可能的实现方式或第三方面的第十一种可能的实现方式，在第十二种可能的实现方式中，所述第一准则或者所述第一阈值，第二阈值，第三阈值和第四阈值为所述第二网络设备通过广播信息，高层信令或者动态信令配置的。

结合第三方面或第三方面的第一种可能的实现方式或第三方面的第二种可能的实现方式或第三方面的第三种可能的实现方式或第三方面的第四种可能的实现方式或第三方面的第五种可能的实现方式或第三方面的第六种可能的实现方式或第三方面的第七种可能的实现方式或第三方面的第八种可能的实现方式或第三方面的第九种可能的实现方式或第三方面的第十种可能的实现方式或第三方面的第十一种可能的实现方式或第三方面的第十二种可能的实现方式，在第十三种可能的实现方式中，所述 M 个天线端口对应于 X 个信道状态信息处理进程 CSI process，N 个天线端口对应于所述 X 个 CSI process 中的一个 CSI process，其中，X 为正整数。

结合第三方面或第三方面的第一种可能的实现方式或第三方面的第二种可能的实现方式或第三方面的第三种可能的实现方式或第三方面的第四种可能的实现方式或第三方面的第五种可能的实现方式或第三方面的第六种可能的实现方式或第三方面的第七种可能的实现方式或第三方面的第八种可能的实现方式或第三方面的第九种可能的实现方式或第三方面的第十种可能的实现方式或第三方面的第十一种可能的实现方式或第三方面的第十二种可能的实现方式或第三方面的第十三种可能的实现方式，在第十四种可能的实现方式中，所述第一信息包括天线相关信息，或者所述 N 个天线端口对应的信道状态信息 CSI，或者所述 N 个天线端口的索引信息。

第四方面，提供了一种第二网络设备，包括:

发送单元，用于向第一网络设备发送 M 个天线端口的信号，其中，M 为正整数;

接收单元，用于接收所述第一网络设备根据第一准则反馈的所述 M 个天线端口中的 N 个天线端口的第一信息，N 为小于等于 M 的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU

（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种。

在第一种可能的实现方式中，所述第一信息包括天线相关信息；

所述第二网络设备，还包括：

确定单元，用于根据所述天线相关信息确定所述 N 个天线端口为所选择的天线端口。

结合第四方面，在第二种可能的实现方式中，所述第一信息包括所述 N 个天线端口对应的信道状态信息 CSI，或者所述 N 个天线端口的索引信息。

结合第四方面或第四方面的第一种可能的实现方式或第四方面的第二种可能的实现方式，在第五种可能的实现方式中，所述发送单元还用于通过广播信息、高层信令或动态信令配置所述第一准则，第一阈值，第二阈值，第三阈值或者第四阈值。

第五方面，提供了一种第一网络设备，包括：接收器和发送器；

接收器，用于接收第二网络设备发送的 M 个天线端口的信号，其中，M 为正整数；

发送器，用于根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，N 为小于等于 M 的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种。

在第一种可能的实现方式中，所述第一准则为天线相关信息；

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息的步骤，具体为：

根据测量的所述 M 个天线端口的天线相关信息，进行小区选择，其中 M 个天线端口对应至少两个小区或者两个传输节点，每个所述小区或传输节点对应至少两个天线端口。

结合第五方面的第一种可能的实现方式，在第二种可能的实现方式中，所述发送器执行所述根据测量的所述 M 个天线端口的天线相关信息，进行小区选择的步骤，具体为：

所述第一网络设备根据测量的所述 M 个天线端口的天线相关信息与第一

阈值的比较结果，选择所述 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第五方面，在第三种可能的实现方式中，所述第一准则为信噪比 SNR;

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息的步骤，具体为:

在 M 个天线端口中选择使得波束赋型或者发射分集后的 SNR 小于等于或大于等于第二阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第五方面，在第四种可能的实现方式中，第一准则为信道容量;

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息的步骤，具体为:

在 M 个天线端口中选择使得信道容量小于等于或大于等于第三阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第五方面，在第五种可能的实现方式中，第一准则为吞吐量;

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息的步骤，具体为:

所述第一网络设备在 M 个天线端口中选择使得吞吐量小于等于或大于等于第四阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第五方面，在第六种可能的实现方式中，第一准则为 SU/MU 传输方式;

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息的步骤，具体为:

在 M 个天线端口中选择 SU 传输最优的第一组天线端口，所述的第一组天线端口包含 N1 个天线端口，得到所述 N1 个天线端口的第一信息并进行反馈; 和/或

在 M 个天线端口中选择 MU 传输最优的第二组天线端口，所述的第二组天线端口包含 N2 个天线端口，得到所述 N2 个天线端口的第一信息并进行反馈。

结合第五方面，在第七种可能的实现方式中，第一准则为传输模式;

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息的步骤，具体为:

在 M 个天线端口中选择传输模式是发射分集传输的最优的第一组天线端口，所述的第一组天线端口包含 N1 个天线端口，得到所述 N1 个天线端口的第一信息并进行反馈; 和/或

在 M 个天线端口中选择传输模式是波束赋型传输的最优的第二组天线端口，所述的第一组天线端口包含 N2 个天线端口，得到所述 N2 个天线端口的第一信息并进行反馈; 和/或

在 M 个天线端口中选择传输模式是空间复用传输的最优的第三组天线端口，所述的第三组天线端口包含 N3 个天线端口，得到所述 N3 个天线端口的第一信息并进行反馈。

结合第五方面，在第八种可能的实现方式中，所述第一准则为码本信息;

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息的步骤，具体为:

在 M 个天线端口中选择采用其对应的第一码本信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第五方面，在第九种可能的实现方式中，所述第一准则为码本信息;

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息的步骤，具体为:

在 M 个天线端口中选择轮询第一码本中的所有码字使得平均信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第五方面，在第十种可能的实现方式中，所述第一准则为码本信息;

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息的步骤，具体为:

在 M 个天线端口中选择轮询第一码本中的所有码字使得其中最好的信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第五方面，在第十一种可能的实现方式中，所述第一准则为数据包信息;

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息的步骤，具体为：

在 M 个天线端口中选择传输第一数据包传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈；和/或

在 M 个天线端口中选择传输第一数据包最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈；和/或

在 M 个天线端口中选择传输第一数据包达到一定性能要求的最少的 N 个天线端口，例如一定误码率的最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第五方面或第五方面的第一种可能的实现方式或第五方面的第二种可能的实现方式或第五方面的第三种可能的实现方式或第五方面的第四种可能的实现方式或第五方面的第五种可能的实现方式或第五方面的第六种可能的实现方式或第五方面的第七种可能的实现方式或第五方面的第八种可能的实现方式或第五方面的第九种可能的实现方式或第五方面的第十种可能的实现方式或第五方面的第十一种可能的实现方式，在第十二种可能的实现方式中，所述第一准则或者所述第一阈值，第二阈值，第三阈值和第四阈值为所述第二网络设备通过广播信息，高层信令或者动态信令配置的。

结合第五方面或第五方面的第一种可能的实现方式或第五方面的第二种可能的实现方式或第五方面的第三种可能的实现方式或第五方面的第四种可能的实现方式或第五方面的第五种可能的实现方式或第五方面的第六种可能的实现方式或第五方面的第七种可能的实现方式或第五方面的第八种可能的实现方式或第五方面的第九种可能的实现方式或第五方面的第十种可能的实现方式或第五方面的第十一种可能的实现方式或第五方面的第十二种可能的实现方式，在第十三种可能的实现方式中，所述 M 个天线端口对应于 X 个信道状态信息处理进程 CSI process，N 个天线端口对应于所述 X 个 CSI process 中的一个 CSI process，其中，X 为正整数。

结合第五方面或第五方面的第一种可能的实现方式或第五方面的第二种可能的实现方式或第五方面的第三种可能的实现方式或第五方面的第四种可能的实现方式或第五方面的第五种可能的实现方式或第五方面的第六种可能的实现方式或第五方面的第七种可能的实现方式或第五方面的第八种可能的

实现方式或第五方面的第九种可能的实现方式或第五方面的第十种可能的实现方式或第五方面的第十一种可能的实现方式或第五方面的第十二种可能的实现方式或第五方面的第十三种可能的实现方式，在第十四种可能的实现方式中，所述第一信息包括天线相关信息，或者所述 N 个天线端口对应的信道状态信息 CSI，或者所述 N 个天线端口的索引信息。

第六方面，提供了一种第二网络设备，包括：发送器和接收器；

发送器，用于向第一网络设备发送 M 个天线端口的信号，其中，M 为正整数；

接收器，用于接收所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，N 为小于等于 M 的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种。

在第一种可能的实现方式中，所述第一信息包括天线相关信息；

所述第二网络设备，还包括：控制器；

控制器，用于根据所述天线相关信息确定所述 N 个天线端口为所选择的天线端口。

结合第六方面，在第二种可能的实现方式中，所述第一信息包括所述 N 个天线端口对应的信道状态信息 CSI，或者所述 N 个天线端口的索引信息。

结合第六方面或第六方面的第一种可能的实现方式或第六方面的第二种可能的实现方式，在第三种可能的实现方式中，所述发送器还用于通过广播信息、高层信令或动态信令配置所述第一准则，第一阈值，第二阈值，第三阈值或者第四阈值。

可见，根据本发明实施例提供的一种信号发送方法及相关设备，通过根据天线相关信息、SNR、信道容量、吞吐量、单用户/多用户传输方式、传输模式、码本信息或数据包大小中的至少一种进行最优天线配置，进行了更有效的天线选择。

附图说明

为了更清楚地说明本发明实施例或现有技术中的技术方案，下面将对实施例中所需要使用的附图作简单地介绍，显而易见地，下面描述中的附图仅仅是本发明的一些实施例，对于本领域普通技术人员来讲，在不付出创造性劳动的前提下，还可以根据这些附图获得其他的附图。

图 1 为本发明实施例提供的一种信号发送方法的流程图；

图 2 为示例的有源天线阵列中的多个天线配置示意图；

图 3 为本发明实施例提供的另一种信号发送方法的流程图；

图 4 为本发明实施例提供的又一种信号发送方法的流程图；

图 5 为本发明实施例提供的一种第一网络设备的结构示意图；

图 6 为本发明实施例提供的一种第二网络设备的结构示意图；

图 7 为本发明实施例提供的另一种第二网络设备的结构示意图；

图 8 为本发明实施例提供的另一种第一网络设备的结构示意图；

图 9 为本发明实施例提供的又一种第二网络设备的结构示意图；

图 10 为本发明实施例提供的又一种第二网络设备的结构示意图。

具体实施方式

下面将结合本发明实施例中的附图，对本发明实施例中的技术方案进行清楚、完整地描述，显然，所描述的实施例仅仅是本发明一部分实施例，而不是全部的实施例。基于本发明中的实施例，本领域普通技术人员在没有作出创造性劳动前提下所获得的所有其他实施例，都属于本发明保护的范围。

请参阅图 1，为本发明实施例提供的一种信号发送方法的流程图，该方法包括以下步骤：

步骤 S101，第一网络设备接收第二网络设备发送的 M 个天线端口的信号，其中，M 为正整数。

在进行天线配置时，第二网络设备给第一网络设备发送 M 个天线端口的配置信息，并将 M 个天线端口的信号发送给第一网络设备，第一网络设备根据配置信息接收第二网络设备发送的 M 个天线端口的信号，其中，M 为正整数，在本实施例中，第一网络设备可以是用户设备(User Equipment，UE)，第二网络设备可以是基站；或者第一网络设备可以是用户设备，第二网络设备可以是用户设备；或者第一网络设备可以是基站，第二网络设备可以是基站。

所述的基站可以是宏站，低功率节点 pico 或者射频拉远单元 RRH。

M 个天线端口的配置信息包括天线端口的图案，即天线端口的时频资源的位置、天线端口信号的发送周期、功率等信息。

第二网络设备可以只发送一个配置信息给第一网络设备，该配置信息是 M 个天线端口的配置信息，或者将 M 个天线端口分成多个组，以多个配置信息的形式发送给第一网络设备，每个配置信息对应其中一个天线端口组的配置。

步骤 S102，所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，N 为小于等于 M 的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种。

第一网络设备需根据一定的准则从 M 个天线端口中选择 N 个天线端口，并将选择的 N 个天线端口的第一信息通知第二网络设备，在这里，第一信息为 N 个天线端口对应的信道状态信息 CSI 或者 N 个天线端口对应的索引信息；或者将 N 个天线端口的第一信息发送给第二网络设备，由第二网络设备确定该 N 个天线端口，在这里，第一信息为天线相关信息。

下面通过具体的实施方式介绍如何根据各种第一准则反馈 M 个天线端口中的 N 个天线端口的第一信息：

作为一种实施方式，所述第一准则为天线相关信息；

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备根据测量的所述 M 个天线端口的天线相关信息，进行小区选择，其中 M 个天线端口对应至少两个小区或者两个传输节点，每个所述小区或传输节点对应至少两个天线端口。

现有技术中，进行小区选择仅考虑根据接收信号功率信息例如 RSRP，RSSI，RSRQ 进行选择，本实施例中，还考虑天线相关性进行小区选择，使得用户能根据自己的业务更全面的考虑小区或者传输节点的选择。

具体实现中，所述第一网络设备根据测量的所述 M 个天线端口的天线相关信息，进行小区选择，具体为：

例如 M=10，对应 5 个小区，每个小区有 2 个天线，小区 1 对应 port0，port1，

小区 1 对应 port2，port3，小区 1 对应 port4，port5，小区 1 对应 port6，port7，小区 1 对应 port8，port9;

UE 测量和这 5 个小区的分别对应的 5 组天线端口，发现小区 1 对应的 port0,1 的接收信号功率最强，例如 RSRP1>RSRP2>RSRP3>RSRP4>RSRP5，RSRP1 代表小区 1 对应的接收信号功率，RSRP2 代表小区 2 对应的接收信号功率，RSRPn 代表小区 n 对应的接收信号功率。但是如果假设第一准则是天线相关信息，并且要求天线相关信息越大越好，则定义天线相关系数为 Cor，例如，小区 1 的天线相关系数 Cor1 为 port0 和 port1 的天线相关性，可以采用信道估计获得 port0 对应的信道系数 H0，port1 对应的信道系数 H1，并计算 H0，H1 的相关来获得 Cor1，例如相关矩阵可以由 $H=[H_0 \quad H_1]$，$R=H^{H}H$ 获得；或者根据 $R_{ik}=\frac{1}{2\Delta}\int_{\theta-\Delta}^{\theta+\Delta}\exp[jz(i-k)\sin\beta]d\beta$ 获得。

其中 i，k 分别为第 i 和第 k 个天线，Δ为角度扩展。

同样方法得到 Cor2，Cor3，Cor4，Cor5，Corn 代表小区 n 对应的天线相关系数。

并且 Cor2> Cor1> Cor3> Cor4> Cor5，则虽然小区 1 的接收信号功率最强，但是综合考虑信号功率和天线相关性，小区 2 最终被 UE 选择，并且驻留在小区 2。

这里第一准则不限定于天线相关性，还可以是 SU/MU,信号传输模式等，并且第一准则可以为预定义的，或者基站广播或者 UE 特定的信令通知。

具体地，所述第一网络设备根据测量的所述 M 个天线端口的天线相关信息，进行小区选择，具体为：所述第一网络设备根据测量的所述 M 个天线端口的天线相关信息与第一阈值的比较结果，选择所述 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

即将 M 个天线端口的相关矩阵或相关系数与设定阈值进行比较，选择相关矩阵或相关系数大于等于或小于等于设定阈值的 N 个天线端口，得到 N 个天线端口对应的信道状态信息(Channel State Singal，CSI)或 N 个天线端口的索引信息，并将这 N 个天线端口对应的 CSI 或 N 个天线端口对应的索引信息通知第二网络设备，以使第二网络设备在该 N 个天线端口给第一网络设备发送数据。

作为另一种实施方式，所述第一准则为信噪比 SNR;

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为:

所述第一网络设备在 M 个天线端口中选择使得波束赋型或者发射分集后的 SNR 小于等于或大于等于第二阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

例如，基站配置给 UE M 个天线端口，如图 2 示例的另一个天线阵列中的多个天线示意图，M=88，UE 在 M 个端口中遍历所有的 N=1 到 N=88 的天线端口组合，对于每个 N 的取值，需要遍历的组合数为 c，例如对于 N=4，组合有组合 1 为 a11，a12，a13，a14，组合 2 为 a12，a13，a14， a15，组合 3 为，a13，a14，a15，a16，组合 4 为 a14，a15，a16，a17，组合 5 为 a15，a16，a17，a18，组合 6 为 b11，b12，b13，b14，...对于每个组合，例如组合 1 a11，a12，a13，a14，UE 通过 a11，a12，a13，a14 得到信道 $H_{N,1}$，然后遍历所有的预编码矩阵 w_i，得到信噪比:

$$SNR_{N,\ m,\ i}=\frac{\left|H_{n,m}W_i\right|^2}{\sigma^2}$$

其中 $H_{N,\ m}$ 表示 N 个天线端口组合情况下的第 m 个配置，Wi 表示第 i 个预编码矩阵，σ^2 为噪声;

遍历所有的 N 端口组合情况下的所有 SNR,找到最大的，例如 max（$SNR_{N,\ m,\ i}, N=4, 1\le m\le C_M^4, 1\le i\le X_4$）=5dB，$X_4$ 表示 N=4 的情况下的预编码矩阵的个数。对于 N=5，采用上述同样的方法进行遍历，max（$SNR_{N,\ m,\ i}, N=5, 1\le m\le C_M^5, 1\le i\le X_5$）=7dB，如果基站通知 UE 天线选择的第一准则为 SNR 要大于等于 6dB 的最少数目的天线，则 N=5 恰巧可以到 6dB，并且是达到 6dB 所需要的天线数目最少的，。因此 UE 可以将 N=5 的达到 7dB 的天线组合的标号，例如，a11，b12，c14，d11，对应的索引反馈给基站。采用 N>5,得到的信噪比会比 N=5 更高，但是对于某些信道，只需达到一定的 SNR 性能要求即可，无需更大的 SNR，采用更多的天线，会导致基站浪费发射功率。

作为又一种实施方式，第一准则为信道容量;

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备在 M 个天线端口中选择使得信道容量小于等于或大于等于第三阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

由于信道容量 C=Blog2(1+SNR)，本实施方式中，根据信道容量进行天线端口的选择的过程与上面实施方式中根据 SNR 进行天线端口的选择的过程类似，在此不再赘述。

作为又一种实施方式，第一准则为吞吐量；

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备在 M 个天线端口中选择使得吞吐量小于等于或大于等于第四阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

同样地，本实施方式中，根据吞吐量进行天线端口的选择的过程与上面实施方式中根据 SNR 或信道容量进行天线端口的选择的过程类似，在此不再赘述。

作为又一种实施方式，第一准则为 SU/MU 传输方式；

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备在 M 个天线端口中选择 SU 传输最优的第一组天线端口，所述的第一组天线端口包含 N1 个天线端口，得到所述 N1 个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在 M 个天线端口中选择 MU 传输最优的第二组天线端口，所述的第二组天线端口包含 N2 个天线端口，得到所述 N2 个天线端口的第一信息并进行反馈。

在本实施方式中，例如，基站配置 UE 按照 SU 传输最优的方式选择天线，则 UE 遍历所有天线，根据使得 UE 自己的性能达到最优的方式选择天线，例

如选择了天线 a11，b13，g15，h18，则将 a11，b13，g15，h18 的天线索引信息上报给基站。

又例如，基站配置 UE1 按照 MU 配对最优的方式选择天线，基站可以将配对用户的信息，例如与 UE1 配对的用户 UE2，UE3 的信息，包括 UE2 的，UE3 的天线信息通知给 UE1，UE1 根据使得配对后的所有用户的总的性能最优的方式选择天线，例如选择天线 c13，d12，e11，f18，将其对应的天线索引信息通知给基站。

也可以同时反馈根据 SU 传输最优的一组天线端口的信息和根据 MU 传输最优的一组天线端口的信息。例如 SU 可以选择交叉极化的天线，天线的相关性小，有利于空间复用；而 MU 配对时，每个用户最好选择同极化的天线，有利用每个用户的波束赋型。其中所述的 SU 为用户单独在一个时频资源上发送自己的数据包，MU 为多个用户可以在相同的时频资源上通过空间复用的方式进行发送各自的数据包。

作为又一种实施方式，第一准则为传输模式；

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备在 M 个天线端口中选择传输模式是发射分集传输的最优的第一组天线端口，所述的第一组天线端口包含 N1 个天线端口，得到所述 N1 个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在 M 个天线端口中选择传输模式是波束赋型传输的最优的第二组天线端口，所述的第一组天线端口包含 N2 个天线端口，得到所述 N2 个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在 M 个天线端口中选择传输模式是空间复用传输的最优的第三组天线端口，所述的第三组天线端口包含 N3 个天线端口，得到所述 N3 个天线端口的第一信息并进行反馈。

作为又一种实施方式，所述第一准则为码本信息；

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备在 M 个天线端口中选择采用其对应的第一码本信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

码本信息是指：包含多个预编码矩阵的信息；

作为又一种实施方式，所述第一准则为码本信息；

例如将M个天线端口分成X组，基站给每组天线端口单独配置一个码本集合。用户设备根据这个配置的码本集合计算SNR，并且反馈给基站设备。例如第一组天线端口对应于天线配置1，包括天线端口port0，port1，基站为天线配置1配置码本集合C1，C1包括的预编码矩阵为（W_{11}, W_{12}, W_{1n}, ...W_{1N}）,第二组天线端口对应与天线配置2，包括天线端口port2，port3，为天线配置2配置码本集合C2，C2包括的预编码矩阵为（W_{21}, W_{22}, W_{2n}, ...W_{2N}），第三组天线端口对应于天线配置3，包括天线端口port4，port5，为天线配置3配置码本集合C3，C3包括的预编码矩阵为（W_{31}, W_{32}, W_{3n}, ...W_{3N}），第四组天线端口对应于天线配置4，包括天线端口port6，port7，为天线配置4配置码本集合C4，C4包括的预编码矩阵为（W_{41}, W_{42}, W_{4n}, ...W_{4N}）。用户设备根据各个天线配置的对应的天线端口在其对应的码本集合Ci内反馈一个最优的秩(rank)，PMI（i）和SNR（i），基站比较各个SNR（i）选择一个最好的天线给用户设备进行配置；或者UE比较各个SNR（i），选择一个最好天线配置并将其对应的第一信息，反馈给基站，第一信息包括天线的索引和或CSI反馈给基站。例如，UE分别测量四组天线端口,得到第三组天线端口port4，port5，在C3包括的预编码矩阵为（W_{31}, W_{32}, W_{3n}, ...W_{3N}）内进行遍历，得到的最优的SNR高于其他三组天线端口，因此UE将第三组天线端口对应的索引反馈给基站。给每组天线端口配置一个码本集合，用户设备根据这个码本集合计算SNR,并且反馈给基站设备。例如给天线配置1配置码本集合C1，给天线配置2配置码本集合C2，给天线配置3配置码本集合C3，给天线配置4配置码本集合C4。用户设备在RRM测量时，根据各个天线配置的导频在其对应的码本集合Ci内，采用随机波束赋形(random beamforming)的方式，计算平均参考信号接收功率(Reference Signal Receiving Power，RSRP)，或者参考信号接收质量(Reference Signal Receiving Quality，RSRQ)进行上报，例如用户设备在天线配置1的导频，采用C1内所有的码本进行随机beamforming的方式，得到RSRP1，天线配置2的导频，采用C2内所有的

码本进行随机beamforming的方式，得到RSRP2，...UE将RSRP最大的天线配置对应的索引反馈给基站。

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备在 M 个天线端口中选择轮询第一码本中的所有码字使得平均信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

作为又一种实施方式，所述第一准则为码本信息；

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备在 M 个天线端口中选择轮询第一码本中的所有码字使得其中最好的信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

作为又一种实施方式，所述第一准则为数据包信息，所述的数据包信息包括传输块大小，调制编码方式；

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备在 M 个天线端口中选择传输第一数据包传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在 M 个天线端口中选择传输第一数据包最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在 M 个天线端口中选择传输第一数据包达到一定性能要求的最少的 N 个天线端口，例如一定误码率的最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

需要说明的是，在以上实施例中，第一准则，第一阈值，第二阈值，第三阈值和第四阈值为第二网络设备通过广播信息，高层信令或者动态信令配置

的。

M 个天线端口对应于 X 个信道状态信息处理进程(CSI process)，N 个端口对应于 X 个 CSI process 中的一个 CSI process，其中，X 为正整数。每个 CSI process 对应一定的测量资源，例如每个 CSI process 配置一个信号测量资源和干扰测量资源，UE 根据信号测量资源和干扰测量资源获得 CSI 进行上报。例如，M=20，对应 5 个 CSI process，则每 4 个天线端口对应 1 个 CSI process，N=4。

可见，根据本发明实施例提供的一种信号发送方法，通过根据天线相关信息、SNR、信道容量、吞吐量、单用户/多用户传输方式、传输模式、码本信息或数据包大小中的至少一种进行最优天线配置，进行了更有效的天线选择。

请参阅图3，为本发明实施例提供的另一种信号发送方法的流程图，该方法包括以下步骤:

步骤S201，第二网络设备向第一网络设备发送M个天线端口的信号，其中，M为正整数。

在进行天线配置时,第二网络设备给第一网络设备发送M个天线端口的配置信息，并将M个天线端口的信号发送给第一网络设备，第一网络设备根据配置信息接收第二网络设备发送的M个天线端口的信号，其中，M为正整数，在本实施例中，第一网络设备可以是用户设备(User Equipment，UE)，第二网络设备可以是基站; 或者第一网络设备可以是用户设备，第二网络设备可以是用户设备; 或者第一网络设备可以是基站，第二网络设备可以是基站。

所述的基站可以是宏站，低功率节点pico或者射频拉远单元RRH。

M个天线端口的配置信息包括天线端口的图案,即天线端口的时频资源的位置、天线端口信号的发送周期、功率等信息。

第二网络设备可以只发送一个配置信息给第一网络设备,该配置信息是M个天线端口的配置信息，或者将M个天线端口分成多个组，以多个配置信息的形式发送给第一网络设备，每个配置信息对应其中一个天线端口组的配置。

步骤S202，所述第二网络设备接收所述第一网络设备根据第一准则反馈的所述M个天线端口中的N个天线端口的第一信息，N为小于等于M的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单

用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种。

第一网络设备需根据一定的准则从M个天线端口中选择N个天线端口，并将选择的N个天线端口的第一信息通知第二网络设备，在这里，第一信息为N个天线端口对应的信道状态信息CSI或者N个天线端口对应的索引信息；或者将N个天线端口的第一信息发送给第二网络设备，由第二网络设备确定该N个天线端口，在这里，第一信息为天线相关信息。

第二网络设备通过广播信息、高层信令或动态信令配置第一准则，第一阈值，第二阈值，第三阈值或者第四阈值。

可见，根据本发明实施例提供的一种信号发送方法，第一网络设备通过根据天线相关信息、SNR、信道容量、吞吐量、单用户/多用户传输方式、传输模式、码本信息或数据包大小中的至少一种进行最优天线配置，将得到的天线相关信息，或者所述N个天线端口对应的信道状态信息CSI，或者所述N个天线端口的索引信息反馈给第二网络设备，使得第一网络设备进行了更有效的天线选择。

请参阅图4，为本发明实施例提供的又一种信号发送方法的流程图，该方法包括以下步骤：

步骤S301，第二网络设备向第一网络设备发送M个天线端口的信号，其中，M为正整数；

步骤S302，所述第二网络设备接收所述第一网络设备根据第一准则反馈的所述M个天线端口中的N个天线端口的第一信息，N为小于等于M的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种，所述第一信息包括天线相关信息。

步骤S301和步骤S302分别与前述实施例的步骤S201和步骤S202相同，具体地，这里的第一信息包括天线相关信息。

步骤S303，所述第二网络设备根据所述天线相关信息确定所述N个天线端口为所选择的天线端口。

第二网络设备根据天线相关信息确定N个天线端口为所选择的天线端口。

可见，根据本发明实施例提供的一种信号发送方法，第一网络设备通过根据天线相关信息、SNR、信道容量、吞吐量、单用户/多用户传输方式、传输模式、码本信息或数据包大小中的至少一种进行最优天线配置，将得到的天线相关信息反馈给第二网络设备，由第二网络设备确定选择的天线端口，使得第一网络设备进行了更有效的天线选择。

请参阅图5，为本发明实施例提供的一种第一网络设备的结构示意图，该第一网络设备1000包括:

接收单元11，用于接收第二网络设备发送的M个天线端口的信号，其中，M为正整数。

在进行天线配置时，第二网络设备给第一网络设备发送M个天线端口的配置信息，并将M个天线端口的信号发送给第一网络设备，第一网络设备根据配置信息接收第二网络设备发送的M个天线端口的信号，其中，M为正整数，在本实施例中，第一网络设备可以是用户设备(User Equipment，UE)，第二网络设备可以是基站；或者第一网络设备可以是用户设备，第二网络设备可以是用户设备；或者第一网络设备可以是基站，第二网络设备可以是基站。

所述的基站可以是宏站，低功率节点pico或者射频拉远单元RRH。

M个天线端口的配置信息包括天线端口的图案，即天线端口的时频资源的位置、天线端口信号的发送周期、功率等信息。

第二网络设备可以只发送一个配置信息给第一网络设备，该配置信息是M个天线端口的配置信息，或者将M个天线端口分成多个组，以多个配置信息的形式发送给第一网络设备，每个配置信息对应其中一个天线端口组的配置。

反馈单元12，用于根据第一准则反馈所述M个天线端口中的N个天线端口的第一信息，N为小于等于M的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种。

第一网络设备需根据一定的准则从M个天线端口中选择N个天线端口，并将选择的N个天线端口的第一信息通知第二网络设备，在这里，第一信息为N个天线端口对应的信道状态信息CSI或者N个天线端口对应的索引信息；或者将N个天线端口的第一信息发送给第二网络设备，由第二网络设备确定该N个

天线端口，在这里，第一信息为天线相关信息。

下面通过具体的实施方式介绍反馈单元12如何根据各种第一准则反馈M个天线端口中的N个天线端口的第一信息:

作为一种实施方式，所述第一准则为天线相关信息;

反馈单元12具体用于根据测量的所述M个天线端口的天线相关信息，进行小区选择，其中M个天线端口对应至少两个小区或者两个传输节点，每个所述小区或传输节点对应至少两个天线端口。

现有技术中，进行小区选择仅考虑根据接收信号功率信息例如RSRP，RSSI，RSRQ进行选择，本实施例中，还考虑天线相关性进行小区选择，使得用户能根据自己的业务更全面的考虑小区或者传输节点的选择。

具体实现中，所述第一网络设备根据测量的所述M个天线端口的天线相关信息，进行小区选择，具体为:

例如M=10，对应5个小区，每个小区有2个天线，小区1对应port0，port1，小区1对应port2，port3，小区1对应port4，port5，小区1对应port6，port7，小区1对应port8，port9;

UE测量和这5个小区的分别对应的5组天线端口，发现小区1对应的port0,1的接收信号功率最强，例如RSRP1>RSRP2>RSRP3>RSRP4>RSRP5，RSRP1代表小区1对应的接收信号功率，RSRP2代表小区2对应的接收信号功率，RSRPn代表小区n对应的接收信号功率。但是如果假设第一准则是天线相关信息，并且要求天线相关信息越大越好，则定义天线相关系数为Cor，例如，小区1的天线相关系数Cor1为port0和port1的天线相关性，可以采用信道估计获得port0对应的信道系数H0，port1对应的信道系数H1，并计算H0，H1的相关来获得Cor1，例如相关矩阵可以由 $H=[H_0 \quad H_1]$，$R=H^{H}H$ 获得。

或者根据 $R_{ik}=\frac{1}{2\Delta}\int_{\theta-\Delta}^{\theta+\Delta}\exp[jz(i-k)\sin\beta]d\beta$ 获得。

其中i，k分别为第i和第k个天线，Δ为角度扩展。

同样方法得到Cor2，Cor3，Cor4，Cor5，Corn代表小区n对应的天线相关系数。.

并且Cor2> Cor1> Cor3> Cor4> Cor5，则虽然小区1的接收信号功率最强，

但是综合考虑信号功率和天线相关性，小区2最终被UE选择，并且驻留在小区2。

这里第一准则不限定于天线相关性，还可以是SU/MU,信号传输模式等，并且第一准则可以为预定义的，或者基站广播或者UE特定的信令通知。

具体地,反馈单元12执行所述根据测量的所述M个天线端口的天线相关信息，进行小区选择的步骤，具体为：所述第一网络设备根据测量的所述M个天线端口的天线相关信息与第一阈值的比较结果，选择所述N个天线端口，得到所述N个天线端口的第一信息并进行反馈。

即将M个天线端口的相关矩阵或相关系数与设定阈值进行比较,选择相关矩阵或相关系数大于等于或小于等于设定阈值的N个天线端口，得到N个天线端口对应的信道状态信息(Channel State Singal，CSI)或N个天线端口的索引信息,并将这N个天线端口对应的CSI或N个天线端口对应的索引信息通知第二网络设备，以使第二网络设备在该N个天线端口给第一网络设备发送数据。

作为另一种实施方式，所述第一准则为信噪比SNR;

反馈单元12具体用于在M个天线端口中选择使得波束赋型或者发射分集后的SNR小于等于或大于等于第二阈值的天线端口组合中数目最少的N个天线端口，得到所述N个天线端口的第一信息并进行反馈。

例如，基站配置给UE M个天线端口，如图2示例的另一个天线阵列中的多个天线示意图，M=88，UE在M个端口中遍历所有的N=1到N=88的天线端口组合，对于每个N的取值，需要遍历的组合数为c，例如对于N=4，组合有组合1为a11，a12，a13，a14，组合2为a12，a13，a14， a15，组合3为，a13，a14，a15，a16，组合4为a14，a15，a16，a17，组合5为a15，a16，a17，a18，组合6为b11，b12，b13，b14，...对于每个组合，例如组合1 a11，a12，a13，a14，UE通过a11，a12，a13，a14得到信道$H_{N,1}$，然后遍历所有的预编码矩阵w_i，得到信噪比:

$$SNR_{N,\ m,\ i}=\frac{\left|H_{n,m}W_i\right|^2}{\sigma^2}$$

其中$H_{N,\ m}$表示N个天线端口组合情况下的第m个配置，Wi表示第i个预编码矩阵，σ^2为噪声;

遍历所有的N端口组合情况下的所有SNR,找到最大的，例如max（$SNR_{N,m,i}, N=4, 1\le m\le C_M^4, 1\le i\le X_4$）=5dB，$X_4$表示N=4的情况下的预编码矩阵的个数。对于N=5，采用上述同样的方法进行遍历，max（$SNR_{N,m,i}, N=5, 1\le m\le C_M^5, 1\le i\le X_5$）=7dB，如果基站通知UE天线选择的第一准则为SNR要大于等于6dB的最少数目的天线，则N=5恰巧可以到6dB，并且是达到6dB所需要的天线数目最少的，。因此UE可以将N=5的达到7dB的天线组合的标号，例如，a11，b12，c14，d11，对应的索引反馈给基站。采用N>5,得到的信噪比会比N=5更高，但是对于某些信道，只需达到一定的SNR性能要求即可，无需更大的SNR，采用更多的天线，会导致基站浪费发射功率。

作为又一种实施方式，第一准则为信道容量;

反馈单元12具体用于在M个天线端口中选择使得信道容量小于等于或大于等于第三阈值的天线端口组合中数目最少的N个天线端口，得到所述N个天线端口的第一信息并进行反馈。

由于信道容量C=Blog2(1+SNR)，本实施方式中，根据信道容量进行天线端口的选择的过程与上面实施方式中根据SNR进行天线端口的选择的过程类似，在此不再赘述。

作为又一种实施方式，第一准则为吞吐量;

反馈单元12具体用于在M个天线端口中选择使得吞吐量小于等于或大于等于第四阈值的天线端口组合中数目最少的N个天线端口，得到所述N个天线端口的第一信息并进行反馈。

同样地，本实施方式中，根据吞吐量进行天线端口的选择的过程与上面实施方式中根据SNR或信道容量进行天线端口的选择的过程类似，在此不再赘述。

作为又一种实施方式，第一准则为SU/MU传输方式;

反馈单元12具体用于在M个天线端口中选择SU传输最优的第一组天线端口，所述的第一组天线端口包含N1个天线端口，得到所述N1个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在M个天线端口中选择MU传输最优的第二组天线端口，所述的第二组天线端口包含N2个天线端口，得到所述N2个天线端口的第一信息并进行反馈。

在本实施方式中，例如，基站配置UE按照SU传输最优的方式选择天线，则UE遍历所有天线，根据使得UE自己的性能达到最优的方式选择天线，例如选择了天线a11，b13，g15，h18，则将a11，b13，g15，h18的天线索引信息上报给基站。

又例如，基站配置UE1按照MU配对最优的方式选择天线，基站可以将配对用户的信息，例如与UE1配对的用户UE2，UE3的信息，包括UE2的，UE3的天线信息通知给UE1，UE1根据使得配对后的所有用户的总的性能最优的方式选择天线，例如选择天线c13，d12，e11，f18，将其对应的天线索引信息通知给基站。

也可以同时反馈根据SU传输最优的一组天线端口的信息和根据MU传输最优的一组天线端口的信息。例如SU可以选择交叉极化的天线，天线的相关性小，有利于空间复用；而MU配对时，每个用户最好选择同极化的天线，有利用每个用户的波束赋型。其中所述的SU为用户单独在一个时频资源上发送自己的数据包，MU为多个用户可以在相同的时频资源上通过空间复用的方式进行发送各自的数据包。

作为又一种实施方式，第一准则为传输模式；

反馈单元12具体用于在M个天线端口中选择传输模式是发射分集传输的最优的第一组天线端口，所述的第一组天线端口包含N1个天线端口，得到所述N1个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在M个天线端口中选择传输模式是波束赋型传输的最优的第二组天线端口，所述的第一组天线端口包含N2个天线端口，得到所述N2个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在M个天线端口中选择传输模式是空间复用传输的最优的第三组天线端口，所述的第三组天线端口包含N3个天线端口，得到所述N3个天线端口的第一信息并进行反馈。

作为又一种实施方式，所述第一准则为码本信息；

反馈单元12具体用于在M个天线端口中选择采用第一码本信息传输性能最优的N个天线端口，得到所述N个天线端口的第一信息并进行反馈。

码本信息是指：包含多个预编码矩阵的信息；

作为又一种实施方式，所述第一准则为码本信息；

例如将M个天线端口分成X组，基站给每组天线端口单独配置一个码本集合。用户设备根据这个配置的码本集合计算SNR，并且反馈给基站设备。例如第一组天线端口对应于天线配置1，包括天线端口port0，port1，基站为天线配置1配置码本集合C1，C1包括的预编码矩阵为（W_{11}, W_{12}, W_{1n}, ...W_{1N}）,第二组天线端口对应与天线配置2，包括天线端口port2，port3，为天线配置2配置码本集合C2，C2包括的预编码矩阵为（W_{21}, W_{22}, W_{2n}, ...W_{2N}），第三组天线端口对应于天线配置3，包括天线端口port4，port5，为天线配置3配置码本集合C3，C3包括的预编码矩阵为（W_{31}, W_{32}, W_{3n}, ...W_{3N}），第四组天线端口对应于天线配置4，包括天线端口port6，port7，为天线配置4配置码本集合C4，C4包括的预编码矩阵为（W_{41}, W_{42}, W_{4n}, ...W_{4N}）。用户设备根据各个天线配置的对应的天线端口在其对应的码本集合Ci内反馈一个最优的秩(rank)，PMI（i）和SNR（i），基站比较各个SNR（i）选择一个最好的天线给用户设备进行配置；或者UE比较各个SNR（i），选择一个最好天线配置并将其对应的第一信息，反馈给基站，第一信息包括天线的索引和或CSI反馈给基站。例如，UE分别测量四组天线端口,得到第三组天线端口port4，port5，在C3包括的预编码矩阵为（W_{31}, W_{32}, W_{3n}, ...W_{3N}）内进行遍历，得到的最优的SNR高于其他三组天线端口，因此UE将第三组天线端口对应的索引反馈给基站。给每组天线端口配置一个码本集合，用户设备根据这个码本集合计算SNR,并且反馈给基站设备。例如给天线配置1配置码本集合C1，给天线配置2配置码本集合C2，给天线配置3配置码本集合C3，给天线配置4配置码本集合C4。用户设备在RRM测量时，根据各个天线配置的导频在其对应的码本集合Ci内，采用随机波束赋形(random beamforming)的方式，计算平均参考信号接收功率(Reference Signal Receiving Power，RSRP)，或者参考信号接收质量(Reference Signal Receiving Quality，RSRQ)进行上报，例如用户设备在天线配置1的导频，采用C1内所有的码本进

行随机beamforming的方式，得到RSRP1，天线配置2的导频，采用C2内所有的码本进行随机beamforming的方式，得到RSRP2，...UE将RSRP最大的天线配置对应的索引反馈给基站。

反馈单元12具体用于在M个天线端口中选择轮询第一码本中的所有码字使得平均信息传输性能最优的N个天线端口，得到所述N个天线端口的第一信息并进行反馈。

作为又一种实施方式，所述第一准则为码本信息;

反馈单元12具体用于在M个天线端口中选择轮询第一码本中的所有码字使

得其中最好的信息传输性能最优的N个天线端口，得到所述N个天线端口的第一信息并进行反馈。

作为又一种实施方式，所述第一准则为数据包信息，所述的数据包信息包括传输块大小，调制编码方式;

反馈单元12具体用于在M个天线端口中选择传输第一数据包传输性能最优的N个天线端口，得到所述N个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在M个天线端口中选择传输第一数据包最少的N个天线端口，得到所述N个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在M个天线端口中选择传输第一数据包达到一定性能要求的最少的N个天线端口，例如一定误码率的最少的N个天线端口，得到所述N个天线端口的第一信息并进行反馈。

需要说明的是，在以上实施例中，第一准则，第一阈值，第二阈值，第三阈值和第四阈值为第二网络设备通过广播信息，高层信令或者动态信令配置的。

M个天线端口对应于X个信道状态信息处理进程(CSI process)，N个端口对应于X个CSI process中的一个CSI process，其中，X为正整数。每个CSI process对应一定的测量资源，例如每个CSI process配置一个信号测量资源和干扰测量

资源，UE根据信号测量资源和干扰测量资源获得CSI进行上报。例如，M=20，对应5个CSI process，则每4个天线端口对应1个CSI process，N=4。

可见，根据本发明实施例提供的一种第一网络设备，通过根据天线相关信息、SNR、信道容量、吞吐量、单用户/多用户传输方式、传输模式、码本信息或数据包大小中的至少一种进行最优天线配置，进行了更有效的天线选择。

请参阅图6，为本发明实施例提供的一种第二网络设备的结构示意图，该第二网络设备2000包括:

发送单元21，用于向第一网络设备发送M个天线端口的信号，其中，M为正整数。

在进行天线配置时，发送单元21给第一网络设备发送M个天线端口的配置信息，并将M个天线端口的信号发送给第一网络设备，第一网络设备根据配置信息接收发送单元21发送的M个天线端口的信号，其中，M为正整数，在本实施例中，第一网络设备可以是用户设备(User Equipment，UE)，第二网络设备可以是基站；或者第一网络设备可以是用户设备，第二网络设备可以是用户设备；或者第一网络设备可以是基站，第二网络设备可以是基站。

所述的基站可以是宏站，低功率节点pico或者射频拉远单元RRH。

M个天线端口的配置信息包括天线端口的图案，即天线端口的时频资源的位置、天线端口信号的发送周期、功率等信息。

第二网络设备可以只发送一个配置信息给第一网络设备，该配置信息是M个天线端口的配置信息，或者将M个天线端口分成多个组，以多个配置信息的形式发送给第一网络设备，每个配置信息对应其中一个天线端口组的配置。

接收单元22，用于接收所述第一网络设备根据第一准则反馈的所述M个天线端口中的N个天线端口的第一信息，N为小于等于M的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种。

第一网络设备需根据一定的准则从M个天线端口中选择N个天线端口，并将选择的N个天线端口的第一信息通知第二网络设备的接收单元22，在这里，第一信息为N个天线端口对应的信道状态信息CSI或者N个天线端口对应的索

引信息；或者将N个天线端口的第一信息发送给第二网络设备，由第二网络设备确定该N个天线端口，在这里，第一信息为天线相关信息。

第二网络设备通过广播信息、高层信令或动态信令配置所述第一准则，第一阈值，第二阈值，第三阈值或者第四阈值。

可见，根据本发明实施例提供的一种第二网络设备，第一网络设备通过根据天线相关信息、SNR、信道容量、吞吐量、单用户/多用户传输方式、传输模式、码本信息或数据包大小中的至少一种进行最优天线配置，将得到的天线相关信息，或者所述N个天线端口对应的信道状态信息CSI，或者所述N个天线端口的索引信息反馈给第二网络设备，使得第一网络设备进行了更有效的天线选择。

请参阅图7，为本发明实施例提供的另一种第二网络设备的结构示意图，该第二网络设备3000包括：

发送单元31，用于向第一网络设备发送M个天线端口的信号，其中，M为正整数；

接收单元32，用于接收所述第一网络设备根据第一准则反馈的所述M个天线端口中的N个天线端口的第一信息，N为小于等于M的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种，所述第一信息包括天线相关信息。

发送单元31和接收单元32的功能分别与前述实施例的发送单元21和接收单元22相同，具体地，这里的第一信息包括天线相关信息。

确定单元33，用于根据所述天线相关信息确定所述N个天线端口为所选择的天线端口。

确定单元33根据天线相关信息确定N个天线端口为所选择的天线端口。

可见，根据本发明实施例提供的一种第二网络设备，第一网络设备通过根据天线相关信息、SNR、信道容量、吞吐量、单用户/多用户传输方式、传输模式、码本信息或数据包大小中的至少一种进行最优天线配置，将得到的天线相关信息反馈给第二网络设备，由第二网络设备确定选择的天线端口，使得第一网络设备进行了更有效的天线选择。

请参阅图8，为本发明实施例提供的另一种第一网络设备的结构示意图，该第一网络设备4000包括：接收器41和发送器42。

接收器41，用于接收第二网络设备发送的M个天线端口的信号，其中，M为正整数；

发送器42，用于根据第一准则反馈所述M个天线端口中的N个天线端口的第一信息，N为小于等于M的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种。

在一种实施方式中，所述第一准则为天线相关信息；

所述发送器42执行所述根据第一准则反馈所述M个天线端口中的N个天线端口的第一信息的步骤，具体为：

根据测量的所述M个天线端口的天线相关信息，进行小区选择，其中M个天线端口对应至少两个小区或者两个传输节点，每个所述小区或传输节点对应至少两个天线端口。

在另一种实施方式中，所述发送器42执行所述根据测量的所述M个天线端口的天线相关信息，进行小区选择的步骤，具体为：

所述第一网络设备根据测量的所述M个天线端口的天线相关信息与第一阈值的比较结果，选择所述N个天线端口，得到所述N个天线端口的第一信息并进行反馈。

在又一种实施方式中，所述第一准则为信噪比SNR；

所述发送器42执行所述根据第一准则反馈所述M个天线端口中的N个天线端口的第一信息的步骤，具体为：

在M个天线端口中选择使得波束赋型或者发射分集后的SNR小于等于或大于等于第二阈值的天线端口组合中数目最少的N个天线端口，得到所述N个天线端口的第一信息并进行反馈。

在又一种实施方式中，第一准则为信道容量；

所述发送器42执行所述根据第一准则反馈所述M个天线端口中的N个天线端口的第一信息的步骤，具体为：

在M个天线端口中选择使得信道容量小于等于或大于等于第三阈值的天线端口组合中数目最少的N个天线端口，得到所述N个天线端口的第一信息并

进行反馈。

在又一种实施方式中，第一准则为吞吐量;

所述发送器42执行所述根据第一准则反馈所述M个天线端口中的N个天线端口的第一信息的步骤，具体为:

所述第一网络设备在M个天线端口中选择使得吞吐量小于等于或大于等于第四阈值的天线端口组合中数目最少的N个天线端口，得到所述N个天线端口的第一信息并进行反馈。

在又一种实施方式中，第一准则为SU/MU传输方式;

所述发送器42执行所述根据第一准则反馈所述M个天线端口中的N个天线端口的第一信息的步骤，具体为:

在M个天线端口中选择SU传输最优的第一组天线端口，所述的第一组天线端口包含N1个天线端口，得到所述N1个天线端口的第一信息并进行反馈;和/或

在M个天线端口中选择MU传输最优的第二组天线端口，所述的第二组天线端口包含N2个天线端口，得到所述N2个天线端口的第一信息并进行反馈。

在又一种实施方式中，第一准则为传输模式;

所述发送器42执行所述根据第一准则反馈所述M个天线端口中的N个天线端口的第一信息的步骤，具体为:

在M个天线端口中选择传输模式是发射分集传输的最优的第一组天线端口，所述的第一组天线端口包含N1个天线端口，得到所述N1个天线端口的第一信息并进行反馈;和/或

在M个天线端口中选择传输模式是波束赋型传输的最优的第二组天线端口，所述的第一组天线端口包含N2个天线端口，得到所述N2个天线端口的第一信息并进行反馈;和/或

在M个天线端口中选择传输模式是空间复用传输的最优的第三组天线端口，所述的第三组天线端口包含N3个天线端口，得到所述N3个天线端口的第一信息并进行反馈。

在又一种实施方式中，所述第一准则为码本信息;

所述发送器42执行所述根据第一准则反馈所述M个天线端口中的N个天线端口的第一信息的步骤，具体为:

在M个天线端口中选择采用第一码本信息传输性能最优的N个天线端口，得到所述N个天线端口的第一信息并进行反馈。

在又一种实施方式中，所述第一准则为码本信息；

所述发送器42执行所述根据第一准则反馈所述M个天线端口中的N个天线端口的第一信息的步骤，具体为：

在M个天线端口中选择轮询第一码本中的所有码字使得平均信息传输性能最优的N个天线端口，得到所述N个天线端口的第一信息并进行反馈。

在又一种实施方式中，所述第一准则为码本信息；

所述发送器42执行所述根据第一准则反馈所述M个天线端口中的N个天线端口的第一信息的步骤，具体为：

在M个天线端口中选择轮询第一码本中的所有码字使得其中最好的信息传输性能最优的N个天线端口，得到所述N个天线端口的第一信息并进行反馈。

在又一种实施方式中，所述第一准则为数据包信息；

所述发送器42执行所述根据第一准则反馈所述M个天线端口中的N个天线端口的第一信息的步骤，具体为：

在M个天线端口中选择传输第一数据包传输性能最优的N个天线端口，得到所述N个天线端口的第一信息并进行反馈；和/或

在M个天线端口中选择传输第一数据包最少的N个天线端口，得到所述N个天线端口的第一信息并进行反馈。

在以上各实施例或实施方式中，所述第一准则，所述第一阈值，第二阈值，第三阈值或者第四阈值为所述第二网络设备通过广播信息，高层信令或者动态信令配置的。

在以上各实施例或实施方式中，所述M个天线端口对应于X个信道状态信息处理进程CSI process，N个天线端口对应于所述X个CSI process中的一个CSI process，其中，X为正整数。

在以上各实施例或实施方式中，所述第一信息包括天线相关信息，或者所述N个天线端口对应的信道状态信息CSI，或者所述N个天线端口的索引信息。

可见，根据本发明实施例提供的一种第一网络设备，通过根据天线相关信息、SNR、信道容量、吞吐量、单用户/多用户传输方式、传输模式、码本

信息或数据包大小中的至少一种进行最优天线配置，进行了更有效的天线选择。

请参阅图9，为本发明实施例提供的又一种第二网络设备的结构示意图，该第二网络设备5000包括：发送器和接收器；

发送器51，用于向第一网络设备发送M个天线端口的信号，其中，M为正整数。

接收器52，用于接收所述第一网络设备根据第一准则反馈所述M个天线端口中的N个天线端口的第一信息，N为小于等于M的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种。

其中，所述第一信息包括所述N个天线端口对应的信道状态信息CSI，或者所述N个天线端口的索引信息，或天线相关信息。

可见，根据本发明实施例提供的一种第二网络设备，第一网络设备通过根据天线相关信息、SNR、信道容量、吞吐量、单用户/多用户传输方式、传输模式、码本信息或数据包大小中的至少一种进行最优天线配置，将得到的天线相关信息，或者所述N个天线端口对应的信道状态信息CSI，或者所述N个天线端口的索引信息反馈给第二网络设备，使得第一网络设备进行了更有效的天线选择。

请参阅图10，为本发明实施例提供的又一种第二网络设备的结构示意图，该第二网络设备6000包括：发送器、接收器和控制器。

发送器61，用于向第一网络设备发送M个天线端口的信号，其中，M为正整数。

接收器62，用于接收所述第一网络设备根据第一准则反馈所述M个天线端口中的N个天线端口的第一信息，N为小于等于M的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种，述第一信息包括天线相关信息。

控制器63，用于根据所述天线相关信息确定所述N个天线端口为所选择的

天线端口。

可见，根据本发明实施例提供的一种第二网络设备，第一网络设备通过根据天线相关信息、SNR、信道容量、吞吐量、单用户/多用户传输方式、传输模式、码本信息或数据包大小中的至少一种进行最优天线配置，将得到的天线相关信息反馈给第二网络设备，由第二网络设备确定选择的天线端口，使得第一网络设备进行了更有效的天线选择。

需要说明的是，对于前述的各方法实施例，为了简单描述，故将其都表述为一系列的动作组合，但是本领域技术人员应该知悉，本发明并不受所描述的动作顺序的限制，因为根据本发明，某些步骤可以采用其他顺序或者同时进行。其次，本领域技术人员也应该知悉，说明书中所描述的实施例均属于优选实施例，所涉及的动作和模块并不一定是本发明所必须的。

在上述实施例中，对各个实施例的描述都各有侧重，某个实施例中没有详述的部分，可以参见其他实施例的相关描述。

通过以上的实施方式的描述，所属领域的技术人员可以清楚地了解到本发明可以用硬件实现，或固件实现，或它们的组合方式来实现。当使用软件实现时，可以将上述功能存储在计算机可读介质中或作为计算机可读介质上的一个或多个指令或代码进行传输。计算机可读介质包括计算机存储介质和通信介质，其中通信介质包括便于从一个地方向另一个地方传送计算机程序的任何介质。存储介质可以是计算机能够存取的任何可用介质。以此为例但不限于：计算机可读介质可以包括随机存取存储器(Random Access Memory，RAM)、只读存储器(Read-Only Memory，ROM)、电可擦可编程只读存储器(Electrically Erasable Programmable Read-Only Memory，EEPROM)、只读光盘(Compact Disc Read-Only Memory，CD-ROM)或其他光盘存储、磁盘存储介质或者其他磁存储设备、或者能够用于携带或存储具有指令或数据结构形式的期望的程序代码并能够由计算机存取的任何其他介质。此外。任何连接可以适当的成为计算机可读介质。例如，如果软件是使用同轴电缆、光纤光缆、双绞线、数字用户线（Digital Subscriber Line，DSL）或者诸如红外线、无线电和微波之类的无线技术从网站、服务器或者其他远程源传输的，那么同轴电缆、光纤光缆、双绞

线、DSL 或者诸如红外线、无线和微波之类的无线技术包括在所属介质的定影中。如本发明所使用的，盘（Disk）和碟（disc）包括压缩光碟（CD）、激光碟、光碟、数字通用光碟（DVD）、软盘和蓝光光碟，其中盘通常磁性的复制数据，而碟则用激光来光学的复制数据。上面的组合也应当包括在计算机可读介质的保护范围之内。

总之，以上所述仅为本发明技术方案的较佳实施例而已，并非用于限定本发明的保护范围。凡在本发明的精神和原则之内，所作的任何修改、等同替换、改进等，均应包含在本发明的保护范围之内。

权 利 要 求

1、一种信号发送方法，其特征在于，包括:

第一网络设备接收第二网络设备发送的 M 个天线端口的信号，其中，M 为正整数;

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，N 为小于等于 M 的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种。

2、根据权利要求 1 所述的方法，其特征在于，所述第一准则为天线相关信息;

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为:

所述第一网络设备根据测量的所述 M 个天线端口的天线相关信息，进行小区选择，其中 M 个天线端口对应至少两个小区或者两个传输节点，每个所述小区或传输节点对应至少两个天线端口。

3、根据权利要求 2 所述的方法，其特征在于，所述第一网络设备根据测量的所述 M 个天线端口的天线相关信息，进行小区选择，具体为:

所述第一网络设备根据测量的所述 M 个天线端口的天线相关信息与第一阈值的比较结果，选择所述 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

4、根据权利要求 1 所述的方法，其特征在于，所述第一准则为信噪比 SNR;

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为:

所述第一网络设备在 M 个天线端口中选择使得波束赋型或者发射分集后的 SNR 小于等于或大于等于第二阈值的天线端口组合中数目最少的 N 个天

线端口，得到所述 N 个天线端口的第一信息并进行反馈。

5、根据权利要求 1 所述的方法，其特征在于，第一准则为信道容量;

所述第一网络设备根据第一准则反馈所述M个天线端口中的N个天线端口的第一信息，具体为:

所述第一网络设备在 M 个天线端口中选择使得信道容量小于等于或大于等于第三阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

6、根据权利要求 1 所述的方法，其特征在于，第一准则为吞吐量;

所述第一网络设备根据第一准则反馈所述M个天线端口中的N个天线端口的第一信息，具体为:

所述第一网络设备在 M 个天线端口中选择使得吞吐量小于等于或大于等于第四阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

7、根据权利要求 1 所述的方法，其特征在于，第一准则为 SU/MU 传输方式;

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为:

所述第一网络设备在 M 个天线端口中选择 SU 传输最优的第一组天线端口，所述的第一组天线端口包含 N1 个天线端口，得到所述 N1 个天线端口的第一信息并进行反馈; 和/或

所述第一网络设备在M个天线端口中选择MU传输最优的第二组天线端口，所述的第二组天线端口包含 N2 个天线端口，得到所述 N2 个天线端口的第一信息并进行反馈。

8、根据权利要求 1 所述的方法，其特征在于，第一准则为传输模式; 所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为:

所述第一网络设备在 M 个天线端口中选择传输模式是发射分集传输的最优的第一组天线端口，所述的第一组天线端口包含 N1 个天线端口，得到所述 N1 个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在 M 个天线端口中选择传输模式是波束赋型传输的最优的第二组天线端口，所述的第一组天线端口包含 N2 个天线端口，得到所述 N2 个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在 M 个天线端口中选择传输模式是空间复用传输的最优的第三组天线端口，所述的第三组天线端口包含 N3 个天线端口，得到所述 N3 个天线端口的第一信息并进行反馈。

9、根据权利要求 1 所述的方法，其特征在于，所述第一准则为码本信息；

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备在 M 个天线端口中选择采用其对应的第一码本信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

10、根据权利要求 1 所述的方法，其特征在于，所述第一准则为码本信息；

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备在 M 个天线端口中选择轮询第一码本中的所有码字使得平均信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

11、根据权利要求 1 所述的方法，其特征在于，所述第一准则为码本信息；

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备在 M 个天线端口中选择轮询第一码本中的所有码字使得其中最好的信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

12、根据权利要求 1 所述的方法，其特征在于，所述第一准则为数据包信息；

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备在 M 个天线端口中选择传输第一数据包传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在 M 个天线端口中选择传输第一数据包最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在 M 个天线端口中选择传输第一数据包达到一定性能要求的最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

13、根据权利要求 1~12 所述的方法，其特征在于，所述第一准则或者所述第一阈值，第二阈值，第三阈值和第四阈值为所述第二网络设备通过广播信息，高层信令或者动态信令配置的。

14、根据权利要求 1~13 所述的方法，其特征在于，所述 M 个天线端口对应于 X 个信道状态信息处理进程 CSI process，N 个天线端口对应于所述 X 个 CSI process 中的一个 CSI process，其中，X 为正整数。

15、根据权利要求 1~14 所述的方法，其特征在于，所述第一信息包括天线相关信息，或者所述 N 个天线端口对应的信道状态信息 CSI，或者所述 N 个天线端口的索引信息。

16、一种信号发送方法，其特征在于，包括：

第二网络设备向第一网络设备发送 M 个天线端口的信号，其中，M 为正整数；

所述第二网络设备接收所述第一网络设备根据第一准则反馈的所述 M 个天线端口中的 N 个天线端口的第一信息，N 为小于等于 M 的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用

户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种。

17、如权利要求 16 所述的方法，其特征在于，所述第一信息包括天线相关信息；

所述方法，还包括：

所述第二网络设备根据所述天线相关信息确定所述 N 个天线端口为所选择的天线端口。

18、如权利要求 16 所述的方法，其特征在于，所述第一信息包括所述 N 个天线端口对应的信道状态信息 CSI，或者所述 N 个天线端口的索引信息。

19、如权利要求 16-18 任意一项所述的方法，其特征在于，还包括：

所述第二网络设备通过广播信息、高层信令或动态信令配置所述第一准则，第一阈值，第二阈值，第三阈值或者第四阈值。

20、一种第一网络设备，其特征在于，包括：

接收单元，用于接收第二网络设备发送的 M 个天线端口的信号，其中，M 为正整数；

反馈单元，用于根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，N 为小于等于 M 的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种。

21、根据权利要求 20 所述的第一网络设备，其特征在于，所述第一准则为天线相关信息；

所述反馈单元具体用于：

根据测量的所述 M 个天线端口的天线相关信息，进行小区选择，其中 M 个天线端口对应至少两个小区或者两个传输节点，每个所述小区或传输节点对应至少两个天线端口。

22、根据权利要求 21 所述的第一网络设备，其特征在于，所述反馈单元执行所述根据测量的所述 M 个天线端口的天线相关信息，进行小区选择，的步骤，具体为：

所述第一网络设备根据测量的所述 M 个天线端口的天线相关信息与第一阈值的比较结果，选择所述 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

23、根据权利要求 20 所述的第一网络设备，其特征在于，所述第一准则为信噪比 SNR;

所述反馈单元具体用于：

在 M 个天线端口中选择使得波束赋型或者发射分集后的 SNR 小于等于或大于等于第二阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

24、根据权利要求 20 所述的第一网络设备，其特征在于，第一准则为信道容量;

所述反馈单元具体用于：

在 M 个天线端口中选择使得信道容量小于等于或大于等于第三阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

25、根据权利要求 20 所述的第一网络设备，其特征在于，第一准则为吞吐量;

所述反馈单元具体用于：

在 M 个天线端口中选择使得吞吐量小于等于或大于等于第四阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

26、根据权利要求 20 所述的第一网络设备，其特征在于，第一准则为 SU/MU 传输方式;

所述反馈单元具体用于:

在 M 个天线端口中选择 SU 传输最优的第一组天线端口，所述的第一组天线端口包含 N1 个天线端口，得到所述 N1 个天线端口的第一信息并进行反馈；和/或

在 M 个天线端口中选择 MU 传输最优的第二组天线端口，所述的第二组天线端口包含 N2 个天线端口，得到所述 N2 个天线端口的第一信息并进行反馈。

27、根据权利要求 20 所述的第一网络设备，其特征在于，第一准则为传输模式;

所述反馈单元具体用于:

在 M 个天线端口中选择传输模式是发射分集传输的最优的第一组天线端口，所述的第一组天线端口包含 N1 个天线端口，得到所述 N1 个天线端口的第一信息并进行反馈；和/或

在 M 个天线端口中选择传输模式是波束赋型传输的最优的第二组天线端口，所述的第一组天线端口包含 N2 个天线端口，得到所述 N2 个天线端口的第一信息并进行反馈；和/或

在 M 个天线端口中选择传输模式是空间复用传输的最优的第三组天线端口，所述的第三组天线端口包含 N3 个天线端口，得到所述 N3 个天线端口的第一信息并进行反馈。

28、根据权利要求 20 所述的第一网络设备，其特征在于，所述第一准则为码本信息;

所述反馈单元具体用于:

在 M 个天线端口中选择采用其对应的第一码本信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

29、根据权利要求 20 所述的第一网络设备，其特征在于，所述第一准则为码本信息;

所述反馈单元具体用于:

在 M 个天线端口中选择轮询第一码本中的所有码字使得平均信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

30、根据权利要求 20 所述的第一网络设备，其特征在于，所述第一准则为码本信息；

所述反馈单元具体用于：

在 M 个天线端口中选择轮询第一码本中的所有码字使得其中最好的信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

31、根据权利要求 20 所述的第一网络设备，其特征在于，所述第一准则为数据包信息；

所述反馈单元具体用于：

在M个天线端口中选择传输第一数据包传输性能最优的N个天线端口，得到所述 N 个天线端口的第一信息并进行反馈；和/或

在 M 个天线端口中选择传输第一数据包最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈；和/或

在 M 个天线端口中选择传输第一数据包达到一定性能要求的最少的 N 个天线端口，例如一定误码率的最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

32、根据权利要求 20-31 所述的第一网络设备，其特征在于，所述第一准则或者所述第一阈值，第二阈值，第三阈值和第四阈值为所述第二网络设备通过广播信息，高层信令或者动态信令配置的。

33、根据权利要求 20-32 所述的第一网络设备，其特征在于，所述 M 个天线端口对应于 X 个信道状态信息处理进程 CSI process，N 个天线端口对应于所述 X 个 CSI process 中的一个 CSI process，其中，X 为正整数。

34、根据权利要求 20-33 所述的方法，其特征在于，所述第一信息包括

天线相关信息，或者所述 N 个天线端口对应的信道状态信息 CSI，或者所述 N 个天线端口的索引信息。

35、一种第二网络设备，其特征在于，包括:

发送单元，用于向第一网络设备发送 M 个天线端口的信号，其中，M 为正整数;

接收单元，用于接收所述第一网络设备根据第一准则反馈的所述 M 个天线端口中的 N 个天线端口的第一信息，N 为小于等于 M 的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种。

36、如权利要求 35 所述的第二网络设备，其特征在于，所述第一信息包括天线相关信息;

所述第二网络设备，还包括:

确定单元，用于根据所述天线相关信息确定所述 N 个天线端口为所选择的天线端口。

37、如权利要求 35 所述的第二网络设备，其特征在于，所述第一信息包括所述 N 个天线端口对应的信道状态信息 CSI，或者所述 N 个天线端口的索引信息。

38、如权利要求 35-37 任意一项所述的第二网络设备，其特征在于，所述发送单元还用于通过广播信息、高层信令或动态信令配置所述第一准则，第一阈值，第二阈值，第三阈值和第四阈值。

39、一种第一网络设备，其特征在于，包括：接收器和发送器;

接收器，用于接收第二网络设备发送的 M 个天线端口的信号，其中，M 为正整数;

发送器，用于根据第一准则反馈所述 M 个天线端口中的 N 个天线端

口的第一信息，N 为小于等于 M 的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种。

40、根据权利要求 39 所述的第一网络设备，其特征在于，所述第一准则为天线相关信息；

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息的步骤，具体为：

根据测量的所述 M 个天线端口的天线相关信息，进行小区选择，其中 M 个天线端口对应至少两个小区或者两个传输节点，每个所述小区或传输节点对应至少两个天线端口。

41、根据权利要求 40 所述的第一网络设备，其特征在于，所述发送器执行所述根据测量的所述 M 个天线端口的天线相关信息，进行小区选择的步骤，具体为：

所述第一网络设备根据测量的所述 M 个天线端口的天线相关信息与第一阈值的比较结果，选择所述 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

42、根据权利要求 39 所述的第一网络设备，其特征在于，所述第一准则为信噪比 SNR；

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息的步骤，具体为：

在 M 个天线端口中选择使得波束赋型或者发射分集后的 SNR 小于等于或大于等于第二阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

43、根据权利要求 39 所述的第一网络设备，其特征在于，第一准则为信道容量；

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天

线端口的第一信息的步骤，具体为：

在 M 个天线端口中选择使得信道容量小于等于或大于等于第三阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

44、根据权利要求 39 所述的第一网络设备，其特征在于，第一准则为吞吐量；

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息的步骤，具体为：

所述第一网络设备在 M 个天线端口中选择使得吞吐量小于等于或大于等于第四阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

45、根据权利要求 39 所述的第一网络设备，其特征在于，第一准则为 SU/MU 传输方式；

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息的步骤，具体为：

在 M 个天线端口中选择 SU 传输最优的第一组天线端口，所述的第一组天线端口包含 N1 个天线端口，得到所述 N1 个天线端口的第一信息并进行反馈；和/或

在 M 个天线端口中选择 MU 传输最优的第二组天线端口，所述的第二组天线端口包含 N2 个天线端口，得到所述 N2 个天线端口的第一信息并进行反馈。

46、根据权利要求 39 所述的第一网络设备，其特征在于，第一准则为传输模式；

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息的步骤，具体为：

在 M 个天线端口中选择传输模式是发射分集传输的最优的第一组天线端口，所述的第一组天线端口包含 N1 个天线端口，得到所述 N1 个天线端

口的第一信息并进行反馈；和/或

在 M 个天线端口中选择传输模式是波束赋型传输的最优的第二组天线端口，所述的第一组天线端口包含 N2 个天线端口，得到所述 N2 个天线端口的第一信息并进行反馈；和/或

在 M 个天线端口中选择传输模式是空间复用传输的最优的第三组天线端口，所述的第三组天线端口包含 N3 个天线端口，得到所述 N3 个天线端口的第一信息并进行反馈。

47、根据权利要求 39 所述的第一网络设备，其特征在于，所述第一准则为码本信息；

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息的步骤，具体为：

在 M 个天线端口中选择采用其对应的第一码本信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

48、根据权利要求 39 所述的第一网络设备，其特征在于，所述第一准则为码本信息；

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息的步骤，具体为：

在 M 个天线端口中选择轮询第一码本中的所有码字使得平均信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

49、根据权利要求 39 所述的第一网络设备，其特征在于，所述第一准则为码本信息；

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息的步骤，具体为：

在 M 个天线端口中选择轮询第一码本中的所有码字使得其中最好的信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

50、根据权利要求 39 所述的第一网络设备，其特征在于，所述第一准则为数据包信息;

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息的步骤，具体为:

在M个天线端口中选择传输第一数据包传输性能最优的N个天线端口，得到所述 N 个天线端口的第一信息并进行反馈; 和/或

在 M 个天线端口中选择传输第一数据包最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈; 和/或

在 M 个天线端口中选择传输第一数据包达到一定性能要求的最少的 N 个天线端口，例如一定误码率的最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

51、根据权利要求 39-50 所述的第一网络设备，其特征在于，所述第一准则或者所述第一阈值，第二阈值，第三阈值和第四阈值为所述第二网络设备通过广播信息，高层信令或者动态信令配置的。

52、根据权利要求 39-51 所述的第一网络设备，其特征在于，所述 M 个天线端口对应于 X 个信道状态信息处理进程 CSI process，N 个天线端口对应于所述 X 个 CSI process 中的一个 CSI process，其中，X 为正整数。

53、根据权利要求 39-52 所述的第一网络设备，其特征在于，所述第一信息包括天线相关信息，或者所述 N 个天线端口对应的信道状态信息 CSI，或者所述 N 个天线端口的索引信息。

54、一种第二网络设备，其特征在于，包括: 发送器和接收器;

发送器，用于向第一网络设备发送 M 个天线端口的信号，其中，M 为正整数;

接收器，用于接收所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，N 为小于等于 M 的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU

（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种。

55、如权利要求 54 所述的第二网络设备，其特征在于，所述第一信息包括天线相关信息；

所述第二网络设备，还包括：控制器；

控制器，用于根据所述天线相关信息确定所述 N 个天线端口为所选择的天线端口。

56、如权利要求 54 所述的第二网络设备，其特征在于，所述第一信息包括所述 N 个天线端口对应的信道状态信息 CSI，或者所述 N 个天线端口的索引信息。

57、如权利要求 54-56 任意一项所述的第二网络设备，其特征在于，所述发送器还用于通过广播信息、高层信令或动态信令配置所述第一准则，第一阈值，第二阈值，第三阈值和第四阈值。

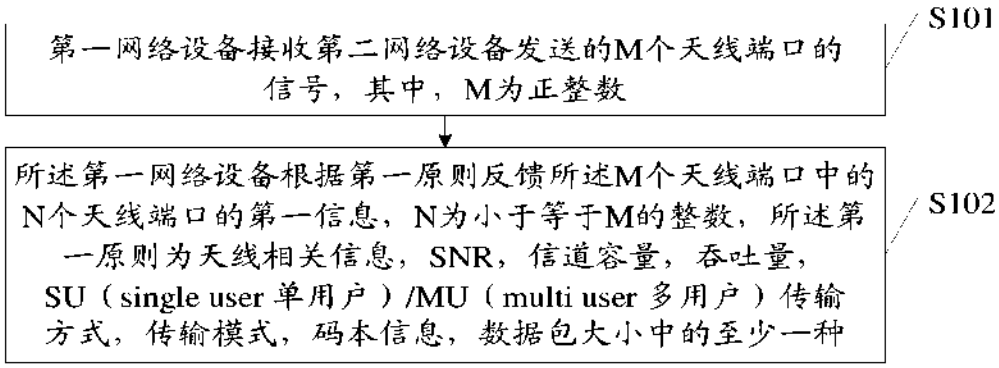

第一网络设备接收第二网络设备发送的M个天线端口的信号，其中，M为正整数
S101
所述第一网络设备根据第一原则反馈所述M个天线端口中的N个天线端口的第一信息，N为小于等于M的整数，所述第一原则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种
S102

图 1

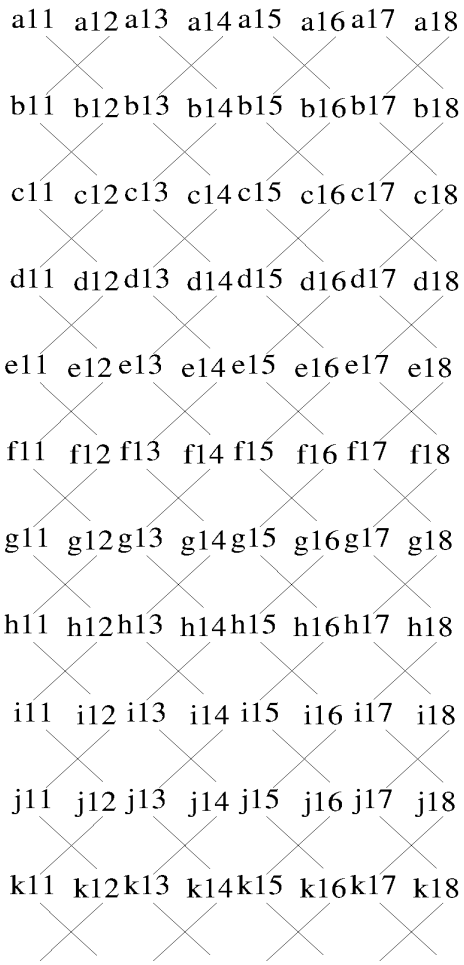

a11 a12 a13 a14 a15 a16 a17 a18
b11 b12 b13 b14 b15 b16 b17 b18
c11 c12 c13 c14 c15 c16 c17 c18
d11 d12 d13 d14 d15 d16 d17 d18
e11 e12 e13 e14 e15 e16 e17 e18
f11 f12 f13 f14 f15 f16 f17 f18
g11 g12 g13 g14 g15 g16 g17 g18
h11 h12 h13 h14 h15 h16 h17 h18
i11 i12 i13 i14 i15 i16 i17 i18
j11 j12 j13 j14 j15 j16 j17 j18
k11 k12 k13 k14 k15 k16 k17 k18

图 2

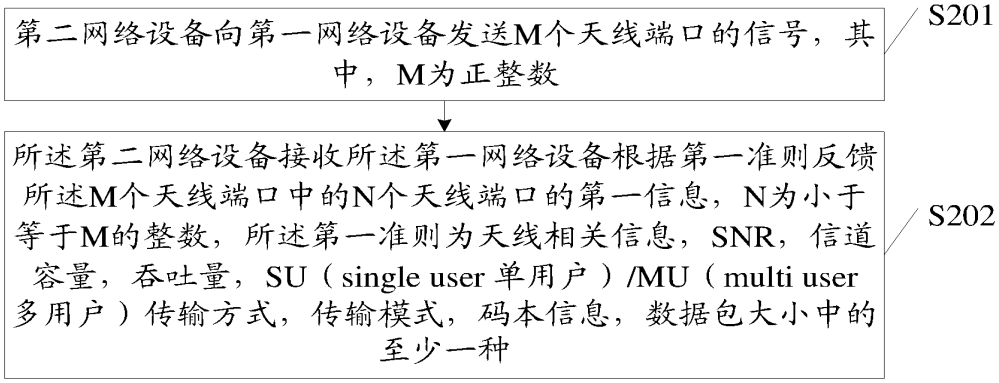

第二网络设备向第一网络设备发送M个天线端口的信号，其中，M为正整数
S201
所述第二网络设备接收所述第一网络设备根据第一准则反馈所述M个天线端口中的N个天线端口的第一信息，N为小于等于M的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种
S202

图 3

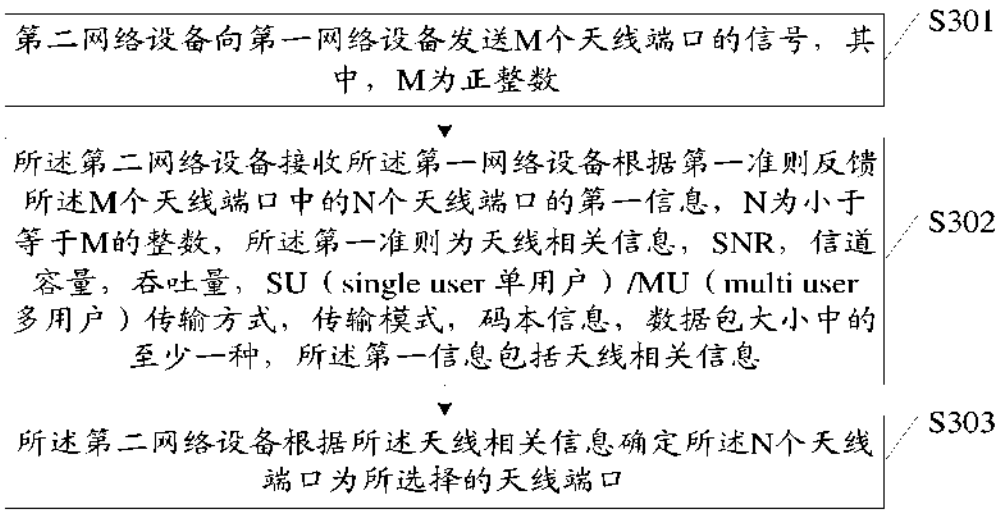

第二网络设备向第一网络设备发送M个天线端口的信号，其中，M为正整数
S301
所述第二网络设备接收所述第一网络设备根据第一准则反馈所述M个天线端口中的N个天线端口的第一信息，N为小于等于M的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种，所述第一信息包括天线相关信息
S302
所述第二网络设备根据所述天线相关信息确定所述N个天线端口为所选择的天线端口
S303

图 4

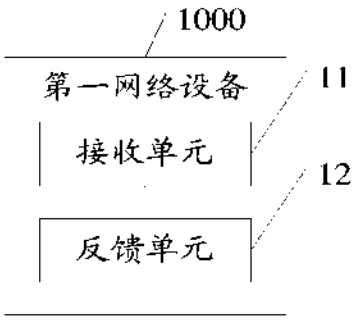

1000
第一网络设备
11
接收单元
12
反馈单元

图 5

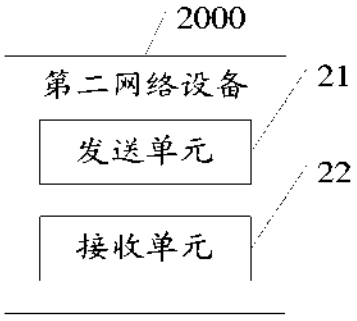

2000
第二网络设备
21
发送单元
22
接收单元

图 6

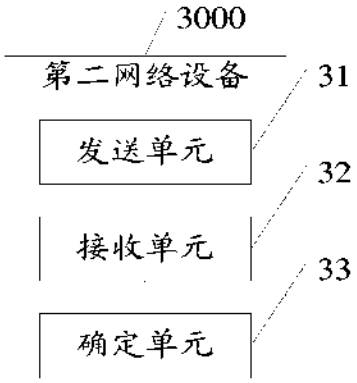

3000
第二网络设备
31
发送单元
32
接收单元
33
确定单元

图 7

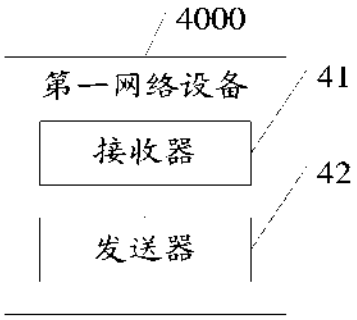

4000
第一网络设备
41
接收器
42
发送器

图 8

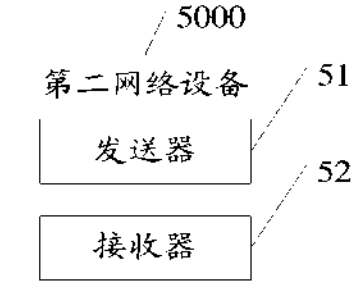

5000
第二网络设备
51
发送器
52
接收器

图 9

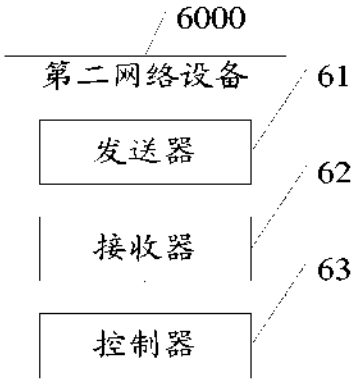


图 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2014/083479

A. CLASSIFICATION OF SUBJECT MATTER

H04B 7/06 (2006.01) i; H04B 7/08 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04B; H04W; H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNPAT, CNKI, WPI, EPODOC: confirm, port, Signal-to-Noise, SNR, codebook, antenna, feedback, feed back, throughput, select+, determin+, capability, group, data packet, mode, way, relate

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 1918817 A (LG ELECTRONICS INC.) 21 February 2007 (21.02.2007) description, page 14, the second paragraph to page 15, the second paragraph, and figures 4-6	1-57
A	CN 101015137 A (SAMSUNG ELECTRONICS CO., LTD. et al.) 08 August 2007 (08.08.2007) the whole document	1-57
A	CN 101359952 A (HUAWEI TECHNOLOGIES CO., LTD.) 04 February 2009 (04.02.2009) the whole document	1-57
A	CN 101013917 A (ZTE CORP.) 08 August 2007 (08.08.2007) the whole document	1-57

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&"document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
08 April 2015	06 May 2015
Name and mailing address of the ISA State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No. (86-10) 62019451	Authorized officer TIAN, Linlin Telephone No. (86-10) 61648260

Form PCT/ISA /210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2014/083479

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 1918817 A	21 February 2007	US 2005195912 A1	08 September 2005
		CN 101764633 A	30 June 2010
		KR 20050081239 A	18 August 2005
		WO 2005076758 A2	25 August 2005
		KR 20060005826 A	18 January 2006
		US 2010185777 A1	22 July 2010
		AT 532275 T	15 November 2011
		EP 1719265 A2	08 November 2006
CN 101015137 A	08 August 2007	KR 20060005683 A	18 January 2006
		US 2006039494 A1	23 February 2006
		EP 1759470 A1	07 March 2007
		JP 2008506330 A	28 February 2008
		WO 2006006826 A1	19 January 2006
CN 101359952 A	04 February 2009	None	
CN 101013917 A	08 August 2007	None	

Form PCT/ISA /210 (patent family annex) (July 2009)

国际检索报告

国际申请号
PCT/CN2014/083479

A. 主题的分类

H04B 7/06(2006.01)i; H04B 7/08(2006.01)i

按照国际专利分类(IPC)或者同时按照国家分类和IPC两种分类

B. 检索领域

检索的最低限度文献(标明分类系统和分类号)

H04B; H04W; H04Q

包含在检索领域中的除最低限度文献以外的检索文献

在国际检索时查阅的电子数据库(数据库的名称，和使用的检索词（如使用）)

CNPAT, CNKT, WPI, EPODOC: 选择，确定，天线，反馈，端口，信噪比，SNR，吞吐量，容量，的本，数据包，模式，方式，相关，组，antenna, feedback, feed back, throughput, select+, determin+, capability, group

C. 相关文件

类 型*	引用文件，必要时，指明相关段落	相关的权利要求
X	CN 1918817 A (LG电子株式会社) 2007年 2月 21日 (2007-02-21) 说明书第14页第2段-第15页第2段，附图4-6	1-57
A	CN 101015137 A (三星电子株式会社等) 2007年 8月 8日 (2007-08-08) 全文	1-57
A	CN 101359952 A (华为技术有限公司) 2009年 2月 4日 (2009-02-04) 全文	1-57
A	CN 101013917 A (中兴通讯股份有限公司) 2007年 8月 8日 (2007-08-08) 全文	1-57

☐ 其余文件在C栏的续页中列出。

☑ 见同族专利附件。

* 引用文件的具体类型：

"A" 认为不特别相关的表示了现有技术一般状态的文件

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"L" 可能对优先权要求构成怀疑的文件，或为确定另一篇引用文件的公布日而引用的或者因其他特殊理由而引用的文件（如具体说明的）

"O" 涉及口头公开、使用、展览或其他方式公开的文件

"P" 公布日先于国际申请日但迟于所要求的优先权日的文件

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"X" 特别相关的文件，单独考虑该文件，认定要求保护的发明不是新颖的或不具有创造性

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"&" 同族专利的文件

国际检索实际完成的日期	国际检索报告邮寄日期
2015年 4月 8日	2015年 5月 6日
ISA/CN的名称和邮寄地址 中华人民共和国国家知识产权局(ISA/CN) 北京市海淀区蓟门桥西上城路6号 100088 中国 传真号 (86-10)62019451	受权官员 田琳琳 电话号码 (86-10)61648260

表 PCT/ISA/210 (第2页) (2009年7月)

国际检索报告
关于同族专利的信息

国际申请号
PCT/CN2014/083479

检索报告引用的专利文件			公布日（年/月/日）	同族专利			公布日（年/月/日）
CN	1918817	A	2007年 2月 21日	US	2005195912	A1	2005年 9月 8日
				CN	101764633	A	2010年 6月 30日
				KR	20050081239	A	2005年 8月 18日
				WO	2005076758	A2	2005年 8月 25日
				KR	20060005826	A	2006年 1月 18日
				US	2010185777	A1	2010年 7月 22日
				AT	532275	T	2011年 11月 15日
				EP	1719265	A2	2006年 11月 8日
CN	101015137	A	2007年 8月 8日	KR	20060005683	A	2006年 1月 18日
				US	2006039494	A1	2006年 2月 23日
				EP	1759470	A1	2007年 3月 7日
				JP	2008506330	A	2008年 2月 28日
				WO	2006006826	A1	2006年 1月 19日
CN	101359952	A	2009年 2月 4日		无		
CN	101013917	A	2007年 8月 8日		无		

表 PCT/ISA/210（同族专利附件）（2009年7月）

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16 December 2015 (16.12.2015)

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(71) Applicant: **INTEL IP CORPORATION** [US/US]; 2200 Mission College Blvd, Santa Clara, CA 95054 (US).

(72) Inventors: **XIONG, Gang**; 16682 NW Arizona Drive, Beaverton, OR 97006 (US). **HE, Hong**; 8F,Raycom Infotech Park A, No.2, KeXueYuan South Road, HaiDian District, Beijing, Heilongjiang 100190 (CN). **CHATTERJEE, Debdeep**; 725 Mariposa Avenue, Apt. 301, Mountain View, CA 94041 (US). **BENDLIN, Ralf**; 15447 NW Nightshade Drive, Portland, OR 97229 (US). **KECICIOGLU, Balkan**; MS JF3-336, 2111 NE 25th Avenue, Hillsboro, OR 97124 (US).

(74) Agent: **HAYMOND, Alex, W.**; Thorpe North & Western LLP, c/o CPA Global, P.O. Box 52050, Minneapolis, MN 55402 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to the identity of the inventor (Rule 4.17(i))*

[Continued on next page]

(54) Title: PERFORMING MISSION CRITICAL COMMUNICATIONS AT A USER EQUIPMENT (UE)

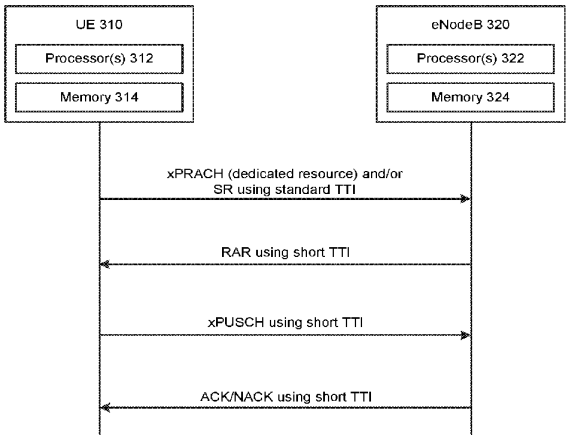


FIG. 3

(57) Abstract: Technology for a user equipment (UE) operable to perform mission critical communications with an eNodeB is disclosed. The UE can transmit a physical random access channel (PRACH) signal to the eNodeB that indicates a mission critical communication to be performed between the UE and the eNodeB. The PRACH signal can be transmitted in accordance with a first transmission time interval (TTI). The UE can receive a random access response (RAR) message from the eNodeB that includes a timing advance (TA) and a resource allocation for the mission critical communication. The RAR message can be transmitted from the eNodeB using a second TTI. The UE can perform the mission critical communication with the eNodeB in an uplink using the TA and the resource allocation indicated in the RAR message. The mission critical communication can be performed using a physical uplink shared channel (PUSCH) and in accordance with the second TTI.

WO 2017/023352 A1

Published:

— *with international search report (Art. 21(3))*

PERFORMING MISSION CRITICAL COMMUNICATIONS AT A USER EQUIPMENT (UE)

BACKGROUND

[0001] Wireless mobile communication technology uses various standards and protocols to transmit data between a node (e.g., a transmission station) and a wireless device (e.g., a mobile device). Some wireless devices communicate using orthogonal frequency-division multiple access (OFDMA) in a downlink (DL) transmission and single carrier frequency division multiple access (SC-FDMA) in uplink (UL). Standards and protocols that use orthogonal frequency-division multiplexing (OFDM) for signal transmission include the third generation partnership project (3GPP) long term evolution (LTE), the Institute of Electrical and Electronics Engineers (IEEE) 1202.16 standard (e.g., 1202.16e, 1202.16m), which is commonly known to industry groups as WiMAX (Worldwide interoperability for Microwave Access), and the IEEE 1202.11 standard, which is commonly known to industry groups as WiFi.

[0002] In 3GPP radio access network (RAN) LTE systems, the node can be a combination of Evolved Universal Terrestrial Radio Access Network (E-UTRAN) Node Bs (also commonly denoted as evolved Node Bs, enhanced Node Bs, eNodeBs, or eNBs) and Radio Network Controllers (RNCs), which communicates with the wireless device, known as a user equipment (UE). The downlink (DL) transmission can be a communication from the node (e.g., eNodeB) to the wireless device (e.g., UE), and the uplink (UL) transmission can be a communication from the wireless device to the node.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] Features and advantages of the disclosure will be apparent from the detailed description which follows, taken in conjunction with the accompanying drawings, which together illustrate, by way of example, features of the disclosure; and, wherein:

[0004] FIG. 1 illustrates a flexible radio access technology (RAT) in accordance with an example;

[0005] FIG. 2 illustrates a subframe structure for low latency applications in accordance

with an example;

[0006] FIG. 3 illustrates a mission critical communication between a user equipment (UE) and an eNodeB in accordance with an example;

[0007] FIG. 4 illustrates a partition of a physical random access channel (PRACH) preamble resource in accordance with an example;

[0008] FIG. 5 illustrates a multiplexing of a physical random access channel (PRACH) signal and a scheduling request (SR) message in a repeated transmission in accordance with an example;

[0009] FIG. 6 illustrates a random access response (RAR) window for repeated transmissions between a user equipment (UE) and an eNodeB in accordance with an example;

[0010] FIGS. 7A to 7C illustrates a resource allocation of a primary partition and a secondary partition within a transmission time interval (TTI) in accordance with an example;

[0011] FIG. 8 illustrates a repeated transmission of a random access response (RAR) message using a short transmission time interval (TTI) in accordance with an example;

[0012] FIG. 9 depicts functionality of a user equipment (UE) operable to perform mission critical communications with an eNodeB in accordance with an example;

[0013] FIG. 10 depicts functionality of a base station operable to receive mission critical communications from a user equipment (UE) in accordance with an example;

[0014] FIG. 11 depicts a flowchart of a machine readable storage medium having instructions embodied thereon for performing mission critical communications between a user equipment (UE) and an eNodeB in accordance with an example;

[0015] FIG. 12 illustrates a diagram of a wireless device (e.g., UE) in accordance with an example; and

[0016] FIG. 13 illustrates a diagram of a wireless device (e.g., UE) in accordance with an example.

[0017] Reference will now be made to the exemplary embodiments illustrated, and specific language will be used herein to describe the same. It will nevertheless be

understood that no limitation of the scope of the technology is thereby intended.

DETAILED DESCRIPTION

[0018] Before the present technology is disclosed and described, it is to be understood that this technology is not limited to the particular structures, process actions, or materials disclosed herein, but is extended to equivalents thereof as would be recognized by those ordinarily skilled in the relevant arts. It should also be understood that terminology employed herein is used for the purpose of describing particular examples only and is not intended to be limiting. The same reference numerals in different drawings represent the same element. Numbers provided in flow charts and processes are provided for clarity in illustrating actions and operations and do not necessarily indicate a particular order or sequence.

EXAMPLE EMBODIMENTS

[0019] An initial overview of technology embodiments is provided below and then specific technology embodiments are described in further detail later. This initial summary is intended to aid readers in understanding the technology more quickly but is not intended to identify key features or essential features of the technology nor is it intended to limit the scope of the claimed subject matter.

[0020] The field of mobile communications has evolved significantly from early voice systems to today's highly sophisticated integrated communication platform. 4G Long Term Evolution (LTE) networks are deployed in more than 100 countries to provide services in various spectrum band allocations depending on spectrum regime. Recently, significant momentum has started to build around the idea of a next generation, i.e., fifth generation (5G) wireless communications technology.

[0021] A wide range of potential applications and services have been identified for the 5G system. Some examples include (1) enhanced mobile broadband, (2) massive machine type communications (MTC), and (3) ultra-reliable and low latency or mission critical communications. In enhanced mobile broadband, increased data rates is expected to be a key driver in network development and evolution for the 5G system. A peak data rate of more than 10 gigabits per second (Gbps) and a minimum guaranteed user data rate of at

least 100 megabits per second (Mbps) are envisioned for the 5G system. With respect to massive MTC, the support of a massive number of Internet of Things (IoT) or MTC devices is expected to be a key feature for the 5G system. MTC devices can be used for a wide variety of applications. MTC devices use low operational power consumption and are expected to communicate with infrequent small burst transmissions. Finally, with respect to ultra-reliable and low latency or mission critical communications, the support of mission critical MTC applications for the 5G system can necessitate a high level of reliable connectivity with guaranteed low latency, availability and reliability-of-service.

[0022] FIG. 1 illustrates an exemplary flexible radio access technology (RAT). The flexible RAT, also referred to as a 5G xRAT, can function to address the diverse features of the 5G system, such as the enhanced mobile broadband, massive MTC, and ultra-reliable and low latency or mission critical communications. The flexible RAT can define a unified framework that supports these diverse applications and services. In addition, the flexible RAT can support multiple frequency bands, multiple application/services, licensed/unlicensed frequency, and multiple RATs.

[0023] As shown in FIG. 1, the flexible RAT can be represented in two dimensions – frequency and time. Multiple RATs/sub-RATs/partitions or applications in the same frequency resources or frequency bands (or different frequency resources or frequency bands) can be multiplexed using time-division multiplexing (TDM), frequency-division multiplexing (FDM), code-division multiplexing (CDM), or a combination of the above.

[0024] In one example, the flexible RAT can include a medium/high frequency band, as well as a low frequency band. In the low frequency band, there can be a primary partition. The primary partition can be in accordance with a standard transmission time interval (TTI). As an example, the standard TTI can be for a Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) Release 8 orthogonal frequency division multiple access (OFDMA) frame structure. The standard TTI can be approximately one millisecond (ms) in duration. Furthermore, in the low frequency band, there can be a first secondary partition and a second secondary partition. The primary partition and the secondary partition can be in both time and frequency. The first secondary partition can be in accordance with a short TTI and the second secondary partition can be in accordance with a long TTI. In general, the short TTI can have a duration that is less than

the standard TTI, and the long TTI can have a duration that is greater than the standard TTI. As non-limiting examples, the short TTI can be approximately 0.1 to 0.2 ms in duration, and the long TTI can be approximately 5 ms in duration. In one example, the primary partition in the flexible RAT can be utilized for non-mission critical communications (e.g., voice, data), and the secondary partition in the flexible RAT can be utilized for mission critical communications.

[0025] In one example, for a carrier frequency below 6 Gigahertz (GHz), the primary partition can reuse existing LTE numerology, while the secondary partition can be designed to support low latency or mission critical MTC applications. In particular, the short TTI can enable the low latency for mission critical MTC communications. In addition, increased subcarrier spacing, e.g., 75 kilohertz (kHz), can be adopted for the secondary partition. In contrast, a 15 KHz subcarrier spacing can be utilized for the primary partition.

[0026] FIG. 2 illustrates an exemplary subframe structure for low latency applications. The subframe structure can be for a secondary partition in a low frequency band, and the secondary partition can be associated with a short TTI of approximately 0.1 to 0.2 ms in duration. In one example, the subframe structure for the secondary partition can be based on an orthogonal frequency division multiplexing (OFDM) waveform.

[0027] In the example shown in FIG. 2, a 0.2ms TTI can be achieved. Within one TTI, 12 OFDM symbols can be grouped together (e.g., symbol 0 to symbol 11). Each OFDM symbol can have a duration of 13.3 micro seconds (us). A cyclic prefix (CP) can be inserted between each OFDM symbol. A CP length can be approximately 3.3 us or 512 samples if a sampling rate is 153.6MHz.

[0028] As described in further detail below, a system and method for mission critical communications in a 5G system is described. The mission critical communication can be performed at a user equipment (UE) in a radio resource control (RRC) idle mode. In one example, the procedure can involve a "keep trying" mechanism in which transmissions are repeated to ensure robust communication. The repeated transmissions can provide the ultra-reliability for the mission critical communication. The procedure can involve using a short transmission time interval (TTI) for signaling between the UE and an eNodeB, thereby providing the low latency for the mission critical communication. In one

example, dedicated resources can be used for a 5G physical random access channel (xPRACH) transmission that triggers or indicates the mission critical communication. The xPRACH transmission can be combined with a contention based scheduling request (SR). In addition, the procedure can involve information content, resource allocation and transmission schemes for random access response (RAR) messages with respect to the mission critical communication.

[0029] FIG. 3 illustrates an exemplary mission critical communication between a user equipment (UE) 310 and an eNodeB 320. In one example, the UE 310 can be a mission critical machine type communication (MTC) device. The UE 310 can initially be in a radio resource control (RRC) idle mode. The UE can include one or more processors 312 and memory 314, and the eNodeB 320 can include one or more processors 322 and memory 324. The mission critical communication between the UE 310 and the eNodeB 320 can include four distinct actions. In a first action, the UE 310 can transmit a fifth generation (5G) physical random access channel (xPRACH) signal to the eNodeB 320 using a dedicated resource to indicate or trigger the mission critical communication. To enable faster uplink access and transmission, the xPRACH signal can be combined together with a scheduling request (SR) message. The xPRACH signal and/or SR message can be transmitted using a standard transmission time interval (TTI) in a primary partition. The standard TTI can be approximately one millisecond (ms) in duration. In addition, the dedicated resource can be represented in the form of an xPRACH preamble signature/sequence, time and frequency resource. In a second action, after successful detection of the xPRACH signal and/or decoding of the SR message, the eNodeB 320 can transmit a random access response (RAR) message using a short TTI in a secondary partition. The short TTI can be approximately 0.1 to 0.2 ms in duration. In general, the short TTI is associated with a time interval that is less than the standard TTI. In one example, the standard TTI can be referred to as a first TTI and the short TTI can be referred to as a second TTI, wherein the second TTI is associated with a time interval that is less than the first TTI. The RAR message may include a timing advance (TA), a resource allocation for an uplink transmission, etc. In a third action, after successfully decoding the RAR message, the UE 310 can transmit uplink data (i.e., the mission critical data) to the eNodeB 320 in a 5G physical uplink shared channel (xPUSCH) using the short TTI in the secondary partition. In other words, the mission critical communication

from the UE 310 to the eNodeB 320 is performed using the 5G xPUSCH and the short TTI. The uplink data in the xPUSCH can be transmitted on the allocated resource in the RAR message. In a fourth action, the eNodeB 320 can transmit acknowledgement (ACK) or negative acknowledgement (NACK) information to the UE 310. The ACK/NACK information can be transmitted in a 5G physical downlink control channel (xPDCCH) or a 5G physical hybrid-ARQ indicator channel (xPHICH) using the short TTI in the secondary partition. The four actions involved in performing the mission critical communication are described in further detail below.

[0030] In one configuration, a transmitter (e.g., the UE 310 or the eNodeB 320) can keep transmitting the signal until a response is received from a receiver (e.g., the eNodeB 320 or the UE 310). This "keep trying" mechanism can ensure high robustness of the reception, which is essential for the mission critical communication. For instance, in the first action, the UE 310 can continue transmitting the xPRACH signal on the dedicated resource until the UE 310 receives the RAR message from the eNodeB 320. The "keep trying" mechanism can be viewed as an early termination of a repeated transmission. In other words, the transmitter can terminate the repeated transmission when the transmitter receives a response/feedback from the receiver. In addition, a maximum repetition number for each action (e.g., actions 1-4 as described above) can be predefined or configured by higher layers via a 5G master information block (xMIB), a 5G system information block (xSIB) or dedicated RRC signaling. When the transmission reaches the maximum repetition number, the UE 310 can perform a random back-off on the xPRACH signal to re-initiate the mission critical communication.

[0031] In one configuration, for each action (e.g., actions 1-4 as described above), the transmitter can repeat the transmission using a fixed number of repetitions (K repetitions). The number of repetitions can be predefined or configured by higher layers via the xMIB, the xSIB or dedicated RRC signaling. In one example, the value of K can be configured as 1, which indicates that no repetition is used for the transmission. When the transmission reaches the fixed repetition number, the UE 310 can perform a random back-off on the xPRACH signal to re-initiate the mission critical communication, or the UE 310 can indicate a random access problem to upper layers in order to trigger corresponding procedure(s).

[0032] In one example, a combination of the above options can be considered for the transmission of channels and signals in each action (e.g., actions 1-4 as described above). In particular, the transmitter can keep sending the signal until the transmitter receives the response from the receiver, wherein each transmission occupies K repetitions. Similar to the above option, the number of repetitions (K) in each transmission can be predefined or configured by higher layers via the xMIB, the xSIB or dedicated RRC signaling.

[0033] In one configuration, a set of dedicated resources can be allocated for the transmission of the xPRACH signal from the UE to indicate or trigger the mission critical communication. The dedicated xPRACH resources can be multiplexed with resources for other applications (i.e., non-mission critical applications) using TDM or FDM or CDM, or a combination of the above. In addition, the partition of the set of dedicated resources for mission critical communications and the resources for other applications can be predefined or configured by higher layer via the xMIB, the xSIB or dedicated RRC signaling.

[0034] In one example, the xPRACH signal can be transmitted using the standard TTI (e.g., 1 ms duration) on the primary partition. Several options can be utilized to allocate the dedicated resource for the transmission of the xPRACH signal. For example, one or a plurality of signatures can be reserved for the xPRACH signal to indicate or trigger the mission critical communication. In addition, to handle the mission critical communication with different applications/services, one or a plurality of dedicated preamble signatures can be reserved for each specific event.

[0035] FIG. 4 illustrates an exemplary partition of a physical random access channel (PRACH) preamble resource. The PRACH preamble resource can include a fifth generation (5G) xPRACH preamble resource. The partition of the xPRACH preamble resource can be for mission critical applications, as well as other applications (i.e., non-mission critical applications). In other words, the xPRACH preamble resource can include a first resource for other applications and a second resource for mission critical applications. In addition, the partition of the xPRACH preamble resource can be associated with different applications and/or events. For example, the xPRACH preamble resource size or the number of reserved sequences for each event can be different. For instance, event #1 in the resource for mission critical applications can correspond to a

mission critical application for earthquake event, and one preamble signature can be reserved for event #1. Event #2 in the resource for mission critical applications can correspond to a mission-critical Vehicular to Vehicular (V2V) application, and five preamble signatures can be reserved for event #2.

[0036] In one example, one or a plurality of frequency resources can be allocated for the xPRACH signal to trigger the mission critical communication. When the UE transmits the xPRACH signal in the dedicated frequency resource, the eNodeB can transmit the corresponding RAR message using the short TTI on the secondary partition. The eNodeB can transmit the corresponding RAR message upon successful detection of xPRACH signal.

[0037] In one example, one or a plurality of time resources can be allocated for the xPRACH signal to trigger the mission critical communication. For example, the xPRACH signal for other applications (i.e., non-mission critical applications) can be transmitted in subframe 0, 2, 4, 6, 8 within one frame, while the xPRACH signal used to trigger the mission critical communication can be transmitted in subframe 1, 3, 5, 7, 9 within one frame.

[0038] In one example, a combination of TDM and/or FDM and/or CDM based multiplexed schemes can be used to separate the resource for mission critical applications and other applications (i.e., non-mission critical applications). For example, a combination of FDM and CDM multiplexing schemes can be utilized, i.e., one additional frequency resource can be reserved for mission critical applications, and within this dedicated frequency resource, different mission critical applications/services can be separated using different xPRACH preamble signatures.

[0039] In another example, a combination of TDM and CDM multiplexing schemes can be utilized. The xPRACH signal for the other application (i.e., a non-mission critical application) can be transmitted in subframe 0, 2, 4, 6, 8 within one frame, while the xPRACH signal used to trigger the mission critical communication can be transmitted in subframe 1, 3, 5, 7, 9 within one frame. Further, different mission critical applications/services can be separated using different xPRACH preamble signatures.

[0040] In one example, with respect to ultra-reliable and low latency communications, multiple mission critical devices can operate as a “single frequency network” (SFN),

which can improve a link level performance for mission critical communication. In this case, the eNodeB can treat multiple mission critical devices as a single mission critical device. For example, the eNodeB can transmit a single RAR message to multiple UEs, and in response, multiple UEs can transmit uplink data (i.e., mission critical data) simultaneously to the eNodeB on the same time and frequency resource.

[0041] In one example, in order to differentiate a typical operation from a "single frequency network" type of operation, different xPRACH resources can be allocated. For example, one event ID or dedicated xPRACH signature can be allocated for the "single frequency network" type of operation. In addition, when repeated transmissions of the xPRACH preamble are used, a starting subframe of the repeated xPRACH transmission can be predefined or configured by higher layers, thereby causing the eNodeB to perform efficient detection of the repeated xPRACH signal.

[0042] A more detailed description is now provided with respect to the first action shown in FIG. 3, in which the UE can transmit the 5G xPRACH signal and/or SR message to the eNodeB using dedicated resources to indicate or trigger the machine critical communication. The xPRACH signal transmission can be combined with a contention based scheduling request (SR) message to allow uplink access in a reduced amount of time, thereby fulfilling the latency constraints for mission critical communications. The contention based SR message can include the UE ID and buffer status report to enable uplink access in the reduced amount of time.

[0043] For mission critical applications, the SR message can be transmitted from the UE to the eNodeB as part of a random access channel (RACH) procedure, which allows for a reduction in connection establishment delay as compared to existing LTE systems. The SR message can be a fixed size and can include several parameters/fields. The SR message can include a mission critical MTC device ID, which can be the same as the UE ID or a different ID. The SR message can include an event ID to indicate an access cause when a same set of xPRACH sequences are allocated for multiple applications/services. The event ID can be included in the SR message to expedite access for the UE. The SR message can include a mission critical MTC device capability, which can include mission critical specific UE radio access capability information, such as carrier aggregation (CA) capability, i.e., component carrier (CC) index(s) that are supported by the UE (e.g., the

mission critical MTC device), supported multiple input multiple output (MIMO) capability, etc. The SR message can include a resource request and modulation and coding scheme (MCS) for an uplink transmission (e.g., mission critical data) from the UE. For example, the SR message can include the resource request in the time and frequency domain, e.g., physical resource block (PRB) index or numbers within one band, or symbol/slot/subframe/frame index or CC index(s) used for the uplink transmission. Alternatively, the UE can indicate the total amount of data for mission critical application and/or channel state information (CSI)/reference signaling measurements, which can subsequently be used for downlink MCS selection and open loop power control calculation.

[0044] In one example, when the resource request of PRB index and MCS are included in the SR message, the eNodeB can feedback 1 bit ACK/NACK information to the UE (or mission critical MTC device). Upon successful ACK detection, the UE can use the resource indicated in the SR message for uplink data transmission based on a predefined timing following a subframe in which the ACK/NACK information is detected.

[0045] In one example, the "keep trying" mechanism or repeated transmission can be employed when transmitting the xPRACH signal and/or SR message to the eNodeB. The same xPRACH preamble signature and the same SR information can be used for the transmission of the xPRACH signal and the SR message during the repetition, respectively. In addition, the SR message can occupy the resource allocated for the SR transmission to further enhance the link level performance.

[0046] In one example, UEs may not have the xPRACH/SR repetition capability, or the function may not be configured at the UE by the eNodeB. In this case, different xPRACH and/or SR resources can be used with respect to (1) an initial transmission that is shared among all UEs and (2) subsequent repeated transmission that is dedicated for UEs enabled with the xPRACH/SR repetition capability. In one example, the resource for the initial transmission of the xPRACH signal and SR message can be selected by the UE within a contention-based resource region, while the resources for subsequent repeated transmissions can be configured by higher-layers (e.g., broadcasted in the xSIB) within a contention-free resource region on the same partition or a different partition.

[0047] In one example, available sets of xPRACH or SR resources reserved for the UE

(e.g., a mission critical MTC device) can be divided into two different regions – a first region can be used for the xPRACH/SR transmission repetition and the second region can be reserved for the xPRACH/SR transmission without repetition. More specifically, an xPRACH signal or SR message can be repeatedly transmitted on a configurable or fixed consecutive xPRACH or SR resources within the first region according to a known pattern (e.g., TDM, CDM or FDM). The number of repetition times can be predefined or configured by higher layers for an individual UE. In addition, one-to-one mapping between the xPRACH repetition level and the xPRACH/SR resource set can be utilized. The UE can select an xPRACH/SR repetition level based on a measurement, such as a reference signal received power (RSRP), and the UE can transmit the xPRACH/SR using the xPRACH/SR resources set according to the selected xPRACH/SR repetition level.

[0048] FIG. 5 illustrates an exemplary multiplexing of a physical random access channel (PRACH) signal and a scheduling request (SR) message in a repeated transmission. The PRACH signal can include a fifth generation (5G) xPRACH signal. Various multiplexing mechanisms, such as time division multiplexing (TDM) or frequency division multiplexing (FDM), can be applied to the xPRACH signal and the SR message. As shown in FIG. 5, TDM multiplexing can be used for repeated transmissions of the xPRACH signal and the SR message, or FDM multiplexing can be used for repeated transmissions of the xPRACH signal and the SR message. In other words, TDM and FDM based multiplexing mechanisms can be applied to the "keep trying" mechanism for repeated transmissions. In addition, the SR message can be transmitted using all the available resource to achieve ultra-reliable communication.

[0049] In one example, with respect to transmission power control mechanism for the transmission of the xPRACH signal and/or the SR message, several options can be used. In one example, when (re)transmitting the xPRACH signal and/or SR message, a maximum transmit power can be used to ensure robust detection at the eNodeB. In another example, an existing power control mechanism can be applied for the transmission and retransmission of the xPRACH signal and/or SR message. In particular, for an initial transmission, the xPRACH transmission power can be set to an initial PRACH power, while for the retransmission, power ramping can be used to increase the actual transmission power.

[0050] In yet another example with respect to transmission power control, repetition level ramping can be applied for the transmission and retransmission of the xPRACH signal and/or SR message. Further, the repetition level ramping mechanism can be combined in conjunction with power ramping to further improve the performance. In one example, the repetition level can be doubled for each retransmission. In the initial transmission, the repetition level can be defined as K, while in the first retransmission, the repetition level can be set to 2K, etc. Additionally, if power ramping is applied on top of the repetition level ramping, the power ramping can be defined so as to account for an increase in the repetition level. Specifically, the power level for the first attempt at a subsequent repetition level can be reduced by a factor of 10*log(numRepL/numRepL-1), wherein numRepL and numRepL-1 are the number of repetitions configured for repetition levels L and L-1, respectively.

[0051] A more detailed description is now provided with respect to the second action shown in FIG. 3, in which the eNodeB can transmit the RAR message to the UE using the short TTI. After identifying the mission critical event based on detection of the xPRACH signal, the eNodeB can dynamically allocate the resource in a secondary partition, and the eNodeB can transmit the corresponding RAR message using the short TTI.

[0052] For mission critical MTC applications, a fixed relationship can be defined between the time (e.g., a last repetition/retransmission) of the xPRACH transmission and a time of the first transmission of the xPDCCH/xPDSCH signal (either scheduling or carrying the RAR message). Additionally, the frequency resource for the xPDCCH (if xPDCCH is not wideband) or xPDSCH can be determined as a function of at least the preamble sequence of the detected xPRACH signal, and possibly also the frequency location of the detected xPRACH signal. If additional flexibility is desired at the eNodeB, then for time-domain scheduling of the RAR message, a short RAR window can be defined in which the UE monitors for the first transmission of the xPDCCH/xPDSCH signal with the RAR message.

[0053] FIG. 6 illustrates an exemplary random access response (RAR) window for repeated transmissions between a user equipment (UE) and an eNodeB. When repeated transmissions are used for the xPRACH signal and/or SR message, the RAR window can be defined such that the UE (e.g., a mission critical MTC device) can monitor for the

RAR message within the RAR window. As shown in FIG. 6, the xPRACH signal and SR message can be transmitted in an uplink in accordance with a standard TTI (e.g., 1 ms in duration). After transmission of the xPRACH signal and SR message, the RAR window can be defined. During the RAR window, the UE can monitor a downlink for the RAR message. The UE can detect the RAR message during the RAR message, wherein the RAR message is transmitted in accordance with a short TTI. In one example, the position of the RAR window can be predefined or configured by higher layer via the xMIB, the xSIB or dedicated RRC signaling. In addition, the starting position of the RAR window can be defined relative to the starting of the last subframe of the repeated xPRACH signal and/or SR message transmission.

[0054] FIGS. 7A to 7C illustrates exemplary resource allocations of a primary partition and a secondary partition within a transmission time interval (TTI). The TTI can be a standard TTI with a duration of one millisecond (ms). Guard bands can be inserted between the primary and secondary partitions in a frequency domain in order to reduce inter-carrier interference.

[0055] As shown in FIG. 7A, a secondary partition using a short TTI (e.g., 0.1 to 0.2 ms) can be allocated after an xPDCCH region. The xPDCCH region can be in the primary partition using the standard TTI. When different numerologies, e.g., subcarrier spacing, are used for the primary and secondary partitions, a guard time may be inserted between the xPDCCH region using the standard TTI and the secondary partition using the short TTI. This option may avoid traffic interruption for the primary partition, as the eNodeB can schedule the downlink and uplink transmission via the xPDCCH within the primary partition.

[0056] As shown in FIG. 7B, a secondary partition using a short TTI (e.g., 0.1 to 0.2 ms) can be allocated after an xPDCCH region. The xPDCCH region can be in the primary partition using the standard TTI. Further, the secondary partition can occupy a full system bandwidth to enhance the link level performance. In this approach, guard times may not be inserted between the xPDCCH region using the standard TTI and the secondary partition using the short TTI.

[0057] As shown in FIG. 7C, a secondary partition using a short TTI (e.g., 0.1 to 0.2 ms) can span a standard TTI (e.g., 1 ms). In this approach, the secondary partition can occupy

a full system bandwidth to enhance the link level performance. In addition, a guard time may be inserted to reduce interference in a primary partition.

[0058] In one example, the resource allocation for the secondary partition can be predefined, or broadcasted in a mission critical specific xSIB message, or indicated in a downlink control information (DCI) format in the xPDCCH using the standard TTI in the primary partition. In the latter case, the UE (e.g., a mission critical MTC device) can monitor the xPDCCH with a cyclic redundancy check (CRC) scrambled by an existing random-access radio network temporary identifier (RA-RNTI) or a newly defined RA-RNTI for mission critical applications. The RA-RNTI can be predefined in the specification or defined as a function of at least one of: the time index, frequency index, preamble sequence, and repetition level used for the detected xPRACH transmission. Upon successful decoding of the xPDCCH signal, the UE can switch to a short TTI mode and decode the RAR message within the secondary partition.

[0059] FIG. 8 illustrates an exemplary repeated transmission of a random access response (RAR) message using a short transmission time interval (TTI). The "keep trying" mechanism or repeated transmissions of the RAR message can be used to improve the link level performance. The repeated RAR transmissions using the short TTI can occur within a secondary partition used for mission critical communication. As shown in FIG. 8, a preamble can be inserted before each transmission of the RAR message to improve a downlink synchronization accuracy, which is useful in view of the higher sampling rate used for the short TTI with large subcarrier spacing (e.g., 15 KHz). The preamble can utilize similar principles as compared to the 5G downlink synchronization channel (xSCH). To differentiate the preamble from the xSCH, independent root sequences can be employed when Zadoff-Chu (ZC) sequences are used for the xSCH.

[0060] In one example, the RAR message can include various parameters. For example, the RAR message can include a timing advance (TA). The eNodeB can estimate an initial TA from the xPRACH signal sent by the UE. The RAR message can include an UL grant for a subsequent uplink transmission. In addition, the UL grant can include a resource allocation of the secondary partition used for the subsequent uplink transmission. When the UE (e.g., a mission critical MTC device) supports carrier aggregation (CA), the resource allocation for multiple component carriers (CCs) can be included in the uplink

grant. The UL grant can include a modulation and coding scheme (MCS) and a power control parameter for the subsequent uplink transmission, as well as the number of repetitions used for the RAR transmission. In one example, the RAR message can include a mission critical MTC device ID, which can be used for contention resolution. The RAR message can include an event ID, which can be obtained from the SR message and used for contention resolution. In addition, the RAR message can include a random access preamble ID that is useful for contention resolution. The random access preamble ID can include a preamble index for the xPRACH transmission.

[0061] In one example, the RAR message can be transmitted in the secondary partition using the short TTI either: (1) on the xPDSCH scheduled by the xPDCCH, or (2) using the xPDCCH directly, or (3) using the xPDSCH directly. With respect to the first option, the xPDCCH can indicate the resource allocation and MCS for the transmission of the xPDSCH signal, while the xPDSCH carries the RAR message. With respect to the second option, the RAR message can be transmitted via the xPDCCH. In this case, the UE (e.g., a mission critical MTC device) can monitor the xPDCCH with the CRC scrambled by the RA-RNTI. With respect to the third option, the RAR message can be transmitted via the xPDSCH using the short TTI. When repeated transmissions or the "keep trying" mechanism is employed for the RAR message, TTI bundling and a predefined redundancy version (RV) pattern (e.g., [0 2 3 1]) can be used when turbo coding is adopted. Further, a scrambling seed for the transmission of the xPDSCH signal can be defined as a function of the RA-RNTI or a group ID with respect to a "single frequency network" (SFN) type of operation. In one example, the group ID can be specified as the event ID.

[0062] In one example, the UE (e.g., a mission critical MTC device) can monitor for the xPDSCH signal using fixed and known values of the MCS and a transport block size (TBS). If a UE processing complexity increase can be accommodated for mission critical devices, then a limited number of options for MCS and TBS for the xPDSCH can be configured, from which the UE can perform blind detection.

[0063] A more detailed description is now provided with respect to the third action shown in FIG. 3, in which the UE can transmit uplink data (i.e., mission critical data) to the eNodeB using the short TTI. A resource allocation for the uplink data transmission can be

indicated in the RAR message. In particular, the resource allocation can be associated with a secondary partition to be used for the uplink data transmission. Further, a scrambling seed for a transmission of the xPUSCH signal can be defined as a function of a mission critical MTC device ID or a group ID with respect to a "single frequency network" type of operation. In one example, the group ID can be specified as the event ID.

[0064] When the repeated transmission is used for the uplink transmission, a gap between the end of a last RAR transmission and a starting subframe of the uplink transmission can be predefined or configured by higher layers via the xMIB, the xSIB or dedicated RRC signaling. Alternatively, to allow additional flexibility, a delay parameter can be indicated in the UL grant of the RAR message, wherein the delay parameter can be of the order of one or more standard or short TTI(s).

[0065] In one example, to improve the robustness of the uplink transmission, the same information can be transmitted on multiple component carriers (CC) simultaneously, or transmitted repeatedly within a CC to fulfil the reliability constraint of the mission critical communication. Further, TTI bundling with a predefined redundancy version (RV) pattern can be employed for performance enhancement. For mission critical applications with small data packet transmissions, tail biting convolution coding (TBCC) can be used as a forward error correction (FEC) scheme as opposed to turbo coding.

[0066] A more detailed description is now provided with respect to the fourth action shown in FIG. 3, in which the eNodeB can transmit ACK/NACK information to the UE using the short TTI. The ACK/NACK can be transmitted via the xPDCCH or the xPHICH using the short TTI on the secondary partition. When repeated transmission are used for the ACK/NACK transmission, a gap between the end of a last uplink data transmission and a starting subframe of the ACK/NACK transmission can be predefined or configured by higher layers via the xMIB, the xSIB or dedicated RRC signaling.

[0067] In one example, when a NACK is received or an ACK is not received, the UE (e.g., a mission critical MTC device) can perform a retransmission of the uplink data. When a maximum number of retransmission is reached, the UE can perform a random back-off and re-initiate the procedure for mission critical communication. Alternatively, assuming that an uplink synchronization has been established via a mission critical

random access procedure, the UE can transmit a scheduling request (SR) using the short TTI on the secondary partition at a next available SR opportunity. In one example, periodically occurring SR opportunities can be defined in the secondary partition. The SR transmission can be based on a physical structure of the xPUSCH or xPUCCH, which are adapted for transmissions using short TTIs. The configuration of the SR opportunities in the secondary partition can be pre-defined or broadcasted using the xSIB. Alternatively, the configuration of the SR opportunities can be indicated via a combination of broadcasted information of system level configurations and UE-specific signaling of the actual configured SR resource periodicity carried in the RAR message.

[0068] In one example, with respect to the "single frequency network (SFN)" type of operation, multiple UEs that are closely co-located (i.e., located within a defined distance from each other) can transmit the xPRACH signal on the same xPRACH resource using the same xPRACH preamble, which can improve the xPRACH detection performance. In response to receiving the xPRACH signal from multiple UEs, the eNodeB can transmit a single RAR message that targets the multiple UEs. In addition, when one or more UEs successfully receive the RAR message, the UEs can transmit the xPUSCH signal simultaneously on the same resource, which can achieve SFN gain.

[0069] In one configuration, a system and method of ultra-reliable and low latency communications for a fifth generation (5G) system is described. A user equipment (UE) can transmit, to an eNodeB, a 5G Physical Random Access Channel (xPRACH) and/or a scheduling request (SR) message to trigger a mission critical communication. The xPRACH and/or SR can be transmitted on a dedicated resource using a standard transmission time interval (TTI) in a primary partition. The UE can receive a random access response (RAR) using a short TTI in a secondary partition. The UE can transmit uplink data to the eNodeB in a 5G physical uplink shared channel (xPUSCH) using the short TTI in the secondary partition. The UE can receive, from the eNodeB, acknowledgement (ACK) or negative acknowledgement (NACK) information in a 5G physical downlink control channel (xPDCCH) or a 5G Physical Hybrid-ARQ Indicator Channel (xPHICH) using the short TTI in the secondary partition.

[0070] In one configuration, a keep trying mechanism is employed between the UE and the eNodeB for ultra-reliable and low latency communication. A transmitter (e.g., the UE

or eNodeB) can keep sending a signal until a response is received from a receiver (e.g., the eNodeB or UE). A maximum repetition number for each transmission can be predefined or configured by higher layers via a 5G master information block (xMIB), a 5G system information block (xSIB) or dedicated RRC signaling.

[0071] In one configuration, a transmitter (e.g., the UE or eNodeB) can repeat the transmission using a fixed number of repetitions. The fixed number of repetitions can be predefined or configured by higher layers via the xMIB, the xSIB or dedicated RRC signaling.

[0072] In one configuration, a transmitter (e.g., the UE or eNodeB) can keep sending the signal until a response is received from a receiver (e.g., the eNodeB or UE). In addition, each transmission can occupy K repetitions, and K is predefined or configured by higher layers via the xMIB, the xSIB or dedicated RRC signaling.

[0073] In one configuration, a set of dedicated xPRACH resources for mission critical communications can be multiplexed with resources for non-mission critical applications using time division multiplexing (TDM) or frequency division multiplexing (FDM) or code division multiplexing (CDM) or a combination of above. In addition, a partition configuration can be predefined or configured by higher layer via the xMIB, the xSIB or dedicated RRC signaling.

[0074] In one configuration, one or more signatures can be reserved for the xPRACH to trigger the mission critical communication.

[0075] In one configuration, one or more time resources can be reserved for the xPRACH to trigger the mission critical communication.

[0076] In one configuration, one or more frequency resources can be reserved for the xPRACH to trigger the mission critical communication.

[0077] In one configuration, one or more xPRACH signatures or time resources or frequency resources can be reserved for "single frequency network" type of operations.

[0078] In one configuration, the SR message can have a fixed size, and the SR can include at least the following parameters or fields: a mission critical machine type communication (MTC) device identifier (ID), an event ID, a mission critical MTC device capability, a resource request, and a modulation and coding scheme (MCS) for

transmission of the uplink data from the UE to the eNodeB. In addition, the resource request can include a physical resource block (PRB) index or numbers within one band, or symbol/slot/subframe/frame index or component carrier (CC) index(s) used for the transmission of the uplink data.

[0079] In one configuration, a resource for an initial transmission of the xPRACH and SR is selected by a given UE within a contention-based resource region, and resources for subsequent repeated transmissions can be configured by higher-layers (e.g.. broadcasted in the xSIB) within a contention-free resource region on a same partition or a different partition.

[0080] In one configuration, a maximum transmit power can be utilized for the transmission and retransmission of the xPRACH signal and/or SR message.

[0081] In one configuration, existing power control mechanisms can be applied for the transmission and retransmission of the xPRACH signal and/or SR message.

[0082] In one configuration, repetition level ramping can be applied for the transmission and retransmission of the xPRACH signal and/or SR message.

[0083] In one configuration, the UE (e.g., a mission critical MTC device) can monitor a random access response (RAR) message within a RAR window. A position of the RAR window can be predefined or configured by higher layers via the xMIB, the xSIB or dedicated RRC signaling.

[0084] In one configuration, a resource allocation of a secondary partition or a RAR transmission is predefined, or broadcasted in a xSIB message, or indicated in a downlink control information (DCI) format in the xPDCCH using a standard TTI in the primary partition.

[0085] In one configuration, the secondary partition can be allocated after the xPDCCH region in the primary partition using the standard TTI (e.g., 1 ms). In addition, the secondary partition can occupy a full system bandwidth.

[0086] In one configuration, the secondary partition can span a standard TTI (e.g., 1 ms). In addition, the secondary partition can occupy a full system bandwidth.

[0087] In one configuration, a preamble can be inserted prior to the transmission of the RAR message. The preamble can be based on a 5G downlink synchronization channel

(xSCH).

[0088] In one configuration, the RAR message can include the following parameters or fields: a timing advance command (TA), an uplink grant, a mission critical MTC device ID, an event ID and a random access preamble ID. The uplink grant can further include a resource allocation of the secondary partition used for a subsequent uplink transmission.

[0089] In one configuration, the RAR message can be transmitted via the xPDSCH using a short TTI. When a repeated transmission mechanism (or "keep trying" mechanism) is employed, TTI bundling and a predefined redundancy version (RV) pattern can be used for the transmission of the RAR message when turbo coding is adopted. In addition, with respect to a "single frequency network" type of operation, a scrambling seed for the transmission of the xPDSCH can be defined as a function of a random access radio network temporary identifier (RA-RNTI), a group ID or an event ID.

[0090] In one configuration, the RAR message can be transmitted via the xPDCCH. The UE (e.g., a mission critical MTC device) can monitor the xPDCCH with a cyclic redundancy check (CRC) scrambled by an RA-RNTI.

[0091] In one configuration, the RAR message can be transmitted via the xPDSCH scheduled by the xPDCCH.

[0092] In one configuration, a gap between an end of a last RAR transmission and a starting subframe of the uplink transmission can be predefined or configured by higher layers via the xMIB, the xSIB or dedicated RRC signaling. In addition, a delay parameter in the order of standard or short TTI can indicated in the UL grant of the RAR message.

[0093] In one configuration, for the uplink transmission, the same information can be transmitted on multiple component carriers (CC) simultaneously or transmitted repeatedly over multiple sets of PRBs within a CC. In one example, TTI bundling with a predefined redundancy version (RV) pattern can be employed for the uplink transmission. In another example, a scrambling seed for the transmission of the xPUSCH can be defined as a function of a mission critical MTC device ID or a group ID for a "single frequency network" type of operation.

[0094] In one configuration, a gap between an end of the uplink data transmission and a starting subframe of the ACK/NACK transmission can be predefined or configured by

higher layers via the xMIB, the xSIB or dedicated RRC signaling.

[0095] In one configuration, when a negative acknowledgement (NACK) is received or an acknowledgement (ACK) is not received, the UE (e.g., a mission critical MTC device) can perform a retransmission of the uplink data. When a maximum number of retransmission is reached, the UE can perform a random back-off and re-initiate the procedure for mission critical communication.

[0096] Another example provides functionality 900 of a user equipment (UE) operable to perform mission critical communications with an eNodeB, as shown in the flow chart in FIG. 9. The UE can comprise one or more processors and memory configured to: transmit, from the UE to the eNodeB, a physical random access channel (PRACH) signal that indicates a mission critical communication to be performed between the UE and the eNodeB, wherein the PRACH signal is transmitted using dedicated PRACH resources and in accordance with a first transmission time interval (TTI), as in block 910. The UE can comprise one or more processors and memory configured to: receive, from the eNodeB, a random access response (RAR) message that includes a timing advance (TA) and a resource allocation for the mission critical communication, wherein the RAR message is transmitted from the eNodeB using a second TTI, wherein the second TTI is associated with a time interval that is less than the first TTI, as in block 920. The UE can comprise one or more processors and memory configured to: decode, at the UE, the RAR message to determine the TA and the resource allocation for the mission critical communication, as in block 930. The UE can comprise one or more processors and memory configured to: perform, at the UE, the mission critical communication with the eNodeB in an uplink using the TA and the resource allocation indicated in the RAR message, wherein the mission critical communication is performed using a physical uplink shared channel (PUSCH) and in accordance with the second TTI, as in block 940.

[0097] Another example provides functionality 1000 of a base station operable to receive mission critical communications from a user equipment (UE), as shown in the flow chart in FIG. 10. The base station can comprise one or more processors and memory configured to: receive, from the UE, a physical random access channel (PRACH) signal that indicates a mission critical communication to be performed between the eNodeB and the UE, wherein the PRACH signal is received using dedicated PRACH resources and in

accordance with a first transmission time interval (TTI), as in block 1010. The base station can comprise one or more processors and memory configured to: transmit, to the UE, a random access response (RAR) message that includes a timing advance (TA) and a resource allocation for the mission critical communication, wherein the RAR message is transmitted from the eNodeB using a second TTI, wherein the second TTI is associated with a time interval that is less than the first TTI, as in block 1020. The base station can comprise one or more processors and memory configured to: receive, from the UE, the mission critical communication on a physical uplink shared channel (PUSCH) and in accordance with the second TTI, wherein the UE is configured to perform the mission critical communication in an uplink using the TA and the resource allocation indicated in the RAR message, as in block 1030. The base station can comprise one or more processors and memory configured to: transmit, to the UE, an acknowledgement (ACK) or a negative acknowledgement (NACK) for the mission critical communication in a physical downlink control channel (PDCCH) or a physical hybrid-ARQ indicator channel (PHICH) channel in accordance with the second TTI, as in block 1040.

[0098] Another example provides at least one machine readable storage medium having instructions 1100 embodied thereon for performing mission critical communications between a user equipment (UE) and an eNodeB, as shown in the flow chart in FIG. 11. The instructions can be executed on a machine, where the instructions are included on at least one computer readable medium or one non-transitory machine readable storage medium. The instructions when executed perform: transmitting, using at least one processor of the UE, a physical random access channel (PRACH) signal to the eNodeB that indicates a mission critical communication to be performed between the UE and the eNodeB, wherein the PRACH signal is transmitted in accordance with a first transmission time interval (TTI), as in block 1110. The instructions when executed perform: receiving, using the at least one processor of the UE, a random access response (RAR) message from the eNodeB that includes a timing advance (TA) and a resource allocation for the mission critical communication, wherein the RAR message is transmitted from the eNodeB using a second TTI, wherein the second TTI is associated with a time interval that is less than the first TTI, as in block 1120. The instructions when executed perform: performing, using the at least one processor of the UE, the mission critical communication with the eNodeB in an uplink using the TA and the resource allocation

indicated in the RAR message, wherein the mission critical communication is performed using a physical uplink shared channel (PUSCH) and in accordance with the second TTI, as in block 1130. The instructions when executed perform: receiving, using the at least one processor of the UE, an acknowledgement (ACK) or a negative acknowledgement (NACK) from the eNodeB for the mission critical communication in a physical downlink control channel (PDCCH) or a physical hybrid-ARQ indicator channel (PHICH) channel in accordance with the second TTI, as in block 1140.

[0099] FIG. 12 provides an example illustration of a user equipment (UE) device 1200, such as a wireless device, a mobile station (MS), a mobile wireless device, a mobile communication device, a tablet, a handset, or other type of wireless device. The UE device 1200 can include one or more antennas configured to communicate with a node or transmission station, such as a base station (BS), an evolved Node B (eNB), a baseband unit (BBU), a remote radio head (RRH), a remote radio equipment (RRE), a relay station (RS), a radio equipment (RE), a remote radio unit (RRU), a central processing module (CPM), or other type of wireless wide area network (WWAN) access point. The UE device 1200 can be configured to communicate using at least one wireless communication standard including 3GPP LTE, WiMAX, High Speed Packet Access (HSPA), Bluetooth, and WiFi. The UE device 1200 can communicate using separate antennas for each wireless communication standard or shared antennas for multiple wireless communication standards. The UE device 1200 can communicate in a wireless local area network (WLAN), a wireless personal area network (WPAN), and/or a WWAN.

[00100] In some embodiments, the UE device 1200 may include application circuitry 1202, baseband circuitry 1204, Radio Frequency (RF) circuitry 1206, front-end module (FEM) circuitry 1208 and one or more antennas 1210, coupled together at least as shown.

[00101] The application circuitry 1202 may include one or more application processors. For example, the application circuitry 1202 may include circuitry such as, but not limited to, one or more single-core or multi-core processors. The processor(s) may include any combination of general-purpose processors and dedicated processors (e.g., graphics processors, application processors, etc.). The processors may be coupled with and/or may include a storage medium 1212, and may be configured to execute instructions stored in the storage medium 1212 to enable various applications and/or operating systems to run on the system.

[00102] The baseband circuitry 1204 may include circuitry such as, but not limited to, one or more single-core or multi-core processors. The baseband circuitry 1204 may include one or more baseband processors and/or control logic to process baseband signals received from a receive signal path of the RF circuitry 1206 and to generate baseband signals for a transmit signal path of the RF circuitry 1206. Baseband processing circuity 1204 may interface with the application circuitry 1202 for generation and processing of the baseband signals and for controlling operations of the RF circuitry 1206. For example, in some embodiments, the baseband circuitry 1204 may include a second generation (2G) baseband processor 1204a, third generation (3G) baseband processor 1204b, fourth generation (4G) baseband processor 1204c, and/or other baseband processor(s) 1204d for other existing generations, generations in development or to be developed in the future (e.g., fifth generation (5G), 6G, etc.). The baseband circuitry 1204 (e.g., one or more of baseband processors 1204a-d) may handle various radio control functions that enable communication with one or more radio networks via the RF circuitry 1206. The radio control functions may include, but are not limited to, signal modulation/demodulation, encoding/decoding, radio frequency shifting, etc. In some embodiments, modulation/demodulation circuitry of the baseband circuitry 1204 may include Fast-Fourier Transform (FFT), precoding, and/or constellation mapping/demapping functionality. In some embodiments, encoding/decoding circuitry of the baseband circuitry 1204 may include convolution, tail-biting convolution, turbo, Viterbi, and/or Low Density Parity Check (LDPC) encoder/decoder functionality. Embodiments of modulation/demodulation and encoder/decoder functionality are not limited to these examples and may include other suitable functionality in other embodiments.

[00103] In some embodiments, the baseband circuitry 1204 may include elements of a protocol stack such as, for example, elements of an evolved universal terrestrial radio access network (EUTRAN) protocol including, for example, physical (PHY), media access control (MAC), radio link control (RLC), packet data convergence protocol (PDCP), and/or radio resource control (RRC) elements. A central processing unit (CPU) 1204e of the baseband circuitry 1204 may be configured to run elements of the protocol stack for signaling of the PHY, MAC, RLC, PDCP and/or RRC layers. In some embodiments, the baseband circuitry may include one or more audio digital signal

processor(s) (DSP) 1204f. The audio DSP(s) 104f may be include elements for compression/decompression and echo cancellation and may include other suitable processing elements in other embodiments. Components of the baseband circuitry may be suitably combined in a single chip, a single chipset, or disposed on a same circuit board in some embodiments. In some embodiments, some or all of the constituent components of the baseband circuitry 1204 and the application circuitry 1202 may be implemented together such as, for example, on a system on a chip (SOC).

[00104] In some embodiments, the baseband circuitry 1204 may provide for communication compatible with one or more radio technologies. For example, in some embodiments, the baseband circuitry 1204 may support communication with an evolved universal terrestrial radio access network (EUTRAN) and/or other wireless metropolitan area networks (WMAN), a wireless local area network (WLAN), a wireless personal area network (WPAN). Embodiments in which the baseband circuitry 1204 is configured to support radio communications of more than one wireless protocol may be referred to as multi-mode baseband circuitry.

[00105] The RF circuitry 1206 may enable communication with wireless networks using modulated electromagnetic radiation through a non-solid medium. In various embodiments, the RF circuitry 1206 may include switches, filters, amplifiers, etc. to facilitate the communication with the wireless network. RF circuitry 1206 may include a receive signal path which may include circuitry to down-convert RF signals received from the FEM circuitry 1208 and provide baseband signals to the baseband circuitry 1204. RF circuitry 1206 may also include a transmit signal path which may include circuitry to up-convert baseband signals provided by the baseband circuitry 1204 and provide RF output signals to the FEM circuitry 1208 for transmission.

[00106] In some embodiments, the RF circuitry 1206 may include a receive signal path and a transmit signal path. The receive signal path of the RF circuitry 1206 may include mixer circuitry 1206a, amplifier circuitry 1206b and filter circuitry 1206c. The transmit signal path of the RF circuitry 1206 may include filter circuitry 1206c and mixer circuitry 1206a. RF circuitry 1206 may also include synthesizer circuitry 1206d for synthesizing a frequency for use by the mixer circuitry 1206a of the receive signal path and the transmit signal path. In some embodiments, the mixer circuitry 1206a of the receive signal path

may be configured to down-convert RF signals received from the FEM circuitry 1208 based on the synthesized frequency provided by synthesizer circuitry 1206d. The amplifier circuitry 1206b may be configured to amplify the down-converted signals and the filter circuitry 1206c may be a low-pass filter (LPF) or band-pass filter (BPF) configured to remove unwanted signals from the down-converted signals to generate output baseband signals. Output baseband signals may be provided to the baseband circuitry 1204 for further processing. In some embodiments, the output baseband signals may be zero-frequency baseband signals, although this is not a requirement. In some embodiments, mixer circuitry 1206a of the receive signal path may comprise passive mixers, although the scope of the embodiments is not limited in this respect.

[00107] In some embodiments, the mixer circuitry 1206a of the transmit signal path may be configured to up-convert input baseband signals based on the synthesized frequency provided by the synthesizer circuitry 1206d to generate RF output signals for the FEM circuitry 1208. The baseband signals may be provided by the baseband circuitry 1204 and may be filtered by filter circuitry 1206c. The filter circuitry 1206c may include a low-pass filter (LPF), although the scope of the embodiments is not limited in this respect.

[00108] In some embodiments, the mixer circuitry 1206a of the receive signal path and the mixer circuitry 1206a of the transmit signal path may include two or more mixers and may be arranged for quadrature down-conversion and/or up-conversion respectively. In some embodiments, the mixer circuitry 1206a of the receive signal path and the mixer circuitry 1206a of the transmit signal path may include two or more mixers and may be arranged for image rejection (e.g., Hartley image rejection). In some embodiments, the mixer circuitry 1206a of the receive signal path and the mixer circuitry 1206a may be arranged for direct down-conversion and/or direct up-conversion, respectively. In some embodiments, the mixer circuitry 1206a of the receive signal path and the mixer circuitry 1206a of the transmit signal path may be configured for super-heterodyne operation.

[00109] In some embodiments, the output baseband signals and the input baseband signals may be analog baseband signals, although the scope of the embodiments is not limited in this respect. In some alternate embodiments, the output baseband signals and the input baseband signals may be digital baseband signals. In these alternate embodiments, the RF circuitry 1206 may include analog-to-digital converter (ADC) and digital-to-analog

converter (DAC) circuitry and the baseband circuitry 1204 may include a digital baseband interface to communicate with the RF circuitry 1206.

[00110] In some dual-mode embodiments, a separate radio IC circuitry may be provided for processing signals for each spectrum, although the scope of the embodiments is not limited in this respect.

[00111] In some embodiments, the synthesizer circuitry 1206d may be a fractional-N synthesizer or a fractional N/N+1 synthesizer, although the scope of the embodiments is not limited in this respect as other types of frequency synthesizers may be suitable. For example, synthesizer circuitry 1206d may be a delta-sigma synthesizer, a frequency multiplier, or a synthesizer comprising a phase-locked loop with a frequency divider.

[00112] The synthesizer circuitry 1206d may be configured to synthesize an output frequency for use by the mixer circuitry 1206a of the RF circuitry 1206 based on a frequency input and a divider control input. In some embodiments, the synthesizer circuitry 1206d may be a fractional N/N+1 synthesizer.

[00113] In some embodiments, frequency input may be provided by a voltage controlled oscillator (VCO), although that is not a requirement. Divider control input may be provided by either the baseband circuitry 1204 or the applications processor 1202 depending on the desired output frequency. In some embodiments, a divider control input (e.g., N) may be determined from a look-up table based on a channel indicated by the applications processor 1202.

[00114] Synthesizer circuitry 1206d of the RF circuitry 1206 may include a divider, a delay-locked loop (DLL), a multiplexer and a phase accumulator. In some embodiments, the divider may be a dual modulus divider (DMD) and the phase accumulator may be a digital phase accumulator (DPA). In some embodiments, the DMD may be configured to divide the input signal by either N or N+1 (e.g., based on a carry out) to provide a fractional division ratio. In some example embodiments, the DLL may include a set of cascaded, tunable, delay elements, a phase detector, a charge pump and a D-type flip-flop. In these embodiments, the delay elements may be configured to break a VCO period up into Nd equal packets of phase, where Nd is the number of delay elements in the delay line. In this way, the DLL provides negative feedback to help ensure that the total delay through the delay line is one VCO cycle.

[00115] In some embodiments, synthesizer circuitry 1206d may be configured to generate a carrier frequency as the output frequency, while in other embodiments, the output frequency may be a multiple of the carrier frequency (e.g., twice the carrier frequency, four times the carrier frequency) and used in conjunction with quadrature generator and divider circuitry to generate multiple signals at the carrier frequency with multiple different phases with respect to each other. In some embodiments, the output frequency may be a LO frequency (fLO). In some embodiments, the RF circuitry 1206 may include an IQ/polar converter.

[00116] FEM circuitry 1208 may include a receive signal path which may include circuitry configured to operate on RF signals received from one or more antennas 1210, amplify the received signals and provide the amplified versions of the received signals to the RF circuitry 1206 for further processing. FEM circuitry 1208 may also include a transmit signal path which may include circuitry configured to amplify signals for transmission provided by the RF circuitry 1206 for transmission by one or more of the one or more antennas 1210.

[00117] In some embodiments, the FEM circuitry 1208 may include a TX/RX switch to switch between transmit mode and receive mode operation. The FEM circuitry may include a receive signal path and a transmit signal path. The receive signal path of the FEM circuitry may include a low-noise amplifier (LNA) to amplify received RF signals and provide the amplified received RF signals as an output (e.g., to the RF circuitry 1206). The transmit signal path of the FEM circuitry 1208 may include a power amplifier (PA) to amplify input RF signals (e.g., provided by RF circuitry 1206), and one or more filters to generate RF signals for subsequent transmission (e.g., by one or more of the one or more antennas 1210.

[00118] FIG. 13 provides an example illustration of the wireless device, such as a user equipment (UE), a mobile station (MS), a mobile wireless device, a mobile communication device, a tablet, a handset, or other type of wireless device. The wireless device can include one or more antennas configured to communicate with a node, macro node, low power node (LPN), or, transmission station, such as a base station (BS), an evolved Node B (eNB), a baseband processing unit (BBU), a remote radio head (RRH), a remote radio equipment (RRE), a relay station (RS), a radio equipment (RE), or other

type of wireless wide area network (WWAN) access point. The wireless device can be configured to communicate using at least one wireless communication standard such as, but not limited to, 3GPP LTE, WiMAX, High Speed Packet Access (HSPA), Bluetooth, and WiFi. The wireless device can communicate using separate antennas for each wireless communication standard or shared antennas for multiple wireless communication standards. The wireless device can communicate in a wireless local area network (WLAN), a wireless personal area network (WPAN), and/or a WWAN. The wireless device can also comprise a wireless modem. The wireless modem can comprise, for example, a wireless radio transceiver and baseband circuitry (e.g., a baseband processor). The wireless modem can, in one example, modulate signals that the wireless device transmits via the one or more antennas and demodulate signals that the wireless device receives via the one or more antennas.

[00119] FIG. 13 also provides an illustration of a microphone and one or more speakers that can be used for audio input and output from the wireless device. The display screen can be a liquid crystal display (LCD) screen, or other type of display screen such as an organic light emitting diode (OLED) display. The display screen can be configured as a touch screen. The touch screen can use capacitive, resistive, or another type of touch screen technology. An application processor and a graphics processor can be coupled to internal memory to provide processing and display capabilities. A non-volatile memory port can also be used to provide data input/output options to a user. The non-volatile memory port can also be used to expand the memory capabilities of the wireless device. A keyboard can be integrated with the wireless device or wirelessly connected to the wireless device to provide additional user input. A virtual keyboard can also be provided using the touch screen.

Examples

[00120] The following examples pertain to specific technology embodiments and point out specific features, elements, or actions that can be used or otherwise combined in achieving such embodiments.

[00121] Example 1 includes an apparatus of a user equipment (UE) operable to perform mission critical communications with an eNodeB, the apparatus comprising one or more processors and memory configured to: transmit, from the UE to the eNodeB, a physical

random access channel (PRACH) signal that indicates a mission critical communication to be performed between the UE and the eNodeB, wherein the PRACH signal is transmitted using dedicated PRACH resources and in accordance with a first transmission time interval (TTI); receive, from the eNodeB, a random access response (RAR) message that includes a timing advance (TA) and a resource allocation for the mission critical communication, wherein the RAR message is transmitted from the eNodeB using a second TTI, wherein the second TTI is associated with a time interval that is less than the first TTI; decode, at the UE, the RAR message to determine the TA and the resource allocation for the mission critical communication; and perform, at the UE, the mission critical communication with the eNodeB in an uplink using the TA and the resource allocation indicated in the RAR message, wherein the mission critical communication is performed using a physical uplink shared channel (PUSCH) and in accordance with the second TTI.

[00122] Example 2 includes the apparatus of Example 1, further configured to receive, from the eNodeB, an acknowledgement (ACK) or a negative acknowledgement (NACK) for the mission critical communication in a physical downlink control channel (PDCCH) or a physical hybrid-ARQ indicator channel (PHICH) channel in accordance with the second TTI.

[00123] Example 3 includes the apparatus of any of Examples 1-2, wherein the first TTI is for a Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) Release 8 orthogonal frequency division multiple access (OFDMA) frame structure and is approximately one millisecond (ms) and the second TTI is approximately 0.1 to 0.2 ms.

[00124] Example 4 includes the apparatus of any of Examples 1-3, wherein the first TTI is associated with a first partition of a low band and the second TTI is associated with a second partition of a low band, wherein the first partition is utilized for non-mission critical communications and the second partition is utilized for mission critical communications.

[00125] Example 5 includes the apparatus of any of Examples 1-4, wherein the UE is configured to: perform repeated transmissions of the PRACH signal to the eNodeB until the RAR message is received from the eNodeB; and perform repeated mission critical communications with the eNodeB until an acknowledgement (ACK) or a negative

acknowledgement (NACK) is received from the eNodeB, wherein a maximum number of repetitions for each transmission from the UE is predefined or configured by higher layers via one of: a master information block (MIB), a system information block (SIB) or dedicated radio resource control (RRC) signaling, wherein the UE performs a random back off and reinitiates a procedure for performing the mission critical communication when the maximum number of repetitions for a defined transmission is reached.

[00126] Example 6 includes the apparatus of any of Examples 1-5, wherein the UE is configured to: repeatedly transmit the PRACH signal to the eNodeB in accordance with a fixed number of repetitions; and repeatedly perform the mission critical communication with the eNodeB in accordance with a fixed number of repetitions, wherein the fixed number of repetitions for each transmission from the UE is predefined or configured by higher layers via one of: a master information block (MIB), a system information block (SIB) or dedicated radio resource control (RRC) signaling.

[00127] Example 7 includes the apparatus of any of Examples 1-6, wherein the dedicated PRACH resources for mission critical communications are multiplexed with PRACH resources for non-mission critical application using at least one of: time division multiplexing (TDM), frequency division multiplexing (FDM) and code division multiplexing (CDM).

[00128] Example 8 includes the apparatus of any of Examples 1-7, wherein a plurality of signatures, time resources and frequency resources are reserved for transmitting the PRACH signal from the UE to trigger the mission critical communication.

[00129] Example 9 includes the apparatus of any of Examples 1-8, wherein the PRACH signal is communicated to the eNodeB with a scheduling request (SR), wherein the SR includes at least one of: a mission critical machine type communication (MTC) device identifier (ID), an event ID, a mission critical MTC device capability, and a resource request and a modulation and coding scheme (MCS) for the mission critical communication in uplink from the UE.

[00130] Example 10 includes the apparatus of any of Examples 1-9, wherein the PRACH signal is transmitted from the UE to the eNodeB in accordance with a maximum transmit power.

[00131] Example 11 includes the apparatus of any of Examples 1-10, wherein the UE is

configured to receive the RAR message from the eNodeB by monitoring a RAR message window, wherein a position of the RAR message window is configured by higher layers via one of: a master information block (MIB), a system information block (SIB) or dedicated radio resource control (RRC) signaling.

[00132] Example 12 includes the apparatus of any of Examples 1-11, further configured to receive a preamble from the eNodeB prior to receiving the RAR message, wherein the preamble functions to improve a downlink synchronization accuracy.

[00133] Example 13 includes the apparatus of any of Examples 1-12, wherein the RAR message received at the UE includes at least one of: the timing advance (TA), an uplink grant that contains the resource allocation for the mission critical communication, a mission critical machine type communication (MTC) device identifier (ID), an event ID, and a random access preamble ID.

[00134] Example 14 includes the apparatus of any of Examples 1-13, wherein: the RAR message is received at the UE via a physical downlink control channel (PDCCH), wherein the UE is configured to monitor the PDCCH using a cyclic redundancy check (CRC) scrambled by a random-access radio network temporary identifier (RA-RNTI); or the RAR message is received at the UE via a physical downlink shared channel (PDSCH) that is scheduled by the PDCCH.

[00135] Example 15 includes the apparatus of any of Examples 1-14, wherein: a gap between a last subframe for a RAR message transmission and a starting subframe of the mission critical communication in uplink is predefined or configured by higher layers via one of: a master information block (MIB), a system information block (SIB) or dedicated radio resource control (RRC) signaling; and a gap between a last subframe of the mission critical communication in uplink and a starting subframe of an acknowledgement (ACK) or a negative acknowledgement (NACK) transmission is predefined or configured by higher layers via one of: the MIB, the SIB, or dedicated RRC signaling.

[00136] Example 16 includes the apparatus of any of Examples 1-15, wherein the UE includes at least one of an antenna, a touch sensitive display screen, a speaker, a microphone, a graphics processor, an application processor, a baseband processor, an internal memory, a non-volatile memory port, and combinations thereof.

[00137] Example 17 includes an apparatus of a base station operable to receive mission

critical communications from a user equipment (UE), the apparatus comprising one or more processors and memory configured to: receive, from the UE, a physical random access channel (PRACH) signal that indicates a mission critical communication to be performed between the eNodeB and the UE, wherein the PRACH signal is received using dedicated PRACH resources and in accordance with a first transmission time interval (TTI); transmit, to the UE, a random access response (RAR) message that includes a timing advance (TA) and a resource allocation for the mission critical communication, wherein the RAR message is transmitted from the eNodeB using a second TTI, wherein the second TTI is associated with a time interval that is less than the first TTI; receive, from the UE, the mission critical communication on a physical uplink shared channel (PUSCH) and in accordance with the second TTI, wherein the UE is configured to perform the mission critical communication in an uplink using the TA and the resource allocation indicated in the RAR message; and transmit, to the UE, an acknowledgement (ACK) or a negative acknowledgement (NACK) for the mission critical communication in a physical downlink control channel (PDCCH) or a physical hybrid-ARQ indicator channel (PHICH) channel in accordance with the second TTI.

[00138] Example 18 includes the apparatus of Example 17, wherein the first TTI is for a Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) Release 8 orthogonal frequency division multiple access (OFDMA) frame structure and is approximately one millisecond (ms) and is associated with a first partition of a low band, wherein the second TTI is approximately 0.1 to 0.2 ms and is associated with a second partition of a low band, wherein the first partition is utilized for non-mission critical communications and the second partition is utilized for mission critical communications.

[00139] Example 19 includes the apparatus of any of Examples 17-18, wherein the dedicated PRACH resources for mission critical communications are multiplexed with PRACH resources for non-mission critical application using at least one of: time division multiplexing (TDM), frequency division multiplexing (FDM) and code division multiplexing (CDM).

[00140] Example 20 includes the apparatus of any of Examples 17-19, wherein: the PRACH signal is received from the UE with a scheduling request (SR), wherein the SR includes at least one of: a mission critical machine type communication (MTC) device

identifier (ID), an event ID, a mission critical MTC device capability, and a resource request and a modulation and coding scheme (MCS) for the mission critical communication in uplink from the UE; and the RAR message transmitted to the UE includes at least one of: the timing advance (TA), an uplink grant that contains the resource allocation for the mission critical communication, a mission critical machine type communication (MTC) device identifier (ID), an event ID, and a random access preamble ID.

[00141] Example 21 includes the apparatus of any of Examples 17-20, wherein the RAR message is transmitted to the UE via a physical downlink control channel (PDCCH) or a physical downlink shared channel (PDSCH).

[00142] Example 22 includes at least one machine readable storage medium having instructions embodied thereon for performing mission critical communications between a user equipment (UE) and an eNodeB, the instructions when executed perform the following: transmitting, using at least one processor of the UE, a physical random access channel (PRACH) signal to the eNodeB that indicates a mission critical communication to be performed between the UE and the eNodeB, wherein the PRACH signal is transmitted in accordance with a first transmission time interval (TTI); receiving, using the at least one processor of the UE, a random access response (RAR) message from the eNodeB that includes a timing advance (TA) and a resource allocation for the mission critical communication, wherein the RAR message is transmitted from the eNodeB using a second TTI, wherein the second TTI is associated with a time interval that is less than the first TTI; performing, using the at least one processor of the UE, the mission critical communication with the eNodeB in an uplink using the TA and the resource allocation indicated in the RAR message, wherein the mission critical communication is performed using a physical uplink shared channel (PUSCH) and in accordance with the second TTI; and receiving, using the at least one processor of the UE, an acknowledgement (ACK) or a negative acknowledgement (NACK) from the eNodeB for the mission critical communication in a physical downlink control channel (PDCCH) or a physical hybrid-ARQ indicator channel (PHICH) channel in accordance with the second TTI.

[00143] Example 23 includes the at least one machine readable storage medium of Example 22, wherein the UE is configured to initiate performance of the mission critical

communication when in a radio resource control (RRC) idle mode.

[00144] Example 24 includes the at least one machine readable storage medium of any of Examples 22-23, wherein the first TTI is approximately one millisecond (ms) and is associated with a first partition of a low band, wherein the second TTI is approximately 0.1 to 0.2 ms and is associated with a second partition of a low band, wherein the first partition is utilized for non-mission critical communications and the second partition is utilized for mission critical communications.

[00145] Example 25 includes the at least one machine readable storage medium of any of Examples 22-24, further comprising instructions which when executed perform the following: performing repeated transmissions of the repeatedly transmit the PRACH signal to the eNodeB until the RAR message is received from the eNodeB; and performing repeated mission critical communications with the eNodeB until an acknowledgement (ACK) or a negative acknowledgement (NACK) is received from the eNodeB.

[00146] Various techniques, or certain aspects or portions thereof, may take the form of program code (i.e., instructions) embodied in tangible media, such as floppy diskettes, compact disc-read-only memory (CD-ROMs), hard drives, non-transitory computer readable storage medium, or any other machine-readable storage medium wherein, when the program code is loaded into and executed by a machine, such as a computer, the machine becomes an apparatus for practicing the various techniques. A non-transitory computer readable storage medium can be a computer readable storage medium that does not include signal. In the case of program code execution on programmable computers, the computing device may include a processor, a storage medium readable by the processor (including volatile and non-volatile memory and/or storage elements), at least one input device, and at least one output device. The volatile and non-volatile memory and/or storage elements may be a random-access memory (RAM), erasable programmable read only memory (EPROM), flash drive, optical drive, magnetic hard drive, solid state drive, or other medium for storing electronic data. The node and wireless device may also include a transceiver module (i.e., transceiver), a counter module (i.e., counter), a processing module (i.e., processor), and/or a clock module (i.e., clock) or timer module (i.e., timer). One or more programs that may implement or utilize

the various techniques described herein may use an application programming interface (API), reusable controls, and the like. Such programs may be implemented in a high level procedural or object oriented programming language to communicate with a computer system. However, the program(s) may be implemented in assembly or machine language, if desired. In any case, the language may be a compiled or interpreted language, and combined with hardware implementations.

[00147] As used herein, the term "circuitry" may refer to, be part of, or include an Application Specific Integrated Circuit (ASIC), an electronic circuit, a processor (shared, dedicated, or group), and/or memory (shared, dedicated, or group) that execute one or more software or firmware programs, a combinational logic circuit, and/or other suitable hardware components that provide the described functionality. In some embodiments, the circuitry may be implemented in, or functions associated with the circuitry may be implemented by, one or more software or firmware modules. In some embodiments, circuitry may include logic, at least partially operable in hardware.

[00148] It should be understood that many of the functional units described in this specification have been labeled as modules, in order to more particularly emphasize their implementation independence. For example, a module may be implemented as a hardware circuit comprising custom very-large-scale integration (VLSI) circuits or gate arrays, off-the-shelf semiconductors such as logic chips, transistors, or other discrete components. A module may also be implemented in programmable hardware devices such as field programmable gate arrays, programmable array logic, programmable logic devices or the like.

[00149] Modules may also be implemented in software for execution by various types of processors. An identified module of executable code may, for instance, comprise one or more physical or logical blocks of computer instructions, which may, for instance, be organized as an object, procedure, or function. Nevertheless, the executables of an identified module may not be physically located together, but may comprise disparate instructions stored in different locations which, when joined logically together, comprise the module and achieve the stated purpose for the module.

[00150] Indeed, a module of executable code may be a single instruction, or many instructions, and may even be distributed over several different code segments, among

different programs, and across several memory devices. Similarly, operational data may be identified and illustrated herein within modules, and may be embodied in any suitable form and organized within any suitable type of data structure. The operational data may be collected as a single data set, or may be distributed over different locations including over different storage devices, and may exist, at least partially, merely as electronic signals on a system or network. The modules may be passive or active, including agents operable to perform desired functions.

[00151] Reference throughout this specification to "an example" or “exemplary” means that a particular feature, structure, or characteristic described in connection with the example is included in at least one embodiment of the present technology. Thus, appearances of the phrases "in an example" or the word “exemplary” in various places throughout this specification are not necessarily all referring to the same embodiment.

[00152] As used herein, a plurality of items, structural elements, compositional elements, and/or materials may be presented in a common list for convenience. However, these lists should be construed as though each member of the list is individually identified as a separate and unique member. Thus, no individual member of such list should be construed as a de facto equivalent of any other member of the same list solely based on their presentation in a common group without indications to the contrary. In addition, various embodiments and example of the present technology may be referred to herein along with alternatives for the various components thereof. It is understood that such embodiments, examples, and alternatives are not to be construed as defacto equivalents of one another, but are to be considered as separate and autonomous representations of the present technology.

[00153] Furthermore, the described features, structures, or characteristics may be combined in any suitable manner in one or more embodiments. In the following description, numerous specific details are provided, such as examples of layouts, distances, network examples, etc., to provide a thorough understanding of embodiments of the technology. One skilled in the relevant art will recognize, however, that the technology can be practiced without one or more of the specific details, or with other methods, components, layouts, etc. In other instances, well-known structures, materials, or operations are not shown or described in detail to avoid obscuring aspects of the

technology.

[00154] While the forgoing examples are illustrative of the principles of the present technology in one or more particular applications, it will be apparent to those of ordinary skill in the art that numerous modifications in form, usage and details of implementation can be made without the exercise of inventive faculty, and without departing from the principles and concepts of the technology. Accordingly, it is not intended that the technology be limited, except as by the claims set forth below.

CLAIMS

What is claimed is:

1. An apparatus of a user equipment (UE) operable to perform mission critical communications with an eNodeB, the apparatus comprising one or more processors and memory configured to:

transmit, from the UE to the eNodeB, a physical random access channel (PRACH) signal that indicates a mission critical communication to be performed between the UE and the eNodeB, wherein the PRACH signal is transmitted using dedicated PRACH resources and in accordance with a first transmission time interval (TTI);

receive, from the eNodeB, a random access response (RAR) message that includes a timing advance (TA) and a resource allocation for the mission critical communication, wherein the RAR message is transmitted from the eNodeB using a second TTI, wherein the second TTI is associated with a time interval that is less than the first TTI;

decode, at the UE, the RAR message to determine the TA and the resource allocation for the mission critical communication; and

perform, at the UE, the mission critical communication with the eNodeB in an uplink using the TA and the resource allocation indicated in the RAR message, wherein the mission critical communication is performed using a physical uplink shared channel (PUSCH) and in accordance with the second TTI.

2. The apparatus of claim 1, further configured to receive, from the eNodeB, an acknowledgement (ACK) or a negative acknowledgement (NACK) for the mission critical communication in a physical downlink control channel (PDCCH) or a physical hybrid-ARQ indicator channel (PHICH) channel in accordance with the second TTI.

3. The apparatus of claim 1, wherein the first TTI is for a Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) Release 8 orthogonal frequency division multiple access (OFDMA) frame structure and is approximately one millisecond (ms) and the second TTI is approximately 0.1 to

0.2 ms.

4. The apparatus of claim 1, wherein the first TTI is associated with a first partition of a low band and the second TTI is associated with a second partition of a low band, wherein the first partition is utilized for non-mission critical communications and the second partition is utilized for mission critical communications.

5. The apparatus of any of claims 1 to 4, wherein the UE is configured to:

perform repeated transmissions of the PRACH signal to the eNodeB until the RAR message is received from the eNodeB; and

perform repeated mission critical communications with the eNodeB until an acknowledgement (ACK) or a negative acknowledgement (NACK) is received from the eNodeB,

wherein a maximum number of repetitions for each transmission from the UE is predefined or configured by higher layers via one of: a master information block (MIB), a system information block (SIB) or dedicated radio resource control (RRC) signaling,

wherein the UE performs a random back off and reinitiates a procedure for performing the mission critical communication when the maximum number of repetitions for a defined transmission is reached.

6. The apparatus of claim 1, wherein the UE is configured to:

repeatedly transmit the PRACH signal to the eNodeB in accordance with a fixed number of repetitions; and

repeatedly perform the mission critical communication with the eNodeB in accordance with a fixed number of repetitions,

wherein the fixed number of repetitions for each transmission from the UE is predefined or configured by higher layers via one of: a master information block (MIB), a system information block (SIB) or dedicated radio resource control (RRC) signaling.

7. The apparatus of claim 1, wherein the dedicated PRACH resources for mission critical communications are multiplexed with PRACH resources for non-mission critical application using at least one of: time division multiplexing (TDM), frequency division multiplexing (FDM) and code division multiplexing (CDM).

8. The apparatus of claim 1, wherein a plurality of signatures, time resources and frequency resources are reserved for transmitting the PRACH signal from the UE to trigger the mission critical communication.

9. The apparatus of claim 1, wherein the PRACH signal is communicated to the eNodeB with a scheduling request (SR), wherein the SR includes at least one of: a mission critical machine type communication (MTC) device identifier (ID), an event ID, a mission critical MTC device capability, and a resource request and a modulation and coding scheme (MCS) for the mission critical communication in uplink from the UE.

10. The apparatus of claim 1, wherein the PRACH signal is transmitted from the UE to the eNodeB in accordance with a maximum transmit power.

11. The apparatus of claim 1, wherein the UE is configured to receive the RAR message from the eNodeB by monitoring a RAR message window, wherein a position of the RAR message window is configured by higher layers via one of: a master information block (MIB), a system information block (SIB) or dedicated radio resource control (RRC) signaling.

12. The apparatus of claim 1, further configured to receive a preamble from the eNodeB prior to receiving the RAR message, wherein the preamble functions to improve a downlink synchronization accuracy.

13. The apparatus of claim 1, wherein the RAR message received at the UE includes at least one of: the timing advance (TA), an uplink grant that contains the resource allocation for the mission critical communication, a mission critical machine type

communication (MTC) device identifier (ID), an event ID, and a random access preamble ID.

14. The apparatus of claim 1, wherein:

the RAR message is received at the UE via a physical downlink control channel (PDCCH), wherein the UE is configured to monitor the PDCCH using a cyclic redundancy check (CRC) scrambled by a random-access radio network temporary identifier (RA-RNTI); or

the RAR message is received at the UE via a physical downlink shared channel (PDSCH) that is scheduled by the PDCCH.

15. The apparatus of any of claims 6 to 14, wherein:

a gap between a last subframe for a RAR message transmission and a starting subframe of the mission critical communication in uplink is predefined or configured by higher layers via one of: a master information block (MIB), a system information block (SIB) or dedicated radio resource control (RRC) signaling; and

a gap between a last subframe of the mission critical communication in uplink and a starting subframe of an acknowledgement (ACK) or a negative acknowledgement (NACK) transmission is predefined or configured by higher layers via one of: the MIB, the SIB, or dedicated RRC signaling.

16. The apparatus of claim 1, wherein the UE includes at least one of an antenna, a touch sensitive display screen, a speaker, a microphone, a graphics processor, an application processor, a baseband processor, an internal memory, a non-volatile memory port, and combinations thereof.

17. An apparatus of a base station operable to receive mission critical communications from a user equipment (UE), the apparatus comprising one or more processors and memory configured to:

receive, from the UE, a physical random access channel (PRACH) signal that indicates a mission critical communication to be performed between the

eNodeB and the UE, wherein the PRACH signal is received using dedicated PRACH resources and in accordance with a first transmission time interval (TTI);

transmit, to the UE, a random access response (RAR) message that includes a timing advance (TA) and a resource allocation for the mission critical communication, wherein the RAR message is transmitted from the eNodeB using a second TTI, wherein the second TTI is associated with a time interval that is less than the first TTI;

receive, from the UE, the mission critical communication on a physical uplink shared channel (PUSCH) and in accordance with the second TTI, wherein the UE is configured to perform the mission critical communication in an uplink using the TA and the resource allocation indicated in the RAR message; and

transmit, to the UE, an acknowledgement (ACK) or a negative acknowledgement (NACK) for the mission critical communication in a physical downlink control channel (PDCCH) or a physical hybrid-ARQ indicator channel (PHICH) channel in accordance with the second TTI.

18. The apparatus of claim 17, wherein the first TTI is for a Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) Release 8 orthogonal frequency division multiple access (OFDMA) frame structure and is approximately one millisecond (ms) and is associated with a first partition of a low band, wherein the second TTI is approximately 0.1 to 0.2 ms and is associated with a second partition of a low band, wherein the first partition is utilized for non-mission critical communications and the second partition is utilized for mission critical communications.

19. The apparatus of claim 17, wherein the dedicated PRACH resources for mission critical communications are multiplexed with PRACH resources for non-mission critical application using at least one of: time division multiplexing (TDM), frequency division multiplexing (FDM) and code division multiplexing (CDM).

20. The apparatus of any of claims 17 to 19, wherein:

the PRACH signal is received from the UE with a scheduling request (SR),

wherein the SR includes at least one of: a mission critical machine type communication (MTC) device identifier (ID), an event ID, a mission critical MTC device capability, and a resource request and a modulation and coding scheme (MCS) for the mission critical communication in uplink from the UE; and

the RAR message transmitted to the UE includes at least one of: the timing advance (TA), an uplink grant that contains the resource allocation for the mission critical communication, a mission critical machine type communication (MTC) device identifier (ID), an event ID, and a random access preamble ID.

21. The apparatus of claim 17, wherein the RAR message is transmitted to the UE via a physical downlink control channel (PDCCH) or a physical downlink shared channel (PDSCH).

22. At least one machine readable storage medium having instructions embodied thereon for performing mission critical communications between a user equipment (UE) and an eNodeB, the instructions when executed perform the following:

transmitting, using at least one processor of the UE, a physical random access channel (PRACH) signal to the eNodeB that indicates a mission critical communication to be performed between the UE and the eNodeB, wherein the PRACH signal is transmitted in accordance with a first transmission time interval (TTI);

receiving, using the at least one processor of the UE, a random access response (RAR) message from the eNodeB that includes a timing advance (TA) and a resource allocation for the mission critical communication, wherein the RAR message is transmitted from the eNodeB using a second TTI, wherein the second TTI is associated with a time interval that is less than the first TTI;

performing, using the at least one processor of the UE, the mission critical communication with the eNodeB in an uplink using the TA and the resource allocation indicated in the RAR message, wherein the mission critical communication is performed using a physical uplink shared channel (PUSCH) and in accordance with the second TTI; and

receiving, using the at least one processor of the UE, an acknowledgement

(ACK) or a negative acknowledgement (NACK) from the eNodeB for the mission critical communication in a physical downlink control channel (PDCCH) or a physical hybrid-ARQ indicator channel (PHICH) channel in accordance with the second TTI.

23. The at least one machine readable storage medium of claim 22, wherein the UE is configured to initiate performance of the mission critical communication when in a radio resource control (RRC) idle mode.

24. The at least one machine readable storage medium of claim 22, wherein the first TTI is approximately one millisecond (ms) and is associated with a first partition of a low band, wherein the second TTI is approximately 0.1 to 0.2 ms and is associated with a second partition of a low band, wherein the first partition is utilized for non-mission critical communications and the second partition is utilized for mission critical communications.

25. The at least one machine readable storage medium of any of claims 22 to 24, further comprising instructions which when executed perform the following:

performing repeated transmissions of the PRACH signal to the eNodeB until the RAR message is received from the eNodeB; and

performing repeated mission critical communications with the eNodeB until an acknowledgement (ACK) or a negative acknowledgement (NACK) is received from the eNodeB.

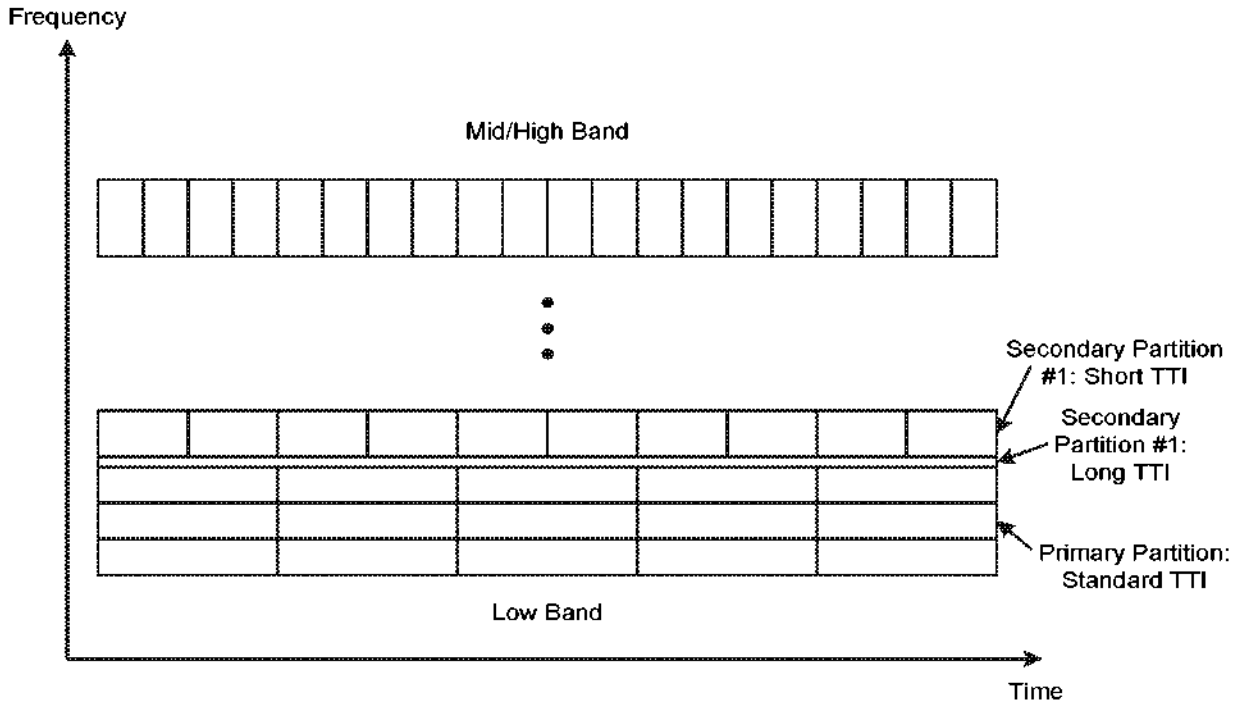

Frequency
Mid/High Band
Secondary Partition #1: Short TTI
Secondary Partition #1: Long TTI
Primary Partition: Standard TTI
Low Band
Time

FIG. 1

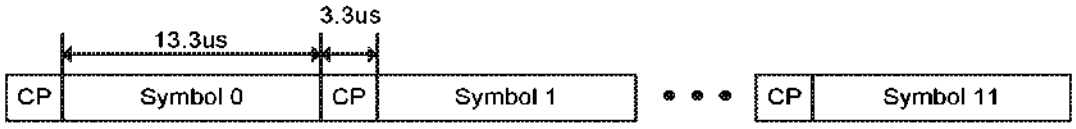

3.3us
13.3us
CP
Symbol 0
CP
Symbol 1
CP
Symbol 11

FIG. 2

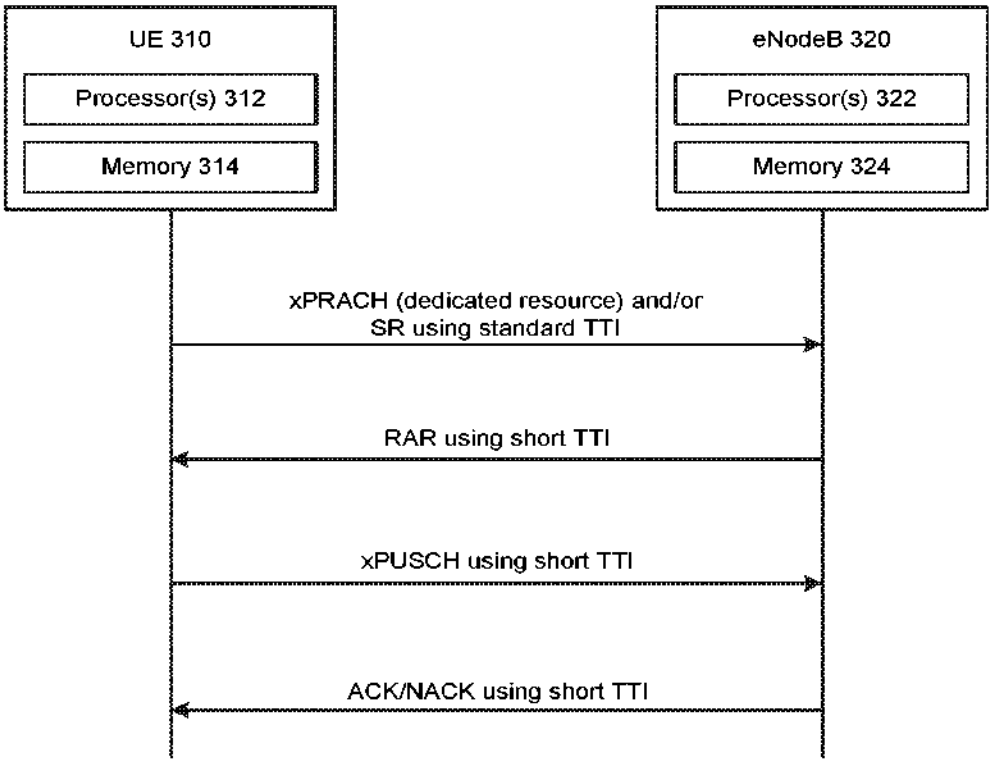

UE 310
Processor(s) 312
Memory 314
eNodeB 320
Processor(s) 322
Memory 324
xPRACH (dedicated resource) and/or
SR using standard TTI
RAR using short TTI
xPUSCH using short TTI
ACK/NACK using short TTI

FIG. 3

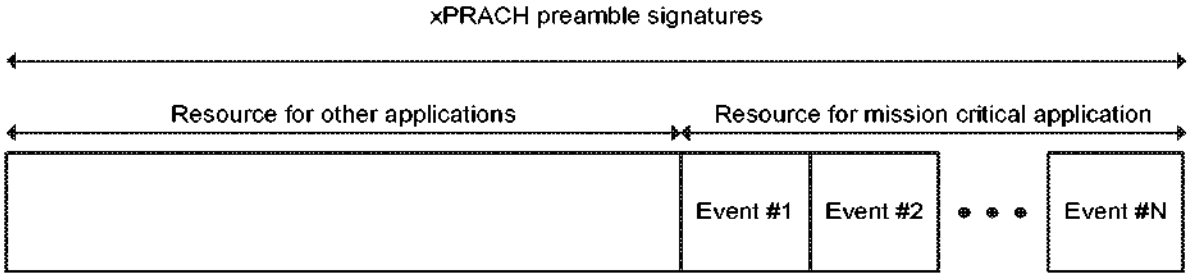

xPRACH preamble signatures
Resource for other applications
Resource for mission critical application
Event #1
Event #2
Event #N

FIG. 4

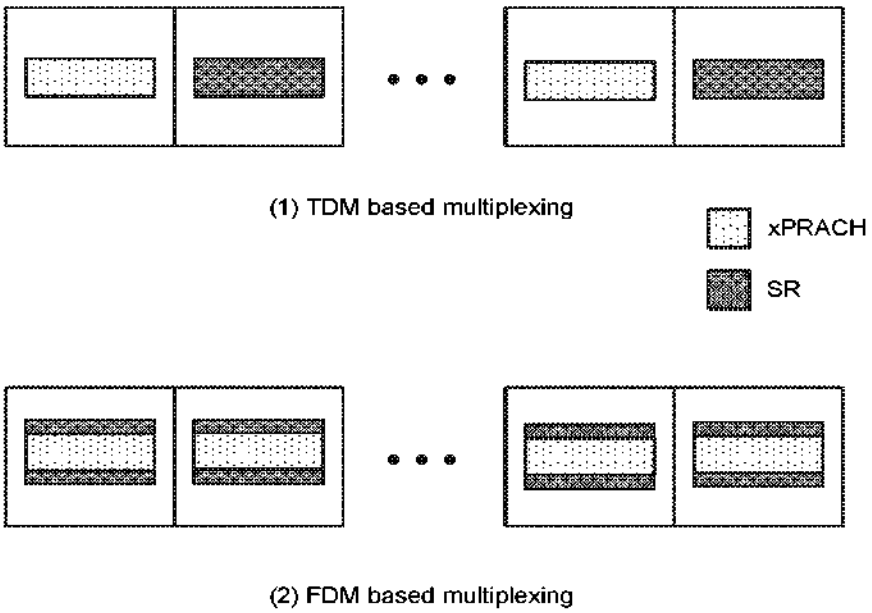

(1) TDM based multiplexing
xPRACH
SR
(2) FDM based multiplexing

FIG. 5

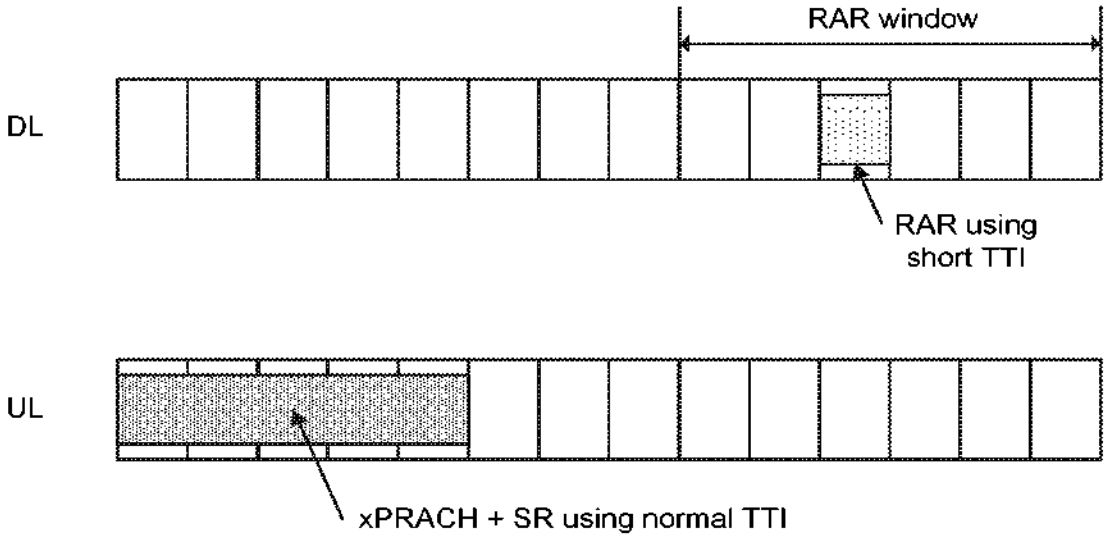

RAR window
DL
RAR using
short TTI
UL
xPRACH + SR using normal TTI

FIG. 6

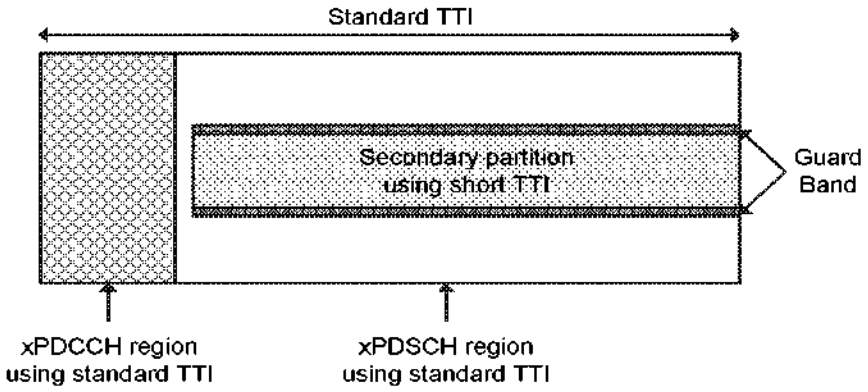


FIG. 7A

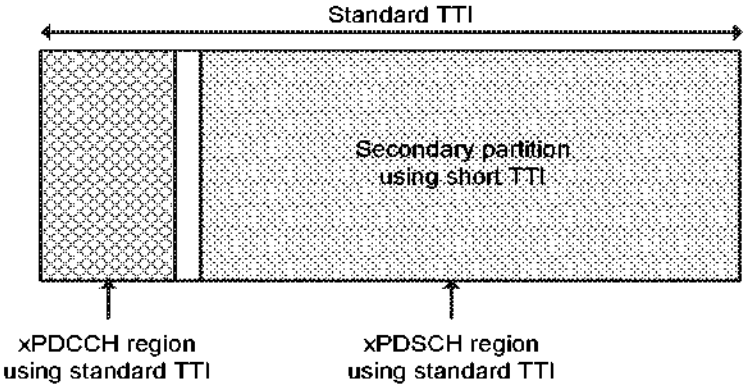


FIG. 7B

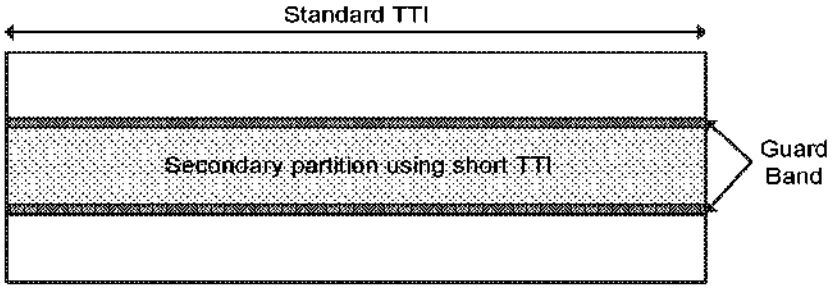


FIG. 7C

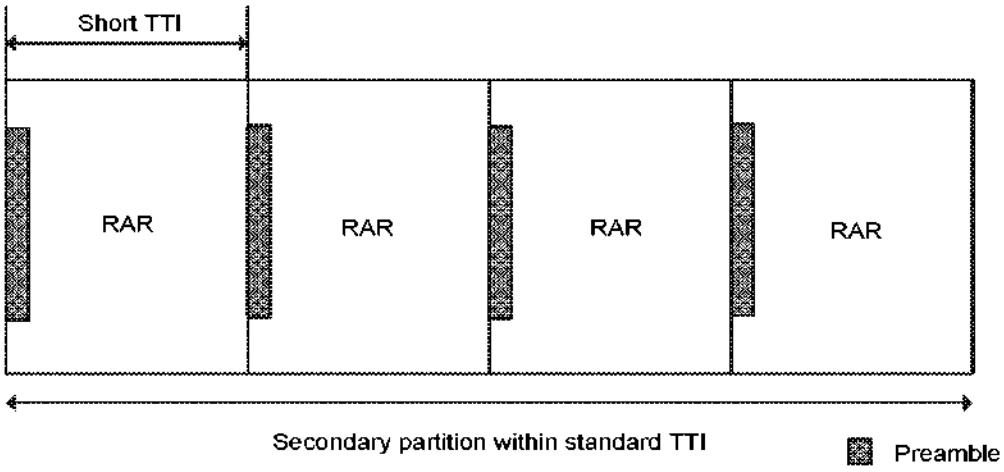

Short TTI
RAR
RAR
RAR
RAR
Secondary partition within standard TTI
Preamble

FIG. 8

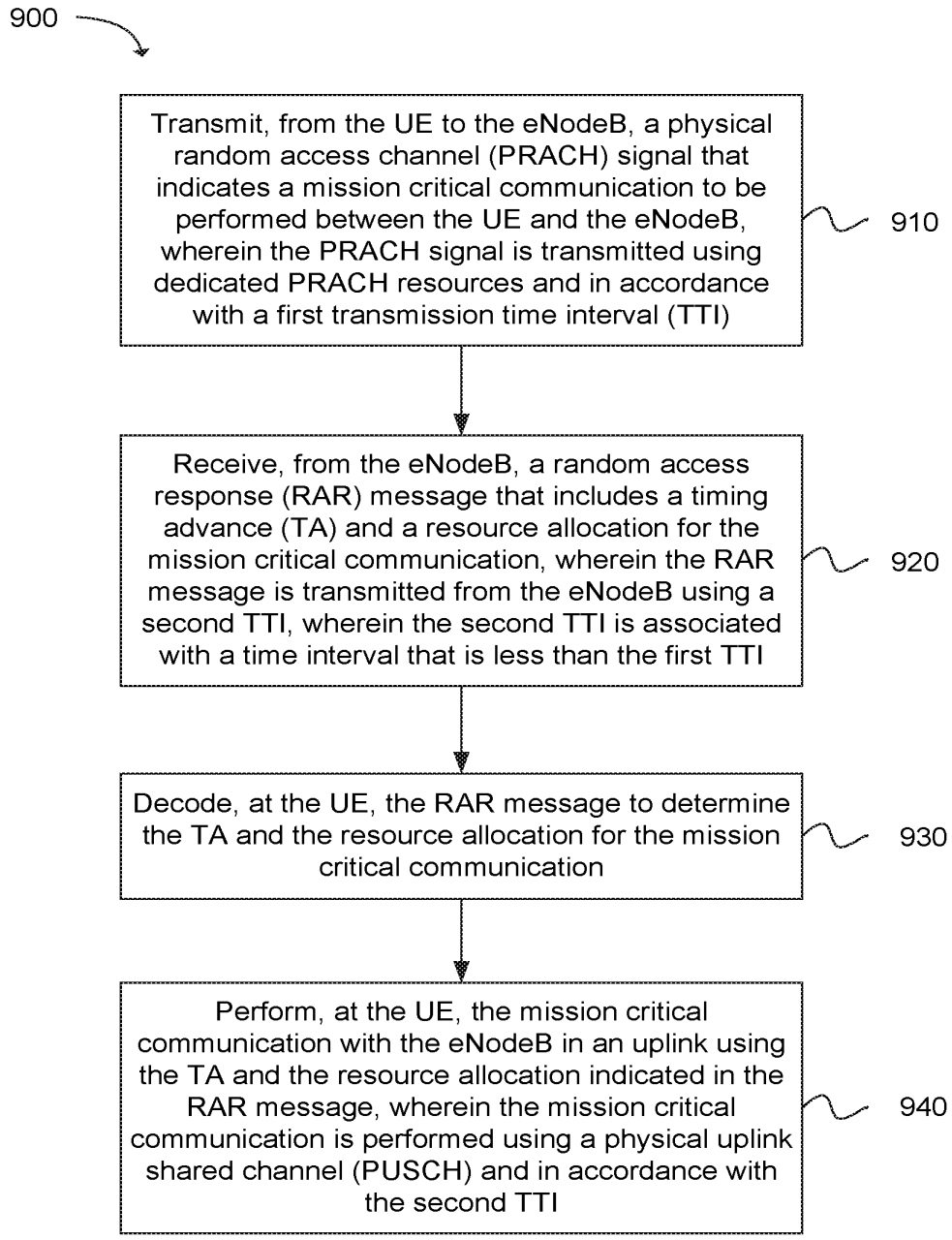

900
Transmit, from the UE to the eNodeB, a physical random access channel (PRACH) signal that indicates a mission critical communication to be performed between the UE and the eNodeB, wherein the PRACH signal is transmitted using dedicated PRACH resources and in accordance with a first transmission time interval (TTI)
910
Receive, from the eNodeB, a random access response (RAR) message that includes a timing advance (TA) and a resource allocation for the mission critical communication, wherein the RAR message is transmitted from the eNodeB using a second TTI, wherein the second TTI is associated with a time interval that is less than the first TTI
920
Decode, at the UE, the RAR message to determine the TA and the resource allocation for the mission critical communication
930
Perform, at the UE, the mission critical communication with the eNodeB in an uplink using the TA and the resource allocation indicated in the RAR message, wherein the mission critical communication is performed using a physical uplink shared channel (PUSCH) and in accordance with the second TTI
940

FIG. 9

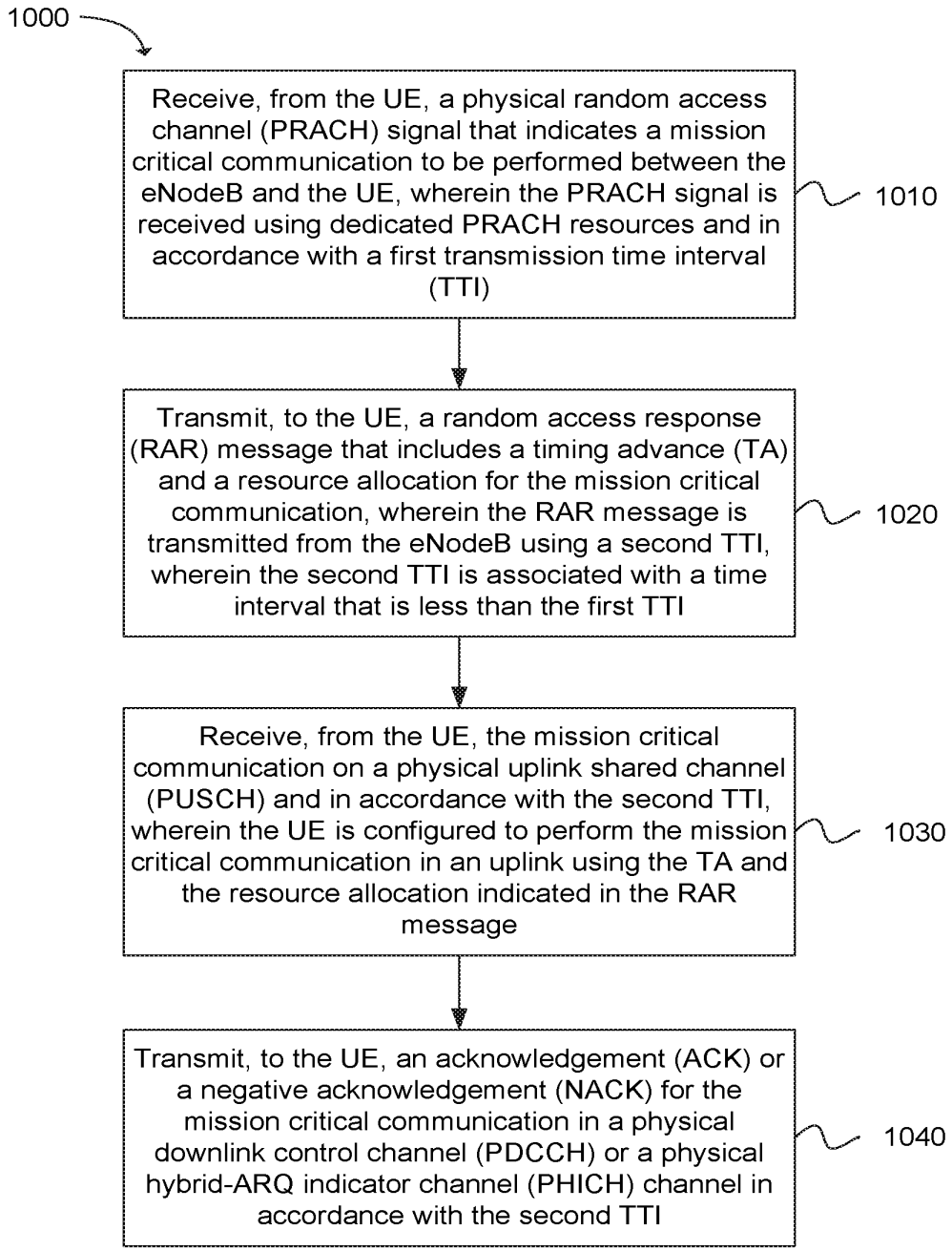

1000
Receive, from the UE, a physical random access channel (PRACH) signal that indicates a mission critical communication to be performed between the eNodeB and the UE, wherein the PRACH signal is received using dedicated PRACH resources and in accordance with a first transmission time interval (TTI)
1010
Transmit, to the UE, a random access response (RAR) message that includes a timing advance (TA) and a resource allocation for the mission critical communication, wherein the RAR message is transmitted from the eNodeB using a second TTI, wherein the second TTI is associated with a time interval that is less than the first TTI
1020
Receive, from the UE, the mission critical communication on a physical uplink shared channel (PUSCH) and in accordance with the second TTI, wherein the UE is configured to perform the mission critical communication in an uplink using the TA and the resource allocation indicated in the RAR message
1030
Transmit, to the UE, an acknowledgement (ACK) or a negative acknowledgement (NACK) for the mission critical communication in a physical downlink control channel (PDCCH) or a physical hybrid-ARQ indicator channel (PHICH) channel in accordance with the second TTI
1040

FIG. 10

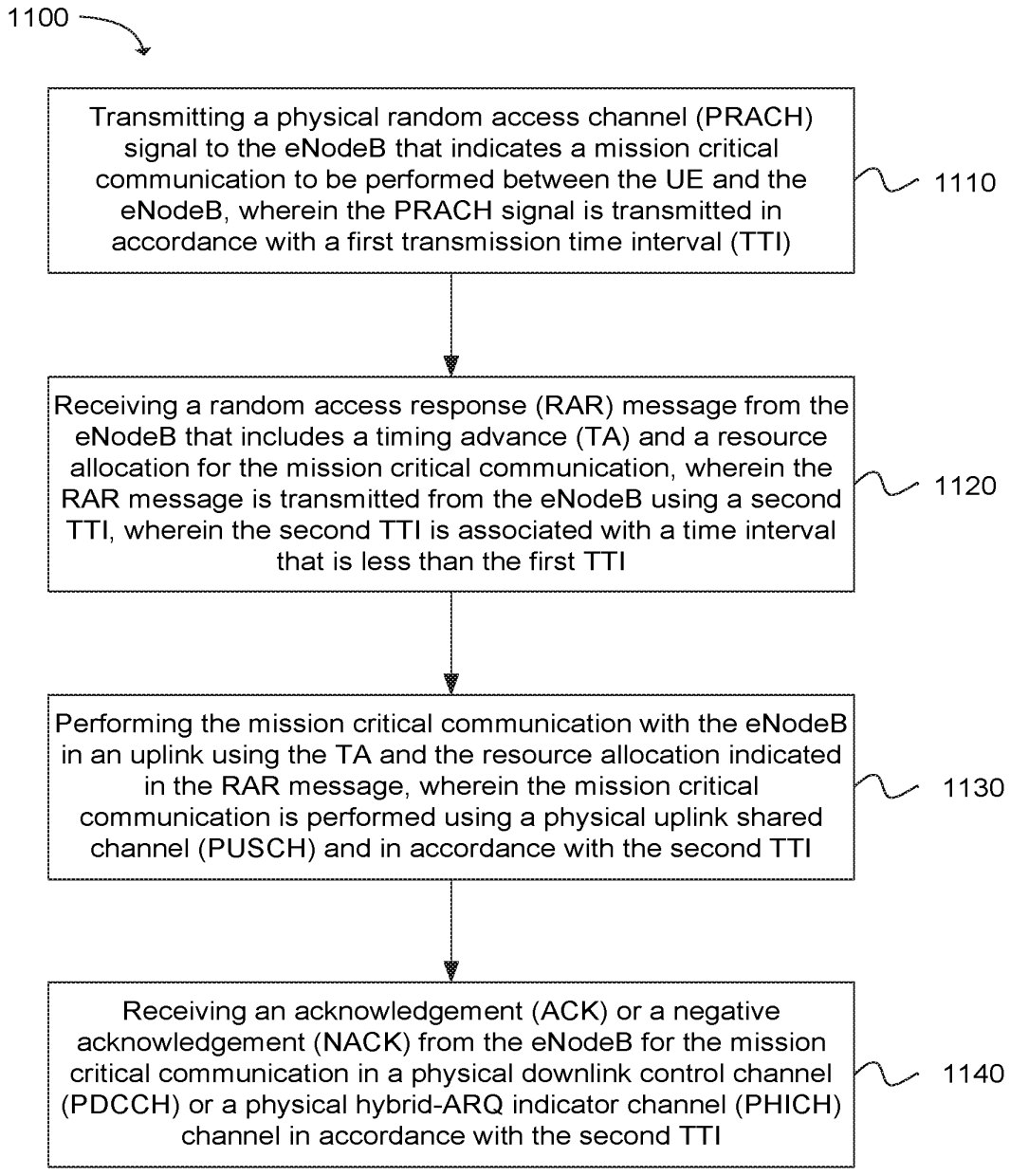

1100
Transmitting a physical random access channel (PRACH) signal to the eNodeB that indicates a mission critical communication to be performed between the UE and the eNodeB, wherein the PRACH signal is transmitted in accordance with a first transmission time interval (TTI)
1110
Receiving a random access response (RAR) message from the eNodeB that includes a timing advance (TA) and a resource allocation for the mission critical communication, wherein the RAR message is transmitted from the eNodeB using a second TTI, wherein the second TTI is associated with a time interval that is less than the first TTI
1120
Performing the mission critical communication with the eNodeB in an uplink using the TA and the resource allocation indicated in the RAR message, wherein the mission critical communication is performed using a physical uplink shared channel (PUSCH) and in accordance with the second TTI
1130
Receiving an acknowledgement (ACK) or a negative acknowledgement (NACK) from the eNodeB for the mission critical communication in a physical downlink control channel (PDCCH) or a physical hybrid-ARQ indicator channel (PHICH) channel in accordance with the second TTI
1140

FIG. 11

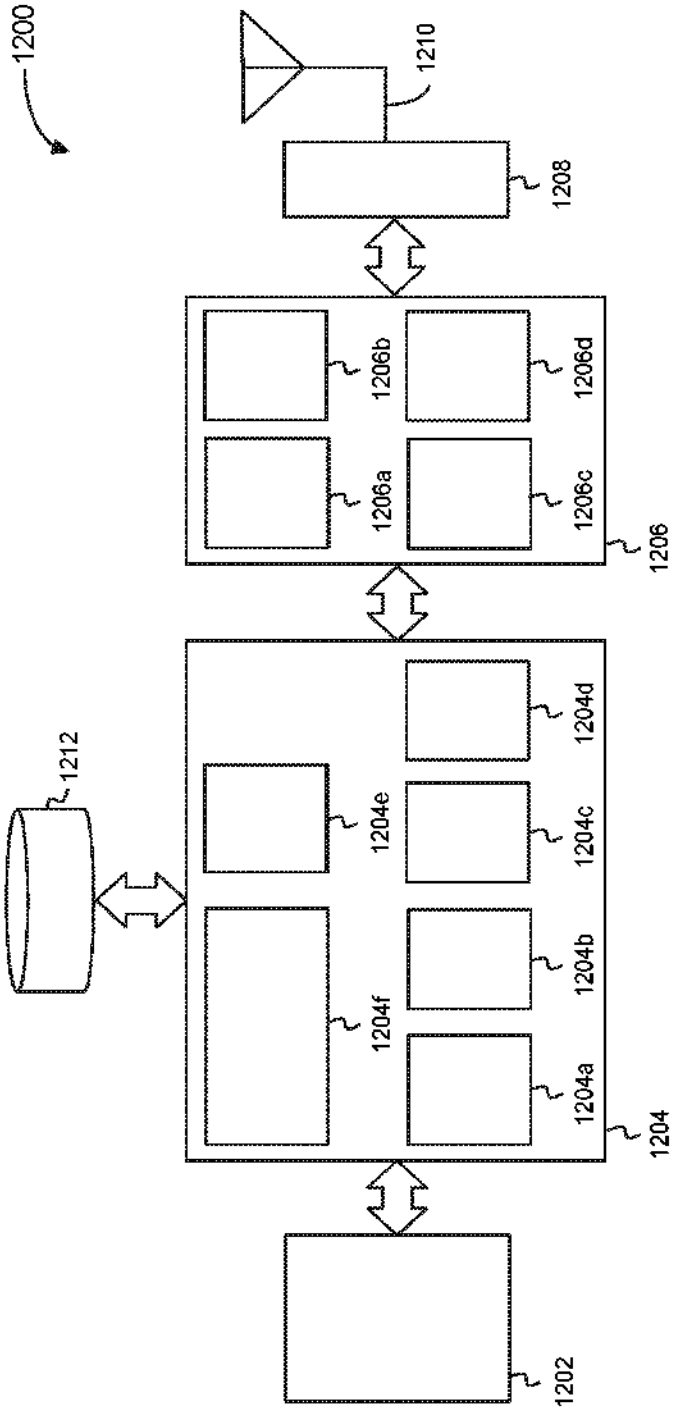

1200
1210
1208
1206b
1206d
1206a
1206c
1206
1212
1204d
1204e
1204c
1204f
1204b
1204a
1204
1202

FIG. 12

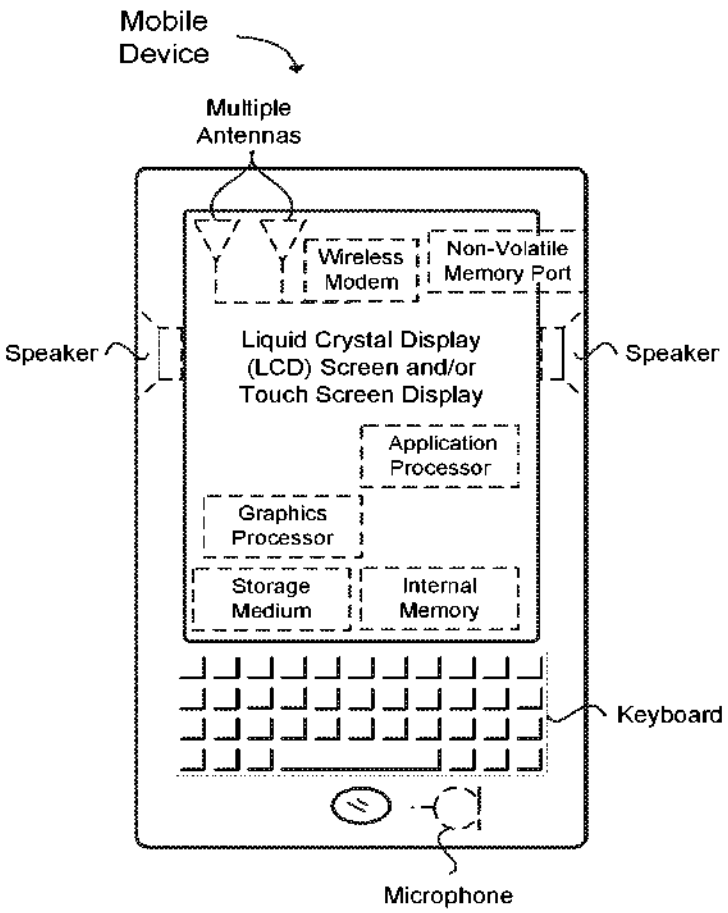

Mobile Device
Multiple Antennas
Wireless Modem
Non-Volatile Memory Port
Speaker
Liquid Crystal Display (LCD) Screen and/or Touch Screen Display
Speaker
Application Processor
Graphics Processor
Storage Medium
Internal Memory
Keyboard
Microphone

FIG. 13

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/066149

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W74/08 H04W72/04
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 2011/087274 A2 (SAMSUNG ELECTRONICS CO LTD [KR]; JEONG KYEONG-IN [KR]; KIM SOENG-HUN [) 21 July 2011 (2011-07-21) figures 2-4, 8-12 paragraphs [0005], [0006] paragraphs [0008], [0009], [0013], [0015] paragraphs [0018], [0019] paragraphs [0036] - [0042] paragraphs [0045] - [0057] paragraphs [0061] - [0072] paragraphs [0076], [0077], [0082] paragraphs [0114] - [0125] paragraphs [0126], [0127] paragraphs [0152], [0156], [0157] paragraphs [0168], [0170], [0177] paragraph [0191] ----- -/--	1-8, 10-19, 21-25 9,20

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 April 2016	04/05/2016

Name and mailing address of the ISA/	Authorized officer
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Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	"3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2 (Release 12)", 3GPP STANDARD; 3GPP TS 36.300, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG2, no. V12.0.0, 10 January 2014 (2014-01-10), pages 1-208, XP050729408, [retrieved on 2014-01-10] Section 10.1.5; pages 73-77 -----	1-25
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A	"3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and modulation (Release 12)", 3GPP STANDARD; 3GPP TS 36.211, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG1, no. V12.0.0, 14 December 2013 (2013-12-14), pages 1-120, XP050729027, [retrieved on 2013-12-14] Section 5.7; pages 46-55 ----- -/--	1-25

1

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	MOTOROLA: "Synchronized Random Access Channel and Scheduling Request", 3GPP DRAFT; R1-062664 SYNCHRACH_SR, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG1, no. Seoul, Korea; 20061006, 6 October 2006 (2006-10-06), XP050103157, [retrieved on 2006-10-06] figure 3 Section 4 -----	9,20

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2015/066149

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2011087274 A2	21-07-2011	EP 2524564 A2	21-11-2012
		KR 20110083547 A	20-07-2011
		US 2012320842 A1	20-12-2012
		WO 2011087274 A2	21-07-2011

Form PCT/ISA/210 (patent family annex) (April 2005)

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Published:

— *with international search report (Art. 21(3))*

(54) **Title**: BEAMFORMED CSI-RS BASED MEASUREMENT FRAMEWORK

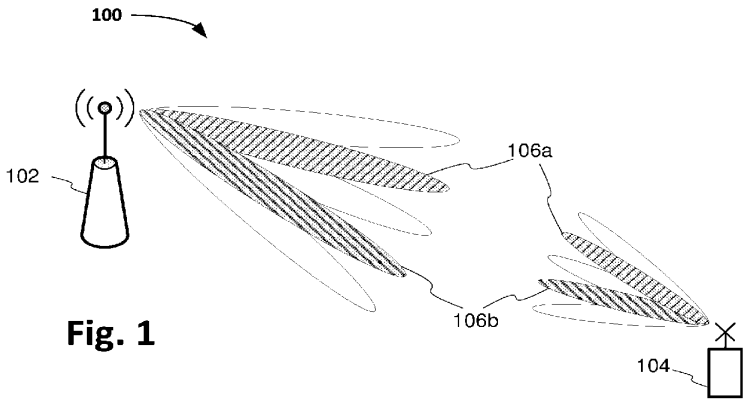


Fig. 1

(57) **Abstract**: There are disclosed methods and apparatus to facilitate beamformed CSI-RS based measurement including an apparatus for use in an eNB in a wireless communication network, the apparatus comprising transmitter circuitry; and control circuitry coupled to the transmitter circuitry, the control circuitry to configure a plurality of channel state information reference signals (CSI-RS), each CSI-RS associated with one of a plurality of virtualized sectors, and cause the transmitter circuitry to transmit the configured CSI-RS, wherein each of the plurality of virtualized sectors comprises a transmit beam beamformed to be vertically narrow and horizontally wide based on an associated vertical downtilt angle.

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BEAMFORMED CSI-RS BASED MEASUREMENT FRAMEWORK

CROSS REFERENCE TO RELATED APPLICATIONS

The present application claims priority to U.S. Provisional Patent Application No. 62/255,865, filed November 16, 2015, entitled "BEAMFORMED CSI-RS BASED MEASUREMENT FRAMEWORK" the entire disclosure of which is hereby incorporated by reference.

TECHNICAL FIELD

Embodiments described herein generally relate to the field of wireless communications and, more particularly, to methods and apparatus for measurement of channel state information reference signals in beamformed transmit beams.

BACKGROUND

It is becoming more important to be able to provide telecommunication services to fixed and mobile subscribers as efficient and inexpensively as possible. Further, the increased use of mobile applications has resulted in much focus on developing wireless systems capable of delivering large amounts of data at high speed.

One approach under consideration for improving the efficient use of spectral resources is massive Multiple Input and Multiple output (MIMO) which allows reuse of frequencies to communicate with different users in the network through spatial multiplexing.

BRIEF DESCRIPTION OF THE DRAWING.

Aspects, features and advantages of embodiments of the present invention will become apparent from the following description of the invention in reference to the appended drawings in which like numerals denote like elements and in which:

Fig. 1 is diagram of an example wireless network according to various embodiments;

Fig. 2 is a block diagram of the example wireless network of Figure 2 according to various embodiments;

Fig. 3 is a sequence diagram of messaging for beamformed channel state information reference signals (CSI-RS) based measurement according to some embodiments;

Fig. 4 is a block diagram of a method performed in an eNB according to some embodiments;

Fig. 5 is a block diagram of a method performed in a UE according to some embodiments;

Fig. 6 is a block diagram of an example system operable to implement some embodiments; and

Fig. 7 is a block diagram of an example User Equipment device operable to implement some embodiments.

DETAILED DESCRIPTION OF EMBODIMENTS

Various aspects of the illustrative embodiments will be described using terms commonly employed by those skilled in the art to convey the substance of their work to others skilled in the art. However, it will be apparent to those skilled in the art that some alternate embodiments may be practiced using with portions of the described aspects. For purposes of explanation, specific numbers, materials, and configurations are set forth in order to provide a thorough understanding of the illustrative embodiments. However, it will be apparent to one skilled in the art that alternate embodiments may be practiced without the specific details. In other instances, well-known features are omitted or simplified in order to not obscure the illustrative embodiments.

Further, various operations will be described as multiple discrete operations, in turn, in a manner that is most helpful in understanding the illustrative embodiments; however, the order of description should not be construed as to imply that these operations are necessarily order dependent. In particular, these operations need not be performed in the order of presentation.

The phrase "in one embodiment" is used repeatedly. The phrase generally does not refer to the same embodiment; however, it may. The terms "comprising," "having," and "including" are synonymous, unless the context dictates otherwise. The phrase "A/B" means "A or B". The phrase "A and/or B" means "(A), (B), or (A and B)". The phrase "at least one of A, B and C" means "(A), (B), (C), (A and B), (A and C), (B and C) or (A, B and C)". The phrase "(A) B" means "(B) or (A B)", that is, A is optional.

Although specific embodiments have been illustrated and described herein, it will be appreciated by those of ordinary skill in the art that a wide variety of alternate and/or equivalent implementations may be substituted for the specific embodiments shown and described, without departing from the scope of the embodiments of the present disclosure. This application is intended to cover any adaptations or variations of the embodiments discussed herein. Therefore, it is manifestly intended that the embodiments of the present disclosure be limited only by the claims and the equivalents thereof.

As used herein, the term "module" may refer to, be part of, or include an Application Specific Integrated Circuit (ASIC), an electronic circuit, a processor (shared, dedicated, or group) and/or memory (shared, dedicated, or group) that execute one or more software or firmware instructions and/or programs, a combinational logic circuit, and/or other suitable components that provide the described functionality.

The following inventive embodiments may be used in a variety of applications including transmitters and receivers of a radio system, although the present invention is not limited in this respect. Radio systems specifically included within the scope of the present invention include, but are not limited to, network interface cards (NICs), network adaptors, fixed or mobile client devices, relays, base stations, femtocells, gateways, bridges, hubs, routers, access points, or other network devices. Further, the radio systems within the scope of the invention may be implemented in cellular radiotelephone systems, satellite systems, two-way radio systems as well as computing devices including such radio systems including personal computers (PCs), tablets and related peripherals, personal digital assistants (PDAs), personal computing accessories, hand-held communication devices and all systems which may be related in nature and to which the principles of the inventive embodiments could be suitably applied.

In a system implementing massive Multiple Input and Multiple output (MIMO), or Full Dimension MIMO (FD-MIMO), a large number of service antennas may be used to provide a number of virtual beams that may provide a high degree of spatial separation between terminals in a wireless network. Thus, using massive MIMO, a system may be able to support a large number of users on the same bandwidth simultaneously.

According to an example massive MIMO implementation, an evolved NodeB ("eNodeB" or "eNB") may transmit a number of analog sector transmitting (Tx) beams, and each sector Tx beam may be generated based on different vertical down tilting angles. That is, a single eNB may provide a plurality of virtualized sectors that are horizontally wide and vertically narrow. The eNB may transmit multiple antenna ports from each sector Tx beam. Within each virtualized sector Tx beam, a digital precoder may be applied to provide further horizontal Tx beamforming.

A user equipment (UE) served by the eNB may select one sector Tx beam and report the Channel State Information (CSI) measured from this sector Tx beam. In particular, the UE may report a Reference Signal Receiving Power (RSRP) of one sector Tx beam. Then the UE may report the CSI for the selected sector Tx beam which may contain a Channel Quality Indicator (CQI), Rank Indicator (RI), and Precoder Matrix Indicator (PMI). The eNB usually relies on the PMI to create a Tx beam for data transmission on the selected sector Tx beam.

However, in systems that implement receiving (Rx) beam beamforming and multiple Rx antenna panels at the UE side, different serving Tx beams for data transmission may be observed from different Rx beams of the same or different antenna panels. In this case, the best Tx beams for data transmission may be within the same or different sector Tx beams.

Figure 1 illustrates one example arrangement of a wireless network 100 including an eNB 102 and a UE 104 configured to use different Tx beam and Rx beam pairs for data transmission. According to the example illustrated in Figure 1, the eNB 102 and UE 104 may have identified a first Tx beam – Rx beam pair 106a for transmission of data and control information, and a second, candidate, Tx beam – Rx beam pair 106b.

As a result of UE rotation, movement, or Doppler Effect, the active antenna panel or active Rx beam on the UE side may change so that the Tx beams for data transmission may need to be updated. The Tx beam change for data transmission may include a sector Tx beam change, horizontal digital Tx beam change within a sector Tx beam, or both. As the CSI-RS may be beamformed within a sector Tx beam, it may be beneficial in some embodiments to measure the receiving power from the narrow vertical and narrow horizontal beams to allow beam switching from any two Tx beams for data transmission from either the same or different sector Tx beams.

Example embodiments provide systems, apparatuses, and methods for beamformed CSI-RS based measurement framework with the UE side Rx beamforming to enable beam mobility in millimeter wave (mmWave) systems.

Figure 2 schematically illustrates the wireless communication network 100 in accordance with various embodiments. Wireless communication network 100 (hereinafter "network 100") may be an access network of a 3rd Generation Partnership Project (3GPP) long-term evolution (LTE), long-term evolution- advanced (LTE-A) network such as an evolved universal mobile telecommunication system (UMTS) terrestrial radio access network (E-UTRAN) or 5G network.

The network 100 may include a base station, e.g., evolved node base station (eNB) 102, configured to wirelessly communicate with one or more mobile device(s) or terminal(s), e.g., user equipment (UE) 104. In various embodiments, the eNB 102 may be a fixed station (e.g., a fixed node) or a mobile station/node.

The eNB 104 may include receiver circuitry 120 with which to receive signals from UE 104 via one or more antennas 130. eNB 104 may include transmitter circuitry 124 with which to transmit signals to UE 104 via one or more antennas 130. eNB 104 may also include controller circuitry 128 in communication with receiver module 120 and transmitter module 124 and configured to encode and decode information communicated by the

signals. Controller module 128 also includes CSI-RS configuration circuitry 126 to facilitate configuration and report processing of beamformed CSI-RS messages in the network 100.

In various embodiments, the control circuitry 128 may be comprised in a separate device from the receiver circuitry 120 and/or the transmitter circuitry 124. For example, the eNB 104 may be implemented as part of a cloud-RAN (C-RAN).

In various embodiments, the UE 104 and/or the eNB 102 may include a plurality of antennas 156, 130 to implement a multiple-input-multiple-output (MIMO) transmission system, which may operate in a variety of MIMO modes, including single-user MIMO (SU-MIMO), multi-user MIMO (MU-MIMO), close loop MIMO, open loop MIMO or variations of smart antenna processing.

In various embodiments, UE 104 comprises transmitter circuitry 148 for transmitting signals to eNB 102 and receiver circuitry 144 for receiving signals from the eNB 102. UE 104 further comprises controller circuitry 152 coupled between receiver circuitry 144 and transmitter circuitry 148 and including communication circuitry 154 to encode and decode information communicated by the signals. Controller circuitry 152 may also include CSI reporting circuitry 158 to facilitate measurement and reporting of channel state information by the UE 102.

According to embodiments, the UE 104 may attempt to receive channel state information reference signals (CSI-RS) for each sector Tx beam using receiver circuitry 144 and then measure a reference signal received power (RSRP) for each sector Tx beam received based on the CSI-RS beamformed within each sector Tx beam. The RSRP may be used as an indication of the signal quality for each sector Tx beam being received by the UE, and therefore the UE may select the sector Tx beam having the highest measured RSRP value. The US 104 may then report the selected Tx beam to the eNB 102, and may include the measured RSRP value associated with the selected sector Tx beam.

According to some embodiments, the UE 104 may report all measured RSRP values and their associated sector Tx beams to the eNB 102, and selection of a sector Tx beam may then be performed in the eNB 102.

Once sector Tx selection has been performed, the UE may then attempt to receive UE specific CSI-RS on the selected sector Tx beam and to determine based on the received CSI-RS a precoder matrix indicator to signal to the eNB 102 a horizontal Tx beam within the selected Tx sector to be used to communicate data.

Based on the information provided by the UE 104 to the eNB 102, a two-dimensional narrow Tx beam may be defined. Further CSI-RS may be transmitted on this two-dimensional narrow beam to allow the UE to determine a channel quality indicator, rank indicator, etc. for the beamformed link.

Thus, the UE 104 may select its sector Tx beam based on the CSI-RS Receiving Power (CSIRS-RP) of each sector Tx beam, as the CSI-RS may be beamformed with different sector Tx beams. The UE may report the horizontal Tx beam directions by the PMI. Then the eNodeB may further transmit one additional beamformed CSI-RS using the Tx beam for data transmission. UE may further measure this additional CSI-RS from this Tx beam to derive CQI RI etc.

At the eNB 102, the active Tx beam may be defined as the one digital narrow beam with the highest reported CQI from the sector Tx beam having highest reported CSIRS-RP. According to some embodiments, a candidate Tx beam can be defined as the digital narrow beam with the highest CQI from the sector beam which is cannot be measured by UE simultaneously as the active Tx beam.

Table 1 illustrates one example for the CSIRS-RPs measured by UE 104 using different Rx beams. In the example of Table 2, Tx beam 2 has the highest reported received power and may be designated to be the active Tx beam and the Tx beam 4 has the second highest reported received power and may be designated to be the candidate Tx beam by the eNB 102.

BRS-RP [dBm]		Sector Tx beam				
		1	2	3	4	5
Rx beam	1				-89	
	2			-88	***-77***	-93
	3		-88		-92	
	4	-83	***-71***	-82		
	5		-80			

Table 1: one example for RSRP measurement result

In some embodiments, the active Tx beam and candidate Tx beam can be the same sector Tx beam.

To support a narrow vertical and horizontal beamformed data transmission within the vertical narrow and horizontal wide beam sector Tx beam, the basic procedure may contain the sector Tx beam selection, digital beam selection and CSIRS-RP measurement and report as illustrated in Figure 3.

According to the method 200 illustrated in the sequence diagram of Figure 3, eNB 102 begins by transmitting 202 multiple CSI-RS(s) on a plurality of vertically narrow, horizontally wide sector Tx beams. These sector Tx beams are monitored by the UE 104,

and RSRP values for one or more sector Tx beams are reported 204 to the eNB to facilitate sector Tx beam selection.

The eNB 102 then transmits 206 UE specific CSI-RS within the selected sector Tx beam. In some embodiments, multiple horizontally narrow beams within the selected sector Tx beam may be used. The UE 104, uses the received CSI-RS information to provide 208 a precoder matrix indicator to the eNB 102 defining a horizontally narrow beam within the Tx sector. The eNB 102 then transmits 210 further UE specific CSI-RS using the defined two-dimensional narrow beam to allow channel state information to be determined by the UE and reported 212 to the eNB 102.

Figure 4 illustrates a method 400 performed by an eNB 102 according to some embodiments. According to the illustrated method, the eNB 102 first configures 402 CSI-RS for each of a number of virtualized, horizontally wide but vertically narrow, sector Tx beams. The eNB 102 then receives 404 at least one RSRP value associated with a sector Tx beam. A selection 406 is then made based on the received RSRP value.

Figure 5 illustrates a method 500 performed at UE 104 according to some embodiments. According to the illustrated method, the UE 104 receives 502 CSI-RS associated with virtualized, horizontally wide but vertically narrow, sector Tx beams. A reference signal received power value is then determined 504 for a virtualized sector based on the associated received CSI-RS. Determined RSRP values are then reported 506 to the eNB 102.

CSIRS-RP Measurement for sector Tx beam selection

According to some embodiments, the UE 104 may need to report an RSRP value for each sector Tx beam, which may help the eNodeB 102 to decide the best sector Tx beam for the UE.

In some embodiments, the UE 104 may maintain two non-simultaneous Rx beam(s), and may report the RSRP value with an indicator to show whether this RSRP value is measured from active Rx beam or candidate Rx beam. A current Rx beam is defined as the Rx beam used for current downlink control and signal receiving. This current Rx beam may switch between active Rx beam and candidate Rx beam according to channel conditions. Hence, in some embodiments, the context for RSRP may contain the following information:

- Cell ID;
- RSRP value;
- Rx beam Indicator;
- Subframe index or CSI-RS process ID; and
- Beam index or CSI-RS port index.

According to some embodiments, the Cell ID may be used to indicate the cell ID which used to generate the CSI-RS. RSRP value may be quantized by several bits. Subframe index may indicate the subframe index for the CSI-RS where the RSRP is measured. The Rx beam indicator may contain 1 bit, where value 0 may indicate the CSIRS-RP is measured from active Rx beam and value 1 may indicate it is measured from candidate Rx beam. Alternatively the Rx beam indicator may not be used and the UE may report two RSRPs values measured from two Rx beams per sector Tx beam to the eNodeB.

The beam index may be equal to the sector Tx beam index. Sometimes, sector Tx beam index is transparent to UE, so CSI-RS port index may be used to implicitly indicate which sector Tx beam is chosen based on the corresponding Rx beam. Two ports may be paired for vertical and horizontal channel measurement, and be equipped with the same sector Tx beam. In this case, report of only one CSI-RS port index may be sufficient. CSI-RS process ID may indicate the RSRP is measured on which CSI-RS symbols.

CSI Feedback for digital beam selection

After sector Tx beam selection, the UE may further select the Tx beam within the selected sector Tx beam. In some embodiments, if more than one simultaneous Rx beam can be applied for CSI-RS receiving, the UE may measure the same CSI-RS in the selected sector Tx beam and report more than one digital beam selection based CSI, e.g. using one PMI for one digital precoder.

According to some embodiments, two PMIs may be restricted to be measured from a rank 1 precoder codebook for N Tx antenna ports based sector Tx beam, where N is equal to the number of antenna ports for sector beam based CSI-RS. The codebook for the two PMIs may be defined by the system.

In embodiments, if the UE cannot use simultaneous Rx beams for receiving the CSI-RS, the PMI for the active Rx beam and candidate Rx beam may be measured in two CSI-RS subframes and reported individually or jointly as in the embodiment above.

CSI-RS Tx beam for CSI measurement

After receiving the PMI for active Rx beam and PMI for candidate Rx beam, the eNodeB may be able to generate the narrow Tx beam based on the feedback PMIs and the sector Tx beam.

In some embodiments, the CSI-RS may be divided into several groups, and each CSI-RS group may include K antenna ports. In one example, K may be equal to 2. Different narrow Tx beams may be applied to different CSI-RS groups. In one example, a narrow Tx beam can be generated as follow.

$$P_{i,j} = P_c^i P_d^j \quad (1)$$

Where P_c^i may indicate the $N_{tx} \times N_p$ analog beamforming weight for sector Tx beam *i*; P_d^j may denote the $N_p \times K$ digital precoder for PMI j; $P_{i,j}$ may refer to the narrow Tx beam for sector *i* and PMI *j*; N_{tx} is the number of Tx antenna; N_p is the number of CSI-RS antenna ports.

The UE may then measure a number of narrow Tx beams of one sector Tx beam in one CSI-RS subframe, and may report the CSI containing the following items:

- Beam Index (BI);
- Rank Indicator (RI);
- Precoding Matrix Indicator (PMI);
- Channel Quality Indicator (CQI); and
- Rx beam Indicator.

In some embodiments, not all the above items in CSI may be transmitted, and the Uplink Control Information (UCI) may contain more than one of the above CSI blocks.

In some embodiments, the UE may measure and report the CSIRS-RP based on each CSI-RS group. Then the UE may report the CSIRS-RP with the following pattern:

- Cell ID;
- RSRP value;
- Rx beam Indicator;
- Subframe index for the measured CSI-RS; and
- Beam index or CSI-RS group index corresponded to active beam.

In another embodiment, the UE may report up to *X* CSIRS-RPs, where *X* can be configured by the system or Radio Resource Control (RRC) signaling, e.g. *X*=8. Further the UE may only include a report for valid beams where a valid beam can be defined as a beam with the following condition in (2) is valid.

$$r_a - r_{c,k} < \Delta \quad (2)$$

Where r_a may indicate the CSIRS-RP measured from active Tx beam with the current Rx beam; $r_{c,k}$ may indicate the CSIRS-RP measured from the Tx beam *c* with Rx beam *k*. The Rx beam *k* can be either the current Rx beam or candidate Rx beam. Threshold Δ denotes the CSIRS-RP threshold, which may be configured via RRC signaling.

Various embodiments have been described in the context of transmit or receive beams that are beamformed to be horizontally and/or vertically narrow as opposed to wide. Such beamforming rely on the use of a plurality of antenna elements with a narrower beam being achievable through the use of a greater number of antenna elements.

According to some embodiments, an antenna port used to transmit a transmit beam for a virtualized sector beamformed to be vertically narrow and horizontally wide is associated with a first number, N_v, of vertical antenna elements and a second number, N_h, of horizontal antenna elements, where N_v is greater than N_h. Furthermore, according to some embodiments N_v is greater than or equal to 8 while N_h is less than or equal to 2.

Throughout the disclosure, the term eNB may loosely refer to a cell or RAN (Radio Access Network) node or transmission point (TP). The relay UE may belong to the same or different eNB or entity. When it belongs to different entity than the direct path of the remote UE, then additional signaling and context transfer might need to happen for the remote UE to switch between the direct path and relay UE path. Furthermore, the remote UE may be receiving data from multiple relay UEs, each associated with the same eNB/entity or different eNB/entity than the remote UE itself.

Embodiments of the technology herein may be described as related to the third generation partnership project (3GPP) long term evolution (LTE) or LTE-advanced (LTE-A) standards. For example, terms or entities such as eNodeB (eNB), mobility management entity (MME), user equipment (UE), etc. may be used that may be viewed as LTE-related terms or entities. However, in other embodiments the technology may be used in or related to other wireless technologies such as the Institute of Electrical and Electronic Engineers (IEEE) 802.16 wireless technology (WiMax), IEEE 802.11 wireless technology (WiFi), various other wireless technologies such as global system for mobile communications (GSM), enhanced data rates for GSM evolution (EDGE), GSM EDGE radio access network (GERAN), universal mobile telecommunications system (UMTS), UMTS terrestrial radio access network (UTRAN), or other 2G, 3G, 4G, 5G, etc. technologies either already developed or to be developed. In those embodiments, where LTE-related terms such as eNB, MME, UE, etc. are used, one or more entities or components may be used that may be considered to be equivalent or approximately equivalent to one or more of the LTE-based terms or entities.

As used herein, the term "circuitry" may refer to, be part of, or include an Application Specific Integrated Circuit (ASIC), an electronic circuit, a processor (shared, dedicated, or group), and/or memory (shared, dedicated, or group) that execute one or more software or firmware programs, a combinational logic circuit, and/or other suitable hardware components that provide the described functionality. In some embodiments, the circuitry may be implemented in, or functions associated with the circuitry may be implemented by, one or more software or firmware modules. In some embodiments, circuitry may include logic, at least partially operable in hardware.

Embodiments described herein may be implemented into a system using any suitably configured hardware and/or software. Figure 6 illustrates, for one embodiment, example components of an electronic device 600. In embodiments, the electronic device 600 may

be, implement, be incorporated into, or otherwise be a part of a user equipment (UE), an evolved NodeB (eNB), or any other suitable electronic device. In some embodiments, the electronic device 600 may include application circuitry 602, baseband circuitry 604, Radio Frequency (RF) circuitry 606, front-end module (FEM) circuitry 608 and one or more antennas 610, coupled together at least as shown.

The application circuitry 602 may include one or more application processors. For example, the application circuitry 602 may include circuitry such as, but not limited to, one or more single-core or multi-core processors. The processor(s) may include any combination of general-purpose processors and dedicated processors (e.g., graphics processors, application processors, etc.). The processors may be coupled with and/or may include memory/storage and may be configured to execute instructions stored in the memory/storage to enable various applications and/or operating systems to run on the system.

The baseband circuitry 604 may include circuitry such as, but not limited to, one or more single-core or multi-core processors. The baseband circuitry 604 may include one or more baseband processors and/or control logic to process baseband signals received from a receive signal path of the RF circuitry 606 and to generate baseband signals for a transmit signal path of the RF circuitry 606. Baseband processing circuity 604 may interface with the application circuitry 602 for generation and processing of the baseband signals and for controlling operations of the RF circuitry 606. For example, in some embodiments, the baseband circuitry 604 may include a second generation (2G) baseband processor 604a, third generation (3G) baseband processor 604b, fourth generation (4G) baseband processor 604c, and/or other baseband processor(s) 604d for other existing generations, generations in development or to be developed in the future (e.g., fifth generation (5G), 6G, etc.). The baseband circuitry 604 (e.g., one or more of baseband processors 604a-d) may handle various radio control functions that enable communication with one or more radio networks via the RF circuitry 606. The radio control functions may include, but are not limited to, signal modulation/demodulation, encoding/decoding, radio frequency shifting, etc. In some embodiments, modulation/demodulation circuitry of the baseband circuitry 604 may include Fast-Fourier Transform (FFT), precoding, and/or constellation mapping/demapping functionality. In some embodiments, encoding/decoding circuitry of the baseband circuitry 604 may include convolution, tail-biting convolution, turbo, Viterbi, and/or Low Density Parity Check (LDPC) encoder/decoder functionality. Embodiments of modulation/demodulation and encoder/decoder functionality are not limited to these examples and may include other suitable functionality in other embodiments.

In some embodiments, the baseband circuitry 604 may include elements of a protocol stack such as, for example, elements of an evolved universal terrestrial radio access

network (EUTRAN) protocol including, for example, physical (PHY), media access control (MAC), radio link control (RLC), packet data convergence protocol (PDCP), and/or radio resource control (RRC) elements. A central processing unit (CPU) 604e of the baseband circuitry 604 may be configured to run elements of the protocol stack for signaling of the PHY, MAC, RLC, PDCP and/or RRC layers. In some embodiments, the baseband circuitry may include one or more audio digital signal processor(s) (DSP) 604f. The audio DSP(s) 604f may be include elements for compression/decompression and echo cancellation and may include other suitable processing elements in other embodiments.

The baseband circuitry 604 may further include memory/storage 604g. The memory/storage 604g may be used to load and store data and/or instructions for operations performed by the processors of the baseband circuitry 604. Memory/storage for one embodiment may include any combination of suitable volatile memory and/or non-volatile memory. The memory/storage 604g may include any combination of various levels of memory/storage including, but not limited to, read-only memory (ROM) having embedded software instructions (e.g., firmware), random access memory (e.g., dynamic random access memory (DRAM)), cache, buffers, etc. The memory/storage 604g may be shared among the various processors or dedicated to particular processors.

Components of the baseband circuitry may be suitably combined in a single chip, a single chipset, or disposed on a same circuit board in some embodiments. In some embodiments, some or all of the constituent components of the baseband circuitry 604 and the application circuitry 602 may be implemented together such as, for example, on a system on a chip (SOC).

In some embodiments, the baseband circuitry 604 may provide for communication compatible with one or more radio technologies. For example, in some embodiments, the baseband circuitry 604 may support communication with an evolved universal terrestrial radio access network (EUTRAN) and/or other wireless metropolitan area networks (WMAN), a wireless local area network (WLAN), a wireless personal area network (WPAN). Embodiments in which the baseband circuitry 604 is configured to support radio communications of more than one wireless protocol may be referred to as multi-mode baseband circuitry.

RF circuitry 606 may enable communication with wireless networks using modulated electromagnetic radiation through a non-solid medium. In various embodiments, the RF circuitry 606 may include switches, filters, amplifiers, etc. to facilitate the communication with the wireless network. RF circuitry 606 may include a receive signal path which may include circuitry to down-convert RF signals received from the FEM circuitry 608 and provide baseband signals to the baseband circuitry 604. RF circuitry 606 may also include a transmit signal path which may include circuitry to up-

convert baseband signals provided by the baseband circuitry 604 and provide RF output signals to the FEM circuitry 608 for transmission.

In some embodiments, the RF circuitry 606 may include a receive signal path and a transmit signal path. The receive signal path of the RF circuitry 606 may include mixer circuitry 606a, amplifier circuitry 606b and filter circuitry 606c. The transmit signal path of the RF circuitry 606 may include filter circuitry 606c and mixer circuitry 606a. RF circuitry 606 may also include synthesizer circuitry 606d for synthesizing a frequency for use by the mixer circuitry 606a of the receive signal path and the transmit signal path. In some embodiments, the mixer circuitry 606a of the receive signal path may be configured to down-convert RF signals received from the FEM circuitry 608 based on the synthesized frequency provided by synthesizer circuitry 606d. The amplifier circuitry 606b may be configured to amplify the down-converted signals and the filter circuitry 606c may be a low-pass filter (LPF) or band-pass filter (BPF) configured to remove unwanted signals from the down-converted signals to generate output baseband signals. Output baseband signals may be provided to the baseband circuitry 604 for further processing. In some embodiments, the output baseband signals may be zero-frequency baseband signals, although this is not a requirement. In some embodiments, mixer circuitry 606a of the receive signal path may comprise passive mixers, although the scope of the embodiments is not limited in this respect.

In some embodiments, the mixer circuitry 606a of the transmit signal path may be configured to up-convert input baseband signals based on the synthesized frequency provided by the synthesizer circuitry 606d to generate RF output signals for the FEM circuitry 608. The baseband signals may be provided by the baseband circuitry 604 and may be filtered by filter circuitry 606c. The filter circuitry 606c may include a low-pass filter (LPF), although the scope of the embodiments is not limited in this respect.

In some embodiments, the mixer circuitry 606a of the receive signal path and the mixer circuitry 606a of the transmit signal path may include two or more mixers and may be arranged for quadrature downconversion and/or upconversion respectively. In some embodiments, the mixer circuitry 606a of the receive signal path and the mixer circuitry 606a of the transmit signal path may include two or more mixers and may be arranged for image rejection (e.g., Hartley image rejection). In some embodiments, the mixer circuitry 606a of the receive signal path and the mixer circuitry 606a may be arranged for direct downconversion and/or direct upconversion, respectively. In some embodiments, the mixer circuitry 606a of the receive signal path and the mixer circuitry 606a of the transmit signal path may be configured for super-heterodyne operation.

In some embodiments, the output baseband signals and the input baseband signals may be analog baseband signals, although the scope of the embodiments is not limited in this respect. In some alternate embodiments, the output baseband signals and the input

baseband signals may be digital baseband signals. In these alternate embodiments, the RF circuitry 606 may include analog-to-digital converter (ADC) and digital-to-analog converter (DAC) circuitry and the baseband circuitry 604 may include a digital baseband interface to communicate with the RF circuitry 606.

In some dual-mode embodiments, a separate radio IC circuitry may be provided for processing signals for each spectrum, although the scope of the embodiments is not limited in this respect.

In some embodiments, the synthesizer circuitry 606d may be a fractional-N synthesizer or a fractional N/N+1 synthesizer, although the scope of the embodiments is not limited in this respect as other types of frequency synthesizers may be suitable. For example, synthesizer circuitry 606d may be a delta-sigma synthesizer, a frequency multiplier, or a synthesizer comprising a phase-locked loop with a frequency divider.

The synthesizer circuitry 606d may be configured to synthesize an output frequency for use by the mixer circuitry 606a of the RF circuitry 606 based on a frequency input and a divider control input. In some embodiments, the synthesizer circuitry 606d may be a fractional N/N+1 synthesizer.

In some embodiments, frequency input may be provided by a voltage controlled oscillator (VCO), although that is not a requirement. Divider control input may be provided by either the baseband circuitry 604 or the applications processor 602 depending on the desired output frequency. In some embodiments, a divider control input (e.g., N) may be determined from a look-up table based on a channel indicated by the applications processor 602.

Synthesizer circuitry 606d of the RF circuitry 606 may include a divider, a delay-locked loop (DLL), a multiplexer and a phase accumulator. In some embodiments, the divider may be a dual modulus divider (DMD) and the phase accumulator may be a digital phase accumulator (DPA). In some embodiments, the DMD may be configured to divide the input signal by either N or N+1 (e.g., based on a carry out) to provide a fractional division ratio. In some example embodiments, the DLL may include a set of cascaded, tunable, delay elements, a phase detector, a charge pump and a D-type flip-flop. In these embodiments, the delay elements may be configured to break a VCO period up into Nd equal packets of phase, where Nd is the number of delay elements in the delay line. In this way, the DLL provides negative feedback to help ensure that the total delay through the delay line is one VCO cycle.

In some embodiments, synthesizer circuitry 606d may be configured to generate a carrier frequency as the output frequency, while in other embodiments, the output frequency may be a multiple of the carrier frequency (e.g., twice the carrier frequency, four times

the carrier frequency) and used in conjunction with quadrature generator and divider circuitry to generate multiple signals at the carrier frequency with multiple different phases with respect to each other. In some embodiments, the output frequency may be a LO frequency (fLO). In some embodiments, the RF circuitry 606 may include an IQ/polar converter.

FEM circuitry 608 may include a receive signal path which may include circuitry configured to operate on RF signals received from one or more antennas 610, amplify the received signals and provide the amplified versions of the received signals to the RF circuitry 606 for further processing. FEM circuitry 608 may also include a transmit signal path which may include circuitry configured to amplify signals for transmission provided by the RF circuitry 606 for transmission by one or more of the one or more antennas 610.

In some embodiments, the FEM circuitry 608 may include a TX/RX switch to switch between transmit mode and receive mode operation. The FEM circuitry may include a receive signal path and a transmit signal path. The receive signal path of the FEM circuitry may include a low-noise amplifier (LNA) to amplify received RF signals and provide the amplified received RF signals as an output (e.g., to the RF circuitry 606). The transmit signal path of the FEM circuitry 608 may include a power amplifier (PA) to amplify input RF signals (e.g., provided by RF circuitry 606), and one or more filters to generate RF signals for subsequent transmission (e.g., by one or more of the one or more antennas 610.

In some embodiments, the electronic device 600 may include additional elements such as, for example, memory/storage, display, camera, sensor, and/or input/output (I/O) interface.

In some embodiments, the electronic device 600 of Figure 6 may be configured to perform one or more processes, techniques, and/or methods as described herein, or portions thereof. Such processes may include one or more of the following examples.

Figure 7 shows an embodiment in which the electronic device 600 implements a UE 102 in the specific form of a mobile device 700.

In various embodiments, user interfaces could include, but are not limited to, a display 740 (e.g., a liquid crystal display, a touch screen display, etc.), a speaker 730, a microphone 790, one or more cameras 780 (e.g., a still camera and/or a video camera), a flashlight (e.g., a light emitting diode flash), and a keyboard 770.

In various embodiments, the peripheral component interfaces may include, but are not limited to, a non-volatile memory port, an audio jack, and a power supply interface.

In various embodiments, the sensors may include, but are not limited to, a gyro sensor, an accelerometer, a proximity sensor, an ambient light sensor, and a positioning unit. The positioning unit may also be part of, or interact with, a network interface to communicate with components of a positioning network, e.g., a global positioning system (GPS) satellite.

In various embodiments, the electronic device 600 may be a mobile computing device such as, but not limited to, a laptop computing device, a tablet computing device, a netbook, a mobile phone, etc. In various embodiments, system 700 may have more or less components, and/or different architectures.

In embodiments, the implemented wireless network may be a 3rd Generation Partnership Project's long term evolution (LTE) advanced wireless communication standard, which may include, but is not limited to releases 8, 9, 10, 11, 12, 13, and 14 or later, of the 3GPP's LTE-A or 5G standards.

Although certain embodiments have been illustrated and described herein for purposes of description, a wide variety of alternate and/or equivalent embodiments or implementations calculated to achieve the same purposes may be substituted for the embodiments shown and described without departing from the scope of the present disclosure. This application is intended to cover any adaptations or variations of the embodiments discussed herein. Therefore, it is manifestly intended that embodiments described herein be limited only by the claims and the equivalents thereof.

EXAMPLES

Example 1 may include a method comprising: configuring beamformed Channel State Information Reference Signal (CSI-RS), wherein the CSI-RS is transmitted with a vertical narrow and horizontal wide sector transmitting (Tx) beam, and each Tx beam is considered as a virtualized sector.

Example 2 may include the method of example 1 or some other example herein, wherein the UE measures and reports the Reference Signal Receiving Power (RSRP) based on the beamformed CSI-RS to indicate the signal quality of one sector Tx beam.

Example 3 may include the method of example 2 or some other example herein, wherein the UE reports a receiving (Rx) beam indicator associated with the RSRP, where value 0 indicates the RSRP is measured from an active Rx beam and value 1 indicates the RSRP is measured from a candidate Rx beam, and wherein the UE cannot receive data from both active Rx beam and candidate Rx beam simultaneously, wherein the Rx beam is defined as an Rx beam used for data and control receiving and is initially set to be either active Rx beam and can be switched to candidate Rx beam.

Example 4 may include the method of example 1 or 3 or some other example herein, wherein the UE reports a digital beam selection Channel State Information (CSI), wherein a Precoder Matrix Indicator (PMI) for the active Rx beam and the PMI for the candidate Rx beam may be reported.

Example 5 may include the method of example 4 or some other example herein, wherein the PMI is measured using a codebook from the CSI-RS transmitted on sector beam, which is defined by the system.

Example 6 may include the method of example 4 or some other example herein, wherein the PMI is selected from a rank 1 codebook.

Example 7 may include the method of example 1 or some other example herein, wherein a UE-specific CSI-RS is transmitted as several groups and each group of the several groups is transmitted using a two dimensional narrow Tx beam.

Example 8 may include the method of example 7 or some other example herein, wherein each of the several groups use two antenna ports sent from both horizontal and vertical polarizations.

Example 9 may include the method of example 7 or some other example herein, wherein the UE measures the CSI-RS Receiving Power (CSIRS-RP) for each CSI-RS group.

Example 10 may include the method of example 9 or some other example herein, wherein the UE reports the CSIRS-RP comprising the value of CSIRS-RP, Rx beam indicator, CSI-RS group index and subframe index, wherein the Rx beam indicator is used to indicate whether this CSIRS-RP is measured from active Rx beam or candidate Rx beam.

Example 11 may include the method of example 10 or some other example herein, wherein the UE may report up to N CSIRS-RPs, where N is to be configured by the system or radio resource control (RRC) signaling.

Example 12 may include the method of example 11 or some other example herein, wherein only a valid CSIRS-RP may be reported and a valid CSIRS-RP is defined as a CSIRS-RP within the CSIRS-RP threshold, which is configured by the system or RRC signaling.

Example 13 may include an apparatus comprising means to perform one or more elements of a method described in or related to any of examples 1-12, or any other method or process described herein.

Example 14 may include one or more non-transitory computer-readable media comprising instructions to cause an electronic device, upon execution of the instructions by one or more processors of the electronic device, to perform one or more elements of

a method described in or related to any of examples 1-12, or any other method or process described herein.

Example 15 may include an apparatus comprising logic, modules, and/or circuitry to perform one or more elements of a method described in or related to any of examples 1-12, or any other method or process described herein.

Example 16 may include a method, technique, or process as described in or related to any of examples 1-12, or portions or parts thereof.

Example 17 may include an apparatus comprising: one or more processors and one or more computer readable media comprising instructions that, when executed by the one or more processors, cause the one or more processors to perform the method, techniques, or process as described in or related to any of examples 1-12, or portions thereof.

Example 18 may include a method of communicating in a wireless network as shown and described herein.

Example 19 may include a system for providing wireless communication as shown and described herein.

Example 20 may include a device for providing wireless communication as shown and described herein.

Example 21 may include an apparatus for use in an eNB in a wireless communication network, the apparatus comprising transmitter circuitry; and control circuitry coupled to the transmitter circuitry, the control circuitry to: configure a plurality of channel state information reference signals (CSI-RS), each CSI-RS associated with one of a plurality of virtualized sectors; and cause the transmitter circuitry to transmit the configured CSI-RS; wherein each of the plurality of virtualized sectors comprises a transmit beam beamformed to be vertically narrow and horizontally wide based on an associated vertical downtilt angle.

Example 22 may include the apparatus of example 21, wherein each of the plurality of virtualized sectors is associated with a different vertical downtilt angle.

Example 23 may include the apparatus of example 21 or example 22 example further comprising receiver circuitry coupled to the control circuitry, the receiver circuitry to receive an indication of a reference signal received power (RSRP) value associated with one of the virtualized sectors from a User Equipment (UE), the indication of RSRP value based on the CSI-RS associated with the one of the virtualized sectors.

Example 24 may include the apparatus of example 23, wherein the indication of RSRP value comprises an indication of a receiving beam associated with the RSRP value.

Example 25 may include the apparatus of example 24, wherein the indication of a receiving beam comprises a first value to indicate that the RSRP value was measured from an active receiving beam and a second value to indicate that the RSRP value was measure from a candidate receiving beam.

Example 26 may include the apparatus of example 23, wherein the control circuitry is further to select a virtualized sector beam for communicating with the UE based on the received indication of RSRP value.

Example 27 may include the apparatus of example 26, wherein the control circuitry is further to configure UE specific CSI-RS associated with the selected virtualized sector and cause the transmitter circuitry to transmit the UE specific CSI-RS to the UE in the selected virtualized sector.

Example 28 may include the apparatus of example 27, wherein the receiver circuitry is further to receive a digital beam selection channel state information (CSI) from the UE in response to the UE specific CSI-RS, the digital beam selection CSI comprising a first precoder matrix indicator (PMI) associated with an active receiving beam.

Example 29 may include the apparatus of example 28, wherein the digital beam selection CSI further comprises a second PMI associated with a candidate receiving beam.

Example 30 may include the apparatus of examples 28 or 29, wherein the PMI is selected from a rank 1 codebook.

Example 31 may include the apparatus of examples 28 or 29, wherein the PMI is measured using a codebook defined by the network.

Example 32 may include the apparatus of any of examples 8 to 10, wherein the control circuitry is further to generate a two dimensional narrow transmit beam within the selected virtualized sector based on a received PMI.

Example 33 may include the apparatus of any of examples 27 to 32, wherein the transmitter circuitry is further to transmit the US specific CSI-RS a plurality of CSI-RS groups, wherein each CSI-RS group of the plurality of CSI-RS groups is associated with a two dimensional narrow transmit beam within the selected virtualized sector.

Example 34 may include the apparatus of example 33, wherein each of the plurality of CSI-RS groups is associated with two antenna ports sent from both horizontal and vertical polarizations.

Example 35 may include the apparatus of example 33 or example 34, the receiver circuitry further to receive a CSI-RS report from the UE, the report comprising: CSI-RS receiving power (CSIRS-RP) value; a receiving beam indicator comprising a first value to indicate the CSIRS-RP value was measured using an active receive beam and a second value to indicate that the CSIRS-RP value was measured using a candidate receive beam; a CSI-RS group index; and a subframe index.

Example 36 may include the apparatus of example 35, the receiver circuitry further to receive a plurality of CSI-RS reports from the UE, each CSI-RS report associated with a CSI-RS group of the plurality of CSI-RS groups.

Example 37 may include the apparatus of example 36, wherein the plurality of CSI-RS reports may comprise N CSI-RP reports, where N is configured by the network or using radio resource control signalling (RRC).

Example 38 may include the apparatus of example 36 or example 37, wherein the plurality of CSI-RS reports comprises CSI-RS reports having a CSIRS-RP value greater than a threshold CSIRS-RP value.

Example 39 may include the apparatus of example 38, wherein the threshold CSIRS-RP value is configured by the network or using radio resource control signalling (RRC).

Example 40 may include an apparatus for use in a user equipment in a wireless communication network, the apparatus comprising receiver circuitry to receive a plurality of channel state information reference signals (CSI-RS) from an eNB, each CSI-RS associated with one of a plurality of virtualized sectors; controller circuitry coupled to the receiver circuitry, the controller circuitry to: obtain a plurality of reference signal receiver power (RSRP) values, each of the plurality of RSRP values associated with one of the received CSI-RS; and generate an indication of RSRP associated with one of the virtualized sectors; and transmitter circuitry to transmit the indication of RSRP to the eNB; and wherein each of the plurality of virtualized sectors comprises a transmit beam beamformed to be vertically narrow and horizontally wide based on an associated vertical downtilt angle.

Example 41 may include the apparatus of example 40, the controller circuitry further to determine a highest RSRP value of the plurality of RSRP values wherein the generated indication comprises an indication of the determined highest RSRP value and the associated virtualized sector.

Example 42 may include the apparatus of example 40 or example 41, wherein the receiver circuitry is operable to receive an active receiving beam and a candidate receiving beam; and wherein the generated indication of RSRP further comprises an indication of a receiving beam associated with the RSRP value, wherein the indication of

a receiving beam comprises a first value to indicate that the RSRP value was measured from the active receiving beam and a second value to indicate that the RSRP value was measure from the candidate receiving beam.

Example 43 may include the apparatus of example 42, wherein the receiver circuitry is operable to receive one of the active receiving beam and the candidate receiving beam at one time.

Example 44 may include the apparatus of any of examples 40 to 43, wherein the receiver circuitry is further to receive UE specific CSI-RS on a first virtualized sector of the plurality of virtualized sectors; and wherein the controller circuitry is further to generate a digital beam selection Channel State Information (CSI) in dependence on the received UE specific CSI-RS.

Example 45 may include the apparatus of example 44, wherein the UE specific CSI-RS comprises a plurality of CSI-RS groups, wherein each CSI-RS group of the plurality of CSI-RS groups is associated with a two dimensional narrow transmit beam within the selected virtualized sector.

Example 46 may include the apparatus of example 44 or example 45, wherein the digital beam selection CSI comprises a first precoder matrix indicator (PMI) associated with an active receiving beam.

Example 47 may include the apparatus of example 46, wherein the digital beam selection CSI further comprises a second PMI associated with a candidate receiving beam.

Example 48 may include the apparatus of example 44 to example 47, wherein the PMI is selected from a rank 1 codebook.

Example 49 may include the apparatus of example 45, the control circuitry to generate a CSI-RS report, the CSI-RP report comprising CSI-RS receiving power (CSIRS-RP) value; a receiving beam indicator comprising a first value to indicate the CSIRS-RP value was measured using an active receive beam and a second value to indicate that the CSIRS-RP value was measured using a candidate receive beam; a CSI-RS group index; and a subframe index.

Example 50 may include the apparatus of example 49, the control circuitry to generate a plurality of CSI-RS reports from the UE, each CSI-RS report associated with a CSI-RS group of the plurality of CSI-RS groups.

Example 51 may include the apparatus of example 50, wherein the plurality of CSI-RS reports may comprise N CSI-RP reports, where N is configured by the network or using radio resource control signalling (RRC).

Example 52 may include the apparatus of example 50 or example 51, wherein the plurality of CSI-RS reports comprises CSI-RS reports having a CSIRS-RP value greater than a threshold CSIRS-RP value.

Example 53 may include the apparatus of example 52, wherein the threshold CSIRS-RP value is configured by the network or using radio resource control signalling (RRC).

Example 54 may include a user equipment comprising an apparatus according to any of examples 20 to 33, the user equipment further comprising at least one of a display; a keyboard; and a touchscreen.

Example 55 may include a computer readable medium comprising computer program code that when executed implements the method of receiving a plurality of channel state information reference signals (CSI-RS) from an eNB, each CSI-RS associated with one of a plurality of virtualized sectors; obtaining a plurality of reference signal receiver power (RSRP) values, each of the plurality of RSRP values associated with one of the received CSI-RS; and generating an indication of RSRP associated with one of the virtualized sectors; and transmitting the indication of RSRP to the eNB; wherein each of the plurality of virtualized sectors comprises a transmit beam beamformed to be vertically narrow and horizontally wide based on an associated vertical downtilt angle.

Example 56 may include a computer readable medium comprising computer program code that when executed implements the method of configuring a plurality of channel state information reference signals (CSI-RS), each CSI-RS associated with one of a plurality of virtualized sectors; and transmitting the configured CSI-RS; wherein each of the plurality of virtualized sectors comprises a transmit beam beamformed to be vertically narrow and horizontally wide based on an associated vertical downtilt angle.

Example 57 may include the apparatus of example 21, wherein a transmit beam associated with a virtualized sector is transmitted using a first antenna port, the first antenna port associated with a first number of vertical antenna elements and a second number of horizontal antenna elements wherein the first number of vertical antenna elements is greater than the second number of horizontal antenna elements.

Example 58 may include the apparatus of example 57, wherein the first number of vertical antenna elements is greater than or equal to 8, and wherein the second number of horizontal antenna elements is less than or equal to 2.

The foregoing description of one or more implementations provides illustration and description, but is not intended to be exhaustive or to limit the scope of the example embodiments to the precise form disclosed. Modifications and variations are possible in light of the above teachings or may be acquired from practice of various implementations of the example embodiments.

CLAIMS

1. An apparatus for use in an eNB in a wireless communication network, the apparatus comprising:

transmitter circuitry; and

control circuitry coupled to the transmitter circuitry, the control circuitry to:

configure a plurality of channel state information reference signals (CSI-RS), each CSI-RS associated with one of a plurality of virtualized sectors; and

cause the transmitter circuitry to transmit the configured CSI-RS;

wherein each of the plurality of virtualized sectors comprises a transmit beam beamformed to be vertically narrow and horizontally wide based on an associated vertical downtilt angle.

2. The apparatus of claim 1, wherein each of the plurality of virtualized sectors is associated with a different vertical downtilt angle.

3. The apparatus of any preceding claim further comprising:

receiver circuitry coupled to the control circuitry, the receiver circuitry to receive an indication of a reference signal received power (RSRP) value associated with one of the virtualized sectors from a User Equipment (UE), the indication of RSRP value based on the CSI-RS associated with the one of the virtualized sectors.

4. The apparatus of claim 3, wherein the control circuitry is further to select a virtualized sector beam for communicating with the UE based on the received indication of RSRP value.

5. The apparatus of claim 4, wherein the control circuitry is further to configure UE specific CSI-RS associated with the selected virtualized sector and cause the transmitter circuitry to transmit the UE specific CSI-RS to the UE in the selected virtualized sector.

6. The apparatus of claim 5, wherein the receiver circuitry is further to receive a digital beam selection channel state information (CSI) from the UE in response

to the UE specific CSI-RS, the digital beam selection CSI comprising a first precoder matrix indicator (PMI) associated with an active receiving beam.

7. The apparatus of claim 6, wherein the digital beam selection CSI further comprises a second PMI associated with a candidate receiving beam.

8. The apparatus of claims 6 or 7, wherein the PMI is selected from a rank 1 codebook defined by the network.

9. The apparatus of any of claims 6 to 8, wherein the control circuitry is further to generate a two dimensional narrow transmit beam within the selected virtualized sector based on a received PMI.

10. The apparatus of any of claims 6 to 9, wherein the transmitter circuitry is further to transmit the US specific CSI-RS a plurality of CSI-RS groups, wherein each CSI-RS group of the plurality of CSI-RS groups is associated with a two dimensional narrow transmit beam within the selected virtualized sector;

wherein each of the plurality of CSI-RS groups is associated with two antenna ports sent from both horizontal and vertical polarizations.

11. The apparatus of any of claims 1 to 10, wherein a transmit beam associated with a virtualized sector is transmitted using a first antenna port, the first antenna port associated with a first number of vertical antenna elements and a second number of horizontal antenna elements wherein the first number of vertical antenna elements is greater than the second number of horizontal antenna elements.

12. The apparatus of claim 10 or claim 11, the receiver circuitry further to:

receive a CSI-RS report from the UE, the report comprising:

CSI-RS receiving power (CSIRS-RP) value;

a receiving beam indicator comprising a first value to indicate the CSIRS-RP value was measured using an active receive beam and a second value to indicate that the CSIRS-RP value was measured using a candidate receive beam;

a CSI-RS group index; and

a subframe index.

13. The apparatus of claim 12, the receiver circuitry further to receive a plurality of CSI-RS reports from the UE, each CSI-RS report associated with a CSI-RS group of the plurality of CSI-RS groups.

14. An apparatus for use in a user equipment (UE) in a wireless communication network, the apparatus comprising:

receiver circuitry to receive a plurality of channel state information reference signals (CSI-RS) from an eNB, each CSI-RS associated with one of a plurality of virtualized sectors;

controller circuitry coupled to the receiver circuitry, the controller circuitry to:

obtain a plurality of reference signal receiver power (RSRP) values, each of the plurality of RSRP values associated with one of the received CSI-RS; and

generate an indication of RSRP associated with one of the virtualized sectors; and

transmitter circuitry to transmit the indication of RSRP to the eNB; and

wherein each of the plurality of virtualized sectors comprises a transmit beam beamformed to be vertically narrow and horizontally wide based on an associated vertical downtilt angle.

15. The apparatus of claim 14, the controller circuitry further to determine a highest RSRP value of the plurality of RSRP values wherein the generated indication comprises an indication of the determined highest RSRP value and the associated virtualized sector.

16. The apparatus of claim 14 or claim 15, wherein the receiver circuitry is operable to receive an active receiving beam and a candidate receiving beam; and

wherein the generated indication of RSRP further comprises an indication of a receiving beam associated with the RSRP value, wherein the indication of a receiving beam comprises a first value to indicate that the RSRP value was measured from the active receiving beam and a second value to indicate that the RSRP value was measure from the candidate receiving beam.

17. The apparatus of claim 16, wherein the receiver circuitry is operable to receive only one of the active receiving beam and the candidate receiving beam at one time.

18. The apparatus of any of claims 14 to 17, wherein the receiver circuitry is further to receive UE specific CSI-RS on a first virtualized sector of the plurality of virtualized sectors; and

wherein the controller circuitry is further to generate a digital beam selection Channel State Information (CSI) in dependence on the received UE specific CSI-RS.

19. The apparatus of claim 18, wherein the UE specific CSI-RS comprises a plurality of CSI-RS groups, wherein each CSI-RS group of the plurality of CSI-RS groups is associated with a two dimensional narrow transmit beam within the selected virtualized sector.

20. The apparatus of claim 18 or claim 19, wherein the digital beam selection CSI comprises a first precoder matrix indicator (PMI) associated with an active receiving beam and a second PMI associated with a candidate receiving beam.

21. The apparatus of claim 19, the control circuitry to generate a CSI-RS report, the CSI-RP report comprising:

CSI-RS receiving power (CSIRS-RP) value;

a receiving beam indicator comprising a first value to indicate the CSIRS-RP value was measured using an active receive beam and a second value to indicate that the CSIRS-RP value was measured using a candidate receive beam;

a CSI-RS group index; and

a subframe index.

22. The apparatus of claim 21, the control circuitry to generate a plurality of CSI-RS reports from the UE, each CSI-RS report associated with a CSI-RS group of the plurality of CSI-RS groups.

23. A user equipment comprising an apparatus according to any of claims 20 to 33, the user equipment further comprising at least one of a display; a keyboard; and a touchscreen.

24. A computer readable medium comprising computer program code that when executed implements the method of:

receiving a plurality of channel state information reference signals (CSI-RS) from an eNB, each CSI-RS associated with one of a plurality of virtualized sectors;

obtaining a plurality of reference signal receiver power (RSRP) values, each of the plurality of RSRP values associated with one of the received CSI-RS; and

generating an indication of RSRP associated with one of the virtualized sectors; and

transmitting the indication of RSRP to the eNB;

wherein each of the plurality of virtualized sectors comprises a transmit beam beamformed to be vertically narrow and horizontally wide based on an associated vertical downtilt angle.

25. A computer readable medium comprising computer program code that when executed implements the method of:

configuring a plurality of channel state information reference signals (CSI-RS), each CSI-RS associated with one of a plurality of virtualized sectors; and

transmitting the configured CSI-RS;

wherein each of the plurality of virtualized sectors comprises a transmit beam beamformed to be vertically narrow and horizontally wide based on an associated vertical downtilt angle.

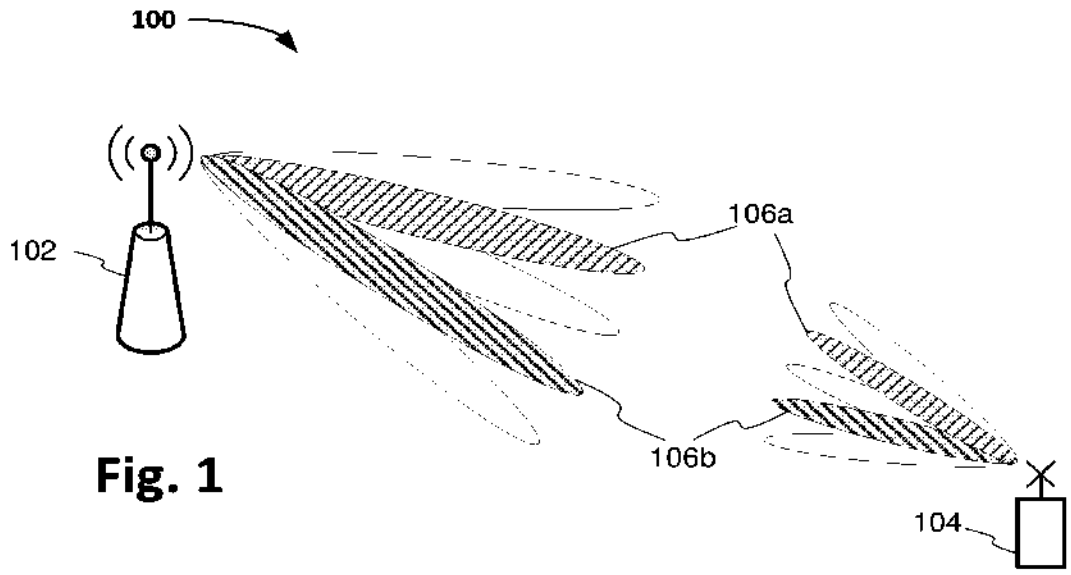

100
102
106a
106b
104

Fig. 1

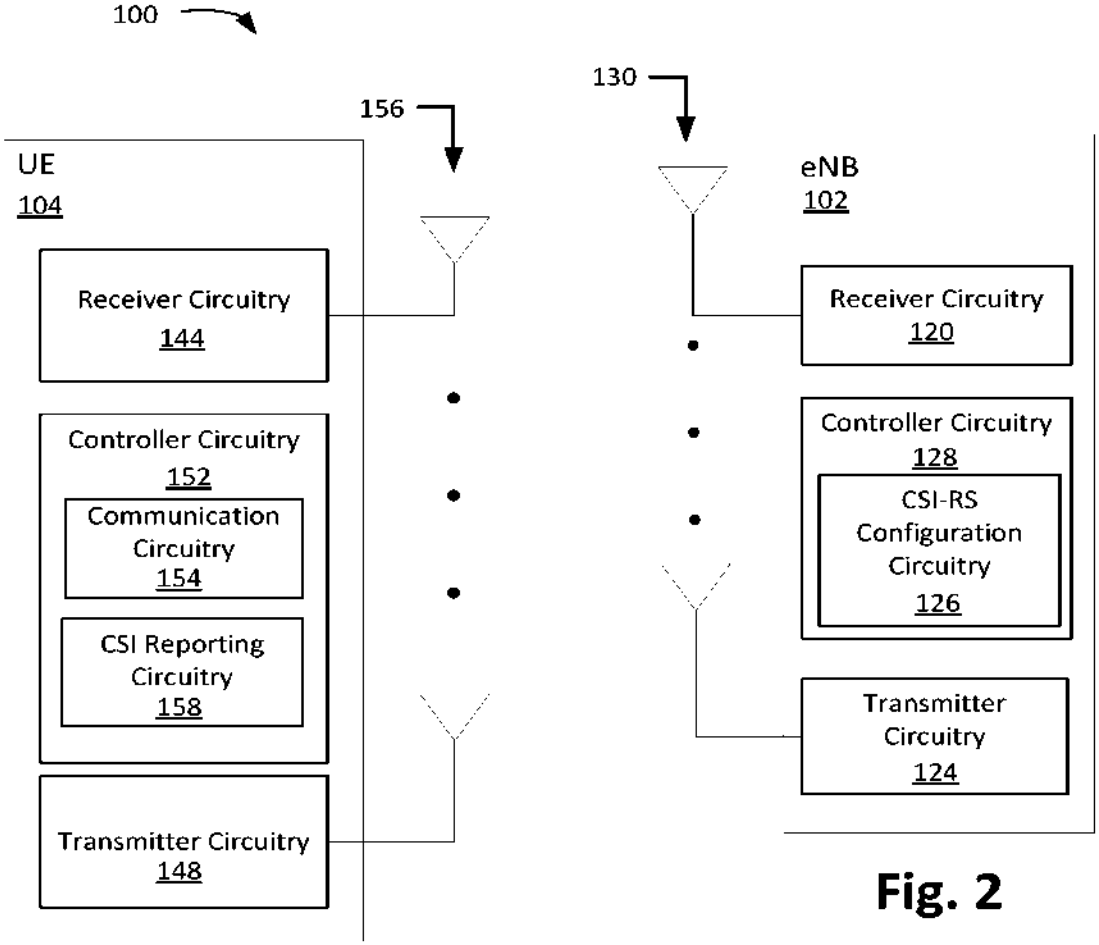

100
156
130
UE
104
Receiver Circuitry
144
Controller Circuitry
152
Communication Circuitry
154
CSI Reporting Circuitry
158
Transmitter Circuitry
148
eNB
102
Receiver Circuitry
120
Controller Circuitry
128
CSI-RS Configuration Circuitry
126
Transmitter Circuitry
124

Fig. 2

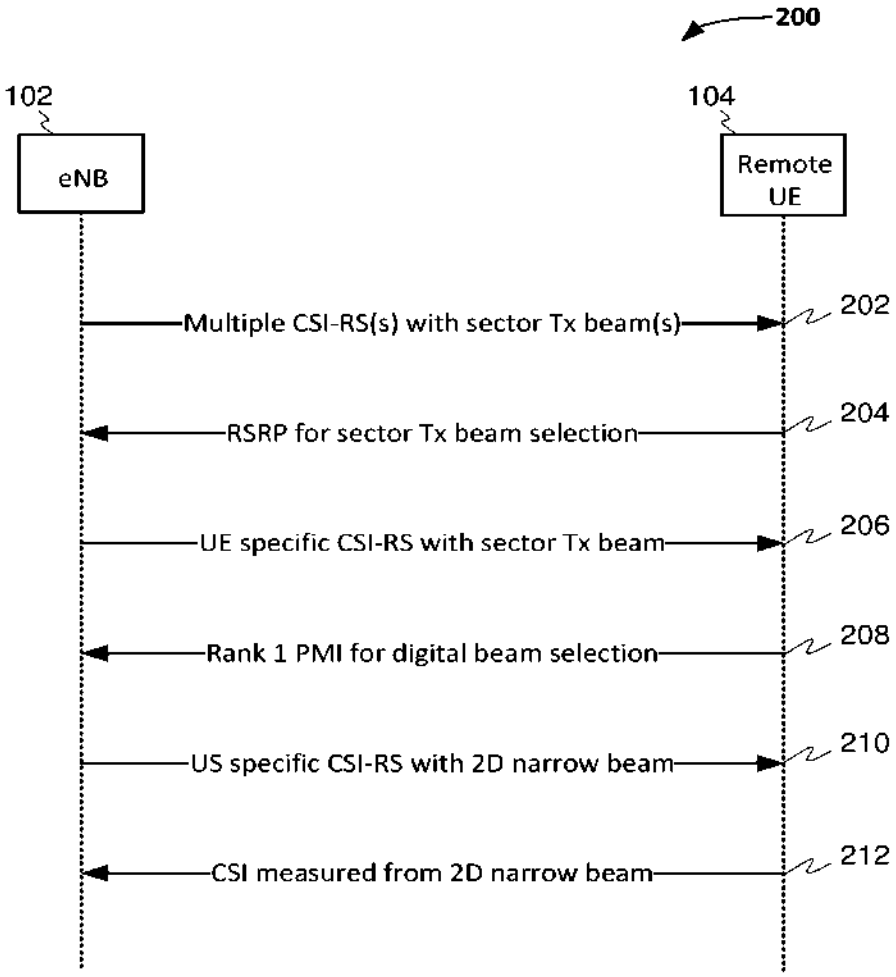

200
102
eNB
104
Remote UE
Multiple CSI-RS(s) with sector Tx beam(s)
202
RSRP for sector Tx beam selection
204
UE specific CSI-RS with sector Tx beam
206
Rank 1 PMI for digital beam selection
208
US specific CSI-RS with 2D narrow beam
210
CSI measured from 2D narrow beam
212

Fig. 3

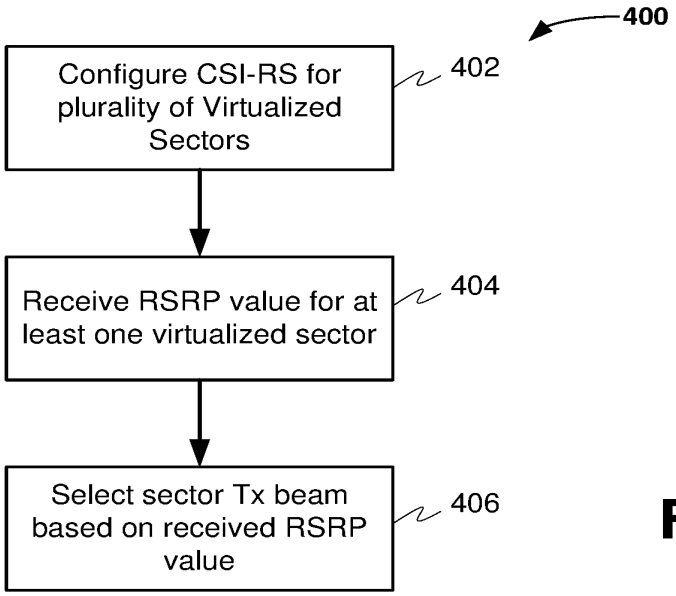

400
Configure CSI-RS for plurality of Virtualized Sectors
402
Receive RSRP value for at least one virtualized sector
404
Select sector Tx beam based on received RSRP value
406

Fig. 4

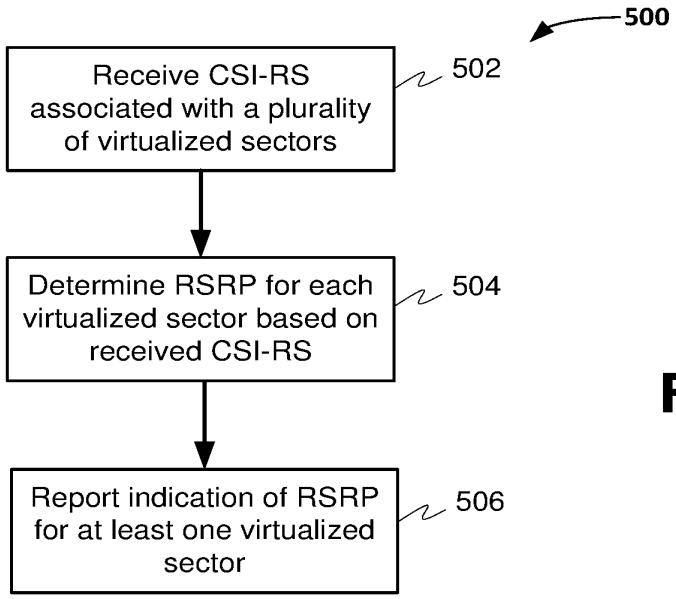

500
Receive CSI-RS associated with a plurality of virtualized sectors
502
Determine RSRP for each virtualized sector based on received CSI-RS
504
Report indication of RSRP for at least one virtualized sector
506

Fig. 5

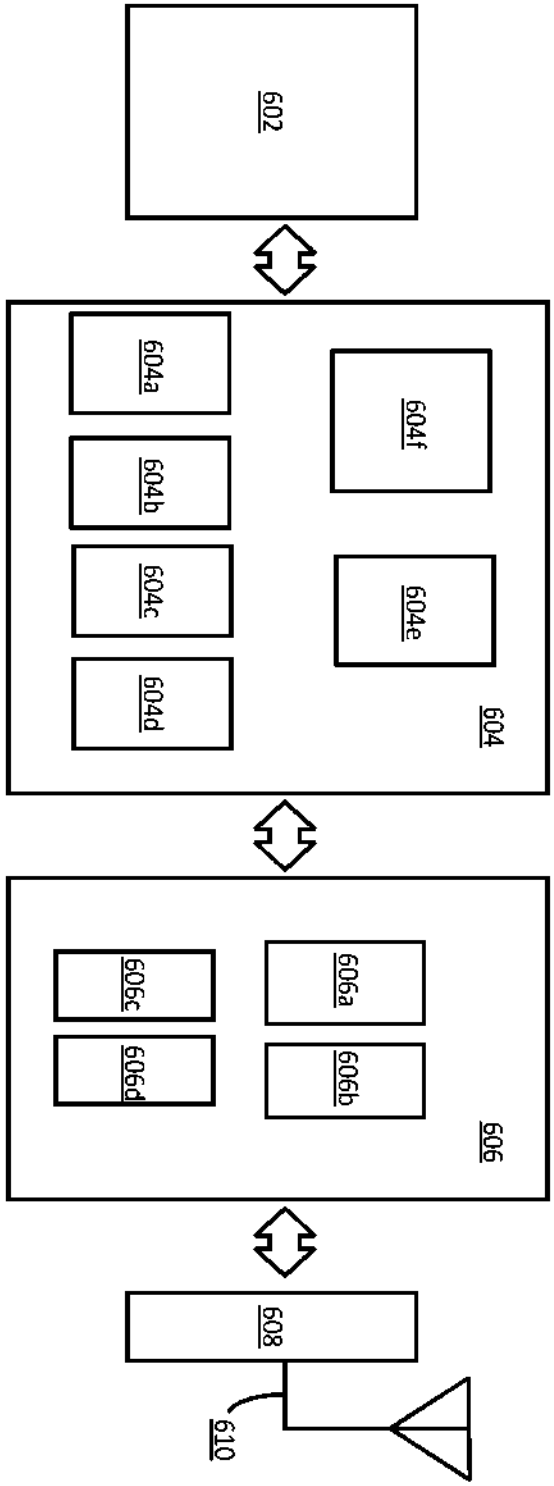

602
604a
604b
604c
604d
604e
604f
604
606a
606b
606c
606d
606
608
610
600

Fig. 6

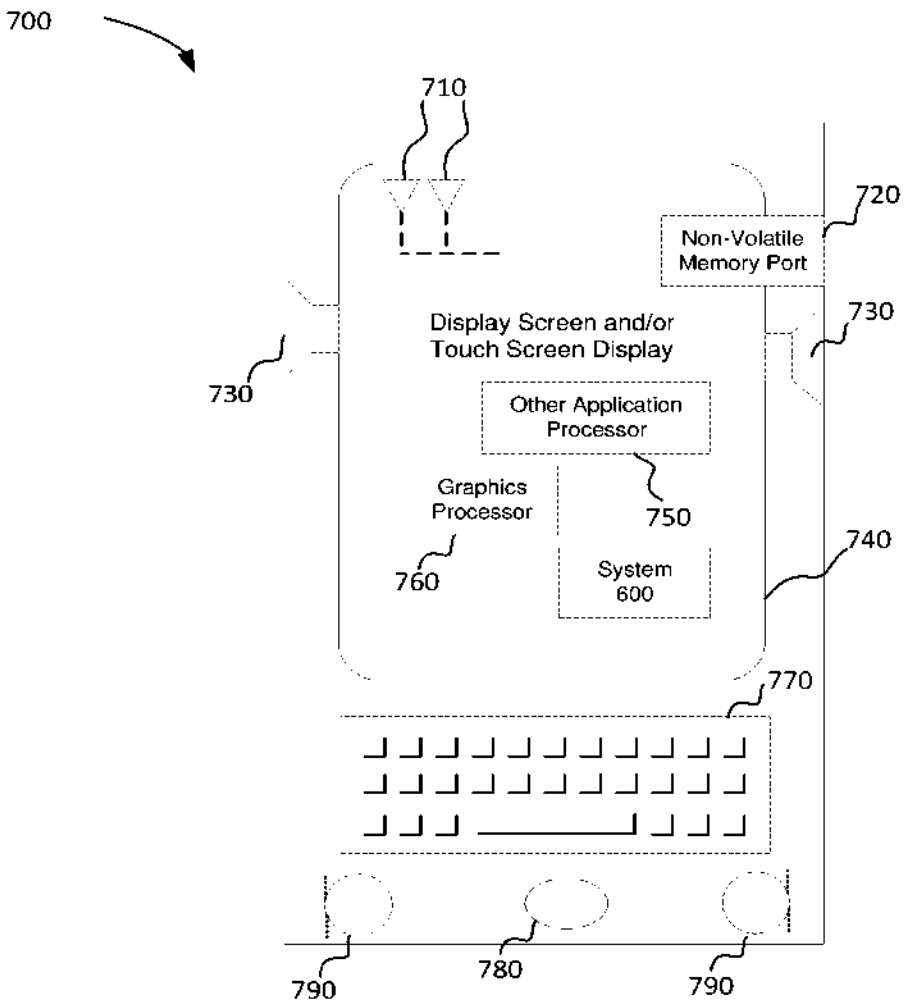

700
710
720
Non-Volatile Memory Port
730
730
Display Screen and/or Touch Screen Display
Other Application Processor
750
Graphics Processor
760
System 600
740
770
790
780
790

Fig. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2016/078453

A. CLASSIFICATION OF SUBJECT MATTER

H04B 7/02(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04B; H04W; H04Q; H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNKI,CNPAT,WPI,EPODOC,IEEE,GOOGLE,3GPP: RS, CSI-RS, eNB, CSI, sectors, RSRP, angle, vertical+, horizontal+, downtilt, tilt, measure, report

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2014182383 A1 (INTEL IP CORPORATION) 13 November 2014 (2014-11-13) description, pages 5-6, 14, figures 4A-4B	1-25
X	WO 2014052806 A1 (INTERDIGITAL PATENT HOLDINGS, INC.) 03 April 2014 (2014-04-03) description, paragraphs [0209]-[0219]	1-25
A	WO 2014099343 A1 (MOTOROLA MOBILITY LLC) 26 June 2014 (2014-06-26) the whole document	1-25
A	US 2011103504 A1 (FUTUREWEI TECHNOLOGIES, INC.) 05 May 2011 (2011-05-05) the whole document	1-25

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 July 2016	**26 July 2016**
Name and mailing address of the ISA/CN **STATE INTELLECTUAL PROPERTY OFFICE OF THE P.R.CHINA** **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088, China** Facsimile No. (**86-10**)**62019451**	Authorized officer **XING,Yunfeng** Telephone No. (**86-10**)**62413374**

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2016/078453

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
WO	2014182383	A1	13 November 2014	US	2016057797	A1	25 February 2016
				CN	105359477	A	24 February 2016
				CN	105340190	A	17 February 2016
				US	2016065290	A1	03 March 2016
				WO	2014182774	A1	13 November 2014
				US	2016157095	A1	02 June 2016
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				EP	2995012	A1	16 March 2016
				EP	2995030	A1	16 March 2016
				CN	105103606	A	25 November 2015
				TW	201509222	A	01 March 2015
				WO	2014182911	A1	13 November 2014
				EP	2995057	A1	16 March 2016
				TW	201507508	A	16 February 2015
				EP	2995105	A1	16 March 2016
				US	2016029417	A1	28 January 2016
				US	2016057636	A1	25 February 2016
				US	2016113050	A1	21 April 2016
				US	2016057044	A1	25 February 2016
				WO	2014182340	A1	13 November 2014
				CN	105103609	A	25 November 2015
				WO	2014182388	A1	13 November 2014
				US	2016044690	A1	11 February 2016
				EP	2995019	A1	16 March 2016
				WO	2014182338	A1	13 November 2014
				WO	2014182339	A1	13 November 2014
				WO	2014113193	A1	24 July 2014
				CN	104854835	A	19 August 2015
				US	2015326572	A1	12 November 2015
				EP	2946539	A1	25 November 2015
				JP	2016510527	A	07 April 2016
WO	2014052806	A1	03 April 2014	EP	2901571	A1	05 August 2015
				JP	2015536099	A	17 December 2015
				TW	201429182	A	16 July 2014
				US	2014098689	A1	10 April 2014
WO	2014099343	A1	26 June 2014	US	2014177683	A1	26 June 2014
US	2011103504	A1	05 May 2011		None		

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(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

(54) **Title**: DOWNLINK CONTROL CHANNEL DESIGN AND SIGNALING FOR BEAMFORMED SYSTEMS

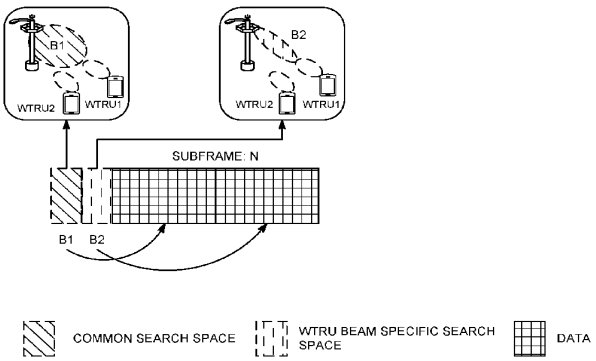


FIG. 22

(57) **Abstract**: Transmit and/or receive beamforming may be applied to the control channel transmission/reception, e.g., in mmW access link system design. Techniques to identify candidate control channel beams and/or their location in the subframe structure may provide for efficient WTRU operation. A framework for beam formed control channel design may support varying capabilities of mBs and/or WTRUs, and/or may support time and/or spatial domain multiplexing of control channel beams. For a multi-beam system, modifications to reference signal design may discover, identify, measure, and/or decode a control channel beam. Techniques may mitigate inter-beam interference. WTRU monitoring may consider beam search space, perhaps in addition to time and/or frequency search space. Enhancements to downlink control channel may support scheduling narrow data beams. Scheduling techniques may achieve high resource utilization, e.g., perhaps when large bandwidths are available and/or WTRUs may be spatially distributed.

WO 2017/083514 A1

DOWNLINK CONTROL CHANNEL DESIGN AND SIGNALING FOR BEAMFORMED SYSTEMS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 62/253,599, filed on November 10, 2015, the entire contents of which being incorporated by reference as if fully set-forth herein, for all purposes.

BACKGROUND

[0002] Small Cell mmW eNB (SCmB) deployment may be based on the 3GPP R12 small cell deployment. The mmW operation may be performed by one or more network nodes. A Small Cell mmW eNB (SCmB) may be an LTE small cell eNB capable of operating an mmW air interface, perhaps with an LTE air interface in the downlink.

[0003] An mmW WTRU (mWTRU) may be capable of operating in LTE and mmW air interface. The mWTRU may have one or more sets of antennas and/or the acccompanied Radio Frequency (RF) chains, perhaps one operating in the LTE band and/or in the mmW frequency band.

SUMMARY

[0004] Initial mmW access link system design may focus on cellular system procedures that enable add-on mmW data transmission (e.g., at least downlink transmission) to an existing network such as a small cell LTE network. Transmit and/or receive beamforming may be applied to the control channel transmission/reception, e.g., to overcome high path loss at > 6Ghz frequencies. Techniques to identify candidate control channel beams and/or their location in the subframe structure may provide for efficient WTRU operation. A framework for beam formed control channel design may support varying capabilities of mBs and/or WTRUs, and/or may support time and/or spatial domain multiplexing of control channel beams. Modifications to reference signal design may discover, identify, measure, and/or decode one or more, or each, control channel beam, for example for a multi-beam system, among other scenarios. Techniques may mitigate inter-beam interference. WTRU monitoring may consider beam search space in addition to time and/or frequency search space. Techniques to downlink control channel may

support scheduling narrow data beams. Scheduling mechanisms may achieve (e.g., high) resource utilization, e.g., perhaps when large bandwidths may be available and/or WTRUs may be spatially distributed.

[0005] For example, one or more beam specific control channels may be utilized. The beam specific control channels may utilize a fixed mapping in a frame structure. For example, a beam specific control channel may be mapped to a fixed symbol and/or a fixed subframe in the frame structure. For example, a flexible mapping may be used for the beam specific control channels within the frame structure.

[0006] For example, a WTRU-specific and/or beam-specific search space may be used for transmitting and/or receiving control channels. The WTRU-specific and/or beam-specific search space may be associated with serving control channel(s) assignments. The WTRU-specific and/or beam-specific search space may be utilized in a WTRU monitoring procedure. For example, the WTRU may be configured to determine a beam specific search space size (e.g., in terms of subframe and symbol location). A WTRU may be configured to determine a WTRU-specific search space within a beam and/or beam-specific search space.

[0007] A WTRU and/or based station may be configured to perform methods for resource allocation for sub-subframe scheduling. For example, sub-subframe scheduling may allow multiple allocations in a given subframe. For example, sub-subframe scheduling may be performed such that multiplexing (e.g., TDM) WTRUs with different downlink beams within a given subframe may be utilized.

[0008] A WTRU may be configured to identify the downlink data beam that an mB may use for the WTRU. For example, the WTRU may be configured to switch the receive beam used for downlink data based on one or more parameters. For example, the WTRU may be configured to switch the receive beam used for downlink data based on resource allocation information. For example, the WTRU may be configured to switch the receive beam used for downlink data independently from the received resource allocation information. For example, beam combining may be used for the DL and/or UL.

[0009] A wireless transmit/receive unit (WTRU) may be configured for wireless communication. The WTRU may comprise a memory. The WTRU may comprise a processor. The processor configured with at least one or more search spaces. The one or more search spaces may be configured to provide for at least one of: a monitor of one or more Downlink (DL) control channels, and/or a receipt of the one or more DL control channels. At least one search space of the one or more search spaces may correspond to at least one reference signal of one or more reference signals. The processor may be configured at least to monitor at least a part of a

control region for at least one reference signal of the one or more reference signals. The processor may be configured to detect the at least one reference signal in the at least part of the control region. The processor may be configured to monitor the at least one search space corresponding to the at least one reference signal for at least one DL control channel upon the detection of the at least one reference signal.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. 1 is an example of mmW Small Cell Deployment.

[0011] FIG. 2 is an example of Comparison of Frequency and Spatial Filtering.

[0012] FIG. 3 is an example of an OFDM Frame Structure.

[0013] FIG. 4 is an example of an mmW Downlink Logical, Transport and Physical Channel.

[0014] FIG. 5 is an example of an mWTRU Fully Digitized Beamforming.

[0015] FIG. 6 is an example of an mWTRU Analogue Beamforming with at least one PAA and at least one RF Chain.

[0016] FIG. 7 is an example of an mWTRU Analog Beamforming with at least one PAA and at least two RF Chains.

[0017] FIG. 8 is an example of an mWTRU Analog Beamforming with at least two PAAs and at least two RF Chains.

[0018] FIG. 9 is an example of an mWTRU Analogue Beamforming with at least two PAAs and at least one RF Chain.

[0019] FIG. 10 is an example of an Illustrative 2D and Realistic 3D Narrow Beam Pattern.

[0020] FIG. 11 is an example of a Realistic 3D Broadside Broad Beam Pattern.

[0021] FIG. 12 is an example of Physical Downlink Control Channel (PDCCH) Type 1a.

[0022] FIG. 13 is an example of PDCCH Type 1b.

[0023] FIG. 14 is an example of PDCCH Type 2.

[0024] FIG. 15 is an example of PDCCH Type 3a.

[0025] FIG. 16 is an example of PDCCH Type 3b.

[0026] FIG. 17 is an example of a Logical Architecture for Control Channel Beam Generation.

[0027] FIG. 18 is an example of a Subframe Structure and Placement for Control BRS.

[0028] FIG. 19 is an example of Resource Allocation in Two Dimension of Frequency and Time.

[0029] FIG. 20 is an example of a Subframe Structure and Placement for Control BRS for Parallel Beam Sweeping.

[0030] FIG. 21 is an example of Resource Allocation in Two Dimension of Frequency and Time.

[0031] FIG. 22 is an example of Common Control Channel Beam and Search Space.

[0032] FIG. 23 is an example of WTRU Beam Specific Search Space.

[0033] FIG. 24A is a System Diagram of an example Communications System.

[0034] FIG. 24B is a System Diagram of an example Wireless Transmit/Receive Unit (WTRU) that May be Used within the Communications System Illustrated in FIG. 24A.

[0035] FIG. 24C is a System Diagram of an example Radio Access Network and an Example Core Network that may be Used within the Communications System Illustrated in FIG. 24A.

[0036] FIG. 24D is a System Diagram of another example Radio Access Network and an Example Core Network that may be Used within the Communications System Illustrated in FIG. 24A.

[0037] FIG. 24E is a System Diagram of another example Radio Access Network and an Example Core Network that may be Used within the Communications System Illustrated in FIG. 24A.

DETAILED DESCRIPTION

[0038] A detailed description of illustrative embodiments will now be described with reference to the various figures. Although this description provides a detailed example of possible implementations, it should be noted that the details are intended to be examples and in no way limit the scope of the application.

[0039] An mmW deployment may be used, e.g., based on a 3GPP R12 small cell deployment perhaps with an extension of a LTE carrier aggregation scheme. An example is a Small Cell mmW eNB (SCmB) deployment. The SCmB may be based on the 3GPP R12 small cell deployment. The mmW operation may be performed by one or more of the following network nodes. A LTE small cell eNB may be capable of operating an mmW air interface, for example in parallel with a LTE air interface in the downlink. The SCmB may simultaneously transmit LTE downlink channels in a wide beam pattern and/or mmW channels in narrow beam

pattern(s), e.g., when it is equipped with advanced antenna configuration and/or beamforming technique(s). The SCmB may support features and/or procedures in a LTE uplink (UL) operation, e.g., to support mmW wireless transmit/receive units (WTRUs) without mmW uplink transmission. A wireless transmit/receive unit (WTRU) that is capable of operating an mmW air interface, possibly in parallel with a non-mmW LTE system, may be referred to as an mmW wireless transmit/receive unit (mWTRU) and/or an mmW user equipment (mUE). A mWTRU and/or a mUE may be used interchangeably herein. A WTRU may be used herein to refer to an mWTRU.

[0040] For example, an mWTRU may comprise antennas (e.g., two or more sets) and/or accompanied RF chains, some operating in a LTE band and/or some for operation in an mmW frequency band. The antennas and/or accompanied RF chains may perform independent baseband processing functions, although portions of the antennas and/or RF chains may share some hardware and/or functional blocks. For example, the baseband functions may share certain hardware blocks, e.g., when the mmW air interface bears similarity with the LTE system.

[0041] For example, mmW channels may be used as an extension of a LTE carrier aggregation scheme. One or more mmW channels may be a carrier type in the mmW frequency band. One or more mmW channels may apply a different air interface and/or legacy LTE. The one or more mmW channels may be of opportunistic use for high-throughput and/or low-latency traffic data application(s).

[0042] LTE channels may carry control signaling, e.g., system information update, paging, Radio Resource Control (RRC) and/or Non-Access Stratum (NAS) signaling (signaling radio bearers), and/or multicast traffic may be carried. LTE channels may be used to carry mmW Layer 1 (L1) control signaling.

[0043] The SCmB and/or mWTRU may employ narrow beamforming, e.g., in non-line of sight (NLOS) at mmW frequency band, perhaps for example due to relatively high propagation loss associated with mmW band. Employing narrow beamforming may provide for a (e.g., sufficient) link budget for high-throughput and/or low-latency data transmission.

[0044] Transmitting and/or receiving narrow beam pairing may be used. For example, at least a consistent coverage with a cell-radius of up to 200 meters may be achieved at 28 GHz and/or 38 GHz in urban areas by using a steerable 10°-beamwidth and/or a 24.5-dBi horn antenna for transmitting and/or receiving.

[0045] To meet the high data rate required for the next generation of cellular communication systems, the wireless industry and/or academia have been exploring ways to leverage the large bandwidths available at above-6 GHz frequencies, e.g. at cmW and/or mmW

frequencies. The large bandwidth available at these frequencies may provide capacity improvement for user-specific data transmission. One challenge of using these above-6 GHz frequencies may be characteristics related to their propagation which may be unfavorable for wireless communication, especially in an outdoor environment. For example, higher frequency transmissions may experience higher free space path loss. Rainfall and/or atmospheric gasses, e.g., oxygen, may add further attenuation and/or foliage may cause attenuation and/or depolarization. Narrow beam patterns which may be used to counter these losses may pose challenges for a base station (e.g., eNB), for example, in delivering cell-specific and/or broadcast information.

[0046] FIG. 1 depicts an example of a SCmB deployment. SCmB may use narrow beams for downlink transmissions. One or more mWTRUs may use receive-side narrow beams for receiving the downlink transmissions. SCmB and/or mWTRUs may apply broad beam pattern for the traditional LTE operation including cell search, random access, and/or cell selection/reselection etc.

[0047] FIG. 2 is an example of the mWTRU receive beamforming, for example, using narrow spatial filtering. FIG. 2 includes an example comparison with a frequency domain filtering to demonstrate the effect of a spatial and/or angular filtering.

[0048] The spatial filtering may allow an mWTRU to detect a channel impulse response at a distinct angular direction captured by the narrow receive beam, perhaps for example similar to a frequency filtering removing unwanted frequency components. This may result in a flat effective channel by excluding angular incoming paths outside of its beamwidth. An R12 LTE WTRU may be assumed to have an omni-directional receive beam pattern and/or may perceive a superimposed channel impulse response over the entire angular domain. An aligned mmW transmit and receive beam pair may provide a degree of freedom in the angular domain compared with the current LTE system.

[0049] An mmW system (e.g., a downlink system) design may focus on integrating directivity, e.g., the directivity of a narrow transmit and/or receive beam pair, into a celluar system which may include L1 control signaling, data scheduling, narrow beam pairing, beam measurement, and/or L1 control information feedback, etc.

[0050] Some examples of mmW system parameters and/or assumptions are described herein. The parameters and/or assumptions may change, for example, depending on the type of deployment. These parameters and/or assumptions are not intended to be limiting but serve to illustrate example set(s) of parameters and/or assumptions of an example mmW system. The parameters and/or assumptions may be utilized in various combinations.

[0051] For example, an example carrier frequency for mmW operation may be 28 GHz. This is an example system numerology. Similar designs may be extended to other mmW frequencies, e.g., 38 GHz, 60 GHz, 72 GHz, etc. A system bandwidth may be a variable (e.g., per carrier), for example up to a specific maximum system bandwidth. For example, 1 GHz may be used as the maximum system bandwidth with carrier aggregation perhaps being used to achieve higher overall bandwidth. An estimated RMS delay spread may be 100-200 ns with narrow beam pattern. A latency may be 1 ms. A waveform may be OFDM-based or broad-band-single-carrier-based. For example, dual connectivity may be based on LTE Small Cell eNB with mmW add-on channels and two separate antennas and/or RF chains connected to two different antenna solutions. A system design parameter may be to achieve DL data rates of 30 Mbit/s for at least 95% of mWTRUs, although other design goals may be used. A mobility may be optimized data connection at 3 km/h and/or maintain connection at 30 km/h. A coverage may meet data rate and/or mobility requirement with less than 100-m cell radius.

[0052] One or more waveforms such as broad-band Cyclic Prefixed Single Carrier (CP-SC), OFDM, SC-OFDM, MC-CDMA, Generalized OFDM, FBMC, and/or other may be used for the air interface of a system, e.g, an above-6 GHz system (e.g., cmW and/or mmW). Frame structure for the system may depend on the applied waveform. A Transmission Time Interval (TTI) length such as 100us may be used, e.g., to achieve low latency. A system bandwidth, e.g., one in the range of 50MHz to 2GHz may be used, for example, to achieve high data rates.

[0053] An mmW frame structure of an OFDM-based waveform may offer flexibility in coordination between the LTE and mmW channels and/or may enable common functional block sharing in a mWTRU device. For example, an mmW sampling frequency may be selected as an integer multiple of the LTE minimum sampling frequency of 1.92 MHz, which may lead to an mmW OFDM sub-carrier spacing Δf being an integer multiple of the LTE sub-carrier spacing of 15 kHz, e.g. $\Delta f = 15*K$ kHz. The selection of the integer multiple K and/or the resulting Δf may take into consideration the sensitivity to the Doppler shift, different types of frequency errors, and/or the ability to remove channel time dispersion, and/or the like. The orthogonality between sub-carriers may deteriorate and/or inter-sub-carrier interference (ISI) may increase, perhaps for example when the Doppler shift increases in proportion to the sub-carrier spacing.

[0054] For example, the maximum Doppler shift at 30 km/h and 28 GHz may be approximately 778 Hz. Example 28-GHz channel time dispersion measurements in dense urban area may indicate an RMS delay spread σ that may be between 100 and 200 ns for up to 200-m cell radius. The 90% coherence bandwidth may be estimated at $1/50\sigma$ of 100 kHz and the 50% coherence bandwidth at $1/5\sigma$ of 1 MHz.

[0055] A sub-carrier spacing Δf between 100 kHz and 1 MHz may be reasonable. A sub-carrier spacing of 300 kHz (K=20) may be robust against Doppler shift and/or other types of frequency error and/or reduce implementation complexity. The corresponding symbol length (1/ Δf) may be approximately 3.33 us.

[0056] A cyclic prefix (CP) length may be configured to span over the entire length of the channel time dispersion in order to eliminate the inter-symbol-interference. For example, a CP may or might not carry useful data, and/or in some scenarios a long CP may cause excessive system overhead. One example of CP length for a T_{symbol} of 3.33us may be selected at 1/14 of T_{symbol}, 0.24 us and/or the corresponding CP overhead may be 7% as calculated by T_{CP} / (T_{CP} + T_{symbol}).

[0057] The TTI length of the mmW transmission may be reduced compared to the 1-ms TTI length of the LTE system, perhaps for example to achieve low latency. In some scenarios, it may be beneficial to have an mmW sub-frame length of 1 ms to align with the LTE 1-ms sub-frame timing. The mmW sub-frame may contain multiple mmW TTIs whose length may be tied to other parameters, e.g., sub-carrier spacing, symbol length, CP length, and/or FFT size, etc.

[0058] Based on these and/or other considerations, an example with a conservative CP length (4x channel delay spread) is summarized in Table 1. It may be assumed that CP length selection is based on the delay spread over potential mmW frequency band of lower than 200 ns.

Table 1 Example mmW Downlink OFDM Numerology

OFDM Numerology Parameters				
System bandwidth (MHz)	125	250	500	1000
Sampling rate (MHz)	153.6	307.2	614.4	1228.8
Sub-carrier spacing (kHz)	300	300	300	300
Number of sub-carrier per RB	12	12	12	12
RB bandwidth (MHz)	3.6	3.6	3.6	3.6
Number of assignable RBs	32	64	128	256
Number of occupied sub-carriers	384	768	1536	3072
Occupied bandwidth (MHz)	115.2	230.4	460.8	921.6
IDFT(Tx)/DFT(Rx) size	512	1024	2048	4096
OFDM symbol duration (us)	3.333	3.333	3.333	3.333
CP length (ratio to symbol length)	1/4	1/4	1/4	1/4
CP length (us)	0.833	0.833	0.833	0.833
Number of symbols per slot	24	24	24	24
Slot duration (TTI) (us)	100	100	100	100
Sub-frame duration (ms)	1	1	1	1
Number of slots per sub-frame	10	10	10	10

Frame duration (ms)	10	10	10	10
Number of sub-frames per frame	10	10	10	10
Number of symbols per TTI per RB	288	288	288	288
Number of symbols per TTI using all RBs	9216	18432	36864	73728
Signaling overhead	20%	20%	20%	20%
Data rate using uncoded 64QAM (Mbps)	442.368	884.736	1769.472	3538.944
Spectral efficiency	3.538944	3.538944	3.538944	3.538944

[0059] FIG. 3 depicts an example OFDM-based frame structure. In FIG. 3, the system bandwidth may be 1GHz and/or a sub-carrier spacing of 300 kHz may be used with a corresponding symbol length of 3.33 us. An example cyclic prefix (CP) length of 1/4 of T_{symbol} which equals 0.833 us may be used.

[0060] Some of the frame structure examples presented herein may be based on an assumption that an OFDM-based mmW waveform, which may be incorporated into the OFDM-based LTE small cell network. The system procedures described herein may be equally applicable to numerous types of frame designs and/or should not be interpreted to be bound by this specific frame structure and/or may be applied to other waveform candidates.

[0061] The SCmB and/or mWTRU deployments may employ one or more of the following mmW physical layer channels and/or reference signals, for example, rather than and/or in addition to the LTE physical channels.

[0062] An SCmB and/or an mWTRU may employ a unique sequence transmitted per transmit beam, e.g., a Beam-Specific Reference Signal (BSRS), used for beam acquisition, timing/frequency synchronization, channel estimation for a Physical Downlink Directional Control Channel (PDDCCH), beam tracking and/or measurement, etc. The BSRS may carry implicitly beam identity information including BSRS sequence index. There may be different types of BSRSs. The BSRS resource allocation may be pre-defined.

[0063] An SCmB and/or an mWTRU may employ a unique sequence scheduled and/or transmitted dynamically for the purpose of beam pair measurement specific for a given antenna port, e.g., an Adaptive Antenna Reference Signal (AARS). The AARS may embed implicitly the beam identity information in the sequence index and/or carry a small payload including the same information.

[0064] An SCmB and/or an mWTRU may utilize a Physical Downlink Directional Control Channel (PDDCCH). The PDDCCH may carry some or all data related control information for an mWTRU to identify, demodulate and/or decode an associated Physical

Downlink Directional Data Channel (PDDDCH) correctly. The PDDCCH may be carried in an mmW narrow beam and/or in a broad beam and/or may be applied for different multiple access. For example, there may be a common PDDCCH transmitted in downlink mmW broad beam covering a sector and/or cell and/or a dedicated PDDCCH transmitted (e.g., transmitted) in a narrow beam pair, for example, when mWTRU-specific data transmission is on-going. The dedicated PDDCCH may carry scheduling information for its associated PDDDCH on a per-TTI basis and/or may or might not carry beam specific information. A common PDDCCH may include cell-specific information including sector/segment identity and/or beam identity. In addition, an mWTRU may read the common PDDCCH to determine if it is scheduled for narrow beam pairing procedure in order to begin narrow beam data transmission subsequently.

[0065] An SCmB and/or an mWTRU may utilize a Physical Downlink Directional Data Channel (PDDDCH). The PDDDCH may carry payload information received in the form of MAC PDU from mmW MAC layer. The resource allocation of this channel may be determined by the downlink scheduling information carried in PDDCCH. The PDDDCH intended for a mWTRU may be transmitted in a narrow Tx beam and/or received in a properly paired narrow Rx beam, e.g., a narrow beam pair. Due to this spatial isolation, PDDDCHs for different WTRUs in different beam pairs may reuse a combination of one or more time, frequency, and/or code resource(s). Multiple PDDDCH may also operate in one beam pair using multiple access in one or more of the time, frequency, code domain, and/or the like. A common PDDDCH may be used to carry data in broad mmW antenna pattern associated with the common PDDCCH.

[0066] An SCmB and/or an mWTRU may utilize symbols embedded in a transmission for channel estimation for PDDDCH, e.g., a Demodulation Reference Signal (DMRS). For example, the DMRS may be placed in the time and/or frequency domain according to pre-defined pattern to ensure correct interpolation and/or reconstruction of the channel.

[0067] Some or all channels and/or reference signals in a narrow beam pair may be beamformed identically and/or considered to be transmitted via a specific and/or single physical antenna port. Although carrying broadcast and/or multicast information on a narrow beam can be utilized, given the directivity of the transmission of these channels, carrying broadcast, multicast, and/or other cell-specific information on the narrow beam may or might not be optimal application. The SCmB deployment with mmW downlink data transmissoin may adopt a channel mapping as illustrated in FIG. 4 and the mmW channels are marked in bolder line color.

[0068] An mWTRU may use a phase antenna array to achieve the beamforming gain, for example, in order to compensate the high path loss at mmW frequencies. At the mmW frequencies the short wavelength may allow a compact form factor of the device design. A large

spacing such as 0.7λ may be applied, for example. An element spacing of 0.5λ may be used in theoretical performance analysis.

[0069] The phase antenna may apply one or more different beamforming methods. For example, a fully digitized beamforming approach may have a dedicated RF chain. For example, the RF chain may include RF processing and/or analog-to-digital conversion (ADC) as depicted in FIG. 5 for an antenna element. The signal processed by an antenna element may be controlled independently in phase and/or amplitude to optimize the channel capacity.

[0070] The configuration may have the same number of RF chains and ADCs as that of antenna elements. The mWTRU antenna may offer (e.g., very) high performance. The mWTRU antenna configuration may impose costs and/or complexity in implementation. The mWTRU antenna configuration may cause high energy consumption in operation. Fully digitized beamforming may or might not be adopted in the initial 5G deployments and/or mWTRU implementations, but may be used in future releases.

[0071] FIG. 6 may be an example of analogue beamforming. In analog beamforming, an RF chain may be applied (e.g., only one RF chain) for a given phase antenna array (PAA). For example, an antenna element may be connected to a phase shifter. The phase shifter may be used to set the weight for beam forming and/or steering. The number of RF chains may be (e.g., significantly) reduced using analog beamforming (e.g., as compared to digital beamforming). The energy consumption may be significantly reduced.

[0072] The phase of the signal (e.g, only the phase) at an antenna element may be adjusted in the beamforming. FIG. 6 shows that the phase shifting and/or combining may be implemented in different stages, e.g., in RF, base-band (BB) analogue, and/or local-osciallator (LO). One or more of the techniaues described herein may be used to evaluate the effectiveness/efficiency of an approach, e.g., signal loss, phase error, and/or power consumption, and/or the like.

[0073] The mWTRU analogue beamforming methods may comprise one or more of the following. The mWTRU analogue beamforming algorithms may comprise a grid of beams having a set of fixed beams, e.g., a fixed codebook-based beamforming. A beam may be formed by the mWTRU applying a beamforming weight vector v chosen from a pre-defined codebook $v \in \{v_1, v_2, v_3 \ldots v_N\}$, where N denotes the number of fixed beams. A vector may comprise pre-calibrated phase shifts for certain (e.g., one or more, or all) phase shifters and/or may represent a unique analogue beam direction, e.g., "beam". The number of beams may depend on the Half-Power-Beam-Width (HPBW) of the beamforming and/or desired coverage. The mWTRU analogue beamforming algorithms may comprise a continuous phase shifting beamforming. For

example, the desired weight of a phase shifter may be calculated based on the estimated short-term channel information and/or converted using a high resolution digital-to-analogue converter (DAC) for the phase shifter. The continuous phase shifting beamforming may provide a continuous and/or adaptive beamforming to track the channel conditions. The algorithm may perform well in one or more scenarios, e.g., with increased multipath, high angular spread, and/or low WTRU mobility.

[0074] An mWTRU may employ a hybrid approach comprising the digitized and analogue beamforming. For example, the analogue beamforming may be performed over the phase array antenna elements where an antenna element is associated with a phase shifter and/or connected to one RF chain. The digitized beamforming may comprise a digital precoding applied on the baseband signal of a RF chain, e.g., when there is more than one RF chain. MIMO schemes may be implemented using digital precoding.

[0075] Examples for the basic system parameters of the hybrid beamforming may include one or more of a Number of data stream, N_{DATA}; Number of RF chain (TRX), N_{TRX}; Number of antenna ports, N_{AP}; Number of antenna elements, N_{AE}; and/or Number of phase antenna array, N_{PAA}, and/or the like. The configuration of these parameters may impact the system function and/or performance.

[0076] For example, perhaps when $N_{PAA} \leq N_{AP} \leq N_{TRX} \leq N_{AE}$, one or more of the following may occur. A PAA may comprise multiple antenna elements, e.g., a PAA of size 4x4 has 16 antenna elements. An antenna port may be defined, and/or the channel over which a symbol on the antenna port is conveyed may be inferred from the channel over which another symbol on the same antenna port is conveyed. There may be certain (e.g., one or more) resource grid per antenna port. One or more cell-specific reference signals may support a configuration of one, two, and/or four antenna ports and/or may be transmitted on antenna ports $p = 0$, $p \in \{0,1\}$ and $p \in \{0,1,2,3\}$, respectively. Multicast-broadcast single-frequency network (MBSFN) reference signals may be transmitted on antenna port $p = 4$. One or more WTRU-specific reference signals associated with PDSCH may be transmitted on antenna port(s) $p = 5$, $p = 7$, $p = 8$, or one or several of $p \in \{7,8,9,10,11,12,13,14\}$.

[0077] One or more demodulation reference signals associated with an enhanced Physical Downlink Control Channel (EPDCCH) may be transmitted on one or several of $p \in \{107,108,109,110\}$. Positioning reference signals may be transmitted on antenna port $p = 6$. CSI reference signals may support a configuration of one, two, four or eight antenna ports and/or may be transmitted on antenna ports $p = 15$, $p \in \{15,16\}$, $p \in \{15,16,17,18\}$, and $p \in$

{15,16,17,18,19,20,21,22}, respectively. An antenna port may carry beamformed reference signal(s) that may be uniquely associated with this antenna port and/or that can be used to identify the antenna port. The antenna configuration may become (e.g., fully) digitized as shown in FIG.5, e.g., perhaps when the number of TRX equals the number of antenna elements. An example may be one RF chain per antenna element. A PAA may be connected to a RF chain (as shown in FIG. 6) and/or multiple RF chains, e.g., depending on the system configuration. In FIG. 7, $N_{PAA} < N_{AP} = N_{TRX} < N_{AE}$, one PAA of size 4x4 is connected to two RF chains and/or one or more, or each RF, chain has a set of 16 phase shifters. The PAA may form two narrow beam patterns within a +45° and -45° coverage in azimuth plane. FIG. 8 is an example of two PAAs and/or one or more, or each, PAA may have a dedicated RF chain, e.g., $N_{PAA} = N_{AP} = N_{TRX} \leq N_{AE}$. The example in FIG. 8 may allow a spatial independence between the two simultaneous beams by placing the PAAs at different orientation e.g. in azimuth plane. An aligned PAA arrangement may provide an aggregated larger coverage compared to the configuration in FIG. 7. Both configurations with two RF chains may apply MIMO with two data streams.

[0078] For example, perhaps when $N_{AE} > N_{PAA} > N_{AP} = N_{TRX}$, multiple PAAs may be connected to a (e.g., single) RF chain by using a switch as depicted in FIG. 9. A PAA may form a narrow beam pattern covering from +45° to -45° in azimuth plane. They may be oriented separately. A single-beam solution may provide (e.g. a good) coverage by using a narrow beam at different direction at different time instances.

[0079] For example, when $N_{DATA} \leq N_{TRX} \leq N_{AE}$, the following may occur.

[0080] For example, when $N_{DATA} = N_{TRX} = 1$, a mWTRU may have a single-beam configuration and/or may operate one beam at a time. One or more of the following may occur. The mWTRU beamforming may form a narrow beam pattern. FIG. 10 is an example for a 16x16 PAA at the strongest angular direction, e.g., a line-of-sight (LOS) path obtained from beam measurement. The mWTRU may form a broad beam pattern, e.g. a wide main lobe. FIG. 11 is an example of a wide main lobe to cover a range of continuous angular directions including strong and/or weak ones in-between. The antenna gain may be reduced (e.g., considerably) with a broad beam pattern, and/or the link budget may worsen.

[0081] For example when $N_{DATA} = 1 < N_{TRX}$, an mWTRU may have simultaneous beam patterns. The beam patterns may be different and/or may be used for different applications. For example, when $N_{TRX} = 2$, an mWTRU may have two simultaneous beam patterns that are different and/or may be used for different applications. One or more of the following may apply. The mWTRU may place two narrow beam patterns at different angular

incoming directions to receive one data stream. For example, coherent beam combining may be used for spatial diversity and/or mitigate the blockage effect and/or weak LOS condition. The mWTRU may form one narrow beam and/or one broad beam for different application. For example, the narrow beam may be used for data transmissoin and/or the broad beam for control signaling.

[0082] For example, perhaps when $1 < N_{DATA} = N_{TRX}$, the transmission may apply MIMO to increase the capacity, e.g., in high SNR channel condition. The mWTRU may place two narrow beam patterns at different angular incoming directions to receive two data streams in parallel.

[0083] One or more of the SCmB beam forming schemes may include fixed beam, adaptive beam forming (e.g., codebook-based and/or non-codebook-based), and/or classical beam forming e.g. Direction-of-Arriaval (DoA) estimation. One or more schemes may use different approaches and/or may work well in certain scenarios. For example the DoA estimation may use smaller angular spread and/or a mWTRU may (e.g., need to) transmit a LTE uplink reference signal to ensure DoA accuracy. The fixed beam system may require beam cycling and/or switching.

[0084] One or more of the examples described herein may be explained in terms that assume an mWTRU antenna configuration and/or beamforming configuration. The mWTRU antenna configuration and/or beamforming configuration may be based on a single-beam mWTRU antenna configuration with analogue beamforming as illustrated in FIG. 6. The methods and/or techniques may also be applied using other beamforming methods such as digital beamforming and/or hybrid beamforming.

[0085] The LTE/LTE-A and/or E-PDCCH have evolved. In Rel-8, REs, REG, CCE and/or PDCCH may be the following. The smallest time-frequency unit for downlink transmission may be denoted a resource element (RE). A (e.g. one or more, or each) element in the resource grid for antenna port p may be called a resource element and/or may be uniquely identified by the index pair (k,l) in a slot where k and/or l may be the indices in the frequency and/or time domains, respectively. A PDCCH (Physical Downlink Control Channel) may carry scheduling assignments and/or other control information. A group of 4 consecutive resource elements may be called Resource Group Elements (REG). A physical control channel may be transmitted on an aggregation of one or several consecutive control channel elements (CCEs), where a control channel element corresponds to 9 REGs.

[0086] In Rel-11, EPDCCH WTRU-specific Search Space may be the following. The EPDCCH has been introduced in Rel-11 LTE-Advanced in order to achieve frequency domain ICIC and/or beamforming gain. Hereafter, EPDCCH, ePDCCH, and/or E-PDCCH may be used interchangeably. Also, EREG and/or ECCE may be interchangeably used as eREG and/or eCCE, respectively.

[0087] In Rel-11, PRB configuration may be the following. In Rel-11, the ePDCCH resources for WTRU-specific search space may be configured as a subset of PRBs in the PDSCH region. The ePDCCH resources may be configured in a WTRU-specific manner and/or up to two ePDCCH resource sets may be configured for a WTRU. An ePDCCH resource set may contain 2, 4, and/or 8 PRB-pairs according to the configuration and/or may be configured as a localized resource set and/or distributed resource set.

[0088] In Rel-11, eREG may be defined as the following. In a (e.g. one or more, or each) PRB-pair which is configured as ePDCCH resource, 16 eREGs may be defined regardless of normal CP and/or extended CP. The REs for eREGs may be allocated cyclically in a frequency first manner and/or may be rate-matched around for the demodulation RS such as antenna ports {107, 108, 109, 110}. Randomizing channel estimation performance across eREGS may occur as the channel estimation performance may be different according to the RE location in a PRB-pair. Since antenna port 107 and/or 108 are defined (e.g., only defined) for extended CP, the REs for eREGs may be allocated cyclically in a frequency first manner and/or may be rate-matched around for the demodulation RS such as antenna ports {107, 108}.

[0089] An eCCE may may be defined as the following. An eCCE may be defined as grouping of 4 and/or 8 eREGs within an ePDCCH resource set. Therefore, the number of eCCEs ($N_{eCCE,set}$) per ePDCCH resource set may be defined as a function of the number of PRB pairs ($N_{PRB,set}$) configured for the ePDCCH resource set and/or the number of eREGs grouped to form an eCCE (N_{eREG}) such as $N_{eCCE,set} = 16xN_{PRB,set}/N_{eREG}$. Two types of eCCE may be defined according to the mode of ePDCCH resource set such as localized eCCE (L-eCCE) and/or distributed eCCE (D-eCCE). To form an L-eCCE, the 4 and/or 8 eREGs located in the same PRB-pair may be grouped together. On the other hand, the eREGs in different PRB-pairs may be grouped to form a D-eCCE. C ertain (e.g., one or more, or all) eREGs in an ePDCCH resource set may be used to form L-eCCE and/or D-eCCE perhaps according to the ePDCCH transmission configured for the ePDCCH resource set. For instance, if an ePDCCH resource set may be configured as localized ePDCCH, then certain (e.g., one or more, or all) eREGs in the ePDCCH resource set may be be used to form L-eCCE. In other words, in an ePDCCH resource

set, there may be be L-eCCEs and/or D-eCCEs. For example, 4 eREGs may be grouped to form an eCCE in the case of normal subframe and/or special subframe configuration 3, 4, 8 in TDD perhaps for example since a (e.g, enough) number of REs may be available per eCCE so that a certain (e.g., required) effective coding rate may be used in one or more scenarios.

[0090] An antenna port mapping may be the following. The antenna ports {107, 108, 109, 110} and {107, 108} may be used for normal CP and/or extended CP, respectively. According to the ePDCCH transmission mode (e.g. localized ePDCCH and/or distributed ePDCCH), the antenna port mapping rules may be different as an (e.g., one or more, or each) ePDCCH transmission mode targeted for different system and/or channel environments. For instance, antenna port mapping for the distributed ePDCCH may be designed to maximize diversity gain as it has been introduced for open-loop transmission. On the other hand, antenna port mapping rules for localized ePDCCH may be defined to exploit WTRU-specific beamforming gain as well as multi-user MIMO gain.

[0091] For the distributed ePDCCH, two (e.g, only two, or more than two) antenna ports {107, 109} may be used out of {107, 108, 109, 110} in order to improve channel estimation gain while certain (e.g., one or more, or all) antenna ports may be used for localized ePDCCH. This may be due to the fact that WTRU-specific beamforming may use (e.g., require) larger number of antenna ports as one PRB-pair may be shared with up to 4 WTRUs. This may allow WTRU-specific beamforming of up to 4 WTRUs within a PRB-pair, for example.

[0092] A reference signal sequence may be the following. A predefined sequence (e.g., Pseudo-random (PN), m-sequence and/or etc.) may be multiplied with downlink RS so as to minimize inter-cell and/or intra-cell interference. This may improve channel estimation accuracy and/or increasing multi-user spatial multiplexing gain. For some (e.g., any) of the EPDCCH antenna ports {107, 108, 109, 110}, the reference signal sequence $r(m)$ may be defined by

$$r(m)=\frac{1}{\sqrt{2}}(1-2\cdot c(2m))+j\frac{1}{\sqrt{2}}(1-2\cdot c(2m+1)),\qquad m=\begin{cases}0,1,\ldots,12N_{\mathrm{RB}}^{\max,\mathrm{DL}}-1 & \text{normal cyclic prefix}\\ 0,1,\ldots,16N_{\mathrm{RB}}^{\max,\mathrm{DL}}-1 & \text{extended cyclic prefix}\end{cases},$$

where the $N_{\mathrm{RB}}^{\max,\mathrm{DL}}$ denotes the maximum number of RBs for the downlink system bandwidth and $c(i)$ denotes pseudo-random sequence. The pseudo-random sequence generator may be initialized with

$$c_{\mathrm{init}}=(\lfloor n_s/2\rfloor+1)\cdot(2n_{\mathrm{ID}}^{\mathrm{EPDCCH}}+1)\cdot 2^{16}+n_{\mathrm{SCID}}^{\mathrm{EPDCCH}}$$

at the start of a (e.g., one or more, or each subframe). The $n_{\mathrm{ID}}^{\mathrm{EPDCCH}}$ may be independently configured for a (e.g., one or more, or each) EPDCCH resource set and $n_{\mathrm{SCID}}^{\mathrm{EPDCCH}}=2$ may be used.

[0093] A WTRU-specific search space may be the following. In Rel-11, a WTRU-specific search space may be introduced (e.g., only introduced) for EPDCCH. Common search

space may be located at the PDCCH region. The WTRU monitoring behavior for downlink control signaling reception may be defined in a downlink subframe as one of following. A WTRU may monitor WTRU-specific search space in EPDCCH and/or common search space in PDCCH, e.g., where the EPDCCH monitoring subframe may be configured via higher layer signaling. A WTRU may monitor WTRU-specific search space and/or common search space in PDCCH. The WTRU-specific search space fallback may be used, perhaps even though a subframe is configured to monitor ePDCCH subframe, e.g., when ePDCCH is not available in that subframe. Some collisions between ePDCCH REs and/or other signals may occur. A WTRU may monitor PDCCH for WTRU-specific search space.

[0094] The aggregation level may increase to keep an effective coding rate, perhaps when the available number of REs may be smaller than a threshold ($n_{\text{EPDCCH}} < 104$). For instance, the supportable ePDCCH formats for localize transmission when $n_{\text{EPDCCH}} < 104$ may be $N_{\text{ECCE}} \in \{2,4,8,16\}$ while $N_{\text{ECCE}} \in \{1,2,4,8\}$ may be used in other cases. The set of aggregation levels may be different according to the ePDCCH transmission modes.

[0095] Collision handling may be performed. The ePDCCH REs may be defined as the REs in a PRB-pair not occupied by antenna port $\{107,108,109,110\}$. FIG. 1-24 may show an example of the ePDCCH RE definition in a PRB-pair according to the CP length without collission with other signals, resulting in 144 and/or 128 available REs for normal CP and/or extended CP, respectively. The ePDCCH resources may be configured in PDSCH region. The REs for ePDCCH may collide with other signals, e.g., CSI-RS, CRS, PRS, PBCH, SCH, and/or PDCCH. The WTRU behavior when the REs collide with other signals may be defined as one or more of the following. The coded bits for ePDCCH may be rate-matched around for the REs colliding with CSI-RS, CRS, and/or PDCCH. The PRB-pair used for PBCH and SCH in a subframe may or might not be used for ePDCCH. The available REs for ePDCCH may become smaller, e.g., when other signals are transmitted in the PRB-pair configured for ePDCCH.

[0096] Transmit and/or receive beamforming may be applied to the control channel transmission/reception, e.g., to overcome high path loss at > 6Ghz frequencies. The resulting beamformed link may be considered as a spatial filtering and/or limit the WTRU to receive incoming angular paths (e.g., only incoming angular paths) within the formed beam pair.

[0097] Legacy cellular systems may rely on Omni directional and/or cell-wide beams for control channel transmissions. From a WTRU's point of view, the placement of control channel may be well defined, e.g. in the control region. At higher frequencies, a (e.g., one or more, or each) base station may have plurality of control channel beams to cover the cell. A WTRU may

be able to (e.g., only be able to) receive a subset of those control channel beams. One or more techniques to identify candidate control channel beams and/or their location in the subframe structure may be defined for efficient WTRU operation.

[0098] One or more mBs and/or WTRUs in a beam formed system may have diverse set of capabilities, for example, different number of RF chains, different beam widths, and/or different number of PAAs, etc. One or more mBs with multiple RF chains may transmit control channel beam(s) in the same control symbol. One or more WTRUs with one or more, or multiple, RF chains may receive using receive beam pattern(s) same control symbol. One or more mBs with, for example, one RF chain may (e.g., need to) multiplex control channel beams in time domain (e.g. different symbols and/or different subframes). One or more mBs with RF chain(s) may multiplex control channel beams in time and/or spatial domains.

[0099] A framework for beam formed control channel design may be used to support varying capabilities of mBs and/or WTRUs and/or support time and/or spatial domain multiplexing of control channel beams.

[0100] The common reference signal design in LTE may assume cell wide transmission. For a multi-beam system, modifications to reference signal design may be used to discover, identify, measure, and/or decode a (e.g., one or more, or each) control channel beam. In a multi-beam system, interference between beams may degrade overall cell capacity, so additional mechanisms to mitigate inter-beam interference may be useful, e.g, for intra-cell and/or inter-cell scenarios.

[0101] WTRU monitoring may be defined to consider beam search space in addition to time and/or frequency search space.

[0102] Enhancements to downlink control channel may be useful to support scheduling narrow data beams. One or more mechanisms may be useful to achieve high resource utilization, e.g., perhaps when large bandwidths are available and/or WTRUs may be spatially distributed.

[0103] A mB, SCmB, mmW eNB, eNB, cell, small cell, Pcell, and/or Scell may be used interchangeably. The term operate may be used interchangeably with transmit and/or receive. Component carrier and/or mmW carrier may be used interchangeably with serving cell.

[0104] The mmW eNB may transmit and/or receive one or more mmW channels in a band (e.g., licensed band and/or unlicensed). The mmW eNB may transmit and/or receive one or more signals in a band (e.g., licensed band and/or unlicensed). One or more WTRUs may be substituted for eNB and still be consistent with the techniques described herein. An eNB may be substituted for WTRUs and still be consistent with the techniques described herein. UL may be

substituted for downlinke (DL) and still be consistent with the techniques described. DL may be substituted for UL and still be consistent with the techniques described herein.

[0105] A channel may refer to a frequency band which may have a center and/or carrier frequency and a bandwidth. Licensed spectrum may include one or more channels which may or might not overlap. Unlicensed spectrum may include one or more channels which may or might not overlap. Channel, frequency channel, wireless channel, and/or mmW channel may be used interchangeably. Accessing a channel may be the same as using (e.g., transmitting on and/or receiving on and/or using) the channel.

[0106] A channel may refer to an mmW channel and/or signal, e.g., an uplink physical channel and/or signal. A channel may refer to an mmW channel and/or signal, e.g., a downlink physical channel and/or signal. Downlink channels and/or signals may comprise one or more of the following: mmW synchronization signal, mmW broadcast channel, mmW cell reference signal, mmW beam reference signal, mmW beam control channel, mmW beam data channel, mmW hybrid ARQ indicator channel, mmW demodulation reference signal, PSS, SSS, DMRS, CRS, CSI-RS, PBCH, PDCCH, PHICH, EPDCCH, and/or PDSCH, and the like. Uplink channels and/or signals may include one or more of the following: mmW PRACH, mmW control channel, mmW data channel, mmW beam reference signal, mmW demodulation reference signal, PRACH, PUCCH, SRS, DMRS, and/or PUSCH, and the like. Channel and mmW channel may be used interchangeably. Channels and signals may be used interchangeably.

[0107] Data/control may mean one or more of the following: data, control signals, and/or channels, and the like. Control may comprise synchronization. The data/control may be mmW data/control. Data/control, data/control channels, and/or signals may be used interchangeably. Channels and signals may be used interchangeably. The terms control channel, control channel beam, PDCCH, mPDCCH, mmW PDCCH, mmW control channel, directional PDCCH, beamformed control channel, spatial control channel, control channel slice, and/or high frequency control channel may be used interchangeably. The terms data channel, data channel beam, PDSCH, mPDSCH, mmW PDSCH, mmW data channel, directional PDSCH, beamformed data channel, spatial data channel, data channel slice, and/or high frequency data channel may be used interchangeably.

[0108] Channel resources may be resources (e.g., 3GPP LTE and/or LTE-A resources), e.g., time, frequency, code, and/or spatial resources. Channel resources, e.g., at least sometimes, carry one or more channels and/or signals. Channel resources may be used interchangeably with channels and/or signals.

[0109] A mmW beam reference signal, mmW reference resource for beam measurement, mmW measurement reference signal, mmW channel state measurement reference signal, mmW demodulation reference signal, mmW sounding reference signal, reference signal, CSI-RS, CRS, DM-RS, DRS, measurement reference signal, reference resource for measurement, CSI-IM, and/or measurement RS may be used interchangeably. A mmW cell, mmW small cell, SCell, secondary cell, license-assisted cell, unlicensed cell, and/or LAA cell may be used interchangeably. A mmW cell, mmW small cell, PCell, primary cell, LTE cell, and/or licensed cell may be used interchangeably. Interference and interference plus noise may be used interchangeably.

[0110] A WTRU may determine the UL and/or DL directions of one or more subframes according to one or more received TDD UL/DL configurations. A WTRU may determine the UL and/or DL directions of one or more subframes according to one or more configured TDD UL/DL configurations. UL/DL and UL-DL may be used interchangeably.

[0111] The techniques described herein for beamformed control and data channels may be applicable to any system, perhaps irrespective of the frequency bands, usage (e.g. licensed, unlicensed, shared), antenna configuration (e.g. phased array and/or patch and/or horn etc.), RF configuration (e.g. single and/or multiple RF chains), beamforming methods used (e.g. digital, analog and/or hybrid, codebook based and/or otherwise), and/or deployments (e.g. macro, small cell, heterogeneous networks, dual connectivity, remote radio heads, carrier aggregation). A mmW (millimeter wave) may be substituted for cmW (centimeter wave) and/or LTE/LTE-A/LTE evolution and still be consistent with the techiques described herein.

[0112] A scheduling interval may refer to the subframe and/or slot and/or frame, and/or schedulable slice and/or control channel periodicity and/or any other pre-defined time unit. Gaps and/or guard periods and/or silence periods and/or switching periods and/or absence of transmission and/or DTX periods may be used interchangeably.

[0113] The terms channel, beam and/or channel beams may be used interchangeably. Antenna pattern, phase weights, steering vector, codebook, precoding, radiation pattern, beam pattern, beam, beam width, beam formed transmission, antenna port, virtual antenna port, transmission associated with a reference signal, directional transmission, and/or spatial channel may be used interchangeably.

[0114] The terms REGs and CCEs may refer to plurality of time, frequency, code and/or spatial resources generally and/or may or might not be limited by the LTE numerology/context (e.g., the LTE REGs and LTE CCEs may be considered types of REGs and CCEs in the context

of the techniques described herein). Radiation pattern may refer to the angular distribution of the radiated electromagnetic field and/or power level in the far field region.

[0115] A beam may be one of the lobes, e.g., main/side/grating lobes of the transmit radiation pattern and receive gain pattern of an antenna array. A beam may denote a spatial direction that may be represented with a beamforming weight vector. A beam may be identified and/or associated with one or more of a reference signal, an antenna port, a beam identity (ID), a scrambling sequence number, and/or the like. A beam may be transmitted and/or received at a specific time. A beam may be transmitted and/or received at a specific frequency. A beam may be transmitted and/or received at a specific code. A beam may be transmitted and/or received at specific spatial resources. A beam may be formed digitally and/or in an analogue manner (hybrid beamforming). The analogue beamforming may be based on fixed code-book and/or continuous phase shifting. A beam may comprise Omni directional and/or Quasi-Omni directional transmission. Two beams may be differentiated by direction of highest radiated power and/or by beam width.

[0116] One or more reference signals may be associated with one or more search spaces and/or one or more antenna ports. One or more search spaces may be associated with one or more beam search spaces and/or one or more antenna port search spaces.

[0117] In some scenarios, the WTRU may be configured to receive one or more search spaces from a wireless communication system network node, perhaps dynamically. In some scenarios, a WTRU may be configured such that the one or more search spaces are predefined on the WTRU.

[0118] A data channel beam may be used to transmit one or more of the following: data channel, data channel beam, PDSCH, mPDSCH, mmW PDSCH, mmW data channel, directional PDSCH, beamformed data channel, spatial data channel, data channel slice, high frequency data channel, and the like. A data channel beam may be identified and/or associated with one or more of the following: a reference signal, an antenna port, a beam identity (ID), a scrambling sequence number and/or a data channel number, and the like. A data channel beam may be transmitted and/or received at a specific time. A data channel beam may be transmitted and/or received at a specific frequency. A data channel beam may be transmitted and/or received at a specific code. A data channel beam may be transmitted and/or received at specific spatial resources.

[0119] A control channel beam may be used to transmit one or more of the following: control channel, PDCCH, mPDCCH, mmW PDCCH, mmW control channel, directional PDCCH, beamformed control channel, spatial control channel, control channel slice, high frequency control channel, and the like. The control channel may carry DCI for one or more

users. The control channel may carry PHICH and PCFICH in the downlink and PUCCH in the uplink. A control channel beam may be identified and/or associated with one or more of the following: a reference signal, an antenna port, a beam identity (ID), a scrambling sequence number, a control channel number, and the like. A control channel beam may be transmitted and/or received at a specific time. A control channel beam may be transmitted and/or received at a specific frequency. A control channel beam may be transmitted and/or received at a specific code. A control channel beam may be transmitted and/or received at specific spatial resources. A control channel beam may be cell specific and/or WTRU specific.

[0120] A common channel may be used to refer to transmission that carries information useful for plurality of WTRUs. The term common channel may be used interchangeably with shared channel.

[0121] Half Power Beam Width (HPBW) may refer to a radiation pattern cut containing the direction of the maximum of a lobe, the angle between two directions in which the radiation intensity is one-half the maximum value . The exact beam width for the beamformed control/data channel may or might not be specified and may depend on mB and/or WTRU implementation. A mB may support WTRUs with varying capabilities. WTRUs may work in an mB with varying capabilities.

[0122] A control channel beam duration may be a number of OFDM symbols in a scheduling interval occupied by a control channel beam.

[0123] A control region may be the number of OFDM symbols in a scheduling interval occupied by some or all of the control channel beams transmitted in the scheduling interval.

[0124] Fixed codebook-based analogue beamforming may refer to a grid of beams that may comprise a set of fixed beams. A beam may be formed by applying a beamforming weight vector v chosen from a pre-defined codebook $v \in \{v_1, v_2, v_3 \ldots v_N\}$ where N denotes the number of fixed beams. The number of beams may depend on the Half-Power-Beam-Width (HPBW) of the beamforming and desired coverage.

[0125] A continuous phase shifting analogue beamforming may provide a continuous and adaptive beamforming to track channel conditions. The desired weight of a phase shifter may be calculated based on the estimated channel information, e.g., angular information. The desired weight of a phase shifter may be converted using a high resolution digital-to-analogue converter (DAC) to apply to the phase shifter.

[0126] An antenna port may be defined. The channel over which a symbol on the antenna port is conveyed may be inferred from the channel over which another symbol on the same antenna port is conveyed. A time-frequency resource grid may be considered to be available per

antenna port. For example, a (e.g., one or more, or each) antenna port may be considered to be orthogonal to other antenna ports such that the time-frequency resources may be used for independent transmissions on a (e.g., one or more, or each) antenna port. Code multiplexing may also be used on one or more antenna ports.

[0127] The beamforming contains building blocks. An example subframe may have the following structure. A subframe and/or scheduling interval and/or slot and/or a predefined time unit may comprise plurality of symbols. One or more symbol(s) may be used to transmit and/or carry and/or include and/or map and/or be configured to receive the one or more control signal/channel/information. One or more symbol(s) may transmit/carry/include and/or be configured to receive one or more data channels.

[0128] Beamformed control and/or data channels may be one or more of the following. Control and/or data channels may be transmitted using a specific radiation pattern and/or beam. A control channel beam may be associated with one or more of the following: a unique reference signal, a steering vector, a scrambling code, an antenna port, time, code, spatial resource, frequency resource, and/or control channel identity, and/or the like. A data channel beam may be associated with one or more of the following: a unique reference signal, a steering vector, a scrambling code, an antenna port, time, code, spatial resource, frequency resource, and/or control channel identity, and the like. An mB and/or cell may transmit plurality of beamformed control and/or data channels. Beamformed control and/or data channels may be multiplexed in time.

[0129] Data region with one or more beamformed data channel(s) may work. One or more symbols within a subframe where the data channel is transmitted may be referred to as data region. Within a subframe, the data region may comprise multiple data channel beams multiplexed in time. For example, a data channel in a particular beam may occupy one more symbol(s). The remaining symbols within the same subframe may be used to transmit data channel in other beams. A data channel beam within the data region may be of variable beam widths. The maximum data channel beam width for a WTRU may be as wide as its control channel beam width. A WTRU may receive one or more data channels transmitted. A WTRU may use one or more beams and/or beam widths within a subframe and/or across different subframes. Plurality of WTRUs may be time multiplexed within a subframe, within same data channel beam and/or across different data channel beams. Minimum schedulable time resource within a subframe may be a symbol and/or group of symbols. Scheduling granularity may be less than a subframe, e.g., a new DCI format may carry allocation information at symbol level/symbol group.

[0130] The system may comprise a control region with one or more beamformed control channel(s). One or more symbols within a subframe where the control channel is transmitted may be referred to as cell specific control region and/or an overall control region. Within a subframe, the cell specific control region may comprise multiple control channel beams multiplexed in time. One or more symbols within a subframe where the control channel for a specific beam is transmitted may be referred to as beam specific control region. The term control region may mean cell specific control region and/or beam specific control region. Control region size may be fixed and/or be flexible. Control region and data region may overlap. One or more symbols may carry control and/or data channel. Control and/or data channel may be multiplexed in frequency and/or code and/or spatial domain.

[0131] The one or more search spaces may be configured to be used to monitor one or more Downlink (DL) control channels. The one or more search spaces may be configured to be used to receive the one or more DL control channels. At least one search space of the one or more search spaces may correspond to at least one reference signal of one or more reference signals. At least a part of a control region may be monitored for at least one reference signal of the one or more reference signals. At least one reference signal in the at least part of the control region may be detected. At least one search space corresponding to the at least one reference signal may be monitored for at least one DL control channel, perhaps for example upon the detection of the at least one reference signal.

[0132] The system may comprise gaps and/or switching periods. Gaps and/or guard periods and/or silence periods and/or switching periods and/or absence of transmission and/or DTX periods may be placed between two consecutive symbols. The two consecutive symbols may carry transmissions with different beam direction and/or radiation pattern and/or steering vector. Different gap types may be identified. One or more of the following examples may be identified, depending on the placement: gaps between two control symbols and/or group of control symbols, gaps between two data symbols and/or group of data symbols, and/or gaps between control symbols and data symbols (e.g. between the last control symbol and first data symbol and/or between the first control symbol and last data symbol), and/or the like.

[0133] Different gap types may be preconfigured with a different duration. Same gap type may be preconfigured with a different duration in different subframes. Gaps may be selectively placed between two consecutive symbols. The two consecutive symbols may be transmitted with a different radiation pattern. The two consecutive symbols may be transmitted with a different beam pattern. The two consecutive symbols may be transmitted with a different direction. The two consecutive symbols may be transmitted with a different channel type. Gaps

may be selectively placed between control and data symbols. Gaps within the same subframe may have different duration. Gaps may or might not be present in some or all of the subframes. Gaps may be placed between control symbols and may or might not be placed in the data symbols. Gaps may be placed between data symbols and may or might not be placed in the control symbols. Within the control and/or data region, gaps may be selectively placed between a subset of symbols.

[0134] The gaps may be defined from a WTRU point of view. A WTRU may or might not be required to receive on the DL during the gap periods (e.g., the gap between control symbols and data symbols for a WTRU). A WTRU may utilize the gap periods to decode the control channel, e.g., control channels received before the start of gap period. A WTRU may utilize the gap periods to switch its receive beam. A WTRU may utilize the gap periods to apply new steering vector to receive the downlink data channel. The downlink data channel may be different from the receive beam and/or steering vector used to receive the downlink control channel. A WTRU may utilize the gap periods (e.g. the gap between data symbols and/or group of data symbols for a WTRU) to switch its receive beam. A WTRU may utilize the gap periods (e.g. the gap between data symbols and/or group of data symbols for a WTRU) to apply new steering vector to receive the downlink data channel, which may be different from the receive beam and/or steering vector used to receive the previous downlink data channel in a subframe (e.g., same or different).

[0135] An mmW control channel may be designed, e.g., to facilitate control channel beam mapping to physical source. One or more control channels in a cell may be beamformed. One or more control channels in a cell may be placed in different control symbol and/or groups of control symbols in a subframe.

[0136] For example, an mB may utilize sweep operation to go through all or some of the control beams. An mB may transmit control channel beams in a subframe, e.g., one or more, or all, the control channel beams in every subframe. An mB may receive control channels in a subframe. For example, entire cell coverage may receive control channels in every subframe. An mB may utilize sweep operation, for example, starting from one control beam and going through some (e.g., one or more, or all) of the control beams in the cell in certain order. The sweep operation may go through selected (e.g., only specific) symbols in a subframe (e.g. only in the control region). The mB may utilize multiple subframes to transmit all or some of the control channel beams. For example, a subframe may comprise a partial sweep of control channel beams. One or more subframes may be used for a complete sweep of control channel beams to cover the entire cell. The mB may follow a certain order for the sweep operation. For example, it

may transmit control channel beams in a sequence based on control channel number and/or BRS sequence number. The mB may follow a random order for the sweep. The random order may be generated from a hashing function. The hashing function may use control channel number and/or subframe number etc.

[0137] The mapping between control channel beam(s) and/or control symbol(s) may be pre-defined and/or signaled via one or more of the following: broadcast channel(s) (e.g., MIB, SIB-x), higher layer signaling (e.g. RRC/MAC), L1 signal/channels, and/or any other common channel, and/or the like. The mapping between control channel beam(s) and control symbol group(s) may be pre-defined and signaled via one or more of the following: broadcast channel(s) (e.g., MIB, SIB-x), higher layer signaling (e.g. RRC/MAC), L1 signal/channels, any other common channel, and the like. WTRUs may determine the control channel beam to control symbol mapping by blind decoding. For example, WTRUs may search for pre-defined BRS sequence in the control region, and WTRUs may determine the control channel beam to symbol mapping, e.g., based on the received BRS signal quality (e.g. RSRP, SNR etc.).

[0138] An mB may select a subset of beams. The mB may transmit a subset of control channel beams in a subframe. The subset may be determined by one or more of the following criterias: distribution of WTRUs in a cell and/or beam, activity level of WTRUs in the cell and/or beam (e.g., buffer status of WTRUs, traffic pattern for WTRUs), WTRU grouping, WTRU service requirements, number of control channels with or without beamforming, scheduling algorithm, intra and inter cell interference, and/or type of control channel (e.g. common control and/or WTRU specific control), and the like. The mB may transmit a (e.g., only one) control channel beam in a subframe. The data region in the subframe may comprise transmissions using the same control channel beam and/or any other data channel beam related to the control channel beam, e.g, narrow data channel beam related to the control channel beam.

[0139] The mapping between a control channel beam and a symbol and/or a symbol group associated with a subframe (e.g., within a subframe and/or across subframes) may be fixed and/or flexible. The following may be applicable irrespective of control channel beam selection mode (e.g. subset transmission and/or full sweep transmission).

[0140] The mapping between a control channel beam and a symbol and/or a symbol group associated with a subframe, e.g., within a subframe and/or across subframes, may be fixed. In a fixed mapping, a control channel beam, e.g, every control channel beam, may be placed and/or transmitted in a pre-defined symbol and/or symbol group within a subframe. The mapping between the control channel beam and the symbol number may be same in certain (e.g., one or more, or all) subframes. For example, control channel beam 1 may be transmitted during symbol

number 1 in a (e.g., every) subframe. Symbol hopping may be used for control channel beams according to a pre-defined hashing function. For example, a function may use control channel number, cell ID, BRS sequence ID, subframe number, symbol number etc. WTRUs may determine the mapping between the control channel beam and the symbol/symbol group, e.g., implicitly based on the PBCH beam mapping. WTRUs may determine the mapping between control channel beam and the symbol/symbol group based on explicit configuration using one or more of the following: broadcast channel(s) (e.g., MIB, SIB-x), higher layer signaling (e.g. RRC/MAC), L1 signal/channels, and the like. WTRUs may determine the mapping between control channel beam and the symbol/symbol group based on a pre-defined function of cell-ID and/or beam-ID. Many to one mapping between control channel beams and control symbol/symbol group may be defined.

[0141] With a fixed mapping structure, control channel beams with no active WTRUs may have blank and/or empty control symbols. The blank and/or empty control symbols may be reclaimed and/or reused to map data channel beams, e.g., to improve resource utilization. The data channel beams may be scheduled by control channel beams occurring before the original blank and/or empty symbol. The data channel beams may be scheduled by control channel beams occurring after the original blank and/or empty symbol. WTRUs may buffer the complete subframe before the control channel decoding is complete. PDSCH may be mapped to the unused (e.g., empty and/or blank) control symbols. The unused control symbols may precede the associated PDCCH.

[0142] The mapping between a control channel beam and a symbol and/or a symbol group associated with a subframe, e.g., within a subframe and/or across subframes, may be flexible. In a flexible mapping, a control channel beam may be placed and/or transmitted in a (e.g., any) symbol and/or symbol group in a subframe. Multiple control channel beams in a subframe may be transmitted using different symbols, e.g., time multiplexed. The mapping between control channel beams and the symbol/symbol group may vary for different subframe. An mB may selectively transmit a subset of control channel beams in a subframe. The number of control channel beams transmitted may vary for different subframes. The number of control symbols occupied by a control channel beam may vary for different subframes. The number of control symbols occupied by different control channel beams in a subframe may vary.

[0143] The mapping between a control channel beam and a symbol and/or a symbol group associated with a subframe, e.g., within a subframe and/or across subframes, in a frame structure may be a hybrid of fixed and flexible mapping. The mB may use a fixed mapping for some beam types (e.g., common control beams and/or Omni beams, and/or WTRU specific

control beams). The mB may use a flexible mapping for other beam types (e.g., WTRU specific control beams, and/or common control beams and/or Omni beams). The mB may use a fixed mapping for some subframes and a flexible mapping for other subframes. The mapping format for different subframes may be explicitly signaled using one or more of the following: broadcast channel(s) (e.g., MIB, SIB-x), higher layer signaling (e.g., RRC/MAC), and/or L1 signal/channels, and the like. The mapping format for different subframes may be implicitly known by the presence of certain channels. For example, subframes with PBCH may use fixed mapping. A flexible mapping may be the default mode, and a fixed mapping may be applied in some (e.g., specific) subframes at a pre-defined periodicity.

[0144] For example, a fixed mapping between control channel beam RS and/or the control symbols may assist WTRU measurement at specific subframes. An mB may use a fixed mapping for a subset of beams for WTRUs in idle mode and a flexible mapping for WTRUs in connected mode. An mB may use a fixed mapping for WTRUs in connected mode and a subset of beams for WTRUs in idle mode. An mB may use a fixed mapping when the cell is lightly loaded (e.g. when the number of active WTRUs are small) switch to a flexible mapping when the cell is highly loaded. WTRUs may determine the mapping format for control channel beams from the configuration received in one or more of the following: broadcast channel(s) (e.g., MIB, SIB-x), higher layer signaling (e.g. RRC/MAC), L1 signal/channels, any other common channel, and/or the like. One or more WTRUs may determine the change/switch in control channel beam mapping from configuration received in one or more of the following: broadcast channel(s) (e.g., MIB, SIB-x), higher layer signaling (e.g. RRC/MAC), and/or L1 signal/channels, any other common channel, and/or the like.

[0145] An mmW control channel beam may have various control channel beams. The mmW control channel beam may carry plurality of control channels addressed to one or more WTRUs. The control channel beam may carry one of more of the following: the Downlink Control Information (DCI) [e.g., the DCI may include scheduling grant (UL and DL)], UL control channel assignment, beam switch command, power control commands and/or any other control information, higher layer messages (MAC, RRC), small payload (e.g. broadcast messages like SIB/Paging), cell and/or beam specific reference signals for demodulation, measurement for one or more WTRUs, and/or the like. The minimum time domain resource occupied by the control channel beam may be one symbol. The maximum time domain resource occupied by the control channel beam may be pre-configured (e.g., in MIB/SIB-x) and/or dynamically signaled using beam specific PCFICH. The dwell time of the control channel beam may be pre-configured (e.g. in MIB/SIB-x) and/or dynamically signaled using beam specific

PCFICH. The time domain resources (e.g. number of symbols) occupied by common control channel beam may be fixed (e.g., in MIB/SIB-x). The WTRU specific control channel beam may be dynamic (e.g., beam specific PCFICH).

[0146] The mmW control beam may carry one or more PDCCHs. The PDCCHs may be addressed for/to one or more WTRUs. A PDCCH may be transmitted on an aggregation of one or several CCEs (Control Channel Elements), e.g., where a control channel element may correspond to two or more REGs (Resource Element Groups). Different PDCCH formats may be defined, e.g., based on aggregation levels of CCEs. PDCCH may be transmitted, e.g., using a hierarchy of different groups of resource elements. The allocation of number of basic resource units for a level of resource group may be associated with PDCCH link adaptation scheme and/or other considerations. One or more characteristics/property of REs may be a function of beam ID and/or beam type. One or more characteristics/property of CCEs may be a function of beam ID and/or beam type.

[0147] Common control channel beams and/or WTRU specific control channel beams may use different PDCCH formats and/or aggregation levels. There may be a fixed aggregation level on the WTRU specific control channel beam. The number of REGs per CCE may vary for different beam type. For example, common control channel beam may have higher number of REGs per CCE. The resource block structure and/or subcarrier spacing may vary for different beam types. For example, symbols carrying common control channel beams and/or symbols carrying WTRU specific control beams may use different subcarrier spacings. Common control channel beams may be scrambled by a cell specific (e.g. cell ID) and/or beam specific (e.g. beam ID) identity. WTRU specific control channel beams may be scrambled by one or more of the following: a cell specific (e.g. cell ID), a beam specific (e.g. beam ID), a WTRU specific identity (e.g. C-RNTI), and/or the like. One or more modulation schemes and/or coding rates used for the control channel beam may be specific to beam type. For example, common control channel may use a fixed and/or preconfigured modulation scheme and/or coding rate. The WTRU specific control channel beam may use a dynamic MCS adaptation. The dynamic MCS adaptation may be signaled using beam PCFICH. Beam types may be WTRU specific. For example, a WTRU may use a common control channel beam. A WTRU may use a WTRU specific control channel beam. A WTRU may use a beam carrying common control channel scheduling and/or WTRU specific scheduling information. The part of the subframe where common control channel beams are transmitted may be referred as common control region. The part of the subframe where WTRU specific control channel beams are transmitted may be referred as dedicated control region.

[0148] The following examples are subframe configurations showing control channel beam placement and/or resource structure. The example figures for different control channel placement shown are not exhaustive and/or other control channel placements may be used. The figures are not meant to be exhaustive, e.g., all channels are not captured in the figure. For purposes of clarity and/or explanation, examples may be described in term of DL subframes and/or (e.g., only DL subframes are shown) UL subframes may be ignored. One or more techniques described in terms of DL operation may be equally applicable to uplink operation. The wide transmit beams at the mB may be referred here as B1, B2, B3, B4 etc. The narrow transmit beams may be referred to as B11, B12 (e.g., within B1), B21, B22 (e.g., within B2) etc.

[0149] In FIG. 12, the mB may transmit one or more wide beam control channels per subframe. For example, subframe 1 may carry the control channel beams B1 and/or B2, subframe 2 may control channel beams B3, etc. A (e.g., one or more, or each) control channel beam may carry DCI for one or more WTRUs. A (e.g., one or more, or each) control channel beam within a subframe may carry some unique content. For example, a DCI for a WTRU (e.g., a particular DCI for a WTRU) may be carried in a (e.g., only one) control channel beam. A control channel beam within the subframe may carry the same DCI content. The number of control channel beams per TTI may vary. For example, it may range from one control channel beam per TTI to the maximum available number of control channel beams in the cell. Length/duration of a (e.g., one or more, or each) control channel beam may vary (e.g. from one to more symbols). The data region within a subframe may carry PDSCH for one or more WTRUs, e.g., the PDSCH transmission for different WTRUs may be multiplexed in time, frequency, and/or spatial domain. For example, multiple PDSCH beams may be transmitted within the data region. The beam width of a data beam may be adjusted based on one or more of the following: WTRU location, throughput requirements, and/or interference consideration, and/or the like. The mapping between the control channel beam and the symbol number within the control region may be flexible. WTRUs may receive assistance information about the control channel configuration, e.g., from PBCH and/or from Omni PCFICH channel.

[0150] In FIG. 13, mB may transmit one (e.g., exactly one) wide beam control channel per subframe. For example subframe 1 may carry the control channel beam B1 and/or B2, subframe 2 may carry control channel beams B3 etc. WTRUs may be configured to monitor certain (e.g., only certain) subframes for a possible occurrence of the pre-selected control channel beam.

[0151] In FIG.14, mB may sweep some or all the control channel beams in a subframe. For example a (e.g., one or more, or each) subframe may carry the control channel beam B1, B2,

B3, and/or B4. A (e.g., one or more, or each) control channel beam may carry DCI for one or more WTRUs. WTRUs with lower SNR may have their DCIs repeated in certain (e.g., all) control channel beams. WTRUs with higher SNR may have their DCIs transmitted in a subset of control channel beams. The mapping between the control channel beam and the control symbol may be fixed. BRS for a control channel beam (e.g., rather than and/or in addition to control channels) may be swept.

[0152] In FIG. 15, the control channel beam may be predefined to symbol mapping, e.g., to reduce the blind decoding attempts for the WTRUs. The WTRUs may attempt to decode the symbols (e.g., only the symbols) carrying pre-selected control channel beams. mB may map/place/transmit data channel beams in some control channel symbols, e.g., control channel symbols that may or might not be occupied by control channel beams. The WTRUs may start to buffer the symbols, e.g., for a possible data channel until it decodes the pre-selected control channel beam at the appropriate control symbol.

[0153] In FIG. 16, many to one mapping may be utilized for control channel beam to control symbol mapping to reduce control overhead, e.g., when the number of control channel beams are high in a cell. In FIG. 16, B1 and/or B5 may be mapped to symbol 1. B1 and/or B5 may be transmitted in control symbol 1, e.g., when the assumption is that one RF chain may be for the mB. WTRUs having B1 control channel beam may be used (e.g., required) to decode control symbol 1. A hashing function may be used, e.g., to reduce blocking probability for control channel beams. The hashing function may avoid mapping the same set of control channel beams to the same control symbol. The hashing may be a function of one or more of the following: subframe number, system frame number, control channel beam ID, cell ID, the control symbol number, and/or the like.

[0154] FIG. 17 is an example of a logical architecture for control channel beam generation. FIG. 17 illustrates an example of the relation between the different mapping/selection functions.

[0155] A mmW PDCCH may use heterogeneous beam types. For WTRU specific control channel, wide beams may be configured and/or assigned for a group of users and/or one or more, or all, the users' control channels, e.g., PDCCHs that may carry user specific DL control information (DCI). One or more narrow beams may be configured and/or assigned for individual WTRU for WTRU-specific control channels. One or more beams may be configured, e.g., such that wide beam(s) may be used to cover a cluster of WTRUs and/or narrow beam(s) may be used for individual WTRUs. Table 2 is an example of some assignments and/or configurations for heterogeneous beam types. For common control channel, wide beam may be

used for individual WTRU and/or a WTRU group. Narrow beam may be used for individual WTRU (e.g., individual WTRU only). Narrow beam may be used as WTRU-specific beam for common control, e.g., depending on the beam configurations. Wide beams (e.g., only wide beams) may be used for a group of WTRUs for common control. For WTRU-specific control channel, narrow beam may be used as WTRU-specific beam for WTRU-specific control. Wide beam (e.g., only wide beams) may be used for a group of WTRUs for WTRU-specific control.

Table 2. Examples for Assignments and/or Configurations for Heterogeneous Beam Types

		Wide beam	Narrow beam
Common Control	Individual WTRU	May use wide beam for easy tracking of WTRUs, etc. WTRU-specific wide beam for common control.	May use narrow beam for high beamforming gain. WTRU-specific narrow beam for common control.
	WTRU group	May use wide beam for WTRU group	May or might not use narrow beam
WTRU-specific Control	Individual WTRU	May use wide beam for easy tracking of WTRUs, etc. WTRU-specific wide beam for WTRU-specific control.	May or might not use narrow beam for high beamforming gain. WTRU-specific narrow beam for WTRU-specific control.
	WTRU group	May use wide beam for WTRU group	May or might not use narrow beam

[0156] A wide beam may be configured and/or used as a WTRU-specific beam for control channels, e.g., to enable easy tracking of WTRUs. The control channels may be common control channels. The control channels may be WTRU-specific control channels, e.g., common DCI carried by PDCCH, and/or ePDCCH, and/or the like. This may enable easy tracking of WTRUs. This may sometimes lower beamforming gain. Easy tracking of WTRUs may be useful. Easy tracking of WTRUs may be useful where beamforming gain may be less of a concern. Beamforming gain may be less of a concern when WTRUs are near the eNB and/or AP. Narrow beam(s) may be configured and/or used (e.g., only used) as WTRU-specific beam(s) for control channels, e.g., to enable high beamforming gain. High beamperforming gain may be useful, e.g., when WTRUs are far away from eNB and/or AP. High beamperforming gain may be useful, e.g., when WTRUs are around the cell edge. The control channels may be common and/or WTRU-

specific control channels. The WTRU-specific control channels may be WTRU-specific DCI carried by PDCCH, and/or ePDCCH, and/or the like.

[0157] Beams with different beam widths may be used to cover different WTRU densities (e.g., the number of WTRUs in a given direction/area relative to the mB). The pairing for which beam with certain width to cover which WTRU density may depend on the density distribution of WTRUs in geography. For example, for high density area, beams with narrower beam width may be configured and/or used. For low density area, beams with medium and/or larger beamwidth may be configured and/or used.

[0158] Beams may be allocated to WTRUs, e.g., such that WTRU density per beam (e.g., number of WTRUs in a beam) may be uniform and/or constant. This may facilitate the use of digital beamforming within analog beam, e.g., to support a given number of active WTRUs. The number of analog beams may be reduced. The control overhead may be mitigated, e.g., when multiple control channels may be sent simultaneously in the same beam and/or frequency resource. Trade-off may occur between the number of OFDM symbols (e.g., for beam sweeping) for control and/or the number of OFDM symbols for data. Different compromises between overhead and throughput may be considered based on the specific deployment scenario.

[0159] Heterogeneous beam types with different beam widths may be configured and/or used, e.g., to improve network operation flexibility and/or to reduce the control overhead.

[0160] Heterogeneous beam types may support one or more of the following: heterogeneous beam types with different beam widths for common and/or WTRU specific channel, heterogeneous beam types with different beam widths for the same WTRU at different time instance, heterogeneous beam types with different beam widths for different WTRUs, and/or heterogeneous beam types with different beam widths for group of WTRUs depending on WTRU's locations, and/or the like. The heterogeneous beam types with different beam widths may be configured and/or used for common control and/or WTRU-specific control channel. Heterogeneous beam types with different beam widths may be configured and/or used for the same WTRUs at different time instance. Heterogeneous beam types with different beam widths may be configured and/or used for different WTRUs at the same and/or different time instances. Heterogeneous beam types with different beam widths may be configured and/or used for a group of WTRUs, e.g., a group of WTRUs with various WTRU's locations. The control overhead, e.g, the number of OFDM symbols for control with respect to the number of OFDM symbols for data and/or the number of beams needed for beam sweeping with respect to number of OFDM symbols for data, may be reduced.

[0161] One or more of the following beam configurations may be considered, e.g., when one RF chain and/or a (e.g., one) beam are formed at a (e.g., any) given time.

[0162] A beam sweeping may use homogeneous beam type (e.g., homogeneous wide beam). A (e.g., one or more, or each) beam may have the same beam width covering 360/N degrees where N is the number of OFDM symbols for control channel. For example, one or more, or each, beam will cover 120 degrees at a time for N=3. A beam sweeping cycle may cover 360 degrees. Homogeneous beam type may be for uniform angular distribution of WTRUs. Homogeneous beam type may become less efficient, e.g, for non-uniform angular distribution of WTRUs,

[0163] Heterogeneous beam type may be efficient, e.g., for non-uniform angular distribution of WTRUs. A beam sweeping may use heterogeneous beam type (e.g., heterogeneous wide beam). One or more, or each beam may have different beam width but still covering 360/N degrees where N is the number of OFDM symbols for control channel. One or more, or each beam may cover more or less than 120 degrees at a time and/or full beam sweeping cycle will cover 360 degrees. For example, for N=3 beams may have beam widths 60, 120 and/or 180 degrees. An eNB may keep the number of WTRUs per beam uniform and/or constant when it transmits control channel to a (e.g., one or more, or each) WTRU. Uniform search space for control channel may be maintained. Search space may avoid being over-utilized for some beams and/or under-utilized for other beams.

[0164] The number of WTRUs per beam may be kept constant and/or near constant, e.g., when two or more RF chains are utilized for hybrid beamforming. Within a beam (e.g., one or more, or each beam) the number of ranks for spatial multiplexing may be limited. Keeping number of WTRUs under such rank per beam may be performed to enable spatial multiplexing for future evolution.

[0165] Beam sweeping may use narrow beams. A beam may have narrow beam width but cover WTRUs within N OFDM symbols for control channel. For example, one or more, or each beam may have narrow beam width but cover one or more, or all WTRUs within N OFDM symbols for control channel. One or more, or each beam may cover a WTRU at a time and/or a full beam sweeping cycle may cover N WTRUs. For K WTRUs, if N>=K, one beam sweeping cycle may deliver control channel to K WTRUs within a TTI. If N<K, one beam sweeping cycle may or might not deliver one or more, or all control channels to one or more, or all K WTRUs within a TTI. Another TTI and/or TTIs may be used (e.g., required) to deliver control channel to remaining K-N WTRUs. How many TTIs may be used (e.g., required) for beam sweeping may depend on N and/or K. K/N beam sweeping cycles and/or TTIs may be required to deliver one

or more, or all control channel to all K WTRUs. This example may work for N>=K. This example may become less efficient when N<K. Overhead may increase, e.g., when the number of OFDM symbols for control increases. The number of WTRUs that may be supported may be limited, e.g., when the number of users and/or K decreases. Beam sweeping may be performed across multiple TTI, introducing latency (e.g., additional latency).

[0166] Beam sweeping may use heterogeneous beam type (e.g., heterogeneous wide/narrow beams). A beam may have a wide and/or narrow beam width but cover WTRUs within N OFDM symbols for control channel. For example, one or more, or each beam may have one or more, or each wide and/or narrow beam width but cover one or more, or all WTRUs within N OFDM symbols for control channel. One or more, or each beam may cover one or more WTRUs at a time and/or full beam sweeping cycle will cover N WTRUs. For K WTRUs, if N>=K, one beam sweeping cycle may deliver control channel to K WTRUs within a TTI. If N<K, one beam sweeping cycle may deliver one or more, or all control channels to one or more, or all K WTRUs within a TTI. For example, N-1 narrow beams may deliver control to N-1 WTRUs, and/or the last beam (wide beam) may deliver control to the remaining K-N+1 WTRUs. Another TTI and/or TTIs may or might not be used (e.g., required) to deliver control channel to remaining K-N WTRUs. How many narrow beams and/or wide beams may be used (e.g., required) may depend on design considerations and/or N and/or K. Using heterogeneous beam type may lower control overhead, lower latency, and/or increase the number of WTRUs that may be supported.

[0167] Heterogeneous beams may be considered. Heterogeneous beams may be s plularity of beams associated with one or more different characteristics and/or properties, e.g., beam width, transmit power, number of lobes, and/or number of active antenna elements, and/or the like. Beams with different beam widths and/or narrow beam may be used for the same cell and/or eNB. A narrow beam carrying control information and/or PDCCH may be used for individual WTRUs. Wide beams may be used for a group of control channels and/or PDCCHs. Heterogeneous beam types, e.g., wide and/or narrow beams, may be used. Heterogeneous beam widths for wide beam may be used. Different beam types and/or beam widths may be used, e.g., when beam sweeping is needed. For example, for three beams, beams 1, 2 and/or 3 may have beam width x, y and/or z respectively. For uniform settings beams 1, 2 and/or 3 may have beamwidth, x=y=z. For non-uniform settings x, y and/or z may or might not equal to each other. Depending on the settings of x, y and/or z, wide beam with different beam widths and/or narrow beam may be configured and/or formed.

[0168] To support beamforming reference signal (BRS), antenna ports may be designed to transmit BRS. Beam-specific antenna ports may be designed and/or allocated. Antenna port may be designed for beams that may be used for sending either common control and/or WTRU-specific control information. An antenna port may be associated with a reference signal called BRS. A BRS may be used to demodulate control channels. Antenna ports may be orthogonal to each other in time, frequency, code and/or any combination of them, e.g., to avoid mutual interferences among BRS. A design may use even/odd pattern for BRS. Even and/or odd BRS may be allocated in different frequency and/or time grid(s). Even BRS (E-BRS) may be placed in the same frequency and/or time grid(s). Odd BRS (O-BRS) may be placed in the same frequency and/or time grid(s). E-BRS and/or O-BRS may be allocated in different resources, e.g, resources that are orthogonal to each other. For control channel, control beam RS (CBRS) may be used. Even CBRS (E-CBRS) may be placed in the same frequency and/or time grid(s). Odd CBRS (O-CBRS) may be placed in the same frequency and/or time grid(s). E-CBRS and/or O-CBRS may be allocated in different resources, e.g., resources that are orthogonal to each other. For data channel, data BRS may be used.

[0169] In even beam, EAP may send E-CBRS for control channel. In odd beam OAP may send O-CBRS for control. EAP and/or OAP may be in orthogonal resources. E-CBRS and/or O-CBRS may be in orthogonal resources. Mutual interference between EAP and/or OAP or between E-CBRS and/or O-CBRS may be avoided.

[0170] One or more (e.g., only one) BRS (e.g., rather than and/or in addition to two BRS (E-CBRS, O-CBRS)) may be used. A (e.g., perfect) spatial separation may be achieved, e.g., to make one BRS more efficient than other designs. A BRS in even beam and/or E-CBRS may be active for control channel. BRS in odd beam and/or O-CBRS may or might not be active for control channel. BRS in odd beam and/or O-CBRS may be reused for data. O-CBRS may be active for control and/or E-CBRS may or might not be active for control. E-CBRS may be reused for data. CBRS in even and/or odd beam may or might not be reused for data, e.g, when perfect spatial separation may or might not be achieved. Side lobes of beams may be related to spatial separation. For example, side lobes of beams may prevent perfect spatial separation. Antenna patterns may be considered when designing antenna ports for BRS and/or CBRS. Side lobes may be considered when designing antenna ports for BRS and/or CBRS. Antenna ports and/or BRS design for data beam may be similar.

[0171] Spatial separation and/or resource reuse factor may be related to the efficiency of the channel design. For example, E-CBRS and/or O-CBRS may avoid mutual interferences between them, when resource reuse factor of two is considered. Resource reuse factor of two

may be considered efficient. Resource reuse factor Q=1 may be considered, e.g., when perfect spatial separation is achievable. Reuse factor Q may be set to two or higher, e.g. when perfect spatial separation may or might not be achieved. Reuse factor may be set to one, e.g., for sequential beam sweeping for control channel. Resource reuse factor may be set to two or higher, e.g., for parallel beam sweeping and/or transmission. Parallel beam sweeping and/or transmission may occur, e.g., when two or more beams transmitted in parallel simultaneously sweep through K WTRUs via N OFDM symbols for control. During parallel beam transmission, potential mutual interferences between beams may occur, e.g., when spatial separation is not perfect. Resource reuse factor may be set to two or higher.

[0172] For multi-layer beamforming, e.g., when wide beam and/or narrow beam may coexist, some offset in frequency/time grids may be applied to enable orthogonality between BRS for wide and/or narrow beams. Narrow beam may serve one WTRU among a WTRU group while a wide beam may serve the remaining WTRUs in the WTRU group, e.g., when they may (e.g., must) be served simultaneously, two (e.g., only two) beams are available, and/or the two beams may comprise a wide beam and/or a narrow beam. The narrow beam and/or wide beam may overlap. Narrow beam and/or wide beam may use FDM to enable coexistence, e.g., when spatial separation between them does not occur. BRS using FDM may be applied for narrow beam and/or wide beam.

[0173] One or more techniques associated with BRS may be applied to data BRS and/or control BRS. Control channel may be decoded. For example, channel estimation may be performed via CBRS to decode control channel.

[0174] Energy detection may be used for channel estimation and/or control channel demodulation, e.g., in even beam. For example, in even beam, E-CBRS may be on and/or O-CBRS may be off. No beam index may be decoded beforehand. Eenergy detection may be used to decide which antenna port to be used for channel estimation to decode control channel.

[0175] Channel estimation may be performed to decode data channel, e.g, when even/odd BRS is used. Beam index may already be decoded in control channel. Even/odd beam index may be obtained by one or more of the following. In even beam, even DBRS may be on, odd DBRS may be off, e.g., to avoid mutual interference between BRS at beam edge. Energy detection may be used to decide which antenna port may be used for channel estimation. It is similar for odd beam. In even beam, even DBRS may be on, odd DBRS may be on but may be used for data, redundant data may be for control and/or carry some short control message. Mutual interference between RS and/or data/else at beam edge may occur. It is similar for odd beam.

[0176] The WTRU may or might not be dependent on blind energy detection. The WTRU may decide between even/odd DBRS, perhaps for example even if a WTRU may or might not detect correct energy level. There may be an assumption that data demodulation may be performed after control channel decoding. One or more beam index may be (e.g., already) obtained in the control channel decoding.

[0177] A (e.g., one or more, or each) cell may have plurality of PDCCH regions, e.g. one for one or more, or each wide beam. A (e.g., one or more, or each) PDCCH may carry beam specific BRS sequence. The BRS REs mapping in the control channel symbols may be a function of PCI. The BRS REs mapping in the control channel symbols may be a function of beam index. The sequence carried in the BRS may be provided by the linked PBCH.

[0178] WTRUs may monitor PDCCH. WTRUs may detect BRS associated with the serving beam at control symbol location. The control symbol location may be fixed. WTRUs may perform BRS detection operation in certain (e.g., one or more, or all) control symbols defined by cell PCFICH, e.g., when the control symbol locations are not fixed and/or variable. WTRUs may perform BRS detection operation in the control symbols (e.g., only the control symbols) defined by beam-specific PCFICH. e.g., perhaps when the control symbol locations might not be fixed and/or variable. WTRUs may compare the measured BRSRP with an implementation dependent threshold. WTRUs may perform PDCCH decoding, e.g., when BRSRP is greater than the threshold. WTRUs may assume no DL/UL grant received in the current TTI, e.g., perhaps unless a semi-static grant is configured.

[0179] Subframe structure and/or placement for PDCCH BRS may be designed. For sequential beam sweeping, FIG. 18 may be an example subframe structure and/or placement for control BRS. The resources may be indicated in the FIG. 18. Example subframe in FIG. 18 shows three control symbols followed by some data symbols. Beams may be swept through three control symbols sequentially by the order of beams 1, 2 and/or 3 (e.g., B1, B2 and/or B3).

[0180] FIG. 19 may be an example resource allocation in two dimension of frequency and/or time. BRS may be used in a (e.g., one or more, or each) control symbol and/or may be placed uniformly (and/or non-uniformly) across frequency. FIG. 19 shows that BRS may have the same location in frequency across one or more, or all control symbols. Other allocations may be used, e.g., BRS may be in different locations in frequency across different control symbols. BRS may be in staggered patterns and/or designs.

[0181] FIG. 20 may be an example control BRS subframe structure and/or placement for parallel beam sweeping. The resources are also indicated in the block diagram. Example subframe in FIG. 20 shows three control symbols followed by some data symbols. One or more

beams may be swept through three control symbols sequentially by the order of beams 1&2, 3&4 and/or 5&6 (e.g., B1/B2, B3/B4 and/or B5/B6). Parallel beams may be used in a control symbol. Two parallel beams may be used simultaneously in a control symbol. For example, total six beams may be be swept through three control symbols. The number of users to be covered by the control channel may increase by using parallel beam transmission and/or sweeping. The capacity of system may increase.

[0182] FIG. 21 may be an example resource allocation in two dimension of frequency and/or time. BRS may be used in a control symbol and/or may be placed uniformly (and/or non-uniformly) across frequency. BRS may also be placed contiguously and/or non-contiguously. For example, O-BRS and/or E-BRS may be placed contiguously within a pair of O-BRS/E-BRS. Pairs of O-BRS/E-BRS may be placed uniformly and/or non-uniformly across frequency. O-BRS and/or E-BRS may be placed non-contiguously within a pair of O-BRS/E-BRS. Pairs of O-BRS/E-BRS may be placed uniformly and/or non-uniformly across frequency. Example may show that O-BRS/E-BRS pairs have the same location in frequency across one or more, or all control symbols. Other allocations may also be used, e.g. when BRS may be in different locations in frequency across different control symbols. A BRS may be in staggered patterns and/or designs.

[0183] Designs of mmW PCFICH may comprise, e.g., cell specific control region and/or beam specific control region. In a subframe, one or more beamformed control channel(s) may be transmitted during one or more control symbol(s) time multiplexed within a control region. The overall control region size/length/duration may be a function of one or more of the following: the number of control channel beams selected for transmission, the number of control symbols occupied by a (e.g., one or more, or each) control channel beam, a pre-defined max size/length/duration of beam specific control region, and/or a pre-defined max size/length/duration of cell specific control region, and/or the like.

[0184] The number of control channel beams and/or maximum number of control channel beams in a subframe may be fixed. The number of control channel beams may be less than or equal to the total number of control channel beams in the cell coverage. The number of control symbols may be a function of the number of control channel beams and/or the number of symbols per control channel beam. The number of control symbols and/or the maximum number of control symbols in a subframe may be fixed. The partial sweep function and/or a control channel beam subset selection function may select control channel beams based on one or more of the following: the number of control symbols in a subframe, and/or the number of control symbols per control channel beam, and the like. The ratio of control symbols to data symbols

may be configured to be less than or equal to a pre-defined value (e.g. control overhead percentage). The number of control symbols per control channel beam may be a function of number of WTRUs within the control channel beam and/or type of the control channel beam (e.g. common control beam and/or WTRU specific control beam).

[0185] At least a part of the control region may be one part of a number of parts of the control region. The number of parts of the control region may be a function of a number of symbols configured for the control region. The number of parts of the control region may be a function of a number of symbols used for the control region.

[0186] Cell specific control region configuration may be indicated. WTRUs may receive indication and/or configuration of cell specific control region from broadcast channel(s) (e.g., MIB, SIB-x) and/or any other common channel. The configuration may be WTRU specific. The configuration may be signaled using dedicated signaling (e.g. MAC and/or RRC message). A physical channel/signal (e.g., cell PCFICH) may be defined. A physical channel/signal may carry the configuration, e.g., for cell specific control region. A new physical channel/signal may be placed in one or more pre-defined symbol(s) in a subframe. Cell PCFICH may be transmitted with an Omni-beam and/or wide beam. Cell PCFICH may be transmitted with a narrow beam. Cell PCFICH may comprise two or more repetitions in wide beams. Cell PCFICH may comprise two or more repetitions in narrow beams. WTRUs may accumulate the energy from cell PCFICH repetitions to increase SNR. Cell PCFICH may be repeated in different directions, e.g., when transmitted using wide and/or narrow beam to provide coverage. Cell PCFICH may be repeated in different beam widths, e.g., when transmitted using wide and/or narrow beam to provide coverage. The beam used for cell PCFICH may be same as the beam used for one or more of synchronization channels (PSS and/or SSS and/or any other signal). The beam used for cell PCFICH may be the same as the beam used for PBCH. One or more WTRUs may determine the location of the cell PCFICH symbol by applying a pre-defined offset from symbol carrying PSS in the same beam.

[0187] At least one DL control channel may be communicated via one or more Orthogonal Frequency Division Multiplexing (OFDM) symbols. The one or more OFDM symbols on which the at least one DL control channel may be communicated may be located in the control region. A WTRU may obtain a number of the one or more OFDM symbols in the control region via a Physical Control Format Indicator Channel (PCFICH). In some scenarios the PCFICH may be obtained via a beam of a synchronization channel and/or via a beam of a Physical Broadcast Channel (PBCH).

[0188] WTRUs may determine the location of the cell PCFICH symbol by applying a pre-defined offset from symbol carrying SSS in the same beam. One or more WTRUs may determine the location of the cell PCFICH symbol by applying a pre-defined offset from symbol carrying PBCH in the same beam. The linkage (e.g., a pre-defined offset between two channel/beams) may be used to determine time and/or frequency location of a channel/beam when the time and/or frequency location of another channel/beam Cell PCFICH may be included in a subframe (e.g., every subframe). The linkage (e.g., a pre-defined offset between two channel/beams) may be used to determine time and/or frequency location of a channel/beam when the time and/or frequency location of another channel/beam Cell PCFICH may be included in n subframes and/or subframe (e.g., every n subframes and/or every subframe). Cell PCFICH may be transmitted in pre-defined locations within a subframe, e.g., first few symbols of a subframe.

[0189] At least one search space corresponding to at least one reference signal may be monitored for at least one data channel, perhaps for example upon the detection of the at least one reference signal. The at least one search space may have a duration. A time location of the at least one data channel may be determined, perhaps for example based on the at least one reference signal, or the duration.

[0190] The cell specific control region size may be fixed. The cell specific control region size may indicate the maximum size/length/duration of the cell specific control region. The cell specific control region size may be semi-static. The cell specific control region size may indicate the size/length/duration of the cell specific control region for n subframes. n may be greater than or equal to the periodicity of corresponding MIB/SIB-x and/or other common channels (e.g., any other common channel). The cell specific control region size may be a greater than or equal to the sum of beam specific control region size of certain (e.g., one or more, or all) control channel beams transmitted in that subframe. Cell specific control region size may be equal to the product of max beam specific control region size and/or max number of control channel beams in a subframe. The max beam specific control region size and/or max number of control channel beams in a subframe may be pre-defined in the standard. The max beam specific control region size and/or max number of control channel beams in a subframe may be configured in common/broadcast channels. One or more symbols within the control region may carry data channels, e.g., when the cell specific control region size is greater than the sum of beam specific control region size of certain (e.g., one or more, or all) of the control channel beams transmitted in that subframe. WTRUs may receive more than one configuration for cell

specific control region. For example one configuration may apply for subframes with flexible mapping. One configuration may apply for subframes with fixed mapping.

[0191] One or more WTRUs may receive configuration for flexible mapping (e.g., only for flexible mapping), and/or WTRUs may apply a pre-defined configuration (e.g. fixed and/or max length for cell specific control region) for fixed mapping. A configuration may apply for common control channels, and/or a configuration for WTRU specific control channel. The cell specific control region configuration, for example cell PCFICH, may be dynamic. The cell specific control region configuration, for example cell PCFICH, may vary for a (e.g., every) subframe. Cell PCIFCH may indicate presence of common control region within a subframe. Cell PCFICH may indicate the end and/or start of common control region within a subframe. WTRUs may assume that the rest of the control region not occupied by common control region may be dedicated control region.

[0192] Cell specific control region configuration may have contents. The configuration may include and/or identify the length of the cell specific control region size/duration/period. The length may be expressed in one or more of the following: a number of subframes, timeslots, and/or OFDM symbols, and/or the like. One or more WTRUs may assume the start of a cell specific control region as the first symbol in a subframe. WTRUs may receive explicit indication of the first and/or last symbol of the cell specific control region. The value transmitted in the cell specific control region configuration may be a logical value. The value transmitted in the cell specific control region configuration may have a pre-defined mapping to the actual duration/length/period of the cell specific control region. A WTRU may use the indications of a cell specific control region configuration to calculate and/or determine the end of the cell specific control region. A WTRU may use the indications of a cell specific control region configuration to calculate and/or determine start of the data region. The configuration may include/identify number of control channel beams transmitted in a subframe (e.g., in the current subframe and/or in n subsequent subframes and/or in some or all subframes). The configuration may include/identify the type of mapping applied for control channel beams (e.g., fixed and/or flexible mapping). The configuration may include beam identification (e.g., RS sequence ID, antenna port number, and/or control channel number) of certain (e.g., one or more, or all) control channel beams transmitted in a subframe. The subframe may be the current subframe, n subsequent subframes, and/or certain (e.g., one or more, or all) subframes.

[0193] Beam specific control region configuration may be indicated. One or more WTRUs may receive indication and/or configuration for beam specific control region size from broadcast channel(s) (e.g., MIB, SIB-x). WTRUs may receive indication and/or configuration for

beam specific control region size from any other common channel/signal. Beam specific control region size/length/duration may be pre-defined as a constant value. The constant value may be treated as a max value. Different beams in a cell may have different beam specific control region configurations. Beam specific control region size/length/duration may be semi-static. Beam specific control region configuration may vary for different beams in the cell. For example, common control channel beams may have a configuration different from the configuration for the WTRU specific control channel beams. Beam specific control region configuration for common control channel may be fixed and/or semi-static. Beam specific control region configuration for WTRU specific control channel beams may be dynamic.

[0194] The configuration may be WTRU specific and/or beam specific. The configuration may be signaled using dedicated signaling (e.g. MAC and/or RRC message). In the absence of dedicated signaling, WTRUs may apply the configuration in MIB/SIB-x and/or a pre-defined value. A physical channel/signal (for example beam PCFICH) may be defined. The physical channel/signal may carry the configuration for beam specific control region. A cell and/or mB may transmit multiple beam PCFICH in the same subframe. A beam PCIFCH may be transmitted with a specific beam pattern and/or beam width. A beam PCIFCH may carry the corresponding beam specific control region configuration. Beam specific control region configuration for a particular beam may vary across subframes. Beam PCFICH for a beam in a subframe may be transmitted conditionally based on the presence of corresponding (e.g., beam with similar properties and/or characteristics) control channel beam in that subframe. Beam PCFICH transmission may be coupled with control channel beam transmission. The control channel and/or the beam PCFICH, e.g., within a beam dwell time, may be transmitted. The beam used for beam PCFICH may be same as the corresponding control channel for which the configuration may be provided/signaled. Beam PCFICH may be time multiplexed (e.g., different symbol and/or first few symbols in a PDCCH). Beam PCFICH may be frequency multiplexed (e.g. CCEs, REs, and/or RBs) with the control channel transmission.

[0195] The mB may transmit certain (e.g., one or more, or all) the beam PCFICHs and/or transmit the control channel beams in certain order. The mB may multiplex beam PCFICH and/or cell PCFICH and/or control channel, e.g., when the cell PCFICH is transmitted with a wide and/or narrow beam. The mB may multiplex beam PCFICH and/or cell PCFICH and/or control channel, e.g., when the cell PCFICH is transmitted with a wide and/or narrow beam. The beam PCFICH may carry cell specific configuration and/or beam specific control region configuration. Beam PCFICHs may be transmitted with a different beam pattern from the beam pattern used by the control channel beams. A (e.g., one) beam PCFICH may carry the

configurations for multiple control channel beams. WTRUs may determine the presence of beam PCFICH. For example, WTRUs may determine the presence of beam PCFICH indicated by a bit and/or bitmap in cell PCFICH. WTRUs may determine the presence of beam PCFICH indicated by a bit and/or bitmap for a (e.g., one or more, or each) control beam in cell PCFICH.

[0196] Beam specific control region configuration may have contents. WTRUs may determine beam specific search space from the beam specific control region configuration. Beam specific control region configuration may include one or more of the following: a (e.g., single) beam specific control region size common for certain (e.g. one or more, or all) beams, a beam specific control region size for a (e.g., one or more, or each) beam separately, and/or a beam specific control region size as a group of beams with similar control region size, and/or the like. The configuration may include and/or identify the length of the beam specific control region size/duration/period. The size may be expressed in one or more of the following: a number of subframes, timeslots, and/or OFDM symbols, and/or the like. One or more WTRUs may receive explicit indication of the first and/or last symbol of the beam specific control region. The value transmitted in the beam specific control region configuration may be a logical value. The value transmitted in the beam specific control region configuration may have a pre-defined mapping to the actual duration/length/period of the beam specific control region. A WTRU may use the indications of a beam specific control region configuration, e.g., to calculate and/or determine the end of the beam specific control region. A WTRU may use the indications of a beam specific control region configuration, e.g., to calculate and/or determine start of the data region.

[0197] The configuration may include/identify the number of control symbols carrying the corresponding control channel beam in a subframe (e.g., in the current subframe and/or in n subsequent subframes and/or in certain (e.g., one or more, or all subframes)). The configuration may include/identify the type of mapping applied for a control channel beam (for example fixed and/or flexible). The configuration may also include beam identification (e.g., RS sequence ID and/or antenna port number and/or control channel number) of the corresponding control channel beam transmitted in a subframe (for example in the current subframe and/or in n subsequent subframes and/or in all subframes).

[0198] WTRU monitoring may be performed in idle mode. The monitoring may select a common control channel beam. WTRUs may or might not be involved in active data transfer (e.g. in idle mode). WTRUs may be in idle mode, e.g. when selecting one or more common control channel beam(s) to perform monitoring. WTRUs may monitor one or more common control channel beams. WTRUs may monitor one or more common control channel beams to receive system information. WTRUs may monitor one or more common control channel beams

to page messages. WTRUs may monitor one or more common control channel beams to perform coarse beam tracking/beam forming. WTRUs may monitor one or more common control channel beams to receive beam training. WTRUs may select one or more common control channel beam(s) for monitoring. WTRUs may perform measurements on beamformed RS. The RS may or might not be multiplexed with common control channel beams for beam evaluation purposes. Common control channel beams may be detected/measured/identified by reference signals that are different from WTRU specific beams. Certain (e.g., one or more, or all) common control channel beams may be associated with the same reference signal that may be cell specific.

[0199] A (e.g., one more, or each) common control channel beam may be associated with a different reference signal sequence. WTRU may select certain (e.g., one or more, or all) common control channel beams. WTRU may select certain common control channel beams whose measured signal quality (e.g. RSRP, SNR, SINR, RSRQ, etc.) may be above a threshold. WTRUs may select a beam (e.g. the best) based on measured signal quality for monitoring purposes. WTRUs may perform signal quality measurements on a restricted set of subframes, e.g., subframes where PBCH and/or Sync channels may be transmitted. WTRUs may perform signal quality measurements on the subframes, e.g., where there is fixed and/or pre-defined mapping between control channel beams and/or control symbols.

[0200] WTRUs may receive an explicit and/or implicit linkage between Sync beams and/or control channel beams, using heterogeneous control channel beams. One or more WTRUS may receive an explicit and/or implicit linkage between PBCH beams and/or control channel beams, using heterogeneous control channel beams. WTRU's cell selection and/or re-selection may be based on the PBCH beams. One or more WTRUs' cell selection and/or re-selection may be based on the sync beams. WTRUs may select control channel beams of certain type based on the linked serving PBCH to perform monitoring herein. WTRUs may select control channel beams of certain type based on the linked serving Sync beam type to perform monitoring herein. For example, a pre-configured offset may be defined between the PBCH/Sync beams and/or the corresponding control channel on the same beam. The offset may be in terms of time (e.g., subframe, symbols) and/or frequency.

[0201] One or more WTRUs may determine the presence of control channel beam by searching for PBCH on the same beam, e.g., at preconfigured locations in the frame structure. WTRUs may detect the presence of a beam type using the beam specific reference signals. Beam specific reference signals may be defined as a function of cell ID. One or more WTRUs may determine the cell ID from the discovery signal and/or the number of beams in the cell via

PBCH. WTRUs may determine the cell ID from the set of beam reference signals associated to the cell. The beam reference signals may be associated to the cell by a predefined function of cell ID and/or number of beams. Beam specific reference signals may identify beam types and/or beams. WTRUs may monitor the control channel beams associated with (e.g., belonging to) beams narrower than the current serving and/or detected PBCH beam type.

[0202] Common control channel beam may have a search space. Control region in a (e.g., one or more, or each) serving cell and/or mB may comprise one or more control symbols carrying one or more control channel beams. Control region of a (e.g., one or more, or each) control channel beam may comprise one or more symbols, where the number of symbols may be either fixed and/or variable. Control region of a (e.g., one or more, or each) control channel beam may comprise one or more symbols, where the symbols and/or symbol group (e.g., exact symbols and/or symbol group) may depend on the mapping function. Common search space may be a function of one or more of the following: number of common control channel beams transmitted by the mB, number of common control channels selected by the WTRU, beam specific control region size/duration, overall control region duration, bandwidth of the cell, and/or aggregation level, and/or the like. Within the symbols used for common control channel beam, frequency domain mapping may be explicitly provided for control channel, e.g., PDCCH candidates mapped to n number of carriers around the center frequency, even/odd RBs, hashing function, and/or any other pattern. The common search space with beamformed control channels may be defined as a set of PDCCH candidates on one or more common control channel beams, e.g., determined by control channel beam selection function. On a control channel beam, one or more WTRUs may monitor the corresponding beam specific control region for a set of PDCCH candidates defined by one or more aggregation levels.

[0203] FIG. 21 is an example of common control channel beam and/or associated search space. WTRUs may perform monitoring. WTRUs may monitor their common search space in idle mode. WTRUs may perform the monitoring on a set of pre-defined subframes, e.g., where the mapping between the common control channel beams may be known and/or configured in terms of control channel beam IDs and/or symbol mapping. WTRUs may search certain subframes (e.g., all subframes and/or preconfigured subframe(s)) for presence of common control channel beams at symbol locations within the control region. WTRUs may search the subframes by correlating a known reference signal sequence (e.g., signal sequences which may be cell specific and/or beam specific). Different reference signal sequences may be defined for common control channel beams and/or WTRU specific control channel beams. A (e.g., one or more, or each) beam may have its own reference signal sequence, perhaps within the common

control channel beams. Within the common control channel beams, one or more beams (e.g., all beams) may use the cell specific sequence. The WTRU may monitor the common search space within the beam specific control region, e.g., when the received reference signal power may be above a threshold. The reference signal sequence may be cell specific. Some or all of the common control channel beams in the cell may carry the same information. A WTRU may accumulate the energy received from some or all the common control channels to increase the SNR.

[0204] WTRUs may perform monitoring in connected mode. WTRU may perform monitoring in connected mode by assigning control channel beams. WTRUS may monitor one or more control channel beams to receive control information in connected mode. The control channel beams may be WTRU specific control channel beams and/or cell specific common control channel beams. The set of control channel beams that the WTRU may monitor may be referred to as serving control channel beams. One or more WTRUs may be assigned one or more serving control channel beam(s). WTRUs may consider some or all the control channel beams from the mB as serving control channels. WTRUs may consider the control channel beams selected during idle mode operation, e.g., as WTRU specific control channel beams for connected mode operation. WTRUs may receive the serving control channel beam(s) configuration using dedicated signaling (e.g. L1 and/or MAC and/or RRC message). One or more WTRUs may monitor one or more serving control channels in the connected mode for one or more of the following: UL and/or DL grants, Beam switch commands, handover commands, higher layer messages, and/or small payloads, and/or any other control information. One or more WTRUs may distinguish common control channel beams from the WTRU specific control channel beams by the presence of pre-defined beam reference signals.

[0205] WTRUs may monitor cell specific common control channel beams to receive common channels (e.g., Paging and/or SIB) while in connected mode. WTRUs may select common control channel beams autonomously. WTRUs may select common control channel beams based on dedicated signaling (e.g. L1 and/or MAC and/or RRC message) received in the serving control channel. WTRUs may monitor serving control channel beam for common channels (e.g. Paging and/or SIB). One or more WTRUs may select common control channel beam(s) that are implicitly and/or explicitly linked to current serving control channel beam(s).

[0206] WTRUs may have beam specific search space. Control region in a serving cell and/or mB may comprise one or more control symbols. Control symbols may carry one or more control channel beams. Control region of a (e.g., one or more, or each) control channel beam

may comprise one or more symbols. For example, the number of symbols may be either fixed and/or variable. The exact symbols and/or symbol group may depend on the mapping function.

[0207] WTRU specific search space may be a function of one or more of the following: the number of control channel beams transmitted by the mB, number of control channels selected by and/or assigned to the WTRUs, beam specific control region size/duration, overall control region duration, bandwidth of the cell, aggregation levels, WTRU ID, subframe number, and/or subframe, and/or the like. WTRU specific search space may be defined as the union of beam specific search space of certain serving control channel beams selected by /assigned to the WTRU. Beam specific search space may be defined as a set of PDCCH candidates in beam specific control region. Beam specific control region may be defined as one or more control symbols and/or symbol groups used to transmit and/or mapped to the corresponding beam. Number of symbols per control channel beam may be static, semi-static and/or dynamic. On a (e.g., one or more, or each) serving control channel beam, a WTRU may monitor the corresponding beam specific control region for set of PDCCH candidates defined by one or more aggregation levels. Within the symbols used for control channel beam, frequency domain mapping and/or restriction may be explicitly and/or implicitly defined for PDCCH candidates (e.g. mapped to n number of carriers around the center frequency and/or even/odd RBs and/or a hashing function and/or any other pattern). WTRUs may be configured with different set of aggregation levels for different control channel beams. WTRU specific search space within a beam may be a function of beam ID, WTRU ID, symbol number, subframe number etc.

[0208] FIG. 22 is an example for WTRU beam specific search space. WTRUs may perform monitoring. WTRUs may monitor their WTRU specific search space in connected mode. WTRUs may monitor common search space in connected mode. WTRUs may perform conditional monitoring, e.g., based on the presence of one or more serving control channel beams. One or more WTRUs may search certain subframes and/or one or more preconfigured subframes for the presence of WTRU specific control channel beam, by correlating one or more of the following: pre-configured beam specific reference signal sequence, cell specific reference signal sequence, and/or beam type specific reference signal sequence in the control region, and/or the like. One or more WTRUs may be configured with mapping between control channel beam and control symbol location. WTRUs may search for (e.g., only for) the configured control channel beams in a (e.g., one or more, or each) symbol location. The WTRUs may monitor PDCCH candidates within the detected beam specific search space, e.g., when the received reference signal power is above a threshold.

[0209] WTRUs may monitor beam specific search space in some or all the subframes and/or in the configured subframes where one or more serving control channel beams may be transmitted. WTRUS may monitor common search space in all or some of the subframes or in the configured subframes where one or more common control channel beams may be transmitted. For example, the control region in pre-configured subframes may comprise one more (e.g. two) parts, one for common control channel beams and/or the other for WTRU specific control channel beams, for example. One or more WTRUs may monitor common search space in the common control region and/or WTRU specific and/or beam specific search space in the dedicated control region.

[0210] WTRUs may perform monitoring using one or more techniques as described herein. WTRUs may determine WTRU specific control channel beam and/or common control channel beam by doing one or more of the following. WTRU specific control channel beam may be configured by the mB. WTRU specific control channel beam may be selected during the cell selection. WTRU specific control channel beam may be selected autonomously by the WTRU and/or indicated to the mB during the random access procedure. Common control channel beam may be selected by the WTRUs autonomously (e.g. linkage to PBCH/Sync beams). Common control channel beam may be selected by the WTRUs implicitly linked to current serving control channel beams (e.g., many to one mapping between WTRU specific beams and common control channel beams). An mB may override the common control channel beam for a WTRU in connected mode.

[0211] WTRUs may determine subframes to monitor, based on beam mapping function through one or more of the following. WTRUs may be preconfigured (in MIB/SIB-x and/or dedicated signaling) with the beam to subframe mapping. WTRUS may monitor those (e.g., only those) subframes, e.g, where one or more serving control channel beam and/or common control channel beams may be transmitted. WTRUs upon wake up from DRX mode may monitor those (e.g., only those) subframes, e.g., where the fixed mapping to the serving control beams may be pre-configured. WTRUs may assume and/or be configured a flexible mapping, e.g., any to any mapping between beams and subframes, with a (e.g., one or more, or each) subframe containing multiple control channel beams. One or more WTRUs may monitor certain (e.g. one or more, or all) the DL subframes for the serving control channel beams and/or common control channel beams. Upon wake up from DRX mode and/or receiving a valid allocation, WTRUs may continue monitoring certain (e.g., one or more, or all) subframes for the serving control channel beams. WTRUs may monitor specific subframes for common control channel beam and/or certain (e.g., one or more, or all) subframes for WTRU specific control channel beams.

[0212] WTRUs may determine overall control region in a subframe. WTRUs may determine the overall control region size/duration in a subframe from MIB/SIB-x. WTRUs may determine the overall control region size/duration in a subframe from a fixed parameter. WTRUs may determine the overall control region size/duration in a subframe dynamically signaled via a cell PCFICH.

[0213] WTRUs may determine beam specific search space by one or more of the following. Within the overall control region, WTRUs may assume one or more beam specific control region. For a (e.g., one or more, or each) monitored control channel beam, WTRUs may determine (e.g., first determine) the presence of those control beams and/or starting symbol for the control channel beams by explicit signaling in cell PCIFCH. For monitored control channel beams, WTRUs may determine the presence of those control beams and/or starting symbol for the control channel beams by detecting beam specific BRS above a threshold. For monitored control channel beams, WTRUs may perform blind decoding, e.g., when a cell specific BRS is used. WTRUs may assume no DCI received in that subframe, e.g, when BRS for certain (e.g., one or more, or all) serving control channel beams are below the threshold. WTRUs may identify the beams based on beam specific preambles added to a (e.g., one or more, or each) control symbol carrying the beam. The preambles may be a function of one or more of the following: beam ID, cell ID, and/or WTRU ID, and/or the like.

[0214] One or more WTRUs may utilize the measurements based on BRS to determine the characteristics/property of the control channel beam, e.g., the presence of a specific control channel type and/or beam, length of the control channel beam etc. For certain (e.g., one or more, or all) detected control channel beams, WTRUs may determine the beam specific control region size/duration and/or last symbol in the beam specific control region from MIB/SIB-x. For certain (e.g., one or more, or all) detected control channel beams, WTRUs may determine the beam specific control region size/duration and/or last symbol in the beam specific control region from a fixed parameter. For certain (e.g., one or more, or all) detected control channel beams, WTRUs may determine the beam specific control region size/duration and/or last symbol in the beam specific control region may be dynamically signaled via beam PCFICH. One or more WTRUs may be (e.g., explicitly) provided with a fixed mapping between the control channel beam and the symbol location of the beam specific control region. One or more WTRUs may be (e.g., explicitly) provided with a fixed mapping between the control channel beam and the size/duration of the beam specific control region. An overall control region may be split into common control region and/or a dedicated control region.

[0215] Within a (e.g., one or more, or each) detected beam specific control region, one or more WTRUs may do one or more of the following. A WTRU may apply the frequency and/or time domain restriction (e.g. central n carriers and/or specific RBs and/or any other pattern and/or remove non-PDCCH channels (e.g. PHICH, beam PCIFICH, sync/PBCH if present). Within the beam specific search space, some (e.g., additional), WTRU specific search space may be configured. For example, starting CCEs may be different for different WTRUs (e.g. based on WTRU ID, beam type, beam ID, subframe number, symbol number etc.). WTRUs may group the REGs within a (e.g., one or more, or each) beam specific control region into one set of CCEs. Within a (e.g., one or more, or each) set of CCEs, WTRUs may monitor one or more PDCCH candidates based on aggregation levels configured for a (e.g., one or more, or each) beam type and/or beam. DCI CRC may be scrambled with beam ID in addition to the WTRU ID (e.g. CRNTI) and/or common ID (e.g. SI_RNTI and/or Paging RNTI). When WTRU specific control channel beams, WTRU specific search space may be simplified (e.g., further simplified) by pre-configuring fixed starting CCEs, explicit indication of aggregation level used etc.

[0216] DL data may perform scheduling. WTRUs may, upon detection of PDCCH in some (e.g., at least one) of the serving control channel beams, indicate DL grant for data and/or some (e.g., any) other higher layer information intended for the WTRUs. WTRUs may attempt to decode the corresponding data channel beam in the resources indicated by the DCI. WTRUs may assume that the serving control channel beam may be used for data transmission, e.g., when no data beam specific identity is included in the DCI message. WTRUs may assume the last indicated data channel beam, e.g, if no data beam specific identity is included in the DCI message. WTRUs may assume the data channel indicated by the higher layer configuration, e.g., if no data beam specific identity is included in the DCI message. The scrambling initialization of the PDSCH may be a function of one or more of the following: control channel beam ID that carries the allocation, beam ID of the DL data channel beam, WTRU specific RNTI (e.g. C-RNTI and/or SPS-RNTI), a fixed RNTI (e.g. SI-RNTI and/or Paging RNTI), and/or beam type, and/or the like.

[0217] Sub-subframe scheduling may perform resource allocation by allowing multiple allocation in a subframe. Beamforming may be used (e.g., required) to compensate additional path loss at higher frequencies. Given the large bandwidths at higher frequencies and/or analog beamforming, one or more WTRUs may be multiplexed with different beams within a subframe and/or scheduling interval. One or more control channels may be transmitted with wide beams. A (e.g., one or more, or each) control channel beam may schedule one or more narrow data beams for one or more WTRUs within the same subframe.

[0218] Minimum schedulable time resource within a subframe may be symbol and/or group of symbols. Scheduling granularity may be less than a subframe and/or a scheduling interval. For example, a new (e.g., fresh and/or heretofore unused) DCI format may be defined to carry allocation information at symbol level/symbol group, to indicate a start offset (e.g., a symbol offset), repetition information (e.g. more than one data channel per WTRU per subframe), and/or spatial information (e.g. transmit beam ID), and/or the like.

[0219] Within a subframe, the data region may comprise multiple data channel beams multiplexed in time. For example, a data channel may occupy several symbols and/or the remaining symbols within the same subframe may be used by other data channel beams addressed to the same and/or different WTRUs. WTRUs may be allocated multiple data channel resources within the same subframe. A (e.g., one or more, or each) set of data channel resources may be associated with a different data beam.

[0220] Downlink data beam that an mB may use for the WTRU may be identified. WTRUs may use a receive beam pattern for downlink data channel reception. WTRUs may use different receive beam pattern for downlink control channel beam reception compared to the receiving beam pattern used for downlink data channel beam reception. An mB may comprise the transmit beam ID corresponding to the data channel beam to enable WTRU to switch receive beam accordingly. One or more WTRUs may use (e.g., require) gap and/or decoding period between the PDCCH carrying the grant and/or the actual data channel resource. Transmit beam ID may be implicitly determined by the WTRU, e.g., when WTRU specific control channel beam is used, as the data beam may be same as the WTRU specific control channel beam.

[0221] The data channel beam information may be coupled with resource allocation information. For example the DCI may include transmit beam identification in PDCCH that carries resource allocation in terms of time (e.g. symbol, symbol group) and/or frequency (e.g. RBs). An mB may explicitly provide a gap and/or guard period between the last symbol of PDCCH and the first symbol of PDSCH within the same subframe. The guard period may be defined from WTRU point of view. mB may use the symbols in the guard period to schedule other WTRUs. WTRUs may assume (e.g., always assume) an offset between PDCCH and PDSCH. For example PDCCH in subframe n may allocate PDSCH in subframe n+k. The value of k may be dynamic and/or may be configured by higher layer signaling (MAC and/or RRC) and/or may be included in DCI message and/or may be a pre-defined constant. WTRUs may assume k=0 for buffering the data in the current subframe. Depending on the value of k in the DCI, WTRUs may determine the PDSCH location in the current subframe (if k=0 and/or not included in DCI) and/or in subframe n+k (if k is included in the DCI).

[0222] At least one search space may include downlink control information (DCI). At least one data channel may be monitored, perhaps for example based at least in part on the DCI. At least one beam for receipt of the at least one data channel may be identified, perhaps for example based at least in part on the DCI.

[0223] The data channel beam information and/or spatial information may be separate from resource allocation (e.g. time, frequency, code) information. The spatial information (e.g., data channel transmit beam identification) may be derived from beam specific reference signal for the corresponding DL beam. The spatial information may be derived from beam specific reference signal for the corresponding antenna port. The spatial information may be derived from beam specific reference signal for the corresponding steering vector and/or codebook index. The spatial information may be signaled using RRC configuration/MAC CE/DCI, decoupled from the time and/or frequency resource allocation information. The spatial information may be acknowledged by the WRTU to prevent mismatch between an mB and the WRTU, before actual data transmission on the indicated data channel beam. The spatial information and/or resource allocation information (e.g. time and/or frequency) may have a pre-defined and/or configured offset to the allocated resources. The spatial information may be associated with a validity period and/or upon expiry of the validity period. WRTUs may perform (e.g., be required to perform) one or more of beam measurement and/or beam tracking and/or beam reporting (e.g. CSI).

[0224] The common channels may be scheduled using separate spatial information. The WTRU specific channels may be scheduled using the coupled spatial information. The common channels may be scheduled using coupled spatial information. The WTRU specific channels may be scheduled using the separate spatial information. Different WTRUs in the same cell may receive the scheduling information using different configuration (e.g. coupled and/or separate).

[0225] DCI may have format and/or contents. Downlink control information for a DL data channel grant may be include one or more of the following: spatial information, time, and/or frequency resource information, and/or the like. Spacial information may comprise one or more of the following: implicit data channel beam identity (e.g. associated Data channel RS sequence number, associated control channel RS sequence number and/or an index in the WTRU measurement report) and/or an explicit data channel ID which may map to a specific data channel beam, UL control channel beam configuration associated with a DL transmission, and/or set of control symbols to monitor for serving control channel beam(s), and/or the like. Time and/or frequency resource information may comprise one or more of the following: the resource allocation information corresponding to downlink data channel beam indicated in the spatial

information, Starting symbol location for PDSCH within the subframe, Duration (in terms of number of symbols), Frequency/Resource Block information, an index to a pre-configured symbol groups/resource groups in time and/or frequency, and/or the like.

[0226] Spatial information may be signaled using L23 signaling (e.g. RRC and/or MAC CE) and/or L1 signaling (e.g. in a DCI). WTRUs may consider the spatial information to be valid after transmitting an ACK corresponding to the DL PDSCH carrying the spatial information. WTRUs may assume that the spatial information valid until they receive RRC/MAC CE/DCI with a different spatial information. Time and/or frequency resource information may be signaled using L1 signaling (e.g. in a DCI). The scheduling information in the time and/or frequency resource information may be valid for (e.g., only for) the subframe where the resource information is received. Different DCI formats may be defined. For example, two different DCI formats may be defined, one with the time and/or frequency resource information and/or the other with time and/or frequency resource information and/or spatial information. A DCI format may contain the time and/or frequency resource information and/or the other(s) DCI format may contain the spatial information.

[0227] Beams may be combined for DL. Plurality of spatial information may be signaled to the WTRU using L23 signaling (e.g. RRC and/or MAC CE) and/or L1 signaling (e.g. in a DCI) for the downlink data transmission. The DCI and/or the L23 message may carry per spatial information, one or more of the following: symbol location, duration, resource block configuration, WTRU specific reference signal ID and/or beam ID, antenna port number, and/or HARQ information (e.g. redundancy version), and/or the like. Spatial information (e.g., one or more, or each spatial information) may identify the transmission direction and/or data channel beam to the WTRUs. WTRUs may receive a single transport block within a subframe and/or sequence of subframes multiplexed in time domain, using plurality of spatial configuration (e.g. multiple data channel beams). WTRUs may soft-combine the spatial repetitions of the transport block to improve the effective SNR. WTRUs may use same and/or different receive antenna configuration and/or receive beam pattern corresponding to the downlink spatial information signaled for beam combining.

[0228] UL data may be scheduled. WTRU upon detection of PDCCH in some (e.g., at least one) of the serving control channel beams in subframe/subframe n, indicating UL grant intended for the WTRU, may transmit PUSCH in subframe/subframe n+k, using the UL data channel beam indicated in the PDCCH., WTRUs may assume that the current UL control channel beam may be used for UL data transmission, e.g., when no data channel beam identity is included in the DCI message. One or more WTRUs may assume the last indicated UL data

channel beam and/or the data channel indicated by higher layer configuration for UL data transmission, e.g. when no data channel beam identity is included in the DCI message. The scrambling initialization of the PUSCH may be a function of control channel beam ID that carries the allocation and/or beam ID of the UL data channel beam and/or WTRU specific RNTI (e.g. C-RNTI and/or SPS-RNTI) and/or beam type.

[0229] Within a UL subframe, the data region may comprise multiple UL data channel beams from one or more WTRUs multiplexed in time. For example, a data channel may occupy one or more symbols and/or the remaining symbols within the same subframe may be used by other UL data channel beams addressed to the same and/or different WTRUs. WTRUs may be allocated multiple UL data channel resources within the same subframe. A (e.g., one or more, or each) set of UL data channel resources may be associated with a different UL data beam.

[0230] Uplink transmissions from multiple WTRUs within the same subframe and/or scheduling interval, may be multiplexed in time domain and/or frequency domain. Scheduling granularity may be less than subframe and/or scheduling interval. A new DCI format may carry UL allocation information at symbol level/symbol group, start offset, repetition information (e.g. more than one UL data channel per WTRU per subframe), spatial information (e.g. UL transmit beam ID).

[0231] One or more WTRUs may identify and/or signal the uplink data beam. One or more WTRUs may use a specific beam pattern for UL data channel transmission. One or more WTRUs may use different transmit beam pattern for uplink control channel compared to the transmit beam pattern used for uplink data channel beam. An mB may include the transmit beam ID corresponding to the UL data channel beam to enable WTRUs to switch transmit beam accordingly. One or more WTRUs may use (e.g., require) gap and/or decoding period between the PDCCH carrying the UL grant and/or the actual UL data channel resource.

[0232] The UL data channel beam information may be coupled with resource allocation information. For example the DCI may include transmit beam identification in PDCCH that carries resource allocation in terms of time (e.g. symbol and/or symbol group) and/or frequency (e.g. RBs). An mB may (e.g., explicitly) provide a gap and/or guard period between the last symbol of PDCCH and the first symbol of PUSCH. The guard period may be defined from WTRU point of view. An mB may use the symbols in the guard period to schedule other WTRUs. WTRUs may assume (e.g. always assume) an offset between PDCCH and PUSCH. For example PDCCH in subframe n may allocats PUSCH in subframe n+k. The value of k may be dynamic and/or may either be configured by higher layer signaling (MAC and/or RRC) and/or may be included in DCI message.

[0233] The UL data channel beam information and/or spatial information may be separate from resource allocation (e.g., time, frequency, code) information. The spatial information, e.g. UL data channel transmit beam identification, may be derived from SRS (e.g. SRS sequence ID and/or SRS configuration ID etc.), decoupled from the time and/or frequency resource allocation information. The spatial information may be derived random access procedure (preamble ID and/or subframe), decoupled from the time and/or frequency resource allocation information. The spatial information may be signaled using RRC configuration/MAC CE/DCI, decoupled from the time and/or frequency resource allocation information. The spatial information may be acknowledged by the WTRU to prevent mismatch between mB and the WTRU, e.g., before actual data transmission on the indicated data channel beam. The spatial information and resource allocation information (e.g. time and/or frequency) may have a pre-defined and/or configured offset to the allocated resources. The spatial information may be associated with a validity period. For example, upon expiry of the validity period, a WTRU may (e.g., be required to) perform one or more of sounding procedure and/or RACH etc.

[0234] The UL control channel beam may be scheduled using separate spatial information. The UL data channel beam may be scheduled using the coupled spatial information. One or more WTRUs in the same cell may receive the scheduling information using different configuration (e.g., coupled and/or separate).

[0235] DCI may have formats and/or contents. Downlink control information for a UL data channel grant may include one or more of the following: spatial information, time resource information, and/or frequency resource information, and/or the like. Spatial information may comprise one or more of the following: implicit data channel beam identity, and/or DL PHICH beam configuration, and/or the like. Implicit data channel beam identity may comprise one or more of the following: SRS sequence ID and/or SRS configuration ID etc., preamble ID, subframe and/or an explicit data channel ID which may map to a specific data channel beam, and/or explicit ID negotiated with the WTRU, and/or the like. Time and/or frequency resource information may comprise one or more of the following: information that may indicate the resource allocation information corresponding to downlink data channel beam indicated in the most recent spatial information, starting symbol location for PUSCH within the subframe, duration (e.g., in terms of number of symbols), frequency/resource block information, and/or an index to a pre-configured symbol groups/resource groups in time and/or frequency, and/or the like.

[0236] Spatial information may be signaled using Layer 2 and/or 3 (L23) signaling (e.g. RRC and/or MAC CE) and/or L1 signaling (e.g. in a DCI). A WTRU may consider the

scheduling information received in the spatial information to be valid after transmitting an ACK corresponding to the DL PDSCH carrying the spatial information. The WTRU may assume that the spatial information valid perhaps until it receives RRC/MAC CE/DCI with a different spatial information, for example. Time and/or frequency resource information may be signaled using L1 signaling (e.g. in a DCI). The scheduling information in the time and/or frequency resource information may be valid for the subframe (e.g., only for the subframe) where the resource information is received.

[0237] Different DCI formats may be defined. One or more (e.g. two) different DCI formats may be defined, perhaps one with the time and/or frequency resource information and/or another other with time and/or frequency resource information and/or spatial information. A DCI format may contain the time and/or frequency resource information and/or the other DCI format may contain the spatial information.

[0238] One or more beams may be combined for UL. A plurality of spatial information may be signaled to the WTRU using L23 signaling (e.g. RRC and/or MAC CE) and/or L1 signaling (e.g. in a DCI) for the uplink data transmission. The DCI and/or the L23 message may carry per spatial information, one or more of the following: symbol location, duration, resource block configuration, WTRU specific reference signal ID and/or beam ID and/or SRS configuration ID, antenna port number, and/or HARQ information (e.g. redundancy version) and/or the like.

[0239] A (e.g., one or more, or each) spatial information may identify (e.g., uniquely identify) the transmission direction and/or data channel beam from the WTRU. A WTRU may transmit a single transport block within a subframe and/or sequence of subframes multiplexed in time domain, perhaps for example using a plurality of spatial configuration (e.g. multiple data channel beams). An mB may soft-combine the spatial repetitions of the transport block, e.g., to improve the effective SNR. An mB may use a same receiving antenna configuration and/or receiving beam pattern corresponding to the uplink spatial information signaled for beam combining. An mB may use different receiving antenna configuration and/or receiving beam pattern corresponding to the uplink spatial information signaled for beam combining.

[0240] UL control channel information may be part of UL data scheduling. DCI may carry UL control channel information and/or the DL grant for data channels. The UL control channel information may include the resources used for feedback (e.g. ACK/NACK and/or CSI etc.). An mB may dynamically signal the WTRU UL control beam for feedback using the DCI carrying the corresponding DL resource allocation. One or more WTRUs may associate the UL control channel resources allocated in a DCI to the DL data channel allocation present in the

same DCI. The UL control channel information may include time (e.g. subframe offset or symbol offset from the current subframe) and/or frequency resources (e.g. Resource blocks). The UL control channel information may include the spatial information for the UL control channel. For example, the UL control beam for the WTRU may be identified by SRS configuration ID and/or SRS sequence and/or RACH identifier (RA-RNTI and/or preamble sequence number) used by the WTRU for the periodic/aperiodic transmission of the corresponding UL control channel beam.

[0241] A mB may pre-configure the mapping between DL control beam carrying the DL data allocation and the WTRU UL control beam carrying the feedback. The configuration may be WTRU specific. A mB may pre-configure the mapping between DL transmit control beam carrying the DL data allocation and the mB UL Rx control beam resources to receive the feedback. The configuration may provide WTRU specific resources within the mB UL Rx beam (e.g. frequency/time/code). A mB may schedule the uplink control beam semi-statically using higher layer signaling. A mB may schedule different uplink control beam for different feedback types (e.g. ACK/NACK vs CSI). In some or all the schemes discussed herein, a mB may configure more than one UL WTRU control beam for feedback (e.g. repetition and/or implicit HARQ retransmission).

[0242] FIG. 24A is a diagram of an example communications system 100 in which one or more disclosed embodiments may be implemented. The communications system 100 may be a multiple access system that provides content, such as voice, data, video, messaging, broadcast, *etc.*, to multiple wireless users. The communications system 100 may enable multiple wireless users to access such content through the sharing of system resources, including wireless bandwidth. For example, the communications systems 100 may employ one or more channel access methods, such as code division multiple access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), orthogonal FDMA (OFDMA), single-carrier FDMA (SC-FDMA), and the like.

[0243] As shown in FIG. 24A, the communications system 100 may include wireless transmit/receive units (WTRUs) 102a, 102b, 102c, and/or 102d (which generally or collectively may be referred to as WTRU 102), a radio access network (RAN) 103/104/105, a core network 106/107/109, a public switched telephone network (PSTN) 108, the Internet 110, and other networks 112, though it will be appreciated that the disclosed embodiments contemplate any number of WTRUs, base stations, networks, and/or network elements. Each of the WTRUs 102a, 102b, 102c, 102d may be any type of device configured to operate and/or communicate in a wireless environment. By way of example, the WTRUs 102a, 102b, 102c, 102d may be

configured to transmit and/or receive wireless signals and may include user equipment (UE), a mobile station, a fixed or mobile subscriber unit, a pager, a cellular telephone, a personal digital assistant (PDA), a smartphone, a laptop, a netbook, a personal computer, a wireless sensor, consumer electronics, and the like.

[0244] The communications systems 100 may also include a base station 114a and a base station 114b. Each of the base stations 114a, 114b may be any type of device configured to wirelessly interface with at least one of the WTRUs 102a, 102b, 102c, 102d to facilitate access to one or more communication networks, such as the core network 106/107/109, the Internet 110, and/or the networks 112. By way of example, the base stations 114a, 114b may be a base transceiver station (BTS), a Node-B, an eNode B, a Home Node B, a Home eNode B, a site controller, an access point (AP), a wireless router, and the like. While the base stations 114a, 114b are each depicted as a single element, it will be appreciated that the base stations 114a, 114b may include any number of interconnected base stations and/or network elements.

[0245] The base station 114a may be part of the RAN 103/104/105, which may also include other base stations and/or network elements (not shown), such as a base station controller (BSC), a radio network controller (RNC), relay nodes, *etc.* The base station 114a and/or the base station 114b may be configured to transmit and/or receive wireless signals within a particular geographic region, which may be referred to as a cell (not shown). The cell may further be divided into cell sectors. For example, the cell associated with the base station 114a may be divided into three sectors. Thus, in one embodiment, the base station 114a may include three transceivers, *e.g.*, one for each sector of the cell. In another embodiment, the base station 114a may employ multiple-input multiple output (MIMO) technology and, therefore, may utilize multiple transceivers for each sector of the cell.

[0246] The base stations 114a, 114b may communicate with one or more of the WTRUs 102a, 102b, 102c, 102d over an air interface 115/116/117, which may be any suitable wireless communication link (*e.g.*, radio frequency (RF), microwave, infrared (IR), ultraviolet (UV), visible light, *etc.*). The air interface 115/116/117 may be established using any suitable radio access technology (RAT).

[0247] More specifically, as noted above, the communications system 100 may be a multiple access system and may employ one or more channel access schemes, such as CDMA, TDMA, FDMA, OFDMA, SC-FDMA, and the like. For example, the base station 114a in the RAN 103/104/105 and the WTRUs 102a, 102b, 102c may implement a radio technology such as Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access (UTRA), which may establish the air interface 115/116/117 using wideband CDMA (WCDMA).

WCDMA may include communication protocols such as High-Speed Packet Access (HSPA) and/or Evolved HSPA (HSPA+). HSPA may include High-Speed Downlink Packet Access (HSDPA) and/or High-Speed Uplink Packet Access (HSUPA).

[0248] In another embodiment, the base station 114a and the WTRUs 102a, 102b, 102c may implement a radio technology such as Evolved UMTS Terrestrial Radio Access (E-UTRA), which may establish the air interface 115/116/117 using Long Term Evolution (LTE) and/or LTE-Advanced (LTE-A).

[0249] In other embodiments, the base station 114a and the WTRUs 102a, 102b, 102c may implement radio technologies such as IEEE 802.16 (*e.g.*, Worldwide Interoperability for Microwave Access (WiMAX)), CDMA2000, CDMA2000 1X, CDMA2000 EV-DO, Interim Standard 2000 (IS-2000), Interim Standard 95 (IS-95), Interim Standard 856 (IS-856), Global System for Mobile communications (GSM), Enhanced Data rates for GSM Evolution (EDGE), GSM EDGE (GERAN), and the like.

[0250] The base station 114b in FIG. 24A may be a wireless router, Home Node B, Home eNode B, or access point, for example, and may utilize any suitable RAT for facilitating wireless connectivity in a localized area, such as a place of business, a home, a vehicle, a campus, and the like. In one embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.11 to establish a wireless local area network (WLAN). In another embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.15 to establish a wireless personal area network (WPAN). In yet another embodiment, the base station 114b and the WTRUs 102c, 102d may utilize a cellular-based RAT (*e.g.*, WCDMA, CDMA2000, GSM, LTE, LTE-A, *etc.*) to establish a picocell or femtocell. As shown in FIG. 24A, the base station 114b may have a direct connection to the Internet 110. Thus, the base station 114b may or might not be used to access the Internet 110 via the core network 106/107/109.

[0251] The RAN 103/104/105 may be in communication with the core network 106/107/109, which may be any type of network configured to provide voice, data, applications, and/or voice over internet protocol (VoIP) services to one or more of the WTRUs 102a, 102b, 102c, 102d. For example, the core network 106/107/109 may provide call control, billing services, mobile location-based services, pre-paid calling, Internet connectivity, video distribution, *etc.*, and/or perform high-level security functions, such as user authentication. Although not shown in FIG. 24A, it will be appreciated that the RAN 103/104/105 and/or the core network 106/107/109 may be in direct or indirect communication with other RANs that employ the same RAT as the RAN 103/104/105 or a different RAT. For example, in addition to

being connected to the RAN 103/104/105, which may be utilizing an E-UTRA radio technology, the core network 106/107/109 may also be in communication with another RAN (not shown) employing a GSM radio technology.

[0252] The core network 106/107/109 may also serve as a gateway for the WTRUs 102a, 102b, 102c, 102d to access the PSTN 108, the Internet 110, and/or other networks 112. The PSTN 108 may include circuit-switched telephone networks that provide plain old telephone service (POTS). The Internet 110 may include a global system of interconnected computer networks and devices that use common communication protocols, such as the transmission control protocol (TCP), user datagram protocol (UDP) and the internet protocol (IP) in the TCP/IP internet protocol suite. The networks 112 may include wired or wireless communications networks owned and/or operated by other service providers. For example, the networks 112 may include another core network connected to one or more RANs, which may employ the same RAT as the RAN 103/104/105 or a different RAT.

[0253] One or more of the WTRUs 102a, 102b, 102c, 102d in the communications system 100 may include multi-mode capabilities, *e.g.*, the WTRUs 102a, 102b, 102c, 102d may include multiple transceivers for communicating with different wireless networks over different wireless links. For example, the WTRU 102c shown in FIG. 24A may be configured to communicate with the base station 114a, which may employ a cellular-based radio technology, and with the base station 114b, which may employ an IEEE 802 radio technology.

[0254] FIG. 24B is a system diagram of an example WTRU 102. As shown in FIG. 24B, the WTRU 102 may include a processor 118, a transceiver 120, a transmit/receive element 122, a speaker/microphone 124, a keypad 126, a display/touchpad 128, non-removable memory 130, removable memory 132, a power source 134, a global positioning system (GPS) chipset 136, and other peripherals 138. It will be appreciated that the WTRU 102 may include any sub-combination of the foregoing elements while remaining consistent with an embodiment. Also, embodiments contemplate that the base stations 114a and 114b, and/or the nodes that base stations 114a and 114b may represent, such as but not limited to transceiver station (BTS), a Node-B, a site controller, an access point (AP), a home node-B, an evolved home node-B (eNodeB), a home evolved node-B (HeNB), a home evolved node-B gateway, and proxy nodes, among others, may include one or more of the elements depicted in FIG. 24B and described herein.

[0255] The processor 118 may be a general purpose processor, a special purpose processor, a conventional processor, a digital signal processor (DSP), a plurality of microprocessors, one or more microprocessors in association with a DSP core, a controller, a

microcontroller, Application Specific Integrated Circuits (ASICs), Field Programmable Gate Array (FPGAs) circuits, any other type of integrated circuit (IC), a state machine, and the like. The processor 118 may perform signal coding, data processing, power control, input/output processing, and/or any other functionality that enables the WTRU 102 to operate in a wireless environment. The processor 118 may be coupled to the transceiver 120, which may be coupled to the transmit/receive element 122. While FIG. 24B depicts the processor 118 and the transceiver 120 as separate components, it will be appreciated that the processor 118 and the transceiver 120 may be integrated together in an electronic package or chip.

[0256] The transmit/receive element 122 may be configured to transmit signals to, or receive signals from, a base station (*e.g.*, the base station 114a) over the air interface 115/116/117. For example, in one embodiment, the transmit/receive element 122 may be an antenna configured to transmit and/or receive RF signals. In another embodiment, the transmit/receive element 122 may be an emitter/detector configured to transmit and/or receive IR, UV, or visible light signals, for example. In yet another embodiment, the transmit/receive element 122 may be configured to transmit and receive both RF and light signals. It will be appreciated that the transmit/receive element 122 may be configured to transmit and/or receive any combination of wireless signals.

[0257] In addition, although the transmit/receive element 122 is depicted in FIG. 24B as a single element, the WTRU 102 may include any number of transmit/receive elements 122. More specifically, the WTRU 102 may employ MIMO technology. Thus, in one embodiment, the WTRU 102 may include two or more transmit/receive elements 122 (*e.g.*, multiple antennas) for transmitting and receiving wireless signals over the air interface 115/116/117.

[0258] The transceiver 120 may be configured to modulate the signals that are to be transmitted by the transmit/receive element 122 and to demodulate the signals that are received by the transmit/receive element 122. As noted above, the WTRU 102 may have multi-mode capabilities. Thus, the transceiver 120 may include multiple transceivers for enabling the WTRU 102 to communicate via multiple RATs, such as UTRA and IEEE 802.11, for example.

[0259] The processor 118 of the WTRU 102 may be coupled to, and may receive user input data from, the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128 (*e.g.*, a liquid crystal display (LCD) display unit or organic light-emitting diode (OLED) display unit). The processor 118 may also output user data to the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128. In addition, the processor 118 may access information from, and store data in, any type of suitable memory, such as the non-removable memory 130 and/or the removable memory 132. The non-removable memory 130 may include random-

access memory (RAM), read-only memory (ROM), a hard disk, or any other type of memory storage device. The removable memory 132 may include a subscriber identity module (SIM) card, a memory stick, a secure digital (SD) memory card, and the like. In other embodiments, the processor 118 may access information from, and store data in, memory that is not physically located on the WTRU 102, such as on a server or a home computer (not shown).

[0260] The processor 118 may receive power from the power source 134, and may be configured to distribute and/or control the power to the other components in the WTRU 102. The power source 134 may be any suitable device for powering the WTRU 102. For example, the power source 134 may include one or more dry cell batteries (*e.g.*, nickel-cadmium (NiCd), nickel-zinc (NiZn), nickel metal hydride (NiMH), lithium-ion (Li-ion), *etc.*), solar cells, fuel cells, and the like.

[0261] The processor 118 may also be coupled to the GPS chipset 136, which may be configured to provide location information (*e.g.*, longitude and latitude) regarding the current location of the WTRU 102. In addition to, or in lieu of, the information from the GPS chipset 136, the WTRU 102 may receive location information over the air interface 115/116/117 from a base station (*e.g.*, base stations 114a, 114b) and/or determine its location based on the timing of the signals being received from two or more nearby base stations. It will be appreciated that the WTRU 102 may acquire location information by way of any suitable location-determination method while remaining consistent with an embodiment.

[0262] The processor 118 may further be coupled to other peripherals 138, which may include one or more software and/or hardware modules that provide additional features, functionality and/or wired or wireless connectivity. For example, the peripherals 138 may include an accelerometer, an e-compass, a satellite transceiver, a digital camera (for photographs or video), a universal serial bus (USB) port, a vibration device, a television transceiver, a hands free headset, a Bluetooth® module, a frequency modulated (FM) radio unit, a digital music player, a media player, a video game player module, an Internet browser, and the like.

[0263] FIG. 24C is a system diagram of the RAN 103 and the core network 106 according to an embodiment. As noted above, the RAN 103 may employ a UTRA radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 115. The RAN 103 may also be in communication with the core network 106. As shown in FIG. 24C, the RAN 103 may include Node-Bs 140a, 140b, 140c, which may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 115. The Node-Bs 140a, 140b, 140c may each be associated with a particular cell (not shown) within the RAN 103. The RAN 103 may also include RNCs 142a, 142b. It will be appreciated that the

RAN 103 may include any number of Node-Bs and RNCs while remaining consistent with an embodiment.

[0264] As shown in FIG. 24C, the Node-Bs 140a, 140b may be in communication with the RNC 142a. Additionally, the Node-B 140c may be in communication with the RNC142b. The Node-Bs 140a, 140b, 140c may communicate with the respective RNCs 142a, 142b via an Iub interface. The RNCs 142a, 142b may be in communication with one another via an Iur interface. Each of the RNCs 142a, 142b may be configured to control the respective Node-Bs 140a, 140b, 140c to which it is connected. In addition, each of the RNCs 142a, 142b may be configured to carry out or support other functionality, such as outer loop power control, load control, admission control, packet scheduling, handover control, macrodiversity, security functions, data encryption, and the like.

[0265] The core network 106 shown in FIG. 24C may include a media gateway (MGW) 144, a mobile switching center (MSC) 146, a serving GPRS support node (SGSN) 148, and/or a gateway GPRS support node (GGSN) 150. While each of the foregoing elements are depicted as part of the core network 106, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

[0266] The RNC 142a in the RAN 103 may be connected to the MSC 146 in the core network 106 via an IuCS interface. The MSC 146 may be connected to the MGW 144. The MSC 146 and the MGW 144 may provide the WTRUs 102a, 102b, 102c with access to circuit-switched networks, such as the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, 102c and land-line communications devices.

[0267] The RNC 142a in the RAN 103 may also be connected to the SGSN 148 in the core network 106 via an IuPS interface. The SGSN 148 may be connected to the GGSN 150. The SGSN 148 and the GGSN 150 may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, such as the Internet 110, to facilitate communications between and the WTRUs 102a, 102b, 102c and IP-enabled devices.

[0268] As noted above, the core network 106 may also be connected to the networks 112, which may include other wired or wireless networks that are owned and/or operated by other service providers.

[0269] FIG. 24D is a system diagram of the RAN 104 and the core network 107 according to an embodiment. As noted above, the RAN 104 may employ an E-UTRA radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 116. The RAN 104 may also be in communication with the core network 107.

[0270] The RAN 104 may include eNode-Bs 160a, 160b, 160c, though it will be appreciated that the RAN 104 may include any number of eNode-Bs while remaining consistent with an embodiment. The eNode-Bs 160a, 160b, 160c may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 116. In one embodiment, the eNode-Bs 160a, 160b, 160c may implement MIMO technology. Thus, the eNode-B 160a, for example, may use multiple antennas to transmit wireless signals to, and receive wireless signals from, the WTRU 102a.

[0271] Each of the eNode-Bs 160a, 160b, 160c may be associated with a particular cell (not shown) and may be configured to handle radio resource management decisions, handover decisions, scheduling of users in the uplink and/or downlink, and the like. As shown in FIG. 24D, the eNode-Bs 160a, 160b, 160c may communicate with one another over an X2 interface.

[0272] The core network 107 shown in FIG. 24D may include a mobility management gateway (MME) 162, a serving gateway 164, and a packet data network (PDN) gateway 166. While each of the foregoing elements are depicted as part of the core network 107, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

[0273] The MME 162 may be connected to each of the eNode-Bs 160a, 160b, 160c in the RAN 104 via an S1 interface and may serve as a control node. For example, the MME 162 may be responsible for authenticating users of the WTRUs 102a, 102b, 102c, bearer activation/deactivation, selecting a particular serving gateway during an initial attach of the WTRUs 102a, 102b, 102c, and the like. The MME 162 may also provide a control plane function for switching between the RAN 104 and other RANs (not shown) that employ other radio technologies, such as GSM or WCDMA.

[0274] The serving gateway 164 may be connected to each of the eNode-Bs 160a, 160b, 160c in the RAN 104 via the S1 interface. The serving gateway 164 may generally route and forward user data packets to/from the WTRUs 102a, 102b, 102c. The serving gateway 164 may also perform other functions, such as anchoring user planes during inter-eNode B handovers, triggering paging when downlink data is available for the WTRUs 102a, 102b, 102c, managing and storing contexts of the WTRUs 102a, 102b, 102c, and the like.

[0275] The serving gateway 164 may also be connected to the PDN gateway 166, which may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, such as the Internet 110, to facilitate communications between the WTRUs 102a, 102b, 102c and IP-enabled devices.

[0276] The core network 107 may facilitate communications with other networks. For example, the core network 107 may provide the WTRUs 102a, 102b, 102c with access to circuit-switched networks, such as the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, 102c and land-line communications devices. For example, the core network 107 may include, or may communicate with, an IP gateway (*e.g.*, an IP multimedia subsystem (IMS) server) that serves as an interface between the core network 107 and the PSTN 108. In addition, the core network 107 may provide the WTRUs 102a, 102b, 102c with access to the networks 112, which may include other wired or wireless networks that are owned and/or operated by other service providers.

[0277] FIG. 24E is a system diagram of the RAN 105 and the core network 109 according to an embodiment. The RAN 105 may be an access service network (ASN) that employs IEEE 802.16 radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 117. As will be further discussed below, the communication links between the different functional entities of the WTRUs 102a, 102b, 102c, the RAN 105, and the core network 109 may be defined as reference points.

[0278] As shown in FIG. 24E, the RAN 105 may include base stations 180a, 180b, 180c, and an ASN gateway 182, though it will be appreciated that the RAN 105 may include any number of base stations and ASN gateways while remaining consistent with an embodiment. The base stations 180a, 180b, 180c may each be associated with a particular cell (not shown) in the RAN 105 and may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 117. In one embodiment, the base stations 180a, 180b, 180c may implement MIMO technology. Thus, the base station 180a, for example, may use multiple antennas to transmit wireless signals to, and receive wireless signals from, the WTRU 102a. The base stations 180a, 180b, 180c may also provide mobility management functions, such as handoff triggering, tunnel establishment, radio resource management, traffic classification, quality of service (QoS) policy enforcement, and the like. The ASN gateway 182 may serve as a traffic aggregation point and may be responsible for paging, caching of subscriber profiles, routing to the core network 109, and the like.

[0279] The air interface 117 between the WTRUs 102a, 102b, 102c and the RAN 105 may be defined as an R1 reference point that implements the IEEE 802.16 specification. In addition, each of the WTRUs 102a, 102b, 102c may establish a logical interface (not shown) with the core network 109. The logical interface between the WTRUs 102a, 102b, 102c and the core network 109 may be defined as an R2 reference point, which may be used for authentication, authorization, IP host configuration management, and/or mobility management.

[0280] The communication link between each of the base stations 180a, 180b, 180c may be defined as an R8 reference point that includes protocols for facilitating WTRU handovers and the transfer of data between base stations. The communication link between the base stations 180a, 180b, 180c and the ASN gateway 182 may be defined as an R6 reference point. The R6 reference point may include protocols for facilitating mobility management based on mobility events associated with each of the WTRUs 102a, 102b, 102c.

[0281] As shown in FIG. 24E, the RAN 105 may be connected to the core network 109. The communication link between the RAN 105 and the core network 109 may defined as an R3 reference point that includes protocols for facilitating data transfer and mobility management capabilities, for example. The core network 109 may include a mobile IP home agent (MIP-HA) 184, an authentication, authorization, accounting (AAA) server 186, and a gateway 188. While each of the foregoing elements are depicted as part of the core network 109, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

[0282] The MIP-HA may be responsible for IP address management, and may enable the WTRUs 102a, 102b, 102c to roam between different ASNs and/or different core networks. The MIP-HA 184 may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, such as the Internet 110, to facilitate communications between the WTRUs 102a, 102b, 102c and IP-enabled devices. The AAA server 186 may be responsible for user authentication and for supporting user services. The gateway 188 may facilitate interworking with other networks. For example, the gateway 188 may provide the WTRUs 102a, 102b, 102c with access to circuit-switched networks, such as the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, 102c and land-line communications devices. In addition, the gateway 188 may provide the WTRUs 102a, 102b, 102c with access to the networks 112, which may include other wired or wireless networks that are owned and/or operated by other service providers.

[0283] Although not shown in FIG. 24E, it will be appreciated that the RAN 105 may be connected to other ASNs and the core network 109 may be connected to other core networks. The communication link between the RAN 105 the other ASNs may be defined as an R4 reference point, which may include protocols for coordinating the mobility of the WTRUs 102a, 102b, 102c between the RAN 105 and the other ASNs. The communication link between the core network 109 and the other core networks may be defined as an R5 reference, which may include protocols for facilitating interworking between home core networks and visited core networks.

[0284] Although features and elements are described above in particular combinations, one of ordinary skill in the art will appreciate that each feature or element can be used alone or in any combination with the other features and elements. In addition, the methods described herein may be implemented in a computer program, software, or firmware incorporated in a computer-readable medium for execution by a computer or processor. Examples of computer-readable media include electronic signals (transmitted over wired or wireless connections) and computer-readable storage media. Examples of computer-readable storage media include, but are not limited to, a read only memory (ROM), a random access memory (RAM), a register, cache memory, semiconductor memory devices, magnetic media such as internal hard disks and removable disks, magneto-optical media, and optical media such as CD-ROM disks, and digital versatile disks (DVDs). A processor in association with software may be used to implement a radio frequency transceiver for use in a WTRU, UE, terminal, base station, RNC, or any host computer.

CLAIMS

What is claimed is:

1. A wireless transmit/receive unit (WTRU) configured for wireless communication, the WTRU comprising:

a memory; and

a processor, the processor configured with at least:

one or more search spaces, the one or more search spaces configured to provide for at least one of: a monitor of one or more Downlink (DL) control channels, or a receipt of the one or more DL control channels, at least one search space of the one or more search spaces corresponding to at least one reference signal of one or more reference signals, the processor configured at least to:

monitor at least a part of a control region for at least one reference signal of the one or more reference signals;

detect the at least one reference signal in the at least part of the control region; and

monitor the at least one search space corresponding to the at least one reference signal for at least one DL control channel upon the detection of the at least one reference signal.

2. The WTRU of claim 1, wherein the processor is further configured to monitor the at least one search space corresponding to the at least one reference signal for at least one data channel upon the detection of the at least one reference signal.

3. The WTRU of claim 2, wherein the at least one search space has a duration.

4. The WTRU of claim 3, wherein the processor is further configured to determine a time location of the at least one data channel based on at least one of: the at least one reference signal, or the duration.

5. The WTRU of claim 1, wherein the at least one search space includes downlink control information (DCI), and the processor is further configured to monitor the at least one DL control channel based at least in part on the DCI.

6. The WTRU of claim 2, wherein the at least one search space includes downlink control information (DCI), and the processor is further configured to monitor the at least one data channel based at least in part on the DCI.

7. The WTRU of claim 6, wherein the processor is further configured to identify at least one beam for receipt of the at least one data channel based at least in part on the DCI.

8. The WTRU of claim 1, wherein the processor is further configured such that the at least part of the control region is one part of a number of parts of the control region.

9. The WTRU of claim 8, wherein the processor is further configured such that the number of parts of the control region is a function of a number of symbols configured for the control region.

10. The WTRU of claim 8, wherein the processor is further configured such that the number of parts of the control region is a function of a number of symbols used for the control region.

11. The WTRU of claim 1, further comprising a transceiver, the transceiver being configured to receive the one or more search spaces from a wireless communication system network node.

12. The WTRU of claim 1, wherein the processor is further configured such that the one or more search spaces are predefined.

13. The WTRU of claim 1, wherein the processor is further configured such that the at least one reference signal of the one or more reference signals is at least one of: a beam reference signal, or an antenna port reference signal.

14. The WTRU of claim 1, wherein the processor is further configured such that the at least one search space of the one or more search spaces is at least one of: a beam search space, or an antenna port search space.

15. The WTRU of claim 1, wherein the processor is further configured such that the at least one reference signal in the at least part of the control region is detected upon a strength of the at least one reference signal crossing a predetermined threshold.

16. The WTRU of claim 1, wherein the processor is further configured such that the at least one DL control channel is communicated via one or more Orthogonal Frequency Division Multiplexing (OFDM) symbols.

17. The WTRU of claim 16, wherein the processor is further configured such that the one or more OFDM symbols on which the at least one DL control channel is communicated is located in the control region.

18. The WTRU of claim of 17, wherein the processor is further configured to obtain a number of the one or more OFDM symbols in the control region via a Physical Control Format Indicator Channel (PCFICH).

19. The WTRU of claim 18, wherein the processor is further configured such that the PCFICH is obtained via a beam of a synchronization channel.

20. The WTRU of claim 18, wherein the processor is further configured such that the PCFICH is obtain via a beam of a Physical Broadcast Channel (PBCH).

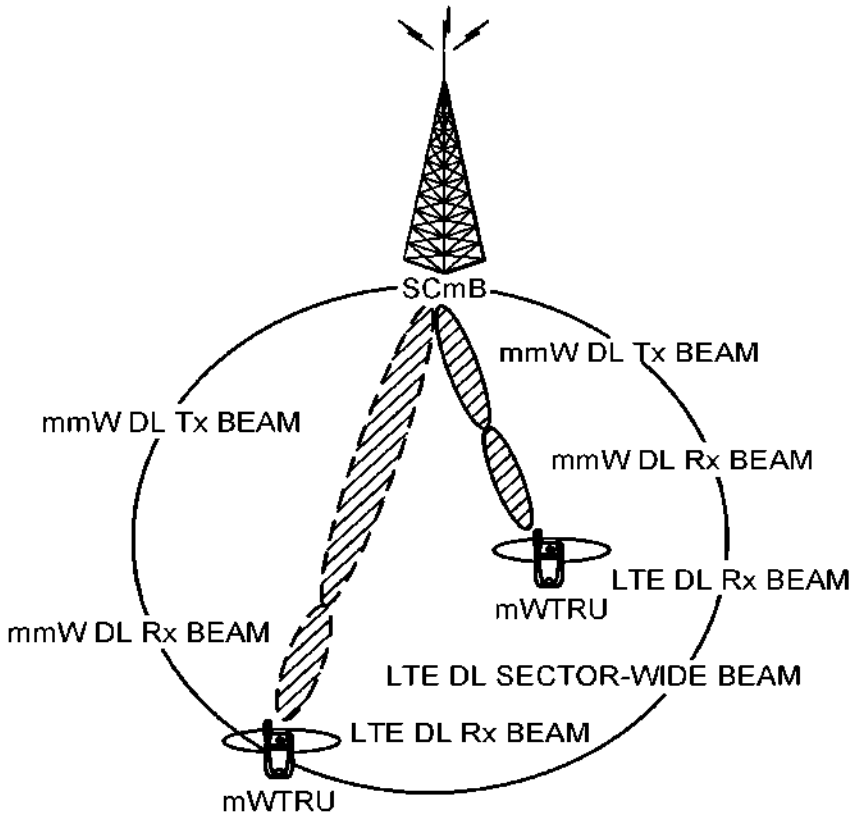

SCmB
mmW DL Tx BEAM
mmW DL Tx BEAM
mmW DL Rx BEAM
LTE DL Rx BEAM
mWTRU
mmW DL Rx BEAM
LTE DL SECTOR-WIDE BEAM
LTE DL Rx BEAM
mWTRU

FIG. 1

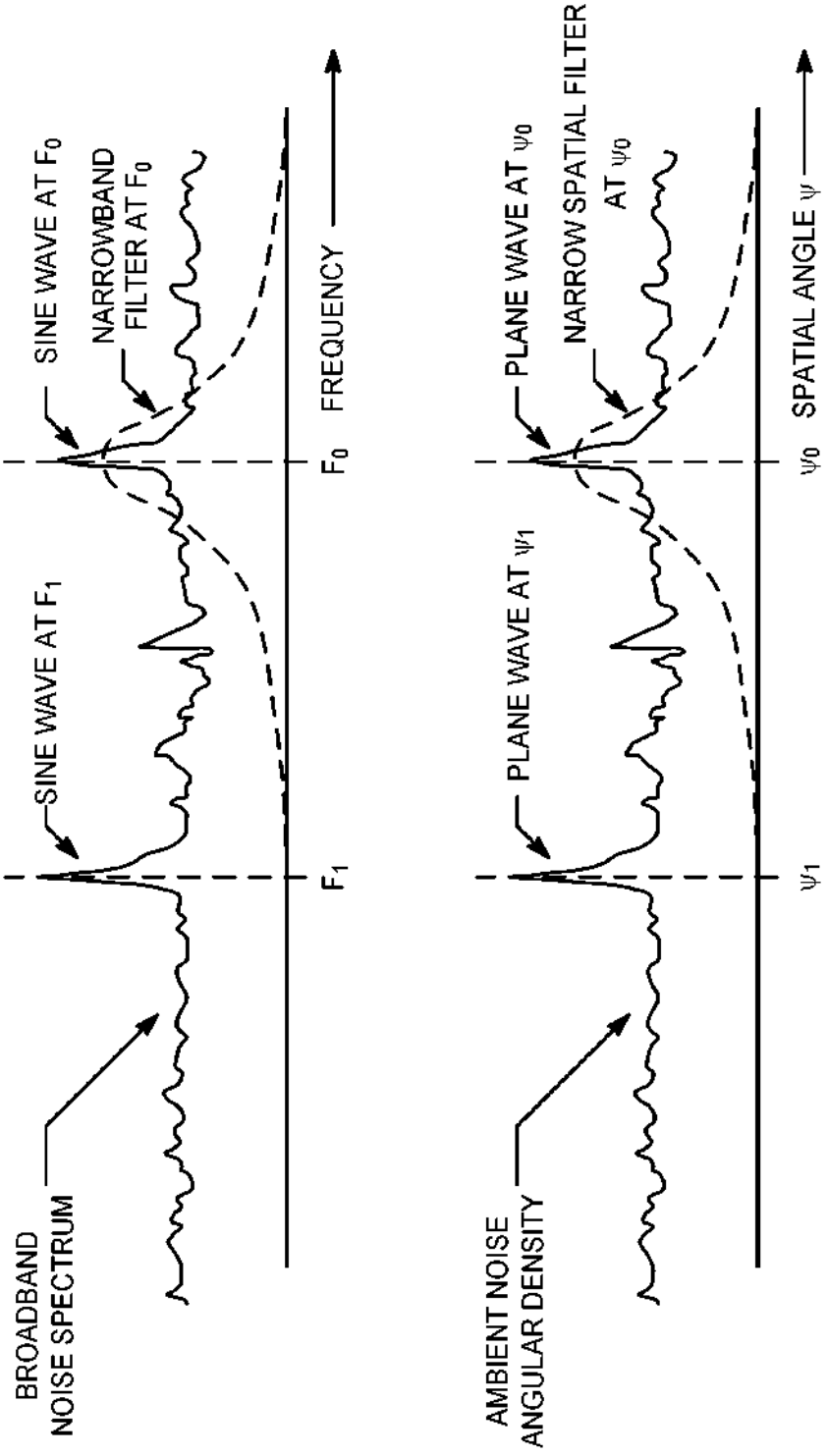

BROADBAND
NOISE SPECTRUM
SINE WAVE AT F_1
SINE WAVE AT F_0
NARROWBAND
FILTER AT F_0
F_1
F_0
FREQUENCY
AMBIENT NOISE
ANGULAR DENSITY
PLANE WAVE AT ψ_1
PLANE WAVE AT ψ_0
NARROW SPATIAL FILTER
AT ψ_0
ψ_1
ψ_0
SPATIAL ANGLE ψ

FIG. 2

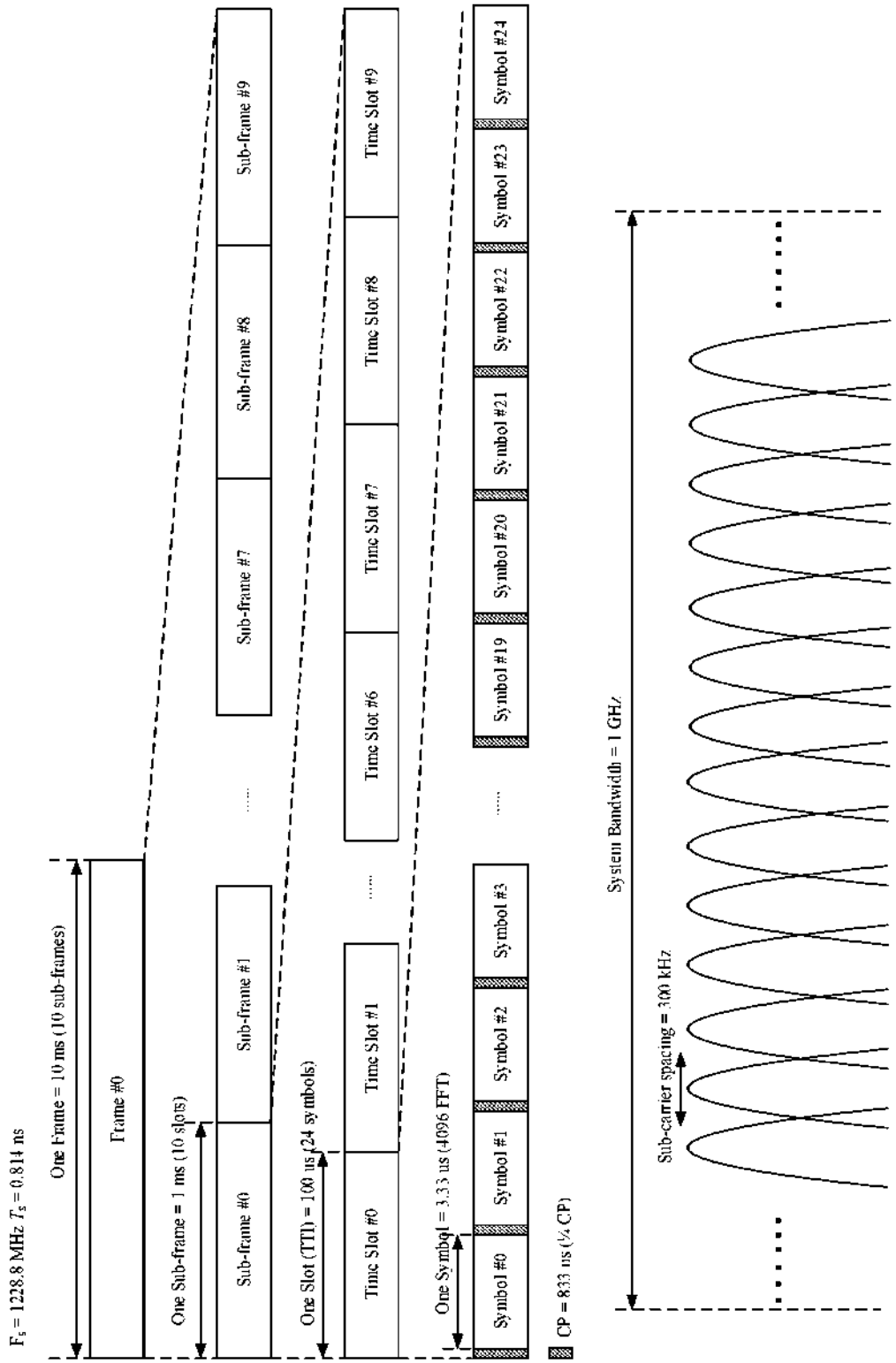

F_s = 1228.8 MHz T_s = 0.814 ns
One Frame = 10 ms (10 sub-frames)
Frame #0
One Sub-frame = 1 ms (10 slots)
Sub-frame #0
Sub-frame #1
Sub-frame #7
Sub-frame #8
Sub-frame #9
One Slot (TTI) = 100 us (24 symbols)
Time Slot #0
Time Slot #1
Time Slot #6
Time Slot #7
Time Slot #8
Time Slot #9
One Symbol = 3.33 us (4096 FFT)
Symbol #0
Symbol #1
Symbol #2
Symbol #3
Symbol #19
Symbol #20
Symbol #21
Symbol #22
Symbol #23
Symbol #24
CP = 833 ns (¼ CP)
System Bandwidth = 1 GHz
Sub-carrier spacing = 300 kHz

FIG. 3

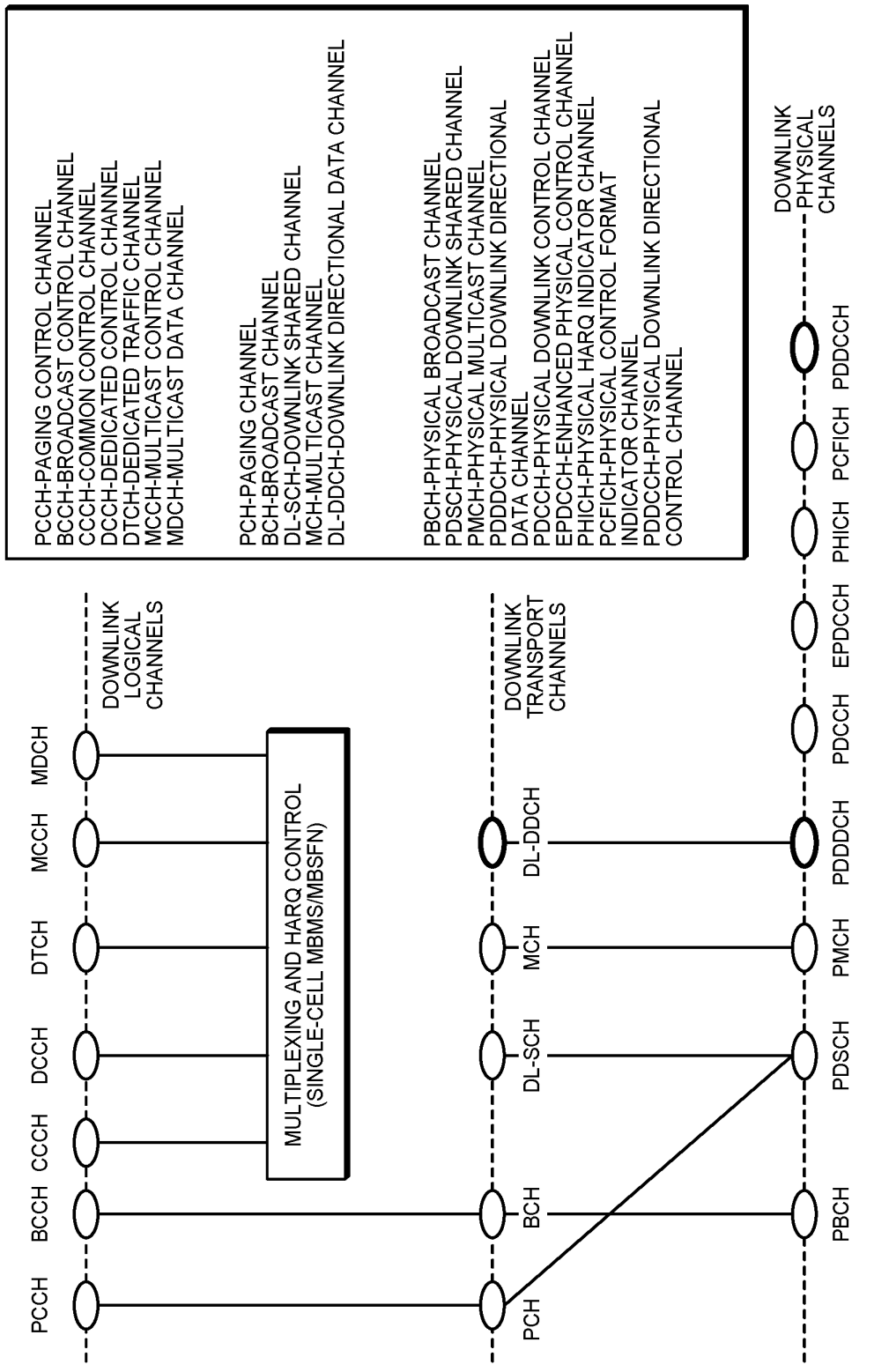

PCCH-PAGING CONTROL CHANNEL
BCCH-BROADCAST CONTROL CHANNEL
CCCH-COMMON CONTROL CHANNEL
DCCH-DEDICATED CONTROL CHANNEL
DTCH-DEDICATED TRAFFIC CHANNEL
MCCH-MULTICAST CONTROL CHANNEL
MDCH-MULTICAST DATA CHANNEL
PCH-PAGING CHANNEL
BCH-BROADCAST CHANNEL
DL-SCH-DOWNLINK SHARED CHANNEL
MCH-MULTICAST CHANNEL
DL-DDCH-DOWNLINK DIRECTIONAL DATA CHANNEL
PBCH-PHYSICAL BROADCAST CHANNEL
PDSCH-PHYSICAL DOWNLINK SHARED CHANNEL
PMCH-PHYSICAL MULTICAST CHANNEL
PDDDCH-PHYSICAL DOWNLINK DIRECTIONAL DATA CHANNEL
PDCCH-PHYSICAL DOWNLINK CONTROL CHANNEL
EPDCCH-ENHANCED PHYSICAL CONTROL CHANNEL
PHICH-PHYSICAL HARQ INDICATOR CHANNEL
PCFICH-PHYSICAL CONTROL FORMAT INDICATOR CHANNEL
PDDCCH-PHYSICAL DOWNLINK DIRECTIONAL CONTROL CHANNEL
DOWNLINK LOGICAL CHANNELS
DOWNLINK TRANSPORT CHANNELS
DOWNLINK PHYSICAL CHANNELS
MULTIPLEXING AND HARQ CONTROL (SINGLE-CELL MBMS/MBSFN)
PCCH
BCCH
CCCH
DCCH
DTCH
MCCH
MDCH
PCH
BCH
DL-SCH
MCH
DL-DDCH
PBCH
PDSCH
PMCH
PDDDCH
PDCCH
EPDCCH
PHICH
PCFICH
PDDCCH

FIG. 4

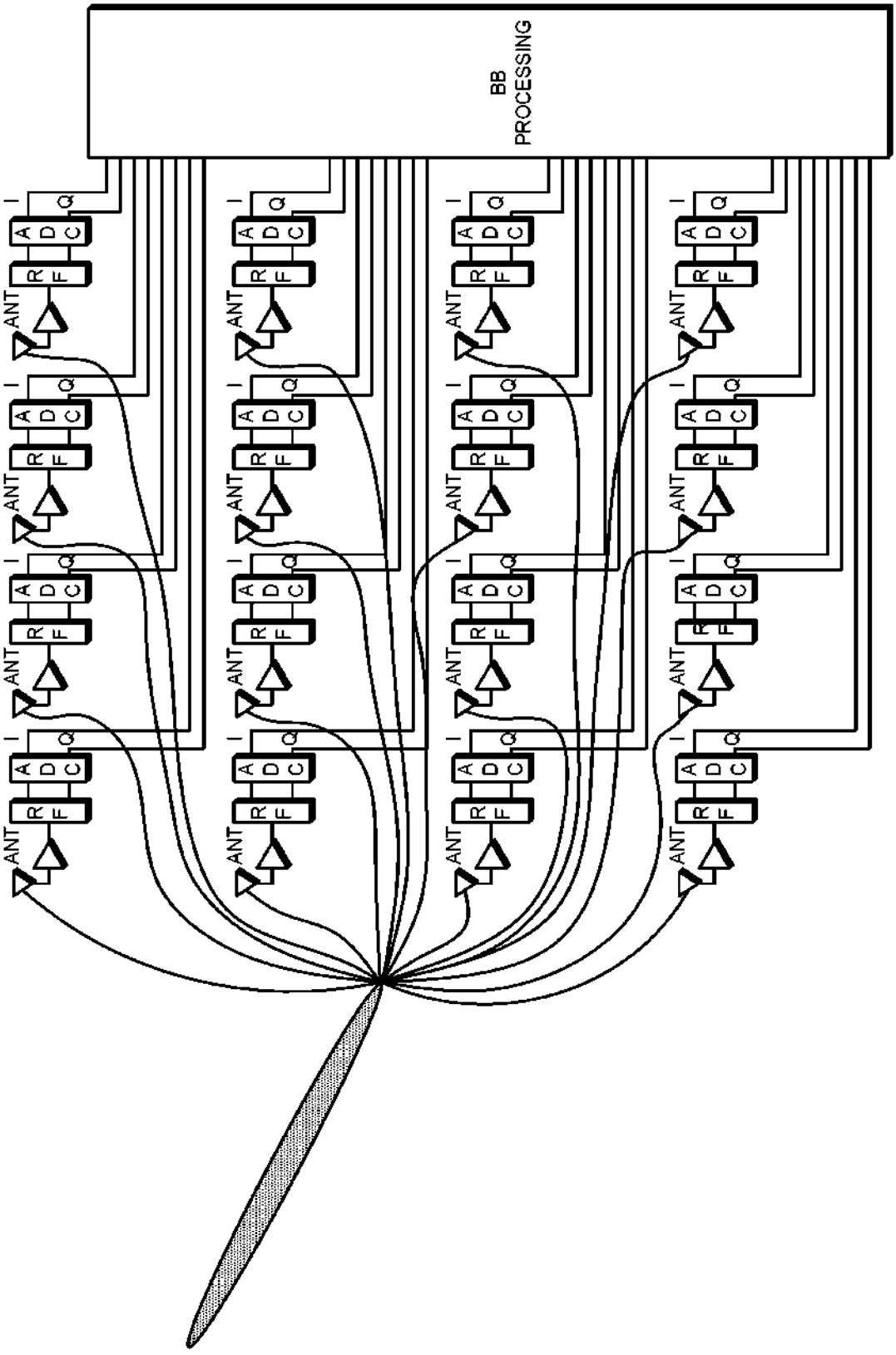


FIG. 5

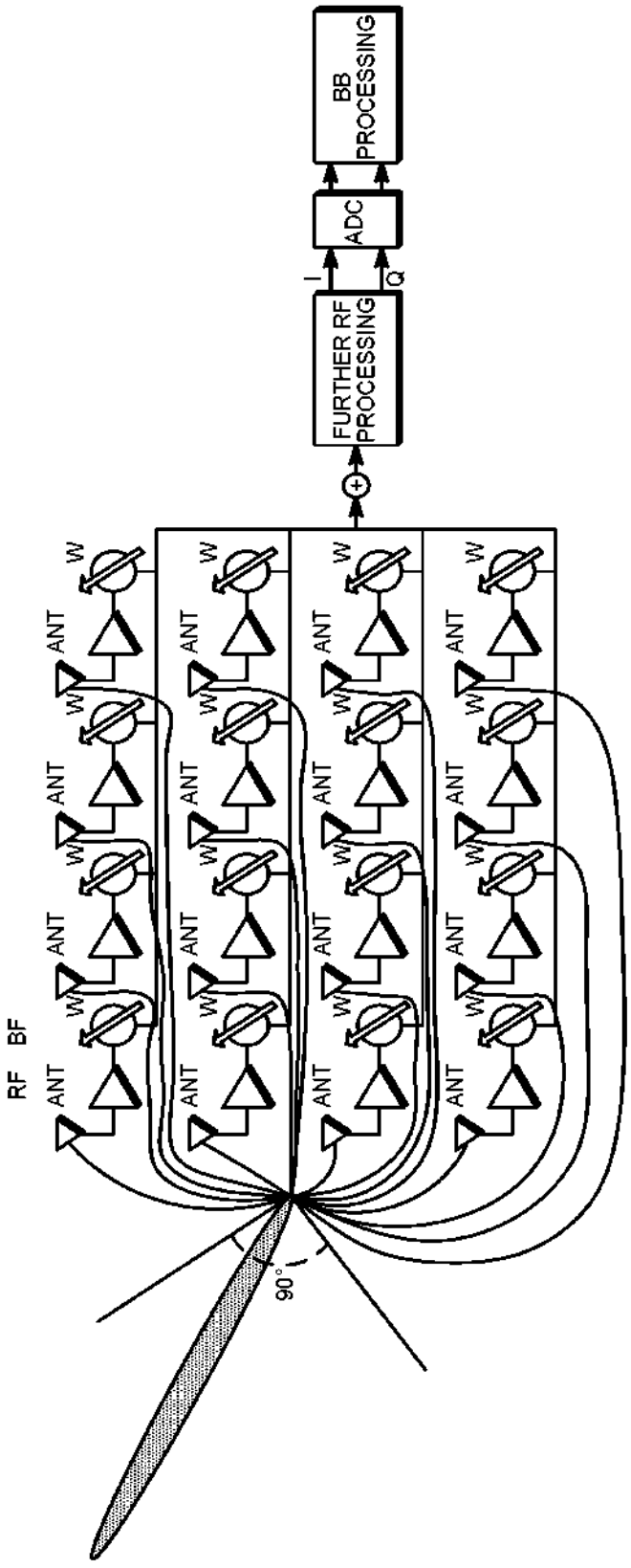


FIG. 6

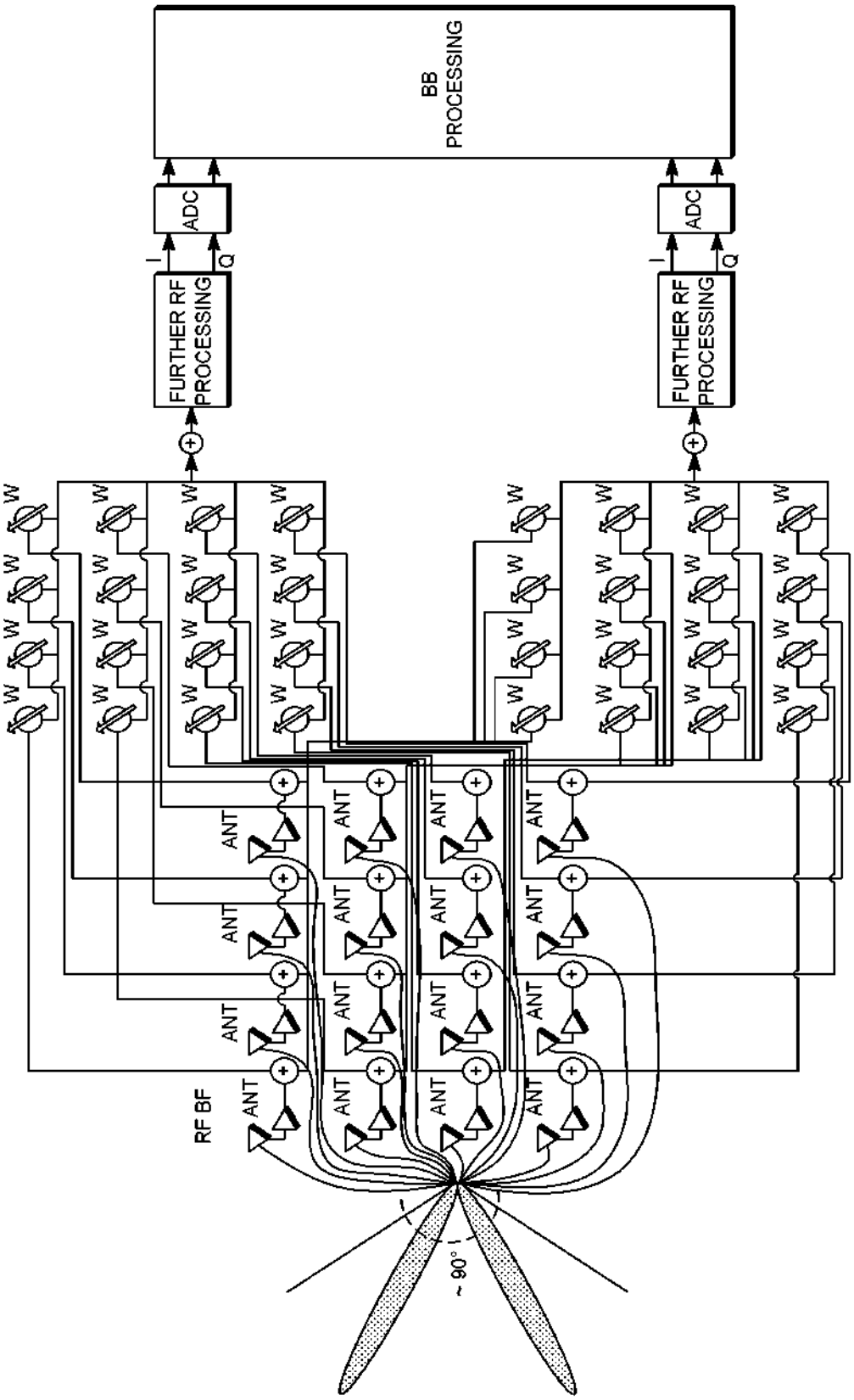

BB PROCESSING
ADC
ADC
I
Q
I
Q
FURTHER RF PROCESSING
FURTHER RF PROCESSING
W
ANT
RF BF
~ 90°

FIG. 7

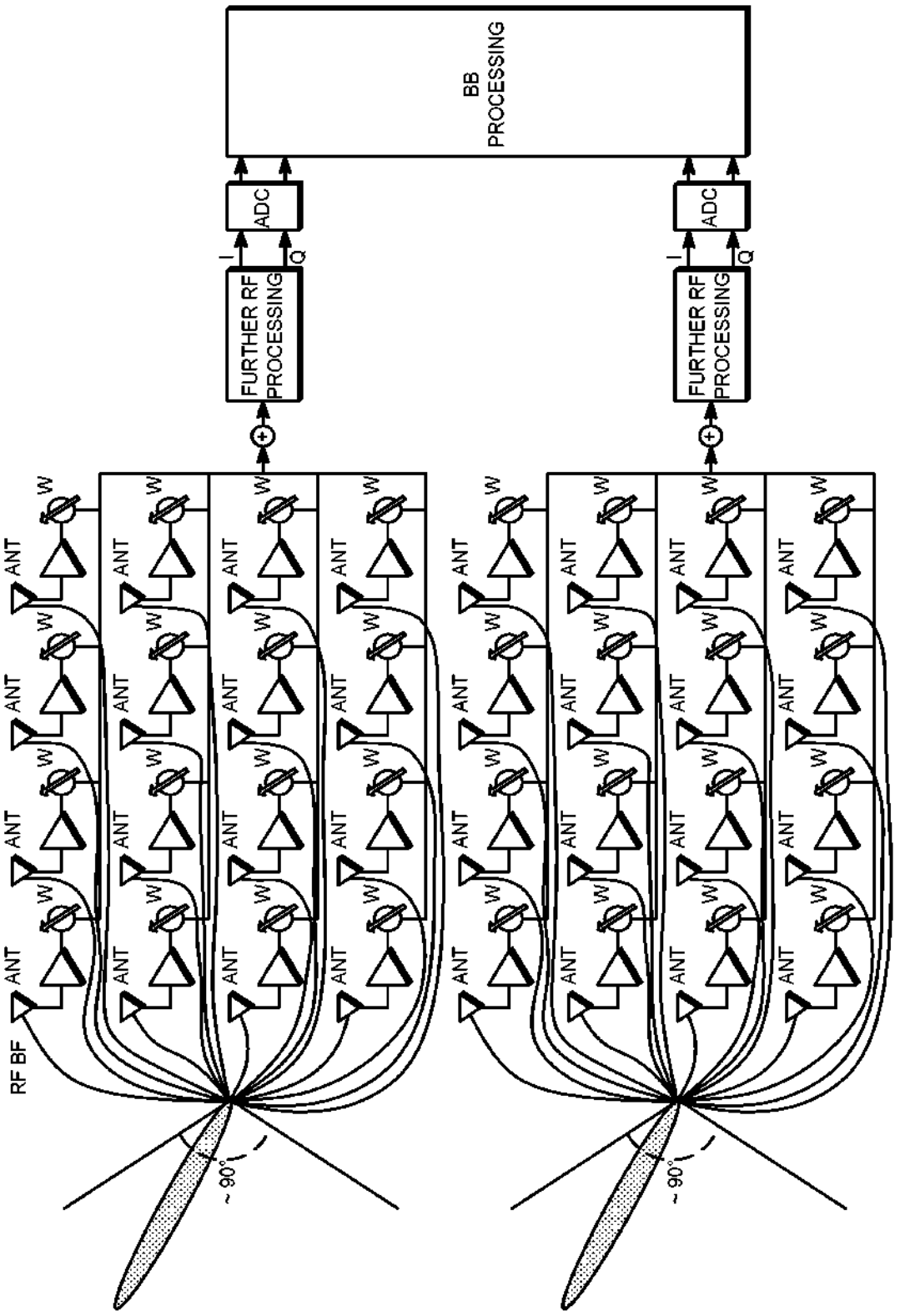

BB PROCESSING
ADC
ADC
I
Q
I
Q
FURTHER RF PROCESSING
FURTHER RF PROCESSING
ANT
W
RF BF
~90°
~90°

FIG. 8

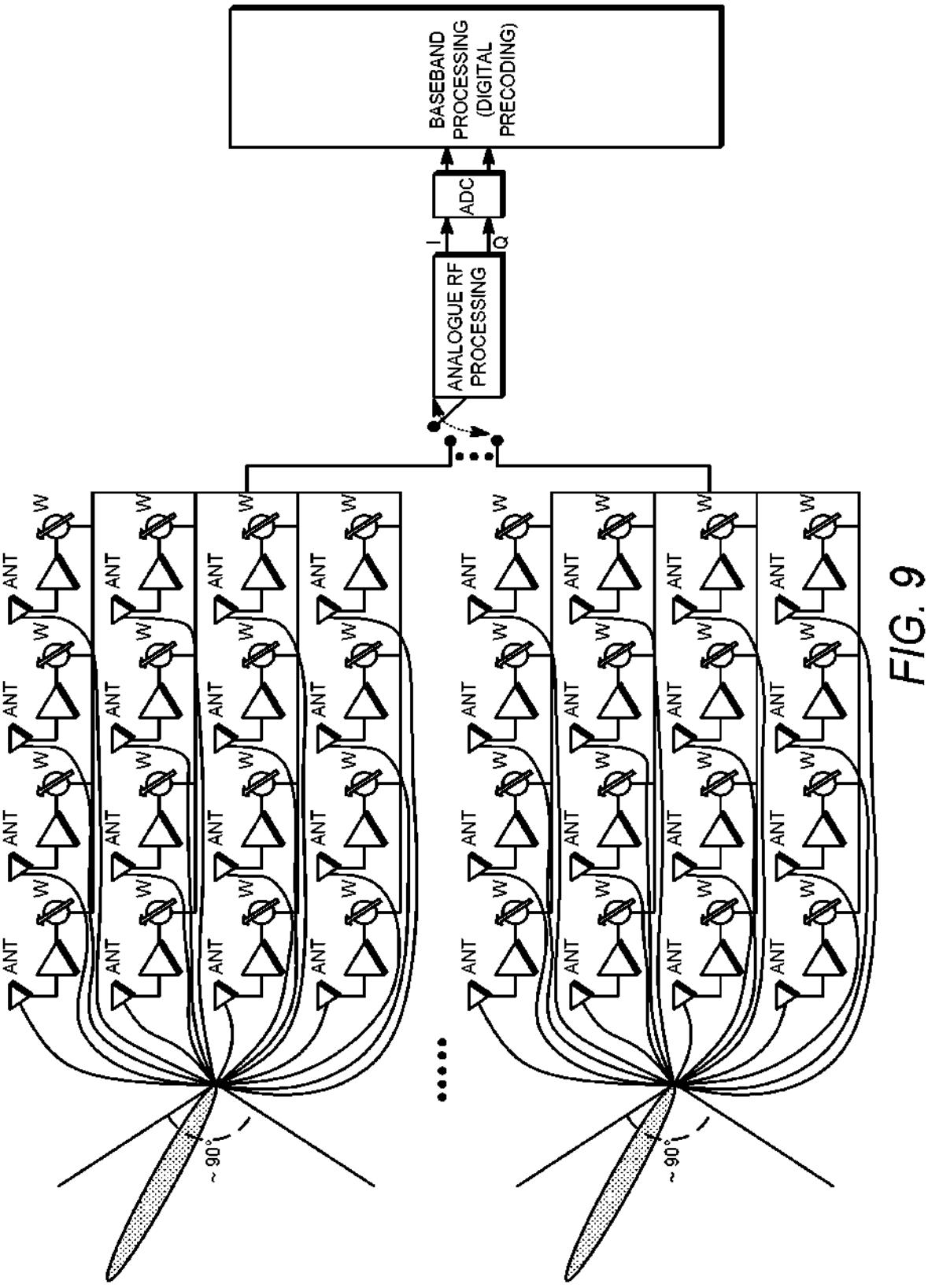

BASEBAND PROCESSING (DIGITAL PRECODING)
ADC
I
Q
ANALOGUE RF PROCESSING
ANT
W
~90°

FIG. 9

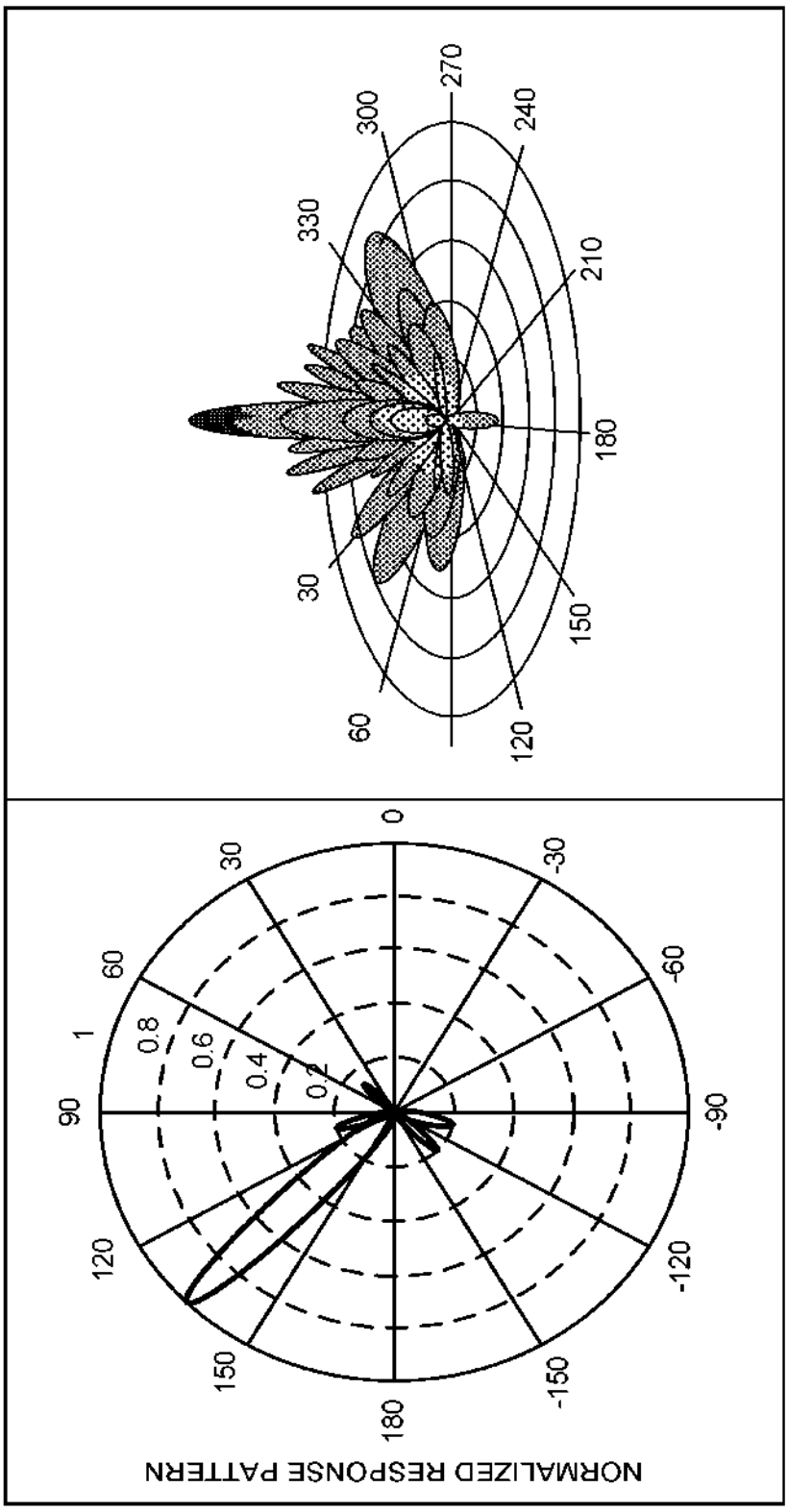

270
300
240
330
210
180
30
150
60
120
0
30
-30
60
-60
1
0.8
0.6
0.4
0.2
90
-90
120
-120
150
-150
180
NORMALIZED RESPONSE PATTERN

FIG. 10

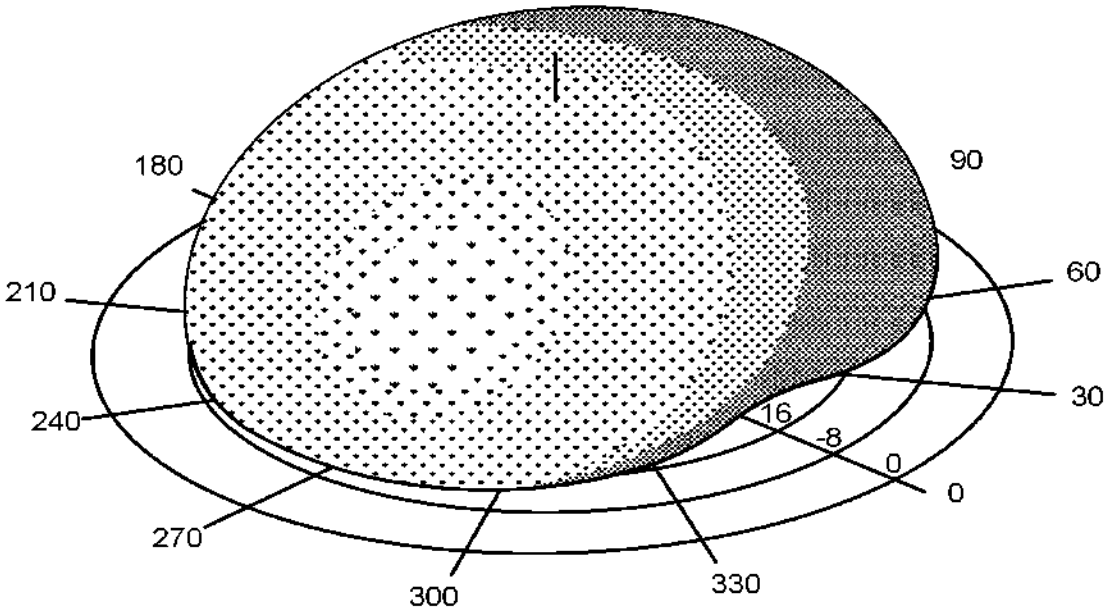


FIG. 11

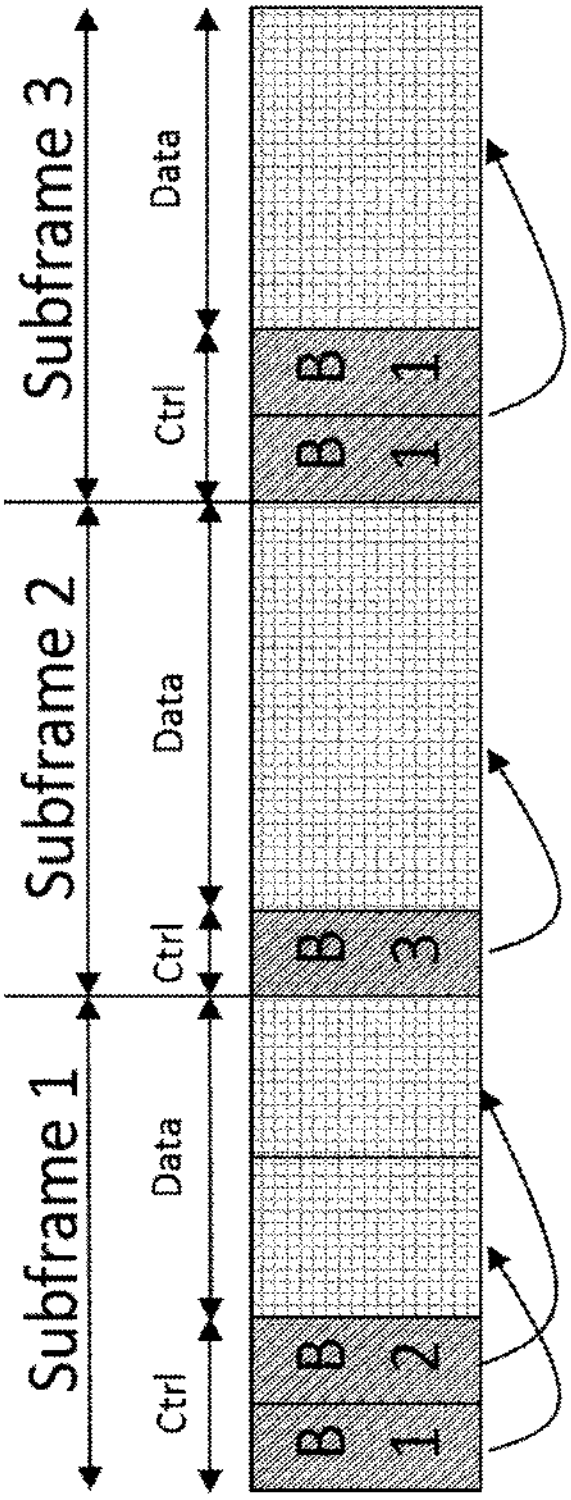

Subframe 1
Subframe 2
Subframe 3
Ctrl
Data
Ctrl
Data
Ctrl
Data
BB 1
BB 2
BB 3
BB 1

FIG. 12

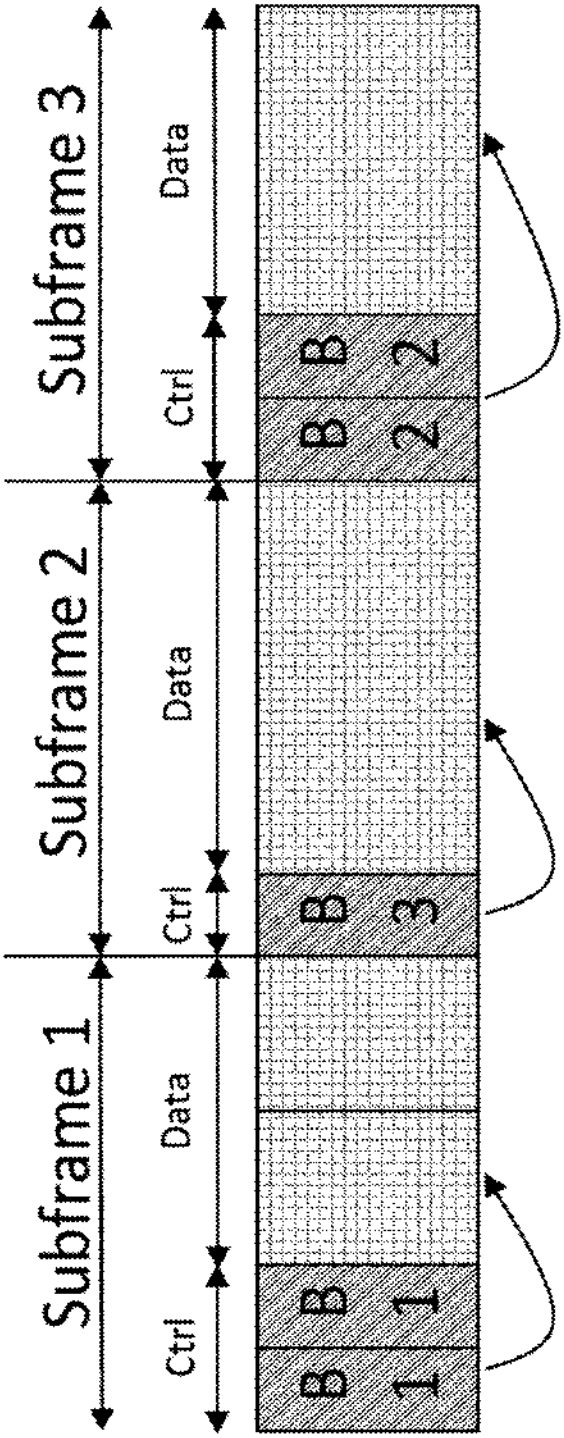

Subframe 1
Subframe 2
Subframe 3
Ctrl
Data
Ctrl
Data
Ctrl
Data
B 1
B 1
B 3
B 2
B 2

FIG. 13

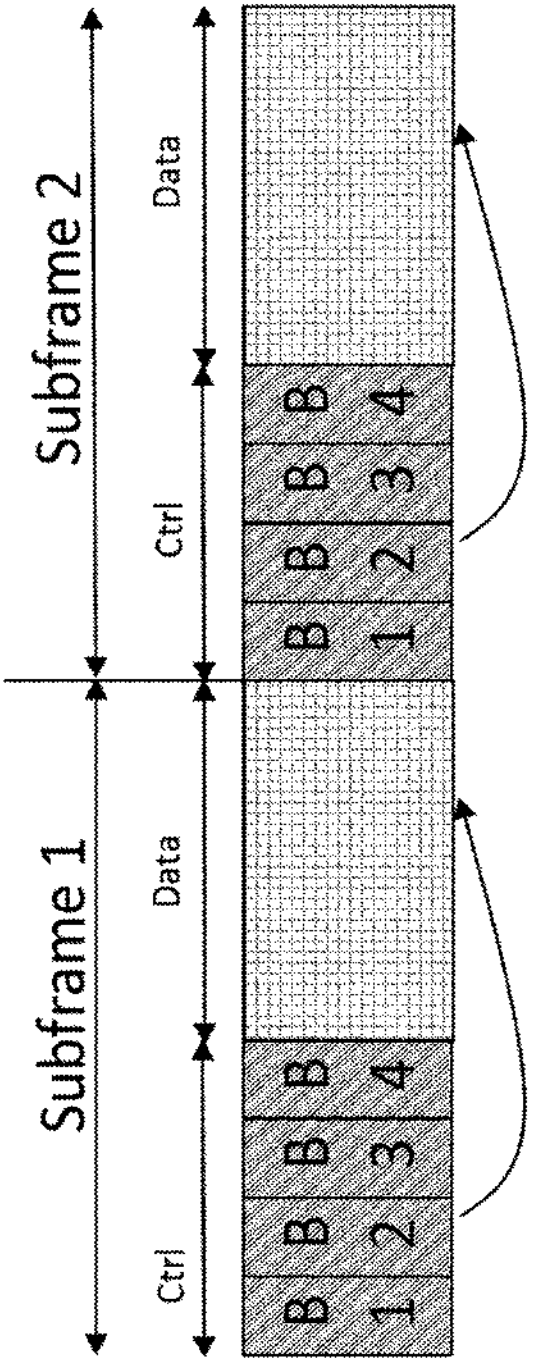

Subframe 2
Data
Ctrl
B B 4
B B 3
B B 2
B 1
Subframe 1
Data
Ctrl
B B 4
B B 3
B B 2
B 1

FIG. 14

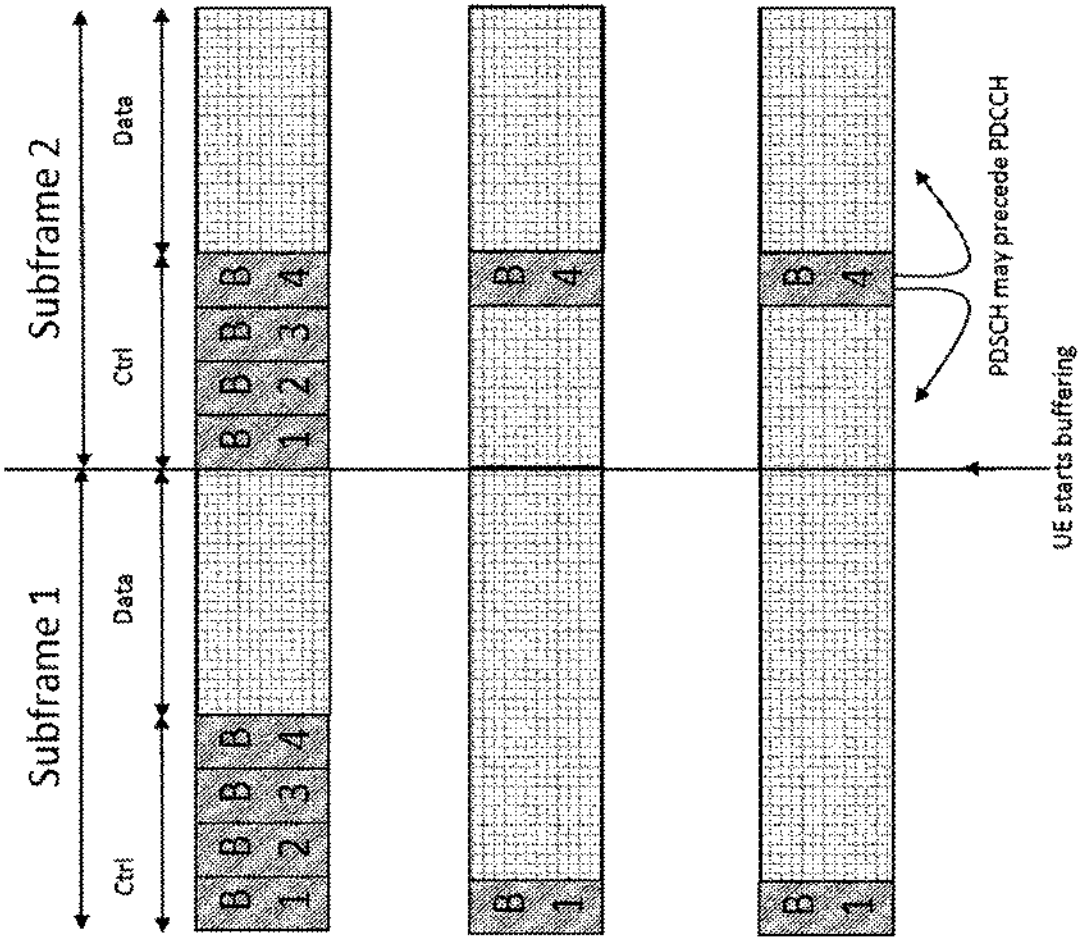

Subframe 2
Ctrl
Data
Subframe 1
Ctrl
Data
B 1
B 2
B 3
B 4
PDSCH may precede PDCCH
UE starts buffering

FIG. 15

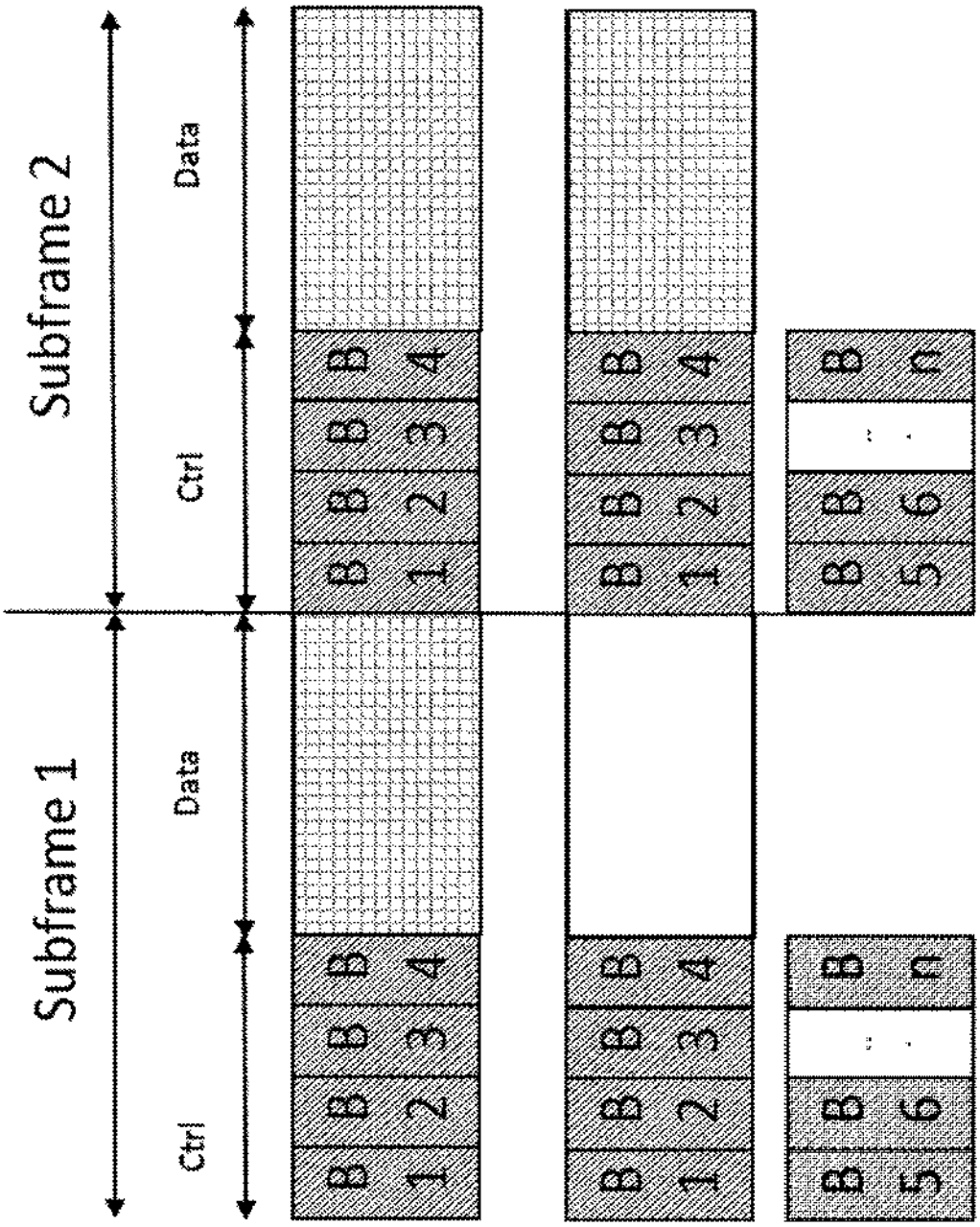

Subframe 1
Subframe 2
Ctrl
Data
Ctrl
Data
BB 1
BB 2
BB 3
BB 4
BB 5
BB 6
BB n

FIG. 16

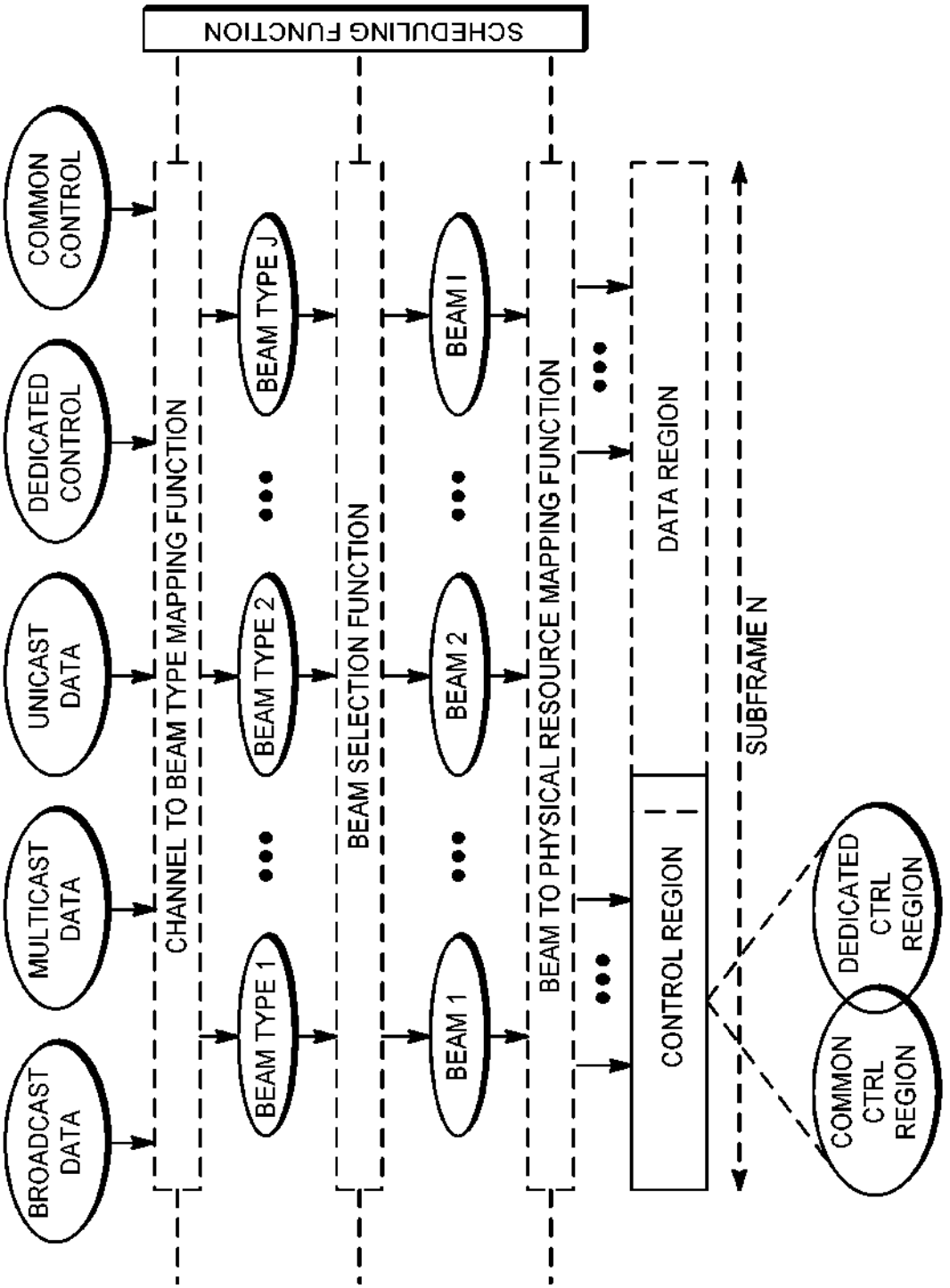

SCHEDULING FUNCTION
BROADCAST DATA
MULTICAST DATA
UNICAST DATA
DEDICATED CONTROL
COMMON CONTROL
CHANNEL TO BEAM TYPE MAPPING FUNCTION
BEAM TYPE 1
BEAM TYPE 2
BEAM TYPE J
BEAM SELECTION FUNCTION
BEAM 1
BEAM 2
BEAM I
BEAM TO PHYSICAL RESOURCE MAPPING FUNCTION
CONTROL REGION
DATA REGION
SUBFRAME N
COMMON CTRL REGION
DEDICATED CTRL REGION

FIG. 17

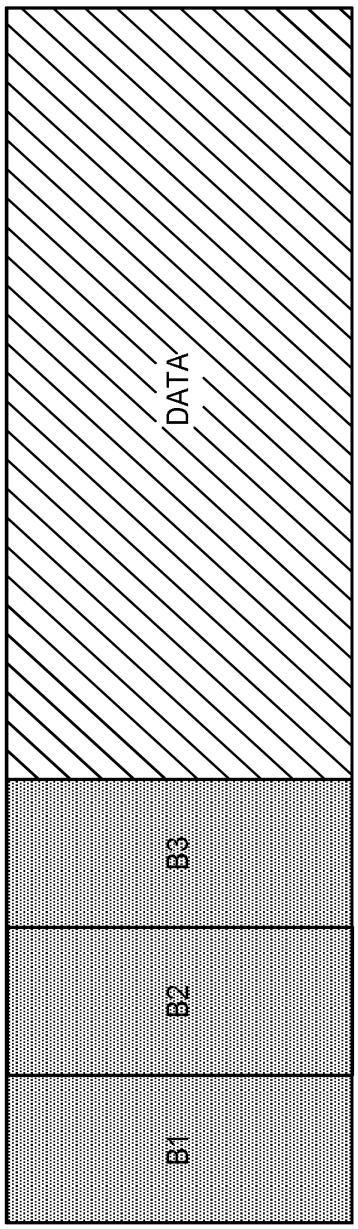


FIG. 18

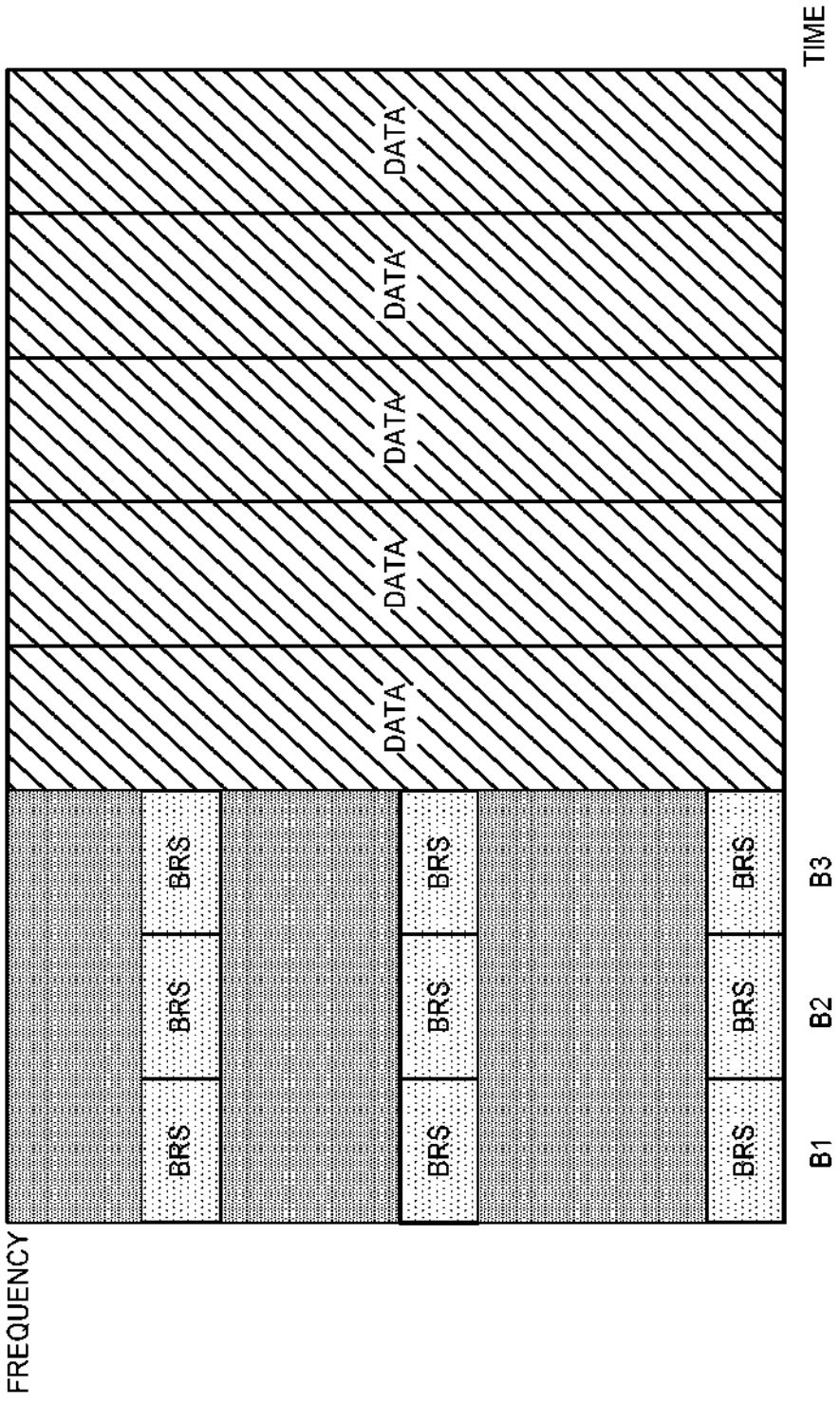


FIG. 19

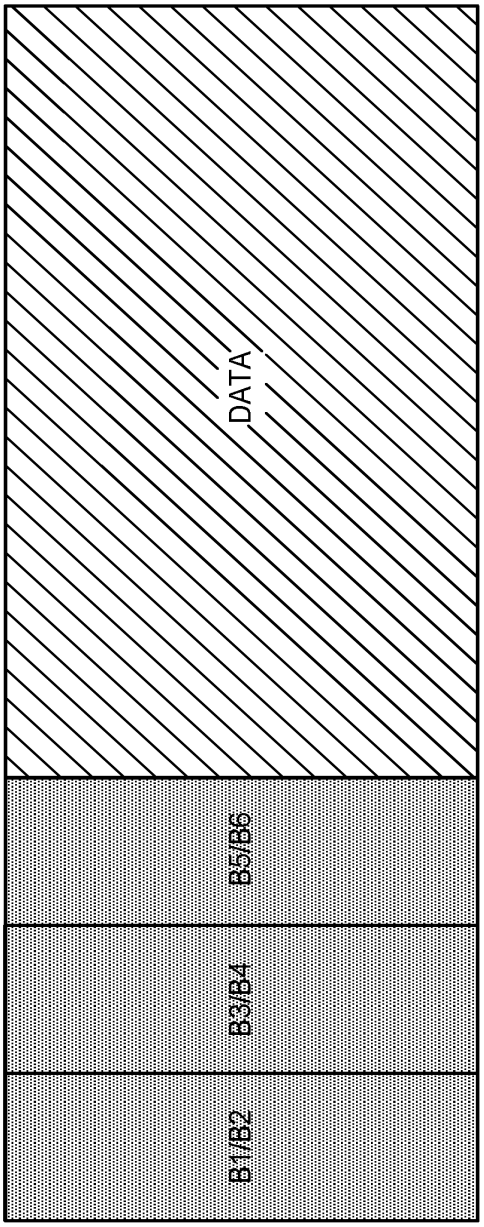


FIG. 20

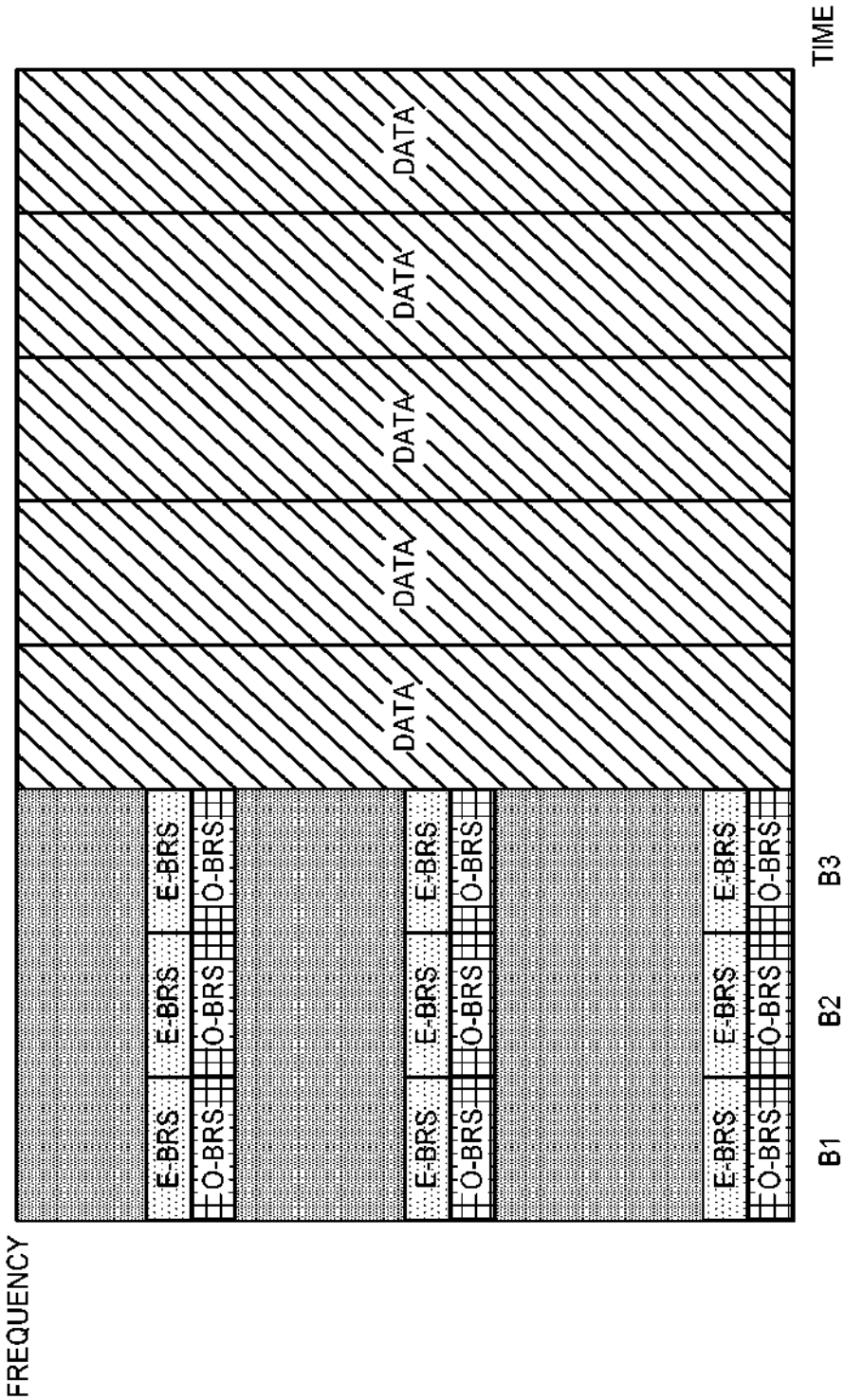


FIG. 21

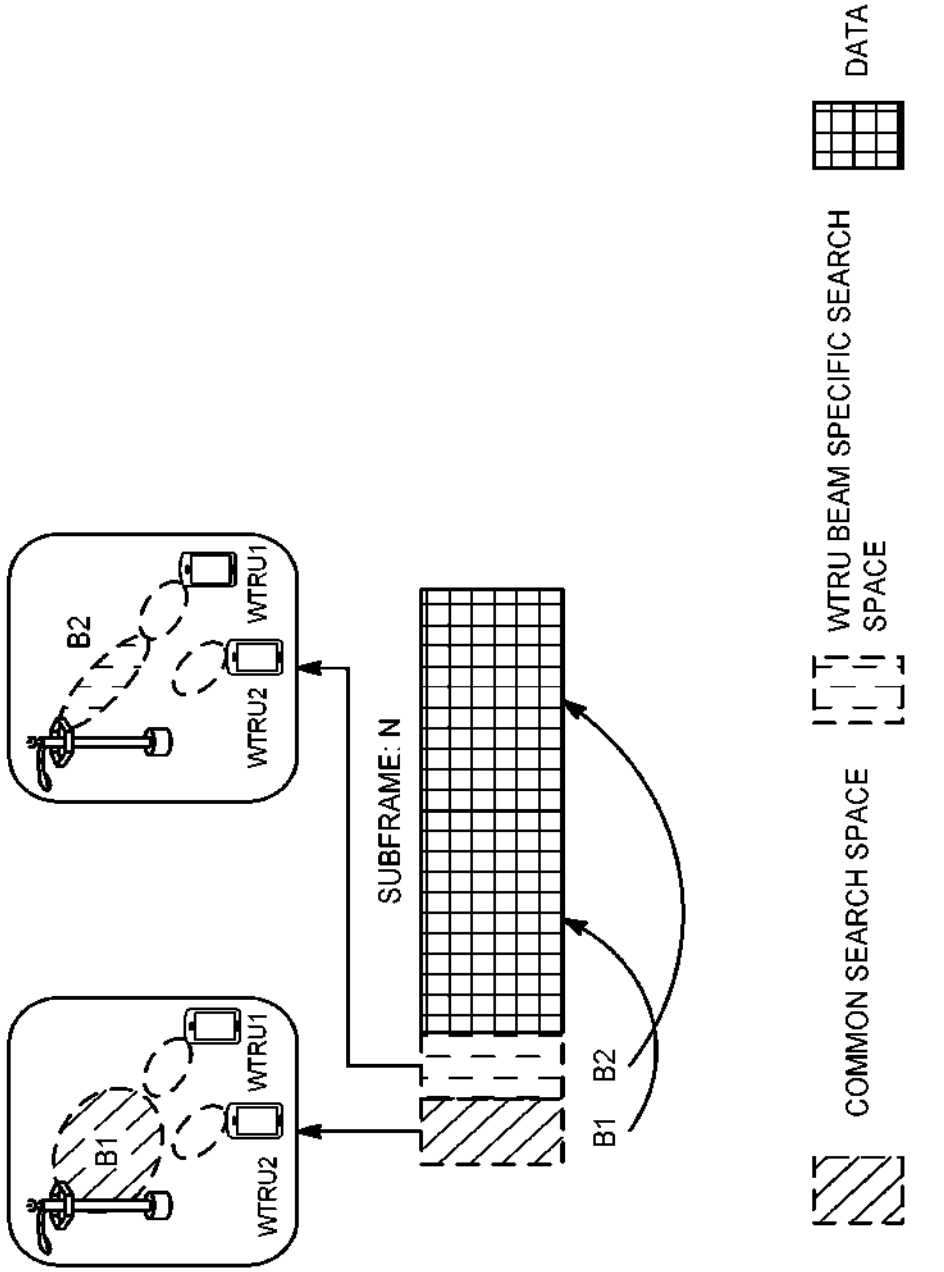

WTRU1
WTRU2
B2
WTRU1
WTRU2
B1
SUBFRAME: N
B1
B2
COMMON SEARCH SPACE
WTRU BEAM SPECIFIC SEARCH SPACE
DATA

FIG. 22

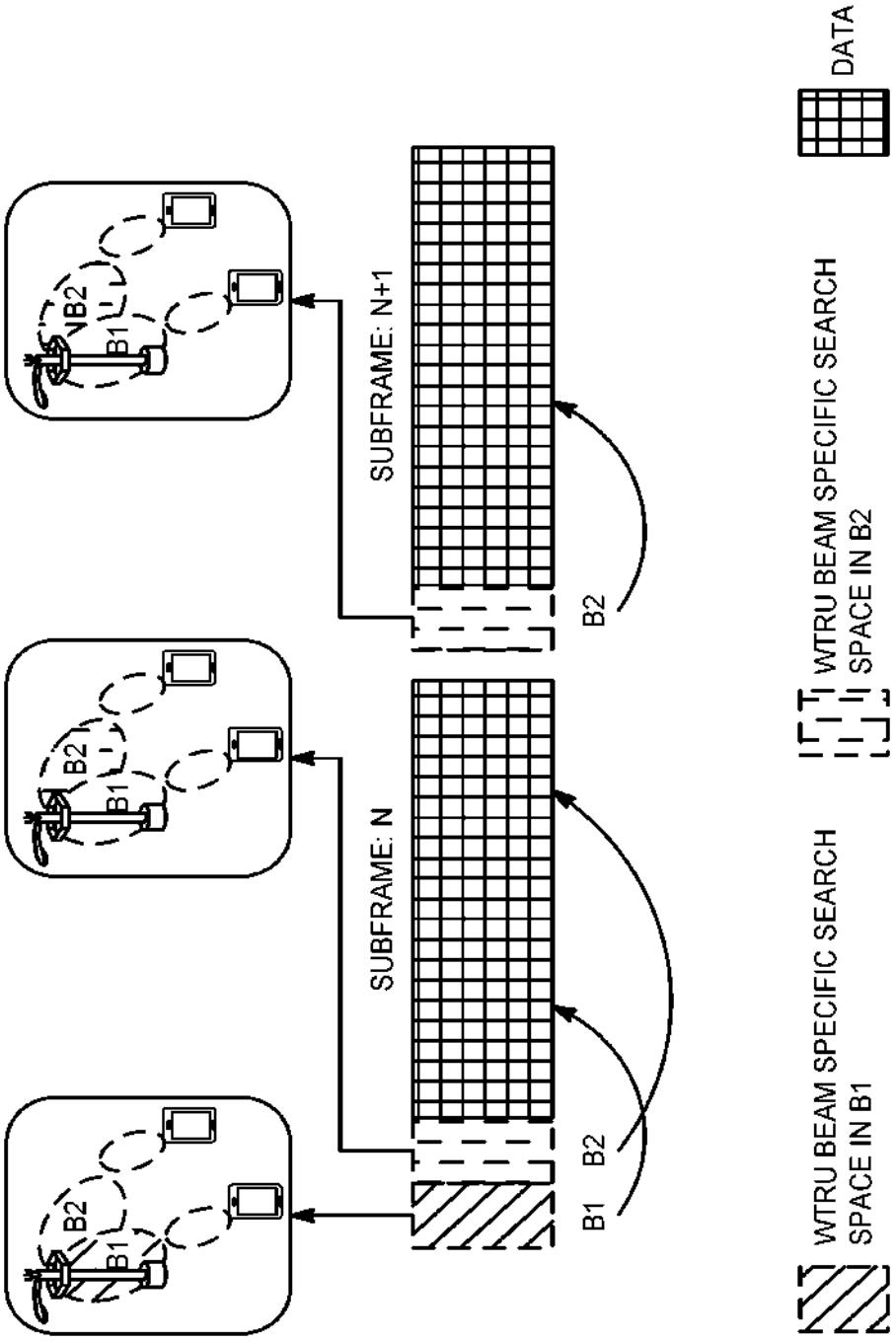

B2
B1
SUBFRAME: N
B1 B2
B2
B1
SUBFRAME: N+1
B2
B1
DATA
WTRU BEAM SPECIFIC SEARCH
SPACE IN B2
WTRU BEAM SPECIFIC SEARCH
SPACE IN B1

FIG. 23

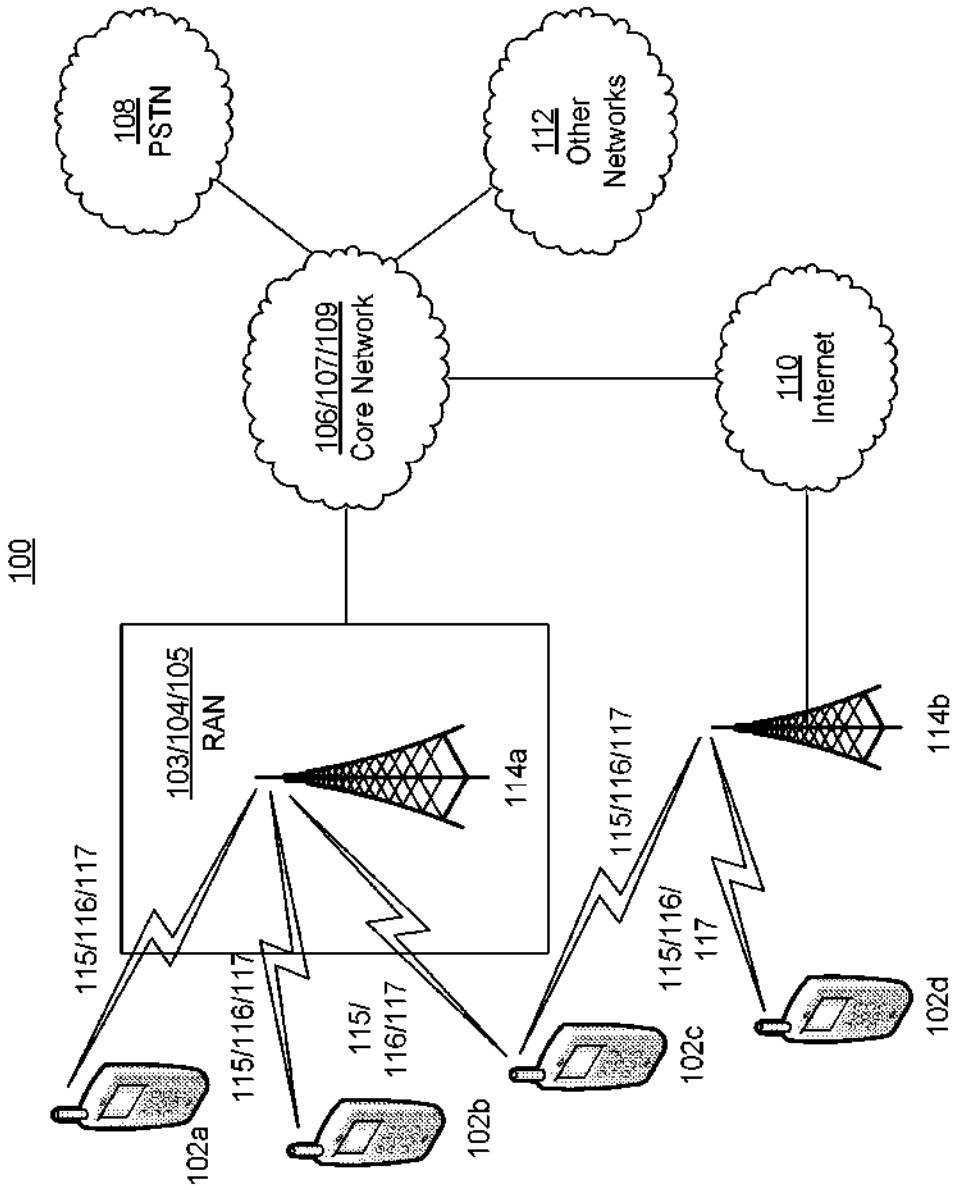

100
108 PSTN
112 Other Networks
106/107/109 Core Network
110 Internet
103/104/105 RAN
114a
114b
115/116/117
115/116/117
115/ 116/117
115/116/117
115/116/ 117
102a
102b
102c
102d

FIG. 24A

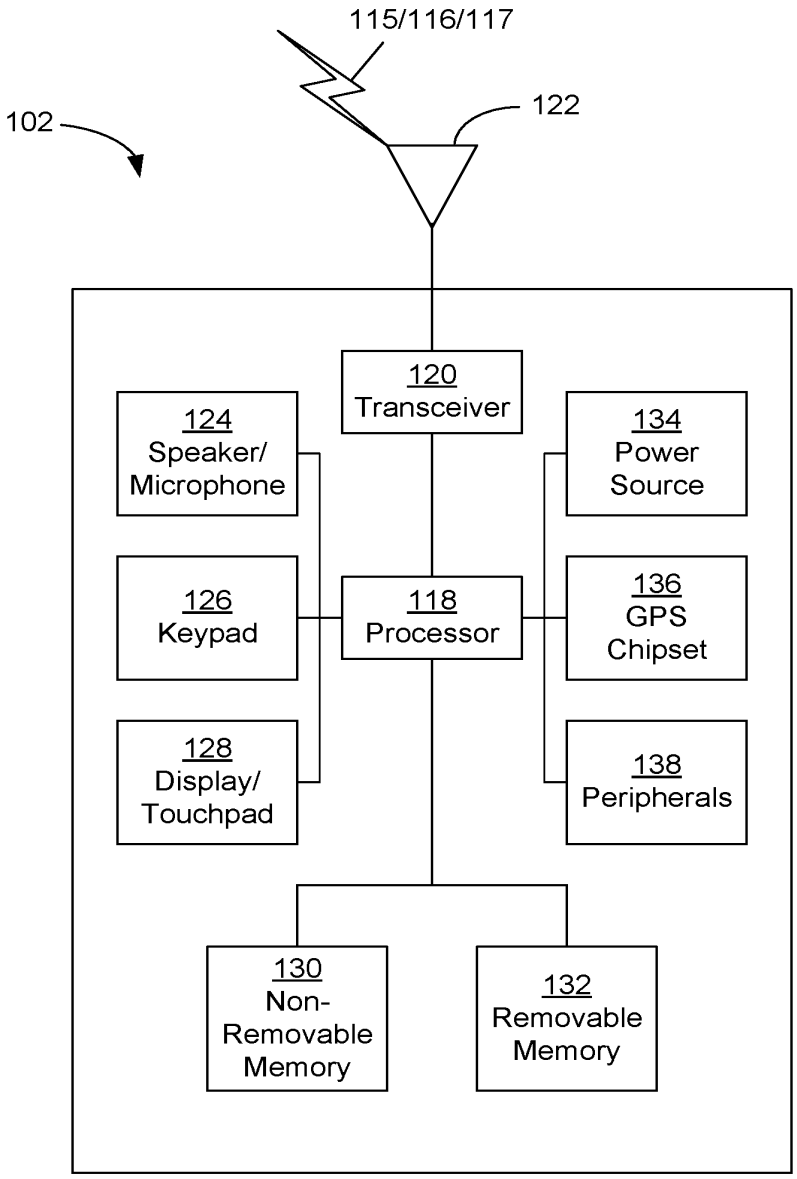

115/116/117
122
102
120
Transceiver
124
Speaker/
Microphone
134
Power
Source
126
Keypad
118
Processor
136
GPS
Chipset
128
Display/
Touchpad
138
Peripherals
130
Non-
Removable
Memory
132
Removable
Memory

FIG. 24B

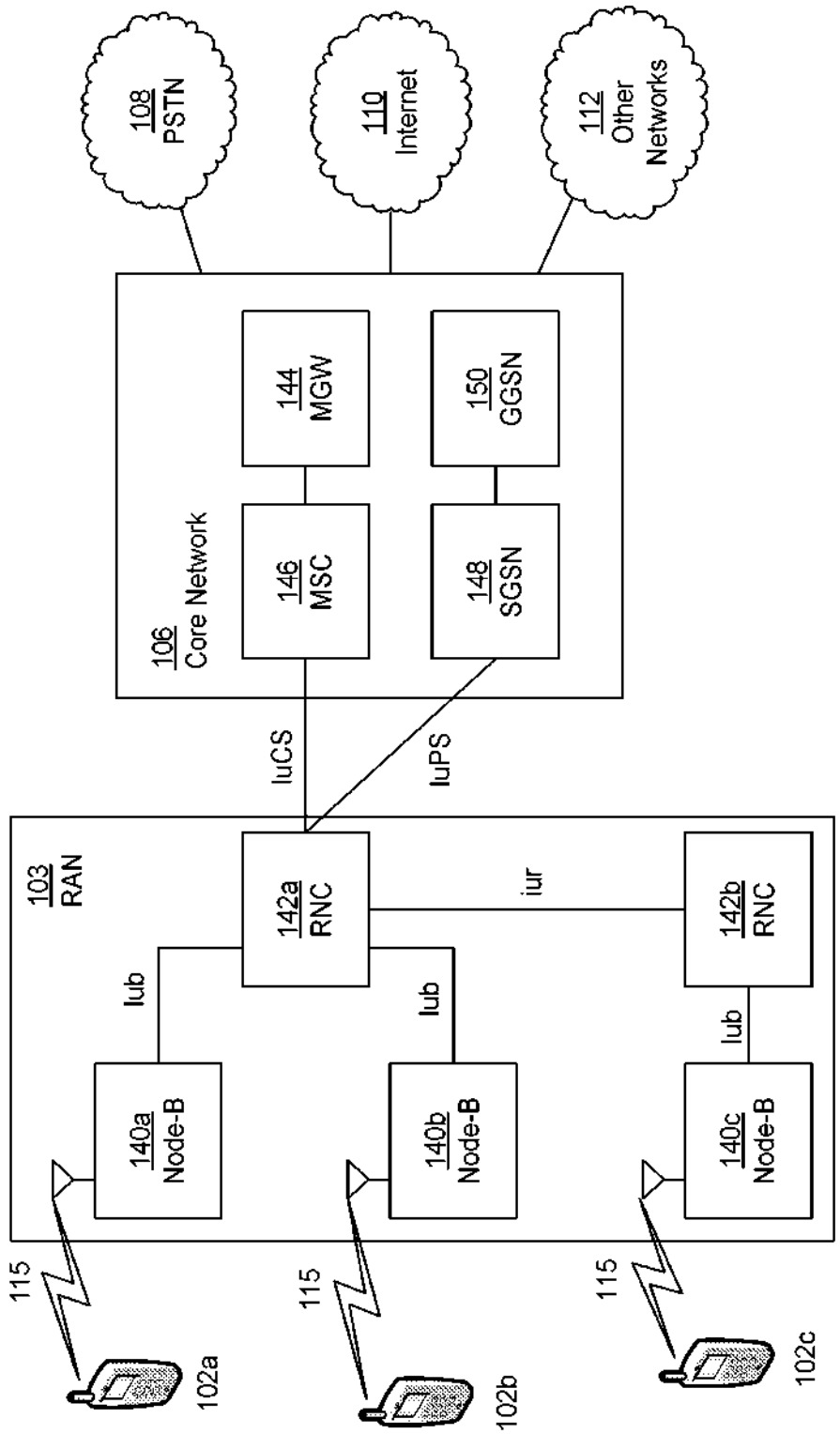

108 PSTN
110 Internet
112 Other Networks
106 Core Network
144 MGW
150 GGSN
146 MSC
148 SGSN
IuCS
IuPS
103 RAN
142a RNC
142b RNC
iur
Iub
Iub
Iub
140a Node-B
140b Node-B
140c Node-B
115
115
115
102a
102b
102c

FIG. 24C

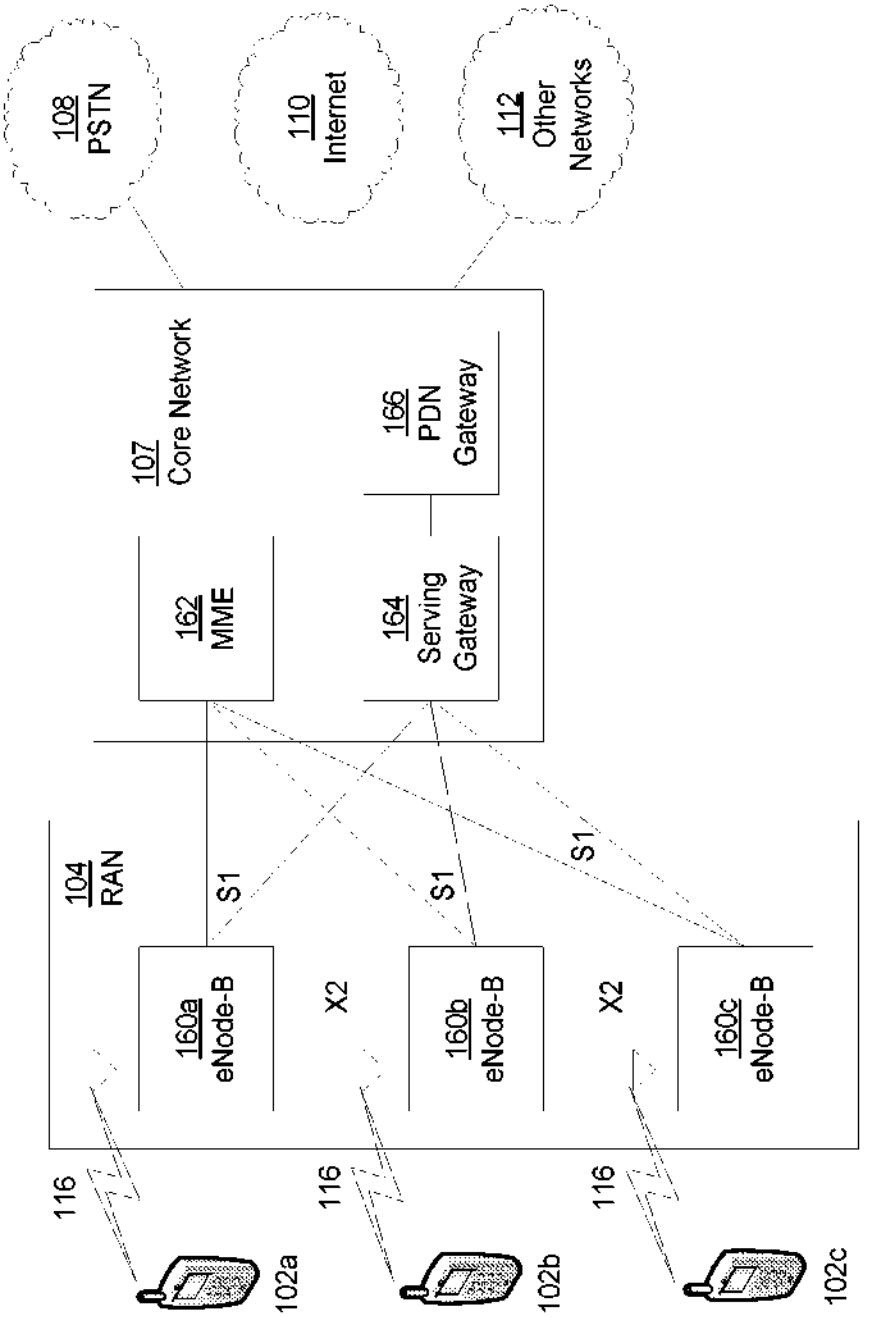

108 PSTN
110 Internet
112 Other Networks
107 Core Network
166 PDN Gateway
162 MME
164 Serving Gateway
104 RAN
S1
S1
S1
160a eNode-B
160b eNode-B
160c eNode-B
X2
X2
116
116
116
102a
102b
102c

FIG. 24D

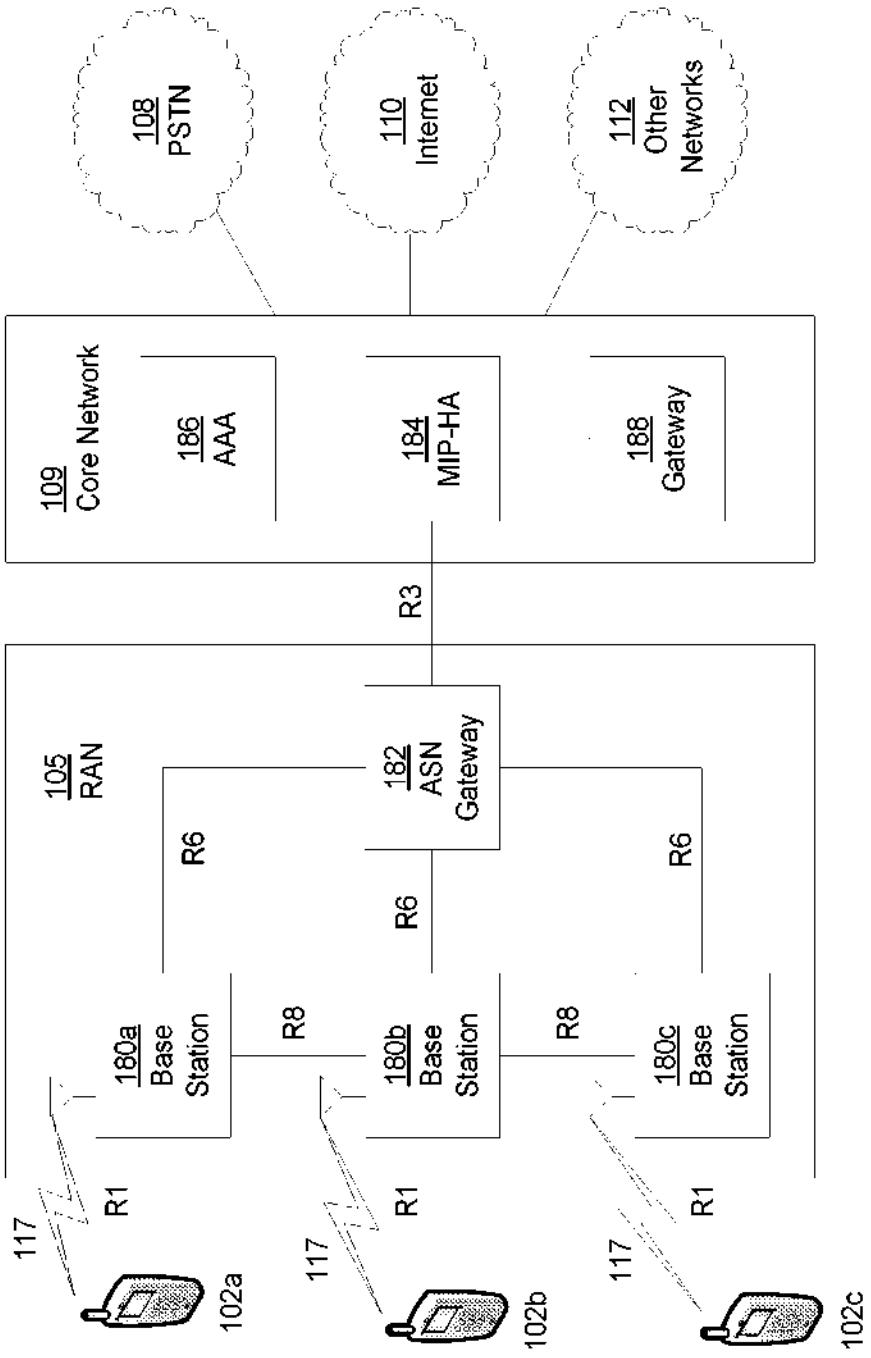

108 PSTN
110 Internet
112 Other Networks
109 Core Network
186 AAA
184 MIP-HA
188 Gateway
R3
105 RAN
182 ASN Gateway
R6
R6
R6
R8
R8
180a Base Station
180b Base Station
180c Base Station
R1
R1
R1
117
117
117
102a
102b
102c

FIG. 24E

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/061324

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04L5/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	US 2013/058285 A1 (KOIVISTO TOMMI [FI] ET AL) 7 March 2013 (2013-03-07) figure 1 paragraph [0127] - paragraph [0132] paragraph [0142] -----	1-14, 16-20 15
A	US 2014/177607 A1 (LI YING [US] ET AL) 26 June 2014 (2014-06-26) figures 10b, 10c paragraph [0122] - paragraph [0134] -----	1-20

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
2 February 2017	10/02/2017

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Hanus, Pavol

1

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2016/061324

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2013058285 A1	07-03-2013	NONE	
US 2014177607 A1	26-06-2014	CN 105122662 A	02-12-2015
		EP 2939349 A1	04-11-2015
		KR 20150100653 A	02-09-2015
		US 2014177607 A1	26-06-2014
		WO 2014104758 A1	03-07-2014

Form PCT/ISA/210 (patent family annex) (April 2005)

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International Bureau

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WIPO | PCT

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PCT/KR2017/003414

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29 March 2017 (29.03.2017)

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(26) Publication Language: English

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62/316,576	1 April 2016 (01.04.2016)	US
62/316,667	1 April 2016 (01.04.2016)	US
62/330,861	3 May 2016 (03.05.2016)	US

(71) Applicant: **LG ELECTRONICS INC.** [KR/KR]; 128, Yeoui-daero, Yeongdeungpo-gu, Seoul, 07336 (KR).

(72) Inventors: **YI, Yunjung**; IP Center, LG Electronics Inc., 19, Yangjae-daero 11-gil, Seocho-gu, Seoul 06772 (KR). **KIM, Kijun**; IP Center, LG Electronics Inc., 19, Yangjae-daero 11-gil, Seocho-gu, Seoul 06772 (KR). **SEO, Hanbyul**; IP Center, LG Electronics Inc., 19, Yangjae-daero 11-gil, Seocho-gu, Seoul 06772 (KR). **KIM, Byounghoon**; IP Center, LG Electronics Inc., 19, Yangjae-daero 11-gil, Seocho-gu, Seoul 06772 (KR).

(74) Agent: **ENVISION PATENT & LAW FIRM**; 5F, 124, Teheran-ro, Gangnam-gu, Seoul 06234 (KR).

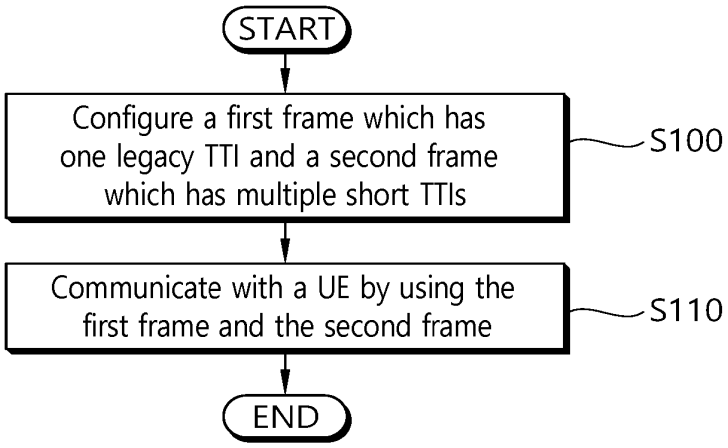
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

(54) Title: METHOD AND APPARATUS FOR CONFIGURING FRAME STRUCTURE FOR NEW RADIO ACCESS TECHNOLOGY IN WIRELESS COMMUNICATION SYSTEM



(57) Abstract: A frame structure for a new radio access technology (RAT) is configured by a network node. The network node configures a first frame which has one legacy transmission time interval (TTI) and a second frame which has multiple short TTIs, and communicates with a user equipment (UE) by using at least one of the first frame and the second frame. The UE may be a one of a massive machine-type communication (mMTC) UE, an ultra-reliable and low latency communication (URLLC) UE or an enhanced vehicle-to-everything (eV2X) UE.

WO 2017/171398 A1

Description

Title of Invention: METHOD AND APPARATUS FOR CONFIGURING FRAME STRUCTURE FOR NEW RADIO ACCESS TECHNOLOGY IN WIRELESS COMMUNICATION SYSTEM

Technical Field

[1] The present invention relates to wireless communications, and more particularly, to a method and apparatus for configuring a frame structure for a new ratio access technology (RAT) in a wireless communication system.

Background Art

[2] 3rd generation partnership project (3GPP) long-term evolution (LTE) is a technology for enabling high-speed packet communications. Many schemes have been proposed for the LTE objective including those that aim to reduce user and provider costs, improve service quality, and expand and improve coverage and system capacity. The 3GPP LTE requires reduced cost per bit, increased service availability, flexible use of a frequency band, a simple structure, an open interface, and adequate power consumption of a terminal as an upper-level requirement.

[3] As more and more communication devices require more communication capacity, there is a need for improved mobile broadband communication over existing radio access technology. Also, massive machine type communications (MTC), which provides various services by connecting many devices and objects, is one of the major issues to be considered in the next generation communication. In addition, communication system design considering reliability/latency sensitive service/UE is being discussed. The introduction of next generation radio access technology considering enhanced mobile broadband communication, massive MTC, ultra-reliable and low latency communication (URLLC) is discussed. This new technology may be called new radio access technology (RAT) for convenience.

[4] In the new RAT, analog beamforming may be introduced. In case of millimeter wave (mmW), the wavelength is shortened so that a plurality of antennas can be installed in the same area. For example, in the 30 GHz band, a total of 100 antenna elements can be installed in a 2-dimension array of 0.5 lambda (wavelength) intervals on a panel of 5 by 5 cm with a wavelength of 1 cm. Therefore, in mmW, multiple antenna elements can be used to increase the beamforming gain to increase the coverage or increase the throughput.

[5] In this case, if a transceiver unit (TXRU) is provided so that transmission power and phase can be adjusted for each antenna element, independent beamforming is possible for each frequency resource. However, installing a TXRU on all 100 antenna elements

has a problem in terms of cost effectiveness. Therefore, a method of mapping a plurality of antenna elements to one TXRU and adjusting the direction of a beam using an analog phase shifter is considered. This analog beamforming method has a disadvantage that it cannot perform frequency selective beaming because it can make only one beam direction in all bands.

[6] A hybrid beamforming with B TXRUs, which is an intermediate form of digital beamforming and analog beamforming, and fewer than Q antenna elements, can be considered. In this case, although there is a difference depending on the connection method of the B TXRU and Q antenna elements, the direction of the beam that can be simultaneously transmitted is limited to B or less.

[7] For operating new RAT efficiently, various schemes have been discussed. Specifically, in perspective of using frequency/spectrum, some new features may need to be required. Further, new frame structure may also need to be required.

Disclosure of Invention

Technical Problem

[8] The present provides a method and apparatus for configuring a frame structure for a new ratio access technology (RAT) in a wireless communication system. The present invention discusses initial access procedure which can allow different use cases supported in the same spectrum, e.g. massive machine-type communication (mMTC) and enhanced mobile broadband (eMBB), for both below and above 6 GHz. The present invention discusses how to support multi/variable transmission time interval (TTI) operation for each channel including hybrid automatic repeat request acknowledgement (HARQ-ACK) operation.

Solution to Problem

[9] In an aspect, a method for configuring a frame structure for a new radio access technology (RAT) by a network node in a wireless communication system is provided. The method includes configuring a first frame which has one legacy transmission time interval (TTI) and a second frame which has multiple short TTIs, and communicating with a user equipment (UE) by using at least one of the first frame and the second frame.

[10] In another aspect, a network node for a new radio access technology (RAT) in a wireless communication system is provided. The network node includes a memory, a transceiver, and a processor, coupled to the memory and the transceiver, that configures a first frame which has one legacy transmission time interval (TTI) and a second frame which has multiple short TTIs, and controls the transceiver to communicate with a user equipment (UE) by using at least one of the first frame and the second frame.

Advantageous Effects of Invention

[11] New frame structure can be configured for new RAT.

Brief Description of Drawings

[12] FIG. 1 shows a wireless communication system.

[13] FIG. 2 shows structure of a radio frame of 3GPP LTE.

[14] FIG. 3 shows a resource grid for one downlink slot.

[15] FIG. 4 shows an example of subframe type for new RAT.

[16] FIG. 5 shows an example of a frame structure for a new RAT according to an embodiment of the present invention.

[17] FIG. 6 shows another example of a frame structure for a new RAT according to an embodiment of the present invention.

[18] FIG. 7 shows an example of nested frame structure for a new RAT according to an embodiment of the present invention.

[19] FIG. 8 shows an example of scheduling of multiple and different TTI via different TTI levels.

[20] FIG. 9 shows an example of overlapped short TTI in a nested frame structure for a new RAT according to an embodiment of the present invention.

[21] FIG. 10 shows another example of overlapped short TTI in a nested frame structure for a new RAT according to an embodiment of the present invention.

[22] FIG. 11 shows another example of a frame structure for a new RAT according to an embodiment of the present invention.

[23] FIG. 12 shows another example of a frame structure for a new RAT according to an embodiment of the present invention.

[24] FIG. 13 shows an example of a nested self-contained subframe according to an embodiment of the present invention.

[25] FIG. 14 shows another example of a frame structure for a new RAT according to an embodiment of the present invention.

[26] FIG. 15 shows another example of a frame structure for a new RAT according to an embodiment of the present invention.

[27] FIG. 16 shows an example of different subcarrier spacing between URLLC and eMBB which are multiplexed in a same carrier or frequency band.

[28] FIG. 17 shows an example of DM-RS sharing according to an embodiment of the present invention.

[29] FIG. 18 shows an example of PUSCH scheduling with DM-RS sharing according to an embodiment of the present invention.

[30] FIG. 19 shows an example of PUCCH scheduling without DM-RS sharing according to an embodiment of the present invention.

[31] FIG. 20 shows a method for configuring a frame structure for a new RAT by a network node according to an embodiment of the present invention.

[32] FIG. 21 shows a wireless communication system to implement an embodiment of the present invention.

Mode for the Invention

[33] Techniques, apparatus and systems described herein may be used in various wireless access technologies such as code division multiple access (CDMA), frequency division multiple access (FDMA), time division multiple access (TDMA), orthogonal frequency division multiple access (OFDMA), single carrier frequency division multiple access (SC-FDMA), etc. The CDMA may be implemented with a radio technology such as universal terrestrial radio access (UTRA) or CDMA2000. The TDMA may be implemented with a radio technology such as global system for mobile communications (GSM)/general packet radio service (GPRS)/enhanced data rates for GSM evolution (EDGE). The OFDMA may be implemented with a radio technology such as institute of electrical and electronics engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802-20, evolved-UTRA (E-UTRA) etc. The UTRA is a part of a universal mobile telecommunication system (UMTS). 3rd generation partnership project (3GPP) long term evolution (LTE) is a part of an evolved-UMTS (E-UMTS) using the E-UTRA. The 3GPP LTE employs the OFDMA in downlink (DL) and employs the SC-FDMA in uplink (UL). LTE-advance (LTE-A) is an evolution of the 3GPP LTE. For clarity, this application focuses on the 3GPP LTE/LTE-A. However, technical features of the present invention are not limited thereto.

[34] FIG. 1 shows a wireless communication system. The wireless communication system 10 includes at least one evolved NodeB (eNB) 11. Respective eNBs 11 provide a communication service to particular geographical areas 15a, 15b, and 15c (which are generally called cells). Each cell may be divided into a plurality of areas (which are called sectors). A user equipment (UE) 12 may be fixed or mobile and may be referred to by other names such as mobile station (MS), mobile terminal (MT), user terminal (UT), subscriber station (SS), wireless device, personal digital assistant (PDA), wireless modem, handheld device. The eNB 11 generally refers to a fixed station that communicates with the UE 12 and may be called by other names such as base station (BS), base transceiver system (BTS), access point (AP), etc.

[35] In general, a UE belongs to one cell, and the cell to which a UE belongs is called a serving cell. An eNB providing a communication service to the serving cell is called a serving eNB. The wireless communication system is a cellular system, so a different cell adjacent to the serving cell exists. The different cell adjacent to the serving cell is called a neighbor cell. An eNB providing a communication service to the neighbor cell

is called a neighbor eNB. The serving cell and the neighbor cell are relatively determined based on a UE.

[36] This technique can be used for DL or UL. In general, DL refers to communication from the eNB 11 to the UE 12, and UL refers to communication from the UE 12 to the eNB 11. In DL, a transmitter may be part of the eNB 11 and a receiver may be part of the UE 12. In UL, a transmitter may be part of the UE 12 and a receiver may be part of the eNB 11.

[37] The wireless communication system may be any one of a multiple-input multiple-output (MIMO) system, a multiple-input single-output (MISO) system, a single-input single-output (SISO) system, and a single-input multiple-output (SIMO) system. The MIMO system uses a plurality of transmission antennas and a plurality of reception antennas. The MISO system uses a plurality of transmission antennas and a single reception antenna. The SISO system uses a single transmission antenna and a single reception antenna. The SIMO system uses a single transmission antenna and a plurality of reception antennas. Hereinafter, a transmission antenna refers to a physical or logical antenna used for transmitting a signal or a stream, and a reception antenna refers to a physical or logical antenna used for receiving a signal or a stream.

[38] FIG. 2 shows structure of a radio frame of 3GPP LTE. Referring to FIG. 2, a radio frame includes 10 subframes. A subframe includes two slots in time domain. A time for transmitting one transport block by higher layer to physical layer (generally over one subframe) is defined as a transmission time interval (TTI). For example, one subframe may have a length of 1ms, and one slot may have a length of 0.5ms. One slot includes a plurality of orthogonal frequency division multiplexing (OFDM) symbols in time domain. Since the 3GPP LTE uses the OFDMA in the DL, the OFDM symbol is for representing one symbol period. The OFDM symbols may be called by other names depending on a multiple-access scheme. For example, when SC-FDMA is in use as a UL multi-access scheme, the OFDM symbols may be called SC-FDMA symbols. A resource block (RB) is a resource allocation unit, and includes a plurality of contiguous subcarriers in one slot. The structure of the radio frame is shown for exemplary purposes only. Thus, the number of subframes included in the radio frame or the number of slots included in the subframe or the number of OFDM symbols included in the slot may be modified in various manners.

[39] The wireless communication system may be divided into a frequency division duplex (FDD) scheme and a time division duplex (TDD) scheme. According to the FDD scheme, UL transmission and DL transmission are made at different frequency bands. According to the TDD scheme, UL transmission and DL transmission are made during different periods of time at the same frequency band. A channel response of the TDD scheme is substantially reciprocal. This means that a DL channel response and a UL

channel response are almost the same in a given frequency band. Thus, the TDD-based wireless communication system is advantageous in that the DL channel response can be obtained from the UL channel response. In the TDD scheme, the entire frequency band is time-divided for UL and DL transmissions, so a DL transmission by the eNB and a UL transmission by the UE cannot be simultaneously performed. In a TDD system in which a UL transmission and a DL transmission are discriminated in units of subframes, the UL transmission and the DL transmission are performed in different subframes. In a TDD system, to allow fast switching between DL and UL, UL and DL transmission may be performed within a same subframe/slot in time division multiplexing (TDM)/frequency division multiplexing (FDM) manner.

[40] FIG. 3 shows a resource grid for one downlink slot. Referring to FIG. 3, a DL slot includes a plurality of OFDM symbols in time domain. It is described herein that one DL slot includes 7 OFDM symbols, and one RB includes 12 subcarriers in frequency domain as an example. However, the present invention is not limited thereto. Each element on the resource grid is referred to as a resource element (RE). One RB includes 12×7 or 12×14 resource elements. The number NDL of RBs included in the DL slot depends on a DL transmit bandwidth. The structure of a UL slot may be same as that of the DL slot. The number of OFDM symbols and the number of subcarriers may vary depending on the length of a CP, frequency spacing, etc. For example, in case of a normal cyclic prefix (CP), the number of OFDM symbols is 7 or 14, and in case of an extended CP, the number of OFDM symbols is 6 or 12. One of 128, 256, 512, 1024, 1536, and 2048 may be selectively used as the number of subcarriers in one OFDM symbol.

[41] 5th generation mobile networks or 5th generation wireless systems, abbreviated 5G, are the proposed next telecommunications standards beyond the current 4G LTE/ international mobile telecommunications (IMT)-dvanced standards. 5G planning aims at higher capacity than current 4G LTE, allowing a higher density of mobile broadband users, and supporting device-to-device, ultra-reliable, and massive machine communications. 5G research and development also aims at lower latency than 4G equipment and lower battery consumption, for better implementation of the Internet of things. Hereinafter, 5G technology may be referred to as new radio access technology (RAT).

[42] In new RAT, utilizing a subframe in which downlink and uplink are contained may be considered. This scheme may be applied for paired spectrum and unpaired spectrum. The paired spectrum means that one carrier consists of two carriers. For example, in the paired spectrum, the one carrier may include a DL carrier and an UL carrier, which are paired with each other. In the paired spectrum, communication, such as DL, UL, device-to-device communication, and/or relay communication, may be

performed by utilizing the paired spectrum. The unpaired spectrum means that that one carrier consists of only one carrier, like the current 4G LTE. In the unpaired spectrum, communication, such as DL, UL, device-to-device communication, and/or relay communication, may be performed in the unpaired spectrum.

[43] Further in new RAT, the following subframe types may be considered to support the paired spectrum and the unpaired spectrum mentioned above.

[44] (1) Subframes including DL control and DL data

[45] (2) Subframes including DL control, DL data, and UL control

[46] (3) Subframes including DL control and UL data

[47] (4) Subframes including DL control, UL data, and UL control

[48] (5) Subframes including access signals or random access signals or other purposes.

[49] (6) Subframes including both DL/UL and all UL signals.

[50] However, the subframe types listed above are only exemplary, and other subframe types may also be considered.

[51] FIG. 4 shows an example of subframe type for new RAT. The subframe shown in FIG. 4 may be used in TDD system of new RAT, in order to minimize latency of data transmission. Referring to FIG. 4, the subframe contains 14 symbols in one TTI, like the current subframe. However, the subframe includes DL control channel in the first symbol, and UL control channel in the last symbol. The remaining symbols may be used for DL data transmission or for UL data transmission. According to this subframe structure, DL transmission and UL transmission may sequentially proceed in one subframe. Accordingly, DL data may be transmitted in the subframe, and UL acknowledgement/non-acknowledgement (ACK/NACK) may also be received in the subframe. In this manner, the subframe shown in FIG. 4 may be referred to as self-contained subframe. As a result, it may take less time to retransmit data when a data transmission error occurs, thereby minimizing the latency of final data transmission. In the self-contained subframe structure, a time gap may be required for the transition process from the transmission mode to the reception mode or from the reception mode to the transmission mode. For this purpose, some OFDM symbols at the time of switching from DL to UL in the subframe structure may be set to the guard period (GP).

[52] Hereinafter, the present invention discusses transmission mechanism and resources used for synchronization signals, physical broadcast channel (PBCH), system information block (SIB) and physical random access channel (PRACH) related procedure for the new RAT, particularly considering forward compatibility in which different UEs are supported with different requirements in terms of radio frequency (RF)/baseband processing capability, latency requirements, power requirements, etc. For example, enhanced mobile broadband (eMBB) high data rate UEs with massive internet-of-things (IoT_ devices with relatively lower data rate and extremely limited

RF/baseband capability may be supported, compared to regular UEs or eMBB high data UEs. However, the present invention which will be described below may be applied to LTE technology wherever applicable.

[53] To allow coexistence of different use cases, at least one of the following aspects may be considered.

[54] - Different RF/baseband bandwidth capability: For example, an IoT device may support only very limited bandwidth such as M MHz of bandwidth or P*one subcarrier spacing. For another example, an IoT device may support 12*one subcarrier spacing (e.g. 12 * 7.5 kHz = 90 kHz).

[55] - Different processing capability in terms of encoding/decoding: For example, an IoT device may not support high processing decoding, such as turbo decoder or low-density parity-check (LDPC). If any common channel is shared among different UEs, this may be taken into account. For this manner, separate SIB may be transmitted per each UE. Alternatively, one main SIB or PBCH may be shared and different branch from the common channel may be allowed.

[56] - Different number of possible concurrent UEs attempting to access the cell: For example, though IoT device may not access the cell frequently, there may be many IoT devices attempting accessing the cell given a time duration. Handling massive UEs may require separate PRACH resource configuration or handling of RACH procedure differently.

[57] - Different synchronization requirement: For example, an IoT device may be supported by joint transmission from multiple cells to improve coverage. This may require larger CP overhead compared to other high data rate UEs.

[58] - Different subcarrier spacing: Due to different synchronization requirement or multiplexing capacity requirements, different subcarrier spacing may be used.

[59] - Different coverage requirement: Depending on use case, coverage and the required repetition numbers may be different.

[60]

[61] 1. Synchronization signal for the new RAT according to an embodiment of the present invention is described.

[62] For example, due to different subcarrier spacing and/or different RF/baseband requirement, synchronization signals, such as primary synchronization signal (PSS)/secondary synchronization signal (SSS), for eMBB and massive machine-type communication (mMTC) UEs may be different from the legacy synchronization signal. For example, synchronization signals for eMBB UEs may be transmitted over larger than M MHz of the lowest bandwidth supported UEs sharing the same spectrum. In this case, at least one of following approaches may be considered.

[63] (1) The common synchronization signals over the minimum system bandwidth (e.g.

M MHz) may be transmitted, and the same density of PSS/SSS may also be transmitted. The density may be determined by the coverage that the network intends to support.

[64] (2) Base sequence of synchronization signal may be transmitted in the minimum system bandwidth with the minimum density required for general UEs. For general UEs, repetition in frequency domain may be considered. And for high coverage requiring UEs, repetition in time domain may be considered. For example, minimum system bandwidth may be 180 kHz with 15 kHz subcarrier spacing with 12 subcarriers, and the bandwidth used for general UEs may be 1.4 MHz which may be repeated 6 times in frequency domain. On the other hand, for high coverage requiring UEs, repetition over multiple subframes may be considered. When repetition occurs in frequency domain, different root sequence may be used (which may affect overall peak-to-average power (PAPR)) or orthogonal cover code (OCC) may be applied over repetitions in frequency domain. Similar mechanism may be applied to repetition in time domain as well. From a UE perspective, if the network supports its UE type, appropriate repetition in either frequency domain or time (or both) domain may be used. In terms of repetition in frequency domain, the repetition may be done consecutively or discontinuously over the frequency.

[65] (3) Base sequence of synchronization signal may be based on synchronization signal system bandwidth designed for general UEs (e.g. 72 subcarriers * subcarrier spacing). For example, if the system bandwidth is K*M MHz, the base sequence may be mapped over k OFDM symbols for UE with lower bandwidth capability. In terms of mapping, M1, M2...Mk may be mapped over K OFDM symbols. Assuming a center frequency of a carrier where synchronization signal is transmitted, center frequency of the system bandwidth/carrier may be the same as the center frequency of synchronization signal for general UEs. Thus, if the channel raster is the same between different UEs, it means that center frequency of synchronization signals for low bandwidth UEs may be offset from the center of general UEs' synchronization signal. This offset may be prefixed. Alternatively, center frequency of system bandwidth/carrier may be the same as the center frequency of synchronization signal for low bandwidth UEs.

[66] (4) Separate synchronization signal may be configured between two types of UEs: In this case, to allow synchronization signal transmissions from different UEs, it is necessary to reserve some frequency regions for different types of UEs. This means that some signals/channels such as beam reference signal (RS) or PBCH or SIB may not be mapped to those reserved regions. At least a few potential regions may be reserved for future use of different system deployment or supporting different types of UEs.

[67] For the reserved regions, the following approaches may be considered. Within the

reserved time resource, any cell-common and/or group-common channels/RS/signals may not be transmitted.

[68] - Frequency resource(s) is reserved: For example, to allow different subcarrier spacing, frequency resource may be reserved. For the reserved frequency resources, the resources aligned with channel raster of low bandwidth UEs or future UEs may be considered. Generally, the same channel raster assumption may be used regardless of UE type. Thus, some frequency location which are aligned with channel raster may be reserved for future uses or supporting some different types of UEs.

[69] - Time resource(s) is reserved: For example, similar to legacy multicast-broadcast single-frequency network (MBSFN) subframe configuration, different types of future use subframes may be considered. In such subframes, one or a few symbols may be still used for control (DL and/or UL) transmissions. Within the reserved time resource, any cell-common and/or group-common channels/RS/signals may not be transmitted.

[70] - Time/frequency resource(s) is reserved: Both time and frequency domain may be considered for the reserved resources.

[71] - Beam direction(s) is reserved: Certain resources associated with a certain beam may be reserved. This implies that subcarrier spacing and/or CP length may be different per beam direction. In case below 6 GHz, this may be associated with a certain channel state information (CSI) RS and its associated virtual cell.

[72] If different subcarrier spacing is used, it may be necessary to fix synchronization signal (if they are common across UEs with different applications/subcarrier spacing values)

[73]

[74] 2. Empty frequency/time resources

[75] It is expected that some resources should be reserved for potential new services in future. The reason of reserving some frequency/time resource is to allow potentially different numerology (such as subcarrier spacing/CP length) and/or potentially different frame structure. In this sense, it is important to not allocate any available resources in frequency and time domain to one specific application. For example, the system bandwidth may not be entirely used for transmission of cell-specific signals, such as reference signals and channels. Also, it may be desirable to reserve some resources over the entire frequency domain rather than reserving some resources at the edge of system bandwidth. In this sense, it may be generally desirable to transmit any cell-specific RS and/or channel in rather discontinuous frequency resources. For example, PBCH may be transmitted in PRBs which are rather distributed over the system bandwidth, assuming minimum bandwidth. For example, if the minimum bandwidth is 20 MHz, and the number of PRBs are 20 with 75 kHz subcarrier spacing and PBCH uses 6 PRBs in one TTI, instead of placing PBCH in a contiguous 6 PRBs,

PBCH may be transmitted over 1 PRB in every 3 PRBs (or 2 PRBs excluding some PRBs used for synchronization signals). By this way, at least one or a few PRBs between PBCH PRBs may be reserved for some other future uses. Since additional RS and/or channels (cell-specific) may be transmitted in one TTI or one OFDM symbol, it may be also desirable to have discontinuous transmission of such RS/channels as well. Overall, the idea is to reserve at least one or a few subcarriers/RBs between two consecutive cell-specific RS/channels for future uses. The location of cell specific RS/channels may be determined based on cell ID and/or subframe and/or radio frame and/or frame index.

[76] Alternatively, signal system bandwidth may be signaled in synchronization signal where different frequency region can be used for different applications. For example, transmission of cell-specific RS may be different based on system bandwidth.

[77]

[78] 3. Frame structure

[79] It is expected that different frame structure may be necessary for the new RAT. Particularly, different frame structure in which UL and DL may be present in every subframe or may change very frequently in the same carrier may be necessary for the new RAT. Different application may require different minimum size of DL or UL portions to support different latency and coverage requirements. For example, mMTC for high coverage case may require relatively long DL and UL portion so that one transmission can be successfully transmitted. Furthermore, due to different requirement on synchronization and tracking accuracy requirements, different subcarrier spacing and/or different CP length may be considered. In this sense, it is necessary to consider mechanisms to allow different frame structures coexisting in the same carrier and be operated by the same cell/eNB.

[80] For the convenience, it is assumed in the description below that a frame structure type 1 (FS1) and a frame structure type 2 (FS2) are configured and coexist in the same carrier. The FS1 may be a baseline frame structure used for such as for eMBB use cases or typical use cases. The FS2 may be used for some other applications such as mMTC, ultra-reliable and low latency communication (URLLC), an enhanced vehicle-to-everything (eV2X) communication. The network or a cell may support one or multiple frame structures at the same time. For the convenience, the present invention may discuss relationship between two frame structures. However, more than two frame structures may be supported simultaneously.

[81]

[82] A. FS2 for mMTC/URLLC in FDD case

[83] In this case, one TTI of FS2 may consist of a few (e.g. 'm') TTIs of FS1. For example, if one TTI of FS1 is X ms, one TTI of FS2 may be 'm'*X ms. For de-

termining 'm', at least one of the following approaches may be considered.

[84] - 'm' may be predetermined. 'm' may be different per frequency or frequency range or frequency bands. To support variable coverage level or repetition level, it may be desirable to have different 'm' per repetition level. 'm' may be 2^N , where N=0,...P.

[85] - 'm' may be determined based on subcarrier spacing used for mMTC. For example, if 15*K1 kHz subcarrier spacing is used for FS1, and 15 kHz subcarrier spacing is used for FS2, 'm' may be same as K1 or multiple of K1.

[86] - Combination of the above two approaches may also be considered.

[87] FIG. 5 shows an example of a frame structure for a new RAT according to an embodiment of the present invention. Referring to FIG. 5, it is shown that FS1 is the same as the conventional frame structure, as one TTI includes 14 symbols. That is, one TTI of FS1 is 1 ms. On the other hand, one TTI of FS2 is 'm' ms. 'm' may be predetermined. Or, 'm' may be determined based on subcarrier spacing used for mMTC.

[88] If different subcarrier spacing is used, it may be necessary to have a gap between two different subcarrier regions. Also, for transmission of synchronization signals, collision between FS1 OFDM symbol carrying PSS and/or SSS and FS2 OFDM symbol carrying PSS and/or SSS should be avoided. For this, FS1 and FS2 may be configured by TDM manner. For this, in terms of system information or master information block (MIB) signaling, a set of subframes not usable may be configured. In other words, the set of available subframes for each FS may be signaled by each system information carried in each FS respectively. However, a set of available TTIs/subframes may not reflect the case where one or a few OFDM symbols within one TTI should not be used. For example, one OFDM symbol of FS2 colliding with synchronization signal(s) of FS1 may be excluded/punctured/rate matched. One or a few patterns of available OFDM symbols per TTI may be configured and signaled per each FS or to FS2. For example, patterns may be {all OFDM symbols available}, {the first symbol is not available}, {the first symbol in each slot is not available}, etc.

[89] Alternatively, CP length of FS2 may be configured smaller than m*CP length of FS1. The remaining portion may be used for gap or blank region between FS1 and FS2.

[90] FIG. 6 shows another example of a frame structure for a new RAT according to an embodiment of the present invention. Referring to FIG. 6, like FIG. 5, one TTI of FS1 is 1 ms, and one TTI of FS2 is 'm' ms. However, CP length of FS2 is configured smaller than m*CP length of FS1, so gap occurs at the end of FS2. PSS/SSS of FS1 may be transmitted in gap of FS2, in order to avoid collision.

[91] Alternatively, when FS2 is constructed, additional gap may be considered, regardless of CP length, such that PSS/SSS (and also necessary system bandwidth wide signals such as CSI-RS, extended synchronization signal (ESS)) can be transmitted. In other

words, one or a few OFDM symbols may be reserved for some other purposes in FS2. For reservation, different CP may be configured so that the number of OFDM symbols within one TTI can be totally smaller than the size of one TTI (e.g. OFDM symbol size of 80 us*12 = 960 us in 1ms TTI leaves 40 us gap). Or, some OFDM symbols may be reserved for further uses. The future use or some other uses may include CSI-RS transmission, UL control transmission, DL control transmission, etc. Depending on reason of reservation, the gap may be formed in the beginning of each TTI (or multiple TTIs) or end of each TTI (or multiple TTIs). To support this, system bandwidth side signals of FS1, such as CSI-RS, ESS, PBCH, etc., may be transmitted in the beginning of TTI or ending of the TTI such that reservation on FS2 may be placed in the beginning or ending of TTI of FS2.

[92] Meanwhile, in order to reduce latency, short TTI which may be shorter than current TTI (i.e. 1ms) has been considered. For example, length of short TTI may be one of 1/2/3/4/7 symbols. When a short TTI is introduced for latency reduction in LTE, E-UTRAN may be configured with both normal TTI with 1ms and short TTI with a value less than 1ms, such as 1 symbol or 0.5ms. With keeping the current LTE frame structure, OFDM symbol length, subcarrier spacing, etc., reduction of TTI generally means smaller transport block size (TBS) contained in one TTI, and relatively larger control overhead if DCI size is kept as the same.

[93] When short TTI is adopted, and as a result, the number of OFDM symbols in reduced in one TTI (e.g. from 14 to 2) or subcarrier spacing increases (e.g. from 15 kHz to 60 kHz), a RB size may be different from the current RB size. For example, with subcarrier spacing of 60 kHz, one RB may include 12×8 resource elements, instead of 12×14 resource elements. For another example, when TTI length is 2 OFDM symbol length, one RB may include 12×2 resource elements. If short TTI is used, particularly with smaller number of OFDM symbols, larger RB size in frequency domain may be considered (e.g. one RB includes 48×2 resource elements).

[94] It is generally desirable to use short TTI for control. However, it may increase control overhead and thus decrease the overall performance benefit with short TTI operation. Thus, it may be desirable to support different TTI length per different application/packet.

[95] Hereinafter, as a proposal for FS2, a nested frame structure using short TTIs according to an embodiment of the present invention is described. It is assumed that "K" different levels (or lengths) of short TTIs is supported in the network. For example, level 1 may correspond to the legacy TTI length (e.g. 14 OFDM symbols with normal CP), which means 1 TTI in the network. Level 2 may correspond to 7 OFDM symbols, which means 2 TTIs in the network, and so on.

[96] FIG. 7 shows an example of nested frame structure for a new RAT according to an

embodiment of the present invention. Different TTI length may be used between FS1 and FS2. FIG. 7-(a) corresponds to level 1, in which one TTI includes 14 OFDM symbols. Level 1 may be called FS1. FIG. 7-(b) corresponds to level 2, in which one short TTI includes 7 OFDM symbols. That is, one TTI of FS1 includes two short TTIs of FS2. FIG. 7-(c) corresponds to level 3, in which one short TTI includes 3/4 OFDM symbols. That is, one TTI of FS1 includes 4 short TTIs of FS2. FIG. 7-(d) corresponds to level 4, in which one short TTI includes 1/2 OFDM symbols. That is, one TTI of FS1 includes eight short TTIs of FS2.

[97] Accordingly, depending on the needed number of short TTIs within one TTI (from 1 to 8, and 14), short TTIs may be placed. However, in FIG. 7-(c), instead of 4/3/4/3 OFDM symbols for short TTIs, 3/4/3/4 OFDM symbols or 3/4/4/3 OFDM symbols or 3/3/4/4 OFDM symbols or 4/4/3/3 OFDM symbols may be used. Similar rotation for 1/2 OFDM symbol may also be applied to FIG. 7-(d). In case of 1 OFDM symbol case, total of 14 short TTIs may be placed. Similar mechanisms may be applied to different OFDM symbols per TTI (e.g. 12 or 10). The proposed frame structure described above may allow that short TTI may be nested to the next level short TTI. In other words, one short TTI of one level may be divided to 2 short TTIs of the next level (except from 8 short TTIs to 14 short TTIs).

[98] In the proposed frame structure, the first one or two OFDM symbols of DL may be used for legacy control region, and the last OFDM symbol of UL may be reserved for sounding reference signal (SRS) transmission (or to minimize the impact by legacy SRS). In terms of SRS transmission for a short TTI supporting UE, the following two approaches may be considered.

[99] (1) If additional SRS configuration is given to short TTIs, a UE may transmit additional SRS according to short TTI configuration. If additional SRS transmission is considered, SRS may be transmitted in the last OFDM symbol of the configured short TTI for level 2 TTI structure. For level 3 and 4, the first OFDM symbol may be used for SRS except for the last short TTI in the legacy TTI. This additional SRS configuration may be cell-specific and may be configured per each TTI configuration. Thus, potentially multiple SRS configuration may be given. A UE configured with one level may perform rate matching or puncture in cell-specific SRS configuration of higher levels (i.e. shorter TTIs) to protect SRS. For example, if a UE is configured with level 2, and the cell also configures SRS for level 3, the UE may puncture or performing rate matching around SRS symbols of level 3.

[100] (2) Only legacy SRS configuration may be used, and additional SRS transmission in short TTI may not be used.

[101] More specifically, in FDD, option (2) above may be used. In TDD, option (1) may also be considered.

[102] With the nested frame structure, a UE supporting short TTI may be configured with multiple short TTI levels for control channel monitoring. For example, if level 4 is configured, the UE may monitor control channel in OFDM symbol 0 (possibly for legacy PDCCH), OFDM symbols 2, 4, 6, 7, 9, 11, and 14. In each short TTI, the multiple TTIs or variable TTI may schedule up to the maximum number of total short TTIs in the legacy TTI or multiple of the maximum short TTI numbers (e.g. 8 or 8*k in this example). For example, if a UE is scheduled with 4*sTTI in 2nd short TTI with level 2, PDSCH may be scheduled in 2nd, 3rd, 4th, 5th short TTIs, which in total of 7 OFDM symbols in length. The level may be determined by short TTI length used for control channel monitoring. More specifically, if the first short TTI schedules PDSCH, and the legacy PDCCH length is equal or larger than the size of short TTI, data may not be mapped to the fully overlapped short TTI. However, it may be counted for multiple TTIs scheduling. In other words, data may be rate matched, though it has been scheduled.

[103] It may be good to restrict the size of data channel only for a few cases (e.g. 1 symbol, 2 symbols, 4 symbols, 7 symbols and 12 symbols). It may be required by the network to schedule data properly not to vary the size of PDSCH in terms of OFDM symbols. For this, similar to ACK/NACK transmission, the timing from control channel to data channel may be considered. The timing from control channel to data channel may be signaled via number of short TTIs where short TTI length can be determined by sPDCCH TTI length (e.g. level 4). Alternatively, the basic short TTI length for ACK/NACK may also be determined by higher layer separately. In other words, a basic short TTI length or the level of short TTI used in DL and UL may be configured, respectively. Based on the basic short TTI length, multi/variable TTI scheduling which allows scheduling longer than the configured TTI length may be considered. If the first symbol is reserved for control channel in every short TTI, PDSCH may be rate matched in such OFDM symbols. Otherwise, data may be transmitted in the first control region of every short TTI as well, and data may be rate matched around its own scheduling DCI. Multi/variable TTI scheduling may be expanded to the next longer short TTI or level 1 TTI. If level 4 is used, data may not be scheduled in the same short TTI if the short TTI length is 1 OFDM symbol. For example, only 2 bits of 1, 2, 4, 8 multiple short TTIs may be scheduled in level 4 which allows PDSCH transmission ends aligned with the next higher level short TTI.

[104] FIG. 8 shows an example of scheduling of multiple and different TTI via different TTI levels. Referring to FIG. 8, legacy PDCCH may schedule PDSCH of level 1, 2, 3 and 4. PDCCH of each level may schedule PDSCH of each level. That is, PDCCH of level 2 may schedule PDSCH of level 2, PDCCH of level 3 may schedule PDSCH of level 3, and PDCCH of level 4 may schedule PDSCH of level 4.

[105] One drawback of the nested frame structure described above is that it leads different TTI lengths among short TTIs in the same level. To overcome this problem, partial overlap between two short TTIs may be considered.

[106] FIG. 9 shows an example of overlapped short TTI in a nested frame structure for a new RAT according to an embodiment of the present invention. That is, in the nested frame structure, short TTIs may be overlapped/shared to allow 2^N symbols per TTI. FIG. 9-(a) shows level 5 in which 16 short TTIs, instead of 14 short TTIs, are configured. In order to configure 16 short TTIs, fourth OFDM symbol are shared between TTI #3 and TTI #4, and eleventh OFDM symbol are shared between TTI #11 and TTI #12. FIG. 9-(b) shows level 4 in which 8 short TTIs are configured. In order to configure 8 short TTIs which has the same length, fourth OFDM symbol are shared between TTI #1 and TTI #2, and eleventh OFDM symbol are shared between TTI #5 and TTI #6. FIG. 9-(c) shows level 3 in which 4 short TTIs are configured. In order to configure 4 short TTIs which has the same length, fourth OFDM symbol are shared between TTI #0 and TTI #1, and eleventh OFDM symbol are shared between TTI #2 and TTI #3. 9-(d) shows level 2 in which 2 short TTIs are configured. In order to configure 2 short TTIs which has the length of 8 OFDM symbols, seventh and eighth OFDM symbols are shared between TTI #0 and TTI #1. The embodiment shown in FIG. 9 is only exemplary, and actual OFDM symbol which is shared between different short TTI may be changed. The idea is to allow some OFDM symbols overlapped among different short TTIs to align short TTI lengths.

[107] The drawback of the above approach is that control/data between two different short TTIs may be overlapped in the overlapped OFDM symbols, which may affect the overall FDM performance of control/data channels. However, if data and control is multiplexed by FDM, this overlap between control and data may be manageable if TDM between control and data is assumed. Alternatively, as the issue becomes more significant in level 2, overlap may not be considered in level 2.

[108] FIG. 10 shows another example of overlapped short TTI in a nested frame structure for a new RAT according to an embodiment of the present invention. Referring to FIG. 10, short TTI length may be configured as 7 actual OFDM symbols and fourth OFDM symbol may be mapped to #3 and #4 in each slot, respectively.

[109] The above approach may be applied to other levels as well. This may be explained that virtually there are 16 OFDM symbols which are mapped to physically 14 OFDM symbols. In this way, the design working for 16 OFDM symbols may be incorporated to 14 OFDM symbols cases (and vice versa). More specifically, in case from 16 OFDM symbols to 14 OFDM symbols, one OFDM symbol may be dropped between #3 and #4. In case from 14 OFDM symbols to 16 OFDM symbols, OFDM symbol #3 may be repeated. In terms of sharing OFDM symbol, at least in TDD, it is desirable to

use OFDM symbol #3 (in normal CP) in each slot may be preferable considering DM-RS position.

[110] When OFDM sharing is used, the number of OFDM symbols of multi/variable TTI scheduling may consider actual number of OFDM symbols in which multiple TTIs are spanning. In this sense, the total number of scheduled length may be smaller than multiple of short TTI length. This approach may allow that the number of OFDM symbols in each short TTI is 2^N, where N is 0, 1, 2...K depending on the necessity of latency and UE processing power requirement. In the overlapped short TTI with level 5 (e.g. TTI #3 and #4), it may be necessary to indicate which TTI is used for control and/or data channel, which may be differentiated via scrambling of control/data (some other means may also be considered). This may be particularly important when HARQ-ACK timing is determined based on 2^N number of OFDM symbols or the number of short TTIs in one the largest TTI size. For example, if TTI #3 schedules with gap of 2 TTI for sPDSCH, this may imply that PDSCH will be scheduled in TTI #5 (which is next OFDM symbol to TTI #3), thus, the gap may be in fact one short TTI. This may simplify the operation if system may require operating in multiple different levels of short TTI lengths. The similar concept may be used for UL as well. In UL, collision in the same resource between two short TTIs with level 5 may be considered as collision and transmission on one channel may be dropped per rule (if the network schedules collisions). For example, the rule may be configured based on uplink control channel information (UCI) priority or based on timing.

[111] For one example of the nested frame structure, if FS1 consists of 30 subframes, one subframe may be overlapped between two TTIs for FS2. If mMTC UE is scheduled in those overlapped TTIs, it may be counted only one as valid. Alternatively, instead of overlap of two TTIs, different TTI lengths may be configured. For example, level 2 of FS2 may have l TTIs with 2/2/2/2/1/2/2/2 in 1.5 ms range. Alternatively, reserve some resources may be reserved not used by mMTC devices. Those reserved resource blocks may be placed in any subframes consecutively or discontinuously. Alternatively, different levels may be defined by multiple of previous level's TTI length.

[112]

[113] B. Frame structure for mMTC in TDD case

[114] The above frame structure may be applied to a frame structure for mMTC in TDD. Additionally, in TDD, two different frame structures may be considered. One is a frame structure in which DL/UL switching may occur in a multiple TTI unit similar to current LTE TDD DL/UL configuration. The other is a frame structure that DL/UL switching may occur in every TTI to allow efficient DL and UL transmission and ACK/NACK transmission. For the latter case, DL control region and UL control region may need to be used for DL and UL, respectively, unless the network supports

full duplex capability. If the network does not support full duplex capability, thus, it may be necessary to align DL portions between FS1 and FS2. For this, the following two approaches may be considered.

[115] (1) FS1 configuration of DL/UL may be given to UEs of FS2, and UEs of FS2 may construct DL portion and UL portion according to DL/UL configuration of FS1. For example, if subcarrier spacing of FS2 is 2 times that of FS1, and the configuration of DL/UL configuration is DDDDDUUUUU (where D indicates subframes in which PDSCH may be transmitted, and U indicates subframes in which PUSCH may be transmitted), then DL and UL portion of FS2 may be constructed as DDSUU, where D indicates DL control and PDSCH portions can be used for DL and U indicates PUSCH portion and UL control portion can be used for UL.

[116] (2) FS2 configuration of DL/UL may be given to UEs of FS1, and UEs of FS1 may assume that subframe type (either PDSCH or PUSCH) may be determined by FS2 configuration, unless it's dynamically changed via scheduling or dynamic indication per each TTI. For example, assuming that the subcarrier spacing of FS2 is two times of that of FS1, FS2 may indicate DDDDDUUUUU. It may imply that default DL/UL configuration of FS1 is DDDDDDDDDDUUUUUUUUUU. More generally, a default DL/UL configuration of FS1 may be configured, and it may be overwritten by dynamic indication of subframe type change and/or via scheduling (e.g. DL grant or UL grant). Higher layer reconfiguration may also be considered.

[117] In terms of configuration of FS1 default DL/UL configuration type, a subset of TTIs/subframes with fixed D or U may be configured. Those fixed subframes may not change the subframe type either via dynamic singling or dynamic scheduling. For FS2, those fixed subframes may be at least used. For other subframes, additional configuration of subframe type and/or DL/UL configuration and/or availability for FS2 UEs' usage may be configured.

[118] Alternatively, In terms of configuration of FS1 default DL/UL configuration type, different types of subframe to FS1 UEs and FS2 UEs may be configured and FS1 UEs and FS2 UEs are multiplexed by FDM between DL and UL. FS1 UEs may be further classified between FS1 UEs with eMBB use cases and FS1 UEs with eV2X use cases. In other words, a subset of subframes with "D" type subframes may be fixed such that measurement signals and/or cell system bandwidth wide and/or cell specific signals/channels can be transmitted. For other subframes, the subframe type may be indicated as "U" from FS1 UE perspective such that sidelink resources can be configured/used in those resources, whereas the subframe type can be indicated as "D" from FS2 UE perspective. From the network perspective, the resource may be shared among FS1 and FS2 UEs and the network may transmit DL signals towards FS2 UEs. This may be applied to the same FS UEs depending on its communication/discovery types as well.

In other words, partial resources may be allocated for sidelink resources which can be multiplexed by FDM with DL resources in the same TTI. However, from a UE perspective, it may either perform DL or SL transmission.

[119]

[120] C. Frame structure for URLLC in TDD case

[121] The above frame structure with different subcarrier spacing may be applied to a frame structure for URLLC in TDD. If short TTI needs to be used for FS2, more DL/UL switching points within one TTI or different subframe type may be used. Or, if shorter OFDM symbol lengths are used for URLLC UEs for FS2, in one TTI of FS1, there may be different OFDM symbols used for DL and UL between FS1 and FS2.

[122] If the network does not support full duplex capability, it seems to be difficult to support different DL and UL in the same OFDM symbol duration. To minimize the impact, partial DL or UL transmission may be used in FS1. In partial DL or UL transmission, a UE may be scheduled with only one slot PDSCH or PUSCH transmission (if subcarrier spacing of FS2 is twice of FS1). In this case, the network may transmit data and then switch to UL and process URLCC uplink data. More generally, if FDM between FS1 and FS2 with different subcarrier spacing is used with potentially different UL/DL direction between FS1 and FS2, length of PDSCH or PUSCH scheduling and/or starting OFDM symbol index of PDSCH/PUSCH may be configured. Supporting partial PDSCH/PUSCH may be enabled by higher layer or dynamically indicated via common signaling or DCI or some signaling. Furthermore, FS2 needs to ensure DL control portion and UL control portion of FS1. Thus, first a few OFDM symbols may be used for DL control portion and last few OFDM symbols may be used for UL control portion. To minimize the DCI overhead, partial subframe length may be higher layer configured, and only starting position may be signaled. 0 or 1 may be used between partial and full TTI scheduling. Alternatively, it may also be combined with multiple TTI scheduling as well. Accordingly, partial TTI scheduling may be one of multi-TTI scheduling option.

[123] FIG. 11 shows another example of a frame structure for a new RAT according to an embodiment of the present invention. FIG. 11 shows examples of frame structures when short TTIs are used in TDD. This may be treated similar to the above case with FDD, assuming that the last short TTI or first short TTI may not be used and gap symbol may be punctured or rate matched. FIG. 11-(a) corresponds to level 1, i.e. FS1. FIG. 11-(b) corresponds to level 2 of FS2, in which one short TTI consists of 6 OFDM symbols. 2 short TTIs are configured in one TTI of FS1. FIG. 11-(c) corresponds to level 3 of FS2, in which one short TTI consists of 3 OFDM symbols. 4 short TTIs are configured in one TTI of FS1. FIG. 11-(d) corresponds to level 4 of FS2, in which one short TTI consists of 1/2 OFDM symbols. For DL, short TTIs having 2/1/2/1/2/1/2/1

OFDM symbols are configured, and for UL, short TTIs having 1/2/1/2/1/2/1/2 OFDM symbols are configured. 8 short TTIs are configured in one TTI of FS1. FIG. 11-(e) corresponds to level 4 of FS2, in which one short TTI consists of 2 OFDM symbols. 6 short TTIs are configured in one TTI of FS1.

[124] Meanwhile, similar to FDD case, different layout may also be possible. For example, if guard period or switching from DL to UL takes more than one OFDM symbol, portioning of short TTIs may be changed. Depending on the network capability, short TTI of FS2 may have different direction from FS1.

[125] For both FDD and TDD, in terms of scheduling, FS1 UE may also be scheduled with FS2, and where only data portion may be mapped over multiple TTIs of FS2. In terms of resource mapping, UEs of FS1 may be configured with the size of FS2 (if any), and the bitmap may indicate the data mapping to a set of short TTIs of FS2. For example, if a case of FIG. 11-(e) is used, bitmap of 6 bits may be used to indicate to which short TTIs FS1 UE PDSCH can be mapped. For example, [1 1 1 1 0 0] may indicate that PDSCH is mapped to first four short TTIs, is not mapped to the last two short TTIs. Depending on the latency requirement, different level of short TTIs may be used for each packet. In terms of scheduling, a UE supporting short TTI may monitor DL control region in the lowest level that the network supports (which may be signaled by SIB or higher layer), or the level may be configured per UE or per session or per application. It is also possible that short TTI transmission may start in the middle of longer TTI transmission. In this case, preemption of longer TTI transmission may also be possible. To minimize the impact from this preemption, the network may send a common signal in short TTI control region which indicates whether there is any short TTI transmission or not. Alternatively, a longer TTI UE may perform blind search on data. Alternatively, in the next longer TTI control, the network may indicate whether there was interrupt in the previous transmission or not, and if so, the network may further indicate which short TTIs have been used.

[126] In summary, the proposed frame structure may allow that shorter TTIs can be nested to the next level of short TTI. In other words, one TTI of one level may be divided to 2 short TTIs of the next level (except from 4 short TTIs to 6 short TTIs and 6 short TTIs to 12 short TTIs if nested frame structure for 8 short TTIs is not used, and if the nested frame structure is used, only exception from 8 short TTIs to 12 short TTIs). Similar to FDD case, the order between 1/2 in 8 short TTIs case may be changed. This nested frame structure may allow multi-TTI scheduling a bit easier. For example, the shortest TTI may be configured to allow potentially many control possibilities with multi-TTI scheduling to [1...N], where N is the level of the configured short TTI level.

[127] FIG. 12 shows another example of a frame structure for a new RAT according to an embodiment of the present invention. If DL and UL portion is equal within one TTI,

potentially limited number of levels may be supported for short TTIs. Referring to FIG. 12, only level 1, level 2, and level 3 are supported. FIG. 12-(a) corresponds to level 1, i.e. FS1. FIG. 12-(b) corresponds to level 2 of FS2, in which one short TTI consists of 6 OFDM symbols. 2 short TTIs are configured in one TTI of FS1. FIG. 12-(c) corresponds to level 3 of FS2. For level 3, short TTI size of 2 OFDM symbols may be considered (in total of 3 short TTIs per DL/UL) or 1/2/1/2 (or 2/1/2/1) short TTI lengths may be considered to support 4 short TTIs.

[128] UL switching symbol may be placed in any OFDM symbol in subframe with DL transmission. In other words, gap for DL to UL switching may be placed in any OFDM symbol which will be used by UE for switching. From DL perspective, the gap and UL symbols may be rate matched or punctured. From UL perspective, the gap and DL symbols may be rate matched or punctured.

[129]

[130] D. Frame structure for eV2X in FDD

[131] In this case, sharing among UEs transmitting towards the network needs to share UEs transmitting sidelink. The resource allocation mechanism or frame structure of eV2X UEs may be similar to other FS1 UEs. From a V2X UE perspective, if the same RF/ baseband capability of DL is used for both reception from the network and reception from other UEs, it may be necessary to separate DL resources between two transmission types.

[132] Similar mechanisms used in TDD case may be applied to FDD case as well, where sidelink resources may be configured in either DL or UL spectrum. The TTI length of sidelink may also be reduced to allow DL control reception and/or gap creation. Similar approach to place SL DL/UL control may be considered. In this case, if sidelink is only configured in UL spectrum, DL control may not be considered. If sidelink is configured in DL spectrum, UL control may not be considered. Alternatively, UL and DL spectrum may be used in a pair among different cells for different UEs. For example, a set of subframes may be fixed as DL or UL in each DL and UL spectrum. These configured subframes may not be configured as sidelink resources in either DL or UL spectrum. Other subframes in either DL or UL may be used for sidelink operation, like multi-carrier sidelink operation. Each UE may determine reception frequency and transmission frequency between DL and UL spectrum. Once it determines its direction, the UE will continue receiving or transmitting in one frequency and do opposite in the other frequency. In other words, other than fixed subframes, flexible subframes in either DL or UL may be used, like one carrier from a sidelink perspective similar to TDD case. More generally, TDD case may be applied in those flexible subframes, and DL carrier may include DL control in each TTI depending on configurations and UL carrier may include UL control in each TTI

depending on configuration.

[133]

[134] E. Frame structure for eV2X in TDD

[135] If TDD is used for eV2X, FS1 may be configured. Depending on its subframe type configuration of FS1, subset of UL portions may be used for sidelink operation (possibly except for UL control regions). Alternatively, a subset of subframes may be configured with subframe type, and the other subframes may be determined based on higher layer signaling and/or dynamic signaling. For example, non-DL subframe may be potentially allowed as sidelink capable subframes, then which subframes are usable for sidelink operation may be dynamically indicated by scheduling assignment (SA) transmission. In this case, to avoid any ambiguity, the SA may be transmitted in fixed UL subframe configured in MIB and/or SIB.

[136] IF DL control is potentially used in flexible subframes (i.e. flexible subframe is a subframe without configured subframe type via MIB and/or SIB), it may be desirable to avoid use of potential DL control portion in sidelink operation to minimize interference to other UEs, and potentially allow listening on DL control by eV2X UEs. In this case, DL control and potentially a gap to switch from DL to UL may be assigned in every flexible subframe. Alternatively, a subset of subframes with DL control may also be preconfigured, and a UE may assume that the first one or a few OFDM symbols may not be used for sidelink transmission in such subframes. To align resources among different cells, cells may be coordinated including DL control portions. Or, simply one or a few first OFDM symbols may always not be used for sidelink transmission in every TTI.

[137] Alternatively, subframe type for FS1 may be ignored and only sidelink resource information may be considered. For example, the network may perform FDM approaches between DL and UL between FS1 UEs receiving the data from the network and sidelink UEs.

[138] Whether to reserve DL control and UL control may be determined by at least one of the following approaches.

[139] - The network may configure the length of sidelink resource used in one TTI or the necessity of DL control and/or UL control region reservation. This may also allow flexible configuration of DL and UL control resource from network perspective. Only DL control portion may be reserved.

[140] - The UE may determine whether to reserve DL control and UL control depending on communication/discovery type. If the network controlled communication/discovery is used, DL control may be reserved. Otherwise, full TTI may be used for sidelink transmission. The gap may be used between DL and UL direction to minimize interference.

[141] - The resource may also include TTI size per each TTI in resource configuration.

[142] - It may be prefixed or follow a rule to determine the size.

[143] When each cell uses dynamic subframe type, different interference may be expected depending on subframe type on sidelink resources. In this sense, a subset of default UL subframes may be configured, and at least control channels of sidelink (such as SA) may be transmitted in those UL subframes. Those fixed UL subframes may be aligned among neighbor cells to minimize the interference among cells (similar concept may also be applied to DL as well).

[144] Also, ACK/NACK and control information for sidelink operations may be supported. Thus, sidelink DL control (configuration of sidelink resources, collision handling, etc., where all UEs except for the controlling UEs are supposed to listen) and ACK/NACK or feedback resource of sidelink (called sidelink UL control) should be placed somewhere. For this, at least one of the following options may be considered.

[145] - Option 1: Sidelink SL control may be multiplexed with DL/UL control by FDM (same direction): Or, the same OFDM symbol for DL control may be used for sidelink DL control and the same OFDM symbol for UL control may be used for sidelink UL control. It may follow the network configuration and the same configuration may be indicated to other UEs. This may be beneficial for relay nodes or UEs without network controlled operation. If this option is used, proper gap or interference mitigation between DL control and sidelink DL control may be assumed.

[146] - Option 2: Sidelink control FDM may be multiplexed with DL/UL control by FDM (opposite direction): Or, sidelink DL control may be placed in UL control region and sidelink UL control may be placed in SL DL control region to minimize the interference, assuming that interference from a UE to the network may be less significant to interference between UEs.

[147] - Option 3: Nested self-contained subframe

[148] FIG. 13 shows an example of a nested self-contained subframe according to an embodiment of the present invention. Referring to FIG. 13, sidelink DL control and/or sidelink UL control may be placed only in resources configured for sidelink operation. Depending on UE capability, gap from sidelink DL control to sidelink-transmit may be necessary. Depending on UE timing advance (TA) and other UL timing, gap between sidelink DL-receive to sidelink UL control may also be necessary. To allow a gap, it may be generally desirable not to use the last OFDM symbol for sidelink. In this case, either sidelink UL control or sidelink DL control may be placed in the second next to the last OFDM symbol.

[149] If the last OFDM symbol is used for UCI transmission toward to the network, it may not be used for the gap. To handle this case, a UE may create a gap by not receiving the next OFDM symbol if the next subframe is also used for sidelink. In this case,

sidelink UL control may be omitted and a UE may not receive sidelink DL control. To avoid such a case, if there is possibility of UCI transmission in the last OFDM symbol, it may be desirable to add one additional gap in the first OFDM symbol of the TTI.

[150] Overall, the followings may be considered for sidelink frame structure. TTI length of a sidelink may be at least 2 * gap OFDM symbols smaller than TTI length of host frame structure (e.g. if the gap size is 1 OFDM symbol, 2 OFDM symbols smaller than the FS1). Further, sidelink DL control and sidelink UL control may be placed in next to DL control and UL control (after and before) in the same TTI. If the gap is necessary to switch from sidelink DL/UL control to DL/UL control, the following order of priorities, UL control, sidelink DL/UL control, and DL control, may be used. If there is no sufficient gap is created by dropping lower priority, the next lower priority channel may be dropped.

[151]

[152] 4. Additional frame structure design for URLLC considering U-plane latency

[153] In the new RAT, scalable numerology may be considered. Some candidates of subcarrier spacing include 15 kHz, 30 kHz, 60 kHz, 120 kHz, etc. Among those, at least 15, 30, 60 kHz subcarrier spacing may be applied for under 6 GHz frequency band. Considering that the requirement of URLLC is 0.5ms for U-plane latency, some consideration on frame structure may be necessary. To minimize the overall U-plane latency, UL subframe boundary may be shifted. Assuming that data at L2/L3 queue may be scheduled to the next available subframe, the average latency may be 0.5*TTI. Assuming that UL subframe boundary is shifted by decoding latency of data channel, the latency to get the data at L2 at the destination side (without considering HARQ process) may be around 2*TTI.

[154]

[155] A. Frame structure for URLLC in FDD

[156] If HARQ process is considered, in FDD, since UL can be available anytime, the latency to encode ACK/NACK and TA may be added with HARQ retransmission latency. Overall, it may become 2.8*TTI (around 3*TTI).

[157] Table 1 shows an example of numerologies for normal CP and extended CP with 30 kHz spacing.

[158] [Table 1]

	eMBB - NCP	eMBB - ECP	URLLC - NCP	URLLC - ECP
OFDM symbol	33.34	33.34	33.34	33.34
Number of OFDM symbols in a TTI	14	12	4/3/4/3 in 0.5 ms	Option 1: 3 symbolsOption 2: 4 symbols
TTI length	0.5 ms	0.5 ms	0.1425/0.1075/0.1425/0.1075 ms	0.125 (with Option 1)0.16667 (with Option 2)
CP length	Half of LTE CP in NCP case	8.33us	Half of LTE CP in NCP case	8.33us

[159] Table 2 shows an example of numerologies for normal CP and extended CP with 15 kHz spacing.

[160] [Table 2]

	eMBB - NCP	eMBB - ECP	URLLC - NCP	URLLC - ECP
OFDM symbol	66.67 us	66.67 us	66.67 us	66.67 us
Number of OFDM symbols in a TTI	14	12	2	2 symbols
TTI length	1 ms	1 ms	0.143 ms	0.1667
CP length	Half of LTE CP in NCP case	Half of LTE CP in ECP case	Half of LTE CP in NCP case	Half of LTE CP in ECP case

[161] Table 3 shows an example of numerologies for normal CP and extended CP with 60 kHz spacing.

[162] [Table 3]

	eMBB - NCP	eMBB - ECP	URLLC - NCP	URLLC - ECP
OFDM symbol	16.67 us	16.67 us	16.67 us	16.67 us
Number of OFDM symbols in a TTI	14	10 (option 1)12 (option 2)	7	5 symbols (option 1)6 symbols (option 2)
TTI length	0.25 ms	0.25 ms	0.125 ms	0.125
CP length	Half of LTE CP in NCP case	8.33us (option 1)4.16 us (option 2)	Half of LTE CP in NCP case	8.33us (option 1)4.16 us (option 2)

[163] If 3 symbol short TTI is used (e.g. URLLC / 30 kHz / option 2), one short TTI may cross the slot boundary of eMBB subframe if slot is defined. More generally, short TTI may be defined over one or multiple subframes. One example is to aggregate two subframes and divide two subframe into multiple short TTIs (e.g. with 14 OFDM symbols of eMBB subframe, 4 OFDM symbol * 7 short TTIs may be constructed over two subframes for URLLC use case). In this case, where the short TTI starts (e.g. every even subframe or every odd subframe) needs to be clarified and may be defined in the specification or determined via initial access procedure.

[164]

[165] B. Frame structure for URLLC in TDD

[166] In TDD, since the ACK/NACK timing may be dependent on the availability of UL, if there is unavailable UL, the latency may be increased. Thus, to support low latency, in every short TTI, it is expected to have UL portion which can be dynamically created, whenever there is UL transmission. In TDD, if UL subframe boundary is shifted, UL transmission may occur in the middle of subframe. This may be handled by the network if the network and/or UE support (semi) full duplex capability. Or, larger delay budget may be assumed for TDD (e.g. 2 * TTI + TA without HARQ, 3 * TTI with HARQ). In TDD, even without subframe offset, as DL portion is relatively smaller compared to FDD, overall decoding latency may also be reduced (which in turn may lead less peak data rate with low latency). For TDD, the similar TTI length and the number of OFDM symbol per TTI may be considered.

[167] FIG. 14 shows another example of a frame structure for a new RAT according to an embodiment of the present invention. In FIG. 14, 2 OFDM symbol length frame structure is supported in TDD. In order to support 2 OFDM symbol length with 15 kHz or other subcarrier spacing, one OFDM symbol may be assumed for DL portion, and

double subcarrier spacing for uplink portion may be assumed (e.g. 30 kHz with 15 kHz DL subcarrier spacing) with keeping the same CP overhead for UL. The remaining part may be used for guard period (GP) including TA and DL/UL switching time.

[168] FIG. 15 shows another example of a frame structure for a new RAT according to an embodiment of the present invention. In FIG. 15, 3 OFDM symbol length frame structure is supported in TDD.

[169] For multiplexing of different use cases from the network perspective, different numerology or different subcarrier spacing may be used where the same CP may be still assumed between two different use cases. For this, 1 OFDM symbol for DL and 1 OFDM symbol for GP and 1 OFDM symbol for UL may be define in 3 OFDM symbol TTI length. Alternatively, similar to 2 OFDM symbol case, only UL portion may use different subcarrier spacing to allow more DL OFDM symbols available.

[170] More generally, this approach may be explained that URLLC can be utilized with extended CP with larger subcarrier spacing compared to eMBB to maintain the same level of CP. The remaining time may be applied towards GP between UL/DL switching and TA. Having larger GP in URLLC, TDD may be beneficial to allow more decoding time and UL transmission preparation. This case may be beneficial to reserve more processing time or allow larger GP which may be beyond one OFDM symbol length in 3 OFDM symbol short TTI case in TDD.

[171] FIG. 16 shows an example of different subcarrier spacing between URLLC and eMBB which are multiplexed in a same carrier or frequency band. From a UE perspective, each portion may be managed by individual transmission point or a cell such that initial access can be achieved separately per use cases. However, URLLC provided by shorter TTI with the same numerology with eMBB may also share the initial access procedure with host eMBB case. In this sense, via the initial access, whether to support short TTI or regular TTI may be informed.

[172] In determining UL portion for short TTI for URLLC, the portion or the number of OFDM symbol for UL portion in each short TTI may also depend on the necessity of demodulation RS (DM-RS) transmission. For example, if a UE requires to transmit DM-RS at least in one subframe in every 7 OFDM symbol, short TTIs within 7 OFDM symbol may not need to transmit DM-RS multiple times. In this sense, the first short TTI in every 7 OFDM symbol may have at least two OFDM symbols for UL portion and the remaining short TTIs may have one OFDM symbol for UL portion. Accordingly, dynamic determination of UL portion size may be supported depending on the necessity of DM-RS transmission in a given short TTI or not. This may also impact the behavior of DL reception, where a UE may puncture or not receiving the last DL OFDM symbol to shift UL portion one symbol forward. This may be restricted in case of 3 OFDM symbol short TTI. In this case, alternative approach is to transmit GP and

DM-RS in one OFDM symbol with different subcarrier spacing or by other means.

[173]

[174] 5. Above 6 GHz frequency

[175] The above description of the present invention may be applied for a frequency band below 6 GHz. The above description of the present invention may be applied for a frequency band above 6 GHz as well. In a frequency band above 6 GHz, analog beam may be used. In this case, the unit of beam switching may be used similar to one TTI mentioned for FS1 and FS2. However, the unit of beam switching for data transmission may be assumed for the unit size. For example, if beam switching occurs in every OFDM symbol for PSS/SSS or control channel transmission, whereas beam switching occurs only once per TTI for data transmission, the basic unit for beam switching may be 1 TTI. If beam switching for data transmission occurs in every 1/2 TTI, the basic unit for beam switching may be 1/2 TTI. When configuring sidelink resources, beam direction of each resource may be indicated such that UEs can communicate each other based on beam direction and based on each other's location information. The same size of subcarrier spacing among different applications may be used for frequencies above 6GHz.

[176]

[177] 7. DM-RS sharing

[178] For PUSCH, depending on coverage level, the network may configure the number of TTIs used for PUSCH transmission. As DM-RS for one OFDM symbol TTI in UL is very challenging (similar issue may be in DL as well, yet the problem may become more significant in UL due to SC-FDM characteristic and PAPR issue), the TTI of UL can be represented a bit differently in consideration of potentially DM-RS sharing among different TTIs.

[179] FIG. 17 shows an example of DM-RS sharing according to an embodiment of the present invention. FIG. 17-(a) shows a case of level 5 (i.e. 1 OFDM symbol short TTI) with discontinuous DM-RS. In this case, one symbol short TTIs share the DM-RS in the middle of legacy slot. Potentially different cyclic shift (CS) may be configured or preconfigured per each OFDM symbol to allow multiplexing of different TTIs. If a UE schedules more than one TTIs sharing the same DM-RS, it may continue using the first DM-RS scrambling/sequence of the first transmission among multiple TTIs. FIG. 17-(b) shows a case of level 4 (i.e. 2 OFDM symbols short TTI) with no DM-RS sharing.

[180] FIG. 17-(c) shows a case of level 4 (i.e. 2 OFDM symbols short TTI) for physical sidelink shard channel (PSSCH) with DM-RS sharing. FIG. 17-(d) also shows a case of level 4 (i.e. 2 OFDM symbols short TTI) for PSSCH with DM-RS sharing. For Level 4 with DM-RS sharing, there may be two different approaches.

[181] - Approach 1: DM-RS sharing does not occur between adjacent short TTIs with 2 OFDM symbols, and DM-RS sharing occurs between short TTIs with 1 OFDM symbol and 2 OFDM symbols. This approach corresponds to FIG. 17-(c).

[182] - Approach 2: DM-RS sharing occurs over all TTIs similar to level 5. One DM-RS symbol is shared by multiple short TTIs. This corresponds to FIG. 17-(d). Similar level 5, CS may be predefined or configured per OFDM symbol, and the first OFDM symbol mapped scrambling/CS/sequence is used if the short TTI size is larger than 1.

[183] FIG. 17-(e) shows a case of level 3 (i.e. 3/4 OFDM symbols short TTI) for physical uplink control channel (PUCCH) with no DM-RS sharing. FIG. 17-(f) shows a case of level 3 (i.e. 3/4 OFDM symbols short TTI) for PSSCH with DM-RS sharing. For level 3, if DM-RS sharing is considered, the fourth OFDM symbol in each slot may be used for DM-RS sharing.

[184] Additional DM-RS within a short TTI may be added which may or may not be shared among different short TTIs. For example, if PUCCH transmission is considered, with DM-RS sharing, additional DM-RS (the same DM-RS or with different CS) may be used in each TTI as well.

[185] FIG. 18 shows an example of PUSCH scheduling with DM-RS sharing according to an embodiment of the present invention. Referring to FIG. 18, PUSCHs of level 4 share DM-RS, and PUSCHs of level 3 with 2 short TTIs may also share DM-RS.

[186] FIG. 19 shows an example of PUCCH scheduling without DM-RS sharing according to an embodiment of the present invention. Referring to FIG. 19, there is no DM-RS sharing.

[187]

[188] 8. ACK/NACK transmission

[189] For ACK/NACK transmission or UCI transmission via PUCCH, the network may also indicate the number of TTIs used for ACK/NACK transmission or PUCCH transmission via DCI or higher layer signaling. As the coverage of ACK/NACK transmission may also be dependent on the number of ACK/NACK bits or UCI bits, it may be dynamically indicated by DL grant. For example, the timing and frequency offset of ACK/NACK transmission, and also the number of TTIs used for ACK/NACK transmission may be configured in DL grant. Or, the length may be determined by the number of UCI bits. The number of TTIs used for PUCCH may be semi-statically configured. In terms of baseline timing of ACK/NACK, (sPDSCH transmission duration + sPDSCH transmission duration (for decoding) or higher layer configured decoding latency + 2 * sTTI for UL for ACK/NACK preparation) may be assumed. If there is offset configured in the DL grant, the offset may be added to the baseline timing of ACK/NACK.

[190]

[191] 9. Short TTI indexing

[192] To indicate a short TTI within the largest TTI, assuming the largest TTI uses the subframe index, separate indexing of short TTI may be considered. In one subframe, K maximum short TTI may be placed. In terms of configuration of e.g. semi-persistent scheduling (SPS), CSI, etc., or any periodic configuration, periodicity may be represented by TTI length or multiple of TTIs. The periodicity may start from SFN=0 and subframe index = 0. Alternatively, periodicity may be represented in two level, i.e. periodicity in subframes and periodicity within a subframe.

[193]

[194] 10. Short TTI length for each channel

[195] There are a couple of aspects to determine right shot TTI length for each channel, e.g. the file size, system resource utilization, UE geometry, etc. Overall, smaller file size in a lighted loaded scenario for good coverage UEs may lead best performance gain, whereas very little or even worse performance may be expected with short TTI for poor coverage UEs with large file sizes. In this sense, it seems considerable to apply UE-specific TTI length at least based on UE geometry. However, the file size also impacts on the overall performance gain due to the associated protocol overhead and control overhead. In this sense, mechanisms to allow dynamic change of sPDSCH/sPUSCH may be beneficial to address the case where a UE has multiple transmission control protocol (TCP) sessions with different file sizes. As packets from different TCP sessions are not differentiable from the physical layer perspective, it may be beneficial to consider dynamic TTI length adaptation via DCI.

[196] To support this, the following overall approaches may be considered.

[197] (1) Dynamic TTI length for all channels: The TTI length of sPDCCH may be dynamically changed which are blindly monitored by a UE. Based on the scheduled sPDCCH, the UE may determine the TTI length for sPDSCH/sPUSCH. This approach however requires some mechanism to identify the length of sPDCCH. One approach is to assume that FDM between sPDCCH and sPDSCH is used such that sPDCCH is transmitted always over the entire short TTI. Or, explicit indication in DCI may be necessary.

[198] (2) Fixed TTI length for sPDCCH with dynamic indication via DCI: Alternatively, the TTI length used for sPDCCH may be higher layer configured, and the TTI length of scheduled sPDSCH or sPUSCH may be dynamically adapted by the signaling in DCI.

[199] The first approach may offer benefits to adapt sPDCCH resource in time domain (if sPDCCH and sPDSCH is multiplexed partially or fully by FDM). This however may be also achieved by different aggregation levels. Furthermore, it seems that both approaches may require potentially explicit indication via DCI. Thus, the clear benefits of

the first approach while it restricts the flexibility are not clear. In this sense, to simplify the UE blind decoding, refer the second approach may be preferred. In other words, supporting different TTI length for data channel may be supported by a multiple TTI scheduling manner.

[200] When variable/multi-TTI length scheduling is supported, the issue with multiplexing between sPDSCH with different TTI lengths may be also considered in terms of processing latency For example, if decoding latency is same as the length of sPDSCH, if longer TTI scheduling occurs before shorter TTI scheduling happens, the decoding or processing of following shorter TTI can be delayed (unless pre-emption is assumed). Thus, depending on the scheduling, the overall latency till ACK/NACK transmission can be changed. To address different cases, asynchronous HARQ-ACK feedback timing for sPDSCH may be considered as well where ACK/NCK timing can be signaled via DL scheduling DCI. Further, the shorter TTI of PUCCH transmission may reduce the overall coverage. This may be all right for good coverage UEs whereas it may impact on the cell edge UEs. In this sense, the TTI length for sPUCCH transmission may be semi-statically configured. Based on the semi-statically configured TTI length for sPDCCH and sPUCCH, timing of DL and UL may be respectively determined which are used for resources for DL and UL transmissions.

[201]

[202] FIG. 20 shows a method for configuring a frame structure for a new RAT by a network node according to an embodiment of the present invention. The present invention described above may be applied to this embodiment.

[203] In step S100, the network node configures a first frame which has one legacy TTI and a second frame which has multiple short TTIs. In step S110, the network node communicates with a UE by using at least one of the first frame and the second frame.

[204] The second frame may have the nested frame structure described above. The second frame may contain different number of short TTIs per a number of symbols in each short TTI. The number of symbols in each short TTI may be identical. In this case, at least one symbol may be shared between adjacent short TTIs.

[205] The second frame may contain at least one of a symbol for DL control, a symbol for UL control, a symbol for a sidelink DL control or a symbol for a sidelink UL control. The symbol for DL control may be placed in a first symbol of the second frame, and the symbol for UL control may be placed in a last symbol of the second frame. The symbol for sidelink DL control may be placed in a second last symbol of the second frame, and the symbol for sidelink UL control may be placed in a second symbol of the second frame. Further, a gap may be configured between the symbol for DL control and the symbol for sidelink UL control, or between the symbol for sidelink DL control and the symbol for UL control.

[206] A synchronization signal may be transmitted in a minimum system bandwidth with minimum density in the second frame. The synchronization signal may be shared among the first frame and the second frame. The synchronization signal may be repeated in a frequency domain or a time domain.

[207] The first frame and the second frame may be configured according to one of different baseband bandwidth capability, different processing capability, different number of possible UEs accessing a cell, different synchronization requirement, different subcarrier spacing or different coverage requirement. The UE may be a one of an mMTC UE, a URLL) UE or an eV2X UE.

[208] FIG. 21 shows a wireless communication system to implement an embodiment of the present invention.

[209] A network node 800 may include a processor 810, a memory 820 and a transceiver 830. The processor 810 may be configured to implement proposed functions, procedures and/or methods described in this description. Layers of the radio interface protocol may be implemented in the processor 810. The memory 820 is operatively coupled with the processor 810 and stores a variety of information to operate the processor 810. The transceiver 830 is operatively coupled with the processor 810, and transmits and/or receives a radio signal.

[210] A UE 900 may include a processor 910, a memory 920 and a transceiver 930. The processor 910 may be configured to implement proposed functions, procedures and/or methods described in this description. Layers of the radio interface protocol may be implemented in the processor 910. The memory 920 is operatively coupled with the processor 910 and stores a variety of information to operate the processor 910. The transceiver 930 is operatively coupled with the processor 910, and transmits and/or receives a radio signal.

[211] The processors 810, 910 may include application-specific integrated circuit (ASIC), other chipset, logic circuit and/or data processing device. The memories 820, 920 may include read-only memory (ROM), random access memory (RAM), flash memory, memory card, storage medium and/or other storage device. The transceivers 830, 930 may include baseband circuitry to process radio frequency signals. When the embodiments are implemented in software, the techniques described herein can be implemented with modules (e.g., procedures, functions, and so on) that perform the functions described herein. The modules can be stored in memories 820, 920 and executed by processors 810, 910. The memories 820, 920 can be implemented within the processors 810, 910 or external to the processors 810, 910 in which case those can be communicatively coupled to the processors 810, 910 via various means as is known in the art.

[212] In view of the exemplary systems described herein, methodologies that may be im-

plemented in accordance with the disclosed subject matter have been described with reference to several flow diagrams. While for purposed of simplicity, the methodologies are shown and described as a series of steps or blocks, it is to be understood and appreciated that the claimed subject matter is not limited by the order of the steps or blocks, as some steps may occur in different orders or concurrently with other steps from what is depicted and described herein. Moreover, one skilled in the art would understand that the steps illustrated in the flow diagram are not exclusive and other steps may be included or one or more of the steps in the example flow diagram may be deleted without affecting the scope of the present disclosure.

[213]

Claims

[Claim 1] A method for configuring a frame structure by a network node in a wireless communication system, the method comprising:
configuring a first frame which has one legacy transmission time interval (TTI) and a second frame which has multiple short TTIs; and
communicating with a user equipment (UE) by using at least one of the first frame and the second frame.

[Claim 2] The method of claim 1, wherein the second frame contains different number of short TTIs per a number of symbols in each short TTI.

[Claim 3] The method of claim 2, wherein the number of symbols in each short TTI is identical.

[Claim 4] The method of claim 3, wherein at least one symbol is shared between adjacent short TTIs.

[Claim 5] The method of claim 1, wherein the second frame contains at least one of a symbol for downlink (DL) control, a symbol for uplink (UL) control, a symbol for a sidelink DL control or a symbol for a sidelink UL control.

[Claim 6] The method of claim 5, wherein the symbol for DL control is placed in a first symbol of the second frame, and
wherein the symbol for UL control is placed in a last symbol of the second frame.

[Claim 7] The method of claim 5, wherein the symbol for sidelink DL control is placed in a second last symbol of the second frame, and
wherein the symbol for sidelink UL control is placed in a second symbol of the second frame.

[Claim 8] The method of claim 5, wherein a gap is configured between the symbol for DL control and the symbol for sidelink UL control, or between the symbol for sidelink DL control and the symbol for UL control.

[Claim 9] The method of claim 1, wherein a synchronization signal is transmitted in a minimum system bandwidth with minimum density in the second frame.

[Claim 10] The method of claim 9, wherein the synchronization signal is shared among the first frame and the second frame.

[Claim 11] The method of claim 9, wherein the synchronization signal is repeated in a frequency domain or a time domain.

[Claim 12] The method of claim 1, wherein the first frame and the second frame

are configured according to one of different baseband bandwidth capability, different processing capability, different number of possible UEs accessing a cell, different synchronization requirement, different subcarrier spacing or different coverage requirement.

[Claim 13] The method of claim 1, wherein the UE is a one of a massive machine-type communication (mMTC) UE, an ultra-reliable and low latency communication (URLLC) UE or an enhanced vehicle-to-everything (eV2X) UE.

[Claim 14] A network node in a wireless communication system, the network node comprising:

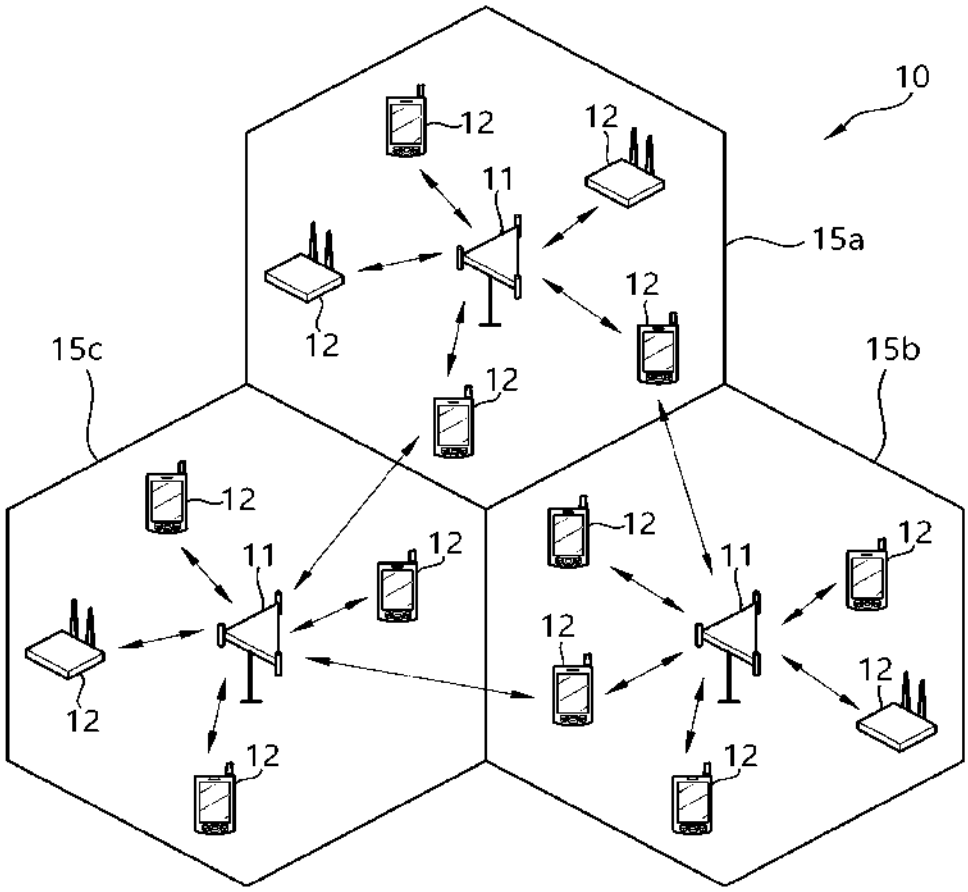
a memory;

a transceiver; and

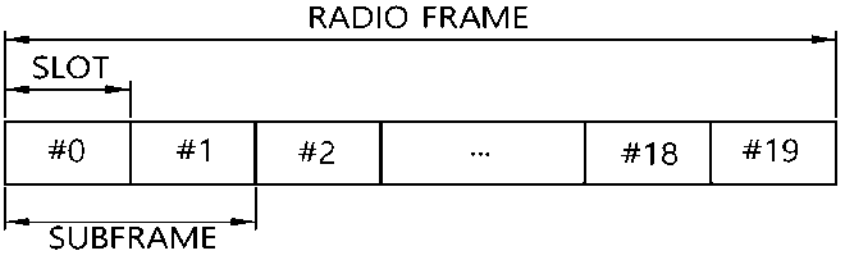
a processor, coupled to the memory and the transceiver, that:

configures a first frame which has one legacy transmission time interval (TTI) and a second frame which has multiple short TTIs, and controls the transceiver to communicate with a user equipment (UE) by using at least one of the first frame and the second frame.

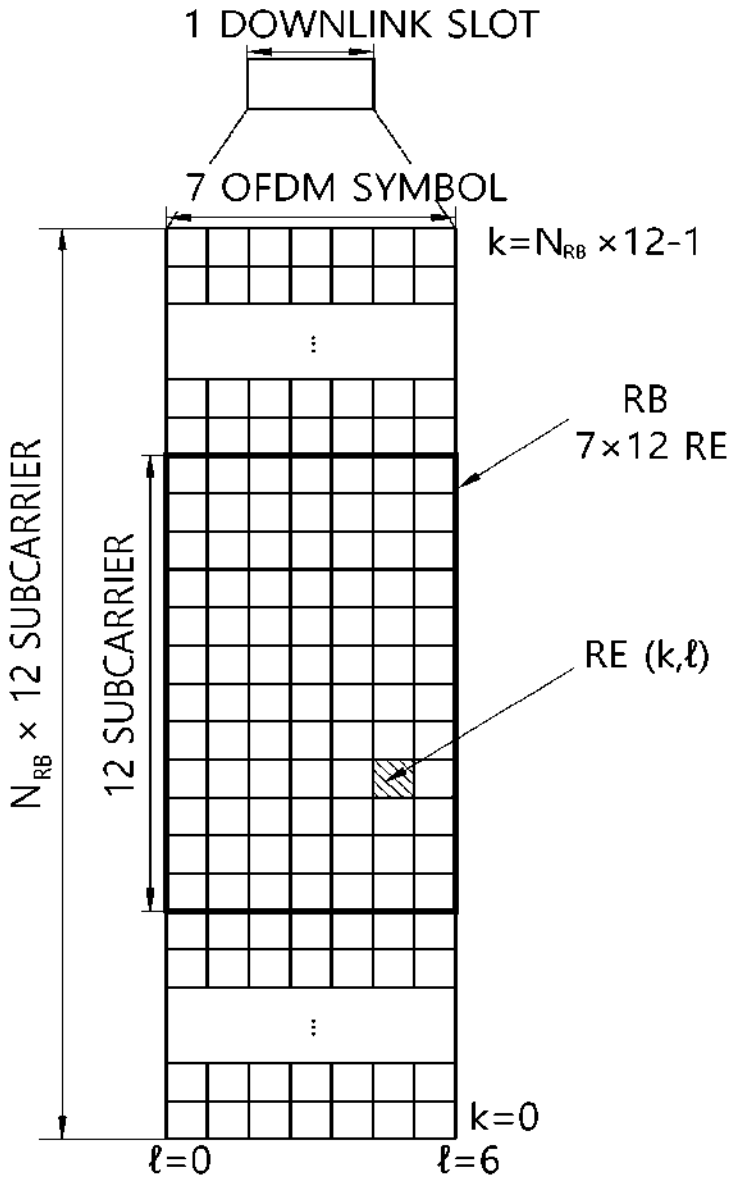
[Fig. 1]



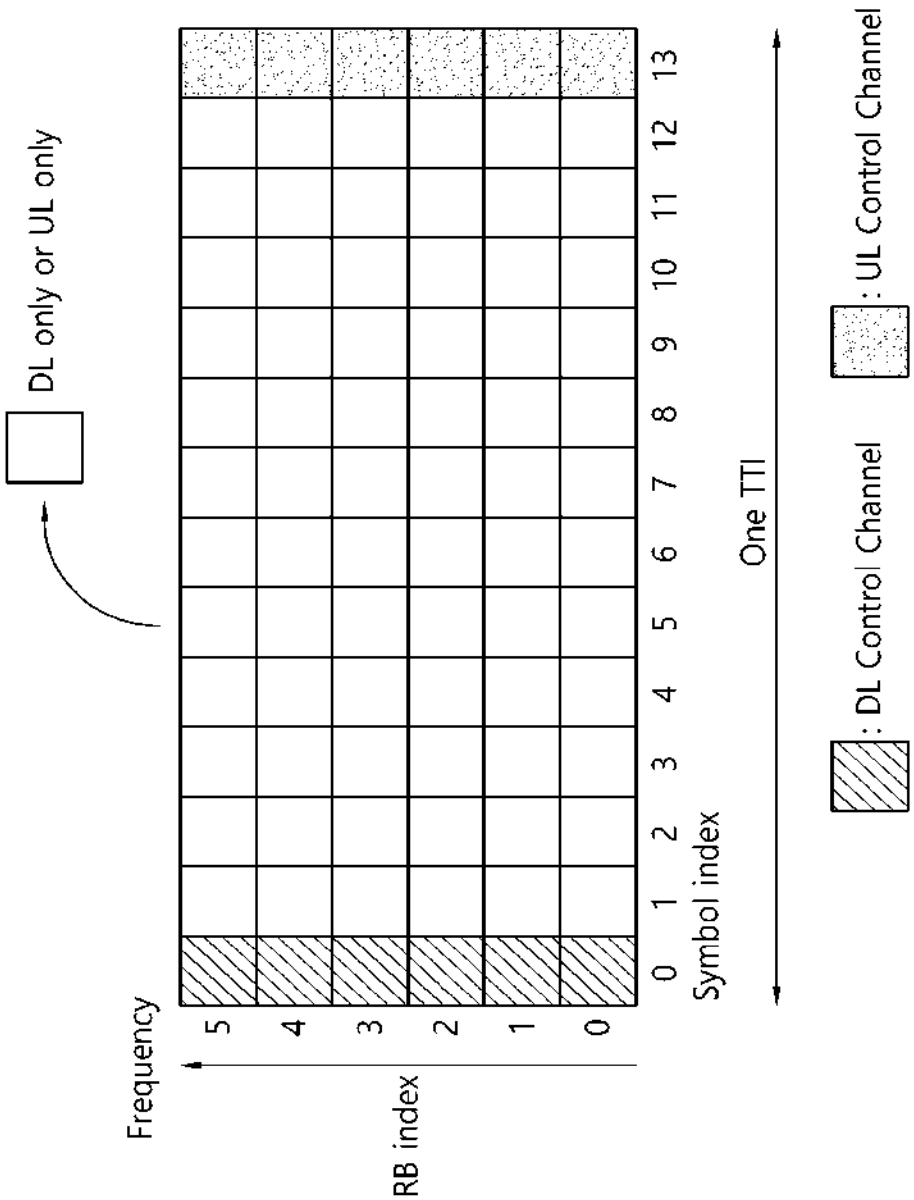
[Fig. 2]



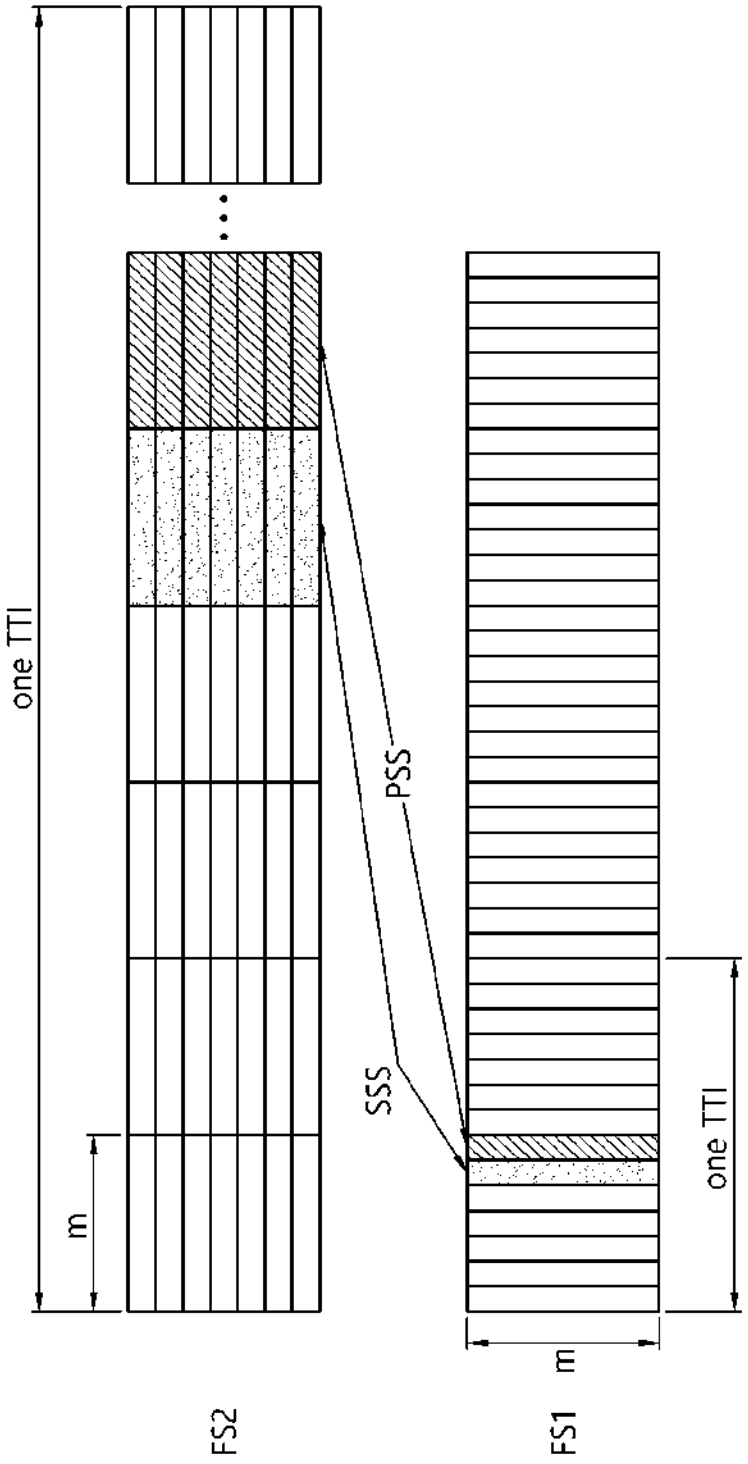
[Fig. 3]


1 DOWNLINK SLOT
7 OFDM SYMBOL
k=N_RB ×12-1
RB
7×12 RE
RE (k,ℓ)
N_RB × 12 SUBCARRIER
12 SUBCARRIER
k=0
ℓ=0
ℓ=6

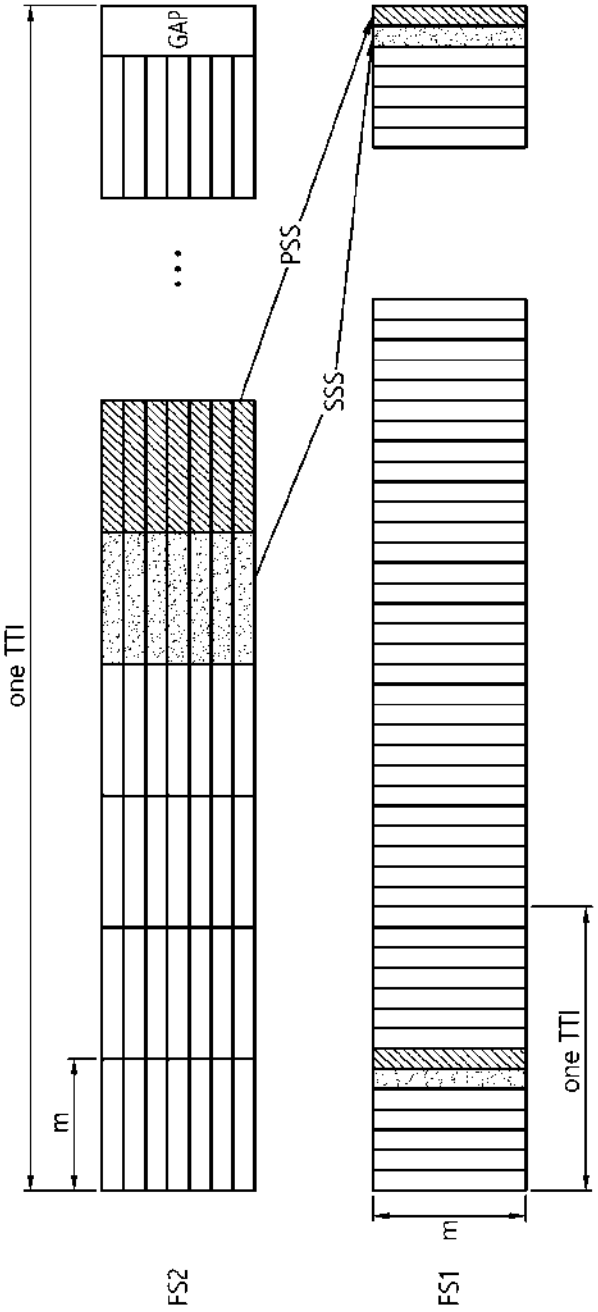
[Fig. 4]


DL only or UL only
Frequency
RB index
5
4
3
2
1
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13
Symbol index
One TTI
: DL Control Channel
: UL Control Channel

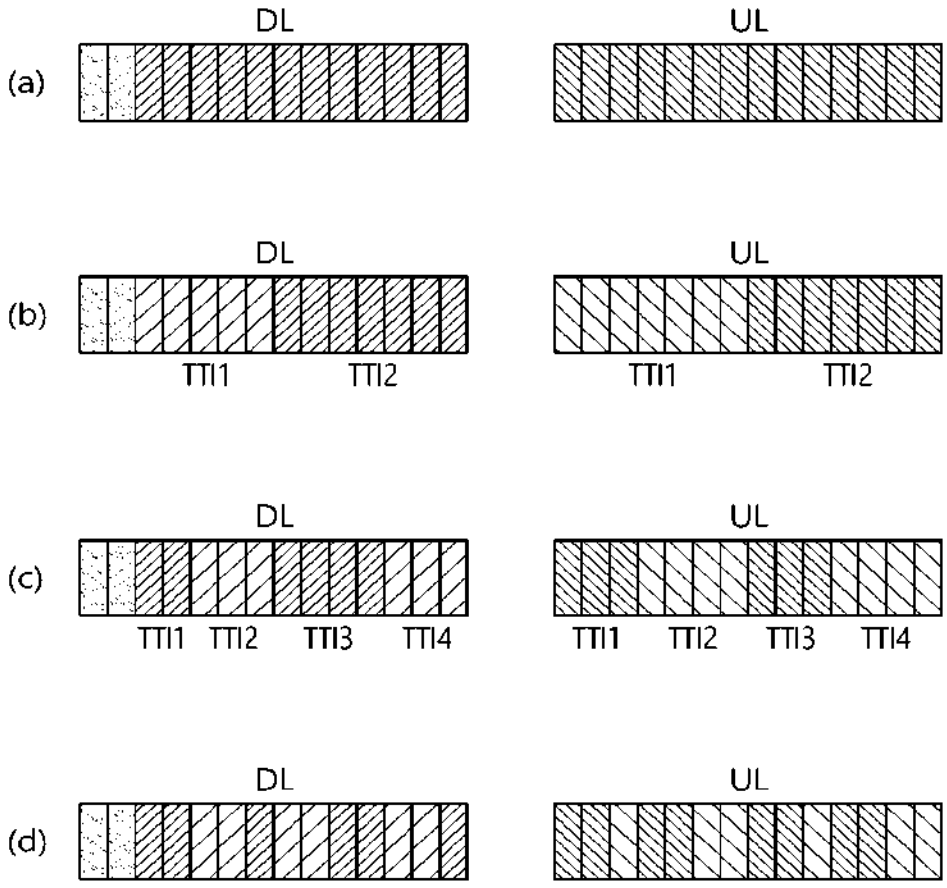
[Fig. 5]



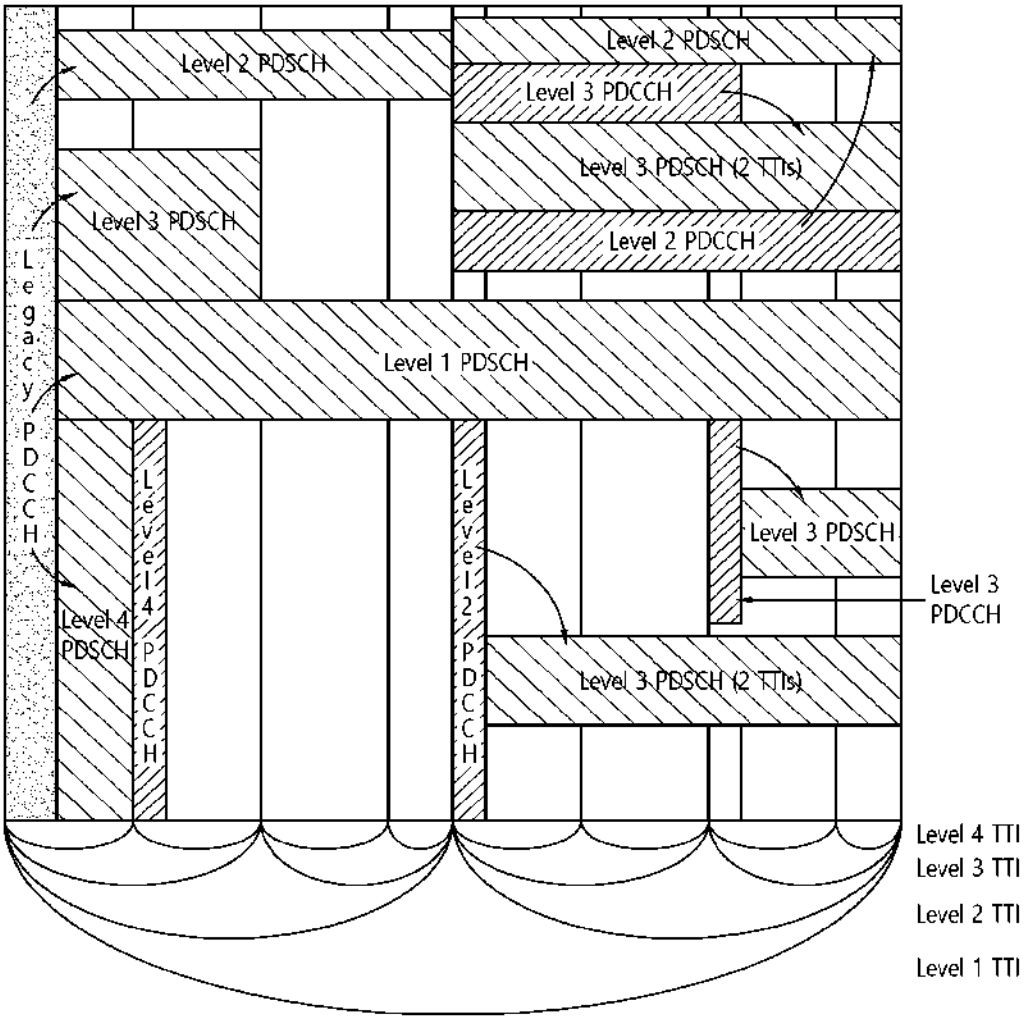
[Fig. 6]



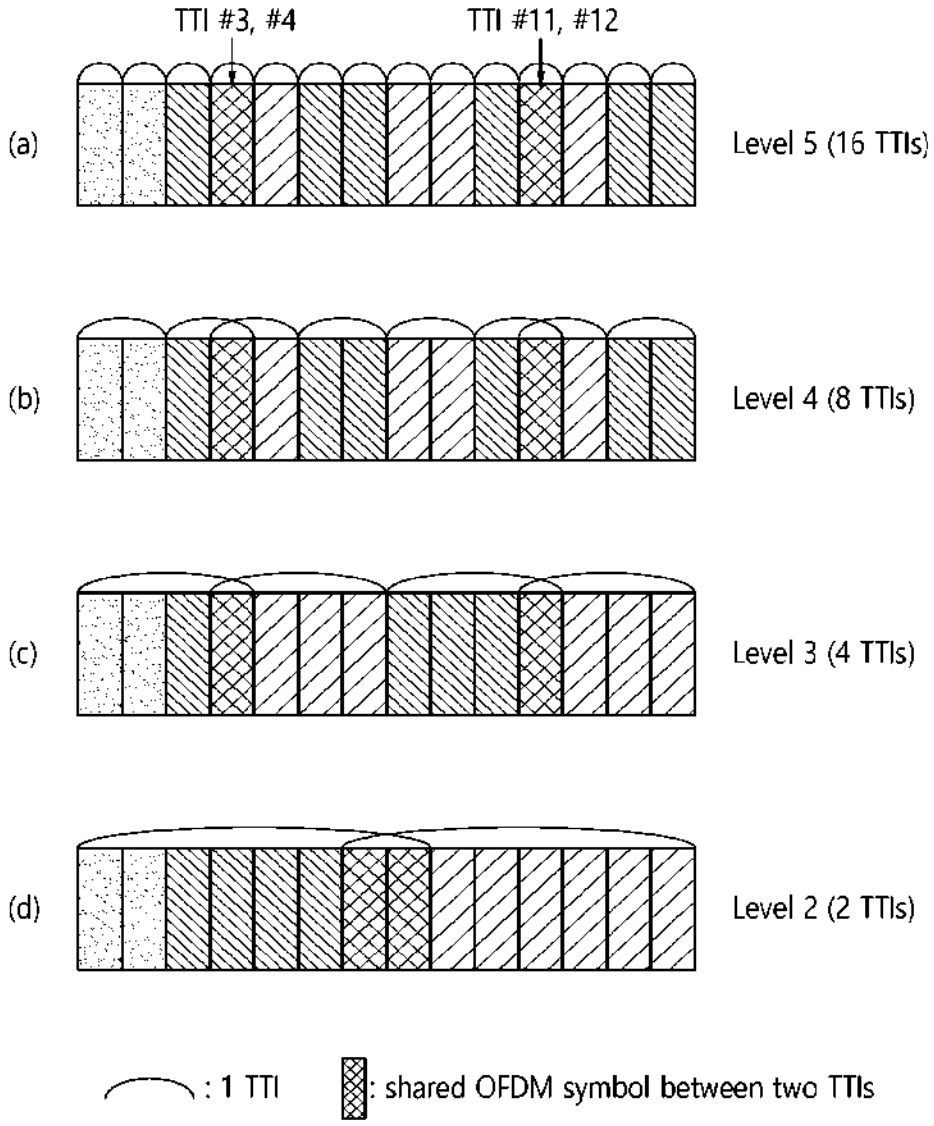
[Fig. 7]


DL
UL
(a)
DL
UL
(b)
TTI1
TTI2
TTI1
TTI2
DL
UL
(c)
TTI1
TTI2
TTI3
TTI4
TTI1
TTI2
TTI3
TTI4
DL
UL
(d)

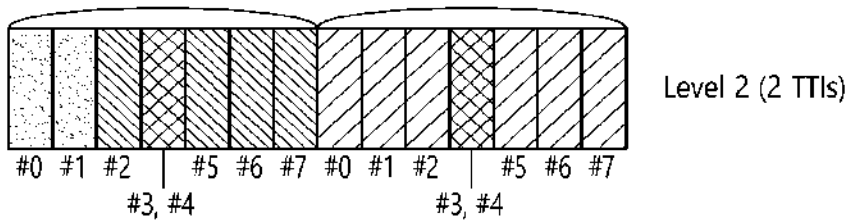
[Fig. 8]


Level 2 PDSCH
Level 2 PDSCH
Level 3 PDCCH
Level 3 PDSCH (2 TTIs)
Level 3 PDSCH
Level 2 PDCCH
Level 1 PDSCH
Legacy PDCCH
Level 4 PDSCH
Level 4 PDCCH
Level 2 PDCCH
Level 3 PDSCH
Level 3 PDCCH
Level 3 PDSCH (2 TTIs)
Level 4 TTI
Level 3 TTI
Level 2 TTI
Level 1 TTI

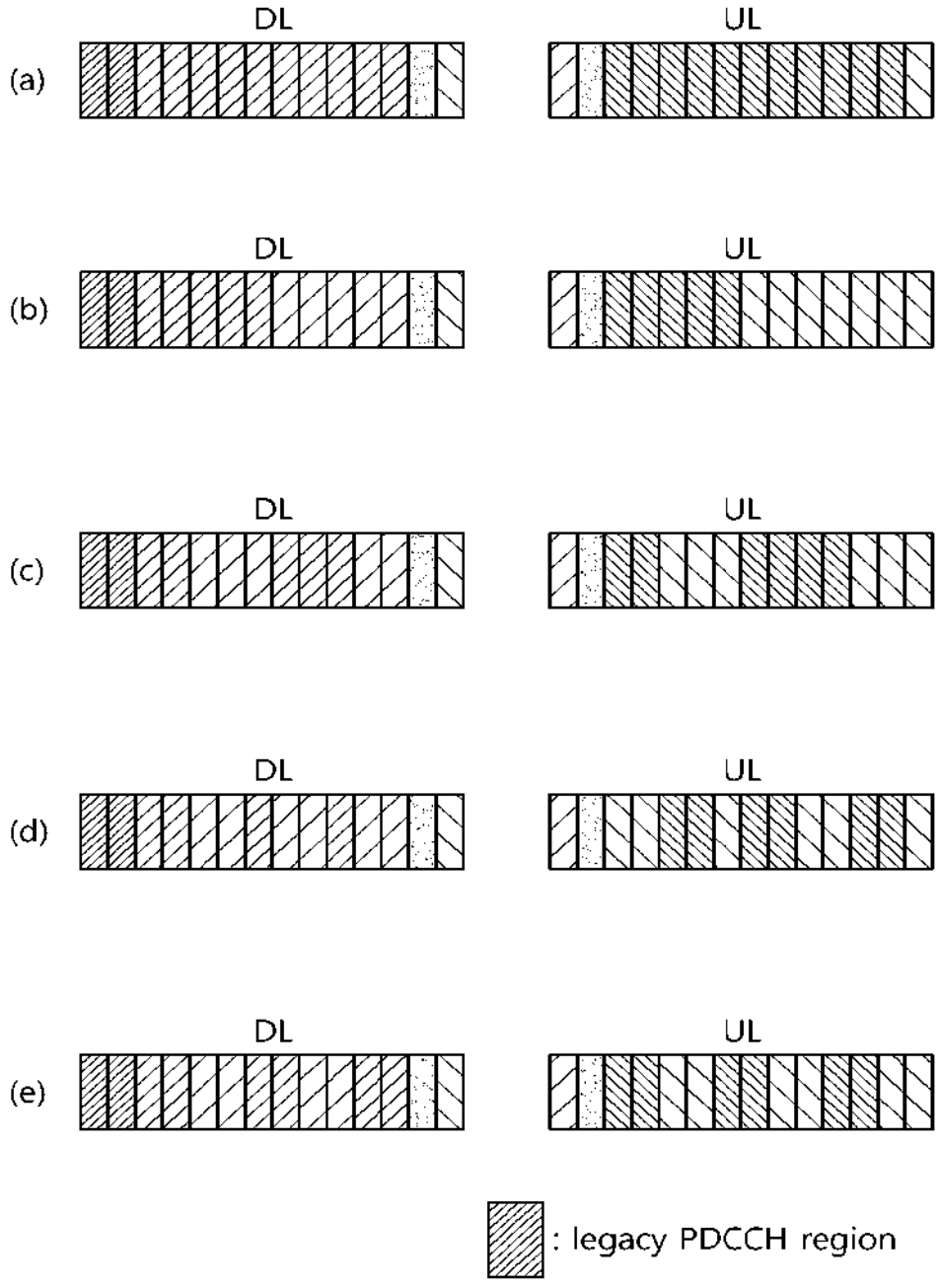
[Fig. 9]


TTI #3, #4
TTI #11, #12
(a)
Level 5 (16 TTIs)
(b)
Level 4 (8 TTIs)
(c)
Level 3 (4 TTIs)
(d)
Level 2 (2 TTIs)
: 1 TTI
: shared OFDM symbol between two TTIs

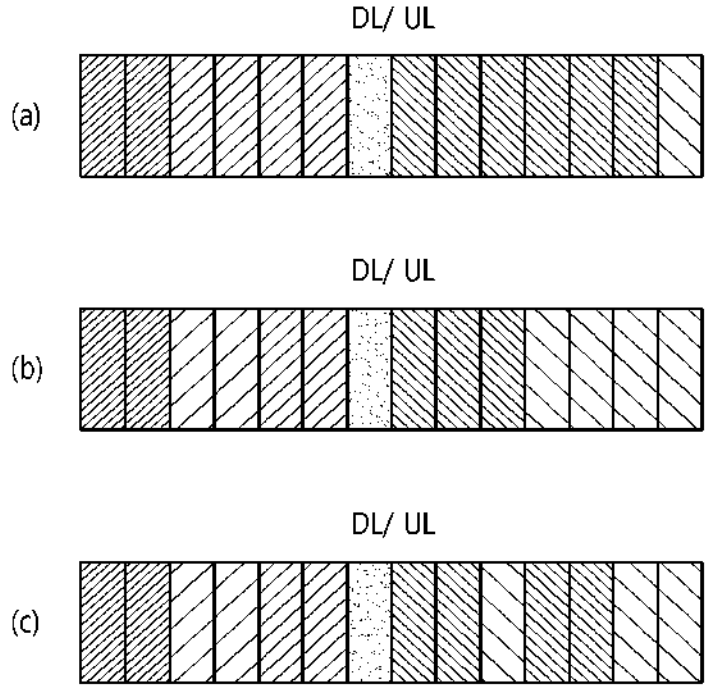
[Fig. 10]


Level 2 (2 TTIs)
#0 #1 #2 #3, #4 #5 #6 #7 #0 #1 #2 #3, #4 #5 #6 #7

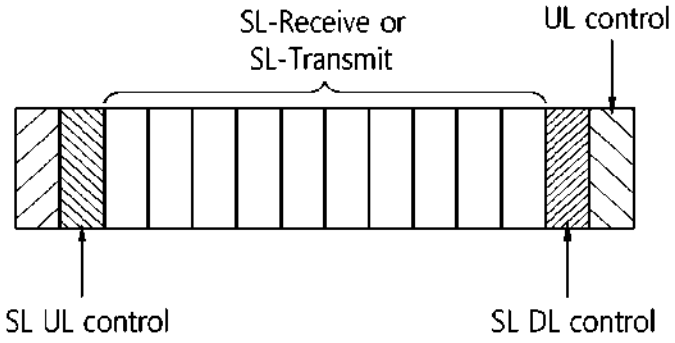
[Fig. 11]



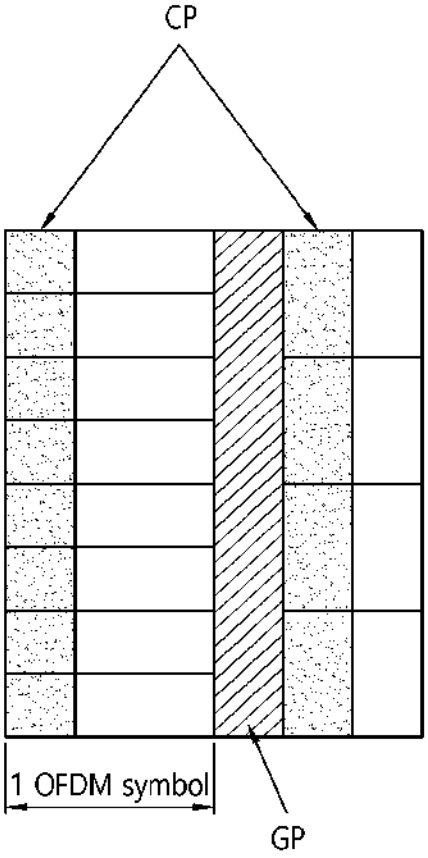
[Fig. 12]


DL/ UL
(a)
DL/ UL
(b)
DL/ UL
(c)

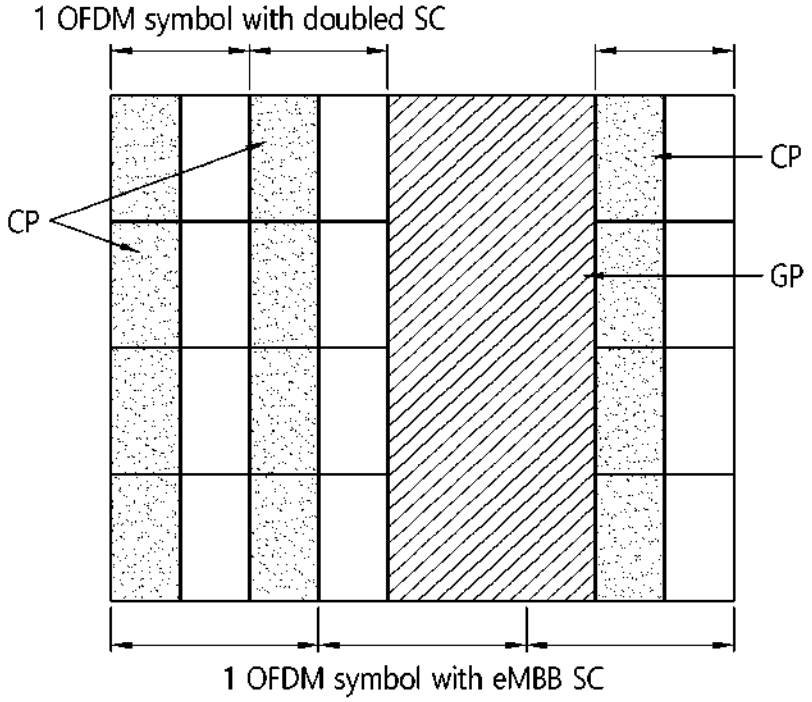
[Fig. 13]


SL-Receive or
SL-Transmit
UL control
SL UL control
SL DL control

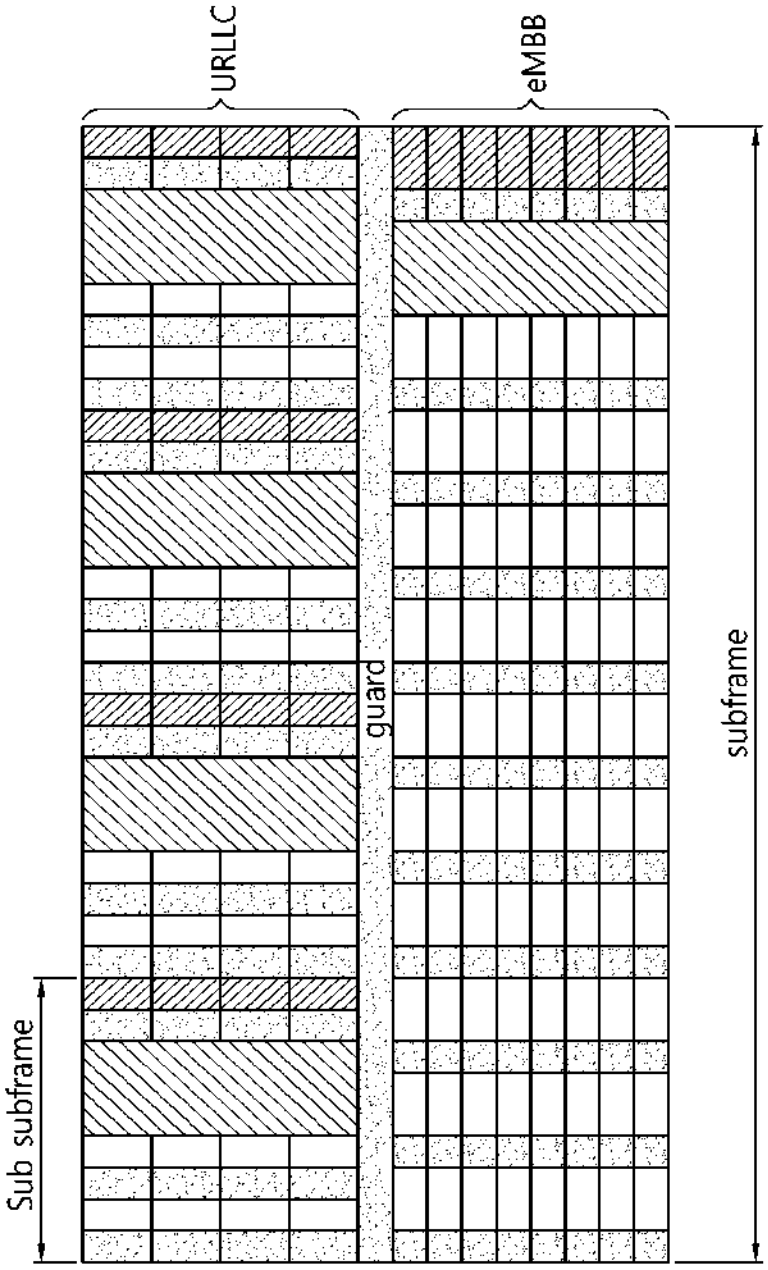
[Fig. 14]



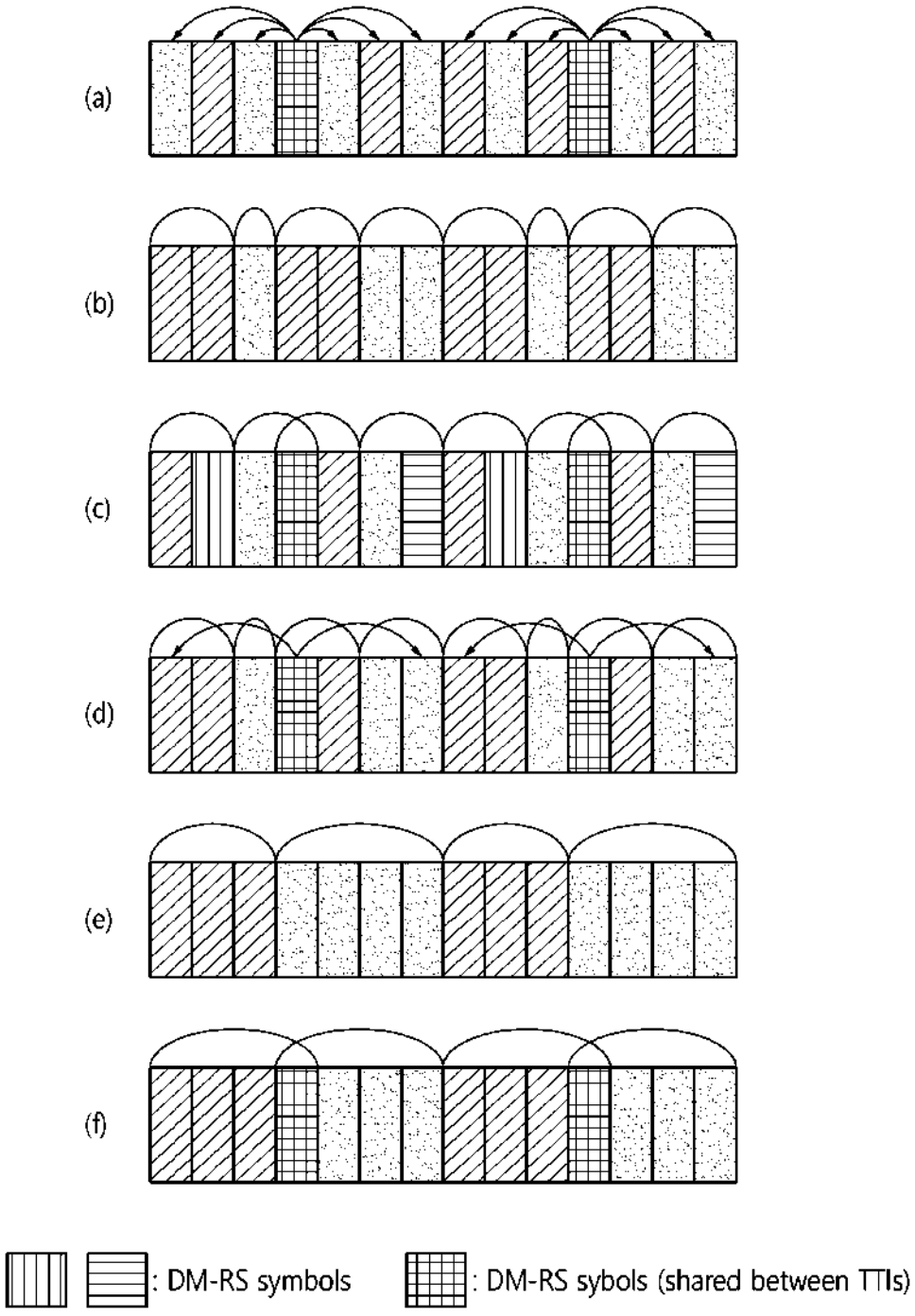
[Fig. 15]


1 OFDM symbol with doubled SC
CP
CP
GP
1 OFDM symbol with eMBB SC

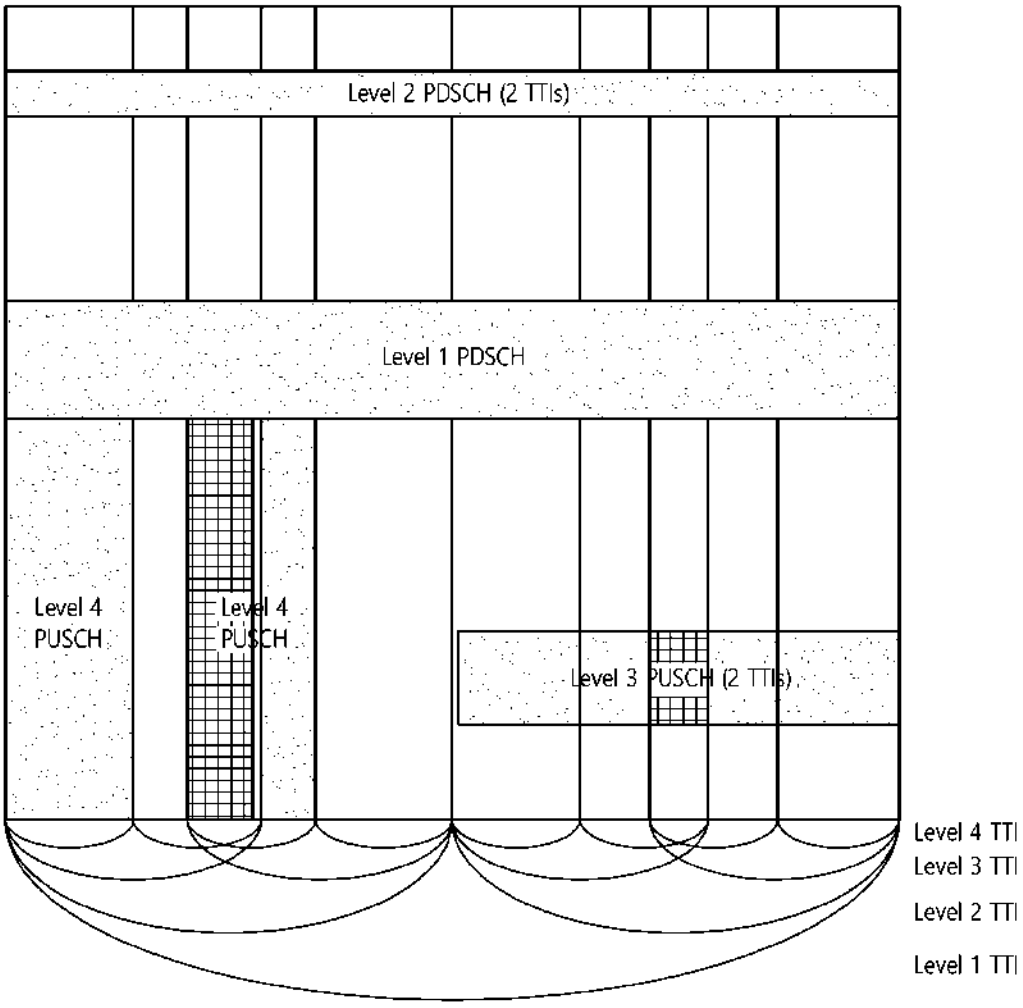
[Fig. 16]



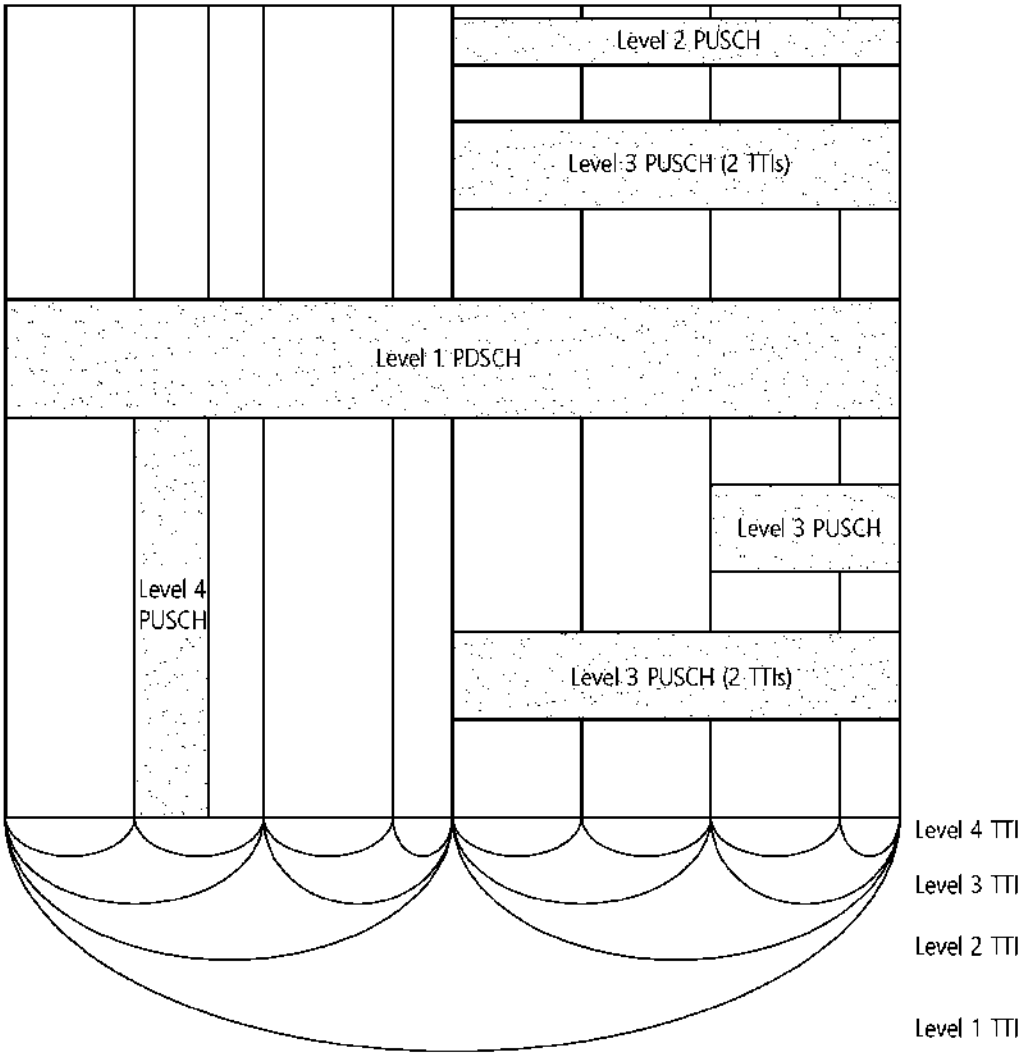
[Fig. 17]



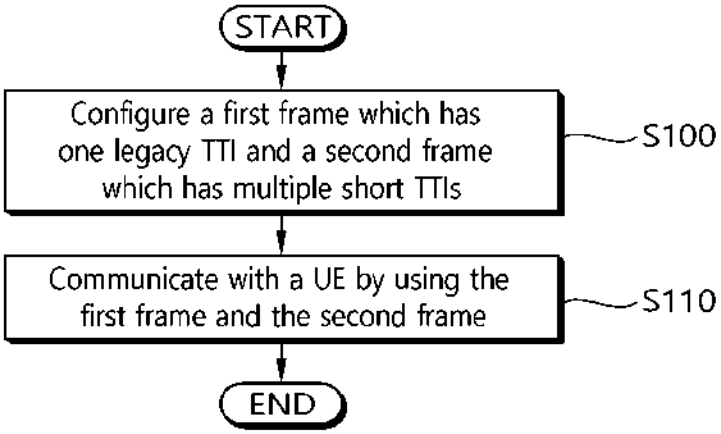
[Fig. 18]


Level 2 PDSCH (2 TTIs)
Level 1 PDSCH
Level 4 PUSCH
Level 4 PUSCH
Level 3 PUSCH (2 TTIs)
Level 4 TTI
Level 3 TTI
Level 2 TTI
Level 1 TTI

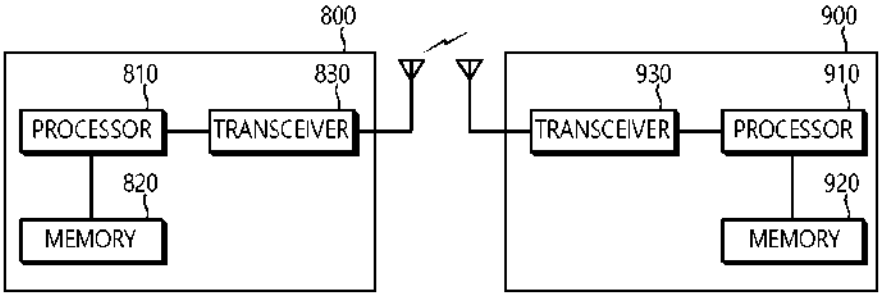
[Fig. 19]


Level 2 PUSCH
Level 3 PUSCH (2 TTIs)
Level 1 PDSCH
Level 3 PUSCH
Level 4 PUSCH
Level 3 PUSCH (2 TTIs)
Level 4 TTI
Level 3 TTI
Level 2 TTI
Level 1 TTI

[Fig. 20]


START
Configure a first frame which has one legacy TTI and a second frame which has multiple short TTIs
S100
Communicate with a UE by using the first frame and the second frame
S110
END

[Fig. 21]


800
810
830
PROCESSOR
TRANSCEIVER
820
MEMORY
900
930
910
TRANSCEIVER
PROCESSOR
920
MEMORY

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2017/003414

A. CLASSIFICATION OF SUBJECT MATTER

H04B 7/26(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04B 7/26; H04J 3/06; H04L 5/00; H04W 56/00; H04W 72/04; H04W 4/00; H04B 1/7073

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: legacy TTI, short TTIs, frames, symbols, synchronization signal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	ETRI, `Overview on frame structure and downlink design for TTI shortening', R1-161011, 3GPP TSG RAN WG1 Meeting #84,Malta, 05 February 2016 See pages 2-6; and figures 1-2.	1-3,5-6,9,11-14
A		4,7-8,10
Y	US 2008-0080476 A1 (JOON-YOUNG CHO et al.) 03 April 2008 See paragraphs [0048]-[0054], [0071]; and figure 6.	1-3,5-6,9,11-14
Y	PETAR POPOVSKI et al., `Deliverable D6.3 Intermediate system evaluation results', ICT-317669-METIS/D6.3, Mobile and wireless communications Enablers for the Twenty-twenty Information Society, 01 August 2014 (https://www.metis2020.com/documents/deliverables/index.html) See page 66; and figure A.28.	5-6
Y	US 2014-0198772 A1 (TELEFONAKTIEBOLAGET L M ERICSSON (PUBL)) 17 July 2014 See paragraphs [0046]-[0058], [0073]; and figure 14.	9,11
Y	US 2015-0282178 A1 (LG ELECTRONICS INC.) 01 October 2015 See paragraphs [0136]-[0146]; claim 5; and figure 13.	12
Y	US 2013-0148564 A1 (HUAWEI TECHNOLOGIES CO., LTD.) 13 June 2013 See paragraphs [0006], [0039]-[0055]; claim 6; and figure 1.	13

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
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INTERNATIONAL SEARCH REPORT

Information on patent family members

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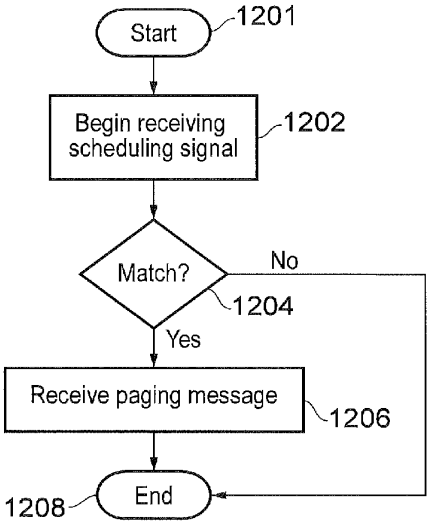


FIG. 12

(57) Abstract: A terminal device for use with a wireless telecommunications network comprising: a transceiver; and a controller. Receiving, during one of a plurality of periodic paging occasions associated with the terminal, a paging scheduling signal for one or more terminal devices, each paging occasion being associated with a value of a characteristic of the scheduling signal which is unique to that paging occasion. Determining whether the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the of periodic paging occasions associated with the terminal device; and control the transceiver to receive the paging message scheduled by the received scheduling message.

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METHOD AND DEVICE FOR PAGING A MACHINE TO MACHINE DEVICE

BACKGROUND

Field of Disclosure

The present disclosure relates to a terminal device, infrastructure equipment, methods and integrated circuitry for use with a wireless telecommunications network.

Description of Related Art

The "background" description provided herein is for the purpose of generally presenting the context of the disclosure. Work of the presently named inventors, to the extent it is described in this background section, as well as aspects of the description which may not otherwise qualify as prior art at the time of filing, are neither expressly or impliedly admitted as prior art against the present disclosure.

Third and fourth generation wireless communications systems, such as those based on the third generation project partnership (3GPP) defined UMTS and Long Term Evolution (LTE) architecture are able to support sophisticated services such as instant messaging, video calls as well as high speed internet access. For example, with the improved radio interface and enhanced data rates provided by LTE systems, a user is able to enjoy high data rate applications such as mobile video streaming and mobile video conferencing that would previously only have been available via a fixed line data connection. The demand to deploy third and fourth generation networks is therefore strong and the coverage area of these networks, i.e. geographic locations where access to the networks is possible, is expected to increase rapidly. However, whilst fourth generation networks can support communications at high data rate and low latencies from devices such as smart phones and tablet computers, it is expected that future wireless communications networks will need to support communications to and from a much wider range of devices, including reduced complexity devices, machine type communication devices, devices which require little or no mobility, high resolution video displays and virtual reality headsets. As such, supporting such a wide range of communications devices can represent a technical challenge for a wireless communications network.

A current technical area of interest to those working in the field of wireless and mobile communications is known as "The Internet of Things" or IoT for short. The 3GPP has proposed to develop technologies for supporting narrow band (NB)-IoT using an LTE or 4G wireless access interface and wireless infrastructure. Such IoT devices are expected to be low complexity and inexpensive devices requiring infrequent communication of relatively low bandwidth data. It is also expected that there will be an extremely large number of IoT devices which would need to be supported in a cell of the wireless

communications network. Furthermore such NB-IoT devices are likely to be deployed indoors and /or in remote locations making radio communications challenging.

SUMMARY OF THE DISCLOSURE

According to a first embodiment, the present technique provides a terminal device for use with a wireless telecommunications network, the terminal device comprising: a transceiver; and a controller operable: to control the transceiver to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging one or more terminal devices of the wireless telecommunications network, each periodic paging occasion associated with the terminal device being associated with a value of a characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network; to determine whether the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device; and if the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device, to control the transceiver to receive the paging message scheduled by the received scheduling message.

According to the first embodiment, the present technique also provides infrastructure equipment for use with a wireless telecommunications network, the infrastructure equipment comprising: a transceiver; and a controller operable: to control the transceiver to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device, wherein a value of a characteristic of the scheduling signal is associated with the one of the plurality of periodic paging occasions associated with the terminal device, each periodic paging occasion associated with the terminal device being associated with a value of the characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network.

According to a second embodiment, the present technique provides a terminal device for use with a wireless telecommunications network, the terminal device comprising: a transceiver; and a controller operable: to control the transceiver to begin receiving, during one of a plurality of periodic paging

occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging the terminal device; wherein the scheduling signal is repeatedly transmitted by the network a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin receiving the scheduling signal; and the controller is operable to control the transceiver to receive the repetitions of the scheduling signal over the predetermined plurality of separate time periods.

According to the second embodiment, the present technique also provides infrastructure equipment for use with a wireless telecommunications network, the infrastructure equipment comprising: a transceiver; and a controller operable: to control the transceiver to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device; wherein the controller is operable to control the transceiver to repeatedly transmit the scheduling signal a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin transmitting the scheduling signal.

The foregoing paragraphs have been provided by way of general introduction, and are not intended to limit the scope of the following claims. The described embodiments, together with further advantages, will be best understood by reference to the following detailed description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the disclosure and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein like reference numerals designate identical or corresponding parts throughout the several views, and wherein:

Figure 1 is a schematic block diagram illustrating an example of a mobile telecommunication system;

Figure 2 is a schematic representation illustrating a frame structure of a downlink of a wireless access interface according to an LTE standard;

Figure 3 is a schematic representation illustrating a frame structure of an uplink of wireless access interface according to an LTE standard;

Figure 4 is a schematic representation of a terminal device and infrastructure equipment;

Figure 5 is a schematic representation of an NB-PDCCH search space;

Figure 6 is a schematic representation of a plurality of paging occasions during which groups of UEs may search the NB-PDCCH search space;

Figure 7 is a schematic representation of an NB-PDCCH search space overlapping paging occasions associated with separate groups of UEs;

Figure 8 is a schematic representation an NB-PDCCH search space overlapping paging occasions associated with the same group of UEs;

Figure 9 is a schematic representation of segmentation of the NB-PDCCH according to a first example;

Figure 10 is a schematic representation of segmentation of the NB-PDCCH according to a second example;

Figure 11 is a schematic representation of segmentation of the NB-PDCCH according to a third example; and

Figure 12 illustrates a flow chart schematically showing a first method; and

Figure 13 illustrates a flow chart schematically showing a second method.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Conventional Communications System

Figure 1 provides a schematic diagram illustrating some basic functionality of a mobile telecommunications network / system 100 operating in accordance with LTE principles and which may be adapted to implement embodiments of the disclosure as described further below. Various elements of Figure 1 and their respective modes of operation are well-known and defined in the relevant standards administered by the 3GPP (RTM) body, and also described in many books on the subject, for example, Holma H. and Toskala A [1]. It will be appreciated that operational aspects of the telecommunications network which are not specifically described below may be implemented in accordance with any known techniques, for example according to the relevant standards.

The network 100 includes a plurality of base stations 101 connected to a core network 102. Each base station provides a coverage area 103 (i.e. a cell) within which data can be communicated to and from communications devices 104. Data is transmitted from base stations 101 to communications devices 104 within their respective coverage areas 103 via a radio downlink. Data is transmitted from communications devices 104 to the base stations 101 via a radio uplink. The uplink and downlink

communications are made using radio resources that are licenced for exclusive use by the operator of the network 100. The core network 102 routes data to and from the communications devices 104 via the respective base stations 101 and provides functions such as authentication, mobility management, charging and so on. Communications devices may also be referred to as mobile stations, user equipment (UE), user device, mobile radio, terminal device and so forth. Base stations may also be referred to as transceiver stations / infrastructure equipment / NodeBs / eNodeBs (eNB for short), and so forth.

Wireless communications systems such as those arranged in accordance with the 3GPP defined Long Term Evolution (LTE) architecture use an orthogonal frequency division modulation (OFDM) based interface for the radio downlink (so-called OFDMA) and a single carrier frequency division multiple access scheme (SC-FDMA) on the radio uplink.

Figure 2 provides a simplified schematic diagram of the structure of a downlink of a wireless access interface that may be provided by or in association with the eNB of Figure 1 when the communications system is operating in accordance with the LTE standard. In LTE systems the wireless access interface of the downlink from an eNB to a UE is based upon an orthogonal frequency division multiplexing (OFDM) access radio interface. In an OFDM interface the resources of the available bandwidth are divided in frequency into a plurality of orthogonal subcarriers and data is transmitted in parallel on a plurality of orthogonal subcarriers, where bandwidths between 1.4MHz and 20MHz bandwidth may be divided into 128 to 2048 orthogonal subcarriers for example. Each subcarrier bandwidth may take any value but in LTE it is conventionally fixed at 15kHz. However it has been proposed in the future [2][3] to provide also a reduced subcarrier spacing of 3.75 kHz for certain parts of the LTE wireless access interface for the uplink. As shown in Figure 2, the resources of the wireless access interface are also temporally divided into frames where a frame 200 lasts 10ms and is subdivided into 10 subframes 201 each with a duration of 1ms. Each subframe is formed from 14 OFDM symbols and is divided into two slots each of which comprise six or seven OFDM symbols depending on whether a normal or extended cyclic prefix is being utilised between OFDM symbols for the reduction of inter symbol interference. The resources within a slot may be divided into resources blocks 203 each comprising 12 subcarriers for the duration of one slot and the resources blocks further divided into resource elements 204 which span one subcarrier for one OFDM symbol, where each rectangle 204 represents a resource element. More details of the downlink structure of the LTE wireless access interface are provided in Annex 1.

Figure 3 provides a simplified schematic diagram of the structure of an uplink of an LTE wireless access interface that may be provided by or in association with the eNB of Figure 1. In LTE networks the uplink wireless access interface is based upon a single carrier frequency division multiplexing FDM (SC-FDM) interface and downlink and uplink wireless access interfaces may be provided by frequency division duplexing (FDD) or time division duplexing (TDD), where in TDD implementations subframes switch

between uplink and downlink subframes in accordance with predefined patterns. However, regardless of the form of duplexing used, a common uplink frame structure is utilised. The simplified structure of Figure 3 illustrates such an uplink frame in an FDD implementation. A frame 300 is divided in to 10 subframes 301 of 1ms duration where each subframe 301 comprises two slots 302 of 0.5ms duration. Each slot is then formed from seven OFDM symbols 303 where a cyclic prefix 304 is inserted between each symbol in a manner equivalent to that in downlink subframes. In Figure 3 a normal cyclic prefix is used and therefore there are seven OFDM symbols within a subframe, however, if an extended cyclic prefix were to be used, each slot would contain only six OFDM symbols. The resources of the uplink subframes are also divided into resource blocks and resource elements in a similar manner to downlink subframes. More details of the LTE uplink represented in Figure 3 are provided in Annex 1.

Narrowband Internet of Things

As explained above, it has been proposed to develop an adaptation of a mobile communications network to accommodate narrow band communications within an existing wireless access interface which has been developed to provide broadband wireless communications. For example, in 3GPP a project relating to improvements to LTE wireless access interfaces to provide for a Narrowband Internet of Things (NB-IoT) was agreed [2]. This project is aimed at improved indoor coverage, support for massive number of low throughput devices, low delay sensitivity, ultra-low device cost, low device power consumption and (optimised) network architecture. An example of such a device is a smart meter. It has been proposed that an NB-IoT communications system supports a bandwidth of only 180 kHz and can have three operational modes:

1. 'Stand-alone operation' utilizing for example the spectrum currently being used by GERAN systems as a replacement of one or more GSM carriers
2. 'Guard band operation' utilizing the unused resource blocks within a LTE carrier's guard-band
3. 'In-band operation' utilizing resource blocks within a normal LTE carrier

Figure 4 provides an example schematic block diagram of a terminal device or UE 104 and an infrastructure equipment or eNB 101 according to embodiments of the present technique. As shown in Figure 4, the UE 104 includes a transmitter 401 and a receiver 402 (which together form a transceiver) which are controlled by a controller 403. The UE 104 also comprises a storage medium 420 for storing data. Correspondingly, the eNB 101 includes a transmitter 411 and a receiver 412 (which together form a transceiver) which are controlled by a controller 413 (which can also implement a scheduler function). The eNB 101 also comprises a storage medium 422 for storing data. As explained above, the UE 104 transmits and receives signals to and from the eNB 101 via a wireless access interface provided by the

eNB as part of the wireless communications network. Each of the UE 104 and eNB 101 are configured to exchange signals with each other using NB-IoT.

One of the objectives of NB-IoT is to provide extended coverage of up to 20 dB. The main mechanism to extend coverage is to perform numerous repetitions of a message to be received at a receiving device, such that the receiver can accumulate the signal energy over the repetitive samples in order for it to have an increased signal-to-noise ratio (SNR), which increases the likelihood of successful decoding of the message at the receiving device. Such a mechanism is known as coverage enhancement (CE).

Coverage enhancement (CE) may have several levels. For example, it may provide one of 5 dB, 15 dB and 20 dB additional coverage enhancement. In NB-IoT, the CE levels may be referred to as the targeted MCL (Max Coupling Loss, the achievable coupling loss (accounting for, for example, path loss, feeder losses and/or antenna gains) between transmitter and receiver) of, for example, 144 dB, 154 dB and 164 dB (so that the higher the targeted MCL, the greater the additional coverage enhancement).

As previously mentioned, repetitions of a signal so that a receiver can accumulate energy of the signal over numerous repetitive samples is the basic method used for coverage enhancement. The number of repetitions required is dependent upon the CE level. Thus, a UE at a lower CE level, such as at 144 dB, MCL requires less repetition compared to one at a higher CE level, such as at 154 dB MCL. The power spectral density, PSD (mW/Hz) of a transmission also affects the number of repetitions required, that is, the larger the PSD, the less the required number of repetitions.

The NB-PDCCH (Narrow Band Physical Downlink Control Channel) is a control channel that is used to schedule downlink resources (downlink grant) and uplink resources (uplink grant) for a NB-PDSCH (Narrow Band Physical Downlink Shared Channel) and a NB-PUSCH (Narrow Band Physical Uplink Shared Channel) that carry data traffic. An NB-PDCCH search space consists of multiple NB-PDCCH candidates wherein each candidate has a specific starting time, set of subcarriers, a defined number of repetitions and an aggregation level (the aggregation level relating to the number of frequency resources occupied by the candidate such that when the candidate occupies a higher number of frequency resources, the aggregation level is higher, and when the candidate occupies a lower number of frequency resources, the aggregation level is lower). Candidates that have a larger number of repetitions and a higher aggregation level are more robust and can reach a UE at poorer coverage compared to candidates that have a smaller number of repetitions and a lower aggregation level.

The eNB uses one of the candidates in the search space to carry the NB-PDCCH. The UE is not aware which candidate is used and so it must blind decode all the candidates in the search space in order to find the candidate used by the eNB for the NB-PDCCH. An example of a typical NB-PDCCH search space is

shown in Figure 5. Here, the search space has 4 repetition levels {R1, R2, R3, R4} where R4 = 2×R3 = 4×R2 = 8×R1. It should be appreciated that an NB-PDCCH search space with other repetition levels is also possible. As an example the eNB can use any of the 15 candidates (labelled as C1 to C15) to carry the NB-PDCCH and the UE has to blind decode for all 15 candidates. The max repetition R_{MAX} (in Figure 5, R_{MAX} = R4) of the search space is assigned to the UE based on the UE's radio condition. Thus, for example, if the UE is in a poorer quality radio coverage location, then the eNB can configure a search space with a larger value of R_{MAX}, and if the UE is in a better quality radio coverage location, then the eNB can configure a search space with a smaller value of R_{MAX}. Typically, a set of NB-PDCCH search spaces is predefined in which each NB-PDCCH search space of the set consists of a set of candidates and a value of R_{MAX}. The UE is then assigned one NB-PDCCH search space in the set of NB-PDCCH search spaces. The maximum repetition R_{MAX} of an NB-PDCCH search space can be selected from the set of values {1, 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024, 2048}, for example.

In NB-IoT, paging is performed when a UE is in idle mode. More specifically, when in idle mode, the UE monitors an NB-PDCCH CSS (Common Search Space) which, in the case that a paging message is to be transmitted to the UE, contains an NB-PDCCH that schedules that paging message (the paging message being carried by an NB-PDSCH). In order to reduce power consumption, the UE monitors the NB-PDCCH CSS during each of a plurality of periodic Paging Occasions (PO) rather than constantly monitoring the NB-PDCCH CCS. The PO occurs periodically for a particular UE (or particular group of UEs), wherein the period is configured by the network, for example. In an embodiment, the network can configure multiple POs in which the specific PO that a UE monitors depends on an identifier of that that UE (UE-ID), for example, the UE's International Mobile Subscriber Identifity (IMSI). This enables the network to spread the paging load. For example in Figure 6, the eNB configures four POs where each PO has a period T_{PO}. The UE thus wakes up every T_{PO} ms to monitor for possible paging. The PO is assigned to the UE based on the UE's ID, using a **MOD** function of the number of POs, for example (thus, in the case of Figure 6, the PO assigned to a particular UE is given by UE_ID **MOD** 4).

As described previously, repetition of the paging CSS can reach 2048. A problem with this is that a PO can overlap another PO, causing confusion for UEs reading the PO. For example in Figure 7, two POs are configured. PO 1 begins at time t_1, where UE 1 belonging to this PO will start monitoring for NB-PDCCH in the paging CSS. This paging CSS ends at time t_3. If the repetition of NB-PDCCH is very long (for example, if the paging CSS ending at time t_3 has the structure shown in Figure 5, and the NB-PDDCH is received via the candidate C15 with the largest number of repetitions) , it will overlap into PO 2 at time t_2. At time t_2 UE 2 belonging to PO 2 will start monitoring for NB-PDCCH and will start to accumulate repetition samples from the NB-PDCCH intended for UE 1 (belong to PO 1). If UE 2 is in a better radio condition than UE 1, it may decode the NB-PDCCH and start to accumulate and decode the corresponding NB-PDSCH containing the paging message. UE 2 will not find any paging indication in

this paging message and would waste battery power accumulating and decoding the NB-PDSCH. This is because the paging message contains an identifier of each UE to be paged. If a paging message is not intended for UE 2, then the identifier of UE 2 will not be included in the paging message and thus UE 2 will not be paged. However, since UE 2 has received the NB-PDCCH during its paging occasion, it will still attempt to read the paging message scheduled by the NB-PDCCH by accumulating and decoding the NB-PDSCH, thus wasting battery power. It should be noted that the NB-PDSCH is also repeated.

It should also be appreciated that if the PO period T_{PO} is shorter than the NB-PDCCH repetition, the PO may overlap itself, as shown in an example in Figure 8, in which the NB-PDCCH for PO 1 starts at time t_1 but the repetition doesn't end till time t_4. It overlaps the next PO 1 at time t_3. In this scenario, the UE belonging to PO 1 is confused as to whether to continue accumulating samples from the previous PO 1 (started at time t_1) or start a new accumulation starting at time t_3. Furthermore, in an embodiment, the NB-PDSCH starting subframe is indicated in the downlink control information (DCI) of the NB-PDCCH, this NB-PDSCH starting subframe being defined relative to the end of the NB-PDCCH that schedules this NB-PDSCH. In order to determine the end of an NB-PDCCH transmission, the repetition of the NB-PDCCH is indicated in the DCI of that NB-PDCCH. For example, in Figure 5, if candidate C11 is used to carry the NB-PDCCH (including the DCI), then the NB-PDSCH scheduled by the NB-PDCCH will start at k subframes after time t_6 (t_6 marking the end of the NB-PDCCH carried by candidate C11) where k is indicated in the DCI. Since the UE can decode a message with less repetition when it has a good radio condition, however, the UE may decode C11 at time t_5 and mistake candidate C11 for candidate C5. The UE will thereby use the wrong reference point for the start of the NB-PDSCH. To avoid this, the repetition of the NB-PDCCH is indicated in the DCI so that the UE will not mistake candidate C11 for C5. However, this does not solve the problem shown in Figure 8 in which the search space overlaps itself. In this case, although the UE will know the repetition of the NB-PDCCH from the DCI information, the UE does not know whether the NP-PDCCH repetitions started at time t_1 or at time t_3. This causes confusion at the UE regarding the candidates.

In LTE Release-13 eMTC (enhanced Machine Type Communication), the POs are separated far apart so that they do not overlap. This is possible because the repetition used in this case is not as large as that used in NB-IoT. Furthermore, eMTC can use different narrowbands for different groups of UEs and avoid overlapping. In contrast, only the anchor NB-IoT can contain the paging CSS and paging message, and therefore problem of overlapping of the NB-PDCCH between different POs requires a new solution.

In an embodiment of the present technique, an indicator is used to distinguish one PO from another. The UE belonging to a PO then uses this indicator to determine whether the NB-PDCCH belongs to it or to another PO.

In one embodiment, the said indicator is a PO index in the DCI (carried by the NB-PDCCH). A new field in the DCI would indicate which PO the DCI (that is, the NB-PDCCH) belongs to. The UE, after accumulating the NB-PDCCH, will then decode the DCI and check the PO index to see whether it matches the PO that the UE belongs to.

In another embodiment, different versions of the same PO are also indicated in the DCI. This is to help overcome the issue of uncertainty at the UE regarding when the search space starts when a NB-PDCCH repetition is larger than the PO period T_{PO} (as described in Figure 8). For example, in Figure 8, PO 1 at time t_1 can be version 1 and PO 1 at time t_3 can be version 2, these versions being distinguishable from each other by the PO identifier in the DCI so the UE is clear where the search space starts. This helps to avoid confusion of the candidates in the search space.

In another embodiment the starting time of the CSS is indicated in the DCI. This is similar to indicating the PO index (which indirectly indicates the starting time of the CSS). After decoding the DCI, the UE will determine whether the starting time of the decoded NB-PDCCH belongs to the CSS that starts at its PO or another PO. If the CSS starts at a time belonging to another PO, the UE can discard the decoded DCI.

In another embodiment, a different P-RNTI (Paging Radio Network Temporary Identifier) is used for one or more of each respective PO and each respective PO version. The P-RNTI of each respective PO and/or each respective PO version can be signalled either explicitly or implicitly (that is, derived from a reference P-RNTI). For example, in the case that a different P-RNTI is used for each respective PO, the eNB may signal a single reference P-RNTI and PO 1 will use this P-RNTI, PO 2 will use this reference P-RNTI + 1, PO 3 will use P-RNTI + 2, and so on.

In another embodiment, a scrambling applied to the NB-PDCCH is dependent upon the PO. The UE then applies a descrambler depending upon which PO it belongs to. A different scrambling may be applied to each respective PO (so as to distinguish, for example, PO 1 from PO 2, but not distinguish between different versions of PO 1 or PO 2). Alternatively, or in addition, a different scrambling may be applied to each respective PO version (so that different versions of, for example, PO 1 or PO 2 may be distinguished from each other).

It will be appreciated that various features of these embodiments may be combined as appropriate. For example, it may be the case that each respective PO is distinguished by a different scrambling, but then each version of that PO is further distinguished in the DCI.

In another embodiment of the present technique, two or more different NB-PDCCH search spaces (that is, Common Search Spaces) are configured wherein at least one of these search spaces has max repetition $R1_{MAX}$ greater than the time between two adjacent POs T_S (thus potentially causing the overlapping issue described in Figure 7) whilst the remaining search spaces have max repetition $R2_{MAX}$ smaller than T_S. In this way the search space with $R1_{MAX}$ can be segmented and interleaved with search spaces with $R2_{MAX}$. An example is shown in Figure 9, where each PO is associated with one of two types of NB-PDCCH Common Search Space (CSS) with $R1_{MAX}$ and $R2_{MAX}$, respectively. CSS1 belongs to PO1, starts at time t_1 and has a max repetition of $R1_{MAX}$ where $R1_{MAX} > T_S$, (meaning that, if measures are not taken, then CSS1 will overlap with the adjacent PO (that is, PO2)). Using the method of an embodiment, CSS1 (belonging to the first version of PO1) is segmented into 3 segments, wherein the 1st segment starts at time t_1 and ends at time t_2. The 2nd segment occupies the time t_3 to t_4, which avoids overlapping CSS2 (belonging to the first version of PO2) between time t_2 and t_3. The 3rd segment occupies time t_5 to t_6, which avoids overlapping CSS3 (belonging to the second version of PO1) between time t_4 and t_5. The segments of CSS1 are therefore interleaved with CSS2 and CSS3. CSS3 and CSS4 belong to PO1 (the second and third versions of PO1, respectively) but with a smaller maximum repetition, that is, $R2_{MAX} < T_S$, and therefore do not overlap with any adjacent PO. CSS3 and CSS4 are thus not segmented. CSS5 belongs to PO2 (in particular, the second version of PO2), and since its max repetition is greater that T_S, it is segmented and interleaved in a similar manner as that for CSS1. The example in Figure 9 shows two types of CSS (that is, with two different max repetition values). However, it should be appreciated this method is also applicable for more than two different max repetition CSSs. Also, the segments of CSS1 can be interleaved using a different pattern, for example, interleaved with different CSSs such as CSS3 and CSS4 (as shown in Figure 10).

In an embodiment, different POs have different max CSS repetitions. For example, the CSS for PO1 may have repetition $R1_{MAX} > T_S$ whilst the CSS for PO2 may have max repetition $R2_{MAX} < T_S$. In this embodiment, the CSS for PO1 is segmented and interleaved with the un-segmented CSS for PO2.

In another embodiment, all CSSs have $R1_{MAX} > T_S$. Each CSS (with $R1_{MAX}$) is segmented and the segment occupies multiple POs. That is, the CSS is spread among multiple POs. An example is shown in Figure 11, where CSS1 (belonging to PO1) has $R1_{MAX} > T_S$ and is segmented into two segments. The first segment occupies time t_1 to t_2 and the 2nd segment occupies time t_4 to t_5. Similarly, CSS5 (belonging to PO2) has $R1_{MAX} > T_S$ and is segmented into two segments. The first segment occupies time t_2 to t_3 and the 2nd segment occupies time t_6 to t_7. It should be noted that the 2nd segment length of each of CSS1 and CSS2 is less than T_S in this example.

In another embodiment, the overlapping problem shown in Figure 8 can be overcome by ensuring the Paging Occasion period $T_{PO} >$ R1max. Note that this is easier to achieve than to ensure that $T_S > R1_{MAX}$,

since T_{PO} can be much larger than T_S (for example, up to 2560 subframes) and multiple different POs may fit within the T_{PO}.

In embodiments, the segments of the NB-PDCCH search space can be defined by a predetermined pattern, this pattern being configured by the network and, for example, transmitted to the UE 104 from the eNB 101 as system information (in the System Information Block (SIB), for example). In an embodiment, the pattern may vary depending on the number of repeats of the NB-PDCCH, an identifier of the CSS which is used, or any other parameter which the UE may discern from the CSS or NB-PDCCH. The relationship between the predetermined pattern and the CSS or NB-PDCCH may be determined and transmitted to the UE 104 by the eNB 101 and may be in the form of a lookup table of the like. In another embodiment, the pattern may be fixed for the set of paging occasions associated with the UE (again, information indicative of this fixed pattern may be determined and transmitted to the UE 104 by the eNB 101).

It will thus be appreciated that, in a first embodiment, the present technique provides a terminal device 104 for use with a wireless telecommunications network. The terminal device comprises a transceiver 401, 402 and a controller 403. The controller is operable to control the transceiver to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device (for example, the plurality of periodic paging occasions PO1 or PO2), a scheduling signal (carried by the NB-PDCCH, for example) scheduling a paging message for paging one or more terminal devices of the wireless telecommunications network. Each periodic paging occasion associated with the terminal device is associated with a value of a characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network. The controller is operable to determine whether the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device, and, if the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device, to control the transceiver to receive the paging message scheduled by the received scheduling message.

In one example, the characteristic of the scheduling signal is a paging occasion identifier identified by the scheduling signal. All periodic paging occasions associated with the terminal device may be associated with the same identifier of the scheduling signal (thus, for example, each paging occasion in the plurality of paging occasions PO1 may have the same index, each paging occasion in the plurality of paging occasions PO2 may have the same index, and so on). Alternatively, each periodic paging occasion

associated with the terminal device may be associated with an identifier of the scheduling signal which is different from the identifier of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device (thus, for example, each paging occasion in the plurality of paging occasions PO1 may have a version number which distinguishes it from the other paging occasions in the plurality PO1, each paging occasion in the plurality of paging occasions PO2 may have a version number which distinguishes it from the other paging occasions in the plurality PO1, and so on). Any suitable identifier may be used as the paging occasion identifier, including, for example, an identifier comprising one or more of a PO index, PO version number or P-RNTI number, as previously discussed.

In another example, the characteristic of the scheduling signal is a scrambling of the scheduling signal. All periodic paging occasions associated with the terminal device may be associated with the same scrambling of the scheduling signal (thus, for example, each paging occasion in the plurality of paging occasions PO1 may be associated with the same scrambling of the scheduling signal, each paging occasion in the plurality of paging occasions PO2 may be associated with the same scrambling of the scheduling signal, and so on). Alternatively, each periodic paging occasion associated with the terminal device may be associated with a scrambling of the scheduling signal which is different from the scrambling of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device (thus, for example, each paging occasion in the plurality of paging occasions PO1 may be associated with a different scrambling of the scheduling signal to the scrambling of the scheduling signal associated with the other paging occasions in the plurality PO1, each paging occasion in the plurality of paging occasions PO2 may be associated with a different scrambling of the scheduling signal to the scrambling of the scheduling signal associated with the other paging occasions in the plurality PO2, and so on).

In another example, the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate, and the controller is operable to control the transceiver to attempt to receive the scheduling signal from each candidate of the radio search space. For example, the radio search space may be a CSS and the scheduling signal may be the repeatedly transmitted NB-PDCCH. In this case the characteristic of the scheduling signal is a starting time of the radio search space indicated by the scheduling signal, and the controller is operable to determine, on the basis of the starting time of the radio search space and a starting time of the scheduling signal, whether the scheduling signal belongs to a radio search space with a starting time which matches the starting time of the one of the plurality of periodic paging occasions associated with the terminal device, wherein the controller determines a match when the scheduling signal is determined to belong to a radio search space

with a starting time which matches the starting time of the one of the plurality of periodic paging occasions associated with the terminal device.

In this first embodiment, the present technique also provides infrastructure equipment 101 for use with a wireless telecommunications network. The infrastructure equipment comprises a transceiver 411, 412 and a controller 413. The controller is operable to control the transceiver to begin transmitting, during the one of the plurality of periodic paging occasions associated with the terminal device 104, the scheduling signal scheduling the paging message for paging the terminal device in the way as described.

It will also be appreciated that, in a second embodiment, the present technique provides a terminal device 101for use with a wireless telecommunications network. The terminal device comprises a transceiver 401, 402 and a controller 403. The controller is operable to control the transceiver to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device (for example, the plurality of periodic paging occasions PO1 or PO2), a scheduling signal (carried by the NB-PDCCH, for example) scheduling a paging message for paging the terminal device. The scheduling signal is repeatedly transmitted by the network a predetermined number of times over a predetermined plurality of separate time periods (in other words, the periodic repeats of the scheduling signal are segmented, as shown in Figures 9 to 11, for example), each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin receiving the scheduling signal. The controller is operable to control the transceiver to receive the repetitions of the scheduling signal over the predetermined plurality of separate time periods.

In one example, the total time taken for the scheduling signal to be repeatedly transmitted by the network is greater than the time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated. Scheduling signals with a duration of that of CSS1 or CSS 5 (shown in Figures 9 to 11) are examples of such scheduling signals.

In one example, the plurality of periodic paging occasions associated with the terminal device are interleaved with the plurality of periodic paging occasions associated with any other terminal device of the wireless telecommunications network. This is shown, for example, in Figures 9 to 11, in which paging occasions belonging to the plurality PO1 are interleaved with paging occasions belonging to the plurality PO2.

In one example, the controller is operable to control the transceiver to receive a signal from the wireless telecommunications network indicative of the predetermined plurality of separate time periods. In this case, for example, information indicative of the predetermined plurality of separate time periods (in other words, the segmentation pattern of the repeatedly transmitted scheduling signal) is stored in the storage medium 422 of the infrastructure equipment 101 and is signalled to the terminal device 104 using the transceiver 411, 412. The transceiver 401, 402 of the terminal device then receives the signal and the information indicative of the predetermined plurality of separate time periods is stored in the storage medium 420.

In one example, the number of other terminal devices of the wireless telecommunications network with which a plurality of periodic paging occasions is associated is one or more, and the plurality of periodic paging occasions associated with the one or more other terminal devices is different to the plurality of periodic paging occasions associated with the terminal device. In this case, for example, there are at least two terminal devices in the wireless telecommunications network, wherein one terminal device is associated with the plurality of periodic paging occasions PO1 and the other terminal device is associated with the plurality of periodic paging occasions PO2, as shown in Figures 9 to 11. In another example, there may be no other terminal devices associated with a plurality of different periodic paging occasions (in which case, the only paging occasions present are those associated with the terminal device 104). It is noted that the present technique will still work in this case, in that if the terminal device knows the predetermined plurality of separate time periods over which the scheduling signal is repeatedly transmitted, the terminal device will know which paging occasion a particular set of repeats of the scheduling signal belongs to (thus avoiding the confusion arising from the situation shown in Figure 8, for example).

In this second embodiment, the present technique also provides infrastructure equipment 101 for use with a wireless telecommunications network. The infrastructure equipment comprises a transceiver 411, 412 and a controller 413. The controller is operable to control the transceiver to begin transmitting, during the one of the plurality of periodic paging occasions associated with a terminal device 104, the scheduling signal scheduling the paging message for paging the terminal device in the way as described.

Figure 12 illustrates a flow chart schematically showing a method according to the first embodiment of the present technique. The method starts at step 1201. At step 1202, the terminal device 104 begins receiving a scheduling signal during one of a plurality of periodic paging occasions associated with the terminal device. At step 1204, it is determined whether a value of a predetermined characteristic associated with each of the received scheduling signal and the one of the plurality of paging occasions matches. In the case that there is no match, the method ends at step 1208. On the other hand, in the case

that there is a match, the method moves on to step 1206, in which the terminal device receives a paging message scheduled by the scheduling signal. The method then ends at step 1208.

Figure 13 illustrates a flow chart schematically showing a method according to the second embodiment of the present technique. The method starts at step 1301. At step 1302, the terminal device 104 begins receiving a scheduling signal during one of a plurality of periodic paging occasions associated with the terminal device. At step 1303, the terminal device receives a predetermined number of repeats of the scheduling signal over a predetermined plurality of separate time periods. At step 1304, the terminal device receives a paging message scheduled by the scheduling signal. The method then ends at step 1305.

Features of various embodiments of the present technique are described by the following numbered clauses:

1. A terminal device for use with a wireless telecommunications network, the terminal device comprising:

a transceiver; and

a controller operable:

to control the transceiver to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging one or more terminal devices of the wireless telecommunications network, each periodic paging occasion associated with the terminal device being associated with a value of a characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network;

to determine whether the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device; and

if the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device, to control the transceiver to receive the paging message scheduled by the received scheduling message.

2. A terminal device according to clause 1, wherein the characteristic of the scheduling signal is a paging occasion identifier identified by the scheduling signal.

3. A terminal device according to clause 2, wherein all periodic paging occasions associated with the terminal device are associated with the same identifier of the scheduling signal.

4. A terminal device according to clause 2, wherein each periodic paging occasion associated with the terminal device is associated with an identifier of the scheduling signal which is different from the identifier of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device.

5. A terminal device according to clause 1, wherein the characteristic of the scheduling signal is a scrambling of the scheduling signal.

6. A terminal device according to clause 5, wherein all periodic paging occasions associated with the terminal device are associated with the same scrambling of the scheduling signal.

7. A terminal device according to clause 5, wherein each periodic paging occasion associated with the terminal device is associated with a scrambling of the scheduling signal which is different from the scrambling of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device.

8. A terminal device according to any preceding clause, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate, and wherein the controller is operable to control the transceiver to attempt to receive the scheduling signal from each candidate of the radio search space.

9. A terminal device according to clause 1, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate, and wherein the controller is operable to control the transceiver to attempt to receive the scheduling signal from each candidate of the radio search space, wherein the characteristic of the scheduling signal is a starting time of the radio search space indicated by the scheduling signal, and the controller is operable to determine, on the basis of the starting time of the radio search space and a starting time of the scheduling signal, whether the scheduling signal belongs to a radio search space with a starting time which matches the starting time of the one of the plurality of periodic paging occasions associated with the terminal device, wherein the controller determines a match when the scheduling signal is determined to belong to a

radio search space with a starting time which matches the starting time of the one of the plurality of periodic paging occasions associated with the terminal device.

10. A terminal device according to any preceding clause, wherein the terminal device is a Narrow Band Internet of Things (NB-IoT) terminal device and the scheduling signal is carried by a Narrow Band Physical Downlink Control Channel (NB-PDCCH).

11. Infrastructure equipment for use with a wireless telecommunications network, the infrastructure equipment comprising:

a transceiver; and

a controller operable:

to control the transceiver to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device, wherein a value of a characteristic of the scheduling signal is associated with the one of the plurality of periodic paging occasions associated with the terminal device, each periodic paging occasion associated with the terminal device being associated with a value of the characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network.

12. Infrastructure equipment according to clause 11, wherein the characteristic of the scheduling signal is a paging occasion identifier identified by the scheduling signal.

13. Infrastructure equipment according to clause 12, wherein all periodic paging occasions associated with the terminal device are associated with the same identifier of the scheduling signal.

14. Infrastructure equipment according to clause 12, wherein each periodic paging occasion associated with the terminal device is associated with an identifier of the scheduling signal which is different from the identifier of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device.

15. Infrastructure equipment according to clause 11, wherein the characteristic of the scheduling signal is a scrambling of the scheduling signal.

16. Infrastructure equipment according to clause 15, wherein all periodic paging occasions associated with the terminal device are associated with the same scrambling of the scheduling signal.

17. Infrastructure equipment according to clause 15, wherein each periodic paging occasion associated with the terminal device is associated with a scrambling of the scheduling signal which is different from the scrambling of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device.

18. Infrastructure equipment according to any one of clauses 11 to 17, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate.

19. Infrastructure equipment according to clause 11, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate, , wherein the characteristic of the scheduling signal is a starting time of the radio search space indicated by the scheduling signal, the starting time of the radio search space matching the starting time of the one of the plurality of periodic paging occasions associated with the terminal device.

20. Infrastructure equipment according to any one of clauses 11 to 19, wherein the terminal device is a Narrow Band Internet of Things (NB-IoT) terminal device and the scheduling signal is carried by a Narrow Band Physical Downlink Control Channel (NB-PDCCH).

21. A method of operating a terminal device for use with a wireless telecommunications network, the method comprising:

controlling a transceiver of the terminal device to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging one or more terminal devices of the wireless telecommunications network, each periodic paging occasion associated with the terminal device being associated with a value of a characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network;

determining whether the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device; and

if the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device, controlling the transceiver to receive the paging message scheduled by the received scheduling message.

22. A method of operating infrastructure equipment for use with a wireless telecommunications network, the method comprising:

controlling a transceiver of the infrastructure equipment to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device, wherein a value of a characteristic of the scheduling signal is associated with the one of the plurality of periodic paging occasions associated with the terminal device, each periodic paging occasion associated with the terminal device being associated with a value of the characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network.

23. Integrated circuitry for a terminal device for use with a wireless telecommunications network, the integrated circuitry comprising:

a transceiver element; and

a controller element operable:

to control the transceiver element to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging one or more terminal devices of the wireless telecommunications network, each periodic paging occasion associated with the terminal device being associated with a value of a characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network;

to determine whether the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device; and

if the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device, to control the transceiver element to receive the paging message scheduled by the received scheduling message.

24. Integrated circuitry for infrastructure equipment for use with a wireless telecommunications network, the integrated circuitry comprising:

a transceiver element; and

a controller element operable:

to control the transceiver element to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device, wherein a value of a characteristic of the scheduling signal is associated with the one of the plurality of periodic paging occasions associated with the terminal device, each periodic paging occasion associated with the terminal device being associated with a value of the characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network.

25. A wireless telecommunications network comprising a terminal device according to clause 1 and infrastructure equipment according to clause 11.

26. A terminal device for use with a wireless telecommunications network, the terminal device comprising:

a transceiver; and

a controller operable:

to control the transceiver to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the scheduling signal is repeatedly transmitted by the network a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin receiving the scheduling signal; and

the controller is operable to control the transceiver to receive the repetitions of the scheduling signal over the predetermined plurality of separate time periods.

27. A terminal device according to clause 26, wherein the total time taken for the scheduling signal to be repeatedly transmitted by the network is greater than the time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated.

28. A terminal device according to clause 26 or 27, wherein the plurality of periodic paging occasions associated with the terminal device are interleaved with the plurality of periodic paging occasions associated with any other terminal device of the wireless telecommunications network.

29. A terminal device according to any one of clauses 26 to 28, wherein the controller is operable to control the transceiver to receive a signal from the wireless telecommunications network indicative of the predetermined plurality of separate time periods.

30. A terminal device according to any one of clauses 26 to 29, wherein the number of other terminal devices of the wireless telecommunications network with which a plurality of periodic paging occasions is associated is one or more, and the plurality of periodic paging occasions associated with the one or more other terminal devices is different to the plurality of periodic paging occasions associated with the terminal device.

31. A terminal device according to any one of clauses 26 to 30, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate, and wherein the controller is operable to control the transceiver to attempt to receive the scheduling signal from each candidate of the radio search space.

32. A terminal device according to any one of clauses 26 to 31, wherein the terminal device is a Narrow Band Internet of Things (NB-IoT) terminal device and the scheduling signal is carried by a Narrow Band Physical Downlink Control Channel (NB-PDCCH).

33. Infrastructure equipment for use with a wireless telecommunications network, the infrastructure equipment comprising:

a transceiver; and

a controller operable:

to control the transceiver to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the controller is operable to control the transceiver to repeatedly transmit the scheduling signal a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin transmitting the scheduling signal.

34. Infrastructure equipment according to clause 33, wherein the total time taken for the scheduling signal to be repeatedly transmitted by the transceiver is greater than the time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated.

35. Infrastructure equipment according to clause 33 or 34, wherein the plurality of periodic paging occasions associated with the terminal device are interleaved with the plurality of periodic paging occasions associated with any other terminal device of the wireless telecommunications network.

36. Infrastructure equipment according to any one of claims 33 to 35, wherein the controller is operable to control the transceiver to transmit a signal to the terminal device indicative of the predetermined plurality of separate time periods.

37. Infrastructure equipment according to any one of clauses 33 to 36, wherein the number of other terminal devices of the wireless telecommunications network with which a plurality of periodic paging occasions is associated is one or more, and the plurality of periodic paging occasions associated with the one or more other terminal devices is different to the plurality of periodic paging occasions associated with the terminal device.

38. Infrastructure equipment according to any one of clauses 33 to 37, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate..

39. Infrastructure equipment according to any one of clauses 33 to 38, wherein the terminal device is a Narrow Band Internet of Things (NB-IoT) terminal device and the scheduling signal is carried by a Narrow Band Physical Downlink Control Channel (NB-PDCCH).

40. A method of operating a terminal device for use with a wireless telecommunications network, the method comprising:

controlling a transceiver of the terminal device to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the scheduling signal is repeatedly transmitted by the network a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin receiving the scheduling signal; and

transceiver is controlled to receive the repetitions of the scheduling signal over the predetermined plurality of separate time periods.

41. A method of operating infrastructure equipment for use with a wireless telecommunications network, the method comprising:

controlling a transceiver of the infrastructure equipment to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the transceiver is controlled to repeatedly transmit the scheduling signal a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin transmitting the scheduling signal.

42. Integrated circuitry for a terminal device for use with a wireless telecommunications network, the integrated circuitry comprising:

a transceiver element; and

a controller element operable:

to control the transceiver element to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the scheduling signal is repeatedly transmitted by the network a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver element is controlled to begin receiving the scheduling signal; and

the controller element is operable to control the transceiver element to receive the repetitions of the scheduling signal over the predetermined plurality of separate time periods.

43. Integrated circuitry for operating infrastructure equipment for use with a wireless telecommunications network, the integrated circuitry comprising:

a transceiver element; and

a controller element operable:

to control the transceiver element to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the controller element is operable to control the transceiver to repeatedly transmit the scheduling signal a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver element is controlled to begin transmitting the scheduling signal.

44. A wireless telecommunications network comprising a terminal device according to clause 26 and infrastructure equipment according to clause 33.

Numerous modifications and variations of the present disclosure are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the disclosure may be practiced otherwise than as specifically described herein.

In so far as embodiments of the disclosure have been described as being implemented, at least in part, by software-controlled data processing apparatus, it will be appreciated that a non-transitory machine-readable medium carrying such software, such as an optical disk, a magnetic disk, semiconductor memory or the like, is also considered to represent an embodiment of the present disclosure.

It will be appreciated that the above description for clarity has described embodiments with reference to different functional units, circuitry and/or processors. However, it will be apparent that any suitable distribution of functionality between different functional units, circuitry and/or processors may be used without detracting from the embodiments.

Described embodiments may be implemented in any suitable form including hardware, software, firmware or any combination of these. Described embodiments may optionally be implemented at least partly as computer software running on one or more data processors and/or digital signal processors. The elements and components of any embodiment may be physically, functionally and logically implemented in any suitable way. Indeed the functionality may be implemented in a single unit, in a plurality of units or as part of other functional units. As such, the disclosed embodiments may be implemented in a single unit or may be physically and functionally distributed between different units, circuitry and/or processors.

Although the present disclosure has been described in connection with some embodiments, it is not intended to be limited to the specific form set forth herein. Additionally, although a feature may appear to be described in connection with particular embodiments, one skilled in the art would recognize that various features of the described embodiments may be combined in any manner suitable to implement the technique.

Annex 1:

The simplified structure of the downlink of an LTE wireless access interface presented in Figure 2, also includes an illustration of each subframe 201, which comprises a control region 205 for the transmission of control data, a data region 206 for the transmission of user data , reference signals 207 and synchronisation signals which are interspersed in the control and data regions in accordance with a predetermined pattern. The control region 204 may contain a number of physical channels for the transmission of control data, such as a physical downlink control channel PDCCH, a physical control format indicator channel PCFICH and a physical HARQ indicator channel PHICH. The data region may contain a number of physical channel for the transmission of data, such as a physical downlink shared channel PDSCH and a physical broadcast channels PBCH. Although these physical channels provide a wide range of functionality to LTE systems, in terms of resource allocation and the present disclosure PDCCH and PDSCH are most relevant. Further information on the structure and functioning of the physical channels of LTE systems can be found in [1].

Resources within the PDSCH may be allocated by an eNodeB to UEs being served by the eNodeB. For example, a number of resource blocks of the PDSCH may be allocated to a UE in order that it may receive data that it has previously requested or data which is being pushed to it by the eNodeB, such as radio resource control RRC signalling. In Figure 2, UE1 has been allocated resources 208 of the data region 206, UE2 resources 209 and UE resources 210. UEs in a an LTE system may be allocated a fraction of the available resources of the PDSCH and therefore UEs are required to be informed of the location of their allocated resources within the PDCSH so that only relevant data within the PDSCH is detected and estimated. In order to inform the UEs of the location of their allocated communications resources, resource control information specifying downlink resource allocations is conveyed across the PDCCH in a form termed downlink control information DCI, where resource allocations for a PDSCH are communicated in a preceding PDCCH instance in the same subframe. During a resource allocation procedure, UEs thus monitor the PDCCH for DCI addressed to them and once such a DCI is detected, receive the DCI and detect and estimate the data from the relevant part of the PDSCH.

Each uplink subframe may include a plurality of different channels, for example a physical uplink shared channel PUSCH 305, a physical uplink control channel PUCCH 306, and a physical random access channel PRACH. The physical Uplink Control Channel PUCCH may carry control information such as ACK/NACK to the eNodeB for downlink transmissions, scheduling request indicators SRI for UEs wishing to be scheduled uplink resources, and feedback of downlink channel state information CSI for example. The PUSCH may carry UE uplink data or some uplink control data. Resources of the PUSCH are granted via PDCCH, such a grant being typically triggered by communicating to the network the amount of data ready to be transmitted in a buffer at the UE. The PRACH may be scheduled in any of the

resources of an uplink frame in accordance with a one of a plurality of PRACH patterns that may be signalled to UE in downlink signalling such as system information blocks. As well as physical uplink channels, uplink subframes may also include reference signals. For example, demodulation reference signals DMRS 307 and sounding reference signals SRS 308 may be present in an uplink subframe where the DMRS occupy the fourth symbol of a slot in which PUSCH is transmitted and are used for decoding of PUCCH and PUSCH data, and where SRS are used for uplink channel estimation at the eNodeB. Further information on the structure and functioning of the physical channels of LTE systems can be found in [1].

In an analogous manner to the resources of the PDSCH, resources of the PUSCH are required to be scheduled or granted by the serving eNodeB and thus if data is to be transmitted by a UE, resources of the PUSCH are required to be granted to the UE by the eNodeB. At a UE, PUSCH resource allocation is achieved by the transmission of a scheduling request or a buffer status report to its serving eNodeB. The scheduling request may be made, when there is insufficient uplink resource for the UE to send a buffer status report, via the transmission of Uplink Control Information UCI on the PUCCH when there is no existing PUSCH allocation for the UE, or by transmission directly on the PUSCH when there is an existing PUSCH allocation for the UE. In response to a scheduling request, the eNodeB is configured to allocate a portion of the PUSCH resource to the requesting UE sufficient for transferring a buffer status report and then inform the UE of the buffer status report resource allocation via a DCI in the PDCCH. Once or if the UE has PUSCH resource adequate to send a buffer status report, the buffer status report is sent to the eNodeB and gives the eNodeB information regarding the amount of data in an uplink buffer or buffers at the UE. After receiving the buffer status report, the eNodeB can allocate a portion of the PUSCH resources to the sending UE in order to transmit some of its buffered uplink data and then inform the UE of the resource allocation via a DCI in the PDCCH. For example, presuming a UE has a connection with the eNodeB, the UE will first transmit a PUSCH resource request in the PUCCH in the form of a UCI. The UE will then monitor the PDCCH for an appropriate DCI, extract the details of the PUSCH resource allocation, and transmit uplink data , at first comprising a buffer status report, and/or later comprising a portion of the buffered data, in the allocated resources.

Although similar in structure to downlink subframes, uplink subframes have a different control structure to downlink subframes, in particular the upper 309 and lower 310 subcarriers/frequencies/resource blocks of an uplink subframe are reserved for control signalling rather than the initial symbols of a downlink subframe. Furthermore, although the resource allocation procedure for the downlink and uplink are relatively similar, the actual structure of the resources that may be allocated may vary due to the different characteristics of the OFDM and SC-FDM interfaces that are used in the downlink and uplink respectively. In OFDM each subcarrier is individually modulated and therefore it is not necessary that frequency/subcarrier allocation are contiguous however, in SC-FDM subcarriers are modulation in

combination and therefore if efficient use of the available resources are to be made contiguous frequency allocations for each UE are preferable.

As a result of the above described wireless interface structure and operation, one or more UEs may communicate data to one another via a coordinating eNodeB, thus forming a conventional cellular telecommunications system. Although cellular communications system such as those based on the previously released LTE standards have been commercially successful, a number of disadvantages are associated with such centralised systems. For example, if two UEs which are in close proximity wish to communicate with each other, uplink and downlink resources sufficient to convey the data are required. Consequently, two portions of the system's resources are being used to convey a single portion of data. A second disadvantage is that an eNodeB is required if UEs, even when in close proximity, wish to communicate with one another. These limitations may be problematic when the system is experiencing high load or eNodeB coverage is not available, for instance in remote areas or when eNodeBs are not functioning correctly. Overcoming these limitations may increase both the capacity and efficiency of LTE networks but also lead to the creations of new revenue possibilities for LTE network operators.

References

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CLAIMS

1. A terminal device for use with a wireless telecommunications network, the terminal device comprising:

a transceiver; and

a controller operable:

to control the transceiver to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging one or more terminal devices of the wireless telecommunications network, each periodic paging occasion associated with the terminal device being associated with a value of a characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network;

to determine whether the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device; and

if the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device, to control the transceiver to receive the paging message scheduled by the received scheduling message.

2. A terminal device according to claim 1, wherein the characteristic of the scheduling signal is a paging occasion identifier identified by the scheduling signal.

3. A terminal device according to claim 2, wherein all periodic paging occasions associated with the terminal device are associated with the same identifier of the scheduling signal.

4. A terminal device according to claim 2, wherein each periodic paging occasion associated with the terminal device is associated with an identifier of the scheduling signal which is different from the identifier of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device.

5. A terminal device according to claim 1, wherein the characteristic of the scheduling signal is a scrambling of the scheduling signal.

6. A terminal device according to claim 5, wherein all periodic paging occasions associated with the terminal device are associated with the same scrambling of the scheduling signal.

7. A terminal device according to claim 5, wherein each periodic paging occasion associated with the terminal device is associated with a scrambling of the scheduling signal which is different from the scrambling of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device.

8. A terminal device according to claim 1, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate, and wherein the controller is operable to control the transceiver to attempt to receive the scheduling signal from each candidate of the radio search space.

9. A terminal device according to claim 1, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate, and wherein the controller is operable to control the transceiver to attempt to receive the scheduling signal from each candidate of the radio search space, wherein the characteristic of the scheduling signal is a starting time of the radio search space indicated by the scheduling signal, and the controller is operable to determine, on the basis of the starting time of the radio search space and a starting time of the scheduling signal, whether the scheduling signal belongs to a radio search space with a starting time which matches the starting time of the one of the plurality of periodic paging occasions associated with the terminal device, wherein the controller determines a match when the scheduling signal is determined to belong to a radio search space with a starting time which matches the starting time of the one of the plurality of periodic paging occasions associated with the terminal device.

10. A terminal device according to claim 1, wherein the terminal device is a Narrow Band Internet of Things (NB-IoT) terminal device and the scheduling signal is carried by a Narrow Band Physical Downlink Control Channel (NB-PDCCH).

11. Infrastructure equipment for use with a wireless telecommunications network, the infrastructure equipment comprising:

a transceiver; and

a controller operable:

to control the transceiver to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device, wherein a value of a characteristic of the scheduling signal is associated with the one of the plurality of periodic paging occasions associated with the terminal device, each periodic paging occasion associated with the terminal device being associated with a value of the characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network.

12. Infrastructure equipment according to claim 11, wherein the characteristic of the scheduling signal is a paging occasion identifier identified by the scheduling signal.

13. Infrastructure equipment according to claim 12, wherein all periodic paging occasions associated with the terminal device are associated with the same identifier of the scheduling signal.

14. Infrastructure equipment according to claim 12, wherein each periodic paging occasion associated with the terminal device is associated with an identifier of the scheduling signal which is different from the identifier of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device.

15. Infrastructure equipment according to claim 11, wherein the characteristic of the scheduling signal is a scrambling of the scheduling signal.

16. Infrastructure equipment according to claim 15, wherein all periodic paging occasions associated with the terminal device are associated with the same scrambling of the scheduling signal.

17. Infrastructure equipment according to claim 15, wherein each periodic paging occasion associated with the terminal device is associated with a scrambling of the scheduling signal which is different from the scrambling of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device.

18. Infrastructure equipment according to claim 11, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate.

19. Infrastructure equipment according to claim 11, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate, , wherein the characteristic of the scheduling signal is a starting time of the radio search space indicated by the scheduling signal, the starting time of the radio search space matching the starting time of the one of the plurality of periodic paging occasions associated with the terminal device.

20. Infrastructure equipment according to claim 11, wherein the terminal device is a Narrow Band Internet of Things (NB-IoT) terminal device and the scheduling signal is carried by a Narrow Band Physical Downlink Control Channel (NB-PDCCH).

21. A method of operating a terminal device for use with a wireless telecommunications network, the method comprising:

controlling a transceiver of the terminal device to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging one or more terminal devices of the wireless telecommunications network, each periodic paging occasion associated with the terminal device being associated with a value of a characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network;

determining whether the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device; and

if the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device, controlling the transceiver to receive the paging message scheduled by the received scheduling message.

22. A method of operating infrastructure equipment for use with a wireless telecommunications network, the method comprising:

controlling a transceiver of the infrastructure equipment to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device, wherein a value of a characteristic of the scheduling signal is associated with the one of the

plurality of periodic paging occasions associated with the terminal device, each periodic paging occasion associated with the terminal device being associated with a value of the characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network.

23. Integrated circuitry for a terminal device for use with a wireless telecommunications network, the integrated circuitry comprising:

a transceiver element; and

a controller element operable:

to control the transceiver element to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging one or more terminal devices of the wireless telecommunications network, each periodic paging occasion associated with the terminal device being associated with a value of a characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network;

to determine whether the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device; and

if the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device, to control the transceiver element to receive the paging message scheduled by the received scheduling message.

24. Integrated circuitry for infrastructure equipment for use with a wireless telecommunications network, the integrated circuitry comprising:

a transceiver element; and

a controller element operable:

to control the transceiver element to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device, wherein a value of a characteristic of the scheduling signal is associated with the one of the plurality of periodic paging occasions associated with the terminal device, each periodic paging occasion associated with the terminal device being associated with a value of the characteristic of the scheduling signal which is different from

a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network.

25. A wireless telecommunications network comprising a terminal device according to claim 1 and infrastructure equipment according to claim 11.

26. A terminal device for use with a wireless telecommunications network, the terminal device comprising:

a transceiver; and

a controller operable:

to control the transceiver to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the scheduling signal is repeatedly transmitted by the network a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin receiving the scheduling signal; and

the controller is operable to control the transceiver to receive the repetitions of the scheduling signal over the predetermined plurality of separate time periods.

27. A terminal device according to claim 26, wherein the total time taken for the scheduling signal to be repeatedly transmitted by the network is greater than the time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated.

28. A terminal device according to claim 26, wherein the plurality of periodic paging occasions associated with the terminal device are interleaved with the plurality of periodic paging occasions associated with any other terminal device of the wireless telecommunications network.

29. A terminal device according to claim 26, wherein the controller is operable to control the transceiver to receive a signal from the wireless telecommunications network indicative of the predetermined plurality of separate time periods.

30. A terminal device according to claim 26, wherein the number of other terminal devices of the wireless telecommunications network with which a plurality of periodic paging occasions is associated is one or more, and the plurality of periodic paging occasions associated with the one or more other terminal devices is different to the plurality of periodic paging occasions associated with the terminal device.

31. A terminal device according to claim 26, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate, and wherein the controller is operable to control the transceiver to attempt to receive the scheduling signal from each candidate of the radio search space.

32. A terminal device according to claim 26, wherein the terminal device is a Narrow Band Internet of Things (NB-IoT) terminal device and the scheduling signal is carried by a Narrow Band Physical Downlink Control Channel (NB-PDCCH).

33. Infrastructure equipment for use with a wireless telecommunications network, the infrastructure equipment comprising:

a transceiver; and

a controller operable:

to control the transceiver to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the controller is operable to control the transceiver to repeatedly transmit the scheduling signal a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin transmitting the scheduling signal.

34. Infrastructure equipment according to claim 33, wherein the total time taken for the scheduling signal to be repeatedly transmitted by the transceiver is greater than the time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated.

35. Infrastructure equipment according to claim 33, wherein the plurality of periodic paging occasions associated with the terminal device are interleaved with the plurality of periodic paging occasions associated with any other terminal device of the wireless telecommunications network.

36. Infrastructure equipment according to claim 33, wherein the controller is operable to control the transceiver to transmit a signal to the terminal device indicative of the predetermined plurality of separate time periods.

37. Infrastructure equipment according to claim 33, wherein the number of other terminal devices of the wireless telecommunications network with which a plurality of periodic paging occasions is associated is one or more, and the plurality of periodic paging occasions associated with the one or more other terminal devices is different to the plurality of periodic paging occasions associated with the terminal device.

38. Infrastructure equipment according to claim 33, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate..

39. Infrastructure equipment according to claim 33, wherein the terminal device is a Narrow Band Internet of Things (NB-IoT) terminal device and the scheduling signal is carried by a Narrow Band Physical Downlink Control Channel (NB-PDCCH).

40. A method of operating a terminal device for use with a wireless telecommunications network, the method comprising:

controlling a transceiver of the terminal device to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the scheduling signal is repeatedly transmitted by the network a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the

plurality of periodic paging occasions during which the transceiver is controlled to begin receiving the scheduling signal; and

transceiver is controlled to receive the repetitions of the scheduling signal over the predetermined plurality of separate time periods.

41. A method of operating infrastructure equipment for use with a wireless telecommunications network, the method comprising:

controlling a transceiver of the infrastructure equipment to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the transceiver is controlled to repeatedly transmit the scheduling signal a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin transmitting the scheduling signal.

42. Integrated circuitry for a terminal device for use with a wireless telecommunications network, the integrated circuitry comprising:

a transceiver element; and

a controller element operable:

to control the transceiver element to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the scheduling signal is repeatedly transmitted by the network a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver element is controlled to begin receiving the scheduling signal; and

the controller element is operable to control the transceiver element to receive the repetitions of the scheduling signal over the predetermined plurality of separate time periods.

43. Integrated circuitry for operating infrastructure equipment for use with a wireless telecommunications network, the integrated circuitry comprising:

a transceiver element; and

a controller element operable:

to control the transceiver element to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the controller element is operable to control the transceiver to repeatedly transmit the scheduling signal a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver element is controlled to begin transmitting the scheduling signal.

44. A wireless telecommunications network comprising a terminal device according to claim 26 and infrastructure equipment according to claim 33.

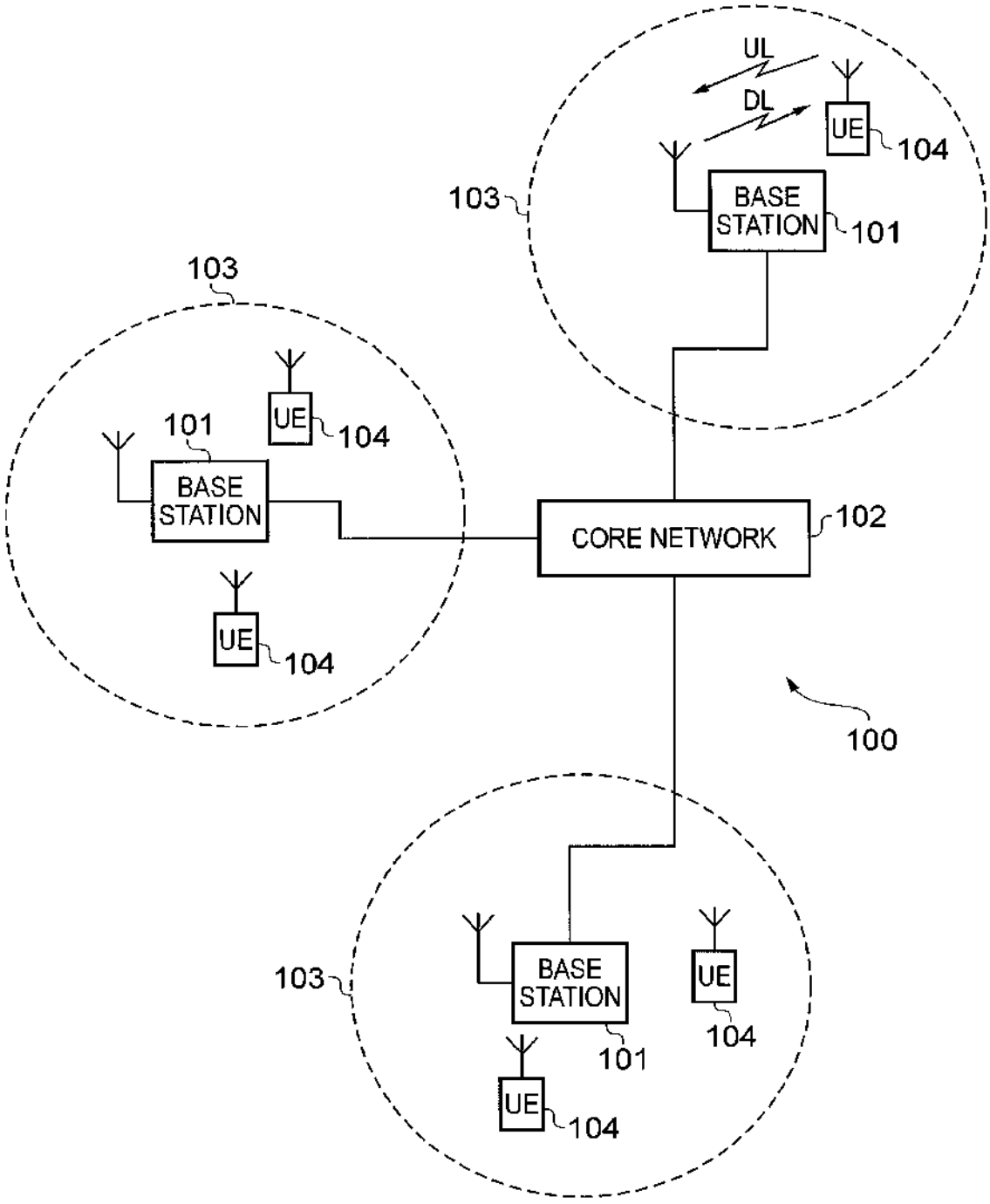

UL
DL
UE
104
103
BASE STATION
101
103
101
UE
104
BASE STATION
CORE NETWORK
102
UE
104
100
103
BASE STATION
UE
101
104
UE
104

FIG. 1

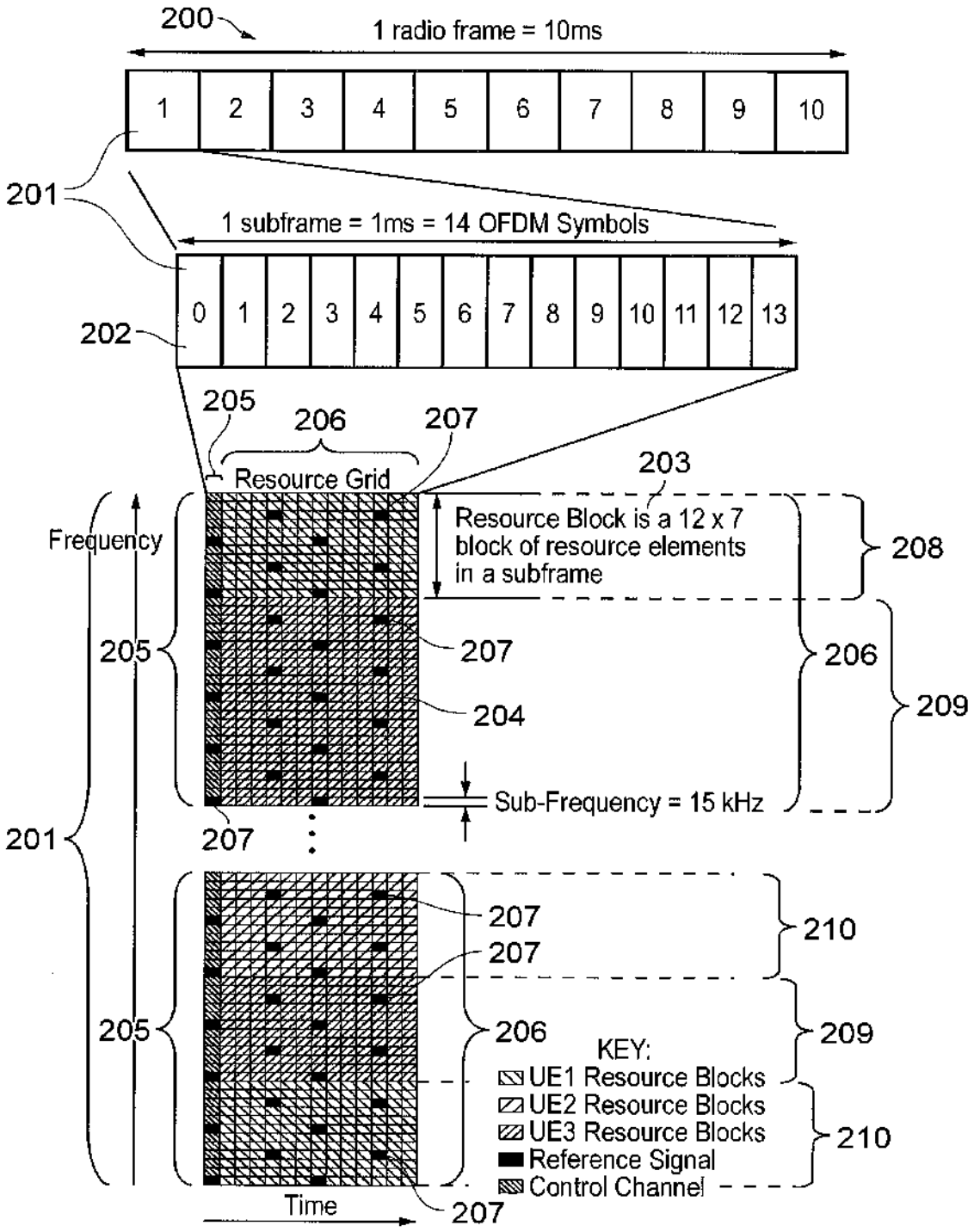

200
1 radio frame = 10ms
1
2
3
4
5
6
7
8
9
10
201
1 subframe = 1ms = 14 OFDM Symbols
0
1
2
3
4
5
6
7
8
9
10
11
12
13
202
205
206
207
Resource Grid
203
Frequency
Resource Block is a 12 x 7 block of resource elements in a subframe
208
205
207
206
209
204
Sub-Frequency = 15 kHz
201
207
207
207
210
205
206
209
KEY:
UE1 Resource Blocks
UE2 Resource Blocks
UE3 Resource Blocks
Reference Signal
Control Channel
210
Time
207

FIG. 2

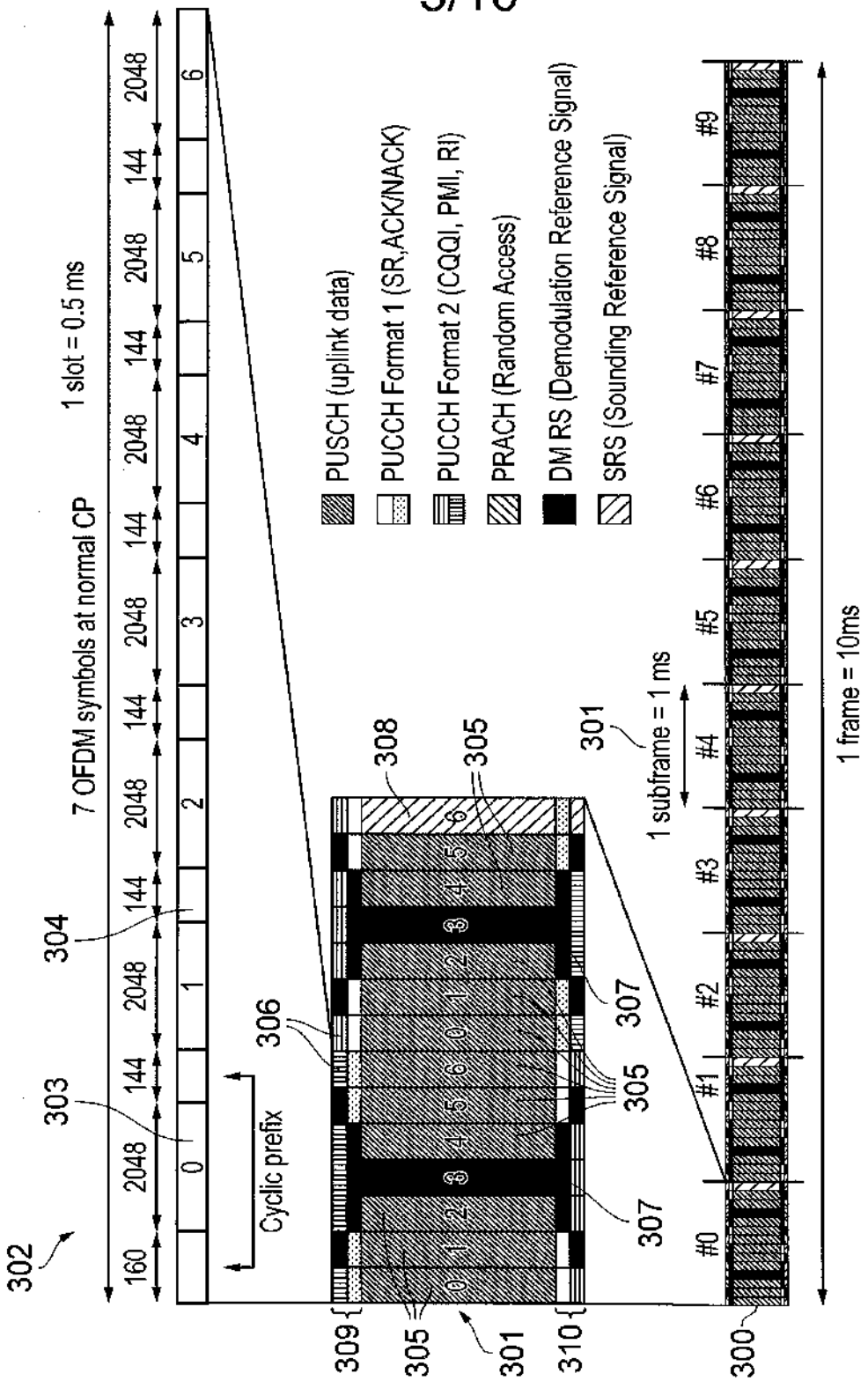

302
303
304
7 OFDM symbols at normal CP
1 slot = 0.5 ms
160
2048
144
2048
Cyclic prefix
306
308
305
301
307
309
310
300
PUSCH (uplink data)
PUCCH Format 1 (SR,ACK/NACK)
PUCCH Format 2 (CQQI, PMI, RI)
PRACH (Random Access)
DM RS (Demodulation Reference Signal)
SRS (Sounding Reference Signal)
1 subframe = 1 ms
#0
#1
#2
#3
#4
#5
#6
#7
#8
#9
1 frame = 10ms

FIG. 3

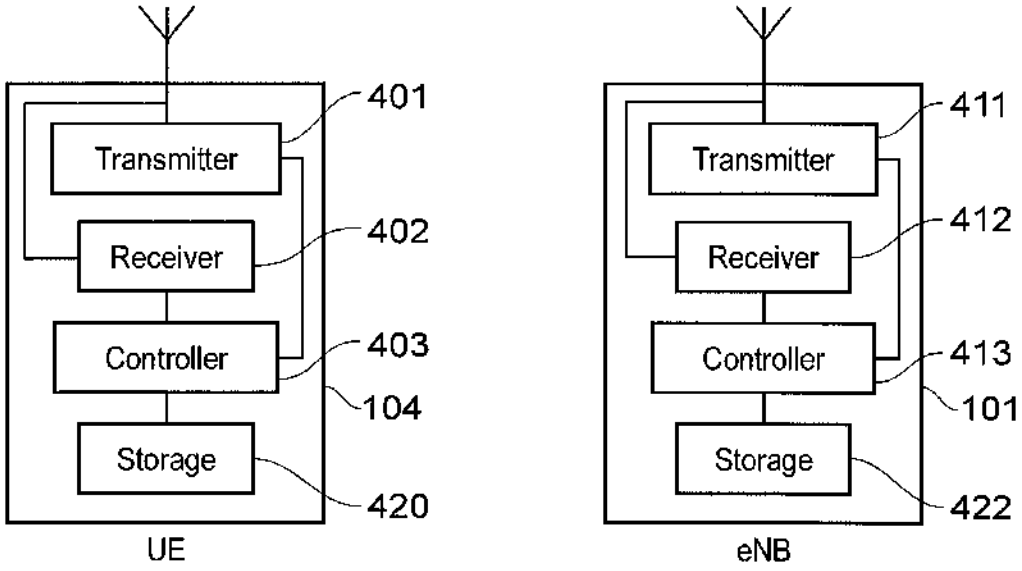

Transmitter
Receiver
Controller
Storage
401
402
403
104
420
UE
Transmitter
Receiver
Controller
Storage
411
412
413
101
422
eNB

FIG. 4

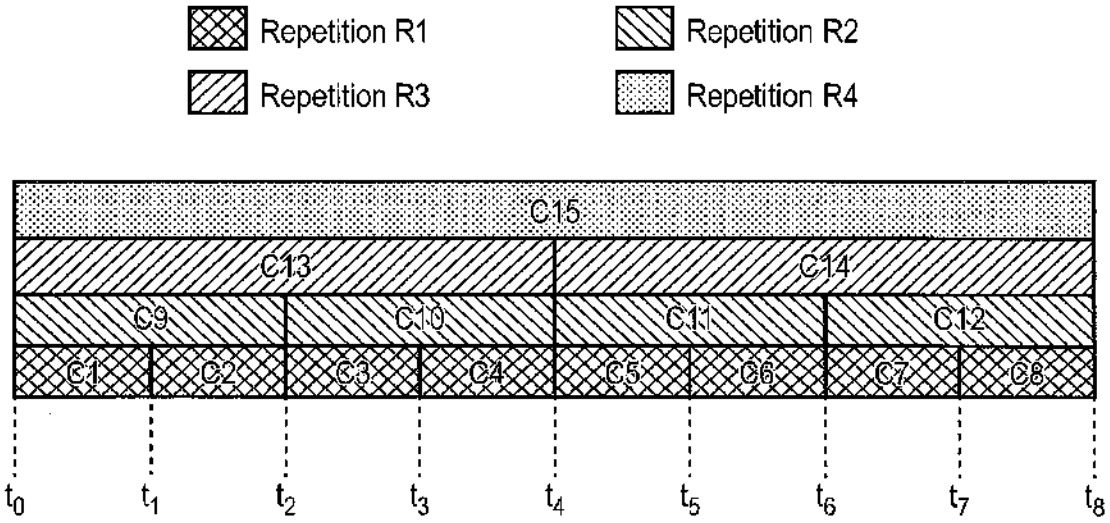

Repetition R1
Repetition R2
Repetition R3
Repetition R4
C15
C13
C14
C9
C10
C11
C12
C1
C2
C3
C4
C5
C6
C7
C8
t0
t1
t2
t3
t4
t5
t6
t7
t8

FIG. 5

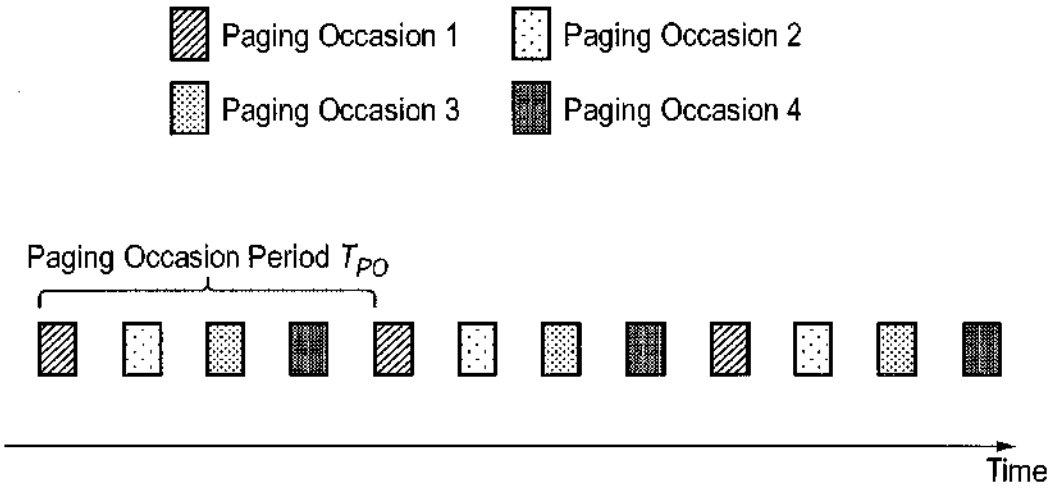

Paging Occasion 1
Paging Occasion 2
Paging Occasion 3
Paging Occasion 4
Paging Occasion Period T_{PO}
Time

FIG. 6

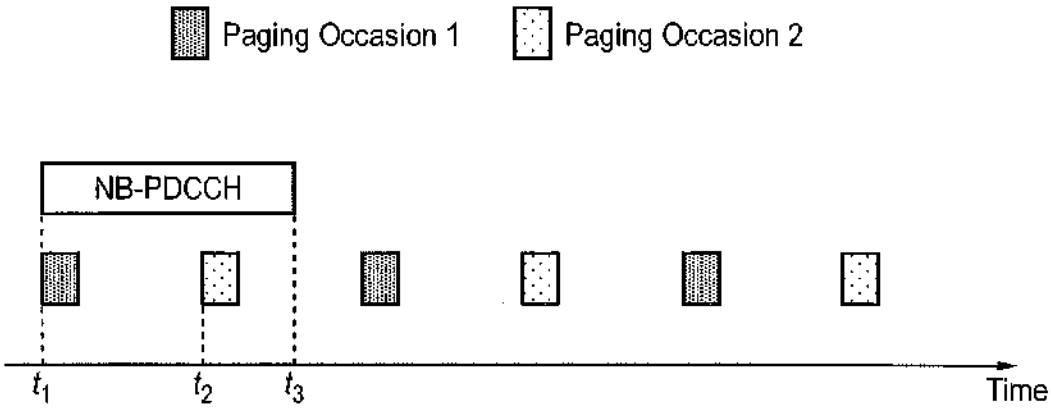

Paging Occasion 1
Paging Occasion 2
NB-PDCCH
t_1
t_2
t_3
Time

FIG. 7

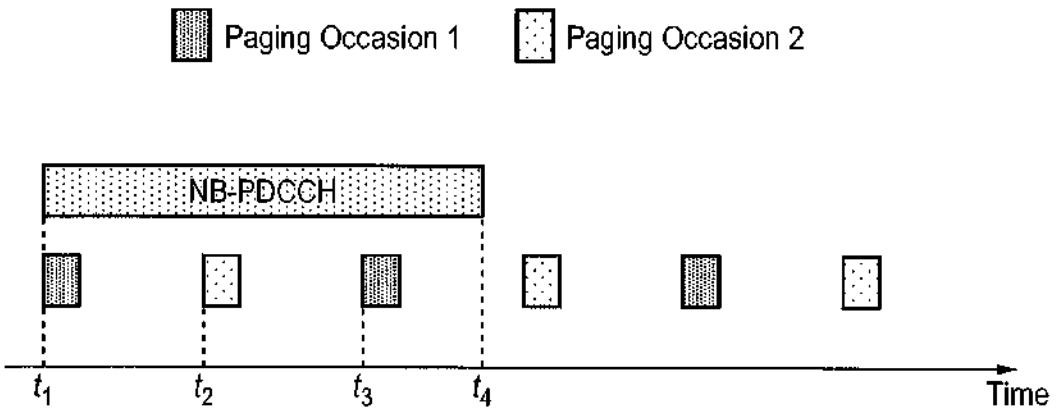

Paging Occasion 1
Paging Occasion 2
NB-PDCCH
t_1
t_2
t_3
t_4
Time

FIG. 8

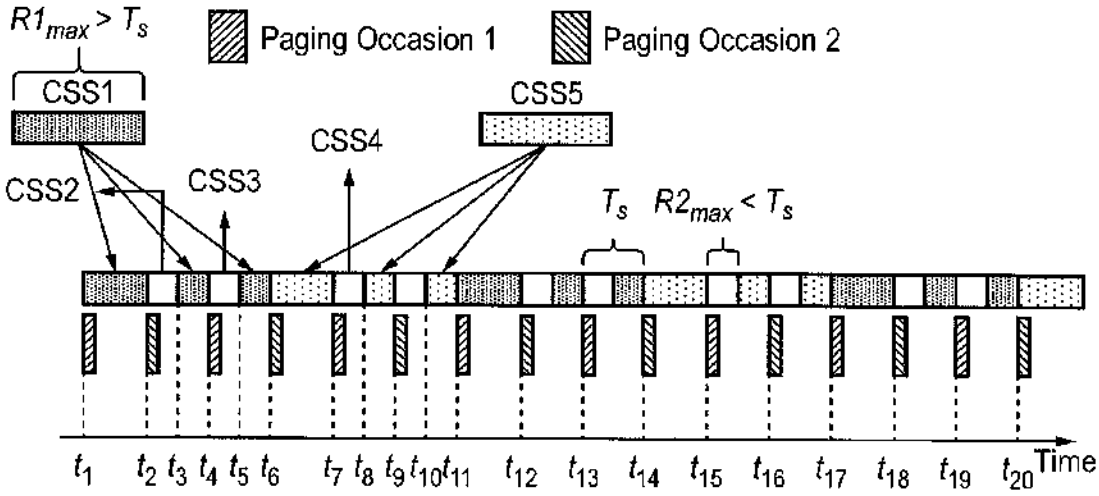

$R1_{max} > T_s$
Paging Occasion 1
Paging Occasion 2
CSS1
CSS5
CSS4
CSS2
CSS3
T_s
$R2_{max} < T_s$
t_1 t_2 t_3 t_4 t_5 t_6 t_7 t_8 t_9 t_{10} t_{11} t_{12} t_{13} t_{14} t_{15} t_{16} t_{17} t_{18} t_{19} t_{20}
Time

FIG. 9

8/10

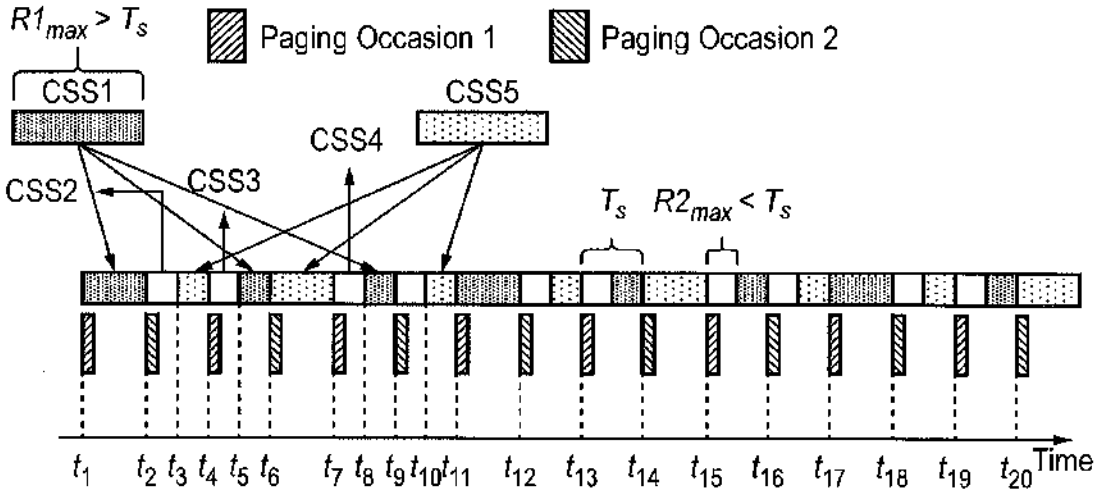


FIG. 10

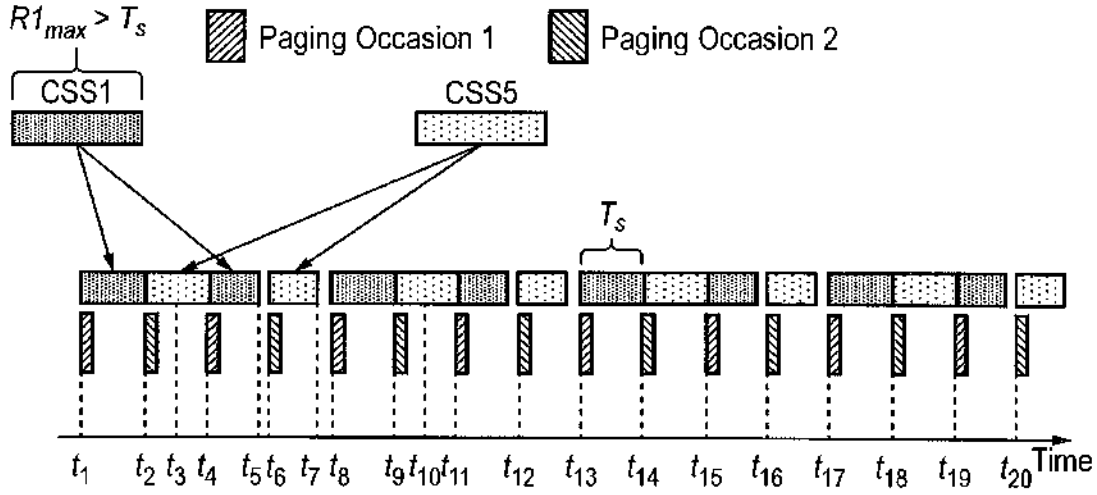


FIG. 11

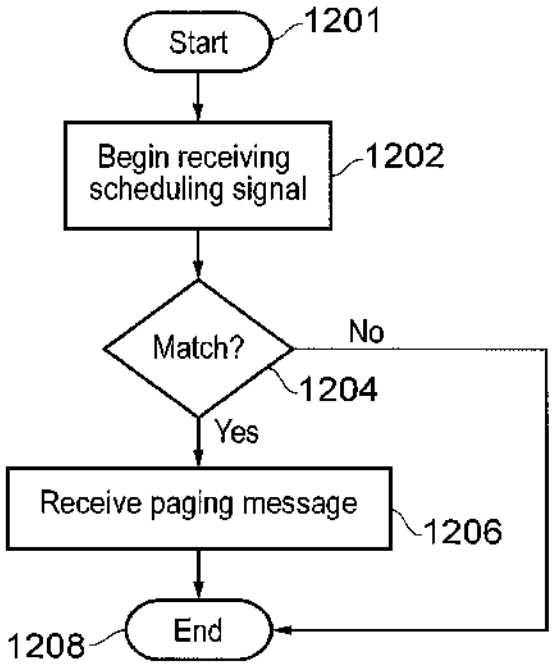

Start
1201
Begin receiving scheduling signal
1202
Match?
No
1204
Yes
Receive paging message
1206
End
1208

FIG. 12

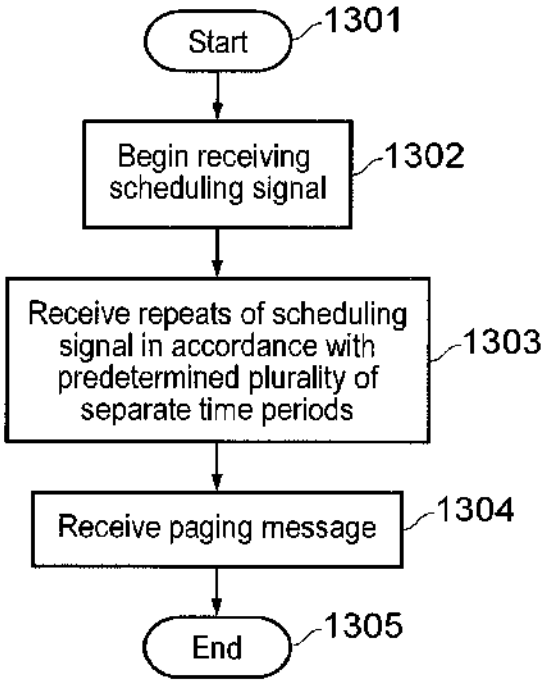

Start
1301
Begin receiving scheduling signal
1302
Receive repeats of scheduling signal in accordance with predetermined plurality of separate time periods
1303
Receive paging message
1304
End
1305

FIG. 13

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/057758

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W68/00
ADD. H04W4/00 H04W68/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 2 999 280 A2 (APPLE INC [US]) 23 March 2016 (2016-03-23) paragraphs [0100] - [0159] ----- -/--	1-25

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 July 2017	20/07/2017

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Bocking, Philip

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Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	ZTE: "Remaining Issues on NB-PDCCH Design of NB-IoT", 3GPP DRAFT; R1-160467 NB-PDCCH, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. St Julian's, Malta; 20160215 - 20160219 5 February 2016 (2016-02-05), XP051063789, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_84/Docs/ [retrieved on 2016-02-05] paragraphs [0004] - [05.2]; figures 4,7 -----	26-44
A	ERICSSON: "Paging and DRX in Idle mode in NB-IoT", 3GPP DRAFT; R2-161311 PAGING AND DRX IN IDLE MODE IN NB-IOT, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG2, no. St. Julian, Malta; 20160215 - 20160219 6 February 2016 (2016-02-06), XP051065779, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_93/Docs/ [retrieved on 2016-02-06] the whole document -----	1-44
A	ZTE: "Issues for PF/PO in NB-IOT", 3GPP DRAFT; R2-160411 ISSUES FOR PAGING IN NB-IOT-FINAL, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG2, no. Budapest, HU; 20160119 - 20160121 13 January 2016 (2016-01-13), XP051066437, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_AHs/2016_01_LTE_NB_IoT/Docs/ [retrieved on 2016-01-13] the whole document ----- -/--	1-44

2

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	INTEL CORPORATION: "Remaining open aspects on NBIOT Paging", 3GPP DRAFT; R2-160445_NB-IOT_PAGING_INTELV04, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG2, no. Budapest, HU; 20160119 - 20160121 18 January 2016 (2016-01-18), XP051054733, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN2/Docs/ [retrieved on 2016-01-18] the whole document -----	1-44
A	NOKIA NETWORKS: "Paging procedure for NB-IoT", 3GPP DRAFT; R2-160495 NB IOT PAGING PROCEDURE, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG2, no. Budapest, HU; 20160119 - 20160121 12 January 2016 (2016-01-12), XP051066428, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_AHs/2016_01_LTE_NB_IoT/Docs/ [retrieved on 2016-01-12] the whole document -----	1-44
A	ERICSSON: "Physical channels for paging in NB-IoT", 3GPP DRAFT; R2-160452 PHYSICAL CHANNELS FOR PAGING IN NB-IOT, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG2, no. Budapest, HU; 20160119 - 20160121 13 January 2016 (2016-01-13), XP051066469, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_AHs/2016_01_LTE_NB_IoT/Docs/ [retrieved on 2016-01-13] the whole document ----- -/--	1-44

2

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	ERICSSON: "NB-IoT - Paging", 3GPP DRAFT; R1-160084 - NB-IOT - PAGING, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. Budapest, HU; 20160118 - 20160120 12 January 2016 (2016-01-12), XP051064699, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_AH/LTE_NB-IoT_1601/Docs/ [retrieved on 2016-01-12] the whole document -----	1-44

2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2017/057758

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-25

   Identification of paging/scheduling signal for a given mobile terminal

   ---

2. claims: 26-44

   Avoiding interference for paging where paging signals are transmitted multiple times (Coverage Enhancement)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2017/057758

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 2999280 A2	23-03-2016	CN 105392197 A	09-03-2016
		EP 2999280 A2	23-03-2016
		JP 2016052127 A	11-04-2016
		US 2016066296 A1	03-03-2016
		US 2017135067 A1	11-05-2017

Form PCT/ISA/210 (patent family annex) (April 2005)

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
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(43) International Publication Date
12 July 2018 (12.07.2018)

WIPO | PCT

(10) International Publication Number
WO 2018/126401 A1

(51) International Patent Classification:
H04L 27/26 (2006.01)

(21) International Application Number:
PCT/CN2017/070309

(22) International Filing Date:
05 January 2017 (05.01.2017)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicant: **NEC CORPORATION** [JP/JP]; 7-1, Shiba 5-chome, Minato-ku, Tokyo 108-8001 (JP).

(72) Inventor; and
(71) Applicant *(for SC only)*: **LIU, Hongmei** [CN/CN]; 11F, Bldg. A, Innovation Plaza, Tsinghua Science Park, Haidian District, Beijing 100084 (CN).

(72) Inventor: **WANG, Gang**; 11F, Bldg. A, Innovation Plaza, Tsinghua Science Park, Haidian District, Beijing 100084 (CN).

(74) Agent: **KING & WOOD MALLESONS**; 20th Floor, East Tower, World Financial Centre, No. 1 Dongsanhuan Zhonglu, Chaoyang District, Beijing 100020 (CN).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

(54) Title: METHODS AND APPARATUSES FOR DOWNLINK CONTROL INFORMATION TRANSMISSION AND RECEIVING

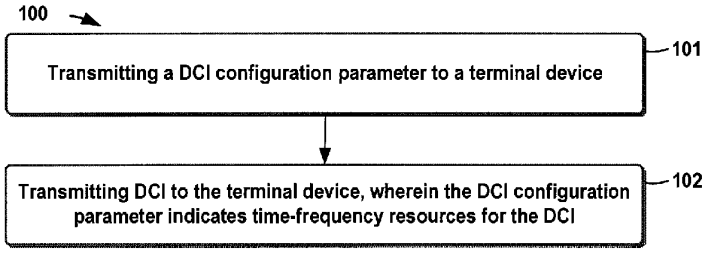


Fig. 1

(57) Abstract: Embodiments of the present disclosure relate to methods and apparatuses for downlink control information (DCI) transmission and receiving in a wireless communication system. A DCI configuration parameter can be first transmitted to a terminal device; and then DCI is transmitted to the terminal device, wherein the DCI configuration parameter indicates time-frequency resources for the DCI. With embodiments of the present disclosure, the UE could perform a flexible DCI monitoring according to the DCI configuration parameter and thus it may support the DCI monitoring occasion change due to numerology and scheduling unit size.

WO 2018/126401 A1

METHODS AND APPARATUSES FOR DOWNLINK CONTROL INFORMATION TRANSMISSION AND RECEIVING

FIELD OF THE INVENTION

[0001] The non-limiting and exemplary embodiments of the present disclosure generally relate to the field of wireless communication techniques, and more particularly relate to methods and apparatuses for downlink control information (DCI) transmission and receiving in a wireless communication system.

BACKGROUND OF THE INVENTION

[0002] New radio access system, which is called as new RAT (NR) system or network for short, is the next generation communication system. In Radio Access Network (RAN) #71 meeting for the third generation Partnership Project (3GPP) working group, study of NR system was approved. The NR system will consider frequency ranging up to 100Ghz with an object of a single technical framework addressing all usage scenarios, requirements and deployment scenarios defined in Technical Report TR 38.913, which include requirements such as enhanced mobile broadband, massive machine-type communications, ultra reliable and low latency communications.

[0003] Especially, in the NR network, different numerologies will coexist in the same carrier and a mini-slot will be introduced to carry Ultra-reliable low latency communication (URLLC) traffic. As a result, DCI monitoring may be performed per symbol based on the specific numerology. Thus, a terminal device like user equipment (UE) needs to know when to monitor the DCI for scheduling related operations.

[0004] In current LTE system, DCI monitoring is performed per subframe or per slot if the UE is in on duration of the discontinuous reception (DRX) active state. The DRX periodicity can be configured by higher layers.

[0005] However, with the current DCI monitoring solution in LTE, it cannot support the DCI monitoring occasion change due to numerology and scheduling unit size.

SUMMARY OF THE INVENTION

[0006] In patent cooperation treaty (PCT) application publication No. WO2016190970A1, there were proposed techniques for selecting data communications with shortened time duration wherein a two-stage grant for communication scheduling was introduced, the first stage grant could include an indication to activate/deactivate ultra-low latency (ULL) communication.

[0007] In US application US20160119969A1, there was proposed a solution for MAC enhancement for concurrent legacy and enhanced component carrier (ECC) operation, wherein a two stage Semi-Persistent Scheduling (SPS) solution was introduced and a first stage grant could contain parameters that may not change much over the course of a given SPS instance while the second stage grant could contain the actual resource for the SPS scheduling.

[0008] In another PCT application publication No. WO2016069270A1, there was proposed another two-stage PDCCH wherein a fast DCI could include a DCI flag and DCI format size indicator to indicate the existence and the size of the slow DCI in the same TTI.

[0009] However, none of the above solutions can address the problems as presented in the back ground.

[0010] To this end, in the present disclosure, there is provided a new solution for DCI transmission and receiving in a wireless communication system, to mitigate or at least alleviate at least part of the issues in the prior art.

[0011] According to a first aspect of the present disclosure, there is provided a DCI transmission in a wireless communication system. The method comprises transmitting a DCI configuration parameter to a terminal device; and transmitting DCI to the terminal device, wherein the DCI configuration parameter indicates time-frequency resources for the DCI.

[0012] According to a second aspect of the present disclosure, there is provided a method of DCI receiving in a wireless communication system. The method comprises receiving a DCI configuration parameter at a terminal device; and receiving DCI within time-frequency resources indicated by the DCI configuration parameter at the terminal device.

[0013] According to a third aspect of the present disclosure, there is provided

an apparatus of DCI transmission in a wireless communication system. The apparatus comprises: a parameter transmission module and a DCI transmission module. The parameter transmission module may be configured to transmit a DCI configuration parameter to a terminal device. The DCI transmission module may be configured to transmit DCI to the terminal device, wherein the DCI configuration parameter indicates time-frequency resources for the DCI

[0014] According to a fourth aspect of the present disclosure, there is provided an apparatus of DCI receiving in a wireless communication system. The apparatus comprises: a parameter receiving module and a DCI receiving module. The parameter receiving module may be configured to receive DCI configuration parameter at a terminal device. The DCI receiving module may be configured to receive DCI within time-frequency resources indicated by the DCI configuration parameter at the terminal device.

[0015] According to a fifth aspect of the present disclosure, there is provided a computer-readable storage media with computer program code embodied thereon, the computer program code configured to, when executed, cause an apparatus to perform actions in the method according to any embodiment in the first aspect.

[0016] According to a sixth aspect of the present disclosure, there is provided a computer-readable storage media with computer program code embodied thereon, the computer program code configured to, when executed, cause an apparatus to perform actions in the method according to any embodiment in the second aspect.

[0017] According to a seventh aspect of the present disclosure, there is provided a computer program product comprising a computer-readable storage media according to the fifth aspect.

[0018] According to an eighth aspect of the present disclosure, there is provided a computer program product comprising a computer-readable storage media according to the sixth aspect.

[0019] With embodiments of the present disclosure, a DCI configuration parameter can be first transmitted to the terminal device, and then the DCI is transmitted to the terminal device. Thus, the terminal device may monitor the transmitted DCI based on the received DCI configuration parameter, which means a flexible DCI monitoring solution and thus can support the DCI monitoring occasion change due to

numerology and scheduling unit size.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] The above and other features of the present disclosure will become more apparent through detailed explanation on the embodiments as illustrated in the embodiments with reference to the accompanying drawings, throughout which like reference numbers represent same or similar components and wherein:

[0021] Fig. 1 schematically illustrates a flow chart of a method of DCI transmission according to an example embodiment of the present disclosure;

[0022] Fig. 2 schematically illustrates DCI occurrence occasions with different numerologies according to example embodiments of the present disclosure;

[0023] Figs. 3A to 3C schematically illustrate DCI occurrence occasions at different levels according to examples embodiments of the present disclosure;

[0024] Figs. 4A and 4C schematically illustrate DCI occurrence occasions with frequency hopping according to example embodiment of the present disclosure;

[0025] Fig. 5A schematically illustrates a two-DCI solution for enhanced mobile broadband (eMBB) and URLLC multiplexing in which control and data are multiplexed in time domain according to an embodiment of the present disclosure;

[0026] Fig. 5B schematically illustrates a two-DCI solution for eMBB and URLLC multiplexing in which control and data are multiplexed in frequency domain according to an embodiment of the present disclosure;

[0027] Figs. 6A to 6D schematically illustrate two-DCI solutions for eMBB and URLLC multiplexing according to an embodiment of the present disclosure, wherein control region and data are multiplexed in time domain and the eMBB and the URLL are multiplexed in TDM, in TDM by symbol, in FDM, and in both FDM and TDM, respectively;

[0028] Figs. 7A to 7D schematically illustrate two-DCI solutions for eMBB and URLLC multiplexing according to an embodiment of the present disclosure, wherein control region and data are multiplexed in frequency domain and the eMBB and the URLL are multiplexed in TDM, in TDM by symbol, in FDM, and in both FDM and TDM, respectively;

[0029] Fig. 8 schematically illustrates a two-DCI solution for eMBB and

URLLC multiplexing according to an embodiment of the present disclosure, wherein two segments are used and the second segment is punctured or not punctured without re-transmission;

[0030] Fig. 9 schematically illustrates a two-DCI solution for eMBB and URLLC multiplexing according to an embodiment of the present disclosure, wherein two segments are used and the second segment is punctured with retransmission;

[0031] Fig. 10 schematically illustrates an example two-DCI division solution according to an embodiment of the present disclosure;

[0032] Fig. 11 schematically illustrates a flow chart of a method for DCI receiving according to an embodiment of the present disclosure;

[0033] Fig. 12 schematically illustrates a block diagram of an apparatus for DCI transmission according to an embodiment of the present disclosure;

[0034] Fig. 13 schematically illustrates a block diagram of an apparatus for DCI receiving according to an embodiment of the present disclosure; and

[0035] Fig. 14 further illustrates a simplified block diagram of an apparatus 1410 that may be embodied as or comprised in a serving node like a base station in a wireless network and an apparatus 1420 that may be embodied as or comprised in a terminal device like UE as described herein.

DETAILED DESCRIPTION OF EMBODIMENTS

[0036] Hereinafter, the solution as provided in the present disclosure will be described in details through embodiments with reference to the accompanying drawings. It should be appreciated that these embodiments are presented only to enable those skilled in the art to better understand and implement the present disclosure, not intended to limit the scope of the present disclosure in any manner.

[0037] In the accompanying drawings, various embodiments of the present disclosure are illustrated in block diagrams, flow charts and other diagrams. Each block in the flowcharts or blocks may represent a module, a program, or a part of code, which contains one or more executable instructions for performing specified logic functions, and in the present disclosure, a dispensable block is illustrated in a dotted line. Besides, although these blocks are illustrated in particular sequences for performing the steps of the methods, as a matter of fact, they may not necessarily be performed strictly

according to the illustrated sequence. For example, they might be performed in reverse sequence or simultaneously, which is dependent on natures of respective operations. It should also be noted that block diagrams and/or each block in the flowcharts and a combination of thereof may be implemented by a dedicated hardware-based system for performing specified functions/operations or by a combination of dedicated hardware and computer instructions.

[0038] Generally, all terms used in the claims are to be interpreted according to their ordinary meaning in the technical field, unless explicitly defined otherwise herein. All references to "a/an/the/said [element, device, component, means, step, etc.]" are to be interpreted openly as referring to at least one instance of said element, device, component, means, unit, step, etc., without excluding a plurality of such devices, components, means, units, steps, etc., unless explicitly stated otherwise. Besides, the indefinite article "a/an" as used herein does not exclude a plurality of such steps, units, modules, devices, and objects, and etc.

[0039] Additionally, in a context of the present disclosure, a user equipment (UE) may refer to a terminal, a Mobile Terminal (MT), a subscriber station, a portable subscriber station, Mobile Station (MS), or an Access Terminal (AT), and some or all of the functions of the UE, the terminal, the MT, the SS, the portable subscriber station, the MS, or the AT may be included. Furthermore, in the context of the present disclosure, the term "BS" may represent, e.g., a node B (NodeB or NB), an evolved NodeB (eNodeB or eNB), gNB (Node B in NR), a radio header (RH), a remote radio head (RRH), a relay, or a low power node such as a femto, a pico, and so on.

[0040] As mentioned hereinbefore, none of the prior arts can support the DCI monitoring occasion change due to numerology and scheduling unit size. Thus, in the present disclosure, there is proposed a new DCI transmission and receiving solution. In the proposed solution, a DCI configuration parameter can be first transmitted to the terminal device, and then the DCI is transmitted to the terminal device. Thus, the terminal device may monitor the DCI based on the received DCI configuration parameter, which means a flexible DCI monitoring solution and thus can support the DCI monitoring occasion change due to numerology and scheduling unit size.

[0041] Hereinafter, reference will be made to Figs. 1 to 14 to describe the DCI transmission and receiving solution.

[0042] Fig.1 schematically illustrates a flow chart of a method 100 of DCI transmission in a wireless communication system according to an embodiment of the present disclosure. The method 100 can be performed at a serving node, for example a BS, like a node B (NodeB or NB).

[0043] As illustrated in Fig. 1, first in step 101, a DCI configuration parameter is transmitted to a terminal device, and the DCI configuration parameter indicates time-frequency resources for a following DCI.

[0044] In an embodiment of the present disclosure, the DCI configuration parameter comprises at least one of: a numerology to be used; a valid duration for the DCI configuration parameter; a duration for a single DCI; and DCI occurrence occasions.

[0045] In NR system, different numerologies might be used, whereas different numerologies might use different transmission parameters, for example different subcarrier spacings. The different subcarrier spacings mean different symbol lengths. For example, for 15 kHz subcarrier spacing, its symbol will have a time length four times as that for 60 kHz subcarrier spacing, as illustrated in Fig. 2. Thus, the numerology to be used can be used to define a symbol.

[0046] The valid duration for the DCI configuration parameter indicates a duration in which the DCI configuration parameter is valid. The valid duration can be a number of symbols (for example, numerology specific) or a number of frames (for example numerology common). In an embodiment of the present disclosure, the values of the start of the valid duration can be an absolute value with respect to the reference numerology. For example, if the configuration signaling is received in symbol 7 of the subframe 2 of frame 6, the starting can be defined as symbol 0 of subframe 0 of frame 6. The definition of the absolute value can be predetermined or configured by a high layer signaling like RRC signaling. In another embodiment of the present disclosure, the first symbol carrying the configuration signaling can be used as the start of the valid duration no matter whether the configuration signaling is configured by DCI or by a RRC signaling.

[0047] The duration for a single DCI indicates the length of the DCI, it can be a number of symbols. Thus, parameter may indicate the length of DCI. It is also possible to use a predetermined length and in such a case, this parameter can be omitted.

[0048] DCI occurrence occasions indicate occasions at which DCI occurs in frames. In an embodiment of the present disclosure, the DCI occurrence occasions can be at a slot level, at subframe level (multi-slot), or at symbol level, as illustrated in Figs. 3A to 3C respectively.

[0049] The DCI occurrence occasions can be periodic. That is to say, the DCI monitoring will be performed periodically, for example every a predetermined number of slots, every a predetermined number of symbols. Fig 3A and Fig. 3B illustrate two examples of periodic DCI occurrence occasions. In Fig. 3A, the DCI occurrence occasions are per slot; in other words, the DCI monitoring is performed every slot, like in slots 0, 1,…,. In Fig. 3B, the DCI occurrence occasions are per multi-slot (e.g., 2 slots, a subframe); that is to say, the DCI monitoring can be performed per multi-slot. In such a case, the DCI occurrence occasions can be indicated by the periodicity and an offset of the DCI occurrence. The periodicity can be, for example, a predetermined number of symbols, slots, or frames.

[0050] Alternatively, the DCI occurrence occasions can also be aperiodic. Fig. 3C illustrates an aperiodic DCI occurrence occasion. In Fig. 3C, the DCI occurrence occasions are per symbol but aperiodic. In such a case, it may predefine a set of possible aperiodic patterns in specification or pre-configure the possible set of aperiodic patterns by a higher layer signaling. In the set of aperiodic patterns, each aperiodic pattern contains one or more symbols within a valid duration. In such a way, the network can inform the aperiodic pattern index to the terminal device in DCI configuration parameter.

[0051] It should be noticed that although the DCI occurrence occasions per slot and multi-slot in Fig.3A and 3B are periodic and the DCI occurrence occasions per symbol in Fig.3C is aperiodic, the present disclosure is not limited thereto. In fact, in each of the DCI occurrence occasions per slot, per multi-slot, per symbol, the DCI occurrence occasions can be periodic or aperiodic.

[0052] As another alternative, the DCI occurrence occasions can be a combination of periodic and aperiodic occasions. In other word, in a time period, it contains an aperiodic pattern including one or more symbols but the aperiodic pattern will repeat by the time period in the valid duration. In such a case, the DCI occurrence occasions can be indicated by the periodicity and the aperiodic pattern.

[0053] In another embodiment of the present disclosure, the DCI configuration parameter may comprise at least one of: frequency domain resource unit; and frequency hopping pattern.

[0054] The frequency domain resource unit indicates the resource unit to be used for DCI in the frequency domain, it could be a control channel element (CCE), a subband, a physical resource block (PRB), or physical resource group (REG). In addition, the frequency domain resource unit can be numerology common, which mean the frequency domain resource unit is same for all numerologies, or numerology specific, which mean that different numerologies might use different frequency domain resource units.

[0055] The frequency hopping pattern indicates a pattern in which the frequency hopping is used. This parameter is required when the frequency hopping pattern is used. An explicit signaling can be used to indicate the frequency resource in each DCI occurrence occasion. The hopping pattern can be a predetermined pattern which is known at both network and the terminal device, or a pattern configured by the network. The hopping pattern can be used to calculate the frequency resource position.

[0056] Figs. 4A to 4C illustrate use of frequency hopping in different DCI occurrence occasions according to embodiments of the present disclosure. DCI occurrence occasions as illustrated in Fig.4A to Fig. 4C are same with those in Fig. 3A to 3C in the time domain but in the frequency domain, the frequency hopping is used for the DCI occurrence occasions. It should be noticed that although the DCI occurrence occasions per slot and per multi-slot in Fig.4A and 4B are periodic and the DCI occurrence occasions per symbol in Fig.4C is aperiodic, the present disclosure is not limited thereto. In fact, in each of the DCI occurrence occasions per slot, per multi-slot, per symbol, the DCI occurrence occasions can be periodic or aperiodic.

[0057] Reference is made back to Fig. 1, in step 102, the DCI can be transmitted to the terminal device. With the DCI configuration parameter, the terminal device may learn the time-frequency resource for the DCI from the DCI configuration parameter and monitor the DCI within the time-frequency resource.

[0058] In an embodiment of the present disclosure, the DCI configuration parameter can be transmitted to the terminal device by a higher layer signaling like a

RRC signaling. That is to say, in the two-stage solution, for the first stage, the higher layer signaling can be used to transmit the DCI configuration indicating the time-frequency resource for the following DCI in the second stage.

[0059] In another embodiment of the present disclosure, the DCI configuration parameter can be transmitted to the terminal device dynamically by another DCI. In such a case, a first DCI is used to transmit the DCI configuration parameter for the following DCI. The actual data scheduling related information is located in the following DCI.

[0060] In addition, considering the payload size of the first DCI, it is also possible to use a combination of DCI and high layer signaling. That is to say, a part of DCI configuration parameter can be transmitted by DCI and another part of the DCI configuration parameter can be transmitted by a high layer signaling.

[0061] In the two stage DCI solution, the first DCI can be cell specific, beam specific, TRP specific, common for a UE group or UE specific. In an embodiment of the present disclosure, the DCI can be scrambled with a specific RNTI. The periodicity of the first DCI can be larger than the second DCI. The occurrence occasions of the first DCI can predetermined or configured by a higher layer signaling such a RRC signaling. The first DCI can be located in common search space. Or alternative, the first DCI can also be located in UE specific search space.

[0062] It shall be noted that there may be a valid duration for the DCI configuration parameter but there is no any restriction on DCI configuration parameter and scheduling unit size. For example, with slot-level DCI monitoring configuration, UE can also be configured with a scheduling unit starting and ending from the symbol boundary rather than a slot boundary. In such a case, the remaining blank symbols can be allocated to other UE with symbol level DCI monitoring configuration. Or alternatively, the remaining blank symbols can also be allocated to other UE with slot-level or multi-slot level DCI configuration.

[0063] In a further embodiment of the present disclosure, the DCI configuration parameter may comprise at least two sets of parameters, from which the terminal device can select a set of parameters based on its requested traffic types. In other words, DCI monitoring can be adapted at UE side after resource requirement by means of random access procedure/scheduling request (SR).

[0064] After a random access procedure, the terminal device starts DL/UL transmission/reception with the eNB. Thus, the DCI monitoring behavior can be based on the reason for random access. If URLLC scheduling request is the reason for random access, the DCI monitoring should be more frequent. If eMBB scheduling request is the reason for random access, the DCI monitoring can be less frequent. By providing two or more different sets of DCI configuration parameters predefined or configured by RRC signaling, the terminal device could choose the suitable parameter set based on its request traffic type. In such a way, it is possible for UE to perform DCI monitoring based on its required traffic type.

[0065] In another aspect of the present disclosure, there is also provided another two-DCI solution for different traffic type multiplexing. In these solutions, two DCIs are used, one of which can be called as prepositive control region (DCI), the other of which can be called as postpostive control region (DCI). The prepositive control region can be used to indicate resource that is allocated to a first traffic type (such as eMBB traffic) but is to be occupied by a second traffic type (such as URLLC traffic), the postpositive control region can be used to indicate resource that allocated to a first traffic type (such as eMBB traffic) but was already occupied by the second traffic type (such as abrupt URLLC traffic). Hereinafter, the URLLC traffic and the eMBB traffic will be taken as examples of different traffic types to describe the two-DCI solution; however, those skilled in the art can readily know that the present disclosure is not limited thereto.

[0066] In an embodiment of the present disclosure, the prepositive control region can include at least one of following fields:

- a field to indicate puncture or rate-matching around some time-frequency resource in a following pattern of time-frequency resource;
- a field to schedule on a following pattern of time-frequency resource (e.g. can be contiguous or non-contiguous symbols/frequency bands);
- a field to indicate re-transmission of previous punctured part;
- a field to indicate the end of one transmission block.

[0067] In an embodiment of the present disclosure, the postpositive region can include at least one of following fields:

- a field to indicate puncture or no puncture of some time-frequency

resources in the previous pattern of time-frequency resource

- a field to indicate re-transmission or no re-transmission of previous punctured part
- a field to indicate the end of one transmission block

[0068] It shall be noted that patterns of time-frequency resource in prepositive and postpositive control regions can be complementary. For example, the two patterns can compose a whole time-frequency resource of a region (subframe). Alternatively, the two patterns can be also partially overlapped.

[0069] Fig. 5A illustrates a two-DCI solution for different traffic type multiplexing according to an embodiment of the present disclosure. The resource of eMBB can be split into two parts as illustrated in Fig. 5, the first one is to be scheduled by the prepostive control region and the other one is to be scheduled by the postpostive control region. For some resources such as first several symbols, the scheduling of URLLC can be known, thus the eMBB UE can be indicated of rate-matching or puncture for the occupied resource in the prepositive control region if it is occupied by the URLLC. While, for some resources, for example when the URLLC occurs abruptly, the scheduling of URLLC cannot be known in the prepositive control region, and thus the eMBB UE can be indicated to puncture for the occupied resources in the postpositive control region.

[0070] In Fig. 5A, it is shown that the control regions and the data regions are multiplexed in the time domain. In another embodiment of the present disclosure, the control regions and data regions can be multiplexed in the frequency domain. Fig. 5B illustrates a two-DCI solution for different traffic type multiplexing according to an embodiment of the present disclosure. Fig. 5B is similar with Fig. 5A but differs in that in Fig. 5B, the control regions and data regions are multiplexed in the frequency domain.

[0071] It should also be noted that resource indicated to eMBB UE can be resource occupied by URLLC or resource reserved as empty for forward phase.

[0072] In addition, it shall also be noted that the split resource parts can also be multiplexed in many different ways, which will be described with reference to Fig. 6A to Fig. 7D.

[0073] Fig. 6A illustrates a two-DCI solution according to an embodiment of

the present disclosure, in which the control region and the data region are multiplexed in TDM and two split parts are multiplexed in time domain multiplexing (TDM). Fig. 6A is substantially same as that in Fig. 5A, and in the two DCI solution, the part scheduled by the prepostive control region is multiplexed with the part scheduled by the postpostive control region in TDM.

[0074] Fig. 6B illustrates another two-DCI solution according to an embodiment of the present disclosure, wherein the control region and the data region are multiplexed in TDM and the two split parts are multiplexed in TDM by symbols. Compared with that illustrated in Fig. 6A, in Fig. 6B, the part scheduled by the prepostive control region is multiplexed with the part scheduled by the postpostive control region also in TDM but by symbol; that is to say, in Fig. 6B, the symbols belonging to each part are not continuous.

[0075] Fig. 6C illustrates a further two-DCI solution according to an embodiment of the present disclosure, wherein the control region and the data region are multiplexed in TDM and the two split parts are multiplexed in frequency domain multiplexing (FDM). Different from that illustrated in Fig. 6A and Fig. 6B, in Fig. 6C the part scheduled by the prepostive control region is multiplexed with the part scheduled by the postpostive control region in FDM, i.e., they respectively occupy different frequency domain resources.

[0076] Fig. 6D illustrates a further two-DCI solution according to an embodiment of the present disclosure, wherein the control region and the data region are multiplexed in TDM and the two split parts are multiplexed in TDM and frequency domain multiplexing (FDM). As illustrated in Fig. 6D, the part scheduled by the prepostive control region is multiplexed with the part scheduled by the postpostive control region in a combination of TDM and FDM.

[0077] Figs. 7A to 7D illustrate two-DCI solutions according to an embodiment of the present disclosure, wherein the control region and the data region are multiplexed in FDM and two split parts are multiplexed in different manners respectively. In Fig. 7A, the two split parts are multiplexed in TDM; in Fig. 7B, the two split parts are multiplexed in TDM by symbol; in Fig. 7C, the two split parts are multiplexed in FDM; and Fig. 7D, the two split parts are multiplexed in TDM and FDM.

[0078] The two split parts can be decoded in any suitable manner. In an embodiment of the present disclosure, the two split part can be separately decoded. In another embodiment of the present disclosure, the two parts can be cascaded to decode, i.e. when UE receives the two parts, then it decodes them immediately or it decodes them after UE receiving the postpositive control region.

[0079] In a further embodiment of the present disclosure, the resource for eMBB can be split for several parts, wherein first parts are to be scheduled by the preposition control region and seconds parts are to be scheduled by the postpostive control region. The several parts are further divided into two segments in the time domain, i.e., segment 1 and segment 2. For some resources such as first several symbols, the scheduling of URLLC can be known, thus the eMBB UE can be indicated of rate-matching or puncture for the occupied resource in the prepositive control region if it is occupied by the URLLC. While, for some resources, for example when the URLLC occurs abruptly, the scheduling of URLLC cannot be known in the prepositive control region, and thus the eMBB UE can be indicated to puncturing or not puncturing for the occupied resources in the postpositive control region. For some resources in the second segment, they may be reserved for re-transmission or be punctured part of transmission in the first segment. This punctured part can be for example a subset of the first segment, and the remaining of the first segment can be used for new transmission. Fig. 8 illustrates a two-DCI solution wherein there is no re-transmission in the second segment; while Fig. 9 illustrates a two-DCI solution wherein, in the second segment, there is a re-transmission of punctured part of the first segment as indicated by blocks filled with cross lines.

[0080] In addition, similarly to solutions as illustrate in Figs. 6A to 7D, the first parts and the second parts can be multiplexed in time and/or frequency domain. Moreover, these parts can be cascaded to decode, i.e. when UE receives the two parts, then it decodes them immediately or it decodes them after UE receiving the postpositive control region.

[0081] In a further aspect of the present disclosure, one transmission block can also be split into several parts. The first part can be scheduled by, for example, prepositive control region, and the second part can be scheduled by, for example, postpositive control region. The UE can decode after receiving the whole transmission

block. The end of the transmission can be indicated in a control region. For example, UE may obtain frequency and time domain mapping for data, then obtain the mapping over resources preempted by URLLC, and after that it decodes the block.

[0082] In another embodiment of the present disclosure, preemption of URLLC can be indicated implicitly. For example, it is possible to use tracking RS to implicitly indicate preemption of URLLC. For example, if the tracking RS is interrupted on some symbols, this means these symbols are occupied by URLLC, and thus this can be used to indicate preemption of URLLC.

[0083] In a further embodiment of the present disclosure, DCI can be cascaded with K-stage DCI. For example, a first stage DCI contains resource allocation field; the second stage DCI contains information of MCS and other information for data transmission (which may also contain detailed information of resource allocation). In such a case, the UE can cascades the two-stage DCI for control information.

[0084] In addition, the first stage DCI can be shared by different UEs, e.g. URLLC UE and eMBB UE, as illustrated in Fig. 10. The URLLC UE could obtain the shared first stage DCI and the second stage DCI for control and/or data transmission. The eMBB UE could obtain the shared first stage DCI for the resource allocation for puncturing or rate-matching. The shared common DCI can be scrambled with shared RNTI, e.g. a resource allocation RNTI calculated considering the resource index.

[0085] In a further embodiment of the present disclosure, the first DCI can include full scheduling information; while the second DCI may include indication of the resource occupied by URLLC or not. In addition, the second DCI can be reduced for some cases. For example, when no MCS needed, the second DCI can be omitted. If the resource is semi-statically reserved for URLLC and known to eMBB UE, the resource allocation is no needed and the second DCI can be reduced as well. In another case, if the resource is known by eMBB UE, and the time-frequency of remaining resource is fixed, then only an indication is needed in the second DCI, which indicates whether the time-frequency resource is occupied. If yes, the resource is for re-transmission or just keeps punctured; if not, the resource will be used for new data transmission.

[0086] It shall be noted that although the aspects and embodiments are described separately, they can also be combined together to achieve more benefits.

[0087] Fig. 11 further schematically illustrates a flow chart of method for DCI receiving according to an example embodiment of the present disclosure. The method 1100 can be implemented at a terminal device, for example UE, or other like terminal devices.

[0088] As illustrated in Fig. 11, the method starts from step 11, in which the terminal device like UE receiving a DCI configuration parameter. The DCI configuration parameter indicates the time-frequency resources for the following DCI.

[0089] In an embodiment of the present disclosure, the DCI configuration parameter may comprise at least one of: numerology to be used; a valid duration for the DCI configuration parameters; a duration for a single DCI; DCI occurrence occasions.

[0090] In another embodiment of the present disclosure, the DCI configuration parameter may comprise at least one of: a frequency domain resource unit; and a frequency hopping pattern.

[0091] In a further embodiment of the present disclosure, the receiving DCI configuration parameter may comprise receiving the DCI configuration parameter in a higher layer signaling.

[0092] In a further embodiment of the present disclosure, the receiving DCI configuration parameter may comprise receiving the DCI configuration parameter in another DCI.

[0093] In addition, considering the payload size of the first DCI, it is also possible to use a combination of DCI and high layer signaling. That is to say, a part of DCI configuration parameter can be received by a first DCI and another part of the DCI configuration parameter can be transmitted by a high layer signaling.

[0094] The first DCI can be cell specific, beam specific, TRP specific, common for a UE group or UE specific. In an embodiment of the present disclosure, the DCI can be scrambled with a specific RNTI. The periodicity of the first DCI can be larger than the second DCI. The occurrence occasions of the first DCI can predetermined or configured by a higher layer signaling such a RRC signaling. The first DCI can be located in common search space. . Or alternative, the first DCI can also be located in UE specific search space.

[0095] Next, in step 1102, DCI is received within time-frequency resources indicated by the DCI configuration parameter at the terminal device. That is to say, at

the terminal device, the terminal device may perform DCI monitoring based on the DCI configuration parameter, which means a flexible DCI monitoring solution and thus can support the DCI monitoring occasion change due to numerology and scheduling unit size.

[0096] In a still further embodiment of the present disclosure, the DCI configuration parameter comprises at least two sets of parameters. In such a case, further in step 1103, the UE may select a set of parameters based on its requested traffic types. In other words, DCI monitoring can be adapted at UE side after resource requirement by means of random access procedure/SR.

[0097] After random access procedure, the terminal device starts DL/UL transmission/reception with the eNB. Thus, the DCI monitoring behavior can be based on the reason for random access. If URLLC scheduling request is the reason for random access, the DCI monitoring should be more frequent. If eMBB scheduling request is the reason for random access, the DCI monitoring can be less frequent. By providing two or more different sets of DCI configuration parameters predefined or configured by RRC signaling, the terminal device could choose the suitable parameter set based on its request traffic type. In such a way, it is possible for UE to perform DCI monitoring based on its required traffic type.

[0098] Besides, in the present disclosure, there are also provided apparatuses for DCI transmission and receiving at the serving node and terminal device in a wireless communication system respectively, which will be described next with reference to Figs. 12 and 13.

[0099] Fig. 12 schematically illustrates a block diagram of an apparatus 1200 for DCI transmission in a wireless communication system according to an embodiment of the present disclosure. The apparatus 1200 can be implemented at a serving node, for example a BS, like a node B (NodeB or NB).

[00100] As illustrated in Fig. 12, the apparatus 1200 may comprise a parameter transmission module 1201 and a DCI transmission module 1202. The parameter transmission module 1201 can be configured to transmit a DCI configuration parameter to a terminal device. The DCI transmission module 1202 can be configured to transmit DCI to the terminal device, wherein the DCI configuration parameter indicates time-frequency resources for the DCI.

[00101] In an embodiment of the present disclosure, the sequence position information may comprise any of: a numerology to be used; a valid duration for the DCI configuration parameters; a duration for a single DCI; DCI occurrence occasions; a frequency domain resource unit; and a frequency hopping pattern.

[00102] In another embodiment of the present disclosure, the parameter transmission module 1201 may be configured to transmit the DCI configuration parameter to the terminal device by a higher layer signaling.

[00103] In a further embodiment of the present disclosure, the parameter transmission module 1201 is configured to transmit the DCI configuration parameter to the terminal device dynamically by another DCI.

[00104] In a still further embodiment of the present disclosure, the another DCI may have a larger periodicity than the DCI.

[00105] In a yet further embodiment of the present disclosure, the DCI configuration parameter may comprise at least two sets of parameters, from which the terminal device can select a set of parameters based on its requested traffic type.

[00106] Fig. 13 further schematically illustrates a block diagram of an apparatus 1300 for DCI receiving in a wireless communication system according to an embodiment of the present disclosure. The apparatus 1300 can be implemented at a terminal device, for example UE, or other like terminal devices.

[00107] As illustrated in Fig. 13, the apparatus 1300 may include a parameter receiving module 1301 and a DCI receiving module 1302. The parameter receiving module 1301 may be configured to receive DCI configuration parameter at a terminal device. The DCI receiving module 1302 can be configured to receive DCI within time-frequency resources indicated by the DCI configuration parameter at a terminal device.

[00108] In an embodiment of the present disclosure, the sequence position information may comprise any of: a numerology to be used; a valid duration for the DCI configuration parameters; a duration for a single DCI; DCI occurrence occasions; a frequency domain resource unit; and a frequency hopping pattern.

[00109] In another embodiment of the present disclosure, the parameter receiving module 1301 may be further configured to receive the DCI configuration parameter in a higher layer signaling.

[00110] In another embodiment of the present disclosure, the parameter receiving module 1301 may be further configured to receive the DCI configuration parameter in another DCI.

[00111] In a still further embodiment of the present disclosure, the another DCI may have a larger periodicity than the DCI.

[00112] In a yet further embodiment of the present disclosure, the DCI configuration parameter may comprise at least two sets of parameters. In such a case, the apparatus 1300 may further comprise a parameter set selection module 1303. The apparatus 1300 may be configured to select a set of parameters based on a traffic type requested by the terminal device and wherein the time-frequency resources are those indicated by the selected set of parameters

[00113] Hereinbefore, the apparatuses 1200 and 1300 are described with reference to Figs. 12 and 13. It is noted that the apparatuses 1200 and 1300 may be configured to implement functionalities as described with reference to Figs. 1 to 11. Therefore, for details about the operations of modules in these apparatuses, one may refer to those descriptions made with respect to the respective steps of the methods with reference to Figs. 1 to 11.

[00114] It is further noted that the components of the apparatuses 1200 and 1300 may be embodied in hardware, software, firmware, and/or any combination thereof. For example, the components of apparatuses 1200 and 1300 may be respectively implemented by a circuit, a processor or any other appropriate selection device.

[00115] Those skilled in the art will appreciate that the aforesaid examples are only for illustration not limitation and the present disclosure is not limited thereto; one can readily conceive many variations, additions, deletions and modifications from the teaching provided herein and all these variations, additions, deletions and modifications fall the protection scope of the present disclosure.

[00116] In addition, in some embodiment of the present disclosure, apparatuses 1200 and 1300 may comprise at least one processor. The at least one processor suitable for use with embodiments of the present disclosure may include, by way of example, both general and special purpose processors already known or developed in the future. Apparatuses 1200 and 1300 may further comprise at least one memory.

The at least one memory may include, for example, semiconductor memory devices, e.g., RAM, ROM, EPROM, EEPROM, and flash memory devices. The at least one memory may be used to store program of computer executable instructions. The program can be written in any high-level and/or low-level compliable or interpretable programming languages. In accordance with embodiments, the computer executable instructions may be configured, with the at least one processor, to cause apparatuses 1200 and 1300 to at least perform operations according to the method as discussed with reference to Figs. 1 to 11 respectively.

[00117] Fig. 14 further illustrates a simplified block diagram of an apparatus 1410 that may be embodied as or comprised in a serving node like a base station in a wireless network and an apparatus 1420 that may be embodied as or comprised in a terminal device like UE as described herein.

[00118] The apparatus 1410 comprises at least one processor 1411, such as a data processor (DP) and at least one memory (MEM) 1412 coupled to the processor 1411. The apparatus 1410 may further comprise a transmitter TX and receiver RX 1413 coupled to the processor 1411, which may be operable to communicatively connect to the apparatus 1420. The MEM 1412 stores a program (PROG) 1414. The PROG 1414 may include instructions that, when executed on the associated processor 1411, enable the apparatus 1410 to operate in accordance with embodiments of the present disclosure, for example the method 100. A combination of the at least one processor 1411 and the at least one MEM 1412 may form processing means 1415 adapted to implement various embodiments of the present disclosure.

[00119] The apparatus 1420 comprises at least one processor 1421, such as a DP, and at least one MEM 1422 coupled to the processor 1421. The apparatus 1420 may further comprise a suitable TX/ RX 1423 coupled to the processor 1421, which may be operable for wireless communication with the apparatus 1410. The MEM 1422 stores a PROG 1424. The PROG 1424 may include instructions that, when executed on the associated processor 1421, enable the apparatus 1420 to operate in accordance with the embodiments of the present disclosure, for example to perform the method 1100. A combination of the at least one processor 1421 and the at least one MEM 1422 may form processing means 1425 adapted to implement various embodiments of the present disclosure.

[00120] Various embodiments of the present disclosure may be implemented by computer program executable by one or more of the processors 1411, 1421, software, firmware, hardware or in a combination thereof.

[00121] The MEMs 1412 and 1422 may be of any type suitable to the local technical environment and may be implemented using any suitable data storage technology, such as semiconductor based memory devices, magnetic memory devices and systems, optical memory devices and systems, fixed memory and removable memory, as non-limiting examples.

[00122] The processors 1411 and 1421 may be of any type suitable to the local technical environment, and may include one or more of general purpose computers, special purpose computers, microprocessors, digital signal processors DSPs and processors based on multicore processor architecture, as non-limiting examples.

[00123] In addition, the present disclosure may also provide a carrier containing the computer program as mentioned above, wherein the carrier is one of an electronic signal, optical signal, radio signal, or computer readable storage medium. The computer readable storage medium can be, for example, an optical compact disk or an electronic memory device like a RAM (random access memory), a ROM (read only memory), Flash memory, magnetic tape, CD-ROM, DVD, Blue-ray disc and the like.

[00124] The techniques described herein may be implemented by various means so that an apparatus implementing one or more functions of a corresponding apparatus described with one embodiment comprises not only prior art means, but also means for implementing the one or more functions of the corresponding apparatus described with the embodiment and it may comprise separate means for each separate function, or means that may be configured to perform two or more functions. For example, these techniques may be implemented in hardware (one or more apparatuses), firmware (one or more apparatuses), software (one or more modules), or combinations thereof. For a firmware or software, implementation may be made through modules (e.g., procedures, functions, and so on) that perform the functions described herein.

[00125] Exemplary embodiments herein have been described above with reference to block diagrams and flowchart illustrations of methods and apparatuses. It will be understood that each block of the block diagrams and flowchart illustrations, and combinations of blocks in the block diagrams and flowchart illustrations, respectively,

can be implemented by various means including computer program instructions. These computer program instructions may be loaded onto a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions which execute on the computer or other programmable data processing apparatus create means for implementing the functions specified in the flowchart block or blocks.

[00126] While this specification contains many specific implementation details, these should not be construed as limitations on the scope of any implementation or of what may be claimed, but rather as descriptions of features that may be specific to particular embodiments of particular implementations. Certain features that are described in this specification in the context of separate embodiments can also be implemented in combination in a single embodiment. Conversely, various features that are described in the context of a single embodiment can also be implemented in multiple embodiments separately or in any suitable sub-combination. Moreover, although features may be described above as acting in certain combinations and even initially claimed as such, one or more features from a claimed combination can in some cases be excised from the combination, and the claimed combination may be directed to a sub-combination or variation of a sub-combination.

[00127] It will be obvious to a person skilled in the art that, as the technology advances, the inventive concept can be implemented in various ways. The above described embodiments are given for describing rather than limiting the disclosure, and it is to be understood that modifications and variations may be resorted to without departing from the spirit and scope of the disclosure as those skilled in the art readily understand. Such modifications and variations are considered to be within the scope of the disclosure and the appended claims. The protection scope of the disclosure is defined by the accompanying claims.

WHAT IS CLAIMED IS:

1. A method of downlink control information (DCI) transmission in a wireless communication system, the method comprising:

transmitting a DCI configuration parameter to a terminal device; and

transmitting DCI to the terminal device, wherein the DCI configuration parameter indicates time-frequency resources for the DCI.

2. The method of Claim 1, wherein the DCI configuration parameter comprises at least one of:

a numerology to be used;

a valid duration for the DCI configuration parameter;

a duration for a single DCI; and

DCI occurrence occasions.

3. The method of Claim 1 or 2, wherein the DCI configuration parameter comprises at least one of:

a frequency domain resource unit; and

a frequency hopping pattern.

4. The method of any of Claims 1 to 3, wherein the transmitting DCI configuration parameter to a terminal device comprises transmitting the DCI configuration parameter to the terminal device by a higher layer signaling.

5. The method of any of Claims 1 to 4, wherein the transmitting DCI configuration parameter to a terminal device comprises transmitting the DCI configuration parameter to the terminal device dynamically by another DCI.

6. The method of Claim 5, wherein the another DCI has a larger periodicity than the DCI.

7. The method of any of Claims 1 to 6, wherein the DCI configuration parameter comprises at least two sets of parameters, from which the terminal device can select a

set of parameters based on its requested traffic type.

8. A method of downlink control information (DCI) receiving in a wireless communication system, the method comprising:

receiving a DCI configuration parameter at a terminal device; and

receiving DCI within time-frequency resources indicated by the DCI configuration parameter at the terminal device.

9. The method of Claim 8, wherein the DCI configuration parameter comprises at least one of:

a numerology to be used;

a valid duration for the DCI configuration parameters;

a duration for a single DCI;

DCI occurrence occasions;

a frequency domain resource unit; and

a frequency hopping pattern.

10. The method of Claim 8 or 9, wherein the receiving DCI configuration parameter comprises receiving the DCI configuration parameter in a higher layer signaling.

11. The method of any Claims 8 to 10, wherein the receiving DCI configuration parameter comprises receiving the DCI configuration parameter in another DCI.

12. The method of Claim 11, wherein the another DCI has a larger periodicity than the DCI.

13. The method of any of Claims 8 to 12, wherein the DCI configuration parameter comprises at least two sets of parameters, wherein the method further comprises selecting a set of parameters based on a traffic type requested by the terminal device and wherein the time-frequency resources are those indicated by the selected set of parameters.

14. An apparatus of downlink control information (DCI) transmission in a wireless communication system, the apparatus comprising:

a parameter transmission module configured to transmit a DCI configuration parameter to a terminal device; and

a DCI transmission module configured to transmit DCI to the terminal device, wherein the DCI configuration parameter indicates time-frequency resources for the DCI.

15. The apparatus of Claim 14, wherein the DCI configuration parameter comprises at least one of:

a numerology to be used;

a valid duration for the DCI configuration parameter;

a duration for a single DCI;

DCI occurrence occasions;

a frequency domain resource unit; and

a frequency hopping pattern .

16. The apparatus of Claim 14 or 15, wherein the parameter transmission module is further configured to transmit the DCI configuration parameter to the terminal device by a higher layer signaling.

17. The apparatus of any of Claims 14 to 16, wherein the parameter transmission module is further configured to transmit the DCI configuration parameter to the terminal device dynamically by another DCI.

18. The apparatus of Claim 17, wherein the another DCI has a larger periodicity than the DCI.

19. The apparatus of any of Claims 14 to 18, wherein the DCI configuration parameter comprises at least two sets of parameters, from which the terminal device can select a set of parameters based on its requested traffic type.

20. An apparatus of downlink control information (DCI) receiving in a wireless

communication system, the apparatus comprising:

a parameter receiving module configured to receive DCI configuration parameter at a terminal device; and

a DCI receiving module, configured to receive DCI within time-frequency resources indicated by the DCI configuration parameter at the terminal device.

21. The apparatus of Claim 20, wherein the DCI configuration parameter comprises at least one of:

a numerology to be used;

a valid duration for the DCI configuration parameters;

a duration for a single DCI;

DCI occurrence occasions;

a frequency domain resource unit; and

a frequency hopping pattern .

22. The apparatus of Claim 20 or 21, wherein the parameter receiving module is further configured to receive the DCI configuration parameter in a higher layer signaling.

23. The apparatus of any of Claims 20 to 22, wherein the parameter receiving module is further configured to receive the DCI configuration parameter in another DCI.

24. The apparatus of Claim 23, wherein the another DCI has a larger periodicity than the DCI.

25. The apparatus of any of Claims 20 to 24, wherein the DCI configuration parameter comprises at least two sets of parameters, wherein the apparatus further comprises a parameter set selection module, configured to select a set of parameters based on a traffic type requested by the terminal device and wherein the time-frequency resources are those indicated by the selected set of parameters.

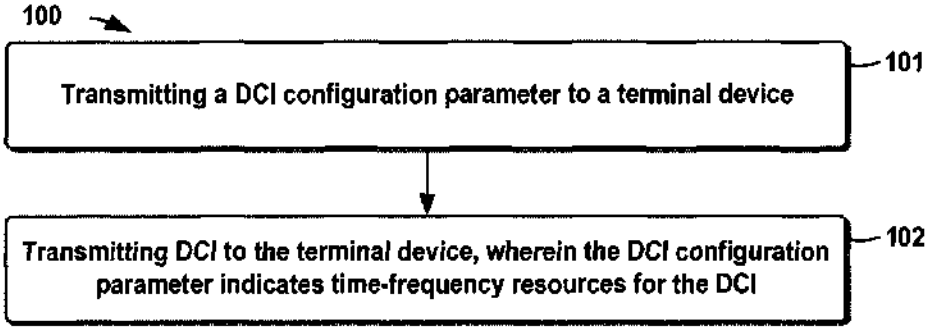


Fig. 1

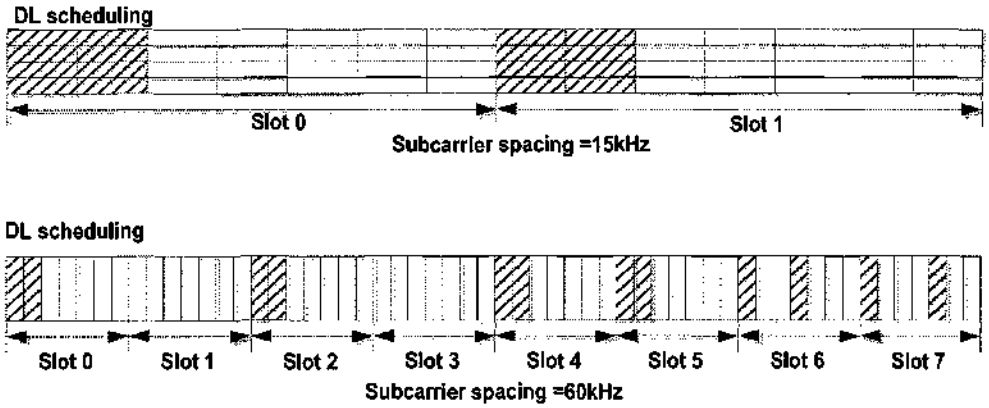


Fig. 2

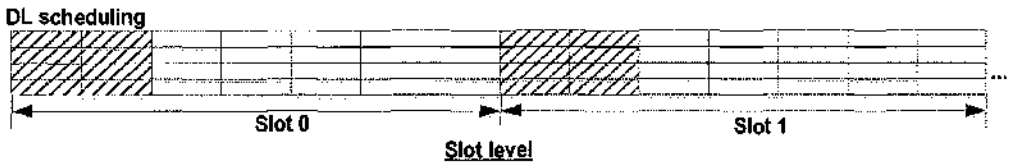


Fig. 3A



Fig. 3B

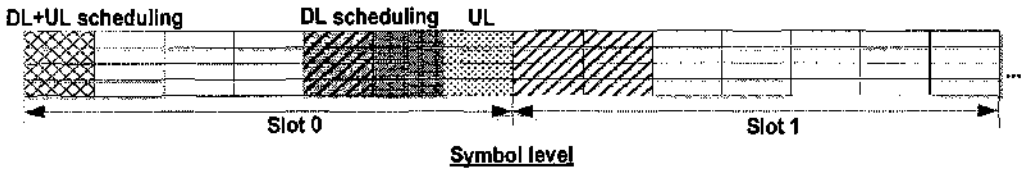


Fig. 3C

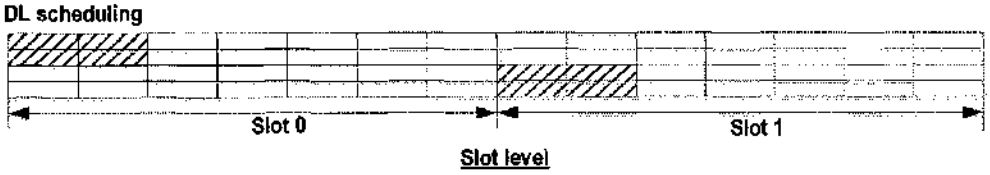


Fig. 4A

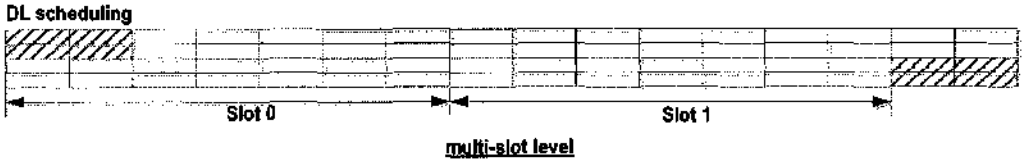


Fig. 4B

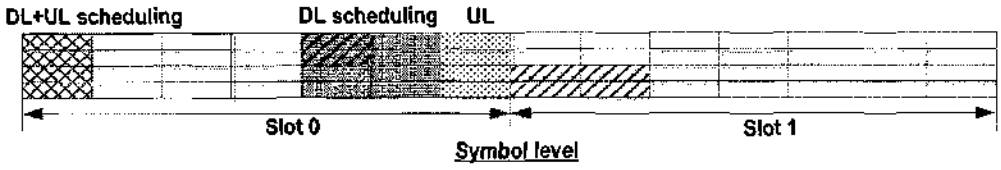


Fig. 4C

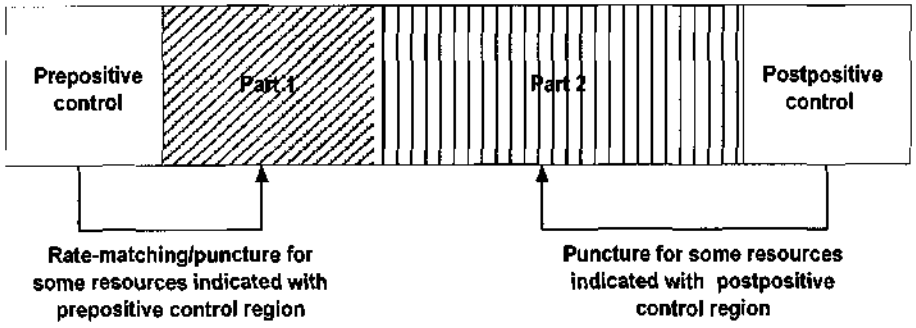


Fig. 5A

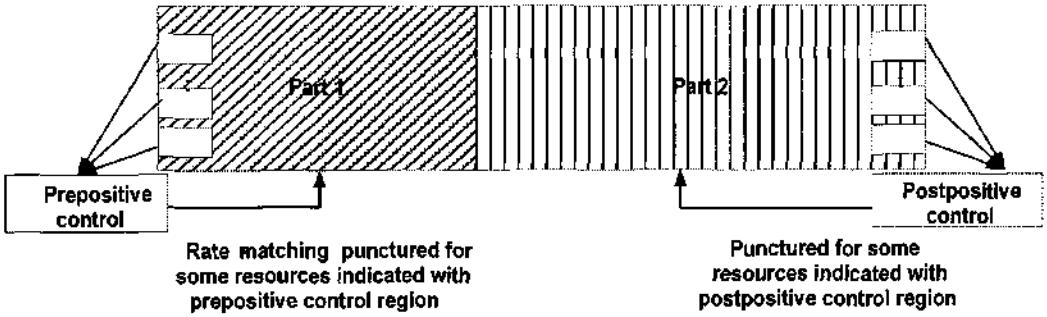
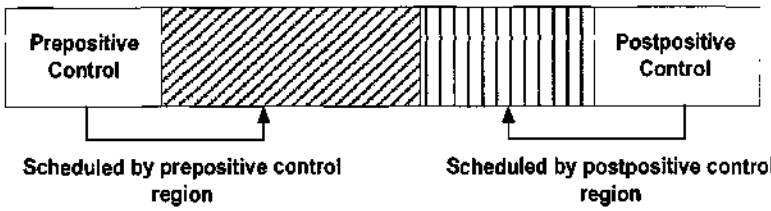
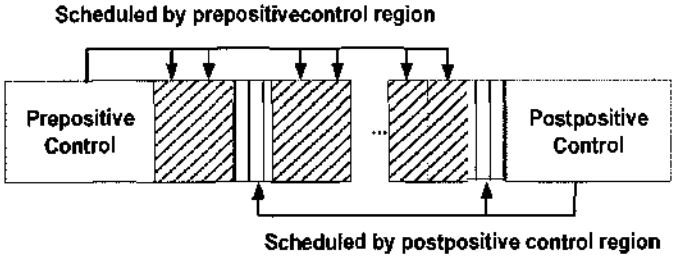


Fig. 5B



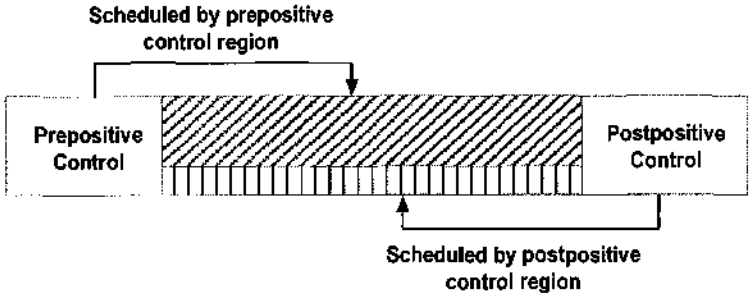
TDM

Fig. 6A



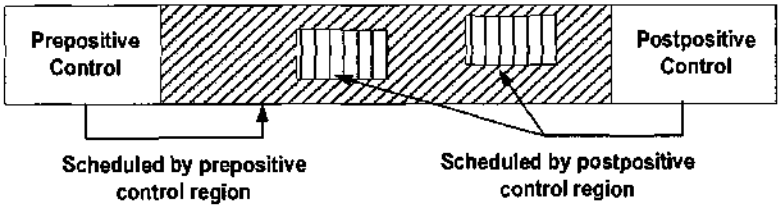
TDM by symbol

Fig. 6B



FDM

Fig. 6C



TDM and FDM

Fig. 6D

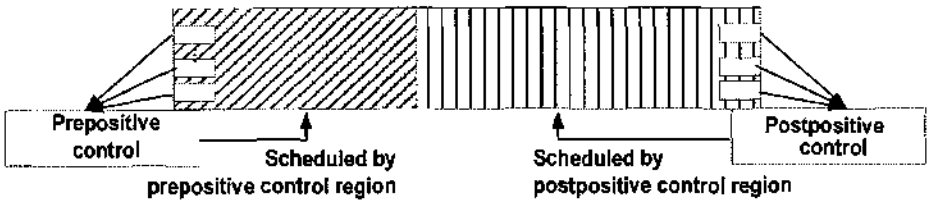


Fig. 7A

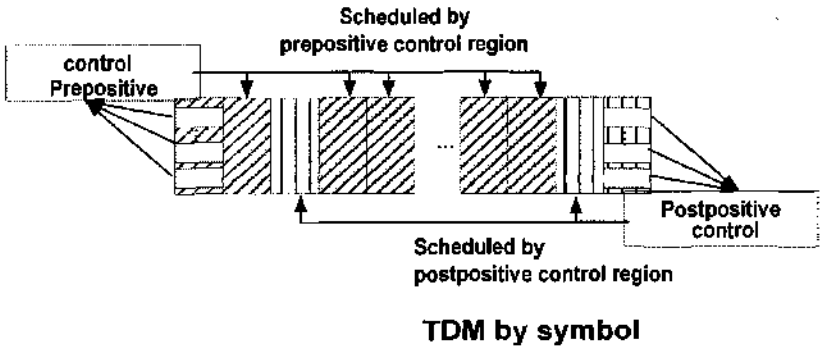


Fig. 7B

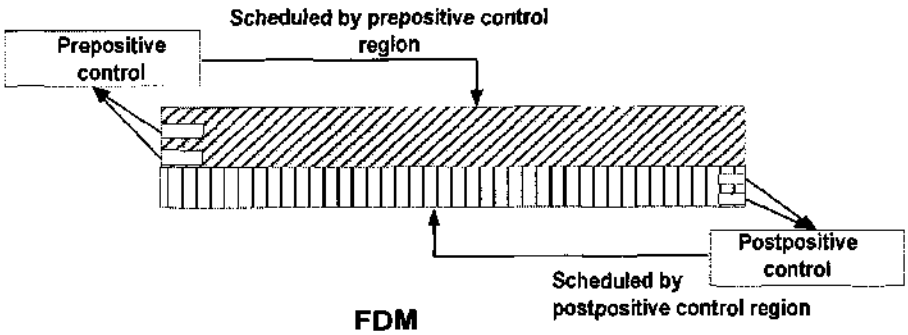
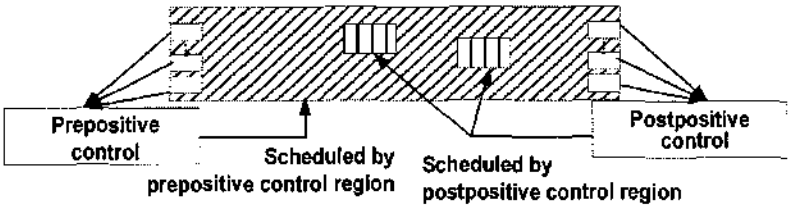


Fig. 7C



TDM and FDM

Fig. 7D

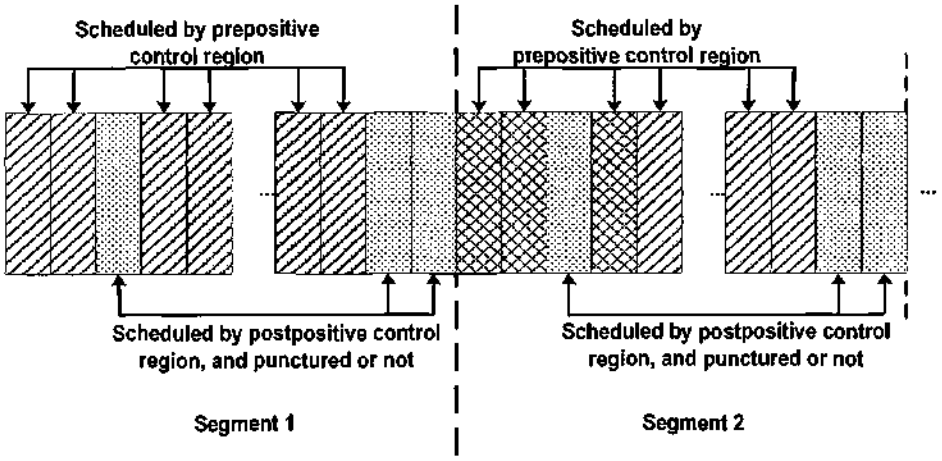


Fig. 8

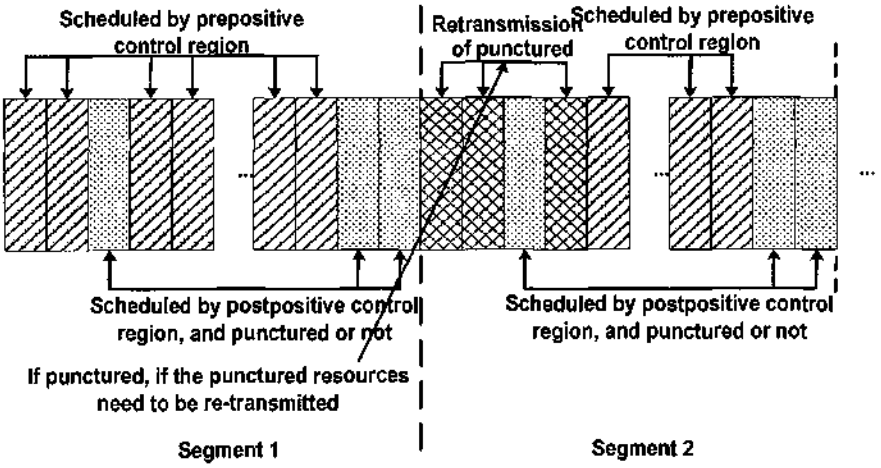


Fig. 9

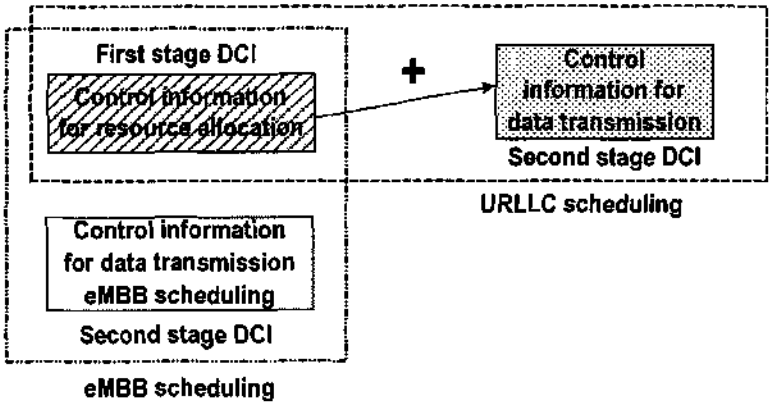


Fig. 10

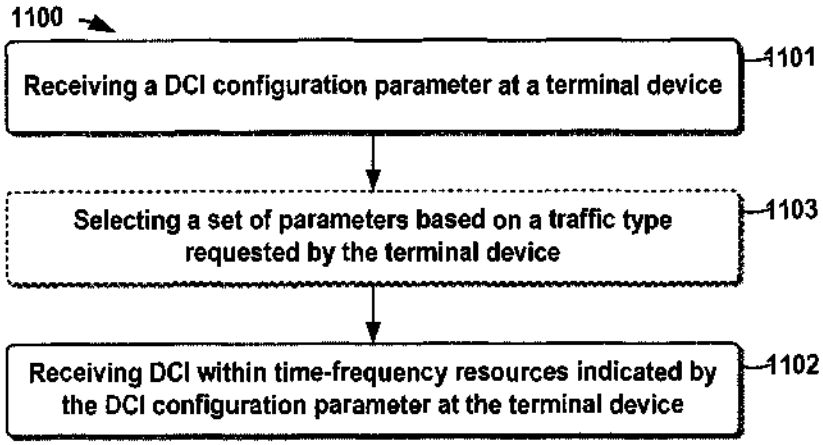


Fig. 11

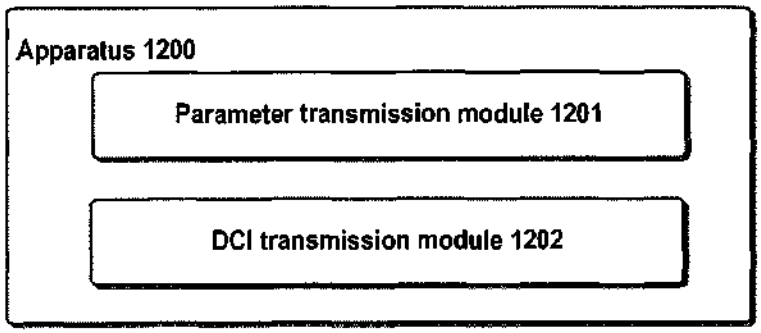


Fig. 12

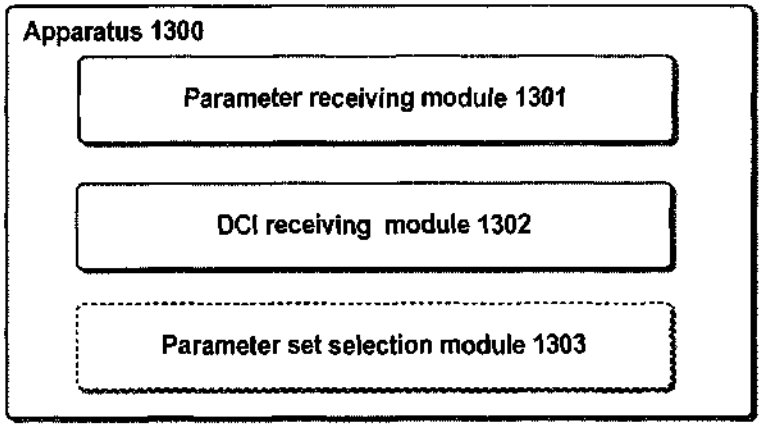

Apparatus 1300
Parameter receiving module 1301
DCI receiving module 1302
Parameter set selection module 1303

Fig. 13

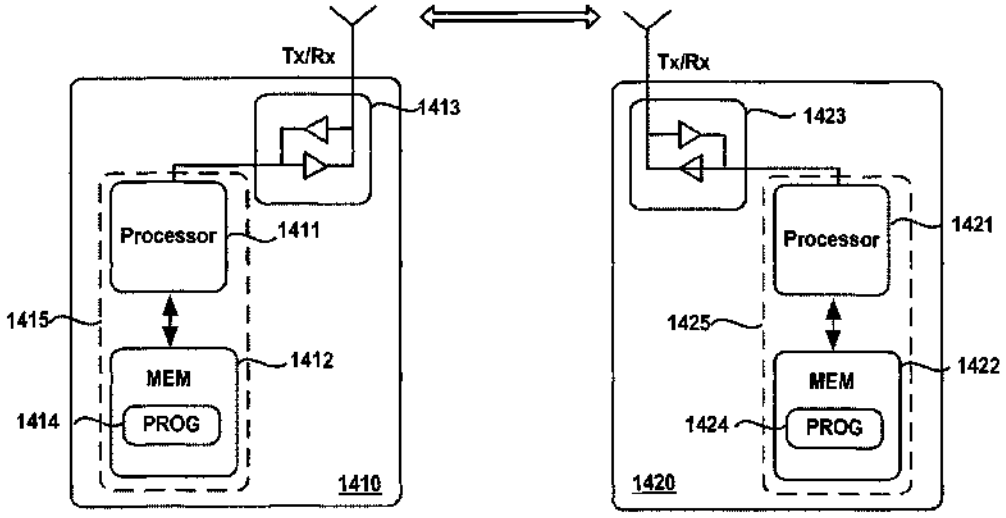

Tx/Rx
1413
Processor
1411
1415
MEM
1412
1414
PROG
1410
Tx/Rx
1423
Processor
1421
1425
MEM
1422
1424
PROG
1420

Fig. 14

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2017/070309

A. CLASSIFICATION OF SUBJECT MATTER

H04L 27/26(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04L,H04W,H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI,EPODOC,CNPAT,CNKI:downlink w control w information, DCI, configur+, parameter, time, frequency, resource+, indicat +, UE, user, transmit+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 106161312 A (CHINA MOBILE COMMUNICATIONS CORPORATION) 23 November 2016 (2016-11-23) description, paragraphs [0001], [0159]-[0166], [0217]-[0232]	1-25
A	CN 103095396 A (CHINA MOBILE COMMUNICATIONS CORPORATION) 08 May 2013 (2013-05-08) the whole document	1-25
A	US 2016345311 A1 (QUALCOMM INCORPORATED) 24 November 2016 (2016-11-24) the whole document	1-25
A	US 2016380737 A1 (LG ELECTRONICS INC.) 29 December 2016 (2016-12-29) the whole document	1-25

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:

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"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particnlar relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
08 August 2017	**06 September 2017**
Name and mailing address of the ISA/CN **STATE INTELLECTUAL PROPERTY OFFICE OF THE P.R.CHINA** **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088** **China** Facsimile No. **(86-10)62019451**	Authorized officer **ZUO,Linzi** Telephone No. **(86-10)62413344**

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2017/070309

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	106161312	A	23 November 2016	WO	2016150224	A1	29 September 2016
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	Application Number	17950726
	Filing Date	2022-09-22
	First Named Inventor	Xiaobo ZHANG
	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

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	1	3GPP TS 36.304 version 14.0.0 release 14, 3rd Generation Partnership Project (3GPP), dated October 3, 2016	☒
	2	3GPP TS 36.304 version 9.1.0 Release 9, 3rd Generation Partnership Project (3GPP), dated February 9, 2010	☒
	3	3GPP TS 36.306 version 14.2.0 release 14, 3rd Generation Partnership Project (3GPP), dated April 11, 2017	☒
	4	3GPP TS 36.321 version 12.3.0 release 12, 3rd Generation Partnership Project (3GPP), dated October 28, 2014	☒
	5	3GPP TS 36.321 version 12.6.0 release 12, 3rd Generation Partnership Project (3GPP), dated June 30, 2015	☒
	6	3GPP TS 36.321 version 12.8.0 release 12, 3rd Generation Partnership Project (3GPP), dated January 4, 2016	☒
	7	3GPP TS 36.321 version 12.8.0 release 12, 3rd Generation Partnership Project (3GPP), dated January 18, 2016	☒
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	9	3GPP TS 36.331 version 12.3.0 release 12, 3rd Generation Partnership Project (3GPP), dated September 29, 2014	☒
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Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

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A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/JIALIN ZHONG/	Date (YYYY-MM-DD)	2023-11-19
Name/Print	JIALIN ZHONG	Registration Number	62937

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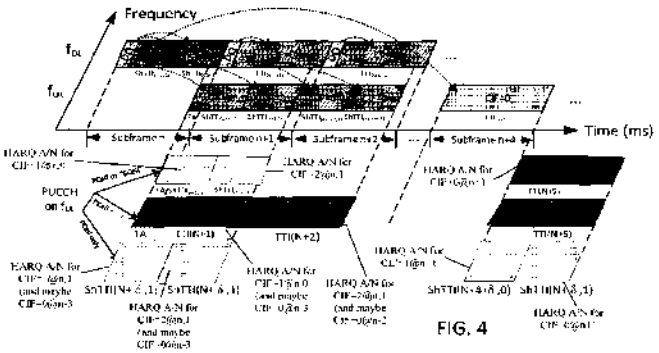


FIG. 4

(57) Abstract: A wireless transmit/receive unit, WTRU and methods of using a WTRU within a wireless communications network include communicating with a serving cell in the wireless communications network and determining, based on downlink control information whether the WTRU shall transmit with a first transmission time interval, TTI, length, using a first set of transmission resources, or a second TTI length, using a second set of transmission resources. Alternatively, determining based on said DCI, that the serving cell has indicated that the WTRU should use a first TTI on a physical uplink channel to communicate with the serving cell, or whether said DCI indicates that the WTRU should use a second TTI that is less than the first transmission time interval to communicate with the wireless communication network on the physical uplink channel or whether the WTRU should transmit using carrier aggregation.

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DEVICE AND METHODS FOR MULTIPLEXING TRANSMISSIONS WITH DIFFERENT TTI DURATION

BACKGROUND

[0001] In a wireless communication network, such as a Long Term Evolution (LTE) system or New Radio (NR), a wireless transmit/receive unit (WTRU) device may access resources of the communication system. Latency associated with transmission of data in a communication system may have one or more latency components. A latency component may be the time to perform the transmission of a transport block, which time may be referred to as a Transmission Time Interval (TTI). Such TTI may be tied to a specific numerology associated with the transmission method and to a specific number of transmission symbols associated with the transmission. Other latency components may include processing time at a receiver, e.g., time decoding a transmission, transmission of feedback (e.g. ACK or NACK) and/or one or more retransmissions with one or more latency components.

SUMMARY

[0002] Systems, methods, and instrumentalities are disclosed for multiplexing transmissions with different durations, for example transmissions that are associated with different TTI lengths. Latency may be reduced (e.g., in an LTE system and/or in a NR system), for example, by multiplexing transmissions with different TTI durations or associated with different transmission numerologies. TTI duration may be modeled based on defining one or more cell(s) for a given carrier frequency, for example that may be associated with different TTI lengths and/or transmission durations. For example, the different transmission durations may be achieved by time-shifting one or more of the cells. In order to support signaling techniques that allow for concurrent and/or complementary scheduling of transmissions associated with different duration, a logical structure for the physical layer resources (e.g., a cell, a spectrum block, etc.) may configured to correspond to a secondary cell ("SCell"). A primary cell ("PCell") may logically maintain a first transmission duration (e.g., a first TTI length such as a legacy TTI length). The SCell may be configured with a second transmission duration (e.g., a second TTI length or a shortened TTI length). One or more of a PCell or an SCell may be configured with either the legacy or shortened TTI length (e.g., a shorter duration TTI (ShTTI).

[0003] By associating different TTI lengths with different cells, the LTE carrier aggregation framework can be utilized to support multiplexing of transmissions of different durations. For example, carrier aggregation signaling, including cross-carrier scheduling mechanisms, can be used to different scheduling grants and assignments of varying length. For example, a WTRU may determine a TTI duration (e.g., first or second TTI length) applicable to a transmission. For example, a WTRU may determine a TTI duration using cross-carrier scheduling. A WTRU may be configured to associate a given cell identity (e.g., servCellID) with a given transmission duration. Different cell identities (e.g., different servCellIDs) may be associated with different transmission durations/different TTI lengths. When a WTRU receives scheduling information applicable to a given cell identity, the WTRU may determine the associated TTI length based on the configuration received for that cell identity.

[0004] A WTRU may determine a TTI length and/or transmission duration based on one or more parameters and/or received fields. For example, a WTRU may associate a given TTI duration with a given transmission mode (TM). A TTI duration may be indicated by a Carrier Indicator Field (CIF), for example where certain values of the CIF are associated with SCells configured with a given TTI durations such as a ShTTI. The CIF may also be referred to as a Carrier Indicator Field (CIF). The TTI duration may be indicated by a field that indicates a set of resources such as a set of PRBs, a carrier, a serving cell of the WTRU's configuration, and/or a spectrum block. A TTI duration may be determined from an identity of a PRB subset associated with the transmissions and/or to a time-shifted cell within a subset of PRBs for a concerned carrier frequency. An applicable TTI duration and/or the identity of a slot/period applicable to a transmission within a subframe may be determined using a medium access control (MAC) Activation/Deactivation control element. MAC Activation/Deactivation CE may be used to toggle between first and second TTIs (e.g. legacy TTI and ShTTIs) or between slot-based ShTTIs and/or may be used to determine zero, one or more TTI (e.g. ShTTI) period(s) within a subframe.

[0005] HARQ processing may be performed according to a first behavior (e.g. legacy behavior) for one or more (e.g. each) time-shifted cell(s), although there may be exceptions. An exception may be timing-relationships, which may be scaled according to an applicable TTI duration. HARQ A/N feedback formats may use LTE Carrier Aggregation (CA) formats and/or (e.g. legacy) subframe-based timing relationships or a timing relationship associated with the HARQ process. Downlink Control Information (DCI) signaling may use a first (e.g. legacy) format, although, for example, interpretation of fields such as the CIF and/or fields that indicate the PRBs applicable for the transmission may be different than the interpretations of the first

(e.g. legacy) format. MAC activation/deactivation signaling may be applicable for time-shifted cells. DRX Timers associated with DRX may scale to HARQ A/N timing according to an applicable TTI duration and/or to the cell associated with an HARQ process. Physical random access channel (PRACH) resources and/or physical downlink control channel (PDCCH) order for RACH may or may not be supported for time-shifted SCells. Timing advance for uplink transmission may be time shifted, for example, according to a shift applied to the TTI associated with a cell. Time shift may be relative to PCell timing, e.g. a PCell may remain a DL timing reference for an SCell with the additional offset corresponding to the start of the ShTTI for those cells.

[0006] A method of using a wireless transmit/receive unit within a wireless communications network that is capable of aggregating different sets of physical layer resources (e.g., such as carrier aggregation, for example) may include communicating with a serving cell in the wireless communications network and determining that the serving cell has indicated that the WTRU should use a first transmission time interval on a physical uplink channel to communicate with the serving cell. The method may also include determining whether downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment) indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network (e.g., on the physical uplink channel). The method may further include communicating with the wireless communications network using the second transmission time interval.

[0007] The method may include determining that a downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment) indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network (e.g, on the physical uplink channel) comprises determining based on a carrier indicator field in received downlink control information.

[0008] The method may include communicating with the wireless communications network using the second transmission time interval comprises communicating with the serving cell using the second transmission time interval.

[0009] The method may include wherein communicating with the wireless communications network using the second transmission time interval includes communicating with a secondary cell using the second transmission time interval.

[0010] The method may include determining that a downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment) indicates that the WTRU should use a third

transmission time interval that is less than the first transmission time interval to communicate with a secondary cell in the wireless communications network. The shorten transmission time interval may correspond to at least one of at least one symbol or at least one resource block. The first transmission time interval may be one millisecond.

[0011] The method may include determining a time to transmit with the second transmission time interval based on the downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment). The time to transmit may defined by a time partition (e.g., a slot in a subframe and/or one or more time symbols, (e.g., OFDM symbols), an arrangement of symbols, a min-slot, or other time for a sub-carrier spacing).

[0012] The method may include determining whether a first downlink control information (e.g., using carrier aggregation fields such as the CIF) indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network (e.g., on the physical uplink channel) or whether the WTRU should transmit using carrier aggregation comprises determining with cross-carrier scheduling.

[0013] A wireless transmit/receive unit (WTRU) for use within a wireless communications network that is capable of carrier aggregation may have a processor having executable instructions that communicate with a serving cell in the wireless communications network and determine that the serving cell has indicated that the WTRU should use a first transmission time interval on an uplink channel (e.g., physical uplink channel) to communicate with the serving cell. The processor instructions may include determining whether a downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment) indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network (e.g., on the physical uplink channel). The WTRU processor instructions may include communicating with the wireless communications network using the second transmission time interval.

[0014] The WTRU processor instructions that determine that a first downlink control information (e.g, carrier aggregation field such as the CIF) indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network (e.g., on the physical uplink channel) may comprise determining based on a carrier indicator field in received downlink control information.

[0015] The WTRU processor executable instructions that communicate with the wireless communications network using the second transmission time interval may comprise communicating with the serving cell using the second transmission time interval.

[0016] The WTRU processor executable instructions that communicate with the wireless communications network using the second transmission time interval may comprise communicating with a secondary cell using the second transmission time interval.

[0017] The WTRU processor executable instructions may include determining that a downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment) indicates that the WTRU should use a third transmission time interval that is less than the first transmission time interval to communicate with a secondary cell in the wireless communications network. The shorten transmission time interval may correspond to at least one of at least one symbol or at least one resource block. The first transmission time interval may be one millisecond.

[0018] The WTRU processor executable instructions may include determining a time to transmit with the second transmission time interval based on the downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment). The time to transmit may be defined by a slot in a subframe.

[0019] The WTRU processor executable instructions that determine whether a downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment) indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network (e.g., on the physical uplink channel).

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] FIG. 1A is a system diagram of an example communications system in which disclosed subject matter may be implemented.

[0021] FIG. 1B is a system diagram of an example wireless transmit/receive unit (WTRU) that may be used in a communications system.

[0022] FIG. 1C is a system diagram of an example radio access network and an example core network that may be used in a communications system.

[0023] FIG. 1D is a system diagram of an example radio access network and an example core network that may be used in a communications system.

[0024] FIG. 1E is a system diagram of an example radio access network and an example core network that may be used in a communications system.

[0025] FIG. 2 shows an example of DL physical layer channels.

[0026] FIG. 3 shows an example of UL physical layer channels.

[0027] FIG. 4 is an example of scheduling with time-shifted cells.

DETAILED DESCRIPTION

[0028] A detailed description of illustrative embodiments will now be described with reference to the various figures. Although this description provides a detailed example of possible implementations, it should be noted that the details are intended to be exemplary and in no way limit the scope of the application.

[0029] FIG. 1A is a diagram of an example communications system 100 in which one or more disclosed embodiments may be implemented. The communications system 100 may be a multiple access system that provides content, for example voice, data, video, messaging, broadcast, etc., to multiple wireless users. The communications system 100 may enable multiple wireless users to access such content through the sharing of system resources, including wireless bandwidth. For example, the communications systems 100 may employ one or more channel access methods, for example code division multiple access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), orthogonal FDMA (OFDMA), single-carrier FDMA (SC-FDMA), and the like.

[0030] As shown in FIG. 1A, the communications system 100 may include wireless transmit/receive units (WTRUs) 102a, 102b, 102c, and/or 102d (which generally or collectively may be referred to as WTRU 102), a radio access network (RAN) 103/104/105, a core network 106/107/109, a public switched telephone network (PSTN) 108, the Internet 110, and other networks 112, though it will be appreciated that the disclosed embodiments contemplate any number of WTRUs, base stations, networks, and/or network elements. Each of the WTRUs 102a, 102b, 102c, 102d may be any type of device configured to operate and/or communicate in a wireless environment. By way of example, the WTRUs 102a, 102b, 102c, 102d may be configured to transmit and/or receive wireless signals and may include a user equipment (WTRU), a mobile station, a fixed or mobile subscriber unit, a pager, a cellular telephone, a personal digital assistant (PDA), a smartphone, a laptop, a netbook, a personal computer, a wireless sensor, consumer electronics, and the like.

[0031] The communications systems 100 may also include a base station 114a and a base station 114b. Each of the base stations 114a, 114b may be any type of device configured to wirelessly interface with at least one of the WTRUs 102a, 102b, 102c, 102d to facilitate access to

one or more communication networks, for example the core network 106/107/109, the Internet 110, and/or the networks 112. By way of example, the base stations 114a, 114b may be a base transceiver station (BTS), a Node-B, an eNode B, a Home Node B, a Home eNode B, a site controller, an access point (AP), a wireless router, and the like. While the base stations 114a, 114b are each depicted as a single element, it will be appreciated that the base stations 114a, 114b may include any number of interconnected base stations and/or network elements.

[0032] The base station 114a may be part of the RAN 103/104/105, which may also include other base stations and/or network elements (not shown), for example a base station controller (BSC), a radio network controller (RNC), relay nodes, etc. The base station 114a and/or the base station 114b may be configured to transmit and/or receive wireless signals within a particular geographic region, which may be referred to as a cell (not shown). The cell may further be divided into cell sectors. For example, the cell associated with the base station 114a may be divided into three sectors. Thus, in one embodiment, the base station 114a may include three transceivers, i.e., one for each sector of the cell. In an embodiment, the base station 114a may employ multiple-input multiple output (MIMO) technology and, therefore, may utilize multiple transceivers for each sector of the cell.

[0033] The base stations 114a, 114b may communicate with one or more of the WTRUs 102a, 102b, 102c, 102d over an air interface 115/116/117, which may be any suitable wireless communication link (e.g. radio frequency (RF), microwave, infrared (IR), ultraviolet (UV), visible light, etc.). The air interface 115/116/117 may be established using any suitable radio access technology (RAT).

[0034] More specifically, as noted above, the communications system 100 may be a multiple access system and may employ one or more channel access schemes, for example CDMA, TDMA, FDMA, OFDMA, SC-FDMA, and the like. For example, the base station 114a in the RAN 103/104/105 and the WTRUs 102a, 102b, 102c may implement a radio technology such as Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access (UTRA), which may establish the air interface 115/116/117 using wideband CDMA (WCDMA). WCDMA may include communication protocols such as High-Speed Packet Access (HSPA) and/or Evolved HSPA (HSPA+). HSPA may include High-Speed Downlink Packet Access (HSDPA) and/or High-Speed Uplink Packet Access (HSUPA).

[0035] In an embodiment, the base station 114a and the WTRUs 102a, 102b, 102c may implement a radio technology such as Evolved UMTS Terrestrial Radio Access (E-UTRA), which may establish the air interface 115/116/117 using Long Term Evolution (LTE) and/or LTE-Advanced (LTE-A).

[0036] In an embodiment, the base station 114a and the WTRUs 102a, 102b, 102c may implement radio technologies such as IEEE 802.16 (i.e., Worldwide Interoperability for Microwave Access (WiMAX)), CDMA2000, CDMA2000 1X, CDMA2000 EV-DO, Interim Standard 2000 (IS-2000), Interim Standard 95 (IS-95), Interim Standard 856 (IS-856), Global System for Mobile communications (GSM), Enhanced Data rates for GSM Evolution (EDGE), GSM EDGE (GERAN), New Radio (NR) and the like. The descriptions and example provided herein apply to any of the air interface and communications standards that have been implemented although the terminology may differ among them for the functional components.

[0037] The base station 114b in FIG. 1A may be a wireless router, Home Node B, Home eNode B, or access point, for example, and may utilize any suitable RAT for facilitating wireless connectivity in a localized area, for example a place of business, a home, a vehicle, a campus, and the like. In one embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.11 to establish a wireless local area network (WLAN). In an embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.15 to establish a wireless personal area network (WPAN). In yet an embodiment, the base station 114b and the WTRUs 102c, 102d may utilize a cellular-based RAT (e.g. WCDMA, CDMA2000, GSM, LTE, LTE-A, etc.) to establish a picocell or femtocell. As shown in FIG. 1A, the base station 114b may have a direct connection to the Internet 110. Thus, the base station 114b may not be required to access the Internet 110 via the core network 106/107/109.

[0038] The RAN 103/104/105 may be in communication with the core network 106/107/109, which may be any type of network configured to provide voice, data, applications, and/or voice over internet protocol (VoIP) services to one or more of the WTRUs 102a, 102b, 102c, 102d. For example, the core network 106/107/109 may provide call control, billing services, mobile location-based services, pre-paid calling, Internet connectivity, video distribution, etc., and/or perform high-level security functions, for example user authentication. Although not shown in FIG. 1A, it will be appreciated that the RAN 103/104/105 and/or the core network 106/107/109 may be in direct or indirect communication with other RANs that employ the same RAT as the RAN 103/104/105 or a different RAT. For example, in addition to being connected to the RAN 103/104/105, which may be utilizing an E-UTRA radio technology, the core network 106/107/109 may also be in communication with a RAN (not shown) employing a GSM radio technology.

[0039] The core network 106/107/109 may also serve as a gateway for the WTRUs 102a, 102b, 102c, 102d to access the PSTN 108, the Internet 110, and/or other networks 112. The

PSTN 108 may include circuit-switched telephone networks that provide plain old telephone service (POTS). The Internet 110 may include a global system of interconnected computer networks and devices that use common communication protocols, for example the transmission control protocol (TCP), user datagram protocol (UDP) and the internet protocol (IP) in the TCP/IP internet protocol suite. The networks 112 may include wired or wireless communications networks owned and/or operated by other service providers. For example, the networks 112 may include a core network connected to one or more RANs, which may employ the same RAT as the RAN 103/104/105 or a different RAT.

[0040] Some or all of the WTRUs 102a, 102b, 102c, 102d in the communications system 100 may include multi-mode capabilities, i.e., the WTRUs 102a, 102b, 102c, 102d may include multiple transceivers for communicating with different wireless networks over different wireless links. For example, the WTRU 102c shown in FIG. 1A may be configured to communicate with the base station 114a, which may employ a cellular-based radio technology, and with the base station 114b, which may employ an IEEE 802 radio technology.

[0041] FIG. 1B is a system diagram of an example WTRU 102. As shown in FIG. 1B, the WTRU 102 may include a processor 118, a transceiver 120, a transmit/receive element 122, a speaker/microphone 124, a keypad 126, a display/touchpad 128, non-removable memory 130, removable memory 132, a power source 134, a global positioning system (GPS) chipset 136, and other peripherals 138. It will be appreciated that the WTRU 102 may include any sub-combination of the foregoing elements while remaining consistent with an embodiment. Also, embodiments contemplate that the base stations 114a and 114b, and/or the nodes that base stations 114a and 114b may represent, for example but not limited to transceiver station (BTS), a Node-B, a site controller, an access point (AP), a home node-B, an evolved home node-B (eNodeB), a home evolved node-B (HeNB), a home evolved node-B gateway, and proxy nodes, among others, may include some or each of the elements depicted in FIG. 1B and described herein.

[0042] The processor 118 may be a general purpose processor, a special purpose processor, a conventional processor, a digital signal processor (DSP), a plurality of microprocessors, one or more microprocessors in association with a DSP core, a controller, a microcontroller, Application Specific Integrated Circuits (ASICs), Field Programmable Gate Array (FPGAs) circuits, any other type of integrated circuit (IC), a state machine, and the like. The processor 118 may perform signal coding, data processing, power control, input/output processing, and/or any other functionality that enables the WTRU 102 to operate in a wireless environment. The processor 118 may be coupled to the transceiver 120, which may be coupled to the

transmit/receive element 122. While FIG. 1B depicts the processor 118 and the transceiver 120 as separate components, it will be appreciated that the processor 118 and the transceiver 120 may be integrated together in an electronic package or chip.

[0043] The transmit/receive element 122 may be configured to transmit signals to, or receive signals from, a base station (e.g. the base station 114a) over the air interface 115/116/117. For example, in one embodiment, the transmit/receive element 122 may be an antenna configured to transmit and/or receive RF signals. In an embodiment, the transmit/receive element 122 may be an emitter/detector configured to transmit and/or receive IR, UV, or visible light signals, for example. In yet an embodiment, the transmit/receive element 122 may be configured to transmit and receive both RF and light signals. It will be appreciated that the transmit/receive element 122 may be configured to transmit and/or receive any combination of wireless signals.

[0044] In addition, although the transmit/receive element 122 is depicted in FIG. 1B as a single element, the WTRU 102 may include any number of transmit/receive elements 122. More specifically, the WTRU 102 may employ MIMO technology. Thus, in one embodiment, the WTRU 102 may include two or more transmit/receive elements 122 (e.g. multiple antennas) for transmitting and receiving wireless signals over the air interface 115/116/117.

[0045] The transceiver 120 may be configured to modulate the signals that are to be transmitted by the transmit/receive element 122 and to demodulate the signals that are received by the transmit/receive element 122. As noted above, the WTRU 102 may have multi-mode capabilities. Thus, the transceiver 120 may include multiple transceivers for enabling the WTRU 102 to communicate via multiple RATs, for example UTRA and IEEE 802.11, for example.

[0046] The processor 118 of the WTRU 102 may be coupled to, and may receive user input data from, the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128 (e.g. a liquid crystal display (LCD) display unit or organic light-emitting diode (OLED) display unit). The processor 118 may also output user data to the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128. In addition, the processor 118 may access information from, and store data in, any type of suitable memory, for example the non-removable memory 130 and/or the removable memory 132. The non-removable memory 130 may include random-access memory (RAM), read-only memory (ROM), a hard disk, or any other type of memory storage device. The removable memory 132 may include a subscriber identity module (SIM) card, a memory stick, a secure digital (SD) memory card, and the like. In an embodiment, the processor 118 may access information from, and store data in, memory that is not physically located on the WTRU 102, for example on a server or a home computer (not shown).

[0047] The processor 118 may receive power from the power source 134, and may be configured to distribute and/or control the power to the other components in the WTRU 102. The power source 134 may be any suitable device for powering the WTRU 102. For example, the power source 134 may include one or more dry cell batteries (e.g. nickel-cadmium (NiCd), nickel-zinc (NiZn), nickel metal hydride (NiMH), lithium-ion (Li-ion), etc.), solar cells, fuel cells, and the like.

[0048] The processor 118 may also be coupled to the GPS chipset 136, which may be configured to provide location information (e.g. longitude and latitude) regarding the current location of the WTRU 102. In addition to, or in lieu of, the information from the GPS chipset 136, the WTRU 102 may receive location information over the air interface 115/116/117 from a base station (e.g. base stations 114a, 114b) and/or determine its location based on the timing of the signals being received from two or more nearby base stations. It will be appreciated that the WTRU 102 may acquire location information by way of any suitable location-determination method while remaining consistent with an embodiment.

[0049] The processor 118 may further be coupled to other peripherals 138, which may include one or more software and/or hardware modules that provide additional features, functionality and/or wired or wireless connectivity. For example, the peripherals 138 may include an accelerometer, an e-compass, a satellite transceiver, a digital camera (for photographs or video), a universal serial bus (USB) port, a vibration device, a television transceiver, a hands free headset, a Bluetooth® module, a frequency modulated (FM) radio unit, a digital music player, a media player, a video game player module, an Internet browser, and the like.

[0050] FIG. 1C is a system diagram of the RAN 103 and the core network 106 according to an embodiment. As noted above, the RAN 103 may employ a UTRA radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 115. The RAN 103 may also be in communication with the core network 106. As shown in FIG. 1C, the RAN 103 may include Node-Bs 140a, 140b, 140c, which may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 115. The Node-Bs 140a, 140b, 140c may each be associated with a particular cell (not shown) within the RAN 103. The RAN 103 may also include RNCs 142a, 142b. It will be appreciated that the RAN 103 may include any number of Node-Bs and RNCs while remaining consistent with an embodiment.

[0051] As shown in FIG. 1C, the Node-Bs 140a, 140b may be in communication with the RNC 142a. Additionally, the Node-B 140c may be in communication with the RNC142b. The Node-Bs 140a, 140b, 140c may communicate with the respective RNCs 142a, 142b via an Iub interface. The RNCs 142a, 142b may be in communication with one another via an Iur interface.

Each of the RNCs 142a, 142b may be configured to control the respective Node-Bs 140a, 140b, 140c to which it is connected. In addition, each of the RNCs 142a, 142b may be configured to carry out or support other functionality, for example outer loop power control, load control, admission control, packet scheduling, handover control, macro diversity, security functions, data encryption, and the like.

[0052] The core network 106 shown in FIG. 1C may include a media gateway (MGW) 144, a mobile switching center (MSC) 146, a serving GPRS support node (SGSN) 148, and/or a gateway GPRS support node (GGSN) 150. While each of the foregoing elements are depicted as part of the core network 106, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

[0053] The RNC 142a in the RAN 103 may be connected to the MSC 146 in the core network 106 via an IuCS interface. The MSC 146 may be connected to the MGW 144. The MSC 146 and the MGW 144 may provide the WTRUs 102a, 102b, 102c with access to circuit-switched networks, for example the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, 102c and traditional land-line communications devices.

[0054] The RNC 142a in the RAN 103 may also be connected to the SGSN 148 in the core network 106 via an IuPS interface. The SGSN 148 may be connected to the GGSN 150. The SGSN 148 and the GGSN 150 may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, for example the Internet 110, to facilitate communications between and the WTRUs 102a, 102b, 102c and IP-enabled devices.

[0055] As noted above, the core network 106 may also be connected to the networks 112, which may include other wired or wireless networks that are owned and/or operated by other service providers.

[0056] FIG. 1D is a system diagram of the RAN 104 and the core network 107 according to an embodiment. As noted above, the RAN 104 may employ an E-UTRA radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 116. The RAN 104 may also be in communication with the core network 107.

[0057] The RAN 104 may include eNode-Bs 160a, 160b, 160c, though it will be appreciated that the RAN 104 may include any number of eNode-Bs while remaining consistent with an embodiment. The eNode-Bs 160a, 160b, 160c may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 116. In one embodiment, the eNode-Bs 160a, 160b, 160c may implement MIMO technology. Thus, the eNode-B 160a, for example, may use multiple antennas to transmit wireless signals to, and receive wireless signals from, the WTRU 102a.

[0058] Each of the eNode-Bs 160a, 160b, 160c may be associated with a particular cell (not shown) and may be configured to handle radio resource management decisions, handover decisions, scheduling of users in the uplink and/or downlink, and the like. As shown in FIG. 1D, the eNode-Bs 160a, 160b, 160c may communicate with one another over an X2 interface.

[0059] The core network 107 shown in FIG. 1D may include a mobility management gateway (MME) 162, a serving gateway 164, and a packet data network (PDN) gateway 166. While each of the foregoing elements are depicted as part of the core network 107, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

[0060] The MME 162 may be connected to each of the eNode-Bs 160a, 160b, 160c in the RAN 104 via an S1 interface and may serve as a control node. For example, the MME 162 may be responsible for authenticating users of the WTRUs 102a, 102b, 102c, bearer activation/deactivation, selecting a particular serving gateway during an initial attach of the WTRUs 102a, 102b, 102c, and the like. The MME 162 may also provide a control plane function for switching between the RAN 104 and other RANs (not shown) that employ other radio technologies, for example GSM or WCDMA.

[0061] The serving gateway 164 may be connected to each of the eNode-Bs 160a, 160b, 160c in the RAN 104 via the S1 interface. The serving gateway 164 may generally route and forward user data packets to/from the WTRUs 102a, 102b, 102c. The serving gateway 164 may also perform other functions, for example anchoring user planes during inter-eNode B handovers, triggering paging when downlink data is available for the WTRUs 102a, 102b, 102c, managing and storing contexts of the WTRUs 102a, 102b, 102c, and the like.

[0062] The serving gateway 164 may also be connected to the PDN gateway 166, which may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, for example the Internet 110, to facilitate communications between the WTRUs 102a, 102b, 102c and IP-enabled devices.

[0063] The core network 107 may facilitate communications with other networks. For example, the core network 107 may provide the WTRUs 102a, 102b, 102c with access to circuit-switched networks, for example the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, 102c and traditional land-line communications devices. For example, the core network 107 may include, or may communicate with, an IP gateway (e.g. an IP multimedia subsystem (IMS) server) that serves as an interface between the core network 107 and the PSTN 108. In addition, the core network 107 may provide the WTRUs 102a, 102b, 102c with access to

the networks 112, which may include other wired or wireless networks that are owned and/or operated by other service providers.

[0064] FIG. 1E is a system diagram of the RAN 105 and the core network 109 according to an embodiment. The RAN 105 may be an access service network (ASN) that employs IEEE 802.16 radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 117. As will be further discussed below, the communication links between the different functional entities of the WTRUs 102a, 102b, 102c, the RAN 105, and the core network 109 may be defined as reference points.

[0065] As shown in FIG. 1E, the RAN 105 may include base stations 180a, 180b, 180c, and an ASN gateway 182, though it will be appreciated that the RAN 105 may include any number of base stations and ASN gateways while remaining consistent with an embodiment. The base stations 180a, 180b, 180c may each be associated with a particular cell (not shown) in the RAN 105 and may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 117. In one embodiment, the base stations 180a, 180b, 180c may implement MIMO technology. Thus, the base station 180a, for example, may use multiple antennas to transmit wireless signals to, and receive wireless signals from, the WTRU 102a. The base stations 180a, 180b, 180c may also provide mobility management functions, for example handoff triggering, tunnel establishment, radio resource management, traffic classification, quality of service (QoS) policy enforcement, and the like. The ASN gateway 182 may serve as a traffic aggregation point and may be responsible for paging, caching of subscriber profiles, routing to the core network 109, and the like.

[0066] The air interface 117 between the WTRUs 102a, 102b, 102c and the RAN 105 may be defined as an R1 reference point that implements the IEEE 802.16 specification. In addition, each of the WTRUs 102a, 102b, 102c may establish a logical interface (not shown) with the core network 109. The logical interface between the WTRUs 102a, 102b, 102c and the core network 109 may be defined as an R2 reference point, which may be used for authentication, authorization, IP host configuration management, and/or mobility management.

[0067] The communication link between each of the base stations 180a, 180b, 180c may be defined as an R8 reference point that includes protocols for facilitating WTRU handovers and the transfer of data between base stations. The communication link between the base stations 180a, 180b, 180c and the ASN gateway 182 may be defined as an R6 reference point. The R6 reference point may include protocols for facilitating mobility management based on mobility events associated with each of the WTRUs 102a, 102b, 102c.

[0068] As shown in FIG. 1E, the RAN 105 may be connected to the core network 109. The communication link between the RAN 105 and the core network 109 may defined as an R3 reference point that includes protocols for facilitating data transfer and mobility management capabilities, for example. The core network 109 may include a mobile IP home agent (MIP-HA) 184, an authentication, authorization, accounting (AAA) server 186, and a gateway 188. While each of the foregoing elements are depicted as part of the core network 109, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

[0069] The MIP-HA may be responsible for IP address management, and may enable the WTRUs 102a, 102b, 102c to roam between different ASNs and/or different core networks. The MIP-HA 184 may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, for example the Internet 110, to facilitate communications between the WTRUs 102a, 102b, 102c and IP-enabled devices. The AAA server 186 may be responsible for user authentication and for supporting user services. The gateway 188 may facilitate interworking with other networks. For example, the gateway 188 may provide the WTRUs 102a, 102b, 102c with access to circuit-switched networks, for example the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, 102c and traditional land-line communications devices. In addition, the gateway 188 may provide the WTRUs 102a, 102b, 102c with access to the networks 112, which may include other wired or wireless networks that are owned and/or operated by other service providers.

[0070] Although not shown in FIG. 1E, it will be appreciated that the RAN 105 may be connected to other ASNs and the core network 109 may be connected to other core networks. The communication link between the RAN 105 the other ASNs may be defined as an R4 reference point, which may include protocols for coordinating the mobility of the WTRUs 102a, 102b, 102c between the RAN 105 and the other ASNs. The communication link between the core network 109 and the other core networks may be defined as an R5 reference, which may include protocols for facilitating interworking between home core networks and visited core networks.

[0071] Systems, methods, and instrumentalities are disclosed for multiplexing transmissions with different durations, for example such as transmission that utilize different TTI lengths. Latency reduction for some transmissions may achieved, for example, by multiplexing transmissions with different TTI durations. Although examples may be described with respect to multiplexing of an LTE legacy TTI (e.g., 1 ms) with a shortened TTI length (e.g., less than 1 ms), the techniques described herein may be generally applicable to the multiplexing of other

types of transmissions that are of different/varying lengths. For example, the examples may be described with respect to transmissions that contain one transport block (TB), but the examples may be equally applicable to transmissions that include a portion of a TB, transmissions that contain multiple TBs, etc. Thus, as may be appreciated, although specific examples herein may be described with respect to multiplexing transmissions associated with a "legacy" 1 ms TTI with transmissions that are less than 1 ms, these examples are not limited to the specific embodiments described and may be applied to transmissions of varying length that include varying amounts of data. Additionally, although examples may be described with respect to multiplexing shorter than 1 ms transmissions into a legacy LTE system that utilizes a legacy TTI length of 1 ms, the techniques may be applied to other types of transmission configurations, for example such as the NR system that may be utilized for 5G cellular communications.

[0072] Transmissions of different length may be realized in multiple ways and be consistent with this disclosure. For example, multiple TTI lengths may be defined, and the system may be configured to multiplex transmissions associated with the different TTI lengths over a common set of transmission resources. In example, rather than or in addition to defining different TTI lengths, transmissions of different durations may be supported, for example where one or more of the transmissions durations may or may not correspond to a TTI. Transmission duration may be defined in a number of ways, for example an amount of time over which the transmission occurs, (e.g., a specific duration or a time partition), a number of symbols over which the transmission occurs (e.g., 14 OFDM symbols, 12 OFDM symbols, 1 OFDM symbol, etc.), a slot, a minislot, a time partition for a sub-carrier spacing, and/or in terms of a specific numerology associated with the transmissions. For example, the numerology may be defined based on one or more of a sub-carrier spacing (e.g., different sub-carrier spacing may lead to different time durations for a symbol), a symbol length, a waveform type, etc.

[0073] Examples may also be described with respect to one or more cells. However, the techniques described herein may be equally applicable to other types of resource partitions. For example, in LTE cells may be defined based on certain OFDM time-frequency resources that are defined for a certain operating band for the cell. However, the multiplexing techniques described herein may be applied to physical resources that may or may not be defined using the cell construct. For example, the techniques described herein may apply of a subset of the physical resources in a cell and/or to physical resources that are not defined using the cell construct.

[0074] In order to TTI duration may be modeled using one or more time-shifted cell(s) for a given carrier frequency, e.g. in an LTE system such as a legacy LTE system. A "logical" cell structure may correspond to an SCell (e.g., a legacy SCell). A PCell may logically maintain

a TTI (e.g., a first TTI such as a legacy TTI that may be 1 ms) or may be (e.g. also) configured with a second duration TTI (e.g., a shorter duration TTI (ShTTI) that may be less than 1 ms).

[0075] In an example, a WTRU may determine a TTI duration (e.g. first or second TTI) applicable to a transmission. A determination may be, for example, a function of one or more facts, factors, and/or parameters. For example, a WTRU may determine a TTI duration using cross-carrier scheduling information. A WTRU may associate a certain TTI duration with a certain cell identity (e.g. servCellID). A WTRU may associate a certain TTI duration with certain a transmission mode (TM). A TTI duration may be indicated by a CIF included in DCI. For example, a first cell identity (e.g., servCellID = 1) may be associated with a first TTI duration and a second cell identity (e.g., servCellID = 2) may be associated with a second TTI duration. When the CIF field indicates that the received DCI is applicable to the first cell identity (e.g., CIF = '001' - servCellID = 1), the WTRU may determine that the scheduled transmission is associated with the first TTI duration. When the CIF field indicates that the received DCI is applicable to the second cell identity (e.g., CIF = '010' - servCellID = 2), the WTRU may determine that the scheduled transmission is associated with the second TTI duration. In this matter, carrier aggregation signaling methods may be reused/reinterpreted in order to support multiple TTI length.

[0076] A TTI duration may be determined from an identity of a PRB subset associated with the transmissions and/or to a time-shifted cell within a subset of PRBs for a concerned carrier frequency. An applicable TTI duration and/or the identity of a slot/period applicable to a transmission within a subframe may be determined using MAC Activation/Deactivation. MAC Activation/Deactivation may be used to toggle between first and second TTIs (e.g. between a legacy TTI and one or more ShTTIs). For example, a WTRU may utilize a first TTI length for a first cell prior to receiving MAC Activation/Deactivation control element. Upon receiving the MAC Activation/Deactivation control element for the first cell, the WTRU may toggle to a second TTI length. In an example, the MAC Activation/Deactivation control element may be used to toggle between different slots used for a ShTTI transmission in a legacy suframe. For example, the MAC Activation/Deactivation control element may be used to switch between the first and second slots for the shortened TTI transmission. MAC Activation/Deactivation may be used to determine zero, one or more ShTTIs period(s) within a subframe.

[0077] HARQ processing may remain according to a first behavior (e.g. legacy behavior) for one or more (e.g. each) time-shifted cell(s), although there may be exceptions. In an example, an exception may be timing-relationships, which may be scaled according to an applicable TTI duration. HARQ A/N feedback formats may use LTE Carrier Aggregation (CA)

formats and/or (e.g., legacy) subframe-based timing relationships or a timing relationship associated with the HARQ process. Downlink Control Information (DCI) signaling may use a first (e.g., legacy) format, although, for example, interpretation of fields such as the CIF and/or PRBs applicable for the transmission may be different than the first (e.g., legacy) format. MAC activation/deactivation signaling may be applicable for time-shifted cells. DRX Timers associated with DRX may scale to HARQ A/N timing according to an applicable TTI duration and/or to the cell associated with an HARQ process. PRACH resources and/or PDCCH order for RACH may or may not be supported for time-shifted SCells. Timing advance for uplink transmission may be time shifted, for example, according to a shift applied to the TTI associated with a cell. Time shift may be relative to PCell timing, e.g., a PCell may remain a DL timing reference for an SCell with the additional offset corresponding to the start of the ShTTI for those cells.

[0078] A device may access resources of a communication system. Latency associated with transmission of data may have one or more latency components. A latency component may be the time to perform the transmission of a transport block, which time may be referred to as a Transmission Time Interval (TTI). A latency component may be processing time at a receiver, e.g., time decoding a transmission. Receiver processing time may be tied to implementation complexity and may be accounted for using a fixed timing relationship between different events associated with the transmission of a data unit. A timing relationship may be fixed, for example, when time-division duplex (TDD) is used for a carrier and/or synchronous Hybrid ARQ (HARQ) operation (e.g., such as for LTE in the uplink).

[0079] There may be additional latency components, for example, when a transmission is not successfully decoded. For example, additional components may include transmission of feedback (e.g. HARQ ACK or NACK), processing time at the receiver and/or one or more retransmissions with one or more latency components.

[0080] Latency components may be measured in integer multiples of a basic time interval (BTI). For example, latency components may be measured in TTIs, e.g., in LTE.

[0081] Latency in wireless networks may be caused by multiple factors. Latency may be affected, e.g., at lower layers, by a need for highly reliable transmissions, which may be obtained using HARQ. One or more retransmissions may affect the latency of a transmission, for example, given that retransmissions may not be performed in adjacent time periods.

[0082] A WTRU may incur processing time, for example, for downlink (DL) transmission, to determine whether a transmission was decoded properly, which may lead to a time interval between reception of a DL transmission and transmission of an ACK or NACK. An eNB may

incur processing time, for example, to determine whether an ACK or NACK was transmitted by the WTRU and/or whether a retransmission is required. A similar consumption of processing time may occur for uplink (UL) transmissions. Processing times may be cumulative. There may be a tradeoff between latency and implementation complexity.

[0083] A system (e.g. LTE) may accommodate processing times in a timing relationship between a first transmission for a transport block and its corresponding ACK-NACK HARQ response for downlink and/or uplink operation and possible retransmission.

[0084] Time Division Duplex (TDD) and Frequency Division Duplex (FDD) DL scheduling timing may be the same, such that a WTRU may receive a scheduling grant for a DL transmission in the same subframe or transmission time interval (TTI).

[0085] A WTRU may transmit a corresponding Physical UL Shared Channel (PUSCH), e.g., in subframe n+4, for example, upon detection of a Physical DL Control Channel PDCCH or enhanced PDCCH (EPDCCH) with UL Downlink Control Information (DCI) format and/or Physical Hybrid ARQ Indicator Channel (PHICH) transmission in subframe n, e.g., in an FDD UL transmission intended for the WTRU. A HARQ ACK/NACK response for a DL or UL transmission in subframe n may be provided in subframe n+4.

[0086] A WTRU may transmit a corresponding PUSCH in subframe n+k, for example, upon detection of a (E)PDCCH with UL DCI format and/or PHICH transmission in subframe n, e.g., for a UL transmission in a TDD system intended for the WTRU. The value of k may depend on the TDD UL/DL configuration, the subframe where the UL DCI and/or PHICH was transmitted and/or the PHICH resource and the MSB or LSB of the UL index in the (E)PDCCH, e.g., in TDD UL/DL configuration 0. A HARQ ACK/NACK response for a DL or UL transmission in subframe n may be provided in subframe n+k, where k may depend on the value of n and the TDD UL/DL configuration. Bundling may be used to provide HARQ for multiple transmissions in one instance.

[0087] Processing time available to a WTRU may depend, for example, on the value of the timing advance or on the distance between the WTRU and the eNB. In an example, an LTE system may have a distance of 100km between a WTRU and an eNB, which may correspond to a (e.g. a maximum) timing advance of 0.67ms. In an example, there may be approximately 2.3 ms left for terminal processing. An eNB may have, for example, 3 ms processing time available, which may be on the same order as that of the terminal.

[0088] FIG. 2 shows an example of DL physical layer channels. In a DL example with reference to the example shown in FIG. 2, there may be three channel areas in a subframe to support DL Shared Channel (DL-SCH) and UL-SCH. Three channel areas may comprise a PDCCH (which may include Physical Control Format Indicator Channel (PCFICH) and PHICH),

a Physical DL Shared Channel (PDSCH) and an EPDCCH. An EPDCCH may include scheduling information for a WTRU while taking advantage of the benefits of the PDSCH region, such as beamforming gain and frequency domain Inter-Cell Interference Coordination (ICIC) and/or improving PDCCH capacity.

[0089] FIG. 3 shows an example of UL physical layer channels. In a UL example with reference to the example shown in FIG. 3, there may be two channel areas in a subframe to support DL-SCH and UL-SCH. Two channel areas may comprise a PUSCH and a PDSCH. These channel areas may be transmitted in different RBs in each time slot (e.g. frequency hopping of PUSCH), for example, to increase robustness in frequency selective channels.

[0090] A transmission time interval (TTI) duration may be based on and/or defined by one or more symbols. A TTI duration may be defined in terms of a number of OFDM symbols. For example, a TTI duration may be defined as an entire (legacy) subframe and/or a pair of physical resource blocks (PRBs). In the legacy 1 ms TTI length, there may be 14 OFDM symbols for normal cyclic prefix and 12 OFDM symbols for extended cyclic prefix. For example when multiplexing ShTTI transmissions with legacy TTI transmissions of 1 ms, a ShTTI may be made as short as a single ODFM symbol. Symbol-based categorization may be referred to as symbol-based TTI durations.

[0091] A TTI duration may be based on time-varying symbol duration. TTI durations may have a fixed number of symbols (e.g., 14 symbols) while symbol duration may vary in time. For example, variable time symbol-based TTI duration may be achieved by modifying subcarrier spacing. In an example, a first TTI duration may be achieved with a first subcarrier spacing and a second TTI duration may be achieved with a second subcarrier spacing. Different bandwidth portions (e.g. PRBs) of a carrier may support different subcarrier spacing, thus enabling different TTI duration for different bandwidth portions (e.g. PRBs). Multiplexing transmissions associated with different sub-carrier spacing and/or symbol duration may be applicable to 5G systems such as NR. Such techniques may also be used in LTE-Advanced.

[0092] A TTI duration may be based on a time slot. A TTI duration may be defined in terms of a time slot (e.g. 7 OFDM symbols for normal cyclic prefix and 6 OFDM symbols for extended cyclic prefix). For example, if a ShTTI is defined as the length of one slot, two ShTTI transmissions may be time multiplexed into a legacy 1 ms TTI length.

[0093] A TTI duration may be based on time. A TTI duration may be defined in terms of a time value (e.g. 1ms legacy TTI or a 100ms ShTTI).

[0094] A TTI duration may be based on a hybrid, such as a combination of forgoing TTI duration bases. In an example of a hybrid method of achieving variable TTI durations, a different number of symbols and different symbol durations may be used.

[0095] Latency may be improved. It may be beneficial to decrease the TTI duration of different channels. A decrease in TTI duration may enable a decrease in WTRU processing time and may permit a WTRU to begin processing data sooner. Such a scenario may enable a shorter HARQ timeline. Different channels may have different TTI durations. A TTI duration shorter than one subframe for one or more of the EPDCCH, PDSCH, PUCCH, PDSCH, etc. may be provided. Effective HARQ feedback for PDSCH and PUSCH transmissions using shorter than (e.g., legacy 1ms) subframe TTI durations may be provided. Shorter TTIs may be referred to as ShTTI.

[0096] ShTTI and/or a combination of TTI and ShTTI may be supported for a given WTRU, for example, to minimize the impact of other aspects related to WTRU transmissions, such as scheduling (e.g., formats of DCIs), HARQ (e.g., related processing/process identities), feedback formats and determination of an applicable TTI duration. For example, the configuration of ShTTIs and/or the signaling of DCI for ShTTIs may utilize certain signaling originally defined for purposes of carrier aggregation in order to limit the amount of complexity at the WTRU and/or facilitated TTI length multiplexing in a backwards compatible manner. One or more latency components may be reduced, for example, to minimize the impact on WTRU implementations.

[0097] A WTRU may (e.g., based on a determination) operate with a one or more TTI durations, such as subframe TTI duration (e.g., 1 ms), a timeslot TTI duration (e.g., 0.5 ms), a symbol-based TTI duration (e.g., one or more OFDM symbols in duration), and/or other shorter than 1 ms TTI durations. In an example, a WTRU may be configured to operate with specific but different TTI duration configuration in downlink and uplink. In an example, a WTRU may be configured to permit the same TTI duration configuration to be used in downlink and uplink for applicable transmissions. For example, if the WTRU receives a configuration that indicates a first cell is associated with a first TTI duration in the downlink, the WTRU may determine that the uplink TTI duration is also the first TTI duration unless the configuration indicates otherwise.

[0098] A TTI duration may be WTRU specific. A WTRU may operate with a TTI duration during a given period. A WTRU may be configured to operate according to one or more of a plurality of possible TTI durations and may operate with the one or more TTI durations for a specific period of time, e.g., based on an L3 (e.g., radio resource control (RRC)) reconfiguration. A TTI duration may be fixed (e.g. statically, semi-statically or dynamically) for a (e.g. every) transmission to and from a WTRU.

[0099] Multiple TTI durations may be concurrently configured and/or used. A WTRU may be configured to operate for transmissions of different TTI durations concurrently. Different TTI durations may be based on, for example, semi-static allocation (e.g. configuration of a subset of frames/subframes dedicated to different TTI durations based on a semi-persistent grant or assignment) and/or dynamic allocation (e.g. based on detection and/or reception of downlink control signaling).

[0100] A TTI duration may be cell/cell group (CG)-specific. Configuration may be applicable per cell of a WTRU's configuration, for a subset of cells of a WTRU's configuration, and/or for all cells of the same timing advance group (TAG) and/or all cells of the same cell group (CG). For example, upon adding a new cell, the TTI duration may be defined for the new cell. As an example, if the WTRU adds an SCell, the SCell configuration may indicated that the WTRU is to utilize a shortened TTI duration for the SCell. The HARQ instances associated with a specific MAC entity may be configured with a similar configuration for TTI duration. A similar or same configuration for TTI duration may be used, for example, for cells associated with the same channel(s) (e.g. PUCCH, PUSCH) for uplink control signaling.

[0101] TTI duration may be modeled using one or more time-shifted cell(s) for a given carrier frequency. Modeling may enable co-existence between WTRUs operating according to different TTI durations, e.g. in legacy LTE systems. A "logical" cell structure may correspond to the use of one or more serving cell(s). Serving cells may include secondary cells, such as an SCell type or a PSCell type defined for LTE CA. A PCell may logically maintain a first (e.g., legacy) TTI such as 1 ms or may be (e.g., also) configured as a ShTTI.

[0102] Multiple serving cells may be associated with a specific TTI duration. A WTRU may support multiple TTI durations based on one or more functions and/or characteristic associated to a serving cell.

[0103] A WTRU may determine the duration of a downlink control region, e.g., according to a first (e.g., legacy) behavior for LTE. A reception of PDCCH may be a first (e.g., legacy) behavior for downlink subframes. In an example, the first ShTTI in a subframe may include a control region, e.g., in case of slot-based operation, such as two slots of 7 symbols where the first slot include 1-3 symbols for PDCCH. In an example, the ShTTI duration may exclude the control region, e.g., in case of symbol-based ShTTIs. In an example, an offset in time or in symbol from the start of a subframe may be used to indicate the start of an ShTTI (e.g., in the DCI).

[0104] In an example, a WTRU may operate on a given carrier frequency (e.g., for downlink and/or uplink) according to at least one of the following: TTI duration per Transmission

Mode (TM), TTI duration per Serving Cell Identity (servCellID), and/or TTI duration per Serving Cell.

[0105] In an example of TTI duration per Transmission Mode (TM), a WTRU may be configured with multiple transmission modes (TM), e.g., one for each applicable TTI duration.

[0106] In an example of TTI duration per Serving Cell Identity (servCellID), a WTRU may be configured with multiple serving cell identities (e.g., servCellIDs), e.g., one for each applicable TTI duration.

[0107] In an example of TTI duration per Serving Cell, a WTRU may be configured with multiple serving cells for a given carrier frequency, e.g. one for each applicable TTI duration.

[0108] Combinations may be made using different types of serving cells. For example, a WTRU may be configured according to any of the following examples or other examples.

[0109] In a first case or example, a WTRU may be configured with one PCell and one SCell (or PSCell). A WTRU may perform a transmission associated with a PCell using a first ShTTI and a transmission associated with the SCell/PSCell using a second ShTTI. A WTRU may transmit Uplink Control Information (UCI) for a transmission associated with a specific cell using the uplink resources associated with the concerned cell (e.g., according to a first (e.g. legacy) behavior or processing time associated with the ShTTI), for example, when an SCell is configured with PUCCH resources or when the WTRU is configured with PSCell. A WTRU may perform the transmission of UCI using resources of the PCell (e.g., according to a first (e.g., legacy) behavior), for example, otherwise. In either case or other cases, a WTRU may transmit UCI using the TTI applicable to the uplink configuration of the concerned cell or according to the ShTTI applicable the received transmission.

[0110] In a second case or example, a WTRU may be configured with one PCell and two SCells. A WTRU may perform a transmissions associated with a PCell using a first TTI (e.g., a legacy 1ms TTI) and a transmission associated with an SCell using a second TTI (e.g., an ShTTI). A WTRU may transmit UCI for a transmission associated with a specific cell using the uplink resources associated with the concerned cell (e.g., according to a first (e.g., legacy) behavior or processing time associated with the ShTTI), for example, when an SCell is configured with PUCCH resources. A WTRU may perform the transmission of UCI using resources of the PCell (e.g., according to a first (e.g., legacy) behavior), for example, otherwise. In either case or other cases, a WTRU may transmit UCI using the TTI applicable to the uplink configuration of the concerned cell or according to the ShTTI applicable to the received transmission.

[0111] In a third case or example, a WTRU may be configured with one PCell and multiple SCells. A configuration may be a generalization of either of the first and second examples,

whereby more than two TTI durations may be supported (e.g., within a first (e.g., legacy) subframe).

[0112] In an example involving a PSCell, a different Cell Radio Network Temporary Identifier (C-RNTI) than that applicable for a PCell may indicate the duration of the TTI. Examples presented and other examples may be used separately or in combination. Other realizations and/or combinations are possible.

[0113] Examples for handling of downlink control region for case 1 with slot-based operation are described.

[0114] A WTRU may be configured with a (e.g., DL) control region of zero symbols for a serving cell used for the purpose of ShTTI, e.g., for the serving cell that corresponds to a second slot in case of slot-based operation. A WTRU may determine that a serving cell is configured for the purpose of ShTTI, for example, based on reception of signaling that indicates such value for the duration of the control region. A WTRU may determine that a serving cell is configured as an ShTTI for the second slot, for example, based on reception of signaling that indicates such value for the duration of the control region. A WTRU may determine that a PCell configuration is used for ShTTI for the first slot.

[0115] Different procedures or algorithms may be used to determine applicable TTI duration, e.g., independent of modeling. For example, a WTRU may determine the TTI duration (e.g. legacy duration such as 1ms or shorter (e.g., ShTTI)) applicable to a transmission as a function of one or more of the following: (a) a WTRU may determine TTI duration using cross-carrier scheduling; (b) a WTRU may associate a TTI duration with a serving cell identity; (c) a TTI duration may be indicated by a Carrier Indicator Field (CIF); (d) a TTI duration may be indicated by C-RNTI applicable to control signaling associated with the allocation of resources; (e) a TTI duration may be determined from the identity of a PRB subset applicable to the transmissions and/or to the time-shifted cell within the entire subset of PRBs for the carrier frequency; (f) a MAC Activation/Deactivation may be used to determine the applicable TTI duration and/or the identity of the slot/period applicable to a transmission within a subframe. A MAC Activation/Deactivation may be used, for example, to toggle between multiple TTIs (e.g. a legacy TTI and one or more ShTTIs), toggle between slot-based ShTTIs and/or to determine zero, one or more ShTTIs period(s) within a subframe.

[0116] HARQ processing may be used (e.g., according to a first (e.g., legacy) behavior) for time-shifted cell(s), although, in an example, timing-relationships may be scaled according to an applicable TTI duration. HARQ A/N feedback formats may reuse LTE CA formats, first (e.g., legacy) subframe-based timing relationships and/or timing relationship associated with the HARQ

process. DCI signaling may reuse a first (e.g., legacy) format, although, in an example, interpretation of fields such as the CIF and/or PRBs applicable for the transmission may be different. MAC activation/deactivation signaling may be applicable for time-shifted cells. DRX Timers associated with DRX may scale to HARQ A/N timing according to an applicable TTI duration and/or to the cell associated with the HARQ process. Physical Random Access Channel (PRACH) resources and/or PDCCH order for RACH may or may not be supported for time-shifted SCells. Timing advance for uplink transmission may be time shifted according to the shift applied to the TTI associated with a cell, for example, when such time shift is relative to the PCell timing (e.g., the PCell remains the DL timing reference for such SCell with the additional offset corresponding to the start of the ShTTI for those cells).

[0117] Any procedure or algorithm that may operate with or indicate a TTI duration may be applicable as a procedure or algorithm to operate with or to indicate a subcarrier spacing.

[0118] Support may be provided for transmissions with different TTI duration. A WTRU may be configured for operation with the LTE physical layer. A WTRU may be configured, for example, for operation according to a first (e.g., legacy) LTE behavior or for operation together with a 5gFLEX configuration, e.g., a configuration that supports a physical layer operating with other variants of potentially filtered OFDM transmissions, such as Universal Filtered OFDM (UF-OFDM), Filtered Based OFDM (FB-OFDM), etc.

[0119] In an example of LTE FDD, a radio frame may consist of 10 subframes of 1ms each with a TTI of 1ms. Each TTI may consist of two 0.5ms slots of 7 symbols for a configuration with a normal cyclic prefix. In the downlink, there may be 8 asynchronous HARQ processes numbered 0-7 that may be addressed by means of downlink DCI. In the uplink, there may be 8 synchronous HARQ processes per RTT, which identity may be tied to the subframe timing. A WTRU may be configured for 1 to 3 symbols at the beginning of the first slot used for control signaling (PDCCH). Control signaling may span the entire bandwidth for a given cell. A TTI duration may be fixed, e.g., at 1ms, as an aspect of the LTE physical layer.

[0120] Different cells of a WTRU's configuration may be (e.g. explicitly) associated with a TTI duration/offset shift. Support for different TTI durations may be realized, for example, by maintaining a unique association between a cell and a TTI duration in a WTRU's configuration. Timing associated with the cell (e.g. a cell of the LTE CA SCell type) may be shifted and/or offset in time with respect to the timing of a reference cell. A reference cell may be the PCell of the WTRU's configuration. The PCell may be considered to have a zero time shift, e.g., by default. In an example of dual connectivity, a PSCell may be considered to have a zero time shift (e.g., by

default), for example, when a secondary group of cells is configured and when the PSCell is used as the timing reference.

[0121] In an example, a time-shifted/TTI duration/offset shift may be associated with an identity. For example, a time-shifted cell may be configured with a serving cell identity, with an offset in time relative to the start of a cell-specific subframe (e.g. where timing may be based on the PCell used as a downlink timing reference) and with a TTI duration (e.g. shorter than a first (e.g. legacy) timing that may be referred to as a shorter TTI or ShTTI).

[0122] TTI duration may be a configuration aspect of a WTRU, such as part of a configured transmission mode associated with the physical layer configuration for the cell.

[0123] Cells using a timing relationship may be configured as part of the same timing advance group (TAG). Cells (e.g., SCells) in a secondary TAG (STAG) supporting ShTTIs may use one of the cells in the same TAG as a timing reference (e.g., a cell used may be a configuration aspect of a WTRU) or may use the PCell as the timing reference (e.g., otherwise).

[0124] Support may be provided for multiplexing transmissions in a cell and/or for a specific WTRU. Support for transmissions using different TTI duration may be for concurrent transmissions in the same cell. For example, transmission may correspond to a single TTI duration for each WTRU at any given time while some WTRUs may have different TTI duration than other WTRUs. Support may be for transmissions for a given WTRU within the same subframe (e.g., within a first (e.g., legacy) subframe such as 1 ms) where different transmissions may be performed according to different TTI durations by the concerned WTRU.

[0125] Procedures may be applicable for uplink and/or downlink transmission and may be a configuration aspect for a WTRU.

[0126] An ShTTI-based transmission mode (TM) and cell timing configuration may be provided. For example, a WTRU may be configured with a PCell (e.g., according to first (e.g., legacy) behavior). For example, a WTRU may operate on a PCell carrier frequency using a first TM (e.g., a TM in the range of 1-10) associated with a first TTI duration (e.g., legacy 1ms). The WTRU may receive a RRC Connection Reconfiguration message that may reconfigure the WTRU according to at least one of the following: the WTRU may reconfigure the PCell and/or may configure at least one SCell.

[0127] In an example of reconfiguring a PCell, the WTRU may reconfigure the PCell such that a second TTI (e.g., ShTTI) of a duration shorter than previously used by the WTRU for the PCell is supported. For example, the WTRU may reconfigure (or add) a TM associated to the PCell. For example, a TM (e.g., TM = 11) may be associated with a TTI duration different than previously used by the WTRU for the PCell.

[0128] For example, a WTRU may configure a TTI duration according to one of the following. In an example, an ShTTI duration may be equal to 1 slot (0.5ms). This may be applicable, for example, to the first case. In another example, an ShTTI may be a duration expressed as an integer multiple of 1 symbol. A duration may include the control region, for example, when the configuration includes a start offset for the ShTTI and such offset is equal to zero. In another example, an ShTTI may be a duration expressed as an integer value in time, e.g. 100 μs or 125μs. Whether an ShTTI duration may include the control region may be determined as a function the value of a start offset for the ShTTI when applicable. A control region may be a separate aspect of a WTRU's configuration for a cell when an offset is equal to a non-zero value.

[0129] For example, a TM may support transmissions in (e.g., only in) the first slot of a first (e.g., legacy) subframe for the concerned ShTTI duration. A WTRU may determine an aspect as a function of the type of cell (e.g., PCell) associated with the TM. A TM may support WTRU-specific demodulation reference signals (e.g., DM-RS) such that their location and density may be better suited for ShTTI operation.

[0130] In an example of reconfiguring a PCell, transmissions on the PCell using a first (e.g., legacy) TTI such as 1ms may be enabled. This may be applicable, for example, in the second case, e.g., when a WTRU may be configured such that PCell operation supports transmissions using a first (e.g. legacy) 1ms TTI and one or more SCells support operation using ShTTI.

[0131] A WTRU may configure a PCell with an additional cell identity to the PCell in the PCell's configuration such that DCI may indicate, for example, "CIF=0" for a transmission on PCell using a first TTI (e.g., 1ms) and "CIF=1" for a transmission on PCell using a second TTI (e.g. a slot-based ShTTI of 0.5ms or similar). This may be applicable, for example, in the first case.

[0132] In an example of reconfiguring at least one SCell, the WTRU may configure an SCell such that an associated TTI duration (e.g., ShTTI) is less than that of a first (e.g., legacy) subframe duration (e.g., less than 1ms). For example, the WTRU may configure a TM associated with the SCell. For example, a TM (e.g., TM = 11) may be associated with a TTI duration similar to that of the PCell (e.g., ShTTI). For example, a ShTTI duration may be equal to 1 slot (0.5ms). This may be applicable, for example, in the first case. A TM (e.g., TM = 11+x) may be (e.g. alternatively) associated with a TTI duration different than that of the PCell, for example, when the TTI duration of such SCell may differ from that of the PCell.

[0133] Combinations of slot-based TTI (e.g., 0.5ms for a PCell) and non slot-based TTIs (e.g., 5 SCells of 100ms each) may be applicable for a given WTRU. Another example may be of a WTRU configured with symbol-based TTIs such that a different number of symbols may be used for each of the control regions (e.g,. 3 symbols), the TTI duration for the PCell (e.g., 5 symbols)

and for a number of SCells of x symbols in duration (e.g., 3 SCells each 2 symbols in TTI duration). Other combinations and/or other values are possible.

[0134] Example procedures may be applicable to any of the cases described above. Procedures may be applicable for uplink and/or downlink transmission and may be a configuration aspect for a WTRU.

[0135] TTI duration may be determined as a function of a Carrier Indicator Field (CIF) in a DCI on PDCCH. A TTI duration may be signaled as a function of the indicated cell identity in the DCI (e.g., by CIF or similar for a given carrier frequency of the WTRU's configuration). A determination or indication may be achieved, for example, by associating a second identity with a cell of the WTRU's configuration or by duplication of a serving cell configuration for a given carrier frequency. The WTRU may determine that the DCI of a given transmission (e.g., PDDCH transmission, serving cell transmission, received downlink control information, or scheduling information) has indicated that the WTRU should use a first transmission time interval on a physical uplink channel to communicate with the serving cell. For example, the determination may be based on the CIF field of the DCI, as the CIF may refer to a serving cell identity that has been configured to utilize the first transmission time interval. In this manner, downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment) may be re-used for scheduling of transmissions associated with the first TTI length. Similarly, the WTRU may determine that the DCI of a given transmission (e.g., PDDCH transmission, serving cell transmission, received downlink control information, or scheduling information) has indicated that the WTRU should use a second transmission time interval on a physical uplink channel to communicate with a second serving cell. For example, the determination may be based on the CIF field of the DCI, as the CIF may refer to the second serving cell identity and the second serving cell may have been configured to utilize the second transmission time interval. One or more of the first or second transmission time intervals may correspond a shortened TTI that is less than the legacy transmission time interval. The first and second serving cells may configured to utilize the same frequency band and/or carrier frequency.

[0136] In an example using slot-based TTI duration, a WTRU may be configured with a PCell with CIF=0, an SCell with CIF=1 and an SCell with CIF=2 for a given carrier frequency. Both SCells may be configured with carrier aggregation cross-carrier scheduling such that scheduling information for the associated resources may be received on the PDCCH associated with the PCell. A WTRU may receive signaling that schedules a transmission on such PDCCH. A WTRU may determine that a TTI duration is according to first (e.g., legacy) operation (e.g., 1ms), for example, when the WTRU determines that the CIF applicable to the transmission is that

of the PCell. The WTRU may determine that the transmission is applicable to the first slot of the concerned subframe, for example, when the WTRU determines that the CIF=1. The WTRU may determine that the transmission is for the second slot of the concerned subframe, for example, when CIF=2.

[0137] Example procedures may be applicable to any of the cases described above. Procedures may be applicable for uplink and/or downlink transmission and may be a configuration aspect for a WTRU.

[0138] A start offset for ShTTI may be a function of CIF in the DCI on PDCCH. In an example, determination of the applicable location in time (e.g., slot in the subframe, applicable starting symbol and/or all applicable symbols or similar) may be enabled for a transmission, for example, when a TTI duration shorter than that of the subframe duration is configured for a given cell.

[0139] A start offset or applicable location in time may be based on signaling received by the WTRU. The WTRU may perform such determination as a function of the indicated cell identity in the DCI, e.g., by Carrier Indicator Field (CIF) or similar for a given carrier frequency of the WTRU's configuration. An indication or determination may be achieved, for example, by associating a specific offset in the subframe with an identity of a cell of the WTRU's configuration or by configuring multiple serving cells for a given carrier frequency each with a different identity and a different offset.

[0140] For example, an offset may indicate one of a first slot or a second slot of a cell-specific subframe or it may indicate an offset in terms of a starting symbol in a subframe or an offset in absolute time (e.g. 500ms). An offset may be applied from the start of a cell-specific subframe. An offset may implicitly indicate a TTI duration (or vice-versa).

[0141] Example procedures may be applicable to any of the cases described above. Procedures may be applicable for uplink and/or downlink transmission and may be a configuration aspect for a WTRU.

[0142] A TTI duration may be a function of PRB(s) for a transmission. In an example, a WTRU may be configured such that a number of PRBs (e.g. a subset of the total set of system-specific PRBs for the concerned carrier frequency) may be associated with a cell of the WTRU's configuration for which the WTRU is operating with shorter than 1ms TTI duration e.g. configured with ShTTI.

[0143] A WTRU may determine an applicable TTI duration as a function of the PRB(s) indicated by the scheduling information. A PRB may correspond to the starting PRB for the resource allocation for the transmission. A set of PRBs may correspond to a range of PRBs. A

WTRU may use the TTI duration associated with a set of PRB(s), for example, when such range includes (e.g., only includes) PRB(s) associated with the concerned set. A WTRU may (e.g., otherwise) use a different TTI duration (e.g., a first (e.g. legacy) TTI duration, such as 1ms, or a configured duration), for example, when such range includes PRBs associated with different sets of PRBs or when such range does not include PRBs associated with any such sets. Sets of PRBs may be a configuration aspect of a WTRU's configuration. For example, a serving cell may be associated with a set of one or more PRBs, for example, when a serving cell is configured for ShTTI operation for a carrier frequency. A WTRU may use the TTI duration associated with such a cell or associated with the concerned PRBs. Scheduling information may be received dynamically in a DCI on PDCCH. Scheduling information may be semi-statically configured. For example, an entire (e.g., system-specific) set of PRBs for a PCell configured with a first (e.g., legacy) operation may be 110 PRBs. A WTRU may (e.g., alternatively) be configured with one or more subsets of PRBs, where each set may be associated with a specific TTI duration.

[0144] A WTRU may (e.g., first) determine the cell configured with ShTTI applicable to the transmission and/or the duration of the TTI (e.g., determining as described herein) and may determine the set of applicable PRBs therefrom (e.g., determining using a configuration of sets of PRBs as discussed herein).

[0145] Example procedures (e.g., operation) may be applicable to any of the cases described above. Procedures may be applicable for uplink and/or downlink transmission and may be a configuration aspect for a WTRU. For example, a procedure may be associated with a transmission mode for downlink and/or uplink. For example, a procedure may be associated with a serving cell of the WTRU's configuration. For example, a WTRU may determine that a configuration is specific to a serving cell of a WTRU's configuration, e.g., a determination may be made that a TTI configuration applies to both DL and UL frequencies. For example, a WTRU may determine that a configuration is specific to a specific direction of a configuration for a given serving cell of the WTRU's configuration, e.g., a determination may be made that a TTI configuration is provided separately for the DL direction and for the UL direction.

[0146] A determination may be made about the start offset time for a transmission. Cell de-activation may control availability of ShTTI. In an example, a first (e.g., legacy) cell activation-deactivation mechanism (e.g., procedure or algorithm) may control the duration (e.g., first or second TTI such as a legacy TTI or an ShTTI duration) of a transmission, e.g., by activating and deactivating the transmission. A WTRU may associate an activation state with an ShTTI, a slot and/or a resource.

[0147] In an example, a WTRU configured using ShTTI cells may receive a first (e.g., legacy) MAC activation/deactivation control element. A WTRU may use the activation/deactivation element as a mechanism to determine the availability of the ShTTI. For example, a WTRU may use a first (e.g., 1ms) TTI duration, e.g., when the WTRU is configured with a single SCell with ShTTI and when the SCell is in a deactivated state when the WTRU determines that it needs to perform a transmission. A WTRU may (e.g., otherwise) use a second TTI duration (e.g., ShTTI) for a transmission, e.g., when the SCell is active. The WTRU may perform a transmission using the second TTI duration (e.g. ShTTI), for example, according to scheduling information independently of the scheduled slot. This example may be extended to apply to the case where a symbol-based TTI duration is used instead of a time duration such as transmission slots.

[0148] In an example where multiple SCells may be used to indicate slot-based transmissions, a WTRU may determine that a first TTI duration is applicable when all cells configured with ShTTI are in a deactivated state. A WTRU may determine (e.g., otherwise) the applicable slot based on the activation state associated with each SCell and associated with each slot. This example may be extended to apply to the case where a symbol-based TTI duration is used, e.g., instead of using time duration such as transmission slots.

[0149] A WTRU may transmit HARQ feedback and/or other Uplink Control Information (UCI) (e.g. CQI, PMI, RI or similar), for example, taking into consideration the configuration of the TTI duration.

[0150] A TTI duration applicable to the transmission of UCI may be a function of at least one of the following: scheduling information, configuration information, TTI applicable to a serving cell, a default configuration for UCI transmission, etc.

[0151] Scheduling information may indicate whether a WTRU has resources for a PUSCH transmission and (e.g., if so) the TTI duration associated with such transmission, which may be determined according to procedures described herein.

[0152] Configuration information may indicate whether a WTRU is configured for simultaneous PUSCH and PUCCH transmission.

[0153] A TTI may be applicable to a serving cell associated with a UCI transmission in the subframe for the concerned UCI transmission.

[0154] A TTI may be applicable (e.g., in duration and/or offset) to a serving cell associated with a UCI transmission in the subframe for a downlink transmission pertaining to the feedback (e.g., in case of HARQ A/N feedback).

[0155] A default configuration for the transmission of UCI may be, for example, for the transmission of UCI on PUCCH (e.g., always a first TTI such as 1 ms TTI on PCell).

[0156] Further examples are provided below.

[0157] An applicable resource may be a PUSCH or PUCCH resource. A WTRU may determine a physical channel to perform the transmission of UCI using any technique, procedure or algorithm. For example, a WTRU may determine that UCI may be included in a PUSCH transmission when the transmission is scheduled, when simultaneous PUSCH and PUCCH transmissions are not configured or on a PUCCH transmission (e.g., otherwise).

[0158] An applicable resource may be a PUSCH resource. A WTRU may perform the transmission of UCI on a PUSCH transmission according to a TTI duration associated with a PUSCH transmission, which may be determined using procedures described herein.

[0159] An applicable resource may be a PUCCH resource. A WTRU may determine that a PUCCH resource may be used for transmission of UCI according to any technique, procedure or algorithm applicable to LTE CA. For example, selection of a resource may be based on the first CCE of the DCI that scheduled a downlink transmission or based on a configuration (e.g. PUCCH format 3 or similar). Bundling and/or multiplexing may be applied, for example, when configured.

[0160] An applicable TTI may be function of the type of transmissions on the carrier frequency PUSCH or PUCCH. Transmission of UCI may use the principles of LTE CA whereby UCI corresponding to transmission on different cells, e.g., including time-shifted cells, maybe multiplexed on a single transmission using a format that supports the required number of information bits (e.g., PUCCH format 3).

[0161] A PUCCH transmission may be performed on a PCell with a first (e.g., 1 ms TTI), where the first TTI may be a fixed TTI. A WTRU may perform PUCCH transmission on resources of an applicable serving cell (e.g., a PCell) according to a TTI duration associated with a concerned (e.g., pertinent) PCell, which may be determined using procedures described herein. In an example, a WTRU may transmit HARQ feedback using a single PUCCH transmission, which may use resources associated with a PCell (e.g. using a 1ms TTI duration), for example, when a WTRU has HARQ A/N feedback to transmit for two slot-based time-shifted cells using PUCCH on the PCell according to a configuration for a given carrier frequency where the PCell uses a first (e.g., 1ms) TTI.

[0162] A PUCCH transmission may be performed on a PCell with alignment in time with TTI being reported. A WTRU may perform PUCCH transmission on resources of an applicable serving cell (e.g. a PCell) according to a TTI duration associated with transmission(s) for which feedback is transmitted. A WTRU may have, for example, HARQ A/N feedback to transmit for

two slot-based time-shifted cells using PUCCH on the PCell according to a configuration for a given carrier frequency. In an example, a WTRU may transmit in the first slot a HARQ feedback for a transmission associated with the first slot and may transmit the HARQ feedback for the other transmission in the second slot for the concerned subframe.

[0163] A PUCCH transmission may be performed on a PCell with TTI/ShTTI of the PCell. A WTRU may perform a PUCCH transmission on resources of an applicable serving cell (e.g. a PCell) according to a TTI duration associated with the PCell, which may be determined using procedures described herein. A PCell may be (e.g., otherwise) configured with a default TTI, such as a first (e.g., 1 ms) TTI or an ShTTI. A WTRU may have HARQ A/N feedback to transmit for two slot-based time-shifted cells using PUCCH on the PCell, e.g., according to a configuration for a given carrier frequency where the PCell uses ShTTI in the concerned subframe (e.g., based on a configuration aspect and/or an activation state such as ShTTI activated for a time-shifted SCell for the concerned subframe), In an example, a WTRU may transmit HARQ feedback using a single PUCCH transmission, which may use resources associated with the PCell using a ShTTI duration with an offset applicable to the PCell.

[0164] A WTRU may transmit HARQ A/N feedback, for example, based on an applicable WTRU processing time for a concerned (e.g., pertinent) HARQ process in a given subframe.

[0165] Processing time associated with a HARQ process may be specific to a TTI associated with a transmissions for a concerned process. Processing time may be specific to a serving cell, a transmission mode or may be indicated by DCI (e.g., from servCellID or CIF) associated with such transmissions for a concerned HARQ process. In an example, HARQ processing time may be the same for all HARQ processes associated with a serving cell configured with a specific TTI (e.g., an ShTTI). Processing time may be a fixed value (e.g., 1ms), a multiple of an ShTTI, etc. Processing time may be determined for a transmission using ShTTI in subframe, the first available occasion in subframe n+2, where an occasion may correspond to a PUCCH or a PUSCH transmission with duration according to a first TTI or second TTI (e.g., ShTTI).

[0166] Systems, methods, and instrumentalities have been disclosed for multiplexing transmissions with different TTI duration. Latency may be reduced (e.g., in an LTE system), for example, by multiplexing transmissions with different TTI durations. TTI duration may be modeled using one or more time-shifted cell(s) for a given carrier frequency. A "logical" cell structure may correspond to an SCell. A PCell may logically maintain a TTI (e.g,. a first TTI) or may be configured with a second duration TTI (e.g., a shorter duration TTI (ShTTI)).

[0167] In an example, a WTRU may determine a TTI duration (e.g., first or second TTI) applicable to a transmission. For example, a WTRU may determine a TTI duration using cross-

carrier scheduling. A WTRU may associate a TTI duration with a cell identity (e.g. servCellID). A WTRU may associate a TTI duration with a transmission mode (TM). A TTI duration may be indicated by Carrier Indicator Field (CIF). A TTI duration may be determined from an identity of a PRB subset applicable to transmissions and/or to a time-shifted cell within a subset of PRBs for a concerned carrier frequency. An applicable TTI duration and/or the identity of a slot/period applicable to a transmission within a subframe may be determined using MAC Activation/Deactivation. MAC Activation/Deactivation may be used to toggle between first and second TTIs (e.g. legacy TTI and ShTTIs) or between slot-based ShTTIs and/or may be used to determine zero, one or more TTI (e.g. ShTTI) period(s) within a subframe.

[0168] HARQ processing may be performed according to a first behavior (e.g. legacy behavior) for one or more (e.g. each) time-shifted cell(s), although there may be exceptions. An exception may be timing-relationships, which may be scaled according to an applicable TTI duration. HARQ A/N feedback formats may use LTE Carrier Aggregation (CA) formats and/or (e.g., legacy) subframe-based timing relationships or a timing relationship associated with the HARQ process. Downlink Control Information (DCI) signaling may use a first (e.g., legacy) format, although, for example, interpretation of fields such as the CIF and/or PRBs applicable for the transmission may be different than the first (e.g., legacy) format. MAC activation/deactivation signaling may be applicable for time-shifted cells. DRX Timers associated with DRX may scale to HARQ A/N timing according to an applicable TTI duration and/or to the cell associated with an HARQ process. PRACH resources and/or PDCCH order for RACH may or may not be supported for time-shifted SCells. Timing advance for uplink transmission may be time shifted, for example, according to a shift applied to the TTI associated with a cell. Time shift may be relative to PCell timing, e.g. a PCell may remain a DL timing reference for an SCell with the additional offset corresponding to the start of the ShTTI for those cells.

[0169] A different TTI may be used in LTE R14 and NR. Multiple serving cells may be configured on the same carrier for a single WTRU. There may be an association between a serving cell and a TTI duration (or more generally – a numerology-related aspect). A WTRU can be configured with multiple such cells on a given carrier to support (*e.g.*, dynamically) a change in transmission duration. A field in downlink control signaling (DCI), *e.g.*, on a downlink control channel (*e.g.*, PDCCH), such as the CIF field in a DCI, may be used to dynamically schedule specific TTI durations for same or later subframes, for UL or DL transmissions.

[0170] The WTRU may be configured with a plurality of transmission methods, where at least two of the configured transmission methods differ in at least the applicable TTI duration.

[0171] A transmission may be associated with a transmission timing (start offset) relative to a timing reference.

[0172] A WTRU transmission mode may be indicated in downlink control information (DCI) signaling.

[0173] WTRU transmissions may be configured for each of a plurality of PRBs in the WTRU's configuration. Each of a plurality of PRBs may correspond to a serving cell of the WTRU's configuration. Each of a plurality of PRBs may correspond to a given carrier.

[0174] An applicable transmission duration/timing may be determined from a serving cell ID indicated in DCI signaling.

[0175] The WTRU may determine the set of resources, transmission duration, and/or uplink control information for a transmission based on a previous combination of received downlink signaling and received transmission duration.

[0176] A WTRU may determine whether a control region (*e.g.*, single control region) (*e.g.*, single level PDCCH) or multiple control regions (*e.g.*, multi-level PDCCH) are applicable and whether they are a function of the PDCCH configuration applicable to the concerned cell(s). A WTRU can determine the location of CCEs with respect to the timing reference (*e.g.*, in support of either self-scheduling or cross-TTI scheduling).

[0177] A WTRU may support mini-slots (*e.g.*, 125usec), slots (*e.g.*, 0.5ms), subframe (*e.g.*, 1ms) and multi-slots (*e.g.*, Multiples of other durations), and transmission durations and use different (*e.g.*, shortened) TTI's based on these time allocations. This may provide a low latency mode, a throughput mode and/or a coverage mode.

[0178] FIG. 4 depicts a scheduling example with time shifted-cells. As shown, there is a frequency axis and a time axis. In Fig. 4, the time is measured in milliseconds and divided into subframes. Other time units can be used such as slots, minislots, symbols, and PRB lengths. The frequency axis shows downlink (DL) and uplink (UL) transmissions. The time axis shows subframes. N, n+1, N=3, etc.... As shown for the DL frequency, for one or more subframes, the WTRU may receive DCI. For subframe n, the DCI may indicate two allocations, for example two ShTTI allocations (*e.g.*, $ShTTI_{DL(n,0)}$ and $ShTTI_{DL(n,1)}$). As an example, setting the CIF equal to 1 may indicate that the allocation is for $ShTTI_{DL(n,0)}$ and setting the CIF equal to 2 may indicate the allocation is for $ShTTI_{DL(n,1)}$. Other values of the CIF may be used to indicate no ShTTI transmissions and/or different transmission durations. For example, the DCI in Subframe

n+1 may indicate that for DL subframe n+1, the transmission has a duration corresponding to the entire subframe by using the value CIF=0 (*see e.g.*, a $TTI_{DL(N+1)}$).

[0179] A similar signaling mechanism can be used for indicating different durations of uplink transmissions. For example, DCI in DL subframe n may indicate that the WTRU has recieved two uplink grants. For example, a first grant for subframe n+1 may be indicate a CIF=1, which may be configured to correspond to $ShTTI_{(n+an\ offset,0)}$, while a CIF equal to 2 may indicate a grant for $ShTTI_{(n+an\ offset,0)}$. Similarly, a different value of the CIF (*e.g.*, CIF = 0) in this example may indicate that the transmissions duration spans an entire legacy TTI as illustrated in FIG. 4. Thus, by associating different CIF values with different transmission durations, the DCI may be used to indicate different transmission durations by referencing the different CIF values. Although the CIF field is used for purposes of illustration, other DCI fields may be used and may have values mapped to/associated with transmissions of different duration.

[0180] FIG. 4 also shows for an example of the PUCCH on the uplink frequency. For the PCell or SCell there may be a HARQ A/N for CIF = 1 at (n, 0) and a HARQ A/N for CIF = 2 at n, 1. For the PCell, (*e.g.*, PCell only), there may be a HARQ A/N for CIF = 0 at (n, 0) or CIF = 0 at n-3. Also, for the PCell, (*e.g.*, PCell only), there may be a HARQ A/N for CIF = 1 at (n, 0) or CIF = 0 at n-3 for the $ShTTI_{(n+?,\ 0)}$ and HARQ A/N for CIF = 2 at (n, 1) or CIF = 0 at n-3 for the $ShTTI_{(n+?,\ 1)}$.

[0181] FIG. 4 shows an example with time shifted cells with an offset of symbols. In this example, the symbol offset is based on CIF. FIG. 4 shows a single HARQ addressing space per TTI duration and start offset in a given subframe. MAC activation/deactivation may be applied by a HARQ process space or CIF value. FIG. 4 also shows a UCI example with time-shifted cells. The first CCE of the DCI on the example channel, PDCCH, may be used for legacy PUCCH resource allocation at TTI or ShTTI. Configured LTE CA PUCCH, PUCCH on an SCell, and/or ARI may be used for UCI using different TTIs. As shown, the WTRU interprets the DCI TTI indication differently in the FIG. 4 example for SCells and PCells to use ShTTI for the SCells. FIG. 4 also shows an example of the frequency being the same for the PCell and SCell. The FIG. 4 example dynamically varies the scheduled TTI for a WTRU and uses the appropriate HARQ signaling. Also, resource allocation for associated control information is resolved and there is flexibility to adapt different time offsets in a subframe and with different ShTTIs.

[0182] Although features and elements are described above in particular combinations, one of ordinary skill in the art will appreciate that each feature or element may be used alone or in any combination with the other features and elements. In addition, the methods described herein

may be implemented in a computer program, software, or firmware incorporated in a computer-readable medium for execution by a computer or processor. Examples of computer-readable media include electronic signals (transmitted over wired or wireless connections) and computer-readable storage media. Examples of computer-readable storage media include, but are not limited to, a read only memory (ROM), a random access memory (RAM), a register, cache memory, semiconductor memory devices, magnetic media such as internal hard disks and removable disks, magneto-optical media, optical media such as CD-ROM disks, and digital versatile disks (DVDs). A processor in association with software may be used to implement a radio frequency transceiver for use in a WTRU, WTRU, terminal, base station, RNC, or any host computer.

CLAIMS

What Is Claimed:

1. A method implemented by a wireless transmit/receive unit (WTRU) for supporting transmissions of different durations, the method comprising:

receiving a first configuration associated with a first set of transmission resources, the first configuration indicating a first transmission time interval (TTI) length for use with the first set of transmission resources;

receiving a second configuration associated with a second set of transmission resources, the second configuration indicating a second transmission time interval (TTI) length for use with the second set of transmission resources;

receiving downlink control information (DCI), wherein the DCI comprises a field that indicates whether the DCI is applicable to first set of transmission resources or the second set of transmission resources; and

determining that a transmission associated with the DCI utilizes the first TTI length on condition that the field indicates that the DCI is applicable to the first set of transmission resources or that the transmission associated with the DCI utilizes the second TTI length on condition that the field indicates that the DCI is applicable to the second set of transmission resources.

2. The method of claim 1, wherein the first set of transmission resources correspond to a first serving cell and the second set of transmission resources correspond to a second serving cell.

3. The method of claim 2, wherein the field corresponds to a carrier indicator field.

4. The method of claim 2, wherein the first serving cell and the second serving cell are associated with the same carrier frequency.

5. The method of claim 2, wherein each of the first and second serving cells are configured as secondary cells (SCells).

6. The method of claim 2, wherein the first serving cell corresponds to a primary cell (PCell), the second serving cells is configured as a secondary cells (SCell), the first TTI length corresponds to 1 millisecond (ms), and the second TTI length corresponds to less than 1 ms.

7. The method of claim 1, wherein the DCI further comprises a physical resource block (PRB) assignment field, and the PRB assignment field is interpreted differently depending on whether the transmission is associated with the first TTI length or the second TTI length.

8. The method as in claim 1, wherein at least the second configuration is received via a radio resource control (RRC) message, and the DCI is received via a physical downlink control channel.

9. The method as in claim 1, wherein a hybrid automatic repeat request timing used for the transmission is dependent on whether the transmission is associated with the first TTI length or the second TTI length.

10. A method implemented by a wireless transmit/receive unit (WTRU) for supporting transmissions of different durations, the method comprising:

receiving downlink control information from a first serving cell in the wireless communications network;

determining that the received downlink control information indicates that the WTRU should use a first transmission time interval to transmit data information to the first serving cell;

determining whether the received downlink control information indicates that the WTRU should use a second transmission time interval that is different than the first transmission time interval to communicate with the wireless communication network on the physical uplink channel or whether the WTRU should transmit using carrier aggregation; and

communicating with the wireless communications network using the second transmission time interval.

11. The method of claim 10, wherein determining that the received downlink control information indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network on the physical uplink channel comprises determining based on a carrier indicator field in the received downlink control information.

12. The method of claim 10, wherein communicating with the wireless communications network using the second transmission time interval comprises communicating with the first serving cell using the second transmission time interval.

13. The method of claim 10, wherein communicating with the wireless communications network using the second transmission time interval comprises communicating with a secondary cell using the second transmission time interval.

14. The method of claim 10, further comprising determining that the WTRU should use a third transmission time interval that is less than the first transmission time interval to communicate with a secondary cell in the wireless communications network.

15. The method of claim 10, wherein the shorten transmission time interval corresponds to at least one of at least one symbol or at least one resource block.

16. The method of claim 10, wherein the first transmission time interval is one millisecond.

17. The method of claim 10, wherein the first transmission time interval is greater than the first transmission time interval.

18. The method of claim 10, wherein the first transmission time interval corresponds to a first sub-carrier spacing and the second transmission time interval corresponds to a second subcarrier spacing.

19. The method of claim 10, wherein the first transmission time interval corresponds to a first number of transmission symbols and the second transmission time interval corresponds to a second number of transmission symbols.

20. The method of claim 10, further comprising the WTRU communicating with the first serving cell and a second serving cell using the same carrier frequency.

21. The method of claim 10, further comprising determining a time to transmit with the second transmission time interval based on the received downlink control information.

22. The method of claim 21, wherein the time to transmit is defined by a slot in a subframe.

23. The method of claim 10, wherein determining whether the received downlink control information indicates that the WTRU should use a second transmission time interval that

is less than the first transmission time interval to communicate with the wireless communication network on the physical uplink channel or whether the WTRU should transmit using carrier aggregation comprises determining with cross-carrier scheduling.

24. A wireless transmit/receive unit (WTRU) for use within a wireless communications network that is capable of carrier aggregation, comprising:

a processor having executable instructions that:

determine that downlink control information from a first serving cell in the wireless communications network has been received;

determine that the received downlink control information indicates that the WTRU should use a first transmission time interval to transmit data information to the first serving cell;

determine whether the received downlink control information indicates that the WTRU should use a second transmission time interval that is different than the first transmission time interval to communicate with the wireless communication network on the physical uplink channel or whether the WTRU should transmit using carrier aggregation; and

communicate with the wireless communications network using the second transmission time interval.

25. The WTRU of claim 24, wherein the processor further comprises executable instructions that determine that the received downlink control information indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network on the physical uplink channel comprises determining based on a carrier indicator field in the received downlink control information.

26. The WTRU of claim 24, wherein the executable instructions that communicate with the wireless communications network using the second transmission time interval comprise communicating with the first serving cell using the second transmission time interval.

27. The WTRU of claim 24, wherein the executable instructions that communicate with the wireless communications network using the second transmission time interval comprise communicating with a secondary cell using the second transmission time interval.

28. The WTRU of claim 24, wherein the processor further comprises executable instructions that determine that the WTRU should use a third transmission time interval that is less than the first transmission time interval to communicate with a secondary cell in the wireless communications network.

29. The WTRU of claim 24, wherein the shorten transmission time interval corresponds to at least one of at least one symbol or at least one resource block.

30. The WTRU of claim 24, wherein the first transmission time interval is one millisecond.

31. The WTRU of claim 24, wherein the processor further comprises executable instructions that determine a time to transmit with the second transmission time interval based on the received downlink control information.

32. The WTRU of claim 31, wherein the time to transmit is defined by a slot in a subframe.

33. The WTRU of claim 24, wherein the executable instructions that determine whether the received downlink control information indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network on the physical uplink channel or whether the WTRU should transmit using carrier aggregation comprise determining with cross-carrier scheduling.

34. The WTRU of claim 24, wherein the first transmission time interval is greater than the first transmission time interval.

35. The method of claim 24, wherein the first transmission time interval corresponds to a first sub-carrier spacing and the second transmission time interval corresponds to a second subcarrier spacing.

36. The method of claim 24, wherein the first transmission time interval corresponds to a first number of transmission symbols and the second transmission time interval corresponds to a second number of transmission symbols.

37. The method of claim 24, further comprising the WTRU communicating with the first serving cell and a second serving cell using the same carrier frequency.

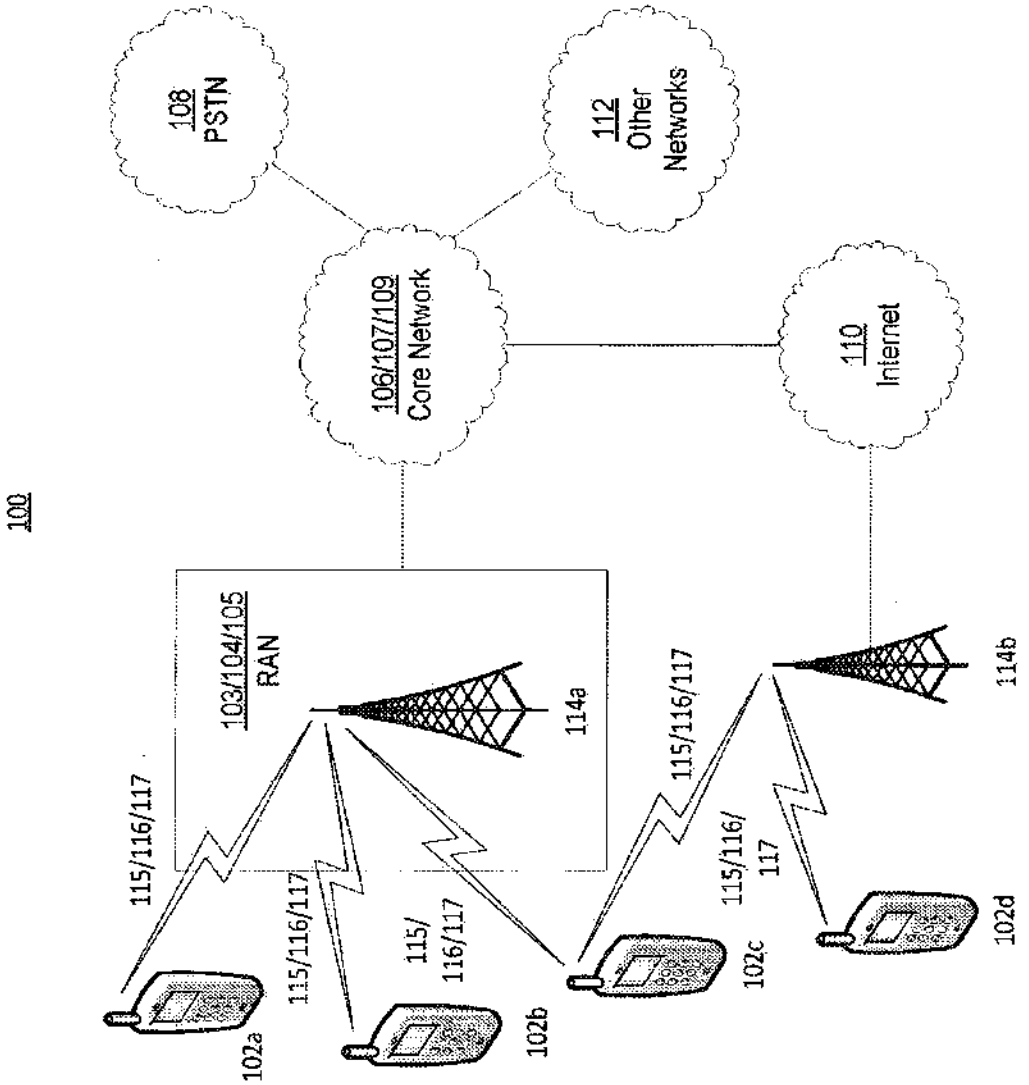

100
108 PSTN
112 Other Networks
106/107/109 Core Network
110 Internet
103/104/105 RAN
114a
114b
115/116/117
115/116/117
115/ 116/117
115/116/117
115/116/ 117
102a
102b
102c
102d

FIG. 1A

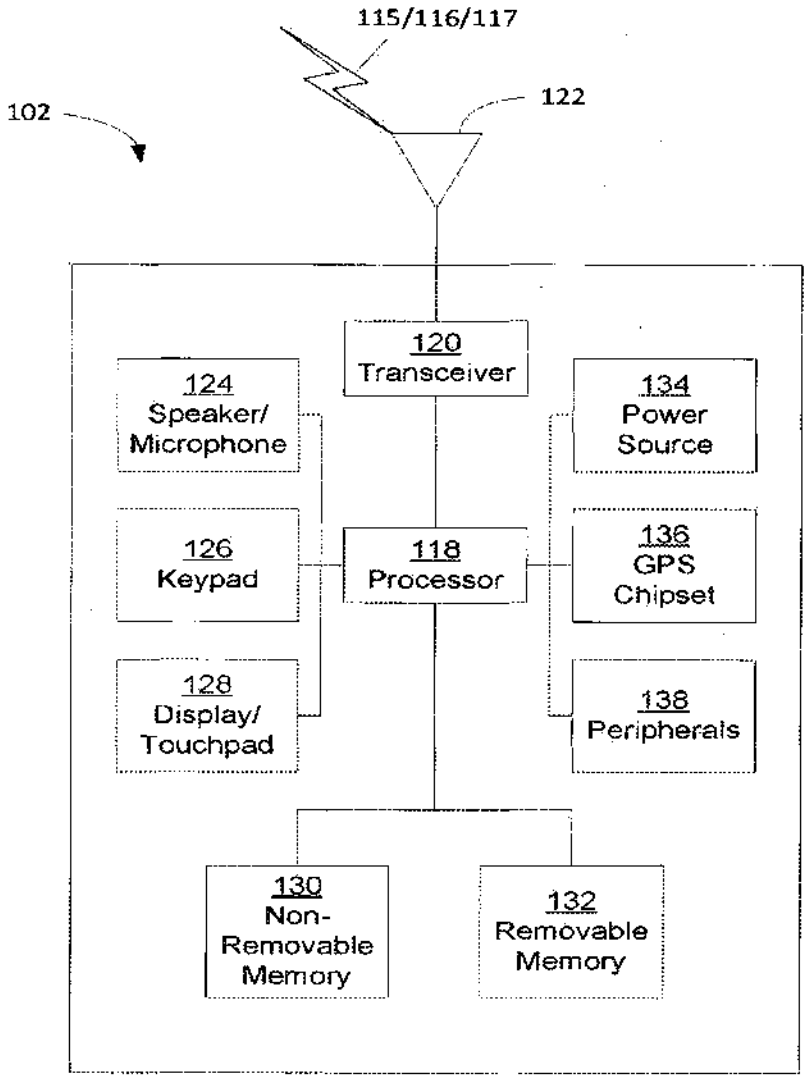

115/116/117
122
102
120
Transceiver
124
Speaker/
Microphone
134
Power
Source
126
Keypad
118
Processor
136
GPS
Chipset
128
Display/
Touchpad
138
Peripherals
130
Non-
Removable
Memory
132
Removable
Memory

FIG. 1B

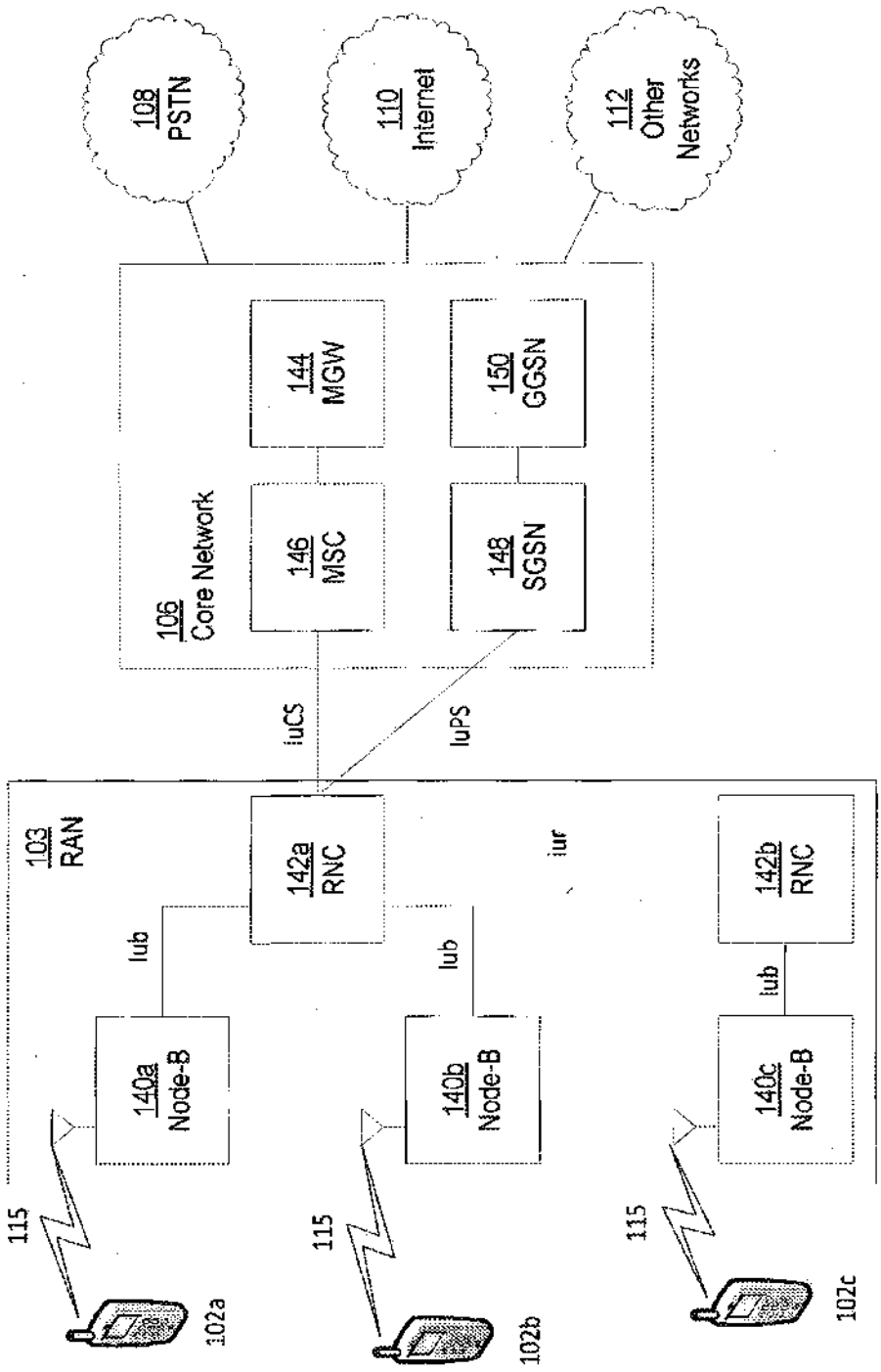

108 PSTN
110 Internet
112 Other Networks
106 Core Network
144 MGW
150 GGSN
146 MSC
148 SGSN
IuCS
IuPS
103 RAN
142a RNC
142b RNC
Iur
Iub
Iub
Iub
140a Node-B
140b Node-B
140c Node-B
115
115
115
102a
102b
102c

FIG. 1C

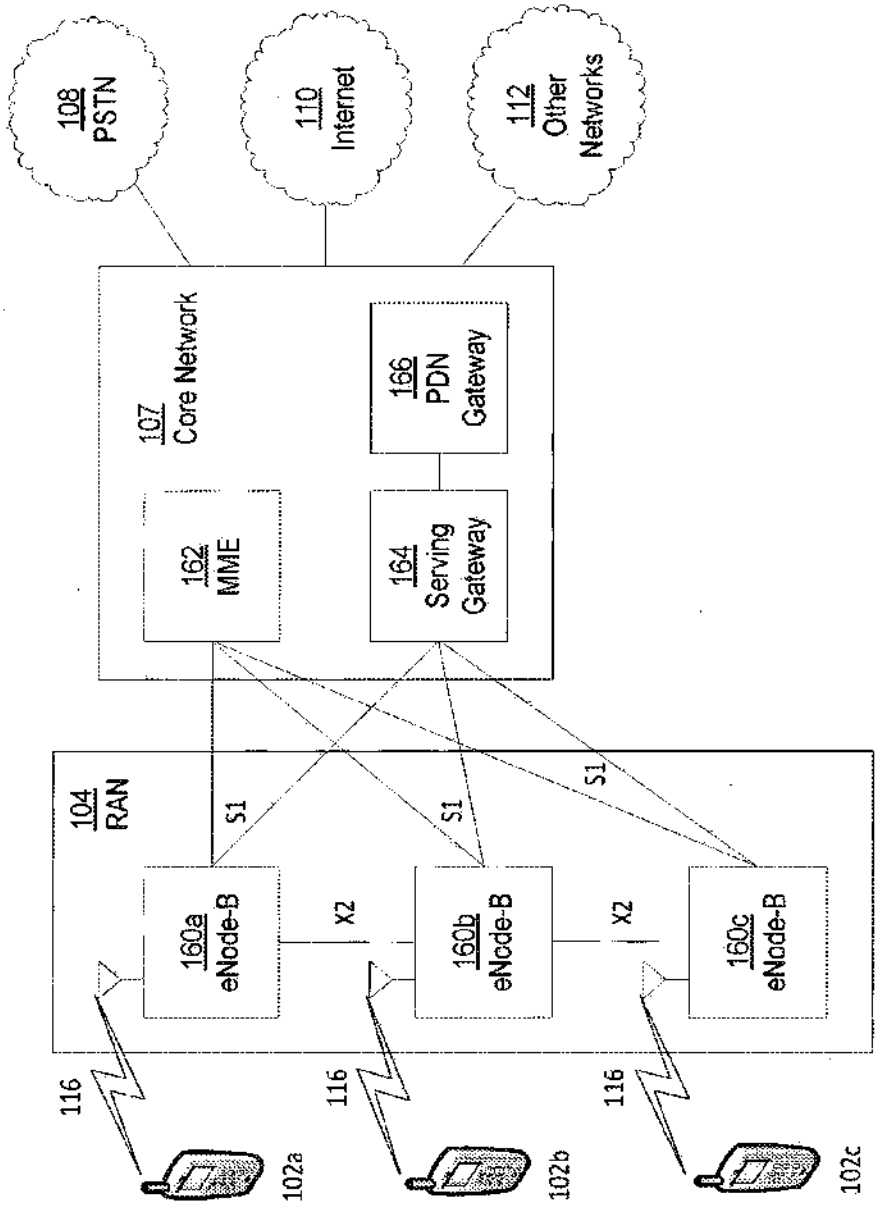

108 PSTN
110 Internet
112 Other Networks
107 Core Network
166 PDN Gateway
162 MME
164 Serving Gateway
104 RAN
S1
S1
S1
160a eNode-B
160b eNode-B
160c eNode-B
X2
X2
116
116
116
102a
102b
102c

FIG. 1D

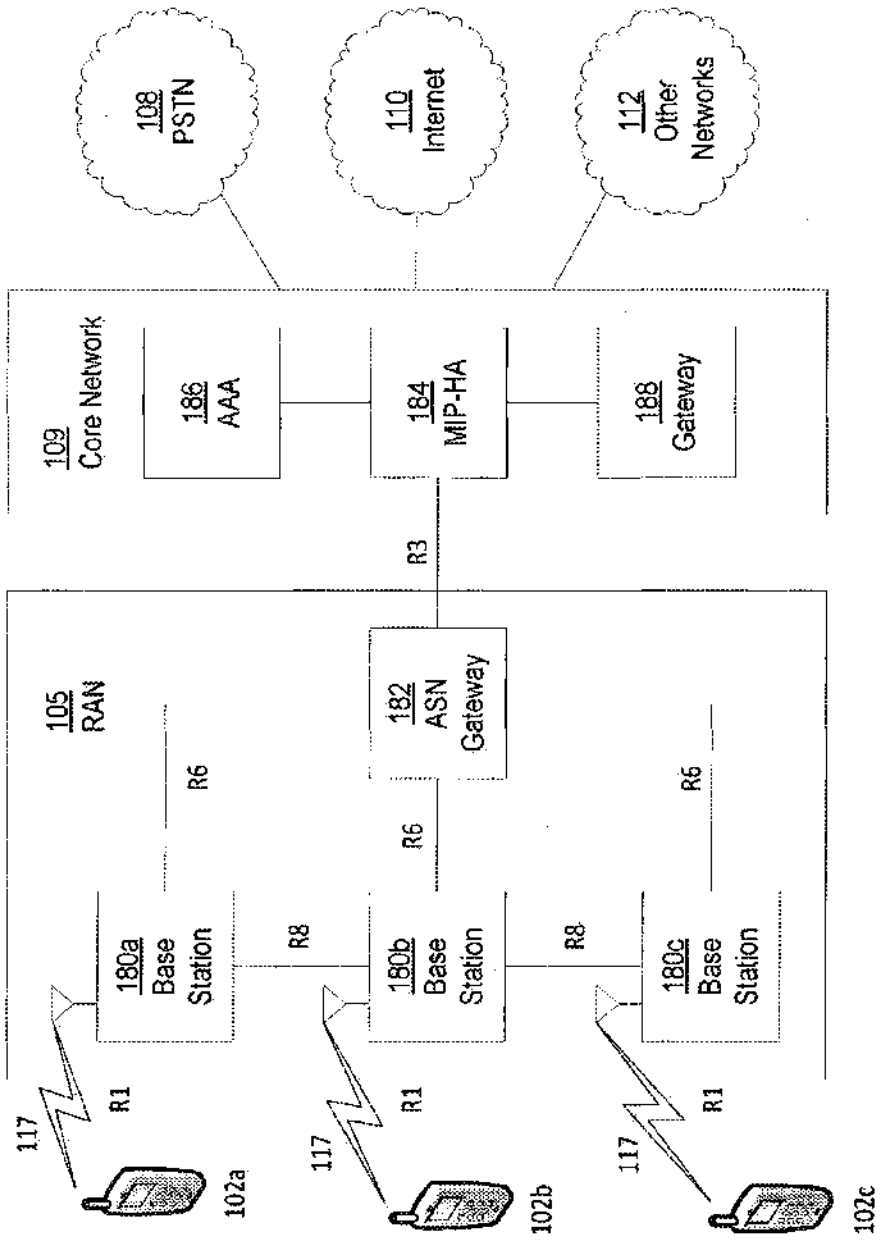

108 PSTN
110 Internet
112 Other Networks
109 Core Network
186 AAA
184 MIP-HA
188 Gateway
R3
105 RAN
182 ASN Gateway
R6
R6
R6
180a Base Station
180b Base Station
180c Base Station
R8
R8
R1
R1
R1
117
117
117
102a
102b
102c

FIG. 1E

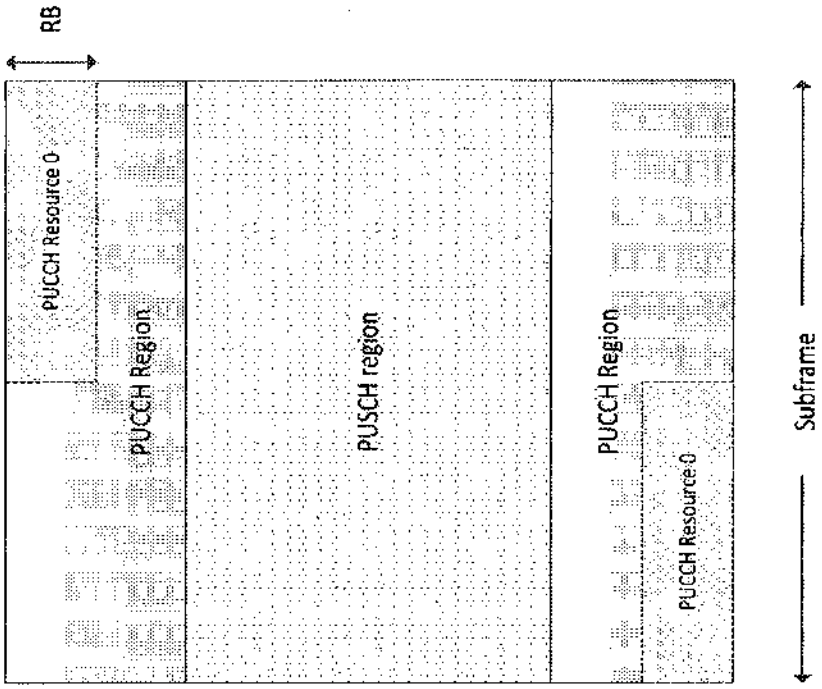

RB
PUCCH Resource 0
PUCCH Region
PUSCH region
PUCCH Region
PUCCH Resource 0
Subframe

FIG. 3

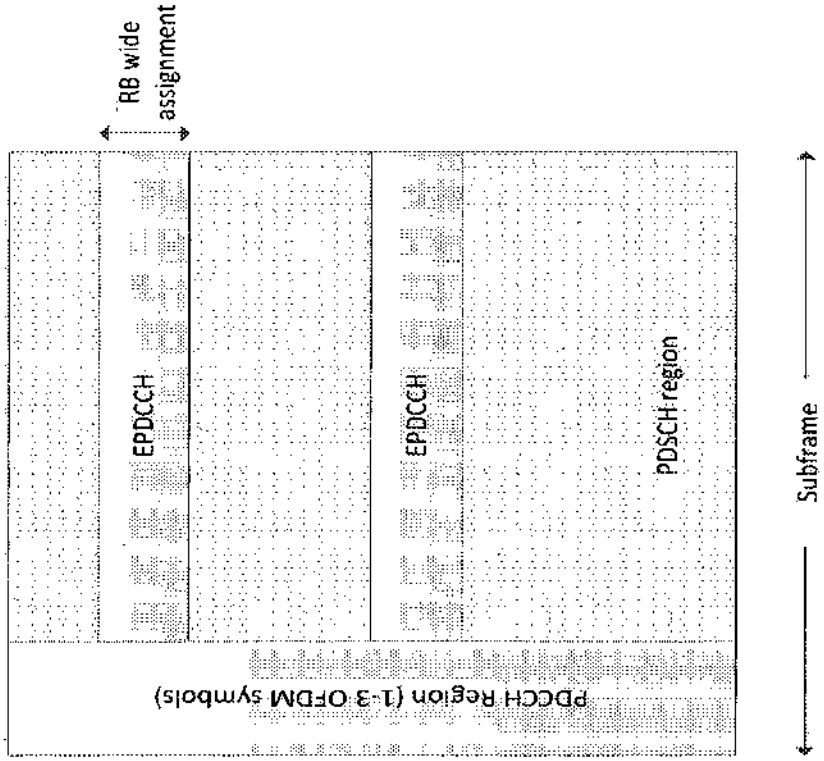

RB wide assignment
EPDCCH
EPDCCH
PDSCH region
PDCCH Region (1-3 OFDM symbols)
Subframe

FIG. 2

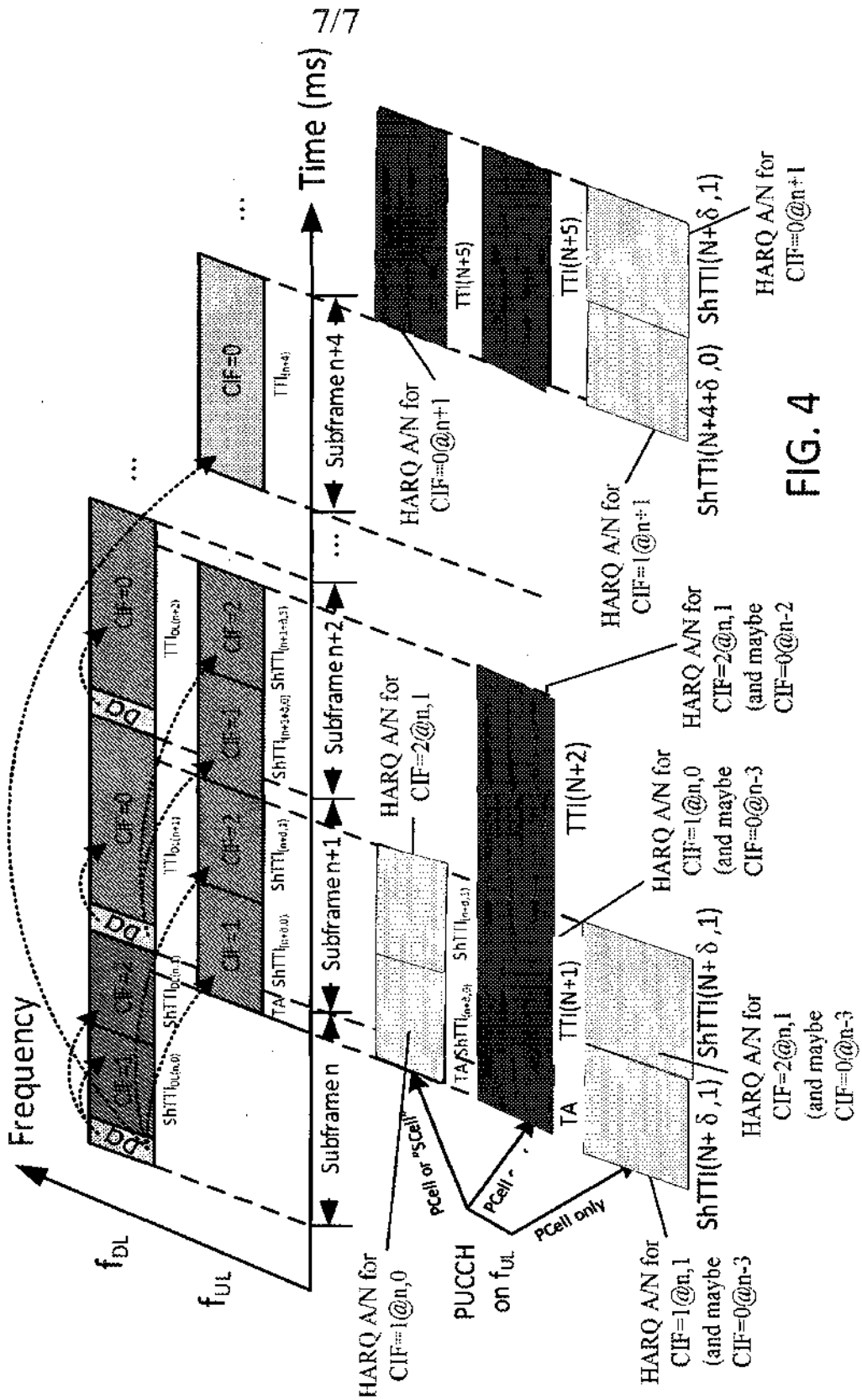

Frequency
Time (ms)
f_{DL}
f_{UL}
Subframe n
Subframe n+1
Subframe n+2
Subframe n+4
CIF=0
CIF=1
CIF=2
DTX
TA
TTI(N+1)
TTI(N+2)
TTI(N+5)
PUCCH on f_{UL}
PCell only
HARQ A/N for CIF=1@n,0
HARQ A/N for CIF=2@n,1
HARQ A/N for CIF=0@n+1
HARQ A/N for CIF=1@n,1 (and maybe CIF=0@n-3
HARQ A/N for CIF=1@n,0 (and maybe CIF=0@n-3
HARQ A/N for CIF=2@n,1 (and maybe CIF=0@n-2
HARQ A/N for CIF=1@n+1
HARQ A/N for CIF=0@n+1
ShTTI(N+δ,1)
ShTTI(N+4+δ,0)
ShTTI(N+δ,1)

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/060481

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W72/12
ADD. H04W28/06 H04L1/18

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2013/041138 A1 (NOKIA SIEMENS NETWORKS OY [FI]; HOLMA HARRI KALEVI [FI]; RAAF BERNHARD) 28 March 2013 (2013-03-28) pages 1,2 page 5, line 29 - page 9, line 35	1-37
X	US 2014/071954 A1 (AU KELVIN KAR KIN [CA] ET AL) 13 March 2014 (2014-03-13)	1,10,24
Y	paragraphs [0001] - [0005], [0022], [0023], [0025], [0027], [0028], [0030], [0032], [0033], [0034] - [0036]; figures 4-6,8,9 abstract	2-9, 11-23, 25-37
	-/--	

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 December 2016	11/01/2017

Name and mailing address of the ISA/	Authorized officer
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1

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/060481

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	EP 2 816 858 A1 (ALCATEL LUCENT [FR]) 24 December 2014 (2014-12-24) abstract; figure 3 paragraphs [0006] - [0010], [0017] - [0021], [0026], [0035], [0041], [0045], [0049], [0063] - [0072] -----	1,10,24 2-9, 11-23, 25-37
X Y	WO 2015/139795 A1 (ERICSSON TELEFON AB L M [SE]) 24 September 2015 (2015-09-24) abstract page 5, lines 1-29 page 16, lines 13-30 -----	1 2-37
Y A	US 2015/256316 A1 (SEO DONGYOUN [KR] ET AL) 10 September 2015 (2015-09-10) abstract paragraphs [0005], [0008], [0010], [0033], [0036], [0052], [0053], [0094], [0105] - [0120], [179.183], [0190], [0202], [0205] paragraphs [0238] - [0248] -----	2-37 1
A	EP 2 341 678 A1 (PANASONIC CORP [JP]) 6 July 2011 (2011-07-06) abstract paragraphs [0001], [0003], [0019], [0020], [0030] -----	1-37
A	ITL: "On data transmission with partial TTI for LAA", 3GPP DRAFT; R1-153274, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. Fukuoka, Japan; 20150525 - 20150529 24 May 2015 (2015-05-24), XP050974055, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_ SYNC/RAN1/Docs/ [retrieved on 2015-05-24] chapter 2.1 -----	1-37
X,P	WO 2016/064048 A1 (LG ELECTRONICS INC [KR]) 28 April 2016 (2016-04-28) paragraphs [0191], [0344] - [0346]; claims 1-6 -----	1-37
E	WO 2016/190970 A1 (QUALCOMM INC [US]) 1 December 2016 (2016-12-01) paragraphs [0006] - [0011]; claims 1-4; figures 4-8 ----- -/--	1-37

1

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/060481

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X,P	WO 2016/064049 A1 (LG ELECTRONICS INC [KR]) 28 April 2016 (2016-04-28) paragraphs [0009] - [0016]; figures 1-24	1-37

1

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2016/060481

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		US 2015351093 A1	03-12-2015
		WO 2014040531 A1	20-03-2014
EP 2816858 A1	24-12-2014	NONE	
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		WO 2015139795 A1	24-09-2015
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		WO 2011082814 A1	14-07-2011
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		WO 2016190970 A1	01-12-2016
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		WO 2016064049 A1	28-04-2016
		WO 2016064059 A1	28-04-2016

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(74) Agent: **CHINA SINDA INTELLECTUAL PROPERTY LTD.**; B11th Floor, Focus Place, 19 Financial Street, Xicheng District, Beijing 100033 (CN).

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(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK,

(54) Title: TRANSMITTING A BEAM RECOVERY REQUEST

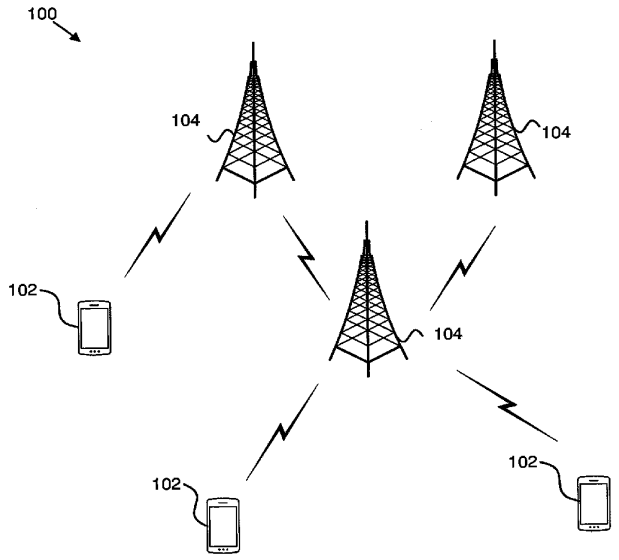


FIG. 1

(57) Abstract: Apparatuses, methods, and systems are disclosed for transmitting a beam recovery request. One apparatus (200) includes a receiver (212) that receives (402) information indicating a resource configured for a beam recovery request. The apparatus (200) includes a transmitter (210) that transmits (404) the beam recovery request on the resource in response to a first trigger condition.

[Continued on next page]

WO 2018/227464 A1

EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

TRANSMITTING A BEAM RECOVERY REQUEST

FIELD

[0001] The subject matter disclosed herein relates generally to wireless communications and more particularly relates to transmitting a beam recovery request.

BACKGROUND

[0002] The following abbreviations are herewith defined, at least some of which are referred to within the following description: Third Generation Partnership Project ("3GPP"), Positive-Acknowledgment ("ACK"), Binary Phase Shift Keying ("BPSK"), Clear Channel Assessment ("CCA"), Cyclic Prefix ("CP"), Cyclical Redundancy Check ("CRC"), Channel State Information ("CSI"), Common Search Space ("CSS"), Discrete Fourier Transform Spread ("DFTS"), Downlink Control Information ("DCI"), Downlink ("DL"), Downlink Pilot Time Slot ("DwPTS"), Enhanced Clear Channel Assessment ("eCCA"), Enhanced Mobile Broadband ("eMBB"), Evolved Node B ("eNB"), European Telecommunications Standards Institute ("ETSI"), Frame Based Equipment ("FBE"), Frequency Division Duplex ("FDD"), Frequency Division Multiple Access ("FDMA"), Guard Period ("GP"), Hybrid Automatic Repeat Request ("HARQ"), Internet-of-Things ("IoT"), Licensed Assisted Access ("LAA"), Load Based Equipment ("LBE"), Listen-Before-Talk ("LBT"), Long Term Evolution ("LTE"), Multiple Access ("MA"), Modulation Coding Scheme ("MCS"), Machine Type Communication ("MTC"), Multiple Input Multiple Output ("MIMO"), Multi User Shared Access ("MUSA"), Narrowband ("NB"), Negative-Acknowledgment ("NACK") or ("NAK"), Next Generation Node B ("gNB"), Non-Orthogonal Multiple Access ("NOMA"), Orthogonal Frequency Division Multiplexing ("OFDM"), Primary Cell ("PCell"), Physical Broadcast Channel ("PBCH"), Physical Downlink Control Channel ("PDCCH"), Physical Downlink Shared Channel ("PDSCH"), Pattern Division Multiple Access ("PDMA"), Physical Hybrid ARQ Indicator Channel ("PHICH"), Physical Random Access Channel ("PRACH"), Physical Resource Block ("PRB"), Physical Uplink Control Channel ("PUCCH"), Physical Uplink Shared Channel ("PUSCH"), Quality of Service ("QoS"), Quadrature Phase Shift Keying ("QPSK"), Radio Resource Control ("RRC"), Random Access Procedure ("RACH"), Random Access Response ("RAR"), Radio Network Temporary Identifier ("RNTI"), Reference Signal ("RS"), Resource Spread Multiple Access ("RSMA"), Round Trip Time ("RTT"), Receive ("RX"), Sparse Code Multiple Access ("SCMA"), Scheduling Request ("SR"), Single Carrier Frequency Division Multiple Access ("SC-FDMA"), Secondary Cell ("SCell"), Shared Channel ("SCH"), Signal-to-Interference-Plus-Noise Ratio ("SINR"), System Information Block ("SIB"), Transport Block ("TB"), Transport Block Size

("TBS"), Time-Division Duplex ("TDD"), Time Division Multiplex ("TDM"), Transmission Time Interval ("TTI"), Transmit ("TX"), Uplink Control Information ("UCI"), User Entity/Equipment (Mobile Terminal) ("UE"), Uplink ("UL"), Universal Mobile Telecommunications System ("UMTS"), Uplink Pilot Time Slot ("UpPTS"), Ultra-reliability and Low-latency Communications ("URLLC"), and Worldwide Interoperability for Microwave Access ("WiMAX"). As used herein, "HARQ-ACK" may represent collectively the Positive Acknowledge ("ACK") and the Negative Acknowledge ("NACK"). ACK means that a TB is correctly received while NACK (or NAK) means a TB is erroneously received.

[0003] In certain wireless communications networks, a beam quality may be degraded. In such configurations, a beam recovery may need to occur.

BRIEF SUMMARY

[0004] Apparatuses for transmitting a beam recovery request are disclosed. Methods and systems also perform the functions of the apparatus. In one embodiment, the apparatus includes a receiver that receives information indicating a resource configured for a beam recovery request. In some embodiments, the apparatus includes a transmitter that transmits the beam recovery request on the resource in response to a first trigger condition.

[0005] In one embodiment, the first trigger condition includes a medium access control layer receiving a number of out-of-sync indications from a physical layer. In a further embodiment, the number of out-of-sync indications is configured by radio resource control signaling. In certain embodiments, the resource configured for the beam recovery request is configured by radio resource control signaling. In various embodiments, the resource configured for the beam recovery request is enabled for use in response to the resource being configured by the radio resource control signaling. In some embodiments, the resource configured for the beam recovery request is enabled for use in response to the resource being activated by a medium access control control element.

[0006] In certain embodiments, the apparatus includes a processor that selects a first available resource to transmit the beam recovery request in response to a contention-free resource and a physical uplink control channel resource being available for transmission of the beam recovery request. In some embodiments, the apparatus includes a processor that selects a physical uplink control channel resource to transmit the beam recovery request in response to a contention-free resource and the physical uplink control channel resource being available for transmission of the beam recovery request and in response to the physical uplink control channel resource having a channel quality greater than a predetermined threshold. In various embodiments, the apparatus includes a processor that selects a physical random access channel

resource to transmit the beam recovery request in response to the physical uplink control channel resource having the channel quality less than the predetermined threshold.

[0007] In one embodiment, the apparatus includes a processor that monitors for a response to transmission of the beam recovery request for a predetermined time in response to transmitting the beam recovery request using a physical random access channel resource and skips a physical uplink control channel resource for the beam recovery request during the predetermined time. In certain embodiments, the apparatus includes a processor that skips a physical random access channel resource for the beam recovery request in response to transmitting the beam recovery request using a physical uplink control channel resource. In some embodiments, the apparatus includes a processor that selects a contention based resource to transmit the beam recovery request in response to a contention-free resource and a physical uplink control channel resource being unavailable for transmission of the beam recovery request. In various embodiments, the apparatus includes a processor that selects the resource to transmit the beam recovery request based on a measurement result and an association between a downlink transmission beam and a physical uplink control channel resource.

[0008] In some embodiments, the association between the downlink transmission beam and the physical uplink control channel resource is configured by radio resource control signaling. In certain embodiments, the measurement result is based on a channel state information reference signal in response to the channel state information reference signal being configured by a base unit. In various embodiments, the measurement result is based on a synchronization signal block in response to a channel state information reference signal not being configured by a base unit. In one embodiment, the apparatus includes a processor that performs a beam measurement to determine the measurement result in response to a second trigger condition. In some embodiments, the second trigger condition includes a quality of a serving beam being less than a predetermined threshold, a number of out-of-sync indications from a physical layer, or some combination thereof. In certain embodiments, the predetermined threshold and the number are configured by radio resource control signaling. In various embodiments, the apparatus includes a processor that starts a timer in response to the first trigger condition. In various embodiments, the processor enters radio link failure in response to the timer expiring. In one embodiment, the processor stops the timer in response to receiving a response to the transmission of the beam recovery request.

[0009] A method for transmitting a beam recovery request, in one embodiment, includes receiving information indicating a resource configured for a beam recovery request. In some

embodiments, the method includes transmitting the beam recovery request on the resource in response to a first trigger condition.

[0010] In one embodiment, an apparatus for receiving a beam recovery request includes a transmitter that transmits information indicating a resource configured for a beam recovery request. In some embodiments, the apparatus includes a receiver that receives the beam recovery request on the resource.

[0011] In certain embodiments, the resource configured for the beam recovery request is configured by radio resource control signaling. In various embodiments, the resource configured for the beam recovery request is enabled for use in response to the resource being configured by the radio resource control signaling. In some embodiments, the resource configured for the beam recovery request is enabled for use in response to the resource being activated by a medium access control control element.

[0012] In certain embodiments, a first available resource is selected to transmit the beam recovery request in response to a contention-free resource and a physical uplink control channel resource being available for transmission of the beam recovery request. In some embodiments, a physical uplink control channel resource is selected to transmit the beam recovery request in response to a contention-free resource and the physical uplink control channel resource being available for transmission of the beam recovery request and in response to the physical uplink control channel resource having a channel quality greater than a predetermined threshold. In various embodiments, a physical random access channel resource is selected to transmit the beam recovery request in response to the physical uplink control channel resource having the channel quality less than the predetermined threshold.

[0013] In one embodiment, the transmitter transmits a response to the beam recovery request. In certain embodiments, a physical random access channel resource for the beam recovery request is skipped in response to the beam recovery request being transmitting using a physical uplink control channel resource. In some embodiments, a contention based resource is selected to transmit the beam recovery request in response to a contention-free resource and a physical uplink control channel resource being unavailable for transmission of the beam recovery request.

[0014] In various embodiments, the resource to transmit the beam recovery request is selected based on a measurement result and an association between a downlink transmission beam and a physical uplink control channel resource. In certain embodiments, the association between the downlink transmission beam and the physical uplink control channel resource is configured by radio resource control signaling. In some embodiments, the measurement result is

based on a channel state information reference signal in response to the channel state information reference signal being configured by a base unit. In one embodiment, the measurement result is based on a synchronization signal block in response to a channel state information reference signal not being configured by a base unit.

[0015] In various embodiments, a beam measurement is performed to determine the measurement result in response to a second trigger condition. In certain embodiments, the second trigger condition includes a quality of a serving beam being less than a predetermined threshold, a number of out-of-sync indications from a physical layer, or some combination thereof. In some embodiments, the predetermined threshold and the number are configured by radio resource control signaling. In one embodiment, a timer is started in response to the first trigger condition. In various embodiments, radio link failure is entered in response to the timer expiring. In certain embodiments, the timer is stopped in response to transmitting a response to receiving the beam recovery request.

[0016] A method for receiving a beam recovery request, in one embodiment, includes transmitting information indicating a resource configured for a beam recovery request. In certain embodiments, the method includes receiving the beam recovery request on the resource.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] A more particular description of the embodiments briefly described above will be rendered by reference to specific embodiments that are illustrated in the appended drawings. Understanding that these drawings depict only some embodiments and are not therefore to be considered to be limiting of scope, the embodiments will be described and explained with additional specificity and detail through the use of the accompanying drawings, in which:

[0018] Figure 1 is a schematic block diagram illustrating one embodiment of a wireless communication system for transmitting and/or receiving a beam recovery request;

[0019] Figure 2 is a schematic block diagram illustrating one embodiment of an apparatus that may be used for transmitting a beam recovery request;

[0020] Figure 3 is a schematic block diagram illustrating one embodiment of an apparatus that may be used for receiving a beam recovery request;

[0021] Figure 4 is a schematic flow chart diagram illustrating one embodiment of a method for transmitting a beam recovery request; and

[0022] Figure 5 is a schematic flow chart diagram illustrating one embodiment of a method for receiving a beam recovery request.

DETAILED DESCRIPTION

[0023] As will be appreciated by one skilled in the art, aspects of the embodiments may be embodied as a system, apparatus, method, or program product. Accordingly, embodiments may take the form of an entirely hardware embodiment, an entirely software embodiment (including firmware, resident software, micro-code, etc.) or an embodiment combining software and hardware aspects that may all generally be referred to herein as a "circuit," "module" or "system." Furthermore, embodiments may take the form of a program product embodied in one or more computer readable storage devices storing machine readable code, computer readable code, and/or program code, referred hereafter as code. The storage devices may be tangible, non-transitory, and/or non-transmission. The storage devices may not embody signals. In a certain embodiment, the storage devices only employ signals for accessing code.

[0024] Certain of the functional units described in this specification may be labeled as modules, in order to more particularly emphasize their implementation independence. For example, a module may be implemented as a hardware circuit comprising custom very-large-scale integration ("VLSI") circuits or gate arrays, off-the-shelf semiconductors such as logic chips, transistors, or other discrete components. A module may also be implemented in programmable hardware devices such as field programmable gate arrays, programmable array logic, programmable logic devices or the like.

[0025] Modules may also be implemented in code and/or software for execution by various types of processors. An identified module of code may, for instance, include one or more physical or logical blocks of executable code which may, for instance, be organized as an object, procedure, or function. Nevertheless, the executables of an identified module need not be physically located together, but may include disparate instructions stored in different locations which, when joined logically together, include the module and achieve the stated purpose for the module.

[0026] Indeed, a module of code may be a single instruction, or many instructions, and may even be distributed over several different code segments, among different programs, and across several memory devices. Similarly, operational data may be identified and illustrated herein within modules, and may be embodied in any suitable form and organized within any suitable type of data structure. The operational data may be collected as a single data set, or may be distributed over different locations including over different computer readable storage devices. Where a module or portions of a module are implemented in software, the software portions are stored on one or more computer readable storage devices.

[0027] Any combination of one or more computer readable medium may be utilized. The computer readable medium may be a computer readable storage medium. The computer readable storage medium may be a storage device storing the code. The storage device may be, for example, but not limited to, an electronic, magnetic, optical, electromagnetic, infrared, holographic, micromechanical, or semiconductor system, apparatus, or device, or any suitable combination of the foregoing.

[0028] More specific examples (a non-exhaustive list) of the storage device would include the following: an electrical connection having one or more wires, a portable computer diskette, a hard disk, a random access memory ("RAM"), a read-only memory ("ROM"), an erasable programmable read-only memory ("EPROM" or Flash memory), a portable compact disc read-only memory ("CD-ROM"), an optical storage device, a magnetic storage device, or any suitable combination of the foregoing. In the context of this document, a computer readable storage medium may be any tangible medium that can contain, or store a program for use by or in connection with an instruction execution system, apparatus, or device.

[0029] Code for carrying out operations for embodiments may be any number of lines and may be written in any combination of one or more programming languages including an object oriented programming language such as Python, Ruby, Java, Smalltalk, C++, or the like, and conventional procedural programming languages, such as the "C" programming language, or the like, and/or machine languages such as assembly languages. The code may execute entirely on the user's computer, partly on the user's computer, as a stand-alone software package, partly on the user's computer and partly on a remote computer or entirely on the remote computer or server. In the latter scenario, the remote computer may be connected to the user's computer through any type of network, including a local area network ("LAN") or a wide area network ("WAN"), or the connection may be made to an external computer (for example, through the Internet using an Internet Service Provider).

[0030] Reference throughout this specification to "one embodiment," "an embodiment," or similar language means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment. Thus, appearances of the phrases "in one embodiment," "in an embodiment," and similar language throughout this specification may, but do not necessarily, all refer to the same embodiment, but mean "one or more but not all embodiments" unless expressly specified otherwise. The terms "including," "comprising," "having," and variations thereof mean "including but not limited to," unless expressly specified otherwise. An enumerated listing of items does not imply that any or all of

the items are mutually exclusive, unless expressly specified otherwise. The terms "a," "an," and "the" also refer to "one or more" unless expressly specified otherwise.

[0031] Furthermore, the described features, structures, or characteristics of the embodiments may be combined in any suitable manner. In the following description, numerous specific details are provided, such as examples of programming, software modules, user selections, network transactions, database queries, database structures, hardware modules, hardware circuits, hardware chips, etc., to provide a thorough understanding of embodiments. One skilled in the relevant art will recognize, however, that embodiments may be practiced without one or more of the specific details, or with other methods, components, materials, and so forth. In other instances, well-known structures, materials, or operations are not shown or described in detail to avoid obscuring aspects of an embodiment.

[0032] Aspects of the embodiments are described below with reference to schematic flowchart diagrams and/or schematic block diagrams of methods, apparatuses, systems, and program products according to embodiments. It will be understood that each block of the schematic flowchart diagrams and/or schematic block diagrams, and combinations of blocks in the schematic flowchart diagrams and/or schematic block diagrams, can be implemented by code. The code may be provided to a processor of a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions/acts specified in the schematic flowchart diagrams and/or schematic block diagrams block or blocks.

[0033] The code may also be stored in a storage device that can direct a computer, other programmable data processing apparatus, or other devices to function in a particular manner, such that the instructions stored in the storage device produce an article of manufacture including instructions which implement the function/act specified in the schematic flowchart diagrams and/or schematic block diagrams block or blocks.

[0034] The code may also be loaded onto a computer, other programmable data processing apparatus, or other devices to cause a series of operational steps to be performed on the computer, other programmable apparatus or other devices to produce a computer implemented process such that the code which execute on the computer or other programmable apparatus provide processes for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

[0035] The schematic flowchart diagrams and/or schematic block diagrams in the Figures illustrate the architecture, functionality, and operation of possible implementations of

apparatuses, systems, methods and program products according to various embodiments. In this regard, each block in the schematic flowchart diagrams and/or schematic block diagrams may represent a module, segment, or portion of code, which includes one or more executable instructions of the code for implementing the specified logical function(s).

[0036] It should also be noted that, in some alternative implementations, the functions noted in the block may occur out of the order noted in the Figures. For example, two blocks shown in succession may, in fact, be executed substantially concurrently, or the blocks may sometimes be executed in the reverse order, depending upon the functionality involved. Other steps and methods may be conceived that are equivalent in function, logic, or effect to one or more blocks, or portions thereof, of the illustrated Figures.

[0037] Although various arrow types and line types may be employed in the flowchart and/or block diagrams, they are understood not to limit the scope of the corresponding embodiments. Indeed, some arrows or other connectors may be used to indicate only the logical flow of the depicted embodiment. For instance, an arrow may indicate a waiting or monitoring period of unspecified duration between enumerated steps of the depicted embodiment. It will also be noted that each block of the block diagrams and/or flowchart diagrams, and combinations of blocks in the block diagrams and/or flowchart diagrams, can be implemented by special purpose hardware-based systems that perform the specified functions or acts, or combinations of special purpose hardware and code.

[0038] The description of elements in each figure may refer to elements of proceeding figures. Like numbers refer to like elements in all figures, including alternate embodiments of like elements.

[0039] Figure 1 depicts an embodiment of a wireless communication system 100 for transmitting and/or receiving a beam recovery request. In one embodiment, the wireless communication system 100 includes remote units 102 and base units 104. Even though a specific number of remote units 102 and base units 104 are depicted in Figure 1, one of skill in the art will recognize that any number of remote units 102 and base units 104 may be included in the wireless communication system 100.

[0040] In one embodiment, the remote units 102 may include computing devices, such as desktop computers, laptop computers, personal digital assistants ("PDAs"), tablet computers, smart phones, smart televisions (e.g., televisions connected to the Internet), set-top boxes, game consoles, security systems (including security cameras), vehicle on-board computers, network devices (e.g., routers, switches, modems), or the like. In some embodiments, the remote units 102 include wearable devices, such as smart watches, fitness bands, optical head-mounted

displays, or the like. Moreover, the remote units 102 may be referred to as subscriber units, mobiles, mobile stations, users, terminals, mobile terminals, fixed terminals, subscriber stations, UE, user terminals, a device, or by other terminology used in the art. The remote units 102 may communicate directly with one or more of the base units 104 via UL communication signals.

[0041] The base units 104 may be distributed over a geographic region. In certain embodiments, a base unit 104 may also be referred to as an access point, an access terminal, a base, a base station, a Node-B, an eNB, a gNB, a Home Node-B, a relay node, a device, or by any other terminology used in the art. The base units 104 are generally part of a radio access network that includes one or more controllers communicably coupled to one or more corresponding base units 104. The radio access network is generally communicably coupled to one or more core networks, which may be coupled to other networks, like the Internet and public switched telephone networks, among other networks. These and other elements of radio access and core networks are not illustrated but are well known generally by those having ordinary skill in the art.

[0042] In one implementation, the wireless communication system 100 is compliant with the 3GPP protocol, wherein the base unit 104 transmits using an OFDM modulation scheme on the DL and the remote units 102 transmit on the UL using a SC-FDMA scheme or an OFDM scheme. More generally, however, the wireless communication system 100 may implement some other open or proprietary communication protocol, for example, WiMAX, among other protocols. The present disclosure is not intended to be limited to the implementation of any particular wireless communication system architecture or protocol.

[0043] The base units 104 may serve a number of remote units 102 within a serving area, for example, a cell or a cell sector via a wireless communication link. The base units 104 transmit DL communication signals to serve the remote units 102 in the time, frequency, and/or spatial domain.

[0044] In one embodiment, a remote unit 102 may receive information indicating a resource configured for a beam recovery request. In some embodiments, the remote unit 102 may transmit the beam recovery request on the resource in response to a first trigger condition. Accordingly, a remote unit 102 may be used for transmitting a beam recovery request.

[0045] In certain embodiments, a base unit 104 may transmit information indicating a resource configured for a beam recovery request. In certain embodiments, the base unit 104 may receive the beam recovery request on the resource in response to a first trigger condition. Accordingly, a base unit 104 may be used for receiving a beam recovery request.

[0046] Figure 2 depicts one embodiment of an apparatus 200 that may be used for transmitting a beam recovery request. The apparatus 200 includes one embodiment of the remote unit 102. Furthermore, the remote unit 102 may include a processor 202, a memory 204, an input device 206, a display 208, a transmitter 210, and a receiver 212. In some embodiments, the input device 206 and the display 208 are combined into a single device, such as a touchscreen. In certain embodiments, the remote unit 102 may not include any input device 206 and/or display 208. In various embodiments, the remote unit 102 may include one or more of the processor 202, the memory 204, the transmitter 210, and the receiver 212, and may not include the input device 206 and/or the display 208.

[0047] The processor 202, in one embodiment, may include any known controller capable of executing computer-readable instructions and/or capable of performing logical operations. For example, the processor 202 may be a microcontroller, a microprocessor, a central processing unit ("CPU"), a graphics processing unit ("GPU"), an auxiliary processing unit, a field programmable gate array ("FPGA"), or similar programmable controller. In some embodiments, the processor 202 executes instructions stored in the memory 204 to perform the methods and routines described herein. The processor 202 is communicatively coupled to the memory 204, the input device 206, the display 208, the transmitter 210, and the receiver 212.

[0048] The memory 204, in one embodiment, is a computer readable storage medium. In some embodiments, the memory 204 includes volatile computer storage media. For example, the memory 204 may include a RAM, including dynamic RAM ("DRAM"), synchronous dynamic RAM ("SDRAM"), and/or static RAM ("SRAM"). In some embodiments, the memory 204 includes non-volatile computer storage media. For example, the memory 204 may include a hard disk drive, a flash memory, or any other suitable non-volatile computer storage device. In some embodiments, the memory 204 includes both volatile and non-volatile computer storage media. In some embodiments, the memory 204 stores data relating to beam recovery requests. In some embodiments, the memory 204 also stores program code and related data, such as an operating system or other controller algorithms operating on the remote unit 102.

[0049] The input device 206, in one embodiment, may include any known computer input device including a touch panel, a button, a keyboard, a stylus, a microphone, or the like. In some embodiments, the input device 206 may be integrated with the display 208, for example, as a touchscreen or similar touch-sensitive display. In some embodiments, the input device 206 includes a touchscreen such that text may be input using a virtual keyboard displayed on the touchscreen and/or by handwriting on the touchscreen. In some embodiments, the input device 206 includes two or more different devices, such as a keyboard and a touch panel.

[0050] The display 208, in one embodiment, may include any known electronically controllable display or display device. The display 208 may be designed to output visual, audible, and/or haptic signals. In some embodiments, the display 208 includes an electronic display capable of outputting visual data to a user. For example, the display 208 may include, but is not limited to, an LCD display, an LED display, an OLED display, a projector, or similar display device capable of outputting images, text, or the like to a user. As another, non-limiting, example, the display 208 may include a wearable display such as a smart watch, smart glasses, a heads-up display, or the like. Further, the display 208 may be a component of a smart phone, a personal digital assistant, a television, a table computer, a notebook (laptop) computer, a personal computer, a vehicle dashboard, or the like.

[0051] In certain embodiments, the display 208 includes one or more speakers for producing sound. For example, the display 208 may produce an audible alert or notification (e.g., a beep or chime). In some embodiments, the display 208 includes one or more haptic devices for producing vibrations, motion, or other haptic feedback. In some embodiments, all or portions of the display 208 may be integrated with the input device 206. For example, the input device 206 and display 208 may form a touchscreen or similar touch-sensitive display. In other embodiments, the display 208 may be located near the input device 206.

[0052] The transmitter 210 is used to provide UL communication signals to the base unit 104 and the receiver 212 is used to receive DL communication signals from the base unit 104. In certain embodiments, the receiver 212 may be used to receive information indicating a resource configured for a beam recovery request. In various embodiments, the transmitter 210 may be used to transmit the beam recovery request on the resource in response to a first trigger condition. Although only one transmitter 210 and one receiver 212 are illustrated, the remote unit 102 may have any suitable number of transmitters 210 and receivers 212. The transmitter 210 and the receiver 212 may be any suitable type of transmitters and receivers. In one embodiment, the transmitter 210 and the receiver 212 may be part of a transceiver.

[0053] In some embodiments, transmitting a beam recovery request (e.g., a beam failure recovery procedure) may be performed using various steps that may be performed in any suitable order and/or some steps may not be performed.

[0054] In a first step, a base unit 104 may configure a remote unit 102 with various information. In one embodiment, in response to the remote unit 102 being configured with a channel state information reference signal ("CSI-RS"), the information may include that the CSI-RS is used to determine a beam failure. In another embodiment, in response to the remote unit 102 not being configured is a CSI-RS, the information may include that a synchronization signal

block ("SS-block") may be used to determine a beam failure. In some embodiments, resources for UL transmission of a beam recovery request may be configured by RRC signaling. In certain embodiments, the information may include a trigger condition to transmit a beam failure recovery request. In various embodiments, the trigger condition may be that a medium access control ("MAC") layer receives a number (e.g., "N") of out-of-sync indications from a physical layer. In one embodiment, the number of out-of-sync indications may be configured by RRC signaling. As used herein, an "out-of-sync indication" may refer to feedback, a response, an indication, and/or a signal that contains information indicating that there is no synchronization between data being received and a device decoding the data being received. In some embodiments, the information may include a trigger condition to identify a candidate DL TX beam. In various embodiments, the trigger condition may include that a serving beam quality becomes worse than a configured and/or predetermined threshold. In certain embodiments, the trigger condition may include that a number ("e.g., "M") of out-of-sync indications are received in a physical layer.

[0055] In a second step, the remote unit 102 may report measurement results periodically to the base unit 104. The report measurement results may include results corresponding to a serving beam.

[0056] In a third step, the base unit 104 may activate a dedicated UL resource for transmitting a beam recovery request based on the measurement results. In some embodiments, the dedicated UL resource may be activated by a MAC control element ("CE"). In one embodiment, the base unit 104 may configure the dedicted UL resource for the remote unit 102 to transmit the beam recovery request using RRC signaling. In such an embodiment, the remote unit 102 may be enabled to use the dedicted UL resource in response to receiving configuration information indicating the dedicated UL resource. In another embodiment, the remote unit 102 may be enabled to use the dedicated UL resource in response to the base unit 104 activating the dedicated UL resource via the MAC CE.

[0057] In a fourth step, an event that triggers a beam failure recovery request may be detected by the remote unit 102. In response to the event triggering the beam failure recovery request for a last active beam, the MAC of the remote unit 102 may start a timer ("T1"). In response to the timer expiring, the remote unit 102 may enter a radio link failure ("RLF") condition. In some embodiments, the timer may stop in response to the remote unit 102 receiving a response to the beam failure recovery request.

[0058] In a fifth step, the remote unit 102 may transmit a beam recovery request to the base unit 104. In some embodiments, a base unit 104 may configure an association between a

DL TX beam and a PUCCH resource. In certain embodiments, based on a measurement result associated to an SS-block or CSI-RS, only a PUCCH resource associated to a suitable beam may be used for a beam failure recovery request. As used herein, a "suitable beam" may mean that a measurement quality is better than a threshold quality configured by the base unit 104. In some embodiments, in response to a contention-free resource for a beam recovery request being available, the remote unit 102 may use the contention-free resource to transmit beam recovery request. In various embodiments, in response to a PUCCH resource such as scheduling request ("SR"), sounding reference signal ("SRS"), PUSCH, and/or PUCCH for a beam recovery request being available, the remote unit 102 may use a first available PUCCH resource to transmit the beam recovery request.

[0059] In certain embodiments, in response to both a contention-free resource and a PUCCH resource for beam recovery request being available, the remote unit 102 may select an UL resource for a beam recovery request based on certain criteria. In one embodiment, the criteria may include the remote unit 102 selecting a first available resource. In some embodiments, the criteria may include the remote unit 102 selecting a PUCCH resource based on a priority in response to a beam including a suitable PUCCH resource. In such embodiments, the criteria may include, in response to all beams associated with the PUCCH resource not being suitable, the remote unit 102 selecting a PRACH resource for transmitting the beam recovery request. As used herein, a beam "not being suitable" may mean that a measurement quality is less than a threshold quality configured by the base unit 104.

[0060] In various embodiments, in response to a beam recovery request being transmitted in a first selected resource, the remote unit 102 may handle other available resources according to certain criteria. In one embodiment, the criteria may include the remote unit 102 skipping other available resources for the beam recovery request. For example, in response to the beam recovery request being transmitted in a PRACH resource, the remote unit 102 may monitor for a response within a time window. During the time window, the remote unit 102 may skip a PUCCH resource for a beam recovery request. As another example, in response to the beam recovery request being transmitted in a PUCCH resource, the remote unit 102 may skip a PRACH resource for a beam recovery request. In some embodiments, the criteria may include the remote unit 102 retransmitting the beam recovery request using other available resources. For example, in response to the beam recovery request being transmitted in a PRACH resource, the remote unit 102 may monitor for a response within a time window. During the time window, the remote unit 102 may retransmit the beam recovery request using a PUCCH resource. As another example, in response to the beam recovery request being transmitted in a PUCCH

resource, the remote unit 102 may retransmit the beam recovery request using a PRACH resource. In various embodiment, in response to both a contention-free resource and a PUCCH resource for a beam recovery request not being available to the remote unit 102, the remote unit 102 may use a contention based resource to transmit a beam recovery request.

[0061] In a sixth step, the base unit 104 may transmit a response to the beam recovey request to the remote unit 102. For example, in response to the base unit 104 receiving the beam recovery request from the remote unit 102, the base unit 104 may transmit the response in a DL beam associated with the UL resource, or in a candidate DL beam signaled in PUCCH.

[0062] In a seventh step, the remote unit 102 monitors for a response from the base unit 104 after transmitting the beam recovery request. In response to the remote unit 102 failing to receive a response from the base unit 104 within a predetermined time window, the remote unit 102 may be enabled to transmit a beam recovery request again.

[0063] Figure 3 depicts one embodiment of an apparatus 300 that may be used for receiving a beam recovery request. The apparatus 300 includes one embodiment of the base unit 104. Furthermore, the base unit 104 may include a processor 302, a memory 304, an input device 306, a display 308, a transmitter 310, and a receiver 312. As may be appreciated, the processor 302, the memory 304, the input device 306, the display 308, the transmitter 310, and the receiver 312 may be substantially similar to the processor 202, the memory 204, the input device 206, the display 208, the transmitter 210, and the receiver 212 of the remote unit 102, respectively.

[0064] In certain embodiments, the transmitter 310 may be used to transmit information indicating a resource configured for a beam recovery request. In some embodiments, the receiver 312 may be used to receive the beam recovery request on the resource in response to a first trigger condition. Although only one transmitter 310 and one receiver 312 are illustrated, the base unit 104 may have any suitable number of transmitters 310 and receivers 312. The transmitter 310 and the receiver 312 may be any suitable type of transmitters and receivers. In one embodiment, the transmitter 310 and the receiver 312 may be part of a transceiver.

[0065] Figure 4 is a schematic flow chart diagram illustrating one embodiment of a method 400 for transmitting a beam recovery request. In some embodiments, the method 400 is performed by an apparatus, such as the remote unit 102. In certain embodiments, the method 400 may be performed by a processor executing program code, for example, a microcontroller, a microprocessor, a CPU, a GPU, an auxiliary processing unit, a FPGA, or the like.

[0066] The method 400 may include receiving 402 information indicating a resource configured for a beam recovery request. In some embodiments, the method 400 includes

transmitting 404 the beam recovery request on the resource in response to a first trigger condition.

[0067] In one embodiment, the first trigger condition includes a medium access control layer receiving a number of out-of-sync indications from a physical layer. In a further embodiment, the number of out-of-sync indications is configured by radio resource control signaling. In certain embodiments, the resource configured for the beam recovery request is configured by radio resource control signaling. In various embodiments, the resource configured for the beam recovery request is enabled for use in response to the resource being configured by the radio resource control signaling. In some embodiments, the resource configured for the beam recovery request is enabled for use in response to the resource being activated by a medium access control control element.

[0068] In certain embodiments, the method 400 includes selecting a first available resource to transmit the beam recovery request in response to a contention-free resource and a physical uplink control channel resource being available for transmission of the beam recovery request. In some embodiments, the method 400 includes selecting a physical uplink control channel resource to transmit the beam recovery request in response to a contention-free resource and the physical uplink control channel resource being available for transmission of the beam recovery request and in response to the physical uplink control channel resource having a channel quality greater than a predetermined threshold. In various embodiments, the method 400 includes selecting a physical random access channel resource to transmit the beam recovery request in response to the physical uplink control channel resource having the channel quality less than the predetermined threshold.

[0069] In one embodiment, the method 400 includes monitoring for a response to transmission of the beam recovery request for a predetermined time in response to transmitting the beam recovery request using a physical random access channel resource and skipping a physical uplink control channel resource for the beam recovery request during the predetermined time. In certain embodiments, the method 400 includes skipping a physical random access channel resource for the beam recovery request in response to transmitting the beam recovery request using a physical uplink control channel resource. In some embodiments, the method 400 includes selecting a contention based resource to transmit the beam recovery request in response to a contention-free resource and a physical uplink control channel resource being unavailable for transmission of the beam recovery request. In various embodiments, the method 400 includes selecting the resource to transmit the beam recovery request based on a measurement

result and an association between a downlink transmission beam and a physical uplink control channel resource.

[0070] In some embodiments, the association between the downlink transmission beam and the physical uplink control channel resource is configured by radio resource control signaling. In certain embodiments, the measurement result is based on a channel state information reference signal in response to the channel state information reference signal being configured by a base unit. In various embodiments, the measurement result is based on a synchronization signal block in response to a channel state information reference signal not being configured by a base unit. In one embodiment, the method 400 includes performing a beam measurement to determine the measurement result in response to a second trigger condition. In some embodiments, the second trigger condition includes a quality of a serving beam being less than a predetermined threshold, a number of out-of-sync indications from a physical layer, or some combination thereof. In certain embodiments, the predetermined threshold and the number are configured by radio resource control signaling. In various embodiments, the method 400 includes starting a timer in response to the first trigger condition. In various embodiments, the method 400 enters radio link failure in response to the timer expiring. In one embodiment, the method 400 stops the timer in response to receiving a response to the transmission of the beam recovery request.

[0071] Figure 5 is a schematic flow chart diagram illustrating one embodiment of a method 500 for receiving a beam recovery request. In some embodiments, the method 500 is performed by an apparatus, such as the base unit 104. In certain embodiments, the method 500 may be performed by a processor executing program code, for example, a microcontroller, a microprocessor, a CPU, a GPU, an auxiliary processing unit, a FPGA, or the like.

[0072] The method 500 may include transmitting 502 information indicating a resource configured for a beam recovery request. In certain embodiments, the method 500 includes receiving 504 the beam recovery request on the resource.

[0073] In one embodiment, the first trigger condition includes a medium access control layer receiving a number of out-of-sync indications from a physical layer. In a further embodiment, the number of out-of-sync indications is configured by radio resource control signaling. In certain embodiments, the resource configured for the beam recovery request is configured by radio resource control signaling. In various embodiments, the resource configured for the beam recovery request is enabled for use in response to the resource being configured by the radio resource control signaling. In some embodiments, the resource configured for the beam

recovery request is enabled for use in response to the resource being activated by a medium access control control element.

[0074] In certain embodiments, a first available resource is selected to transmit the beam recovery request in response to a contention-free resource and a physical uplink control channel resource being available for transmission of the beam recovery request. In some embodiments, a physical uplink control channel resource is selected to transmit the beam recovery request in response to a contention-free resource and the physical uplink control channel resource being available for transmission of the beam recovery request and in response to the physical uplink control channel resource having a channel quality greater than a predetermined threshold. In various embodiments, a physical random access channel resource is selected to transmit the beam recovery request in response to the physical uplink control channel resource having the channel quality less than the predetermined threshold.

[0075] In one embodiment, the method 500 includes transmitting a response to the beam recovery request. In certain embodiments, a physical random access channel resource for the beam recovery request is skipped in response to the beam recovery request being transmitting using a physical uplink control channel resource. In some embodiments, a contention based resource is selected to transmit the beam recovery request in response to a contention-free resource and a physical uplink control channel resource being unavailable for transmission of the beam recovery request.

[0076] In various embodiments, the resource to transmit the beam recovery request is selected based on a measurement result and an association between a downlink transmission beam and a physical uplink control channel resource. In certain embodiments, the association between the downlink transmission beam and the physical uplink control channel resource is configured by radio resource control signaling. In some embodiments, the measurement result is based on a channel state information reference signal in response to the channel state information reference signal being configured by a base unit. In one embodiment, the measurement result is based on a synchronization signal block in response to a channel state information reference signal not being configured by a base unit.

[0077] In various embodiments, a beam measurement is performed to determine the measurement result in response to a second trigger condition. In certain embodiments, the second trigger condition includes a quality of a serving beam being less than a predetermined threshold, a number of out-of-sync indications from a physical layer, or some combination thereof. In some embodiments, the predetermined threshold and the number are configured by radio resource control signaling. In one embodiment, a timer is started in response to the first

trigger condition. In various embodiments, radio link failure is entered in response to the timer expiring. In certain embodiments, the timer is stopped in response to transmitting a response to receiving the beam recovery request.

[0078] Embodiments may be practiced in other specific forms. The described embodiments are to be considered in all respects only as illustrative and not restrictive. The scope of the invention is, therefore, indicated by the appended claims rather than by the foregoing description. All changes which come within the meaning and range of equivalency of the claims are to be embraced within their scope.

CLAIMS

1. A method comprising:

receiving information indicating a resource configured for a beam recovery request; and

transmitting the beam recovery request on the resource in response to a first trigger condition.

2. The method of claim 1, wherein the first trigger condition comprises a medium access control layer receiving a number of out-of-sync indications from a physical layer.

3. The method of claim 1, wherein the resource configured for the beam recovery request is configured by radio resource control signaling.

4. The method of claim 3, wherein the resource configured for the beam recovery request is enabled for use in response to the resource being configured by the radio resource control signaling.

5. The method of claim 3, wherein the resource configured for the beam recovery request is enabled for use in response to the resource being activated by a medium access control control element.

6. The method of claim 1, further comprising selecting a first available resource to transmit the beam recovery request in response to a contention-free resource and a physical uplink control channel resource being available for transmission of the beam recovery request.

7. The method of claim 1, further comprising selecting a physical uplink control channel resource to transmit the beam recovery request in response to a contention-free resource and the physical uplink control channel resource being available for transmission of the beam recovery request and in response to the physical uplink control channel resource having a channel quality greater than a predetermined threshold.

8. The method of claim 7, further comprising selecting a physical random access channel resource to transmit the beam recovery request in response to the physical uplink control channel resource having the channel quality less than the predetermined threshold.

9. The method of claim 1, further comprising monitoring for a response to transmission of the beam recovery request for a predetermined time in response to transmitting the beam recovery request using a physical random access channel resource and skipping a physical uplink control channel resource for the beam recovery request during the predetermined time.

10. The method of claim 1, further comprising skipping a physical random access channel resource for the beam recovery request in response to transmitting the beam recovery request using a physical uplink control channel resource.

11. The method of claim 1, further comprising selecting a contention based resource to transmit the beam recovery request in response to a contention-free resource and a physical uplink control channel resource being unavailable for transmission of the beam recovery request.

12. The method of claim 1, further comprising selecting the resource to transmit the beam recovery request based on a measurement result and an association between a downlink transmission beam and a physical uplink control channel resource.

13. The method of claim 12, wherein the association between the downlink transmission beam and the physical uplink control channel resource is configured by radio resource control signaling.

14. The method of claim 12, wherein the measurement result is based on a channel state information reference signal in response to the channel state information reference signal being configured by a base unit.

15. The method of claim 12, wherein the measurement result is based on a synchronization signal block in response to a channel state information reference signal not being configured by a base unit.

16. The method of claim 12, further comprising performing a beam measurement to determine the measurement result in response to a second trigger condition.

17. The method of claim 16, wherein the second trigger condition comprises a quality of a serving beam being less than a predetermined threshold, a number of out-of-sync indications from a physical layer, or some combination thereof.

18. The method of claim 1, further comprising starting a timer in response to the first trigger condition.

19. An apparatus comprising:

a receiver that receives information indicating a resource configured for a beam recovery request; and

a transmitter that transmits the beam recovery request on the resource in response to a first trigger condition.

20. An apparatus comprising:

a transmitter that transmits information indicating a resource configured for a beam recovery request; and

a receiver that receives the beam recovery request on the resource.

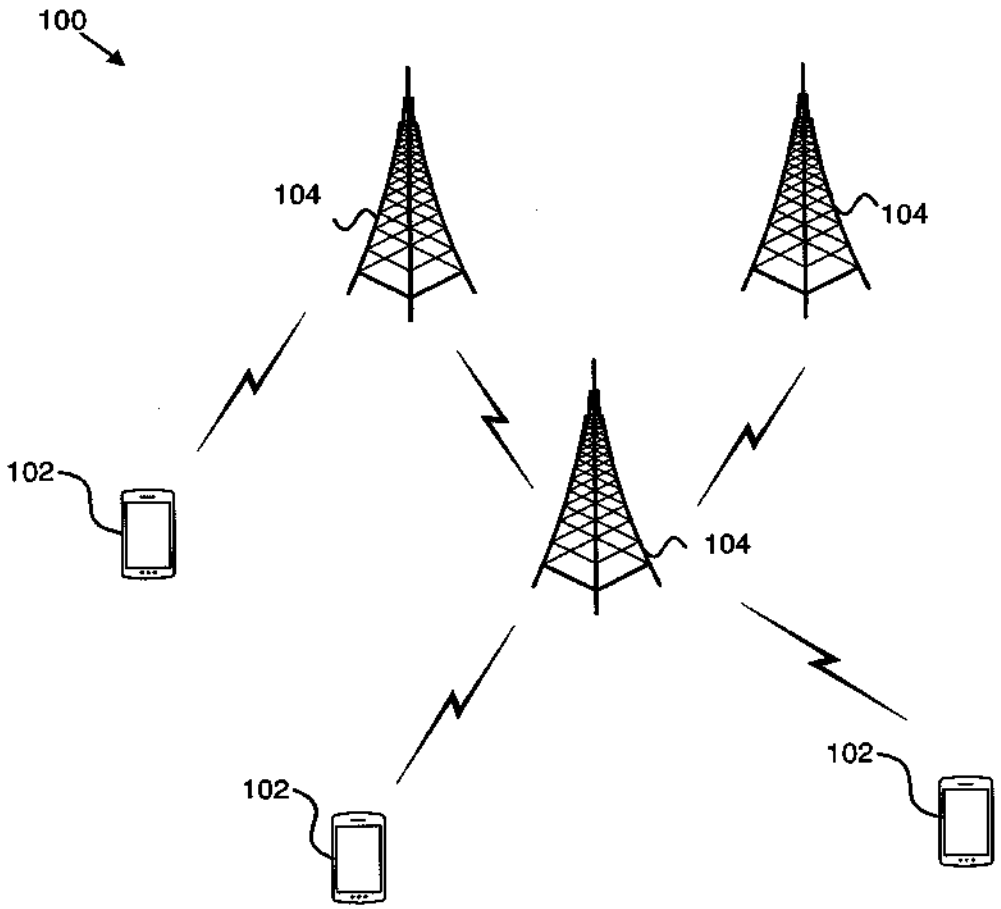


FIG. 1

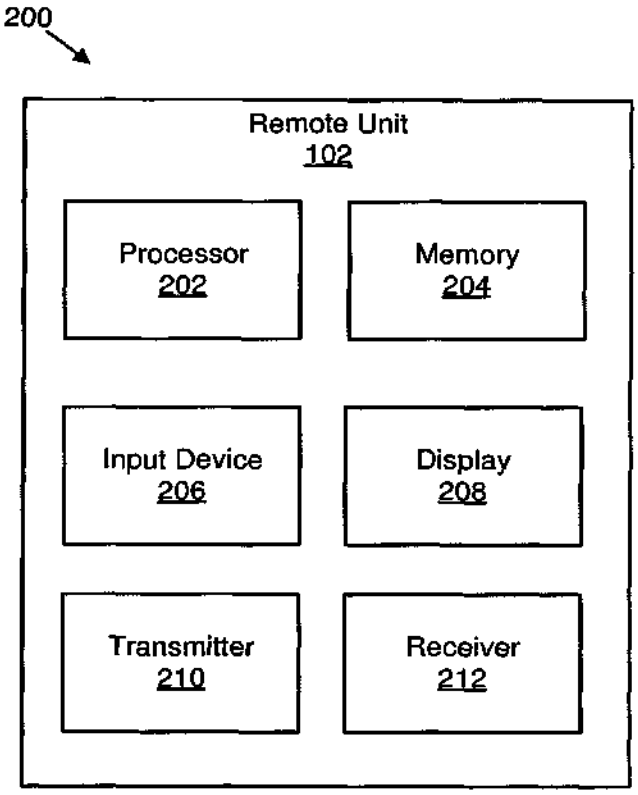

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Remote Unit
102
Processor
202
Memory
204
Input Device
206
Display
208
Transmitter
210
Receiver
212

FIG. 2

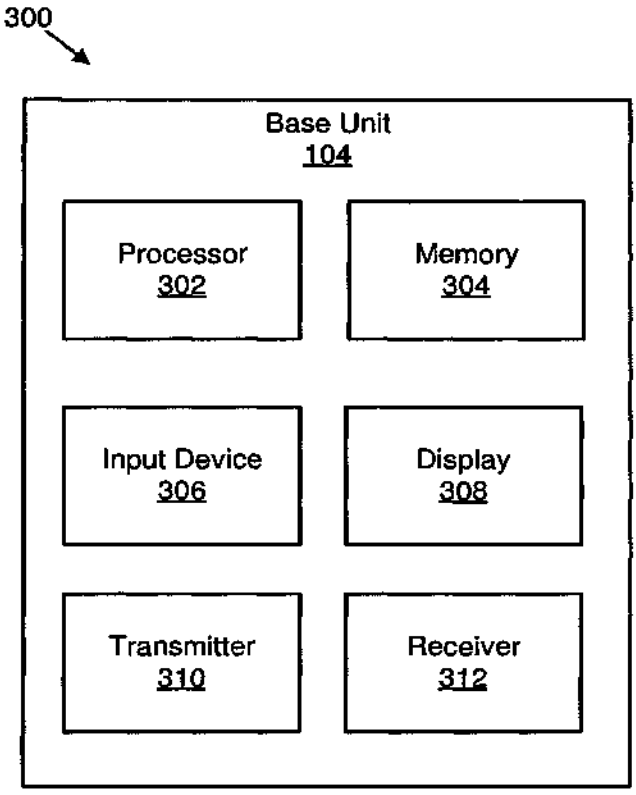

300
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104
Processor
302
Memory
304
Input Device
306
Display
308
Transmitter
310
Receiver
312

FIG. 3

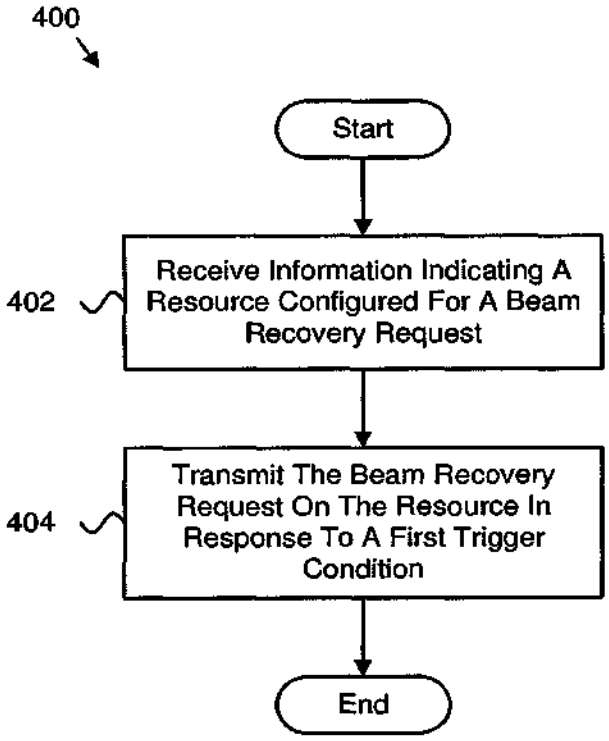

400
Start
Receive Information Indicating A Resource Configured For A Beam Recovery Request
402
Transmit The Beam Recovery Request On The Resource In Response To A First Trigger Condition
404
End

FIG. 4

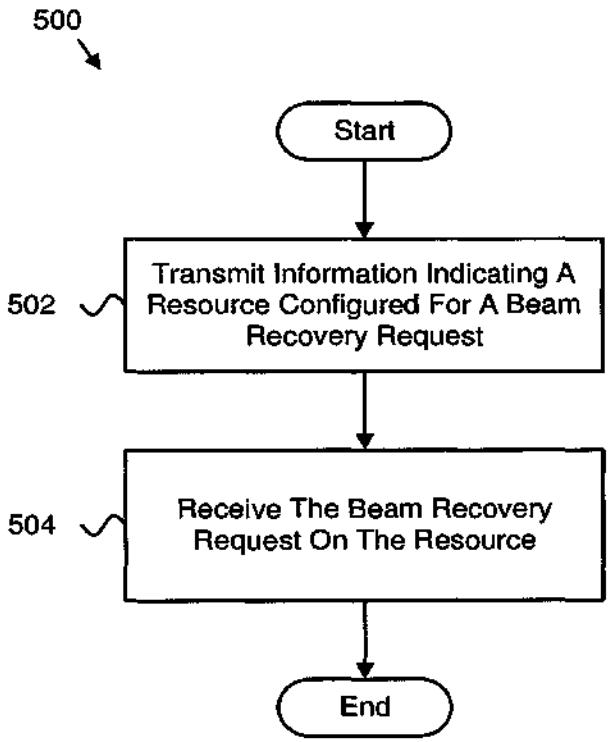

500
Start
Transmit Information Indicating A Resource Configured For A Beam Recovery Request
502
Receive The Beam Recovery Request On The Resource
504
End

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2017/088407

A. CLASSIFICATION OF SUBJECT MATTER

H04B 7/06(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04B; H04W; H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNTXT;CNABS;CNKI;WOTXT;USTXT;JPTXT;EPTXT;VEN;XP3GPP:beam?, recover+, request+, fail+, resource, trigger, sync+, timer, BFR

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Samsung. "R2-1705731 NR beam recovery" *3GPP TSG-RAN WG2 2017 RAN2#98 Meeting, http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN2/Docs/*, 14 May 2017 (2017-05-14), pages 1 and 2	1-20
X	WO 2017024516 A1 (TELEFONAKTIEBOLAGET LM ERICSSON PUBLET AL.) 16 February 2017 (2017-02-16) description, paragraphs [034]-[067]	1-20
A	US 2016183233 A1 (ELECTRONICS AND TELECOMMUNICATIONS RESEARCH INSTITUTE) 23 June 2016 (2016-06-23) the whole document	1-20

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 February 2018	**19 March 2018**
Name and mailing address of the ISA/CN **STATE INTELLECTUAL PROPERTY OFFICE OF THE P.R.CHINA** **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088** **China** Facsimile No. **(86-10)62019451**	Authorized officer **HUANG,Hui** Telephone No. **(86-10)62089455**

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2017/088407

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
WO	2017024516	A1	16 February 2017	CN	107079459	A	18 August 2017
US	2016183233	A1	23 June 2016	KR	101810633	B1	19 December 2017
				US	9769717	B2	19 September 2017
				KR	20160075217	A	29 June 2016

Form PCT/ISA/210 (patent family annex) (July 2009)

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ELECTRONIC PAYMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
17/950,726	**11/19/2023 10:47:29 PM Z ET**	**ZL0205-0004-US-CON3**

Title of Invention

METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	6005	FILED BY	Jialin Zhong
PATENT CENTER #	63311403	AUTHORIZED BY	-
CUSTOMER #	155075	FILING DATE	09/22/2022
CORRESPONDENCE ADDRESS	-	FIRST NAMED INVENTOR	Xiaobo ZHANG

Payment Information

PAYMENT METHOD	PAYMENT TRANSACTION ID	PAYMENT AUTHORIZED BY
CARD / 9295	E2023AIM48365804	Jialin Zhong

FEE CODE	DESCRIPTION	ITEM PRICE($)	QUANTITY	ITEM TOTAL($)
2806	SUBMISSION OF AN INFORMATION DISCLOSURE STATEMENT	104.00	1	104.00
			TOTAL AMOUNT:	**$104.00**

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Espacenet

KR20130130593A METHOD AND APPARATUS FOR MEASURING REFERENCE SIGNAL IN WIRELESS COMMUNICATION SYSTEM COMPRISING A PLURALITY BASE STATION USING A DISTRIBUTED ANTENNA

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Classifications:

IPC ***H04B7/04; H04J11/00;***

CPC **H04B17/24 (KR); H04B7/04 (US); H04B7/0417 (EP,CN,US); H04B7/0486 (US); H04B7/0626 (US); H04B7/063 (KR); H04B7/0639 (KR); H04L25/0224 (KR); H04W24/10 (EP,CN,US); H04W72/23 (US); H04W72/541 (US);** H04B7/022 (EP,CN,US); H04B7/063 (EP,CN,US); H04B7/0632 (EP,CN,US); H04B7/0639 (EP,CN,US); H04B7/0645 (EP,CN,US);

Priorities: KR20120054112A 2012-05-22; KR20120066676A 2012-06-21

Application: KR20120068479A 2012-06-26

Publication: KR20130130593A 2013-12-02

Published as: **CN104508988A; CN104508988B; EP2853040A1; EP2853040A4; EP2853040B1;** KR20130130593A; **US2013315081A1; US2015230260A1; US2016028461A1; US9014043B2; US9320046B2; US9641233B2; WO2013176480A1**

METHOD AND APPARATUS FOR MEASURING REFERENCE SIGNAL IN WIRELESS COMMUNICATION SYSTEM COMPRISING A PLURALITY BASE STATION USING A DISTRIBUTED ANTENNA

Abstract

Normally, a cellular wireless mobile communication system is organized by constructing a plurality of cells in a restricted area. Base station equipment which manages mobile communication within the corresponding cell is located at the center of the cell area. The base station equipment provides a mobile communication service to an antenna which transmits a wireless signal and terminals located at the center of the cell. The system is called as a centralized antenna system (CAS) and is a normal type of the mobile communication system. A contrasting system is a distributed antenna system (DAS), uniformly distributes antennas to service areas of the cells, and can provide the improved mobile communication service. The present invention proposes an interference measuring method and an interference measuring apparatus for effective communication in the distributed antenna systems (DAS) distributed in the service area of each base station. [Reference numerals] (700) Base station determines the feedback setup of a terminal;(710) Is it RI/PMI report unavailable setup?;(720) Transmitting PDSCH to a terminal based on the CSI of a terminal measured by CSH-RS;(730) Is it CRS allocation for CSI measurement?;(740) Notifying a RS switch bit to a terminal by setting Z as 0;(750) Notifying a RS switch bit to a terminal by setting Z as 1;(760) Transmitting PDSCH to a terminal based on the CSI of a terminal measured by CRS;(770) Transmitting PDSCH to a terminal based on the CQI of a terminal measured by CSI-RS

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H04B 7/04 (2006.01) *H04J 11/00* (2006.01)
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(30) 우선권주장
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(74) 대리인
윤동열

전체 청구항 수 : 총 24 항

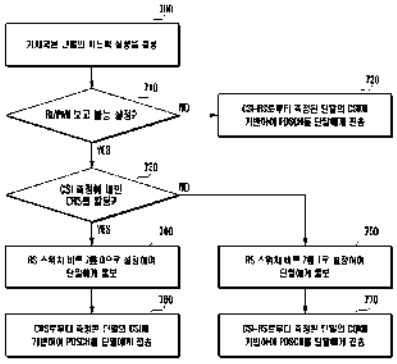
(54) 발명의 명칭 분산 안테나를 사용하는 복수 개의 기지국을 포함하는 무선통신 시스템에서 기준 신호 측정 방법 및 장치

(57) 요 약

일반적으로 셀룰러 무선 이동 통신 시스템은 한정된 지역에 복수개의 셀을 구축함으로서 이루어진다. 각 셀에는 해당 셀 내에서의 이동통신을 전담하는 기지국 장비가 셀 영역의 가운데에 위치하게 된다. 상기 기지국 장비로는 무선신호를 전송하는 안테나 및 신호처리 부분이 있으며 셀의 중앙에서 셀 내의 단말들에게 이동통신 서비스를 제공한다. 이와 같이 안테나가 셀의 중앙에 설치되는 시스템은 중앙 집중형 안테나 시스템 (Centralized Antenna System: CAS)이라고 하며 일반적인 이동통신 시스템이 이 형태이다.

이와 대비되는 시스템으로는 분산 안테나 시스템 (Distributed Antenna System: DAS)이 있으며 DAS의 경우 안테나들을 셀의 서비스영역에 골고루 분산함으로써 CAS와 대비하여 향상된 이동통신 서비스를 제공할 수 있다. 본 발명은 각 기지국의 서비스 영역에 분산되어 배치되어 있는 분산 안테나 시스템 (Distributed Antenna System: DAS)에서 효율적인 통신을 위한 간섭 측정 방법 및 장치를 제안한다.

대 표 도 도7



(72) 발명자

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특허청구의 범위

청구항 1

분산 안테나를 사용하는 복수 개의 기지국을 포함하는 이동통신 시스템에서 기준신호 측정 정보를 기지국이 단말에 통보하는 방법에 있어서,

상기 단말의 RI/PMI 보고 불능 설정 여부를 결정하는 단계;

상기 단말의 RI/PMI 보고 불능 설정 시, CRS 또는 CSI-RS 중 단말이 측정할 기준 신호를 결정하는 단계;

상기 결정된 기준 신호를 상기 단말에게 통보하는 단계;

상기 결정된 기준 신호를 측정하여 단말이 생성한 제1 채널 정보를 상기 단말로부터 수신하는 단계; 및

상기 제1 채널 정보에 기반하여 상기 단말에게 데이터를 전송하는 단계를 포함하는 것을 특징으로 하는 방법.

청구항 2

제1항에 있어서,

상기 단말의 RI/PMI 보고 설정 시, 상기 단말이 CSI-RS를 측정하도록 통보하는 단계;

상기 단말이 상기 CSI-RS를 측정하여 생성한 제2 채널 정보를 수신하는 단계; 및

상기 제2 채널 정보에 기반하여 상기 단말에게 데이터를 전송하는 단계를 포함하는 것을 특징으로 하는 방법.

청구항 3

제1항에 있어서, 상기 통보 단계는,

상기 단말이 측정하도록 결정된 기준 신호 정보를 비트 형식으로 지시하는 기준 신호 측정 정보를 상기 단말에게 통보하는 것을 특징으로 하는 방법.

청구항 4

제3항에 있어서, 상기 기준 신호 측정 정보는,

상위 시그널링 또는 물리계층 시그널링을 통해 상기 단말에게 전송되는 것을 특징으로 하는 방법.

청구항 5

제1항에 있어서, 상기 통보 단계는,

간섭 측정 자원을 상기 단말에게 통보하거나 또는 복수 개의 피드백을 상기 단말에게 통보하는 단계; 및

상기 단말이 CSI-RS를 측정하여 생성한 제3 채널 정보를 상기 단말로부터 수신하는 단계를 더 포함하는 것을 특징으로 하는 방법.

청구항 6

제1항에 있어서, 상기 데이터 전송 단계는,

특정 프리코더가 적용된 데이터를 상기 단말에 전송하는 것을 특징으로 하며,

상기 프리코더는, 상기 프리코더가 속한 집합 및 각 서브밴드에 적용될 프리코더가 미리 결정된 것을 특징으로 하는 방법.

청구항 7

분산 안테나를 사용하는 복수 개의 기지국을 포함하는 이동통신 시스템에서 단말의 하향링크 측정 방법에 있어서,

상기 단말의 RI/PMI 보고 불능 설정 여부에 대한 정보를 기지국으로부터 수신하는 단계;

상기 RI/PMI 보고 불능 설정 시, CRS 또는 CSI-RS 중 상기 단말이 측정하도록 결정된 기준 신호에 대한 정보를 상기 기지국으로부터 수신하는 단계;

상기 결정된 기준 신호를 측정하여 제1 채널 정보를 생성하고 상기 기지국으로 전송하는 단계; 및

상기 제1 채널 정보에 기반하여 전송되는 데이터를 상기 기지국으로부터 수신하는 단계를 포함하는 것을 특징으로 하는 하향링크 측정 방법.

청구항 8

제7항에 있어서,

상기 단말의 RI/PMI 보고 설정 시, 상기 CSI-RS를 측정하여 제2 채널 정보를 생성하는 단계; 및

상기 생성된 제2 채널 정보를 상기 기지국으로 전송하는 단계를 더 포함하는 것을 특징으로 하는 하향링크 측정 방법.

청구항 9

제7항에 있어서, 상기 기준 신호에 대한 정보 수신 단계는,

상기 단말이 측정하도록 결정된 기준 신호 정보를 비트 형식으로 지시하는 기준 신호 측정 정보를 수신하는 것을 특징으로 하는 하향링크 측정 방법.

청구항 10

제9항에 있어서, 상기 기준 신호 측정 정보는,

상위 시그널링 또는 물리계층 시그널링을 통해 상기 기지국으로부터 수신되는 것을 특징으로 하는 하향링크 측정 방법.

청구항 11

제7항에 있어서, 상기 기준 신호에 대한 정보 수신 단계는,

상기 기지국으로부터 간섭 측정 자원을 통보받거나 또는 복수 개의 피드백을 보고하도록 통보받는 경우, 상기 CSI-RS를 측정하여 제3 채널 정보를 생성하는 단계; 및

상기 생성된 제3 채널 정보를 상기 기지국으로 전송하는 단계를 더 포함하는 것을 특징으로 하는 하향링크 측정 방법.

청구항 12

제7항에 있어서, 상기 데이터 수신 단계는,

특정 프리코더가 적용된 데이터를 상기 기지국으로부터 수신하며,

상기 프리코더는, 상기 프리코더가 속한 집합 및 각 서브밴드에 적용될 프리코더가 미리 결정된 것을 특징으로 하는 하향링크 측정 방법.

청구항 13

분산 안테나를 사용하는 복수 개의 기지국을 포함하는 이동통신 시스템에서 기준 신호 측정 정보를 단말에 통보하는 기지국에 있어서,

상기 기준 신호 측정 정보 또는 데이터를 상기 단말에 전송하고, 상기 단말로부터 전송되는 채널 측정 정보를 수신하는 송수신부; 및

상기 단말의 RI/PMI 보고 불능 여부를 결정하고, 상기 단말의 RI/PMI 보고 불능 결정 시 CRS 또는 CSI-RS 중 단말이 측정할 기준 신호를 결정하며, 상기 결정된 기준 신호를 상기 단말에게 통보하고, 상기 결정된 기준 신호를 측정하여 단말이 생성한 제1 채널 정보를 상기 단말로부터 수신하며, 상기 제1 채널 정보에 기반하여 상기

단말에게 데이터를 전송하도록 제어하는 제어기를 포함하는 것을 특징으로 하는 기지국.

청구항 14

제13항에 있어서, 상기 제어기는,

상기 단말의 RI/PMI 보고 결정 시 상기 단말이 CSI-RS를 측정하도록 통보하고, 상기 단말이 상기 CSI-RS를 측정하여 생성한 제2 채널 정보를 수신하며, 상기 제2 채널 정보에 기반하여 상기 단말에게 데이터를 전송하도록 제어하는 것을 특징으로 하는 기지국.

청구항 15

제13항에 있어서, 상기 제어기는,

상기 단말이 측정하도록 결정된 기준 신호 정보를 비트 형식으로 지시하는 기준 신호 측정 정보를 생성하여 상기 단말에 통보하는 것을 특징으로 하는 기지국.

청구항 16

제15항에 있어서, 상기 기준 신호 측정 정보는,

상위 시그널링 또는 물리계층 시그널링을 통해 상기 단말에게 전송되는 것을 특징으로 하는 기지국.

청구항 17

제13항에 있어서, 상기 제어기는,

간섭 측정 자원을 상기 단말에게 통보하거나 또는 복수 개의 피드백을 상기 단말에게 통보하고, 상기 단말이 CSI-RS를 측정하여 생성한 제3 채널 정보를 상기 단말로부터 수신하도록 제어하는 것을 특징으로 하는 기지국.

청구항 18

제13항에 있어서, 상기 제어기는,

특정 프리코더가 적용된 데이터를 상기 단말에 전송하도록 제어하며,

상기 프리코더는, 상기 프리코더가 속한 집합 및 각 서브밴드에 적용될 프리코더가 미리 결정된 것을 특징으로 하는 기지국.

청구항 19

분산 안테나를 사용하는 복수 개의 기지국을 포함하는 이동통신 시스템에서 하향링크를 측정하여 보고하는 단말에 있어서,

기지국으로부터 전송되는 기준 신호 측정 정보 또는 데이터를 수신하고, 상기 단말이 측정한 채널 측정 정보를 상기 기지국으로 전송하는 송수신부; 및

상기 단말의 RI/PMI 보고 불능 설정 여부에 대한 정보를 기지국으로부터 수신하고, 상기 RI/PMI 보고 불능 설정 시 CRS 또는 CSI-RS 중 상기 단말이 측정하도록 결정된 기준 신호에 대한 정보를 상기 기지국으로부터 수신하며, 상기 결정된 기준 신호를 측정하여 제1 채널 정보를 생성하고 상기 기지국으로 전송하며, 상기 제1 채널 정보에 기반하여 전송되는 데이터를 상기 기지국으로부터 수신하도록 제어하는 제어기를 포함하는 것을 특징으로 하는 단말.

청구항 20

제19항에 있어서, 상기 제어기는,

상기 단말의 RI/PMI 보고 설정 시 상기 CSI-RS를 측정하여 제2 채널 정보를 생성하고, 상기 생성된 제2 채널 정보를 상기 기지국으로 전송하도록 제어하는 것을 특징으로 하는 단말.

청구항 21

제19항에 있어서, 상기 제어기는,

상기 단말이 측정하도록 결정된 기준 신호 정보를 비트 형식으로 지시하는 기준 신호 측정 정보를 수신하는 것을 특징으로 하는 단말.

청구항 22

제21항에 있어서, 상기 기준 신호 측정 정보는,

상위 시그널링 또는 물리계층 시그널링을 통해 상기 기지국으로부터 수신되는 것을 특징으로 하는 단말.

청구항 23

제19항에 있어서, 상기 제어기는,

상기 기지국으로부터 간섭 측정 자원을 통보받거나 또는 복수 개의 피드백을 보고하도록 통보받는 경우 상기 CSI-RS를 측정하여 제3 채널 정보를 생성하고, 상기 생성된 제3 채널 정보를 상기 기지국으로 전송하도록 제어하는 것을 특징으로 하는 단말.

청구항 24

제19항에 있어서, 상기 제어기는,

특정 프리코더가 적용된 데이터를 상기 기지국으로부터 수신하도록 제어하며,

상기 프리코더는, 상기 프리코더가 속한 집합 및 각 서브밴드에 적용될 프리코더가 미리 결정된 것을 특징으로 하는 단말.

명 세 서

기 술 분 야

[0001] 본 발명은 분산 안테나를 사용하는 복수 개의 기지국을 포함하는 무선통신 시스템에서 기준 신호 측정 방법 및 장치에 관한 것이다. 보다 구체적으로, 본 발명에서는 복수 개의 기지국이 존재하는 이동통신 시스템에서 각 기지국이 운용하는 안테나가 해당 기지국의 서비스 영역에 분산되어 배치되어 있는 분산 안테나 시스템(Distributed Antenna System: DAS)에서 하향링크에서 효과적인 통신을 위하여 단말에서 간섭측정을 수행하는 방법을 제안한다.

배 경 기 술

[0002] 이동통신 시스템은 초기의 음성 위주의 서비스를 제공하던 것에서 벗어나 데이터 서비스 및 멀티미디어 서비스 제공을 위해 고속, 고품질의 무선 패킷 데이터 통신 시스템으로 발전하고 있다. 최근 3GPP의 HSDPA(High Speed Downlink Packet Access), HSUPA(High Speed Uplink Packet Access), LTE (Long Term Evolution), LTE-A (Long Term Evolution Advanced), 3GPP2의 HRPD(High Rate Packet Data), 그리고 IEEE의 802.16 등 다양한 이동 통신 표준이 고속, 고품질의 무선 패킷 데이터 전송 서비스를 지원하기 위해 개발되었다. 특히 LTE 시스템은 고속 무선 패킷 데이터 전송을 효율적으로 지원하기 위하여 개발된 시스템으로 다양한 무선접속 기술을 활용하여 무선시스템 용량을 최대화한다. LTE-A 시스템은 LTE 시스템의 진보된 무선시스템으로 LTE와 비교하여 향상된 데이터 전송능력을 가지고 있다.

[0003] 상기 LTE는 일반적으로 3GPP 표준단체의 Release 8 또는 9에 해당하는 기지국 및 단말 장비를 의미하며 LTE-A는 3GPP 표준단체의 Release 10에 해당하는 기지국 및 단말 장비를 의미한다. 3GPP 표준단체에서는 LTE-A 시스템의 표준화 이후에도 이를 기반으로 하며 향상된 성능을 갖는 후속 Release에 대한 표준화를 진행하고 있다.

[0004] HSDPA, HSUPA, HRPD, LTE/LTE-A 등의 현존하는 3세대 및 4세대 무선 패킷 데이터 통신 시스템은 전송 효율을 개선하기 위해 적응 변조 및 부호(Adaptive Modulation and Coding, 이하 AMC) 방법과 채널 감응 스케줄링 방법 등의 기술을 이용한다. 상기의 AMC 방법을 활용하면 송신기는 채널 상태에 따라 전송하는 데이터의 양을 조절할 수 있다. 즉 채널 상태가 좋지 않으면 전송하는 데이터의 양을 줄여서 수신 오류 확률을 원하는 수준에 맞추고, 채널 상태가 좋으면 전송하는 데이터의 양을 늘려서 수신 오류 확률은 원하는 수준에 맞추면서도 많은 정보를 효과적으로 전송할 수 있다. 상기의 채널 감응 스케줄링 자원 관리 방법을 활용하면 송신기는 여러 사용자 중에서 채널 상태가 우수한 사용자를 선택적으로 서비스하기 때문에 한 사용자에게 채널을 할당하고 서비스해주는 것에 비해 시스템 용량이 증가한다. 이와 같은 용량 증가를 소위 다중 사용자 다이버시티(Multi-user

Diversity) 이득이라 한다. 요컨대 상기의 AMC 방법과 채널 감응 스케줄링 방법은 수신기로부터 부분적인 채널 상태 정보를 피드백(feedback) 받아서 가장 효율적이라고 판단되는 시점에 적절한 변조 및 부호 기법을 적용하는 방법이다.

[0005] 상기와 같은 AMC 방법은 MIMO (Multiple Input Multiple Output) 전송방식과 함께 사용될 경우 전송되는 신호의 spatial layer의 개수 또는 rank를 결정하는 기능도 포함할 수 있다. 이 경우 AMC 방법은 최적의 data rate를 결정하는데 단순히 부호화율과 변조방식만을 생각하지 않고 MIMO를 이용하여 몇 개의 layer로 전송할지도 고려하게 된다.

[0006] 최근 2세대와 3세대 이동 통신 시스템에서 사용되던 다중 접속 방식인 CDMA (Code Division Multiple Access)을 차세대 시스템에서 OFDMA(Orthogonal Frequency Division Multiple Access)으로 전환하려는 연구가 활발히 진행되고 있다. 3GPP와 3GPP2는 OFDMA를 사용하는 진화 시스템에 관한 표준화를 진행하기 시작하였다. CDMA 방식에 비해 OFDMA 방식에서 용량 증대를 기대할 수 있는 것으로 알려져 있다. OFDMA 방식에서 용량 증대를 낳는 여러 가지 원인 중의 하나가 주파수 축 상에서의 스케줄링(Frequency Domain Scheduling)을 수행할 수 있다는 것이다. 채널이 시간에 따라 변하는 특성에 따라 채널 감응 스케줄링 방법을 통해 용량 이득을 얻었듯이 채널이 주파수에 따라 다른 특성을 활용하면 더 많은 용량 이득을 얻을 수 있다.

[0007] 도 1은 LTE/LTE-A 시스템에서 시간 및 주파수 자원을 도시하는 도면이다.

[0008] 도 1에서 도시되는 바와 같이, eNB가 단말에게 전송하는 무선자원은 주파수 축 상에서는 RB (resource block) 단위로 나누어지며 시간 축 상에서는 서브프레임(subframe) 단위로 나누어진다. 상기 RB는 LTE/LTE-A 시스템에서 일반적으로 12개의 부반송파로 이루어지며 180kHz의 대역을 차지한다.

[0009] 반면 서브프레임은 LTE/LTE-A 시스템에서 일반적으로 14개의 OFDM 심볼구간으로 이루어지며 1 msec의 시간구간을 차지한다. LTE/LTE-A 시스템은 스케줄링을 수행함에 있어서 시간축에서는 서브프레임 단위로 자원을 할당할 수 있으며 주파수축에서는 RB 단위로 자원을 할당할 수 있다.

[0010] 도 2는 LTE/LTE-A 시스템에서 하향링크로 스케줄링 할 수 있는 최소 단위인 1 서브프레임 및 1 RB의 무선자원을 도시하는 도면이다.

[0011] 도 2에서 도시되는 바와 같이, 무선자원은 시간축 상에서 한 개의 서브프레임으로 이루어지며 주파수축상에서 한 개의 RB로 이루어진다. 이와 같은 무선자원은 주파수 영역에서 12개의 서브캐리어(subcarrier)(또는, 부반송파)로 이루어지며 시간영역에서 14개의 OFDM 심볼로 이루어져서 총 168개의 고유 주파수 및 시간 위치 갖도록 한다. LTE/LTE-A에서는 상기 도 2의 각각의 고유 주파수 및 시간 위치를 RE (resource element)라 한다.

[0012] 상기 도 2에 도시된 무선자원에는 다음과 같은 복수개의 서로 다른 종류의 신호가 전송될 수 있다.

[0013] 1. CRS (셀 특정 기준 신호, Cell Specific RS): 한 개의 셀(cell)에 속한 모든 단말을 위하여 주기적으로 전송되는 기준신호이며 복수개의 단말들이 공통적으로 이용할 수 있다.

[0014] 2. DMRS (복조 기준 신호, Demodulation Reference Signal): 특정 단말을 위하여 전송되는 기준신호이며 해당 단말에게 데이터를 전송할 경우에만 전송된다. DMRS는 총 8개의 DMRS 포트(port)들로 이루어질 수 있다. LTE/LTE-A에서는 port 7에서 port 14까지 DMRS port에 해당하며 port들은 CDM또는 FDM을 이용하여 서로 간섭을 발생시키지 않도록 직교성(orthogonality)을 유지한다.

[0015] 3. PDSCH (물리 하향링크 공유 채널, Physical Downlink Shared Channel): 하향링크로 전송되는 데이터 채널로 기지국이 단말에게 트래픽을 전송하기 위하여 이용하며 상기 도 2의 데이터 영역(data region)에서 기준신호가 전송되지 않는 RE를 이용하여 전송됨

[0016] 4. CSI-RS (채널 상태 정보 기준 신호, Channel Status Information Reference Signal): 한 개의 cell에 속한 단말들을 위하여 전송되는 기준신호를 채널상태를 측정하는데 이용됨. 한 개의 셀에는 복수개의 CSI-RS가 전송될 수 있음.

[0017] 5. 기타 제어채널 (PHICH, PCFICH, PDCCH): 단말이 PDSCH를 수신하는데 필요한 제어정보를 제공하거나 상향링크의 데이터 송신에 대한 HARQ를 운용하기 위한 ACK/NACK 전송

[0018] 상기 신호 외에 LTE-A 시스템에서는 다른 기지국의 전송하는 CSI-RS가 해당 셀의 단말들에게 간섭없이 수신될 수 있도록 뮤팅(muting)을 설정할 수 있다. 상기 muting은 CSI-RS가 전송될 수 있는 위치에서 적용될 수 있으며 일반적으로 단말은 해당 무선 자원을 건너뛰어 트래픽 신호를 수신한다. LTE-A 시스템에서 뮤팅은 또 다른 용어로 0 전력 CSI-RS((zero-power CSI-RS)라고 불리기도 한다. 뮤팅의 특성상 CSI-RS의 위치에 적용되며 전송전력이 송신되지 않기 때문이다.

[0019] 상기 도 2에서 도시되는 바와 같이, CSI-RS는 CSI-RS를 전송하는 안테나들 수에 따라 A, B, C, D, E, E, F, G, H, I, J로 표시된 위치의 일부를 이용하여 전송될 수 있다. 또한 뮤팅도 A, B, C, D, E, E, F, G, H, I, J로 표시된 위치의 일부에 적용될 수 있다. 특히 CSI-RS는 전송하는 안테나포트 수에 따라서 2개, 4개, 8개의 RE로 전송될 수 있다.

[0020] 안테나포트수가 2개일 경우 상기 도 2에서 특정 패턴의 절반에 CSI-RS가 전송되며 안테나포트수가 4개일 경우 특정 패턴의 전체에 CSI-RS가 전송되고 안테나포트수가 8개일 경우 두 개의 패턴을 이용하여 CSI-RS가 전송된다.

[0021] 반면 뮤팅의 경우 언제나 한 개의 패턴 단위로 이루어진다. 즉, 뮤팅은 복수개의 패턴에 적용될 수는 있지만 CSI-RS와 위치가 겹치지 않는 경우 한 개의 패턴의 일부에만 적용될 수는 없다. 단, CSI-RS의 위치와 뮤팅의 위치가 겹칠 경우에 한해서 한 개의 패턴의 일부에만 적용될 수 있다.

[0022] 두 개의 안테나포트에 대한 CSI-RS가 전송될 경우 CSI-RS는 시간축에서 연결된 두 개의 RE에서 두 안테나포트의 신호를 전송하며 각 안테나포트의 신호는 직교코드로 구분된다. 또한 네 개의 안테나포트에 대한 CSI-RS가 전송될 경우 두 개의 안테나포트를 위한 CSI-RS에 추가로 두 개의 RE를 더 이용하여 동일한 방법으로 추가로 두 개의 안테나포트에 대한 신호를 전송한다. 8개의 안테나포트에 대한 CSI-RS가 전송될 경우도 마찬가지이다.

[0023] 셀룰러 시스템에서 하향링크 채널 상태를 측정하기 위하여 기지국은 단말에게 기준신호 (reference signal, RS)를 전송해야 한다. 3GPP의 LTE-A (Long Term Evolution Advanced) 시스템의 경우 기지국이 전송하는 CRS 또는 CSI-RS (Channel Status Information Reference Signal)를 이용하여 단말은 기지국과 자신 사이의 채널 상태를 측정한다.

[0024] 상기 채널 상태는 기본적으로 몇 가지 요소가 고려되어야 하며 여기에는 하향링크에서의 간섭량이 포함된다. 상기 하향링크에서의 간섭량은 인접 기지국에 속한 안테나 의하여 발생되는 간섭신호 및 열잡음 등이 포함되며 단말이 하향링크의 채널 상황을 판단하는데 중요하다. 한 예로 송신안테나가 한 개인 기지국에서 수신안테나가 한 개의 단말로 전송할 경우 단말은 기지국에서 수신된 기준신호에서 하향링크로 수신할 수 있는 심볼당 에너지와 해당 심볼을 수신하는 구간에서 동시에 수신될 간섭량을 판단하여 Es/Io를 결정해야 한다. 결정된 Es/Io는 기지국으로 통보되어 기지국이 하향링크로 단말에게 어떤 데이터 전송속도로 전송을 수행할지를 판단할 수 있게 한다.

[0025] 일반적인 이동통신 시스템의 경우 각 셀의 중간 지점에 기지국 장비가 배치되며 해당 기지국 장비는 한정된 장소에 위치한 한 개 또는 복수개의 안테나를 이용하여 단말과 이동통신을 수행한다. 상기와 같이 한 개의 셀에 속한 안테나들이 동일한 위치에 배치된 이동통신 시스템을 CAS(Centralized Antenna System)이라고 한다. 반면 한 개의 셀에 속한 안테나(RRH: Remote Radio Head)들이 셀 내의 분산된 위치에 배치된 이동통신 시스템을 DAS (Distributed Antenna System: 분산안테나 시스템)이라고 한다.

[0026] 도 3은 일반적인 분산안테나 시스템에서 안테나의 분산된 위치에의 배치를 도시하는 도면이다.

[0027] 도 3에서 도시되는 바와 같이, 두 개의 셀 300과 셀 310은 분산안테나 시스템에 해당한다. 셀 300의 경우 다섯 개의 전송지점(transmission point)으로 이루어지며 한 개의 고출력 전송지점(320)과 네 개의 저출력 전송지점(340, 350, 360, 370)들로 이루어진다. 이 경우, 각각의 전송지점은 한 개 또는 복수개의 전송 안테나를 가질 수 있다.

[0028] 상기 고출력 전송지점은 셀영역 에 포함되는 전역에 최소한의 서비스를 제공할 수 있도록 하는 반면 분산된 저출력 전송지점들은 셀 내 제한된 영역에서 제한된 단말들에게 높은 데이터 속도를 기반으로 하는 서비스를 제공할 수 있다. 또한 저출력 전송지점들 및 고출력 전송지점은 330과 같이 모두 중앙제어기에 연결되어 중앙제어기

의 스케줄링 및 무선자원 할당에 따라 동작한다.

[0029] 상기 분산안테나 시스템에서 한 개의 지리적으로 분리된 전송지점 위치에는 한 개 또는 복수개의 안테나들이 배치될 수 있다. 분산안테나 시스템에서 동일한 전송지점에 배치된 안테나 또는 안테나들을 본 발명에서는 안테나 그룹 (RRH group)이라고도 한다. 상기 도 3과 같은 분산안테나 시스템에서 단말은 한 개의 지리적으로 분리된 안테나 그룹에서 신호를 수신하는 반면 나머지 안테나 그룹에서 전송되는 것은 간섭으로 작용한다.

[0030] 도 3과 같은 분산 안테나 시스템에서 CRS를 전송하기 위한 경우 한 개의 셀에 속한 모든 안테나들이 전송에 참여한다. 즉, 한 개의 셀에 속한 모든 안테나는 CRS를 위하여 CRS를 전송하거나 다른 안테나들이 CRS를 전송하는데 간섭을 발생시키지 않도록 CRS가 전송되는 RE 위치에서 다른 신호를 전송하지 않는다. 한 개의 셀에 속한 모든 안테나가 CRS를 위한 신호를 전송하는 경우 CRS를 기반으로 전송되는 데이터 신호는 셀에 속한 모든 안테나에서 전송된다.

[0031] 반면 한 개의 셀에 속한 일부 안테나들만 CRS를 위한 신호를 전송하는 경우 CRS를 위한 신호를 전송하지 않는 안테나들은 다른 안테나들에서 전송되는 CRS에 간섭을 발생시키지 않기 위하여 해당 CRS가 전송되는 RE 위치에서 다른 신호를 전송하지 않는다. 또한 CRS를 기반으로 전송되는 데이터 신호는 CRS를 전송하는 안테나들에서만 전송된다.

[0032] 반면 CSI-RS의 경우 한 개의 셀에 속한 안테나별로 다른 CSI-RS가 전송될 수 있다. 즉, 상기 도 3에서 동일한 CRS가 전송지점 320, 340, 350, 360, 370에서 전송되지만 CSI-RS는 전송지점 320, 340, 350, 360, 370마다 별도의 CSI-RS가 전송될 수 있다. 전송지점마다 다른 CSI-RS를 전송하는 방법으로는 상기 도 2에서 도시화된 복수개의 CSI-RS 전송위치 중 다른 것을 전송지점마다 할당하거나 동일한 전송위치를 이용하여 전송하되 전송지점마다 다른 scrambling을 적용하는 것이 있다.

[0033] LTE-A 시스템의 경우 단말은 하향링크의 채널상태에 대한 정보를 기지국에게 피드백하여 기지국의 하향링크 스케줄링에 활용할 수 있도록 한다. 즉, 단말은 하향링크로 기지국이 전송하는 기준신호를 측정하고 여기에서 추출한 정보를 LTE/LTE-A 표준에서 정의하는 형태로 기지국으로 피드백하는 것이다. LTE/LTE-A에서 단말이 피드백하는 정보로는 크게 다음의 세가지 정보가 있다.

[0034] - RI (랭크 지시자, Rank Indicator): 단말이 현재의 채널상태에서 수신할 수 있는 공간 레이어(spatial layer)의 개수

[0035] - PMI (프리코더 매트릭스 지시자, Precoder Matrix Indicator): 단말이 현재의 채널상태에서 선호하는 프리코딩 매트릭스(precoding matrix)에 대한 지시자

[0036] - CQI (채널 품질 지시자, Channel Quality Indicator): 단말이 현재의 채널상태에서 수신할 수 있는 최대 데이터 전송률 (data rate). CQI는 최대 데이터 전송률과 유사하게 활용될 수 있는 SINR, 최대의 오류정정 부호화율 (code rate) 및 변조 방식, 주파수당 데이터 효율 등으로 대체될 수 도 있음.

[0037] 상기 RI, PMI, CQI는 서로 연관되어 의미를 갖는다. 한 예로 LTE/LTE-A에서 지원하는 프리코딩 매트릭스 (precoding matrix)는 랭크(rank)별로 다르게 정의되어 있다. 때문에 RI가 1의 값을 가질 때 PMI 값 X와 RI가 2의 값을 가질 때 PMI 값 X는 다르게 해석이 된다. 또한 단말이 CQI를 결정할 때에도 자신이 기지국에 통보한 PMI와 X가 기지국에서 적용되었다는 가정을 한다. 즉, 단말이 RI_X, PMI_Y, CQI_Z를 기지국에 통보한 것은 랭크를 RI_X로 하고 프리코딩 을 PMI_Y로 할 때 CQI_Z에 해당하는 데이터 전송률을 해당 단말이 수신할 수 있다고 통보하는 것과 같다. 이와 같이 단말은 CQI를 계산할 때에 기지국에 어떤 전송방식을 수행할 지를 가정하여 해당 전송방식으로 실제 전송을 수행하였을 때 최적화된 성능을 얻을 수 있도록 한다.

[0038] LTE/LTE-A에서는 RI 및 PMI이 없이 CQI만을 피드백시키는 RI/PMI 불능 모드(이하, RI/PMI disabled mode)를 지원한다. 상기 RI/PMI disabled mode가 적용된 단말은 RI 및 PMI를 피드백하지 않고 CQI만을 기지국에게 피드백한다.

[0039] 도 4는 단말의 RI/PMI 보고(reporting)가 인에이블(enabled)된 상태와 RI/PMI reporting이 불능으로 설정(disabled)된 상태의 피드백을 도시하는 도면이다.

[0040] 도 4에서 도시되는 바와 같이, RI/PMI reporting이 enable된 상태에서 단말은 다음과 같이 RI, PMI, CQI를 전송한다.

[0041] - 400, 430의 위치에서 RI를 전송

[0042] - 410, 440의 위치에서 PMI를 전송

[0043] - 420, 450의 위치에서 CQI를 전송

[0044] 반면 RI/PMI가 disable된 상태에서 단말은 RI, PMI를 전송하지 않으며, 다만 CQI만을 460, 470의 위치에서 전송한다. RI/PMI를 disable시키는 것은 단말이 기지국으로 전송해야 하는 피드백 오버헤드를 감소시켜서 상향링크의 시스템 용량을 개선시키는 효과가 있으며 단말이 전송해야 하는 채널상태 정보량이 감소함에 따라 단말의 베터리 소모량을 감소시키는 효과도 있다.

[0045] LTE/LTE-A 시스템에서 RI/PMI reporting이 disable된 경우 단말은 언제나 CRS를 측정하여 CQI를 생성하게 되어 있다.

[0046] 상기에서 언급한 바와 같이 CQI를 생성하기 위해서 단말은 특정 전송방법을 가정해야 한다. LTE/LTE-A 시스템의 경우 RI/PMI가 disable될 경우 단말은 기지국이 두 개의 송신안테나를 가지면 SFBC (Space Frequency Block Code)에 따른 precoding이 적용된다는 가정하에서 CQI를 생성한다. 반면 기지국이 네 개의 송신안테나를 가지면 FSTD (Frequency Shift Time Diversity)에 다른 precoding이 적용된다는 가정하에서 CQI를 생성한다.

[0047] 상기와 같이 LTE/LTE-A에서 RI/PMI reporting이 disable된 경우 단말이 CRS를 측정하여 CQI를 생성하는 방법에는 두 가지의 주요 문제점이 있다.

[0048] <첫 번째 문제점>

[0049] CRS를 측정하기 때문에 상기 도 3과 같은 분산안테나 시스템에 적합하지 않다. CRS는 한 개의 cell내에 포함된 복수의 전송지점에서 동시 전송되기 때문에 CRS를 측정하여 얻어지는 CQI는 cell내의 모든 전송지점에서 동시에 단말에게 PDSCH를 전송하는 경우에만 정확하다. 일반적으로 분산안테나 시스템에서는 단말에게 상대적으로 가까운 전송지점에서만 PDSCH 전송을 수행한다. 이와 같이 가까운 전송지점에서만 PDSCH 전송을 수행할 경우 다른 전송지점들은 또 다른 단말에게 PDSCH 전송을 수행할 수 있기 때문에 시스템의 성능이 향상될 수 있다. 이와 같이 분산안테나 시스템에서 전송지점 별 하향 채널에 대한 정확한 CQI를 생성하기 위해서는 CRS가 아닌 CSI-RS를 측정해야 된다.

[0050] <두 번째 문제점>

[0051] CRS는 최대 4개의 송신안테나까지만 지원된다. 때문에 전송지점별 CRS 안테나 수가 2개 또는 4개일 때는 상기에서 언급한 바와 같이 SFBC 또는 FSTD에 따른 프리코딩 이 적용되지만 분산안테나 시스템에서 각 전송지점은 최대 8개의 안테나를 이용할 수 있다. 한 개의 전송지점이 8개의 안테나를 가질 경우 적용할 프리코딩이 정의되지 않았기 때문에 문제가 된다. 또한 상기의 SFBC 및 FSTD의 경우 CRS에 대해서만 정의되어 있기 때문에 CSI-RS에 적용하기에 어렵다.

[0052] 종래 기술에서 단말의 RI/PMI 보고가 불능(RI/PMI reporting이 disable)으로 설정된 경우에 CRS가 아닌 CSI-RS를 측정하여 CQI를 생성하는 방법으로 상기의 문제점을 해결할 수 있다.

[0053] 하지만 상기의 CRS를 측정하여 발생하는 문제는 종래 LTE/LTE-A 이동통신 시스템에서 언제나 발생되는 문제가 아닌 분산안테나 시스템이 구축되어 있을 경우에만 발생한다. 즉, 분산안테나 시스템이 구축되지 않았다면 단말은 RI/PMI reporting이 disable된 경우에 CRS를 측정하여 CQI를 생성하는 것이 시스템 성능관점에서 유리할 수 있다. 하지만 단말은 분산안테나 시스템이 구축되었는지 구축되지 않았는지 스스로 판단할 수 없기 때문에 독자적으로 CRS 또는 CSI-RS를 선택하여 측정할 수는 없다.

발명의 내용

해결하려는 과제

[0054] 본 발명의 목적은 LTE-A 시스템을 기반으로 하는 분산안테나 시스템에서 RI/PMI 보고가 불능으로 설정된 경우 정확한 CQI를 생성할 수 있도록 단말이 측정할 기준 신호를 기지국이 선택하여 단말에게 통보하는 방법 및 장치를 제공함에 있다. 또한 RI/PMI 보고가 불능으로 설정된 경우 단말이 CQI를 생성하기 위하여 가정하는 기지국의

전송방법을 정의한다.

과제의 해결 수단

[0055] 상기와 같은 문제점을 해결하기 위한 본 발명의 분산 안테나를 사용하는 복수 개의 기지국을 포함하는 이동통신 시스템에서 기준신호 측정 정보를 기지국이 단말에 통보하는 방법은 상기 단말의 RI/PMI 보고 불능 설정 여부를 결정하는 단계, 상기 단말의 RI/PMI 보고 불능 설정 시 CRS 또는 CSI-RS 중 단말이 측정할 기준 신호를 결정하는 단계, 상기 결정된 기준 신호를 상기 단말에게 통보하는 단계, 상기 결정된 기준 신호를 측정하여 단말이 생성한 제1 채널 정보를 상기 단말로부터 수신하는 단계, 및 상기 제1 채널 정보에 기반하여 상기 단말에게 데이터를 전송하는 단계를 포함하는 것을 특징으로 한다.

[0056] 또한, 본 발명의 분산 안테나를 사용하는 복수 개의 기지국을 포함하는 이동통신 시스템에서 단말의 하향링크 측정 방법은 상기 단말의 RI/PMI 보고 불능 설정 여부에 대한 정보를 기지국으로부터 수신하는 단계, 상기 RI/PMI 보고 불능 설정 시, CRS 또는 CSI-RS 중 상기 단말이 측정하도록 결정된 기준 신호에 대한 정보를 상기 기지국으로부터 수신하는 단계, 상기 결정된 기준 신호를 측정하여 제1 채널 정보를 생성하고 상기 기지국으로 전송하는 단계, 및 상기 제1 채널 정보에 기반하여 전송되는 데이터를 상기 기지국으로부터 수신하는 단계를 포함하는 것을 특징으로 한다.

[0057] 또한, 본 발명의 분산 안테나를 사용하는 복수 개의 기지국을 포함하는 이동통신 시스템에서 기준 신호 측정 정보를 단말에 통보하는 기지국은 상기 기준 신호 측정 정보 또는 데이터를 상기 단말에 전송하고, 상기 단말로부터 전송되는 채널 측정 정보를 수신하는 송수신부, 및 상기 단말의 RI/PMI 보고 불능 여부를 결정하고, 상기 단말의 RI/PMI 보고 불능 결정 시 CRS 또는 CSI-RS 중 단말이 측정할 기준 신호를 결정하며, 상기 결정된 기준 신호를 상기 단말에게 통보하고, 상기 결정된 기준 신호를 측정하여 단말이 생성한 제1 채널 정보를 상기 단말로부터 수신하며, 상기 제1 채널 정보에 기반하여 상기 단말에게 데이터를 전송하도록 제어하는 제어기를 포함하는 것을 특징으로 한다.

[0058] 그리고 본 발명의 분산 안테나를 사용하는 복수 개의 기지국을 포함하는 이동통신 시스템에서 하향링크를 측정하여 보고하는 단말은 기지국으로부터 전송되는 기준 신호 측정 정보 또는 데이터를 수신하고, 상기 단말이 측정한 채널 측정 정보를 상기 기지국으로 전송하는 송수신부, 및 상기 단말의 RI/PMI 보고 불능 설정 여부에 대한 정보를 기지국으로부터 수신하고, 상기 RI/PMI 보고 불능 설정 시 CRS 또는 CSI-RS 중 상기 단말이 측정하도록 결정된 기준 신호에 대한 정보를 상기 기지국으로부터 수신하며, 상기 결정된 기준 신호를 측정하여 제1 채널 정보를 생성하고 상기 기지국으로 전송하며, 상기 제1 채널 정보에 기반하여 전송되는 데이터를 상기 기지국으로부터 수신하도록 제어하는 제어부를 포함하는 것을 특징으로 한다.

발명의 효과

[0059] 본 발명의 실시예에 따르면 LTE-A 시스템을 기반으로 하는 분산안테나 시스템에서 RI/PMI 보고가 불능으로 설정된 경우 단말이 측정할 기준 신호를 기지국이 선택하여 단말에게 통보해준다. 이에 따라, 단말은 종래 시스템에서보다 보다 정확한 채널 측정 정보를 생성하여 기지국으로 피드백해줄 수 있다.

도면의 간단한 설명

[0060] 도 1은 LTE/LTE-A 시스템에서 시간 및 주파수 자원을 도시하는 도면.

도 2는 LTE/LTE-A 시스템에서 하향링크로 스케줄링 할 수 있는 최소 단위인 1 서브프레임 및 1 RB의 무선자원을 도시하는 도면.

도 3은 일반적인 분산안테나 시스템에서 안테나의 분산된 위치에의 배치를 도시하는 도면.

도 4는 단말의 RI/PMI 보고(reporting)가 인에이블(enabled)된 상태와 RI/PMI reporting이 불능으로 설정(disabled)된 상태의 피드백을 도시하는 도면.

도 5는 CRS를 측정하여 얻어지는 무선채널에 대한 CQI와 전송지점별 CSI-RS를 측정하여 얻어지는 무선채널에 대한 CQI를 비교하는 도면.

도 6은 상기 도 5의 분산안테나 시스템에서 CRS를 이용하여 CQI를 측정할 경우 발생하는 부정확한 CQI의 문제를 도시하는 도면.

도 7은 본 발명에서 제안하는 분산안테나 시스템에서 RI/PMI reporting이 disable된 상태에서 단말에게 어떤 RS를 이용하여 하향링크를 측정할지를 통보하는 기지국의 동작 순서를 도시하는 순서도.

도 8은 본 발명에서 제안하는 분산안테나 시스템에서 RI/PMI reporting이 disable된 상태에서 단말이 어떤 RS를 이용하여 하향링크를 측정할지를 판단하는 동작을 순서도로 도시한 도면.

도 9는 단말과 기지국이 주파수 영역에서 복수개의 프리코딩이 번갈아 가며 적용되는 실시예를 도시하는 도면.

도 10은 프리코더 후보집합에 포함된 프리코딩 들이 한 개의 서브프레임 내의 한 개의 RB 내에서 번갈아가며 적용되는 것을 도시하는 도면.

도 11은 본 발명의 실시예에 따른 기지국의 내부 구조를 도시하는 블록도.

도 12는 본 발명의 실시예에 따른 단말의 내부 구조를 도시하는 블록도.

도 13은 본 발명에서 제안하는 공간 시간/주파수 블록 코드의 적용을 위한 단말 수신기에서의 안테나 가상화를 설명하기 위한 도면

발명을 실시하기 위한 구체적인 내용

[0061] 이하 본 발명의 실시예를 첨부한 도면과 함께 상세히 설명한다. 또한 본 발명을 설명함에 있어서 관련된 공지 기능 혹은 구성에 대한 구체적인 설명이 본 발명의 요지를 불필요하게 흐릴 수 있다고 판단된 경우 그 상세한 설명은 생략한다. 그리고 후술되는 용어들은 본 발명에서의 기능을 고려하여 정의된 용어들로서 이는 사용자, 운용자의 의도 또는 관례 등에 따라 달라질 수 있다. 그러므로 그 정의는 본 명세서 전반에 걸친 내용을 토대로 내려져야 할 것이다.

[0062] 또한, 본 발명의 실시예들을 구체적으로 설명함에 있어서, OFDM 기반의 무선통신 시스템, 특히 3GPP EUTRA 표준을 주된 대상으로 할 것이지만, 본 발명의 주요한 요지는 유사한 기술적 배경 및 채널형태를 가지는 여타의 통신 시스템에도 본 발명의 범위를 크게 벗어나지 아니하는 범위에서 약간의 변형으로 적용 가능하며, 이는 본 발명의 기술분야에서 숙련된 기술적 지식을 가진 자의 판단으로 가능할 것이다.

[0063] 도 5는 CRS를 측정하여 얻어지는 무선채널에 대한 CQI와 전송지점별 CSI-RS를 측정하여 얻어지는 무선채널에 대한 CQI를 비교하는 도면이다.

[0064] 도 5에서 도시되는 바와 같이, cell 500의 경우 단말 (UE1)은 CRS를 측정하여 CQI를 생성한다. CRS는 cell내에 속한 모든 전송지점에서 동시에 전송되는 신호이기 때문에 단말이 CRS를 측정하여 CQI를 발생할 경우 해당 CQI에 맞는 PDSCH를 전송하기 위해서는 PDSCH 역시 모든 전송지점에서 송신되어야 한다. 즉, 상기 도 5에서 CRS를 측정하여 얻은 CQI에 따라 PDSCH를 전송하면서 PDSCH를 전송하는 전송지점을 cell내에 있는 특정 전송지점으로 제한시키는 것은 PDSCH 수신 성능을 충분히 보장시키지 못하는 단점을 발생시킨다.

[0065] 도 6은 상기 도 5의 분산안테나 시스템에서 CRS를 이용하여 CQI를 측정할 경우 발생하는 부정확한 CQI의 문제를 도시하는 도면이다.

[0066] 도 6에서 cell 600의 UE1은 상기 도 5에서와 같이 CRS를 측정하여 CQI를 발생하여 기지국에 통보한다. 반면 PDSCH는 한 개의 전송지점으로부터 수신한다. 도 6에서 도시되는 바와 같이, 분산안테나 시스템에서 CRS를 측정하여 CQI를 생성하고, 이에 대응하여 PDSCH를 한 개의 전송지점으로부터 수신할 경우 기지국에 통보한 CQI가 PDSCH를 전송하는 전송지점과 단말 사이의 무선채널의 상태를 정확히 반영시키지 못하기 때문에 성능을 저하시키게 된다는 문제점이 있다.

[0067] 반면 cell 610의 UE3과 UE4는 분산안테나 시스템에서 CRS가 아닌 전송지점별 CSI-RS를 측정하여 CQI를 생성하였기 때문에 기지국에 통보한 CQI가 PDSCH를 전송하는 각각의 전송지점과 단말 사이의 무선채널의 상태를 정확히 반영시키고 있다.

[0068] 본 발명은 분산안테나 시스템에서 단말의 RI/PMI reporting이 disable된 상기 도 5의 cell 510과 같이 전송지점별 CSI-RS를 측정하도록 하는 방법을 제공한다. 상기에서 언급한 바와 같이 단말이 속한 cell에 분산안테나 시스템이 구축되었느냐 여부에 따라 RI/PMI reporting이 disable되었을 때 CRS 또는 CSI-RS를 선택하여 측정하는

것이 성능관점에서 유리하다.

[0069] 본 발명에서는 단말의 RI/PMI reporting이 disable된 상태에서 단말이 CRS 또는 CSI-RS 중 어느 것을 측정하여 CQI를 생성하여 보고할지 여부에 대한 정보를 기지국이 단말에게 통보하는 방법을 제안한다. 상기 통보 방법은 후술하는 바와 같이 명시적(explicit)으로 통보할 수도 있고, 또는 암묵적(implicit)으로 통보할 수도 있다. 이에 대한 구체적인 설명은 하기 및 해당 부분에서 설명하도록 한다.

[0070] 단말이 측정할 기준 신호의 종류를 명시적으로 통보하는 방법에 대한 일 실시예로, 본 발명에서는 'RS_Switch 비트' 라는 제어정보(이하에서는 기준 신호 측정 정보라는 용어와 혼용하여 사용하기로 한다)를 제안한다.

[0071] 상기 RS_Switch 비트의 값에 따라 단말은 RI/PMI reporting이 disable된 상태에서 CRS 또는 CSI-RS를 측정하여 CQI를 생성한다. 한 예로 RI/PMI reporting이 disable되었을 때 단말은 기지국이 통보한 RS_Switch 비트의 값이 '0' 일 경우 CRS를 측정하여 CQI를 생성하는 반면 RS_Switch 비트의 값이 '1' 일 경우 CSI-RS를 측정하여 CQI를 생성한다. 이와 같은 방법은 LTE/LTE-A 시스템의 릴리즈 10과 그 이후 릴리즈들에서 지원되는 TM9 (Transmission Mode 9)(전송 모드 9)에서 적용될 수 있으며 이후에 추가되는 전송 모드 들에서도 적용될 수 있다.

[0072] 도 7은 본 발명에서 제안하는 분산안테나 시스템에서 RI/PMI reporting이 disable된 상태에서 단말에게 어떤 RS를 이용하여 하향링크를 측정할지를 통보하는 기지국의 동작 순서를 도시하는 순서도이다.

[0073] 도 7에서 도시되는 바와 같이, 기지국은 과정 700과 같이 단말에게 어떤 종류의 피드백을 설정할지를 결정한다. 상기 과정 700에서 고려되는 것 중 하나는 단말의 RI/PMI 보고 불능 설정 여부를 결정(RI/PMI reporting을 disable할지)하는 것을 포함할 수 있다..

[0074] 해당 단말의 RI/PMI reporting을 disable시키지 않는 것으로 과정 710에서 판단할 경우, 기지국은 과정 720과 같이 단말이 CSI-RS를 측정하여 생성한 CSI(RI, PMI, CQI)를 기반으로 PDSCH 전송을 수행한다. 이를 위해, 본 발명의 일 실시예에 따르면, 기지국은 단말의 RI/PMI 보고 설정 시, 상기 단말이 CSI-RS를 측정하도록 통보하고, 이에 대응하여 단말이 상기 CSI-RS를 측정하여 생성한 제2 채널 정보를 수신할 수 있다. 그러면 기지국은 제2 채널 정보에 기반하여 상기 단말에게 데이터 즉, PDSCH를 전송할 수 있다.

[0075] 반면 해당 단말의 RI/PMI reporting을 disable시키는 것으로 과정 710에서 판단할 경우, 기지국은 과정 730에서 해당 단말이 CRS를 측정하여 CQI를 생성시킬지 아니면 CSI-RS를 측정하여 CQI를 생성시킬지를 판단한다.

[0076] 상기 과정 730에서 단말이 CRS를 측정하여 CQI를 생성하는 것으로 기지국이 판단할 경우, 기지국은 과정 740과 같이 RS_Switch 비트(또는, 기준 신호 측정 정보, 이하 동일하다)를 '0' 으로 설정하여 단말에게 통보한다. 그리고 기지국은 과정 760로 진행하여 해당 단말이 CRS를 측정하여 생성한 CQI를 기반으로 PDSCH 전송을 수행한다.

[0077] 반면, 과정 730에서 단말이 CSI-RS를 측정하여 CQI를 생성하는 것으로 판단할 경우, 기지국은 과정 750과 같이 RS_Switch 비트를 '1' 로 설정하여 단말에게 통보한다. 그리고 기지국은 과정 770로 진행하여 해당 단말이 CSI-RS를 측정하여 생성한 CQI를 기반으로 PDSCH 전송을 수행한다.

[0078] 참고로, 기지국이 결정한 기준 신호 종류에 따라 단말이 해당 기준 신호를 측정하여 생성한 CQI를 제1 채널 정보라고 일컬을 수 있다.

[0079] 도 8은 본 발명에서 제안하는 분산안테나 시스템에서 RI/PMI reporting이 disable된 상태에서 단말이 어떤 RS를 이용하여 하향링크를 측정할지를 판단하는 동작을 순서도로 도시한 도면이다.

[0080] 도 8에서 도시되는 바와 같이, 단말은 과정 800과 같이 기지국에서 피드백 설정에 대한 제어정보를 수신한다. 본 발명의 일 실싱예에 따르면, 상기 제어 정보는 상기 단말의 RI/PMI 보고 불능 설정 여부를 포함할 수 있다.

[0081] 과정 810에서, 상기 제어정보를 통해 단말의 RI/PMI reporting이 disable되지 않았을 경우, 단말은 과정 820로 진행하여 CSI-RS를 측정하고 RI/PMI/CQI(제2 채널 정보)를 생성한다. 그리고 단말은 상기 측정 결과인 RI/PMI/CQI를 기지국으로 전송할 수 있다.

[0082] 반면 단말의 RI/PMI가 disable된 경우, 단말은 CRS 또는 CSI-RS 중 상기 단말이 측정하도록 결정된 기준 신호에 대한 정보를 상기 기지국으로부터 수신할 수 있다. 그리고 기지국은 상기 기준 신호에 대한 정보에 포함된 RS_Switch 비트에 따라 어떤 RS를 측정하여 CQI를 생성할지를 결정한다.

[0083] 보다 구체적으로, 단말은 수신한 RS_Switch 비트가 '0' 으로 설정되어 있을 경우 과정 840과 같이 CRS를 측정하여 CQI를 생성한다. 반면 단말은 수신한 RS_Switch 비트가 '1' 로 설정되어 있을 경우 과정 850과 같이 CSI-RS를 측정하여 CQI를 생성한다.

[0084] 참고로, 기지국이 결정한 기준 신호 종류에 따라 단말이 해당 기준 신호를 측정하여 생성한 CQI를 제1 채널 정보라고 일컬을 수 있다.

[0085] 일반적으로 RI/PMI reporting을 enable 또는 disable시킬지 여부는 네트워크의 구현여부에 따라 결정되며 이때 고려될 수 있는 요소 중 하나는 상기에서 언급한 바와 같이 분산안테나 시스템의 구축여부이다. 기지국은 네트워크의 구현에 최선인 RS를 선택하여 그 선택결과를 상기의 RS_Switch 비트를 이용하여 단말에게 통보한다. 상기 RS_Switch 비트는 상위 시그널링 또는 물리계층 시그널링을 이용하여 기지국에서 단말에게 전송된다.

[0086] RS_Switch 비트가 상위 시그널링을 이용하여 단말에게 통보될 경우 시스템 정보의 일부에 포함되어 불특정 다수의 단말에게 방송되는 형태 또는 특정 단말에게만 통보되는 유니캐스트(unicast) 형태로 전송될 수 있다. RS_Switch 비트가 물리계층 시그널링을 이용하여 단말에게 통보될 경우 LTE/LTE-A에서 지원하는 PDCCH 또는 E-PDCCH에 실리어 단말에게 전송될 수 있다.

[0087] 상기에서는 기지국이 RS_Switch 비트를 단말에게 직접적으로 전송하여 어느 RS를 측정하는지를 직접적(명시적, explicit)으로 통보하는 방법에 대하여 설명하였다.

[0088] 본 발명에서 제안하는 또 하나의 방법은 RS_Switch 비트의 전달과 같은 직접적인 지시 정보 없이 다른 제어 정보 또는 시스템 설정 정보를 활용하여 기지국이 단말에게 어느 RS를 사용할지를 간접적(implicit)으로 통보하는 것이다. RS_Switch 비트와 같은 직접적인 지시 정보 없이 어느 RS를 사용할지를 통보할 수 있는 방법으로는 다음의 두 가지가 있다.

[0089] <측정할 RS 종류에 대한 간접통보 방법1>

[0090] LTE/LTE-A 시스템에서 특정 셀(cell)이 분산안테나 시스템으로 구축될 경우 간섭측정을 위하여 별도의 간섭측정 자원이 단말에게 통보된다. 분산안테나 시스템으로 구현되지 않은 종래의 LTE/LTE-A 이동통신 시스템의 경우 단말이 CRS를 이용하여 간섭측정을 수행하지만 분산안테나 시스템에서는 CRS를 이용하여 간섭측정을 수행할 경우 잘못된 간섭량을 측정하게 되기 때문에 기지국이 단말에게 별도의 간섭측정 자원을 통보한다.

[0091] 이와 같은 특징을 활용하여 RS_Switch 비트와 같은 별도의 제어정보를 단말에게 전송할 필요 없이 기지국과 단말은 간섭측정 자원이 단말에게 통보되면 RI/PMI reporting이 disabling되더라도 CSI-RS를 측정하여 CQI를 생성하는 것으로 가정하는 방법을 이용하면 된다.

[0092] 즉, 단말은 RI/PMI reporting이 disabling되더라도 간섭측정 자원에 대한 시그널링을 통보 받은 상태라면 CSI-RS를 측정하여 CQI를 생성하고 기지국인 이를 기반으로 PDSCH를 전송한다. 반면 단말은 RI/PMI reporting이 disable되었지만 간섭측정 자원에 대한 시그널링을 통보 받지 못한 상태라면 CRS를 측정하여 CQI를 생성한다. 이와 같은 방법은 상위 시그널링 오버헤드를 증가시키지 않으면서도 기지국이 단말에게 어떤 RS를 측정할지를 통보할 수 있는 수단을 제공한다.

[0093] < 측정할 RS 종류에 대한 간접통보 방법2>

[0094] LTE/LTE-A 시스템에서 특정 셀(cell)이 분산안테나 시스템으로 구축될 경우 분산된 전송지점들 사이의 협력통신을 위하여 복수개의 피드백을 단말에게 설정할 수 있다. 일반적으로 한 개의 피드백이라 함은 RI/PMI reporting이 disable되지 않은 상태에서는 별도의 RI/PMI/CQI를 의미하며 RI/PMI/CQI가 disable된 상태에서는 별도의 CQI를 의미한다.

[0095] 즉, RI/PMI reporting이 disable된 상태에서 복수개의 피드백이 단말이 설정될 경우 단말은 두 개 이상의 서로 다른 전송지점 또는 간섭상황에 대한 CQI를 기지국으로 통보하도록 설정된다. 이와 같이 분산안테나 시스템에서는 복수개의 피드백이 설정된다는 것을 이용하여 RI/PMI reporting이 disable된 상태에서 RS_Switch 비트와 같은 별도의 제어정보를 단말에게 전송할 필요 없이 단말에게 어떤 RS를 이용할 지를 통보할 수 있다. 즉, 단말은 RI/PMI reporting이 disable된 상태에서 자신에게 복수개의 CQI가 설정될 경우에는 CSI-RS를 측정하여 CQI를 생성한다. 반면 단말은 RI/PMI reporting이 disable된 상태에서 자신에게 한 개의 CQI가 설정될 경우에는 CRS를

측정하여 CQI를 생성한다. 이와 같은 방법은 상위 시그널링 오버헤드를 증가시키지 않으면서도 기지국이 단말에게 어떤 RS를 측정할지를 통보할 수 있는 수단을 제공한다.

[0096] RI/PMI reporting이 disable될 경우 CQI를 단말이 생성하기 위해서 해결해야 하는 또 하나의 문제는 어떤 프리코딩(precoding)을 가정하여 CQI를 계산할 것인가 이다.

[0097] 구체적으로 기지국이 RI/PMI reporting이 disable될 경우 CSI-RS를 측정하여 CQI를 계산하라고 통보하였을 때 복수개의 CSI-RS 안테나 포트들 사이에 적용할 프리코딩이 단말과 기지국 사이에 공유되어야 한다. 상기 프리코딩이 공유되어야 하는 이유는 기지국이 단말이 적용한 프리코딩을 알고 있어야 단말이 요청한 CQI에 해당하는 MCS로 PDSCH를 전송하기 위해서 자신이 어떤 프리코딩을 적용해야 하는지를 알아야 하기 때문이다. 이와 같이 단말이 적용할 프리코딩을 결정하는 방법으로는 다음의 두 가지 방법이 가능할 수 있다.

[0098] <프리코딩 방법1>

[0099] 첫 번째 방법은 특정 프리코딩을 이용할 것을 단말과 기지국이 사전에 약속하는 것이다.

[0100] 이와 같은 특정 프리코딩은 PMI가 지정할 수 있는 복수개의 프리코딩들 중 한가지일 수 있다. 한 예로 기지국과 단말은 CSI-RS가 네 개의 안테나 포트를 가질 경우 $[+0.5\ +0.5\ +0.5\ +0.5]^{T}$이라고 가정하는 것이다. 이외에 기지국과 단말은 복수개의 프리코딩이 주어진 시간 또는 주파수 영역 내에서 번갈아 가며 적용된다고 가정할 수도 있다.

[0101] 도 9는 단말과 기지국이 주파수 영역에서 복수개의 프리코딩이 번갈아 가며 적용되는 실시예를 도시하는 도면이다.

[0102] 도 9에서 도시되는 바와 같이, 단말은 서브밴드(Subband) 0에서 서브밴드(Subband) 4까지 서로 다른 프리코더(precoder)가 적용된다고 가정하고 있다.

[0103] 이와 같은 서브밴드별 프리코딩의 적용은 기지국도 공유하고 있는 것이다. 단말은 상기의 서브밴드별 프리코딩을 가정하고 CQI를 생성한다. 이와 같이 주파수 또는 시간 영역에서 프리코더를 번갈아 가며 적용된다고 가정하고 CQI를 생성하는 것은 특정 한 개의 프리코더만 적용된다고 가정했을 경우와 비교하여 다이버시티(diversity) 효과가 존재한다. 여기서 다이버시티 효과라 함은 복수개의 프리코더를 가정하여 CQI를 단말이 피드백 함으로써 좋지 않은 프리코더 에 대해서만 연속적으로 CQI를 피드백하는 것을 방지하는 것이다.

[0104] 이와 같은 프리코더 다이버시티(precoder diversity)는 실제로 시스템의 성능을 개선시키는 효과가 있다. RI/PMI reporting이 disabling된 상태에서 상기의 프리코더 다이버시티 가 동작하기 위해서는 단말과 기지국 사이에 어떤 집합의 프리코더를 가정할지와 어떤 프리코더를 각 서브밴드에 적용할지를 기지국과 단말에 약속되어 있어야 한다.

[0105] 한 실시예로 기지국은 별도의 시그널링 없이 사전에 약속된 프리코더 집합을 서브밴드 인덱스(subband index)에 따라 각 서브밴드별로 가정할 수 있다. 즉, 서브밴드에 CQI를 생성할 때 가정할 프리코더는 다음의 수학식으로 결정된다.

[0106] <수학식1>

[0107] $\text{precoder index} = \text{subband index modulo } N_{\text{precoder}}$

[0108] 상기 수학식 1에서 N_{precoder}는 프리코더 다이버시티(precoder diversity)에 활용할 프리코더의 개수이다.

[0109] <프리코딩 방법2>

[0110] 단말이 적용할 프리코딩을 결정하기 위한 또 다른 방법에서는 기지국이 상위 시그널링을 이용하여 단말에게 프리코더 집합을 통보하고 단말은 상기의 수학식 1을 이용하여 각 서브밴드별로 어떤 프리코딩을 가정하여 CQI를 생성할지를 결정할 수 있다.

[0111] 상기에서는 주파수 영역에서 프리코딩을 번갈아 가며 가정하는 경우에 대하여 설명하였지만 동일한 방법이 시간 영역에서도 적용될 수 있다.

[0112] <프리코딩 방법3>

[0113] 상기에서는 프리코더 후보집합에 포함된 프리코딩들이 시간 또는 주파수 영역에서 번갈아 가며 적용된다는 가정하에서 단말이 CQI를 생성하였다. 이와 같은 방법외에도 단말은 프리코더 후보집합에 포함된 프리코딩들이 한 개의 subframe의 일부 RE들에서 번갈이 적용된다는 가정하에서 CQI를 생성할 수 있다.

[0114] 도 10은 이와 같이 프리코더 후보집합에 포함된 프리코딩들이 한 개의 서브프레임 내의 한 개의 RB내에서 번갈아 가며 적용되는 것을 도시한 것이다.

[0115] 도 10에서와 같이 단말은 OFDM 심볼마다 프리코더가 번갈아 가며 적용된다는 가정하고 CQI를 생성한다. 상기 도 10에서는 OFDM 심볼마다 프리코더가 번갈아 가며 적용되는 경우를 도시하였지만 이와 같은 방법 외에 한 개의 RB내의 RE들을 임의의 방법으로 복수 개의 그룹으로 나누고 각 그룹마다 프리코더를 번갈아 가며 적용하는 것도 가능하다.

[0116] 상기 프리코딩 방법 3에서 단말은 사전에 설정되어 있는 프리코더 집합 또는 기지국이 통보한 프리코더 집합을 상기 수학식 1과 유사한 방법을 이용하여 한 개의 RB내의 RE들마다 어떤 프리코딩을 가정할지를 판단한다.

[0117] 상기 프리코딩 방법 1, 방법 2, 방법 3 외에도 단말이 각 RE마다 공간 시간/주파수 블록 코드(Space time/frequency block code)를 가정하고 CQI를 생성하는 방법도 가능하다. 공간 시간/주파수 블록 코드(Space time/frequency block code)를 가정하고 CQI를 생성하는 방법에 대해서는 이하에서 구체적으로 기술하도록 한다.

[0118] <프리코딩 방법4>

[0119] Space time/frequency block code를 가정하고 CQI를 생성하는 방법에서는 단말이 시간, 주파수, 안테나 영역에서 규격화되어 있는 부호화 방식을 가정하여 CQI를 생성한다. Space time/frequency block code는 복수 개 무선채널의 효과를 평균화시키는 효과를 얻을 수 있도록 한다.

[0120] 현재 LTE/LTE-A에서 정의하고 있는 space time/frequency block code로는 송신안테나의 개수에 따라 하기의 수학식 2 및 수학식 3에서 도시되는 두 가지 종류의 space time/frequency block code가 적용될 수 있다. 송신안테나의 개수가 두 개일 경우 하기의 수학식 2에서 정의되는 space time/frequency block code가 적용된다.

[0121] <수학식 2>

[0122]
$$\begin{bmatrix} y^{(0)}(2i) \\ y^{(1)}(2i) \\ y^{(0)}(2i+1) \\ y^{(1)}(2i+1) \end{bmatrix} = \frac{1}{\sqrt{2}} \begin{bmatrix} 1 & 0 & j & 0 \\ 0 & -1 & 0 & j \\ 0 & 1 & 0 & j \\ 1 & 0 & -j & 0 \end{bmatrix} \begin{bmatrix} \mathrm{Re}\left(x^{(0)}(i)\right) \\ \mathrm{Re}\left(x^{(1)}(i)\right) \\ \mathrm{Im}\left(x^{(0)}(i)\right) \\ \mathrm{Im}\left(x^{(1)}(i)\right) \end{bmatrix}$$

[0123] 상기 수학식 2에서 y는 부화화된 신호이며 x는 부호화기에 입력되는 신호이다. 또한 i는 부호화기에 입력되는 신호의 순서를 나타내는 인덱스이다. 또한 Re(Z)는 복소수 Z의 실수성분을 의미하며 Im(Z)는 복소수 Z의 허수성분을 의미한다. 또한 $x^{(k)}(i)$ 및 $y^{(k)}(i)$에서 k는 안테나 포트 인덱스에 해당한다.

[0124] 송신안테나의 개수가 네 개일 경우 하기의 수학식 3에서 정의되는 space time/frequency block code가 적용된다.

[0125] <수학식3>

$$\begin{bmatrix} y^{(0)}(4i) \\ y^{(1)}(4i) \\ y^{(2)}(4i) \\ y^{(3)}(4i) \\ y^{(0)}(4i+1) \\ y^{(1)}(4i+1) \\ y^{(2)}(4i+1) \\ y^{(3)}(4i+1) \\ y^{(0)}(4i+2) \\ y^{(1)}(4i+2) \\ y^{(2)}(4i+2) \\ y^{(3)}(4i+2) \\ y^{(0)}(4i+3) \\ y^{(1)}(4i+3) \\ y^{(2)}(4i+3) \\ y^{(3)}(4i+3) \end{bmatrix} = \frac{1}{\sqrt{2}} \begin{bmatrix} 1 & 0 & 0 & 0 & j & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 & 0 & j & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & j & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & -j & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & j & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & -1 & 0 & 0 & 0 & j \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & j \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & -j & 0 \end{bmatrix} \begin{bmatrix} \mathrm{Re}\left(x^{(0)}(i)\right) \\ \mathrm{Re}\left(x^{(1)}(i)\right) \\ \mathrm{Re}\left(x^{(2)}(i)\right) \\ \mathrm{Re}\left(x^{(3)}(i)\right) \\ \mathrm{Im}\left(x^{(0)}(i)\right) \\ \mathrm{Im}\left(x^{(1)}(i)\right) \\ \mathrm{Im}\left(x^{(2)}(i)\right) \\ \mathrm{Im}\left(x^{(3)}(i)\right) \end{bmatrix}$$

[0126]

[0127] LTE/LTE-A 시스템에서 단말이 상기 수학식2 또는 수학식3과 같은 space time/frequency block code를 가정하고 CQI를 생성하는 경우, 발생할 수 있는 문제점은 현재 LTE/LTE-A 시스템의 경우 space time/frequency block code가 두 개 또는 네 개의 송신안테나에 대해서만 정의가 되어 있다는 점이다. 때문에 CSI-RS가 8개의 안테나 포트를 가질 경우 상기와 같은 space time/frequency block code를 가정하고 CQI를 생성하기 위해서는 별도의 방안이 필요하다.

[0128] 상기와 같이 CSI-RS가 8개의 안테나 포트를 가지는 경우에도 space time/frequency block code를 가정하고 CQI를 생성하도록 하기 위해, 본 발명에서는 단말이 자체적으로 안테나 가상화(virtualization)를 수행하는 방안을 제안한다.

[0129] 즉, CSI-RS의 안테나 포트수가 가정해야 하는 space time/frequency block code가 지원하는 송신안테나 수보다 적을 경우, 단말은 안테나 가상화(virtualization)를 통하여 해당 space time/frequency block code에 적합하도록 CSI-RS를 결합할 수 있다. 이하에서는 구체적인 예시를 들어, 단말의 안테나 가상화 방법에 대해 설명하도록 한다.

[0130] 예를 들어, 단말이 상기 수학식 2에서 도시되는 바와 같은 두 개의 안테나를 위한 space time/frequency block code를 이용할 수 있고 CSI-RS는 안테나 포트수가 8개인 경우를 가정한다. 이 경우, 단말은 8개의 안테나 포트를 갖는 CSI-RS를 수신하여 이를 2개의 송신안테나에 대한 수신신호로 안테나 가상화를 수행한다. 단말에서 안테나 가상화를 수행하는 방법은 미리 정해진 규칙에 따라 CSI-RS 안테나포트 별로 수신한 신호를 더하는 것이다. 한 예로, 단말은 CSI-RS 안테나포트 1, 2, 3, 4, 5, 6, 7, 8에 대한 수신신호가 각각 있을 경우 단말은 CSI-RS 안테나포트 1, 2, 3, 4의 수신신호를 결합하여 송신안테나 1에 대한 수신신호를 생성하고 CSI-RS 안테나포트 5, 6, 7, 8의 수신신호를 결합하여 송신안테나 2에 대한 수신신호를 생성한다. 그리고 단말은 상기 수학식 2에 따른 space time/frequency block code를 가정하여 CQI를 생성할 수 있다.

[0131] 또는 단말과 기지국의 약속에 따라, 1, 3, 5, 7의 수신신호를 결합하여 송신안테나 1에 대한 수신신호를 생성하고 CSI-RS 안테나포트 2, 4, 6, 8의 수신신호를 결합하여 송신안테나 2에 대한 수신신호를 생성할 수 도 있다.

[0132] 상기에서 더하기를 수행할 경우 각 안테나별 신호에 단말과 기지국 사이에 약속된 상수 값을 곱한 후 더하기를 수행하는 것도 가능하다.

[0133] 도 13은 본 발명에서 제안하는 공간 시간/주파수 블록 코드의 적용을 위한 단말 수신기에서의 안테나 가상화를 설명하기 위한 도면이다.

[0134] 상기 도 13에서 단말은 8개의 안테나 포트에 대한 CSI-RS를 RE 위치 1300(P1, P2), 1310(P5, P6), 1320(P3, P4), 1330(P7, P8)을 통해 수신한다.

[0135] 단말이 CQI를 생성하기 위하여 가정해야 하는 space time/frequency block code가 두 개의 송신안테나를 지원한

다고 가정할 경우, 단말은 상기 8개의 안테나 포트에 대한 CSI-RS의 수신신호를 안테나 가상화(antenna virtualization)를 통하여 결합하여 두 개의 송신안테나에 대한 수신신호로 변환한다. 즉, 상기 도 13에서 1300, 1310, 1320, 1330의 수신신호를 임의의 규칙에 따라 더하여 두 개의 송신안테나에 대한 수신신호를 생성한다.

[0136] 이 경우, 8개의 안테나 포트에 대한 CSI-RS 수신 신호를 두 개의 송신안테나에 대한 수신신호로 변환하기 위한 일 예로, 수신 신호를 OFDM 심볼 별로 더하는 방법을 고려해볼 수 있다. 상기 도 13에서 1300, 1310, 1320, 1330의 수신신호를 OFDM 심볼 별로 더할 경우, 두 개의 RE에 대한 신호를 얻을 수 있으며 이에 대하여 송신단에서 안테나포트를 구분하기 위하여 이용한 직교코드 두 개로 correlation을 취함으로서 두 개의 안테나포트에 대한 신호를 얻을 수 있다.

[0137] 또한 단말이 CQI를 생성하기 위하여 가정해야 하는 space time/frequency block code가 네 개의 송신안테나를 지원할 경우, 단말은 상기 8개의 안테나 포트에 대한 CSI-RS의 수신신호를 안테나 가상화(antenna virtualization)을 통하여 결합하여 네 개의 송신안테나에 대한 수신신호로 변환한다. 즉, 상기 도 13에서 1300, 1310, 1320, 1330의 수신신호를 사전에 정해진 규칙에 따라 더하여 두 개의 송신안테나에 대한 수신신호를 생성한다.

[0138] 이 경우, 8개의 안테나 포트에 대한 CSI-RS 수신 신호를 네 개의 송신안테나에 대한 수신신호로 변환하기 위한 일 예로, 상기 도 13의 1300, 1310, 1320, 1330을 두 쌍씩 더하여 네 개의 송신안테나에 대한 수신신호를 얻는 방법을 고려해볼 수 있다. 이와 같이 두 쌍씩 더하여 네 개의 송신안테나에 대한 수신신호를 얻는 경우 기지국과 단말은 각 쌍이 어느 위치의 CSI-RS 수신신호를 더하여 얻어지는지를 사전에 약속한대로 수행해야 한다. 즉, 단말과 기지국이 1300과 1320을 더하고 1310과 1330을 더하기로 약속한 경우 단말은 언제나 이와 같은 조합으로 수신신호를 더해야 한다.

[0139] 도 11는 본 발명의 실시예에 따른 기지국의 내부 구조를 도시하는 블록도이다.

[0140] 상기 도 11에서 기지국의 장치 1100인 제어기는 다음의 사항을 결정한다.

[0141] - RI/PMI reporting disable 여부 및 이와 관련된 대한 설정 정보를 단말에게 통보

[0142] - RI/PMI reporting이 disable되었을 경우 CRS와 CSI-RS 중 어느 것을 단말에게 측정하도록 할지 및 이와 관련된 설정 정보를 단말에게 통보

[0143] - RI/PMI reporting이 disable되었을 경우 주파수 및 시간영역에서 어떤 프리코딩을 가정하여 CQI를 생성할지 및 이와 관련된 설정 정보를 단말에게 통보

[0144] 상기의 결정 사항이 이루어지면 제어기 1100은 RI/PMI reporting과 관련된 설정 정보, 어떤 RS를 이용할지에 대한 설정 정보, 어떤 프리코딩 집합을 가정할지 등에 대한 설정 정보를 결정하고 전송신호를 생성한다. 상기 장치 1100에서 생성된 전송신호는 CRS 신호 생성기 1110 및 CSI-RS 신호 생성기 1120에서 생성된 전송신호와 함께 장치 1130 멀티플렉서(multiplexor)에서 주파수영역 또는 시간영역에서 먹싱(muxing)되어 장치 1140의 OFDMA 신호발생기를 이용하여 전송된다.

[0145] 상기한 제어기 1100가 수행하는 동작을 정리하면, 제어기1100는 상기 단말의 RI/PMI 보고 불능 여부를 결정하고, 상기 단말의 RI/PMI 보고 불능 결정 시 CRS 또는 CSI-RS 중 단말이 측정할 기준 신호를 결정하며, 상기 결정된 기준 신호를 상기 단말에게 통보하고, 상기 결정된 기준 신호를 측정하여 단말이 생성한 제1 채널 정보를 상기 단말로부터 수신하며, 상기 제1 채널 정보에 기반하여 상기 단말에게 데이터를 전송하도록 제어할 수 있다.

[0146] 한편, 제어기 1100는 상기 단말의 RI/PMI 보고 결정 시 상기 단말이 CSI-RS를 측정하도록 통보하고, 상기 단말이 상기 CSI-RS를 측정하여 생성한 제2 채널 정보를 수신하며, 상기 제2 채널 정보에 기반하여 상기 단말에게 데이터를 전송하도록 제어할 수 있다.

[0147] 본 발명의 일 실시예에 따르면, 제어기 1100는 상기 단말이 측정하도록 결정된 기준 신호 정보를 비트 형식으로 지시하는 기준 신호 측정 정보를 생성하여 상기 단말에 직접적으로 통보할 수 있다. 이 경우, 제어기 1100는 상위 시그널링 또는 물리계층 시그널링을 통해 상기 기준 신호 측정 정보를 단말에게 전송할 수 있다.

[0148] 한편, 본 발명의 다른 실시예에 따르면, 제어기 1100는 간섭 측정 자원을 상기 단말에게 통보하거나 또는 복수개의 피드백을 상기 단말에게 통보하고, 상기 단말이 CSI-RS를 측정하여 생성한 제3 채널 정보를 상기 단말로부

터 수신하도록 제어할 수도 있다. 이는 단말이 측정할 기준 신호의 종류를 간접적으로 단말에게 통보해주는 실시예에 대한 기술이다.

[0149] 또한, 제어기 1100는 특정 프리코더가 적용된 데이터를 상기 단말에 전송하도록 제어할 수 있다. 이 경우, 상기 프리코더는, 상기 프리코더가 속한 집합 및 각 서브밴드에 적용될 프리코더가 미리 결정된 것일 수 있다.

[0150] 도 12은 본 발명의 실시예에 따른 단말의 내부 구조를 도시하는 블록도이다.

[0151] 단말기는 장치 1200의 OFDMA 수신기를 통하여 기지국으로부터의 무선신호를 수신한다. 수신된 신호는 장치 1210의 디멀티플렉서(demultiplexor)에서 RI/PMI reporting관련 설정정보를 장치 1230의 제어기로 전달한다.

[0152] 상기 장치 1230의 제어기는 RI/PMI reporting이 disable될 경우 설정정보에 따라 어떤 RS를 이용할지, 어떤 프리코딩을 가정하고 CQI를 생성할지 등을 판단한다. 여기서 판단된 결과에 따라, RI/PMI reporting이 disable될 경우 제어기는 장치 1240의 CSI-RS 수신기에서 검출한 CSI-RS에 적절한 프리코딩을 가정하여 장치 1250(CQI 생성기)에서 CQI를 생성하거나 장치 1220의 CRS 수신기에서 검출한 CRS를 이용하여 장치 1250에서 CQI를 생성한다. 또한, RI/PMI reporting이 enable된 경우, 단말은 CSI-RS를 이용하여 장치 1240의 CSI-RS 수신기에서 검출한 CSI-RS를 이용하여 CQI를 장치 1250에서 생성한다.

[0153] 상기한 제어기 1230가 수행하는 동작을 정리하면, 상기 제어기 1230는 단말의 RI/PMI 보고 불능 설정 여부에 대한 정보를 기지국으로부터 수신하고, 상기 RI/PMI 보고 불능 설정 시 CRS 또는 CSI-RS 중 상기 단말이 측정하도록 결정된 기준 신호에 대한 정보를 상기 기지국으로부터 수신한다. 그리고 제어기 1230는 상기 결정된 기준 신호를 측정하여 제1 채널 정보를 생성하고 상기 기지국으로 전송한다. 그리고 제어기 1230는 상기 제1 채널 정보에 기반하여 전송되는 데이터를 상기 기지국으로부터 수신하도록 제어한다.

[0154] 한편, 제어기 1230는 단말의 RI/PMI 보고 설정 시 상기 CSI-RS를 측정하여 제2 채널 정보를 생성하고, 상기 생성된 제2 채널 정보를 상기 기지국으로 전송하도록 제어할 수 있다.

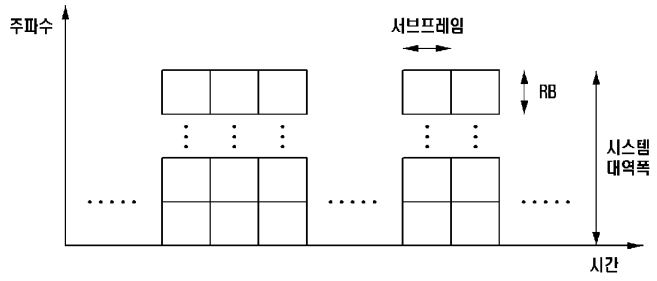
[0155] 본 발명의 일 실시예에 따르면, 제어기 1230는 상기 단말이 측정하도록 결정된 기준 신호 정보를 비트 형식으로 지시하는 기준 신호 측정 정보를 기지국으로부터 명시적으로 수신할 수 있다. 이 경우, 상기 기준 신호 측정 정보는 상위 시그널링 또는 물리계층 시그널링을 통해 상기 기지국으로부터 수신될 수 있다.

[0156] 반면, 본 발명의 다른 실시예에 따르면, 제어기 1230는 기지국으로부터 간섭 측정 자원을 통보받거나 또는 복수개의 피드백을 보고하도록 통보받는 경우, 이를 CSI-RS를 측정하라는 간접적 통보방법으로 인지하고, 상기 CSI-RS를 측정하여 제3 채널 정보를 생성할 수 있다.

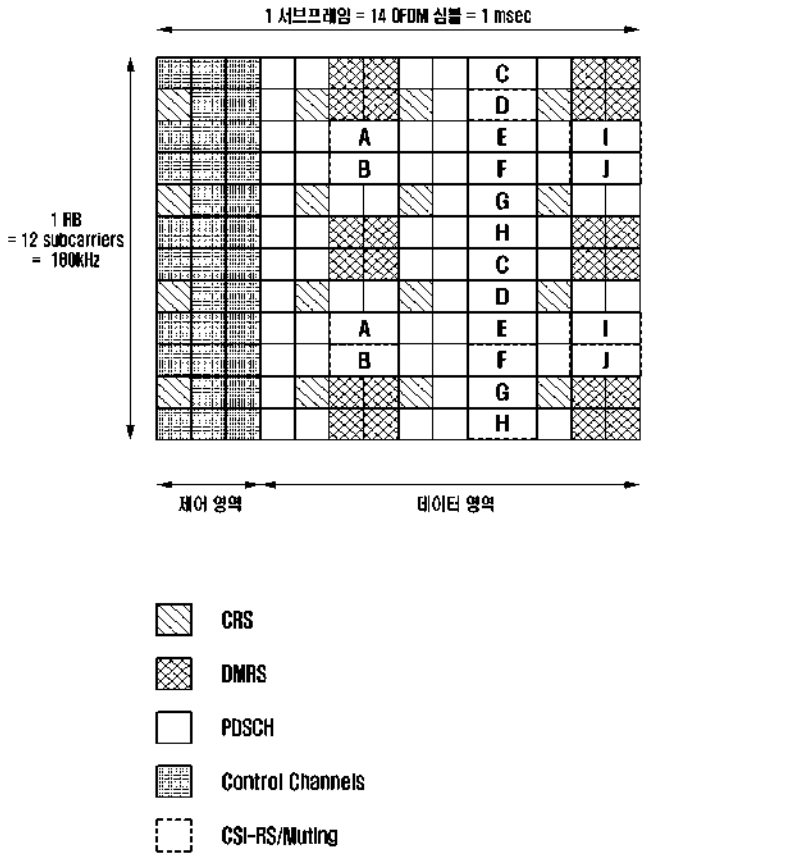
[0157] 본 명세서와 도면에 개시된 본 발명의 실시예들은 본 발명의 기술 내용을 쉽게 설명하고 본 발명의 이해를 돕기 위해 특정 예를 제시한 것일 뿐이며, 본 발명의 범위를 한정하고자 하는 것은 아니다. 여기에 개시된 실시예들 이외에도 본 발명의 기술적 사상에 바탕을 둔 다른 변형 예들이 실시 가능하다는 것은 본 발명이 속하는 기술 분야에서 통상의 지식을 가진 자에게 자명한 것이다.

도면

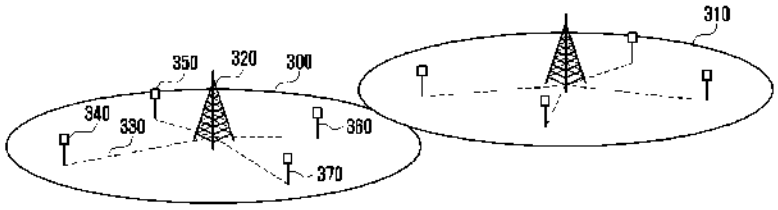
도면1



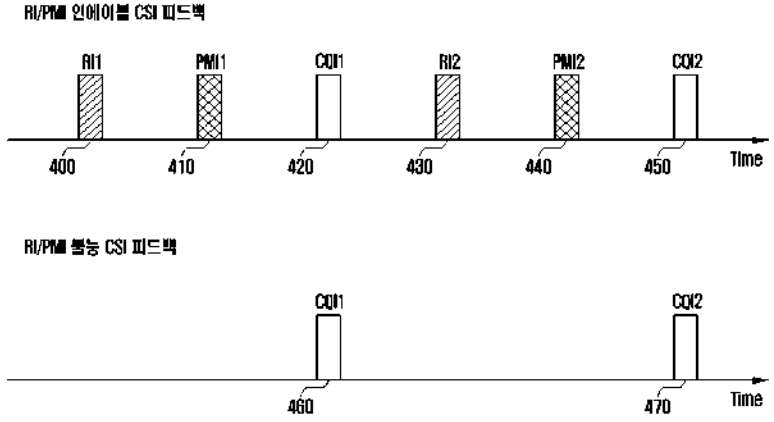
도면8


1 서브프레임 = 14 OFDM 심볼 = 1 msec
1 RB
= 12 subcarriers
= 180kHz
제어 영역
데이터 영역
CRS
DMRS
PDSCH
Control Channels
CSI-RS/Muting

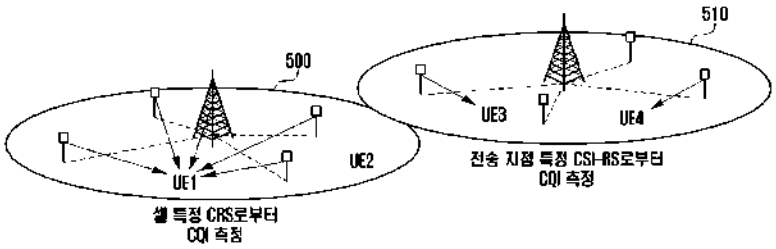
도면9


310
350
320
300
340
330
360
370

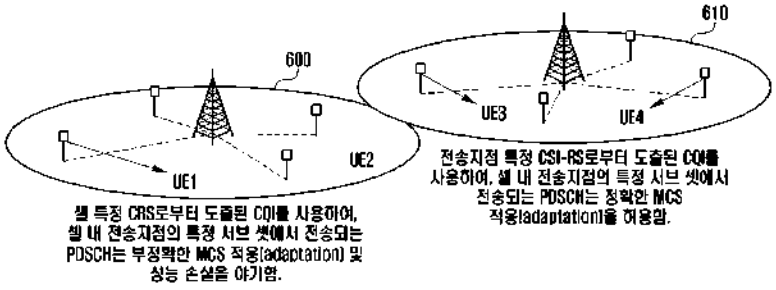
도 4


RI/PMI 인에이블 CSI 피드백
RI1
PMI1
CQI1
RI2
PMI2
CQI2
400
410
420
430
440
450
Time
RI/PMI 디스에이블 CSI 피드백
CQI1
CQI2
460
470
Time

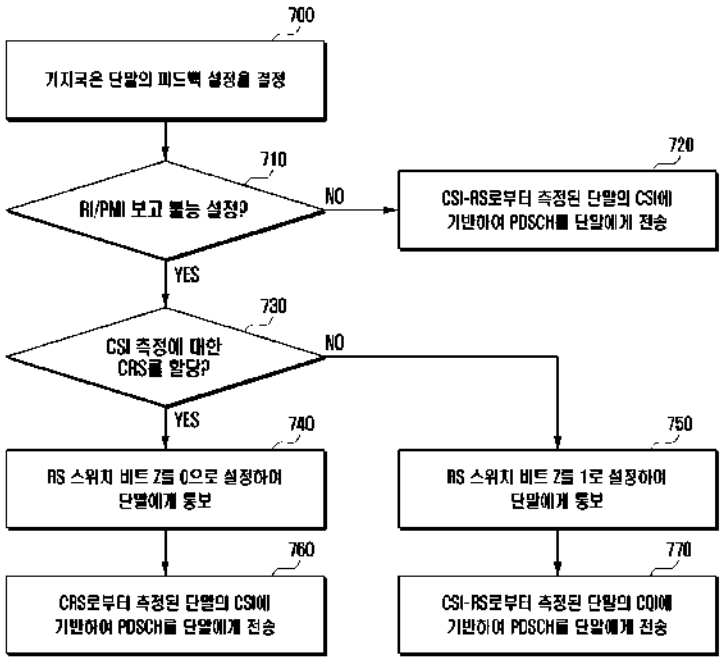
도 5


500
510
UE1
UE2
UE3
UE4
셀 특정 CRS로부터
CQI 측정
전송 지점 특정 CSI-RS로부터
CQI 측정

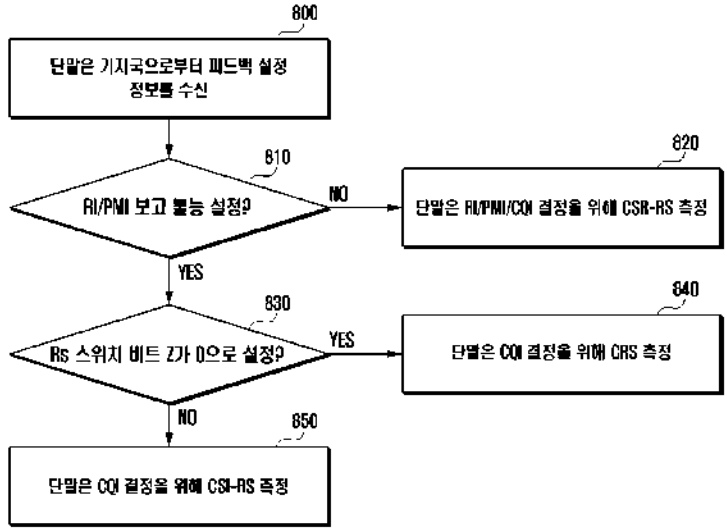
도 6


600
610
UE1
UE2
UE3
UE4
셀 특정 CRS로부터 도출된 CQI를 사용하여,
셀 내 전송지점의 특정 서브 셋에서 전송되는
PDSCH는 부정확한 MCS 적응(adaptation) 및
성능 손실을 야기함.
전송지점 특정 CSI-RS로부터 도출된 CQI를
사용하여, 셀 내 전송지점의 특정 서브 셋에서
전송되는 PDSCH는 정확한 MCS
적응(adaptation)을 허용함.

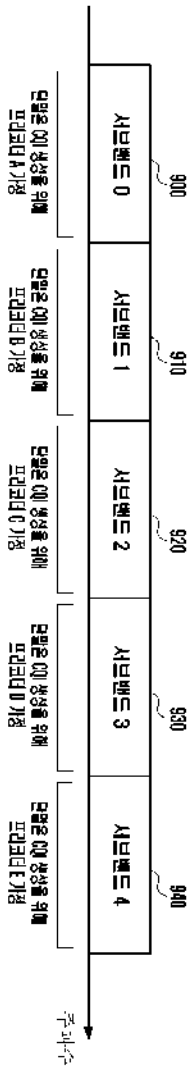
도 17


700
기지국은 단말의 피드백 설정을 결정
710
RI/PMI 보고 불능 설정?
NO
720
CSI-RS로부터 측정된 단말의 CSI에 기반하여 PDSCH를 단말에게 전송
YES
730
CSI 측정에 대한 CRS를 할당?
NO
YES
740
RS 스위치 비트 Z를 0으로 설정하여 단말에게 통보
750
RS 스위치 비트 Z를 1로 설정하여 단말에게 통보
760
CRS로부터 측정된 단말의 CSI에 기반하여 PDSCH를 단말에게 전송
770
CSI-RS로부터 측정된 단말의 CQI에 기반하여 PDSCH를 단말에게 전송

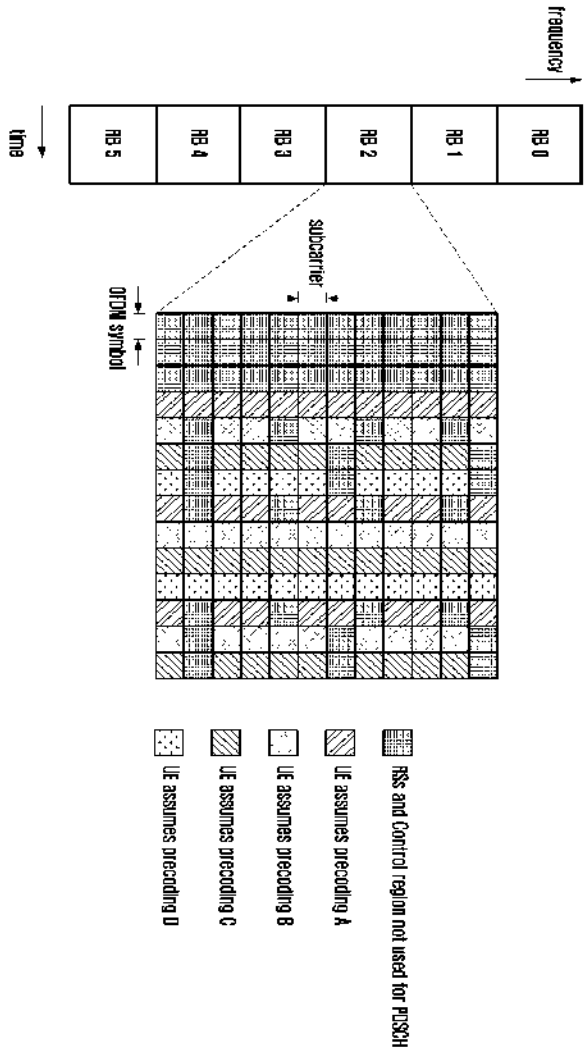
도 18


800
단말은 기지국으로부터 피드백 설정 정보를 수신
810
RI/PMI 보고 불능 설정?
NO
820
단말은 RI/PMI/CQI 결정을 위해 CSR-RS 측정
YES
830
Rs 스위치 비트 Z가 0으로 설정?
YES
840
단말은 CQI 결정을 위해 CRS 측정
NO
850
단말은 CQI 결정을 위해 CSI-RS 측정

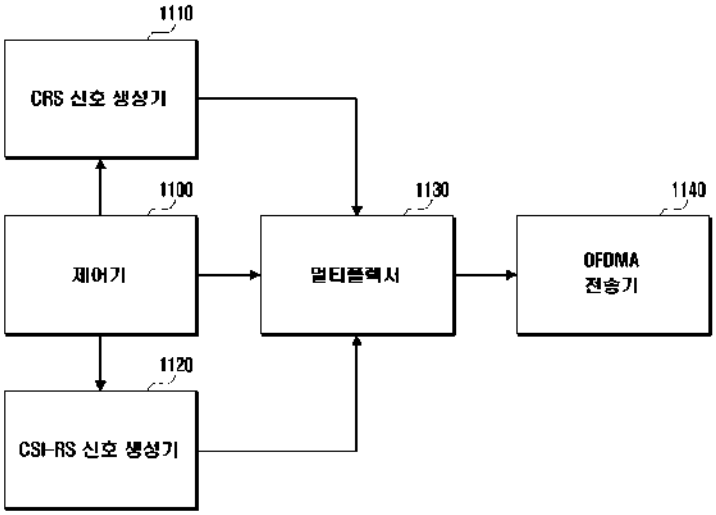
도면


서브프레임 0
서브프레임 1
서브프레임 2
서브프레임 3
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PDSCH 영역
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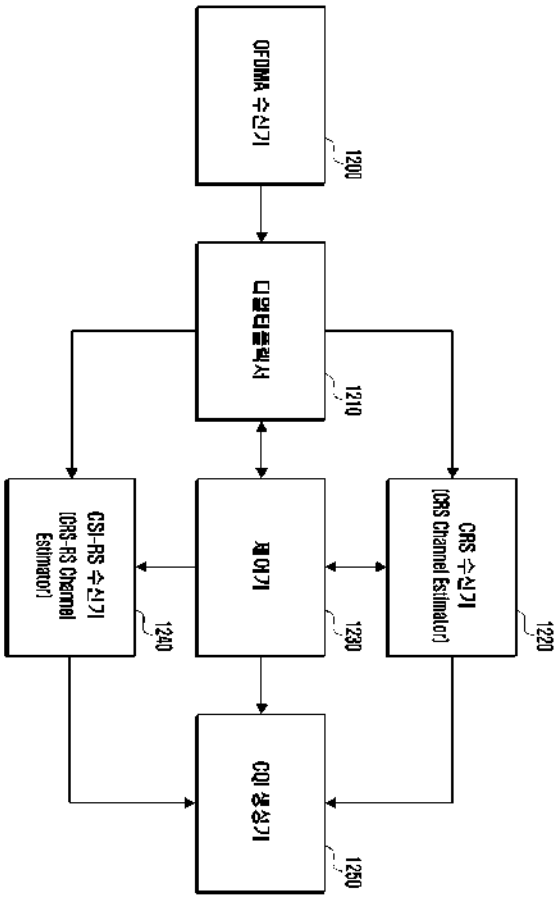
도면10


frequency
time
RB 0
RB 1
RB 2
RB 3
RB 4
RB 5
subcarrier
OFDM symbol
RSs and Control region not used for PDSCH
UE assumes precoding A
UE assumes precoding B
UE assumes precoding C
UE assumes precoding D

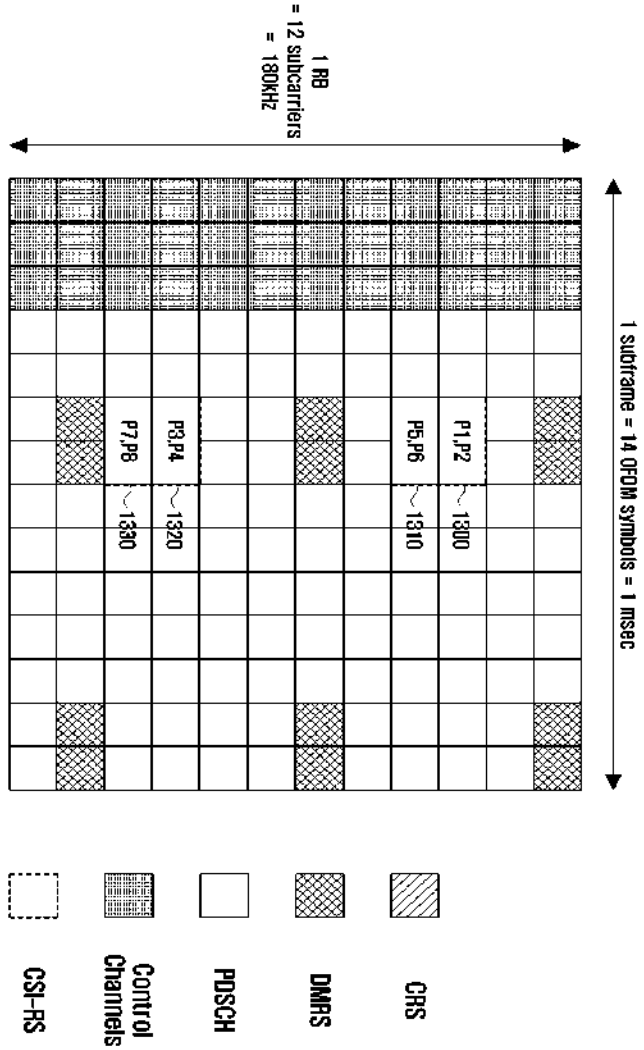
도면11


1110
CRS 신호 생성기
1100
제어기
1130
멀티플렉서
1140
OFDMA
전송기
1120
CSI-RS 신호 생성기

도면12


OFDMA 수신기
1200
디멀티플렉서
1210
CSI-RS 수신기
[CRS-RS Channel
Estimator]
1240
제어기
1230
CRS 수신기
[CRS Channel Estimator]
1220
CQI 생성기
1250

도면13


1 RB
= 12 subcarriers
= 180KHz
1 subframe = 14 OFDM symbols = 1 msec
P1,P2
~1300
P5,P6
~1310
P3,P4
~1320
P7,P8
~1330
CRS
DMRS
PDSCH
Control Channels
CSI-RS

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ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
17/950,726	**11/19/2023 10:16:18 PM Z ET**	**ZL0205-0004-US-CON3**

Title of Invention

METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	6005	FILED BY	Jialin Zhong
PATENT CENTER #	63311391	FILING DATE	09/22/2022
CUSTOMER #	155075	FIRST NAMED INVENTOR	Xiaobo ZHANG
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	-

Documents

TOTAL DOCUMENTS: 0

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)

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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C.

371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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17/950,726	11/19/2023 11:36:01 AM Z ET	ZL0205-0004-US-CON3

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Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	6005	FILED BY	Jialin Zhong
PATENT CENTER #	63310400	FILING DATE	09/22/2022
CUSTOMER #	155075	FIRST NAMED INVENTOR	Xiaobo ZHANG
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	-

Documents

TOTAL DOCUMENTS: 61

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
R2 1706926 Qualcomm.pdf	3	Non Patent Literature	1172 KB
R1 1700771 Ericsson.pdf	4	Non Patent Literature	1311 KB
R1 1612056 Qualcomm.pdf	4	Non Patent Literature	1367 KB
R1 1700703 InterDigital.pdf	4	Non Patent Literature	1291 KB
R1 1609525 Intel.pdf	4	Non Patent Literature	1366 KB
R4 161779 Qualcomm.pdf	6	Non Patent Literature	1490 KB
R1 1710078 CATT.pdf	3	Non Patent Literature	1385 KB

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3GPP TS 36.213 v12.8.0 Annex A 2015-12.pdf	8	Non Patent Literature	1588 KB
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2023.03.02 ZTE Invalidity Contentions.pdf	3002B9C4B7D58C549CB47835E80D2B24C24CD9E882B42FEB654108DB73F2415D4CC2D8C86CD3A6F8488098B16190DD679ECA600ED47D2380444946DE97F0EFF2
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2023 03 02 Samsung Invalidity Contentions.pdf	3E15D3586D72E145904F01B5D79DB36B248F30135DB5B1BB6A8AA12DD6F613A6B5C771316B84F10E09D085CF712F114A33DC9F94D2CD804C28686452DF43E720

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If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

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If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
17/950,726	**11/19/2023 11:10:02 AM Z ET**	**ZL0205-0004-US-CON3**

Title of Invention

METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	6005	FILED BY	Jialin Zhong
PATENT CENTER #	63310282	FILING DATE	09/22/2022
CUSTOMER #	155075	FIRST NAMED INVENTOR	Xiaobo ZHANG
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	-

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TOTAL DOCUMENTS: 90

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An Enhanced Multi-Antenna Solution Through Beamforming Long.pdf	0747136D0E0C4522008BB25756C6B28A24AF53B2D1156EDCE329F9BE4C66E20F8589F7D70120191AFD5E4A542467A0A2F88130F8E6160E37C6D55A0C2183E386
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3GPP TS 26.304 v9.1.0 2010-2.pdf	FF37607DA79F2C7015D82E8B789D2594D648533340A4E2B7A8 0AE1E3890E74624F10CDA8A282A46FA0B8A1E899A6BB5E999 86636A6D14F9C153B446C54766C65

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APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
17/950,726	**11/19/2023 09:53:45 AM Z ET**	**ZL0205-0004-US-CON3**

Title of Invention

METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	6005	FILED BY	Jialin Zhong
PATENT CENTER #	63310258	FILING DATE	09/22/2022
CUSTOMER #	155075	FIRST NAMED INVENTOR	Xiaobo ZHANG
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	-

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TOTAL DOCUMENTS: 58

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3GPP TS 36.300 v12.8.0 2015-12 pp136-190.pdf	55	Non Patent Literature	21137 KB
3GPP TS 36.300 v12.8.0 2015-12 pp86-135.pdf	50	Non Patent Literature	20827 KB
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Digest

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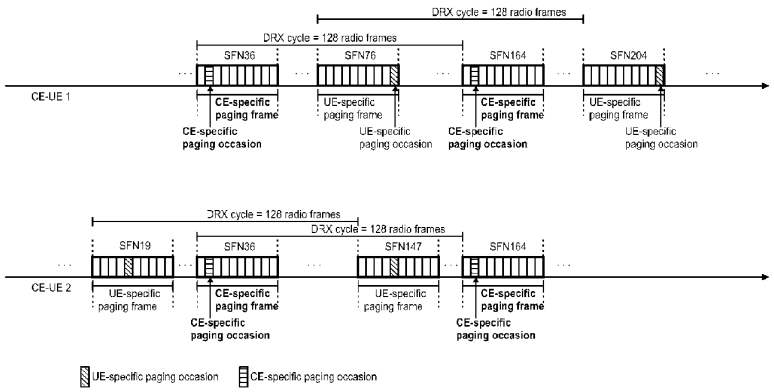
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(54) **Title**: IMPROVED PAGING PROCEDURES FOR USER EQUIPMENTS REQUIRING COVERAGE EXTENSION



(57) **Abstract**: The present disclosure relates to a method for paging coverage extension UEs in a cell controlled by a radio base station. At least one regularly-occurring coverage-extension-specific paging possibility (CE-specific paging possibility), is defined for paging CE UEs. The CE-UEs in the cell regularly monitor the at least one CE-specific paging possibility. When the radio base station determines to page all the user equipments in the cell, it pages the CE user equipments in the cell at the CE-specific paging possibility, using a coverage extension technique. The present disclosure also relates to a method for paging a CE UE, which performs radio measurements by the CE-capable user equipment to determine whether coverage extension is necessary. The radio base station is informed about whether the CE-capable user equipment needs coverage extension or not and then pages the CE UEs applying or not applying a CE technique depending on whether coverage extension is necessary or not.

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Description

Title of Invention: IMPROVED PAGING PROCEDURES FOR USER EQUIPMENTS REQUIRING COVERAGE EXTENSION

Technical Field

[0001] The present disclosure relates to methods for paging one or several user equipments in a cell of a radio base station, where the user equipment(s) do require coverage extension to be reliably paged. The present disclosure is also providing the user equipment and radio base station for participating in the methods described herein.

Background

[0002] Long Term Evolution (LTE)

Third-generation mobile systems (3G) based on WCDMA radio-access technology are being deployed on a broad scale all around the world. A first step in enhancing or evolving this technology entails introducing High-Speed Downlink Packet Access (HSDPA) and an enhanced uplink, also referred to as High Speed Uplink Packet Access (HSUPA), giving a radio access technology that is highly competitive.

[0003] In order to be prepared for further increasing user demands and to be competitive against new radio access technologies, 3GPP introduced a new mobile communication system which is called Long Term Evolution (LTE). LTE is designed to meet the carrier needs for high speed data and media transport as well as high capacity voice support for the next decade. The ability to provide high bit rates is a key measure for LTE.

[0004] The work item (WI) specification on Long-Term Evolution (LTE) called Evolved UMTS Terrestrial Radio Access (UTRA) and UMTS Terrestrial Radio Access Network (UTRAN) is finalized as Release 8 (LTE Rel. 8). The LTE system represents efficient packet-based radio access and radio access networks that provide full IP-based functionalities with low latency and low cost. In LTE, scalable multiple transmission bandwidths are specified such as 1.4, 3.0, 5.0, 10.0, 15.0, and 20.0 MHz, in order to achieve flexible system deployment using a given spectrum. In the downlink, Orthogonal Frequency Division Multiplexing (OFDM) based radio access was adopted because of its inherent immunity to multipath interference (MPI) due to a low symbol rate, the use of a cyclic prefix (CP) and its affinity to different transmission bandwidth arrangements. Single-carrier frequency division multiple access (SC-FDMA) based radio access was adopted in the uplink, since provisioning of wide area coverage was prioritized over improvement in the peak data rate considering the restricted transmit power of the user equipment (UE). Many key packet radio access techniques are employed including multiple-input multiple-output

(MIMO) channel transmission techniques and a highly efficient control signaling structure is achieved in LTE Rel. 8/9.

[0005] LTE architecture

The overall architecture is shown in Fig. 1 and a more detailed representation of the E-UTRAN architecture is given in Fig. 2. The E-UTRAN consists of an eNodeB, providing the E-UTRA user plane (PDCP/RLC/MAC/PHY) and control plane (RRC) protocol terminations towards the user equipment (UE). The eNodeB (eNB) hosts the Physical (PHY), Medium Access Control (MAC), Radio Link Control (RLC) and Packet Data Control Protocol (PDCP) layers that include the functionality of user-plane header-compression and encryption. It also offers Radio Resource Control (RRC) functionality corresponding to the control plane. It performs many functions including radio resource management, admission control, scheduling, enforcement of negotiated uplink Quality of Service (QoS), cell information broadcast, ciphering/ deciphering of user and control plane data, and compression/ decompression of downlink/uplink user plane packet headers. The eNodeBs are interconnected with each other by means of the X2 interface.

[0006] The eNodeBs are also connected by means of the S1 interface to the EPC (Evolved Packet Core), more specifically to the MME (Mobility Management Entity) by means of the S1-MME and to the Serving Gateway (SGW) by means of the S1-U. The S1 interface supports a many-to-many relation between MMEs/Serving Gateways and eNodeBs. The SGW routes and forwards user data packets, while also acting as the mobility anchor for the user plane during inter-eNodeB handovers and as the anchor for mobility between LTE and other 3GPP technologies (terminating S4 interface and relaying the traffic between 2G/3G systems and PDN GW). For idle state user equipments, the SGW terminates the downlink data path and triggers paging when downlink data arrives for the user equipment. It manages and stores user equipment contexts, e.g. parameters of the IP bearer service, network internal routing information. It also performs replication of the user traffic in case of lawful interception.

[0007] The MME is the key control-node for the LTE access-network. It is responsible for idle mode user equipment tracking and paging procedure including retransmissions. It is involved in the bearer activation/deactivation process and is also responsible for choosing the SGW for a user equipment at the initial attach and at time of intra-LTE handover involving Core Network (CN) node relocation. It is responsible for authenticating the user (by interacting with the HSS). The Non-Access Stratum (NAS) signaling terminates at the MME and it is also responsible for generation and allocation of temporary identities to user equipments. It checks the authorization of the user equipment to camp on the service provider's Public Land Mobile Network (PLMN) and enforces user equipment roaming restrictions. The MME is the ter-

mination point in the network for ciphering/integrity protection for NAS signaling and handles the security key management. Lawful interception of signaling is also supported by the MME. The MME also provides the control plane function for mobility between LTE and 2G/3G access networks with the S3 interface terminating at the MME from the SGSN. The MME also terminates the S6a interface towards the home HSS for roaming user equipments.

[0008] LTE RRC states

LTE is based on only two main states: "RRC_IDLE" and "RRC_CONNECTED".

[0009] In RRC_IDLE the radio is not active, but an ID is assigned and tracked by the core network. More specifically, a mobile terminal in RRC_IDLE performs cell selection and reselection — in other words, it decides on which cell to camp. The cell (re)selection process takes into account the priority of each applicable frequency of each applicable Radio Access Technology (RAT), the radio link quality and the cell status (i.e. whether a cell is barred or reserved). An RRC_IDLE mobile terminal monitors a paging channel to detect incoming calls, and also acquires system information. The system information mainly consists of parameters by which the network (E-UTRAN) can control the cell (re)selection process and also how the mobile terminal accesses the network. RRC specifies the control signalling applicable for a mobile terminal in RRC_IDLE, namely paging and system information. The mobile terminal behaviour in RRC_IDLE is specified in more detail e.g. in TS 36.304, current version 12.0.0(NPL 1), chapter 4 "General description of Idle mode" incorporated herein by reference.

[0010] In RRC_CONNECTED the mobile terminal has an active radio operation with contexts in the eNodeB. The E-UTRAN allocates radio resources to the mobile terminal to facilitate the transfer of (unicast) data via shared data channels. To support this operation, the mobile terminal monitors an associated control channel which is used to indicate the dynamic allocation of the shared transmission resources in time and frequency. The mobile terminal provides the network with reports of its buffer status and of the downlink channel quality, as well as neighbouring cell measurement information to enable E-UTRAN to select the most appropriate cell for the mobile terminal. These measurement reports include cells using other frequencies or RATs. The UE also receives system information, consisting mainly of information required to use the transmission channels. To extend its battery lifetime, a UE in RRC_CONNECTED may be configured with a Discontinuous Reception (DRX) cycle. RRC is the protocol by which the E-UTRAN controls the UE behaviour in RRC_CONNECTED.

[0011] The various functions of the mobile terminal in RRC Protocol for and including Connected Mode are described in 3GPP TS 36.331, current version 12.4.1(NPL 2), in

Ch. 4 "Functions", incorporated herein by reference.

[0012] Paging

The present application will differentiate between two types of paging, namely the paging initiated from the non-access stratum (NAS) (termed exemplarily in the following "Paging-NAS") and the paging initiated from the eNodeB (termed exemplarily in the following "Paging-eNB"). Paging-NAS relates to the paging of a particular UE e.g. when paging a UE in connection with an incoming data connection e.g. a mobile-terminating (MT) call. On the other hand, paging-eNB relates to the paging of all the UEs in the cell, and e.g. is used to inform them about a system information change, ETWS message (Earthquake and Tsunami Warning System), CMAS message (Commercial Mobile Alert System) etc. Furthermore, depending on whether the UE is in RRC idle or connected state, the actual paging messages are transmitted differently to the UE. However, the two paging procedures have a lot in common too.

[0013] In general, the UE in RRC_Idle state monitors for paging to detect incoming calls, system information change, for ETWS capable UEs, ETWS notification, and for CMAS capable UEs, CMAS notification. The UE in RRC_Connected state monitors for paging and/or System Information Block Type 1 contents to detect system information change, for ETWS capable UEs, ETWS notification, and for CMAS capable UEs, CMAS notification (see 3GPP TS 36.331, current version v12.4.1, subclause 4.2.1, incorporated herein by reference).

The general paging procedure for transmitting the paging message from EUTRAN to the UE is defined in TS 36.331, current version 12.4.1, subclause 5.3.2 incorporated herein by reference, describing that the purpose of the paging procedure is:

[0014] - to transmit paging information to a UE in RRC_IDLE (Paging-NAS) and/ or;

- to inform UEs in RRC_IDLE and UEs in RRC_CONNECTED about a system information change (Paging-eNB) and/ or;

- to inform about an ETWS primary notification and/ or ETWS secondary notification (Paging-eNB) and/ or;

- to inform about a CMAS notification (Paging-eNB).

[0015] The paging information received in the UE is provided to upper layers, which in response e.g. may the initiate RRC connection establishment to receive an incoming call.

[0016] E-UTRAN performs the paging procedure by transmitting the Paging message at the UE's paging occasion as specified in TS 36.304. E-UTRAN may address multiple UEs within a Paging message by including one PagingRecord for each UE.

[0017] To receive paging messages from E-UTRAN, UEs in idle mode monitor the PDCCH channel for an RNTI value used to indicate paging: the P-RNTI (Paging radio network

temporary identity) which is a common RNTI, i.e. not allocated to any UE explicitly. The UE only needs to monitor the PDCCH channel at certain UE-specific paging possibilities, i.e. at specific subframes within specific radio frames as will be discussed in more detail in the following. The E-UTRAN configures which of the radio frames and subframes can be used for paging in its cell. Each cell broadcasts a default paging cycle Tc, and in addition, upper layers may use dedicated signaling to configure a UE-specific paging cycle TUE; if both are configured, the UE applies the lowest value for the DRX cycle T of the UE.

[0018] In order to explain the procedure for paging as currently defined for LTE-A, the following exemplary cases A, B, and C are defined, as taken from the book LTE – The UMTS Long Term Evolution – From Theory to Practice, Edited by: Stefania Sesia, Issam Toufik, and Matthew Baker, Second Edition, ISBN 9780470660256, section 3.4(NPL 3).

[0019] [Table 1]

Case	UE_ID	T_C	T_{UE}	T	nB	N	Ns	PF	i_s	PO
A	147	256	256	256	64	64	1	76	0	9
B	147	256	128	128	32	32	1	76	0	9
C	147	256	128	128	256	128	2	19	1	4

[0020] The following parameters are used in said respect:

- "TC" is the cell-specific default paging cycle, and can be 32, 64, 128, or 256 radio frames,
- "TUE" is the UE-specific paging cycle of the UE, and can be 32, 64, 128, or 256 radio frames,
- "N" is the number of paging frames within the paging cycle of the UE, and is min (T, nB),
- Ns is the number of paging subframes in a radio frame that may be used for paging, and is max (1, nB/T),

[0021] - nB is the number of paging subframes per paging cycle (across all UEs in the cell), and can be 4T, 2T, T, T/2, T/4, T/8, T/16, T/32; the parameter determines to a large extent the paging capability of the eNB across all UEs in the cell. In general, if nB is set equal to or larger than T, all radio frames may be used for paging (see also parameter N), and there are nB/T POs per PF (see also parameter Ns). In turn, if nB is set lower than T, only a fraction nB/T of the radio frames may be used for paging (see also parameter N), and there is one PO per PF (see also parameter Ns).

[0022] - "T" is the DRX cycle of the UE (also termed paging cycle), is min of TC and TUE,

and specifies how frequently a UE monitors for paging, where a shorter DRX cycle decreases the time for paging but increases battery consumption.

[0023] For example, for cases A and B E-UTRAN has configured one out of every four radio frames and specifically one subframe in each of those radio frames, to be used for paging (see T, Ns, respectively). For case C, there are two subframes in each radio frame that can be used for paging, i.e. Ns=2, and 128 paging frames within the UE's paging cycle, i.e. N=128, available for paging the UEs in the cell. Furthermore, for case B, there are 32 paging frames within the UE's paging cycle (N=32). Across these generally-available paging opportunities configured by the eNB, the paging possibilities for paging the UEs are distributed based on the UE identity.

[0024] In said respect, the particular radio frame and subframe used for paging a particular UE is calculated as follows. A Paging Occasion (PO) is a subframe where there may be a P-RNTI (Paging radio network temporary identity) transmitted on PDCCH addressing the paging message. A Paging Frame (PF) is a radio frame, which may contain one or multiple Paging Occasion(s). In the context of this patent application, the term paging possibility shall refer to the combination of the paging frame and paging subframe.

[0025] The paging frames and paging occasions are defined for example in 3GPP TS 36.304, current version 12.0.0, subclause 7, incorporated herein by reference. Accordingly, the paging frame number (SFN) is calculated according to the following formula:

SFN mod T = (T div N)*(UE_ID mod N)

where UE_ID is IMSI mod 1024.

[0026] When assuming an UE_ID of 147 for all three cases A, B, and C, calculating the above formula results in the paging frame 76 for cases A and B, and paging frame 19 for case C. Furthermore, i_s would be calculated to be 0 for cases A and B, and be 1 for case C.

[0027] The paging occasion has values in the range of [0, 1, ... 9], as in LTE there are 10 subframes within one radio frame. The paging occasion number is selected from a preconfigured table based on the parameters Ns and i_s calculated according to the following formula:

i_s= floor(UE_ID / N) mod Ns.

[0028] The following table is taken from TS 36.304, current version 12.0.0, and is used to determine the Paging Occasion for a particular UE, based on the above parameters Ns and i_s. The following table is intended for FDD.

[0029]

[Table 2]

	PO when i_s=0	PO when i_s=1	PO when i_s=2	PO when i_s=3
1	9	N/A	N/A	N/A
2	4	9	N/A	N/A
4	0	4	5	9

[0030] Therefore, for case A and B, with Ns=1 and i_s=0, the table would yield the subframe number 9, such that the UE for cases A and B would be paged regularly in subframe 9 of radio frame 76 of every paging cycle; i.e. for case A next radio frame 332 and for case B next radio frame 204 etc. For case C, the UE would be paged regularly in subframe 4 of radio frame 19 of every paging cycle, i.e. next radio frame 147 etc.

[0031] The paging frame and paging occasion for the above-discussed cases B and C, is exemplarily depicted in Fig. 3.

[0032] Paging-NAS

For instance, in order to re-establish a connection towards a UE in idle mode, the MME - having been informed e.g. by the UE's P/SGW - sends a paging request message to all eNBs that are part of the so-called tracking area(s) to which the UE belongs and within which the UE can move without having to perform the Tracking Area Update (TAU) procedure (except the periodic TAU procedure).

[0033] When receiving the paging request, the eNodeB(s) of the tracking area(s) then broadcast(s) another paging message over the radio interface in the cells The UE is notified about the paging based on the P-RNTI on the PDCCH and then receives the paging message transmitted over the PDSCH, in the radio resources as indicated by the PDCCH paging notification. When the UE in RRC idle receives the paging message/ signal, it transfers from IDLE to CONNECTED state and establishes an RRC connection with that eNB where it is camped in IDLE mode (e.g. the UE initiates the RRC connection establishment procedure).

[0034] A system overview and message exchange is exemplarily illustrated in Fig. 4, assuming that the UE to be paged by the MME (as triggered by the SGW) is registered at tracking areas TAC1 and TAC3. Consequently, the MME will provide the S1AP paging request to the eNBs of those tracking areas, which in turn will transmit a page at the UE-specific paging possibility (i.e. the PDCCH notification) and then the paging message on the PDSCH resources. The UE is consequently notified about the paging, receives the paging message on the PDSCH, and after confirming its own identity in the paging message, processes the paging message and responds to the paging by e.g. by sending a service request to the MME.

[0035] In the current LTE system, the paging message transmitted from the MME to the eNB, and its content, are defined e.g. by 3GPP TS 36.413, current version 12.4.0(NPL 4), in sub-clauses 8.5 and 9.1.6, incorporated herein by reference. The paging message from the MME to the eNB contains amongst other the following information:

[0036] - UE_ID Index Value: known as UE_ID, which is calculated by (IMSI mod 1024). Correspondingly, the UE_ID may have values in the range of [0, 1 ... 1023].

[0037] - UE Paging Identity: can be the IMSI (as stored on the SIM card) or the SAE-Temporary Mobile subscriber ID (S-TMSI) assigned to the UE during the attach procedure. The UE Paging Identity is transmitted from the eNB to the UE in a paging message over the radio interface (i.e. Uu interface).

[0038] - Paging DRX cycle: is the Discontinuous Reception (DRX) cycle configured in the UE (using NAS signalling) or the default DRX cycle broadcast in the System Information Block (SIB). The default DRX cycle is also known as Paging Cycle in the RadioResourceConfigCommon SIB. The UE may use discontinued reception in IDLE mode in order to reduce power consumption. The DRX cycle is a time interval between monitoring Paging Occurrences for a specific UE. The values of the default DRX/paging cycle broadcast in the SIB are 32, 64, 128 or 256 radio frames.

- UE radio Capability for paging: including the radio access capabilities of the UE, including the coverage extension capability.

[0039] The paging message transmitted from the eNodeB is broadcast in a defined paging possibility as explained above. Paging possibilities are known to the eNodeB and the UE so that they send/listen to the paging message at the same time.

[0040] When Discontinues Reception (DRX) is used, the UE needs only to monitor one PO per DRX cycle.

[0041] As mentioned before, the paging initiated by the non-access stratum (NAS) is UE specific. Consequently, the UE is paged by using the IMSI (or S-TMSI) of the UE as paging identity in the paging message sent in the PDSCH. Therefore, for each UE a separate paging message has to be transmitted from the MME to the eNB(s), which has then to be broadcast from the corresponding eNB(s).

[0042] The paging message transmitted from the eNodeB to the UE is defined in TS 36.331, current version 12.4.1, subclause 6.2.2 Message definition, section "Paging", incorporated herein by reference. This message may contain the following:

[0043] - cmas-Indication: if present, indication of a CMAS notification

- cn-Domain: indicates the origin of paging

- eab-ParamModification: if present, indication of an EAB parameter (SIB14) modification

- etws-Indication: if present, indication often ETWS primary/secondary notification

- imsi: The International Mobile Subscriber Identity, a globally unique permanent

subscriber identity; can also be part of the Paging UE-Identity below
- systemInfoModification: if present, indication of a BCCH modification, other than SIB10-SIB12, SIB14
- ue-Identity: provides the NAS identity of the UE that is being paged

[0044] In the above description, it has been assumed that the UE is in an idle state when receiving the paging, such that the paging message is sent to the UE addressed to the P-RNTI on PDCCH at the UE-specific paging possibilities (based on IMSI of this UE) where the UE verifies that the paging message is indeed intended for it by checking the IDs in the included paging records.

[0045] However, also UEs in RRC connected state may be paged. In this case a downlink information transfer (DLInformationTransfer), containing the paging related information from the NAS, is sent to the UE addressed to the C-RNTI (Cell-RNTI, a unique ID used for identifying RRC connection and scheduling dedicated to a particular UE) on the PDCCH. The DLInformationTransfer message is used for the downlink transfer of NAS or non-3GPP dedicated information. The RRC layer is transparent for this information. For more information, reference is made to TS 36.331, current version 12.4.1, subclause 5.6.1 "DL information transfer" and 6.2.2 "Message definitions" section DLInformationTransfer, incorporate herein by reference.

[0046] Paging from eNB

One of the reasons for an eNodeB to page the UE is a change of system information. In general a change of system information only occurs at specific radio frames, thus implementing the concept of a modification period. System information may be transmitted a number of times with the same content within a modification period. When the network changes (some of) the system information, it first notifies the UEs about this change, which may be done throughout a modification period. In the next modification period, the network then transmits the updated system information. Upon receiving a change notification, the UE acquires the new system information immediately from the start of the next modification period. A paging message is used to inform the UEs in RRC idle and UEs in RRC connected state about a system information change (as mentioned e.g. in TS 36.304, current version 12.0.0, subclause 6.1). If the UE receives a paging message including the systemInfoModification, it knows that the system information will change at the next modification period and boundary. In said case, the UE does not need to check for the UE_ID (not included in the paging message), in view of the presence of the systemInfoModification. Further information in said respect can be found in TS 36.331, current version 12.4.1, subclause 5.2.1.3, incorporated herein by reference.

[0047] Another reason for the eNodeB to page the UEs is an ETWS (Earthquake and Tsunami Warning system) notification, where the paging message is used to inform

ETWS-capable UEs in RRC idle and in RRC connected state about the presence of an ETWS primary/secondary notification. Further information in said respect can be found in TS 36.331, current version 12.4.1, subclause 5.2.1.4, incorporated herein by reference. The paging message may also be used to inform CMAS-capable UEs in RRC idle and RRC connected state about the presence of one or more CMAS (Commercial Mobile Alert System) notifications. Further information in said respect can be found in TS 36.331, current version 12.4.1, subclause 5.2.1.5, incorporated herein by reference. Still another reason for the eNB to page UEs in its cell relates e.g. to Enhanced Access Barring for MTC devices, EAB, as explained for example in TS 36.331, current version 12.4.1, subclause 5.2.1.6 incorporated herein by reference.

[0048] For UEs in both RRC connected and idle state the eNB sends a paging notification to the UE(s) addressed to the P-RNTI on the PDCCH at all possible paging occasions (e.g. at subframes 0, 4, 5, and 9) and at all possible paging frames (e.g. N different radio frames in total, calculated according to SFN mod T=T/N (UE_ID mod N) for every possible "UE_ID mod N" value) irrespective of the IMSI of a particular UE in the cell. By transmitting the paging message at all possible paging possibilities within a paging cycle, the eNB ensures that all the UEs receive the paging message. The detailed definitions for determining the paging occasions and paging frames are given above.

[0049] Machine Type Communication (MTC)

As LTE deployments evolve, operators strive to reduce the cost of overall network maintenance by minimizing the number of RATs. In this respect, Machine-Type Communications (MTC) devices is a market that is likely to continue expanding in the future.

[0050] Many MTC devices are targeting low-end (low cost, low data rate) applications that can be handled adequately by GSM/GPRS. Owing to the low cost of these devices and good coverage of GSM/GPRS, there is very little motivation for MTC device suppliers to use modules supporting the LTE radio interface.

[0051] As more and more MTC devices are deployed in the field, this naturally increases the reliance on GSM/GPRS networks. This will cost operators not only in terms of maintaining multiple RATs, but also prevent operators reaping the maximum benefit out of their spectrum (given the non-optimal spectrum efficiency of GSM/GPRS). With users and traffic becoming denser, using more spectral-efficient technologies, such as Long Term Evolution (LTE), allow the operators to utilize their spectrum in a much more efficient way.

[0052] Given the likely high number of MTC devices, the overall resource they will need for service provision may be correspondingly significant, and inefficiently assigned (for further details on objectives for MTC, see for example 3GPP, RP-111112, Vodafone:

"Provision of low-cost MTC UEs based on LTE"(NPL 5), section 4, available at http://www.3gpp.org and incorporated herein by reference).

[0053] Approaches to lower the cost of LTE presently regard the volume of products as the primary reason. The impact of volume can be seen in two possible ways, depending on how low-cost MTC is developed. Firstly, if low-cost MTC may be very similar to mainline LTE and included in LTE chipsets, MTC has the benefit of the volume of LTE. Secondly, a low-cost MTC based on LTE may have significantly lower cost than mainline LTE. Although it appears not to have the volume benefit of LTE, the volume of MTC devices can be even larger due to a potentially greater number of supported MTC applications and scenarios.

[0054] In this respect, the following approaches to lower the cost of LTE, i.e. defining low-cost MTC are discussed and found to have significant UE cost impact (for further details on low-cost MTC devices, see for example 3GPP, R1-112912, Huawei, HiSilicon, CMCC: "Overview on low-cost MTC UEs based on LTE"(NPL 6), section 4, available at http://www.3gpp.org and incorporated herein by reference):

[0055] - Reduction in supported bandwidth for the low-cost LTE: The low cost of 1.4 MHz (6 RB) downlink bandwidth could cover most application scenarios of MTC. However, 3 MHz (15 RB) or 5 MHz (25 RB) could be considered given that the complexity does not increase much. Given that the uplink may have a larger requirement for MTC services, the possibility of reduced transmit power, and small baseband complexity (relative to downlink reception), any reduction in minimum transmission bandwidth in the UE should be carefully justified.

[0056] - Modified PDCCH-related design for the low-cost LTE to simplify the PDCCH blind decoding and give efficient channel access for a large number of MTC devices. A reduction in maximum bandwidth (e.g., 1.4MHz) decreases PDCCH blind decoding naturally.

[0057] - Protocol simplification including HARQ consideration, MAC, RLC and RRC protocol. Signaling reduction between low duty cycle MTC devices and the base station.

- Transmission modes down-selection to maintain coverage and balance complexity.

[0058] Further considerations on low-cost MTC devices relate to an improved indoor coverage. A number of applications require indoor deployment of Machine Type Communication, MTC, devices, e.g. in an apartment basement, or on indoor equipment that may be close to the ground floor etc. These UEs would experience significantly greater penetration losses on the radio interface than normal LTE devices. This effectively means that indoor coverage should be readily available and reliable: i.e. should provide a significant improvement on existing coverage.

[0059] Additionally, regarding the power consumption of low-cost MTC devices it is noted

that many applications require devices to have up to ten years of battery life. In this respect, presently available Power Save Modes appear not sufficient to achieve the envisaged battery life. In this respect, it is anticipated that further techniques are proposed to significantly cut down the power usage of MTC devices e.g. by optimizing signaling exchanges in the system, in order to realize battery life of up to ten years.

[0060] Enhanced Coverage mode (EC mode)

For improving indoor coverage (for low-cost MTC devices), recent developments have focused on an Enhanced Coverage, EC, mode that is applicable to UEs e.g. operating delay tolerant MTC applications. Another term is "Coverage Extension". The corresponding Work Item in 3GPP Release 12 "Low cost & enhanced coverage MTC UE for LTE" came to the conclusion that further complexity reduction of LTE devices for MTC can be achieved if additional complexity reduction techniques are supported, as apparent from the study report TR 36.888. The study report TR 36.888 concluded that a coverage improvement target of 15-20 dB for both FDD and TDD in comparison to a normal LTE footprint could be achieved to support the use cases where MTC devices are deployed in challenging locations, e.g. deep inside buildings, and to compensate for gain loss caused by complexity-reduction techniques. MTC coverage enhancements are now expected to be introduced in 3GPP Release 13.

[0061] The general objective is to specify a new UE for MTC operation in LTE that allows for enhanced coverage and lower power consumption. Some of the additional objectives are given below:

- Reduced UE bandwidth of 1.4 MHz in downlink and uplink.

-- Bandwidth reduced UEs should be able to operate within any system bandwidth.

-- Frequency multiplexing of bandwidth reduced UEs and non-MTC UEs should be supported.

-- The UE only needs to support 1.4 MHz RF bandwidth in downlink and uplink.

-- The allowed re-tuning time supported by specification (e.g. ~0 ms, 1 ms) should be determined by RAN4.

[0062] - Reduced maximum transmit power.

-- The maximum transmit power of the new UE power class should be determined by RAN4 and should support an integrated PA implementation.

[0063] - Reduced support for downlink transmission modes.

[0064] - The following further UE processing relaxations can also be considered within this work item:

-- Reduced maximum transport block size for unicast and/or broadcast signalling.

-- Reduced support for simultaneous reception of multiple transmissions.

-- Relaxed transmit and/or receive EVM requirement including restricted modulation scheme. Reduced physical control channel processing (e.g. reduced number of blind

decoding attempts).

-- Reduced physical data channel processing (e.g. relaxed downlink HARQ time line or reduced number of HARQ processes).

-- Reduced support for CQI/CSI reporting modes.

[0065] A relative LTE coverage improvement - corresponding to 15 dB for FDD - for the UE category/type defined above and other UEs operating delay-tolerant MTC applications with respect to their respective normal coverage shall be possible. At least some of the following techniques, which shall be applicable for both FDD and TDD, can be considered to achieve this:

[0066] - Subframe bundling techniques with HARQ for physical data channels (e.g. PDSCH, PUSCH)

- Elimination of use of control channels (e.g. PCFICH, PDCCH)
- Repetition techniques for control channels (e.g. PBCH, PRACH, (E)PDCCH)
- Either elimination or repetition techniques (e.g. PBCH, PHICH, PUCCH)
- Uplink PSD boosting with smaller granularity than 1 PRB
- Resource allocation using EPDCCH with cross-subframe scheduling and repetition (EPDCCH-less operation can also be considered)

[0067] - New physical channel formats with repetition for SIB/RAR/Paging

- A new SIB for bandwidth reduced and/or coverage enhanced UEs
- Increased reference symbol density and frequency hopping techniques
- Relaxed "probability of missed detection" for PRACH and initial UE system acquisition time for PSS/SSS/PBCH/SIBs can be considered as long as the UE power consumption impact can be kept on a reasonable level.
- Spreading: Spreading refers to spreading of information across resources including time-frequency domain resources or even spreading using Scrambling (or Channelization) codes.

[0068] There can be also other techniques than those listed above.

The amount of coverage enhancement should be configurable per cell and/or per UE and/or per channel and/or group of channels, such that different levels of coverage enhancements exist. The different levels of coverage enhancement could mean different level of CE techniques being applied to support the CE-device transmission and reception. Relevant UE measurements and reporting to support this functionality should be defined.

[0069] For more details, see for example 3GPP RP-141865 "Revised WI: Further LTE Physical Layer Enhancements for MTC"(NPL 7) sourced by Ericsson, available at http://www.3gpp.org and incorporated herein by reference.

[0070] Notably, coverage enhancements of 15/ 20 dB for UEs in the Enhanced Coverage mode with respect to their nominal coverage means that the UEs have to be capable of

receiving extremely low signal strengths. This applies not only to the initial scanning operation, the cell search and the cell selection operation but also the subsequent communication scheme to be performed by the UE.

[0071] Early attempts to define the Enhanced Coverage mode have focused on modifications of the radio transmissions. In this respect, discussions have focused on repeated transmissions as being the main technique to improve the coverage. Repetitions can be applied to every channel for coverage improvement.

[0072] An exemplary implementation of these repeated transmissions prescribes that the same data is transmitted across multiple sub-frames. Yet, it will become immediately apparent that these repeated transmissions will use more resource blocks (time-frequency) resources than required for normal coverage UEs.

Citation List

Non Patent Literature

[0073] NPL 1: 3GPP TS 36.304, "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) procedures in idle mode", version 12.0.0

NPL 2: 3GPP TS 36.331, "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification", version 12.4.1

NPL 3: Theory to Practice, Edited by: Stefania Sesia, Issam Toufik, and Matthew Baker, Second Edition, ISBN 9780470660256, section 3.4

NPL 4: 3GPP TS 36.413, "Evolved Universal Terrestrial Radio Access Network (E-UTRAN); S1 Application Protocol (S1AP) ", version 12.4.0

NPL 5: 3GPP, RP-111112, Vodafone: "Provision of low-cost MTC UEs based on LTE"

NPL 6: 3GPP, R1-112912, Huawei, HiSilicon, CMCC: "Overview on low-cost MTC UEs based on LTE"

NPL 7: 3GPP RP-141865 "Revised WI: Further LTE Physical Layer Enhancements for MTC"

NPL 8: 3GPP TS 36.214, "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer; Measurements", version 10.1.0

Summary

[0074] One non-limiting and exemplary embodiment provides an improved method for paging all user equipments in a cell, particularly involving user equipments which need coverage extension. Another non-limiting and exemplary embodiment provides an improved method for paging one user equipment in a cell, particularly a user equipment which needs coverage extension.

The independent claims provide non-limiting and exemplary embodiments. Advantageous embodiments are subject to the dependent claims.

According to a first aspect, the present disclosure improves the paging procedure by which a radio base station can page the user equipments in its cell, particularly for the case where the paging shall also reach user equipments which require coverage extension, i.e. user equipments that are in poor radio conditions but support coverage extension techniques as explained in the background section. The first aspect refers to the case were paging is initiated by the radio base station and shall reach all user equipments in the cell of the radio base station; in other words, the paging is not UE specific but cell specific, and can be for example used so as to broadcast a warning message or to inform UEs about an imminent system information change.

[0075] Consequently, the paging must reach user equipments that require coverage extension as well as "normal" user equipments which do not require coverage extension. One main idea of the first aspect is the definition of a coverage-extension-specific paging possibility, which is specifically defined for those user equipments that support coverage extension techniques, and more precisely which need coverage extension to be reliably reached. Correspondingly, the CE-UEs not only monitor the UE-specific paging possibility, calculated based on their identities, but additionally monitor a (at least one) different paging possibility dedicated to achieve coverage extension paging. Both CE-user equipments in idle and connected state can be configured to monitor this CE-specific paging possibility. Consequently, in order to reach those CE-UEs, the radio base station pages the CE-UEs at said CE-specific paging possibility, and uses one of the plurality of available techniques (e.g. repetition or increased transmission power) for extending the coverage of the paging and thus to reliably reach the CE-UE.

[0076] Like a usual UE-specific paging possibility, this CE-specific paging possibility is defined by a particular radio frame number and subframe number, and occurs regularly e.g. at every paging cycle.

[0077] Since the CE-specific paging possibility shall preferably only be monitored by CE-UEs, the radio base station still needs to reach the other non-CE-UEs and can thus, as described in the background section, perform the paging at all possible paging possibilities of a paging cycle, so as to reach all UEs in the cell. In this case the radio base station would not use a coverage extension technique, since the radio base station can be sure that the CE-UEs will be reached by the paging at the CE-specific paging possibility and not for all possible.

[0078] One advantage of the above-described first aspect is that, by providing one dedicated paging possibility for CE-UEs, downlink resources can be saved. The coverage extension techniques, which can be a heavy burden to the radio base station(s) are applied in a very limited manner, namely for just one paging possibility.

[0079] One set of variants of the first aspect differs as to how this CE-specific paging pos-

sibility is defined. In general, it can be said that the CE-specific paging possibility must be known to both the CE-UE(s) and the radio base station(s), so as to ensure that the paging can be successful. However, how exactly the CE-specific paging possibility is defined can vary. One solution is that the radio frame number and the subframe number of the CE-specific paging possibility is fixed beforehand such that corresponding information can be e.g. pre-stored at the radio base station and the CE-UE (e.g. in the USIM), or the radio base station can broadcast same in its cell. Another possible solution is that a plurality of possible paging subframes, generally configured for the system by the radio base station, is divided to be used either as a UE-specific paging subframe or as a CE-specific paging subframe. By correspondingly configuring the paging parameter(s) (e.g. nB) of normal UEs and CE-UEs it is possible that CE-UEs are assigned e.g. one normal UE-specific paging subframe and one CE-specific paging subframe. Still another solution is based on an additional CE-specific UE identity that is assigned exclusively to CE-UEs and which can be used for calculating the CE-specific paging possibility; in addition, as in the prior art, the UE-specific paging possibility is calculated based on the usual identity of the CE-UE (e.g. IMSI).

[0080] According to a second aspect, the paging procedure by which a radio base station pages a user equipment which requires coverage extension in its cell is improved. This second aspect refers to the case where the paging is initiated in the core network (NAS) and is destined to a single UE (or a very limited number of UEs), in contrast to the first aspect dealing with cell-wide paging initiated by the eNB. The paging which is directed at a particular CE-UE shall reliably reach the CE-UE, and thus the radio base station shall use one appropriate coverage extension technique for the CE paging. In order to avoid unnecessary CE paging from the radio base station, the CE-capable UEs will implement a measurement and reporting procedure according to which the radio base station is informed as to the current CE status of the UE. The radio base station will thus only perform a CE paging for a CE-capable UE that is indeed currently in the CE status, i.e. currently requiring coverage extension. CE-UEs, although CE capable, will not be paged with a coverage extension technique, if the status of the CE-capable UE, informed to the radio base station, indicates that no coverage extension is actually required by this CE-capable UE at the moment.

[0081] Appropriate radio measurements are regularly performed by the CE-capable UE(s) to determine whether coverage extension is necessary or not at the moment. The measurements could also be triggered by the radio base station or a core network entity when being interested in the current CE status. These measurements could include e.g. at least one of RSRQ, RSRP, channel quality, block error rate, or any other suitable measurement parameter. Appropriate threshold(s) can be defined to which the CE-capable UE(s) compare(s) the measurement results to determine whether it requires or

not coverage extension.

[0082] Consequently, a particular CE-capable UE can change it CE-status, i.e. toggle between being a CE-UE (i.e. indeed requiring coverage extension) and a non-CE-UE (i.e. supporting CE but not requiring CE at the moment).

[0083] The radio base station is kept updated on the current CE status of the CE-capable UE and thus (should) knows at the time of paging whether coverage extension is indeed necessary or not for the paging. In order to limit uplink traffic, the informing of the radio base station could be limited to the cases where the CE status of the CE-capable UE is changed, i.e. from non-CE-UE to CE-UE and vice versa. Of course it should also be possible for the CE-capable UE to measure and report such information/ measurements periodically even in the absence of said toggling. In this case, the eNB could, based on its implementation, perform some averaging of the received information including measurement reports and determine that a toggling of CE state is indeed helpful. The step of informing may be done, e.g. directly between the CE-capable UE and the radio base station, e.g. for CE-capable UEs that are in connected state and thus may provide the corresponding CE status to the radio base station. Alternatively, the CE-capable UE may report to a core network entity, which in turn may inform the radio base station, at the latest when triggering for paging; this may be done e.g. for those cases where the CE-capable UE is in idle state and thus has no active connection with the radio base station.

[0084] Correspondingly, the paging for CE-UE is performed by the radio base station by using a CE technique, whereas paging for a non-CE-UE is performed without using a CE technique. The CE-capable UE appropriately receives the CE paging or normal paging.

[0085] Correspondingly, in one general first aspect, the techniques disclosed here feature a method for paging all user equipments in a cell controlled by a radio base station in a mobile communication system. At least one regularly-occurring coverage-extension-specific paging possibility, in short CE-specific paging possibility, is defined for paging user equipments that require coverage extension, in short CE user equipments. The radio base station is capable to use one of a plurality of techniques for achieving a coverage extension for a CE user equipment. The CE user equipments in the cell regularly monitor the at least one CE-specific paging possibility. When the radio base station determines to page all the user equipments in the cell, the radio base station pages the CE user equipments in the cell at the CE-specific paging possibility, using one of the plurality of techniques for achieving the coverage extension.

[0086] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, a plurality of UE-specific paging possibilities is defined for paging a specific user equipment in the cell of the radio base station. The

CE user equipments and non-CE user equipments each monitor a respective UE-specific paging possibility out of the plurality of UE-specific paging possibilities. The radio base station — upon determining to page all the user equipments in the cell - additionally performs paging at all of the plurality of UE-specific paging possibilities without using one of the plurality of techniques for achieving coverage extension. According to a further example, each of the plurality of UE-specific paging possibilities is different from the at least one CE-specific paging possibility.

[0087] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, each of the at least one CE-specific paging possibility refers to radio resources of a control channel defined by a radio frame number and subframe number and is repeated every paging cycle. The at least one CE-specific paging possibility is only monitored by CE user equipments. For example, the at least one CE-specific paging possibility is monitored by CE user equipments in idle state and CE user equipments in connected state.

[0088] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, the step of paging includes transmitting by the radio base station a first paging notification at radio resources of a control channel specified by the at least one CE-specific paging possibility, and includes transmitting by the radio base station a second paging message at radio resources of another channel specified by the first paging notification. For example, the technique for achieving the coverage extension is applied to both steps of transmitting the first paging notification and of transmitting the second paging message.

[0089] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, the plurality of techniques for achieving the coverage extension comprise at least one of a repetition technique where a message is repeated by the radio base station for a pre-configured number of times, an increase in transmission power, where a message is transmitted by the radio base station with an increased transmission power, a bundling technique where a .same message is transmitted in a plurality of consecutive subframes, and a spreading technique where a message is transmitted by a larger resource, e.g. via a larger frequency-time resource or channelization code.

[0090] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, the step of determining by the radio base station to page all user equipments in the cell is triggered by a change of system information applicable to the cell controlled by the radio base station or by the presence of a message, e.g. a warning message, to be broadcast in the cell controlled by the radio base station.

[0091] According to an advantageous variant of the first aspect which can be used in

addition or alternatively to the above, each of the at least one CE-specific paging possibility refers to radio resources of a control channel defined by a radio frame number and a subframe number which are pre-configured such that the radio frame number and the subframe number are fixed for the CE-specific paging possibility. For example, information to determine the pre-configured radio frame number and the pre-configured subframe number is stored in a Universal Subscriber Identity Module, USIM, of the CE user equipment, or broadcast by the radio base station in the cell. Further exemplary, the pre-configured subframe number is 1, 2, 3, 6, 7, or 8.

[0092] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, a plurality of paging possibilities are defined for paging in the cell of the radio base station, wherein a first value of at least one parameter for calculating the UE-specific paging possibility is different from a second value of the at least one parameter for calculating a CE-specific paging possibility such that the plurality of paging possibilities are divided to be used either as the CE-specific paging possibility or the UE-specific paging possibility. CE user equipments are configured to use the first value of the at least one parameter for calculating the UE-specific paging possibility and to use the second value of the at least one parameter for calculating the CE-specific paging possibility. Non-CE user equipments are configured to use the first value of the at least one parameter for calculating the UE-specific paging possibility and to not calculate the CE-specific paging possibility.

[0093] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, 6, wherein CE user equipments are assigned a CE-specific user equipment identity based on which the CE-specific paging possibility is calculated by the radio base station and the CE user equipments. For example, the CE-specific user equipment identity is the same for all CE-configured user equipments, and the CE-specific user equipment identity is stored in a Universal Subscriber Identity Module, USIM, of the CE user equipment or broadcast by the radio base station in the cell. Further for example, a plurality of different levels of coverage extension is defined, and wherein for each level of coverage extension a different CE-specific user equipment identity is defined.

[0094] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, wherein a plurality of different levels of coverage extension is defined, and wherein for each level of coverage extension a different CE-specific paging possibility is defined for paging the CE user equipments configured for that level of coverage extension.

[0095] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, the radio base station determines whether there are CE user equipments in idle state in its cell by performing a counting procedure

where the CE user equipments in idle state inform the radio base station about their presence in the cell controlled by the radio base station. For example, the determination is only performed in case there are no CE user equipments in connected state in the cell.

[0096] Correspondingly, in one general first aspect, the techniques disclosed here feature a user equipment located in a cell controlled by a radio base station in a mobile communication system. The user equipment, in short CE user equipment, requires coverage extension, wherein at least one regularly-occurring coverage-extension-specific paging possibility, in short CE-specific paging possibility, is defined for the CE user equipment. The radio base station is capable to use one of a plurality of techniques for achieving a coverage extension for the CE user equipment. A processor of the CE user equipment regularly monitors the at least one CE-specific paging possibility. A receiver of the CE user equipment receives a paging from the radio base station at the CE-specific paging possibility, using one of the plurality of techniques for achieving the coverage extension.

[0097] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, a plurality of UE-specific paging possibilities is defined for paging a specific user equipment in the cell of the radio base station. The processor of the CE user equipment monitors a respective UE-specific paging possibility out of the plurality of UE-specific paging possibilities. In a further example, each of the plurality of UE-specific paging possibilities is different from the at least one CE-specific paging possibility.

[0098] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, wherein each of the at least one CE-specific paging possibility refers to radio resources of a control channel defined by a radio frame number and subframe number and is repeated every paging cycle. In a further example, the at least one CE-specific paging possibility is monitored by the CE user equipment when in idle state and when in connected state.

[0099] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, the receiver receiving the paging includes: receiving a first paging notification at radio resources of a control channel specific by the at least one CE-specific paging possibility, and includes receiving a second paging message at radio resources of another channel specific by the first paging notification. In a further example, the technique for achieving the coverage extension is used by the CE user equipment to both receive the first paging notification and receive the second paging message.

[0100] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, each of the at least one CE-specific paging pos-

sibility refers to radio resources of a control channel defined by a radio frame number and a subframe number which are pre-configured such that the radio frame number and the subframe number are fixed for the CE-specific paging possibility. In a further example, a memory of the CE user equipment is adapted to store information to determine the pre-configured radio frame number and the pre-configured subframe number. Exemplarily, the memory is a Universal Subscriber Identity Module, USIM, of the CE user equipment. Or, the receiver of the CE user equipment receives information to determine the pre-configured radio frame number and the pre-configured subframe number, broadcast by the radio base station in the cell.

[0101] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, the CE user equipment is assigned a CE-specific user equipment identity, wherein the processor of the CE user equipment is adapted to calculate the CE-specific paging possibility based on the CE-specific user equipment identity. Exemplarily, the CE-specific user equipment identity is the same for all CE-configured user equipments. In a further example, a plurality of different levels of coverage extension is defined. For each level of coverage extension a different CE-specific user equipment identity is defined.

[0102] Correspondingly, in one general first aspect, the techniques disclosed here feature a radio base station for paging all user equipments in a cell controlled by the radio base station in a mobile communication system. At least one regularly-occurring coverage-extension-specific paging possibility, in short CE-specific paging possibility, is defined for paging user equipments that require coverage extension, in short CE user equipments. The radio base station is capable to use one of a plurality of techniques for achieving a coverage extension for a CE user equipment. A processor of the radio base station determines whether to page all the user equipments in the cell. A transmitter of the radio base station pages the CE user equipments in the cell at the CE-specific paging possibility, using one of the plurality of techniques for achieving the coverage extension.

[0103] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, a plurality of UE-specific paging possibilities are defined for paging a specific user equipment in the cell of the radio base station, wherein transmitter of the radio base station — upon the processor determining to page all the user equipments in the cell —additionally pages at all of the plurality of UE-specific paging possibilities without using one of the plurality of techniques for achieving coverage extension. For example, each of the plurality of UE-specific paging possibilities is different from the at least one CE-specific paging possibility.

[0104] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, the transmitter of the radio base station is

adapted to transmit a first paging notification at radio resources of a control channel specified by the at least one CE-specific paging possibility, and to transmit a second paging message at radio resources of another channel specified by the first paging notification. Exemplarily, the technique for achieving the coverage extension is applied to both the transmitting of the first paging notification and the transmitting of the second paging message.

[0105] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, the processor determines to page all the user equipments in the cell when being triggered by a change of system information applicable to the cell controlled by the radio base station or by the presence of a message, e.g. a warning message, to be broadcast in the cell controlled by the radio base station.

[0106] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, each of the at least one CE-specific paging possibility refers to radio resources of a control channel defined by a radio frame number and a subframe number which are pre-configured such that the radio frame number and the subframe number are fixed for the CE-specific paging possibility. Exemplarily, information to determine the pre-configured radio frame number and the pre-configured subframe number is stored in the radio base station, wherein the transmitter of the radio base station broadcasts the information to determine the pre-configured radio frame number and subframe number.

[0107] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, a CE-specific user equipment identity is assigned to the CE user equipments, wherein the processor of the radio base station is adapted to calculate the CE-specific paging possibility based on the CE-specific user equipment identity. Exemplarily, the transmitter of the radio base station is adapted to broadcast the CE-specific user equipment identity in the cell.

[0108] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, the processor of the radio base station determines whether there are CE user equipments in idle state in its cell by performing a counting procedure. Exemplarily, the determination is only performed in case there are no CE user equipments in connected state in the cell.

[0109] Correspondingly, in one general second aspect, the techniques disclosed here feature a method for paging a user equipment in a cell controlled by a radio base station in a mobile communication system. The user equipment supports coverage extension techniques, wherein the radio base station is capable to use one of a plurality of techniques for achieving a coverage extension for the CE-capable user equipment. Radio measurements are performed by the CE-capable user equipment, which determines whether coverage extension is necessary or not, based on the results of the

radio measurements. The radio base station is informed about whether the CE-capable user equipment needs coverage extension or not, based on the determination result. When paging the CE-capable user equipment, the radio base station applies or not applies one of the plurality of techniques for achieving coverage extension depending on whether coverage extension is necessary or not for the CE-capable user equipment.

[0110] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the radio measurements performed by the CE-capable user equipment include measurements of a Reference Signal Received Power, RSRP, and/or Reference Signal Received Quality, RSRQ, and/or a channel quality, and/or a block error rate and/ or HARQ operating point.

[0111] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the step of determining whether coverage extension is necessary comprises the step of comparing by the CE-capable user equipment the result of the radio measurements with a first threshold to determine whether coverage extension is necessary. For example, the comparison determines that coverage extension is necessary when the result of the radio measurements falls below the first threshold. The step further comprises comparing by the CE-capable user equipment the result of the radio measurements with a second threshold to determine whether coverage extension is not necessary. For example, the comparison determines that coverage extension is not necessary when the result of the radio measurement exceeds the second threshold.

[0112] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the step of informing the radio base station about the CE-capable user equipment needing coverage extension or not, includes the steps of either transmitting by the CE-capable user equipment information about whether the CE-capable user equipment needs coverage extension or not to the radio base station. In this case, for example the CE-capable user equipment is in a connected state. In a further example, it is avoided that the CE-capable user equipment is changing into the idle state by keeping it in the connected state. Alternatively, the step of informing includes the steps of transmitting by the CE-capable user equipment information about whether the CE-capable user equipment needs coverage extension or not to a core network entity. In this case, the core network entity provides the received information to the radio base station. For example, the CE-capable user equipment is in a connected state or in an idle state. In a further example, the core network entity is a mobility management entity.

[0113] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the radio base station is triggered to page the CE-capable user equipment by a core network entity that initiates and controls the paging,

preferably wherein the core network entity initiating the paging is a mobility management entity.

[0114] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the steps of performing the radio measurements and of determining whether coverage extension is necessary or not is performed regularly at a pre-configured time interval and/or triggered by the radio base station.

[0115] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the step of informing the radio base station is only performed when the result of the determination is different from the result of the determination previously informed to the radio base station.

[0116] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the radio base station determines whether the CE-capable user equipment needs coverage extension or not based on the radio resources selected by the CE-capable user equipment for initially attaching to the radio base station; for example, based on the selected preamble or access slot used for a random access procedure performed by the CE-capable user equipment when initially attaching to the radio base station.

[0117] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the step of paging the CE-capable user equipment comprises the steps of transmitting by the radio base station a first paging notification at radio resources of a control channel specified by a paging possibility specific to the CE-capable user equipment, and transmitting by the radio base station a second paging message at radio resources of another channel specified by the first paging notification. In a further example, the technique for achieving the coverage extension is applied to both steps of transmitting the first paging notification and of transmitting the second paging message.

[0118] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, upon successfully being paged by the radio base station, the CE-capable user equipment informs the radio base station about the successful paging, and the radio base station can inform a core network entity responsible for initiating the paging about the successful paging.

[0119] Correspondingly, in one general second aspect, the techniques disclosed here feature a user equipment located in a cell controlled by a radio base station in a mobile communication system. The user equipment, in short CE user equipment, supports coverage extension techniques. The radio base station is capable to use one of a plurality of techniques for achieving a coverage extension for the CE-capable user equipment. A processor of the CE user equipment performs radio measurements, and determines whether coverage extension is necessary or not, based on the results of the

radio measurements. A transmitter of the CE user equipment informs the radio base station about whether the CE-capable user equipment needs coverage extension or not, based on the determination result. A receiver of the CE user equipment receives paging from the radio base station, applying or not applying one of the plurality of techniques for achieving coverage extension depending on whether coverage extension is necessary or not.

[0120] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the radio measurements performed by the CE-capable user equipment include measurements of a Reference Signal Received Power, RSRP, and/or Reference Signal Received Quality, RSRQ, and/or a channel quality, and/or a block error rate and/ or HARQ operating point.

[0121] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the processor determines whether coverage extension is necessary or not by comparing the result of the radio measurements with a first threshold to determine whether coverage extension is necessary. For example, the comparison determines that coverage extension is necessary when the result of the radio measurements falls below the first threshold. Furthermore, the result of the radio measurements is compared with a second threshold to determine whether coverage extension is not necessary. For example, the comparison determines that coverage extension is not necessary when the result of the radio measurement exceeds the second threshold.

[0122] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the transmitter informs the radio base station by transmitting information about whether the CE-capable user equipment needs coverage extension or not to the radio base station. For example, the CE-capable user equipment is in a connected state, and furthermore it is avoided that the CE-capable user equipment is changing into the idle state by keeping it in the connected state. Alternatively, information about whether the CE-capable user equipment needs coverage extension or not is transmitted to a core network entity. The core network entity provides the received information to the radio base station, preferably wherein the CE-capable user equipment is in a connected state or in an idle state.

[0123] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the processor performing the radio measurements and determining whether coverage extension is necessary or not is performed regularly at a pre-configured time interval and/or triggered by the radio base station.

[0124] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the transmitter informs the radio base station

only when the result of the determination is different from the result of the determination previously informed to the radio base station.

[0125] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the receiver receiving the paging includes receiving a first paging notification at radio resources of a control channel specific by a paging possibility specific to the CE-capable user equipment, and receiving a second paging message at radio resources of another channel specific by the first paging notification. For example, the technique for achieving the coverage extension is used by the CE user equipment to both receive the first paging notification and receive the second paging message.

[0126] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the transmitter is further adapted to inform the radio base station about the successful paging.

[0127] Correspondingly, in one general second aspect, the techniques disclosed here feature a radio base station for paging a user equipment in a cell controlled by the radio base station in a mobile communication system. The user equipment supports coverage extension techniques. The radio base station is capable to use one of a plurality of techniques for achieving a coverage extension for the CE-capable user equipment. A receiver of the radio base station receives information about whether the CE-capable user equipment needs coverage extension or not. A transmitter of the radio base station, when paging the CE-capable user equipment, applies or not applies one of the plurality of techniques for achieving coverage extension depending on whether coverage extension is necessary or not for the CE-capable user equipment.

[0128] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the receiver receiving the information includes receiving from the CE-capable user equipment or from a core network entity the information about whether the CE-capable user equipment needs coverage extension or not.

According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the transmitter of the radio base station transmit a first paging notification at radio resources of a control channel specified by a paging possibility specific to the CE user equipment, and transmit a second paging message at radio resources of another channel specified by the first paging notification. For example, the technique for achieving the coverage extension is applied to both the transmitting of the first paging notification and the transmitting of the second paging message.

[0129] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, a receiver of the radio base station receives in-

formation about the successful paging of the CE user equipment, and the transmitter of the radio base station informs a core network entity responsible for initiating the paging about the successful paging.

[0130] Additional benefits and advantages of the disclosed embodiments will be apparent from the specification and Figures. The benefits and/or advantages may be individually provided by the various embodiments and features of the specification and drawings disclosure, and need not all be provided in order to obtain one or more of the same.

[0131] These general and specific aspects may be implemented using a system, a method, and a computer program, and any combination of systems, methods, and computer programs.

Brief Description of Drawings

[0132] [fig.1]Fig.1 shows an exemplary architecture of a 3GPP LTE system.

[fig.2]Fig. 2 shows an exemplary overview of the overall E-UTRAN architecture of 3GPP LTE.

[fig.3]Fig. 3 illustrates cyclical paging frames and paging occasions for two different cases.

[fig.4]Fig. 4 shows a system overview and message exchange for a paging which is initiated by the MME and spread across the different tracking areas at which the UE is registered.

[fig.5]Fig. 5 illustrates the UE-specific paging possibilities and CE-specific paging possibilities of two CE-UEs according to one exemplary first embodiment.

[fig.6]Fig. 6 shows a sequence diagram for the UE behavior according to one exemplary first embodiment.

[fig.7]Fig. 7 shows a sequence diagram for the eNB behavior according to one exemplary first embodiment.

[fig.8]Fig. 8 shows a message sequence diagram for a message exchange for measurement reporting and paging according to one exemplary second embodiment.

[fig.9]Fig. 9 shows a sequence diagram for the UE behavior according to one exemplary second embodiment.

[fig.10]Fig. 10 shows a sequence diagram for the eNB behavior according to one exemplary second embodiment.

Description of Embodiments

[0133] A mobile station or mobile node or user terminal or user equipment is a physical entity within a communication network. One node may have several functional entities. A functional entity refers to a software or hardware module that implements and/or offers a predetermined set of functions to other functional entities of a node or the network. Nodes may have one or more interfaces that attach the node to a commu-

nication facility or medium over which nodes can communicate. Similarly, a network entity may have a logical interface attaching the functional entity to a communication facility or medium over which it may communicate with other functional entities or correspondent nodes.

[0134] The term "radio resources" as used in the set of claims and in the application is to be broadly understood as referring to physical radio resources, such as time-frequency resources.

The term "paging possibility" as used in the set of claims and in the application is to be broadly understood as referring to physical radio resources (frequency-time resources) of a control channel (e.g. the PDCCH), which are defined by a radio frame number (also termed paging frame, PF) and a subframe number (also termed paging occasion, PO).

[0135] The expression "coverage-extension UE" (or "CE UE") as used in the set of claims and in the application is to be broadly understood as referring to a UE which requires coverage extension, e.g. because it is in a bad radio condition. The expression "CE-capable UE" shall be used for a UE supporting the coverage extension techniques, irrespective of whether or not the UE indeed requires coverage extension, i.e. a UE can support coverage extension techniques but can still be understood as a "non-CE UE" in case that no coverage extension is currently necessary. From eNB-perspective, it may be unclear at any particular point in time whether a CE-capable UE indeed requires coverage extension or not. The second embodiment is directed at said drawback.

[0136] Correspondingly, the expression "non-CE-UE" as used in the set of claims and in the application is to be broadly understood as referring to a UE which either does not require coverage extension (even when actually supporting the corresponding CE techniques) or does not support coverage extension techniques.

[0137] The expression "UE-specific paging possibility" as used in the set of claims and in the application is to be broadly understood as that paging possibility which is calculated based on the UE-ID (e.g. IMSI), and should be understood in the context of the CE-specific paging possibility which is specific to only coverage extension. As described in the background section, there is only a limited amount of paging possibilities available, across which the UEs are then disposed depending on their IDs. Although a particular paging possibility may be monitored by several UEs, the paging possibilities are UE-specific in the sense that the paging possibility to be monitored by a UE is determined based on the respective UE-ID.

[0138] The terms "paging notification" and "paging message" are distinguished in the set of claims and in the application to respectively refer to the first PDCCH message (which is basically an indication notifying about a paging message e.g. by use of the common P-RNTI) and the subsequent PDSCH message with the actual paging information. The

term "paging" does not make this distinction and shall cover both.

[0139] The term "CE-page" or "CE-paging" as used in the application shall refer broadly to a paging where one out of a plurality of coverage extension techniques is used. For example, when considering the repetition technique as the CE-technique used by an eNB, the "CE-page" will involve repeating the transmission of both paging messages, i.e. the paging notification on the PDCCH and the actual paging message on the PDSCH, for a pre-configured number of times as defined for the repetition technique.

[0140] As explained in the background section, coverage extension techniques are to be implemented for (MTC) devices, and it is unclear how the coverage extension shall be achieved for the paging procedure. However, expenditure is quite high for any of these techniques, such that they should be only used when necessary. For the paging which is initiated by the eNB, and is directed to all UEs in the cell, the currently-implemented paging is applied to all possible paging possibilities so as to reach all UEs. In order to reach also the CE-UEs, a coverage extension technique may be applied to the paging at all possible paging possibilities, which however results in a high expenditure of resources.

[0141] For the paging which is initiated by the NAS, and is directed to one UE only (or a very limited number of UEs), the MME inform the eNB over the S1 interface about the capability of a RRC_Connected UE to allow coverage extension and thus to support the coverage enhancement techniques mentioned above. However, it is unclear whether the UE is actually requiring coverage extension at the time of the page, (e.g. the UE, e.g. MTC device, moved from the cellar to open terrain). Consequently, the eNB might page the UE at the UE-specific paging possibility by using one of the CE techniques, even though the UE is in a good radio condition and would not have needed a coverage extension page. Again, resources are wasted.

[0142] The following exemplary embodiments are conceived by the inventors to mitigate the problems explained above.

[0143] Some of these are to be implemented in the wide specification as given by the 3GPP standards and explained partly in the background section, with the particular key features as explained in the following pertaining to the various embodiments. It should be noted that the embodiments may be advantageously used for example in a mobile communication system, such as 3GPP LTE-A (Release 10/11/12/13) communication systems as described in the Technical Background section above, but the embodiments are not limited to its use in this particular exemplary communication networks.

[0144] The explanations should not be understood as limiting the scope of the disclosure, but as a mere example of embodiments to better understand the present disclosure. A skilled person should be aware that the general principles of the present disclosure as laid out in the claims can be applied to different scenarios and in ways that are not ex-

plicitly described herein. Correspondingly, the following scenarios assumed for explanatory purposes of the various embodiments shall not limit the present disclosure and its embodiments as such.

[0145] In the following a set of embodiments will be explained. Although in the following embodiment, the broad expressions UE, CE-UE, CE-capable UE, are used, the embodiments may be equally applied for MTC devices, i.e. a CE-MTC device or CE-capable MTC device etc.

[0146] First embodiment

According to a first exemplary embodiment, a paging procedure according to which the eNB can page all the UEs in its cell, including those UEs which require coverage extension (and of course also support coverage extension), is presented.

[0147] For this first embodiment it is assumed that the paging is initiated (i.e. triggered) by the eNB itself; in contrast to paging being initiated by the Non-Access-Stratum for which the second embodiment provides an improved paging procedure. As already explained in the background section, paging may be initiated by the eNB for several reasons. For example, system information applicable to the cell may change, and the eNB wants to notify the UEs in its cell such that the UEs may acquire the updated system information immediately from the start of the next modification period. Another reason is that a warning message shall be broadcast in the cell, such as a message from the ETWS or CMAS system, or a message in relation to EAB (Enhanced Access Barring for MTC devices). More detailed information is omitted here, and reference is made to the corresponding passages in the background section which equally apply to the first embodiment.

[0148] Consequently, due to nature of those reasons, the eNB wants to make sure that the paging reaches all UEs in the cell, including those UEs which need coverage extension to be successfully reached. According to the first embodiment, a paging possibility is established for specifically paging those CE-UEs, termed in the following CE-specific paging possibility. More precisely, a CE-specific paging frame and a CE-specific subframe are defined referring to radio resources of the PDCCH that can be used for the CE-paging. In a similarly manner as for the UE-specific paging possibilities defined in the current systems, the CE-specific paging possibility shall occur regularly, e.g. in a cyclic manner according to the paging cycle followed by the UE. The CE-specific paging possibility can be defined in addition to the normal UE-specific paging possibilities already established by the prior art, as discussed in the background section. The CE-specific paging possibility is independent from the UE's identity and shall be the same for a plurality of CE-UEs, e.g. CE-UEs of a particular cell or all CE-UEs in general (or at least all CE-UEs of a specific CE level as will be explained later); this is different from the normal UE-specific paging possibility which — even though

several UEs may monitor the same paging possibility - is specific to the UE due to being calculating based on the ID of the UE(s). This CE-specific paging possibility is known at least to the eNB and the CE-UEs; non-CE-UEs may or may not be informed about this CE-specific paging possibility; however, these non-CE-UEs shall not monitor the CE-specific paging possibility since they may be reached by "normal", i.e. non-CE, paging.

[0149] Furthermore, the paging initiated by the eNB shall reach both UEs in RRC-idle state as well as UEs in RRC-connected state. Consequently, the CE-specific paging possibility shall be monitored by UEs in RRC-idle state and UEs in RRC-connected state.

[0150] The CE-UEs regularly monitor the CE-specific paging possibility to receive the CE-paging, thereby ensuring that they can be successfully paged.

[0151] From the perspective of the eNB, when a page is triggered (e.g. by a system information change), in order to reach the CE-UEs, the eNB will wait for the corresponding paging opportunity given by the CE-specific paging possibility and will then perform a CE page at the CE-specific paging possibility which is monitored by all the CE-UEs in its cell. In a similar manner as for the UE-specific paging possibility, this particularly involves the transmission of the paging notification on the PDCCH at that radio frame and subframe of the CE-specific paging possibility and the corresponding transmission of the paging message on resources of the PDSCH as indicated by the paging notification on the PDCCH. This transmission of the two messages of the CE page is performed by using one appropriate technique of the plurality of CE techniques which are foreseen for achieving the coverage extension, e.g. a repetition technique or a technique where a significantly increased power is used for the transmission.

[0152] The CE-UE(s) in the cell of the eNB monitor the CE-specific paging possibility and thus will receive the paging notification on the PDCCH and subsequently the paging message on the PDSCH. Furthermore, since the eNB will use a coverage extension technique for the paging, which is known to the CE-UE(s), the CE-UE(s) will correspondingly react to the CE-paging by e.g. additionally receiving the repetitions of the paging notification and paging message.

[0153] The paging message will inform the CE-UE(s) about e.g. the system information change or a warning message etc. Depending on the content of the paging message on the PDSCH, the CE-UE will react accordingly, e.g. by acquiring the system information at the next modification period or by providing the warning message to the user of the CE-UE.

[0154] Of course, in a preferred first embodiment the eNB will also want to page the other (non-CE) UEs and for said purpose will page them at all possible paging possibilities, as discussed in the background section, i.e. this will be done without using any CE technique. The non-CE-UEs will each monitor their UE-specific paging possibility and

will thus receive one of the paging performed by the eNB.

[0155] In general, the CE-specific paging possibility may be different from any of the UE-specific paging possibilities, assignable for the UEs, although this is not strictly necessary for the functioning of the first embodiment. For example, only subframes 1, 2, 3, 6, 7, and 8 might be possible for the CE-specific paging possibility, considering that the other subframes 0, 4, 5, 9 are candidates for being selected/calculated as the UE-specific paging possibilities.

[0156] In one possible embodiment, the CE-UEs may keep on regularly monitoring their UE-specific paging possibility, calculated based on their identity as explained in the background section, in addition to the CE-specific paging possibility. Alternatively, the CE-UEs may not monitor the CE-specific paging possibility and the UE-specific paging possibility at the same time, but may only monitor the CE-specific paging possibility.

[0157] Fig. 5 shows, in a similar manner as Fig. 3, the paging possibilities monitored by two different CE-UEs, UE1 and UE2. As apparent from Fig. 5, it is assumed that CE-UE1 monitors a UE-specific paging possibility at radio frame number 76 and number 204 (76+128) etc., respectively at subframe 9 (see also Fig. 3, case B), and that CE-UE2 monitors a UE-specific paging possibility at radio frame number 19 and 147 (19+128) etc., respectively at subframe 4 (see also Fig. 3, case C). In addition, both CE-UE1 and CE-UE2 monitor the same CE-specific paging possibility, which in this exemplary illustration, is assumed to occur at CE-specific paging frames 36, 164 (36+128) etc. and at respective CE-specific subframe 1.

[0158] Fig. 6 shows a sequence diagram for the behavior of a CE-UE for an exemplary variant of the first embodiment. Particularly, it is assumed, in concordance with Fig. 5, that the CE-UE monitors both the CE-specific paging possibility as well as the UE-specific paging possibility, and when it receives the paging notification, the CE-UE will proceed to receive the corresponding paging message at the PDSCH resources indicated by the PDCCH paging notification, either applying or not applying a CE technique. Depending on the content of the paging message, the CE-UE will then react accordingly.

[0159] Fig. 7 shows a sequence diagram for the corresponding behavior of an eNB which wants to perform a paging. After the eNB decides to perform a paging of all UEs in its cell (e.g. due to system information change), it will proceed to perform the usual page at all possible UE-specific paging possibilities to reach all non-CE-UEs, without using any CE technique. On the other hand, to also reach the CE-UEs, the eNB will perform the CE paging at the CE-specific paging possibility, by using one appropriate CE-technique (e.g. repetition or increased transmission power).

[0160] The first embodiment as explained above has the advantage that the use of the

coverage extension technique(s) is limited to one particular CE-specific paging possibility, instead of having to be applied to all possible UE-specific paging possibilities. By using one paging possibility, all (or at least a plurality) of CE-UEs can be paged at the same time. Corresponding downlink resources can thus be saved. Furthermore, the CE-specific paging possibility is independent from the real IMSI of any CE-UE.

[0161] The CE-specific paging possibility can be defined in a number of different ways, but must always provide a CE-specific paging radio frame number and CE-specific paging subframe number, known to both the CE-UE(s) and the eNB(s).

[0162] According to a first variant of the first embodiment, the CE-specific paging possibility is fixed beforehand, e.g. not calculated but directly indicated. In one example, the numbers for the CE-specific paging radio frame and subframe are directly defined e.g. in the CE-UE (e.g. in its USIM, UICC etc) and the eNB; in other words, the CE-UE and the eNB would have information indicating particular radio frame and subframe numbers (such as radio frame number 36 and subframe number 1, as for the example of Fig. 4) for the CE-specific paging possibility. This information need not be pre-stored in the CE-UE (e.g. by use of the USIM) but could also be broadcast by the eNB in its cell, e.g. as part of the system information or indicated with a dedicated message when possible, such that the CE-UE(s) learn about the CE-specific paging possibility to be used for CE-paging from the eNB. This would allow different CE-specific paging possibilities to be used by different eNBs.

[0163] Alternatively, instead of directly indicating the CE-specific subframe number, the parameters Ns and i_s (already known from the calculation of the UE-specific paging possibility) could be reused in said respect. In particular, the following exemplary extended table can be used, which, in comparison with the table available from TS 36.304 as explained in the background section, includes at least one additional row for e.g. Ns= 5 (any other unused Ns number can be used of course) with the possible POs at subframes 1, 2, 3, and 6.

[0164] [Table 3]

Ns	PO when i_s=0	PO when i_s=1	PO when i_s=2	PO when i_s=3
1	9	N/A	N/A	N/A
2	4	9	N/A	N/A
4	0	4	5	9
5	1	2	3	6

[0165] For this alternative, Ns and i_s values would be pre-configured for the CE-specific paging possibility such that the CE-UE and eNB could determine, based on the exemplary table above, which CE-specific paging subframe to use. The CE-specific

paging radio frame would in this example still be directly indicated by a corresponding radio frame number.

[0166] The advantage of this first variant is that the CE-UE(s) would not need to calculate Ns and i_s, but may directly use the indicated numbers for the radio frame and subframe of the CE-specific paging possibility.

[0167] According to a second variant of the first embodiment to define the CE-specific paging possibility vis-a-vis the UE-specific paging possibility, the CE-specific paging possibilities are defined by providing different parameter values to the CE-UE(s) than to the non-CE-UEs. It is assumed, that the CE-specific paging subframe is calculated following the equations and principles explained for the UE-specific paging possibility in the background section. By using different parameter values for the same UE, the calculation of the UE-specific paging subframe yields different subframe numbers than the corresponding subframe numbers of the CE-specific paging possibility. As with the first variant explained above, the radio frame number for the CE-specific paging possibility is fixed.

[0168] In one example, the parameter with the different value is "nB", i.e. indicating the number of paging subframes per paging cycle (across all UEs in the cell), where one value is defined for CE-UEs and another value is defined for non-CE-UEs. There could however be another parameter broadcasted by the network for indicating rather directly the segregation of paging subframes between CE-UEs and non-CE-UEs.

[0169] According to a third variant of the first embodiment to define the CE-specific paging possibility, a CE-specific UE identity (e.g. CE-IMSI) is introduced. When considering the various CE levels a CE-UE can be configured for, a CE-level-specific UE identity can be introduced for each CE level. In any case, the CE-IMSI(s) is known to both the eNB and the CE-UE(s). The CE-specific UE identity(ies) can be provided to the CE-UEs beforehand, e.g. broadcast in the cell, or pre-stored in the SIM/ USIM or UICC or even in the Mobile Device, ME. A particular CE-UE and the network will use one of these identities corresponding to the required level of coverage extension support required e.g. one CE-UE deep down in bad radio and the network will use UE-identity1; whereas the same UE when coming back in relatively better radio, but still requiring CE support, will rather use UE-identity2 which is the corresponding use UE-identity for this level of Coverage Extension required. For this to work, it is important that the UE-identity to be used and the corresponding coverage extension required is known to both the network and the CE-UE e.g. by way of specification, or broadcasting etc. and there is a hand-shake between the CE-UE and the network about what level applies to the particular CE-UE at any given point in time. The hand-shake includes the measurement configuration and reporting as described previously.

[0170] It is assumed that basically the same calculation and principles are applied when cal-

culating the CE-specific paging possibility as explained for the UE-specific paging possibility in the background section. Both the eNB and the CE-UE(s) can calculate the same CE-(level)-specific paging possibility by the CE-(level)-specific IMSI instead of using the CE-UE's real IMSI.

[0171] As already mentioned in the background section, different coverage extension levels can be defined (e.g. 15dB, 13 dB etc.), where the respective coverage extension technique can be adapted appropriately to ensure achieving the corresponding coverage extension level. When e.g. considering the repetition CE technique, a coverage extension level to ensure 15dB might require 100 repetitions, whereas less or more repetitions may be necessary to ensure a different CE level. Similarly considerations apply to the other CE-techniques.

[0172] A particular CE-UE is configured for one of those coverage extension levels. Correspondingly, according to further examples of the first embodiment, one CE-specific paging possibility is defined per CE level, i.e. a CE-level-specific paging possibility, such that a CE-UE will only monitor the CE-level-specific paging possibility of the CE-level for which it is configured but not other CE-level-specific paging possibilities that are defined for other CE-levels.

[0173] A further improvement to the first embodiment is that CE-UEs which are in RRC-connected mode may try to read and receive paging at the UE-specific paging possibilities of other UEs. The UE_ID, which is IMSI mod 1024, can only take up to 1024 different values, and the radio frame is calculated based on "UE_ID mod N" such that only N different radio frames are used in each paging cycle. Consequently, a CE-UE could be configured to monitor some or all of the possible radio frames and subframes available for other UEs. This allows the network to not make as many repetitions as would otherwise be required if the UE was not receiving paging other than the UE-specific paging possibilities.

[0174] A further improvement to the first embodiment focuses on when to actually perform a CE page. Until now it has been (silently) assumed that there would be always a CE-UE in a cell, such that any eNB, at any time when paging is triggered, would perform the CE-paging at the CE-specific paging possibility(ies). The eNB is aware of all (CE-)UEs that are in RRC-Connected mode, since these have an active connection with the eNB, and thus the eNB determines whether a CE-UE that require coverage extension is in its cell or not. However, the eNB is not aware of which CE-UEs in RRC-Idle mode are currently in its cell. Consequently, assuming that no CE-UEs in RRC-Connected mode are in the cell of the eNB, the eNB is unaware of whether there is at least one CE-UE in RRC-Idle mode in its cell. To make sure that any possible CE-UEs in Idle mode are reached too, in these cases, the eNB will always have to performing the CE paging. This however may result in a waste of resources for the

case where no CE-UE(s) in RRC-Idle mode were in its cell either.

[0175] According to this improvement, this waste of resources shall be avoided by providing a procedure that allows the eNB to determine whether any CE-UEs are in its cell, be it in RRC-Idle or RRC-Connected state. To said end, the eNB might first determine whether there are any CE-UEs in RRC-Connected mode, which could be done e.g. by maintaining a table with UE-capability information received from the MME or UE. Subsequently, in case the eNB determines that there are no CE-UEs in RRC-Connected mode, a counting procedure is initiated which allows the eNB to determine/estimate the number of CE-UEs in RRC-idle state in its cell. In one example of a counting procedure the UEs in RRC-Idle on a more or less round robin fashion go to RRC-Connected state and inform the network about the presence of the CE UE in RRC-Idle mode (i.e. about itself). The round robin method can e.g. be implemented using a persistence check method wherein the Idle UEs compare a randomly drawn number against a number broadcasted by the network. Only the one(s) drawing a smaller value will transit to RRC Connected to inform the network. The network can keep the broadcasted value to be small enough so that only a very small percentage of UEs should really pass this test at a given time. This is similar to what is done in MBMS Counting procedure as depicted in RRC specification 3GPP TS 36.331, current version 12.4.1 incorporated herein by reference.

[0176] In consequence, the eNB will only perform the CE page when it has determined that there is at least one CE-UE in its cell, be it in RRC-Idle or RRC-Connected state. As a result, the additional resources for a CE-page are not used in vain.

[0177] Second embodiment

As explained above, the first embodiment relates to an improvement for a paging procedure initiated by the eNB, which then shall page all UEs in its cell. The second embodiment to be presented relates to an improvement for a paging procedure that is initiated by the NAS (Non-Access-Stratum), e.g. the MME, and which is dedicated to just a single UE, or a rather limited number of UEs.

[0178] In particular, for this second embodiment it is assumed that the paging is initiated by the NAS, for instance in order to establish a call with a particular CE-UE; details in said respect have already been provided in the background section (see also Fig. 4) and apply equally to the second embodiment. In this respect the "call" need not be just a voice call but can also refer to other terminating service like SMS, MMS or Pager etc. For instance, the MME — in response to a corresponding trigger from the SGW in the core network — sends a paging message to all eNBs that belong to the tracking area(s) for which the CE-UE is currently registered. Particularly, the MME does not know where a CE-UE in RRC idle is located. Each eNB belonging to one of the TAs in an associated TA-list, in turn, then has to perform paging so as to page this CE-UE to

which the call is destined. Finally, the CE-UE being paged can then establish a connection with the eNB where it is camped and then proceed to accept the incoming call (see also Fig. 4).

[0179] In the above-described scenario, the MME informs the eNBs (over the S1 interface) about the capability(ies) of a (CE-)UE, e.g. whether the UE is capable of supporting coverage extension (and optionally which level of coverage extension). As explained before, this general capability information however gives no information on whether a particular CE-capable UE indeed requires coverage extension at the moment or not; e.g. while a CE-capable UE might have been in a basement for a long time, i.e. thus requiring coverage extension for compensating the bad radio conditions, this very same CE-capable UE might in mean time have emerged from the basement and thus might no longer require coverage extension or still require coverage extension but corresponding to a less demanding coverage extension level.

[0180] Consequently, according to the second embodiment, a procedure is implemented according to which the eNB can learn whether a CE-capable UE is indeed requiring coverage extension or not at the time of paging. To said end, a new measurement and reporting procedure is implemented between the UE and the eNB as will be explained in detail below.

[0181] The CE-capable UE is configured to perform radio measurements that allow determining whether the CE-capable UE is currently indeed requiring coverage extension or not. The radio measurements could refer for example to one or more of the following: Reference Signal Received Power (RSRP), Reference Signal Received Quality (RSRQ), channel quality etc. e.g. as defined in Chapter 5 of 3GPP TS36.214 v10.1.0(NPL 8), or even current Block Error Rate (BLER) estimates or HARQ operating point and any other suitable measurement target. In any case, a skilled person is well aware of how to determine the current radio conditions of a CE-capable UE that allow, in a subsequent step, to determine whether coverage extension is indeed necessary or not.

[0182] After performing the appropriate radio measurements, the CE-capable UE shall then determine whether coverage extension is necessary based on the results of the measurements. In one example, two appropriate thresholds can be defined, to which the measurements results are compared by the CE-capable UE so as to determine the current CE status of the CE-capable UE. For example, an upper threshold can be defined, where if the measurements results (e.g. RSRP or RSRQ) exceed the upper threshold, the CE-capable UE would determine that it does not require coverage extension, i.e. that it currently is a non-CE-UE. Conversely, a different lower threshold can be defined, where if the measurement results (e.g. again RSRP or RSRQ) fall below the lower threshold, the CE-capable would conclude that it does require

coverage extension, i.e. that is currently is a CE-UE. Instead of using two thresholds, the determination of whether CE is required or not, could of course also be determined by simply using one threshold, where measurements results exceeding the threshold would mean that coverage extension is not necessary, and measurements results falling below the threshold would mean that coverage extension is necessary. The same technique can also be used for other measurement possibility like for HARQ operating point i.e. where HARQ operating point exceeding the corresponding HARQ operating point-threshold would mean that coverage extension is not necessary, and HARQ operating point falling below the HARQ operating point-threshold would mean that coverage extension is necessary.

[0183] The radio measurements and CE status determination can be performed regularly by the CE-capable UE, i.e. at specific, pre-configured, intervals, and/or event triggered (one even for exceeding the threshold in either direction as described above), e.g. , and/or triggered by the eNB. In addition to the absolute threshold for the corresponding measurement, the network might also provide the corresponding Hysteresis and Time to Trigger values as described in 3GPP TS 36.331, current version 12.4.1. Hysteresis basically gives a margin or allowance in breaching the threshold in either direction, and the Time to Trigger (TTT) indicates at least how long the said threshold should remain breached/ exceeded for the UE to trigger the corresponding event.

[0184] Which radio measurements shall be performed, at which intervals, against which threshold(s) the measurement results should be compared, and any other necessary information can be pre-configured in the CE-capable UE or provided to the CE-capable UEs from the eNB, e.g. within a corresponding control message which could be signaled by RRC or Layer2 (MAC) or Layer1 (Physical layer signal) and may contain additional parameters including Hysteresis, TTT and the target object like current/ serving and neighbor cell list.

[0185] The CE-capable UE has to make sure that the eNB is kept updated on the current CE status, i.e. on whether the CE-capable UE needs coverage extension or not. This may be done e.g. by reporting every change of CE status to the eNB, such that the eNB knows at the time of paging whether a coverage extension technique shall be applied to the paging or not. Of course the same information can be used for DL messages other than paging and also to UL messages including paging response and other non-paging related messages. Depending on whether the CE-capable UE is in idle mode or connected mode, the reporting of the CE status to the eNB may be different. If the CE-capable UE is in RRC connected state and thus has an active connection with the eNB, the CE-capable UE can directly transmit a CE-status report, e.g. RRC Measurement Report, to the eNB.

[0186] Since such a direct report is not possible for CE-capable UEs in RRC-IDLE (since no

active connection with the eNB is available), the CE-capable UE in idle will report the CE status to the MME, which thus knows whether coverage extension is indeed required or not (independent from the CE-capability of a UE). The MME may either keep the eNB(s) regularly up to date in said respect, or might only provide the corresponding information to the eNB(s) when also triggering the eNB for paging. Of course, also CE-capable UEs in RRC connected could inform the MME, instead of or in addition to the eNB.

[0187] In another alternative, the CE-capable UE in idle will report the CE status and UE NAS identity directly to the serving eNB where the UE is camped in currently e.g. upon cell Selection and Reselection(s), which thus knows whether coverage extension is indeed required or not by maintaining a new Table including the UE NAS identity and CE-requirement.

[0188] Alternatively, another improvement provides that the CE-capable UEs do not change into RRC-idle state and thus remain all the time in RRC-connected state, such that the CE-capable UE can always transmit the measurement report directly to the eNB. The eNB can ensure that the UE remains in connected state by never sending the RRC Connection Release message to the UE i.e. basically ignoring any inactivity timer in the eNB for this UE.

[0189] In any case, the eNB, when being triggered to page a particular CE-capable UE, will be informed about and will consider whether said CE-capable UE indeed requires coverage extension or not. Based on the thus known current CE status of the UE, the eNB will or will not apply an appropriate CE technique to the paging of the CE-capable UE. As explained in detail for the first embodiment already, applying the CE technique to paging involves applying the CE technique to both the paging notification transmitted on the PDCCH and the actual paging message transmitted on the PDSCH as addressed by the PDCCH.

[0190] In other words, two measurement events are defined, one referring to the case where the radio measurements indicate that coverage extension is required, and the other referring to the case where the radio measurements indicate that coverage extension is not required. When any of the two events occur, this is reported to the eNB (either directly or via the core network entity, e.g. MME).

[0191] Fig. 8 shows a message sequence diagram for an exemplary paging procedure according to the second embodiment. As apparent therefrom, a measurement control message is provided from the eNB to the UE, which is assumed to include all information necessary to configure the UE to perform the radio measurements and to determine the CE-status based on the measurement results. Fig. 8 also shows the measurement report message from the UE to the eNB, which is transmitted to the eNB to allow the eNB to update the CE status of the UE. This allows in consequence that the

eNB performs the paging of the UE by using or not using a CE technique depending on the CE status of the UE.

[0192] Fig. 9 shows a simplified sequence process diagram for the CE-capable UE for one particular exemplary second embodiment as explained above where the measurement and reporting procedure is depicted in parallel to the page monitoring procedure.

[0193] Fig. 10 shows a simplified sequence process diagram for the eNB as explained above including the reception and update procedure for the CE status of the UE, and the parallel paging procedure which depends on the CE status.

[0194] Fig. 8 additionally shows an optional determination of the initial coverage extension status of the UE, which can be done directly upon the initial access of the UE to the eNB (see dashed box). In particular, the UE when initially attaching to a cell (and to the corresponding eNB) usually performs a RACH procedure, which involves e.g. the selection of an appropriate preamble, access slot etc. The CE-capable UE would, during initial access, determine its CE status in order to appropriately select the RACH resources (e.g. preamble, access slot, etc). Now, the eNB can estimate the radio conditions of the UE, and thus the CE status of the UE, based on the parameters, like preambles, preamble format or even the physical resources that the UE selected to perform the RACH procedure.

[0195] Another improvement of the second embodiment, which is also illustrated in Fig. 8 by use of a dashed arrow, refers to a feedback message transmitted from the eNB to the UE about the successful reception of the measurement report, i.e. CE status update, and confirmation that the toggling (between CE and non-CE) is successfully applied at the network side and therefore the UE should also toggle and transmit/ receive according to the new toggled state. By e.g. sending back information on the current CE status, the eNB can make sure that the CE-capable UE and the eNB have the same understanding of the CE status, and behave accordingly in a same manner. For instance, if the measurement report is lost, or decoded incorrectly at the eNB, the eNB would not change the CE status, and the UE and eNB would have different CE status (e.g. until the next, successful, measurement report is received by the eNB). Also, even successful reception of the measurement report is not a guarantee that eNB is fine with the toggling for reasons like admission control or for independent toggling evaluation at the eNB side. In this respect, the triggering of a measurement event is just one of the input parameter for the eNB to decide about the said toggling of CE state, and eNB may take the final decision based on cell and System specific considerations. In absence of the feedback message transmitted from the eNB to the UE about the successful reception of the measurement report and confirming that the toggling (between CE and non-CE) is successfully applied at the network side, obviously, different CE status might lead to a waste of radio resources or to an unsuccessful

paging, which is avoided by providing a feedback on the successful CE status update.

[0196] Still a further improvement of the second embodiment is also illustrated in Fig. 8. As indicated by the dashed arrow, the UE can inform the eNB immediately when a CE page was successful. In particular, instead of waiting to receive e.g. all repetitions of the CE page, as soon as the CE page is successfully received (e.g. the actual paging message was successfully decoded/delivered to the higher layer), the CE-capable UE informs the eNB in said respect. In turn, the eNB can inform the MME in the core network, which may then abort the page in the other eNBs of all the tracking areas (not shown in Fig. 8) pertaining to a corresponding TA-list. Radio resources are thus not wasted by other eNBs.

[0197] Third embodiment

According to a third embodiment, the first embodiment and the second embodiments are combined such that CE devices can be paged both at the NAS level and the AS level (i.e. initiated by NAS and initiated by eNB). Thus, the separation of NAS and AS is maintained as in legacy systems. Furthermore, the first and second embodiments are simple to implement and have no impact on legacy procedures.

[0198] Hardware and Software Implementation of the present disclosure

Other exemplary embodiments relate to the implementation of the above described various embodiments using hardware and software. In this connection a user terminal (mobile terminal) and an eNodeB (base station) are provided. The user terminal and base station is adapted to perform the methods described herein, including corresponding entities to participate appropriately in the methods, such as receiver, transmitter, processors.

[0199] It is further recognized that the various embodiments may be implemented or performed using computing devices (processors). A computing device or processor may for example be general purpose processors, digital signal processors (DSP), application specific integrated circuits (ASIC), field programmable gate arrays (FPGA) or other programmable logic devices, etc. The various embodiments may also be performed or embodied by a combination of these devices.

[0200] Further, the various embodiments may also be implemented by means of software modules, which are executed by a processor or directly in hardware. Also a combination of software modules and a hardware implementation may be possible. The software modules may be stored on any kind of computer readable storage media, for example RAM, EPROM, EEPROM, flash memory, registers, hard disks, CD-ROM, DVD, etc.

[0201] It should be further noted that the individual features of the different embodiments may individually or in arbitrary combination be subject matter to another embodiment.

[0202] It would be appreciated by a person skilled in the art that numerous variations and/or

modifications may be made to the present disclosure as shown in the specific embodiments. The present embodiments are, therefore, to be considered in all respects to be illustrative and not restrictive.

Claims

[Claim 1] A method for paging all user equipments in a cell controlled by a radio base station in a mobile communication system, wherein at least one regularly-occurring coverage-extension-specific paging possibility, in short CE-specific paging possibility, is defined for paging user equipments that require coverage extension, in short CE user equipments, wherein the radio base station is capable to use one of a plurality of techniques for achieving a coverage extension for a CE user equipment, the method comprising the steps of:
regularly monitoring by the CE user equipments in the cell the at least one CE-specific paging possibility,
determining by the radio base station to page all the user equipments in the cell, and
paging by the radio base station the CE user equipments in the cell at the CE-specific paging possibility, using one of the plurality of techniques for achieving the coverage extension.

[Claim 2] The method according to claim 1, wherein a plurality of UE-specific paging possibilities are defined for paging a specific user equipment in the cell of the radio base station, wherein the CE user equipments and non-CE user equipments each monitor a respective UE-specific paging possibility out of the plurality of UE-specific paging possibilities,
wherein the radio base station — upon determining to page all the user equipments in the cell - additionally performs paging at all of the plurality of UE-specific paging possibilities without using one of the plurality of techniques for achieving coverage extension,
preferably wherein each of the plurality of UE-specific paging possibilities is different from the at least one CE-specific paging possibility.

[Claim 3] The method according to claim 1 or 2, wherein the step of paging includes:
transmitting by the radio base station a first paging notification at radio resources of a control channel specified by the at least one CE-specific paging possibility, and
transmitting by the radio base station a second paging message at radio resources of another channel specified by the first paging notification,
preferably wherein the technique for achieving the coverage extension is applied to both steps of transmitting the first paging notification and of transmitting the second paging message.

[Claim 4] The method according to one of claims 1 to 3, wherein each of the at least one CE-specific paging possibility refers to radio resources of a control channel defined by a radio frame number and a subframe number which are pre-configured such that the radio frame number and the subframe number are fixed for the CE-specific paging possibility, preferably wherein information to determine the pre-configured radio frame number and the pre-configured subframe number is stored in a Universal Subscriber Identity Module, USIM, of the CE user equipment, or broadcast by the radio base station in the cell, and preferably wherein the pre-configured subframe number is 1, 2, 3, 6, 7, or 8.

[Claim 5] The method according to one of claims 1 to 3, wherein CE user equipments are assigned a CE-specific user equipment identity based on which the CE-specific paging possibility is calculated by the radio base station and the CE user equipments,
preferably wherein the CE-specific user equipment identity is the same for all CE-configured user equipments,
preferably wherein the CE-specific user equipment identity is stored in a Universal Subscriber Identity Module, USIM, of the CE user equipment or broadcast by the radio base station in the cell;
preferably wherein a plurality of different levels of coverage extension is defined, and wherein for each level of coverage extension a different CE-specific user equipment identity is defined.

[Claim 6] A user equipment located in a cell controlled by a radio base station in a mobile communication system, the user equipment, in short CE user equipment, requiring coverage extension, wherein at least one regularly-occurring coverage-extension-specific paging possibility, in short CE-specific paging possibility, is defined for the CE user equipment, wherein the radio base station is capable to use one of a plurality of techniques for achieving a coverage extension for the CE user equipment, the CE user equipment comprising:
a processor adapted to regularly monitor the at least one CE-specific paging possibility,
a receiver adapted to receive a paging from the radio base station at the CE-specific paging possibility, using one of the plurality of techniques for achieving the coverage extension.

[Claim 7] The user equipment according to claim 6, wherein each of the at least one CE-specific paging possibility refers to radio resources of a control

channel defined by a radio frame number and a subframe number which are pre-configured such that the radio frame number and the subframe number are fixed for the CE-specific paging possibility, preferably wherein a memory of the CE user equipment is adapted to store information to determine the pre-configured radio frame number and the pre-configured subframe number, preferably wherein the memory is a Universal Subscriber Identity Module, USIM, of the CE user equipment, or
preferably wherein the receiver of the CE user equipment is further adapted to receive information to determine the pre-configured radio frame number and the pre-configured subframe number, broadcast by the radio base station in the cell.

[Claim 8] A radio base station for paging all user equipments in a cell controlled by the radio base station in a mobile communication system, wherein at least one regularly-occurring coverage-extension-specific paging possibility, in short CE-specific paging possibility, is defined for paging user equipments that require coverage extension, in short CE user equipments, wherein the radio base station is capable to use one of a plurality of techniques for achieving a coverage extension for a CE user equipment, the radio base station comprising:
a processor adapted to determine whether to page all the user equipments in the cell, and
a transmitter adapted to page the CE user equipments in the cell at the CE-specific paging possibility, using one of the plurality of techniques for achieving the coverage extension.

[Claim 9] A method for paging a user equipment in a cell controlled by a radio base station in a mobile communication system, wherein the user equipment supports coverage extension techniques, wherein the radio base station is capable to use one of a plurality of techniques for achieving a coverage extension for the CE-capable user equipment, the method comprising the steps of:
performing radio measurements by the CE-capable user equipment,
determining by the CE-capable user equipment whether coverage extension is necessary or not, based on the results of the radio measurements,
wherein the radio base station is informed about whether the CE-capable user equipment needs coverage extension or not, based on the determination result,

when paging the CE-capable user equipment, applying or not applying by the radio base station one of the plurality of techniques for achieving coverage extension depending on whether coverage extension is necessary or not for the CE-capable user equipment.

[Claim 10] The method according to claim 9, wherein the radio measurements performed by the CE-capable user equipment include measurements of a Reference Signal Received Power, RSRP, and/or Reference Signal Received Quality, RSRQ, and/or a channel quality, and/or a block error rate and/ or HARQ operating point.

[Claim 11] The method according to claim 9 or 10, wherein the step of determining whether coverage extension is necessary comprises the steps of:
comparing by the CE-capable user equipment the result of the radio measurements with a first threshold to determine whether coverage extension is necessary, preferably wherein the comparison determines that coverage extension is necessary when the result of the radio measurements falls below the first threshold,
comparing by the CE-capable user equipment the result of the radio measurements with a second threshold to determine whether coverage extension is not necessary, preferably wherein the comparison determines that coverage extension is not necessary when the result of the radio measurement exceeds the second threshold.

[Claim 12] The method according to one of claims 9 to 11, wherein the step of paging the CE-capable user equipment comprises the steps of:
transmitting by the radio base station a first paging notification at radio resources of a control channel specified by a paging possibility specific to the CE-capable user equipment, and
transmitting by the radio base station a second paging message at radio resources of another channel specified by the first paging notification, preferably wherein the technique for achieving the coverage extension is applied to both steps of transmitting the first paging notification and of transmitting the second paging message.

[Claim 13] A user equipment located in a cell controlled by a radio base station in a mobile communication system, the user equipment, in short CE user equipment, supporting coverage extension techniques, wherein the radio base station is capable to use one of a plurality of techniques for achieving a coverage extension for the CE-capable user equipment, the user equipment comprising:
a processor adapted to perform radio measurements,

the processor being further adapted to determine whether coverage extension is necessary or not, based on the results of the radio measurements,

a transmitter adapted to inform the radio base station about whether the CE-capable user equipment needs coverage extension or not, based on the determination result,

a receiver adapted to receive paging from the radio base station, applying or not applying one of the plurality of techniques for achieving coverage extension depending on whether coverage extension is necessary or not.

[Claim 14] The user equipment according to claim 13, wherein the transmitter informs the radio base station by:

transmitting information about whether the CE-capable user equipment needs coverage extension or not to the radio base station, preferably wherein the CE-capable user equipment is in a connected state, preferably wherein it is avoided that the CE-capable user equipment is changing into the idle state by keeping it in the connected state, or

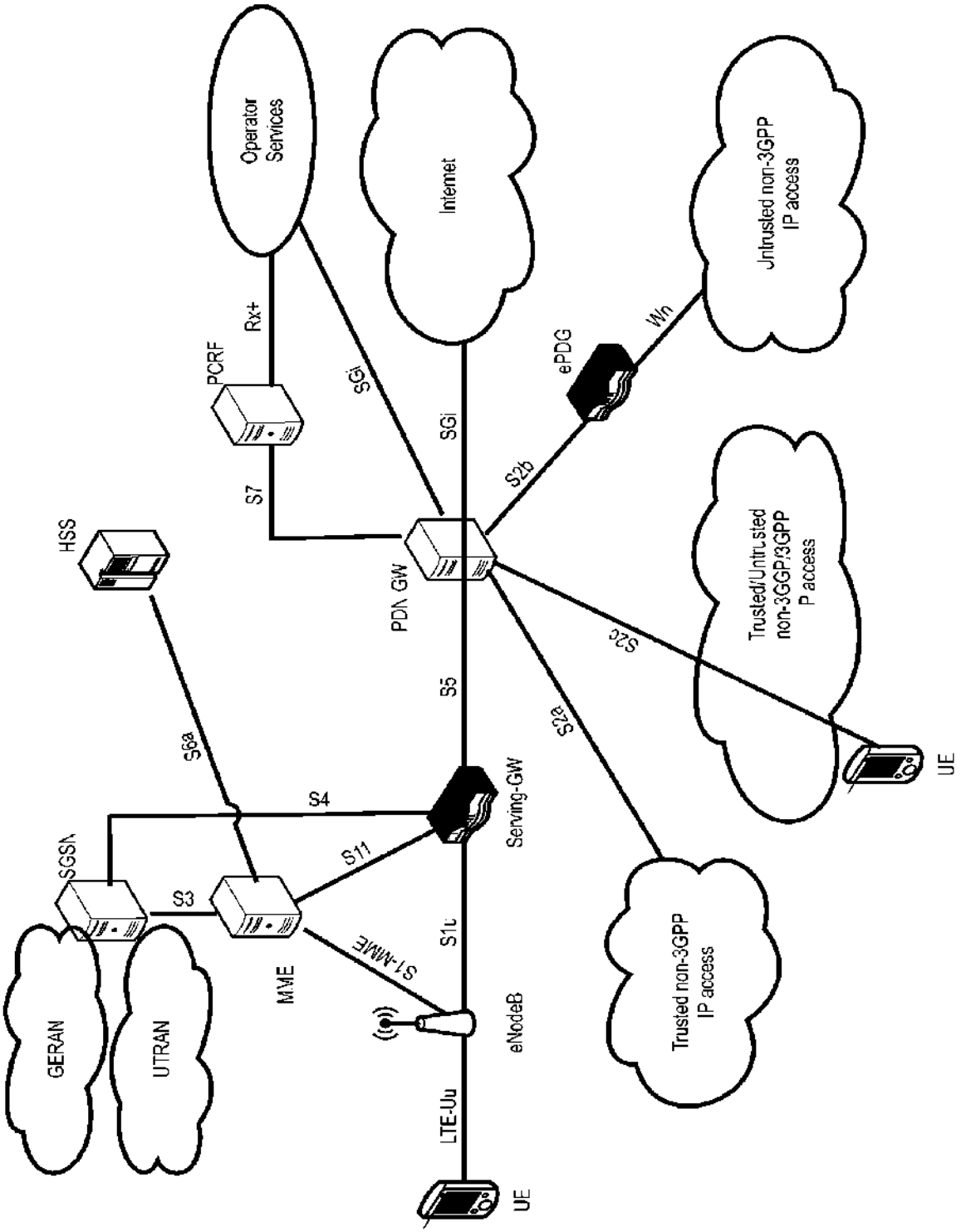
transmitting information about whether the CE-capable user equipment needs coverage extension or not to a core network entity, and wherein the core network entity provides the received information to the radio base station, preferably wherein the CE-capable user equipment is in a connected state or in an idle state.

[Claim 15] A radio base station for paging a user equipment in a cell controlled by the radio base station in a mobile communication system, wherein the user equipment supports coverage extension techniques, wherein the radio base station is capable to use one of a plurality of techniques for achieving a coverage extension for the CE-capable user equipment, the radio base station comprising:

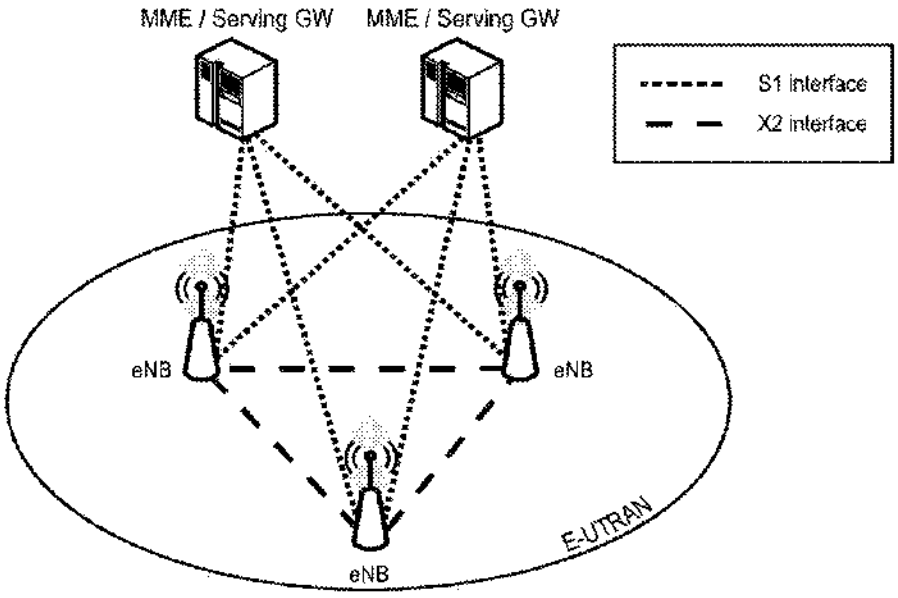
a receiver adapted to receive information about whether the CE-capable user equipment needs coverage extension or not,

a transmitter being adapted to, when paging the CE-capable user equipment, apply or not apply one of the plurality of techniques for achieving coverage extension depending on whether coverage extension is necessary or not for the CE-capable user equipment.

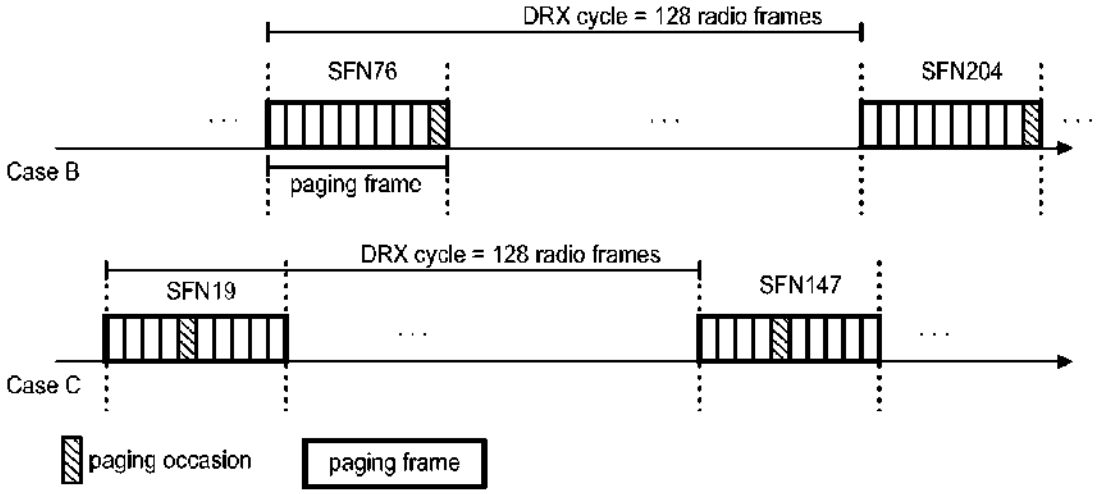
[Fig. 1]


Operator Services
Internet
Untrusted non-3GPP IP access
Rx+
PCRF
SGi
SGi
ePDG
Wn
S7
S2b
HSS
PDN GW
Trusted/Untrusted non-3GPP/3GPP P access
S2c
S5
S6a
S2a
UE
S4
Serving-GW
SGSN
S11
S3
S1u
S1-MME
GERAN
UTRAN
MME
eNodeB
Trusted non-3GPP IP access
LTE-Uu
UE

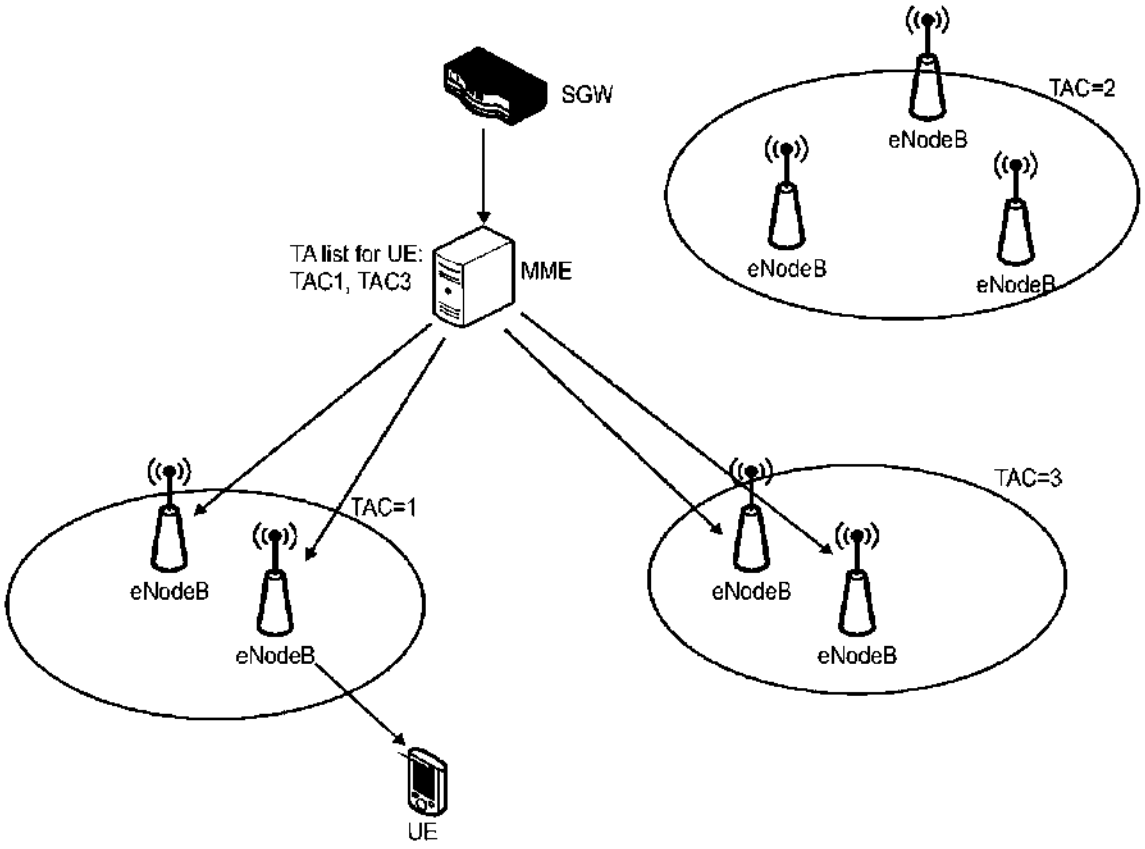
[Fig. 2]


MME / Serving GW
MME / Serving GW
S1 interface
X2 interface
eNB
eNB
eNB
E-UTRAN

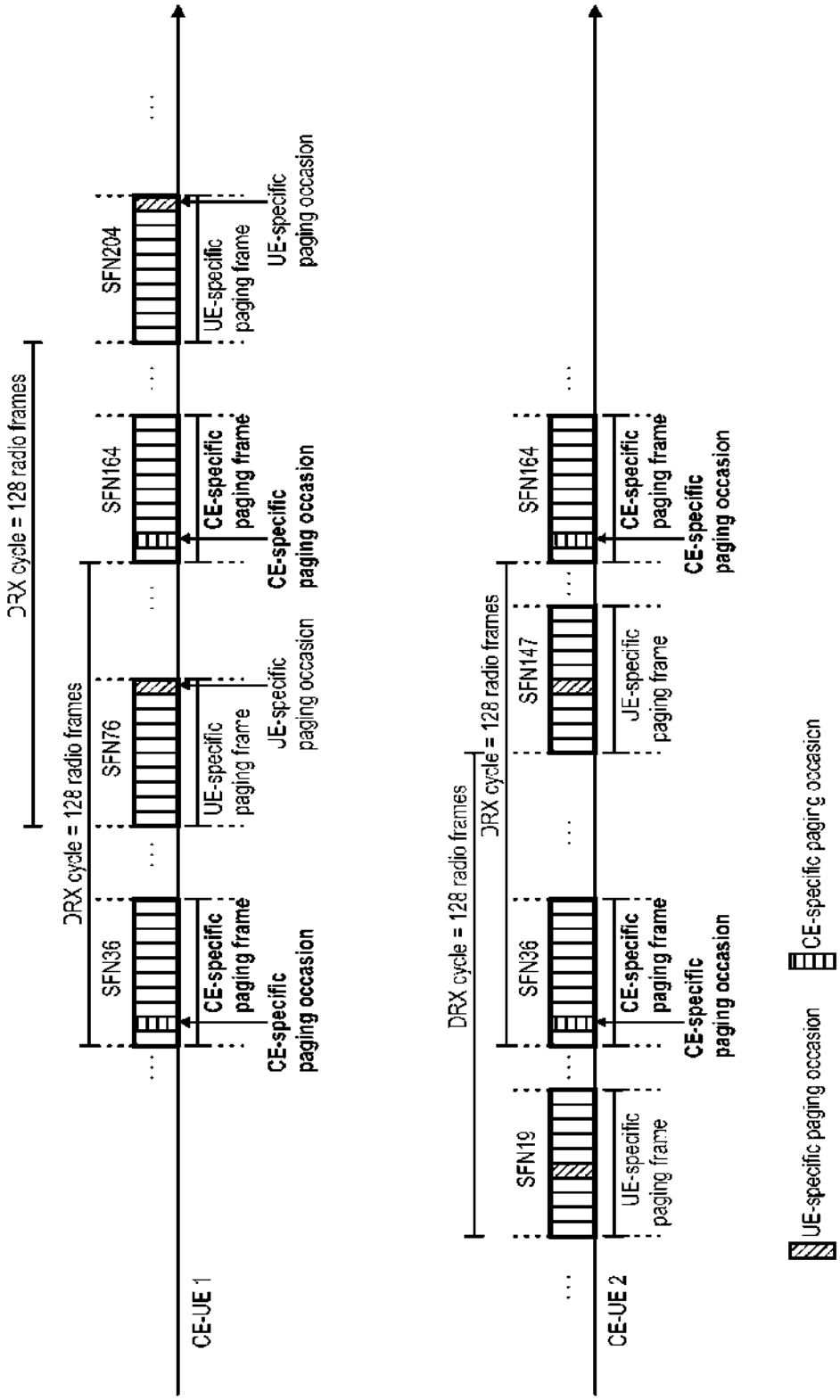
[Fig. 3]


DRX cycle = 128 radio frames
SFN76
SFN204
Case B
paging frame
DRX cycle = 128 radio frames
SFN19
SFN147
Case C
paging occasion
paging frame

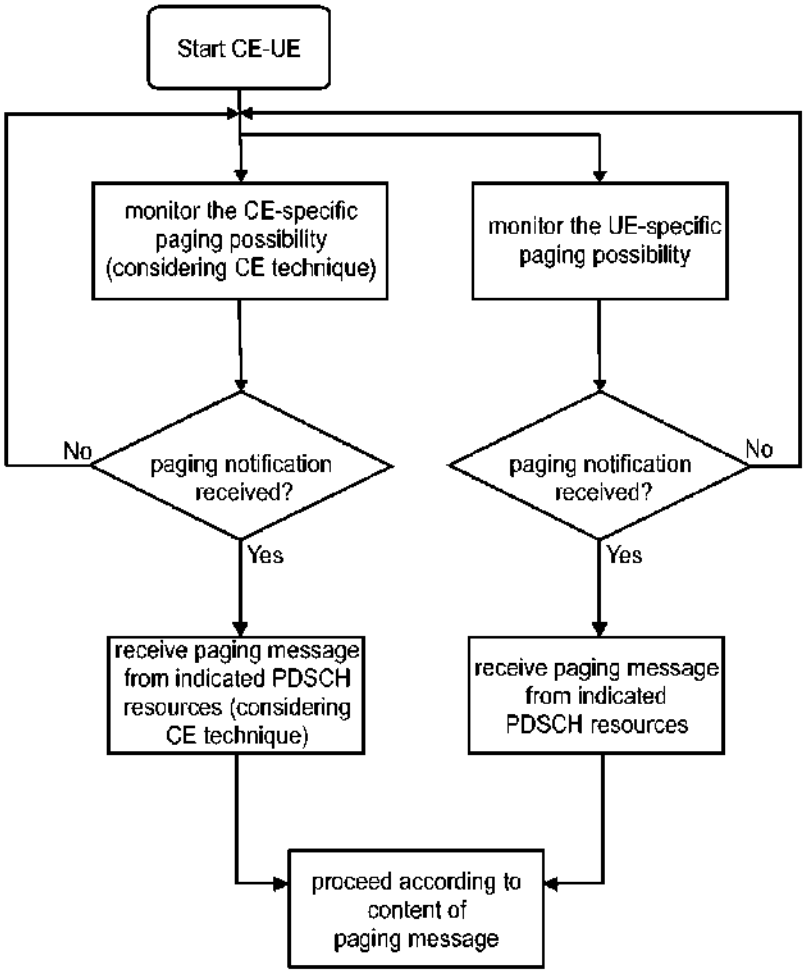
[Fig. 4]


SGW
TAC=2
eNodeB
eNodeB
eNodeB
TA list for UE:
TAC1, TAC3
MME
TAC=1
eNodeB
eNodeB
TAC=3
eNodeB
eNodeB
UE

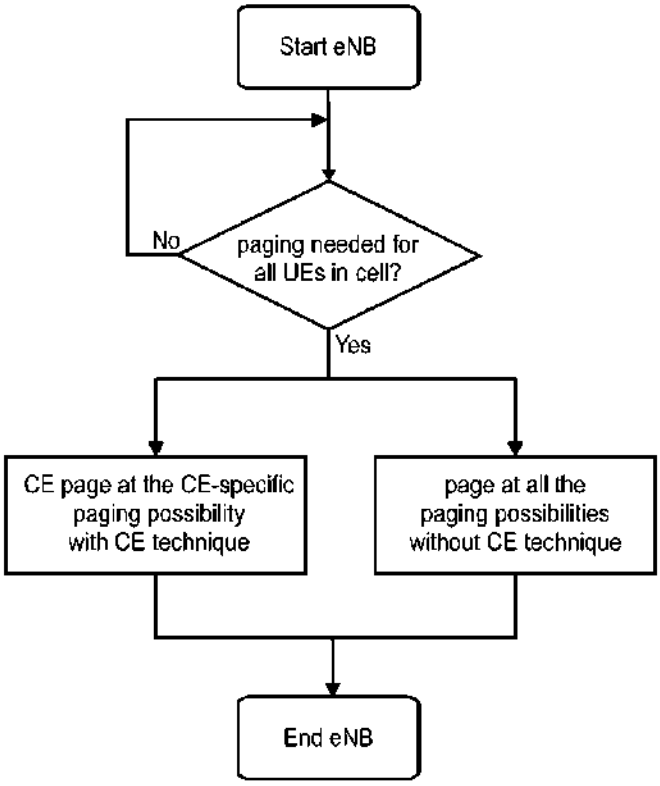
[Fig. 5]


DRX cycle = 128 radio frames
SFN36
SFN76
SFN164
SFN204
CE-specific paging frame
UE-specific paging frame
CE-specific paging occasion
UE-specific paging occasion
CE-UE 1
DRX cycle = 128 radio frames
SFN19
SFN36
SFN147
SFN164
CE-UE 2
UE-specific paging occasion
CE-specific paging occasion

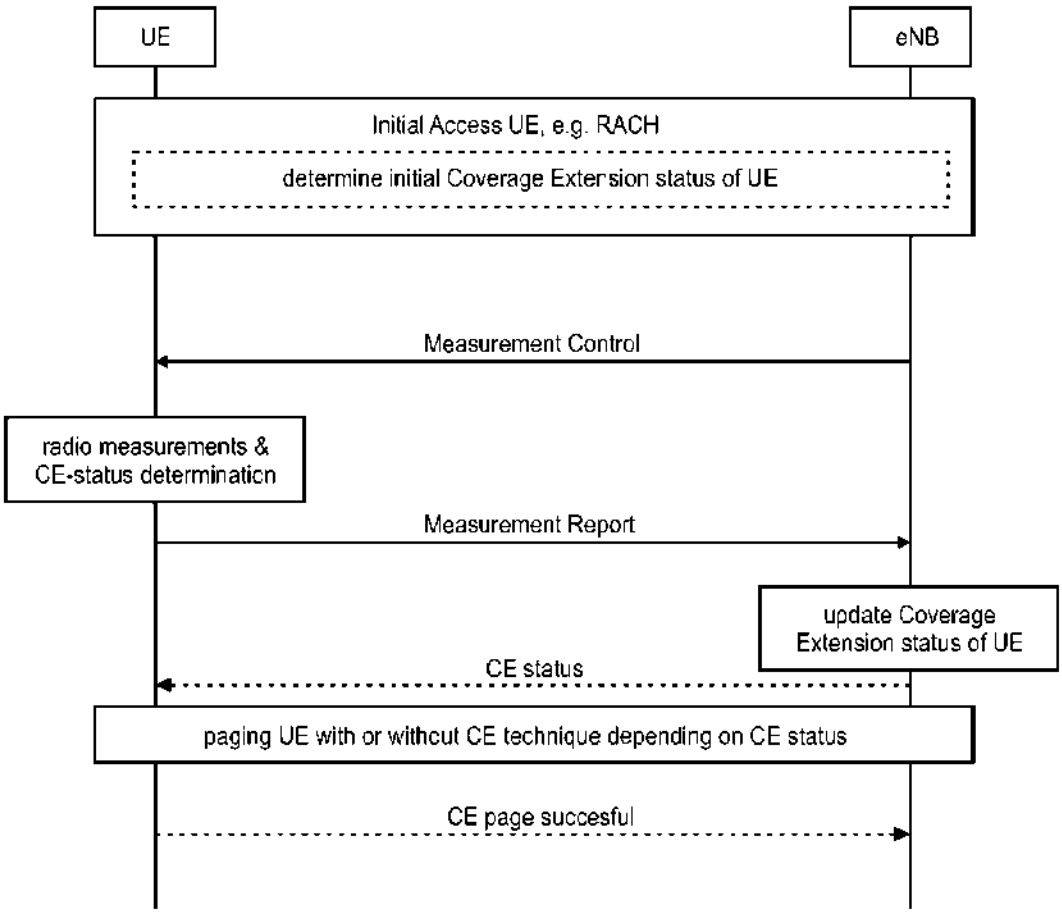
[Fig. 6]


Start CE-UE
monitor the CE-specific paging possibility (considering CE technique)
monitor the UE-specific paging possibility
No
paging notification received?
Yes
paging notification received?
No
Yes
receive paging message from indicated PDSCH resources (considering CE technique)
receive paging message from indicated PDSCH resources
proceed according to content of paging message

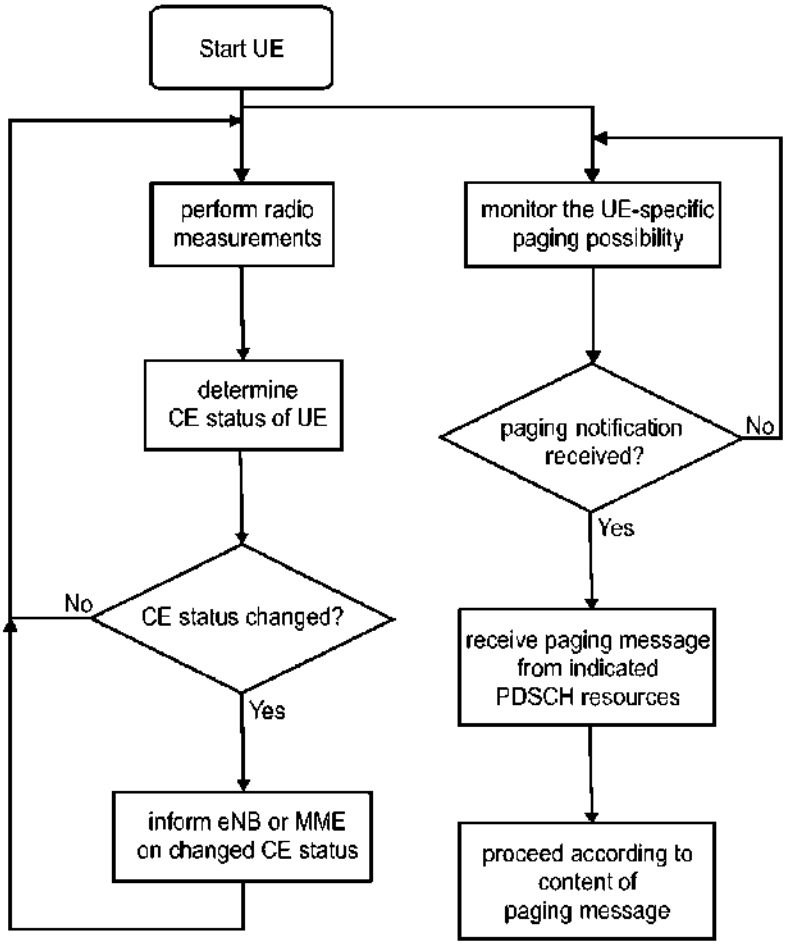
[Fig. 7]


Start eNB
No
paging needed for all UEs in cell?
Yes
CE page at the CE-specific paging possibility with CE technique
page at all the paging possibilities without CE technique
End eNB

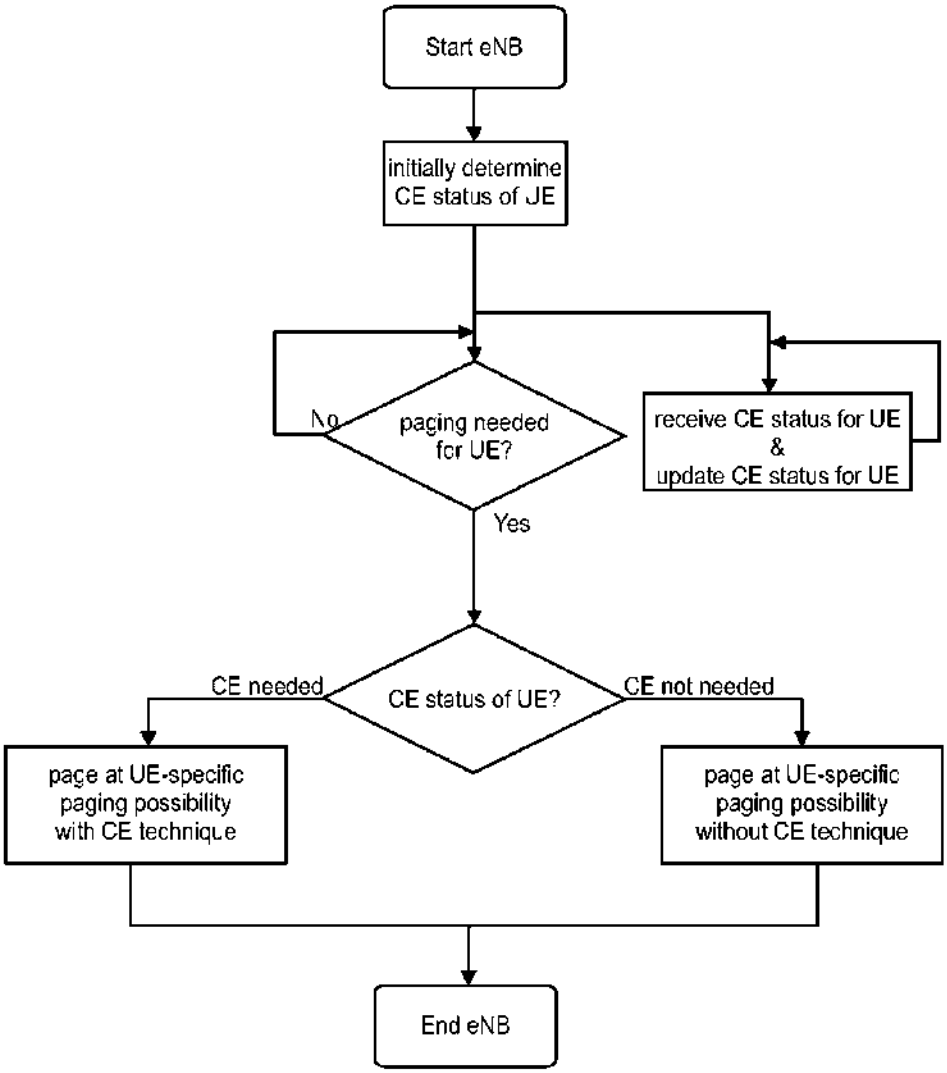
[Fig. 8]


UE
eNB
Initial Access UE, e.g. RACH
determine initial Coverage Extension status of UE
Measurement Control
radio measurements &
CE-status determination
Measurement Report
update Coverage
Extension status of UE
CE status
paging UE with or without CE technique depending on CE status
CE page succesful

[Fig. 9]


Start UE
perform radio measurements
determine CE status of UE
CE status changed?
No
Yes
inform eNB or MME on changed CE status
monitor the UE-specific paging possibility
paging notification received?
No
Yes
receive paging message from indicated PDSCH resources
proceed according to content of paging message

[Fig. 10]


Start eNB
initially determine CE status of JE
No
paging needed for UE?
receive CE status for UE & update CE status for UE
Yes
CE needed
CE status of UE?
CE not needed
page at UE-specific paging possibility with CE technique
page at UE-specific paging possibility without CE technique
End eNB

INTERNATIONAL SEARCH REPORT

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According to International Patent Classification (IPC) or to both national classification and IPC

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Minimum documentation searched (classification system followed by classification symbols)

Int.Cl. H04W68/08

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2016
Registered utility model specifications of Japan 1996-2016
Published registered utility model applications of Japan 1994-2016

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2014/0098761 A1 (INTERDIGITAL PATENT HOLDINGS, INC.) 2014.04.10, whole document & JP 2015-537422 A & EP 2904850 A1 & TW 201429174 A & CN 104704884 A & KR 10-2015-0064196 A	1-15
A	Alcatel-Lucent, Alcatel-Lucent Shanghai Bell, Capability signaling for Low Complexity MTC UE[online], 3GPP TSG-RAN WG2#85 R2-140727, URL:http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_85/Docs/R2-140727.zip, 2014.02.01	1-15

☑ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
12.04.2016	19.04.2016

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/000417

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Alcatel-Lucent, Alcatel-Lucent Shanghai Bell, Coverage enhancement for common control messages[online], 3GPP TSG-RAN WG1#78b R1-144077, URL:http://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_78b/Docs/R1-144077.zip, 2014.09.27	1-15

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(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) **Title**: METHODS AND MACHINE TYPE COMMUNICATION, MTC, DEVICE, IMPLEMENTING PAGING PROCEDURES FOR REDUCED BANDWITH MTC DEVICES

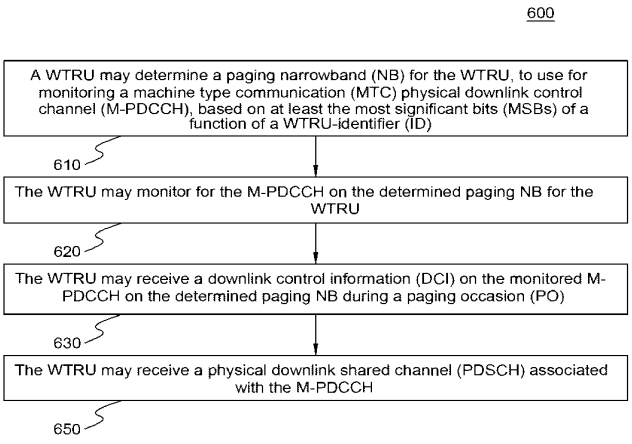


FIG. 6

(57) **Abstract**: Methods for paging for reduced bandwidth wireless transmit/receive units, WTRUs, in machine type communication, MTC, are provided. A WTRU determines (610) a paging narrowband, NB, for the WTRU, to use for monitoring an MTC physical downlink control channel, M-PDCCH, based on at least the most significant bits, MSBs, of a function of a WTRU-identifier, WTRU-ID. The WTRU monitors (620) for the M-PDCCH on the determined paging NB for the WTRU. The WTRU then receives (630) a downlink control information, DCI, on the monitored M-PDCCH on the determined paging NB during a paging occasion, PO.The WTRU then receives (650) a physical downlink shared channel, PDSCH, associated with the M-PDCCH. Alternatively, the WTRU monitors (420) the M-PDCCH in the M-PDCCH search space, wherein the M-PDCCH has a starting enahnced control channel element, ECCE, index for a WTRU group containing the WTR, and wherein the M-PDCCH includes (430) the DCI.

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METHODS AND MACHINE TYPE COMMUNICATION, MTC, DEVICE, IMPLEMENTING PAGING PROCEDURES FOR REDUCED BANDWITH MTC DEVICES

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 62/250,803 filed November 4, 2015, U.S. Provisional Application No. 62/290,790 filed February 3, 2016, and U.S. Provisional Application 62/308,042 filed March 14, 2016, the contents of which are hereby incorporated by reference herein.

BACKGROUND

[0002] As wireless communication systems such as Long Term Evolution (LTE) systems mature and their network deployment evolve, it may be beneficial for network operators to reduce the cost of the communication network, maintenance needs of the communication network or both. One technique to reduce the cost of the network may be to reduce the channel bandwidth and data rate used to communicate with devices.

[0003] For example, a portion of the channel bandwidth rather than the entire channel bandwidth may be supported by the devices in the network and/or the network itself when communicating with such devices. Current wireless communication systems, for example, LTE, have recently considered a bandwidth reduction for some devices including machine type communication (MTC) devices to some level, for example, 1.4 megahertz (MHz).

SUMMARY

[0004] Methods for paging for reduced bandwidth wireless transmit/receive units (WTRUs) in machine type communication (MTC) are provided. A WTRU may determine a paging narrowband (NB) for the WTRU, to use for monitoring an MTC physical downlink control channel (M-PDCCH), based on at least the most significant bits (MSBs) of a function of a WTRU-identifier (WTRU-ID). The WTRU may monitor for the M-PDCCH on the

determined paging NB for the WTRU. The WTRU may then receive a downlink control information (DCI) on the monitored M-PDCCH on the determined paging NB during a paging occasion (PO). The DCI may include a scrambled cyclic redundancy check (CRC). The CRC may be scrambled with a Paging Radio Network Temporary Identifier (P-RNTI). Also, the WTRU may receive a physical downlink shared channel (PDSCH) associated with the M-PDCCH.

[0005] In an example, the WTRU may determine the paging NB based on at least the 3 MSBs of a function of the WTRU-ID. In another example, the WTRU may determine the paging NB based on at least the 4 MSBs of a function of the WTRU-ID.

[0006] Further, the PDSCH may be scheduled by the DCI. In an example, the DCI may include a paging message. In another example, the DCI may include system information update related information. In a further example, the PDSCH may include a paging message. In an additional example, the PDSCH may include system information update related information.

[0007] In addition, a WTRU may monitor for a M-PDCCH in an M-PDCCH search space. The WTRU may receive an M-PDCCH in the M-PDCCH search space, wherein the M-PDCCH has a starting enhanced control channel element (ECCE) index for the WTRU group containing the WTRU. Further, the WTRU may decode the M-PDCCH, wherein the M-PDCCH includes a DCI. In addition, the WTRU may receive a PDSCH associated with the M-PDCCH.

[0008] Further, the WTRU may receive, decode, and/or demodulate the PDSCH based on the DCI, wherein the PDSCH includes a paging message. The WTRU may then change operations based on the paging message. For example, the WTRU may change from idle mode to connected mode based on the paging message. In an example, the ECCE aggregation level may be 16.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] A more detailed understanding may be had from the following description, given by way of example in conjunction with the accompanying drawings wherein:

[0010] FIG. 1A is a system diagram of an example communications system in which one or more disclosed embodiments may be implemented;

[0011] FIG. 1B is a system diagram of an example wireless transmit/receive unit (WTRU) that may be used within the communications system illustrated in FIG. 1A;

[0012] FIG. 1C is a system diagram of an example radio access network and an example core network that may be used within the communications system illustrated in FIG. 1A;

[0013] FIG. 2 is an exemplary timing diagram which illustrates hyper frames and paging within hyper frames;

[0014] FIG. 3 is an exemplary diagram which illustrates WTRU group-specific starting enhanced control channel element (ECCE) indexes;

[0015] FIG. 4 is a diagram of an example flow chart showing a WTRU receiving a machine type communication (MTC) physical downlink control channel (M-PDCCH) with a starting ECCE index based on the WTRU group of the WTRU;

[0016] FIG. 5 is an exemplary diagram which illustrates WTRU group-specific random ECCE ordering;

[0017] FIG. 6 is a diagram of an example flow chart showing a WTRU using a WTRU-ID to determine a paging narrowband (NB) to use for monitoring an M-PDCCH;

[0018] FIG. 7 is a diagram illustrating an example of code-block segment multiplexing in a physical downlink shared channel (PDSCH), which may be scheduled by an associated physical downlink control channel (PDCCH) in a paging occasion (PO); and

[0019] FIG. 8 is a diagram illustrating an example of code-block segments transmitted via multiple PDSCHs, which may be scheduled by an associated PDCCH in a PO.

DETAILED DESCRIPTION

[0020] FIG. 1A is a diagram of an example communications system 100 in which one or more disclosed embodiments may be implemented. The communications system 100 may be a multiple access system that provides content, such as voice, data, video, messaging, broadcast, etc., to multiple wireless users. The communications system 100 may enable multiple wireless users to access such content through the sharing of system resources, including wireless bandwidth. For example, the communications systems 100 may employ one or more channel access methods, such as code division multiple access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), orthogonal FDMA (OFDMA), single-carrier FDMA (SC-FDMA), and the like.

[0021] As shown in FIG. 1A, the communications system 100 may include wireless transmit/receive units (WTRUs) 102a, 102b, 102c, 102d, a radio access network (RAN) 104, a core network 106, a public switched telephone network (PSTN) 108, the Internet 110, and other networks 112, though it will be appreciated that the disclosed embodiments contemplate any number of WTRUs, base stations, networks, and/or network elements. Each of the WTRUs 102a, 102b, 102c, 102d may be any type of device configured to operate and/or communicate in a wireless environment. By way of example, the WTRUs 102a, 102b, 102c, 102d may be configured to transmit and/or receive wireless signals and may include user equipment (UE), a mobile station, a fixed or mobile subscriber unit, a pager, a cellular telephone, a personal digital assistant (PDA), a smartphone, a laptop, a netbook, a personal computer, a wireless sensor, consumer electronics, and the like.

[0022] The communications systems 100 may also include a base station 114a and a base station 114b. Each of the base stations 114a, 114b may be any type of device configured to wirelessly interface with at least one of the WTRUs 102a, 102b, 102c, 102d to facilitate access to one or more communication networks, such as the core network 106, the Internet 110, and/or the other networks 112. By way of example, the base stations 114a, 114b may be a base transceiver station (BTS), a Node-B, an eNode B, a Home

Node B, a Home eNode B, a site controller, an access point (AP), a wireless router, and the like. While the base stations 114a, 114b are each depicted as a single element, it will be appreciated that the base stations 114a, 114b may include any number of interconnected base stations and/or network elements.

[0023] The base station 114a may be part of the RAN 104, which may also include other base stations and/or network elements (not shown), such as a base station controller (BSC), a radio network controller (RNC), relay nodes, etc. The base station 114a and/or the base station 114b may be configured to transmit and/or receive wireless signals within a particular geographic region, which may be referred to as a cell (not shown). The cell may further be divided into cell sectors. For example, the cell associated with the base station 114a may be divided into three sectors. Thus, in one embodiment, the base station 114a may include three transceivers, i.e., one for each sector of the cell. In another embodiment, the base station 114a may employ multiple-input multiple-output (MIMO) technology and, therefore, may utilize multiple transceivers for each sector of the cell.

[0024] The base stations 114a, 114b may communicate with one or more of the WTRUs 102a, 102b, 102c, 102d over an air interface 116, which may be any suitable wireless communication link (for example, radio frequency (RF), microwave, infrared (IR), ultraviolet (UV), visible light, etc.). The air interface 116 may be established using any suitable radio access technology (RAT).

[0025] More specifically, as noted above, the communications system 100 may be a multiple access system and may employ one or more channel access schemes, such as CDMA, TDMA, FDMA, OFDMA, SC-FDMA, and the like. For example, the base station 114a in the RAN 104 and the WTRUs 102a, 102b, 102c may implement a radio technology such as Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access (UTRA), which may establish the air interface 116 using wideband CDMA (WCDMA). WCDMA may include communication protocols such as High-Speed Packet Access (HSPA) and/or Evolved HSPA (HSPA+). HSPA may include High-Speed Downlink Packet Access (HSDPA) and/or High-Speed Uplink Packet Access (HSUPA).

[0026] In another embodiment, the base station 114a and the WTRUs 102a, 102b, 102c may implement a radio technology such as Evolved UMTS Terrestrial Radio Access (E-UTRA), which may establish the air interface 116 using Long Term Evolution (LTE) and/or LTE-Advanced (LTE-A).

[0027] In other embodiments, the base station 114a and the WTRUs 102a, 102b, 102c may implement radio technologies such as IEEE 802.16 (i.e., Worldwide Interoperability for Microwave Access (WiMAX)), CDMA2000, CDMA2000 1X, CDMA2000 EV-DO, Interim Standard 2000 (IS-2000), Interim Standard 95 (IS-95), Interim Standard 856 (IS-856), Global System for Mobile communications (GSM), Enhanced Data rates for GSM Evolution (EDGE), GSM EDGE (GERAN), and the like.

[0028] The base station 114b in FIG. 1A may be a wireless router, Home Node B, Home eNode B, or access point, for example, and may utilize any suitable RAT for facilitating wireless connectivity in a localized area, such as a place of business, a home, a vehicle, a campus, and the like. In one embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.11 to establish a wireless local area network (WLAN). In another embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.15 to establish a wireless personal area network (WPAN). In yet another embodiment, the base station 114b and the WTRUs 102c, 102d may utilize a cellular-based RAT (for example, WCDMA, CDMA2000, GSM, LTE, LTE-A, etc.) to establish a picocell or femtocell. As shown in FIG. 1A, the base station 114b may have a direct connection to the Internet 110. Thus, the base station 114b may not be required to access the Internet 110 via the core network 106.

[0029] The RAN 104 may be in communication with the core network 106, which may be any type of network configured to provide voice, data, applications, and/or voice over internet protocol (VoIP) services to one or more of the WTRUs 102a, 102b, 102c, 102d. For example, the core network 106 may provide call control, billing services, mobile location-based services, pre-paid calling, Internet connectivity, video distribution, etc., and/or perform high-level security functions, such as user authentication. Although not shown in

FIG. 1A, it will be appreciated that the RAN 104 and/or the core network 106 may be in direct or indirect communication with other RANs that employ the same RAT as the RAN 104 or a different RAT. For example, in addition to being connected to the RAN 104, which may be utilizing an E-UTRA radio technology, the core network 106 may also be in communication with another RAN (not shown) employing a GSM radio technology.

[0030] The core network 106 may also serve as a gateway for the WTRUs 102a, 102b, 102c, 102d to access the PSTN 108, the Internet 110, and/or other networks 112. The PSTN 108 may include circuit-switched telephone networks that provide plain old telephone service (POTS). The Internet 110 may include a global system of interconnected computer networks and devices that use common communication protocols, such as the transmission control protocol (TCP), user datagram protocol (UDP) and the internet protocol (IP) in the TCP/IP internet protocol suite. The networks 112 may include wired or wireless communications networks owned and/or operated by other service providers. For example, the networks 112 may include another core network connected to one or more RANs, which may employ the same RAT as the RAN 104 or a different RAT.

[0031] Some or all of the WTRUs 102a, 102b, 102c, 102d in the communications system 100 may include multi-mode capabilities, i.e., the WTRUs 102a, 102b, 102c, 102d may include multiple transceivers for communicating with different wireless networks over different wireless links. For example, the WTRU 102c shown in FIG. 1A may be configured to communicate with the base station 114a, which may employ a cellular-based radio technology, and with the base station 114b, which may employ an IEEE 802 radio technology.

[0032] FIG. 1B is a system diagram of an example WTRU 102. As shown in FIG. 1B, the WTRU 102 may include a processor 118, a transceiver 120, a transmit/receive element 122, a speaker/microphone 124, a keypad 126, a display/touchpad 128, non-removable memory 130, removable memory 132, a power source 134, a global positioning system (GPS) chipset 136, and other peripherals 138. It will be appreciated that the WTRU 102 may include any

sub-combination of the foregoing elements while remaining consistent with an embodiment.

[0033] The processor 118 may be a general purpose processor, a special purpose processor, a conventional processor, a digital signal processor (DSP), a plurality of microprocessors, one or more microprocessors in association with a DSP core, a controller, a microcontroller, Application Specific Integrated Circuits (ASICs), Field Programmable Gate Array (FPGAs) circuits, any other type of integrated circuit (IC), a state machine, and the like. The processor 118 may perform signal coding, data processing, power control, input/output processing, and/or any other functionality that enables the WTRU 102 to operate in a wireless environment. The processor 118 may be coupled to the transceiver 120, which may be coupled to the transmit/receive element 122. While FIG. 1B depicts the processor 118 and the transceiver 120 as separate components, it will be appreciated that the processor 118 and the transceiver 120 may be integrated together in an electronic package or chip.

[0034] The transmit/receive element 122 may be configured to transmit signals to, or receive signals from, a base station (for example, the base station 114a) over the air interface 116. For example, in one embodiment, the transmit/receive element 122 may be an antenna configured to transmit and/or receive RF signals. In another embodiment, the transmit/receive element 122 may be an emitter/detector configured to transmit and/or receive IR, UV, or visible light signals, for example. In yet another embodiment, the transmit/receive element 122 may be configured to transmit and receive both RF and light signals. It will be appreciated that the transmit/receive element 122 may be configured to transmit and/or receive any combination of wireless signals.

[0035] In addition, although the transmit/receive element 122 is depicted in FIG. 1B as a single element, the WTRU 102 may include any number of transmit/receive elements 122. More specifically, the WTRU 102 may employ MIMO technology. Thus, in one embodiment, the WTRU 102 may include two or more transmit/receive elements 122 (for example, multiple

antennas) for transmitting and receiving wireless signals over the air interface 116.

[0036] The transceiver 120 may be configured to modulate the signals that are to be transmitted by the transmit/receive element 122 and to demodulate the signals that are received by the transmit/receive element 122. As noted above, the WTRU 102 may have multi-mode capabilities. Thus, the transceiver 120 may include multiple transceivers for enabling the WTRU 102 to communicate via multiple RATs, such as UTRA and IEEE 802.11, for example.

[0037] The processor 118 of the WTRU 102 may be coupled to, and may receive user input data from, the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128 (for example, a liquid crystal display (LCD) display unit or organic light-emitting diode (OLED) display unit). The processor 118 may also output user data to the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128. In addition, the processor 118 may access information from, and store data in, any type of suitable memory, such as the non-removable memory 130 and/or the removable memory 132. The non-removable memory 130 may include random-access memory (RAM), read-only memory (ROM), a hard disk, or any other type of memory storage device. The removable memory 132 may include a subscriber identity module (SIM) card, a memory stick, a secure digital (SD) memory card, and the like. In other embodiments, the processor 118 may access information from, and store data in, memory that is not physically located on the WTRU 102, such as on a server or a home computer (not shown).

[0038] The processor 118 may receive power from the power source 134, and may be configured to distribute and/or control the power to the other components in the WTRU 102. The power source 134 may be any suitable device for powering the WTRU 102. For example, the power source 134 may include one or more dry cell batteries (for example, nickel-cadmium (NiCd), nickel-zinc (NiZn), nickel metal hydride (NiMH), lithium-ion (Li-ion), etc.), solar cells, fuel cells, and the like.

[0039] The processor 118 may also be coupled to the GPS chipset 136, which may be configured to provide location information (for example, longitude and latitude) regarding the current location of the WTRU 102. In addition to, or in lieu of, the information from the GPS chipset 136, the WTRU 102 may receive location information over the air interface 116 from a base station (for example, base stations 114a, 114b) and/or determine its location based on the timing of the signals being received from two or more nearby base stations. It will be appreciated that the WTRU 102 may acquire location information by way of any suitable location-determination method while remaining consistent with an embodiment.

[0040] The processor 118 may further be coupled to other peripherals 138, which may include one or more software and/or hardware modules that provide additional features, functionality and/or wired or wireless connectivity. For example, the peripherals 138 may include an accelerometer, an e-compass, a satellite transceiver, a digital camera (for photographs or video), a universal serial bus (USB) port, a vibration device, a television transceiver, a hands free headset, a Bluetooth® module, a frequency modulated (FM) radio unit, a digital music player, a media player, a video game player module, an Internet browser, and the like.

[0041] FIG. 1C is a system diagram of the RAN 104 and the core network 106 according to an embodiment. As noted above, the RAN 104 may employ an E-UTRA radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 116. The RAN 104 may also be in communication with the core network 106.

[0042] The RAN 104 may include eNode-Bs 140a, 140b, 140c, though it will be appreciated that the RAN 104 may include any number of eNode-Bs while remaining consistent with an embodiment. The eNode-Bs 140a, 140b, 140c may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 116. In one embodiment, the eNode-Bs 140a, 140b, 140c may implement MIMO technology. Thus, the eNode-B 140a, for example, may use multiple antennas to transmit wireless signals to, and receive wireless signals from, the WTRU 102a.

[0043] Each of the eNode-Bs 140a, 140b, 140c may be associated with a particular cell (not shown) and may be configured to handle radio resource management decisions, handover decisions, scheduling of users in the uplink and/or downlink, and the like. As shown in FIG. 1C, the eNode-Bs 140a, 140b, 140c may communicate with one another over an X2 interface.

[0044] The core network 106 shown in FIG. 1C may include a mobility management entity gateway (MME) 142, a serving gateway 144, and a packet data network (PDN) gateway 146. While each of the foregoing elements are depicted as part of the core network 106, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

[0045] The MME 142 may be connected to each of the eNode-Bs 140a, 140b, 140c in the RAN 104 via an S1 interface and may serve as a control node. For example, the MME 142 may be responsible for authenticating users of the WTRUs 102a, 102b, 102c, bearer activation/deactivation, selecting a particular serving gateway during an initial attach of the WTRUs 102a, 102b, 102c, and the like. The MME 142 may also provide a control plane function for switching between the RAN 104 and other RANs (not shown) that employ other radio technologies, such as GSM or WCDMA.

[0046] The serving gateway 144 may be connected to each of the eNode Bs 140a, 140b, 140c in the RAN 104 via the S1 interface. The serving gateway 144 may generally route and forward user data packets to/from the WTRUs 102a, 102b, 102c. The serving gateway 144 may also perform other functions, such as anchoring user planes during inter-eNode B handovers, triggering paging when downlink data is available for the WTRUs 102a, 102b, 102c, managing and storing contexts of the WTRUs 102a, 102b, 102c, and the like.

[0047] The serving gateway 144 may also be connected to the PDN gateway 146, which may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, such as the Internet 110, to facilitate communications between the WTRUs 102a, 102b, 102c and IP-enabled devices.

[0048] The core network 106 may facilitate communications with other networks. For example, the core network 106 may provide the WTRUs 102a, 102b, 102c with access to circuit-switched networks, such as the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, 102c and traditional land-line communications devices. For example, the core network 106 may include, or may communicate with, an IP gateway (for example, an IP multimedia subsystem (IMS) server) that serves as an interface between the core network 106 and the PSTN 108. In addition, the core network 106 may provide the WTRUs 102a, 102b, 102c with access to the networks 112, which may include other wired or wireless networks that are owned and/or operated by other service providers.

[0049] Other network 112 may further be connected to an IEEE 802.11 based wireless local area network (WLAN) 160. The WLAN 160 may include an access router 165. The access router may contain gateway functionality. The access router 165 may be in communication with a plurality of access points (APs) 170a, 170b. The communication between access router 165 and APs 170a, 170b may be via wired Ethernet (IEEE 802.3 standards), or any type of wireless communication protocol. AP 170a is in wireless communication over an air interface with WTRU 102d.

[0050] As wireless communication systems such as LTE systems mature and their network deployment evolve, it may be beneficial for network operators to reduce the cost of the communication network, maintenance needs of the communication network or both. One technique to reduce the cost of the network may be to reduce the channel bandwidth and data rate used to communicate with devices. For example, a portion of the channel bandwidth rather than the entire channel bandwidth may be supported by the devices in the network and/or the network itself when communicating with such devices. Current wireless communication systems, for example, LTE, have recently considered a bandwidth reduction for some devices including machine type communication (MTC) devices to some level, for example, 1.4 megahertz (MHz). The considered level may enable more compatibility with legacy systems and reduce the time and/or cost of a new design, since, for

example LTE may already support operation with a system bandwidth of 1.4 MHz. Further bandwidth reduction, however, may be desirable for some devices, for example, smart watches and alarms, for example to reduce costs even further. Further reduction of the bandwidth, for example, on the order of 200 kilohertz (kHz), has been suggested. Additional system design may be needed to support operation with a reduced bandwidth which may be less compatible with legacy system operation.

[0051] A reduced bandwidth (BW) WTRU may be a WTRU which may support or may only support a certain limited BW, for example, RF BW or a certain limited number of resource blocks (RBs) in the downlink (DL) and/or uplink (UL), which may be independent of the BW of the eNode-B or cell with which the WTRU may communicate. For example, a reduced BW WTRU, which may also be referred to as a limited BW WTRU, may support or may only support a certain number of RBs, for example, 6 RBs or 1 RB, or a certain BW, for example, 1.4 MHz or 180 kHz, for transmission and/or reception. Such a WTRU may communicate with an eNode-B or cell for which the BW may be larger, for example, 20 MHz or 100 RBs.

[0052] An enhanced machine type communication (eMTC) WTRU may be a limited BW WTRU which may support a first number of RBs and/or a BW of a first bandwidth. A first number may be represented by N1 and a first bandwidth may be represented by B1. N1 may, for example, be 6 and B1 may, for example be 1.4 MHz. In an example, 6 RBs may correspond to a BW of 1.4 MHz. An eMTC WTRU may be used to represent a non-limiting example of a limited BW WTRU. Another WTRU which may be referred to as a narrowband LTE (NB-LTE) or narrowband internet of things (NB-IoT) WTRU may be a limited BW WTRU which may support a second number of RBs and/or a BW of a second bandwidth. A second number may be represented by N2 and a second bandwidth may be represented by B2. N2 may be less than N1. B2 may be less than B1. N2 may, for example, be 1 and B2 may, for example, be 180 kHz. In an example, 1 RB may correspond to a BW of 180 kHz. An NB-LTE WTRU and/or NB-IoT WTRU may be used to represent a non-limiting example of a limited BW WTRU. A narrowband (NB) WTRU may be used to

represent a non-limiting example of a WTRU or limited BW WTRU. WTRU, limited BW WTRU, BW limited WTRU, reduced BW WTRU, limited capability WTRU, low cost-MTC (LC-MTC) WTRU, low-complexity WTRU, MTC WTRU, eMTC WTRU, NB-IoT WTRU, eMTC, NB-IoT, and NB WTRU may be used interchangeably herein. An RB may be a physical RB (PRB). The terms RB and PRB may be used interchangeably herein.

[0053] A limited BW WTRU may use or require special procedures to operate in a portion of the full BW of the cell. Reduced bandwidth, limited bandwidth, and bandwidth limited may be used interchangeably herein. A WTRU which may support the full BW of a cell may be referred to as a full BW WTRU. BW may include a number of RBs and/or a location in a band such as the center of the band.

[0054] A WTRU may at least sometimes communicate, behave, or operate in a manner which may be consistent, or for example, at least partially consistent, with that of a full BW WTRU and may also at least sometimes, for example, some other times than when operating as a full BW WTRU, communicate, behave, or operate in a manner which may be consistent, or for example, at least partially consistent, with that of a reduced BW WTRU. For example, a WTRU which may support the full BW of a cell may communicate, behave, or operate in a manner which may be consistent, or for example, at least partially consistent with that of a reduced BW WTRU at certain times such as when it may be coverage limited or when it may operate in a coverage enhanced mode. A WTRU, such as this example WTRU, may be or may be considered a full BW WTRU at times and/or a reduced BW WTRU at times, for example at other times.

[0055] A WTRU may be or may be considered to be a reduced BW WTRU while it may, may need to, or may intend to behave or operate like, or for example, at least partially like, a reduced BW WTRU. A WTRU that may communicate, for example, with an eNode-B, behave, or operate in a manner which may be consistent, or for example, at least partially consistent with that of a reduced BW WTRU may be or may be considered to be a reduced BW WTRU, for example at least sometimes, such as when the WTRU may

communicate, behave, or operate in a manner which may be consistent, or for example, at least partially consistent, with that of a reduced BW WTRU.

[0056] It should be noted that the terms eNB, eNode-B and cell may be used interchangeably herein. Embodiments and examples described for reduced BW WTRUs may be applied to coverage limited WTRUs and vice versa.

[0057] Coverage limited and reduced BW WTRUs are examples of WTRUs which may use the example methods and procedures described herein. These coverage limited and reduced BW WTRUs are non-limiting examples of such example WTRUs. Application to a WTRU of any kind, with any capabilities, or reduced capabilities may still be consistent with the example methods and procedures described herein.

[0058] The term physical downlink control channel (PDCCH) may be replaced by enhanced PDCCH (EPDCCH), machine type communication (MTC) physical downlink control channel (M-PDCCH), or another DL control channel, and vice versa and still be consistent with the example methods and procedures described herein. The terms component carrier (CC) and serving cell may be used interchangeably herein. The terms WTRU, WTRU medium access control (MAC) entity, and MAC entity may be used interchangeably herein.

[0059] The terms a WTRU, a certain WTRU or certain WTRUs may be replaced by at least a WTRU, at least a certain WTRU or at least certain WTRUs and still be consistent with the example methods and procedures described herein. The phrase intended for may be replaced by at least intended for or intended for at least and still be consistent with the example methods and procedures described herein.

[0060] The example methods and procedures described herein may be described for a random access response (RAR), paging channel (PCH), or physical downlink shared channel (PDSCH) carrying or which may carry a RAR or PCH. These are used as non-limiting examples. RAR may be replaced by PCH or PCH PDSCH and vice versa and still be consistent with the example methods and procedures described herein. The channel or other

contents which may be carried by the PDSCH may be replaced with any channel or contents and still be consistent with the example methods and procedures described herein.

[0061] Example methods and procedures involving coverage enhancement (CE) are disclosed herein. A coverage enhanced WTRU may be a WTRU which may require coverage enhancement or a WTRU which may employ coverage enhancement techniques or may support a CE mode. The terms coverage limited WTRU and coverage enhanced WTRU may be used interchangeably herein. CE may refer to extending or improving coverage, for example for low data rate applications. CE may refer to extending or improving coverage, for example to enable communication with devices with reduced capabilities such as devices employing a single receiver or devices using a reduced bandwidth. CE may refer to extending or improving coverage, for example to enable communication with devices for which communication may be hampered such as indoor devices or devices in basements where penetration losses may impede communication. In at least some examples, CE may involve extending or improving coverage by reducing the data rate. In at least some examples, CE may involve extending or improving coverage by employing repetition techniques. In at least some examples, CE may be used for MTC applications. In at least some examples, CE may be used for NB or NB-IoT applications. The terms CE operation and coverage enhanced operation may be used interchangeably herein.

[0062] A repetitive transmission of a physical channel may be used for CE. The CE level may be determined based on the number of repetitions, for example, that may be needed or used to achieve the intended coverage improvement. The terms repetition number, number of repetitions, repetition level, and CE level may be used interchangeably herein.

[0063] A CE mode may be used with one or more CE levels, or for example, repetition levels. The CE levels or repetition levels supported within a CE mode may be changed dynamically.

[0064] An eMTC WTRU may be for example, a low-cost WTRU. An eMTC WTRU may be for example, a WTRU with limited or reduced

capabilities. Limited or reduced capabilities may include at least one of a limited or reduced BW capability, for example a BW using 6 RBs , low throughput performance, and a single RF chain at the receiver. An eMTC WTRU may be delay tolerant. An eMTC WTRU may be served in an LTE network which may or may not have a system BW larger than the eMTC supportable BW that may for example be a BW of 1.4 MHz.

[0065] An eMTC WTRU may support coverage enhanced operation. For example, two CE modes of operation may be supported such as CE mode-A and CE mode-B. Normal and small CE levels may be supported in CE mode-A, and medium and large CE levels may be supported in CE mode-B. Normal CE may be the same as normal operation or no CE, which may involve for example, no use of repetitions for CE.

[0066] An NB-IoT WTRU may be, for example, a low-cost WTRU. An NB-IoT WTRU may be, for example, a WTRU with limited or reduced capabilities that may, for example, be more limited or reduced more than the capabilities of an eMTC WTRU in at least one aspect. For example an NB-IoT WTRU may support or use a further reduced BW, for example, a BW of 1 RB, that may be smaller than the supportable BW for an eMTC WTRU.

[0067] An NB-IoT WTRU may, or may be intended to, support CE, for example, with up to 20 decibel (dB) CE, with a battery life that may be longer than the intended or expected battery life of an eMTC WTRU. An NB-IoT WTRU may be intended or expected to support a battery life such as 10 years. The population of NB-IoT WTRUs in a cell may be significantly larger than for other types of devices.

[0068] Example methods and procedures of paging are discussed herein. As used herein, paging may refer to network initiated connection setup. As used herein, paging may refer to a mechanism that a network may use to provide information such as system information modification information or warning system information, for example Earthquake and Tsunami Warning System (ETWS) information, to one or more WTRUs that may, for example, employ techniques for battery saving such as discontinuous reception (DRX). In some examples, paging may be used when a WTRU is in idle mode. In other

examples, paging may be used when a WTRU is in connected mode. A WTRU may, for example periodically, monitor a PDCCH for a DL control information (DCI) or DL assignment on a PDCCH masked with a Paging Radio Network Temporary Identifier (P-RNTI), for example in idle mode and/or in connected mode. When a WTRU detects or receives a DCI or DL assignment using a P-RNTI, the WTRU may demodulate the associated or indicated PDSCH RBs and/or may decode a Paging Channel (PCH) that may be carried on an associated or indicated PDSCH. A PDSCH which may carry PCH may be referred to as a PCH PDSCH. The terms paging, paging message, and PCH may be used interchangeably herein. As used herein, the terms downlink control channel, DL control channel for NB WTRU, M-PDCCH, PDCCH, NB PDCCH (NB-PDCCH), internet of things PDCCH (IoT-PDCCH), and NB IoT-PDCCH (NB-IoT-PDCCH) may be used interchangeably.

[0069] The paging frame (PF) and subframe within that PF, for example, the paging occasion (PO), that a WTRU may monitor for the paging channel, for example in idle mode, may be determined based on the WTRU identifier (ID), for example, WTRU_ID or UE_ID, and parameters which may be specified by the network. The parameters may include the Paging Cycle (PC) length, for example in frames, which may be the same as a discontinuous reception (DRX) cycle and another parameter, for example, nB, which together may enable the determination of the number of PF per PC and the number of PO per PF which may be in the cell. The WTRU ID, in an example, may be the WTRU international mobile subscriber identity (IMSI) mod 1024. The terms WTRU ID, WTRU-ID, and WTRU_ID may be used interchangeably herein.

[0070] From the network perspective, there may be multiple PFs per paging cycle and multiple POs within a PF, for example, more than one subframe per paging cycle may carry PDCCH masked with a P-RNTI. Additionally, from the WTRU perspective, a WTRU may monitor a PO per paging cycle, and such a PO may be determined based on the parameters specified herein, which may be provided to the WTRU via system information, dedicated signaling information, and the like. POs may include pages for one

or more specific WTRUs, or they may include system information change pages which may be directed to each of the WTRUs, multiple WTRUs, or all WTRUs. In idle mode, a WTRU may receive pages for reasons such as an incoming call or system information update changes.

[0071] In connected mode, a WTRU may receive pages related to system information change, for example, and the WTRU may not receive WTRU-specific pages such as those that may be used for an incoming call. As such, a WTRU in connected mode may not monitor a specific PO. Additionally, for frequency division duplex (FDD), the PO subframes may be limited to certain subframes such as subframes 0, 4, 5 and 9 and/or for time division duplex (TDD), the PO subframes may be limited to certain subframes such as subframes 0, 1, 5 and 6.

[0072] As used herein, DRX may refer to a WTRU monitoring for DL control signaling or a DL control channel at certain times, for example only at certain times, during a cycle. For example, a WTRU using DRX may monitor for a DL control channel during certain time periods, for example only during certain time periods. During other time periods, the WTRU may switch off at least part of its receiver circuitry and reduce power consumption. A time period may, for example, be a subframe. Example methods for operation using DRX are discussed herein.

[0073] In idle mode, for example, radio resource control (RRC) idle mode and/or evolved packet system (EPS) connection management (ECM) idle mode, a WTRU may monitor for or listen to a paging message to know about one or more of: an incoming call, a system information change, an Earthquake and Tsunami Warning System (ETWS) notification for ETWS capable WTRUs, a commercial mobile alert service (CMAS) notification and an extended access barring (EAB) parameters modification.

[0074] A WTRU may monitor PDCCH for P-RNTI discontinuously, for example to reduce battery consumption when there may be no pages for the WTRU. DRX may be or may include the process of monitoring PDCCH discontinuously. In idle mode, DRX may be or may include the process of

monitoring PDCCH discontinuously for P-RNTI, for example to monitor or listen for a paging message during RRC idle state.

[0075] The terms idle mode, idle state, RRC idle mode, RRC idle state, and RRC_IDLE mode or state may be used interchangeably herein. The terms RRC idle and ECM idle may be used interchangeably herein. DRX may also be enabled and/or used in connected mode. When in connected mode, if DRX is configured, the MAC entity may monitor the PDCCH discontinuously, for example using DRX operation. The terms connected mode, connected state, and RRC_CONNECTED mode or state may be used interchangeably herein.

[0076] Examples of operation in idle mode DRX are discussed herein. A WTRU may use one or more DRX parameters that may be broadcast, for example in a system information block (SIB) such as a SIB2, to determine the PF and/or PO to monitor for paging. The WTRU may, for example, alternatively, use one or more WTRU specific DRX cycle parameters that may be signaled to the WTRU, for example by the MME through non-access stratum (NAS) signaling.

[0077] Table 1 provides examples of DRX parameters including example ranges and an example source of the DRX parameter, for example, an eNode-B or an MME.

Table 1. Example DRX Cycle Parameters.

DRX parameter	Notation	Value Range	Configuring Network Node
WTRU Specific DRX cycle	TWTRU	32, 4, 128 and 256 radio frames where each radio frame may be 10 milliseconds (ms)	MME, for example, via NAS signaling
Cell specific DRX cycle	TCELL	32, 4, 128 and 256 radio frames	eNode-B, for example, via system information such as a SIB2
Number of POs per DRX cycle, for example, DRX cycle across all users in the cell	nB	4T, 2T, T, T/2, T/4, T/8, T/16, T/32 where T may be the DRX cycle of the WTRU, for example, TCELL or the smaller of TWTRU, if provided, and TCELL	eNode-B, for example, via system information such as a SIB2

[0078] The DRX cycle T of a WTRU may indicate the number of radio frames in the paging cycle. A larger value of T may result in less WTRU battery power consumption. A smaller value of T may increase WTRU battery power consumption. A DRX cycle may be cell specific or WTRU specific.

[0079] A DRX cycle provided by an eNode-B may be cell specific and may be provided to at least some, or for example all, WTRUs in a cell. The DRX cycle that may be provided by the eNode-B may be the default paging cycle. A DRX cycle provided by an MME may be WTRU specific. The WTRU may use the smaller of the default paging cycle and the WTRU specific DRX cycle as its DRX or paging cycle. An MME may provide a WTRU specific DRX cycle to a WTRU using NAS signaling, for example as 'WTRU specific DRX cycle'. An MME may provide a WTRU specific DRX cycle to an eNode-B in a PAGING S1 AP message, as 'Paging DRX', for example, for an MME initiated paging message that may be intended for the WTRU.

[0080] The WTRU and/or eNode-B may use the minimum of the default and WTRU specific DRX cycle. For example, T = Min (T_{WTRU}, T_{CELL}) in radio

frames. A WTRU with a DRX cycle of N (for example, 128) radio frames may wake up or may need to wake up every N x frame time (for example, every 1.28 seconds for a frame time of 10 ms) and look for a paging message.

[0081] The parameter nB may indicate the number of paging occasions or POs in a cell specific DRX cycle. The parameter may be cell specific. Configuration of the nB value may depend on the paging capacity that may be desired or used in a cell. A larger value of nB may be used, for example to increase paging capacity. A smaller value of nB may be used, for example for a smaller paging capacity.

[0082] The eNode-B and/or WTRU may calculate the WTRU's PFs according to the following relation: a PF is given by the following equation or occurs when SFN mod T = (T div N)*(WTRU_ID mod N), where N = min (T, nB) and div may represent division. The WTRU specific PO within the PF may be determined from a set of paging subframes. The set may be a function of predefined allowed subframes for paging and/or the number of POs per PF which may be a function of at least nB and/or T. The system frame number (SFN) may have a range of values such as 0 through 1023.

[0083] Examples of connected mode DRX are discussed herein. In connected mode, a PF and PO may be determined in a similar manner as in idle mode. The DRX cycle parameters may be different for idle and connected modes. A WTRU may monitor a PO, for example, any PO, in a PC in connected mode, for example to obtain system information change information.

[0084] Extended DRX (eDRX) is disclosed herein. It may be desirable to have extended or longer DRX cycles, for example for devices such as MTC devices. Extended or longer DRX cycles may be useful for some devices such as delay tolerant devices and may, for example, reduce battery consumption and/or increase battery life for those devices. A new time unit, for example, a hyper frame (HF), may be used, for example, with, as an extension of, or on top of radio frames and/or SFN timing, for example, legacy SFN timing.

[0085] FIG. 2 is an exemplary timing diagram which illustrates HFs and paging within HFs. One HF may include an SFN cycle, for example, 1024 radio frames or 10.24 s. A HF may have a Hyper-System Frame Number (H-

SFN). An H-SFN cycle may be 1024 SFN cycles. An H-SFN cycle may last 1024*1024*10 ms, for example, 174.76 minutes. In an example shown in timing diagram 200, HF 210 may have H-SFN 0 and may contain an SFN cycle of 1024 radio frames, from radio frame 0 through radio frame 1023. Likewise, HF 220 may have H-SFN 1023 and contain its own SFN cycle of 1024 radio frames. H-SFN cycle 230 may contain 1024 HFs, including HF 210 through HF 220.

[0086] An idle mode extended DRX (I-eDRX) cycle may include up to 256 H-SFN cycles and may, for example, last 256*1024*10 ms, for example, 43.69 minutes. The H-SFN may be broadcast by the cell. The H-SFN may increment at SFN cycle boundaries.

[0087] The H-SFN in which a WTRU may become reachable for paging may be referred to as a paging hyper frame (PH) or as the WTRU's PH. The PH may be applicable, or only applicable, in ECM-IDLE. The PH may be computed as a function of the extended DRX cycle and/or WTRU ID, for example, IMSI mod 1024. Within a PH, the determination of the PF and/or PO may follow the regular DRX rules and/or formulas. A WTRU's paging window (PW) may be the window or time span corresponding to the set of PFs in the WTRU's PH during which the WTRU may monitor for paging and/or may be paged. The PW may include a subset of the available PFs in the PH. In an example shown in timing diagram 200, PW 250 may include PF 260, PF 270 and PF 280. PF 260, PF 270 and PF 280 may be PFs within PH 290. eDRX cycle 295 may include PH 290. The PW may be signaled to the WTRU, for example by the MME in a NAS message. In a PF, a WTRU may monitor or only monitor one PO. Paging to a WTRU may be repeated in one or more of a WTRU's PFs in its PW, for example if the WTRU does not respond to a previous page.

[0088] A cell's support of idle mode extended DRX may be implicitly indicated by the broadcast of H-SFN. For long DRX cycles, it may be useful for the MME to have some awareness of when the WTRU may be become reachable, for example to avoid storing paging requests at the eNode-B for a long time. In connected mode, the DRX cycle may be extended up to the SFN

limit, for example, by extending the range of values for long DRX cycles to 10.24 seconds.

[0089] A large population of NB WTRUs may be multiplexed within a limited number of paging resources. If the distribution of WTRUs among paging resources is based on WTRU-ID, for example IMSI or IMSI modulo 1024, there may, for example still be a large number of WTRUs sharing the same paging resources in time and/or frequency, for example sharing the same PO and/or paging NB.

[0090] A NB WTRU may monitor M-PDCCH in a PO or each of its POs. If the M-PDCCH, or a DCI in the M-PDCCH, indicates the scheduling of an associated PDSCH for paging message, the NB WTRU may receive the associated PDSCH, for example, to check if there may be a paging message targeted to the NB WTRU.

[0091] Since a large number of NB WTRUs may share the same paging resources, a NB WTRU may receive the associated PDSCH when the paging message may not be targeted to the NB WTRU. The reception of an associated PDSCH that may not be intended for the WTRU may, for example, increase the WTRU's battery consumption unnecessarily. If the NB WTRU is in a CE level that may use a large number of repetitions, the impact to the WTRU may be worse, and may be, for example, significantly worse.

[0092] A NB WTRU may monitor M-PDCCH, for example in a PO or in each PO, in a NB WTRU specific or a NB WTRU group specific manner. The M-PDCCH may implicitly or explicitly indicate the necessity of receiving and/or decoding the M-PDCCH and/or an associated PDSCH, for example by a WTRU or group of WTRUs. For example, the M-PDCCH may implicitly or explicitly indicate the intended recipient or recipients of the M-PDCCH, an associated PDSCH, a page, a paging message or a PDSCH carrying a paging message or channel. Further, an implicit indication of paging reception, the need for paging reception, or the intended recipient or recipients of a M-PDCCH, a PDSCH, a page, a paging message or a PDSCH carrying a paging message or channel may be employed which uses one or more of: a scrambling indication; a scrambling sequence such as a scrambling sequence for M-

PDCCH randomization, a WTRU group-specific or WTRU-specific scrambling sequence, an information type specific scrambling sequence, or a scrambling sequence for paging reception; a starting enhanced control channel element (ECCE) index for M-PDCCH randomization, a bit interleaver for M-PDCCH randomization; and/or one or more Radio Network Temporary Identifiers (RNTIs).

[0093] In an example, a scrambling sequence may be used to randomize a bit sequence of an M-PDCCH. A WTRU that may use the same scrambling sequence to descramble the received bits may receive or may be able to receive the M-PDCCH. In an example, only a WTRU that may use the same scrambling sequence to descramble the received bits may receive or may be able to receive the M-PDCCH.

[0094] The bit sequence of an M-PDCCH may be a bit sequence before the modulation of M-PDCCH. For example, the bit sequence of an M-PDCCH may be a bit sequence after rate matching. A coded bit sequence may be an input bit sequence of the rate matching and an output bit sequence of the rate matching may be the bit sequence of an M-PDCCH. A DCI with cyclic redundancy check (CRC) scrambled by an RNTI may be an input bit sequence of the channel coding block and an output bit sequence may be a coded bit sequence.

[0095] The bit sequence of an M-PDCCH may be a bit sequence before the channel coding. For example, a DCI with CRC scrambled by an RNTI may be the bit sequence of an M-PDCCH.

[0096] For the RNTI, one or more of following examples may apply. The RNTI may be a P-RNTI, for example, if the DCI may be used for the paging. In another example, the RNTI may be a group-specific P-RNTI which may be associated with a scrambling sequence. In a further example, the RNTI may be the N least significant bits (LSBs) of a WTRU-ID that may be used for paging. N may be the number of CRC bits, which may be referred to as NCRC. For example, the 16 LSBs of a WTRU-ID, for example, IMSI or System Architecture Evolution (SAE)-Temporary Mobile Subscriber Identity (s-TMSI), may be used. The N bits used for the RNTI may be the same N bits that

correspond to WTRU-ID modulo (2^N), for example, IMSI modulo (2^N), where N may be 16.

[0097] In an example, a bit sequence of M-PDCCH $b(0),\ldots,b(M_{\text{bit}}-1)$ may be scrambled with a certain scrambling sequence, $c(i)$, where M_{bit} may be the number of bits in the bit sequence of an M-PDCCH. The result of a WTRU-specific or a WTRU group-specific scrambling sequence may be referred to as $\tilde{b}(0),\ldots,\tilde{b}(M_{\text{bit}}-1)$.

[0098] In an example, the $\tilde{b}(0),\ldots,\tilde{b}(M_{\text{bit}}-1)$ bit sequence may be determined based on $\tilde{b}(i)=(b(i)+c(i))\text{mod}2$, where mod2 may be modulo-2 operation. Further, the scrambling sequence $c(i)$ may be a Pseudo-random sequence that may be determined based on an initialization value, c_{init}, where i may be a bit index of the bit sequence.

[0099] The certain scrambling sequence may be determined based on at least one of whether the M-PDCCH or scrambling sequence may be WTRU-specific or WTRU group-specific, information type in the associated DCI and information type in the associated PDSCH. The initialization value (c_{init}) may be determined based on at least the WTRU-ID, at least the associated WTRU group number, at least the information type in the associated DCI, at least the information type in the associated PDSCH and/or an RNTI.

[0100] In an example, a WTRU which may monitor or attempt to decode a bit sequence of M-PDCCH may use its associated scrambling sequence. The associated scrambling sequence may be determined based on at least one of whether the M-PDCCH or scrambling sequence may be WTRU-specific or WTRU group-specific, and/or information type in the DCI. For example, the associated scrambling sequence may be determined based on the type of the information in the DCI for which the WTRU may be monitoring, such as WTRU-specific or WTRU group-specific paging. In an example, the WTRU may perform descrambling with an input bit sequence of the channel decoder. Also, the WTRU may perform descrambling with an output bit sequence of the channel decoder. In an example, if the bit sequence of M-PDCCH received at the WTRU receiver is $d(0),\ldots,d(M_{\text{bit}}-1)$, the $\tilde{d}(0),\ldots,\tilde{d}(M_{\text{bit}}-1)$ sequence may be

referred to as a descrambled bit sequence with the associated scrambling sequence $c(i)$. As an example, the WTRU may perform descrambling with $\tilde{d}(i) = (d(i) + c(i)) \bmod 2$.

[0101] A WTRU-specific scrambling sequence and/or a WTRU group-specific scrambling sequence may be provided and/or used. In an example, a WTRU-specific or WTRU group-specific scrambling sequence, for example a first scrambling sequence, may be used to scramble a bit sequence of an M-PDCCH, for example in a PO or each PO. In an example, a WTRU or a WTRU group that may use the same scrambling sequence, for example the first scrambling sequence, may decode or may be able to decode the M-PDCCH. For example only a WTRU or a WTRU group that may use the same scrambling sequence, for example the first scrambling sequence, may decode or may be able to decode the M-PDCCH.

[0102] In an example of using a WTRU group-specific scrambling sequence, N_g scrambling sequences may be used for N_g WTRU groups for a PO and a bit sequence of M-PDCCH intended or targeted for a WTRU group, for example a first WTRU group, within N_g WTRU groups may be scrambled with the corresponding scrambling sequence, for example a first scrambling sequence. In an example, the WTRU group using the corresponding scrambling sequence, for example the first scrambling sequence, may receive or may be able to receive the M-PDCCH. In a further example, only the WTRU group using the corresponding scrambling sequence, for example the first scrambling sequence, may receive or may be able to receive the M-PDCCH. The WTRU group-specific scrambling sequence may be determined based on at least one of following: a modulo operation that may, for example, be based on at least N_g and the WTRU-ID; a hashing function that may, for example, be based on N_g and the WTRU-ID; and the WTRU group number that may, for example, be determined based on at least a CE level.

[0103] A modulo operation may be used where the modulo operation may be based on at least N_g and the WTRU-ID (N_{WTRUID}). The WTRU group number (N_{group}) may be determined by WTRU-ID modulo N_g (for example

$N_{group} = (N_{WTRUID}) \bmod N_g$). A subframe number and/or a frame number (for example SFN) may be used. For example, $N_{group} = (N_{WTRUID} \cdot N_{Frame}) \bmod N_g$.

[0104] A hashing function may be used where the hashing function may be based on N_g and the WTRU-ID. In this case, for example, $N_{group} = (A \cdot N_{WTRUID}) \bmod N_g$, where the A may be a prime number (for example A = 39,827), or $N_{group} = ((A \cdot N_{WTRUID}) \bmod D) \bmod N_g$, where the D may be a prime number which may be different from A (for example D = 65,537). The hashing function may be based on a subframe number and/or a frame number.

[0105] The WTRU group number may be determined based on at least a CE level. For example, WTRUs with a first CE level (for example CE level-1) may be grouped as a first WTRU group and WTRUs with a second CE level (for example CE level-2) may be grouped as a second WTRU group.

[0106] The WTRU-ID may be at least one of an RNTI allocated for a WTRU, IMSI, and s-TMSI, and/or a part of at least one of the allocated RNTI, IMSI, and s-TMSI. For example, WTRU-ID may be IMSI modulo M or s-TMSI modulo N. M and/or N may be 1024. A and/or D may be a function of N_g. A and/or D may be fixed and/or configured, for example, by the eNode-B via signaling. A N_{WTRUID} may be the WTRU-ID or a portion of or function of the WTRUs IMSI or s-TMSI. For example N_{WTRUID} for a WTRU may be IMSI-10, or IMSI modulo X, where X may be a number less than or equal to 1024.

[0107] In an example of using a WTRU specific scrambling sequence, a WTRU specific scrambling sequence may be used for a bit sequence of M-PDCCH intended or targeted for a WTRU, where the WTRU specific scrambling sequence may be determined based on at least a WTRU-ID or a part of a WTRU-ID. In MME initiated paging, the WTRU-ID may be provided by the MME to the eNode-B in an S1 paging message or request.

[0108] In an example, the scrambling sequence may be determined based on the specific information type which may be carried in the DCI. For example, a first scrambling sequence may be used for a bit sequence of an M-PDCCH in which the DCI may carry a first information type and a second

scrambling sequence may be used for a bit sequence of an M-PDCCH in which the DCI may carry a second information type.

[0109] The first information type may include, but not be limited to, at least one or more system information update indications such as system information modification indication, an ETWS indication, a CMAS indication, and an EAB parameter modification indication. One or more system information indications may be a single bit to indicate the system information update or multiple bits to indicate the system information update of multiple SIs, for example, SIBs or SI-messages. An additional indicator may be included, for example, a flag bit to indicate a DCI format or a DCI type. The scrambling sequence for the first information type may be based on at least one of cell-specific parameters, such as for example, a physical cell-ID.

[0110] The second information type may be at least scheduling information of the associated PDSCH. The scrambling sequence for the second information type may be based on at least one of WTRU-specific parameters, such as for example, a WTRU-ID.

[0111] In another example, the scrambling sequence may be determined based on the information type carried in a DCI and/or WTRU-ID. For example, a first scrambling sequence may be used for a bit sequence of an M-PDCCH in which the DCI may carry a first information type, and a second scrambling sequence may be used for a bit sequence of an M-PDCCH in a which the DCI may carry a second information type. The first scrambling sequence may be predefined. The second scrambling sequence may be determined based on a WTRU-ID.

[0112] In an example, the PO for the first information type and the second information type may the same. Further, a WTRU may monitor M-PDCCH for both the first information type and the second information type. Also, a WTRU may monitor M-PDCCH for the first information type in a subset of POs or all POs. A WTRU may monitor M-PDCCH for the second information type in a subset of POs or all POs.

[0113] In another example, the PO for the first information type and the second information type may be different. The time and/or frequency location

of the PO for the first information type may be determined based on at least one cell-specific parameter. The cell-specific parameters may include, for example, a physical cell-ID, a system bandwidth, a subframe number, a frame number such as an SFN and the like. The time and/or frequency location of the PO for the second information type may be determined based on at least one WTRU-specific parameter, such as, for example, a WTRU-ID.

[0114] Examples which include the use of a scrambling sequence for paging reception are disclosed herein. A WTRU may determine a bit scrambling sequence, for example, an M-PDCCH bit scrambling sequence according to one or more examples described herein. In an example, the WTRU may monitor for an M-PDCCH in a PO. The WTRU may descramble the received signal or M-PDCCH using the bit scrambling sequence. The WTRU may determine if the descrambled M-PDCCH may carry a DCI masked with an RNTI that the WTRU may use for paging. The RNTI may be, for example, a P-RNTI. If the WTRU determines the DCI is masked with the RNTI, such as, for example, the P-RNTI, the WTRU may read the contents of the DCI to obtain one or more of system information update information and/or PDSCH scheduling information. The WTRU may use the scheduling information to receive an associated PDSCH that may carry one or more paging records or paging messages.

[0115] Examples using a starting ECCE index for M-PDCCH randomization are disclosed herein. In an example, an M-PDCCH search space may be used for monitoring for an M-PDCCH or a DCI, where the starting ECCE index, for example for monitoring, may be determined based on at least one WTRU-specific parameter. For example, a WTRU may use an M-PDCCH search space for monitoring for a an M-PDCCH or a DCI, where the starting ECCE index, for example for monitoring, may be determined based on at least one WTRU-specific parameter. As used herein, control channel element (CCE), ECCE and NB-IoT control channel element (NCCE) may be used interchangeably.

[0116] FIG. 3 is an exemplary diagram which illustrates WTRU group-specific starting ECCE indexes. Diagram 300 shows an example of ECCEs in a

subframe 310 at ECCE aggregation level 16. In other examples, other ECCE aggregation levels such as 1, 2, 4, 8 and 32 may be used. In an example shown in FIG. 3, a WTRU may use a different starting ECCE index depending upon the group the WTRU is in. For example, the WTRUs may be divided among four WTRU groups, numbered WTRU group #1 through WTRU group #4. WTRUs in WTRU group #1 may use a starting ECCE index 330 with a starting ECCE of 1, WTRUs in WTRU group #2 may use a starting ECCE index 350 with a starting ECCE of 5, WTRUs in WTRU group #3 may use a starting ECCE index 370 with a starting ECCE of 9, and WTRUs in WTRU group #4 may use a starting ECCE index 390 with a starting ECCE of 12.

[0117] FIG. 4 is a diagram of an example flow chart showing a WTRU receiving a machine type communication (MTC) physical downlink control channel (M-PDCCH) with a starting ECCE index based on the WTRU group of the WTRU. In an example shown in chart 400, a WTRU may monitor for an M-PDCCH in an M-PDCCH search space 410. The WTRU may monitor for the M-PDCCH using a starting ECCE index for the WTRU group containing the WTRU. The WTRU may then receive the M-PDCCH in the M-PDCCH search space, wherein the M-PDCCH may have a starting ECCE index for the WTRU group containing the WTRU 420. In an example corresponding to the WTRU groups shown in FIG. 3, the WTRU may be in WTRU group #2 and may therefore monitor for and/or receive an M-PDCCH with a starting ECCE index 350 of 5. Further, the WTRU may decode the M-PDCCH, wherein the M-PDCCH includes a DCI 430. The WTRU may receive a PDSCH associated with the M-PDCCH 440 or the DCI, for example a PDSCH scheduled by the M-PDCCH or the DCI. In an example, the WTRU may receive, decode, attempt to decode, demodulate, and/or attempt to demodulate the PDSCH based on the DCI, wherein the PDSCH may include a paging message. As a result, the WTRU may change its operation based on the paging message. For example, the WTRU may change from idle mode to connected mode based on the paging message. The WTRU may then begin to transmit and receive in connected mode. In another example, the WTRU may already be in connected

mode and may change its system operation based on system information change information in the page message.

[0118] In another example, an M-PDCCH search space may be used for a DCI monitoring, where the starting ECCE index and ordering (for example, an ascending order, a descending order, a random order and/or a predefined order) may be used to determine an M-PDCCH candidate. For example, if a number of ECCEs, $N_{ECCE,}$ is available in the search space and an ECCE aggregation level is the same as N_{ECCE} for an M-PDCCH candidate, one or more M-PDCCH candidates may be determined based on the starting ECCE index and/or ordering.

[0119] An M-PDCCH candidate may be defined or configured with N_{ECCE} ECCEs which may be aggregated in an ascending order, descending order, ascending order with a starting ECCE index, or descending order with a starting ECCE index. In an example, the starting ECCE index and/or ordering may be determined based on at least one WTRU-specific parameter. In a further example, the starting ECCE index and/or ordering may be determined based on at least information type carried in the DCI.

[0120] In another example, an M-PDCCH search space may be used for a DCI monitoring, where the ECCE aggregation may be based on a sequence. The sequence for the ECCE ordering may be determined based on at least one WTRU-specific parameter.

[0121] FIG. 5 is an exemplary diagram which illustrates WTRU group-specific random ECCE ordering. A sequence for the ECCE ordering may be determined based on at least one WTRU-specific parameter as shown in diagram 500. Similar to FIG. 3, FIG. 5 shows an example of ECCEs in a subframe 510, at ECCE aggregation level 16. In an example, a sequence may determine the ECCE ordering for ECCE aggregation. In a further example, the sequence for ECCE ordering may be determined based on at least one of: a WTRU-specific parameter, an information type carried in the DCI, an RNTI that may be used for CRC scrambling, a DCI format used and a CE level or repetition number such as, for example a repetition number of an M-PDCCH candidate.

[0122] In yet a further example, a set of random sequences may be predefined or configured, for example for a group of WTRUs. A sequence may correspond to a starting ECCE index. A sequence may correspond to ECCE aggregation ordering.

[0123] In an example shown in FIG. 5, a WTRU may use a different starting ECCE index depending upon a random sequence that may be defined, configured and/or used by or for the group the WTRU is in. For example, the WTRUs may be divided among four WTRU groups, numbered WTRU group #1 through WTRU group #4. WTRUs in WTRU group #1 may use a first random sequence 530 that may correspond to a starting ECCE index of 4, WTRUs in WTRU group #2 may use a second random sequence 550 that may correspond to a starting ECCE index of 5, WTRUs in WTRU group #3 may use a third random sequence 570 that may correspond to a starting ECCE index of 9, and WTRUs in WTRU group #4 may use a fourth random sequence 590 that may correspond to a starting ECCE index of 12. A random sequence, for example, within the set, may be determined based on at least one of: a WTRU-specific parameter, an information type carried in the DCI, an RNTI that may be used for CRC scrambling, a DCI format used, or a CE level or repetition number, such as, for example, a repetition number of an M-PDCCH candidate.

[0124] Examples using a bit interleaver for M-PDCCH randomization are disclosed herein. In an example, a bit sequence for an M-PDCCH may be interleaved with an interleaving sequence. The interleaving sequence may be a sequence with the length of the bit sequence. The bit positions may be interleaved based on the interleaving sequence. In an example, the interleaving sequence may be determined based on one or more of at least one WTRU-specific parameter, an information type carried in the DCI, an RNTI that may be used for CRC scrambling, a DCI format used, and a CE level or repetition number such as, for example a repetition number of an M-PDCCH candidate. In a further example, a WTRU may use the interleaving sequence to de-interleave the received bit sequence before it may attempt to decode the received bit sequence.

[0125] In an example, one or more RNTIs may be used for a DCI, for example to indicate to a WTRU whether to decode an associated PDSCH. For example, a cell-specific P-RNTI and one or more WTRU group specific P-RNTIs may be used. A WTRU may attempt to decode the M-PDCCH with the cell-specific P-RNTI and/or an associated WTRU group specific P-RNTI in a PO. In an example, a first P-RNTI may be used for a DCI carrying a first information type. In a further example, a second P-RNTI may be used for a DCI carrying a second information type. Also, in a PO, a WTRU may attempt to decode a DCI with the first P-RNTI and/or the second P-RNTI.

[0126] A first P-RNTI may be used for a DCI carrying a first information type. The first P-RNTI may be a cell-specific P-RNTI. The first information type may include but not be limited to at least one or more system information update indications such as a system information modification indication, an ETWS indication, a CMAS indication, and an EAB parameter modification indication. One or more system information indications may be a single bit to indicate the system information update or multiple bits to indicate the system information update of multiple SIs, such as, for example, SIBs or SI-messages. An additional indicator may be included, such as, for example a flag bit to indicate a DCI format or a DCI type. The first P-RNTI may be based on at least one cell-specific parameter, such as, for example a physical cell-ID.

[0127] A second P-RNTI may be used for a DCI carrying a second information type. A set of P-RNTIs may be predefined or configured for the second P-RNTI and one of the predefined or configured P-RNTIs may be determined in a WTRU-specific or a WTRU group specific manner. A modulo operation with a WTRU-ID and/or the number of P-RNTIs configured may be used to determine the associated P-RNTI. A hashing function may be used with a WTRU-ID and/or the number of P-RNTIs configured to determine the associated P-RNTI.

[0128] In a PO, a WTRU may attempt to decode a DCI with the first P-RNTI. The WTRU may also attempt to decode a DCI with the second P-RNTI which may be associated with the WTRU. If a WTRU may successfully decode a DCI with the first P-RNTI, then the WTRU may not monitor a DCI with the

second P-RNTI. If a WTRU may not successfully decode a DCI with the second P-RNTI, then the WTRU may assume that the associated PDSCH may not be scheduled.

[0129] An explicit indication of paging reception is disclosed herein including the use of: a paging occasion type; a monitoring indicator for a paging occasion, a paging type, a paging message, a paging window, among others; multiple monitoring indicators; and multiple monitoring indicators with explicit and implicit indications. In examples, one or more paging occasion types may be used, configured, or defined, for example for a RRC idle WTRU and/or a RRC connected WTRU.

[0130] A first paging occasion type may be used for a paging message transmission in which a WTRU may monitor for a paging message. The paging message may include one or more paging records and/or one or more system information update indications. In an example, the paging message may be carried in a DCI. In a further example, the paging message may be carried in a PDSCH and the scheduling information of the PDSCH may be provided in an associated DCI. Also, the paging message may be carried in a PDSCH without an associated DCI for the scheduling information. Further, the contents of the paging message may be indicated from the associated DCI. For example, a DCI may indicate the information type included in the paging message.

[0131] In an example, a second paging occasion type may be used for one or more system information update indications. In a further example, one or more paging occasion types may be located in a same time/frequency resource and monitored separately.

[0132] The time/frequency locations for one or more paging occasion types may be determined independently. A time/frequency location of a first paging occasion type may be determined based on at least one WTRU-specific parameter, such as, for example, a WTRU-ID. A time/frequency location of a second paging occasion type may be determined based on at least one cell-specific parameter, such as, for example, a physical cell-ID, (e)DRX cycle, system bandwidth and the like.

[0133] In an example, a DCI format or DCI contents may be different according to the paging occasion type. Further, an associated RNTI may be different according to the paging occasion type.

[0134] In an example, an indication for monitoring, for example, a monitoring indicator, of one or more of PO types may be transmitted in a broadcast channel, such as, for example, in a MIB, in a DCI in common search space and the like. For example, a broadcast channel may be transmitted in every x ms and one or more POs may be associated with a broadcast transmission. The broadcast transmission may indicate if a WTRU may need to monitor one or more POs associated with the broadcast transmission. A WTRU may attempt to decode or read a broadcast channel which may carry the monitoring indicator before it may monitor one or more POs. In an example, a monitoring indicator may be associated with one or more PO types. For example, the monitoring indicator may be associated with a first PO type. In a further example, the monitoring indicator may be associated only with a first PO type. In another example, the monitoring indicator may be associated with a second PO type. In a still further example, the monitoring indicator may be associated only with a second PO type. In an example, the monitoring indicator may be set to TRUE or FALSE. Based on the monitoring indicator, a WTRU may monitor a WTRU-group specific PO which may be determined based on at least one of a WTRU-specific parameter, such as, for example a WTRU-ID, or a cell-specific PO that may be determined based on at least one cell-specific parameter, such as, for example, a physical cell-ID.

[0135] A monitoring indicator may be associated with one or more POs. For example, a monitoring indicator may be associated with POs within a certain time window. If a WTRU receives the monitoring indicator, the WTRU may attempt to receive or monitor POs within the certain time window.

[0136] A monitoring indicator may indicate a WTRU group index and a WTRU group associated with the monitoring indicator may monitor the POs. In an example, the monitoring indicator may indicate which WTRU group may need to monitor POs. The WTRU group may include all WTRU groups for a system information update. In another example, the monitoring indicator

may have a number of states, such as four states and may indicate at least one of the states. The states may, for example include cell common paging, a first WTRU group, a second WTRU group, and a third WTRU group. In an example, the cell common page may be or occur in a cell-specific PO. A WTRU may monitor a PO or monitor for a page according to a monitoring indicator state.

[0137] A monitoring indicator may indicate a PO type and a WTRU may monitor POs corresponding to the PO type. In an example, a WTRU may receive a monitoring indicator which indicates a first PO type, and then the WTRU may monitor POs corresponding to the first PO type. Further, a WTRU may receive a monitoring indicator which indicates a first PO type, and then the WTRU may monitor POs corresponding to the first PO type only.

[0138] In another example, a monitoring indicator may be used with a WTRU group specific M-PDCCH scrambling sequence, a WTRU group specific RNTI, a WTRU group specific starting ECCE index, and/or a WTRU group specific interleaver. A monitoring indicator may be used to indicate if a WTRU may need to monitor POs associated with it and an implicit indication of paging reception schemes may be used in each PO. A WTRU may, for example, attempt to decode, receive, or monitor the monitoring indicator and, if the monitoring indicator indicates that the WTRU may need to monitor the POs, the WTRU may attempt to decode or monitor the POs, for an M-PDCCH, for example, with its associated scrambling sequence, starting ECCE index, RNTI, and/or interleaving sequence. Further, a WTRU may first attempt to decode, receive, or monitor the monitoring indicator and, if the monitoring indicator indicates that the WTRU may need to monitor the POs, the WTRU may attempt to decode or monitor the POs, for an M-PDCCH, for example, with its associated scrambling sequence, starting ECCE index, RNTI, and/or interleaving sequence.

[0139] In an example, one or more monitoring indicators may be used and a WTRU may determine if the WTRU may need to monitor, receive, or attempt to decode an M-PDCCH and/or a PDSCH carrying paging related information. A monitoring indicator may be used to determine if a WTRU

needs to monitor or attempt to decode a M-PDCCH in a PO, which may be referred to as a PO (paging occasion) monitoring indicator. A monitoring indicator may be used to determine if a WTRU needs to receive an associated PDSCH which may carry a paging message (PM), which may be referred to as a PM monitoring indicator. A monitoring indicator may be used to determine if a WTRU needs to monitor POs within a paging window (PW), which may be referred to as a PW monitoring indicator. A PW may include one or more POs for a WTRU. A PW may be defined or determined based on a number of POs. For example, a PW may be defined to include N_{PO} POs where N_{PO} may be a positive integer number.

[0140] A monitoring indicator may be used to determine if a WTRU needs to receive, attempt to decode, or monitor a subsequent monitoring indicator. A WTRU may receive a monitoring indicator before it may decode, monitor, attempt to decode, receive, or attempt to receive a signal, for example an M-PDCCH or a PDSCH, in a PO. Two monitoring indicators may be used and a first monitoring indicator may be a PO monitoring indicator and a second monitoring indicator may be a PM monitoring indicator. The first monitoring indicator may be transmitted in a broadcast channel. The second monitoring indicator may be transmitted in a DCI, for example in an M-PDCCH.

[0141] A PM monitoring indicator may be comprised of one or more bits to indicate at least one of the following: a presence of an associated PDSCH which may carry a paging message; a WTRU group index, or WTRU group ID, which may be associated with a paging message; and a type of information carried in a paging message.

[0142] In another example, one or more monitoring indicators may be used and each monitoring indicator may be used to indicate a WTRU group, a WTRU group index or a WTRU group ID. A WTRU which may be associated with a WTRU group, a WTRU group index or a WTRU group ID may need to monitor or receive a paging message, for example when a monitoring indicator for the WTRU group, the WTRU group index or the WTRU group ID indicates to monitor or read a paging message. A hierarchical WTRU group index may

be used, where a first WTRU group index may include a set of WTRUs or WTRU-IDs and a second WTRU group index may include a subset of WTRUs or WTRU-IDs within the set of WTRUs or WTRU-IDs indicated from the first WTRU group index. The first WTRU group index may be determined based on a WTRU-ID, for example, IMSI, and the second WTRU group index may be determined based on a different WTRU-ID, for example, s-TMSI. The first WTRU group index may be determined based on a modulo operation based on WTRU-ID and the number of WTRU groups for the first WTRU group index, and the second WTRU group index may be determined based on a hashing function with a WTRU-ID and the number of WTRU groups for the second WTRU group index.

[0143] A combination of a first monitoring indicator and a second monitoring indicator may be used to determine a WTRU group index. If N1 WTRU groups for a first monitoring indicator and N2 WTRU groups for a second monitoring indicator are used, the combined WTRU group may be indicated as N1 x N2 WTRU groups.

[0144] Examples of using multiple monitoring indicators for paging with explicit and implicit indications are discussed herein. In an example, one or more monitoring indicators may be used and a first monitoring indicator may be based on one or more explicit bits while a second monitoring indicator may be based on an RNTI. For example, a WTRU may receive or receive an indication from a PO monitoring indicator in a first channel and the WTRU may receive or receive an indication from a PM monitoring indicator in a second channel.

[0145] In an example, the first channel may be a broadcast channel and the second channel may be a physical downlink control channel, for example, an M-PDCCH. In another example, the first channel may be an M-PDCCH monitored in a cell-specific time/frequency resource, such as, for example, a common search space, and the second channel may be an M-PDCCH monitored in a WTRU-specific or WTRU-group specific time/frequency resource, such as, for example, a WTRU-specific or WTRU group-specific search space. In a further example, the PO monitoring indicator may be one or

more bits transmitted in a broadcast channel. Also, the PM monitoring indicator may be a set of RNTIs reserved for the PM monitoring indication.

[0146] Example methods for a WTRU to perform a paging NB determination are discussed herein. A WTRU may determine the NB to use for paging in its PO, for example based on at least one of its WTRU ID, the number of paging NBs, , and the DL system bandwidth. The WTRU ID may be an IMSI or an s-TMSI. An option is to use IMSI modulo 1024 to determine the NB, for example, since IMSI modulo 1024 may be used to determine the WTRU's PO. The number of paging NBs may be broadcast, may be received via broadcast signaling, and/or may be received via system information. A paging NB may be a NB that may be used for paging. In an example, a NB may be or may represent a set of RBs or subcarriers within a system BW.

[0147] The parameters used for paging may include DRX cycle, nB and the like. Depending on the parameters that may be used for paging and the number of NBs, the use of IMSI modulo 1024 to determine the NB, however, may result in some or all WTRUs in a given PO determining the same NB. This may defeat the purpose of having multiple NBs for paging.

[0148] Several example solutions are discussed herein for a WTRU to better determine a NB for paging. In an example solution, IMSI-10 may be used to represent IMSI modulo 1024 or the least significant 10 bits of an IMSI. For MME initiated paging of a WTRU, the MME may include the IMSI-10 and/or the s-TMSI for the WTRU in the S1 paging message to the eNode-B to request the page. When paging a WTRU, an eNode-B may know the IMSI-10 and/or the s-TMSI of the WTRU. The WTRU and/or eNode-B may use one or both of these values to determine the WTRU's NB for paging. For example, the WTRU and/or eNode-B may use one or both of these values to determine the WTRU's NB for paging in the WTRU's PO.

[0149] A function, such as a hashing function, that may be based on at least the WTRU ID may be used by a WTRU and/or eNode-B to determine the NB for paging. For example, the function may be based on at least IMSI-10 or IMSI modulo X. In an example, the hashing function may be based on at least IMSI-10 or IMSI modulo X.

[0150] For example, a function such as a hashing function may be used based on N_b and/or the WTRU ID. In an example, N_b may be the number of NBs. In a further example, N_b may be the number of NBs to use for paging or that may be used for paging. For example, the NB for a WTRU, NB_{WTRU}, may be determined, for example, by the WTRU and/or eNode-B according to:

$$NB_{WTRU} = (A \cdot N_{WTRUID}) \bmod N_b \quad \text{Equation (1)}$$

where the A may be a prime number, for example, A = 39827. In a further example, NB_{WTRU}, may be determined according to:

$$NB_{WTRU} = ((A \cdot N_{WTRUID}) \bmod D) \bmod N_b \quad \text{Equation (2)}$$

where D may be a prime number which may be different from A, for example, D = 65537.

[0151] A and/or D may be a function of N_b. A and/or D may be fixed and/or configured, for example, by the eNode-B via signaling. N_{WTRUID} may be the WTRU ID or a portion of or function of the WTRU's IMSI or s-TMSI. For example N_{WTRUID} for a WTRU may be IMSI-10, IMSI modulo X, where X may be a number less than or equal to 1024 or IMSI modulo Y, where Y may be a number less than or equal to 16,384. The number of NBs for paging may be provided by the eNode-B and/or received by the WTRU in signaling such as higher layer signaling which may be broadcast, for example, in system information.

[0152] Additional IMSI bits or an additional portion or function of the IMSI may be used by a WTRU and/or eNode-B to determine the NB for paging. The MME may include the additional bits in the S1 paging message to the eNode-B. The eNode-B may receive the additional bits and may use them to determine the NB in which to page the WTRU.

[0153] For example, the most significant B bits of IMSI modulo Z may be used to determine the NB for paging, where Z may be at least one of (2^B) x 1024, (2^C) x 1024 and a number less than or equal to 16,384. In an example, C may be a number or integer that may be different than B. Further, the B MSBs, for example the value of the B MSBs, MB, may be used to determine the NB, for example according to MB modulo N_b.

[0154] In an example, if there are up to 16 narrowbands for paging, B may be 4. The 4 MSBs of IMSI modulo 16,384 may be used to determine the NB for paging, where IMSI modulo 16,384 may be derived from IMSI modulo Z and Z = (2^B) x 1024. Since B may be 4, then (2^4) x 1024 = 16 x 1024 = 16,384. Further, since B may be 4, the 4 MSBs, M4, may be used to determine the NB, for example according to M4 modulo N_b. M4 may be used to represent the 4 MSBs or the value of the 4 MSBs.

[0155] In another example, B may be 3 and C may be 4. The 3 MSBs of IMSI modulo 16,384 may be used to determine the NB for paging, where IMSI modulo 16,384 may be derived from IMSI modulo Z and Z = (2^C) x 1024. Since C may 4, then (2^4) x 1024 = 16 x 1024 = 16,384. Further, since B may be 3, the 3 MSBs, M3, may be used to determine the NB, for example according to M3 modulo N_b. M3 may be used to represent the 3 MSBs or the value of the 3 MSBs.

[0156] In other examples, different numbers of narrowbands for paging may be used and still be consistent with the examples discussed herein. Further, in other examples, different values for B, for C or for both may be used.

[0157] The 14 bits, IMSI-14, that may correspond to IMSI modulo 16,384 may be used to determine the NB, for example according to IMSI-14 modulo N_b. Further, the 14 bits, IMSI-14, that may correspond to IMSI modulo 16,384 may be used to determine the NB, for example according to IMSI-14 modulo N_b modified by one or more other parameters.

[0158] FIG. 6 is a diagram of an example flow chart showing a WTRU using a WTRU-ID to determine a paging NB to use for monitoring an M-PDCCH. As shown in flow chart 600, a WTRU may determine a paging NB for the WTRU, to use for monitoring an M-PDCCH, based on at least the MSBs of a function of a WTRU-ID 610. The WTRU may monitor for the M-PDCCH on the determined paging NB for the WTRU 620. For example, the WTRU may monitor for the M-PDCCH on the determined paging NB in or during a PO that may be a PO of the WTRU. The WTRU may monitor for an M-PDCCH masked with a P-RNTI or for an M-PDCCH or DCI with a CRC scrambled

with a P-RNTI. The WTRU may then receive a DCI on the monitored M-PDCCH on the determined paging NB during a PO 630 that may be a PO of the WTRU. The DCI may include a CRC that may be scrambled with a P-RNTI. The WTRU may receive a physical downlink shared channel (PDSCH) associated with the M-PDCCH 650 or the DCI, for example a PDSCH scheduled by the M-PDCCH or the DCI. The WTRU may receive system information update related information and/or a paging message in or from the DCI or the PDSCH.

[0159] In a further example, the most significant N bits of IMSI-10 may be used to determine the NB for paging. N may be a function of the number of NBs configured or available, for example, in a PO, for paging.

[0160] In the embodiments and examples described herein, the term mobile subscriber identification number (MSIN) may be substituted for IMSI and vice versa and still be consistent with embodiments and examples disclosed herein. Further, various example numbers of digits may be used for MSIN and IMSI, including but not limited to 8, 10, 14, 16, 32, 64 and the like.

[0161] Examples of a WTRU determining a paging HF are discussed herein. Within a PH, WTRUs with the same IMSI modulo 1024 may determine the same PF and the same PO. Depending on the paging parameters, WTRUs may not be distributed well among the PFs and the PO.

[0162] IMSI may be comprised of decimal digits (0 through 9) and may include one or more of mobile country code (MCC), mobile network code (MNC) and MSIN. An IMSI may use binary-coded decimal (BCD) representation. IMSI may comprise 64 bits where each digit may by coded over 4 separate bits. The digits 0 to 9 may be encoded 0000 to 1001 and there may be two digits per octet. For the function IMSI modulo X, IMSI may be the decimal representation of the IMSI, the BCD representation of the IMSI, the hexadecimal representation of the IMSI, or another representation of the IMSI.

[0163] One or more of the examples described herein for the determination of a paging NB, for example, for and/or by a WTRU, may be applied to the determination of one or more of PH, PF, and PO, for example,

for and/or by a WTRU. A separate, for example, different function, aspect, or portion of the WTRU-ID, for example, IMSI or s-TMSI, may be used for each of PH and PF determination for and/or by a WTRU.

[0164] A $WTRU_ID_{PH}$ may represent the function, aspect, or portion of the WTRU-ID that may be used in the PH calculation. $WTRU_ID_{PF}$ may represent the function, aspect, or portion of the WTRU-ID that may be used in the PF calculation. $WTRU_ID_{PH}$-10 may represent $WTRU_ID_{PH}$ modulo 1024. $WTRU_ID_{PF}$-10 may represent $WTRU_ID_{PF}$ modulo 1024. For MME initiated paging of a WTRU, the MME may include $WTRU_ID_{PH}$-10 and/or $WTRU_ID_{PF}$-10 in the S1 paging message to the eNode-B to request the page.

[0165] A $WTRU_ID_{PH}$-10 and/or the $WTRU_ID_{PF}$-10 may be given to the eNode-B by the MME. A $WTRU_ID_{PH}$-10 and/or the $WTRU_ID_{PF}$-10 may be given to the eNode-B by the MME as a bit string of size 10. The bits may follow the normal binary representation or the BCD representation.

[0166] When paging a WTRU, an eNode-B may know $WTRU_ID_{PH}$-10 and/or $WTRU_ID_{PF}$-10. The WTRU and/or eNode-B may use one or both of these values to determine the WTRU's PH and/or PF. The WTRU and/or eNode-B may use $WTRU_ID_{PH}$-10 to determine the WTRU's PH or PHs for paging. The WTRU and/or eNode-B may use $WTRU_ID_{PF}$-10 to determine the WTRU's PF or PFs for paging.

[0167] In an example, $WTRU_ID_{PH}$ may be the WTRU's MSIN. MSIN may be the least N1, for example, 9, significant decimal digits of the IMSI in decimal representation, for example, if the concatenation of MCC and MNC is 6 digits. MSIN may be the least N2, for example, 10, significant decimal digits of the IMSI, for example, if the IMSI is 15 digits. $WTRU_ID_{PF}$ may be the WTRU's IMSI. $WTRU_ID_{PH}$-10 may be MSIN modulo 1024 and/or the $WTRU_ID_{PF}$-10 may be IMSI modulo 1024.

[0168] In another example, $WTRU_ID_{PH}$ may be the IMSI and $WTRU_ID_{PF}$ may be the MSIN. In another example, if the concatenation of the MCC and MNC part of the IMSI is an even number, the IMSI may be transformed such that the concatenation of the MCC and the MNC part of the

IMSI is an odd number. For example, one may be added or subtracted from the concatenation of the MCC and MNC part of the IMSI.

[0169] In another example, MSIN-10Q may be used to represent FLOOR [MSIN/1024] or (FLOOR [MSIN/1024]) modulo 1024. $WTRU_ID_{PH}$-10 may be MSIN-10Q.

[0170] Modified paging reception examples are disclosed herein. In an example, a WTRU may determine its PH, PF, and PO according to a set of rules, such as, for example, regular rules. The WTRU may receive and/or use additional configuration or information to determine when to monitor or skip monitoring for paging, for example, when to monitor or skip monitoring for a M-PDCCH masked with a paging RNTI, and/or receive or skip receiving an associated PDSCH or PCH.

[0171] At least some of the configuration and/or information may be provided by or received from an MME via NAS signaling or via an eNode-B via RRC signaling. The WTRU may maintain the configuration and/or information while in idle mode. A WTRU may monitor for paging in the PFs of its PW in one PH per I-eDRX cycle. In an example, a WTRU may be configured to skip its PH in one or more I-eDRX cycles and/or to skip one or more PFs in its PW.

[0172] In an example, whether the WTRU ID is an odd or even number may be used to determine whether a WTRU may read or receive, or may skip reading or receiving, a page in a PF and/or a PH. Reading and/or receiving a page may correspond to monitoring for M-PDCCH with a paging RNTI. Reading and/or receiving a page may correspond to receiving, decoding, and/or reading a PDSCH which may be associated with, indicated by, or allocated by an M-PDCCH with a paging RNTI. Reading and/or receiving a page may correspond to receiving, decoding, and/or reading a PDSCH that may carry a paging message. Skipping reading or receiving a page may be the same as not reading or receiving or not attempting to read or receive a page. Skipping reading or receiving a page may be the same as skipping one or more of a PO, PF or a PH.

[0173] A WTRU may read or monitor for a page, for example, in a PO, if WTRU ID is an odd number and skip reading or monitoring for a page, for example, in a PO, if WTRU ID is an even number, for example if reading and/or monitoring by a WTRU with an odd number WTRU ID is indicated. A WTRU may read or monitor for a page, for example, in a PO if the WTRU ID is an even number and skip reading or monitoring for a page, for example, in a PO if WTRU ID is an odd number, for example if reading and/or monitoring by a WTRU with an even number WTRU ID is indicated.

[0174] $WTRU_ID_{PH}$-10 and/or $WTRU_ID_{PF}$-10 may be substituted for WTRU ID and still be consistent with this disclosure. WTRU ID may be IMSI modulo 1024, MSIN modulo 1024, and/or FLOOR [MSIN/1024], among others.

[0175] Whether odd numbered WTRUs or even numbered WTRUs may receive a page in a PF or PO may be determined based on one or more of: a WTRU ID odd/even indicator; a PH odd/even indicator; and/or a PF odd/even indicator.

[0176] One bit may be used for an indicator. One state of the bit may be used to indicate even and the other state may be used to indicate odd. 0 may be used for even and 1 for odd or vice versa. One or more of the indicators may be signaled, for example, by the eNode-B, for example in the MIB, in a SIB, or in the M-PDCCH for paging.

[0177] A WTRU may read one or more of the indicators prior to at least one of its PHs and/or PFs and/or POs. The WTRU may read one or more of the indicators in an M-PDCCH for paging in one of its POs. The WTRU may determine the state of one or more of the indicators and based on the state or states the WTRU may determine whether to monitor for a page and/or receive a PDSCH that may carry a page. An indicator in the MIB may be used by a WTRU to determine whether to monitor for a paging M-PDCCH in one or more POs. An indicator in the M-PDCCH for paging may be used by a WTRU to determine whether to reads a PDSCH associated with the M-PDCCH that may carry a paging message.

[0178] For example, for WTRU ID odd/even = even and PH odd/even = odd, a WTRU with an even WTRU ID may read or monitor for a page in, for

example, only in, an odd numbered PH. The WTRU may skip reading or monitoring for a page in an even numbered PH. A WTRU with an odd WTRU ID may skip reading or monitoring for a page when WTRU odd/even is set to even, for example, in one or more, for example, both odd and even PHs.

[0179] In an example, (0,0) may mean the WTRU ID is even and PH is even, (1,0) may mean the WTRU ID is odd and PH is even, (0,1) may mean the WTRU ID is even and PH is odd, and (1,1) may mean the WTRU ID and PH are odd. The eNode-B may use one of these codes as a paging reading indicator, for example, at any time.

[0180] In another example, a single bit for odd/even WTRU ID may be used. A WTRU with an even WTRU ID may read or monitor for a page when WTRU odd/even is set to even and may skip reading or monitoring for a page when WTRU odd/even is set to odd. A WTRU with an odd WTRU ID may read or monitor for a page when WTRU odd/even is set to odd and may skip reading or monitoring for a page when WTRU odd/even is set to even.

[0181] The eNode-B may signal some or all of the bits of the current value of the paging reading indicator in the MIB, or in the SIB or in M-PDCCH (or PDCCH). The WTRU may make the determination to skip a PH based on the value of the paging indicator signaled by the eNode-B. The WTRU may make the determination to skip a PF based on the value of the paging reading indicator.

[0182] The eNode-B may use a paging reading indicator to indicate to one or more WTRUs to skip or read a page in a PH and/or PF. The eNode-B may use separate paging reading indicators to indicate to skip or read a page in a PF and to skip or read pages in all the PFs in a PH.

[0183] Odd/even indication may be replaced by a group ID that may represent another way to distinguish groups. More bits may be used as is appropriate. For example, there may be 4 groups and the least significant 2 bits of the WTRU ID may be used for the determination of which WTRUs may read or monitor for pages.

[0184] In a PO, multiple paging messages intended for multiple WTRUs may be multiplexed into a transport block and jointly coded by a channel

coder, where the WTRUs may have a different coverage level, thus requiring repetitions targeting for a worst coverage case. This may result in resource waste for paging transmissions.

[0185] In an example, multiple paging messages may be separately coded as code-block segments within a PDSCH transmission. For example, a PDSCH, for example, an NB-PDSCH carrying one or more paging message(s) may be scheduled by an associated PDCCH, for example, an NB-PDCCH, in each PO. The paging messages multiplexed in the PDSCH may be split into one or more code-block segments.

[0186] Each code-block segment may be coded separately by a channel code, for example, a turbo code, convolutional code, or block code. Each code-block segment may be attached with a CRC. A code-block segment may be associated with one or more paging messages. A code-block segment may be associated with one or more coverage levels. A code-block segment may be associated with a WTRU-ID. The WTRU-ID used for PO determination and code-block segment determination may be different. For example, the PO may be determined based on a first WTRU-ID, for example, IMSI-10, while the code-block segment may be determined based on a second WTRU-ID, for example, s-TMSI.

[0187] FIG. 7 is a diagram illustrating an example of code-block segment multiplexing in a PDSCH which may be scheduled by an associated PDCCH in a PO. The paging message, paging information, and paging record may be used interchangeably. As shown in diagram 700, code-block segments 710, 720 and 780 may be each associated with one or more respective coverage levels or CE levels. For example, code-block segment 710 may be associated with CE level 1, code-block segment 720 may be associated with CE level 2 and code-block segment 780 may be associated with CE level 3.

[0188] A PDSCH carrying one or more paging messages may be transmitted over multiple subframes. The number of subframes used for the PDSCH transmission may be indicated from the associated PDCCH. The number of subframes for the PDSCH transmission may be determined based on the transport block size, where the transport block size may include all

code-block segments multiplexed in the PDSCH. The number of repetitions may be indicated from the associated PDCCH. For example, the number of subframes Ns for the PDSCH transmission may be determined as a function of the transport block size and the number of repetitions Nrep may be indicated from the associated PDCCH. The total number of subframes used for the PDSCH transmission including repetitions may be Ns x Nrep.

[0189] A NB-subframe may include one of more subframes. The NB-subframe length may be determined based on the transport block size of the PDSCH transmission.

[0190] A code-block segment may be transmitted within an NB-subframe, where the NB-subframe length, for example, as a number of subframes, TTIs, ms, or the like, may be determined based on the size of the code-block segment. Multiple code-block segments may be multiplexed in a PDSCH. In an example shown in FIG. 7, code-block segments 710, 720 and 780 may be multiplexed in PDSCH 790. In an example, if Nc code-block segments are multiplexed in a PDSCH, the PDSCH may be transmitted over Nc NB-subframes. A NB-subframe length associated with a code-block segment may be determined based on the code-block segment size. The size of code-block segments may be indicated in the associated PDCCH. Based on the code-block segment sizes, a WTRU may determine the NB-subframe length of each code-block segment.

[0191] One or more code-block segments may be multiplexed in a PDSCH and the time/frequency resource locations for each code-block segment may be predefined. A WTRU may monitor all code-block segments within the PDSCH or a WTRU may monitor a subset of code-block segments. Each code-block segment may be associated with a CE level and a WTRU with a certain CE level may monitor, attempt to decode, or receive a code-block segment associated with the CE level. Each code-block segment may be associated with a WTRU-ID or a WTRU-group ID, and a WTRU may monitor, attempt to decode, or receive a code-block segment associated with the WTRU-ID or a WTRU-group ID.

[0192] In an example, multiple paging messages may be separately coded as code-block segments and each code-block segment may be transmitted in a PDSCH. For example, if Nc code-block segments are transmitted, the Nc PDSCHs may be transmitted and the Nc PDSCHs may be scheduled in an associated PDCCH in a PO. Each PDSCH carrying a code-block segment may be transmitted in one or more subframes. The starting subframe of each PDSCH carrying a code-block segment may be determined based on the last subframe of the associated PDCCH. Alternatively, the starting subframe of each PDSCH carrying a code-block segment may be determined based on the last subframe of the associated PDCCH and the size of the code-block segment. The number of subframes for a PDSCH carrying a code-block segment may be determined based on the size of the code-block segment. The size of the code-block segment may be a number of bits for the code-block segment after coding and rate-matching.

[0193] FIG. 8 is a diagram illustrating an example of code-block segments transmitted via multiple PDSCHs which may be scheduled by an associated PDCCH in a PO. An associated PDCCH transmitted in a PO may schedule one or more PDSCHs carrying paging messages. A PDSCH may be associated with a code-block segment.

[0194] As shown in diagram 800, code-block segments 810, 820 and 860 may be each associated with one or more respective coverage levels or CE levels, in a manner similar to that in FIG. 7. For example, code-block segment 810 may be associated with CE level 1, code-block segment 820 may be associated with CE level 2 and code-block segment 860 may be associated with CE level 3. However, in FIG. 8, each different respective PDSCH may be associated with each different respective code-block segment. For example, code-block segment 810 may be associated with PDSCH 870, code-block segment 820 may be associated with PDSCH 880 and code-block segment 860 may be associated with PDSCH 890.

[0195] The PDSCHs may be multiplexed in the time domain. For example, the PDSCHs may be transmitted in a different time (e.g., different

time window). The starting subframe of the PDSCHs may be predetermined based on the last subframe of the associated PDCCH.

[0196] In another example, the PDSCHs carrying code-block segments may be transmitted without an associated PDCCH. In each PO, one or more time windows may be configured, used, or allocated and a WTRU may attempt to decode, monitor, or receive a PDSCH carrying a code-block segment in a time window. The code-block segment size for a PDSCH may be predefined. One or more code-block segment sizes may be used and a WTRU may attempt to decode all candidate code-block segment sizes. The time windows for PDSCHs may be non-overlapped. Each time window may be associated with a CE level or WRTU-ID.

[0197] In another example, one or more PDSCHs carrying code-block segments may be transmitted and a first PDSCH may be scheduled by an associated PDCCH and the subsequent PDSCH(s) may be scheduled based on the previous PDSCH. An indication may be transmitted in a PDSCH to indicate whether a subsequent PDSCH carrying code-block segment may follow or may be transmitted. The indication may be based on a sequence masked in the CRC. For example, if the CRC is masked with a first sequence, there may not be a subsequent PDSCH while if the CRC is masked with a second sequence, there may be a subsequent PDSCH. The indication may be a bit transmitted in a code-block segment. A scheduling information may be transmitted with the indication. The first PDSCH may be based on the highest CE level, for example, a largest repetition number, and a subsequent PDSCH may be based on a lower CE level. The terms code-block segment and paging message may be interchangeably used herein.

[0198] The following examples include sending a direct indication in a paging DCI without PDSCH scheduling. When an eNode-B updates, or changes, a frequency location of an anchor RB, for example an anchor PRB, which may contain a synchronization signal and/or broadcasting signals such as a NB master information block (NB-MIB) and/or a NB-SIB, the eNode-B may need to indicate the update, or changes, via paging for WTRUs that are in RRC idle mode. If the indication bits are transmitted in a paging message, the

resource overhead may be increased significantly since the eNode-B may need to send this signal in all POs.

[0199] In an example, a WTRU may monitor or attempt to decode a DCI located in a NB-PDCCH search space. The NB-PDCCH may be in a PO. The NB-PDCCH and/or the PO may be intended for the WTRU. The DCI may carry one or more information types. The terms information type and DCI contents may be used interchangeably herein. One or more of following example parameters may apply.

[0200] A first information type may be scheduling information of the associated PDSCH carrying a paging message. A second information type may be a direct indication which may be related to a system configuration. The second information type may not include scheduling information of the associated PDSCH.

[0201] The information type related to system configuration may include at least one of following parameters or indications: a system information update indication; a public warning indication, such as an ETWS or a CMAS indication; an access barring parameter, such as an EAB parameter modification indication; scheduling information of one or more SIBs, where one or more SIBs may be transmitted without an associated DL control channel (NB-PDCCH); configuration information related to the anchor RB, for example the anchor PRB, for NB-IoT; a same-physical cell-ID (PCI) indicator, which may indicate if the PCI for a cell-specific reference signal (CRS) port and the PCI for an NB reference signal (NB-RS) are the same; and a valueTag, which may include one or more bits to indicate which SIB or SIBs are updated.

[0202] The scheduling information of a SIB or SIBs may include at least one of the following parameters: transport block size (TBS), frequency location, frequency hopping related information, and coverage level, which may be, for example, a repetition number. As described herein, an anchor RB, for example an anchor PRB, may include or may include transmission of at least one of the following: a synchronization signal (for example, a NB primary synchronization signal (NB-PSS), a NB secondary synchronization signal NB-

SSS and the like), a broadcast signal (for example, an NB physical broadcast channel (NB-PBCH), an NB-SIB and the like), and a NB-PDCCH common search space. The configuration information for an anchor RB, for example an anchor PRB, may include at least one of the following parameters: a RB location, for example a PRB location, within a system bandwidth, a raster offset, and a PCI of the NB-Sync.

[0203] In an example, the information type for the DCI may be determined based on a flag field in the DCI. For example, the flag field may indicate the information type carried. In another example, the information type for the DCI may be determined based on a RNTI used for the DCI. A first RNTI (e.g., P-RNTI-1) may be used if the DCI carries scheduling information of a corresponding PDSCH. A second RNTI (e.g., P-RNTI-2) may be used if the DCI carries direct information such as one or more indications related to a system configuration. In other examples, the information type for the DCI may be determined based on a scrambling sequence used for the DCI or a starting ECCE index used.

[0204] In examples, an eNode-B may page one or more WTRUs to indicate or provide a broadcast transmission or a multicast transmission. For example, for a downlink burst transmission to a group of WTRUs or all WTRUs in a cell, such as, for example, for or to perform a software upgrade of one or more NB-IoT devices, an eNode-B may page or may need to page the group of WTRUs or all WTRUs in the cell. For example, the eNode-B may need to page the group of WTRUs or all WTRUs in the cell if the WTRUs are in RRC idle. The eNode-B may need to transmit the downlink burst for each WTRU via WTRU-dedicated resources. This may result in inefficient resource utilization and WTRU battery consumption. A downlink burst transmission may be used herein as a non-limiting example of a broadcast or multicast transmission.

[0205] In an example, a common PO may be used for a downlink burst transmission. For example, a DCI scrambled with a certain RNTI, such as, for example, a downlink burst RNTI (DB-RNTI), may be monitored by a WTRU in

a PDCCH search space in the common PO. The DCI may schedule a PDSCH carrying a downlink burst traffic.

[0206] A WTRU may monitor or attempt to decode the DCI in a PDCCH search space. The PDCCH search space may be located in a certain time/frequency resource configured or used for the common PO. The time/frequency resource for a common PO may be determined based on at least one of the following parameters: system parameters, such as, for example, system bandwidth, physical cell-ID, duplex mode, TDD subframe configuration; subframe number and/or radio frame number, for example SFN; WTRU-ID, such as, for example, full or partial information of IMSI, s-TMSI and the like; operation mode, such as, for example, in-band, guard-band, and stand-alone operation; one or more coverage levels, which may be represented by, for example, repetition numbers; WTRU category and/or WTRU capabilities; and paging NBs, which may be configured or determined.

[0207] The DCI may activate and/or deactivate the PDSCH transmission for downlink burst transmission. The PDSCH may be transmitted in predefined time/frequency resources. The predefined time/frequency resources may be transmitted with a duty cycle.

[0208] In an example, a scheduling information of the downlink burst may be transmitted in a broadcast channel or in system information, such as, for example, in a MIB or a SIB. A WTRU may receive an indication or may be indicated, triggered, or informed to read the broadcast channel or the system information. The indication may be signaled in a paging message or as a direct indication in a DCI for paging. The scheduling information of the downlink burst may be transmitted in a broadcast channel or in system information. A WTRU may receive or attempt to decode the broadcast channel or system information if the WTRU receives a system information update indication.

[0209] In an example, an ordered PDSCH transmission may be used for the downlink burst transmission. For example, downlink burst traffic may be split into *N*_burst transport blocks and may be numbered in an increasing order. Each transport block may be transmitted in a PDSCH transmission. Scheduling information for the downlink burst transmission may indicate the

number of transport blocks, represented by, for example *N*_burst, for the downlink burst transmission. Scheduling information for a PDSCH carrying one or more downlink burst transport blocks may indicate the ordering number of the PDSCH.

[0210] Each transport block may be transmitted in a certain time and/or frequency resource. A transport block with a certain transport block number may be associated with a certain subframe number, a certain SFN and/or a certain hyper frame number. Therefore, a WTRU may determine, assume, or understand which transport block may be transmitted in a certain time/frequency resource for the burst transmission. If a WTRU fails to receive a subset of the transport blocks of the *N*_burst transport blocks, the WTRU may receive the failed transport blocks in a next downlink burst transmission. A transport block with a certain transport block number may be associated with a certain frequency resource. The certain time/frequency resources may be configured via higher layer signaling.

[0211] Each PDSCH carrying a transport block may be transmitted with a repetition, where the repetition number may be indicated in the scheduling information. The repetition number may include a value of "1" as a no repetition case.

[0212] In an example, a WTRU that fails to receive one or more PDSCH transmissions for a downlink burst transmission may perform one or more of following actions. The WTRU may attempt to receive the failed PDSCH transmission in a following transmission or a following transmission window. A maximum number of attempts may be predefined or configured by higher layers. The maximum number of attempts may include a value of "1".

[0213] If the WTRU fails to receive one or more PDSCH transmissions after the maximum number of attempts, the WTRU may attempt to change operation mode, such as, for example, from RRC idle mode to RRC connected mode, and/or the WTRU may initiate a random access or random access channel (RACH) procedure.

[0214] In another example, a WTRU that fails to receive one or more PDSCH transmissions for a downlink burst transmission may perform one or

more of the following actions. The WTRU may send a corresponding hybrid automatic repeat request acknowledgement (HARQ-ACK) transmission in an associated HARQ-ACK resource. A HARQ transmission for reception failure may be a negative acknowledgement (NACK). A subset of physical random access channel (PRACH) resources may be reserved as an associated HARQ-ACK resource for the downlink burst transmission. For example, a WTRU may send a HARQ transmission that may be a NACK on a PRACH resource when it fails to receive one or more PDSCH transmissions for a downlink burst transmission. A set of physical uplink control channel (PUCCH) resources may be configured, indicated, or used for HARQ transmission, for example for NACK transmission. For example, a WTRU may send a HARQ transmission that may be a NACK on a PUCCH resource that may be configured or indicated when it fails to receive one or more PDSCH transmissions for a downlink burst transmission.

[0215] Although features and elements are described above in particular combinations, one of ordinary skill in the art will appreciate that each feature or element can be used alone or in any combination with the other features and elements. In addition, the methods described herein may be implemented in a computer program, software, or firmware incorporated in a computer-readable medium for execution by a computer or processor. Examples of computer-readable media include electronic signals (transmitted over wired or wireless connections) and computer-readable storage media. Examples of computer-readable storage media include, but are not limited to, a read only memory (ROM), a random access memory (RAM), a register, cache memory, semiconductor memory devices, magnetic media such as internal hard disks and removable disks, magneto-optical media, and optical media such as CD-ROM disks, and digital versatile disks (DVDs). A processor in association with software may be used to implement a radio frequency transceiver for use in a WTRU, UE, terminal, base station, RNC, or any host computer.

* * *

CLAIMS

What is claimed is:

1. A method performed in a machine type communication (MTC) wireless transmit/receive unit (WTRU), the method comprising:

determining, by the WTRU, a paging narrowband (NB) for the WTRU, to use for monitoring an MTC physical downlink control channel (M-PDCCH), based on at least the most significant bits (MSBs) of a function of a WTRU-identifier (WTRU-ID);

monitoring, by the WTRU, for the M-PDCCH on the determined paging NB for the WTRU;

receiving, by the WTRU, a downlink control information (DCI) on the monitored M-PDCCH on the determined paging NB during a paging occasion (PO); and

receiving, by the WTRU, a physical downlink shared channel (PDSCH) associated with the M-PDCCH.

2. The method of claim 1, wherein the WTRU determines the paging NB based on at least the 3 MSBs of a function of the WTRU-ID.

3. The method of claim 1, wherein the WTRU determines the paging NB based on at least the 4 MSBs of a function of the WTRU-ID.

4. The method of claim 1, wherein the DCI includes a cyclic redundancy check (CRC) that is scrambled with a Paging Radio Network Temporary Identifier (P-RNTI).

5. The method of claim 1, wherein the PDSCH is scheduled by the DCI.

6. The method of claim 1, wherein the DCI includes system information update related information.

7. The method of claim 1, where in the PDSCH includes system information update related information.

8. The method of claim 1, wherein the PDSCH includes a paging message.

9. The method of claim 1, wherein the WTRU-ID is a WTRU international mobile subscriber identity (IMSI).

10. The method of claim 9, wherein the function includes IMSI mod 16,384.

11. The method of claim 1, wherein determining the paging NB for the WTRU is further based on a number of NBs for paging.

12. A machine type communication (MTC) wireless transmit/receive unit (WTRU), the WTRU comprising:

a processor configured to determine a paging narrowband (NB) for the WTRU, to use for monitoring an MTC physical downlink control channel (M-PDCCH), based on at least the most significant bits (MSBs) of a function of a WTRU-identifier (WTRU-ID);

a transceiver operatively coupled to the processor, the transceiver and processor configured to monitor for the M-PDCCH on the determined paging NB for the WTRU;

the transceiver and processor configured to receive a downlink control information (DCI) on the monitored M-PDCCH on the determined paging NB during a paging occasion (PO); and

the transceiver and processor configured to receive a physical downlink shared channel (PDSCH) associated with the M-PDCCH.

13. The WTRU of claim 12, wherein the WTRU determines the paging NB based on at least the 3 MSBs of a function of the WTRU-ID.

14. The WTRU of claim 12, wherein the WTRU determines the paging NB based on at least the 4 MSBs of a function of the WTRU-ID.

15. The WTRU of claim 12, wherein the DCI includes a cyclic redundancy check (CRC) that is scrambled with a Paging Radio Network Temporary Identifier (P-RNTI).

16. The WTRU of claim 12, wherein the PDSCH is scheduled by the DCI.

17. The WTRU of claim 12, wherein the DCI includes system information update related information.

18. The WTRU of claim 12, wherein the PDSCH includes system information update related information.

19. The WTRU of claim 12, wherein the PDSCH includes a paging message.

20. The WTRU of claim 12, wherein the WTRU-ID is a WTRU international mobile subscriber identity (IMSI).

21. The WTRU of claim 20, wherein the function includes IMSI mod 16,384.

22. The WTRU of claim 12, wherein the determining the paging NB for the WTRU is further based on a number of NBs for paging.

23. A method performed in a machine type communication (MTC) wireless transmit/receive unit (WTRU), the method comprising:

monitoring, by the WTRU, for an MTC physical downlink control channel (M-PDCCH) in an M-PDCCH search space;

receiving, by the WTRU, an M-PDCCH in the M-PDCCH search space, wherein the M-PDCCH has a starting enhanced control channel element (ECCE) index for a WTRU group containing the WTRU;

decoding, by the WTRU, the M-PDCCH, wherein the M-PDCCH includes a downlink control information (DCI); and

receiving, by the WTRU, a physical downlink shared channel (PDSCH) associated with the M-PDCCH.

24. The method of claim 23, further comprising:

demodulating, by the WTRU, the PDSCH based on the DCI, wherein the PDSCH includes a paging message.

25. The method of claim 24, wherein the WTRU changes operations based on the paging message.

26. The method of claim 25, wherein the WTRU changing operations includes the WTRU changing from idle mode to connected mode based on the paging message.

27. The method of claim 23, wherein an ECCE aggregation level is 16.

28. The method of claim 23, further comprising:

receiving, by the WTRU, the PDSCH based on the DCI, wherein the PDSCH includes a paging message.

29. The method of claim 23, further comprising:

decoding, by the WTRU, the PDSCH based on the DCI, wherein the PDSCH includes a paging message.

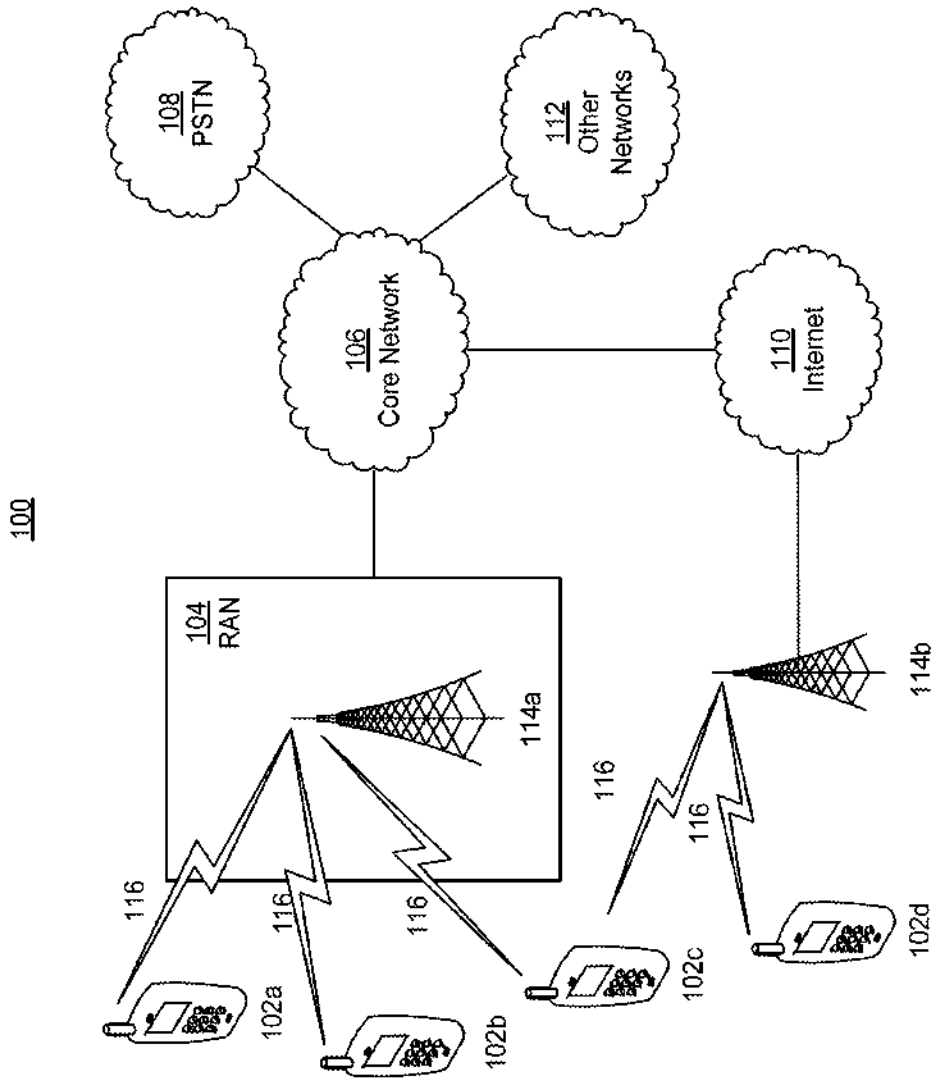

100
108 PSTN
112 Other Networks
106 Core Network
110 Internet
104 RAN
114a
114b
116
102a
102b
102c
102d

FIG. 1A

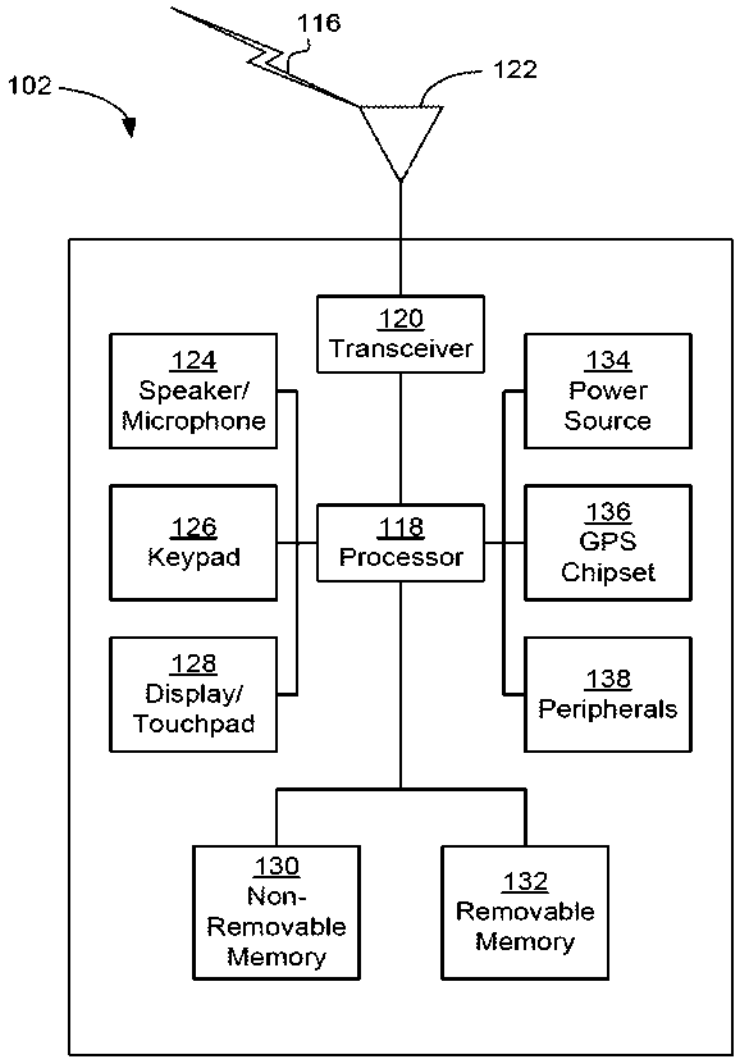

116
122
102
120
Transceiver
124
Speaker/
Microphone
134
Power
Source
126
Keypad
118
Processor
136
GPS
Chipset
128
Display/
Touchpad
138
Peripherals
130
Non-
Removable
Memory
132
Removable
Memory

FIG. 1B

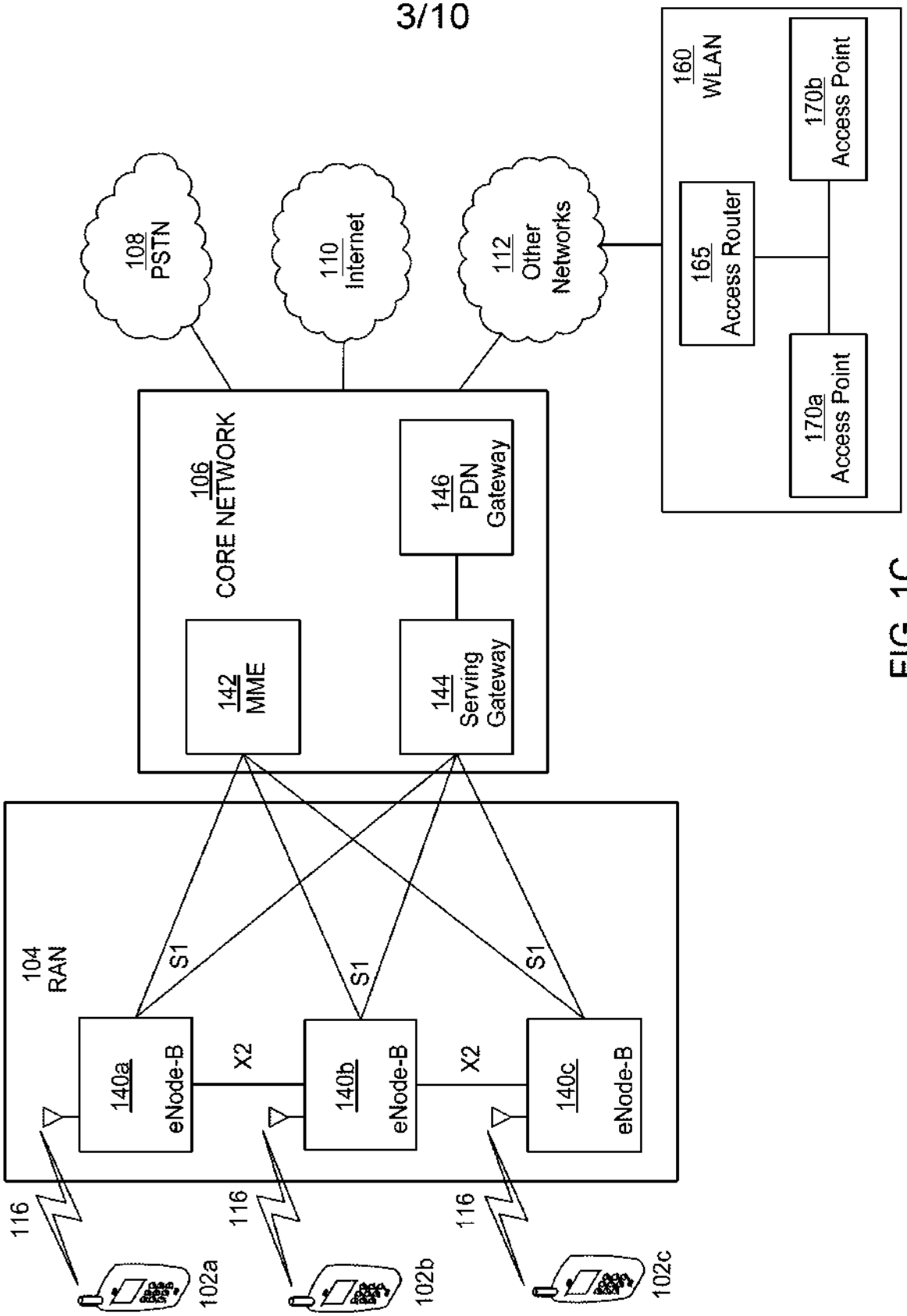

102a
102b
102c
116
116
116
104
RAN
140a
eNode-B
140b
eNode-B
140c
eNode-B
X2
X2
S1
S1
S1
106
CORE NETWORK
142
MME
144
Serving
Gateway
146
PDN
Gateway
108
PSTN
110
Internet
112
Other
Networks
160
WLAN
165
Access Router
170a
Access Point
170b
Access Point

FIG. 1C

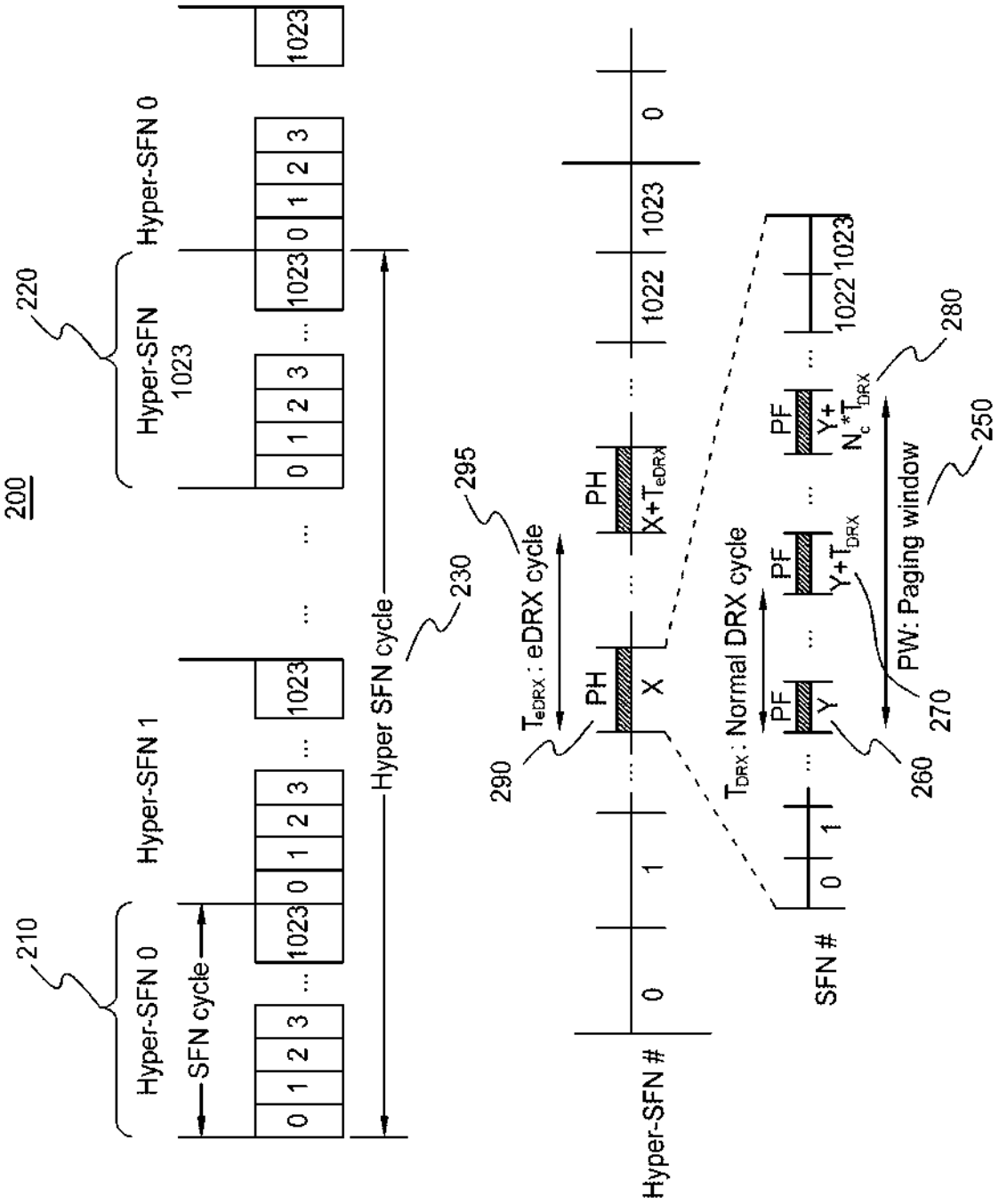

200
210
Hyper-SFN 0
SFN cycle
0 1 2 3 ... 1023
Hyper-SFN 1
0 1 2 3 ... 1023
220
Hyper-SFN 0
Hyper-SFN 1023
0 1 2 3 ... 1023
Hyper SFN cycle
230
295
290
T_{eDRX} : eDRX cycle
Hyper-SFN #
0 1 ... PH X ... PH $X+T_{eDRX}$ ... 1022 1023 0
T_{DRX} : Normal DRX cycle
SFN #
0 1 ... PF Y ... PF $Y+T_{DRX}$ ... PF $Y+N_c*T_{DRX}$ ... 1022 1023
260
270
PW: Paging window
280
250

FIG. 2

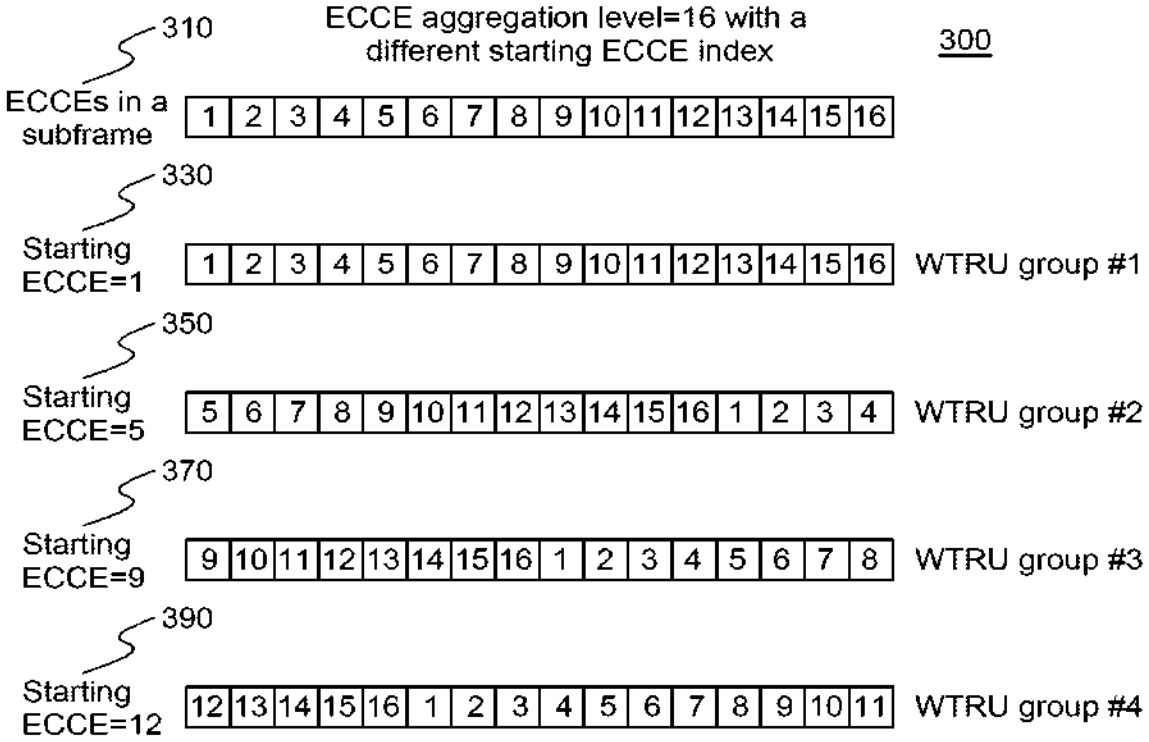

ECCE aggregation level=16 with a different starting ECCE index
300
310
ECCEs in a subframe
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
330
Starting ECCE=1
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
WTRU group #1
350
Starting ECCE=5
5 6 7 8 9 10 11 12 13 14 15 16 1 2 3 4
WTRU group #2
370
Starting ECCE=9
9 10 11 12 13 14 15 16 1 2 3 4 5 6 7 8
WTRU group #3
390
Starting ECCE=12
12 13 14 15 16 1 2 3 4 5 6 7 8 9 10 11
WTRU group #4

FIG. 3

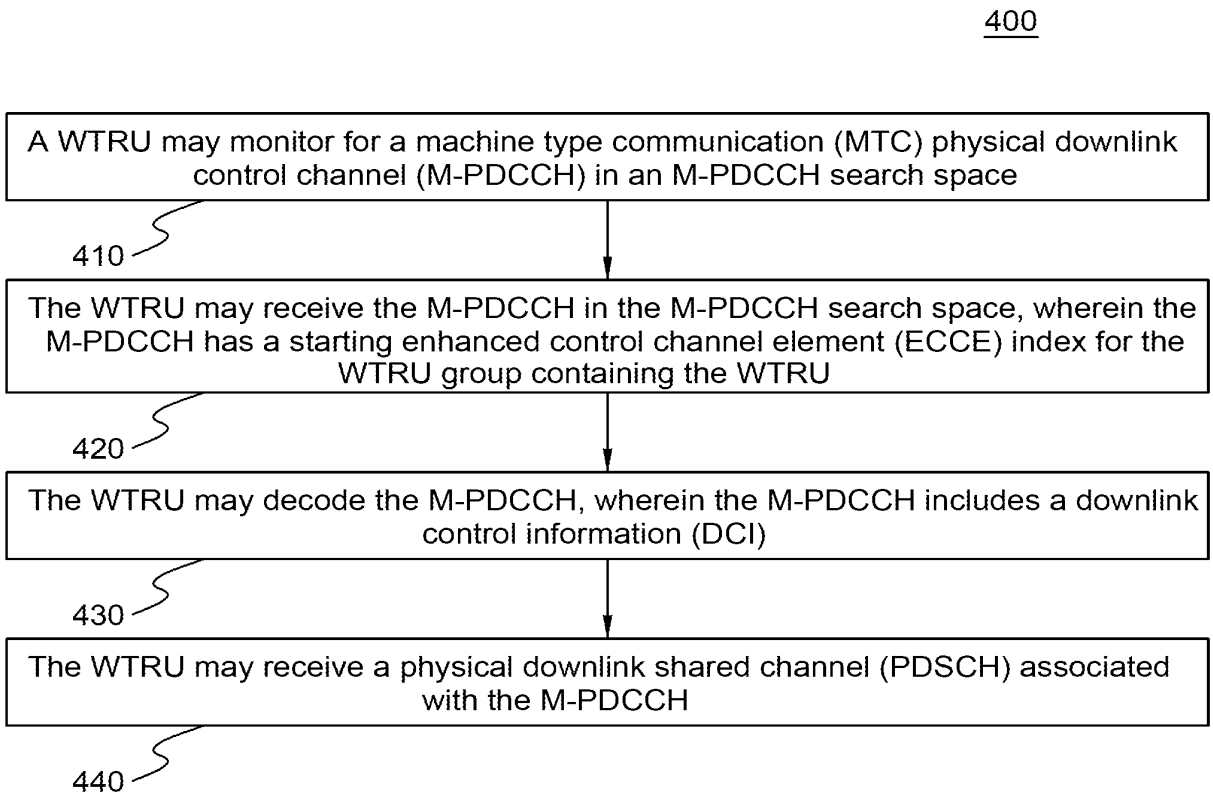

400
A WTRU may monitor for a machine type communication (MTC) physical downlink control channel (M-PDCCH) in an M-PDCCH search space
410
The WTRU may receive the M-PDCCH in the M-PDCCH search space, wherein the M-PDCCH has a starting enhanced control channel element (ECCE) index for the WTRU group containing the WTRU
420
The WTRU may decode the M-PDCCH, wherein the M-PDCCH includes a downlink control information (DCI)
430
The WTRU may receive a physical downlink shared channel (PDSCH) associated with the M-PDCCH
440

FIG. 4

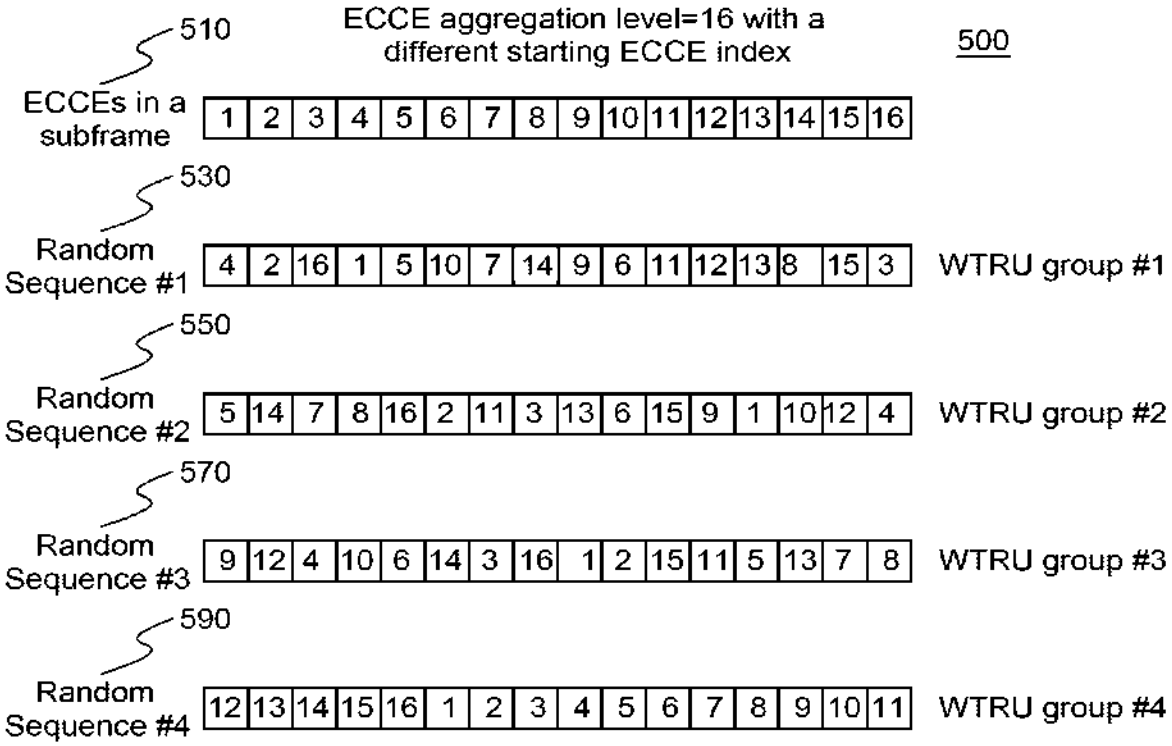

510
ECCE aggregation level=16 with a different starting ECCE index
500
ECCEs in a subframe
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
530
Random Sequence #1
4 2 16 1 5 10 7 14 9 6 11 12 13 8 15 3
WTRU group #1
550
Random Sequence #2
5 14 7 8 16 2 11 3 13 6 15 9 1 10 12 4
WTRU group #2
570
Random Sequence #3
9 12 4 10 6 14 3 16 1 2 15 11 5 13 7 8
WTRU group #3
590
Random Sequence #4
12 13 14 15 16 1 2 3 4 5 6 7 8 9 10 11
WTRU group #4

FIG. 5

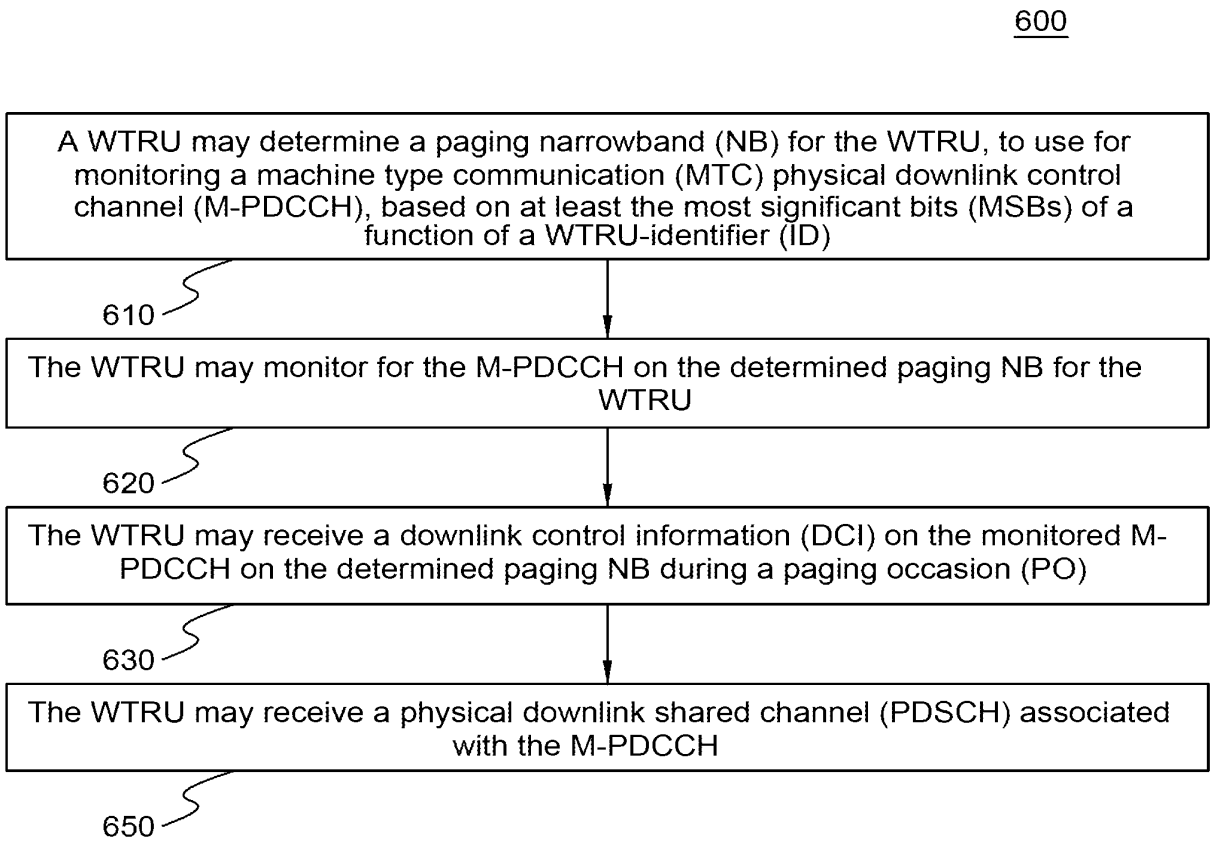

600
A WTRU may determine a paging narrowband (NB) for the WTRU, to use for monitoring a machine type communication (MTC) physical downlink control channel (M-PDCCH), based on at least the most significant bits (MSBs) of a function of a WTRU-identifier (ID)
610
The WTRU may monitor for the M-PDCCH on the determined paging NB for the WTRU
620
The WTRU may receive a downlink control information (DCI) on the monitored M-PDCCH on the determined paging NB during a paging occasion (PO)
630
The WTRU may receive a physical downlink shared channel (PDSCH) associated with the M-PDCCH
650

FIG. 6

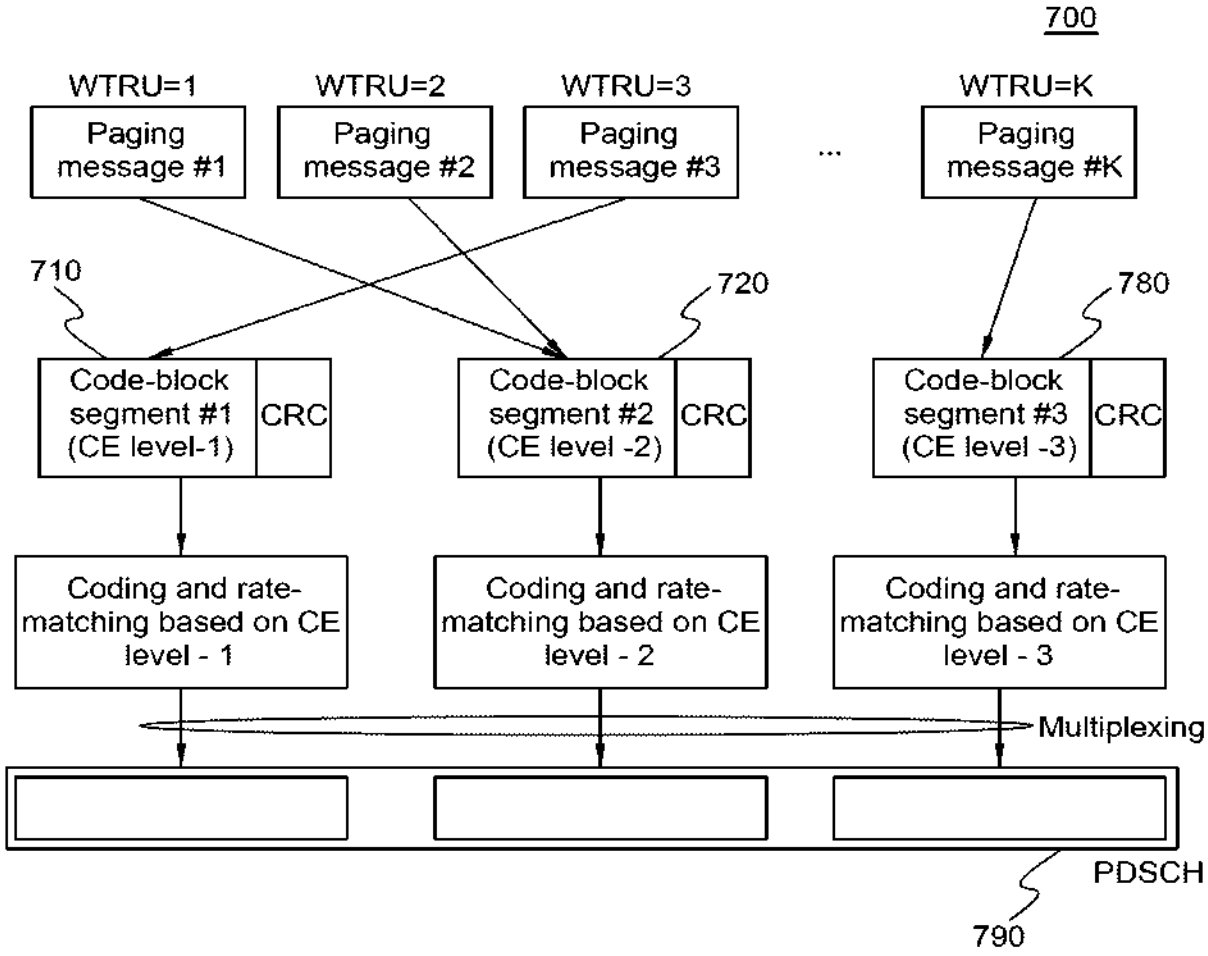

700
WTRU=1
WTRU=2
WTRU=3
...
WTRU=K
Paging message #1
Paging message #2
Paging message #3
Paging message #K
710
720
780
Code-block segment #1 (CE level-1)
CRC
Code-block segment #2 (CE level -2)
CRC
Code-block segment #3 (CE level -3)
CRC
Coding and rate-matching based on CE level - 1
Coding and rate-matching based on CE level - 2
Coding and rate-matching based on CE level - 3
Multiplexing
PDSCH
790

FIG. 7

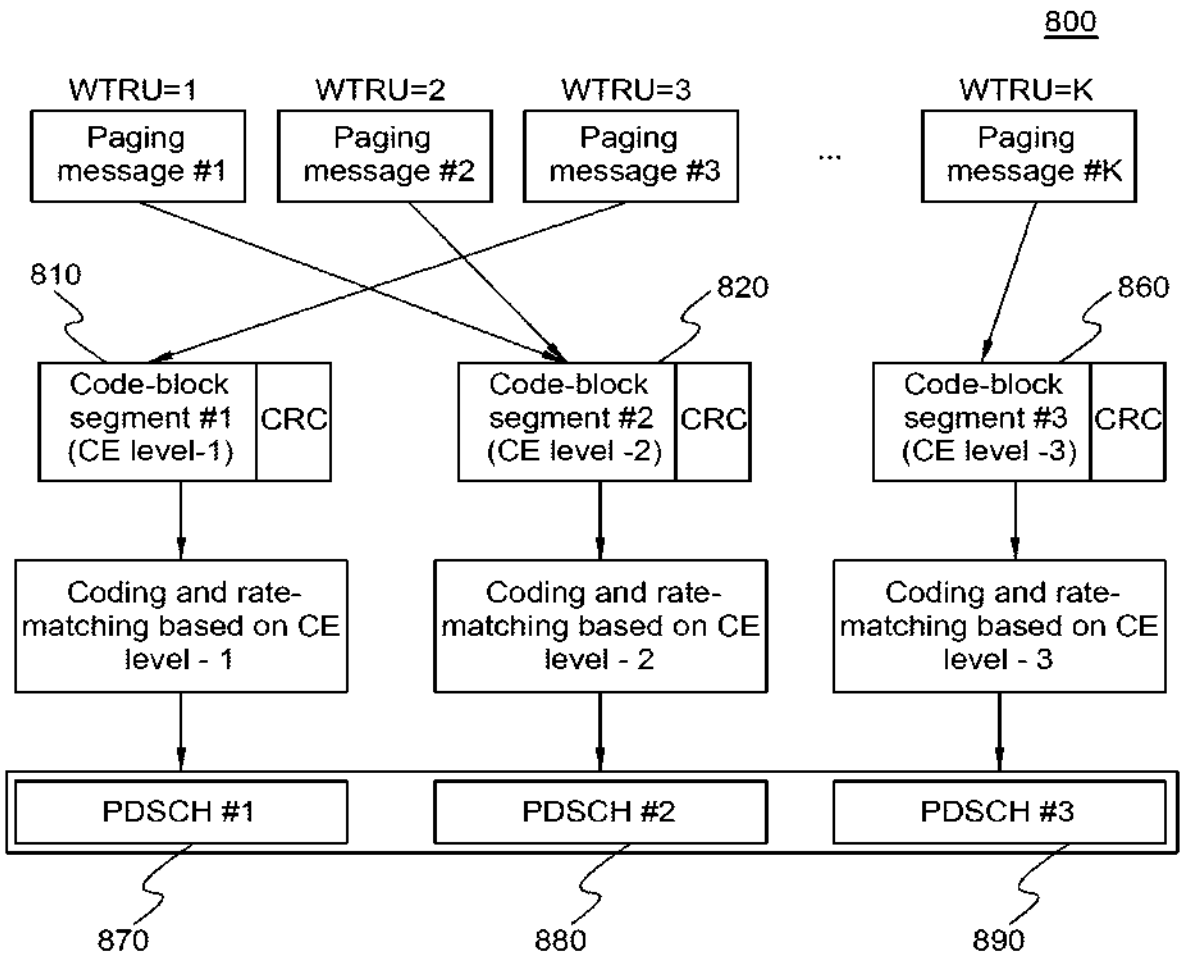

800
WTRU=1
WTRU=2
WTRU=3
WTRU=K
Paging message #1
Paging message #2
Paging message #3
...
Paging message #K
810
820
860
Code-block segment #1 (CE level-1)
CRC
Code-block segment #2 (CE level -2)
CRC
Code-block segment #3 (CE level -3)
CRC
Coding and rate-matching based on CE level - 1
Coding and rate-matching based on CE level - 2
Coding and rate-matching based on CE level - 3
PDSCH #1
PDSCH #2
PDSCH #3
870
880
890

FIG. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/060554

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W68/00
ADD. H04W4/00 H04L5/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2014/069946 A1 (LG ELECTRONICS INC [KR]) 8 May 2014 (2014-05-08) abstract paragraphs [0008] - [0014], [0048], [0051], [0052], [0060], [0061], [0076], [0093], [0095], [0096], [0100] - [0101] paragraphs [0121] - [0123], [0127], [0130] - [0133]; claim 1 ----- -/--	1-29

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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Date of the actual completion of the international search	Date of mailing of the international search report
23 December 2016	12/01/2017

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Englund, Terese

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2014/126409 A1 (AHN JOON KUI [KR] ET AL) 8 May 2014 (2014-05-08) abstract paragraphs [0005] - [0007], [0009], [0010], [0012], [0013], [0038], [0040], [0041], [0046], [0047], [0051], [0053] - [0056] paragraphs [0077], [0079], [0086], [0088], [0090]; claims 1,2,5,6	1-29
X	US 2013/194931 A1 (LEE MOON-IL [US] ET AL) 1 August 2013 (2013-08-01) abstract paragraphs [0004], [0005], [0038] - [0041], [0044], [0120], [0149], [0196] - [0201], [0203], [0204], [0209] paragraphs [0221] - [0222], [0224], [0226], [0244], [0245], [0248] - [0251], [0254], [0255] paragraphs [0262], [0269] - [0270], [0276]	1-29
X	US 2015/146692 A1 (YI YUNJUNG [KR] ET AL) 28 May 2015 (2015-05-28) paragraphs [0054], [0055], [0063], [0064], [0065], [0070], [0074], [0076], [0079] - [0083], [0106], [0116], [0151]	1-29
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2016/060554

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		WO 2014069946 A1	08-05-2014
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		WO 2011100497 A1	18-08-2011

Form PCT/ISA/210 (patent family annex) (April 2005)

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(26) **Publication Language**: English

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(74) **Agent**: **CHINA PATENT AGENT (H.K.) LTD.**; 22/F, Great Eagle Centre, 23 Harbour Road, Wanchai, Hong Kong (CN).

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(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

(54) **Title**: RECOVERY FROM BEAM FAILURE

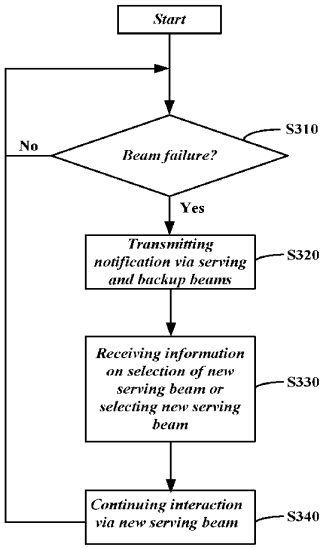


Fig. 3

(57) **Abstract**: The present invention generally relates to wireless communication, more particularly, relates to recovery from beam failure in a wireless access network where beamforming technique is used in communication between network elements. According to one aspect of the present invention, there is provided a method for recovery from beam failure in a wireless access network accessed by a user equipment (UE). The method comprises: at the wireless access network, determining whether the beam failure occurs on the basis of presence of a response from the UE during communicating between the wireless access network and the UE via a first beam; and if it is determined that the beam failure occurs, communicating with the UE via an available beam selected from the first beam and one or more second beams.

WO 2017/024516 A1

RECOVERY FROM BEAM FAILURE

TECHNICAL FIELD

[001] The present invention generally relates to wireless communication, more particularly, relates to recovery from beam failure in a wireless access network where beamforming technique is used in communication between network elements.

BACKGROUND

[002] The ultimate goal of mobile broadband should be the ubiquitous and sustainable provision of non-limiting data rates to everyone and everything at every time. Along this path, Ultra-Dense Network (UDN) is an important next step following the successful introduction of LTE for wide-area and local-area access.

[003] Ultra-dense network (UDN) is envisioned to provide ubiquitous mobile broadband with access-node densities considerably higher than the current densest cellular networks. UDN can be deployed in areas with high traffic consumption. Through overprovision and related low average loads in an access network, UDN creates ubiquitous access opportunities which – even under realistic assumptions on user density and traffic – provide users with the desired data rates.

[004] Overprovisioning is achieved by an extremely dense grid of access nodes; inter-access-node distances in the order of tens of meters and below are envisioned. For in-indoor deployments, one or even multiple access nodes are conceivable in each room. Additionally, in order to increase network capacity, densification – via reduced transmit powers – also offers access to vast spectrum holdings in the millimeter-wave bands and thus higher data rates.

[005] Beamforming for concentrating transmitted energy on an intended receiver plays a critical role for UDN. However, using more narrow transmission beams also makes a wireless system more susceptible to sudden coverage loss due to beam failure. In light of the above, an

efficient and reliable recovery from the beam failure constitutes an urgent issue to be addressed.

SUMMARY OF THE INVENTION

[006] According to one aspect of the present invention, there is provided a method for recovery from beam failure in a wireless access network accessed by a user equipment (UE). The method comprises: at the wireless access network, determining whether the beam failure occurs on the basis of presence of a response from the UE during communication between the wireless access network and the UE via a first beam; and if it is determined that the beam failure occurs, communicating with the UE via an available beam selected from the first beam and one or more second beams.

[007] According to the above aspect of the present invention, the beam failure can be effectively detected by a feedback-based determination without always-on reference signal. This is especially advantageous for a UE specific beam-based system such as UDN.

[008] In an embodiment according to the present invention, the response is one selected from a group consisting of: an acknowledgment(ACK) message or a negative Acknowledgment(NACK) message responding to a data message transmitted from an AN of the wireless access network on a downlink associated with the first beam, and a data message responding to a grant message transmitted from an AN of the wireless access network on a downlink associated with the first beam.

[009] In an embodiment according to the present invention, the selection of the available beam is on the basis of radio link quality for downlinks associated with the first beam and the one or more second beams.

[010] In an embodiment according to the present invention, the step of communicating with the UE via the available beam comprises: upon determining that the beam failure occurs, transmitting to the UE a message from one or more ANs of the wireless access network via the first beam and the one or more second beams; receiving information on the selection of the available beam from the UE; and using the selected available beam

during communication with the UE.

[011] In an embodiment according to the present invention, the step of communicating with the UE via the available beam comprises: upon determining that the beam failure occurs, transmitting to the UE a message from a first AN and a second AN of the wireless access network, wherein the message from the first AN is transmitted via the first beam and the message from the second AN is transmitted via the one or more second beams; receiving information on the selection of the available beam from the UE; and using the selected available beam during communication with the UE.

[012] In an embodiment according to the present invention, the step of communicating with the UE via the available beam comprises: upon determining that the beam failure occurs, transmitting a message from a first AN and second AN of the wireless access network, wherein the message from the first AN is transmitted via the first beam and at least one of the second beams and the message from the second AN is transmitted via the other of the second beams; receiving information on the selection of the available beam from the UE; and using the selected available beam during communication with the UE.

[013] According to another aspect of the present invention, there is provided a method for recovery from beam failure for a user equipment (UE) accessing a wireless access network. The method comprises: at the UE, determining whether the beam failure occurs on the basis of presence of a response from the wireless access network during communication between the wireless access network and the UE via a first beam; and if it is determined that the beam failure occurs, communicating with the wireless access network via an available beam selected from the first beam and one or more second beams.

[014] In an embodiment according to the present invention, the response is one selected from a group consisting of: a grant message responding to a service request transmitted from the UE on an uplink associated with the first beam and an random access response message responding to a random access request transmitted from the UE on an uplink associated with the first beam.

[015] In an embodiment according to the present invention, the selection of the available beam is on the basis of radio link quality for uplinks associated with the first beam and the one or more second beams.

[016] In an embodiment according to the present invention, the step of communicating with the wireless access network via the available beam comprises: upon determining that the beam failure occurs, transmitting to one or more ANs of the wireless access network a message from the UE via the first beam and the one or more second beams; receiving information on the selection of the available beam from the one or more ANs of the wireless access network; and using the selected available beam during communication with the wireless access network.

[017] According to another aspect of the present invention, there is provided an access node (AN) capable of communicating with a user equipment (UE). The AN is configured to: determine whether beam failure occurs on the basis of presence of a response from the UE during communication between the AN and the UE via a first beam; and if it is determined that the beam failure occurs, communicate with the UE via an available beam selected from the first beam and one or more second beams, or transfer to another AN communication with the UE, the communication being made via the available beam.

[018] According to another aspect of the present invention, there is provided a user equipment (UE) capable of communicating with a wireless access network. The UE is configured to: determine whether the beam failure occurs on the basis of presence of a response from the wireless access network during commnication between the wireless access network and the UE via a first beam; and if it is determined that the beam failure occurs, communicate with the wireless access network via an available beam selected from the first beam and one or more second beams.

[019] According to another aspect of the present invention, there is provided a user equipment (UE) capable of interacting with a wireless access network. The UE comprises: a determining unit configured to determine whether the beam failure occurs on the basis of presence of a response from the wireless access network during communication between the wireless access network and the UE via a first beam; and a transceiver configured to communicate with the wireless access network via an available beam selected from the first beam and one or more second beams if determining that the beam failure occurs.

[020] In an embodiment according to the present invention, for communicating with the wireless access network via the available beam, the transceiver is configured to: transmit to one or more ANs of the wireless access network a message from the UE via the first beam and the one or more second beams if determining that the beam failure occurs; receive information on the selection of the available beam from the one or more ANs of the wireless access network; and use the selected available beam to communicate with the wireless access network.

[021] According to another aspect of the present invention, there is provided an access node (AN) capable of communicating with a user equipment (UE). The AN comprises: a determining unit configured to determine whether beam failure occurs on the basis of presence of a response from the UE during communication between the AN and the UE via a first beam; and a transceiver configured to, if the determining unit determines that the beam failure occurs, communicate with the UE via an available beam selected from the first beam and one or more second beams, or transfer to another AN communication with the UE, the communication being made via the available beam.

BRIEF DESCRIPTION OF THE DRAWINGS

[022] The invention is herein described, by way of example only, with reference to the accompanying drawings. With specific reference now to the drawings in detail, it is stressed that the particulars shown are by way of example and for purposes of illustrative discussion of the preferred embodiments of the present invention only, and are presented in order to provide what is believed to be the most useful and readily understood description of the principles and conceptual aspects of the invention. In this regard, no attempt is made to show structural details of the invention in more detail than is necessary for a fundamental understanding of the invention, the description taken with the drawings making apparent to those skilled in the art how the several forms of the invention may be embodied in practice.

[023] In the drawings:

[024] Fig. 1 is a schematic diagram depicting an Ultra-dense network (UDN) architecture.

[025] Fig. 2 is a process flow diagram of a method for reaching pre-agreement on backup beam(s) according to one exemplary embodiment of the present invention.

[026] Fig. 3 is a process flow diagram of a method for recovery from beam failure in a wireless access network according to another exemplary embodiment of the present invention.

[027] Fig. 4 is a process flow diagram of a method for recovery from beam failure in a wireless access network according to another exemplary embodiment of the present invention.

[028] Fig. 5 is a block diagram illustrating a user equipment (UE) having recovery capability from beam failure according to another exemplary embodiment of the present invention.

[029] Fig. 6 is a block diagram illustrating an access node (AN) having recovery capability from beam failure according to another exemplary embodiment of the present invention.

DETAILED DESCRIPTION

[030] The principles and operation of the present invention may be better understood with reference to the drawings and accompanying description.

[031] Before explaining at least one embodiment of the invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of the components set forth in the following description or illustrated in the drawings. The invention is capable of being implemented by other embodiments or of being practiced or carried out in various ways. Also, it is to be understood that the phraseology and terminology employed herein is for the purpose of description and should not be regarded as limiting.

[032] All references to "a/an/the element, apparatus, component, means, step, etc." are to be interpreted as referring to at least one instance of the element, apparatus, component, means, step, etc., unless explicitly stated otherwise. The steps of any method disclosed herein do not have to be performed in the exact order disclosed, unless explicitly stated. The

discussion above and below in respect of any of the aspects of the present disclosure is also in applicable parts relevant to any other aspect of the present disclosure.

[033] Generally, all terms used in the claims and the description are to be interpreted according to their ordinary meaning in the technical field, unless explicitly defined otherwise herein. For example, the term "user equipment (UE)" may refer to any suitable terminal capable of wireless communication, such as a mobile phone or a portable computer. Likewise, the term "access node (AN)" may refer to any suitable intermediary devices providing wireless communication, such as a relay node, a router, an access point, a base station or a base site, which is capable of connecting a user equipment to another wireless access node or connecting a user equipment to a core network. The term "wireless link" or "radio link" may refer to a radio channel connecting wireless communication devices such as UEs and ANs with each other, and thus may refer to anyone of an uplink (UL), a downlink (DL), a forward link (FL) and a reverse link (RL).

[034] Beamforming is a signal processing technique used for directional signal transmission or reception. Beamforming can be used at both transmitting and receiving sides in order to achieve spatial selectivity. In a typical beamforming configuration, a transmitter with an antenna array amplifies a signal by different "weights" at the respective antennas, and thus the signal experiences constructive interference at particular directions or sectors and destructive interference at other directions or sectors. As a result, it can have a desired sensitivity pattern where a main lobe, serving as a beam for transmitting the signal to a receiver, is produced together with nulls and side lobes. By adjusting the main lobe width and the side lobe levels, the position of a null can be controlled. This is useful to ignore noise or jammers in one particular direction, while listening for events in other directions. A similar result can be obtained on reception. The details on beamforming are described in, e.g., IEEE 802.11ad, which is incorporated herein by reference in its entirety.

[035] Beam failure, as discussed throughout the present disclosure, refers

to such a situation where a beam currently being used for communication between a transceiver and a receiver becomes unavailable due to e.g., deteriorative radio link quality. A variety of events such as UE mobility, appearance of obstacle and orientation change for a UE may deteriorate the radio link quality.

[036] Fig. 1 is a schematic diagram depicting an Ultra-dense network (UDN) architecture. Referring to Fig. 1, a wireless network, e.g., UDN 110 herein, comprises ANs 111A-111G, which are configured to provide UEs 112A-112B with wireless access within their respective coverages by beamforming technique. For illustrative purpose, UEs 112A and 112B are communicatively coupled to ANs 111E and 111G, respectively. On the other hand, ANs 111A-111G are communicatively coupled with each other. In particular, as shown in Fig. 1, ANs 111A and 111C are connected together via a fixed backhaul link, and other ANs 111B, 111D-111G are connected to AN 111A or 111C via wireless links. As a result, ANs 111A-111G are either directly connected to fixed transport backhaul or wirelessly backhauled by other ANs. Moreover, these ANs are coupled to a transport aggregation node 113, over which they can communicate with an operator core network 120 or an external data network 130, e.g., internet.

[037] As stated above, it has a correlation between the beam failure and the deteriorated radio link quality. Therefore, one can determine whether the beam failure occurs on the basis of the radio link quality. However, this heavily relies on an always-on common reference signal on uplinks or downlinks and thus is not attainable for a typical UDN radio access configuration where beamforming is used widely to compensate the limited link budget in high-frequency spectrum and thus transmission is UE specific rather than UE common, i.e., reference signals are transmitted only when a UE is expected to receive them.

[038] According to one aspect of the present invention, a transmitter utilizes a feedback or response from a receiver to determine the occurrence of the beam failure. For example, in the UDN as shown Fig. 1, assuming that AN 111E and UE 112A communicate with each other via beam E1. In

a session, AN 111E transmits to UE 112A a data message via beam E1 and then waits for an acknowledgment(ACK) message or a negative Acknowledgment(NACK) message from UE 112A. If AN 111E receives neither the ACK message nor the NACK message via beam E1 within a predetermined time interval, it will determine the occurrence of the beam failure for beam E1. As another example, UE 112A transmits a service request to AN 111E via beam E1 and then waits for a grant message from AN 111E. If UE 112A fails to receive the grant message via beam E1 within a predetermined time interval, it will determine the occurrence of the beam failure for beam E1.

[039] It shall be noted that the feedback-based determination as described above is also applicable to other message types. For example, at AN side, the determination may be established on a data message responding to a grant message transmitted from AN 111E; and at UE side, one can make the determination on the basis of an random access response message responding to a random access request transmitted from UE 112A.

[040] With the feedback-based determination, the always-on reference signal is not necessary and thus the beam failure can be effectively detected in a UE specific beam-based system such as UDN.

[041] Typically, for communication between a UE and a wireless access network, two or more beams are available and one of them may be selected for serving the communication. For example, in the UDN as shown in Fig. 1, UE 112A and AN 111E can communicate with each other via beams E1, E2 and E4. These beams are collectively referred to be "candidate beam" hereinafter. Among the candidate beams, one currently serving the communication or interaction is referred to as "serving beam" or "first beam" hereinafter; and other candidate beam(s) are referred to as "backup beam" or "second beam" hereinafter. One way to recover from beam failure is to use one of the backup beams to take over the coverage in case of the sudden beam loss of the serving beam. Note that the candidate beams is unnecessarily limited to only a pair of a UE and a specific AN. As described below, for the candidate beams, some of them

may belong to the UE and one AN and the others may belong to the UE and another AN.

[042] According to another aspect of the present invention, a UE (UE side) and a wireless access network (network side) reach pre-agreement on which beams qualify as the backup beams for a serving beam. The pre-agreement may be periodically carried out between these participators, or carried out at the beginning of establishing connection between them. In one embodiment, the UE side or the network side as a transmitter side (Tx side), transmits to the network side or the UE side as a receiver side (Rx side) a reference signal in different directions or via different beams associated with uplinks or downlinks. The receiver side reports the beam(s) via which the reference signal is received, preferably along with radio link quality associated with them. Therefore, for each beam being as a serving beam, one or more backup beams are identified by the participators. For example, assuming the Tx side transmits the reference signal to the Rx side via beams X1, ... Xn, wherein n represents the number of the transmitting beams. If the Rx side receives the reference signal via beams X1, X3 and Xi, beams X3 and Xi are identified as the backup beams for beam X1, beams X1 and Xi are identified as the backup beams for beam X3, and beams X1 and X3 are identified as the backup beams for beam Xi.

[043] Preferably, in case of a plurality of backup beams for a serving beam, one is designated as a primary backup beam, which will be firstly selected as a new serving beam if the beam failure occurs. More preferably, the designation is made at the receiver side and is based on the radio link quality of the forward links associated with the backup beams. The radio link quality may be obtained from RSRP or SINR measurements at the receiver side. More preferably, the primary backup beam corresponds to one forward link having the best radio link quality.

[044] In case of the network or AN side being as the transmitter side, the designation is made at the UE side. Since the network side does not dominate the designation of the primary backup beam associated with the downlink, it takes a risk that no radio resources are available when the beam failure occurs or the utilization of radio resources is not optimum. In

one embodiment, the designation is always dominated at the network side so as to avoid the above defects. Particularly, the network side designates the primary backup beam based on, e.g., the radio link quality measurement made by the UE side and the current load distribution around the UE side. In one embodiment, the network side indicates the primary backup beam in each downlink transmission, e.g., as additional information in a Scheduling Assignment (SA) or as a MAC Control Element (MAC CE) in a MAC Protocol Data Unit (MAC PDU) carrying data. Alternatively, the network side may send a separate indicator on the primary backup beams by using a MAC CE, e.g., in a MAC PDU without higher layer data, or Radio Resources Control (RRC) signaling. In another embodiment, the primary backup beam is determined in a hybrid mode. As described above, the pre-agreement is periodically carried out between a UE side and a network side. At the beginning of the current pre-agreement cycle, the UE side, being as a receiver side, designates the backup beam corresponding to one forward link having the best radio link quality as the primary backup beam. However, the designation is changeable by the network side during the current pre-agreement cycle. For example, the network side may send a command for changing the primary backup beam in a downlink transmission, either in conjunction with data transmission or as a separate signaling message. Alternatively, the changed primary backup beam is valid until the next sending of the command. In other words, whatever measurements for radio link quality vary from one cycle to another cycle, the primary backup beam will be kept unchanged until the network side sends the command again.

[045] According to another aspect of the present invention, the identified backup beams are mapped into specific downlink and uplink resources. The specific uplink resources may be UL PHY resources, e.g., random access channel resources or scheduling request resources, and the specific downlink resources may be DL PHY resources, e.g., downlink control channel resources according to a Discontinuous Reception (DRX) pattern.

[046] As a result, a transmitter side (e.g., network or AN side in case of DL and UE side in case of UL) will notify the occurrence of beam failure

for a serving beam via both of the current serving beam and the backup beam(s), or only via the backup beam(s), and a receiver side (e.g., network side in case of UL and UE side in case of DL) will recognize the beam failure by monitoring the mapped radio link resources. For UL, the AN side is ready for uplink reception on the mapped resources associated with the backup beams. If the AN side receives a request for transmission resources through a Scheduling Request (SR), e.g., on Physical Downlink Control Channel (PDCCH) resources or through a random access procedure initiated on a Random Access Channel (RACH) mapped to the resources associated with one of the backup beams, it recognizes that this backup beam is in use for the reselection of the serving beam. On the other hand, for DL, the UE side is ready for downlink reception on the mapped resources associated with the backup beams. If the UE receives SA on PDCCH of the mapped downlink resources associated with one of the backup beam, it recognizes that this backup beam is in use for the reselection of the serving beam.

[047] According to another aspect of the present invention, if, at the transmitter side, e.g., at the network or UE side, it determines that the beam failure for the current serving beam occurs, a new serving beam needs to be reselected from the candidate beams, including the current serving beam and the backup beam(s), or only from the backup beam(s). Note that at this time, it has no knowledge on which link (forward link, reverse link, or both) causes the beam failure. Therefore, a transmitter will notify a receiver of the occurrence of the beam failure via the current serving beam and the backup beam(s), or only via the backup beam(s). The notification may be transmitted in a forward link transmission, either in conjunction with data transmission or as a separate signaling message. Note that the explicit notification is unnecessary and the receiver side can recognize the beam failure only from the event that the data transmission is performed via the backup beam(s). At the receiver side, e.g., the network side or UE side, it monitors the forward links associated with the candidate beams. Upon receiving the notification or the data transmission via the backup beams, the receiver side utilizes an available beam as a new

serving beam to communicate with the transmitter side. The available beam is selected from the serving beam and the backup beam(s), or only from the backup beam(s).

[048] In one embodiment, the selection is made on the basis of the radio link quality. For example, assuming the transmitter side transmits the notification or the data transmission via beams X1, X2, X3 and X4, and at the receiver side, the notification or the data transmission is received via beams X1, X2 and X3. If the forward link associated with beam X2 has the highest link quality, beam X2 is selected as the new serving beam.

[049] Alternatively, in case of the receiver side being the UE side, the new serving beam is selected by the network side. Particularly, upon receiving the notification or the data transmission via beams X1, X2 and X3, the receiver reports the radio link quality for the forward links. Then, at the transmitter, the new serving beam is selected on the basis of the radio link quality measurement made by the UE side and the current load distribution around the UE side.

[050] Preferably, upon receiving the notification or the data transmission via beams X1, X2 and X3, the receiver reports to the transmitter the receipt of the notification or the data transmission via beams X1, X2 and X3. Then, in response to the report from the receiver, the transmitter selects the new serving beam on the basis of the radio link quality for the reverse links associated with beams X1, X2 and X3, and optionally along with the current load distribution around the UE side. In another embodiment, the new serving beam may be the primary backup beam designated in the manner as described above.

[051] As a result, the communication continues between the transmitter side and the receiver side via the new serving beam. The new serving beam may be the serving beam previously in use or a backup beam.

[052] Fig. 2 is a process flow diagram of a method for reaching pre-agreement on backup beam(s) according to one exemplary embodiment of the present invention. For illustrative purpose, the following depiction is made in the context of the above architecture as

shown in Fig. 1. However, one skilled artisan in the art would recognize that the present invention is applicable to other architectures. Moreover, one skilled artisan will recognize that all of the aspects of the present invention as described above are applicable to the present exemplary embodiment.

[053] With reference to Fig. 2, at step S210, it determines whether a routine for reaching pre-agreement on backup beams for the current serving beams shall be initiated. Note that the routine may be triggered periodically or by the occurrence of a predefined event, e.g., establishment of connection between UE 112A and AN 111E. If the routine shall be initiated, the process proceeds to step S220; otherwise, the process continues to determine whether the routine shall be initiated at step S210.

[054] At step S220, the routine for reaching pre-agreement on backup beams for the current serving beam is initiated. The initiator for the routine may be either UE 112A or AN 111E. For example, as a initiator, AN 111E initiates the routine by transmitting to UE 112A a reference signal via beams E1, E2, E3 and E4 associated with downlinks.

[055] Assuming UE 112A receives the reference signal via downlinks associated with beams E1, E2 and E4. Thus, at step S230, UE112A will respond to AN 111E via uplinks associated with beams E1, E2 and E4. Preferably, the response to AN 111E may include radio link quality for the downlinks associated with these beams. As a result, the participants will identify backup beams for each beam. In particular, beams E2 and E4 are identified as the backup beams for beam E1, beams E1 and E4 as the backup beams for beam E2, and beams E1 and E2 as the backup beams for beam E4. The identified backup beams are mapped into specific downlink and uplink resources and thus the receiver side can recognize the beam failure by monitoring the mapped specific radio link resources.

[056] At UE 112A, one of beams E2 and E4 may be designated as a primary backup beam based on the radio link quality of the downlinks associated with these backup beams. Alternatively, the designation is performed by UE 111E on the basis of the radio link quality and the current load distribution around UE 112A.

[057] After step S230, the process proceeds to step S210.

[058] Fig. 3 is a process flow diagram of a method for recovery from beam failure in a wireless access network according to another exemplary embodiment of the present invention. For illustrative purpose, the following depiction is made in the context of the above architecture as shown in Fig. 1. However, one skilled artisan in the art would recognize that the present invention is applicable to other architectures. Moreover, one skilled artisan will recognize that all of the aspects of the present invention as described above are applicable to the present exemplary embodiment.

[059] For illustrative purpose, in the present exemplary embodiment, it assumes that UE 112A accesses to UDN 110 through AN 111E via beam E1, which is taken as the current serving beam at the beginning of the process, and under pre-agreement, beams E2 and E4 are taken as the backup beams for beam E1.

[060] At step S310, UE 112A or AN 111E determines whether beam failure for the current serving beam, i.e., beam E1, occurs. The determination may be the feedback-based determination as described above. In particular, UE 112A or AN 111E may utilize a feedback or response from a receiver to determine the occurrence of the beam failure. If it determines the beam failure occurs, the process proceeds to step S320; otherwise, the process continues to determine whether the beam failure occurs at step S310.

[061] For illustrative purpose, it assumes that the beam failure is determined at AN 111E. Then at step S320, AN 111E transmits notification of the occurrence of the beam failure to UE 112A via the current serving beam E1 and the backup beams E2 and E4. Alternatively, the notification may be transmitted only via the backup beams E2 and E4. Likewise, the notification may be transmitted either in conjunction with data transmission or as a separate signaling message.

[062] As described above, upon receiving the notification or the data transmission via the backup beams, the receiver side utilizes an available

beam as a new serving beam to communicate with the transmitter side. The available beam is selected from the serving beam and the backup beams, or only from the backup beams. Therefore, at step S330, AN 111E receives from UE 112A information on the selection of the available beam or the new serving beam. For illustrative purpose, assuming beam E4 is selected as the new serving beam.

[063] Alternatively, instead of selecting a new serving beam, the receiver side may send to the transmitter side a report on the beams via which the notification or the data transmission is received. For example, it assumes the notification or the data transmission is received via beams E1 and E4 at the receiver side. Thus, it will be reported that the notification or the data transmission is received via beams E1 and E4. Accordingly, at step S330, upon receiving the report from the receiver side, the transmitter side selects a new serving beam based on the radio link quality for the forward links associated with the reported beams, i.e., beams E1 and E4. For illustrative purpose, assuming that the forward link associated with beam E4 has the best radio link quality, As a result, beam E4 is selected as the new serving beam at the transmitter side.

[064] At step S340, AN 111E continues the interaction or communication with UE 112A via beam E4 and then returns step S310.

[065] In case the beam failure is determined at UE 112A, UE 112A transmits notification of the occurrence of the beam failure to AN 111E via beams E1, E2 and E4 or only via beams E2 and E4 at step S320. Then at step S330, UE 112A receives from AN 111E information on the selection of the available beam or the new serving beam. The process proceeds to step S340, where UE 112A continues the communication with AN 111E via beam E4 and then returns step S310.

[066] In the above embodiments, it assumes that the backup beams belong to the same AN. However, this assumption is not necessary and the present invention may be extended to such a scenario where, for a serving beam, some or all of the backup beams belong to an AN different from the AN of the serving beam. For example, as shown in Fig. 1, UE 112B can access to AN 111G via beams G1 or G2, or to AN 111F via beam F2.

Therefore, for serving beam G1(G2), besides backup beam G2(G1) in AN 111G, beam F2 in AN 111F can be also used as a backup beam; likewise, for serving beam F2, beams G1 and G2 can be used as backup beams. The above configuration enhances recovery capability from beam failure, especially when all of the beams within an AN are unavailable.

[067] In case the backup beams involve with multiple ANs, it is advantageous to introduce inter-AN coordination between the involved ANs in the pre-agreement on the backup beams and the selection of the new serving beam. Preferably, the inter-AN coordination is performed via an intermediate node, e.g., a control node acting as a cluster head for controlling a cluster comprising the involved ANs. Alternatively, the inter-AN coordination may be performed directly between the involved ANs.

[068] Fig. 4 is a process flow diagram of a method for recovery from beam failure in a wireless access network according to another exemplary embodiment of the present invention. For illustrative purpose, the following depiction is made in the context of the above architecture as shown in Fig. 1. However, one skilled artisan in the art would recognize that the present invention is applicable to other architectures. Moreover, one skilled artisan will recognize that all of the aspects of the present invention as described above are applicable to the present exemplary embodiment.

[069] For illustrative purpose, in the present exemplary embodiment, it assumes that UE 112B access to UDN 110 through AN 111G (referred to be "serving node" hereinafter) via beam G1, which is taken as the current serving beam at the beginning of the process, and between AN 111G, AN 111F (referring to as "neighboring node" hereinafter) and UE 112B, it reaches pre-agreement that beams G2 and F2 are backup beams for beam G1. As described above, an intermediate node such as a cluster head, e.g., transport aggregation node 113 as shown in Fig. 1, coordinates the pre-agreement on the backup beams. Likewise, the pre-agreement may be updated periodically or by the occurrence of a predefined event, e.g., establishment of connection between UE 112B and AN 111E. The

identified backup beams G2 and F2 are mapped into specific downlink and uplink resources and thus the receiver side can recognize the beam failure by monitoring the mapped specific radio link resources.

[070] With reference to Fig. 4, at step S410, UE 112B determines that beam failure for the current serving beam, i.e., beam G1, occurs. Likewise, the determination may be the feedback-based determination as described above. For example, if UE 112B fails to receive a follow-up DL signaling after an UL transmission, e.g., an Ack/Nack feedback, it determines the beam failure for beam G1 occurs.

[071] Then at step S420, UE 112B initiates multiple transmission e.g., by sending a backup beam activation command via uplinks associated with both of the serving and backup beams, i.e., beams G2 and F2. The backup beam activation command may be in the form of a SR.

[072] The serving and neighboring nodes, i.e., AN 111G and AN 111F, keep on monitoring the mapped specific uplink resources, e.g., the SR resources. Assuming that beam F2 is designated as a primary backup beam for beam G1, or the radio link quality for beam F2 is superior to G2, or beams failure for beam G2 also occurs. Thus, with the inter-AN coordination by the cluster head, beam F2 is selected as the new serving beam. As a result, at step S430, the neighboring node returns a UL grant to UE 112B to confirm the activation of the backup beam, i.e., beam F2. Then at step S440, AN 111F and UE 112B start to communicate with each other.

[073] At step S450, with the inter-AN coordination by the cluster head, the serving node notifies the neighboring node of the deactivation of beam G1, which was previously taken as the serving beam. Afterwards, at step S460, the neighboring node transmits DL signaling, e.g., a beam deactivation command to UE 112B to confirm the deactivation of previous serving beam G1.

[074] In the above embodiment, a third node such as a cluster head participates in the inter-AN coordination. As described above, however, the inter-AN coordination may be performed directly between the serving

node and the neighboring node.

[075] Fig. 5 is a block diagram illustrating a user equipment (UE) having recovery capability from beam failure according to another exemplary embodiment of the present invention. For illustrative purpose, the present embodiment is described in the context of the UDN architecture as discussed with reference to Fig1. However, one skilled artisan in the art would recognize that the present invention is applicable to other wireless access networks. Moreover, one skilled artisan will recognize that the aspects of the present invention as described above are applicable to the present exemplary embodiment.

[076] With reference to Fig. 5, in the present embodiment, a UE 500 comprises a transceiver 510 and a determining unit 520 coupled to each other.

[077] The transceiver 510 is configured to interact with one or more ANs in a wireless access network, e.g., ANs 111A-111G in UDN 110 as shown in Fig. 1. For example, the transceiver 510 is able to communicate or interact with AN 111E via beams E1, E2 and E4. Assuming beam E1 is selected as a current serving beam and beams E2 and E4 are selected as backup beams. As an example, the transceiver 510 transmits a service request or a random access request on an uplink associated with beam E1 and waits for a response responding to the service request or the random access request on a downlink associated with beam E1. Meanwhile, the transceiver 510 monitors the mapped specific radio link resources associated with beams E2 and E4.

[078] The determining unit 520 is configured to determine whether beam failure for the current serving beam, i.e., beam E1, occurs. The determination may be the feedback-based determination as described above. If determining the beam failure occurs, the determining unit 520 instructs the transceiver 510 to transmit notification of the occurrence of the beam failure to AN 111E via uplinks associated with the current serving beam E1 and the backup beams E2 and E4. Alternatively, the notification may be transmitted only via uplinks associated with the backup beams E2 and E4.

[079] When the transceiver 510 receives from AN 111E information on the selection of the available beam or the new serving beam, e.g., beam E2, the determining unit 520 will instruct the transceiver 510 to continue the communication or interaction with AN 111E via the new serving beam. Note that the information may be sent via downlinks associated with the new serving beam only, or associated with all of the beams linked to the mapped specific radio link resources.

[080] Note that in case the backup beams involve with multiple ANs, the determining unit 520 is further configured to instruct the transceiver 510 to transmit the notification to all involved ANs, and the transceiver 510 is configured to communicate or interact with the wireless access network via the new serving beam selected with an inter-AN coordination.

[081] Fig. 6 is a block diagram illustrating an access node (AN) having recovery capability from beam failure according to another exemplary embodiment of the present invention. For illustrative purpose, the present embodiment is described in the context of the UDN architecture as discussed with reference to Fig 1. However, one skilled artisan in the art would recognize that the present invention is applicable to other wireless access networks. Moreover, one skilled artisan will recognize that the aspects of the present invention as described above are applicable to the present exemplary embodiment.

[082] With reference to Fig. 6, in the present embodiment, an AN 600, e.g., anyone of ANs 111A-111G as shown in Fig.1, comprises a transceiver 610 and a determining unit 620 coupled to each other.

[083] The transceiver 610 is configured to interact with a UE, e.g., UE 112A or 112B as shown in Fig. 1, and other ANs in a wireless access network, e.g., UDN 110 as shown in Fig. 1. For example, the transceiver 610, e.g., in AN 111G, is able to interact with UE 112B via beams G1 and G2, and is connected to AN 111F directly or via a third node(s). Assuming beam G1 is selected as a current serving beam and beams G2 and F2 are selected as backup beams. As an example, the transceiver 610, e.g., in AN 111G transmits a data message or a grant message on a downlink associated with beam G1, and then waits for an acknowledgment(ACK)

message or a negative Acknowledgment(NACK) message to the data message, or a data message to the grant message on a downlink associated with beam G1. Meanwhile, with a pre-agreement, the transceivers 610, e.g., in AN 111G and AN 111F monitor the mapped specific radio link resources associated with beams G2 and F2, respectively.

[084] The determining unit 620, e.g., in AN 111G is configured to determine whether beam failure for the current serving beam, i.e., beam G1, occurs. The determination may be also the feedback-based determination as described above. If determining the beam failure occurs, in AN 111G, the determining unit 620 instructs the transceiver 610 to transmit notification of the occurrence of the beam failure to UE 112B via uplinks associated with the current serving beam G1 and the backup beams G2. Moreover, with an inter-AN coordination, the transceiver 610 in AN 111F transmits the notification to UE 112B via an uplink associated with beams F2. Alternatively, the notification may be transmitted only via uplinks associated with the backup beams G2 and F2.

[085] Assuming beam F2 is the primary backup beam as designated or is selected as a new serving beam by UE 112B. Thus, UE 112B will send information on the new serving beam, e.g., beam F2. At AN 111F, if the transceiver 610 receives the information from UE 112B, the determining unit 620 will instruct the transceiver 610 to communicate or interact with UE 112B via the new serving beam.

[086] In the exemplary embodiment described with reference to Figs. 5 and 6, the determining unit can be implemented as a processor or part of the processor to perform various tasks as discussed above. The processor can include a microprocessor, microcontroller, processor module or subsystem, programmable integrated circuit, programmable gate array, or another control or computing device.

[087] It should be noted that the aforesaid embodiments are illustrative of this invention instead of restricting this invention, substitute embodiments may be designed by those skilled in the art without departing from the scope of the claims enclosed. The wordings such as “include”, “including”, “comprise” and “comprising” do not exclude elements or

steps which are present but not listed in the description and the claims. It also shall be noted that as used herein and in the appended claims, the singular forms “a”, “an”, and “the” include plural referents unless the context clearly dictates otherwise. This invention can be achieved by means of hardware including several different elements or by means of a suitably programmed computer. In the unit claims that list several means, several ones among these means can be specifically embodied in the same hardware item. The use of such words as first, second, third does not represent any order, which can be simply explained as names.

What is claimed is:

1. A user equipment (UE) capable of communicating with a wireless access network, comprising:

a determining unit configured to determine whether beam failure occurs on the basis of presence of a response from the wireless access network during communication between the wireless access network and the UE via a first beam; and

a transceiver configured to communicate with the wireless access network via an available beam selected from the first beam and one or more second beams if the determined unit determines that the beam failure occurs.

2. The UE according to claim 1, wherein the response is one selected from a group consisting of: a grant message responding to a service request transmitted from the UE on an uplink associated with the first beam and an random access response message responding to a random access request transmitted from the UE on an uplink associated with the first beam.

3. The UE according to claim 1 or 2, wherein the selection of the available beam is on the basis of radio link quality for uplinks associated with the first beam and the one or more second beams.

4. The UE according to claim 1, wherein for communicating with the wireless access network via the available beam, the transceiver is configured to:

transmit to one or more ANs of the wireless access network a message from the UE via the first beam and the one or more second beams if determining that the beam failure occurs;

receive information on the selection of the available beam from the one or more ANs of the wireless access network; and

use the selected available beam during communication with the wireless access network.

5. An access node (AN) capable of communicating with a user equipment (UE), comprising:

a determining unit configured to determine whether beam failure occurs on the basis of presence of a response from the UE during an interaction between the AN and the UE via a first beam; and

a transceiver configured to, if the determining unit determines that the beam failure occurs, communicatewith the UE via an available beam selected from the first beam and one or more second beams, or transfer to another AN communication with the UE, the communication being made via the available beam.

6. The AN according to claim 5, wherein the response is one selected from a group consisting of: an acknowledgment(ACK) message or a negative Acknowledgment(NACK) message responding to a data message transmitted from the AN on a downlink associated with the first beam, and a data message responding to a grant message transmitted from the AN on a downlink associated with the first beam.

7. The AN according to claim 5 or 6, wherein the selection of the available beam is on the basis of radio link quality for downlinks associated with the first beam and the one or more second beams.

8. A user equipment (UE) capable of communicating with a wireless access network, configured to:

determine whether beam failure occurs on the basis of presence of a response from the wireless access network during communication between the wireless access network and the UE via a first beam; and

if it is determined that the beam failure occurs, communicate with the wireless access network via an available beam selected from the first beam and one or more second beams.

9. An access node (AN) capable of communicating with a user equipment (UE), configured to:

determine whether beam failure occurs on the basis of presence of a response from the UE during an interaction between the AN and the UE via a first beam; and

if it is determined that the beam failure occurs, communicate with the UE via an available beam selected from the first beam and one or more second beams, or transfer to another AN communication with the UE, the communication being made via the available beam.

10. A method for recovery from beam failure in a wireless access network accessed by a user equipment (UE), comprising:

at the wireless access network, determining whether beam failure occurs on the basis of presence of a response from the UE during communication between the wireless access network and the UE via a first beam; and

if it is determined that the beam failure occurs, communicating with the UE via an available beam selected from the first beam and one or more second beams.

11. The method according to claim 10, wherein the response is one selected from a group consisting of: an acknowledgment(ACK) message or a negative Acknowledgment(NACK) message responding to a data message transmitted from an AN of the wireless access network on a downlink associated with the first beam, and a data message responding to a grant message transmitted from an AN of the wireless access network on a downlink associated with the first beam.

12. The method according to claim 10 or 11, wherein the selection of the available beam is on the basis of radio link quality for downlinks associated with the first beam and the one or more second beams.

13. The method according to claim 10, wherein the step of communicating with the UE via the available beam comprising:

upon determining that the beam failure occurs, transmitting to the UE a message from one or more ANs of the wireless access network via the first beam and the one or more second beams;

receiving information on the selection of the available beam from the UE; and

using the selected available beam during communication with the UE.

14. The method according to claim 10, wherein the step of communicating with the UE via the available beam comprising:

upon determining that the beam failure occurs, transmitting to the UE a message from a first AN and a second AN of the wireless access network, wherein the message from the first AN is transmitted via the first beam and the message from the second AN is transmitted via the one or more second beams;

receiving information on the selection of the available beam from the UE; and

using the selected available beam during communication with the UE.

15. The method according to claim 10, wherein the step of communicating with the UE via the available beam comprising:

upon determining that the beam failure occurs, transmitting a message from a first AN and second AN of the wireless access network, wherein the message from the first AN is transmitted via the first beam and at least one of the second beams and the message from the second AN is transmitted via the other of the second beams;

receiving information on the selection of the available beam from the UE; and

using the selected available beam during communication with the UE.

16. A method for recovery from beam failure for a user equipment (UE) accessing a wireless access network, comprising:

at the UE, determining whether beam failure occurs on the basis of presence of a response from the wireless access network during communication between the wireless access network and the UE via a first beam; and

if it is determined that the beam failure occurs, communicating with the wireless access network via an available beam selected from the first beam and one or more second beams.

17. The method according to claim 15, wherein the response is one selected from a group consisting of: a grant message responding to a service request transmitted from the UE on an uplink associated with the first beam and an random access response message responding to a random access request transmitted from the UE on an uplink associated with the first beam.

18. The method according to claim 16 or 17, wherein the selection of the available beam is on the basis of radio link quality for uplinks associated with the first beam and the one or more second beams.

19. The method according to claim 16, wherein the step of communicating with the wireless access network via the available beam comprising:

upon determining that the beam failure occurs, transmitting to one or more ANs of the wireless access network a message from the UE via the first beam and the one or more second beams;

receiving information on the selection of the available beam from the one or more ANs of the wireless access network; and

using the selected available beam during communication with the wireless access network.

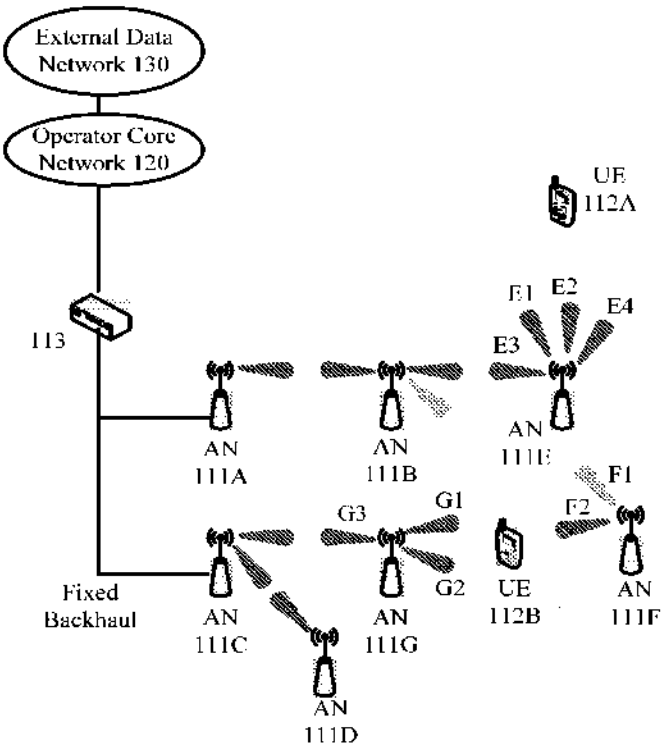

External Data Network 130
Operator Core Network 120
113
Fixed Backhaul
AN 111A
AN 111B
AN 111C
AN 111D
AN 111E
AN 111F
AN 111G
UE 112A
UE 112B
E1
E2
E3
E4
F1
F2
G1
G2
G3

Fig. 1

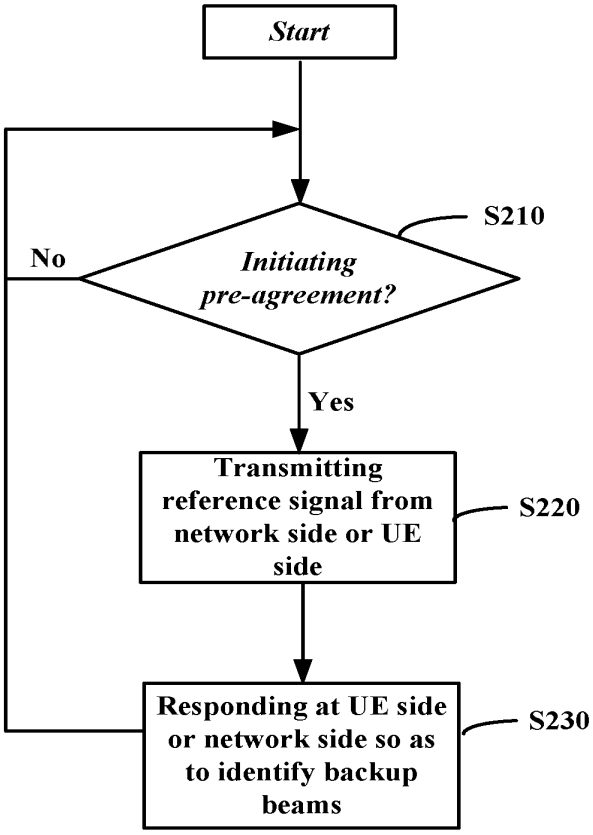

Start
S210
No
Initiating pre-agreement?
Yes
Transmitting reference signal from network side or UE side
S220
Responding at UE side or network side so as to identify backup beams
S230

Fig. 2

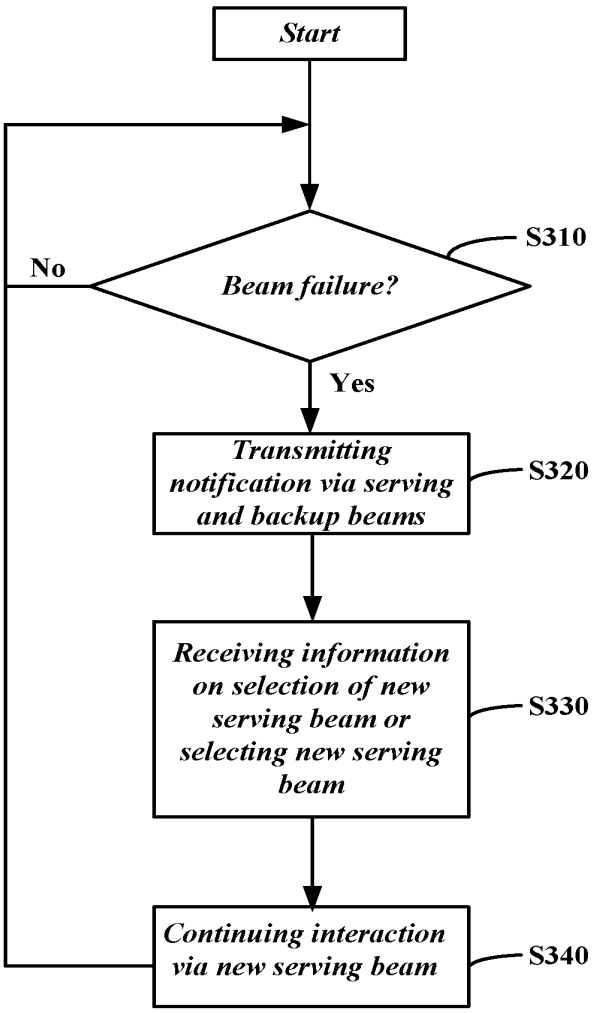

Start
S310
Beam failure?
No
Yes
Transmitting notification via serving and backup beams
S320
Receiving information on selection of new serving beam or selecting new serving beam
S330
Continuing interaction via new serving beam
S340

Fig. 3

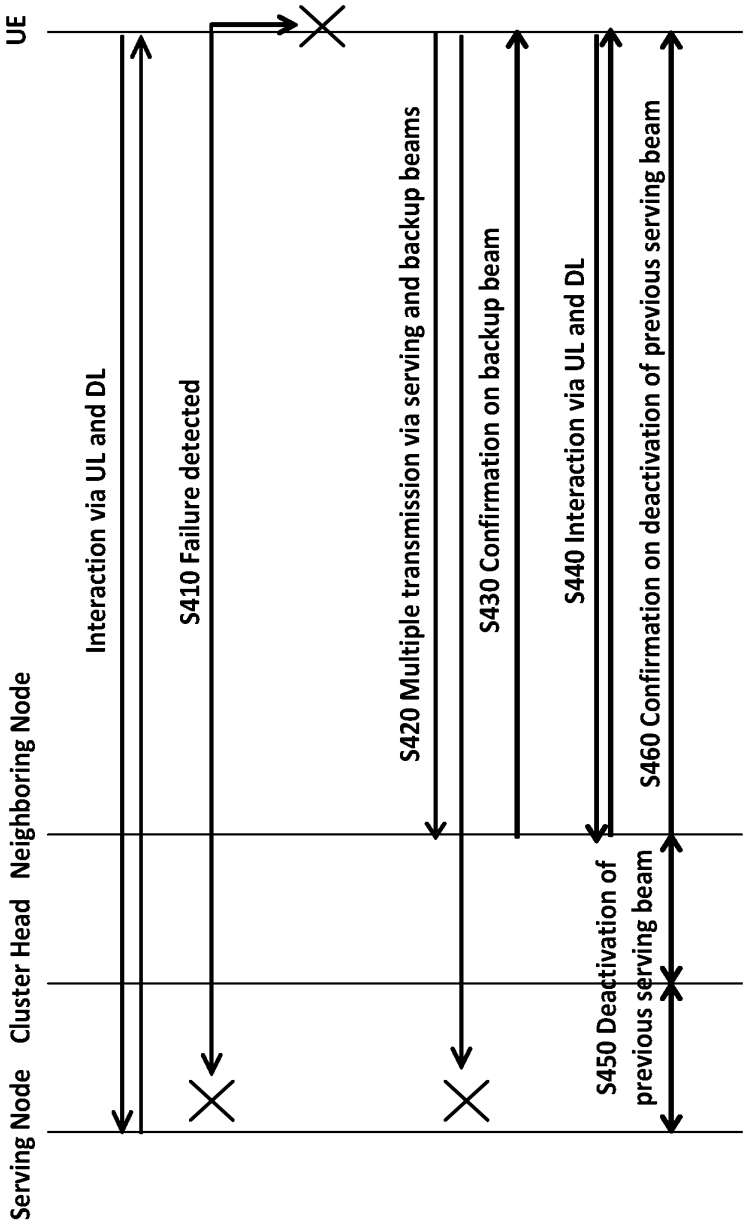

UE
Serving Node
Cluster Head
Neighboring Node
Interaction via UL and DL
S410 Failure detected
S420 Multiple transmission via serving and backup beams
S430 Confirmation on backup beam
S440 Interaction via UL and DL
S450 Deactivation of previous serving beam
S460 Confirmation on deactivation of previous serving beam

Fig. 4

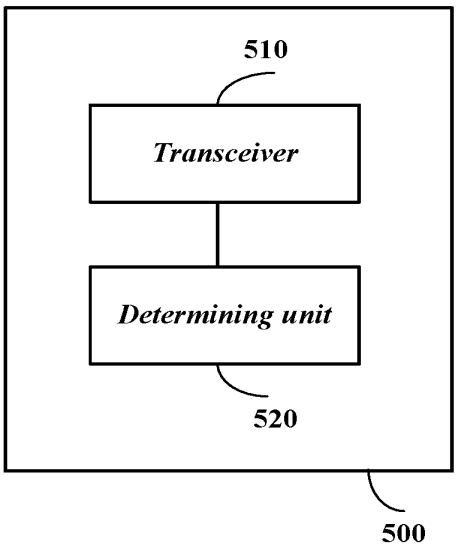

510
Transceiver
Determining unit
520
500

Fig. 5

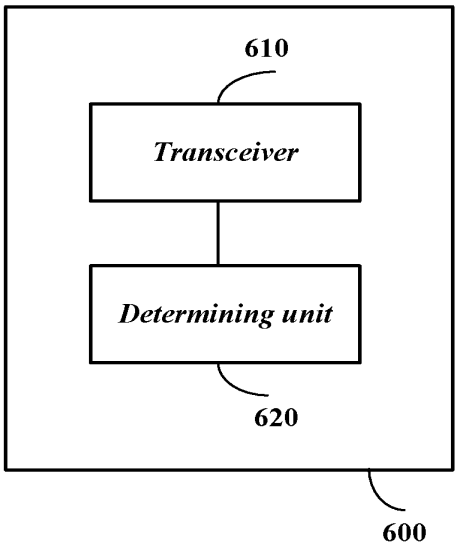

610
Transceiver
Determining unit
620
600

Fig. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2015/086611

A. CLASSIFICATION OF SUBJECT MATTER

H04W 72/08(2009.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04W; H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNPAT,CNKI,WPI,EPODOC,3GPP:beam, form+, beam?form+, fail+, error, fault, quality, disconnect+, low, lost+, miss+, receiv+, recept+, reselect+, chang+, switch+, backup

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2013039345 A1 (SAMSUNG ELECTRONICS CO., LTD.) 14 February 2013 (2013-02-14) description, paragraphs [0036]-[0066]	1-19
Y	WO 2013039331 A2 (SAMSUNG ELECTRONICS CO., LTD.) 21 March 2013 (2013-03-21) description, paragraphs [51]-[52]	1-19
A	US 2006098580 A1 (LI, QINGHUA ET AL.) 11 May 2006 (2006-05-11) the whole document	1-19
A	US 2015223222 A1 (PANASONIC INTELLECTUAL PROPERTY MANAGEMENT CO., LTD.) 06 August 2015 (2015-08-06) the whole document	1-19

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 April 2016	**28 April 2016**
Name and mailing address of the ISA/CN **STATE INTELLECTUAL PROPERTY OFFICE OF THE P.R.CHINA** **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088, China**	Authorized officer **YAO,Yaqian**
Facsimile No. (**86-10**)**62019451**	Telephone No. (**86-10**)**62413297**

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2015/086611

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
US	2013039345	A1	14 February 2013	EP	2742604	A1	18 June 2014
				WO	2013024942	A1	21 February 2013
				US	2014056256	A1	27 February 2014
				CN	103875191	A	18 June 2014
				JP	2014526217	A	02 October 2014
				KR	20130017932	A	20 February 2013
				AU	2011375057	A1	20 February 2014
				CA	2844372	A1	21 February 2013
				IN	KOLNP201400186	E	28 March 2014
WO	2013039331	A2	21 March 2013	WO	2013039331	A2	21 March 2013
				KR	20130029204	A	22 March 2013
				JP	2014530534	A	17 November 2014
				US	2013065622	A1	14 March 2013
				EP	2756607	A2	23 July 2014
				CN	103931109	A	16 July 2014
US	2006098580	A1	11 May 2006	None			
US	2015223222	A1	06 August 2015	WO	2014199610	A1	18 December 2014

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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— *with international search report (Art. 21(3))*

(54) Title: METHODS AND APPARATUSES FOR DOWNLINK CONTROL INFORMATION TRANSMISSION AND RECEIVING

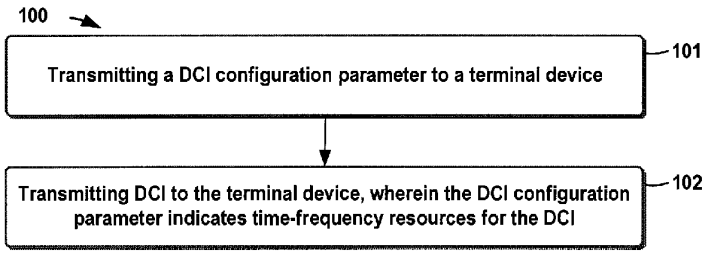


Fig. 1

(57) Abstract: Embodiments of the present disclosure relate to methods and apparatuses for downlink control information (DCI) transmission and receiving in a wireless communication system. A DCI configuration parameter can be first transmitted to a terminal device; and then DCI is transmitted to the terminal device, wherein the DCI configuration parameter indicates time-frequency resources for the DCI. With embodiments of the present disclosure, the UE could perform a flexible DCI monitoring according to the DCI configuration parameter and thus it may support the DCI monitoring occasion change due to numerology and scheduling unit size.

WO 2018/126401 A1

METHODS AND APPARATUSES FOR DOWNLINK CONTROL INFORMATION TRANSMISSION AND RECEIVING

FIELD OF THE INVENTION

[0001] The non-limiting and exemplary embodiments of the present disclosure generally relate to the field of wireless communication techniques, and more particularly relate to methods and apparatuses for downlink control information (DCI) transmission and receiving in a wireless communication system.

BACKGROUND OF THE INVENTION

[0002] New radio access system, which is called as new RAT (NR) system or network for short, is the next generation communication system. In Radio Access Network (RAN) #71 meeting for the third generation Partnership Project (3GPP) working group, study of NR system was approved. The NR system will consider frequency ranging up to 100Ghz with an object of a single technical framework addressing all usage scenarios, requirements and deployment scenarios defined in Technical Report TR 38.913, which include requirements such as enhanced mobile broadband, massive machine-type communications, ultra reliable and low latency communications.

[0003] Especially, in the NR network, different numerologies will coexist in the same carrier and a mini-slot will be introduced to carry Ultra-reliable low latency communication (URLLC) traffic. As a result, DCI monitoring may be performed per symbol based on the specific numerology. Thus, a terminal device like user equipment (UE) needs to know when to monitor the DCI for scheduling related operations.

[0004] In current LTE system, DCI monitoring is performed per subframe or per slot if the UE is in on duration of the discontinuous reception (DRX) active state. The DRX periodicity can be configured by higher layers.

[0005] However, with the current DCI monitoring solution in LTE, it cannot support the DCI monitoring occasion change due to numerology and scheduling unit size.

SUMMARY OF THE INVENTION

[0006] In patent cooperation treaty (PCT) application publication No. WO2016190970A1, there were proposed techniques for selecting data communications with shortened time duration wherein a two-stage grant for communication scheduling was introduced, the first stage grant could include an indication to activate/deactivate ultra-low latency (ULL) communication.

[0007] In US application US20160119969A1, there was proposed a solution for MAC enhancement for concurrent legacy and enhanced component carrier (ECC) operation, wherein a two stage Semi-Persistent Scheduling (SPS) solution was introduced and a first stage grant could contain parameters that may not change much over the course of a given SPS instance while the second stage grant could contain the actual resource for the SPS scheduling.

[0008] In another PCT application publication No. WO2016069270A1, there was proposed another two-stage PDCCH wherein a fast DCI could include a DCI flag and DCI format size indicator to indicate the existence and the size of the slow DCI in the same TTI.

[0009] However, none of the above solutions can address the problems as presented in the back ground.

[0010] To this end, in the present disclosure, there is provided a new solution for DCI transmission and receiving in a wireless communication system, to mitigate or at least alleviate at least part of the issues in the prior art.

[0011] According to a first aspect of the present disclosure, there is provided a DCI transmission in a wireless communication system. The method comprises transmitting a DCI configuration parameter to a terminal device; and transmitting DCI to the terminal device, wherein the DCI configuration parameter indicates time-frequency resources for the DCI.

[0012] According to a second aspect of the present disclosure, there is provided a method of DCI receiving in a wireless communication system. The method comprises receiving a DCI configuration parameter at a terminal device; and receiving DCI within time-frequency resources indicated by the DCI configuration parameter at the terminal device.

[0013] According to a third aspect of the present disclosure, there is provided

an apparatus of DCI transmission in a wireless communication system. The apparatus comprises: a parameter transmission module and a DCI transmission module. The parameter transmission module may be configured to transmit a DCI configuration parameter to a terminal device. The DCI transmission module may be configured to transmit DCI to the terminal device, wherein the DCI configuration parameter indicates time-frequency resources for the DCI

[0014] According to a fourth aspect of the present disclosure, there is provided an apparatus of DCI receiving in a wireless communication system. The apparatus comprises: a parameter receiving module and a DCI receiving module. The parameter receiving module may be configured to receive DCI configuration parameter at a terminal device. The DCI receiving module may be configured to receive DCI within time-frequency resources indicated by the DCI configuration parameter at the terminal device.

[0015] According to a fifth aspect of the present disclosure, there is provided a computer-readable storage media with computer program code embodied thereon, the computer program code configured to, when executed, cause an apparatus to perform actions in the method according to any embodiment in the first aspect.

[0016] According to a sixth aspect of the present disclosure, there is provided a computer-readable storage media with computer program code embodied thereon, the computer program code configured to, when executed, cause an apparatus to perform actions in the method according to any embodiment in the second aspect.

[0017] According to a seventh aspect of the present disclosure, there is provided a computer program product comprising a computer-readable storage media according to the fifth aspect.

[0018] According to an eighth aspect of the present disclosure, there is provided a computer program product comprising a computer-readable storage media according to the sixth aspect.

[0019] With embodiments of the present disclosure, a DCI configuration parameter can be first transmitted to the terminal device, and then the DCI is transmitted to the terminal device. Thus, the terminal device may monitor the transmitted DCI based on the received DCI configuration parameter, which means a flexible DCI monitoring solution and thus can support the DCI monitoring occasion change due to

numerology and scheduling unit size.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] The above and other features of the present disclosure will become more apparent through detailed explanation on the embodiments as illustrated in the embodiments with reference to the accompanying drawings, throughout which like reference numbers represent same or similar components and wherein:

[0021] Fig. 1 schematically illustrates a flow chart of a method of DCI transmission according to an example embodiment of the present disclosure;

[0022] Fig. 2 schematically illustrates DCI occurrence occasions with different numerologies according to example embodiments of the present disclosure;

[0023] Figs. 3A to 3C schematically illustrate DCI occurrence occasions at different levels according to examples embodiments of the present disclosure;

[0024] Figs. 4A and 4C schematically illustrate DCI occurrence occasions with frequency hopping according to example embodiment of the present disclosure;

[0025] Fig. 5A schematically illustrates a two-DCI solution for enhanced mobile broadband (eMBB) and URLLC multiplexing in which control and data are multiplexed in time domain according to an embodiment of the present disclosure;

[0026] Fig. 5B schematically illustrates a two-DCI solution for eMBB and URLLC multiplexing in which control and data are multiplexed in frequency domain according to an embodiment of the present disclosure;

[0027] Figs. 6A to 6D schematically illustrate two-DCI solutions for eMBB and URLLC multiplexing according to an embodiment of the present disclosure, wherein control region and data are multiplexed in time domain and the eMBB and the URLL are multiplexed in TDM, in TDM by symbol, in FDM, and in both FDM and TDM, respectively;

[0028] Figs. 7A to 7D schematically illustrate two-DCI solutions for eMBB and URLLC multiplexing according to an embodiment of the present disclosure, wherein control region and data are multiplexed in frequency domain and the eMBB and the URLL are multiplexed in TDM, in TDM by symbol, in FDM, and in both FDM and TDM, respectively;

[0029] Fig. 8 schematically illustrates a two-DCI solution for eMBB and

URLLC multiplexing according to an embodiment of the present disclosure, wherein two segments are used and the second segment is punctured or not punctured without re-transmission;

[0030] Fig. 9 schematically illustrates a two-DCI solution for eMBB and URLLC multiplexing according to an embodiment of the present disclosure, wherein two segments are used and the second segment is punctured with retransmission;

[0031] Fig. 10 schematically illustrates an example two-DCI division solution according to an embodiment of the present disclosure;

[0032] Fig. 11 schematically illustrates a flow chart of a method for DCI receiving according to an embodiment of the present disclosure;

[0033] Fig. 12 schematically illustrates a block diagram of an apparatus for DCI transmission according to an embodiment of the present disclosure;

[0034] Fig. 13 schematically illustrates a block diagram of an apparatus for DCI receiving according to an embodiment of the present disclosure; and

[0035] Fig. 14 further illustrates a simplified block diagram of an apparatus 1410 that may be embodied as or comprised in a serving node like a base station in a wireless network and an apparatus 1420 that may be embodied as or comprised in a terminal device like UE as described herein.

DETAILED DESCRIPTION OF EMBODIMENTS

[0036] Hereinafter, the solution as provided in the present disclosure will be described in details through embodiments with reference to the accompanying drawings. It should be appreciated that these embodiments are presented only to enable those skilled in the art to better understand and implement the present disclosure, not intended to limit the scope of the present disclosure in any manner.

[0037] In the accompanying drawings, various embodiments of the present disclosure are illustrated in block diagrams, flow charts and other diagrams. Each block in the flowcharts or blocks may represent a module, a program, or a part of code, which contains one or more executable instructions for performing specified logic functions, and in the present disclosure, a dispensable block is illustrated in a dotted line. Besides, although these blocks are illustrated in particular sequences for performing the steps of the methods, as a matter of fact, they may not necessarily be performed strictly

according to the illustrated sequence. For example, they might be performed in reverse sequence or simultaneously, which is dependent on natures of respective operations. It should also be noted that block diagrams and/or each block in the flowcharts and a combination of thereof may be implemented by a dedicated hardware-based system for performing specified functions/operations or by a combination of dedicated hardware and computer instructions.

[0038] Generally, all terms used in the claims are to be interpreted according to their ordinary meaning in the technical field, unless explicitly defined otherwise herein. All references to "a/an/the/said [element, device, component, means, step, etc.]" are to be interpreted openly as referring to at least one instance of said element, device, component, means, unit, step, etc., without excluding a plurality of such devices, components, means, units, steps, etc., unless explicitly stated otherwise. Besides, the indefinite article "a/an" as used herein does not exclude a plurality of such steps, units, modules, devices, and objects, and etc.

[0039] Additionally, in a context of the present disclosure, a user equipment (UE) may refer to a terminal, a Mobile Terminal (MT), a subscriber station, a portable subscriber station, Mobile Station (MS), or an Access Terminal (AT), and some or all of the functions of the UE, the terminal, the MT, the SS, the portable subscriber station, the MS, or the AT may be included. Furthermore, in the context of the present disclosure, the term "BS" may represent, e.g., a node B (NodeB or NB), an evolved NodeB (eNodeB or eNB), gNB (Node B in NR), a radio header (RH), a remote radio head (RRH), a relay, or a low power node such as a femto, a pico, and so on.

[0040] As mentioned hereinbefore, none of the prior arts can support the DCI monitoring occasion change due to numerology and scheduling unit size. Thus, in the present disclosure, there is proposed a new DCI transmission and receiving solution. In the proposed solution, a DCI configuration parameter can be first transmitted to the terminal device, and then the DCI is transmitted to the terminal device. Thus, the terminal device may monitor the DCI based on the received DCI configuration parameter, which means a flexible DCI monitoring solution and thus can support the DCI monitoring occasion change due to numerology and scheduling unit size.

[0041] Hereinafter, reference will be made to Figs. 1 to 14 to describe the DCI transmission and receiving solution.

[0042] Fig.1 schematically illustrates a flow chart of a method 100 of DCI transmission in a wireless communication system according to an embodiment of the present disclosure. The method 100 can be performed at a serving node, for example a BS, like a node B (NodeB or NB).

[0043] As illustrated in Fig. 1, first in step 101, a DCI configuration parameter is transmitted to a terminal device, and the DCI configuration parameter indicates time-frequency resources for a following DCI.

[0044] In an embodiment of the present disclosure, the DCI configuration parameter comprises at least one of: a numerology to be used; a valid duration for the DCI configuration parameter; a duration for a single DCI; and DCI occurrence occasions.

[0045] In NR system, different numerologies might be used, whereas different numerologies might use different transmission parameters, for example different subcarrier spacings. The different subcarrier spacings mean different symbol lengths. For example, for 15 kHz subcarrier spacing, its symbol will have a time length four times as that for 60 kHz subcarrier spacing, as illustrated in Fig. 2. Thus, the numerology to be used can be used to define a symbol.

[0046] The valid duration for the DCI configuration parameter indicates a duration in which the DCI configuration parameter is valid. The valid duration can be a number of symbols (for example, numerology specific) or a number of frames (for example numerology common). In an embodiment of the present disclosure, the values of the start of the valid duration can be an absolute value with respect to the reference numerology. For example, if the configuration signaling is received in symbol 7 of the subframe 2 of frame 6, the starting can be defined as symbol 0 of subframe 0 of frame 6. The definition of the absolute value can be predetermined or configured by a high layer signaling like RRC signaling. In another embodiment of the present disclosure, the first symbol carrying the configuration signaling can be used as the start of the valid duration no matter whether the configuration signaling is configured by DCI or by a RRC signaling.

[0047] The duration for a single DCI indicates the length of the DCI, it can be a number of symbols. Thus, parameter may indicate the length of DCI. It is also possible to use a predetermined length and in such a case, this parameter can be omitted.

[0048] DCI occurrence occasions indicate occasions at which DCI occurs in frames. In an embodiment of the present disclosure, the DCI occurrence occasions can be at a slot level, at subframe level (multi-slot), or at symbol level, as illustrated in Figs. 3A to 3C respectively.

[0049] The DCI occurrence occasions can be periodic. That is to say, the DCI monitoring will be performed periodically, for example every a predetermined number of slots, every a predetermined number of symbols. Fig 3A and Fig. 3B illustrate two examples of periodic DCI occurrence occasions. In Fig. 3A, the DCI occurrence occasions are per slot; in other words, the DCI monitoring is performed every slot, like in slots 0, 1,…,. In Fig. 3B, the DCI occurrence occasions are per multi-slot (e.g., 2 slots, a subframe); that is to say, the DCI monitoring can be performed per multi-slot. In such a case, the DCI occurrence occasions can be indicated by the periodicity and an offset of the DCI occurrence. The periodicity can be, for example, a predetermined number of symbols, slots, or frames.

[0050] Alternatively, the DCI occurrence occasions can also be aperiodic. Fig. 3C illustrates an aperiodic DCI occurrence occasion. In Fig. 3C, the DCI occurrence occasions are per symbol but aperiodic. In such a case, it may predefine a set of possible aperiodic patterns in specification or pre-configure the possible set of aperiodic patterns by a higher layer signaling. In the set of aperiodic patterns, each aperiodic pattern contains one or more symbols within a valid duration. In such a way, the network can inform the aperiodic pattern index to the terminal device in DCI configuration parameter.

[0051] It should be noticed that although the DCI occurrence occasions per slot and multi-slot in Fig.3A and 3B are periodic and the DCI occurrence occasions per symbol in Fig.3C is aperiodic, the present disclosure is not limited thereto. In fact, in each of the DCI occurrence occasions per slot, per multi-slot, per symbol, the DCI occurrence occasions can be periodic or aperiodic.

[0052] As another alternative, the DCI occurrence occasions can be a combination of periodic and aperiodic occasions. In other word, in a time period, it contains an aperiodic pattern including one or more symbols but the aperiodic pattern will repeat by the time period in the valid duration. In such a case, the DCI occurrence occasions can be indicated by the periodicity and the aperiodic pattern.

[0053] In another embodiment of the present disclosure, the DCI configuration parameter may comprise at least one of: frequency domain resource unit; and frequency hopping pattern.

[0054] The frequency domain resource unit indicates the resource unit to be used for DCI in the frequency domain, it could be a control channel element (CCE), a subband, a physical resource block (PRB), or physical resource group (REG). In addition, the frequency domain resource unit can be numerology common, which mean the frequency domain resource unit is same for all numerologies, or numerology specific, which mean that different numerologies might use different frequency domain resource units.

[0055] The frequency hopping pattern indicates a pattern in which the frequency hopping is used. This parameter is required when the frequency hopping pattern is used. An explicit signaling can be used to indicate the frequency resource in each DCI occurrence occasion. The hopping pattern can be a predetermined pattern which is known at both network and the terminal device, or a pattern configured by the network. The hopping pattern can be used to calculate the frequency resource position.

[0056] Figs. 4A to 4C illustrate use of frequency hopping in different DCI occurrence occasions according to embodiments of the present disclosure. DCI occurrence occasions as illustrated in Fig.4A to Fig. 4C are same with those in Fig. 3A to 3C in the time domain but in the frequency domain, the frequency hopping is used for the DCI occurrence occasions. It should be noticed that although the DCI occurrence occasions per slot and per multi-slot in Fig.4A and 4B are periodic and the DCI occurrence occasions per symbol in Fig.4C is aperiodic, the present disclosure is not limited thereto. In fact, in each of the DCI occurrence occasions per slot, per multi-slot, per symbol, the DCI occurrence occasions can be periodic or aperiodic.

[0057] Reference is made back to Fig. 1, in step 102, the DCI can be transmitted to the terminal device. With the DCI configuration parameter, the terminal device may learn the time-frequency resource for the DCI from the DCI configuration parameter and monitor the DCI within the time-frequency resource.

[0058] In an embodiment of the present disclosure, the DCI configuration parameter can be transmitted to the terminal device by a higher layer signaling like a

RRC signaling. That is to say, in the two-stage solution, for the first stage, the higher layer signaling can be used to transmit the DCI configuration indicating the time-frequency resource for the following DCI in the second stage.

[0059] In another embodiment of the present disclosure, the DCI configuration parameter can be transmitted to the terminal device dynamically by another DCI. In such a case, a first DCI is used to transmit the DCI configuration parameter for the following DCI. The actual data scheduling related information is located in the following DCI.

[0060] In addition, considering the payload size of the first DCI, it is also possible to use a combination of DCI and high layer signaling. That is to say, a part of DCI configuration parameter can be transmitted by DCI and another part of the DCI configuration parameter can be transmitted by a high layer signaling.

[0061] In the two stage DCI solution, the first DCI can be cell specific, beam specific, TRP specific, common for a UE group or UE specific. In an embodiment of the present disclosure, the DCI can be scrambled with a specific RNTI. The periodicity of the first DCI can be larger than the second DCI. The occurrence occasions of the first DCI can predetermined or configured by a higher layer signaling such a RRC signaling. The first DCI can be located in common search space. Or alternative, the first DCI can also be located in UE specific search space.

[0062] It shall be noted that there may be a valid duration for the DCI configuration parameter but there is no any restriction on DCI configuration parameter and scheduling unit size. For example, with slot-level DCI monitoring configuration, UE can also be configured with a scheduling unit starting and ending from the symbol boundary rather than a slot boundary. In such a case, the remaining blank symbols can be allocated to other UE with symbol level DCI monitoring configuration. Or alternatively, the remaining blank symbols can also be allocated to other UE with slot-level or multi-slot level DCI configuration.

[0063] In a further embodiment of the present disclosure, the DCI configuration parameter may comprise at least two sets of parameters, from which the terminal device can select a set of parameters based on its requested traffic types. In other words, DCI monitoring can be adapted at UE side after resource requirement by means of random access procedure/scheduling request (SR).

[0064] After a random access procedure, the terminal device starts DL/UL transmission/reception with the eNB. Thus, the DCI monitoring behavior can be based on the reason for random access. If URLLC scheduling request is the reason for random access, the DCI monitoring should be more frequent. If eMBB scheduling request is the reason for random access, the DCI monitoring can be less frequent. By providing two or more different sets of DCI configuration parameters predefined or configured by RRC signaling, the terminal device could choose the suitable parameter set based on its request traffic type. In such a way, it is possible for UE to perform DCI monitoring based on its required traffic type.

[0065] In another aspect of the present disclosure, there is also provided another two-DCI solution for different traffic type multiplexing. In these solutions, two DCIs are used, one of which can be called as prepositive control region (DCI), the other of which can be called as postpostive control region (DCI). The prepositive control region can be used to indicate resource that is allocated to a first traffic type (such as eMBB traffic) but is to be occupied by a second traffic type (such as URLLC traffic), the postpositive control region can be used to indicate resource that allocated to a first traffic type (such as eMBB traffic) but was already occupied by the second traffic type (such as abrupt URLLC traffic). Hereinafter, the URLLC traffic and the eMBB traffic will be taken as examples of different traffic types to describe the two-DCI solution; however, those skilled in the art can readily know that the present disclosure is not limited thereto.

[0066] In an embodiment of the present disclosure, the prepositive control region can include at least one of following fields:

- a field to indicate puncture or rate-matching around some time-frequency resource in a following pattern of time-frequency resource;
- a field to schedule on a following pattern of time-frequency resource (e.g. can be contiguous or non-contiguous symbols/frequency bands);
- a field to indicate re-transmission of previous punctured part;
- a field to indicate the end of one transmission block.

[0067] In an embodiment of the present disclosure, the postpositive region can include at least one of following fields:

- a field to indicate puncture or no puncture of some time-frequency

resources in the previous pattern of time-frequency resource

- a field to indicate re-transmission or no re-transmission of previous punctured part
- a field to indicate the end of one transmission block

[0068] It shall be noted that patterns of time-frequency resource in prepositive and postpositive control regions can be complementary. For example, the two patterns can compose a whole time-frequency resource of a region (subframe). Alternatively, the two patterns can be also partially overlapped.

[0069] Fig. 5A illustrates a two-DCI solution for different traffic type multiplexing according to an embodiment of the present disclosure. The resource of eMBB can be split into two parts as illustrated in Fig. 5, the first one is to be scheduled by the prepostive control region and the other one is to be scheduled by the postpostive control region. For some resources such as first several symbols, the scheduling of URLLC can be known, thus the eMBB UE can be indicated of rate-matching or puncture for the occupied resource in the prepositive control region if it is occupied by the URLLC. While, for some resources, for example when the URLLC occurs abruptly, the scheduling of URLLC cannot be known in the prepositive control region, and thus the eMBB UE can be indicated to puncture for the occupied resources in the postpositive control region.

[0070] In Fig. 5A, it is shown that the control regions and the data regions are multiplexed in the time domain. In another embodiment of the present disclosure, the control regions and data regions can be multiplexed in the frequency domain. Fig. 5B illustrates a two-DCI solution for different traffic type multiplexing according to an embodiment of the present disclosure. Fig. 5B is similar with Fig. 5A but differs in that in Fig. 5B, the control regions and data regions are multiplexed in the frequency domain.

[0071] It should also be noted that resource indicated to eMBB UE can be resource occupied by URLLC or resource reserved as empty for forward phase.

[0072] In addition, it shall also be noted that the split resource parts can also be multiplexed in many different ways, which will be described with reference to Fig. 6A to Fig. 7D.

[0073] Fig. 6A illustrates a two-DCI solution according to an embodiment of

the present disclosure, in which the control region and the data region are multiplexed in TDM and two split parts are multiplexed in time domain multiplexing (TDM). Fig. 6A is substantially same as that in Fig. 5A, and in the two DCI solution, the part scheduled by the prepostive control region is multiplexed with the part scheduled by the postpostive control region in TDM.

[0074] Fig. 6B illustrates another two-DCI solution according to an embodiment of the present disclosure, wherein the control region and the data region are multiplexed in TDM and the two split parts are multiplexed in TDM by symbols. Compared with that illustrated in Fig. 6A, in Fig. 6B, the part scheduled by the prepostive control region is multiplexed with the part scheduled by the postpostive control region also in TDM but by symbol; that is to say, in Fig. 6B, the symbols belonging to each part are not continuous.

[0075] Fig. 6C illustrates a further two-DCI solution according to an embodiment of the present disclosure, wherein the control region and the data region are multiplexed in TDM and the two split parts are multiplexed in frequency domain multiplexing (FDM). Different from that illustrated in Fig. 6A and Fig. 6B, in Fig. 6C the part scheduled by the prepostive control region is multiplexed with the part scheduled by the postpostive control region in FDM, i.e., they respectively occupy different frequency domain resources.

[0076] Fig. 6D illustrates a further two-DCI solution according to an embodiment of the present disclosure, wherein the control region and the data region are multiplexed in TDM and the two split parts are multiplexed in TDM and frequency domain multiplexing (FDM). As illustrated in Fig. 6D, the part scheduled by the prepostive control region is multiplexed with the part scheduled by the postpostive control region in a combination of TDM and FDM.

[0077] Figs. 7A to 7D illustrate two-DCI solutions according to an embodiment of the present disclosure, wherein the control region and the data region are multiplexed in FDM and two split parts are multiplexed in different manners respectively. In Fig. 7A, the two split parts are multiplexed in TDM; in Fig. 7B, the two split parts are multiplexed in TDM by symbol; in Fig. 7C, the two split parts are multiplexed in FDM; and Fig. 7D, the two split parts are multiplexed in TDM and FDM.

[0078] The two split parts can be decoded in any suitable manner. In an embodiment of the present disclosure, the two split part can be separately decoded. In another embodiment of the present disclosure, the two parts can be cascaded to decode, i.e. when UE receives the two parts, then it decodes them immediately or it decodes them after UE receiving the postpositive control region.

[0079] In a further embodiment of the present disclosure, the resource for eMBB can be split for several parts, wherein first parts are to be scheduled by the preposition control region and seconds parts are to be scheduled by the postpostive control region. The several parts are further divided into two segments in the time domain, i.e., segment 1 and segment 2. For some resources such as first several symbols, the scheduling of URLLC can be known, thus the eMBB UE can be indicated of rate-matching or puncture for the occupied resource in the prepositive control region if it is occupied by the URLLC. While, for some resources, for example when the URLLC occurs abruptly, the scheduling of URLLC cannot be known in the prepositive control region, and thus the eMBB UE can be indicated to puncturing or not puncturing for the occupied resources in the postpositive control region. For some resources in the second segment, they may be reserved for re-transmission or be punctured part of transmission in the first segment. This punctured part can be for example a subset of the first segment, and the remaining of the first segment can be used for new transmission. Fig. 8 illustrates a two-DCI solution wherein there is no re-transmission in the second segment; while Fig. 9 illustrates a two-DCI solution wherein, in the second segment, there is a re-transmission of punctured part of the first segment as indicated by blocks filled with cross lines.

[0080] In addition, similarly to solutions as illustrate in Figs. 6A to 7D, the first parts and the second parts can be multiplexed in time and/or frequency domain. Moreover, these parts can be cascaded to decode, i.e. when UE receives the two parts, then it decodes them immediately or it decodes them after UE receiving the postpositive control region.

[0081] In a further aspect of the present disclosure, one transmission block can also be split into several parts. The first part can be scheduled by, for example, prepositive control region, and the second part can be scheduled by, for example, postpositive control region. The UE can decode after receiving the whole transmission

block. The end of the transmission can be indicated in a control region. For example, UE may obtain frequency and time domain mapping for data, then obtain the mapping over resources preempted by URLLC, and after that it decodes the block.

[0082] In another embodiment of the present disclosure, preemption of URLLC can be indicated implicitly. For example, it is possible to use tracking RS to implicitly indicate preemption of URLLC. For example, if the tracking RS is interrupted on some symbols, this means these symbols are occupied by URLLC, and thus this can be used to indicate preemption of URLLC.

[0083] In a further embodiment of the present disclosure, DCI can be cascaded with K-stage DCI. For example, a first stage DCI contains resource allocation field; the second stage DCI contains information of MCS and other information for data transmission (which may also contain detailed information of resource allocation). In such a case, the UE can cascades the two-stage DCI for control information.

[0084] In addition, the first stage DCI can be shared by different UEs, e.g. URLLC UE and eMBB UE, as illustrated in Fig. 10. The URLLC UE could obtain the shared first stage DCI and the second stage DCI for control and/or data transmission. The eMBB UE could obtain the shared first stage DCI for the resource allocation for puncturing or rate-matching. The shared common DCI can be scrambled with shared RNTI, e.g. a resource allocation RNTI calculated considering the resource index.

[0085] In a further embodiment of the present disclosure, the first DCI can include full scheduling information; while the second DCI may include indication of the resource occupied by URLLC or not. In addition, the second DCI can be reduced for some cases. For example, when no MCS needed, the second DCI can be omitted. If the resource is semi-statically reserved for URLLC and known to eMBB UE, the resource allocation is no needed and the second DCI can be reduced as well. In another case, if the resource is known by eMBB UE, and the time-frequency of remaining resource is fixed, then only an indication is needed in the second DCI, which indicates whether the time-frequency resource is occupied. If yes, the resource is for re-transmission or just keeps punctured; if not, the resource will be used for new data transmission.

[0086] It shall be noted that although the aspects and embodiments are described separately, they can also be combined together to achieve more benefits.

[0087] Fig. 11 further schematically illustrates a flow chart of method for DCI receiving according to an example embodiment of the present disclosure. The method 1100 can be implemented at a terminal device, for example UE, or other like terminal devices.

[0088] As illustrated in Fig. 11, the method starts from step 11, in which the terminal device like UE receiving a DCI configuration parameter. The DCI configuration parameter indicates the time-frequency resources for the following DCI.

[0089] In an embodiment of the present disclosure, the DCI configuration parameter may comprise at least one of: numerology to be used; a valid duration for the DCI configuration parameters; a duration for a single DCI; DCI occurrence occasions.

[0090] In another embodiment of the present disclosure, the DCI configuration parameter may comprise at least one of: a frequency domain resource unit; and a frequency hopping pattern.

[0091] In a further embodiment of the present disclosure, the receiving DCI configuration parameter may comprise receiving the DCI configuration parameter in a higher layer signaling.

[0092] In a further embodiment of the present disclosure, the receiving DCI configuration parameter may comprise receiving the DCI configuration parameter in another DCI.

[0093] In addition, considering the payload size of the first DCI, it is also possible to use a combination of DCI and high layer signaling. That is to say, a part of DCI configuration parameter can be received by a first DCI and another part of the DCI configuration parameter can be transmitted by a high layer signaling.

[0094] The first DCI can be cell specific, beam specific, TRP specific, common for a UE group or UE specific. In an embodiment of the present disclosure, the DCI can be scrambled with a specific RNTI. The periodicity of the first DCI can be larger than the second DCI. The occurrence occasions of the first DCI can predetermined or configured by a higher layer signaling such a RRC signaling. The first DCI can be located in common search space. . Or alternative, the first DCI can also be located in UE specific search space.

[0095] Next, in step 1102, DCI is received within time-frequency resources indicated by the DCI configuration parameter at the terminal device. That is to say, at

the terminal device, the terminal device may perform DCI monitoring based on the DCI configuration parameter, which means a flexible DCI monitoring solution and thus can support the DCI monitoring occasion change due to numerology and scheduling unit size.

[0096] In a still further embodiment of the present disclosure, the DCI configuration parameter comprises at least two sets of parameters. In such a case, further in step 1103, the UE may select a set of parameters based on its requested traffic types. In other words, DCI monitoring can be adapted at UE side after resource requirement by means of random access procedure/SR.

[0097] After random access procedure, the terminal device starts DL/UL transmission/reception with the eNB. Thus, the DCI monitoring behavior can be based on the reason for random access. If URLLC scheduling request is the reason for random access, the DCI monitoring should be more frequent. If eMBB scheduling request is the reason for random access, the DCI monitoring can be less frequent. By providing two or more different sets of DCI configuration parameters predefined or configured by RRC signaling, the terminal device could choose the suitable parameter set based on its request traffic type. In such a way, it is possible for UE to perform DCI monitoring based on its required traffic type.

[0098] Besides, in the present disclosure, there are also provided apparatuses for DCI transmission and receiving at the serving node and terminal device in a wireless communication system respectively, which will be described next with reference to Figs. 12 and 13.

[0099] Fig. 12 schematically illustrates a block diagram of an apparatus 1200 for DCI transmission in a wireless communication system according to an embodiment of the present disclosure. The apparatus 1200 can be implemented at a serving node, for example a BS, like a node B (NodeB or NB).

[00100] As illustrated in Fig. 12, the apparatus 1200 may comprise a parameter transmission module 1201 and a DCI transmission module 1202. The parameter transmission module 1201 can be configured to transmit a DCI configuration parameter to a terminal device. The DCI transmission module 1202 can be configured to transmit DCI to the terminal device, wherein the DCI configuration parameter indicates time-frequency resources for the DCI.

[00101] In an embodiment of the present disclosure, the sequence position information may comprise any of: a numerology to be used; a valid duration for the DCI configuration parameters; a duration for a single DCI; DCI occurrence occasions; a frequency domain resource unit; and a frequency hopping pattern.

[00102] In another embodiment of the present disclosure, the parameter transmission module 1201 may be configured to transmit the DCI configuration parameter to the terminal device by a higher layer signaling.

[00103] In a further embodiment of the present disclosure, the parameter transmission module 1201 is configured to transmit the DCI configuration parameter to the terminal device dynamically by another DCI.

[00104] In a still further embodiment of the present disclosure, the another DCI may have a larger periodicity than the DCI.

[00105] In a yet further embodiment of the present disclosure, the DCI configuration parameter may comprise at least two sets of parameters, from which the terminal device can select a set of parameters based on its requested traffic type.

[00106] Fig. 13 further schematically illustrates a block diagram of an apparatus 1300 for DCI receiving in a wireless communication system according to an embodiment of the present disclosure. The apparatus 1300 can be implemented at a terminal device, for example UE, or other like terminal devices.

[00107] As illustrated in Fig. 13, the apparatus 1300 may include a parameter receiving module 1301 and a DCI receiving module 1302. The parameter receiving module 1301 may be configured to receive DCI configuration parameter at a terminal device. The DCI receiving module 1302 can be configured to receive DCI within time-frequency resources indicated by the DCI configuration parameter at a terminal device.

[00108] In an embodiment of the present disclosure, the sequence position information may comprise any of: a numerology to be used; a valid duration for the DCI configuration parameters; a duration for a single DCI; DCI occurrence occasions; a frequency domain resource unit; and a frequency hopping pattern.

[00109] In another embodiment of the present disclosure, the parameter receiving module 1301 may be further configured to receive the DCI configuration parameter in a higher layer signaling.

[00110] In another embodiment of the present disclosure, the parameter receiving module 1301 may be further configured to receive the DCI configuration parameter in another DCI.

[00111] In a still further embodiment of the present disclosure, the another DCI may have a larger periodicity than the DCI.

[00112] In a yet further embodiment of the present disclosure, the DCI configuration parameter may comprise at least two sets of parameters. In such a case, the apparatus 1300 may further comprise a parameter set selection module 1303. The apparatus 1300 may be configured to select a set of parameters based on a traffic type requested by the terminal device and wherein the time-frequency resources are those indicated by the selected set of parameters

[00113] Hereinbefore, the apparatuses 1200 and 1300 are described with reference to Figs. 12 and 13. It is noted that the apparatuses 1200 and 1300 may be configured to implement functionalities as described with reference to Figs. 1 to 11. Therefore, for details about the operations of modules in these apparatuses, one may refer to those descriptions made with respect to the respective steps of the methods with reference to Figs. 1 to 11.

[00114] It is further noted that the components of the apparatuses 1200 and 1300 may be embodied in hardware, software, firmware, and/or any combination thereof. For example, the components of apparatuses 1200 and 1300 may be respectively implemented by a circuit, a processor or any other appropriate selection device.

[00115] Those skilled in the art will appreciate that the aforesaid examples are only for illustration not limitation and the present disclosure is not limited thereto; one can readily conceive many variations, additions, deletions and modifications from the teaching provided herein and all these variations, additions, deletions and modifications fall the protection scope of the present disclosure.

[00116] In addition, in some embodiment of the present disclosure, apparatuses 1200 and 1300 may comprise at least one processor. The at least one processor suitable for use with embodiments of the present disclosure may include, by way of example, both general and special purpose processors already known or developed in the future. Apparatuses 1200 and 1300 may further comprise at least one memory.

The at least one memory may include, for example, semiconductor memory devices, e.g., RAM, ROM, EPROM, EEPROM, and flash memory devices. The at least one memory may be used to store program of computer executable instructions. The program can be written in any high-level and/or low-level compliable or interpretable programming languages. In accordance with embodiments, the computer executable instructions may be configured, with the at least one processor, to cause apparatuses 1200 and 1300 to at least perform operations according to the method as discussed with reference to Figs. 1 to 11 respectively.

[00117] Fig. 14 further illustrates a simplified block diagram of an apparatus 1410 that may be embodied as or comprised in a serving node like a base station in a wireless network and an apparatus 1420 that may be embodied as or comprised in a terminal device like UE as described herein.

[00118] The apparatus 1410 comprises at least one processor 1411, such as a data processor (DP) and at least one memory (MEM) 1412 coupled to the processor 1411. The apparatus 1410 may further comprise a transmitter TX and receiver RX 1413 coupled to the processor 1411, which may be operable to communicatively connect to the apparatus 1420. The MEM 1412 stores a program (PROG) 1414. The PROG 1414 may include instructions that, when executed on the associated processor 1411, enable the apparatus 1410 to operate in accordance with embodiments of the present disclosure, for example the method 100. A combination of the at least one processor 1411 and the at least one MEM 1412 may form processing means 1415 adapted to implement various embodiments of the present disclosure.

[00119] The apparatus 1420 comprises at least one processor 1421, such as a DP, and at least one MEM 1422 coupled to the processor 1421. The apparatus 1420 may further comprise a suitable TX/ RX 1423 coupled to the processor 1421, which may be operable for wireless communication with the apparatus 1410. The MEM 1422 stores a PROG 1424. The PROG 1424 may include instructions that, when executed on the associated processor 1421, enable the apparatus 1420 to operate in accordance with the embodiments of the present disclosure, for example to perform the method 1100. A combination of the at least one processor 1421 and the at least one MEM 1422 may form processing means 1425 adapted to implement various embodiments of the present disclosure.

[00120] Various embodiments of the present disclosure may be implemented by computer program executable by one or more of the processors 1411, 1421, software, firmware, hardware or in a combination thereof.

[00121] The MEMs 1412 and 1422 may be of any type suitable to the local technical environment and may be implemented using any suitable data storage technology, such as semiconductor based memory devices, magnetic memory devices and systems, optical memory devices and systems, fixed memory and removable memory, as non-limiting examples.

[00122] The processors 1411 and 1421 may be of any type suitable to the local technical environment, and may include one or more of general purpose computers, special purpose computers, microprocessors, digital signal processors DSPs and processors based on multicore processor architecture, as non-limiting examples.

[00123] In addition, the present disclosure may also provide a carrier containing the computer program as mentioned above, wherein the carrier is one of an electronic signal, optical signal, radio signal, or computer readable storage medium. The computer readable storage medium can be, for example, an optical compact disk or an electronic memory device like a RAM (random access memory), a ROM (read only memory), Flash memory, magnetic tape, CD-ROM, DVD, Blue-ray disc and the like.

[00124] The techniques described herein may be implemented by various means so that an apparatus implementing one or more functions of a corresponding apparatus described with one embodiment comprises not only prior art means, but also means for implementing the one or more functions of the corresponding apparatus described with the embodiment and it may comprise separate means for each separate function, or means that may be configured to perform two or more functions. For example, these techniques may be implemented in hardware (one or more apparatuses), firmware (one or more apparatuses), software (one or more modules), or combinations thereof. For a firmware or software, implementation may be made through modules (e.g., procedures, functions, and so on) that perform the functions described herein.

[00125] Exemplary embodiments herein have been described above with reference to block diagrams and flowchart illustrations of methods and apparatuses. It will be understood that each block of the block diagrams and flowchart illustrations, and combinations of blocks in the block diagrams and flowchart illustrations, respectively,

can be implemented by various means including computer program instructions. These computer program instructions may be loaded onto a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions which execute on the computer or other programmable data processing apparatus create means for implementing the functions specified in the flowchart block or blocks.

[00126] While this specification contains many specific implementation details, these should not be construed as limitations on the scope of any implementation or of what may be claimed, but rather as descriptions of features that may be specific to particular embodiments of particular implementations. Certain features that are described in this specification in the context of separate embodiments can also be implemented in combination in a single embodiment. Conversely, various features that are described in the context of a single embodiment can also be implemented in multiple embodiments separately or in any suitable sub-combination. Moreover, although features may be described above as acting in certain combinations and even initially claimed as such, one or more features from a claimed combination can in some cases be excised from the combination, and the claimed combination may be directed to a sub-combination or variation of a sub-combination.

[00127] It will be obvious to a person skilled in the art that, as the technology advances, the inventive concept can be implemented in various ways. The above described embodiments are given for describing rather than limiting the disclosure, and it is to be understood that modifications and variations may be resorted to without departing from the spirit and scope of the disclosure as those skilled in the art readily understand. Such modifications and variations are considered to be within the scope of the disclosure and the appended claims. The protection scope of the disclosure is defined by the accompanying claims.

WHAT IS CLAIMED IS:

1. A method of downlink control information (DCI) transmission in a wireless communication system, the method comprising:

transmitting a DCI configuration parameter to a terminal device; and

transmitting DCI to the terminal device, wherein the DCI configuration parameter indicates time-frequency resources for the DCI.

2. The method of Claim 1, wherein the DCI configuration parameter comprises at least one of:

a numerology to be used;

a valid duration for the DCI configuration parameter;

a duration for a single DCI; and

DCI occurrence occasions.

3. The method of Claim 1 or 2, wherein the DCI configuration parameter comprises at least one of:

a frequency domain resource unit; and

a frequency hopping pattern.

4. The method of any of Claims 1 to 3, wherein the transmitting DCI configuration parameter to a terminal device comprises transmitting the DCI configuration parameter to the terminal device by a higher layer signaling.

5. The method of any of Claims 1 to 4, wherein the transmitting DCI configuration parameter to a terminal device comprises transmitting the DCI configuration parameter to the terminal device dynamically by another DCI.

6. The method of Claim 5, wherein the another DCI has a larger periodicity than the DCI.

7. The method of any of Claims 1 to 6, wherein the DCI configuration parameter comprises at least two sets of parameters, from which the terminal device can select a

set of parameters based on its requested traffic type.

8. A method of downlink control information (DCI) receiving in a wireless communication system, the method comprising:

receiving a DCI configuration parameter at a terminal device; and

receiving DCI within time-frequency resources indicated by the DCI configuration parameter at the terminal device.

9. The method of Claim 8, wherein the DCI configuration parameter comprises at least one of:

a numerology to be used;

a valid duration for the DCI configuration parameters;

a duration for a single DCI;

DCI occurrence occasions;

a frequency domain resource unit; and

a frequency hopping pattern.

10. The method of Claim 8 or 9, wherein the receiving DCI configuration parameter comprises receiving the DCI configuration parameter in a higher layer signaling.

11. The method of any Claims 8 to 10, wherein the receiving DCI configuration parameter comprises receiving the DCI configuration parameter in another DCI.

12. The method of Claim 11, wherein the another DCI has a larger periodicity than the DCI.

13. The method of any of Claims 8 to 12, wherein the DCI configuration parameter comprises at least two sets of parameters, wherein the method further comprises selecting a set of parameters based on a traffic type requested by the terminal device and wherein the time-frequency resources are those indicated by the selected set of parameters.

14. An apparatus of downlink control information (DCI) transmission in a wireless communication system, the apparatus comprising:

a parameter transmission module configured to transmit a DCI configuration parameter to a terminal device; and

a DCI transmission module configured to transmit DCI to the terminal device, wherein the DCI configuration parameter indicates time-frequency resources for the DCI.

15. The apparatus of Claim 14, wherein the DCI configuration parameter comprises at least one of:

a numerology to be used;

a valid duration for the DCI configuration parameter;

a duration for a single DCI;

DCI occurrence occasions;

a frequency domain resource unit; and

a frequency hopping pattern .

16. The apparatus of Claim 14 or 15, wherein the parameter transmission module is further configured to transmit the DCI configuration parameter to the terminal device by a higher layer signaling.

17. The apparatus of any of Claims 14 to 16, wherein the parameter transmission module is further configured to transmit the DCI configuration parameter to the terminal device dynamically by another DCI.

18. The apparatus of Claim 17, wherein the another DCI has a larger periodicity than the DCI.

19. The apparatus of any of Claims 14 to 18, wherein the DCI configuration parameter comprises at least two sets of parameters, from which the terminal device can select a set of parameters based on its requested traffic type.

20. An apparatus of downlink control information (DCI) receiving in a wireless

communication system, the apparatus comprising:

a parameter receiving module configured to receive DCI configuration parameter at a terminal device; and

a DCI receiving module, configured to receive DCI within time-frequency resources indicated by the DCI configuration parameter at the terminal device.

21. The apparatus of Claim 20, wherein the DCI configuration parameter comprises at least one of:

a numerology to be used;

a valid duration for the DCI configuration parameters;

a duration for a single DCI;

DCI occurrence occasions;

a frequency domain resource unit; and

a frequency hopping pattern .

22. The apparatus of Claim 20 or 21, wherein the parameter receiving module is further configured to receive the DCI configuration parameter in a higher layer signaling.

23. The apparatus of any of Claims 20 to 22, wherein the parameter receiving module is further configured to receive the DCI configuration parameter in another DCI.

24. The apparatus of Claim 23, wherein the another DCI has a larger periodicity than the DCI.

25. The apparatus of any of Claims 20 to 24, wherein the DCI configuration parameter comprises at least two sets of parameters, wherein the apparatus further comprises a parameter set selection module, configured to select a set of parameters based on a traffic type requested by the terminal device and wherein the time-frequency resources are those indicated by the selected set of parameters.

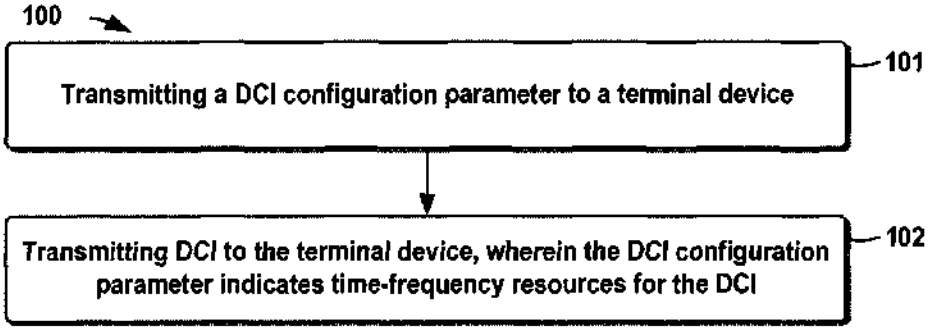


Fig. 1

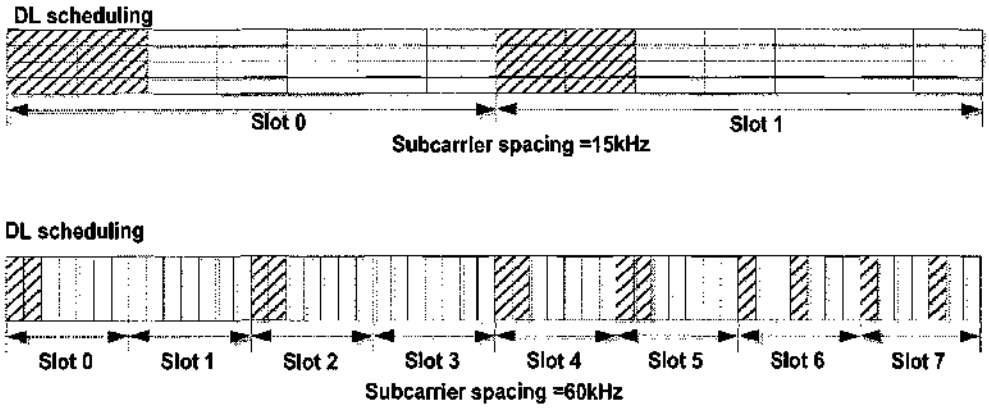


Fig. 2

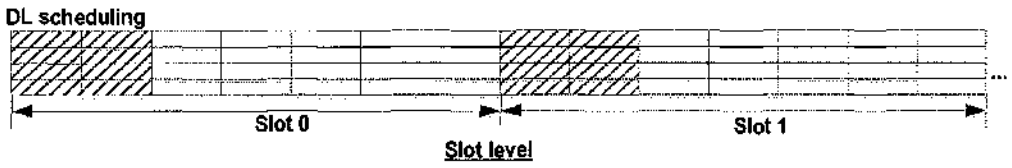


Fig. 3A



Fig. 3B

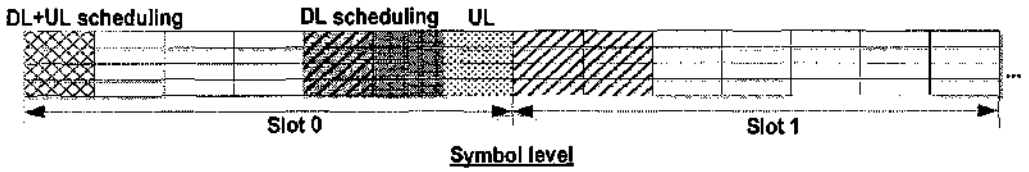


Fig. 3C

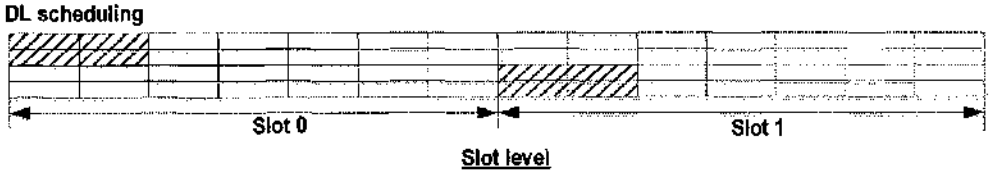


Fig. 4A

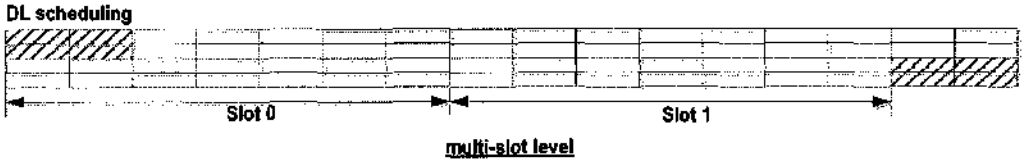


Fig. 4B

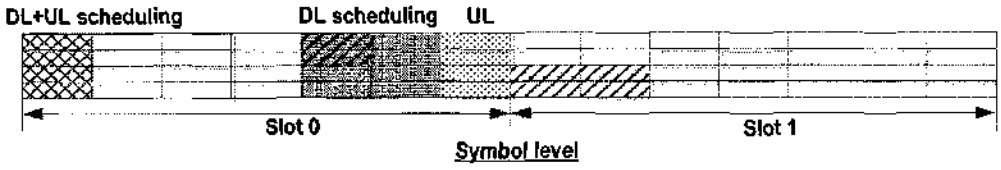


Fig. 4C

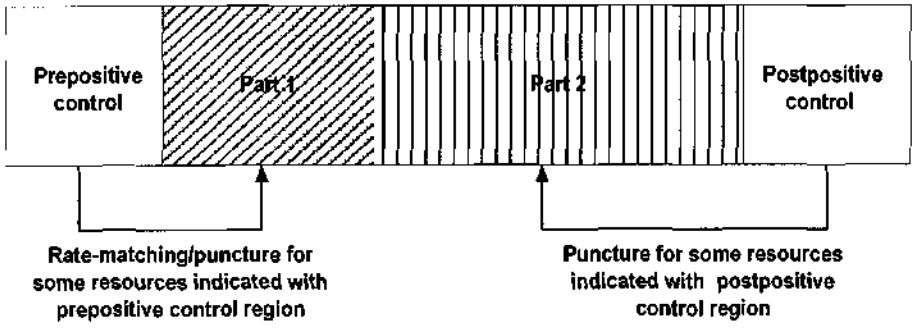


Fig. 5A

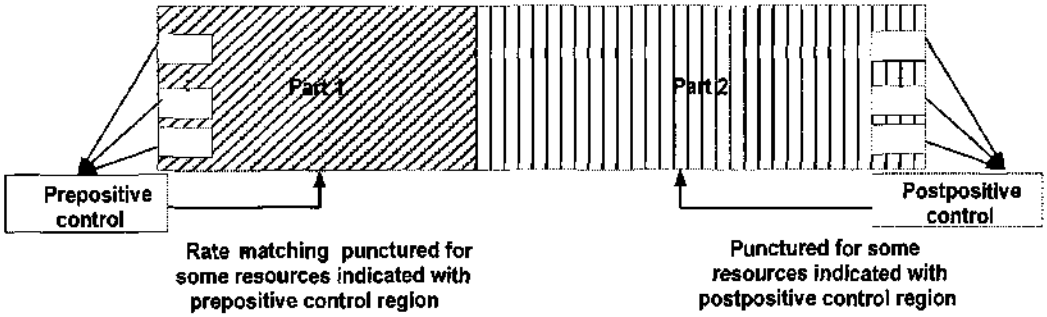
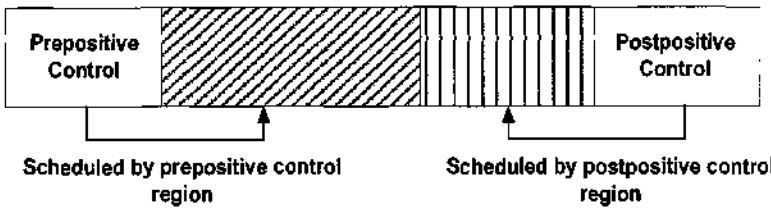
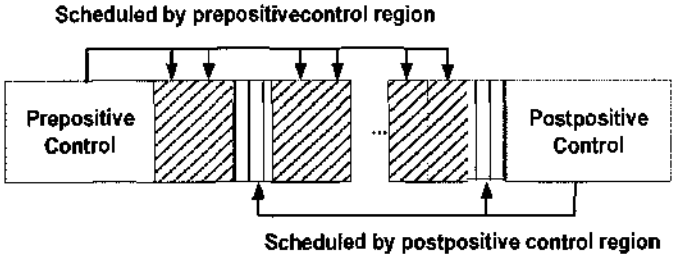


Fig. 5B



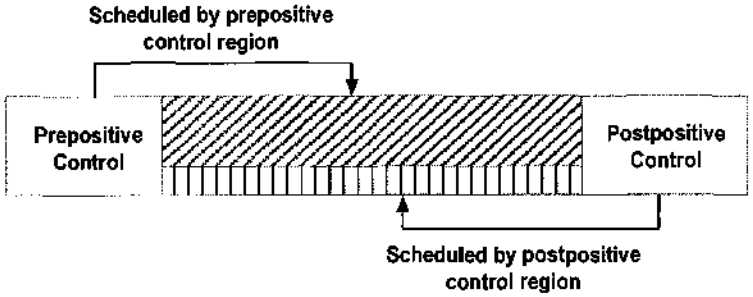
TDM

Fig. 6A



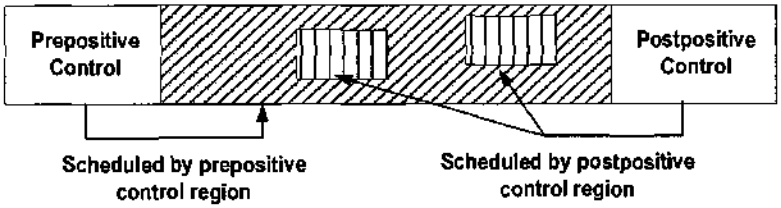
TDM by symbol

Fig. 6B



FDM

Fig. 6C



TDM and FDM

Fig. 6D

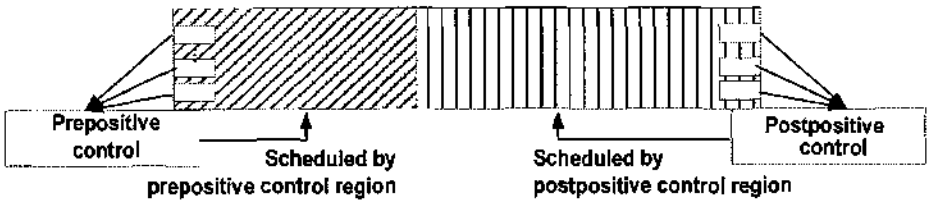


Fig. 7A

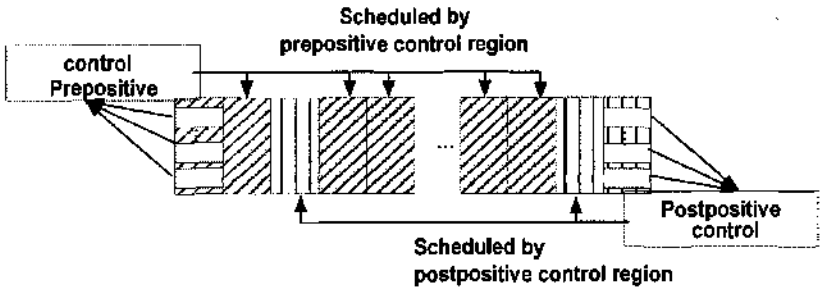


Fig. 7B

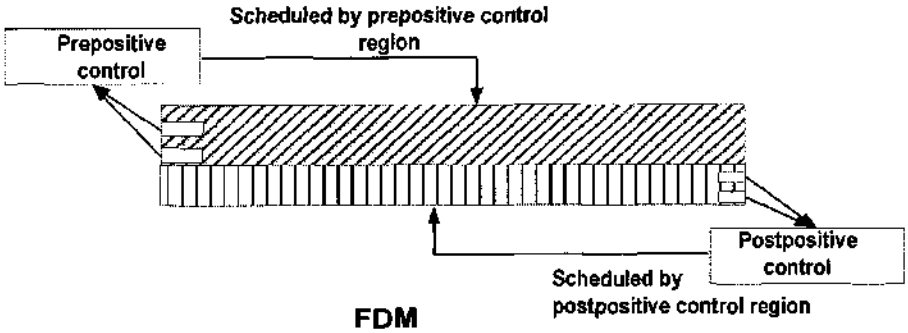
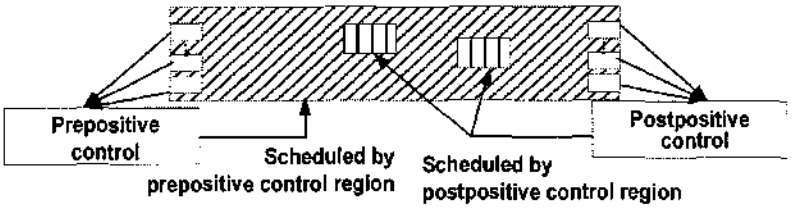


Fig. 7C



TDM and FDM

Fig. 7D

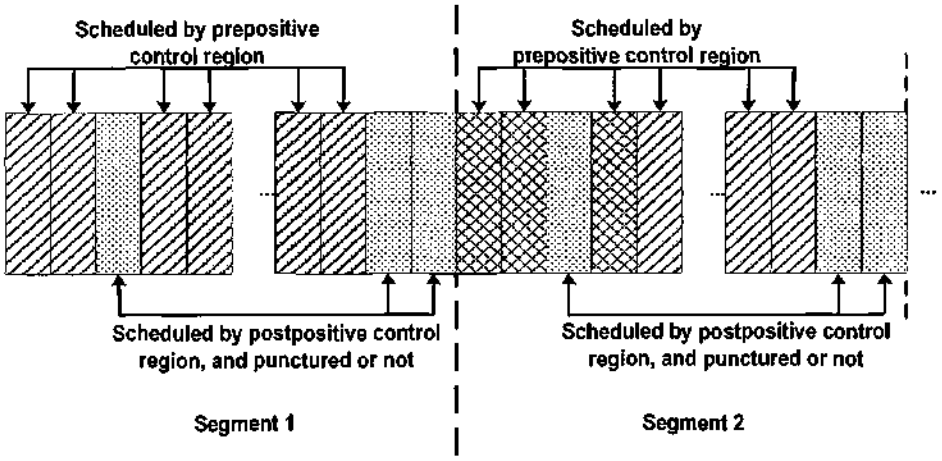


Fig. 8

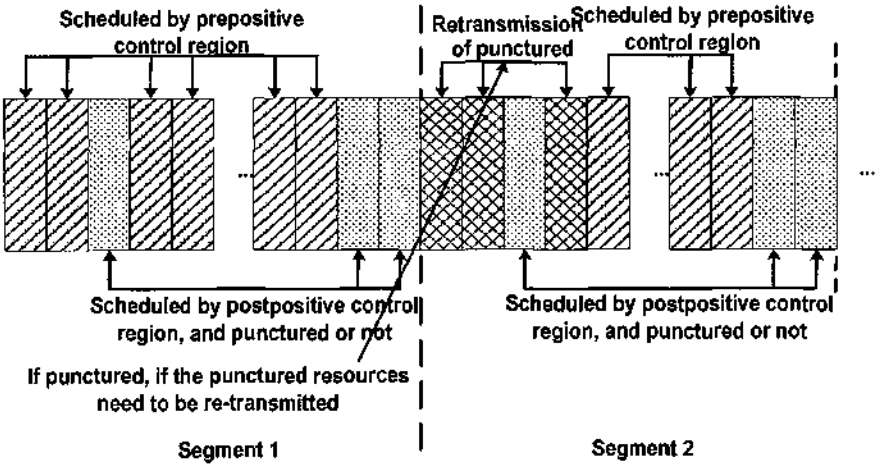


Fig. 9

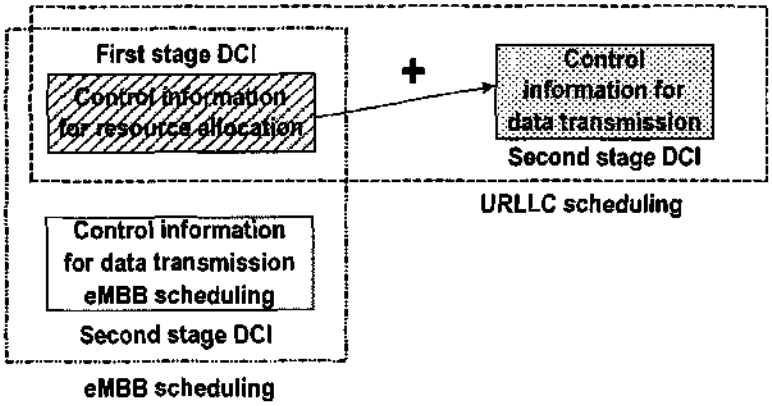


Fig. 10

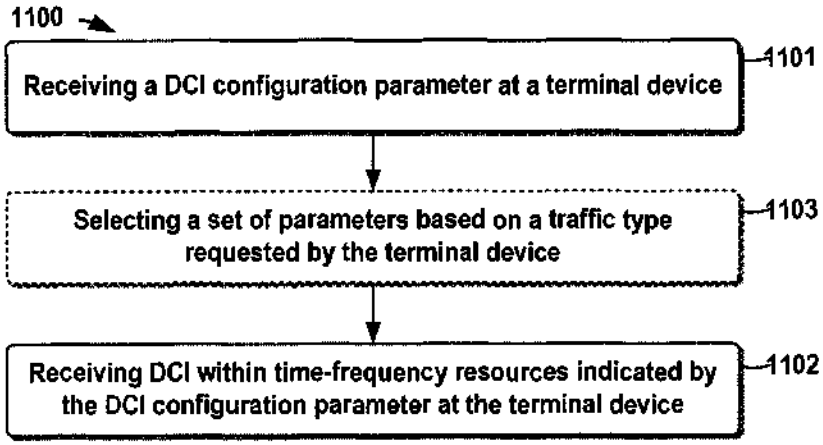


Fig. 11

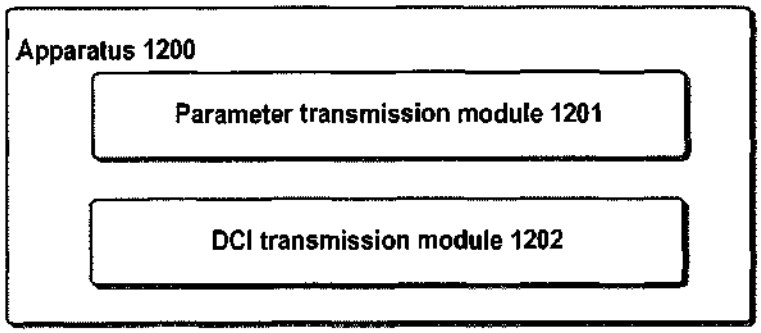


Fig. 12

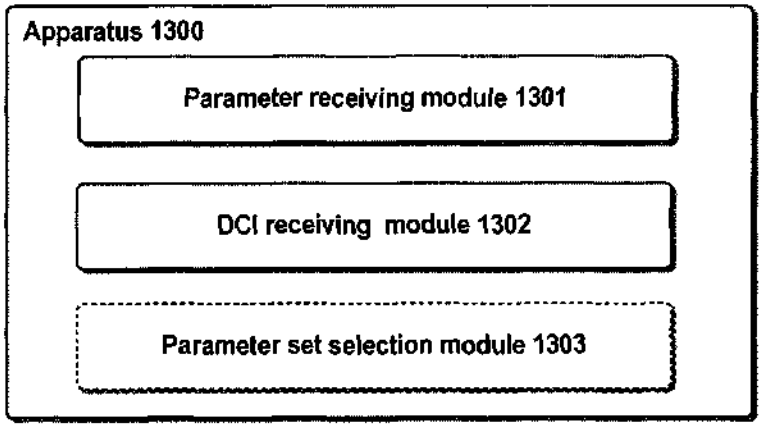

Apparatus 1300
Parameter receiving module 1301
DCI receiving module 1302
Parameter set selection module 1303

Fig. 13

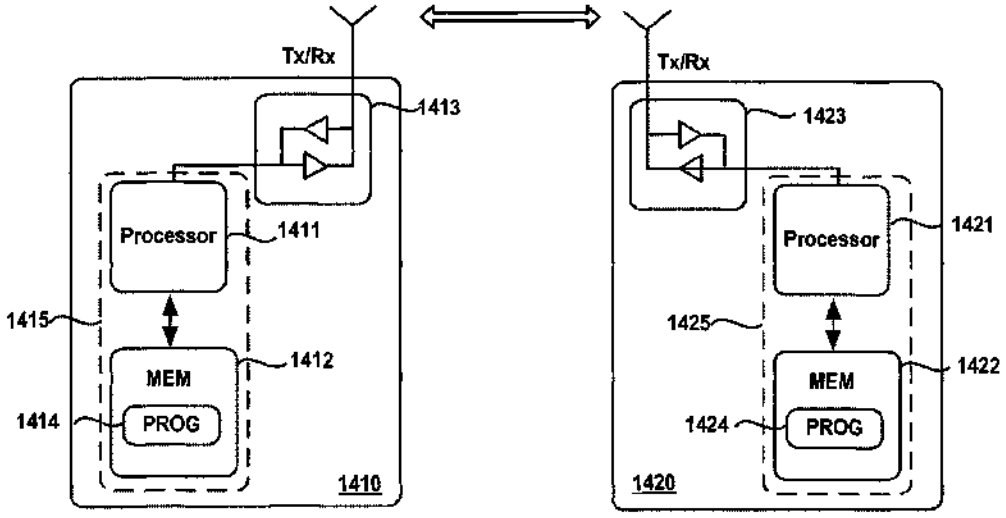

Tx/Rx
1413
Processor
1411
1415
MEM
1412
1414
PROG
1410
Tx/Rx
1423
Processor
1421
1425
MEM
1422
1424
PROG
1420

Fig. 14

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2017/070309

A. CLASSIFICATION OF SUBJECT MATTER

H04L 27/26(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04L,H04W,H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI,EPODOC,CNPAT,CNKI:downlink w control w information, DCI, configur+, parameter, time, frequency, resource+, indicat +, UE, user, transmit+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 106161312 A (CHINA MOBILE COMMUNICATIONS CORPORATION) 23 November 2016 (2016-11-23) description, paragraphs [0001], [0159]-[0166], [0217]-[0232]	1-25
A	CN 103095396 A (CHINA MOBILE COMMUNICATIONS CORPORATION) 08 May 2013 (2013-05-08) the whole document	1-25
A	US 2016345311 A1 (QUALCOMM INCORPORATED) 24 November 2016 (2016-11-24) the whole document	1-25
A	US 2016380737 A1 (LG ELECTRONICS INC.) 29 December 2016 (2016-12-29) the whole document	1-25

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particnlar relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
08 August 2017	**06 September 2017**

Name and mailing address of the ISA/CN	Authorized officer
STATE INTELLECTUAL PROPERTY OFFICE OF THE P.R.CHINA **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088** **China**	**ZUO,Linzi**
Facsimile No. **(86-10)62019451**	Telephone No. **(86-10)62413344**

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2017/070309

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	106161312	A	23 November 2016	WO	2016150224	A1	29 September 2016
CN	103095396	A	08 May 2013		无		
US	2016345311	A1	24 November 2016	WO	2016190970	A1	01 December 2016
US	2016380737	A1	29 December 2016	KR	101525746	B1	03 June 2015
				US	2015215095	A1	30 July 2015

Form PCT/ISA/210 (patent family annex) (July 2009)

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(74) Agent: **CHINA SINDA INTELLECTUAL PROPERTY LTD.**; B11th Floor, Focus Place, 19 Financial Street, Xicheng District, Beijing 100033 (CN).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK,

(54) Title: TRANSMITTING A BEAM RECOVERY REQUEST

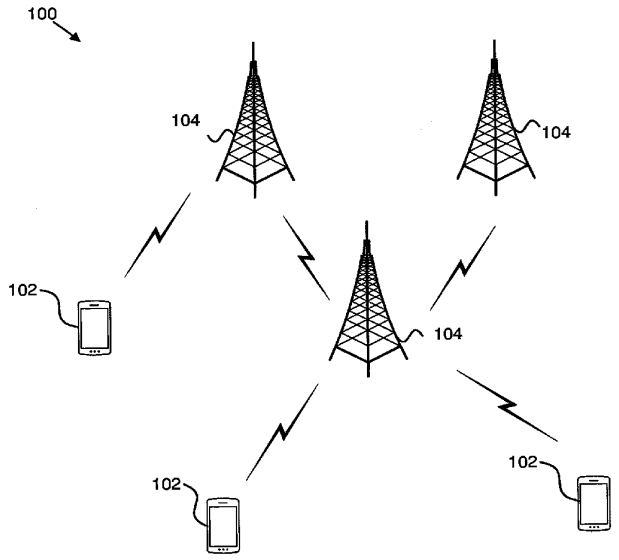


FIG. 1

(57) Abstract: Apparatuses, methods, and systems are disclosed for transmitting a beam recovery request. One apparatus (200) includes a receiver (212) that receives (402) information indicating a resource configured for a beam recovery request. The apparatus (200) includes a transmitter (210) that transmits (404) the beam recovery request on the resource in response to a first trigger condition.

[Continued on next page]

WO 2018/227464 A1

EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

TRANSMITTING A BEAM RECOVERY REQUEST

FIELD

[0001] The subject matter disclosed herein relates generally to wireless communications and more particularly relates to transmitting a beam recovery request.

BACKGROUND

[0002] The following abbreviations are herewith defined, at least some of which are referred to within the following description: Third Generation Partnership Project ("3GPP"), Positive-Acknowledgment ("ACK"), Binary Phase Shift Keying ("BPSK"), Clear Channel Assessment ("CCA"), Cyclic Prefix ("CP"), Cyclical Redundancy Check ("CRC"), Channel State Information ("CSI"), Common Search Space ("CSS"), Discrete Fourier Transform Spread ("DFTS"), Downlink Control Information ("DCI"), Downlink ("DL"), Downlink Pilot Time Slot ("DwPTS"), Enhanced Clear Channel Assessment ("eCCA"), Enhanced Mobile Broadband ("eMBB"), Evolved Node B ("eNB"), European Telecommunications Standards Institute ("ETSI"), Frame Based Equipment ("FBE"), Frequency Division Duplex ("FDD"), Frequency Division Multiple Access ("FDMA"), Guard Period ("GP"), Hybrid Automatic Repeat Request ("HARQ"), Internet-of-Things ("IoT"), Licensed Assisted Access ("LAA"), Load Based Equipment ("LBE"), Listen-Before-Talk ("LBT"), Long Term Evolution ("LTE"), Multiple Access ("MA"), Modulation Coding Scheme ("MCS"), Machine Type Communication ("MTC"), Multiple Input Multiple Output ("MIMO"), Multi User Shared Access ("MUSA"), Narrowband ("NB"), Negative-Acknowledgment ("NACK") or ("NAK"), Next Generation Node B ("gNB"), Non-Orthogonal Multiple Access ("NOMA"), Orthogonal Frequency Division Multiplexing ("OFDM"), Primary Cell ("PCell"), Physical Broadcast Channel ("PBCH"), Physical Downlink Control Channel ("PDCCH"), Physical Downlink Shared Channel ("PDSCH"), Pattern Division Multiple Access ("PDMA"), Physical Hybrid ARQ Indicator Channel ("PHICH"), Physical Random Access Channel ("PRACH"), Physical Resource Block ("PRB"), Physical Uplink Control Channel ("PUCCH"), Physical Uplink Shared Channel ("PUSCH"), Quality of Service ("QoS"), Quadrature Phase Shift Keying ("QPSK"), Radio Resource Control ("RRC"), Random Access Procedure ("RACH"), Random Access Response ("RAR"), Radio Network Temporary Identifier ("RNTI"), Reference Signal ("RS"), Resource Spread Multiple Access ("RSMA"), Round Trip Time ("RTT"), Receive ("RX"), Sparse Code Multiple Access ("SCMA"), Scheduling Request ("SR"), Single Carrier Frequency Division Multiple Access ("SC-FDMA"), Secondary Cell ("SCell"), Shared Channel ("SCH"), Signal-to-Interference-Plus-Noise Ratio ("SINR"), System Information Block ("SIB"), Transport Block ("TB"), Transport Block Size

("TBS"), Time-Division Duplex ("TDD"), Time Division Multiplex ("TDM"), Transmission Time Interval ("TTI"), Transmit ("TX"), Uplink Control Information ("UCI"), User Entity/Equipment (Mobile Terminal) ("UE"), Uplink ("UL"), Universal Mobile Telecommunications System ("UMTS"), Uplink Pilot Time Slot ("UpPTS"), Ultra-reliability and Low-latency Communications ("URLLC"), and Worldwide Interoperability for Microwave Access ("WiMAX"). As used herein, "HARQ-ACK" may represent collectively the Positive Acknowledge ("ACK") and the Negative Acknowledge ("NACK"). ACK means that a TB is correctly received while NACK (or NAK) means a TB is erroneously received.

[0003] In certain wireless communications networks, a beam quality may be degraded. In such configurations, a beam recovery may need to occur.

BRIEF SUMMARY

[0004] Apparatuses for transmitting a beam recovery request are disclosed. Methods and systems also perform the functions of the apparatus. In one embodiment, the apparatus includes a receiver that receives information indicating a resource configured for a beam recovery request. In some embodiments, the apparatus includes a transmitter that transmits the beam recovery request on the resource in response to a first trigger condition.

[0005] In one embodiment, the first trigger condition includes a medium access control layer receiving a number of out-of-sync indications from a physical layer. In a further embodiment, the number of out-of-sync indications is configured by radio resource control signaling. In certain embodiments, the resource configured for the beam recovery request is configured by radio resource control signaling. In various embodiments, the resource configured for the beam recovery request is enabled for use in response to the resource being configured by the radio resource control signaling. In some embodiments, the resource configured for the beam recovery request is enabled for use in response to the resource being activated by a medium access control control element.

[0006] In certain embodiments, the apparatus includes a processor that selects a first available resource to transmit the beam recovery request in response to a contention-free resource and a physical uplink control channel resource being available for transmission of the beam recovery request. In some embodiments, the apparatus includes a processor that selects a physical uplink control channel resource to transmit the beam recovery request in response to a contention-free resource and the physical uplink control channel resource being available for transmission of the beam recovery request and in response to the physical uplink control channel resource having a channel quality greater than a predetermined threshold. In various embodiments, the apparatus includes a processor that selects a physical random access channel

resource to transmit the beam recovery request in response to the physical uplink control channel resource having the channel quality less than the predetermined threshold.

[0007] In one embodiment, the apparatus includes a processor that monitors for a response to transmission of the beam recovery request for a predetermined time in response to transmitting the beam recovery request using a physical random access channel resource and skips a physical uplink control channel resource for the beam recovery request during the predetermined time. In certain embodiments, the apparatus includes a processor that skips a physical random access channel resource for the beam recovery request in response to transmitting the beam recovery request using a physical uplink control channel resource. In some embodiments, the apparatus includes a processor that selects a contention based resource to transmit the beam recovery request in response to a contention-free resource and a physical uplink control channel resource being unavailable for transmission of the beam recovery request. In various embodiments, the apparatus includes a processor that selects the resource to transmit the beam recovery request based on a measurement result and an association between a downlink transmission beam and a physical uplink control channel resource.

[0008] In some embodiments, the association between the downlink transmission beam and the physical uplink control channel resource is configured by radio resource control signaling. In certain embodiments, the measurement result is based on a channel state information reference signal in response to the channel state information reference signal being configured by a base unit. In various embodiments, the measurement result is based on a synchronization signal block in response to a channel state information reference signal not being configured by a base unit. In one embodiment, the apparatus includes a processor that performs a beam measurement to determine the measurement result in response to a second trigger condition. In some embodiments, the second trigger condition includes a quality of a serving beam being less than a predetermined threshold, a number of out-of-sync indications from a physical layer, or some combination thereof. In certain embodiments, the predetermined threshold and the number are configured by radio resource control signaling. In various embodiments, the apparatus includes a processor that starts a timer in response to the first trigger condition. In various embodiments, the processor enters radio link failure in response to the timer expiring. In one embodiment, the processor stops the timer in response to receiving a response to the transmission of the beam recovery request.

[0009] A method for transmitting a beam recovery request, in one embodiment, includes receiving information indicating a resource configured for a beam recovery request. In some

embodiments, the method includes transmitting the beam recovery request on the resource in response to a first trigger condition.

[0010] In one embodiment, an apparatus for receiving a beam recovery request includes a transmitter that transmits information indicating a resource configured for a beam recovery request. In some embodiments, the apparatus includes a receiver that receives the beam recovery request on the resource.

[0011] In certain embodiments, the resource configured for the beam recovery request is configured by radio resource control signaling. In various embodiments, the resource configured for the beam recovery request is enabled for use in response to the resource being configured by the radio resource control signaling. In some embodiments, the resource configured for the beam recovery request is enabled for use in response to the resource being activated by a medium access control control element.

[0012] In certain embodiments, a first available resource is selected to transmit the beam recovery request in response to a contention-free resource and a physical uplink control channel resource being available for transmission of the beam recovery request. In some embodiments, a physical uplink control channel resource is selected to transmit the beam recovery request in response to a contention-free resource and the physical uplink control channel resource being available for transmission of the beam recovery request and in response to the physical uplink control channel resource having a channel quality greater than a predetermined threshold. In various embodiments, a physical random access channel resource is selected to transmit the beam recovery request in response to the physical uplink control channel resource having the channel quality less than the predetermined threshold.

[0013] In one embodiment, the transmitter transmits a response to the beam recovery request. In certain embodiments, a physical random access channel resource for the beam recovery request is skipped in response to the beam recovery request being transmitting using a physical uplink control channel resource. In some embodiments, a contention based resource is selected to transmit the beam recovery request in response to a contention-free resource and a physical uplink control channel resource being unavailable for transmission of the beam recovery request.

[0014] In various embodiments, the resource to transmit the beam recovery request is selected based on a measurement result and an association between a downlink transmission beam and a physical uplink control channel resource. In certain embodiments, the association between the downlink transmission beam and the physical uplink control channel resource is configured by radio resource control signaling. In some embodiments, the measurement result is

based on a channel state information reference signal in response to the channel state information reference signal being configured by a base unit. In one embodiment, the measurement result is based on a synchronization signal block in response to a channel state information reference signal not being configured by a base unit.

[0015] In various embodiments, a beam measurement is performed to determine the measurement result in response to a second trigger condition. In certain embodiments, the second trigger condition includes a quality of a serving beam being less than a predetermined threshold, a number of out-of-sync indications from a physical layer, or some combination thereof. In some embodiments, the predetermined threshold and the number are configured by radio resource control signaling. In one embodiment, a timer is started in response to the first trigger condition. In various embodiments, radio link failure is entered in response to the timer expiring. In certain embodiments, the timer is stopped in response to transmitting a response to receiving the beam recovery request.

[0016] A method for receiving a beam recovery request, in one embodiment, includes transmitting information indicating a resource configured for a beam recovery request. In certain embodiments, the method includes receiving the beam recovery request on the resource.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] A more particular description of the embodiments briefly described above will be rendered by reference to specific embodiments that are illustrated in the appended drawings. Understanding that these drawings depict only some embodiments and are not therefore to be considered to be limiting of scope, the embodiments will be described and explained with additional specificity and detail through the use of the accompanying drawings, in which:

[0018] Figure 1 is a schematic block diagram illustrating one embodiment of a wireless communication system for transmitting and/or receiving a beam recovery request;

[0019] Figure 2 is a schematic block diagram illustrating one embodiment of an apparatus that may be used for transmitting a beam recovery request;

[0020] Figure 3 is a schematic block diagram illustrating one embodiment of an apparatus that may be used for receiving a beam recovery request;

[0021] Figure 4 is a schematic flow chart diagram illustrating one embodiment of a method for transmitting a beam recovery request; and

[0022] Figure 5 is a schematic flow chart diagram illustrating one embodiment of a method for receiving a beam recovery request.

DETAILED DESCRIPTION

[0023] As will be appreciated by one skilled in the art, aspects of the embodiments may be embodied as a system, apparatus, method, or program product. Accordingly, embodiments may take the form of an entirely hardware embodiment, an entirely software embodiment (including firmware, resident software, micro-code, etc.) or an embodiment combining software and hardware aspects that may all generally be referred to herein as a "circuit," "module" or "system." Furthermore, embodiments may take the form of a program product embodied in one or more computer readable storage devices storing machine readable code, computer readable code, and/or program code, referred hereafter as code. The storage devices may be tangible, non-transitory, and/or non-transmission. The storage devices may not embody signals. In a certain embodiment, the storage devices only employ signals for accessing code.

[0024] Certain of the functional units described in this specification may be labeled as modules, in order to more particularly emphasize their implementation independence. For example, a module may be implemented as a hardware circuit comprising custom very-large-scale integration ("VLSI") circuits or gate arrays, off-the-shelf semiconductors such as logic chips, transistors, or other discrete components. A module may also be implemented in programmable hardware devices such as field programmable gate arrays, programmable array logic, programmable logic devices or the like.

[0025] Modules may also be implemented in code and/or software for execution by various types of processors. An identified module of code may, for instance, include one or more physical or logical blocks of executable code which may, for instance, be organized as an object, procedure, or function. Nevertheless, the executables of an identified module need not be physically located together, but may include disparate instructions stored in different locations which, when joined logically together, include the module and achieve the stated purpose for the module.

[0026] Indeed, a module of code may be a single instruction, or many instructions, and may even be distributed over several different code segments, among different programs, and across several memory devices. Similarly, operational data may be identified and illustrated herein within modules, and may be embodied in any suitable form and organized within any suitable type of data structure. The operational data may be collected as a single data set, or may be distributed over different locations including over different computer readable storage devices. Where a module or portions of a module are implemented in software, the software portions are stored on one or more computer readable storage devices.

[0027] Any combination of one or more computer readable medium may be utilized. The computer readable medium may be a computer readable storage medium. The computer readable storage medium may be a storage device storing the code. The storage device may be, for example, but not limited to, an electronic, magnetic, optical, electromagnetic, infrared, holographic, micromechanical, or semiconductor system, apparatus, or device, or any suitable combination of the foregoing.

[0028] More specific examples (a non-exhaustive list) of the storage device would include the following: an electrical connection having one or more wires, a portable computer diskette, a hard disk, a random access memory ("RAM"), a read-only memory ("ROM"), an erasable programmable read-only memory ("EPROM" or Flash memory), a portable compact disc read-only memory ("CD-ROM"), an optical storage device, a magnetic storage device, or any suitable combination of the foregoing. In the context of this document, a computer readable storage medium may be any tangible medium that can contain, or store a program for use by or in connection with an instruction execution system, apparatus, or device.

[0029] Code for carrying out operations for embodiments may be any number of lines and may be written in any combination of one or more programming languages including an object oriented programming language such as Python, Ruby, Java, Smalltalk, C++, or the like, and conventional procedural programming languages, such as the "C" programming language, or the like, and/or machine languages such as assembly languages. The code may execute entirely on the user's computer, partly on the user's computer, as a stand-alone software package, partly on the user's computer and partly on a remote computer or entirely on the remote computer or server. In the latter scenario, the remote computer may be connected to the user's computer through any type of network, including a local area network ("LAN") or a wide area network ("WAN"), or the connection may be made to an external computer (for example, through the Internet using an Internet Service Provider).

[0030] Reference throughout this specification to "one embodiment," "an embodiment," or similar language means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment. Thus, appearances of the phrases "in one embodiment," "in an embodiment," and similar language throughout this specification may, but do not necessarily, all refer to the same embodiment, but mean "one or more but not all embodiments" unless expressly specified otherwise. The terms "including," "comprising," "having," and variations thereof mean "including but not limited to," unless expressly specified otherwise. An enumerated listing of items does not imply that any or all of

the items are mutually exclusive, unless expressly specified otherwise. The terms "a," "an," and "the" also refer to "one or more" unless expressly specified otherwise.

[0031] Furthermore, the described features, structures, or characteristics of the embodiments may be combined in any suitable manner. In the following description, numerous specific details are provided, such as examples of programming, software modules, user selections, network transactions, database queries, database structures, hardware modules, hardware circuits, hardware chips, etc., to provide a thorough understanding of embodiments. One skilled in the relevant art will recognize, however, that embodiments may be practiced without one or more of the specific details, or with other methods, components, materials, and so forth. In other instances, well-known structures, materials, or operations are not shown or described in detail to avoid obscuring aspects of an embodiment.

[0032] Aspects of the embodiments are described below with reference to schematic flowchart diagrams and/or schematic block diagrams of methods, apparatuses, systems, and program products according to embodiments. It will be understood that each block of the schematic flowchart diagrams and/or schematic block diagrams, and combinations of blocks in the schematic flowchart diagrams and/or schematic block diagrams, can be implemented by code. The code may be provided to a processor of a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions/acts specified in the schematic flowchart diagrams and/or schematic block diagrams block or blocks.

[0033] The code may also be stored in a storage device that can direct a computer, other programmable data processing apparatus, or other devices to function in a particular manner, such that the instructions stored in the storage device produce an article of manufacture including instructions which implement the function/act specified in the schematic flowchart diagrams and/or schematic block diagrams block or blocks.

[0034] The code may also be loaded onto a computer, other programmable data processing apparatus, or other devices to cause a series of operational steps to be performed on the computer, other programmable apparatus or other devices to produce a computer implemented process such that the code which execute on the computer or other programmable apparatus provide processes for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

[0035] The schematic flowchart diagrams and/or schematic block diagrams in the Figures illustrate the architecture, functionality, and operation of possible implementations of

apparatuses, systems, methods and program products according to various embodiments. In this regard, each block in the schematic flowchart diagrams and/or schematic block diagrams may represent a module, segment, or portion of code, which includes one or more executable instructions of the code for implementing the specified logical function(s).

[0036] It should also be noted that, in some alternative implementations, the functions noted in the block may occur out of the order noted in the Figures. For example, two blocks shown in succession may, in fact, be executed substantially concurrently, or the blocks may sometimes be executed in the reverse order, depending upon the functionality involved. Other steps and methods may be conceived that are equivalent in function, logic, or effect to one or more blocks, or portions thereof, of the illustrated Figures.

[0037] Although various arrow types and line types may be employed in the flowchart and/or block diagrams, they are understood not to limit the scope of the corresponding embodiments. Indeed, some arrows or other connectors may be used to indicate only the logical flow of the depicted embodiment. For instance, an arrow may indicate a waiting or monitoring period of unspecified duration between enumerated steps of the depicted embodiment. It will also be noted that each block of the block diagrams and/or flowchart diagrams, and combinations of blocks in the block diagrams and/or flowchart diagrams, can be implemented by special purpose hardware-based systems that perform the specified functions or acts, or combinations of special purpose hardware and code.

[0038] The description of elements in each figure may refer to elements of proceeding figures. Like numbers refer to like elements in all figures, including alternate embodiments of like elements.

[0039] Figure 1 depicts an embodiment of a wireless communication system 100 for transmitting and/or receiving a beam recovery request. In one embodiment, the wireless communication system 100 includes remote units 102 and base units 104. Even though a specific number of remote units 102 and base units 104 are depicted in Figure 1, one of skill in the art will recognize that any number of remote units 102 and base units 104 may be included in the wireless communication system 100.

[0040] In one embodiment, the remote units 102 may include computing devices, such as desktop computers, laptop computers, personal digital assistants ("PDAs"), tablet computers, smart phones, smart televisions (e.g., televisions connected to the Internet), set-top boxes, game consoles, security systems (including security cameras), vehicle on-board computers, network devices (e.g., routers, switches, modems), or the like. In some embodiments, the remote units 102 include wearable devices, such as smart watches, fitness bands, optical head-mounted

displays, or the like. Moreover, the remote units 102 may be referred to as subscriber units, mobiles, mobile stations, users, terminals, mobile terminals, fixed terminals, subscriber stations, UE, user terminals, a device, or by other terminology used in the art. The remote units 102 may communicate directly with one or more of the base units 104 via UL communication signals.

[0041] The base units 104 may be distributed over a geographic region. In certain embodiments, a base unit 104 may also be referred to as an access point, an access terminal, a base, a base station, a Node-B, an eNB, a gNB, a Home Node-B, a relay node, a device, or by any other terminology used in the art. The base units 104 are generally part of a radio access network that includes one or more controllers communicably coupled to one or more corresponding base units 104. The radio access network is generally communicably coupled to one or more core networks, which may be coupled to other networks, like the Internet and public switched telephone networks, among other networks. These and other elements of radio access and core networks are not illustrated but are well known generally by those having ordinary skill in the art.

[0042] In one implementation, the wireless communication system 100 is compliant with the 3GPP protocol, wherein the base unit 104 transmits using an OFDM modulation scheme on the DL and the remote units 102 transmit on the UL using a SC-FDMA scheme or an OFDM scheme. More generally, however, the wireless communication system 100 may implement some other open or proprietary communication protocol, for example, WiMAX, among other protocols. The present disclosure is not intended to be limited to the implementation of any particular wireless communication system architecture or protocol.

[0043] The base units 104 may serve a number of remote units 102 within a serving area, for example, a cell or a cell sector via a wireless communication link. The base units 104 transmit DL communication signals to serve the remote units 102 in the time, frequency, and/or spatial domain.

[0044] In one embodiment, a remote unit 102 may receive information indicating a resource configured for a beam recovery request. In some embodiments, the remote unit 102 may transmit the beam recovery request on the resource in response to a first trigger condition. Accordingly, a remote unit 102 may be used for transmitting a beam recovery request.

[0045] In certain embodiments, a base unit 104 may transmit information indicating a resource configured for a beam recovery request. In certain embodiments, the base unit 104 may receive the beam recovery request on the resource in response to a first trigger condition. Accordingly, a base unit 104 may be used for receiving a beam recovery request.

[0046] Figure 2 depicts one embodiment of an apparatus 200 that may be used for transmitting a beam recovery request. The apparatus 200 includes one embodiment of the remote unit 102. Furthermore, the remote unit 102 may include a processor 202, a memory 204, an input device 206, a display 208, a transmitter 210, and a receiver 212. In some embodiments, the input device 206 and the display 208 are combined into a single device, such as a touchscreen. In certain embodiments, the remote unit 102 may not include any input device 206 and/or display 208. In various embodiments, the remote unit 102 may include one or more of the processor 202, the memory 204, the transmitter 210, and the receiver 212, and may not include the input device 206 and/or the display 208.

[0047] The processor 202, in one embodiment, may include any known controller capable of executing computer-readable instructions and/or capable of performing logical operations. For example, the processor 202 may be a microcontroller, a microprocessor, a central processing unit ("CPU"), a graphics processing unit ("GPU"), an auxiliary processing unit, a field programmable gate array ("FPGA"), or similar programmable controller. In some embodiments, the processor 202 executes instructions stored in the memory 204 to perform the methods and routines described herein. The processor 202 is communicatively coupled to the memory 204, the input device 206, the display 208, the transmitter 210, and the receiver 212.

[0048] The memory 204, in one embodiment, is a computer readable storage medium. In some embodiments, the memory 204 includes volatile computer storage media. For example, the memory 204 may include a RAM, including dynamic RAM ("DRAM"), synchronous dynamic RAM ("SDRAM"), and/or static RAM ("SRAM"). In some embodiments, the memory 204 includes non-volatile computer storage media. For example, the memory 204 may include a hard disk drive, a flash memory, or any other suitable non-volatile computer storage device. In some embodiments, the memory 204 includes both volatile and non-volatile computer storage media. In some embodiments, the memory 204 stores data relating to beam recovery requests. In some embodiments, the memory 204 also stores program code and related data, such as an operating system or other controller algorithms operating on the remote unit 102.

[0049] The input device 206, in one embodiment, may include any known computer input device including a touch panel, a button, a keyboard, a stylus, a microphone, or the like. In some embodiments, the input device 206 may be integrated with the display 208, for example, as a touchscreen or similar touch-sensitive display. In some embodiments, the input device 206 includes a touchscreen such that text may be input using a virtual keyboard displayed on the touchscreen and/or by handwriting on the touchscreen. In some embodiments, the input device 206 includes two or more different devices, such as a keyboard and a touch panel.

[0050] The display 208, in one embodiment, may include any known electronically controllable display or display device. The display 208 may be designed to output visual, audible, and/or haptic signals. In some embodiments, the display 208 includes an electronic display capable of outputting visual data to a user. For example, the display 208 may include, but is not limited to, an LCD display, an LED display, an OLED display, a projector, or similar display device capable of outputting images, text, or the like to a user. As another, non-limiting, example, the display 208 may include a wearable display such as a smart watch, smart glasses, a heads-up display, or the like. Further, the display 208 may be a component of a smart phone, a personal digital assistant, a television, a table computer, a notebook (laptop) computer, a personal computer, a vehicle dashboard, or the like.

[0051] In certain embodiments, the display 208 includes one or more speakers for producing sound. For example, the display 208 may produce an audible alert or notification (e.g., a beep or chime). In some embodiments, the display 208 includes one or more haptic devices for producing vibrations, motion, or other haptic feedback. In some embodiments, all or portions of the display 208 may be integrated with the input device 206. For example, the input device 206 and display 208 may form a touchscreen or similar touch-sensitive display. In other embodiments, the display 208 may be located near the input device 206.

[0052] The transmitter 210 is used to provide UL communication signals to the base unit 104 and the receiver 212 is used to receive DL communication signals from the base unit 104. In certain embodiments, the receiver 212 may be used to receive information indicating a resource configured for a beam recovery request. In various embodiments, the transmitter 210 may be used to transmit the beam recovery request on the resource in response to a first trigger condition. Although only one transmitter 210 and one receiver 212 are illustrated, the remote unit 102 may have any suitable number of transmitters 210 and receivers 212. The transmitter 210 and the receiver 212 may be any suitable type of transmitters and receivers. In one embodiment, the transmitter 210 and the receiver 212 may be part of a transceiver.

[0053] In some embodiments, transmitting a beam recovery request (e.g., a beam failure recovery procedure) may be performed using various steps that may be performed in any suitable order and/or some steps may not be performed.

[0054] In a first step, a base unit 104 may configure a remote unit 102 with various information. In one embodiment, in response to the remote unit 102 being configured with a channel state information reference signal ("CSI-RS"), the information may include that the CSI-RS is used to determine a beam failure. In another embodiment, in response to the remote unit 102 not being configured is a CSI-RS, the information may include that a synchronization signal

block ("SS-block") may be used to determine a beam failure. In some embodiments, resources for UL transmission of a beam recovery request may be configured by RRC signaling. In certain embodiments, the information may include a trigger condition to transmit a beam failure recovery request. In various embodiments, the trigger condition may be that a medium access control ("MAC") layer receives a number (e.g., "N") of out-of-sync indications from a physical layer. In one embodiment, the number of out-of-sync indications may be configured by RRC signaling. As used herein, an "out-of-sync indication" may refer to feedback, a response, an indication, and/or a signal that contains information indicating that there is no synchronization between data being received and a device decoding the data being received. In some embodiments, the information may include a trigger condition to identify a candidate DL TX beam. In various embodiments, the trigger condition may include that a serving beam quality becomes worse than a configured and/or predetermined threshold. In certain embodiments, the trigger condition may include that a number ("e.g., "M") of out-of-sync indications are received in a physical layer.

[0055] In a second step, the remote unit 102 may report measurement results periodically to the base unit 104. The report measurement results may include results corresponding to a serving beam.

[0056] In a third step, the base unit 104 may activate a dedicated UL resource for transmitting a beam recovery request based on the measurement results. In some embodiments, the dedicated UL resource may be activated by a MAC control element ("CE"). In one embodiment, the base unit 104 may configure the dedicted UL resource for the remote unit 102 to transmit the beam recovery request using RRC signaling. In such an embodiment, the remote unit 102 may be enabled to use the dedicted UL resource in response to receiving configuration information indicating the dedicated UL resource. In another embodiment, the remote unit 102 may be enabled to use the dedicated UL resource in response to the base unit 104 activating the dedicated UL resource via the MAC CE.

[0057] In a fourth step, an event that triggers a beam failure recovery request may be detected by the remote unit 102. In response to the event triggering the beam failure recovery request for a last active beam, the MAC of the remote unit 102 may start a timer ("T1"). In response to the timer expiring, the remote unit 102 may enter a radio link failure ("RLF") condition. In some embodiments, the timer may stop in response to the remote unit 102 receiving a response to the beam failure recovery request.

[0058] In a fifth step, the remote unit 102 may transmit a beam recovery request to the base unit 104. In some embodiments, a base unit 104 may configure an association between a

DL TX beam and a PUCCH resource. In certain embodiments, based on a measurement result associated to an SS-block or CSI-RS, only a PUCCH resource associated to a suitable beam may be used for a beam failure recovery request. As used herein, a "suitable beam" may mean that a measurement quality is better than a threshold quality configured by the base unit 104. In some embodiments, in response to a contention-free resource for a beam recovery request being available, the remote unit 102 may use the contention-free resource to transmit beam recovery request. In various embodiments, in response to a PUCCH resource such as scheduling request ("SR"), sounding reference signal ("SRS"), PUSCH, and/or PUCCH for a beam recovery request being available, the remote unit 102 may use a first available PUCCH resource to transmit the beam recovery request.

[0059] In certain embodiments, in response to both a contention-free resource and a PUCCH resource for beam recovery request being available, the remote unit 102 may select an UL resource for a beam recovery request based on certain criteria. In one embodiment, the criteria may include the remote unit 102 selecting a first available resource. In some embodiments, the criteria may include the remote unit 102 selecting a PUCCH resource based on a priority in response to a beam including a suitable PUCCH resource. In such embodiments, the criteria may include, in response to all beams associated with the PUCCH resource not being suitable, the remote unit 102 selecting a PRACH resource for transmitting the beam recovery request. As used herein, a beam "not being suitable" may mean that a measurement quality is less than a threshold quality configured by the base unit 104.

[0060] In various embodiments, in response to a beam recovery request being transmitted in a first selected resource, the remote unit 102 may handle other available resources according to certain criteria. In one embodiment, the criteria may include the remote unit 102 skipping other available resources for the beam recovery request. For example, in response to the beam recovery request being transmitted in a PRACH resource, the remote unit 102 may monitor for a response within a time window. During the time window, the remote unit 102 may skip a PUCCH resource for a beam recovery request. As another example, in response to the beam recovery request being transmitted in a PUCCH resource, the remote unit 102 may skip a PRACH resource for a beam recovery request. In some embodiments, the criteria may include the remote unit 102 retransmitting the beam recovery request using other available resources. For example, in response to the beam recovery request being transmitted in a PRACH resource, the remote unit 102 may monitor for a response within a time window. During the time window, the remote unit 102 may retransmit the beam recovery request using a PUCCH resource. As another example, in response to the beam recovery request being transmitted in a PUCCH

resource, the remote unit 102 may retransmit the beam recovery request using a PRACH resource. In various embodiment, in response to both a contention-free resource and a PUCCH resource for a beam recovery request not being available to the remote unit 102, the remote unit 102 may use a contention based resource to transmit a beam recovery request.

[0061] In a sixth step, the base unit 104 may transmit a response to the beam recovey request to the remote unit 102. For example, in response to the base unit 104 receiving the beam recovery request from the remote unit 102, the base unit 104 may transmit the response in a DL beam associated with the UL resource, or in a candidate DL beam signaled in PUCCH.

[0062] In a seventh step, the remote unit 102 monitors for a response from the base unit 104 after transmitting the beam recovery request. In response to the remote unit 102 failing to receive a response from the base unit 104 within a predetermined time window, the remote unit 102 may be enabled to transmit a beam recovery request again.

[0063] Figure 3 depicts one embodiment of an apparatus 300 that may be used for receiving a beam recovery request. The apparatus 300 includes one embodiment of the base unit 104. Furthermore, the base unit 104 may include a processor 302, a memory 304, an input device 306, a display 308, a transmitter 310, and a receiver 312. As may be appreciated, the processor 302, the memory 304, the input device 306, the display 308, the transmitter 310, and the receiver 312 may be substantially similar to the processor 202, the memory 204, the input device 206, the display 208, the transmitter 210, and the receiver 212 of the remote unit 102, respectively.

[0064] In certain embodiments, the transmitter 310 may be used to transmit information indicating a resource configured for a beam recovery request. In some embodiments, the receiver 312 may be used to receive the beam recovery request on the resource in response to a first trigger condition. Although only one transmitter 310 and one receiver 312 are illustrated, the base unit 104 may have any suitable number of transmitters 310 and receivers 312. The transmitter 310 and the receiver 312 may be any suitable type of transmitters and receivers. In one embodiment, the transmitter 310 and the receiver 312 may be part of a transceiver.

[0065] Figure 4 is a schematic flow chart diagram illustrating one embodiment of a method 400 for transmitting a beam recovery request. In some embodiments, the method 400 is performed by an apparatus, such as the remote unit 102. In certain embodiments, the method 400 may be performed by a processor executing program code, for example, a microcontroller, a microprocessor, a CPU, a GPU, an auxiliary processing unit, a FPGA, or the like.

[0066] The method 400 may include receiving 402 information indicating a resource configured for a beam recovery request. In some embodiments, the method 400 includes

transmitting 404 the beam recovery request on the resource in response to a first trigger condition.

[0067] In one embodiment, the first trigger condition includes a medium access control layer receiving a number of out-of-sync indications from a physical layer. In a further embodiment, the number of out-of-sync indications is configured by radio resource control signaling. In certain embodiments, the resource configured for the beam recovery request is configured by radio resource control signaling. In various embodiments, the resource configured for the beam recovery request is enabled for use in response to the resource being configured by the radio resource control signaling. In some embodiments, the resource configured for the beam recovery request is enabled for use in response to the resource being activated by a medium access control control element.

[0068] In certain embodiments, the method 400 includes selecting a first available resource to transmit the beam recovery request in response to a contention-free resource and a physical uplink control channel resource being available for transmission of the beam recovery request. In some embodiments, the method 400 includes selecting a physical uplink control channel resource to transmit the beam recovery request in response to a contention-free resource and the physical uplink control channel resource being available for transmission of the beam recovery request and in response to the physical uplink control channel resource having a channel quality greater than a predetermined threshold. In various embodiments, the method 400 includes selecting a physical random access channel resource to transmit the beam recovery request in response to the physical uplink control channel resource having the channel quality less than the predetermined threshold.

[0069] In one embodiment, the method 400 includes monitoring for a response to transmission of the beam recovery request for a predetermined time in response to transmitting the beam recovery request using a physical random access channel resource and skipping a physical uplink control channel resource for the beam recovery request during the predetermined time. In certain embodiments, the method 400 includes skipping a physical random access channel resource for the beam recovery request in response to transmitting the beam recovery request using a physical uplink control channel resource. In some embodiments, the method 400 includes selecting a contention based resource to transmit the beam recovery request in response to a contention-free resource and a physical uplink control channel resource being unavailable for transmission of the beam recovery request. In various embodiments, the method 400 includes selecting the resource to transmit the beam recovery request based on a measurement

result and an association between a downlink transmission beam and a physical uplink control channel resource.

[0070] In some embodiments, the association between the downlink transmission beam and the physical uplink control channel resource is configured by radio resource control signaling. In certain embodiments, the measurement result is based on a channel state information reference signal in response to the channel state information reference signal being configured by a base unit. In various embodiments, the measurement result is based on a synchronization signal block in response to a channel state information reference signal not being configured by a base unit. In one embodiment, the method 400 includes performing a beam measurement to determine the measurement result in response to a second trigger condition. In some embodiments, the second trigger condition includes a quality of a serving beam being less than a predetermined threshold, a number of out-of-sync indications from a physical layer, or some combination thereof. In certain embodiments, the predetermined threshold and the number are configured by radio resource control signaling. In various embodiments, the method 400 includes starting a timer in response to the first trigger condition. In various embodiments, the method 400 enters radio link failure in response to the timer expiring. In one embodiment, the method 400 stops the timer in response to receiving a response to the transmission of the beam recovery request.

[0071] Figure 5 is a schematic flow chart diagram illustrating one embodiment of a method 500 for receiving a beam recovery request. In some embodiments, the method 500 is performed by an apparatus, such as the base unit 104. In certain embodiments, the method 500 may be performed by a processor executing program code, for example, a microcontroller, a microprocessor, a CPU, a GPU, an auxiliary processing unit, a FPGA, or the like.

[0072] The method 500 may include transmitting 502 information indicating a resource configured for a beam recovery request. In certain embodiments, the method 500 includes receiving 504 the beam recovery request on the resource.

[0073] In one embodiment, the first trigger condition includes a medium access control layer receiving a number of out-of-sync indications from a physical layer. In a further embodiment, the number of out-of-sync indications is configured by radio resource control signaling. In certain embodiments, the resource configured for the beam recovery request is configured by radio resource control signaling. In various embodiments, the resource configured for the beam recovery request is enabled for use in response to the resource being configured by the radio resource control signaling. In some embodiments, the resource configured for the beam

recovery request is enabled for use in response to the resource being activated by a medium access control control element.

[0074] In certain embodiments, a first available resource is selected to transmit the beam recovery request in response to a contention-free resource and a physical uplink control channel resource being available for transmission of the beam recovery request. In some embodiments, a physical uplink control channel resource is selected to transmit the beam recovery request in response to a contention-free resource and the physical uplink control channel resource being available for transmission of the beam recovery request and in response to the physical uplink control channel resource having a channel quality greater than a predetermined threshold. In various embodiments, a physical random access channel resource is selected to transmit the beam recovery request in response to the physical uplink control channel resource having the channel quality less than the predetermined threshold.

[0075] In one embodiment, the method 500 includes transmitting a response to the beam recovery request. In certain embodiments, a physical random access channel resource for the beam recovery request is skipped in response to the beam recovery request being transmitting using a physical uplink control channel resource. In some embodiments, a contention based resource is selected to transmit the beam recovery request in response to a contention-free resource and a physical uplink control channel resource being unavailable for transmission of the beam recovery request.

[0076] In various embodiments, the resource to transmit the beam recovery request is selected based on a measurement result and an association between a downlink transmission beam and a physical uplink control channel resource. In certain embodiments, the association between the downlink transmission beam and the physical uplink control channel resource is configured by radio resource control signaling. In some embodiments, the measurement result is based on a channel state information reference signal in response to the channel state information reference signal being configured by a base unit. In one embodiment, the measurement result is based on a synchronization signal block in response to a channel state information reference signal not being configured by a base unit.

[0077] In various embodiments, a beam measurement is performed to determine the measurement result in response to a second trigger condition. In certain embodiments, the second trigger condition includes a quality of a serving beam being less than a predetermined threshold, a number of out-of-sync indications from a physical layer, or some combination thereof. In some embodiments, the predetermined threshold and the number are configured by radio resource control signaling. In one embodiment, a timer is started in response to the first

trigger condition. In various embodiments, radio link failure is entered in response to the timer expiring. In certain embodiments, the timer is stopped in response to transmitting a response to receiving the beam recovery request.

[0078] Embodiments may be practiced in other specific forms. The described embodiments are to be considered in all respects only as illustrative and not restrictive. The scope of the invention is, therefore, indicated by the appended claims rather than by the foregoing description. All changes which come within the meaning and range of equivalency of the claims are to be embraced within their scope.

CLAIMS

1. A method comprising:

receiving information indicating a resource configured for a beam recovery request; and

transmitting the beam recovery request on the resource in response to a first trigger condition.

2. The method of claim 1, wherein the first trigger condition comprises a medium access control layer receiving a number of out-of-sync indications from a physical layer.

3. The method of claim 1, wherein the resource configured for the beam recovery request is configured by radio resource control signaling.

4. The method of claim 3, wherein the resource configured for the beam recovery request is enabled for use in response to the resource being configured by the radio resource control signaling.

5. The method of claim 3, wherein the resource configured for the beam recovery request is enabled for use in response to the resource being activated by a medium access control control element.

6. The method of claim 1, further comprising selecting a first available resource to transmit the beam recovery request in response to a contention-free resource and a physical uplink control channel resource being available for transmission of the beam recovery request.

7. The method of claim 1, further comprising selecting a physical uplink control channel resource to transmit the beam recovery request in response to a contention-free resource and the physical uplink control channel resource being available for transmission of the beam recovery request and in response to the physical uplink control channel resource having a channel quality greater than a predetermined threshold.

8. The method of claim 7, further comprising selecting a physical random access channel resource to transmit the beam recovery request in response to the physical uplink control channel resource having the channel quality less than the predetermined threshold.

9. The method of claim 1, further comprising monitoring for a response to transmission of the beam recovery request for a predetermined time in response to transmitting the beam recovery request using a physical random access channel resource and skipping a physical uplink control channel resource for the beam recovery request during the predetermined time.

10. The method of claim 1, further comprising skipping a physical random access channel resource for the beam recovery request in response to transmitting the beam recovery request using a physical uplink control channel resource.

11. The method of claim 1, further comprising selecting a contention based resource to transmit the beam recovery request in response to a contention-free resource and a physical uplink control channel resource being unavailable for transmission of the beam recovery request.

12. The method of claim 1, further comprising selecting the resource to transmit the beam recovery request based on a measurement result and an association between a downlink transmission beam and a physical uplink control channel resource.

13. The method of claim 12, wherein the association between the downlink transmission beam and the physical uplink control channel resource is configured by radio resource control signaling.

14. The method of claim 12, wherein the measurement result is based on a channel state information reference signal in response to the channel state information reference signal being configured by a base unit.

15. The method of claim 12, wherein the measurement result is based on a synchronization signal block in response to a channel state information reference signal not being configured by a base unit.

16. The method of claim 12, further comprising performing a beam measurement to determine the measurement result in response to a second trigger condition.

17. The method of claim 16, wherein the second trigger condition comprises a quality of a serving beam being less than a predetermined threshold, a number of out-of-sync indications from a physical layer, or some combination thereof.

18. The method of claim 1, further comprising starting a timer in response to the first trigger condition.

19. An apparatus comprising:

a receiver that receives information indicating a resource configured for a beam recovery request; and

a transmitter that transmits the beam recovery request on the resource in response to a first trigger condition.

20. An apparatus comprising:

a transmitter that transmits information indicating a resource configured for a beam recovery request; and

a receiver that receives the beam recovery request on the resource.

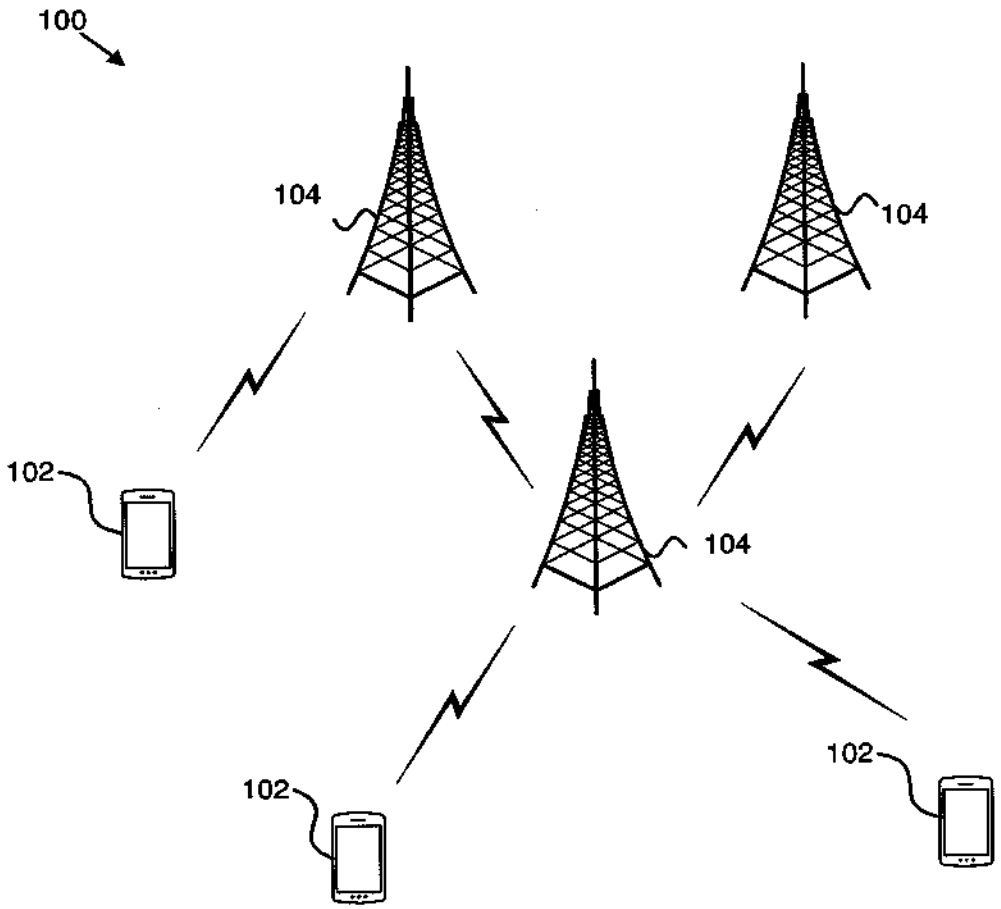


FIG. 1

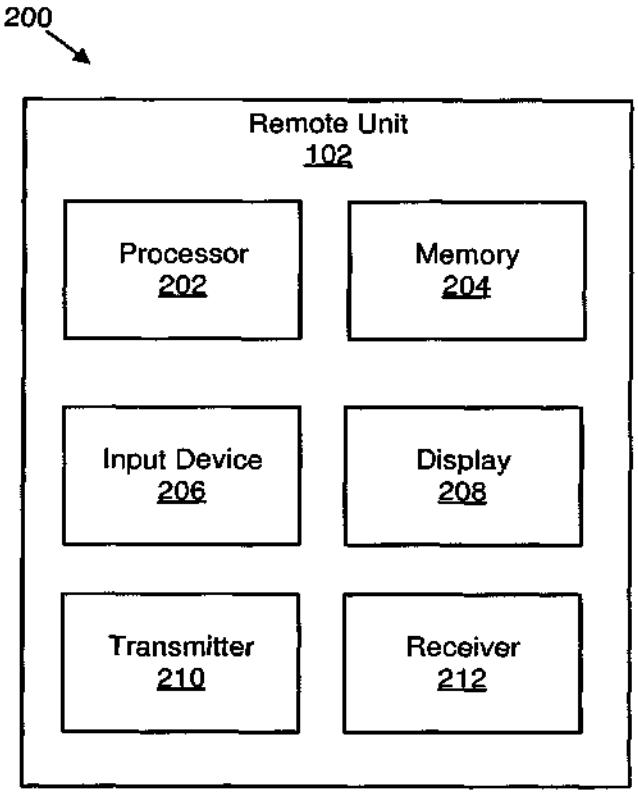

200
Remote Unit
102
Processor
202
Memory
204
Input Device
206
Display
208
Transmitter
210
Receiver
212

FIG. 2

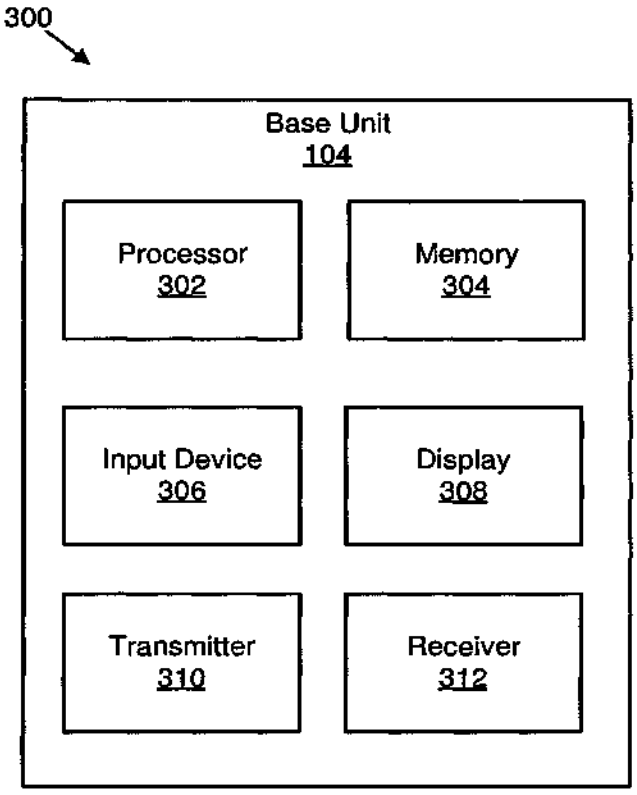

300
Base Unit
104
Processor
302
Memory
304
Input Device
306
Display
308
Transmitter
310
Receiver
312

FIG. 3

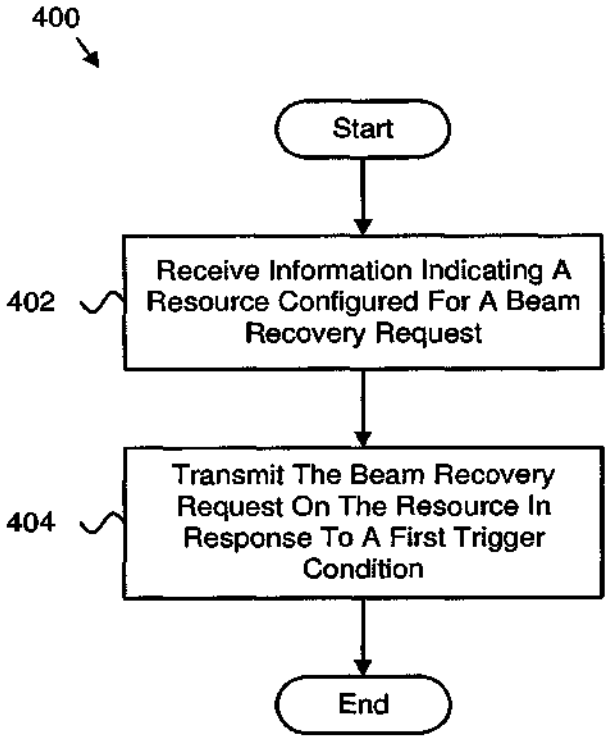

400
Start
Receive Information Indicating A Resource Configured For A Beam Recovery Request
402
Transmit The Beam Recovery Request On The Resource In Response To A First Trigger Condition
404
End

FIG. 4

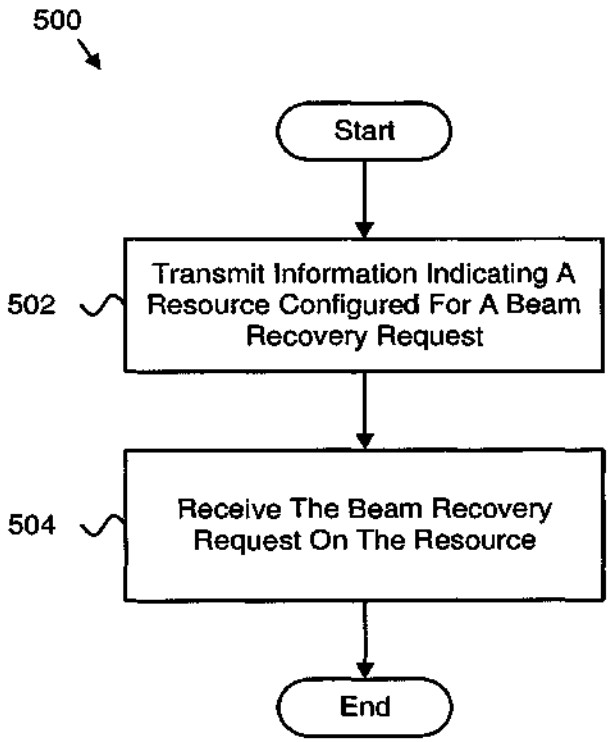

500
Start
Transmit Information Indicating A Resource Configured For A Beam Recovery Request
502
Receive The Beam Recovery Request On The Resource
504
End

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2017/088407

A. CLASSIFICATION OF SUBJECT MATTER

H04B 7/06(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04B; H04W; H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNTXT;CNABS;CNKI;WOTXT;USTXT;JPTXT;EPTXT;VEN;XP3GPP:beam?, recover+, request+, fail+, resource, trigger, sync+, timer, BFR

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Samsung. "R2-1705731 NR beam recovery" *3GPP TSG-RAN WG2 2017 RAN2#98 Meeting, http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN2/Docs/*, 14 May 2017 (2017-05-14), pages 1 and 2	1-20
X	WO 2017024516 A1 (TELEFONAKTIEBOLAGET LM ERICSSON PUBLET AL.) 16 February 2017 (2017-02-16) description, paragraphs [034]-[067]	1-20
A	US 2016183233 A1 (ELECTRONICS AND TELECOMMUNICATIONS RESEARCH INSTITUTE) 23 June 2016 (2016-06-23) the whole document	1-20

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
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"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 February 2018	**19 March 2018**
Name and mailing address of the ISA/CN **STATE INTELLECTUAL PROPERTY OFFICE OF THE P.R.CHINA** **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088** **China** Facsimile No. **(86-10)62019451**	Authorized officer **HUANG,Hui** Telephone No. **(86-10)62089455**

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2017/088407

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
WO	2017024516	A1	16 February 2017	CN	107079459	A	18 August 2017
US	2016183233	A1	23 June 2016	KR	101810633	B1	19 December 2017
				US	9769717	B2	19 September 2017
				KR	20160075217	A	29 June 2016

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[Continued on next page]

(54) Title: METHOD AND DEVICE FOR PAGING A MACHINE TO MACHINE DEVICE

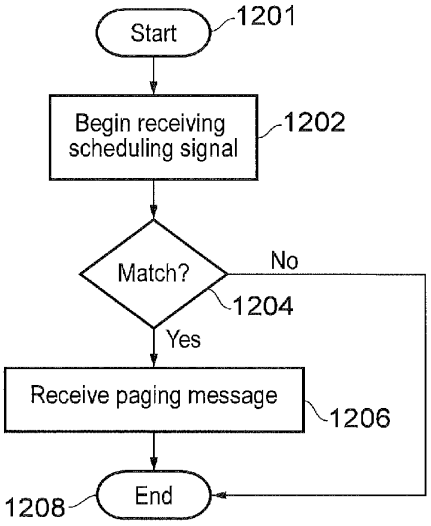


FIG. 12

(57) Abstract: A terminal device for use with a wireless telecommunications network comprising: a transceiver; and a controller. Receiving, during one of a plurality of periodic paging occasions associated with the terminal, a paging scheduling signal for one or more terminal devices, each paging occasion being associated with a value of a characteristic of the scheduling signal which is unique to that paging occasion. Determining whether the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the of periodic paging occasions associated with the terminal device; and control the transceiver to receive the paging message scheduled by the received scheduling message.

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LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

METHOD AND DEVICE FOR PAGING A MACHINE TO MACHINE DEVICE

BACKGROUND

Field of Disclosure

The present disclosure relates to a terminal device, infrastructure equipment, methods and integrated circuitry for use with a wireless telecommunications network.

Description of Related Art

The "background" description provided herein is for the purpose of generally presenting the context of the disclosure. Work of the presently named inventors, to the extent it is described in this background section, as well as aspects of the description which may not otherwise qualify as prior art at the time of filing, are neither expressly or impliedly admitted as prior art against the present disclosure.

Third and fourth generation wireless communications systems, such as those based on the third generation project partnership (3GPP) defined UMTS and Long Term Evolution (LTE) architecture are able to support sophisticated services such as instant messaging, video calls as well as high speed internet access. For example, with the improved radio interface and enhanced data rates provided by LTE systems, a user is able to enjoy high data rate applications such as mobile video streaming and mobile video conferencing that would previously only have been available via a fixed line data connection. The demand to deploy third and fourth generation networks is therefore strong and the coverage area of these networks, i.e. geographic locations where access to the networks is possible, is expected to increase rapidly. However, whilst fourth generation networks can support communications at high data rate and low latencies from devices such as smart phones and tablet computers, it is expected that future wireless communications networks will need to support communications to and from a much wider range of devices, including reduced complexity devices, machine type communication devices, devices which require little or no mobility, high resolution video displays and virtual reality headsets. As such, supporting such a wide range of communications devices can represent a technical challenge for a wireless communications network.

A current technical area of interest to those working in the field of wireless and mobile communications is known as "The Internet of Things" or IoT for short. The 3GPP has proposed to develop technologies for supporting narrow band (NB)-IoT using an LTE or 4G wireless access interface and wireless infrastructure. Such IoT devices are expected to be low complexity and inexpensive devices requiring infrequent communication of relatively low bandwidth data. It is also expected that there will be an extremely large number of IoT devices which would need to be supported in a cell of the wireless

communications network. Furthermore such NB-IoT devices are likely to be deployed indoors and /or in remote locations making radio communications challenging.

SUMMARY OF THE DISCLOSURE

According to a first embodiment, the present technique provides a terminal device for use with a wireless telecommunications network, the terminal device comprising: a transceiver; and a controller operable: to control the transceiver to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging one or more terminal devices of the wireless telecommunications network, each periodic paging occasion associated with the terminal device being associated with a value of a characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network; to determine whether the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device; and if the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device, to control the transceiver to receive the paging message scheduled by the received scheduling message.

According to the first embodiment, the present technique also provides infrastructure equipment for use with a wireless telecommunications network, the infrastructure equipment comprising: a transceiver; and a controller operable: to control the transceiver to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device, wherein a value of a characteristic of the scheduling signal is associated with the one of the plurality of periodic paging occasions associated with the terminal device, each periodic paging occasion associated with the terminal device being associated with a value of the characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network.

According to a second embodiment, the present technique provides a terminal device for use with a wireless telecommunications network, the terminal device comprising: a transceiver; and a controller operable: to control the transceiver to begin receiving, during one of a plurality of periodic paging

occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging the terminal device; wherein the scheduling signal is repeatedly transmitted by the network a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin receiving the scheduling signal; and the controller is operable to control the transceiver to receive the repetitions of the scheduling signal over the predetermined plurality of separate time periods.

According to the second embodiment, the present technique also provides infrastructure equipment for use with a wireless telecommunications network, the infrastructure equipment comprising: a transceiver; and a controller operable: to control the transceiver to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device; wherein the controller is operable to control the transceiver to repeatedly transmit the scheduling signal a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin transmitting the scheduling signal.

The foregoing paragraphs have been provided by way of general introduction, and are not intended to limit the scope of the following claims. The described embodiments, together with further advantages, will be best understood by reference to the following detailed description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the disclosure and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein like reference numerals designate identical or corresponding parts throughout the several views, and wherein:

Figure 1 is a schematic block diagram illustrating an example of a mobile telecommunication system;

Figure 2 is a schematic representation illustrating a frame structure of a downlink of a wireless access interface according to an LTE standard;

Figure 3 is a schematic representation illustrating a frame structure of an uplink of wireless access interface according to an LTE standard;

Figure 4 is a schematic representation of a terminal device and infrastructure equipment;

Figure 5 is a schematic representation of an NB-PDCCH search space;

Figure 6 is a schematic representation of a plurality of paging occasions during which groups of UEs may search the NB-PDCCH search space;

Figure 7 is a schematic representation of an NB-PDCCH search space overlapping paging occasions associated with separate groups of UEs;

Figure 8 is a schematic representation an NB-PDCCH search space overlapping paging occasions associated with the same group of UEs;

Figure 9 is a schematic representation of segmentation of the NB-PDCCH according to a first example;

Figure 10 is a schematic representation of segmentation of the NB-PDCCH according to a second example;

Figure 11 is a schematic representation of segmentation of the NB-PDCCH according to a third example; and

Figure 12 illustrates a flow chart schematically showing a first method; and

Figure 13 illustrates a flow chart schematically showing a second method.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Conventional Communications System

Figure 1 provides a schematic diagram illustrating some basic functionality of a mobile telecommunications network / system 100 operating in accordance with LTE principles and which may be adapted to implement embodiments of the disclosure as described further below. Various elements of Figure 1 and their respective modes of operation are well-known and defined in the relevant standards administered by the 3GPP (RTM) body, and also described in many books on the subject, for example, Holma H. and Toskala A [1]. It will be appreciated that operational aspects of the telecommunications network which are not specifically described below may be implemented in accordance with any known techniques, for example according to the relevant standards.

The network 100 includes a plurality of base stations 101 connected to a core network 102. Each base station provides a coverage area 103 (i.e. a cell) within which data can be communicated to and from communications devices 104. Data is transmitted from base stations 101 to communications devices 104 within their respective coverage areas 103 via a radio downlink. Data is transmitted from communications devices 104 to the base stations 101 via a radio uplink. The uplink and downlink

communications are made using radio resources that are licenced for exclusive use by the operator of the network 100. The core network 102 routes data to and from the communications devices 104 via the respective base stations 101 and provides functions such as authentication, mobility management, charging and so on. Communications devices may also be referred to as mobile stations, user equipment (UE), user device, mobile radio, terminal device and so forth. Base stations may also be referred to as transceiver stations / infrastructure equipment / NodeBs / eNodeBs (eNB for short), and so forth.

Wireless communications systems such as those arranged in accordance with the 3GPP defined Long Term Evolution (LTE) architecture use an orthogonal frequency division modulation (OFDM) based interface for the radio downlink (so-called OFDMA) and a single carrier frequency division multiple access scheme (SC-FDMA) on the radio uplink.

Figure 2 provides a simplified schematic diagram of the structure of a downlink of a wireless access interface that may be provided by or in association with the eNB of Figure 1 when the communications system is operating in accordance with the LTE standard. In LTE systems the wireless access interface of the downlink from an eNB to a UE is based upon an orthogonal frequency division multiplexing (OFDM) access radio interface. In an OFDM interface the resources of the available bandwidth are divided in frequency into a plurality of orthogonal subcarriers and data is transmitted in parallel on a plurality of orthogonal subcarriers, where bandwidths between 1.4MHz and 20MHz bandwidth may be divided into 128 to 2048 orthogonal subcarriers for example. Each subcarrier bandwidth may take any value but in LTE it is conventionally fixed at 15kHz. However it has been proposed in the future [2][3] to provide also a reduced subcarrier spacing of 3.75 kHz for certain parts of the LTE wireless access interface for the uplink. As shown in Figure 2, the resources of the wireless access interface are also temporally divided into frames where a frame 200 lasts 10ms and is subdivided into 10 subframes 201 each with a duration of 1ms. Each subframe is formed from 14 OFDM symbols and is divided into two slots each of which comprise six or seven OFDM symbols depending on whether a normal or extended cyclic prefix is being utilised between OFDM symbols for the reduction of inter symbol interference. The resources within a slot may be divided into resources blocks 203 each comprising 12 subcarriers for the duration of one slot and the resources blocks further divided into resource elements 204 which span one subcarrier for one OFDM symbol, where each rectangle 204 represents a resource element. More details of the downlink structure of the LTE wireless access interface are provided in Annex 1.

Figure 3 provides a simplified schematic diagram of the structure of an uplink of an LTE wireless access interface that may be provided by or in association with the eNB of Figure 1. In LTE networks the uplink wireless access interface is based upon a single carrier frequency division multiplexing FDM (SC-FDM) interface and downlink and uplink wireless access interfaces may be provided by frequency division duplexing (FDD) or time division duplexing (TDD), where in TDD implementations subframes switch

between uplink and downlink subframes in accordance with predefined patterns. However, regardless of the form of duplexing used, a common uplink frame structure is utilised. The simplified structure of Figure 3 illustrates such an uplink frame in an FDD implementation. A frame 300 is divided in to 10 subframes 301 of 1ms duration where each subframe 301 comprises two slots 302 of 0.5ms duration. Each slot is then formed from seven OFDM symbols 303 where a cyclic prefix 304 is inserted between each symbol in a manner equivalent to that in downlink subframes. In Figure 3 a normal cyclic prefix is used and therefore there are seven OFDM symbols within a subframe, however, if an extended cyclic prefix were to be used, each slot would contain only six OFDM symbols. The resources of the uplink subframes are also divided into resource blocks and resource elements in a similar manner to downlink subframes. More details of the LTE uplink represented in Figure 3 are provided in Annex 1.

Narrowband Internet of Things

As explained above, it has been proposed to develop an adaptation of a mobile communications network to accommodate narrow band communications within an existing wireless access interface which has been developed to provide broadband wireless communications. For example, in 3GPP a project relating to improvements to LTE wireless access interfaces to provide for a Narrowband Internet of Things (NB-IoT) was agreed [2]. This project is aimed at improved indoor coverage, support for massive number of low throughput devices, low delay sensitivity, ultra-low device cost, low device power consumption and (optimised) network architecture. An example of such a device is a smart meter. It has been proposed that an NB-IoT communications system supports a bandwidth of only 180 kHz and can have three operational modes:

1. 'Stand-alone operation' utilizing for example the spectrum currently being used by GERAN systems as a replacement of one or more GSM carriers
2. 'Guard band operation' utilizing the unused resource blocks within a LTE carrier's guard-band
3. 'In-band operation' utilizing resource blocks within a normal LTE carrier

Figure 4 provides an example schematic block diagram of a terminal device or UE 104 and an infrastructure equipment or eNB 101 according to embodiments of the present technique. As shown in Figure 4, the UE 104 includes a transmitter 401 and a receiver 402 (which together form a transceiver) which are controlled by a controller 403. The UE 104 also comprises a storage medium 420 for storing data. Correspondingly, the eNB 101 includes a transmitter 411 and a receiver 412 (which together form a transceiver) which are controlled by a controller 413 (which can also implement a scheduler function). The eNB 101 also comprises a storage medium 422 for storing data. As explained above, the UE 104 transmits and receives signals to and from the eNB 101 via a wireless access interface provided by the

eNB as part of the wireless communications network. Each of the UE 104 and eNB 101 are configured to exchange signals with each other using NB-IoT.

One of the objectives of NB-IoT is to provide extended coverage of up to 20 dB. The main mechanism to extend coverage is to perform numerous repetitions of a message to be received at a receiving device, such that the receiver can accumulate the signal energy over the repetitive samples in order for it to have an increased signal-to-noise ratio (SNR), which increases the likelihood of successful decoding of the message at the receiving device. Such a mechanism is known as coverage enhancement (CE).

Coverage enhancement (CE) may have several levels. For example, it may provide one of 5 dB, 15 dB and 20 dB additional coverage enhancement. In NB-IoT, the CE levels may be referred to as the targeted MCL (Max Coupling Loss, the achievable coupling loss (accounting for, for example, path loss, feeder losses and/or antenna gains) between transmitter and receiver) of, for example, 144 dB, 154 dB and 164 dB (so that the higher the targeted MCL, the greater the additional coverage enhancement).

As previously mentioned, repetitions of a signal so that a receiver can accumulate energy of the signal over numerous repetitive samples is the basic method used for coverage enhancement. The number of repetitions required is dependent upon the CE level. Thus, a UE at a lower CE level, such as at 144 dB, MCL requires less repetition compared to one at a higher CE level, such as at 154 dB MCL. The power spectral density, PSD (mW/Hz) of a transmission also affects the number of repetitions required, that is, the larger the PSD, the less the required number of repetitions.

The NB-PDCCH (Narrow Band Physical Downlink Control Channel) is a control channel that is used to schedule downlink resources (downlink grant) and uplink resources (uplink grant) for a NB-PDSCH (Narrow Band Physical Downlink Shared Channel) and a NB-PUSCH (Narrow Band Physical Uplink Shared Channel) that carry data traffic. An NB-PDCCH search space consists of multiple NB-PDCCH candidates wherein each candidate has a specific starting time, set of subcarriers, a defined number of repetitions and an aggregation level (the aggregation level relating to the number of frequency resources occupied by the candidate such that when the candidate occupies a higher number of frequency resources, the aggregation level is higher, and when the candidate occupies a lower number of frequency resources, the aggregation level is lower). Candidates that have a larger number of repetitions and a higher aggregation level are more robust and can reach a UE at poorer coverage compared to candidates that have a smaller number of repetitions and a lower aggregation level.

The eNB uses one of the candidates in the search space to carry the NB-PDCCH. The UE is not aware which candidate is used and so it must blind decode all the candidates in the search space in order to find the candidate used by the eNB for the NB-PDCCH. An example of a typical NB-PDCCH search space is

shown in Figure 5. Here, the search space has 4 repetition levels {R1, R2, R3, R4} where R4 = 2×R3 = 4×R2 = 8×R1. It should be appreciated that an NB-PDCCH search space with other repetition levels is also possible. As an example the eNB can use any of the 15 candidates (labelled as C1 to C15) to carry the NB-PDCCH and the UE has to blind decode for all 15 candidates. The max repetition R_{MAX} (in Figure 5, R_{MAX} = R4) of the search space is assigned to the UE based on the UE's radio condition. Thus, for example, if the UE is in a poorer quality radio coverage location, then the eNB can configure a search space with a larger value of R_{MAX}, and if the UE is in a better quality radio coverage location, then the eNB can configure a search space with a smaller value of R_{MAX}. Typically, a set of NB-PDCCH search spaces is predefined in which each NB-PDCCH search space of the set consists of a set of candidates and a value of R_{MAX}. The UE is then assigned one NB-PDCCH search space in the set of NB-PDCCH search spaces. The maximum repetition R_{MAX} of an NB-PDCCH search space can be selected from the set of values {1, 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024, 2048}, for example.

In NB-IoT, paging is performed when a UE is in idle mode. More specifically, when in idle mode, the UE monitors an NB-PDCCH CSS (Common Search Space) which, in the case that a paging message is to be transmitted to the UE, contains an NB-PDCCH that schedules that paging message (the paging message being carried by an NB-PDSCH). In order to reduce power consumption, the UE monitors the NB-PDCCH CSS during each of a plurality of periodic Paging Occasions (PO) rather than constantly monitoring the NB-PDCCH CCS. The PO occurs periodically for a particular UE (or particular group of UEs), wherein the period is configured by the network, for example. In an embodiment, the network can configure multiple POs in which the specific PO that a UE monitors depends on an identifier of that that UE (UE-ID), for example, the UE's International Mobile Subscriber Identifity (IMSI). This enables the network to spread the paging load. For example in Figure 6, the eNB configures four POs where each PO has a period T_{PO}. The UE thus wakes up every T_{PO} ms to monitor for possible paging. The PO is assigned to the UE based on the UE's ID, using a **MOD** function of the number of POs, for example (thus, in the case of Figure 6, the PO assigned to a particular UE is given by UE_ID **MOD** 4).

As described previously, repetition of the paging CSS can reach 2048. A problem with this is that a PO can overlap another PO, causing confusion for UEs reading the PO. For example in Figure 7, two POs are configured. PO 1 begins at time t_1, where UE 1 belonging to this PO will start monitoring for NB-PDCCH in the paging CSS. This paging CSS ends at time t_3. If the repetition of NB-PDCCH is very long (for example, if the paging CSS ending at time t_3 has the structure shown in Figure 5, and the NB-PDDCH is received via the candidate C15 with the largest number of repetitions) , it will overlap into PO 2 at time t_2. At time t_2 UE 2 belonging to PO 2 will start monitoring for NB-PDCCH and will start to accumulate repetition samples from the NB-PDCCH intended for UE 1 (belong to PO 1). If UE 2 is in a better radio condition than UE 1, it may decode the NB-PDCCH and start to accumulate and decode the corresponding NB-PDSCH containing the paging message. UE 2 will not find any paging indication in

this paging message and would waste battery power accumulating and decoding the NB-PDSCH. This is because the paging message contains an identifier of each UE to be paged. If a paging message is not intended for UE 2, then the identifier of UE 2 will not be included in the paging message and thus UE 2 will not be paged. However, since UE 2 has received the NB-PDCCH during its paging occasion, it will still attempt to read the paging message scheduled by the NB-PDCCH by accumulating and decoding the NB-PDSCH, thus wasting battery power. It should be noted that the NB-PDSCH is also repeated.

It should also be appreciated that if the PO period T_{PO} is shorter than the NB-PDCCH repetition, the PO may overlap itself, as shown in an example in Figure 8, in which the NB-PDCCH for PO 1 starts at time t_1 but the repetition doesn't end till time t_4. It overlaps the next PO 1 at time t_3. In this scenario, the UE belonging to PO 1 is confused as to whether to continue accumulating samples from the previous PO 1 (started at time t_1) or start a new accumulation starting at time t_3. Furthermore, in an embodiment, the NB-PDSCH starting subframe is indicated in the downlink control information (DCI) of the NB-PDCCH, this NB-PDSCH starting subframe being defined relative to the end of the NB-PDCCH that schedules this NB-PDSCH. In order to determine the end of an NB-PDCCH transmission, the repetition of the NB-PDCCH is indicated in the DCI of that NB-PDCCH. For example, in Figure 5, if candidate C11 is used to carry the NB-PDCCH (including the DCI), then the NB-PDSCH scheduled by the NB-PDCCH will start at k subframes after time t_6 (t_6 marking the end of the NB-PDCCH carried by candidate C11) where k is indicated in the DCI. Since the UE can decode a message with less repetition when it has a good radio condition, however, the UE may decode C11 at time t_5 and mistake candidate C11 for candidate C5. The UE will thereby use the wrong reference point for the start of the NB-PDSCH. To avoid this, the repetition of the NB-PDCCH is indicated in the DCI so that the UE will not mistake candidate C11 for C5. However, this does not solve the problem shown in Figure 8 in which the search space overlaps itself. In this case, although the UE will know the repetition of the NB-PDCCH from the DCI information, the UE does not know whether the NP-PDCCH repetitions started at time t_1 or at time t_3. This causes confusion at the UE regarding the candidates.

In LTE Release-13 eMTC (enhanced Machine Type Communication), the POs are separated far apart so that they do not overlap. This is possible because the repetition used in this case is not as large as that used in NB-IoT. Furthermore, eMTC can use different narrowbands for different groups of UEs and avoid overlapping. In contrast, only the anchor NB-IoT can contain the paging CSS and paging message, and therefore problem of overlapping of the NB-PDCCH between different POs requires a new solution.

In an embodiment of the present technique, an indicator is used to distinguish one PO from another. The UE belonging to a PO then uses this indicator to determine whether the NB-PDCCH belongs to it or to another PO.

In one embodiment, the said indicator is a PO index in the DCI (carried by the NB-PDCCH). A new field in the DCI would indicate which PO the DCI (that is, the NB-PDCCH) belongs to. The UE, after accumulating the NB-PDCCH, will then decode the DCI and check the PO index to see whether it matches the PO that the UE belongs to.

In another embodiment, different versions of the same PO are also indicated in the DCI. This is to help overcome the issue of uncertainty at the UE regarding when the search space starts when a NB-PDCCH repetition is larger than the PO period T_{PO} (as described in Figure 8). For example, in Figure 8, PO 1 at time t_1 can be version 1 and PO 1 at time t_3 can be version 2, these versions being distinguishable from each other by the PO identifier in the DCI so the UE is clear where the search space starts. This helps to avoid confusion of the candidates in the search space.

In another embodiment the starting time of the CSS is indicated in the DCI. This is similar to indicating the PO index (which indirectly indicates the starting time of the CSS). After decoding the DCI, the UE will determine whether the starting time of the decoded NB-PDCCH belongs to the CSS that starts at its PO or another PO. If the CSS starts at a time belonging to another PO, the UE can discard the decoded DCI.

In another embodiment, a different P-RNTI (Paging Radio Network Temporary Identifier) is used for one or more of each respective PO and each respective PO version. The P-RNTI of each respective PO and/or each respective PO version can be signalled either explicitly or implicitly (that is, derived from a reference P-RNTI). For example, in the case that a different P-RNTI is used for each respective PO, the eNB may signal a single reference P-RNTI and PO 1 will use this P-RNTI, PO 2 will use this reference P-RNTI + 1, PO 3 will use P-RNTI + 2, and so on.

In another embodiment, a scrambling applied to the NB-PDCCH is dependent upon the PO. The UE then applies a descrambler depending upon which PO it belongs to. A different scrambling may be applied to each respective PO (so as to distinguish, for example, PO 1 from PO 2, but not distinguish between different versions of PO 1 or PO 2). Alternatively, or in addition, a different scrambling may be applied to each respective PO version (so that different versions of, for example, PO 1 or PO 2 may be distinguished from each other).

It will be appreciated that various features of these embodiments may be combined as appropriate. For example, it may be the case that each respective PO is distinguished by a different scrambling, but then each version of that PO is further distinguished in the DCI.

In another embodiment of the present technique, two or more different NB-PDCCH search spaces (that is, Common Search Spaces) are configured wherein at least one of these search spaces has max repetition $R1_{MAX}$ greater than the time between two adjacent POs T_S (thus potentially causing the overlapping issue described in Figure 7) whilst the remaining search spaces have max repetition $R2_{MAX}$ smaller than T_S. In this way the search space with $R1_{MAX}$ can be segmented and interleaved with search spaces with $R2_{MAX}$. An example is shown in Figure 9, where each PO is associated with one of two types of NB-PDCCH Common Search Space (CSS) with $R1_{MAX}$ and $R2_{MAX}$, respectively. CSS1 belongs to PO1, starts at time t_1 and has a max repetition of $R1_{MAX}$ where $R1_{MAX} > T_S$, (meaning that, if measures are not taken, then CSS1 will overlap with the adjacent PO (that is, PO2)). Using the method of an embodiment, CSS1 (belonging to the first version of PO1) is segmented into 3 segments, wherein the 1st segment starts at time t_1 and ends at time t_2. The 2nd segment occupies the time t_3 to t_4, which avoids overlapping CSS2 (belonging to the first version of PO2) between time t_2 and t_3. The 3rd segment occupies time t_5 to t_6, which avoids overlapping CSS3 (belonging to the second version of PO1) between time t_4 and t_5. The segments of CSS1 are therefore interleaved with CSS2 and CSS3. CSS3 and CSS4 belong to PO1 (the second and third versions of PO1, respectively) but with a smaller maximum repetition, that is, $R2_{MAX} < T_S$, and therefore do not overlap with any adjacent PO. CSS3 and CSS4 are thus not segmented. CSS5 belongs to PO2 (in particular, the second version of PO2), and since its max repetition is greater that T_S, it is segmented and interleaved in a similar manner as that for CSS1. The example in Figure 9 shows two types of CSS (that is, with two different max repetition values). However, it should be appreciated this method is also applicable for more than two different max repetition CSSs. Also, the segments of CSS1 can be interleaved using a different pattern, for example, interleaved with different CSSs such as CSS3 and CSS4 (as shown in Figure 10).

In an embodiment, different POs have different max CSS repetitions. For example, the CSS for PO1 may have repetition $R1_{MAX} > T_S$ whilst the CSS for PO2 may have max repetition $R2_{MAX} < T_S$. In this embodiment, the CSS for PO1 is segmented and interleaved with the un-segmented CSS for PO2.

In another embodiment, all CSSs have $R1_{MAX} > T_S$. Each CSS (with $R1_{MAX}$) is segmented and the segment occupies multiple POs. That is, the CSS is spread among multiple POs. An example is shown in Figure 11, where CSS1 (belonging to PO1) has $R1_{MAX} > T_S$ and is segmented into two segments. The first segment occupies time t_1 to t_2 and the 2nd segment occupies time t_4 to t_5. Similarly, CSS5 (belonging to PO2) has $R1_{MAX} > T_S$ and is segmented into two segments. The first segment occupies time t_2 to t_3 and the 2nd segment occupies time t_6 to t_7. It should be noted that the 2nd segment length of each of CSS1 and CSS2 is less than T_S in this example.

In another embodiment, the overlapping problem shown in Figure 8 can be overcome by ensuring the Paging Occasion period $T_{PO} >$ R1max. Note that this is easier to achieve than to ensure that $T_S > R1_{MAX}$,

since T_{PO} can be much larger than T_S (for example, up to 2560 subframes) and multiple different POs may fit within the T_{PO}.

In embodiments, the segments of the NB-PDCCH search space can be defined by a predetermined pattern, this pattern being configured by the network and, for example, transmitted to the UE 104 from the eNB 101 as system information (in the System Information Block (SIB), for example). In an embodiment, the pattern may vary depending on the number of repeats of the NB-PDCCH, an identifier of the CSS which is used, or any other parameter which the UE may discern from the CSS or NB-PDCCH. The relationship between the predetermined pattern and the CSS or NB-PDCCH may be determined and transmitted to the UE 104 by the eNB 101 and may be in the form of a lookup table of the like. In another embodiment, the pattern may be fixed for the set of paging occasions associated with the UE (again, information indicative of this fixed pattern may be determined and transmitted to the UE 104 by the eNB 101).

It will thus be appreciated that, in a first embodiment, the present technique provides a terminal device 104 for use with a wireless telecommunications network. The terminal device comprises a transceiver 401, 402 and a controller 403. The controller is operable to control the transceiver to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device (for example, the plurality of periodic paging occasions PO1 or PO2), a scheduling signal (carried by the NB-PDCCH, for example) scheduling a paging message for paging one or more terminal devices of the wireless telecommunications network. Each periodic paging occasion associated with the terminal device is associated with a value of a characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network. The controller is operable to determine whether the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device, and, if the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device, to control the transceiver to receive the paging message scheduled by the received scheduling message.

In one example, the characteristic of the scheduling signal is a paging occasion identifier identified by the scheduling signal. All periodic paging occasions associated with the terminal device may be associated with the same identifier of the scheduling signal (thus, for example, each paging occasion in the plurality of paging occasions PO1 may have the same index, each paging occasion in the plurality of paging occasions PO2 may have the same index, and so on). Alternatively, each periodic paging occasion

associated with the terminal device may be associated with an identifier of the scheduling signal which is different from the identifier of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device (thus, for example, each paging occasion in the plurality of paging occasions PO1 may have a version number which distinguishes it from the other paging occasions in the plurality PO1, each paging occasion in the plurality of paging occasions PO2 may have a version number which distinguishes it from the other paging occasions in the plurality PO1, and so on). Any suitable identifier may be used as the paging occasion identifier, including, for example, an identifier comprising one or more of a PO index, PO version number or P-RNTI number, as previously discussed.

In another example, the characteristic of the scheduling signal is a scrambling of the scheduling signal. All periodic paging occasions associated with the terminal device may be associated with the same scrambling of the scheduling signal (thus, for example, each paging occasion in the plurality of paging occasions PO1 may be associated with the same scrambling of the scheduling signal, each paging occasion in the plurality of paging occasions PO2 may be associated with the same scrambling of the scheduling signal, and so on). Alternatively, each periodic paging occasion associated with the terminal device may be associated with a scrambling of the scheduling signal which is different from the scrambling of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device (thus, for example, each paging occasion in the plurality of paging occasions PO1 may be associated with a different scrambling of the scheduling signal to the scrambling of the scheduling signal associated with the other paging occasions in the plurality PO1, each paging occasion in the plurality of paging occasions PO2 may be associated with a different scrambling of the scheduling signal to the scrambling of the scheduling signal associated with the other paging occasions in the plurality PO2, and so on).

In another example, the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate, and the controller is operable to control the transceiver to attempt to receive the scheduling signal from each candidate of the radio search space. For example, the radio search space may be a CSS and the scheduling signal may be the repeatedly transmitted NB-PDCCH. In this case the characteristic of the scheduling signal is a starting time of the radio search space indicated by the scheduling signal, and the controller is operable to determine, on the basis of the starting time of the radio search space and a starting time of the scheduling signal, whether the scheduling signal belongs to a radio search space with a starting time which matches the starting time of the one of the plurality of periodic paging occasions associated with the terminal device, wherein the controller determines a match when the scheduling signal is determined to belong to a radio search space

with a starting time which matches the starting time of the one of the plurality of periodic paging occasions associated with the terminal device.

In this first embodiment, the present technique also provides infrastructure equipment 101 for use with a wireless telecommunications network. The infrastructure equipment comprises a transceiver 411, 412 and a controller 413. The controller is operable to control the transceiver to begin transmitting, during the one of the plurality of periodic paging occasions associated with the terminal device 104, the scheduling signal scheduling the paging message for paging the terminal device in the way as described.

It will also be appreciated that, in a second embodiment, the present technique provides a terminal device 101for use with a wireless telecommunications network. The terminal device comprises a transceiver 401, 402 and a controller 403. The controller is operable to control the transceiver to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device (for example, the plurality of periodic paging occasions PO1 or PO2), a scheduling signal (carried by the NB-PDCCH, for example) scheduling a paging message for paging the terminal device. The scheduling signal is repeatedly transmitted by the network a predetermined number of times over a predetermined plurality of separate time periods (in other words, the periodic repeats of the scheduling signal are segmented, as shown in Figures 9 to 11, for example), each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin receiving the scheduling signal. The controller is operable to control the transceiver to receive the repetitions of the scheduling signal over the predetermined plurality of separate time periods.

In one example, the total time taken for the scheduling signal to be repeatedly transmitted by the network is greater than the time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated. Scheduling signals with a duration of that of CSS1 or CSS 5 (shown in Figures 9 to 11) are examples of such scheduling signals.

In one example, the plurality of periodic paging occasions associated with the terminal device are interleaved with the plurality of periodic paging occasions associated with any other terminal device of the wireless telecommunications network. This is shown, for example, in Figures 9 to 11, in which paging occasions belonging to the plurality PO1 are interleaved with paging occasions belonging to the plurality PO2.

In one example, the controller is operable to control the transceiver to receive a signal from the wireless telecommunications network indicative of the predetermined plurality of separate time periods. In this case, for example, information indicative of the predetermined plurality of separate time periods (in other words, the segmentation pattern of the repeatedly transmitted scheduling signal) is stored in the storage medium 422 of the infrastructure equipment 101 and is signalled to the terminal device 104 using the transceiver 411, 412. The transceiver 401, 402 of the terminal device then receives the signal and the information indicative of the predetermined plurality of separate time periods is stored in the storage medium 420.

In one example, the number of other terminal devices of the wireless telecommunications network with which a plurality of periodic paging occasions is associated is one or more, and the plurality of periodic paging occasions associated with the one or more other terminal devices is different to the plurality of periodic paging occasions associated with the terminal device. In this case, for example, there are at least two terminal devices in the wireless telecommunications network, wherein one terminal device is associated with the plurality of periodic paging occasions PO1 and the other terminal device is associated with the plurality of periodic paging occasions PO2, as shown in Figures 9 to 11. In another example, there may be no other terminal devices associated with a plurality of different periodic paging occasions (in which case, the only paging occasions present are those associated with the terminal device 104). It is noted that the present technique will still work in this case, in that if the terminal device knows the predetermined plurality of separate time periods over which the scheduling signal is repeatedly transmitted, the terminal device will know which paging occasion a particular set of repeats of the scheduling signal belongs to (thus avoiding the confusion arising from the situation shown in Figure 8, for example).

In this second embodiment, the present technique also provides infrastructure equipment 101 for use with a wireless telecommunications network. The infrastructure equipment comprises a transceiver 411, 412 and a controller 413. The controller is operable to control the transceiver to begin transmitting, during the one of the plurality of periodic paging occasions associated with a terminal device 104, the scheduling signal scheduling the paging message for paging the terminal device in the way as described.

Figure 12 illustrates a flow chart schematically showing a method according to the first embodiment of the present technique. The method starts at step 1201. At step 1202, the terminal device 104 begins receiving a scheduling signal during one of a plurality of periodic paging occasions associated with the terminal device. At step 1204, it is determined whether a value of a predetermined characteristic associated with each of the received scheduling signal and the one of the plurality of paging occasions matches. In the case that there is no match, the method ends at step 1208. On the other hand, in the case

that there is a match, the method moves on to step 1206, in which the terminal device receives a paging message scheduled by the scheduling signal. The method then ends at step 1208.

Figure 13 illustrates a flow chart schematically showing a method according to the second embodiment of the present technique. The method starts at step 1301. At step 1302, the terminal device 104 begins receiving a scheduling signal during one of a plurality of periodic paging occasions associated with the terminal device. At step 1303, the terminal device receives a predetermined number of repeats of the scheduling signal over a predetermined plurality of separate time periods. At step 1304, the terminal device receives a paging message scheduled by the scheduling signal. The method then ends at step 1305.

Features of various embodiments of the present technique are described by the following numbered clauses:

1. A terminal device for use with a wireless telecommunications network, the terminal device comprising:

a transceiver; and

a controller operable:

to control the transceiver to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging one or more terminal devices of the wireless telecommunications network, each periodic paging occasion associated with the terminal device being associated with a value of a characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network;

to determine whether the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device; and

if the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device, to control the transceiver to receive the paging message scheduled by the received scheduling message.

2. A terminal device according to clause 1, wherein the characteristic of the scheduling signal is a paging occasion identifier identified by the scheduling signal.

3. A terminal device according to clause 2, wherein all periodic paging occasions associated with the terminal device are associated with the same identifier of the scheduling signal.

4. A terminal device according to clause 2, wherein each periodic paging occasion associated with the terminal device is associated with an identifier of the scheduling signal which is different from the identifier of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device.

5. A terminal device according to clause 1, wherein the characteristic of the scheduling signal is a scrambling of the scheduling signal.

6. A terminal device according to clause 5, wherein all periodic paging occasions associated with the terminal device are associated with the same scrambling of the scheduling signal.

7. A terminal device according to clause 5, wherein each periodic paging occasion associated with the terminal device is associated with a scrambling of the scheduling signal which is different from the scrambling of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device.

8. A terminal device according to any preceding clause, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate, and wherein the controller is operable to control the transceiver to attempt to receive the scheduling signal from each candidate of the radio search space.

9. A terminal device according to clause 1, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate, and wherein the controller is operable to control the transceiver to attempt to receive the scheduling signal from each candidate of the radio search space, wherein the characteristic of the scheduling signal is a starting time of the radio search space indicated by the scheduling signal, and the controller is operable to determine, on the basis of the starting time of the radio search space and a starting time of the scheduling signal, whether the scheduling signal belongs to a radio search space with a starting time which matches the starting time of the one of the plurality of periodic paging occasions associated with the terminal device, wherein the controller determines a match when the scheduling signal is determined to belong to a

radio search space with a starting time which matches the starting time of the one of the plurality of periodic paging occasions associated with the terminal device.

10. A terminal device according to any preceding clause, wherein the terminal device is a Narrow Band Internet of Things (NB-IoT) terminal device and the scheduling signal is carried by a Narrow Band Physical Downlink Control Channel (NB-PDCCH).

11. Infrastructure equipment for use with a wireless telecommunications network, the infrastructure equipment comprising:

a transceiver; and

a controller operable:

to control the transceiver to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device, wherein a value of a characteristic of the scheduling signal is associated with the one of the plurality of periodic paging occasions associated with the terminal device, each periodic paging occasion associated with the terminal device being associated with a value of the characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network.

12. Infrastructure equipment according to clause 11, wherein the characteristic of the scheduling signal is a paging occasion identifier identified by the scheduling signal.

13. Infrastructure equipment according to clause 12, wherein all periodic paging occasions associated with the terminal device are associated with the same identifier of the scheduling signal.

14. Infrastructure equipment according to clause 12, wherein each periodic paging occasion associated with the terminal device is associated with an identifier of the scheduling signal which is different from the identifier of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device.

15. Infrastructure equipment according to clause 11, wherein the characteristic of the scheduling signal is a scrambling of the scheduling signal.

16. Infrastructure equipment according to clause 15, wherein all periodic paging occasions associated with the terminal device are associated with the same scrambling of the scheduling signal.

17. Infrastructure equipment according to clause 15, wherein each periodic paging occasion associated with the terminal device is associated with a scrambling of the scheduling signal which is different from the scrambling of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device.

18. Infrastructure equipment according to any one of clauses 11 to 17, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate.

19. Infrastructure equipment according to clause 11, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate, , wherein the characteristic of the scheduling signal is a starting time of the radio search space indicated by the scheduling signal, the starting time of the radio search space matching the starting time of the one of the plurality of periodic paging occasions associated with the terminal device.

20. Infrastructure equipment according to any one of clauses 11 to 19, wherein the terminal device is a Narrow Band Internet of Things (NB-IoT) terminal device and the scheduling signal is carried by a Narrow Band Physical Downlink Control Channel (NB-PDCCH).

21. A method of operating a terminal device for use with a wireless telecommunications network, the method comprising:

controlling a transceiver of the terminal device to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging one or more terminal devices of the wireless telecommunications network, each periodic paging occasion associated with the terminal device being associated with a value of a characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network;

determining whether the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device; and

if the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device, controlling the transceiver to receive the paging message scheduled by the received scheduling message.

22. A method of operating infrastructure equipment for use with a wireless telecommunications network, the method comprising:

controlling a transceiver of the infrastructure equipment to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device, wherein a value of a characteristic of the scheduling signal is associated with the one of the plurality of periodic paging occasions associated with the terminal device, each periodic paging occasion associated with the terminal device being associated with a value of the characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network.

23. Integrated circuitry for a terminal device for use with a wireless telecommunications network, the integrated circuitry comprising:

a transceiver element; and

a controller element operable:

to control the transceiver element to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging one or more terminal devices of the wireless telecommunications network, each periodic paging occasion associated with the terminal device being associated with a value of a characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network;

to determine whether the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device; and

if the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device, to control the transceiver element to receive the paging message scheduled by the received scheduling message.

24. Integrated circuitry for infrastructure equipment for use with a wireless telecommunications network, the integrated circuitry comprising:

a transceiver element; and

a controller element operable:

to control the transceiver element to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device, wherein a value of a characteristic of the scheduling signal is associated with the one of the plurality of periodic paging occasions associated with the terminal device, each periodic paging occasion associated with the terminal device being associated with a value of the characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network.

25. A wireless telecommunications network comprising a terminal device according to clause 1 and infrastructure equipment according to clause 11.

26. A terminal device for use with a wireless telecommunications network, the terminal device comprising:

a transceiver; and

a controller operable:

to control the transceiver to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the scheduling signal is repeatedly transmitted by the network a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin receiving the scheduling signal; and

the controller is operable to control the transceiver to receive the repetitions of the scheduling signal over the predetermined plurality of separate time periods.

27. A terminal device according to clause 26, wherein the total time taken for the scheduling signal to be repeatedly transmitted by the network is greater than the time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated.

28. A terminal device according to clause 26 or 27, wherein the plurality of periodic paging occasions associated with the terminal device are interleaved with the plurality of periodic paging occasions associated with any other terminal device of the wireless telecommunications network.

29. A terminal device according to any one of clauses 26 to 28, wherein the controller is operable to control the transceiver to receive a signal from the wireless telecommunications network indicative of the predetermined plurality of separate time periods.

30. A terminal device according to any one of clauses 26 to 29, wherein the number of other terminal devices of the wireless telecommunications network with which a plurality of periodic paging occasions is associated is one or more, and the plurality of periodic paging occasions associated with the one or more other terminal devices is different to the plurality of periodic paging occasions associated with the terminal device.

31. A terminal device according to any one of clauses 26 to 30, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate, and wherein the controller is operable to control the transceiver to attempt to receive the scheduling signal from each candidate of the radio search space.

32. A terminal device according to any one of clauses 26 to 31, wherein the terminal device is a Narrow Band Internet of Things (NB-IoT) terminal device and the scheduling signal is carried by a Narrow Band Physical Downlink Control Channel (NB-PDCCH).

33. Infrastructure equipment for use with a wireless telecommunications network, the infrastructure equipment comprising:

a transceiver; and

a controller operable:

to control the transceiver to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the controller is operable to control the transceiver to repeatedly transmit the scheduling signal a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin transmitting the scheduling signal.

34. Infrastructure equipment according to clause 33, wherein the total time taken for the scheduling signal to be repeatedly transmitted by the transceiver is greater than the time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated.

35. Infrastructure equipment according to clause 33 or 34, wherein the plurality of periodic paging occasions associated with the terminal device are interleaved with the plurality of periodic paging occasions associated with any other terminal device of the wireless telecommunications network.

36. Infrastructure equipment according to any one of claims 33 to 35, wherein the controller is operable to control the transceiver to transmit a signal to the terminal device indicative of the predetermined plurality of separate time periods.

37. Infrastructure equipment according to any one of clauses 33 to 36, wherein the number of other terminal devices of the wireless telecommunications network with which a plurality of periodic paging occasions is associated is one or more, and the plurality of periodic paging occasions associated with the one or more other terminal devices is different to the plurality of periodic paging occasions associated with the terminal device.

38. Infrastructure equipment according to any one of clauses 33 to 37, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate..

39. Infrastructure equipment according to any one of clauses 33 to 38, wherein the terminal device is a Narrow Band Internet of Things (NB-IoT) terminal device and the scheduling signal is carried by a Narrow Band Physical Downlink Control Channel (NB-PDCCH).

40. A method of operating a terminal device for use with a wireless telecommunications network, the method comprising:

controlling a transceiver of the terminal device to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the scheduling signal is repeatedly transmitted by the network a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin receiving the scheduling signal; and

transceiver is controlled to receive the repetitions of the scheduling signal over the predetermined plurality of separate time periods.

41. A method of operating infrastructure equipment for use with a wireless telecommunications network, the method comprising:

controlling a transceiver of the infrastructure equipment to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the transceiver is controlled to repeatedly transmit the scheduling signal a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin transmitting the scheduling signal.

42. Integrated circuitry for a terminal device for use with a wireless telecommunications network, the integrated circuitry comprising:

a transceiver element; and

a controller element operable:

to control the transceiver element to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the scheduling signal is repeatedly transmitted by the network a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver element is controlled to begin receiving the scheduling signal; and

the controller element is operable to control the transceiver element to receive the repetitions of the scheduling signal over the predetermined plurality of separate time periods.

43. Integrated circuitry for operating infrastructure equipment for use with a wireless telecommunications network, the integrated circuitry comprising:

a transceiver element; and

a controller element operable:

to control the transceiver element to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the controller element is operable to control the transceiver to repeatedly transmit the scheduling signal a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver element is controlled to begin transmitting the scheduling signal.

44. A wireless telecommunications network comprising a terminal device according to clause 26 and infrastructure equipment according to clause 33.

Numerous modifications and variations of the present disclosure are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the disclosure may be practiced otherwise than as specifically described herein.

In so far as embodiments of the disclosure have been described as being implemented, at least in part, by software-controlled data processing apparatus, it will be appreciated that a non-transitory machine-readable medium carrying such software, such as an optical disk, a magnetic disk, semiconductor memory or the like, is also considered to represent an embodiment of the present disclosure.

It will be appreciated that the above description for clarity has described embodiments with reference to different functional units, circuitry and/or processors. However, it will be apparent that any suitable distribution of functionality between different functional units, circuitry and/or processors may be used without detracting from the embodiments.

Described embodiments may be implemented in any suitable form including hardware, software, firmware or any combination of these. Described embodiments may optionally be implemented at least partly as computer software running on one or more data processors and/or digital signal processors. The elements and components of any embodiment may be physically, functionally and logically implemented in any suitable way. Indeed the functionality may be implemented in a single unit, in a plurality of units or as part of other functional units. As such, the disclosed embodiments may be implemented in a single unit or may be physically and functionally distributed between different units, circuitry and/or processors.

Although the present disclosure has been described in connection with some embodiments, it is not intended to be limited to the specific form set forth herein. Additionally, although a feature may appear to be described in connection with particular embodiments, one skilled in the art would recognize that various features of the described embodiments may be combined in any manner suitable to implement the technique.

Annex 1:

The simplified structure of the downlink of an LTE wireless access interface presented in Figure 2, also includes an illustration of each subframe 201, which comprises a control region 205 for the transmission of control data, a data region 206 for the transmission of user data , reference signals 207 and synchronisation signals which are interspersed in the control and data regions in accordance with a predetermined pattern. The control region 204 may contain a number of physical channels for the transmission of control data, such as a physical downlink control channel PDCCH, a physical control format indicator channel PCFICH and a physical HARQ indicator channel PHICH. The data region may contain a number of physical channel for the transmission of data, such as a physical downlink shared channel PDSCH and a physical broadcast channels PBCH. Although these physical channels provide a wide range of functionality to LTE systems, in terms of resource allocation and the present disclosure PDCCH and PDSCH are most relevant. Further information on the structure and functioning of the physical channels of LTE systems can be found in [1].

Resources within the PDSCH may be allocated by an eNodeB to UEs being served by the eNodeB. For example, a number of resource blocks of the PDSCH may be allocated to a UE in order that it may receive data that it has previously requested or data which is being pushed to it by the eNodeB, such as radio resource control RRC signalling. In Figure 2, UE1 has been allocated resources 208 of the data region 206, UE2 resources 209 and UE resources 210. UEs in a an LTE system may be allocated a fraction of the available resources of the PDSCH and therefore UEs are required to be informed of the location of their allocated resources within the PDCSH so that only relevant data within the PDSCH is detected and estimated. In order to inform the UEs of the location of their allocated communications resources, resource control information specifying downlink resource allocations is conveyed across the PDCCH in a form termed downlink control information DCI, where resource allocations for a PDSCH are communicated in a preceding PDCCH instance in the same subframe. During a resource allocation procedure, UEs thus monitor the PDCCH for DCI addressed to them and once such a DCI is detected, receive the DCI and detect and estimate the data from the relevant part of the PDSCH.

Each uplink subframe may include a plurality of different channels, for example a physical uplink shared channel PUSCH 305, a physical uplink control channel PUCCH 306, and a physical random access channel PRACH. The physical Uplink Control Channel PUCCH may carry control information such as ACK/NACK to the eNodeB for downlink transmissions, scheduling request indicators SRI for UEs wishing to be scheduled uplink resources, and feedback of downlink channel state information CSI for example. The PUSCH may carry UE uplink data or some uplink control data. Resources of the PUSCH are granted via PDCCH, such a grant being typically triggered by communicating to the network the amount of data ready to be transmitted in a buffer at the UE. The PRACH may be scheduled in any of the

resources of an uplink frame in accordance with a one of a plurality of PRACH patterns that may be signalled to UE in downlink signalling such as system information blocks. As well as physical uplink channels, uplink subframes may also include reference signals. For example, demodulation reference signals DMRS 307 and sounding reference signals SRS 308 may be present in an uplink subframe where the DMRS occupy the fourth symbol of a slot in which PUSCH is transmitted and are used for decoding of PUCCH and PUSCH data, and where SRS are used for uplink channel estimation at the eNodeB. Further information on the structure and functioning of the physical channels of LTE systems can be found in [1].

In an analogous manner to the resources of the PDSCH, resources of the PUSCH are required to be scheduled or granted by the serving eNodeB and thus if data is to be transmitted by a UE, resources of the PUSCH are required to be granted to the UE by the eNodeB. At a UE, PUSCH resource allocation is achieved by the transmission of a scheduling request or a buffer status report to its serving eNodeB. The scheduling request may be made, when there is insufficient uplink resource for the UE to send a buffer status report, via the transmission of Uplink Control Information UCI on the PUCCH when there is no existing PUSCH allocation for the UE, or by transmission directly on the PUSCH when there is an existing PUSCH allocation for the UE. In response to a scheduling request, the eNodeB is configured to allocate a portion of the PUSCH resource to the requesting UE sufficient for transferring a buffer status report and then inform the UE of the buffer status report resource allocation via a DCI in the PDCCH. Once or if the UE has PUSCH resource adequate to send a buffer status report, the buffer status report is sent to the eNodeB and gives the eNodeB information regarding the amount of data in an uplink buffer or buffers at the UE. After receiving the buffer status report, the eNodeB can allocate a portion of the PUSCH resources to the sending UE in order to transmit some of its buffered uplink data and then inform the UE of the resource allocation via a DCI in the PDCCH. For example, presuming a UE has a connection with the eNodeB, the UE will first transmit a PUSCH resource request in the PUCCH in the form of a UCI. The UE will then monitor the PDCCH for an appropriate DCI, extract the details of the PUSCH resource allocation, and transmit uplink data , at first comprising a buffer status report, and/or later comprising a portion of the buffered data, in the allocated resources.

Although similar in structure to downlink subframes, uplink subframes have a different control structure to downlink subframes, in particular the upper 309 and lower 310 subcarriers/frequencies/resource blocks of an uplink subframe are reserved for control signalling rather than the initial symbols of a downlink subframe. Furthermore, although the resource allocation procedure for the downlink and uplink are relatively similar, the actual structure of the resources that may be allocated may vary due to the different characteristics of the OFDM and SC-FDM interfaces that are used in the downlink and uplink respectively. In OFDM each subcarrier is individually modulated and therefore it is not necessary that frequency/subcarrier allocation are contiguous however, in SC-FDM subcarriers are modulation in

combination and therefore if efficient use of the available resources are to be made contiguous frequency allocations for each UE are preferable.

As a result of the above described wireless interface structure and operation, one or more UEs may communicate data to one another via a coordinating eNodeB, thus forming a conventional cellular telecommunications system. Although cellular communications system such as those based on the previously released LTE standards have been commercially successful, a number of disadvantages are associated with such centralised systems. For example, if two UEs which are in close proximity wish to communicate with each other, uplink and downlink resources sufficient to convey the data are required. Consequently, two portions of the system's resources are being used to convey a single portion of data. A second disadvantage is that an eNodeB is required if UEs, even when in close proximity, wish to communicate with one another. These limitations may be problematic when the system is experiencing high load or eNodeB coverage is not available, for instance in remote areas or when eNodeBs are not functioning correctly. Overcoming these limitations may increase both the capacity and efficiency of LTE networks but also lead to the creations of new revenue possibilities for LTE network operators.

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CLAIMS

1. A terminal device for use with a wireless telecommunications network, the terminal device comprising:

a transceiver; and

a controller operable:

to control the transceiver to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging one or more terminal devices of the wireless telecommunications network, each periodic paging occasion associated with the terminal device being associated with a value of a characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network;

to determine whether the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device; and

if the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device, to control the transceiver to receive the paging message scheduled by the received scheduling message.

2. A terminal device according to claim 1, wherein the characteristic of the scheduling signal is a paging occasion identifier identified by the scheduling signal.

3. A terminal device according to claim 2, wherein all periodic paging occasions associated with the terminal device are associated with the same identifier of the scheduling signal.

4. A terminal device according to claim 2, wherein each periodic paging occasion associated with the terminal device is associated with an identifier of the scheduling signal which is different from the identifier of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device.

5. A terminal device according to claim 1, wherein the characteristic of the scheduling signal is a scrambling of the scheduling signal.

6. A terminal device according to claim 5, wherein all periodic paging occasions associated with the terminal device are associated with the same scrambling of the scheduling signal.

7. A terminal device according to claim 5, wherein each periodic paging occasion associated with the terminal device is associated with a scrambling of the scheduling signal which is different from the scrambling of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device.

8. A terminal device according to claim 1, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate, and wherein the controller is operable to control the transceiver to attempt to receive the scheduling signal from each candidate of the radio search space.

9. A terminal device according to claim 1, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate, and wherein the controller is operable to control the transceiver to attempt to receive the scheduling signal from each candidate of the radio search space, wherein the characteristic of the scheduling signal is a starting time of the radio search space indicated by the scheduling signal, and the controller is operable to determine, on the basis of the starting time of the radio search space and a starting time of the scheduling signal, whether the scheduling signal belongs to a radio search space with a starting time which matches the starting time of the one of the plurality of periodic paging occasions associated with the terminal device, wherein the controller determines a match when the scheduling signal is determined to belong to a radio search space with a starting time which matches the starting time of the one of the plurality of periodic paging occasions associated with the terminal device.

10. A terminal device according to claim 1, wherein the terminal device is a Narrow Band Internet of Things (NB-IoT) terminal device and the scheduling signal is carried by a Narrow Band Physical Downlink Control Channel (NB-PDCCH).

11. Infrastructure equipment for use with a wireless telecommunications network, the infrastructure equipment comprising:

a transceiver; and

a controller operable:

to control the transceiver to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device, wherein a value of a characteristic of the scheduling signal is associated with the one of the plurality of periodic paging occasions associated with the terminal device, each periodic paging occasion associated with the terminal device being associated with a value of the characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network.

12. Infrastructure equipment according to claim 11, wherein the characteristic of the scheduling signal is a paging occasion identifier identified by the scheduling signal.

13. Infrastructure equipment according to claim 12, wherein all periodic paging occasions associated with the terminal device are associated with the same identifier of the scheduling signal.

14. Infrastructure equipment according to claim 12, wherein each periodic paging occasion associated with the terminal device is associated with an identifier of the scheduling signal which is different from the identifier of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device.

15. Infrastructure equipment according to claim 11, wherein the characteristic of the scheduling signal is a scrambling of the scheduling signal.

16. Infrastructure equipment according to claim 15, wherein all periodic paging occasions associated with the terminal device are associated with the same scrambling of the scheduling signal.

17. Infrastructure equipment according to claim 15, wherein each periodic paging occasion associated with the terminal device is associated with a scrambling of the scheduling signal which is different from the scrambling of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device.

18. Infrastructure equipment according to claim 11, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate.

19. Infrastructure equipment according to claim 11, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate, , wherein the characteristic of the scheduling signal is a starting time of the radio search space indicated by the scheduling signal, the starting time of the radio search space matching the starting time of the one of the plurality of periodic paging occasions associated with the terminal device.

20. Infrastructure equipment according to claim 11, wherein the terminal device is a Narrow Band Internet of Things (NB-IoT) terminal device and the scheduling signal is carried by a Narrow Band Physical Downlink Control Channel (NB-PDCCH).

21. A method of operating a terminal device for use with a wireless telecommunications network, the method comprising:

controlling a transceiver of the terminal device to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging one or more terminal devices of the wireless telecommunications network, each periodic paging occasion associated with the terminal device being associated with a value of a characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network;

determining whether the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device; and

if the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device, controlling the transceiver to receive the paging message scheduled by the received scheduling message.

22. A method of operating infrastructure equipment for use with a wireless telecommunications network, the method comprising:

controlling a transceiver of the infrastructure equipment to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device, wherein a value of a characteristic of the scheduling signal is associated with the one of the

plurality of periodic paging occasions associated with the terminal device, each periodic paging occasion associated with the terminal device being associated with a value of the characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network.

23. Integrated circuitry for a terminal device for use with a wireless telecommunications network, the integrated circuitry comprising:

a transceiver element; and

a controller element operable:

to control the transceiver element to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging one or more terminal devices of the wireless telecommunications network, each periodic paging occasion associated with the terminal device being associated with a value of a characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network;

to determine whether the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device; and

if the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device, to control the transceiver element to receive the paging message scheduled by the received scheduling message.

24. Integrated circuitry for infrastructure equipment for use with a wireless telecommunications network, the integrated circuitry comprising:

a transceiver element; and

a controller element operable:

to control the transceiver element to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device, wherein a value of a characteristic of the scheduling signal is associated with the one of the plurality of periodic paging occasions associated with the terminal device, each periodic paging occasion associated with the terminal device being associated with a value of the characteristic of the scheduling signal which is different from

a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network.

25. A wireless telecommunications network comprising a terminal device according to claim 1 and infrastructure equipment according to claim 11.

26. A terminal device for use with a wireless telecommunications network, the terminal device comprising:

a transceiver; and

a controller operable:

to control the transceiver to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the scheduling signal is repeatedly transmitted by the network a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin receiving the scheduling signal; and

the controller is operable to control the transceiver to receive the repetitions of the scheduling signal over the predetermined plurality of separate time periods.

27. A terminal device according to claim 26, wherein the total time taken for the scheduling signal to be repeatedly transmitted by the network is greater than the time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated.

28. A terminal device according to claim 26, wherein the plurality of periodic paging occasions associated with the terminal device are interleaved with the plurality of periodic paging occasions associated with any other terminal device of the wireless telecommunications network.

29. A terminal device according to claim 26, wherein the controller is operable to control the transceiver to receive a signal from the wireless telecommunications network indicative of the predetermined plurality of separate time periods.

30. A terminal device according to claim 26, wherein the number of other terminal devices of the wireless telecommunications network with which a plurality of periodic paging occasions is associated is one or more, and the plurality of periodic paging occasions associated with the one or more other terminal devices is different to the plurality of periodic paging occasions associated with the terminal device.

31. A terminal device according to claim 26, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate, and wherein the controller is operable to control the transceiver to attempt to receive the scheduling signal from each candidate of the radio search space.

32. A terminal device according to claim 26, wherein the terminal device is a Narrow Band Internet of Things (NB-IoT) terminal device and the scheduling signal is carried by a Narrow Band Physical Downlink Control Channel (NB-PDCCH).

33. Infrastructure equipment for use with a wireless telecommunications network, the infrastructure equipment comprising:

a transceiver; and

a controller operable:

to control the transceiver to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the controller is operable to control the transceiver to repeatedly transmit the scheduling signal a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin transmitting the scheduling signal.

34. Infrastructure equipment according to claim 33, wherein the total time taken for the scheduling signal to be repeatedly transmitted by the transceiver is greater than the time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated.

35. Infrastructure equipment according to claim 33, wherein the plurality of periodic paging occasions associated with the terminal device are interleaved with the plurality of periodic paging occasions associated with any other terminal device of the wireless telecommunications network.

36. Infrastructure equipment according to claim 33, wherein the controller is operable to control the transceiver to transmit a signal to the terminal device indicative of the predetermined plurality of separate time periods.

37. Infrastructure equipment according to claim 33, wherein the number of other terminal devices of the wireless telecommunications network with which a plurality of periodic paging occasions is associated is one or more, and the plurality of periodic paging occasions associated with the one or more other terminal devices is different to the plurality of periodic paging occasions associated with the terminal device.

38. Infrastructure equipment according to claim 33, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate..

39. Infrastructure equipment according to claim 33, wherein the terminal device is a Narrow Band Internet of Things (NB-IoT) terminal device and the scheduling signal is carried by a Narrow Band Physical Downlink Control Channel (NB-PDCCH).

40. A method of operating a terminal device for use with a wireless telecommunications network, the method comprising:

controlling a transceiver of the terminal device to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the scheduling signal is repeatedly transmitted by the network a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the

plurality of periodic paging occasions during which the transceiver is controlled to begin receiving the scheduling signal; and

transceiver is controlled to receive the repetitions of the scheduling signal over the predetermined plurality of separate time periods.

41. A method of operating infrastructure equipment for use with a wireless telecommunications network, the method comprising:

controlling a transceiver of the infrastructure equipment to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the transceiver is controlled to repeatedly transmit the scheduling signal a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin transmitting the scheduling signal.

42. Integrated circuitry for a terminal device for use with a wireless telecommunications network, the integrated circuitry comprising:

a transceiver element; and

a controller element operable:

to control the transceiver element to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the scheduling signal is repeatedly transmitted by the network a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver element is controlled to begin receiving the scheduling signal; and

the controller element is operable to control the transceiver element to receive the repetitions of the scheduling signal over the predetermined plurality of separate time periods.

43. Integrated circuitry for operating infrastructure equipment for use with a wireless telecommunications network, the integrated circuitry comprising:

a transceiver element; and

a controller element operable:

to control the transceiver element to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the controller element is operable to control the transceiver to repeatedly transmit the scheduling signal a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver element is controlled to begin transmitting the scheduling signal.

44. A wireless telecommunications network comprising a terminal device according to claim 26 and infrastructure equipment according to claim 33.

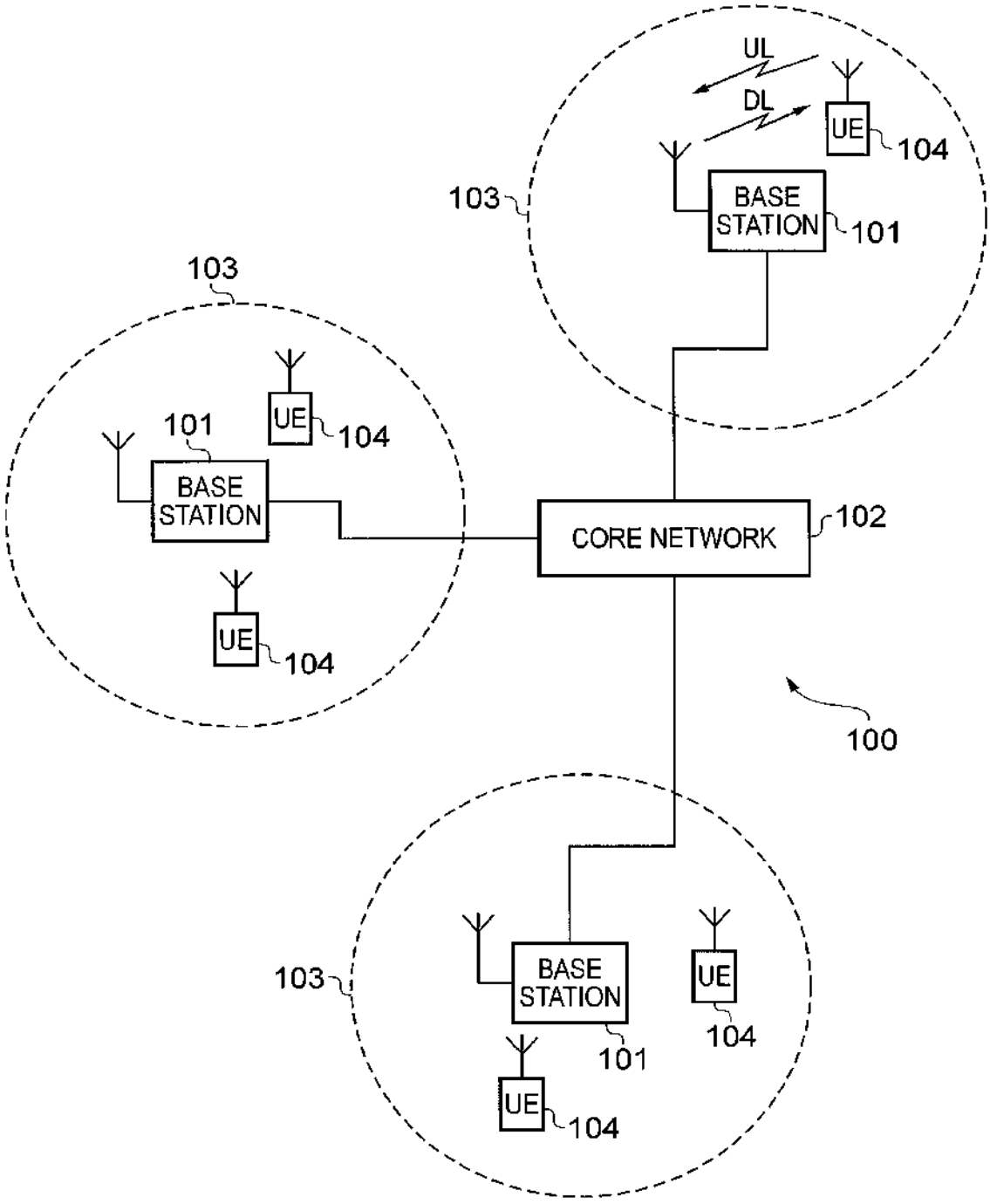


FIG. 1

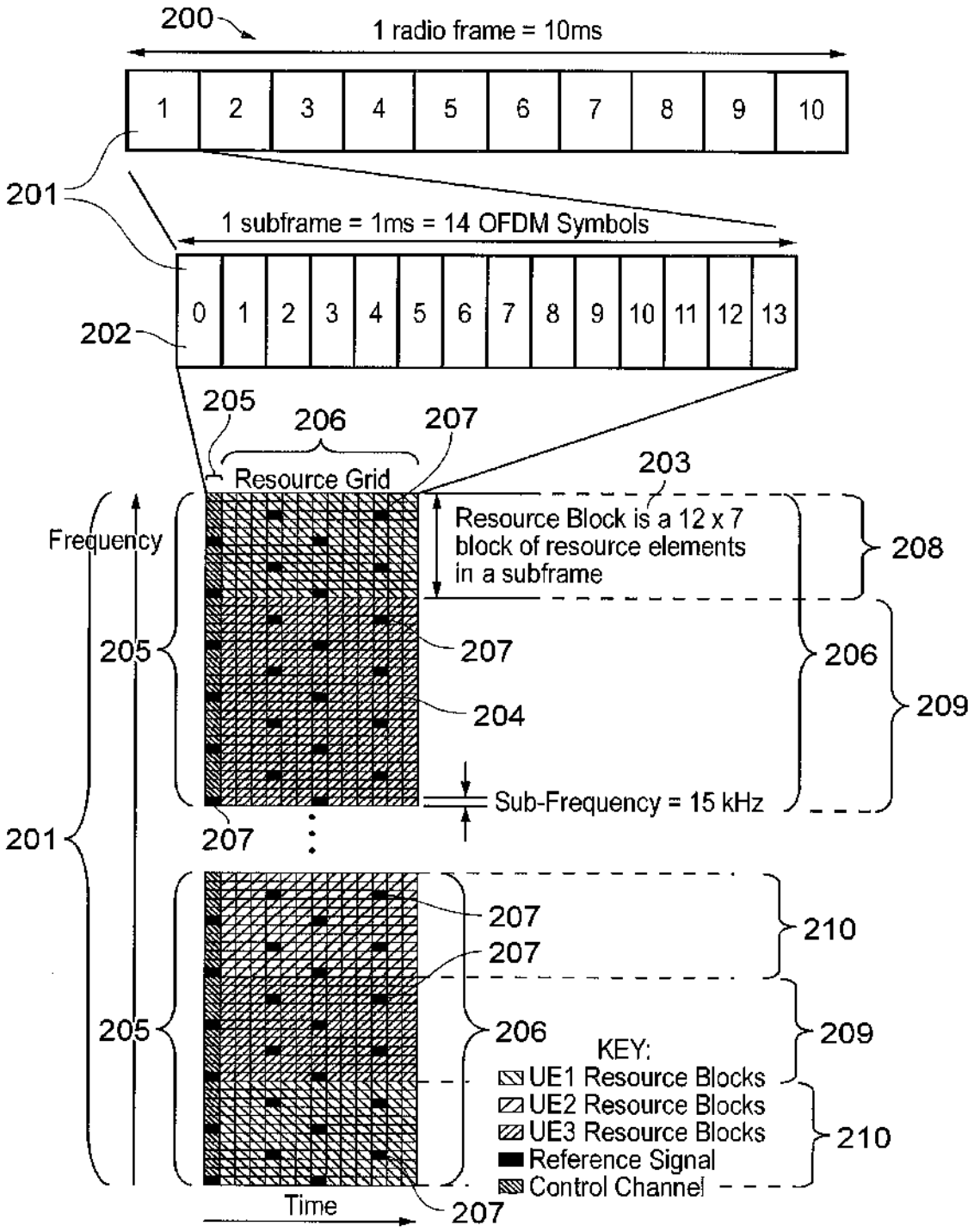

200
1 radio frame = 10ms
1 2 3 4 5 6 7 8 9 10
201
1 subframe = 1ms = 14 OFDM Symbols
0 1 2 3 4 5 6 7 8 9 10 11 12 13
202
205
206
207
Resource Grid
203
Frequency
Resource Block is a 12 x 7 block of resource elements in a subframe
208
205
207
206
209
204
Sub-Frequency = 15 kHz
201
207
207
207
210
205
206
209
KEY:
UE1 Resource Blocks
UE2 Resource Blocks
UE3 Resource Blocks
Reference Signal
Control Channel
210
Time
207

FIG. 2

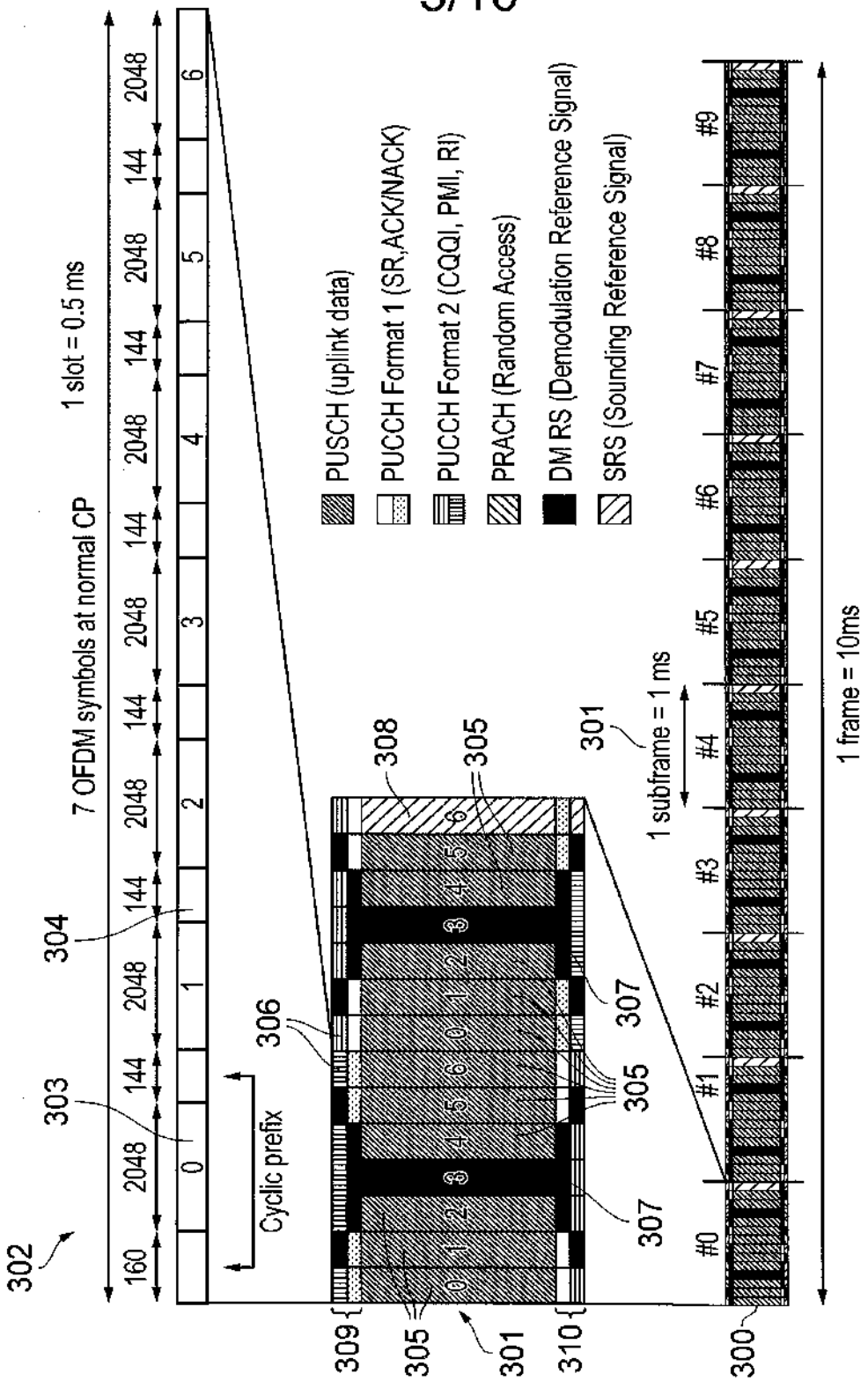

302
303
304
7 OFDM symbols at normal CP
1 slot = 0.5 ms
160
2048
144
Cyclic prefix
306
308
305
301
307
309
310
300
PUSCH (uplink data)
PUCCH Format 1 (SR,ACK/NACK)
PUCCH Format 2 (CQQI, PMI, RI)
PRACH (Random Access)
DM RS (Demodulation Reference Signal)
SRS (Sounding Reference Signal)
1 subframe = 1 ms
#0
#1
#2
#3
#4
#5
#6
#7
#8
#9
1 frame = 10ms

FIG. 3

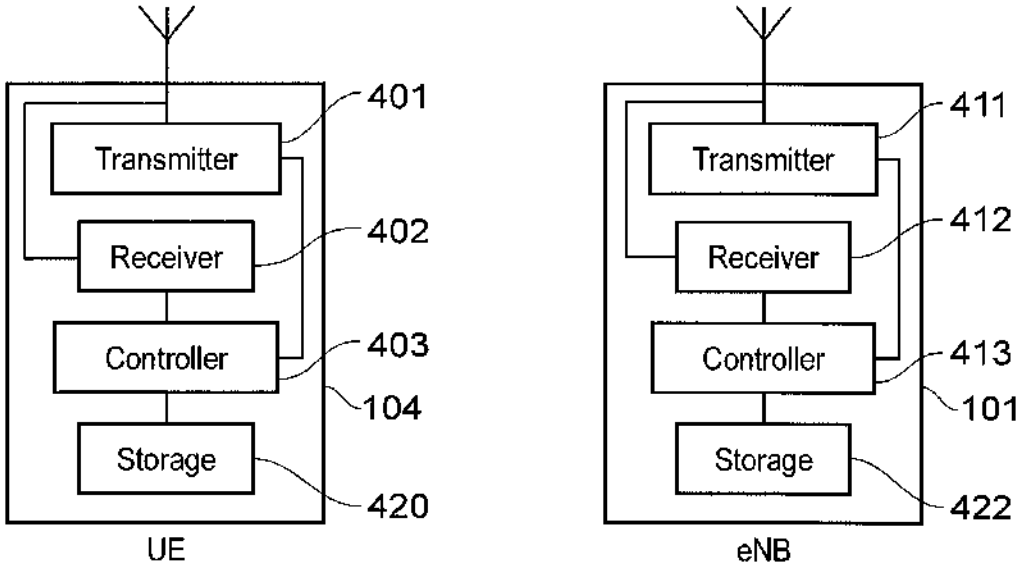

Transmitter
Receiver
Controller
Storage
401
402
403
104
420
UE
Transmitter
Receiver
Controller
Storage
411
412
413
101
422
eNB

FIG. 4

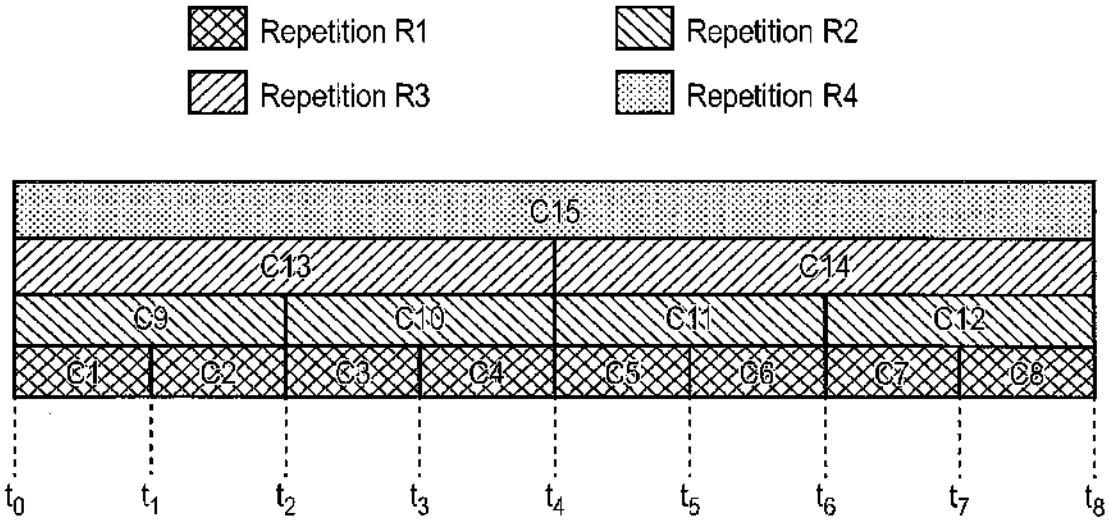

Repetition R1
Repetition R2
Repetition R3
Repetition R4
C15
C13
C14
C9
C10
C11
C12
C1
C2
C3
C4
C5
C6
C7
C8
t0
t1
t2
t3
t4
t5
t6
t7
t8

FIG. 5

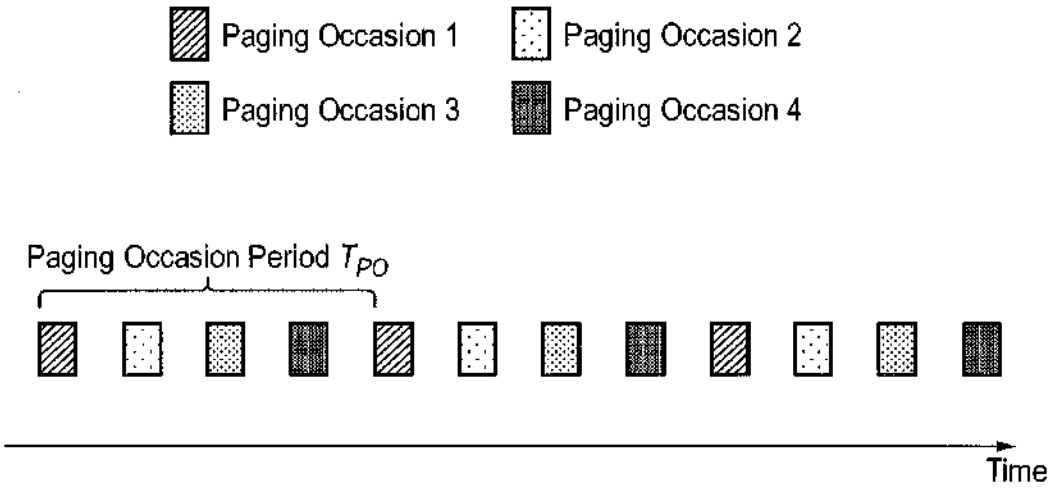

Paging Occasion 1
Paging Occasion 2
Paging Occasion 3
Paging Occasion 4
Paging Occasion Period T_{PO}
Time

FIG. 6

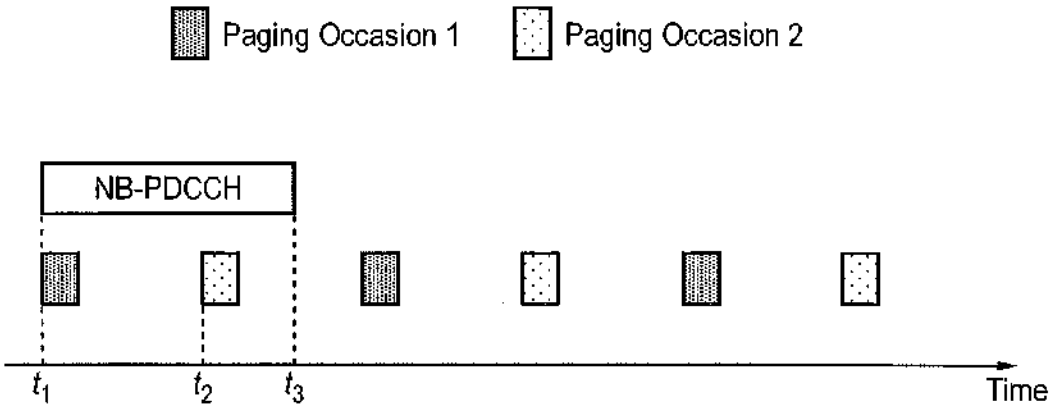

Paging Occasion 1
Paging Occasion 2
NB-PDCCH
t_1
t_2
t_3
Time

FIG. 7

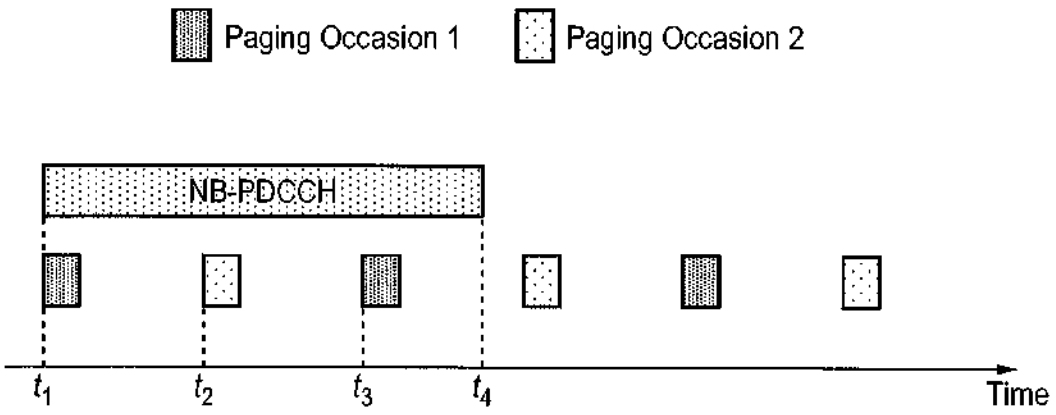

Paging Occasion 1
Paging Occasion 2
NB-PDCCH
t_1
t_2
t_3
t_4
Time

FIG. 8

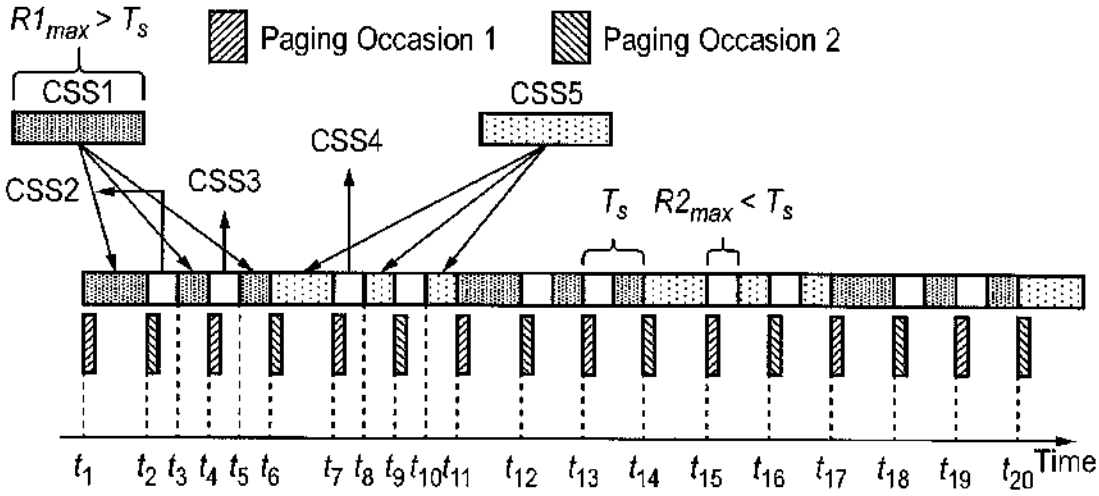

$R1_{max} > T_s$
Paging Occasion 1
Paging Occasion 2
CSS1
CSS5
CSS4
CSS2
CSS3
T_s
$R2_{max} < T_s$
t_1 t_2 t_3 t_4 t_5 t_6 t_7 t_8 t_9 t_{10} t_{11} t_{12} t_{13} t_{14} t_{15} t_{16} t_{17} t_{18} t_{19} t_{20}
Time

FIG. 9

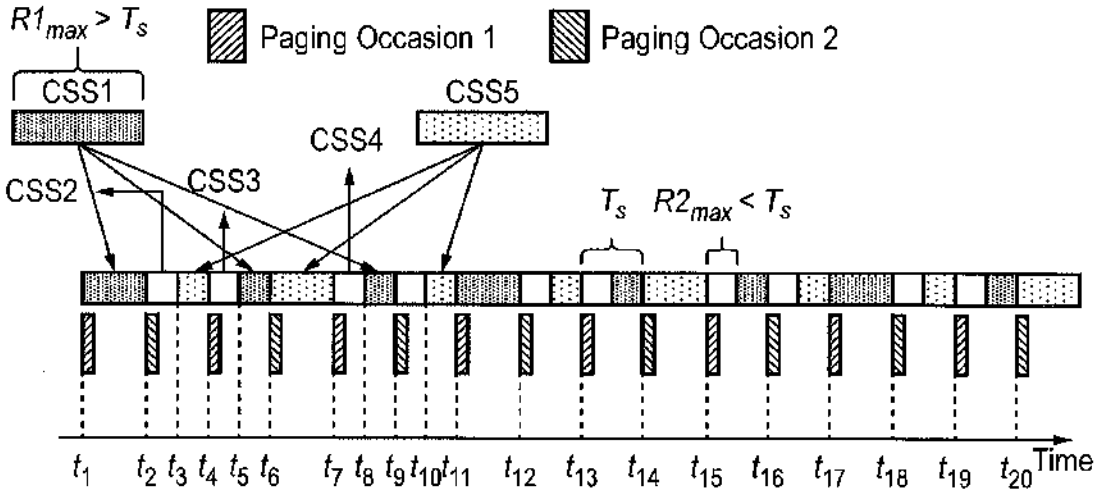

$R1_{max} > T_s$
Paging Occasion 1
Paging Occasion 2
CSS1
CSS5
CSS4
CSS2
CSS3
T_s
$R2_{max} < T_s$
t_1 t_2 t_3 t_4 t_5 t_6 t_7 t_8 t_9 t_{10} t_{11} t_{12} t_{13} t_{14} t_{15} t_{16} t_{17} t_{18} t_{19} t_{20}
Time

FIG. 10

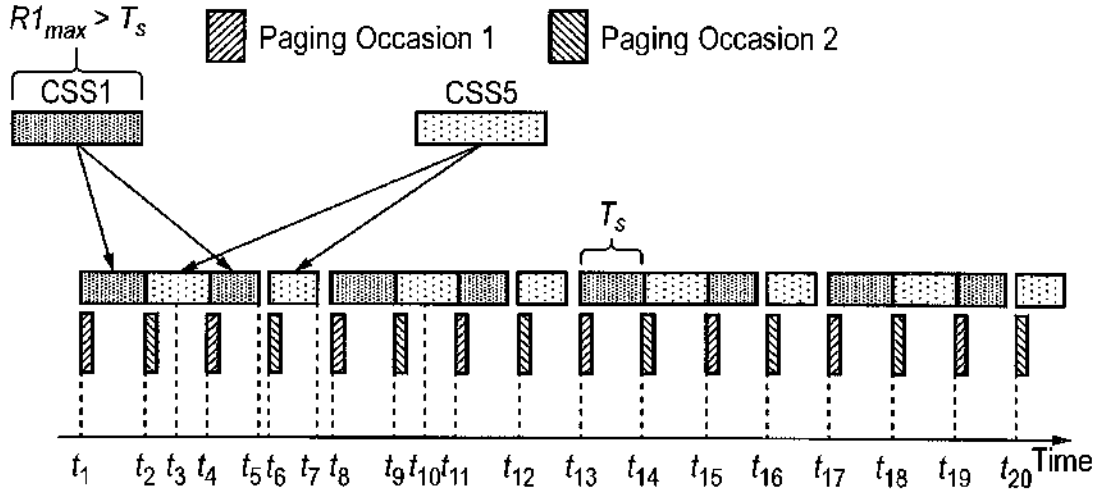

$R1_{max} > T_s$
Paging Occasion 1
Paging Occasion 2
CSS1
CSS5
T_s
t_1 t_2 t_3 t_4 t_5 t_6 t_7 t_8 t_9 t_{10} t_{11} t_{12} t_{13} t_{14} t_{15} t_{16} t_{17} t_{18} t_{19} t_{20}
Time

FIG. 11

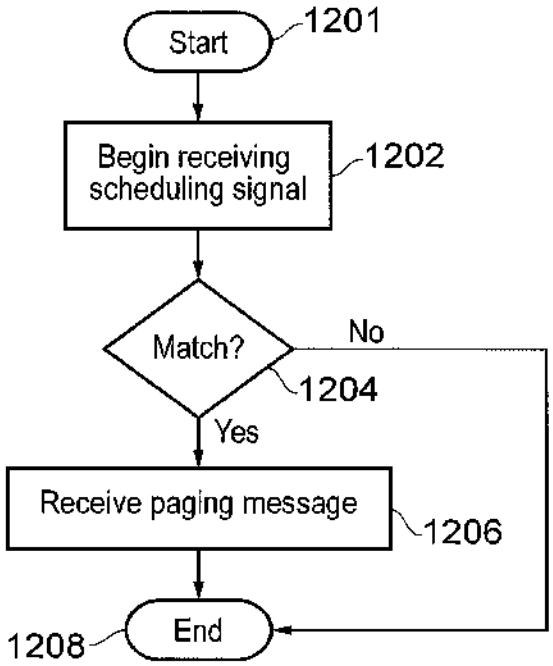

Start
1201
Begin receiving scheduling signal
1202
Match?
No
1204
Yes
Receive paging message
1206
End
1208

FIG. 12

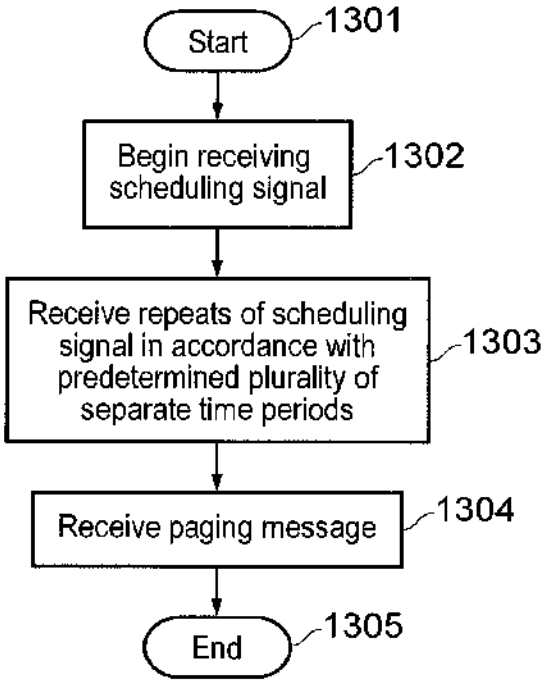

Start
1301
Begin receiving scheduling signal
1302
Receive repeats of scheduling signal in accordance with predetermined plurality of separate time periods
1303
Receive paging message
1304
End
1305

FIG. 13

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/057758

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W68/00
ADD. H04W4/00 H04W68/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 2 999 280 A2 (APPLE INC [US]) 23 March 2016 (2016-03-23) paragraphs [0100] - [0159] ----- -/--	1-25

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 July 2017	20/07/2017

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Bocking, Philip

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Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	ZTE: "Remaining Issues on NB-PDCCH Design of NB-IoT", 3GPP DRAFT; R1-160467 NB-PDCCH, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. St Julian's, Malta; 20160215 - 20160219 5 February 2016 (2016-02-05), XP051063789, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_84/Docs/ [retrieved on 2016-02-05] paragraphs [0004] - [05.2]; figures 4,7 -----	26-44
A	ERICSSON: "Paging and DRX in Idle mode in NB-IoT", 3GPP DRAFT; R2-161311 PAGING AND DRX IN IDLE MODE IN NB-IOT, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG2, no. St. Julian, Malta; 20160215 - 20160219 6 February 2016 (2016-02-06), XP051065779, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_93/Docs/ [retrieved on 2016-02-06] the whole document -----	1-44
A	ZTE: "Issues for PF/PO in NB-IOT", 3GPP DRAFT; R2-160411 ISSUES FOR PAGING IN NB-IOT-FINAL, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG2, no. Budapest, HU; 20160119 - 20160121 13 January 2016 (2016-01-13), XP051066437, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_AHs/2016_01_LTE_NB_IoT/Docs/ [retrieved on 2016-01-13] the whole document ----- -/--	1-44

2

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	INTEL CORPORATION: "Remaining open aspects on NBIOT Paging", 3GPP DRAFT; R2-160445_NB-IOT_PAGING_INTELV04, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG2, no. Budapest, HU; 20160119 - 20160121 18 January 2016 (2016-01-18), XP051054733, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN2/Docs/ [retrieved on 2016-01-18] the whole document -----	1-44
A	NOKIA NETWORKS: "Paging procedure for NB-IoT", 3GPP DRAFT; R2-160495 NB IOT PAGING PROCEDURE, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG2, no. Budapest, HU; 20160119 - 20160121 12 January 2016 (2016-01-12), XP051066428, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_AHs/2016_01_LTE_NB_IoT/Docs/ [retrieved on 2016-01-12] the whole document -----	1-44
A	ERICSSON: "Physical channels for paging in NB-IoT", 3GPP DRAFT; R2-160452 PHYSICAL CHANNELS FOR PAGING IN NB-IOT, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG2, no. Budapest, HU; 20160119 - 20160121 13 January 2016 (2016-01-13), XP051066469, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_AHs/2016_01_LTE_NB_IoT/Docs/ [retrieved on 2016-01-13] the whole document ----- -/--	1-44

2

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	ERICSSON: "NB-IoT - Paging", 3GPP DRAFT; R1-160084 - NB-IOT - PAGING, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. Budapest, HU; 20160118 - 20160120 12 January 2016 (2016-01-12), XP051064699, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_AH/LTE_NB-IoT_1601/Docs/ [retrieved on 2016-01-12] the whole document -----	1-44

2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2017/057758

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-25

   Identification of paging/scheduling signal for a given mobile terminal

   ---

2. claims: 26-44

   Avoiding interference for paging where paging signals are transmitted multiple times (Coverage Enhancement)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2017/057758

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 2999280 A2	23-03-2016	CN 105392197 A	09-03-2016
		EP 2999280 A2	23-03-2016
		JP 2016052127 A	11-04-2016
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		US 2017135067 A1	11-05-2017

Form PCT/ISA/210 (patent family annex) (April 2005)

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	17950726
Filing Date	2022-09-22
First Named Inventor	Xiaobo ZHANG
Art Unit	2471
Examiner Name	AHMED ELALLAM
Attorney Docket Number	ZL0205-0004-US-CON3

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
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	First Named Inventor	Xiaobo ZHANG
	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

	1	R1-1710596, Lenovo, Motorola Mobility, dated June 27-30, 2017 (Meeting dates) June 16, 2017 (Publication)	☒
	2	R1-1710810, MediaTek Inc., dated June 27-30, 2017 (Meeting dates) June 17, 2017 (Publication)	☒
	3	R1-1710871, InterDigital Inc., dated June 20-27, 2017 (Meeting date) June 16, 2017 (Publication)	☒
	4	R1-1711161, Qualcomm Incorporated, dated June 27-30, 2017 (Meeting dates) June 17, 2017 (Publication)	☒
	5	R2-1700902, Ericsson, dated February 13-17, 2017 (Meeting date) February 4, 2017 (Publication)	☒
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	7	R2-1702662, Ericsson, dated April 3-7, 2017 (Meeting dates) March 25, 2017 (Publication)	☒
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	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

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	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

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	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

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	First Named Inventor	Xiaobo ZHANG
	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

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EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

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	Filing Date	2022-09-22
	First Named Inventor	Xiaobo ZHANG
	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/JIALIN ZHONG/	Date (YYYY-MM-DD)	2023-11-19
Name/Print	JIALIN ZHONG	Registration Number	62937

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

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(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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5 April 2016 (05.04.2016)

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62/255,865 16 November 2015 (16.11.2015) US

(71) Applicant: **INTEL IP CORPORATION** [US/US]; 2200 Mission College Boulevard, M/S: RNB-4-150, Santa Clara, CA 95054 (US).

(72) Inventors; and

(71) Applicants *(for US only)*: **ZHANG, Yushu** [CN/CN]; 8F, Raycom Info Park A, No. 2, Kexueyuan South Road, Haidian District, Beijing 100190 (CN). **ZHU, Yuan** [CN/CN]; Room 605, Building 16, Mo Li Yuan, Bei Yuan Jia Yuan, Chao Yang District, Beijing 100012 (CN). **CHANG, Wenting** [CN/CN]; 8F, Raycom Infotech Park A, No. 2, Kexueyuan South Road, Beijing 100190 (CN). **XIONG, Gang Gary** [CN/US]; 16682 NW Arizona Dr, Beaverton, OR 97006 (US). **NIU, Huaning** [CN/US]; 1308 Knollview Dr, Milpitas, CA 95035 (US).

(74) Agent: **SHANGHAI PATENT & TRADEMARK LAW OFFICE, LLC**; 435 Guiping Road, Shanghai 200233 (CN).

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Published:

— *with international search report (Art. 21(3))*

(54) **Title**: BEAMFORMED CSI-RS BASED MEASUREMENT FRAMEWORK

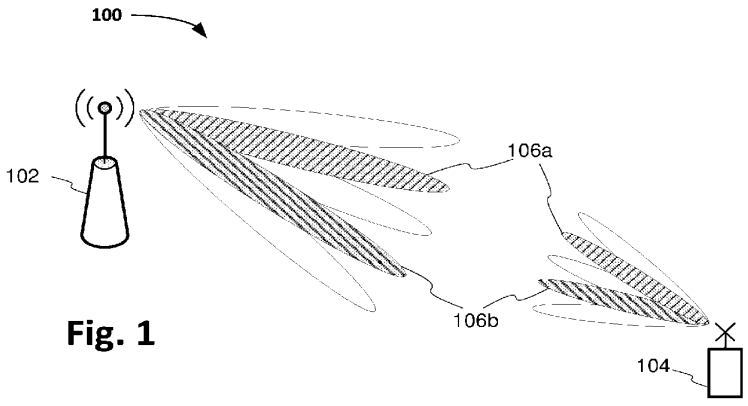


Fig. 1

(57) **Abstract**: There are disclosed methods and apparatus to facilitate beamformed CSI-RS based measurement including an apparatus for use in an eNB in a wireless communication network, the apparatus comprising transmitter circuitry; and control circuitry coupled to the transmitter circuitry, the control circuitry to configure a plurality of channel state information reference signals (CSI-RS), each CSI-RS associated with one of a plurality of virtualized sectors, and cause the transmitter circuitry to transmit the configured CSI-RS, wherein each of the plurality of virtualized sectors comprises a transmit beam beamformed to be vertically narrow and horizontally wide based on an associated vertical downtilt angle.

WO 2017/084235 A1

BEAMFORMED CSI-RS BASED MEASUREMENT FRAMEWORK

CROSS REFERENCE TO RELATED APPLICATIONS

The present application claims priority to U.S. Provisional Patent Application No. 62/255,865, filed November 16, 2015, entitled "BEAMFORMED CSI-RS BASED MEASUREMENT FRAMEWORK" the entire disclosure of which is hereby incorporated by reference.

TECHNICAL FIELD

Embodiments described herein generally relate to the field of wireless communications and, more particularly, to methods and apparatus for measurement of channel state information reference signals in beamformed transmit beams.

BACKGROUND

It is becoming more important to be able to provide telecommunication services to fixed and mobile subscribers as efficient and inexpensively as possible. Further, the increased use of mobile applications has resulted in much focus on developing wireless systems capable of delivering large amounts of data at high speed.

One approach under consideration for improving the efficient use of spectral resources is massive Multiple Input and Multiple output (MIMO) which allows reuse of frequencies to communicate with different users in the network through spatial multiplexing.

BRIEF DESCRIPTION OF THE DRAWING.

Aspects, features and advantages of embodiments of the present invention will become apparent from the following description of the invention in reference to the appended drawings in which like numerals denote like elements and in which:

Fig. 1 is diagram of an example wireless network according to various embodiments;

Fig. 2 is a block diagram of the example wireless network of Figure 2 according to various embodiments;

Fig. 3 is a sequence diagram of messaging for beamformed channel state information reference signals (CSI-RS) based measurement according to some embodiments;

Fig. 4 is a block diagram of a method performed in an eNB according to some embodiments;

Fig. 5 is a block diagram of a method performed in a UE according to some embodiments;

Fig. 6 is a block diagram of an example system operable to implement some embodiments; and

Fig. 7 is a block diagram of an example User Equipment device operable to implement some embodiments.

DETAILED DESCRIPTION OF EMBODIMENTS

Various aspects of the illustrative embodiments will be described using terms commonly employed by those skilled in the art to convey the substance of their work to others skilled in the art. However, it will be apparent to those skilled in the art that some alternate embodiments may be practiced using with portions of the described aspects. For purposes of explanation, specific numbers, materials, and configurations are set forth in order to provide a thorough understanding of the illustrative embodiments. However, it will be apparent to one skilled in the art that alternate embodiments may be practiced without the specific details. In other instances, well-known features are omitted or simplified in order to not obscure the illustrative embodiments.

Further, various operations will be described as multiple discrete operations, in turn, in a manner that is most helpful in understanding the illustrative embodiments; however, the order of description should not be construed as to imply that these operations are necessarily order dependent. In particular, these operations need not be performed in the order of presentation.

The phrase "in one embodiment" is used repeatedly. The phrase generally does not refer to the same embodiment; however, it may. The terms "comprising," "having," and "including" are synonymous, unless the context dictates otherwise. The phrase "A/B" means "A or B". The phrase "A and/or B" means "(A), (B), or (A and B)". The phrase "at least one of A, B and C" means "(A), (B), (C), (A and B), (A and C), (B and C) or (A, B and C)". The phrase "(A) B" means "(B) or (A B)", that is, A is optional.

Although specific embodiments have been illustrated and described herein, it will be appreciated by those of ordinary skill in the art that a wide variety of alternate and/or equivalent implementations may be substituted for the specific embodiments shown and described, without departing from the scope of the embodiments of the present disclosure. This application is intended to cover any adaptations or variations of the embodiments discussed herein. Therefore, it is manifestly intended that the embodiments of the present disclosure be limited only by the claims and the equivalents thereof.

As used herein, the term "module" may refer to, be part of, or include an Application Specific Integrated Circuit (ASIC), an electronic circuit, a processor (shared, dedicated, or group) and/or memory (shared, dedicated, or group) that execute one or more software or firmware instructions and/or programs, a combinational logic circuit, and/or other suitable components that provide the described functionality.

The following inventive embodiments may be used in a variety of applications including transmitters and receivers of a radio system, although the present invention is not limited in this respect. Radio systems specifically included within the scope of the present invention include, but are not limited to, network interface cards (NICs), network adaptors, fixed or mobile client devices, relays, base stations, femtocells, gateways, bridges, hubs, routers, access points, or other network devices. Further, the radio systems within the scope of the invention may be implemented in cellular radiotelephone systems, satellite systems, two-way radio systems as well as computing devices including such radio systems including personal computers (PCs), tablets and related peripherals, personal digital assistants (PDAs), personal computing accessories, hand-held communication devices and all systems which may be related in nature and to which the principles of the inventive embodiments could be suitably applied.

In a system implementing massive Multiple Input and Multiple output (MIMO), or Full Dimension MIMO (FD-MIMO), a large number of service antennas may be used to provide a number of virtual beams that may provide a high degree of spatial separation between terminals in a wireless network. Thus, using massive MIMO, a system may be able to support a large number of users on the same bandwidth simultaneously.

According to an example massive MIMO implementation, an evolved NodeB ("eNodeB" or "eNB") may transmit a number of analog sector transmitting (Tx) beams, and each sector Tx beam may be generated based on different vertical down tilting angles. That is, a single eNB may provide a plurality of virtualized sectors that are horizontally wide and vertically narrow. The eNB may transmit multiple antenna ports from each sector Tx beam. Within each virtualized sector Tx beam, a digital precoder may be applied to provide further horizontal Tx beamforming.

A user equipment (UE) served by the eNB may select one sector Tx beam and report the Channel State Information (CSI) measured from this sector Tx beam. In particular, the UE may report a Reference Signal Receiving Power (RSRP) of one sector Tx beam. Then the UE may report the CSI for the selected sector Tx beam which may contain a Channel Quality Indicator (CQI), Rank Indicator (RI), and Precoder Matrix Indicator (PMI). The eNB usually relies on the PMI to create a Tx beam for data transmission on the selected sector Tx beam.

However, in systems that implement receiving (Rx) beam beamforming and multiple Rx antenna panels at the UE side, different serving Tx beams for data transmission may be observed from different Rx beams of the same or different antenna panels. In this case, the best Tx beams for data transmission may be within the same or different sector Tx beams.

Figure 1 illustrates one example arrangement of a wireless network 100 including an eNB 102 and a UE 104 configured to use different Tx beam and Rx beam pairs for data transmission. According to the example illustrated in Figure 1, the eNB 102 and UE 104 may have identified a first Tx beam – Rx beam pair 106a for transmission of data and control information, and a second, candidate, Tx beam – Rx beam pair 106b.

As a result of UE rotation, movement, or Doppler Effect, the active antenna panel or active Rx beam on the UE side may change so that the Tx beams for data transmission may need to be updated. The Tx beam change for data transmission may include a sector Tx beam change, horizontal digital Tx beam change within a sector Tx beam, or both. As the CSI-RS may be beamformed within a sector Tx beam, it may be beneficial in some embodiments to measure the receiving power from the narrow vertical and narrow horizontal beams to allow beam switching from any two Tx beams for data transmission from either the same or different sector Tx beams.

Example embodiments provide systems, apparatuses, and methods for beamformed CSI-RS based measurement framework with the UE side Rx beamforming to enable beam mobility in millimeter wave (mmWave) systems.

Figure 2 schematically illustrates the wireless communication network 100 in accordance with various embodiments. Wireless communication network 100 (hereinafter "network 100") may be an access network of a 3rd Generation Partnership Project (3GPP) long-term evolution (LTE), long-term evolution- advanced (LTE-A) network such as an evolved universal mobile telecommunication system (UMTS) terrestrial radio access network (E-UTRAN) or 5G network.

The network 100 may include a base station, e.g., evolved node base station (eNB) 102, configured to wirelessly communicate with one or more mobile device(s) or terminal(s), e.g., user equipment (UE) 104. In various embodiments, the eNB 102 may be a fixed station (e.g., a fixed node) or a mobile station/node.

The eNB 104 may include receiver circuitry 120 with which to receive signals from UE 104 via one or more antennas 130. eNB 104 may include transmitter circuitry 124 with which to transmit signals to UE 104 via one or more antennas 130. eNB 104 may also include controller circuitry 128 in communication with receiver module 120 and transmitter module 124 and configured to encode and decode information communicated by the

signals. Controller module 128 also includes CSI-RS configuration circuitry 126 to facilitate configuration and report processing of beamformed CSI-RS messages in the network 100.

In various embodiments, the control circuitry 128 may be comprised in a separate device from the receiver circuitry 120 and/or the transmitter circuitry 124. For example, the eNB 104 may be implemented as part of a cloud-RAN (C-RAN).

In various embodiments, the UE 104 and/or the eNB 102 may include a plurality of antennas 156, 130 to implement a multiple-input-multiple-output (MIMO) transmission system, which may operate in a variety of MIMO modes, including single-user MIMO (SU-MIMO), multi-user MIMO (MU-MIMO), close loop MIMO, open loop MIMO or variations of smart antenna processing.

In various embodiments, UE 104 comprises transmitter circuitry 148 for transmitting signals to eNB 102 and receiver circuitry 144 for receiving signals from the eNB 102. UE 104 further comprises controller circuitry 152 coupled between receiver circuitry 144 and transmitter circuitry 148 and including communication circuitry 154 to encode and decode information communicated by the signals. Controller circuitry 152 may also include CSI reporting circuitry 158 to facilitate measurement and reporting of channel state information by the UE 102.

According to embodiments, the UE 104 may attempt to receive channel state information reference signals (CSI-RS) for each sector Tx beam using receiver circuitry 144 and then measure a reference signal received power (RSRP) for each sector Tx beam received based on the CSI-RS beamformed within each sector Tx beam. The RSRP may be used as an indication of the signal quality for each sector Tx beam being received by the UE, and therefore the UE may select the sector Tx beam having the highest measured RSRP value. The US 104 may then report the selected Tx beam to the eNB 102, and may include the measured RSRP value associated with the selected sector Tx beam.

According to some embodiments, the UE 104 may report all measured RSRP values and their associated sector Tx beams to the eNB 102, and selection of a sector Tx beam may then be performed in the eNB 102.

Once sector Tx selection has been performed, the UE may then attempt to receive UE specific CSI-RS on the selected sector Tx beam and to determine based on the received CSI-RS a precoder matrix indicator to signal to the eNB 102 a horizontal Tx beam within the selected Tx sector to be used to communicate data.

Based on the information provided by the UE 104 to the eNB 102, a two-dimensional narrow Tx beam may be defined. Further CSI-RS may be transmitted on this two-dimensional narrow beam to allow the UE to determine a channel quality indicator, rank indicator, etc. for the beamformed link.

Thus, the UE 104 may select its sector Tx beam based on the CSI-RS Receiving Power (CSIRS-RP) of each sector Tx beam, as the CSI-RS may be beamformed with different sector Tx beams. The UE may report the horizontal Tx beam directions by the PMI. Then the eNodeB may further transmit one additional beamformed CSI-RS using the Tx beam for data transmission. UE may further measure this additional CSI-RS from this Tx beam to derive CQI RI etc.

At the eNB 102, the active Tx beam may be defined as the one digital narrow beam with the highest reported CQI from the sector Tx beam having highest reported CSIRS-RP. According to some embodiments, a candidate Tx beam can be defined as the digital narrow beam with the highest CQI from the sector beam which is cannot be measured by UE simultaneously as the active Tx beam.

Table 1 illustrates one example for the CSIRS-RPs measured by UE 104 using different Rx beams. In the example of Table 2, Tx beam 2 has the highest reported received power and may be designated to be the active Tx beam and the Tx beam 4 has the second highest reported received power and may be designated to be the candidate Tx beam by the eNB 102.

BRS-RP [dBm]		Sector Tx beam				
		1	2	3	4	5
Rx beam	1				-89	
	2			-88	***-77***	-93
	3		-88		-92	
	4	-83	***-71***	-82		
	5		-80			

Table 1: one example for RSRP measurement result

In some embodiments, the active Tx beam and candidate Tx beam can be the same sector Tx beam.

To support a narrow vertical and horizontal beamformed data transmission within the vertical narrow and horizontal wide beam sector Tx beam, the basic procedure may contain the sector Tx beam selection, digital beam selection and CSIRS-RP measurement and report as illustrated in Figure 3.

According to the method 200 illustrated in the sequence diagram of Figure 3, eNB 102 begins by transmitting 202 multiple CSI-RS(s) on a plurality of vertically narrow, horizontally wide sector Tx beams. These sector Tx beams are monitored by the UE 104,

and RSRP values for one or more sector Tx beams are reported 204 to the eNB to facilitate sector Tx beam selection.

The eNB 102 then transmits 206 UE specific CSI-RS within the selected sector Tx beam. In some embodiments, multiple horizontally narrow beams within the selected sector Tx beam may be used. The UE 104, uses the received CSI-RS information to provide 208 a precoder matrix indicator to the eNB 102 defining a horizontally narrow beam within the Tx sector. The eNB 102 then transmits 210 further UE specific CSI-RS using the defined two-dimensional narrow beam to allow channel state information to be determined by the UE and reported 212 to the eNB 102.

Figure 4 illustrates a method 400 performed by an eNB 102 according to some embodiments. According to the illustrated method, the eNB 102 first configures 402 CSI-RS for each of a number of virtualized, horizontally wide but vertically narrow, sector Tx beams. The eNB 102 then receives 404 at least one RSRP value associated with a sector Tx beam. A selection 406 is then made based on the received RSRP value.

Figure 5 illustrates a method 500 performed at UE 104 according to some embodiments. According to the illustrated method, the UE 104 receives 502 CSI-RS associated with virtualized, horizontally wide but vertically narrow, sector Tx beams. A reference signal received power value is then determined 504 for a virtualized sector based on the associated received CSI-RS. Determined RSRP values are then reported 506 to the eNB 102.

CSIRS-RP Measurement for sector Tx beam selection

According to some embodiments, the UE 104 may need to report an RSRP value for each sector Tx beam, which may help the eNodeB 102 to decide the best sector Tx beam for the UE.

In some embodiments, the UE 104 may maintain two non-simultaneous Rx beam(s), and may report the RSRP value with an indicator to show whether this RSRP value is measured from active Rx beam or candidate Rx beam. A current Rx beam is defined as the Rx beam used for current downlink control and signal receiving. This current Rx beam may switch between active Rx beam and candidate Rx beam according to channel conditions. Hence, in some embodiments, the context for RSRP may contain the following information:

- Cell ID;
- RSRP value;
- Rx beam Indicator;
- Subframe index or CSI-RS process ID; and
- Beam index or CSI-RS port index.

According to some embodiments, the Cell ID may be used to indicate the cell ID which used to generate the CSI-RS. RSRP value may be quantized by several bits. Subframe index may indicate the subframe index for the CSI-RS where the RSRP is measured. The Rx beam indicator may contain 1 bit, where value 0 may indicate the CSIRS-RP is measured from active Rx beam and value 1 may indicate it is measured from candidate Rx beam. Alternatively the Rx beam indicator may not be used and the UE may report two RSRPs values measured from two Rx beams per sector Tx beam to the eNodeB.

The beam index may be equal to the sector Tx beam index. Sometimes, sector Tx beam index is transparent to UE, so CSI-RS port index may be used to implicitly indicate which sector Tx beam is chosen based on the corresponding Rx beam. Two ports may be paired for vertical and horizontal channel measurement, and be equipped with the same sector Tx beam. In this case, report of only one CSI-RS port index may be sufficient. CSI-RS process ID may indicate the RSRP is measured on which CSI-RS symbols.

CSI Feedback for digital beam selection

After sector Tx beam selection, the UE may further select the Tx beam within the selected sector Tx beam. In some embodiments, if more than one simultaneous Rx beam can be applied for CSI-RS receiving, the UE may measure the same CSI-RS in the selected sector Tx beam and report more than one digital beam selection based CSI, e.g. using one PMI for one digital precoder.

According to some embodiments, two PMIs may be restricted to be measured from a rank 1 precoder codebook for N Tx antenna ports based sector Tx beam, where N is equal to the number of antenna ports for sector beam based CSI-RS. The codebook for the two PMIs may be defined by the system.

In embodiments, if the UE cannot use simultaneous Rx beams for receiving the CSI-RS, the PMI for the active Rx beam and candidate Rx beam may be measured in two CSI-RS subframes and reported individually or jointly as in the embodiment above.

CSI-RS Tx beam for CSI measurement

After receiving the PMI for active Rx beam and PMI for candidate Rx beam, the eNodeB may be able to generate the narrow Tx beam based on the feedback PMIs and the sector Tx beam.

In some embodiments, the CSI-RS may be divided into several groups, and each CSI-RS group may include K antenna ports. In one example, K may be equal to 2. Different narrow Tx beams may be applied to different CSI-RS groups. In one example, a narrow Tx beam can be generated as follow.

$$P_{i,j} = P_c^i P_d^j \quad (1)$$

Where P_c^i may indicate the $N_{tx} \times N_p$ analog beamforming weight for sector Tx beam *i*; P_d^j may denote the $N_p \times K$ digital precoder for PMI j; $P_{i,j}$ may refer to the narrow Tx beam for sector *i* and PMI *j*; N_{tx} is the number of Tx antenna; N_p is the number of CSI-RS antenna ports.

The UE may then measure a number of narrow Tx beams of one sector Tx beam in one CSI-RS subframe, and may report the CSI containing the following items:

- Beam Index (BI);
- Rank Indicator (RI);
- Precoding Matrix Indicator (PMI);
- Channel Quality Indicator (CQI); and
- Rx beam Indicator.

In some embodiments, not all the above items in CSI may be transmitted, and the Uplink Control Information (UCI) may contain more than one of the above CSI blocks.

In some embodiments, the UE may measure and report the CSIRS-RP based on each CSI-RS group. Then the UE may report the CSIRS-RP with the following pattern:

- Cell ID;
- RSRP value;
- Rx beam Indicator;
- Subframe index for the measured CSI-RS; and
- Beam index or CSI-RS group index corresponded to active beam.

In another embodiment, the UE may report up to *X* CSIRS-RPs, where *X* can be configured by the system or Radio Resource Control (RRC) signaling, e.g. *X*=8. Further the UE may only include a report for valid beams where a valid beam can be defined as a beam with the following condition in (2) is valid.

$$r_a - r_{c,k} < \Delta \quad (2)$$

Where r_a may indicate the CSIRS-RP measured from active Tx beam with the current Rx beam; $r_{c,k}$ may indicate the CSIRS-RP measured from the Tx beam *c* with Rx beam *k*. The Rx beam *k* can be either the current Rx beam or candidate Rx beam. Threshold Δ denotes the CSIRS-RP threshold, which may be configured via RRC signaling.

Various embodiments have been described in the context of transmit or receive beams that are beamformed to be horizontally and/or vertically narrow as opposed to wide. Such beamforming rely on the use of a plurality of antenna elements with a narrower beam being achievable through the use of a greater number of antenna elements.

According to some embodiments, an antenna port used to transmit a transmit beam for a virtualized sector beamformed to be vertically narrow and horizontally wide is associated with a first number, N_v, of vertical antenna elements and a second number, N_h, of horizontal antenna elements, where N_v is greater than N_h. Furthermore, according to some embodiments N_v is greater than or equal to 8 while N_h is less than or equal to 2.

Throughout the disclosure, the term eNB may loosely refer to a cell or RAN (Radio Access Network) node or transmission point (TP). The relay UE may belong to the same or different eNB or entity. When it belongs to different entity than the direct path of the remote UE, then additional signaling and context transfer might need to happen for the remote UE to switch between the direct path and relay UE path. Furthermore, the remote UE may be receiving data from multiple relay UEs, each associated with the same eNB/entity or different eNB/entity than the remote UE itself.

Embodiments of the technology herein may be described as related to the third generation partnership project (3GPP) long term evolution (LTE) or LTE-advanced (LTE-A) standards. For example, terms or entities such as eNodeB (eNB), mobility management entity (MME), user equipment (UE), etc. may be used that may be viewed as LTE-related terms or entities. However, in other embodiments the technology may be used in or related to other wireless technologies such as the Institute of Electrical and Electronic Engineers (IEEE) 802.16 wireless technology (WiMax), IEEE 802.11 wireless technology (WiFi), various other wireless technologies such as global system for mobile communications (GSM), enhanced data rates for GSM evolution (EDGE), GSM EDGE radio access network (GERAN), universal mobile telecommunications system (UMTS), UMTS terrestrial radio access network (UTRAN), or other 2G, 3G, 4G, 5G, etc. technologies either already developed or to be developed. In those embodiments, where LTE-related terms such as eNB, MME, UE, etc. are used, one or more entities or components may be used that may be considered to be equivalent or approximately equivalent to one or more of the LTE-based terms or entities.

As used herein, the term "circuitry" may refer to, be part of, or include an Application Specific Integrated Circuit (ASIC), an electronic circuit, a processor (shared, dedicated, or group), and/or memory (shared, dedicated, or group) that execute one or more software or firmware programs, a combinational logic circuit, and/or other suitable hardware components that provide the described functionality. In some embodiments, the circuitry may be implemented in, or functions associated with the circuitry may be implemented by, one or more software or firmware modules. In some embodiments, circuitry may include logic, at least partially operable in hardware.

Embodiments described herein may be implemented into a system using any suitably configured hardware and/or software. Figure 6 illustrates, for one embodiment, example components of an electronic device 600. In embodiments, the electronic device 600 may

be, implement, be incorporated into, or otherwise be a part of a user equipment (UE), an evolved NodeB (eNB), or any other suitable electronic device. In some embodiments, the electronic device 600 may include application circuitry 602, baseband circuitry 604, Radio Frequency (RF) circuitry 606, front-end module (FEM) circuitry 608 and one or more antennas 610, coupled together at least as shown.

The application circuitry 602 may include one or more application processors. For example, the application circuitry 602 may include circuitry such as, but not limited to, one or more single-core or multi-core processors. The processor(s) may include any combination of general-purpose processors and dedicated processors (e.g., graphics processors, application processors, etc.). The processors may be coupled with and/or may include memory/storage and may be configured to execute instructions stored in the memory/storage to enable various applications and/or operating systems to run on the system.

The baseband circuitry 604 may include circuitry such as, but not limited to, one or more single-core or multi-core processors. The baseband circuitry 604 may include one or more baseband processors and/or control logic to process baseband signals received from a receive signal path of the RF circuitry 606 and to generate baseband signals for a transmit signal path of the RF circuitry 606. Baseband processing circuity 604 may interface with the application circuitry 602 for generation and processing of the baseband signals and for controlling operations of the RF circuitry 606. For example, in some embodiments, the baseband circuitry 604 may include a second generation (2G) baseband processor 604a, third generation (3G) baseband processor 604b, fourth generation (4G) baseband processor 604c, and/or other baseband processor(s) 604d for other existing generations, generations in development or to be developed in the future (e.g., fifth generation (5G), 6G, etc.). The baseband circuitry 604 (e.g., one or more of baseband processors 604a-d) may handle various radio control functions that enable communication with one or more radio networks via the RF circuitry 606. The radio control functions may include, but are not limited to, signal modulation/demodulation, encoding/decoding, radio frequency shifting, etc. In some embodiments, modulation/demodulation circuitry of the baseband circuitry 604 may include Fast-Fourier Transform (FFT), precoding, and/or constellation mapping/demapping functionality. In some embodiments, encoding/decoding circuitry of the baseband circuitry 604 may include convolution, tail-biting convolution, turbo, Viterbi, and/or Low Density Parity Check (LDPC) encoder/decoder functionality. Embodiments of modulation/demodulation and encoder/decoder functionality are not limited to these examples and may include other suitable functionality in other embodiments.

In some embodiments, the baseband circuitry 604 may include elements of a protocol stack such as, for example, elements of an evolved universal terrestrial radio access

network (EUTRAN) protocol including, for example, physical (PHY), media access control (MAC), radio link control (RLC), packet data convergence protocol (PDCP), and/or radio resource control (RRC) elements. A central processing unit (CPU) 604e of the baseband circuitry 604 may be configured to run elements of the protocol stack for signaling of the PHY, MAC, RLC, PDCP and/or RRC layers. In some embodiments, the baseband circuitry may include one or more audio digital signal processor(s) (DSP) 604f. The audio DSP(s) 604f may be include elements for compression/decompression and echo cancellation and may include other suitable processing elements in other embodiments.

The baseband circuitry 604 may further include memory/storage 604g. The memory/storage 604g may be used to load and store data and/or instructions for operations performed by the processors of the baseband circuitry 604. Memory/storage for one embodiment may include any combination of suitable volatile memory and/or non-volatile memory. The memory/storage 604g may include any combination of various levels of memory/storage including, but not limited to, read-only memory (ROM) having embedded software instructions (e.g., firmware), random access memory (e.g., dynamic random access memory (DRAM)), cache, buffers, etc. The memory/storage 604g may be shared among the various processors or dedicated to particular processors.

Components of the baseband circuitry may be suitably combined in a single chip, a single chipset, or disposed on a same circuit board in some embodiments. In some embodiments, some or all of the constituent components of the baseband circuitry 604 and the application circuitry 602 may be implemented together such as, for example, on a system on a chip (SOC).

In some embodiments, the baseband circuitry 604 may provide for communication compatible with one or more radio technologies. For example, in some embodiments, the baseband circuitry 604 may support communication with an evolved universal terrestrial radio access network (EUTRAN) and/or other wireless metropolitan area networks (WMAN), a wireless local area network (WLAN), a wireless personal area network (WPAN). Embodiments in which the baseband circuitry 604 is configured to support radio communications of more than one wireless protocol may be referred to as multi-mode baseband circuitry.

RF circuitry 606 may enable communication with wireless networks using modulated electromagnetic radiation through a non-solid medium. In various embodiments, the RF circuitry 606 may include switches, filters, amplifiers, etc. to facilitate the communication with the wireless network. RF circuitry 606 may include a receive signal path which may include circuitry to down-convert RF signals received from the FEM circuitry 608 and provide baseband signals to the baseband circuitry 604. RF circuitry 606 may also include a transmit signal path which may include circuitry to up-

convert baseband signals provided by the baseband circuitry 604 and provide RF output signals to the FEM circuitry 608 for transmission.

In some embodiments, the RF circuitry 606 may include a receive signal path and a transmit signal path. The receive signal path of the RF circuitry 606 may include mixer circuitry 606a, amplifier circuitry 606b and filter circuitry 606c. The transmit signal path of the RF circuitry 606 may include filter circuitry 606c and mixer circuitry 606a. RF circuitry 606 may also include synthesizer circuitry 606d for synthesizing a frequency for use by the mixer circuitry 606a of the receive signal path and the transmit signal path. In some embodiments, the mixer circuitry 606a of the receive signal path may be configured to down-convert RF signals received from the FEM circuitry 608 based on the synthesized frequency provided by synthesizer circuitry 606d. The amplifier circuitry 606b may be configured to amplify the down-converted signals and the filter circuitry 606c may be a low-pass filter (LPF) or band-pass filter (BPF) configured to remove unwanted signals from the down-converted signals to generate output baseband signals. Output baseband signals may be provided to the baseband circuitry 604 for further processing. In some embodiments, the output baseband signals may be zero-frequency baseband signals, although this is not a requirement. In some embodiments, mixer circuitry 606a of the receive signal path may comprise passive mixers, although the scope of the embodiments is not limited in this respect.

In some embodiments, the mixer circuitry 606a of the transmit signal path may be configured to up-convert input baseband signals based on the synthesized frequency provided by the synthesizer circuitry 606d to generate RF output signals for the FEM circuitry 608. The baseband signals may be provided by the baseband circuitry 604 and may be filtered by filter circuitry 606c. The filter circuitry 606c may include a low-pass filter (LPF), although the scope of the embodiments is not limited in this respect.

In some embodiments, the mixer circuitry 606a of the receive signal path and the mixer circuitry 606a of the transmit signal path may include two or more mixers and may be arranged for quadrature downconversion and/or upconversion respectively. In some embodiments, the mixer circuitry 606a of the receive signal path and the mixer circuitry 606a of the transmit signal path may include two or more mixers and may be arranged for image rejection (e.g., Hartley image rejection). In some embodiments, the mixer circuitry 606a of the receive signal path and the mixer circuitry 606a may be arranged for direct downconversion and/or direct upconversion, respectively. In some embodiments, the mixer circuitry 606a of the receive signal path and the mixer circuitry 606a of the transmit signal path may be configured for super-heterodyne operation.

In some embodiments, the output baseband signals and the input baseband signals may be analog baseband signals, although the scope of the embodiments is not limited in this respect. In some alternate embodiments, the output baseband signals and the input

baseband signals may be digital baseband signals. In these alternate embodiments, the RF circuitry 606 may include analog-to-digital converter (ADC) and digital-to-analog converter (DAC) circuitry and the baseband circuitry 604 may include a digital baseband interface to communicate with the RF circuitry 606.

In some dual-mode embodiments, a separate radio IC circuitry may be provided for processing signals for each spectrum, although the scope of the embodiments is not limited in this respect.

In some embodiments, the synthesizer circuitry 606d may be a fractional-N synthesizer or a fractional N/N+1 synthesizer, although the scope of the embodiments is not limited in this respect as other types of frequency synthesizers may be suitable. For example, synthesizer circuitry 606d may be a delta-sigma synthesizer, a frequency multiplier, or a synthesizer comprising a phase-locked loop with a frequency divider.

The synthesizer circuitry 606d may be configured to synthesize an output frequency for use by the mixer circuitry 606a of the RF circuitry 606 based on a frequency input and a divider control input. In some embodiments, the synthesizer circuitry 606d may be a fractional N/N+1 synthesizer.

In some embodiments, frequency input may be provided by a voltage controlled oscillator (VCO), although that is not a requirement. Divider control input may be provided by either the baseband circuitry 604 or the applications processor 602 depending on the desired output frequency. In some embodiments, a divider control input (e.g., N) may be determined from a look-up table based on a channel indicated by the applications processor 602.

Synthesizer circuitry 606d of the RF circuitry 606 may include a divider, a delay-locked loop (DLL), a multiplexer and a phase accumulator. In some embodiments, the divider may be a dual modulus divider (DMD) and the phase accumulator may be a digital phase accumulator (DPA). In some embodiments, the DMD may be configured to divide the input signal by either N or N+1 (e.g., based on a carry out) to provide a fractional division ratio. In some example embodiments, the DLL may include a set of cascaded, tunable, delay elements, a phase detector, a charge pump and a D-type flip-flop. In these embodiments, the delay elements may be configured to break a VCO period up into Nd equal packets of phase, where Nd is the number of delay elements in the delay line. In this way, the DLL provides negative feedback to help ensure that the total delay through the delay line is one VCO cycle.

In some embodiments, synthesizer circuitry 606d may be configured to generate a carrier frequency as the output frequency, while in other embodiments, the output frequency may be a multiple of the carrier frequency (e.g., twice the carrier frequency, four times

the carrier frequency) and used in conjunction with quadrature generator and divider circuitry to generate multiple signals at the carrier frequency with multiple different phases with respect to each other. In some embodiments, the output frequency may be a LO frequency (fLO). In some embodiments, the RF circuitry 606 may include an IQ/polar converter.

FEM circuitry 608 may include a receive signal path which may include circuitry configured to operate on RF signals received from one or more antennas 610, amplify the received signals and provide the amplified versions of the received signals to the RF circuitry 606 for further processing. FEM circuitry 608 may also include a transmit signal path which may include circuitry configured to amplify signals for transmission provided by the RF circuitry 606 for transmission by one or more of the one or more antennas 610.

In some embodiments, the FEM circuitry 608 may include a TX/RX switch to switch between transmit mode and receive mode operation. The FEM circuitry may include a receive signal path and a transmit signal path. The receive signal path of the FEM circuitry may include a low-noise amplifier (LNA) to amplify received RF signals and provide the amplified received RF signals as an output (e.g., to the RF circuitry 606). The transmit signal path of the FEM circuitry 608 may include a power amplifier (PA) to amplify input RF signals (e.g., provided by RF circuitry 606), and one or more filters to generate RF signals for subsequent transmission (e.g., by one or more of the one or more antennas 610.

In some embodiments, the electronic device 600 may include additional elements such as, for example, memory/storage, display, camera, sensor, and/or input/output (I/O) interface.

In some embodiments, the electronic device 600 of Figure 6 may be configured to perform one or more processes, techniques, and/or methods as described herein, or portions thereof. Such processes may include one or more of the following examples.

Figure 7 shows an embodiment in which the electronic device 600 implements a UE 102 in the specific form of a mobile device 700.

In various embodiments, user interfaces could include, but are not limited to, a display 740 (e.g., a liquid crystal display, a touch screen display, etc.), a speaker 730, a microphone 790, one or more cameras 780 (e.g., a still camera and/or a video camera), a flashlight (e.g., a light emitting diode flash), and a keyboard 770.

In various embodiments, the peripheral component interfaces may include, but are not limited to, a non-volatile memory port, an audio jack, and a power supply interface.

In various embodiments, the sensors may include, but are not limited to, a gyro sensor, an accelerometer, a proximity sensor, an ambient light sensor, and a positioning unit. The positioning unit may also be part of, or interact with, a network interface to communicate with components of a positioning network, e.g., a global positioning system (GPS) satellite.

In various embodiments, the electronic device 600 may be a mobile computing device such as, but not limited to, a laptop computing device, a tablet computing device, a netbook, a mobile phone, etc. In various embodiments, system 700 may have more or less components, and/or different architectures.

In embodiments, the implemented wireless network may be a 3rd Generation Partnership Project's long term evolution (LTE) advanced wireless communication standard, which may include, but is not limited to releases 8, 9, 10, 11, 12, 13, and 14 or later, of the 3GPP's LTE-A or 5G standards.

Although certain embodiments have been illustrated and described herein for purposes of description, a wide variety of alternate and/or equivalent embodiments or implementations calculated to achieve the same purposes may be substituted for the embodiments shown and described without departing from the scope of the present disclosure. This application is intended to cover any adaptations or variations of the embodiments discussed herein. Therefore, it is manifestly intended that embodiments described herein be limited only by the claims and the equivalents thereof.

EXAMPLES

Example 1 may include a method comprising: configuring beamformed Channel State Information Reference Signal (CSI-RS), wherein the CSI-RS is transmitted with a vertical narrow and horizontal wide sector transmitting (Tx) beam, and each Tx beam is considered as a virtualized sector.

Example 2 may include the method of example 1 or some other example herein, wherein the UE measures and reports the Reference Signal Receiving Power (RSRP) based on the beamformed CSI-RS to indicate the signal quality of one sector Tx beam.

Example 3 may include the method of example 2 or some other example herein, wherein the UE reports a receiving (Rx) beam indicator associated with the RSRP, where value 0 indicates the RSRP is measured from an active Rx beam and value 1 indicates the RSRP is measured from a candidate Rx beam, and wherein the UE cannot receive data from both active Rx beam and candidate Rx beam simultaneously, wherein the Rx beam is defined as an Rx beam used for data and control receiving and is initially set to be either active Rx beam and can be switched to candidate Rx beam.

Example 4 may include the method of example 1 or 3 or some other example herein, wherein the UE reports a digital beam selection Channel State Information (CSI), wherein a Precoder Matrix Indicator (PMI) for the active Rx beam and the PMI for the candidate Rx beam may be reported.

Example 5 may include the method of example 4 or some other example herein, wherein the PMI is measured using a codebook from the CSI-RS transmitted on sector beam, which is defined by the system.

Example 6 may include the method of example 4 or some other example herein, wherein the PMI is selected from a rank 1 codebook.

Example 7 may include the method of example 1 or some other example herein, wherein a UE-specific CSI-RS is transmitted as several groups and each group of the several groups is transmitted using a two dimensional narrow Tx beam.

Example 8 may include the method of example 7 or some other example herein, wherein each of the several groups use two antenna ports sent from both horizontal and vertical polarizations.

Example 9 may include the method of example 7 or some other example herein, wherein the UE measures the CSI-RS Receiving Power (CSIRS-RP) for each CSI-RS group.

Example 10 may include the method of example 9 or some other example herein, wherein the UE reports the CSIRS-RP comprising the value of CSIRS-RP, Rx beam indicator, CSI-RS group index and subframe index, wherein the Rx beam indicator is used to indicate whether this CSIRS-RP is measured from active Rx beam or candidate Rx beam.

Example 11 may include the method of example 10 or some other example herein, wherein the UE may report up to N CSIRS-RPs, where N is to be configured by the system or radio resource control (RRC) signaling.

Example 12 may include the method of example 11 or some other example herein, wherein only a valid CSIRS-RP may be reported and a valid CSIRS-RP is defined as a CSIRS-RP within the CSIRS-RP threshold, which is configured by the system or RRC signaling.

Example 13 may include an apparatus comprising means to perform one or more elements of a method described in or related to any of examples 1-12, or any other method or process described herein.

Example 14 may include one or more non-transitory computer-readable media comprising instructions to cause an electronic device, upon execution of the instructions by one or more processors of the electronic device, to perform one or more elements of

a method described in or related to any of examples 1-12, or any other method or process described herein.

Example 15 may include an apparatus comprising logic, modules, and/or circuitry to perform one or more elements of a method described in or related to any of examples 1-12, or any other method or process described herein.

Example 16 may include a method, technique, or process as described in or related to any of examples 1-12, or portions or parts thereof.

Example 17 may include an apparatus comprising: one or more processors and one or more computer readable media comprising instructions that, when executed by the one or more processors, cause the one or more processors to perform the method, techniques, or process as described in or related to any of examples 1-12, or portions thereof.

Example 18 may include a method of communicating in a wireless network as shown and described herein.

Example 19 may include a system for providing wireless communication as shown and described herein.

Example 20 may include a device for providing wireless communication as shown and described herein.

Example 21 may include an apparatus for use in an eNB in a wireless communication network, the apparatus comprising transmitter circuitry; and control circuitry coupled to the transmitter circuitry, the control circuitry to: configure a plurality of channel state information reference signals (CSI-RS), each CSI-RS associated with one of a plurality of virtualized sectors; and cause the transmitter circuitry to transmit the configured CSI-RS; wherein each of the plurality of virtualized sectors comprises a transmit beam beamformed to be vertically narrow and horizontally wide based on an associated vertical downtilt angle.

Example 22 may include the apparatus of example 21, wherein each of the plurality of virtualized sectors is associated with a different vertical downtilt angle.

Example 23 may include the apparatus of example 21 or example 22 example further comprising receiver circuitry coupled to the control circuitry, the receiver circuitry to receive an indication of a reference signal received power (RSRP) value associated with one of the virtualized sectors from a User Equipment (UE), the indication of RSRP value based on the CSI-RS associated with the one of the virtualized sectors.

Example 24 may include the apparatus of example 23, wherein the indication of RSRP value comprises an indication of a receiving beam associated with the RSRP value.

Example 25 may include the apparatus of example 24, wherein the indication of a receiving beam comprises a first value to indicate that the RSRP value was measured from an active receiving beam and a second value to indicate that the RSRP value was measure from a candidate receiving beam.

Example 26 may include the apparatus of example 23, wherein the control circuitry is further to select a virtualized sector beam for communicating with the UE based on the received indication of RSRP value.

Example 27 may include the apparatus of example 26, wherein the control circuitry is further to configure UE specific CSI-RS associated with the selected virtualized sector and cause the transmitter circuitry to transmit the UE specific CSI-RS to the UE in the selected virtualized sector.

Example 28 may include the apparatus of example 27, wherein the receiver circuitry is further to receive a digital beam selection channel state information (CSI) from the UE in response to the UE specific CSI-RS, the digital beam selection CSI comprising a first precoder matrix indicator (PMI) associated with an active receiving beam.

Example 29 may include the apparatus of example 28, wherein the digital beam selection CSI further comprises a second PMI associated with a candidate receiving beam.

Example 30 may include the apparatus of examples 28 or 29, wherein the PMI is selected from a rank 1 codebook.

Example 31 may include the apparatus of examples 28 or 29, wherein the PMI is measured using a codebook defined by the network.

Example 32 may include the apparatus of any of examples 8 to 10, wherein the control circuitry is further to generate a two dimensional narrow transmit beam within the selected virtualized sector based on a received PMI.

Example 33 may include the apparatus of any of examples 27 to 32, wherein the transmitter circuitry is further to transmit the US specific CSI-RS a plurality of CSI-RS groups, wherein each CSI-RS group of the plurality of CSI-RS groups is associated with a two dimensional narrow transmit beam within the selected virtualized sector.

Example 34 may include the apparatus of example 33, wherein each of the plurality of CSI-RS groups is associated with two antenna ports sent from both horizontal and vertical polarizations.

Example 35 may include the apparatus of example 33 or example 34, the receiver circuitry further to receive a CSI-RS report from the UE, the report comprising: CSI-RS receiving power (CSIRS-RP) value; a receiving beam indicator comprising a first value to indicate the CSIRS-RP value was measured using an active receive beam and a second value to indicate that the CSIRS-RP value was measured using a candidate receive beam; a CSI-RS group index; and a subframe index.

Example 36 may include the apparatus of example 35, the receiver circuitry further to receive a plurality of CSI-RS reports from the UE, each CSI-RS report associated with a CSI-RS group of the plurality of CSI-RS groups.

Example 37 may include the apparatus of example 36, wherein the plurality of CSI-RS reports may comprise N CSI-RP reports, where N is configured by the network or using radio resource control signalling (RRC).

Example 38 may include the apparatus of example 36 or example 37, wherein the plurality of CSI-RS reports comprises CSI-RS reports having a CSIRS-RP value greater than a threshold CSIRS-RP value.

Example 39 may include the apparatus of example 38, wherein the threshold CSIRS-RP value is configured by the network or using radio resource control signalling (RRC).

Example 40 may include an apparatus for use in a user equipment in a wireless communication network, the apparatus comprising receiver circuitry to receive a plurality of channel state information reference signals (CSI-RS) from an eNB, each CSI-RS associated with one of a plurality of virtualized sectors; controller circuitry coupled to the receiver circuitry, the controller circuitry to: obtain a plurality of reference signal receiver power (RSRP) values, each of the plurality of RSRP values associated with one of the received CSI-RS; and generate an indication of RSRP associated with one of the virtualized sectors; and transmitter circuitry to transmit the indication of RSRP to the eNB; and wherein each of the plurality of virtualized sectors comprises a transmit beam beamformed to be vertically narrow and horizontally wide based on an associated vertical downtilt angle.

Example 41 may include the apparatus of example 40, the controller circuitry further to determine a highest RSRP value of the plurality of RSRP values wherein the generated indication comprises an indication of the determined highest RSRP value and the associated virtualized sector.

Example 42 may include the apparatus of example 40 or example 41, wherein the receiver circuitry is operable to receive an active receiving beam and a candidate receiving beam; and wherein the generated indication of RSRP further comprises an indication of a receiving beam associated with the RSRP value, wherein the indication of

a receiving beam comprises a first value to indicate that the RSRP value was measured from the active receiving beam and a second value to indicate that the RSRP value was measure from the candidate receiving beam.

Example 43 may include the apparatus of example 42, wherein the receiver circuitry is operable to receive one of the active receiving beam and the candidate receiving beam at one time.

Example 44 may include the apparatus of any of examples 40 to 43, wherein the receiver circuitry is further to receive UE specific CSI-RS on a first virtualized sector of the plurality of virtualized sectors; and wherein the controller circuitry is further to generate a digital beam selection Channel State Information (CSI) in dependence on the received UE specific CSI-RS.

Example 45 may include the apparatus of example 44, wherein the UE specific CSI-RS comprises a plurality of CSI-RS groups, wherein each CSI-RS group of the plurality of CSI-RS groups is associated with a two dimensional narrow transmit beam within the selected virtualized sector.

Example 46 may include the apparatus of example 44 or example 45, wherein the digital beam selection CSI comprises a first precoder matrix indicator (PMI) associated with an active receiving beam.

Example 47 may include the apparatus of example 46, wherein the digital beam selection CSI further comprises a second PMI associated with a candidate receiving beam.

Example 48 may include the apparatus of example 44 to example 47, wherein the PMI is selected from a rank 1 codebook.

Example 49 may include the apparatus of example 45, the control circuitry to generate a CSI-RS report, the CSI-RP report comprising CSI-RS receiving power (CSIRS-RP) value; a receiving beam indicator comprising a first value to indicate the CSIRS-RP value was measured using an active receive beam and a second value to indicate that the CSIRS-RP value was measured using a candidate receive beam; a CSI-RS group index; and a subframe index.

Example 50 may include the apparatus of example 49, the control circuitry to generate a plurality of CSI-RS reports from the UE, each CSI-RS report associated with a CSI-RS group of the plurality of CSI-RS groups.

Example 51 may include the apparatus of example 50, wherein the plurality of CSI-RS reports may comprise N CSI-RP reports, where N is configured by the network or using radio resource control signalling (RRC).

Example 52 may include the apparatus of example 50 or example 51, wherein the plurality of CSI-RS reports comprises CSI-RS reports having a CSIRS-RP value greater than a threshold CSIRS-RP value.

Example 53 may include the apparatus of example 52, wherein the threshold CSIRS-RP value is configured by the network or using radio resource control signalling (RRC).

Example 54 may include a user equipment comprising an apparatus according to any of examples 20 to 33, the user equipment further comprising at least one of a display; a keyboard; and a touchscreen.

Example 55 may include a computer readable medium comprising computer program code that when executed implements the method of receiving a plurality of channel state information reference signals (CSI-RS) from an eNB, each CSI-RS associated with one of a plurality of virtualized sectors; obtaining a plurality of reference signal receiver power (RSRP) values, each of the plurality of RSRP values associated with one of the received CSI-RS; and generating an indication of RSRP associated with one of the virtualized sectors; and transmitting the indication of RSRP to the eNB; wherein each of the plurality of virtualized sectors comprises a transmit beam beamformed to be vertically narrow and horizontally wide based on an associated vertical downtilt angle.

Example 56 may include a computer readable medium comprising computer program code that when executed implements the method of configuring a plurality of channel state information reference signals (CSI-RS), each CSI-RS associated with one of a plurality of virtualized sectors; and transmitting the configured CSI-RS; wherein each of the plurality of virtualized sectors comprises a transmit beam beamformed to be vertically narrow and horizontally wide based on an associated vertical downtilt angle.

Example 57 may include the apparatus of example 21, wherein a transmit beam associated with a virtualized sector is transmitted using a first antenna port, the first antenna port associated with a first number of vertical antenna elements and a second number of horizontal antenna elements wherein the first number of vertical antenna elements is greater than the second number of horizontal antenna elements.

Example 58 may include the apparatus of example 57, wherein the first number of vertical antenna elements is greater than or equal to 8, and wherein the second number of horizontal antenna elements is less than or equal to 2.

The foregoing description of one or more implementations provides illustration and description, but is not intended to be exhaustive or to limit the scope of the example embodiments to the precise form disclosed. Modifications and variations are possible in light of the above teachings or may be acquired from practice of various implementations of the example embodiments.

CLAIMS

1. An apparatus for use in an eNB in a wireless communication network, the apparatus comprising:

transmitter circuitry; and

control circuitry coupled to the transmitter circuitry, the control circuitry to:

configure a plurality of channel state information reference signals (CSI-RS), each CSI-RS associated with one of a plurality of virtualized sectors; and

cause the transmitter circuitry to transmit the configured CSI-RS;

wherein each of the plurality of virtualized sectors comprises a transmit beam beamformed to be vertically narrow and horizontally wide based on an associated vertical downtilt angle.

2. The apparatus of claim 1, wherein each of the plurality of virtualized sectors is associated with a different vertical downtilt angle.

3. The apparatus of any preceding claim further comprising:

receiver circuitry coupled to the control circuitry, the receiver circuitry to receive an indication of a reference signal received power (RSRP) value associated with one of the virtualized sectors from a User Equipment (UE), the indication of RSRP value based on the CSI-RS associated with the one of the virtualized sectors.

4. The apparatus of claim 3, wherein the control circuitry is further to select a virtualized sector beam for communicating with the UE based on the received indication of RSRP value.

5. The apparatus of claim 4, wherein the control circuitry is further to configure UE specific CSI-RS associated with the selected virtualized sector and cause the transmitter circuitry to transmit the UE specific CSI-RS to the UE in the selected virtualized sector.

6. The apparatus of claim 5, wherein the receiver circuitry is further to receive a digital beam selection channel state information (CSI) from the UE in response

to the UE specific CSI-RS, the digital beam selection CSI comprising a first precoder matrix indicator (PMI) associated with an active receiving beam.

7. The apparatus of claim 6, wherein the digital beam selection CSI further comprises a second PMI associated with a candidate receiving beam.

8. The apparatus of claims 6 or 7, wherein the PMI is selected from a rank 1 codebook defined by the network.

9. The apparatus of any of claims 6 to 8, wherein the control circuitry is further to generate a two dimensional narrow transmit beam within the selected virtualized sector based on a received PMI.

10. The apparatus of any of claims 6 to 9, wherein the transmitter circuitry is further to transmit the US specific CSI-RS a plurality of CSI-RS groups, wherein each CSI-RS group of the plurality of CSI-RS groups is associated with a two dimensional narrow transmit beam within the selected virtualized sector;

wherein each of the plurality of CSI-RS groups is associated with two antenna ports sent from both horizontal and vertical polarizations.

11. The apparatus of any of claims 1 to 10, wherein a transmit beam associated with a virtualized sector is transmitted using a first antenna port, the first antenna port associated with a first number of vertical antenna elements and a second number of horizontal antenna elements wherein the first number of vertical antenna elements is greater than the second number of horizontal antenna elements.

12. The apparatus of claim 10 or claim 11, the receiver circuitry further to:

receive a CSI-RS report from the UE, the report comprising:

CSI-RS receiving power (CSIRS-RP) value;

a receiving beam indicator comprising a first value to indicate the CSIRS-RP value was measured using an active receive beam and a second value to indicate that the CSIRS-RP value was measured using a candidate receive beam;

a CSI-RS group index; and

a subframe index.

13. The apparatus of claim 12, the receiver circuitry further to receive a plurality of CSI-RS reports from the UE, each CSI-RS report associated with a CSI-RS group of the plurality of CSI-RS groups.

14. An apparatus for use in a user equipment (UE) in a wireless communication network, the apparatus comprising:

receiver circuitry to receive a plurality of channel state information reference signals (CSI-RS) from an eNB, each CSI-RS associated with one of a plurality of virtualized sectors;

controller circuitry coupled to the receiver circuitry, the controller circuitry to:

obtain a plurality of reference signal receiver power (RSRP) values, each of the plurality of RSRP values associated with one of the received CSI-RS; and

generate an indication of RSRP associated with one of the virtualized sectors; and

transmitter circuitry to transmit the indication of RSRP to the eNB; and

wherein each of the plurality of virtualized sectors comprises a transmit beam beamformed to be vertically narrow and horizontally wide based on an associated vertical downtilt angle.

15. The apparatus of claim 14, the controller circuitry further to determine a highest RSRP value of the plurality of RSRP values wherein the generated indication comprises an indication of the determined highest RSRP value and the associated virtualized sector.

16. The apparatus of claim 14 or claim 15, wherein the receiver circuitry is operable to receive an active receiving beam and a candidate receiving beam; and

wherein the generated indication of RSRP further comprises an indication of a receiving beam associated with the RSRP value, wherein the indication of a receiving beam comprises a first value to indicate that the RSRP value was measured from the active receiving beam and a second value to indicate that the RSRP value was measure from the candidate receiving beam.

17. The apparatus of claim 16, wherein the receiver circuitry is operable to receive only one of the active receiving beam and the candidate receiving beam at one time.

18. The apparatus of any of claims 14 to 17, wherein the receiver circuitry is further to receive UE specific CSI-RS on a first virtualized sector of the plurality of virtualized sectors; and

wherein the controller circuitry is further to generate a digital beam selection Channel State Information (CSI) in dependence on the received UE specific CSI-RS.

19. The apparatus of claim 18, wherein the UE specific CSI-RS comprises a plurality of CSI-RS groups, wherein each CSI-RS group of the plurality of CSI-RS groups is associated with a two dimensional narrow transmit beam within the selected virtualized sector.

20. The apparatus of claim 18 or claim 19, wherein the digital beam selection CSI comprises a first precoder matrix indicator (PMI) associated with an active receiving beam and a second PMI associated with a candidate receiving beam.

21. The apparatus of claim 19, the control circuitry to generate a CSI-RS report, the CSI-RP report comprising:

CSI-RS receiving power (CSIRS-RP) value;

a receiving beam indicator comprising a first value to indicate the CSIRS-RP value was measured using an active receive beam and a second value to indicate that the CSIRS-RP value was measured using a candidate receive beam;

a CSI-RS group index; and

a subframe index.

22. The apparatus of claim 21, the control circuitry to generate a plurality of CSI-RS reports from the UE, each CSI-RS report associated with a CSI-RS group of the plurality of CSI-RS groups.

23. A user equipment comprising an apparatus according to any of claims 20 to 33, the user equipment further comprising at least one of a display; a keyboard; and a touchscreen.

24. A computer readable medium comprising computer program code that when executed implements the method of:

receiving a plurality of channel state information reference signals (CSI-RS) from an eNB, each CSI-RS associated with one of a plurality of virtualized sectors;

obtaining a plurality of reference signal receiver power (RSRP) values, each of the plurality of RSRP values associated with one of the received CSI-RS; and

generating an indication of RSRP associated with one of the virtualized sectors; and

transmitting the indication of RSRP to the eNB;

wherein each of the plurality of virtualized sectors comprises a transmit beam beamformed to be vertically narrow and horizontally wide based on an associated vertical downtilt angle.

25. A computer readable medium comprising computer program code that when executed implements the method of:

configuring a plurality of channel state information reference signals (CSI-RS), each CSI-RS associated with one of a plurality of virtualized sectors; and

transmitting the configured CSI-RS;

wherein each of the plurality of virtualized sectors comprises a transmit beam beamformed to be vertically narrow and horizontally wide based on an associated vertical downtilt angle.

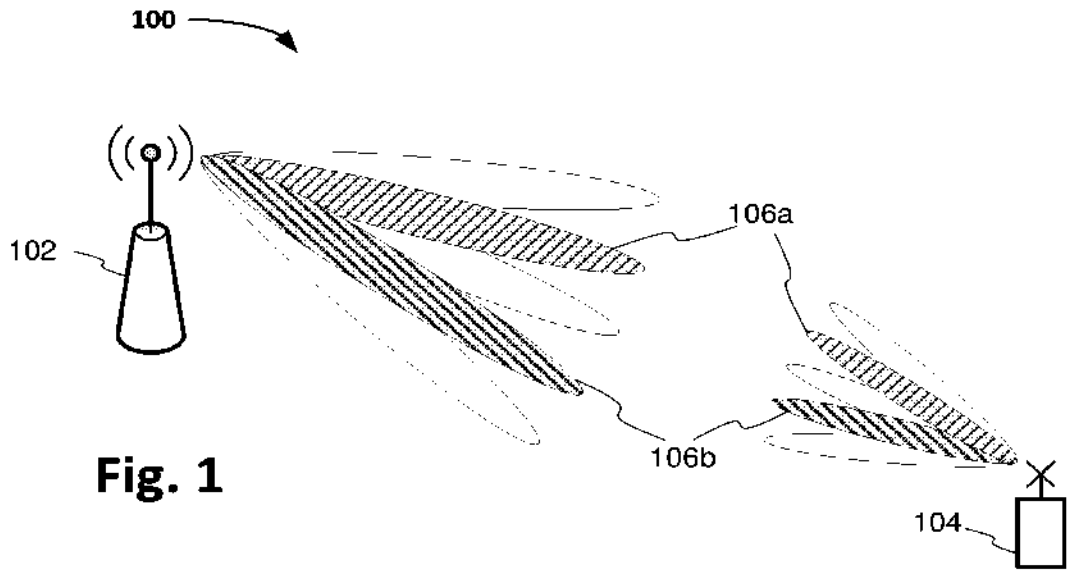

100
102
106a
106b
104

Fig. 1

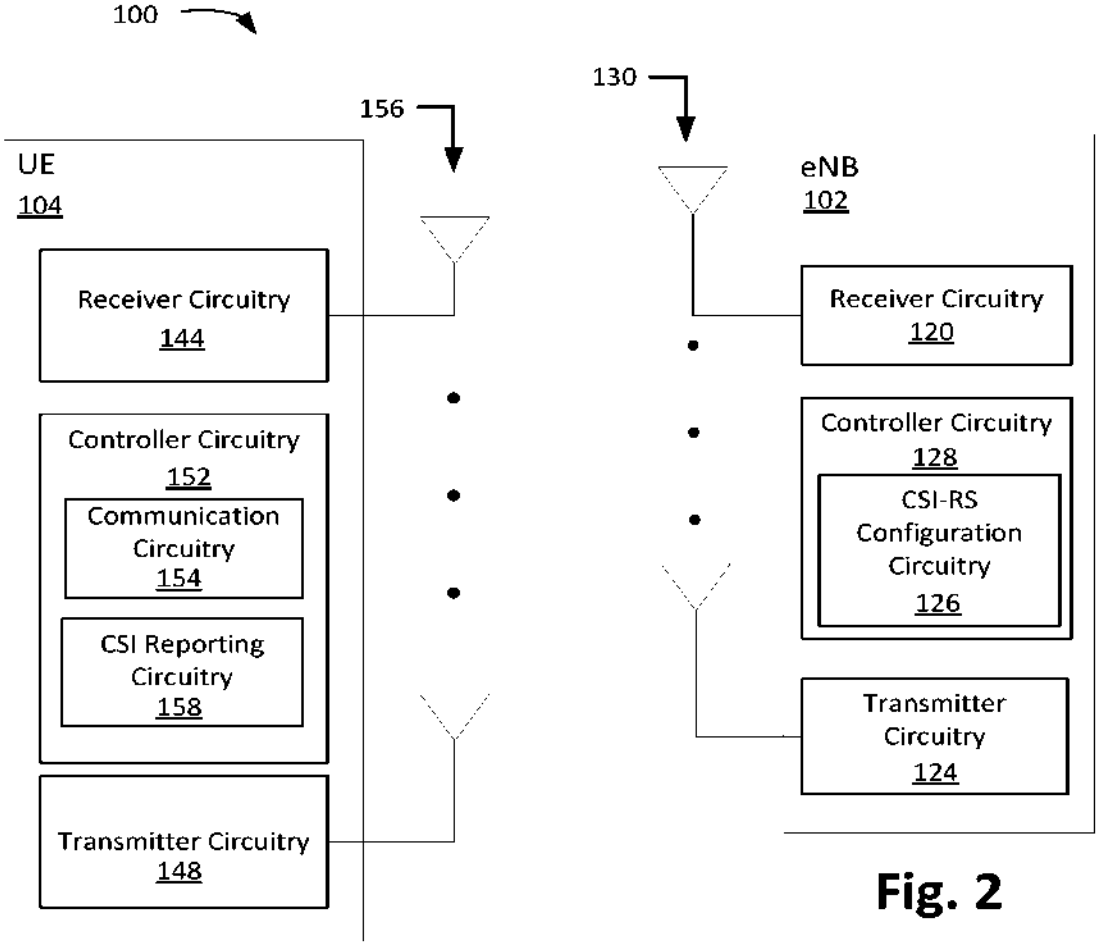

100
156
130
UE
104
Receiver Circuitry
144
Controller Circuitry
152
Communication Circuitry
154
CSI Reporting Circuitry
158
Transmitter Circuitry
148
eNB
102
Receiver Circuitry
120
Controller Circuitry
128
CSI-RS Configuration Circuitry
126
Transmitter Circuitry
124

Fig. 2

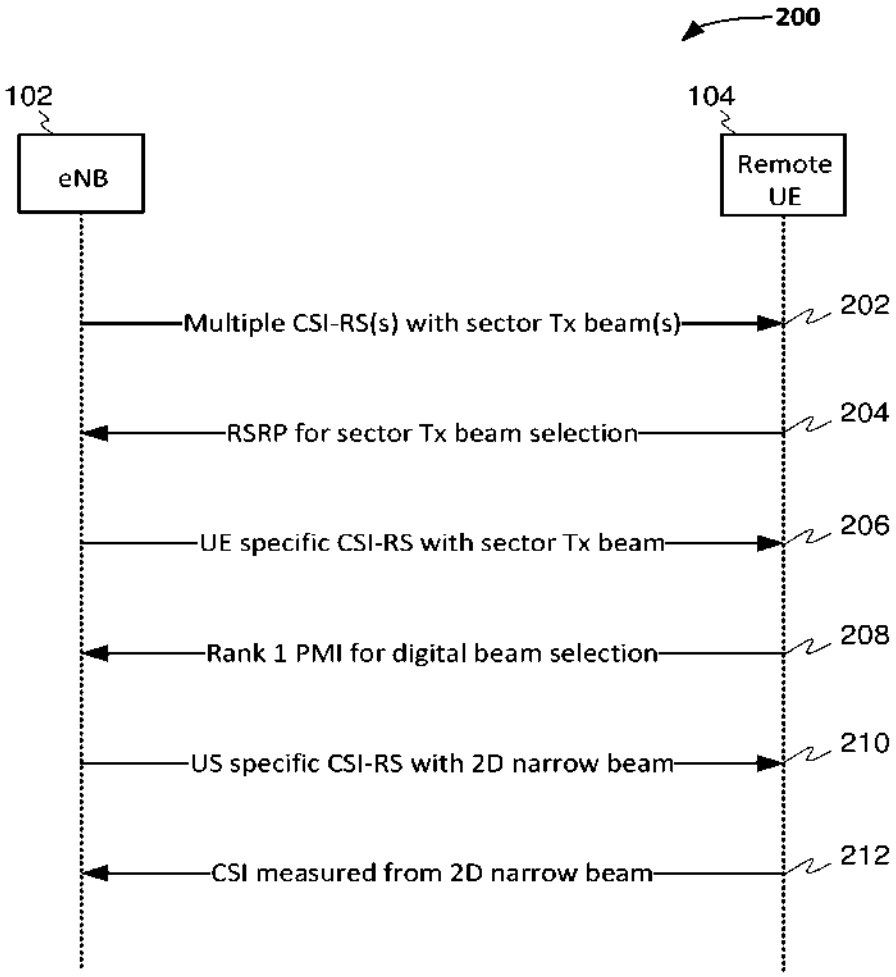

200
102
eNB
104
Remote UE
Multiple CSI-RS(s) with sector Tx beam(s)
202
RSRP for sector Tx beam selection
204
UE specific CSI-RS with sector Tx beam
206
Rank 1 PMI for digital beam selection
208
US specific CSI-RS with 2D narrow beam
210
CSI measured from 2D narrow beam
212

Fig. 3

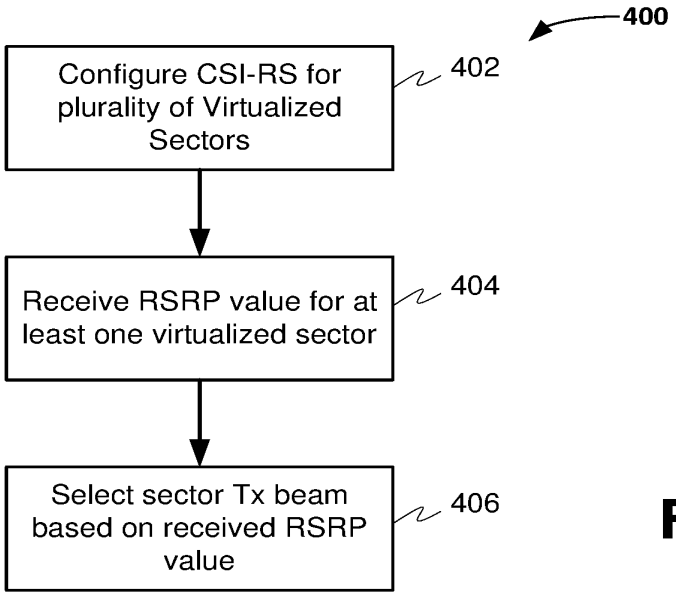

400
Configure CSI-RS for plurality of Virtualized Sectors
402
Receive RSRP value for at least one virtualized sector
404
Select sector Tx beam based on received RSRP value
406

Fig. 4

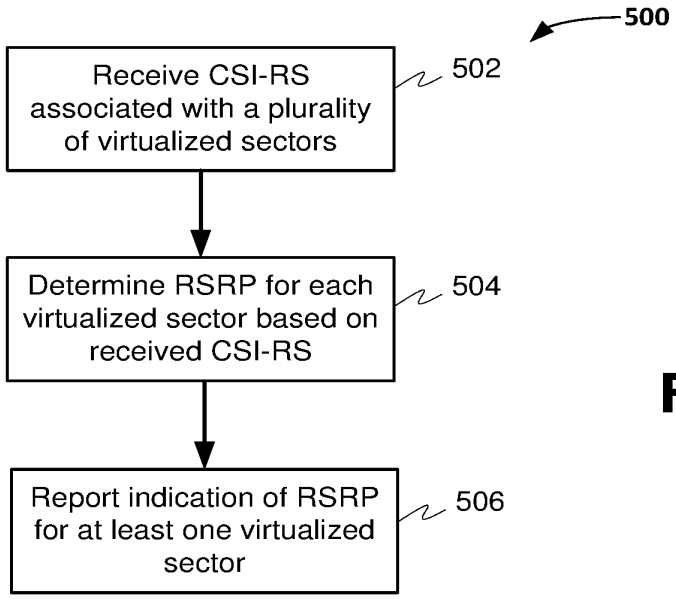

500
Receive CSI-RS associated with a plurality of virtualized sectors
502
Determine RSRP for each virtualized sector based on received CSI-RS
504
Report indication of RSRP for at least one virtualized sector
506

Fig. 5

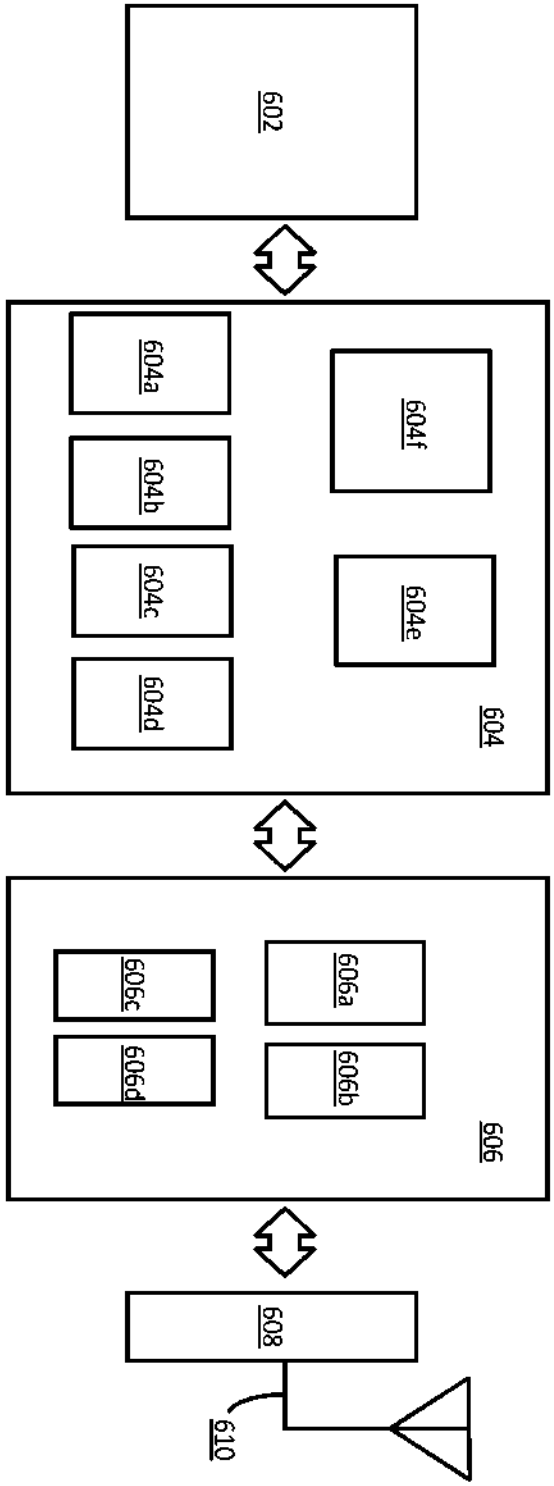

602
604a
604b
604c
604d
604f
604e
604
606c
606d
606a
606b
606
608
610
600

Fig. 6

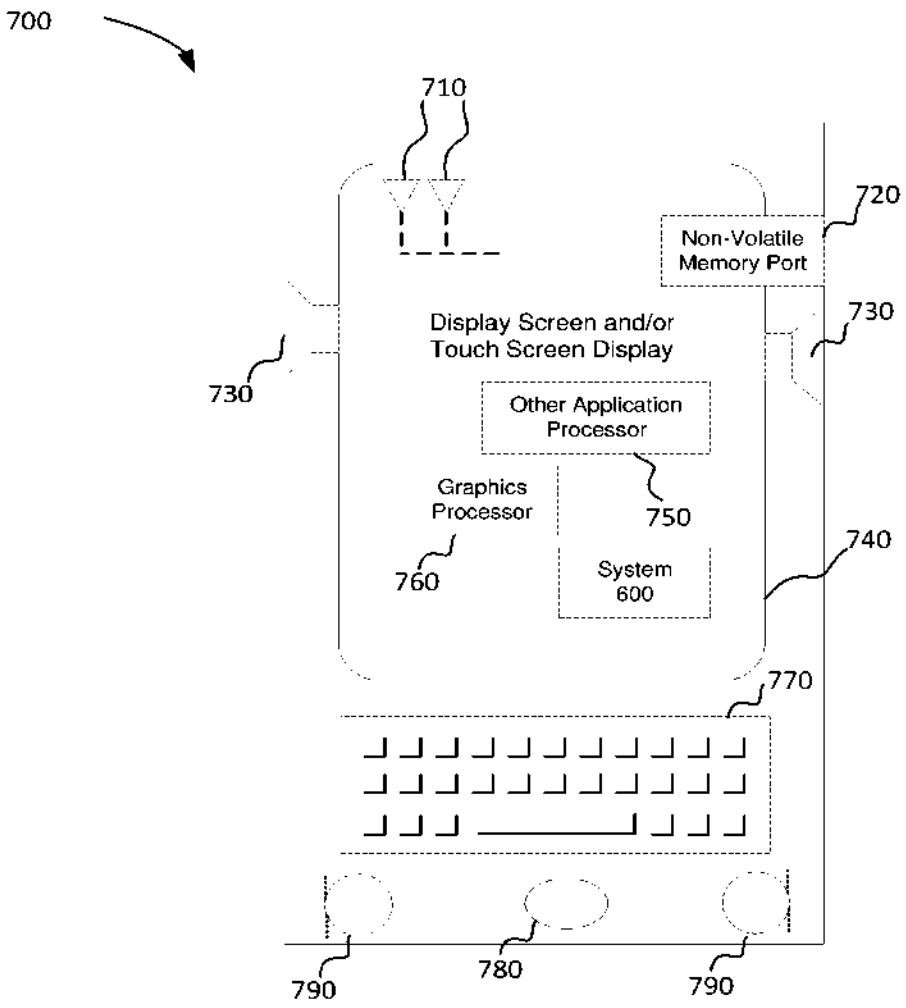

700
710
720
Non-Volatile
Memory Port
730
730
Display Screen and/or
Touch Screen Display
Other Application
Processor
750
Graphics
Processor
760
System
600
740
770
790
780
790

Fig. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2016/078453

A. CLASSIFICATION OF SUBJECT MATTER

H04B 7/02(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04B; H04W; H04Q; H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNKI,CNPAT,WPI,EPODOC,IEEE,GOOGLE,3GPP: RS, CSI-RS, eNB, CSI, sectors, RSRP, angle, vertical+, horizontal+, downtilt, tilt, measure, report

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2014182383 A1 (INTEL IP CORPORATION) 13 November 2014 (2014-11-13) description, pages 5-6, 14, figures 4A-4B	1-25
X	WO 2014052806 A1 (INTERDIGITAL PATENT HOLDINGS, INC.) 03 April 2014 (2014-04-03) description, paragraphs [0209]-[0219]	1-25
A	WO 2014099343 A1 (MOTOROLA MOBILITY LLC) 26 June 2014 (2014-06-26) the whole document	1-25
A	US 2011103504 A1 (FUTUREWEI TECHNOLOGIES, INC.) 05 May 2011 (2011-05-05) the whole document	1-25

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 July 2016	**26 July 2016**
Name and mailing address of the ISA/CN **STATE INTELLECTUAL PROPERTY OFFICE OF THE P.R.CHINA** **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088, China** Facsimile No. (**86-10**)**62019451**	Authorized officer **XING,Yunfeng** Telephone No. (**86-10**)**62413374**

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2016/078453

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
WO	2014182383	A1	13 November 2014	US	2016057797	A1	25 February 2016
				CN	105359477	A	24 February 2016
				CN	105340190	A	17 February 2016
				US	2016065290	A1	03 March 2016
				WO	2014182774	A1	13 November 2014
				US	2016157095	A1	02 June 2016
				CN	105122672	A	02 December 2015
				CN	105191200	A	23 December 2015
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(Not for submission under 37 CFR 1.99)

Application Number	17950726
Filing Date	2022-09-22
First Named Inventor	Xiaobo ZHANG
Art Unit	2471
Examiner Name	AHMED ELALLAM
Attorney Docket Number	ZL0205-0004-US-CON3

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	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

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	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

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	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

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	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

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☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

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SIGNATURE

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Signature	/JIALIN ZHONG/	Date (YYYY-MM-DD)	2023-11-19
Name/Print	JIALIN ZHONG	Registration Number	62937

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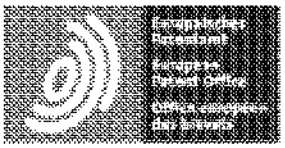
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Espacenet

CN108633047A Channel transmission method and network device

Applicants: HUAWEI TECH CO LTD

Inventors: WANG TING,LIANG JINYAO,DOU SHENGYUE,LI YUANJIE

Classifications:

IPC ***H04W72/04; H04W72/12;***

CPC **H04L5/0053 (EP,US); H04L5/0064 (EP,US); H04L5/0091 (EP,US); H04W72/0453 (CN,US); H04W72/12 (US); H04W72/23 (EP,CN,US); H04W72/535 (CN,US);** H04L5/001 (EP,US); H04L5/0026 (EP,US); H04L5/0035 (EP,US); Y02D30/70 (US);

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Channel transmission method and network device

Abstract

Embodiments of the invention disclose a channel transmission method and a network device. The method includes steps: a first network device determines a search space of at least two downlink control channels; the first network device respectively determines resources occupied by the at least two downlink control channels in the search space, wherein the resources scheduled by the at least two downlink control channels belong to one carrier; and the first network device obtains the at least two downlink control channels by employing the resources. By adopting the method and the device, data ofone carrier can be scheduled through a plurality of downlink control channels so that the efficiency and the reliability of information transmission are improved.

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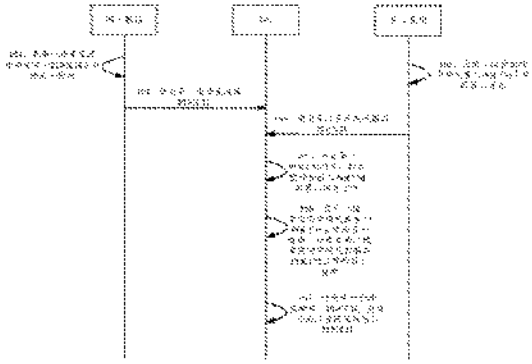
权利要求书6页 说明书32页 附图14页

(54)发明名称

一种信道传输方法及网络设备

(57)摘要

本发明实施例公开了一种信道传输方法及网络设备。其中，该方法包括：第一网络设备确定至少两个下行控制信道的搜索空间；所述第一网络设备在所述搜索空间中分别确定出所述至少两个下行控制信道占用的资源，所述至少两个下行控制信道调度的资源属于一个载波；所述第一网络设备使用所述资源获取所述至少两个下行控制信道。采用本发明实施例，能够实现通过多个下行控制信道调度一个载波的数据，从而提升了信息传输的效率及可靠性。



CN 108633047 B

1.一种信道传输方法,其特征在于,包括:

用户设备确定至少两个下行控制信道的搜索空间;

所述用户设备在所述搜索空间中分别确定出所述至少两个下行控制信道占用的资源,所述至少两个下行控制信道调度的数据所占的资源属于一个载波;

所述用户设备使用所述至少两个下行控制信道占用的资源,获取所述至少两个下行控制信道。

2.根据权利要求1所述的方法,其特征在于,所述至少两个下行控制信道的搜索空间相同;所述用户设备确定至少两个下行控制信道的搜索空间,包括:

所述用户设备基于第一参数确定至少两个下行控制信道的搜索空间;其中,所述第一参数包括控制信道元素CCE个数、第一时间单元的标识以及下行控制信道的候选位置中的至少一项;

所述至少两个下行控制信道的搜索空间的CCE的个数相同;或,

所述至少两个下行控制信道的第一时间单元的标识是基于所述至少两个下行控制信道占用的资源的子载波间隔确定的;或,

所述至少两个下行控制信道的第一时间单元的标识是根据预设子载波间隔下的时间单元中与所述至少两个下行控制信道的第一时间单元对应的时间单元的标识确定的;或,

所述至少两个下行控制信道的候选位置不同,所述至少两个下行控制信道的候选位置是基于第二参数确定的,所述第二参数包括设备类型、设备标识、聚合等级中的至少一项。

3.根据权利要求1所述的方法,其特征在于,所述至少两个下行控制信道的搜索空间不同;所述用户设备确定至少两个下行控制信道的搜索空间,包括:

所述用户设备分别确定至少两个下行控制信道的搜索空间占用的资源,所述至少两个下行控制信道的搜索空间占用的资源不同,其中,所述至少两个下行控制信道的搜索空间占用的资源包括频域资源或时域资源;

所述用户设备基于所述至少两个下行控制信道的搜索空间占用的资源分别确定所述至少两个下行控制信道的搜索空间。

4.根据权利要求3所述的方法,其特征在于,所述用户设备分别确定至少两个下行控制信道的搜索空间占用的资源,包括:

所述用户设备确定第一资源配置信息,并基于所述第一资源配置信息确定至少两个下行控制信道的搜索空间占用的资源;

其中,所述第一资源配置信息包括所述至少两个下行控制信道的搜索空间所在的控制信道资源集合占用的资源信息,且所述至少两个下行控制信道对应的搜索空间的个数与控制信道资源集合的个数相同。

5.根据权利要求3所述的方法,其特征在于,所述用户设备分别确定至少两个下行控制信道的搜索空间占用的资源,包括:

所述用户设备确定第二资源配置信息,并基于所述第二资源配置信息确定至少两个下行控制信道的搜索空间占用的资源;

其中,所述第二资源配置信息包括所述至少两个下行控制信道的搜索空间所在的至少两个控制信道资源集合占用的资源信息、所述至少两个控制信道资源集合的标识以及第一偏移值中的至少一项,所述第一偏移值是基于所述至少两个控制信道资源集合的标识确定

出的，且所述至少两个控制信道资源集合占用的资源相重叠。

6.根据权利要求3所述的方法，其特征在于，所述用户设备分别确定至少两个下行控制信道的搜索空间占用的资源，包括：

所述用户设备确定第三资源配置信息，并基于所述第三资源配置信息确定至少两个下行控制信道的搜索空间占用的资源；

其中，所述第三资源配置信息包括所述至少两个下行控制信道的搜索空间所在的控制信道资源集合占用的资源信息、所述至少两个下行控制信道的搜索空间的标识以及第二偏移值中的至少一项，所述第二偏移值是基于所述至少两个下行控制信道的搜索空间的标识确定出的，且所述至少两个下行控制信道对应的搜索空间所在的控制信道资源集合相同。

7.根据权利要求3所述的方法，其特征在于，所述至少两个下行控制信道的搜索空间占用的资源包括时域资源；所述方法还包括：

所述用户设备接收至少一个第二网络设备发送的通知消息，所述通知消息包括所述至少两个下行控制信道的搜索空间占用的第二时间单元的标识。

8.一种信道传输方法，其特征在于，包括：

第一网络设备在第一搜索空间中确定第一下行控制信道占用的第一资源；

第二网络设备在第二搜索空间中确定第二下行控制信道占用的第二资源，所述第一下行控制信道调度的资源和所述第二下行控制信道调度的数据所占的资源属于一个载波；

所述第一网络设备使用所述第一资源向用户设备发送所述第一下行控制信道；

所述第二网络设备使用所述第二资源向所述用户设备发送所述第二下行控制信道。

9.根据权利要求8所述的方法，其特征在于，所述第一搜索空间和所述第二搜索空间相同；所述方法还包括：

所述第一网络设备或所述第二网络设备基于第一参数确定所述第一搜索空间；

其中，所述第一参数包括控制信道元素CCE的个数、第一时间单元的标识以及下行控制信道的候选位置中的至少一项；

所述第一网络设备对应的第一参数包括的CCE的个数和所述第二网络设备对应的第一参数包括的CCE的个数相同；或，

所述第一下行控制信道的第一时间单元的标识或所述第二下行控制信道的第一时间单元的标识是基于所述第一资源和第二资源的子载波间隔确定的；或，

所述第一下行控制信道的第一时间单元的标识是根据预设子载波间隔下的时间单元中与所述第一下行控制信道的第一时间单元对应的时间单元的标识确定的，所述第二下行控制信道的第一时间单元的标识是根据所述预设子载波间隔下的时间单元中与所述第二下行控制信道的第一时间单元对应的时间单元的标识确定出的；或，

所述第一下行控制信道的候选位置与所述第二下行控制信道的候选位置不同，所述第一下行控制信道或所述第二下行控制信道的候选位置是基于第二参数确定的，所述第二参数包括设备类型、设备标识、聚合等级中的至少一项。

10.根据权利要求8所述的方法，其特征在于，所述第一搜索空间和所述第二搜索空间不同；所述方法还包括：

所述第一网络设备确定第一搜索空间占用的第三资源；其中，所述第三资源包括频域资源或时域资源；

所述第一网络设备基于所述第三资源确定所述第一搜索空间。

11.根据权利要求10所述的方法，其特征在于，所述第一网络设备基于所述第三资源确定所述第一搜索空间，包括：

所述第一网络设备确定第一资源配置信息，并基于所述第一资源配置信息确定所述第一搜索空间，所述第一资源配置信息包括所述第一搜索空间所在的控制信道资源集合占用的资源信息。

12.根据权利要求10所述的方法，其特征在于，所述第一网络设备基于所述第三资源确定所述第一搜索空间，包括：

所述第一网络设备确定第二资源配置信息，并基于所述第二资源配置信息确定所述第一搜索空间，所述第二资源配置信息包括所述第一搜索空间所在的控制信道资源集合占用的资源信息、所述控制信道资源集合的标识以及第一偏移值中的至少一项，所述第一偏移值是基于所述控制信道资源集合的标识确定出的。

13.根据权利要求10所述的方法，其特征在于，所述第一网络设备基于所述第三资源确定所述第一搜索空间，包括：

所述第一网络设备确定第三资源配置信息，并基于所述第三资源配置信息确定所述第一搜索空间，所述第三资源配置信息包括所述第一搜索空间所在的控制信道资源集合占用的资源信息、所述第一搜索空间的标识以及第二偏移值中的至少一项，所述第二偏移值是基于所述第一搜索空间的标识确定出的。

14.根据权利要求10所述的方法，其特征在于，所述第三资源包括时域资源；所述方法还包括：

所述第一网络设备向所述用户设备发送通知消息，所述通知消息包括所述第一搜索空间占用的第二时间单元的标识。

15.根据权利要求8所述的方法，其特征在于，所述方法还包括：

所述第一网络设备基于第三参数确定所述第一搜索空间，其中，所述第一搜索空间包括至少一个控制信道元素CCE，所述第三参数包括CCE的个数或CCE的标识。

16.一种用户设备，其特征在于，包括：

确定模块，用于确定至少两个下行控制信道的搜索空间；

所述确定模块，还用于在所述搜索空间中分别确定出所述至少两个下行控制信道占用的资源，所述至少两个下行控制信道调度的数据所占的资源属于一个载波；

通信模块，用于使用所述至少两个下行控制信道占用的资源获取所述至少两个下行控制信道。

17.根据权利要求16所述的用户设备，其特征在于，所述至少两个下行控制信道的搜索空间相同；所述确定模块在确定至少两个下行控制信道的搜索空间时，具体用于：

基于第一参数确定至少两个下行控制信道的搜索空间；其中，所述第一参数包括控制信道元素CCE个数、第一时间单元的标识以及下行控制信道的候选位置中的至少一项；

所述至少两个下行控制信道的搜索空间的CCE的个数相同；或，

所述至少两个下行控制信道的第一时间单元的标识是基于所述至少两个下行控制信道占用的资源的子载波间隔确定的；或，

所述至少两个下行控制信道的第一时间单元的标识是根据预设子载波间隔下的时间

单元中与所述至少两个下行控制信道的第一时间单元对应的时间单元的标识确定的；或，

所述至少两个下行控制信道的候选位置不同，所述至少两个下行控制信道的候选位置是基于第二参数确定的，所述第二参数包括设备类型、设备标识、聚合等级中的至少一项。

18.根据权利要求16所述的用户设备，其特征在于，所述至少两个下行控制信道的搜索空间不同；所述确定模块在确定至少两个下行控制信道的搜索空间时，具体用于：

分别确定至少两个下行控制信道的搜索空间占用的资源，所述至少两个下行控制信道的搜索空间占用的资源不同，其中，所述至少两个下行控制信道的搜索空间占用的资源包括频域资源或时域资源；

基于所述至少两个下行控制信道的搜索空间占用的资源分别确定所述至少两个下行控制信道的搜索空间。

19.根据权利要求18所述的用户设备，其特征在于，所述确定模块在分别确定至少两个下行控制信道的搜索空间占用的资源时，具体用于：

确定第一资源配置信息，并基于所述第一资源配置信息确定至少两个下行控制信道的搜索空间占用的资源；

其中，所述第一资源配置信息包括所述至少两个下行控制信道的搜索空间所在的控制信道资源集合占用的资源信息，且所述至少两个下行控制信道对应的搜索空间的个数与控制信道资源集合的个数相同。

20.根据权利要求18所述的用户设备，其特征在于，所述确定模块在分别确定至少两个下行控制信道的搜索空间占用的资源时，具体用于：

确定第二资源配置信息，并基于所述第二资源配置信息确定至少两个下行控制信道的搜索空间占用的资源；

其中，所述第二资源配置信息包括所述至少两个下行控制信道的搜索空间所在的至少两个控制信道资源集合占用的资源信息、所述至少两个控制信道资源集合的标识以及第一偏移值中的至少一项，所述第一偏移值是基于所述至少两个控制信道资源集合的标识确定出的，且所述至少两个控制信道资源集合占用的资源相重叠。

21.根据权利要求18所述的用户设备，其特征在于，所述确定模块在分别确定至少两个下行控制信道的搜索空间占用的资源时，具体用于：

确定第三资源配置信息，并基于所述第三资源配置信息确定至少两个下行控制信道的搜索空间占用的资源；

其中，所述第三资源配置信息包括所述至少两个下行控制信道的搜索空间所在的控制信道资源集合占用的资源信息、所述至少两个下行控制信道的搜索空间的标识以及第二偏移值中的至少一项，所述第二偏移值是基于所述至少两个下行控制信道的搜索空间的标识确定出的，且所述至少两个下行控制信道对应的搜索空间所在的控制信道资源集合相同。

22.根据权利要求18所述的用户设备，其特征在于，所述至少两个下行控制信道的搜索空间占用的资源包括时域资源；

所述通信模块，还用于接收至少一个另一网络设备发送的通知消息，所述通知消息包括所述至少两个下行控制信道的搜索空间占用的第二时间单元的标识。

23.一种网络设备，其特征在于，包括：

第一确定模块，用于在第一搜索空间中确定第一下行控制信道占用的第一资源；

第二确定模块，用于在第二搜索空间中确定第二下行控制信道占用的第二资源，所述第一下行控制信道调度的资源和所述第二下行控制信道调度的数据所占的资源属于一个载波；

第一通信模块，用于使用所述第一资源向用户设备发送所述第一下行控制信道；

第二通信模块，用于使用所述第二资源向所述用户设备发送所述第二下行控制信道。

24.根据权利要求23所述的网络设备，其特征在于，所述第一搜索空间和所述第二搜索空间相同；

所述第一确定模块，还用于基于第一参数确定所述第一搜索空间；

所述第二确定模块，还用于基于第一参数确定所述第一搜索空间；其中，所述第一参数包括控制信道元素CCE的个数、第一时间单元的标识以及下行控制信道的候选位置中的至少一项；

所述第一确定模块确定出的第一参数包括的CCE的个数和所述第二确定模块确定出的第一参数包括的CCE的个数相同；或，

所述第一下行控制信道的第一时间单元的标识或所述第二下行控制信道的第一时间单元的标识是基于所述第一资源和第二资源的子载波间隔确定的；或，

所述第一下行控制信道的第一时间单元的标识是根据预设子载波间隔下的时间单元中与所述第一下行控制信道的第一时间单元对应的时间单元的标识确定的，所述第二下行控制信道的第一时间单元的标识是根据所述预设子载波间隔下的时间单元中与所述第二下行控制信道的第一时间单元对应的时间单元的标识确定出的；或，

所述第一下行控制信道的候选位置与所述第二下行控制信道的候选位置不同，所述第一下行控制信道或所述第二下行控制信道的候选位置是基于第二参数确定的，所述第二参数包括设备类型、设备标识、聚合等级中的至少一项。

25.根据权利要求23所述的网络设备，其特征在于，所述第一搜索空间和所述第二搜索空间不同；

所述第一确定模块，还用于确定第一搜索空间占用的第三资源，并基于所述第三资源确定所述第一搜索空间；其中，所述第三资源包括频域资源或时域资源。

26.根据权利要求25所述的网络设备，其特征在于，所述第一确定模块在基于所述第三资源确定所述第一搜索空间时，具体用于：

确定第一资源配置信息，并基于所述第一资源配置信息确定所述第一搜索空间，所述第一资源配置信息包括所述第一搜索空间所在的控制信道资源集合占用的资源信息。

27.根据权利要求25所述的网络设备，其特征在于，所述第一确定模块在基于所述第三资源确定所述第一搜索空间时，具体用于：

确定第二资源配置信息，并基于所述第二资源配置信息确定所述第一搜索空间，所述第二资源配置信息包括所述第一搜索空间所在的控制信道资源集合占用的资源信息、所述控制信道资源集合的标识以及第一偏移值中的至少一项，所述第一偏移值是基于所述控制信道资源集合的标识确定出的。

28.根据权利要求25所述的网络设备，其特征在于，所述第一确定模块在基于所述第三资源确定所述第一搜索空间时，具体用于：

确定第三资源配置信息，并基于所述第三资源配置信息确定所述第一搜索空间，所述

第三资源配置信息包括所述第一搜索空间所在的控制信道资源集合占用的资源信息、所述第一搜索空间的标识以及第二偏移值中的至少一项，所述第二偏移值是基于所述第一搜索空间的标识确定出的。

29.根据权利要求25所述的网络设备，其特征在于，所述第三资源包括时域资源；

所述第一通信模块，还用于向所述用户设备发送通知消息，所述通知消息包括所述第一搜索空间占用的第二时间单元的标识。

30.根据权利要求23所述的网络设备，其特征在于，

所述第一确定模块，还用于基于第三参数确定所述第一搜索空间，其中，所述第一搜索空间包括至少一个控制信道元素CCE，所述第三参数包括CCE的个数或CCE的标识。

一种信道传输方法及网络设备

技术领域

[0001] 本申请涉及通信技术领域，尤其涉及一种信道传输方法及网络设备。

背景技术

[0002] 目前，基站和用户设备(英文:User Equipment，缩写:UE)之间可采用多点协作传输(英文:Coordinated Multiple Points Transmission/Reception，缩写:CoMP)技术进行信息传输，CoMP主要是指使用地理位置上分离的多个基站，协同参与为一个UE的物理下行共享信道(英文:Physical Downlink Sharing Channel，缩写:PDSCH)数据进行传输，或者联合接收一个UE发送的物理上行共享信道(英文:Physical Uplink Sharing Channel，缩写:PUSCH)数据，以提升UE的覆盖性能。现有的长期演进(英文:Long Term Evolution，缩写:LTE)系统中一个小区中的物理下行控制信道(英文:Physical Downlink Control Channel，缩写:PDCCH)的发送是采用全带宽的方式，在一个子帧中通过不同的载波协作传输一个UE的多个PDCCH，不同的PDCCH用于调度不同载波的数据。从而UE能够使用自身的无线网络临时标识(英文:RNTI Radio Network Tempory Identity，缩写:RNTI)对该子帧包括的所有PDCCH进行尝试解码，基于该RNTI解码得到属于自己的PDCCH，并基于该PDCCH进行信息发送或者接收。然而，对于同一个UE，目前一个子帧中只能携带该UE调度的一个载波的一个PDCCH，传输效率较低。而且，在协作传输的场景下，多基站是可以进行独立调度的，仅发送一个PDCCH往往会存在时延问题，导致发送该PDCCH前获知的信道状态信息(英文:Channel State Information，缩写:CSI)可能失效，进而导致导致PDCCH携带的信息不能适用于真正的信道状况，使得基于该PDCCH的信息传输不可靠。

发明内容

[0003] 本发明实施例提供了一种信道传输方法及网络设备，能够实现在通过多个下行控制信道调度一个载波的数据，从而提升了信息传输的效率及可靠性。

[0004] 第一方面，本发明实施例提供了一种信道传输方法，包括：

[0005] 第一网络设备确定至少两个下行控制信道的搜索空间，在该搜索空间中分别确定出该至少两个下行控制信道占用的资源，并使用该资源获取该至少两个下行控制信道。

[0006] 其中，该至少两个下行控制信道调度的资源属于一个载波。该下行控制信道可以包括下行调度信息，也可以包括上行调度信息。

[0007] 可选的，该至少两个下行控制信道可以是一个网络设备发送给该第一网络设备的，也可以是多个网络设备发送给该第一网络设备的。该第一网络设备可以为基站，也可以为用户设备。

[0008] 进一步可选的，该至少两个下行控制信道的搜索空间可以相同也可以不同。

[0009] 在一些可能的实现中，该至少两个下行控制信道的搜索空间可以相同，该第一网络设备确定至少两个下行控制信道的搜索空间时，可基于第一参数确定至少两个下行控制信道的搜索空间。

[0010] 其中，该第一参数可包括控制信道元素(英文:Control Channel Element，缩写:CCE)个数、第一时间单元的标识以及下行控制信道的候选位置中的至少一项。可选的，该第一参数可以是该第一网络设备确定出的;该第一参数也可以是发送该至少两个下行控制信道的网络设备发送给该第一网络设备的，从而该第一网络设备可接收至少一个网络设备发送的该第一参数，以基于该第一参数确定出该至少两个下行控制信道的搜索空间。

[0011] 在一些可能的实现中，该至少两个下行控制信道的搜索空间的CCE的个数相同;或，该至少两个下行控制信道的第一时间单元的标识是基于该至少两个下行控制信道占用的资源的子载波间隔确定的;或，该至少两个下行控制信道的第一时间单元的标识是根据预设子载波间隔下的时间单元中与该至少两个下行控制信道的第一时间单元对应的时间单元的标识确定的;或，该至少两个下行控制信道的候选位置不同，该至少两个下行控制信道的候选位置是基于第二参数确定的，该第二参数包括设备类型、设备标识、聚合等级中的至少一项。

[0012] 在一些可能的实现中，该第一网络设备还可基于至少两个下行控制信道的时间单元信息确定该至少两个下行控制信道的搜索空间对应的CCE的个数;其中，该时间单元信息包括第二时间单元的个数或第二时间单元的标识。也就是说，该第一网络设备还可以基于该至少两个下行控制信道(或其搜索空间)所在的第二时间单元的个数或标识确定出该至少两个下行控制信道的搜索空间的CCE个数，或该至少两个下行控制信道的搜索空间所在的控制信道资源集合的CCE个数，以确定出该至少两个下行控制信道的搜索空间。可选的，该第二时间单元对应的时间单位和该第一时间单元对应的时间单位可以相同也可以不同。

[0013] 在一些可能的实现中，该至少两个下行控制信道的搜索空间也可以不同;该第一网络设备确定至少两个下行控制信道的搜索空间时，可以具体为:第一网络设备分别确定至少两个下行控制信道的搜索空间占用的资源，该至少两个下行控制信道的搜索空间占用的资源不同，并基于该资源分别确定该至少两个下行控制信道的搜索空间。其中，该资源可以包括频域资源或时域资源。

[0014] 也就是说，当第一网络设备接收的多个下行控制信道的搜索空间不同时，该第一网络设备在确定该多个下行控制信道的搜索空间时，可分别确定该多个下行控制信道的搜索空间占用的时域资源和/或频域资源，并基于该资源分别确定该多个下行控制信道的搜索空间。

[0015] 在一些可能的实现中，该第一网络设备分别确定至少两个下行控制信道的搜索空间占用的资源，可以具体为:第一网络设备确定第一资源配置信息，并基于该第一资源配置信息确定至少两个下行控制信道的搜索空间占用的资源。其中，该第一资源配置信息包括该至少两个下行控制信道的搜索空间所在的控制信道资源集合占用的资源信息，且该至少两个下行控制信道对应的搜索空间的个数与控制信道资源集合的个数相同。也就是说，该至少两个下行控制信道对应的至少两个搜索空间可以处于至少两个控制信道资源集合中，该至少两个控制信道资源集合的频域资源不重叠，也即该至少两个下行控制信道的搜索空间所在的控制信道资源集合不同。

[0016] 在一些可能的实现中，该第一网络设备分别确定至少两个下行控制信道的搜索空间占用的资源，可以具体为:第一网络设备确定第二资源配置信息，并基于该第二资源配置信息确定至少两个下行控制信道的搜索空间占用的资源。其中，该第二资源配置信息包括

该至少两个下行控制信道的搜索空间所在的至少两个控制信道资源集合占用的资源信息、该至少两个控制信道资源集合的标识以及第一偏移值中的至少一项，该第一偏移值是基于该至少两个控制信道资源集合的标识确定出的，且该至少两个控制信道资源集合占用的资源相重叠。也就是说，该至少两个下行控制信道对应的至少两个搜索空间可以处于至少两个控制信道资源集合中，该至少两个控制信道资源集合的频域资源可以完全重叠，且该至少两个下行控制信道对应的搜索空间的个数与该控制信道资源集合的个数相同。

[0017] 在一些可能的实现中，该第一网络设备分别确定至少两个下行控制信道的搜索空间占用的资源，可以具体为：第一网络设备确定第三资源配置信息，并基于该第三资源配置信息确定至少两个下行控制信道的搜索空间占用的资源。其中，该第三资源配置信息包括该至少两个下行控制信道的搜索空间所在的控制信道资源集合占用的资源信息、该至少两个下行控制信道的搜索空间的标识以及第二偏移值中的至少一项，该第二偏移值是基于该至少两个下行控制信道的搜索空间的标识确定出的，且该至少两个下行控制信道对应的搜索空间所在的控制信道资源集合相同。也就是说，该至少两个下行控制信道对应的搜索空间可以处于一个控制信道资源集合中。

[0018] 可选的，该第一资源配置信息或该第二资源配置信息或该第三资源配置信息中还可携带CCE标识等信息，以结合该CCE标识进一步确定该搜索空间。

[0019] 进一步可选的，该第一资源配置信息或该第二资源配置信息或该第三资源配置信息还可以是至少一个第二网络设备发送给该第一网络设备的，比如通过某一通知消息指示该第一资源配置信息或该第二资源配置信息或该第三资源配置信息。其中，该第二网络设备可以是发送该至少两个下行控制信道中的一个或多个下行控制信道的网络设备。

[0020] 在一些可能的实现中，该资源可包括时域资源；则该第一网络设备还可接收该至少一个第二网络设备发送的通知消息，该通知消息可用于指示该至少两个下行控制信道的搜索空间占用的第三时间单元的标识，比如该通知消息中可以携带该第三时间单元的标识。可选的，该第三时间单元对应的时间单位可以与该第一时间单元对应的时间单位相同，也可以不同；该第三时间单元对应的时间单位可以与该第二时间单元对应的时间单位相同，也可以不同，本申请不做限定。

[0021] 在一些可能的实现中，第一网络设备确定至少两个下行控制信道的搜索空间，可以具体为：第一网络设备基于第三参数确定该至少两个下行控制信道的搜索空间。其中，该搜索空间包括至少一个CCE，该第三参数包括CCE的个数或CCE的标识。从而第一网络设备可基于该CCE个数或CCE标识确定出该搜索空间。

[0022] 进一步可选的，该第一网络设备还可接收该至少一个第二网络设备发送的第一消息，该第一消息用于指示发送的下行控制信道的个数，从而该第一网络设备可基于该个数获取下行控制信道，在获取的下行控制信道的个数达到该第一消息指示的个数之后即可停止盲检，从而减少了盲检次数，降低了设备开销。或者，该第一网络设备还可以向该至少一个第二网络设备发送第二消息，该第二消息用于指示第一网络设备支持接收的下行控制信道的个数，从而第二网络设备可以基于该第二消息指示的个数进行下行控制信道的发送，其发送的下行控制信道的个数不超过该第二消息指示的个数。可选的，该第一消息或第二消息指示的个数的值可以与该第一网络设备的接收能力相关，或者与当前的信道条件相关，接收能力越强，个数越大，信道条件越好，个数越大，等等，本申请不做限定。进一步可选

的，该搜索空间还可以是基于聚合级别、控制信息的格式、控制信息的大小以及搜索空间的个数中的至少一项确定出的。从而能够减少盲检次数，降低系统开销。

[0023] 第二方面，本发明实施例提供了一种信道传输方法，包括：

[0024] 第一网络设备在第一搜索空间中确定第一下行控制信道占用的第一资源；

[0025] 第二网络设备在第二搜索空间中确定第二下行控制信道占用的第二资源；

[0026] 第一网络设备使用该第一资源向发送该第一下行控制信道；

[0027] 第二网络设备使用该第二资源向该第三网络设备发送该第二下行控制信道。

[0028] 其中，该第一下行控制信道调度的资源和该第二下行控制信道调度的资源属于一个载波。

[0029] 在一些可能的实现中，该第一网络设备可确定该第一搜索空间；该第二网络设备确定该第二搜索空间。可选的，该第一网络设备和第二网络设备可以是相同的网络设备，即通过同一个网络设备给第三网络设备即其他网络设备发送多个下行控制信道；或者，该第一网络设备和第二网络设备还可以是不同的网络设备，即实现通过一个或多个网络设备向第三网络设备发送多个下行控制信道。其中，该第一网络设备和第二网络设备可以是基站，也可以是用户设备；该第三网络设备可以是用户设备，也可以是基站。该第一网络设备和第二网络设备可以和上述第一方面的信道传输方法中的至少一个第二网络设备相对应，该第三网络设备可以和上述第一方面的信道传输方法中的第一网络设备相对应。

[0030] 可选的，该至少两个下行控制信道的搜索空间可以相同也可以不同。

[0031] 在一些可能的实现中，该第一搜索空间和该第二搜索空间可以相同，则该第一网络设备可基于第一参数确定该第一搜索空间。进一步可选的，该第二网络设备可基于第二参数确定该第二搜索空间。其中，该第一参数或该第二参数可包括CCE的个数、第一时间单元的标识以及下行控制信道的候选位置中的至少一项。

[0032] 可选的，该第一参数包括的CCE的个数和该第二参数包括的CCE的个数相同；或，该第一下行控制信道的第一时间单元的标识或该第二下行控制信道的第一时间单元的标识是基于该第一资源和第二资源的子载波间隔确定的；或，该第一下行控制信道的第一时间单元的标识是根据预设子载波间隔下的时间单元中与该第一下行控制信道的第一时间单元对应的时间单元的标识确定的，该第二下行控制信道的第一时间单元的标识是根据该预设子载波间隔下的时间单元中与该第二下行控制信道的第一时间单元对应的时间单元的标识确定出的；或，该第一下行控制信道的候选位置与该第二下行控制信道的候选位置不同，该第一下行控制信道或该第二下行控制信道的候选位置是基于第三参数确定的，该第三参数可包括设备类型、设备标识、聚合等级中的至少一项。

[0033] 在一些可能的实现中，该第一网络设备或该第二网络设备还可向该第三网络设备发送该第一参数和/或第二参数和/或第三参数。

[0034] 在一些可能的实现中，该第一搜索空间和该第二搜索空间不同；该第一网络设备确定该第一搜索空间，可以具体为：第一网络设备确定第一搜索空间占用的第三资源，并基于该第三资源确定该第一搜索空间。其中，该第三资源可包括频域资源或时域资源。

[0035] 在一些可能的实现中，该第二网络设备确定该第二搜索空间，可以具体为：该第二网络设备确定第二搜索空间占用的第四资源，并基于该第四资源确定该第二搜索空间。其中，该第四资源可包括频域资源或时域资源；

[0036] 在一些可能的实现中，该第一网络设备基于该第三资源确定该第一搜索空间，可以具体为：第一网络设备确定第一资源配置信息，并基于该第一资源配置信息确定该第一搜索空间，该第一资源配置信息包括该第一搜索空间所在的控制信道资源集合占用的资源信息。相应的，该第二网络设备基于该第四资源确定该第二搜索空间，可以具体为：第二网络设备确定第四资源配置信息，并基于该第四资源配置信息确定该第二搜索空间，该第四资源配置信息包括该第二搜索空间所在的控制信道资源集合占用的资源信息。

[0037] 在一些可能的实现中，该第一网络设备基于该第三资源确定该第一搜索空间，可以具体为：该第一网络设备确定第二资源配置信息，并基于该第二资源配置信息确定该第一搜索空间，该第二资源配置信息包括该第一搜索空间所在的控制信道资源集合占用的资源信息、该控制信道资源集合的标识以及第一偏移值中的至少一项，该第一偏移值是基于该控制信道资源集合的标识确定出的。相应的，该第二网络设备基于该第四资源确定该第一搜索空间，可以具体为：该第二网络设备确定第五资源配置信息，并基于该第五资源配置信息确定该第二搜索空间，该第五资源配置信息包括该第二搜索空间所在的控制信道资源集合占用的资源信息、该控制信道资源集合的标识以及第一偏移值中的至少一项，该第一偏移值是基于该控制信道资源集合的标识确定出的。

[0038] 在一些可能的实现中，该第一网络设备基于该第三资源确定该第一搜索空间，可以具体为：该第一网络设备确定第三资源配置信息，并基于该第三资源配置信息确定该第一搜索空间，该第三资源配置信息包括该第一搜索空间所在的控制信道资源集合占用的资源信息、该第一搜索空间的标识以及第二偏移值中的至少一项，该第二偏移值是基于该第一搜索空间的标识确定出的。相应的，该第二网络设备基于该第四资源确定该第一搜索空间，可以具体为：该第二网络设备确定第六资源配置信息，并基于该第六资源配置信息确定该第二搜索空间，该第六资源配置信息包括该第二搜索空间所在的控制信道资源集合占用的资源信息、该第二搜索空间的标识以及第二偏移值中的至少一项，该第二偏移值是基于该第二搜索空间的标识确定出的。

[0039] 在一些可能的实现中，该第一网络设备还可向该第三网络设备发送通知消息，该通知消息用于指示第一资源配置信息或第二资源配置信息或第三资源配置信息。也就是说，第一网络设备在确定出第一资源配置信息之后，还可向第三网络设备发送用于指示该第一资源配置信息的通知消息，以告知第三网络设备该第一资源配置信息，以使该第三网络设备基于该第一资源配置信息确定搜索空间以获取下行控制信道。进一步的，该第一网络设备还可在确定出第二资源配置信息之后，还可向第三网络设备发送用于指示该第二资源配置信息的通知消息，在确定出第三资源配置信息之后，还可向第三网络设备发送用于指示该第三资源配置信息的通知消息，此处不赘述。进一步的，该第二网络设备还可向该第三网络设备发送通知消息，该通知消息用于指示第四资源配置信息或第五资源配置信息或第六资源配置信息。

[0040] 在一些可能的实现中，该第三资源可包括时域资源；则该第一网络设备还可向第三网络设备发送通知消息，该通知消息包括该第一搜索空间占用的第二时间单元的标识。相应的，该第二网络设备还可向第三网络设备发送通知消息，该通知消息包括该第二搜索空间占用的第二时间单元的标识。

[0041] 在一些可能的实现中，该第一网络设备还可以向该第三网络设备发送第一消息，

该第一消息用于指示发送的下行控制信道的个数(还可以指示搜索空间的个数),从而第三网络设备可以基于该第一消息指示的个数进行下行控制信道的接收,在接收的下行控制信道的个数达到该第一消息指示的个数之后即可停止盲检,从而减少了盲检次数,降低了设备开销。该第一网络设备还可接收该第三网络设备发送的第二消息,该第二消息用于指示第三网络设备支持接收的下行控制信道的个数(还可以指示搜索空间的个数),从而该第一网络设备可基于该个数发送下行控制信道,其发送的下行控制信道的个数可不超过该第二消息指示的个数。可选的,该第一消息或第二消息指示的个数的值可以与该第三网络设备的接收能力相关,或者与当前的信道条件相关,接收能力越强,个数越大,信道条件越好,个数越大,等等,本申请不做限定。进一步可选的,该搜索空间可以是基于聚合级别、控制信息的格式、控制信息的大小以及搜索空间的个数中的至少一项确定出的。从而能够减少盲检次数,降低系统开销。

[0042] 在一些可能的实现中,该第一网络设备还可基于第四参数确定该第一搜索空间,其中,该第一搜索空间包括至少一个控制信道元素CCE,该第四参数可包括CCE的个数或CCE的标识等等。相应的,该第二网络设备还可基于第五参数确定该第二搜索空间,其中,该第二搜索空间包括至少一个CCE,该第五参数可包括CCE的个数或CCE的标识等等。

[0043] 第三方面,本申请还提供了一种网络设备,该网络设备包括:确定模块和通信模块,该网络设备通过上述模块实现上述第一方面的信道传输方法中的第一网络设备的部分或全部步骤。所述模块可以是软件和/或是硬件。

[0044] 第四方面,本申请还提供了一种网络设备,该网络设备包括:第一确定模块、第二确定模块、第一通信模块和第二通信模块,该网络设备通过上述模块实现上述第二方面的信道传输方法中的第一网络设备或第二网络设备的部分或全部步骤。该模块可以是软件和/或是硬件。

[0045] 第五方面,本申请还提供了一种计算机存储介质,该计算机存储介质存储有程序,该程序执行时包括上述第一方面的信道传输方法的部分或全部的步骤。

[0046] 第六方面,本申请还提供了一种计算机存储介质,该计算机存储介质存储有程序,该程序执行时包括上述第二方面的信道传输方法的部分或全部的步骤。

[0047] 第七方面,本申请还提供了一种网络设备,包括:通信接口、存储器和处理器,该处理器分别与该通信接口及该存储器连接;其中,

[0048] 该存储器用于存储程序指令;

[0049] 该处理器用于调用该存储器中的程序指令执行上述第一方面的信道传输方法的部分或全部的步骤。

[0050] 第八方面,本申请还提供了一种网络设备,包括:通信接口、存储器和处理器,该处理器分别与该通信接口及该存储器连接;其中,

[0051] 该存储器用于存储程序指令;

[0052] 该处理器用于调用该存储器中的程序指令执行上述第二方面的信道传输方法的部分或全部步骤。

[0053] 第九方面,本申请还提供了一种信道传输系统,包括第一网络设备和至少一个第二网络设备;其中,该第一网络设备用于执行上述第一方面的信道传输方法的部分或全部步骤;该第二网络设备用于执行上述第二方面的信道传输方法的部分或全部步骤。

[0054] 本申请的又一方面提供了一种包含指令的计算机程序产品，当其在计算机上运行时，使得计算机执行上述各方面所述的方法。

[0055] 在本申请提供的技术方案中，网络设备能够通过确定调度的资源属于一个载波的多个下行控制信道如PDCCH的搜索空间，并进一步在该搜索空间中分别确定出该多个PDCCH占用的资源，以使用该资源传输该多个PDCCH，从而使得一个网络设备能够接收一个或多个其他网络设备发送的多个PDCCH，并通过该多个PDCCH调度一个载波的数据，这就提升了信息传输的效率，并提升了信息传输的可靠性。

附图说明

[0056] 为了更清楚地说明本发明实施例或背景技术中的技术方案，下面将对本发明实施例或背景技术中所需要使用的附图进行说明。

[0057] 图1是本发明实施例提供的一种通信系统的架构图；

[0058] 图2是本发明实施例提供的一种信道传输方法的交互示意图；

[0059] 图3是本发明实施例提供的一种RS配置示意图；

[0060] 图4是本发明实施例提供的一种基于不同子载波间隔的子帧示意图；

[0061] 图5a是本发明实施例提供的一种候选位置的结构示意图；

[0062] 图5b是本发明实施例提供的另一种候选位置的结构示意图；

[0063] 图5c是本发明实施例提供的又一种候选位置的结构示意图；

[0064] 图6是本发明实施例提供的另一种信道传输方法的交互示意图；

[0065] 图7是本发明实施例提供的一种基于频分方式的搜索空间的配置示意图；

[0066] 图8a是本发明实施例提供的一种控制信道资源集合和搜索空间的结构示意图；

[0067] 图8b是本发明实施例提供的另一种控制信道资源集合和搜索空间的结构示意图；

[0068] 图8c是本发明实施例提供的又一种控制信道资源集合和搜索空间的结构示意图；

[0069] 图9是本发明实施例提供的一种基于时分方式的搜索空间的配置示意图；

[0070] 图10a是本发明实施例提供的一种搜索空间的CCE结构示意图；

[0071] 图10b是本发明实施例提供的另一种搜索空间的CCE结构示意图；

[0072] 图11是本发明实施例提供的又一种信道传输方法的交互示意图；

[0073] 图12是本发明实施例提供的一种网络设备的结构示意图；

[0074] 图13是本发明实施例提供的另一种网络设备的结构示意图；

[0075] 图14是本发明实施例提供的一种信道传输系统的结构示意图；

[0076] 图15是本发明实施例提供的又一种网络设备的结构示意图；

[0077] 图16是本发明实施例提供的又一种网络设备的结构示意图。

具体实施方式

[0078] 下面结合本发明实施例中的附图对本发明实施例进行描述。

[0079] 应理解，本申请的技术方案可具体应用于各种通信系统中，例如：全球移动通讯系统(Global System of Mobile communication，缩写：GSM)，码分多址(英文：Code Division Multiple Access，缩写：CDMA)、宽带码分多址(英文：Wideband Code Division Multiple Access，缩写：WCDMA)、时分同步码分多址(英文：Time Division-Synchronous

Code Division Multiple Access,缩写:TD-SCDMA)、通用移动通信系统(英文:Universal Mobile Telecommunication System,缩写:UMTS)、长期演进(英文:Long Term Evolution,缩写:LTE)系统等,随着通信技术的不断发展,本申请的技术方案还可用于未来网络,如第五代移动通信技术(英文:The Fifth Generation Mobile Communication Technology,缩写:5G)系统,也可以称为NR(英文:New Radio,缩写:NR)系统,或者可用于D2D(device to device)系统,M2M(machine to machine)系统等等。

[0080] 本申请结合网络设备进行描述,其中,网络设备可以是基站,也可以是用户设备。示例的,本申请中涉及的通信既可以是基站和用户设备之间的,也可以是基站和基站之间的,比如宏基站和小基站之间的,还可以是用户设备和用户设备之间的,比如D2D网络中的通信。

[0081] 在本申请中,用户设备(英文:User Equipment,缩写:UE)还可称之为终端(terminal)、移动台(英文:Mobile Station,缩写:MS)、移动终端(mobile terminal)、订户单元(英文:Subscriber Unit;缩写:SU)、订户站(英文:Subscriber Station;缩写:SS),移动站(英文:Mobile Station;缩写:MB)、远程站(英文:Remote Station;缩写:RS)、接入点(英文:Access Point;缩写:AP)、远程终端(英文:Remote Terminal;缩写:RT)、接入终端(英文:Access Terminal;缩写:AT)、用户终端(英文:User Terminal;缩写:UT)、用户代理(英文:User Agent;缩写:UA)、终端设备(英文:User Device;缩写:UD)或用户装备(英文:User Equipment;缩写:UE)等,本申请不做限定。该用户设备可以是指无线终端、有线终端。该无线终端可以是指向用户提供语音和/或数据连通性的设备,具有无线连接功能的手持式设备、或连接到无线调制解调器的其他处理设备,其可以经无线接入网(如RAN,radio access network)与一个或多个核心网进行通信。例如,该用户设备可以是移动终端,如移动电话(或称为"蜂窝"电话)和具有移动终端的计算机,还可以是便携式、袖珍式、手持式、计算机内置的或者车载的移动装置,如个人通信业务(英文:Personal Communication Service;缩写:PCS)电话、无绳电话、会话发起协议(英文:Session Initiation Protocol;缩写:SIP)话机、无线本地环路(英文:Wireless Local Loop;缩写:WLL)站、个人数字助理(英文:Personal Digital Assistant;缩写:PDA)等,它们与无线接入网交换语言和/或数据。

[0082] 在本申请中,基站可以是指接入网中在空中接口上通过一个或多个扇区与用户设备通信的设备,其可协调对空中接口的属性管理。例如,该基站可以是如GSM或CDMA中的基站,如基站收发台(base transceiver station,缩写:BTS),也可以是WCDMA中的基站,如NodeB,还可以是LTE中的演进型基站,如eNB或e-NodeB(evolutional Node B),还可以是5G系统中的基站,如gNB,或未来网络中的基站,或者可以是传输点(英文:Transmission point,缩写:TP)、收发点(英文:transmission and receiver point,缩写:TRP)、中继设备,或者具备基站功能的其他网络设备等等,本申请不做限定。

[0083] 本申请中涉及的控制信道主要用于承载资源调度信息和其他控制信息,例如该控制信道可以是物理下行控制信道(英文:Physical Downlink Control Channel,缩写:PDCCH)、增强物理下行控制信道(英文:Enhanced Physical Downlink Control Channel,缩写:EPDCCH)、新空口物理下行控制信道(英文:New Radio Physical Downlink Control Channel,缩写:NR-PDCCH)以及随着网络演变而定义的具有上述功能的其他下行信道,或者

可以为上行控制信道，比如物理上行控制信道为(Physical Uplink Control CHannel，缩写：PUCCH)等等，本申请以PDCCH为例进行说明。在本申请中，信道也可以叫做信号或者其余名称，本申请不做限定。

[0084] 在本申请中，时间单元是指一种时间单位对应的一个单元。该时间单位是指用于进行信息传输的时域内的时间单位或者调度单位，该时间单元时域内包含整数个符号，如该时间单位可以是指子帧，也可以是指时隙(slot)，还可是指无线帧、微时隙(mini slot或sub slot)、多个聚合的时隙、多个聚合的子帧、符号等等，还可以是指传输时间间隔(英文：Transmission Time Interval，缩写：TTI)，本申请不做限定。其中，一种时间单位的一个或多个时间单元时域内可包含整数个另一种时间单位的时间单元，或者，一种时间单位的一个或多个时间单元时域内长度等于整数个另一种时间单位的时间单元长度和，例如，一个微时隙/时隙/子帧/无线帧内包含整数个符号，一个时隙/子帧/无线帧内包含整数个微时隙，一个子帧/无线帧内包含整数个时隙，一个无线帧包含整数个子帧等，也可以存在其余包含举例，本申请不做限定。

[0085] 下面对本申请的应用场景进行介绍，本申请以基站和UE之间的通信为例进行描述。请参见图1，图1是本发明实施例提供的一种通信系统的架构图。具体的，如图1所示，该通信系统中包括至少一个基站(图1中示出2个基站)和UE，基站与UE之间可采用各种通信系统进行通信，如上述无线通信系统中的5G系统，也可以称为NR系统，又如LTE系统等，从而实现信息传输。

[0086] 在基站和UE进行信息传输时，UE需要监听并尝试解码一个时间单元如子帧中的所有PDCCH候选位置(候选资源)，该候选资源上包括需要监听的一个或多个PDCCH。本申请能够通过在一个时间单元上通过不同的PDCCH搜索空间(Search Space)配置同一UE的多个PDCCH，或者通过相同的PDCCH搜索空间配置同一UE的多个PDCCH。可选的，该多个PDCCH可以通过相同的波束发送(即通过一个波束发送)，也可以通过不同的波束发送。使得一个UE能够接收到多个PDCCH，并基于接收的多个PDCCH调度一个载波的数据，以进行信息传输。其中，该多个PDCCH中的每个PDCCH可包括下行调度信息，也可以包括上行调度信息。在本申请中，PDCCH搜索空间由至少一个CCE组成，具体可包括一个时间单元如子帧中的控制区域的CCE的总数。CCE是控制信道资源的基本单位，CCE可由一个或者多个资源元素组(英文：Resource Element Group，缩写：REG)组成，REG是由一个或者多个资源元素RE组成，RE为基本的资源单位，比如LTE中一个RE为频域上的一个子载波和时域上的一个符号。进一步的，搜索空间中可以包括一个或者多个PDCCH候选资源，该候选资源可以与聚合级别有关，聚合级别可以是指一个PDCCH是由几个CCE传输，或者承载在几个CCE资源上。

[0087] 本申请公开了一种信道传输方法、网络设备及系统，能够实现通过多个下行控制信道调度一个载波的数据，从而提升了信息传输的效率及可靠性。在本申请中，UE可通过分别确定调度的资源属于一个载波的至少两个PDCCH在PDCCH搜索空间占用的资源，以使用该资源获取该至少两个PDCCH，从而实现一个UE对多个PDCCH的接收。其中，该调度的资源可以是指下行控制信道中调度的数据所占的资源。下面以UE接收两个PDCCH，如接收第一基站发送的第一PDCCH和第二基站发送的第二PDCCH为例进行详细说明。

[0088] 请参见图2，图2是本发明实施例提供的一种信道传输方法的交互示意图。具体的，如图2所示，本发明实施例的所述信道传输方法包括以下步骤：

[0089] 101、第一基站在第一搜索空间中确定第一PDCCH占用的第一资源。

[0090] 102、第二基站在第二搜索空间中确定第二PDCCH占用的第二资源，该第一搜索空间和该第二搜索空间相同。

[0091] 其中，该第一PDCCH调度的资源和第二PDCCH调度的资源属于一个载波，该调度的资源可以是指PDCCH中调度的数据所占的资源。可选的，传输该第一PDCCH和第二PDCCH的资源可以在一个载波上，即在相同的载波，也可以是在不同的载波。

[0092] 可选的，该第一基站和第二基站可以是相同的基站，即通过同一个基站给一个UE发送多个PDCCH；或者，该第一基站和第二基站还可以是不同的基站。进一步可选的，系统中还可存在第三基站、第四基站等等，每个基站可向同一个UE发送一个或多个PDCCH，即实现通过一个或多个基站向一个UE发送多个PDCCH，本发明实施例不做限定。

[0093] 可选的，系统中的多个基站向UE发送多个PDCCH时，可先确定出发送的PDCCH的搜索空间（又称“PDCCH搜索空间”），进而在该搜索空间中确定PDCCH占用的资源。也即，在本发明实施例中，该第一基站可确定该第一PDCCH搜索空间（即第一搜索空间），该第二基站可确定该第二PDCCH搜索空间（即第二搜索空间）。

[0094] 其中，该多个PDCCH的搜索空间可以相同也可以不同。也即，该第一PDCCH搜索空间和该第二PDCCH搜索空间可以相同，也可以不同。

[0095] 可选的，当该第一PDCCH搜索空间和该第二PDCCH搜索空间相同时，该第一基站在确定该第一PDCCH搜索空间时，可基于第一参数确定该第一PDCCH搜索空间；其中，该第一参数可包括CCE的个数、第一时间单元的标识以及PDCCH候选位置中的至少一项。相应的，该第二基站确定该第二PDCCH搜索空间时，也可基于第一参数确定该第一PDCCH搜索空间，该第一基站对应的第一参数和第二基站对应的第一参数的参数值可以相同也可以不同。也就是说，基站在确定PDCCH搜索空间时，可以是基于CCE的个数、第一时间单元的标识以及PDCCH候选位置等参数确定出的。进一步可选的，该CCE的个数可以是指PDCCH搜索空间的CCE的个数或该PDCCH搜索空间所在的控制信道资源集合（control resource set）包括的CCE的个数。

[0096] 具体的，基站在UE相同的搜索空间中发送PDCCH时，可先确定出control resource set，即PDCCH的搜索空间的所在的资源位置，包括时频资源位置。比如频域可以是一段带宽，也可以是连续的资源块（英文：Resource Block，缩写：RB）资源或者不连续的RB资源，或者一个或者多个子带，或者子带部分等；时域可以是时间单元的个数，如子帧或者时隙或者微时隙中的符号个数（比如可默认前几个符号），或者可以是时间单元的标识，如具体的一个或者多个符号位置。其中，RB是时频资源大小的一种衡量单位，比如LTE中的一个RB在频域上为12个子载波以及在时域上为一个时隙。随着系统的不断发展，RB资源块可以重新定义，本发明实施例不做限定。从而UE可在control resource set中进行PDCCH搜索空间的确定以及盲检。该确定方式有多种，本发明实施例按照如下方式进行举例说明。

[0097] 基站或UE在确定PDCCH搜索空间$S_k^{(L)}$时，可以按照以下公式确定出该搜索空间$S_k^{(L)}$：

[0098] $$L\left\{(Y_k+m')\bmod\left\lfloor N_{CCE,k}/L\right\rfloor\right\}+i$$

[0099] 其中，L为聚合级别（Aggregation level）的大小，其取值可以为1、2、4或8，或者还可以取其他值，L可表示用于传输该PDCCH的资源CCE个数。$N_{CCE,k}$为时间单元k如子帧k时包含

的控制区域(即控制信道资源集合)的CCE个数(Size),i=,0,…L1-且m=0,…,$M^{(L)}$-1。$M^{(L)}$为给定的搜索空间内需要监听的PDCCH candidate数目,即需要监听的PDCCH候选数目。例如,该L、$N_{CCE,k}$和$M^{(L)}$的对应关系可以如下表一所示。

[0100] 表一

[0101]

Search space $S_k^{(L)}$			Number of PDCCH candidates $M^{(L)}$
Type	Aggregation level L	Size [in CCEs]	
UE-specific	1	6	6
	2	12	6
	4	8	2
	8	16	2
Common	4	16	4
	8	16	2

[0102] 具体的,PDCCH搜索空间可分为公共搜索空间(Common)和用户搜索空间(UE-specific,即UE特定的搜索空间)。对于公共搜索空间,m′=m,Y_k为0。对于用户搜索空间,Y_k定义为:$Y_k=(A\cdot Y_{k-1})\ \mathrm{mod}D$,其中,$Y_{-1}=n_{RNTI}\neq 0$,A=39827,D=65537,$k=\lfloor n_s/2\rfloor$,$n_s$为一个无线帧中的时隙(slot)编号(取值范围可以为0～19)。可选的,该搜索空间还可以基于其他方式确定出,本发明实施例不做限定。

[0103] 也就是说,为了确保第一基站和第二基站也即多个基站在UE相同的PDCCH搜索空间中发送PDCCH,则该多个基站需确保该PDCCH搜索空间对应的时间单位(比如子帧,时隙,微时隙)上总的CCE个数相同,即搜索空间的CCE个数相同;和/或,还需该多个基站对于相同时域上的时间单元的标识相同;和/或,需要确保该发送的多个PDCCH在不同的PDCCH候选位置。

[0104] 具体的,该第一基站对应的第一参数包括的CCE的个数和该第二基站对应的第一参数包括的CCE的个数相同。假设分配频域资源为全带宽或者部分带宽或者子带等等,为第一基站和第二基站的分配的频域资源相同,当第一基站和第二基站的PDCCH搜索空间(控制区域)的时间单元如符号数相同时,若控制区域的符号上没有参考信号(英文:Reference Signal,缩写:RS),则可以确保PDCCH搜索空间对应的CCE个数相同;若该控制区域的符号上有RS,但该控制区域的导频图案(pattern)或者RE相同,则可以保证CCE相同。例如,第一基站和第二基站的该RS可以码分,此时第一基站和第二基站需要分别通知UE具体的导频序列,也即,针对一个PDCCH搜索空间所在的control resource set通知2种导频序列,使得UE能够根据该两种导频序列估计到两个基站的信道情况,进而进行信道估计以解码得到该PDCCH搜索空间中的多个PDCCH。若该控制区域的符号上有RS,且该控制区域的pattern或者RE不同,也可以保证CCE相同。例如,该第一基站和第二基站的该RS可以时分或者频分,此时需要通知UE具体的RS位置,也即,针对一个PDCCH搜索空间所在的control resource set通知2种RS的pattern或者RE,使得UE能够根据每种RS pattern确定出参考信号位置,进而进

行信道估计以解码得到该PDCCH搜索空间中的多个PDCCH。如图3所示，左图为时分方案，右图为频分方案，每个基站的RS占用不同的符号位置。可选的，对于不同基站的RS的位置按照以下两种处理方法：在第一基站的RS位置，第二基站不发送任何信号，该方式保证了基站间导频没有任何干扰，提高了解调性能；或者，在第一基站的RS位置，第二基站正常发送信号，这就使得UE可以在RS的位置先解RS，后续消除RS，再解有用信号，从而提升了信息传输的可靠性。

[0105] 进一步可选的，该第一基站还可向第二基站发送指示消息，该指示消息用于指示该第一PDCCH对应的第一时间单元信息；第二基站还可向第一基站发送指示消息，以指示该第二PDCCH对应的第二时间单元信息；该第一基站接收该第二基站发送的第二时间单元信息，该第二时间单元信息为该第二PDCCH对应的时间单元信息；该第一基站可基于该第一时间单元信息和该第二时间单元信息确定第一PDCCH搜索空间对应的CCE的个数；第二基站可基于该第一时间单元信息和该第二时间单元信息确定第二PDCCH搜索空间对应的CCE的个数。其中，该第一时间单元信息或该第二时间单元信息包括第二时间单元的个数或第二时间单元的标识。

[0106] 可选的，本发明实施例涉及的消息如该指示消息可以为高层信息，比如系统消息，或者无线资源控制(英文：Radio Resource Control，缩写：RRC)信令，或者媒体接入控制(英文：Medium Access Control，缩写：MAC)信令。或者，可选的，该指示消息还可以为物理层信令，比如物理层下行控制信息(英文：Downlink Control Information，缩写：DCI)信息，等等，本发明实施例不做限定。

[0107] 也就是说，当第一基站和第二基站的PDCCH搜索空间(控制区域)的符号数不同时，基站间可交互各自的符号数或符号标识等时间单元信息，以确保对于为UE分配的总体CCE相同。例如，该第一基站和该第二基站可以取两个基站符号数较小者作为确定CCE个数的符号数。

[0108] 可选的，在统一多个基站对于时间单元的标识的规则的理解时，该第一PDCCH的时间单元的标识或该第二PDCCH的时间单元的标识可以是基于该第一资源和第二资源的子载波间隔确定的。或者，该第一PDCCH的时间单元的标识还可以是根据预设子载波间隔下的时间单元中与该第一PDCCH的时间单元对应的时间单元的标识确定的，该第二PDCCH的时间单元的标识是根据该预设子载波间隔下的时间单元中与该第二PDCCH的时间单元对应的时间单元的标识确定出的。从而确保信道传输系统中的多个基站即协作的多个基站在相同时域上的时间单元的标识相同。

[0109] 具体的，由于不同的基站在不同的子帧上采用的帧结构可能是不同的，其结构与子载波间隔有关。如图4所示，分别为15kHz，30kHz，60kHz子载波间隔下子帧示意图。由此，在确定控制区域的时间单元的标识如时隙的编号时，可采用各自子载波间隔下的时隙号，因不同的子载波间隔下的时域长度成比例关系，因此，针对不同的子载波间隔下的时隙号，可以进行同样的处理：比如子载波间隔15kHz时，时间变量为$k=\lfloor n_s/2 \rfloor$；若子载波间隔为15*2nkHz，则时间变量为$k=\lfloor n_s/(2n) \rfloor$；若子载波间隔为$15*2^n$kHz，则时间变量为$k=\lfloor n_s/2^n \rfloor$，其中，$n_s$可以为时隙号或者微时隙号。或者，在确定时隙号时，可直接采用预设子载波间隔比如15kHz子载波间隔下的时隙编号，若一个时隙中有多个微时隙，则可按照15kHz子载波

间隔下的微时隙号(n_{mini_s})来确定搜索搜索空间。

[0110] 进一步可选的，该第一基站还可以向该UE发送该第一参数，该第二基站还可以向该UE发送该第一参数，以使UE快速确定出需要接收的PDCCH的搜索空间。

[0111] 可选的，该第一PDCCH的候选位置与该第二PDCCH的候选位置不同，该第一PDCCH或该第二PDCCH的候选位置是基于候选位置参数即第二参数确定的，该第二参数可包括基站类型、基站标识、聚合等级中的至少一项。

[0112] 具体的，在确保不同的基站在UE相同的PDCCH搜索空间中发送PDCCH时，第一基站和第二基站在决策时还需确保不在同一候选位置发送PDCCH。可选的，该第一基站和第二基站之间可交互或者预定义REG到CCE的映射，以及CCE到搜索空间候选的映射。其中，每个CCE可以包括4～8个REG，或者其他数目，REG到CCE可以是集中式映射也可以是分布式映射，REG到CCE的映射可以是先频域再时域，也可以先时域再频域，CCE到搜索空间的映射可以是先频域再时域，也可以先时域再频域，本发明实施例不做限定。

[0113] 进一步的，该第一PDCCH和该第二PDCCH的聚合级别可以相同也可以不同。当两个PDCCH的聚合级别相同时，基站之间可按照预定义或者基站交互的方式确定各自占用的候选空间(候选位置)。例如，可预定义为：第一基站(TP1，如服务基站)占前半部分，第二基站(TP2，如协作基站)占后半部分，如图5a所示；或者，可预定义为：交叉的方式，第一基站占候选1、3、5，第二基站占候选2、4、6等等，如图5b所示。或者，可按照基站编号(比如第一基站编号0，第二基站编号1)，编号小的用前半部分，编号大的用后半部分。或者，基站之间可以交互所使用的候选空间。当两个PDCCH的聚合级别不同时，可以预定义低聚合级别(Lower L)采用前半部分候选空间，高聚合级别(Higher L)采用后半部分候选空间，如图5c所示；或者预定义为低聚合级别采用后半部分候选空间，高聚合级别采用前半部分候选空间，或者基站间可交互各自采用的候选空间，等等。其中，该聚合级别L的高低可以是基站间交互或者预定义得到的，比如可定义L＝1，2代表低聚合级别，L＝4，8代表高聚合级别；或者可定义L＝1，2，4代表低聚合级别，L＝8，16，32为高聚合级别等。进一步可选的，若2个基站的信道特性差异比较大，则基站可以提前通知UE，2个PDCCH的聚合级别不同。其中，图5a或图5b或图5c中的方框可代表一个CCE。

[0114] 进一步可选的，该第一基站和第二基站还可以向该UE发送第二参数，即告知UE该第一基站和第二基站的基站类型、基站标识、聚合等级等参数。从而UE在基于该基站类型、基站标识、聚合等级等参数行盲检时，UE检测到一个PDCCH后，另一个PDCCH的盲检范围可以减小，进而减小盲检次数，降低UE开销。

[0115] 103、第一基站使用第一资源向UE发送所述第一PDCCH。

[0116] 104、第二基站使用第二资源向该UE发送所述第二PDCCH。

[0117] 其中，该第一资源可以是指时频域资源(时域资源和/或频域资源)，也可以是指码分资源。可选的，该第一PDCCH和第二PDCCH可以通过相同的波束发送，或者可以通过不同的波束发送，本发明实施例不做限定。

[0118] 进一步可选的，该一个或多个基站还可以分别通知UE需要接收的PDCCH的个数或搜索空间的个数，以便于UE基于该个数接收PDCCH(接收的PDCCH的个数不超过该通知的个数)；或者，该多个基站可接收用于指示UE发送的能够接收的PDCCH的个数或检查的搜索空间的个数的消息，以使基站基于该个数进行PDCCH的发送(发送的PDCCH的个数不超过该消

息指示的个数)。进一步的,该多个基站还可基于该个数进行交互,以确定各基站发送的PDCCH的个数,进而进行PDCCH的搜索空间配置,从而减小UE的盲检次数,降低UE开销,并提升PDCCH传输的可靠性。

[0119] 105、UE确定第一PDCCH的第一搜索空间和第二PDCCH的第二搜索空间。

[0120] 106、UE在该第一搜索空间中确定出该第一PDCCH占用的第一资源,以及在该第二搜索空间中确定出该第二PDCCH占用的第二资源。

[0121] 具体的,UE在确定PDCCH搜索空间时,UE可确定PDCCH搜索空间所在的控制信道资源集合control resource set,即传输控制信道的资源位置,包括时频资源位置。比如频域可以是整个带宽,也可以是连续的RB资源或者不连续的RB资源,或者一个或者多个子带,或者子带部分等;时域可以是时间单元如子帧或者时隙或者微时隙中的符号个数(如默认前几个符号),或者具体的一个或者多个符号位置。进而UE可在control resource set中进行PDCCH的搜索空间的确定以及盲检。可选的,基站在确定出control resource set之后,还可向UE发送该control resource set的配置信息,以指示该control resource set的位置。UE可接收该配置信息以确定该control resource set,或者,该control resource set可以是预定义得到的。

[0122] 可选的,UE在确定至少两个PDCCH的PDCCH搜索空间如该第一PDCCH搜索空间和该第二PDCCH搜索空间时,该UE可基于第一参数确定该第一PDCCH搜索空间和该第二PDCCH搜索空间;其中,该第一参数可包括CCE个数、第一时间单元的标识以及PDCCH的候选位置中的至少一项。可选的,该第一参数可以是至少一个基站发送给UE的,比如UE可接收第一基站发送的用于指示该第一PDCCH搜索空间的第一参数,UE还可接收第二基站发送的用于指示该第二PDCCH搜索空间的第一参数;或者,该第一参数也可以是UE按照预设规则确定的;或者,该第一参数还可以是基站和UE预先协商确定的,本发明实施例不做限定。

[0123] 可选的,为了确保该第一PDCCH搜索空间和该第二PDCCH搜索空间相同,则该第一PDCCH搜索空间的CCE的个数和该第二PDCCH搜索空间的CCE个数相同;或,该第一PDCCH的时间单元的标识和该第二PDCCH的时间单元的标识分别是基于该第一PDCCH和该第二PDCCH占用的资源的子载波间隔确定的;或,该第一PDCCH的时间单元的标识还可以是根据预设子载波间隔下的时间单元中与该第一PDCCH的时间单元对应的时间单元的标识确定的,该第二PDCCH的时间单元的标识是根据该预设子载波间隔下的时间单元中与该第二PDCCH的时间单元对应的时间单元的标识确定出的;或,该第一PDCCH和该第二PDCCH的候选位置不同,该候选位置可以是基于候选位置参数即第二参数确定的,该第二参数可包括基站类型、基站标识、聚合等级中的至少一项。

[0124] 具体的,该第一PDCCH的候选位置与该第二PDCCH的候选位置不同,从而UE可以根据各PDCCH的候选位置来进行盲检。例如,针对如图5a或5c所示的对半分的方案,如果UE在前半部分检测到一个PDCCH,接下来UE可以仅检测后半部分候选区域即可;如果UE在后半部分检测到一个PDCCH,接下来可以仅检测前半部分候选区域即可。再如,针对如图5b交叉分的方案,如果在第1、3、5...个候选区域检测到一个PDCCH,则接下来可以仅检测第2、4、6...个候选区域即可。又如,对于低聚合级别,UE可仅检测前半部分搜索空间候选;对于高聚合级别下,UE可仅检测后半部分搜索空间候选;再如,两个PDCCH搜索空间的聚合级别相同的情况下,UE可再按照基站的编号(比如第一基站编号0,第二基站编号1),编号小的检测前半

部分，编号大的检测后半部分，等等。从而UE在进行盲检时，UE在检测到一个PDCCH后，另一个PDCCH的盲检范围可以减小，进而可以减小盲检次数，降低UE开销。

[0125] 107、UE使用该第一资源获取第一PDCCH，并使用该第二资源获取第二PDCCH。

[0126] 可选的，可以设置一个最大盲检次数，当UE达到最大盲检次数停止盲检。从而能够进一步减小盲检次数，降低UE开销。可选的，该最大盲检次数可以协议预定义的，或者是由UE自定义设置得到，或者由基站通知得到，等等，本发明实施例不做限定。

[0127] 进一步可选的，该搜索空间可以是基于聚合级别、PDCCH的个数、控制信息的格式、控制信息的大小以及搜索空间的个数中的至少一项确定出的。比如该聚合级别、PDCCH的个数、控制信息格式、控制信息大小以及搜索空间的个数可以是基站通知给UE的，如在基站确定control resource set时通知给UE的(如可携带于control resource set的配置信息中)。其中，该控制信息可以是指下行控制信道如本发明实施例中的PDCCH承载的控制信息，如DCI。

[0128] 举例来说，第一基站或第二基站可以是在配置(确定)control resource set时可通知UE一个或者多个聚合级别。比如第一基站或第二基站可以配置聚合级别为4，则UE在监测时仅检测聚合级别为4的候选即可；或者第一基站或第二基站可以配置为4、8、16等多个聚合级别，则UE在监测时仅检测指示的聚合级别对应的候选即可，从而能够降低盲检次数。

[0129] 又例如，第一基站或第二基站可以通知UE针对该control resource set需要监测的PDCCH的个数。比如如果配置UE监测1个PDCCH，则UE监测到一个PDCCH或者到达最大盲检次数后停止监测；如果配置UE监测2个PDCCH，则UE监测到2个PDCCH或者到达最大盲检次数后停止监测。

[0130] 再例如，第一基站或第二基站可以通知UE针对该control resource set需要监测的PDCCH的个数以及对应的聚合级别。比如配置UE检测1个PDCCH而且对应的聚合级别为4，则UE仅针对聚合级别为4的候选进行监测，而且当UE监测到一个PDCCH或者到达最大盲检次数后停止监测；或者配置UE检测1个PDCCH而且对应的聚合级别为4、8、16等多个聚合级别，则UE仅针对指示的聚合级别的候选进行监测，当UE监测到一个PDCCH或者到达最大盲检次数后停止监测；或者，第一基站或第二基站可配置UE检测2个PDCCH，且两个对应的聚合级别相同，比如分别对应的聚合级别为4，则UE可仅针对聚合级别为4的候选进行监测，而且当UE监测到2个PDCCH或者到达最大盲检次数后停止监测；或者配置UE检测2个PDCCH而且两个对应的聚合级别相同，比如分别对应的聚合级别为4、8、16等多个聚合级别，则UE仅针对指示的聚合级别的候选进行监测，而且当UE监测到2个PDCCH或者到达最大盲检次数后停止监测；或者，第一基站或第二基站可配置UE检测2个PDCCH而且两个对应的聚合级别不同，比如第一个PDCCH对应的聚合级别为4，第二个PDCCH对应的聚合级别为8，则UE对于第一个PDCCH仅针对聚合级别为4的候选进行监测，而且当UE监测到1个PDCCH或者到达最大盲检次数后再进行第二个PDCCH的监测，针对第二个PDCCH，则UE仅针对聚合级别为8的候选进行监测，当UE检测到1个PDCCH或者达到最大盲检次数后停止监测；其中，第一PDCCH和第二PDCCH的检测顺序可以不分先后。或者，第一基站或第二基站可配置UE检测2个PDCCH，且两个对应的聚合级别不同，比如第一PDCCH对应的聚合级别为4、8、16等多个聚合级别，第二PDCCH对应的聚合级别为8、16、32等多个聚合级别，则UE可对于第一PDCCH仅针对指示的聚合级别比如4、8、16等的候选进行监测，而且当UE监测到1个PDCCH或者到达最大盲检次数后再进行第二

个PDCCH的监测，针对第二PDCCH，则UE仅针对指示的聚合级别比如8、16、32等的候选进行监测，当UE检测到1个PDCCH或者达到最大盲检次数后停止监测；其中，第一PDCCH和第二PDCCH的检测顺序可以不分先后，或者可以同时进行检测，比如在两者的聚合级别相同时，可以同时进行2个PDCCH的检测，本发明实施例不做限定。

[0131] 进一步可选的，第一基站或第二基站还可以通知UE针对该control resource set的控制信息格式或者控制信息大小中的至少一项。比如配置UE检测控制信息格式DCI format 2D或者检测控制信息大小为A的PDCCH，A的取值可以为20bit或者40bit或者其他数值。可选的，第一基站或第二基站可以针对多个搜索空间或者多个PDCCH配置多个控制信息个数或者控制信息大小的信息，或者可以针对多个搜索空间或者多个PDCCH配置一个控制信息个数或者控制信息大小的信息，或者可以针对一个搜索空间或者一个PDCCH配置多个控制信息个数或者控制信息大小的信息，或者该控制信息个数或者控制信息大小为预定义的，本发明实施例不做限定。从而UE能够快速进行PDCCH的检测和解码。

[0132] 进一步可选的，第一基站或第二基站还可以通知UE针对该control resource set的搜索空间个数，该一个搜索空间可以包括一个或者多个PDCCH。进一步的，第一基站或第二基站还可以通知针对搜索空间的PDCCH的个数以及对应的聚合级别、控制信息格式、控制信息大小，等等，具体请参考上述描述，此处不赘述。

[0133] 也就是说，UE在确定出每个PDCCH的搜索空间之后，即可在该搜索空间进行盲检，进一步在该搜索空间中确定出该PDCCH占用的资源，从而能够使用该资源获取该PDCCH。

[0134] 在本发明实施例中，多个基站能够在UE相同的PDCCH搜索空间中向UE发送多个PDCCH，从而UE能够接收多个PDCCH，并通过该多个PDCCH调度一个载波的数据，这就提升了信息传输的效率，并提升了信息传输的可靠性。本发明实施例通过设计多个PDCCH的搜索空间候选，设计多个PDCCH的CCE不重叠，解决了现有技术无法支持多个PDCCH传输的问题，并降低了UE盲检次数，提升了UE盲检效率。

[0135] 请参见图6，图6是本发明实施例提供的另一种信道传输方法的交互示意图。具体的，如图6所示，本发明实施例的所述信道传输方法包括以下步骤：

[0136] 201、第一基站在第一搜索空间中确定第一PDCCH占用的第一资源。

[0137] 202、第二基站在第二搜索空间中确定第二PDCCH占用的第二资源，该第一搜索空间和该第二搜索空间不同。

[0138] 其中，该第一PDCCH调度的资源和第二PDCCH调度的资源属于一个载波，该调度的资源可以是指PDCCH中调度的数据所占的资源。可选的，传输第一PDCCH和第二PDCCH的资源可以在一个载波上，即在相同的载波，也可以是在不同的载波。

[0139] 可选的，通信系统中的多个基站向UE发送多个PDCCH时，可先确定出发送的PDCCH的搜索空间，进而在该搜索空间中确定PDCCH占用的资源。也即，在本发明实施例中，该第一基站可确定该第一PDCCH搜索空间(即第一搜索空间)，该第二基站可确定该第二PDCCH搜索空间(即第二搜索空间)。

[0140] 其中，该多个PDCCH的搜索空间可以相同也可以不同。也即，该第一PDCCH搜索空间和该第二PDCCH搜索空间可以相同，也可以不同。

[0141] 可选的，当该第一PDCCH搜索空间和该第二PDCCH搜索空间不同时，该第一基站确定该第一PDCCH搜索空间时，可确定第一PDCCH搜索空间占用的第三资源，并基于该第三资

源确定该第一PDCCH搜索空间。相应的，该第二基站确定该第二PDCCH搜索空间时，可确定第二PDCCH搜索空间占用的第四资源，并基于该第四资源确定该第二PDCCH搜索空间。其中，该PDCCH搜索空间占用的资源即上述的第三资源和/或第四资源可包括频域资源或时域资源。从而能够在不同的时域资源或频域资源上发送不同的PDCCH，以实现UE进行多PDCCH的接收。

[0142] 进一步可选的，当该第一PDCCH搜索空间和该第二PDCCH搜索空间不同时，第一PDCCH和第二PDCCH可以从频域资源区分，如第一PDCCH搜索空间和第二PDCCH搜索空间可分别为不同的频域资源，如图7所示。

[0143] 作为一种可选的实施方式，该第一基站基于该第三资源确定该第一PDCCH搜索空间时，可确定第一资源配置信息，并基于该第一资源配置信息确定该第一PDCCH搜索空间，该第一资源配置信息可包括该第一PDCCH搜索空间所在的控制信道资源集合占用的资源信息。相应的，该第二基站基于该第四资源确定该第二PDCCH搜索空间时，也可确定第四资源配置信息，并基于该第四资源配置信息确定该第二PDCCH搜索空间，该第四资源配置信息包括该第二PDCCH搜索空间所在的控制信道资源集合占用的资源信息。进一步可选的，该第一资源配置信息和/或该第四资源配置信息中还可包括该CCE标识如CCE编号信息。

[0144] 进一步可选的，该第一基站还可向UE发送该第一通知消息，该第一通知消息用于指示该第一资源配置信息，该第二基站还可向UE发送该第四通知消息，该第四通知消息用于指示第四资源配置信息。从而UE能够根据该第一资源配置信息和该第四资源配置信息确定出两个PDCCH搜索空间。进一步的，该第一通知消息或第四通知消息可以是第一基站或第二基站在配置control resource set时发送给UE的，比如该第一资源配置信息或第四资源配置信息可以携带在control resource set的配置信息中发送给UE。该control resource set的配置信息还可包括PDCCH的个数、搜索空间的个数、聚合等级、控制信息格式、控制信息大小等信息。具体的配置方法如上述实施例所述，在此不做赘述。

[0145] 具体的，该第一PDCCH搜索空间和第二PDCCH搜索空间可以处于两个control resource set，两个set的频域资源不重叠，即两个PDCCH搜索空间所在的control resource set不同。进一步的，各自set的CCE编号可以分别编号，比如从0开始，如图8a所示，第一基站在control resource set1(控制信道资源集合1)中发送PDCCH(搜索空间1)，第二基站在control resource set2(控制信道资源集合2)中发送PDCCH(搜索空间2)。从而UE可基于该编号计算搜索空间位置，进行搜索空间候选的盲检测。或者，该两个control resource set中的CCE编号也可以是联合编号的，对于该control resource set的个数和CCE编号方式，本发明实施例不做限定。

[0146] 作为一种可选的实施方式，该第一基站基于该第三资源确定该第一PDCCH搜索空间时，可确定第二资源配置信息，并基于该第二资源配置信息确定该第一PDCCH搜索空间，该第二资源配置信息可包括该第一PDCCH搜索空间所在的控制信道资源集合占用的资源信息、该控制信道资源集合的标识以及第一偏移值中的至少一项，该第一偏移值可以是基于该控制信道资源集合的标识确定出的。相应的，该第二基站基于该第四资源确定该第二PDCCH搜索空间时，也可确定第五资源配置信息，并基于该第五资源配置信息确定该第二PDCCH搜索空间，该第五资源配置信息包括该第二PDCCH搜索空间所在的控制信道资源集合占用的资源信息、该控制信道资源集合的标识以及第一偏移值中的至少一项，该第一偏移

值可以是基于该控制信道资源集合的标识确定出的。进一步可选的，该第二资源配置信息和/或该第五资源配置信息中还可包括该CCE标识如CCE编号信息。

[0147] 进一步可选的，该第一基站还可向UE发送该第二通知消息，该第二通知消息用于指示第二资源配置信息，该第二基站还可向UE发送该第五通知消息，该第五通知消息用于指示第五资源配置信息。从而UE能够根据该第二资源配置信息和该第五资源配置信息确定出两个PDCCH搜索空间。进一步的，该第二通知消息或第五通知消息可以是第一基站或第二基站在配置control resource set时发送给UE的，比如该第二资源配置信息或第五资源配置信息可以携带在control resource set的配置信息中发送给UE。该control resource set的配置信息还可包括PDCCH的个数、搜索空间的个数、聚合等级、控制信息格式、控制信息大小等信息。具体的配置方法如上述实施例所述，在此不做赘述。

[0148] 具体的，该第一PDCCH搜索空间和第二PDCCH搜索空间可以处于两个control resource set，即control resource set1(控制信道资源集合1)和control resource set2(控制信道资源集合2)，两个set的资源可以完全重叠。进一步的，PDCCH搜索空间的CCE编号可以与set编号相关，比如可以配置一个第一偏移值offset1，则第一个set对应的第一PDCCH搜索空间的CCE编号可按公式确定出，第二个set对应的PDCCH搜索空间的CCE编号可增加offset1值。比如第一个set的某个CCE编号为1，则第二个set计算的CCE编号可以为1+offset1。其中，offset1可以为固定的值或者基站信令通知给UE，比如该offset1可以为8、16、32、64或其他整数。进一步的，offset1也可以是根据set编号确定的，比如offset1＝N*M，其中，N为set编号，M为偏移差值，比如8、16、32、64或其他整数。如图8b所示，最大圆圈指示了control resource set1的资源位置，也即control resource set2的资源位置，上面的圆圈指示了control resource set1的搜索空间(搜索空间1)即第一PDCCH搜索空间的CCE位置，下面的圆圈指示了control resource set2的搜索空间(搜索空间1)即第二PDCCH搜索空间的CCE的位置，其CCE编号增加了offset1值。

[0149] 作为一种可选的实施方式，该第一基站基于该第三资源确定该第一PDCCH搜索空间时，可确定第三资源配置信息，并基于该第三资源配置信息确定该第一PDCCH搜索空间，该第三资源配置信息包括该第一PDCCH搜索空间所在的控制信道资源集合占用的资源信息、该第一PDCCH搜索空间的标识以及第二偏移值中的至少一项，该第二偏移值是基于该第一PDCCH搜索空间的标识确定出的。相应的，该第二基站基于该第四资源确定该第二PDCCH搜索空间时，也可确定第六资源配置信息，并基于该第六资源配置信息确定该第二PDCCH搜索空间，该第六资源配置信息包括该第二PDCCH搜索空间所在的控制信道资源集合占用的资源信息、该第二PDCCH搜索空间的标识以及第二偏移值中的至少一项，该第二偏移值是基于该第二PDCCH搜索空间的标识确定出的。进一步可选的，该第三资源配置信息和/或该第六资源配置信息中还可包括该CCE标识如CCE编号信息。

[0150] 进一步可选的，该第一基站还可向UE发送该第三通知消息，该第三通知消息用于指示第三资源配置信息，该第二基站还可向UE发送该第六通知消息，该第六通知消息用于指示第六资源配置信息。从而UE能够根据该第三资源配置信息和该第六资源配置信息确定出该两个PDCCH搜索空间。进一步的，该第三通知消息或第六通知消息可以是第一基站或第二基站在配置control resource set时发送给UE的，比如该第三资源配置信息或第六资源配置信息可以携带在control resource set的配置信息中发送给UE，或者，该第三资源配

置信息或第六资源配置信息可以携带搜索空间的配置信息中(如第一搜索空间的配置信息携带该第三资源配置信息,第二搜索空间的配置信息携带该第六资源配置信息)。进一步可选的,该control resource set的配置信息或搜索空间的配置信息还可包括PDCCH的个数、搜索空间的个数、搜索空间的编号、聚合等级、控制信息格式、控制信息大小等信息。具体的配置方法如上述实施例所述,在此不做赘述。

[0151] 具体的,该第一PDCCH搜索空间(search space 1,即搜索空间1)和第二PDCCH搜索空间(search space 2,即搜索空间2)可以处于一个control resource set(control resource set1,即控制信道资源集合1)中。进一步的,PDCCH搜索空间的CCE编号可以与搜索空间的编号相关,比如针对搜索空间配置信息中可以配置一个第二偏移值offset2,具体的比如针对第一个搜索空间的offset2配置为0,的针对第二个搜索空间的offset2配置为offset2的值,则第一PDCCH搜索空间的CCE编号可按公式确定出,第二PDCCH搜索空间的CCE编号可增加offset2值。比如第一PDCCH搜索空间计算的某个CCE编号为1,则第二PDCCH搜索空间的CCE编号可以为1+offset2。其中,offset2可以为固定的值或者基站信令通知给UE,比如该offset2可以为8、16、32、64或其他整数,offset2可与PDCCH搜索空间编号相关,比如offset2=N*M,其中N为搜索空间search space的编号,M为偏移差值,比如8、16、32、64或其他整数。如图8c所示,最大圆圈指示了control resource set1的资源位置,上面的圆圈指示了control resource set1的search space 1的CCE位置,下面的圆圈指示了control resource set1的search space 2的CCE的位置,其CCE编号增加了offset2值。

[0152] 进一步可选的,针对不同的control resource set,第一基站或第二基站可以进行REG到CCE的映射,以及CCE到搜索空间候选的映射,该映射可以是集中式映射或者分布式映射。

[0153] 可选的,则该第一基站还可向UE发送第七通知消息,该第七通知消息包括该第一PDCCH搜索空间占用的第三时间单元的标识,该第二基站还可向UE发送第八通知消息,该第八通知消息包括该第二PDCCH搜索空间占用的第四时间单元的标识。

[0154] 也就是说,该第三资源可包括时域资源;当该第一PDCCH搜索空间和该第二PDCCH搜索空间不同时,第一PDCCH搜索空间和第二PDCCH搜索空间还可以从时域资源区分,如第一PDCCH搜索空间和第二PDCCH搜索空间可分别为不同的时域资源。如图9所示,可以将第一PDCCH搜索空间或第一PDCCH(PDCCH1)使用的时间单元的位置和第二PDCCH搜索空间或第二PDCCH(PDCCH2)使用的时间单元位置区分开,该时间单元对应的时间单位可以是子帧、时隙、微时隙、符号等等,图9中以时间单位为符号为例,比如第一PDCCH搜索空间占用第一个符号的资源,第二PDCCH搜索空间占用第二和第三个符号的资源。可选的,针对不同的时域资源,第一基站或第二基站可以进行REG到CCE的映射,以及CCE到搜索空间候选的映射,该映射可以是集中式映射或者分布式映射。

[0155] 举例来说,第一基站和第二基站可分别指示PDCCH1和PDCCH2的时间单元的标识如符号编号信息,比如在control resource set中指示PDCCH1和PDCCH2的符号编号信息。可选的,该符号编号信息可以用2个bit表示,比如00代表第一个符号,01代表第二个符号,10代表第三个符号,11代表第四个符号;或者,该符号编号信息可以采用bitmap的形式,用4个bit表示,比如1100代表使用第一个和第二个符号,0011代表使用第三个和第四个符号,1010代表使用第一个和第三个符号,0101代表使用第二个和第四个符号,等等;或者,该符

号编号信息也可以使用其他的bit个数或者bit含义指示，此处不一一列举；或者，该符号编号信息还可以直接指示，比如符号#0，#1可以表示使用符号编号为0和1的符号位置等等，本发明实施例不做限定。

[0156] 又例如，该第一基站和第二基站也可以先指示小区级的符号个数，再指示UE级的符号位置。从而第一基站和第二基站可通知各自小区内所有UE的可用符号个数，比如第一基站通知小区内UE的可用符号个数为2个，第二基站通知小区内UE的可用符号个数为3个，并能够进一步通知UE可用的符号编号，比如第一基站通知该UE该PDCCH1的可用符号编号为0，第二基站通知该UE该PDCCH2的可用符号编号为2。或者，第一基站和第二基站也可直接指示UE级的符号位置，比如第一基站和第二基站可通知UE可用的符号编号，如第一基站通知该UE该PDCCH1的可用符号编号为0，第二基站通知该UE该PDCCH2的可用符号编号为2。

[0157] 可选的，若PDCCH1和PDCCH2分别为不同的时域资源，在进行CCE编号时，CCE编号可以都从0开始。如图10a所示，假设针对两个control resource set，符号0代表第一个control resource set，符号1和2代表第二个control resource set，两个control resource set都从0开始编号。此时，若其他UE分配的也是1个符号或者2个符号，则可以将每个control resource set进行独立CCE编号，UE检索时按照每个Control resource set的总的N_{CCE}计算的盲检的CCE。从而能够避免不同符号间的交织情况。其中，该符号编号可在指示control resource set时携带。

[0158] 可选的，若PDCCH1和PDCCH2分别为不同的时域资源，在进行CCE编号时，可以根据符号所在位置，进行连续编号。如图10b所示，假设针对两个control resource set，符号0代表第一个control resource set，符号1和2代表第二个control resource set时，两个control resource set的编号与所在符号位置相关，比如位于符号0的control resource set的CCE可以从0开始编号，而位于符号1的control resource set的CCE从N开始编号。其中，N为第一个符号上包含的总的CCE个数。

[0159] 进一步可选的，该符号位置的信息可以携带于control resource set的配置信息发送给UE。比如第一基站或第二基站还可以配置一个control resource set，并且在该control resource set的配置信息中携带2种符号位置(符号位置可以是符号个数及符号编号的至少一项)的信息，该2种符号位置可分别对应2个搜索空间。或者，第一基站或第二基站可以配置2个control resource set，每个control resource set中可以携带一个符号位置的信息，等等，本发明实施例不做限定。

[0160] 203、第一基站使用第一资源向UE发送所述第一PDCCH。

[0161] 204、第二基站使用第二资源向该UE发送所述第二PDCCH。

[0162] 进一步的，第一基站和第二基站在确定PDCCH的资源位置之后，即可在该资源位置发送该PDCCH。其中，该第一资源可以是时频域资源，也可以是码分资源。

[0163] 进一步的，在可选的实施例中，该步骤203和204可以均执行或者仅执行一项，比如第一基站和第二基站都为UE的协作基站时，在不同的时刻传输数据的基站可以不同，如在时刻1第一基站和第二基站都需要发送下行控制信息(信道)对该UE进行数据调度时，则步骤203和步骤204可以都执行。又如在时刻2仅有第一基站需要发送下行控制信息对该UE进行数据调度时，则仅需要执行步骤203。又如在时刻3仅有第二基站需要发送下行控制信息对该UE进行数据调度时，则仅需要执行步骤204。具体哪一个或者哪几个基站对该UE进行数

据调度，可以取决于信道状况以及基站的调度决策等调度相关信息。其中时刻1、2、3可以是具体的时间单元的标识，比如该时间单元对应的时间单位可以是无线帧、子帧、时隙、微时隙、符号等等。

[0164] 205、UE确定第一PDCCH的第一搜索空间和第二PDCCH的第二搜索空间。

[0165] 具体的，当UE接收的多个PDCCH的PDCCH搜索空间不同时，该UE在确定该多个PDCCH的PDCCH搜索空间时，可分别确定该多个PDCCH的PDCCH搜索空间占用的资源，并基于该资源分别确定该多个PDCCH的PDCCH搜索空间。其中，该资源可包括频域资源，也可以包括时域资源。

[0166] 可选的，该UE分别确定该多个PDCCH的PDCCH搜索空间占用的资源时，可按照一定的规则确定该多个PDCCH的PDCCH搜索空间占用的资源，或者多个基站发送的通知消息来确定该多个PDCCH的PDCCH搜索空间占用的资源。比如UE可接收至少一个基站如该第一基站发送的用于指示第一资源配置信息的第一通知消息以及第二基站发送的用于指示第四资源配置信息的第四通知消息，并可基于该第一资源配置信息和第四资源配置信息确定该多个PDCCH的PDCCH搜索空间占用的资源。其中，该第一资源配置信息和第四资源配置信息可包括该多个PDCCH的PDCCH搜索空间所在的控制信道资源集合占用的资源信息。在本发明实施例中，该第一资源配置信息和第四资源配置信息可以是第一基站和第二基站分别发送的各自的资源配置信息，即该第一资源配置信息可包括该第一PDCCH搜索空间所在的控制信道资源集合占用的资源信息，该第四资源配置信息可包括该第二PDCCH搜索空间所在的控制信道资源集合占用的资源信息，即该控制信道集合的个数为2，即该多个PDCCH对应的PDCCH搜索空间的个数与控制信道资源集合的个数相同。进一步可选的，该第一资源配置信息和/或该第四资源配置信息中还可包括该CCE标识如CCE编号信息。UE可通过接收第一基站或第二基站发送的control resource set的配置信息获取该第一资源配置信息或第四资源配置信息。也即，该第一资源配置信息或该第四资源配置信息可以为基站发送的control resource set的配置信息。

[0167] 具体的，该第一PDCCH搜索空间和第二PDCCH搜索空间可以处于两个control resource set，两个set的频域资源不重叠，即两个PDCCH搜索空间所在的control resource set不同。进一步的，各自set的CCE编号可以从0开始，如图8a所示，从而UE可在control resource set1和control resource set2中基于该CCE编号计算搜索空间位置，进行搜索空间候选的盲检测。

[0168] 可选的，该UE分别确定该多个PDCCH的PDCCH搜索空间占用的资源时，还可接收第一基站发送的用于指示第二资源配置信息的第二通知消息以及第二基站发送的用于指示第五资源配置信息的第五通知消息，并基于该第二资源配置信息和第五资源配置信息确定第一PDCCH搜索空间和第二PDCCH搜索空间占用的资源。其中，该第二资源配置信息和该第五资源配置信息可包括该第一PDCCH搜索空间和该第二PDCCH所在的两个控制信道资源集合占用的资源信息，该两个控制信道资源集合的标识以及第一偏移值中的至少一项，该第一偏移值可以是基于该两个控制信道资源集合的标识确定出的(或者该第一偏移值还可由UE确定出，或者偏移值是预定义的)，且该两个控制信道资源集合占用的资源相重叠。进一步可选的，该第二资源配置信息和/或该第五资源配置信息中还可包括该CCE标识如CCE编号信息。UE可通过接收第一基站或第二基站发送的control resource set的配置信息获取

该第二资源配置信息或第五资源配置信息。也即，该第二资源配置信息或该第五资源配置信息可以为基站发送的control resource set的配置信息。

[0169] 具体的，该第一PDCCH搜索空间和第二PDCCH搜索空间可以处于两个control resource set，即control resource set1和control resource set2，两个set的资源可以完全重叠。进一步的，PDCCH搜索空间的CCE编号可以与set编号相关，比如可以配置一个第一偏移值offset1，则第一个set对应的第一PDCCH搜索空间的CCE编号可按公式确定出，第二个set对应的PDCCH搜索空间的CCE编号可增加offset1值。比如第一个set的某个CCE编号为1，则第二个set计算的CCE编号可以为1+offset1。其中，offset1可以为固定的值或者基站信令通知给UE，此处不赘述。如图8b所示，UE即可在control resource set1和control resource set2中基于该CCE编号计算搜索空间位置，进行搜索空间候选的盲检测。

[0170] 可选的，该UE分别确定该多个PDCCH的PDCCH搜索空间占用的资源时，还可接收第一基站发送的用于指示第三资源配置信息的第三通知消息以及第二基站发送的用于指示第六资源配置信息的第六通知消息，并基于该第三资源配置信息和第六资源配置信息确定第一PDCCH搜索空间和第二PDCCH搜索空间占用的资源。其中，该第三资源配置信息和该第六资源配置信息可以是第一基站和第二基站分别发送的各自的资源配置信息，该第三资源配置信息可包括该第一PDCCH搜索空间所在的控制信道资源集合占用的资源信息，该第一PDCCH搜索空间的标识以及第二偏移值中的至少一项，该第六资源配置信息可包括该第二PDCCH搜索空间所在的控制信道资源集合占用的资源信息，该第二PDCCH搜索空间的标识以及第二偏移值中的至少一项。该第二偏移值是基于该第一PDCCH搜索空间的标识和该第二PDCCH搜索空间的标识确定出的(该第二偏移值还可由UE确定出)，且该第一PDCCH搜索空间和该第二PDCCH搜索空间所在的控制信道资源集合相同。进一步可选的，该第三资源配置信息和/或该第六资源配置信息中还可包括该CCE标识如CCE编号信息。UE可通过接收第一基站或第二基站发送的control resource set的配置信息或搜索空间的配置信息以获取该第三资源配置信息或第六资源配置信息。也即，该第三资源配置信息或该第六资源配置信息可以为基站发送的control resource set的配置信息或搜索空间的配置信息。

[0171] 具体的，该第一PDCCH搜索空间(search space 1)和第二PDCCH搜索空间(search space 2)可以处于一个control resource set(control resource set1)中。进一步的，PDCCH搜索空间的CCE编号可以与搜索空间的编号相关，比如可以配置一个第二偏移值offset2，则第一PDCCH搜索空间的CCE编号可按公式确定出，第二PDCCH搜索空间的CCE编号可增加offset2值。比如第一PDCCH搜索空间计算的某个CCE编号为1，则第二PDCCH搜索空间的CCE编号可以为1+offset2。其中，offset2可以为固定的值或者基站信令通知给UE，此处不赘述。如图8c所示，UE即可在control resource set1和control resource set2中基于该CCE编号计算搜索空间位置，进行搜索空间候选的盲检测。

[0172] 进一步可选的，该资源可包括时域资源；则UE还可接收该第一基站和该第二基站发送的通知消息，如上述的第七通知消息和第八通知消息。该通知消息分别包括该第一PDCCH搜索空间占用的第三时间单元的标识和该第二PDCCH搜索空间占用的第四时间单元的标识。从而第一PDCCH搜索空间和第二PDCCH搜索空间可以从时域资源区分，如图9所示。UE即可基于各PDCCH搜索空间占用的时间单元的标识如符号编号去确定搜索空间并进行盲检。

[0173] 也就是说，该搜索空间可以是基于聚合级别、PDCCH的个数、控制信息的格式、控制信息的大小以及搜索空间的个数中的至少一项确定出的。比如该聚合级别、PDCCH的个数、控制信息的格式、控制信息的大小以及搜索空间的个数可以是基站通知给UE的，如在基站确定control resource set时通知给UE的。

[0174] 举例来说，第一基站或第二基站可以是在配置(确定)control resource set时可通知UE一个或者多个聚合级别。比如第一基站或第二基站可以配置聚合级别为4，则UE在监测时仅检测聚合级别为4的候选即可；或者第一基站或第二基站可以配置为4、8、16等多个聚合级别，则UE在监测时仅检测指示的聚合级别对应的候选即可，从而能够降低盲检次数。或者，第一基站或第二基站可以通知UE针对该control resource set需要监测的PDCCH的个数。比如如果配置UE监测1个PDCCH，则UE监测到一个PDCCH或者到达最大盲检次数后停止监测；如果配置UE监测2个PDCCH，则UE监测到2个PDCCH或者到达最大盲检次数后停止监测。

[0175] 又例如，第一基站或第二基站可以通知UE针对该control resource set需要监测的PDCCH的个数以及对应的聚合级别。比如配置UE检测1个PDCCH而且对应的聚合级别为4，则UE仅针对聚合级别为4的候选进行监测，而且当UE监测到一个PDCCH或者到达最大盲检次数后停止监测；或者配置UE检测1个PDCCH而且对应的聚合级别为4、8、16等多个聚合级别，则UE仅针对指示的聚合级别的候选进行监测，当UE监测到一个PDCCH或者到达最大盲检次数后停止监测；或者，第一基站或第二基站可配置UE检测2个PDCCH而且两个对应的聚合级别相同，比如分别对应的聚合级别为4，则UE可仅针对聚合级别为4的候选进行监测，而且当UE监测到2个PDCCH或者到达最大盲检次数后停止监测；或者配置UE检测2个PDCCH而且两个对应的聚合级别相同，比如分别对应的聚合级别为4、8、16等多个聚合级别，则UE仅针对指示的聚合级别的候选进行监测，而且当UE监测到2个PDCCH或者到达最大盲检次数后停止监测；或者，第一基站或第二基站可配置UE检测2个PDCCH而且两个对应的聚合级别不同，比如第一个PDCCH对应的聚合级别为4，第二个PDCCH对应的聚合级别为8，则UE对于第一个PDCCH仅针对聚合级别为4的候选进行监测，而且当UE监测到1个PDCCH或者到达最大盲检次数后再进行第二个PDCCH的监测，针对第二个PDCCH，则UE仅针对聚合级别为8的候选进行监测，当UE检测到1个PDCCH或者达到最大盲检次数后停止监测；其中，第一PDCCH和第二PDCCH的检测顺序可以不分先后。或者，第一基站或第二基站可配置UE检测2个PDCCH而且两个对应的聚合级别不同，比如第一PDCCH对应的聚合级别为4、8、16等多个聚合级别，第二PDCCH对应的聚合级别为8、16、32等多个聚合级别，则UE可对于第一PDCCH仅针对指示的聚合级别比如4、8、16等的候选进行监测，而且当UE监测到1个PDCCH或者到达最大盲检次数后再进行第二个PDCCH的监测，针对第二PDCCH，则UE仅针对指示的聚合级别比如8、16、32等的候选进行监测，当UE检测到1个PDCCH或者达到最大盲检次数后停止监测；其中，第一PDCCH和第二PDCCH的检测顺序可以不分先后，或者可以同时进行检测，比如在两者的聚合级别相同时，可以同时进行2个PDCCH的检测，本发明实施例不做限定。

[0176] 进一步可选的，第一基站或第二基站可以通知UE针对该control resource set的控制信息格式或者控制信息大小中的至少一项。比如配置UE检测控制信息格式DCI format 2D或者检测控制信息大小为A的PDCCH，A的取值为20bit或者40bit或者其他数值。可以针对多个搜索空间或者多个PDCCH配置多个控制信息个数或者控制信息大小的信息。或者可以针对多个搜索空间或者多个PDCCH配置一个控制信息个数或者控制信息大小的信息。或者

可以针对一个搜索空间或者一个PDCCH配置多个个控制信息个数或者控制信息大小的信息。或者控制信息个数或者控制信息大小为预定义。采用该方案，便于UE进行PDCCH的正确检测和解码。

[0177] 进一步可选的，第一基站或第二基站可以通知UE针对该control resource set的搜索空间个数，一个搜索空间可以包括一个或者多个PDCCH，进一步还可以通知针对搜索空间的PDCCH的个数以及对应的聚合级别、控制信息的格式、控制信息的大小，此处不赘述。

[0178] 206、UE在该第一搜索空间中确定出该第一PDCCH占用的第一资源，以及在该第二搜索空间中确定出该第二PDCCH占用的第二资源。

[0179] 207、该UE使用该第一资源获取第一PDCCH，并使用该第二资源获取第二PDCCH。

[0180] 进一步的，UE在确定出每个PDCCH的搜索空间之后，即可确定出每个PDCCH在该PDCCH搜索空间中占用的资源，并使用该资源获取该PDCCH，该资源包括时频资源或码分得到的资源，从而UE可在确定出的时频资源上获取该PDCCH，或者在确定出的码分资源上获取该PDCCH。

[0181] 在本发明实施例中，多个基站能够在UE不同的PDCCH搜索空间中向UE发送多个PDCCH，从而UE能够接收多个PDCCH，并通过该多个PDCCH调度一个载波的数据，这就提升了信息传输的效率，并提升了信息传输的可靠性。本发明实施例能够根据时频资源配置不同的control resource set及search space，并通过设计多个PDCCH的搜索空间候选，确保了多个PDCCH的CCE不重叠，从而解决了现有技术无法支持多个PDCCH传输的问题，并能够提升协作传输下分布式MIMO多流传输的性能，且降低了UE盲检次数，提升了UE盲检效率。

[0182] 请参见图11，图11是本发明实施例提供的又一种信道传输方法的交互示意图。具体的，如图11所示，本发明实施例的所述信道传输方法包括以下步骤：

[0183] 301、第一基站确定协作的第一搜索空间。

[0184] 302、第二基站确定协作的第二搜索空间。

[0185] 可选的，该第一基站确定该第一PDCCH搜索空间(即第一搜索空间)时，还可以是基于第三参数确定该第一PDCCH搜索空间。相应的，该第二基站在确定该第二PDCCH搜索空间(即第二搜索空间)时，还可以是基于第三参数确定该第二PDCCH搜索空间，其中，该第一PDCCH搜索空间或第二PDCCH搜索空间可包括至少一个CCE，该第三参数包括CCE的个数或CCE的标识。进一步可选的，该第一PDCCH搜索空间对应的第三参数和该第二PDCCH搜索空间对应的第三参数包括的CCE个数(或标识)可以相同，也可以不同。

[0186] 也就是说，该协作的第一PDCCH搜索空间或第二PDCCH搜索空间是指用于协作传输的专用搜索空间(又称“协作的搜索空间”)，该第一PDCCH搜索空间和该第二PDCCH搜索空间可以是预定义得到的。可选的，该协作的第一PDCCH搜索空间和该第二PDCCH搜索空间可以是为UE配置的搜索空间，也可以是为基站统一配置的搜索空间，也可以是为不同的基站分别配置的搜索空间，等等，本发明实施例不做限定。

[0187] 例如，对于为UE配置协作的搜索空间的方式，可以预定义该协作的搜索空间的大小和位置，并将该协作的搜索空间与UE的标识相关联。比如将时隙的前16个CCE作为该UE的协作搜索空间，该方式下，该第一PDCCH搜索空间和该第二PDCCH搜索空间相同。可选的，对于配置了协作的搜索空间的UE，可以按照一定的规则盲检PDCCH，比如搜索空间的确定与是否为协作控制信道相关，如果是协作控制信道，则将用于确定搜索空间的Y_k取值为固定的

值，比如将Y_k取值1或2等。或者令$Y_k'=Y_k+ID_{TP}$，并可将该Y_k'作为Y_k代入到上面的公式来确定搜索空间。其中，ID_{TP}可以表示协作的小区的标识，该标识可以是小区编号或者其他标识。进一步的，如果协作的搜索空间有空余，则正常UE的搜索空间与协作UE的搜索空间可以重叠，即正常UE也可以使用该协作的搜索空间，以避免资源浪费。例如，某个UE的RNTI模$\lfloor N_{CCE,k}/L \rfloor$等于1时，则该UE的搜索空间可以与协作的搜索空间全部或部分重叠，在该协作的搜索空间存在空余时可以传输该UE的PDCCH。

[0188] 又例如，协作的搜索空间可以由基站统一配置，如基站可通过RRC或MAC层信令配置第一配置信息，以基于该第一配置信息确定共用的协作搜索空间。可选的，该第一配置信息可包括以下至少一项：coordinated search space-config，用于指示协作的搜索空间的配置，也可以是协作的控制信道资源集合的配置；subframe pattern，用于指示时域资源的配置信息，比如可以是子帧、时隙、微时隙等等；symbol number，用于指示协作控制信道资源占用的符号个数；symbol Index，用于指示协作控制信道资源（该协作控制信道资源可以是协作的搜索空间或协作的控制信道资源集合）占用的符号所在的编号信息；CCE_number，用于指示协作的搜索空间占用的CCE的个数，或者是CCE的位置信息，比如可默认为某个时间单元中的前面几个CCE等；Yk_value，用于指示协作的搜索空间计算相关的变量值；frequencyResource，用于指示协作控制信道资源占用的频域资源位置信息。该方式下，不同基站共用一个协作的搜索空间，基站可以按照上述搜索空间相同的场景进行不同基站间的CCE的分配，此处不赘述。例如，该第一配置信息可以按照如下所示：

[0189]

```
Coordinated search space-Config ::=        SEQUENCE{
        subframePattern          MeasSubframePattern          OPTIONAL, -- Need ON
        SymbolNumber-r11         INTEGER (1..4)               OPTIONAL, -- Need OP
        SymbolIndex-r11          BIT STRING (size(4)) or INTEGER (1..4)
                                                              OPTIONAL, -- Need OP
        CCE_number               ENUMERATED {16,32,64}        OPTIONAL,-- Need ON
        Yk_value                 INTEGER (0,1..4)             OPTIONAL-- Need ON
        frequencyResource        ENUMERATED {16,32,64} or BIT STRING
                                     (size(4))or INTEGER (1..4)  OPTIONAL,-- Need ON
        }
    }
}
```

[0190] 又例如，不同的基站可以配置不同的协作搜索空间，此时，一个基站或者不同的基站可通过RRC或MAC层信令配置至少两个第二配置信息，每个第二配置信息可携带协作的搜索空间标识。可选的，该第二配置信息包括以下至少一项：coordinated search space-config，用于指示协作的搜索空间的配置，也可以是协作的控制信道资源集合配置；Coordinated search space_ID，用于指示协作的搜索空间的配置标识，也可以是协作的控制信道资源集合的配置标识；subframe pattern，用于指示时域资源的配置信息，比如可以是子帧，时隙，微时隙等等；symbol number，用于指示协作控制信道资源占用的符号个数；symbol Index，用于指示协作控制信道资源占用的符号所在的编号信息；CCE_number，用于指示协作的搜索空间占用的CCE的个数，或者是CCE的位置信息，比如可默认前面的CCE等；

Yk_value，用于指示协作的搜索空间计算相关的变量值；frequencyResource，用于指示协作控制信道资源占用的频域资源位置信息；Coordinated search space_ID，用于指示协作的搜索空间配置标识，也可以是协作控制信道资源集合配置标识；Coordinated search space_ID_List，用于指示协作的搜索空间的配置标识列表，也可以是协作的控制信道资源集合的配置标识列表；symbol Index_List，用于指示协作控制信道资源占用的符号所在的编号信息列表；CCE_index_List，用于指示协作的搜索空间占用的CCE的情况列表，或者是CCE个数列表，或者是CCE的位置信息列表；frequencyResource_List，用于指示协作控制信道资源占用的频域资源位置信息列表。从而UE能够通过该第二配置信息区分出多个基站的协作的搜索空间的CCE，以进行PDCCH盲检，而且不影响正常UE的接收。例如，该第二配置信息可以按照如下所示：

[0191]

```
Coordinated search space_ID      INTEGER (1..4)
subframePattern                  MeasSubframePattern-r10      OPTIONAL, -- Need ON
SymbolNumber                     INTEGER (1..4)               OPTIONAL, -- Need OP
SymbolIndex                      BIT STRING (size(4))    or INTEGER (1..4)
                                                              OPTIONAL, -- Need OP
CCE_index                        ENUMERATED {0~16,16~32,32~64}
                                                              OPTIONAL, -- Need ON
Yk_value                         INTEGER (0,1..4)             OPTIONAL, -- Need ON
frequencyResource                ENUMERATED {16,32,64}or BIT STRING (size(4))or
                                 INTEGER (1..4)               OPTIONAL, -- Need ON
        }
    }
}
```

[0192] 又如，该第二配置信息还可以按照如下所示：

[0193]

```
Coordinated search space-Config::=    SEQUENCE{
    Coordinated search space_ID_LIST  INTEGER (1..4)
    symbol Index_List                 SEQUENCE{ SIZE OF ENUMERATED
                                      {0,0~1,0~2,1~2,,1,2}} OPTIONAL -- Need ON
    CCE_index_List                    SEQUENCE{ SIZE OF ENUMERATED
                                      {0~16,16~32,32~64}} OPTIONAL -- Need ON
  frequencyResource_List              SEQUENCE{ ENUMERATED {16,32,64}or BIT
                                      STRING (size(4))or INTEGER (1..4) }
                                                              OPTIONAL, -- Need ON
}
```

[0194]

[0195] 303、第一基站在第一搜索空间中的第一资源向该UE发送第一PDCCH。

[0196] 304、第二基站在第二搜索空间中的第二资源向该UE发送第二PDCCH。

[0197] 305、UE确定该第一搜索空间和该第二搜索空间。

[0198] 306、UE使用该第一搜索空间中的第一资源获取该第一PDCCH，以及使用该第二搜索空间中的第二资源获取该第二PDCCH。

[0199] 具体的，该UE在确定第一PDCCH搜索空间和第二PDCCH搜索空间时，仍可基于第一

基站和第二基站发送的包括CCE的个数或CCE的标识的参数信息，或者预定义的CCE的个数或CCE的标识等参数信息，来确定该协作的第一PDCCH搜索空间和第二PDCCH搜索空间，从而在该确定出的PDCCH搜索空间上进行盲检，以获取得到第一PDCCH和第二PDCCH。

[0200] 可选的，该第一搜索空间和该第二搜索空间可以相同，也可以不同。该第一基站或第二基站确定PDCCH占用的资源，以及UE获取PDCCH的方式可以参照上述实施例中的描述，此处不赘述。

[0201] 进一步可选的，该第一基站或第二基站还可通知UE聚合级别和/或PDCCH的个数和/或搜索空间的个数和/或控制信息格式和/或控制信息大小，从而UE可基于该聚合级别和/或PDCCH的个数和/或搜索空间的个数和/或控制信息格式和/或控制信息大小来进行搜索空间的确定，具体可参照上述实施例中的描述，此处不赘述。

[0202] 在本发明实施例中，多个基站能够通过设计的协作的搜索空间向UE发送属于多个PDCCH，从而UE能够接收多个PDCCH，并通过该多个PDCCH调度一个载波的数据，本发明实施例通过设计多个PDCCH的搜索空间候选，确保了多个PDCCH的CCE不重叠，从而解决了现有技术无法支持多个PDCCH传输以调度一个载波的数据的问题，从而提升了信息传输的效率，并提升了信息传输的可靠性，且降低了UE盲检次数，提升了UE盲检效率。

[0203] 请参见图12，图12是本发明实施例提供的一种网络设备的结构示意图。具体的，如图12所示，本发明实施例的该网络设备可包括确定模块11和通信模块模块12。其中，

[0204] 确定模块11，用于确定至少两个下行控制信道的搜索空间；

[0205] 该确定模块11，还用于在该搜索空间中分别确定出该至少两个下行控制信道占用的资源，该至少两个下行控制信道调度的资源属于一个载波；

[0206] 通信模块12，用于使用该资源获取该至少两个下行控制信道。

[0207] 可选的，该至少两个下行控制信道的搜索空间可以相同，则该确定模块11在确定至少两个下行控制信道的搜索空间时，可具体用于：

[0208] 基于第一参数确定至少两个下行控制信道的搜索空间；其中，该第一参数包括控制信道元素CCE个数、第一时间单元的标识以及下行控制信道的候选位置中的至少一项。

[0209] 进一步可选的，该至少两个下行控制信道的搜索空间的CCE的个数相同；或，该至少两个下行控制信道的第一时间单元的标识是基于该至少两个下行控制信道占用的资源的子载波间隔确定的；或，该至少两个下行控制信道的第一时间单元的标识是根据预设子载波间隔下的时间单元中与该至少两个下行控制信道的第一时间单元对应的时间单元的标识确定的；或，该至少两个下行控制信道的候选位置不同，该至少两个下行控制信道的候选位置是基于第二参数确定的，该第二参数包括设备类型、设备标识、聚合等级中的至少一项。

[0210] 可选的，该至少两个下行控制信道的搜索空间也可以不同，则该确定模块11在确定至少两个下行控制信道的搜索空间时，可具体用于：

[0211] 分别确定至少两个下行控制信道的搜索空间占用的资源，该至少两个下行控制信道的搜索空间占用的资源不同，并基于该资源分别确定该至少两个下行控制信道的搜索空间。其中，该确定的资源可包括频域资源或时域资源。

[0212] 进一步可选的，该确定模块11在分别确定至少两个下行控制信道的搜索空间占用的资源时，可具体用于：

[0213] 确定第一资源配置信息，并基于该第一资源配置信息确定至少两个下行控制信道的搜索空间占用的资源。其中，该第一资源配置信息可包括该至少两个下行控制信道的搜索空间所在的控制信道资源集合占用的资源信息，且该至少两个下行控制信道对应的搜索空间的个数与控制信道资源集合的个数相同。

[0214] 进一步可选的，该确定模块11在分别确定至少两个下行控制信道的搜索空间占用的资源时，可具体用于：

[0215] 确定第二资源配置信息，并基于该第二资源配置信息确定至少两个下行控制信道的搜索空间占用的资源。其中，该第二资源配置信息可包括该至少两个下行控制信道的搜索空间所在的至少两个控制信道资源集合占用的资源信息、该至少两个控制信道资源集合的标识以及第一偏移值中的至少一项，该第一偏移值是基于该至少两个控制信道资源集合的标识确定出的，且该至少两个控制信道资源集合占用的资源相重叠。

[0216] 进一步可选的，该确定模块11在分别确定至少两个下行控制信道的搜索空间占用的资源时，可具体用于：

[0217] 确定第三资源配置信息，并基于该第三资源配置信息确定至少两个下行控制信道的搜索空间占用的资源。其中，该第三资源配置信息包括该至少两个下行控制信道的搜索空间所在的控制信道资源集合占用的资源信息、该至少两个下行控制信道的搜索空间的标识以及第二偏移值中的至少一项，该第二偏移值是基于该至少两个下行控制信道的搜索空间的标识确定出的，且该至少两个下行控制信道对应的搜索空间所在的控制信道资源集合相同。

[0218] 进一步可选的，该资源可包括时域资源；

[0219] 该通信模块11，还可用于接收至少一个另一网络设备发送的通知消息，该通知消息包括该至少两个下行控制信道的搜索空间占用的第二时间单元的标识。

[0220] 可选的，该网络设备可通过上述模块实现上述图2至图11对应实施例中的信道传输方法中用户设备执行的部分或全部步骤。应理解，本发明实施例是对应方法实施例的装置实施例，对方法实施例的描述，也适用于本发明实施例。

[0221] 请参见图13，图13是本发明实施例提供的另一种网络设备的结构示意图。具体的，如图13所示，本发明实施例的该网络设备包括第一确定模块21、第二确定模块22、第一通信模块23和第二通信模块24。其中，

[0222] 第一确定模块21，用于在第一搜索空间中确定第一下行控制信道占用的第一资源；

[0223] 第二确定模块22，用于在第二搜索空间中确定第二下行控制信道占用的第二资源，该第一下行控制信道调度的资源和该第二下行控制信道调度的资源属于一个载波；

[0224] 第一通信模块23，用于使用该第一资源向另一网络设备发送该第一下行控制信道；

[0225] 第二通信模块24，用于使用该第二资源向该另一网络设备发送该第二下行控制信道。

[0226] 可选的，该第一确定模块21、第一通信模块23和该第二确定模块22、第二通信模块24可以设置于同一网络设备中，也可以设置于不同的网络设备中，本发明实施例不做限定。

[0227] 其中，该第一搜索空间和该第二搜索空间可以相同也可以不同。

[0228] 可选的，该第一搜索空间和该第二搜索空间可以相同；

[0229] 第一确定模块21，还用于基于第一参数确定该第一搜索空间；

[0230] 第二确定模块22，还用于基于第一参数确定该第一搜索空间；其中，该第一参数包括CCE的个数、第一时间单元的标识以及下行控制信道的候选位置中的至少一项。

[0231] 进一步可选的，该第一确定模块21确定出的第一参数包括的CCE的个数和该第二确定模块22确定出的第一参数包括的CCE的个数相同；或，该第一下行控制信道的第一时间单元的标识或该第二下行控制信道的第一时间单元的标识是基于该第一资源和第二资源的子载波间隔确定的；或，该第一下行控制信道的第一时间单元的标识是根据预设子载波间隔下的时间单元中与该第一下行控制信道的第一时间单元对应的时间单元的标识确定的，该第二下行控制信道的第一时间单元的标识是根据该预设子载波间隔下的时间单元中与该第二下行控制信道的第一时间单元对应的时间单元的标识确定出的；或，该第一下行控制信道的候选位置与该第二下行控制信道的候选位置不同，该第一下行控制信道或该第二下行控制信道的候选位置是基于第二参数确定的，该第二参数包括设备类型、设备标识、聚合等级中的至少一项。

[0232] 可选的，该第一搜索空间和该第二搜索空间也可以不同；

[0233] 第一确定模块21，还可用于确定第一搜索空间占用的第三资源，并基于该第三资源确定该第一搜索空间。其中，该第三资源可包括频域资源或时域资源。

[0234] 进一步可选的，该第一确定模块21在基于该第三资源确定该第一搜索空间时，可具体用于：

[0235] 确定第一资源配置信息，并基于该第一资源配置信息确定该第一搜索空间。其中，该第一资源配置信息包括该第一搜索空间所在的控制信道资源集合占用的资源信息。

[0236] 进一步可选的，该第一确定模块21在基于该第三资源确定该第一搜索空间时，可具体用于：

[0237] 确定第二资源配置信息，并基于该第二资源配置信息确定该第一搜索空间。其中，该第二资源配置信息包括该第一搜索空间所在的控制信道资源集合占用的资源信息、该控制信道资源集合的标识以及第一偏移值中的至少一项，该第一偏移值是基于该控制信道资源集合的标识确定出的。

[0238] 进一步可选的，该第一确定模块21在基于该第三资源确定该第一搜索空间时，可具体用于：

[0239] 确定第三资源配置信息，并基于该第三资源配置信息确定该第一搜索空间。其中，该第三资源配置信息包括该第一搜索空间所在的控制信道资源集合占用的资源信息、该第一搜索空间的标识以及第二偏移值中的至少一项，该第二偏移值是基于该第一搜索空间的标识确定出的。

[0240] 进一步可选的，该第一搜索空间和该第二搜索空间也可以不同；第二确定模块22，还可用于确定第二搜索空间占用的第四资源，并基于该第四资源确定该第一搜索空间。具体的，该第二确定模块22基于该第四资源确定该第二搜索空间与该第一确定模块21基于该第三资源确定该第一搜索空间的方式相同，此处不赘述。

[0241] 可选的，该第三资源可包括时域资源；

[0242] 该第一通信模块23，还用于向该另一网络设备发送通知消息，该通知消息包括该

第一搜索空间占用的第二时间单元的标识。

[0243] 可选的，该第一确定模块21，还用于基于第三参数确定该第一搜索空间。其中，该第一搜索空间包括至少一个CCE，该第三参数包括CCE的个数或CCE的标识。

[0244] 具体的，该第一通信模块23和第二通信模块24在第二搜索空间中确定第二下行控制信道占用的第二资源的方式以及发送第二下行控制信道的方式与该第一确定模块21和第二确定模块22在第一搜索空间中确定第一下行控制信道占用的第一资源的方式以及发送第一下行控制信道的方式类似，此处不赘述。

[0245] 可选的，该网络设备可通过上述模块实现上述图2至图11对应实施例中的信道传输方法中基站执行的部分或全部步骤。应理解，本发明实施例是对应方法实施例的装置实施例，对方法实施例的描述，也适用于本发明实施例。

[0246] 在本发明实施例中，能够通过设计多个下行控制信道的搜索空间候选，实现多个下行控制信道的CCE不重叠，从而解决了现有技术无法支持多个PDCCH传输以调度一个载波的数据的问题，并降低了用户设备盲检次数，提升了盲检效率。

[0247] 请参见图14，图14是本发明实施例提供的一种信道传输系统的结构示意图。具体的，如图14所示，本发明实施例的信息传输系统可包括第一网络设备1、第二网络设备2和第三网络设备3。其中，

[0248] 第一网络设备1，用于在第一搜索空间中确定第一下行控制信道占用的第一资源，并使用该第一资源向第三网络设备3发送该第一下行控制信道；

[0249] 第二网络设备2，用于在第二搜索空间中确定第二下行控制信道占用的第二资源，并使用该第二资源向该第三网络设备3发送该第二下行控制信道；其中，该第一下行控制信道调度的资源和该第二下行控制信道调度的资源属于一个载波；

[0250] 第三网络设备3，用于确定该第一下行控制信道的第一搜索空间和该第二下行控制信道的第二搜索空间，在第一搜索空间中确定该第一下行控制信道占用的第一资源，在第二搜索空间中确定该第二下行控制信道占用的第二资源，使用该第一资源获取该第一下行控制信道以及使用该第二资源获取该第二下行控制信道。

[0251] 可选的，该第一搜索空间和第二搜索空间可以相同也可以不同。该网络设备如上述的第一网络设备、第二网络设备或第三网络设备可以是基站，也可以是用户设备。该第一网络设备和第二网络设备可以是相同的网络设备，即通过同一个网络设备如基站给另一个网络设备如用户设备发送多个下行控制信道；或者，该第一网络设备和第二网络设备还可以是不同的网络设备，本发明实施例不做限定。

[0252] 具体的，该第一网络设备和该第二网络设备可参照上述图2至图11对应实施例中的基站的相关描述，该第三网络设备可参照上述图2至图11对应实施例中的用户设备的相关描述，此处不赘述。

[0253] 请参见图15，图15是本发明实施例提供的又一种网络设备的结构示意图。具体的，如图15所示，本发明实施例的所述网络设备可包括：通信接口300、存储器200和处理器100，所述处理器100分别与所述通信接口300及所述存储器200连接。

[0254] 所述通信接口300、存储器200以及处理器100之间可以通过总线进行数据连接，也可以通过其他方式数据连接。本实施例中以总线连接进行说明。

[0255] 所述处理器100可以是中央处理器(英文：Central Processing Unit，缩写：CPU)，

网络处理器(英文:Network Processor,缩写:NP)或CPU和NP的组合。

[0256] 所述处理器100还可以进一步包括硬件芯片。上述硬件芯片可以是专用集成电路(英文:Application-Specific Integrated Circuit,缩写:ASIC),可编程逻辑器件(英文:Programmable Logic Device,缩写:PLD)或其组合。上述PLD可以是复杂可编程逻辑器件(英文:Complex Programmable Logic Device,缩写:CPLD),现场可编程逻辑门阵列(英文:Field-Programmable Gate Array,缩写:FPGA),通用阵列逻辑(英文:Generic Array Logic,缩写:GAL)或其任意组合。

[0257] 所述存储器200可以包括易失性存储器(英文:Volatile Memory),例如随机存取存储器(英文:Random-Access Memory,缩写:RAM);存储器也可以包括非易失性存储器(英文:non-volatile memory),例如快闪存储器(英文:flash memory),硬盘(英文:Hard Disk Drive,缩写:HDD)或固态硬盘(英文:Solid-State Drive,缩写:SSD);存储器200还可以包括上述种类的存储器的组合。

[0258] 其中,该网络设备可以是用户设备,也可以是基站。可选的,存储器200可以用于存储程序指令,该处理器100调用该存储器200中存储的程序指令,可以执行图2至图11所示实施例中的一个或多个步骤,或其中可选的实施方式,使得该网络设备实现上述方法中的功能。例如,该网络设备可通过上述模块实现上述图2至图11对应实施例中的信道传输方法中的网络设备如用户设备执行的部分或全部步骤。

[0259] 请参见图16,图16是本发明实施例提供的又一种网络设备的结构示意图。具体的,如图16所示,本发明实施例的网络设备可包括:通信接口600、存储器500和处理器400,该处理器400分别与通信接口600及存储器500连接。

[0260] 所述通信接口600、存储器500以及处理器400之间可以通过总线进行数据连接,也可以通过其他方式数据连接。本实施例中以总线连接进行说明。

[0261] 所述处理器400可以是CPU,NP或CPU和NP的组合。

[0262] 所述处理器400还可以进一步包括硬件芯片。上述硬件芯片可以是ASIC,PLD或其组合。上述PLD可以是CPLD,FPGA,GAL或其任意组合。

[0263] 所述存储器500可以包括易失性存储器(英文:Volatile Memory),例如RAM;存储器也可以包括非易失性存储器(英文:non-volatile memory),例如快闪存储器(英文:flash memory),HDD或SSD;存储器500还可以包括上述种类的存储器的组合。

[0264] 其中,该网络设备可以是基站,也可以是用户设备。可选的,存储器500可以用于存储程序指令,该处理器400调用该存储器500中存储的程序指令,可以执行图2至图11所示实施例中的一个或多个步骤,或其中可选的实施方式,使得该网络设备实现上述方法中的功能。例如,该网络设备可通过上述模块实现上述图2至图11对应实施例中的信道传输方法中的网络设备如基站执行的部分或全部步骤。

[0265] 在上述实施例中,可以全部或部分地通过软件、硬件、固件或者其任意组合来实现。当使用软件实现时,可以全部或部分地以计算机程序产品的形式实现。所述计算机程序产品包括一个或多个计算机指令。在计算机上加载和执行所述计算机程序指令时,全部或部分地产生按照本发明实施例所述的流程或功能。所述计算机可以是通用计算机、专用计算机、计算机网络、或者其他可编程装置。所述计算机指令可以存储在计算机可读存储介质中,或者从一个计算机可读存储介质向另一个计算机可读存储介质传输,例如,所述计算机

指令可以从一个网站站点、计算机、服务器或数据中心通过有线(例如同轴电缆、光纤、数字用户线(DSL))或无线(例如红外、无线、微波等)方式向另一个网站站点、计算机、服务器或数据中心进行传输。所述计算机可读存储介质可以是计算机能够存取的任何可用介质或者是包含一个或多个可用介质集成的服务器、数据中心等数据存储设备。所述可用介质可以是磁性介质,(例如,软盘、硬盘、磁带)、光介质(例如,DVD)、或者半导体介质(例如固态硬盘Solid State Disk(SSD))等。

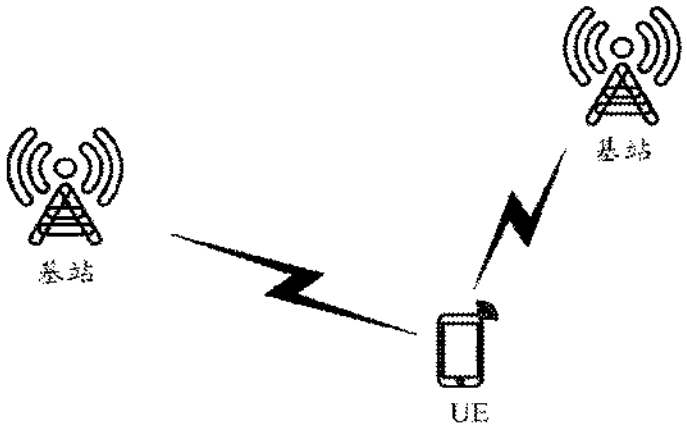

基站
基站
UE

图1

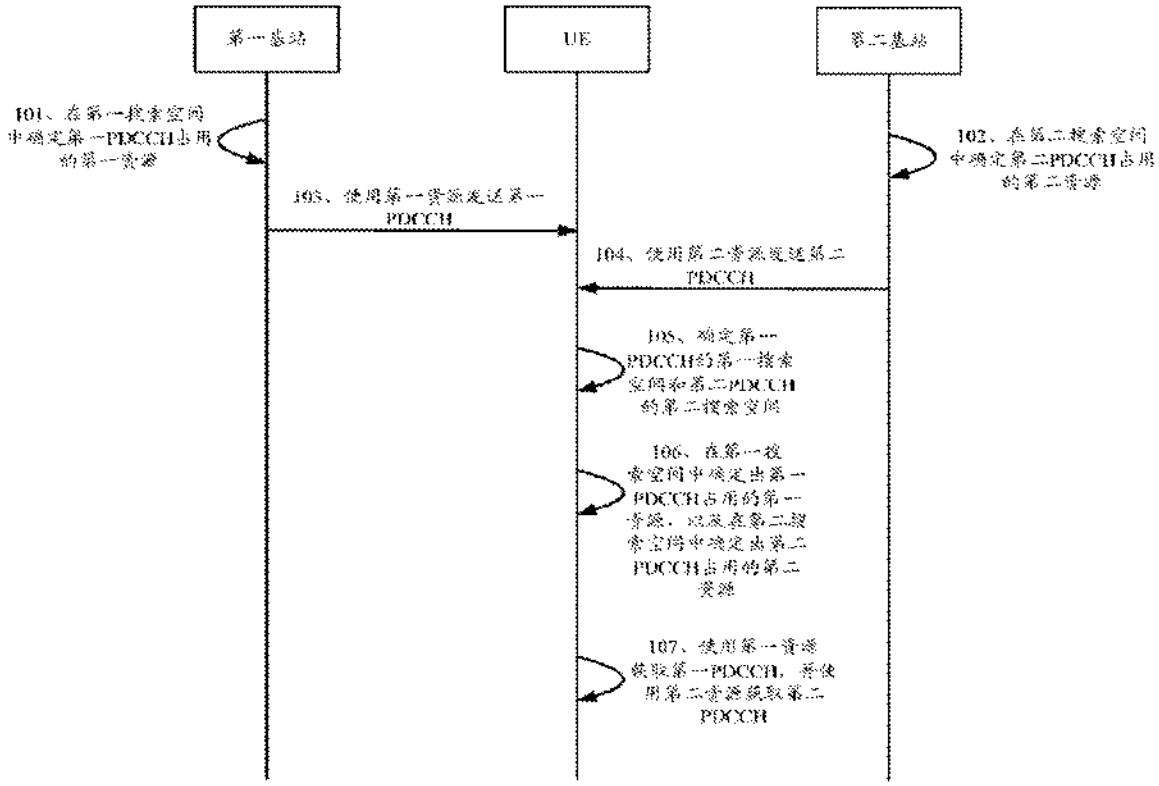

第一基站
UE
第二基站
101、在第一搜索空间中确定第一PDCCH占用的第一资源
102、在第二搜索空间中确定第二PDCCH占用的第二资源
103、使用第一资源发送第一PDCCH
104、使用第二资源发送第二PDCCH
105、确定第一PDCCH的第一搜索空间和第二PDCCH的第二搜索空间
106、在第一搜索空间中确定出第一PDCCH占用的第一资源，以及在第二搜索空间中确定出第二PDCCH占用的第二资源
107、使用第一资源获取第一PDCCH，并使用第二资源获取第二PDCCH

图2

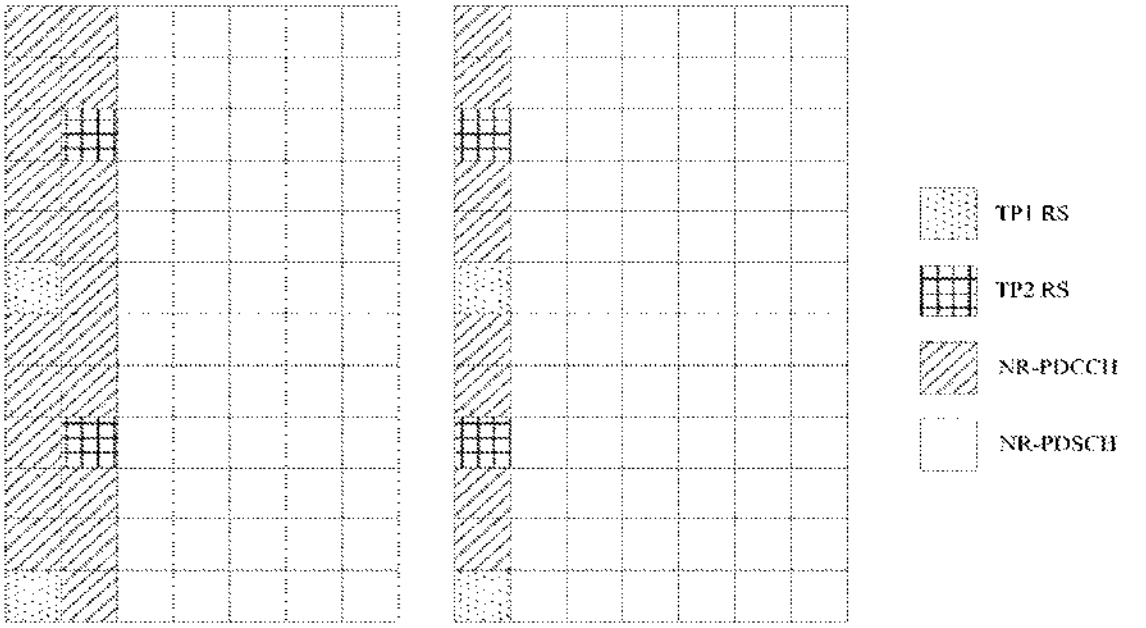


图3

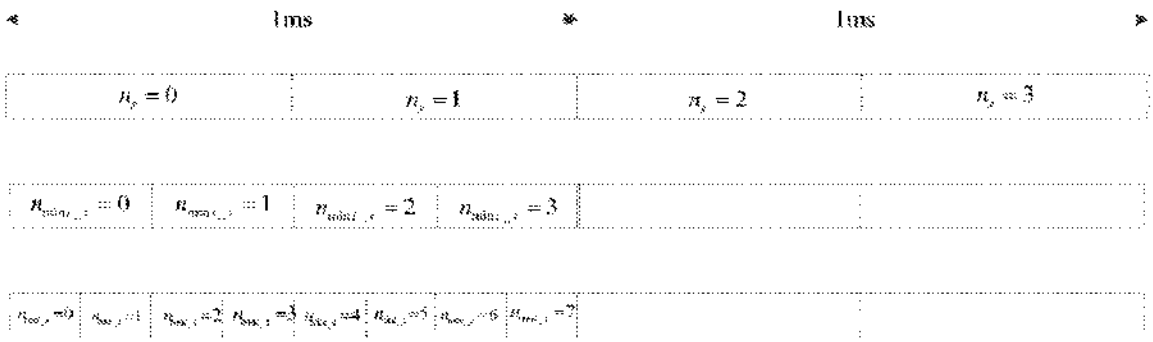


图4

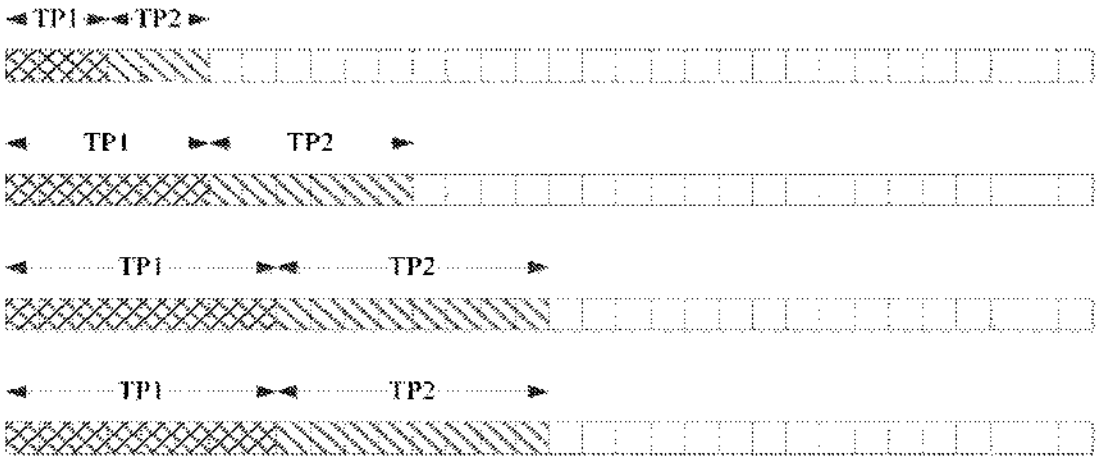


图5a

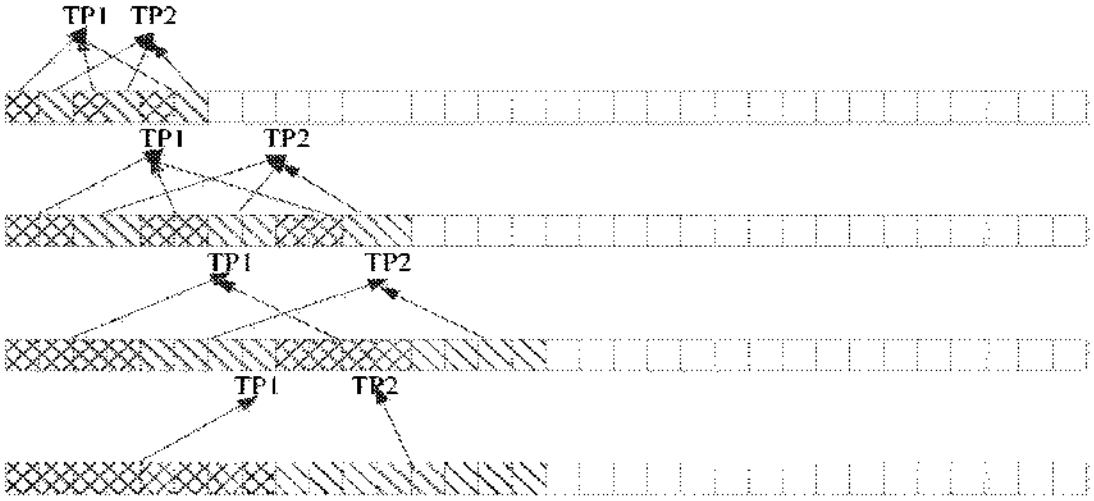


图5b

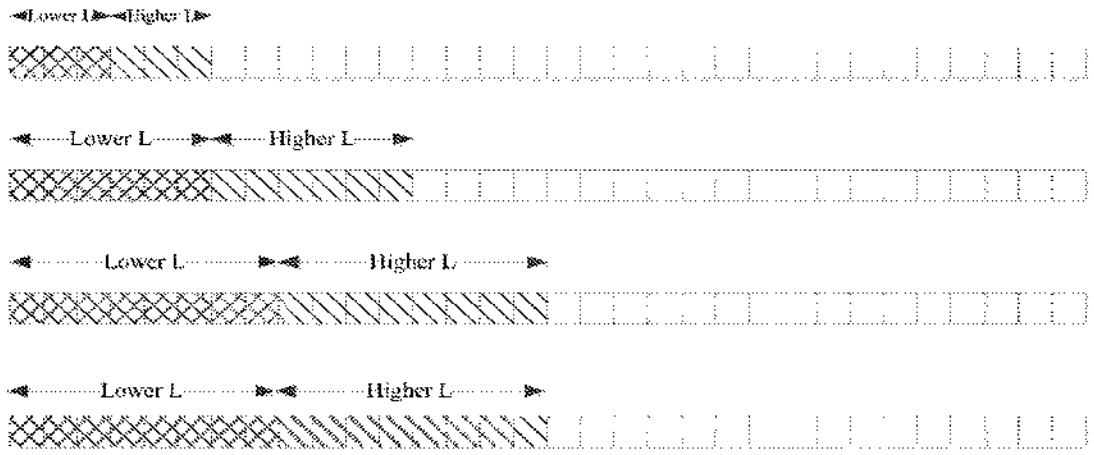

Lower L
Higher L
Lower L
Higher L
Lower L
Higher L
Lower L
Higher L

图5c

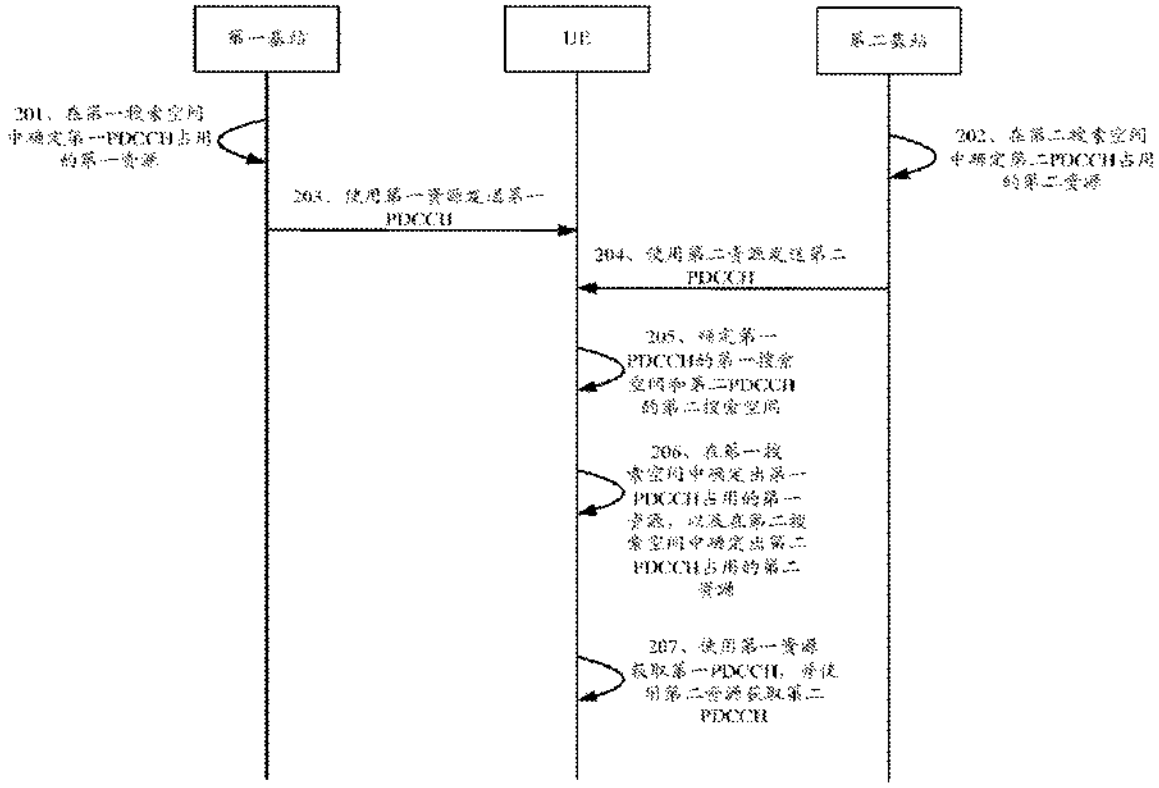

第一基站
UE
第二基站
201、在第一搜索空间中确定第一PDCCH占用的第一资源
202、在第二搜索空间中确定第二PDCCH占用的第二资源
203、使用第一资源发送第一PDCCH
204、使用第二资源发送第二PDCCH
205、确定第一PDCCH的第一搜索空间和第二PDCCH的第二搜索空间
206、在第一搜索空间中确定出第一PDCCH占用的第一资源，以及在第二搜索空间中确定出第二PDCCH占用的第二资源
207、使用第一资源获取第一PDCCH，并使用第二资源获取第二PDCCH

图6

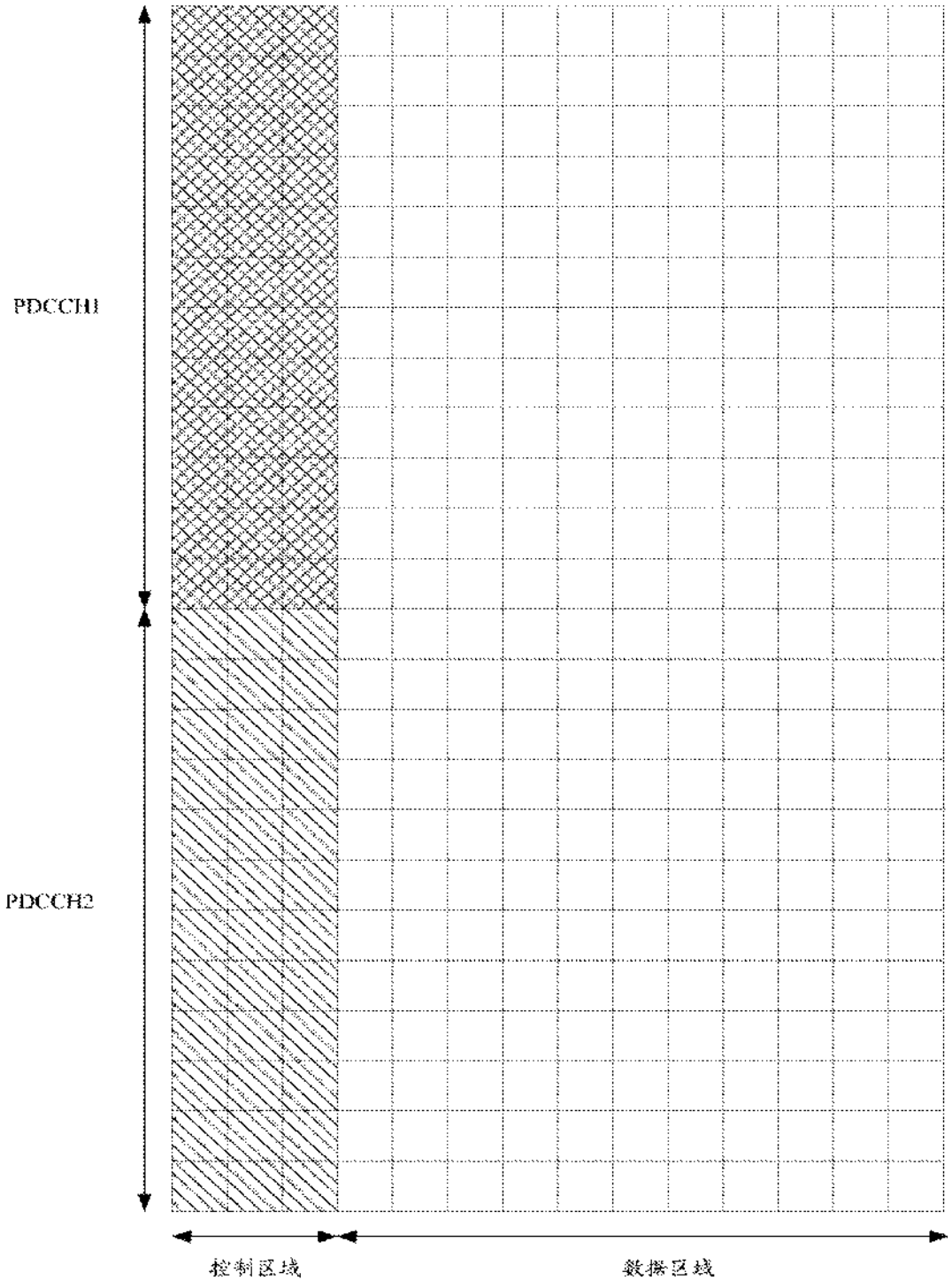


图7

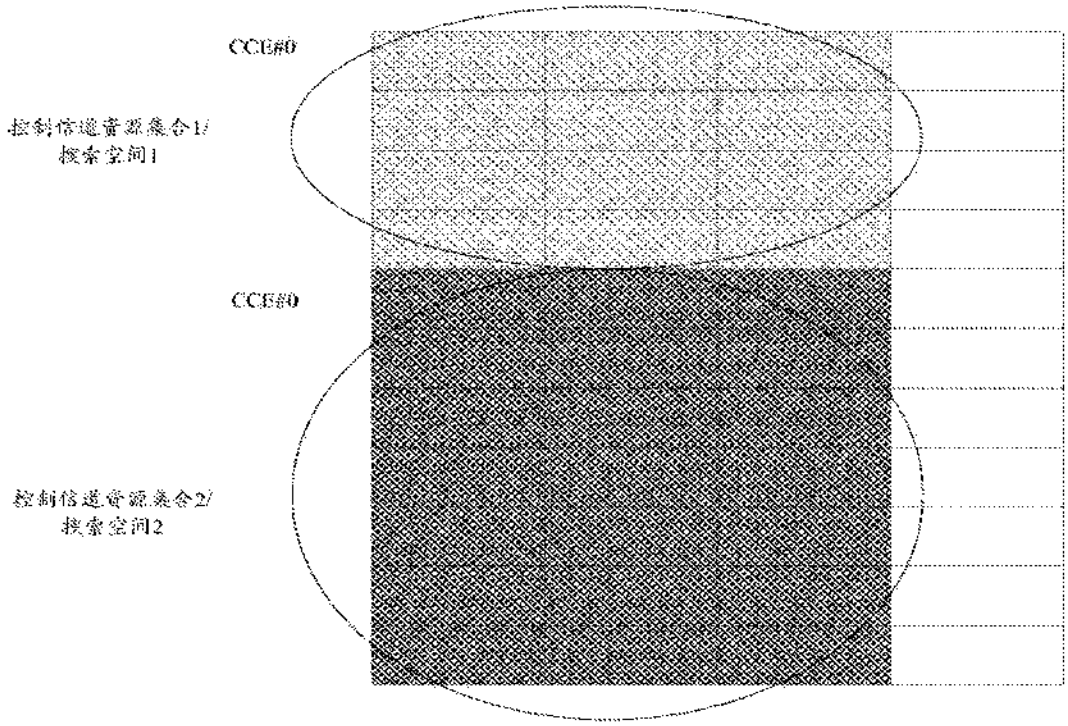


图8a

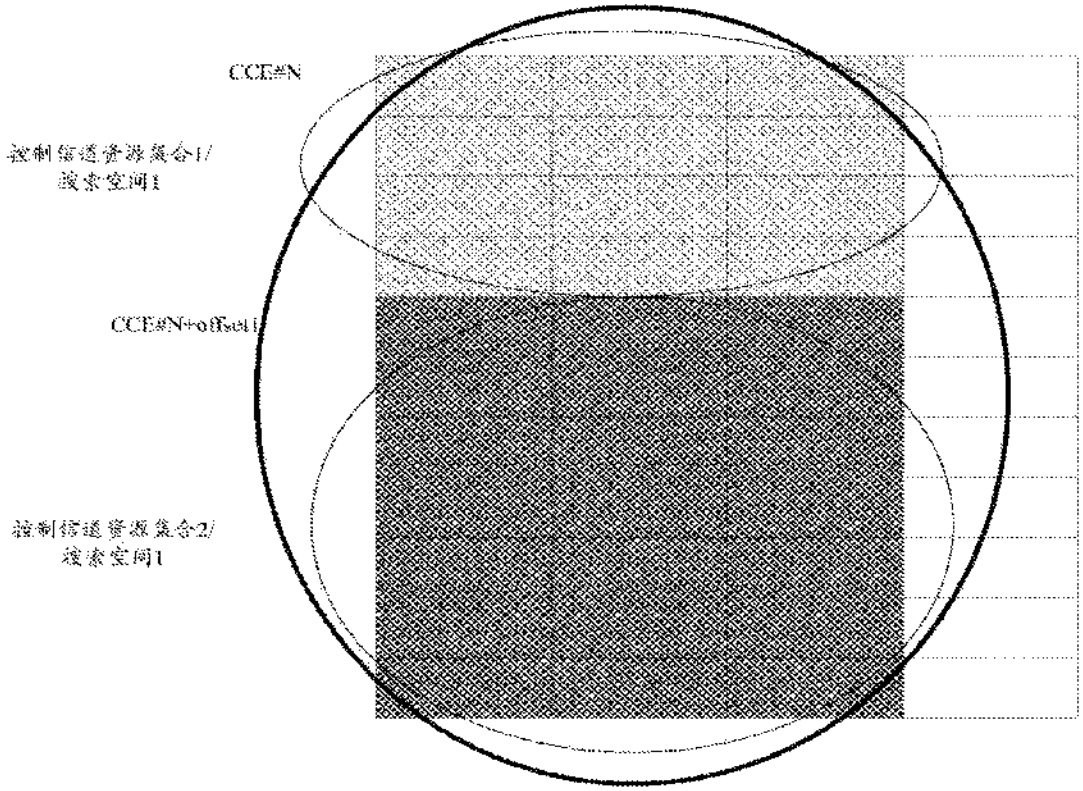


图8b

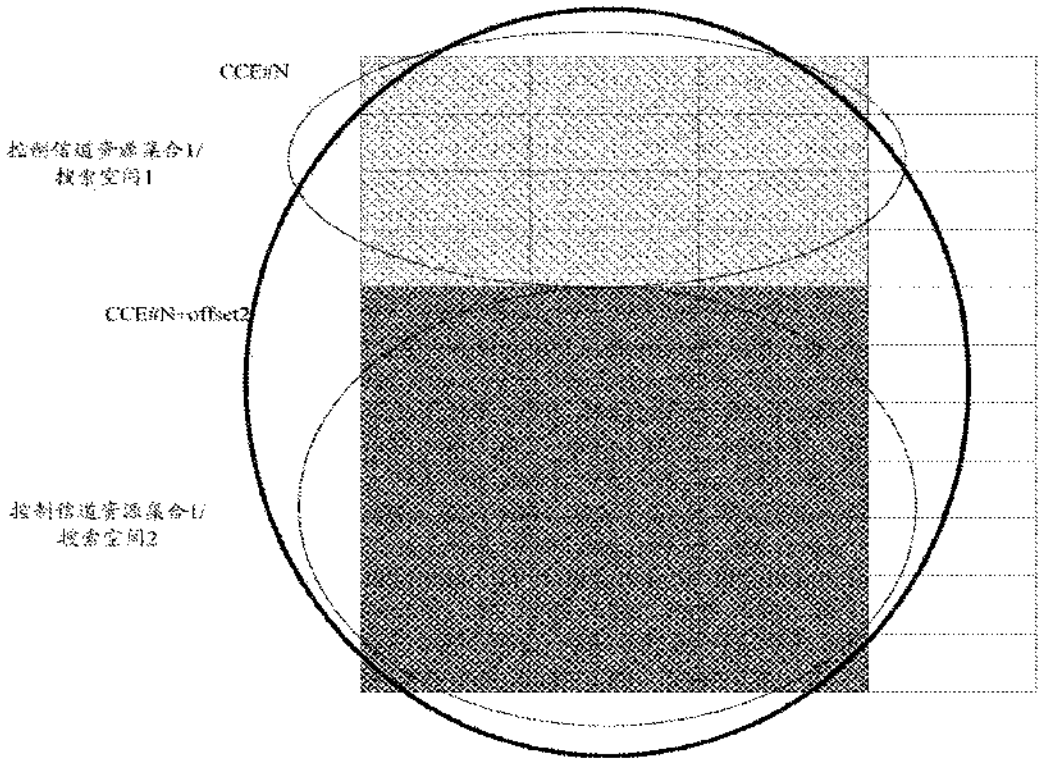


图8c

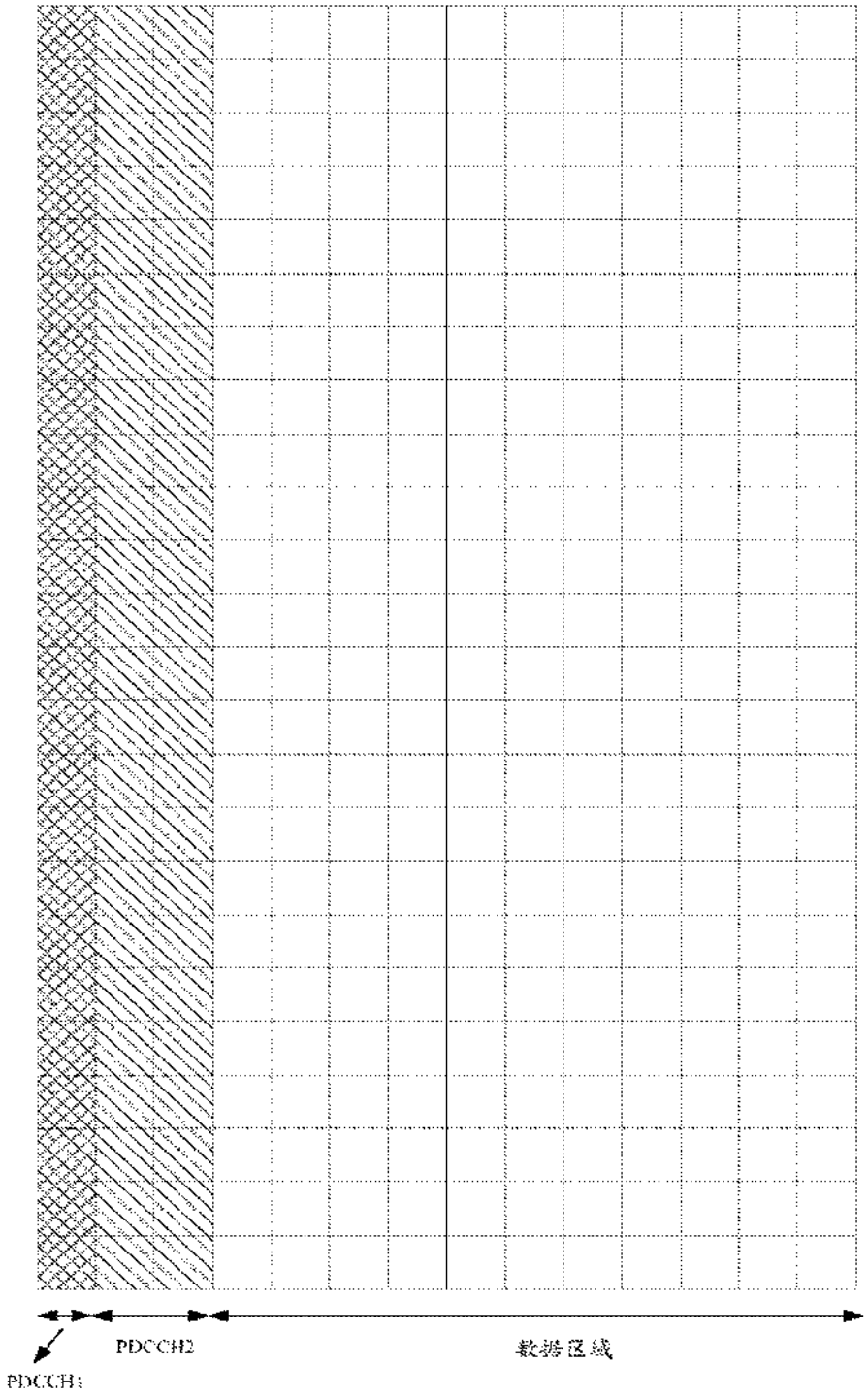


图9

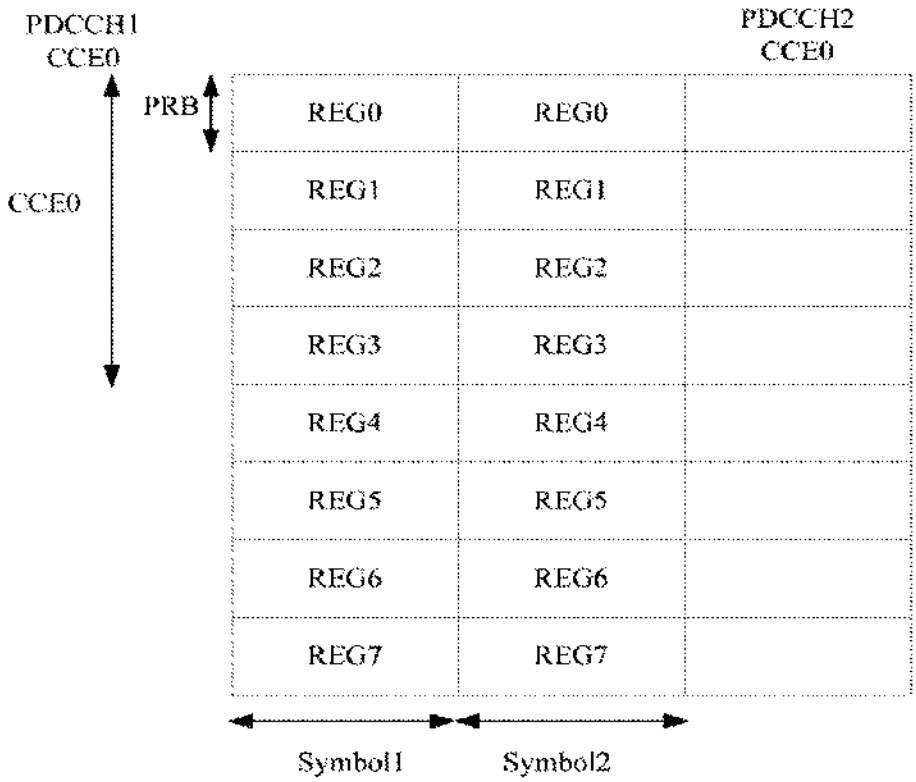

PDCCH1
CCE0
PRB
CCE0
PDCCH2
CCE0
REG0
REG0
REG1
REG1
REG2
REG2
REG3
REG3
REG4
REG4
REG5
REG5
REG6
REG6
REG7
REG7
Symbol1
Symbol2

图10a

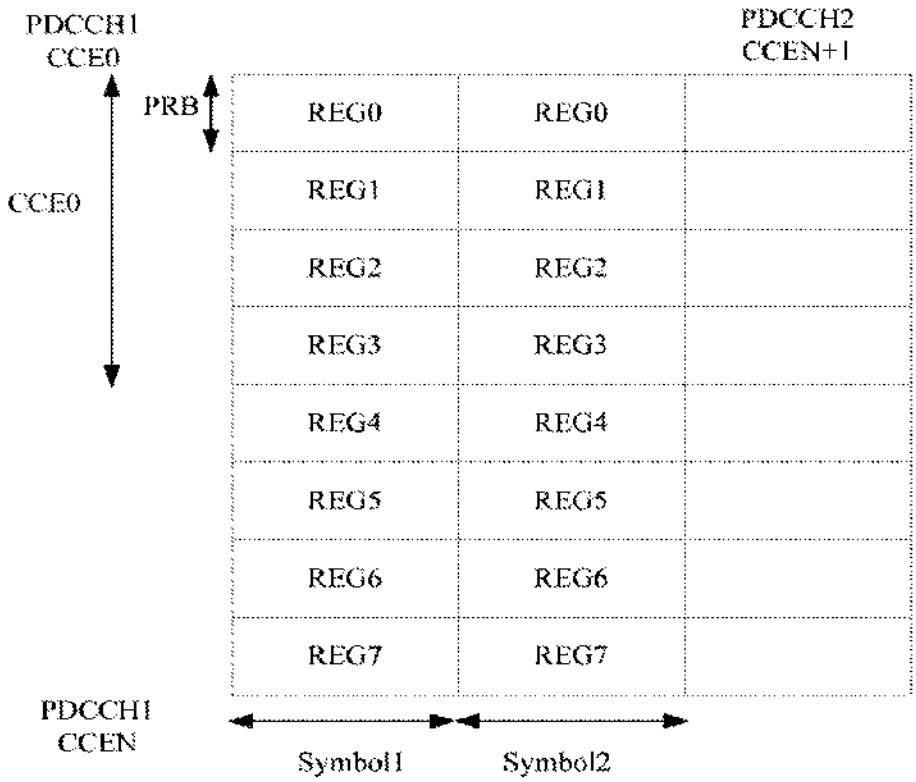

PDCCH1
CCE0
PDCCH2
CCEN+1
PRB
CCE0
REG0
REG1
REG2
REG3
REG4
REG5
REG6
REG7
PDCCH1
CCEN
Symbol1
Symbol2

图10b

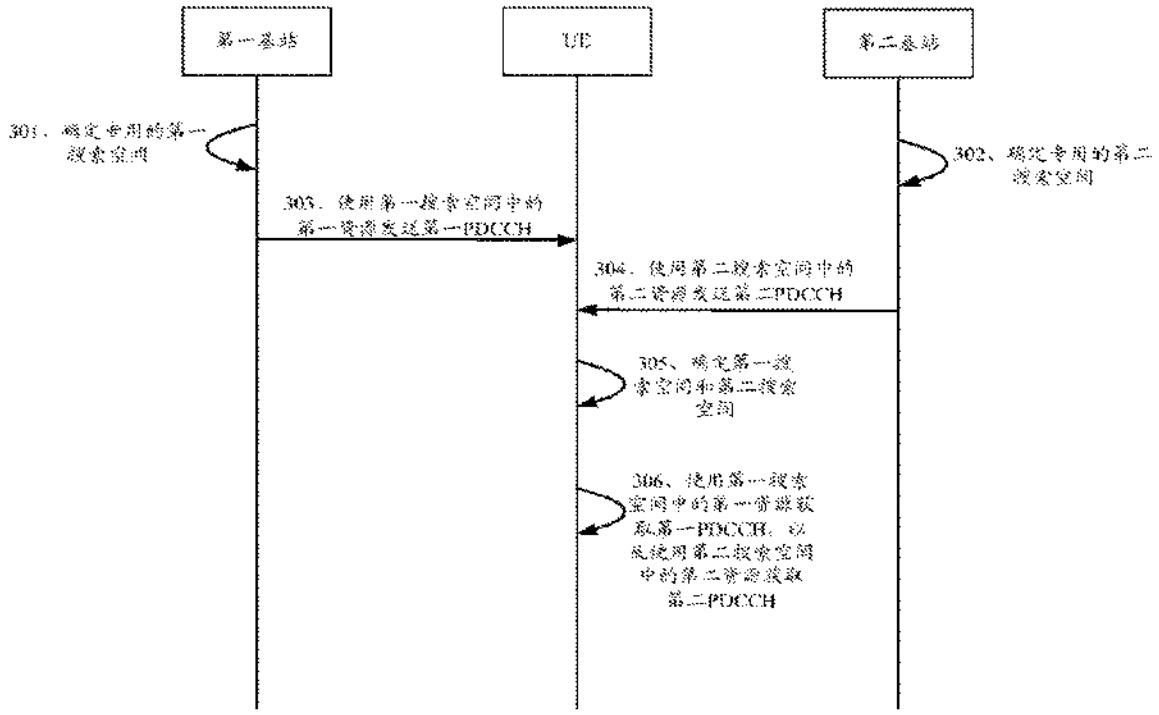

第一基站
UE
第二基站
301、确定专用的第一搜索空间
302、确定专用的第二搜索空间
303、使用第一搜索空间中的第一资源发送第一PDCCH
304、使用第二搜索空间中的第二资源发送第二PDCCH
305、确定第一搜索空间和第二搜索空间
306、使用第一搜索空间中的第一资源获取第一PDCCH，以及使用第二搜索空间中的第二资源获取第二PDCCH

图11

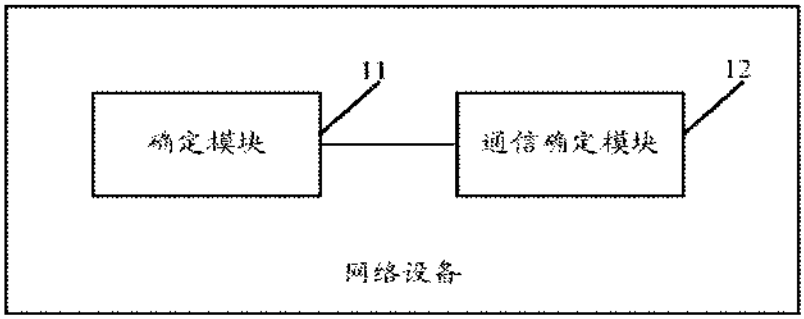

11
12
确定模块
通信确定模块
网络设备

图12

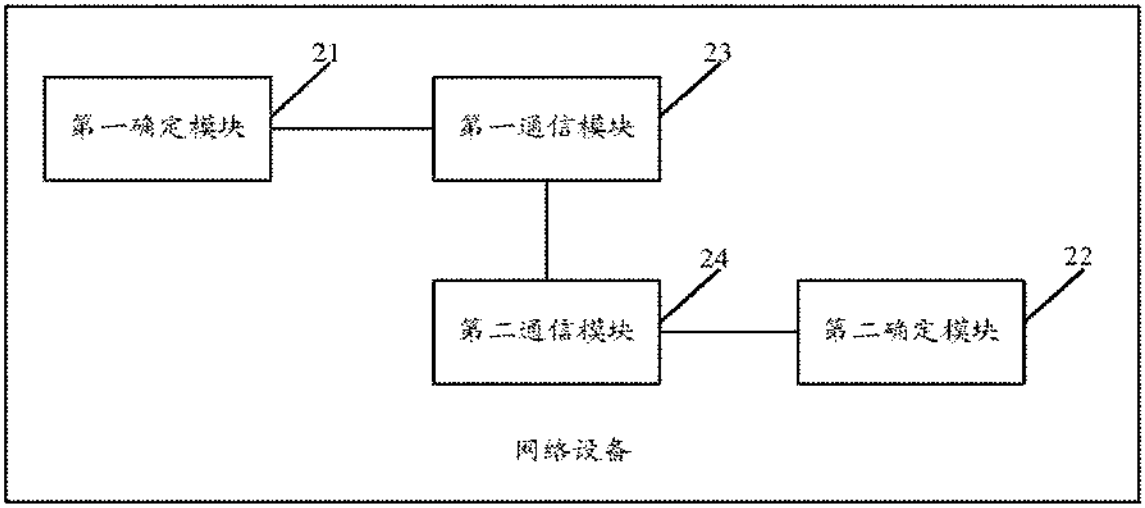

21
第一确定模块
23
第一通信模块
24
第二通信模块
22
第二确定模块
网络设备

图13

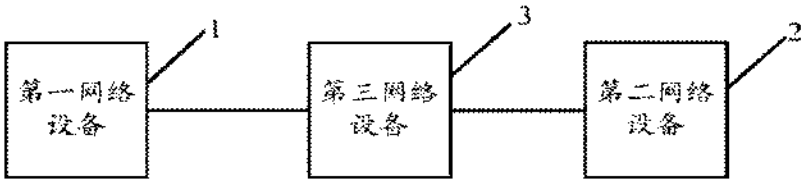

1
第一网络设备
3
第三网络设备
2
第二网络设备

图14

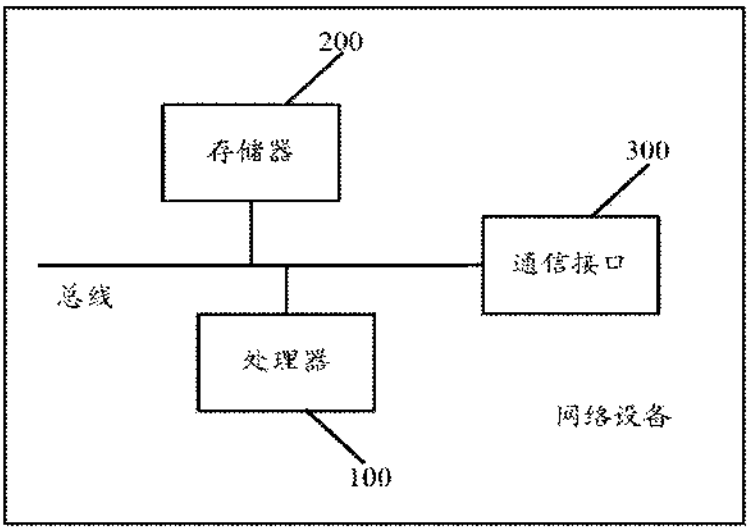

200
存储器
300
通信接口
总线
处理器
网络设备
100

图15

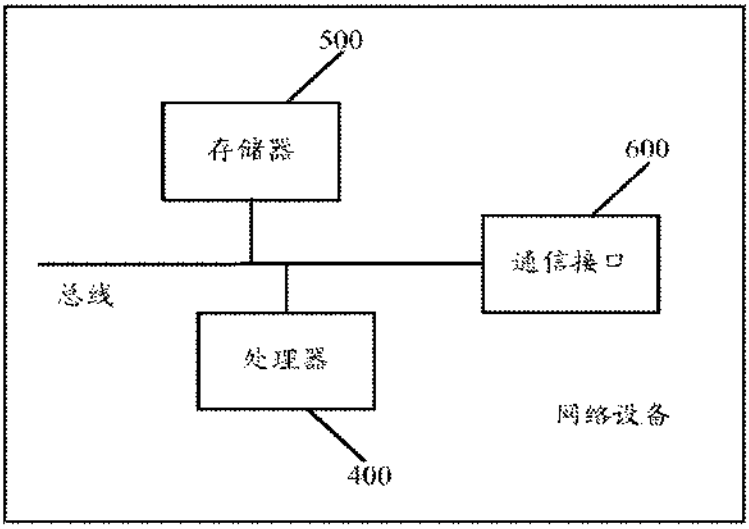

500
存储器
600
通信接口
总线
处理器
网络设备
400

图16

(12) 按照专利合作条约所公布的国际申请

(19) 世界知识产权组织
国 际 局

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(81) 指定国 (除另有指明, 要求每一种可提供的国家保护): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW。

(84) 指定国 (除另有指明, 要求每一种可提供的地区保护): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), 欧亚 (AM, AZ, BY, KG, KZ, RU, TJ, TM), 欧洲 (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO,

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(54) Title: SIGNAL TRANSMISSION METHOD AND ASSOCIATED DEVICE

(54) 发明名称 : 一种信号发送方法及相关设备

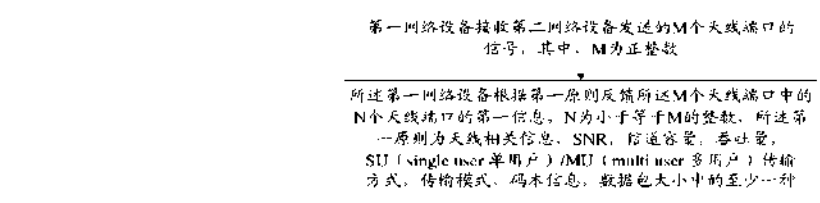


图 1 / Fig. 1

S101 A FIRST NETWORK DEVICE RECEIVES SIGNALS OF M ANTENNA PORTS SENT BY A SECOND NETWORK DEVICE, WHERE M IS A POSITIVE INTEGER

S102 THE FIRST NETWORK DEVICE FEEDS BACK FIRST INFORMATION OF N ANTENNA PORTS IN THE M ANTENNA PORTS ACCORDING TO A FIRST RULE, WHERE N IS AN INTEGER SMALLER THAN OR EQUAL TO M, AND THE FIRST RULE IS AT LEAST ONE OF ANTENNA ASSOCIATED INFORMATION, SNR, CHANNEL CAPACITY, THROUGHPUT, AN SU (SINGLE-USER)/MU (MULTI-USER) TRANSMISSION MANNER, A TRANSMISSION MODE, CODEBOOK INFORMATION AND A DATA PACKET SIZE

(57) Abstract: A signal transmission method and an associated device. The method comprises: a first network device receives signals of M antenna ports sent by a second network device, where M is a positive integer; the first network device feeds back first information of N antenna ports in the M antenna ports according to a first rule, where N is an integer smaller than or equal to M, and the first rule is at least one of antenna associated information, SNR, channel capacity, throughput, an SU (single-user)/MU (multi-user) transmission manner, a transmission mode, codebook information and a data packet size. The present invention performs the optimum antenna configuration according to at least one of antenna associated information, SNR, channel capacity, throughput, an SU/MU transmission manner, a transmission mode, codebook information or a data packet size and carries out more effective antenna selection.

(57) 摘要: 一种信号发送方法及相关设备。其中的方法包括：第一网络设备接收第二网络设备发送的 M 个天线端口的信号，其中，M 为正整数；所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，N 为小于等于 M 的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU(single user 单用户)/MU(multi user 多用户)传输方式，传输模式，码本信息，数据包大小中的至少一种。本发明实施例通过根据天线相关信息、SNR、信道容量、吞吐量、单用户/多用户传输方式、传输模式、码本信息或数据包大小中的至少一种进行最优天线配置，进行了更有效的天线选择。

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RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG)。

本国际公布:

— 包括国际检索报告(条约第 21 条(3))。

一种信号发送方法及相关设备

技术领域

本发明涉及通信技术领域，尤其涉及一种信号发送方法及相关设备。

背景技术

通过发射波束赋形(Beam Forming，BF)/预编码和接收合并，多输入多输出(Multiple-Input Multiple-Output，MIMO)无线系统可以得到分集和阵列增益。利用 BF 或者预编码的典型系统通常可以表示为：

$$\mathbf{y}=\mathbf{HVs}+\mathbf{n}$$

其中 $\mathbf{y}$ 是接收信号矢量，$\mathbf{H}$ 是信道矩阵，$\mathbf{V}$ 是预编码矩阵，$\mathbf{s}$ 是发射的符号矢量，$\mathbf{n}$ 是测量噪声。最优预编码通常需要发射机完全已知信道状态信息（Channel State Information，CSI）。常用的方法是用户设备对瞬时 CSI 进行量化并反馈给基站设备。现有 LTE R8 系统反馈的 CSI 信息包括秩指示（RI）、预编码矩阵指示（PMI）和信道质量指示（CQI）信息等，其中 RI 和 PMI 分别指示使用的层数和预编码矩阵。

现在为了进一步提高小区用户总吞吐率和平均吞吐率，使用动态三维(3 Dimensions，3D)波束赋形技术等 3D 多天线技术。但在现有蜂窝系统中，基站发射端波束仅能在水平维进行调整，而垂直维对每个用户都是固定的下倾角，因此各种波束赋形/预编码技术等均是基于水平维信道信息的。事实上，由于信道是 3D 的，固定下倾角的方法往往不能使系统的吞吐量达到最优。因此在 3D 天线可以通过不同的驱动网络形成对应于不同下倾角的天线端口，即不同的天线端口的天线方向图不同。同时，随着高频技术的演进，将会引入 massive MIMO 技术，massive MIMO 采用大规模天线，不同的天线间的信道特性不会完全相同。

综上所述，3D 多天线，或者大规模天线技术中需要有更有效的天线选择方法。

发明内容

本发明实施例提供一种信号发送方法及相关设备，以进行更有效的天线选择。

第一方面，提供了一种信号发送方法，包括:

第一网络设备接收第二网络设备发送的 M 个天线端口的信号，其中，M 为正整数;

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，N 为小于等于 M 的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种。

在第一种可能的实现方式中，所述第一准则为天线相关信息;

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为:

所述第一网络设备根据测量的所述 M 个天线端口的天线相关信息，进行小区选择，其中 M 个天线端口对应至少两个小区或者两个传输节点，每个所述小区或传输节点对应至少两个天线端口。

结合第一方面的第一种可能的实现方式，在第二种可能的实现方式中，所述第一网络设备根据测量的所述 M 个天线端口的天线相关信息，进行小区选择，具体为:

所述第一网络设备根据测量的所述 M 个天线端口的天线相关信息与第一阈值的比较结果，选择所述 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第一方面，在第三种可能的实现方式中，所述第一准则为信噪比 SNR;

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为:

所述第一网络设备在 M 个天线端口中选择使得波束赋型或者发射分集后的 SNR 小于等于或大于等于第二阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第一方面，在第四种可能的实现方式中，第一准则为信道容量;

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为:

所述第一网络设备在 M 个天线端口中选择使得信道容量小于等于或大于等于第三阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天

线端口的第一信息并进行反馈。

结合第一方面，在第五种可能的实现方式中，第一准则为吞吐量；

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备在 M 个天线端口中选择使得吞吐量小于等于或大于等于第四阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第一方面，在第六种可能的实现方式中，第一准则为 SU/MU 传输方式；

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备在 M 个天线端口中选择 SU 传输最优的第一组天线端口，所述的第一组天线端口包含 N1 个天线端口，得到所述 N1 个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在 M 个天线端口中选择 MU 传输最优的第二组天线端口，所述的第二组天线端口包含 N2 个天线端口，得到所述 N2 个天线端口的第一信息并进行反馈。

结合第一方面，在第七种可能的实现方式中，第一准则为传输模式；所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备在 M 个天线端口中选择传输模式是发射分集传输的最优的第一组天线端口，所述的第一组天线端口包含 N1 个天线端口，得到所述 N1 个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在 M 个天线端口中选择传输模式是波束赋型传输的最优的第二组天线端口，所述的第一组天线端口包含 N2 个天线端口，得到所述 N2 个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在 M 个天线端口中选择传输模式是空间复用传输的最优的第三组天线端口，所述的第三组天线端口包含 N3 个天线端口，得到所述 N3 个天线端口的第一信息并进行反馈。

结合第一方面，在第八种可能的实现方式中，所述第一准则为码本信息；

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备在 M 个天线端口中选择采用其对应的第一码本信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第一方面，在第九种可能的实现方式中，所述第一准则为码本信息；

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备在 M 个天线端口中选择轮询第一码本中的所有码字使得平均信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第一方面，在第十种可能的实现方式中，所述第一准则为码本信息；

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备在 M 个天线端口中选择轮询第一码本中的所有码字使得其中最好的信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第一方面，在第十一种可能的实现方式中，所述第一准则为数据包信息；

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备在 M 个天线端口中选择传输第一数据包传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在 M 个天线端口中选择传输第一数据包最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在 M 个天线端口中选择传输第一数据包达到一定性能要求的最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第一方面或第一方面的第一种可能的实现方式或第一方面的第二种可能的实现方式或第一方面的第三种可能的实现方式或第一方面的第四种可能的实现方式或第一方面的第五种可能的实现方式或第一方面的第六种可能的实现方式或第一方面的第七种可能的实现方式或第一方面的第八种可能的

实现方式或第一方面的第九种可能的实现方式或第一方面的第十种可能的实现方式或第一方面的第十一种可能的实现方式，在第十二种可能的实现方式中，所述第一准则或者所述第一阈值，第二阈值，第三阈值和第四阈值为所述第二网络设备通过广播信息，高层信令或者动态信令配置的。

结合第一方面或第一方面的第一种可能的实现方式或第一方面的第二种可能的实现方式或第一方面的第三种可能的实现方式或第一方面的第四种可能的实现方式或第一方面的第五种可能的实现方式或第一方面的第六种可能的实现方式或第一方面的第七种可能的实现方式或第一方面的第八种可能的实现方式或第一方面的第九种可能的实现方式或第一方面的第十种可能的实现方式或第一方面的第十一种可能的实现方式或第一方面的第十二种可能的实现方式，在第十三种可能的实现方式中，所述 M 个天线端口对应于 X 个信道状态信息处理进程 CSI process，N 个天线端口对应于所述 X 个 CSI process 中的一个 CSI process，其中，X 为正整数。

结合第一方面或第一方面的第一种可能的实现方式或第一方面的第二种可能的实现方式或第一方面的第三种可能的实现方式或第一方面的第四种可能的实现方式或第一方面的第五种可能的实现方式或第一方面的第六种可能的实现方式或第一方面的第七种可能的实现方式或第一方面的第八种可能的实现方式或第一方面的第九种可能的实现方式或第一方面的第十种可能的实现方式或第一方面的第十一种可能的实现方式或第一方面的第十二种可能的实现方式或第一方面的第十三种可能的实现方式，在第十四种可能的实现方式中，所述第一信息包括天线相关信息，或者所述 N 个天线端口对应的信道状态信息 CSI，或者所述 N 个天线端口的索引信息。

第二方面，提供了一种信号发送方法，包括:

第二网络设备向第一网络设备发送 M 个天线端口的信号，其中，M 为正整数;

所述第二网络设备接收所述第一网络设备根据第一准则反馈的所述 M 个天线端口中的 N 个天线端口的第一信息，N 为小于等于 M 的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少

一种。

在第一种可能的实现方式中，所述第一信息包括天线相关信息；

所述方法，还包括：

所述第二网络设备根据所述天线相关信息确定所述 N 个天线端口为所选择的天线端口。

结合第二方面，在第二种可能的实现方式中，所述第一信息包括所述 N 个天线端口对应的信道状态信息 CSI，或者所述 N 个天线端口的索引信息。

结合第二方面或第二方面的第一种可能的实现方式或第二方面的第二种可能的实现方式，在第三种可能的实现方式中，所述第二网络设备通过广播信息、高层信令或动态信令配置所述第一准则，第一阈值，第二阈值，第三阈值或者第四阈值。

第三方面，提供了一种第一网络设备，包括：

接收单元，用于接收第二网络设备发送的 M 个天线端口的信号，其中，M 为正整数；

反馈单元，用于根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，N 为小于等于 M 的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种。

在第一种可能的实现方式中，所述第一准则为天线相关信息；

所述反馈单元具体用于：

根据测量的所述 M 个天线端口的天线相关信息，进行小区选择，其中 M 个天线端口对应至少两个小区或者两个传输节点，每个所述小区或传输节点对应至少两个天线端口。

结合第三方面的第一种可能的实现方式，在第二种可能的实现方式中，所述反馈单元执行所述根据测量的所述 M 个天线端口的天线相关信息，进行小区选择，的步骤，具体为：

所述第一网络设备根据测量的所述 M 个天线端口的天线相关信息与第一阈值的比较结果，选择所述 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第三方面，在第三种可能的实现方式中，所述第一准则为信噪比 SNR;

所述反馈单元具体用于:

在 M 个天线端口中选择使得波束赋型或者发射分集后的 SNR 小于等于或大于等于第二阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第三方面，在第四种可能的实现方式中，第一准则为信道容量;

所述反馈单元具体用于:

在 M 个天线端口中选择使得信道容量小于等于或大于等于第三阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第三方面，在第五种可能的实现方式中，第一准则为吞吐量;

所述反馈单元具体用于:

在 M 个天线端口中选择使得吞吐量小于等于或大于等于第四阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第三方面，在第六种可能的实现方式中，第一准则为 SU/MU 传输方式;

所述反馈单元具体用于:

在 M 个天线端口中选择 SU 传输最优的第一组天线端口，所述的第一组天线端口包含 N1 个天线端口，得到所述 N1 个天线端口的第一信息并进行反馈; 和/或

在 M 个天线端口中选择 MU 传输最优的第二组天线端口，所述的第二组天线端口包含 N2 个天线端口，得到所述 N2 个天线端口的第一信息并进行反馈。

结合第三方面，在第七种可能的实现方式中，第一准则为传输模式;

所述反馈单元具体用于:

在 M 个天线端口中选择传输模式是发射分集传输的最优的第一组天线端口，所述的第一组天线端口包含 N1 个天线端口，得到所述 N1 个天线端口的第一信息并进行反馈; 和/或

在 M 个天线端口中选择传输模式是波束赋型传输的最优的第二组天线端

口，所述的第一组天线端口包含 N2 个天线端口，得到所述 N2 个天线端口的第一信息并进行反馈；和/或

在 M 个天线端口中选择传输模式是空间复用传输的最优的第三组天线端口，所述的第三组天线端口包含 N3 个天线端口，得到所述 N3 个天线端口的第一信息并进行反馈。

结合第三方面，在第八种可能的实现方式中，所述第一准则为码本信息；

所述反馈单元具体用于：

在 M 个天线端口中选择采用其对应的第一码本信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第三方面，在第九种可能的实现方式中，所述第一准则为码本信息；

所述反馈单元具体用于：

在 M 个天线端口中选择轮询第一码本中的所有码字使得平均信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第三方面，在第十种可能的实现方式中，所述第一准则为码本信息；

所述反馈单元具体用于：

在 M 个天线端口中选择轮询第一码本中的所有码字使得其中最好的信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第三方面，在第十一种可能的实现方式中，所述第一准则为数据包信息；

所述反馈单元具体用于：

在 M 个天线端口中选择传输第一数据包传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈；和/或

在 M 个天线端口中选择传输第一数据包最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在 M 个天线端口中选择传输第一数据包达到一定性能要求的最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第三方面或第三方面的第一种可能的实现方式或第三方面的第二种可能的实现方式或第三方面的第三种可能的实现方式或第三方面的第四种可能的实现方式或第三方面的第五种可能的实现方式或第三方面的第六种可能

的实现方式或第三方面的第七种可能的实现方式或第三方面的第八种可能的实现方式或第三方面的第九种可能的实现方式或第三方面的第十种可能的实现方式或第三方面的第十一种可能的实现方式，在第十二种可能的实现方式中，所述第一准则或者所述第一阈值，第二阈值，第三阈值和第四阈值为所述第二网络设备通过广播信息，高层信令或者动态信令配置的。

结合第三方面或第三方面的第一种可能的实现方式或第三方面的第二种可能的实现方式或第三方面的第三种可能的实现方式或第三方面的第四种可能的实现方式或第三方面的第五种可能的实现方式或第三方面的第六种可能的实现方式或第三方面的第七种可能的实现方式或第三方面的第八种可能的实现方式或第三方面的第九种可能的实现方式或第三方面的第十种可能的实现方式或第三方面的第十一种可能的实现方式或第三方面的第十二种可能的实现方式，在第十三种可能的实现方式中，所述 M 个天线端口对应于 X 个信道状态信息处理进程 CSI process，N 个天线端口对应于所述 X 个 CSI process 中的一个 CSI process，其中，X 为正整数。

结合第三方面或第三方面的第一种可能的实现方式或第三方面的第二种可能的实现方式或第三方面的第三种可能的实现方式或第三方面的第四种可能的实现方式或第三方面的第五种可能的实现方式或第三方面的第六种可能的实现方式或第三方面的第七种可能的实现方式或第三方面的第八种可能的实现方式或第三方面的第九种可能的实现方式或第三方面的第十种可能的实现方式或第三方面的第十一种可能的实现方式或第三方面的第十二种可能的实现方式或第三方面的第十三种可能的实现方式，在第十四种可能的实现方式中，所述第一信息包括天线相关信息，或者所述 N 个天线端口对应的信道状态信息 CSI，或者所述 N 个天线端口的索引信息。

第四方面，提供了一种第二网络设备，包括:

发送单元，用于向第一网络设备发送 M 个天线端口的信号，其中，M 为正整数;

接收单元，用于接收所述第一网络设备根据第一准则反馈的所述 M 个天线端口中的 N 个天线端口的第一信息，N 为小于等于 M 的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU

（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种。

在第一种可能的实现方式中，所述第一信息包括天线相关信息；

所述第二网络设备，还包括：

确定单元，用于根据所述天线相关信息确定所述 N 个天线端口为所选择的天线端口。

结合第四方面，在第二种可能的实现方式中，所述第一信息包括所述 N 个天线端口对应的信道状态信息 CSI，或者所述 N 个天线端口的索引信息。

结合第四方面或第四方面的第一种可能的实现方式或第四方面的第二种可能的实现方式，在第五种可能的实现方式中，所述发送单元还用于通过广播信息、高层信令或动态信令配置所述第一准则，第一阈值，第二阈值，第三阈值或者第四阈值。

第五方面，提供了一种第一网络设备，包括：接收器和发送器；

接收器，用于接收第二网络设备发送的 M 个天线端口的信号，其中，M 为正整数；

发送器，用于根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，N 为小于等于 M 的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种。

在第一种可能的实现方式中，所述第一准则为天线相关信息；

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息的步骤，具体为：

根据测量的所述 M 个天线端口的天线相关信息，进行小区选择，其中 M 个天线端口对应至少两个小区或者两个传输节点，每个所述小区或传输节点对应至少两个天线端口。

结合第五方面的第一种可能的实现方式，在第二种可能的实现方式中，所述发送器执行所述根据测量的所述 M 个天线端口的天线相关信息，进行小区选择的步骤，具体为：

所述第一网络设备根据测量的所述 M 个天线端口的天线相关信息与第一

阈值的比较结果，选择所述 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第五方面，在第三种可能的实现方式中，所述第一准则为信噪比 SNR;

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息的步骤，具体为:

在 M 个天线端口中选择使得波束赋型或者发射分集后的 SNR 小于等于或大于等于第二阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第五方面，在第四种可能的实现方式中，第一准则为信道容量;

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息的步骤，具体为:

在 M 个天线端口中选择使得信道容量小于等于或大于等于第三阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第五方面，在第五种可能的实现方式中，第一准则为吞吐量;

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息的步骤，具体为:

所述第一网络设备在 M 个天线端口中选择使得吞吐量小于等于或大于等于第四阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第五方面，在第六种可能的实现方式中，第一准则为 SU/MU 传输方式;

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息的步骤，具体为:

在 M 个天线端口中选择 SU 传输最优的第一组天线端口，所述的第一组天线端口包含 N1 个天线端口，得到所述 N1 个天线端口的第一信息并进行反馈; 和/或

在 M 个天线端口中选择 MU 传输最优的第二组天线端口，所述的第二组天线端口包含 N2 个天线端口，得到所述 N2 个天线端口的第一信息并进行反馈。

结合第五方面，在第七种可能的实现方式中，第一准则为传输模式;

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息的步骤，具体为:

在 M 个天线端口中选择传输模式是发射分集传输的最优的第一组天线端口，所述的第一组天线端口包含 N1 个天线端口，得到所述 N1 个天线端口的第一信息并进行反馈; 和/或

在 M 个天线端口中选择传输模式是波束赋型传输的最优的第二组天线端口，所述的第一组天线端口包含 N2 个天线端口，得到所述 N2 个天线端口的第一信息并进行反馈; 和/或

在 M 个天线端口中选择传输模式是空间复用传输的最优的第三组天线端口，所述的第三组天线端口包含 N3 个天线端口，得到所述 N3 个天线端口的第一信息并进行反馈。

结合第五方面，在第八种可能的实现方式中，所述第一准则为码本信息;

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息的步骤，具体为:

在 M 个天线端口中选择采用其对应的第一码本信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第五方面，在第九种可能的实现方式中，所述第一准则为码本信息;

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息的步骤，具体为:

在 M 个天线端口中选择轮询第一码本中的所有码字使得平均信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第五方面，在第十种可能的实现方式中，所述第一准则为码本信息;

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息的步骤，具体为:

在 M 个天线端口中选择轮询第一码本中的所有码字使得其中最好的信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第五方面，在第十一种可能的实现方式中，所述第一准则为数据包信息;

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息的步骤，具体为：

在 M 个天线端口中选择传输第一数据包传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈；和/或

在 M 个天线端口中选择传输第一数据包最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈；和/或

在 M 个天线端口中选择传输第一数据包达到一定性能要求的最少的 N 个天线端口，例如一定误码率的最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

结合第五方面或第五方面的第一种可能的实现方式或第五方面的第二种可能的实现方式或第五方面的第三种可能的实现方式或第五方面的第四种可能的实现方式或第五方面的第五种可能的实现方式或第五方面的第六种可能的实现方式或第五方面的第七种可能的实现方式或第五方面的第八种可能的实现方式或第五方面的第九种可能的实现方式或第五方面的第十种可能的实现方式或第五方面的第十一种可能的实现方式，在第十二种可能的实现方式中，所述第一准则或者所述第一阈值，第二阈值，第三阈值和第四阈值为所述第二网络设备通过广播信息，高层信令或者动态信令配置的。

结合第五方面或第五方面的第一种可能的实现方式或第五方面的第二种可能的实现方式或第五方面的第三种可能的实现方式或第五方面的第四种可能的实现方式或第五方面的第五种可能的实现方式或第五方面的第六种可能的实现方式或第五方面的第七种可能的实现方式或第五方面的第八种可能的实现方式或第五方面的第九种可能的实现方式或第五方面的第十种可能的实现方式或第五方面的第十一种可能的实现方式或第五方面的第十二种可能的实现方式，在第十三种可能的实现方式中，所述 M 个天线端口对应于 X 个信道状态信息处理进程 CSI process，N 个天线端口对应于所述 X 个 CSI process 中的一个 CSI process，其中，X 为正整数。

结合第五方面或第五方面的第一种可能的实现方式或第五方面的第二种可能的实现方式或第五方面的第三种可能的实现方式或第五方面的第四种可能的实现方式或第五方面的第五种可能的实现方式或第五方面的第六种可能的实现方式或第五方面的第七种可能的实现方式或第五方面的第八种可能的

实现方式或第五方面的第九种可能的实现方式或第五方面的第十种可能的实现方式或第五方面的第十一种可能的实现方式或第五方面的第十二种可能的实现方式或第五方面的第十三种可能的实现方式，在第十四种可能的实现方式中，所述第一信息包括天线相关信息，或者所述 N 个天线端口对应的信道状态信息 CSI，或者所述 N 个天线端口的索引信息。

第六方面，提供了一种第二网络设备，包括：发送器和接收器；

发送器，用于向第一网络设备发送 M 个天线端口的信号，其中，M 为正整数；

接收器，用于接收所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，N 为小于等于 M 的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种。

在第一种可能的实现方式中，所述第一信息包括天线相关信息；

所述第二网络设备，还包括：控制器；

控制器，用于根据所述天线相关信息确定所述 N 个天线端口为所选择的天线端口。

结合第六方面，在第二种可能的实现方式中，所述第一信息包括所述 N 个天线端口对应的信道状态信息 CSI，或者所述 N 个天线端口的索引信息。

结合第六方面或第六方面的第一种可能的实现方式或第六方面的第二种可能的实现方式，在第三种可能的实现方式中，所述发送器还用于通过广播信息、高层信令或动态信令配置所述第一准则，第一阈值，第二阈值，第三阈值或者第四阈值。

可见，根据本发明实施例提供的一种信号发送方法及相关设备，通过根据天线相关信息、SNR、信道容量、吞吐量、单用户/多用户传输方式、传输模式、码本信息或数据包大小中的至少一种进行最优天线配置，进行了更有效的天线选择。

附图说明

为了更清楚地说明本发明实施例或现有技术中的技术方案，下面将对实施例中所需要使用的附图作简单地介绍，显而易见地，下面描述中的附图仅仅是本发明的一些实施例，对于本领域普通技术人员来讲，在不付出创造性劳动的前提下，还可以根据这些附图获得其他的附图。

图 1 为本发明实施例提供的一种信号发送方法的流程图；

图 2 为示例的有源天线阵列中的多个天线配置示意图；

图 3 为本发明实施例提供的另一种信号发送方法的流程图；

图 4 为本发明实施例提供的又一种信号发送方法的流程图；

图 5 为本发明实施例提供的一种第一网络设备的结构示意图；

图 6 为本发明实施例提供的一种第二网络设备的结构示意图；

图 7 为本发明实施例提供的另一种第二网络设备的结构示意图；

图 8 为本发明实施例提供的另一种第一网络设备的结构示意图；

图 9 为本发明实施例提供的又一种第二网络设备的结构示意图；

图 10 为本发明实施例提供的又一种第二网络设备的结构示意图。

具体实施方式

下面将结合本发明实施例中的附图，对本发明实施例中的技术方案进行清楚、完整地描述，显然，所描述的实施例仅仅是本发明一部分实施例，而不是全部的实施例。基于本发明中的实施例，本领域普通技术人员在没有作出创造性劳动前提下所获得的所有其他实施例，都属于本发明保护的范围。

请参阅图 1，为本发明实施例提供的一种信号发送方法的流程图，该方法包括以下步骤：

步骤 S101，第一网络设备接收第二网络设备发送的 M 个天线端口的信号，其中，M 为正整数。

在进行天线配置时，第二网络设备给第一网络设备发送 M 个天线端口的配置信息，并将 M 个天线端口的信号发送给第一网络设备，第一网络设备根据配置信息接收第二网络设备发送的 M 个天线端口的信号，其中，M 为正整数，在本实施例中，第一网络设备可以是用户设备(User Equipment，UE)，第二网络设备可以是基站；或者第一网络设备可以是用户设备，第二网络设备可以是用户设备；或者第一网络设备可以是基站，第二网络设备可以是基站。

所述的基站可以是宏站，低功率节点 pico 或者射频拉远单元 RRH。

M 个天线端口的配置信息包括天线端口的图案，即天线端口的时频资源的位置、天线端口信号的发送周期、功率等信息。

第二网络设备可以只发送一个配置信息给第一网络设备，该配置信息是 M 个天线端口的配置信息，或者将 M 个天线端口分成多个组，以多个配置信息的形式发送给第一网络设备，每个配置信息对应其中一个天线端口组的配置。

步骤 S102，所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，N 为小于等于 M 的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种。

第一网络设备需根据一定的准则从 M 个天线端口中选择 N 个天线端口，并将选择的 N 个天线端口的第一信息通知第二网络设备，在这里，第一信息为 N 个天线端口对应的信道状态信息 CSI 或者 N 个天线端口对应的索引信息；或者将 N 个天线端口的第一信息发送给第二网络设备，由第二网络设备确定该 N 个天线端口，在这里，第一信息为天线相关信息。

下面通过具体的实施方式介绍如何根据各种第一准则反馈 M 个天线端口中的 N 个天线端口的第一信息：

作为一种实施方式，所述第一准则为天线相关信息；

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备根据测量的所述 M 个天线端口的天线相关信息，进行小区选择，其中 M 个天线端口对应至少两个小区或者两个传输节点，每个所述小区或传输节点对应至少两个天线端口。

现有技术中，进行小区选择仅考虑根据接收信号功率信息例如 RSRP，RSSI，RSRQ 进行选择，本实施例中，还考虑天线相关性进行小区选择，使得用户能根据自己的业务更全面的考虑小区或者传输节点的选择。

具体实现中，所述第一网络设备根据测量的所述 M 个天线端口的天线相关信息，进行小区选择，具体为：

例如 M=10，对应 5 个小区，每个小区有 2 个天线，小区 1 对应 port0，port1，

小区 1 对应 port2，port3，小区 1 对应 port4，port5，小区 1 对应 port6，port7，小区 1 对应 port8，port9;

UE 测量和这 5 个小区的分别对应的 5 组天线端口，发现小区 1 对应的 port0,1 的接收信号功率最强，例如 RSRP1>RSRP2>RSRP3>RSRP4>RSRP5，RSRP1 代表小区 1 对应的接收信号功率，RSRP2 代表小区 2 对应的接收信号功率，RSRPn 代表小区 n 对应的接收信号功率。但是如果假设第一准则是天线相关信息，并且要求天线相关信息越大越好，则定义天线相关系数为 Cor，例如，小区 1 的天线相关系数 Cor1 为 port0 和 port1 的天线相关性，可以采用信道估计获得 port0 对应的信道系数 H0，port1 对应的信道系数 H1，并计算 H0，H1 的相关来获得 Cor1，例如相关矩阵可以由 $H=[H_0 \quad H_1]$，$R=H^{H}H$ 获得；或者根据 $R_{ik}=\frac{1}{2\Delta}\int_{\theta-\Delta}^{\theta+\Delta}\exp[jz(i-k)\sin\beta]d\beta$ 获得。

其中 i，k 分别为第 i 和第 k 个天线，Δ为角度扩展。

同样方法得到 Cor2，Cor3，Cor4，Cor5，Corn 代表小区 n 对应的天线相关系数。

并且 Cor2> Cor1> Cor3> Cor4> Cor5，则虽然小区 1 的接收信号功率最强，但是综合考虑信号功率和天线相关性，小区 2 最终被 UE 选择，并且驻留在小区 2。

这里第一准则不限定于天线相关性，还可以是 SU/MU,信号传输模式等，并且第一准则可以为预定义的，或者基站广播或者 UE 特定的信令通知。

具体地，所述第一网络设备根据测量的所述 M 个天线端口的天线相关信息，进行小区选择，具体为：所述第一网络设备根据测量的所述 M 个天线端口的天线相关信息与第一阈值的比较结果，选择所述 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

即将 M 个天线端口的相关矩阵或相关系数与设定阈值进行比较，选择相关矩阵或相关系数大于等于或小于等于设定阈值的 N 个天线端口，得到 N 个天线端口对应的信道状态信息(Channel State Singal，CSI)或 N 个天线端口的索引信息，并将这 N 个天线端口对应的 CSI 或 N 个天线端口对应的索引信息通知第二网络设备，以使第二网络设备在该 N 个天线端口给第一网络设备发送数据。

作为另一种实施方式，所述第一准则为信噪比 SNR;

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为:

所述第一网络设备在 M 个天线端口中选择使得波束赋型或者发射分集后的 SNR 小于等于或大于等于第二阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

例如，基站配置给 UE M 个天线端口，如图 2 示例的另一个天线阵列中的多个天线示意图，M=88，UE 在 M 个端口中遍历所有的 N=1 到 N=88 的天线端口组合，对于每个 N 的取值，需要遍历的组合数为 c，例如对于 N=4，组合有组合 1 为 a11，a12，a13，a14，组合 2 为 a12，a13，a14， a15，组合 3 为，a13，a14，a15，a16，组合 4 为 a14，a15，a16，a17，组合 5 为 a15，a16，a17，a18，组合 6 为 b11，b12，b13，b14，...对于每个组合，例如组合 1 a11，a12，a13，a14，UE 通过 a11，a12，a13，a14 得到信道 $H_{N,1}$，然后遍历所有的预编码矩阵 w_i，得到信噪比:

$$SNR_{N,\ m,\ i}=\frac{\left|H_{n,m}W_i\right|^2}{\sigma^2}$$

其中 $H_{N,\ m}$ 表示 N 个天线端口组合情况下的第 m 个配置，Wi 表示第 i 个预编码矩阵，σ^2 为噪声;

遍历所有的 N 端口组合情况下的所有 SNR,找到最大的，例如 max（$SNR_{N,\ m,\ i}, N=4, 1\le m\le C_M^4, 1\le i\le X_4$）=5dB，$X_4$ 表示 N=4 的情况下的预编码矩阵的个数。对于 N=5，采用上述同样的方法进行遍历，max（$SNR_{N,\ m,\ i}, N=5, 1\le m\le C_M^5, 1\le i\le X_5$）=7dB，如果基站通知 UE 天线选择的第一准则为 SNR 要大于等于 6dB 的最少数目的天线，则 N=5 恰巧可以到 6dB，并且是达到 6dB 所需要的天线数目最少的，。因此 UE 可以将 N=5 的达到 7dB 的天线组合的标号，例如，a11，b12，c14，d11，对应的索引反馈给基站。采用 N>5,得到的信噪比会比 N=5 更高，但是对于某些信道，只需达到一定的 SNR 性能要求即可，无需更大的 SNR，采用更多的天线，会导致基站浪费发射功率。

作为又一种实施方式，第一准则为信道容量;

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备在 M 个天线端口中选择使得信道容量小于等于或大于等于第三阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

由于信道容量 C=Blog2(1+SNR)，本实施方式中，根据信道容量进行天线端口的选择的过程与上面实施方式中根据 SNR 进行天线端口的选择的过程类似，在此不再赘述。

作为又一种实施方式，第一准则为吞吐量；

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备在 M 个天线端口中选择使得吞吐量小于等于或大于等于第四阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

同样地，本实施方式中，根据吞吐量进行天线端口的选择的过程与上面实施方式中根据 SNR 或信道容量进行天线端口的选择的过程类似，在此不再赘述。

作为又一种实施方式，第一准则为 SU/MU 传输方式；

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备在 M 个天线端口中选择 SU 传输最优的第一组天线端口，所述的第一组天线端口包含 N1 个天线端口，得到所述 N1 个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在 M 个天线端口中选择 MU 传输最优的第二组天线端口，所述的第二组天线端口包含 N2 个天线端口，得到所述 N2 个天线端口的第一信息并进行反馈。

在本实施方式中，例如，基站配置 UE 按照 SU 传输最优的方式选择天线，则 UE 遍历所有天线，根据使得 UE 自己的性能达到最优的方式选择天线，例

如选择了天线 a11，b13，g15，h18，则将 a11，b13，g15，h18 的天线索引信息上报给基站。

又例如，基站配置 UE1 按照 MU 配对最优的方式选择天线，基站可以将配对用户的信息，例如与 UE1 配对的用户 UE2，UE3 的信息，包括 UE2 的，UE3 的天线信息通知给 UE1，UE1 根据使得配对后的所有用户的总的性能最优的方式选择天线，例如选择天线 c13，d12，e11，f18，将其对应的天线索引信息通知给基站。

也可以同时反馈根据 SU 传输最优的一组天线端口的信息和根据 MU 传输最优的一组天线端口的信息。例如 SU 可以选择交叉极化的天线，天线的相关性小，有利于空间复用；而 MU 配对时，每个用户最好选择同极化的天线，有利用每个用户的波束赋型。其中所述的 SU 为用户单独在一个时频资源上发送自己的数据包，MU 为多个用户可以在相同的时频资源上通过空间复用的方式进行发送各自的数据包。

作为又一种实施方式，第一准则为传输模式；

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备在 M 个天线端口中选择传输模式是发射分集传输的最优的第一组天线端口，所述的第一组天线端口包含 N1 个天线端口，得到所述 N1 个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在 M 个天线端口中选择传输模式是波束赋型传输的最优的第二组天线端口，所述的第一组天线端口包含 N2 个天线端口，得到所述 N2 个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在 M 个天线端口中选择传输模式是空间复用传输的最优的第三组天线端口，所述的第三组天线端口包含 N3 个天线端口，得到所述 N3 个天线端口的第一信息并进行反馈。

作为又一种实施方式，所述第一准则为码本信息；

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备在 M 个天线端口中选择采用其对应的第一码本信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

码本信息是指：包含多个预编码矩阵的信息；

作为又一种实施方式，所述第一准则为码本信息；

例如将M个天线端口分成X组，基站给每组天线端口单独配置一个码本集合。用户设备根据这个配置的码本集合计算SNR，并且反馈给基站设备。例如第一组天线端口对应于天线配置1，包括天线端口port0，port1，基站为天线配置1配置码本集合C1，C1包括的预编码矩阵为（W_{11}, W_{12}, W_{1n}, ...W_{1N}）,第二组天线端口对应与天线配置2，包括天线端口port2，port3，为天线配置2配置码本集合C2，C2包括的预编码矩阵为（W_{21}, W_{22}, W_{2n}, ...W_{2N}），第三组天线端口对应于天线配置3，包括天线端口port4，port5，为天线配置3配置码本集合C3，C3包括的预编码矩阵为（W_{31}, W_{32}, W_{3n}, ...W_{3N}），第四组天线端口对应于天线配置4，包括天线端口port6，port7，为天线配置4配置码本集合C4，C4包括的预编码矩阵为（W_{41}, W_{42}, W_{4n}, ...W_{4N}）。用户设备根据各个天线配置的对应的天线端口在其对应的码本集合Ci内反馈一个最优的秩(rank)，PMI（i）和SNR（i），基站比较各个SNR（i）选择一个最好的天线给用户设备进行配置；或者UE比较各个SNR（i），选择一个最好天线配置并将其对应的第一信息，反馈给基站，第一信息包括天线的索引和或CSI反馈给基站。例如，UE分别测量四组天线端口,得到第三组天线端口port4，port5，在C3包括的预编码矩阵为（W_{31}, W_{32}, W_{3n}, ...W_{3N}）内进行遍历，得到的最优的SNR高于其他三组天线端口，因此UE将第三组天线端口对应的索引反馈给基站。给每组天线端口配置一个码本集合，用户设备根据这个码本集合计算SNR,并且反馈给基站设备。例如给天线配置1配置码本集合C1，给天线配置2配置码本集合C2，给天线配置3配置码本集合C3，给天线配置4配置码本集合C4。用户设备在RRM测量时，根据各个天线配置的导频在其对应的码本集合Ci内，采用随机波束赋形(random beamforming)的方式，计算平均参考信号接收功率(Reference Signal Receiving Power，RSRP)，或者参考信号接收质量(Reference Signal Receiving Quality，RSRQ)进行上报，例如用户设备在天线配置1的导频，采用C1内所有的码本进行随机beamforming的方式，得到RSRP1，天线配置2的导频，采用C2内所有的

码本进行随机beamforming的方式，得到RSRP2，...UE将RSRP最大的天线配置对应的索引反馈给基站。

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备在 M 个天线端口中选择轮询第一码本中的所有码字使得平均信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

作为又一种实施方式，所述第一准则为码本信息；

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备在 M 个天线端口中选择轮询第一码本中的所有码字使得其中最好的信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

作为又一种实施方式，所述第一准则为数据包信息，所述的数据包信息包括传输块大小，调制编码方式；

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备在 M 个天线端口中选择传输第一数据包传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在 M 个天线端口中选择传输第一数据包最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在 M 个天线端口中选择传输第一数据包达到一定性能要求的最少的 N 个天线端口，例如一定误码率的最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

需要说明的是，在以上实施例中，第一准则，第一阈值，第二阈值，第三阈值和第四阈值为第二网络设备通过广播信息，高层信令或者动态信令配置

的。

M 个天线端口对应于 X 个信道状态信息处理进程(CSI process)，N 个端口对应于 X 个 CSI process 中的一个 CSI process，其中，X 为正整数。每个 CSI process 对应一定的测量资源，例如每个 CSI process 配置一个信号测量资源和干扰测量资源，UE 根据信号测量资源和干扰测量资源获得 CSI 进行上报。例如，M=20，对应 5 个 CSI process，则每 4 个天线端口对应 1 个 CSI process，N=4。

可见，根据本发明实施例提供的一种信号发送方法，通过根据天线相关信息、SNR、信道容量、吞吐量、单用户/多用户传输方式、传输模式、码本信息或数据包大小中的至少一种进行最优天线配置，进行了更有效的天线选择。

请参阅图3，为本发明实施例提供的另一种信号发送方法的流程图，该方法包括以下步骤:

步骤S201，第二网络设备向第一网络设备发送M个天线端口的信号，其中，M为正整数。

在进行天线配置时,第二网络设备给第一网络设备发送M个天线端口的配置信息，并将M个天线端口的信号发送给第一网络设备，第一网络设备根据配置信息接收第二网络设备发送的M个天线端口的信号，其中，M为正整数，在本实施例中，第一网络设备可以是用户设备(User Equipment，UE)，第二网络设备可以是基站; 或者第一网络设备可以是用户设备，第二网络设备可以是用户设备; 或者第一网络设备可以是基站，第二网络设备可以是基站。

所述的基站可以是宏站，低功率节点pico或者射频拉远单元RRH。

M个天线端口的配置信息包括天线端口的图案,即天线端口的时频资源的位置、天线端口信号的发送周期、功率等信息。

第二网络设备可以只发送一个配置信息给第一网络设备,该配置信息是M个天线端口的配置信息，或者将M个天线端口分成多个组，以多个配置信息的形式发送给第一网络设备，每个配置信息对应其中一个天线端口组的配置。

步骤S202，所述第二网络设备接收所述第一网络设备根据第一准则反馈的所述M个天线端口中的N个天线端口的第一信息，N为小于等于M的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单

用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种。

第一网络设备需根据一定的准则从M个天线端口中选择N个天线端口，并将选择的N个天线端口的第一信息通知第二网络设备，在这里，第一信息为N个天线端口对应的信道状态信息CSI或者N个天线端口对应的索引信息；或者将N个天线端口的第一信息发送给第二网络设备，由第二网络设备确定该N个天线端口，在这里，第一信息为天线相关信息。

第二网络设备通过广播信息、高层信令或动态信令配置第一准则，第一阈值，第二阈值，第三阈值或者第四阈值。

可见，根据本发明实施例提供的一种信号发送方法，第一网络设备通过根据天线相关信息、SNR、信道容量、吞吐量、单用户/多用户传输方式、传输模式、码本信息或数据包大小中的至少一种进行最优天线配置，将得到的天线相关信息，或者所述N个天线端口对应的信道状态信息CSI，或者所述N个天线端口的索引信息反馈给第二网络设备，使得第一网络设备进行了更有效的天线选择。

请参阅图4，为本发明实施例提供的又一种信号发送方法的流程图，该方法包括以下步骤：

步骤S301，第二网络设备向第一网络设备发送M个天线端口的信号，其中，M为正整数；

步骤S302，所述第二网络设备接收所述第一网络设备根据第一准则反馈的所述M个天线端口中的N个天线端口的第一信息，N为小于等于M的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种，所述第一信息包括天线相关信息。

步骤S301和步骤S302分别与前述实施例的步骤S201和步骤S202相同，具体地，这里的第一信息包括天线相关信息。

步骤S303，所述第二网络设备根据所述天线相关信息确定所述N个天线端口为所选择的天线端口。

第二网络设备根据天线相关信息确定N个天线端口为所选择的天线端口。

可见，根据本发明实施例提供的一种信号发送方法，第一网络设备通过根据天线相关信息、SNR、信道容量、吞吐量、单用户/多用户传输方式、传输模式、码本信息或数据包大小中的至少一种进行最优天线配置，将得到的天线相关信息反馈给第二网络设备，由第二网络设备确定选择的天线端口，使得第一网络设备进行了更有效的天线选择。

请参阅图5，为本发明实施例提供的一种第一网络设备的结构示意图，该第一网络设备1000包括:

接收单元11，用于接收第二网络设备发送的M个天线端口的信号，其中，M为正整数。

在进行天线配置时，第二网络设备给第一网络设备发送M个天线端口的配置信息，并将M个天线端口的信号发送给第一网络设备，第一网络设备根据配置信息接收第二网络设备发送的M个天线端口的信号，其中，M为正整数，在本实施例中，第一网络设备可以是用户设备(User Equipment，UE)，第二网络设备可以是基站；或者第一网络设备可以是用户设备，第二网络设备可以是用户设备；或者第一网络设备可以是基站，第二网络设备可以是基站。

所述的基站可以是宏站，低功率节点pico或者射频拉远单元RRH。

M个天线端口的配置信息包括天线端口的图案，即天线端口的时频资源的位置、天线端口信号的发送周期、功率等信息。

第二网络设备可以只发送一个配置信息给第一网络设备，该配置信息是M个天线端口的配置信息，或者将M个天线端口分成多个组，以多个配置信息的形式发送给第一网络设备，每个配置信息对应其中一个天线端口组的配置。

反馈单元12，用于根据第一准则反馈所述M个天线端口中的N个天线端口的第一信息，N为小于等于M的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种。

第一网络设备需根据一定的准则从M个天线端口中选择N个天线端口，并将选择的N个天线端口的第一信息通知第二网络设备，在这里，第一信息为N个天线端口对应的信道状态信息CSI或者N个天线端口对应的索引信息；或者将N个天线端口的第一信息发送给第二网络设备，由第二网络设备确定该N个

天线端口，在这里，第一信息为天线相关信息。

下面通过具体的实施方式介绍反馈单元12如何根据各种第一准则反馈M个天线端口中的N个天线端口的第一信息:

作为一种实施方式，所述第一准则为天线相关信息;

反馈单元12具体用于根据测量的所述M个天线端口的天线相关信息，进行小区选择，其中M个天线端口对应至少两个小区或者两个传输节点，每个所述小区或传输节点对应至少两个天线端口。

现有技术中，进行小区选择仅考虑根据接收信号功率信息例如RSRP，RSSI，RSRQ进行选择，本实施例中，还考虑天线相关性进行小区选择，使得用户能根据自己的业务更全面的考虑小区或者传输节点的选择。

具体实现中，所述第一网络设备根据测量的所述M个天线端口的天线相关信息，进行小区选择，具体为:

例如M=10，对应5个小区，每个小区有2个天线，小区1对应port0，port1，小区1对应port2，port3，小区1对应port4，port5，小区1对应port6，port7，小区1对应port8，port9;

UE测量和这5个小区的分别对应的5组天线端口，发现小区1对应的port0,1的接收信号功率最强，例如RSRP1>RSRP2>RSRP3>RSRP4>RSRP5，RSRP1代表小区1对应的接收信号功率，RSRP2代表小区2对应的接收信号功率，RSRPn代表小区n对应的接收信号功率。但是如果假设第一准则是天线相关信息，并且要求天线相关信息越大越好，则定义天线相关系数为Cor，例如，小区1的天线相关系数Cor1为port0和port1的天线相关性，可以采用信道估计获得port0对应的信道系数H0，port1对应的信道系数H1，并计算H0，H1的相关来获得Cor1，例如相关矩阵可以由 $H=[H_0 \quad H_1]$，$R=H^{H}H$ 获得。

或者根据 $R_{ik}=\frac{1}{2\Delta}\int_{\theta-\Delta}^{\theta+\Delta}\exp[jz(i-k)\sin\beta]d\beta$ 获得。

其中i，k分别为第i和第k个天线，Δ为角度扩展。

同样方法得到Cor2，Cor3，Cor4，Cor5，Corn代表小区n对应的天线相关系数。.

并且Cor2> Cor1> Cor3> Cor4> Cor5，则虽然小区1的接收信号功率最强，

但是综合考虑信号功率和天线相关性，小区2最终被UE选择，并且驻留在小区2。

这里第一准则不限定于天线相关性，还可以是SU/MU,信号传输模式等，并且第一准则可以为预定义的，或者基站广播或者UE特定的信令通知。

具体地,反馈单元12执行所述根据测量的所述M个天线端口的天线相关信息，进行小区选择的步骤，具体为：所述第一网络设备根据测量的所述M个天线端口的天线相关信息与第一阈值的比较结果，选择所述N个天线端口，得到所述N个天线端口的第一信息并进行反馈。

即将M个天线端口的相关矩阵或相关系数与设定阈值进行比较,选择相关矩阵或相关系数大于等于或小于等于设定阈值的N个天线端口，得到N个天线端口对应的信道状态信息(Channel State Singal，CSI)或N个天线端口的索引信息,并将这N个天线端口对应的CSI或N个天线端口对应的索引信息通知第二网络设备，以使第二网络设备在该N个天线端口给第一网络设备发送数据。

作为另一种实施方式，所述第一准则为信噪比SNR;

反馈单元12具体用于在M个天线端口中选择使得波束赋型或者发射分集后的SNR小于等于或大于等于第二阈值的天线端口组合中数目最少的N个天线端口，得到所述N个天线端口的第一信息并进行反馈。

例如，基站配置给UE M个天线端口，如图2示例的另一个天线阵列中的多个天线示意图，M=88，UE在M个端口中遍历所有的N=1到N=88的天线端口组合，对于每个N的取值，需要遍历的组合数为c，例如对于N=4，组合有组合1为a11，a12，a13，a14，组合2为a12，a13，a14， a15，组合3为，a13，a14，a15，a16，组合4为a14，a15，a16，a17，组合5为a15，a16，a17，a18，组合6为b11，b12，b13，b14，...对于每个组合，例如组合1 a11，a12，a13，a14，UE通过a11，a12，a13，a14得到信道$H_{N,1}$，然后遍历所有的预编码矩阵w_i，得到信噪比:

$$SNR_{N,\ m,\ i}=\frac{\left|H_{n,m}W_i\right|^2}{\sigma^2}$$

其中$H_{N,\ m}$表示N个天线端口组合情况下的第m个配置，Wi表示第i个预编码矩阵，σ^2为噪声;

遍历所有的N端口组合情况下的所有SNR,找到最大的，例如max（$SNR_{N,m,i}, N=4, 1\le m\le C_M^4, 1\le i\le X_4$）=5dB，$X_4$表示N=4的情况下的预编码矩阵的个数。对于N=5，采用上述同样的方法进行遍历，max（$SNR_{N,m,i}, N=5, 1\le m\le C_M^5, 1\le i\le X_5$）=7dB，如果基站通知UE天线选择的第一准则为SNR要大于等于6dB的最少数目的天线，则N=5恰巧可以到6dB，并且是达到6dB所需要的天线数目最少的，。因此UE可以将N=5的达到7dB的天线组合的标号，例如，a11，b12，c14，d11，对应的索引反馈给基站。采用N>5,得到的信噪比会比N=5更高，但是对于某些信道，只需达到一定的SNR性能要求即可，无需更大的SNR，采用更多的天线，会导致基站浪费发射功率。

作为又一种实施方式，第一准则为信道容量;

反馈单元12具体用于在M个天线端口中选择使得信道容量小于等于或大于等于第三阈值的天线端口组合中数目最少的N个天线端口，得到所述N个天线端口的第一信息并进行反馈。

由于信道容量C=Blog2(1+SNR)，本实施方式中，根据信道容量进行天线端口的选择的过程与上面实施方式中根据SNR进行天线端口的选择的过程类似，在此不再赘述。

作为又一种实施方式，第一准则为吞吐量;

反馈单元12具体用于在M个天线端口中选择使得吞吐量小于等于或大于等于第四阈值的天线端口组合中数目最少的N个天线端口，得到所述N个天线端口的第一信息并进行反馈。

同样地，本实施方式中，根据吞吐量进行天线端口的选择的过程与上面实施方式中根据SNR或信道容量进行天线端口的选择的过程类似，在此不再赘述。

作为又一种实施方式，第一准则为SU/MU传输方式;

反馈单元12具体用于在M个天线端口中选择SU传输最优的第一组天线端口，所述的第一组天线端口包含N1个天线端口，得到所述N1个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在M个天线端口中选择MU传输最优的第二组天线端口，所述的第二组天线端口包含N2个天线端口，得到所述N2个天线端口的第一信息并进行反馈。

在本实施方式中，例如，基站配置UE按照SU传输最优的方式选择天线，则UE遍历所有天线，根据使得UE自己的性能达到最优的方式选择天线，例如选择了天线a11，b13，g15，h18，则将a11，b13，g15，h18的天线索引信息上报给基站。

又例如，基站配置UE1按照MU配对最优的方式选择天线，基站可以将配对用户的信息，例如与UE1配对的用户UE2，UE3的信息，包括UE2的，UE3的天线信息通知给UE1，UE1根据使得配对后的所有用户的总的性能最优的方式选择天线，例如选择天线c13，d12，e11，f18，将其对应的天线索引信息通知给基站。

也可以同时反馈根据SU传输最优的一组天线端口的信息和根据MU传输最优的一组天线端口的信息。例如SU可以选择交叉极化的天线，天线的相关性小，有利于空间复用；而MU配对时，每个用户最好选择同极化的天线，有利用每个用户的波束赋型。其中所述的SU为用户单独在一个时频资源上发送自己的数据包，MU为多个用户可以在相同的时频资源上通过空间复用的方式进行发送各自的数据包。

作为又一种实施方式，第一准则为传输模式；

反馈单元12具体用于在M个天线端口中选择传输模式是发射分集传输的最优的第一组天线端口，所述的第一组天线端口包含N1个天线端口，得到所述N1个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在M个天线端口中选择传输模式是波束赋型传输的最优的第二组天线端口，所述的第一组天线端口包含N2个天线端口，得到所述N2个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在M个天线端口中选择传输模式是空间复用传输的最优的第三组天线端口，所述的第三组天线端口包含N3个天线端口，得到所述N3个天线端口的第一信息并进行反馈。

作为又一种实施方式，所述第一准则为码本信息；

反馈单元12具体用于在M个天线端口中选择采用第一码本信息传输性能最优的N个天线端口，得到所述N个天线端口的第一信息并进行反馈。

码本信息是指：包含多个预编码矩阵的信息；

作为又一种实施方式，所述第一准则为码本信息；

例如将M个天线端口分成X组，基站给每组天线端口单独配置一个码本集合。用户设备根据这个配置的码本集合计算SNR，并且反馈给基站设备。例如第一组天线端口对应于天线配置1，包括天线端口port0，port1，基站为天线配置1配置码本集合C1，C1包括的预编码矩阵为（W_{11}, W_{12}, W_{1n}, ...W_{1N}）,第二组天线端口对应与天线配置2，包括天线端口port2，port3，为天线配置2配置码本集合C2，C2包括的预编码矩阵为（W_{21}, W_{22}, W_{2n}, ...W_{2N}），第三组天线端口对应于天线配置3，包括天线端口port4，port5，为天线配置3配置码本集合C3，C3包括的预编码矩阵为（W_{31}, W_{32}, W_{3n}, ...W_{3N}），第四组天线端口对应于天线配置4，包括天线端口port6，port7，为天线配置4配置码本集合C4，C4包括的预编码矩阵为（W_{41}, W_{42}, W_{4n}, ...W_{4N}）。用户设备根据各个天线配置的对应的天线端口在其对应的码本集合Ci内反馈一个最优的秩(rank)，PMI（i）和SNR（i），基站比较各个SNR（i）选择一个最好的天线给用户设备进行配置；或者UE比较各个SNR（i），选择一个最好天线配置并将其对应的第一信息，反馈给基站，第一信息包括天线的索引和或CSI反馈给基站。例如，UE分别测量四组天线端口,得到第三组天线端口port4，port5，在C3包括的预编码矩阵为（W_{31}, W_{32}, W_{3n}, ...W_{3N}）内进行遍历，得到的最优的SNR高于其他三组天线端口，因此UE将第三组天线端口对应的索引反馈给基站。给每组天线端口配置一个码本集合，用户设备根据这个码本集合计算SNR,并且反馈给基站设备。例如给天线配置1配置码本集合C1，给天线配置2配置码本集合C2，给天线配置3配置码本集合C3，给天线配置4配置码本集合C4。用户设备在RRM测量时，根据各个天线配置的导频在其对应的码本集合Ci内，采用随机波束赋形(random beamforming)的方式，计算平均参考信号接收功率(Reference Signal Receiving Power，RSRP)，或者参考信号接收质量(Reference Signal Receiving Quality，RSRQ)进行上报，例如用户设备在天线配置1的导频，采用C1内所有的码本进

行随机beamforming的方式，得到RSRP1，天线配置2的导频，采用C2内所有的码本进行随机beamforming的方式，得到RSRP2，...UE将RSRP最大的天线配置对应的索引反馈给基站。

反馈单元12具体用于在M个天线端口中选择轮询第一码本中的所有码字使得平均信息传输性能最优的N个天线端口，得到所述N个天线端口的第一信息并进行反馈。

作为又一种实施方式，所述第一准则为码本信息;

反馈单元12具体用于在M个天线端口中选择轮询第一码本中的所有码字使

得其中最好的信息传输性能最优的N个天线端口，得到所述N个天线端口的第一信息并进行反馈。

作为又一种实施方式，所述第一准则为数据包信息，所述的数据包信息包括传输块大小，调制编码方式;

反馈单元12具体用于在M个天线端口中选择传输第一数据包传输性能最优的N个天线端口，得到所述N个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在M个天线端口中选择传输第一数据包最少的N个天线端口，得到所述N个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在M个天线端口中选择传输第一数据包达到一定性能要求的最少的N个天线端口，例如一定误码率的最少的N个天线端口，得到所述N个天线端口的第一信息并进行反馈。

需要说明的是，在以上实施例中，第一准则，第一阈值，第二阈值，第三阈值和第四阈值为第二网络设备通过广播信息，高层信令或者动态信令配置的。

M个天线端口对应于X个信道状态信息处理进程(CSI process)，N个端口对应于X个CSI process中的一个CSI process，其中，X为正整数。每个CSI process对应一定的测量资源，例如每个CSI process配置一个信号测量资源和干扰测量

资源，UE根据信号测量资源和干扰测量资源获得CSI进行上报。例如，M=20，对应5个CSI process，则每4个天线端口对应1个CSI process，N=4。

可见，根据本发明实施例提供的一种第一网络设备，通过根据天线相关信息、SNR、信道容量、吞吐量、单用户/多用户传输方式、传输模式、码本信息或数据包大小中的至少一种进行最优天线配置，进行了更有效的天线选择。

请参阅图6，为本发明实施例提供的一种第二网络设备的结构示意图，该第二网络设备2000包括:

发送单元21，用于向第一网络设备发送M个天线端口的信号，其中，M为正整数。

在进行天线配置时，发送单元21给第一网络设备发送M个天线端口的配置信息，并将M个天线端口的信号发送给第一网络设备，第一网络设备根据配置信息接收发送单元21发送的M个天线端口的信号，其中，M为正整数，在本实施例中，第一网络设备可以是用户设备(User Equipment，UE)，第二网络设备可以是基站；或者第一网络设备可以是用户设备，第二网络设备可以是用户设备；或者第一网络设备可以是基站，第二网络设备可以是基站。

所述的基站可以是宏站，低功率节点pico或者射频拉远单元RRH。

M个天线端口的配置信息包括天线端口的图案，即天线端口的时频资源的位置、天线端口信号的发送周期、功率等信息。

第二网络设备可以只发送一个配置信息给第一网络设备，该配置信息是M个天线端口的配置信息，或者将M个天线端口分成多个组，以多个配置信息的形式发送给第一网络设备，每个配置信息对应其中一个天线端口组的配置。

接收单元22，用于接收所述第一网络设备根据第一准则反馈的所述M个天线端口中的N个天线端口的第一信息，N为小于等于M的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种。

第一网络设备需根据一定的准则从M个天线端口中选择N个天线端口，并将选择的N个天线端口的第一信息通知第二网络设备的接收单元22，在这里，第一信息为N个天线端口对应的信道状态信息CSI或者N个天线端口对应的索

引信息；或者将N个天线端口的第一信息发送给第二网络设备，由第二网络设备确定该N个天线端口，在这里，第一信息为天线相关信息。

第二网络设备通过广播信息、高层信令或动态信令配置所述第一准则，第一阈值，第二阈值，第三阈值或者第四阈值。

可见，根据本发明实施例提供的一种第二网络设备，第一网络设备通过根据天线相关信息、SNR、信道容量、吞吐量、单用户/多用户传输方式、传输模式、码本信息或数据包大小中的至少一种进行最优天线配置，将得到的天线相关信息，或者所述N个天线端口对应的信道状态信息CSI，或者所述N个天线端口的索引信息反馈给第二网络设备，使得第一网络设备进行了更有效的天线选择。

请参阅图7，为本发明实施例提供的另一种第二网络设备的结构示意图，该第二网络设备3000包括：

发送单元31，用于向第一网络设备发送M个天线端口的信号，其中，M为正整数；

接收单元32，用于接收所述第一网络设备根据第一准则反馈的所述M个天线端口中的N个天线端口的第一信息，N为小于等于M的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种，所述第一信息包括天线相关信息。

发送单元31和接收单元32的功能分别与前述实施例的发送单元21和接收单元22相同，具体地，这里的第一信息包括天线相关信息。

确定单元33，用于根据所述天线相关信息确定所述N个天线端口为所选择的天线端口。

确定单元33根据天线相关信息确定N个天线端口为所选择的天线端口。

可见，根据本发明实施例提供的一种第二网络设备，第一网络设备通过根据天线相关信息、SNR、信道容量、吞吐量、单用户/多用户传输方式、传输模式、码本信息或数据包大小中的至少一种进行最优天线配置，将得到的天线相关信息反馈给第二网络设备，由第二网络设备确定选择的天线端口，使得第一网络设备进行了更有效的天线选择。

请参阅图8，为本发明实施例提供的另一种第一网络设备的结构示意图，该第一网络设备4000包括：接收器41和发送器42。

接收器41，用于接收第二网络设备发送的M个天线端口的信号，其中，M为正整数；

发送器42，用于根据第一准则反馈所述M个天线端口中的N个天线端口的第一信息，N为小于等于M的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种。

在一种实施方式中，所述第一准则为天线相关信息；

所述发送器42执行所述根据第一准则反馈所述M个天线端口中的N个天线端口的第一信息的步骤，具体为：

根据测量的所述M个天线端口的天线相关信息，进行小区选择，其中M个天线端口对应至少两个小区或者两个传输节点，每个所述小区或传输节点对应至少两个天线端口。

在另一种实施方式中，所述发送器42执行所述根据测量的所述M个天线端口的天线相关信息，进行小区选择的步骤，具体为：

所述第一网络设备根据测量的所述M个天线端口的天线相关信息与第一阈值的比较结果，选择所述N个天线端口，得到所述N个天线端口的第一信息并进行反馈。

在又一种实施方式中，所述第一准则为信噪比SNR；

所述发送器42执行所述根据第一准则反馈所述M个天线端口中的N个天线端口的第一信息的步骤，具体为：

在M个天线端口中选择使得波束赋型或者发射分集后的SNR小于等于或大于等于第二阈值的天线端口组合中数目最少的N个天线端口，得到所述N个天线端口的第一信息并进行反馈。

在又一种实施方式中，第一准则为信道容量；

所述发送器42执行所述根据第一准则反馈所述M个天线端口中的N个天线端口的第一信息的步骤，具体为：

在M个天线端口中选择使得信道容量小于等于或大于等于第三阈值的天线端口组合中数目最少的N个天线端口，得到所述N个天线端口的第一信息并

进行反馈。

在又一种实施方式中，第一准则为吞吐量;

所述发送器42执行所述根据第一准则反馈所述M个天线端口中的N个天线端口的第一信息的步骤，具体为:

所述第一网络设备在M个天线端口中选择使得吞吐量小于等于或大于等于第四阈值的天线端口组合中数目最少的N个天线端口，得到所述N个天线端口的第一信息并进行反馈。

在又一种实施方式中，第一准则为SU/MU传输方式;

所述发送器42执行所述根据第一准则反馈所述M个天线端口中的N个天线端口的第一信息的步骤，具体为:

在M个天线端口中选择SU传输最优的第一组天线端口，所述的第一组天线端口包含N1个天线端口，得到所述N1个天线端口的第一信息并进行反馈;和/或

在M个天线端口中选择MU传输最优的第二组天线端口，所述的第二组天线端口包含N2个天线端口，得到所述N2个天线端口的第一信息并进行反馈。

在又一种实施方式中，第一准则为传输模式;

所述发送器42执行所述根据第一准则反馈所述M个天线端口中的N个天线端口的第一信息的步骤，具体为:

在M个天线端口中选择传输模式是发射分集传输的最优的第一组天线端口，所述的第一组天线端口包含N1个天线端口，得到所述N1个天线端口的第一信息并进行反馈;和/或

在M个天线端口中选择传输模式是波束赋型传输的最优的第二组天线端口，所述的第一组天线端口包含N2个天线端口，得到所述N2个天线端口的第一信息并进行反馈;和/或

在M个天线端口中选择传输模式是空间复用传输的最优的第三组天线端口，所述的第三组天线端口包含N3个天线端口，得到所述N3个天线端口的第一信息并进行反馈。

在又一种实施方式中，所述第一准则为码本信息;

所述发送器42执行所述根据第一准则反馈所述M个天线端口中的N个天线端口的第一信息的步骤，具体为:

在M个天线端口中选择采用第一码本信息传输性能最优的N个天线端口，得到所述N个天线端口的第一信息并进行反馈。

在又一种实施方式中，所述第一准则为码本信息；

所述发送器42执行所述根据第一准则反馈所述M个天线端口中的N个天线端口的第一信息的步骤，具体为：

在M个天线端口中选择轮询第一码本中的所有码字使得平均信息传输性能最优的N个天线端口，得到所述N个天线端口的第一信息并进行反馈。

在又一种实施方式中，所述第一准则为码本信息；

所述发送器42执行所述根据第一准则反馈所述M个天线端口中的N个天线端口的第一信息的步骤，具体为：

在M个天线端口中选择轮询第一码本中的所有码字使得其中最好的信息传输性能最优的N个天线端口，得到所述N个天线端口的第一信息并进行反馈。

在又一种实施方式中，所述第一准则为数据包信息；

所述发送器42执行所述根据第一准则反馈所述M个天线端口中的N个天线端口的第一信息的步骤，具体为：

在M个天线端口中选择传输第一数据包传输性能最优的N个天线端口，得到所述N个天线端口的第一信息并进行反馈；和/或

在M个天线端口中选择传输第一数据包最少的N个天线端口，得到所述N个天线端口的第一信息并进行反馈。

在以上各实施例或实施方式中，所述第一准则，所述第一阈值，第二阈值，第三阈值或者第四阈值为所述第二网络设备通过广播信息，高层信令或者动态信令配置的。

在以上各实施例或实施方式中，所述M个天线端口对应于X个信道状态信息处理进程CSI process，N个天线端口对应于所述X个CSI process中的一个CSI process，其中，X为正整数。

在以上各实施例或实施方式中，所述第一信息包括天线相关信息，或者所述N个天线端口对应的信道状态信息CSI，或者所述N个天线端口的索引信息。

可见，根据本发明实施例提供的一种第一网络设备，通过根据天线相关信息、SNR、信道容量、吞吐量、单用户/多用户传输方式、传输模式、码本

信息或数据包大小中的至少一种进行最优天线配置，进行了更有效的天线选择。

请参阅图9，为本发明实施例提供的又一种第二网络设备的结构示意图，该第二网络设备5000包括：发送器和接收器；

发送器51，用于向第一网络设备发送M个天线端口的信号，其中，M为正整数。

接收器52，用于接收所述第一网络设备根据第一准则反馈所述M个天线端口中的N个天线端口的第一信息，N为小于等于M的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种。

其中，所述第一信息包括所述N个天线端口对应的信道状态信息CSI，或者所述N个天线端口的索引信息，或天线相关信息。

可见，根据本发明实施例提供的一种第二网络设备，第一网络设备通过根据天线相关信息、SNR、信道容量、吞吐量、单用户/多用户传输方式、传输模式、码本信息或数据包大小中的至少一种进行最优天线配置，将得到的天线相关信息，或者所述N个天线端口对应的信道状态信息CSI，或者所述N个天线端口的索引信息反馈给第二网络设备，使得第一网络设备进行了更有效的天线选择。

请参阅图10，为本发明实施例提供的又一种第二网络设备的结构示意图，该第二网络设备6000包括：发送器、接收器和控制器。

发送器61，用于向第一网络设备发送M个天线端口的信号，其中，M为正整数。

接收器62，用于接收所述第一网络设备根据第一准则反馈所述M个天线端口中的N个天线端口的第一信息，N为小于等于M的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种，述第一信息包括天线相关信息。

控制器63，用于根据所述天线相关信息确定所述N个天线端口为所选择的

天线端口。

可见，根据本发明实施例提供的一种第二网络设备，第一网络设备通过根据天线相关信息、SNR、信道容量、吞吐量、单用户/多用户传输方式、传输模式、码本信息或数据包大小中的至少一种进行最优天线配置，将得到的天线相关信息反馈给第二网络设备，由第二网络设备确定选择的天线端口，使得第一网络设备进行了更有效的天线选择。

需要说明的是，对于前述的各方法实施例，为了简单描述，故将其都表述为一系列的动作组合，但是本领域技术人员应该知悉，本发明并不受所描述的动作顺序的限制，因为根据本发明，某些步骤可以采用其他顺序或者同时进行。其次，本领域技术人员也应该知悉，说明书中所描述的实施例均属于优选实施例，所涉及的动作和模块并不一定是本发明所必须的。

在上述实施例中，对各个实施例的描述都各有侧重，某个实施例中没有详述的部分，可以参见其他实施例的相关描述。

通过以上的实施方式的描述，所属领域的技术人员可以清楚地了解到本发明可以用硬件实现，或固件实现，或它们的组合方式来实现。当使用软件实现时，可以将上述功能存储在计算机可读介质中或作为计算机可读介质上的一个或多个指令或代码进行传输。计算机可读介质包括计算机存储介质和通信介质，其中通信介质包括便于从一个地方向另一个地方传送计算机程序的任何介质。存储介质可以是计算机能够存取的任何可用介质。以此为例但不限于：计算机可读介质可以包括随机存取存储器(Random Access Memory，RAM)、只读存储器(Read-Only Memory，ROM)、电可擦可编程只读存储器(Electrically Erasable Programmable Read-Only Memory，EEPROM)、只读光盘(Compact Disc Read-Only Memory，CD-ROM)或其他光盘存储、磁盘存储介质或者其他磁存储设备、或者能够用于携带或存储具有指令或数据结构形式的期望的程序代码并能够由计算机存取的任何其他介质。此外。任何连接可以适当的成为计算机可读介质。例如，如果软件是使用同轴电缆、光纤光缆、双绞线、数字用户线（Digital Subscriber Line，DSL）或者诸如红外线、无线电和微波之类的无线技术从网站、服务器或者其他远程源传输的，那么同轴电缆、光纤光缆、双绞

线、DSL 或者诸如红外线、无线和微波之类的无线技术包括在所属介质的定影中。如本发明所使用的，盘（Disk）和碟（disc）包括压缩光碟（CD）、激光碟、光碟、数字通用光碟（DVD）、软盘和蓝光光碟，其中盘通常磁性的复制数据，而碟则用激光来光学的复制数据。上面的组合也应当包括在计算机可读介质的保护范围之内。

总之，以上所述仅为本发明技术方案的较佳实施例而已，并非用于限定本发明的保护范围。凡在本发明的精神和原则之内，所作的任何修改、等同替换、改进等，均应包含在本发明的保护范围之内。

权 利 要 求

1、一种信号发送方法，其特征在于，包括:

第一网络设备接收第二网络设备发送的 M 个天线端口的信号，其中，M 为正整数;

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，N 为小于等于 M 的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种。

2、根据权利要求 1 所述的方法，其特征在于，所述第一准则为天线相关信息;

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为:

所述第一网络设备根据测量的所述 M 个天线端口的天线相关信息，进行小区选择，其中 M 个天线端口对应至少两个小区或者两个传输节点，每个所述小区或传输节点对应至少两个天线端口。

3、根据权利要求 2 所述的方法，其特征在于，所述第一网络设备根据测量的所述 M 个天线端口的天线相关信息，进行小区选择，具体为:

所述第一网络设备根据测量的所述 M 个天线端口的天线相关信息与第一阈值的比较结果，选择所述 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

4、根据权利要求 1 所述的方法，其特征在于，所述第一准则为信噪比 SNR;

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为:

所述第一网络设备在 M 个天线端口中选择使得波束赋型或者发射分集后的 SNR 小于等于或大于等于第二阈值的天线端口组合中数目最少的 N 个天

线端口，得到所述 N 个天线端口的第一信息并进行反馈。

5、根据权利要求 1 所述的方法，其特征在于，第一准则为信道容量;

所述第一网络设备根据第一准则反馈所述M个天线端口中的N个天线端口的第一信息，具体为:

所述第一网络设备在 M 个天线端口中选择使得信道容量小于等于或大于等于第三阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

6、根据权利要求 1 所述的方法，其特征在于，第一准则为吞吐量;

所述第一网络设备根据第一准则反馈所述M个天线端口中的N个天线端口的第一信息，具体为:

所述第一网络设备在 M 个天线端口中选择使得吞吐量小于等于或大于等于第四阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

7、根据权利要求 1 所述的方法，其特征在于，第一准则为 SU/MU 传输方式;

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为:

所述第一网络设备在 M 个天线端口中选择 SU 传输最优的第一组天线端口，所述的第一组天线端口包含 N1 个天线端口，得到所述 N1 个天线端口的第一信息并进行反馈; 和/或

所述第一网络设备在M个天线端口中选择MU传输最优的第二组天线端口，所述的第二组天线端口包含 N2 个天线端口，得到所述 N2 个天线端口的第一信息并进行反馈。

8、根据权利要求 1 所述的方法，其特征在于，第一准则为传输模式; 所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为:

所述第一网络设备在 M 个天线端口中选择传输模式是发射分集传输的最优的第一组天线端口，所述的第一组天线端口包含 N1 个天线端口，得到所述 N1 个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在 M 个天线端口中选择传输模式是波束赋型传输的最优的第二组天线端口，所述的第一组天线端口包含 N2 个天线端口，得到所述 N2 个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在 M 个天线端口中选择传输模式是空间复用传输的最优的第三组天线端口，所述的第三组天线端口包含 N3 个天线端口，得到所述 N3 个天线端口的第一信息并进行反馈。

9、根据权利要求 1 所述的方法，其特征在于，所述第一准则为码本信息；

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备在 M 个天线端口中选择采用其对应的第一码本信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

10、根据权利要求 1 所述的方法，其特征在于，所述第一准则为码本信息；

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备在 M 个天线端口中选择轮询第一码本中的所有码字使得平均信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

11、根据权利要求 1 所述的方法，其特征在于，所述第一准则为码本信息；

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备在 M 个天线端口中选择轮询第一码本中的所有码字使得其中最好的信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

12、根据权利要求 1 所述的方法，其特征在于，所述第一准则为数据包信息；

所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，具体为：

所述第一网络设备在 M 个天线端口中选择传输第一数据包传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在 M 个天线端口中选择传输第一数据包最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈；和/或

所述第一网络设备在 M 个天线端口中选择传输第一数据包达到一定性能要求的最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

13、根据权利要求 1~12 所述的方法，其特征在于，所述第一准则或者所述第一阈值，第二阈值，第三阈值和第四阈值为所述第二网络设备通过广播信息，高层信令或者动态信令配置的。

14、根据权利要求 1~13 所述的方法，其特征在于，所述 M 个天线端口对应于 X 个信道状态信息处理进程 CSI process，N 个天线端口对应于所述 X 个 CSI process 中的一个 CSI process，其中，X 为正整数。

15、根据权利要求 1~14 所述的方法，其特征在于，所述第一信息包括天线相关信息，或者所述 N 个天线端口对应的信道状态信息 CSI，或者所述 N 个天线端口的索引信息。

16、一种信号发送方法，其特征在于，包括：

第二网络设备向第一网络设备发送 M 个天线端口的信号，其中，M 为正整数；

所述第二网络设备接收所述第一网络设备根据第一准则反馈的所述 M 个天线端口中的 N 个天线端口的第一信息，N 为小于等于 M 的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用

户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种。

17、如权利要求 16 所述的方法，其特征在于，所述第一信息包括天线相关信息；

所述方法，还包括：

所述第二网络设备根据所述天线相关信息确定所述 N 个天线端口为所选择的天线端口。

18、如权利要求 16 所述的方法，其特征在于，所述第一信息包括所述 N 个天线端口对应的信道状态信息 CSI，或者所述 N 个天线端口的索引信息。

19、如权利要求 16-18 任意一项所述的方法，其特征在于，还包括：

所述第二网络设备通过广播信息、高层信令或动态信令配置所述第一准则，第一阈值，第二阈值，第三阈值或者第四阈值。

20、一种第一网络设备，其特征在于，包括：

接收单元，用于接收第二网络设备发送的 M 个天线端口的信号，其中，M 为正整数；

反馈单元，用于根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，N 为小于等于 M 的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种。

21、根据权利要求 20 所述的第一网络设备，其特征在于，所述第一准则为天线相关信息；

所述反馈单元具体用于：

根据测量的所述 M 个天线端口的天线相关信息，进行小区选择，其中 M 个天线端口对应至少两个小区或者两个传输节点，每个所述小区或传输节点对应至少两个天线端口。

22、根据权利要求 21 所述的第一网络设备，其特征在于，所述反馈单元执行所述根据测量的所述 M 个天线端口的天线相关信息，进行小区选择，的步骤，具体为：

所述第一网络设备根据测量的所述 M 个天线端口的天线相关信息与第一阈值的比较结果，选择所述 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

23、根据权利要求 20 所述的第一网络设备，其特征在于，所述第一准则为信噪比 SNR;

所述反馈单元具体用于：

在 M 个天线端口中选择使得波束赋型或者发射分集后的 SNR 小于等于或大于等于第二阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

24、根据权利要求 20 所述的第一网络设备，其特征在于，第一准则为信道容量;

所述反馈单元具体用于：

在 M 个天线端口中选择使得信道容量小于等于或大于等于第三阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

25、根据权利要求 20 所述的第一网络设备，其特征在于，第一准则为吞吐量;

所述反馈单元具体用于：

在 M 个天线端口中选择使得吞吐量小于等于或大于等于第四阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

26、根据权利要求 20 所述的第一网络设备，其特征在于，第一准则为 SU/MU 传输方式;

所述反馈单元具体用于:

在 M 个天线端口中选择 SU 传输最优的第一组天线端口，所述的第一组天线端口包含 N1 个天线端口，得到所述 N1 个天线端口的第一信息并进行反馈；和/或

在 M 个天线端口中选择 MU 传输最优的第二组天线端口，所述的第二组天线端口包含 N2 个天线端口，得到所述 N2 个天线端口的第一信息并进行反馈。

27、根据权利要求 20 所述的第一网络设备，其特征在于，第一准则为传输模式;

所述反馈单元具体用于:

在 M 个天线端口中选择传输模式是发射分集传输的最优的第一组天线端口，所述的第一组天线端口包含 N1 个天线端口，得到所述 N1 个天线端口的第一信息并进行反馈；和/或

在 M 个天线端口中选择传输模式是波束赋型传输的最优的第二组天线端口，所述的第一组天线端口包含 N2 个天线端口，得到所述 N2 个天线端口的第一信息并进行反馈；和/或

在 M 个天线端口中选择传输模式是空间复用传输的最优的第三组天线端口，所述的第三组天线端口包含 N3 个天线端口，得到所述 N3 个天线端口的第一信息并进行反馈。

28、根据权利要求 20 所述的第一网络设备，其特征在于，所述第一准则为码本信息;

所述反馈单元具体用于:

在 M 个天线端口中选择采用其对应的第一码本信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

29、根据权利要求 20 所述的第一网络设备，其特征在于，所述第一准则为码本信息;

所述反馈单元具体用于:

在 M 个天线端口中选择轮询第一码本中的所有码字使得平均信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

30、根据权利要求 20 所述的第一网络设备，其特征在于，所述第一准则为码本信息；

所述反馈单元具体用于：

在 M 个天线端口中选择轮询第一码本中的所有码字使得其中最好的信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

31、根据权利要求 20 所述的第一网络设备，其特征在于，所述第一准则为数据包信息；

所述反馈单元具体用于：

在M个天线端口中选择传输第一数据包传输性能最优的N个天线端口，得到所述 N 个天线端口的第一信息并进行反馈；和/或

在 M 个天线端口中选择传输第一数据包最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈；和/或

在 M 个天线端口中选择传输第一数据包达到一定性能要求的最少的 N 个天线端口，例如一定误码率的最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

32、根据权利要求 20-31 所述的第一网络设备，其特征在于，所述第一准则或者所述第一阈值，第二阈值，第三阈值和第四阈值为所述第二网络设备通过广播信息，高层信令或者动态信令配置的。

33、根据权利要求 20-32 所述的第一网络设备，其特征在于，所述 M 个天线端口对应于 X 个信道状态信息处理进程 CSI process，N 个天线端口对应于所述 X 个 CSI process 中的一个 CSI process，其中，X 为正整数。

34、根据权利要求 20-33 所述的方法，其特征在于，所述第一信息包括

天线相关信息，或者所述 N 个天线端口对应的信道状态信息 CSI，或者所述 N 个天线端口的索引信息。

35、一种第二网络设备，其特征在于，包括:

发送单元，用于向第一网络设备发送 M 个天线端口的信号，其中，M 为正整数;

接收单元，用于接收所述第一网络设备根据第一准则反馈的所述 M 个天线端口中的 N 个天线端口的第一信息，N 为小于等于 M 的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种。

36、如权利要求 35 所述的第二网络设备，其特征在于，所述第一信息包括天线相关信息;

所述第二网络设备，还包括:

确定单元，用于根据所述天线相关信息确定所述 N 个天线端口为所选择的天线端口。

37、如权利要求 35 所述的第二网络设备，其特征在于，所述第一信息包括所述 N 个天线端口对应的信道状态信息 CSI，或者所述 N 个天线端口的索引信息。

38、如权利要求 35-37 任意一项所述的第二网络设备，其特征在于，所述发送单元还用于通过广播信息、高层信令或动态信令配置所述第一准则，第一阈值，第二阈值，第三阈值和第四阈值。

39、一种第一网络设备，其特征在于，包括：接收器和发送器;

接收器，用于接收第二网络设备发送的 M 个天线端口的信号，其中，M 为正整数;

发送器，用于根据第一准则反馈所述 M 个天线端口中的 N 个天线端

口的第一信息，N 为小于等于 M 的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种。

40、根据权利要求 39 所述的第一网络设备，其特征在于，所述第一准则为天线相关信息；

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息的步骤，具体为：

根据测量的所述 M 个天线端口的天线相关信息，进行小区选择，其中 M 个天线端口对应至少两个小区或者两个传输节点，每个所述小区或传输节点对应至少两个天线端口。

41、根据权利要求 40 所述的第一网络设备，其特征在于，所述发送器执行所述根据测量的所述 M 个天线端口的天线相关信息，进行小区选择的步骤，具体为：

所述第一网络设备根据测量的所述 M 个天线端口的天线相关信息与第一阈值的比较结果，选择所述 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

42、根据权利要求 39 所述的第一网络设备，其特征在于，所述第一准则为信噪比 SNR；

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息的步骤，具体为：

在 M 个天线端口中选择使得波束赋型或者发射分集后的 SNR 小于等于或大于等于第二阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

43、根据权利要求 39 所述的第一网络设备，其特征在于，第一准则为信道容量；

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天

线端口的第一信息的步骤，具体为：

在 M 个天线端口中选择使得信道容量小于等于或大于等于第三阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

44、根据权利要求 39 所述的第一网络设备，其特征在于，第一准则为吞吐量；

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息的步骤，具体为：

所述第一网络设备在 M 个天线端口中选择使得吞吐量小于等于或大于等于第四阈值的天线端口组合中数目最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

45、根据权利要求 39 所述的第一网络设备，其特征在于，第一准则为 SU/MU 传输方式；

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息的步骤，具体为：

在 M 个天线端口中选择 SU 传输最优的第一组天线端口，所述的第一组天线端口包含 N1 个天线端口，得到所述 N1 个天线端口的第一信息并进行反馈；和/或

在 M 个天线端口中选择 MU 传输最优的第二组天线端口，所述的第二组天线端口包含 N2 个天线端口，得到所述 N2 个天线端口的第一信息并进行反馈。

46、根据权利要求 39 所述的第一网络设备，其特征在于，第一准则为传输模式；

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息的步骤，具体为：

在 M 个天线端口中选择传输模式是发射分集传输的最优的第一组天线端口，所述的第一组天线端口包含 N1 个天线端口，得到所述 N1 个天线端

口的第一信息并进行反馈；和/或

在 M 个天线端口中选择传输模式是波束赋型传输的最优的第二组天线端口，所述的第一组天线端口包含 N2 个天线端口，得到所述 N2 个天线端口的第一信息并进行反馈；和/或

在 M 个天线端口中选择传输模式是空间复用传输的最优的第三组天线端口，所述的第三组天线端口包含 N3 个天线端口，得到所述 N3 个天线端口的第一信息并进行反馈。

47、根据权利要求 39 所述的第一网络设备，其特征在于，所述第一准则为码本信息；

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息的步骤，具体为：

在 M 个天线端口中选择采用其对应的第一码本信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

48、根据权利要求 39 所述的第一网络设备，其特征在于，所述第一准则为码本信息；

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息的步骤，具体为：

在 M 个天线端口中选择轮询第一码本中的所有码字使得平均信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

49、根据权利要求 39 所述的第一网络设备，其特征在于，所述第一准则为码本信息；

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息的步骤，具体为：

在 M 个天线端口中选择轮询第一码本中的所有码字使得其中最好的信息传输性能最优的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

50、根据权利要求 39 所述的第一网络设备，其特征在于，所述第一准则为数据包信息；

所述发送器执行所述根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息的步骤，具体为：

在M个天线端口中选择传输第一数据包传输性能最优的N个天线端口，得到所述 N 个天线端口的第一信息并进行反馈；和/或

在 M 个天线端口中选择传输第一数据包最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈；和/或

在 M 个天线端口中选择传输第一数据包达到一定性能要求的最少的 N 个天线端口，例如一定误码率的最少的 N 个天线端口，得到所述 N 个天线端口的第一信息并进行反馈。

51、根据权利要求 39-50 所述的第一网络设备，其特征在于，所述第一准则或者所述第一阈值，第二阈值，第三阈值和第四阈值为所述第二网络设备通过广播信息，高层信令或者动态信令配置的。

52、根据权利要求 39-51 所述的第一网络设备，其特征在于，所述 M 个天线端口对应于 X 个信道状态信息处理进程 CSI process，N 个天线端口对应于所述 X 个 CSI process 中的一个 CSI process，其中，X 为正整数。

53、根据权利要求 39-52 所述的第一网络设备，其特征在于，所述第一信息包括天线相关信息，或者所述 N 个天线端口对应的信道状态信息 CSI，或者所述 N 个天线端口的索引信息。

54、一种第二网络设备，其特征在于，包括：发送器和接收器；

发送器，用于向第一网络设备发送 M 个天线端口的信号，其中，M 为正整数；

接收器，用于接收所述第一网络设备根据第一准则反馈所述 M 个天线端口中的 N 个天线端口的第一信息，N 为小于等于 M 的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU

（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种。

55、如权利要求 54 所述的第二网络设备，其特征在于，所述第一信息包括天线相关信息；

所述第二网络设备，还包括：控制器；

控制器，用于根据所述天线相关信息确定所述 N 个天线端口为所选择的天线端口。

56、如权利要求 54 所述的第二网络设备，其特征在于，所述第一信息包括所述 N 个天线端口对应的信道状态信息 CSI，或者所述 N 个天线端口的索引信息。

57、如权利要求 54-56 任意一项所述的第二网络设备，其特征在于，所述发送器还用于通过广播信息、高层信令或动态信令配置所述第一准则，第一阈值，第二阈值，第三阈值和第四阈值。

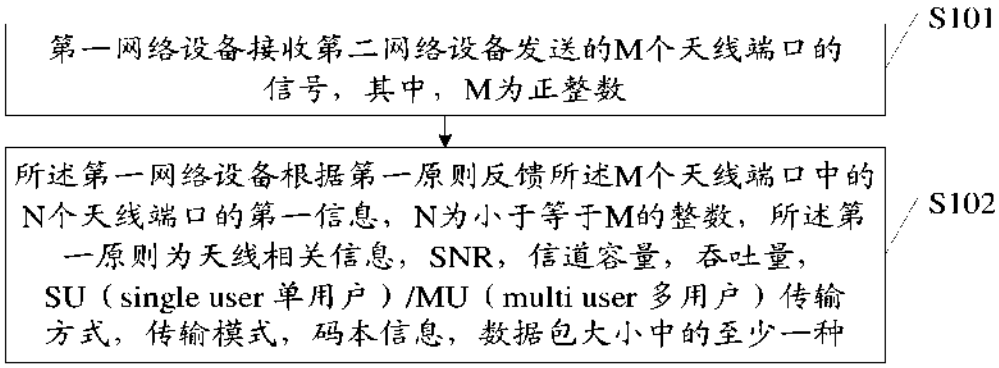

第一网络设备接收第二网络设备发送的M个天线端口的信号，其中，M为正整数
S101
所述第一网络设备根据第一原则反馈所述M个天线端口中的N个天线端口的第一信息，N为小于等于M的整数，所述第一原则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种
S102

图 1

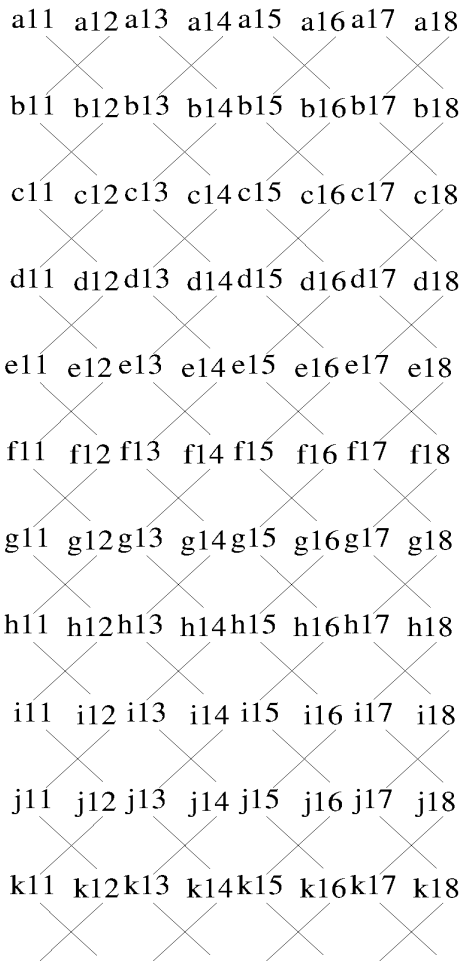

a11 a12 a13 a14 a15 a16 a17 a18
b11 b12 b13 b14 b15 b16 b17 b18
c11 c12 c13 c14 c15 c16 c17 c18
d11 d12 d13 d14 d15 d16 d17 d18
e11 e12 e13 e14 e15 e16 e17 e18
f11 f12 f13 f14 f15 f16 f17 f18
g11 g12 g13 g14 g15 g16 g17 g18
h11 h12 h13 h14 h15 h16 h17 h18
i11 i12 i13 i14 i15 i16 i17 i18
j11 j12 j13 j14 j15 j16 j17 j18
k11 k12 k13 k14 k15 k16 k17 k18

图 2

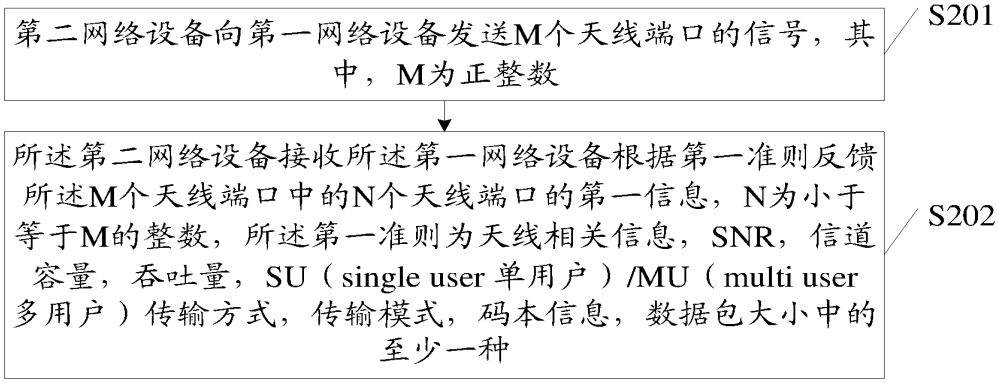

第二网络设备向第一网络设备发送M个天线端口的信号，其中，M为正整数
S201
所述第二网络设备接收所述第一网络设备根据第一准则反馈所述M个天线端口中的N个天线端口的第一信息，N为小于等于M的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种
S202

图 3

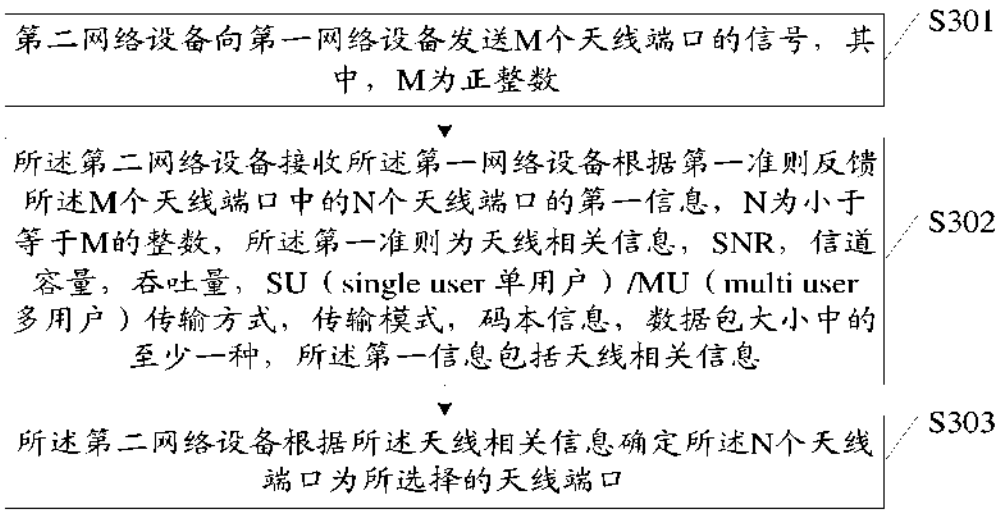

第二网络设备向第一网络设备发送M个天线端口的信号，其中，M为正整数
S301
所述第二网络设备接收所述第一网络设备根据第一准则反馈所述M个天线端口中的N个天线端口的第一信息，N为小于等于M的整数，所述第一准则为天线相关信息，SNR，信道容量，吞吐量，SU（single user 单用户）/MU（multi user 多用户）传输方式，传输模式，码本信息，数据包大小中的至少一种，所述第一信息包括天线相关信息
S302
所述第二网络设备根据所述天线相关信息确定所述N个天线端口为所选择的天线端口
S303

图 4

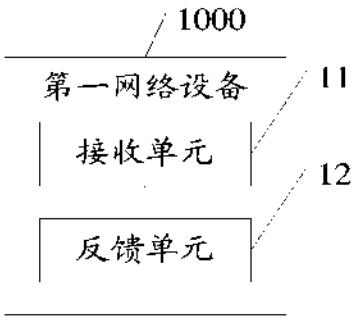

1000
第一网络设备
11
接收单元
12
反馈单元

图 5

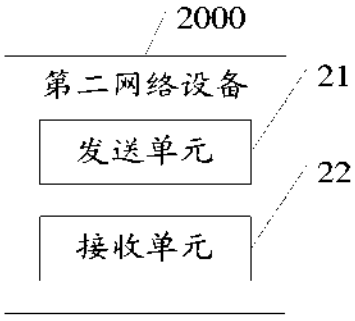

2000
第二网络设备
21
发送单元
22
接收单元

图 6

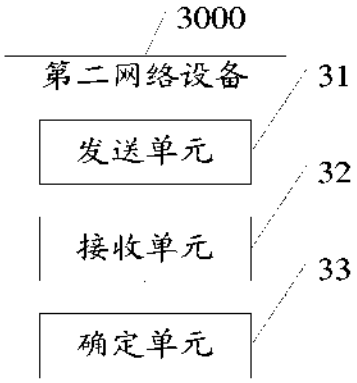

3000
第二网络设备
31
发送单元
32
接收单元
33
确定单元

图 7

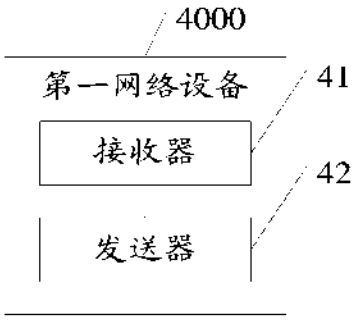

4000
第一网络设备
41
接收器
42
发送器

图 8

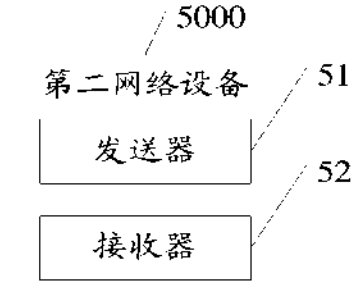

5000
第二网络设备
51
发送器
52
接收器

图 9

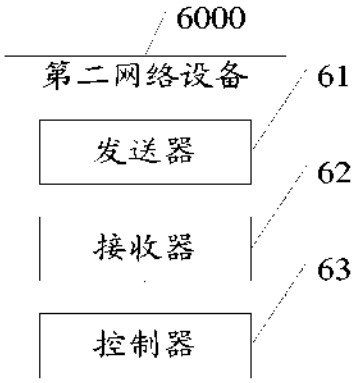


图 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2014/083479

A. CLASSIFICATION OF SUBJECT MATTER

H04B 7/06 (2006.01) i; H04B 7/08 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04B; H04W; H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNPAT, CNKI, WPI, EPODOC: confirm, port, Signal-to-Noise, SNR, codebook, antenna, feedback, feed back, throughput, select+, determin+, capability, group, data packet, mode, way, relate

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 1918817 A (LG ELECTRONICS INC.) 21 February 2007 (21.02.2007) description, page 14, the second paragraph to page 15, the second paragraph, and figures 4-6	1-57
A	CN 101015137 A (SAMSUNG ELECTRONICS CO., LTD. et al.) 08 August 2007 (08.08.2007) the whole document	1-57
A	CN 101359952 A (HUAWEI TECHNOLOGIES CO., LTD.) 04 February 2009 (04.02.2009) the whole document	1-57
A	CN 101013917 A (ZTE CORP.) 08 August 2007 (08.08.2007) the whole document	1-57

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&"document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
08 April 2015	06 May 2015
Name and mailing address of the ISA State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No. (86-10) 62019451	Authorized officer TIAN, Linlin Telephone No. (86-10) 61648260

Form PCT/ISA /210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2014/083479

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 1918817 A	21 February 2007	US 2005195912 A1	08 September 2005
		CN 101764633 A	30 June 2010
		KR 20050081239 A	18 August 2005
		WO 2005076758 A2	25 August 2005
		KR 20060005826 A	18 January 2006
		US 2010185777 A1	22 July 2010
		AT 532275 T	15 November 2011
		EP 1719265 A2	08 November 2006
CN 101015137 A	08 August 2007	KR 20060005683 A	18 January 2006
		US 2006039494 A1	23 February 2006
		EP 1759470 A1	07 March 2007
		JP 2008506330 A	28 February 2008
		WO 2006006826 A1	19 January 2006
CN 101359952 A	04 February 2009	None	
CN 101013917 A	08 August 2007	None	

Form PCT/ISA /210 (patent family annex) (July 2009)

国际检索报告

国际申请号
PCT/CN2014/083479

A. 主题的分类

H04B 7/06(2006.01)i; H04B 7/08(2006.01)i

按照国际专利分类(IPC)或者同时按照国家分类和IPC两种分类

B. 检索领域

检索的最低限度文献(标明分类系统和分类号)

H04B; H04W; H04Q

包含在检索领域中的除最低限度文献以外的检索文献

在国际检索时查阅的电子数据库(数据库的名称，和使用的检索词（如使用）)

CNPAT, CNKT, WPI, EPODOC: 选择，确定，天线，反馈，端口，信噪比，SNR，吞吐量，容量，的本，数据包，模式，方式，相关，组，antenna, feedback, feed back, throughput, select+, determin-, capability, group

C. 相关文件

类 型*	引用文件，必要时，指明相关段落	相关的权利要求
X	CN 1918817 A (LG电子株式会社) 2007年 2月 21日 (2007 - 02 - 21) 说明书第14页第2段-第15页第2段，附图4-6	1-57
A	CN 101015137 A (三星电子株式会社等) 2007年 8月 8日 (2007 - 08 - 08) 全文	1-57
A	CN 101359952 A (华为技术有限公司) 2009年 2月 4日 (2009 - 02 - 04) 全文	1-57
A	CN 101013917 A (中兴通讯股份有限公司) 2007年 8月 8日 (2007 - 08 - 08) 全文	1-57

☐ 其余文件在C栏的续页中列出。

☑ 见同族专利附件。

* 引用文件的具体类型：

"A" 认为不特别相关的表示了现有技术一般状态的文件

"E" 在国际申请日的当天或之后公布的在先申请或专利

"L" 可能对优先权要求构成怀疑的文件，或为确定另一篇引用文件的公布日而引用的或者因其他特殊理由而引用的文件（如具体说明的）

"O" 涉及口头公开、使用、展览或其他方式公开的文件

"P" 公布日先于国际申请日但迟于所要求的优先权日的文件

"T" 在申请日或优先权日之后公布，与申请不相抵触，但为了理解发明之理论或原理的在后文件

"X" 特别相关的文件，单独考虑该文件，认定要求保护的发明不是新颖的或不具有创造性

"Y" 特别相关的文件，当该文件与另一篇或者多篇该类文件结合并且这种结合对于本领域技术人员为显而易见时，要求保护的发明不具有创造性

"&" 同族专利的文件

国际检索实际完成的日期	国际检索报告邮寄日期
2015年 4月 8日	2015年 5月 6日
ISA/CN的名称和邮寄地址 中华人民共和国国家知识产权局(ISA/CN) 北京市海淀区蓟门桥西上城路6号 100088 中国 传真号 (86-10)62019451	受权官员 田琳琳 电话号码 (86-10)61648260

表 PCT/ISA/210 (第2页) (2009年7月)

国际检索报告
关于同族专利的信息

国际申请号
PCT/CN2014/083479

检索报告引用的专利文件			公布日（年/月/日）	同族专利			公布日（年/月/日）
CN	1918817	A	2007年 2月 21日	US	2005195912	A1	2005年 9月 8日
				CN	101764633	A	2010年 6月 30日
				KR	20050081239	A	2005年 8月 18日
				WO	2005076758	A2	2005年 8月 25日
				KR	20060005826	A	2006年 1月 18日
				US	2010185777	A1	2010年 7月 22日
				AT	532275	T	2011年 11月 15日
				EP	1719265	A2	2006年 11月 8日
CN	101015137	A	2007年 8月 8日	KR	20060005683	A	2006年 1月 18日
				US	2006039494	A1	2006年 2月 23日
				EP	1759470	A1	2007年 3月 7日
				JP	2008506330	A	2008年 2月 28日
				WO	2006006826	A1	2006年 1月 19日
CN	101359952	A	2009年 2月 4日		无		
CN	101013917	A	2007年 8月 8日		无		

表 PCT/ISA/210（同族专利附件）（2009年7月）

(12) 특허협력조약에 의하여 공개된 국제출원

(19) 세계지식재산권기구
국제사무국

(43) 국제공개일
2016 년 8 월 4 일 (04.08.2016)

WIPO | PCT

(10) 국제공개번호
WO 2016/122232 A1

(51) 국제특허분류:
H04B 17/382 (2015.01) *H04B 7/04* (2006.01)

(21) 국제출원번호: PCT/KR2016/000945

(22) 국제출원일: 2016 년 1 월 28 일 (28.01.2016)

(25) 출원언어: 한국어

(26) 공개언어: 한국어

(30) 우선권정보:
62/109,616 2015 년 1 월 30 일 (30.01.2015) US

(71) 출원인: 엘지전자(주) (LG ELECTRONICS INC.) [KR/KR]; 07336 서울시 영등포구 여의대로 128, Seoul (KR).

(72) 발명자: 박종현 (PARK, Jonghyun); 06772 서울시 서초구 양재대로 11 길 19, LG 전자 특허센터, Seoul (KR). 김기준 (KIM, Kijun); 06772 서울시 서초구 양재대로 11 길 19, LG 전자 특허센터, Seoul (KR). 서한별 (SEO, Hanbyul); 06772 서울시 서초구 양재대로 11 길 19, LG 전자 특허센터, Seoul (KR).

(74) 대리인: 특허법인 로얄 (ROYAL PATENT & LAW OFFICE); 08806 서울시 관악구 남부순환로 2072, 도원회관 빌딩 1 층, Seoul (KR).

(81) 지정국 (별도의 표시가 없는 한, 가능한 모든 종류의 국내 권리의 보호를 위하여): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

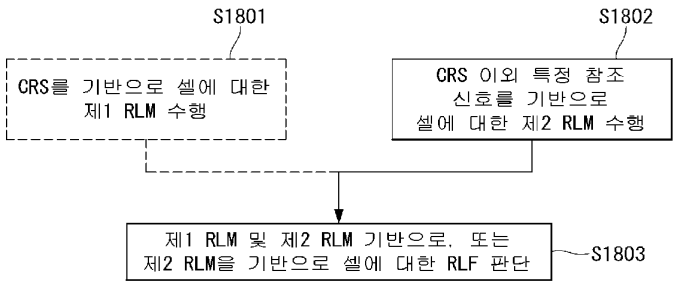
(84) 지정국 (별도의 표시가 없는 한, 가능한 모든 종류의 역내 권리의 보호를 위하여): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), 유라시아 (AM, AZ, BY, KG, KZ, RU, TJ, TM), 유럽 (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

공개:
— 국제조사보고서와 함께 (조약 제 21 조(3))

(54) Title: RADIO LINK MONITORING METHOD IN WIRELESS COMMUNICATION SYSTEM AND DEVICE THEREFOR

(54) 발명의 명칭 : 무선 통신 시스템에서 무선 링크 모니터링 방법 및 이를 위한 장치

[도18]



S1801 ... Perform first RLM for cell on basis of CRS
S1802 ... Perform second RLM for cell on basis of particular reference signal except for CRS
S1803 ... Determine RLM for cell, on basis of first RLM and second RLM or on basis of second RLM

(57) **Abstract**: Disclosed are a radio link monitoring method in a wireless communication system and a device therefor. Specifically, the method for performing radio link monitoring (RLM) by a terminal in a wireless communication system comprises the steps of: performing second RLM for a cell, on the basis of a reference signal except for a cell-specific reference signal (CRS); and determining a radio link failure (RLF) for the cell, on the basis of the second RLM, wherein a determination condition for RLF determination applied to the second RLM may be different from a determination condition for RLF determination applied to CRS-based first RLM.

(57) **요약서**: 무선 통신 시스템에서 무선 링크 모니터링 방법 및 이를 위한 장치가 개시된다. 구체적으로, 무선 통신 시스템에서 단말이 무선 링크 모니터링(RLM: radio link monitoring)을 수행하는 방법에 있어서, 셀 특정 참조 신호(CRS: cell-specific reference signal) 이외 참조 신호를 기반으로 셀에 대한 제 2 RLM 을 수행하는 단계 및 상기 제 2 RLM 을 기반으로 상기 셀에 대한 무선 링크 실패(RLF: radio link failure)를 판단하는 단계를 포함하고, 상기 제 2 RLM 에 적용되는 RLF 판단을 위한 판단 조건은 CRS 기반 제 1 RLM 에 적용되는 RLF 판단을 위한 판단 조건과 상이할 수 있다.

WO 2016/122232 A1

명세서

발명의 명칭: 무선 통신 시스템에서 무선 링크 모니터링 방법 및 이를 위한 장치

기술분야

[1] 본 발명은 무선 통신 시스템에 관한 것으로서, 보다 상세하게 단말에서 참조 신호(reference signal)을 기반으로 무선 링크 모니터링을 수행하기 위한 방법 및 이를 지원하는 장치에 관한 것이다.

배경기술

[2] 이동 통신 시스템은 사용자의 활동성을 보장하면서 음성 서비스를 제공하기 위해 개발되었다. 그러나 이동통신 시스템은 음성뿐 아니라 데이터 서비스까지 영역을 확장하였으며, 현재에는 폭발적인 트래픽의 증가로 인하여 자원의 부족 현상이 야기되고 사용자들이 보다 고속의 서비스에 대한 요구하므로, 보다 발전된 이동 통신 시스템이 요구되고 있다.

[3] 차세대 이동 통신 시스템의 요구 조건은 크게 폭발적인 데이터 트래픽의 수용, 사용자 당 전송률의 획기적인 증가, 대폭 증가된 연결 디바이스 개수의 수용, 매우 낮은 단대단 지연(End-to-End Latency), 고에너지 효율을 지원할 수 있어야 한다. 이를 위하여 이중 연결성(Dual Connectivity), 대규모 다중 입출력(Massive MIMO: Massive Multiple Input Multiple Output), 전이중(In-band Full Duplex), 비직교 다중접속(NOMA: Non-Orthogonal Multiple Access), 초광대역(Super wideband) 지원, 단말 네트워킹(Device Networking) 등 다양한 기술들이 연구되고 있다.

발명의 상세한 설명

기술적 과제

[4] 본 발명의 목적은 무선 통신 시스템에서 단말이 셀 특정 참조 신호(CRS: Cell-specific Reference Signal)과는 별도로 설정되는 무선 자원 무선 자원 관리(RRM: Radio Resource Management) 측정을 위한 참조 신호(RRM-RS)를 기반으로 단말이 셀을 (재)선택하는 방법을 제안한다.

[5] 또한, 본 발명의 목적은 RRM-RS 기반으로 선택된 최적의 셀로 초기 접속(initial access) 과정을 수행하기 위한 방법을 제안한다.

[6] 또한, 본 발명의 목적은 CRS 이외의 참조 신호를 기반으로 무선 링크 모니터링(radio link monitoring)을 수행하는 방법을 제안한다.

[7] 본 발명에서 이루고자 하는 기술적 과제들은 이상에서 언급한 기술적 과제들로 제한되지 않으며, 언급하지 않은 또 다른 기술적 과제들은 아래의 기재로부터 본 발명이 속하는 기술분야에서 통상의 지식을 가진 자에게 명확하게 이해될 수 있을 것이다.

과제 해결 수단

[8] 본 발명의 일 양상은, 무선 통신 시스템에서 단말이 무선 링크 모니터링(RLM: radio link monitoring)을 수행하는 방법에 있어서, 셀 특정 참조 신호(CRS: cell-specific reference signal) 이외 참조 신호를 기반으로 셀에 대한 제2 RLM을 수행하는 단계 및 상기 제2 RLM을 기반으로 상기 셀에 대한 무선 링크 실패(RLF: radio link failure)를 판단하는 단계를 포함하고, 상기 제2 RLM에 적용되는 RLF 판단을 위한 판단 조건은 CRS 기반 제1 RLM에 적용되는 RLF 판단을 위한 판단 조건과 상이할 수 있다.

[9] 본 발명의 다른 일 양상은, 무선 통신 시스템에서 무선 링크 모니터링(RLM: radio link monitoring)을 수행하는 단말에 있어서, 무선 신호를 송수신하기 위한 RF(Radio Frequency) 유닛 및 상기 RF 유닛을 제어하는 프로세서를 포함하고, 상기 셀 특정 참조 신호(CRS: cell-specific reference signal) 이외 참조 신호를 기반으로 셀에 대한 제2 RLM을 수행하고, 상기 제2 RLM을 기반으로 상기 셀에 대한 무선 링크 실패(RLF: radio link failure)를 판단하도록 구성되고, 상기 제2 RLM에 적용되는 RLF 판단을 위한 판단 조건은 CRS 기반 제1 RLM에 적용되는 RLF 판단을 위한 판단 조건과 상이할 수 있다.

[10] 바람직하게, 상기 CRS 기반으로 상기 제1 RLM을 수행하는 단계를 더 포함하고, 상기 셀에 대한 RLF는 상기 제1 RLM 및 상기 제2 RLM을 기반으로 판단될 수 있다.

[11] 바람직하게, 상기 RLF 판단을 위한 판단 조건은 제어 채널 전송 파라미터, 비동기(out-of-sync)/동기(in-sync) 상태 판단을 위한 임계값 및 RLF 타이머 중 적어도 어느 하나를 포함할 수 있다.

[12] 바람직하게, 상기 제2 RLM의 경우, 상기 제2 모니터링을 위한 하향링크 제어 정보(DCI: Downlink Control Information)가 소정의 진보된 물리 하향링크 제어 채널(EPDCCH: Enhanced Physical Downlink Control Channel) 세트로부터 전송된다고 가정될 수 있다.

[13] 바람직하게, 상기 단말이 풀 차원 다중 입력 다중 출력(FD-MIMO: full dimension-Multi Input Multi Output) 지원 가능한 경우, 상기 제2 RLM이 수행될 수 있다.

[14] 바람직하게, 상기 단말이 FD-MIMO 지원 가능하고 상기 단말이 FD-MIMO 모드가 활성화된 경우, 상기 제2 RLM이 수행될 수 있다.

[15] 바람직하게, 상기 셀에 대한 RLF가 상기 제1 RLM 및 상기 제2 RLM을 기반으로 판단되는 경우, 상기 제1 RLM 및 상기 제2 RLM 중 적어도 어느 하나에 의해 상기 셀에 대한 RLF가 결정되면, 상기 셀에 대한 RLF가 결정될 수 있다.

[16] 바람직하게, 상기 제1 RLM 및 상기 제2 RLM 중 어느 하나가 상기 셀에 대한 RLF 판단에 있어서 높은 우선 순위를 가질 수 있다.

[17] 바람직하게, 상기 셀에 대한 RLF가 상기 제1 RLM 및 상기 제2 RLM을 기반으로 판단되는 경우, 상기 제1 RLM 및 상기 제2 RLM 모두에 의해 상기 셀에 대한 RLF가 결정되면, 상기 셀에 대한 RLF가 결정될 수 있다.

[18] 바람직하게, 상기 제2 RLM은 상기 제1 RLM에 의해 소정의 조건이 만족되는 경우 수행될 수 있다.

[19] 바람직하게, 상기 제1 RLM에 의한 RLF 타이머가 가동된 시점으로부터 소정의 오프셋 시간 이후 상기 제2 RLM이 개시될 수 있다.

[20] 바람직하게, 상기 제1 RLM에 의한 RLF 타이머가 가동된 시점으로부터 상기 단말에 의한 다른 셀의 선택(selection) 또는 재선택(reselection) 절차가 완료되기까지 구간 동안, 상기 제2 RLM과 연계된 EPDCCH 세트를 통해 DCI가 수신되고, 상기 DCI에 의해 스케줄링된 물리 하향링크 공유 채널(PDSCH: Physical Downlink Shared Channel)를 통해 하향링크 데이터가 수신될 수 있다.

[21] 바람직하게, 미리 정해진 무선 네트워크 임시 식별자(RNTI: Radio Network Temporary Identifier)로 마스킹된 DCI만 상기 EPDCCH 세트를 통해 수신될 수 있다.

[22] 바람직하게, 상기 CSI 이외 참조 신호는 채널 상태 정보 참조 신호(CSI-RS: Channel State Information-Reference Signal), 디스커버리 참조 신호(DRS: Discovery Reference Signal), 프리코딩된(precoded) 참조 신호 및 셀 (재)선택 관련 동작 시에 적용하도록 설정된 참조 서로 다른 셀 또는 전송 포인트(TP: Transmission Point)의 개수로 구성되는 무정형 셀(amorphous cell)에서 전송되는 참조 신호 중 어느 하나일 수 있다.

발명의 효과

[23] 본 발명의 실시예에 따르면, 무선 통신 시스템에서, 특히 풀-차원-MIMO(full-dimension MIMO)를 사용하거나 진보된 무정형 셀(amorphous cell)을 지원하는 환경에서, 단말에게 가장 효율이 좋은 최적의 셀이 선택될 수 있다.

[24] 또한, 본 발명의 실시예에 따르면, 단말에게 가장 효율이 좋은 최적의 셀로 초기 접속(initial access)함으로써 단말의 초기 셀 접속 과정에서의 지연(latency)을 최소화할 수 있다.

[25] 또한, 본 발명의 실시예에 따르면, 단말에게 가장 효율이 좋은 최적의 셀로 초기 접속(initial access)함으로써, 단말의 추가적인 핸드오버(hand-over)나 셀 재선택(cell re-selection) 과정 없이 빠르게 정상 동작 상태에 진입할 수 있도록 하는 장점이 있다.

[26] 또한, 본 발명의 실시예에 따르면, (CRS 기반 무선 링크 모니터링과 함께) CRS 이외 참조 신호 기반 무선 링크 모니터링에 의해 무선 링크 실패를 판단함으로써 빔포밍된 채널(예를 들어, 풀 차원 다중 입출력(FD-MIMO: Full Dimension Multi-Input Multi-Output) 등이 적용된 채널)에 따른 무선 링크 품질을 고려할 수 있다.

[27] 또한, 본 발명의 실시예에 따르면, 빔포밍된 채널에 따른 무선 링크 품질을 고려함으로써, 빔포밍된 채널 환경이 좋은 상태에서 통신 링크가 단절되는

현상을 줄이며, 또한 빔포밍된 채널을 통한 송수신 동작을 유지함에 따른 성능 이득을 얻을 수 있다.

[28] 본 발명에서 얻을 수 있는 효과는 이상에서 언급한 효과로 제한되지 않으며, 언급하지 않은 또 다른 효과들은 아래의 기재로부터 본 발명이 속하는 기술분야에서 통상의 지식을 가진 자에게 명확하게 이해될 수 있을 것이다.

도면의 간단한 설명

[29] 본 발명에 관한 이해를 돕기 위해 상세한 설명의 일부로 포함되는, 첨부 도면은 본 발명에 대한 실시예를 제공하고, 상세한 설명과 함께 본 발명의 기술적 특징을 설명한다.

[30] 도 1은 본 발명이 적용될 수 있는 무선 통신 시스템에서 무선 프레임의 구조를 나타낸다.

[31] 도 2는 본 발명이 적용될 수 있는 무선 통신 시스템에서 하나의 하향링크 슬롯에 대한 자원 그리드(resource grid)를 예시한 도면이다.

[32] 도 3은 본 발명이 적용될 수 있는 무선 통신 시스템에서 하향링크 서브 프레임의 구조를 나타낸다.

[33] 도 4는 본 발명이 적용될 수 있는 무선 통신 시스템에서 상향링크 서브 프레임의 구조를 나타낸다.

[34] 도 5는 일반적인 다중 입출력 안테나(MIMO) 통신 시스템의 구성도이다.

[35] 도 6은 다수의 송신 안테나에서 하나의 수신 안테나로의 채널을 나타낸 도이다.

[36] 도 7은 본 발명이 적용될 수 있는 무선 통신 시스템에서 컴포넌트 캐리어 및 캐리어 병합의 일례를 나타낸다.

[37] 도 8은 본 발명이 적용될 수 있는 무선 통신 시스템에서 경쟁 기반 랜덤 액세스 절차를 설명하기 위한 도면이다.

[38] 도 9는 본 발명이 적용될 수 있는 무선 통신 시스템에서 하향링크 자원 블록 쌍에 매핑된 참조 신호 패턴을 예시한다.

[39] 도 10은 본 발명이 적용될 수 있는 무선 통신 시스템에서 CSI-RS 구성을 예시하는 도면이다.

[40] 도 11은 본 발명이 적용될 수 있는 무선 통신 시스템에서 기지국 또는 단말이 AAS 기반의 3D(3-Dimension) 빔 형성이 가능한 다수의 송/수신 안테나를 갖고 있는 시스템을 예시한다.

[41] 도 12는 본 발명의 일 실시예에 따른 RRM-RS의 안테나 포트 별 RSRP를 예시한다.

[42] 도 13은 본 발명의 일 실시예에 따른 RRM-RS 안테나 포트 그룹핑 레벨을 예시한다.

[43] 도 14는 본 발명의 일 실시예에 따른 이차원 인덱스로 배열된 RRM-RS의 안테나 포트와 안테나 포트 그룹을 예시하는 도면이다.

[44] 도 15는 본 발명의 일 실시예에 따른 RRM-RS 기반 셀 선택 방법을 예시하는

도면이다.

[45] 도 16은 본 발명의 일 실시예에 따른 RRM 측정 방법을 예시하는 도면이다.

[46] 도 17은 본 발명의 일 실시예에 따른 랜덤 액세스 절차를 예시하는 도면이다.

[47] 도 18은 본 발명의 일 실시예에 따른 무선 링크 모니터링을 위한 방법을 예시하는 도면이다.

[48] 도 19는 본 발명의 일 실시예에 따른 무선 통신 장치의 블록 구성도를 예시한다.

발명의 실시를 위한 형태

[49] 이하, 본 발명에 따른 바람직한 실시 형태를 첨부된 도면을 참조하여 상세하게 설명한다. 첨부된 도면과 함께 이하에 개시될 상세한 설명은 본 발명의 예시적인 실시형태를 설명하고자 하는 것이며, 본 발명이 실시될 수 있는 유일한 실시형태를 나타내고자 하는 것이 아니다. 이하의 상세한 설명은 본 발명의 완전한 이해를 제공하기 위해서 구체적 세부사항을 포함한다. 그러나, 당업자는 본 발명이 이러한 구체적 세부사항 없이도 실시될 수 있음을 안다.

[50] 몇몇 경우, 본 발명의 개념이 모호해지는 것을 피하기 위하여 공지의 구조 및 장치는 생략되거나, 각 구조 및 장치의 핵심기능을 중심으로 한 블록도 형식으로 도시될 수 있다.

[51] 본 명세서에서 기지국은 단말과 직접적으로 통신을 수행하는 네트워크의 종단 노드(terminal node)로서의 의미를 갖는다. 본 문서에서 기지국에 의해 수행되는 것으로 설명된 특정 동작은 경우에 따라서는 기지국의 상위 노드(upper node)에 의해 수행될 수도 있다. 즉, 기지국을 포함하는 다수의 네트워크 노드들(network nodes)로 이루어지는 네트워크에서 단말과의 통신을 위해 수행되는 다양한 동작들은 기지국 또는 기지국 이외의 다른 네트워크 노드들에 의해 수행될 수 있음은 자명하다. '기지국(BS: Base Station)'은 고정국(fixed station), Node B, eNB(evolved-NodeB), BTS(base transceiver system), 액세스 포인트(AP: Access Point) 등의 용어에 의해 대체될 수 있다. 또한, '단말(Terminal)'은 고정되거나 이동성을 가질 수 있으며, UE(User Equipment), MS(Mobile Station), UT(user terminal), MSS(Mobile Subscriber Station), SS(Subscriber Station), AMS(Advanced Mobile Station), WT(Wireless terminal), MTC(Machine-Type Communication) 장치, M2M(Machine-to-Machine) 장치, D2D(Device-to-Device) 장치 등의 용어로 대체될 수 있다.

[52] 이하에서, 하향링크(DL: downlink)는 기지국에서 단말로의 통신을 의미하며, 상향링크(UL: uplink)는 단말에서 기지국으로의 통신을 의미한다. 하향링크에서 송신기는 기지국의 일부이고, 수신기는 단말의 일부일 수 있다. 상향링크에서 송신기는 단말의 일부이고, 수신기는 기지국의 일부일 수 있다.

[53] 이하의 설명에서 사용되는 특정 용어들은 본 발명의 이해를 돕기 위해서 제공된 것이며, 이러한 특정 용어의 사용은 본 발명의 기술적 사상을 벗어나지 않는 범위에서 다른 형태로 변경될 수 있다.

[54] 이하의 기술은 CDMA(code division multiple access), FDMA(frequency division multiple access), TDMA(time division multiple access), OFDMA(orthogonal frequency division multiple access), SC-FDMA(single carrier frequency division multiple access), NOMA(non-orthogonal multiple access) 등과 같은 다양한 무선 접속 시스템에 이용될 수 있다. CDMA는 UTRA(universal terrestrial radio access)나 CDMA2000과 같은 무선 기술(radio technology)로 구현될 수 있다. TDMA는 GSM(global system for mobile communications)/GPRS(general packet radio service)/EDGE(enhanced data rates for GSM evolution)와 같은 무선 기술로 구현될 수 있다. OFDMA는 IEEE 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802-20, E-UTRA(evolved UTRA) 등과 같은 무선 기술로 구현될 수 있다. UTRA는 UMTS(universal mobile telecommunications system)의 일부이다. 3GPP(3rd generation partnership project) LTE(long term evolution)은 E-UTRA를 사용하는 E-UMTS(evolved UMTS)의 일부로써, 하향링크에서 OFDMA를 채용하고 상향링크에서 SC-FDMA를 채용한다. LTE-A(advanced)는 3GPP LTE의 진화이다.

[55] 본 발명의 실시예들은 무선 접속 시스템들인 IEEE 802, 3GPP 및 3GPP2 중 적어도 하나에 개시된 표준 문서들에 의해 뒷받침될 수 있다. 즉, 본 발명의 실시예들 중 본 발명의 기술적 사상을 명확히 드러내기 위해 설명하지 않은 단계들 또는 부분들은 상기 문서들에 의해 뒷받침될 수 있다. 또한, 본 문서에서 개시하고 있는 모든 용어들은 상기 표준 문서에 의해 설명될 수 있다.

[56] 설명을 명확하게 하기 위해, 3GPP LTE/LTE-A를 위주로 기술하지만 본 발명의 기술적 특징이 이에 제한되는 것은 아니다.

[57]

[58] **본 발명이 적용될 수 있는 무선 통신 시스템 일반**

[59] 도 1은 본 발명이 적용될 수 있는 무선 통신 시스템에서 무선 프레임의 구조를 나타낸다.

[60] 3GPP LTE/LTE-A에서는 FDD(Frequency Division Duplex)에 적용 가능한 타입 1 무선 프레임(radio frame) 구조와 TDD(Time Division Duplex)에 적용 가능한 타입 2의 무선 프레임 구조를 지원한다.

[61] 도 1에서 무선 프레임의 시간 영역에서의 크기는 $T_s=1/(15000*2048)$의 시간 단위의 배수로 표현된다. 하향링크 및 상향링크 전송은 $T_f=307200*T_s=10ms$의 구간을 가지는 무선 프레임으로 구성된다.

[62] 도 1의 (a)는 타입 1 무선 프레임의 구조를 예시한다. 타입 1 무선 프레임은 전이중(full duplex) 및 반이중(half duplex) FDD에 모두 적용될 수 있다.

[63] 무선 프레임(radio frame)은 10개의 서브프레임(subframe)으로 구성된다. 하나의 무선 프레임은 $T_{slot}=15360*T_s=0.5ms$ 길이의 20개의 슬롯으로 구성되고, 각 슬롯은 0부터 19까지의 인덱스가 부여된다. 하나의 서브프레임은 시간 영역(time domain)에서 연속적인 2개의 슬롯(slot)으로 구성되고, 서브프레임 i는 슬롯 2i 및 슬롯 2i+1로 구성된다. 하나의 서브프레임을 전송하는데 걸리는 시간을

TTI(transmission time interval)이라 한다. 예를 들어, 하나의 서브 프레임은 길이는 1ms이고, 하나의 슬롯의 길이는 0.5ms일 수 있다.

[64] FDD에서 상향링크 전송 및 하향링크 전송은 주파수 도메인에서 구분된다. 전이중 FDD에 제한이 없는 반면, 반이중 FDD 동작에서 단말은 동시에 전송 및 수신을 할 수 없다.

[65] 하나의 슬롯은 시간 영역에서 복수의 OFDM(orthogonal frequency division multiplexing) 심볼을 포함하고, 주파수 영역에서 다수의 자원블록(RB: Resource Block)을 포함한다. 3GPP LTE는 하향링크에서 OFDMA를 사용하므로 OFDM 심볼은 하나의 심볼 구간(symbol period)을 표현하기 위한 것이다. OFDM 심볼은 하나의 SC-FDMA 심볼 또는 심볼 구간이라고 할 수 있다. 자원 블록(resource block)은 자원 할당 단위이고, 하나의 슬롯에서 복수의 연속적인 부반송파(subcarrier)를 포함한다.

[66] 도 1의 (b)는 타입 2 프레임 구조(frame structure type 2)를 나타낸다.

[67] 타입 2 무선 프레임은 각 153600*T_s=5ms의 길이의 2개의 하프 프레임(half frame)으로 구성된다. 각 하프 프레임은 30720*T_s=1ms 길이의 5개의 서브프레임으로 구성된다.

[68] TDD 시스템의 타입 2 프레임 구조에서 상향링크-하향링크 구성(uplink-downlink configuration)은 모든 서브프레임에 대하여 상향링크와 하향링크가 할당(또는 예약)되는지 나타내는 규칙이다.

[69] 표 1은 상향링크-하향링크 구성을 나타낸다.

[70] [표1]

Uplink-Downlink configu-ration	Downlink-to-Uplink Switch-point periodicity	Subframe number									
		0	1	2	3	4	5	6	7	8	9
0	5ms	D	S	U	U	U	D	S	U	U	U
1	5ms	D	S	U	U	D	D	S	U	U	D
2	5ms	D	S	U	D	D	D	S	U	D	D
3	10ms	D	S	U	U	U	D	D	D	D	D
4	10ms	D	S	U	U	D	D	D	D	D	D
5	10ms	D	S	U	D	D	D	D	D	D	D
6	5ms	D	S	U	U	U	D	S	U	U	D

[71] 표 1을 참조하면, 무선 프레임의 각 서브프레임 별로, 'D'는 하향링크 전송을 위한 서브프레임을 나타내고, 'U'는 상향링크 전송을 위한 서브프레임을 나타내며, 'S'는 DwPTS(Downlink Pilot Time Slot), 보호구간(GP: Guard Period), UpPTS(Uplink Pilot Time Slot) 3가지의 필드로 구성되는 스페셜 서브프레임(special subframe)을 나타낸다.

[72] DwPTS는 단말에서의 초기 셀 탐색, 동기화 또는 채널 추정에 사용된다. UpPTS는 기지국에서의 채널 추정과 단말의 상향링크 전송 동기를 맞추는 데 사용된다. GP는 상향링크와 하향링크 사이에 하향링크 신호의 다중경로

지연으로 인해 상향링크에서 생기는 간섭을 제거하기 위한 구간이다.

[73] 각 서브프레임 i는 각 T_slot=15360*T_s=0.5ms 길이의 슬롯 2i 및 슬롯 2i+1로 구성된다.

[74] 상향링크-하향링크 구성은 7가지로 구분될 수 있으며, 각 구성 별로 하향링크 서브프레임, 스페셜 서브프레임, 상향링크 서브프레임의 위치 및/또는 개수가 다르다.

[75] 하향링크에서 상향링크로 변경되는 시점 또는 상향링크에서 하향링크로 전환되는 시점을 전환 시점(switching point)이라 한다. 전환 시점의 주기성(Switch-point periodicity)은 상향링크 서브프레임과 하향링크 서브프레임이 전환되는 양상이 동일하게 반복되는 주기를 의미하며, 5ms 또는 10ms가 모두 지원된다. 5ms 하향링크-상향링크 전환 시점의 주기를 가지는 경우에는 스페셜 서브프레임(S)은 하프-프레임 마다 존재하고, 5ms 하향링크-상향링크 전환 시점의 주기를 가지는 경우에는 첫번째 하프-프레임에만 존재한다.

[76] 모든 구성에 있어서, 0번, 5번 서브프레임 및 DwPTS는 하향링크 전송만을 위한 구간이다. UpPTS 및 서브프레임 서브프레임에 바로 이어지는 서브프레임은 항상 상향링크 전송을 위한 구간이다.

[77] 이러한, 상향링크-하향링크 구성은 시스템 정보로써 기지국과 단말이 모두 알고 있을 수 있다. 기지국은 상향링크-하향링크 구성 정보가 바뀔 때마다 구성 정보의 인덱스만을 전송함으로써 무선 프레임의 상향링크-하향링크 할당상태의 변경을 단말에 알려줄 수 있다. 또한, 구성 정보는 일종의 하향링크 제어정보로서 다른 스케줄링 정보와 마찬가지로 PDCCH(Physical Downlink Control Channel)를 통해 전송될 수 있으며, 방송 정보로서 브로드캐스트 채널(broadcast channel)을 통해 셀 내의 모든 단말에 공통으로 전송될 수도 있다.

[78] 표 2는 스페셜 서브프레임의 구성(DwPTS/GP/UpPTS의 길이)을 나타낸다.

[79] [표2]

Special subframe configuration	Normal cyclic prefix in downlink			Extended cyclic prefix in downlink		
	DwPTS	UpPTS		DwPTS	UpPTS	
		Normal cyclic prefix in uplink	Extended cyclic prefix in uplink		Normal cyclic prefix in uplink	Extended cyclic prefix in uplink
0	$6592 \cdot T_s$	$2192 \cdot T_s$	$2560 \cdot T_s$	$7680 \cdot T_s$	$2192 \cdot T_s$	$2560 \cdot T_s$
1	$19760 \cdot T_s$			$20480 \cdot T_s$		
2	$21952 \cdot T_s$			$23040 \cdot T_s$		
3	$24144 \cdot T_s$			$25600 \cdot T_s$		
4	$26336 \cdot T_s$			$7680 \cdot T_s$	$4384 \cdot T_s$	$5120 \cdot T_s$
5	$6592 \cdot T_s$	$4384 \cdot T_s$	$5120 \cdot T_s$	$20480 \cdot T_s$		
6	$19760 \cdot T_s$			$23040 \cdot T_s$		
7	$21952 \cdot T_s$			-	-	-
8	$24144 \cdot T_s$			-	-	-

[80] 도 1의 예시에 따른 무선 프레임의 구조는 하나의 예시에 불과하며, 무선 프레임에 포함되는 부 반송파의 수 또는 서브 프레임에 포함되는 슬롯의 수, 슬롯에 포함되는 OFDM 심볼의 수는 다양하게 변경될 수 있다.

[81] 도 2는 본 발명이 적용될 수 있는 무선 통신 시스템에서 하나의 하향링크 슬롯에 대한 자원 그리드(resource grid)를 예시한 도면이다.

[82] 도 2를 참조하면, 하나의 하향링크 슬롯은 시간 영역에서 복수의 OFDM 심볼을 포함한다. 여기서, 하나의 하향링크 슬롯은 7개의 OFDM 심볼을 포함하고, 하나의 자원 블록은 주파수 영역에서 12개의 부 반송파를 포함하는 것을 예시적으로 기술하나, 이에 한정되는 것은 아니다.

[83] 자원 그리드 상에서 각 요소(element)를 자원 요소(resource element)하고, 하나의 자원 블록(RB: resource block)은 12 × 7 개의 자원 요소를 포함한다. 하향링크 슬롯에 포함되는 자원 블록들의 수 N^DL은 하향링크 전송 대역폭(bandwidth)에 종속한다.

[84] 상향링크 슬롯의 구조는 하향링크 슬롯의 구조와 동일할 수 있다.

[85] 도 3은 본 발명이 적용될 수 있는 무선 통신 시스템에서 하향링크 서브 프레임의 구조를 나타낸다.

[86] 도 3을 참조하면, 서브 프레임내의 첫번째 슬롯에서 앞의 최대 3개의 OFDM 심볼들이 제어 채널들이 할당되는 제어 영역(control region)이고, 나머지 OFDM 심볼들은 PDSCH(Physical Downlink Shared Channel)이 할당되는 데이터 영역(data region)이다. 3GPP LTE에서 사용되는 하향링크 제어 채널의 일례로 PCFICH(Physical Control Format Indicator Channel), PDCCH(Physical Downlink Control Channel), PHICH(Physical Hybrid-ARQ Indicator Channel) 등이 있다.

[87] PCFICH는 서브 프레임의 첫번째 OFDM 심볼에서 전송되고, 서브 프레임 내에 제어 채널들의 전송을 위하여 사용되는 OFDM 심볼들의 수(즉, 제어 영역의

크기)에 관한 정보를 나른다. PHICH는 상향 링크에 대한 응답 채널이고, HARQ(Hybrid Automatic Repeat Request)에 대한 ACK(Acknowledgement)/NACK(Not-Acknowledgement) 신호를 나른다. PDCCH를 통해 전송되는 제어 정보를 하향링크 제어정보(DCI: downlink control information)라고 한다. 하향링크 제어정보는 상향링크 자원 할당 정보, 하향링크 자원 할당 정보 또는 임의의 단말 그룹에 대한 상향링크 전송(Tx) 파워 제어 명령을 포함한다.

[88] PDCCH는 DL-SCH(Downlink Shared Channel)의 자원 할당 및 전송 포맷(이를 하향링크 그랜트라고도 한다.), UL-SCH(Uplink Shared Channel)의 자원 할당 정보(이를 상향링크 그랜트라고도 한다.), PCH(Paging Channel)에서의 페이징(paging) 정보, DL-SCH에서의 시스템 정보, PDSCH에서 전송되는 랜덤 액세스 응답(random access response)과 같은 상위 레이어(upper-layer) 제어 메시지에 대한 자원 할당, 임의의 단말 그룹 내 개별 단말들에 대한 전송 파워 제어 명령들의 집합, VoIP(Voice over IP)의 활성화 등을 나를 수 있다. 복수의 PDCCH들은 제어 영역 내에서 전송될 수 있으며, 단말은 복수의 PDCCH들을 모니터링할 수 있다. PDCCH는 하나 또는 복수의 연속적인 CCE(control channel elements)의 집합으로 구성된다. CCE는 무선 채널의 상태에 따른 부호화율(coding rate)을 PDCCH에 제공하기 위하여 사용되는 논리적 할당 단위이다. CCE는 복수의 자원 요소 그룹(resource element group)들에 대응된다. PDCCH의 포맷 및 사용 가능한 PDCCH의 비트 수는 CCE들의 수와 CCE들에 의해 제공되는 부호화율 간의 연관 관계에 따라 결정된다.

[89] 기지국은 단말에게 전송하려는 DCI에 따라 PDCCH 포맷을 결정하고, 제어 정보에 CRC(Cyclic Redundancy Check)를 붙인다. CRC에는 PDCCH의 소유자(owner)나 용도에 따라 고유한 식별자(이를 RNTI(Radio Network Temporary Identifier)라고 한다.)가 마스킹된다. 특정의 단말을 위한 PDCCH라면 단말의 고유한 식별자, 예를 들어 C-RNTI(Cell-RNTI)가 CRC에 마스킹될 수 있다. 또는 페이징 메시지를 위한 PDCCH라면 페이징 지시 식별자, 예를 들어 P-RNTI(Paging-RNTI)가 CRC에 마스킹될 수 있다. 시스템 정보, 더욱 구체적으로 시스템 정보 블록(SIB: system information block)를 위한 PDCCH라면 시스템 정보 식별자, SI-RNTI(system information RNTI)가 CRC에 마스킹될 수 있다. 단말의 랜덤 액세스 프리앰블의 전송에 대한 응답인 랜덤 액세스 응답을 지시하기 위하여, RA-RNTI(random access-RNTI)가 CRC에 마스킹될 수 있다.

[90] EPDCCH(enhanced PDCCH)는 단말 특정(UE-specific) 시그널링을 나른다. EPDCCH는 단말 특정하게 설정된 물리 자원 블록(PRB: physical resource block)에 위치한다. 다시 말해, 상술한 바와 같이 PDCCH는 서브 프레임내의 첫번째 슬롯에서 앞의 최대 3개의 OFDM 심볼들에서 전송될 수 있으나, EPDCCH는 PDCCH 이외의 자원 영역에서 전송될 수 있다. 서브프레임 내 EPDCCH가 시작되는 시점(즉, 심볼)은 상위 계층 시그널링(예를 들어, RRC 시그널링 등)을

통해 단말에 설정될 수 있다.

[91] EPDCCH는 DL-SCH와 관련된 전송 포맷, 자원 할당 및 HARQ 정보, UL-SCH와 관련된 전송 포맷, 자원 할당 및 HARQ 정보, SL-SCH(Sidelink Shared Channel) 및 PSCCH(Physical Sidelink Control Channel)과 관련된 자원 할당 정보 등을 나를 수 있다. 다중의 EPDCCH가 지원될 수 있으며, 단말은 EPCCH의 세트를 모니터링할 수 있다.

[92] EPDCCH는 하나 또는 그 이상의 연속된 진보된 CCE(ECCE: enhanced CCE)를 이용하여 전송될 수 있으며, 각 EPDCCH 포맷 별로 단일의 EPDCCH 당 ECCE의 개수가 정해질 수 있다.

[93] 각 ECCE는 복수의 자원 요소 그룹(EREG: enhanced resource element group)으로 구성될 수 있다. EREG는 ECCE의 RE에의 매핑을 정의하기 위하여 사용된다. PRB 쌍 별로 16개의 EREG가 존재한다. 각 PRB 쌍 내에서 DMRS를 나르는 RE를 제외하고, 모든 RE는 주파수가 증가하는 순서대로 그 다음 시간이 증가하는 순서대로 0 내지 15까지의 번호가 부여된다.

[94] 단말은 복수의 EPDCCH를 모니터링할 수 있다. 예를 들어, 단말이 EPDCCH 전송을 모니터링하는 하나의 PRB 쌍 내 하나 또는 두 개의 EPDCCH 세트가 설정될 수 있다.

[95] 서로 다른 개수의 ECCE가 병합됨으로써 EPCCH를 위한 서로 다른 부호화율(coding rate)이 실현될 수 있다. EPCCH는 지역적 전송(localized transmission) 또는 분산적 전송(distributed transmission)을 사용할 수 있으며, 이에 따라 PRB 내 RE에 ECCE의 매핑이 달라질 수 있다.

[96] 도 4는 본 발명이 적용될 수 있는 무선 통신 시스템에서 상향링크 서브 프레임의 구조를 나타낸다.

[97] 도 4를 참조하면, 상향링크 서브 프레임은 주파수 영역에서 제어 영역과 데이터 영역으로 나눌 수 있다. 제어 영역에는 상향링크 제어 정보를 나르는 PUCCH(Physical Uplink Control Channel)이 할당된다. 데이터 영역은 사용자 데이터를 나르는 PUSCH(Physical Uplink Shared Channel)이 할당된다. 단일 반송파 특성을 유지하기 위해 하나의 단말은 PUCCH와 PUSCH을 동시에 전송하지 않는다.

[98] 하나의 단말에 대한 PUCCH에는 서브 프레임 내에 자원 블록(RB: Resource Block) 쌍이 할당된다. RB 쌍에 속하는 RB들은 2개의 슬롯들의 각각에서 서로 다른 부 반송파를 차지한다. 이를 PUCCH에 할당된 RB 쌍은 슬롯 경계(slot boundary)에서 주파수 도약(frequency hopping)된다고 한다.

[99]

[100] **MIMO**(Multi-Input Multi-Output)

[101] MIMO 기술은 지금까지 일반적으로 한 개의 송신안테나와 한 개의 수신안테나를 사용했던 것에서 탈피하여, 다중 송신(Tx) 안테나와 다중 수신(Rx) 안테나를 사용한다. 다시 말해서, MIMO 기술은 무선 통신 시스템의 송신단 또는

수신단에서 다중 입출력 안테나를 사용하여 용량 증대 또는 성능 개성을 꾀하기 위한 기술이다. 이하에서는 'MIMO'를 '다중 입출력 안테나'라 칭하기로 한다.

[102] 더 구체적으로, 다중 입출력 안테나 기술은 하나의 완전한 메시지(total message)를 수신하기 위하여 한 개의 안테나 경로에 의존하지 않으며, 여러 개의 안테나를 통해 수신한 복수의 데이터 조각을 수집하여 완전한 데이터를 완성시킨다. 결과적으로, 다중 입출력 안테나 기술은 특정 시스템 범위 내에서 데이터 전송율을 증가시킬 수 있으며, 또한 특정 데이터 전송율을 통해 시스템 범위를 증가시킬 수 있다.

[103] 차세대 이동통신은 기존 이동통신에 비해 훨씬 높은 데이터 전송률을 요구하므로 효율적인 다중 입출력 안테나 기술이 반드시 필요할 것으로 예상된다. 이와 같은 상황에서 MIMO 통신 기술은 이동통신 단말과 중계기 등에 폭넓게 사용할 수 있는 차세대 이동통신 기술이며, 데이터 통신 확대 등으로 인해 한계 상황에 따라 다른 이동통신의 전송량 한계를 극복할 수 있는 기술로서 관심을 모으고 있다.

[104] 한편, 현재 연구되고 있는 다양한 전송효율 향상 기술 중 다중 입출력 안테나(MIMO) 기술은 추가적인 주파수 할당이나 전력증가 없이도 통신 용량 및 송수신 성능을 획기적으로 향상시킬 수 있는 방법으로서 현재 가장 큰 주목을 받고 있다.

[105] 도 5는 일반적인 다중 입출력 안테나(MIMO) 통신 시스템의 구성도이다.

[106] 도 5를 참조하면, 송신 안테나의 수를 N_T개로, 수신 안테나의 수를 N_R개로 동시에 늘리게 되면, 송신기나 수신기에서만 다수의 안테나를 사용하게 되는 경우와 달리 안테나 수에 비례하여 이론적인 채널 전송 용량이 증가하므로, 전송 레이트(transfer rate)를 향상시키고, 주파수 효율을 획기적으로 향상시킬 수 있다. 이 경우, 채널 전송 용량의 증가에 따른 전송 레이트는 하나의 안테나를 이용하는 경우의 최대 전송 레이트(R_o)에 다음과 같은 레이트 증가율(R_i)이 곱해진 만큼으로 이론적으로 증가할 수 있다.

[107] [수식1]

$$R_i = \min\left(N_T, N_R\right)$$

[108] 즉, 예를 들어, 4개의 송신 안테나와 4개의 수신 안테나를 이용하는 MIMO 통신 시스템에서는 단일 안테나 시스템에 비해 이론상 4배의 전송 레이트를 획득할 수 있다.

[109] 이와 같은 다중 입출력 안테나의 기술은 다양한 채널 경로를 통과한 심볼들을 이용하여 전송 신뢰도를 높이는 공간 다이버시티(spatial diversity) 방식과, 다수의 송신 안테나를 이용하여 다수의 데이터 심볼을 동시에 송신하여 전송률을 향상시키는 공간 멀티플렉싱(spatial multiplexing) 방식으로 나눌 수 있다. 또한 이러한 두 가지 방식을 적절히 결합하여 각각의 장점을 적절히 얻고자 하는 방식에 대한 연구도 최근 많이 연구되고 있는 분야이다.

[110] 각각의 방식에 대해 좀더 구체적으로 살펴보면 다음과 같다.

[111] 첫째로, 공간 다이버시티 방식의 경우에는 시공간 블록 부호 계열과, 다이버시티 이득과 부호화 이득을 동시에 이용하는 시공간 트렐리스(Trelis) 부호 계열 방식이 있다. 일반적으로 비트 오류율 개선 성능과 부호 생성 자유도는 트렐리스 부호 방식이 우수하지만, 연산 복잡도는 시공간 블록 부호가 간단하다. 이와 같은 공간 다이버서티 이득은 송신 안테나 수(N_T)와 수신 안테나 수(N_R)의 곱(N_T × N_R)에 해당되는 양을 얻을 수 있다.

[112] 둘째로, 공간 멀티플렉싱 기법은 각 송신 안테나에서 서로 다른 데이터 열을 송신하는 방법인데, 이때 수신기에서는 송신기로부터 동시에 전송된 데이터 사이에 상호 간섭이 발생하게 된다. 수신기에서는 이 간섭을 적절한 신호처리 기법을 이용하여 제거한 후 수신한다. 여기에 사용되는 잡음 제거 방식은 MLD(maximum likelihood detection) 수신기, ZF(zero-forcing) 수신기, MMSE(minimum mean square error) 수신기, D-BLAST (Diagonal-Bell Laboratories Layered Space-Time), V-BLAST(Vertical-Bell Laboratories Layered Space-Time) 등이 있으며, 특히 송신단에서 채널 정보를 알 수 있는 경우에는 SVD(singular value decomposition) 방식 등을 사용할 수 있다.

[113] 셋째로, 공간 다이버시티와 공간 멀티플렉싱의 결합된 기법을 들 수 있다. 공간 다이버시티 이득만을 얻을 경우 다이버시티 차수의 증가에 따른 성능개선 이득이 점차 포화되며, 공간 멀티플렉싱 이득만을 취하면 무선 채널에서 전송 신뢰도가 떨어진다. 이를 해결하면서 두 가지 이득을 모두 얻는 방식들이 연구되어 왔으며, 이 중 시공간 블록 부호 (Double-STTD), 시공간 BICM(STBICM) 등의 방식이 있다.

[114] 상술한 바와 같은 다중 입출력 안테나 시스템에 있어서의 통신 방법을 보다 구체적인 방법으로 설명하기 위해 이를 수학적으로 모델링하는 경우 다음과 같이 나타낼 수 있다.

[115] 먼저, 도 5에 도시된 바와 같이 N_T개의 송신 안테나와 N_R개의 수신 안테나가 존재하는 것을 가정한다.

[116] 먼저, 송신 신호에 대해 살펴보면, 이와 같이 N_T개의 송신 안테나가 있는 경우 최대 전송 가능한 정보는 N_T개 이므로, 이를 다음과 같은 벡터로 나타낼 수 있다.

[117] [수식2]

$$\mathbf{s} = \left[s_1, s_2, \cdots, s_{N_T}\right]^T$$

[118] 한편, 각각의 전송 정보 s_1, s_2, ..., s_N_T에 있어 전송 전력을 달리 할 수 있으며, 이때 각각의 전송 전력을 P_1, P_2, ..., P_N_T라 하면, 전송 전력이 조정된 전송 정보는 다음과 같은 벡터로 나타낼 수 있다.

[119] [수식3]

$$\hat{\mathbf{s}} = \left[\hat{s}_1, \hat{s}_2, \cdots, \hat{s}_{N_T}\right]^T = \left[P_1 s_1, P_2 s_2, \cdots, P_{N_T} s_{N_T}\right]^T$$

[120] 또한, 수학식 3의 전송 전력이 조정된 전송 정보를 전송 전력의 대각 행렬 P로 다음과 같이 나타낼 수 있다.

[121] [수식4]

$$\hat{\mathbf{s}} = \begin{bmatrix} P_1 & & & 0 \\ & P_2 & & \\ & & \ddots & \\ 0 & & & P_{N_T} \end{bmatrix} \begin{bmatrix} s_1 \\ s_2 \\ \vdots \\ s_{N_T} \end{bmatrix} = \mathbf{Ps}$$

[122] 한편, 수학식 4의 전송 전력이 조정된 정보 벡터는 그 후 가중치 행렬 W가 곱해져 실제 전송되는 N_T개의 전송 신호 x_1, x_2, ..., x_N_T를 구성한다. 여기서, 가중치 행렬은 전송 채널 상황 등에 따라 전송 정보를 각 안테나에 적절히 분배해 주는 역할을 수행한다. 이와 같은 전송 신호 x_1, x_2, ..., x_N_T를 벡터 x를 이용하여 다음과 같이 나타낼 수 있다.

[123] [수식5]

$$\mathbf{x} = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_i \\ \vdots \\ x_{N_T} \end{bmatrix} = \begin{bmatrix} w_{11} & w_{12} & \cdots & w_{1N_T} \\ w_{21} & w_{22} & \cdots & w_{2N_T} \\ \vdots & & \ddots & \\ w_{i1} & w_{i2} & \cdots & w_{iN_T} \\ \vdots & & \ddots & \\ w_{N_T1} & w_{N_T2} & \cdots & w_{N_TN_T} \end{bmatrix} \begin{bmatrix} \hat{s}_1 \\ \hat{s}_2 \\ \vdots \\ \hat{s}_j \\ \vdots \\ \hat{s}_{N_T} \end{bmatrix} = \mathbf{W}\hat{\mathbf{s}} = \mathbf{WPs}$$

[124] 여기서, w_ij는 i번째 송신 안테나와 j번째 전송 정보간의 가중치를 나타내며, W는 이를 행렬로 나타낸 것이다. 이와 같은 행렬 W를 가중치 행렬(Weight Matrix) 또는 프리코딩 행렬(Precoding Matrix)라 부른다.

[125] 한편, 상술한 바와 같은 전송 신호(x)는 공간 다이버시티를 사용하는 경우와 공간 멀티플랙싱을 사용하는 경우로 나누어 생각해 볼 수 있다.

[126] 공간 멀티플랙싱을 사용하는 경우는 서로 다른 신호를 다중화하여 보내게 되므로, 정보 벡터 s의 원소들이 모두 다른 값을 가지게 되는 반면, 공간 다이버시티를 사용하게 되면 같은 신호를 여러 채널 경로를 통하여 보내게 되므로 정보 벡터 s의 원소들이 모두 같은 값을 갖게 된다.

[127] 물론, 공간 멀티플랙싱과 공간 다이버시티를 혼합하는 방법도 고려 가능하다. 즉, 예를 들어 3 개의 송신 안테나를 통하여 같은 신호를 공간 다이버시티를 이용하여 전송하고, 나머지는 각각 다른 신호를 공간 멀티플랙싱하여 보내는 경우도 고려할 수 있다.

[128] 다음으로, 수신신호는 N_R개의 수신 안테나가 있는 경우, 각 안테나의 수신신호 y_1, y_2, ..., y_N_R을 벡터 y로 다음과 같이 나타내기로 한다.

[129] [수식6]

$$\mathbf{y} = \left[y_1, y_2, \cdots, y_{N_R} \right]^{\mathrm{T}}$$

[130] 한편, 다중 입출력 안테나 통신 시스템에 있어서의 채널을 모델링하는 경우, 각각의 채널은 송수신 안테나 인덱스에 따라 구분할 수 있으며, 송신 안테나 j로부터 수신 안테나 i를 거치는 채널을 h_ij로 표시하기로 한다. 여기서, h_ij의 인덱스의 순서가 수신 안테나 인덱스가 먼저, 송신안테나의 인덱스가 나중임에 유의한다.

[131] 이러한 채널은 여러 개를 한데 묶어서 벡터 및 행렬 형태로도 표시 가능하다. 벡터 표시의 예를 들어 설명하면 다음과 같다.

[132] 도 6은 다수의 송신 안테나에서 하나의 수신 안테나로의 채널을 나타낸 도이다.

[133] 도 6에 도시된 바와 같이 총 N_T개의 송신 안테나로부터 수신안테나 i로 도착하는 채널은 다음과 같이 표현 가능하다.

[134] [수식7]

$$\mathbf{h}_i^T = \left[h_{i1}, h_{i2}, \cdots, h_{iN_T} \right]$$

[135] 또한, 상기 수학식 7과 같은 행렬 표현을 통해 N_T개의 송신 안테나로부터 N_R개의 수신 안테나를 거치는 채널을 모두 나타내는 경우 다음과 같이 나타낼 수 있다.

[136] [수식8]

$$\mathbf{H} = \begin{bmatrix} \mathbf{h}_1^{\mathrm{T}} \\ \mathbf{h}_2^{\mathrm{T}} \\ \vdots \\ \mathbf{h}_i^{\mathrm{T}} \\ \vdots \\ \mathbf{h}_{\mathrm{N_R}}^{\mathrm{T}} \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} & \cdots & h_{1N_T} \\ h_{21} & h_{22} & \cdots & h_{2N_T} \\ \vdots & & \ddots & \\ h_{i1} & h_{i2} & \cdots & h_{iN_T} \\ \vdots & & \ddots & \\ h_{N_R1} & h_{N_R2} & \cdots & h_{N_RN_T} \end{bmatrix}$$

[137] 한편, 실제 채널은 위와 같은 채널 행렬 H를 거친 후에 백색 잡음(AWGN: Additive White Gaussian Noise)가 더해지게 되므로, N_R개의 수신 안테나 각각에 더해지는 백색 잡음 n_1, n_2, ..., n_N_R을 백터로 표현하면 다음과 같다.

[138] [수식9]

$$\mathbf{n} = \left[n_1, n_2, \cdots, n_{N_R} \right]^{\mathrm{T}}$$

[139] 상술한 바와 같은 전송 신호, 수신 신호, 채널, 및 백색 잡음의 모델링을 통해 다중 입출력 안테나 통신 시스템에서의 각각은 다음과 같은 관계를 통해 나타낼 수 있다.

[140] [수식10]

$$\mathbf{y} = \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_i \\ \vdots \\ y_{N_R} \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} & \cdots & h_{1N_T} \\ h_{21} & h_{22} & \cdots & h_{2N_T} \\ \vdots & & \ddots & \\ h_{i1} & h_{i2} & \cdots & h_{iN_T} \\ \vdots & & \ddots & \\ h_{N_R1} & h_{N_R2} & \cdots & h_{N_RN_T} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_j \\ \vdots \\ x_{N_T} \end{bmatrix} + \begin{bmatrix} n_1 \\ n_2 \\ \vdots \\ n_i \\ \vdots \\ n_{N_R} \end{bmatrix} = \mathbf{Hx} + \mathbf{n}$$

[141] 한편, 채널의 상태를 나타내는 채널 행렬 H의 행과 열의 수는 송수신 안테나 수에 의해서 결정된다. 채널 행렬 H는 앞서 살펴본 바와 같이 행의 수는 수신 안테나의 수 N_R과 같아지고, 열의 수는 송신 안테나의 수 N_T와 같아 지게 된다. 즉, 채널 행렬 H는 N_R×N_T 행렬이 된다.

[142] 일반적으로, 행렬의 랭크(rank)는 서로 독립인(independent) 행 또는 열의 개수 중에서 최소 개수로 정의된다. 따라서, 행렬의 랭크는 행 또는 열의 개수보다 클 수 없게 된다. 수식적으로 예를 들면, 채널 행렬 H의 랭크(rank(H))는 다음과 같이 제한된다.

[143] [수식11]

$$rank(\mathbf{H}) \le \min(N_T, N_R)$$

[144] 또한, 행렬을 고유치 분해(Eigen value decomposition)를 하였을 때, 랭크는 고유치(eigen value)들 중에서 0이 아닌 고유치들의 개수로 정의할 수 있다. 비슷한 방법으로, 랭크를 SVD(singular value decomposition) 했을 때 0이 아닌 특이값(singular value)들의 개수로 정의할 수 있다. 따라서, 채널 행렬에서 랭크의 물리적인 의미는 주어진 채널에서 서로 다른 정보를 보낼 수 있는 최대 수라고 할 수 있다.

[145] 본 명세서에 있어, MIMO 전송에 대한 '랭크(Rank)'는 특정 시점 및 특정 주파수 자원에서 독립적으로 신호를 전송할 수 있는 경로의 수를 나타내며, '레이어(layer)의 개수'는 각 경로를 통해 전송되는 신호 스트림의 개수를 나타낸다. 일반적으로 송신단은 신호 전송에 이용되는 랭크 수에 대응하는 개수의 레이어를 전송하기 때문에 특별한 언급이 없는 한 랭크는 레이어 개수와 동일한 의미를 가진다.

[146]

[147] 캐리어 병합(Carrier Aggregation)

[148] 본 발명의 실시예들에서 고려하는 통신 환경은 멀티 캐리어(Multi-carrier) 지원 환경을 모두 포함한다. 즉, 본 발명에서 사용되는 멀티 캐리어 시스템 또는 캐리어 병합(CA: Carrier Aggregation) 시스템이라 함은 광대역을 지원하기 위해서, 목표로 하는 광대역을 구성할 때 목표 대역보다 작은 대역폭(bandwidth)을 가지는 1개 이상의 컴포넌트 캐리어(CC: Component

Carrier)를 병합(aggregation)하여 사용하는 시스템을 말한다.

[149] 본 발명에서 멀티 캐리어는 캐리어의 병합(또는, 반송파 집성)을 의미하며, 이때 캐리어의 병합은 인접한(contiguous) 캐리어 간의 병합뿐 아니라 비 인접한(non-contiguous) 캐리어 간의 병합을 모두 의미한다. 또한, 하향링크와 상향링크 간에 집성되는 컴포넌트 캐리어들의 수는 다르게 설정될 수 있다. 하향링크 컴포넌트 캐리어(이하, 'DL CC'라 한다.) 수와 상향링크 컴포넌트 캐리어(이하, 'UL CC'라 한다.) 수가 동일한 경우를 대칭적(symmetric) 집성이라고 하고, 그 수가 다른 경우를 비대칭적(asymmetric) 집성이라고 한다. 이와 같은 캐리어 병합은 반송파 집성, 대역폭 집성(bandwidth aggregation), 스펙트럼 집성(spectrum aggregation) 등과 같은 용어와 혼용되어 사용될 수 있다.

[150] 두 개 이상의 컴포넌트 캐리어가 결합되어 구성되는 캐리어 병합은 LTE-A 시스템에서는 100MHz 대역폭까지 지원하는 것을 목표로 한다. 목표 대역보다 작은 대역폭을 가지는 1개 이상의 캐리어를 결합할 때, 결합하는 캐리어의 대역폭은 기존 IMT 시스템과의 호환성(backward compatibility) 유지를 위해서 기존 시스템에서 사용하는 대역폭으로 제한할 수 있다. 예를 들어서 기존의 3GPP LTE 시스템에서는 {1.4, 3, 5, 10, 15, 20}MHz 대역폭을 지원하며, 3GPP LTE-advanced 시스템(즉, LTE-A)에서는 기존 시스템과의 호환을 위해 상기의 대역폭들만을 이용하여 20MHz보다 큰 대역폭을 지원하도록 할 수 있다. 또한, 본 발명에서 사용되는 캐리어 병합 시스템은 기존 시스템에서 사용하는 대역폭과 상관없이 새로운 대역폭을 정의하여 캐리어 병합을 지원하도록 할 수도 있다.

[151] LTE-A 시스템은 무선 자원을 관리하기 위해 셀(cell)의 개념을 사용한다.

[152] 상술한 캐리어 병합 환경은 다중 셀(multiple cells) 환경으로 일컬을 수 있다. 셀은 하향링크 자원(DL CC)과 상향링크 자원(UL CC) 한 쌍의 조합으로 정의되나, 상향링크 자원은 필수 요소는 아니다. 따라서, 셀은 하향링크 자원 단독, 또는 하향링크 자원과 상향링크 자원으로 구성될 수 있다. 특정 단말이 단 하나의 설정된 서빙 셀(configured serving cell)을 가지는 경우 1개의 DL CC와 1개의 UL CC를 가질 수 있으나, 특정 단말이 2개 이상의 설정된 서빙 셀을 가지는 경우에는 셀의 수만큼의 DL CC를 가지며 UL CC의 수는 그와 같거나 그보다 작을 수 있다.

[153] 또는, 그 반대로 DL CC와 UL CC가 구성될 수도 있다. 즉, 특정 단말이 다수의 설정된 서빙 셀을 가지는 경우 DL CC의 수보다 UL CC가 더 많은 캐리어 병합 환경도 지원될 수 있다. 즉, 캐리어 병합(carrier aggregation)은 각각 캐리어 주파수(셀의 중심 주파수)가 서로 다른 둘 이상의 셀들의 병합으로 이해될 수 있다. 여기서, 말하는 '셀(Cell)'은 일반적으로 사용되는 기지국이 커버하는 영역으로서의 '셀'과는 구분되어야 한다.

[154] LTE-A 시스템에서 사용되는 셀은 프라이머리 셀(PCell: Primary Cell) 및 세컨더리 셀(SCell: Secondary Cell)을 포함한다. P셀과 S셀은 서빙 셀(Serving

Cell)로 사용될 수 있다. RRC_CONNECTED 상태에 있지만 캐리어 병합이 설정되지 않았거나 캐리어 병합을 지원하지 않는 단말의 경우, P셀로만 구성된 서빙 셀이 단 하나 존재한다. 반면, RRC_CONNECTED 상태에 있고 캐리어 병합이 설정된 단말의 경우 하나 이상의 서빙 셀이 존재할 수 있으며, 전체 서빙 셀에는 P셀과 하나 이상의 S셀이 포함된다.

[155] 서빙 셀(P셀과 S셀)은 RRC 파라미터를 통해 설정될 수 있다. PhysCellId는 셀의 물리 계층 식별자로 0부터 503까지의 정수값을 가진다. SCellIndex는 S셀을 식별하기 위하여 사용되는 간략한(short) 식별자로 1부터 7까지의 정수값을 가진다. ServCellIndex는 서빙 셀(P셀 또는 S셀)을 식별하기 위하여 사용되는 간략한(short) 식별자로 0부터 7까지의 정수값을 가진다. 0값은 P셀에 적용되며, SCellIndex는 S셀에 적용하기 위하여 미리 부여된다. 즉, ServCellIndex에서 가장 작은 셀 ID (또는 셀 인덱스)을 가지는 셀이 P셀이 된다.

[156] P셀은 프라이머리 주파수(또는, primary CC) 상에서 동작하는 셀을 의미한다. 단말이 초기 연결 설정(initial connection establishment) 과정을 수행하거나 연결 재-설정 과정을 수행하는데 사용될 수 있으며, 핸드오버 과정에서 지시된 셀을 지칭할 수도 있다. 또한, P셀은 캐리어 병합 환경에서 설정된 서빙 셀 중 제어관련 통신의 중심이 되는 셀을 의미한다. 즉, 단말은 자신의 P셀에서만 PUCCH를 할당 받아 전송할 수 있으며, 시스템 정보를 획득하거나 모니터링 절차를 변경하는데 P셀만을 이용할 수 있다. E-UTRAN(Evolved Universal Terrestrial Radio Access)은 캐리어 병합 환경을 지원하는 단말에게 이동성 제어 정보(mobilityControlInfo)를 포함하는 상위 계층의 RRC 연결 재설정(RRCConnectionReconfigutaion) 메시지를 이용하여 핸드오버 절차를 위해 P셀만을 변경할 수도 있다.

[157] S셀은 세컨더리 주파수(또는, Secondary CC) 상에서 동작하는 셀을 의미할 수 있다. 특정 단말에 P셀은 하나만 할당되며, S셀은 하나 이상 할당될 수 있다. S셀은 RRC 연결이 설정이 이루어진 이후에 구성 가능하고 추가적인 무선 자원을 제공하는데 사용될 수 있다. 캐리어 병합 환경에서 설정된 서빙 셀 중에서 P셀을 제외한 나머지 셀들, 즉 S셀에는 PUCCH가 존재하지 않는다. E-UTRAN은 S셀을 캐리어 병합 환경을 지원하는 단말에게 추가할 때, RRC_CONNECTED 상태에 있는 관련된 셀의 동작과 관련된 모든 시스템 정보를 특정 시그널(dedicated signal)을 통해 제공할 수 있다. 시스템 정보의 변경은 관련된 S셀의 해제 및 추가에 의하여 제어될 수 있으며, 이 때 상위 계층의 RRC 연결 재설정 (RRCConnectionReconfigutaion) 메시지를 이용할 수 있다. E-UTRAN은 관련된 S셀 안에서 브로드캐스트하기 보다는 단말 별로 상이한 파라미터를 가지는 특정 시그널링(dedicated signaling) 할 수 있다.

[158] 초기 보안 활성화 과정이 시작된 이후에, E-UTRAN은 연결 설정 과정에서 초기에 구성되는 P셀에 부가하여 하나 이상의 S셀을 포함하는 네트워크를 구성할 수 있다. 캐리어 병합 환경에서 P셀 및 S셀은 각각의 컴포넌트

캐리어로서 동작할 수 있다. 이하의 실시 예에서는 프라이머리 컴포넌트 캐리어(PCC)는 P셀과 동일한 의미로 사용될 수 있으며, 세컨더리 컴포넌트 캐리어(SCC)는 S셀과 동일한 의미로 사용될 수 있다.

[159] 도 7은 본 발명이 적용될 수 있는 무선 통신 시스템에서 컴포넌트 캐리어 및 캐리어 병합의 일례를 나타낸다.

[160] 도 7의 (a)는 LTE 시스템에서 사용되는 단일 캐리어 구조를 나타낸다. 컴포넌트 캐리어에는 DL CC와 UL CC가 있다. 하나의 컴포넌트 캐리어는 20MHz의 주파수 범위를 가질 수 있다.

[161] 도 7의 (b)는 LTE_A 시스템에서 사용되는 캐리어 병합 구조를 나타낸다. 도 7의 (b)의 경우에 20MHz의 주파수 크기를 갖는 3 개의 컴포넌트 캐리어가 결합된 경우를 나타낸다. DL CC와 UL CC가 각각 3 개씩 있으나, DL CC와 UL CC의 개수에 제한이 있는 것은 아니다. 캐리어 병합의 경우 단말은 3개의 CC를 동시에 모니터링할 수 있고, 하향링크 신호/데이터를 수신할 수 있고 상향링크 신호/데이터를 송신할 수 있다.

[162] 만약, 특정 셀에서 N개의 DL CC가 관리되는 경우에는, 네트워크는 단말에 M (M≤N)개의 DL CC를 할당할 수 있다. 이때, 단말은 M 개의 제한된 DL CC 만을 모니터링하고 DL 신호를 수신할 수 있다. 또한, 네트워크는 L (L≤M≤N)개의 DL CC에 우선순위를 주어 주된 DL CC를 단말에 할당할 수 있으며, 이러한 경우 UE는 L 개의 DL CC는 반드시 모니터링해야 한다. 이러한 방식은 상향링크 전송에도 똑같이 적용될 수 있다.

[163] 하향링크 자원의 반송파 주파수(또는 DL CC)와 상향링크 자원의 반송파 주파수(또는, UL CC) 사이의 링키지(linkage)는 RRC 메시지와 같은 상위계층 메시지나 시스템 정보에 의해 지시될 수 있다. 예를 들어, SIB2(System Information Block Type2)에 의해서 정의되는 링키지에 의해서 DL 자원과 UL 자원의 조합이 구성될 수 있다. 구체적으로, 링키지는 UL 그랜트를 나르는 PDCCH가 전송되는 DL CC와 상기 UL 그랜트를 사용하는 UL CC간의 맵핑 관계를 의미할 수 있으며, HARQ를 위한 데이터가 전송되는 DL CC(또는 UL CC)와 HARQ ACK/NACK 신호가 전송되는 UL CC(또는 DL CC)간의 맵핑 관계를 의미할 수도 있다.

[164] 단말이 하나 이상의 S셀이 설정되면, 네트워크는 설정된 S셀(들)을 활성화(activate) 또는 비활성화(deactivate)할 수 있다. P셀은 항상 활성화된다. 네트워크는 활성/비활성(Activation/Deactivation) MAC 제어 요소(MAC control element)를 전송함으로써 S셀(들)을 활성화 또는 비활성화한다.

[165] 활성/비활성 MAC 제어 요소는 고정된 크기를 가지고, 7개의 C 필드(C-field)와 1개의 R 필드(R-field)를 포함하는 단일의 옥텟(octet)으로 구성된다. C 필드는 각 S셀 인덱스(SCellIndex) 별로 구성되고, S셀의 활성/비활성 상태를 지시한다. C 필드 값이 '1'로 셋팅되면 해당 S셀 인덱스를 가지는 S셀의 활성화되는 것을 지시하고, '0'으로 셋팅되면 해당 S셀 인덱스를 가지는 S셀의 비활성화되는 것을

지시한다.

[166] 또한, 단말은 설정된 S셀 별로 타이머(sCellDeactivationTimer)를 유지하고, 타이머가 만료될 때 관련된 S셀을 비활성화한다. 동일한 초기 타이머 값이 타이머(sCellDeactivationTimer)의 각 인스턴스(instance)에 적용되며, RRC 시그널링에 의해 설정된다. S셀(들)이 추가될 때 또는 핸드오버 이후, 초기 S셀(들)은 비활성화 상태이다.

[167] 단말은 각 TTI에서 각각의 설정된 S셀(들)에 대하여 아래와 같은 동작을 수행한다.

[168] - 단말이 특정 TTI(서브프레임 n)에서 S셀을 활성화하는 활성/비활성 MAC 제어 요소를 수신하면, 단말은 정해진 타이밍에 해당하는 TTI(서브프레임 n+8 또는 그 이후)에서 S셀을 활성화하고, 해당 S셀과 관련된 타이머를 (재)시작시킨다. 단말이 S셀을 활성화한다는 것은 단말이 S셀 상에서 SRS(Sounding Reference Signal) 전송, S셀을 위한 CQI(Channel Quality Indicator)/PMI(Precoding Matrix Indicator)/RI(Rank Indication)/PTI(Precoding Type Indicator) 보고, S셀 상에서 PDCCH 모니터링, S셀을 위한 PDCCH 모니터링과 같은 일반 S셀 동작을 적용한다는 것을 의미한다.

[169] - 단말이 특정 TTI(서브프레임 n)에서 S셀을 비활성화하는 활성/비활성 MAC 제어 요소를 수신하거나 또는 특정 TTI(서브프레임 n) 활성화된 S셀과 관련된 타이머가 만료되면, 단말은 정해진 타이밍에 해당하는 TTI(서브프레임 n+8 또는 그 이후)에서 S셀을 비활성화하고, 해당 S셀의 타이머를 중단하며, 해당 S셀과 관련된 모든 HARQ 버퍼를 비운다(flush).

[170] - 활성화된 S셀 상의 PDCCH가 상향링크 그랜트(uplink grant) 또는 하향링크 승인(downlink assignment)을 지시하거나, 또는 활성화된 S셀을 스케줄링하는 서빙 셀 상의 PDCCH가 활성화된 S셀을 위한 상향링크 그랜트(uplink grant) 또는 하향링크 승인(downlink assignment)을 지시하면, 단말은 해당 S셀과 관련된 타이머를 재시작한다.

[171] - S셀이 비활성화되면, 단말은 S셀 상에서 SRS를 전송하지 않고, S셀을 위한 CQI/PMI/RI/PTI를 보고하지 않으며, S셀 상에서 UL-SCH를 전송하지 않으며, S셀 상에서 PDCCH를 모니터하지 않는다.

[172]

[173] **랜덤 액세스 절차(Random Access Procedure)**

[174] 이하에서는 LTE/LTE-A 시스템에서 제공하는 랜덤 액세스 절차(random access procedure)에 대해 살펴본다.

[175] 랜덤 액세스 절차는 단말이 기지국과 상향링크 동기를 얻거나 상향링크 무선 자원을 할당 받기 위해 사용된다. 단말의 전원이 켜진 후, 단말은 초기 셀과의 하향링크 동기를 획득하고 시스템 정보를 수신한다. 시스템 정보로부터 사용 가능한 랜덤 액세스 프리앰블(random access preamble)의 집합과 랜덤 액세스 프리앰블의 전송에 사용되는 무선 자원에 관한 정보를 얻는다. 랜덤 액세스

프리앰블의 전송에 사용되는 무선 자원은 적어도 하나 이상의 서브프레임 인덱스와 주파수 영역 상의 인덱스의 조합으로 특정될 수 있다. 단말은 랜덤 액세스 프리앰블의 집합으로부터 임의로 선택한 랜덤 액세스 프리앰블을 전송하고, 상기 랜덤 액세스 프리앰블을 수신한 기지국은 상향링크 동기를 위한 타이밍 정렬(TA: timing alignment) 값을 랜덤 액세스 응답을 통해 단말로 보낸다. 이로써 단말은 상향링크 동기를 획득하는 것이다.

[176] 랜덤 액세스 절차는 FDD(frequency division duplex)와 TDD(time division duplex)에서 공통적인 절차이다. 랜덤 액세스 절차는 셀 사이즈에 무관하며, 캐리어 병합(CA: carrier aggregation)이 설정된 경우 서빙 셀(serving cell)의 개수와도 무관하다.

[177] 먼저, 단말이 랜덤 액세스 절차를 수행하는 경우로는 다음과 같은 경우가 있다.

[178] - 단말이 기지국과의 RRC 연결(RRC Connection)이 없어, RRC 아이들 상태에서 초기 접속 (initial access)을 수행하는 경우

[179] - RRC 연결 재-확립 절차(RRC connection re-establishment procedure)를 수행하는 경우

[180] - 단말이 핸드오버 과정에서, 타겟(target) 셀로 처음 접속하는 경우

[181] - 기지국의 명령에 의해 랜덤 액세스 절차가 요청되는 경우

[182] - RRC 연결 상태 중, 상향링크 시간 동기가 맞지 않은 상황에서(non-synchronized) 하향링크로 전송될 데이터가 발생하는 경우

[183] - RRC 연결 상태 중, 상향링크의 시간 동기가 맞지 않거나(non-synchronized), 무선자원을 요청하기 위해 사용되는 지정된 무선자원이 할당되지 않은 상황에서, 상향링크로 전송할 데이터가 발생하는 경우

[184] - RRC 연결 상태 중, 타이밍 어드밴스(timing advance)가 필요한 상황에서 단말의 위치 결정(positioning)을 수행하는 경우

[185] - 무선 연결 실패(radio link failure) 또는 핸드오버 실패(handover failure) 시 복구 과정을 수행하는 경우

[186] 3GPP Rel-10에서는 캐리어 병합을 지원하는 무선 접속 시스템에서 하나의 특정 셀(예를 들어, P셀)에 적용 가능한 TA(timing advance) 값을 복수의 셀에 공통으로 적용하는 것을 고려하였다. 다만, 단말이 서로 다른 주파수 밴드에 속한(즉, 주파수 상에서 크게 이격된) 복수의 셀들 혹은 전파(propagation) 특성이 다른 복수의 셀들을 병합할 수 있다. 또한 특정 셀의 경우 커버리지 확대 혹은 커버리지 홀의 제거를 위해 RRH(remote radio header)(즉, 리피터), 펨토 셀(femto cell) 혹은 피코 셀(pico cell) 등과 같은 스몰 셀(small cell) 또는 세컨더리 기지국(SeNB: secondary eNB)이 셀 내에 배치되는 상황에서 단말은 하나의 셀을 통해 기지국(즉, 매크로 기지국(macro eNB))과 통신을 수행하고, 다른 셀을 통해 세컨더리 기지국과 통신을 수행하는 경우 복수의 셀들이 서로 다른 전파 지연 특성을 가지게 될 수 있다. 이 경우, 하나의 TA 값을 복수의 셀들에 공통으로 적용하는 방식으로 사용하는 상향링크 전송을 수행할 경우 복수의 셀들 상에서

전송되는 상향링크 신호의 동기에 심각한 영향을 끼칠 수 있다. 따라서, 복수의 셀들이 병합된 CA 상황에서 복수의 TA를 가지는 것이 바람직할 수 있으며, 3GPP Rel-11에서는 다중 TA(multiple TA)를 지원하기 위하여 특정 셀 그룹 단위로 TA를 독립적으로 할당하는 것을 고려한다. 이를 TA 그룹(TAG: TA group)이라 하며, TAG는 하나 이상의 셀들을 포함할 수 있으며, TAG 내 포함된 하나 이상의 셀에는 동일한 TA가 공통적으로 적용될 수 있다. 이러한 다중 TA를 지원하기 위하여, MAC TA 명령 제어 요소(element)는 2 비트의 TAG 식별자(TAG ID)와 6 비트의 TA 명령 필드로 구성된다.

[187] 캐리어 병합이 설정된 단말은 P셀과 관련되어 앞서 설명한 랜덤 액세스 절차를 수행하는 경우가 발생되면 랜덤 액세스 절차를 수행하게 된다. P셀이 속한 TAG(즉, pTAG: primary TAG)의 경우, 기존과 동일하게 P셀을 기준으로 결정되는, 혹은 P셀에 수반되는 랜덤 액세스 절차를 통해 조정되는 TA를 pTAG 내 모든 셀(들)에 적용할 수 있다. 반면, S셀로만 구성되는 TAG(즉, sTAG: secondary TAG)의 경우, sTAG 내 특정 S셀을 기준으로 결정되는 TA는 해당 sTAG 내 모든 셀(들)에 적용할 수 있으며, 이 때 TA는 기지국에 의해 개시되 랜덤 액세스 절차에 의해 획득될 수 있다. 구체적으로, sTAG 내에서 S셀은 RACH(Random Access Channel) 자원으로 설정되고, 기지국은 TA를 결정하기 위하여 S셀에서 RACH 접속을 요청한다. 즉, 기지국은 P셀에서 전송되는 PDCCH 오더에 의해 S셀들 상에서 RACH 전송을 개시시킨다. S셀 프리앰블에 대한 응답 메시지는 RA-RNTI를 사용하여 P셀을 통해 전송된다. 단말은 랜덤 액세스를 성공적으로 마친 S셀을 기준으로 결정되는 TA는 해당 sTAG 내 모든 셀(들)에 적용할 수 있다. 이와 같이, 랜덤 액세스 절차는 S셀에서도 해당 S셀이 속한 sTAG의 타이밍 정렬(timing alignment)을 획득하기 위하여 S셀에서도 수행될 수 있다.

[188] LTE/LTE-A 시스템에서는 랜덤 액세스 프리앰블(random access preamble, RACH preamble)을 선택하는 과정에서, 특정한 집합 안에서 단말이 임의로 하나의 프리앰블을 선택하여 사용하는 경쟁 기반 랜덤 액세스 절차(contention based random access procedure)과 기지국이 특정 단말에게만 할당해준 랜덤 액세스 프리앰블을 사용하는 비 경쟁 기반 랜덤 액세스 절차(non-contention based random access procedure)을 모두 제공한다. 다만, 비 경쟁 기반 랜덤 액세스 절차는, 상술한 핸드오버 과정, 기지국의 명령에 의해 요청되는 경우, 단말 위치 결정(positioning) 및/또는 sTAG을 위한 타이밍 어드밴스 정렬에 한하여 사용될 수 있다. 랜덤 액세스 절차가 완료된 후에 일반적인 상향링크/하향링크 전송이 발생된다.

[189] 한편, 릴레이 노드(RN: relay node) 또한 경쟁 기반 랜덤 액세스 절차와 비 경쟁 기반 랜덤 액세스 절차를 모두 지원한다. 릴레이 노드가 랜덤 액세스 절차를 수행할 때, 그 시점에서 RN 서브프레임 구성(configuration)을 중단시킨다(suspend). 즉, 이는 일시적으로 RN 서브프레임 구성을 폐기하는

것으로 의미한다. 이후, 성공적으로 랜덤 액세스 절차가 완료되는 시점에서 RN 서브프레임 구성이 재개된다.

[190] 도 8은 본 발명이 적용될 수 있는 무선 통신 시스템에서 경쟁 기반 랜덤 액세스 절차를 설명하기 위한 도면이다.

[191] (1) 제1 메시지(Msg 1, message 1)

[192] 먼저, 단말은 시스템 정보(system information) 또는 핸드오버 명령(handover command)을 통해 지시된 랜덤 액세스 프리앰블의 집합에서 임의로(randomly) 하나의 랜덤 액세스 프리앰블(random access preamble, RACH preamble)을 선택하고, 상기 랜덤 액세스 프리앰블을 전송할 수 있는 PRACH(physical RACH) 자원을 선택하여 전송한다.

[193] 랜덤 액세스 프리앰블은 RACH 전송 채널에서 6비트로 전송되고, 6비트는 RACH 전송한 단말을 식별하기 위한 5비트의 임의 식별자(radom identity)와, 추가 정보를 나타내기 위한 1비트(예를 들어, 제3 메시지(Msg 3)의 크기를 지시)로 구성된다.

[194] 단말로부터 랜덤 액세스 프리앰블을 수신한 기지국은 프리앰블을 디코딩하고, RA-RNTI를 획득한다. 랜덤 액세스 프리앰블이 전송된 PRACH와 관련된 RA-RNTI는 해당 단말이 전송한 랜덤 액세스 프리앰블의 시간-주파수 자원에 따라 결정된다.

[195] (2) 제2 메시지(Msg 2, message 2)

[196] 기지국은 제1 메시지 상의 프리앰블을 통해서 획득한 RA-RNTI로 지시(address)되는 랜덤 액세스 응답(random access response)을 단말로 전송한다. 랜덤 액세스 응답에는 랜덤 액세스 프리앰블 구분자/식별자(RA preamble index/identifier), 상향링크 무선자원을 알려주는 상향링크 승인(UL grant), 임시 셀 식별자(TC-RNTI: Temporary C-RNTI) 그리고 시간 동기 값(TAC: time alignment command)들이 포함될 수 있다. TAC는 기지국이 단말에게 상향링크 시간 정렬(time alignment)을 유지하기 위해 보내는 시간 동기 값을 지시하는 정보이다. 단말은 상기 시간 동기 값을 이용하여, 상향링크 전송 타이밍을 갱신한다. 단말이 시간 동기를 갱신하면, 시간 동기 타이머(time alignment timer)를 개시 또는 재시작한다. UL grant는 후술하는 스케줄링 메시지(제3 메시지)의 전송에 사용되는 상향링크 자원 할당 및 TPC(transmit power command)를 포함한다. TPC는 스케줄링된 PUSCH를 위한 전송 파워의 결정에 사용된다.

[197] 단말은 랜덤 액세스 프리앰블을 전송 후에, 기지국이 시스템 정보 또는 핸드오버 명령을 통해 지시된 랜덤 액세스 응답 윈도우(random access response window) 내에서 자신의 랜덤 액세스 응답(random access response)의 수신을 시도하며, PRACH에 대응되는 RA-RNTI로 마스킹된 PDCCH를 검출하고, 검출된 PDCCH에 의해 지시되는 PDSCH를 수신하게 된다. 랜덤 액세스 응답 정보는 MAC PDU(MAC packet data unit)의 형식으로 전송될 수 있으며, 상기 MAC

PDU는 PDSCH을 통해 전달될 수 있다. PDCCH에는 상기 PDSCH를 수신해야 하는 단말의 정보와, 상기 PDSCH의 무선 자원의 주파수 그리고 시간 정보, 그리고 상기 PDSCH의 전송 형식 등이 포함되어 있는 것이 바람직하다. 상술한 바와 같이, 일단 단말이 자신에게 전송되는 PDCCH의 검출에 성공하면, 상기 PDCCH의 정보들에 따라 PDSCH로 전송되는 랜덤 액세스 응답을 적절히 수신할 수 있다.

[198] 랜덤 액세스 응답 윈도우는 프리앰블을 전송한 단말이 랜덤 액세스 응답 메시지를 수신하기 위해서 대기하는 최대 시구간을 의미한다. 랜덤 액세스 응답 윈도우는 프리앰블이 전송되는 마지막 서브프레임에서 3개의 서브프레임 이후의 서브프레임으로부터 시작하여 'ra-ResponseWindowSize'의 길이를 가진다. 즉, 단말은 프리앰블을 전송이 종료된 서브프레임으로부터 3개의 서브프레임 이후부터 확보한 랜덤 액세스 윈도우 동안 랜덤 액세스 응답을 수신하기 위해 대기한다. 단말은 시스템 정보(system information)을 통해 랜덤 액세스 윈도우 사이즈('ra-ResponseWindowsize') 파라미터 값을 획득할 수 있으며, 랜덤 액세스 윈도우 사이즈는 2부터 10 사이의 값으로 결정될 수 있다.

[199] 단말은 기지국에 전송하였던 랜덤 액세스 프리앰블과 동일한 랜덤 액세스 프리앰블 구분자/식별자를 가지는 랜덤 액세스 응답을 성공적으로 수신하면, 랜덤 액세스 응답의 모니터링을 중지한다. 반면, 랜덤 액세스 응답 윈도우가 종료될 때까지 랜덤 액세스 응답 메시지를 수신하지 못하거나, 기지국에 전송하였던 랜덤 액세스 프리앰블과 동일한 랜덤 액세스 프리앰블 구분자를 가지는 유효한 랜덤 액세스 응답을 수신하지 못한 경우 랜덤 액세스 응답의 수신은 실패하였다고 간주되고, 이후 단말은 프리앰블 재전송을 수행할 수 있다.

[200] 상술한 바와 같이 랜덤 액세스 응답에서 랜덤 액세스 프리앰블 구분자가 필요한 이유는, 하나의 랜덤 액세스 응답에는 하나 이상의 단말들을 위한 랜덤 액세스 응답 정보가 포함될 수 있기 때문에, 상기 UL grant, TC-RNTI 그리고 TAC가 어느 단말에게 유효한지를 알려주기 위는 것이 필요하기 때문이다.

[201] (3) 제3 메시지(Msg 3, message 3)

[202] 단말이 자신에게 유효한 랜덤 액세스 응답을 수신한 경우에는, 상기 랜덤 액세스 응답에 포함된 정보들을 각각 처리한다. 즉, 단말은 TAC을 적용시키고, TC-RNTI를 저장한다. 또한, UL grant를 이용하여, 단말의 버퍼에 저장된 데이터 또는 새롭게 생성된 데이터를 기지국으로 전송한다. 단말의 최초 접속의 경우, RRC 계층에서 생성되어 CCCH를 통해 전달된 RRC 연결 요청이 제3 메시지에 포함되어 전송될 수 있으며, RRC 연결 재확립 절차의 경우 RRC 계층에서 생성되어 CCCH를 통해 전달된 RRC 연결 재확립 요청이 제3 메시지에 포함되어 전송될 수 있다. 또한, NAS 접속 요청 메시지를 포함할 수도 있다.

[203] 제3 메시지는 단말의 식별자가 포함되어야 한다. 경쟁 기반 랜덤 액세스 절차에서는 기지국에서 어떠한 단말들이 상기 랜덤 액세스 절차를 수행하는지 판단할 수 없는데, 차후에 충돌 해결을 하기 위해서는 단말을 식별해야 하기

때문이다.

[204] 단말의 식별자를 포함시키는 방법으로는 두 가지 방법이 존재한다. 첫 번째 방법은 단말이 상기 랜덤 액세스 절차 이전에 이미 해당 셀에서 할당 받은 유효한 셀 식별자(C-RNTI)를 가지고 있었다면, 단말은 상기 UL grant에 대응하는 상향링크 전송 신호를 통해 자신의 셀 식별자를 전송한다. 반면에, 만약 랜덤 액세스 절차 이전에 유효한 셀 식별자를 할당 받지 못하였다면, 단말은 자신의 고유 식별자(예를 들면, S-TMSI 또는 임의 값(random number))를 포함하여 전송한다. 일반적으로 상기의 고유 식별자는 C-RNTI보다 길다. UL-SCH 상의 전송에서는 단말 특정 스크램블링이 사용된다. 다만, 단말이 아직 C-RNTI를 할당받지 못한 경우라면, 스크램블링은 C-RNTI에 기반할 수 없으며 대신 랜덤 액세스 응답에서 수신한 TC-RNTI가 사용된다. 단말은 상기 UL grant에 대응하는 데이터를 전송하였다면, 충돌 해결을 위한 타이머(contention resolution timer)를 개시한다.

[205] (4) 제4 메시지(Msg 4, message 4)

[206] 기지국은 단말로부터 제3 메시지를 통해 해당 단말의 C-RNTI를 수신한 경우 수신한 C-RNTI를 이용하여 단말에게 제4 메시지를 전송한다. 반면, 단말로부터 제3 메시지를 통해 상기 고유 식별자(즉, S-TMSI 또는 임의 값(random number))를 수신한 경우, 랜덤 액세스 응답에서 해당 단말에게 할당한 TC-RNTI를 이용하여 제4 메시지를 단말에게 전송한다. 여기서, 제4 메시지는 C-RNTI를 포함하는 RRC 연결 설정 메시지(RRC connection setup)가 해당될 수 있다.

[207] 단말은 랜덤 액세스 응답에 포함된 UL grant를 통해 자신의 식별자를 포함한 데이터를 전송한 이후, 충돌 해결을 위해 기지국의 지시를 기다린다. 즉, 특정 메시지를 수신하기 위해 PDCCH의 수신을 시도한다. 상기 PDCCH를 수신하는 방법에 있어서도 두 가지 방법이 존재한다. 앞에서 언급한 바와 같이 상기 UL grant에 대응하여 전송된 제3 메시지가 자신의 식별자가 C-RNTI인 경우, 자신의 C-RNTI를 이용하여 PDCCH의 수신을 시도하고, 상기 식별자가 고유 식별자(즉, S-TMSI 또는 임의 값(random number))인 경우에는, 랜덤 액세스 응답에 포함된 TC-RNTI를 이용하여 PDCCH의 수신을 시도한다. 그 후, 전자의 경우, 만약 상기 충돌 해결 타이머가 만료되기 전에 자신의 C-RNTI를 통해 PDCCH를 수신한 경우에, 단말은 정상적으로 랜덤 액세스 절차가 수행되었다고 판단하고, 랜덤 액세스 절차를 종료한다. 후자의 경우에는 상기 충돌 해결 타이머가 만료되기 전에 TC-RNTI를 통해 PDCCH를 수신하였다면, 상기 PDCCH가 지시하는 PDSCH이 전달하는 데이터를 확인한다. 만약 상기 데이터의 내용에 자신의 고유 식별자가 포함되어 있다면, 단말은 정상적으로 랜덤 액세스 절차가 수행되었다고 판단하고, 랜덤 액세스 절차를 종료한다. 제4 메시지를 통해 단말은 C-RNTI를 획득하고, 이후 단말과 네트워크는 C-RNTI를 이용하여 단말 특정 메시지(dedicated message)를 송수신하게 된다.

[208] 다음은 랜덤 액세스에서 충돌 해결을 위한 방법에 대하여 설명한다.

[209] 랜덤 액세스를 수행함에 있어서 충돌이 발생하는 이유는 기본적으로 랜덤 액세스 프리앰블의 수가 유한하기 때문이다. 즉, 기지국은 모든 단말들에게 단말 고유의 랜덤 액세스 프리앰블을 부여할 수 없기 때문에, 단말은 공통의 랜덤 액세스 프리앰블들 중에서 임의적으로 하나를 선택해서 전송하게 된다. 이에 따라 동일한 무선 자원(PRACH 자원)을 통해 둘 이상의 단말들이 같은 랜덤 액세스 프리앰블을 선택하여 전송하게 되는 경우가 발생하지만, 기지국에서는 하나의 단말에게서 전송되는 하나의 랜덤 액세스 프리앰블로 판단하게 된다. 이로 인해, 기지국은 랜덤 액세스 응답을 단말에게 전송하고 랜덤 액세스 응답은 하나의 단말이 수신할 것으로 예측한다. 하지만, 상술한 바와 같이 충돌이 발생할 수 있기 때문에, 둘 이상의 단말들이 하나의 랜덤 액세스 응답을 수신하게 되며, 이에 따라 단말마다 각각 랜덤 액세스 응답의 수신에 따른 동작을 수행하게 된다. 즉, 랜덤 액세스 응답에 포함된 하나의 UL Grant를 이용하여, 둘 이상의 단말들이 서로 다른 데이터를 동일한 무선자원에 전송하게 되는 문제점이 발생하게 된다. 이에 따라, 상기 데이터의 전송은 모두 실패할 수도 있고, 단말들의 위치 또는 전송파워에 따라 특정 단말의 데이터만을 기지국에서 수신할 수도 있다. 후자의 경우, 둘 이상의 단말들은 모두 자신의 데이터의 전송이 성공했다고 가정하기 때문에, 기지국은 경쟁에서 실패한 단말들에게 실패 사실에 대한 정보를 알려주어야 한다. 즉, 상기 경쟁의 실패 또는 성공에 대한 정보를 알려주는 것이 충돌 해결(contention resolution)라 한다.

[210] 충돌 해결 방법에는 두 가지 방법이 있는데 한 가지 방법은, 충돌 해결 타이머(contention resolution timer)를 이용하는 방법과, 다른 한가지 방법은 성공한 단말의 식별자를 단말들에게 전송하는 방법이다. 전자의 경우는, 단말이 랜덤 액세스 과정 전에 이미 고유의 C-RNTI를 가지고 있는 경우에 사용된다. 즉, 이미 C-RNTI를 가지고 있는 단말은 랜덤 액세스 응답에 따라 자신의 C-RNTI를 포함한 데이터를 기지국으로 전송하고, 충돌 해결 타이머를 작동한다. 그리고, 충돌 해결 타이머가 만료되기 전에, 자신의 C-RNTI에 의해 지시되는 PDCCH 정보가 수신되면, 단말은 자신이 경쟁에서 성공했다고 판단하고, 랜덤 액세스를 정상적으로 마치게 된다. 반대로, 만약 충돌 해결 타이머가 만료되기 전에, 자신의 C-RNTI에 의해 지시되는 PDCCH를 전송 받지 못한 경우는, 자신이 경쟁에서 실패했다고 판단하고, 랜덤 액세스 과정을 다시 수행하거나, 상위 계층으로 실패 사실을 통보할 수 있다. 충돌 해소 방법 중 후자의 경우, 즉 성공한 단말의 식별자를 전송하는 방법은, 단말이 랜덤 액세스 과정 전에 고유의 셀 식별자가 없는 경우에 사용된다. 즉, 단말 자신이 셀 식별자가 없는 경우, 랜덤 액세스 응답에 포함된 UL Grant 정보에 따라 데이터에 셀 식별자 보다 상위 식별자(S-TMSI 또는 random number)를 포함하여 전송하고, 단말은 충돌 해결 타이머를 작동시킨다. 충돌 해결 타이머가 만료되기 전에, 자신의 상위 식별자를 포함한 데이터가 DL-SCH로 전송된 경우, 단말은 랜덤 액세스 과정이 성공했다고 판단한다. 반면에, 충돌 해결 타이머가 만료되기 전에, 자신의 상위

식별자를 포함한 데이터를 DL-SCH로 전송 받지 못하는 경우에는, 단말은 랜덤 액세스 과정이 실패했다고 판단하게 되는 것이다.

[211] 한편, 비경쟁 기반 임의접속 과정에서의 동작은 도 8에 도시된 경쟁 기반 임의접속 과정과 달리 제1 메시지 전송 및 제2 메시지 전송만으로 임의접속 절차가 종료되게 된다. 다만, 제1 메시지로서 단말이 기지국에 임의접속 프리엠블을 전송하기 전에 단말은 기지국으로부터 임의접속 프리엠블을 할당받게 되며, 이 할당받은 임의접속 프리엠블을 기지국에 제1 메시지로서 전송하고, 기지국으로부터 임의접속 응답을 수신함으로써 임의접속 절차가 종료되게 된다.

[212]

[213] 참조 신호(RS: Reference Signal)

[214] 무선 통신 시스템에서 데이터는 무선 채널을 통해 전송되기 때문에, 신호는 전송 중에 왜곡될 수 있다. 수신단에서 왜곡된 신호를 정확하게 수신하기 위하여, 수신된 신호의 왜곡은 채널 정보를 이용하여 보정되어야 한다. 채널 정보를 검출하기 위하여 송신측과 수신측 모두 알고 있는 신호 전송 방법과 신호가 채널을 통해 전송될 때 왜곡된 정도를 이용하여 채널 정보를 검출하는 방법을 주로 이용한다. 상술한 신호를 파일럿 신호 또는 참조 신호(RS: reference signal)라고 한다.

[215] 또한 최근 대부분의 이동통신 시스템에서 패킷을 전송할 때, 지금까지 한 개의 송신안테나와 한 개의 수신안테나를 사용했던 것에서 탈피, 다중송신안테나와 다중수신안테나를 채택해 송수신 데이터 효율을 향상시킬 수 있는 방법을 사용한다. 다중 입출력 안테나를 이용하여 데이터를 송수신할 때, 신호를 정확하게 수신하기 위하여 송신 안테나와 수신 안테나 간의 채널 상태가 검출되어야 한다. 따라서 각 송신 안테나는 개별적인 참조 신호를 가져야 한다.

[216] 이동 통신 시스템에서 RS는 그 목적에 따라 크게 두 가지로 구분될 수 있다. 채널 정보 획득을 위한 목적의 RS와 데이터 복조를 위해 사용되는 RS가 있다. 전자는 UE가 하향 링크로의 채널 정보를 획득하는데 그 목적이 있으므로, 광대역으로 전송되어야 하고, 특정 서브 프레임에서 하향 링크 데이터를 수신하지 않는 UE라도 그 RS를 수신하고 측정할 수 있어야 한다. 또한 이는 핸드오버 등의 측정 등을 위해서도 사용된다. 후자는 기지국이 하향링크를 보낼 때 해당 리소스에 함께 보내는 RS로서, UE는 해당 RS를 수신함으로써 채널 추정을 할 수 있고, 따라서 데이터를 복조할 수 있게 된다. 이 RS는 데이터가 전송되는 영역에 전송되어야 한다.

[217] 하향 참조 신호는 셀 내 모든 단말이 공유하는 채널 상태에 대한 정보 획득 및 핸드오버 등의 측정 등을 위한 하나의 공통 참조 신호(CRS: common RS)와 특정 단말만을 위하여 데이터 복조를 위해 사용되는 전용 참조 신호(dedicated RS)가 있다. 이와 같은 참조 신호들을 이용하여 복조(demodulation)와 채널 측정(channel measurement)을 위한 정보를 제공할 수 있다. 즉, DRS는 데이터 복조용으로만

사용되며 CRS는 채널 정보 획득 및 데이터 복조의 두 가지 목적으로 다 사용된다.

[218] 수신 측(즉, 단말)은 CRS로부터 채널 상태를 측정하고, CQI(Channel Quality Indicator), PMI(Precoding Matrix Index) 및/또는 RI(Rank Indicator)와 같은 채널 품질과 관련된 지시자를 송신 측(즉, 기지국)으로 피드백한다. CRS는 셀 특정 기준신호(cell-specific RS)라고도 한다. 반면, 채널 상태 정보(CSI: Channel State Information)의 피드백과 관련된 참조 신호를 CSI-RS라고 정의할 수 있다.

[219] DRS는 PDSCH 상의 데이터 복조가 필요한 경우 자원 요소들을 통해 전송될 수 있다. 단말은 상위 계층을 통하여 DRS의 존재 여부를 수신할 수 있으며, 상응하는 PDSCH가 매핑되었을 때만 유효하다. DRS를 단말 특정 참조 신호(UE-specific RS) 또는 복조 참조 신호(DMRS: Demodulation RS)라고 할 수 있다.

[220] 도 9는 본 발명이 적용될 수 있는 무선 통신 시스템에서 하향링크 자원 블록 쌍에 매핑된 참조 신호 패턴을 예시한다.

[221] 도 9를 참조하면, 참조 신호가 매핑되는 단위로 하향링크 자원 블록 쌍은 시간 영역에서 하나의 서브 프레임 × 주파수 영역에서 12개의 부 반송파로 나타낼 수 있다. 즉, 시간 축(x축) 상에서 하나의 자원 블록 쌍은 일반 순환 전치(normal CP: normal Cyclic Prefix) 인 경우 14개의 OFDM 심볼의 길이를 가지고(도 9(a)의 경우), 확장 순환 전치(extended CP: extended Cyclic Prefix)인 경우 12개의 OFDM 심볼의 길이를 가진다(도 9(b)의 경우). 자원 블록 격자에서 '0', '1', '2' 및 '3'으로 기재된 자원 요소들(REs)은 각각 안테나 포트 인덱스 '0', '1', '2' 및 '3'의 CRS의 위치를 의미하며, 'D'로 기재된 자원 요소들은 DRS의 위치를 의미한다.

[222] 이하 CRS에 대하여 좀 더 상세하게 기술하면, CRS는 물리적 안테나의 채널을 추정하기 위해 사용되고, 셀 내에 위치한 모든 단말에 공통적으로 수신될 수 있는 참조 신호로써 전체 주파수 대역에 분포된다. 즉, 이 CRS는 cell-specific한 시그널로, 광대역에 대해서 매 서브 프레임마다 전송된다. 또한, CRS는 채널 품질 정보(CSI) 및 데이터 복조를 위해 이용될 수 있다.

[223] CRS는 전송 측(기지국)에서의 안테나 배열에 따라 다양한 포맷으로 정의된다. 3GPP LTE 시스템(예를 들어, 릴리즈-8)에서는 기지국의 전송 안테나 개수에 따라서 최대 4개의 안테나 포트에 대한 RS가 전송된다. 하향링크 신호 송신 측은 단일의 송신 안테나, 2개의 송신 안테나 및 4개의 송신 안테나와 같이 3 종류의 안테나 배열을 가진다. 예를 들어 기지국의 송신 안테나의 개수가 두 개일 경우, 0번과 1번 안테나 포트에 대한 CRS가 전송되고, 네 개인 경우 0~3 번 안테나 포트에 대한 CRS가 각각 전송된다. 기지국의 송신 안테나가 4개일 경우 한 RB에서의 CRS 패턴은 도 9와 같다.

[224] 기지국이 단일의 송신 안테나를 사용하는 경우, 단일 안테나 포트를 위한 참조 신호가 배열된다.

[225] 기지국이 2개의 송신 안테나를 사용하는 경우, 2개의 송신 안테나 포트를 위한

참조 신호는 시분할 다중화(TDM: Time Division Multiplexing) 및/또는 주파수 분할 다중화(FDM Frequency Division Multiplexing) 방식을 이용하여 배열된다. 즉, 2개의 안테나 포트를 위한 참조 신호는 각각이 구별되기 위해 서로 다른 시간 자원 및/또는 서로 다른 주파수 자원이 할당된다.

[226] 게다가, 기지국이 4개의 송신 안테나를 사용하는 경우, 4개의 송신 안테나 포트를 위한 참조 신호는 TDM 및/또는 FDM 방식을 이용하여 배열된다. 하향링크 신호의 수신 측(단말)에 의하여 측정된 채널 정보는 단일의 송신 안테나 전송, 송신 다이버시티, 폐쇄 루프 공간 다중화(closed-loop spatial multiplexing), 개방 루프 공간 다중화(open-loop spatial multiplexing) 또는 다중 사용자-다중 입출력 안테나(Multi-User MIMO)와 같은 전송 방식을 이용하여 전송된 데이터를 복조하기 위하여 사용될 수 있다.

[227] 다중 입출력 안테나가 지원되는 경우 참조 신호가 특정의 안테나 포트로부터 전송될 때, 상기 참조 신호는 참조 신호의 패턴에 따라 특정된 자원 요소들의 위치에 전송되며, 다른 안테나 포트를 위해 특정된 자원 요소들의 위치에 전송되지 않는다. 즉, 서로 다른 안테나 사이의 참조 신호는 서로 겹치지 않는다.

[228] 이하 DRS에 대하여 좀 더 상세하게 기술하면, DRS는 데이터를 복조하기 위하여 사용된다. 다중 입출력 안테나 전송에서 특정의 단말을 위해 사용되는 선행 부호화(precoding) 가중치는 단말이 참조 신호를 수신하였을 때 각 송신 안테나에서 전송된 전송 채널과 결합되어 상응하는 채널을 추정하기 위하여 변경 없이 사용된다.

[229] 3GPP LTE 시스템(예를 들어, 릴리즈-8)은 최대로 4개의 전송 안테나를 지원하고, 랭크 1 빔포밍(beamforming)을 위한 DRS가 정의된다. 랭크 1 빔포밍을 위한 DRS는 또한 안테나 포트 인덱스 5 를 위한 참조 신호를 나타낸다.

[230] LTE 시스템의 진화 발전된 형태의 LTE-A 시스템에서 기지국의 하향 링크로 최대 8개의 송신 안테나를 지원할 수 있도록 디자인되어야 한다. 따라서 최대 8개 송신 안테나에 대한 RS 역시 지원되어야 한다. LTE 시스템에서 하향 링크 RS는 최대 4개의 안테나 포트에 대한 RS만 정의되어 있으므로, LTE-A 시스템에서 기지국이 4개 이상 최대 8개의 하향 링크 송신 안테나를 가질 경우 이들 안테나 포트에 대한 RS가 추가적으로 정의되고 디자인되어야 한다. 최대 8개의 송신 안테나 포트에 대한 RS는 위에서 설명한 채널 측정을 위한 RS와 데이터 복조를 위한 RS 두 가지가 모두 디자인되어야 한다.

[231] LTE-A 시스템을 디자인 함에 있어서 중요한 고려 사항 중 하나는 하위 호환성(backward compatibility), 즉 LTE 단말이 LTE-A 시스템에서도 아무 무리 없이 잘 동작해야 하고, 시스템 또한 이를 지원해야 한다는 것이다. RS 전송 관점에서 보았을 때, LTE에서 정의되어 있는 CRS가 전 대역으로 매 서브 프레임마다 전송되는 시간-주파수 영역에서 추가적으로 최대 8개의 송신 안테나 포트에 대한 RS가 추가적으로 정의되어야 한다. LTE-A 시스템에서 기존 LTE의 CRS와 같은 방식으로 최대 8개의 송신 안테나에 대한 RS 패턴을 매 서브

프레임마다 전 대역에 추가하게 되면 RS 오버헤드가 지나치게 커지게 된다.

[232] 따라서 LTE-A 시스템에서 새로이 디자인되는 RS는 크게 두 가지 분류로 나누게 되는데, MCS, PMI 등의 선택을 위한 채널 측정 목적의 RS (CSI-RS: Channel State Information-RS, Channel State Indication-RS 등)와 8개의 전송 안테나로 전송되는 데이터 복조를 위한 RS(DM-RS: Data Demodulation-RS)이다.

[233] 채널 측정 목적의 CSI-RS는 기존의 CRS가 채널 측정, 핸드 오버 등의 측정 등의 목적과 동시에 데이터 복조를 위해 사용되는 것과 달리 채널 측정 위주의 목적을 위해서 디자인되는 특징이 있다. 물론 이 또한 핸드 오버 등의 측정 등의 목적으로도 사용될 수도 있다. CSI-RS가 채널 상태에 대한 정보를 얻는 목적으로만 전송되므로 CRS와 달리 매 서브 프레임마다 전송되지 않아도 된다. CSI-RS의 오버헤드를 줄이기 위하여 CSI-RS는 시간 축 상에서 간헐적으로 전송된다.

[234] 데이터 복조를 위해서 해당 시간-주파수 영역에서 스케줄링 된 UE에게 전용적(dedicated)으로 DM-RS가 전송된다. 즉, 특정 UE의 DM-RS는 해당 UE가 스케줄링 된 영역, 즉 데이터를 수신 받는 시간-주파수 영역에만 전송되는 것이다.

[235] LTE-A 시스템에서 eNB는 모든 안테나 포트에 대한 CSI-RS를 전송해야 한다. 최대 8개의 송신 안테나 포트에 대한 CSI-RS를 매 서브 프레임마다 전송하는 것은 오버헤드가 너무 큰 단점이 있으므로, CSI-RS는 매 서브 프레임마다 전송되지 않고 시간 축에서 간헐적으로 전송되어야 그 오버헤드를 줄일 수 있다. 즉, CSI-RS는 한 서브 프레임의 정수 배의 주기를 가지고 주기적으로 전송되거나 특정 전송 패턴으로 전송될 수 있다. 이 때 CSI-RS가 전송되는 주기나 패턴은 eNB가 설정할 수 있다.

[236] CSI-RS를 측정하기 위해서 UE는 반드시 자신이 속한 셀의 각각의 CSI-RS 안테나 포트에 대한 CSI-RS의 전송 서브 프레임 인덱스, 전송 서브 프레임 내에서 CSI-RS 자원 요소(RE) 시간-주파수 위치, 그리고 CSI-RS 시퀀스 등에 대한 정보를 알고 있어야 한다.

[237] LTE-A 시스템에 eNB는 CSI-RS를 최대 8개의 안테나 포트에 대해서 각각 전송해야 한다. 서로 다른 안테나 포트의 CSI-RS 전송을 위해 사용되는 자원은 서로 직교(orthogonal)해야 한다. 한 eNB가 서로 다른 안테나 포트에 대한 CSI-RS를 전송할 때 각각의 안테나 포트에 대한 CSI-RS를 서로 다른 RE에 맵핑함으로써 FDM/TDM방식으로 이들 자원을 orthogonal하게 할당할 수 있다. 또는 서로 다른 안테나 포트에 대한 CSI-RS를 서로 orthogonal한 코드에 맵핑시키는 CDM방식으로 전송할 수 있다.

[238] CSI-RS에 관한 정보를 eNB가 자기 셀 UE에게 알려줄 때, 먼저 각 안테나 포트에 대한 CSI-RS가 매핑되는 시간-주파수에 대한 정보를 알려줘야 한다. 구체적으로, CSI-RS가 전송되는 서브 프레임 번호들, 또는 CSI-RS가 전송되는 주기, CSI-RS가 전송되는 서브 프레임 오프셋이며, 특정 안테나의 CSI-RS RE가

전송되는 OFDM 심볼 번호, 주파수 간격(spacing), 주파수 축에서의 RE의 오프셋 또는 쉬프트 값 등이 있다.

[239] CSI-RS는 1개, 2개, 4개 또는 8개의 안테나 포트를 통해 전송된다. 이때, 사용되는 안테나 포트는 각각 p=15, p=15,16, p=15,...,18, p=15,...,22이다. CSI-RS는 서브캐리어 간격 Δf=15kHz에 대해서만 정의될 수 있다.

[240] (k',l')(여기서, k'는 자원 블록 내 부반송파 인덱스이고, l'는 슬롯 내 OFDM 심볼 인덱스를 나타낸다.) 및 n_s의 조건은 아래 표 4 또는 표 5와 같은 CSI-RS 설정(configuration)에 따라 결정된다.

[241] 표 3은 일반 CP에서 CSI-RS 구성으로부터 (k',l')의 매핑을 예시한다.

[242] [표3]

	CSI reference signal configuration	Number of CSI reference signals configured					
		1 or 2		4		8	
		(k',l')	$n_s \bmod 2$	(k',l')	$n_s \bmod 2$	(k',l')	$n_s \bmod 2$
Frame structure type 1 and 2	0	(9,5)	0	(9,5)	0	(9,5)	0
	1	(11,2)	1	(11,2)	1	(11,2)	1
	2	(9,2)	1	(9,2)	1	(9,2)	1
	3	(7,2)	1	(7,2)	1	(7,2)	1
	4	(9,5)	1	(9,5)	1	(9,5)	1
	5	(8,5)	0	(8,5)	0		
	6	(10,2)	1	(10,2)	1		
	7	(8,2)	1	(8,2)	1		
	8	(6,2)	1	(6,2)	1		
	9	(8,5)	1	(8,5)	1		
	10	(3,5)	0				
	11	(2,5)	0				
	12	(5,2)	1				
	13	(4,2)	1				
	14	(3,2)	1				
	15	(2,2)	1				
	16	(1,2)	1				
	17	(0,2)	1				
	18	(3,5)	1				
	19	(2,5)	1				
Frame structure type 2 only	20	(11,1)	1	(11,1)	1	(11,1)	1
	21	(9,1)	1	(9,1)	1	(9,1)	1
	22	(7,1)	1	(7,1)	1	(7,1)	1
	23	(10,1)	1	(10,1)	1		
	24	(8,1)	1	(8,1)	1		
	25	(6,1)	1	(6,1)	1		
	26	(5,1)	1				
	27	(4,1)	1				
	28	(3,1)	1				
	29	(2,1)	1				
	30	(1,1)	1				
	31	(0,1)	1				

[243] 표 4는 확장 CP에서 CSI-RS 구성으로부터 (k',l')의 매핑을 예시한다.

[244] [표4]

	CSI reference signal configuration	Number of CSI reference signals configured 1 or 2		4		8	
		(k',l')	$n_s \bmod 2$	(k',l')	$n_s \bmod 2$	(k',l')	$n_s \bmod 2$
Frame structure type 1 and 2	0	(11,4)	0	(11,4)	0	(11,4)	0
	1	(9,4)	0	(9,4)	0	(9,4)	0
	2	(10,4)	1	(10,4)	1	(10,4)	1
	3	(9,4)	1	(9,4)	1	(9,4)	1
	4	(5,4)	0	(5,4)	0		
	5	(3,4)	0	(3,4)	0		
	6	(4,4)	1	(4,4)	1		
	7	(3,4)	1	(3,4)	1		
	8	(8,4)	0				
	9	(6,4)	0				
	10	(2,4)	0				
	11	(0,4)	0				
	12	(7,4)	1				
	13	(6,4)	1				
	14	(1,4)	1				
	15	(0,4)	1				
Frame structure type 2 only	16	(11,1)	1	(11,1)	1	(11,1)	1
	17	(10,1)	1	(10,1)	1	(10,1)	1
	18	(9,1)	1	(9,1)	1	(9,1)	1
	19	(5,1)	1	(5,1)	1		
	20	(4,1)	1	(4,1)	1		
	21	(3,1)	1	(3,1)	1		
	22	(8,1)	1				
	23	(7,1)	1				
	24	(6,1)	1				
	25	(2,1)	1				
	26	(1,1)	1				
	27	(0,1)	1				

[245] 표 3 및 표 4를 참조하면, CSI-RS의 전송에 있어서, 이종 네트워크(HetNet: heterogeneous network) 환경을 포함하여 멀티 셀 환경에서 셀간 간섭(ICI: inter-cell interference)을 줄이기 위하여 최대 32개(일반 CP 경우) 또는 최대 28개(확장 CP 경우)의 서로 다른 구성(configuration)이 정의된다.

[246] CSI-RS 구성은 셀 내의 안테나 포트의 개수 및 CP에 따라 서로 다르며, 인접한 셀은 최대한 서로 다른 구성을 가질 수 있다. 또한, CSI-RS 구성은 프레임 구조에 따라 FDD 프레임과 TDD 프레임에 모두 적용하는 경우와 TDD 프레임에만 적용하는 경우로 나눠질 수 있다.

[247] 표 3 및 표 4를 기반으로 CSI-RS 구성에 따라 (k',l') 및 n_s가 정해지고, 각 CSI-RS 안테나 포트가 CSI-RS 전송에 이용하는 시간-주파수 자원이 결정된다.

[248] 도 10은 본 발명이 적용될 수 있는 무선 통신 시스템에서 CSI-RS 구성을 예시하는 도면이다.

[249] 도 10(a)는 1개 또는 2개의 CSI-RS 안테나 포트들에 의한 CSI-RS 전송에 사용

가능한 20가지 CSI-RS 구성들을 나타낸 것이고, 도 10(b)는 4개의 CSI-RS 안테나 포트들에 의해 사용 가능한 10가지 CSI-RS 구성들을 나타낸 것이며, 도 10(c)는 8개의 CSI-RS 안테나 포트들에 의해 CSI-RS 전송에 사용 가능한 5가지 CSI-RS 구성들을 나타낸 것이다.

[250] 이와 같이, 각 CSI-RS 구성에 따라 CSI-RS가 전송되는 무선 자원(즉, RE 쌍)이 결정된다.

[251] 특정 셀에 대하여 CSI-RS 전송을 위해 1개 혹은 2개의 안테나 포트가 설정되면, 도 10(a)에 도시된 20가지 CSI-RS 구성들 중 설정된 CSI-RS 구성에 따른 무선 자원 상에서 CSI-RS가 전송된다.

[252] 마찬가지로, 특정 셀에 대하여 CSI-RS 전송을 위해 4개의 안테나 포트가 설정되면, 도 10(b)에 도시된 10가지 CSI-RS 구성들 중 설정된 CSI-RS 구성에 따른 무선 자원 상에서 CSI-RS가 전송된다. 또한, 특정 셀에 대하여 CSI-RS 전송을 위해 8개의 안테나 포트가 설정되면, 도 10(c)에 도시된 5가지 CSI-RS 구성들 중 설정된 CSI-RS 구성에 따른 무선 자원 상에서 CSI-RS가 전송된다.

[253] 2개의 안테나 포트 별(즉, {15,16}, {17,18}, {19,20}, {21,22})로 각각의 안테나 포트에 대한 CSI-RS는 동일한 무선 자원에 CDM되어 전송된다. 안테나 포트 15 및 16를 예를 들면, 안테나 포트 15 및 16에 대한 각각의 CSI-RS 복소 심볼은 동일하나, 서로 다른 직교 코드(예를 들어, 왈시 코드(walsh code)가 곱해져서 동일한 무선 자원에 매핑된다. 안테나 포트 15에 대한 CSI-RS의 복소 심볼에는 [1, 1]이 곱해지고, 안테나 포트 16에 대한 CSI-RS의 복소 심볼에는 [1 -1]이 곱해져서 동일한 무선 자원에 매핑된다. 이는 안테나 포트 {17,18}, {19,20}, {21,22}도 마찬가지이다.

[254] UE는 전송된 심볼에 곱해진 코드를 곱하여 특정 안테나 포트에 대한 CSI-RS를 검출할 수 있다. 즉, 안테나 포트 15에 대한 CSI-RS를 검출하기 위해서 곱해진 코드 [1 1]을 곱하고, 안테나 포트 16에 대한 CSI-RS를 검출하기 위해서 곱해진 코드 [1 -1]을 곱한다.

[255] 도 10(a) 내지 (c)를 참조하면, 동일한 CSI-RS 구성 인덱스에 해당하게 되면, 안테나 포트 수가 많은 CSI-RS 구성에 따른 무선 자원은 CSI-RS 안테나 포트 수가 적은 CSI-RS 구성에 따른 무선 자원을 포함한다. 예를 들어, CSI-RS 구성 0의 경우, 8개 안테나 포트 수에 대한 무선 자원은 4개 안테나 포트 수에 대한 무선 자원과 1 또는 2개의 안테나 포트 수에 대한 무선 자원을 모두 포함한다.

[256] 하나의 셀에서 복수의 CSI-RS 구성이 사용될 수 있다. 넌-제로 전력(NZP: non-zero power) CSI-RS는 0개 또는 1개 CSI-RS 구성만이 이용되고, 제로 전력(ZP: zero power) CSI-RS는 0개 또는 여러 개의 CSI-RS 구성이 이용될 수 있다.

[257] 상위 계층에 의해 설정되는 16 비트의 비트맵인 ZP CSI-RS(ZeroPowerCSI-RS)에서 1로 설정된 각 비트 별로, UE는 위의 표 3 및 표 4의 4개의 CSI-RS 열(column)에 해당하는 RE들에서(상위 계층에 의해 설정된

NZP CSI-RS를 가정하는 RE와 중복되는 경우를 제외) 제로 전송 전력을 가정한다. 최상위 비트(MSB: Most Significant Bit)는 가장 낮은 CSI-RS 구성 인덱스에 해당하고, 비트맵 내에서 그 다음의 비트는 순서대로 다음의 CSI-RS 구성 인덱스에 해당한다.

[258] CSI-RS는 위의 표 3 및 표 4에서 (n_s mod 2)의 조건을 만족하는 하향링크 슬롯 및 CSI-RS 서브프레임 구성을 만족하는 서브프레임에서만 전송된다.

[259] 프레임 구조 타입 2(TDD)의 경우, 스페셜 서브프레임, 동기 신호(SS), PBCH 또는 SIB 1(SystemInformationBlockType1) 메시지 전송과 충돌되는 서브프레임 또는 페이징 메시지 전송을 위해 설정된 서브프레임에서 CSI-RS는 전송되지 않는다.

[260] 또한, 안테나 포트 세트 S(S={15}, S={15,16}, S={17,18}, S={19,20} 또는 S={21,22}) 내 속하는 어떠한 안테나 포트에 대한 CSI-RS가 전송되는 RE는 PDSCH 또는 다른 안테나 포트의 CSI-RS 전송에 사용되지 않는다.

[261] CSI-RS 전송에 사용되는 시간-주파수 자원들은 데이터 전송에 사용될 수 없으므로, CSI-RS 오버헤드가 증가할수록 데이터 처리량(throughput)이 감소하게 된다. 이를 고려하여 CSI-RS는 매 서브프레임마다 전송되도록 구성되지 않고, 다수의 서브프레임에 해당하는 소정의 전송 주기마다 전송되도록 구성된다. 이 경우, 매 서브프레임마다 CSI-RS가 전송되는 경우에 비하여 CSI-RS 전송 오버헤드가 많이 낮아질 수 있다.

[262] CSI-RS 전송을 위한 서브프레임 주기(이하, 'CSI 전송 주기'로 지칭함)(T_CSI-RS) 및 서브프레임 오프셋(Δ_CSI-RS)은 아래 표 5과 같다.

[263] 표 5은 CSI-RS 서브프레임 구성을 예시한다.

[264] [표5]

CSI-RS-SubframeConfig I_{CSI-RS}	CSI-RS periodicity T_{CSI-RS} (subframes)	CSI-RS subframe offset Δ_{CSI-RS} (subframes)
0 - 4	5	I_{CSI-RS}
5 - 14	10	$I_{CSI\ RS}-5$
15 - 34	20	$I_{CSI-RS}-15$
35 - 74	40	$I_{CSI-RS}-35$
75 - 154	80	$I_{CSI-RS}-75$

[265] 표 5을 참조하면, CSI-RS 서브프레임 구성(I_CSI-RS)에 따라 CSI-RS 전송 주기(T_CSI-RS) 및 서브프레임 오프셋(Δ_CSI-RS)이 결정된다.

[266] 표 5의 CSI-RS 서브프레임 구성은 앞서 'SubframeConfig' 필드 및 'zeroTxPowerSubframeConfig' 필드 중 어느 하나로 설정될 수 있다. CSI-RS 서브프레임 구성은 NZP CSI-RS 및 ZP CSI-RS에 대하여 개별적으로(separately) 설정될 수 있다.

[267] CSI-RS를 포함하는 서브프레임은 아래 수학식 12를 만족한다.

[268] [수식12]

$$(10n_f + \lfloor n_s/2 \rfloor - \Delta_{CSI-RS}) \bmod T_{CSI-RS} = 0$$

[269] 수학식 12에서 T_CSI-RS는 CSI-RS 전송 주기, Δ_CSI-RS는 서브프레임 오프셋 값, n_f는 시스템 프레임 넘버, n_s는 슬롯 넘버를 의미한다.

[270] 서빙 셀에 대해 전송 모드 9(transmission mode 9)가 설정된 UE의 경우, UE는 하나의 CSI-RS 자원 구성이 설정될 수 있다. 서빙 셀에 대해 전송 모드 10(transmission mode 10)이 설정된 UE의 경우, UE는 하나 또는 그 이상의 CSI-RS 자원 구성(들)이 설정될 수 있다.

[271] 각 CSI-RS 자원 구성을 위한 아래와 같이 파라미터가 상위 계층 시그널링을 통해 설정된다.

[272] - 전송 모드 10이 설정된 경우, CSI-RS 자원 구성 식별자

[273] - CSI-RS 포트 개수

[274] - CSI-RS 구성 (표 3 및 표 4 참조)

[275] - CSI-RS 서브프레임 구성(I_CSI-RS) (표 5 참조)

[276] - 전송 모드 9가 설정된 경우, CSI 피드백을 위한 전송 파워(P_C)

[277] - 전송 모드 10이 설정된 경우, 각 CSI 프로세스에 대하여 CSI 피드백을 위한 전송 파워(P_C). CSI 프로세스에 대하여 CSI 서브프레임 세트들 C_CSI,0 및 C_CSI,1가 상위 계층에 의해 설정되면, P_C는 CSI 프로세스의 각 CSI 서브프레임 세트 별로 설정된다.

[278] - 임의 랜덤(pseudo-rnadom) 시퀀스 발생기 파라미터(n_ID)

[279] - 전송 모드 10이 설정된 경우, QCL(QuasiCo-Located) 타입 B UE 가정을 위한 QCL 스크램블링 식별자(qcl-ScramblingIdentity-r11), CRS 포트 카운트(crs-PortsCount-r11), MBSFN 서브프레임 설정 리스트(mbsfn-SubframeConfigList-r11) 파라미터를 포함하는 상위 계층 파라미터('qcl-CRS-Info-r11')

[280] UE가 도출한 CSI 피드백 값이 [-8, 15] dB 범위 내의 값을 가질 때, P_C는 CSI-RS EPRE에 대한 PDSCH EPRE의 비율로 가정된다. 여기서, PDSCH EPRE는 CRS EPRE에 대한 PDSCH EPRE의 비율이 ρ_A인 심볼에 해당한다.

[281] 서빙 셀의 동일한 서브프레임에서 CSI-RS와 PMCH이 함께 설정되지 않는다.

[282] 프레임 구조 타입 2에서 4개의 CRS 안테나 포트가 설정된 경우, UE는 일반 CP의 경우 [20-31] 세트(표 3 참조) 또는 확장 CP의 경우 [16-27] 세트(표 4 참조)에 속하는 CSI-RS 구성 인덱스가 설정되지 않는다.

[283] UE는 CSI-RS 자원 구성의 CSI-RS 안테나 포트가 지연 확산(delay spread), 도플러 확산(Doppler spread), 도플러 쉬프트(Doppler shift), 평균 이득(average gain) 및 평균 지연(average delay)에 대하여 QCL 관계를 가진다고 가정할 수 있다.

[284] 전송 모드 10 그리고 QCL 타입 B가 설정된 UE는 CSI-RS 자원 구성에 해당하는

안테나 포트 0-3과 CSI-RS 자원 구성에 해당하는 안테나 포트 15-22가 도플러 확산(Doppler spread), 도플러 쉬프트(Doppler shift)에 대하여 QCL 관계라고 가정할 수 있다.

[285] 전송 모드 10이 설정된 UE의 경우, 서빙 셀에 대하여 하나 또는 그 이상의 CSI-IM(Channel-State Information - Interference Measurement) 자원 구성이 설정될 수 있다.

[286] 상위 계층 시그널링을 통해 각 CSI-IM 자원 구성을 위한 아래와 같은 파라미터가 설정될 수 있다.

[287] - ZP CSI-RS 구성 (표 3 및 표 4 참조)

[288] - ZP CSI RS 서브프레임 구성(I_CSI-RS) (표 5 참조)

[289] CSI-IM 자원 구성은 설정된 ZP CSI-RS 자원 구성 중 어느 하나와 동일하다.

[290] 서빙 셀의 동일한 서브프레임 내 CSI-IM 자원과 PMCH가 동시에 설정되지 않는다.

[291] 전송 모드 1-9가 설정된 UE의 경우, 서빙 셀에 대하여 UE는 하나의 ZP CSI-RS 자원 구성이 설정될 수 있다. 전송 모드 10이 설정된 UE의 경우, 서빙 셀에 대하여 UE는 하나 또는 그 이상의 ZP CSI-RS 자원 구성이 설정될 수 있다.

[292] 상위 계층 시그널링을 통해 ZP CSI-RS 자원 구성을 위한 아래와 같은 파라미터가 설정될 수 있다.

[293] - ZP CSI-RS 구성 리스트 (표 3 및 표 4 참조)

[294] - ZP CSI-RS 서브프레임 구성(I_CSI-RS) (표 5 참조)

[295] 서빙 셀의 동일한 서브프레임에서 ZP CSI-RS와 PMCH가 동시에 설정되지 않는다.

[296]

[297] **셀 측정(Cell Measurement)/측정 보고(Measurement Report)**

[298] 단말의 이동성(mobility) 보장을 위한 여러 방법들(핸드오버, 랜덤 액세스, 셀 탐색 등) 중 하나 또는 그 여러 방법들을 위하여 UE는 셀 측정(cell measurement)한 결과를 기지국(혹은 네트워크)에 보고한다.

[299] 3GPP LTE/LTE-A 시스템에서 셀 특정 참조 신호(CRS)는 시간 축으로 각 서브프레임 내의 0, 4, 7, 11 번째 OFDM 심볼을 통해 전송되고, 이는 셀 측정(cell measurement)를 위해 기본적으로 사용된다. 즉, 단말은 서빙 셀(serving cell)과 이웃 셀(neighbor cell)로부터 각각 수신되는 CRS를 이용하여, 셀 측정을 수행한다.

[300] 셀 측정(cell measurement)은 서빙 셀 및 이웃 셀의 신호 세기 혹은 총 수신 전력 대비 신호 세기 등을 측정하는 참조 신호 수신 전력(RSRP: Reference signal receive power), 수신신호강도(RSSI: Received signal strength indicator), 참조신호수신품질(RSRQ: Reference signal received quality) 등의 RRM(Radio resource management) 측정과 서빙 셀과의 링크 품질을 측정하여 라디오 링크 실패(radio link failure) 여부를 평가할 수 있는 RLM(Radio Link Monitoring)

측정을 포함하는 개념이다.

[301] RSRP는 측정 주파수 대역 내에서 CRS가 전송되는 RE의 전력 분배의 선형 평균이다. RSRP 결정을 위해, 안테나 포트 '0'에 해당하는 CRS(R0)가 사용될 수 있다. 또한, RSRP 결정을 위해, 안테나 포트 '1'에 해당하는 CRS(R1)가 추가로 사용될 수도 있다. RSRP를 결정하기 위하여 UE에 의해 이용되는 측정 주파수 대역 및 측정 구간 내에서 이용하는 RE들의 수는 해당 측정 정확도 요구(accuracy requirements)가 만족되는 한도에서 UE가 결정할 수 있다. 또한, RE 당 전력은 순환 전치(CP)를 제외한 심볼의 나머지 부분 내에서 수신한 에너지로부터 결정될 수 있다.

[302] RSSI는 측정 대역 내에서 안테나 포트 '0'에 해당하는 RS를 포함하는 OFDM 심볼들에서 동일 채널(co-channel)의 서빙 셀(serving cell)과 넌-서빙 셀(non-serving cell), 인접 채널로부터의 간섭, 열 잡음(thermal noise) 등을 포함하는 해당 UE에 의해 모든 소스들로부터 감지된 총 수신 전력의 선형 평균으로 도출된다. 상위 계층 시그널링에 의하여 RSRQ 측정을 수행하기 위한 특정 서브프레임들이 지시되는 경우, RSSI는 지시된 서브프레임들 내의 모든 OFDM 심볼에 통해 측정된다.

[303] RSRQ는 N×RSRP/RSSI로 도출된다. 여기서, N은 RSSI 측정 대역폭의 RB 개수를 의미한다. 또한, 위의 식에서 분자 및 분모의 측정은 동일한 RB의 세트에서 구해질 수 있다.

[304] 기지국은 상위 계층 시그널링(예를 들어, RRC 연결 재구성(RRC Connection Reconfiguration) 메시지)을 통해 UE에게 측정(measurement)을 위한 설정 정보를 전달할 수 있다.

[305] RRC 연결 재구성 메시지는 무선 자원 구성 전용('radioResourceConfigDedicated') 정보 요소(IE: Information Element)와, 측정 설정('measConfig') IE를 포함한다.

[306] 'measConfig' IE는 UE에 의해 수행되어야 하는 측정을 특정하고, 측정 갭(measurement gap)의 구성 뿐만 아니라 인트라-주파수(intra-frequency) 이동성, 인터-주파수(inter-frequency) 이동성, 인터-RAT(inter-RAT) 이동성을 위한 설정 정보를 포함한다.

[307] 특히, 'measConfig' IE는 측정에서 제거될 측정 대상('measObject')의 리스트를 나타내는 'measObjectToRemoveList'와 새로이 추가되거나 수정될 리스트를 나타내는 'measObjectToAddModList'가 포함된다. 또한, 'measObject'에는 통신 기술에 따라 'MeasObjectCDMA2000', 'MeasObjctEUTRA', 'MeasObjectGERAN' 등이 포함된다.

[308] 'RadioResourceConfigDedicated' IE는 무선 베어러(Radio Bearer)를 설정/변경/해제(setup/modify/release) 하거나, MAC 메인 구성을 변경하거나, 반정적 스케줄링(SPS: Semi-Persistent Scheduling) 설정을 변경하거나 및 전용 물리적 설정(dedicated physical configuration)을 변경하기 위하여 사용된다.

[309] 'RadioResourceConfigDedicated' IE는 서빙 셀 측정을 위한 시간 영역 측정 자원 제한 패턴(time domain measurement resource restriction pattern)을 지시하는 'measSubframePattern-Serv' 필드를 포함한다. 또한, UE에 의해 측정될 이웃 셀을 지시하는 'measSubframeCellList' 와 이웃 셀 측정을 위한 시간 영역 측정 자원 제한 패턴을 지시하는 'measSubframePattern-Neigh'를 포함한다.

[310] 측정 셀(서빙 셀 및 이웃 셀 포함)을 위해 설정된 시간 영역 측정 자원 제한 패턴(time domain measurement resource restriction pattern)은 RSRQ 측정을 수행하기 위한 무선 프레임 당 적어도 하나의 서브프레임을 지시할 수 있다. 측정 셀을 위해 설정된 시간 영역 측정 자원 제한 패턴에 의하여 지시된 서브프레임 이외에서는 RSRQ 측정이 수행되지 않는다.

[311] 이와 같이, UE(예를 들어, 3GPP Rel-10)는 서빙 셀 측정을 위한 서브프레임 패턴('measSubframePattern-Serv') 및 이웃 셀 측정을 위한 서브프레임 패턴('measSubframePattern-Neigh')에 의해 설정된 구간에서만 RSRQ가 측정되어야 한다.

[312] 다만, RSRP는 이러한 패턴 내 측정이 제약되어 있지 않지만, 정확도 요구(accuracy requirement)를 위해서는 이러한 패턴 내에서만 측정되는 것이 바람직하다.

[313]

[314] <u>안테나 포트 간 QCL(quasi co-located)</u>

[315] QC/QCL(quasi co-located 혹은 quasi co-location)은 다음과 같이 정의될 수 있다.

[316] 두 개의 안테나 포트가 QC/QCL 관계에 있다(혹은 QC/QCL 되었다)고 하면, 하나의 안테나 포트를 통해 전달되는 신호의 광범위 특성(large-scale property)이 다른 하나의 안테나 포트를 통해 전달되는 신호로부터 암시(infer)될 수 있다고 단말이 가정할 수 있다. 여기서, 상기 광범위 특성은 지연 확산(Delay spread), 도플러 확산(Doppler spread), 주파수 쉬프트(Frequency shift), 평균 수신 파워(Average received power), 수신 타이밍(Received Timing) 중 하나 이상을 포함한다.

[317] 또한, 다음과 같이 정의될 수도 있다. 두 개의 안테나 포트가 QC/QCL 관계에 있다(혹은 QC/QCL 되었다)고 하면, 하나의 안테나 포트를 통해 일 심볼이 전달되는 채널의 광범위 특성(large-scale property)이 다른 하나의 안테나 포트를 통해 일 심볼이 전달되는 무선 채널로부터 암시(infer)될 수 있다고 단말이 가정할 수 있다. 여기서, 상기 광범위 특성은 지연 확산(delay spread), 도플러 확산(Doppler spread), 도플러 쉬프트(Doppler shift), 평균 이득(average gain) 및 평균 지연(average delay) 중 하나 이상을 포함한다.

[318] 즉, 두 개의 안테나 포트들이 QC/QCL 관계에 있다(혹은 QC/QCL 되었다)고 함은, 하나의 안테나 포트로부터의 무선 채널의 광범위 특성이 나머지 하나의 안테나 포트로부터의 무선 채널의 광범위 특성과 같음을 의미한다. RS가 전송되는 복수의 안테나 포트를 고려하면, 서로 다른 두 종류의 RS가 전송되는

안테나 포트들이 QCL 관계에 있으면, 한 종류의 안테나 포트로부터의 무선 채널의 광범위 특성을 다른 한 종류의 안테나 포트로부터의 무선 채널의 광범위 특성으로 대체할 수 있을 것이다.

[319] 본 명세서에서 위 QC/QCL 관련 정의들을 구분하지 않는다. 즉, QC/QCL 개념은 위 정의들 중에 하나를 따를 수 있다. 혹은 유사한 다른 형태로, QC/QCL 가정이 성립하는 안테나 포트 간에는 마치 동일 위치(co-location)에서 전송하는 것처럼 가정할 수 있다는 형태 (예를 들어, 동일 전송 포인트(transmission point)에서 전송하는 안테나 포트라고 단말이 가정할 수 있다는 등)으로 QC/QCL 개념 정의가 변형될 수도 있으며, 본 발명의 사상은 이와 같은 유사 변형예들을 포함한다. 본 발명에서는 설명의 편의상 위 QC/QCL 관련 정의들을 혼용하여 사용한다.

[320] 상기 QC/QCL의 개념에 따라, 단말은 비-QC/QCL(Non-QC/QCL) 안테나 포트들에 대해서는 해당 안테나 포트들로부터의 무선 채널 간에 동일한 상기 광범위 특성을 가정할 수 없다. 즉, 이 경우 단말은 타이밍 획득 및 트랙킹(tracking), 주파수 오프셋 추정 및 보상, 지연 추정 및 도플러 추정 등에 대하여 각각의 설정된 비-QC/QCL 안테나 포트 별로 독립적인 프로세싱을 수행하여야 한다.

[321] QC/QCL을 가정할 수 있는 안테나 포트들간에 대해서, 단말은 다음과 같은 동작을 수행할 수 있다는 장점이 있다:

[322] - 지연 확산 및 도플러 확산에 대하여, 단말은 어떤 하나의 안테나 포트로부터의 무선 채널에 대한 전력-지연-프로파일(power-delay profile), 지연 확산 및 도플러 스펙트럼(Doppler spectrum), 도플러 확산 추정 결과를, 다른 안테나 포트로부터의 무선 채널에 대한 채널 추정 시 사용되는 위너 필터(Wiener filter) 등에 동일하게 적용할 수 있다.

[323] - 주파수 쉬프트(shift) 및 수신된 타이밍에 대하여, 단말은 어떤 하나의 안테나 포트에 대한 시간 및 주파수 동기화 수행한 후, 동일한 동기화를 다른 안테나 포트의 복조에 적용할 수 있다.

[324] - 평균 수신 전력에 대하여, 단말은 둘 이상의 안테나 포트들에 대하여 RSRP(Reference Signal Received Power) 측정을 평균할 수 있다.

[325] 예를 들어, 단말이 하향링크 데이터 채널 복조를 위한 DMRS 안테나 포트가 서빙 셀의 CRS 안테나 포트와 QC/QCL 되었다면, 단말은 해당 DMRS 안테나 포트를 통한 채널 추정 시 자신의 CRS 안테나 포트로부터 추정했던 무선 채널의 광범위 특성들(large-scale properties)을 동일하게 적용하여 DMRS 기반 하향링크 데이터 채널 수신 성능을 향상시킬 수 있다.

[326] 왜냐하면, CRS는 매 서브프레임 그리고 전체 대역에 걸쳐 상대적으로 높은 밀도(density)로 브로드캐스팅되는 참조 신호이므로, 광범위 특성에 관한 추정치는 CRS로부터 보다 안정적으로 획득이 가능하기 때문이다. 반면, DMRS는 특정 스케줄링된 RB에 대해서는 단말 특정하게 전송되며, 또한

PRG(precoding resource block group) 단위가 기지국이 전송에 사용하는 프리코딩 행렬(precoding matrix)가 변할 수 있으므로 단말에게 수신되는 유효 채널은 PRG 단위로 달라질 수 있어 다수의 PRG를 스케줄링 받은 경우라고 하더라도 넓은 대역에 걸쳐 DMRS를 무선 채널의 광범위 특성 추정용으로 사용 시에 성능 열화가 발생할 수 있다. 또한, CSI-RS도 그 전송 주기가 수~수십 ms가 될 수 있고, 자원 블록 당 평균적으로 안테나 포트 당 1 자원 요소의 낮은 밀도를 가지므로 CSI-RS도 마찬가지로 무선 채널의 광범위 특성 추정용으로 사용할 경우 성능 열화가 발생할 수 있다.

[327] 즉, 안테나 포트 간의 QC/QCL 가정을 함으로써 단말은 하향링크 참조 신호의 검출/수신, 채널 추정, 채널 상태 보고 등에 활용할 수 있다.

[328]

[329] <u>제한된 RLM 및 RRM/CSI 측정</u>

[330] 간섭 조정(Interference coordination)의 한 방법으로서, 공격 셀(aggressor cell)이 일부 물리 채널의 전송 파워(transmission power)/동작(activity)를 줄이는 (여기서, 전송 파워/동작을 줄이는 것은 제로 파워로 설정하는 동작까지 포함할 수 있음) 침묵 서브프레임(silent subframe)(또는, ABS(almost blank subframe)으로 지칭될 수 있음)을 사용하고, 희생 셀(victim cell)이 이를 고려하여 UE를 스케줄링하는 시간 도메인 셀 간 간섭 조정(scheduling하는 time domain inter-cell interference coordination)이 가능하다.

[331] 이 경우, 희생 셀(victim cell) UE의 입장에서는 간섭 레벨(interference level)이 서브프레임에 따라서 크게 변화할 수 있다.

[332] 이러한 상황에서 각 서브프레임에서의 보다 정확한 무선 링크 모니터링(RLM: radio link monitoring)이나 RSRP/RSRQ 등을 측정하는 무선 자원 관리(RRM: radio resource management) 동작을 수행하거나 링크 적응(link adaptation)을 위해서 채널 상태 정보(CSI: channel state information)를 측정하기 위해서, 상기 모니터링/측정은 균일한 간섭 특성을 지니는 서브프레임의 세트들로 제한되어야 한다. 3GPP LTE 시스템에서는 아래와 같이 제한된 RLM 및 RRM/CSI 측정을 정의한다.

[333] UE는 Pcell의 하향링크 무선 링크 품질(downlink link quality)을 감지하기 위하여 셀 특정 참조 신호(CRS)에 기반하여 하향링크 링크 품질을 모니터한다. 단말은 하향링크 무선 링크 품질을 추정하고, Pcell의 하향링크 무선 링크 품질을 모니터링하기 위하여 임계치 Q_out 및 Q_in와 추정치를 비교한다.

[334] 임계치 Q_out은 하향링크 무선 링크가 신뢰있게(reliably) 수신될 수 없는 레벨로 정의되고, 아래 표 6에서 명시된 전송 파라미터에 기반하여 PCFICH 에러를 고려한 가상의(hypothetical) PDCCH 전송의 10% 블록 에러율(BER: block error rate)에 해당한다.

[335] 임계치 Q_in는 하향링크 무선 링크 품질이 Q_out에서의 하향링크 무선 링크 품질 보다 현저하게 신뢰있게 수신될 수 있는 레벨로 정의되고, 아래 표 7에서

명시된 전송 파라미터에 기반하여 PCFICH 에러를 고려한 가상의(hypothetical) PDCCH 전송의 2% BER에 해당한다.

[336] 상위 계층 시그널링이 제한된 RLM을 위한 특정 서브프레임을 지시할 때, 무선 링크 품질이 모니터링된다.

[337] RLM 측정을 수행하기 위한 시간 도메인 측정 자원 제한 패턴이 상위 계층에 의해 설정될 때, 또한 측정되는 셀을 위해 설정된 시간 도메인 측정 자원 제한 패턴이 RLM 측정을 수행하기 위한 무선 프레임 당 적어도 하나의 서브프레임을 지시한다면, 일정한 요구 사항이 적용된다.

[338] CRS 지원(assistance) 정보가 제공되는 경우, CRS 지원 정보가 제공된 하나 또는 그 이상의 셀의 전송 안테나 포트(transmit antenna port)의 개수가 RLM이 수행되는 셀의 전송 안테나 포트의 개수와 상이할 때 상기 요구 사항이 만족될 수 있다.

[339] 만약, 단말이 CRS 지원 정보를 제공받지 않거나 CRS 지원 데이터가 전체 평가 기간 동안에 유효하지 않으면, CRS와 논-MBSFN(multicast broadcast single frequency network) 서브프레임 내에서 설정된 ABS의 충돌 하에 시간 도메인 측정 제한이 적용될 수 있다.

[340] 표 6은 동기가 맞지 않은 상태(out-of-sync)에 대한 PDCCH/PCFICH 전송 파라미터를 예시한다.

[341] [표6]

속성(Attribute)	값(Value)
DCI 포맷	1A
제어 OFDM 심볼의 수	2; 대역폭 ≥ 10 MHz 3; 3 MHz ≤ 대역폭 ≤ 10 MHz 4; 대역폭 = 1.4 MHz
병합 레벨(Aggregation level) (CCE)	4; 대역폭 = 1.4 MHz 8; 대역폭 ≥ 3 MHz
PDCCH RE 에너지 대 평균 RS RE 에너지의 비 (Ratio of PDCCH RE energy to average RS RE energy)	4 dB; Pcell에 의한 CRS 전송을 위해 단일 안테나 포트가 사용되는 경우 1 dB; Pcell에 의한 CRS 전송을 위해 2개 또는 4개 안테나 포트가 사용되는 경우
PCFICH RE 에너지 대 평균 RS RE 에너지의 비 (Ratio of PCFICH RE energy to average RS RE energy)	4 dB; Pcell에 의한 CRS 전송을 위해 단일 안테나 포트가 사용되는 경우 1 dB: Pcell에 의한 CRS 전송을 위해 2개 또는 4개 안테나 포트가 사용되는 경우

[342] 표 7은 동기가 맞는 상태(in-sync)에 대한 PDCCH/PCFICH 전송 파라미터를 예시한다.

[343] [표7]

속성(Attribute)	값(Value)
DCI 포맷	1C
제어 OFDM 심볼의 수	2; 대역폭 ≥ 10 MHz 3; 3 MHz ≤ 대역폭 ≤ 10 MHz 4; 대역폭 = 1.4 MHz
병합 레벨(Aggregation level) (CCE)	4
PDCCH RE 에너지와 평균 RS RE 에너지 간 비율 (Ratio of PDCCH RE energy to average RS RE energy)	0 dB; Pcell에 의한 CRS 전송을 위해 단일 안테나 포트가 사용되는 경우 -3 dB; Pcell에 의한 CRS 전송을 위해 2개 또는 4개 안테나 포트가 사용되는 경우
PCFICH RE 에너지 대 평균 RS RE 에너지의 비 (Ratio of PCFICH RE energy to average RS RE energy)	4 dB; Pcell에 의한 CRS 전송을 위해 단일 안테나 포트가 사용되는 경우 1 dB; Pcell에 의한 CRS 전송을 위해 2개 또는 4개 안테나 포트가 사용되는 경우

[344] Pcell에 대한 하향링크 무선 링크 품질은 UE에 의해 상위 계층에 동기가 맞지 않은 상태(out-of-sync status)/동기가 맞는 상태(in-sync status)를 지시하기 위하여 모니터된다.

[345] 비-DRX(non-DRX) 모드 동작에서, UE의 물리 계층은 매 무선 프레임에서 임계치(Q_out 및 Q_in)를 고려하여 이전 시간 구간 동안 평가된 무선 링크 품질을 측정(assess)한다.

[346] 상위 계층 시그널링이 제한된 RLM을 위한 특정 서브프레임을 지시하면, 무선 링크 품질의 측정은 상위 계층 시그널링에서 지시되지 않는 이외 다른 서브프레임에서 수행되지 않는다.

[347] 무선 링크 품질이 임계치 Q_out 보다 불량하면, UE의 물리 계층은 무선 링크 품질이 측정된 무선 프레임 내에서 상위 계층에게 out-of-sync를 지시한다. 무선 링크 품질이 임계치 Q_in 보다 양호하면, UE의 물리 계층은 무선 링크 품질이 측정된 무선 프레임 내에서 상위 계층에게 in-sync를 지시한다.

[348]

[349] <u>매시브 MIMO(Massive MIMO)</u>

[350] LTE 릴리즈(Rel: release)-12 이후의 무선 통신 시스템에서는 능동 안테나 시스템(AAS: Active Antenna System)의 도입이 고려되고 있다.

[351] 신호의 위상 및 크기를 조정할 수 있는 증폭기와 안테나가 분리되어 있는 기존의 수동 안테나 시스템과 달리, AAS는 각각의 안테나가 증폭기와 같은 능동 소자를 포함하도록 구성된 시스템을 의미한다.

[352] AAS는 능동 안테나 사용에 따라 증폭기와 안테나를 연결하기 위한 별도의 케이블, 커넥터, 기타 하드웨어 등이 필요하지 않고, 따라서 에너지 및 운용 비용 측면에서 효율성이 높은 특징을 갖는다. 특히, AAS는 각 안테나 별 전자식 빔 제어(electronic beam control) 방식을 지원하기 때문에 빔 방향 및 빔 폭을 고려한

정교한 빔 패턴 형성 또는 3차원 빔 패턴을 형성하는 등의 진보된 MIMO 기술을 가능하게 한다.

[353] AAS 등의 진보된 안테나 시스템의 도입으로 다수의 입출력 안테나와 다차원 안테나 구조를 갖는 대규모 MIMO 구조 또한 고려되고 있다. 일례로, 기존의 일자 형 안테나 배열과 달리 2차원 안테나 배열을 형성할 경우, AAS의 능동 안테나에 의해 3차원 빔 패턴을 형성할 수 있다. 송신 안테나 관점에서 상기 3차원 빔 패턴을 활용할 경우, 빔의 수평 방향뿐만 아니라 수직 방향으로의 준-정적 또는 동적인 빔 형성을 수행할 수 있으며 일례로 수직 방향의 섹터 형성 등의 응용을 고려할 수 있다.

[354] 또한, 수신 안테나 관점에서는 대규모 수신 안테나를 활용하여 수신 빔을 형성할 때, 안테나 배열 이득(antenna array gain)에 따른 신호 전력 상승 효과를 기대할 수 있다. 따라서, 상향링크의 경우, 기지국이 다수의 안테나를 통해 단말로부터 전송되는 신호를 수신할 수 있으며, 이때 단말은 간섭 영향을 줄이기 위해 대규모 수신 안테나의 이득을 고려하여 자신의 송신 전력을 매우 낮게 설정할 수 있는 장점이 있다.

[355] 도 11은 본 발명이 적용될 수 있는 무선 통신 시스템에서 기지국 또는 단말이 AAS 기반의 3D(3-Dimension) 빔 형성이 가능한 다수의 송/수신 안테나를 갖고 있는 시스템을 예시한다.

[356] 도 11은 앞서 설명한 예를 도식화한 것으로서, 2차원 안테나 배열(즉, 2D-AAS)를 이용한 3D MIMO 시스템을 예시한다.

[357]

[358] <u>매시브 MIMO의 셀 커버리지(Cell coverage of massive MIMO)</u>

[359] 다중 안테나 시스템, 일례로서 N개의 전송 안테나를 갖는 시스템은 단일 안테나 시스템에 비교해서 전체 전송 전력을 동일하게 전송한다고 가정하면, 특정 지점에 수신 파워가 최대 N배 높도록 빔포밍(beamforming) 해줄 수 있다.

[360] 다중 안테나를 갖는 기지국에서도 CRS, PSS/SSS, PBCH 및 브로드캐스트(broadcast) 정보를 전달하는 채널은 기지국 커버리지 영역내의 모든 UE들이 수신할 수 있도록 특정 방향으로 beamforming을 해주지는 않는다.

[361] 이와 달리, 특정 UE에게 유니캐스트(unicast) 정보를 전달하는 채널인 PDSCH는 해당 UE의 위치 및 링크 상황에 맞추어 beamforming을 해주어 전송 효율을 높이도록 한다. 즉, PDSCH의 전송 데이터 스트림은 특정 방향으로 빔을 형성하기 위하여 프로코딩(precoding)되어 다중의 안테나 포트를 통해 전송된다. 그러므로 대표적으로 CRS와 PDSCH의 전송 전력이 동일한 경우에, 특정 UE에게 CRS의 평균 수신 전력과 비교해서 해당 UE를 향해 beamforming 된 프로코딩된(precoded) PDSCH의 수신 전력은 최대 N배까지 높을 수 있다.

[362] 현재까지 LTE Rel-11 시스템에서 최대 8개의 전송 안테나를 갖는 기지국을 고려하는데, 이는 CRS 평균 수신 전력에 비해서 precoded PDSCH 수신 전력이 8배 클 수 있음을 의미한다. 그러나, 향후에 매시브 MIMO 시스템의 도입으로

기지국의 전송 안테나가 100개 이상 되는 경우에 CRS와 precoded PDSCH의 수신 전력은 100배 이상 차이를 나타낼 수 있다. 결론적으로 massive MIMO 시스템의 도입으로 특정 기지국에서 전송하는 CRS의 커버리지 영역과 DM-RS 기반 PDSCH의 커버리지 영역이 일치하지 않게 된다.

[363] 특히, 이러한 현상은 인접한 두 개의 기지국의 전송 안테나 개수의 차이가 많을 때 크게 나타날 수 있다. 대표적으로 64개의 전송 안테나를 갖는 매크로 셀(macro cell)과 단일 전송 안테나를 갖는 마이크로 셀(micro cell)(예를 들어, 피코 셀(pico cell))이 인접하고 있는 경우를 예로 들 수 있다. Massive MIMO의 초기 배치(deployment) 과정에서 서빙받는(served) UE가 많은 macro cell부터 먼저 안테나 개수를 늘릴 것으로 기대하고 있기 때문에 macro cell, micro cell 그리고 pico cell이 혼재되어 있는 이종의 네트워크(heterogeneous network)의 경우에 인접한 기지국간에 전송 안테나의 개수가 크게 차이 나게 된다.

[364] 예를 들어, 단일 전송 안테나를 갖는 pico cell의 경우에 CRS와 PDSCH의 커버리지 영역이 일치하게 된다. 그러나 64개의 전송 안테나를 갖는 macro cell의 경우에 CRS의 커버리지 영역보다 PDSCH의 커버리지 영역이 더 크게 된다. 그러므로 macro cell과 pico cell의 경계에서 CRS의 수신 품질인 RSRP 또는 RSRQ에만 의존하여 초기접속 및 핸드오버를 결정하게 되면 PDSCH의 최대 품질을 제공해 줄 기지국을 서빙 셀(serving cell)로 선택할 수 없게 된다. 이에 대한 단순한 해결책으로 N개의 전송 안테나를 갖는 기지국의 PDSCH 수신 전력은 N배 클 것으로 가정할 수 있으나, 기지국이 가능한 모든 방향으로 beamforming을 다 해줄 수 없는 경우를 고려할 때 최적 해결책은 아니다.

[365]

[366] **RRM-RS**

[367] 본 특허에서는 프리코딩된 RS(precoded RS)를 전송하고 이에 대한 RRM 측정(measurement)를 수행하는 방법을 제안한다. 이하, 본 명세서에서는 이러한 목적의 precoded RS를 'RRM-RS'라고 명칭하도록 한다. RRM-RS는 다수개의 안테나 포트로 구성되어 있으며 각 안테나 포트 별로 beamforming을 다르게 설정하여 각 전송 빔(beam) 별로 UE가 RSRP를 측정할 수 있도록 한다. 일례로, 기지국에서 M개의 방향으로 beamforming이 가능한 경우에 M 포트(M-port)로 구성된 RRM-RS를 설정하도록 한다.

[368]

[369] **RRM-RS의 주기 및 다중화(multiplexing)**

[370] M-port RRM-RS는 동일 서브프레임에서 CDM되거나 또는 FDM/TDM으로 구분되어 전송될 수 있다. 즉, M-port RRM-RS의 각 안테나 포트 별 전송 신호는 동일 서브프레임에서 다른 전송 RE를 사용하여 전송되거나, 또는 동일 RE를 사용하여 전송되는 경우에 안테나 포트 간에 직교 스크램블링 코드(orthogonal scrambling code)를 사용하여 상호간에 간섭 없이 구분할 수 있도록 한다.

[371] 이와 달리 하나의 서브프레임에서 동시에 전송 가능한 RRM-RS의 안테나 포트

수를 K로 설정하고 (M/K)개의 서브프레임에 나누어 전송할 수 있다.

[372] 이 경우, RRM-RS의 설정 파라미터는 전체 안테나 포트의 개수 M과 하나의 서브프레임에서 동시 전송되는 안테나 포트 수 K를 포함한다. RRM-RS의 설정 파라미터로써 RRM-RS 전송 주기 P와 오프셋 O를 포함한다. 여기서, RRM-RS 전송 주기는 RRM-RS가 전송되는 서브프레임의 간격으로 정의한다. 예로써 P=10, O=5, M=64, K=32인 경우에 RRM-RS는 서브프레임 인덱스(SFI: subframe index)가 5, 15, 25, 35, ... 인 서브프레임에서 전송되며, SFI=5인 서브프레임에서 안테나 포트 0에서 31의 RRM-RS가 전송되고, SFI=15인 서브프레임에서 안테나 포트 32에서 63의 RRM-RS가 전송되고, SFI=25인 서브프레임에서 안테나 포트 0에서 31의 RRM-RS가 또다시 전송된다.

[373] 이와 달리 RRM-RS 전송 주기를 동일 안테나 port의 RS가 전송되는 서브프레임의 간격으로 정의하고, (M/K)개의 서브프레임에 RRM-RS의 안테나 포트들을 나누어 전송하는 방식에서 (M/K)개의 연속된 서브프레임에 나누어 전송하도록 한다. 예로써 P=20, O=5, M=64, K=32인 경우에 RRM-RS는 SFI가 5, 6, 25, 26, 45, 46, ...인 서브프레임에서 전송되며, SFI=5인 서브프레임에서 안테나 포트 0에서 31의 RRM-RS가 전송되고, SFI=6인 서브프레임에서 안테나 포트 32에서 63의 RRM-RS가 전송되고, SFI=25인 서브프레임에서 안테나 포트 0에서 31의 RRM-RS가 또다시 전송된다.

[374]

[375] **RSRP** 측정 및 보고

[376] RRM-RS의 RSRP는 안테나 포트 별로 측정하여 보고하도록 한다. UE는 다수개의 RRM-RS를 설정 받을 수 있다.

[377] 각 셀에서 RRM-RS를 하나씩 전송하는 경우에, UE는 서빙 셀 및 인접 셀들이 전송하는 RRM-RS들의 설정을 지정 받을 수 있다. 하나의 셀이 다수개의 RRM-RS를 전송할 수도 있다. UE는 RRM-RS의 RSRP를 보고할 때 해당 RSRP가 몇 번째 RRM-RS의 몇 번째 안테나 포트의 RSRP 측정결과인지 함께 알려준다.

[378] RRM-RS의 RSRP를 계산하기 위하여 각 안테나 포트의 수신 신호 레벨의 평균을 취하는데, 평균을 취하는 시간 윈도우(window)를 기지국이 지정해 줄 수 있거나, 또는 미리 정해진 시간 (예를 들어, 200ms) 동안 RRM-RS의 각 안테나 포트 별 수신 신호 레벨의 평균을 취하여 RSRP를 얻도록 한다. 또는 각각의 시간 윈도우에서 얻은 평균 수신 파워를 다시 필터링하여 보고할 RSRP를 얻을 수 있다.

[379] 다수개의 RRM-RS를 설정 받은 UE는 각 RRM-RS의 각 안테나 포트별 RSRP를 측정한다. RRM-RS를 R개 설정 받고 r번째 RRM-RS의 안테나 포트 수가 M_r인 경우에, r번째 RRM-RS의 m번째 안테나 포트의 RSRP를 RSRP(r,m)로 정의한다. UE는 RSRP(r,m)을 정렬하고 그 중에서 강하게 수신되는 L개 안테나 포트의 RSRP를 선택하여 보고하도록 한다.

[380] 위 방식을 약간 변형하여 UE는 RSRP(r,m)을 정렬하고 그 중에서 가장 강하게

수신되는 안테나 port를 선택하고 선택된 안테나 포트의 RSRP, 즉 max(RSRP(r,m))와 대비하여 일정 차이 내로 들어오는 포트의 RSRP들로 보고를 한정시킨다. 즉, 다음과 같이 RSRP 비율(ratio) 또는 dB 스케일(scale) 표현에서 RSRP의 차이가 일정 임계치 보다 높은 최대 L개의 안테나 포트의 RSRP를 보고하도록 한다.

[381] [수식13]

```
RSRP(r,m) - max(RSRP(r,m)) > Threshold
```

[382] 다른 일례로, UE는 참조(reference) 안테나 포트를 지정 받을 수 있다. 참조 안테나 포트로써 해당 UE에게 설정된 프리코딩된(precoded) CSI-RS와 빔 방향이 유사한 서빙 셀이 전송하는 RRM-RS의 안테나 포트를 지정해 주는 것이 바람직하다. UE는 r_0번째 RRM-RS의 m_0번째 안테나 포트를 참조 안테나 포트로 지정 받은 경우에, 참조 안테나 포트의 RSRP에 비해 다른 안테나 포트의 RSRP가 일정 차이 내로 들어오는 경우에 보고하도록 한다. 즉 다음과 같이 RSRP 비율(ratio) 또는 dB 스케일(scale) 표현에서 RSRP의 차이가 일정 임계치를 넘는 경우에 보고하도록 한다.

[383] [수식14]

```
RSRP(r,m) - RSRP(r_0,m_0) > Threshold
```

[384] 도 12는 본 발명의 일 실시예에 따른 RRM-RS의 안테나 포트 별 RSRP를 예시한다.

[385] 도 12에서는 32 안테나 포트로 구성된 RRM-RS의 각 안테나 포트별 RSRP의 일 예시를 나타내고 있다.

[386] 최대 RSRP를 갖는 안테나 포트에 비교해서 5dB이내의 RSRP를 갖는 안테나 포트들의 RSRP를 보고하도록 설정된 경우, 도 12와 같이 안테나 포트 13이 최대 RSRP 40dB를 가지므로 RSRP가 35dB를 넘는 안테나 포트에 대해 보고하도록 한다. 즉, 안테나 포트 13을 포함하여 안테나 포트 24, 25, 26의 RSRP가 기지국에 보고된다.

[387]

[388] <u>안테나 포트 그룹핑(Antenna port grouping)</u>

[389] 안테나 포트 별로 빔 포밍을 다르게 설정할 수 있으므로, 이 경우 안테나 포트와 빔은 일대일 대응 관계를 갖는다.

[390] 그러므로 안테나 포트 인덱스 (i)는 빔 인덱스(beam index) (i)와 일대일로 매핑시킬 수 있다. (i)번째 빔과 (i+1)번째 빔의 방향이 서로 인접하도록 빔들을 인덱싱하는 경우, 앞서 도 12의 예시에서처럼 인접한 안테나 포트들간의 RSRP는 서로 유사한 특징을 보이게 된다. 이러한 유사도는 (i)번째 빔과 (i+c)번째 빔 사이에서도 나타나지만 c가 커질수록 유사도는 떨어진다. 몇 개의 연속된 인접 빔들 사이에서 높은 유사도가 나올지는, 빔의 간격 및 빔의 폭(width), 그리고 다중-경로(multipath)들의 분산(scattering) 정도에 따라서 좌우된다.

[391] RRM-RS에 기반한 RSRP 측정 결과를 보고 받은 기지국은 해당 UE의 대략적 위치를 파악하고 해당 지점으로 향하여 전송되는 프리코딩된(precoded) CSI-RS 설정을 UE에게 알려주어 UE가 CSI-RS를 측정하여 PDSCH 스케줄링을 위한 CSI(RI, PMI, CQI 등)를 피드백 할 수 있도록 한다. 또한, 다수의 셀에서 전송하는 RRM-RS들에 기반한 RSRP 측정 결과를 보고 받은 기지국은 RSRP 측정 결과에 기반하여 해당 UE를 어떤 셀로 핸드오버 시킬지 그리고 타겟 셀에서 어떤 프리코딩된(precoded) CSI-RS를 UE에게 설정해 줄지 결정한다. 즉, RRM-RS에 기반한 RSRP 측정 결과는 해당 UE에게 향후에 어떤 프리코딩된(precoded) CSI-RS를 설정해 줄지를 판단하는데 필요한 중요 정보를 기지국에 제공한다.

[392] 앞서 도 12의 예시와 같은 RSRP 측정 결과를 바탕으로 해당 UE에게 최대 4개의 데이터 스트림 전송이 가능하도록 하거나 또는 페이딩(fading)의 변화에 맞추어 빠르게 최상의 빔 스위칭(best beam switching)을 하기 위하여 4-포트 CSI-RS를 설정해주는 경우에, RSRP가 가장 큰 RRM-RS 포트 13, 24, 25, 26의 빔 방향과 동일한 4-포트 CSI-RS를 생성하여 설정해 주는 것이 최적일 것으로 예상된다. 하지만 CSI-RS가 UE 별로 최적화하여 생성하고 전송하기에는 오버헤드(overhead)가 너무 크다. 그러므로 동일 환경에 있는 많은 UE들이 CSI-RS를 공유하는 것이 CSI-RS 전송 오버헤드를 줄일 수 있는 방법이다. 이러한 목적을 달성하기 위하여 하나의 CSI-RS 설정내의 CSI-RS 안테나 포트들의 프리코딩은 인접 방향으로 전송되는 빔의 특징을 나타내도록 프리코딩되어야 한다. 즉, 다른 서빙 받는 UE(served UE)들을 고려하여 미리 RRM-RS 포트 12, 13, 14, 15의 빔 방향과 동일한 4-포트 CSI-RS1과 RRM-RS 포트 24, 25, 26, 27의 빔 방향과 동일한 4-포트 CSI-RS2가 미리 설정되어 있는 경우에, 해당 UE에게 어떤 CSI-RS를 설정해주는 것이 좋을지를 RRM-RS의 RSRP 보고를 통해 판단할 수 있어야 한다.

[393] 본 발명의 또 다른 실시예로서 안테나 포트 그룹(antenna port group)에 대해서 RSRP를 측정 보고하도록 한다. 제안 방식에서 안테나 포트들을 그룹핑하고 그룹에 속하는 안테나 포트의 RSRP들을 평균 취하여 해당 안테나 포트 그룹의 RSRP를 얻도록 한다. 그룹은 미리 정해져 있거나 또는 기지국이 정해서 알려 줄 수 있다. 또는 UE가 그룹핑 방식을 정하고 이를 보고 할 수 있다.

[394] 앞서 도 12의 예시에서처럼 32-포트로 구성된 RRM-RS의 경우에 4 포트 씩 그룹핑 될 수 있다. 각 그룹들간에 분리(disjoint)하여 8(=32/4)개의 그룹으로 그룹핑될 수 있다. 이 경우에 (i)번째 포트 그룹은 RRM-RS 포트 (4i), (4i+1), (4i+2), (4i+3)로 구성된다. (i)번째 포트 그룹의 RSRP는 안테나 포트 (4i), (4i+1), (4i+2), 그리고 (4i+3)의 RSRP의 평균으로 정의한다.

[395] 또 다른 실시예로서, 그룹간의 중첩을 허용하여 그룹핑할 수 있다. 32-포트로 구성된 RRM-RS을 4 포트씩 그룹핑하는 경우에 15개의 그룹으로 그룹핑하도록 한다. 이 경우에 (i)번째 포트 그룹은 RRM-RS 포트 (2i), (2i+1), (2i+2), (2i+3)로 구성된다. 제안 방식을 일반화하여 A 개의 포트씩 그룹핑하고, 인접 그룹간의

포트 간격을 B로 설정하면, (i)번째 포트 그룹은 RRM-RS 포트 (B*i), (B*i+1), ..., (B*i+A-1)로 구성된다. 파라미터 A와 B의 설정은 기지국이 UE에게 지정해 주거나, 또는 UE가 채널 환경 및 UE 능력(capability)을 고려하여 선정하여 보고할 수 있다.

[396] 제안 방식의 변형으로 UE는 보고할 안테나 포트 그룹을 선택하는 방식으로 RSRP보다 해당 안테나 포트 그룹으로 얻을 수 있는 능력(capability)을 고려할 수 있다. 이 경우에 UE는 안테나 포트 그룹내의 다수의 안테나로부터 다중-계층(multi-layer) 데이터 전송을 고려하여 능력을 계산하도록 한다.

[397]

[398] 안테나 포트 그룹핑 레벨(Antenna port grouping level)

[399] 제안 방식에서 크기가 다른 다수개의 그룹핑 방법을 사용할 수 있다. 즉, A1 포트씩 그룹핑하는 방법과 A2 포트씩 그룹핑하는 방법을 동시에 사용할 수 있다. 이하, A_i 포트씩 그룹핑하는 방법을 그룹핑 레벨(grouping level) i로 명칭하도록 한다.

[400] 도 13은 본 발명의 일 실시예에 따른 RRM-RS 안테나 포트 그룹핑 레벨을 예시한다.

[401] 도 13에서는 16 포트 RRM-RS를 4단계의 그룹핑 레벨을 적용하여 그룹핑하는 방식의 일례를 보여주고 있다. 예시에서 그룹핑 레벨 1은 1 포트씩 그룹핑하는 방법으로 그룹핑을 하지 않지 않는 방식을 나타낸다. 그리고 그룹핑 레벨 2, 3, 4는 각각 2 포트, 4 포트, 8 포트씩 그룹핑하고 있다. 그림의 예시에서는 동일 레벨의 안테나 포트 그룹들이 분히(disjoint)하여 설정된 경우를 나타내고 있다.

[402] 이러한 다중 그룹핑 방식에서 UE는 그룹핑 레벨 별로 RSRP를 보고한다. 즉 각 그룹핑 레벨 별로 RSRP가 높은 안테나 그룹을 선택하여 보고하도록 한다. 또는 레벨이 다른 안테나 그룹간에 RSRP를 비교하여 최상의(best) 그룹과 그룹 레벨을 보고할 수 있다. 레벨1이 다른 안테나 그룹간의 RSRP를 비교하기 위하여 각 레벨의 그룹 RSRP에 일정 오프셋만큼 보정하고 비교하도록 한다. RRM-RS를 R개 설정 받은 경우에, (r)번째 RRM-RS의 (l)번째 그룹핑 레벨의 (g)번째 안테나 포트 그룹의 RSRP를 GRSRP(r,l,g)로 정의하면, 다음과 같이 기지국으로부터 (r)번째 RRM-RS의 (l)번째 그룹핑 레벨을 위해 지정 받은 offset(r,l)만큼을 보정하여 Adj_GRSRP(r,l,g)를 계산하고 이를 비교하도록 한다.

[403] [수식15]

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Adj_GRSRP(r,l,g) = GRSRP(r,l,g) + offset(r,l)
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[404] 추가적으로, 그룹핑 레벨 별로 또는 전체 그룹핑 방식에서 최상의(best) L개의 포트 그룹 RSRP를 보고하는 방식에서 보고되는 최상의(best) L에 대한 잦은 변동을 줄이기 위해 히스테리시스 파라미터(Hysteresis parameter), Hy를 추가하여 RSRP를 보정할 수 있다.

[405] [수식16]

$$Adj_GRSRP(r,l,g) = GRSRP(r,l,g) + offset(r,l) \pm Hy$$

[406] 여기서, Hy는 해당 포트 그룹이 이전 보고에서 최상의(best) L GRSRP에 포함되는지 여부에 따라서 Hy를 더할지 뺄지 결정된다. 해당 포트 그룹이 이전 보고에서 최상의(best) L GRSRP에 포함되어 있는 경우에 Hy를 더하여 높은 Adj_RSRP를 갖도록 바이어스를 줘서 최상의(best) L Adj_GRSRP를 갖는 포트 그룹이 자주 바뀌는 것을 줄여 주도록 한다.

[407] 제안 방식으로 UE는 참조(reference) 안테나 포트 그룹을 지정 받을 수 있다. 기지국은 해당 UE에게 설정된 프리코딩된(precoded) CSI-RS와 빔 방향이 동일한 서빙 셀이 전송하는 RRM-RS의 안테나 포트 그룹을 참조 안테나 포트 그룹으로 지정해 주는 것이 바람직하다. UE는 그룹핑 레벨 별로 참조 안테나 포트 그룹을 지정 받을 수 있다. 또는 전체 그룹핑 레벨에서 하나의 참조 안테나 포트 그룹을 지정 받을 수 있다. UE는 r_0번째 RRM-RS의 l_0번째 그룹핑 레벨의 m_0번째 안테나 포트 그룹을 참조 안테나 포트 그룹으로 지정 받은 경우에, 참조 안테나 포트 그룹의 Adj_GRSRP에 비해 다른 안테나 포트 그룹의 Adj_GRSRP가 일정 임계츠를 넘는 경우에 보고하도록 한다. 즉 다음과 같이 Adj_GRSRP 비율(ratio) 또는 dB 스케일(scale) 표현에서 RSRP의 차이가 일정 임계치를 넘는 경우에 보고하도록 한다.

[408] [수식17]

$$Adj_GRSRP(r,l,g) - Adj_GRSRP(r_0, l_0, m_0) > Threshold$$

[409] 또는 제안 방식의 변형으로 참조 RSRP를 현재 설정되어 있는 CSI-RS를 통해 특정하여 CSI-RS 기반 RSRP에 비해 RRM-RS 기반 RSRP 결과를 비교하여 선택 보고하도록 한다.

[410]

[411] **3차원(3D: 3-Dimension)을 위한 RRM-RS**

[412] 앞서 본 발명에서 제안하는 방식은 빔(beam)의 방향성이 2차원 공간에서 3차원 공간으로 확장되는 경우에도 변형하여 적용 가능하다. 3차원 공간상에서 빔의 방향성은 상하각(수직각)과 좌우각(수평각)의 두 개의 각도의 의해 조절된다. 그러므로 인접 빔 여부를 파악하기 위하여 빔들을 두 개의 인덱스, 즉 수평 인덱스와 수직 인덱스로 인덱스하는 것이 효율적이다. 본 발명의 특징에 따라 빔 인덱스와 RRM-RS 포트 인덱스와 일대일 대응 관계를 갖기 위하여 RRM-RS 포트도 수평 인덱스와 수직 인덱스로 인덱싱되는 것이 바람직하다.

[413] 수직 방향으로 M_v개의 빔을 갖고 수평 방향으로 M_h개의 빔을 갖는 3D MIMO 시스템의 경우에 전체 (M_v×M_h)개의 빔이 가능하다. 본 발명에서는 (M_v×M_h)-포트 RRM-RS를 설정하고 각 안테나 포트에 수평 인덱스 j_h(j_h=0, ..., M_h-1)와 수직 인덱스 j_v(j_v=0, ..., M_v-1)를 부여하도록 한다. (M_v×M_h)-포트 RRM-RS의 자원 매핑을 고려하여 각 안테나 포트들은 일차원

인덱스 i(i=0, ..., M_v×M_h-1)와 이차원 인덱스 j_h와 j_v를 부여 받게 되는데, (i) = f(j_h, j_v)의 관계를 갖게 된다.

[414] 도 14는 본 발명의 일 실시예에 따른 이차원 인덱스로 배열된 RRM-RS의 안테나 포트와 안테나 포트 그룹을 예시하는 도면이다.

[415] 도 14를 참조하면, 각 안테나 포트들은 (j_h, j_v)로 인덱싱되어 있다. 본 발명에서 제안하는 방식을 적용하여 A_h×A_v 개의 포트씩 그룹핑하고, 인접 그룹간의 포트 간격을 B_h와 B_v로 설정하면, (i_h, i_v)번째 포트 그룹은 RRM-RS port (B_h×i_h+j_h, B_v×i_v+j_v), (j_h=0, ..., A_h-1), (j_v=0, ..., A_v-1)로 구성된다. 파라미터 A_h, A_v와 B_h, B_v의 설정은 기지국이 UE에게 지정해 주거나, 또는 UE가 채널 환경 및 UE 능력(capability)를 고려하여 선정하여 보고할 수 있다.

[416]

[417] **RRM**-RS과 CSI-RS의 차이점

[418] 기존 LTE/LTE-A 시스템에서는 CSI 보고의 목적으로 CSI-RS를 전송한다. UE는 CSI로써 RI, PMI, CQI 등을 보고한다. 이와 달리 본 발명에서 제안하는 RRM-RS는 안테나 포트 별로 RSRP를 측정하기 위해 사용된다. RRM-RS의 전송 자원을 새롭게 정의하기 보다는 기존의 CSI-RS가 설정 가능한 자원을 사용하는 것이 바람직하다. 이는 레가시(legacy) UE들의 전송 효율을 떨어뜨리지 않기 때문이다. 새로운 자원에 RRM-RS를 전송하는 경우에 레가시(legacy) UE들은 이를 인식하지 못하므로, RRM-RS이 전송되는 서브프레임에서 전송 효율이 떨어지거나 또는 스케줄링하지 못하게 된다. 그러므로 기존의 CSI-RS가 설정 가능한 자원을 사용하여 RRM-RS를 전송하는 방식은 레가시(legacy) UE에게 해당 자원을 포함하여 CSI-RS 설정을 해주어 해당 자원에 데이터 매핑이 되지 않음을 알려줄 수 있다.

[419] UE에게 CSI 보고를 위해 설정된 다수개의 CSI-RS에는 데이터 매핑이 이루어지지 않는다. 즉 CSI-RS가 매핑되는 RE를 제외하고 PDSCH를 매핑한다. 본 발명의 제안 방식에서 RRM-RS는 CSI-RS 마찬가지로 RRM-RS가 매핑되는 RE를 제외하고 PDSCH를 매핑하도록 할 수 있다. 그러나 변형된 방식으로 RRM-RS와 무관하게 PDSCH를 매핑하도록 할 수 있다. 이 경우에 UE는 동일 RE에서 RRM-RS와 PDSCH를 동시에 수신할 수 있어야 한다. 또는 기지국이 RRM-RS의 안전한 수신을 보장하기 위하여 해당 자원을 ZP-CSI-RS로 설정하여 PDSCH가 매핑되지 않도록 할 수 있다.

[420]

[421] **RRM**-RS의 QCL 설정

[422] 각 셀에서 RRM-RS를 전송하는 경우에, UE는 서빙 셀 및 인접 셀들이 전송하는 RRM-RS들의 설정을 지정 받을 수 있다. 이를 통하여 UE는 서빙 셀의 빔포밍(beamforming)에 따른 이득 및 인접 셀의 beamforming에 따른 이득을 측정하여 네트워크에 보고하고 핸드오버의 판단 기준으로 활용하도록 해준다.

RRM-RS는 전송 밀도(density)가 매우 낮게 설정되므로 신호의 트래킹(tracking) 목적으로 부족할 수 있다. 그러므로 밀도(density)가 높아 신뢰(reliable)있게 수신되는 신호 대표적으로 CRS를 트래킹(tracking)하고 RRM-RS의 검출하는데 트래킹(tracking) 결과를 활용하도록 한다. 즉, 서빙 셀과 인접 셀의 반송파 주파수를 발생하는 오실레이터의 오차에 의하여 서빙 셀의 CRS에 의해 트래킹(tracking)된 결과를 인접 셀에서 전송된 RRM-RS를 위해 사용하기에는 부적합하다. 그러므로 각각의 RRM-RS 별로 RRM-RS를 검출할 때 사용할 QCL(Quasi Co-Located)된 CRS (혹은 CSI-RS 등 특정 다른 RS)를 알려주도록 한다. UE는 QCL된 CRS (혹은 CSI-RS 등 특정 다른 RS)로부터 추정된 채널의 광범위 특성(large-scale) 특성을 RRM-RS의 검출에 사용한다. 여기서 채널의 광범위 특성(large-scale) 특성은 지연 확산(Delay spread), 도플러 확산(Doppler spread), 도플러 쉬프트(Doppler shift), 평균 이득(average gain), 그리고 평균 지연(average delay) 중에 하나 이상을 포함할 수 있다.

[423]

[424] **RSRQ로 확장**

[425] 본 발명의 제안 방식들은 RRM-RS의 각 안테나 포트 별로 RSRQ를 측정하는 방식으로 확장 적용될 수 있다. RSRQ는 RSRP와 RSSI의 비율로 정의된다. 그러므로 추가적으로 RSSI의 측정이 추가된다. RSSI의 측정 자원은 동일 반송파 주파수를 갖는, 즉 동일 컴포넌트 캐리어(component carrier)에 설정된 모든 RRM-RS들에 있어서 동일하게 설정될 수 있다. 이 경우에 동일 컴포넌트 캐리어 내의 RRM-RS들의 포트들 간의 비교는 RSRP을 사용하나 RSRQ를 사용하나 동일하다. 그러나 이종 동일 컴포넌트 캐리어 내의 RRM-RS들의 포트들간의 비교는 RSRP을 사용할지 RSRQ를 사용할지에 따라 달라진다. 그러므로 기지국은 UE에게 RRM-RS에 기반한 RRM 보고를 수행함에 있어서 RSRP을 사용할지 RSRQ를 사용할지를 지정해 주도록 한다.

[426] 이와 달리 각각의 RRM-RS들 개별적으로 RSSI 측정 자원을 따로 설정해 줄 수 있다. 이 경우에는 동일 컴포넌트 캐리어 내에서도 RRM-RS들의 포트들간의 비교는 RSRP을 사용할지 RSRQ를 사용할지에 따라 달라진다. 그러므로 기지국은 UE에게 RRM-RS에 기반한 RRM 보고를 수행함에 있어서 RSRP을 사용할지 RSRQ를 사용할지를 지정해 주도록 한다.

[427]

[428] **RRM-RS RSRP와 CRS RSRP의 연관성**

[429] 본 발명의 RRM-RS에 기반한 RSRP는 다중 안테나를 가지고 있는 기지국의 beamforming 이득을 서빙 셀 선택에 반영함을 목적으로 하고 있다. RRM-RS의 RSRP에 근거하여 특정 인접 셀의 beamforing이 가장 좋다고 판단되어도, 해당 셀에서 브로드캐스트하는 채널들, 즉 CRS 기반 복조(demodulation)를 하는 채널이 안정적으로 수신되지 않으면 해당 인접 셀로 UE를 핸드오버 시킬 수 없다. 그러므로 UE에게 특정 기지국에서 전송하는 RRM-RM와 CRS 모두 좋은

품질을 갖는지 보고 받고 이를 근거를 핸드오버 결정 및 빔 선택(beam selection을 수행해야 한다. 이를 위하여 UE는 설정 받은 i번째 RRM-RS의 j번째 안테나 포트 또는 포트그룹의 RSRP를 보고하면서 i번째 RRM-RS과 연결된 CRS의 RSRP를 같이 보고 하도록 한다. 여기서 RRM-RS와 연결된 CRS는 RRM-RS와 QCL된 CRS일 수 있다.

[430]

[431] 개선된 RRM 및 RLM 동작

[432] FD-MIMO가 사용될 때, 일반적인 셀 연관(conventional cell association) 방법으로 인하여 셀 경계(cell-edge) 사용자는 현저하게 성능 저하(degradation)가 유발될 수 있다. 또한, CRS/PDCCH의 수직 빔(vertical beam)의 폭(width)은, 폭이 좁은 수직 빔(narrow vertical beam)으로 인해 발생되는 CRS/PDCCH의 커버리지 홀(coverage hole) 때문에 성능 저하(degradation)가 유발되는 시스템의 수율(throughput)에 현저한 영향을 미칠 수 있다. 만약, FD-MIMO를 위해 CRS 가상화(virtualization)가 사용된다면, 시스템 성능 측면에서 특히, 셀 경계(cell edge) UE의 부적절한 셀 연관(cell association)을 야기시킬 수 있다. FD-MIMO 전송 방식은 일반적인 전송 방식에 비하여 더 높은 빔 이득으로 동작하기 때문에, UE는 해당 UE를 위한 PDSCH에 적용되는 최적인 수직 빔을 제공할 수 있는 셀에 어태치되어야 한다.

[433] 즉, FD-MIMO 동작에 있어서, UE는 해당 UE에 대한 PDSCH에 적용되는 최적의 수직 빔(best vertical beam)을 제공할 수 있는 셀에 어태치(attach)되어야 한다.

[434] UE가 셀에 미리 어태치(attach)되어 있는 상황에서는 CSI-RS(디스커버리 RS(DRS: Discovery RS)로서 이용되는 경우 DRS-CSI-RS) 기반 RRM 측정을 통해 이를 가능하게 할 수 있다. 더욱 구체적으로, (FD-MIMO를 지원하는) UE는 상술한 FD-MIMO 측면에서 최적의 셀(best cell)이 아니더라도 주로 RACH 절차를 포함하는 기존의 CRS 기반 셀 선택 절차에 따라 셀에 어태치된다. UE가 RRC-Connected 모드에 셋업되면, UE는 DRS 측정 타이밍 설정(DMTC: DRS measurement timing configuration), DRS-CSI-RS 설정 등을 포함하는 디스커버리 절차를 위하여 필요한 모든 상위 계층 시그널링이 설정될 필요가 있다. 이러한 설정에 따라, UE는 DMTC 내 설정된 주기(예를 들어, 40, 80 또는 160 ms)에 따라 주기적으로 DRS-CSI-RS를 측정한다.

[435] 특히, UE는 DRS-CSI-RS 기반 RRM 측정에 기반하여(예를 들어, FD-MIMO 사용 케이스에서 각각 서로 다른 수직 빔(vertical beam)이 적용되는 경우 등), 특수한 동작에 따라 CSI-RS 기반 RRM 보고를 수행할 수 있다. eNB에서 이러한 RRM 보고 결과를 취합하고, eNB가 해당 UE의 현재 서빙 셀이 FD-MIMO 모드에 의해 전송된 PDSCH에 적용되는 최적의 수직 빔을 UE에게 제공하지 않는다고 판단하면, UE는 eNB으로부터 다른 셀로 핸드오버하도록 지시 받을 수 있다. 다시 말해, 서빙 셀 이외 다른 셀로부터 전송되는 특정 DRS-CSI-RS에 기반하여

최적 RRM 결과가 도출되고, 보고될 수 있다.

[436] DRS와 같이 프리코딩된 CSI-RS는 FD-MIMO를 지원하는 UE를 위한 잠재적인 핸드오버 결정뿐만 아니라 최적의 수직 빔 선택을 포함하는 RRM을 위해 이용될 수 있다.

[437] 그러나, FD-MIMO를 더 효율적으로 지원하기 위하여, 순수하게 RRM 측정 목적의 RS를 설계하는 것이 고려될 수 있다.

[438] 현재 DRS-CSI-RS는 안테나 포트 15에서만 전송되기 때문에, 셀 별로 서로 다른 수직 빔 각각에 상응하는 개별적인 DRS-CSI-RS 설정이 단말에 설정되는 것이 필요하다. 다만, FD-MIMO를 지원하기 위한 RRM 목적을 고려하여, 자원 사용 효율을 높이기 위해 CSI-RS 설정 내 안테나 포트 간 CDM(예를 들어, 안테나 포트 15 및 16)이 여전히 적용되기 위하여, 동일 셀 내 서로 다른 수직 빔 방향에 각각 적용되는 다중의 CSI-RS 안테나 포트가 단일의 CSI-RS 설정 내 설정될 수 있다. 또한, 설정들과 관련된 DRS 시점(occasion) 등을 포함하여 디스커버리 절차를 위해 필요한 다른 설정 및 동작은 이러한 RRM 목적을 위해 생략될 수 있다.

[439] 따라서, FD-MIMO를 지원하기 위하여 RRM 목적을 위한 개별적인 RS가 요구된다.

[440] UE을 위한 PDSCH에 적용되는 최적의 수직 빔(best vertical beam)을 제공할 수 있는 셀에 적절히 연관(association)하는 중에 발생되는 상술한 지연(latency)을 고려하여, 그러한 지연을 감소시키는 방법 또한 UE이 최초 접속 단계(initial access stage)에서도 최적의 셀에 연관하는 방법이 요구된다.

[441] 더욱 구체적으로, 일반적인 셀 연관 동작(cell association behavior)에 따라, 최악의 경우에서 지연(worst-case latency)은 UE가 그러한 디스커버리 절차와 관련된 DMTC를 포함하는 RRC 시그널링을 수신하고, UE가 설정된 RRC 시그널링에 따라 장기(long-term) DRS-CSI-RS 측정 및 보고를 수행하고, UE가 FD-MIMO 측면에서 최적이 아닌 셀에 어태치되었음이 판명된 경우 또 다른 셀로 핸드오버하는 것일 수 있다.

[442] 이에 따라 UE가 아이들 모드(idle mode)일 때 최적의 셀(best cell)을 최초로 탐색할 수 있도록 FD-MIMO를 지원하는 UE를 위한 셀 선택/재선택 절차의 개선을 고려할 수 있다.

[443] 또한, FD-MIMO 전송에 의해 서비스받는 단말이 최적의 셀에 연관(association)하기 위한 측면에서 무선 링크 모니터링 동작에 대한 개선이 필요하다.

[444] 따라서, FD-MIMO를 지원하는 UE이 최적의 셀로 적절히 연관하는 중에 발생될 수 있는 잠재적인 지연을 감소시키는 방법이 요구된다.

[445]

[446] <u>RRM-RS 기반 셀 선택 방법</u>

[447] 상술한 RRM-RS 등과 같이 특정 방향 빔포밍된 RS 포트(beamformed RS ports)

또는, (서로 다른 TP(들)/셀(들)의 개수로 구성되는) 무정형 셀(amorphous cells) 환경에서의 서로 다른 RS 포트(different RS ports)에 기반하여 단말이 RRM 측정치(예를 들어, RSRP, RSRQ 등)들을 기지국에 보고함으로써 기지국의 단말 연관(association) 결정을 도울 수 있다.

[448] 여기서, 무정형 셀(amorphous cell)은 고정적인 셀 형태를 가지지 않고, 단말 중심으로 무정형하게 구성되는 셀을 의미한다. 즉, 고정적인 셀 형태 없이 밀집한 (스몰) 셀들 간의 협력을 통해 이동 단말에게 데이터를 전달함으로써 커버리지를 형성하게 된다. 따라서, 단말이 이동하면 이동한 위치의 셀이 고려가 되어 핸드오버를 최소화할 수 있다.

[449] 즉, 이러한 일련의 동작을 단말이 수행하기 위해서는 우선 종래의 랜덤 액세스 절차(즉, RACH(Random Access Channel) 절차) 등의 초기 접속(initial access) 과정을 통해 특정 셀에 접속을 하여야 하고, 단말은 RRC 연결(RRC-connected) 상태에서 상기 RRM-RS 관련 설정 정보 등 다양한 사전 정보를 RRC 시그널링에 의해 제공 받아야 한다. 그 후, 상기 설명된 다양한 RRM 보고 절차에 따라 기지국에 각종 RRM 측정치들을 보고하는 동작까지가 단말이 수행하게 된다. 그 후, 최적의 셀 선택/핸드오버(best cell selection/hand-over) 과정들은 기지국에서 수행/결정함으로써, 해당 단말을 필요 시에 핸드오버(hand-over)시키거나 최적의 전송 포인트(best TP(transmission point))를 결정하여 CSI-RS 설정 등에 반영하는 형태로 동작될 수 있다. 결국, 이러한 일련의 과정을 통해 단말의 최적의 서빙 셀(best serving-cell)이 초기 접속 과정에 의해 접속된 서빙 셀이 아닌 것으로 판명되는 경우, 불가피하게 핸드오버가 발생할 수 있다. 따라서, 만일 초기에 접속하자 마자 위와 같은 과정을 통해 다른 셀로 조기에 핸드오버되는 단말의 경우, 최적의 셀 연관(best cell association)에 있어서 불필요한 큰 지연(latency)이 발생한다는 한계가 있다.

[450] 또 다른 종래 기술의 활용의 한계점에 관한 예시로서, 릴리즈(Rel: release)-12 스몰 셀 향상(small-cell enhancement)에 따른 디스커버리 절차(discovery procedure)를 활용하여, 예를 들어 상기 RRM-RS의 역할을 하는 RS(예를 들어, 디스커버리 신호(discovery signal) 또는 디스커버리 참조 신호(DRS: discovery reference signal) 또는 DRS-CSI-RS)(이하, 편의상 DRS로 지칭함)가 설정되고, DRS 측정 타이밍 설정(DMTC: DRS measurement timing configuration)을 포함한 DRS 기반 측정 관련 제반 정보가 설정될 수 있다. 그리고, 이를 통해 상기 풀-차원-MIMO(FD-MIMO: full-dimension MIMO) 사용 케이스 또는 진보된 무정형 셀(amorphous cells) 환경에서의 최적의 UE 기준의 셀 선택(best UE-centric cell selection)에 활용할 수 있는 방법이 존재한다.

[451] DMTC는 상위 계층 메시지(예를 들어, RRC 메시지)를 통해 단말에 제공될 수 있다. DMTC는 DRS 전송 주기/오프셋, 측정 주파수 대역, 측정 구간(즉, 디스커버리 신호 시점(discovery signal occasion)), DRS 안테나 포트 정보 등을 포함할 수 있다.

[452] 보다 구체적으로 살펴보면, 스몰 셀 향상은 스몰 셀의 에너지 절감(saving) 및 인접 셀로의 간섭을 감소시키기 위하여 단말이 스몰 셀 커버리지 내 존재하는 경우에만 스몰 셀의 온 상태(on-state)를 유지하고, 그렇지 않으면 스몰 셀의 오프 상태(off-state)를 유지하는 스몰 셀 on/off 메커니즘을 지원한다. 이 경우, 단말에서 스몰 셀이 on/off-state를 판단할 수 있도록 디스커버리 절차(discovery procedure)가 필요하다. 이를 위해, on/off-state와 무관하게 스몰 셀은 항상 DRS를 전송(즉, 방송)한다. 즉, 스몰 셀이 off-state인 경우에도 일정 주기를 가지고 DRS를 방송한다. 일정 주기를 측정 주기(measurement period) 또는 DRS 측정 타이밍 설정(DMTC) 주기라고 지칭할 수 있으며, 일례로 40ms, 80ms, 160ms 등이 해당될 수 있다.

[453] 이때, 스몰 셀은 DRS를 방송하는 on-state를 일정 시간(예를 들어, 1개 내지 5개 서브프레임) 유지할 수 있다. 예를 들어, 측정 주기가 40ms인 경우, 6ms 동안 on-state를 유지하면서 DRS를 방송하고, 나머지 34ms 동안 off-state를 유지할 수 있다. 이처럼 DRS를 전송하는 구간을 측정 윈도우(measurement window) 또는 디스커버리 신호 시점(DRS occasion)라고 지칭할 수 있다. 즉, 디스커버리 신호 시점은 연속된 서브프레임의 구간(예를 들어, 1개(또는 2개) 내지 5개의 연속된 서브프레임 구간)으로 구성될 수 있으며, 하나의 디스커버리 신호 시점은 매 측정 주기(또는 DMTC 주기) 내에서 한 번씩 존재할 수 있다.

[454] 단말은 스몰 셀로부터 수신한 DRS를 기반으로 측정(measurement)를 수행하고, 기지국(또는 네트워크)에게 측정 보고(measurement report)를 전송한다. 이와 같이, 단말로 하여금 스몰 셀이 on/off-state인지 무관하게 항상 스몰셀에서 전송되는 DRS를 측정하여 기지국(또는 네트워크)에게 보고하도록 함으로써, 기지국(네트워크)은 해당 단말 주변에 가장 효율이 좋은 스몰 셀을 파악할 수 있다. 예를 들어, 기지국(네트워크)이 UE로부터 측정 결과를 보고 받은 결과, off-state인 스몰 셀이나 단말에서의 DRS 수신 파워가 큰 경우에 기지국은 해당 스몰 셀을 on-state로 전환시킬 수 있다.

[455] 그러나 이 경우도 마찬가지로, 우선 UE가 특정 서빙 셀에 종래 방식대로 어태치(attach)된 후 RRC-connected 상태에서 DMTC 등 스몰 셀 디스커버리 관련 설정 정보를 RRC 시그널링을 통해 수신한 후, (프리코딩된(precoded)) DRS들(각각이 별도의 FD-MIMO 빔 방향을 타겟하거나, 또는 서로 다른 무정형 셀을 구성하는 TP들로부터 전송됨)에 대한 다수개의 CSI-RS-RSRP 보고(즉, DRS 기반 RSRP 보고)를 수행하여야 하며, 이것들에 기반하여 기지국이 해당 단말이 CRS 기반 RSRP 관점에서는 최적(best)이 아니지만 FD-MIMO 또는 무정형 셀 관점에서 최적의 셀이 따로 있다면 해당 셀로 핸드오버 시켜야 한다. 결국, 이 방식도 마찬가지로, 최적의 셀(best cell)로 연관(association)되기까지 (예를 들어, RRC-connection → DMTC 관련 RRC 정보 수신 → 장기(long-term) DRS-CSI-RS 측정 및 보고 → 핸드오버 절차의 과정을 모두 거쳐야 하는 단말이 있을 수 있으므로) 지연이 크게 증가할 수 있다는 한계가 있다.

[456] 따라서, 본 발명에서는 상기 FD-MIMO 또는 무정형 셀(amorphous cell) 환경 등과 같이, 종래의 셀 특정(cell-specific)하게 전송되는 RS(예를 들어, CRS)와 다른 별도의 RS(예를 들어, RRM 측정을 위한 RS, 셀 선택/재선택을 위한 RS) 포트를 활용하여 특정 RRM 측정(예를 들어, RSRP, RSRQ 등)을 단말이 수행하는 방법 및/또는 RRM 측정치들을 기반으로 단말이 초기 접속 시 등의 RRC 아이들 모드(idle-mode)(예를 들어, RRC_IDLE) 상태에서도 자신이 설정 받을 최적의 전송 모드를 미리 고려하여 최적의 셀을 선택(selection) 또는 재선택(reselection)하는 방법 및/또는 선택된 최적의 셀로 초기 접속(initial access) 과정을 개시하는 방법을 제안한다. 또한, 단말은 본 발명에서 제안하는 방법들을 순차적으로 수행함으로써 단말의 초기 접속(initial access) 과정을 수행할 수 있다.

[457] 이하, 본 발명의 설명함에 있어서, RRM-RS는 앞서 설명한 바와 같이 FD-MIMO와 같이 날카로운 빔(sharp beam)을 통해 지역적으로 방향을 다르게 전송되는 RS, 지리적으로 분산되어 배치된 TP(또는 cell) 별로 서로 다른 안테나 포트를 통해 전송되는 RS, 그 외에도 셀 특정 참조 신호(CRS)와 다른 별도의 RRM 측정 및 보고를 위한 RS(예를 들어, CSI-RS, DRS 등)를 통칭한다.

[458]

[459] 1. 단말의 초기 셀 탐색 과정

[460] - 본 발명에 따른 초기 접속(initial access) 과정의 첫 번째 과정으로서 단말의 초기 셀 탐색 과정이 수행될 수 있다.

[461] 단말의 초기 셀 탐색(initial cell search) 과정에서, 단말은 종래와 동일하게 각 셀이 전송하는 1차 동기신호(PSS: Primary Synchronization Signal) 및 2차 동기신호(SSS: Secondary Synchronization Signal) 등의 특정 동기 신호를 검출함으로써 해당 셀이 사용하고 있는 물리 셀 식별자(PCI: physical (layer) cell-ID)를 획득할 수 있다.

[462] PSS와 SSS의 특정 시퀀스에 의하여 단말은 PCI를 획득할 수 있다. 즉, SS는 3개의 PSS와 168개의 SSS의 조합을 통해 총 504개의 고유한 PCI를 나타낼 수 있다.

[463] 다시 말해, 상기 PCI들은 각 PCI가 오직 하나의 PCI 그룹의 부분이 되도록 각 그룹이 3개의 고유한 식별자들을 포함하는 168개의 PCI 그룹들로 그룹핑된다. 따라서, 물리 계층 셀 식별자 N_ID^cell = 3N_ID^(1) + N_ID^(2)는 PCI 그룹을 나타내는 0부터 167까지의 범위 내 번호 N_ID^(1)와 상기 PCI 그룹 내 상기 PCI를 나타내는 0부터 2까지의 번호 N_ID^(2)에 의해 고유하게 정의된다.

[464] 단말은 PSS를 검출하여 특정 PCI 그룹 내 3개의 고유한 PCI 중 하나를 알 수 있고, SSS를 검출하여 상기 PCI에 연관된 168개의 PCI 그룹들 중 하나를 식별할 수 있다.

[465] 그리고, 단말은 검출된 해당 PCI를 사용하여, 전송되는 해당 셀의 CRS를 검출 시도함으로써, 셀 ID(cell-ID)의 검증(verification)을 수행할 수 있다.

[466]

[467] 2. 탐색된 셀에서 시스템 정보 획득 과정

[468] 단말은 셀이 전송하는 예를 들어, PBCH(Physical Broadcast Channel), PDSCH(Physical Downlink Shared Channel) 등을 읽어서 해당 채널 상에서 전달되는 각종 시스템 정보(system information)를 획득한다.

[469] 시스템 정보(system information)는 마스터 정보 블록(MIB: Master Information Block)과 복수의 시스템 정보 블록(SIB: System Information Block)으로 나뉠 수 있다. 이하, SIB 타입 x(SystemInformationBlockTypex)를 간단히 'SIB x'로 지칭한다.

[470] 단말은 네트워크에 의해 브로드캐스트되는 시스템 정보를 획득하기 위하여 시스템 정보 획득 절차를 이용한다. 시스템 정보 획득 절차는 RRC_IDLE 모드인 단말 및 RRC_CONNECTED 모드인 단말 모두에게 적용된다. 예를 들어, 셀 선택(예를 들어, 단말 전원이 켜질 때) 및 셀 재선택, 핸드오버 완료 후, 다른 무선 접속 기술(RAT: Radio Access Technology)에 진입할 때, 커버리지 밖에서 커버리지 내로 진입할 때, 시스템 정보가 변경되었다는 통지를 수신하였을 때, 최대 유효 지속 기간(maximum validity duration)을 경과하였을 때 등 단말은 시스템 정보 획득 절차를 개시할 수 있다.

[471] 먼저, 단말은 네트워크로부터 MIB를 수신한다. 이때, MIB는 물리 채널(physical channel) PBCH에서 전송된다. MIB는 시스템 프레임 번호(SFN: System Frame Number) mod 4 = 0 인 무선 프레임의 서브프레임 #0에서 스케줄되고, 해당 주기 내에서 다른 모든 무선 프레임의 서브프레임 #0에서 반복된다. 그리고, 무선 프레임의 서브프레임 #0의 두 번째 슬롯의 처음 4개의 OFDM 심볼 내에서 중심의 72 서브캐리어를 점유한다.

[472] 단말은 MIB로부터 수신한 파라미터를 사용하여 네트워크로부터 SIB 1을 수신한다. 그리고, 단말은 SIB 1으로부터 획득한 스케줄링 정보 리스트(schedulingInfoList)를 기반으로, 네트워크로부터 SIB 1 이외의 SIB x를 수신한다.

[473] SIB 1은 SFN mod 8 = 0 인 무선 프레임의 서브프레임 #5에서 스케줄되고, 80 ms 주기 내에서 SFN mod 2 = 0 인 다른 모든 무선 프레임의 서브프레임 #5에서 반복된다. 반면, SIB 1을 제외한 나머지 SIB는 동일한 전송 주기를 가지는 SIB 별로 시스템 정보(SI: System Information) 메시지에 매핑되어 전송된다.

[474] 모든 SIB는 물리 채널 PDSCH에서 전달된다. SIB을 위한 PDCCH는 SI-RNTI(system information-RNTI)에 의해 스크램블된 CRC가 부착된 DCI를 전달하고, PDCCH로부터 SIB를 전달하는 PDSCH가 식별된다.

[475] 단말은 PDCCH 상의 SI-RNTI를 디코딩함으로써 SI 메시지를 전달하는 PDSCH의 구체적인 시간/주파수 자원 영역 스케줄링 등을 획득할 수 있다. 하나의 SI-RNTI가 SIB 1뿐만 아니라 모든 SI 메시지를 어드레스하기 위하여 사용된다.

[476] 단말은 시스템 정보 획득 절차를 통해 획득한 시스템 정보를 이미 저장되어 있는 시스템 정보에 덮어쓸 수 있다(overwrite).

[477] 이하, 본 발명에서는 MIB 또는 특정 SIB X 등 시스템 정보에 다음과 같은 RRM-RS 설정 관련 정보 중 적어도 하나가 포함되어 단말에게 전송하는 방법을 제안한다. 이에 대하여 아래 도면을 참조하여 설명한다.

[478] 도 15는 본 발명의 일 실시예에 따른 RRM-RS 기반 셀 선택 방법을 예시하는 도면이다.

[479] 도 15를 참조하면, 기지국은 단말에게 RRM-RS 설정 정보를 포함하는 시스템 정보를 전송한다(S1501).

[480] 상술한 바와 같이 이하 RRM-RS는 설명의 편의상 부여된 명칭일 뿐, CSI-RS 등과 동일 혹은 유사한 포맷으로 설정될 수 있는 등 다양한 명칭/변형 형태로 정의될 수 있다.

[481] - PCI (및/또는 인접 셀(neighbor-cell) 리스트)를 수반한 RRM-RS 설정(RRM-RS configurations with PCI)

[482] 해당 셀에서 전송하는 RRM-RS 설정 정보뿐만 아니라 인접 셀들에서 전송하는 RRM-RS 설정 정보도 함께 시스템 정보로서 단말에게 제공될 수 있다. 즉, 특정 RRM-RS 설정(들)은 특정 PCI와 연동(또는 대응)되어 있고 이 연동 정보가 함께 제공될 수 있다. 이때, 하나의 PCI 당 하나 이상의 RRM-RS가 연동(또는 대응)될 수 있다.

[483] 여기서, 인접 셀(neighbor-cell) 리스트는 인접-셀의 PCI 리스트를 포함한다. 일례로, 인접 셀의 일례로 해당 셀 주변의 1-타이어(tier) 정도의 영역에 존재하는 eNB 위치(site)에 속하는 셀들이 대상이 될 수 있다.

[484] 이러한 RRM-RS 설정 정보를 통해, 단말은 시스템 정보를 읽음으로써 해당 셀이 전송하는 RRM-RS 안테나 포트 뿐만 아니라 주변의 셀들이 전송하는 RRM-RS 안테나 포트에 대한 정보도 함께 획득할 수 있으므로 인접 셀들을 포함하여 최상의 RRM 측정치를 찾는 과정에 도움이 될 수 있다.

[485] 또한, 단말은 이와 같이 제공된 상기 RRM-RS 별로 연동된 특정 PCI 정보를 통해, 해당 RRM-RS 포트와 해당 연동된 PCI로 생성되는 CRS 포트 간에 서로 QCL(quasi-co-location) 가정을 할 수 있다. 이때, QCL 가정이 가능한 무선 채널의 광범위 특성(large-scale properties)은 {도플러 쉬프트(Doppler shift), 도플러 확산(Doppler spread), 평균 지연(average delay), 지연 확산(delay spread), 평균 이득(average gain)} 중에 적어도 하나를 포함할 수 있다.

[486] 또는, 평균 이득(average gain)은 RS가 서로 다르므로 QCL 가정에서 제외하고, QCL 가정이 가능한 무선 채널의 광범위 특성(large-scale properties)은 {도플러 쉬프트(Doppler shift), 도플러 확산(Doppler spread), 평균 지연(average delay), 지연 확산(delay spread)} 중에 적어도 하나를 포함하도록 정의될 수 있다).

[487] 보다 특징적으로 QCL 가정이 가능한 무선 채널의 광범위 특성은 {도플러 쉬프트(Doppler shift), 도플러 확산(Doppler spread)}로만 제한되어, 단말이 해당

RRM-RS의 주파수 동기(frequency sync)를 해당 연동된 CRS를 통해 획득하도록 할 수 있다. 이 경우, 단말은 시간 동기(time sync)를 RRM-RS 자체적으로 획득할 수 있다고 간주할 수 있다.

[488] 또는, 오직 단말이 RRM-RS로 RRM 측정만을 수행한다고 정의되거나 또는 설정된다면, QCL 가정이 가능한 무선 채널의 광범위 특성은 {도플러 쉬프트(Doppler shift)}만 적용할 수도 있다.

[489] 또는, 단말이 시간 동기(time sync)를 획득하기 위하여 CRS의 도움을 받아야 하고, 또한 RRM-RS로 RRM 측정 목적만이 있다면, QCL 가정이 가능한 무선 채널의 광범위 특성은 {도플러 쉬프트(Doppler shift), 평균 지연(average delay)}을 포함할 수 있으며, RRM-RS의 복조에 CRS를 통해 획득된 동기를 적용할 수 있도록 한다.

[490] 앞서 RRM-RS의 QCL 가정에 관하여 설명된 문장에서, CRS 대신 "PSS 및/또는 SSS"가 대체되어 모든 문장 또는 일부 문장에 적용될 수도 있다. 다시 말해, RRM-RS 복조에 CRS로부터 획득된 주파수 및/또는 시간 동기를 적용할 수 있으며, 그리고/또는 (해당 PCI로 (함께) 연동된) PSS/SSS로부터 획득된 주파수 및/또는 시간 동기를 적용할 수도 있다. 즉, 해당 PCI로 연동된 상기 특정 {RRM-RS, CRS, PSS/SSS} 간에 전체 또는 일부에 대해 서로 QCL 가정이 성립함을 단말에게 설정하거나 사전에 정의될 수 있다.

[491] - RRM-RS 설정 당 RRM-RS 안테나 포트 수 정보, RRM-RS 안테나 포트 매핑 정보, 해당 RRM-RS 전송 주기/오프셋 관련 정보 및/또는 전송 (주파수/시간) 자원 관련 정보 등과 같은 단말이 해당 RRM-RS를 측정하기 위해 필요한 설정 정보들이 제공된다.

[492] 즉, 상술한 바와 같이, 하나의 PCI(즉, 셀) 당 하나 이상의 RRM-RS 설정이 연동(또는 대응)될 수 있으며, 하나의 RRM-RS 설정 당 해당 RRM-RS를 측정하기 위해 필요한 설정 정보들이 제공된다.

[493] 만일, 이러한 RRM-RS가 스몰 셀 디스커버리(discovery)에서의 DRS(또는 DRS-CSI-RS)를 재사용하는 형태 등으로 구성된다면, DMTC 등 DRS로서의 CSI-RS를 측정하기 위해 필요한 설정 정보도 해당 시스템 정보에 더 포함되어 전달될 수 있다.

[494] 위와 같은 형태로, 해당 RRM-RS 관련 설정 정보가 명시적인 시그널링(explicit signaling)될 수도 있지만, 앞서 설명한 "1. 단말의 초기 셀 탐색 과정"에서 검출된 해당 PCI에 연동되는 암묵적인 지시(implicit indication) 형태로 상술한 RRM-RS 관련 설정 정보 중 일부가 암묵적으로 제공되는 방식도 가능하다. 즉, 상기 시스템 정보는 RRM-RS 관련 설정 정보로서 PCI를 포함하지 않을 수 있으며, 단말은 시스템 정보에 포함된 RRM-RS 설정 정보를 초기 셀 탐색 과정에서 검출된 PCI와 연동(또는 대응)되는 RRM-RS 설정 정보로 판단(또는 간주)할 수 있다.

[495] 예를 들어, 상기 전송 (주파수/시간) 자원 관련 정보는 PCI에 따라 특정 참조

자원(reference resource) 위치가 사전에 고정적으로 정의되어 있을 수 있다. 물론, RRM-RS 안테나 포트 수 정보, RRM-RS 안테나 포트 매핑 정보, 해당 RRM-RS 전송 주기/오프셋 관련 정보 중 하나 이상도 해당 PCI에 따라 암묵적 매핑(즉, 고정)되어 있을 수도 있다.

[496] 그러나, RRM-RS 안테나 포트 수나 RRM-RS 전송 주기/오프셋 관련 정보는 상기 설명한 시스템 정보로서 개별적인 셀 별(즉, PCI 별)로 제공하는 것이 바람직할 수 있다. 이 경우, 예를 들어 32개의 안테나 포트 RRM-RS가 40ms 주기와 오프셋 5ms에 따라 전송된다는 설정 정보가 상기 시스템 정보로서 제공되었다면, 상기 "참조 자원(reference resource)" 위치는 특정 서브프레임 내에서의 특정 참조 RE 위치를 의미하는 형태로 사전에 정의될 수 있다. 즉, PCI에 의해 고정적으로 정의되어 있는 상기 참조 RE 위치를 시작점으로 하여 32개의 안테나 포트가 순차적으로 매핑되는 관계는 사전에 규칙이 정의될 수 있으며, 따라서 해당 참조 RE 위치로부터 32개의 안테나 포트에 대한 RS 매핑 위치가 모두 정해지게 된다. 이때, 만일 1-순환(cycle)의 RRM-RS 전송이 단일 서브프레임에서 모두 전송될 수 없고 다중 서브프레임에 걸쳐서 전송되는 형태라면, 그 중 첫 서브프레임에 상기 참조 RE 위치가 적용되는 것으로 정의될 수 있다.

[497] RRM-RS 설정 정보를 수신한 단말은 RRM-RS 설정 정보에 기초하여 RRM 측정을 수행하게 된다. 즉, 단말은 RRM-RS 설정 정보에 기초하여 RACH(즉, PRACH)를 전송하기 이전(즉, 랜덤 액세스 절차를 개시하기 전)에 다중 RRM-RS 포트에 대한 RRM 측정을 수행할 수 있다.

[498]

[499] 3. RRM-RS 등 기반 진보된(enhanced) RRM 측정의 수행에 따른 단말 관점에서의 선호 셀 결정

[500] 도 16은 본 발명의 일 실시예에 따른 RRM 측정 방법을 예시하는 도면이다.

[501] 도 16을 참조하면, 단말은 기지국으로부터 전송되는 셀 특정 참조 신호(CRS) 및/또는 RRM 참조 신호(RRM-RS)를 기반으로 RRM(예를 들어, RSRP, RSRQ 등)을 측정한다(S1601).

[502] 단말은 CRS 기반 RRM 측정값 및/또는 RRM-RS 기반 RRM 측정값을 기반으로 셀 선택한다(S1602).

[503] 단말은 초기 셀 탐색(initial cell search) 과정을 통해 탐색된 셀 또는 단말의 서빙 셀(또는 단말이 현재 캠핑(camping)하는 셀), 단말에 의해 탐색된 셀에 인접한 셀 또는 단말의 서빙 셀에 인접한 셀 중에서 CRS 기반 RRM 측정 값 및/또는 RRM-RS 기반 RRM 측정값을 기반으로 셀을 (재)선택한다. 이후, RRC_IDLE 단말의 경우 (재)선택된 셀로 초기 접속(initial access) 과정을 수행하거나 해당 셀에 캠핑(camping)한다. 또한, RRC_CONNECTED 단말의 경우 (재)선택된 셀로 핸드오버(handover) 과정을 수행할 수 있다.

[504] 보다 구체적으로 살펴보면, 앞서 설명된 RRM-RS 관련 설정 정보들을 토대로,

단말은 다중 RRM-RS 포트에 대한 별도의 RRM 측정을 수행한다. 상술한 바와 같이, 이러한 RRM 측정은 단일 타겟 셀에 국한된 것이 아닌 인접 후보 셀들이 전송하는 RRM-RS들도 포함하여 수행될 수 있다.

[505] 예를 들어, 단말은 셀 1(PCI 1) 및 셀 2(PCI 2)에서 전송하는 RRM-RS 세트 1 및 RRM-RS 세트 2에 대해 RRM-RS 기반 RRM 측정을 수행한 후, 각 세트 별로 최상의(best) RRM(예를 들어, RSRP, RSRQ 등) 측정치를 나타낸 RRM-RS 포트를 파악한다.

[506] 그리고, 단말은 이 중 가장 큰 RRM-RS 기반 RRM 값(즉, 최상의(best) 값)을 나타내는 RRM-RS를 전송한 셀로 초기 접속 (예를 들어, RACH 프리앰블(preamble) 전송에 의한 RACH 절차)를 개시할 수 있다. 즉, 단말은 해당 셀로 RACH 프리앰블을 송신함으로써 랜덤 액세스 절차(즉, RACH 절차)를 시작할 수 있다. 또는, RRC_IDLE 단말은 가장 큰 RRM-RS 기반 RRM 값(즉, 최상의(best) 값)을 나타내는 RRM-RS를 전송한 셀을 선택(selection)하거나 재선택(reselection)하여 해당 셀에서 캠핑(camping)할 수 있다. 또한, RRC_CONNECTED 단말은 가장 큰 RRM-RS 기반 RRM 값(즉, 최상의(best) 값)을 나타내는 RRM-RS를 전송한 셀로 핸드오버(handover)를 진행할 수 있다.

[507] RRC_IDLE 상태의 단말은 항상 적절한 품질의 셀을 선택하여 이 셀을 통해 서비스를 제공받기 위한 준비를 하고 있어야 한다. 예를 들어, 전원이 막 켜진 단말은 네트워크에 등록을 하기 위해 적절한 품질의 셀을 선택해야 한다. RRC_CONNECTED 상태에 있던 단말이 RRC_IDLE 상태에 진입하면, 상기 단말은 RRC_IDLE 상태에서 머무를 셀을 선택해야 한다. 이와 같이, 상기 단말이 RRC_IDLE 상태와 같은 서비스 대기 상태로 머물고 있기 위해서 어떤 조건을 만족하는 셀을 고르는 과정을 셀 선택(Cell Selection)이라고 한다.

[508] 그리고, 단말이 일단 셀 선택 과정을 통해 어떤 셀을 선택한 이후, 단말의 이동성 또는 무선 환경의 변화 등으로 단말과 기지국간의 신호의 세기나 품질이 바뀔 수 있다. 따라서 만약 선택한 셀의 품질이 저하되는 경우, 단말은 더 좋은 품질을 제공하는 다른 셀을 선택할 수 있다. 이렇게 셀을 다시 선택하는 경우, 일반적으로 현재 선택된 셀보다 더 좋은 신호 품질을 제공하는 셀을 선택한다. 이런 과정을 셀 재선택(Cell Reselection)이라고 한다.

[509] 이하, 설명의 편의를 위해 (초기 접속) 타겟 셀로 선택한다는 것은 단말이 RACH 절차를 개시하기 위한 셀을 선택하거나, 또는 RRC_IDLE 단말이 캠핑 셀(camping cell)을 선택 또는 재선택하거나, 또는 RRC_CONNECTED 단말이 핸드오버를 수행할 타겟 셀을 선택한다는 의미로 해석될 수 있다.

[510] 또는, 최상의(best) RRM-RS 기반 RRM 측정치를 보인 특정 RRM-RS를 전송한 셀로 RACH 프리앰블을 전송(즉, 랜덤 액세스 절차 개시)하는 방법 뿐만 아니라, RRM-RS 기반 RRM 측정치와 해당 셀이 전송하는 CRS 기반 RRM(CRS-based RRM) 측정 값도 함께 비교하여 최적의 초기 접속 타겟 셀을 결정하는 특정 함수(또는 규칙) 형태가 사전에 정의되거나 단말에 설정될 수 있다.

[511] 예를 들어, 최상의(best) RRM-RS 기반 RRM 측정치를 보인 특정 RRM-RS를 전송한 셀의 CRS 기반 RRM 측정값이, 다른 셀로부터의 CRS 기반 RRM 측정값(예를 들어, 가장 큰 CRS 기반 RRM 측정 값) 대비 임계값(즉, Y dB) 차이보다도 더 나쁜(작은) 경우에는 해당 셀은 타겟 셀이 될 수 없다는 등의 조건(또는 규칙)과 함께 특정 임계치 값 Y가 정의될 수도 있다. 이처럼 최상의(best) RRM-RS 기반 RRM 측정치를 보인 특정 RRM-RS를 전송한 셀이 타겟 셀에서 제외되는 경우, 단말은 그 다음으로 큰 큰 RRM-RS 기반 RRM 측정치를 가지는 셀을 선택할 수 있다. 이는 해당 셀의 기본적인 제어 채널(예를 들어, PDCCH) 전송에 대한 수신 품질이 지나치게 떨어질 경우 이 셀에 접속하는 것을 방지하기 위한 것이다.

[512] 또 다른 예시로는, 단말은 RRM-RS 기반 RRM(RRM-RS-based RRM) 측정치와 해당 셀이 전송하는 CRS 기반 RRM 측정치간에 특정 가중된 평균(weighted average)을 취하여 최적의(best) 타겟 셀을 결정할 수도 있다. 즉, 단말은 RRM-RS 기반 RRM 측정 값과 CRS 기반 RRM 측정 값의 가중 평균치가 가장 큰 셀을 타겟 셀로 선택할 수 있다.

[513] 이때, 가중된 평균(weighted average)에 관한 가중치(weights) 값은 사전에 정의될 수 있다. 또한, 가중치(weights) 값은 어느 정도 단말 구현의 범주로 허용하되 단말 테스트 시에 특정 테스트 벡터에 의해 성능에 대한 검증이 수행될 수 있다.

[514] 또 다른 예시로는, 각 검출된 셀 별로의 CRS 기반 RRM 측정치들을 크기 순서대로 나열했을 때, 예를 들어 가장 큰 측정치 값이 C1 (예를 들어, PCI 7에 대한)이고 그 다음 C2(예를 들어, PCI 9에 대한), C3(예를 들어, PCI 6에 대한), C4(예를 들어, PCI 5에 대한), ... 순서로 정렬되었을 때, C1-C4 > Y 로서 임계치 Y를 넘어가는 C4 이하의 RRM 측정치 값들은 타겟 셀 대상에서 제외할 수 있다. 즉, 가장 큰 CRS 기반 RRM 측정치와의 차이가 임계치 이하(또는 미만)인 셀을 타겟 셀 후보로 결정할 수 있다. 따라서, 위의 경우 C1, C2, C3의 CRS 기반 RRM 측정치에 해당하는 각 셀 (PCI 7, PCI 9, 또는 PCI 6를 가지는 셀)이 타겟 셀 후보로 고려될 수 있다. 그리고, 단말은 타겟 셀 후보 중에서 RRM-RS 기반 RRM 측정 값이 가장 큰 셀을 타겟 셀로 선택할 수 있다.

[515] 만약, 종래 동작에 따르면 단말은 C1값을 갖는 PCI 7 셀에 초기 접속을 개시하는 것이 바람직하다. 다만, 본 발명의 또 다른 실시예에 따르면 각 C1, C2, C3 값 각각에 대해 추가적으로 각 셀에서 전송하는 RRM-RS들 중에 최상의(best) RRM-RS 기반 RRM 측정치를 산출하여 추가 비교할 수 있다.

[516] 예를 들어, C1값을 나타낸 PCI 7 셀에서 전송하는 RRM-RS들 중에 최상의(best) RRM 측정치 값을 R1이라고 하고, C2값을 나타낸 PCI 9 셀에서 전송하는 RRM-RS들 중에 최상의(best) RRM 측정치 값을 R2이라고 하고, C3값을 나타낸 PCI 6 셀에서 전송하는 RRM-RS들 중에 최상의(best) RRM 측정치 값을 R3이라고 가정한다. 그리고, R2 = max{R1, R2, R3}라고 가정하고, 크기 순서로

정렬하자면 R2 > R3 > R1이었다고 가정한다.

[517] 이때, 결국 어떠한 셀에 초기 접속을 개시하도록 할 것인지에 관해 정형화된 규칙이 미리 정해지거나 단말에 설정될 수 있다.

[518] 이를 위해 사전에 상기 임계치 Y를 좀더 세분화 하여 0 < Y1 < Y2 < ... < Yn < Y 과 같은 형태로 세분화된 임계치가 사전에 정의되거나 단말에 설정될 수 있다. 예를 들어, 설명의 편의상 n=3으로 가정한다. 그러면, 0 < Y1 < Y2 < Y3 < Y 의 조건이 성립하는 세분화된 임계치 Y1, Y2, Y3가 미리 정의되거나 단말에 설정될 수 있다.

[519] 또한, 유사하게 상기 R1, R2, R3 값들에 대한 비교를 위해서도 사전에 0 < Z1 < Z2 < ... < Zm < Z 의 임계치 값들이 미리 정의되거나 단말에 설정될 수 있다. 예를 들어, 설명의 편의상 m=3으로 가정한다. 그러면, 0 < Z1 < Z2 < Z3 < Z 의 조건이 성립하는 세분화된 임계치 Z1, Z2, Z3가 미리 정의되거나 단말에 설정될 수 있다.

[520] 예를 들어 다음과 같은 형태의 규칙이 충족될 경우에만 상기 최상의(best) CRS 기반 RRM 측정치 C1을 나타낸 PCI7 셀이 아닌 다른 셀로 초기 접속을 개시할 수 있도록 하는 특정 명확한 동작이 정의될 수 있다.

[521] 이하, 상술한 규칙에 대하여 예시한다.

[522] (1) 특정 셀 i에 대한 Ci가 Y3 ≤ C1-Ci < Y 범위에 있는 경우, 해당 셀 i에 대한 Ri가 0 ≤ max_j{Rj} - Ri < Z1 인 경우에만 해당 셀 i를 초기 접속 타겟 셀로 선택할 수 있다.

[523] (2) 특정 셀 i에 대한 Ci가 Y2 ≤ C1-Ci < Y3 범위에 있는 경우, 해당 셀 i에 대한 Ri가 0 ≤ max_j{Rj} - Ri < Z2 인 경우에만 해당 셀 i를 초기 접속 타겟 셀로 선택할 수 있다.

[524] (3) 특정 셀 i에 대한 Ci가 Y1 ≤ C1-Ci < Y2 범위에 있는 경우, 해당 셀 i에 대한 Ri가 0 ≤ max_j{Rj} - Ri < Z3 인 경우에만 해당 셀 i를 초기 접속 타겟 셀로 선택할 수 있다.

[525] (4) 특정 셀 i에 대한 Ci가 0 ≤ C1-Ci < Y1 범위에 있는 경우, 해당 셀 i에 대한 Ri가 0 ≤ max_j{Rj} - Ri < Z 인 경우에만 해당 셀 i를 초기 접속 타겟 셀로 선택할 수 있다.

[526] 위의 수식을 살펴보면, 최상의 CRS 기반 RRM 측정값과 측정 대상 셀에 대한 CRS 기반 RRM 측정값의 차이와, 최상의 RRM-RS 기반 RRM 측정값과 측정 대상 셀의 최상의 RRM-RS 기반 측정값의 차이를 기반으로 초기 접속 타겟 셀이 선택될 수 있다. 다시 말해, 가장 큰 CRS 기반 RRM 측정 값과 특정 셀의 CRS 기반 RRM 측정 값의 차이가 상대적으로 크다면, 가장 큰 RRM-RS 기반 RRM 측정 값과 해당 특정 셀의 RRM-RS 기반 RRM 측정 값의 차이가 상대적으로 작은 경우에만 해당 특정 셀을 타겟 셀로 선택할 수 있다. 반대로, 가장 큰 CRS 기반 RRM 측정 값과 특정 셀의 CRS 기반 RRM 측정 값의 차이가 상대적으로 작다면, 가장 큰 RRM-RS 기반 RRM 측정 값과 해당 특정 셀의 RRM-RS 기반 RRM 측정 값의 차이가 상대적으로 크더라도 해당 특정 셀을 타겟 셀로 선택할

수 있다. 결국, 단말은 CRS 기반 RRM 측정 값과 RRM-RS 기반 RRM 측정 값 중 어느 하나라도 양호한 셀을 타겟 셀로 선택할 수 있다.

[527] 만일 상기 (1), (2), (3), (4) 조건들 중 다수가 충족되는 상황에서는, 그 중에서 가장 높은 Ri 값을 나타내는 셀을 초기 접속의 타겟 셀로 결정하여 RACH 프리앰블을 송신할 수 있다. 또한, RRC_IDLE 단말의 가장 높은 Ri 값을 나타내는 셀을 선택(selection)하거나 재선택(reselection)할 수 있다.

[528] 위 규칙은 하나의 예시에 불과하며, 본 발명이 이에 한정되는 것은 아니다. 즉, 이와 같이 CRS 기반 RRM 값(즉, C1, C2, C3,...)들과 RRM-RS 기반 RRM(즉, R1, R2, R3,...)들을 동시에 고려하여 초기 접속 타겟 셀을 결정하도록 하는 구체적인 조건 수식은 변형될 수 있다.

[529] 앞서 설명한 바와 같이, CRS 기반 RRM 측정치를 함께 고려하여 최적의(best) 타겟 셀을 정하지 않고, 오직 상기 RRM-RS 기반 RRM 측정치에 입각하여 최적의(best) 타겟 셀을 정하여 초기 접속을 개시하도록 하는 경우에는, 이후에 공통의 제어 채널(common control channel) 등 제어 채널의 경우 곧바로 단말 특정(UE-dedicated) 제어 채널 (예를 들어, EPDCCH)을 통해서만 제어가 이루어질 수 있는 시스템(예를 들어, CRS 및 PDCCH가 존재하지 않는 새로운 캐리어 타입(NCT: new-carrier type) 시스템)에서 활용될 수 있다.

[530] 이 경우, 상기 SIB X 등 시스템 정보에 (또는 RACH 절차 상의 초기에) EPDCCH 설정 관련 정보도 미리 단말들에게 알려 줄 수 있다. 예를 들어, 상기 시스템 정보를 통해 단말에게 분산 EPCCH(distributed EPDCCH) 관련 설정 정보만 우선 제공될 수 있다. 그 후에, 단말이 특정 RRM-RS가 최상의(best) RRM 측정치를 보이는 것으로 보고가 된다면, 이를 바탕으로 기지국이 해당 단말에게 보다 최적화된 지역 EPDCCH(localized EPDCCH) 관련 설정 정보를 제공하고 지역 EPDCCH(localized EPDCCH)에 의한 제어 정보가 전달되도록 할 수 있다.

[531]

[532] 4. RACH 절차 상에서의 추가 개선 동작

[533] 도 17은 본 발명의 일 실시예에 따른 랜덤 액세스 절차를 예시하는 도면이다.

[534] 이하, 설명의 편의를 위해 본 발명의 일 실시예에 따른 랜덤 액세스 절차는 앞서 도 8에 따른 랜덤 액세스 절차와 비교하여 차이가 있는 부분을 위주로 설명하며, 이하 설명되지 않은 내용은 앞서 도 8에 따른 랜덤 액세스 절차로 대체될 수 있다.

[535] 1) 1 단계 (단말의 RACH 프리앰블 송신)

[536] 단말은 RACH 프리앰블을 전송하는 타겟 셀은 앞서 설명한 "3. RRM-RS 등 기반 진보된(enhanced) RRM 측정의 수행에 따른 단말 관점에서의 선호 셀 결정"에서 설명한 방법들 중 적어도 어느 하나를 적용하여 결정하고, 해당 타겟 셀로 RACH 프리앰블(즉, 제1 메시지)을 송신한다(S1701).

[537] 이때, RRM 측정 값(예를 들어, RRM-RS 기반 RRM 측정 값 및/또는 CRS 기반 RRM 측정 값)을 RACH 절차 내에서 보고하는 단말은 그렇지 않은

레가시(legacy) 단말과 구분될 수 있도록, 레가시(legacy) 단말과 다른 RACH 프리앰블 집합에서 RACH 프리앰블을 선택할 수 있다. 이에 따라 기지국은 단말로부터 수신한 RACH 프리앰블이 속한 RACH 프리앰블 집합에 따라 해당 단말이 RACH 절차 내에서 RRM 측정 값을 보고하는 단말인지 여부를 판단할 수 있다. 이처럼 RACH 절차 내에서 RRM 측정 값을 보고하는 단말과 레가시(legacy) 단말이 서로 다른 RACH 프리앰블 집합을 이용하는 경우, 기지국은 시스템 정보에서 RACH 프리앰블 집합 정보를 전송할 수도 있다. 예를 들어, 앞서 도 15의 S1501 단계에서 RRM-RS 기반 RRM 측정을 수행한 단말 및/또는 레가시(legacy) 단말을 위한 RACH 프리앰블 집합 정보를 전송할 수 있다.

[538] 2) 2 단계 (기지국으로부터의 랜덤 액세스 응답(RAR: random access response) 수신)

[539] 기지국은 제2 메시지(message 2)(즉, RAR)를 통해 해당 단말이 전송한 RACH 프리앰블에 대한 응답을 전송한다(S1702).

[540] 현재 단계에서 기지국은 해당 단말이 상기 FD-MIMO 등을 지원할 수 있는 진보된(enhanced) 단말(즉, RRM-RS 기반 RRM 측정을 수행한 단말)에 대한 정보들을 알지 못하므로 레가시(legacy) 단말에 대한 동일한 형태의 제2 메시지(message 2) 응답을 제공할 수 있다.

[541] 또는, 상술한 바와 같이, RACH 절차 내에서 RRM 측정 값을 전송하는 단말과 레가시 단말이 서로 다른 RACH 프리앰블 집합에서 RACH 프리앰블을 선택하는 경우, RACH 절차 내에서 RRM 측정 값을 전송하는 단말과 레가시 단말에게 전송되는 제2 메시지는 서로 다른 포맷을 가질 수 있다. 예를 들어, 이와 같이 제2 메시지의 포맷이 구분되는 경우, RACH 절차 내에서 RRM 측정 값을 전송하는 단말에게 전송되는 제2 메시지에서만 후술하는 임계치 Z 값을 포함할 수 있다. 또한, 기지국은 RACH 절차 내에서 RRM 측정 값을 전송하는 단말에게는, 해당 단말이 후술하는 RRM 측정치를 포함하는 제3 메시지의 전송하는 점을 고려하여 시간/주파수 자원을 할당할 수 있다.

[542] 3 단계 (단말의 L2(layer 2)/L3(layer 3) 메시지 전송)

[543] 단말은 S1702 단계에서 기지국으로부터 수신한 RAR에 대한 응답으로 PUSCH를 통해 상향링크 메시지(즉, 제3 메시지(message 3))를 전송한다(S1703).

[544] 이때, S1702 단계에서 기지국으로부터 RAR을 통해 제공받은 (임시(temporal)) C-RNTI를 통해 PUSCH를 전송할 수 있다.

[545] 본 발명의 일 실시예에 따르면, 단말은 참조 신호 기반으로 측정된 RRM 측정치 값을 제3 메시지를 통해 기지국에 보고할 수 있다. 이때, RRM 측정 값은 앞서 설명한 RRM-RS 기반 측정치들이 해당되거나, 또는 CRS 기반 RRM 측정치들이 해당되거나, 또는 RRM-RS 기반 측정치와 CRS 기반 RRM 측정치가 모두 해당될 수도 있다.

[546] 예를 들어, 현재 제3 메시지(message 3)를 전송하는 타겟 셀이 전송하는

RRM-RS 설정들 및 모든 포트에 대한 RRM 측정치들을 모두 보고하도록 정의될 수 있다. 이를 통해 해당 셀은 이후 이 단말에게 적절한 CSI-RS 설정들을 할 때에 이 보고 정보에 기반하여 효과적으로 CSI-RS를 설정할 수 있다는 장점이 있다.

[547] 또는, 모든 RRM-RS 측정치들을 보고하는 것이 아니라, 최상의(best) RRM-RS 측정치 대비 Z dB 이내의 RRM-RS 측정치들을 보고하도록 정의될 수 있다.

[548] 이때, 임계치 Z 값은 사전에 고정적으로 정의되어 있거나, 앞서 S1702 단계의 RAR 메시지를 통해 기지국이 알려줄 수도 있다. 이 경우, 이 정보는 진보된 단말(enhanced UE)만 이해할 수 있는 정보로서 취급될 수 있다.

[549] 또한, 이와 같이 단말이 RRM-RS 측정치들을 보고할 때, 해당 RRM-RS를 전송하는 셀의 PCI를 함께 연동정보로서 보고할 수 있다.

[550] 이는 대상 셀 이외에도 인접 셀(neighbor cell)이 전송하고 있는 RRM-RS에 대한 RRM 측정값도 어느 수준 이상 높은 값을 보이고 있다면 (예를 들어, 임계치 Z' 이내), 해당 단말에게 가해지고 있는 인접 셀들로부터의 간섭 수준을 미리 파악할 수 있다는 장점이 있고 이를 통해 CSI 프로세스(CSI process) 관련 설정 등에 있어서 참고로 활용될 수 있다.

[551] 이와 같이 단말이 상기 RRM-RS 기반 RRM 측정치들 및/또는 CRS 기반 RRM 측정치 값들 자체를 기지국에 보고해주는 시점은 제3 메시지를 전송하는 단계(즉, S1703 단계)가 아니라 그 이후 다른 단계에서 보고될 수도 있다. 이 경우, 단말은 이후의 단계에서 상기 RRM-RS 기반 RRM 측정치들 및/또는 CRS 기반 RRM 측정치 값들을 보고한다는 것을 기지국에 알리기 위한 지시자(예를 들어, 1 비트 지시자)를 포함시켜 제3 메시지를 전송할 수도 있다.

[552] 예를 들어, 제4 메시지(message 4)를 단말이 기지국으로부터 수신한 후에 (그리고 제4 메시지에서 단말의 식별자를 포함함으로써 기지국이 충돌 해결을 확인(confirmation)을 해준 경우), 단말은 긍정 응답(positive ACKnowledgement)(즉, 'ACK')을 기지국에 전송하도록 종래 동작이 정의되어 있다. 이 시점과 연동되어 함께 상기 RRM-RS 기반 RRM 측정치들 및 CRS 기반 RRM 측정치 값들을 기지국에 보고하도록 전송 시점이 정의될 수 있다.

[553] 즉, 이러한 ACK을 보내는 시점이 서브프레임(SF: subframe) #n이라면, 단말이 상기 RRM-RS 기반 RRM 측정치들 및 CRS 기반 RRM 측정치 값들을 동일 SF #n에 전송하는 것으로 (예를 들어, PUSCH에 의해) 정의될 수 있다.

[554] 또는, 특정 SF 오프셋 k값이 사전에 정의되거나 기지국의 선행하는 메시지(예를 들어, 시스템 정보 또는 제2 메시지 등)를 통해 알려주는 경우 해당 k값을 적용하여 SF #n+k 시점에 상기 RRM-RS 기반 RRM 측정치들 및 CRS 기반 RRM 측정치 값들을 전송하는 것으로 미리 정의되거나 단말에 설정될 수 있다.

[555] 또는, 기지국으로부터 명시적인 트리거링(explicit triggering) (예를 들어, UL 그랜트(grant))에 따라 해당 시점에 전송하는 것으로 정의될 수도 있다. 다시 말해, 이 경우 모든 RACH 절차가 완료된 후 기지국으로부터 특정 UL 그랜트를 수신할 수 있고 (예를 들어, 해당 UL 그랜트 내에 특정 명시적(explicit) 또는

암묵적(implicit) 필드 지시가 포함되거나 별도의 RNTI로 마스킹(masking)되는 형태 등 특정 규약된 시그널링 형태를 따를 수 있음), 이와 같이 상기 RRM-RS 기반 RRM 측정치들 및 CRS 기반 RRM 측정치 값들을 기지국으로 전송하라는 특정 UL 그랜트를 수신한 시점(즉, UL 그랜트에 대한 응답으로)에 이 정보들을 기지국에 전송하도록 정의되거나 단말에 설정될 수 있다.

[556] Step 4 (기지국으로부터 충돌 해결 메시지(Contention resolution message) 수신)

[557] 기지국은 충돌 해결 메시지(즉, 제4 메시지)를 단말에게 전송할 수 있다. 이 단계 자체에 대해서는 도 8의 예시에 따른 방식을 그대로 사용할 수 있다.

[558] 또는, 본 발명의 또 다른 일 실시예에 따르면, 이 단계와 동시에 즉, 충돌 해결 메시지(즉, 제4 메시지) 내에서 기지국은 상기 제3 메시지(message 3) 단계에서의 RRM-RS 기반 RRM 보고 정보들을 고려하여 바로 해당 단말에게 전송 모드(transport mode) 설정 및 CSI 피드백 관련 설정 정보들을 제공할 수 있다.

[559] 이러한 과정을 통해, 본 발명에 따르면 단말의 정상적인 전송 모드 설정 및 CSI 피드백, 그리고 송/수신 동작을 위해 추가적인 핸드오버(hand-over)나 셀 재선택(cell re-selection) 과정 없이 빠르게 정상 동작 상태에 진입할 수 있도록 하는 장점이 있다.

[560] 앞서 본 발명에 대한 설명에 있어서, 설명의 편의상 FD-MIMO를 활용 사례를 위주로 설명을 하였으나, 상기 언급한 바와 같이 무정형 셀(amorphous cells) 환경에서의 다수의 RRM-RS 설정 (즉, 서로 다른 개수의 TP(들)들로 무정형 셀이 구성됨에 따라 서로 다른 개수의 TP(들)이 함께 각 RRM-RS를 전송하는 형태) 등 다양한 활용 사례에도 적용될 수 있음은 자명하다. 그 밖에도 종래의 셀 별로 단일 CRS 기반 RRM 측정치에 기반하여 초기 접속(initial access)을 위한 타겟 셀을 고려하는 방식이 아닌, 별도의 다른 RS(앞서 설명의 편의상 RRM-RS로 지칭하였음)들부터의 RRM 측정치에 기반하여 초기 접속(initial access)이 수행되도록 하는 또 다른 다양한 환경에서도 적용이 가능하다.

[561] 앞서 1. 내지 4.에서는 설명의 편의상 단말이 네트워크로의 초기 접속(initial access)하는 상황을 가정하여 설명하였으나, 반드시 1. 내지 4. 방법이 단말의 초기 접속(initial access) 과정에서만 순차적으로 적용될 필요는 없으며 각각의 방법이 독립적으로 수행될 수 있음은 물론이다.

[562] 앞서 2. 방법의 경우, 반드시 단말이 네트워크에 초기 접속 이전에 기지국으로부터 수신하는 시스템 정보로 한정될 필요는 없으며, 기지국으로부터 브로드캐스트되는 어떠한 시스템 정보를 통해서도 RRM-RS 설정 정보가 단말에게 제공될 수 있다.

[563] 또한, 앞서 3. 방법의 경우, 반드시 단말이 네트워크에 초기 접속 과정을 수행하기 전에 셀을 선택하는 경우로 한정될 필요는 없으며, 단말이 캠핑(camping)하는 셀을 (재)선택하거나 핸드오버(handover)하는 등 최적의 셀을 선택하기 위한 어떠한 상황에서든 이 방법이 적용될 수 있다.

[564] 또한, 앞서 4. 방법의 경우, 반드시 단말이 네트워크에 초기 접속하기 위한

RACH 절차로 한정될 필요는 없으며, 그 외에도 단말이 수행하는 어떠한 RACH 절차에서도 적용될 수 있다. 또한, 레가시(legacy) 단말에서도 CRS 기반 RRM 측정값을 기지국에 전송하기 위하여 4. 방법이 적용될 수 있다.

[565]

[566] 진보된 RLM(advanced RLM) 동작

[567] UE는 무선링크 상태 및 수신신호 품질에 대한 측정/보고/관리를 목적으로 상기 RRM 뿐만 아니라, 무선 링크 모니터링(RLM) 동작을 수행하여야 한다.

[568] RLM의 경우 구체적으로, UE는 주어진 시간 구간/주기(예를 들어, 특정 무선 프레임/서브프레임)에 대하여 참조 신호(예를 들어, CRS 등)를 기반으로 측정된 특정 시점(예를 들어, 서브프레임)에서 무선 링크 품질(예를 들어, 신호 대 잡음비(SNR: Signal-to-Noise Ratio) 또는 신호 대 간섭 및 잡음비(SINR: Signal-to-Interference plus Noise Ratio) 등)을 특정 임계치(즉, Q_out 및 Q_in)과 비교하고, 이를 토대로 무선 링크 상태(예를 들어, out-of sync 상태 또는 in-sync 상태)를 모니터링/평가할 수 있다.

[569] 이하, 본 발명의 설명에 있어서, 종래의 또는 통상적인 RLM 동작들을 통칭하여 편의상 "제1 RLM 동작(behaviors)"으로 지칭하기로 한다.

[570] UE 동작의 예를 들면, 제1 RLM 동작에 따라 UE는 자신이 접속해 있는 셀의 (CRS 기반의) 하향링크 링크 품질을 측정하고 이를 임계치 Q_out 및 Q_in와 비교하는 것을 포함하는 RLM 동작을 수행하게 된다. 만일, 해당 하향링크 무선 링크가 "신뢰있게 수신(reliably received)"되기 어렵다고 판정되는 경우(예를 들어, 3GPP TS 36.133에서 명시된 동작에 따라 무선 링크 품질이 임계치 Q_out 보다 불량한 경우)(또는 미리 정의된 횟수만큼 무선 링크 품질이 임계치 Q_out 보다 불량하다고 판단된 경우), UE는 특정 "무선 링크 실패(RLF: Radio Link Failure) 타이머(timer)" 관련 동작에 의해 무선 링크 실패(RLF)를 판정하기 위한 타이머를 가동시킨다. 그리고, UE는 해당 타이머가 만료(expire)되면 대상 셀과의 링크를 초기화하고, 새로운 셀을 탐색하는 등의 셀 (재)선택 과정을 수행할 수 있다. 만일, 상기 RLF 타이머가 만료되기 전에 다시 상기 Q_in 관련 조건을 충족하게 되면(즉, 무선 링크 품질이 임계치 Q_in 보다 양호한 경우)(또는 미리 정의된 횟수만큼 무선 링크 품질이 임계치 Q_in 보다 양호하다고 판단된 경우), UE는 해당 셀과의 링크를 유지할 수 있다. 이 경우 단말은 RLF 타이머를 중단할 수 있다.

[571] 이러한 동작이 상기 FD-MIMO 사용 케이스에 그대로 적용되는 상황을 고려하면, 단말이 상기 통상적인 (CRS 기반) RLM 동작에 따라 특정 셀에 대하여 무선 링크 품질이 매우 낮아져서 RLF를 판정하게 되는 상황이 발생할 경우라 하더라도, 만일 해당 단말에게 FD-MIMO 빔포밍이 적용되고 있는 PDSCH 그리고/또는 EPDCCH 전송의 무선 링크 품질이 여전히 안정적인 품질을 보이고 있다면, 해당 링크를 유지하도록 하는 것이 바람직할 수 있다.

[572] 즉, 이를 통해 통신 링크 단절 현상을 줄이고, 예를 들어 제어 채널은 FD-MIMO

빔포밍된 EPDCCH로부터 수신하고, 데이터 채널은 FD-MIMO 빔포밍된 PDSCH로부터 수신하는 동작을 유지함에 따른 성능 이득을 기대할 수 있다. 이는 FD-MIMO 전송 시 eNB단에서 많은 수의 안테나 요소를 활용하여 매우 높은 FD-MIMO 빔포밍 이득을 얻도록 할 수 있기 때문이다.

[573] 본 발명의 이하에서는 이러한 동작을 가능하게 하기 위해, 상기 "제1 RLM 동작"을 대체하여, 또는 상기 "제1 RLM 동작"에 추가하여 다음과 같은 요소들 중 적어도 하나를 포함하는 특정 "제2 RLM 동작"을 정의하거나 UE에 설정 UE에 설정(예를 들어, RRC 시그널링 등에 의해)하는 방법을 제안한다.

[574]

[575] (1) "제2 RLM 동작"은 상기 "제1 RLM 동작"에서 기반이 되는 CRS가 아닌, 별도의 특정 참조 신호(RS)를 기반으로 RLM 동작이 수행될 수 있다.

[576] 이러한 별도의 RS의 예시로는, 다음과 같은 RS 중 적어도 하나를 포함할 수 있다.

[577] 특정 CSI-RS(예를 들어, 단말에 설정된 가장 낮은 또는 가장 높은 CSI-RS 인덱스에 해당하는 CSI-RS)가 이용될 수 있다. 여기서, CSI-RS는 프리코딩된(pre-coded) CSI-RS일 수 있다.

[578] 또한, DRS-CSI-RS(즉, 디스커버리 참조 신호(DRS)로서 이용되는 CSI-RS)가 이용될 수 있다. 이때, 물리 셀 식별자(PCI 또는 PCID)는 상기 통상적인 "제1 RLM 동작"을 수행하는 대상이 되는 셀 ID일 수 있다. 즉, UE는 해당 PCI로 생성된 CRS를 기반으로 해당 셀에 대한 제1 RLM behaviors를 수행하고, 그리고/또는 해당 PCI에 연동된(또는 연관된) 특정 DRS-CSI-RS에 대하여 상기 제2 RLM 동작을 수행할 수 있다. 여기서, DRS-CSI-RS는 프리코딩된(pre-coded) DRS-CSI-RS일 수 있다.

[579] 또한, 앞서 설명한 별도의 RRM-RS가 이용될 수 있다. 여기서, 예를 들어, 이러한 RRM-RS는 상기 설명된 바와 같이 SIB 등 시스템 정보 관련 시그널링 메시지에 포함되어 단말의 초기 접속 시 그리고/또는 아이들 모드(idle mode)에서의 셀 (재)선택 관련 동작 시에 적용하도록 별도로 설정된 RRM-RS일 수 있다. 또 다른 일례로, RRM-RS는 앞서 설명한 바와 같이 FD-MIMO와 같이 날카로운 빔(sharp beam)을 통해 지역적으로 방향을 다르게 전송되는 RS에 해당될 수도 있으며 또는 서로 다른 셀 또는 전송 포인트(TP: Transmission Point)의 개수로 구성되는 무정형 셀(amorphous cell)에서 전송되는 RS에 해당될 수도 있다.

[580]

[581] (2) "제2 RLM 동작"과 관련하여, 제1 RLM 동작에 적용하는 RLF 판단을 위한 판정 조건(예를 들어, 전송 파라미터(앞서 표 6 및 표 7), out-of-sync/in-sync 판정을 위한 임계치 및/또는 RLF 타이머 등을 포함)과 별개의 독립적인 판정 조건들이 정의되거나 UE에 설정(예를 들어, RRC 시그널링 등에 의해)될 수 있다.

[582] 예를 들어, 제2 RLM 동작에 관한 DCI 포맷은 제1 RLM 동작에서의 DCI 1A (표 6 참조) 및 DCI 1C (표 7 참조)와 독립적인 특정 DCI 포맷으로 out-of-sync 및 in-sync를 각각 새롭게 정의하거나 UE에게 설정될 수 있다.

[583] 즉, UE는 제2 RLM 동작과 관련하여 사전에 정의되거나 UE에 설정된 DCI 포맷을 eNB로부터 수신할 때의 무선 링크 품질을 추정(또는 측정)하고, 추정(또는 측정)된 결과와 임계치(즉, Q'_out 및 Q'_in)를 비교하여 out-of-sync/in-sync 상태를 판단할 수 있다.

[584] 또한, 제2 RLM 동작에 관하여 정의/설정된 해당 DCI(예를 들어, out-of-sync 또는 in-sync에 대한)는 특정 EPDCCH 세트(예를 들어, 가장 낮은 또는 가장 높은 EPDCCH 세트)으로부터 전송되는 것을 UE가 가정하도록 정의되거나 UE에게 설정될 수 있다. 이는, 해당 특정 EPDCCH 세트로부터 전송되는 DCI가 FD-MIMO 빔포밍에 의해 전송되는 것(즉, FD-MIMO 빔포밍이 적용되는 것)을 고려하기 위함이다.

[585] - "제어 OFDM 심볼의 수(Number of control OFDM symbols)", "병합 레벨(CCE 또는 ECCE)", "(E)PDCCH RE 에너지 대 평균 RS RE 에너지의 비(Ratio of (E)PDCCH RE energy to average RS RE energy)" 등의 요소들 중 적어도 하나에 대해서도, out-of-sync 및 in-sync 각각에 대해 제1 RLM 동작에 적용하는 전송 파라미터와 독립적으로 (해당 EPDCCH 기반으로 계산될 수 있도록) 별도의 값들이 사전에 정의되거나 UE에게 설정될 수 있다.

[586] 이때, 예를 들어, 제2 RLM 동작에 적용되는 제어 OFDM 심볼의 수(Number of control OFDM symbols), (E)CCE 병합 레벨은 셀(또는 캐리어) 대역폭에 따라 상이하게 설정될 수 있다. 또한, (E)PDCCH RE 에너지 대 평균 RS RE 에너지의 비는 앞서 (1)에서 설명한 RS가 전송되는 안테나 포트의 개수에 따라 상이하게 설정될 수 있다.

[587] - 제1 RLM 동작과 별개로 제2 RLM 동작에서 RLF 관련 판정 조건에 사용되는 임계치가 독립적으로 정의되거나 UE에게 설정될 수 있다. 본 명세서에서는 설명의 편의상 이를 Q'_in 및 Q'_out으로 표기한다.

[588] - 임계치 Q'_out은 하향링크 무선 링크가 신뢰있게(reliably) 수신될 수 없는 레벨로 정의되고, 가상의(hypothetical) (E)PDCCH 전송(즉, EPDCCH 세트(예를 들어, 가장 낮은 EPDCCH 세트) 및 미리 정의된 관련 기준에 따른)의 X% 블록 에러율(BER)에 해당할 수 있다.

[589] - 임계치 Q'_in는 하향링크 무선 링크 품질이 Q'_out에서의 하향링크 무선 링크 품질 보다 현저하게 신뢰있게 수신될 수 있는 레벨로 정의되고, 가상의(hypothetical) (E)PDCCH 전송(즉, EPDCCH 세트(예를 들어, 가장 낮은 EPDCCH 세트) 및 미리 정의된 관련 기준에 따른)의 Y% BER에 해당할 수 있다.

[590]

[591] (3) 앞서 (1) 및/또는 (2)에서 설명한 "제2 RLM 동작"은 특정 상위 계층 신호(예를 들어, RRC 시그널링 등)에 의한 지시/설정에 따라, "제1 RLM 동작"을

대체하여 수행되도록 또는 병행하여 독립적인 조건에 따라 수행되도록 지시/설정될 수 있다.

[592] - 여기서, 특정 FD-MIMO 가능한(capable) UE(또는 보다 일반적으로, 본 발명에서 제안하는 제2 RLM 동작을 지원하는 UE 등)에게 상기 "제2 RLM 동작"은 항상 활성화될 수 있다. 즉, 특정 FD-MIMO 가능한(capable) UE의 경우 항상 제2 RLM 동작을 수행할 수 있다.

[593] 또는, 특정 FD-MIMO 가능한(capable) UE(또는 보다 일반적으로, 본 발명에서 제안하는 제2 RLM 동작을 지원하는 UE 등)라도 "제2 RLM 동작"이 항상 활성화되지는 않고, 해당 단말에게 FD-MIMO 관련 모드(또는 보다 일반적으로, 본 발명에서 제안하는 제2 RLM 동작을 지원하는 모드 등)가 설정된 경우에 "제2 RLM 동작"이 활성화될 수도 있다. 즉, 특정 FD-MIMO 가능한(capable) UE의 경우라도 항상 제2 RLM 동작을 수행하지 않고, FD-MIMO 관련 동작이 활성화(즉, FD-MIMO 관련 모드 설정)된 경우 제2 RLM 동작을 수행할 수 있다.

[594] 이 경우, 제1 RLM 동작을 대체하여 제2 RLM 동작을 수행하도록 정의 또는 UE에게 설정되거나, 제1 RLM 동작과 함께 제2 RLM 동작을 함께 병행하여 수행하도록 정의되거나 UE에게 설정될 수 있다.

[595] 후자와 같이, 제1 RLM 동작과 제2 RLM 동작의 병행하여 동작되는 경우, 제2 RLM 동작이 항상 별도의 동작 조건에 의해 제1 RLM 동작과 무관하게 동작될 수도 있다. 또는 제2 RLM 동작은 제1 RLM 동작에 종속되어, 제1 RLM 동작에 의해 특정 조건이 충족되는 경우, 여기에 연동되어 제2 RLM 동작의 동작 조건이 종속적으로 정의되거나 UE에게 설정될 수도 있다. 예를 들어, 후술하는 (4) 등의 실시예와 같이 제2 RLM 동작은 제1 RLM 동작에 종속되어 수행될 수 있다.

[596] 상술한, FD-MIMO 가능한(capable) UE는 UE가 네트워크에 초기 접속 시에 자신의 특정 능력 시그널링(즉, FD-MIMO 지원 가능한 능력)을 기지국에 전달할 수 있다. 이때, 이에 관한 특정 FD-MIMO 관련 능력 시그널링 포맷이 정의될 수 있다. 예를 들어, FD-MIMO 가능한(capable) UE(예를 들어, FD-MIMO 지원 가능한 능력을 시그널링한 UE)는 상기 제2 RLM 동작이 적용될 수 있다.

[597] 또는, 상기 제2 RLM 동작의 적용 가능 여부에 관한 능력 시그널링 형태로 세분화될 수도 있다. 즉, 특정 FD-MIMO 관련 능력 메시지는 제2 RLM 동작의 적용 가능 여부를 지시하는 정보를 포함할 수도 있다.

[598] 또한, 상기 RRM-RS 그리고/또는 연관된 최초 접속(initial access) 동작 방식에 관해서도 특정 능력 시그널링 형태로 유사하게 세분화될 수 있다. 즉, UE는 상술한 RRM-RS의 지원 가능 여부에 대한 능력 및/또는 이와 연관된 최초 접속(initial access) 동작 방식의 지원 가능 여부에 대한 능력 시그널링을 eNB에게 전송할 수 있다.

[599] - 만일, 상기 제2 RLM 동작이 제1 RLM 동작을 대체하는 형태로 정의되거나 UE에 설정된 경우라면, 이 UE의 RLF 판정 여부는 오직 상기 제2 RLM 동작 관련 판정 조건에 따라 정해진다. 즉, 앞서 (2)에서 설명한 제2 RLM 동작에 대한 판정

조건만으로 UE는 RLF를 판정할 수 있다.

[600] - 또한 만일, 상기 제2 RLM 동작이 제1 RLM 동작과 병행하여 둘 다 활성화되는 상태로 유지되는 형태로 정의되거나 UE에 설정된 경우라면, 이 UE의 RLF 판정 여부는 제1 RLM 동작과 제2 RLM 동작 관련 판정 조건을 모두 고려하여, 두 경우 모두에서 RLF 판정이 내려진 경우에만 해당 셀의 통신 링크를 끊을 수 있도록(즉, 해당 셀과의 링크를 초기화하도록) 정의되거나 UE에 설정될 수 있다.

[601] 또는, 제1 RLM 동작과 제2 RLM 동작 중 어느 하나라도 RLF 판정이 내려진 경우에는 해당 셀의 통신 링크를 끊을 수 있도록(즉, 해당 셀과의 링크를 초기화하도록) 정의되거나 UE에 설정될 수 있다. 그리고/또는, 제2(또는 제1) RLM 동작에 의해서 RLF 판정이 내려진 경우에는 제1(또는 제2) RLM 동작의 판정 결과와 무관하게 RLF 판정을 내리는 것으로 정해질 수도 있다. 즉, 제1 RLM 동작과 제2 RLM 동작 중 어느 하나가 RLF 판정에 있어서 다른 하나보다 높은 우선순위를 가질 수 있다.

[602]

[603] (4) 상술한 바와 같이 제2 RLM 동작은 제1 RLM 동작에 종속적으로 수행될 수 있다.

[604] 일례로, "제1 RLM 동작"에 의해 RLF 타이머가 작동 개시된 시점 t1으로부터 특정 오프셋 시간인 d1만큼의 시간(예를 들어, d1=0, 또는 d1은 특정 양수 값 등)이 지난 후부터, 상기 (1)에서 설명한 특정 RS에 대하여 "제2 RLM 동작"에 따른 RLF 판정 관련 동작이 개시될 수 있다.

[605] 또한, 상기 제1 RLM 동작에 의해 RLF 타이머가 작동 개시되고 만료되기 전까지, 상기 제2 RLM 동작에 의해 특정 Q'_in 조건이 충족하게 되는 경우(즉, 무선 링크 품질이 Q'_in 보다 양호한 경우), 해당 셀에 대해서는 RLF를 판정하지 않을 수 있다.

[606] 이러한 제안 동작에 의해, "제2 RLM 동작"은 오직 "제1 RLM 동작"의 RLF 타이머가 작동되는 시점과 연동된 특정 시간 구간 동안에만 활성화되는 것으로 제한함으로써, 단말의 불필요한 배터리 소모를 방지할 수 있다.

[607] 또한, UE가 새로운 셀을 (재)선택하여 정상적으로 (재)접속이 완료되기 까지(또는 (재)접속이 완료되어 해당 새로운 셀로부터 정상적인 "제1 RLM 동작"이 개시될 수 있는 상태가 되기까지)의 구간 동안에는, 반드시 이 UE에게는 해당 "제2 RLM 동작"과 연계된 특정 EPDCCH 세트(예를 들어, 가장 낮은 EPDCCH 세트)로부터의 DCI들을 통한 제어 시그널링만 수신이 가능한 것으로 정의되거나 설정될 수 있다. 그리고, EPDCCH에 의해 특정 PDSCH 수신 및 상향링크 송신 등의 동작이 지시될 수 있다.

[608] 또한, 새로운 셀을 (재)선택하여 정상적으로 (재)접속이 완료되기 까지(또는 (재)접속이 완료되어 해당 새로운 셀로부터 정상적인 "제1 RLM 동작"이 개시될 수 있는 상태가 되기까지)의 구간 동안에는 C-RNTI, SPS C-RNTI 등 특정 RNTI(들)로 마스킹된 DCI만 해당 EPDCCH 세트로부터 수신이 가능한 것으로

한정될 수도 있다. 즉, 이 경우 UE는 이러한 제한된 형태의 DCI들만 블라인드 검출(blind detection)을 시도하면 된다.

[609] 그리고/또는, UE는 이러한 상태에서 특정 정의되거나 UE에 설정된 동작 조건에 따라, 계속해서 새로운 셀 탐색 관련 동작을 수행해야 할 수 있다. 즉, 이와 같은 새로운 셀 탐색 관련 동작을 지속적으로 수행함과 동시에, 상기 "제2 RLM 동작"과 연계된 특정 EPDCCH 세트를 통한 특정 EPDCCH DCI(들)의 모니터링은 지속해야 한다. 이를 통해, FD-MIMO 빔포밍된 EPDCCH에 의해 스케줄링되는 FD-MIMO 빔포밍된 PDSCH는 (상기 "제1 RLM 동작"에 의해서는 RLF가 판정된 상태라 할지라도) 여전히 지속적으로 수행될 수 있도록 함으로써 통신 링크의 연결성을 크게 증대시킬 수 있다는 장점이 있다.

[610] 또 다른 일례로, "제1 RLM 동작"에 의한 RLF 판정 결과에 따라 "제2 RLM 동작"이 개시될 수도 있다.

[611] 예를 들어, "제1 RLM 동작"과 "제2 RLM 동작"의 판정 조건을 모두 고려하여, 두 경우 모두 RLF 판정이 내려진 경우에만 해당 셀의 통신 링크를 끊는(즉, 해당 셀과의 링크를 초기화) 경우를 가정한다. 이 경우, "제1 RLM 동작"에 의한 RLF 판정이 내려진 경우(즉, 무선 링크 품질이 임계치 Q_out 보다 불량하여 구동이 개시된 RLF 타이머가 만료된 경우)에만 "제2 RLM 동작"이 개시될 수도 있다. 반면, "제1 RLM 동작"에 의한 RLF 타이머가 작동 개시되었더라도 무선 링크 품질이 임계치 Q_in보다 양호한 경우에는 "제2 RLM 동작"이 개시되지 않을 수 있다.

[612] 또 다른 예로, "제1 RLM 동작"과 "제2 RLM 동작" 중 어느 하나라도 RLF 판정이 내려진 경우에는 해당 셀의 통신 링크를 끊을 수 있도록(즉, 해당 셀과의 링크를 초기화하도록) 정의되거나 UE에 설정된 경우를 가정한다. 또한, 제1 RLM 동작에 의해서 RLF 판정이 내려진 경우에는 제2 RLM 동작의 판정 결과와 무관하게 RLF 판정을 내리는 경우도 마찬가지이다. 이 경우, "제1 RLM 동작"에 의한 RLF 판정이 내려진 경우(즉, 무선 링크 품질이 임계치 Q_out 보다 불량하여 구동이 개시된 RLF 타이머가 만료된 경우)에는 해당 셀의 통신 링크를 끊게되며(즉, 해당 셀과의 링크를 초기화), "제2 RLM 동작"이 개시되지 않을 수 있다.

[613] 도 18은 본 발명의 일 실시예에 따른 무선 링크 모니터링을 위한 방법을 예시하는 도면이다.

[614] 도 18을 참조하면, UE는 CRS를 기반으로 셀(cell)에 대한 무선 링크 모니터링(이하, '제1 RLM')을 수행할 수 있다(S1801).

[615] UE는 CRS 이외 특정 참조 신호(RS)를 기반으로 셀(cell)에 대한 무선 링크 모니터링(이하, '제2 RLM')을 수행한다(S1802).

[616] 여기서, 특정 RS는 CRS 이외 앞서 (1)에서 설명한 RS를 의미할 수 있다. 예를 들어, (pre-coded) CSI-RS, (pre-coded) DRS-CSI-RS, 단말의 초기 접속 시 그리고/또는 아이들 모드(idle mode)에서의 셀 (재)선택 관련 동작 시에

적용하도록 별도로 설정된 RRM-RS, FD-MIMO와 같이 날카로운 빔(sharp beam)을 통해 지역적으로 방향을 다르게 전송되는 RS, 또는 서로 다른 셀 또는 전송 포인트(TP: Transmission Point)의 개수로 구성되는 무정형 셀(amorphous cell)에서 전송되는 RS가 해당될 수 있다.

[617] UE는 CRS 기반 제1 RLM 및 CRS 이외 참조 신호 기반 제2 RLM을 기반으로 또는 CRS 이외 참조 신호 기반 제2 RLM을 기반으로 셀에 대한 RLF를 판단한다(S1803).

[618] 여기서, S1803 단계에서 제2 RLM에 의해서만 해당 셀에 대한 RLF를 판단하는 경우, 앞서 S1801 단계는 수행되지 않을 수도 있다.

[619] 보다 구체적으로 살펴보면, UE는 해당 셀에 대한 하향링크 무선 링크 품질을 모니터링하고, 모니터링에 의한 측정치와 미리 정해진 임계치를 비교할 수 있다.

[620] 여기서, CRS 기반 제1 RLM의 경우, UE는 CRS 기반 모니터링에 의한 측정치를 Q_in 및 Q_out과 비교할 수 있다.

[621] 또한, CRS 이외 참조 신호 기반 제2 RLM의 경우, UE는 CRS 이외 참조 신호 기반 모니터링에 의한 측정치를 Q'_in 및 Q'_out과 비교할 수 있다. 이때, 상술한 바와 같이, Q'_in 및 Q'_out는 Q_in 및 Q_out와 독립적으로 미리 정의되거나, UE에게 설정될 수 있다.

[622] 여기서, 상술한 바와 같이, Q'_in 및 Q'_out은 각각 미리 정의된 전송 파라미터(즉, (E)PDCCH 전송 파라미터)를 이용한 가상의 (E)PDCCH 전송에 대한 BER에 해당할 수 있다. 즉, 가상의 (E)PDCCH 전송은 (E)PDCCH 전송 파라미터에 기반하여 전송된다고 가정되는 (E)PDCCH 전송을 의미한다. 이때, (E)PDCCH 전송 파라미터는 앞서 CRS 기반 제1 모니터링을 위한 전송 파라미터(즉, PDCCH/PCFICH 전송 파라미터)와 독립적으로 정의되거나 UE에게 설정될 수 있다.

[623] 그리고, UE는 모니터링에 의한 측정치와 미리 정해진 임계치를 비교한 결과에 기반하여 RLF 타이머를 구동시킬 수 있다. 그리고, RLF 타이머가 만료되면 상기 셀에 대한 RLF라고 결정할 수 있다.

[624] 예를 들어, CRS 기반 제1 RLM의 경우, 무선 링크 품질이 Q_out 보다 불량한 경우 out-of-sync 상태로 판단할 수 있으며, 무선 링크 품질이 Q_in 보다 양호한 경우 in-sync 상태로 판단할 수 있다. 이때, 무선 링크 품질이 Q_out 보다 불량한 경우(또는, 미리 정의된 횟수만큼 무선 링크 품질이 임계치 Q_out 보다 불량하다고 판단된 경우), UE는 제1 RLM에 대한 RLF 타이머를 구동시킬 수 있다. 그리고, 제1 RLM에 대한 RLF 타이머가 만료되면 상기 셀에 대한 RLF라고 결정할 수 있다. 이때, 제1 RLM에 대한 RLF 타이머 구동 중 무선 링크 품질이 Q_in 보다 양호한 경우(또는 미리 정의된 횟수만큼 무선 링크 품질이 임계치 Q_in 보다 양호하다고 판단된 경우), 제1 RLM에 대한 RLF 타이머를 중단시킬 수 있다.

[625] 또한, CRS 이외 참조 신호 기반 제2 RLM의 경우, 무선 링크 품질이 Q'_out 보다

불량한 경우 out-of-sync 상태로 판단할 수 있으며, 무선 링크 품질이 Q'_in 보다 양호한 경우 in-sync 상태로 판단할 수 있다. 이때, 무선 링크 품질이 Q'_out 보다 불량한 경우(또는, 미리 정의된 횟수만큼 무선 링크 품질이 임계치 Q'_out 보다 불량하다고 판단된 경우), UE는 제2 RLM에 대한 RLF 타이머를 구동시킬 수 있다. 그리고, 제2 RLM에 대한 RLF 타이머가 만료되면 상기 셀에 대한 RLF라고 결정할 수 있다. 이때, 제2 RLM에 대한 RLF 타이머 구동 중 무선 링크 품질이 Q'_in 보다 양호한 경우(또는 미리 정의된 횟수만큼 무선 링크 품질이 임계치 Q'_in 보다 양호하다고 판단된 경우), 제2 RLM에 대한 RLF 타이머를 중단시킬 수 있다.

[626] 상술한 바와 같이, UE는 제1 RLM 동작을 대체하여 제2 RLM 동작을 수행할 수도 있으나, 제1 RLM 동작과 함께 제2 RLM 동작을 수행할 수도 있다.

[627] 즉, 제1 RLM 동작을 대체하여 제2 RLM 동작을 수행하는 경우, UE는 제2 RLM 동작에 의해 해당 셀에 대한 RLF를 판단할 수 있다.

[628] 반면, 제1 RLM 동작과 함께 제2 RLM 동작을 수행하는 경우, UE는 제1 RLM 동작과 무관하게 제2 RLM 동작을 수행할 수도 있으나, 제1 RLM 동작에 의해 특정 조건이 만족되는 경우 제2 RLM 동작을 수행할 수도 있다.

[629] 예를 들어, 제1 RLM에 대한 RLF 타이머가 작동 개시된 시점으로부터 특정 오프셋 시간 이후부터 제2 RLM이 수행될 수 있다. 또는, 제1 RLM에 의해 해당 셀이 RLF라고 판단되면, 제2 RLM이 수행될 수도 있다.

[630] 이와 같이 제1 RLM 동작과 함께 제2 RLM 동작을 수행하는 경우, UE는 제1 RLM 동작 및 제2 RLM 동작에 의해 모두 해당 셀에 대한 RLF가 판정된 경우, 최종적으로 해당 셀에 대한 RLF라고 판단할 수 있다.

[631] 또는, 제1 RLM 동작과 함께 제2 RLM 동작을 수행하는 경우, UE는 제1 RLM 동작 또는 제2 RLM 동작에 의해 해당 셀에 대한 RLF가 판정된 경우, 최종적으로 해당 셀에 대한 RLF라고 판단할 수 있다. 이때, 제1 RLM 동작 및 제2 RLM 동작 중 어느 하나에 의해 RLF라고 판단된 경우, 이외 동작에 대한 판정 결과와 무관하게 최종적으로 해당 셀에 대한 RLF라고 판단할 수도 있다.

[632] 위와 같이, 제1 RLM 및/또는 제2 RLM에 의해 최종적으로 해당 셀에 대하여 RLF라고 판단된 경우, UE는 해당 셀과의 링크를 초기화하고, 새로운 셀을 탐색하는 등의 셀 (재)선택 과정을 수행할 수 있다.

[633]

[634] 앞서, 본 발명의 설명에 있어서, 설명의 편의상 FD-MIMO 사용 케이스를 위주로 설명하였으나, 앞서 설명한 바와 같이 무정형 셀(amorphous cells) 환경에서 다수의 RRM-RS 설정 (각 RRM-RS는 서로 다른 개수의 TP(들)/셀(들)이 함께 전송하는 형태) 등 다양한 사용 케이스에도 본 발명이 동일하게 적용될 수 있다. 즉, 앞서 통상적인 "제1 RLM 동작"과 상이하게 상기 앞서 본 발명에서 제안된 다양한 형태의 동작/적용 조건에 의해 별도의 "제2 RLM 동작"이 정의되거나 UE에게 설정될 수 있으며, 이에 따라 RLF 판정 조건 등이 상이하게

적용되도록 하는 형태로 일반화되어 확장 적용될 수 있음은 자명하다. 이러한 사용 케이스는 그 밖에도 다양하게 존재할 수 있으며, 본 발명의 제안 방식들은 특정 사용 케이스에 제한되지 않는다.

[635] 또한, 본 발명에서 "최초 접속(initial access) 관련 동작" 또는 "초기 접속 시에" 등의 표현은, 설명의 편의를 위한 것이고, 본 발명의 제안은 일반적으로 UE가 아이들 상태(예를 들어, RRC-connected 상태가 아닌 상태)에서 셀 선택/재선택을 수행할 때에 일반적으로 적용될 수 있는 것으로 이해되어야 한다. 즉, UE가 초기 턴-온(turn-on)되어 셀 선택을 해야 하는 상태 이외에도, 단말이 특정 셀에 접속된 후에라도 콜 드랍(call drop)이나, 휴지 기간 등의 여러 가지 이유로 아이들 상태에 있을 때, 지속적으로 최적의 셀을 탐색하고, 필요 시 다른 셀로 접속하여야 하므로 이러한 동작에 있어서도 일반적으로 적용될 수 있다.

[636] 구체적 예시로는, 이와 같이 단말이 아이들 상태에서 특정 셀에 접속하기 위해서는, 본 발명에서의 제안 방식이 우선 기존과 같이 CRS 기반으로 가장 평균 수신 파워가 강한 특정 셀의 시스템 정보를 획득하고 여기에 주변 인접 셀들의 상기 RRM-RS와 같은 목적의 RS 관련 정보가 제공되는 경우, 이에 따라 UE는 (아이들 상태에서) 인접 셀들의 RRM-RS 등을 함께 측정하여, 인접 셀이 (상기 "FD-MIMO" 관점에서) 더 최적의 셀(best cell)인 경우 해당 인접 셀로 (아이들 상태에서) 바로 셀-재선택(cell-reselection)을 수행 후 해당 인접 셀로 접속하는 방식이 적용될 수 있다.

[637]

[638] 본 발명이 적용될 수 있는 장치 일반

[639] 도 19는 본 발명의 일 실시예에 따른 무선 통신 장치의 블록 구성도를 예시한다.

[640] 도 19를 참조하면, 무선 통신 시스템은 기지국(1910)과 기지국(1910) 영역 내에 위치한 다수의 단말(1920)을 포함한다.

[641] 기지국(1910)은 프로세서(processor, 1911), 메모리(memory, 1912) 및 RF부(radio frequency unit, 1913)을 포함한다. 프로세서(1911)는 앞서 도 1 내지 도 18에서 제안된 기능, 과정 및/또는 방법을 구현한다. 무선 인터페이스 프로토콜의 계층들은 프로세서(1911)에 의해 구현될 수 있다. 메모리(1912)는 프로세서(1911)와 연결되어, 프로세서(1911)를 구동하기 위한 다양한 정보를 저장한다. RF부(1913)는 프로세서(1911)와 연결되어, 무선 신호를 송신 및/또는 수신한다.

[642] 단말(1920)은 프로세서(1921), 메모리(1922) 및 RF부(1923)을 포함한다. 프로세서(1921)는 앞서 도 1 내지 도 18에서 제안된 기능, 과정 및/또는 방법을 구현한다. 무선 인터페이스 프로토콜의 계층들은 프로세서(1921)에 의해 구현될 수 있다. 메모리(1922)는 프로세서(1921)와 연결되어, 프로세서(1921)를 구동하기 위한 다양한 정보를 저장한다. RF부(1923)는 프로세서(1921)와 연결되어, 무선 신호를 송신 및/또는 수신한다.

[643] 메모리(1912, 1922)는 프로세서(1911, 1921) 내부 또는 외부에 있을 수 있고, 잘

알려진 다양한 수단으로 프로세서(1911, 1921)와 연결될 수 있다. 또한, 기지국(1910) 및/또는 단말(1920)은 한 개의 안테나(single antenna) 또는 다중 안테나(multiple antenna)를 가질 수 있다.

[644] 이상에서 설명된 실시예들은 본 발명의 구성요소들과 특징들이 소정 형태로 결합된 것들이다. 각 구성요소 또는 특징은 별도의 명시적 언급이 없는 한 선택적인 것으로 고려되어야 한다. 각 구성요소 또는 특징은 다른 구성요소나 특징과 결합되지 않은 형태로 실시될 수 있다. 또한, 일부 구성요소들 및/또는 특징들을 결합하여 본 발명의 실시예를 구성하는 것도 가능하다. 본 발명의 실시예들에서 설명되는 동작들의 순서는 변경될 수 있다. 어느 실시예의 일부 구성이나 특징은 다른 실시예에 포함될 수 있고, 또는 다른 실시예의 대응하는 구성 또는 특징과 교체될 수 있다. 특허청구범위에서 명시적인 인용 관계가 있지 않은 청구항들을 결합하여 실시예를 구성하거나 출원 후의 보정에 의해 새로운 청구항으로 포함시킬 수 있음은 자명하다.

[645] 본 발명에 따른 실시예는 다양한 수단, 예를 들어, 하드웨어, 펌웨어(firmware), 소프트웨어 또는 그것들의 결합 등에 의해 구현될 수 있다. 하드웨어에 의한 구현의 경우, 본 발명의 일 실시예는 하나 또는 그 이상의 ASICs(application specific integrated circuits), DSPs(digital signal processors), DSPDs(digital signal processing devices), PLDs(programmable logic devices), FPGAs(field programmable gate arrays), 프로세서, 콘트롤러, 마이크로 콘트롤러, 마이크로 프로세서 등에 의해 구현될 수 있다.

[646] 펌웨어나 소프트웨어에 의한 구현의 경우, 본 발명의 일 실시예는 이상에서 설명된 기능 또는 동작들을 수행하는 모듈, 절차, 함수 등의 형태로 구현될 수 있다. 소프트웨어 코드는 메모리에 저장되어 프로세서에 의해 구동될 수 있다. 상기 메모리는 상기 프로세서 내부 또는 외부에 위치하여, 이미 공지된 다양한 수단에 의해 상기 프로세서와 데이터를 주고 받을 수 있다.

[647] 본 발명은 본 발명의 필수적 특징을 벗어나지 않는 범위에서 다른 특정한 형태로 구체화될 수 있음은 당업자에게 자명하다. 따라서, 상술한 상세한 설명은 모든 면에서 제한적으로 해석되어서는 아니 되고 예시적인 것으로 고려되어야 한다. 본 발명의 범위는 첨부된 청구항의 합리적 해석에 의해 결정되어야 하고, 본 발명의 등가적 범위 내에서의 모든 변경은 본 발명의 범위에 포함된다.

산업상 이용가능성

[648] 본 발명의 무선 통신 시스템에서 단말이 무선 링크 모니터링 방안은 3GPP LTE/LTE-A 시스템에 적용되는 예를 중심으로 설명하였으나, 3GPP LTE/LTE-A 시스템 이외에도 다양한 무선 통신 시스템에 적용하는 것이 가능하다.

청구범위

[청구항 1] 무선 통신 시스템에서 단말이 무선 링크 모니터링(RLM: radio link monitoring)을 수행하는 방법에 있어서,
셀 특정 참조 신호(CRS: cell-specific reference signal) 이외 참조 신호를 기반으로 셀에 대한 제2 RLM을 수행하는 단계; 및
상기 제2 RLM을 기반으로 상기 셀에 대한 무선 링크 실패(RLF: radio link failure)를 판단하는 단계를 포함하고,
상기 제2 RLM에 적용되는 RLF 판단을 위한 판단 조건은 CRS 기반 제1 RLM에 적용되는 RLF 판단을 위한 판단 조건과 상이한 무선 링크 모니터링 방법.

[청구항 2] 제1항에 있어서,
상기 CRS 기반으로 상기 제1 RLM을 수행하는 단계를 더 포함하고,
상기 셀에 대한 RLF는 상기 제1 RLM 및 상기 제2 RLM을 기반으로 판단되는 무선 링크 모니터링 방법.

[청구항 3] 제1항에 있어서,
상기 RLF 판단을 위한 판단 조건은 제어 채널 전송 파라미터, 비동기(out-of-sync)/동기(in-sync) 상태 판단을 위한 임계값 및 RLF 타이머 중 적어도 어느 하나를 포함하는 무선 링크 모니터링 방법.

[청구항 4] 제1항에 있어서,
상기 제2 RLM의 경우, 상기 제2 모니터링을 위한 하향링크 제어 정보(DCI: Downlink Control Information)가 소정의 진보된 물리 하향링크 제어 채널(EPDCCH: Enhanced Physical Downlink Control Channel) 세트로부터 전송된다고 가정되는 무선 링크 모니터링 방법.

[청구항 5] 제1항에 있어서,
상기 단말이 풀 차원 다중 입력 다중 출력(FD-MIMO: full dimension-Multi Input Multi Output) 지원 가능한 경우, 상기 제2 RLM이 수행되는 무선 링크 모니터링 방법.

[청구항 6] 제1항에 있어서,
상기 단말이 FD-MIMO 지원 가능하고 상기 단말이 FD-MIMO 모드가 활성화된 경우, 상기 제2 RLM이 수행되는 무선 링크 모니터링 방법.

[청구항 7] 제2항에 있어서,
상기 셀에 대한 RLF가 상기 제1 RLM 및 상기 제2 RLM을 기반으로 판단되는 경우,
상기 제1 RLM 및 상기 제2 RLM 중 적어도 어느 하나에 의해 상기 셀에 대한 RLF가 결정되면, 상기 셀에 대한 RLF가 결정되는 무선 링크 모니터링 방법.

[청구항 8] 제7항에 있어서,

상기 제1 RLM 및 상기 제2 RLM 중 어느 하나가 상기 셀에 대한 RLF 판단에 있어서 높은 우선 순위를 가지는 무선 링크 모니터링 방법.

[청구항 9] 제2항에 있어서,
상기 셀에 대한 RLF가 상기 제1 RLM 및 상기 제2 RLM을 기반으로 판단되는 경우,
상기 제1 RLM 및 상기 제2 RLM 모두에 의해 상기 셀에 대한 RLF가 결정되면, 상기 셀에 대한 RLF가 결정되는 무선 링크 모니터링 방법.

[청구항 10] 제2항에 있어서,
상기 제2 RLM은 상기 제1 RLM에 의해 소정의 조건이 만족되는 경우 수행되는 무선 링크 모니터링 방법.

[청구항 11] 제10항에 있어서,
상기 제1 RLM에 의한 RLF 타이머가 가동된 시점으로부터 소정의 오프셋 시간 이후 상기 제2 RLM이 개시되는 무선 링크 모니터링 방법.

[청구항 12] 제11항에 있어서,
상기 제1 RLM에 의한 RLF 타이머가 가동된 시점으로부터 상기 단말에 의한 다른 셀의 선택(selection) 또는 재선택(reselection) 절차가 완료되기까지 구간 동안, 상기 제2 RLM과 연계된 EPDCCH 세트를 통해 DCI가 수신되고, 상기 DCI에 의해 스케줄링된 물리 하향링크 공유 채널(PDSCH: Physical Downlink Shared Channel)를 통해 하향링크 데이터가 수신되는 무선 링크 모니터링 방법.

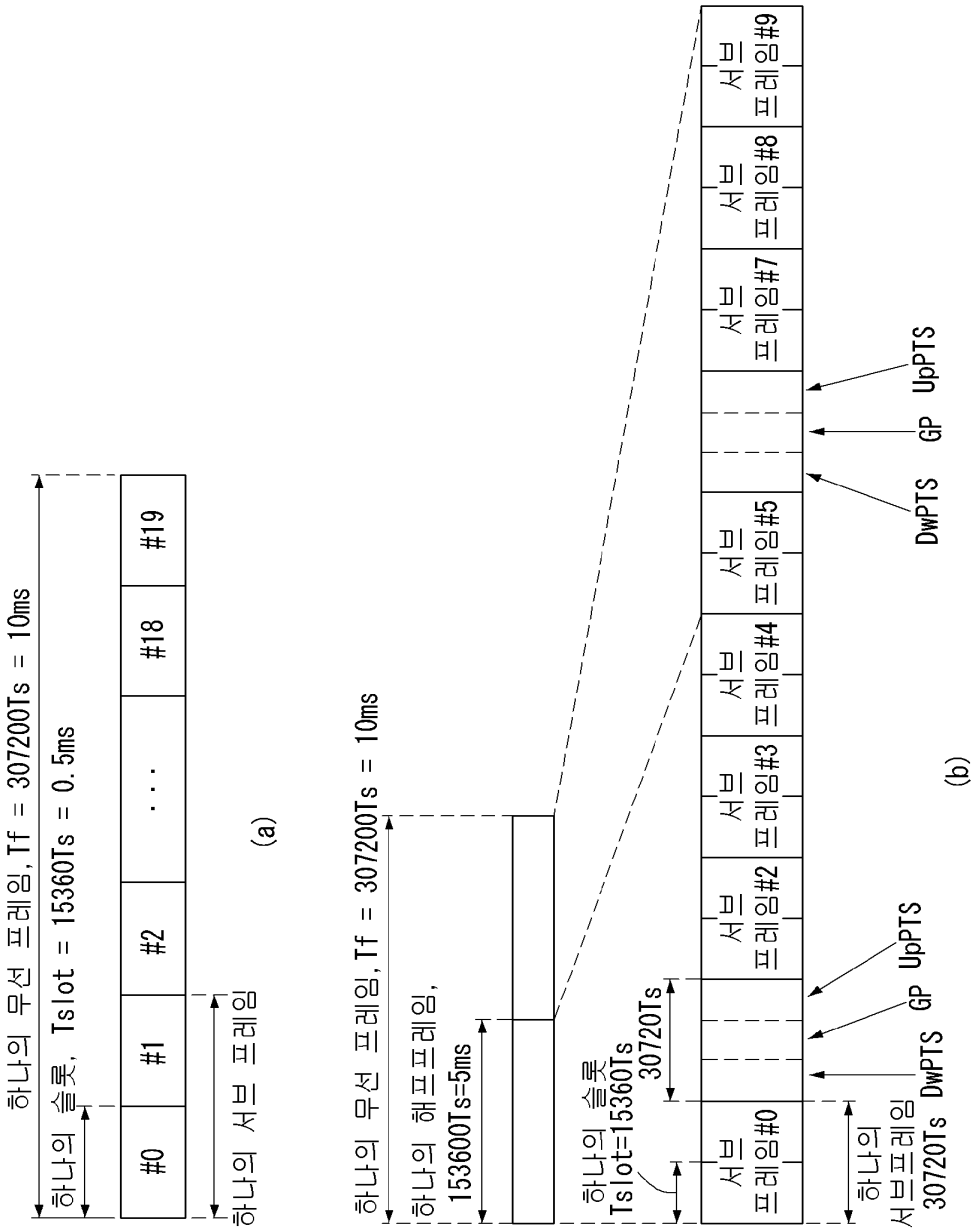
[청구항 13] 제12항에 있어서,
미리 정해진 무선 네트워크 임시 식별자(RNTI: Radio Network Temporary Identifier)로 마스킹된 DCI만 상기 EPDCCH 세트를 통해 수신되는 무선 링크 모니터링 방법.

[청구항 14] 제1항에 있어서,
상기 CSI 이외 참조 신호는 채널 상태 정보 참조 신호(CSI-RS: Channel State Information-Reference Signal), 디스커버리 참조 신호(DRS: Discovery Reference Signal), 프리코딩된(precoded) 참조 신호 및 셀 (재)선택 관련 동작 시에 적용하도록 설정된 참조 서로 다른 셀 또는 전송 포인트(TP: Transmission Point)의 개수로 구성되는 무정형 셀(amorphous cell)에서 전송되는 참조 신호 중 어느 하나인 무선 링크 모니터링 방법.

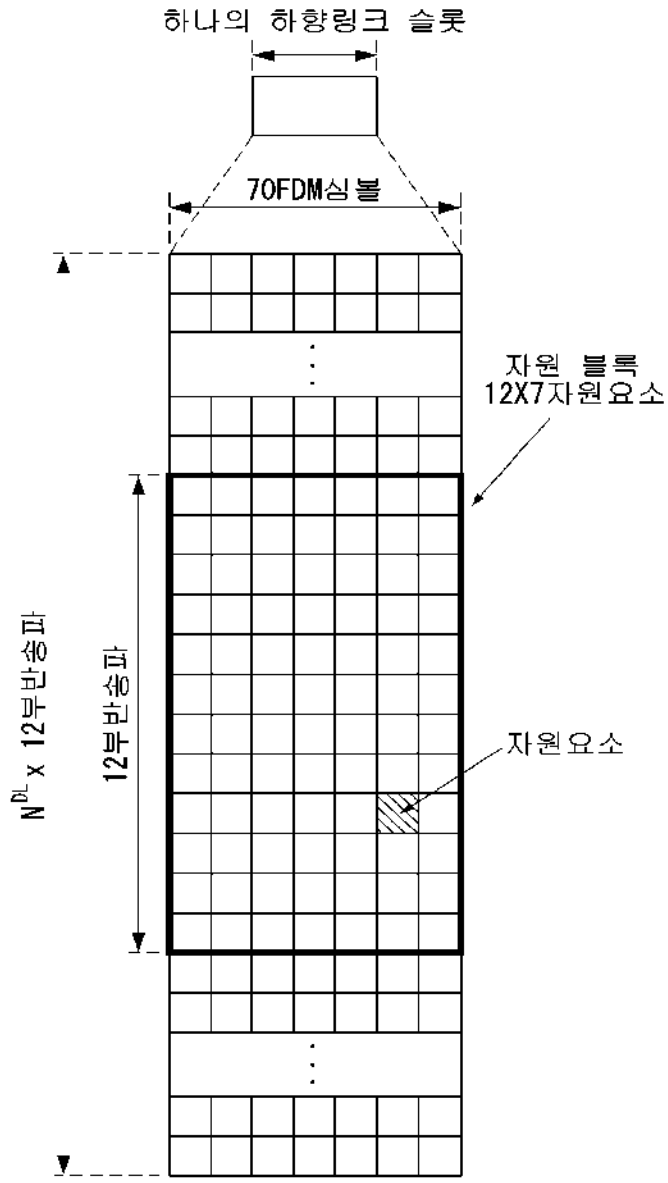
[청구항 15] 무선 통신 시스템에서 무선 링크 모니터링(RLM: radio link monitoring)을 수행하는 단말에 있어서,
무선 신호를 송수신하기 위한 RF(Radio Frequency) 유닛; 및
상기 RF 유닛을 제어하는 프로세서를 포함하고,
상기 셀 특정 참조 신호(CRS: cell-specific reference signal) 이외 참조 신호를 기반으로 셀에 대한 제2 RLM을 수행하고,
상기 제2 RLM을 기반으로 상기 셀에 대한 무선 링크 실패(RLF: radio link

failure)를 판단하도록 구성되고,
상기 제2 RLM에 적용되는 RLF 판단을 위한 판단 조건은 CRS 기반 제1 RLM에 적용되는 RLF 판단을 위한 판단 조건과 상이한 단말.

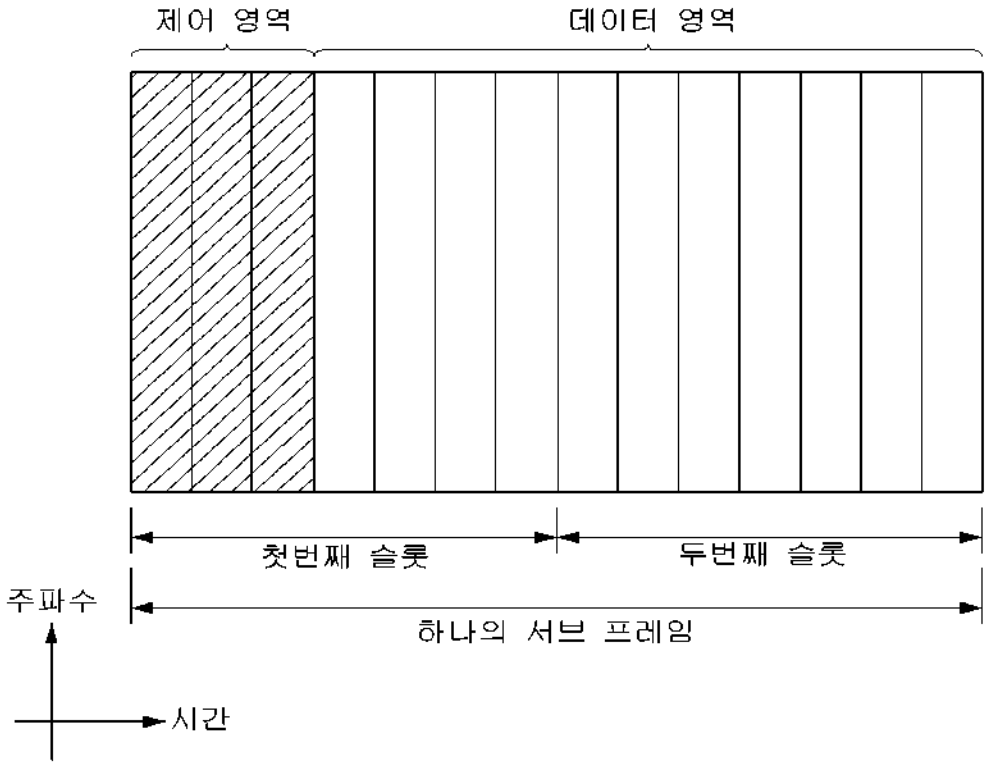
[도1]


하나의 무선 프레임, Tf = 307200Ts = 10ms
하나의 슬롯, Tslot = 15360Ts = 0.5ms
#0
#1
#2
...
#18
#19
하나의 서브 프레임
(a)
하나의 무선 프레임, Tf = 307200Ts = 10ms
하나의 해프프레임, 153600Ts=5ms
하나의 슬롯 Tslot=15360Ts
30720Ts
서브 프레임#0
서브 프레임#2
서브 프레임#3
서브 프레임#4
서브 프레임#5
서브 프레임#7
서브 프레임#8
서브 프레임#9
UpPTS
GP
DwPTS
하나의 서브프레임 30720Ts
(b)

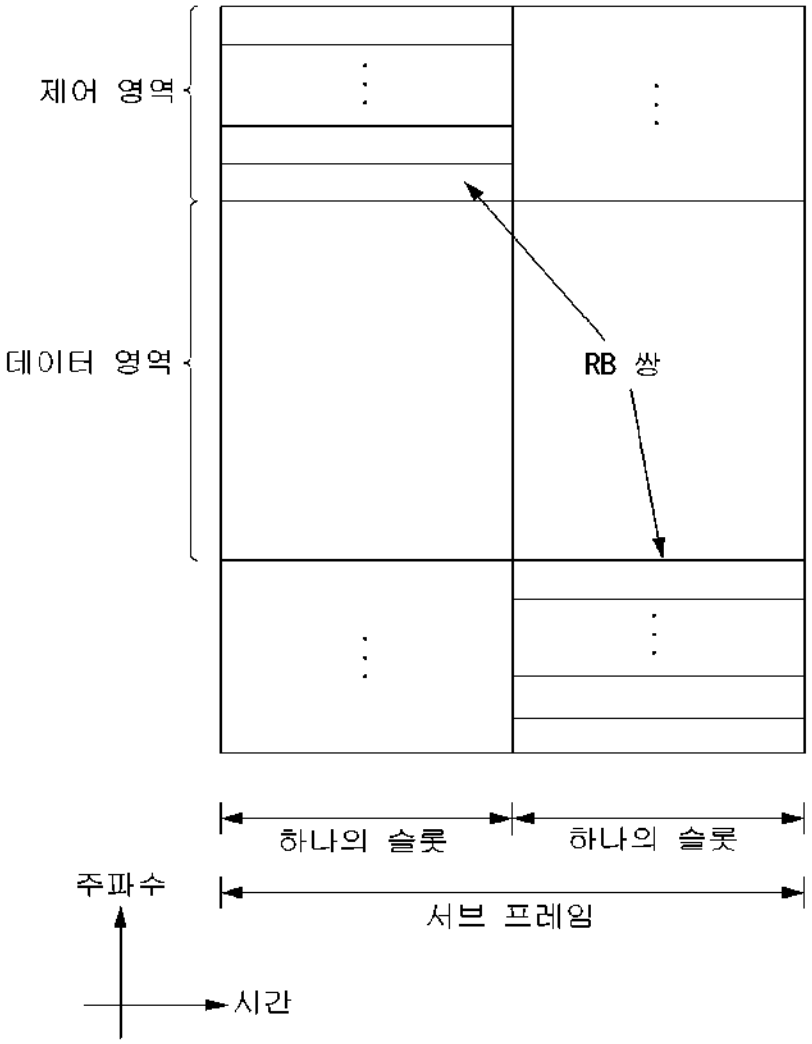
[도2]



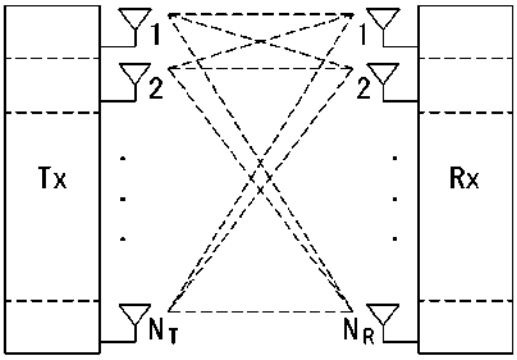
[도3]



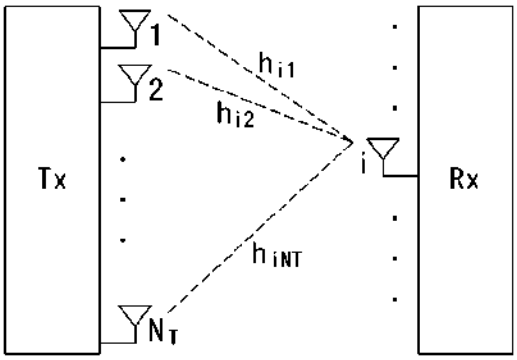
[도4]



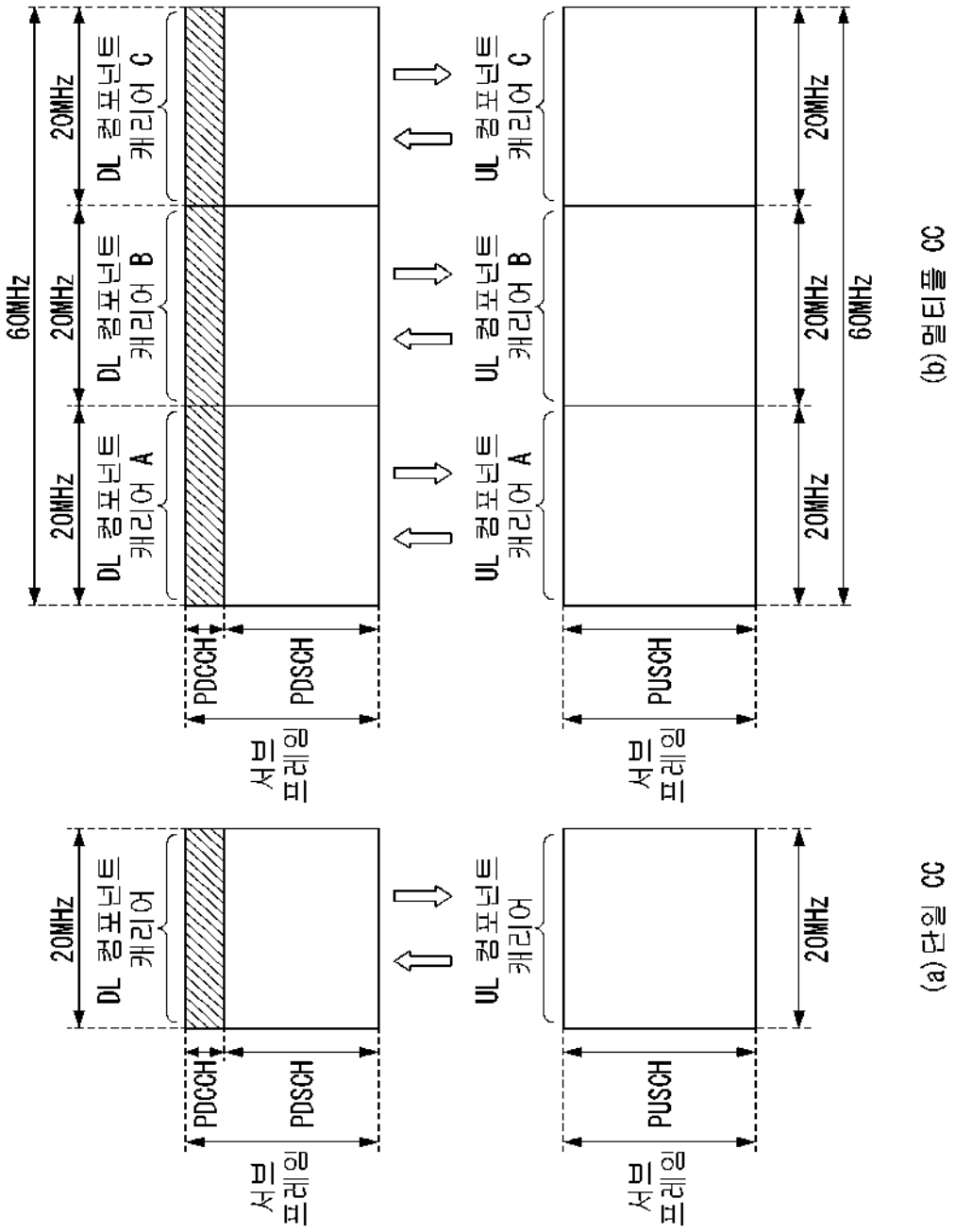
[도5]



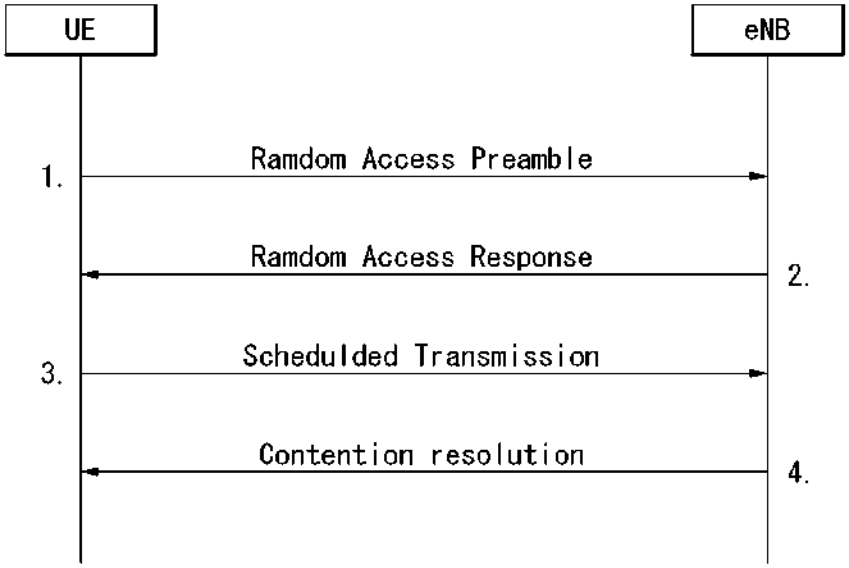
[도6]



[도7]

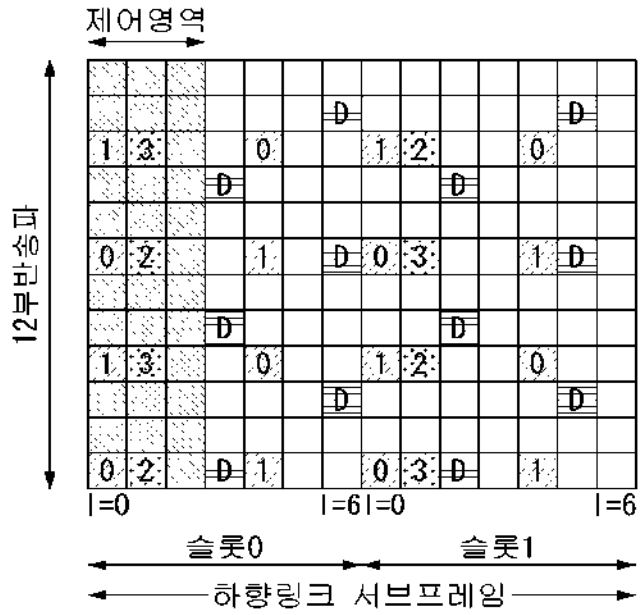

60MHz
20MHz
20MHz
20MHz
DL 컴포넌트 캐리어 A
DL 컴포넌트 캐리어 B
DL 컴포넌트 캐리어 C
PDCCH
PDSCH
서브프레임
UL 컴포넌트 캐리어 A
UL 컴포넌트 캐리어 B
UL 컴포넌트 캐리어 C
PUSCH
서브프레임
(b) 멀티플 CC
20MHz
DL 컴포넌트 캐리어
PDCCH
PDSCH
서브프레임
UL 컴포넌트 캐리어
PUSCH
서브프레임
(a) 단일 CC

[도8]

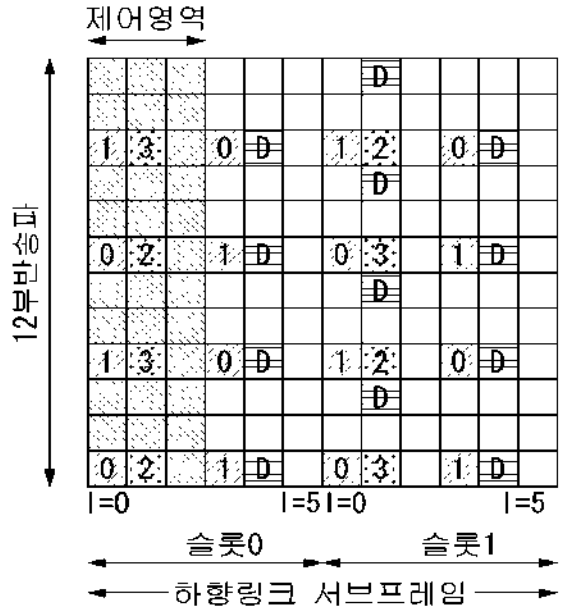

UE
eNB
1.
Ramdom Access Preamble
Ramdom Access Response
2.
3.
Schedulded Transmission
Contention resolution
4.

[도9]

(a)

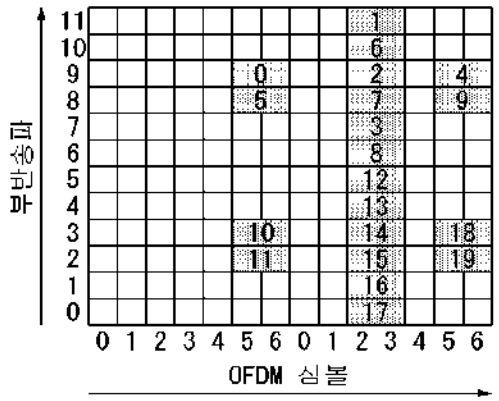

제어영역
12부반송파
l=0
l=6
l=0
l=6
슬롯0
슬롯1
하향링크 서브프레임

(b)

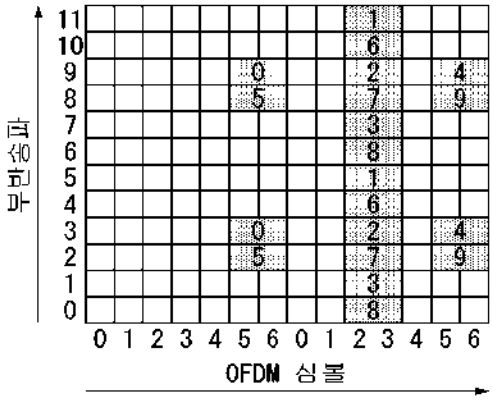

제어영역
12부반송파
l=0
l=5
l=0
l=5
슬롯0
슬롯1
하향링크 서브프레임

[도10]

(a) 1개 또는 2개 CSI-RS 포트



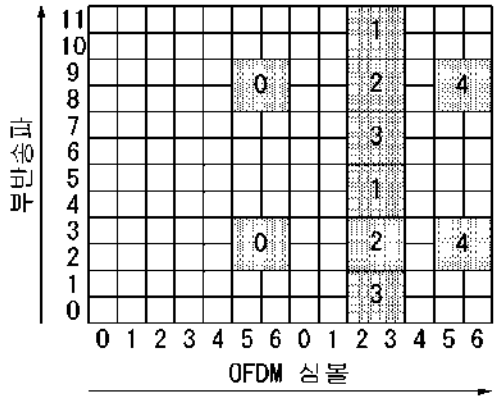
(b) 4개 CSI-RS 포트



i :1개 또는 2개 CSI-RS 포트를 위해 이용가능한 CSI-RS 구성 i

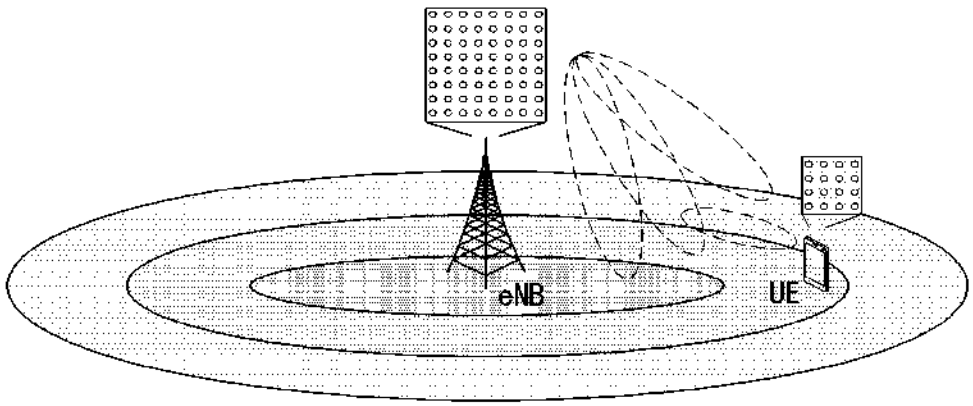
i :4개 CSI-RS 포트를 위해 이용가능한 CSI-RS 구성 i

(c) 8개 CSI-RS 포트

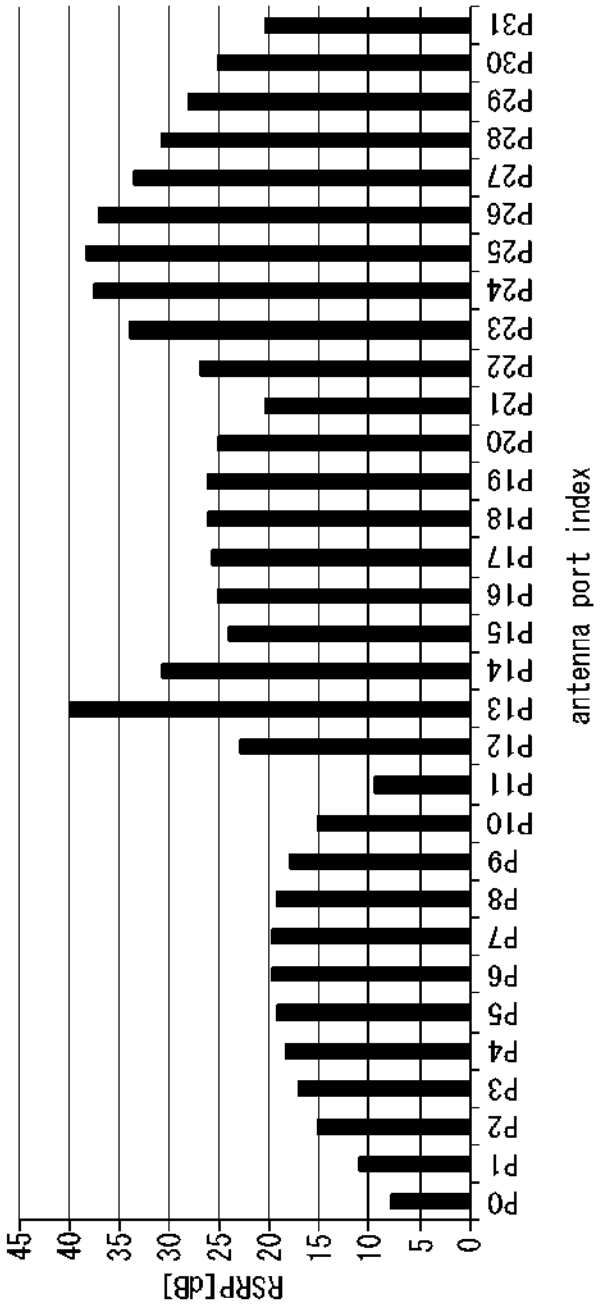


i :8개 CSI-RS 포트를 위해 이용가능한 CSI-RS 구성 i

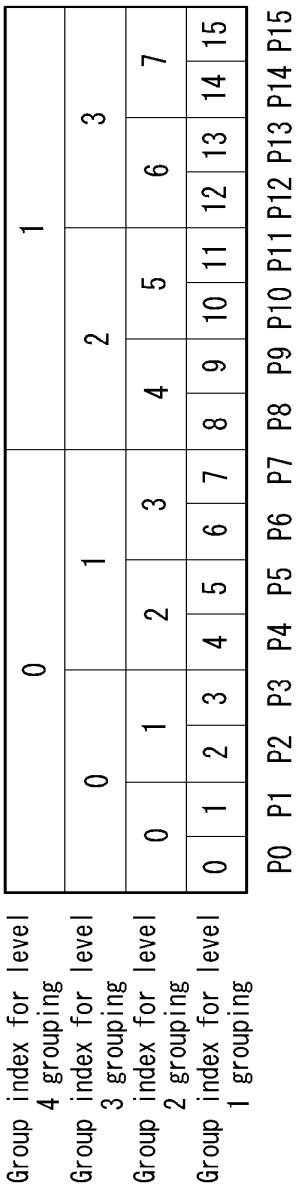
[도11]



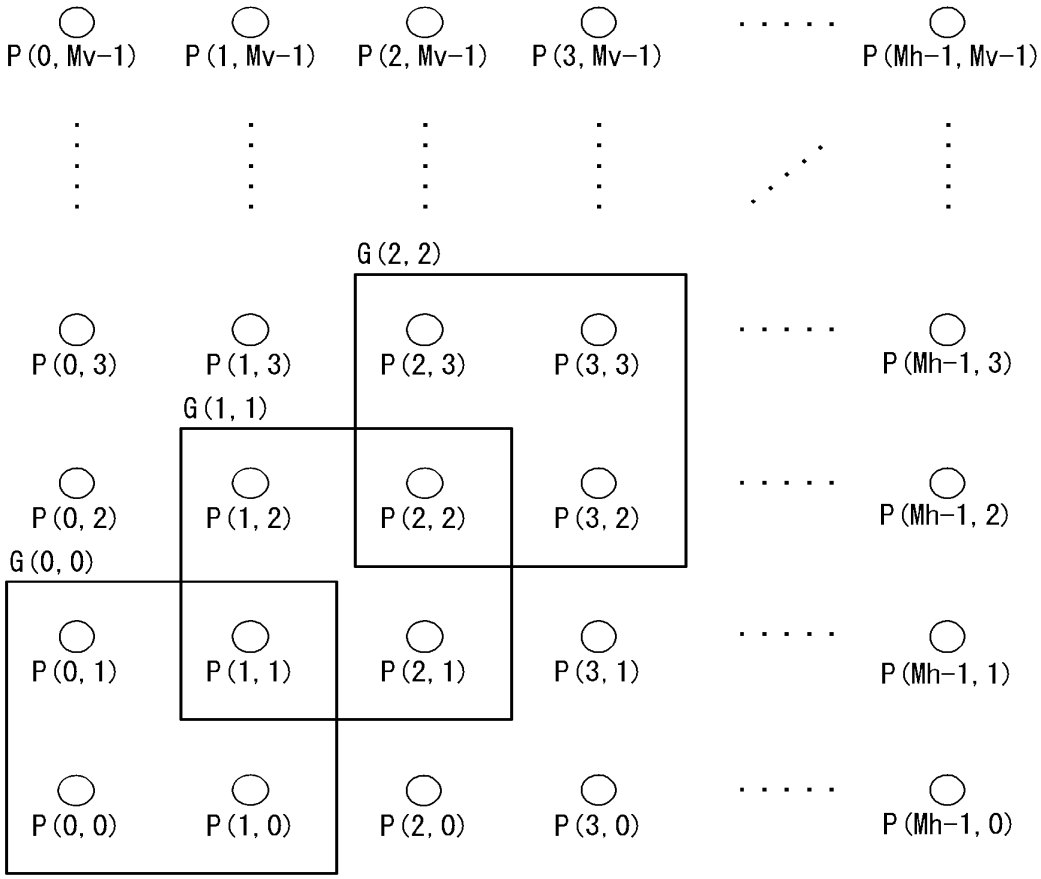
[도12]


RSRP[dB]
45
40
35
30
25
20
15
10
5
0
antenna port index
P0
P1
P2
P3
P4
P5
P6
P7
P8
P9
P10
P11
P12
P13
P14
P15
P16
P17
P18
P19
P20
P21
P22
P23
P24
P25
P26
P27
P28
P29
P30
P31

[도13]


Group index for level 4 grouping
Group index for level 3 grouping
Group index for level 2 grouping
Group index for level 1 grouping
0
1
0
1
2
3
0
1
2
3
4
5
6
7
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
P0 P1 P2 P3 P4 P5 P6 P7 P8 P9 P10 P11 P12 P13 P14 P15

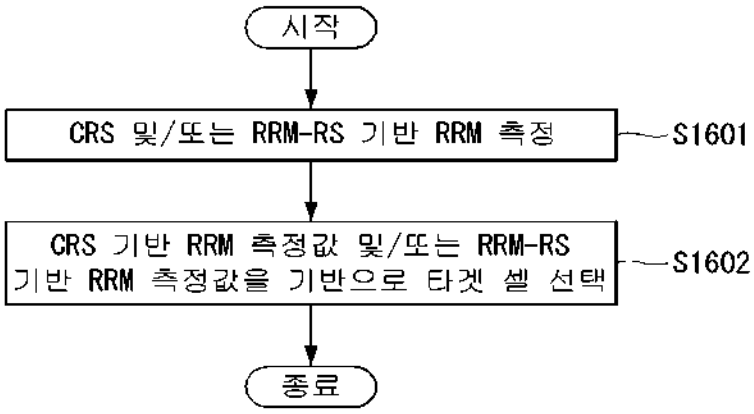
[도14]


P(0, Mv-1)
P(1, Mv-1)
P(2, Mv-1)
P(3, Mv-1)
P(Mh-1, Mv-1)
G(2, 2)
P(0, 3)
P(1, 3)
P(2, 3)
P(3, 3)
P(Mh-1, 3)
G(1, 1)
P(0, 2)
P(1, 2)
P(2, 2)
P(3, 2)
P(Mh-1, 2)
G(0, 0)
P(0, 1)
P(1, 1)
P(2, 1)
P(3, 1)
P(Mh-1, 1)
P(0, 0)
P(1, 0)
P(2, 0)
P(3, 0)
P(Mh-1, 0)

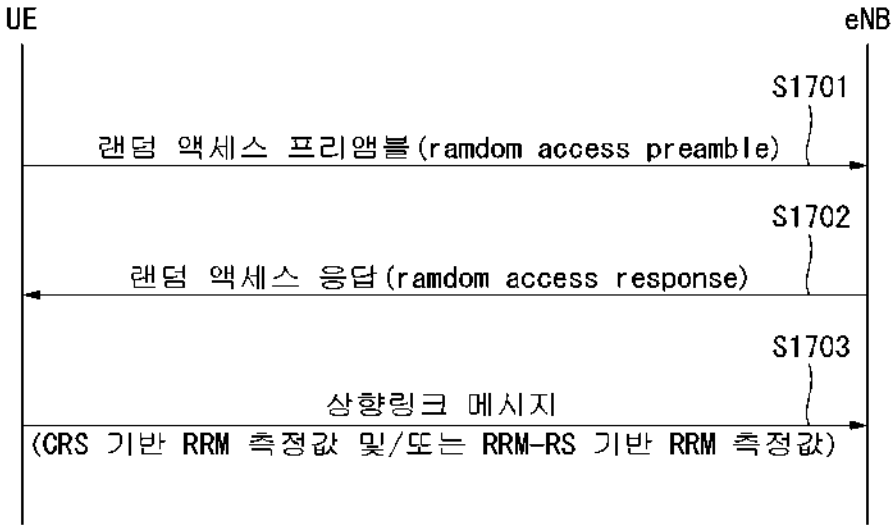
[도15]


UE
eNB
S1501
시스템 정보 (RRM-RS 설정 정보)

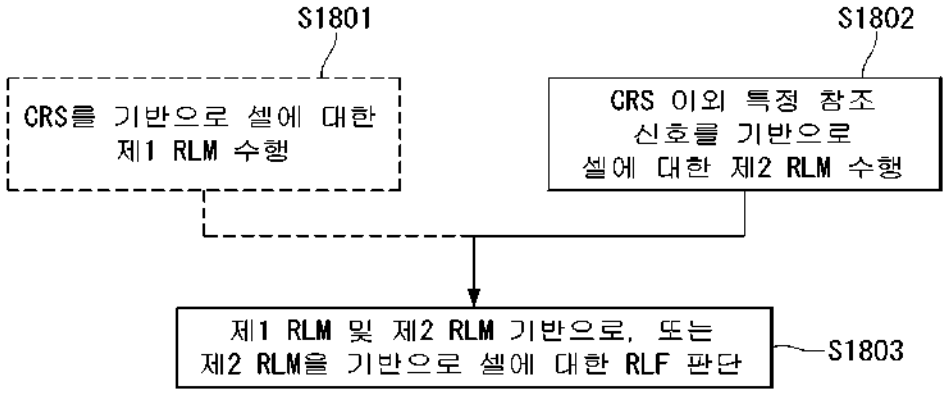
[도16]


시작
CRS 및/또는 RRM-RS 기반 RRM 측정
S1601
CRS 기반 RRM 측정값 및/또는 RRM-RS 기반 RRM 측정값을 기반으로 타겟 셀 선택
S1602
종료

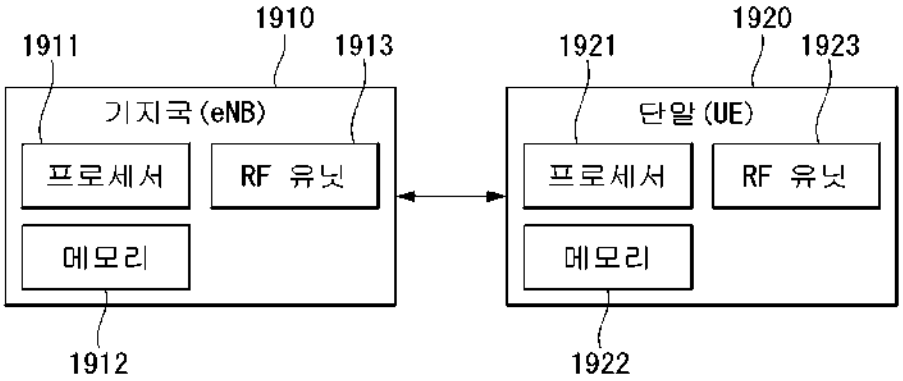
[도17]


UE
eNB
S1701
랜덤 액세스 프리앰블(ramdom access preamble)
S1702
랜덤 액세스 응답(ramdom access response)
S1703
상향링크 메시지
(CRS 기반 RRM 측정값 및/또는 RRM-RS 기반 RRM 측정값)

[도18]


S1801
CRS를 기반으로 셀에 대한 제1 RLM 수행
S1802
CRS 이외 특정 참조 신호를 기반으로 셀에 대한 제2 RLM 수행
제1 RLM 및 제2 RLM 기반으로, 또는 제2 RLM을 기반으로 셀에 대한 RLF 판단
S1803

[도19]


1910
1911
1913
기지국(eNB)
프로세서
RF 유닛
메모리
1912
1920
1921
1923
단말(UE)
프로세서
RF 유닛
메모리
1922

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2016/000945

A. CLASSIFICATION OF SUBJECT MATTER

H04B 17/382(2014.01)i, H04B 7/04(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04B 17/382; H04W 24/00; H04W 56/00; H04W 24/10; **H**04W 24/08; **H**04B 7/04

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Utility models and applications for Utility models: IPC as above
Japanese Utility models and applications for Utility models: IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS (KIPO internal) & Keywords: radio link monitoring(RLM: radio link monitoring), CRS, primary RLM, secondary RLM, radio link failure (RLF: radio link failure), determination condition, different, control channel transmission parameter, out-of-sync (out-of-sync)/in-sync(in-sync), RLF timer, DCI, EPDCCH, FD-MIMO, cell section, cell resection, RNTI, CSI-RS, DRS, amorphous cell

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2014-093659 A (NTT DOCOMO, INC.) 19 May 2014 See paragraphs [0020]-[0063]; and figures 4-8.	1-4,7,9,14,15
Y		5,6
A		8,10-13
Y	SONY, "On Reference Signals from RRM Measurements in FD-MIMO", R1-145022, 3GPP TSG RAN WG1 #79, San Francisco, USA, 08 November 2014 See pages 1, 2.	5,6
A	US 2014-0043988 A1 (QUALCOMM INCORPORATED) 13 February 2014 See paragraphs [0056]-[0065]; claims 1, 12, 16-20; and figure 5.	1-15
A	WO 2014-068535 A2 (RENESAS MOBILE CORPORATION) 08 May 2014 See page 10, line 20-page 16, line 11; and figures 3, 4.	1-15
A	US 2013-0252606 A1 (NIMBALKER, Ajit et al.) 26 September 2013 See paragraphs [0048]-[0065]; and figures 4, 5.	1-15

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
04 MAY 2016 (04.05.2016)	**04 MAY 2016 (04.05.2016)**
Name and mailing address of the ISA/KR Korean Intellectual Property Office Government Complex-Daejeon, 189 Seonsa-ro, Daejeon 302-701, Republic of Korea Facsimile No. 82-42-472-7140	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2016/000945

Patent document cited in search report	Publication date	Patent family member	Publication date
JP 2014-093659 A	19/05/2014	EP 2916581 A1	09/09/2015
		US 2015-0296487 A1	15/10/2015
		WO 2014-069382 A1	08/05/2014
US 2014-0043988 A1	13/02/2014	CN 104509018 A	08/04/2015
		KR 10-1551743 B1	09/09/2015
		KR 10-2015-0041007 A	15/04/2015
		US 8976698 B2	10/03/2015
		WO 2014-025380 A1	13/02/2014
WO 2014-068535 A2	08/05/2014	GB 201219885 D0	19/12/2012
		GB 2507570 A	07/05/2014
		WO 2014-068535 A3	24/07/2014
US 2013-0252606 A1	26/09/2013	CN 104303562 A	21/01/2015
		EP 2829130 A1	28/01/2015
		US 8971881 B2	03/03/2015
		WO 2013-142222 A1	26/09/2013
		WO 2013-142222 A8	16/10/2014

Form PCT/ISA/210 (patent family annex) (January 2015)

국 제 조 사 보 고 서

국제출원번호
PCT/KR2016/000945

A. 발명이 속하는 기술분류(국제특허분류(IPC))

H04B 17/382(2014.01)i, H04B 7/04(2006.01)i

B. 조사된 분야

조사된 최소문헌(국제특허분류를 기재)

H04B 17/382; H04W 24/00; H04W 56/00; H04W 24/10; H04W 24/08; H04B 7/04

조사된 기술분야에 속하는 최소문헌 이외의 문헌

한국등록실용신안공보 및 한국공개실용신안공보: 조사된 최소문헌란에 기재된 IPC

일본등록실용신안공보 및 일본공개실용신안공보: 조사된 최소문헌란에 기재된 IPC

국제조사에 이용된 전산 데이터베이스(데이터베이스의 명칭 및 검색어(해당하는 경우))

eKOMPASS(특허청 내부 검색시스템) & 키워드: 무선 링크 모니터링 (RLM: radio link monitoring), 셀 특정 참조 신호 (CRS), 제1 RLM, 제2 RLM, 무선 링크 실패 (RLF: radio link failure), 판단 조건, 상이, 에어 체넌 전송 파라미터, 비동기(out of sync)/동기(in sync), RLF 타이머, DCI, EPDCCH, FD-MIMO, 셀 선택, 셀 재선택, RNTI, CSI-RS, DRS, 무정형 셀

C. 관련 문헌

카테고리*	인용문헌명 및 관련 구절(해당하는 경우)의 기재	관련 청구항
X	JP 2014-093659 A (NTT DOCOMO, INC.) 2014.05.19 단락 [0020]-[0063]; 및 도면 4-8 참조.	1-4,7,9,14,15
Y		5,6
A		8,10-13
Y	SONY, 'On reference signals from RRM measurements in FD-MIMO', R1-145022, 3GPP TSG RAN WG1 #79, San Francisco, USA, 2014.11.08 페이지 1, 2 참조.	5,6
A	US 2014-0043988 A1 (QUALCOMM INCORPORATED) 2014.02.13 단락 [0056]-[0065]; 청구항 1, 12, 16-20; 및 도면 5 참조.	1-15
A	WO 2014-068535 A2 (RENESAS MOBILE CORPORATION) 2014.05.08 페이지 10, 라인 20 - 페이지 16, 라인 11; 및 도면 3, 4 참조.	1-15
A	US 2013-0252606 A1 (AJIT NIMBALKER 등) 2013.09.26 단락 [0048]-[0065]; 및 도면 1, 5 참조.	1-15

☐ 추가 문헌이 C(계속)이 기재되어 있습니다.

☒ 대응특허에 관한 별지를 참조하십시오.

* 인용된 문헌의 특별 카테고리

"A" 특별히 관련이 없는 것으로 보이는 일반적인 기술수준을 정의한 문헌

"B" 국제출원일보다 빠른 출원일 또는 우선일을 가지나 국제출원일 이후에 공개된 선출원 또는 특허 문헌

"L" 우선권 주장에 의문을 제기하는 문헌 또는 다른 인용문헌의 공개일 또는 다른 특별한 이유(이유를 명시)를 밝히기 위하여 인용된 문헌

"O" 구두 개시, 사용, 전시 또는 기타 수단을 언급하고 있는 문헌

"P" 우선일 이후에 공개되었으나 국제출원일 이전에 공개된 문헌

"T" 국제출원일 또는 우선일 후에 공개된 문헌으로, 출원과 상충하지 않으며 발명의 기초가 되는 원리나 이론을 이해하기 위해 인용된 문헌

"X" 특별한 관련이 있는 문헌. 해당 문헌 하나만으로 청구된 발명의 신규성 또는 진보성이 없는 것으로 본다.

"Y" 특별한 관련이 있는 문헌. 해당 문헌이 하나 이상의 다른 문헌과 조합하는 것으로 그 조합이 당업자에게 자명한 경우 청구된 발명은 진보성이 없는 것으로 본다.

"&" 동일한 대응특허문헌에 속하는 문헌

국제조사의 실제 완료일	국제조사보고서 발송일
2016년 05월 04일 (04.05.2016)	2016년 05월 04일 (04.05.2016)

ISA/KR의 명칭 및 우편주소
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서식 PCT/ISA/210 (두 번째 용지) (2015년 1월)

국 제 조 사 보 고 서
대응특허에 관한 정보

국제출원번호
PCT/KR2016/000945

국제조사보고서에서 인용된 특허문헌	공개일	대응특허문헌	공개일
JP 2014-093659 A	2014/05/19	EP 2916581 A1	2015/09/09
		US 2015-0296487 A1	2015/10/15
		WO 2014-069382 A1	2014/05/08
US 2014-0043988 A1	2014/02/13	CN 104509018 A	2015/04/08
		KR 10-1551743 B1	2015/09/09
		KR 10-2015-0041007 A	2015/04/15
		US 8976698 B2	2015/03/10
		WO 2014-025380 A1	2014/02/13
WO 2014-068535 A2	2014/05/08	GB 201219885 D0	2012/12/19
		GB 2507570 A	2014/05/07
		WO 2014-068535 A3	2014/07/24
US 2013-0252606 A1	2013/09/26	CN 104303562 A	2015/01/21
		EP 2829130 A1	2015/01/28
		US 8971881 B2	2015/03/03
		WO 2013-142222 A1	2013/09/26
		WO 2013-142222 A8	2014/10/16

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(51) International Patent Classification:
H04W 72/04 (2009.01)

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PCT/CN2016/000597

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03 November 2016 (03.11.2016)

(25) Filing Language: English

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(71) Applicant: **NEC CORPORATION** [JP/JP]; 7-1, Shiba 5-chome, Minato-ku, Tokyo 108-8001 (JP).

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(71) Applicant *(for SC only)*: **LIU, Hongmei** [CN/CN]; 11F, Bldg. A, Innovation Plaza, Tsinghua Science Park, Haidian District, Beijing 100084 (CN).

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

(54) Title: METHOD AND DEVICE FOR INDICATING NUMEROLOGY

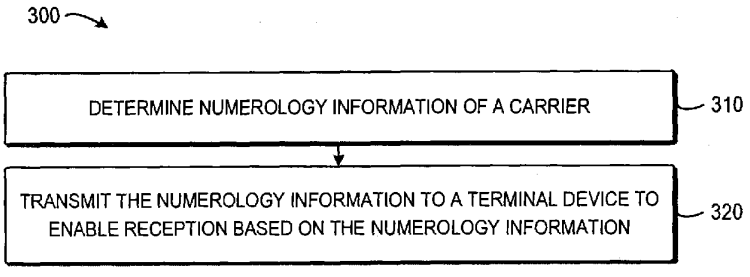


FIG. 3

(57) Abstract: Embodiments of the disclosure provide a method and device for indicating numerology. The method comprises: determining numerology information of a carrier, the numerology information indicating numerologies of one or more basic units for the carrier; and transmitting the numerology information to a terminal device to enable reception based on the numerology information.

WO 2018/081913 A1

METHOD AND DEVICE FOR INDICATING NUMEROLOGY

FIELD OF THE INVENTION

[0001] Embodiments of the present disclosure generally relate to communication techniques. More particularly, embodiments of the present disclosure relate to a method and device for indicating numerology.

BACKGROUND OF THE INVENTION

[0002] Newly-developed mobile standards call for higher data transfer speeds, greater numbers of connections, and better coverage, among other improvements. The 5G standard, according to the Next Generation Mobile Networks Alliance, is expected to provide data rates of several tens of megabits per second to each of tens of thousands of users, with 1 gigabit per second to tens of workers on an office floor. Several hundreds of thousands of simultaneous connections should be supported in order to support large sensor deployments. Consequently, the spectral efficiency is expected to be enhanced to meet more requirements of the new standards.

[0003] Conventionally, for a single carrier, there is one numerology. Therefore, terminal devices have to employ the same numerology in communication with a network device. This inevitably brings undesired, delays, low spectral efficiency for some kind of traffic.

[0004] Accordingly, there is a need for development of better transmission/processing techniques for wireless data transmission to meet different requirements of different applications/users at the same time.

SUMMARY OF THE INVENTION

[0005] The present disclosure proposes a solution for indicating numerology.

[0006] According to a first aspect of embodiments of the present disclosure, embodiments of the disclosure provide a method performed by a network device. The network device determines numerology information of a carrier. The numerology information indicates numerologies of one or more basic units for the

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carrier. Then the network device transmits the numerology information to a terminal device to enable reception based on the numerology information.

[0007] According to a second aspect of embodiments of the present disclosure, embodiments of the disclosure provide method performed by a terminal device. The terminal device receives numerology information of a carrier from a network device. The numerology information indicates numerologies of one or more basic units for the carrier. Then the terminal device decodes a signal based on the numerology information.

[0008] According to a third aspect of embodiments of the present disclosure, embodiments of the disclosure provide a network device. The network device comprises: a controller configured to determine numerology information of a carrier, the numerology information indicating numerologies of one or more basic units for the carrier; and a transmitter the numerology information to a terminal device to enable reception based on the numerology information.

[0009] According to a fourth aspect of embodiments of the present disclosure, embodiments of the disclosure provide a terminal device. The terminal device comprises: a receiver configured to receive numerology information of a carrier from a network device, the numerology information indicating numerologies of one or more basic units for the carrier; and a decoder configured to decode a signal based on the numerology information.

[0010] Other features and advantages of the embodiments of the present disclosure will also be apparent from the following description of specific embodiments when read in conjunction with the accompanying drawings, which illustrate, by way of example, the principles of embodiments of the disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Embodiments of the disclosure are presented in the sense of examples and their advantages are explained in greater detail below, with reference to the accompanying drawings, where

[0012] FIG. 1 illustrates a schematic diagram of a communication system 100 according to embodiments of the present disclosure;

[0013] FIG. 2A illustrates a diagram 200 of a basic unit in accordance with embodiments of the present disclosure;

[0014] FIG. 2B illustrates a diagram 260 of a basic unit in accordance with further embodiments of the present disclosure;

[0015] FIG. 3 illustrates a flow chart of a method 300 for performing communication according to embodiments of the present disclosure;

[0016] FIG. 4 illustrates a diagram 400 of the distributed indication according to embodiments of the present disclosure;

[0017] FIG. 5 illustrates a diagram 500 of the centralized indication according to embodiments of the present disclosure;

[0018] FIG. 6 illustrates a diagram 600 of a guard band 610 according to embodiments of the present disclosure;

[0019] FIG. 7 illustrates a diagram 700 of indication of a guard band according to embodiments of the present disclosure;

[0020] FIG. 8 illustrates a diagram 800 of indication of a guard band according to embodiments of the present disclosure;

[0021] FIG. 9 illustrates a diagram 900 of a resource unit 910 according to embodiments of the present disclosure;

[0022] FIG. 10 illustrates a diagram 1000 of information transmission according to embodiments of the present disclosure;

[0023] FIG. 11 illustrates a flow chart of a method 1100 for performing communication according to embodiments of the present disclosure;

[0024] FIG. 12 illustrates a schematic diagram of a network device 1200 according to an embodiment of the present disclosure; and

[0025] FIG. 13 illustrates a schematic diagram of a terminal device 1300 according to an embodiment of the present disclosure.

[0026] Throughout the figures, same or similar reference numbers indicate same or similar elements.

DETAILED DESCRIPTION OF EMBODIMENTS

[0027] The subject matter described herein will now be discussed with reference to several example embodiments. It should be understood these embodiments are discussed only for the purpose of enabling those skilled persons in the art to better understand and thus implement the subject matter described herein, rather than suggesting any limitations on the scope of the subject matter.

[0028] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of example embodiments. As used herein, the singular forms "a," "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises," "comprising," "includes" and/or "including," when used herein, specify the presence of stated features, integers, steps, operations, elements and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components and/or groups thereof.

[0029] It should also be noted that in some alternative implementations, the functions/acts noted may occur out of the order noted in the figures. For example, two functions or acts shown in succession may in fact be executed concurrently or may sometimes be executed in the reverse order, depending upon the functionality/acts involved.

[0030] As used herein, the term "communication network" refers to a network following any suitable communication standards, such as Long Term Evolution (LTE), LTE-Advanced (LTE-A), Wideband Code Division Multiple Access (WCDMA), High-Speed Packet Access (HSPA), and so on. Furthermore, the communications between a terminal device and a network device in the communication network may be performed according to any suitable generation communication protocols, including, but not limited to, the first generation (1G), the second generation (2G), 2.5G, 2.75G, the third generation (3G), the fourth generation (4G), 4.5G, the future fifth generation (5G) communication protocols, and/or any other protocols either currently known or to be developed in the future.

[0031] Embodiments of the present disclosure may be applied in various communication systems. Given the rapid development in communications, there

will of course also be future type communication technologies and systems with which the present disclosure may be embodied. It should not be seen as limiting the scope of the present disclosure to only the aforementioned system.

[0032] The term "network device" includes, but not limited to, a base station (BS), a gateway, a management entity, and other suitable device in a communication system. The term "base station" or "BS" represents a node B (NodeB or NB), an evolved NodeB (eNodeB or eNB), a Remote Radio Unit (RRU), a radio header (RH), a remote radio head (RRH), a relay, a low power node such as a femto, a pico, and so forth.

[0033] The term "terminal device" includes, but not limited to, "user equipment (UE)" and other suitable end device capable of communicating with the network device. By way of example, the "terminal device" may refer to a terminal, a Mobile Terminal (MT), a Subscriber Station (SS), a Portable Subscriber Station, a Mobile Station (MS), or an Access Terminal (AT).

[0034] Now some exemplary embodiments of the present disclosure will be described below with reference to the figures. Reference is first made to FIG. 1, which illustrates schematic diagram of a communication system 100 according to embodiments of the present disclosure.

[0035] In the communication system 100, there illustrate a network device (for example, an eNB) 110 that communicates with a terminal device (for example, a UE) 120 by using a certain transmission pattern. The network device 110 sends numerology information to the terminal device 120, wherein the numerology information indicates numerologies of one or more basic units for a carrier. As such, the terminal device 120 is enabled to receive signals from the network device 110 based on the numerology information.

[0036] In the context of the present disclosure, the term "numerology" refers to a set of parameters. In an Orthogonal Frequency Division Multiplexing (OFDM)-based system, the parameters include, for example, but not limited to, a subcarrier spacing, a symbol length, a length of a cyclic prefix (CP), and so on. For instance, a numerology for a subcarrier spacing of 15KHz may include 14 symbols in one subframe, a normal CP, and so on. A numerology for a subcarrier spacing of 30KHz may include 28 symbols in one subframe, a normal CP, and so on. Such a numerology is different from the numerology for the subcarrier spacing of 15KHz.

[0037] The term "basic unit" refers to a block of time-frequency resource. The size of a basic unit may depend on the employed numerology. The basic unit may be determined based on a subcarrier spacing and a symbol length used by subcarriers of the carrier. In a frequency domain, the basic unit may be decided by the largest subcarrier spacing. For example, a physical resource block (PRB) with the largest subcarrier spacing may be the frequency size of a basic unit, and/or the largest symbol length may be the time size of the basic unit.

[0038] FIG. 2A illustrates a diagram of a basic unit 240 in accordance with embodiments of the present disclosure. There are three subcarriers, Sc1-Sc3, illustrated in the example of FIG. 2A. In the frequency domain, the basic unit 240 is determined based on the largest subcarrier spacing, 60KHz. That is, the frequency size of the basic unit 240 equals to one PRB of the subcarrier Sc1 of 60KHz, 2 PRBs of the subcarrier Sc2 of 30KHz, and 4 PRBs of the subcarrier Sc3 of 15KHz.

[0039] In the time domain, the basic unit 240 is determined based on the largest symbol length. Thus, the time size of the basic unit 240 equals to a symbol of Sc3 of 15KHz, which has a largest symbol length among Sc1 to Sc3.

[0040] In addition to the above, the basic unit according embodiments of the present disclosure may be implemented in other suitable forms, for example, multiples of the largest symbol length in time domain, and/or multiples of the largest subcarrier spacing, multiples of a PRB, one or multiples of the smallest subcarrier spacing. FIG. 2B illustrates a diagram 200 of another basic unit 270 in accordance with further embodiments of the present disclosure. In the example shown in FIG. 2B, the basic unit 270 is defined based on the smallest subcarrier spacing in frequency domain. The time domain duration may be indicated by other ways explicitly or implicitly. For instance, the basic unit 270 may have the same duration as the basic unit 240 in the time domain, or the time duration may be multiples of the time duration of the basic unit 240.

[0041] It is to be understood that, the above examples are discussed for purpose of illustration, rather than limitation. Those skilled in the art would appreciate that the basic unit can be implemented other suitable forms with the scope of the subject matter of the present disclosure.

[0042] Conventionally, a carrier employs a single numerology, thus spectrum

utilization may be inefficient when terminal devices have different communication demands. To solve this problem, embodiments of the present disclosure propose a solution as discussed below to employ multiple numerologies in a single carrier. By receiving numerology information indicating numerologies of one or more basic units for the carrier, the terminal devices can receive signals based on the numerology information.

[0043] Now some exemplary embodiments of the present disclosure will be described below with reference to the following figures. FIG. 3 illustrates a flow chart of a method 300 for indicating numerology according to embodiments of the present disclosure. The method 300 may be implemented by the network device 110, for example, an eNB or other suitable device.

[0044] The method 300 is entered at 310, where the network device determines numerology information of a carrier. The numerology information indicates numerologies of one or more basic units for the carrier. At 320, the network device transmits the numerology information to a terminal device to enable reception based on the numerology information.

[0045] According to embodiments of the present disclosure, there may be a variety of ways to indicate numerology. In some embodiments, the numerology information may be indicated in a distributed way, which is also referred to as "distributed indication". In this case, the numerology of each basic unit is indicated. For purpose of illustration, the basic unit 240 of FIG. 2A is discussed in these embodiments. Thus, at 310, the network device may determine numerologies for all the basic units. In some implementations, a bitmap may be used to indicate the numerologies of the basic units, that is, one or more bits may be used to indicate the numerology for each basic unit. For example, two bits may be used to indicate subcarrier spacing 15KHz, 30KHz, 60KHz, and 120KHz, respectively. If the bits are "00", it means that the subcarrier of the numerology is 15KHz *1, and if the bits are "01", it means that the subcarrier of the numerology is 15KHz *2 = 30KHz. At 320, the network device may transmit information about the numerologies for all the basic units to the terminal device. FIG. 4 illustrates a diagram 400 of the distributed indication according to embodiments of the present disclosure. As shown in FIG. 4, there are six basic units in a carrier, namely, basic units 1 to 6, and there are 6

numerology indications are used for each of the basic units 1 to 6. In this way, the numerologies may be indicated in a flexible way.

[0046] In some other embodiments, if the basic unit is defined as the basic unit 270 as discussed with reference to FIG. 2B, when the numerology is changed from a small subcarrier spacing to a larger one, numerologies of at least multiple basic units need to be the same. For example, if the basic unit is based on 15KHz subcarrier spacing, and the numerology is changed from 15KHz to 30KHz, then numerology of at least two adjacent basic units should be same; if the numerology is changed to be 60KHz, then numerology of at least four adjacent basic units should be the same.

[0047] Alternatively, in some embodiments, the numerology information may be indicated in a centralized way, which is also referred to as "centralized indication." In this case, the carrier bandwidth may be divided into several groups, and each group may have a group-specific numerology. One group may include one or more basic units. Details of group division may be defined by a pattern, for example, referred to as a grouping pattern. The grouping pattern may be predefined in several ways, for example, according to the traffic characteristics, similar as Time Division Duplex (TDD) configuration. The grouping pattern may be alternatively defined in specification. In some implementations, the grouping pattern may be carried by system information and/or a Physical broadcast channel (PBCH). In the embodiments, the network device may inform the terminal device the grouping pattern and/or the group-specific numerology. The number of groups may be decided by the grouping pattern. The number may change due to different grouping patterns. The maximum group number may be reserved. In this case, the terminal device may need to firstly decode the grouping pattern, and then decode the corresponding numerology for each group based on the pattern.

[0048] In these embodiments, at 310, the network device may determine a grouping pattern indicating groups of the basic units, and then determine a numerology for each of the groups. At 320, the network device may transmit information about the grouping pattern and/or the numerology for each of the groups to the terminal device. FIG. 5 illustrates a diagram 500 of the centralized indication according to embodiments of the present disclosure. In the example of FIG. 5, there are six basic units in a carrier, namely, basic units 1 to 6, and they are divided into three groups,

namely, groups 1 to 3. As shown, group 1 includes basic units 1 and 2, group 2 includes basic unit 3, and group 3 includes basic units 4-6. A numerology is determined for each of the groups. As such, there are three numerology indications for groups 1, 2 and 3, respectively.

[0049] In some other embodiments, if the basic unit is defined as the basic unit 270 as discussed with reference to FIG. 2B, when the numerology is changed from a small subcarrier spacing to a larger one, the basic units may be divided into groups to guarantee basic units in each group have the same numerology. Still referring to FIG. 5, if basic units 1 to 6 are each defined as the basic unit 270, and basic units 1 and 2 correspond to numerology 1, basic unit 3 corresponds to numerology 2 and basic units 4, 5 and 6 correspond to numerology 3, then the basic units 1 to 6 may be divided into three groups to guarantee basic units in each group have the same numerology when the numerology is changed from 15KHz to 30KHz.

[0050] As a further alternative, the indication may be from a numerology perspective. That is to say, one or more basic units may be indicated for a specific numerology. The indication may be similar to a legacy approach of LTE resource allocation. The basic units corresponding to a numerology may be continuous or discontinuous. In some embodiments, the numerology information may be determined as below. At 310, the network device may determine numerologies for the basic units and determine an association between the numerologies and the basic units. Then, at 320, the network device may transmit information about the numerologies and/or the association to the terminal device. In an embodiment, the numerology information may be implemented in the form of the following table 1.

	NUMEROLOGY ID	BASIC UNIT ID
1	Numerology 1	Basic unit 1, 2
2	Numerology 2	Basic unit 3
3	Numerology 3	Basic unit 4, 5, 6

[0051] Upon receipt of the numerology information, the terminal device would understand that three numerologies (i.e., Numerology 1, 2 and 3) are designed for the carrier, Basic units 1 and 2 are associated with Numerology 1, Basic unit 3 is associated with Numerology 2, and Basic units 4, 5 and 6 are associated with

Numerology 3.

[0052] As a still further alternative, the bandwidth of the carrier may be divided into groups, and each group has the same numerology distribution pattern. A numerology distribution pattern indicating numerologies for basic units in one of the groups. For example, if in a group, the ith basic unit (also referred to as basic unit i, i=1,...M, and M indicates the total number of basic units in the group) has a numerology corresponding to 15KHz, and basic unit i+4 has a numerology corresponding to 60KHz, and basic units i and i+4 within another group share the same numerology 15KHz and 60KHz, respectively, then the numerology distribution patterns are the same for these two groups. In this case, the network device may indicate the numerology distribution pattern for a single group to the terminal device, and/or information about the group division, and/or the like. The numerology distribution pattern and/or information about the group division may be specified by specification, by RRC configuration, or in other suitable ways. The numerology distribution pattern for each group can also be indicated dynamically in downlink control information. In some embodiments, the numerology information may be determined as below. At 310, the network device may divide the basic units into groups and determine a numerology distribution pattern indicating numerologies for basic units in one of the groups. Then, at 320, the network device may transmit information about the numerology distribution pattern and/or information about the groups to the terminal device.

[0053] In accordance with embodiments of the present disclosure, for different adjacent numerologies, puncturing of one or more subcarriers may be used if a guard band is necessary. From efficiency point of view, the smaller subcarrier spacing may be punctured. In some embodiments, if new waveform design can mitigate the necessity of a guard band, then the puncturing may be unnecessary. According to embodiments of the present disclosure, the guard band may be indicated in a variety of ways. A size for a unit of the guard band (also referred to as a "guard band unit" hereafter) in the frequency domain may be a subcarrier, a PRB, or other suitable length, depending on the adjacent numerologies and/or numerology bandwidth and/or transmission direction. One or more guard band units may be indicated as a guard band.

[0054] FIG. 6 illustrates a diagram 600 of a guard band 610 according to embodiments of the present disclosure. As shown in FIG. 6, there is a guard band 610 between different subcarrier spacings, Sc2 of 30KHz and Sc3 of 15 KHz. The size of the guard band unit is a subcarrier/PRB, and the guard band in this example includes 3 guard band units.

[0055] According to embodiments of the present disclosure, optionally, after 320, the network device may further determines guard band information about a guard band between adjacent basic units based on numerologies of the adjacent basic units, and transmits the guard band information to the terminal device for each basic unit.

[0056] According to further embodiments of the present disclosure, optionally, after 320, the network device may further determine guard band information about a guard band between adjacent basic units based on transmission directions of the basic units. For example, a basic unit is used for downlink transmission and the adjacent basic unit is uplink transmission, then there will be a guard band between them. If the transmission direction is changed semi-statically, then the guard band information may be indicated to the terminal device in RRC signaling or PBCH. If the transmission direction, for example, downlink or uplink, is changed dynamically, then the guard band information may be indicated to a terminal device in downlink control information.

[0057] In the determination of the guard band information, the network device may detect whether there is a change between numerologies of the adjacent basic units and then determine occurrence of a guard band between the adjacent basic units based on the detection. In some embodiments, the guard band information may include: a number of subcarriers occupied by the guard band, a number of physical resource blocks occupied by the guard band, a basic unit where the guard band is located, and/or the like. The guard band information may indicate whether a guard band exists. From signaling point of view, even the guard band is to be decided not existent, it can be expressed by indicating the guard band to be 0.

[0058] After determining the guard band information, the network device may transmit the guard band information to the terminal device. In an embodiment, the guard band information may be transmitted together with the numerology information. Referring back to the embodiments of FIG. 4, the guard band information may be transmitted together with the numerology information for each basic unit. In another

embodiment, referring back to the embodiments of FIG. 5, the guard band information may be transmitted together with the numerology information for each group of basic units. More details about the indication of the guard band information will be discussed with the following embodiments with reference to FIGs. 7 and 8.

[0059] In some embodiments, the guard band may be defined by specification. In this case, the guard band may be impacted by adjacent numerology combination, and may be located in the side of the lower subcarrier spacing. For example, when a subcarrier spacing of 30KHz and a subcarrier spacing of 60KHz are located adjacently, no matter the detailed bandwidth for each subcarrier spacing, the guard band is the same and is always located in the 30KHz side. FIG. 7 illustrates a diagram 700 of indication of a guard band according to embodiments of the present disclosure. As shown in FIG. 7, there are two change points of numerologies of basic units 1-6, and two guard bands 710 and 720 defined by specification are located at the change points. In this case, the network device may inform the terminal device information about the numerology, and based on the derived numerology, the terminal device may deduce that there are guard bands 710 and 720.

[0060] Alternatively, in some embodiments, the guard band information and/or the numerology information may be transmitted or indicated by system information/PBCH or Dynamic Control Information (DCI). The indication of the guard band information may be according to the numerology distribution pattern, similar to the indication of the numerology information. In this case, the guard band may be impacted by both the adjacent numerology combination and the bandwidth of each numerology.

[0061] In an embodiment, there is a guard band for each basic unit. The guard band may be zero if no numerology change between adjacent basic units or new wave form adoption. Such guard band information may be transmitted together with the numerology information as discussed with reference to FIG. 4. For each basic unit, the numerology and the guard band are indicated. Both independent indication and joint encoding may be employed. FIG. 8 illustrates a diagram 800 of indication of a guard band according to such an embodiment.

[0062] In an alternative embodiment, there is a guard band for each numerology change. In this case, the guard band information may be transmitted together with

the numerology information as discussed with reference to FIG. 5. For example, the guard band information and/or the numerology information may indicate the numerology distribution pattern. Thus, upon receipt of the information, the terminal device may obtain a change point of numerologies based thereon, and then determine the position of the guard band according to the change point. In this embodiment, the guard band information is transmitted when numerologies of two adjacent basic units change. As such, overhead of transmitting the guard band information is reduced.

[0063] In accordance with embodiments of the present disclosure, the network device may further inform the terminal device information about resource allocation. The allocated resource may be indicated by a common index irrespectively of numerology. Thus, the terminal device may understand the resource allocated to it. In some embodiments, the network device may allocate a resource to one or more terminal devices, and then transmit information about the allocated resource to the terminal device. The information about the allocated resource may include one or more of: an index of a basic unit allocated to the terminal devices, an index of a physical resource block in a basic unit allocated to the terminal devices, and other suitable information.

[0064] In some embodiments, the basic units may be indexed from 0 to N-1, where N is a total number of the basic units. The total number may be determined in several ways. For example, if the carrier bandwidth is B and the bandwidth of the basic frequency variation units is W, then the total number may be calculated below:

$$N = \text{ceil}(B/W),$$

where "ceil" indicates an operation of rounding up.

[0065] The total PRB number (denoted as N_p) within a basic unit may be calculated as:

$$N_p = W/Sc/N_Sc$$

where Sc represents the subcarrier spacing for this basic unit, and N_Sc represents the subcarrier number within a PRB.

[0066] The network device may determine which PRB(s) and/or which basic unit(s) are allocated to terminal devices, and transmit the information about the allocated

resource to the terminal devices. The information may include index of the basic unit(s). A terminal device, for example, the terminal device 120, upon receipt of the information about the allocated resource, may identify the index of the basic unit(s) first. Then, the terminal device may determine which PRBs in the allocated basic unit(s) can be used.

[0067] In some implementations, one or more bits may be used to indicate the index of the basic unit(s). Then, one or more additional bits may be used to indicate PRBs within the basic unit. These bits may be used in both downlink and uplink to indicate the corresponding allocated frequency domain resource.

[0068] Alternatively, in some embodiments, the resource allocation information may be indicated by resource unit(s). The resource unit may be defined based on the smallest subcarrier spacing in frequency domain. For a larger subcarrier spacing, resources allocated to a single UE should consider the relationship between the smallest subcarrier spacing and the larger subcarrier spacing. By way of example, if the resource unit is based on 15KHz subcarrier spacing, and for a 60KHz resource allocation, the allocated resources may be multiple of 4, where 4 is obtained by dividing 60KHz by 15KHz. The time domain duration may be indicated by other ways explicitly or implicitly. For instance, the resource unit may have the same duration as the basic unit discussed above in the time domain, or the time duration may be multiples of the time duration of the basic unit.

[0069] FIG. 9 illustrates a diagram 900 of a resource unit 910 according to embodiments of the present disclosure. In the frequency domain, the resource unit 910 corresponds to the PRB of the smallest subcarrier spacing, namely, Sc3 of 15KHz. In the time domain, the resource unit 910 corresponds to a symbol of the smallest subcarrier spacing.

[0070] With respect the above embodiments, if different channel coding schemes are used for different information block sizes, or if the time domain transmission duration may change due to multi-subframe or mini-slot scheduling, the corresponding Modulation and Coding Scheme (MCS)/Transmission Block Size (TBS) table may change. The chosen of MCS/TBS table may be configured by Radio resource configuration (RRC) signaling.

[0071] In accordance with embodiments of the present disclosure, the network device may transmit the numerology information, and/or the guard band information, and/or the information about resource allocation in a variety of ways. In some embodiments, the network device may transmit the numerology information/guard band information in a region of the carrier corresponding to a reference numerology, and transmit the information about the allocated resource in one or more of the basic units, the region of the carrier for transmitting the reference numerology, and/or the like.

[0072] In some embodiments, the numerology information, the guard band information, and/or the information about resource allocation may be carried by PDCCH/Enhanced PDCCH (ePDCCH). The PDCCH carrying the numerology information and/or guard band information may be shared by a group of UEs, and may be scrambled by a cell specific/beam specific sequence. And the PDCCH carrying the resource allocation information may be scrambled in a UE-specific way. With respect to the terminal device, for example, a UE, it may decode received signals to obtain the numerology information and/or the guard band information. Then, the UE may decode the information about resource allocation to obtain allocated resources, MCS/TBS, transmission duration, and/or the like, which are collectively called as UE specific control information hereafter.

[0073] In some embodiments, the UE specific control information may be located at a time-frequency resource corresponding to a specific numerology. Alternatively, the UE specific control information may also be located at the time-frequency resource corresponding to the reference numerology, combined with the cell/beam-specific control information to be carried in a single PDCCH or scrambled independently to form an independent PDCCH. In some implementations, the PDCCH may occur in a periodical way or in aperiodical way. In the case of the aperiodical implementation, the UE may perform blind detection to identify the PDCCH.

[0074] In some alternative embodiments, the control information may also be carried by PBCH or RRC signaling. As a further alternative, the control information may be carried by a combination of RRC signaling and physical layer control information. In such a case, RRC signaling may be used to indicate a subset of possible

numerologies/guard band configurations, and physical layer control information may be used to indicate the numerology within the subset dynamically.

[0075] FIG. 10 illustrates a diagram 1000 of transmission of UE specific control information 1010 and numerology information/guard band 1020 according to embodiments of the present disclosure. As shown in the example of FIG. 10, the UE specific control information 1010 is transmitted via basic unit 1, and the numerology information/guard band information are transmitted in a region 1030 of the carrier corresponding to the reference numerology.

[0076] Reference is now made to FIG. 11, which illustrates a flow chart of a method 1100 for performing communication according to embodiments of the present disclosure. The method 1100 may be implemented by the terminal device 120, for example, a UE or other suitable device.

[0077] The method 1100 is entered at 1110, where the terminal device receives numerology information of a carrier from a network device. The numerology information may indicate numerologies of one or more basic units for the carrier. The basic unit may be determined based on a subcarrier spacing and a symbol length used by subcarriers of the carrier. For example, in the frequency domain, the basic unit may be determined based on the largest subcarrier spacing. In the time domain, the basic unit 240 may be determined based on the largest symbol length. In another example, the basic unit may also be determined based on the smallest subcarrier spacing in frequency domain, and/or determined based on the smallest symbol length in time domain.

[0078] In some embodiments, at 1110, the terminal device may receive information about numerologies for all the basic units. Alternatively, the terminal device may receive information about a grouping pattern indicating groups of the basic units and/or a numerology for each of the groups. As a further alternative, the terminal device may receive information about numerologies for the basic units and/or an association between the numerologies and the basic units. As a still further alternative, the basic units are divided into groups, and the basic units in each of the groups having the same numerology distribution pattern. In this case, the terminal device may receive at least one of information about a numerology distribution

pattern indicating numerologies for basic units in one of groups of basic units and/or information about the groups.

[0079] At 1120, the terminal device decodes a signal based on the numerology information.

[0080] In some embodiments, optionally, the terminal device may further receive guard band information about a guard band between adjacent basic units. In this case, at 1120, the terminal device may decode the signal based on the numerology information and the guard band information.

[0081] In some embodiments, optionally, the terminal device may further information about allocated resource of one or more terminal devices from the network device. The information about allocated resource may include an index of a basic unit allocated to the terminal devices, an index of a physical resource block in a basic unit allocated to the terminal devices, and/or the like. In this case, at 1120, the terminal device may decode the signal based on the numerology information and the information about allocated resource (also referred to as "information about resource allocation").

[0082] In some embodiments, the numerology information may be received in a region of the carrier for transmitting a reference numerology, and the information about the allocated resource may be received in one or more of the basic units, or in the region of the carrier for transmitting the reference numerology, or other suitable regions.

[0083] FIG. 12 illustrates a schematic diagram of a network device 1200 according to an embodiment of the present disclosure. According to embodiments of the present disclosure, the network device 1200 may be implemented as the network device 110 or other suitable device in the communication system.

[0084] As shown in FIG. 12, the network device 1200 comprises: a controller 1210 configured to determine numerology information of a carrier, the numerology information indicating numerologies of one or more basic units for the carrier; and a transmitter 1220 configured to transmit the numerology information to a terminal device to enable reception based on the numerology information.

[0085] In some embodiments, the basic unit may be determined based on a subcarrier spacing and a symbol length used by subcarriers of the carrier.

[0086] In some embodiments, the controller 1210 may be further configured to determine numerologies for all the basic units, and wherein the transmitter 1220 may be further configured to transmit information about the numerologies for all the basic units to the terminal device.

[0087] In some embodiments, the controller 1210 may be further configured to: determine a grouping pattern indicating groups of the basic units; and determine a numerology for each of the groups, and wherein the transmitter may be further configured to transmit information about the grouping pattern and/or the numerology for each of the groups to the terminal device.

[0088] In some embodiments, the controller 1210 may be further configured to: determine numerologies for the basic units; and determine an association between the numerologies and the basic units, and wherein the transmitter 1220 may be further configured to transmit information about the numerologies and/or the association to the terminal device.

[0089] In some embodiments, the controller 1210 may be further configured to: divide the basic units into groups; and determine a numerology distribution pattern indicating numerologies for basic units in one of the groups, and wherein the transmitter may be further configured to transmit information about the numerology distribution pattern and/or information about the groups to the terminal device.

[0090] In some embodiments, the controller 1210 may be further configured to: determine guard band information about a guard band between adjacent basic units based on numerologies of the adjacent basic units; and wherein the transmitter may be further configured to transmit the guard band information to the terminal device.

[0091] In some embodiments, the controller 1210 may be further configured to: detect whether there is a change between numerologies of the adjacent basic units; and determine occurrence of a guard band between the adjacent basic units based on the detection.

[0092] In some embodiments, the guard band information may further include one or more of: a number of subcarriers occupied by the guard band, a number of physical resource blocks occupied by the guard band, and a basic unit where the guard band is located.

[0093] In some embodiments, the transmitter 1220 may be further configured to transmit the guard band information to the terminal device based on the numerology information.

[0094] In some embodiments, the controller 1210 may be further configured to allocate a resource to one or more terminal devices, and wherein the transmitter 1220 may be further configured to transmit information about the allocated resource to the terminal device, wherein the information about the allocated resource includes at least one of: an index of a basic unit allocated to the terminal devices, and an index of a physical resource block in a basic unit allocated to the terminal devices.

[0095] In some embodiments, the transmitter 1220 may be further configured to: transmit the numerology information in a region of the carrier for transmitting a reference numerology; and transmit the information about the allocated resource in at least one of: one or more of the basic units, and the region of the carrier for transmitting the reference numerology.

[0096] FIG. 13 illustrates a schematic diagram of a terminal device 1300 according to an embodiment of the present disclosure. According to embodiments of the present disclosure, the terminal device 1300 may be implemented as the network device 120 or other suitable device in the communication system.

[0097] As shown in FIG. 13, the terminal device 1300 comprises: a receiver 1310 configured to receive numerology information of a carrier from a network device, the numerology information indicating numerologies of one or more basic units for the carrier; and a decoder 1320 configured to decode a signal based on the numerology information.

[0098] In some embodiments, the basic unit may be determined based on a subcarrier spacing and a symbol length used by subcarriers of the carrier.

[0099] In some embodiments, the receiver 1310 may be further configured to receive at least one of: information about numerologies for all the basic units; information about a grouping pattern indicating groups of the basic units and/or a numerology for each of the groups; information about numerologies for the basic units and/or an association between the numerologies and the basic units; and at least one of information about a numerology distribution pattern indicating numerologies for basic units in one of groups of basic units and/or information about the groups, the basic

units in the groups having the same numerology distribution pattern.

[00100] In some embodiments, the receiver 1310 may be further configured to receive guard band information about a guard band between adjacent basic units, wherein the decoder 1320 may be further configured to decode the signal based on the numerology information and the guard band information.

[00101] In some embodiments, the receiver 1310 may be further configured to receive information about allocated resource of one or more terminal devices from the network device, wherein the information about allocated resource includes at least one of: an index of a basic unit allocated to the terminal devices, and an index of a physical resource block in a basic unit allocated to the terminal devices.

[00102] In some embodiments, wherein the numerology information may be received in a region of the carrier for transmitting a reference numerology, and the information about the allocated resource may be received in at least one of: one or more of the basic units, and the region of the carrier for transmitting the reference numerology.

[00103] It is also to be noted that the device 1200 or 1300 may be respectively implemented by any suitable technique either known at present or developed in the future. Further, a single device shown in FIG. 12 or 13 may be alternatively implemented in multiple devices separately, and multiple separated devices may be implemented in a single device. The scope of the present disclosure is not limited in these regards.

[00104] It is noted that the device 1200 or 1300 may be configured to implement functionalities as described with reference to FIGs. 3-10 or FIG. 11. Therefore, the features discussed with respect to the method 300 may apply to the corresponding components of the device 1200, and the features discussed with respect to the method 1100 may apply to the corresponding components of the device 1300. It is further noted that the components of the device 1200 or 1300 may be embodied in hardware, software, firmware, and/or any combination thereof. For example, the components of the device 1200 or 1300may be respectively implemented by a circuit, a processor or any other appropriate device. Those skilled in the art will appreciate that the aforesaid examples are only for illustration not limitation.

[00105] In some embodiment of the present disclosure, the device 1200 or 1300 may

comprise at least one processor. The at least one processor suitable for use with embodiments of the present disclosure may include, by way of example, both general and special purpose processors already known or developed in the future. The device 1200 or 1300 may further comprise at least one memory. The at least one memory may include, for example, semiconductor memory devices, e.g., RAM, ROM, EPROM, EEPROM, and flash memory devices. The at least one memory may be used to store program of computer executable instructions. The program can be written in any high-level and/or low-level compliable or interpretable programming languages. In accordance with embodiments, the computer executable instructions may be configured, with the at least one processor, to cause the device 1200 to at least perform according to the method 300 as discussed above and to cause the device 1300 to at least perform according to the method 1100 as discussed above.

[00106] Based on the above description, the skilled in the art would appreciate that the present disclosure may be embodied in an apparatus, a method, or a computer program product. In general, the various exemplary embodiments may be implemented in hardware or special purpose circuits, software, logic or any combination thereof. For example, some aspects may be implemented in hardware, while other aspects may be implemented in firmware or software which may be executed by a controller, microprocessor or other computing device, although the disclosure is not limited thereto. While various aspects of the exemplary embodiments of this disclosure may be illustrated and described as block diagrams, flowcharts, or using some other pictorial representation, it is well understood that these blocks, apparatus, systems, techniques or methods described herein may be implemented in, as non-limiting examples, hardware, software, firmware, special purpose circuits or logic, general purpose hardware or controller or other computing devices, or some combination thereof.

[00107] The various blocks shown in FIG. 3 or 11 may be viewed as method steps, and/or as operations that result from operation of computer program code, and/or as a plurality of coupled logic circuit elements constructed to carry out the associated function(s). At least some aspects of the exemplary embodiments of the disclosures may be practiced in various components such as integrated circuit chips and modules, and that the exemplary embodiments of this disclosure may be realized in an apparatus that is embodied as an integrated circuit, FPGA or ASIC that is configurable

to operate in accordance with the exemplary embodiments of the present disclosure.

[00108] While this specification contains many specific implementation details, these should not be construed as limitations on the scope of any disclosure or of what may be claimed, but rather as descriptions of features that may be specific to particular embodiments of particular disclosures. Certain features that are described in this specification in the context of separate embodiments can also be implemented in combination in a single embodiment. Conversely, various features that are described in the context of a single embodiment can also be implemented in multiple embodiments separately or in any suitable sub-combination. Moreover, although features may be described above as acting in certain combinations and even initially claimed as such, one or more features from a claimed combination can in some cases be excised from the combination, and the claimed combination may be directed to a sub-combination or variation of a sub-combination.

[00109] Similarly, while operations are depicted in the drawings in a particular order, this should not be understood as requiring that such operations be performed in the particular order shown or in sequential order, or that all illustrated operations be performed, to achieve desirable results. In certain circumstances, multitasking and parallel processing may be advantageous. Moreover, the separation of various system components in the embodiments described above should not be understood as requiring such separation in all embodiments, and it should be understood that the described program components and systems can generally be integrated together in a single software product or packaged into multiple software products.

[00110] Various modifications, adaptations to the foregoing exemplary embodiments of this disclosure may become apparent to those skilled in the relevant arts in view of the foregoing description, when read in conjunction with the accompanying drawings. Any and all modifications will still fall within the scope of the non-limiting and exemplary embodiments of this disclosure. Furthermore, other embodiments of the disclosures set forth herein will come to mind to one skilled in the art to which these embodiments of the disclosure pertain having the benefit of the teachings presented in the foregoing descriptions and the associated drawings.

[00111] Therefore, it is to be understood that the embodiments of the disclosure are not to be limited to the specific embodiments disclosed and that modifications and

other embodiments are intended to be included within the scope of the appended claims. Although specific terms are used herein, they are used in a generic and descriptive sense only and not for purpose of limitation.

WHAT IS CLAIMED IS:

1. A method performed by a network device, comprising:

determining numerology information of a carrier, the numerology information indicating numerologies of one or more basic units for the carrier; and

transmitting the numerology information to a terminal device to enable reception based on the numerology information.

2. The method according to Claim 1, wherein the basic unit is determined based on a subcarrier spacing and a symbol length used by subcarriers of the carrier.

3. The method according to Claim 1, wherein determining the numerology information comprises: determining numerologies for all the basic units, and

wherein transmitting the numerology information comprises: transmitting information about the numerologies for all the basic units to the terminal device.

4. The method according to Claim 1, wherein determining the numerology information comprises:

determining a grouping pattern indicating groups of the basic units; and

determining a numerology for each of the groups, and

wherein transmitting the numerology information comprises: transmitting information about the grouping pattern and/or the numerology for each of the groups to the terminal device.

5. The method according to Claim 1, wherein determining the numerology information comprises:

determining numerologies for the basic units; and

determining an association between the numerologies and the basic units, and

wherein transmitting the numerology information comprises: transmitting information about the numerologies and/or the association to the terminal device.

6. The method according to Claim 1, wherein determining the numerology information comprises:

dividing the basic units into groups; and

determining a numerology distribution pattern indicating numerologies for basic units in one of the groups, and

wherein transmitting the numerology information comprises: transmitting information about the numerology distribution pattern and/or information about the groups to the terminal device.

7. The method according to Claim 1, further comprising:

determining guard band information about a guard band between adjacent basic units based on numerologies of the adjacent basic units; and

transmitting the guard band information to the terminal device.

8. The method according to Claim 7, wherein determining the guard band information comprises:

detecting whether there is a change between numerologies of the adjacent basic units; and

determining occurrence of a guard band between the adjacent basic units based on the detection.

9. The method according to Claim 7 or 8, wherein the guard band information further includes one or more of:

a number of subcarriers occupied by the guard band,

a number of physical resource blocks occupied by the guard band, and

a basic unit where the guard band is located.

10. The method according to Claim 7, wherein transmitting the guard band information to the terminal device comprises:

transmitting the guard band information to the terminal device based on the numerology information.

11. The method according to Claim 1, further comprising:

allocating a resource to one or more terminal devices; and

transmitting information about the allocated resource to the terminal device,

wherein the information about the allocated resource includes at least one of: an index of a basic unit allocated to the terminal devices, and an index of a physical resource block in a basic unit allocated to the terminal devices.

12. The method according to Claim 11, wherein transmitting the numerology information comprises:

transmitting the numerology information in a region of the carrier for transmitting a reference numerology; and

transmitting the information about the allocated resource in at least one of: one or more of the basic units, and the region of the carrier for transmitting the reference numerology.

13. A method performed by a terminal device, comprising:

receiving numerology information of a carrier from a network device, the numerology information indicating numerologies of one or more basic units for the carrier; and

decoding a signal based on the numerology information.

14. The method according to Claim 13, wherein the basic unit is determined based on a subcarrier spacing and a symbol length used by subcarriers of the carrier.

15. The method according to Claim 13, wherein receiving the numerology information comprises at least one of:

receiving information about numerologies for all the basic units;

receiving information about a grouping pattern indicating groups of the basic units and/or a numerology for each of the groups;

receiving information about numerologies for the basic units and/or an association between the numerologies and the basic units; and

receiving at least one of information about a numerology distribution pattern indicating numerologies for basic units in one of groups of basic units and/or information about the groups, the basic units in the groups having the same numerology distribution pattern.

16. The method according to Claim 13, further comprising:

receiving guard band information about a guard band between adjacent basic units,

wherein decoding the signal comprises: decoding the signal based on the numerology information and the guard band information.

17. The method according to Claim 13, further comprising:

receiving information about allocated resource of one or more terminal devices from the network device, wherein the information about allocated resource includes at least one of: an index of a basic unit allocated to the terminal devices, and an index of a physical resource block in a basic unit allocated to the terminal devices.

18. The method according to Claim 17, wherein the numerology information is received in a region of the carrier for transmitting a reference numerology, and the information about the allocated resource is received in at least one of: one or more of the basic units, and the region of the carrier for transmitting the reference numerology.

19. A network device, comprising:

a controller configured to determine numerology information of a carrier, the numerology information indicating numerologies of one or more basic units for the carrier; and

a transmitter configured to transmit the numerology information to a terminal device to enable reception based on the numerology information.

20. The network device according to Claim 19, wherein the basic unit is determined based on a subcarrier spacing and a symbol length used by subcarriers of the carrier.

21. The network device according to Claim 19, wherein the controller is further configured to determine numerologies for all the basic units, and

wherein the transmitter is further configured to transmit information about the numerologies for all the basic units to the terminal device.

22. The network device according to Claim 19, wherein the controller is further configured to:

determine a grouping pattern indicating groups of the basic units; and

determine a numerology for each of the groups, and

wherein the transmitter is further configured to transmit information about the grouping pattern and/or the numerology for each of the groups to the terminal device.

23. The network device according to Claim 19, wherein the controller is further configured to:

determine numerologies for the basic units; and

determine an association between the numerologies and the basic units, and

wherein the transmitter is further configured to transmit information about the numerologies and/or the association to the terminal device.

24. The network device according to Claim 19, wherein the controller is further configured to:

divide the basic units into groups; and

determine a numerology distribution pattern indicating numerologies for basic units in one of the groups, and

wherein the transmitter is further configured to transmit information about the numerology distribution pattern and/or information about the groups to the terminal device.

25. The network device according to Claim 19, wherein the controller is further configured to:

determine guard band information about a guard band between adjacent basic units based on numerologies of the adjacent basic units; and

wherein the transmitter is further configured to transmit the guard band information to the terminal device.

26. The network device according to Claim 25, wherein the controller is further configured to:

detect whether there is a change between numerologies of the adjacent basic units; and

determine occurrence of a guard band between the adjacent basic units based on the detection.

27. The network device according to Claim 25 or 26, wherein the guard band information further includes one or more of:

a number of subcarriers occupied by the guard band,

a number of physical resource blocks occupied by the guard band, and

a basic unit where the guard band is located.

28. The network device according to Claim 25, wherein the transmitter is further configured to transmit the guard band information to the terminal device based on the numerology information.

29. The network device according to Claim 19, wherein the controller is further configured to allocate a resource to one or more terminal devices, and wherein the transmitter is further configured to transmit information about the allocated resource to the terminal device,

wherein the information about the allocated resource includes at least one of: an index of a basic unit allocated to the terminal devices, and an index of a physical resource block in a basic unit allocated to the terminal devices.

30. The network device according to Claim 29, wherein the transmitter is further configured to:

transmit the numerology information in a region of the carrier for transmitting a reference numerology; and

transmit the information about the allocated resource in at least one of: one or more of the basic units, and the region of the carrier for transmitting the reference numerology.

31. A terminal device, comprising:

a receiver configured to receive numerology information of a carrier from a network device, the numerology information indicating numerologies of one or more basic units for the carrier; and

a decoder configured to decode a signal based on the numerology information.

32. The terminal device according to Claim 31, wherein the basic unit is determined based on a subcarrier spacing and a symbol length used by subcarriers of the carrier.

33. The terminal device according to Claim 31, wherein the receiver is further configured to receive at least one of:

information about numerologies for all the basic units;

information about a grouping pattern indicating groups of the basic units and/or a numerology for each of the groups;

information about numerologies for the basic units and/or an association between the numerologies and the basic units; and

at least one of information about a numerology distribution pattern indicating numerologies for basic units in one of groups of basic units and/or information about the groups, the basic units in the groups having the same numerology distribution pattern.

34. The terminal device according to Claim 31, wherein the receiver is further configured to receive guard band information about a guard band between adjacent basic units,

wherein the decoder is further configured to decode the signal based on the numerology information and the guard band information.

35. The terminal device according to Claim 31, wherein the receiver is further configured to receive information about allocated resource of one or more terminal devices from the network device, wherein the information about allocated resource includes at least one of: an index of a basic unit allocated to the terminal

devices, and an index of a physical resource block in a basic unit allocated to the terminal devices.

36. The terminal device according to Claim 35, wherein the numerology information is received in a region of the carrier for transmitting a reference numerology, and the information about the allocated resource is received in at least one of: one or more of the basic units, and the region of the carrier for transmitting the reference numerology.

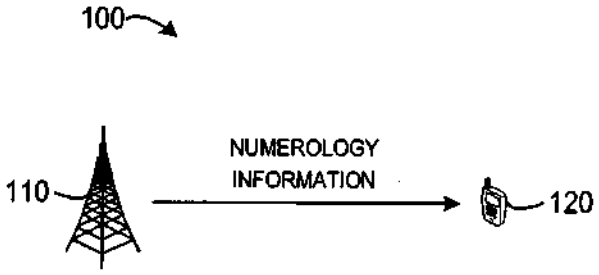

100
110
NUMEROLOGY
INFORMATION
120

FIG. 1

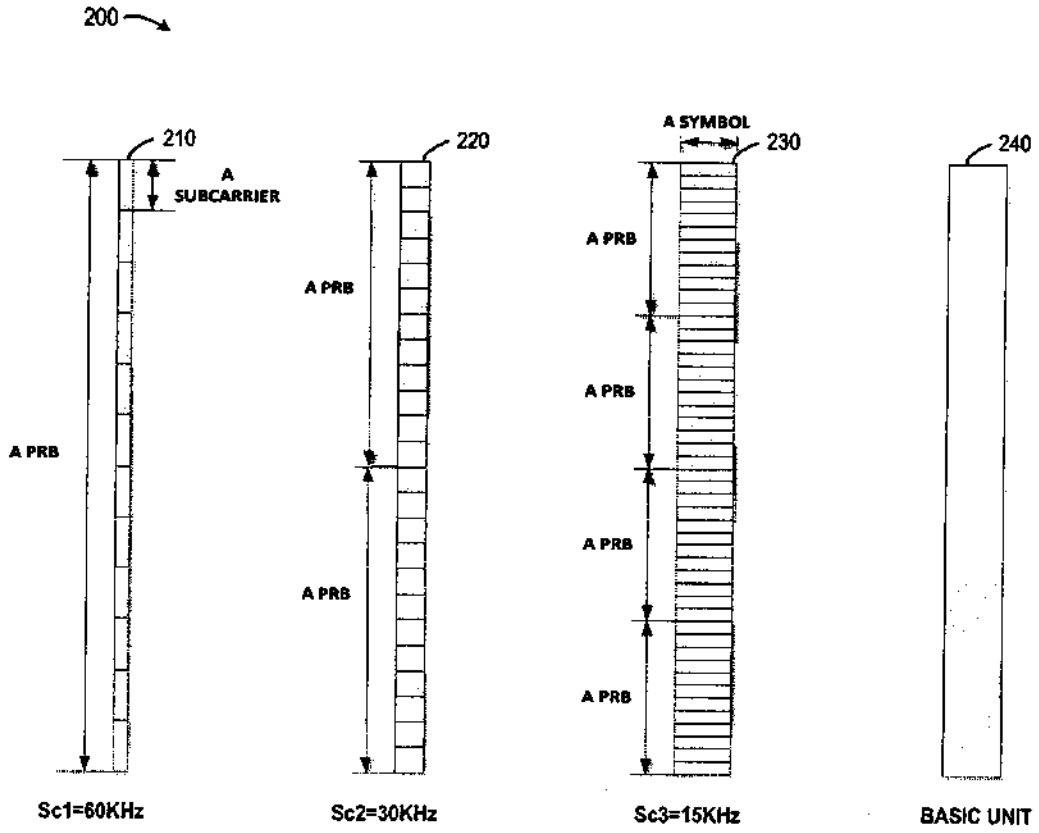

200
210
A
SUBCARRIER
A PRB
Sc1=60KHz
220
A PRB
A PRB
Sc2=30KHz
A SYMBOL
230
A PRB
A PRB
A PRB
A PRB
Sc3=15KHz
240
BASIC UNIT

FIG. 2A

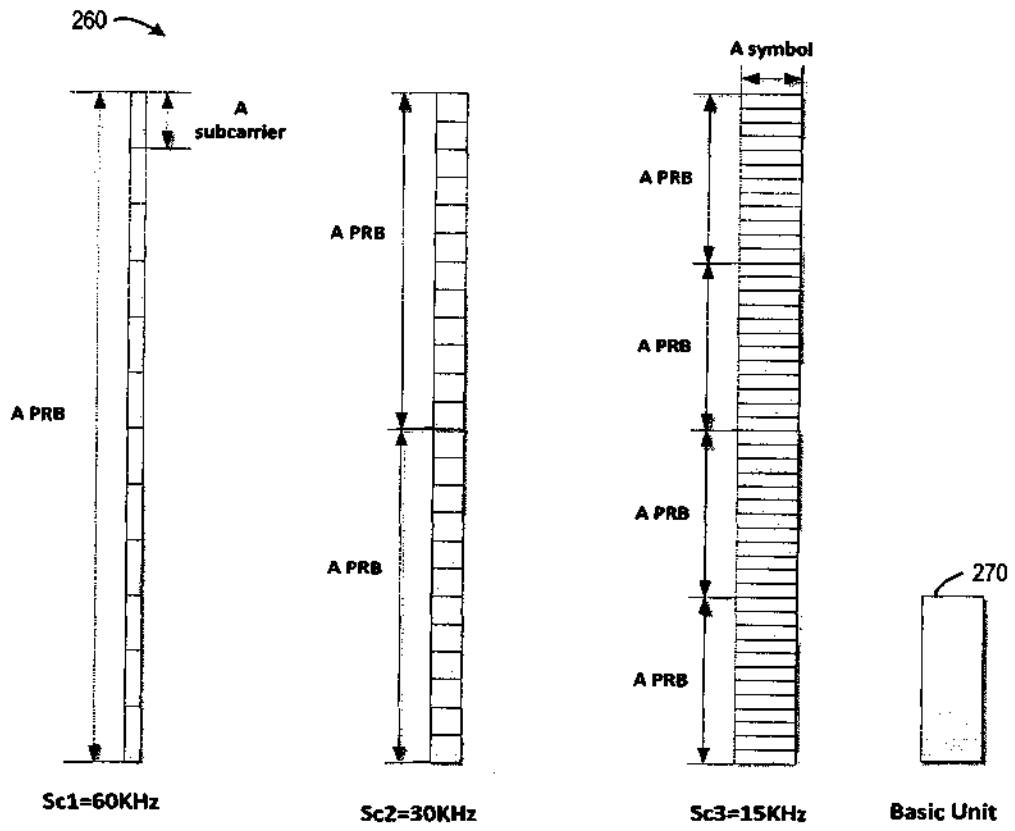

260
A subcarrier
A PRB
A PRB
A PRB
A symbol
A PRB
A PRB
A PRB
A PRB
270
Sc1=60KHz
Sc2=30KHz
Sc3=15KHz
Basic Unit

FIG. 2B

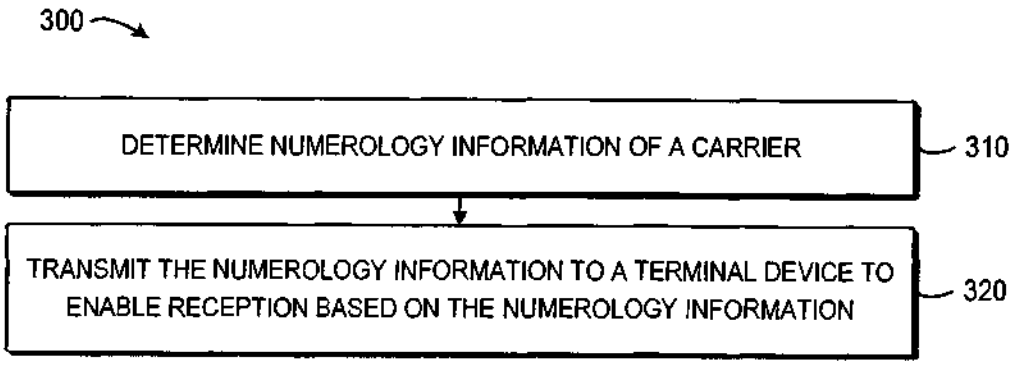

300
DETERMINE NUMEROLOGY INFORMATION OF A CARRIER
310
TRANSMIT THE NUMEROLOGY INFORMATION TO A TERMINAL DEVICE TO ENABLE RECEPTION BASED ON THE NUMEROLOGY INFORMATION
320

FIG. 3

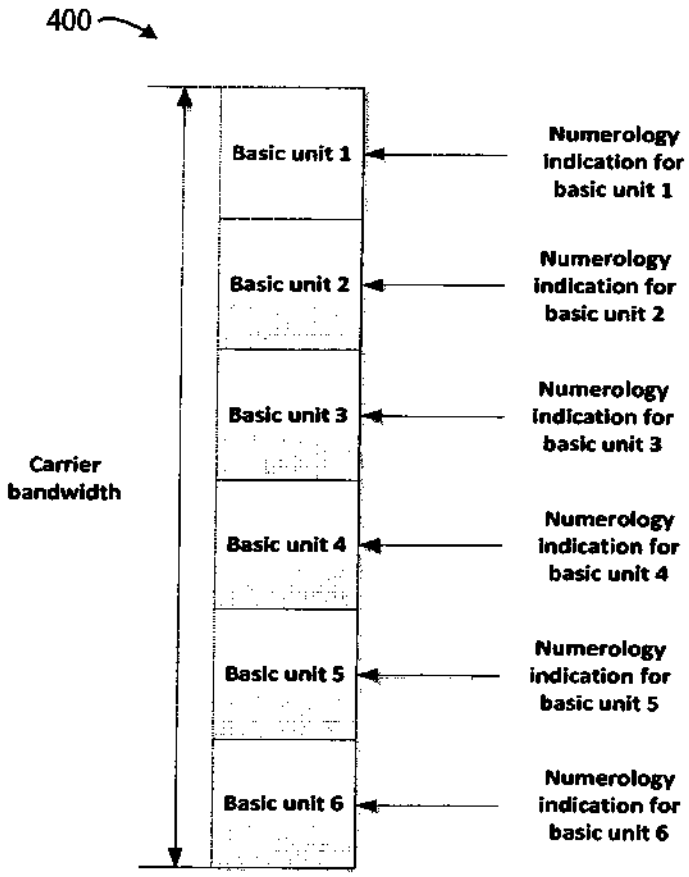

400
Carrier bandwidth
Basic unit 1
Basic unit 2
Basic unit 3
Basic unit 4
Basic unit 5
Basic unit 6
Numerology indication for basic unit 1
Numerology indication for basic unit 2
Numerology indication for basic unit 3
Numerology indication for basic unit 4
Numerology indication for basic unit 5
Numerology indication for basic unit 6

FIG. 4

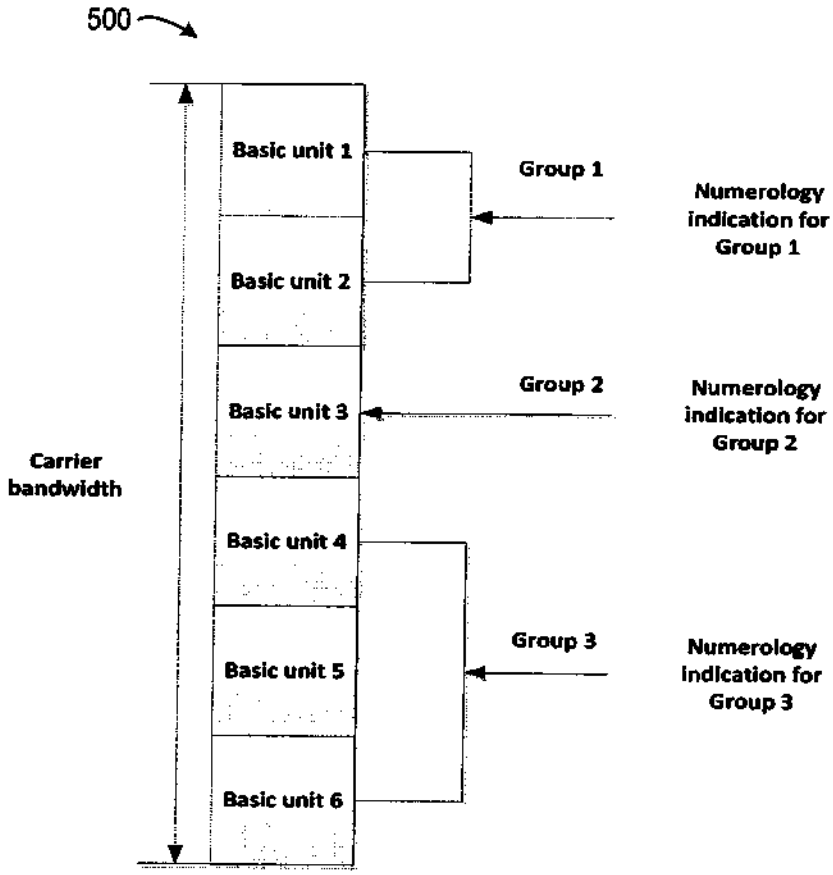

500
Basic unit 1
Basic unit 2
Basic unit 3
Basic unit 4
Basic unit 5
Basic unit 6
Carrier bandwidth
Group 1
Group 2
Group 3
Numerology indication for Group 1
Numerology indication for Group 2
Numerology indication for Group 3

FIG. 5

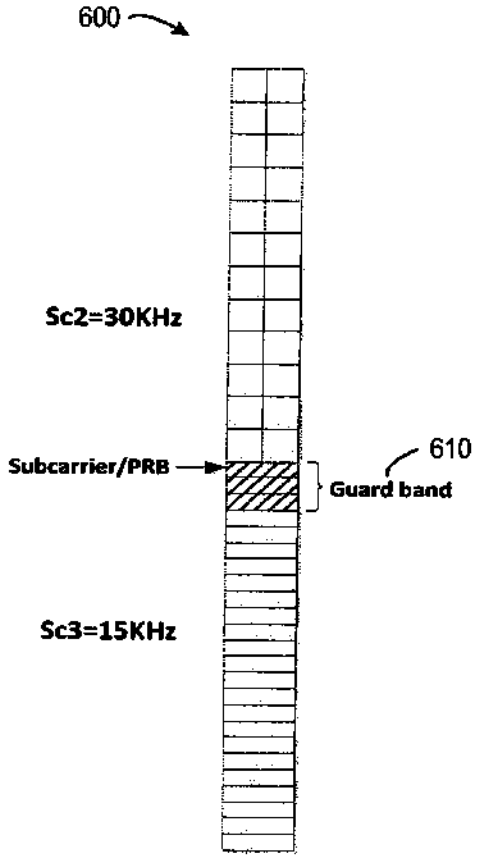


FIG. 6

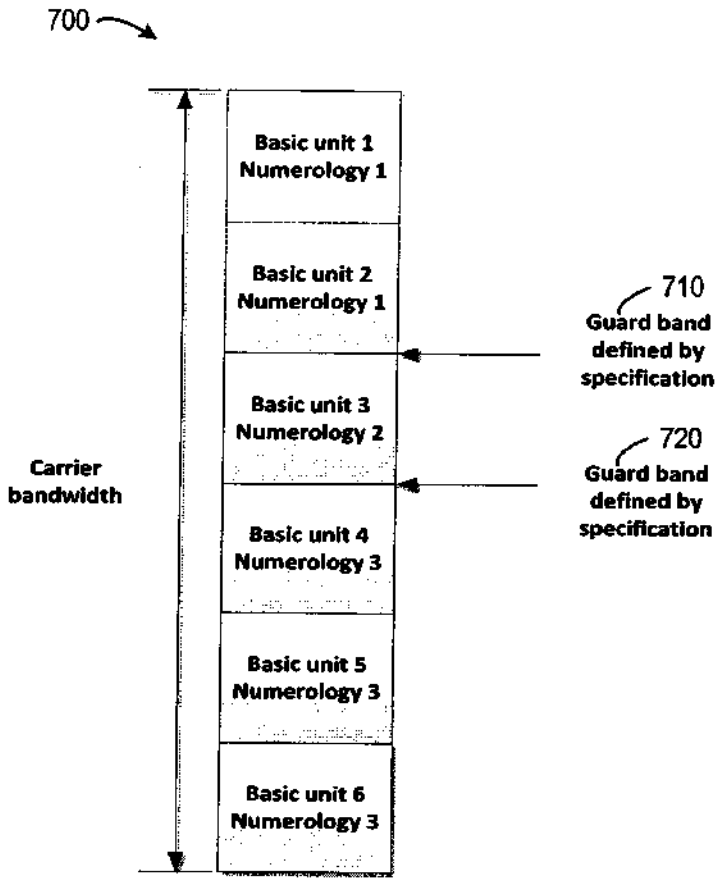

700
Basic unit 1
Numerology 1
Basic unit 2
Numerology 1
Basic unit 3
Numerology 2
Basic unit 4
Numerology 3
Basic unit 5
Numerology 3
Basic unit 6
Numerology 3
Carrier bandwidth
710
Guard band defined by specification
720
Guard band defined by specification

FIG. 7

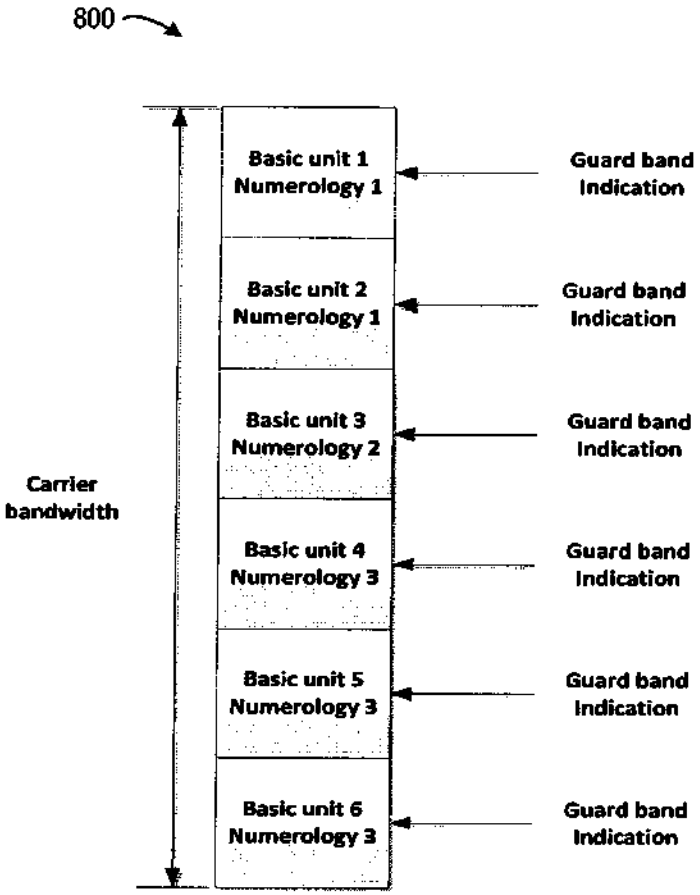

800
Carrier bandwidth
Basic unit 1 Numerology 1
Basic unit 2 Numerology 1
Basic unit 3 Numerology 2
Basic unit 4 Numerology 3
Basic unit 5 Numerology 3
Basic unit 6 Numerology 3
Guard band Indication
Guard band Indication
Guard band Indication
Guard band Indication
Guard band Indication
Guard band Indication

FIG. 8

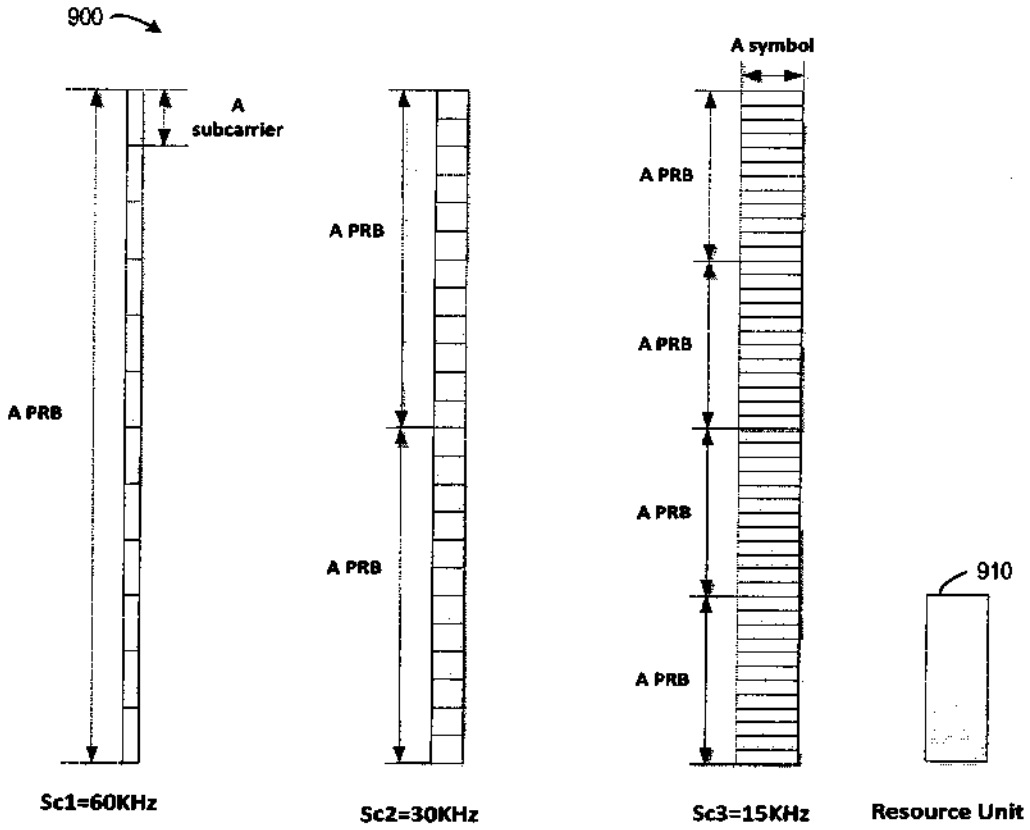

900
A subcarrier
A PRB
A PRB
A PRB
A symbol
A PRB
A PRB
A PRB
A PRB
910
Sc1=60KHz
Sc2=30KHz
Sc3=15KHz
Resource Unit

FIG. 9

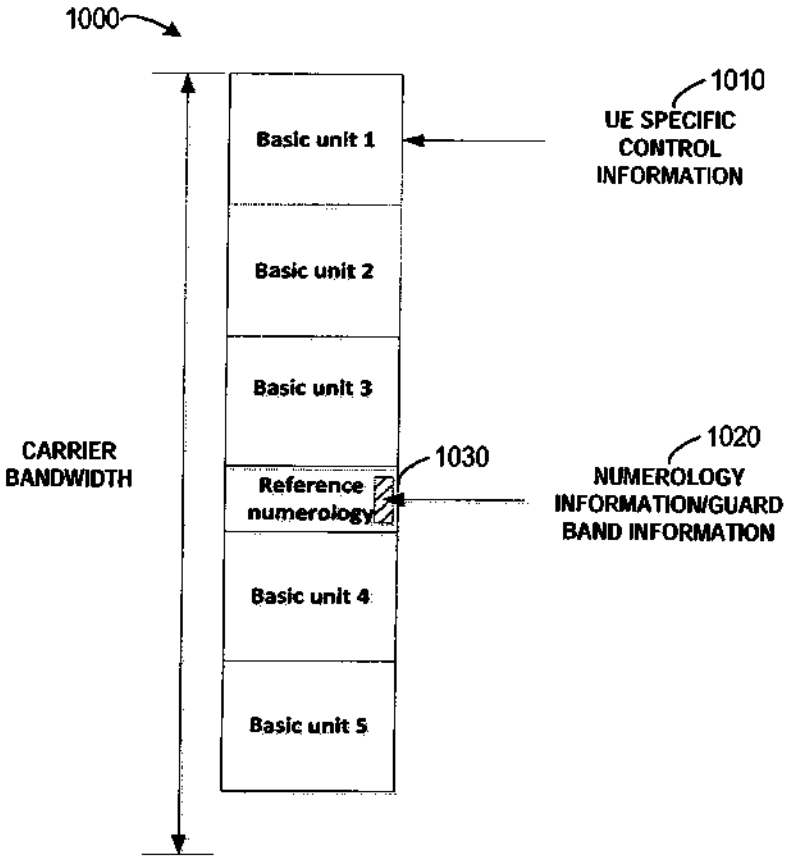

1000
Basic unit 1
Basic unit 2
Basic unit 3
Reference numerology
Basic unit 4
Basic unit 5
CARRIER BANDWIDTH
1010
UE SPECIFIC CONTROL INFORMATION
1020
NUMEROLOGY INFORMATION/GUARD BAND INFORMATION
1030

FIG. 10

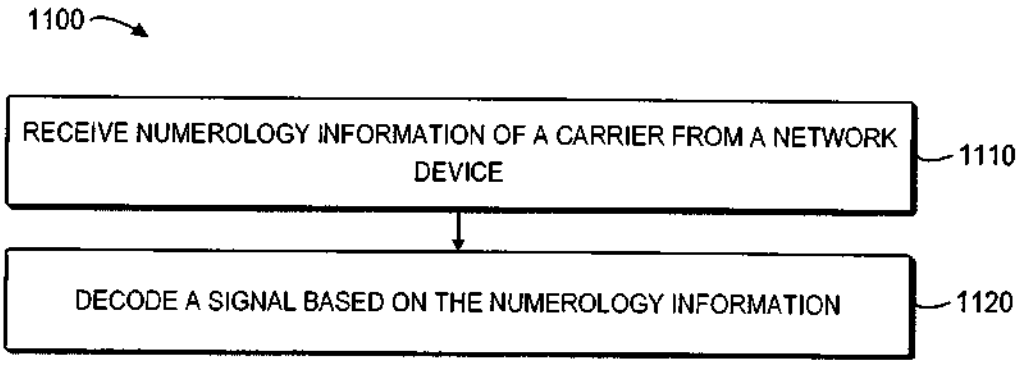

1100
RECEIVE NUMEROLOGY INFORMATION OF A CARRIER FROM A NETWORK DEVICE
1110
DECODE A SIGNAL BASED ON THE NUMEROLOGY INFORMATION
1120

FIG. 11

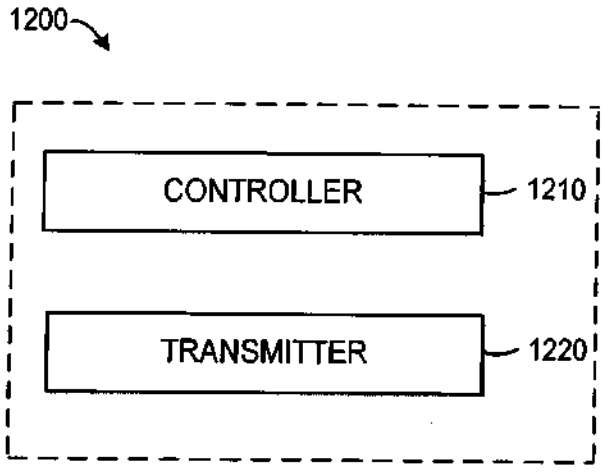

1200
CONTROLLER
1210
TRANSMITTER
1220

FIG. 12

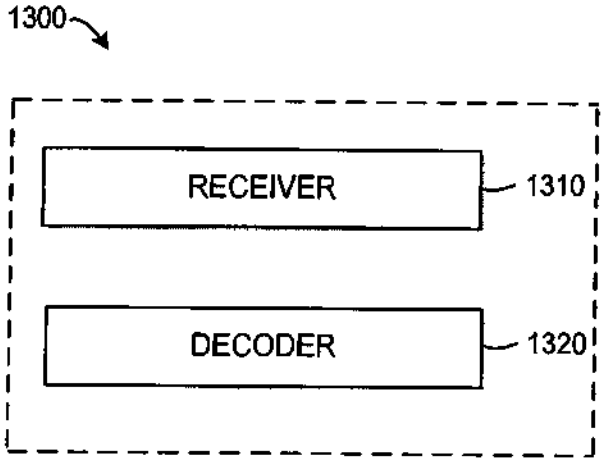

1300
RECEIVER
1310
DECODER
1320

FIG. 13

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2016/000597

A. CLASSIFICATION OF SUBJECT MATTER

H04W 72/04(2009.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04W; H04L; H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI; EPODOC; CNKI; CNPAT; 3GPP: numerology, parameter, carrier, subcarrier, basic unit, subcarrier spacing, symbol length, cyclic prefix, time frequency resource, physical resource block, nodeB, eNodeB, eNB, UE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	PANASONIC. "3GPP TSG-RAN WG1 Meeting #86bis R1-1610217" *Resource assignment for mixed numerologies,* 14 October 2016 (2016-10-14), the whole document	1-36
X	NEC. "3GPP TSG RAN WG1 Meeting #86bis R1-1609145" *Discussion on numerology multiplexing for supporting different service requirements,* 14 October 2016 (2016-10-14), the whole document	1-36
A	US 2015215148 A1 (SAMSUNG ELECTRONICS CO., LTD.) 30 July 2015 (2015-07-30) the whole document	1-36
A	CN 101932104 A (INDUSTRIAL TECHNOLOGY RESEARCH INSTITUTE) 29 December 2010 (2010-12-29) the whole document	1-36

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
06 July 2017	**27 July 2017**
Name and mailing address of the ISA/CN **STATE INTELLECTUAL PROPERTY OFFICE OF THE P.R.CHINA** **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088** **China** Facsimile No. **(86-10)62019451**	Authorized officer **LIU,Qingfeng** Telephone No. **(86-10)62413279**

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2016/000597

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
US	2015215148	A1	30 July 2015	US	2013051485	A1	28 February 2013
				KR	20130022523	A	07 March 2013
CN	101932104	A	29 December 2010	TW	201129188	A	16 August 2011
				CN	102932124	A	13 February 2013
				US	2010322175	A1	23 December 2010

Form PCT/ISA/210 (patent family annex) (July 2009)

(12) 按照专利合作条约所公布的国际申请

(19) 世界知识产权组织
国 际 局

(43) 国际公布日
2018 年 11 月 8 日 (08.11.2018)

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(25) 申请语言: 中文

(26) 公布语言: 中文

(30) 优先权:
201710307962.5 2017年5月4日 (04.05.2017) CN

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(81) 指定国 (除另有指明, 要求每一种可提供的国家保护): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK,

(54) Title: MESSAGE DECODING METHOD, SENDING TERMINAL DEVICE AND RECEIVING TERMINAL DEVICE

(54) 发明名称: 一种消息解码方法、发送端设备和接收端设备

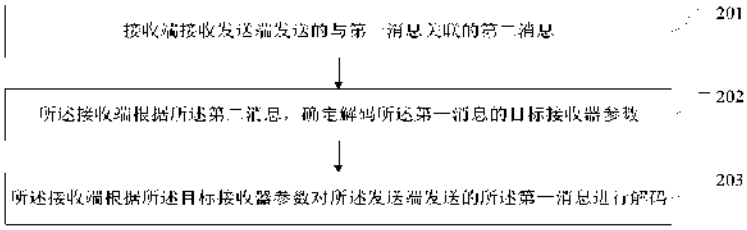


图 2

201 A receiving terminal receives a second message sent by a sending terminal and associated with a first message
202 The receiving terminal determines target receiver parameters for decoding the first message, according to the second message
203 The receiving terminal decodes the first message sent by the sending terminal according to the target receiver parameters

(57) **Abstract:** Provided in embodiments of the present disclosure are a message decoding method, a sending terminal device and a receiving terminal device. The method may comprise: a receiving terminal device receiving a second message sent by a sending terminal and associated with a first message; the receiving terminal device determining target receiver parameters for decoding the first message, according to the second message; the receiving terminal device decoding the first message sent by the sending terminal device according to the target receiver parameters. In this way, an embodiment of the present disclosure can implement a receiving terminal device determining receiver parameters according to a second message associated with a first message, and can increase message transmission functionality.

(57) 摘要: 本公开实施例提供一种消息解码方法、发送端设备和接收端设备。该方法可包括: 接收端设备接收发送端设备发送的与第一消息关联的第二消息; 所述接收端设备根据所述第二消息, 确定解码所述第一消息的目标接收器参数; 所述接收端设备根据所述目标接收器参数对所述发送端设备发送的所述第一消息进行解码。这样本公开实施例可以实现接收端设备根据与第一消息关联的第二消息确定接收器参数, 且还可以提高消息传输性能。

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本国际公布：

— 包括国际检索报告(条约第21条(3))。

一种消息解码方法、发送端设备和接收端设备

相关申请的交叉引用

本申请主张在 2017 年 5 月 4 日在中国提交的中国专利申请号 No. 201710307962.5 的优先权，其全部内容通过引用包含于此。

技术领域

本公开实施例涉及通信技术领域，特别涉及一种消息解码方法、发送端设备和接收端设备。

背景技术

随着通信技术的发展，目前通信设备均支持多天线系统。例如：支持高达 128、256 或者 512 个天线单元，以及高达 128、256 或者 512 个收发单元，其中每个天线单元连接一个收发单元。此外，目前通信设备还支持多波束，不同的波束的覆盖范围可以不同。这样发送端设备（例如：网络侧设备）在发送消息时，就可以在多个发送器参数（例如：发送波束）中选择相应的发送器参数进行发送，以提高通信性能。而接收端设备（例如：用户终端）如何选择相应的接收器参数（例如：接收波束）对发送端设备发送的消息进行解码目前还未明确。可见，接收端设备如何选择相应的接收器参数对发送端设备发送的消息进行解码是当前急需解决的技术问题。

发明内容

本公开实施例的目的在于提供一种消息解码方法、发送端设备和接收端设备，以解决接收端设备如何选择相应的接收器参数对发送端设备发送的消息进行解码的技术问题。

为了达到上述目的，在第一个方面中，本公开实施例提供一种消息解码方法，包括：

接收端设备接收发送端设备发送的与第一消息关联的第二消息；

所述接收端设备根据所述第二消息，确定解码所述第一消息的目标接收

器参数；以及

所述接收端设备根据所述目标接收器参数对所述发送端设备发送的所述第一消息进行解码。

在本公开的一个可行实施例中，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端设备默认的接收器参数。

在本公开的一个可行实施例中，所述接收端设备默认的接收器参数包括：

所述接收端设备当前使用的接收器参数、所述接收端设备接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端设备向所述发送端设备上报时间最近的发送器参数对应的接收器参数。

在本公开的一个可行实施例中，所述参数指示信息显式或者隐式指示所述目标接收器参数。

在本公开的一个可行实施例中，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端设备选择的发送器参数，所述接收端设备将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

在本公开的一个可行实施例中，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

在本公开的一个可行实施例中，所述参数切换指示集对应的调度时间单位在时域上周期性存在；和/或

所述参数切换指示集对应的调度时间单位由所述发送端设备半静态或半持续配置，并通知所述接收端设备。

在本公开的一个可行实施例中，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，

以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前，所述接收端设备根据所述目标接收器参数对所述第一消息进行解码，包括：

若所述第二消息包括参数指示信息，则所述接收端设备根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示信息，则所述接收端设备丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示信息，则所述接收端设备根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息不包括参数指示信息，则所述接收端设备根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端设备根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端设备丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端设备根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段指示没有参数指示信息或者没有参数改变，则所述接收端设备根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

在本公开的一个可行实施例中，所述方法还包括：

所述接收端设备接收所述发送端设备发送的第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第

二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

在本公开的一个可行实施例中，所述第三消息用于指示 M 个时间单位内的第二消息是否包括参数指示信息，所述 M 为大于或者等于 1 的整数， 所述 M 个时间单位连续或者不连续。

在本公开的一个可行实施例中，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

在本公开的一个可行实施例中，所述空域的接收器参数包括所述接收端设备的接收波束。

在第二个方面中，本公开实施例还提供一种消息解码方法，包括：

发送端设备向接收端设备发送与第一消息关联的第二消息，所述第二消息用于所述接收端设备确定解码所述第一消息的目标接收器参数；以及

所述发送端设备向所述接收端设备发送所述第一消息。

在本公开的一个可行实施例中，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端设备默认的接收器参数。

在本公开的一个可行实施例中，所述接收端设备默认的接收器参数包括：

所述接收端设备当前使用的接收器参数、所述接收端设备接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端设备向所述发送端设备上报时间最近的发送器参数对应的接收器参数。

在本公开的一个可行实施例中，所述参数指示信息显式或者隐式指示所述目标接收器参数。

在本公开的一个可行实施例中，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端设备选择的发送器参数，所述接收端设备将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

在本公开的一个可行实施例中，若所述第二消息是在预先确定的参数切

换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

在本公开的一个可行实施例中，所述参数切换指示集对应的调度时间单位在时域上周期性存在；和/或

所述参数切换指示集对应的调度时间单位由所述发送端设备半静态或半持续配置，并通知所述接收端设备。

在本公开的一个可行实施例中，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前。

在本公开的一个可行实施例中，所述方法还包括：

所述发送端设备向所述接收端设备发送第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

在本公开的一个可行实施例中，所述第三消息用于指示 M 个时间单位内的第二消息是否包括参数指示信息，所述 M 为大于或者等于 1 的整数， 所述 M 个时间单位连续或者不连续。

在本公开的一个可行实施例中，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

在本公开的一个可行实施例中，所述空域的接收器参数包括所述接收端设备的接收波束。

在第三个方面中，本公开实施例还提供一种接收端设备，包括：

第一接收模块，用于接收发送端设备发送的与第一消息关联的第二消息；

确定模块，用于根据所述第二消息，确定解码所述第一消息的目标接收

器参数；以及

解码模块，用于根据所述目标接收器参数对所述发送端设备发送的所述第一消息进行解码。

在本公开的一个可行实施例中，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端设备默认的接收器参数。

在本公开的一个可行实施例中，所述接收端设备默认的接收器参数包括：

所述接收端设备当前使用的接收器参数、所述接收端设备接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端设备向所述发送端设备上报时间最近的发送器参数对应的接收器参数。

在本公开的一个可行实施例中，所述参数指示信息显式或者隐式指示所述目标接收器参数。

在本公开的一个可行实施例中，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端设备选择的发送器参数，所述接收端设备将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

在本公开的一个可行实施例中，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

在本公开的一个可行实施例中，所述参数切换指示集对应的调度时间单位在时域上周期性存在；和/或

所述参数切换指示集对应的调度时间单位由所述发送端设备半静态或半持续配置，并通知所述接收端设备。

在本公开的一个可行实施例中，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，

以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前；

所述解码模块用于若所述第二消息包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示信息，则根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息不包括参数指示信息，则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示字段，且所述参数指示字段指示没有参数指示信息或者没有参数改变，则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

在本公开的一个可行实施例中，所述接收端设备还包括：

第二接收模块，用于接收所述发送端设备发送的第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间

隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

在本公开的一个可行实施例中，所述第三消息用于指示 M 个时间单位内的第二消息是否包括参数指示信息，所述 M 为大于或者等于 1 的整数， 所述 M 个时间单位连续或者不连续。

在本公开的一个可行实施例中，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

在本公开的一个可行实施例中，所述空域的接收器参数包括所述接收端设备的接收波束。

在第四个方面中，本公开实施例还提供一种发送端设备，包括：

第一发送模块，用于发送端设备向接收端设备发送与第一消息关联的第二消息，所述第二消息用于所述接收端设备确定解码所述第一消息的目标接收器参数；以及

第二发送模块，用于向所述接收端设备发送所述第一消息。

在本公开的一个可行实施例中，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端设备默认的接收器参数。

在本公开的一个可行实施例中，所述接收端设备默认的接收器参数包括：

所述接收端设备当前使用的接收器参数、所述接收端设备接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端设备向所述发送端设备上报时间最近的发送器参数对应的接收器参数。

在本公开的一个可行实施例中，所述参数指示信息显式或者隐式指示所述目标接收器参数。

在本公开的一个可行实施例中，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端设备选择的发送器参数，所述接收端设备将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

在本公开的一个可行实施例中，若所述第二消息是在预先确定的参数切

换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

在本公开的一个可行实施例中，所述参数切换指示集对应的调度时间单位在时域上周期性存在；和/或

所述参数切换指示集对应的调度时间单位由所述发送端设备半静态或半持续配置，并通知所述接收端设备。

在本公开的一个可行实施例中，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前。

在本公开的一个可行实施例中，所述发送端设备还包括：

第三发送模块，用于向所述接收端设备发送第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

在本公开的一个可行实施例中，所述第三消息用于指示 M 个时间单位内的第二消息是否包括参数指示信息，所述 M 为大于或者等于 1 的整数， 所述 M 个时间单位连续或者不连续。

在本公开的一个可行实施例中，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

在本公开的一个可行实施例中，所述空域的接收器参数包括所述接收端设备的接收波束。

在第五个方面中，本公开实施例还提供一种接收端设备，包括：处理器、收发机、存储器、用户接口和总线接口，其中：

所述处理器，用于读取所述存储器中的程序，执行本公开实施例提供的

接收端设备对应的消息解码方法中的步骤。

在第六个方面中，本公开实施例还提供一种发送端设备，包括：处理器、收发机、存储器、用户接口和总线接口，其中：

所述处理器，用于读取所述存储器中的程序，执行本公开实施例提供的发送端设备对应的消息解码方法的步骤。

在第七个方面中，本公开实施例还提供一种计算机可读存储介质，所述计算机可读存储介质上存储有计算机程序，所述计算机程序被处理器执行时实现本公开实施例提供的接收端设备对应的消息解码方法中的步骤。

在第八个方面中，本公开实施例还提供一种计算机可读存储介质，所述计算机可读存储介质上存储有计算机程序，所述计算机程序被处理器执行时实现本公开实施例提供的发送端设备对应的消息解码方法的步骤。

本公开实施例所提供的上述技术方案至少具有如下有益效果：

根据本公开实施例，接收端设备接收发送端设备发送的与第一消息关联的第二消息；所述接收端设备根据所述第二消息，确定解码所述第一消息的目标接收器参数；所述接收端设备根据所述目标接收器参数对所述发送端设备发送的所述第一消息进行解码。这样可以实现接收端设备根据与第一消息关联的第二消息确定接收器参数，且还可以提高消息传输性能。

附图说明

为了更清楚地说明本公开文本实施例或相关技术中的技术方案，下面将对实施例描述中所需要使用的附图作简单地介绍，显而易见地，下面描述中的附图仅仅是本公开文本的一些实施例，对于本领域普通技术人员来讲，在不付出创造性劳动的前提下，还可以根据这些附图获得其他的附图。

图 1 为本公开实施例可应用的网络结构示意图；

图 2 为本公开实施例提供的一种消息解码方法的流程图；

图 3 为本公开实施例提供的一种消息发送的示意图；

图 4 为本公开实施例提供的另一种消息发送的示意图；

图 5 为本公开实施例提供的另一种消息发送的示意图；

图 6 为本公开实施例提供的另一种消息发送的示意图；

图 7 为本公开实施例提供的另一种消息解码方法的流程图；

图 8 为本公开实施例提供的一种接收端设备的结构示意图；

图 9 为本公开实施例提供的另一种接收端设备的结构示意图；

图 10 为本公开实施例提供的一种发送端设备的结构示意图；

图 11 为本公开实施例提供的另一种发送端设备的结构示意图；

图 12 为本公开实施例提供的另一种接收端设备的结构示意图；以及

图 13 为本公开实施例提供的另一种发送端设备的结构示意图。

具体实施方式

为使本公开要解决的技术问题、技术方案和优点更加清楚，下面将结合附图及具体实施例进行详细描述。

参见图 1，图 1 为本公开实施例可应用的网络结构示意图。如图 1 所示，包括发送端设备 11 和接收端设备 12。其中，发送端设备 11 可以是基站或者终端，而接收端设备 12 也可以是终端或者基站。例如：发送端设备 11 为基站，接收端设备 12 为终端，则可以实现终端与基站之间的通信，又或者发送端设备 11 为终端，则接收端设备 12 为基站，也可以实现终端与基站之间的通信，又或者发送端设备 11 为基站，接收端设备 12 也为基站，则可以实现基站与基站之间的通信，又或者发送端设备 11 为终端，接收端设备 12 也为终端，则可以实现终端与终端之间的通信。当然，本公开实施例中，并不限定发送端设备 11 只能是终端或者基站，例如：发送端设备 11 还可以是其他的网络侧设备。同理，接收端设备 12 也并不限定只是终端或者设备，例如：接收端设备 12 还可以是其他的网络侧设备，对此本公开实施例不作限定。其中，附图 1，以发送端设备 11 为基站，接收端设备 12 为终端进行举例示意。终端可以是用户终端（User Equipment，UE），例如：可以是手机、平板电脑（Tablet Personal Computer）、膝上型电脑（Laptop Computer）、个人数字助理（personal digital assistant，简称 PDA）、移动上网装置（Mobile Internet Device，MID）或可穿戴式设备（Wearable Device）等终端侧设备。需要说明的是，在本公开实施例中并不限定终端的具体类型。基站可以是宏站，如 LTE eNB、5G NR NB 等；也可以是小站，如低功率节点（LPN：low power node）pico、

femto 等小站，或者可以是接入点（AP，access point）。基站也可以是中央单元（CU，central unit）与其管理和控制的多个传输接收点（TRP，Transmission Reception Point）共同组成的网络节点。另外，一个基站下有一个或多个小区（例如：不同的频点或扇区分裂）。需要说明的是，在本公开实施例中并不限定基站的具体类型。

请参考图 2，图 2 是本本公开实施例提供一种消息解码方法的流程图，如图 2 所示，包括以下步骤：

201、接收端设备接收发送端设备发送的与第一消息关联的第二消息；

202、所述接收端设备根据所述第二消息，确定解码所述第一消息的目标接收器参数；以及

203、所述接收端设备根据所述目标接收器参数对所述发送端设备发送的所述第一消息进行解码。

其中，上述第一消息可以是发送端设备需要向接收端设备发送的信号，例如：数据和/或控制消息等等，如上述第一消息可以是下行链路信号。另外，本公开实施例中，可以将第一消息定义为 msg1。而上述第二消息可以理解为用于通知接收端设备接收器参考的消息，例如：控制消息或者调度消息等等。另外，本公开实施例中第二消息可以定义为 msg2。

上述根据所述第二消息，确定解码所述第一消息的目标接收器参数可以是，若上述第二消息中包括了参数指示信息，则确定该参数指示信息指示的接收器参数作为上述目标器参数，若上述第二消息中不包括参数指示信息，则确定默认的接收器参数作为上述目标器参数。即本公开实施例中，上述第二消息可以存在两种情况，一种是存在参数指示信息，该情况下接收端设备可能需要进行接收器参数切换，再对发送端设备发送的消息进行解码。另一种是不存在参数指示信息，该情况下接收端设备可能不需要进行波束接收器参数切换，直接对接收端设备发送的消息进行解码。另外，目标接收器参数可以是接收端设备中接收器的相关参数，例如：接收波束、均衡器和接收滤波器等参数中的至少一项，对此本公开实施例不作限定。例如：以目标接收器参数为目标接收波束为例，上述确定解码所述第一消息的目标接收波束还可以是在接收端设备的多个接收波束（Rx 波束）中选择一个或者多个接收波

束。且接收端设备的多个接收器参数可以是与发送端设备无关的，或者接收端设备的多个接收器参数对于发送端设备来说也可以是已知的，例如：通过预配置或反馈通知发送端设备，对此本公开实施例不作限定。

本公开实施例中，通过上述步骤就可以实现通过专门的第二消息向接收端设备通知发送端设备发送的第一消息的接收波束，从而使得接收端设备和发送端设备获得更准确的波束组合信息，支持多波束传输，以及提高波束传输性能。另外，本公开实施例可以用于在无线通信系统中的接收端设备的模拟波束切换，以及还可以用于接收端设备的数字波束切换等，对此本公开实施例不作限定。

在本公开的一个可行实施例中，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端设备默认的接收器参数。

该实施方式中，可以实现上述第二消息中包括或者不包括参数指示信息，若包括，则将参数指示信息指示的接收器参数作为上述目标接收器参数。其中，参数指示信息指示接收波束可以是与接收端设备当前使用的接收器参数为不同的接收器参数，这时接收端设备需要进行接收器参数切换。而使用默认的接收器参数，可以不进行切换，例如：默认的接收器参数就可以是接收端设备当前使用的接收器参数，以快速对发送端设备发送的消息进行解码。另外，本公开实施例中，第二消息中的参数指示信息可以是，第二消息中的参数指示字段，即第二消息中可以存在或者不存在该参数指示字段。

例如：所述接收端设备默认的接收器参数包括：

所述接收端设备当前使用的接收器参数、所述接收端设备接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端设备向所述发送端设备上报时间最近的发送器参数对应的接收器参数。

该实施方式中，通过上述默认波束可以减少接收器参数的切换，例如：减少接收波束的切换，以提高传输性能。例如，第二消息与第一消息之间可以不存在间隙。

另外，本公开实施例中，上述参数指示信息可以显式或者隐式指示所述

目标接收器参数。例如：显式或者隐式指示所述目标接收波束。

其中，显式指示可以理解为直接指示，例如：以接收波束举例，接收端设备具有一组 L 个预配置的接收波束，这些对于发送端设备可以是已知的。这样上述参数指示信息例如可以携带 Log2（L）位的字段，以指示接收端设备的推荐接收波束。在接收到第二消息后，接收端设备就可以确定对应的接收波束用于解码 msg1。而上述隐式指示可以理解为间接指示，例如：上述参数指示信息可以是指示发送波束（Tx 波束），通过指示的发送波束隐式指示该发送波束对应的接收波束。该实施方式中，通过上述显式或者隐式的方式可以实现灵活地向接收端设备指示接收波束，以提高系统的灵活性。

在本公开的一个可行实施例中，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端设备选择的发送器参数，所述接收端设备将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

该实施方式中，可以实现通过发送器参数来隐式指示接收器参数，例如：以目标接收器参数为目标波束举例，发送端设备可以具有用于下行链路传输的 M 个候选发送波束。发送端设备配置 M 个参考符号（RS）资源，并将每个发送波束应用于相应的 RS 资源。对于每个 RS 资源，接收端设备可以测试一组候选接收波束，并确定每个 RS 资源（例如发送波束）的最佳接收波束。在本公开的一个可行实施例中，接收端设备可以将至少推荐的发送波束的信息反馈给发送端设备，例如，以推荐的 RS 资源的形式，但这一步是可选的。在发送第一消息之前，发送端设备以第二消息的方式发送其选定的发送波束的指示。接收端设备接收到第二消息后，获得所使用的发送波束的信息，并获得最佳的接收波束作为上述目标接收波束，该最佳的接收波束可以是从先前的测量已知并保存在接收端设备中。

该实施方式中，可以实现通过发送器参数来隐式指示接收器参数，从而有利于接收端设备与发送端设备之间的传输。当然，在一些实施方式中，发送端设备可以是根据接收端设备返回的推荐信息自主选择相应的发送器参数，例如：发送波束。

在本公开的一个可行实施例中，若所述第二消息是在预先确定的参数切

换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

该实施方式中，上述参数切换指示集（BSIS）对应的调度时间单位可以是子帧或者时隙（slots）等时间单位。且发送端设备和接收端设备对 BSIS 可以具有一致的认识。只有在 BSIS 对应的 slot（这里以 slot 为例）中，第二消息才可能会携带参数指示信息，否则第二消息不携带参数指示信息。这意味着在 BSIS 对应的时隙之外的所有时隙中可以不执行接收器参数切换，例如：接收波束切换，而仅在周期性的选定时隙（例如 BSIS 中的时隙）中执行接收器参数切换。

另外，由于第二消息包括参数指示信息时，所述第二消息与所述第一消息之间存在间隙，这样接收端设备可以是在该间隙切换进行接收器参数切换，例如：接收波束切换，从而不影响消息的传输。而所述第二消息不包括参数指示信息时，所述第二消息与所述第一消息之间可以不存在间隙，这样可以节约传输资源。这是因为该情况下，接收端设备可能是不需要进行接收器参数切换，例如：接收波束切换，进而第二消息和第一消息连续传输也不会影响接收端设备的解码。且上述第二消息和第一消息可以采用相同的频域资源发送的，或者采用相同的信道发送等，对此本公开实施例不作限定。

例如：对于在 BSIS 中的时隙中发送的第二消息，携带参数指示信息。在这种情况下，同一时隙中的第一消息和第二消息之间有切换时间。否则对于 BSIS 外的时隙中的第二消息传输，发送端设备发送第二消息，而不携带波束指示字段。在这种情况下，接收端设备可以准备在第二消息之后立即接收第一消息（没有间隙）。例如：图 3 所示的第二个 slot。另外，当尝试在每个时隙中接收到第二消息或者第一消息时，接收端设备可以根据假定存在或者不存在参数指示信息来解码第二消息。换句话说，在 BSIS 中的时隙中，第二消息可以携带参数指示信息，接收端设备尝试解码第二消息，假设有一个参数指示信息。在其他时隙中，接收器解码第二消息，假设没有参数指示信息。

在第二消息不携带参数指示信息的时隙中，接收端设备仍然可以选择一个接收器参数（例如：接收波束）来解码第一消息。接收端设备可以使用在最新的携带参数指示字段的第二消息中指示的接收器参数。如果没有接收到参数指示信息，则接收机可以使用默认的接收器参数来解码第一消息。

在本公开的一个可行实施例中，所述参数切换指示集对应的调度时间单位在时域上周期性存在；和/或

所述参数切换指示集对应的调度时间单位由所述发送端设备半静态或半持续(semi-persistent)配置，并通知所述接收端设备。

其中，上述参数切换指示集对应的调度时间单位在时域上周期性存在可以是，上述参数切换指示集对应的调度时间单位具有周期性，例如：参数切换指示集在时域中可以周期性地具有预配置的周期和定时偏移，其中，该定时偏移可以是相对于另一个定时参考的偏移，如帧边界。例如，参数切换指示集可以具有 10ms 的周期，其指示在 10 个 slots 中的 1 个中发送的第二消息可能会携带参数指示信息，而其他 9 个 slots 中的第二消息不携带参数指示信息。上述参数切换指示集对应的调度时间单位由所述发送端设备半静态或半持续配置，并通知所述接收端设备可以是，发送端设备半静态或半持续配置，并通知接收端设备参数切换指示集的集合，即指示多个参数切换指示集。或者上述参数切换指示集可以由接收端设备获得，并作为推荐被反馈给发送端设备。发送端设备可以使用接收端设备推荐的参数切换指示集，或覆盖接收端设备推荐的参数切换指示集，并选择一个新的参数切换指示集。发送端设备可以需要向接收端设备指示是否确认接收端设备推荐的参数切换指示集，或者将其选择的参数切换指示集指示给接收端设备。

在本公开的一个可行实施例中，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前，所述接收端设备根据所述目标接收器参数对所述第一消息进行解码，包括：

若所述第二消息包括参数指示信息，则所述接收端设备根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示信息，则所述接收端设备丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示信息，则所述接收端设备根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息不包括参数指示信息，则所述接收端设备根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

该实施方式中，所述第一消息分为时域上连续的第一部分内容和第二部分内容可以是接收端设备将第一消息分为两个部分，这里将第一消息分为两个部分可以理解为将第一消息看作两个部分，这是因为此时接收端设备还未接收到第一消息，不能对其进行拆分。

例如：发送端设备可以发送携带与接收第一消息有关的下行调度信息的第二消息。第二消息可以携带或不携带参数指示信息，对此接收端设备可以没有先验知识。如果第二消息没有参数指示信息，则第二消息的有效载荷较小（表示为 A 位）。如果第二消息具有参数指示信息，则第二消息的有效载荷较大（表示为 B 位，其中 B> A）。在发送端设备发送第二消息后，接收端设备可以尝试用盲解码第二消息。因为接收端设备没有关于第二消息的有效载荷的先验信息，因此需要基于不同的可能的第二消息有效载荷来执行盲解码。例如，接收端设备将执行假设有效载荷 A 位的第二消息的一次盲解码，以及假设 B 位的有效载荷的另一个第二消息的盲解码。这样根据第二消息的实际有效负载，两个盲解码之一将成功解码第二消息。之后，接收端设备就可以将第一消息分为第一部分内容和第二部分内容 （part 1 and part 2），第一部分内容在第二部分内容前面，并且在时域中为时分复用（TDM）。第一消息的第一部分部分紧随着第二消息，即两者没有间隙，第一消息的第二部分内容紧邻第一部分内容，例如：图 4 所示的第二个 slot。

另外，由于第一部分内容和第二部分内容属于同一消息，从而接收端设备可以分别对第一部分内容和第二部分内容执行符号级处理。

该实施方式中，由于若所述第二消息包括参数指示信息时，则所述接收

端设备使用所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码，其中，所述发送端设备未发送所述第一部分内容。例如：图 4 所示的第一个 slot。这样可以提高接收端设备解码的准确性。

另外，由于第二消息包括参数指示信息时，可以丢弃所述第一部分内容，以及使用所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码。即可以丢弃图 4 所示的第二个 slot 的第一部分内容，同样能够保证发送端设备与接收端设备之间的性能，这是因为在该情况下发送端设备可以在第一部分内容中传输非重要信息，而在第二部分内容中传输重要信息。当然，本公开实施例并不以此为限，在第一消息包括参数指示信息时，还可以是发送端设备可以在第一部分内容中传输重要信息，而在第二部分内容中传输非重要信息。

另外，由于第二消息包括参数指示信息时，可以使用默认的接收器参数对所述第一部分内容进行解码，以及使用所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码。这样可以实现接收到准备地解码第一部分部分和第二部分内容。

另外，由于第二消息不包括参数指示信息，可以实现使用默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。即图 4 所示的第三个 slot。

另外，发送端设备和接收端设备可以将其对接收端设备上确切的第一消息解码行为的理解对齐。这可以由网络半静态地或半持续地配置给接收端设备，或者使用另一个动态控制消息动态地指示给接收端设备。

可选的，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前，所述接收端设备根据所述目标接收器参数对所述发送端设备发送的所述第一消息进行解码，包括：

若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端设备根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端设备丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端设备根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段指示没有参数指示信息或者没有参数改变，则所述接收端设备根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

该实施方式中，可以实现第二消息始终具有参数指示字段，例如：波束指示字段，例如 S 比特位。且参数指示字段具有至少一个状态指示，即没有参数指示信息或者没有参数改变的状态指示，以及还可以指示用于解码第一消息的接收器参数的其他状态。因此，第二消息的有效载荷预先已知到发送端设备和接收端设备。例如对应于 4 个可能的接收器参数指示状态的 S=2。一个状态向接收机指示存在“没有参数指示信息或者没有参数改变”，而其他 3 个状态指示到接收机的接收器参数。

另外，该实施方式中，关于第一消息的第一部分内容和第二部分内容可以参考上一实施方式中的相应描述，此处不作赘述。

且关于第二消息中是否包括参数指示信息的情况，如何对第一部分内容和第二部分内容的解码，可以参见上述实施方式的相应描述，此处不作赘述，且可以达到相同或相似的有益效果。

在本公开的一个可行实施例中，所述方法还包括：

所述接收端设备接收所述发送端设备发送的第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

其中，上述第三消息可以定义为 msg3，该实施方式中，通过第三消息通

知接收端设备第二消息是否包括参数指示信息，更为具体的可以指示第二消息指示的接收器参数对于接收端设备是否存在接收器参数改变，这样可以实现当不存在接收器参数改变或者不包括参数指示信息时，接收端设备甚至可以不接收第二消息，直接使用当前的接收器参数对第一消息进行解码。另外，在一些实施方式中，第三消息可以具有固定有效载荷，其中第二消息中的参数指示信息的存在或者不存在对应于第三消息中的两个不同状态。例如，第三消息有 1 位表示第二消息是否携带参数指示信息。

另外，本公开实施例中，上述第三消息可以对应于一个第二消息，即一个第三消息指示一个第二消息，例如：如图 5 所示。且第三消息、第二消息可以是以相同的调度时间单位（例如，时隙）发送，其中图 5 给出了一个示例。可以以不同的调度时间单位发送的第三消息和第二消息。如果第二消息有参数指示信息，第一消息和第二消息之间可以有一个间隙。如果第二消息没有参数指示信息，第一消息和第二消息之间可以没有间隙。

在本公开的一个可行实施例中，所述第三消息用于指示 M 个时间单位内的第二消息是否包括参数指示信息，所述 M 为大于或者等于 1 的整数， 所述 M 个时间单位连续或者不连续。

该实施方式中，可以实现通过第三消息指示多个第二消息，例如：第三消息用于指示 M 个时隙中的 M 个第二消息是否包括参数指示信息，这样可以节省消息开销。另外，上述 M 的值和 M 个第二消息的时间位置可以预定义的半静态或半持续配置的，并且对发送端设备和接收端设备均是已知的。其中，图 6 示出了一个例子，其中 M = 3。一旦接收到第三消息，该第三消息就向接收端设备指示相应的 M 个时隙中的第二消息是否携带参数指示信息。

另外，第三消息可以是可以在每个调度时间单位（例如 slots）或在由发送端设备预配置的时隙的子集（例如，具有预先配置的传输周期和偏移）中被发送。对于后一种情况，发送端设备可以事先向接收端设备指示第三消息的发生。

在本公开的一个可行实施例中，本公开实施例中，目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

这样可以实现根据发送端设备的第二消息灵活选择时域、频域和空域中

的至少一项的接收器参数，对第一消息进行解码。在本公开的一个可行实施例中，所述空域的接收器参数包括所述接收端设备的接收波束。这样可以实现接收端设备根据与第一消息关联的第二消息确定接收波束，且还可以提高波束传输性能。

需要说明的是，本公开实施例介绍的多种可选的实施方式均可以相互结合实现，也可以单独实现，对此本公开实施例不作限定。

本公开实施例，接收端设备接收发送端设备发送的与第一消息关联的第二消息；所述接收端设备根据所述第二消息，确定解码所述第一消息的目标接收器参数；所述接收端设备根据所述目标接收器参数对所述发送端设备发送的所述第一消息进行解码。这样可以实现接收端设备根据与第一消息关联的第二消息确定接收器参数，且还可以提高消息传输性能。

请参阅图 7，图 7 是本公开实施例提供的另一种消息解码方法的流程图，如图 7 所示，包括以下步骤：

701、发送端设备向接收端设备发送与第一消息关联的第二消息，所述第二消息用于所述接收端设备确定解码所述第一消息的目标接收器参数；以及

702、所述发送端设备向所述接收端设备发送所述第一消息。

在本公开的一个可行实施例中，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端设备默认的接收器参数。

在本公开的一个可行实施例中，所述接收端设备默认的接收器参数包括：

所述接收端设备当前使用的接收器参数、所述接收端设备接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端设备向所述发送端设备上报时间最近的发送器参数对应的接收器参数。

在本公开的一个可行实施例中，所述参数指示信息显式或者隐式指示所述目标接收器参数。

在本公开的一个可行实施例中，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端设备选择的发送器参数，所述接收端设备将预先为所述发送器参数选择的接收器参数作为所述目标接

收器参数。

在本公开的一个可行实施例中，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

在本公开的一个可行实施例中，所述参数切换指示集对应的调度时间单位在时域上周期性存在；和/或

所述参数切换指示集对应的调度时间单位由所述发送端设备半静态或半持续配置，并通知所述接收端设备。

在本公开的一个可行实施例中，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前。

在本公开的一个可行实施例中，所述方法还包括：

所述发送端设备向所述接收端设备发送第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

在本公开的一个可行实施例中，所述第三消息用于指示 M 个时间单位内的第二消息是否包括参数指示信息，所述 M 为大于或者等于 1 的整数， 所述 M 个时间单位连续或者不连续。

在本公开的一个可行实施例中，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

在本公开的一个可行实施例中，所述空域的接收器参数包括所述接收端设备的接收波束。

需要说明的是，本实施例作为与图 2 所示的实施例中对应的发送端设备

的实施方式，其具体的实施方式可以参见图 2 所示的实施例的相关说明，为了避免重复说明，本实施例不再赘述，且还可以达到相同或相似有益效果。

请参考图 8，图 8 是本公开实施例提供一种接收端设备的结构图，如图 8 所示，接收端设备 800 包括：

第一接收模块 801，用于接收发送端设备发送的与第一消息关联的第二消息；

确定模块 802，用于根据所述第二消息，确定解码所述第一消息的目标接收器参数；以及

解码模块 803，用于根据所述目标接收器参数对所述发送端设备发送的所述第一消息进行解码。

在本公开的一个可行实施例中，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端设备默认的接收器参数。

在本公开的一个可行实施例中，所述接收端设备默认的接收器参数包括：

所述接收端设备当前使用的接收器参数、所述接收端设备接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端设备向所述发送端设备上报时间最近的发送器参数对应的接收器参数。

在本公开的一个可行实施例中，所述参数指示信息显式或者隐式指示所述目标接收器参数。

在本公开的一个可行实施例中，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端设备选择的发送器参数，所述接收端设备将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

在本公开的一个可行实施例中，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息

之间不存在间隙。

在本公开的一个可行实施例中，所述参数切换指示集对应的调度时间单位在时域上周期性存在；和/或

所述参数切换指示集对应的调度时间单位由所述发送端设备半静态或半持续配置，并通知所述接收端设备。

在本公开的一个可行实施例中，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前；

所述解码模块 803 用于若所述第二消息包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块 803 用于若所述第二消息包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块 803 用于若所述第二消息包括参数指示信息，则根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块 803 用于若所述第二消息不包括参数指示信息，则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码；或者

所述解码模块 803 用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块 803 用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块 803 用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第

二部分内容进行解码；或者

所述解码模块 803 用于若所述第二消息包括参数指示字段，且所述参数指示字段指示没有参数指示信息或者没有参数改变，则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

在本公开的一个可行实施例中，如图 9 所示，所述接收端设备 800 还包括：

第二接收模块 804，用于接收所述发送端设备发送的第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

在本公开的一个可行实施例中，所述第三消息用于指示 M 个时间单位内的第二消息是否包括参数指示信息，所述 M 为大于或者等于 1 的整数， 所述 M 个时间单位连续或者不连续。

在本公开的一个可行实施例中，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

在本公开的一个可行实施例中，所述空域的接收器参数包括所述接收端设备的接收波束。

需要说明的是，本实施例中上述接收端设备 800 可以是本公开实施例中方法实施例中任意实施方式的接收端设备，本公开实施例中方法实施例中接收端设备的任意实施方式都可以被本实施例中的上述接收端设备 800 所实现，以及达到相同或相似的有益效果，此处不再赘述。

请参阅图 10，图 10 是本公开实施例提供的一种发送端设备的结构图，如图 10 所示，发送端设备 1000 包括：

第一发送模块 1001，用于发送端设备向接收端设备发送与第一消息关联的第二消息，所述第二消息用于所述接收端设备确定解码所述第一消息的目标接收器参数；

第二发送模块 1002，用于向所述接收端设备发送所述第一消息。

在本公开的一个可行实施例中，若所述第二消息包括参数指示信息，则

所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端设备默认的接收器参数。

在本公开的一个可行实施例中，所述接收端设备默认的接收器参数包括：

所述接收端设备当前使用的接收器参数、所述接收端设备接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端设备向所述发送端设备上报时间最近的发送器参数对应的接收器参数。

在本公开的一个可行实施例中，所述参数指示信息显式或者隐式指示所述目标接收器参数。

在本公开的一个可行实施例中，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端设备选择的发送器参数，所述接收端设备将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

在本公开的一个可行实施例中，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

在本公开的一个可行实施例中，所述参数切换指示集对应的调度时间单位在时域上周期性存在；和/或

所述参数切换指示集对应的调度时间单位由所述发送端设备半静态或半持续配置，并通知所述接收端设备。

在本公开的一个可行实施例中，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前。

在本公开的一个可行实施例中，如图 11 所示，所述发送端设备还包括：

第三发送模块 1003，用于向所述接收端设备发送第三消息，所述第三消

息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

在本公开的一个可行实施例中，所述第三消息用于指示 M 个时间单位内的第二消息是否包括参数指示信息，所述 M 为大于或者等于 1 的整数，所述 M 个时间单位连续或者不连续。

在本公开的一个可行实施例中，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

在本公开的一个可行实施例中，所述空域的接收器参数包括所述接收端设备的接收波束。

需要说明的是，本实施例中上述发送端设备 1000 可以是本公开实施例中方法实施例中任意实施方式的发送端设备，本公开实施例中方法实施例中发送端设备的任意实施方式都可以被本实施例中的上述发送端设备 1000 所实现，以及达到相同或相似的有益效果，此处不再赘述。

请参考图 12，图 12 是本公开实施例提供的另一种接收端设备的结构图，如图 12 所示，该接收端设备包括：处理器 1200、收发机 1210、存储器 1220、用户接口 1230 和总线接口，其中：

处理器 1200，用于读取存储器 1220 中的程序，执行下列过程：

通过收发机 1210 接收端设备接收发送端设备发送的与第一消息关联的第二消息；

根据所述第二消息，确定解码所述第一消息的目标接收器参数；

根据所述目标接收器参数对所述发送端设备发送的所述第一消息进行解码。

其中，收发机 1210，用于在处理器 1200 的控制下接收和发送数据。

在图 12 中，总线架构可以包括任意数量的互联的总线和桥，具体由处理器 1200 代表的一个或多个处理器和存储器 1220 代表的存储器的各种电路链接在一起。总线架构还可以将诸如外围设备、稳压器和功率管理电路等之类的各种其他电路链接在一起，这些都是本领域所公知的，因此，本文不再对

其进行进一步描述。总线接口提供接口。收发机 1210 可以是多个元件，即包括发送机和接收机，提供用于在传输介质上与各种其他装置通信的单元。针对不同的用户设备，用户接口 1230 还可以是能够外接内接需要设备的接口，连接的设备包括但不限于小键盘、显示器、扬声器、麦克风、操纵杆等。

处理器 1200 负责管理总线架构和通常的处理，存储器 1220 可以存储处理器 1200 在执行操作时所使用的数据。

在本公开的一个可行实施例中，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端设备默认的接收器参数。

在本公开的一个可行实施例中，所述接收端设备默认的接收器参数包括：

所述接收端设备当前使用的接收器参数、所述接收端设备接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端设备向所述发送端设备上报时间最近的发送器参数对应的接收器参数。

在本公开的一个可行实施例中，所述参数指示信息显式或者隐式指示所述目标接收器参数。

在本公开的一个可行实施例中，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端设备选择的发送器参数，所述接收端设备将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

在本公开的一个可行实施例中，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

在本公开的一个可行实施例中，所述参数切换指示集对应的调度时间单位在时域上周期性存在；和/或

所述参数切换指示集对应的调度时间单位由所述发送端设备半静态或半

持续配置，并通知所述接收端设备。

在本公开的一个可行实施例中，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前，所述根据所述目标接收器参数对所述第一消息进行解码，包括：

若所述第二消息包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示信息，则根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息不包括参数指示信息，则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段指示没有参数指示信息或者没有参数改变，则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

在本公开的一个可行实施例中，处理器 1200 还用于：

通过收发机 1210 接收所述发送端设备发送的第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

在本公开的一个可行实施例中，所述第三消息用于指示 M 个时间单位内的第二消息是否包括参数指示信息，所述 M 为大于或者等于 1 的整数， 所述 M 个时间单位连续或者不连续。

在本公开的一个可行实施例中，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

在本公开的一个可行实施例中，所述空域的接收器参数包括所述接收端设备的接收波束。

需要说明的是，本实施例中上述接收端设备可以是图 1-图 7 所示的实施例中的终端，图 1-图 7 所示实施例中接收端设备的任意实施方式都可以被本实施例中的上述接收端设备所实现，以及达到相同或相似的有益效果，此处不再赘述。

请参考图 13，图 13 是本公开实施例提供的另一种发送端设备的结构图，如图 13 所示，该发送端设备包括：处理器 1300、收发机 1310、存储器 1320、用户接口 1330 和总线接口，其中：

处理器 1300，用于读取存储器 1320 中的程序，执行下列过程：

通过收发机 1310 向接收端设备发送与第一消息关联的第二消息，所述第二消息用于所述接收端设备确定解码所述第一消息的目标接收器参数；

通过收发机 1310 向所述接收端设备发送所述第一消息。

其中，收发机 1310，用于在处理器 1300 的控制下接收和发送数据。

在图 13 中，总线架构可以包括任意数量的互联的总线和桥，具体由处理器 1300 代表的一个或多个处理器和存储器 1320 代表的存储器的各种电路链接在一起。总线架构还可以将诸如外围设备、稳压器和功率管理电路等之类的各种其他电路链接在一起，这些都是本领域所公知的，因此，本文不再对

其进行进一步描述。总线接口提供接口。收发机 1310 可以是多个元件，即包括发送机和接收机，提供用于在传输介质上与各种其他装置通信的单元。针对不同的用户设备，用户接口 1330 还可以是能够外接内接需要设备的接口，连接的设备包括但不限于小键盘、显示器、扬声器、麦克风、操纵杆等。

处理器 1300 负责管理总线架构和通常的处理，存储器 1320 可以存储处理器 1300 在执行操作时所使用的数据。

在本公开的一个可行实施例中，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端设备默认的接收器参数。

在本公开的一个可行实施例中，所述接收端设备默认的接收器参数包括：

所述接收端设备当前使用的接收器参数、所述接收端设备接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端设备向所述发送端设备上报时间最近的发送器参数对应的接收器参数。

在本公开的一个可行实施例中，所述参数指示信息显式或者隐式指示所述目标接收器参数。

在本公开的一个可行实施例中，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端设备选择的发送器参数，所述接收端设备将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

在本公开的一个可行实施例中，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

在本公开的一个可行实施例中，所述参数切换指示集对应的调度时间单位在时域上周期性存在；和/或

所述参数切换指示集对应的调度时间单位由所述发送端设备半静态或半

持续配置，并通知所述接收端设备。

在本公开的一个可行实施例中，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前。

在本公开的一个可行实施例中，处理器 1300 还用于：

通过收发机 1310 向所述接收端设备发送第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

在本公开的一个可行实施例中，所述第三消息用于指示 M 个时间单位内的第二消息是否包括参数指示信息，所述 M 为大于或者等于 1 的整数， 所述 M 个时间单位连续或者不连续。

在本公开的一个可行实施例中，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

在本公开的一个可行实施例中，所述空域的接收器参数包括所述接收端设备的接收波束。

需要说明的是，本实施例中上述发送端设备可以是图 1-图 7 所示的实施例中的发送端设备，图 1-图 7 所示实施例中发送端设备的任意实施方式都可以被本实施例中的上述发送端设备所实现，以及达到相同或相似的有益效果，此处不再赘述。

在本申请所提供的几个实施例中，应该理解到，所揭露方法和装置，可以通过其它的方式实现。例如，以上所描述的装置实施例仅仅是示意性的。例如，所述单元的划分，仅仅为一种逻辑功能划分，实际实现时可以有另外的划分方式，例如多个单元或组件可以结合或者可以集成到另一个系统，或一些特征可以忽略，或不执行。另一点，所显示或讨论的相互之间的耦合或直接耦合或通信连接可以是通过一些接口，装置或单元的间接耦合或通信连接，可以是电性，机械或其它的形式。

另外，在本公开各个实施例中的各功能单元可以集成在一个处理单元中，也可以是各个单元单独物理包括，也可以两个或两个以上单元集成在一个单元中。上述集成的单元既可以采用硬件的形式实现，也可以采用硬件加软件功能单元的形式实现。

上述以软件功能单元的形式实现的集成的单元，可以存储在一个计算机可读取存储介质中。上述软件功能单元存储在一个存储介质中，包括若干指令用以使得一台计算机设备（可以是个人计算机，服务器，或者网络设备等）执行本公开各个实施例所述收发方法的部分步骤。而前述的存储介质包括：U 盘、移动硬盘、只读存储器（Read-Only Memory，简称 ROM）、随机存取存储器（Random Access Memory，简称 RAM）、磁碟或者光盘等各种可以存储程序代码的介质。

以上所述是本公开的优选实施方式，应当指出，对于本技术领域的普通技术人员来说，在不脱离本公开所述原理的前提下，还可以作出若干改进和润饰，这些改进和润饰也应视为本公开的保护范围。

权 利 要 求 书

1. 一种消息解码方法，包括：

接收端设备接收发送端设备发送的与第一消息关联的第二消息；

所述接收端设备根据所述第二消息，确定解码所述第一消息的目标接收器参数；以及

所述接收端设备根据所述目标接收器参数对所述发送端设备发送的所述第一消息进行解码。

2. 如权利要求 1 所述的方法，其中，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端设备默认的接收器参数。

3. 如权利要求 2 所述的方法，其中，所述接收端设备默认的接收器参数包括：

所述接收端设备当前使用的接收器参数、所述接收端设备接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端设备向所述发送端设备上报时间最近的发送器参数对应的接收器参数。

4. 如权利要求 2 或 3 所述的方法，其中，所述参数指示信息显式或者隐式指示所述目标接收器参数。

5. 如权利要求 4 所述的方法，其中，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端设备选择的发送器参数，所述接收端设备将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

6. 如权利要求 1-5 中任一项所述的方法，其中，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

7. 如权利要求 6 所述的方法，其中，所述参数切换指示集对应的调度时间单位在时域上周期性存在；和/或

所述参数切换指示集对应的调度时间单位由所述发送端设备半静态或半持续配置，并通知所述接收端设备。

8. 如权利要求 1-5 中任一项所述的方法，其中，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前，所述接收端设备根据所述目标接收器参数对所述第一消息进行解码，包括：

若所述第二消息包括参数指示信息，则所述接收端设备根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示信息，则所述接收端设备丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示信息，则所述接收端设备根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息不包括参数指示信息，则所述接收端设备根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端设备根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端设备丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端设备根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段指示没有参数指示信息或者没有参数改变，则所述接收端设备根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

9. 如权利要求 1-5 中任一项所述的方法，其中，所述方法还包括：

所述接收端设备接收所述发送端设备发送的第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

10. 如权利要求 9 所述的方法，其中，所述第三消息用于指示 M 个时间单位内的第二消息是否包括参数指示信息，所述 M 为大于或者等于 1 的整数，所述 M 个时间单位连续或者不连续。

11. 如权利要求 1-5 中任一项所述的方法，其中，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

12. 如权利要求 11 所述的方法，其中，所述空域的接收器参数包括所述接收端设备的接收波束。

13. 一种消息解码方法，包括：

发送端设备向接收端设备发送与第一消息关联的第二消息，所述第二消息用于所述接收端设备确定解码所述第一消息的目标接收器参数；以及

所述发送端设备向所述接收端设备发送所述第一消息。

14. 如权利要求 13 所述的方法，其中，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端设备默认的接收器参数。

15. 如权利要求 14 所述的方法，其中，所述接收端设备默认的接收器参数包括：

所述接收端设备当前使用的接收器参数、所述接收端设备接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端设备向所述发送端设备上报时间最近的发送器参数对应的接收器参数。

16. 如权利要求 14 或 15 所述的方法，其中，所述参数指示信息显式或者隐式指示所述目标接收器参数。

17. 如权利要求 16 所述的方法，其中，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端设备选择的发送器参数，所述接收端设备将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

18. 如权利要求 13-17 中任一项所述的方法，其中，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

19. 如权利要求 18 所述的方法，其中，所述参数切换指示集对应的调度时间单位在时域上周期性存在；和/或

所述参数切换指示集对应的调度时间单位由所述发送端设备半静态或半持续配置，并通知所述接收端设备。

20. 如权利要求 13-17 中任一项所述的方法，其中，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前。

21. 如权利要求 13-17 中任一项所述的方法，其中，所述方法还包括：

所述发送端设备向所述接收端设备发送第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

22. 如权利要求 21 所述的方法，其中，所述第三消息用于指示 M 个时间单位内的第二消息是否包括参数指示信息，所述 M 为大于或者等于 1 的整数，所述 M 个时间单位连续或者不连续。

23. 如权利要求 13-17 中任一项所述的方法，其中，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

24. 如权利要求 23 所述的方法，其中，所述空域的接收器参数包括所述接收端设备的接收波束。

25. 一种接收端设备，包括：

第一接收模块，用于接收发送端设备发送的与第一消息关联的第二消息；

确定模块，用于根据所述第二消息，确定解码所述第一消息的目标接收器参数；以及

解码模块，用于根据所述目标接收器参数对所述发送端设备发送的所述第一消息进行解码。

26. 如权利要求 25 所述的接收端设备，其中，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端设备默认的接收器参数。

27. 如权利要求 25 或 26 所述的接收端设备，其中，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

28. 如权利要求 25 或 26 所述的接收端设备，其中，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前；

所述解码模块用于若所述第二消息包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示信息，则根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息不包括参数指示信息，则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示字段，且所述参数指示字段指示没有参数指示信息或者没有参数改变，则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

29. 如权利要求 25 或 26 所述的接收端设备，其中，所述接收端设备还包括：

第二接收模块，用于接收所述发送端设备发送的第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

30. 一种发送端设备，包括：

第一发送模块，用于发送端设备向接收端设备发送与第一消息关联的第二消息，所述第二消息用于所述接收端设备确定解码所述第一消息的目标接收器参数；以及

第二发送模块，用于向所述接收端设备发送所述第一消息。

31. 如权利要求 30 所述的发送端设备，其中，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端设备默认的接收器参数。

32. 如权利要求 30 或 31 所述的发送端设备，其中，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

33. 如权利要求 30 或 31 所述的发送端设备，其中，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前。

34. 如权利要求 30 或 31 所述的发送端设备，其中，所述发送端设备还包括：

第三发送模块，用于向所述接收端设备发送第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

35. 一种接收端设备，包括：处理器、存储器及存储在所述存储器上并可在所述处理器上运行的计算机程序，所述计算机程序被所述处理器执行时实现如权利要求 1 至 12 中任一项所述的消息解码方法中的步骤。

36. 一种发送端设备，包括：处理器、存储器及存储在所述存储器上并可在所述处理器上运行的计算机程序，所述计算机程序被所述处理器执行时实现如权利要求 13 至 24 中任一项所述的消息解码方法中的步骤。

37. 一种计算机可读存储介质，所述计算机可读存储介质上存储有计算

机程序，所述计算机程序被处理器执行时实现如权利要求 1 至 12 中任一项所述的消息解码方法中的步骤。

38. 一种计算机可读存储介质，所述计算机可读存储介质上存储有计算机程序，所述计算机程序被处理器执行时实现如权利要求 13 至 24 中任一项所述的消息解码方法中的步骤。

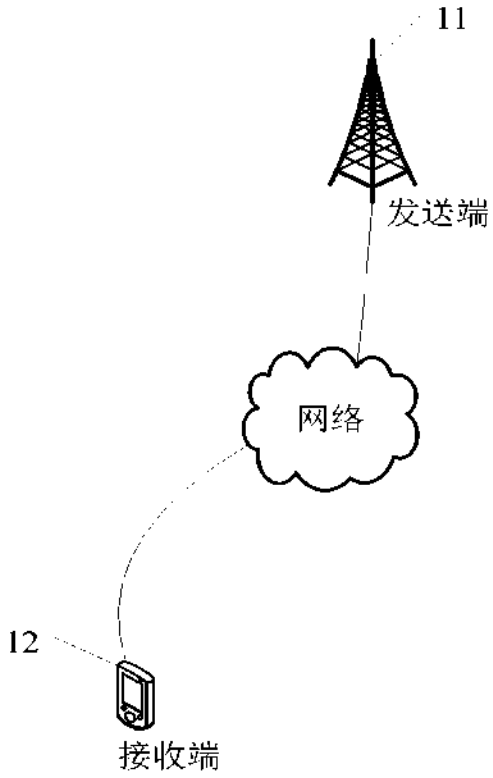

11
发送端
网络
12
接收端

图 1

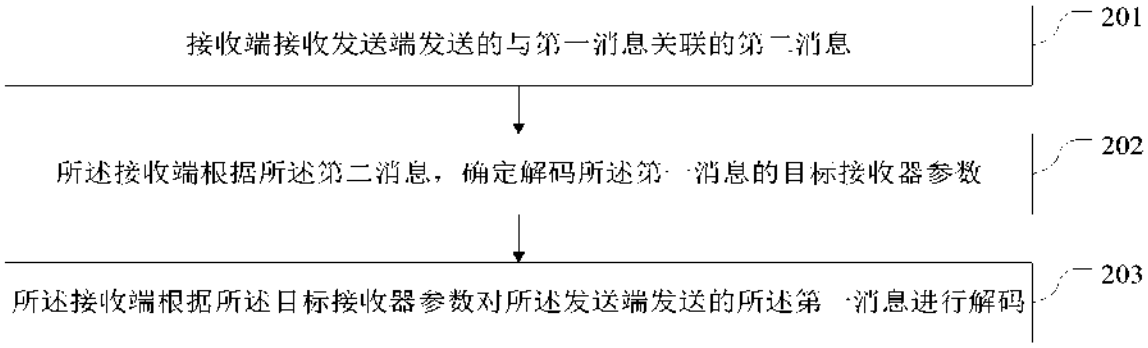

接收端接收发送端发送的与第一消息关联的第二消息
201
所述接收端根据所述第二消息，确定解码所述第一消息的目标接收器参数
202
所述接收端根据所述目标接收器参数对所述发送端发送的所述第一消息进行解码
203

图 2

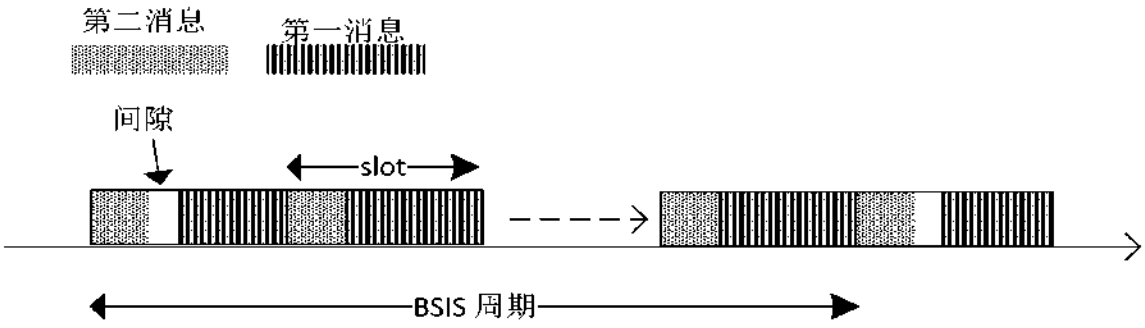

第二消息
第一消息
间隙
slot
BSIS 周期

图 3

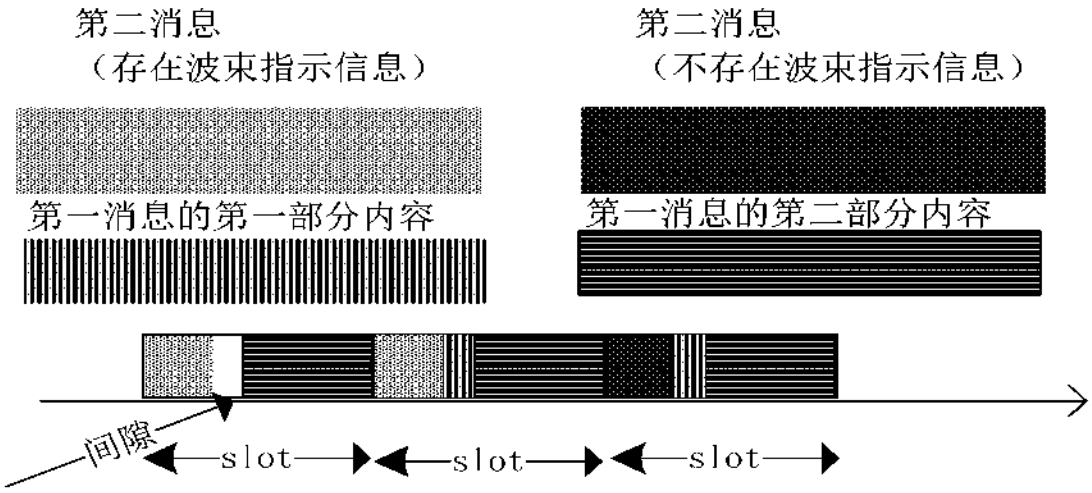

第二消息
（存在波束指示信息）
第二消息
（不存在波束指示信息）
第一消息的第一部分内容
第一消息的第二部分内容
间隙
slot
slot
slot

图 4

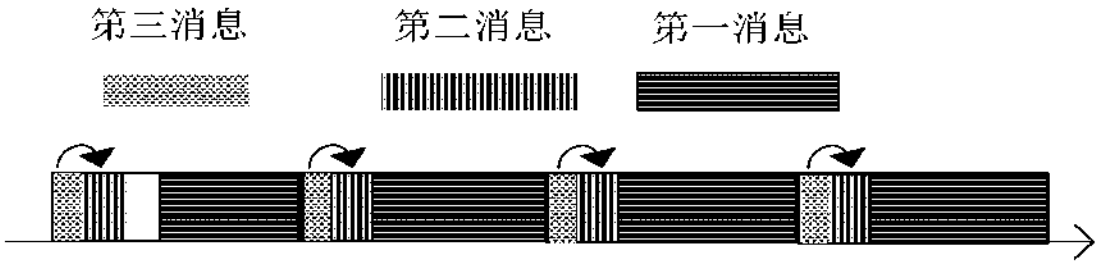

第三消息
第二消息
第一消息

图 5

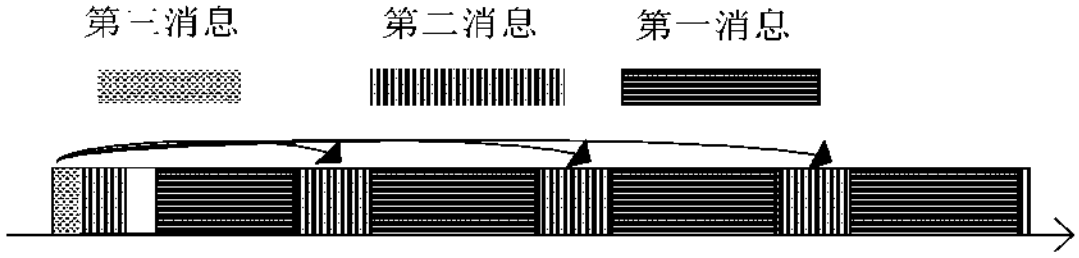

第三消息
第二消息
第一消息

图 6

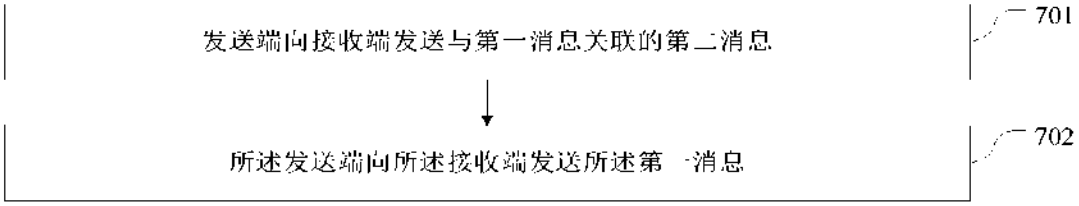

发送端向接收端发送与第一消息关联的第二消息
701
所述发送端向所述接收端发送所述第一消息
702

图 7

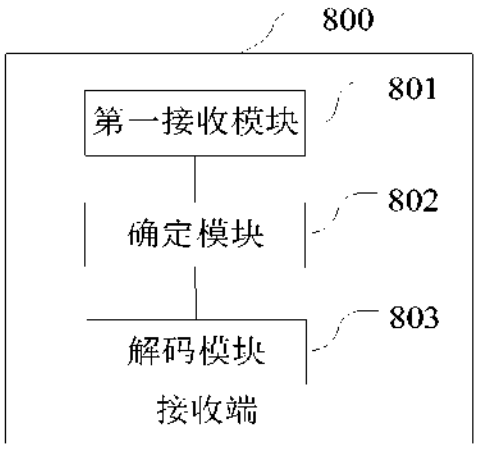

800
801
第一接收模块
802
确定模块
803
解码模块
接收端

图 8

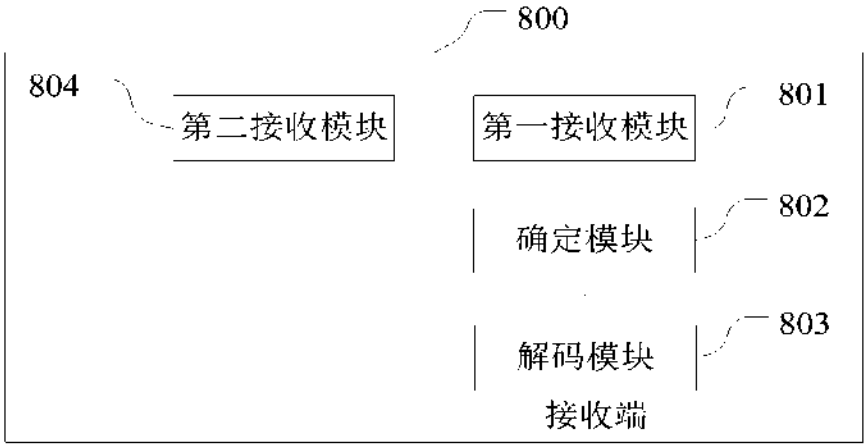

800
804
第二接收模块
第一接收模块
801
802
确定模块
803
解码模块
接收端

图 9

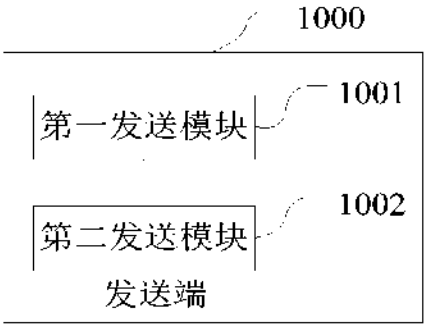

1000
1001
第一发送模块
1002
第二发送模块
发送端

图 10

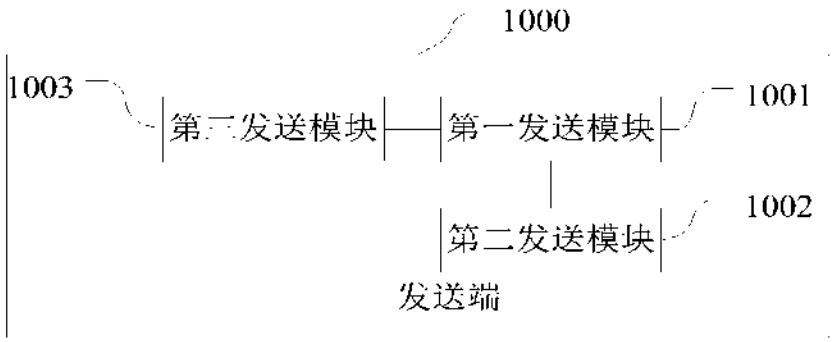

1000
1003
第三发送模块
第一发送模块
1001
1002
第二发送模块
发送端

图 11

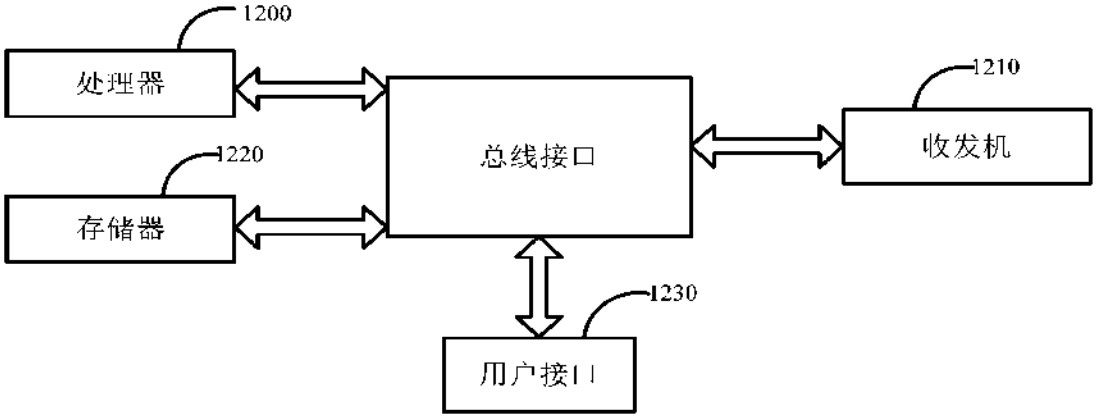

1200
处理器
1210
总线接口
收发机
1220
存储器
1230
用户接口

图 12

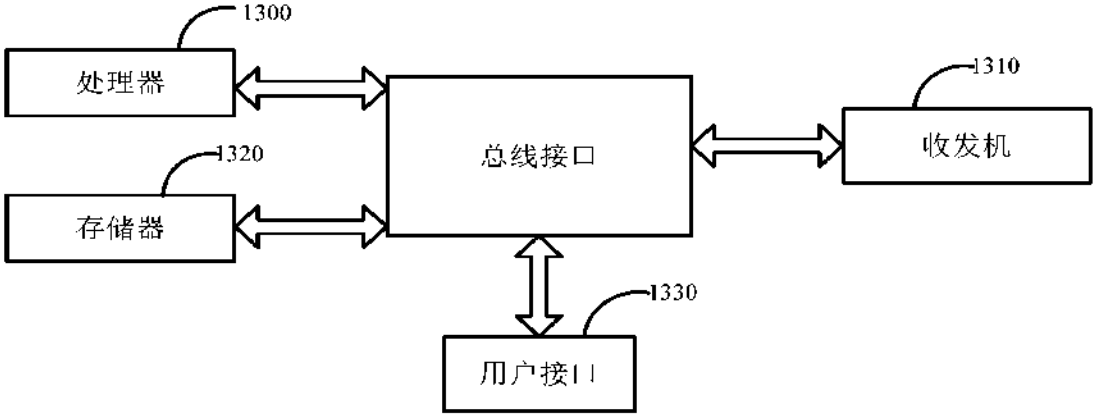

1300
处理器
1310
总线接口
收发机
1320
存储器
1330
用户接口

图 13

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2018/082472

A. CLASSIFICATION OF SUBJECT MATTER

H04L 29/02 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04L; H04W; H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNPAT, CNKI, EPODOC, WPI, 3GPP: 解码, 盲检, 检测, 指示, 推荐, 通知, 接收器参数, 接收参数, 波束, decod???, indicat???, inform???, beam, receiv+, parameter

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CATT, "Beam Management for Control and Data Channel", 3GPP TSG RAN WG1 AH_NR Meeting R1-1700192, 20 January 2017 (20.01.2017), section 2	1-38
X	CATT, "Beamforming for Data and Control Channel", 3GPP TSG RAN WG1 Meeting #87 R1-1611386, 18 November 2016 (18.11.2016), section 2	1-38
A	SONY, "RACH Procedure for Multi-beam Operation", 3GPP TSG RAN WG1 Meeting #88bis R1-1705212, 07 April 2017 (07.04.2017), entire document	1-38
A	INTEL CORPORATION, "On Beam Indication on Control and Data Channel", 3GPP TSG RAN WG1 #88 R1-1702200, 17 February 2017 (17.02.2017), entire document	1-38
A	CN 104380140 A (TELEFONAKTIEBOLAGET LM ERICSSON), 25 February 2015 (25.02.2015), entire document	1-38
A	EP 2661033 A2 (MEDIA TEK SINGAPORE PTE LTD.), 06 November 2013 (06.11.2013), entire document	1-38

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
05 June 2018	27 June 2018
Name and mailing address of the ISA State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No. (86-10) 62019451	Authorized officer LIU, Hanyan Telephone No. 86-010-53961659

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2018/082472

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2016066536 A1 (SONY CORPORATION et al.), 06 May 2016 (06.05.2016), entire document	1-38

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2018/082472

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 104380140 A	25 February 2015	US 2016195603 A1	07 July 2016
		WO 2013185322 A1	19 December 2013
		EP 2748633 A1	02 July 2014
EP 2661033 A2	06 November 2013	US 2016191136 A1	30 June 2016
		US 2013343211 A1	26 December 2013
WO 2016066536 A1	06 May 2016	CN 107079454 A	18 August 2017
		US 2017303255 A1	19 October 2017
		JP 2017533671 A	09 November 2017
		EP 3213574 A1	06 September 2017

Form PCT/ISA/210 (patent family annex) (January 2015)

国际检索报告

国际申请号
PCT/CN2018/082472

A. 主题的分类

H04L 29/02(2006.01)i

按照国际专利分类(IPC)或者同时按照国家分类和IPC两种分类

B. 检索领域

检索的最低限度文献(标明分类系统和分类号)

H04L; H04W; H04Q

包含在检索领域中的除最低限度文献以外的检索文献

在国际检索时查阅的电子数据库(数据库的名称，和使用的检索词（如使用）)

CNPAT, CNKI, EPODOC, WPI, 3GPP: 解码, 盲检, 检测, 指示, 推荐, 通知, 接收器参数, 接收参数, 波束, decod???, ind?cat???, inform???, beam, receiv+, parameter

C. 相关文件

类 型*	引用文件，必要时，指明相关段落	相关的权利要求
X	CATT. "Beam management for control and data channel" 3GPP TSG RAN WG1 AH NR Meeting R1-1700192, 2017年 1月 20日 (2017-01-20), 第2节	1-38
X	CATT. "Beamforming for data and control channel" 3GPP TSG RAN WG1 Meeting #87 R1-1611386, 2016年 11月 18日 (2016-11-18), 第2节	1-38
A	SONY. "RACH Procedure for Multi-beam Operation" 3GPP TSG RAN WG1 Meeting #88bis R1-1705212, 2017年 4月 7日 (2017-04-07), 全文	1-38
A	INTEL CORPORATION. "On beam indication on control and data channel" 3GPP TSG RAN WG1 #88 R1-1702200, 2017年 2月 17日 (2017-02-17), 全文	1-38
A	CN 104380140 A (爱立信中国通信有限公司) 2015年 2月 25日 (2015-02-25) 全文	1-38
A	EP 2661033 A2 (MEDIA TEK SINGAPORE PTE LTD.) 2013年 11月 6日 (2013-11-06) 全文	1-38

☑ 其余文件在C栏的续页中列出。　☑ 见同族专利附件。

* 引用文件的具体类型:

"A" 认为不特别相关的表示了现有技术一般状态的文件

"E" 在国际申请日的当天或之后公布的在先申请或专利

"L" 可能对优先权要求构成怀疑的文件，或为确定另一篇引用文件的公布日而引用的或者因其他特殊理由而引用的文件（如具体说明的）

"O" 涉及口头公开、使用、展览或其他方式公开的文件

"P" 公布日先于国际申请日但迟于所要求的优先权日的文件

"T" 在同请日或优先权日之后公布，与申请不相抵触，但为了理解发明之理论或原理的在后文件

"X" 特别相关的文件，单独考虑该文件，认定要求保护的发明不是新颖的或不具有创造性

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"&" 同族专利的文件

国际检索实际完成的日期	国际检索报告邮寄日期
2018年 6月 5日	2018年 6月 27日
ISA/CN的名称和邮寄地址 中华人民共和国国家知识产权局(ISA/CN) 中国北京市海淀区蓟门桥西土城路6号 100088 传真号 (86-10)62019451	受权官员 刘寒艳 电话号码 86-010-53961659

表 PCT/ISA/210 (第2页) (2015年1月)

国际检索报告

国际申请号
PCT/CN2018/082472

C. 相关文件

类 型*	引用文件，必要时，指明相关段落	相关的权利要求
A	WO 2016066536 A1 (SONY CORPORATION等) 2016年 5月 6日 (2016 - 05 - 06) 全文	1 38

表 PCT/ISA/210 (第2页) (2015年1月)

国际检索报告
关于同族专利的信息

国际申请号
PCT/CN2018/082472

检索报告引用的专利文件			公布日（年/月/日）	同族专利			公布日（年/月/日）
CN	104380140	A	2015年 2月 25日	US	2016195603	A1	2016年 7月 7日
				WO	2013185322	A1	2013年 12月 19日
				EP	2748633	A1	2014年 7月 2日
EP	2661033	A2	2013年 11月 6日	US	2016191136	A1	2016年 6月 30日
				US	2013343211	A1	2013年 12月 26日
WO	2016066536	A1	2016年 5月 6日	CN	107079454	A	2017年 8月 18日
				US	2017303255	A1	2017年 10月 19日
				JP	2017533671	A	2017年 11月 9日
				EP	3213574	A1	2017年 9月 6日

表 PCT/ISA/210（同族专利附件）（2015年1月）

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	17950726
Filing Date	2022-09-22
First Named Inventor	Xiaobo ZHANG
Art Unit	2471
Examiner Name	AHMED ELALLAM
Attorney Docket Number	ZL0205-0004-US-CON3

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Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17950726
	Filing Date	2022-09-22
	First Named Inventor	Xiaobo ZHANG
	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

	1	3GPP TS 36.304 version 14.0.0 release 14, 3rd Generation Partnership Project (3GPP), dated October 3, 2016	☒
	2	3GPP TS 36.304 version 9.1.0 Release 9, 3rd Generation Partnership Project (3GPP), dated February 9, 2010	☒
	3	3GPP TS 36.306 version 14.2.0 release 14, 3rd Generation Partnership Project (3GPP), dated April 11, 2017	☒
	4	3GPP TS 36.321 version 12.3.0 release 12, 3rd Generation Partnership Project (3GPP), dated October 28, 2014	☒
	5	3GPP TS 36.321 version 12.6.0 release 12, 3rd Generation Partnership Project (3GPP), dated June 30, 2015	☒
	6	3GPP TS 36.321 version 12.8.0 release 12, 3rd Generation Partnership Project (3GPP), dated January 4, 2016	☒
	7	3GPP TS 36.321 version 12.8.0 release 12, 3rd Generation Partnership Project (3GPP), dated January 18, 2016	☒
	8	3GPP TS 36.321 version 14.3.0 release 14, Project (3GPP) ETSI publication of 3rd Generation, dated July 27, 2017	☒
	9	3GPP TS 36.331 version 12.3.0 release 12, 3rd Generation Partnership Project (3GPP), dated September 29, 2014	☒
	10	3GPP TS 36.331 version 12.8.0 release 12, 3rd Generation Partnership Project (3GPP), dated January 18, 2016	☒
	11	3GPP TS 36.331 version 13.0.0 release 13, 3rd Generation Partnership Project (3GPP), dated January 6, 2016	☒

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17950726
	Filing Date	2022-09-22
	First Named Inventor	Xiaobo ZHANG
	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

	12	3GPP TS 36.331 version 13.3.0 release 13, 3rd Generation Partnership Project (3GPP), dated October 3, 2016	☒
	13	3GPP TS 36.331 version 13.5.0 release 13, 3rd Generation Partnership Project (3GPP), dated April 11, 2017	☒
	14	3GPP TS 38.212 version 15.2.0 release 15, 3rd Generation Partnership Project (3GPP), dated June 29, 2018	☒
	15	3GPP TS 38.214 version 15.2.0 release 15, 3rd Generation Partnership Project (3GPP), dated June 29, 2018	☒
	16	3GPP TS 38.306 version 15.5.0 release 15, 3rd Generation Partnership Project (3GPP), dated April 11, 2019	☒
	17	3GPP TS 36.304 version 13.0.0 release 13, 3rd Generation Partnership Project (3GPP), dated February 2, 2016	☒
	18	3GPP TS 36.331 version 12.8.0 release 12, 3rd Generation Partnership Project (3GPP), dated January 4, 2016	☒
	19	4G LTE/LTE Advanced for Mobile Broadband, Erik Dahlman, dated 2011	☒
	20	4G LTE/LTE Advanced for Mobile Broadband, Erik Dahlman, dated 2014	☒
	21	1st 5G Algorithm Innovation Competition - Filtered-OFDM, Terasic Inc., dated 2015	☒
	22	A Comparison of Symbol-wise and Self-contained Frame Structure for 5G Services, Mohamed Ibrahim, dated 2016	☒

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17950726
	Filing Date	2022-09-22
	First Named Inventor	Xiaobo ZHANG
	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

	23	Accurate Determination of Transport Block Size for 5G New Radio, Hao Wu, dated April 30, 2020	☒
	24	An Enhanced Multiantenna Solution through Beamforming to 3G Long-term Evolution, Ken Long, dated 2009	☒
	25	Antenna Grouping based Feedback Compression for FDD-based Massive MIMO Systems, Byungju Lee, dated July 21, 2015	☒
	26	Antenna Grouping Techniques for MIMO Beamforming Systems, Kyungchul Kim, dated 2008	☒
	27	Beam Selection Strategies for Orthogonal Random Beamforming in Sparse Networks, Jose Lopez Vicario, dated September 2008	☒
	28	Comparison Between Bit Error Rate And Signal To Noise Ratio in OFDM Using LSE Algorithm, Raghav Pandey, dated 2013	☒
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	First Named Inventor	Xiaobo ZHANG
	Art Unit	2471
	Examiner Name	AHMED ELALLAM
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	34	Joint Transmitter- Receiver Beamforming Over Space-Time Fading Channels, T. Zhang, A. Manikas, dated 2007	☒
	35	LTE – The UMTS Long Term Evolution from Theory to Practice, Second Edition, Stefania Sesia, dated 2011	☒
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	37	MIMO Beamforming for High-Bit-Rate Transmission over Frequency-Selective Fading Channels, Huy Hoang Pham, dated 2004	☒
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	40	Overview of Narrowband IoT in LTE Rel-13, Rapeepat Ratasuk, dated 2016	☒
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	44	R1-144047, LG Electronics, dated October 6-10, 2014 (Meeting dates) September 27, 2014 (Publication)	☒

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	47	R1-151535, LG Electronics, dated April 20-24, 2015 (Meeting date) April 11, 2015 (Publication)	☒
	48	R1-153175, Ericsson, dated May 25-29, 2015 (Meeting date) May 16, 2015 (Publication)	☒
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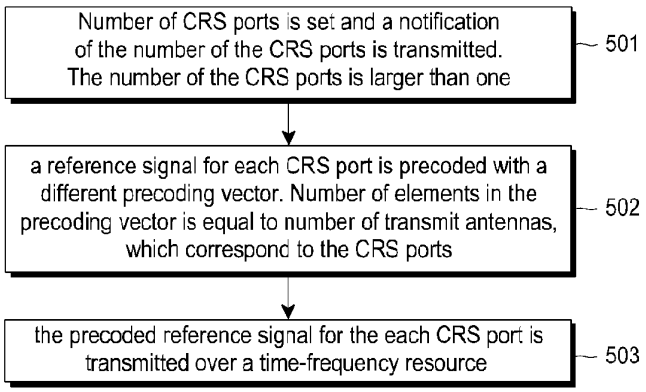
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[Continued on next page]

(54) Title: METHOD AND APPARATUS FOR REFERENCE SIGNAL TRANSMITTING AND RECEIVING IN ACTIVE ANTENNA SYSTEMS



(57) Abstract: Embodiments of the present disclosure provide reference signal transmitting and receiving methods and devices in an active antenna system. Port virtualization to a transmit antennas may be implemented for multiple cell-specific reference signal (CRS) antenna ports and applying different vertical beamforming vectors to implement port virtualization for the different CRS antenna ports. The User Equipment (UE) reports the maximum RSRP/RSRQ value measured based on multiple CRS ports, or the UE simultaneously reports multiple RSRP/RSRQ values and the information of the multiple CRS antenna ports. Therefore, the coverage problem of the CRS signal and Physical Broadcast Channel (PBCH)/Physical Downlink Control Channel (PDCCH)/Physical Downlink Shared Channel (PDSCH) demodulated based on CRS and the problem of measurement for Radio Resource Management (RRM) in the active antenna system may be avoided. Specifically, the following problems may be solved. 1) Coverage differences between CRS and PBCH/PDCCH/PDSCH demodulated based on CRS transmission and Enhanced PDCCH (E-PDCCH)/PDSCH signal transmission, which is measured based on the CSI-RS or demodulated based on the DMRS may be reduced or avoided. 2) The cell association problem due to the different vertical beamforming technologies adopted by the CSI-RS or DMRS and by the CRS may be avoided. 3) Deep spatial fading state may be avoided for CRS reception and PBCH/PDCCH/PDSCH demodulated based on the CRS.

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Description

Title of Invention: METHOD AND APPARATUS FOR REFERENCE SIGNAL TRANSMITTING AND RECEIVING IN ACTIVE ANTENNA SYSTEMS

Technical Field

[1] The present disclosure relates to a field of mobile communication systems, and more particularly to a method and apparatus for reference signal transmitting and receiving in active antenna systems.

Background Art

[2] In mobile communication systems, the wireless fading channels are time-varying. In order to effectively detect signals, channel information is needed to implement relevant detection. In order to obtain the channel information, the base station transmits the signals or sequences, which are known to the UE, via wireless channels. And the UE obtains the channel information via detecting the known signals or sequences. The known signals or sequences are called pilot signals or reference signals.

[3] A Long Term Evolution/ Long Term Evolution-Advanced (LTE/LTE-A) system is a typical correlation detection system. There are seven kinds of pilot signals or reference signals according to the purposes as described below.

[4] A Cell-specific Reference Signal (CRS) is used for data demodulation of PBCH, PDCCH, and some of PDSCHs, measurement of Channel State Information (CSI) of downlink shared channel (PDSCH) of transmission modes 1 to 8.

[5] A Multimedia Broadcast Multicast Service Single Frequency Network Reference Signal (MBSFN- RS) is used for data demodulation of a Multicast Channel (MCH).

[6] A downlink User Equipment-specific Reference Signal (DMRS) is used for data demodulation of PDSCH of transmission modes 7 to 10.

[7] A Channel State Information Reference Signal (CSI-RS) is used for measurement of the CSI for PDSCH of transmission modes 9 to 10.

[8] A Positioning Reference Signal (PRS) is used for performing positioning function.

[9] An uplink Demodulation Reference Signal (DMRS) is used for data demodulation of physical uplink shared channel (PUSCH) and physical uplink control channel (PUCCH).

[10] An uplink Sounding Reference Signal (SRS) is used for measurement of uplink CSI and obtaining downlink channel information via channel reciprocity for TDD systems.

[11] Besides CSI measurement, data demodulation and synchronization assistance, the CRS is further used for measurement of Reference Signal Receive Power (RSRP/RSRQ) to implement path loss estimation, cell association, etc.

[12] Reference signal received power (RSRP/RSRQ), is defined as the linear average over the power contributions (in [W]) of the resource elements that carry cell-specific reference signals within the considered measurement frequency bandwidth.

[13] For RSRP/RSRQ determination the cell-specific reference signals R0 according to TS 36.211 shall be used. If the UE can reliably detect that R1 is available it may use R1 in addition to R0 to determine RSRP/RSRQ, where R0 and R1 are reference signal of CRS port 0 and port 1, respectively.

[14] Reference Signal Received Quality (RSRQ) is defined as the ratio K×RSRP/RSRQ / (E-UTRA carrier RSSI), where K is the number of RB's of the E-UTRA carrier RSSI measurement bandwidth. The measurements in the numerator and denominator shall be made over the same set of resource blocks.

[15] E-UTRA Carrier Received Signal Strength Indicator (RSSI), comprises the linear average of the total received power (in [W]) observed only in OFDM symbols containing reference symbols for antenna port 0, in the measurement bandwidth, over K number of resource blocks by the UE from all sources, including co-channel serving and non-serving cells, adjacent channel interference, thermal noise etc. If higher-layer signalling indicates certain subframes for performing RSRQ measurements, then RSSI is measured over all OFDM symbols in the indicated subframes.

[16] An antenna port is defined such that the channel over which a symbol on the antenna port is conveyed can be inferred from the channel over which another symbol on the same antenna port is conveyed. There is not necessarily a one-to-one relationship between the antenna port and physical antenna. The signal of each antenna port may be transmitted by combining signals over one antenna or multiple antennas. This process is called port virtualization.

[17] With development of antenna technologies, particularly active antenna array technologies, physical antenna elements are not only distributed in a horizontal dimension, but also distributed in both the vertical dimension and the horizontal dimension to form a 2-Dimension (2-D) antenna array. As shown in Fig. 1 and Fig. 2, Fig. 1 is a schematic diagram illustrating structure of an active antenna cross-polarized 2-D antenna array in accordance with an embodiment of the prior art. Fig. 2 is a schematic diagram illustrating structure of a co-polarized 2-D antenna array in accordance with an embodiment of the prior art. N is the number of antennas in a horizontal co-polarized direction and M is the number of antennas in the vertical dimension.

[18] Using the 2-D antenna array, thevertical beamforming and/or dynamic vertical sectorization is possible. Narrow beams, which directly point to the UE or avoid interfere to the UE using the same time frequency resource, are generated in the vertical dimension via multiplexing different weighting factor to each antenna. Therefore, the received signal power may be improved or the interference to the other UEs using the

same time frequency resources may be avoided.

[19] At present, although the LTE/LTE-A system supports that different reference signals may adopt different port virtualization methods, in the LTE/LTE-A specification, only passive antenna array is only taken into consideration in standardization process, the characteristics of the active antenna array are not taken into consideration.

[20] For the convenience of description, the wireless communication system with the active antenna array is called an active antenna system hereinafter. In order to obtain a vertical beamforming gain, a UE-specific vertical beamforming technology may be adopted for PDSCH. In order to ensure that UE in anywhere of a cell can receive the CRS, a cell-specific vertical beamforming vector may be adopted in the vertical dimension. In this way, the transmission of the CRS and transmission of data, which is measured based on the CSI-RS or demodulated based on the DMRSDMRS, may have different beamforming gains in the vertical dimension, resulting in different received signal strength. Fig. 3 is a diagram illustrating that the CRS and the PDSCH, which is measured based on the CSI-RS or demodulated based on the DMRS, adopt different vertical beamforming in accordance with an embodiment in the prior art.

[21] In LTE/LTE-A systems, cell association is implemented based on a Reference Signal Receiving Power RSRP/RSRQ value reported measured based on CRS port 0. Since the CRS and PDSCH, which is measured based on the CSI-RS or demodulated based on the DMRS, are transmitted with different vertical beamforming technologies, the cell association may be not suitable for PDSCH, which is measured based on the CSI-RS or demodulated based on the DMRS.

[22] Fig. 4 is a diagram illustrating the transmission of the CRS in accordance with an embodiment in the prior art. As shown in Fig. 4, the CRS is virtualized with a fixed vertical beamforming vector. Generally, in order to control interference to the adjacent cells, a down-tilt angle may be to be formed. For instance, in the typical Urban Marco (UMa) scenario, the base station (BS) antenna height is 25m, and the inter-site distance is 500m. The UEs are distributed outdoor or in low buildings with height of 18~24m. The 90 degree represents the horizontal direction, the 0 degree represents vertically pointing to the sky, and the 180 degree presents vertically pointing to the ground. Then, electronic down-tilt of CRS is 102 degree. In that case, the CRS vertical antenna array gain received by the UE is much small if the UE antenna height is larger than or equal to the BS antenna height. The signal strength of the CRS received by the UE is relatively weak no matter of accessing which cell. The CRS receiving for these UEs are in deep spatial fading.

[23] On the other hand, the RSRP/RSRQ value measured based on the CRS port 0 is used to estimate the path loss value for the uplink power control. Inappropriate RSRP/RSRQ report may affect performance of the uplink control in the active antenna

systems. In LTE/LTE-A standardization with passive antennas, it is assumed that the uplink path loss and downlink path loss is approximately symmetrical. This is because in the passive antenna system, the uplink channel and downlink channel may experience the same large-scale fading and similar antenna array gain. However, in the active antenna systems adopting the vertical beamforming, if the CRS adopts the fixed vertical beamforming, while the Maximal Ratio Combining (MRC) detection is used in the uplink receiving, the antenna gains for the uplink and downlink are asymmetric. Therefore, the downlink path loss estimated with the RSRP/RSRQ value is significantly different from the actual uplink path loss and the uplink power control performance may be further affected.

Disclosure of Invention

Technical Problem

[24] In view of the above, embodiments of the present disclosure provide reference signal transmitting and receiving methods in the active antenna systems. With these methods, the coverage problem of CRS signal and physical broadcast channel (PBCH)/physical downlink control channel (PDCCH)/physical downlink shared channel (PDSCH) demodulated based on CRS and the problem of measurement for radio resource management (RRM) in the active antenna systems may be avoided.

[25] Embodiments of the present disclosure further provide reference signal transmitting and receiving devices in the active antenna system. With these devices, the coverage problem of CRS signal and physical broadcast channel (PBCH)/physical downlink control channel (PDCCH)/physical downlink shared channel (PDSCH) demodulated based on CRS and the problem of measurement for radio resource management (RRM) in the active antenna systems may be avoided.

Solution to Problem

[26] According to the above objectives, the present disclosure is implemented as follows.

[27] A reference signal transmitting method in an active antenna system includes:

[28] setting number of Cell-specific Reference Signal (CRS) ports and transmitting a notification of number of the CRS ports, wherein the number of the CRS ports is larger than 1;

[29] precoding a reference signal with a different precoding vector for each of the CRS ports, wherein number of elements in the precoding vector is equal to number of transmit antennas, which correspond to the CRS ports; and

[30] transmitting the precoded reference signal for the each of the CRS ports over a corresponding frequency-time resource.

[31] A reference signal receiving method in an active antenna system includes:

[32] receiving a notification of number of Cell-specific Reference Signal (CRS) ports,

wherein the number of the CRS ports is larger than 1; and

[33] receiving a reference signal over a time-frequency resource.

[34] A reference signal transmitting device in an active antenna system includes:

[35] a notification module, to set number of Cell-specific Reference Signal (CRS) ports and transmit a notification of number of the CRS ports, wherein the number of the CRS ports is larger than 1;

[36] a precoding module, to precode a reference signal with a different precoding vector for each of the CRS ports, wherein number of elements in the precoding vector is equal to number of transmit antennas, which correspond to the CRS ports; and

[37] a transmitting module, to transmit the precoded reference signal for the each of the CRS ports over a corresponding frequency-time resource.

[38] A reference signal receiving device in an active antenna system includes:

[39] a signaling receiving module, to receive a notification of number of Cell-specific Reference Signal (CRS) ports, wherein the number of the CRS ports is larger than 1; and

[40] a signal receiving module, to receive a reference signal over a time-frequency resource.

[41] It can be seen from the above technical scheme that embodiments of the present disclosure implement port virtualization to transmit antennas via using multiple CRS antenna ports and applying different vertical beamforming vectors to the different CRS antenna ports. When the UE reports the RSRP/RSRQ value, the UE simultaneously reports the information of the CRS antenna ports. Therefore, the problems of unsatisfactory CRS signal coverage and RSRP/RSRQ report in the active antenna system may be solved. Specifically, following problems may be solved. 1) Differences between transmission signal coverage of the CRS and transmission signal coverage of data, which is measured based on the CSI-RS or demodulated based on the DMRS may be reduced or avoided. 2) The problem that differences between the vertical beamforming technologies adopted by the CSI-RS or DMRS and that adopted by the CRS make it inappropriate for the UE to access a cell may be avoided. 3) It may be avoided that when the UE with a specific-height antenna receives the data signal and/or control signal, which are demodulated based on the CRS, the vertical antenna array gain is in a deep spatial fading state.

Brief Description of Drawings

[42] Fig. 1 is a schematic diagram illustrating structure of an active cross-polarized 2-D antenna array in accordance with an embodiment of the prior art;

[43] Fig. 2 is a schematic diagram illustrating structure of a co-polarized 2-D antenna array in accordance with an embodiment of the prior art;

[44] Fig. 3 is a diagram illustrating that the CRS and the PDSCH, which is measured based on the CSI-RS or demodulated based on the DMRS, adopt different vertical beamforming for port virtualization in accordance with an embodiment in the prior art;

[45] Fig. 4 is a diagram illustrating the transmission of the CRS in accordance with an embodiment in the prior art;

[46] Fig. 5 is a flow chart illustrating a reference signal transmitting method in an active antenna system in accordance with an embodiment of the present disclosure;

[47] Fig. 6 is a flow chart illustrating a reference signal receiving method in an active antenna system in accordance with an embodiment of the present disclosure;

[48] Fig. 7 is a schematic diagram illustrating structure of a reference signal transmitting device in an active antenna system in accordance with an embodiment of the present disclosure;

[49] Fig. 8 is a schematic diagram illustrating structure of a reference signal receiving device in an active antenna system in accordance with an embodiment of the present disclosure;

[50] Fig. 9 is a flow chart illustrating a reference signal transmitting method in an active antenna system in accordance with a first embodiment of the present disclosure;

[51] Fig. 10 is a schematic diagram illustrating a CRS transmitting process in the physical layer in accordance with a first embodiment of the present disclosure;

[52] Fig. 11 is a diagram illustrating a CRS time-frequency resource pattern in accordance with a first embodiment of the present disclosure;

[53] Fig. 12 is a flow chart illustrating a reference signal transmitting method in an active antenna system in accordance with a second embodiment of the present disclosure;

[54] Fig. 13 is a diagram illustrating the process of PBCH/PDCCH/PDSCH, which is de-modulated based on a CRS, in accordance with a second embodiment of the present disclosure;

[55] Fig. 14 is a flow chart illustrating a reference signal receiving method in an active antenna system in accordance with a third embodiment of the present disclosure;

[56] Fig. 15 is a diagram illustrating a CRS time-frequency resource pattern in accordance with a third embodiment of the present disclosure;

[57] Fig. 16 is a flow chart illustrating a reference signal transmitting method in an active antenna system in accordance with a fourth embodiment of the present disclosure;

[58] Fig. 17 is a flow chart illustrating a first method for determining specific UE-specific information/configuration in accordance with a fourth embodiment of the present disclosure;

[59] Fig. 18 is a flow chart illustrating a second method for determining the specific UE-specific information/configuration in accordance with a fourth embodiment of the present disclosure;

[60] Fig. 19 is a diagram illustrating determination of UE-specific CSI-RS resource configuration with RSRP/RSRQ values in accordance with a fourth embodiment of the present disclosure; and

[61] Fig. 20 is a flow chart illustrating a third method for determining the specific UE-specific information/configuration in accordance with a fourth embodiment of the present disclosure.

Mode for the Invention

[62] To make the objective and technical solution of the merits of the present disclosure more apparent, the present disclosure may be described in detail with reference to accompanying Fig.s.

[63] In the active antenna system, following problems are caused when the reference signal is transmitted or received. 1) Coverage differences between CRS and PBCH/PDCCH/PDSCH demodulated based on CRS transmission and Enhanced PDCCH (E-PDCCH)/PDSCH signal transmission, which is measured based on the CSI-RS or demodulated based on the DMRS may be occurred. 2) Cell association using RSRP/RSRQ measured from CRS may not guarantee the best performance in PDSCH/EPDCCH reception due to different beamforming gains between CRS and PDSCH/EPDCCH/DMRS for port virtualization. 3) A fixed vertical weighted vector is used by CRS while the UE is distributed in a large range of height, which leads to deep spatial fading for some UEs of CRS/PBCH/PDCCH/PDSCH demodulated based on the CRS. Therefore, in order to avoid the above problems, an embodiment of the present disclosure using multiple CRS ports. Port virtualization to transmit antennas may be implemented for multiple Cell-specific Reference Signal (CRS) antenna ports and applying different vertical beamforming vectors to implement port virtualization for the different CRS antenna ports. When the User Equipment (UE) reports the maximum RSRP/RSRQ values measured based on multiple CRS ports, or the UE simultaneously reports multiple RSRP/RSRQ values and the information of the multiple CRS antenna ports.

[64] Further, on the premise that a same channel measurement effect is obtained, the method and device provided by embodiments may reduce the resource of CSI-RS, which are used by the UE to perform CSI measurement, and may reduce the path loss estimation error RSRP/RSRQ for uplink power control.

[65] Fig. 5 is a flow chart illustrating a reference signal transmitting method in an active antenna system in accordance with an embodiment of the present disclosure. The blocks are as follows.

[66] AT block 501, number of CRS ports is set and a notification of the number of the CRS ports is transmitted. The number of the CRS ports is larger than one.

[67] At block 502, a reference signal for each CRS port is precoded with a different precoding vector. Number of elements in the precoding vector is equal to number of transmit antennas, which correspond to the CRS ports.

[68] At block 503, the precoded reference signal for the each CRS port is transmitted over a time-frequency resource.

[69] After block 503, the method further includes:

[70] receiving RSRP/RSRQ information and/or CRS port information. Number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than or equal to 1.

[71] After block 502 and before block 503, the method further includes:

[72] respectively precoding a data signal and/or control signal corresponding to the each CRS port based on the precoding vector adopted by the each CRS port.

[73] When block 503 is performed, the precoded data signal and/or control signal is transmitted over the time-frequency resource.

[74] Fig. 6 is a flow chart illustrating a reference signal receiving method in an active antenna system in accordance with an embodiment of the present disclosure. The blocks are as follows.

[75] At block 601, a notification of number of CRS ports is received. The number of the CRS ports is larger than 1.

[76] At block 602, a precoded reference signal is received over a time-frequency resource.

[77] This method further includes: obtaining RSRP/RSRQ information and/or CRS port information by measurement based on the CRS ports. Number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than 1 or equal to 1.

[78] The method further includes: receiving a precoded data signal and/or control signal over the time-frequency resource.

[79] Fig. 7 is a schematic diagram illustrating structure of a reference signal transmitting device in an active antenna system in accordance with an embodiment of the present disclosure. As shown in Fig. 7, the reference signal transmitting device includes: a notification module, a precoding module and a transmitting module.

[80] The notification module is to set number of CRS ports and transmit a notification of the number of the CRS ports. The number of the CRS ports is larger than 1.

[81] The precoding module is to precode a reference signal with a different precoding vector for each CRS port. Number of elements in the precoding vector is equal to number of transmit antennas, which correspond to the CRS ports.

[82] The transmitting module is to transmit the precoded reference signal for the each CRS port over a time-frequency resource.

[83] The reference signal transmitting device further includes a RSRP/RSRQ receiving module. The RSRP/RSRQ receiving module is to receive RSRP/RSRQ information and/or CRS port information. Number of RSRP/RSRQ values in the RSRP/RSRQ in-

formation is larger than or equal to 1.

[84] In this reference signal transmitting device, the precoding module is further to respectively precode a data signal and/or control signal corresponding to each CRS port based on the precoding vector adopted by the each CRS port.

[85] The transmitting module is further to transmit the precoded data signal and/or control over the time-frequency resource.

[86] In this reference signal transmitting device, the RSRP/RSRQ receiving module is further to determine specific UE-specific information/configuration according to the RSRP/RSRQ information and/or CRS port information.

[87] Fig. 8 is a schematic diagram illustrating structure of a reference signal receiving device in an active antenna system in accordance with an embodiment of the present disclosure. As shown in Fig. 8, the reference signal receiving device includes: a signaling receiving module and a signal receiving module.

[88] The signaling receiving module is to receive a notification of number of CRS ports. The number of the CRS port is larger than 1.

[89] The signal receiving module is to receive a precoded reference signal over a time-frequency resource.

[90] The reference signal receiving device further includes: a measurement report module. The measurement report module is to obtain RSRP/RSRQ information and/or CRS port information by measurement based on the CRS ports and transmit the RSRP/RSRQ information and/or CRS port information. Number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than or equal to 1.

[91] In the reference signal receiving device, the signal receiving module is further to receive a precoded data signal and/or control signal over the time-frequency resource.

[92] The present disclosure is described hereinafter in detail with reference to several specific embodiments.

[93] Embodiment one

[94] Fig. 9 is a flow chart illustrating a reference signal transmitting method in an active antenna system in accordance with a first embodiment of the present disclosure. Blocks are as follows.

[95] At block 901, the number of CRS ports is set and a notification of the number of the CRS ports is transmitted. The number of the CRS ports is larger than one.

[96] At this block, the notification of the number of the CRS ports may be performed in an implicit way. Specifically, the notification of the number of the CRS ports is implicitly performed by different Physical Broadcast Channel (PBCH) Cyclic Redundancy Check (CRC) scrambling codes. After the CRC attachment of PBCH, the CRC bits are scrambled according to the eNodeB transmit antenna configuration with the sequence as indicated in Table 1, Thus, the CRS port index can be determined

based on CRC mask at the UE side.

[97] Table 1

[Table 1]

Number of transmit antenna ports at eNodeB	PBCH CRC mask<$x_{ant,0}$, $x_{ant,1}$, ..., $x_{ant,15}$>
1	<0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0>
2	<1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1>
4	<0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1>

[98] In the active antenna systems, the number of the CRS ports is a positive integer, which is larger than 1. The base station may determine the number of CRS ports considering CRS overheads and the UE distribution of , d and transmit the notification of the number of the CRS ports. For instance, in typical UMa scenarios, the BS antenna height of a base station antenna is 25m. The inter-site distance is 500m. The UEs are distributed outdoor or distributed in low buildings with height of 18-24m. All vertical leaving angles of the UE are larger than 90 degree (The 90 degree represents a horizontal direction. The 0 degree represents vertically pointing to the sky. The 180 degree presents vertically pointing to the ground). Considering the CRS overhead and UE distribution, the number of the CRS ports may be set as 2.

[99] At block 902, a reference signal for each CRS port is precoded with a different precoding vector. Number of elements in the precoding vector is equal to number of transmit antennas, which correspond to the CRS ports.

[100] At this block, the CRS port adopts a different precoding vector to implement port virtualization to transmit antennas. Fig. 10 is a schematic diagram illustrating a CRS transmitting process in the physical layer in accordance with a first embodiment of the present disclosure. The port virtualization to transmit antennas refers to precoding the reference signal for the CRS port with a precoding vector. The number of elements in the precoding vector is equal to the number of transmit antennas, which transmitting the same CRS.

[101] Take the typical UMa for example, assuming a physical antenna configuration is cross-polarized 2-D antenna array, M=10 and N=1. Both the two polarization directions include M antenna groups distributed in the vertical dimension, i.e. antenna group 0 and antenna group 1. Suppose the distance between two transmit antennas is half-wavelength. The virtualization from signals of CRS port 0 to the antenna group 0 is implemented via the precoding vector $W_0 = \left[w_0^{(0)} w_1^{(0)} \cdots w_{M-1}^{(0)} \right]^T$. The virtualization from signals of CRS port 1 to the antenna group 1 is implemented via the

$W_1 = [\, w_0^{(1)} w_1^{(1)} \cdots w_{M-1}^{(1)} \,]^T$, $w_m^{(p)} = \frac{1}{\sqrt{M}} \exp(-j \frac{2\Pi}{\lambda} m \cdot d_v \cdot \cos\theta_p)$, dv denotes the distance between the vertical antennas, p denotes the index of CRS port, m denotes the m-th element of the precoding vectors, θ_p denotes the down-tilt angle corresponding to the p-th port. For instance, the electronic down-tilt angle corresponding to the port 0 is 102 degree, and the electronic down-tilt angle corresponding to port 1 is 95 degree.

[102] At block 903, the precoded reference signal for each CRS port is transmitted over the time-frequency resource.

[103] At this block, Fig. 11 is a diagram illustrating a CRS time-frequency resource pattern in accordance with a first embodiment of the present disclosure.

[104] At block 904, RSRP/RSRQ information and/or CRS port information is received. Number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than or equal to 1.

[105] At this block, the RSRP/RSRQ information and/or CRS port information may be an RSRP/RSRQ value measured by a CRS port with the maximum receiving power and the corresponding CRS port index. As shown in table 2, the reporting range of RSRP/RSRQ is defined from -140 dBm to -44 dBm with 1 dB resolution. The mapping of measured quantity and CRS port index may be mapped in Table 2. 4 RSRP/RSRQ states indicating the number of the CRS antenna ports may be reported RSRP/RSRQ simultaneously with RSRP/RSRQ value.

[106] Table 2

[Table 2]

Reported value	Measured quantity value	Unit
RSRP/RSRQ _00	RSRP/RSRQ -140	dBm
RSRP/RSRQ _01	-140 $\leq$ RSRP/RSRQ < -139	dBm
RSRP/RSRQ _02	-139 $\leq$ RSRP/RSRQ < -138	dBm
...	...	...
RSRP/RSRQ _95	-46 $\leq$ RSRP/RSRQ < -45	dBm
RSRP/RSRQ _96	-45 $\leq$ RSRP/RSRQ < -44	dBm
RSRP/RSRQ _97	-44 $\leq$ RSRP/RSRQ	dBm
RSRP/RSRQ _98	Port 0	
RSRP/RSRQ _99	Port 1	
RSRP/RSRQ _100	Port 2	
RSRP/RSRQ _101	Port 3	

[107] As shown in table 3, the RSRP/RSRQ information and/or CRS port information may further be the RSRP/RSRQ value measured by the port.

[108] Table 3

[Table 3]

Reported value	Measured quantity value	Unit
RSRP/RSRQ _00	Port 0 RSRP/RSRQ < -140	dBm
RSRP/RSRQ _01	Port 0 -140 $\leq$ RSRP/RSRQ < -139	dBm
RSRP/RSRQ _02	Port 0 -139 $\leq$ RSRP/RSRQ < -138	dBm
...	...	...
RSRP/RSRQ _95	Port 0 -46 $\leq$ RSRP/RSRQ < -45	dBm
RSRP/RSRQ _96	Port 0 -45 $\leq$ RSRP/RSRQ < -44	dBm
RSRP/RSRQ _97	Port 0 -44 $\leq$ RSRP/RSRQ	dBm
RSRP/RSRQ _98	Port 1 RSRP/RSRQ < -140	dBm
RSRP/RSRQ _99	Port 1 -140 $\leq$ RSRP/RSRQ < -139	dBm
RSRP/RSRQ _100	Port 1 -139 $\leq$ RSRP/RSRQ < -138	dBm
...	...	...
RSRP/RSRQ _183	Port 1 -46 $\leq$ RSRP/RSRQ < -45	dBm
RSRP/RSRQ _184	Port 1 -45 $\leq$ RSRP/RSRQ < -44	dBm
RSRP/RSRQ _185	Port 1 -44 $\leq$ RSRP/RSRQ	dBm
...	...	...

[109] The RSRP/RSRQ information and/or CRS port information may further be the RSRP/RSRQ value measured by the CRS port 0 or a relative RSRP/RSRQ value of another port to that of the CRS port 0.

[110] The RSRP/RSRQ information and/or CRS port information may further be the RSRP/RSRQ values measured by K CRS ports. K is larger than 1 and less than total number of the CRS antenna ports. Corresponding antenna port index is also reported.

[111] With the above processing, since different CRS ports adopt different vertical beamforming, UE which is not covered by the beam of the CRS port 0, may be covered by the beam of another CRS port. Therefore, it may be reduced or avoided that when the terminal with the specific-height antenna receives the CRS, the vertical antenna gain remains at the deep spatial fading state for a long time of given UE.

[112] In this embodiment, the received RSRP/RSRQ information and/or CRS port information provides not only the information of the RSRP/RSRQ value measured based on the CRS port with the maximum receiving power, but also the port information corresponding to the RSRP/RSRQ value measured based on the CRS port with the maximum receiving power. The BS may implement subsequent optimization for PBCH/PDCCH/PDSCH transmission, cell association, uplink power control, etc. with the above information.

[113] Embodiment two

[114] Fig. 12 is a flow chart illustrating a reference signal transmitting method in an active antenna system in accordance with a second embodiment of the present disclosure. Specific blocks are as follows.

[115] At block 1201, number of CRS ports is set and a notification of the number of the CRS ports is transmitted. The number of the CRS ports is larger than one.

[116] At block 1202, a reference signal for each CRS port is precoded with a different precoding vector. Number of elements in the precoding vector is equal to number of transmit antennas, which correspond to the CRS ports.

[117] At block 1203, a data signal and/or control signal corresponding to the each CRS port is respectively precoded based on the precoding vector adopted by the each CRS port. Number of elements in the precoding vector is equal to number of transmit antennas, which transmit the data signal and/or control signal.

[118] At this block, port virtualization to transmit antenna processing is performed for PBCH/PDCCH/PDSCH, which is demodulated based on the CRS, using the precoding vectors corresponding to the CRS ports. The physical layer processing process of PBCH/PDCCH/PDSCH, which is demodulated based on the CRS, is shown in Fig. 13. Fig. 13 is a diagram illustrating a physical layer processing of PBCH/PDCCH/PDSCH, which is demodulated based on CRS, in accordance with the second embodiment of the present disclosure. For instance, the CRS of port 0 adopts the precoding vector W0 to implement the port virtualization to transmit antennas. The PBCH/PDCCH/PDSCH over port 0 also implements the port virtualization to transmit antennas with the same precoding vector. Other ports adopt similar processing.

[119] At block 1204, the precoded reference signal for the each CRS port and the precoded data signal and/or control signal for the each CRS port are transmitted over the time-frequency resource.

[120] At block 1205, the RSRP/RSRQ information and/or CRS port information is received. Number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than or equal to 1.

[121] With the method shown in Fig. 12, since the reference signal and PBCH/PDCCH/PDSCH, which is demodulated based on the CRS of each CRS port adopt

different vertical beamforming, UE, which is not covered by the beam of the CRS port 0, may be covered by the beam of another CRS ports. Therefore, it may be reduced or avoided that the deep spatial fading problem may be reduced or avoided. Thus, the coverage of PBCH/PDCCH/PDSCH, which is demodulated based on the CRS, is improved.

[122] Embodiment three

[123] Fig. 14 is a flow chart illustrating a reference signal receiving method in an active antenna system in accordance with a third embodiment of the present disclosure. Specific blocks are as follows.

[124] At block 1401, a notification of number of CRS ports is received. The number of the CRS port is larger than 1.

[125] At this block, the number of antenna ports may be determined according to PBCH scrambling mask via decoding the signals of the PBCH over the CRS port 0.

[126] At block 1402, a precoded reference signal is received over a time-frequency resource.

[127] As exclusively used at this block, the precoded reference signal may be received according to the CRS time-frequency resource pattern shown in Fig. 15. Fig. 15 is a diagram illustrating a CRS time-frequency resource pattern in accordance with a third embodiment of the present disclosure.

[128] At block 1403, RSRP/RSRQ information and/or CRS port information is obtained by measurement based on the CRS ports. Number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than or equal to 1.

[129] At this block, the RSRP/RSRQ value measured based on the CRS port with maximum receiving power and the corresponding CRS antenna port index may be reported. For instance, as shown in table 2, four states indicating the CRS antenna port index are reported during the report of the RSRP/RSRQ value. Alternatively, as shown in table 3, the RSRP/RSRQ value of the each port is reported at the same time. Alternatively, the RSRP/RSRQ value of the CRS port 0 and a relative RSRP/RSRQ value of another port to that of the CRS port 0 are reported. Alternatively, the RSRP/RSRQ values of N CRS ports and corresponding antenna port number information are reported. N is larger than 1 and less than total number of the CRS antenna ports.

[130] With the above processing, the base station may obtain more RSRP/RSRQ information of the CRS port, which is convenient for the network side to make further processing to obtain the corresponding gain.

[131] Embodiment four

[132] Fig. 16 is a flow chart illustrating a reference signal transmitting method in an active antenna system in accordance with a fourth embodiment of the present disclosure. Specific blocks are as follows.

[133] At block 1601, number of CRS ports is set and a notification of the number of the CRS ports is transmitted. The number of the CRS ports is larger than one.

[134] At this block, in typical UMa scenarios, the BS antenna height is 10m. The inter-site distance is 200m. The UEs are distributed outdoor or distributed in low buildings with the height of 18-24m. Taking account of that vertical leaving angles of the UEs are in a large range and taking account of factors, such CRS overhead influence, the number of the CRS ports is set as 4.

[135] At block 1602, each CRS port adopts a different precoding vector to implement port virtualization to transmit antennas.

[136] At this block, four different precoding vectors are adopted to implement the port virtualization to transmit antennas of four CRS ports. The virtualization of the CRS port 0 to the antenna group 0 is implemented via the precoding vector $W_0 = [w_0^{(0)} w_1^{(0)} \ldots w_{M-1}^{(0)}]^T$. The virtualization of the CRS port 1 to the antenna group 1 is implemented via the precoding vector $W_1 = [w_0^{(1)} w_1^{(1)} \ldots w_{M-1}^{(1)}]^T$.

$w_m^{(p)} = \frac{1}{\sqrt{M}} \exp(-j\frac{2\Pi}{\lambda} m \cdot d_v \cdot \cos\theta_p)$, dv denotes the distance between the vertical antennas, p denotes the index of the CRS port, m denotes the m-th element of the precoding vectors, θ_p denotes a down-tilt angle corresponding to the p-th port. The down-tilt angle corresponding to the port 0 is 102 degree, the downward inclination angle corresponding to the port 1 is 95 degree, the down-tilt angle corresponding to the port 2 is 85 degree, the down-tilt angle corresponding to the port 3 is 75 degree.

[137] At block 1603, the precoded reference signal of each CRS port is transmitted over the time-frequency resource.

[138] At block 1604, the RSRP/RSRQ information and/or CRS port information is received. Number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than or equal to 1.

[139] At this block, the RSRP/RSRQ information may be the RSRP/RSRQ value measured by the CRS port with the maximum receiving power. The corresponding port information is the CRS port index corresponding to the RSRP/RSRQ value of measured by the CRS port with the maximum receiving power. The RSRP/RSRQ information may include the RSRP/RSRQ value of the each CRS port. The RSRP/RSRQ information may include the RSRP/RSRQ values of partial CRS ports and the number index information of the partial CRS ports.

[140] At block 1605, after the RSRP/RSRQ information and/or CRS port information is received, specific UE-specific information/configuration is determined.

[141] At this block, the specific UE-specific information/configuration includes: one or

combination of information of cell association, a path loss value for uplink power control and/or UE-specific CSI-RS resource configuration.

[142] Specifically speaking, Fig. 17 is a flow chart illustrating a first method for determining UE-specific information/configuration in accordance with a fourth embodiment of the present disclosure. Following blocks are included.

[143] At block 1701, RSRP/RSRQ information and/or CRS port information is received.

[144] At block 1702, a cell association is determined based on the RSRP/RSRQ information.

[145] At this block, each CRS port adopts a different vertical beam. The RSRP/RSRQ information includes the vertical beamforming gain of the best direction. Therefore, the difference between the RSRP/RSRQ and the beamforming gain of the CSI-RS and DMRS after the UE-specific vertical beamforming adopted is relatively reduced. Therefore, the selected cell is more suitable for the PDSCH/E-PDCCH transmission of the UE.

[146] Fig. 18 is a flow chart illustrating a second method for determining the specific UE-specific information/configuration in accordance with a fourth embodiment of the present disclosure. Following blocks are included.

[147] At block 1801, RSRP/RSRQ information and/or CRS port information is received.

[148] At block 1802, a UE-specific CSI-RS resource configuration is determined based on the RSRP/RSRQ information.

[149] At this block, the UE-specific CSI-RS resource configuration is determined based on the correlation of beamforming vectors used for the CSI-RS resources port virtualization and the CRS ports virtualization, RSRP/RSRQ information and CRS port information. The CSI-RS resources in the active antenna system are grouped according to the correlation of the vertical beamforming vectors used for CSI-RS port virtualization and CRS port virtualization. After the RSRP/RSRQ information and/or CRS port information is received, the CSI-RS resources in the CSI-RS resource group corresponding to the CRS port with RSRP/RSRQ value measured with the maximum receiving power, may be determined as the UE-specific CSI-RS resource configuration. Alternatively, CSI-RS resources in CSI-RS resource groups corresponding to the two CRS ports with the RSRP/RSRQ values with the maximum receiving power and second maximum receiving power may be determined as the UE-specific CSI-RS resource configurations.

[150] A specific example is given hereinafter for illustration, suppose two CRS ports adopt two different vertical beams. In the transmission mode using the CSI-RS measurement and DMRS demodulation, such as transmission mode 10 of LTE/LTE-A, the UE-specific vertical beamforming may be implemented via configuring multiple CSI-RS resources and multiple CSI processes for the UE. Fig. 19 is a diagram illustrating de-

termination of UE-specific CSI-RS resource configuration with RSRP/RSRQ reporting in accordance with a fourth embodiment of the present disclosure. As shown in Fig. 19, 9 CSI-RS resources are conFig.d in the active antenna systems. Each CSI-RS resource adopts different vertical beams to perform the beamforming. The 9 CSI-RS resources are divided into three groups. Each group includes 3 CSI-RS resources and the 3 CSI-RS resources adopt adjacent vertical beams to implement port virtualization to transmit antennas. The coverage of the first group of CSI-RS vertical beams in the vertical dimension is close to that of the CRS beam 0. The coverage of the third group of CSI-RS vertical beams in the vertical dimension is close to that of the CRS beam 1. And the coverage of the second group of CSI-RS vertical beams in the vertical dimension is between that of two CRS beams.

[151] If the RSRP/RSRQ CRS port with largest RSRP/RSRQ value is CRS port 0, the first group of CSI-RS resources is allocated to the UE. If the reported port with the largest RSRP/RSRQ value is port 01, the third group of CSI-RS resources is allocated to the UE. If the reported two ports, the RSRP/RSRQ values of which are close to each other, the second group of CSI-RS resources are allocated to the UE.

[152] The UE performs feedback of three CSI processes based three conFig.d CSI-RS resources in one group, such as CSI-RS resource 2-1, CSI-RS resource 2-2 and CSI-RS resource 2-3 in the second group. The base station selects the best vertical beamforming direction based on CSI feedback. For instance, the vertical beamforming direction corresponding to the CSI-RS resource 2-3 is taken as the beamforming direction used by the UE in the data transmission.

[153] In the above second embodiment, apparently, if the CRS port information is not reported, the UE needs to measure 9 different CSI-RS configurations to select the best beam from the nine vertical beams and simultaneously complete nine CSI report processes. Using the RSRP/RSRQ and CRS port information report, the best beam may be selected from the nine vertical beams via measuring only three CSI-RS configurations and completing three CSI report processes.

[154] Fig. 20 is a flow chart illustrating a method for determining the specific UE-specific information/configuration in accordance with a fourth embodiment of the present disclosure. Following blocks are included.

[155] At block 2001, RSRP/RSRQ information and/or CRS port information is received.

[156] At block 2002, the path loss value for uplink power control of a UE is determined based on the RSRP/RSRQ information.

[157] At this block, each CRS port adopts a different vertical beam. The RSRP/RSRQ information is measured based on the vertical beamforming in the best direction. Therefore, the difference between the RSRP/RSRQ value and an uplink antenna array gain of receiver is relatively reduced. Therefore, the difference between the path loss

estimation based on the RSRP/RSRQ and the uplink actual path loss is reduced and thus the uplink power control performance is improved.

[158] It can be seen from the methods and devices provided by embodiments of the present disclosure, coverage differences between CRS and PBCH/PDCCH/PDSCH demodulated based on CRS transmission and Enhanced PDCCH (E-PDCCH)/PDSCH signal transmission, which is measured based on the CSI-RS or demodulated based on the DMRS may be reduced or avoided. The cell association problem due to the different vertical beamforming technologies adopted by the CSI-RS or DMRS and by the CRS may be avoided. Deep spatial fading state may be avoided for CRS reception and PBCH/PDCCH/PDSCH demodulated based CRS. On the premise that a same channel measurement effect is obtained, embodiments of the present disclosure may reduce the number of CSI-RS configurations, which are used by the UE to perform channel estimation. Embodiments of the present disclosure may reduce the differences between the path loss of RSRP/RSRQ value estimation and the uplink actual path loss and may improve the uplink power control performance.

[159] The foregoing description only describes preferred embodiments of the present invention and may not be used for limiting the protection scope thereof. Any modification, equivalent substitution, or improvement made without departing from the spirit and principle of the present invention should be covered by the protection scope of the present invention.

Claims

[Claim 1] A reference signal transmitting method in an active antenna system, comprising:
setting number of Cell-specific Reference Signal (CRS) ports and transmitting a notification of number of the CRS ports, wherein the number of the CRS ports is larger than 1;
precoding a reference signal with a different precoding vector for each of the CRS ports, wherein number of elements in the precoding vector is equal to number of transmit antennas, which correspond to the CRS ports; and
transmitting the precoded reference signal for the each of the CRS ports over a corresponding frequency-time resource.

[Claim 2] The transmitting method according to claim 1, further comprising:
receiving Reference Signal Receive Power (RSRP)/Reference Signal Received Quality (RSRQ) information and/or CRS port information;
wherein number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than or equal to 1.

[Claim 3] The transmitting method according to claim 2, wherein the RSRP/RSRQ information and/or CRS port information comprises:
an RSRP/RSRQ value measured by a CRS port with the maximum receiving power and a corresponding CRS port index; or
RSRP/RSRQ values measured by the CRS ports; or
an RSRP/RSRQ value measured by CRS port 0 and a relative RSRP/RSRQ value of another port to that of the CRS port 0; or
RSRP/RSRQ values measured by N CRS ports and corresponding CRS port indexes, N is larger than 1 and less than total number of the CRS ports.

[Claim 4] The transmitting method according to claim 2, further comprising:
determining specific UE-specific information/configuration according to the RSRP/RSRQ information and/or the CRS port information.

[Claim 5] The transmitting method according to claim 4, wherein the specific UE-specific information/configuration comprises one or any combination of: information of cell association, a path loss value for uplink power control and Channel State Information Reference Signal (CSI-RS) resource configuration.

[Claim 6] The transmitting method according to claim 5, wherein when the specific UE-specific information/configuration is the information of

cell association, determining the specific UE-specific information/ configuration according to the RSRP/RSRQ information and/or the CRS port information comprises:
determining the cell association according to an RSRP/RSRQ value measured by the CRS port with maximum receiving power.

[Claim 7] The transmitting method according to claim 5, when the specific UE-specific information/configuration is the path loss value for uplink power control, determining the specific UE-specific information/configuration according to the RSRP/RSRQ information and/or the CRS port information comprises:
determining the path loss value for uplink power control based on an RSRP/RSRQ value measured by the CRS port with the maximum receiving power.

[Claim 8] The transmitting method according to claim 5, when the specific UE-specific information/configuration is the CSI-RS resource configuration, determining the specific UE-specific information/configuration according to the RSRP/RSRQ information and/or CRS port information comprises:
determining the UE-specific CSI-RS resource configuration based on correlation of beamforming vectors used for CSI-RS port virtualization and CRS port virtualization.

[Claim 9] The transmitting method according to claim 8, wherein determining the UE-specific CSI-RS resource configuration comprises:
grouping CSI-RS resources in an active antenna system according to the correlation of beamforming vectors used for the CSI-RS port virtualization and the CRS port virtualization;
after receiving the reported RSRP/RSRQ information and/or the CRS port information, determining CSI-RS resources in a CSI-RS resource group corresponding to a CRS port with an RSRP/RSRQ value measured by the CRS port with the maximum receiving power, as the UE-specific CSI-RS resource configuration; or
determining CSI-RS resources in CSI-RS resource groups corresponding to two CRS ports with RSRP/RSRQ values measured with the maximum receiving power and second maximum receiving power, as the UE-specific CSI-RS resource configurations.

[Claim 10] The transmitting method according to claim 1, wherein before transmitting the precoded reference signal for the each of the CRS ports over the corresponding frequency-time resource, the method further

comprises:
respectively precoding a data signal and/or control signal corresponding to the each of the CRS ports based on the precoding vector adopted by the each of the CRS ports;
when transmitting the precoded reference signal for the each of the CRS ports over corresponding frequency-time resource, the method further comprises:
transmitting the precoded data signal and/or control signal for the each of the CRS ports over the corresponding frequency-time resource.

[Claim 11] A reference signal receiving method in an active antenna system, comprising:
receiving a notification of number of Cell-specific Reference Signal (CRS) ports, wherein the number of the CRS ports is larger than 1; and
receiving a reference signal over a time-frequency resource.

[Claim 12] The receiving method according to claim 11, further comprising:
obtaining Reference Signal Receive Power (RSRP)/Reference Signal Received Quality (RSRQ) information and/ or CRS port information by measurement based on the CRS ports; wherein number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than or equal to 1.

[Claim 13] The receiving method according to claim 11, wherein the RSRP/RSRQ information and/or CRS port information comprises:
an RSRP/RSRQ value measured by a CRS port with the maximum receiving power and a corresponding CRS port index; or
RSRP/RSRQ values measured by the CRS ports; or
an RSRP/RSRQ value measured by CRS port 0 and a relative RSRP/RSRQ value of another port to that of the CRS port 0; or
RSRP/RSRQ values measured by N CRS ports and corresponding CRS port indexes, N is larger than 1 and less than total number of the CRS ports.

[Claim 14] The receiving method according to claim 11, further comprising:
receiving a precoded data signal and/or control signal, which are demodulated based on the CRS ports.

[Claim 15] A reference signal transmitting device in an active antenna system, comprising:
a notification module, to set number of Cell-specific Reference Signal (CRS) ports and transmit a notification of number of the CRS ports, wherein the number of the CRS ports is larger than 1;
a precoding module, to precode a reference signal with a different

precoding vector for each of the CRS ports, wherein number of elements in the precoding vector is equal to number of transmit antennas, which correspond to the CRS ports; and

a transmitting module, to transmit the precoded reference signal for the each of the CRS ports over a corresponding frequency-time resource.

[Claim 16] The transmitting device according to claim 15, further comprising:

a Reference Signal Receive Power (RSRP)/Reference Signal Received Quality (RSRQ) receiving module, to receive Reference Signal Receive Power (RSRP)/Reference Signal Received Quality (RSRQ) information and/or CRS port information; wherein number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than or equal to 1.

[Claim 17] The transmitting device according to claim 16, wherein the RSRP/ RSRQ receiving module is further to determine specific UE-specific information/configuration according to the RSRP/RSRQ information and/or CRS port information.

[Claim 18] The transmitting device according to claim 15, wherein

the precoding module is further to respectively precode a data signal and/or control signal corresponding to the each of the CRS ports based on the precoding vector adopted by the each of the CRS ports; and

the transmitting module is further to transmit the precoded data signal and/or control over the time-frequency resource.

[Claim 19] A reference signal receiving device in an active antenna system, comprising:

a signaling receiving module, to receive a notification of number of Cell-specific Reference Signal (CRS) ports, wherein the number of the CRS ports is larger than 1; and

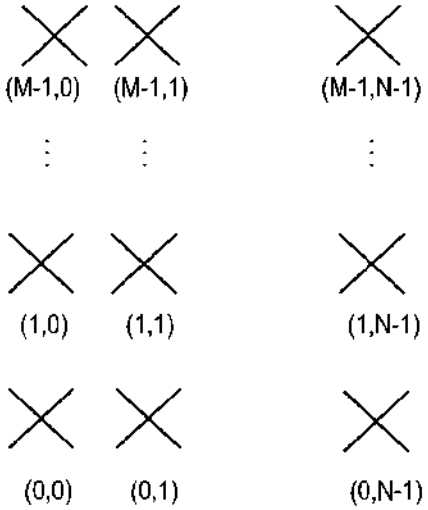
a signal receiving module, to receive a reference signal over a time-frequency resource.

[Claim 20] The receiving device according to claim 19, further comprising:

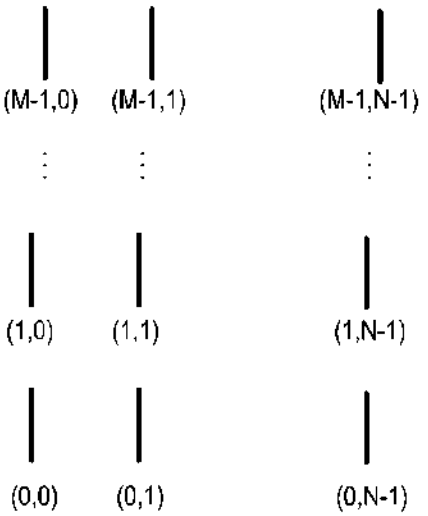
a measurement report module, to obtain Reference Signal Receive Power (RSRP)/ Reference Signal Received Quality (RSRQ) information and/or CRS port information by measurement based on the CRS ports; wherein number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than or equal to 1.

[Claim 21] The receiving device according to claim 19, wherein the signaling receiving module is further to receive a data signal and/or control signal over the time-frequency resource.

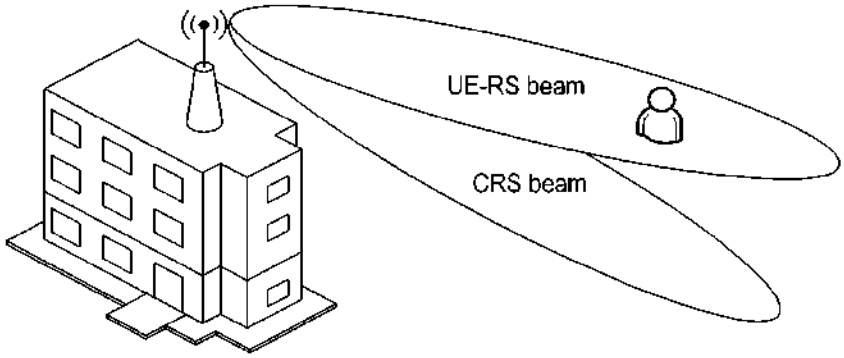
[Fig. 1]



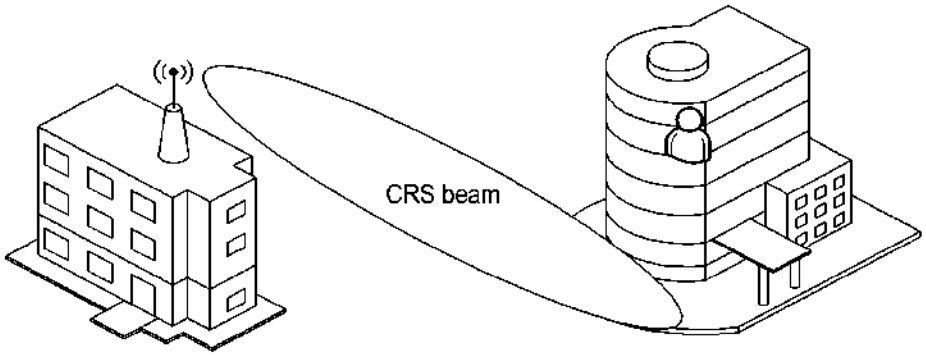
[Fig. 2]



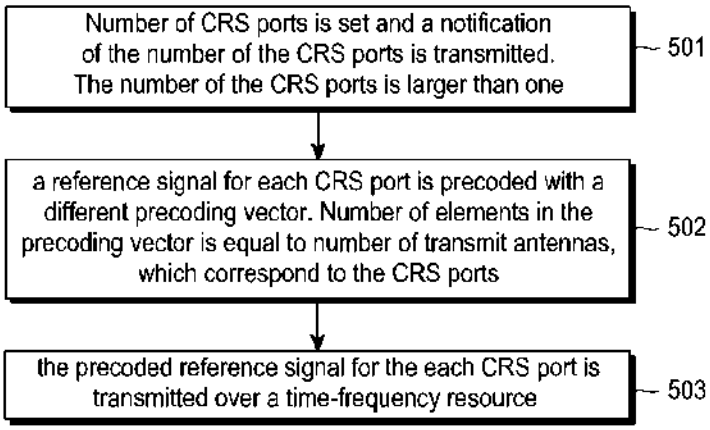
[Fig. 3]



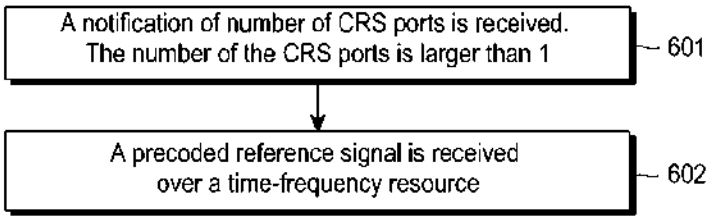
[Fig. 4]



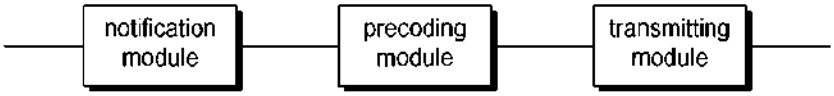
[Fig. 5]



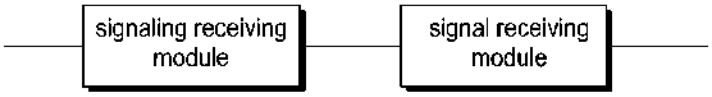
[Fig. 6]



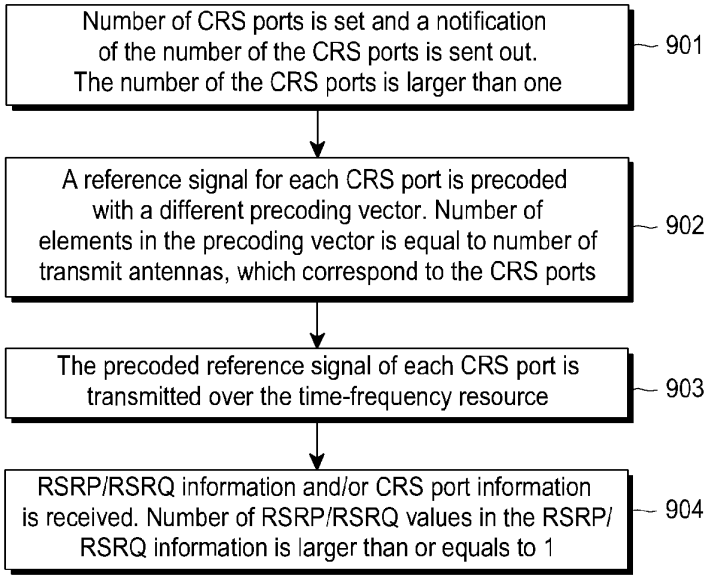
[Fig. 7]



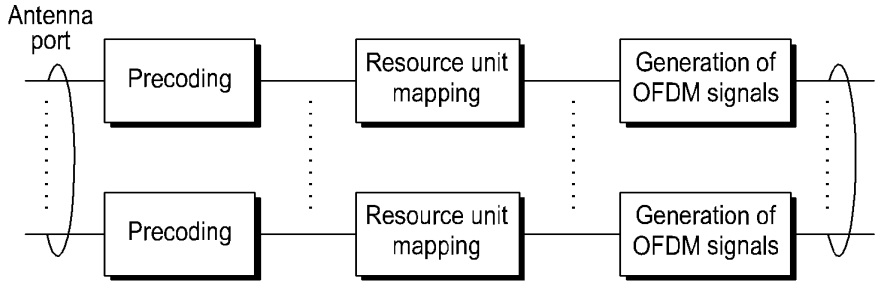
[Fig. 8]



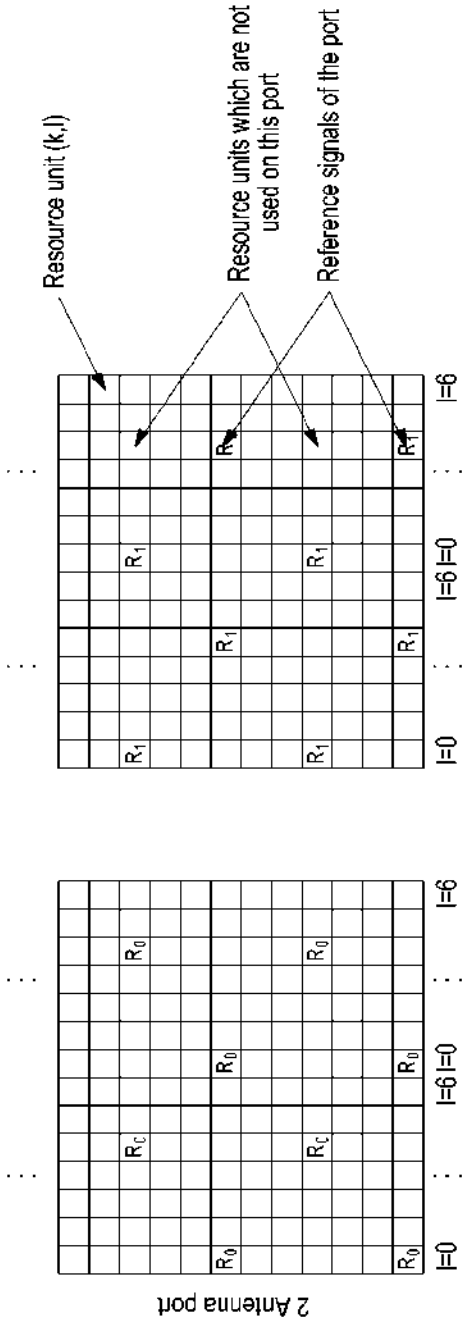
[Fig. 9]


Number of CRS ports is set and a notification of the number of the CRS ports is sent out. The number of the CRS ports is larger than one
901
A reference signal for each CRS port is precoded with a different precoding vector. Number of elements in the precoding vector is equal to number of transmit antennas, which correspond to the CRS ports
902
The precoded reference signal of each CRS port is transmitted over the time-frequency resource
903
RSRP/RSRQ information and/or CRS port information is received. Number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than or equals to 1
904

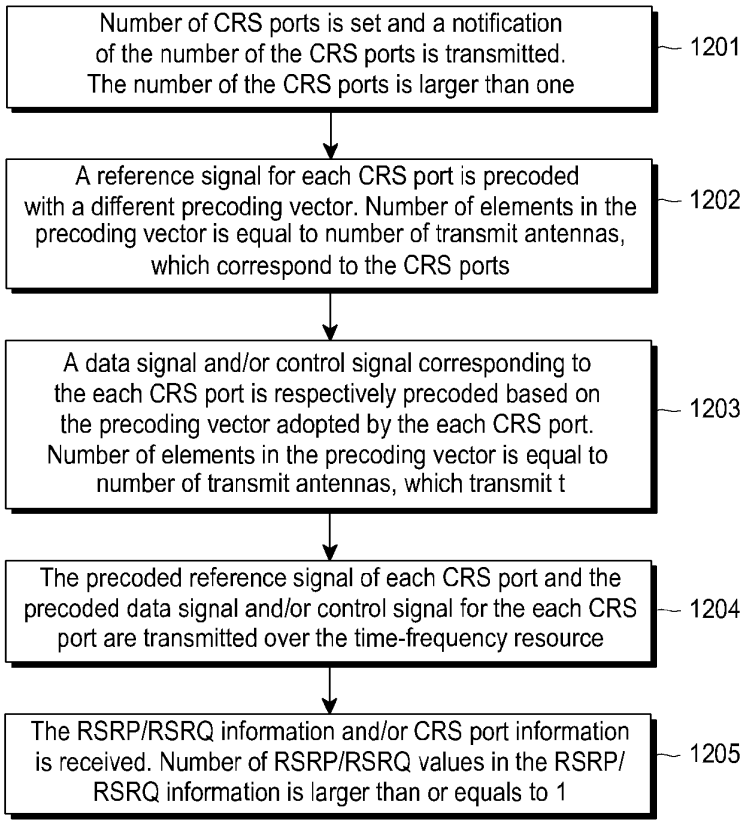
[Fig. 10]


Antenna port
Precoding
Precoding
Resource unit mapping
Resource unit mapping
Generation of OFDM signals
Generation of OFDM signals

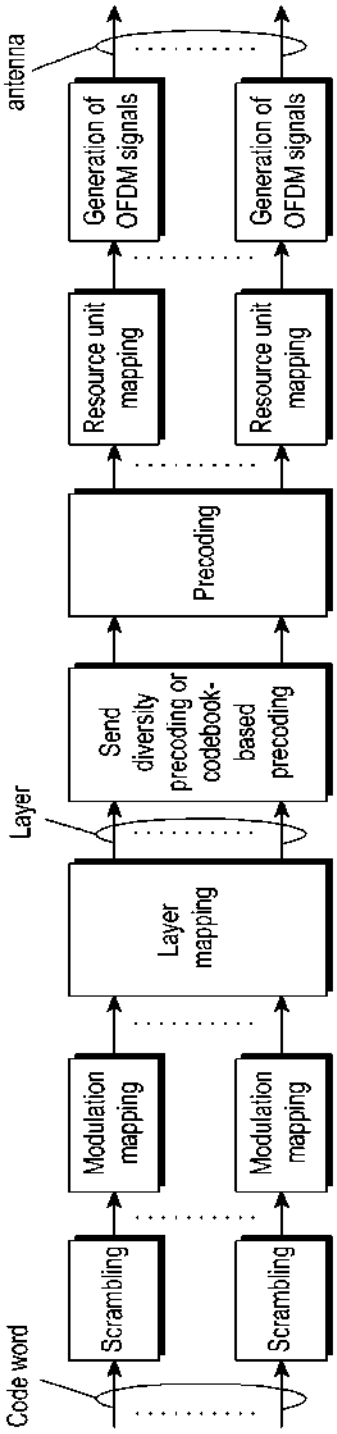
[Fig. 11]


Resource unit (k,l)
Resource units which are not used on this port
Reference signals of the port
l=6
l=6 l=0
l=0
2 Antenna port

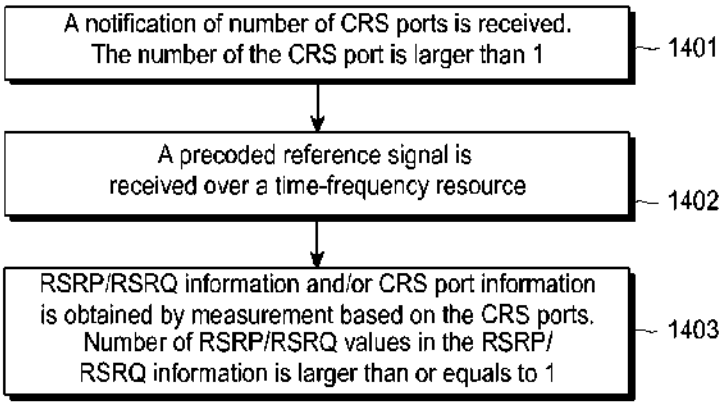
[Fig. 12]


Number of CRS ports is set and a notification of the number of the CRS ports is transmitted. The number of the CRS ports is larger than one
1201
A reference signal for each CRS port is precoded with a different precoding vector. Number of elements in the precoding vector is equal to number of transmit antennas, which correspond to the CRS ports
1202
A data signal and/or control signal corresponding to the each CRS port is respectively precoded based on the precoding vector adopted by the each CRS port. Number of elements in the precoding vector is equal to number of transmit antennas, which transmit t
1203
The precoded reference signal of each CRS port and the precoded data signal and/or control signal for the each CRS port are transmitted over the time-frequency resource
1204
The RSRP/RSRQ information and/or CRS port information is received. Number of RSRP/RSRQ values in the RSRP/RSRQ information is larger than or equals to 1
1205

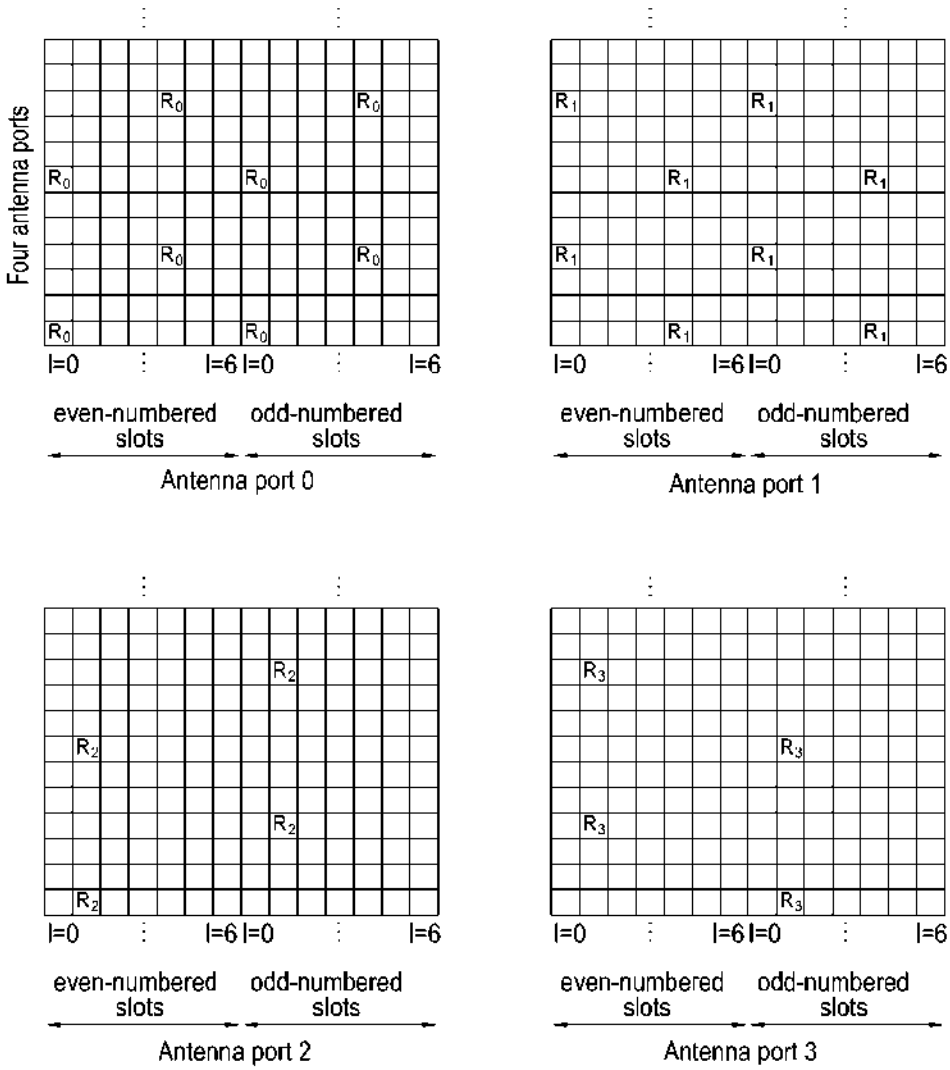
[Fig. 13]


Physical antenna
Generation of OFDM signals
Generation of OFDM signals
Resource unit mapping
Resource unit mapping
Precoding
Send diversity precoding or codebook-based precoding
Layer
Layer mapping
Modulation mapping
Modulation mapping
Scrambling
Scrambling
Code word

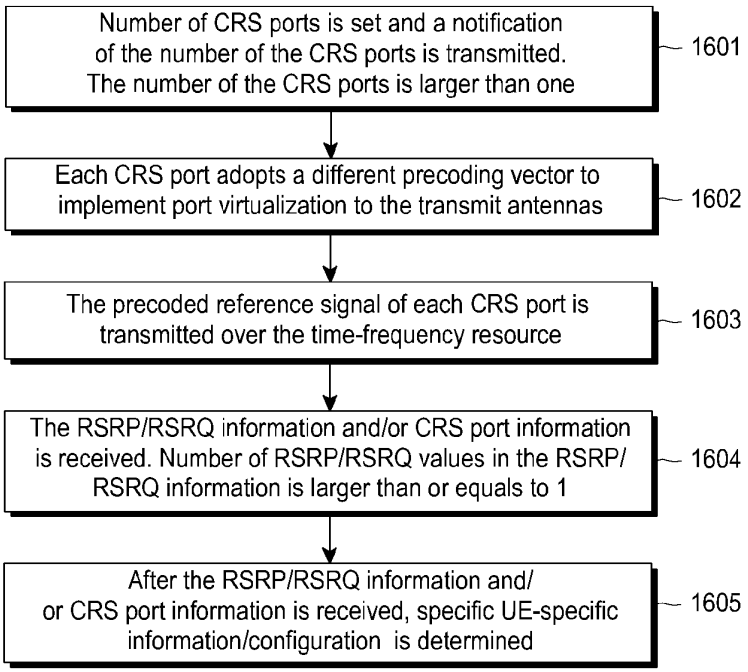
[Fig. 14]


A notification of number of CRS ports is received. The number of the CRS port is larger than 1
1401
A precoded reference signal is received over a time-frequency resource
1402
RSRP/RSRQ information and/or CRS port information is obtained by measurement based on the CRS ports. Number of RSRP/RSRQ values in the RSRP/ RSRQ information is larger than or equals to 1
1403

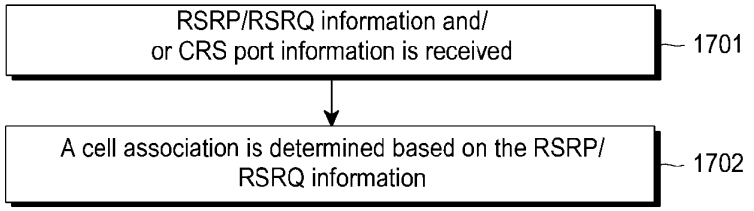
[Fig. 15]


Four antenna ports
R0
R1
R2
R3
l=0
l=6
even-numbered slots
odd-numbered slots
Antenna port 0
Antenna port 1
Antenna port 2
Antenna port 3

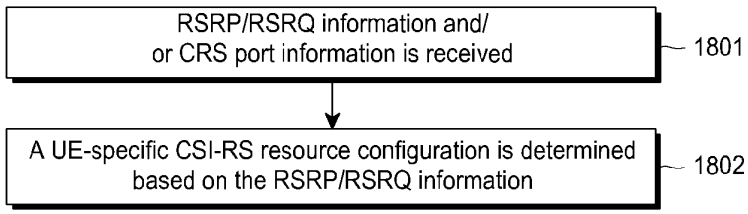
[Fig. 16]



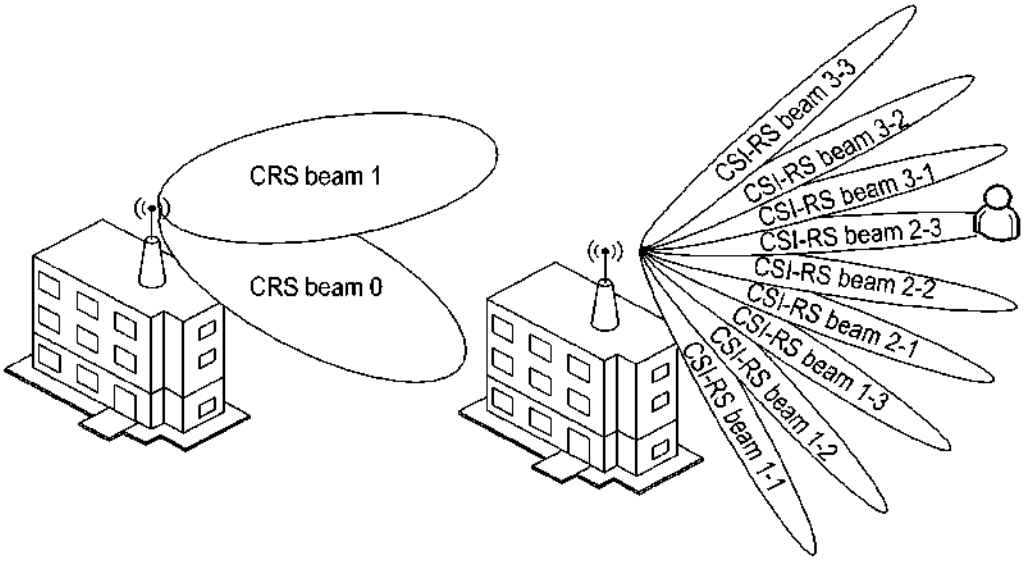
[Fig. 17]



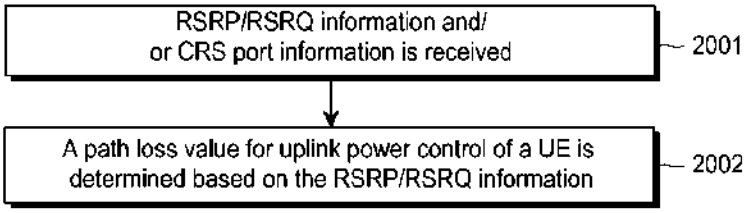
[Fig. 18]



[Fig. 19]


CRS beam 1
CRS beam 0
CSI-RS beam 3-3
CSI-RS beam 3-2
CSI-RS beam 3-1
CSI-RS beam 2-3
CSI-RS beam 2-2
CSI-RS beam 2-1
CSI-RS beam 1-3
CSI-RS beam 1-2
CSI-RS beam 1-1

[Fig. 20]


RSRP/RSRQ information and/
or CRS port information is received
2001
A path loss value for uplink power control of a UE is
determined based on the RSRP/RSRQ information
2002

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2015/006369

A. CLASSIFICATION OF SUBJECT MATTER

H04L 5/00(2006.01)i, H04L 1/06(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04L 5/00; H04L 1/06; H04B 7/06; H04W 72/00; H04B 7/04; H04W 24/08

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & keywords: CRS port, notify, precoding, RSRP/RSRQ(Reference Signal Receive Power/ Received Quality)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2013-0315191 A1 (TAKASHI YOSHIMOTO et al.) 28 November 2013 See paragraph [0099]; and figure 1.	1,11,14,15,19,21
A		2-10,12,13,16-18 ,20
Y	US 2103-0107746 A1 (FUJITSU LIMITED) 02 May 2013 See paragraphs [0089]-[0103]; claims 1, 5; and figures 1, 2.	1,11,14,15,19,21
A	US 2013-0329772 A1 (NIKLAS WERNERSSON et al.) 12 December 2013 See paragraphs [0093]-[0152]; and figures 6-9.	1-21
A	US 2014-0098689 A1 (INTERDIGITAL PATENT HOLDINGS, INC.) 10 April 2014 See paragraphs [0076]-[0079]; and figure 3.	1-21
A	WO 2014-073846 A1 (PANTECH CO., LTD.) 15 May 2014 See paragraphs [0252]-[0297]; and figures 28, 29.	1-21

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
08 October 2015 (08.10.2015)	**08 October 2015 (08.10.2015)**

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Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/KR2015/006369

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H04L 27/26 (2006.01) *H04W 84/00* (2009.01)

(21) International Application Number:
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26 December 2015 (26.12.2015)

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62/203,301 10 August 2015 (10.08.2015) US

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(74) Agent: **OLSON, Jared**; Ledell Ansari, LLP, c/o Cpa Global, P.O. Box 52050, Minneapolis, MN 55402 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

(54) **Title**: ENHANCED PHYSICAL SIGNAL STRUCTURE FOR LTE V2V COMMUNICATIONS

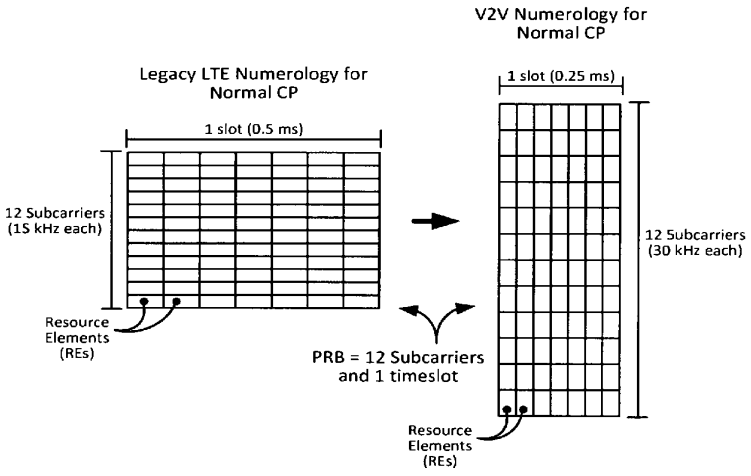


Fig. 4

(57) **Abstract**: A vehicle may wirelessly communicate with another vehicle via a physical channel (a vehicle-to-vehicle (V2V) channel) that is robust and reliable under high mobility propagation conditions. The physical channel may be created by modifying an existing long-term evolution (LTE) physical channel, such as an LTE sidelink (SL) channel. For instance, the V2V physical channel may be created by increasing, by a particular factor, the subcarrier spacing of legacy LTE channels (e.g., from 15 kilohertz (kHz) to 30 kHz). Additionally, a symbol duration and a fast Fourier transform (FFT) size for the V2V physical channel may each be reduced by the same factor. Doing so may enable the V2V physical channel to be implemented without significant modifications to other aspects of the LTE standard.

WO 2017/026983 A1

ENHANCED PHYSICAL SIGNAL STRUCTURE FOR LTE V2V COMMUNICATIONS

RELATED APPLICATIONS

The present application claims the benefit of U.S. Provisional Patent Application No. 62/203,301, which was filed on August 10, 2015, the contents of which are hereby incorporated by reference as though fully set forth herein.

BACKGROUND

The so-called "connected car concept" includes the idea that vehicles may be enabled to communicate wirelessly with one another. The 3GPP (3rd Generation Partnership Project) Long Term Evolution (LTE) communications standard has been proposed as the communication standard for implementing the connected car concept (also referred to as vehicle-to-vehicle (V2V) communications). V2V communications include one vehicle establishing a direct connection with one or multiple other vehicles.

Examples of such connections may include an LTE sidelink connection (also referred as direct connection, a proximity services (ProSe) connection, a device-to-device (D2D) connection, etc.). Once connected, vehicles may communicate a variety of information to each other, such as location information, velocity information, acceleration information, directional information, performance information, and more. Such information may be used to provide a variety of functionalities, such as preventing car accidents, determining driving conditions (e.g., traffic jams, icy roads, car accidents, etc.), determining optimal routes for driving from one location to another, etc.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments described herein will be readily understood by the following detailed description in conjunction with the accompanying drawings. To facilitate this description, like reference numerals may designate like structural elements. Embodiments are illustrated by way of example and not by way of limitation in the figures of the accompanying drawings.

Fig. 1 is a diagram of an example environment in which systems and/or methods described herein may be implemented;

Fig. 2 is a diagram illustrating an example process for sending information to another vehicle;

Fig. 3 is a diagram illustrating an example process for receiving information from another vehicle;

Fig. 4 is a diagram of an example physical resource block (PRB) of a legacy long term evolution (LTE) numerology and an example PRB of a vehicle-to-vehicle (V2V) numerology, under normal cyclic prefix (CP) conditions;

Fig. 5 is a diagram of an example PRB of a legacy LTE numerology and an example PRB of a V2V numerology, under extended CP conditions;

Fig. 6 is a diagram of example PRB pairs of a legacy LTE numerology and example PRB pairs of a V2V numerology, under normal CP conditions;

Fig. 7 is a diagram of example PRB pairs of a legacy LTE numerology and PRB pairs of a V2V numerology, under extended CP conditions;

Figs. 8A-8D are diagrams of example PRBs according to one or more embodiments described herein;

Figs. 9A-9D are diagrams of example PRBs according to one or more embodiments described herein;

Fig. 10 is a table of example characteristics of a legacy LTE numerology and a V2V numerology with 30 kilohertz (kHz) subcarrier spacing;

Fig. 11 is a table of example characteristics of a legacy LTE numerology and a V2V numerology with 60 kHz subcarrier spacing;

Fig. 12 is a table representing an example of legacy LTE and V2V transmission multiplexing; and

Fig. 13 illustrates, for one embodiment, example components of an electronic device.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The following detailed description refers to the accompanying drawings. The same reference numbers in different drawings may identify the same or similar elements. It is to be understood that other embodiments may be utilized and structural or logical changes may be made without departing from the scope of the present disclosure. Therefore, the following detailed description is not to be taken in a limiting sense, and the scope of embodiments defined by the appended claims and their equivalents.

As mentioned above, the 3GPP (3rd Generation Partnership Project) Long Term Evolution (LTE) communications standard has been proposed as the communication standard for vehicle-to-vehicle (V2V) communications. One reason behind the proposal is the reliability and high data rate capabilities of LTE technology. However, the current LTE standard includes

certain limitations when it comes to enabling vehicles to communicate with one another directly. For example, legacy LTE sidelink (SL) physical channels (also referred to as PC5 channels or device-to-device (D2D) channels) are considered to be used or enable V2V communications. At the same time, the legacy SL physical channels were designed with an assumption of substantially lower mobility conditions than the ones considered to be used for V2V communication (e.g., a scenario in which two vehicles are driving toward one another at 140 kilometers per hour (km/h) each). As a result, when subjected to wireless propagation in high mobility conditions (that may cause high Doppler fading and/or frequency shifts), legacy LTE physical channels may experience an unacceptably high block error rate (BLER) performance and/or use an unacceptably high signal-to-interference-noise ratio (SINR) to achieve reliable performance for V2V wireless communication.

Techniques described herein may be used to provide a physical channel (referred to herein as "V2V physical channel") of greater robustness and reliability when subjected to the high mobility conditions of V2V communications. For example, a V2V physical channel may have increased subcarrier spacing (e.g., 30 kilohertz (kHz) subcarriers) instead of the 15 kHz subcarrier spacing used in legacy LTE SL physical channels. The increased subcarrier spacing may improve physical channel robustness (particularly under high mobility wireless propagation effects) via a reduction of the impacts of frequency offset errors on the subcarriers orthogonality, reduced channel variations on the packet transmission duration, etc.

In some embodiments, the V2V physical channel may include additional alterations from current LTE SL physical channels. For example, the V2V physical channel may include a reduced symbol duration (e.g., a single-carrier frequency-division multiple access (SC-FDMA) symbol duration, etc.). The decrease in symbol duration may be proportional to the increased subcarrier spacing. For instance, if the subcarrier spacing of the V2V physical channel is twice as large as subcarrier spacing of a legacy LTE SL physical channel (e.g., 30 kHz instead of 15 kHz), the symbol duration for the V2V physical channel may be halved. Additionally, the decrease in symbol duration may be accompanied by a similar decrease (e.g., half) to a fast Fourier transform (FTT) size.

Additionally, since LTE air interfaces currently implement physical resource blocks (PRBs) as a fundamental unit of allocation for air interface resources, the techniques described herein may include one or more PRB formats for implementing the enhancements described above regarding modified subcarrier spacing and symbol duration of the V2V physical channels. For instance, a PRB of the V2V physical channel may

include time-domain changes, such as a change in the duration of each PRB and/or the number of slots per PRB. Similarly, a PRB of the V2V channel may include frequency-domain changes, such as the number of subcarriers per PRB, the PRB size in terms of frequency, etc. PRB formats may be discussed herein in terms of numerologies (e.g., legacy LTE numerologies and V2V numerologies), which may include a representation of subcarriers, slot durations, and resource elements (REs) of a PRB or PRB pair.

In some embodiments, the techniques described herein may be implemented within the context of cyclic prefixing (CP). For example, in the 3GPP LTE communication standard, CP may include copying a portion of one symbol (e.g., an end portion of the symbol) and adding the copied portion to a beginning portion of the symbol, such that the symbol begins and ends with the same portion. Doing so may, for example, reduce inter-symbol interference.

Fig. 1 is a diagram of an example environment 100 in which systems and/or methods described herein may be implemented. Environment 100 may include one or more vehicles with vehicle-to-X (V2X) devices 110, user equipment devices (UEs) 120, and network 130.

V2X device 110 may include a computing and communication device installed in a vehicle, such as a car, a truck, a sports utility vehicle (SUV), etc. V2X device 110 may be capable of gathering, processing, and communicating information regarding the vehicle in which V2X device 110 is installed. Examples of such information may include vehicle performance information, vehicle location information, vehicle usage information, vehicle status information, vehicle diagnostic information, etc. In some embodiments, V2X device 110 may be capable over gathering, processing, and communicating other types of information, such as information relating to a driver or passenger of the vehicle. V2X device 110 may be an example of user equipment device (UE) or another type of end terminal.

As shown, V2X device 110 may be capable of communicating with one or more networks or devices, such as UE 120, the V2X device of another vehicle, network 130, etc. In some embodiments, V2X device 110 may do so by establishing a connection that is based on a particular communications standard, such as the 3GPP LTE communication standard. For instance, V2X device 110 may establish a vehicle-to-pedestrian (V2P) connection with UE 120, which may include a D2D connection, an LTE SL connection, or other type of direct connection. V2X device 110 may also, or alternatively, establish a vehicle-to-infrastructure/network (V2I) connection with network 130. The V2I connection may include a standard connection with a base station (e.g., an evolved Node B (eNB)), a wireless access point (AP), or another device capable of enabling V2X device 110 to communicate with network 130.

As such, the "X" in "V2X device," may represent an ability of V2X device 110 to communicate with one or more types of devices (e.g., other V2X devices, UEs 120, a base station, a network access point (AP), etc.).

Additionally, or alternatively, V2X device 110 may establish a V2V connection with the V2X device of another vehicle. The V2V connection may include a D2D connection, an LTE SL connection, or other type of direct connection between UEs (e.g., a connection that does not, for example, include network 130). In some embodiments, V2X device 110 may be capable of communicating with other V2X devices using one or more of the techniques described herein. For example, V2X device 110 may be capable of using a V2V physical channel that ensure improved robustness and reliability when subjected to the high mobility conditions of V2V communications. The V2V physical channel may, for example, include greater subcarrier spacing and reduced symbol durations to, for example, improve demodulation performance including BLER reduction but still operating within the framework of an established communications standard (such as the 3GPP LTE communications standard).

UE 120 may include a portable computing and communication device, such as a personal digital assistant (PDA), a smart phone, a cellular phone, a laptop computer with connectivity to a cellular wireless network, a tablet computer, etc. UE 120 may also include non-portable computing devices, such as a desktop computer, a consumer or business appliance, or other devices that have the ability to connect to network 130. UE 120 may also include a computing and communication device that may be worn by a user (also referred to as wearable devices) as a watch, a fitness band, a necklace, glasses, an eyeglass, a ring, a belt, a headset, or another type of wearable device. As shown, UE 120 may establish a direct connection (e.g., a D2D connection) with V2X device 110. Additionally, UE 120 may communicate with V2X device 110 regarding the vehicle of V2X device 110, a driver or passenger of the vehicle, a user of UE 120, a location of the vehicle with respect to the user of UE 120, etc.

Network 130 may include one or more wired and/or wireless networks. For example, network 130 may include an LTE network. In some embodiments, network 130 may include one or more additional networks, such as a cellular network (e.g., a second generation (2G) network, a third generation (3G) network, a fourth generation (4G) network, a fifth generation (5G) network, a global system for mobile (GSM) network, a code division multiple access (CDMA) network, an evolution-data optimized (EVDO) network, or the like), a public land mobile network (PLMN), and/or another network. Additionally, or alternatively, network 150 may include a local area network (LAN), a wireless LAN (WLAN), a wide area network (WAN), a metropolitan network (MAN), the Public Switched Telephone Network (PSTN), an

ad hoc network, a managed IP network, a virtual private network (VPN), an intranet, the Internet, a fiber optic-based network, and/or a combination of these or other types of networks.

The quantity of devices and/or networks, illustrated in Fig. 1, is provided for explanatory purposes only. In practice, there may be additional devices and/or networks; fewer devices and/or networks; different devices and/or networks; or differently arranged devices and/or networks than illustrated in Fig. 1. Alternatively, or additionally, one or more of the devices of environment 100 may perform one or more functions described as being performed by another one or more of the devices of system 100. Furthermore, while "direct" connections are shown in Fig. 1, these connections should be interpreted as logical communication pathways, and in practice, one or more intervening devices (e.g., routers, gateways, modems, switches, hubs, etc.) may be present.

Additionally, while some of the techniques described herein may involve V2V communications as an example, the techniques described herein may be applied to various scenarios and/or other types of communications. For example, techniques described herein may be applicable to time division duplexing (TDD) or frequency division duplexing (FDD) communications. In some embodiments, techniques described herein may be applied to all of downlink (DL), uplink (UL), and sidelink (SL) communications, while other embodiments may only apply the techniques described herein to DL or UL or SL communications. Additionally, while the techniques described herein may be described within the context of the 3GPP LTE communications standard, the techniques may also be applied to other communication standards. Additionally, while examples provided herein may include enabling vehicles to communicate with one another more reliably, the techniques described herein may be applied to other scenarios as well (such as another system or device that may experience significant Doppler fading conditions when attempting to communicate wirelessly).

Fig. 2 is a diagram illustrating an example process 200 for sending information to another vehicle. Process 200 may be particularly appropriate for devices capable of wireless communications that may be subjected to high mobility propagation conditions (e.g., wireless propagation in high mobility conditions characterized by high Doppler fading and/or frequency shifts that may jeopardize the integrity or reliability of the wireless communications). Process 200 may be implemented by, for example, V2X device 110. Additionally, process 200 provides an example of how a V2V physical channel may be used; however, it should be noted that the V2V physical channel, as described herein, may

be used in additional and alternative ways, which may include fewer, additional, and/or alternative operations than the operations described below with reference to Fig. 2.

As shown, process 200 may include identifying a physical channel that is appropriate for communicating with another vehicle (block 210). For example, in some embodiments, V2X device 110 may be capable of using multiple physical channels for communicating with another vehicle. As described above, examples of such channels may include an LTE SL physical channel, a V2V physical channel (as described herein), etc. In some embodiments, V2X device 110 may identify the appropriate physical channel based on one or more factors.

Examples of such factors may include whether the physical channel will likely be subjected to high mobility propagation conditions. For instance, if the vehicle of the V2X device 110 and/or the other vehicle are traveling at a high speed, V2X device 110 may determine that communications between the vehicles are likely to be subjected to such conditions. As such, a V2V physical channel (as opposed to, for example, a legacy LTE SL channel) may be appropriate for communicating with the other vehicle.

Another example of a factor that may be considered by V2X device 110 may include the communication capabilities of the other vehicle. For example, V2X device 110 may determine the types of physical channels that the other vehicle is capable of using and select the most appropriate physical channel from on the physical channels that the other vehicle is capable of using. In some embodiments, determining the communication capabilities of the other vehicle may include determining what type of communications device is being implemented by the other vehicle (e.g., a V2X device or another type of communications device).

Additional examples of factors that may be used to identify an appropriate physical channel may include physical channel availability (e.g., whether V2X device is already using one or more physical channels), a measure of importance regarding the information (or type of information) that is to be sent to the other vehicle (e.g., less important information may be allocated with less reliable physical channels), a measure of importance of other information that is to communicated to a different vehicle, etc. In yet another example, V2X device may implement one or more rules for prioritizing which type of physical channel (e.g., an LTE SL channel, a V2V physical channel, etc.) should be implemented in light of one or more of the factors described above.

Process 200 may include generating information to communicate to the vehicle (block 220). For example, V2X device 110 may generate the information that is to be

transmitted to the other vehicle. Examples of such information may include vehicle performance information, vehicle location information, vehicle usage information, vehicle status information, vehicle diagnostic information, information relating to a driver or passenger of the vehicle, etc.

Process 200 may include processing the information based on the physical channel identified for communicating with the other vehicle (block 230). For example, V2X device 110 may arrange the information in accordance with a particular PRB format, which may be particular to the type of physical channel identified as the suitable for communicating with the other vehicle. For instance, if the identified physical channel corresponds to a currently available physical channel (such as an LTE LS physical channel), the information may be allocated to accommodate a format where a PRB includes 12 subcarriers (also referred to herein as frequency REs) with 15 kHz subcarrier spacing and 1 slot of 0.5 ms duration in time. However, if the identified physical channel corresponds to a V2V physical channel, the information may be allocated to accommodate a format where a PRB includes 12 subcarriers with 30 kHz subcarrier spacing and 1 slot of 0.25 ms duration in time. Alternatively, for V2V physical channel, the information may be allocated to accommodate a format where a PRB includes 12 subcarriers with 60 kHz subcarrier spacing and 1 slot of 0.125 ms duration in time. Additional examples of PRB formats are discussed below with reference to Figs. 4-9.

Process 200 may include using the physical channel to communicate information to vehicle (block 240). For example, V2X device 110 may use the physical channel identified as being appropriate for communicating with the vehicle to transmit the information to the vehicle. As described above, the physical channel may include a legacy channel (such as an LTE SL channel) or a V2V physical channel, and the information may be formatted in accordance with a format (e.g., a PRB format) that is particular to the physical channel used to transmit the information.

Fig. 3 is a diagram illustrating an example process 300 for receiving information from another vehicle. Process 300 may be particularly appropriate for devices capable of wireless communications that may be subjected to high mobility conditions (e.g., that may cause high Doppler fading and/or frequency shifts) during V2V communications. Process 300 may be implemented by, for example, V2X device 110.

As shown, process 300 may include receiving information from another vehicle via a physical channel (block 310). For example, V2X device 110 may be capable of using physical channels for communicating with another vehicle. As described above, examples

of such channels may include an LTE SL channel, a V2V physical channel, etc. The information sent and received between vehicles may include vehicle performance information, vehicle location information, vehicle usage information, vehicle status information, vehicle diagnostic information, information relating to a driver or passenger of the vehicle, etc.

Process 300 may include determining a physical channel type corresponding to the physical channel (block 320). For example, V2X device 110 may identify the type of physical channel (e.g., an LTE SL channel, a V2V channel, etc.) used to receive the information. In some embodiments, V2X device 110 may determine the manner in which the information is arranged in the physical channel based on the physical channel type may include. For example, if the physical channel corresponds to an LTE SL physical channel, the information may be formatted into PRBs that include 12 subcarriers with 15 kHz subcarrier spacing and 1 slot of 0.5 ms duration in time. In another example, if the physical channel corresponds to a V2V physical channel, the information may be formatted into PRBs that include 12 subcarriers with 30 kHz subcarrier spacing and 1 slot of 0.25 ms duration in time. Alternatively, for a V2V physical channel, the information may be allocated to accommodate a format where a PRB includes 12 subcarriers with 60 kHz subcarrier spacing and 1 slot of 0.125 ms duration in time. Additional examples of PRB formats are discussed below with reference to Figs. 4-9.

Process 300 may include interpreting the information based on the physical channel type of the physical channel (block 330). For example, V2X device 110 may interpret the information, received from another vehicle, based on a type of physical channel used to communicate the information. For instance, if the physical channel corresponds to an LTE LS physical channel, the information may be interpreted based on the assumption that the information was formatted into PRBs that include 12 subcarriers with 15 kHz subcarrier spacing and 1 slot of 0.5 ms duration in time. By contrast, if the physical channel corresponds to a V2V physical channel, the information may be interpreted based on the assumption that the information was formatted into PRBs that include 12 subcarriers with 30 kHz subcarrier spacing and 1 slot of 0.25 ms duration in time. Alternatively, for V2V physical channel, the information may be interpreted based on the assumption that the information was formatted into PRBs that include 12 subcarriers with 60 kHz subcarrier spacing and 1 slot of 0.125 ms duration in time.

Fig. 4 is a diagram of an example PRB of a legacy LTE numerology and an example PRB of a V2V numerology, under normal CP conditions. The legacy LTE numerology may correspond to a legacy LTE physical channel (e.g., an LTE SL channel), while the V2V

numerology may correspond to a V2V physical channel. A numerology, as discussed herein, may include parameters and characteristics of a physical channel (e.g., a legacy LTE SL channel or a V2V physical channel).

Such parameters and characteristics may include a bandwidth supported by the physical channel, a number of subcarriers per channel, a subcarrier spacing, a fast Fourier transform (FFT) size, a symbol duration, a slot duration, a subframe duration. Additional examples of numerological parameters and characteristics may include a direct, or indirect, description of a PRB and/or PRB pair of the physical channel, such as a number of subcarriers per PRB, a PRB duration (e.g., a number of slots per PRB), a number of resource elements (REs) per PRB, a number of symbols per PRB, etc.

Additionally, in the 3GPP LTE communication standard, CP may include copying a small portion of one symbol (e.g., an end portion of the symbol) and adding the copied portion to a beginning portion of the symbol, such that the symbol begins and ends with the same portion. Normal CP (as depicted in Figs. 4 and 6) may be implemented for wireless communications over shorter distances, while extended CP (as depicted in Figs. 5 and 7) may be implemented for wireless communications over longer distances. As such, normal CP may include a PRB of more symbols (or REs) per slot in time domain (e.g., 7), while extended CP may include a PRB of fewer symbols (or REs) per slot in time domain (e.g., 6).

As shown in Fig. 4, a PRB of the legacy LTE numerology for normal CP may include 12 subcarriers with 15 kHz subcarrier spacing, a slot of 0.5 ms in time domain comprising 7 consecutive symbols, and 84 REs in total. By contrast, the PRB of the V2V numerology for normal CP may include 12 subcarriers with 30 kHz subcarrier spacing, 1 slot of 0.25 ms in the time domain, comprising 7 consecutive symbols, and 84 REs in total. As such, each subcarrier of a V2V physical channel PRB may have twice as much subcarrier spacing as the subcarriers of the legacy LTE channel PRB; however, the duration of the slot of the V2V physical channel may be half the duration of the slot of the legacy LTE physical channel. As mentioned above, the decrease in slot duration may be accompanied by a similar decrease (e.g., a factor of 2, 4, etc.) to the FTT size associated with the V2V physical channel. Doing so may help ensure that the sampling time and/or sampling frequency of the V2V physical channel remains the same as the sampling time and sampling frequency of the legacy LTE channel.

For example, sampling time, as described herein, may include the basic time unit for the corresponding physical channel. For instance, in the 3GPP LTE communication standard, sampling time may be represented by "Ts" and may be equal to 1/(subcarrier spacing x FFT

size) (e.g., 1/(1500Hz x 2048)). By contrast, sampling frequency, as described herein, may include the basic frequency unit for a particular physical channel. For example, in the 3GPP LTE communication standard, sampling frequency may be represented by "Fs" and may be equal to subcarrier spacing (e.g., 15 kHz) multiplied by the number of FFT time samples (e.g., 2048).

As described above, a V2V channel may have increased subcarrier spacing (e.g., 30 kHz or 60 kHz instead of 15 kHz) but still be implemented within the LTE framework since decreasing symbol duration and FFT size proportionally may help ensure that sampling frequency and sampling time for the V2V channel are the same as the sampling frequency and sampling time of legacy LTE channels (e.g., an LTE SL channel). For example, since sampling time is equal to the inverse of subcarrier spacing multiplied by the corresponding FFT size, increasing the subcarrier spacing by a factor of two (e.g., from 15 kHz to 30 kHz) or four (e.g., from 15 kHz to 60 kHz) does not change the sampling time so long as the FFT size is reduced by the same factor (e.g., from 2048 to 1024 for factor of two or from 2048 to 512 for factor of four). The same can be said for sampling frequency since sampling frequency may be equal to subcarrier spacing multiplied by the corresponding FFT size. As such, the arrow depicted in Fig. 4 may represent that the techniques described herein may enable legacy LTE channels to be modified (or replaced) by V2V channels (which may be more robust and reliable in high mobility conditions (e.g., that may cause high Doppler fading and/or frequency shifts)) without affecting other aspects of the LTE communications standard.

For example, in some embodiments, the duration for a single subframe of a V2V channel may be set to 0.5 ms, such that the subframe may include 2 slots at 0.25 ms each. In such an implementation, relatively few (if any) modifications to the 3GPP LTE communication standard may implement the V2V channel since, for example, legacy LTE channels also include 2 slots per subframe. In other embodiments, the duration for a single subframe of the V2V channel may be set to 1.0 ms (for example), which may result in a subframe including 4 slots at 0.25 ms each. In such embodiments, certain modifications to the 3GPP LTE communications standard may be beneficial, such as modifications to the size of transport blocks, the transport block sizes (TBS) tables, etc.

Fig. 5 is a diagram of an example PRB of a legacy LTE numerology and an example PRB of a V2V numerology, under extended CP conditions. The legacy LTE numerology may correspond to a legacy LTE channel (e.g., an LTE SL channel), while the V2V numerology may correspond to a V2V channel. As shown, a PRB of the legacy LTE numerology for extended CP may include 12 subcarriers of 15 kHz each, a slot of 0.5 ms, and 72 REs (6 symbols or (REs)

per slot). By contrast, the PRB of the V2V numerology for normal CP may include 12 subcarriers of 30 kHz each, 1 slot of 0.25 ms, and 84 REs. As such, each subcarrier of a V2V channel PRB may include twice as much bandwidth as the subcarriers of the legacy LTE channel PRB; however, the slot of the V2V channel PRB may be half the duration of the slot of the legacy LTE channel PRB. As mentioned above, the decrease in slot duration may be accompanied by a similar decrease (e.g., a factor of 2, 4, etc.) to the FTT size associated with the V2V channel. The sampling frequency of the V2V channel may remain the same as the sampling frequency of the legacy LTE channel. As such, the arrow depicted in Fig. 5 may represent that the techniques described herein may enable legacy LTE channels to be modified (or replaced) by V2V channels (which may be more robust and reliable in high mobility conditions) without affecting other aspects of the LTE communications standard.

Fig. 6 is a diagram of example PRB pairs of a legacy LTE numerology and example PRB pairs of a V2V numerology, under normal CP conditions. As shown, the legacy LTE numerology and the V2V numerology may each include 4 PRBs, PRB 6.1 through PRB 6.4 and PRB 6.5 through 6.8, respectively. Each PRB of the legacy LTE numerology, and each PRB of the V2V numerology, may be similar to the corresponding PRBs discussed above with reference to Fig. 4. Additionally, the PRBs of Fig. 6 may corresponds to normal CP conditions since the PRB format includes 7 symbols (or REs) for each slot.

In the legacy LTE numerology, the PRB pairs may be differentiated from one another in the frequency domain, such that PRB 6.1 and PRB 6.2 include one pair (e.g., a 1st PRB pair) and PRB 6.3 and PRB 6.4 are another pair (e.g., a 2nd PRB pair). By contrast, in V2V numerology, the PRB pairs may be differentiated from one another in the time domain, such that PRB 6.5 and PRB 6.6 include one pair (e.g., a 1st PRB pair) and PRB 6.7 and PRB 6.8 are another pair (e.g., a 2nd PRB pair). Similar to the arrows in Fig. 4 and Fig. 5, the arrow depicted in Fig. 6 may represent that the techniques described herein may enable legacy LTE channels to be modified (or replaced) by V2V channels affecting other aspects of the LTE communications standard.

Fig. 7 is a diagram of example PRB pairs of a legacy LTE numerology and PRB pairs of a V2V numerology, under extended CP conditions. As shown, the legacy LTE numerology and the V2V numerology may each include 4 PRBs, PRB 7.1 through PRB 7.4 and PRB 7.5 through 7.8, respectively. Each PRB of the legacy LTE numerology, and each PRB of the V2V numerology, may be similar to the corresponding PRBs discussed above with reference to Fig. 5. Additionally, the PRBs of Fig. 7 may correspond to extended CP conditions since the PRB format includes 6 symbols (or REs) for each slot.

In the legacy LTE numerology, the PRB pairs may be differentiated from one another in the frequency domain, such that PRB 7.1 and PRB 7.2 include one pair (e.g., a 1st PRB pair) and PRB 6.3 and PRB 6.4 are another pair (e.g., a 2nd PRB pair). By contrast, in V2V numerology, the PRB pairs may be differentiated from one another in the time domain, such that PRB 7.5 and PRB 7.6 include one pair (e.g., a 1st PRB pair) and PRB 7.7 and PRB 7.8 are another pair (e.g., a 2nd PRB pair). Similar to the arrow in Fig. 6, the arrow depicted in Fig. 7 may represent that the techniques described herein may enable legacy LTE channels to be modified (or replaced) by V2V channels affecting other aspects of the LTE communications standard.

Figs. 8A-8D are diagrams of example PRBs according to one or more embodiments described herein. Additionally, the PRBs of Figs. 8A-8D may corresponds to normal CP conditions since each PRB includes 7 symbols per slot in time domain. The example PRB of Fig. 8A may correspond to the V2V channel PRB described above with reference to Fig. 4. The example PRBs of Fig. 8B may include a PRB pair (PRB 8.1 and PRB 8.2), similar to the V2V channel PRB pairs described above with reference to Fig. 5. Fig. 8C may include an example PRB that is similar to the PRB of Fig. 8A, except that the example PRB of Fig. 8C includes only 6 subcarriers (also, "REs in frequency" or "Frequency REs") of 30 kHz each. Similarly, Fig. 8D may include an example PRB pair (PRB 8.3 and PRB 8.4) that is similar to the PRB pair of Fig. 9B, except that the example PRBs of Fig. 8D include only 6 subcarriers with 30 kHz subcarrier spacing. In some embodiments, reducing the number of subcarriers per V2V channel may increase the number of transmission channels that may be used for V2V communications, which may in turn increase V2V system capacity (e.g., in a location with a high number of vehicles, such as a traffic jam on a freeway or major intersection).

Figs. 9A-9D are diagrams of example PRBs according to one or more embodiments described herein. Additionally, the PRBs of Figs. 9A-9D may correspond to extended CP conditions since each PRB includes 6 symbols per slot. The example PRB of Fig. 9A may correspond to the V2V channel PRB described above with reference to Fig. 5. The example PRBs of Fig. 9B may include a PRB pair (PRB 9.1 and PRB 9.2), similar to the V2V channel PRB pairs described above with reference to Fig. 5. Fig. 9C may include an example PRB that is similar to the PRB of Fig. 9A, except that the example PRB of Fig. 9C includes only 6 subcarriers (also, "REs in frequency" or "Frequency REs") of 30 kHz each. Similarly, Fig. 9D may include an example PRB pair (PRB 9.3 and PRB 9.4) that is similar to the PRB pair of Fig. 9B, except that the example PRBs of Fig. 9D include only 6 (instead of 12) subcarriers of 30 kHz each. As described above with reference to Figs. 8A-8D, in some embodiments, reducing

the number of subcarriers per V2V channel may increase the number of transmission channels that may be used for V2V communications, which may in turn increase the level of V2V system capacity (e.g., in a location with a high number of vehicles, such as a traffic jam on a freeway or major intersection).

Fig. 10 is a table of example characteristics of a legacy LTE numerology and a V2V numerology with 30 kHz subcarrier spacing. As shown, the table of Fig. 10 includes a Channel Characteristics column, a Legacy LTE Channel Numerology column, and a V2V Channel numerology column. Fig. 10 provides a non-limiting example of differences and similarities that may exists between a legacy LTE channel and a V2V channel.

For example, a legacy LTE channel may include a subcarrier spacing of 15 kHz, while a V2V channel may include a subcarrier spacing of 30 kHz. Both channels may support the same bandwidths; however, the channels may only support some of the same FTT sizes. For instance, only the legacy LTE channel may use FTT sizes of 1536 and 2048, and the V2V channel may use FTT sizes of 64 and 768. As such, the FFT size for the legacy LTE channel may include a lower limit of 128 for the 1.4 MHz bandwidth and an upper limit of 2048 for 20 MHz bandwidth, while the FFT size for the V2V channel (with 30 kHz subcarrier spacing), may include a lower limit of 64 for 1.4 MHz bandwidth and an upper limit of 1024 for the 20 MHz bandwidth. As described above, this is due to reducing the FTT sizes for the V2V channel by the same factor (e.g., "2") that was used to increase the subcarrier spacing of the V2V channel. The following table may represent a logical relationship between different BWs, legacy LTE FFT sizes, and V2V channel FFT sizes (when the subcarrier spacing for the V2V channel is 30 kHz).

Bandwidth (BW)	Nominal FFT Size	
	Legacy LTE Channel	V2V Channel with 30 kHz
1.4 MHz	128	64
3 MHz	256	128
5 MHz	512	256
10 MHz	1024	512
15 MHz	1536	768
20 MHz	2048	1024

Since the same factor was used to increase and decrease the subcarrier spacing and FFT size (respectively), both channels may have the same sampling time (Ts) of 32.55 nanoseconds

(ns) because sampling time may be calculated by taking the inverse of the product of the subcarrier spacing and the FFT size (e.g., Ts = 1/(subcarrier spacing x FFT size). In some embodiments, for similar reasons, both channels may also have the same sampling frequency (Fs) (e.g., Fs = subcarrier spacing x FFT size). As mentioned above, maintaining the same sampling time and sampling frequency as the legacy LTE channel may help ensure that the V2V channel can be implemented in an LTE environment without having to make significant adjustments to other aspects of the 3GPP LTE communication standard.

Similar to the change in FFT size, the symbol durations for the V2V channel may also be reduced by the same factor (e.g., "2") that was used to increase the subcarrier spacing of the V2V channel. As shown in Figs. 6-7, this may enable PRBs and PRB pairs to be formatted in a manner that enables the V2V channel to reduce the slot duration by half (e.g., from 0.5 ms to 0.25 ms) and output PRBs at the same rate as the legacy LTE channel, even though the subcarrier spacing for the V2V channel was doubled. Similar to maintaining the same sampling time and sampling frequency, maintaining a similar output rate as the legacy LTE channel, may help reduce the impact of the V2V channel on other aspects of the 3GPP LTE communication standard.

Additionally, the single subframe duration for the legacy LTE channel may be 1.0 ms, whereas the single subframe duration for the V2V channel may be 0.5 or 1.0 ms. A single subframe duration of 0.5 ms may enable the V2V channel to have two slots per subframe since the slot duration for the V2V channel was reduced to 0.25 ms. Additionally, since a PRB duration may be 0.25 ms (which corresponds to 1 slot), a 0.5 ms subframe may consist of one PRB pair (i.e., two 0.25 ms PRBs). In other words, the V2V channel may have a subframe-to-PRB-pair ratio of 1:1 when the subframe duration of the V2V channel is 0.5 ms, which may reduce the impact of the V2V channel on the 3GPP LTE communication standard since, for example, the legacy LTE channel also has a subframe-to-PRB-pair ratio of 1:1.

By contrast, a single subframe duration of 1.0 ms may enable the V2V channel to have four slots per subframe since the slot duration for the V2V channel was reduced to 0.25 ms. As such, the subframe may include four slots. In other words, a subframe duration of 1.0 ms, as opposed to the 0.5 ms subframe scenario above, may give rise to a relative increase in the amount of information that may be communicated in one subframe. As a result, implementing a 1.0 ms subframe may additional modifications to the 3GPP LTE communication standard, including changes to the design of physical channels, such as modifications to the size of transport blocks, the transport block sizes (TBS) tables, etc.

As shown in Fig. 10, whether the legacy LTE channel and the V2V channel have the same number of subcarriers per PRB may depend on the scenario or embodiment. For example, both channels may have 12 subcarriers for each PRB. Additionally, or alternatively, the V2V channel may have 6 subcarriers per PRB. In some embodiments, while allocating 6 subcarriers (instead of 12) to each PRB may decrease the rate at which a channel may transmit data, doing so may also increase the number of V2V channels that are available for V2X devices 110 to communicate with other V2X devices, UEs, etc. As such, allocating 6 subcarriers to each V2V channel may be beneficial in scenarios where V2V channels might not benefit from a high data rate connections and/or a vehicle with a V2X device is in a traffic jam, rush hour traffic, or in another situation involving a lot of V2X devices 110, UEs 110, etc., that within range of one another.

Fig. 11 is a table of example characteristics of a legacy LTE numerology and a V2V numerology with 60 kHz subcarrier spacing. As shown, the table of Fig. 11 includes a Channel Characteristics column, a Legacy LTE Channel Numerology column, and a V2V Channel numerology column. Fig. 11 provides a non-limiting example of differences and similarities that may exists between a legacy LTE channel and a V2V channel.

For example, a legacy LTE channel may include a subcarrier spacing of 15 kHz, while a V2V channel may include a subcarrier spacing of 60 kHz. Both channels may support the same bandwidths; however, the channels may only support some of the same FTT sizes. For instance, only the legacy LTE channel may support FTT sizes of 1024, 1536, and 2048, and only the V2V channel may support an FTT size of 32, 64, and 384. As such, the FFT size for the legacy LTE channel may include a lower limit of 128 and an upper limit of 2048, while the FFT size for the V2V channel (with 60 kHz subcarrier spacing), may include a lower limit of 32 kHz and an upper limit of 512 kHz. This may be due to reducing the FTT sizes for the V2V channel by the same factor (e.g., "4") that was used to increase the subcarrier spacing of the V2V channel. The following table may represent a logical relationship between different BWs, legacy LTE FFT sizes, and V2V channel FFT sizes (when the subcarrier spacing for the V2V channel is 30 kHz).

Bandwidth (BW)	Nominal FFT Size	
	Legacy LTE Channel	V2V Channel with 60 kHz
1.5 MHz	128	32
3 MHz	256	64
5 MHz	512	128
10 MHz	1024	256

15 MHz	1536	384
20 MHz	2048	512

Since the same factor was used to increase and decrease the subcarrier spacing and FFT size (respectively), both channels may have the same sampling time (Ts) of 32.55 nanoseconds (ns) because sampling time may be calculated by taking the inverse of the product of the subcarrier spacing and the FFT size (e.g., Ts = 1/(subcarrier spacing x FFT size). In some embodiments, for similar reasons, both channels may also have the same sampling frequency (Fs) (e.g., Fs = subcarrier spacing x FFT size). As mentioned above, maintaining the same sampling time and sampling frequency as the legacy LTE channel may help ensure that the V2V channel can be implemented in an LTE environment without having to make significant adjustments to other aspects of the 3GPP LTE communication standard.

Similar to the change in FFT size, the symbol durations for the V2V channel may also be reduced by the same factor (e.g., "4") that was used to increase the subcarrier spacing of the V2V channel. This may enable PRBs and PRB pairs to be formatted in a manner that enables the V2V channel to reduce the slot duration by one-fourth (e.g., from 1.0 ms to 0.125 ms) and output PRBs at the same rate as the legacy LTE channel, even though the subcarrier spacing for the V2V channel was quadrupled. Similar to maintaining the same sampling time and sampling frequency, maintaining a similar output rate as the legacy LTE channel, may help reduce the impact of the V2V channel on other aspects of the 3GPP LTE communication standard.

Additionally, the single subframe duration for the legacy LTE channel may be 1.0 ms, whereas the single subframe duration for the V2V channel may be 0.25 or 1.0 ms. A single subframe duration of 0.25 ms may enable the V2V channel to have two slots per subframe since the slot duration for the V2V channel was reduced to 0.125 ms. Additionally, since a PRB duration may be 0.125 ms (which corresponds to 1 slot), a 0.25 ms subframe may consist of one PRB pair (i.e., two 0.125 ms PRBs). In other words, the V2V channel may have a subframe-to-PRB-pair ratio of 1:1 when the subframe duration of the V2V channel is 0.25 ms, which may reduce the impact of the V2V channel on the 3GPP LTE communication standard since, for example, the legacy LTE channel also has a subframe-to-PRB-pair ratio of 1:1.

By contrast, a single subframe duration of 1.0 ms may enable the V2V channel to have eight slots per subframe since the slot duration for the V2V channel was reduced to 0.125 ms. As such, the subframe may include eight slots. In other words, a subframe duration of 1.0 ms, as opposed to the 0.25 ms subframe scenario above, may give rise to a relative increase in the amount of information that may be communicated in one subframe. As a result, implementing a

1.0 ms subframe may additional modifications to the 3GPP LTE communication standard, including changes to the design of physical channels, such as modifications to the size of transport blocks, the transport block sizes (TBS) tables, etc.

As shown in Fig. 11, whether the legacy LTE channel and the V2V channel have the same number of subcarriers per PRB may depend on the scenario or embodiment. For example, both channels may have 12 subcarriers for each PRB. Additionally, or alternatively, the V2V channel may have 3 or 6 subcarriers per PRB. In some embodiments, while allocating 3 or 6 subcarriers (instead of 12) to each PRB may decrease the rate at which a channel may transmit data, doing so may also increase the number of V2V channels that are available for V2X devices 110 to communicate with other V2X devices, UEs, etc. As such, allocating 3 or 6 subcarriers to each V2V channel may be beneficial in scenarios where V2V channels might not benefit from high data rate connections and/or a vehicle with a V2X device is in a traffic jam, rush hour traffic, or in another situation involving a lot of V2X devices 110, UEs 110, etc., that within range of one another.

Fig. 12 is a table representing an example of legacy LTE and V2V transmission multiplexing. As shown, Fig. 12 may include a vertical axis representing frequency and a horizontal axis representing time. V2V devices 110, UEs 110, etc., may support both legacy and V2V PHY numerologies (e.g. for cellular and V2V operation). Time domain multiplexing of legacy and V2V transmissions at one UE 110 may be used for these purposes. To facilitate efficient use of resources the minimum granularity for time domain multiplexing may be a multiple of legacy subframe granularity (e.g., 1.0 ms).

In one example, subframes for legacy LTE and V2V operation may be semi-statically, higher-layer configured, by an eNB (e.g., via radio resource control (RRC) protocol), on a per V2V device basis (or V2V device group basis). Semi-statically may include, for example, physical channels that are predefined by the eNB and assigned to a particular V2V device 210 or UE in a given scenario. In another example, subframes for legacy LTE and V2V operation may be dynamically assigned. In yet another example, subframes for legacy LTE and V2V operation may be specified by a communications standard (such as the 3GPP LTE communication standard).

A V2V transmissions (e.g., transmissions with a V2V numerology) may take place in either TDD or FDD modes. In the latter case, the transmissions may be configured in either a DL or a UL spectrum and can be configured independently (e.g., V2V transmissions on a UL spectrum may not impose use of V2V numerology in a DL spectrum in the same time resources).

In some embodiments, V2V device 110, UE 110, etc., may implement an autonomous selection capability for the numerology for the V2V transmissions (e.g., either a legacy LTE numerology or a V2V numerology) based on one or more instructions, conditions, or other criteria. As such, a V2V receiver (or another type of communication component) may either be informed on the type of the transmission in advance or may dynamically detect the transmission type. In embodiments where the transmission type is dynamically detected, a receiver (or another component of V2V device 110) may attempt to receive information under different hypothesis simultaneously (e.g., attempt to receive a signal under both a 15 kHz subcarrier spacing assumption and a 30 kHz subcarrier spacing assumptions)

As used herein, the term "circuitry" or "processing circuitry" may refer to, be part of, or include an Application Specific Integrated Circuit (ASIC), an electronic circuit, a processor (shared, dedicated, or group), and/or memory (shared, dedicated, or group) that execute one or more software or firmware programs, a combinational logic circuit, and/or other suitable hardware components that provide the described functionality. In some embodiments, the circuitry may be implemented in, or functions associated with the circuitry may be implemented by, one or more software or firmware modules. In some embodiments, circuitry may include logic, at least partially operable in hardware.

Embodiments described herein may be implemented into a system using any suitably configured hardware and/or software. Fig. 13 illustrates, for one embodiment, example components of an electronic device 1300. In embodiments, the electronic device 1300 may be a UE, an eNB, a WLAN AP, or some other appropriate electronic device. In some embodiments, the electronic device 1300 may include application circuitry 1302, baseband circuitry 1304, Radio Frequency (RF) circuitry 1306, front-end module (FEM) circuitry 1308 and one or more antennas 1360, coupled together at least as shown.

The application circuitry 1302 may include one or more application processors. For example, the application circuitry 1302 may include circuitry such as, but not limited to, one or more single-core or multi-core processors. The processor(s) may include any combination of general-purpose processors and dedicated processors (e.g., graphics processors, application processors, etc.). The processors may be coupled with and/or may include memory/storage, such as storage medium 1303, and may be configured to execute instructions stored in the memory/storage to enable various applications and/or operating systems to run on the system. In some implementations, storage medium 1303 may include a non-transitory computer-readable medium. Application circuitry 1302 may, in some embodiments, connect to or include one or more sensors, such as environmental sensors, cameras, etc.

Baseband circuitry 1304 may include circuitry such as, but not limited to, one or more single-core or multi-core processors. The baseband circuitry 1304 may include one or more baseband processors and/or control logic to process baseband signals received from a receive signal path of the RF circuitry 1306 and to generate baseband signals for a transmit signal path of the RF circuitry 1306. Baseband processing circuitry 1304 may interface with the application circuitry 1302 for generation and processing of the baseband signals and for controlling operations of the RF circuitry 1306. For example, in some embodiments, the baseband circuitry 1304 may include a second generation (2G) baseband processor 1304a, third generation (3G) baseband processor 1304b, fourth generation (4G) baseband processor 1304c, and/or other baseband processor(s) 1304d for other existing generations, generations in development or to be developed in the future (e.g., fifth generation (5G), 6G, etc.). The baseband circuitry 1304 (e.g., one or more of baseband processors 1304a-d) may handle various radio control functions that enable communication with one or more radio networks via the RF circuitry 1306. The radio control functions may include, but are not limited to, signal modulation/demodulation, encoding/decoding, radio frequency shifting, etc. In some implementations, baseband circuitry 1304 may be associated with storage medium 1303 or with another storage medium.

In some embodiments, modulation/demodulation circuitry of the baseband circuitry 1304 may include FFT, precoding, and/or constellation mapping/demapping functionality. In some embodiments, encoding/decoding circuitry of the baseband circuitry 1304 may include convolution, tail-biting convolution, turbo, Viterbi, and/or Low Density Parity Check (LDPC) encoder/decoder functionality. Embodiments of modulation/demodulation and encoder/decoder functionality are not limited to these examples and may include other suitable functionality in other embodiments. In some embodiments, the baseband circuitry 1304 may include elements of a protocol stack such as, for example, elements of an evolved universal terrestrial radio access network (E-UTRAN) protocol including, for example, physical (PHY), MAC, radio link control (RLC), packet data convergence protocol (PDCP), and/or radio resource control (RRC) elements. A central processing unit (CPU) 1304e of the baseband circuitry 1304 may be configured to run elements of the protocol stack for signaling of the PHY, MAC, RLC, PDCP and/or RRC layers. In some embodiments, the baseband circuitry may include one or more audio digital signal processor(s) (DSP) 1304f. The audio DSP(s) 1304f may be include elements for compression/decompression and echo cancellation and may include other suitable processing elements in other embodiments.

The baseband circuitry 1304 may further include memory/storage 1304g. The memory/storage 1304g may be used to load and store data and/or instructions for operations

performed by the processors of the baseband circuitry 1304. Memory/storage for one embodiment may include any combination of suitable volatile memory and/or non-volatile memory. The memory/storage 1304g may include any combination of various levels of memory/storage including, but not limited to, read-only memory (ROM) having embedded software instructions (e.g., firmware), random access memory (e.g., dynamic random access memory (DRAM)), cache, buffers, etc. The memory/storage 1304g may be shared among the various processors or dedicated to particular processors.

Components of the baseband circuitry may be suitably combined in a single chip, a single chipset, or disposed on a same circuit board in some embodiments. In some embodiments, some or all of the constituent components of the baseband circuitry 1304 and the application circuitry 1302 may be implemented together such as, for example, on a system on a chip (SOC).

In some embodiments, the baseband circuitry 1304 may provide for communication compatible with one or more radio technologies. For example, in some embodiments, the baseband circuitry 1304 may support communication with an E-UTRAN and/or other wireless metropolitan area networks (WMAN), a WLAN, a wireless personal area network (WPAN). Embodiments in which the baseband circuitry 1304 is configured to support radio communications of more than one wireless protocol may be referred to as multi-mode baseband circuitry.

RF circuitry 1306 may enable communication with wireless networks using modulated electromagnetic radiation through a non-solid medium. In various embodiments, the RF circuitry 1306 may include switches, filters, amplifiers, etc. to facilitate the communication with the wireless network. RF circuitry 1306 may include a receive signal path which may include circuitry to down-convert RF signals received from the FEM circuitry 1308 and provide baseband signals to the baseband circuitry 1304. RF circuitry 1306 may also include a transmit signal path which may include circuitry to up-convert baseband signals provided by the baseband circuitry 1304 and provide RF output signals to the FEM circuitry 1308 for transmission.

In some embodiments, the RF circuitry 1306 may include a receive signal path and a transmit signal path. The receive signal path of the RF circuitry 1306 may include mixer circuitry 1306a, amplifier circuitry 1306b and filter circuitry 1306c. The transmit signal path of the RF circuitry 1306 may include filter circuitry 1306c and mixer circuitry 1306a. RF circuitry 1306 may also include synthesizer circuitry 1306d for synthesizing a frequency for use by the mixer circuitry 1306a of the receive signal path and the transmit signal path. In some

embodiments, the mixer circuitry 1306a of the receive signal path may be configured to down-convert RF signals received from the FEM circuitry 1308 based on the synthesized frequency provided by synthesizer circuitry 1306d. The amplifier circuitry 1306b may be configured to amplify the down-converted signals and the filter circuitry 1306c may be a low-pass filter (LPF) or band-pass filter (BPF) configured to remove unwanted signals from the down-converted signals to generate output baseband signals.

Output baseband signals may be provided to the baseband circuitry 1304 for further processing. In some embodiments, the output baseband signals may be zero-frequency baseband signals. In some embodiments, mixer circuitry 1306a of the receive signal path may comprise passive mixers, although the scope of the embodiments is not limited in this respect.

In some embodiments, the mixer circuitry 1306a of the transmit signal path may be configured to up-convert input baseband signals based on the synthesized frequency provided by the synthesizer circuitry 1306d to generate RF output signals for the FEM circuitry 1308. The baseband signals may be provided by the baseband circuitry 1304 and may be filtered by filter circuitry 1306c. The filter circuitry 1306c may include a low-pass filter (LPF), although the scope of the embodiments is not limited in this respect.

In some embodiments, the mixer circuitry 1306a of the receive signal path and the mixer circuitry 1306a of the transmit signal path may include two or more mixers and may be arranged for quadrature downconversion and/or upconversion respectively. In some embodiments, the mixer circuitry 1306a of the receive signal path and the mixer circuitry 1306a of the transmit signal path may include two or more mixers and may be arranged for image rejection (e.g., Hartley image rejection). In some embodiments, the mixer circuitry 1306a of the receive signal path and the mixer circuitry 1306a may be arranged for direct downconversion and/or direct upconversion, respectively. In some embodiments, the mixer circuitry 1306a of the receive signal path and the mixer circuitry 1306a of the transmit signal path may be configured for super-heterodyne operation.

In some embodiments, the output baseband signals and the input baseband signals may be analog baseband signals, although the scope of the embodiments is not limited in this respect. In some alternate embodiments, the output baseband signals and the input baseband signals may be digital baseband signals. In these alternate embodiments, the RF circuitry 1306 may include analog-to-digital converter (ADC) and digital-to-analog converter (DAC) circuitry and the baseband circuitry 1304 may include a digital baseband interface to communicate with the RF circuitry 1306.

In some dual-mode embodiments, a separate radio IC circuitry may be provided for processing signals for each spectrum, although the scope of the embodiments is not limited in this respect.

In some embodiments, the synthesizer circuitry 1306d may be a fractional-N synthesizer or a fractional N/N+6 synthesizer, although the scope of the embodiments is not limited in this respect as other types of frequency synthesizers may be suitable. For example, synthesizer circuitry 1306d may be a delta-sigma synthesizer, a frequency multiplier, or a synthesizer comprising a phase-locked loop with a frequency divider.

The synthesizer circuitry 1306d may be configured to synthesize an output frequency for use by the mixer circuitry 1306a of the RF circuitry 1306 based on a frequency input and a divider control input. In some embodiments, the synthesizer circuitry 1306d may be a fractional N/N+6 synthesizer.

In some embodiments, frequency input may be provided by a voltage controlled oscillator (VCO. Divider control input may be provided by either the baseband circuitry 1304 or the applications processor 1302 depending on the desired output frequency. In some embodiments, a divider control input (e.g., N) may be determined from a look-up table based on a channel indicated by the applications processor 1302.

Synthesizer circuitry 1306d of the RF circuitry 1306 may include a divider, a delay-locked loop (DLL), a multiplexer and a phase accumulator. In some embodiments, the divider may be a dual modulus divider (DMD) and the phase accumulator may be a digital phase accumulator (DPA). In some embodiments, the DMD may be configured to divide the input signal by either N or N+6 (e.g., based on a carry out) to provide a fractional division ratio. In some example embodiments, the DLL may include a set of cascaded, tunable, delay elements, a phase detector, a charge pump and a D-type flip-flop. In these embodiments, the delay elements may be configured to break a VCO period up into Nd equal packets of phase, where Nd is the number of delay elements in the delay line. In this way, the DLL provides negative feedback to help ensure that the total delay through the delay line is one VCO cycle.

In some embodiments, synthesizer circuitry 1306d may be configured to generate a carrier frequency as the output frequency, while in other embodiments, the output frequency may be a multiple of the carrier frequency (e.g., twice the carrier frequency, four times the carrier frequency) and used in conjunction with quadrature generator and divider circuitry to generate multiple signals at the carrier frequency with multiple different phases with respect to each other. In some embodiments, the output frequency may be a LO frequency (fLO). In some embodiments, the RF circuitry 1306 may include an IQ/polar converter.

FEM circuitry 1308 may include a receive signal path which may include circuitry configured to operate on RF signals received from one or more antennas 1360, amplify the received signals and provide the amplified versions of the received signals to the RF circuitry 1306 for further processing. FEM circuitry 1308 may also include a transmit signal path which may include circuitry configured to amplify signals for transmission provided by the RF circuitry 1306 for transmission by one or more of the one or more antennas 1360.

In some embodiments, the FEM circuitry 1308 may include a TX/RX switch to switch between transmit mode and receive mode operation. The FEM circuitry may include a receive signal path and a transmit signal path. The receive signal path of the FEM circuitry may include a low-noise amplifier (LNA) to amplify received RF signals and provide the amplified received RF signals as an output (e.g., to the RF circuitry 1306). The transmit signal path of the FEM circuitry 1308 may include a power amplifier (PA) to amplify input RF signals (e.g., provided by RF circuitry 1306), and one or more filters to generate RF signals for subsequent transmission (e.g., by one or more of the one or more antennas 1360.

In some embodiments, the electronic device 1300 may include additional elements such as, for example, memory/storage, display, camera, sensors, and/or input/output (I/O) interface. In some embodiments, the electronic device of Fig. 13 may be configured to perform one or more methods, processes, and/or techniques such as those described herein.

A number of examples, relating to embodiments of the techniques described above, will next be given.

In a first example, a communication device may comprise: a radio frequency (RF) circuitry to communicate with other communication devices via a physical channel; and baseband circuitry to cause the RF circuitry to communicate with another communication device via the physical channel, the physical channel including: a single-carrier frequency-division multiple access (SC-FDMA) symbol duration (SC-FDMA) or an orthogonal frequency division multiplexing (OFDM) waveform, a subcarrier spacing of at least 30 kilohertz (kHz) in a frequency domain, and a symbol duration of 0.042 milliseconds (ms) or less in a time domain.

In example 2, the subject matter of example 1, or any of the examples herein, may further include wherein a physical resource block (PRB), corresponding to a signal of the physical channel, includes 12 subcarriers in a frequency domain with 30 kHz or with 60 kHz subcarrier spacing.

In example 3, the subject matter of example 1, or any of the examples herein, may further include wherein a PRB, corresponding to the physical channel, includes 6

subcarriers in frequency domain with 30 kHz subcarrier spacing or 3 subcarriers with 60 kHz subcarrier spacing.

In example 4, the subject matter of example 1, or any of the examples herein, may further include wherein two PRBs form a PRB pair, of the physical channel, that corresponds to two consecutive PRBs in a time-domain.

In example 5, the subject matter of example 1, or any of the examples herein, may further include wherein the physical channel corresponds to at least one of: a vehicle-to-vehicle (V2V) communication, a vehicular-to-infrastructure (V2I) communication, or a vehicular-to-pedestrian (V2P) communication.

In example 6, the subject matter of example 1, or any of the examples herein, may further include wherein the physical channel corresponds to at least one of: an long-term evolution (LTE) sidelink (SL) physical channels, an LTE downlink (DL) physical channels, or an LTE uplink (UL) physical channels.

In a seventh example, an apparatus for a wireless communication device may comprise: a radio (RF) circuitry to communicate with other communication devices via a physical channel; and a baseband circuitry to: use a physical channel, from a plurality of physical channel types, that is appropriate for communicating with the other wireless communication devices, the plurality of physical channel types including: a long-term evolution (LTE) physical channel, and a V2V physical channel that includes: a bandwidth that is at least as large as a bandwidth of the LTE physical channel; a subcarrier spacing that is greater, by a preselected factor, than a subcarrier spacing corresponding to the LTE physical channel, a fast Fourier transform (FFT) size that is less, by the preselected factor, than an FFT size corresponding to the LTE physical channel, a symbol duration that is less, by the preselected factor, than a symbol duration corresponding to the LTE physical channel, and a sampling frequency that is equal to a sampling frequency of the LTE physical channel, and a sampling time that is equal to a sampling time of the LTE physical channel; and communicate with the other wireless communication devices via the V2V physical channel.

In example 8, the subject matter of example 7, or any of the examples herein, may further include wherein the physical channel corresponds to at least one of: an LTE sidelink (SL) physical channels, an LTE downlink (DL) physical channels, or an LTE uplink (UL) physical channels.

In example 9, the subject matter of example 7, or any of the examples herein, may further include wherein the V2V physical channel includes physical resource blocks (PRBs) that

each include a number of subcarriers that is less than, or equal to, a number of subcarriers of the PRBs of the LTE physical channel.

In example 10, the subject matter of example 7, or any of the examples herein, may further include wherein: the subcarrier spacing for the V2V physical channel is 30 or 60 kilohertz (kHz); and the subcarrier spacing for the LTE physical channel is 15 kHz.

In example 11, the subject matter of example 7, or any of the examples herein, may further include wherein, for normal cyclic prefix (CP) conditions and extended CP conditions, a number of resource elements (REs) and a number of single-carrier frequency-division multiple access (SC-FDMA) or orthogonal frequency division multiplexing (OFDM) symbols per a physical resource block (PRB) of the V2V physical channel is equal to the number of REs and a number of SC-FDMA or OFDM symbols per PRB of the LTE physical channel.

In example 12, the subject matter of example 7, or any of the examples herein, may further include wherein application circuitry is to: communicate with a user equipment device (UE) of a vehicle via a vehicle-to-vehicle (V2V) connection, communicate with a UE of a user via a vehicle-to-pedestrian (V2P) connection, or communicate with a wireless telecommunications network via a vehicle-to-infrastructure (V2I) connection.

In example 13, the subject matter of example 7, or any of the examples herein, may further include wherein the baseband circuitry uses the type of physical channel that is appropriate for communicating with the other wireless communication device based on at least one of: a likelihood of communications, between the wireless communication device and the other wireless communication device being subjected to high mobility conditions, whether the other wireless communication device is capable of communicating via the LTE physical channel or the V2V physical channel, an availability, of the LTE physical channel or the V2V physical channel, for communicating with the other wireless communication device, a measure of importance regarding information that will be communicated to the other wireless communication device, or a preselected priority for communicating via the LTE physical channel or the V2V physical channel.

In example 14, the subject matter of example 7, or any of the examples herein, may further include wherein the baseband circuitry is configured, by via an eNB, to use the V2V physical channel or the LTE physical channel.

In example 15, the subject matter of example 7, or any of the examples herein, may further include wherein the baseband circuitry uses time-division multiplexing of the V2V physical channel and the LTE physical channel to communicate in different subframes.

In example 16, the subject matter of example 7, or any of the examples herein, may further include wherein subframes for the V2V physical channel and the LTE physical channel are semi-statically configured by an eNB.

In a seventeenth example, a wireless communication device as in the first or seventh examples, wherein a physical resource block (PRB), corresponding to the vehicle-to-vehicle (V2V) physical channel, includes: 7 consecutive single-carrier frequency-division multiple access (SC-FDMA) or orthogonal frequency division multiplexing (OFDM) symbols in time domain under normal cyclic prefix (CP) conditions, and 6 consecutive SC-FDMA or OFDM symbols in time domain under extended CP conditions.

In example 18, the subject matter of example 17, or any of the examples herein, may further include a subframe, corresponding to the V2V physical channel, includes two slots, a physical resource block (PRB), corresponding to the V2V physical channel, contains one slot; and a subframe duration, corresponding to the V2V physical channel, is equal to at least one of: 0.5 milliseconds (ms) and a slot duration is 0.25 ms when subcarrier spacing for the V2V physical channel is 30 kilohertz (kHz); or 0.25 milliseconds (ms) and a slot duration is 0.125 ms when subcarrier spacing for the V2V physical channel is 60 kilohertz (kHz).

In example 19, the subject matter of example 17, or any of the examples herein, may further include a subframe duration, corresponding to the vehicle-to-vehicle (V2V) physical channel, is equal to 1.0 ms, and the subframe, corresponding to the V2V physical channel, includes four slots with 0.25 ms duration and a physical resource block (PRB), corresponding to the V2V physical channel, contains two slots when subcarrier spacing for the V2V physical channel is 30 kilohertz (kHz), or the subframe, corresponding to the V2V physical channel, includes eight slots with 0.125 ms duration and a physical resource block (PRB), corresponding to the V2V physical channel, contains four slots when subcarrier spacing for the V2V physical channel is 60 kHz.

In a twentieth example, a computer readable medium may contain program instructions for causing one or more processors to: communicate with other communication devices via a physical channel, the physical channel including: a single-carrier frequency-division multiple access (SC-FDMA) symbol duration (SC-FDMA) or an orthogonal frequency division multiplexing (OFDM) waveform, a subcarrier spacing of at least 30 kilohertz (kHz) in a frequency domain, and a symbol duration of 0.042 milliseconds (ms) or less in a time domain.

In example 21, the subject matter of example 20, or any of the examples herein, may further include wherein a physical resource block (PRB), corresponding to a signal of the physical channel, includes 12 subcarriers in a frequency domain with 30 kHz or with 60 kHz subcarrier spacing.

In example 22, the subject matter of example 20, or any of the examples herein, may further include wherein a PRB, corresponding to the physical channel, includes 6 subcarriers in frequency domain with 30 kHz subcarrier spacing or 3 subcarriers with 60 kHz subcarrier spacing.

In example 23, the subject matter of example 20, or any of the examples herein, may further include wherein the physical channel corresponds to at least one of: a vehicle-to-vehicle (V2V) communication, a vehicular-to-infrastructure (V2I) communication, or a vehicular-to-pedestrian (V2P) communication.

In example 24, the subject matter of example 20, or any of the examples herein, may further include wherein the physical channel corresponds to at least one of: an LTE sidelink (SL) physical channels, an LTE downlink (DL) physical channels, or an LTE uplink (UL) physical channels.

In example 25, the subject matter of example 20, or any of the examples herein, may further include wherein two PRBs form a PRB pair, of the physical channel, that corresponds to two consecutive PRBs in a time-domain.

In a twenty-sixth example, a communication device may comprise: a means for communicating with other communication devices via a physical channel; and a means for causing the means for communicating to communicate with another communication device via the physical channel, the physical channel including: a single-carrier frequency-division multiple access (SC-FDMA) symbol duration (SC-FDMA) or an orthogonal frequency division multiplexing (OFDM) waveform, a subcarrier spacing of at least 30 kilohertz (kHz) in a frequency domain, and a symbol duration of 0.042 milliseconds (ms) or less in a time domain.

In example 27, the subject matter of example 26, or any of the examples herein, may further include wherein a physical resource block (PRB), corresponding to a signal of the physical channel, includes 12 subcarriers in a frequency domain with 30 kHz or with 60 kHz subcarrier spacing.

In example 28, the subject matter of example 26, or any of the examples herein, may further include wherein a PRB, corresponding to the physical channel, includes 6

subcarriers in frequency domain with 30 kHz subcarrier spacing or 3 subcarriers with 60 kHz subcarrier spacing.

In example 29, the subject matter of example 26, or any of the examples herein, may further include wherein two PRBs form a PRB pair, of the physical channel, that corresponds to two consecutive PRBs in a time-domain.

In the preceding specification, various embodiments have been described with reference to the accompanying drawings. It will, however, be evident that various modifications and changes may be made thereto, and additional embodiments may be implemented, without departing from the broader scope as set forth in the claims that follow. The specification and drawings are accordingly to be regarded in an illustrative rather than restrictive sense.

For example, while series of signals and/or operations have been described with regard to Figs. 3-4, the order of the signals and/or operations may be modified in other embodiments. Further, non-dependent signals may be performed in parallel.

It will be apparent that example aspects, as described above, may be implemented in many different forms of software, firmware, and hardware in the embodiments illustrated in the figures. The actual software code or specialized control hardware used to implement these aspects should not be construed as limiting. Thus, the operation and behavior of the aspects were described without reference to the specific software code--it being understood that software and control hardware could be designed to implement the aspects based on the description herein.

Further, certain portions may be implemented as "logic" that performs one or more functions. This logic may include hardware, such as an application-specific integrated circuit ("ASIC") or a field programmable gate array ("FPGA"), or a combination of hardware and software.

Even though particular combinations of features are recited in the claims and/or disclosed in the specification, these combinations are not intended to be limiting. In fact, many of these features may be combined in ways not specifically recited in the claims and/or disclosed in the specification.

No element, act, or instruction used in the present application should be construed as critical or essential unless explicitly described as such. An instance of the use of the term "and," as used herein, does not necessarily preclude the interpretation that the phrase "and/or" was intended in that instance. Similarly, an instance of the use of the term "or," as used herein, does not necessarily preclude the interpretation that the phrase "and/or" was intended in that instance. Also, as used herein, the article "a" is intended to include one or more items, and may be used

interchangeably with the phrase "one or more." Where only one item is intended, the terms "one," "single," "only," or similar language is used.

WHAT IS CLAIMED IS:

1. A communication device, comprising:

a radio frequency (RF) circuitry to communicate with other communication devices via a physical channel; and

baseband circuitry to cause the RF circuitry to communicate with another communication device via the physical channel, the physical channel including:

a single-carrier frequency-division multiple access (SC-FDMA) symbol duration (SC-FDMA) or an orthogonal frequency division multiplexing (OFDM) waveform,

a subcarrier spacing of at least 30 kilohertz (kHz) in a frequency domain, and

a symbol duration of 0.042 milliseconds (ms) or less in a time domain.

2. The communication device of claim 1, wherein a physical resource block (PRB), corresponding to a signal of the physical channel, includes 12 subcarriers in a frequency domain with 30 kHz or with 60 kHz subcarrier spacing.

3. The communication device of claim 1, wherein a PRB, corresponding to the physical channel, includes 6 subcarriers in frequency domain with 30 kHz subcarrier spacing or 3 subcarriers with 60 kHz subcarrier spacing.

4. The communication device of claim 1, wherein two PRBs form a PRB pair, of the physical channel, that corresponds to two consecutive PRBs in a time-domain.

5. The communication device of claim 1, wherein the physical channel corresponds to at least one of:

a vehicle-to-vehicle (V2V) communication,

a vehicular-to-infrastructure (V2I) communication, or

a vehicular-to-pedestrian (V2P) communication.

6. The communication device of claim 1, wherein the physical channel corresponds to at least one of:

an long-term evolution (LTE) sidelink (SL) physical channel,

an LTE downlink (DL) physical channel, or

an LTE uplink (UL) physical channel.

7. An apparatus for a wireless communication device, comprising:

a radio (RF) circuitry to communicate with other communication devices via a physical channel; and

a baseband circuitry to:

use a physical channel, from a plurality of physical channel types, that is appropriate for communicating with the other wireless communication devices, the plurality of physical channel types including:

a long-term evolution (LTE) physical channel, and

a V2V physical channel that includes:

a bandwidth that is at least as large as a bandwidth of the LTE physical channel;

a subcarrier spacing that is greater, by a preselected factor, than a subcarrier spacing corresponding to the LTE physical channel,

a fast Fourier transform (FFT) size that is less, by the preselected factor, than an FFT size corresponding to the LTE physical channel,

a symbol duration that is less, by the preselected factor, than a symbol duration corresponding to the LTE physical channel, and

a sampling frequency that is equal to a sampling frequency of the LTE physical channel, and

a sampling time that is equal to a sampling time of the LTE physical channel; and

communicate with the other wireless communication devices via the V2V physical channel.

8. The apparatus of claim 7, wherein the LTE physical channel and the V2V physical channel correspond to at least one of:

long-term evolution (LTE) sidelink (SL) physical channels,

LTE downlink (DL) physical channels, or

LTE uplink (UL) physical channels.

9. The apparatus of claim 7, wherein the V2V physical channel includes physical resource blocks (PRBs) that each include a number of subcarriers that is less than, or equal to, a number of subcarriers of the PRBs of the LTE physical channel.

10. The apparatus of claim 7, wherein:
the subcarrier spacing for the V2V physical channel is 30 or 60 kilohertz (kHz); and
the subcarrier spacing for the LTE physical channel is 15 kHz.

11. The apparatus of claim 7, wherein, for normal cyclic prefix (CP) conditions and extended CP conditions, a number of resource elements (REs) and a number of single-carrier frequency-division multiple access (SC-FDMA) or orthogonal frequency division multiplexing (OFDM) symbols per a physical resource block (PRB) of the V2V physical channel is equal to the number of REs and a number of SC-FDMA or OFDM symbols per PRB of the LTE physical channel.

12. The apparatus of claim 7, wherein application circuitry is to:
communicate with a user equipment device (UE) of a vehicle via a vehicle-to-vehicle (V2V) connection,
communicate with a UE of a user via a vehicle-to-pedestrian (V2P) connection, or
communicate with a wireless telecommunications network via a vehicle-to-infrastructure (V2I) connection.

13. The apparatus of claim 7, wherein the baseband circuitry uses the type of physical channel that is appropriate for communicating with the other wireless communication device based on at least one of:
a likelihood of communications, between the wireless communication device and the other wireless communication device being subjected to high mobility conditions,
whether the other wireless communication device is capable of communicating via the LTE physical channel or the V2V physical channel,
an availability, of the LTE physical channel or the V2V physical channel, for communicating with the other wireless communication device,
a measure of importance regarding information that will be communicated to the other wireless communication device, or

a preselected priority for communicating via the LTE physical channel or the V2V physical channel.

14. The apparatus of claim 7, wherein the baseband circuitry is configured, by via an eNB, to use the V2V physical channel or the LTE physical channel.

15. The apparatus of claim 7, wherein the baseband circuitry uses time-division multiplexing of the V2V physical channel and the LTE physical channel to communicate in different subframes.

16. The apparatus of either of claims 15, wherein subframes for the V2V physical channel and the LTE physical channel are semi-statically configured by an eNB.

17. A wireless communication device as in claims 1 or 7, wherein a physical resource block (PRB), corresponding to the vehicle-to-vehicle (V2V) physical channel, includes:

7 consecutive single-carrier frequency-division multiple access (SC-FDMA) or orthogonal frequency division multiplexing (OFDM) symbols in time domain under normal cyclic prefix (CP) conditions, and

6 consecutive SC-FDMA or OFDM symbols in time domain under extended CP conditions.

18. The wireless communication device of claim 17, wherein:

a subframe, corresponding to the V2V physical channel, includes two slots,

a physical resource block (PRB), corresponding to the V2V physical channel, contains one slot; and

a subframe duration, corresponding to the V2V physical channel, is equal to at least one of:

0.5 milliseconds (ms) and a slot duration is 0.25 ms when subcarrier spacing for the V2V physical channel is 30 kilohertz (kHz); or

0.25 milliseconds (ms) and a slot duration is 0.125 ms when subcarrier spacing for the V2V physical channel is 60 kilohertz (kHz).

19. The wireless communication device of claim 17, wherein:

a subframe duration, corresponding to the vehicle-to-vehicle (V2V) physical

channel, is equal to 1.0 ms, and

the subframe, corresponding to the V2V physical channel, includes four slots with 0.25 ms duration and a physical resource block (PRB), corresponding to the V2V physical channel, contains two slots when subcarrier spacing for the V2V physical channel is 30 kilohertz (kHz), or

the subframe, corresponding to the V2V physical channel, includes eight slots with 0.125 ms duration and a physical resource block (PRB), corresponding to the V2V physical channel, contains four slots when subcarrier spacing for the V2V physical channel is 60 kHz.

20. A computer readable medium containing program instructions for causing one or more processors to:

communicate with other communication devices via a physical channel, the physical channel including:

a single-carrier frequency-division multiple access (SC-FDMA) symbol duration (SC-FDMA) or an orthogonal frequency division multiplexing (OFDM) waveform,

a subcarrier spacing of at least 30 kilohertz (kHz) in a frequency domain, and

a symbol duration of 0.042 milliseconds (ms) or less in a time domain.

21. The computer readable medium of claim 20, wherein a physical resource block (PRB), corresponding to a signal of the physical channel, includes 12 subcarriers in a frequency domain with 30 kHz or with 60 kHz subcarrier spacing.

22. The computer readable medium of claim 20, wherein a PRB, corresponding to the physical channel, includes 6 subcarriers in frequency domain with 30 kHz subcarrier spacing or 3 subcarriers with 60 kHz subcarrier spacing.

23. The computer readable medium of claim 20, wherein the physical channel corresponds to at least one of:

a vehicle-to-vehicle (V2V) communication,

a vehicular-to-infrastructure (V2I) communication, or

a vehicular-to-pedestrian (V2P) communication.

24. The computer readable medium of claim 20, wherein the physical channel corresponds to at least one of:

an long-term evolution (LTE) sidelink (SL) physical channel,

an LTE downlink (DL) physical channel, or

an LTE uplink (UL) physical channel.

25. The computer readable medium of claim 20, wherein a PRB pair, of the physical channel, corresponds to two consecutive PRBs in a time-domain.

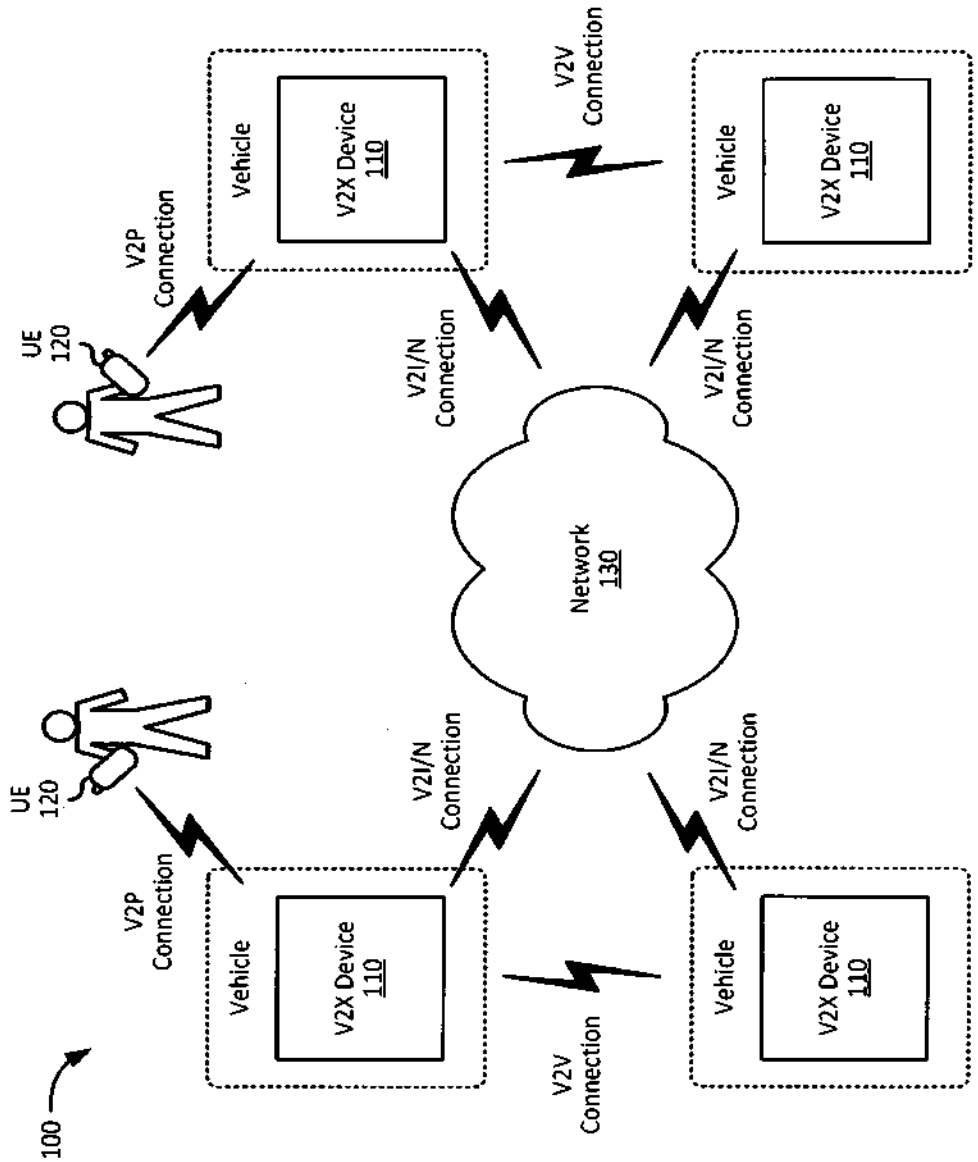

100
UE 120
UE 120
V2P Connection
V2P Connection
Vehicle
V2X Device 110
Vehicle
V2X Device 110
Vehicle
V2X Device 110
Vehicle
V2X Device 110
V2V Connection
V2V Connection
V2I/N Connection
V2I/N Connection
V2I/N Connection
V2I/N Connection
Network 130

Fig. 1

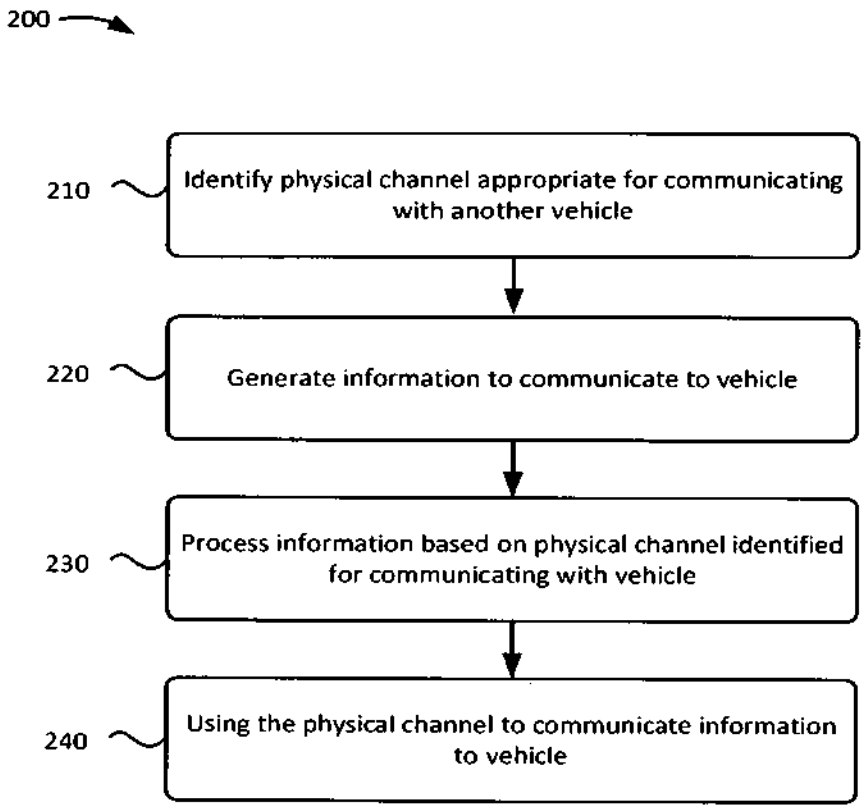

200
210
Identify physical channel appropriate for communicating with another vehicle
220
Generate information to communicate to vehicle
230
Process information based on physical channel identified for communicating with vehicle
240
Using the physical channel to communicate information to vehicle

Fig. 2

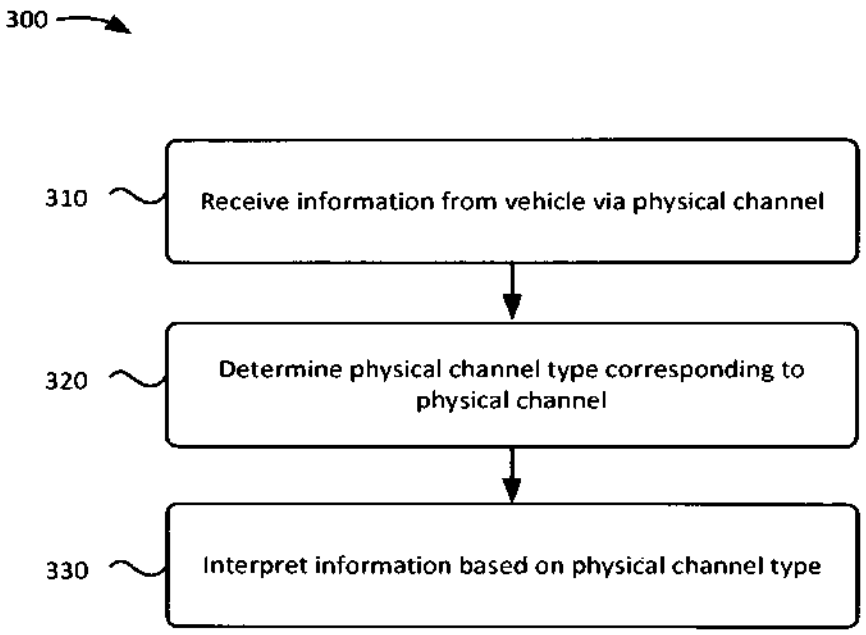

300
310
Receive information from vehicle via physical channel
320
Determine physical channel type corresponding to physical channel
330
Interpret information based on physical channel type

Fig. 3

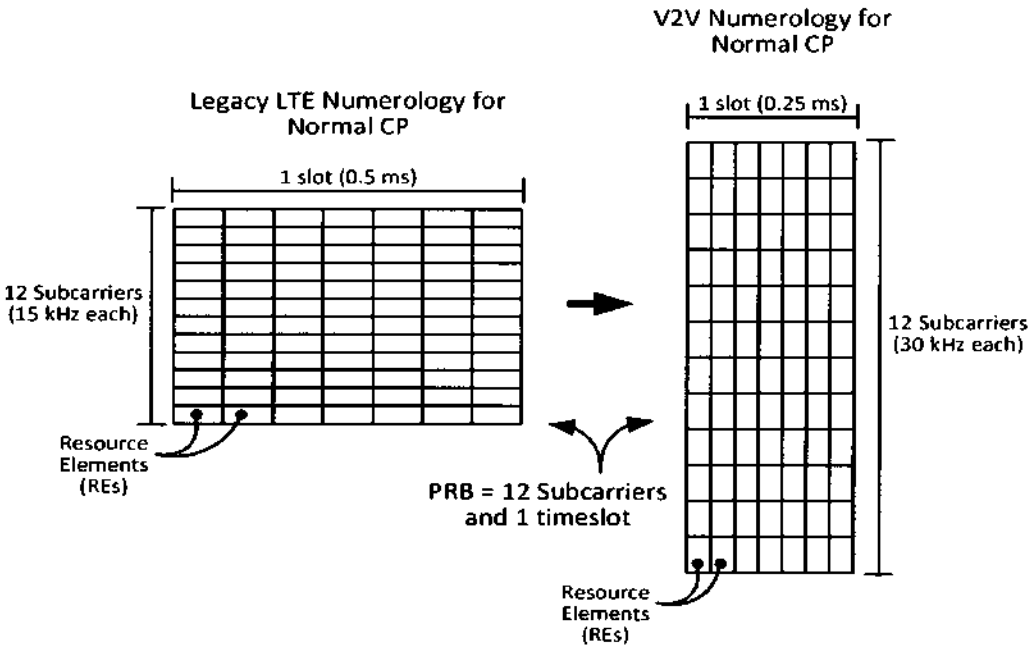

V2V Numerology for Normal CP
Legacy LTE Numerology for Normal CP
1 slot (0.25 ms)
1 slot (0.5 ms)
12 Subcarriers (15 kHz each)
12 Subcarriers (30 kHz each)
Resource Elements (REs)
PRB = 12 Subcarriers and 1 timeslot
Resource Elements (REs)

Fig. 4

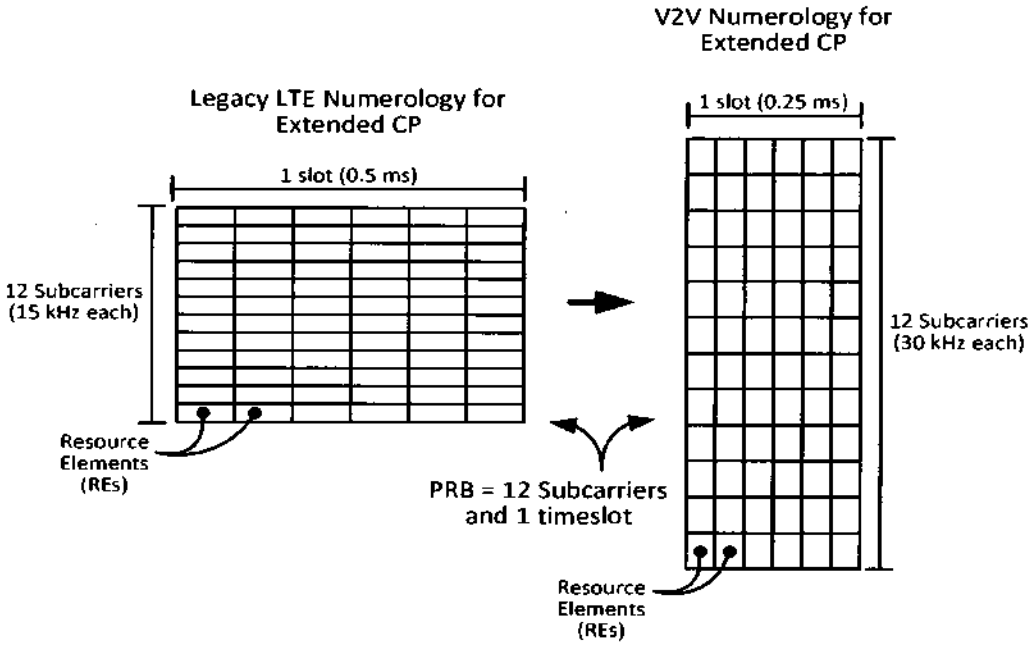

V2V Numerology for Extended CP
Legacy LTE Numerology for Extended CP
1 slot (0.25 ms)
1 slot (0.5 ms)
12 Subcarriers (15 kHz each)
12 Subcarriers (30 kHz each)
Resource Elements (REs)
PRB = 12 Subcarriers and 1 timeslot
Resource Elements (REs)

Fig. 5

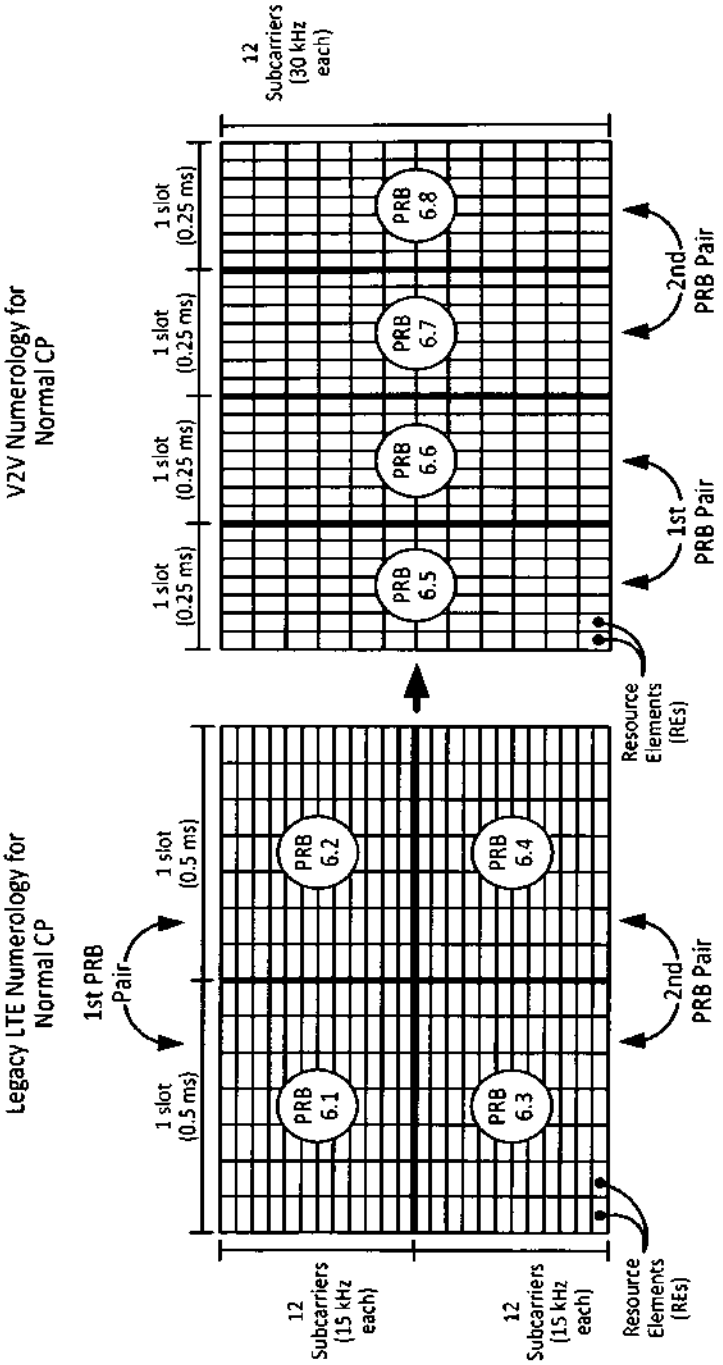

Legacy LTE Numerology for Normal CP
1st PRB Pair
1 slot (0.5 ms)
1 slot (0.5 ms)
PRB 6.1
PRB 6.2
PRB 6.3
PRB 6.4
2nd PRB Pair
12 Subcarriers (15 kHz each)
12 Subcarriers (15 kHz each)
Resource Elements (REs)
V2V Numerology for Normal CP
12 Subcarriers (30 kHz each)
1 slot (0.25 ms)
1 slot (0.25 ms)
1 slot (0.25 ms)
1 slot (0.25 ms)
PRB 6.5
PRB 6.6
PRB 6.7
PRB 6.8
1st PRB Pair
2nd PRB Pair
Resource Elements (REs)

Fig. 6

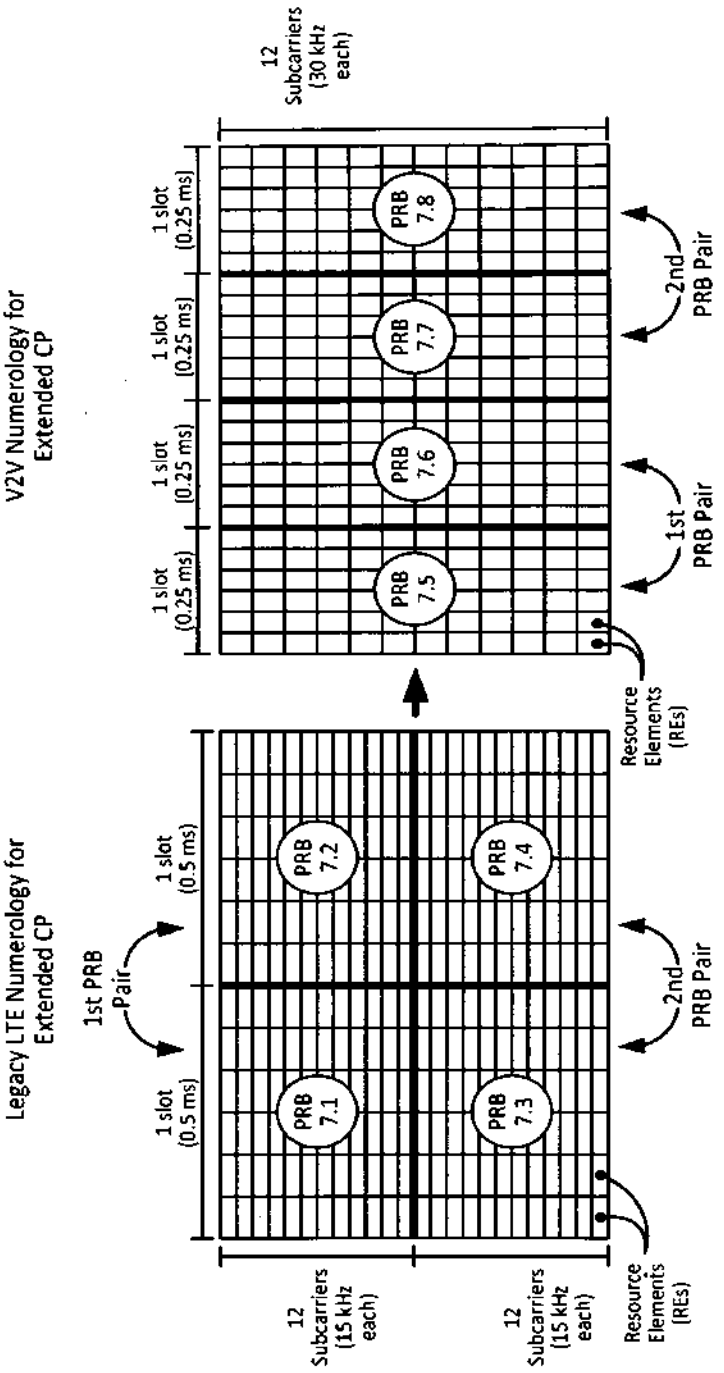

Legacy LTE Numerology for Extended CP
1st PRB Pair
1 slot (0.5 ms)
1 slot (0.5 ms)
PRB 7.1
PRB 7.2
PRB 7.3
PRB 7.4
12 Subcarriers (15 kHz each)
12 Subcarriers (15 kHz each)
Resource Elements (REs)
2nd PRB Pair
V2V Numerology for Extended CP
12 Subcarriers (30 kHz each)
1 slot (0.25 ms)
1 slot (0.25 ms)
1 slot (0.25 ms)
1 slot (0.25 ms)
PRB 7.5
PRB 7.6
PRB 7.7
PRB 7.8
Resource Elements (REs)
1st PRB Pair
2nd PRB Pair

Fig. 7

V2V Numerology for Normal CP

1 PRB = 12 Frequency REs and 1 timeslot

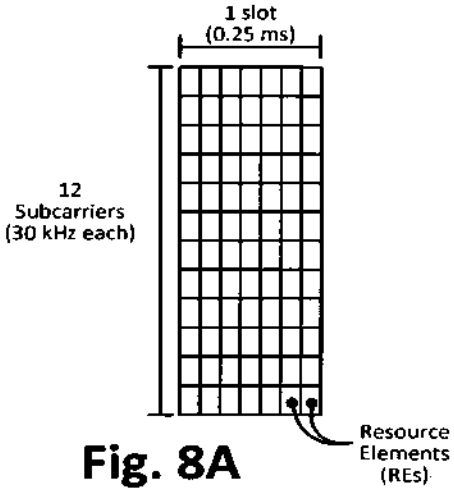


Fig. 8A

1 PRB Pair = 12 Frequency REs and 2 timeslots

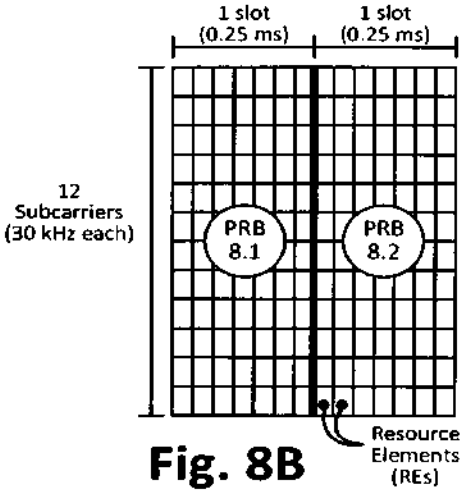


Fig. 8B

1 PRB = 6 Frequency REs and 1 timeslot

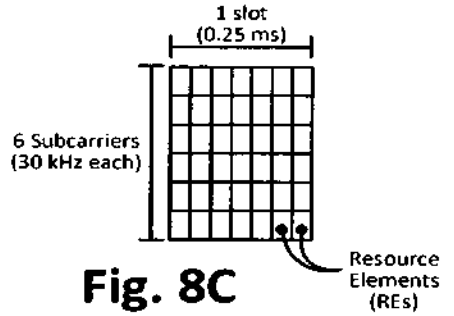


Fig. 8C

1 PRB Pair = 6 Frequency REs and 2 timeslots

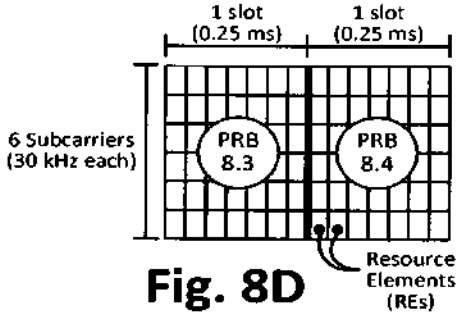


Fig. 8D

V2V Numerology for Extended CP

1 PRB = 12 Frequency Res and 1 timeslot

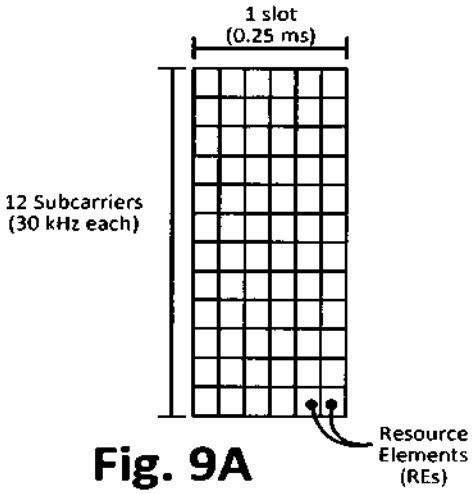


Fig. 9A

1 PRB Pair = 12 Frequency Res and 2 timeslots

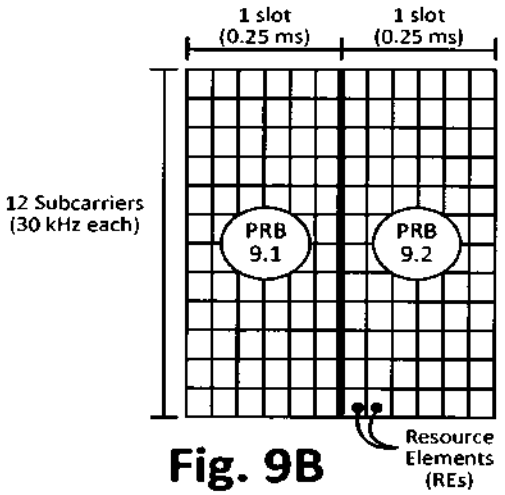


Fig. 9B

1 PRB = 6 Frequency REs and 1 timeslot

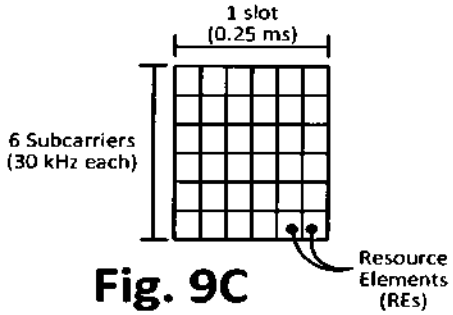


Fig. 9C

1 PRB Pair = 6 Frequency REs and 2 timeslots

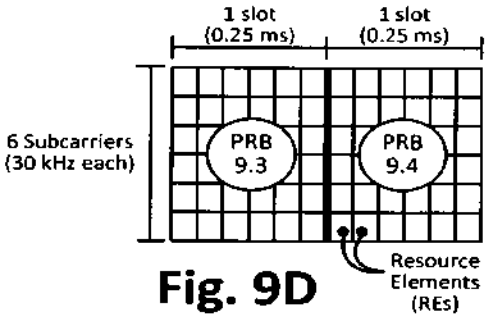


Fig. 9D

Channel Characteristic	Legacy LTE Channel Numerology	V2V Channel Numerology
Subcarrier Spacing	15 kHz	30 kHz
Supported Bandwidths	1.4, 3, 5, 10, 15, and 20 MHz	1.4, 3, 5, 10, 15, and 20 MHz
FFT Size	128, 256, 512, 1024, 1536, and 2048 MHz	64, 128, 256, 512, 768, and 1024 MHz
Sampling Time (Ts)	32.55 ns	32.55 ns
Symbol Duration (OFDM / SC-FDMA)	Normal CP, symbol 0: {(160+2048) x Ts) Normal CP, symbols 1-6: {(144+2048) x Ts) Extended CP: {(512+2048) x Ts)	Normal CP, symbol 0: {(160+2048) x Ts)/2 Normal CP, symbols 1-6: {(144+2048) x Ts)/2 Extended CP: {(512+2048) x Ts)/2
Single Timeslot Duration	0.5 ms (7 symbols for Normal CP) (6 symbols for Extended CP)	0.25 ms (7 symbols for Normal CP) (6 symbols for Extended CP
Single Subframe Duration	1.0 ms	0.5 or 1.0 ms
Subcarriers per PRB (Frequency REs)	12 subcarriers per PRB	6 or 12 subcarriers per PRB

Fig. 10

Channel Characteristic	Legacy LTE Channel Numerology	V2V Channel Numerology
Subcarrier Spacing	15 kHz	60 kHz
Supported Bandwidths	1.4, 3, 5, 10, 15, and 20 MHz	1.4, 3, 5, 10, 15, and 20 MHz
FFT Size	128, 256, 512, 1024, 1536, and 2048 MHz	64, 128, 256, 512, 768, and 1024 MHz
Sampling Time (Ts)	32.55 ns	32.55 ns
Symbol Duration (OFDM / SC-FDMA)	Normal CP, symbol 0: ((160+2048) x Ts) Normal CP, symbols 1-6: ((144+2048) x Ts) Extended CP: ((512+2048) x Ts)	Normal CP, symbol 0: ((160+2048) x Ts)/4 Normal CP, symbols 1-6: ((144+2048) x Ts)/4 Extended CP: ((512+2048) x Ts)/4
Single Timeslot Duration	0.5 ms (7 symbols for Normal CP) (6 symbols for Extended CP)	0.125 ms (7 symbols for Normal CP) (6 symbols for Extended CP
Single Subframe Duration	1.0 ms	0.5 or 1.0 ms
Subcarriers per PRB (Frequency REs)	12 subcarriers per PRB	3, 6, or 12 subcarriers per PRB

Fig. 11

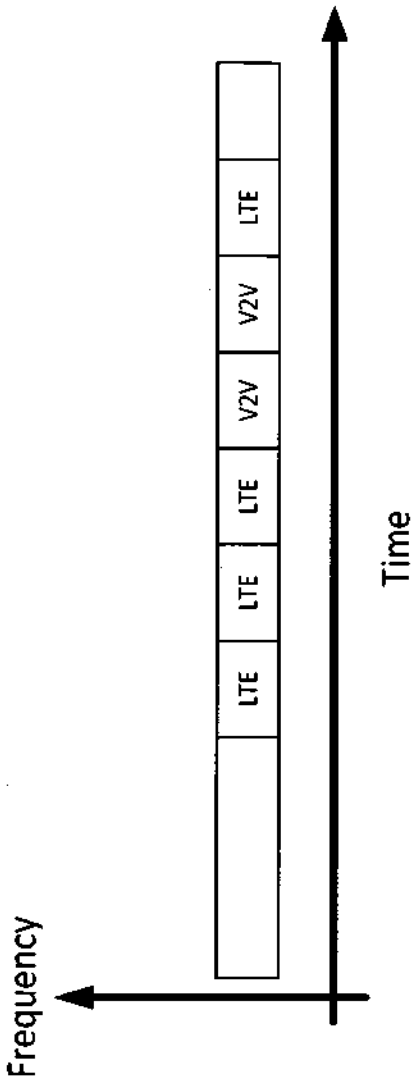


Fig. 12

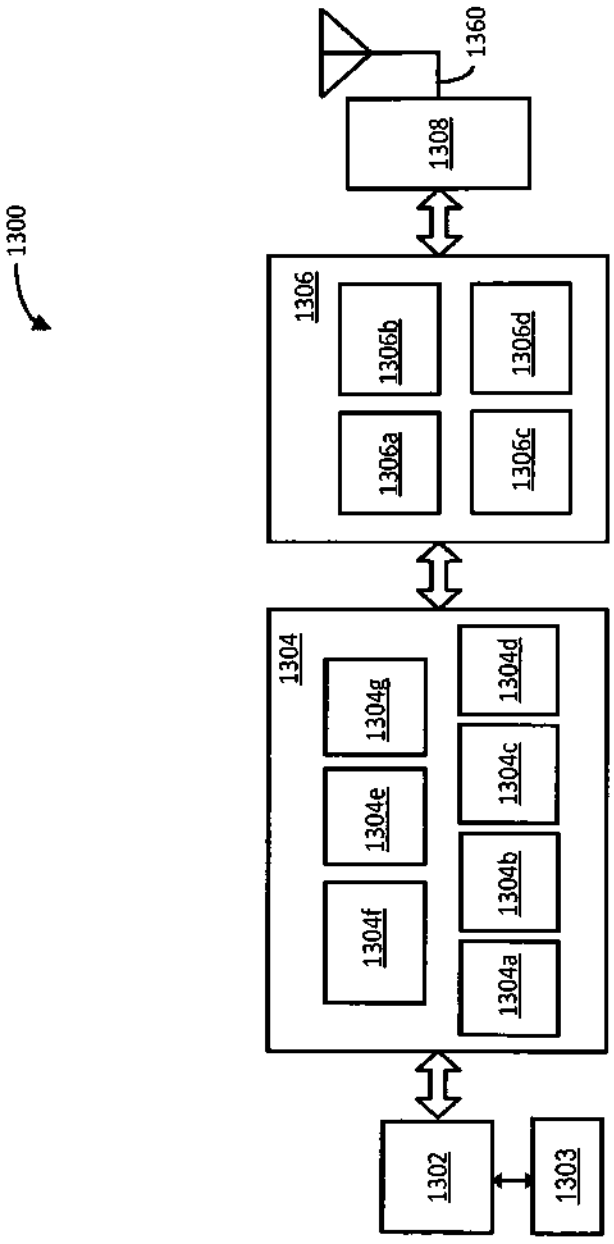

1300
1360
1308
1306
1306b
1306d
1306a
1306c
1304
1304g
1304d
1304e
1304c
1304f
1304b
1304a
1302
1303

Fig. 13

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/000466

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04L5/00 H04L27/26 H04W88/06 H04W84/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04L H04W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2014/065563 A1 (LG ELECTRONICS INC) 1 May 2014 (2014-05-01) the whole document -& US 2015/282178 A1 (KIM KITAE [KR] ET AL) 1 October 2015 (2015-10-01) paragraph [0010] paragraph [0023] paragraph [0045] - paragraph [0046] paragraph [0061] - paragraph [0065] paragraph [0082] paragraph [0094] paragraph [0110] - paragraph [0111] paragraph [0131] paragraph [0156] paragraph [0166] - paragraph [0177] figures 6,13,18 tables 1,4,6,8 ----- -/--	1-12,14, 17-25

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
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Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Tanbourgi, Ralph

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Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/000466

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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X	US 2015/180622 A1 (YOO TAESANG [US] ET AL) 25 June 2015 (2015-06-25) paragraph [0007] paragraph [0012] paragraph [0054] - paragraph [0062] paragraph [0068] - paragraph [0080] paragraph [0140] - paragraph [0141] figures 2,3a,3c,8-10,12,13 -----	1-25
A	Erik Dahlman ET AL: "Physical Transmission Resources (Chapter 9)" In: "4G: LTE/LTE-Advanced for Mobile Broadband (second edition) [Kindle Edition]", 7 October 2013 (2013-10-07), Academic Press, XP055167425, ISBN: 978-0-12-419997-2 pages 141-159, the whole document -----	1-25
A	Deliverable D2: "Document Number: ICT-317669-METIS/D2.4 Project Name: Mobile and wireless communications Enablers for the Twenty-twenty Information Society (METIS)", , 28 February 2015 (2015-02-28), XP055248907, Retrieved from the Internet: URL:https://www.metis2020.com/wp-content/uploads/deliverables/METIS_D2.4_v1.pdf [retrieved on 2016-02-10] Chapters 3 and 6 -----	1-25

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Form PCT/ISA/210 (continuation of second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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Description

TECHNICAL FIELD

[0001] The present invention relates to the field of communications technologies, and in particular, to a method and an apparatus for measuring communication quality.

BACKGROUND

[0002] In the field of communications technologies, signals may usually be classified into two types: one type of signal carries information from a higher layer; the other type of signal does not carry information from a higher layer, and this type of signal is usually used for assisting in or indicating reception of the former type of signal. A transmit power of a signal is a very important parameter for both types of signals above. For example, a power of a reference signal may be used for deriving a path loss estimation value, and the path loss estimation value may be used as a part of open-loop control to implement uplink power control, or may be used as a basis for selecting a cell (or a transmit node, or a receive node). A power ratio of a physical downlink shared channel (PDSCH) signal to a reference signal (for example, a cell-specific reference signal (CRS) or a channel state information reference signal (CSI-RS)) may be used for deriving channel state information (CSI), thereby facilitating implementation of scheduling and link adaptation.

[0003] In existing Long Term Evolution (LTE) Releases R8-R11, a power-related parameter is determined on a base station side or a network side, and is notified to user equipment (UE) by using higher layer signaling. Because a conventional base station antenna configuration has a fixed downtilt, and an uplink and a downlink undergo similar path losses, so that a downlink path loss can be desirably used for estimating an uplink path loss. Therefore, distinguishing of antenna ports can be omitted in the power-related parameter sent by the base station side or the network side, and especially in a case of multiple antenna ports. If antenna ports are not distinguished, a downlink path loss can be desirably used for estimating an uplink path loss. The technology is desirably applicable to the conventional base station antenna configuration, especially if transmit powers of antenna ports are the same. In another aspect, a reference signal received power (RSRP), of a current cell/node or an adjacent cell/node, reported by user equipment (UE) may be used by a base station or an evolved node B (eNB) to select a serving cell or node for the UE. In the prior art, the RSRP is an estimation obtained by performing averaging on different antenna ports.

[0004] To lower a system cost and at the same time reach a higher system capacity and coverage requirement, active antenna systems (AAS) have been widely deployed in practice. At present, the LTE R12 standard that is about to be launched is considering enhancement of communication performance after introduction of an AAS system. Different from a conventional base station antenna, an AAS further provides design flexibility in a vertical direction of an antenna, where independent downtilts may be used in an uplink and a downlink, and powers of different antenna ports may be different. In addition, for AAS base stations, even if the AAS base stations have a same quantity of antenna ports, antenna array structures of the AAS base stations may also be different. Therefore, antenna ports having a same sequence number may also have different transmit powers in different array structures. In such a case, in the prior art, power control is implemented based on a downlink reference signal received power, or a method for selecting a cell/node is no longer effective. In the prior art, correct distinguishing cannot be performed if transmit powers of antenna ports are different, and a technical solution that accurately and effectively estimates an uplink path loss and estimates channel state information cannot be provided.

[0005] US 2012/176939 A1 discloses a communications system and a method for performing communications, wherein User Equipments (UEs) are provided with UE-specific configuration information, such as CSI-RS (Channel Status Indication-Reference Signal) patterns, antenna port groupings, reference signal configurations, subframe configurations, and/or scrambling codes.

[0006] WO 2013/081368 A1 discloses a method and apparatus for transmitting a reference signal and discloses an uplink transmission method and apparatus using the same. The method of transmitting a reference signal in a Cooperative Multi-Point (CoMP) system includes sending configuration information on the reference signal and sending the reference signal based on the configuration information on the reference signal, wherein the configuration information on the reference signal indicates Energy Per Resource Element (EPRE), used to transmit the reference signal, for each of transmission points that participate in the transmission of the reference signal.

SUMMARY

[0007] Embodiments of the present invention provide methods for measuring communication quality, thereby overcoming a problem in the prior art that accurate signal quality measurement information cannot be acquired in a multi-antenna system.

[0008] An aspect provides a method for measuring communication quality, including:

receiving reference signal resource configuration information sent by a base station, where the reference signal resource configuration information includes reference signal port configuration information, where the reference signal port configuration information is used for indicating a mapping relationship between a reference signal port and a port group;

obtaining reference signal port information in at least one port group according to the reference signal port configuration information; and

acquiring signal quality measurement information according to the reference signal port information in the at least one port group;

wherein the reference signal resource configuration information further includes: reference signal power information of at least two port groups that is used by the user equipment to acquire the signal quality measurement information according to the reference signal port configuration information and in combination with the reference signal power information of the at least two port groups,

wherein the acquiring the signal quality measurement information according to the reference signal port configuration information and in combination with the reference signal power information of the at least two port groups includes:

obtaining, according to the reference signal port configuration information, signal quality measurement information corresponding to the at least two port groups;

performing, according to the reference signal power information of the at least two port groups, weighted averaging on the obtained signal quality measurement information corresponding to the at least two port groups in accordance with a port group power, to obtain the signal quality measurement information, wherein the performing, according to the reference signal power information of the at least two port groups, weighted averaging on the obtained signal quality measurement information corresponding to the at least two port groups in accordance with a port group power, to obtain the signal quality measurement information includes:

obtaining the signal quality measurement information according to a formula

$$SQ = \left(\sum_{g=0}^{n-1} p_g \cdot SQ_g \right) \Big/ \left(\sum_{g=0}^{n-1} p_g \right),$$

where

SQ_g is signal quality measurement information of a specified port group, g is a sequence number of a specified port group, n is a quantity of specified port groups, $n \geq 2$, and p_g is a reference signal power of a specified port group, where the reference signal power of the specified port group is obtained according to the reference signal power information of the at least two port groups.

[0009] In a first possible implementation manner with reference to the above aspect, the reference signal power information of the at least two port groups includes:

a reference signal power of a first port group, and a ratio of a reference signal power of each port group among the rest port groups to the reference signal power of the first port group; or

a reference signal power of a first port group, and a differential between a reference signal power of each port group among the rest port groups and the reference signal power of the first port group.

[0010] According to the method for measuring communication quality provided in the embodiments of the present invention, reference signal resource configuration information is sent to UE on a user side, and the UE may perform processing according to reference signal quality, of one port group or multiple port groups, in the reference signal resource configuration information to obtain final signal quality measurement information, so that a UE side can distinguish ports according to different port groups, which differs from a case in which transmit powers of different ports cannot be distinguished in the prior art. Therefore, UE is enabled to acquire signal quality measurement information, so that the UE can perform more accurate cell selection and uplink power control.

BRIEF DESCRIPTION OF DRAWINGS

[0011] To describe the technical solutions in the embodiments of the present invention or in the prior art more clearly, the following briefly introduces the accompanying drawings required for describing the embodiments or the prior art. Apparently, the accompanying drawings in the following description show merely some embodiments of the present invention, and a person of ordinary skill in the art may still derive other drawings from these accompanying drawings

without creative efforts. It has to be noted that Embodiment 2 described below is an embodiment of the present invention as defined in the claims, while Embodiment 1 and 3-12 are examples not covered by the claims.

FIG. 1 is a flowchart of a method for measuring communication quality according to Embodiment 1 of the present invention;
FIG. 2 is a flowchart of a method for measuring communication quality according to Embodiment 2 of the present invention;
FIG. 3 is a brief schematic diagram of different uniform linear array antenna array configurations;
FIG. 4 is a brief schematic diagram of different cross-polarization antenna array configurations;
FIG. 5 is a flowchart of a method for measuring communication quality according to Embodiment 3 of the present invention;
FIG. 6 is a flowchart of a method for measuring communication quality according to Embodiment 4 of the present invention;
FIG. 7 is a brief schematic diagram of a network side apparatus according to Embodiment 5 of the present invention;
FIG. 8 is a brief schematic diagram of user equipment according to Embodiment 6 of the present invention;
FIG. 9 is a brief schematic diagram of a network side apparatus according to Embodiment 7 of the present invention;
FIG. 10 is a brief schematic diagram of user equipment according to Embodiment 8 of the present invention;
FIG. 11 is a brief schematic diagram of a network side apparatus according to Embodiment 9 of the present invention;
FIG. 12 is a brief schematic diagram of user equipment according to Embodiment 10 of the present invention;
FIG. 13 is a brief schematic diagram of a network side apparatus according to Embodiment 11 of the present invention; and
FIG. 14 is a brief schematic diagram of user equipment according to Embodiment 12 of the present invention.

DESCRIPTION OF EMBODIMENTS

[0012] The following clearly and completely describes the technical solutions in the embodiments of the present invention with reference to the accompanying drawings in the embodiments of the present invention. Apparently, the described embodiments are merely some but not all of the embodiments of the present invention. All other embodiments obtained by a person of ordinary skill in the art based on the embodiments of the present invention without creative efforts shall fall within the protection scope of the present invention.

Embodiment 1

[0013] An embodiment of the present invention provides a method for measuring communication quality. As shown in FIG. 1, the method includes:

Step S01: Determine reference signal resource configuration information, where the reference signal resource configuration information includes: reference signal port configuration information, where the reference signal port configuration information is used for indicating a mapping between the reference signal port and a port group.

[0014] The operation may specifically be executed on a base station side or a network side (for example, a Universal Terrestrial Radio Access Network (UTRAN)), or an evolved UTRAN, or an evolved node B.

[0015] When the reference signal resource configuration information includes the reference signal port configuration information, and optionally, the reference signal resource configuration information may further include reference signal power information of at least one port group, the reference signal resource configuration information is sent to user equipment (UE), so that the user equipment acquires signal quality measurement information according to the reference signal resource configuration information. Because reference signal ports are allocated to multiple groups, the UE may perform processing according to reference signal quality, of one port group or multiple port groups, in the reference signal resource configuration information to obtain final signal quality measurement information, so that a UE side can distinguish ports according to different port groups, which differs from a case in which transmit powers of different ports cannot be distinguished in the prior art. Therefore, the signal quality measurement information acquired in the solution enables the UE to perform more accurate cell selection and uplink power control.

[0016] It should be further understood that for detailed description of the reference signal port configuration information included in the reference signal resource configuration information, reference may be made to the description of step 101 in Embodiment 2.

[0017] Further, the reference signal resource configuration information may further include: any one of a reference signal configuration and a reference signal subframe configuration. Therefore, the UE can receive a reference signal according to the information. It should be understood that, however, this embodiment of the present invention does not limit that any one of the reference signal configuration and the reference signal subframe configuration is necessarily delivered to the UE by using the reference signal resource configuration information, and may also be delivered to the

UE in a form of other information. It should be pointed out that the reference signal configuration or the reference signal subframe configuration may also be predefined, or is implicitly derived according to a parameter, for example, a cell ID or a UE ID, that is known in advance, and is known to both a base station and the UE, which is not limited in this embodiment of the present invention.

[0018] Step S02: Send the determined reference signal resource configuration information to user equipment, so that the user equipment acquires signal quality measurement information according to the reference signal port configuration information.

[0019] Specifically, the foregoing signal quality measurement information may include:
any one or any combination of a reference signal received power RSRP, a reference signal received quality RSRQ, and a reference signal strength indicator RSSI.

[0020] According to the method described in Embodiment 1 above, in the method, reference signal resource configuration information is determined on a network side, and the reference signal resource configuration information is sent to a user side, where the reference signal resource configuration information includes reference signal port configuration information, where the reference signal port configuration information is used for indicating a mapping between the reference signal port and a port group. In the method, it can be avoided that reference signal power related information is indicated port by port, so as to reduce a signaling overhead; further, a uniform power indicator is used for ports in a port group, and for different port groups, power related information of the port groups may be indicated independently, so that full use of an antenna configuration or an antenna array structure is made, thereby enabling a system to flexibly select reference signal power related information according to the antenna configuration or the antenna array structure; because an antenna array may have symmetric weights, by means of the symmetry of the weights, design complexity in beamforming or side lobe suppression can be reduced.

[0021] Further, the reference signal resource configuration information is sent to UE on the user side, and the UE may perform processing according to reference signal quality of at least one port group in the reference signal resource configuration information to obtain final signal quality measurement information, so that a UE side can distinguish ports according to different port groups, which differs from a case in which transmit powers of different ports cannot be distinguished in the prior art. The UE is enabled to acquire signal quality measurement information, so that the UE can perform more accurate cell selection and uplink power control.

[0022] Optionally, the method further includes:
Step S03: Receive the signal quality measurement information sent by the user equipment.

[0023] Optionally, when the signal quality measurement information is a reference signal received power RSRP, the method further includes:
Step S04: Send, to the user equipment, filter coefficient information that is used by the user equipment to perform, based on the filter coefficient information, filtering on the reference signal received power RSRP and obtain a path loss estimation value.

[0024] Specifically, the filter coefficient information may be sent to the user equipment at a same time when the determined reference signal resource configuration information is sent to the user equipment in step S02, for example, the filter coefficient information and the determined reference signal resource configuration information are sent in a same subframe; or may be sent before or after the determined reference signal resource configuration information is sent to the user equipment in step S02. The filter coefficient information and the reference signal resource configuration information may be sent in an information element (IE) of same or different higher layer signaling such as RRC signaling, or same or different downlink control information (DCI).

[0025] Optionally, the method further includes:
Step S05: Receive an uplink physical channel or an uplink physical signal sent by the user equipment, where a transmit power of the uplink physical channel or the uplink physical signal is obtained by means of calculation by the user equipment according to the path loss estimation value.

[0026] Optionally, the reference signal resource configuration information further includes: reference signal power information of at least two port groups that is used by the user equipment to acquire the signal quality measurement information according to the reference signal port configuration information and in combination with the reference signal power information of the at least two port groups; and
the reference signal power information of the at least two port groups includes:

a reference signal power of a first port group, and a ratio of a reference signal power of each port group among the rest port groups to the reference signal power of the first port group; or
a reference signal power of a first port group, and a differential between a reference signal power of each port group among the rest port groups and the reference signal power of the first port group.

[0027] Optionally, the reference signal port configuration information is a single index, or is a double index, or is an index after combined coding.

[0028] Optionally, the reference signal power information of the port group at least includes: reference signal powers of ports in one port group are the same.

[0029] The first port group is one port group among the at least one port group.

Embodiment 2

[0030] This embodiment of the present invention provides a method for measuring communication quality. As shown in FIG. 2, the method includes:

Step 101: Receive reference signal resource configuration information sent by a base station, where the reference signal resource configuration information includes reference signal port configuration information, where the reference signal port configuration information is used for indicating a mapping relationship between a reference signal port and a port group.

[0031] Specifically, UE receives the reference signal resource configuration information, which may be that the UE receives, by using higher layer signaling (for example, radio resource control (RRC) signaling) or dynamic signaling (for example, downlink control information (DCI), the reference signal resource configuration information notified by an eNB, or obtains, based on a cell identity (ID), the reference signal resource configuration information. The higher layer signaling may be sent by using a data channel such as a physical downlink shared channel (PDSCH for short). The dynamic signaling, for example, the DCI, is sent by using a control channel such as a physical downlink control channel (PDCCH) or an enhanced PDCCH (ePDCCH).

[0032] It should be understood that the reference signal port configuration information is used for indicating a mapping between a reference signal port and a port group. The mapping relationship between a reference signal port and a port group may be predefined, and is known to both the base station and the user equipment. Therefore, a base station side and a user equipment side can both find the reference signal port configuration message by means of identification.

[0033] It should be further understood that according to information about a mapping relationship between a reference signal port group and a corresponding port, and a mapping index of the port group, a port included in the port group may be uniquely determined. As shown in Tables 1 to 3, after learning the information about the mapping relationship between a reference signal port group and a corresponding port, and the mapping index of the port group, a device can learn a port in the corresponding port group. Ports included in the port group may be predefined, and for a different index, a predefined port group may be obtained according to planning. It should be noted that one reference signal port corresponds to one antenna port, and one antenna port corresponds to one reference signal port. Channel information of an antenna signal port is obtained by means of measurement of a reference signal port. Therefore, usually the predefined port group may be obtained according to planning of an antenna port array configuration.

[0034] One reference signal port or antenna port usually corresponds to one physical antenna or one virtual antenna, where the virtual antenna may be obtained by means of weighted combination of multiple physical antennas. An actual antenna deployment may have a different antenna configuration and antenna port array form. For example, FIG. 3 shows different uniform linear array (ULA) antenna port array configurations. An antenna port array A is a 2-row 4-column uniform linear array, an antenna port array B is a 2-row 8-column uniform linear array, and an antenna port array C is a 4-row 4-column uniform linear array. Although both the antenna port array B and the antenna port array C have 16 ports, array forms of the antenna port array B and the antenna port array C are also different. For another example, FIG. 4 shows different cross-polarization (XPO) antenna array configurations. An antenna port array A is a 2-row 2-column cross-polarization antenna array, an antenna port array B is a 2-row 4-column uniform linear array, and an antenna port array C is a 4-row 2-column uniform linear array. Different polarization antennas may be located in a same column. Although both the antenna port array B and the antenna port array C have 16 ports, array forms of the antenna port array B and the antenna port array C are also different. The antenna port array is referred to as an antenna array for short below.

[0035] Optionally, as another embodiment, the reference signal port configuration information includes a quantity of reference signal ports and a mapping index, where the mapping index is used for indicating a mapping between a reference signal port group and a corresponding port. 8-antenna arrays represented by the antenna array A shown in FIG. 3 and the antenna array A shown in FIG. 4 are used as examples. The reference signal port configuration information includes: a quantity of reference signal ports is 8 and a mapping index is 0 or 1. The predefined mapping relationship between a reference signal port and a port group may be defined by using a function, or may be regulated by using a predefined table. For example, as shown in Table 1, the first row may be the reference signal port configuration information of the antenna array A in FIG. 3, and the mapping indication information includes: a quantity of reference signal ports is 8, a mapping index is 0, and two port groups are a port group 0 and a port group 1. The second row in Table 1 may be the reference signal port configuration information of the antenna array A in FIG. 4, and the mapping indication information includes: a quantity of reference signal ports is 8, a mapping index is 1, and two port groups are a port group 0 and a port group 1. It should be pointed out that, in this embodiment, a reference signal port and a reference signal port group may be interchangeable with an antenna port and an antenna port group.

Table 1-Mapping between a port and a port group

Index	Mapping between a port and a port group	
	0	1
0	0, 3, 4, 7	1, 2, 5, 6
1	0, 1, 4, 5	2, 3, 6, 7

[0036] Further, when a mapping index value is 0, the port group 0 includes reference signal ports (or antenna ports) 0, 3, 4, and 7, the port group 1 includes reference signal ports (or antenna ports) 1, 2, 5, and 6; when a mapping index value is 1, the port group 0 includes reference signal ports (or antenna ports) 0, 1, 4, and 5, the port group 1 includes reference signal ports (or antenna ports) 2, 3, 6, and 7.

[0037] 16-antenna arrays represented by the antenna array B or the antenna array C shown in FIG. 3 and the antenna array B or the antenna array C shown in FIG. 4 are used as examples. The reference signal port configuration information includes: a quantity of reference signal ports is 16, and a mapping index is 0 or 1 or 2 or 3. The predefined mapping relationship between a reference signal port and a port group may be defined by using a function, or may be regulated by using a predefined table, for example, as shown in Table 2:

Table 2-Mapping between a port and a port group

Index	Mapping between a port and a port group			
	0	1	2	3
0	0, 3, 8, 11	4, 7, 12, 15	1, 2, 9, 10	5, 6, 13, 14
1	0, 1, 12, 13	2,3, 14, 15	4, 5, 8, 9	6, 7, 10, 11
2	0, 7, 8, 15	1, 6, 9, 14	2, 5, 10, 13	3, 4, 11, 12
3	0, 3, 12, 15	1,2, 13, 14	4, 7, 8, 11	5, 6, 9, 10

[0038] It may be assumed that the antenna array B in FIG. 3 is the first row in Table 2, that is, a mapping index value is 0, a port group 0 includes reference signal ports (or antenna ports) 0, 3, 8, and 11, a port group 1 includes reference signal ports (or antenna ports) 4, 7, 12, and 15, a port group 2 includes reference signal ports (or antenna ports) 1, 2, 9, and 10, and a port group 3 includes reference signal ports (or antenna ports) 5, 6, 13, and 14. When the mapping index value is 1 or 2 or 3, reference signal ports included in each port group may be sequentially obtained by analogy from the foregoing Table.

[0039] Optionally, as another embodiment, the reference signal port configuration information may include a port group mapping double index (m, n). In this case, the predefined mapping relationship between a reference signal port and a port group may be defined by using a function, or may be regulated by using a predefined table, for example, as shown in Table 3:

Table 3-Mapping between a port and a port group

Double index (m, n)	Mapping between a port and a port group			
	0	1	2	3
(2, 4)	0, 1, 4, 5	2, 3, 6, 7	-	-
(2, 8)	0, 3, 8, 11	4, 7, 12, 15	1, 2, 9, 10	6, 7, 10, 11
(4, 4)	0, 1, 12, 13	2, 3, 14, 15	4, 5, 8, 9	6, 7, 10, 11

[0040] Optionally, the double index (m, n) may indicate that a quantity of reference signal ports is a product of m and n.

[0041] Further, combined coding may be performed on the double index information. For example, combined coding of the double index in Table 3 above is shown in Table 3a or 3b.

Table 3a-Mapping between a port and a port group

Combined coding of a double index (m, n)	Double index (m, n)	Mapping between a port and a port group			
		0	1	2	3
0	(2, 4)	0, 1, 4, 5	2, 3, 6, 7	-	-
1	(2, 8)	0, 3, 8, 11	4, 7, 12, 15	1, 2, 9, 10	6, 7, 10, 11
2	(4, 4)	0, 1, 12, 13	2, 3, 14, 15	4, 5, 8, 9	6, 7, 10, 11

or

Table 3b-Mapping between a port and a port group

Mapping index	Double index (m, n)	Mapping between a port and a port group			
		0	1	2	3
0	(2, 4)	0, 1, 4, 5	2, 3, 6, 7	-	-
1	(2, 8)	0, 3, 8, 11	4, 7, 12, 15	1, 2, 9, 10	6, 7, 10, 11
2	(4, 4)	0, 1, 12, 13	2, 3, 14, 15	4, 5, 8, 9	6, 7, 10, 11

[0042] Optionally, grouping of port groups may be that 4 reference signal ports (or antenna ports) are used as one port group.

[0043] It should be further pointed out that grouping of port groups may also be not limited to a port group including 4 reference signal ports, or may be a port group having 2 or 8 ports or in another formation. In addition, a number of a reference signal port included in each port group is also not limited to the foregoing value, and may be flexibly selected according to an actual antenna configuration or deployment. The foregoing predefined port group mapping and mapping indication information may enable a system to adapt to more antenna configurations and antenna array deployments.

[0044] Optionally, the reference signal resource configuration information may further include: any one of a reference signal configuration and a reference signal subframe configuration. The reference signal configuration may include: any one of a subcarrier used by a reference signal port, an orthogonal frequency division multiplexing (OFDM) symbol, and a code resource. The reference signal subframe configuration may include: any one of a subframe position occupied by a reference signal port, a subframe period, and a subframe offset. It should be pointed out that the reference signal configuration or the reference signal subframe configuration may also be predefined, or is implicitly derived according to a parameter, for example, a cell ID or a UE ID, that is known in advance, and is known to both the base station and the UE, which is not limited in this embodiment of the present invention.

[0045] Step 102: Obtain reference signal port information in at least one port group according to the reference signal port configuration information.

[0046] Step 103: Acquire signal quality measurement information according to the reference signal port information in the at least one port group.

[0047] Specifically, the reference signal or signal may specifically include a cell-specific reference signal CSR, or a channel state information reference signal (CSI-RS), or a demodulation reference signal (DMRS), but is not limited to current examples.

[0048] The signal quality measurement information may be a reference signal received power (RSRP) or a reference signal received quality (RSRQ) or a reference signal strength indicator (RSSI), or may also be other signal quality measurement information defined based on a reference signal.

[0049] In this embodiment, a reference signal received power RSRP is used as an example and one implementation is described in detail. This solution is not limited to another implementation solution, and a solution of acquiring other signal quality measurement information is also not limited.

[0050] Optionally, the obtaining reference signal port information in at least one port group according to the reference signal port configuration information in step 102 may include:

obtaining reference signal port information in one specified port group according to the reference signal port configuration information; and

the acquiring signal quality measurement information according to the reference signal port information in the at least one port group in step 103 includes:

acquiring the signal quality measurement information according to the reference signal port information in the one

specified port group.

[0051] For example, a mapping index in Table 2 is 0, and in this case, reference signal ports included in a port group 0 are 0, 3, 8, and 11. Complex RSRP measurement of each antenna port may be correlation between two adjacent reference signal resource elements (RE, Resource Element). The two adjacent REs herein may refer to two adjacent REs in a frequency domain, or two adjacent REs in a time domain, or two adjacent REs in a time-frequency domain.

$$RSRP(r,p)=\frac{1}{K_s-1}\sum_{m=0}^{K_s-1}\hat{h}_p(m)\cdot\hat{h}_p(m+1),p=0,3,8,11 \quad (1)$$

where $\hat{h}_p(m)$ is a channel estimation on a reference signal RE whose label number is m, K_s is a total sample quantity of usable reference signal REs in measurement bandwidth, p is a number of a reference signal port in the one specified port group, and r is an index of a receive antenna. An RSRP corresponding to the antenna port group 0 may be obtained by combining (combine) *RSRP*(*r*,*p*). Specifically, a reference signal received power *RSRP*(*r*,*p*) of a pth port of an rth receive antenna is obtained and the RSRP is obtained by combining *RSRP*(*r*,*p*). For example, for *RSRP*(*r*,*p*) above, linear (correlated or uncorrelated) averaging is performed on ports p and receive antennas, and then an absolute value is taken, to obtain the RSRP corresponding to the port group 0. Alternatively, for *RSRP*(*r*,*p*) above, linear (correlated or uncorrelated) averaging is performed on one port p and receive antennas, and then an absolute value is taken, to obtain the RSRP corresponding to the port group 0. By means of sequential analogy, the RSRP may also be obtained by using reference signals of another port group.

[0052] In step 103 in this embodiment, the port group used for obtaining an RSRP and a port in the port group may be predefined (for example, the port group 0, and the port 0 in the port group 0, or the ports 0 and 3 in the port group 0, or all the ports in the port group 0, or others) or notified by a base station eNB by using higher layer signaling such as RRC signaling or by using downlink control information. In the foregoing, an RSRP is obtained based on one port group or some or all ports in one port group, and RSRPs do not need to be measured port by port, so that implementation complexity in measuring an RSRP by UE can be reduced; at the same time, a port group is predefined or notified, so that the UE and the eNB have consistent understanding of measurement, thereby ensuring consistency in measurement of RSRPs. At the same time, for different port groups, powers of the port groups may be independently indicated, and full use of antenna configurations and antenna array structures shown in FIG. 3 and FIG. 4 is made, so as to adapt to changes in an antenna structure to perform flexible indication, thereby ensuring that the base station eNB can adapt to multiple antenna configurations and antenna arrays.

[0053] Optionally, reference signal power information, of one or more port groups, included in the reference signal resource configuration information received by the UE in step 101 is used for indicating a reference signal power of ports in a corresponding port group.

[0054] 16 reference signal ports are used as an example, and reference signal powers of 4 port groups may be shown in Table 4:

Table 4-Table of reference signal powers of port groups

Port group number	0	1	2	3
Reference signal power	p0	p1	p2	p3

[0055] In this case, a power of a reference signal port included in a port group 0 is p0, and powers of reference signal ports included in port groups 1, 2, and 3 may be sequentially obtained by analogy, which are respectively p1, p2, and p3.

[0056] Alternatively, reference signal power information of the foregoing one or more port groups may also be jointly represented by using a reference signal power of one port group (for example, the port group 0) among the one or more port groups and a ratio of a reference signal power of another port group (for example, the port group 1) to the reference signal power of the port group (for example, the port group 0) or ratios of reference signal powers of multiple port groups (for example, the port groups 1, 2, and 3) to the reference signal power of the port group (for example, the port group 0). For example, the reference signal power of the port group 0 is p0, the ratios of the reference signal powers of the port groups 1, 2, and 3 to the reference signal power of the port group 0 are respectively $\rho 1$, $\rho 2$, and $\rho 3$. In this case, the UE may obtain that the reference signal powers of the port groups 1, 2, and 3 are respectively $p0*\rho 1$, $p0*\rho 2$, and $p0*\rho 3$.

[0057] In addition, reference signal power information of the one or more port groups may also be represented by using a reference signal power of one port group (for example, the port group 0) among the one or more port groups and a differential between a reference signal power of another port group (for example, the port group 1) and the reference signal power of the port group (for example, the port group 0) or differentials between reference signal powers of multiple

port groups (for example, the port groups 1, 2, and 3) and the reference signal power of the port group (for example, the port group 0). For example, the reference signal power of the port group 0 is p0, the differentials between the reference signal powers of the port groups 1, 2, and 3 and the reference signal power of the port group 0 are respectively d1, d2, and d3. In this case, the UE may obtain that the reference signal powers of the port groups 1, 2, and 3 are respectively p0+d1, p0+d2, and p0+d3.

[0058] It is used above that reference signal power information is separately indicated for port groups, and it can be avoided that reference signal powers are indicated port by port, so as to reduce a signaling overhead; further, a uniform power indicator is used for ports in a port group, and for different port groups, different port groups powers may be independently indicated, so that full use of an antenna configuration or an antenna array structure is made, thereby enabling a system to flexibly select a reference signal power according to the antenna configuration or the antenna array structure. In addition, it should be further pointed that that grouping of port groups is not limited to a port group including 4 reference signal ports, and the grouping of port groups and the formation of the ports in Tables 1, 2, and 3 above may further enable the antenna arrays in FIG. 3 or FIG. 4 to have powers symmetric about array structures, that is, the ports may have symmetric weights relative to the array, and by means of the symmetry of the weights, design complexity in beamforming or side lobe suppression can be reduced.

[0059] Further, the reference signal power above may also be represented by using an energy per resource element (EPRE).

[0060] Optionally, reference signal power information of at least two port groups includes:

a reference signal power of a first port group, and a ratio of a reference signal power of each port group among the rest port groups to the reference signal power of the first port group; or
a reference signal power of a first port group, and a differential between a reference signal power of each port group among the rest port groups and the reference signal power of the first port group.

[0061] Optionally, the foregoing acquiring the signal quality measurement information according to the reference signal port configuration information and in combination with the reference signal power information of the at least two port groups includes:

obtaining, according to the reference signal port configuration information, signal quality measurement information corresponding to the at least two port groups; and
performing, according to the reference signal power information of the at least two port groups, weighted averaging on the obtained signal quality measurement information corresponding to the at least two port groups in accordance with a port group power, to obtain the signal quality measurement information.

[0062] Specifically, the signal quality measurement information may be obtained by combining reference signal received powers of more than one port group.

[0063] For example, there are 4 port groups in total: port groups 0, 1, 2, and 3. Based on the foregoing method for obtaining an RSRP of one port group, reference signal received powers $RSRP_g$ corresponding to the port groups 0, 1, 2, and 3 may be separately obtained, where $g = 0,1,2,3$. The reference signal resource configuration information received according to step 101 further includes: reference signal power information of at least two port groups that is used by the user equipment to acquire the signal quality measurement information according to the reference signal port configuration information and in combination with the reference signal power information of the at least two port groups.

[0064] The performing, according to the reference signal power information of the at least two port groups, weighted averaging on the obtained signal quality measurement information corresponding to the at least two port groups in accordance with a port group power, to obtain the signal quality measurement information includes:

according to a formula

$$SQ = \left(\sum_{g=0}^{n-1} p_g \cdot SQ_g \right) \Big/ \left(\sum_{g=0}^{n-1} p_g \right) \quad (2)$$

obtaining the signal quality measurement information, where
SQ_g is signal quality measurement information of a specified port group, g is a sequence number of a specified port group, n is a quantity of specified port groups, $n \geq 2$, and p_g is a reference signal power of a specified port group, where the reference signal power of the specified port group is obtained according to the reference signal power information of the at least two port groups.

[0065] The multiple port groups above may be all port groups, or may be some port groups. Therefore, preset port information may be information about all port groups, or may be information about some port groups. The some port groups may be agreed in advance (for example, the port group 0 and the port group 1) or notified by the base station eNB by using higher layer signaling such as RRC signaling or by using downlink control information. In the foregoing, RSRPs of the multiple port groups are obtained, and processing such as smoothing or filtering may be performed on the RSRP obtained for each port group, so as to further increase precision of measuring an RSRP; at the same time, it is avoided that the UE performs calculation port by port, thereby lowering implementation complexity. In addition, a configuration of a port group can ensure that the base station eNB can adapt to multiple antenna configurations and antenna arrays.

[0066] Likewise, a similar method is used. Based on the reference signal port configuration information in the reference signal resource configuration information and a reference signal configuration or a subframe configuration, a reference signal sent by the base station is received, and the UE may further obtain signal quality measurement information, such as a reference signal received quality (RSRQ) or a reference signal strength indicator (RSSI), of one or more port groups. The RSSI is a received total wideband power, including a power of interference and a power of thermal noise, and the RSRQ is a ratio of an RSRP to the RSSI.

[0067] Further, the method for measuring communication quality may further include:

[0068] Step 104: The UE reports, to a base station eNB, the channel quality measurement information, for example, an RSRP, so as to help implement cell selection or cell handover.

[0069] Optionally, when the signal quality measurement information is the reference signal received power RSRP, the method for measuring communication quality may further include:

Step 105: Receive filter coefficient information sent by the base station.

[0070] Step 106: Perform, based on the filter coefficient information, filtering on the reference signal received power RSRP, and obtain a path loss estimation value.

[0071] Specifically, the user equipment may receive filter coefficient information sent by the base station at the same time when the reference signal resource configuration information is received in step 101, for example, the filter coefficient information and the reference signal resource configuration information are received in a same subframe. The filter coefficient information sent by the base station may also be received before or after the reference signal resource configuration information is received in step 101. The filter coefficient information and the reference signal resource configuration information may be received in an information element (IE) of same or different higher layer signaling such as RRC signaling, or same or different downlink control information (DCI).

[0072] Specifically, for the method in step 103, a reference signal received power of one or more port groups may be obtained, for example, reference signal received powers $RSRP_g$ corresponding to port groups 0, 1, 2, and 3 maybe obtained, where g = 0,1,2,3.

[0073] The path loss estimation may be obtained based on a reference signal received power of one port group and a corresponding reference signal power:

$$PL(g) = \text{a reference signal power of a port group g} - \text{a higher layer filtered RSRP of the port group g.}$$

where $PL(g)$ represents the PL estimation obtained based on the port group g, where a higher layer filtering parameter is notified by using higher layer signaling. A PL estimation may be obtained by using a PL of one port group, for example, the port group 0. The higher layer filtered RSRP of the port group g is obtained by performing filtering on the RSRP of the port group g by using the higher layer filter parameter notified by using the higher layer signaling.

[0074] The foregoing port group for obtaining a PL estimation may be predefined (for example, the port group 0) or notified by the base station eNB by using higher layer signaling such as RRC signaling or by using downlink control information. A PL estimation is obtained above based on one port group, which can reduce implementation complexity of PL estimation by UE, and ensure consistency of PL estimation. In addition, a configuration of a port group can ensure that the base station eNB can adapt to multiple antenna configurations and antenna arrays.

[0075] The path loss estimation may also be obtained based on reference signal received powers of multiple port groups and corresponding reference signal powers. Specifically, the PL estimation may be a linear average of PL estimations obtained for the multiple port groups.

[0076] The multiple port groups above may be all port groups, or may be some port groups. The some port groups may be agreed in advance (for example, the port group 0 and the port group 1) or notified by the base station eNB by using higher layer signaling such as RRC signaling or by using downlink control information. In the foregoing, PL estimations are obtained for multiple port groups, which can further increase precision of PL estimation, and avoid excessively high complexity of implementation by UE. In addition, a configuration of a port group can ensure that the base station

eNB can adapt to multiple antenna configurations and antenna arrays.

[0077] Further, the method for measuring communication quality may further include:

Step 107: Send an uplink physical channel or an uplink physical signal to the base station, where a transmit power of the uplink physical channel or the uplink physical signal is obtained by means of calculation according to the path loss estimation value.

[0078] The physical channel may be a physical uplink control channel PUCCH, a physical uplink shared channel PUSCH, or the like. The physical signal may be a sounding reference signal (SRS) or a demodulation reference signal (DMRS) that is used for the uplink physical channel.

[0079] Specifically, according to the foregoing obtained path loss estimation, a setting of the transmit power of the physical uplink control channel PUCCH may be defined as the following formula (3):

$$P_{\mathrm{PUCCH}}(i) = \min\left\{P_{\mathrm{CMAX,c}}(i), P_{\mathrm{O_PUCCH}} + PL_c + h\left(n_{CQI}, n_{HARQ}, n_{SR}\right) + \Delta_{\mathrm{F_PUCCH}}(F) + \Delta_{TxD}(F') + g(i)\right\}$$

where $P_{\mathrm{CMAX,c}}(i)$ is a maximum transmit power configured on UE in a subframe i of a serving cell c, and $P_{\mathrm{O_PUCCH}}$ is a parameter formed by the sum of a cell-specific parameter $P_{\mathrm{O_NOMINAL_PUCCH}}$ provided by a higher layer and a UE specific parameter $P_{\mathrm{O_UE_PUCCH}}$. $h(n_{CQI},n_{HARQ},n_{SR})$ is a value dependent on a PUCCH format, where n_{CQI} corresponds to a quantity of information bits of a CQI. For the parameter n_{SR}, n_{SR} = 1 if subframe i is configured for SR for the UE not having any associated transport block for UL-SCH, or otherwise n_{SR} = 0. The parameter n_{HARQ} is a quantity of HARQ-ACK bits sent in the subframe i. The parameter $\Delta_{\mathrm{F_PUCCH}}(F)$ is provided by a higher layer, and a value of each $\Delta_{\mathrm{F_PUCCH}}(F)$ corresponds to a PUCCH format (F). For the parameter $\Delta_{TxD}(F')$, if the UE is configured by a higher layer to transmit a PUCCH on two antenna ports, a value of $\Delta_{TxD}(F')$ is provided by a higher layer, where each PUCCH format F' is predefined; otherwise, $\Delta_{TxD}(F') = 0$. $g(i)$ is a current PUCCH power control state of the UE. PL_c is an estimation value, of a path loss, obtained for the cell C by the UE by using the method in step 104.

[0080] For another example, according to the foregoing obtained path loss estimation, a setting of the transmit power of the physical uplink shared channel PUSCH may be defined as the following formula (4):

$$P_{\mathrm{PUSCH,c}}(i) = \min\left\{P_{\mathrm{CMAX,c}}(i), 10\log_{10}\left(M_{\mathrm{PUSCH,c}}(i)\right) + P_{\mathrm{O_PUSCH,c}}(j) + \alpha_c(j)\cdot PL_c + \Delta_{\mathrm{TF,c}}(i) + f_c(i)\right\}$$

where $P_{\mathrm{CMAX,c}}(i)$ is a maximum transmit power configured on UE in a subframe i of a serving cell c; $M_{\mathrm{PUSCH,c}}(i)$ is the bandwidth of the PUSCH resource assignment expressed in number of resource blocks valid for subframe i and serving cell c. $P_{\mathrm{O_PUSCH,c}}(j)$ is a parameter formed by a component $P_{\mathrm{O_NOMINAL_PUSCH,c}}(j)$ and a component $P_{\mathrm{O_UE_PUSCH,c}}(j)$ that are provided by a higher layer, where j=0, 1. $\alpha_c \in \{0,0.4,0.5,0.6,0.7,0.8,0.9,1\}$ is a 3-bit parameter, and is provided by a higher layer. $\Delta_{TF,c}(i)$ is a parameter that is determined by using higher layer signaling and related to a transmission format. $f_c(i)$ is a current PUSCH power control adjustment state of the UE. PL_c is an estimation value, of a path loss, obtained for the cell C by the UE by using the method in step 104.

[0081] For still another example, according to the foregoing obtained path loss estimation, a setting of a transmit power of a sounding reference signal SRS may be defined as the following formula:

$$P_{\mathrm{SRS,c}}(i) = \min\left\{P_{\mathrm{CMAX,c}}(i), P_{\mathrm{SRS_OFFSET,c}}(m) + 10\log_{10}\left(M_{\mathrm{SRS,c}}\right) + P_{\mathrm{O_PUSCH,c}}(j) + \alpha_c(j)\cdot PL_c + f_c(i)\right\} \quad ,$$

where $P_{\mathrm{SRS_OFFSET,c}}(m)$ is a parameter semi-statically configured by a higher layer for a serving cell c, where m=0 and m=1. For SRS transmission, if a trigger type is 0, m=0; if a trigger type 1, m=1. $M_{\mathrm{SRS,c}}$ is bandwidth of SRS transmission of a subframe i of the serving cell c. $f_c(i)$ is a current PUSCH power control adjustment state of the serving cell c. $P_{\mathrm{O_PUSCH,c}}(j)$ and $\alpha_c(j)$ are predefined parameters, for example, it is defined in Section 5.1.1.1 in LTE 36.213 that j=1. PL_c is an estimation value, of a path loss, obtained for the cell C by the UE by using the method in step 104.

[0082] The above path loss estimation is used for open-loop control of an uplink channel, which can further improve reliability of power control, and ensure that the base station eNB can adapt to multiple antenna configurations and antenna arrays.

Embodiment 3

[0083] This embodiment of the present invention provides a method for measuring communication quality. As shown in FIG. 5, the method includes:

Step S21: Determine reference signal resource configuration information, and send the reference signal resource configuration information to user equipment, where the reference signal resource configuration information includes: refer-

ence signal port configuration information and power ratio information, where the reference signal port configuration information is used for indicating a mapping between the reference signal port and a port group, and the power ratio information is used for indicating a power ratio of a data channel of at least one port group to a reference signal.

[0084] When the reference signal resource configuration information includes: the reference signal port configuration information and the power ratio information, the reference signal resource configuration information is sent to the user equipment (UE), so that the user equipment acquires channel state information CSI according to the reference signal resource configuration information. Because reference signal ports are allocated to multiple groups, the UE may perform processing according to reference signal quality, of one port group or multiple port groups, in the reference signal resource configuration information to obtain final signal quality measurement information, so that a UE side can distinguish ports according to different port groups, which differs from a case in which transmit powers of different ports cannot be distinguished in the prior art. Therefore, channel state information acquired in the solution may enable the UE to perform more accurate modulation and coding scheme (MCS) selection or scheduling, thereby increasing a throughput of a system.

[0085] Step S22: Receive channel state information CSI sent by the user equipment, where the CSI is obtained by the user equipment according to the reference signal port configuration information and the power ratio information.

[0086] The channel state information CSI includes: any one or any combination of a channel quality indicator CQI, a precoding matrix indicator PMI, and a rank indicator RI.

[0087] According to the method described in Embodiment 3 above, in the method, reference signal resource configuration information is determined on a network side, and the reference signal resource configuration information is sent to a user side, where the reference signal resource configuration information at least includes: reference signal power related information of a port group, and reference signal port configuration information, where the reference signal port configuration information is used for indicating a mapping between the reference signal port and a port group. In the method, it can be avoided that reference signal power related information is indicated port by port, so as to reduce a signaling overhead; further, a uniform power indicator is used for ports in a port group, and for different port groups, power related information of the port groups may be indicated independently, so that full use of an antenna configuration or an antenna array structure is made, thereby enabling a system to flexibly select reference signal power related information according to the antenna configuration or the antenna array structure; because an antenna array may have symmetric weights, by means of the symmetry of the weights, design complexity in beamforming or side lobe suppression can be reduced.

[0088] Further, the reference signal resource configuration information is sent to UE on the user side, and the UE may perform processing according to reference signal quality, of one port group or multiple port groups, in the reference signal resource configuration information to obtain final signal quality measurement information, so that a UE side can distinguish ports according to different port groups, which differs from a case in which transmit powers of different ports cannot be distinguished in the prior art. The UE is enabled to acquire channel state information, so that the UE can perform more accurate modulation and coding scheme (MCS) selection or scheduling, thereby increasing a throughput of a system.

[0089] Optionally, the reference signal port configuration information is a single index, or is a double index, or is an index after combined coding. Refer to Embodiment 1 for the detailed description, which is no longer repeated herein.

[0090] Optionally, in step S21, in the power ratio information:

power ratios of data channels on antenna ports in each port group among the at least one port group to a reference signal are the same; or

power ratios of data channels on ports in one port group among the at least one port group and data channels on ports in another port group to a reference signal are the same.

[0091] Optionally, the power ratio information is used for indicating multiple sets of power ratios of data channels of the at least one port group to a reference signal; and

the receiving channel state information CSI sent by the user equipment includes: receiving multiple sets of channel state information CSI that are sent by the user equipment, where each set of channel state information CSI is obtained by the user equipment according to one set of power ratios among the multiple sets of power ratios.

[0092] The "multiple sets" in this embodiment refers to use of multiple sets of values. For the multiple sets of values, multiple sets of signaling having a same format may be used. For example,

a signaling format is: power ratios of data channels on ports in at least one port group to a reference signal are the same, that is, powers of ports in a port group are the same; and

another signaling format is: power ratios of data channels on ports in one port group and data channels on ports in another port group to a reference signal are the same; however, powers of ports in a port group are different.

[0093] Two different signaling formats are listed as examples in the foregoing, and they may be understood as specific examples of this embodiment, and should not be construed as limitations to this embodiment.

Embodiment 4

[0094] This embodiment of the present invention provides a method for measuring communication quality. The method is similar to Embodiment 2 above, and a difference lies in that, after receiving reference signal resource configuration information sent by a network side, UE on a user side uses the information to acquire channel state information, so that the UE can perform corresponding modulation and coding scheme MCS selection or resource scheduling according to the channel state information.

[0095] As shown in FIG. 6, the method includes:

Step 201: Receive reference signal resource configuration information sent by a base station, where the reference signal resource configuration information includes: reference signal port configuration information and power ratio information, where the reference signal port configuration information is used for indicating a mapping between the reference signal port and a port group, and the power ratio information is used for indicating a power ratio of a data channel of at least one port group to a reference signal.

[0096] For detailed description of the reference signal port configuration information included in the reference signal resource configuration information, reference may be made to the description of the reference signal port configuration information in step 101. That is, the reference signal port configuration information is used for indicating the mapping between a reference signal port and a port group, and the mapping relationship between a reference signal port and a port group is predefined.

[0097] The data channel may be a physical downlink shared channel (PDSCH), or may be a channel used for transmitting control information. A power of a data channel may be an energy per resource element (EPRE).

[0098] Specifically, the UE receives a reference signal resource configuration, which may be that the UE receives, by using higher layer signaling such as radio resource control (RRC) signaling or dynamic signaling such as downlink control information (DCI), the reference signal resource configuration notified by an eNB, or obtains, based on a cell identity ID, the reference signal resource configuration.

[0099] Specifically, the reference signal port configuration information is used for indicating the mapping between the reference signal port and a port group.

[0100] One reference signal port usually corresponds to one physical antenna or one virtual antenna, where the virtual antenna may be obtained by means of weighted combination of multiple physical antennas. An actual antenna deployment may have a different antenna configuration and an antenna array form. It should be pointed out that, in this embodiment, a reference signal port and a reference signal port group may be interchangeable with an antenna port and an antenna port group.

[0101] Optionally, the reference signal port configuration information is used for indicating the mapping relationship between the reference signal port and a port group, and may include a quantity of reference signal ports and a mapping index, where the mapping index is used for indicating a mapping between a reference signal port group and a corresponding port. 8-antenna arrays represented by an antenna array A shown in FIG. 3 and an antenna array A shown in FIG. 4 are used as examples, and the reference signal port configuration information includes: a quantity of reference signal ports is 8 and a mapping index is 0 or 1. The predefined mapping relationship between a reference signal port and a port group may be defined by using a function, or may be regulated by using a predefined table, as shown in Table 1.

[0102] 16-antenna arrays represented by an antenna array B or an antenna array C shown in FIG. 3 and an antenna array B or an antenna array C shown in FIG. 4 are used as examples, and the reference signal port configuration information includes: a quantity of reference signal ports is 16 and a mapping index is 0 or 1 or 2 or 3. The predefined mapping relationship between a reference signal port and a port group may be defined by using a function, or may be regulated by using a predefined table, as shown in Table 2.

[0103] Specifically, the reference signal port configuration information may include a double index (m, n). In this case, the predefined mapping relationship between a reference signal port and a port group may be defined by using a function, or may be regulated by using a predefined table, as shown in Table 3.

[0104] Further, the double index (m, n) may indicate that a quantity of reference signal ports is a product of m and n.

[0105] Further, for the double index information, combined coding may be performed, for example, combined coding of the double index in Table 3 above is shown in Table 3a or 3b.

[0106] Optionally, grouping of port groups may be that 4 reference signal ports/antenna ports form one port group.

[0107] It should be further pointed out that grouping of port groups is not limited to a port group including 4 reference signal ports, or may be a port group having 2 or 8 ports or in another formation. In addition, a number of a reference signal port included in each port group is also not limited to the foregoing value, and may be flexibly selected according to an actual antenna configuration or deployment. The foregoing predefined port group mapping and mapping indication information may enable a system to adapt to more antenna configurations and antenna array deployments.

[0108] In the power ratio information in step 201, power ratios of data channels on antenna ports in each port group among the at least one port group to a reference signal are the same. 16 reference signal ports are used as an example, and it is assumed that a data channel is a PDSCH, and a power corresponds to an EPRE, so that a signal power ratio

of a 4-port group may be:

Table 4-Power ratio

Port group number	0	1	2	3
A ratio of an EPRE of a PDSCH to an EPRE of a reference signal	$\rho 0$	$\rho 1$	$\rho 2$	$\rho 3$

[0109] Further, power ratios of data channels on each antenna port in the at least one port group to a reference signal are equal. Table 4 is used as an example, where power ratios of data channels on ports in a port group 0 to a reference signal may be equal.

[0110] Optionally, as another embodiment, in the power ratio information in step 201, power ratios of data channels on ports in one port group among the at least one port group and data channels on ports in another port group to a reference signal are the same.

[0111] Specifically, a port group having 4 ports is used as an example. For example, ports of a port group 0 are 0, 1, 4, and 5, and ports of a port group 1 are 2, 3, 6, and 7. Power ratios of data channels in the port group 0 to a reference signal are shown in Table 4a.

Table 4a-Power ratio of a port group 0

Port number	0	1	4	5
A ratio of an EPRE of a PDSCH to an EPRE of a reference signal	$\rho 0$	$\rho 1$	$\rho 2$	$\rho 3$

[0112] The power ratios of data channels, corresponding to the ports in the port group 0 and the ports in the port group 1, to a reference signal are the same; that is, power ratios of data channels, corresponding to the ports 2, 3, 6, and 7 in the port group 1, to a reference signal are respectively $\rho 0$, $\rho 1$, $\rho 2$, and $\rho 3$.

[0113] Optionally, as another embodiment, the power ratio of the data channel in the one or more port groups to the reference signal in step 201 may include multiple sets of values. The sets of values may be values shown in Table 4 or 4a.

[0114] In addition, the reference signal resource configuration information may further include: any one of a reference signal configuration and a reference signal subframe configuration. The reference signal configuration may include a subcarrier used by a reference signal port or an OFDM symbol or a code resource. The reference signal subframe configuration may include a subframe position occupied by a reference signal port, a subframe period or a subframe offset. It should be pointed out that the reference signal configuration or the reference signal subframe configuration may also be predefined, or is implicitly derived according to a parameter, for example, a cell ID or a UE ID, that is known in advance, and is known to both the base station and the UE, which is not limited in this embodiment of the present invention.

[0115] Step 202: Obtain a power ratio of a data channel on each antenna port in the at least one port group to a reference signal according to the reference signal port configuration information and the power ratio information.

[0116] Step 203: Obtain channel state information CSI according to the power ratio of the data channel on each antenna port to the reference signal.

[0117] Specifically, the obtaining channel state information CSI according to the power ratio of the data channel on each antenna port to the reference signal may include:

obtaining, according to the reference signal on each antenna port, a channel measurement value corresponding to each antenna port;

obtaining a channel estimation value of the data channel on each antenna port according to the channel measurement value corresponding to each antenna port and the power ratio of the data channel on each antenna port to the reference signal; and

obtaining the channel state information CSI according to the channel estimation value of the data channel on each antenna port.

[0118] It should be pointed out that the present invention does not limit an execution sequence of obtaining a channel measurement value corresponding to each reference signal port in the at least one port group and obtaining a power ratio of a data channel, corresponding to each antenna port in the at least one port group, to a reference signal.

[0119] Specifically, the reference signal may specifically include a cell-specific reference signal CSR, or a received channel state information reference signal (CSI-RS), or a demodulation reference signal (DMRS).

[0120] The channel state information (CSI) may be a channel quality indicator (CQI) or a precoding matrix indicator (PMI) or a rank indicator (RI); or may be other channel state information such as a precoding type indicator (PTI).

[0121] Specifically, when calculating channel state information based on a ratio of an EPRE of a PDSCH signal to an EPRE of a channel state information reference signal (CSI-RS), the UE obtains a transmit power of a corresponding PDSCH on an antenna port.

[0122] 16 reference signal ports are used as an example, and it is assumed that the reference signal port configuration information notified in step 201 includes: a quantity of reference signal ports is 16 and a mapping index is 1; a mapping relationship is shown in Table 2, and power ratios are shown in Table 4. It can be known according to Table 2 and Table 4 that:

EPRE or power ratios of PDSCHs, corresponding to reference signal ports 0, 1, 12, and 13, to a reference signal are $\rho 0$;
EPRE or power ratios of PDSCHs, corresponding to reference signal ports 2,3,14, and 15, to a reference signal are $\rho 1$;
EPRE or power ratios of PDSCHs, corresponding to reference signal ports 4, 5, 8, and 9, to a reference signal are $\rho 2$; and
EPRE or power ratios of PDSCHs, corresponding to reference signal ports 6, 7, 10, and 11, to a reference signal are $\rho 3$.

[0123] It should be noted that the reference signal ports correspond to the antenna ports on a one-to-one basis.

[0124] In addition, the UE receives a reference signal according to the reference signal resource configuration information, and a channel measurement value corresponding to each antenna port may be obtained as follows:

$$\mathbf{H} = \begin{bmatrix} \mathbf{h}_0 & \mathbf{h}_1 & \cdots & \mathbf{h}_{15} \end{bmatrix}$$

where $\mathbf{h}_p$,p= 0,...,15 is a channel measurement value corresponding to an antenna port p, and the measurement value may be obtained based on a manner such as the least square method according to a specific reference signal such as a CSI RS, which is the prior art and is not further elaborated.

[0125] According to the foregoing channel measurement value corresponding to each antenna port, the UE may obtain a channel measurement value or channel estimation value of a data channel PDSCH on each antenna port according to an EPRE or power ratio of the PDSCH to a reference signal, as follows:

$$\hat{\mathbf{H}} = \begin{bmatrix} \hat{\mathbf{h}}_0 & \hat{\mathbf{h}}_1 & \cdots & \hat{\mathbf{h}}_{15} \end{bmatrix}$$

where a channel measurement value or channel estimation value $\hat{\mathbf{h}}_p$ of a data channel PDSCH on the antenna port p is:

$$\hat{\mathbf{h}}_p = \sqrt{\rho_p}\mathbf{h}_p$$

where p is an index of the antenna port, ρ_p is a power ratio of the data channel on the antenna port p to a reference signal, $\mathbf{h}_p$ is a channel measurement value corresponding to the antenna port p, and $\hat{\mathbf{h}}_p$ is a channel estimation value of the data channel on the antenna port p; that is,

$$\hat{\mathbf{h}}_p = \begin{cases} \sqrt{\rho 0}\mathbf{h}_p, p = 0,1,12,13 \\ \sqrt{\rho 1}\mathbf{h}_p, p = 2,3,14,15 \\ \sqrt{\rho 2}\mathbf{h}_p, p = 4,5,8,9 \\ \sqrt{\rho 3}\mathbf{h}_p, p = 6,7,10,11 \end{cases}$$

the UE may calculate channel state information CSI based on the following equation (5):

$$\mathrm{y} = \hat{\mathrm{H}}\mathrm{Ps} + \mathrm{n} \qquad (5)$$

where **P** is a precoding matrix, and for a non-precoding system, P is a unit array; **S** is a sent information symbol, for example, a modulation symbol; **n** is interference and noise vectors; and **y** is a received signal.

[0126] The channel state information, for example, any one or any combination of a channel quality indicator (CQI) or a precoding matrix indicator (PMI)/a rank indicator (RI) is obtained according to the equation (5) above. A specific process of obtaining channel state information, for example, a CQI or a PMI or an RI according to the equation (5) above is the prior art, which is no longer further elaborated herein.

[0127] Optionally, as another embodiment, the power ratio information is used for indicating multiple sets of power ratios of data channels of the at least one port group to a reference signal.

[0128] 16 reference signal ports are used as an example, and it is assumed that the reference signal port configuration information notified in step 201 includes: a quantity of reference signal ports is 16 and a mapping index is 1; a mapping relationship is shown in Table 2, and power ratios are shown in Table 4b. It can be known according to Table 2 and Table 4b that:

EPRE ratios or a first set of power ratios of PDSCHs, corresponding to reference signal ports 0, 1, 12, and 13, to a reference signal are x0;
EPRE ratios or a first set of power ratios of PDSCHs, corresponding to reference signal ports 2, 3, 14, and 15, to a reference signal are x1;
EPRE ratios or a first set of power ratios of PDSCHs, corresponding to reference signal ports 4, 5, 8, and 9, to a reference signal are x2;
EPRE ratios or a first set of power ratios of PDSCHs, corresponding to reference signal ports 6, 7, 10, and 11, to a reference signal are x3;
EPRE ratios or a second set of power ratios of PDSCHs, corresponding to reference signal ports 0, 1, 12, and 13, to a reference signal are y0;
EPRE ratios or a second set of power ratios of PDSCHs, corresponding to reference signal ports 2, 3, 14, and 15, to a reference signal are y1;
EPRE ratios or a second set of power ratios of PDSCHs, corresponding to reference signal ports 4, 5, 8, and 9, to a reference signal are y2; and
EPRE ratios or a second set of power ratios of PDSCHs, corresponding to reference signal ports 6, 7, 10, and 11, to a reference signal are y3.

Table 4b-Multiple sets of power ratios of a port group 0

Port number	0	1	4	5
A first ratio of an EPRE of a PDSCH to an EPRE of a reference signal	x0	x1	x2	x3
A second ratio of an EPRE of a PDSCH to an EPRE of a reference signal	y0	y1	y2	y3

[0129] Step 204: Send the channel state information CSI to the base station.

[0130] Specifically, the channel state information may be sent to the base station by using a physical uplink control channel PUCCH or a physical uplink shared channel PUSCH.

[0131] Optionally, the sending the channel state information CSI to the base station includes: sending multiple sets of channel state information CSI to the base station, where each set of channel state information CSI is obtained according to one set of power ratios among the multiple sets of power ratios.

[0132] 16 reference signal ports are used as an example, and it is assumed that the reference signal port configuration information notified in step 201 includes: a quantity of reference signal ports is 16 and a mapping index is 1; a mapping relationship is shown in Table 2, and power ratios are shown in Table 4b. It can be known according to Table 2 and Table 4b that UE sends two sets of channel state information CSI to the base station. The first set of CSI is calculated according to a first set of power ratios in Table 4c below:

Table 4c-First set of power ratios of a port group 0

Port number	0	1	4	5
A ratio of an EPRE of a PDSCH to an EPRE of a reference signal	x0	x1	x2	x3

[0133] The second set of CSI is calculated according to a second set of power ratios in Table 4d:

Table 4d-Second set of power ratios of a port group 0

Port number	0	1	4	5
A ratio of an EPRE of a PDSCH to an EPRE of a reference signal	y0	y1	y2	y3

[0134] In the foregoing, a port group is used to separately indicate a ratio of a power of a data channel to a power of a reference signal, which can reduce a signaling overhead and enable a system to flexibly configure a signal power according to an antenna configuration or an antenna array structure. In addition, it should be further pointed out that although grouping of a port group is not limited to a port group including 4 reference signal ports, grouping of port groups and formation of ports in Tables 1, 2, and 3 above may further enable the antenna arrays in FIG. 3 or FIG. 4 to have powers symmetric about array structures, that is, the ports may have symmetric weights relative to the array, so as to implement beamforming or side lobe suppression.

Embodiment 5

[0135] This embodiment of the present invention provides a network side apparatus. As shown in FIG. 7, the apparatus includes: a determining unit 601 and a first sending unit 602.

[0136] The determining unit 601 is configured to determine reference signal resource configuration information, where the reference signal resource configuration information includes reference signal port configuration information, where the reference signal port configuration information is used for indicating a mapping relationship between a reference signal port and a port group.

[0137] The first sending unit 602 is configured to send, to user equipment, the reference signal resource configuration information determined by the determining unit 601, so that the user equipment acquires signal quality measurement information according to the reference signal port configuration information.

[0138] The network side apparatus described in this embodiment may be a base station on a network side, and reference may be made to the description of the corresponding steps in Embodiment 1 for implementation of functions of units of the network side apparatus, which is no longer repeated herein.

[0139] In the apparatus described in Embodiment 5 above, reference signal resource configuration information is determined on a network side, and the reference signal resource configuration information is sent to a user side, where the reference signal resource configuration information includes reference signal port configuration information, where the reference signal port configuration information is used for indicating a mapping relationship between a reference signal port and a port group. The apparatus can avoid that reference signal power related information is indicated port by port, so as to reduce a signaling overhead; further, a uniform power indicator is used for ports in a port group, and for different port groups, power related information of the port groups may be indicated independently, so that full use of an antenna configuration or an antenna array structure is made, thereby enabling a system to flexibly select reference signal power related information according to the antenna configuration or the antenna array structure; because an antenna array may have symmetric weights, by means of the symmetry of the weights, design complexity in beamforming or side lobe suppression can be reduced.

[0140] Further, the reference signal resource configuration information is sent to UE on the user side, and the UE may perform processing according to reference signal quality, of at least one port group, in the reference signal resource configuration information to obtain final signal quality measurement information, so that a UE side can distinguish ports according to different port groups, which differs from a case in which transmit powers of different ports cannot be distinguished in the prior art. The UE is enabled to acquire signal quality measurement information, so that the UE can perform more accurate cell selection and uplink power control.

[0141] Optionally, the reference signal resource configuration information determined by the determining unit 601 further includes: reference signal power information of at least two port groups that is used by the user equipment to acquire the signal quality measurement information according to the reference signal port configuration information and in combination with the reference signal power information of the at least two port groups; and
the reference signal power information of the at least two port groups includes:

a reference signal power of a first port group, and a ratio of a reference signal power of each port group among the rest port groups to the reference signal power of the first port group; or
a reference signal power of a first port group, and a differential between a reference signal power of each port group among the rest port groups and the reference signal power of the first port group.

[0142] Optionally, when the signal quality measurement information is a reference signal received power RSRP, the

first sending unit 602 is further configured to send, to the user equipment, filter coefficient information that is used by the user equipment to perform, based on the filter coefficient information, filtering on the reference signal received power RSRP and obtain a path loss estimation value.

[0143] Optionally, the apparatus further includes:

a first receiving unit 603, configured to receive an uplink physical channel or an uplink physical signal sent by the user equipment, where a transmit power of the uplink physical channel or the uplink physical signal is obtained by means of calculation by the user equipment according to the path loss estimation value.

[0144] Optionally, the signal quality measurement information includes:

any one or any combination of a reference signal received power RSRP, a reference signal received quality RSRQ, and a reference signal strength indicator RSSI.

[0145] Optionally, the apparatus further includes: a second receiving unit 604, where

the second receiving unit 604 is configured to receive the signal quality measurement information sent by the user equipment.

[0146] The first receiving unit 603 and the second receiving unit 604 may be integrated in a same physical module, or may be regarded as being implemented by using a same module; the description of the first receiving unit and the second receiving unit is used for better understanding of connection relationships among modules in the network side apparatus.

Embodiment 6

[0147] This embodiment of the present invention provides user equipment. As shown in FIG. 8, the user equipment includes: a third receiving unit 701, a first acquiring unit 702, and a second acquiring unit 703.

[0148] The third receiving unit 701 is configured to receive reference signal resource configuration information sent by a base station, where the reference signal resource configuration information includes reference signal port configuration information, where the reference signal port configuration information is used for indicating a mapping relationship between a reference signal port and a port group.

[0149] The first acquiring unit 702 is configured to obtain reference signal port information in at least one port group according to the reference signal port configuration information received by the third receiving unit 701.

[0150] The second acquiring unit 703 is configured to acquire signal quality measurement information according to the reference signal port information, in the at least one port group, obtained by the first acquiring unit 702.

[0151] For the user equipment described in this embodiment, reference may be made to the description of the corresponding steps in Embodiment 2 for implementation of functions of units of the user equipment, which is no longer repeated herein.

[0152] The apparatus described in Embodiment 6 above receives reference signal resource configuration information determined on a network side, where the reference signal resource configuration information includes reference signal port configuration information, where the reference signal port configuration information is used for indicating a mapping relationship between a reference signal port and a port group. The apparatus can avoid that reference signal power related information is indicated port by port, so as to reduce a signaling overhead; further, a uniform power indicator is used for ports in a port group, and for different port groups, power related information of the port groups may be indicated independently, so that full use of an antenna configuration or an antenna array structure is made, thereby enabling a system to flexibly select reference signal power related information according to the antenna configuration or the antenna array structure; because an antenna array may have symmetric weights, by means of the symmetry of the weights, design complexity in beamforming or side lobe suppression can be reduced.

[0153] Further, the reference signal resource configuration information is sent to UE on a user side, and the UE may perform processing according to reference signal quality, of at least one port group, in the reference signal resource configuration information to obtain final signal quality measurement information, so that a UE side can distinguish ports according to different port groups, which differs from a case in which transmit powers of different ports cannot be distinguished in the prior art. The UE is enabled to acquire signal quality measurement information, so that the UE can perform more accurate cell selection and uplink power control.

[0154] Optionally, the first acquiring unit 702 is specifically configured to obtain reference signal port information in one specified port group according to the reference signal port configuration information received by the third receiving unit 701.

[0155] The second acquiring unit 703 is specifically configured to acquire the signal quality measurement information according to the reference signal port information, in the one specified port group, obtained by the first acquiring unit 702.

[0156] Optionally, when the signal quality measurement information is a reference signal received power RSRP, the second acquiring unit 703 is specifically configured to:

obtain reference signal received power $RSRP(r,p)$ of a pth port of an rth receive antenna according to a formula

$$RSRP(r,p)=\frac{1}{K_s-1}\sum_{m=0}^{K_s-1}\hat{h}_p(m)\cdot\hat{h}_p(m+1)$$ and obtain the RSRP by combining $RSRP(r,p)$, where $\hat{h}_p(m)$ is a channel estimation on a reference signal RE whose label number is m, K_s is a total sample quantity of usable reference signal REs in measurement bandwidth, p is a number of a reference signal port in the one specified port group, and r is an index of a receive antenna.

[0157] Optionally, the reference signal resource configuration information received by the third receiving unit 701 further includes: reference signal power information of at least two port groups.

[0158] The second acquiring unit 703 is further configured to acquire the signal quality measurement information according to the reference signal port configuration information and in combination with the reference signal power information of the at least two port groups.

[0159] Optionally, the second acquiring unit 703 is specifically configured to:

obtain, according to the reference signal port configuration information, signal quality measurement information corresponding to the at least two port groups; and
perform, according to the reference signal power information of the at least two port groups, weighted averaging on the obtained signal quality measurement information corresponding to the at least two port groups in accordance with a port group power, to obtain the signal quality measurement information.

[0160] Optionally, the performing, by the second acquiring unit 703, according to the reference signal power information of the at least two port groups, weighted averaging on the obtained signal quality measurement information corresponding to the at least two port groups in accordance with a port group power, to obtain the signal quality measurement information includes:

obtaining the signal quality measurement information according to a formula

$$SQ=\left(\sum_{g=0}^{n-1}p_g\cdot SQ_g\right)\Big/\left(\sum_{g=0}^{n-1}p_g\right),$$

where
SQ_g is signal quality measurement information of a specified port group, g is a sequence number of a specified port group, n is a quantity of specified port groups, $n \geq 2$, and p_g is a reference signal power of a specified port group, where the reference signal power of the specified port group is obtained according to the reference signal power information of the at least two port groups.

[0161] Optionally, the reference signal power information, of the at least two port groups, received by the third receiving unit 701 includes:

a reference signal power of a first port group, and a ratio of a reference signal power of each port group among the rest port groups to the reference signal power of the first port group; or
a reference signal power of a first port group, and a differential between a reference signal power of each port group among the rest port groups and the reference signal power of the first port group.

[0162] Optionally, the user equipment further includes: a second sending unit 704, configured to send the signal quality measurement information to the base station.

[0163] Optionally,
the third receiving unit 701 is further configured to: when the signal quality measurement information is a reference signal received power RSRP, receive filter coefficient information sent by the base station; and
the user equipment further includes: a third acquiring unit 705, where
the third acquiring unit 705 is configured to perform, based on the filter coefficient information received by the third receiving unit 701, filtering on the reference signal received power RSRP, and obtain a path loss estimation value.

[0164] Optionally, the user equipment further includes: a third sending unit 706, where
the third sending unit 706 is further configured to send an uplink physical channel or an uplink physical signal to the base station, where a transmit power of the uplink physical channel or the uplink physical signal is obtained by means of calculation according to the path loss estimation value.

[0165] The third sending unit 706 and the second sending unit 704 may be implemented by using a same physical module, and this time are described separately for ease of understanding.

[0166] Optionally, the signal quality measurement information includes: a reference signal received power RSRP, a reference signal strength indicator RSSI, or a reference signal received quality RSRQ.

Embodiment 7

[0167] This embodiment of the present invention provides a network side apparatus. As shown in FIG. 9, the apparatus includes: a fourth sending unit 801 and a fourth receiving unit 802.

[0168] The fourth sending unit 801 is configured to send reference signal resource configuration information to user equipment, where the reference signal resource configuration information includes: reference signal port configuration information and power ratio information, where the reference signal port configuration information is used for indicating a mapping relationship between the reference signal port and a port group, and the power ratio information is used for indicating a power ratio of a data channel of at least one port group to a reference signal.

[0169] The fourth receiving unit 802 is configured to receive channel state information CSI sent by the user equipment, where the CSI is obtained by the user equipment according to the reference signal port configuration information and the power ratio information.

[0170] The network side apparatus described in Embodiment 7 above determines reference signal resource configuration information by using a network side, and sends the reference signal resource configuration information to a user side, where the reference signal resource configuration information includes reference signal port configuration information and power ratio information, where the reference signal port configuration information is used for indicating a mapping relationship between the reference signal port and a port group, and the power ratio information is used for indicating a power ratio of a data channel of at least one port group to a reference signal. The apparatus can avoid that reference signal power related information is indicated port by port, so as to reduce a signaling overhead; further, a uniform power indicator is used for ports in a port group, and for different port groups, power related information of the port groups may be indicated independently, so that full use of an antenna configuration or an antenna array structure is made, thereby enabling a system to flexibly select reference signal power related information according to the antenna configuration or the antenna array structure; because an antenna array may have symmetric weights, by means of the symmetry of the weights, design complexity in beamforming or side lobe suppression can be reduced.

[0171] Further, the reference signal resource configuration information is sent to UE on the user side, and the UE may perform processing according to reference signal quality, of one port group or multiple port groups, in the reference signal resource configuration information to obtain final signal quality measurement information, so that a UE side can distinguish ports according to different port groups, which differs from a case in which transmit powers of different ports cannot be distinguished in the prior art. The UE is enabled to acquire channel state information, so that the UE can perform more accurate modulation and coding scheme (MCS) selection or scheduling, thereby increasing a throughput of a system.

[0172] Optionally, in the power ratio information:

power ratios of data channels on antenna ports in each port group among the at least one port group to a reference signal are the same; or
power ratios of data channels on ports in one port group among the at least one port group and data channels on ports in another port group to a reference signal are the same.

[0173] Optionally, the power ratio information is used for indicating multiple sets of power ratios of data channels of the at least one port group to a reference signal; and
the fourth receiving unit 802 is specifically configured to receive multiple sets of channel state information CSI that are sent by the user equipment, where each set of channel state information CSI is obtained by the user equipment according to one set of power ratios among the multiple sets of power ratios.

[0174] Optionally, the channel state information CSI received by the fourth receiving unit 802 includes: any one or any combination of a channel quality indicator CQI, a precoding matrix indicator PMI, and a rank indicator RI.

[0175] The network side apparatus provided in this embodiment may be a base station on a network side, and reference may be made to the description of the corresponding steps in Embodiment 3 for implementation of functions of units of the network side apparatus, which is no longer repeated herein.

Embodiment 8

[0176] This embodiment of the present invention provides user equipment. As shown in FIG. 10, the user equipment includes: a fifth receiving unit 901, a fourth acquiring unit 902, a fifth acquiring unit 903, and a fifth sending unit 904.

[0177] The fifth receiving unit 901 is configured to receive reference signal resource configuration information sent by a base station, where the reference signal resource configuration information includes: reference signal port configuration information and power ratio information, where the reference signal port configuration information is used for indicating a mapping relationship between the reference signal port and a port group, and the power ratio information is used for indicating a power ratio of a data channel of at least one port group to a reference signal.

[0178] The fourth acquiring unit 902 is configured to obtain a power ratio of a data channel on each antenna port in the at least one port group to a reference signal according to the reference signal port configuration information and the power ratio information that are received by the fifth receiving unit 901.

[0179] The fifth acquiring unit 903 is configured to obtain channel state information CSI according to the power ratio, of the data channel on each antenna port to the reference signal, obtained by the fourth acquiring unit 902.

[0180] The fifth sending unit 904 is configured to send, to the base station, the channel state information CSI obtained by the fifth acquiring unit 903.

[0181] This embodiment of the present invention provides user equipment. The apparatus may perform processing according to reference signal quality of one port group or multiple port groups to obtain final signal quality measurement information, so that a UE side can distinguish ports according to different port groups, which differs from a case in which transmit powers of different ports cannot be distinguished in the prior art. The UE is enabled to acquire channel state information, so that the UE can perform more accurate modulation and coding scheme (MCS) selection or scheduling, thereby increasing a throughput of a system.

[0182] Optionally, the fifth acquiring unit 903 is specifically configured to:

obtain, according to the reference signal on each antenna port, a channel measurement value corresponding to each antenna port;
obtain a channel estimation value of the data channel on each antenna port according to the channel measurement value corresponding to each antenna port and the power ratio of the data channel on each antenna port to the reference signal; and
obtain the channel state information CSI according to the channel estimation value of the data channel on each antenna port.

[0183] Optionally, the obtaining, by the fifth acquiring unit 903, a channel estimation value of the data channel on each antenna port according to the channel measurement value corresponding to each antenna port and the power ratio of the data channel on each antenna port to the reference signal includes:
obtaining a channel estimation value of a data channel on an antenna port p according to a formula

$$\hat{\mathbf{h}}_p = \sqrt{\rho_p}\mathbf{h}_p,$$

where
p is an index of the antenna port, ρ_p is a power ratio of the data channel on the antenna port p to a reference signal, $\mathbf{h}_p$ is a channel measurement value corresponding to the antenna port p, and $\hat{\mathbf{h}}_p$ is a channel estimation value of the data channel on the antenna port p.

[0184] Optionally, in the power ratio information:

power ratios of data channels on antenna ports in each port group among the at least one port group to a reference signal are the same; or
power ratios of data channels on ports in one port group among the at least one port group and data channels on ports in another port group to a reference signal are the same.

[0185] Optionally, the reference signal resource configuration information received by the fifth receiving unit 901 includes: the reference signal port configuration information and the power ratio information.

[0186] The power ratio information is used for indicating multiple sets of power ratios of data channels of the at least one port group to a reference signal; and
the fifth sending unit 904 is specifically configured to:
send multiple sets of channel state information CSI to the base station, where each set of channel state information CSI is obtained according to one set of power ratios among the multiple sets of power ratios.

[0187] Optionally, the channel state information CSI obtained by the fifth acquiring unit 903 includes: any one or any combination of a channel quality indicator CQI, a precoding matrix indicator PMI, and a rank indicator RI.

[0188] For the user equipment provided in this embodiment, reference may be made to the description of the corre-

sponding steps in Embodiment 4 for implementation of functions of units of the user equipment, which is no longer repeated herein.

Embodiment 9

[0189] A network side apparatus is provided and can support a radio communications technology. Transmission of a data packet can be performed based on the method described in Embodiment 1 among units in a communications device in this embodiment. A schematic structural diagram is shown in FIG. 11, and the network side apparatus includes: a processor 21, a receiver 23, and a transmitter 24 that are separately connected to a bus.

[0190] Optionally, the shown network side apparatus may further include: a memory 20.

[0191] Where:

the memory 20 is configured to store data input from the receiver 23, and may further store information such as a necessary file for the processor 21 to process data; and the receiver 23 and the transmitter 24 are ports by using which a communications device communicates with another device.

[0192] The processor 21 is configured to determine reference signal resource configuration information, where the reference signal resource configuration information includes reference signal port configuration information, where the reference signal port configuration information is used for indicating a mapping relationship between a reference signal port and a port group.

[0193] The transmitter 24 is configured to send the reference signal resource configuration information to user equipment, so that the user equipment acquires signal quality measurement information according to the reference signal port configuration information.

[0194] Optionally, the reference signal resource configuration information determined by the processor 21 further includes: reference signal power information of at least two port groups that is used by the user equipment to acquire the signal quality measurement information according to the reference signal port configuration information and in combination with the reference signal power information of the at least two port groups.

[0195] The reference signal power information of the at least two port groups includes:

a reference signal power of a first port group, and a ratio of a reference signal power of each port group among the rest port groups to the reference signal power of the first port group; or

a reference signal power of a first port group, and a differential between a reference signal power of each port group among the rest port groups and the reference signal power of the first port group.

[0196] Optionally, when the signal quality measurement information is a reference signal received power RSRP, the transmitter 24 is further configured to send, to the user equipment, filter coefficient information that is used by the user equipment to perform, based on the filter coefficient information, filtering on the reference signal received power RSRP and obtain a path loss estimation value.

[0197] Optionally, the receiver 23 is configured to receive an uplink physical channel or an uplink physical signal sent by the user equipment, where a transmit power of the uplink physical channel or the uplink physical signal is obtained by means of calculation by the user equipment according to the path loss estimation value.

[0198] Optionally, the signal quality measurement information includes:

any one or any combination of a reference signal received power RSRP, a reference signal received quality RSRQ, and a reference signal strength indicator RSSI.

[0199] Optionally, the receiver 23 is further configured to receive the signal quality measurement information sent by the user equipment.

[0200] The network side apparatus described in this embodiment may be a base station on a network side, and reference may be made to the description of the corresponding steps in Embodiment 1 for implementation of functions of units of the network side apparatus, which is no longer repeated herein.

Embodiment 10

[0201] This embodiment provides user equipment, which can support a radio communications technology. Transmission of a data packet can be performed based on the method described in Embodiment 2 among units in a communications device in this embodiment. A schematic structural diagram is shown in FIG. 12, and the user equipment includes: a processor 31, a receiver 33, and a transmitter 34 that are separately connected to a bus.

[0202] Optionally, the shown network side apparatus may further include: a memory 30.

[0203] The memory 30 is configured to store data input from the receiver 33, and may further store information such as a necessary file for the processor 31 to process data; and the receiver 33 and the transmitter 34 are ports by using which a communications device communicates with another device.

[0204] The receiver 33 is configured to receive reference signal resource configuration information sent by a base station, where the reference signal resource configuration information includes reference signal port configuration information, where the reference signal port configuration information is used for indicating a mapping relationship between a reference signal port and a port group.

[0205] The processor 31 is configured to obtain reference signal port information in at least one port group according to the reference signal port configuration information; and acquire signal quality measurement information according to the reference signal port information in the at least one port group.

[0206] Optionally, the processor 31 is specifically configured to:

obtain reference signal port information in one specified port group according to the reference signal port configuration information; and
acquire the signal quality measurement information according to the reference signal port information in the one specified port group.

[0207] Optionally, when the signal quality measurement information is a reference signal received power RSRP, the acquiring, by the processor 31, the signal quality measurement information according to the reference signal port information in the one specified port group includes:
obtaining a reference signal received power $RSRP(r,p)$ of a pth port of an rth receive antenna according to a formula

$$RSRP(r,p)=\frac{1}{K_s-1}\sum_{m=0}^{K_s-1}\hat{h}_p(m)\cdot\hat{h}_p(m+1)$$

and obtaining the RSRP by combining $RSRP(r,p)$, where $\hat{h}_p(m)$ is a channel estimation on a reference signal RE whose label number is m, K_s is a total sample quantity of usable reference signal REs in measurement bandwidth, p is a number of a reference signal port in the one specified port group, and r is an index of a receive antenna.

[0208] Optionally, the reference signal resource configuration information received by the receiver 33 further includes: reference signal power information of at least two port groups that is used by the user equipment to acquire the signal quality measurement information according to the reference signal port configuration information and in combination with the reference signal power information of the at least two port groups.

[0209] Optionally, the acquiring, by the processor 31, the signal quality measurement information according to the reference signal port configuration information and in combination with the reference signal power information of the at least two port groups includes:

obtaining, according to the reference signal port configuration information, signal quality measurement information corresponding to the at least two port groups; and
performing, according to the reference signal power information of the at least two port groups, weighted averaging on the obtained signal quality measurement information corresponding to the at least two port groups in accordance with a port group power, to obtain the signal quality measurement information.

[0210] Optionally, the performing, by the processor 31, according to the reference signal power information of the at least two port groups, weighted averaging on the obtained signal quality measurement information corresponding to the at least two port groups in accordance with a port group power, to obtain the signal quality measurement information includes:
obtaining the signal quality measurement information according to a formula

$$SQ=\left(\sum_{g=0}^{n-1}p_g\cdot SQ_g\right)\Big/\left(\sum_{g=0}^{n-1}p_g\right),$$

where
SQ_g is signal quality measurement information of a specified port group, g is a sequence number of a specified port group, n is a quantity of specified port groups, $n\geq 2$, and p_g is a reference signal power of a specified port group, where the reference signal power of the specified port group is obtained according to the reference signal power information of the at least two port groups.

[0211] Optionally, the reference signal power information, of the at least two port groups, received by the receiver 33 includes:

a reference signal power of a first port group, and a ratio of a reference signal power of each port group among the rest port groups to the reference signal power of the first port group; or
a reference signal power of a first port group, and a differential between a reference signal power of each port group among the rest port groups and the reference signal power of the first port group.

[0212] Optionally, the transmitter 34 is configured to send the signal quality measurement information to the base station.

[0213] Optionally, when the signal quality measurement information is a reference signal received power RSRP, the receiver 33 is further configured to receive filter coefficient information sent by the base station; and
the processor 31 is further configured to perform, based on the filter coefficient information, filtering on the reference signal received power RSRP, and obtain a path loss estimation value.

[0214] Optionally, the transmitter 34 is further configured to send an uplink physical channel or an uplink physical signal to the base station, where a transmit power of the uplink physical channel or the uplink physical signal is obtained by means of calculation according to the path loss estimation value.

[0215] Optionally, the signal quality measurement information includes: a reference signal received power RSRP, a reference signal strength indicator RSSI, or a reference signal received quality RSRQ.

Embodiment 11

[0216] A network side apparatus is provided and can support a radio communications technology. Transmission of a data packet can be performed based on the method described in Embodiment 3 among units in a communications device in this embodiment. A schematic structural diagram is shown in FIG. 13, and the network side apparatus includes: a processor 41, a receiver 43, and a transmitter 44 that are separately connected to a bus.

[0217] Optionally, the shown network side apparatus may further include: a memory 40.

[0218] The memory 40 is configured to store data input from the receiver 43, and may further store information such as a necessary file for the processor 41 to process data; and the receiver 43 and the transmitter 44 are ports by using which a communications device communicates with another device.

[0219] The transmitter 44 is configured to send reference signal resource configuration information to user equipment, where the reference signal resource configuration information includes: reference signal port configuration information and power ratio information, where the reference signal port configuration information is used for indicating a mapping relationship between the reference signal port and a port group, and the power ratio information is used for indicating a power ratio of a data channel of at least one port group to a reference signal; and
the receiver 43 is configured to receive channel state information CSI sent by the user equipment, where the CSI is obtained by the user equipment according to the reference signal port configuration information and the power ratio information.

[0220] Optionally, in the power ratio information:

power ratios of data channels on antenna ports in each port group among the at least one port group to a reference signal are the same; or
power ratios of data channels on ports in one port group among the at least one port group and data channels on ports in another port group to a reference signal are the same.

[0221] Optionally, the power ratio information is used for indicating multiple sets of power ratios of data channels of the at least one port group to a reference signal; and
the receiving, by the receiver 33, channel state information CSI sent by the user equipment includes: receiving multiple sets of channel state information CSI that are sent by the user equipment, where each set of channel state information CSI is obtained by the user equipment according to one set of power ratios among the multiple sets of power ratios.

[0222] Optionally, the channel state information CSI received by the receiver 33 includes: any one or any combination of a channel quality indicator CQI, a precoding matrix indicator PMI, and a rank indicator RI.

[0223] The network side apparatus provided in this embodiment may be a base station on a network side, and reference may be made to the description of the corresponding steps in Embodiment 3 for implementation of functions of units of the network side apparatus, which is no longer repeated herein.

Embodiment 12

[0224] This embodiment provides user equipment, which can support a radio communications technology. Transmission of a data packet can be performed based on the method described in Embodiment 4 among units in a communications device in this embodiment. A schematic structural diagram is shown in FIG. 14, and the user equipment includes: a

processor 51, a receiver 53, and a transmitter 54 that are separately connected to a bus.

[0225] Optionally, the shown network side apparatus may further include: a memory 50.

[0226] The memory 50 is configured to store data input from the receiver 53, and may further store information such as a necessary file for the processor 51 to process data; and the receiver 53 and the transmitter 54 are ports by using which a communications device communicates with another device.

[0227] The receiver 53 is configured to receive reference signal resource configuration information sent by a base station, where the reference signal resource configuration information includes: reference signal port configuration information and power ratio information, where the reference signal port configuration information is used for indicating a mapping relationship between the reference signal port and a port group, and the power ratio information is used for indicating a power ratio of a data channel of at least one port group to a reference signal.

[0228] The processor 51 is configured to obtain a power ratio of a data channel on each antenna port in the at least one port group to a reference signal according to the reference signal port configuration information and the power ratio information, and obtain channel state information CSI according to the power ratio of the data channel on each antenna port to the reference signal.

[0229] The transmitter 54 is configured to send the channel state information CSI to the base station.

[0230] Optionally, the obtaining, by the processor 51, channel state information CSI according to the power ratio of the data channel on each antenna port to the reference signal includes:

obtaining, according to the reference signal on each antenna port, a channel measurement value corresponding to each antenna port;

obtaining a channel estimation value of the data channel on each antenna port according to the channel measurement value corresponding to each antenna port and the power ratio of the data channel on each antenna port to the reference signal; and

obtaining the channel state information CSI according to the channel estimation value of the data channel on each antenna port.

[0231] Optionally, the obtaining, by the processor 51, a channel estimation value of the data channel on each antenna port according to the channel measurement value corresponding to each antenna port and the power ratio of the data channel on each antenna port to the reference signal includes:

obtaining a channel estimation value of a data channel on an antenna port p according to a formula

$$\hat{\mathbf{h}}_p = \sqrt{\rho_p}\mathbf{h}_p,$$

where

p is an index of the antenna port, ρ_p is a power ratio of the data channel on the antenna port p to a reference signal, $\mathbf{h}_p$ is a channel measurement value corresponding to the antenna port p, and $\hat{\mathbf{h}}_p$ is a channel estimation value of the data channel on the antenna port p.

[0232] Optionally, in the power ratio information:

power ratios of data channels on antenna ports in each port group among the at least one port group to a reference signal are the same; or

power ratios of data channels on ports in one port group among the at least one port group and data channels on ports in another port group to a reference signal are the same.

[0233] Optionally, the power ratio information is used for indicating multiple sets of power ratios of data channels of the at least one port group to a reference signal; and

the transmitter 54 is specifically configured to:

send multiple sets of channel state information CSI to the base station, where each set of channel state information CSI is obtained according to one set of power ratios among the multiple sets of power ratios.

[0234] Optionally, the channel state information CSI obtained by the processor 51 includes: any one or any combination of a channel quality indicator CQI, a precoding matrix indicator PMI, and a rank indicator RI.

[0235] A person of ordinary skill in the art may understand that all or a part of the steps of the methods in the embodiments may be implemented by a program instructing relevant hardware. The program may be stored in a computer readable storage medium. The storage medium may include: a ROM, a RAM, a magnetic disk, or an optical disc.

[0236] The method and the apparatus for measuring communication quality provided in the embodiments of the present invention are introduced above in detail. In this specification, specific examples are used to describe the principle and

implementation manners of the present invention, and the description of the embodiments is only intended to help understand the method and core idea of the present invention defined by the scope of the appended claims. Meanwhile, a person of ordinary skill in the art may, based on the idea of the present invention, make modifications with respect to the specific implementation manners. Therefore, the content of this specification shall not be construed as a limitation to the present invention, which is defined by the scope of the appended claims.

Claims

1. A method for measuring communication quality in an active antenna system performed by a user equipment, comprising:

receiving (101) reference signal resource configuration information sent by a base station, wherein the reference signal resource configuration information comprises reference signal port configuration information, wherein the reference signal port configuration information is used for indicating a mapping relationship between a reference signal port and a port group, wherein the port group is a group of ports of an antenna port array;
obtaining (102) reference signal port information in at least one port group according to the reference signal port configuration information; and
acquiring (103) signal quality measurement information according to the reference signal port information in the at least one port group; wherein the reference signal resource configuration information further comprises: reference signal power information of at least two port groups that is used by the user equipment to acquire the signal quality measurement information according to the reference signal port configuration information and in combination with the reference signal power information of the at least two port groups,
characterized in,
that the acquiring the signal quality measurement information according to the reference signal port configuration information and in combination with the reference signal power information of the at least two port groups comprises:

obtaining, according to the reference signal port configuration information, signal quality measurement information corresponding to the at least two port groups; and
performing, according to the reference signal power information of the at least two port groups, weighted averaging on the obtained signal quality measurement information corresponding to the at least two port groups in accordance with a port group power, to obtain the signal quality measurement information,

wherein the performing, according to the reference signal power information of the at least two port groups, weighted averaging on the obtained signal quality measurement information corresponding to the at least two port groups in accordance with a port group power, to obtain the signal quality measurement information comprises:
obtaining the signal quality measurement information according to a formula

$$SQ = \left(\sum_{g=0}^{n-1} p_g \cdot SQ_g \right) \Big/ \left(\sum_{g=0}^{n-1} p_g \right),$$

wherein
SQ_g is signal quality measurement information of a specified port group, g is a sequence number of a specified port group, n is a quantity of specified port groups, $n \geq 2$, and p_g is a reference signal power of a specified port group, wherein the reference signal power of the specified port group is obtained according to the reference signal power information of the at least two port groups.

2. The method according to claim 1, wherein the reference signal power information of the at least two port groups comprises:

a reference signal power of a first port group, and a ratio of a reference signal power of each port group among the rest port groups to the reference signal power of the first port group; or
a reference signal power of a first port group, and a differential between a reference signal power of each port group among the rest port groups and the reference signal power of the first port group.

Patentansprüche

1. Verfahren zum Messen der Kommunikationsqualität in einem aktiven Antennensystem, durchgeführt von einem Benutzergerät, das Folgendes umfasst:

   Empfangen (101) der von einer Basisstation gesendeten Referenzsignal-Ressourcenkonfigurationsinformationen, wobei die Referenzsignal-Ressourcenkonfigurationsinformationen Referenzsignal-Anschlusskonfigurationsinformationen umfassen, wobei die Referenzsignal-Anschlusskonfigurationsinformationen zum Angeben einer Zuordnungsbeziehung zwischen einem Referenzsignalanschluss und einer Anschlussgruppe verwendet werden, wobei die Anschlussgruppe eine Gruppe von Anschlüssen eines Antennenanschlussarrays ist;
   Erhalten (102) von Referenzsignal-Anschlussinformationen in mindestens einer Anschlussgruppe gemäß den Referenzsignal-Anschlusskonfigurationsinformationen; und
   Erfassen (103) von Signalqualitätsmessungsinformationen gemäß den Referenzsignal-Anschlussinformationen in der mindestens einen Anschlussgruppe; wobei die Referenzsignal-Ressourcenkonfigurationsinformationen ferner Folgendes umfassen: Referenzsignal-Leistungsinformationen von mindestens zwei Anschlussgruppen, die von dem Benutzergerät verwendet werden, um die Signalqualitätsmessungsinformationen gemäß den Referenzsignal-Anschlusskonfigurationsinformationen und in Kombination mit den Referenzsignal-Leistungsinformationen der mindestens zwei Anschlussgruppen zu erfassen,
   gekennzeichnet dadurch,
   dass das Erfassen der Signalqualitätsmessungsinformationen gemäß den Referenzsignal-Anschlusskonfigurationsinformationen und in Kombination mit den Referenzsignal-Leistungsinformationen der mindestens zwei Anschlussgruppen Folgendes umfasst:

      Erhalten, gemäß den Referenzsignal-Anschlusskonfigurationsinformationen, von Signalqualitätsmessungsinformationen, die den mindestens zwei Anschlussgruppen entsprechen; und
      Durchführen, gemäß den Referenzsignal-Leistungsinformationen der mindestens zwei Anschlussgruppen, einer gewichteten Mittelung an den erhaltenen Signalqualitätsmessungsinformationen, die den mindestens zwei Anschlussgruppen entsprechen, im Einklang mit einer Anschlussgruppenleistung, um die Signalqualitätsmessungsinformationen zu erhalten,

   wobei das Durchführen, gemäß den Referenzsignal-Leistungsinformationen der mindestens zwei Anschlussgruppen, einer gewichteten Mittelung an den erhaltenen Signalqualitätsmessungsinformationen, die den mindestens zwei Anschlussgruppen entsprechen, im Einklang mit einer Anschlussgruppenleistung, um die Signalqualitätsmessungsinformationen zu erhalten, Folgendes umfasst:
   Erhalten der Signalqualitätsmessungsinformationen gemäß einer Formel

$$= (\sum_{g=0}^{n-1} Pg \cdot SQg)/(\sum_{g=0}^{n-1} Pg),$$

   wobei
   SQg die Signalqualitätsmessungsinformationen einer angegebenen Anschlussgruppe sind, g eine Folgenummer einer angegebenen Anschlussgruppe ist, n eine Menge von angegebenen Anschlussgruppen ist, $n \geq 2$ ist, und Pg eine Referenzsignalleistung einer angegebenen Anschlussgruppe ist, wobei die Referenzsignalleistung der angegebenen Anschlussgruppe gemäß den Referenzsignal-Leistungsinformationen der mindestens zwei Anschlussgruppen erhalten wird.

2. Verfahren gemäß Anspruch 1, wobei die Referenzsignal-Leistungsinformationen der mindestens zwei Anschlussgruppen Folgendes umfassen:

   eine Referenzsignalleistung einer ersten Anschlussgruppe und ein Verhältnis einer Referenzsignalleistung jeder Anschlussgruppe unter den restlichen Anschlussgruppen zu der Referenzsignalleistung der ersten Anschlussgruppe; oder
   eine Referenzsignalleistung einer ersten Anschlussgruppe und eine Differenz zwischen einer Referenzsignalleistung jeder Anschlussgruppe unter den restlichen Anschlussgruppen und der Referenzsignalleistung der ersten Anschlussgruppe.

Revendications

1. Procédé de mesure d'une qualité de communication dans un système d'antenne actif exécuté par un équipement utilisateur, consistant à :

recevoir (101) des informations de configuration de ressources de signal de référence envoyées par une station de base, dans lequel les informations de configuration de ressources de signal de référence comprennent des informations de configuration de ports de signal de référence, dans lequel les informations de configuration de ports de signal de référence sont utilisées pour indiquer un rapport de mappage entre un port de signal de référence et un groupe de ports, le groupe de ports étant un groupe de ports d'un ensemble de ports d'antennes ;
obtenir (102) des informations de ports de signal de référence dans au moins un groupe de ports en fonction des informations de configuration de ports de signal de référence ; et
acquérir (103) des informations de mesures de qualité de signal en fonction des informations de ports de signal de référence dans l'au moins un groupe de ports ; les informations de configuration de ressources de signal de référence comprenant en outre : des informations de puissance de signal de référence d'au moins deux groupes de ports qui sont utilisées par l'équipement utilisateur pour acquérir les informations de mesures de qualité de signal en fonction des informations de configuration de ports de signal de référence et en combinaison avec les informations de puissance de signal de référence des au moins deux groupes de ports,
caractérisé en ce que
l'acquisition des informations de mesures de qualité de signal en fonction des informations de configuration de ports de signal de référence et en combinaison avec les informations de puissance de signal de référence des au moins deux groupes de ports consiste à :

obtenir, en fonction des informations de configuration de ports de signal de référence, des informations de mesures de qualité de signal correspondant aux au moins deux groupes de ports ; et
exécuter, en fonction des informations de puissance de signal de référence des au moins deux groupes de ports, un moyennage pondéré sur les informations de mesures de qualité de signal obtenues correspondant aux au moins deux groupes de ports en fonction d'une puissance des groupes de ports, pour obtenir les informations de mesures de qualité de signal,

dans lequel l'exécution, en fonction des informations de puissance de signal de référence des au moins deux groupes de ports, du moyennage pondéré sur les informations de mesures de qualité de signal obtenues correspondant aux au moins deux groupes de ports en fonction d'une puissance des groupes de ports, pour obtenir les informations de mesures de qualité de signal consiste à :
obtenir les informations de mesures de qualité de signal selon une formule

$$SQ = \left(\sum_{g=0}^{n-1} p_g \cdot SQ_g \right) \Big/ \left(\sum_{g=0}^{n-1} p_g \right),$$

dans laquelle
SQg représente les informations de mesures de qualité de signal d'un groupe de ports spécifié, g est un numéro de séquence d'un groupe de ports spécifié, n est une quantité de groupes de ports spécifiés, $n \geq 2$, et Pg représente une puissance de signal de référence d'un groupe de ports spécifiés, la puissance de signal de référence du groupe de ports spécifié étant obtenue en fonction des informations de puissance de signal de référence des au moins deux groupes de ports.

2. Procédé selon la revendication 1, dans lequel les informations de puissance de signal de référence des au moins deux groupes de ports comprennent :

une puissance de signal de référence d'un premier groupe de ports, et un rapport d'une puissance de signal de référence de chaque groupe de ports parmi les groupes de ports restants par rapport à la puissance de signal de référence du premier groupe de ports ; ou
une puissance de signal de référence d'un premier groupe de ports, et un différentiel entre une puissance de signal de référence de chaque groupe de ports parmi les groupes de ports restants et la puissance de signal de référence du premier groupe de ports.

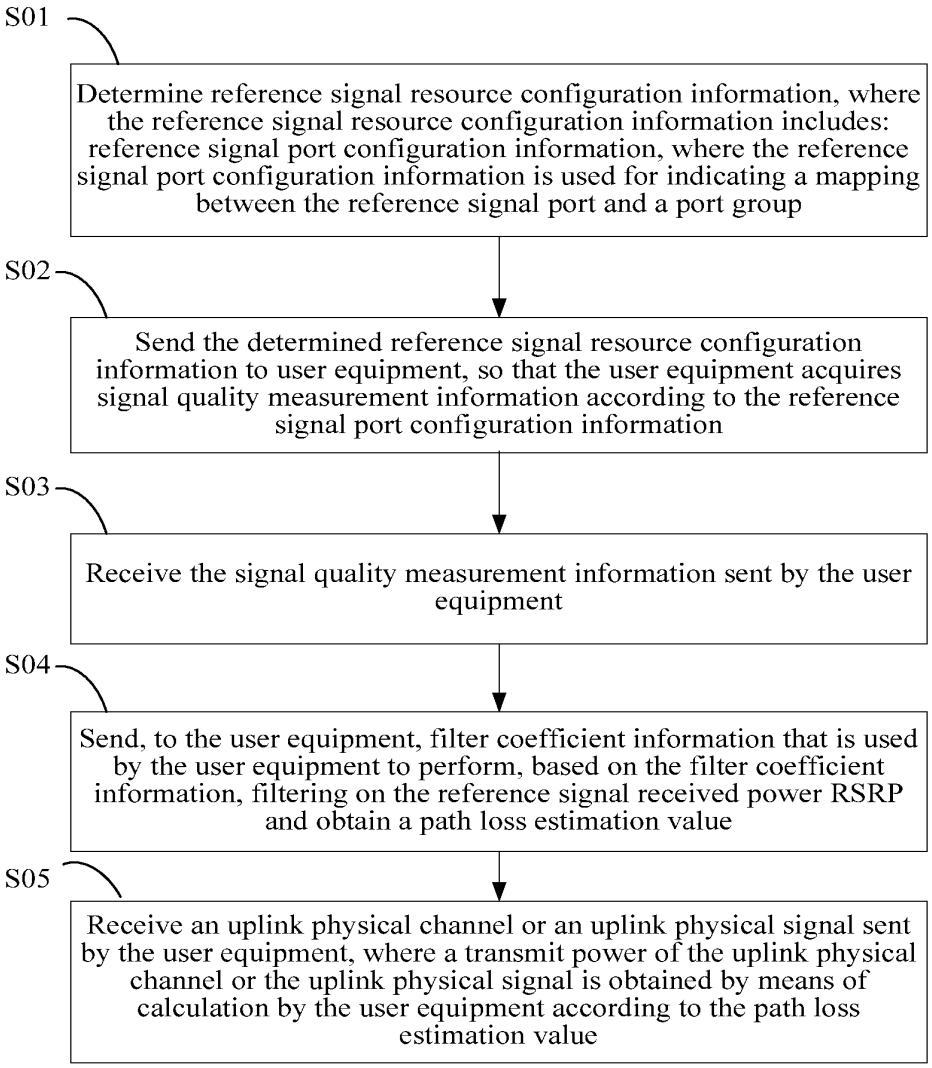

S01
Determine reference signal resource configuration information, where the reference signal resource configuration information includes: reference signal port configuration information, where the reference signal port configuration information is used for indicating a mapping between the reference signal port and a port group
S02
Send the determined reference signal resource configuration information to user equipment, so that the user equipment acquires signal quality measurement information according to the reference signal port configuration information
S03
Receive the signal quality measurement information sent by the user equipment
S04
Send, to the user equipment, filter coefficient information that is used by the user equipment to perform, based on the filter coefficient information, filtering on the reference signal received power RSRP and obtain a path loss estimation value
S05
Receive an uplink physical channel or an uplink physical signal sent by the user equipment, where a transmit power of the uplink physical channel or the uplink physical signal is obtained by means of calculation by the user equipment according to the path loss estimation value

FIG. 1

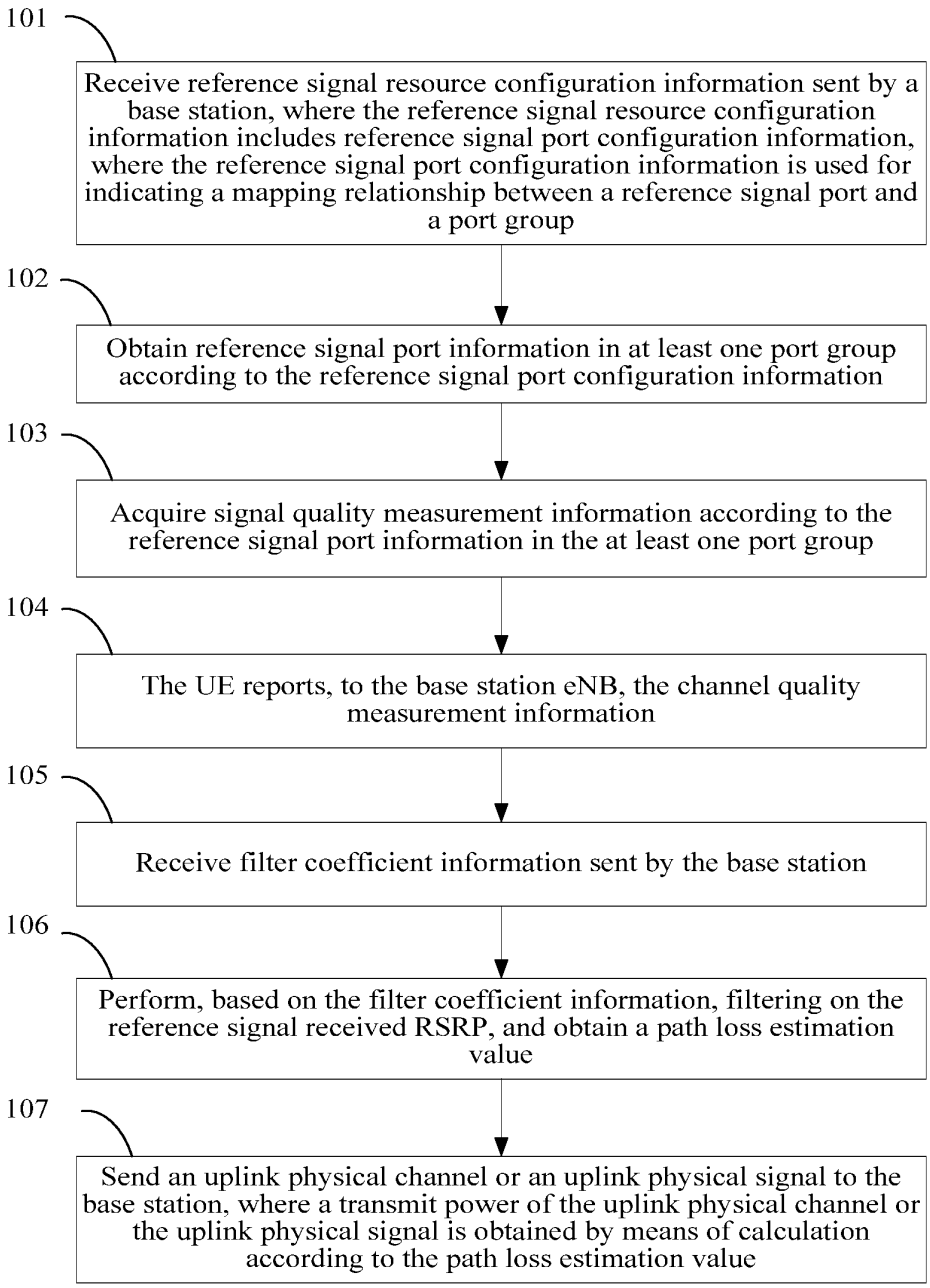

101
Receive reference signal resource configuration information sent by a base station, where the reference signal resource configuration information includes reference signal port configuration information, where the reference signal port configuration information is used for indicating a mapping relationship between a reference signal port and a port group
102
Obtain reference signal port information in at least one port group according to the reference signal port configuration information
103
Acquire signal quality measurement information according to the reference signal port information in the at least one port group
104
The UE reports, to the base station eNB, the channel quality measurement information
105
Receive filter coefficient information sent by the base station
106
Perform, based on the filter coefficient information, filtering on the reference signal received RSRP, and obtain a path loss estimation value
107
Send an uplink physical channel or an uplink physical signal to the base station, where a transmit power of the uplink physical channel or the uplink physical signal is obtained by means of calculation according to the path loss estimation value

FIG. 2

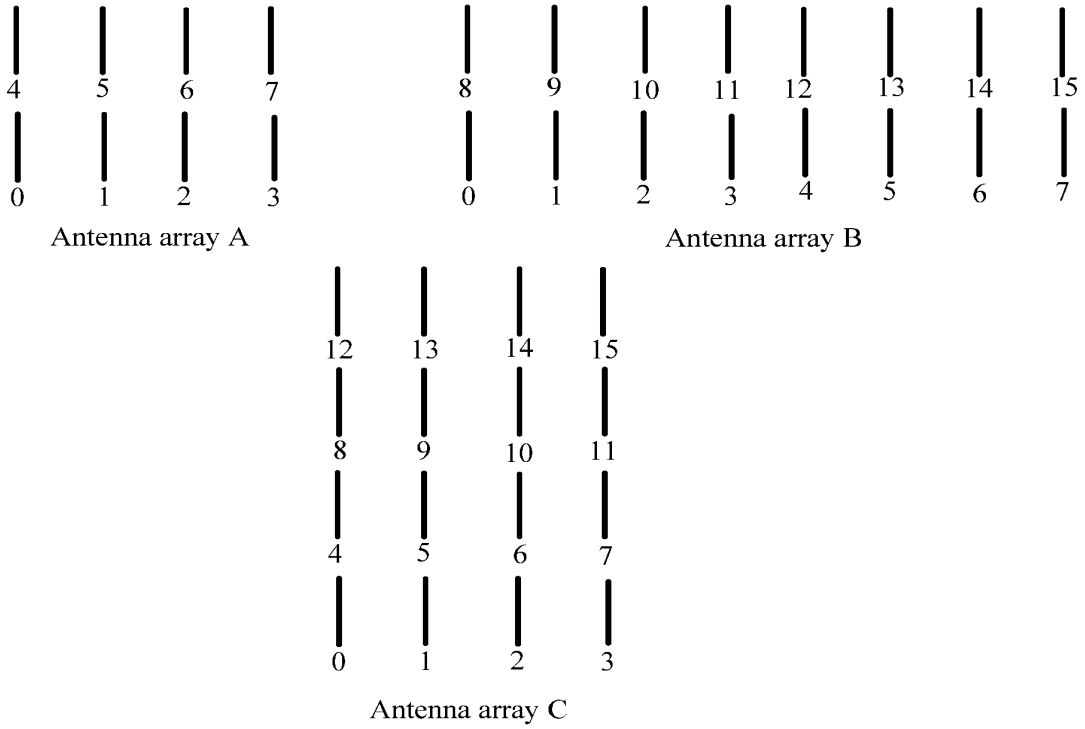

4 5 6 7
0 1 2 3
Antenna array A
8 9 10 11 12 13 14 15
0 1 2 3 4 5 6 7
Antenna array B
12 13 14 15
8 9 10 11
4 5 6 7
0 1 2 3
Antenna array C

FIG. 3

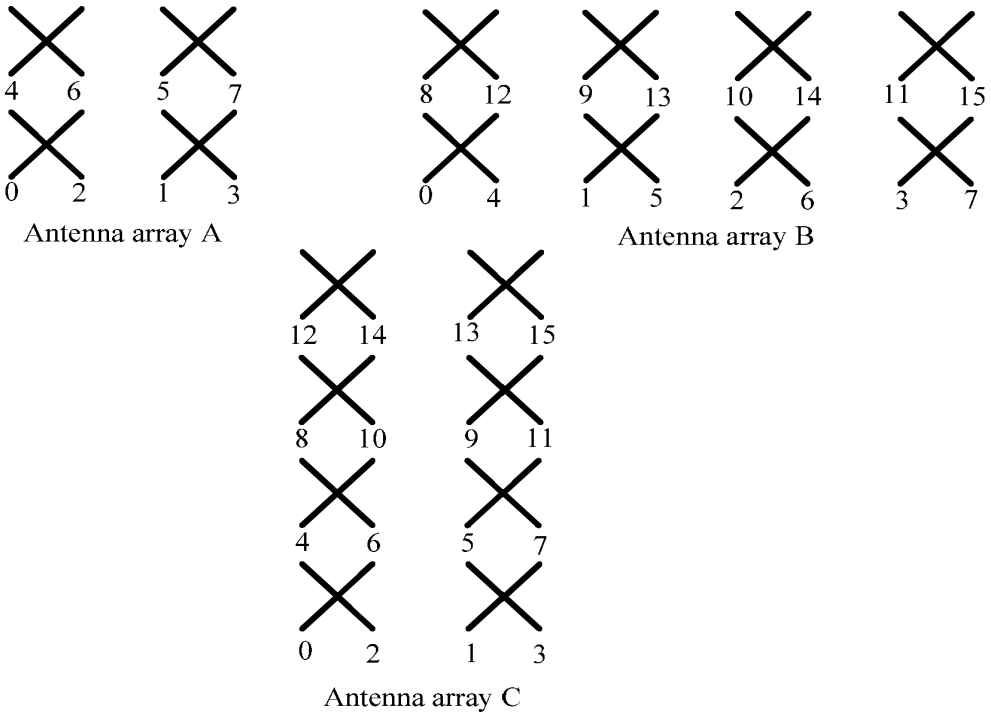

4 6
5 7
0 2
1 3
Antenna array A
8 12
9 13
10 14
11 15
0 4
1 5
2 6
3 7
Antenna array B
12 14
13 15
8 10
9 11
4 6
5 7
0 2
1 3
Antenna array C

FIG. 4

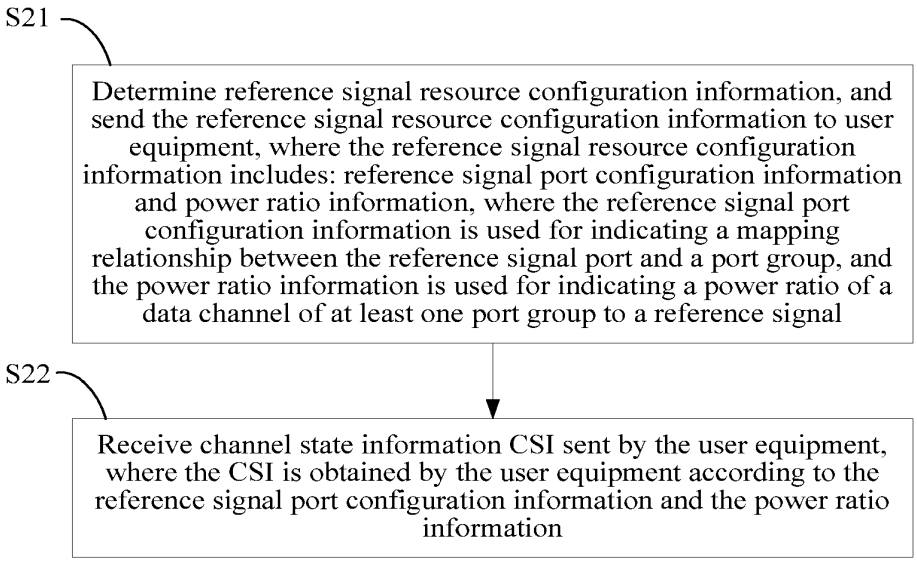

S21
Determine reference signal resource configuration information, and send the reference signal resource configuration information to user equipment, where the reference signal resource configuration information includes: reference signal port configuration information and power ratio information, where the reference signal port configuration information is used for indicating a mapping relationship between the reference signal port and a port group, and the power ratio information is used for indicating a power ratio of a data channel of at least one port group to a reference signal
S22
Receive channel state information CSI sent by the user equipment, where the CSI is obtained by the user equipment according to the reference signal port configuration information and the power ratio information

FIG. 5

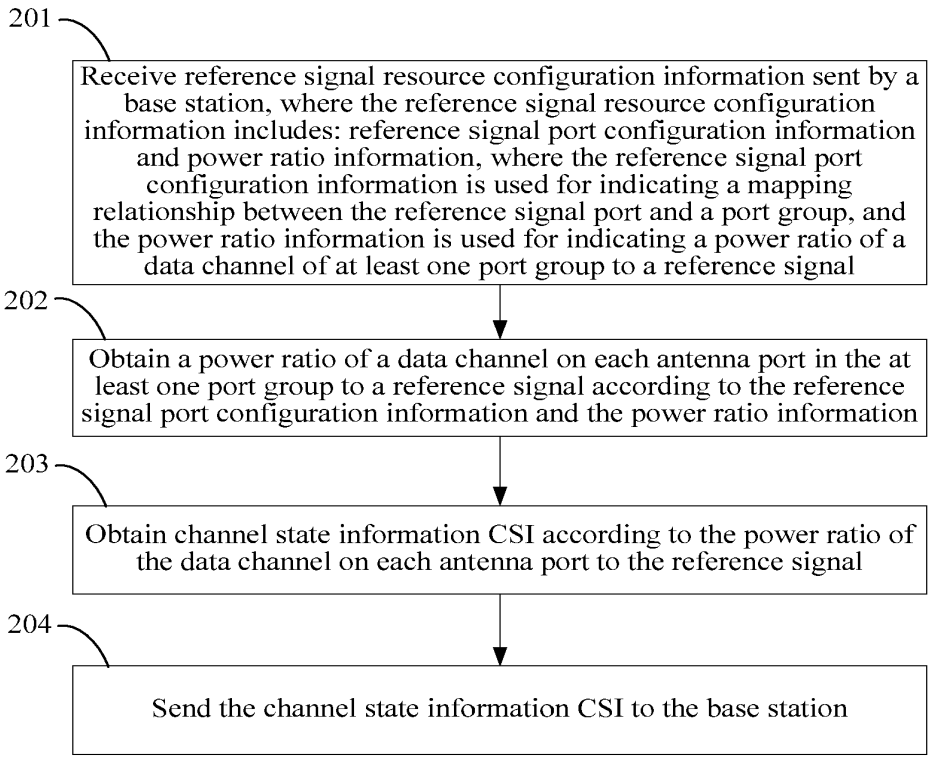

201
Receive reference signal resource configuration information sent by a base station, where the reference signal resource configuration information includes: reference signal port configuration information and power ratio information, where the reference signal port configuration information is used for indicating a mapping relationship between the reference signal port and a port group, and the power ratio information is used for indicating a power ratio of a data channel of at least one port group to a reference signal
202
Obtain a power ratio of a data channel on each antenna port in the at least one port group to a reference signal according to the reference signal port configuration information and the power ratio information
203
Obtain channel state information CSI according to the power ratio of the data channel on each antenna port to the reference signal
204
Send the channel state information CSI to the base station

FIG. 6

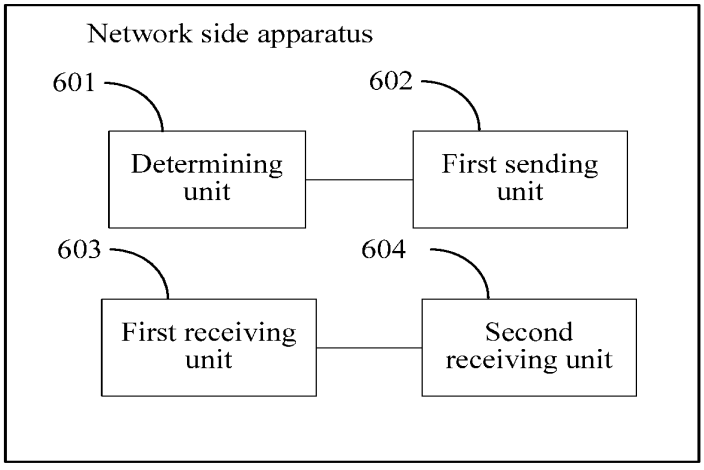

Network side apparatus
601
Determining unit
602
First sending unit
603
First receiving unit
604
Second receiving unit

FIG. 7

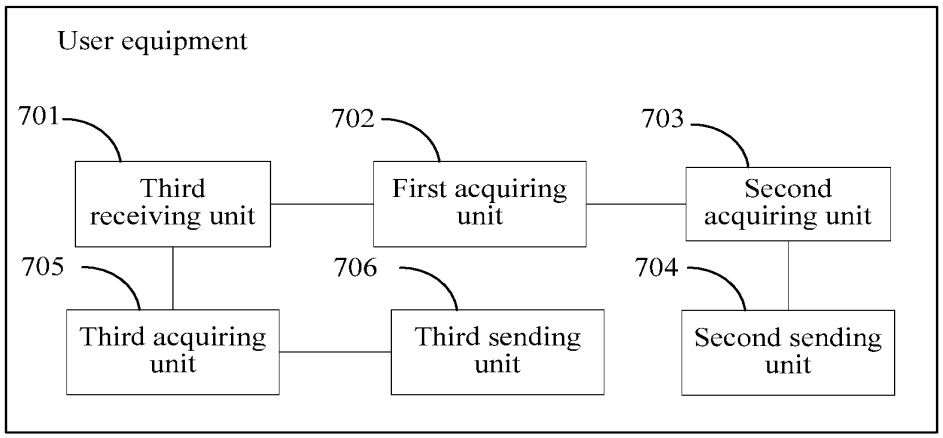


FIG. 8

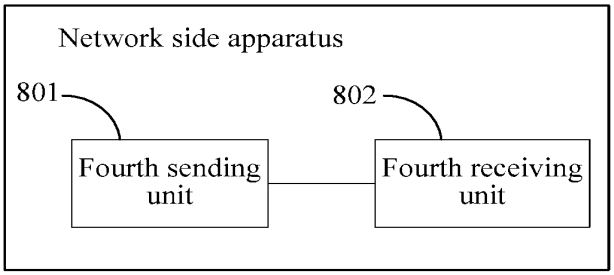


FIG. 9

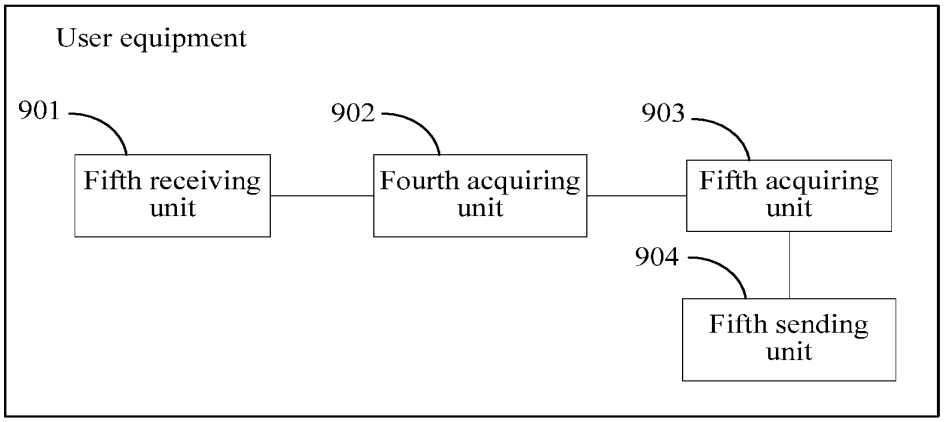


FIG. 10

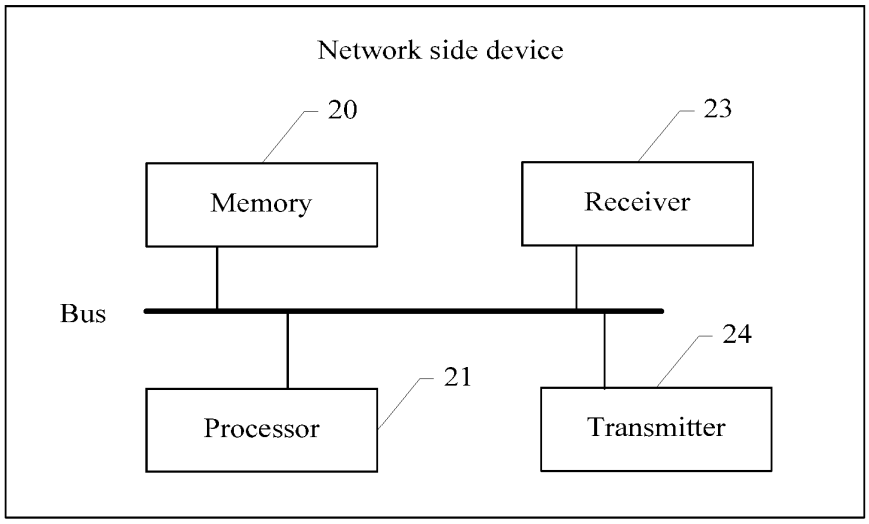

Network side device
20
23
Memory
Receiver
Bus
24
21
Processor
Transmitter

FIG. 11

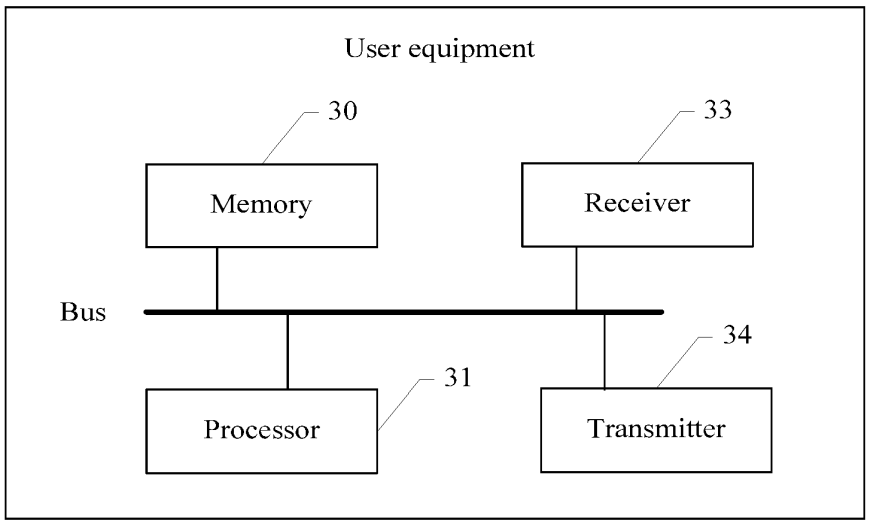

User equipment
30
33
Memory
Receiver
Bus
34
31
Processor
Transmitter

FIG. 12

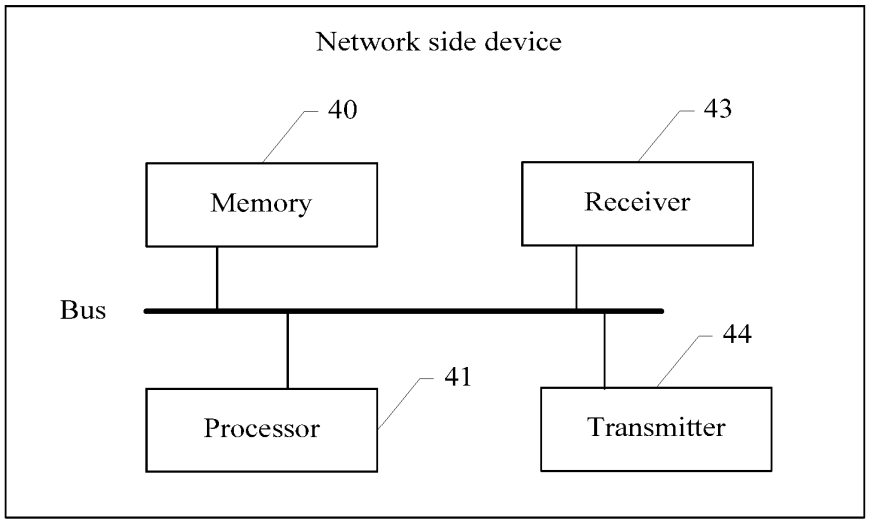

Network side device
40
43
Memory
Receiver
Bus
44
41
Processor
Transmitter

FIG. 13

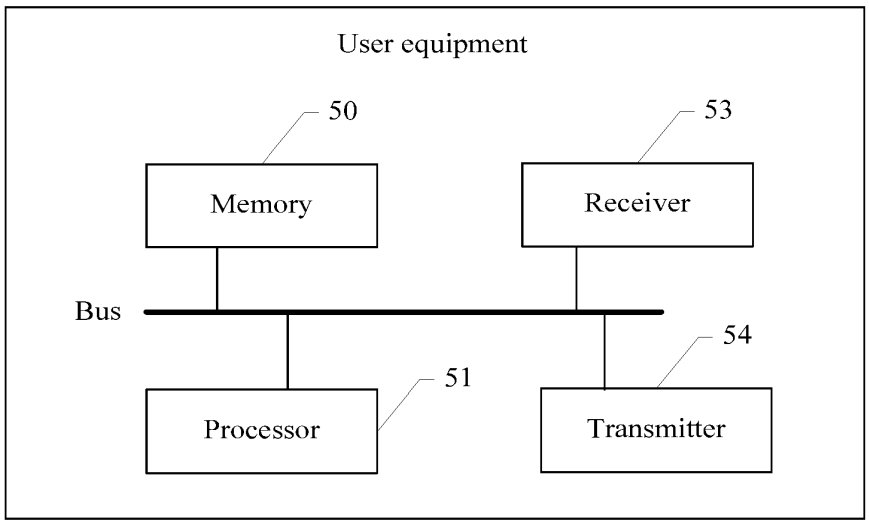

User equipment
50
53
Memory
Receiver
Bus
54
51
Processor
Transmitter

FIG. 14

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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- WO 2013081368 A1 **[0006]**

(12) 按照专利合作条约所公布的国际申请

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(54) Title: CHANNEL INFORMATION FEEDBACK METHOD, AND PILOT AND BEAM TRANSMISSION METHOD, SYSTEM AND DEVICE

(54) 发明名称: 信道信息的反馈方法、导频及波束发送方法、系统及装置

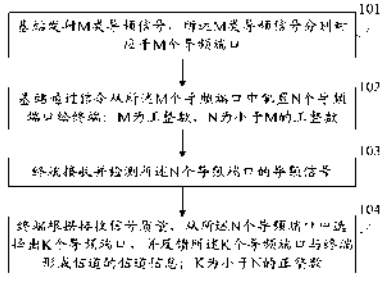


图 1 / FIG.1

101 TRANSMITTING, BY A BASE STATION, M TYPES OF PILOT SIGNALS, WHEREIN THE M TYPES OF PILOT SIGNALS RESPECTIVELY CORRESPOND TO M PILOT PORTS

102 CONFIGURING, BY THE BASE STATION, N PILOT PORTS FROM THE M PILOT PORTS TO A TERMINAL THROUGH SIGNALLING, WHERE M IS A POSITIVE INTEGER, AND N IS A POSITIVE INTEGER LESS THAN M

103 RECEIVING AND DETECTING, BY THE TERMINAL, PILOT SIGNALS OF THE N PILOT PORTS

104 ACCORDING TO THE QUALITY OF THE RECEIVED SIGNALS, SELECTING, BY THE TERMINAL, K PILOT PORTS FROM THE N PILOT PORTS, AND FEEDING BACK CHANNEL INFORMATION ABOUT A CHANNEL FORMED BY THE K PILOT PORTS AND THE TERMINAL, WHERE K IS A POSITIVE INTEGER LESS THAN N

(57) **Abstract**: Disclosed are a channel information feedback method, and a pilot and beam transmission method, system and device. The channel information feedback method comprises: transmitting, by a base station, M types of pilot signals, wherein the M types of pilot signals respectively correspond to M pilot ports; configuring, by the base station, N pilot ports from the M pilot ports to a terminal through signalling, where M is a positive integer, and N is a positive integer less than M; receiving and detecting, by the terminal, pilot signals of the N pilot ports; and according to the quality of the received signals, selecting K pilot ports from the N pilot ports, and feeding back channel information about a channel formed by the K pilot ports and the terminal, where K is a positive integer less than N.

(57) **摘要**: 本发明公开了一种信道信息的反馈方法、导频及波束发送方法、系统及装置，所述信道信息的反馈方法包括：基站发射 M 类导频信号，所述 M 类导频信号分别对应于 M 个导频端口；基站通过信令从所述 M 个导频端口中配置 N 个导频端口给终端；M 为正整数，N 为小于 M 的正整数；终端接收并检测所述 N 个导频端口的导频信号；根据接收信号质量，从所述 N 个导频端口中选择出 K 个导频端口，并反馈所述 K 个导频端口与终端形成信道的信道信息；K 为小于 N 的正整数。

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本国际公布:

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信道信息的反馈方法、导频及波束发送方法、系统及装置

技术领域

本发明涉及通信中的信道信息反馈技术，尤其涉及信道信息的反馈方法、导频及波束发送方法、系统及装置。

背景技术

在无线通信系统中，发送端和接收端采取空间复用的方式，使用多根天线来获取更高的数据传输速率。相对于一般的空间复用方式，一种增强的空间复用方式是通过接收端反馈信道信息给发送端，发送端根据获得的信道信息采用发射预编码技术进行数据的传输，能够极大提高传输性能。对于单用户多输入多输出（MIMO，Multi-Input Multi-Output），直接使用信道特征矢量信息进行预编码；对于多用户 MIMO，需要更加准确的信道信息。

在第四代移动电话行动通信标准（4G，fourth Generation of mobile phone mobile communications standards）的一些技术，如长期演进（LTE，Long Term Evolution）802.16m 标准规范中，信道信息的反馈主要是利用较简单的单一码本的反馈方法，而 MIMO 的发射预编码技术的性能更依赖于码本反馈的准确度。基于码本的信道信息量化反馈的基本原理如下：

假设有限反馈信道容量为 B bps/Hz，那么可用的码字的个数为 $N=2^B$ 个。信道矩阵的特征矢量空间经过量化构成码本空间 $\Re=\{F_1,F_2\cdots F_N\}$。发射端与接收端共同保存或实时产生此码本。接收端采用获得的信道矩阵 H，并根据一定准则从 $\Re$ 中选择一个与信道最匹配的码字 $\hat{F}$，并将码字序号 i 反馈至发射端。这里，码字序号是指预编码矩阵指示符（PMI，Precoding Matrix Indicator）。发射端根据此序号 i 查询到相应的预编码码字 $\hat{F}$，而获得信道信

息，这里，$\hat{r}$表示信道的特征矢量信息。

随着无线通信技术的高速发展，用户端的无线应用越来越丰富，这带动了无线数据业务迅速增长，然而，这也给无线接入网络带来了巨大的挑战。多天线技术是应对无线数据业务爆发式增长挑战的关键技术，目前4G支持的多天线技术仅仅支持最大 8 端口的水平维度波束赋形技术。多天线技术的演进主要围绕着以下几个目标：①更大的波束赋形/预编码增益；②更多的空间复用层数及更小的层间干扰；③更全面的覆盖；④更小的站点间干扰。大型 MIMO（Massive MIMO）是下一代无线通信中 MIMO 演进的最主要的技术。

对于 Massive MIMO 技术，基站侧配置有大规模天线阵列，比如 100 个天线，甚至更多，在数据传输的时候，利用多用户 MIMO（MU-MIMO，Multi-User-MIMO）技术同时同频复用多个用户，一般情况，天线数目是复用用户数目的 5 至 10 倍左右。无论是在视距环境的强相关信道，还是富散射下的非相关信道，任意两个用户的信道之间的相关系数随着天线数目的增加成指数形式衰减，比如当基站侧配置有 100 根天线时，任意两个用户的信道之间相关系数趋近于 0，也即是说多用户对应信道之间接近正交。另一方面，大阵列可以带来非常可观的阵列增益和分集增益。

对于 Massive MIMO 技术，由于大量天线的引入，每根天线都需要发送信道状态信息参考符号（CSI-RS，Channel State Information-Reference Symbol），而终端检测 CSI-RS 并通过信道估计获得每个传输资源对应的信道矩阵，根据信道矩阵获得最佳的基带上每个频域子带预编码矢量和宽带的最佳传输层数信息，然后基于码本反馈技术进行反馈，这种方式在 Massive MIMO 中应用时存在比较大的问题。主要体现在如下方面：导频开销会随天线数目的增多而增加，除此之外，由于使用传统的码本反馈技术反馈时，使用的码本中需要包含非常多的码字，码字的选择十分困难，造

成终端的复杂度增加，难以实现；码本反馈的开销很大，导致上行链路的开销巨大。利用码本反馈技术很难在大规模天线系统中获得比较好的性能。

综上所述，对于大规模的天线系统，信道信息反馈的效率和反馈的复杂度是重要的技术问题，目前还没有有效的方法能够提高信道信息的反馈效率和降低反馈的复杂度，严重影响了 Massive MIMO 的工业实用性。

发明内容

为解决上述技术问题，本发明实施例提供了信道信息的反馈方法、导频及波束发送方法、系统及装置。

本发明实施例提供的信道信息的反馈方法包括:

基站发射 M 类导频信号，所述 M 类导频信号分别对应于 M 个导频端口；基站通过信令从所述 M 个导频端口中配置 N 个导频端口给终端；M 为正整数，N 为小于 M 的正整数;

终端接收并检测所述 N 个导频端口的导频信号；根据接收信号质量，从所述 N 个导频端口中选择出 K 个导频端口，并反馈所述 K 个导频端口与终端形成信道的信道信息；K 为小于 N 的正整数。

优选地，所述信道信息至少包括以下之一：K 个导频端口的索引信息、K 个导频端口之间的幅度比例信息、K 个导频端口之间的相位差信息、K 个导频端口的接收功率信息、K 个导频端口的信干噪比信息。

优选地，所述方法还包括:

通过相同的一组天线虚拟化形成所述 K 个导频端口；其中，K 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

优选地，所述方法还包括:

通过相同的一组天线虚拟化形成所述 N 个导频端口；其中，述 N 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

优选地，所述方法还包括:

所述基站根据所述终端反馈的信道统计信息确定所述 N 个导频端口；其中，所述信道统计信息为相关矩阵信息；所述 N 个导频端口对应的虚拟化预编码权值为相关矩阵特征矢量。

优选地，所述 N 个导频端口对应的虚拟化预编码权值为：DFT 矢量 v_k、或者 DFT 矢量的克罗内克积 $f(v_k, v_l)$；其中，

$$v_k = \begin{bmatrix} 1 & e^{j\phi_k} & \cdots & e^{j(n-1)\phi_k} \end{bmatrix}^H$$

$$f(v_k, v_l) = v_k \otimes v_l \text{ 或者 } f(v_k, v_l) = \begin{bmatrix} v_k \\ v_l \end{bmatrix}$$

其中，k,l 为正整数，j 为虚数单位，n 为大于 1 的正整数，ϕ_k 为相位参数；$[\ ]^H$ 表示共轭转置运算，$\otimes$ 为直乘符号。

优选地，所述方法还包括：

终端根据基站配置的功率门限从所述 N 个导频端口中选择出 K 个导频端口；其中，所述功率门限为相对门限或绝对门限。

优选地，所述方法还包括：

基站根据终端的上报的终端信息，从所述 M 个导频端口中配置 N 个导频端口给所述终端。

优选地，所述方法还包括：

终端反馈导频端口的选择信息，所述导频端口的选择信息采用选择的导频端口数目和选择的导频端口标识联合编码；其中，不同的导频端口被选择的概率不同，不同的导频端口数目对应的状态位不同。

本发明实施例提供的导频发送方法包括：

基站发射 M 类导频信号，所述 M 类导频信号分别对应于 M 个导频端口；基站通过信令从所述 M 个导频端口中配置 N 个导频端口给终端；M 为正整数，N 为小于 M 的正整数。

优选地，所述方法还包括：

通过相同的一组天线虚拟化形成所述 N 个导频端口；其中，述 N 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

优选地，所述方法还包括:

所述基站根据所述终端反馈的信道统计信息确定所述 N 个导频端口；其中，所述信道统计信息为相关矩阵信息；所述 N 个导频端口对应的虚拟化预编码权值为相关矩阵特征矢量。

优选地，所述 N 个导频端口对应的虚拟化预编码权值为：离散傅里叶变换 DFT 矢量 v_k 、或者由 DFT 矢量的克罗内克积 $f(v_k,v_l)$；其中，

$$v_k=\begin{bmatrix}1 & e^{j\phi_k} & \cdots & e^{j(n-1)\phi_k}\end{bmatrix}^H$$

$$f(v_k,v_l)=v_k\otimes v_l \text{ 或者 } f(v_k,v_l)=\begin{bmatrix}v_k\\v_l\end{bmatrix}$$

其中，k,l 为正整数，j 为虚数单位，n 为大于 1 的正整数，ϕ_k 为相位参数；$[\ ]^H$ 表示共轭转置运算，$\otimes$ 为直乘符号。

优选地，所述方法还包括:

基站根据终端的上报的终端信息，从所述 M 个导频端口中配置 N 个导频端口给所述终端。

本发明实施例提供的信道信息的反馈方法包括:

终端接收并检测由基站配置的 N 个导频端口的导频信号；根据接收信号质量，从所述 N 个导频端口中选择出 K 个导频端口，并反馈所述 K 个导频端口与终端形成信道的信道信息；K 为小于 N 的正整数。

优选地，所述信道信息至少包括以下之一：K 个导频端口的索引信息、K 个导频端口之间的幅度比例信息、K 个导频端口之间的相位差信息、K 个导频端口的接收功率信息、K 个导频端口的信干噪比信息。

优选地，所述方法还包括：所述方法还包括:

终端根据基站配置的功率门限从所述 N 个导频端口中选择出 K 个导频

端口；其中，所述功率门限为相对门限或绝对门限。

优选地，所述方法还包括：

终端反馈导频端口的选择信息，所述导频端口的选择信息采用选择的导频端口数目和选择的导频端口标识联合编码；其中，不同的导频端口被选择的概率不同，不同的导频端口数目对应的状态位不同。

优选地，所述方法还包括：

通过相同的一组天线虚拟化形成所述 K 个导频端口；其中，K 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

本发明实施例提供的波束发送方法包括：

基站预先选定 P 个波束权值，并根据终端反馈的信道相关矩阵对所述 P 个波束权值进行处理，获得 P 个新波束；将所述 P 个新波束发送至终端；

终端从所述 P 个新波束中选择 Q 个波束，并将所述 Q 个波束将反馈至基站。

优选地，所述信道相关矩阵是多个终端的相关矩阵信息的叠加合并。

优选地，所述 P 个波束权值为：P 个 DFT 矢量、或者是两个 DFT 矢量的函数。

本发明实施例提供的信道信息的反馈系统包括：基站、终端；其中，

所述基站，配置为发射 M 类导频信号，所述 M 类导频信号分别对应于 M 个导频端口；通过信令从所述 M 个导频端口中配置 N 个导频端口给终端；M 为正整数，N 为小于 M 的正整数；

所述终端，配置为接收并检测所述 N 个导频端口的导频信号；根据接收信号质量，从所述 N 个导频端口中选择出 K 个导频端口，并反馈所述 K 个导频端口与终端形成信道的信道信息；K 为小于 N 的正整数。

优选地，所述信道信息至少包括以下之一：K 个导频端口的索引信息、K 个导频端口之间的幅度比例信息、K 个导频端口之间的相位差信息、K

个导频端口的接收功率信息、K 个导频端口的信干噪比信息。

优选地，所述终端，还配置为通过相同的一组天线虚拟化形成所述 K 个导频端口；其中，K 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

优选地，所述基站，还配置为通过相同的一组天线虚拟化形成所述 N 个导频端口；其中，述 N 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

优选地，所述基站，还配置为根据所述终端反馈的信道统计信息确定所述 N 个导频端口；其中，所述信道统计信息为相关矩阵信息；所述 N 个导频端口对应的虚拟化预编码权值为相关矩阵特征矢量。

优选地，所述 N 个导频端口对应的虚拟化预编码权值为：离散傅里叶变换 DFT 矢量 v_k、或者 DFT 矢量的克罗内克积 $f(v_k,v_l)$；其中，

$$v_k=\begin{bmatrix}1 & e^{j\phi_k} & \cdots & e^{j(n-1)\phi_k}\end{bmatrix}^H$$

$$f(v_k,v_l)=v_k\otimes v_l \text{ 或者 } f(v_k,v_l)=\begin{bmatrix}v_k\\v_l\end{bmatrix}$$

其中，k,l 为正整数，j 为虚数单位，n 为大于 1 的正整数，ϕ_k 为相位参数；$[\ ]^H$ 表示共轭转置运算，$\otimes$ 为直乘符号。

优选地，所述终端，还配置为根据基站配置的功率门限从所述 N 个导频端口中选择出 K 个导频端口；其中，所述功率门限为相对门限或绝对门限。

优选地，所述基站，还配置为根据终端的上报的终端信息，从所述 M 个导频端口中配置 N 个导频端口给所述终端。

优选地，所述终端，还配置为反馈导频端口的选择信息，所述导频端口的选择信息采用选择的导频端口数目和选择的导频端口标识联合编码；其中，不同的导频端口被选择的概率不同，不同的导频端口数目对应的状

态位不同。

本发明实施例提供的基站包括：发射单元、配置单元；其中，

所述发射单元，配置为发射 M 类导频信号，所述 M 类导频信号分别对应于 M 个导频端口；

所述配置单元，配置为通过信令从所述 M 个导频端口中配置 N 个导频端口给终端；M 为正整数，N 为小于 M 的正整数。

优选地，所述基站还包括：虚拟化单元，配置为通过相同的一组天线虚拟化形成所述 N 个导频端口；其中，述 N 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

优选地，所述配置单元，还配置为根据所述终端反馈的信道统计信息确定所述 N 个导频端口；其中，所述信道统计信息为相关矩阵信息；所述 N 个导频端口对应的虚拟化预编码权值为相关矩阵特征矢量。

优选地，所述 N 个导频端口对应的虚拟化预编码权值为：离散傅里叶变换 DFT 矢量 v_k、或者由 DFT 矢量的克罗内克积 $f(v_k,v_l)$；其中，

$$v_k=\begin{bmatrix}1 & e^{j\phi_k} & \cdots & e^{j(n-1)\phi_k}\end{bmatrix}^H$$

$$f(v_k,v_l)=v_k\otimes v_l \text{ 或者 } f(v_k,v_l)=\begin{bmatrix}v_k\\ v_l\end{bmatrix}$$

其中，k,l 为正整数，j 为虚数单位，n 为大于 1 的正整数，ϕ_k 为相位参数；$[\ ]^H$ 表示共轭转置运算，$\otimes$ 为直乘符号。

优选地，所述配置单元，还配置为根据终端的上报的终端信息，从所述 M 个导频端口中配置 N 个导频端口给所述终端。

本发明实施例提供的终端包括：接收单元、选择单元、反馈单元；其中，

所述接收单元，配置为接收并检测由基站配置的 N 个导频端口的导频信号；

所述选择单元，配置为根据接收信号质量，从所述 N 个导频端口中选择出 K 个导频端口；

所述反馈单元，配置为反馈所述 K 个导频端口与终端形成信道的信道信息；K 为小于 N 的正整数。

优选地，所述信道信息至少包括以下之一：K 个导频端口的索引信息、K 个导频端口之间的幅度比例信息、K 个导频端口之间的相位差信息、K 个导频端口的接收功率信息、K 个导频端口的信干噪比信息。

优选地，所述选择单元，还配置为根据基站配置的功率门限从所述 N 个导频端口中选择出 K 个导频端口；其中，所述功率门限为相对门限或绝对门限。

优选地，所述反馈单元，还配置为反馈导频端口的选择信息，所述导频端口的选择信息采用选择的导频端口数目和选择的导频端口标识联合编码；其中，不同的导频端口被选择的概率不同，不同的导频端口数目对应的状态位不同。

优选地，所述终端还包括：虚拟化单元，配置为通过相同的一组天线虚拟化形成所述 K 个导频端口；其中，K 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

本发明实施例提供的波束发送系统包括：基站、终端；其中，

所述基站，配置为预先选定 P 个波束权值，并根据终端反馈的信道相关矩阵对所述 P 个波束权值进行处理，获得 P 个新波束；将所述 P 个新波束发送至终端；

所述终端，配置为从所述 P 个新波束中选择 Q 个波束，并将所述 Q 个波束将反馈至基站。

优选地，所述信道相关矩阵是多个终端的相关矩阵信息的叠加合并。

优选地，所述 P 个波束权值为：P 个 DFT 矢量、或者是两个 DFT 矢量

的函数。

本发明实施例的技术方案中，基站发射 M 类导频信号，所述 M 类导频信号分别对应于 M 个导频端口；基站通过信令从所述 M 个导频端口中配置 N 个导频端口给终端；M 为正整数，N 为小于 M 的正整数，如此，将 M 个导频端口的信道信息的维度降低至了 N 个导频端口的信道信息的维度，使得终端从所述 N 个导频端口中选择 K 个导频端口可以基于相关性确定的一个子空间内进行信道信息的反馈。并且，通过终端从所述 N 个导频端口中选择 K 个导频端口进行信道信息的反馈，能够进一步降低信道信息的维度，大大节约了信道信息反馈的开销。

附图说明

图 1 为本发明实施例一的信道信息的反馈方法的流程示意图；

图 2 为本发明实施例二的导频发送方法的流程示意图；

图 3 为本发明实施例三的信道信息的反馈方法的流程示意图；

图 4 为本发明实施例四的波束发送方法的流程示意图；

图 5 为本发明实施例一的信道信息的反馈系统的结构组成示意图；

图 6 为本发明实施例二的基站的结构组成示意图；

图 7 为本发明实施例三的终端的结构组成示意图；

图 8 为本发明实施例四的波束发送系统的结构组成示意图；

图 9 为本发明实施例的基站预编码的示意图；

图 10 为本发明实施例的 DFT 矢量预编码的示意图；

图 11 为本发明实施例的信道相关矩阵预编码的示意图；

图 12 为本发明实施例的基于波束权值进行信道信息反馈的示意图。

具体实施方式

为了能够更加详尽地了解本发明实施例的特点与技术内容，下面结合

附图对本发明实施例的实现进行详细阐述，所附附图仅供参考说明之用，并非用来限定本发明实施例。

图 1 为本发明实施例一的信道信息的反馈方法的流程示意图，本示例中的信道信息的反馈方法应用于信道信息的反馈系统中，如图 1 所示，本示例中的信道信息的反馈方法包括以下步骤:

步骤 101: 基站发射 M 类导频信号，所述 M 类导频信号分别对应于 M 个导频端口。

这里，M 为大于 1 的整数，例如 M 为 64。

具体地，参照图 9，基站具有 Nt 根相同的发射天线，Nt 为大于 1 的整数，每根发射天线发射出一路信号，Nt 根发射天线发射出 Nt 路信号，本实施例对 Nt 根发射天线发射出的 Nt 路信号进行虚拟化，而得到 M 类导频信号。这里，虚拟化具体为预编码，即对 Nt 路信号分别乘以对应的 Nt 个权值，而得到一类导频信号。基于此，Nt 个权值组成一套权值矢量，维度为 Nt，每类导频信号对应的所述一套权值矢量不同，也即 M 类导频信号对应于 M 套权值矢量。应当注意的是，由于权值矢量具有方向性，因此通过权值矢量进行预编码的导频信号也具备方向性。

步骤 102: 基站通过信令从所述 M 个导频端口中配置 N 个导频端口给终端; M 为正整数，N 为小于 M 的正整数。

优选地，所述方法还包括:

基站根据终端的上报的终端信息，从所述 M 个导频端口中配置 N 个导频端口给所述终端。

优选地，所述方法还包括:

通过相同的一组天线虚拟化形成所述 N 个导频端口; 其中，述 N 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

优选地，所述方法还包括:

所述基站根据所述终端反馈的信道统计信息确定所述 N 个导频端口；其中，所述信道统计信息为相关矩阵信息；所述 N 个导频端口对应的虚拟化预编码权值为相关矩阵特征矢量。

优选地，所述 N 个导频端口对应的虚拟化预编码权值为：离散傅里叶变换（DFT，Discrete Fourier Transform）矢量v_k、或者 DFT 矢量的克罗内克积$f(v_k,v_l)$；其中，

$$v_k=\begin{bmatrix}1 & e^{j\phi_k} & \cdots & e^{j(n-1)\phi_k}\end{bmatrix}^H$$

$$f(v_k,v_l)=v_k\otimes v_l \text{ 或者 } f(v_k,v_l)=\begin{bmatrix}v_k\\ v_l\end{bmatrix}$$

其中，k,l为正整数，j为虚数单位，n为大于 1 的正整数，ϕ_k为相位参数；$[\ ]^H$表示共轭转置运算，$\otimes$为直乘符号。

具体地，参照图 10，预设的波束权值可以是 DFT 矢量，M 类导频信号，也即 M 个导频端口对应的 M 个 DFT 矢量如公式（1）：

$$\begin{aligned}\mathbf{v_1}&=\begin{bmatrix}1 & e^{j\phi_1} & \cdots & e^{j(P1-1)\phi_1}\end{bmatrix}^H\\ \mathbf{v_2}&=\begin{bmatrix}1 & e^{j\phi_2} & \cdots & e^{j(P2-1)\phi_2}\end{bmatrix}^H\\ &\cdots\\ \mathbf{v_M}&=\begin{bmatrix}1 & e^{j\phi_M} & \cdots & e^{j(PM-1)\phi_M}\end{bmatrix}^H\end{aligned} \qquad (1)$$

其中，$\mathbf{v_1}$，$\mathbf{v_2}$，…，$\mathbf{v_M}$表示 M 个 DFT 矢量；$P1$，$P2$，…，PM均等于 Nt；ϕ_1，ϕ_2，…，ϕ_M为 0 至2π中均匀量化的相位参数；$[\quad\cdots\quad]^H$表示转置共轭。

上述 DFT 矢量利用了多径的原理，即以 DFT 矢量去对应径的最优波束权值。由于信道是由多径合成的，因此对于 M 类导频信号，有些导频端口收到较强的导频信号，收到较强导频信号也即多径分量较强；有些导频端口收到较弱的导频信号，收到较弱导频信号也即多径分量较弱。

上述方案中，Nt 根发射天线为线性阵列，当 Nt 根发射天线为其他形式

的天线阵列，例如二维天线阵列时，M 个导频信号对应的波束权值为两个 DFT 矢量的函数形式，如公式（2）:

$$f\left(\mathbf{v}_i, \mathbf{v}_j\right) = \mathbf{v}_i \otimes \mathbf{v}_j \qquad (2)$$

其中，$\mathbf{v}_i$和$\mathbf{v}_j$如公式（1）所示，$\mathbf{v}_i$对应的Pi和$\mathbf{v}_j$对应的Pj相乘等于发射天线的数目 Nt。

二维天线阵列的 M 个导频信号对应的波束权值还可以通过公式（3）得到:

$$f\left(\mathbf{v}_i, \mathbf{v}_j\right) = \begin{bmatrix} \mathbf{v}_i \\ \mathbf{v}_j \end{bmatrix} \qquad (3)$$

其中，$\mathbf{v}_i$和$\mathbf{v}_j$如公式（1）所示，$\mathbf{v}_i$对应的Pi以及$\mathbf{v}_j$对应的Pj均等于发射天线的数目的一半 Nt/2。

这里，不是每个终端都需要检测 M 类导频信号对应的 M 个导频端口，基站可以针对每个终端配置一些端口进行检测，比如对于用户设备（UE，User Equipment）1 可以配置 N1=16 个导频端口进行检测，对于 UE2 可以配置 N2=8 个导频端口进行检测，具体的导频端口可以是基站根据终端的位置信息或终端上报的一些粗的信道信息进行确定。

步骤 103：终端接收并检测所述 N 个导频端口的导频信号。

具体地，基站将 N 个导频端口的端口信息发送至终端。并且，终端根据所述端口信息，对所述 N 个导频端口的 N 类导频信号进行检测，以得到所述 N 类导频信号对应的接收功率；终端基于所述 N 类导频信号对应的接收功率，从所述 N 个导频端口中选择 K 个导频端口；终端将 K 个导频端口的信道信息发送至基站。

具体地，终端接收基站发送的 N 个导频端口的端口信息。这里，基站根据终端的位置信息或信道信息在生成的 M 个导频端口中选择 N 个导频端口，其中，N<M。

步骤 104：终端根据接收信号质量，从所述 N 个导频端口中选择出 K 个导频端口，并反馈所述 K 个导频端口与终端形成信道的信道信息；K 为小于 N 的正整数。

优选地，所述方法还包括:

终端根据基站配置的功率门限从所述 N 个导频端口中选择出 K 个导频端口；其中，所述功率门限为相对门限或绝对门限。

终端获取基站发送的端口信息后，在相应的端口位置上进行导频信号的检测，以得到所述 N 类导频信号对应的接收功率。具体地，当 N 为 8 时，

终端检测到导频信号 0 的接收功率为 a_0 dBm;

终端检测到导频信号 1 的接收功率为 a_1 dBm;

终端检测到导频信号 2 的接收功率为 a_2 dBm;

……

终端检测到导频信号 7 的接收功率为 a_7 dBm。

优选地，所述信道信息至少包括以下之一：K 个导频端口的索引信息、K 个导频端口之间的幅度比例信息、K 个导频端口之间的相位差信息、K 个导频端口的接收功率信息、K 个导频端口的信干噪比信息。

具体地，将所述 N 类导频信号对应的接收功率分别与预设的门限值进行比较;

当所述接收功率大于或等于所述门限值时，确定所述接收功率对应的导频端口为第一类端口;

当所述接收功率小于所述门限值时，确定所述接收功率对应的导频端口为第二类端口;

从所述 N 个导频端口中选择所述第一类端口，所述第一类端口的个数为 K。

或者，在所述 N 类导频信号对应的接收功率中确定出最大的接收功率;

将所述 N 类导频信号对应的接收功率分别与所述最大的接收功率进行比较；

当所述接收功率与所述最大的接收功率的比值大于或等于预设的阈值时，确定所述接收功率对应的导频端口为第一类端口；

当所述接收功率与所述最大的接收功率的比值小于所述阈值时，确定所述接收功率对应的导频端口为第二类端口；

从所述 N 个导频端口中选择所述第一类端口，所述第一类端口的个数为 K。

优选地，基站预先设置导频端口的最大数目，K 小于或等于所述导频端口的最大数目。

上述方案中，从所述 N 个导频端口中选择 K 个导频端口的两种选择方式可以结合，具体为：所选择的导频端口的导频信号的接收功率大于或等于所述门限值，并且所选择的导频端口的导频信号的接收功率与所述最大的接收功率的比值大于或等于预设的阈值时，所述导频端口为第一类端口。

优选地，所述方法还包括：

通过相同的一组天线虚拟化形成所述 K 个导频端口；其中，K 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

优选地，所述方法还包括：

终端反馈导频端口的选择信息，所述导频端口的选择信息采用选择的导频端口数目和选择的导频端口标识联合编码；其中，不同的导频端口被选择的概率不同，不同的导频端口数目对应的状态位不同。

本实施例中，在从所述 N 个导频端口中选择 K 个导频端口之后，还上报 K 个导频端口的选择信息，具体地，每个导频端口被选到的概率是不一样的，部分导频端口的选择概率高，部分导频端口的选择概率低，因此可以通过编码表示导频端口的概率。例如，以在 N=8 个导频端口中选出 K=2

个导频端口为例，编码信息如表 1 所示。

0000	Port1,Port2	1000	Port2,Port4
0001	Port1,Port3	1001	Port2,Port5
0010	Port1,Port4	1010	Port2,Port6
0011	Port1,Port5	1011	Port2,Port7
0100	Port1,Port6	1100	Port2,Port8
0101	Port1,Port7	1101	Port3,Port4
0110	Port1,Port8	1110	Port3,Port5
0111	Port2,Port3	1111	Port4,Port5

表 1

例如，以 N=8 个导频端口中选出 K=3 个导频端口为例，编码信息如表 2 所示。

0000	Port1,Port2,Port3	1000	Port1,Port3,Port6
0001	Port1,Port2,Port4	1001	Port1,Port3,Port7
0010	Port1,Port2,Port5	1010	Port1,Port3,Port8
0011	Port1,Port2,Port6	1011	Port2,Port3,Port4
0100	Port1,Port2,Port7	1100	Port2,Port3,Port5
0101	Port1,Port2,Port8	1101	Port2,Port3,Port6
0110	Port1,Port3,Port4	1110	Port2,Port3,Port7
0111	Port1,Port3,Port5	1111	Port2,Port3,Port8

表 2

另外，考虑到选择到的导频端口的数目也是不等概率的，例如，选到导频端口的数目为 2 和选到导频端口的数目为 4 的概率不同，因此，也可以进行导频端口数目与导频端口概率的联合编码，以压缩编码开销，编码信息如表 3 所示。

0000	Port1,Port2	1000	Port2,Port4
0001	Port1,Port3	1001	Port3,Port4
0010	Port1,Port4	1010	Port3,Port5
0011	Port1,Port5	1011	Port4,Port5
0100	Port1,Port6	1100	Port1,Port2,Port3
0101	Port1,Port7	1101	Port1,Port2,Port4
0110	Port1,Port8	1110	Port1,Port3,Port4
0111	Port2,Port3	1111	Port2,Port3,Port4

表 3

所述相位差信息是各接收天线收到的波束信号的平均后，再计算相位差。

具体地，对于选择的导频端口，终端反馈导频端口的幅度/功率信息，以及相位信息，这里较佳的是反馈导频端口之间的相对信息，比如幅度/功率比例，相位差信息。幅度功率比例可以采用以下方式：指示最强功率的导频端口，并反馈与最强功率的导频端口的幅度或功率的比例，具体地，如表 4 所示，首先指示一个幅度或功率的量级，然后再指示一个在该量级上的一个系数。该系数可以均匀量化。相位差信息可以在 0 至 2π 内均匀量化反馈。

00	$10^{-0.5}$

01	10^{-1}
10	$10^{-1.5}$
11	10^{-2}

表 4

这里，当波束权值为 DFT 矢量时，接收功率信息、相位差信息具体为多径的幅度和相位差信息，基站基于接收到的信道信息，可以重新构造波束权值，进而优化预编码。

图 2 为本发明实施例二的导频发送方法的流程示意图，本示例中的导频发送方法应用于基站中，如图 2 所示，本示例中的导频发送方法包括以下步骤：

步骤 201：基站发射 M 类导频信号，所述 M 类导频信号分别对应于 M 个导频端口。

步骤 202：基站通过信令从所述 M 个导频端口中配置 N 个导频端口给终端；M 为正整数，N 为小于 M 的正整数。

优选地，所述方法还包括：

通过相同的一组天线虚拟化形成所述 N 个导频端口；其中，述 N 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

优选地，所述方法还包括：

所述基站根据所述终端反馈的信道统计信息确定所述 N 个导频端口；其中，所述信道统计信息为相关矩阵信息；所述 N 个导频端口对应的虚拟化预编码权值为相关矩阵特征矢量。

优选地，所述 N 个导频端口对应的虚拟化预编码权值为：离散傅里叶变换 DFT 矢量 v_k、或者由 DFT 矢量的克罗内克积 $f(v_k, v_l)$；其中，

$$v_k = \begin{bmatrix} 1 & e^{j\psi_k} & \cdots & e^{j(n-1)\psi_k} \end{bmatrix}^H$$

$$f(v_k,v_l)=v_k\otimes v_l \text{ 或者 } f(v_k,v_l)=\begin{bmatrix}v_k\\v_l\end{bmatrix}$$

其中，k,l 为正整数，j 为虚数单位，n 为大于 1 的正整数，ϕ_k 为相位参数；$[\ ]^H$ 表示共轭转置运算，$\otimes$ 为直乘符号。

优选地，所述方法还包括:

基站根据终端的上报的终端信息，从所述 M 个导频端口中配置 N 个导频端口给所述终端。

图 3 为本发明实施例三的信道信息的反馈方法的流程示意图，本示例中的信道信息的反馈方法应用于终端中，如图 3 所示，本示例中的信道信息的反馈方法包括以下步骤:

步骤 301：终端接收并检测由基站配置的 N 个导频端口的导频信号。

步骤 302：根据接收信号质量，从所述 N 个导频端口中选择出 K 个导频端口。

优选地，所述方法还包括：所述方法还包括:

终端根据基站配置的功率门限从所述 N 个导频端口中选择出 K 个导频端口；其中，所述功率门限为相对门限或绝对门限。

步骤 303：反馈所述 K 个导频端口与终端形成信道的信道信息；K 为小于 N 的正整数。

优选地，所述信道信息至少包括以下之一：K 个导频端口的索引信息、K 个导频端口之间的幅度比例信息、K 个导频端口之间的相位差信息、K 个导频端口的接收功率信息、K 个导频端口的信干噪比信息。

优选地，所述方法还包括:

终端反馈导频端口的选择信息，所述导频端口的选择信息采用选择的导频端口数目和选择的导频端口标识联合编码；其中，不同的导频端口被选择的概率不同，不同的导频端口数目对应的状态位不同。

优选地，所述方法还包括:

通过相同的一组天线虚拟化形成所述 K 个导频端口；其中，K 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

图 4 为本发明实施例四的波束发送方法的流程示意图，本示例中的波束发送方法应用于波束发送系统中，如图 4 所示，本示例中的波束发送方法包括以下步骤:

步骤 401: 基站预先选定 P 个波束权值，并根据终端反馈的信道相关矩阵对所述 P 个波束权值进行处理，获得 P 个新波束；将所述 P 个新波束发送至终端。

优选地，所述信道相关矩阵是多个终端的相关矩阵信息的叠加合并。

具体地，将接收到的一个以上信道相关子矩阵进行叠加，而得到信道相关矩阵;

根据所述信道相关矩阵的特征矢量，对多个发射天线对应的信号进行预编码，而得到 M 类导频信号。

具体地，参照图 11，预设的波束权值还可以是信道相关矩阵 **R**，基站接收一个以上 UE 反馈的信道相关子矩阵，并将一个以上信道相关子矩阵进行叠加，得到信道相关矩阵 **R**。这里，信道相关子矩阵为终端的信道相关矩阵信息，例如信道相关矩阵 **R** 的每个元素的信息、信道相关矩阵 **R** 的特征值信息、信道相关矩阵 **R** 的特征矢量信息。

当波束权值为信道相关矩阵 **R** 时，基站基于接收到的一个以上终端发送的信道信息对所述相关矩阵 **R** 进行叠加，以重新构造波束权值，进而优化预编码。

具体地，参照图 12，基站预先选定 P 个波束权值，这 P 个波束权值可以是比较均匀的一些权值，即弦距离要大于一个门限，例如 0.9。选定的 P 个波束权值可以是一些 DFT 矢量，也可以是由格拉斯曼（Grassmanian）方法生成的一些 Nt 维空间中均匀的矢量。

终端反馈其对应的信道相关子矩阵，这个信道相关子矩阵是终端测量获取的。基站可以将一个终端的信道相关子矩阵或者多个终端的信道相关子矩阵的叠加值**R**作为波束权值旋转矩阵，将波束权值旋转矩阵乘以选定的P个波束权值，然后进行归一化的功率处理。

进行旋转后，均匀的 P 个波束会根据**R**中的相关性进行分布调整，对于部分子空间波束比较密集，部分子空间波束比较稀疏。而终端的特征矢量更多的处于波束比较密集的子空间。

终端在收到的导频信号中选择最优的一个或多个导频端口对应的信息上报至基站，基站可以根据终端上报的端口信息，查询到对应的导频端口及对应的波束权值，利用该波束权值进行预编码。

优选地，所述P个波束权值为：P个DFT矢量、或者是两个DFT矢量的函数。

步骤402：终端从所述P个新波束中选择Q个波束，并将所述Q个波束将反馈至基站。

图 5 为本发明实施例一的信道信息的反馈系统的结构组成示意图，如图5所示，所述系统包括：基站51、终端52；其中，

所述基站51，配置为发射M类导频信号，所述M类导频信号分别对应于M个导频端口；通过信令从所述M个导频端口中配置N个导频端口给终端52；M为正整数，N为小于M的正整数；

所述终端52，配置为接收并检测所述N个导频端口的导频信号；根据接收信号质量，从所述N个导频端口中选择出K个导频端口，并反馈所述K个导频端口与终端52形成信道的信道信息；K为小于N的正整数。

优选地，所述信道信息至少包括以下之一：K个导频端口的索引信息、K 个导频端口之间的幅度比例信息、K 个导频端口之间的相位差信息、K个导频端口的接收功率信息、K个导频端口的信干噪比信息。

优选地，所述终端 52，还配置为通过相同的一组天线虚拟化形成所述 K 个导频端口；其中，K 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

优选地，所述基站 51，还配置为通过相同的一组天线虚拟化形成所述 N 个导频端口；其中，述 N 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

优选地，所述基站 51，还配置为根据所述终端 52 反馈的信道统计信息确定所述 N 个导频端口；其中，所述信道统计信息为相关矩阵信息；所述 N 个导频端口对应的虚拟化预编码权值为相关矩阵特征矢量。

优选地，所述 N 个导频端口对应的虚拟化预编码权值为：离散傅里叶变换 DFT 矢量 v_k、或者 DFT 矢量的克罗内克积 $f(v_k,v_l)$；其中，

$$v_k=\begin{bmatrix}1 & e^{j\phi_k} & \cdots & e^{j(n-1)\phi_k}\end{bmatrix}^H$$

$$f(v_k,v_l)=v_k\otimes v_l \text{ 或者 } f(v_k,v_l)=\begin{bmatrix}v_k\\ v_l\end{bmatrix}$$

其中，k,l 为正整数，j 为虚数单位，n 为大于 1 的正整数，ϕ_k 为相位参数；$[\ ]^H$ 表示共轭转置运算，$\otimes$ 为直乘符号。

优选地，所述终端 52，还配置为根据基站 51 配置的功率门限从所述 N 个导频端口中选择出 K 个导频端口；其中，所述功率门限为相对门限或绝对门限。

优选地，所述基站 51，还配置为根据终端 52 的上报的终端 52 信息，从所述 M 个导频端口中配置 N 个导频端口给所述终端 52。

优选地，所述终端 52，还配置为反馈导频端口的选择信息，所述导频端口的选择信息采用选择的导频端口数目和选择的导频端口标识联合编码；其中，不同的导频端口被选择的概率不同，不同的导频端口数目对应的状态位不同。

本领域技术人员应当理解，图 5 所示的信道信息的反馈系统中的基站 51 和终端 52 的实现功能可参照前述信道信息的反馈方法的相关描述而理解。

图 6 为本发明实施例二的基站的结构组成示意图，如图 6 所示，所述基站包括：发射单元 61、配置单元 62；其中，

所述发射单元 61，配置为发射 M 类导频信号，所述 M 类导频信号分别对应于 M 个导频端口；

所述配置单元 62，配置为通过信令从所述 M 个导频端口中配置 N 个导频端口给终端；M 为正整数，N 为小于 M 的正整数。

优选地，所述基站还包括：虚拟化单元 63，配置为通过相同的一组天线虚拟化形成所述 N 个导频端口；其中，述 N 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

优选地，所述配置单元 62，还配置为根据所述终端反馈的信道统计信息确定所述 N 个导频端口；其中，所述信道统计信息为相关矩阵信息；所述 N 个导频端口对应的虚拟化预编码权值为相关矩阵特征矢量。

优选地，所述 N 个导频端口对应的虚拟化预编码权值为：离散傅里叶变换 DFT 矢量 v_k 、或者由 DFT 矢量的克罗内克积 $f(v_k,v_l)$；其中，

$$v_k=\begin{bmatrix}1 & e^{j\phi_k} & \cdots & e^{j(n-1)\phi_k}\end{bmatrix}^H$$

$$f(v_k,v_l)=v_k\otimes v_l \text{ 或者 } f(v_k,v_l)=\begin{bmatrix}v_k\\ v_l\end{bmatrix}$$

其中，k,l 为正整数，j 为虚数单位，n 为大于 1 的正整数，ϕ_k 为相位参数；$[\ ]^H$ 表示共轭转置运算，$\otimes$ 为直乘符号。

优选地，所述配置单元 62，还配置为根据终端的上报的终端信息，从所述 M 个导频端口中配置 N 个导频端口给所述终端。

本领域技术人员应当理解，图 6 所示的基站中的各单元的实现功能可

参照前述导频发送方法的相关描述而理解。

在实际应用中，所述基站中的发射单元 61、配置单元 62 以及虚拟化单元 63 可由基站中的中央处理器（CPU，Central Processing Unit）、或数字信号处理器（DSP，Digital Signal Processor）、或可编程门阵列（FPGA，Field－Programmable Gate Array）实现。

图 7 为本发明实施例三的终端的结构组成示意图，如图 7 所示，所述终端包括：接收单元 71、选择单元 72、反馈单元 73；其中，

所述接收单元 71，配置为接收并检测由基站配置的 N 个导频端口的导频信号；

所述选择单元 72，配置为根据接收信号质量，从所述 N 个导频端口中选择出 K 个导频端口；

所述反馈单元 73，配置为反馈所述 K 个导频端口与终端形成信道的信道信息；K 为小于 N 的正整数。

优选地，所述信道信息至少包括以下之一：K 个导频端口的索引信息、K 个导频端口之间的幅度比例信息、K 个导频端口之间的相位差信息、K 个导频端口的接收功率信息、K 个导频端口的信干噪比信息。

优选地，所述选择单元 72，还配置为根据基站配置的功率门限从所述 N 个导频端口中选择出 K 个导频端口；其中，所述功率门限为相对门限或绝对门限。

优选地，所述反馈单元 73，还配置为反馈导频端口的选择信息，所述导频端口的选择信息采用选择的导频端口数目和选择的导频端口标识联合编码；其中，不同的导频端口被选择的概率不同，不同的导频端口数目对应的状态位不同。

优选地，所述终端还包括：虚拟化单元 74，配置为通过相同的一组天线虚拟化形成所述 K 个导频端口；其中，K 个导频端口中的每个导频端口

均对应一套虚拟化预编码权值。

本领域技术人员应当理解，图 7 所示的终端中的各单元的实现功能可参照前述信道信息的反馈方法的相关描述而理解。

在实际应用中，所述终端中的接收单元 71、选择单元 72、反馈单元 73 以及虚拟化单元 74 可由终端中的 CPU、或 DSP、或 FPGA 实现。

图 8 为本发明实施例四的波束发送系统的结构组成示意图，如图 8 所示，所述系统包括：基站 81、终端 82；其中，

所述基站 81，配置为预先选定 P 个波束权值，并根据终端 82 反馈的信道相关矩阵对所述 P 个波束权值进行处理，获得 P 个新波束；将所述 P 个新波束发送至终端 82；

所述终端 82，配置为从所述 P 个新波束中选择 Q 个波束，并将所述 Q 个波束将反馈至基站 81。

优选地，所述信道相关矩阵是多个终端 82 的相关矩阵信息的叠加合并。

优选地，所述 P 个波束权值为：P 个 DFT 矢量、或者是两个 DFT 矢量的函数。

本领域技术人员应当理解，图 8 所示的波束发送系统中的基站 81、终端 82 的实现功能可参照前述波束发送方法的相关描述而理解。

在本申请所提供的几个实施例中，应该理解到，所揭露的设备和方法，可以通过其它的方式实现。以上所描述的设备实施例仅仅是示意性的，例如，所述单元的划分，仅仅为一种逻辑功能划分，实际实现时可以有另外的划分方式，如：多个单元或组件可以结合，或可以集成到另一个系统，或一些特征可以忽略，或不执行。另外，所显示或讨论的各组成部分相互之间的耦合、或直接耦合、或通信连接可以是通过一些接口，设备或单元的间接耦合或通信连接，可以是电性的、机械的或其它形式的。

上述作为分离部件说明的单元可以是、或也可以不是物理上分开的，

作为单元显示的部件可以是、或也可以不是物理单元，即可以位于一个地方，也可以分布到多个网络单元上；可以根据实际的需要选择其中的部分或全部单元来实现本实施例方案的目的。

另外，在本发明各实施例中的各功能单元可以全部集成在一个处理单元中，也可以是各单元分别单独作为一个单元，也可以两个或两个以上单元集成在一个单元中；上述集成的单元既可以采用硬件的形式实现，也可以采用硬件加软件功能单元的形式实现。

本领域普通技术人员可以理解：实现上述方法实施例的全部或部分步骤可以通过程序指令相关的硬件来完成，前述的程序可以存储于一计算机可读取存储介质中，该程序在执行时，执行包括上述方法实施例的步骤；而前述的存储介质包括：移动存储设备、只读存储器（ROM，Read Only Memory）、磁碟或者光盘等各种可以存储程序代码的介质。

或者，本发明上述集成的单元如果以软件功能模块的形式实现并作为独立的产品销售或使用时，也可以存储在一个计算机可读取存储介质中。基于这样的理解，本发明实施例的技术方案本质上或者说对现有技术做出贡献的部分可以以软件产品的形式体现出来，该计算机软件产品存储在一个存储介质中，包括若干指令用以使得一台计算机设备（可以是个人计算机、服务器、或者网络设备等）执行本发明各个实施例所述方法的全部或部分。而前述的存储介质包括：移动存储设备、只读存储器（ROM，Read Only Memory）、磁碟或者光盘等各种可以存储程序代码的介质。

以上所述，仅为本发明的具体实施方式，但本发明的保护范围并不局限于此，任何熟悉本技术领域的技术人员在本发明揭露的技术范围内，可轻易想到变化或替换，都应涵盖在本发明的保护范围之内。因此，本发明的保护范围应以所述权利要求的保护范围为准。

以上所述，仅为本发明的较佳实施例而已，并非用于限定本发明的保

护范围。

权利要求书

1、一种信道信息的反馈方法，所述方法包括:

基站发射 M 类导频信号，所述 M 类导频信号分别对应于 M 个导频端口；基站通过信令从所述 M 个导频端口中配置 N 个导频端口给终端；M 为正整数，N 为小于 M 的正整数;

终端接收并检测所述 N 个导频端口的导频信号；根据接收信号质量，从所述 N 个导频端口中选择出 K 个导频端口，并反馈所述 K 个导频端口与终端形成信道的信道信息；K 为小于 N 的正整数。

2、根据权利要求 1 所述的信道信息的反馈方法，其中，所述信道信息至少包括以下之一：K 个导频端口的索引信息、K 个导频端口之间的幅度比例信息、K 个导频端口之间的相位差信息、K 个导频端口的接收功率信息、K 个导频端口的信干噪比信息。

3、根据权利要求 1 所述的信道信息的反馈方法，其中，所述方法还包括:

通过相同的一组天线虚拟化形成所述 K 个导频端口；其中，所述 K 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

4、根据权利要求 1 所述的信道信息的反馈方法，其中，所述方法还包括:

通过相同的一组天线虚拟化形成所述 N 个导频端口；其中，所述 N 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

5、根据权利要求 4 所述的信道信息的反馈方法，其中，所述方法还包括:

所述基站根据所述终端反馈的信道统计信息确定所述 N 个导频端口；其中，所述信道统计信息为相关矩阵信息；所述 N 个导频端口对应的虚拟化预编码权值为相关矩阵特征矢量。

6、根据权利要求 1 所述的信道信息的反馈方法，其中，所述 N 个导频端口对应的虚拟化预编码权值为：离散傅里叶变换 DFT 矢量v_k、或者 DFT 矢量的克罗内克积$f(v_k,v_l)$；其中，

$$v_k=\begin{bmatrix}1 & e^{j\phi_k} & \cdots & e^{j(n-1)\phi_k}\end{bmatrix}^H$$

$$f(v_k,v_l)=v_k\otimes v_l \text{ 或者 } f(v_k,v_l)=\begin{bmatrix}v_k\\v_l\end{bmatrix}$$

其中，k,l为正整数，j为虚数单位，n为大于 1 的正整数，ϕ_k为相位参数；$[\ ]^H$表示共轭转置运算，$\otimes$为直乘符号。

7、根据权利要求 1 所述的信道信息的反馈方法，其中，所述方法还包括:

终端根据基站配置的功率门限从所述 N 个导频端口中选择出 K 个导频端口；其中，所述功率门限为相对门限或绝对门限。

8、根据权利要求 1 所述的信道信息的反馈方法，其中，所述方法还包括:

基站根据终端的上报的终端信息，从所述 M 个导频端口中配置 N 个导频端口给所述终端。

9、根据权利要求 1 至 8 任一项所述的信道信息的反馈方法，其中，所述方法还包括:

终端反馈导频端口的选择信息，所述导频端口的选择信息采用选择的导频端口数目和选择的导频端口标识联合编码；其中，不同的导频端口被选择的概率不同，不同的导频端口数目对应的状态位不同。

10、一种导频发送方法，所述方法包括:

基站发射 M 类导频信号，所述 M 类导频信号分别对应于 M 个导频端口；基站通过信令从所述 M 个导频端口中配置 N 个导频端口给终端；M 为正整数，N 为小于 M 的正整数。

11、根据权利要求 10 所述的导频发送方法，其中，所述方法还包括:

通过相同的一组天线虚拟化形成所述 N 个导频端口；其中，述 N 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

12、根据权利要求 10 所述的导频发送方法，其中，所述方法还包括:

所述基站根据所述终端反馈的信道统计信息确定所述 N 个导频端口；其中，所述信道统计信息为相关矩阵信息；所述 N 个导频端口对应的虚拟化预编码权值为相关矩阵特征矢量。

13、根据权利要求 10 所述的导频发送方法，其中，所述 N 个导频端口对应的虚拟化预编码权值为：离散傅里叶变换 DFT 矢量 v_k、或者由 DFT 矢量的克罗内克积 $f(v_k,v_l)$；其中，

$$v_k=\begin{bmatrix}1 & e^{j\phi_k} & \cdots & e^{j(n-1)\phi_k}\end{bmatrix}^H$$

$$f(v_k,v_l)=v_k\otimes v_l \text{ 或者 } f(v_k,v_l)=\begin{bmatrix}v_k\\ v_l\end{bmatrix}$$

其中，k,l 为正整数，j 为虚数单位，n 为大于 1 的正整数，ϕ_k 为相位参数；$[\ ]^H$ 表示共轭转置运算，$\otimes$ 为直乘符号。

14、根据权利要求 10 至 13 任一项所述的导频发送方法，其中，所述方法还包括:

基站根据终端的上报的终端信息，从所述 M 个导频端口中配置 N 个导频端口给所述终端。

15、一种信道信息的反馈方法，所述方法包括:

终端接收并检测由基站配置的 N 个导频端口的导频信号；根据接收信号质量，从所述 N 个导频端口中选择出 K 个导频端口，并反馈所述 K 个导频端口与终端形成信道的信道信息；K 为小于 N 的正整数。

16、根据权利要求 15 所述的信道信息的反馈方法，其中，所述信道信息至少包括以下之一：K 个导频端口的索引信息、K 个导频端口之间的幅

度比例信息、K 个导频端口之间的相位差信息、K 个导频端口的接收功率信息、K 个导频端口的信干噪比信息。

17、根据权利要求 15 所述的信道信息的反馈方法，其中，所述方法还包括：所述方法还包括：

终端根据基站配置的功率门限从所述 N 个导频端口中选择出 K 个导频端口；其中，所述功率门限为相对门限或绝对门限。

18、根据权利要求 15 所述的信道信息的反馈方法，其中，所述方法还包括：

终端反馈导频端口的选择信息，所述导频端口的选择信息采用选择的导频端口数目和选择的导频端口标识联合编码；其中，不同的导频端口被选择的概率不同，不同的导频端口数目对应的状态位不同。

19、根据权利要求 15 至 18 任一项所述的信道信息的反馈方法，其中，所述方法还包括：

通过相同的一组天线虚拟化形成所述 K 个导频端口；其中，K 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

20、一种波束发送方法，所述方法包括：

基站预先选定 P 个波束权值，并根据终端反馈的信道相关矩阵对所述 P 个波束权值进行处理，获得 P 个新波束；将所述 P 个新波束发送至终端；

终端从所述 P 个新波束中选择 Q 个波束，并将所述 Q 个波束将反馈至基站。

21、根据权利要求 20 所述的波束发送方法，其中，所述信道相关矩阵为多个终端的相关矩阵信息的叠加合并。

22、根据权利要求 20 或 21 所述的波束发送方法，其中，所述 P 个波束权值为：P 个 DFT 矢量、或者两个 DFT 矢量的函数。

23、一种信道信息的反馈系统，所述系统包括：基站、终端；其中，

所述基站，配置为发射 M 类导频信号，所述 M 类导频信号分别对应于 M 个导频端口；通过信令从所述 M 个导频端口中配置 N 个导频端口给终端；M 为正整数，N 为小于 M 的正整数；

所述终端，配置为接收并检测所述 N 个导频端口的导频信号；根据接收信号质量，从所述 N 个导频端口中选择出 K 个导频端口，并反馈所述 K 个导频端口与终端形成信道的信道信息；K 为小于 N 的正整数。

24、根据权利要求 23 所述的信道信息的反馈系统，其中，所述信道信息至少包括以下之一：K 个导频端口的索引信息、K 个导频端口之间的幅度比例信息、K 个导频端口之间的相位差信息、K 个导频端口的接收功率信息、K 个导频端口的信干噪比信息。

25、根据权利要求 23 所述的信道信息的反馈系统，其中，所述终端，还配置为通过相同的一组天线虚拟化形成所述 K 个导频端口；其中，K 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

26、根据权利要求 23 所述的信道信息的反馈系统，其中，所述基站，还配置为通过相同的一组天线虚拟化形成所述 N 个导频端口；其中，述 N 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

27、根据权利要求 26 所述的信道信息的反馈系统，其中，所述基站，还配置为根据所述终端反馈的信道统计信息确定所述 N 个导频端口；其中，所述信道统计信息为相关矩阵信息；所述 N 个导频端口对应的虚拟化预编码权值为相关矩阵特征矢量。

28、根据权利要求 23 所述的信道信息的反馈系统，其中，所述 N 个导频端口对应的虚拟化预编码权值为：离散傅里叶变换 DFT 矢量 v_k、或者 DFT 矢量的克罗内克积 $f(v_k, v_l)$；其中，

$$v_k = \begin{bmatrix} 1 & e^{j\phi_k} & \cdots & e^{j(n-1)\phi_k} \end{bmatrix}^H$$

$$f(v_k,v_l)=v_k\otimes v_l \text{ 或者 } f(v_k,v_l)=\begin{bmatrix}v_k\\v_l\end{bmatrix}$$

其中，k,l 为正整数，j 为虚数单位，n 为大于 1 的正整数，ϕ_k 为相位参数；$[\ ]^H$ 表示共轭转置运算，$\otimes$ 为直乘符号。

29、根据权利要求 23 所述的信道信息的反馈系统，其中，所述终端，还配置为根据基站配置的功率门限从所述 N 个导频端口中选择出 K 个导频端口；其中，所述功率门限为相对门限或绝对门限。

30、根据权利要求 23 所述的信道信息的反馈系统，其中，所述基站，还配置为根据终端的上报的终端信息，从所述 M 个导频端口中配置 N 个导频端口给所述终端。

31、根据权利要求 23 至 30 任一项所述的信道信息的反馈系统，其中，所述终端，还配置为反馈导频端口的选择信息，所述导频端口的选择信息采用选择的导频端口数目和选择的导频端口标识联合编码；其中，不同的导频端口被选择的概率不同，不同的导频端口数目对应的状态位不同。

32、一种基站，所述基站包括：发射单元、配置单元；其中，

所述发射单元，配置为发射 M 类导频信号，所述 M 类导频信号分别对应于 M 个导频端口；

所述配置单元，配置为通过信令从所述 M 个导频端口中配置 N 个导频端口给终端；M 为正整数，N 为小于 M 的正整数。

33、根据权利要求 32 所述的基站，其中，所述基站还包括：虚拟化单元，配置为通过相同的一组天线虚拟化形成所述 N 个导频端口；其中，述 N 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

34、根据权利要求 32 所述的基站，其中，所述配置单元，还配置为根据所述终端反馈的信道统计信息确定所述 N 个导频端口；其中，所述信道统计信息为相关矩阵信息；所述 N 个导频端口对应的虚拟化预编码权值为相关矩阵特征矢量。

35、根据权利要求 32 所述的基站，其中，所述 N 个导频端口对应的虚拟化预编码权值为：离散傅里叶变换 DFT 矢量 v_k、或者由 DFT 矢量的克罗内克积 $f(v_k,v_l)$；其中，

$$v_k=\begin{bmatrix}1 & e^{j\phi_k} & \cdots & e^{j(n-1)\phi_k}\end{bmatrix}^H$$

$$f(v_k,v_l)=v_k\otimes v_l \text{ 或者 } f(v_k,v_l)=\begin{bmatrix}v_k\\v_l\end{bmatrix}$$

其中，k,l 为正整数，j 为虚数单位，n 为大于 1 的正整数，ϕ_k 为相位参数；$[\ ]^H$ 表示共轭转置运算，$\otimes$ 为直乘符号。

36、根据权利要求 32 至 35 任一项所述的基站，其中，所述配置单元，还配置为根据终端的上报的终端信息，从所述 M 个导频端口中配置 N 个导频端口给所述终端。

37、一种终端，所述终端包括：接收单元、选择单元、反馈单元；其中，

所述接收单元，配置为接收并检测由基站配置的 N 个导频端口的导频信号；

所述选择单元，配置为根据接收信号质量，从所述 N 个导频端口中选择出 K 个导频端口；

所述反馈单元，配置为反馈所述 K 个导频端口与终端形成信道的信道信息；K 为小于 N 的正整数。

38、根据权利要求 37 所述的终端，其中，所述信道信息至少包括以下之一：K 个导频端口的索引信息、K 个导频端口之间的幅度比例信息、K 个导频端口之间的相位差信息、K 个导频端口的接收功率信息、K 个导频端口的信干噪比信息。

39、根据权利要求 37 所述的终端，其中，所述选择单元，还配置为根据基站配置的功率门限从所述 N 个导频端口中选择出 K 个导频端口；其中，

所述功率门限为相对门限或绝对门限。

40、根据权利要求 37 所述的终端，其中，所述反馈单元，还配置为反馈导频端口的选择信息，所述导频端口的选择信息采用选择的导频端口数目和选择的导频端口标识联合编码；其中，不同的导频端口被选择的概率不同，不同的导频端口数目对应的状态位不同。

41、根据权利要求 37 至 40 任一项所述的终端，其中，所述终端还包括：虚拟化单元，配置为通过相同的一组天线虚拟化形成所述 K 个导频端口；其中，K 个导频端口中的每个导频端口均对应一套虚拟化预编码权值。

42、一种波束发送系统，所述系统包括：基站、终端；其中，

所述基站，配置为预先选定 P 个波束权值，并根据终端反馈的信道相关矩阵对所述 P 个波束权值进行处理，获得 P 个新波束；将所述 P 个新波束发送至终端；

所述终端，配置为从所述 P 个新波束中选择 Q 个波束，并将所述 Q 个波束将反馈至基站。

43、根据权利要求 42 所述的波束发送系统，其中，所述信道相关矩阵为多个终端的相关矩阵信息的叠加合并。

44、根据权利要求 42 或 43 所述的波束发送系统，其中，所述 P 个波束权值为：P 个 DFT 矢量、或者两个 DFT 矢量的函数。

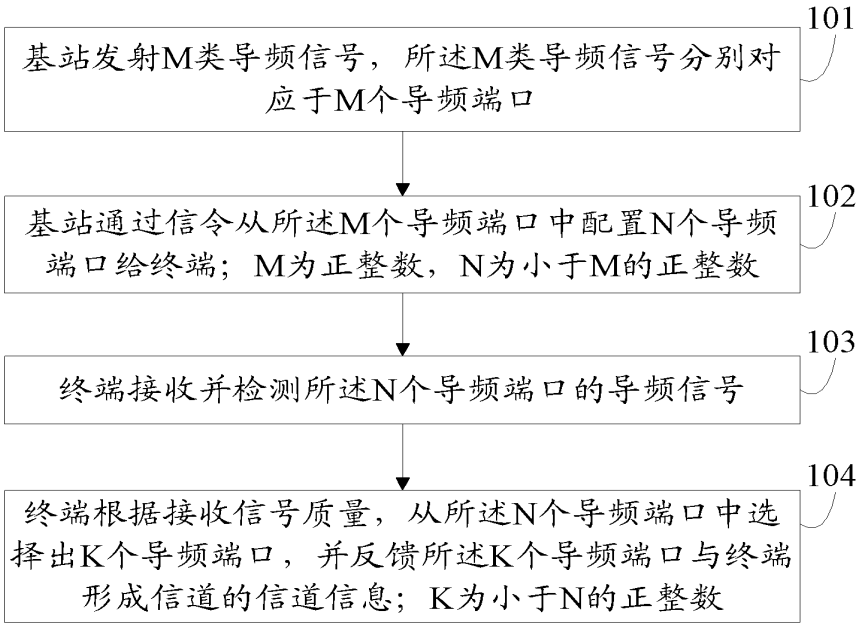

101
基站发射M类导频信号，所述M类导频信号分别对应于M个导频端口
102
基站通过信令从所述M个导频端口中配置N个导频端口给终端；M为正整数，N为小于M的正整数
103
终端接收并检测所述N个导频端口的导频信号
104
终端根据接收信号质量，从所述N个导频端口中选择出K个导频端口，并反馈所述K个导频端口与终端形成信道的信道信息；K为小于N的正整数

图 1

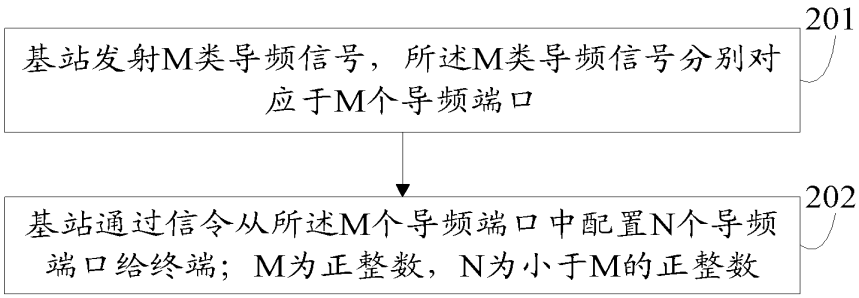

201
基站发射M类导频信号，所述M类导频信号分别对应于M个导频端口
202
基站通过信令从所述M个导频端口中配置N个导频端口给终端；M为正整数，N为小于M的正整数

图 2

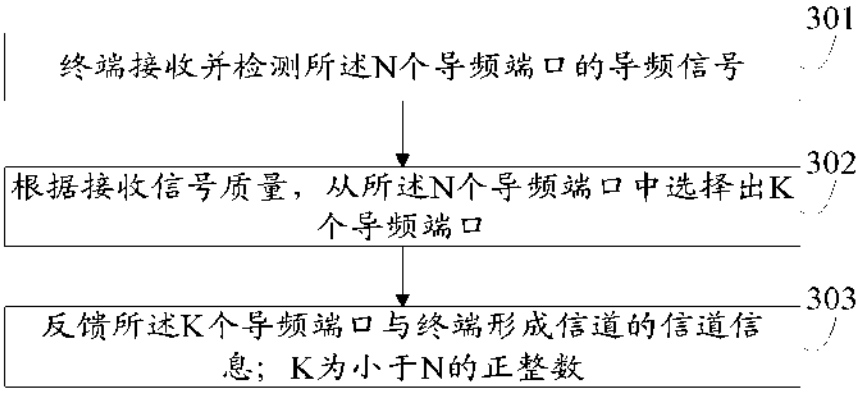

301
终端接收并检测所述N个导频端口的导频信号
302
根据接收信号质量，从所述N个导频端口中选择出K个导频端口
303
反馈所述K个导频端口与终端形成信道的信道信息；K为小于N的正整数

图 3

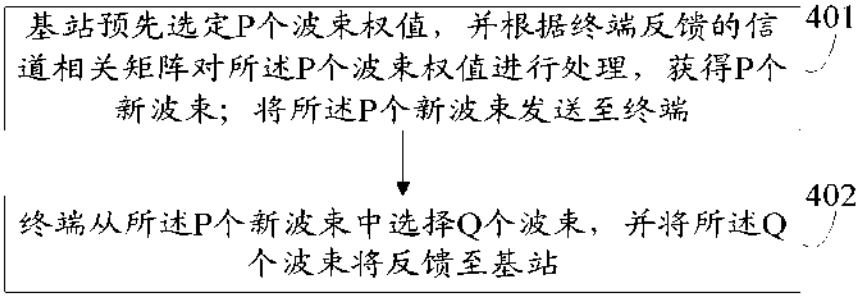

401
基站预先选定P个波束权值，并根据终端反馈的信道相关矩阵对所述P个波束权值进行处理，获得P个新波束；将所述P个新波束发送至终端
402
终端从所述P个新波束中选择Q个波束，并将所述Q个波束将反馈至基站

图 4

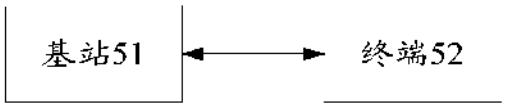

基站51
终端52

图 5

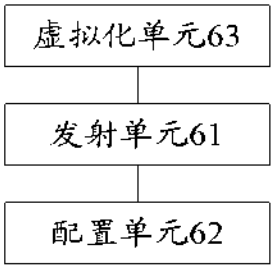

虚拟化单元63
发射单元61
配置单元62

图 6

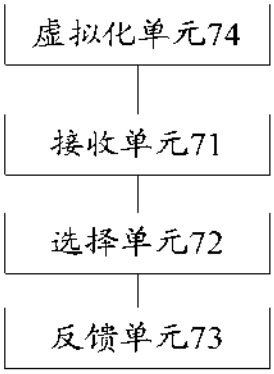


图 7

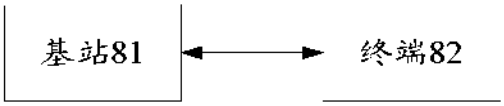


图 8

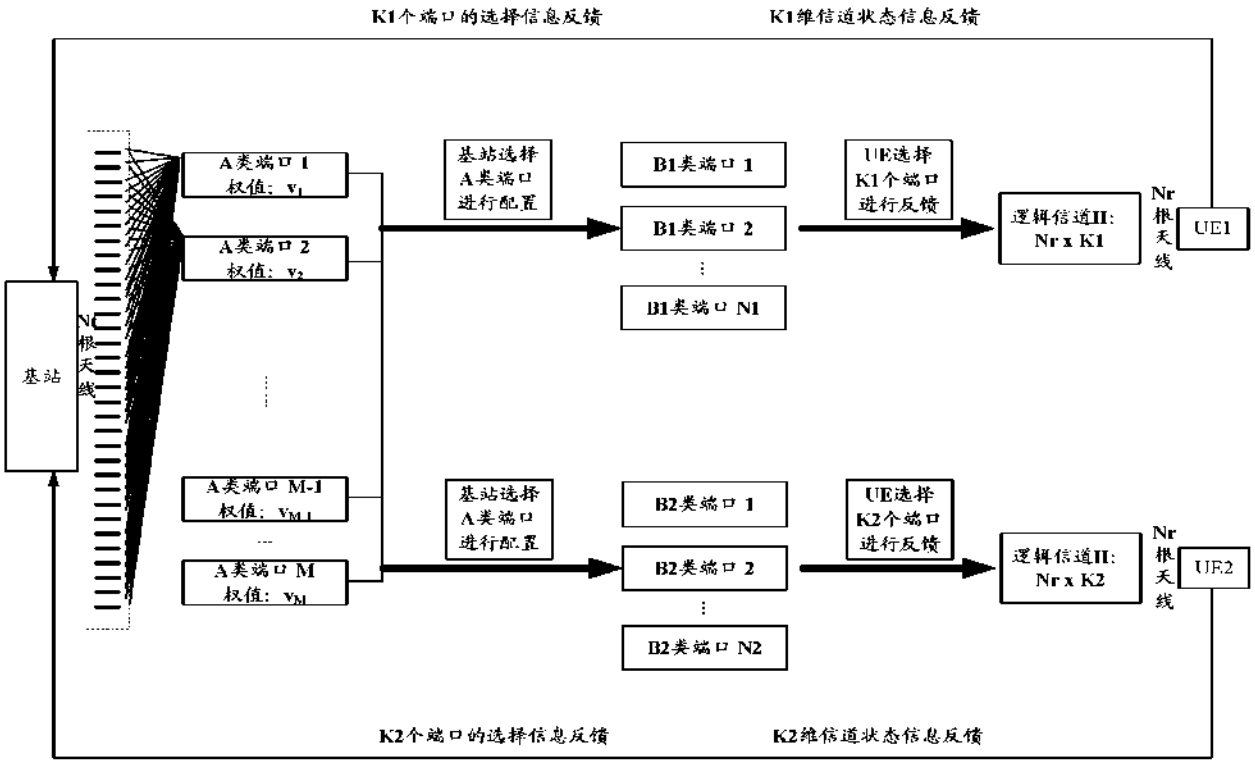

K1个端口的选择信息反馈
K1维信道状态信息反馈
基站
N根天线
A类端口 1
权值：v_1
A类端口 2
权值：v_2
A类端口 M-1
权值：v_{M-1}
A类端口 M
权值：v_M
基站选择A类端口进行配置
B1类端口 1
B1类端口 2
B1类端口 N1
UE选择K1个端口进行反馈
逻辑信道II：Nr x K1
Nr根天线
UE1
基站选择A类端口进行配置
B2类端口 1
B2类端口 2
B2类端口 N2
UE选择K2个端口进行反馈
逻辑信道II：Nr x K2
Nr根天线
UE2
K2个端口的选择信息反馈
K2维信道状态信息反馈

图 9

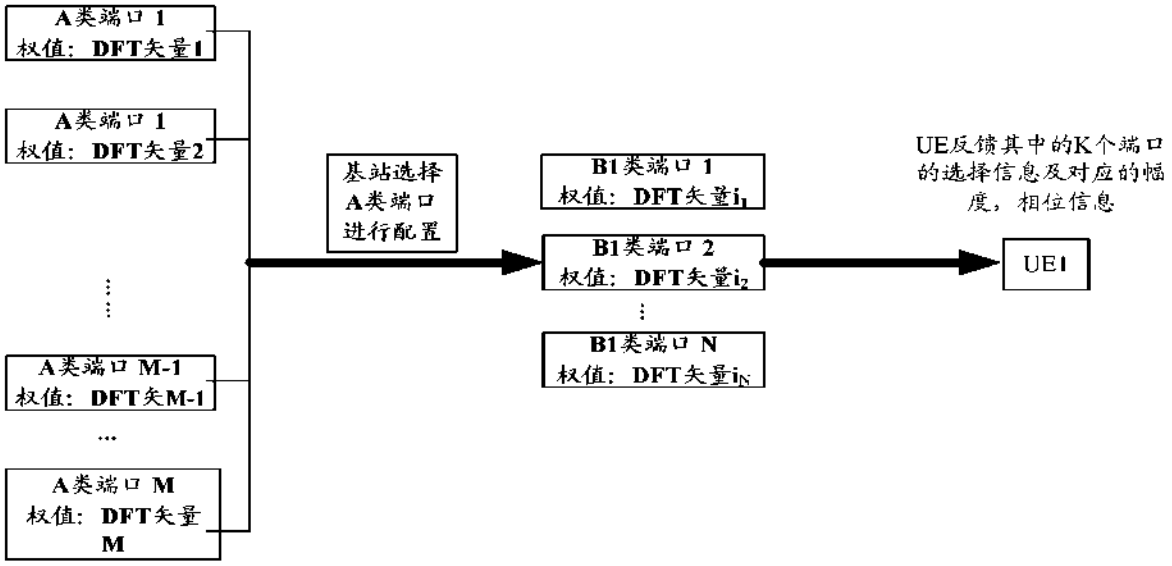

A类端口 1
权值：DFT矢量1
A类端口 1
权值：DFT矢量2
A类端口 M-1
权值：DFT矢M-1
A类端口 M
权值：DFT矢量M
基站选择A类端口进行配置
B1类端口 1
权值：DFT矢量i_1
B1类端口 2
权值：DFT矢量i_2
B1类端口 N
权值：DFT矢量i_N
UE反馈其中的K个端口的选择信息及对应的幅度，相位信息
UE1

图 10

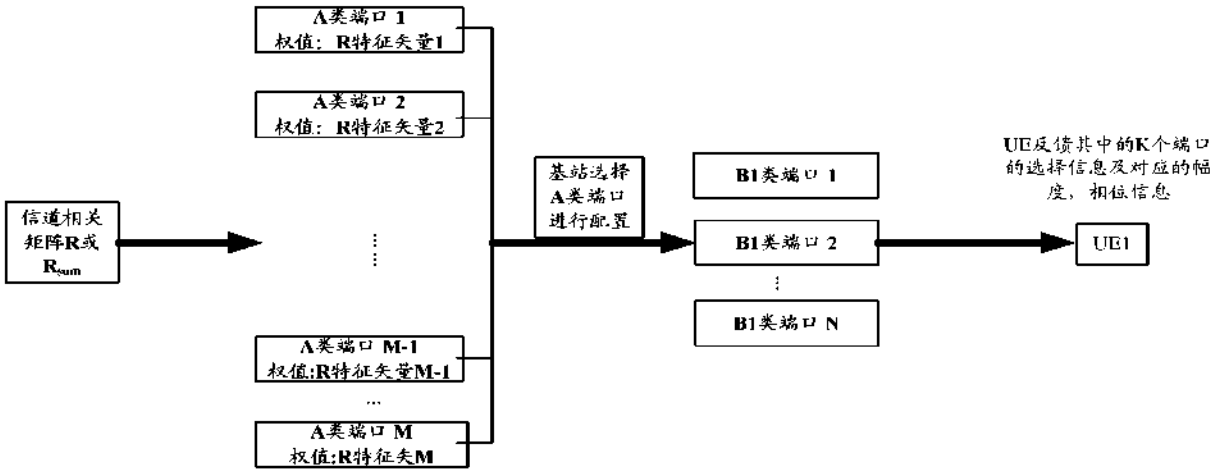

A类端口 1
权值：R特征矢量1
A类端口 2
权值：R特征矢量2
信道相关矩阵R或R_{sum}
基站选择A类端口进行配置
B1类端口 1
B1类端口 2
B1类端口 N
UE反馈其中的K个端口的选择信息及对应的幅度，相位信息
UE1
A类端口 M-1
权值:R特征矢量M-1
A类端口 M
权值:R特征矢M

图 11

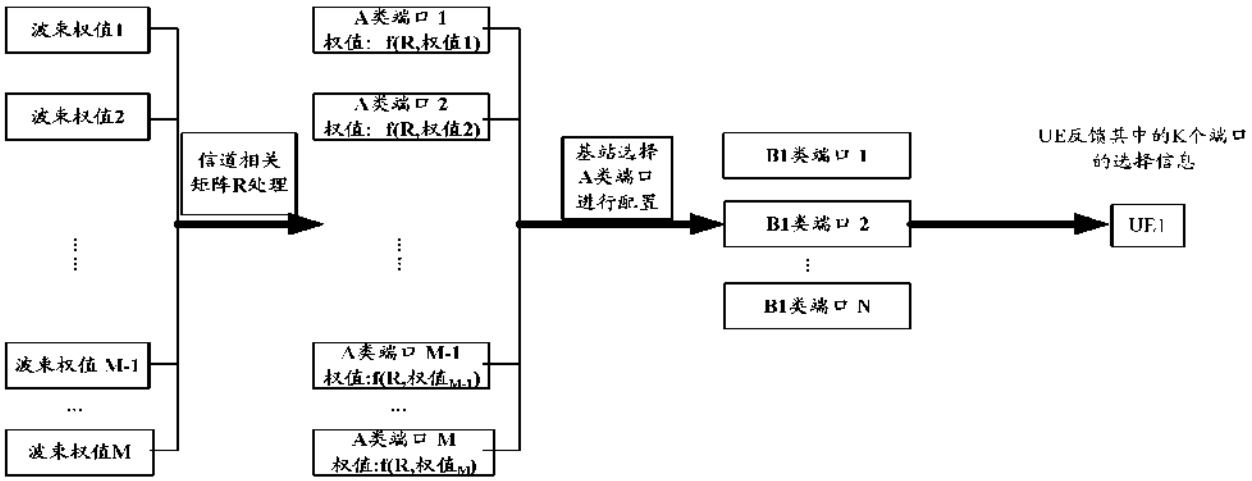

波束权值1
波束权值2
波束权值 M-1
波束权值M
信道相关矩阵R处理
A类端口 1
权值：f(R,权值1)
A类端口 2
权值：f(R,权值2)
A类端口 M-1
权值:f(R,权值$_{M-1}$)
A类端口 M
权值:f(R,权值$_M$)
基站选择A类端口进行配置
B1类端口 1
B1类端口 2
B1类端口 N
UE反馈其中的K个端口的选择信息
UE1

图 12

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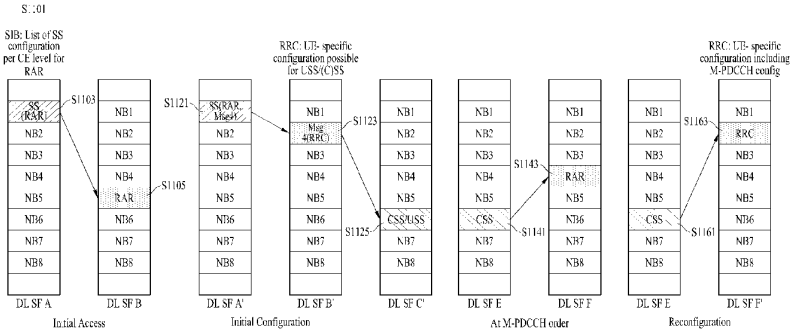
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(54) Title: METHOD AND USER EQUIPMENT FOR RECEIVING DOWNLINK CONTROL INFORMATION, AND METHOD AND BASE STATION FOR TRANSMITTING DOWNLINK CONTROL INFORMATION



(57) Abstract: A search space (hereinafter, CSS) for a control channel for scheduling a random access response may be configured by a system information block. A user equipment (UE) may attempt to receive a control channel for a random access response on the assumption that CSS is configured in accordance with a configuration based on the system information block. The UE may attempt to receive the control channel within a UE-specific search space (USS) by assuming that the USS is configured in accordance with the configuration of the CSS until a configuration for the USS is received.

Description

Title of Invention: METHOD AND USER EQUIPMENT FOR RECEIVING DOWNLINK CONTROL INFORMATION, AND METHOD AND BASE STATION FOR TRANSMITTING DOWNLINK CONTROL INFORMATION

Technical Field

[1] The present invention relates to a wireless communication system, and more particularly, to a method for transmitting or receiving downlink control information and a device therefor.

Background Art

[2] With appearance and spread of machine-to-machine (M2M) communication and a variety of devices such as smartphones and tablet PCs and technology demanding a large amount of data transmission, data throughput needed in a cellular network has rapidly increased. To satisfy such rapidly increasing data throughput, carrier aggregation technology, cognitive radio technology, etc. for efficiently employing more frequency bands and multiple input multiple output (MIMO) technology, multi-base station (BS) cooperation technology, etc. for raising data capacity transmitted on limited frequency resources have been developed.

[3] A general wireless communication system performs data transmission/reception through one downlink (DL) band and through one uplink (UL) band corresponding to the DL band (in case of a frequency division duplex (FDD) mode), or divides a prescribed radio frame into a UL time unit and a DL time unit in the time domain and then performs data transmission/reception through the UL/DL time unit (in case of a time division duplex (TDD) mode). A base station (BS) and a user equipment (UE) transmit and receive data and/or control information scheduled on a prescribed time unit basis, e.g. on a subframe basis. The data is transmitted and received through a data region configured in a UL/DL subframe and the control information is transmitted and received through a control region configured in the UL/DL subframe. To this end, various physical channels carrying radio signals are formed in the UL/DL subframe. In contrast, carrier aggregation technology serves to use a wider UL/DL bandwidth by aggregating a plurality of UL/DL frequency blocks in order to use a broader frequency band so that more signals relative to signals when a single carrier is used can be simultaneously processed.

[4] In addition, a communication environment has evolved into increasing density of nodes accessible by a user at the periphery of the nodes. A node refers to a fixed point

capable of transmitting/receiving a radio signal to/from the UE through one or more antennas. A communication system including high-density nodes may provide a better communication service to the UE through cooperation between the nodes.

Disclosure of Invention

Technical Problem

[5] Due to introduction of new radio communication technology, the number of user equipments (UEs) to which a BS should provide a service in a prescribed resource region increases and the amount of data and control information that the BS should transmit to the UEs increases. Since the amount of resources available to the BS for communication with the UE(s) is limited, a new method in which the BS efficiently receives/transmits uplink/downlink data and/or uplink/downlink control information using the limited radio resources is needed.

[6] The technical objects that can be achieved through the present invention are not limited to what has been particularly described hereinabove and other technical objects not described herein will be more clearly understood by persons skilled in the art from the following detailed description.

Solution to Problem

[7] A search space (hereinafter, CSS_RAR) for a control channel for scheduling a random access response may be configured by a system information block. A user equipment (UE) may attempt to receive a control channel for a random access response by assuming that CSS_RAR is configured in accordance with a configuration based on the system information block. If the UE receives the control channel for a random access response, the UE may receive the random access response to a random access preamble transmitted therefrom in accordance with control information carried by the control channel. The UE may attempt to receive a control channel within a UE-specific search space (hereinafter, USS) by assuming that the USS is configured in accordance with the configuration of the CSS until a configuration for the USS is received.

[8] In an aspect of the present invention, provided herein is a method for receiving, by a user equipment (UE), downlink control information (DCI) for the UE. The method comprises: receiving, by the UE, a common search space configuration for a common search space; receiving, by the UE, a first physical downlink control channel (PDCCH) scheduling a random access response; and receiving, by the UE, a second PDCCH carrying the DCI for the UE. The UE can monitor first PDCCH candidates of the common search space according to the common search space configuration in order to receive the first PDCCH. The UE can monitor second PDCCH candidates of a UE-specific search space in order to receive the second PDCCH. The UE can assume that configuration of the UE-specific search space is the same as that of the common search

space until the UE receives a UE-specific search space configuration.

[9] In another aspect of the present invention, provided herein is a method for transmitting, by a base station (BS), downlink control information (DCI) for a user equipment (UE). The method comprises: transmitting, by the BS, common search space configuration for a common search space; transmitting, by the BS to the UE, a first physical downlink control channel (PDCCH) scheduling a random access response; and transmitting, by the BS to the UE, a second PDCCH carrying the DCI for the UE. The BS can transmit the first PDCCH by using one of first PDCCH candidates of the common search space according to the common search space configuration. The BS can transmit the second PDCCH by using one of second PDCCH candidates of a UE-specific search space. The BS can configure the UE-specific search space according to the same configuration as the common search space configuration until the BS transmits a UE-specific search space configuration to the UE.

[10] In still another aspect of the present invention, provided herein a user equipment (UE) for receiving downlink control information (DCI) for the UE. The UE comprises a radio frequency (RF) unit and a processor connected to the RF unit. The processor can be configured to control the RF unit to receive common search space configuration for a common search space; control the RF unit to receive a first physical downlink control channel (PDCCH) scheduling a random access response; and control the RF unit to receive a second PDCCH carrying the DCI for the UE. The processor can be configured to monitor first PDCCH candidates of the common search space according to the common search space configuration in order to detect the firs PDCCH. The processor can be configured to monitor second PDCCH candidates of a UE-specific search space in order to detect the second PDCCH. The processor can be configured to assume that configuration of the UE-specific search space is the same as that of the common search space until the UE receives a UE-specific search space configuration.

[11] In a further aspect of the present invention, provided herein a base station (BS) for transmitting downlink control information (DCI) for a user equipment (UE). The BS comprises a radio frequency (RF) unit and a processor connected to the RF unit. The processor can be configured to control the RF unit to transmit common search space configuration for a common search space; control the RF unit to transmit a first physical downlink control channel (PDCCH) scheduling a random access response; and control the RF unit to transmit a second PDCCH carrying the DCI for the UE. The processor can be configured to control the RF unit to transmit the first PDCCH using one of first PDCCH candidates of the common search space according to the common search space configuration. The processor can be configured to control the RF unit to transmit the second PDCCH using one of second PDCCH candidates of a UE-specific search space. The processor can configure the UE-specific search space according to

the same as that of the common search space until the BS transmits a UE-specific search space configuration.

[12] In each aspect of the present invention, the common search space configuration can include information on a narrowband for the common search space. The second PDCCH candidates of the UE-specific search space can be configured on the same narrowband as the narrowband for the common search space until the UE-specific search space configuration is transmitted to the UE.

[13] In each aspect of the present invention, the common search space configuration can include information on a maximum number of repetitions for the first common search space. The second PDCCH candidates of the UE-specific search space can be configured based on the same number as the maximum number of repetitions for the common search space until the UE-specific search space configuration is transmitted to the UE.

[14] In each aspect of the present invention, the common search space configuration can include information on a first physical resource block (PRB) set for transmitting the first PDCCH. The same physical resource block set as the first PRB set can be used for the second PDCCH candidates until the UE-specific search space configuration is transmitted to the UE

[15] In each aspect of the present invention, the first PDCCH candidates of the common search space can be configured according to aggregation levels larger than or equal to 8 among a plurality of aggregation levels, whereas the second PDCCH candidates of the UE-specific search space can be configured according to the plurality of aggregation levels.

[16] In each aspect of the present invention, the UE can transmit a random access preamble using a physical random access channel (PRACH) resource. The UE can monitor the first PDCCH candidates in response to transmission of the random access preamble. The UE can receive the random access response according to control information carried by the first PDCCH. The BS can receive a random access preamble using a physical random access channel (PRACH) resource. The BS can transmit the first PDCCH in response to reception of the random access preamble. The BS can transmit the random access response according to control information carried by the first PDCCH.

[17] The above technical solutions are merely some parts of the embodiments of the present invention and various embodiments into which the technical features of the present invention are incorporated can be derived and understood by persons skilled in the art from the following detailed description of the present invention.

Advantageous Effects of Invention

[18] According to the present invention, uplink/downlink signals can be efficiently transmitted/received. Therefore, overall throughput of a radio communication system can be improved.

[19] According to one embodiment of the present invention, a low cost/complexity UE can perform communication with a BS at low cost while maintaining compatibility with a legacy system.

[20] According to one embodiment of the present invention, the UE can be implemented at low cost/complexity.

[21] According to one embodiment of the present invention, coverage can be enhanced.

[22] According to one embodiment of the present invention, the UE and the BS can perform communication with each other at a narrowband.

[23] It will be appreciated by persons skilled in the art that that the effects that can be achieved through the present invention are not limited to what has been particularly described hereinabove and other advantages of the present invention will be more clearly understood from the following detailed description.

Brief Description of Drawings

[24] The accompanying drawings, which are included to provide a further understanding of the invention, illustrate embodiments of the invention and together with the description serve to explain the principle of the invention.

[25] FIG. 1 illustrates the structure of a radio frame used in a wireless communication system.

[26] FIG. 2 illustrates the structure of a downlink (DL)/uplink (UL) slot in a wireless communication system.

[27] FIG. 3 illustrates a radio frame structure for transmission of a synchronization signal (SS).

[28] FIG. 4 illustrates the structure of a DL subframe used in a wireless communication system.

[29] FIG. 5 illustrates the structure of a UL subframe used in a wireless communication system.

[30] FIG. 6 illustrates an example of a signal band for MTC.

[31] FIG. 7 illustrates repeated transmission of a channel for coverage enhancement.

[32] FIG. 8 illustrates a configuration of a common search space (CSS) for paging according to the present invention.

[33] FIG. 9 illustrates a configuration of a common search space (CSS) for random access response (RAR) according to the present invention.

[34] FIG. 10 illustrates the example of the monitoring time region of USS and CSS.

[35] FIG. 11 illustrates a procedure of configuring a search space according to the present

invention.

[36] FIG. 12 illustrates a configuration of M-PDCCH repeated transmission according to the present invention.

[37] FIG. 13 is a block diagram illustrating elements of a transmitting device 10 and a receiving device 20 for implementing the present invention.

Mode for the Invention

[38] Reference will now be made in detail to the exemplary embodiments of the present invention, examples of which are illustrated in the accompanying drawings. The detailed description, which will be given below with reference to the accompanying drawings, is intended to explain exemplary embodiments of the present invention, rather than to show the only embodiments that can be implemented according to the invention. The following detailed description includes specific details in order to provide a thorough understanding of the present invention. However, it will be apparent to those skilled in the art that the present invention may be practiced without such specific details.

[39] In some instances, known structures and devices are omitted or are shown in block diagram form, focusing on important features of the structures and devices, so as not to obscure the concept of the present invention. The same reference numbers will be used throughout this specification to refer to the same or like parts.

[40] The following techniques, apparatuses, and systems may be applied to a variety of wireless multiple access systems. Examples of the multiple access systems include a code division multiple access (CDMA) system, a frequency division multiple access (FDMA) system, a time division multiple access (TDMA) system, an orthogonal frequency division multiple access (OFDMA) system, a single carrier frequency division multiple access (SC-FDMA) system, and a multicarrier frequency division multiple access (MC-FDMA) system. CDMA may be embodied through radio technology such as universal terrestrial radio access (UTRA) or CDMA2000. TDMA may be embodied through radio technology such as global system for mobile communications (GSM), general packet radio service (GPRS), or enhanced data rates for GSM evolution (EDGE). OFDMA may be embodied through radio technology such as institute of electrical and electronics engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20, or evolved UTRA (E-UTRA). UTRA is a part of a universal mobile telecommunications system (UMTS). 3rd generation partnership project (3GPP) long term evolution (LTE) is a part of evolved UMTS (E-UMTS) using E-UTRA. 3GPP LTE employs OFDMA in DL and SC-FDMA in UL. LTE-advanced (LTE-A) is an evolved version of 3GPP LTE. For convenience of description, it is assumed that the present invention is applied to 3GPP LTE/LTE-A. However, the

technical features of the present invention are not limited thereto. For example, although the following detailed description is given based on a mobile communication system corresponding to a 3GPP LTE/LTE-A system, aspects of the present invention that are not specific to 3GPP LTE/LTE-A are applicable to other mobile communication systems.

[41] For example, the present invention is applicable to contention based communication such as Wi-Fi as well as non-contention based communication as in the 3GPP LTE/LTE-A system in which an eNB allocates a DL/UL time/frequency resource to a UE and the UE receives a DL signal and transmits a UL signal according to resource allocation of the eNB. In a non-contention based communication scheme, an access point (AP) or a control node for controlling the AP allocates a resource for communication between the UE and the AP, whereas, in a contention based communication scheme, a communication resource is occupied through contention between UEs which desire to access the AP. The contention based communication scheme will now be described in brief. One type of the contention based communication scheme is carrier sense multiple access (CSMA). CSMA refers to a probabilistic media access control (MAC) protocol for confirming, before a node or a communication device transmits traffic on a shared transmission medium (also called a shared channel) such as a frequency band, that there is no other traffic on the same shared transmission medium. In CSMA, a transmitting device determines whether another transmission is being performed before attempting to transmit traffic to a receiving device. In other words, the transmitting device attempts to detect presence of a carrier from another transmitting device before attempting to perform transmission. Upon sensing the carrier, the transmitting device waits for another transmission device which is performing transmission to finish transmission, before performing transmission thereof. Consequently, CSMA can be a communication scheme based on the principle of "sense before transmit" or "listen before talk". A scheme for avoiding collision between transmitting devices in the contention based communication system using CSMA includes carrier sense multiple access with collision detection (CSMA/CD) and/or carrier sense multiple access with collision avoidance (CSMA/CA). CSMA/CD is a collision detection scheme in a wired local area network (LAN) environment. In CSMA/CD, a personal computer (PC) or a server which desires to perform communication in an Ethernet environment first confirms whether communication occurs on a network and, if another device carries data on the network, the PC or the server waits and then transmits data. That is, when two or more users (e.g. PCs, UEs, etc.) simultaneously transmit data, collision occurs between simultaneous transmission and CSMA/CD is a scheme for flexibly transmitting data by monitoring collision. A transmitting device using CSMA/CD adjusts data transmission thereof by sensing data transmission performed by another

device using a specific rule. CSMA/CA is a MAC protocol specified in IEEE 802.11 standards. A wireless LAN (WLAN) system conforming to IEEE 802.11 standards does not use CSMA/CD which has been used in IEEE 802.3 standards and uses CA, i.e. a collision avoidance scheme. Transmission devices always sense carrier of a network and, if the network is empty, the transmission devices wait for determined time according to locations thereof registered in a list and then transmit data. Various methods are used to determine priority of the transmission devices in the list and to re-configure priority. In a system according to some versions of IEEE 802.11 standards, collision may occur and, in this case, a collision sensing procedure is performed. A transmission device using CSMA/CA avoids collision between data transmission thereof and data transmission of another transmission device using a specific rule.

[42] In the present invention, a user equipment (UE) may be a fixed or mobile device. Examples of the UE include various devices that transmit and receive user data and/or various kinds of control information to and from a base station (BS). The UE may be referred to as a terminal equipment (TE), a mobile station (MS), a mobile terminal (MT), a user terminal (UT), a subscriber station (SS), a wireless device, a personal digital assistant (PDA), a wireless modem, a handheld device, etc. In addition, in the present invention, a BS generally refers to a fixed station that performs communication with a UE and/or another BS, and exchanges various kinds of data and control information with the UE and another BS. The BS may be referred to as an advanced base station (ABS), a node-B (NB), an evolved node-B (eNB), a base transceiver system (BTS), an access point (AP), a processing server (PS), etc. In describing the present invention, a BS will be referred to as an eNB.

[43] In the present invention, a node refers to a fixed point capable of transmitting/receiving a radio signal through communication with a UE. Various types of eNBs may be used as nodes irrespective of the terms thereof. For example, a BS, a node B (NB), an e-node B (eNB), a pico-cell eNB (PeNB), a home eNB (HeNB), a relay, a repeater, etc. may be a node. In addition, the node may not be an eNB. For example, the node may be a radio remote head (RRH) or a radio remote unit (RRU). The RRH or RRU generally has a lower power level than a power level of an eNB. Since the RRH or RRU (hereinafter, RRH/RRU) is generally connected to the eNB through a dedicated line such as an optical cable, cooperative communication between RRH/RRU and the eNB can be smoothly performed in comparison with cooperative communication between eNBs connected by a radio line. At least one antenna is installed per node. The antenna may mean a physical antenna or mean an antenna port, a virtual antennIn the present invention, a cell refers to a prescribed geographical area to which one or more nodes provide a communication service. Accordingly, in the present invention, communicating with a specific cell may mean communicating with an eNB

or a node which provides a communication service to the specific cell. In addition, a DL/UL signal of a specific cell refers to a DL/UL signal from/to an eNB or a node which provides a communication service to the specific cell. A node providing UL/DL communication services to a UE is called a serving node and a cell to which UL/DL communication services are provided by the serving node is especially called a serving cell. Furthermore, channel status/quality of a specific cell refers to channel status/ quality of a channel or communication link formed between an eNB or node which provides a communication service to the specific cell and a UE. The UE may measure DL channel state received from a specific node using cell-specific reference signal(s) (CRS(s)) transmitted on a CRS resource and/or channel state information reference signal(s) (CSI-RS(s)) transmitted on a CSI-RS resource, allocated by antenna port(s) of the specific node to the specific node. Detailed CSI-RS configuration may be understood with reference to 3GPP TS 36.211 and 3GPP TS 36.331 documents.

[44] Meanwhile, a 3GPP LTE/LTE-A system uses the concept of a cell in order to manage radio resources and a cell associated with the radio resources is distinguished from a cell of a geographic region.

[45] A "cell" of a geographic region may be understood as coverage within which a node can provide service using a carrier and a "cell" of a radio resource is associated with bandwidth (BW) which is a frequency range configured by the carrier. Since DL coverage, which is a range within which the node is capable of transmitting a valid signal, and UL coverage, which is a range within which the node is capable of receiving the valid signal from the UE, depends upon a carrier carrying the signal, the coverage of the node may be associated with coverage of the "cell" of a radio resource used by the node. Accordingly, the term "cell" may be used to indicate service coverage of the node sometimes, a radio resource at other times, or a range that a signal using a radio resource can reach with valid strength at other times. The "cell" of the radio resource will be described later in more detail.

[46] 3GPP LTE/LTE-A standards define DL physical channels corresponding to resource elements carrying information derived from a higher layer and DL physical signals corresponding to resource elements which are used by a physical layer but which do not carry information derived from a higher layer. For example, a physical downlink shared channel (PDSCH), a physical broadcast channel (PBCH), a physical multicast channel (PMCH), a physical control format indicator channel (PCFICH), a physical downlink control channel (PDCCH), and a physical hybrid ARQ indicator channel (PHICH) are defined as the DL physical channels, and a reference signal and a synchronization signal are defined as the DL physical signals. A reference signal (RS), also called a pilot, refers to a special waveform of a predefined signal known to both a BS and a UE. For example, a cell-specific RS (CRS), a UE-specific RS (UE-RS), a po-

sitioning RS (PRS), and channel state information RS (CSI-RS) may be defined as DL RSs. Meanwhile, the 3GPP LTE/LTE-A standards define UL physical channels corresponding to resource elements carrying information derived from a higher layer and UL physical signals corresponding to resource elements which are used by a physical layer but which do not carry information derived from a higher layer. For example, a physical uplink shared channel (PUSCH), a physical uplink control channel (PUCCH), and a physical random access channel (PRACH) are defined as the UL physical channels, and a demodulation reference signal (DM RS) for a UL control/data signal and a sounding reference signal (SRS) used for UL channel measurement are defined as the UL physical signals.

[47] In the present invention, a physical downlink control channel (PDCCH), a physical control format indicator channel (PCFICH), a physical hybrid automatic retransmit request indicator channel (PHICH), and a physical downlink shared channel (PDSCH) refer to a set of time-frequency resources or resource elements (REs) carrying downlink control information (DCI), a set of time-frequency resources or REs carrying a control format indicator (CFI), a set of time-frequency resources or REs carrying downlink acknowledgement (ACK)/negative ACK (NACK), and a set of time-frequency resources or REs carrying downlink data, respectively. In addition, a physical uplink control channel (PUCCH), a physical uplink shared channel (PUSCH) and a physical random access channel (PRACH) refer to a set of time-frequency resources or REs carrying uplink control information (UCI), a set of time-frequency resources or REs carrying uplink data and a set of time-frequency resources or REs carrying random access signals, respectively. In the present invention, in particular, a time-frequency resource or RE that is assigned to or belongs to PDCCH/PCFICH/PHICH/PDSCH/PUCCH/PUSCH/PRACH is referred to as PDCCH/PCFICH/PHICH/PDSCH/PUCCH/PUSCH/PRACH RE or PDCCH/PCFICH/PHICH/PDSCH/PUCCH/PUSCH/PRACH time-frequency resource, respectively. Therefore, in the present invention, PUCCH/PUSCH/PRACH transmission of a UE is conceptually identical to UCI/uplink data/random access signal transmission on PUSCH/PUCCH/PRACH, respectively. In addition, PDCCH/PCFICH/PHICH/PDSCH transmission of an eNB is conceptually identical to downlink data/DCI transmission on PDCCH/PCFICH/PHICH/PDSCH, respectively.

[48] Hereinafter, OFDM symbol/subcarrier/RE to or for which CRS/DMRS/CSI-RS/SRS/UE-RS/TRS is assigned or configured will be referred to as CRS/DMRS/CSI-RS/SRS/UE-RS/TRS symbol/carrier/subcarrier/RE. For example, an OFDM symbol to or for which a tracking RS (TRS) is assigned or configured is referred to as a TRS symbol, a subcarrier to or for which the TRS is assigned or configured is referred to as a TRS subcarrier, and an RE to or for which the TRS is

assigned or configured is referred to as a TRS RE. In addition, a subframe configured for transmission of the TRS is referred to as a TRS subframe. Moreover, a subframe in which a broadcast signal is transmitted is referred to as a broadcast subframe or a PBCH subframe and a subframe in which a synchronization signal (e.g. PSS and/or SSS) is transmitted is referred to a synchronization signal subframe or a PSS/SSS subframe. OFDM symbol/subcarrier/RE to or for which PSS/SSS is assigned or configured is referred to as PSS/SSS symbol/subcarrier/RE, respectively.

[49] In the present invention, a CRS port, a UE-RS port, a CSI-RS port, and a TRS port refer to an antenna port configured to transmit a CRS, an antenna port configured to transmit a UE-RS, an antenna port configured to transmit a CSI-RS, and an antenna port configured to transmit a TRS, respectively. Antenna ports configured to transmit CRSs may be distinguished from each other by the locations of REs occupied by the CRSs according to CRS ports, antenna ports configured to transmit UE-RSs may be distinguished from each other by the locations of REs occupied by the UE-RSs according to UE-RS ports, and antenna ports configured to transmit CSI-RSs may be distinguished from each other by the locations of REs occupied by the CSI-RSs according to CSI-RS ports. Therefore, the term CRS/UE-RS/CSI-RS/TRS ports may also be used to indicate a pattern of REs occupied by CRSs/UE-RSs/CSI-RSs/TRSs in a predetermined resource region. In the present invention, both a DMRS and a UE-RS refer to RSs for demodulation and, therefore, the terms DMRS and UE-RS are used to refer to RSs for demodulation.

[50] FIG. 1 illustrates the structure of a radio frame used in a wireless communication system.

[51] Specifically, FIG. 1(a) illustrates an exemplary structure of a radio frame which can be used in frequency division multiplexing (FDD) in 3GPP LTE/LTE-A and FIG. 1(b) illustrates an exemplary structure of a radio frame which can be used in time division multiplexing (TDD) in 3GPP LTE/LTE-A.

[52] Referring to FIG. 1, a 3GPP LTE/LTE-A radio frame is 10ms ($307,200T_s$) in duration. The radio frame is divided into 10 subframes of equal size. Subframe numbers may be assigned to the 10 subframes within one radio frame, respectively. Here, T_s denotes sampling time where T_s=1/(2048*15kHz). Each subframe is 1ms long and is further divided into two slots. 20 slots are sequentially numbered from 0 to 19 in one radio frame. Duration of each slot is 0.5ms. A time interval in which one subframe is transmitted is defined as a transmission time interval (TTI). Time resources may be distinguished by a radio frame number (or radio frame index), a subframe number (or subframe index), a slot number (or slot index), and the like.

[53] A radio frame may have different configurations according to duplex modes. In FDD mode for example, since DL transmission and UL transmission are discriminated

according to frequency, a radio frame for a specific frequency band operating on a carrier frequency includes either DL subframes or UL subframes. In TDD mode, since DL transmission and UL transmission are discriminated according to time, a radio frame for a specific frequency band operating on a carrier frequency includes both DL subframes and UL subframes.

[54] Table 1 shows an exemplary UL-DL configuration within a radio frame in TDD mode.

[55] [Table 1]

DL-UL configuration	Downlink-to-Uplink Switch-point periodicity	Subframe number									
		0	1	2	3	4	5	6	7	8	9
0	5ms	D	S	U	U	U	D	S	U	U	U
1	5ms	D	S	U	U	D	D	S	U	U	D
2	5ms	D	S	U	D	D	D	S	U	D	D
3	10ms	D	S	U	U	U	D	D	D	D	D
4	10ms	D	S	U	U	D	D	D	D	D	D
5	10ms	D	S	U	D	D	D	D	D	D	D
6	5ms	D	S	U	U	U	D	S	U	U	D

[56] In Table 1, D denotes a DL subframe, U denotes a UL subframe, and S denotes a special subframe. The special subframe includes three fields, i.e. downlink pilot time slot (DwPTS), guard period (GP), and uplink pilot time slot (UpPTS). DwPTS is a time slot reserved for DL transmission and UpPTS is a time slot reserved for UL transmission. Table 2 shows an example of the special subframe configuration.

[57] [Table 2]

Special subframe configuration	Normal cyclic prefix in downlink			Extended cyclic prefix in downlink		
	DwPTS	UpPTS		DwPTS	UpPTS	
		Normal cyclic prefix in uplink	Extended cyclic prefix in uplink		Normal cyclic prefix in uplink	Extended cyclic prefix in uplink
0	$6592 \cdot T_s$	$2192 \cdot T_s$	$2560 \cdot T_s$	$7680 \cdot T_s$	$2192 \cdot T_s$	$2560 \cdot T_s$
1	$19760 \cdot T_s$			$20480 \cdot T_s$		
2	$21952 \cdot T_s$			$23040 \cdot T_s$		
3	$24144 \cdot T_s$			$25600 \cdot T_s$		
4	$26336 \cdot T_s$			$7680 \cdot T_s$	$4384 \cdot T_s$	$5120 \cdot T_s$
5	$6592 \cdot T_s$	$4384 \cdot T_s$	$5120 \cdot T_s$	$20480 \cdot T_s$		
6	$19760 \cdot T_s$			$23040 \cdot T_s$		
7	$21952 \cdot T_s$			$12800 \cdot T_s$		
8	$24144 \cdot T_s$			-	-	-
9	$13168 \cdot T_s$			-	-	-

[58] FIG. 2 illustrates the structure of a DL/UL slot structure in a wireless communication system.

[59] Referring to FIG. 2, a slot includes a plurality of orthogonal frequency division multiplexing (OFDM) symbols in the time domain and includes a plurality of resource blocks (RBs) in the frequency domain. The OFDM symbol may refer to one symbol duration. Referring to FIG. 2, a signal transmitted in each slot may be expressed by a resource grid including $N^{DL/UL}_{RB} * N^{RB}_{sc}$ subcarriers and $N^{DL/UL}_{symb}$ OFDM symbols. N^{DL}_{RB} denotes the number of RBs in a DL slot and N^{UL}_{RB} denotes the number of RBs in a UL slot. N^{DL}_{RB} and N^{UL}_{RB} depend on a DL transmission bandwidth and a UL transmission bandwidth, respectively. N^{DL}_{symb} denotes the number of OFDM symbols in a DL slot, N^{UL}_{symb} denotes the number of OFDM symbols in a UL slot, and N^{RB}_{sc} denotes the number of subcarriers configuring one RB.

[60] An OFDM symbol may be referred to as an OFDM symbol, a single carrier frequency division multiplexing (SC-FDM) symbol, etc. according to multiple access schemes. The number of OFDM symbols included in one slot may be varied according to channel bandwidths and CP lengths. For example, in a normal cyclic prefix (CP) case, one slot includes 7 OFDM symbols. In an extended CP case, one slot includes 6

OFDM symbols. Although one slot of a subframe including 7 OFDM symbols is shown in FIG. 2 for convenience of description, embodiments of the present invention are similarly applicable to subframes having a different number of OFDM symbols. Referring to FIG. 2, each OFDM symbol includes $N^{DL/UL}_{RB} * N^{RB}_{sc}$ subcarriers in the frequency domain. The type of the subcarrier may be divided into a data subcarrier for data transmission, a reference signal (RS) subcarrier for RS transmission, and a null subcarrier for a guard band and a DC component. The null subcarrier for the DC component is unused and is mapped to a carrier frequency f_0 in a process of generating an OFDM signal or in a frequency up-conversion process. The carrier frequency is also called a center frequency f_c.

[61] One RB is defined as $N^{DL/UL}_{symb}$ (e.g. 7) consecutive OFDM symbols in the time domain and as N^{RB}_{sc} (e.g. 12) consecutive subcarriers in the frequency domain. For reference, a resource composed of one OFDM symbol and one subcarrier is referred to a resource element (RE) or tone. Accordingly, one RB includes $N^{DL/UL}_{symb} * N^{RB}_{sc}$ REs. Each RE within a resource grid may be uniquely defined by an index pair (k, l) within one slot. k is an index ranging from 0 to $N^{DL/UL}_{RB} * N^{RB}_{sc}$—1 in the frequency domain, and l is an index ranging from 0 to $N^{DL/UL}_{symb}$—1 in the time domain.

[62] Meanwhile, one RB is mapped to one physical resource block (PRB) and one virtual resource block (VRB). A PRB is defined as N^{DL}_{symb} (e.g. 7) consecutive OFDM or SC-FDM symbols in the time domain and N^{RB}_{sc} (e.g. 12) consecutive subcarriers in the frequency domain. Accordingly, one PRB is configured with $N^{DL/UL}_{symb} * N^{RB}_{sc}$ REs. In one subframe, two RBs each located in two slots of the subframe while occupying the same N^{RB}_{sc} consecutive subcarriers are referred to as a physical resource block (PRB) pair. Two RBs configuring a PRB pair have the same PRB number (or the same PRB index).

[63] FIG. 3 illustrates a radio frame structure for transmission of a synchronization signal (SS). Specifically, FIG. 3 illustrates a radio frame structure for transmission of an SS and a PBCH in frequency division duplex (FDD), wherein FIG. 3(a) illustrates transmission locations of an SS and a PBCH in a radio frame configured as a normal cyclic prefix (CP) and FIG. 3(b) illustrates transmission locations of an SS and a PBCH in a radio frame configured as an extended CP.

[64] If a UE is powered on or newly enters a cell, the UE performs an initial cell search procedure of acquiring time and frequency synchronization with the cell and detecting a physical cell identity N^{cell}_{ID} of the cell. To this end, the UE may establish synchronization with the eNB by receiving synchronization signals, e.g. a primary synchronization signal (PSS) and a secondary synchronization signal (SSS), from the eNB and obtain information such as a cell identity (ID).

[65] An SS will be described in more detail with reference to FIG. 3. An SS is categorized

into a PSS and an SSS. The PSS is used to acquire time-domain synchronization of OFDM symbol synchronization, slot synchronization, etc. and/or frequency-domain synchronization and the SSS is used to acquire frame synchronization, a cell group ID, and/or CP configuration of a cell (i.e. information as to whether a normal CP is used or an extended CP is used). Referring to FIG. 3, each of a PSS and an SSS is transmitted on two OFDM symbols of every radio frame. More specifically, SSs are transmitted in the first slot of subframe 0 and the first slot of subframe 5, in consideration of a global system for mobile communication (GSM) frame length of 4.6 ms for facilitation of inter-radio access technology (inter-RAT) measurement. Especially, a PSS is transmitted on the last OFDM symbol of the first slot of subframe 0 and on the last OFDM symbol of the first slot of subframe 5 and an SSS is transmitted on the second to last OFDM symbol of the first slot of subframe 0 and on the second to last OFDM symbol of the first slot of subframe 5. A boundary of a corresponding radio frame may be detected through the SSS. The PSS is transmitted on the last OFDM symbol of a corresponding slot and the SSS is transmitted on an OFDM symbol immediately before an OFDM symbol on which the PSS is transmitted. A transmit diversity scheme of an SS uses only a single antenna port and standards therefor are not separately defined. That is, a single antenna port transmission scheme or a transmission scheme transparent to a UE (e.g. precoding vector switching (PVS), time switched transmit diversity (TSTD), or cyclic delay diversity (CDD)) may be used for transmit diversity of an SS.

[66] Upon detecting a PSS, a UE may discern that a corresponding subframe is one of subframe 0 and subframe 5 because the PSS is transmitted every 5ms but the UE cannot discern whether the subframe is subframe 0 or subframe 5. Accordingly, the UE cannot recognize the boundary of a radio frame only by the PSS. That is, frame synchronization cannot be acquired only by the PSS. The UE detects the boundary of a radio frame by detecting an SSS which is transmitted twice in one radio frame with different sequences.

[67] The UE, which has determined time and frequency parameters necessary for demodulating a DL signal and transmitting a UL signal at an accurate time by performing a cell search procedure using PSS/SSS, can communicate with the eNB only after acquiring system information necessary for system configuration of the UE from the eNB.

[68] The system information is configured by a master information block (MIB) and system information blocks (SIBs). Each SIB includes a set of functionally associated parameters and is categorized into an MIB, SIB Type 1 (SIB 1), SIB Type 2 (SIB2), and SIB3 to SIB17 in accordance with the parameters.

[69] The MIB includes most frequently transmitted parameters which are essential for

initial access of the UE to a network of the eNB. The UE may receive the MIB through a broadcast channel (e.g. PBCH). The MIB includes a DL bandwidth (BW), PHICH configuration, and a system frame number (SFN). Accordingly, the UE may be explicitly aware of information about the DL BW, SFN, and PHICH configuration by receiving the MIB. Meanwhile, information which may be implicitly recognized by the UE through reception of the PBCH includes the number of transmit antenna ports of the eNB. Information about the number of transmit antennas of the eNB is implicitly signaled by masking (e.g. XOR operation) a sequence corresponding to the number of transmit antennas to a 16-bit cyclic redundancy check (CRC) used for error detection of the PBCH.

[70] The SIB1 includes parameters needed to determine if a specific cell is suitable for cell selection, as well as information about time-domain scheduling of the other SIBs. The SIB1 is received by the UE through broadcast signaling or dedicated signaling.

[71] DL carrier frequency and corresponding system bandwidth may be acquired by the MIB carried by the PBCH. UL carrier frequency and corresponding system bandwidth may be acquired by system information which is a DL signal. The UE which has received the MIB applies a DL BW value within the MIB to a UL-bandwidth (UL BW) until system information block type 2 (SystemInformationBlockType2, SIB2) is received if there is no valid system information stored in a corresponding cell. For example, the UE may identify a full UL system band, which may be used by itself for UL transmission, through UL-carrier frequency and UL-bandwidth information within the SIB2 by acquiring system information block type 2 (SystemInformationBlockType2, SIB2).

[72] In the frequency domain, a PSS/SSS and a PBCH are transmitted only in a total of 6 RBs, i.e. a total of 72 subcarriers, irrespective of actual system BW, wherein 3 RBs are in the left and the other 3 RBs are in the right centering on a DC subcarrier on corresponding OFDM symbols. Therefore, the UE is configured to detect or decode the SS and the PBCH irrespective of DL BW configured for the UE.

[73] After initial cell search, the UE may perform a random access procedure to complete access to the eNB. To this end, the UE may transmit a preamble through a physical random access channel (PRACH) and receive a response message to the preamble through a PDCCH and a PDSCH. In contention based random access, the UE may perform additional PRACH transmission and a contention resolution procedure of a PDCCH and a PDSCH corresponding to the PDCCH.

[74] After performing the aforementioned procedure, the UE may perform PDDCH/PDSCH reception and PUSCH/PUCCH transmission as general uplink/downlink transmission procedures.

[75] The random access procedure is also called RACH (random access channel)

procedure. The random access procedure is used for initial access, uplink synchronization adjustment, resource assignment, handover, etc. The random access procedure is classified into a contention-based process and a dedicated (i.e. non-contention-based) process. The contention-based random access procedure includes initial access and is normally used, whereas the dedicated random access procedure is limitedly used for handover. In the contention-based random access procedure, a UE randomly select a RACH preamble sequence. Accordingly, a plurality of UEs can simultaneously transmit the same RACH preamble sequence and thus a contention resolution procedure is not needed. In the dedicated random access procedure, a UE uses a RACH preamble sequence uniquely allocated thereto by an eNB. Accordingly, the UE can perform the random access procedure without colliding with other UEs.

[76] The contention-based random access procedure has the following four steps. Hereinafter, messages transmitted in steps 1 to 4 may be respectively referred to as Msg 1 to Msg 4.

[77] - Step 1: RACH preamble (via PRACH) (UE to eNB)

[78] - Step 2: Random access response (RAR) (via PDCCH and PDSCH) (eNB to UE)

[79] - Step 3: Layer 2/Layer 3 message (via PUSCH) (UE to eNB)

[80] - Step 4: Contention resolution message (eNB to UE)

[81] The dedicated random access procedure includes the following three steps. Hereinafter, uplink transmission (i.e. step 3) corresponding to a RAR may be performed as a part of the random access procedure. The dedicated random access procedure can be triggered using a PDCCH (hereinafter, referred to as PDCCH order) used for an eNB to command RACH preamble transmission.

[82] - Step 0: PACH preamble allocation through dedicated signaling (eNB to UE)

[83] - Step 1: RACH preamble (via PRACH) (UE to eNB)

[84] - Step 2: RAR (via PDCCH and PDSCH) (eNB to UE)

[85] After transmission of RACH preamble, the UE attempts to receive a random access response (RAR) within a predetermined time window. Specifically, the UE attempts to detect a PDCCH (hereinafter, referred to as RA-RNTI PDCCH) having an RA-RNTI (Random Access RNTI) (e.g., CRC is masked with RA-RNTI in the PDCCH) within the time window. The UE checks whether a RAR therefor is present in a PDSCH corresponding to the RA-RNTI PDCCH during RA-RNTI PDCCH detection. The RAR includes timing advance (TA) information indicating timing offset information for UL synchronization, UL resource allocation information (UL grant information), a temporary UE identifier (e.g., temporary cell-RNTI, TC-RNTI), etc. The UE can perform UL transmission (e.g., Msg3) in accordance with resource allocation information and TA value in the RAR. HARQ is applied to UL transmission corresponding to the RAR. Accordingly, the UE can receive acknowledgement information

(e.g., PHICH) corresponding to Msg 3 after transmission of Msg 3.

[86] The random access preamble, i.e., RACH preamble consists of a cyclic prefix of length T_{CP} and a sequence part of length T_{SEQ} in the physical layer. T_{CP} and T_{SEQ} depend on the frame structure and the random access configuration. The preamble format is controlled by higher layers. The following table shows examples of T_{CP} and T_{SEQ}.

[87] [Table 3]

Preamble format	T_{CP}	T_{SEQ}
0	$3168 \cdot T_s$	$24576 \cdot T_s$
1	$21024 \cdot T_s$	$24576 \cdot T_s$
2	$6240 \cdot T_s$	$2 \cdot 24576 \cdot T_s$
3	$21024 \cdot T_s$	$2 \cdot 24576 \cdot T_s$
4(see NOTE)	$448 \cdot T_s$	$4096 \cdot T_s$
NOTE: Frame structure type 2 and special subframe configuration with UpPTS lengths $4384 \cdot T_s$ and $5120 \cdot T_s$ only.		

[88] The random access preamble is transmitted in UL subframe(s). The transmission of a random access preamble is restricted to certain time and frequency resources. These resources are called PRACH resources. The PRACH resources, are enumerated in increasing order of the subframe number within the radio frame and the PRBs in the frequency domain such that index 0 correspond to the lowest numbered PRB and subframe within the radio frame. PRACH resources within the radio frame are indicated by a PRACH configuration index.

[89] For frame structure type 1 with preamble format 0-3, for each of the PRACH configurations there is at most one random access resource per subframe. The following table shows examples of the preamble formats and the subframes in which random access preamble transmission is allowed for a given configuration in frame structure type 1. The PRACH configuration index is given by a higher layer signal (transmitted by an eNB).

[90] [Table 4]

PRACH Configuration Index	Preamble Format	SFN	Subframe number	PRACH Configuration Index	Preamble Format	SFN	Subframe number
0	0	Even	1	32	2	Even	1
1	0	Even	4	33	2	Even	4
2	0	Even	7	34	2	Even	7
3	0	Any	1	35	2	Any	1
4	0	Any	4	36	2	Any	4
5	0	Any	7	37	2	Any	7
6	0	Any	1,6	38	2	Any	1,6
7	0	Any	2,7	39	2	Any	2,7
8	0	Any	3,8	40	2	Any	3,8
9	0	Any	1,4,7	41	2	Any	1,4,7
10	0	Any	2,5,8	42	2	Any	2,5,8
11	0	Any	3,6,9	43	2	Any	3,6,9
12	0	Any	0,2,4,6,8	44	2	Any	0,2,4,6,8
13	0	Any	1,3,5,7,9	45	2	Any	1,3,5,7,9
14	0	Any	0,1,2,3,4,5,6,7,8,9	46	N/A	N/A	N/A
15	0	Even	9	47	2	Even	9
16	1	Even	1	48	3	Even	1
17	1	Even	4	49	3	Even	4
18	1	Even	7	50	3	Even	7
19	1	Any	1	51	3	Any	1
20	1	Any	4	52	3	Any	4
21	1	Any	7	53	3	Any	7
22	1	Any	1,6	54	3	Any	1,6
23	1	Any	2,7	55	3	Any	2,7
24	1	Any	3,8	56	3	Any	3,8
25	1	Any	1,4,7	57	3	Any	1,4,7

26	1	Any	2,5,8	58	3	Any	2,5,8
27	1	Any	3,6,9	59	3	Any	3,6,9
28	1	Any	0,2,4,6,8	60	N/A	N/A	N/A
29	1	Any	1,3,5,7,9	61	N/A	N/A	N/A
30	N/A	N/A	N/A	62	N/A	N/A	N/A
31	1	Even	9	63	3	Even	9

[91] In Table 4, SFN denotes a system frame number.

[92] The first PRB, n^{RA}_{PRB}, allocated to the PRACH opportunity considered for preamble formats 0, 1, 2 and 3 is defined by $n^{RA}_{PRB}=n^{RA}_{PRBoffset}$, where the PRACH frequency offset $n^{RA}_{PRBoffset}$ is a PRB configured by higher layers and satisfies $0\leq n^{RA}_{PRBoffset}\leq N^{UL}_{RB}-6$.

[93] In case of frame structure type 2 with preamble formats 0 to 4, a plurality of random access resources may exist within UL subframe (or UpPTS for preamble format 4) in accordance with UL/DL configuration. The random access resources for the frame structure type 2 are defined in accordance with PRACH configuration index (see 3GPP TS 36.211 standard document).

[94] FIG. 4 illustrates the structure of a DL subframe used in a wireless communication system.

[95] Referring to FIG. 4, A DL subframe is divided into a control region and a data region in the time domain. Referring to FIG. 4, a maximum of 3 (or 4) OFDM symbols located in a front part of a first slot of a subframe corresponds to the control region. Hereinafter, a resource region for PDCCH transmission in a DL subframe is referred to as a PDCCH region. OFDM symbols other than the OFDM symbol(s) used in the control region correspond to the data region to which a physical downlink shared channel (PDSCH) is allocated. Hereinafter, a resource region available for PDSCH transmission in the DL subframe is referred to as a PDSCH region.

[96] Examples of a DL control channel used in 3GPP LTE include a physical control format indicator channel (PCFICH), a physical downlink control channel (PDCCH), a physical hybrid ARQ indicator channel (PHICH), etc.

[97] The PCFICH is transmitted in the first OFDM symbol of a subframe and carries information about the number of OFDM symbols available for transmission of a control channel within a subframe. The PCFICH notifies the UE of the number of OFDM symbols used for the corresponding subframe every subframe. The PCFICH is located at the first OFDM symbol. The PCFICH is configured by four resource element groups (REGs), each of which is distributed within a control region on the basis of cell ID. One REG includes four REs.

[98] A set of OFDM symbols available for the PDCCH at a subframe is given by the following Table.

[99] [Table 5]

Subframe	Number of OFDM symbols for PDCCH when $N^{DL}_{RB}>10$	Number of OFDM symbols for PDCCH when $N^{DL}_{RB}\leq 10$
Subframe 1 and 6 for frame structure type 2	1, 2	2
MBSFN subframes on a carrier supporting PDSCH, configured with 1 or 2 cell-specfic antenna ports	1, 2	2
MBSFN subframes on a carrier supporting PDSCH, configured with 4 cell-specific antenna ports	2	2
Subframes on a carrier not supporting PDSCH	0	0
Non-MBSFN subframes (except subframe 6 for frame structure type 2) configured with positioning reference signals	1, 2, 3	2, 3
All other cases	1, 2, 3	2, 3, 4

[100] A subset of downlink subframes within a radio frame on a carrier for supporting PDSCH transmission may be configured as MBSFN subframe(s) by a higher layer. Each MBSFN subframe is divided into a non-MBSFN region and an MBSFN region. The non-MBSFN region spans first one or two OFDM symbols, and its length is given by Table 5. The same CP as cyclic prefix (CP) used for subframe 0 is used for transmission within the non-MBSFN region of the MBSFN subframe. The MBSFN region within the MBSFN subframe is defined as OFDM symbols which are not used in the non-MBSFN region.

[101] The PCFICH carries a control format indicator (CFI), which indicates any one of values of 1 to 3. For a downlink system bandwidth $N^{DL}_{RB}>10$, the number 1, 2 or 3 of OFDM symbols which are spans of DCI carried by the PDCCH is given by the CFI. For a downlink system bandwidth $N^{DL}_{RB}\leq 10$, the number 2, 3 or 4 of OFDM symbols which are spans of DCI carried by the PDCCH is given by CFI+1. The CFI is coded in accordance with the following Table.

[102] [Table 6]

CFI	CFI code word<b_0, b_1, ..., b_{31}>
1	<0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1>
2	<1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0>
3	<1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1>
4(Reserved)	<0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0>

[103] The PHICH carries a HARQ (Hybrid Automatic Repeat Request) ACK/NACK (acknowledgment/negative-acknowledgment) signal as a response to UL transmission. The PHICH includes three REGs, and is scrambled cell-specifically. ACK/NACK is indicated by 1 bit, and the ACK/NACK of 1 bit is repeated three times. Each of the repeated ACK/NACK bits is spread with a spreading factor (SF) 4 or 2 and then mapped into a control region.

[104] The control information transmitted through the PDCCH will be referred to as downlink control information (DCI). The DCI includes resource allocation information for a UE or UE group and other control information. Transmit format and resource allocation information of a downlink shared channel (DL-SCH) are referred to as DL scheduling information or DL grant. Transmit format and resource allocation information of an uplink shared channel (UL-SCH) are referred to as UL scheduling information or UL grant. The size and usage of the DCI carried by one PDCCH are varied depending on DCI formats. The size of the DCI may be varied depending on a coding rate. In the current 3GPP LTE system, various formats are defined, wherein formats 0 and 4 are defined for a UL, and formats 1, 1A, 1B, 1C, 1D, 2, 2A, 2B, 2C, 3 and 3A are defined for a DL. Combination selected from control information such as a hopping flag, RB allocation, modulation coding scheme (MCS), redundancy version (RV), new data indicator (NDI), transmit power control (TPC), cyclic shift, cyclic shift demodulation reference signal (DM RS), UL index, channel quality information (CQI) request, DL assignment index, HARQ process number, transmitted precoding matrix indicator (TPMI), precoding matrix indicator (PMI) information is transmitted to the UE as the DCI. The following table shows examples of DCI formats.

[105] [Table 7]

DCI format	Description
0	Resource grants for the PUSCH transmissions (uplink)
1	Resource assignments for single codeword PDSCH transmissions
1A	Compact signaling of resource assignments for single codeword PDSCH
1B	Compact signaling of resource assignments for single codeword PDSCH
1C	Very compact resource assignments for PDSCH (e.g. paging/broadcast system information)
1D	Compact resource assignments for PDSCH using multi-user MIMO
2	Resource assignments for PDSCH for closed-loop MIMO operation
2A	Resource assignments for PDSCH for open-loop MIMO operation
2B	Resource assignments for PDSCH using up to 2 antenna ports with UE-specific reference signals
2C	Resource assignment for PDSCH using up to 8 antenna ports with UE-specific reference signals
3/3A	Power control commands for PUCCH and PUSCH with 2-bit/1-bit power adjustments
4	Scheduling of PUSCH in one UL Component Carrier with multi-antenna port transmission mode

[106] Other DCI formats in addition to the DCI formats defined in Table 7 may be defined.

[107] A plurality of PDCCHs may be transmitted within a control region. A UE may monitor the plurality of PDCCHs. An eNB determines a DCI format depending on the DCI to be transmitted to the UE, and attaches cyclic redundancy check (CRC) to the DCI. The CRC is masked (or scrambled) with an identifier (for example, a radio network temporary identifier (RNTI)) depending on usage of the PDCCH or owner of the PDCCH. For example, if the PDCCH is for a specific UE, the CRC may be masked with an identifier (for example, cell-RNTI (C-RNTI)) of the corresponding UE. If the PDCCH is for a paging message, the CRC may be masked with a paging identifier (for example, paging-RNTI (P-RNTI)). If the PDCCH is for system information (in more detail, system information block (SIB)), the CRC may be masked with system information RNTI (SI-RNTI). If the PDCCH is for a random access response, the CRC may be masked with a random access RNTI (RA-RNTI). For example, CRC masking

(or scrambling) includes XOR operation of CRC and RNTI at the bit level.

[108] Generally, a DCI format, which may be transmitted to the UE, is varied depending on a transmission mode configured for the UE. In other words, certain DCI format(s) corresponding to the specific transmission mode not all DCI formats may only be used for the UE configured to a specific transmission mode.

[109] For example, a transmission mode is semi-statically configured for the UE by a higher layer so that the UE may receive a PDSCH transmitted in accordance with one of a plurality of transmission modes which are previously defined. The UE attempts to decode a PDCCH using DCI formats only corresponding to its transmission mode. In other words, in order to maintain UE operation load according to blind decoding attempt, at a certain level or less, all DCI formats are not searched by the UE at the same time. Table 8 illustrates transmission modes for configuring multi-antenna technology and DCI formats for allowing a UE to perform blind decoding at the corresponding transmission mode. Particularly, Table 8 illustrates a relation between PDCCH and PDSCH configured by C-RNTI (Cell RNTI(Radio Network Temporary Identifier)).

[110] [Table 8]

Transmission mode	DCI format	Search Space	Transmission scheme of PDSCH corresponding to PDCCH
Mode 1	DCI format 1A	Common andUE specific by C-RNTI	Single-antenna port, port 0
	DCI format 1	UE specific by C-RNTI	Single-antenna port, port 0
Mode 2	DCI format 1A	Common andUE specific by C-RNTI	Transmit diversity
	DCI format 1	UE specific by C-RNTI	Transmit diversity
Mode 3	DCI format 1A	Common andUE specific by C-RNTI	Transmit diversity
	DCI format 2A	UE specific by C-RNTI	Large delay CDD or Transmit diversity
Mode 4	DCI format 1A	Common andUE specific by C-RNTI	Transmit diversity
	DCI format 2	UE specific by C-RNTI	Closed-loop spatial multiplexing or Transmit diversity
Mode 5	DCI format 1A	Common andUE specific by C-RNTI	Transmit diversity
	DCI format 1D	UE specific by C-RNTI	Multi-user MIMO
Mode 6	DCI format 1A	Common andUE specific by C-RNTI	Transmit diversity
	DCI format 1B	UE specific by C-RNTI	Closed-loop spatial multiplexing using a single transmission layer
Mode 7	DCI format	Common andUE	If the number of PBCH antenna ports

	1A	specific by C-RNTI	is one, Single-antenna port, port 0 is used, otherwise Transmit diversity
	DCI format 1	UE specific by C-RNTI	Single-antenna port, port 5
Mode 8	DCI format 1A	Common andUE specific by C-RNTI	If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used, otherwise Transmit diversity
	DCI format 2B	UE specific by C-RNTI	Dual layer transmission, port 7 and 8 or single-antenna port, port 7 or 8
Mode 9	DCI format 1A	Common andUE specific by C-RNTI	Non-MBSFN subframe: If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used, otherwise Transmit diversity.MBSFN subframe: Single-antenna port, port 7
	DCI format 2C	UE specific by C-RNTI	Up to 8 layer transmission, ports 7-14 or single-antenna port, port 7 or 8
Mode 10	DCI format 1A	Common andUE specific by C-RNTI	Non-MBSFN subframe: If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used, otherwise Transmit diversity.MBSFN subframe: Single-antenna port, port 7
	DCI format 2D	UE specific by C-RNTI	Up to 8 layer transmission, ports 7-14 or single antenna port, port 7 or 8

[111] Although transmission modes 1 to 10 are listed in Table 8, other transmission modes in addition to the transmission modes defined in Table 8 may be defined.

[112] Referring to Table 8, a UE configured to a transmission mode 9, for example, tries to decode PDCCH candidates of a UE-specific search space (USS) to a DCI format 1A, and tries to decode PDCCH candidates of a common search space (CSS) and the USS to a DCI format 2C. The UE may decode a PDSCH in accordance with DCI based on the DCI format successfully decoded. If DCI decoding from one of a plurality of PDCCH candidates to the DCI format 1A is successfully performed, the UE may decode the PDSCH by assuming that up to 8 layers from antenna ports 7 to 14 are transmitted thereto through the PDSCH, or may decode the PDSCH by assuming that a single layer from the antenna port 7 or 8 is transmitted thereto through the PDSCH.

[113] The PDCCH is allocated to first m number of OFDM symbol(s) within a subframe.

In this case, m is an integer equal to or greater than 1, and is indicated by the PCFICH.

[114] The PDCCH is transmitted on an aggregation of one or a plurality of continuous control channel elements (CCEs). The CCE is a logic allocation unit used to provide a coding rate based on the status of a radio channel to the PDCCH. The CCE corresponds to a plurality of resource element groups (REGs). For example, one CCE corresponds to nine resource element groups (REGs), and one REG corresponds to four REs. Four QPSK symbols are mapped to each REG. A resource element (RE) occupied by the reference signal (RS) is not included in the REG. Accordingly, the number of REGs within given OFDM symbols is varied depending on the presence of the RS. The REGs are also used for other downlink control channels (that is, PCFICH and PHICH).

[115] Assuming that the number of REGs not allocated to the PCFICH or the PHICH is N_{REG}, the number of available CCEs in a DL subframe for PDCCH(s) in a system is numbered from 0 to N_{CCE}—1, where $N_{CCE} = \text{floor}(N_{REG}/9)$.

[116] A PDCCH format and the number of DCI bits are determined in accordance with the number of CCEs. The CCEs are numbered and consecutively used. To simplify the decoding process, a PDCCH having a format including n CCEs may be initiated only on CCEs assigned numbers corresponding to multiples of n. The number of CCEs used for transmission of a specific PDCCH is determined by a network or the eNB in accordance with channel status. For example, one CCE may be required for a PDCCH for a UE (for example, adjacent to eNB) having a good downlink channel. However, in case of a PDCCH for a UE (for example, located near the cell edge) having a poor channel, eight CCEs may be required to obtain sufficient robustness. Additionally, a power level of the PDCCH may be adjusted to correspond to a channel status.

[117] In a 3GPP LTE/LTE-A system, a set of CCEs on which a PDCCH can be located for each UE is defined. A CCE set in which the UE can detect a PDCCH thereof is referred to as a PDCCH search space or simply as a search space (SS). An individual resource on which the PDCCH can be transmitted in the SS is called a PDCCH candidate. A set of PDCCH candidates that the UE is to monitor is defined in terms of SSs, where a search space $S^{(L)}_k$ at aggregation level $L \in \{1,2,4,8\}$ is defined by a set of PDCCH candidates. SSs for respective PDCCH formats may have different sizes and a dedicated SS and a common SS are defined. The dedicated SS is a UE-specific SS (USS) and is configured for each individual UE. The common SS (CSS) is configured for a plurality of UEs.

[118] The following table shows an example of aggregation levels for defining SS.

[119] [Table 9]

Search space $S^{(L)}_k$			Number of PDCCH candidates $M^{(L)}$
Type	Aggregation level L	Size [in CCEs]	
UE-specific	1	6	6
	2	12	6
	4	8	2
	8	16	2
Common	4	16	4
	8	16	2

[120] For each serving cell on which PDCCH is monitored, the CCEs corresponding to PDCCH candidates m of the search space $S^{(L)}_k$ are configured by "$L*\{Y_k+m'\}$ mod floor($N_{CCE,k}/L$}+i", where i=0,...,L—1. For the common search space $m'=m$. For the PDCCH UE specific search space, for the serving cell on which PDCCH is monitored, if the monitorng UE is configured with carrier indicator field then $m'=m+M^{(L)}*n_{CI}$ where n_{CI} is the carrier indicator field (CIF) value, else if the monitoring UE is not configured with carrier indicator field then $m'=m$, where m=0,1,...,$M^{(L)}$—1. $M^{(L)}$ is the number of PDCCH candidates to monitor at aggregation level L in the given search space. The carrier indication field value can be the same as a serving cell index (*Serv-CellIndex*). For the common search space, Y_k is set to 0 for the two aggregation levels L=4 and L=8. For the UE-specific search space $S^{(L)}_k$ at aggregation level D, the variable Y_k is defined by "$Y_k = (A\cdot Y_{k-1})$ mod D", where $Y_{-1}=n_{RNTI}\neq 0$, A=39827, D=65537 and k =floor(n_s/2). n_s is the slot number within a radio frame.

[121] The eNB transmits an actual PDCCH (DCI) on a PDCCH candidate in a search space and the UE monitors the search space to detect the PDCCH (DCI). Here, monitoring implies attempting to decode each PDCCH in the corresponding SS according to all monitored DCI formats. The UE may detect a PDCCH thereof by monitoring a plurality of PDCCHs. Basically, the UE does not know the location at which a PDCCH thereof is transmitted. Therefore, the UE attempts to decode all PDCCHs of the corresponding DCI format for each subframe until a PDCCH having an ID thereof is detected and this process is referred to as blind detection (or blind decoding (BD)).

[122] For example, it is assumed that a specific PDCCH is CRC-masked with a radio network temporary identity (RNTI) 'A' and information about data transmitted using a radio resource 'B' (e.g. frequency location) and using transport format information 'C' (e.g. transmission block size, modulation scheme, coding information, etc.) is transmitted in a specific DL subframe. Then, the UE monitors the PDCCH using RNTI

information thereof. The UE having the RNTI 'A' receives the PDCCH and receives the PDSCH indicated by 'B' and 'C' through information of the received PDCCH.

[123] FIG. 5 illustrates the structure of a UL subframe used in a wireless communication system.

[124] Referring to FIG. 5, a UL subframe may be divided into a data region and a control region in the frequency domain. One or several PUCCHs may be allocated to the control region to deliver UCI. One or several PUSCHs may be allocated to the data region of the UE subframe to carry user data.

[125] In the UL subframe, subcarriers distant from a direct current (DC) subcarrier are used as the control region. In other words, subcarriers located at both ends of a UL transmission BW are allocated to transmit UCI. A DC subcarrier is a component unused for signal transmission and is mapped to a carrier frequency f_0 in a frequency up-conversion process. A PUCCH for one UE is allocated to an RB pair belonging to resources operating on one carrier frequency and RBs belonging to the RB pair occupy different subcarriers in two slots. The PUCCH allocated in this way is expressed by frequency hopping of the RB pair allocated to the PUCCH over a slot boundary. If frequency hopping is not applied, the RB pair occupies the same subcarriers.

[126] The PUCCH may be used to transmit the following control information.

[127] - Scheduling request (SR): SR is information used to request a UL-SCH resource and is transmitted using an on-off keying (OOK) scheme.

[128] - HARQ-ACK: HARQ-ACK is a response to a PDCCH and/or a response to a DL data packet (e.g. a codeword) on a PDSCH. HARQ-ACK indicates whether the PDCCH or PDSCH has been successfully received. 1-bit HARQ-ACK is transmitted in response to a single DL codeword and 2-bit HARQ-ACK is transmitted in response to two DL codewords. A HARQ-ACK response includes a positive ACK (simply, ACK), negative ACK (NACK), discontinuous transmission (DTX), or NACK/DRX. HARQ-ACK is used interchangeably with HARQ ACK/NACK and ACK/NACK.

[129] - Channel state information (CSI): CSI is feedback information for a DL channel. CSI may include channel quality information (CQI), a precoding matrix indicator (PMI), a precoding type indicator, and/or a rank indicator (RI). In the CSI, MIMO-related feedback information includes the RI and the PMI. The RI indicates the number of streams or the number of layers that the UE can receive through the same time-frequency resource. The PMI is a value reflecting a space characteristic of a channel, indicating an index of a preferred precoding matrix for DL signal transmission based on a metric such as an SINR. The CQI is a value of channel strength, indicating a received SINR that can be obtained by the UE generally when the eNB uses the PMI.

[130] A general wireless communication system performs data transmission/reception through one downlink (DL) band and through one uplink (UL) band corresponding to

the DL band (in case of a frequency division duplex (FDD) mode), or divides a prescribed radio frame into a UL time unit and a DL time unit in the time domain and then performs data transmission/reception through the UL/DL time unit (in case of a time division duplex (TDD) mode). Recently, to use a wider frequency band in recent wireless communication systems, introduction of carrier aggregation (or BW aggregation) technology that uses a wider UL/DL BW by aggregating a plurality of UL/DL frequency blocks has been discussed. A carrier aggregation (CA) is different from an orthogonal frequency division multiplexing (OFDM) system in that DL or UL communication is performed using a plurality of carrier frequencies, whereas the OFDM system carries a base frequency band divided into a plurality of orthogonal subcarriers on a single carrier frequency to perform DL or UL communication. Hereinbelow, each of carriers aggregated by carrier aggregation will be referred to as a component carrier (CC).

[131] For example, three 20MHz CCs may be aggregated on each of a UL and a DL to support a bandwidth of 60MHz. The respective CCs may be contiguous or non-contiguous in the frequency domain. For convenience, although it has been described that the bandwidth of UL CC and the bandwidth of DL CC are the same as each other and symmetric to each other, the bandwidth of each CC may be independently determined. Asymmetrical carrier aggregation in which the number of UL CCs is different from the number of DL CCs may be implemented. DL/UL CC limited to a specific UE may be referred to as a serving UL/DL CC configured for the specific UE.

[132] Meanwhile, the 3GPP LTE-A standard uses the concept of a cell to manage radio resources. The "cell" associated with the radio resources is defined by combination of downlink resources and uplink resources, that is, combination of DL CC and UL CC. The cell may be configured by downlink resources only, or may be configured by downlink resources and uplink resources. If carrier aggregation is supported, linkage between a carrier frequency of the downlink resources (or DL CC) and a carrier frequency of the uplink resources (or UL CC) may be indicated by system information. For example, combination of the DL resources and the UL resources may be indicated by linkage of system information block type 2 (SIB2). In this case, the carrier frequency means a center frequency of each cell or CC. A cell operating on a primary frequency may be referred to as a primary cell (Pcell) or PCC, and a cell operating on a secondary frequency may be referred to as a secondary cell (Scell) or SCC. The carrier corresponding to the Pcell on downlink will be referred to as a downlink primary CC (DL PCC), and the carrier corresponding to the Pcell on uplink will be referred to as an uplink primary CC (UL PCC). A Scell means a cell that may be configured after completion of radio resource control (RRC) connection establishment and used to provide additional radio resources. The Scell may form a set of serving cells for the UE

together with the Pcell in accordance with capabilities of the UE. The carrier corresponding to the Scell on the downlink will be referred to as downlink secondary CC (DL SCC), and the carrier corresponding to the Scell on the uplink will be referred to as uplink secondary CC (UL SCC). Although the UE is in RRC-CONNECTED state, if it is not configured by carrier aggregation or does not support carrier aggregation, a single serving cell configured by the Pcell only exists.

[133] The eNB may activate all or some of the serving cells configured in the UE or deactivate some of the serving cells for communication with the UE. The eNB may change the activated/deactivated cell, and may change the number of cells which is/are activated or deactivated. If the eNB allocates available cells to the UE cell-specifically or UE-specifically, at least one of the allocated cells is not deactivated unless cell allocation to the UE is fully reconfigured or unless the UE performs handover. Such a cell which is not deactivated unless CC allocation to the UE is fully reconfigured will be referred to as Pcell, and a cell which may be activated/deactivated freely by the eNB will be referred to as Scell. The Pcell and the Scell may be discriminated from each other on the basis of the control information. For example, specific control information may be set to be transmitted and received through a specific cell only. This specific cell may be referred to as the Pcell, and the other cell(s) may be referred to as Scell(s).

[134] A configured cell refers to a cell in which carrier aggregation is performed for a UE based on measurement report from another eNB or UE among cells of an eNB and is configured per UE. The cell configured for the UE may be a serving cell in terms of the UE. For the cell configured for the UE, i.e. the serving cell, resources for ACK/NACK transmission for PDSCH transmission are reserved in advance. An activated cell refers to a cell configured to be actually used for PDSCH/PUSCH transmission among cells configured for the UE and CSI reporting and SRS transmission for PDSCH/PUSCH transmission are performed in the activated cell. A deactivated cell refers to a cell configured not to be used for PDSCH/PUSCH transmission by the command of an eNB or the operation of a timer and, if a cell is deactivated, CSI reporting and SRS transmission are also stopped in the cell.

[135] For reference, a carrier indicator (CI) denots a serving cell index (*ServCellIndex*), CI=0 is applied to Pcell. The serving cell index is a short ID used to identify a serving cell. For example, any one of integers from 0 to 'maximum number of carrier frequencies which can be configured for the UE at a time - 1' may be allocated to one serving cell as the serving cell index. That is, the serving cell index may be a logical index used to identify a specific serving cell among cells allocated to the UE rather than a physical index used to identify a specific carrier frequency among all carrier frequencies.

[136] Meanwhile, the 3GPP LTE-A standard uses the concept of a cell to manage radio

resources.

[137] The cell mentioned in the present invention means a cell of carrier aggregation which is combination of UL CC and DL CC unless specifically noted.

[138] Meanwhile, since one serving cell is only present in case of communication based on a single carrier, a PDCCH carrying UL/DL grant and corresponding PUSCH/PDSCH are transmitted on one cell. In other words, in case of FDD under a single carrier environment, a PDCCH for a DL grant for a PDSCH, which will be transmitted on a specific DL CC, is transmitted on the specific CC, and a PDCCH for a UL grant for a PUSCH, which will be transmitted on a specific UL CC, is transmitted on a DL CC linked to the specific UL CC. In case of TDD under a single carrier environment, a PDCCH for a DL grant for a PDSCH, which will be transmitted on a specific DL CC, is transmitted on the specific CC, and a PDCCH for a UL grant for a PUSCH, which will be transmitted on a specific UL CC, is transmitted on the specific CC.

[139] On the contrary, since a plurality of serving cells may be configured in a multi-carrier system, transmission of UL/DL grant through a serving cell having a good channel status may be allowed. In this way, if a cell carrying UL/DL grant which is scheduling information is different from a cell where UL/DL transmission corresponding to the UL/DL grant is performed, this will be referred to as cross-carrier scheduling.

[140] Hereinafter, the case where the cell is scheduled from itself and the case where the cell is scheduled from another cell will be referred to as self-CC scheduling and cross-CC scheduling, respectively.

[141] For data transmission rate enhancement and stable control signaling, the 3GPP LTE/LTE-A may support aggregation of a plurality of CCs and a cross carrier-scheduling operation based on the aggregation.

[142] If cross-carrier scheduling (or cross-CC scheduling) is applied, a PDCCH for downlink allocation for a DL CC B or DL CC C, that is, carrying a DL grant may be transmitted through a DL CC A, and a corresponding PDSCH may be transmitted through the DL CC B or DL CC C. For cross-CC scheduling, a carrier indicator field (CIF) may be introduced. The presence or absence of the CIF within the PDCCH may be semi-statically and UE-specifically (or UE-group-specifically) configured by higher layer signaling (e.g., RRC signaling).

[143] Meanwhile, if RRH technology, cross-carrier scheduling technology, etc. are introduced, the amount of PDCCH which should be transmitted by the eNB is gradually increased. However, since a size of a control region within which the PDCCH may be transmitted is the same as before, PDCCH transmission acts as a bottleneck of system throughput. Although channel quality may be improved by the introduction of the aforementioned multi-node system, application of various communication schemes, etc., the introduction of a new control channel is required to apply the legacy commu-

nication scheme and the carrier aggregation technology to a multi-node environment. Due to the need, a configuration of a new control channel in a data region (hereinafter, referred to as PDSCH region) not the legacy control region (hereinafter, referred to as PDCCH region) has been discussed. Hereinafter, the new control channel will be referred to as an enhanced PDCCH (hereinafter, referred to as EPDCCH).

[144] The EPDCCH may be configured within rear OFDM symbols starting from a configured OFDM symbol, instead of front OFDM symbols of a subframe. The EPDCCH may be configured using continuous frequency resources, or may be configured using discontinuous frequency resources for frequency diversity. By using the EPDCCH, control information per node may be transmitted to a UE, and a problem that a legacy PDCCH region may not be sufficient may be solved. For reference, the PDCCH may be transmitted through the same antenna port(s) as that(those) configured for transmission of a CRS, and a UE configured to decode the PDCCH may demodulate or decode the PDCCH by using the CRS. Unlike the PDCCH transmitted based on the CRS, the EPDCCH is transmitted based on the demodulation RS (hereinafter, DMRS). Accordingly, the UE decodes/demodulates the PDCCH based on the CRS and decodes/demodulates the EPDCCH based on the DMRS. The DMRS associated with EPDCCH is transmitted on the same antenna port $p \in \{107,108,109,110\}$ as the associated EPDCCH physical resource, is present for EPDCCH demodulation only if the EPDCCH transmission is associated with the corresponding antenna port, and is transmitted only on the PRB(s) upon which the corresponding EPDCCH is mapped. For example, the REs occupied by the UE-RS(s) of the antenna port 7 or 8 may be occupied by the DMRS(s) of the antenna port 107 or 108 on the PRB to which the EPDCCH is mapped, and the REs occupied by the UE-RS(s) of antenna port 9 or 10 may be occupied by the DMRS(s) of the antenna port 109 or 110 on the PRB to which the EPDCCH is mapped. In other words, a certain number of REs are used on each RB pair for transmission of the DMRS for demodulation of the EPDCCH regardless of the UE or cell if the type of EPDCCH and the number of layers are the same as in the case of the UE-RS for demodulation of the PDSCH.

[145] For each serving cell, higher layer signalling can configure a UE with one or two EPDCCH-PRB-sets for EPDCCH monitoring. The PRB-pairs corresponding to an EPDCCH-PRB-set are indicated by higher layers. Each EPDCCH-PRB-set consists of set of ECCEs numbered from 0 to $N_{ECCE,p,k}$—1, where $N_{ECCE,p,k}$ is the number of ECCEs in EPDCCH-PRB-set p of subframe k. Each EPDCCH-PRB-set can be configured for either localized EPDCCH transmission or distributed EPDCCH transmission.

[146] The UE shall monitor a set of EPDCCH candidates on one or more activated serving cells as configured by higher layer signaling for control information.

[147] The set of EPDCCH candidates to monitor are defined in terms of EPDCCH UE-

specific search spaces. For each serving cell, the subframes in which the UE monitors EPDCCH UE-specific search spaces are configured by higher layers.

[148] An EPDCCH UE-specific search space $ES^{(L)}_k$ at aggregation level $L \in \{1,2,4,8,16,32\}$ is defined by a set of EPDCCH candidates.

[149] For an EPDCCH-PRB-set p, the ECCEs corresponding to EPDCCH candidate m of the search space $ES^{(L)}_k$ are given by the following equation.

[150] [Math.1]

$$L\left\{ (Y_{p,k} + \left\lfloor \frac{m \cdot N_{ECCE,p,k}}{L \cdot M_p^{(L)}} \right\rfloor + b) \bmod \lfloor N_{\mathrm{ECCE},p,k} / L \rfloor \right\} + i$$

[151] where $i=0,\ldots,L-1$. $b=n_{CI}$ if the UE is configured with a carrier indicator field for the serving cell on which EPDCCH is monitored, otherwise $b=0$. n_{CI} is the carrier indicator field (CIF) value, which is the same as a serving cell index (*ServCellIndex*). $m=0,1,\ldots,$ $M^{(L)}_p-1$, $M^{(L)}_p$ is the number of EPDCCH candidates to monitor at aggregation level L in EPDDCH-PRB-set p. The variable $Y_{p,k}$ is defined by '$Y_{p,k} = (A_p \cdot Y_{p,k-1}) \bmod D$', where $Y_{p,-1}=n_{RNTI} \neq 0$, $A_0=39827$, $A_0=39829$,$D=65537$ and $k=\mathrm{floor}(n_s/2)$. n_s is the slot number within a radio frame.

[152] A UE is not expected to monitor an EPDCCH candidate, if an ECCE corresponding to that EPDCCH candidate is mapped to a PRB pair that overlaps in frequency with a transmission of either PBCH or PSS/SSS in the same subframe.

[153] An EPDCCH is transmitted using an aggregation of one or several consecutive enhanced control channel elements (ECCEs). Each ECCE consists of multiple enhanced resource element groups (EREGs). EEREGs are used for defining the mapping of enhanced control channels to resource elements. There are 16 EREGs, numbered from 0 to 15, per physical resource block (PRB) pair. Number all resource elements (REs), except resource elements carrying DMRS (hereinafter EPDCCH DMRS) for demoduation of the EPDCCH, in a physical resource-block pair cyclically from 0 to 15 in an increasing order of first frequency, then time. Therefore all the REs, except REs carrying the EPDCCH DMRS, in the PRB pair has any one of numbers 0 to 15. All REs with number i in that PRB pair constitutes EREG number i.As described above, it is noted that EREGs are distributed on frequency and time axes within the PRB pair and an EPDCCH transmitted using aggregation of one or more ECCEs, each of which includes a plurality of EREGs, is also distributed on frequency and time axes within the PRB pair.

[154] The number of ECCEs used for one EPDCCH depends on the EPDCCH format as given by Table 10, the number of EREGs per ECCE is given by Table 11. Table 10 shows an example of supported EPDCCH formats, and Table 11 shows an example of

the number of EREGs per ECCE, N^{EREG}_{ECCE}. Both localized and distributed transmission is supported.

[155] [Table 10]

EPDCCH format	Number of ECCEs for one EPDCCH, N^{ECCE}_{EPDCCH}			
	Case A		Case B	
	Localized transmission	Distributed transmission	Localized transmission	Distributed transmission
0	2	2	1	1
1	4	4	2	2
2	8	8	4	4
3	16	16	8	8
4	-	32	-	16

[156] [Table 11]

Normal cyclic prefix			Extended cyclic prefix	
Normal subframe	Special subframe,configuration3, 4, 8	Special subframe,configuration1, 2, 6, 7, 9	Normal subframe	Special subframe,configuration1, 2, 3, 5, 6
4		8		

[157] An EPDCCH can use either localized or distributed transmission, differing in the mapping of ECCEs to EREGs and PRB pairs. One or two sets of PRB pairs which a UE shall monitor for EPDCCH transmissions can be configured. All EPDCCH candidates in EPDCCH set S_p (i.e., EPDCCH-PRB-set) use either only localized or only distributed transmission as configured by higher layers. Within EPDCCH set S_p in subframe k, the ECCEs available for transmission of EPDCCHs are numbered from 0 to $N_{ECCE,p,k}$—1. ECCE number n is corresponding to the following EREG(s):

[158] - EREGs numbered $(n \bmod N^{ECCE}_{RB})+jN^{ECCE}_{RB}$ in PRB index floor(n/N^{ECCE}_{RB}) for localized mapping, and

[159] - EREGs numbered floor $(n/N^{Sm}_{RB})+jN^{ECCE}_{RB}$ in PRB indices $(n+j\max(1,N^{Sp}_{RB}/N^{EREG}_{ECCE}))\bmod N^{Sp}_{RB}$ for distributed mapping,

[160] where $j=0,1,\ldots,N^{EREG}_{ECCE}-1$, N^{EREG}_{ECCE} is the number of EREGs per ECCE, and $N^{ECCE}_{RB}=16/N^{EREG}_{ECCE}$ is the number of ECCEs per RB pair. The PRB pairs constituting EPDCCH set S_p are assumed to be numbered in ascending order from 0 to $N^{Sp}_{RB}-1$.

[161] Case A in Table 10 applies when:

[162] - DCI formats 2, 2A, 2B, 2C or 2D is used and $N^{DL}_{RB}\geq 25$, or

[163] - any DCI format when n_{EPDCCH}<104 and normal cyclic prefix is used in normal subframes or special subframes with configuration 3, 4, 8.

[164] Otherwise case B is used. The quantity n_{EPDCCH} for a particular UE is defined as the number of downlink resource elements (k,l) in a PRB pair configured for possible EPDCCH transmission of EPDCCH set S_0 and and fulfilling all of the following criteria,

[165] - they are part of any one of the 16 EREGs in the physical resource-block pair,

[166] - they are assumed by the UE not to be used for CRSs or CSI-RSs,

[167] - the index l in a subframe fulfils $l \geq l_{EPDCCHStart}$.

[168] where $l_{EPDCCHStart}$ is given based on higher layer signaling '*epdcch*-StartSymbol-r11', higher layer signaling '*pdsch*-Start-r11', or CFI value carried by PCFICH.

[169] The mapping to resource elements (k,l) on antenna port p meeting the criteria above is in increasing order of first the index k and then the index l, starting with the first slot and ending with the second slot in a subframe.

[170] For localized transmission, the single antenna port p to use is given by Table 12 with $n' = n_{ECCE,low} \bmod N^{ECCE}_{RB} + n_{RNTI} \bmod \min(N^{ECCE}_{EPDCCH}, N^{ECCE}_{RB})$, where $n_{ECCE,low}$ is the lowest ECCE index used by this EPDCCH transmission in the EPDCCH set, n_{RNTI} corresponds to the RNTI associated with the EPDCCH transmission, and N^{ECCE}_{EPDCCH} is the number of ECCEs used for this EPDCCH.

[171] [Table 12]

n'	Normal cyclic prefix		Extended cyclic prefix
	Normal subframes,Special subframes,configurations3, 4, 8	Special subframes, configurations1, 2, 6, 7, 9	Any subframe
0	107	107	107
1	108	109	108
2	109	-	-
3	110	-	-

[172] For distributed transmission, each resource element in an EREG is associated with one out of two antenna ports in an alternating manner where $p \in \{107,109\}$ for normal cyclic prefix and $p \in \{107,108\}$ for extended cyclic prefix.

[173] Recently, machine type communication (MTC) has come to the fore as a significant communication standard issue. MTC refers to exchange of information between a machine and an eNB without involving persons or with minimal human intervention. For example, MTC may be used for data communication for measurement/

sensing/reporting such as meter reading, water level measurement, use of a surveillance camera, inventory reporting of a vending machine, etc. and may also be used for automatic application or firmware update processes for a plurality of UEs. In MTC, the amount of transmission data is small and UL/DL data transmission or reception (hereinafter, transmission/reception) occurs occasionally. In consideration of such properties of MTC, it would be better in terms of efficiency to reduce production cost and battery consumption of UEs for MTC (hereinafter, MTC UEs) according to data transmission rate. Since the MTC UE has low mobility, the channel environment thereof remains substantially the same. If an MTC UE is used for metering, reading of a meter, surveillance, and the like, the MTC UE is very likely to be located in a place such as a basement, a warehouse, and mountain regions which the coverage of a typical eNB does not reach. In consideration of the purposes of the MTC UE, it is better for a signal for the MTC UE to have wider coverage than the signal for the conventional UE (hereinafter, a legacy UE).

[174] When considering the usage of the MTC UE, there is a high probability that the MTC UE requires a signal of wide coverage compared with the legacy UE. Therefore, if the eNB transmits a PDCCH, a PDSCH, etc. to the MTC UE using the same scheme as a scheme of transmitting the PDCCH, the PDSCH, etc. to the legacy UE, the MTC UE has difficulty in receiving the PDCCH, the PDSCH, etc. Therefore, the present invention proposes that the eNB apply a coverage enhancement scheme such as subframe repetition (repetition of a subframe with a signal) or subframe bundling upon transmission of a signal to the MTC UE having a coverage issue so that the MTC UE can effectively receive a signal transmitted by the eNB. For example, the PDCCH and PDSCH may be transmitted to the MTC UE having the coverage issue in a plurality of subframes (e.g. about 100 subframes).

[175] FIG. 6 illustrates an example of signals band for MTC.

[176] As one method for reducing the cost of the MTC UE, an operation of the MTC UE may be performed at a reduced UE downlink and uplink bandwidth of 1.4 MHz, for example, regardless of an operating system bandwidth of a cell. At this time, a subband (narrowband) for operating the MTC UE may always be located at the center (e.g., 6 center PRBs) of a cell as shown in FIG. 6(a), or several subbands for MTC may be provided for one subframe to multiplex MTC UEs as shown in FIG. 6(b), whereby the UEs may use their respective subbands different from each other or the UEs use the same subband not the subband of 6 center PRBs.

[177] In this case, the MTC UE cannot receive a legacy PDCCH transmitted through a full system band normally, and transmission of PDCCH for the MTC UE from an OFDM symbol region within which the legacy PDCCH is transmitted may not be preferable due to multiplexing issue with a PDCCH transmitted to another UE. As one method for

solving this, it is required to introduce a control channel transmitted within a subband where MTC is operated for the MTC UE. As a downlink control channel for such a low-complexity MTC UE, the legacy EPDCCH may be used as it is. Or, M-PDCCH for the MTC UE which is a control channel of a modified type of the legacy PDCCH/ EPDCCH may be introduced. Hereinafter, in the present invention, the legacy EPDCCH or M-PDCCH for the low-complexity MTC UE or normal complexity MTC UE will be referred to as M-PDCCH. Also, MTC-EPDCCH is hereinafter used to refer to M-PDCCH.

[178] A data channel (e.g., PDSCH, PUSCH) and/or a control channel (e.g., M-PDCCH, PUCCH, PHICH) may be transmitted for coverage enhancement (CE) of the UE by using a repetition or TTI bundling scheme through multiple subframes. The control/ data channel may be transmitted by additionally using cross-subframe channel estimation and frequency (narrowband) hopping for CE. In this case, cross-subframe channel estimation means a channel estimation method means channel estimation using a reference signal within a subframe of a corresponding channel and a reference signal within neighboring subframe(s).

[179] The MTC UE may need CE of 15dB, for example. However, all MTC UEs do not exist in an environment that CE is needed. Also, the same requirements of QoS are not applied to all MTC UEs. For example, since devices such as sensor and meter have low mobility and are likely to be located in a shaded area even while having a small amount of data transmission and reception, the devices may need high CE. However, wearable devices such as smart watch may have mobility and are likely to be located in a place not a shaded area while having a relatively large amount of data transmission and reception. Therefore, all MTC UEs do not need CE of high level, and their requirement capability may be varied depending on their type.

[180] In the present invention, an operation for monitoring M-PDCCH by means of an MTC UE (which needs coverage enhancement (CE)) will be suggested. Hereinafter, M-PDCCH monitoring, search space monitoring, or M-PDCCH candidates monitoring may mean that reception or detection of M-PDCCH is attempted within a corresponding search space or from one of M-PDCCH candidates configuring the corresponding search space.

[181] In the following embodiments, the expression "assume" may mean that an entity for transmitting a channel transmits the channel to be suitable for the corresponding "assumption". An entity for receiving the channel may receive or decode the channel to be suitable for the corresponding "assumption" provided that the channel has been transmitted to be suitable for the corresponding "assumption".

[182] FIG. 7 illustrates repeated transmission of a channel for coverage enhancement.

[183] A search space for M-PDCCH may be configured over a plurality of downlink

subframes. For example, M-PDCCH search space having an aggregation level L and a repetition level R is defined by a set of M-PDCCH candidates. In this case, each M-PDCCH candidate may be repeated within a set of R number of consecutive downlink subframes. Referring to FIG. 7, in an example of maximum repetitions R_{max}=8 and a possible repetition level of $R \in \{1, 2, 4, 0\}$, a UE may attempt decoding of M-PDCCH by assuming that repetition of M-PDCCH (transmitted at an aggregation level L) exists in each of R number of consecutive downlink subframes. For example, the UE may attempt decoding of M-PDCCH by regarding signals received from each of 8 subframes as those of the same M-PDCCH in case of a repetition level $R = 8$ and attempt decoding of different M-PDCCHs in each of 8 subframes in case of a repetition level $R = 1$.

[184] In FIG. 7, repetition of a channel is performed over consecutive downlink subframes. However, a data channel and/or a control channel (hereinafter, data/control channel) transmitted to/from the MTC UE which needs CE may be transmitted by being repeated through non-consecutive subframes. For example, the control/data channel for a specific MTC UE may not be in all downlink subframes but may be restricted to some downlink subframes. Non-consecutive downlink subframes available at the MTC UE may be configured in such a manner that a downlink subframe group comprised of one or more consecutive downlink subframes is repeated with a periodicity greater than the number of subframes within the downlink subframe group. In other words, the data/control channel may be transmitted not in physically consecutive subframes, but transmitted in transmitted in each of physically non-consecutive subframes (excluding uplink subframes in case of downlink transmission, downlink subframes in case of uplink transmission, and/or subframes except subframe used for other purpose of use and cannot be used for data/control channel transmission). Use of non-consecutive (downlink or uplink) subframes for repeated transmission of the data/control channel of the MTC UE may increase transmission/reception latency. However, as time diversity effect is obtained in the time domain by use of non-consecutive subframes, the number of repetitions or the number of subframes used for channel transmission may be reduced as compared with transmission based on consecutive subframes. Therefore, overall system throughput may be increased. The embodiments of the present invention, which will be described later, suggest UE operation and transmission subframe during transmission/reception of a corresponding channel when a data/control channel transmitted from MTC UE is transmitted with repetition through consecutive subframes or non-consecutive subframes.

[185] In the following embodiments, each search space within an interval where a UE monitors M-PDCCH (CSS and/or USS) may be configured over one or more (consecutive or non-consecutive) downlink subframes. That is, a search space for

reception of the same M-PDCCH may be configured in each of one or more downlink subframes.

[186] For example, referring to FIG. 8, in case of no CE or CE having a repetition level = 1, each of CSSs of FIG. 8 may be CSS on which a respective M-PDCCH can be transmitted. At this time, a CSS starting subframe may mean a first subframe of paging occasions for allowing a UE to monitor M-PDCCH for a paging message. As another example, referring to FIG. 9, in case of no CE or CE having a repetition level = 1, each of CSSs of FIG. 9 may be CSS on which a respective M-PDCCH can be transmitted. At this time, a CSS starting subframe may mean a first subframe of a RAR window for allowing a UE to monitor M-PDCCH for scheduling RAR.

[187] In case of coverage enhancement (CE), M-PDCCH may be transmitted by being repeated once or multiple times. Therefore, a search space where M-PDCCH (hereinafter, paging M-PDCCH) will be monitored may be configured repeatedly over a plurality of downlink subframes, and a UE may attempt repeated reception of M-PDCCH within search spaces within the plurality of downlink subframes. If CE having a repetition level greater than 1 is applied, for example, each CSS shown in FIG. 8 may be a plurality of consecutive subframes that may have repetitions of M-PDCCH. If CE having a repetition level greater than 1 is applied, as another example, a plurality of CSSs within the same paging occasion shown in FIG. 8 may be CSSs for repetitions of the same M-PDCCH. If CE having a repetition level greater than 1 is applied, as still another example, a plurality of CSSs over a plurality of paging occasions shown in FIG. 8 may be CSSs for repetitions of the same M-PDCCH.

[188] ■ Section 1. M-PDCCH CSS for paging message scheduling

[189] In Section 1, details on M-PDCCH CSS for paging message scheduling are discussed.

[190] The paging message is used to notify UE(s) under RRC_IDLE and UE(s) under RRC_CONNECTED of system information modification.

[191] An eNB initiates a paging process by transmitting the paging message at a paging occasion of a UE. The eNB may address a plurality of UEs within the paging message by including a paging record (*PagingRecord*) per UE. The paging record may include information indicating NAS (non-access stratum) identifier of a UE which is paged and information indicating the origin of paging. One paging occasion means a subframe having P-RNTI transmitted on PDCCH/M-PDCCH addressing the paging message. A paging frame (PF) means one radio frame that includes one or a plurality of paging occasion(s).

[192] The UE may use discontinuous reception (DRX) in an idle mode to reduce power consumption. If DRX is used, the UE monitors only one paging occasion per DRX cycle.

[193] The paging message may be transmitted through a PDSCH, and the PDSCH carrying the paging message may be scheduled by PDCCH/M-PDCCH.

[194] For paging message scheduling, multiple narrowbands can be configured by eNB. Then, a narrowband location for a paging occasion monitoring of a UE is determined by at least UE ID at least for paging record(s). However, the narrowband location and paging occasion for common signal transmission (e.g., SI update, earthquake and tsunami warning system (ETWS), and/or commercial mobile alert system (CMAS)) is not determined yet. To reduce UE complexity, it would be beneficial to apply the same paging occasion and narrowband location for paging record(s) reception and other information reception such as SI update, ETWS, and CMAS. For example, the UE may attempt reception of M-PDCCH for scheduling the paging message on the same narrowband at the same paging occasion for SI update and reception of ETWS and CMAS instead of monitoring different paging occasions and/or different narrowbands for SI update and reception of ETWS and CMAS.

[195] FIG. 8 illustrates a configuration of a common search space (CSS) for paging according to the present invention.

[196] Under the assumption that a paging occasion is a time region for M-PDCCH monitoring for paging message scheduling, a UE can monitor a common search space (CSS) within a paging occasion to check paging message transmission. Depending on duration of paging occasion and period of CSS starting subframe, there can be multiple CSS monitoring opportunities within a paging occasion as shown in FIG. 8. The period and offset of CSS starting subframe location can be configured by eNB. In this case, offset k_{offset} of the CSS starting subframe may mean a difference from a reference subframe n (e.g., subframe 0) to a subframe $n+k_{offset}$ in which the CSS starting subframe is first applied.

[197] The composition of decoding candidates (i.e. M-PDCCH candidates) and a subset of $\{L, R\}$ for CSS for paging should be composed to supports all UEs with different CE levels. In this case, L indicates an aggregation level, and M-PDCCH of the aggregation level L is transmitted using aggregation of L number of M-CCEs. ECCE may be used as M-CCE, and CCE for MTC UE may newly be defined as M-CCE for MTC UE.

[198] To transmit paging message adapt to the target CE level, a subset of $\{L, R\}$ of CSS for paging needs to be composed to cover all range of CE levels or all range of repetition numbers. One simple configuration is $\{8, R1\}$, $\{16, R1\}$, $\{24, R1\}$, $\{24, R2\}$, $\{24, R3\}$, $\{24, R4\}$ where $R1 = 1$ and $R4$ is the maximum repetition level.

[199] In the present invention, a paging occasion may be defined as an interval where a UE monitors a paging M-PDCCH. For example, the UE may attempt reception of (same) paging M-PDCCH (or M-PDCCH scrambled by P-RNTI) within CSS(s) existing in the paging occasion or paging M-PDCCH search space(s) as shown in FIG. 8. Since the

paging M-PDCCH may be transmitted in any one of CSS(s) within the paging occasion, the UE continuously monitors the CSS(s) within the paging occasion. If the paging M-PDCCH (or M-PDCCH scrambled by P-RNTI) is received within the corresponding interval, the UE may receive a PDSCH carrying the corresponding paging message even though a paging message scheduled by the corresponding M-PDCCH, that is, a PDSCH carrying paging is transmitted outside a paging occasion interval.

[200] A duration of the paging occasion may be configured to be a multiple of the number of subframes configuring CSSs or search spaces on which the paging M-PDCCH is transmitted. For example, if the paging M-PDCCH search space is configured in each of R number of (consecutive or non-consecutive) downlink subframes, the paging occasion may be configured to have a duration of R*X number of subframes (where X is a positive integer).

[201] ■ Section 2. M-PDCCH CSS for RAR scheduling

[202] FIG. 9 illustrates a configuration of a common search space (CSS) for RAR according to the present invention.

[203] There would be multiple narrowbands for CSS for RAR scheduling, and the narrowband location of a UE for RAR monitoring is determined by PRACH resource set.

[204] After transmitting PRACH, a UE would try to receive RAR. Similar to paging occasion, there can be multiple CSS regions within a RAR window as depicted in Figure 9. So, the UE can monitor M-PDCCH scheduling RAR in CSS region(s) within the RAR window.

[205] A subset of $\{L, R\}$ and composition of decoding candidates of CSS for RAR can depend on CE level of corresponding PRACH resource set. For example, for each CE level, PRACH resource set(s) and available repetition level(s) may be configured. In this case, the UE may monitor a CSS, that is, M-PDCCH in accordance with a set of $\{L, R\}$ configured for a CE level associated with a PRACH resource used for a successful RACH procedure. Regardless of CSS and USS, same composition of decoding candidates and same subset of $\{L, R\}$ can be used for same CE level of the search space. For example, the UE may monitor a CSS and a USS in accordance with $\{L, R\}$ of the same set with respect to the same CE level.

[206] The present invention suggests that a RAR window interval should be defined as an interval where a UE monitor M-PDCCH (hereinafter, RAR M-PDCCH) for scheduling RAR. That is, as shown in FIG. 9, the UE may attempt reception of RAR M-PDCCH (e.g., M-PDCCH scheduled by RA-RNTI) on CSS(s) existing within a RAR window or a search space(s) (hereinafter, RAR M-PDCCH search space) on which RAR M-PDCCH is transmitted. If the UE receives RAR M-PDCCH within the corresponding interval, the UE may receive a PDSCH through which the corresponding RAR is

transmitted, even though RAR (e.g., PDSCH carrying RAR) scheduled by the corresponding M-PDCCH is transmitted outside the RAR window interval.

[207] A duration of the RAR window may be configured to become a multiple of the number of subframes configuring CSSs or RAR M-PDCCH search spaces. For example, if RAR M-PDCCH search space is configured in each of R number of (consecutive or non-consecutive) downlink subframes, the RAR window may be configured to have a duration of R*X number of subframes (in this case, X is a positive integer).

[208] ■ Section 3. M-PDCCH CSS for other purposes

[209] M-PDCCH CSS can be used to transmit DCIs for other purposes except paging message and RAR scheduling. For example, M-PDCCH CSS can be used for transmission of DCI for unicast data, DCI for TPC, DCI for enhanced interference management and traffic adaptation (eIMTA), and DCI for enhanced PHICH (EPHICH). If CSS is used to transmit these DCIs, the narrowband location, monitoring subframe location, and decoding candidates composition need to be specified. Hereinafter, the CSS will be referred to as CSS_regular or CSS_others.

[210] CSS for these purposes (i.e. CSS_regular) can be located in the same narrowband to USS. Then, a UE does not need to re-tune its operating frequency to monitor this CSS.

[211] To reconfigure CE level of a UE, the CSS needs to support the maximum CE level of the cell considering CE level reconfiguration message can be transmitted by this CSS. Therefore, CE level or a subset of $\{L, R\}$ composing the CSS should support all CE level of the cell.

[212] FIG. 10 illustrates the example of the monitoring time region of USS and CSS.

[213] Period of starting subframe for M-PDCCH USS monitoring and CSS monitoring can be configured independently. The period of CSS monitoring can be longer than the period of USS, since CE level of USS and CSS can be different and CSS can be occurred sparsely to reduce UE complexity.

[214] Referring to Math Figure 1 which is a hashing function, it is noted that $Y_{p,k}$ is varied depending on n_{RNTI} which is UE ID. In this way, CCE(s) or ECCE(s) configuring decoding candidates in the USS is(are) determined UE-specifically to be monitored by a specific UE. M-PDCCH CSS can be monitored by a group of MTC UEs. Therefore, for CSS, there should not be a hashing function to randomize the starting ECCE location composing a search space UE-specifically.

[215] ■ Section 4. Coverage enhancement level of CSS

[216] For transmission of a broadcast PDSCH (e.g., paging, RAR), CSSs for other purposes such as unicast data, TPC, eIMTA DCI and EPHICH may exist, and USS where a UE monitors unicast data may exist. Hereinafter, a coverage enhancement level of corresponding search spaces will be described.

[217] The present invention suggests that a plurality of SS types exist as follows in accordance with a coverage enhancement level supported by a search space or repetitions of M-PDCCH.

[218] - Method 1.

[219] In view of the UE, two types of search spaces (SSs) may exist as follows:

[220] * SS type 1: SS supporting all coverage enhancement levels or all repetitions of M-PDCCH, and

[221] * SS type 2: SS where the number of repetitions of M-PDCCH which is supported is varied depending on a coverage enhancement level of the UE.

[222] In this case, the UE may assume that CSS for paging and/or CSS_regular has SS type 1, and CSS and/or USS for RAR has SS type 2.

[223] Alternatively, as SS monitored by the UE, one SS having SS type 1 and one SS having SS type 2 may exist. CSS for paging and/or CSS_regular may be the same as SS having SS type 1, and CSS and/or USS for RAR may be the same as SS having SS type 2.

[224] - Method 2.

[225] When N number of coverage enhancement levels (or the number of repetitions of M-PDCCH) supported by a cell exist, in view of the cell, a plurality of SS types may exist as follows:

[226] * SS type 1: SS supporting coverage enhancement level 1 (or the number of repetitions R_1 of M-PDCCH),

[227] * SS type 2: SS supporting coverage enhancement level 2 (or the number of repetitions R_2 of M-PDCCH),

[228] ...

[229] * SS type N: SS supporting coverage enhancement level N (or the number of repetitions R_N of M-PDCCH),

[230] * SS type N+1: SS supporting all coverage enhancement levels (or all repetitions for M-PDCCH).

[231] In this case, SS supporting the coverage enhancement level n may mean SS supporting the coverage enhancement levels 1 to n or the maximum number of repetitions R_n of M-PDCCH.

[232] In this case, the UE may assume that the CSS for paging and CSS_regular has SS type N+1, and the CSS for RAR and/or USS has SS type k if the coverage enhancement level of the UE is k.

[233] ■ Section 5. Relationship between search spaces

[234] **CSS for paging (i.e., CSS_paging)**

[235] It is a CSS for paging monitoring in RRC_IDLE state. Since UEs in different CE levels monitor the same CSS for paging scheduling, it should be designed to cover all

the CE levels. CSS_paging are configured by SIB. In other words, the configuration of CSS_paging may be transmitted through SIB. The UE may identify the configuration of CSS_paging by reading SIB. The UE may monitor M-PDCCH candidates of CSS within subframe(s) and/or narrowband(s) according to the CSS_paging configuration.

[236] **CSS for** RAR corresponding to initial RACH procedure (i.e., CSS_RAR)

[237] Using CSS for RAR, a UE can monitor RAR, Msg3 (for retransmission), and Msg4. Though it can be considered to allow separate SS configurations for Msg3 re-transmission and Msg4 scheduling M-PDCCH from the SS configuration for RAR, given that those (i.e. RAR, Msg3 and Msg4) will be used only for initial access, the present invention proposes that the same configuration is used for initial RACH procedure. Required configurations for CSS_RAR can be configured by SIB per CE level. Then, in a UE perspective, configurations for CSS_RAR can be determined based on the CE level of PRACH resource set used for the latest PRACH transmission.

[238] **CSS for others (i.e., CSS_others or CSS_regular)**

[239] M-PDCCH CSS can be used to transmit DCIs for other purposes except paging message and initial RAR scheduling. For example, CSS is required to transmit TPC, unicast data for reconfiguration (such as CE level, transmission mode, USS recon-figuration), a DCI transmitting multiple HARQ-ACK corresponding to PUSCH to multiple UEs (if supported), transmit RAR corresponding to PRACH triggered by M-PDCCH order. CSS for these purposes can be located in the same narrowband to USS once a UE is connected to the network. Then, a UE does not need to re-tune its operating frequency to monitor this CSS. A UE can monitor CSS_others (i.e., CSS_regular) and USS simultaneously.

[240] If there is a complexity issue, TDM of CSS and USS monitoring can be considered. In other words, CSS and USS are time-division multiplexed, whereby the CSS and the USS may not be monitored at the same time.

[241] If CSS for other purposes are not defined, legacy PUCCH TPC via DCI format 3/3A cannot be supported. Then, if downlink traffic is occurred sparsely, it could be difficult to adopt PUCCH power since PUCCH TPC is accomplished by accumulated way. So, other way to handle this issue needs to be considered such as absolute PUCCH TPC via DL grant or unicast DCI for PUCCH TPC transmitted by USS. Thus, at least for CE mode A (for TCP and reconfiguration), CSS_others needs to be supported.

[242] **USS**

[243] USS is a search space for unicast data scheduling. Configurations for USS can be configured by SIB and Msg4. If necessary, reconfiguration can be utilized by radio resource control (RRC) layer (i.e. RRC signal). Configurations for USS also can be applied for CSS_others. In this case, individual configurations for CSS_others and USS may not be required.

[244] FIG. 11 illustrates a procedure of configuring a search space according to the present invention.

[245] Referring to FIG. 11, the UE may receive a list of search space (SS) configurations per CE level for RAR through SIB (S1101). The UE may transmit RACH preamble through PRACH by using a PRACH resource. PRACH resource(s) per CE level may be configured by SIB. The UE may monitor M-PDCCH for scheduling a response to the RACH preamble transmitted therefrom, that is, a response to transmission of the PRACH in a search space (S1103). The UE may assume that a search space for M-PDCCH scheduling the RAR depends on SS configuration (e.g., CSS_RAR configuration) received through the SIB. The UE which has received RAR M-PDCCH may receive RAR in accordance with DCI carried by the RAR M-PDCCH (S1105).

[246] Initial configuration for RAR, Msg3 and/or Msg4 may depend on SS configuration per CE level received (S1101) through SIB (S1121). The UE may monitor M-PDCCH for scheduling Msg4, which includes CSS configuration/reconfiguration and/or USS configuration/reconfiguration parameters, in the SS according to initial configuration through SIB (S1121). For example, the UE may monitor Msg4 M-PDCCH by assuming that the maximum number of repetitions, narrowband, PRB-set, etc. which are the same as those of CSS for RAR, are also applied to M-PDCCH (hereinafter, Msg4 M-PDCCH) for scheduling Msg4 (S1121). The UE which has received Msg4 M-PDCCH may receive Msg4 in accordance with DCI of the Msg4 M-PDCCH (S1123). The Msg4 may carry RRC message that includes UE-specific configuration for USS and/or CSS. In this case, the UE may monitor M-PDCCH by applying the UE-specific SS configuration instead of initial SS configuration (S1125).

[247] The UE may monitor M-PDCCH order within the CSS according to the UE-specific CSS configuration (S1141). The UE which has received the M-PDCCH order may receive RAR in accordance with scheduling information carried by the M-PDCCH order (S1143).

[248] The UE may monitor M-PDCCH for scheduling RRC message having UE-specific reconfiguration parameter(s) within the CSS according to the UE-specific CSS configuration (S1161). The UE-specific reconfiguration may include M-PDCCH configuration. The UE which has received the M-PDCCH may receive a PDSCH carrying the RRC message in accordance with scheduling information (that is, DCI) of the M-PDCCH (S1163). The UE may reconfigure M-PDCCH search space in accordance with the UE-specific reconfiguration.

[249] Table 13 illustrates parameters and configuration details required for search spaces. All or some of the parameters illustrated in Table 13 may be configured and/or reconfigured in accordance with Table 13.

[250] [Table 13]

Parameters	Configuration details				Description
	CSS_paging	CSS_RAR	CSS_others	USS	
Subset of L	Fixed to {8, 16, 24}			{1, 2, 4, 8, 16, 24}	
R_{max}	Configurable by SIB.	Configured by SIB per CE level (configuration can be shared for CSS_RAR, CSS_others, USS).For CSS_others/USS, it can be reconfigured by RRC.			Subset of repetition numbers is determined based on R_{max}. Details are described in Subsection 5.1.
PRB-sets	Configured by SIB.	Configured by SIB per CE level specific and cell-specific.	Alt 1. Configured by Msg4 per UE.Alt 2. Configured by SIB per CE level (in this case, same configuration for CSS_RAR, CSS_others, USS).It can be reconfigured by RRC.		This configuration includes the number of PRB-sets, PRB size/ location of each PRB-set.
Transmission type	Configured by SIB per PRB-set.	Configured by SIB per PRB-set.	Alt 1. Configured by Msg4 per UE (the network ensures the same type is used beween CSS_others and USS in case both are monitored at the same time).Alt 2. Configured by SIB per CE level (in this case, same configuration for CSS_RAR, CSS_others, USS).It can be reconfigured by RRC.		
Narrowband	Determined	Based on	Default value can be		

	by UE ID among paging narrowbands configured by SIB.	PRACH resource set where RAR narrowband corresponding to each PRACH resource set is configured by SIB.	CSS_RAR's narrowband location. Configurable by Msg 4 per UEIt can be reconfigured by RRC.	
M-PDCCH monitoring starting	Alt 1. Configured by SIB per CE level.Alt 2. Configured by SIB regardless of CE level (one maximum value to reset monitoring starting subframe).			See FIG. 7 and Subsection 5.1.
M-PDCCH starting subframe	Determined by repetition number R per repetition number R.	Alt 1. Determined by R_{max} for CE Mode A, determined by repetition number R per repetition number R for CE Mode B.Alt 2. Determined by repetition number R per repetition number R.		See FIG. 7 and Subsection 5.1.

[251] In Table 13, a merged cell means that the configuration can be shared by corresponding search spaces, so individual configuration is not needed for each search space. For example, referring to Table 13, "Fixed to {8, 16, 24}" which is the description of a subset of an aggregation level L exists within a cell merged for CSS_paging, CSS_RAR and CSS_others (i.e., CSS_regular), and thus means that a corresponding parameter is not required to be configured individually for CSS_paging, CSS_RAR and CSS_others(i.e. CSS_reguar) and a common parameter is applied to CSS_paging, CSS_RAR and CSS_others. According to Table 13, the UE may attempt reception of M-PDCCH at an aggregation level $L\in\{8, 16, 24\}$ for CSS_paging, CSS_RAR and CSS_others, and may attempt reception of M-PDCCH at $L\in\{1, 2, 4, 8, 16, 24\}$ for the USS.

[252] Reconfigurable parameters in Table 13 mean that the same value as initial configuration or default configuration is applied until a corresponding parameter is reconfigured, whereby search space(s) is(are) configured.

[253] For example, referring to Table 13, the maximum number of repetitions R_{max} of M-PDCCH may be provided through SIB as a configuration for CSS_RAR. The UE may monitor CSS_RAR, CSS_others and/or USS by assuming that R_{max} included in the SIB is applied to CSS_RAR, CSS_others, and USS. That is, the UE may monitor rep-

etitions of M-PDCCH in SS within maximum R_{max} number of subframes. According to Table 13, since R_{max} for CSS_others and/or USS (hereinafter, CSS_others/USS) may be reconfigured, if R_{max} for CSS_others/USS is reconfigured by RRC signal, the UE may monitor CSS_others/USS in accordance with the reconfigured R_{max}. In other words, the UE may monitor CSS_others/USS in accordance with R_{max} for CSS_RAR until R_{max} for CSS_others/USS is received.

[254] For another example, referring to parameters of PRB-sets in Table 13, PRBs on which PRB-set(s) for CSS_RAR, that is, RAR M-PDCCH may be transmitted may be configured CE level-specifically and cell-specifically by SIB. Referring to Alt 2, these PRB-sets configured per CE level may be applied to CSS_others and USS by SIB. Since PRB-set parameter for CSS_others and USS may be reconfigured by RRC, the UE may monitor CSS_others/USS by applying PRB-set(s) for CSS_RAR until reconfiguration PRB-set parameter for CSS_others/USS is received, and may monitor CSS_others/USS by applying the reconfiguration PRB-set parameter if the reconfiguration PRB-set parameter for CSS_others/USS is received. For example, if PRB-set(s) of CSS_RAR are fixed to 6, the UE may monitor M-PDCCH USS by assuming all PRBs within a narrowband according to CSS_RAR configuration as PRB-set(s) for USS until configuration of separate PRB-set(s) for USS is received.

[255] For still another example, referring to a narrowband parameter of Table 13, a narrowband (hereinafter, RAR narrowband) having CSS_RAR may be determined based on a PRACH resource set. In this case, a corresponding RAR narrowband per PRACH resource set is configured by SIB. A default narrowband location of CSS_others and/or USS may be a narrowband location of CSS_RAR. A narrowband for CSS_others/USS may be configured per UE by Msg4, and may be reconfigured by RRC. Therefore, the UE may monitor CSS_others/USS on the same narrowband as that for CSS_RAR until a narrowband parameter for CSS_others/USS is received, and if Msg4 for CSS_others/USS or reconfiguration RRC message is received, may monitor CSS_others/USS on a narrowband according to the Msg4 or the RRC message.

[256] □ Subsection 5.1. Aggregation levels and repetition numbers

[257] Search space configuration parameters of Table 13 may be applied as follows in view of an aggregation level and the number of repetitions. For example, a subset (and/or starting subframe of M-PDCCH SS and/or starting subframe of M-PDCCH) of the number of repetitions R based on R_{max} may be determined in accordance with the following description.

[258] **CSS for paging (i.e., CSS_paging)**

[259] - Aggregation levels:

[260] Since data transmission scheduled by CSS is targeted to multicast/broadcast, similar

to PDCCH CSS, some high aggregation levels can be supported. Aggregation levels (ALs) {8, 16, 24} can be supported for normal CP and ALs {4, 8, 12} can be supported for extended CP.

[261] - Repetition numbers:

[262] A subset of R for CSS for paging monitoring depends on the maximum R (i.e., R_{max}) where R_{max} is configured by SIB. To support wide range of repetition numbers, the subset of R monitored for CSS_paging can be {$R_{max}/64$, $R_{max}/16$, $R_{max}/4$, R_{max}}.

[263] **CSS for** RAR corresponding to initial RACH procedure (i.e., CSS_RAR)

[264] - Aggregation levels:

[265] Similar to CSS_paging, ALs $L \in \{8, 16, 24\}$ can be supported for normal CP and ALs $L \in \{4, 8, 12\}$ can be supported for extended CP.

[266] - Repetition numbers:

[267] For CSS scheduling RAR, the subset of R depends on the maximum R (i.e., R_{max}) where R_{max} is configured by SIB per CE level. The subset of R monitored for CSS_RAR can be {$R_{max}/4$, $R_{max}/2$, R_{max}}.

[268] **CSS for others (i.e., CSS_others)**

[269] - Aggregation levels:

[270] Similar to CSS_paging, ALs $L \in \{8, 16, 24\}$ can be supported for normal CP and ALs $L \in \{4, 8, 12\}$ can be supported for extended CP.

[271] - Repetition numbers:

[272] For CSS_others, the subset of R depends on the maximum R (i.e., R_{max}) where R_{max} is configured by SIB per CE level or Msg4. R_{max} can be reconfigured by RRC if necessary. The subset of R monitored for CSS_others can be {$R_{max}/4$, $R_{max}/2$, R_{max}}. Or, to reduce UE complexity, the subset of R monitored for CSS_others can be {$R_{max}/2$, R_{max}}.

[273] **USS**

[274] - Aggregation levels:

[275] For CE Mode A, ALs $L \in \{1, 2, 4, 8, 16, 24\}$ are supported for normal CP. ALs $L \in \{1, 2, 4, 8, 12\}$ are supported for extended CP. For CE Mode B, ALs $L \in \{8, 16, 24\}$ is supported for normal CP. ALs $L \in \{4, 8, 12\}$ are supported for extended CP.

[276] - Repetition numbers:

[277] For USS, the subset of R depends on the maximum R (i.e., R_{max}) where R_{max} is configured by SIB per CE level or Msg4. R_{max} can be reconfigured by RRC if necessary. The subset of R monitored for USS can be {$R_{max}/4$, $R_{max}/2$, R_{max}}. Or, to support higher R to CSS_others for CE level reconfiguration reliably, subset of R monitored for USS can be {$R_{max}/8$, $R_{max}/4$, $R_{max}/2$}.

[278] ■ Section 6. Collision of M-PDCCH(s)

[279] If there are some subframes not available for downlink transmission, M-

PDCCH/PDSCH transmission or repetitions can be postponed till the next available subframe. It can be applied in case unavailable subframes are aligned between eNB and UE.

[280] FIG. 12 illustrates a configuration of M-PDCCH repeated transmission according to the present invention.

[281] If a small interval (e.g., cycle of starting subframe of M-PDCCH search space) of M-PDCCH search space is configured or a large number of invalid subframes, which cannot have M-PDCCH, are provided between M-PDCCH search space starting subframes, M-PDCCH2 transmission may not end until next starting subframe of the search space, in the same manner as M-PDCCH2 transmission of FIG. 12. That is, the subframes configuring two search spaces may be overlapped with each other. In this case, the UE may be in the status that the UE should perform monitoring for M-PDCCH transmitted in a previous search space and monitoring for M-PDCCH transmitted in a next search space. However, this operation may not be preferable due to buffer size and complexity issue of the UE. In this case, the UE may perform reception of M-PDCCH as follows.

[282] - Method 1. If a starting time (hereinafter, subframe #n) of next search space occurs before reception of M-PDCCH is ended, the UE may assume that the M-PDCCH is transmitted up to subframe #n-1 and is not transmitted in subframe #n. In this case, the UE may attempt reception of the M-PDCCH by using repetitions smaller than the number of expected repetitions of M-PDCCH.

[283] - Method 2. If a starting time (hereinafter, subframe #n) of next search space occurs before reception of M-PDCCH is ended, the UE may determine that the M-PDCCH that the UE is receiving is invalid, and may not perform reception of the corresponding M-PDCCH.

[284] - Method 3. If subframe(s) configuring two search spaces are overlapped with each other, the UE may determine that a search space existing at an earlier time is invalid, and may not perform reception of M-PDCCH for one of the two search space, which is first started in a time domain.

[285] FIG. 13 is a block diagram illustrating elements of a transmitting device 10 and a receiving device 20 for implementing the present invention.

[286] The transmitting device 10 and the receiving device 20 respectively include Radio Frequency (RF) units 13 and 23 capable of transmitting and receiving radio signals carrying information, data, signals, and/or messages, memories 12 and 22 for storing information related to communication in a wireless communication system, and processors 11 and 21 operationally connected to elements such as the RF units 13 and 23 and the memories 12 and 22 to control the elements and configured to control the memories 12 and 22 and/or the RF units 13 and 23 so that a corresponding device may

perform at least one of the above-described embodiments of the present invention.

[287] The memories 12 and 22 may store programs for processing and controlling the processors 11 and 21 and may temporarily store input/output information. The memories 12 and 22 may be used as buffers.

[288] The processors 11 and 21 generally control the overall operation of various modules in the transmitting device and the receiving device. Especially, the processors 11 and 21 may perform various control functions to implement the present invention. The processors 11 and 21 may be referred to as controllers, microcontrollers, microprocessors, or microcomputers. The processors 11 and 21 may be implemented by hardware, firmware, software, or a combination thereof. In a hardware configuration, application specific integrated circuits (ASICs), digital signal processors (DSPs), digital signal processing devices (DSPDs), programmable logic devices (PLDs), or field programmable gate arrays (FPGAs) may be included in the processors 11 and 21. Meanwhile, if the present invention is implemented using firmware or software, the firmware or software may be configured to include modules, procedures, functions, etc. performing the functions or operations of the present invention. Firmware or software configured to perform the present invention may be included in the processors 11 and 21 or stored in the memories 12 and 22 so as to be driven by the processors 11 and 21.

[289] The processor 11 of the transmitting device 10 performs predetermined coding and modulation for a signal and/or data scheduled to be transmitted to the outside by the processor 11 or a scheduler connected with the processor 11, and then transfers the coded and modulated data to the RF unit 13. For example, the processor 11 converts a data stream to be transmitted into K layers through demultiplexing, channel coding, scrambling, and modulation. The coded data stream is also referred to as a codeword and is equivalent to a transport block which is a data block provided by a MAC layer. One transport block (TB) is coded into one codeword and each codeword is transmitted to the receiving device in the form of one or more layers. For frequency up-conversion, the RF unit 13 may include an oscillator. The RF unit 13 may include N_t (where N_t is a positive integer) transmit antennas.

[290] A signal processing process of the receiving device 20 is the reverse of the signal processing process of the transmitting device 10. Under control of the processor 21, the RF unit 23 of the receiving device 20 receives radio signals transmitted by the transmitting device 10. The RF unit 23 may include N_r (where N_r is a positive integer) receive antennas and frequency down-converts each signal received through receive antennas into a baseband signal. The processor 21 decodes and demodulates the radio signals received through the receive antennas and restores data that the transmitting device 10 intended to transmit.

[291] The RF units 13 and 23 include one or more antennas. An antenna performs a function for transmitting signals processed by the RF units 13 and 23 to the exterior or receiving radio signals from the exterior to transfer the radio signals to the RF units 13 and 23. The antenna may also be called an antenna port. Each antenna may correspond to one physical antenna or may be configured by a combination of more than one physical antenna element. The signal transmitted from each antenna cannot be further deconstructed by the receiving device 20. An RS transmitted through a corresponding antenna defines an antenna from the view point of the receiving device 20 and enables the receiving device 20 to derive channel estimation for the antenna, irrespective of whether the channel represents a single radio channel from one physical antenna or a composite channel from a plurality of physical antenna elements including the antenna. That is, an antenna is defined such that a channel carrying a symbol of the antenna can be obtained from a channel carrying another symbol of the same antenna. An RF unit supporting a MIMO function of transmitting and receiving data using a plurality of antennas may be connected to two or more antennas.

[292] In the embodiments of the present invention, a UE operates as the transmitting device 10 in UL and as the receiving device 20 in DL. In the embodiments of the present invention, an eNB operates as the receiving device 20 in UL and as the transmitting device 10 in DL. Hereinafter, a processor, an RF unit, and a memory included in the UE will be referred to as a UE processor, a UE RF unit, and a UE memory, respectively, and a processor, an RF unit, and a memory included in the eNB will be referred to as an eNB processor, an eNB RF unit, and an eNB memory, respectively.

[293] The eNB processor of the present invention may configure or reconfigure CSS_paging in accordance with section 1, section 5 and/or section 6. The eNB processor may control the eNB RF unit to transmit SIB or RRC message, which includes configuration for CSS_paging, to the UE in accordance with section 1, section 5 and/or section 6. The eNB processor may control the eNB RF unit to transmit M-PDCCH for scheduling a paging message within CSS_paging according to CSS_paging configuration. The UE processor of the present invention may control the UE RF unit to receive configuration or reconfiguration information on CSS_paging from the eNB in accordance with section 1, section 5 and/or section 6. The UE may attempt reception of paging M-PDCCH from CSS_paging according to the CSS_paging configuration.

[294] The eNB processor of the present invention may configure or reconfigure CSS_RAR in accordance with section 2, section 5 and/or section 6. The eNB processor may control the eNB RF unit to transmit SIB or RRC message, which includes configuration for CSS_RAR, to the UE in accordance with section 2, section 5 and/or section 6. The eNB processor may control the eNB RF unit to transmit M-PDCCH for

scheduling RAR, Msg3 and/or Msg4 within a CSS according to CSS_RAR configuration. The UE processor of the present invention may control the UE RF unit to receive configuration or reconfiguration information on CSS_RAR from the eNB in accordance with section 2, section 5 and/or section 6. The UE may attempt reception of RAR M-MPDCCH, Msg3 M-PDCCH and/or Msg4 M-PDCCH from the CSS according to the CSS_RAR configuration.

[295] The eNB processor of the present invention may configure or reconfigure CSS_others in accordance with section 3, section 5 and/or section 6. The eNB processor may control the eNB RF unit to transmit SIB or RRC message, which includes configuration for CSS_others, to the UE in accordance with section 3, section 5 and/or section 6. The eNB processor may control the eNB RF unit to transmit M-PDCCH for other purpose within a CSS according to CSS_others configuration. The UE processor of the present invention may control the UE RF unit to receive configuration or reconfiguration information on CSS_others from the eNB in accordance with section 3, section 5 and/or section 6. The UE may attempt reception of M-PDCCH for other purpose from the CSS according to the CSS_others configuration.

[296] The eNB processor of the present invention may transmit initial configuration for CSS through SIB in accordance with section 6. The eNB processor may configure CSS and/or USS in accordance with the initial configuration until the other configuration (e.g., UE-specific configuration/reconfiguration) for SS is transmitted. The initial configuration may include a configuration (e.g., narrowband, PRB-set(s), starting subframe and/or period, and the number of maximum repetitions of SS) of time-frequency resources of SS. The eNB processor may transmit M-PDCCH in accordance with the initial configuration until the other configuration for SS is transmitted. For example, the eNB processor may control the eNB RF unit to transmit M-PDCCH by applying the number of repetitions R based on maximum R_{max} according to the initial configuration within the PRB-set according to the initial configuration on a narrowband according to the initial configuration. If the other configuration for SS is transmitted, the eNB processor may control the eNB RF unit to transmit M-PDCCH on the SS configured in accordance with the other configuration. The UE processor may receive the initial configuration for CSS through SIB in accordance with section 6. The UE processor may assume that CSS and/or USS is configured in accordance with the initial configuration until the other configuration (e.g., UE-specific configuration/reconfiguration) for SS is received. The UE processor may monitor M-PDCCH in accordance with the initial configuration until the other configuration for SS is transmitted. For example, the UE processor may control the UE RF unit to receive or monitor M-PDCCH by applying the number of repetitions R based on maximum R_{max} according to the initial configuration within the PRB-set according to the initial con-

figuration on a narrowband according to the initial configuration. If the other configuration for SS is received, the UE processor may control the UE RF unit to receive or monitor M-PDCCH on the SS configured in accordance with the other configuration.

[297] As described above, the detailed description of the preferred embodiments of the present invention has been given to enable those skilled in the art to implement and practice the invention. Although the invention has been described with reference to exemplary embodiments, those skilled in the art will appreciate that various modifications and variations can be made in the present invention without departing from the spirit or scope of the invention described in the appended claims. Accordingly, the invention should not be limited to the specific embodiments described herein, but should be accorded the broadest scope consistent with the principles and novel features disclosed herein.

Industrial Applicability

[298] The embodiments of the present invention are applicable to a BS, a UE, or other devices in a wireless communication system.

Claims

[Claim 1] A method for receiving, by a user equipment (UE), downlink control information (DCI) for the UE, the method comprising:
receiving, by the UE, a common search space configuration for a common search space;
receiving, by the UE, a first physical downlink control channel (PDCCH) scheduling a random access response by monitoring first PDCCH candidates of the common search space according to the common search space configuration; and
receiving, by the UE, a second PDCCH carrying the DCI for the UE by monitoring second PDCCH candidates of a UE-specific search space,
wherein the second PDCCH candidates of the UE-specific search space are monitored according to the same configuration as the common search space configuration until the UE receives a UE-specific search space configuration.

[Claim 2] The method according to claim 1,
wherein the common search space configuration includes information on a narrowband for the common search space, and
wherein the second PDCCH candidates of the UE-specific search space are monitored on the same narrowband as the narrowband for the common search space until the UE receives a UE-specific search space configuration.

[Claim 3] The method according to claim 1 or 2,
wherein the common search space configuration includes information on a maximum number of repetitions for the common common search space, and
wherein the second PDCCH candidates of the UE-specific search space are monitored based on the same number as the maximum number of repetitions for the common search space until the UE receives a UE-specific search space configuration.

[Claim 4] The method according to any one of claims 1 to 3,
wherein the common search space configuration includes information on a first physical resource block (PRB) set for monitoring the first PDCCH, and
wherein the same physical resource block set as the first PRB set is used for monitoring the second PDCCH candidates until the UE receives a UE-specific search space configuration.

[Claim 5] The method according to any one of claims 1 to 4,
wherein the first PDCCH candidates of the common search space are monitored according to aggregation levels larger than or equal to 8 among a plurality of aggregation levels, and the second PDCCH candidates of the UE-specific search space are monitored according to the plurality of aggregation levels.

[Claim 6] A method for transmitting, by a base station (BS), downlink control information (DCI) for a user equipment (UE), the method comprising:
transmitting, by the BS, common search space configuration for a common search space;
transmitting, by the BS to the UE, a first physical downlink control channel (PDCCH) scheduling a random access response by using one of first PDCCH candidates of the common search space according to the common search space configuration; and
transmitting, by the BS to the UE, a second PDCCH carrying the DCI for the UE by using one of second PDCCH candidates of a UE-specific search space,
wherein the second PDCCH candidates of the UE-specific search space are configured according to the same configuration as the common search space configuration until a UE-specific search space configuration is transmitted to the UE.

[Claim 7] The method according to claim 6,
wherein the common search space configuration includes information on a narrowband for the common search space, and
wherein the second PDCCH candidates of the UE-specific search space are configured on the same narrowband as the narrowband for the common search space until the UE-specific search space configuration is transmitted to the UE.

[Claim 8] The method according to claim 6 or 7,
wherein the common search space configuration includes information on a maximum number of repetitions for the first common search space, and
wherein the second PDCCH candidates of the UE-specific search space are configured based on the same number as the maximum number of repetitions for the common search space until the UE-specific search space configuration is transmitted to the UE.

[Claim 9] The method according to any one of claims 6 to 8,
wherein the common search space configuration includes information

on a first physical resource block (PRB) set for transmitting the first PDCCH, and
wherein the same physical resource block set as the first PRB set is used for the second PDCCH candidates until the UE-specific search space configuration is transmitted to the UE.

[Claim 10] The method according to any one of claims 6 to 9,
wherein the first PDCCH candidates of the common search space are configured according to aggregation levels larger than or equal to 8 among a plurality of aggregation levels, and the second PDCCH candidates of the UE-specific search space are configured according to the plurality of aggregation levels.

[Claim 11] A user equipment (UE) for receiving downlink control information (DCI) for the UE, the UE comprising:
a radio frequency (RF) unit, and
a processor connected to the RF unit, the processor configured to:
control the RF unit to receive common search space configuration for a common search space;
control the RF unit to receive a first physical downlink control channel (PDCCH) scheduling a random access response by monitoring first PDCCH candidates of the common search space according to the common search space configuration; and
control the RF unit to receive a second PDCCH carrying the DCI for the UE by monitoring second PDCCH candidates of a UE-specific search space,
wherein the second PDCCH candidates of the UE-specific search space are monitored according to the same configuration as the common search space configuration until the UE receives a UE-specific search space configuration.

[Claim 12] The UE according to claim 11,
wherein the common search space configuration includes information on a narrowband for the common search space, and
wherein the second PDCCH candidates of the UE-specific search space are monitored on the same narrowband as the narrowband for the common search space until the UE receives a UE-specific search space configuration.

[Claim 13] The UE according to claim 11 or 12,
wherein the common search space configuration includes information on a maximum number of repetitions for the common common search

space, and
wherein the second PDCCH candidates of the UE-specific search space are monitored based on the same number as the maximum number of repetitions for the common search space until the UE receives a UE-specific search space configuration.

[Claim 14] The UE according to any one of claims 11 to 13,
wherein the common search space configuration includes information on a first physical resource block (PRB) set for monitoring the first PDCCH, and
wherein the same physical resource block set as the first PRB set is used for monitoring the second PDCCH candidates until the UE receives a UE-specific search space configuration.

[Claim 15] The UE according to any one of claims 11 to 14,
wherein the first PDCCH candidates of the common search space are monitored according to aggregation levels larger than or equal to 8 among a plurality of aggregation levels, and the second PDCCH candidates of the UE-specific search space are monitored according to the plurality of aggregation levels.

[Claim 16] A base station (BS) for transmitting downlink control information (DCI) to a user equipment (UE), the BS comprising:
a radio frequency (RF) unit, and
a processor connected to the RF unit, the processor configured to:
control the RF unit to transmit common search space configuration for a common search space;
control the RF unit to transmit, to the UE, a first physical downlink control channel (PDCCH) scheduling a random access response by using one of first PDCCH candidates of the common search space according to the common search space configuration; and
control the RF unit to transmit, to the UE, a second PDCCH carrying the DCI for the UE by using one of second PDCCH candidates of a UE-specific search space,
wherein the second PDCCH candidates of the UE-specific search space are configured according to the same configuration as the common search space configuration until a UE-specific search space configuration is transmitted to the UE.

[Claim 17] The BS according to claim 16,
wherein the common search space configuration includes information on a narrowband for the common search space, and

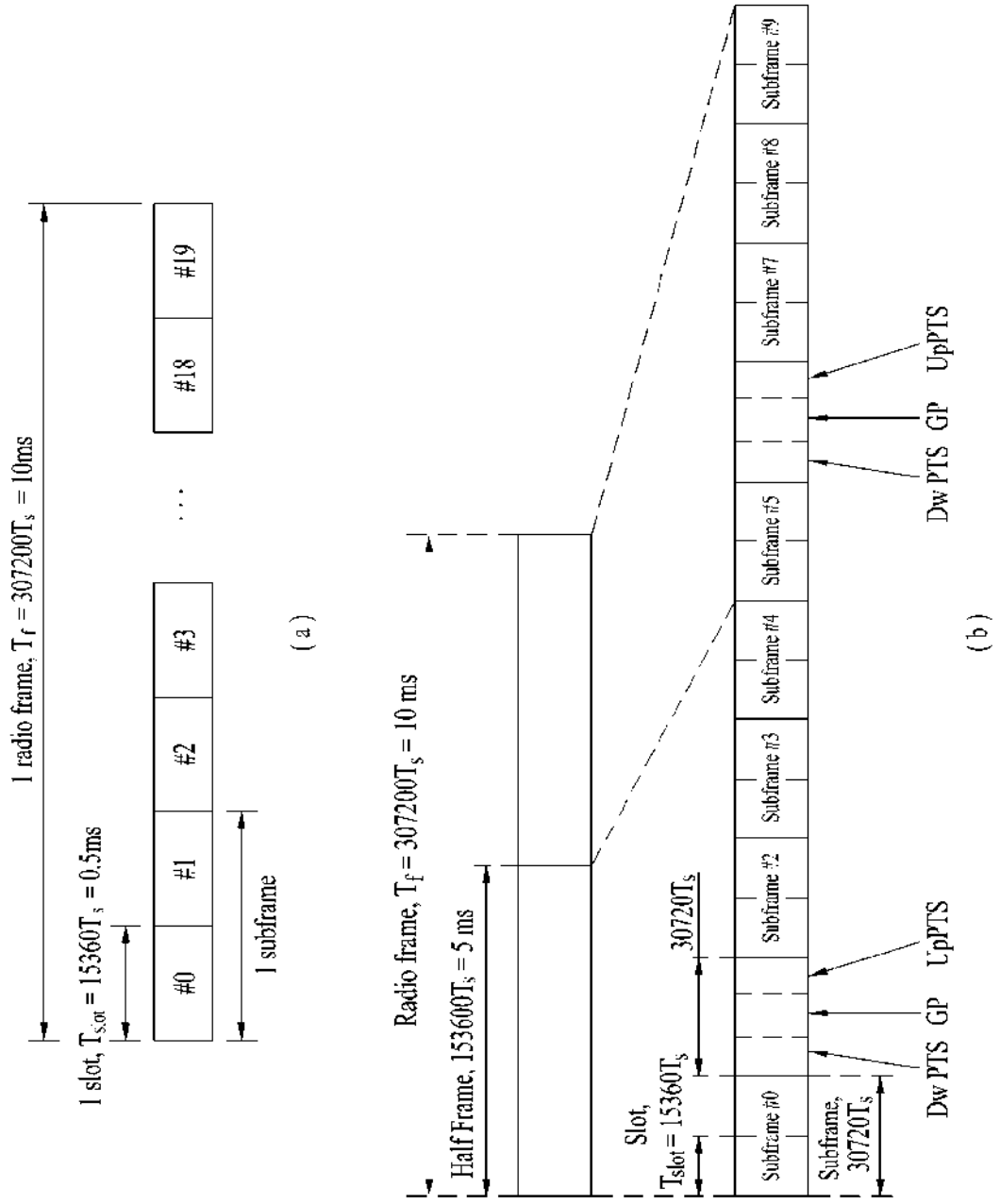
wherein the second PDCCH candidates of the UE-specific search space are configured on the same narrowband as the narrowband for the common search space until the UE-specific search space configuration is transmitted to the UE.

[Claim 18] The BS according to claim 16 or 17,
wherein the common search space configuration includes information on a maximum number of repetitions for the first common search space, and
wherein the second PDCCH candidates of the UE-specific search space are configured based on the same number as the maximum number of repetitions for the common search space until the UE-specific search space configuration is transmitted to the UE.

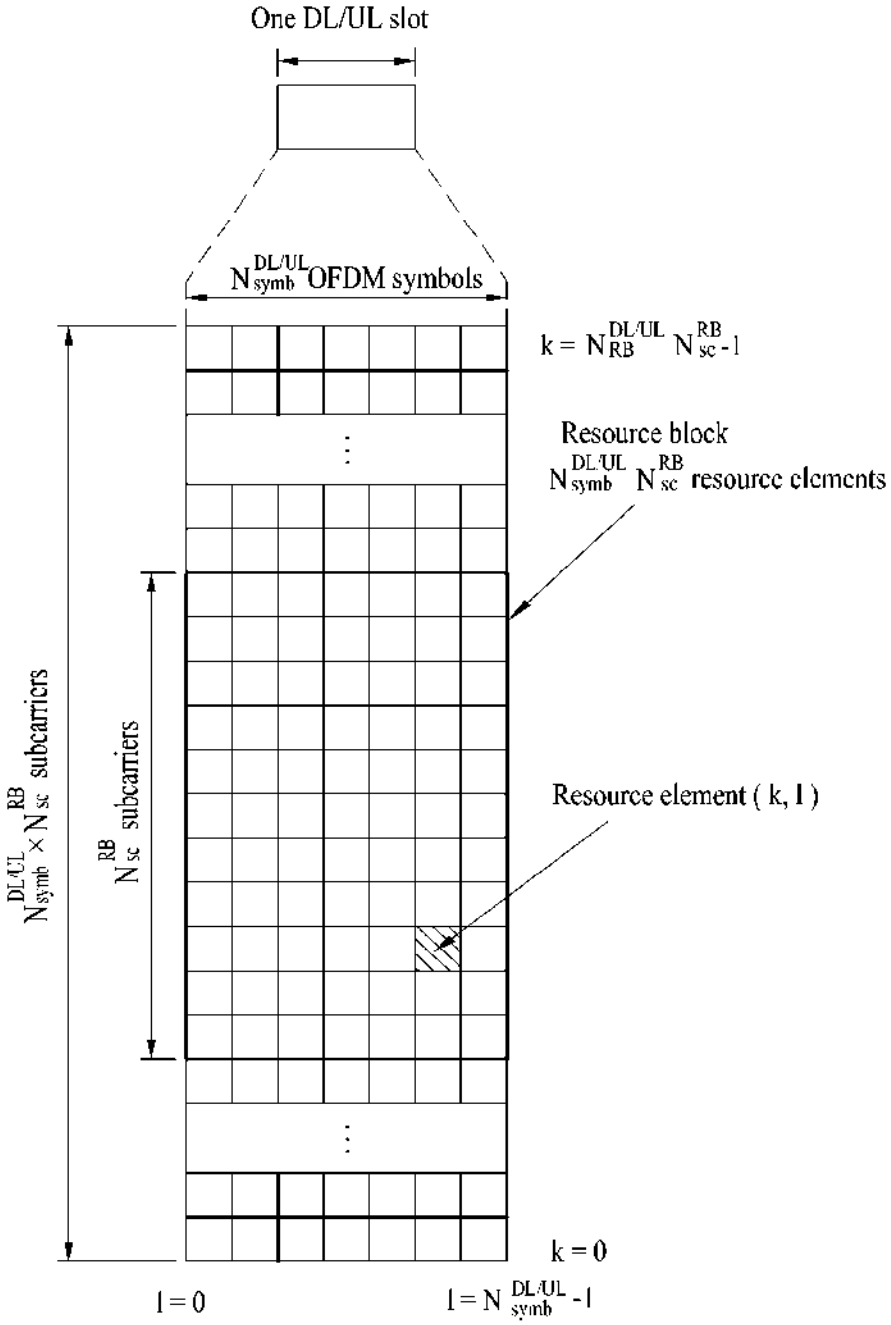
[Claim 19] The BS according to any one of claims 16 to 18,
wherein the common search space configuration includes information on a first physical resource block (PRB) set for transmitting the first PDCCH, and
wherein the same physical resource block set as the first PRB set is used for the second PDCCH candidates until the UE-specific search space configuration is transmitted to the UE.

[Claim 20] The BS according to any one of claims 16 to 19,
wherein the first PDCCH candidates of the common search space are configured according to aggregation levels larger than or equal to 8 among a plurality of aggregation levels, and the second PDCCH candidates of the UE-specific search space are configured according to the plurality of aggregation levels.

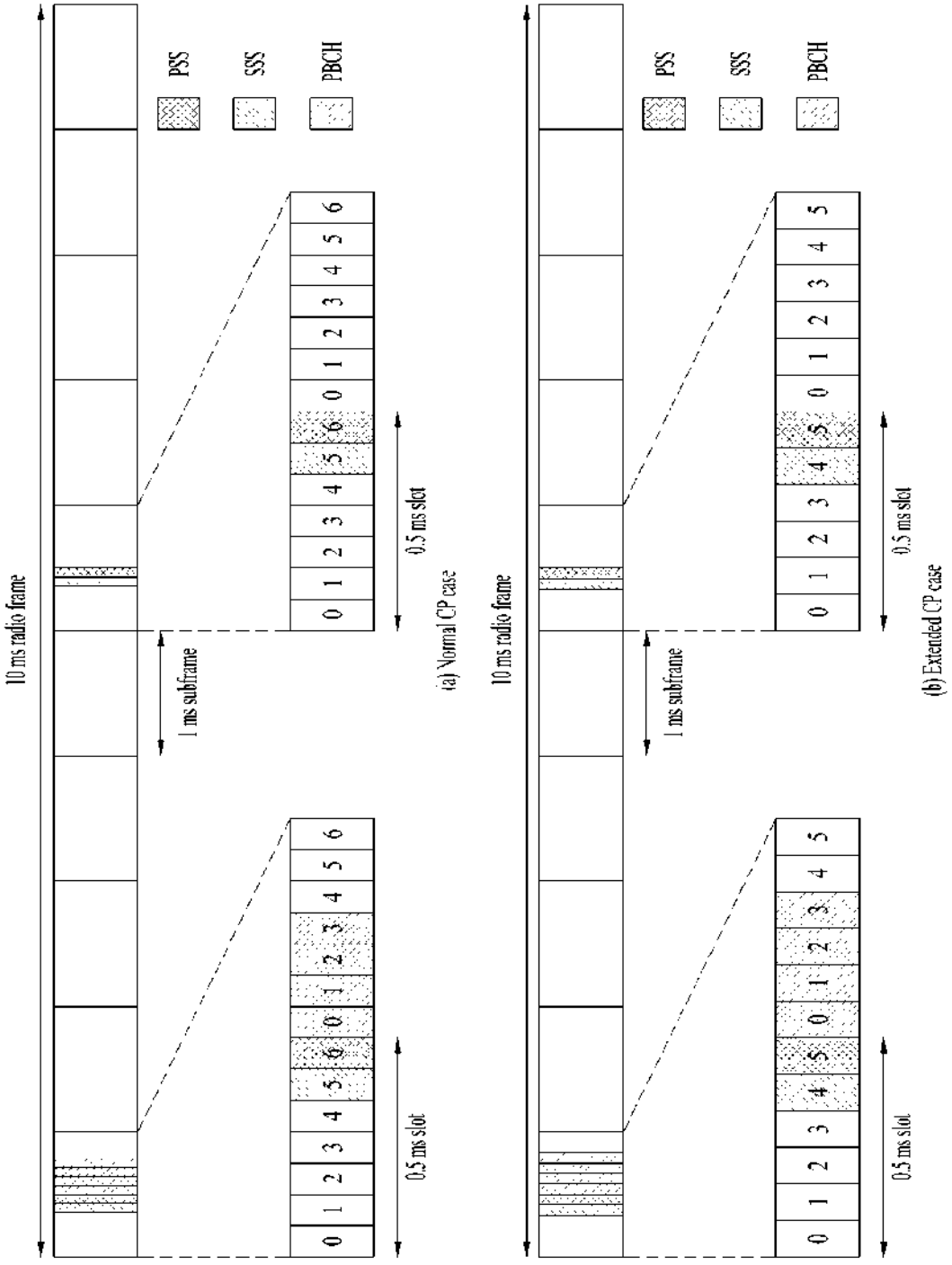
[Fig. 1]


1 radio frame, $T_f = 307200T_s = 10ms$
1 slot, $T_{slot} = 15360T_s = 0.5ms$
#0
#1
#2
#3
#18
#19
1 subframe
(a)
Radio frame, $T_f = 307200T_s = 10$ ms
Half Frame, $153600T_s = 5$ ms
Slot, $T_{slot} = 15360T_s$
$30720T_s$
Subframe, $30720T_s$
Subframe #0
Subframe #1
Subframe #2
Subframe #3
Subframe #4
Subframe #5
Subframe #6
Subframe #7
Subframe #8
Subframe #9
DwPTS
GP
UpPTS
DwPTS
GP
UpPTS
(b)

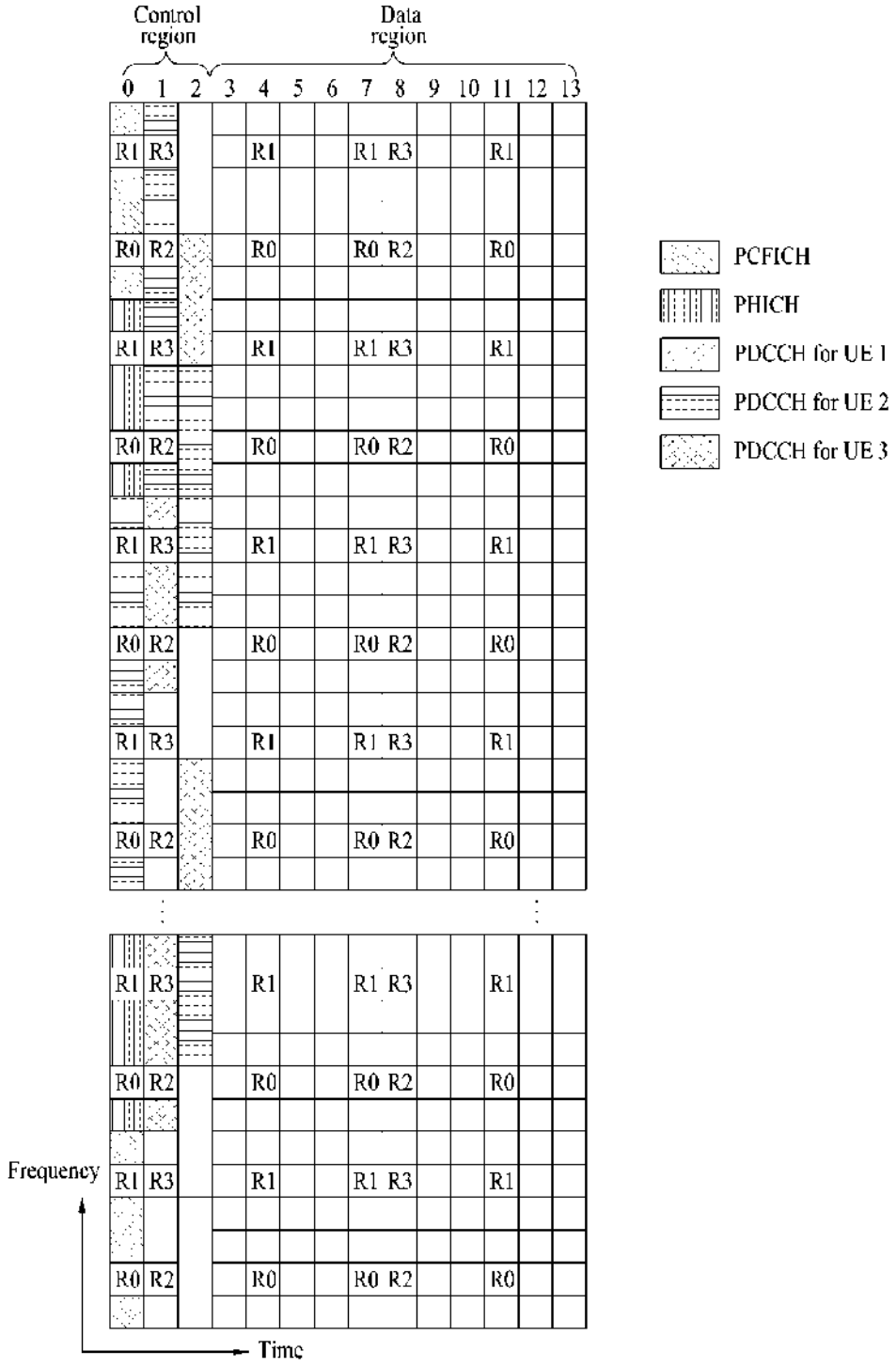
[Fig. 2]


One DL/UL slot
$N_{symb}^{DL/UL}$ OFDM symbols
$k = N_{RB}^{DL/UL} N_{sc}^{RB} - 1$
Resource block
$N_{symb}^{DL/UL} N_{sc}^{RB}$ resource elements
Resource element (k, l)
$N_{symb}^{DL/UL} \times N_{sc}^{RB}$ subcarriers
N_{sc}^{RB} subcarriers
k = 0
l = 0
$l = N_{symb}^{DL/UL} - 1$

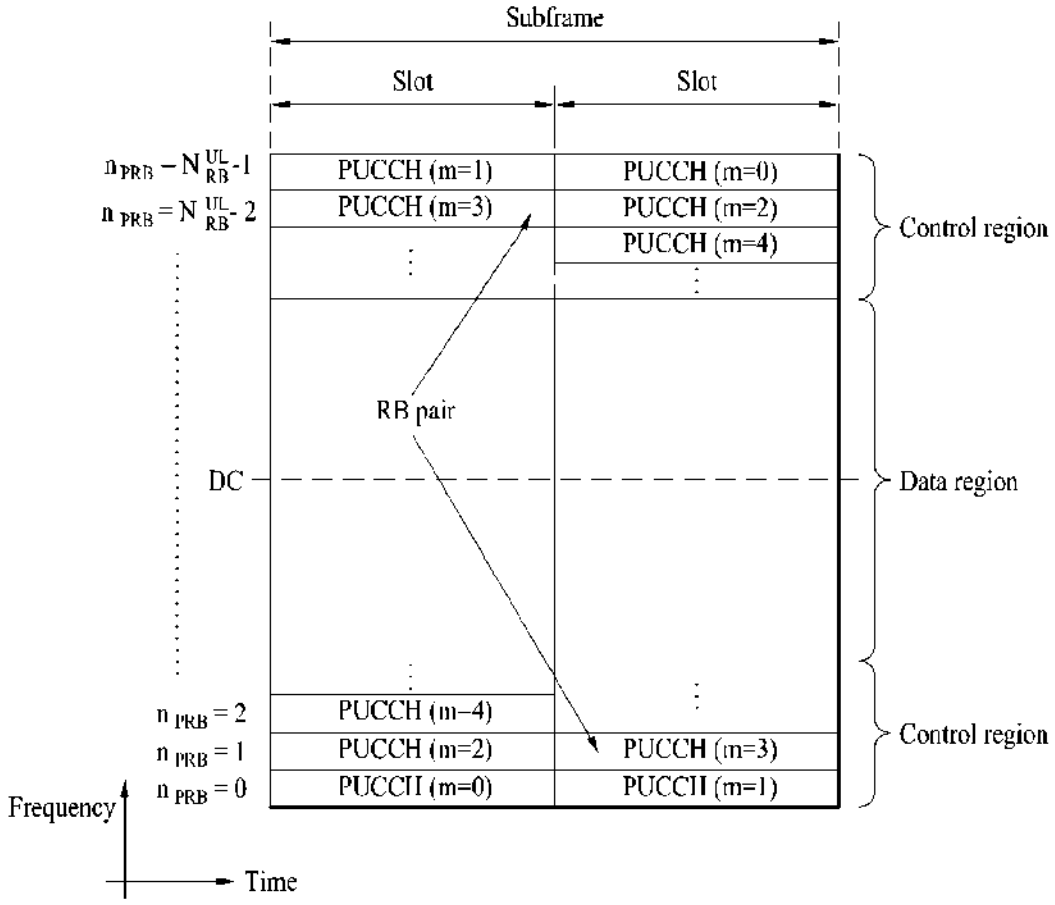
[Fig. 3]


10 ms radio frame
PSS
SSS
PBCH
1 ms subframe
0.5 ms slot
(a) Normal CP case
10 ms radio frame
PSS
SSS
PBCH
1 ms subframe
0.5 ms slot
(b) Extended CP case

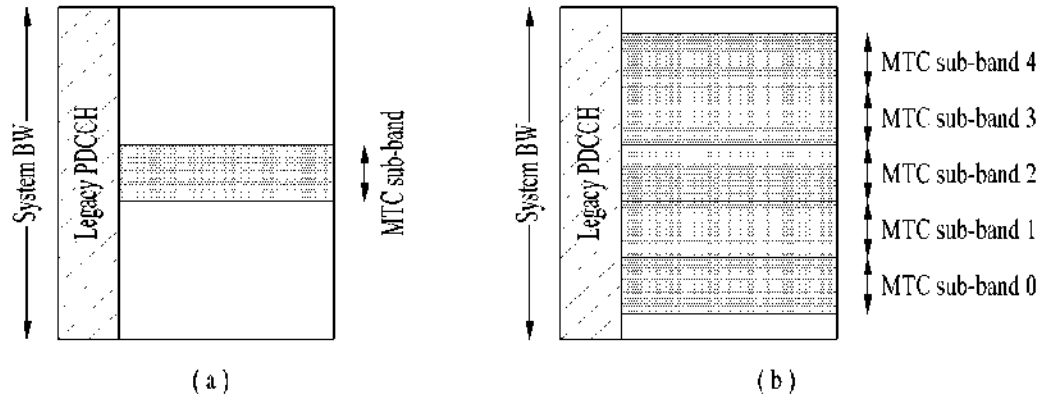
[Fig. 4]


Control region
Data region
0 1 2 3 4 5 6 7 8 9 10 11 12 13
R1 R3
R1
R1 R3
R1
R0 R2
R0
R0 R2
R0
PCFICH
PHICH
PDCCH for UE 1
PDCCH for UE 2
PDCCH for UE 3
Frequency
Time

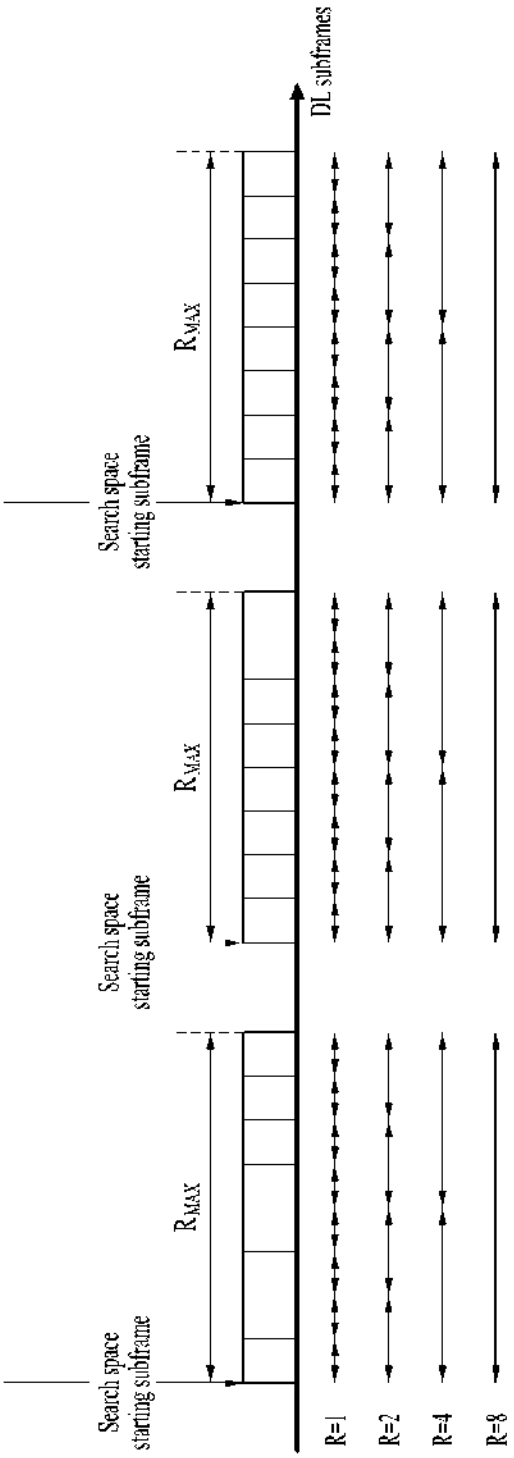
[Fig. 5]


Subframe
Slot
Slot
$n_{PRB} = N_{RB}^{UL} - 1$
$n_{PRB} = N_{RB}^{UL} - 2$
PUCCH (m=1)
PUCCH (m=0)
PUCCH (m=3)
PUCCH (m=2)
PUCCH (m=4)
Control region
RB pair
DC
Data region
$n_{PRB} = 2$
$n_{PRB} = 1$
$n_{PRB} = 0$
PUCCH (m=4)
PUCCH (m=2)
PUCCH (m=0)
PUCCH (m=3)
PUCCH (m=1)
Control region
Frequency
Time

[Fig. 6]


System BW
Legacy PDCCH
MTC sub-band
(a)
System BW
Legacy PDCCH
MTC sub-band 4
MTC sub-band 3
MTC sub-band 2
MTC sub-band 1
MTC sub-band 0
(b)

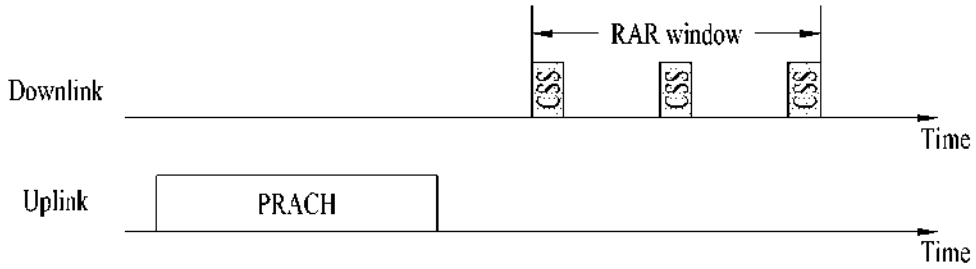
[Fig. 7]


DL subframes
Search space starting subframe
Search space starting subframe
Search space starting subframe
R_{MAX}
R_{MAX}
R_{MAX}
R=1
R=2
R=4
R=8

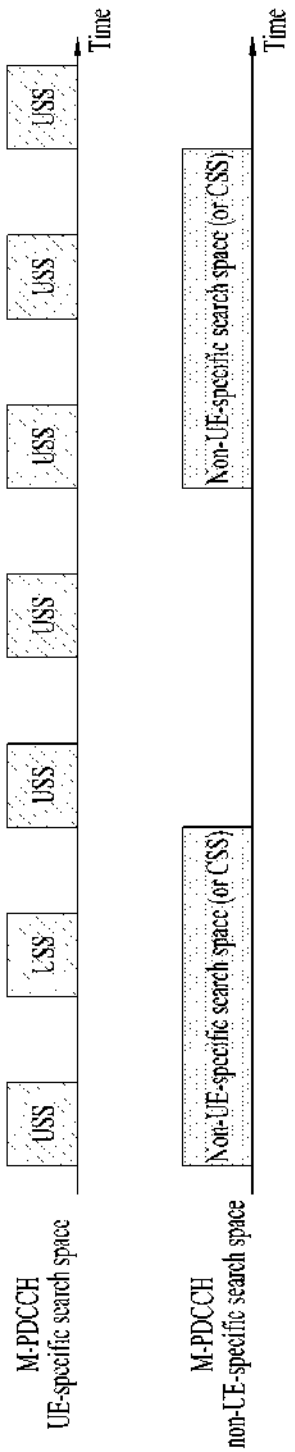
[Fig. 8]


Time
SSO
SSO
SSO
Paging occasion
SSO
SSO
SSO
Paging occasion

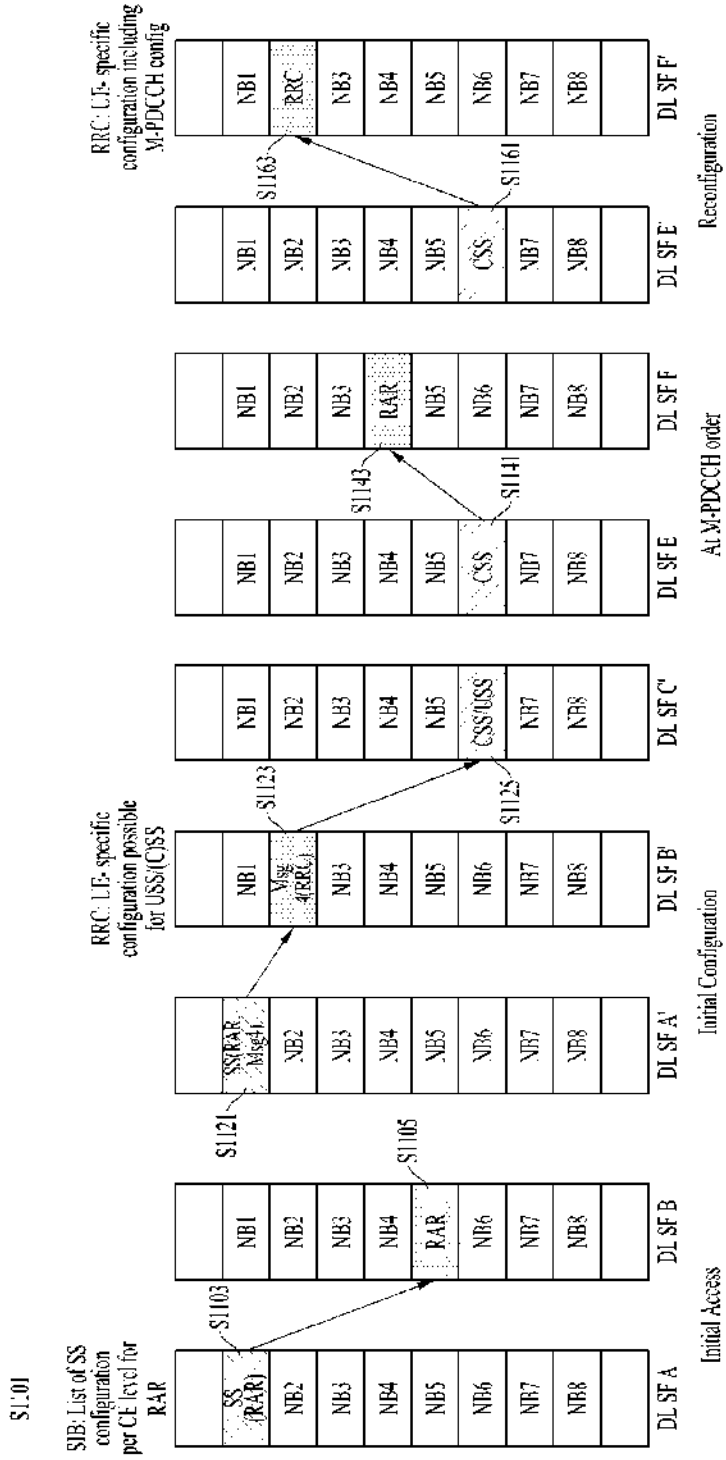
[Fig. 9]


RAR window
Downlink
CSS
CSS
CSS
Time
Uplink
PRACH
Time

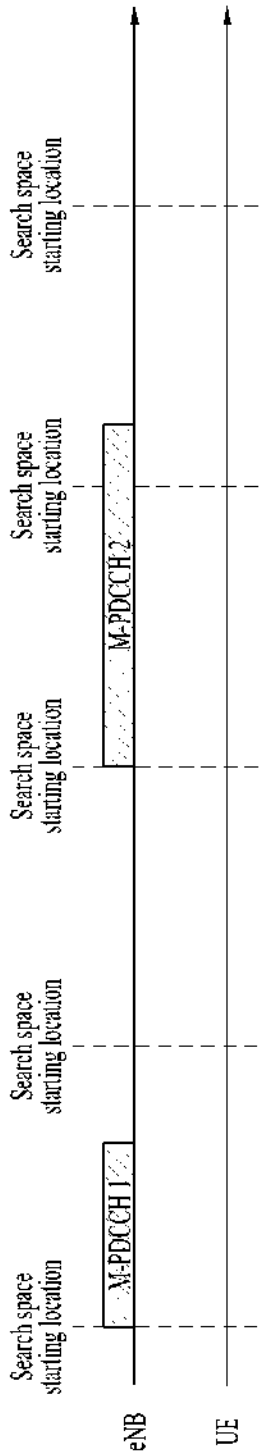
[Fig. 10]


Time
USS
USS
USS
USS
USS
USS
M-PDCCH
UE-specific search space
Time
Non-UE-specific search space (or CSS)
Non-UE-specific search space (or CSS)
M-PDCCH
non-UE-specific search space

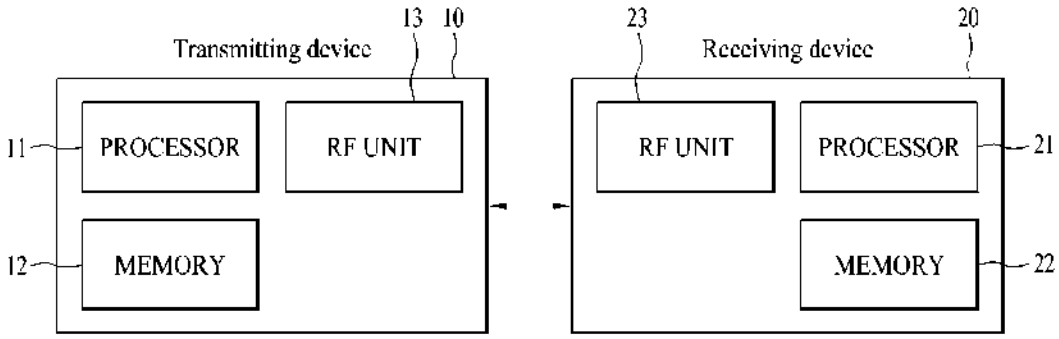
[Fig. 11]


S1101
SIB: List of SS configuration per CE level for RAR
SS (RAR)
NB1
NB2
NB3
NB4
NB5
NB6
NB7
NB8
DL SF A
S1103
DL SF B
RAR
S1105
Initial Access
S1121
SS(RAR Msg4)
DL SF A'
RRC UE-specific configuration possible for USS/(C)SS
S1123
Msg 4(RRC)
DL SF B'
Initial Configuration
S1125
CSS/USS
DL SF C'
S1141
CSS
DL SF E
S1143
RAR
DL SF F
At M-PDCCH order
S1161
CSS
DL SF E'
S1163
RRC
DL SF F'
Reconfiguration

[Fig. 12]


Search space starting location
Search space starting location
Search space starting location
Search space starting location
Search space starting location
M-PDCCH 1
M-PDCCH 2
eNB
UE

[Fig. 13]


Transmitting device
13
10
11
PROCESSOR
RF UNIT
12
MEMORY
23
Receiving device
20
RF UNIT
PROCESSOR
21
MEMORY
22

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2016/010542

A. CLASSIFICATION OF SUBJECT MATTER

H04L 5/00(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04L 5/00; H04W 72/04; H04W 24/08

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: common search space configuration, UE-specific search space, random access response, first PDCCH candidates, downlink control information, second PDCCH candidates, monitor, same configuration

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	ERICSSON, `EPDCCH initialization for MTC`, R1-153731, 3GPP TSG RAN WG1 Meeting #82, Beijing, China, 15 August 2015 See sections 2-3.1; and fig. 1.	1,2,6,7,11,12,16,17
A		3-5,8-10,13-15,18-20
Y	LG ELECTRONICS, `Discussion on Resource configuration for low complexity MTC UEs`, R1-154229, 3GPP TSG RAN WG1 Meeting #82, Beijing, China, 15 August 2015 See sections 2, 3; and figs. 2, 3.	1,2,6,7,11,12,16,17
A	ZTE, `Further considerations on M-PDCCH for MTC`, R1-154432, 3GPP TSG RAN WG1 Meeting #82, Beijing, China, 15 August 2015 See sections 2-3.3.	1-20
A	US 2014-0307560 A1 (LG ELECTRONICS INC.) 16 October 2014 See paragraphs [0102]-[0149]; and figs. 6, 7.	1-20
A	US 2015-0181577 A1 (FUJITSU LIMITED) 25 June 2015 See paragraphs [0145]-[0153]; and fig. 7.	1-20

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
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Date of the actual completion of the international search	Date of mailing of the international search report
21 December 2016 (21.12.2016)	**22 December 2016 (22.12.2016)**

Name and mailing address of the ISA/KR
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/KR2016/010542

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		KR 10-2015-0024926 A	09/03/2015
		WO 2014-019790 A1	06/02/2014

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(54) **Title**: DOWNLINK CONTROL CHANNEL DESIGN AND SIGNALING FOR BEAMFORMED SYSTEMS

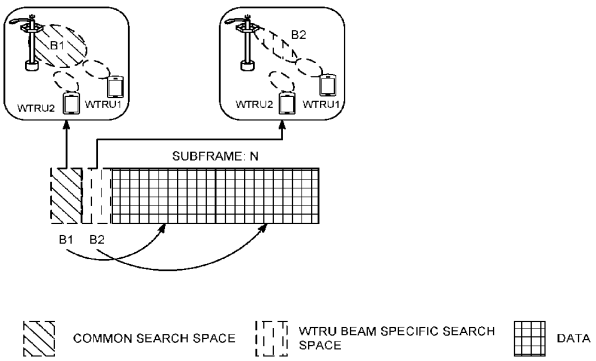


FIG. 22

(57) **Abstract**: Transmit and/or receive beamforming may be applied to the control channel transmission/reception, e.g., in mmW access link system design. Techniques to identify candidate control channel beams and/or their location in the subframe structure may provide for efficient WTRU operation. A framework for beam formed control channel design may support varying capabilities of mBs and/or WTRUs, and/or may support time and/or spatial domain multiplexing of control channel beams. For a multi-beam system, modifications to reference signal design may discover, identify, measure, and/or decode a control channel beam. Techniques may mitigate inter-beam interference. WTRU monitoring may consider beam search space, perhaps in addition to time and/or frequency search space. Enhancements to downlink control channel may support scheduling narrow data beams. Scheduling techniques may achieve high resource utilization, e.g., perhaps when large bandwidths are available and/or WTRUs may be spatially distributed.

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DOWNLINK CONTROL CHANNEL DESIGN AND SIGNALING FOR BEAMFORMED SYSTEMS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 62/253,599, filed on November 10, 2015, the entire contents of which being incorporated by reference as if fully set-forth herein, for all purposes.

BACKGROUND

[0002] Small Cell mmW eNB (SCmB) deployment may be based on the 3GPP R12 small cell deployment. The mmW operation may be performed by one or more network nodes. A Small Cell mmW eNB (SCmB) may be an LTE small cell eNB capable of operating an mmW air interface, perhaps with an LTE air interface in the downlink.

[0003] An mmW WTRU (mWTRU) may be capable of operating in LTE and mmW air interface. The mWTRU may have one or more sets of antennas and/or the acccompanied Radio Frequency (RF) chains, perhaps one operating in the LTE band and/or in the mmW frequency band.

SUMMARY

[0004] Initial mmW access link system design may focus on cellular system procedures that enable add-on mmW data transmission (e.g., at least downlink transmission) to an existing network such as a small cell LTE network. Transmit and/or receive beamforming may be applied to the control channel transmission/reception, e.g., to overcome high path loss at > 6Ghz frequencies. Techniques to identify candidate control channel beams and/or their location in the subframe structure may provide for efficient WTRU operation. A framework for beam formed control channel design may support varying capabilities of mBs and/or WTRUs, and/or may support time and/or spatial domain multiplexing of control channel beams. Modifications to reference signal design may discover, identify, measure, and/or decode one or more, or each, control channel beam, for example for a multi-beam system, among other scenarios. Techniques may mitigate inter-beam interference. WTRU monitoring may consider beam search space in addition to time and/or frequency search space. Techniques to downlink control channel may

support scheduling narrow data beams. Scheduling mechanisms may achieve (e.g., high) resource utilization, e.g., perhaps when large bandwidths may be available and/or WTRUs may be spatially distributed.

[0005] For example, one or more beam specific control channels may be utilized. The beam specific control channels may utilize a fixed mapping in a frame structure. For example, a beam specific control channel may be mapped to a fixed symbol and/or a fixed subframe in the frame structure. For example, a flexible mapping may be used for the beam specific control channels within the frame structure.

[0006] For example, a WTRU-specific and/or beam-specific search space may be used for transmitting and/or receiving control channels. The WTRU-specific and/or beam-specific search space may be associated with serving control channel(s) assignments. The WTRU-specific and/or beam-specific search space may be utilized in a WTRU monitoring procedure. For example, the WTRU may be configured to determine a beam specific search space size (e.g., in terms of subframe and symbol location). A WTRU may be configured to determine a WTRU-specific search space within a beam and/or beam-specific search space.

[0007] A WTRU and/or based station may be configured to perform methods for resource allocation for sub-subframe scheduling. For example, sub-subframe scheduling may allow multiple allocations in a given subframe. For example, sub-subframe scheduling may be performed such that multiplexing (e.g., TDM) WTRUs with different downlink beams within a given subframe may be utilized.

[0008] A WTRU may be configured to identify the downlink data beam that an mB may use for the WTRU. For example, the WTRU may be configured to switch the receive beam used for downlink data based on one or more parameters. For example, the WTRU may be configured to switch the receive beam used for downlink data based on resource allocation information. For example, the WTRU may be configured to switch the receive beam used for downlink data independently from the received resource allocation information. For example, beam combining may be used for the DL and/or UL.

[0009] A wireless transmit/receive unit (WTRU) may be configured for wireless communication. The WTRU may comprise a memory. The WTRU may comprise a processor. The processor configured with at least one or more search spaces. The one or more search spaces may be configured to provide for at least one of: a monitor of one or more Downlink (DL) control channels, and/or a receipt of the one or more DL control channels. At least one search space of the one or more search spaces may correspond to at least one reference signal of one or more reference signals. The processor may be configured at least to monitor at least a part of a

control region for at least one reference signal of the one or more reference signals. The processor may be configured to detect the at least one reference signal in the at least part of the control region. The processor may be configured to monitor the at least one search space corresponding to the at least one reference signal for at least one DL control channel upon the detection of the at least one reference signal.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. 1 is an example of mmW Small Cell Deployment.

[0011] FIG. 2 is an example of Comparison of Frequency and Spatial Filtering.

[0012] FIG. 3 is an example of an OFDM Frame Structure.

[0013] FIG. 4 is an example of an mmW Downlink Logical, Transport and Physical Channel.

[0014] FIG. 5 is an example of an mWTRU Fully Digitized Beamforming.

[0015] FIG. 6 is an example of an mWTRU Analogue Beamforming with at least one PAA and at least one RF Chain.

[0016] FIG. 7 is an example of an mWTRU Analog Beamforming with at least one PAA and at least two RF Chains.

[0017] FIG. 8 is an example of an mWTRU Analog Beamforming with at least two PAAs and at least two RF Chains.

[0018] FIG. 9 is an example of an mWTRU Analogue Beamforming with at least two PAAs and at least one RF Chain.

[0019] FIG. 10 is an example of an Illustrative 2D and Realistic 3D Narrow Beam Pattern.

[0020] FIG. 11 is an example of a Realistic 3D Broadside Broad Beam Pattern.

[0021] FIG. 12 is an example of Physical Downlink Control Channel (PDCCH) Type 1a.

[0022] FIG. 13 is an example of PDCCH Type 1b.

[0023] FIG. 14 is an example of PDCCH Type 2.

[0024] FIG. 15 is an example of PDCCH Type 3a.

[0025] FIG. 16 is an example of PDCCH Type 3b.

[0026] FIG. 17 is an example of a Logical Architecture for Control Channel Beam Generation.

[0027] FIG. 18 is an example of a Subframe Structure and Placement for Control BRS.

[0028] FIG. 19 is an example of Resource Allocation in Two Dimension of Frequency and Time.

[0029] FIG. 20 is an example of a Subframe Structure and Placement for Control BRS for Parallel Beam Sweeping.

[0030] FIG. 21 is an example of Resource Allocation in Two Dimension of Frequency and Time.

[0031] FIG. 22 is an example of Common Control Channel Beam and Search Space.

[0032] FIG. 23 is an example of WTRU Beam Specific Search Space.

[0033] FIG. 24A is a System Diagram of an example Communications System.

[0034] FIG. 24B is a System Diagram of an example Wireless Transmit/Receive Unit (WTRU) that May be Used within the Communications System Illustrated in FIG. 24A.

[0035] FIG. 24C is a System Diagram of an example Radio Access Network and an Example Core Network that may be Used within the Communications System Illustrated in FIG. 24A.

[0036] FIG. 24D is a System Diagram of another example Radio Access Network and an Example Core Network that may be Used within the Communications System Illustrated in FIG. 24A.

[0037] FIG. 24E is a System Diagram of another example Radio Access Network and an Example Core Network that may be Used within the Communications System Illustrated in FIG. 24A.

DETAILED DESCRIPTION

[0038] A detailed description of illustrative embodiments will now be described with reference to the various figures. Although this description provides a detailed example of possible implementations, it should be noted that the details are intended to be examples and in no way limit the scope of the application.

[0039] An mmW deployment may be used, e.g., based on a 3GPP R12 small cell deployment perhaps with an extension of a LTE carrier aggregation scheme. An example is a Small Cell mmW eNB (SCmB) deployment. The SCmB may be based on the 3GPP R12 small cell deployment. The mmW operation may be performed by one or more of the following network nodes. A LTE small cell eNB may be capable of operating an mmW air interface, for example in parallel with a LTE air interface in the downlink. The SCmB may simultaneously transmit LTE downlink channels in a wide beam pattern and/or mmW channels in narrow beam

pattern(s), e.g., when it is equipped with advanced antenna configuration and/or beamforming technique(s). The SCmB may support features and/or procedures in a LTE uplink (UL) operation, e.g., to support mmW wireless transmit/receive units (WTRUs) without mmW uplink transmission. A wireless transmit/receive unit (WTRU) that is capable of operating an mmW air interface, possibly in parallel with a non-mmW LTE system, may be referred to as an mmW wireless transmit/receive unit (mWTRU) and/or an mmW user equipment (mUE). A mWTRU and/or a mUE may be used interchangeably herein. A WTRU may be used herein to refer to an mWTRU.

[0040] For example, an mWTRU may comprise antennas (e.g., two or more sets) and/or accompanied RF chains, some operating in a LTE band and/or some for operation in an mmW frequency band. The antennas and/or accompanied RF chains may perform independent baseband processing functions, although portions of the antennas and/or RF chains may share some hardware and/or functional blocks. For example, the baseband functions may share certain hardware blocks, e.g., when the mmW air interface bears similarity with the LTE system.

[0041] For example, mmW channels may be used as an extension of a LTE carrier aggregation scheme. One or more mmW channels may be a carrier type in the mmW frequency band. One or more mmW channels may apply a different air interface and/or legacy LTE. The one or more mmW channels may be of opportunistic use for high-throughput and/or low-latency traffic data application(s).

[0042] LTE channels may carry control signaling, e.g., system information update, paging, Radio Resource Control (RRC) and/or Non-Access Stratum (NAS) signaling (signaling radio bearers), and/or multicast traffic may be carried. LTE channels may be used to carry mmW Layer 1 (L1) control signaling.

[0043] The SCmB and/or mWTRU may employ narrow beamforming, e.g., in non-line of sight (NLOS) at mmW frequency band, perhaps for example due to relatively high propagation loss associated with mmW band. Employing narrow beamforming may provide for a (e.g., sufficient) link budget for high-throughput and/or low-latency data transmission.

[0044] Transmitting and/or receiving narrow beam pairing may be used. For example, at least a consistent coverage with a cell-radius of up to 200 meters may be achieved at 28 GHz and/or 38 GHz in urban areas by using a steerable 10°-beamwidth and/or a 24.5-dBi horn antenna for transmitting and/or receiving.

[0045] To meet the high data rate required for the next generation of cellular communication systems, the wireless industry and/or academia have been exploring ways to leverage the large bandwidths available at above-6 GHz frequencies, e.g. at cmW and/or mmW

frequencies. The large bandwidth available at these frequencies may provide capacity improvement for user-specific data transmission. One challenge of using these above-6 GHz frequencies may be characteristics related to their propagation which may be unfavorable for wireless communication, especially in an outdoor environment. For example, higher frequency transmissions may experience higher free space path loss. Rainfall and/or atmospheric gasses, e.g., oxygen, may add further attenuation and/or foliage may cause attenuation and/or depolarization. Narrow beam patterns which may be used to counter these losses may pose challenges for a base station (e.g., eNB), for example, in delivering cell-specific and/or broadcast information.

[0046] FIG. 1 depicts an example of a SCmB deployment. SCmB may use narrow beams for downlink transmissions. One or more mWTRUs may use receive-side narrow beams for receiving the downlink transmissions. SCmB and/or mWTRUs may apply broad beam pattern for the traditional LTE operation including cell search, random access, and/or cell selection/reselection etc.

[0047] FIG. 2 is an example of the mWTRU receive beamforming, for example, using narrow spatial filtering. FIG. 2 includes an example comparison with a frequency domain filtering to demonstrate the effect of a spatial and/or angular filtering.

[0048] The spatial filtering may allow an mWTRU to detect a channel impulse response at a distinct angular direction captured by the narrow receive beam, perhaps for example similar to a frequency filtering removing unwanted frequency components. This may result in a flat effective channel by excluding angular incoming paths outside of its beamwidth. An R12 LTE WTRU may be assumed to have an omni-directional receive beam pattern and/or may perceive a superimposed channel impulse response over the entire angular domain. An aligned mmW transmit and receive beam pair may provide a degree of freedom in the angular domain compared with the current LTE system.

[0049] An mmW system (e.g., a downlink system) design may focus on integrating directivity, e.g., the directivity of a narrow transmit and/or receive beam pair, into a celluar system which may include L1 control signaling, data scheduling, narrow beam pairing, beam measurement, and/or L1 control information feedback, etc.

[0050] Some examples of mmW system parameters and/or assumptions are described herein. The parameters and/or assumptions may change, for example, depending on the type of deployment. These parameters and/or assumptions are not intended to be limiting but serve to illustrate example set(s) of parameters and/or assumptions of an example mmW system. The parameters and/or assumptions may be utilized in various combinations.

[0051] For example, an example carrier frequency for mmW operation may be 28 GHz. This is an example system numerology. Similar designs may be extended to other mmW frequencies, e.g., 38 GHz, 60 GHz, 72 GHz, etc. A system bandwidth may be a variable (e.g., per carrier), for example up to a specific maximum system bandwidth. For example, 1 GHz may be used as the maximum system bandwidth with carrier aggregation perhaps being used to achieve higher overall bandwidth. An estimated RMS delay spread may be 100-200 ns with narrow beam pattern. A latency may be 1 ms. A waveform may be OFDM-based or broad-band-single-carrier-based. For example, dual connectivity may be based on LTE Small Cell eNB with mmW add-on channels and two separate antennas and/or RF chains connected to two different antenna solutions. A system design parameter may be to achieve DL data rates of 30 Mbit/s for at least 95% of mWTRUs, although other design goals may be used. A mobility may be optimized data connection at 3 km/h and/or maintain connection at 30 km/h. A coverage may meet data rate and/or mobility requirement with less than 100-m cell radius.

[0052] One or more waveforms such as broad-band Cyclic Prefixed Single Carrier (CP-SC), OFDM, SC-OFDM, MC-CDMA, Generalized OFDM, FBMC, and/or other may be used for the air interface of a system, e.g, an above-6 GHz system (e.g., cmW and/or mmW). Frame structure for the system may depend on the applied waveform. A Transmission Time Interval (TTI) length such as 100us may be used, e.g., to achieve low latency. A system bandwidth, e.g., one in the range of 50MHz to 2GHz may be used, for example, to achieve high data rates.

[0053] An mmW frame structure of an OFDM-based waveform may offer flexibility in coordination between the LTE and mmW channels and/or may enable common functional block sharing in a mWTRU device. For example, an mmW sampling frequency may be selected as an integer multiple of the LTE minimum sampling frequency of 1.92 MHz, which may lead to an mmW OFDM sub-carrier spacing Δf being an integer multiple of the LTE sub-carrier spacing of 15 kHz, e.g. $\Delta f = 15*K$ kHz. The selection of the integer multiple K and/or the resulting Δf may take into consideration the sensitivity to the Doppler shift, different types of frequency errors, and/or the ability to remove channel time dispersion, and/or the like. The orthogonality between sub-carriers may deteriorate and/or inter-sub-carrier interference (ISI) may increase, perhaps for example when the Doppler shift increases in proportion to the sub-carrier spacing.

[0054] For example, the maximum Doppler shift at 30 km/h and 28 GHz may be approximately 778 Hz. Example 28-GHz channel time dispersion measurements in dense urban area may indicate an RMS delay spread σ that may be between 100 and 200 ns for up to 200-m cell radius. The 90% coherence bandwidth may be estimated at $1/50\sigma$ of 100 kHz and the 50% coherence bandwidth at $1/5\sigma$ of 1 MHz.

[0055] A sub-carrier spacing Δf between 100 kHz and 1 MHz may be reasonable. A sub-carrier spacing of 300 kHz (K=20) may be robust against Doppler shift and/or other types of frequency error and/or reduce implementation complexity. The corresponding symbol length (1/ Δf) may be approximately 3.33 us.

[0056] A cyclic prefix (CP) length may be configured to span over the entire length of the channel time dispersion in order to eliminate the inter-symbol-interference. For example, a CP may or might not carry useful data, and/or in some scenarios a long CP may cause excessive system overhead. One example of CP length for a T_{symbol} of 3.33us may be selected at 1/14 of T_{symbol}, 0.24 us and/or the corresponding CP overhead may be 7% as calculated by T_{CP} / (T_{CP} + T_{symbol}).

[0057] The TTI length of the mmW transmission may be reduced compared to the 1-ms TTI length of the LTE system, perhaps for example to achieve low latency. In some scenarios, it may be beneficial to have an mmW sub-frame length of 1 ms to align with the LTE 1-ms sub-frame timing. The mmW sub-frame may contain multiple mmW TTIs whose length may be tied to other parameters, e.g., sub-carrier spacing, symbol length, CP length, and/or FFT size, etc.

[0058] Based on these and/or other considerations, an example with a conservative CP length (4x channel delay spread) is summarized in Table 1. It may be assumed that CP length selection is based on the delay spread over potential mmW frequency band of lower than 200 ns.

Table 1 Example mmW Downlink OFDM Numerology

OFDM Numerology Parameters				
System bandwidth (MHz)	125	250	500	1000
Sampling rate (MHz)	153.6	307.2	614.4	1228.8
Sub-carrier spacing (kHz)	300	300	300	300
Number of sub-carrier per RB	12	12	12	12
RB bandwidth (MHz)	3.6	3.6	3.6	3.6
Number of assignable RBs	32	64	128	256
Number of occupied sub-carriers	384	768	1536	3072
Occupied bandwidth (MHz)	115.2	230.4	460.8	921.6
IDFT(Tx)/DFT(Rx) size	512	1024	2048	4096
OFDM symbol duration (us)	3.333	3.333	3.333	3.333
CP length (ratio to symbol length)	1/4	1/4	1/4	1/4
CP length (us)	0.833	0.833	0.833	0.833
Number of symbols per slot	24	24	24	24
Slot duration (TTI) (us)	100	100	100	100
Sub-frame duration (ms)	1	1	1	1
Number of slots per sub-frame	10	10	10	10

Frame duration (ms)	10	10	10	10
Number of sub-frames per frame	10	10	10	10
Number of symbols per TTI per RB	288	288	288	288
Number of symbols per TTI using all RBs	9216	18432	36864	73728
Signaling overhead	20%	20%	20%	20%
Data rate using uncoded 64QAM (Mbps)	442.368	884.736	1769.472	3538.944
Spectral efficiency	3.538944	3.538944	3.538944	3.538944

[0059] FIG. 3 depicts an example OFDM-based frame structure. In FIG. 3, the system bandwidth may be 1GHz and/or a sub-carrier spacing of 300 kHz may be used with a corresponding symbol length of 3.33 us. An example cyclic prefix (CP) length of 1/4 of T_{symbol} which equals 0.833 us may be used.

[0060] Some of the frame structure examples presented herein may be based on an assumption that an OFDM-based mmW waveform, which may be incorporated into the OFDM-based LTE small cell network. The system procedures described herein may be equally applicable to numerous types of frame designs and/or should not be interpreted to be bound by this specific frame structure and/or may be applied to other waveform candidates.

[0061] The SCmB and/or mWTRU deployments may employ one or more of the following mmW physical layer channels and/or reference signals, for example, rather than and/or in addition to the LTE physical channels.

[0062] An SCmB and/or an mWTRU may employ a unique sequence transmitted per transmit beam, e.g., a Beam-Specific Reference Signal (BSRS), used for beam acquisition, timing/frequency synchronization, channel estimation for a Physical Downlink Directional Control Channel (PDDCCH), beam tracking and/or measurement, etc. The BSRS may carry implicitly beam identity information including BSRS sequence index. There may be different types of BSRSs. The BSRS resource allocation may be pre-defined.

[0063] An SCmB and/or an mWTRU may employ a unique sequence scheduled and/or transmitted dynamically for the purpose of beam pair measurement specific for a given antenna port, e.g., an Adaptive Antenna Reference Signal (AARS). The AARS may embed implicitly the beam identity information in the sequence index and/or carry a small payload including the same information.

[0064] An SCmB and/or an mWTRU may utilize a Physical Downlink Directional Control Channel (PDDCCH). The PDDCCH may carry some or all data related control information for an mWTRU to identify, demodulate and/or decode an associated Physical

Downlink Directional Data Channel (PDDDCH) correctly. The PDDCCH may be carried in an mmW narrow beam and/or in a broad beam and/or may be applied for different multiple access. For example, there may be a common PDDCCH transmitted in downlink mmW broad beam covering a sector and/or cell and/or a dedicated PDDCCH transmitted (e.g., transmitted) in a narrow beam pair, for example, when mWTRU-specific data transmission is on-going. The dedicated PDDCCH may carry scheduling information for its associated PDDDCH on a per-TTI basis and/or may or might not carry beam specific information. A common PDDCCH may include cell-specific information including sector/segment identity and/or beam identity. In addition, an mWTRU may read the common PDDCCH to determine if it is scheduled for narrow beam pairing procedure in order to begin narrow beam data transmission subsequently.

[0065] An SCmB and/or an mWTRU may utilize a Physical Downlink Directional Data Channel (PDDDCH). The PDDDCH may carry payload information received in the form of MAC PDU from mmW MAC layer. The resource allocation of this channel may be determined by the downlink scheduling information carried in PDDCCH. The PDDDCH intended for a mWTRU may be transmitted in a narrow Tx beam and/or received in a properly paired narrow Rx beam, e.g., a narrow beam pair. Due to this spatial isolation, PDDDCHs for different WTRUs in different beam pairs may reuse a combination of one or more time, frequency, and/or code resource(s). Multiple PDDDCH may also operate in one beam pair using multiple access in one or more of the time, frequency, code domain, and/or the like. A common PDDDCH may be used to carry data in broad mmW antenna pattern associated with the common PDDCCH.

[0066] An SCmB and/or an mWTRU may utilize symbols embedded in a transmission for channel estimation for PDDDCH, e.g., a Demodulation Reference Signal (DMRS). For example, the DMRS may be placed in the time and/or frequency domain according to pre-defined pattern to ensure correct interpolation and/or reconstruction of the channel.

[0067] Some or all channels and/or reference signals in a narrow beam pair may be beamformed identically and/or considered to be transmitted via a specific and/or single physical antenna port. Although carrying broadcast and/or multicast information on a narrow beam can be utilized, given the directivity of the transmission of these channels, carrying broadcast, multicast, and/or other cell-specific information on the narrow beam may or might not be optimal application. The SCmB deployment with mmW downlink data transmissoin may adopt a channel mapping as illustrated in FIG. 4 and the mmW channels are marked in bolder line color.

[0068] An mWTRU may use a phase antenna array to achieve the beamforming gain, for example, in order to compensate the high path loss at mmW frequencies. At the mmW frequencies the short wavelength may allow a compact form factor of the device design. A large

spacing such as 0.7λ may be applied, for example. An element spacing of 0.5λ may be used in theoretical performance analysis.

[0069] The phase antenna may apply one or more different beamforming methods. For example, a fully digitized beamforming approach may have a dedicated RF chain. For example, the RF chain may include RF processing and/or analog-to-digital conversion (ADC) as depicted in FIG. 5 for an antenna element. The signal processed by an antenna element may be controlled independently in phase and/or amplitude to optimize the channel capacity.

[0070] The configuration may have the same number of RF chains and ADCs as that of antenna elements. The mWTRU antenna may offer (e.g., very) high performance. The mWTRU antenna configuration may impose costs and/or complexity in implementation. The mWTRU antenna configuration may cause high energy consumption in operation. Fully digitized beamforming may or might not be adopted in the initial 5G deployments and/or mWTRU implementations, but may be used in future releases.

[0071] FIG. 6 may be an example of analogue beamforming. In analog beamforming, an RF chain may be applied (e.g., only one RF chain) for a given phase antenna array (PAA). For example, an antenna element may be connected to a phase shifter. The phase shifter may be used to set the weight for beam forming and/or steering. The number of RF chains may be (e.g., significantly) reduced using analog beamforming (e.g., as compared to digital beamforming). The energy consumption may be significantly reduced.

[0072] The phase of the signal (e.g, only the phase) at an antenna element may be adjusted in the beamforming. FIG. 6 shows that the phase shifting and/or combining may be implemented in different stages, e.g., in RF, base-band (BB) analogue, and/or local-osciallator (LO). One or more of the techniaues described herein may be used to evaluate the effectiveness/efficiency of an approach, e.g., signal loss, phase error, and/or power consumption, and/or the like.

[0073] The mWTRU analogue beamforming methods may comprise one or more of the following. The mWTRU analogue beamforming algorithms may comprise a grid of beams having a set of fixed beams, e.g., a fixed codebook-based beamforming. A beam may be formed by the mWTRU applying a beamforming weight vector v chosen from a pre-defined codebook $v \in \{v_1, v_2, v_3 \ldots v_N\}$, where N denotes the number of fixed beams. A vector may comprise pre-calibrated phase shifts for certain (e.g., one or more, or all) phase shifters and/or may represent a unique analogue beam direction, e.g., "beam". The number of beams may depend on the Half-Power-Beam-Width (HPBW) of the beamforming and/or desired coverage. The mWTRU analogue beamforming algorithms may comprise a continuous phase shifting beamforming. For

example, the desired weight of a phase shifter may be calculated based on the estimated short-term channel information and/or converted using a high resolution digital-to-analogue converter (DAC) for the phase shifter. The continuous phase shifting beamforming may provide a continuous and/or adaptive beamforming to track the channel conditions. The algorithm may perform well in one or more scenarios, e.g., with increased multipath, high angular spread, and/or low WTRU mobility.

[0074] An mWTRU may employ a hybrid approach comprising the digitized and analogue beamforming. For example, the analogue beamforming may be performed over the phase array antenna elements where an antenna element is associated with a phase shifter and/or connected to one RF chain. The digitized beamforming may comprise a digital precoding applied on the baseband signal of a RF chain, e.g., when there is more than one RF chain. MIMO schemes may be implemented using digital precoding.

[0075] Examples for the basic system parameters of the hybrid beamforming may include one or more of a Number of data stream, N_{DATA}; Number of RF chain (TRX), N_{TRX}; Number of antenna ports, N_{AP}; Number of antenna elements, N_{AE}; and/or Number of phase antenna array, N_{PAA}, and/or the like. The configuration of these parameters may impact the system function and/or performance.

[0076] For example, perhaps when $N_{PAA} \leq N_{AP} \leq N_{TRX} \leq N_{AE}$, one or more of the following may occur. A PAA may comprise multiple antenna elements, e.g., a PAA of size 4x4 has 16 antenna elements. An antenna port may be defined, and/or the channel over which a symbol on the antenna port is conveyed may be inferred from the channel over which another symbol on the same antenna port is conveyed. There may be certain (e.g., one or more) resource grid per antenna port. One or more cell-specific reference signals may support a configuration of one, two, and/or four antenna ports and/or may be transmitted on antenna ports $p = 0$, $p \in \{0,1\}$ and $p \in \{0,1,2,3\}$, respectively. Multicast-broadcast single-frequency network (MBSFN) reference signals may be transmitted on antenna port $p = 4$. One or more WTRU-specific reference signals associated with PDSCH may be transmitted on antenna port(s) $p = 5$, $p = 7$, $p = 8$, or one or several of $p \in \{7,8,9,10,11,12,13,14\}$.

[0077] One or more demodulation reference signals associated with an enhanced Physical Downlink Control Channel (EPDCCH) may be transmitted on one or several of $p \in \{107,108,109,110\}$. Positioning reference signals may be transmitted on antenna port $p = 6$. CSI reference signals may support a configuration of one, two, four or eight antenna ports and/or may be transmitted on antenna ports $p = 15$, $p \in \{15,16\}$, $p \in \{15,16,17,18\}$, and $p \in$

{15,16,17,18,19,20,21,22}, respectively. An antenna port may carry beamformed reference signal(s) that may be uniquely associated with this antenna port and/or that can be used to identify the antenna port. The antenna configuration may become (e.g., fully) digitized as shown in FIG.5, e.g., perhaps when the number of TRX equals the number of antenna elements. An example may be one RF chain per antenna element. A PAA may be connected to a RF chain (as shown in FIG. 6) and/or multiple RF chains, e.g., depending on the system configuration. In FIG. 7, $N_{PAA} < N_{AP} = N_{TRX} < N_{AE}$, one PAA of size 4x4 is connected to two RF chains and/or one or more, or each RF, chain has a set of 16 phase shifters. The PAA may form two narrow beam patterns within a +45° and -45° coverage in azimuth plane. FIG. 8 is an example of two PAAs and/or one or more, or each, PAA may have a dedicated RF chain, e.g., $N_{PAA} = N_{AP} = N_{TRX} \leq N_{AE}$. The example in FIG. 8 may allow a spatial independence between the two simultaneous beams by placing the PAAs at different orientation e.g. in azimuth plane. An aligned PAA arrangement may provide an aggregated larger coverage compared to the configuration in FIG. 7. Both configurations with two RF chains may apply MIMO with two data streams.

[0078] For example, perhaps when $N_{AE} > N_{PAA} > N_{AP} = N_{TRX}$, multiple PAAs may be connected to a (e.g., single) RF chain by using a switch as depicted in FIG. 9. A PAA may form a narrow beam pattern covering from +45° to -45° in azimuth plane. They may be oriented separately. A single-beam solution may provide (e.g. a good) coverage by using a narrow beam at different direction at different time instances.

[0079] For example, when $N_{DATA} \leq N_{TRX} \leq N_{AE}$, the following may occur.

[0080] For example, when $N_{DATA} = N_{TRX} = 1$, a mWTRU may have a single-beam configuration and/or may operate one beam at a time. One or more of the following may occur. The mWTRU beamforming may form a narrow beam pattern. FIG. 10 is an example for a 16x16 PAA at the strongest angular direction, e.g., a line-of-sight (LOS) path obtained from beam measurement. The mWTRU may form a broad beam pattern, e.g. a wide main lobe. FIG. 11 is an example of a wide main lobe to cover a range of continuous angular directions including strong and/or weak ones in-between. The antenna gain may be reduced (e.g., considerably) with a broad beam pattern, and/or the link budget may worsen.

[0081] For example when $N_{DATA} = 1 < N_{TRX}$, an mWTRU may have simultaneous beam patterns. The beam patterns may be different and/or may be used for different applications. For example, when $N_{TRX} = 2$, an mWTRU may have two simultaneous beam patterns that are different and/or may be used for different applications. One or more of the following may apply. The mWTRU may place two narrow beam patterns at different angular

incoming directions to receive one data stream. For example, coherent beam combining may be used for spatial diversity and/or mitigate the blockage effect and/or weak LOS condition. The mWTRU may form one narrow beam and/or one broad beam for different application. For example, the narrow beam may be used for data transmissoin and/or the broad beam for control signaling.

[0082] For example, perhaps when $1 < N_{DATA} = N_{TRX}$, the transmission may apply MIMO to increase the capacity, e.g., in high SNR channel condition. The mWTRU may place two narrow beam patterns at different angular incoming directions to receive two data streams in parallel.

[0083] One or more of the SCmB beam forming schemes may include fixed beam, adaptive beam forming (e.g., codebook-based and/or non-codebook-based), and/or classical beam forming e.g. Direction-of-Arriaval (DoA) estimation. One or more schemes may use different approaches and/or may work well in certain scenarios. For example the DoA estimation may use smaller angular spread and/or a mWTRU may (e.g., need to) transmit a LTE uplink reference signal to ensure DoA accuracy. The fixed beam system may require beam cycling and/or switching.

[0084] One or more of the examples described herein may be explained in terms that assume an mWTRU antenna configuration and/or beamforming configuration. The mWTRU antenna configuration and/or beamforming configuration may be based on a single-beam mWTRU antenna configuration with analogue beamforming as illustrated in FIG. 6. The methods and/or techniques may also be applied using other beamforming methods such as digital beamforming and/or hybrid beamforming.

[0085] The LTE/LTE-A and/or E-PDCCH have evolved. In Rel-8, REs, REG, CCE and/or PDCCH may be the following. The smallest time-frequency unit for downlink transmission may be denoted a resource element (RE). A (e.g. one or more, or each) element in the resource grid for antenna port p may be called a resource element and/or may be uniquely identified by the index pair (k,l) in a slot where k and/or l may be the indices in the frequency and/or time domains, respectively. A PDCCH (Physical Downlink Control Channel) may carry scheduling assignments and/or other control information. A group of 4 consecutive resource elements may be called Resource Group Elements (REG). A physical control channel may be transmitted on an aggregation of one or several consecutive control channel elements (CCEs), where a control channel element corresponds to 9 REGs.

[0086] In Rel-11, EPDCCH WTRU-specific Search Space may be the following. The EPDCCH has been introduced in Rel-11 LTE-Advanced in order to achieve frequency domain ICIC and/or beamforming gain. Hereafter, EPDCCH, ePDCCH, and/or E-PDCCH may be used interchangeably. Also, EREG and/or ECCE may be interchangeably used as eREG and/or eCCE, respectively.

[0087] In Rel-11, PRB configuration may be the following. In Rel-11, the ePDCCH resources for WTRU-specific search space may be configured as a subset of PRBs in the PDSCH region. The ePDCCH resources may be configured in a WTRU-specific manner and/or up to two ePDCCH resource sets may be configured for a WTRU. An ePDCCH resource set may contain 2, 4, and/or 8 PRB-pairs according to the configuration and/or may be configured as a localized resource set and/or distributed resource set.

[0088] In Rel-11, eREG may be defined as the following. In a (e.g. one or more, or each) PRB-pair which is configured as ePDCCH resource, 16 eREGs may be defined regardless of normal CP and/or extended CP. The REs for eREGs may be allocated cyclically in a frequency first manner and/or may be rate-matched around for the demodulation RS such as antenna ports {107, 108, 109, 110}. Randomizing channel estimation performance across eREGS may occur as the channel estimation performance may be different according to the RE location in a PRB-pair. Since antenna port 107 and/or 108 are defined (e.g., only defined) for extended CP, the REs for eREGs may be allocated cyclically in a frequency first manner and/or may be rate-matched around for the demodulation RS such as antenna ports {107, 108}.

[0089] An eCCE may may be defined as the following. An eCCE may be defined as grouping of 4 and/or 8 eREGs within an ePDCCH resource set. Therefore, the number of eCCEs ($N_{eCCE,set}$) per ePDCCH resource set may be defined as a function of the number of PRB pairs ($N_{PRB,set}$) configured for the ePDCCH resource set and/or the number of eREGs grouped to form an eCCE (N_{eREG}) such as $N_{eCCE,set} = 16xN_{PRB,set}/N_{eREG}$. Two types of eCCE may be defined according to the mode of ePDCCH resource set such as localized eCCE (L-eCCE) and/or distributed eCCE (D-eCCE). To form an L-eCCE, the 4 and/or 8 eREGs located in the same PRB-pair may be grouped together. On the other hand, the eREGs in different PRB-pairs may be grouped to form a D-eCCE. C ertain (e.g., one or more, or all) eREGs in an ePDCCH resource set may be used to form L-eCCE and/or D-eCCE perhaps according to the ePDCCH transmission configured for the ePDCCH resource set. For instance, if an ePDCCH resource set may be configured as localized ePDCCH, then certain (e.g., one or more, or all) eREGs in the ePDCCH resource set may be be used to form L-eCCE. In other words, in an ePDCCH resource

set, there may be be L-eCCEs and/or D-eCCEs. For example, 4 eREGs may be grouped to form an eCCE in the case of normal subframe and/or special subframe configuration 3, 4, 8 in TDD perhaps for example since a (e.g, enough) number of REs may be available per eCCE so that a certain (e.g., required) effective coding rate may be used in one or more scenarios.

[0090] An antenna port mapping may be the following. The antenna ports {107, 108, 109, 110} and {107, 108} may be used for normal CP and/or extended CP, respectively. According to the ePDCCH transmission mode (e.g. localized ePDCCH and/or distributed ePDCCH), the antenna port mapping rules may be different as an (e.g., one or more, or each) ePDCCH transmission mode targeted for different system and/or channel environments. For instance, antenna port mapping for the distributed ePDCCH may be designed to maximize diversity gain as it has been introduced for open-loop transmission. On the other hand, antenna port mapping rules for localized ePDCCH may be defined to exploit WTRU-specific beamforming gain as well as multi-user MIMO gain.

[0091] For the distributed ePDCCH, two (e.g, only two, or more than two) antenna ports {107, 109} may be used out of {107, 108, 109, 110} in order to improve channel estimation gain while certain (e.g., one or more, or all) antenna ports may be used for localized ePDCCH. This may be due to the fact that WTRU-specific beamforming may use (e.g., require) larger number of antenna ports as one PRB-pair may be shared with up to 4 WTRUs. This may allow WTRU-specific beamforming of up to 4 WTRUs within a PRB-pair, for example.

[0092] A reference signal sequence may be the following. A predefined sequence (e.g., Pseudo-random (PN), m-sequence and/or etc.) may be multiplied with downlink RS so as to minimize inter-cell and/or intra-cell interference. This may improve channel estimation accuracy and/or increasing multi-user spatial multiplexing gain. For some (e.g., any) of the EPDCCH antenna ports {107, 108, 109, 110}, the reference signal sequence $r(m)$ may be defined by

$$r(m)=\frac{1}{\sqrt{2}}(1-2\cdot c(2m))+j\frac{1}{\sqrt{2}}(1-2\cdot c(2m+1)),\qquad m=\begin{cases}0,1,\ldots,12N_{\mathrm{RB}}^{\max,\mathrm{DL}}-1 & \text{normal cyclic prefix}\\ 0,1,\ldots,16N_{\mathrm{RB}}^{\max,\mathrm{DL}}-1 & \text{extended cyclic prefix}\end{cases},$$

where the $N_{\mathrm{RB}}^{\max,\mathrm{DL}}$ denotes the maximum number of RBs for the downlink system bandwidth and $c(i)$ denotes pseudo-random sequence. The pseudo-random sequence generator may be initialized with

$$c_{\mathrm{init}}=(\lfloor n_s/2\rfloor+1)\cdot(2n_{\mathrm{ID}}^{\mathrm{EPDCCH}}+1)\cdot 2^{16}+n_{\mathrm{SCID}}^{\mathrm{EPDCCH}}$$

at the start of a (e.g., one or more, or each subframe). The $n_{\mathrm{ID}}^{\mathrm{EPDCCH}}$ may be independently configured for a (e.g., one or more, or each) EPDCCH resource set and $n_{\mathrm{SCID}}^{\mathrm{EPDCCH}}=2$ may be used.

[0093] A WTRU-specific search space may be the following. In Rel-11, a WTRU-specific search space may be introduced (e.g., only introduced) for EPDCCH. Common search

space may be located at the PDCCH region. The WTRU monitoring behavior for downlink control signaling reception may be defined in a downlink subframe as one of following. A WTRU may monitor WTRU-specific search space in EPDCCH and/or common search space in PDCCH, e.g., where the EPDCCH monitoring subframe may be configured via higher layer signaling. A WTRU may monitor WTRU-specific search space and/or common search space in PDCCH. The WTRU-specific search space fallback may be used, perhaps even though a subframe is configured to monitor ePDCCH subframe, e.g., when ePDCCH is not available in that subframe. Some collisions between ePDCCH REs and/or other signals may occur. A WTRU may monitor PDCCH for WTRU-specific search space.

[0094] The aggregation level may increase to keep an effective coding rate, perhaps when the available number of REs may be smaller than a threshold ($n_{\text{EPDCCH}} < 104$). For instance, the supportable ePDCCH formats for localize transmission when $n_{\text{EPDCCH}} < 104$ may be $N_{\text{ECCE}} \in \{2,4,8,16\}$ while $N_{\text{ECCE}} \in \{1,2,4,8\}$ may be used in other cases. The set of aggregation levels may be different according to the ePDCCH transmission modes.

[0095] Collision handling may be performed. The ePDCCH REs may be defined as the REs in a PRB-pair not occupied by antenna port {107,108,109,110}. FIG. 1-24 may show an example of the ePDCCH RE definition in a PRB-pair according to the CP length without collission with other signals, resulting in 144 and/or 128 available REs for normal CP and/or extended CP, respectively. The ePDCCH resources may be configured in PDSCH region. The REs for ePDCCH may collide with other signals, e.g., CSI-RS, CRS, PRS, PBCH, SCH, and/or PDCCH. The WTRU behavior when the REs collide with other signals may be defined as one or more of the following. The coded bits for ePDCCH may be rate-matched around for the REs colliding with CSI-RS, CRS, and/or PDCCH. The PRB-pair used for PBCH and SCH in a subframe may or might not be used for ePDCCH. The available REs for ePDCCH may become smaller, e.g., when other signals are transmitted in the PRB-pair configured for ePDCCH.

[0096] Transmit and/or receive beamforming may be applied to the control channel transmission/reception, e.g., to overcome high path loss at > 6Ghz frequencies. The resulting beamformed link may be considered as a spatial filtering and/or limit the WTRU to receive incoming angular paths (e.g., only incoming angular paths) within the formed beam pair.

[0097] Legacy cellular systems may rely on Omni directional and/or cell-wide beams for control channel transmissions. From a WTRU's point of view, the placement of control channel may be well defined, e.g. in the control region. At higher frequencies, a (e.g., one or more, or each) base station may have plurality of control channel beams to cover the cell. A WTRU may

be able to (e.g., only be able to) receive a subset of those control channel beams. One or more techniques to identify candidate control channel beams and/or their location in the subframe structure may be defined for efficient WTRU operation.

[0098] One or more mBs and/or WTRUs in a beam formed system may have diverse set of capabilities, for example, different number of RF chains, different beam widths, and/or different number of PAAs, etc. One or more mBs with multiple RF chains may transmit control channel beam(s) in the same control symbol. One or more WTRUs with one or more, or multiple, RF chains may receive using receive beam pattern(s) same control symbol. One or more mBs with, for example, one RF chain may (e.g., need to) multiplex control channel beams in time domain (e.g. different symbols and/or different subframes). One or more mBs with RF chain(s) may multiplex control channel beams in time and/or spatial domains.

[0099] A framework for beam formed control channel design may be used to support varying capabilities of mBs and/or WTRUs and/or support time and/or spatial domain multiplexing of control channel beams.

[0100] The common reference signal design in LTE may assume cell wide transmission. For a multi-beam system, modifications to reference signal design may be used to discover, identify, measure, and/or decode a (e.g., one or more, or each) control channel beam. In a multi-beam system, interference between beams may degrade overall cell capacity, so additional mechanisms to mitigate inter-beam interference may be useful, e.g, for intra-cell and/or inter-cell scenarios.

[0101] WTRU monitoring may be defined to consider beam search space in addition to time and/or frequency search space.

[0102] Enhancements to downlink control channel may be useful to support scheduling narrow data beams. One or more mechanisms may be useful to achieve high resource utilization, e.g., perhaps when large bandwidths are available and/or WTRUs may be spatially distributed.

[0103] A mB, SCmB, mmW eNB, eNB, cell, small cell, Pcell, and/or Scell may be used interchangeably. The term operate may be used interchangeably with transmit and/or receive. Component carrier and/or mmW carrier may be used interchangeably with serving cell.

[0104] The mmW eNB may transmit and/or receive one or more mmW channels in a band (e.g., licensed band and/or unlicensed). The mmW eNB may transmit and/or receive one or more signals in a band (e.g., licensed band and/or unlicensed). One or more WTRUs may be substituted for eNB and still be consistent with the techniques described herein. An eNB may be substituted for WTRUs and still be consistent with the techniques described herein. UL may be

substituted for downlinke (DL) and still be consistent with the techniques described. DL may be substituted for UL and still be consistent with the techniques described herein.

[0105] A channel may refer to a frequency band which may have a center and/or carrier frequency and a bandwidth. Licensed spectrum may include one or more channels which may or might not overlap. Unlicensed spectrum may include one or more channels which may or might not overlap. Channel, frequency channel, wireless channel, and/or mmW channel may be used interchangeably. Accessing a channel may be the same as using (e.g., transmitting on and/or receiving on and/or using) the channel.

[0106] A channel may refer to an mmW channel and/or signal, e.g., an uplink physical channel and/or signal. A channel may refer to an mmW channel and/or signal, e.g., a downlink physical channel and/or signal. Downlink channels and/or signals may comprise one or more of the following: mmW synchronization signal, mmW broadcast channel, mmW cell reference signal, mmW beam reference signal, mmW beam control channel, mmW beam data channel, mmW hybrid ARQ indicator channel, mmW demodulation reference signal, PSS, SSS, DMRS, CRS, CSI-RS, PBCH, PDCCH, PHICH, EPDCCH, and/or PDSCH, and the like. Uplink channels and/or signals may include one or more of the following: mmW PRACH, mmW control channel, mmW data channel, mmW beam reference signal, mmW demodulation reference signal, PRACH, PUCCH, SRS, DMRS, and/or PUSCH, and the like. Channel and mmW channel may be used interchangeably. Channels and signals may be used interchangeably.

[0107] Data/control may mean one or more of the following: data, control signals, and/or channels, and the like. Control may comprise synchronization. The data/control may be mmW data/control. Data/control, data/control channels, and/or signals may be used interchangeably. Channels and signals may be used interchangeably. The terms control channel, control channel beam, PDCCH, mPDCCH, mmW PDCCH, mmW control channel, directional PDCCH, beamformed control channel, spatial control channel, control channel slice, and/or high frequency control channel may be used interchangeably. The terms data channel, data channel beam, PDSCH, mPDSCH, mmW PDSCH, mmW data channel, directional PDSCH, beamformed data channel, spatial data channel, data channel slice, and/or high frequency data channel may be used interchangeably.

[0108] Channel resources may be resources (e.g., 3GPP LTE and/or LTE-A resources), e.g., time, frequency, code, and/or spatial resources. Channel resources, e.g., at least sometimes, carry one or more channels and/or signals. Channel resources may be used interchangeably with channels and/or signals.

[0109] A mmW beam reference signal, mmW reference resource for beam measurement, mmW measurement reference signal, mmW channel state measurement reference signal, mmW demodulation reference signal, mmW sounding reference signal, reference signal, CSI-RS, CRS, DM-RS, DRS, measurement reference signal, reference resource for measurement, CSI-IM, and/or measurement RS may be used interchangeably. A mmW cell, mmW small cell, SCell, secondary cell, license-assisted cell, unlicensed cell, and/or LAA cell may be used interchangeably. A mmW cell, mmW small cell, PCell, primary cell, LTE cell, and/or licensed cell may be used interchangeably. Interference and interference plus noise may be used interchangeably.

[0110] A WTRU may determine the UL and/or DL directions of one or more subframes according to one or more received TDD UL/DL configurations. A WTRU may determine the UL and/or DL directions of one or more subframes according to one or more configured TDD UL/DL configurations. UL/DL and UL-DL may be used interchangeably.

[0111] The techniques described herein for beamformed control and data channels may be applicable to any system, perhaps irrespective of the frequency bands, usage (e.g. licensed, unlicensed, shared), antenna configuration (e.g. phased array and/or patch and/or horn etc.), RF configuration (e.g. single and/or multiple RF chains), beamforming methods used (e.g. digital, analog and/or hybrid, codebook based and/or otherwise), and/or deployments (e.g. macro, small cell, heterogeneous networks, dual connectivity, remote radio heads, carrier aggregation). A mmW (millimeter wave) may be substituted for cmW (centimeter wave) and/or LTE/LTE-A/LTE evolution and still be consistent with the techiques described herein.

[0112] A scheduling interval may refer to the subframe and/or slot and/or frame, and/or schedulable slice and/or control channel periodicity and/or any other pre-defined time unit. Gaps and/or guard periods and/or silence periods and/or switching periods and/or absence of transmission and/or DTX periods may be used interchangeably.

[0113] The terms channel, beam and/or channel beams may be used interchangeably. Antenna pattern, phase weights, steering vector, codebook, precoding, radiation pattern, beam pattern, beam, beam width, beam formed transmission, antenna port, virtual antenna port, transmission associated with a reference signal, directional transmission, and/or spatial channel may be used interchangeably.

[0114] The terms REGs and CCEs may refer to plurality of time, frequency, code and/or spatial resources generally and/or may or might not be limited by the LTE numerology/context (e.g., the LTE REGs and LTE CCEs may be considered types of REGs and CCEs in the context

of the techniques described herein). Radiation pattern may refer to the angular distribution of the radiated electromagnetic field and/or power level in the far field region.

[0115] A beam may be one of the lobes, e.g., main/side/grating lobes of the transmit radiation pattern and receive gain pattern of an antenna array. A beam may denote a spatial direction that may be represented with a beamforming weight vector. A beam may be identified and/or associated with one or more of a reference signal, an antenna port, a beam identity (ID), a scrambling sequence number, and/or the like. A beam may be transmitted and/or received at a specific time. A beam may be transmitted and/or received at a specific frequency. A beam may be transmitted and/or received at a specific code. A beam may be transmitted and/or received at specific spatial resources. A beam may be formed digitally and/or in an analogue manner (hybrid beamforming). The analogue beamforming may be based on fixed code-book and/or continuous phase shifting. A beam may comprise Omni directional and/or Quasi-Omni directional transmission. Two beams may be differentiated by direction of highest radiated power and/or by beam width.

[0116] One or more reference signals may be associated with one or more search spaces and/or one or more antenna ports. One or more search spaces may be associated with one or more beam search spaces and/or one or more antenna port search spaces.

[0117] In some scenarios, the WTRU may be configured to receive one or more search spaces from a wireless communication system network node, perhaps dynamically. In some scenarios, a WTRU may be configured such that the one or more search spaces are predefined on the WTRU.

[0118] A data channel beam may be used to transmit one or more of the following: data channel, data channel beam, PDSCH, mPDSCH, mmW PDSCH, mmW data channel, directional PDSCH, beamformed data channel, spatial data channel, data channel slice, high frequency data channel, and the like. A data channel beam may be identified and/or associated with one or more of the following: a reference signal, an antenna port, a beam identity (ID), a scrambling sequence number and/or a data channel number, and the like. A data channel beam may be transmitted and/or received at a specific time. A data channel beam may be transmitted and/or received at a specific frequency. A data channel beam may be transmitted and/or received at a specific code. A data channel beam may be transmitted and/or received at specific spatial resources.

[0119] A control channel beam may be used to transmit one or more of the following: control channel, PDCCH, mPDCCH, mmW PDCCH, mmW control channel, directional PDCCH, beamformed control channel, spatial control channel, control channel slice, high frequency control channel, and the like. The control channel may carry DCI for one or more

users. The control channel may carry PHICH and PCFICH in the downlink and PUCCH in the uplink. A control channel beam may be identified and/or associated with one or more of the following: a reference signal, an antenna port, a beam identity (ID), a scrambling sequence number, a control channel number, and the like. A control channel beam may be transmitted and/or received at a specific time. A control channel beam may be transmitted and/or received at a specific frequency. A control channel beam may be transmitted and/or received at a specific code. A control channel beam may be transmitted and/or received at specific spatial resources. A control channel beam may be cell specific and/or WTRU specific.

[0120] A common channel may be used to refer to transmission that carries information useful for plurality of WTRUs. The term common channel may be used interchangeably with shared channel.

[0121] Half Power Beam Width (HPBW) may refer to a radiation pattern cut containing the direction of the maximum of a lobe, the angle between two directions in which the radiation intensity is one-half the maximum value . The exact beam width for the beamformed control/data channel may or might not be specified and may depend on mB and/or WTRU implementation. A mB may support WTRUs with varying capabilities. WTRUs may work in an mB with varying capabilities.

[0122] A control channel beam duration may be a number of OFDM symbols in a scheduling interval occupied by a control channel beam.

[0123] A control region may be the number of OFDM symbols in a scheduling interval occupied by some or all of the control channel beams transmitted in the scheduling interval.

[0124] Fixed codebook-based analogue beamforming may refer to a grid of beams that may comprise a set of fixed beams. A beam may be formed by applying a beamforming weight vector v chosen from a pre-defined codebook $v \in \{v_1, v_2, v_3 \ldots v_N\}$ where N denotes the number of fixed beams. The number of beams may depend on the Half-Power-Beam-Width (HPBW) of the beamforming and desired coverage.

[0125] A continuous phase shifting analogue beamforming may provide a continuous and adaptive beamforming to track channel conditions. The desired weight of a phase shifter may be calculated based on the estimated channel information, e.g., angular information. The desired weight of a phase shifter may be converted using a high resolution digital-to-analogue converter (DAC) to apply to the phase shifter.

[0126] An antenna port may be defined. The channel over which a symbol on the antenna port is conveyed may be inferred from the channel over which another symbol on the same antenna port is conveyed. A time-frequency resource grid may be considered to be available per

antenna port. For example, a (e.g., one or more, or each) antenna port may be considered to be orthogonal to other antenna ports such that the time-frequency resources may be used for independent transmissions on a (e.g., one or more, or each) antenna port. Code multiplexing may also be used on one or more antenna ports.

[0127] The beamforming contains building blocks. An example subframe may have the following structure. A subframe and/or scheduling interval and/or slot and/or a predefined time unit may comprise plurality of symbols. One or more symbol(s) may be used to transmit and/or carry and/or include and/or map and/or be configured to receive the one or more control signal/channel/information. One or more symbol(s) may transmit/carry/include and/or be configured to receive one or more data channels.

[0128] Beamformed control and/or data channels may be one or more of the following. Control and/or data channels may be transmitted using a specific radiation pattern and/or beam. A control channel beam may be associated with one or more of the following: a unique reference signal, a steering vector, a scrambling code, an antenna port, time, code, spatial resource, frequency resource, and/or control channel identity, and/or the like. A data channel beam may be associated with one or more of the following: a unique reference signal, a steering vector, a scrambling code, an antenna port, time, code, spatial resource, frequency resource, and/or control channel identity, and the like. An mB and/or cell may transmit plurality of beamformed control and/or data channels. Beamformed control and/or data channels may be multiplexed in time.

[0129] Data region with one or more beamformed data channel(s) may work. One or more symbols within a subframe where the data channel is transmitted may be referred to as data region. Within a subframe, the data region may comprise multiple data channel beams multiplexed in time. For example, a data channel in a particular beam may occupy one more symbol(s). The remaining symbols within the same subframe may be used to transmit data channel in other beams. A data channel beam within the data region may be of variable beam widths. The maximum data channel beam width for a WTRU may be as wide as its control channel beam width. A WTRU may receive one or more data channels transmitted. A WTRU may use one or more beams and/or beam widths within a subframe and/or across different subframes. Plurality of WTRUs may be time multiplexed within a subframe, within same data channel beam and/or across different data channel beams. Minimum schedulable time resource within a subframe may be a symbol and/or group of symbols. Scheduling granularity may be less than a subframe, e.g., a new DCI format may carry allocation information at symbol level/symbol group.

[0130] The system may comprise a control region with one or more beamformed control channel(s). One or more symbols within a subframe where the control channel is transmitted may be referred to as cell specific control region and/or an overall control region. Within a subframe, the cell specific control region may comprise multiple control channel beams multiplexed in time. One or more symbols within a subframe where the control channel for a specific beam is transmitted may be referred to as beam specific control region. The term control region may mean cell specific control region and/or beam specific control region. Control region size may be fixed and/or be flexible. Control region and data region may overlap. One or more symbols may carry control and/or data channel. Control and/or data channel may be multiplexed in frequency and/or code and/or spatial domain.

[0131] The one or more search spaces may be configured to be used to monitor one or more Downlink (DL) control channels. The one or more search spaces may be configured to be used to receive the one or more DL control channels. At least one search space of the one or more search spaces may correspond to at least one reference signal of one or more reference signals. At least a part of a control region may be monitored for at least one reference signal of the one or more reference signals. At least one reference signal in the at least part of the control region may be detected. At least one search space corresponding to the at least one reference signal may be monitored for at least one DL control channel, perhaps for example upon the detection of the at least one reference signal.

[0132] The system may comprise gaps and/or switching periods. Gaps and/or guard periods and/or silence periods and/or switching periods and/or absence of transmission and/or DTX periods may be placed between two consecutive symbols. The two consecutive symbols may carry transmissions with different beam direction and/or radiation pattern and/or steering vector. Different gap types may be identified. One or more of the following examples may be identified, depending on the placement: gaps between two control symbols and/or group of control symbols, gaps between two data symbols and/or group of data symbols, and/or gaps between control symbols and data symbols (e.g. between the last control symbol and first data symbol and/or between the first control symbol and last data symbol), and/or the like.

[0133] Different gap types may be preconfigured with a different duration. Same gap type may be preconfigured with a different duration in different subframes. Gaps may be selectively placed between two consecutive symbols. The two consecutive symbols may be transmitted with a different radiation pattern. The two consecutive symbols may be transmitted with a different beam pattern. The two consecutive symbols may be transmitted with a different direction. The two consecutive symbols may be transmitted with a different channel type. Gaps

may be selectively placed between control and data symbols. Gaps within the same subframe may have different duration. Gaps may or might not be present in some or all of the subframes. Gaps may be placed between control symbols and may or might not be placed in the data symbols. Gaps may be placed between data symbols and may or might not be placed in the control symbols. Within the control and/or data region, gaps may be selectively placed between a subset of symbols.

[0134] The gaps may be defined from a WTRU point of view. A WTRU may or might not be required to receive on the DL during the gap periods (e.g., the gap between control symbols and data symbols for a WTRU). A WTRU may utilize the gap periods to decode the control channel, e.g., control channels received before the start of gap period. A WTRU may utilize the gap periods to switch its receive beam. A WTRU may utilize the gap periods to apply new steering vector to receive the downlink data channel. The downlink data channel may be different from the receive beam and/or steering vector used to receive the downlink control channel. A WTRU may utilize the gap periods (e.g. the gap between data symbols and/or group of data symbols for a WTRU) to switch its receive beam. A WTRU may utilize the gap periods (e.g. the gap between data symbols and/or group of data symbols for a WTRU) to apply new steering vector to receive the downlink data channel, which may be different from the receive beam and/or steering vector used to receive the previous downlink data channel in a subframe (e.g., same or different).

[0135] An mmW control channel may be designed, e.g., to facilitate control channel beam mapping to physical source. One or more control channels in a cell may be beamformed. One or more control channels in a cell may be placed in different control symbol and/or groups of control symbols in a subframe.

[0136] For example, an mB may utilize sweep operation to go through all or some of the control beams. An mB may transmit control channel beams in a subframe, e.g., one or more, or all, the control channel beams in every subframe. An mB may receive control channels in a subframe. For example, entire cell coverage may receive control channels in every subframe. An mB may utilize sweep operation, for example, starting from one control beam and going through some (e.g., one or more, or all) of the control beams in the cell in certain order. The sweep operation may go through selected (e.g., only specific) symbols in a subframe (e.g. only in the control region). The mB may utilize multiple subframes to transmit all or some of the control channel beams. For example, a subframe may comprise a partial sweep of control channel beams. One or more subframes may be used for a complete sweep of control channel beams to cover the entire cell. The mB may follow a certain order for the sweep operation. For example, it

may transmit control channel beams in a sequence based on control channel number and/or BRS sequence number. The mB may follow a random order for the sweep. The random order may be generated from a hashing function. The hashing function may use control channel number and/or subframe number etc.

[0137] The mapping between control channel beam(s) and/or control symbol(s) may be pre-defined and/or signaled via one or more of the following: broadcast channel(s) (e.g., MIB, SIB-x), higher layer signaling (e.g. RRC/MAC), L1 signal/channels, and/or any other common channel, and/or the like. The mapping between control channel beam(s) and control symbol group(s) may be pre-defined and signaled via one or more of the following: broadcast channel(s) (e.g., MIB, SIB-x), higher layer signaling (e.g. RRC/MAC), L1 signal/channels, any other common channel, and the like. WTRUs may determine the control channel beam to control symbol mapping by blind decoding. For example, WTRUs may search for pre-defined BRS sequence in the control region, and WTRUs may determine the control channel beam to symbol mapping, e.g., based on the received BRS signal quality (e.g. RSRP, SNR etc.).

[0138] An mB may select a subset of beams. The mB may transmit a subset of control channel beams in a subframe. The subset may be determined by one or more of the following criterias: distribution of WTRUs in a cell and/or beam, activity level of WTRUs in the cell and/or beam (e.g., buffer status of WTRUs, traffic pattern for WTRUs), WTRU grouping, WTRU service requirements, number of control channels with or without beamforming, scheduling algorithm, intra and inter cell interference, and/or type of control channel (e.g. common control and/or WTRU specific control), and the like. The mB may transmit a (e.g., only one) control channel beam in a subframe. The data region in the subframe may comprise transmissions using the same control channel beam and/or any other data channel beam related to the control channel beam, e.g, narrow data channel beam related to the control channel beam.

[0139] The mapping between a control channel beam and a symbol and/or a symbol group associated with a subframe (e.g., within a subframe and/or across subframes) may be fixed and/or flexible. The following may be applicable irrespective of control channel beam selection mode (e.g. subset transmission and/or full sweep transmission).

[0140] The mapping between a control channel beam and a symbol and/or a symbol group associated with a subframe, e.g., within a subframe and/or across subframes, may be fixed. In a fixed mapping, a control channel beam, e.g, every control channel beam, may be placed and/or transmitted in a pre-defined symbol and/or symbol group within a subframe. The mapping between the control channel beam and the symbol number may be same in certain (e.g., one or more, or all) subframes. For example, control channel beam 1 may be transmitted during symbol

number 1 in a (e.g., every) subframe. Symbol hopping may be used for control channel beams according to a pre-defined hashing function. For example, a function may use control channel number, cell ID, BRS sequence ID, subframe number, symbol number etc. WTRUs may determine the mapping between the control channel beam and the symbol/symbol group, e.g., implicitly based on the PBCH beam mapping. WTRUs may determine the mapping between control channel beam and the symbol/symbol group based on explicit configuration using one or more of the following: broadcast channel(s) (e.g., MIB, SIB-x), higher layer signaling (e.g. RRC/MAC), L1 signal/channels, and the like. WTRUs may determine the mapping between control channel beam and the symbol/symbol group based on a pre-defined function of cell-ID and/or beam-ID. Many to one mapping between control channel beams and control symbol/symbol group may be defined.

[0141] With a fixed mapping structure, control channel beams with no active WTRUs may have blank and/or empty control symbols. The blank and/or empty control symbols may be reclaimed and/or reused to map data channel beams, e.g., to improve resource utilization. The data channel beams may be scheduled by control channel beams occurring before the original blank and/or empty symbol. The data channel beams may be scheduled by control channel beams occurring after the original blank and/or empty symbol. WTRUs may buffer the complete subframe before the control channel decoding is complete. PDSCH may be mapped to the unused (e.g., empty and/or blank) control symbols. The unused control symbols may precede the associated PDCCH.

[0142] The mapping between a control channel beam and a symbol and/or a symbol group associated with a subframe, e.g., within a subframe and/or across subframes, may be flexible. In a flexible mapping, a control channel beam may be placed and/or transmitted in a (e.g., any) symbol and/or symbol group in a subframe. Multiple control channel beams in a subframe may be transmitted using different symbols, e.g., time multiplexed. The mapping between control channel beams and the symbol/symbol group may vary for different subframe. An mB may selectively transmit a subset of control channel beams in a subframe. The number of control channel beams transmitted may vary for different subframes. The number of control symbols occupied by a control channel beam may vary for different subframes. The number of control symbols occupied by different control channel beams in a subframe may vary.

[0143] The mapping between a control channel beam and a symbol and/or a symbol group associated with a subframe, e.g., within a subframe and/or across subframes, in a frame structure may be a hybrid of fixed and flexible mapping. The mB may use a fixed mapping for some beam types (e.g., common control beams and/or Omni beams, and/or WTRU specific

control beams). The mB may use a flexible mapping for other beam types (e.g., WTRU specific control beams, and/or common control beams and/or Omni beams). The mB may use a fixed mapping for some subframes and a flexible mapping for other subframes. The mapping format for different subframes may be explicitly signaled using one or more of the following: broadcast channel(s) (e.g., MIB, SIB-x), higher layer signaling (e.g., RRC/MAC), and/or L1 signal/channels, and the like. The mapping format for different subframes may be implicitly known by the presence of certain channels. For example, subframes with PBCH may use fixed mapping. A flexible mapping may be the default mode, and a fixed mapping may be applied in some (e.g., specific) subframes at a pre-defined periodicity.

[0144] For example, a fixed mapping between control channel beam RS and/or the control symbols may assist WTRU measurement at specific subframes. An mB may use a fixed mapping for a subset of beams for WTRUs in idle mode and a flexible mapping for WTRUs in connected mode. An mB may use a fixed mapping for WTRUs in connected mode and a subset of beams for WTRUs in idle mode. An mB may use a fixed mapping when the cell is lightly loaded (e.g. when the number of active WTRUs are small) switch to a flexible mapping when the cell is highly loaded. WTRUs may determine the mapping format for control channel beams from the configuration received in one or more of the following: broadcast channel(s) (e.g., MIB, SIB-x), higher layer signaling (e.g. RRC/MAC), L1 signal/channels, any other common channel, and/or the like. One or more WTRUs may determine the change/switch in control channel beam mapping from configuration received in one or more of the following: broadcast channel(s) (e.g., MIB, SIB-x), higher layer signaling (e.g. RRC/MAC), and/or L1 signal/channels, any other common channel, and/or the like.

[0145] An mmW control channel beam may have various control channel beams. The mmW control channel beam may carry plurality of control channels addressed to one or more WTRUs. The control channel beam may carry one of more of the following: the Downlink Control Information (DCI) [e.g., the DCI may include scheduling grant (UL and DL)], UL control channel assignment, beam switch command, power control commands and/or any other control information, higher layer messages (MAC, RRC), small payload (e.g. broadcast messages like SIB/Paging), cell and/or beam specific reference signals for demodulation, measurement for one or more WTRUs, and/or the like. The minimum time domain resource occupied by the control channel beam may be one symbol. The maximum time domain resource occupied by the control channel beam may be pre-configured (e.g., in MIB/SIB-x) and/or dynamically signaled using beam specific PCFICH. The dwell time of the control channel beam may be pre-configured (e.g. in MIB/SIB-x) and/or dynamically signaled using beam specific

PCFICH. The time domain resources (e.g. number of symbols) occupied by common control channel beam may be fixed (e.g., in MIB/SIB-x). The WTRU specific control channel beam may be dynamic (e.g., beam specific PCFICH).

[0146] The mmW control beam may carry one or more PDCCHs. The PDCCHs may be addressed for/to one or more WTRUs. A PDCCH may be transmitted on an aggregation of one or several CCEs (Control Channel Elements), e.g., where a control channel element may correspond to two or more REGs (Resource Element Groups). Different PDCCH formats may be defined, e.g., based on aggregation levels of CCEs. PDCCH may be transmitted, e.g., using a hierarchy of different groups of resource elements. The allocation of number of basic resource units for a level of resource group may be associated with PDCCH link adaptation scheme and/or other considerations. One or more characteristics/property of REs may be a function of beam ID and/or beam type. One or more characteristics/property of CCEs may be a function of beam ID and/or beam type.

[0147] Common control channel beams and/or WTRU specific control channel beams may use different PDCCH formats and/or aggregation levels. There may be a fixed aggregation level on the WTRU specific control channel beam. The number of REGs per CCE may vary for different beam type. For example, common control channel beam may have higher number of REGs per CCE. The resource block structure and/or subcarrier spacing may vary for different beam types. For example, symbols carrying common control channel beams and/or symbols carrying WTRU specific control beams may use different subcarrier spacings. Common control channel beams may be scrambled by a cell specific (e.g. cell ID) and/or beam specific (e.g. beam ID) identity. WTRU specific control channel beams may be scrambled by one or more of the following: a cell specific (e.g. cell ID), a beam specific (e.g. beam ID), a WTRU specific identity (e.g. C-RNTI), and/or the like. One or more modulation schemes and/or coding rates used for the control channel beam may be specific to beam type. For example, common control channel may use a fixed and/or preconfigured modulation scheme and/or coding rate. The WTRU specific control channel beam may use a dynamic MCS adaptation. The dynamic MCS adaptation may be signaled using beam PCFICH. Beam types may be WTRU specific. For example, a WTRU may use a common control channel beam. A WTRU may use a WTRU specific control channel beam. A WTRU may use a beam carrying common control channel scheduling and/or WTRU specific scheduling information. The part of the subframe where common control channel beams are transmitted may be referred as common control region. The part of the subframe where WTRU specific control channel beams are transmitted may be referred as dedicated control region.

[0148] The following examples are subframe configurations showing control channel beam placement and/or resource structure. The example figures for different control channel placement shown are not exhaustive and/or other control channel placements may be used. The figures are not meant to be exhaustive, e.g., all channels are not captured in the figure. For purposes of clarity and/or explanation, examples may be described in term of DL subframes and/or (e.g., only DL subframes are shown) UL subframes may be ignored. One or more techniques described in terms of DL operation may be equally applicable to uplink operation. The wide transmit beams at the mB may be referred here as B1, B2, B3, B4 etc. The narrow transmit beams may be referred to as B11, B12 (e.g., within B1), B21, B22 (e.g., within B2) etc.

[0149] In FIG. 12, the mB may transmit one or more wide beam control channels per subframe. For example, subframe 1 may carry the control channel beams B1 and/or B2, subframe 2 may control channel beams B3, etc. A (e.g., one or more, or each) control channel beam may carry DCI for one or more WTRUs. A (e.g., one or more, or each) control channel beam within a subframe may carry some unique content. For example, a DCI for a WTRU (e.g., a particular DCI for a WTRU) may be carried in a (e.g., only one) control channel beam. A control channel beam within the subframe may carry the same DCI content. The number of control channel beams per TTI may vary. For example, it may range from one control channel beam per TTI to the maximum available number of control channel beams in the cell. Length/duration of a (e.g., one or more, or each) control channel beam may vary (e.g. from one to more symbols). The data region within a subframe may carry PDSCH for one or more WTRUs, e.g., the PDSCH transmission for different WTRUs may be multiplexed in time, frequency, and/or spatial domain. For example, multiple PDSCH beams may be transmitted within the data region. The beam width of a data beam may be adjusted based on one or more of the following: WTRU location, throughput requirements, and/or interference consideration, and/or the like. The mapping between the control channel beam and the symbol number within the control region may be flexible. WTRUs may receive assistance information about the control channel configuration, e.g., from PBCH and/or from Omni PCFICH channel.

[0150] In FIG. 13, mB may transmit one (e.g., exactly one) wide beam control channel per subframe. For example subframe 1 may carry the control channel beam B1 and/or B2, subframe 2 may carry control channel beams B3 etc. WTRUs may be configured to monitor certain (e.g., only certain) subframes for a possible occurrence of the pre-selected control channel beam.

[0151] In FIG.14, mB may sweep some or all the control channel beams in a subframe. For example a (e.g., one or more, or each) subframe may carry the control channel beam B1, B2,

B3, and/or B4. A (e.g., one or more, or each) control channel beam may carry DCI for one or more WTRUs. WTRUs with lower SNR may have their DCIs repeated in certain (e.g., all) control channel beams. WTRUs with higher SNR may have their DCIs transmitted in a subset of control channel beams. The mapping between the control channel beam and the control symbol may be fixed. BRS for a control channel beam (e.g., rather than and/or in addition to control channels) may be swept.

[0152] In FIG. 15, the control channel beam may be predefined to symbol mapping, e.g., to reduce the blind decoding attempts for the WTRUs. The WTRUs may attempt to decode the symbols (e.g., only the symbols) carrying pre-selected control channel beams. mB may map/place/transmit data channel beams in some control channel symbols, e.g., control channel symbols that may or might not be occupied by control channel beams. The WTRUs may start to buffer the symbols, e.g., for a possible data channel until it decodes the pre-selected control channel beam at the appropriate control symbol.

[0153] In FIG. 16, many to one mapping may be utilized for control channel beam to control symbol mapping to reduce control overhead, e.g., when the number of control channel beams are high in a cell. In FIG. 16, B1 and/or B5 may be mapped to symbol 1. B1 and/or B5 may be transmitted in control symbol 1, e.g., when the assumption is that one RF chain may be for the mB. WTRUs having B1 control channel beam may be used (e.g., required) to decode control symbol 1. A hashing function may be used, e.g., to reduce blocking probability for control channel beams. The hashing function may avoid mapping the same set of control channel beams to the same control symbol. The hashing may be a function of one or more of the following: subframe number, system frame number, control channel beam ID, cell ID, the control symbol number, and/or the like.

[0154] FIG. 17 is an example of a logical architecture for control channel beam generation. FIG. 17 illustrates an example of the relation between the different mapping/selection functions.

[0155] A mmW PDCCH may use heterogeneous beam types. For WTRU specific control channel, wide beams may be configured and/or assigned for a group of users and/or one or more, or all, the users' control channels, e.g., PDCCHs that may carry user specific DL control information (DCI). One or more narrow beams may be configured and/or assigned for individual WTRU for WTRU-specific control channels. One or more beams may be configured, e.g., such that wide beam(s) may be used to cover a cluster of WTRUs and/or narrow beam(s) may be used for individual WTRUs. Table 2 is an example of some assignments and/or configurations for heterogeneous beam types. For common control channel, wide beam may be

used for individual WTRU and/or a WTRU group. Narrow beam may be used for individual WTRU (e.g., individual WTRU only). Narrow beam may be used as WTRU-specific beam for common control, e.g., depending on the beam configurations. Wide beams (e.g., only wide beams) may be used for a group of WTRUs for common control. For WTRU-specific control channel, narrow beam may be used as WTRU-specific beam for WTRU-specific control. Wide beam (e.g., only wide beams) may be used for a group of WTRUs for WTRU-specific control.

Table 2. Examples for Assignments and/or Configurations for Heterogeneous Beam Types

		Wide beam	Narrow beam
Common Control	Individual WTRU	May use wide beam for easy tracking of WTRUs, etc. WTRU-specific wide beam for common control.	May use narrow beam for high beamforming gain. WTRU-specific narrow beam for common control.
	WTRU group	May use wide beam for WTRU group	May or might not use narrow beam
WTRU-specific Control	Individual WTRU	May use wide beam for easy tracking of WTRUs, etc. WTRU-specific wide beam for WTRU-specific control.	May or might not use narrow beam for high beamforming gain. WTRU-specific narrow beam for WTRU-specific control.
	WTRU group	May use wide beam for WTRU group	May or might not use narrow beam

[0156] A wide beam may be configured and/or used as a WTRU-specific beam for control channels, e.g., to enable easy tracking of WTRUs. The control channels may be common control channels. The control channels may be WTRU-specific control channels, e.g., common DCI carried by PDCCH, and/or ePDCCH, and/or the like. This may enable easy tracking of WTRUs. This may sometimes lower beamforming gain. Easy tracking of WTRUs may be useful. Easy tracking of WTRUs may be useful where beamforming gain may be less of a concern. Beamforming gain may be less of a concern when WTRUs are near the eNB and/or AP. Narrow beam(s) may be configured and/or used (e.g., only used) as WTRU-specific beam(s) for control channels, e.g., to enable high beamforming gain. High beamperforming gain may be useful, e.g., when WTRUs are far away from eNB and/or AP. High beamperforming gain may be useful, e.g., when WTRUs are around the cell edge. The control channels may be common and/or WTRU-

specific control channels. The WTRU-specific control channels may be WTRU-specific DCI carried by PDCCH, and/or ePDCCH, and/or the like.

[0157] Beams with different beam widths may be used to cover different WTRU densities (e.g., the number of WTRUs in a given direction/area relative to the mB). The pairing for which beam with certain width to cover which WTRU density may depend on the density distribution of WTRUs in geography. For example, for high density area, beams with narrower beam width may be configured and/or used. For low density area, beams with medium and/or larger beamwidth may be configured and/or used.

[0158] Beams may be allocated to WTRUs, e.g., such that WTRU density per beam (e.g., number of WTRUs in a beam) may be uniform and/or constant. This may facilitate the use of digital beamforming within analog beam, e.g., to support a given number of active WTRUs. The number of analog beams may be reduced. The control overhead may be mitigated, e.g., when multiple control channels may be sent simultaneously in the same beam and/or frequency resource. Trade-off may occur between the number of OFDM symbols (e.g., for beam sweeping) for control and/or the number of OFDM symbols for data. Different compromises between overhead and throughput may be considered based on the specific deployment scenario.

[0159] Heterogeneous beam types with different beam widths may be configured and/or used, e.g., to improve network operation flexibility and/or to reduce the control overhead.

[0160] Heterogeneous beam types may support one or more of the following: heterogeneous beam types with different beam widths for common and/or WTRU specific channel, heterogeneous beam types with different beam widths for the same WTRU at different time instance, heterogeneous beam types with different beam widths for different WTRUs, and/or heterogeneous beam types with different beam widths for group of WTRUs depending on WTRU's locations, and/or the like. The heterogeneous beam types with different beam widths may be configured and/or used for common control and/or WTRU-specific control channel. Heterogeneous beam types with different beam widths may be configured and/or used for the same WTRUs at different time instance. Heterogeneous beam types with different beam widths may be configured and/or used for different WTRUs at the same and/or different time instances. Heterogeneous beam types with different beam widths may be configured and/or used for a group of WTRUs, e.g., a group of WTRUs with various WTRU's locations. The control overhead, e.g, the number of OFDM symbols for control with respect to the number of OFDM symbols for data and/or the number of beams needed for beam sweeping with respect to number of OFDM symbols for data, may be reduced.

[0161] One or more of the following beam configurations may be considered, e.g., when one RF chain and/or a (e.g., one) beam are formed at a (e.g., any) given time.

[0162] A beam sweeping may use homogeneous beam type (e.g., homogeneous wide beam). A (e.g., one or more, or each) beam may have the same beam width covering 360/N degrees where N is the number of OFDM symbols for control channel. For example, one or more, or each, beam will cover 120 degrees at a time for N=3. A beam sweeping cycle may cover 360 degrees. Homogeneous beam type may be for uniform angular distribution of WTRUs. Homogeneous beam type may become less efficient, e.g, for non-uniform angular distribution of WTRUs,

[0163] Heterogeneous beam type may be efficient, e.g., for non-uniform angular distribution of WTRUs. A beam sweeping may use heterogeneous beam type (e.g., heterogeneous wide beam). One or more, or each beam may have different beam width but still covering 360/N degrees where N is the number of OFDM symbols for control channel. One or more, or each beam may cover more or less than 120 degrees at a time and/or full beam sweeping cycle will cover 360 degrees. For example, for N=3 beams may have beam widths 60, 120 and/or 180 degrees. An eNB may keep the number of WTRUs per beam uniform and/or constant when it transmits control channel to a (e.g., one or more, or each) WTRU. Uniform search space for control channel may be maintained. Search space may avoid being over-utilized for some beams and/or under-utilized for other beams.

[0164] The number of WTRUs per beam may be kept constant and/or near constant, e.g., when two or more RF chains are utilized for hybrid beamforming. Within a beam (e.g., one or more, or each beam) the number of ranks for spatial multiplexing may be limited. Keeping number of WTRUs under such rank per beam may be performed to enable spatial multiplexing for future evolution.

[0165] Beam sweeping may use narrow beams. A beam may have narrow beam width but cover WTRUs within N OFDM symbols for control channel. For example, one or more, or each beam may have narrow beam width but cover one or more, or all WTRUs within N OFDM symbols for control channel. One or more, or each beam may cover a WTRU at a time and/or a full beam sweeping cycle may cover N WTRUs. For K WTRUs, if N>=K, one beam sweeping cycle may deliver control channel to K WTRUs within a TTI. If N<K, one beam sweeping cycle may or might not deliver one or more, or all control channels to one or more, or all K WTRUs within a TTI. Another TTI and/or TTIs may be used (e.g., required) to deliver control channel to remaining K-N WTRUs. How many TTIs may be used (e.g., required) for beam sweeping may depend on N and/or K. K/N beam sweeping cycles and/or TTIs may be required to deliver one

or more, or all control channel to all K WTRUs. This example may work for N>=K. This example may become less efficient when N<K. Overhead may increase, e.g., when the number of OFDM symbols for control increases. The number of WTRUs that may be supported may be limited, e.g., when the number of users and/or K decreases. Beam sweeping may be performed across multiple TTI, introducing latency (e.g., additional latency).

[0166] Beam sweeping may use heterogeneous beam type (e.g., heterogeneous wide/narrow beams). A beam may have a wide and/or narrow beam width but cover WTRUs within N OFDM symbols for control channel. For example, one or more, or each beam may have one or more, or each wide and/or narrow beam width but cover one or more, or all WTRUs within N OFDM symbols for control channel. One or more, or each beam may cover one or more WTRUs at a time and/or full beam sweeping cycle will cover N WTRUs. For K WTRUs, if N>=K, one beam sweeping cycle may deliver control channel to K WTRUs within a TTI. If N<K, one beam sweeping cycle may deliver one or more, or all control channels to one or more, or all K WTRUs within a TTI. For example, N-1 narrow beams may deliver control to N-1 WTRUs, and/or the last beam (wide beam) may deliver control to the remaining K-N+1 WTRUs. Another TTI and/or TTIs may or might not be used (e.g., required) to deliver control channel to remaining K-N WTRUs. How many narrow beams and/or wide beams may be used (e.g., required) may depend on design considerations and/or N and/or K. Using heterogeneous beam type may lower control overhead, lower latency, and/or increase the number of WTRUs that may be supported.

[0167] Heterogeneous beams may be considered. Heterogeneous beams may be s plularity of beams associated with one or more different characteristics and/or properties, e.g., beam width, transmit power, number of lobes, and/or number of active antenna elements, and/or the like. Beams with different beam widths and/or narrow beam may be used for the same cell and/or eNB. A narrow beam carrying control information and/or PDCCH may be used for individual WTRUs. Wide beams may be used for a group of control channels and/or PDCCHs. Heterogeneous beam types, e.g., wide and/or narrow beams, may be used. Heterogeneous beam widths for wide beam may be used. Different beam types and/or beam widths may be used, e.g., when beam sweeping is needed. For example, for three beams, beams 1, 2 and/or 3 may have beam width x, y and/or z respectively. For uniform settings beams 1, 2 and/or 3 may have beamwidth, x=y=z. For non-uniform settings x, y and/or z may or might not equal to each other. Depending on the settings of x, y and/or z, wide beam with different beam widths and/or narrow beam may be configured and/or formed.

[0168] To support beamforming reference signal (BRS), antenna ports may be designed to transmit BRS. Beam-specific antenna ports may be designed and/or allocated. Antenna port may be designed for beams that may be used for sending either common control and/or WTRU-specific control information. An antenna port may be associated with a reference signal called BRS. A BRS may be used to demodulate control channels. Antenna ports may be orthogonal to each other in time, frequency, code and/or any combination of them, e.g., to avoid mutual interferences among BRS. A design may use even/odd pattern for BRS. Even and/or odd BRS may be allocated in different frequency and/or time grid(s). Even BRS (E-BRS) may be placed in the same frequency and/or time grid(s). Odd BRS (O-BRS) may be placed in the same frequency and/or time grid(s). E-BRS and/or O-BRS may be allocated in different resources, e.g, resources that are orthogonal to each other. For control channel, control beam RS (CBRS) may be used. Even CBRS (E-CBRS) may be placed in the same frequency and/or time grid(s). Odd CBRS (O-CBRS) may be placed in the same frequency and/or time grid(s). E-CBRS and/or O-CBRS may be allocated in different resources, e.g., resources that are orthogonal to each other. For data channel, data BRS may be used.

[0169] In even beam, EAP may send E-CBRS for control channel. In odd beam OAP may send O-CBRS for control. EAP and/or OAP may be in orthogonal resources. E-CBRS and/or O-CBRS may be in orthogonal resources. Mutual interference between EAP and/or OAP or between E-CBRS and/or O-CBRS may be avoided.

[0170] One or more (e.g., only one) BRS (e.g., rather than and/or in addition to two BRS (E-CBRS, O-CBRS)) may be used. A (e.g., perfect) spatial separation may be achieved, e.g., to make one BRS more efficient than other designs. A BRS in even beam and/or E-CBRS may be active for control channel. BRS in odd beam and/or O-CBRS may or might not be active for control channel. BRS in odd beam and/or O-CBRS may be reused for data. O-CBRS may be active for control and/or E-CBRS may or might not be active for control. E-CBRS may be reused for data. CBRS in even and/or odd beam may or might not be reused for data, e.g, when perfect spatial separation may or might not be achieved. Side lobes of beams may be related to spatial separation. For example, side lobes of beams may prevent perfect spatial separation. Antenna patterns may be considered when designing antenna ports for BRS and/or CBRS. Side lobes may be considered when designing antenna ports for BRS and/or CBRS. Antenna ports and/or BRS design for data beam may be similar.

[0171] Spatial separation and/or resource reuse factor may be related to the efficiency of the channel design. For example, E-CBRS and/or O-CBRS may avoid mutual interferences between them, when resource reuse factor of two is considered. Resource reuse factor of two

may be considered efficient. Resource reuse factor Q=1 may be considered, e.g., when perfect spatial separation is achievable. Reuse factor Q may be set to two or higher, e.g. when perfect spatial separation may or might not be achieved. Reuse factor may be set to one, e.g., for sequential beam sweeping for control channel. Resource reuse factor may be set to two or higher, e.g., for parallel beam sweeping and/or transmission. Parallel beam sweeping and/or transmission may occur, e.g., when two or more beams transmitted in parallel simultaneously sweep through K WTRUs via N OFDM symbols for control. During parallel beam transmission, potential mutual interferences between beams may occur, e.g., when spatial separation is not perfect. Resource reuse factor may be set to two or higher.

[0172] For multi-layer beamforming, e.g., when wide beam and/or narrow beam may coexist, some offset in frequency/time grids may be applied to enable orthogonality between BRS for wide and/or narrow beams. Narrow beam may serve one WTRU among a WTRU group while a wide beam may serve the remaining WTRUs in the WTRU group, e.g., when they may (e.g., must) be served simultaneously, two (e.g., only two) beams are available, and/or the two beams may comprise a wide beam and/or a narrow beam. The narrow beam and/or wide beam may overlap. Narrow beam and/or wide beam may use FDM to enable coexistence, e.g., when spatial separation between them does not occur. BRS using FDM may be applied for narrow beam and/or wide beam.

[0173] One or more techniques associated with BRS may be applied to data BRS and/or control BRS. Control channel may be decoded. For example, channel estimation may be performed via CBRS to decode control channel.

[0174] Energy detection may be used for channel estimation and/or control channel demodulation, e.g., in even beam. For example, in even beam, E-CBRS may be on and/or O-CBRS may be off. No beam index may be decoded beforehand. Eenergy detection may be used to decide which antenna port to be used for channel estimation to decode control channel.

[0175] Channel estimation may be performed to decode data channel, e.g, when even/odd BRS is used. Beam index may already be decoded in control channel. Even/odd beam index may be obtained by one or more of the following. In even beam, even DBRS may be on, odd DBRS may be off, e.g., to avoid mutual interference between BRS at beam edge. Energy detection may be used to decide which antenna port may be used for channel estimation. It is similar for odd beam. In even beam, even DBRS may be on, odd DBRS may be on but may be used for data, redundant data may be for control and/or carry some short control message. Mutual interference between RS and/or data/else at beam edge may occur. It is similar for odd beam.

[0176] The WTRU may or might not be dependent on blind energy detection. The WTRU may decide between even/odd DBRS, perhaps for example even if a WTRU may or might not detect correct energy level. There may be an assumption that data demodulation may be performed after control channel decoding. One or more beam index may be (e.g., already) obtained in the control channel decoding.

[0177] A (e.g., one or more, or each) cell may have plurality of PDCCH regions, e.g. one for one or more, or each wide beam. A (e.g., one or more, or each) PDCCH may carry beam specific BRS sequence. The BRS REs mapping in the control channel symbols may be a function of PCI. The BRS REs mapping in the control channel symbols may be a function of beam index. The sequence carried in the BRS may be provided by the linked PBCH.

[0178] WTRUs may monitor PDCCH. WTRUs may detect BRS associated with the serving beam at control symbol location. The control symbol location may be fixed. WTRUs may perform BRS detection operation in certain (e.g., one or more, or all) control symbols defined by cell PCFICH, e.g., when the control symbol locations are not fixed and/or variable. WTRUs may perform BRS detection operation in the control symbols (e.g., only the control symbols) defined by beam-specific PCFICH. e.g., perhaps when the control symbol locations might not be fixed and/or variable. WTRUs may compare the measured BRSRP with an implementation dependent threshold. WTRUs may perform PDCCH decoding, e.g., when BRSRP is greater than the threshold. WTRUs may assume no DL/UL grant received in the current TTI, e.g., perhaps unless a semi-static grant is configured.

[0179] Subframe structure and/or placement for PDCCH BRS may be designed. For sequential beam sweeping, FIG. 18 may be an example subframe structure and/or placement for control BRS. The resources may be indicated in the FIG. 18. Example subframe in FIG. 18 shows three control symbols followed by some data symbols. Beams may be swept through three control symbols sequentially by the order of beams 1, 2 and/or 3 (e.g., B1, B2 and/or B3).

[0180] FIG. 19 may be an example resource allocation in two dimension of frequency and/or time. BRS may be used in a (e.g., one or more, or each) control symbol and/or may be placed uniformly (and/or non-uniformly) across frequency. FIG. 19 shows that BRS may have the same location in frequency across one or more, or all control symbols. Other allocations may be used, e.g., BRS may be in different locations in frequency across different control symbols. BRS may be in staggered patterns and/or designs.

[0181] FIG. 20 may be an example control BRS subframe structure and/or placement for parallel beam sweeping. The resources are also indicated in the block diagram. Example subframe in FIG. 20 shows three control symbols followed by some data symbols. One or more

beams may be swept through three control symbols sequentially by the order of beams 1&2, 3&4 and/or 5&6 (e.g., B1/B2, B3/B4 and/or B5/B6). Parallel beams may be used in a control symbol. Two parallel beams may be used simultaneously in a control symbol. For example, total six beams may be be swept through three control symbols. The number of users to be covered by the control channel may increase by using parallel beam transmission and/or sweeping. The capacity of system may increase.

[0182] FIG. 21 may be an example resource allocation in two dimension of frequency and/or time. BRS may be used in a control symbol and/or may be placed uniformly (and/or non-uniformly) across frequency. BRS may also be placed contiguously and/or non-contiguously. For example, O-BRS and/or E-BRS may be placed contiguously within a pair of O-BRS/E-BRS. Pairs of O-BRS/E-BRS may be placed uniformly and/or non-uniformly across frequency. O-BRS and/or E-BRS may be placed non-contiguously within a pair of O-BRS/E-BRS. Pairs of O-BRS/E-BRS may be placed uniformly and/or non-uniformly across frequency. Example may show that O-BRS/E-BRS pairs have the same location in frequency across one or more, or all control symbols. Other allocations may also be used, e.g. when BRS may be in different locations in frequency across different control symbols. A BRS may be in staggered patterns and/or designs.

[0183] Designs of mmW PCFICH may comprise, e.g., cell specific control region and/or beam specific control region. In a subframe, one or more beamformed control channel(s) may be transmitted during one or more control symbol(s) time multiplexed within a control region. The overall control region size/length/duration may be a function of one or more of the following: the number of control channel beams selected for transmission, the number of control symbols occupied by a (e.g., one or more, or each) control channel beam, a pre-defined max size/length/duration of beam specific control region, and/or a pre-defined max size/length/duration of cell specific control region, and/or the like.

[0184] The number of control channel beams and/or maximum number of control channel beams in a subframe may be fixed. The number of control channel beams may be less than or equal to the total number of control channel beams in the cell coverage. The number of control symbols may be a function of the number of control channel beams and/or the number of symbols per control channel beam. The number of control symbols and/or the maximum number of control symbols in a subframe may be fixed. The partial sweep function and/or a control channel beam subset selection function may select control channel beams based on one or more of the following: the number of control symbols in a subframe, and/or the number of control symbols per control channel beam, and the like. The ratio of control symbols to data symbols

may be configured to be less than or equal to a pre-defined value (e.g. control overhead percentage). The number of control symbols per control channel beam may be a function of number of WTRUs within the control channel beam and/or type of the control channel beam (e.g. common control beam and/or WTRU specific control beam).

[0185] At least a part of the control region may be one part of a number of parts of the control region. The number of parts of the control region may be a function of a number of symbols configured for the control region. The number of parts of the control region may be a function of a number of symbols used for the control region.

[0186] Cell specific control region configuration may be indicated. WTRUs may receive indication and/or configuration of cell specific control region from broadcast channel(s) (e.g., MIB, SIB-x) and/or any other common channel. The configuration may be WTRU specific. The configuration may be signaled using dedicated signaling (e.g. MAC and/or RRC message). A physical channel/signal (e.g., cell PCFICH) may be defined. A physical channel/signal may carry the configuration, e.g., for cell specific control region. A new physical channel/signal may be placed in one or more pre-defined symbol(s) in a subframe. Cell PCFICH may be transmitted with an Omni-beam and/or wide beam. Cell PCFICH may be transmitted with a narrow beam. Cell PCFICH may comprise two or more repetitions in wide beams. Cell PCFICH may comprise two or more repetitions in narrow beams. WTRUs may accumulate the energy from cell PCFICH repetitions to increase SNR. Cell PCFICH may be repeated in different directions, e.g., when transmitted using wide and/or narrow beam to provide coverage. Cell PCFICH may be repeated in different beam widths, e.g., when transmitted using wide and/or narrow beam to provide coverage. The beam used for cell PCFICH may be same as the beam used for one or more of synchronization channels (PSS and/or SSS and/or any other signal). The beam used for cell PCFICH may be the same as the beam used for PBCH. One or more WTRUs may determine the location of the cell PCFICH symbol by applying a pre-defined offset from symbol carrying PSS in the same beam.

[0187] At least one DL control channel may be communicated via one or more Orthogonal Frequency Division Multiplexing (OFDM) symbols. The one or more OFDM symbols on which the at least one DL control channel may be communicated may be located in the control region. A WTRU may obtain a number of the one or more OFDM symbols in the control region via a Physical Control Format Indicator Channel (PCFICH). In some scenarios the PCFICH may be obtained via a beam of a synchronization channel and/or via a beam of a Physical Broadcast Channel (PBCH).

[0188] WTRUs may determine the location of the cell PCFICH symbol by applying a pre-defined offset from symbol carrying SSS in the same beam. One or more WTRUs may determine the location of the cell PCFICH symbol by applying a pre-defined offset from symbol carrying PBCH in the same beam. The linkage (e.g., a pre-defined offset between two channel/beams) may be used to determine time and/or frequency location of a channel/beam when the time and/or frequency location of another channel/beam Cell PCFICH may be included in a subframe (e.g., every subframe). The linkage (e.g., a pre-defined offset between two channel/beams) may be used to determine time and/or frequency location of a channel/beam when the time and/or frequency location of another channel/beam Cell PCFICH may be included in n subframes and/or subframe (e.g., every n subframes and/or every subframe). Cell PCFICH may be transmitted in pre-defined locations within a subframe, e.g., first few symbols of a subframe.

[0189] At least one search space corresponding to at least one reference signal may be monitored for at least one data channel, perhaps for example upon the detection of the at least one reference signal. The at least one search space may have a duration. A time location of the at least one data channel may be determined, perhaps for example based on the at least one reference signal, or the duration.

[0190] The cell specific control region size may be fixed. The cell specific control region size may indicate the maximum size/length/duration of the cell specific control region. The cell specific control region size may be semi-static. The cell specific control region size may indicate the size/length/duration of the cell specific control region for n subframes. n may be greater than or equal to the periodicity of corresponding MIB/SIB-x and/or other common channels (e.g., any other common channel). The cell specific control region size may be a greater than or equal to the sum of beam specific control region size of certain (e.g., one or more, or all) control channel beams transmitted in that subframe. Cell specific control region size may be equal to the product of max beam specific control region size and/or max number of control channel beams in a subframe. The max beam specific control region size and/or max number of control channel beams in a subframe may be pre-defined in the standard. The max beam specific control region size and/or max number of control channel beams in a subframe may be configured in common/broadcast channels. One or more symbols within the control region may carry data channels, e.g., when the cell specific control region size is greater than the sum of beam specific control region size of certain (e.g., one or more, or all) of the control channel beams transmitted in that subframe. WTRUs may receive more than one configuration for cell

specific control region. For example one configuration may apply for subframes with flexible mapping. One configuration may apply for subframes with fixed mapping.

[0191] One or more WTRUs may receive configuration for flexible mapping (e.g., only for flexible mapping), and/or WTRUs may apply a pre-defined configuration (e.g. fixed and/or max length for cell specific control region) for fixed mapping. A configuration may apply for common control channels, and/or a configuration for WTRU specific control channel. The cell specific control region configuration, for example cell PCFICH, may be dynamic. The cell specific control region configuration, for example cell PCFICH, may vary for a (e.g., every) subframe. Cell PCIFCH may indicate presence of common control region within a subframe. Cell PCFICH may indicate the end and/or start of common control region within a subframe. WTRUs may assume that the rest of the control region not occupied by common control region may be dedicated control region.

[0192] Cell specific control region configuration may have contents. The configuration may include and/or identify the length of the cell specific control region size/duration/period. The length may be expressed in one or more of the following: a number of subframes, timeslots, and/or OFDM symbols, and/or the like. One or more WTRUs may assume the start of a cell specific control region as the first symbol in a subframe. WTRUs may receive explicit indication of the first and/or last symbol of the cell specific control region. The value transmitted in the cell specific control region configuration may be a logical value. The value transmitted in the cell specific control region configuration may have a pre-defined mapping to the actual duration/length/period of the cell specific control region. A WTRU may use the indications of a cell specific control region configuration to calculate and/or determine the end of the cell specific control region. A WTRU may use the indications of a cell specific control region configuration to calculate and/or determine start of the data region. The configuration may include/identify number of control channel beams transmitted in a subframe (e.g., in the current subframe and/or in n subsequent subframes and/or in some or all subframes). The configuration may include/identify the type of mapping applied for control channel beams (e.g., fixed and/or flexible mapping). The configuration may include beam identification (e.g., RS sequence ID, antenna port number, and/or control channel number) of certain (e.g., one or more, or all) control channel beams transmitted in a subframe. The subframe may be the current subframe, n subsequent subframes, and/or certain (e.g., one or more, or all) subframes.

[0193] Beam specific control region configuration may be indicated. One or more WTRUs may receive indication and/or configuration for beam specific control region size from broadcast channel(s) (e.g., MIB, SIB-x). WTRUs may receive indication and/or configuration for

beam specific control region size from any other common channel/signal. Beam specific control region size/length/duration may be pre-defined as a constant value. The constant value may be treated as a max value. Different beams in a cell may have different beam specific control region configurations. Beam specific control region size/length/duration may be semi-static. Beam specific control region configuration may vary for different beams in the cell. For example, common control channel beams may have a configuration different from the configuration for the WTRU specific control channel beams. Beam specific control region configuration for common control channel may be fixed and/or semi-static. Beam specific control region configuration for WTRU specific control channel beams may be dynamic.

[0194] The configuration may be WTRU specific and/or beam specific. The configuration may be signaled using dedicated signaling (e.g. MAC and/or RRC message). In the absence of dedicated signaling, WTRUs may apply the configuration in MIB/SIB-x and/or a pre-defined value. A physical channel/signal (for example beam PCFICH) may be defined. The physical channel/signal may carry the configuration for beam specific control region. A cell and/or mB may transmit multiple beam PCFICH in the same subframe. A beam PCIFCH may be transmitted with a specific beam pattern and/or beam width. A beam PCIFCH may carry the corresponding beam specific control region configuration. Beam specific control region configuration for a particular beam may vary across subframes. Beam PCFICH for a beam in a subframe may be transmitted conditionally based on the presence of corresponding (e.g., beam with similar properties and/or characteristics) control channel beam in that subframe. Beam PCFICH transmission may be coupled with control channel beam transmission. The control channel and/or the beam PCFICH, e.g., within a beam dwell time, may be transmitted. The beam used for beam PCFICH may be same as the corresponding control channel for which the configuration may be provided/signaled. Beam PCFICH may be time multiplexed (e.g., different symbol and/or first few symbols in a PDCCH). Beam PCFICH may be frequency multiplexed (e.g. CCEs, REs, and/or RBs) with the control channel transmission.

[0195] The mB may transmit certain (e.g., one or more, or all) the beam PCFICHs and/or transmit the control channel beams in certain order. The mB may multiplex beam PCFICH and/or cell PCFICH and/or control channel, e.g., when the cell PCFICH is transmitted with a wide and/or narrow beam. The mB may multiplex beam PCFICH and/or cell PCFICH and/or control channel, e.g., when the cell PCFICH is transmitted with a wide and/or narrow beam. The beam PCFICH may carry cell specific configuration and/or beam specific control region configuration. Beam PCFICHs may be transmitted with a different beam pattern from the beam pattern used by the control channel beams. A (e.g., one) beam PCFICH may carry the

configurations for multiple control channel beams. WTRUs may determine the presence of beam PCFICH. For example, WTRUs may determine the presence of beam PCFICH indicated by a bit and/or bitmap in cell PCFICH. WTRUs may determine the presence of beam PCFICH indicated by a bit and/or bitmap for a (e.g., one or more, or each) control beam in cell PCFICH.

[0196] Beam specific control region configuration may have contents. WTRUs may determine beam specific search space from the beam specific control region configuration. Beam specific control region configuration may include one or more of the following: a (e.g., single) beam specific control region size common for certain (e.g. one or more, or all) beams, a beam specific control region size for a (e.g., one or more, or each) beam separately, and/or a beam specific control region size as a group of beams with similar control region size, and/or the like. The configuration may include and/or identify the length of the beam specific control region size/duration/period. The size may be expressed in one or more of the following: a number of subframes, timeslots, and/or OFDM symbols, and/or the like. One or more WTRUs may receive explicit indication of the first and/or last symbol of the beam specific control region. The value transmitted in the beam specific control region configuration may be a logical value. The value transmitted in the beam specific control region configuration may have a pre-defined mapping to the actual duration/length/period of the beam specific control region. A WTRU may use the indications of a beam specific control region configuration, e.g., to calculate and/or determine the end of the beam specific control region. A WTRU may use the indications of a beam specific control region configuration, e.g., to calculate and/or determine start of the data region.

[0197] The configuration may include/identify the number of control symbols carrying the corresponding control channel beam in a subframe (e.g., in the current subframe and/or in n subsequent subframes and/or in certain (e.g., one or more, or all subframes)). The configuration may include/identify the type of mapping applied for a control channel beam (for example fixed and/or flexible). The configuration may also include beam identification (e.g., RS sequence ID and/or antenna port number and/or control channel number) of the corresponding control channel beam transmitted in a subframe (for example in the current subframe and/or in n subsequent subframes and/or in all subframes).

[0198] WTRU monitoring may be performed in idle mode. The monitoring may select a common control channel beam. WTRUs may or might not be involved in active data transfer (e.g. in idle mode). WTRUs may be in idle mode, e.g. when selecting one or more common control channel beam(s) to perform monitoring. WTRUs may monitor one or more common control channel beams. WTRUs may monitor one or more common control channel beams to receive system information. WTRUs may monitor one or more common control channel beams

to page messages. WTRUs may monitor one or more common control channel beams to perform coarse beam tracking/beam forming. WTRUs may monitor one or more common control channel beams to receive beam training. WTRUs may select one or more common control channel beam(s) for monitoring. WTRUs may perform measurements on beamformed RS. The RS may or might not be multiplexed with common control channel beams for beam evaluation purposes. Common control channel beams may be detected/measured/identified by reference signals that are different from WTRU specific beams. Certain (e.g., one or more, or all) common control channel beams may be associated with the same reference signal that may be cell specific.

[0199] A (e.g., one more, or each) common control channel beam may be associated with a different reference signal sequence. WTRU may select certain (e.g., one or more, or all) common control channel beams. WTRU may select certain common control channel beams whose measured signal quality (e.g. RSRP, SNR, SINR, RSRQ, etc.) may be above a threshold. WTRUs may select a beam (e.g. the best) based on measured signal quality for monitoring purposes. WTRUs may perform signal quality measurements on a restricted set of subframes, e.g., subframes where PBCH and/or Sync channels may be transmitted. WTRUs may perform signal quality measurements on the subframes, e.g., where there is fixed and/or pre-defined mapping between control channel beams and/or control symbols.

[0200] WTRUs may receive an explicit and/or implicit linkage between Sync beams and/or control channel beams, using heterogeneous control channel beams. One or more WTRUS may receive an explicit and/or implicit linkage between PBCH beams and/or control channel beams, using heterogeneous control channel beams. WTRU's cell selection and/or re-selection may be based on the PBCH beams. One or more WTRUs' cell selection and/or re-selection may be based on the sync beams. WTRUs may select control channel beams of certain type based on the linked serving PBCH to perform monitoring herein. WTRUs may select control channel beams of certain type based on the linked serving Sync beam type to perform monitoring herein. For example, a pre-configured offset may be defined between the PBCH/Sync beams and/or the corresponding control channel on the same beam. The offset may be in terms of time (e.g., subframe, symbols) and/or frequency.

[0201] One or more WTRUs may determine the presence of control channel beam by searching for PBCH on the same beam, e.g., at preconfigured locations in the frame structure. WTRUs may detect the presence of a beam type using the beam specific reference signals. Beam specific reference signals may be defined as a function of cell ID. One or more WTRUs may determine the cell ID from the discovery signal and/or the number of beams in the cell via

PBCH. WTRUs may determine the cell ID from the set of beam reference signals associated to the cell. The beam reference signals may be associated to the cell by a predefined function of cell ID and/or number of beams. Beam specific reference signals may identify beam types and/or beams. WTRUs may monitor the control channel beams associated with (e.g., belonging to) beams narrower than the current serving and/or detected PBCH beam type.

[0202] Common control channel beam may have a search space. Control region in a (e.g., one or more, or each) serving cell and/or mB may comprise one or more control symbols carrying one or more control channel beams. Control region of a (e.g., one or more, or each) control channel beam may comprise one or more symbols, where the number of symbols may be either fixed and/or variable. Control region of a (e.g., one or more, or each) control channel beam may comprise one or more symbols, where the symbols and/or symbol group (e.g., exact symbols and/or symbol group) may depend on the mapping function. Common search space may be a function of one or more of the following: number of common control channel beams transmitted by the mB, number of common control channels selected by the WTRU, beam specific control region size/duration, overall control region duration, bandwidth of the cell, and/or aggregation level, and/or the like. Within the symbols used for common control channel beam, frequency domain mapping may be explicitly provided for control channel, e.g., PDCCH candidates mapped to n number of carriers around the center frequency, even/odd RBs, hashing function, and/or any other pattern. The common search space with beamformed control channels may be defined as a set of PDCCH candidates on one or more common control channel beams, e.g., determined by control channel beam selection function. On a control channel beam, one or more WTRUs may monitor the corresponding beam specific control region for a set of PDCCH candidates defined by one or more aggregation levels.

[0203] FIG. 21 is an example of common control channel beam and/or associated search space. WTRUs may perform monitoring. WTRUs may monitor their common search space in idle mode. WTRUs may perform the monitoring on a set of pre-defined subframes, e.g., where the mapping between the common control channel beams may be known and/or configured in terms of control channel beam IDs and/or symbol mapping. WTRUs may search certain subframes (e.g., all subframes and/or preconfigured subframe(s)) for presence of common control channel beams at symbol locations within the control region. WTRUs may search the subframes by correlating a known reference signal sequence (e.g., signal sequences which may be cell specific and/or beam specific). Different reference signal sequences may be defined for common control channel beams and/or WTRU specific control channel beams. A (e.g., one or more, or each) beam may have its own reference signal sequence, perhaps within the common

control channel beams. Within the common control channel beams, one or more beams (e.g., all beams) may use the cell specific sequence. The WTRU may monitor the common search space within the beam specific control region, e.g., when the received reference signal power may be above a threshold. The reference signal sequence may be cell specific. Some or all of the common control channel beams in the cell may carry the same information. A WTRU may accumulate the energy received from some or all the common control channels to increase the SNR.

[0204] WTRUs may perform monitoring in connected mode. WTRU may perform monitoring in connected mode by assigning control channel beams. WTRUS may monitor one or more control channel beams to receive control information in connected mode. The control channel beams may be WTRU specific control channel beams and/or cell specific common control channel beams. The set of control channel beams that the WTRU may monitor may be referred to as serving control channel beams. One or more WTRUs may be assigned one or more serving control channel beam(s). WTRUs may consider some or all the control channel beams from the mB as serving control channels. WTRUs may consider the control channel beams selected during idle mode operation, e.g., as WTRU specific control channel beams for connected mode operation. WTRUs may receive the serving control channel beam(s) configuration using dedicated signaling (e.g. L1 and/or MAC and/or RRC message). One or more WTRUs may monitor one or more serving control channels in the connected mode for one or more of the following: UL and/or DL grants, Beam switch commands, handover commands, higher layer messages, and/or small payloads, and/or any other control information. One or more WTRUs may distinguish common control channel beams from the WTRU specific control channel beams by the presence of pre-defined beam reference signals.

[0205] WTRUs may monitor cell specific common control channel beams to receive common channels (e.g., Paging and/or SIB) while in connected mode. WTRUs may select common control channel beams autonomously. WTRUs may select common control channel beams based on dedicated signaling (e.g. L1 and/or MAC and/or RRC message) received in the serving control channel. WTRUs may monitor serving control channel beam for common channels (e.g. Paging and/or SIB). One or more WTRUs may select common control channel beam(s) that are implicitly and/or explicitly linked to current serving control channel beam(s).

[0206] WTRUs may have beam specific search space. Control region in a serving cell and/or mB may comprise one or more control symbols. Control symbols may carry one or more control channel beams. Control region of a (e.g., one or more, or each) control channel beam

may comprise one or more symbols. For example, the number of symbols may be either fixed and/or variable. The exact symbols and/or symbol group may depend on the mapping function.

[0207] WTRU specific search space may be a function of one or more of the following: the number of control channel beams transmitted by the mB, number of control channels selected by and/or assigned to the WTRUs, beam specific control region size/duration, overall control region duration, bandwidth of the cell, aggregation levels, WTRU ID, subframe number, and/or subframe, and/or the like. WTRU specific search space may be defined as the union of beam specific search space of certain serving control channel beams selected by /assigned to the WTRU. Beam specific search space may be defined as a set of PDCCH candidates in beam specific control region. Beam specific control region may be defined as one or more control symbols and/or symbol groups used to transmit and/or mapped to the corresponding beam. Number of symbols per control channel beam may be static, semi-static and/or dynamic. On a (e.g., one or more, or each) serving control channel beam, a WTRU may monitor the corresponding beam specific control region for set of PDCCH candidates defined by one or more aggregation levels. Within the symbols used for control channel beam, frequency domain mapping and/or restriction may be explicitly and/or implicitly defined for PDCCH candidates (e.g. mapped to n number of carriers around the center frequency and/or even/odd RBs and/or a hashing function and/or any other pattern). WTRUs may be configured with different set of aggregation levels for different control channel beams. WTRU specific search space within a beam may be a function of beam ID, WTRU ID, symbol number, subframe number etc.

[0208] FIG. 22 is an example for WTRU beam specific search space. WTRUs may perform monitoring. WTRUs may monitor their WTRU specific search space in connected mode. WTRUs may monitor common search space in connected mode. WTRUs may perform conditional monitoring, e.g., based on the presence of one or more serving control channel beams. One or more WTRUs may search certain subframes and/or one or more preconfigured subframes for the presence of WTRU specific control channel beam, by correlating one or more of the following: pre-configured beam specific reference signal sequence, cell specific reference signal sequence, and/or beam type specific reference signal sequence in the control region, and/or the like. One or more WTRUs may be configured with mapping between control channel beam and control symbol location. WTRUs may search for (e.g., only for) the configured control channel beams in a (e.g., one or more, or each) symbol location. The WTRUs may monitor PDCCH candidates within the detected beam specific search space, e.g., when the received reference signal power is above a threshold.

[0209] WTRUs may monitor beam specific search space in some or all the subframes and/or in the configured subframes where one or more serving control channel beams may be transmitted. WTRUS may monitor common search space in all or some of the subframes or in the configured subframes where one or more common control channel beams may be transmitted. For example, the control region in pre-configured subframes may comprise one more (e.g. two) parts, one for common control channel beams and/or the other for WTRU specific control channel beams, for example. One or more WTRUs may monitor common search space in the common control region and/or WTRU specific and/or beam specific search space in the dedicated control region.

[0210] WTRUs may perform monitoring using one or more techniques as described herein. WTRUs may determine WTRU specific control channel beam and/or common control channel beam by doing one or more of the following. WTRU specific control channel beam may be configured by the mB. WTRU specific control channel beam may be selected during the cell selection. WTRU specific control channel beam may be selected autonomously by the WTRU and/or indicated to the mB during the random access procedure. Common control channel beam may be selected by the WTRUs autonomously (e.g. linkage to PBCH/Sync beams). Common control channel beam may be selected by the WTRUs implicitly linked to current serving control channel beams (e.g., many to one mapping between WTRU specific beams and common control channel beams). An mB may override the common control channel beam for a WTRU in connected mode.

[0211] WTRUs may determine subframes to monitor, based on beam mapping function through one or more of the following. WTRUs may be preconfigured (in MIB/SIB-x and/or dedicated signaling) with the beam to subframe mapping. WTRUS may monitor those (e.g., only those) subframes, e.g, where one or more serving control channel beam and/or common control channel beams may be transmitted. WTRUs upon wake up from DRX mode may monitor those (e.g., only those) subframes, e.g., where the fixed mapping to the serving control beams may be pre-configured. WTRUs may assume and/or be configured a flexible mapping, e.g., any to any mapping between beams and subframes, with a (e.g., one or more, or each) subframe containing multiple control channel beams. One or more WTRUs may monitor certain (e.g. one or more, or all) the DL subframes for the serving control channel beams and/or common control channel beams. Upon wake up from DRX mode and/or receiving a valid allocation, WTRUs may continue monitoring certain (e.g., one or more, or all) subframes for the serving control channel beams. WTRUs may monitor specific subframes for common control channel beam and/or certain (e.g., one or more, or all) subframes for WTRU specific control channel beams.

[0212] WTRUs may determine overall control region in a subframe. WTRUs may determine the overall control region size/duration in a subframe from MIB/SIB-x. WTRUs may determine the overall control region size/duration in a subframe from a fixed parameter. WTRUs may determine the overall control region size/duration in a subframe dynamically signaled via a cell PCFICH.

[0213] WTRUs may determine beam specific search space by one or more of the following. Within the overall control region, WTRUs may assume one or more beam specific control region. For a (e.g., one or more, or each) monitored control channel beam, WTRUs may determine (e.g., first determine) the presence of those control beams and/or starting symbol for the control channel beams by explicit signaling in cell PCIFCH. For monitored control channel beams, WTRUs may determine the presence of those control beams and/or starting symbol for the control channel beams by detecting beam specific BRS above a threshold. For monitored control channel beams, WTRUs may perform blind decoding, e.g., when a cell specific BRS is used. WTRUs may assume no DCI received in that subframe, e.g, when BRS for certain (e.g., one or more, or all) serving control channel beams are below the threshold. WTRUs may identify the beams based on beam specific preambles added to a (e.g., one or more, or each) control symbol carrying the beam. The preambles may be a function of one or more of the following: beam ID, cell ID, and/or WTRU ID, and/or the like.

[0214] One or more WTRUs may utilize the measurements based on BRS to determine the characteristics/property of the control channel beam, e.g., the presence of a specific control channel type and/or beam, length of the control channel beam etc. For certain (e.g., one or more, or all) detected control channel beams, WTRUs may determine the beam specific control region size/duration and/or last symbol in the beam specific control region from MIB/SIB-x. For certain (e.g., one or more, or all) detected control channel beams, WTRUs may determine the beam specific control region size/duration and/or last symbol in the beam specific control region from a fixed parameter. For certain (e.g., one or more, or all) detected control channel beams, WTRUs may determine the beam specific control region size/duration and/or last symbol in the beam specific control region may be dynamically signaled via beam PCFICH. One or more WTRUs may be (e.g., explicitly) provided with a fixed mapping between the control channel beam and the symbol location of the beam specific control region. One or more WTRUs may be (e.g., explicitly) provided with a fixed mapping between the control channel beam and the size/duration of the beam specific control region. An overall control region may be split into common control region and/or a dedicated control region.

[0215] Within a (e.g., one or more, or each) detected beam specific control region, one or more WTRUs may do one or more of the following. A WTRU may apply the frequency and/or time domain restriction (e.g. central n carriers and/or specific RBs and/or any other pattern and/or remove non-PDCCH channels (e.g. PHICH, beam PCIFICH, sync/PBCH if present). Within the beam specific search space, some (e.g., additional), WTRU specific search space may be configured. For example, starting CCEs may be different for different WTRUs (e.g. based on WTRU ID, beam type, beam ID, subframe number, symbol number etc.). WTRUs may group the REGs within a (e.g., one or more, or each) beam specific control region into one set of CCEs. Within a (e.g., one or more, or each) set of CCEs, WTRUs may monitor one or more PDCCH candidates based on aggregation levels configured for a (e.g., one or more, or each) beam type and/or beam. DCI CRC may be scrambled with beam ID in addition to the WTRU ID (e.g. CRNTI) and/or common ID (e.g. SI_RNTI and/or Paging RNTI). When WTRU specific control channel beams, WTRU specific search space may be simplified (e.g., further simplified) by pre-configuring fixed starting CCEs, explicit indication of aggregation level used etc.

[0216] DL data may perform scheduling. WTRUs may, upon detection of PDCCH in some (e.g., at least one) of the serving control channel beams, indicate DL grant for data and/or some (e.g., any) other higher layer information intended for the WTRUs. WTRUs may attempt to decode the corresponding data channel beam in the resources indicated by the DCI. WTRUs may assume that the serving control channel beam may be used for data transmission, e.g., when no data beam specific identity is included in the DCI message. WTRUs may assume the last indicated data channel beam, e.g, if no data beam specific identity is included in the DCI message. WTRUs may assume the data channel indicated by the higher layer configuration, e.g., if no data beam specific identity is included in the DCI message. The scrambling initialization of the PDSCH may be a function of one or more of the following: control channel beam ID that carries the allocation, beam ID of the DL data channel beam, WTRU specific RNTI (e.g. C-RNTI and/or SPS-RNTI), a fixed RNTI (e.g. SI-RNTI and/or Paging RNTI), and/or beam type, and/or the like.

[0217] Sub-subframe scheduling may perform resource allocation by allowing multiple allocation in a subframe. Beamforming may be used (e.g., required) to compensate additional path loss at higher frequencies. Given the large bandwidths at higher frequencies and/or analog beamforming, one or more WTRUs may be multiplexed with different beams within a subframe and/or scheduling interval. One or more control channels may be transmitted with wide beams. A (e.g., one or more, or each) control channel beam may schedule one or more narrow data beams for one or more WTRUs within the same subframe.

[0218] Minimum schedulable time resource within a subframe may be symbol and/or group of symbols. Scheduling granularity may be less than a subframe and/or a scheduling interval. For example, a new (e.g., fresh and/or heretofore unused) DCI format may be defined to carry allocation information at symbol level/symbol group, to indicate a start offset (e.g., a symbol offset), repetition information (e.g. more than one data channel per WTRU per subframe), and/or spatial information (e.g. transmit beam ID), and/or the like.

[0219] Within a subframe, the data region may comprise multiple data channel beams multiplexed in time. For example, a data channel may occupy several symbols and/or the remaining symbols within the same subframe may be used by other data channel beams addressed to the same and/or different WTRUs. WTRUs may be allocated multiple data channel resources within the same subframe. A (e.g., one or more, or each) set of data channel resources may be associated with a different data beam.

[0220] Downlink data beam that an mB may use for the WTRU may be identified. WTRUs may use a receive beam pattern for downlink data channel reception. WTRUs may use different receive beam pattern for downlink control channel beam reception compared to the receiving beam pattern used for downlink data channel beam reception. An mB may comprise the transmit beam ID corresponding to the data channel beam to enable WTRU to switch receive beam accordingly. One or more WTRUs may use (e.g., require) gap and/or decoding period between the PDCCH carrying the grant and/or the actual data channel resource. Transmit beam ID may be implicitly determined by the WTRU, e.g., when WTRU specific control channel beam is used, as the data beam may be same as the WTRU specific control channel beam.

[0221] The data channel beam information may be coupled with resource allocation information. For example the DCI may include transmit beam identification in PDCCH that carries resource allocation in terms of time (e.g. symbol, symbol group) and/or frequency (e.g. RBs). An mB may explicitly provide a gap and/or guard period between the last symbol of PDCCH and the first symbol of PDSCH within the same subframe. The guard period may be defined from WTRU point of view. mB may use the symbols in the guard period to schedule other WTRUs. WTRUs may assume (e.g., always assume) an offset between PDCCH and PDSCH. For example PDCCH in subframe n may allocate PDSCH in subframe n+k. The value of k may be dynamic and/or may be configured by higher layer signaling (MAC and/or RRC) and/or may be included in DCI message and/or may be a pre-defined constant. WTRUs may assume k=0 for buffering the data in the current subframe. Depending on the value of k in the DCI, WTRUs may determine the PDSCH location in the current subframe (if k=0 and/or not included in DCI) and/or in subframe n+k (if k is included in the DCI).

[0222] At least one search space may include downlink control information (DCI). At least one data channel may be monitored, perhaps for example based at least in part on the DCI. At least one beam for receipt of the at least one data channel may be identified, perhaps for example based at least in part on the DCI.

[0223] The data channel beam information and/or spatial information may be separate from resource allocation (e.g. time, frequency, code) information. The spatial information (e.g., data channel transmit beam identification) may be derived from beam specific reference signal for the corresponding DL beam. The spatial information may be derived from beam specific reference signal for the corresponding antenna port. The spatial information may be derived from beam specific reference signal for the corresponding steering vector and/or codebook index. The spatial information may be signaled using RRC configuration/MAC CE/DCI, decoupled from the time and/or frequency resource allocation information. The spatial information may be acknowledged by the WRTU to prevent mismatch between an mB and the WRTU, before actual data transmission on the indicated data channel beam. The spatial information and/or resource allocation information (e.g. time and/or frequency) may have a pre-defined and/or configured offset to the allocated resources. The spatial information may be associated with a validity period and/or upon expiry of the validity period. WRTUs may perform (e.g., be required to perform) one or more of beam measurement and/or beam tracking and/or beam reporting (e.g. CSI).

[0224] The common channels may be scheduled using separate spatial information. The WTRU specific channels may be scheduled using the coupled spatial information. The common channels may be scheduled using coupled spatial information. The WTRU specific channels may be scheduled using the separate spatial information. Different WTRUs in the same cell may receive the scheduling information using different configuration (e.g. coupled and/or separate).

[0225] DCI may have format and/or contents. Downlink control information for a DL data channel grant may be include one or more of the following: spatial information, time, and/or frequency resource information, and/or the like. Spacial information may comprise one or more of the following: implicit data channel beam identity (e.g. associated Data channel RS sequence number, associated control channel RS sequence number and/or an index in the WTRU measurement report) and/or an explicit data channel ID which may map to a specific data channel beam, UL control channel beam configuration associated with a DL transmission, and/or set of control symbols to monitor for serving control channel beam(s), and/or the like. Time and/or frequency resource information may comprise one or more of the following: the resource allocation information corresponding to downlink data channel beam indicated in the spatial

information, Starting symbol location for PDSCH within the subframe, Duration (in terms of number of symbols), Frequency/Resource Block information, an index to a pre-configured symbol groups/resource groups in time and/or frequency, and/or the like.

[0226] Spatial information may be signaled using L23 signaling (e.g. RRC and/or MAC CE) and/or L1 signaling (e.g. in a DCI). WTRUs may consider the spatial information to be valid after transmitting an ACK corresponding to the DL PDSCH carrying the spatial information. WTRUs may assume that the spatial information valid until they receive RRC/MAC CE/DCI with a different spatial information. Time and/or frequency resource information may be signaled using L1 signaling (e.g. in a DCI). The scheduling information in the time and/or frequency resource information may be valid for (e.g., only for) the subframe where the resource information is received. Different DCI formats may be defined. For example, two different DCI formats may be defined, one with the time and/or frequency resource information and/or the other with time and/or frequency resource information and/or spatial information. A DCI format may contain the time and/or frequency resource information and/or the other(s) DCI format may contain the spatial information.

[0227] Beams may be combined for DL. Plurality of spatial information may be signaled to the WTRU using L23 signaling (e.g. RRC and/or MAC CE) and/or L1 signaling (e.g. in a DCI) for the downlink data transmission. The DCI and/or the L23 message may carry per spatial information, one or more of the following: symbol location, duration, resource block configuration, WTRU specific reference signal ID and/or beam ID, antenna port number, and/or HARQ information (e.g. redundancy version), and/or the like. Spatial information (e.g., one or more, or each spatial information) may identify the transmission direction and/or data channel beam to the WTRUs. WTRUs may receive a single transport block within a subframe and/or sequence of subframes multiplexed in time domain, using plurality of spatial configuration (e.g. multiple data channel beams). WTRUs may soft-combine the spatial repetitions of the transport block to improve the effective SNR. WTRUs may use same and/or different receive antenna configuration and/or receive beam pattern corresponding to the downlink spatial information signaled for beam combining.

[0228] UL data may be scheduled. WTRU upon detection of PDCCH in some (e.g., at least one) of the serving control channel beams in subframe/subframe n, indicating UL grant intended for the WTRU, may transmit PUSCH in subframe/subframe n+k, using the UL data channel beam indicated in the PDCCH., WTRUs may assume that the current UL control channel beam may be used for UL data transmission, e.g., when no data channel beam identity is included in the DCI message. One or more WTRUs may assume the last indicated UL data

channel beam and/or the data channel indicated by higher layer configuration for UL data transmission, e.g. when no data channel beam identity is included in the DCI message. The scrambling initialization of the PUSCH may be a function of control channel beam ID that carries the allocation and/or beam ID of the UL data channel beam and/or WTRU specific RNTI (e.g. C-RNTI and/or SPS-RNTI) and/or beam type.

[0229] Within a UL subframe, the data region may comprise multiple UL data channel beams from one or more WTRUs multiplexed in time. For example, a data channel may occupy one or more symbols and/or the remaining symbols within the same subframe may be used by other UL data channel beams addressed to the same and/or different WTRUs. WTRUs may be allocated multiple UL data channel resources within the same subframe. A (e.g., one or more, or each) set of UL data channel resources may be associated with a different UL data beam.

[0230] Uplink transmissions from multiple WTRUs within the same subframe and/or scheduling interval, may be multiplexed in time domain and/or frequency domain. Scheduling granularity may be less than subframe and/or scheduling interval. A new DCI format may carry UL allocation information at symbol level/symbol group, start offset, repetition information (e.g. more than one UL data channel per WTRU per subframe), spatial information (e.g. UL transmit beam ID).

[0231] One or more WTRUs may identify and/or signal the uplink data beam. One or more WTRUs may use a specific beam pattern for UL data channel transmission. One or more WTRUs may use different transmit beam pattern for uplink control channel compared to the transmit beam pattern used for uplink data channel beam. An mB may include the transmit beam ID corresponding to the UL data channel beam to enable WTRUs to switch transmit beam accordingly. One or more WTRUs may use (e.g., require) gap and/or decoding period between the PDCCH carrying the UL grant and/or the actual UL data channel resource.

[0232] The UL data channel beam information may be coupled with resource allocation information. For example the DCI may include transmit beam identification in PDCCH that carries resource allocation in terms of time (e.g. symbol and/or symbol group) and/or frequency (e.g. RBs). An mB may (e.g., explicitly) provide a gap and/or guard period between the last symbol of PDCCH and the first symbol of PUSCH. The guard period may be defined from WTRU point of view. An mB may use the symbols in the guard period to schedule other WTRUs. WTRUs may assume (e.g. always assume) an offset between PDCCH and PUSCH. For example PDCCH in subframe n may allocats PUSCH in subframe n+k. The value of k may be dynamic and/or may either be configured by higher layer signaling (MAC and/or RRC) and/or may be included in DCI message.

[0233] The UL data channel beam information and/or spatial information may be separate from resource allocation (e.g., time, frequency, code) information. The spatial information, e.g. UL data channel transmit beam identification, may be derived from SRS (e.g. SRS sequence ID and/or SRS configuration ID etc.), decoupled from the time and/or frequency resource allocation information. The spatial information may be derived random access procedure (preamble ID and/or subframe), decoupled from the time and/or frequency resource allocation information. The spatial information may be signaled using RRC configuration/MAC CE/DCI, decoupled from the time and/or frequency resource allocation information. The spatial information may be acknowledged by the WTRU to prevent mismatch between mB and the WTRU, e.g., before actual data transmission on the indicated data channel beam. The spatial information and resource allocation information (e.g. time and/or frequency) may have a pre-defined and/or configured offset to the allocated resources. The spatial information may be associated with a validity period. For example, upon expiry of the validity period, a WTRU may (e.g., be required to) perform one or more of sounding procedure and/or RACH etc.

[0234] The UL control channel beam may be scheduled using separate spatial information. The UL data channel beam may be scheduled using the coupled spatial information. One or more WTRUs in the same cell may receive the scheduling information using different configuration (e.g., coupled and/or separate).

[0235] DCI may have formats and/or contents. Downlink control information for a UL data channel grant may include one or more of the following: spatial information, time resource information, and/or frequency resource information, and/or the like. Spatial information may comprise one or more of the following: implicit data channel beam identity, and/or DL PHICH beam configuration, and/or the like. Implicit data channel beam identity may comprise one or more of the following: SRS sequence ID and/or SRS configuration ID etc., preamble ID, subframe and/or an explicit data channel ID which may map to a specific data channel beam, and/or explicit ID negotiated with the WTRU, and/or the like. Time and/or frequency resource information may comprise one or more of the following: information that may indicate the resource allocation information corresponding to downlink data channel beam indicated in the most recent spatial information, starting symbol location for PUSCH within the subframe, duration (e.g., in terms of number of symbols), frequency/resource block information, and/or an index to a pre-configured symbol groups/resource groups in time and/or frequency, and/or the like.

[0236] Spatial information may be signaled using Layer 2 and/or 3 (L23) signaling (e.g. RRC and/or MAC CE) and/or L1 signaling (e.g. in a DCI). A WTRU may consider the

scheduling information received in the spatial information to be valid after transmitting an ACK corresponding to the DL PDSCH carrying the spatial information. The WTRU may assume that the spatial information valid perhaps until it receives RRC/MAC CE/DCI with a different spatial information, for example. Time and/or frequency resource information may be signaled using L1 signaling (e.g. in a DCI). The scheduling information in the time and/or frequency resource information may be valid for the subframe (e.g., only for the subframe) where the resource information is received.

[0237] Different DCI formats may be defined. One or more (e.g. two) different DCI formats may be defined, perhaps one with the time and/or frequency resource information and/or another other with time and/or frequency resource information and/or spatial information. A DCI format may contain the time and/or frequency resource information and/or the other DCI format may contain the spatial information.

[0238] One or more beams may be combined for UL. A plurality of spatial information may be signaled to the WTRU using L23 signaling (e.g. RRC and/or MAC CE) and/or L1 signaling (e.g. in a DCI) for the uplink data transmission. The DCI and/or the L23 message may carry per spatial information, one or more of the following: symbol location, duration, resource block configuration, WTRU specific reference signal ID and/or beam ID and/or SRS configuration ID, antenna port number, and/or HARQ information (e.g. redundancy version) and/or the like.

[0239] A (e.g., one or more, or each) spatial information may identify (e.g., uniquely identify) the transmission direction and/or data channel beam from the WTRU. A WTRU may transmit a single transport block within a subframe and/or sequence of subframes multiplexed in time domain, perhaps for example using a plurality of spatial configuration (e.g. multiple data channel beams). An mB may soft-combine the spatial repetitions of the transport block, e.g., to improve the effective SNR. An mB may use a same receiving antenna configuration and/or receiving beam pattern corresponding to the uplink spatial information signaled for beam combining. An mB may use different receiving antenna configuration and/or receiving beam pattern corresponding to the uplink spatial information signaled for beam combining.

[0240] UL control channel information may be part of UL data scheduling. DCI may carry UL control channel information and/or the DL grant for data channels. The UL control channel information may include the resources used for feedback (e.g. ACK/NACK and/or CSI etc.). An mB may dynamically signal the WTRU UL control beam for feedback using the DCI carrying the corresponding DL resource allocation. One or more WTRUs may associate the UL control channel resources allocated in a DCI to the DL data channel allocation present in the

same DCI. The UL control channel information may include time (e.g. subframe offset or symbol offset from the current subframe) and/or frequency resources (e.g. Resource blocks). The UL control channel information may include the spatial information for the UL control channel. For example, the UL control beam for the WTRU may be identified by SRS configuration ID and/or SRS sequence and/or RACH identifier (RA-RNTI and/or preamble sequence number) used by the WTRU for the periodic/aperiodic transmission of the corresponding UL control channel beam.

[0241] A mB may pre-configure the mapping between DL control beam carrying the DL data allocation and the WTRU UL control beam carrying the feedback. The configuration may be WTRU specific. A mB may pre-configure the mapping between DL transmit control beam carrying the DL data allocation and the mB UL Rx control beam resources to receive the feedback. The configuration may provide WTRU specific resources within the mB UL Rx beam (e.g. frequency/time/code). A mB may schedule the uplink control beam semi-statically using higher layer signaling. A mB may schedule different uplink control beam for different feedback types (e.g. ACK/NACK vs CSI). In some or all the schemes discussed herein, a mB may configure more than one UL WTRU control beam for feedback (e.g. repetition and/or implicit HARQ retransmission).

[0242] FIG. 24A is a diagram of an example communications system 100 in which one or more disclosed embodiments may be implemented. The communications system 100 may be a multiple access system that provides content, such as voice, data, video, messaging, broadcast, *etc.*, to multiple wireless users. The communications system 100 may enable multiple wireless users to access such content through the sharing of system resources, including wireless bandwidth. For example, the communications systems 100 may employ one or more channel access methods, such as code division multiple access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), orthogonal FDMA (OFDMA), single-carrier FDMA (SC-FDMA), and the like.

[0243] As shown in FIG. 24A, the communications system 100 may include wireless transmit/receive units (WTRUs) 102a, 102b, 102c, and/or 102d (which generally or collectively may be referred to as WTRU 102), a radio access network (RAN) 103/104/105, a core network 106/107/109, a public switched telephone network (PSTN) 108, the Internet 110, and other networks 112, though it will be appreciated that the disclosed embodiments contemplate any number of WTRUs, base stations, networks, and/or network elements. Each of the WTRUs 102a, 102b, 102c, 102d may be any type of device configured to operate and/or communicate in a wireless environment. By way of example, the WTRUs 102a, 102b, 102c, 102d may be

configured to transmit and/or receive wireless signals and may include user equipment (UE), a mobile station, a fixed or mobile subscriber unit, a pager, a cellular telephone, a personal digital assistant (PDA), a smartphone, a laptop, a netbook, a personal computer, a wireless sensor, consumer electronics, and the like.

[0244] The communications systems 100 may also include a base station 114a and a base station 114b. Each of the base stations 114a, 114b may be any type of device configured to wirelessly interface with at least one of the WTRUs 102a, 102b, 102c, 102d to facilitate access to one or more communication networks, such as the core network 106/107/109, the Internet 110, and/or the networks 112. By way of example, the base stations 114a, 114b may be a base transceiver station (BTS), a Node-B, an eNode B, a Home Node B, a Home eNode B, a site controller, an access point (AP), a wireless router, and the like. While the base stations 114a, 114b are each depicted as a single element, it will be appreciated that the base stations 114a, 114b may include any number of interconnected base stations and/or network elements.

[0245] The base station 114a may be part of the RAN 103/104/105, which may also include other base stations and/or network elements (not shown), such as a base station controller (BSC), a radio network controller (RNC), relay nodes, *etc.* The base station 114a and/or the base station 114b may be configured to transmit and/or receive wireless signals within a particular geographic region, which may be referred to as a cell (not shown). The cell may further be divided into cell sectors. For example, the cell associated with the base station 114a may be divided into three sectors. Thus, in one embodiment, the base station 114a may include three transceivers, *e.g.*, one for each sector of the cell. In another embodiment, the base station 114a may employ multiple-input multiple output (MIMO) technology and, therefore, may utilize multiple transceivers for each sector of the cell.

[0246] The base stations 114a, 114b may communicate with one or more of the WTRUs 102a, 102b, 102c, 102d over an air interface 115/116/117, which may be any suitable wireless communication link (*e.g.*, radio frequency (RF), microwave, infrared (IR), ultraviolet (UV), visible light, *etc.*). The air interface 115/116/117 may be established using any suitable radio access technology (RAT).

[0247] More specifically, as noted above, the communications system 100 may be a multiple access system and may employ one or more channel access schemes, such as CDMA, TDMA, FDMA, OFDMA, SC-FDMA, and the like. For example, the base station 114a in the RAN 103/104/105 and the WTRUs 102a, 102b, 102c may implement a radio technology such as Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access (UTRA), which may establish the air interface 115/116/117 using wideband CDMA (WCDMA).

WCDMA may include communication protocols such as High-Speed Packet Access (HSPA) and/or Evolved HSPA (HSPA+). HSPA may include High-Speed Downlink Packet Access (HSDPA) and/or High-Speed Uplink Packet Access (HSUPA).

[0248] In another embodiment, the base station 114a and the WTRUs 102a, 102b, 102c may implement a radio technology such as Evolved UMTS Terrestrial Radio Access (E-UTRA), which may establish the air interface 115/116/117 using Long Term Evolution (LTE) and/or LTE-Advanced (LTE-A).

[0249] In other embodiments, the base station 114a and the WTRUs 102a, 102b, 102c may implement radio technologies such as IEEE 802.16 (*e.g.*, Worldwide Interoperability for Microwave Access (WiMAX)), CDMA2000, CDMA2000 1X, CDMA2000 EV-DO, Interim Standard 2000 (IS-2000), Interim Standard 95 (IS-95), Interim Standard 856 (IS-856), Global System for Mobile communications (GSM), Enhanced Data rates for GSM Evolution (EDGE), GSM EDGE (GERAN), and the like.

[0250] The base station 114b in FIG. 24A may be a wireless router, Home Node B, Home eNode B, or access point, for example, and may utilize any suitable RAT for facilitating wireless connectivity in a localized area, such as a place of business, a home, a vehicle, a campus, and the like. In one embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.11 to establish a wireless local area network (WLAN). In another embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.15 to establish a wireless personal area network (WPAN). In yet another embodiment, the base station 114b and the WTRUs 102c, 102d may utilize a cellular-based RAT (*e.g.*, WCDMA, CDMA2000, GSM, LTE, LTE-A, *etc.*) to establish a picocell or femtocell. As shown in FIG. 24A, the base station 114b may have a direct connection to the Internet 110. Thus, the base station 114b may or might not be used to access the Internet 110 via the core network 106/107/109.

[0251] The RAN 103/104/105 may be in communication with the core network 106/107/109, which may be any type of network configured to provide voice, data, applications, and/or voice over internet protocol (VoIP) services to one or more of the WTRUs 102a, 102b, 102c, 102d. For example, the core network 106/107/109 may provide call control, billing services, mobile location-based services, pre-paid calling, Internet connectivity, video distribution, *etc.*, and/or perform high-level security functions, such as user authentication. Although not shown in FIG. 24A, it will be appreciated that the RAN 103/104/105 and/or the core network 106/107/109 may be in direct or indirect communication with other RANs that employ the same RAT as the RAN 103/104/105 or a different RAT. For example, in addition to

being connected to the RAN 103/104/105, which may be utilizing an E-UTRA radio technology, the core network 106/107/109 may also be in communication with another RAN (not shown) employing a GSM radio technology.

[0252] The core network 106/107/109 may also serve as a gateway for the WTRUs 102a, 102b, 102c, 102d to access the PSTN 108, the Internet 110, and/or other networks 112. The PSTN 108 may include circuit-switched telephone networks that provide plain old telephone service (POTS). The Internet 110 may include a global system of interconnected computer networks and devices that use common communication protocols, such as the transmission control protocol (TCP), user datagram protocol (UDP) and the internet protocol (IP) in the TCP/IP internet protocol suite. The networks 112 may include wired or wireless communications networks owned and/or operated by other service providers. For example, the networks 112 may include another core network connected to one or more RANs, which may employ the same RAT as the RAN 103/104/105 or a different RAT.

[0253] One or more of the WTRUs 102a, 102b, 102c, 102d in the communications system 100 may include multi-mode capabilities, *e.g.*, the WTRUs 102a, 102b, 102c, 102d may include multiple transceivers for communicating with different wireless networks over different wireless links. For example, the WTRU 102c shown in FIG. 24A may be configured to communicate with the base station 114a, which may employ a cellular-based radio technology, and with the base station 114b, which may employ an IEEE 802 radio technology.

[0254] FIG. 24B is a system diagram of an example WTRU 102. As shown in FIG. 24B, the WTRU 102 may include a processor 118, a transceiver 120, a transmit/receive element 122, a speaker/microphone 124, a keypad 126, a display/touchpad 128, non-removable memory 130, removable memory 132, a power source 134, a global positioning system (GPS) chipset 136, and other peripherals 138. It will be appreciated that the WTRU 102 may include any sub-combination of the foregoing elements while remaining consistent with an embodiment. Also, embodiments contemplate that the base stations 114a and 114b, and/or the nodes that base stations 114a and 114b may represent, such as but not limited to transceiver station (BTS), a Node-B, a site controller, an access point (AP), a home node-B, an evolved home node-B (eNodeB), a home evolved node-B (HeNB), a home evolved node-B gateway, and proxy nodes, among others, may include one or more of the elements depicted in FIG. 24B and described herein.

[0255] The processor 118 may be a general purpose processor, a special purpose processor, a conventional processor, a digital signal processor (DSP), a plurality of microprocessors, one or more microprocessors in association with a DSP core, a controller, a

microcontroller, Application Specific Integrated Circuits (ASICs), Field Programmable Gate Array (FPGAs) circuits, any other type of integrated circuit (IC), a state machine, and the like. The processor 118 may perform signal coding, data processing, power control, input/output processing, and/or any other functionality that enables the WTRU 102 to operate in a wireless environment. The processor 118 may be coupled to the transceiver 120, which may be coupled to the transmit/receive element 122. While FIG. 24B depicts the processor 118 and the transceiver 120 as separate components, it will be appreciated that the processor 118 and the transceiver 120 may be integrated together in an electronic package or chip.

[0256] The transmit/receive element 122 may be configured to transmit signals to, or receive signals from, a base station (*e.g.*, the base station 114a) over the air interface 115/116/117. For example, in one embodiment, the transmit/receive element 122 may be an antenna configured to transmit and/or receive RF signals. In another embodiment, the transmit/receive element 122 may be an emitter/detector configured to transmit and/or receive IR, UV, or visible light signals, for example. In yet another embodiment, the transmit/receive element 122 may be configured to transmit and receive both RF and light signals. It will be appreciated that the transmit/receive element 122 may be configured to transmit and/or receive any combination of wireless signals.

[0257] In addition, although the transmit/receive element 122 is depicted in FIG. 24B as a single element, the WTRU 102 may include any number of transmit/receive elements 122. More specifically, the WTRU 102 may employ MIMO technology. Thus, in one embodiment, the WTRU 102 may include two or more transmit/receive elements 122 (*e.g.*, multiple antennas) for transmitting and receiving wireless signals over the air interface 115/116/117.

[0258] The transceiver 120 may be configured to modulate the signals that are to be transmitted by the transmit/receive element 122 and to demodulate the signals that are received by the transmit/receive element 122. As noted above, the WTRU 102 may have multi-mode capabilities. Thus, the transceiver 120 may include multiple transceivers for enabling the WTRU 102 to communicate via multiple RATs, such as UTRA and IEEE 802.11, for example.

[0259] The processor 118 of the WTRU 102 may be coupled to, and may receive user input data from, the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128 (*e.g.*, a liquid crystal display (LCD) display unit or organic light-emitting diode (OLED) display unit). The processor 118 may also output user data to the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128. In addition, the processor 118 may access information from, and store data in, any type of suitable memory, such as the non-removable memory 130 and/or the removable memory 132. The non-removable memory 130 may include random-

access memory (RAM), read-only memory (ROM), a hard disk, or any other type of memory storage device. The removable memory 132 may include a subscriber identity module (SIM) card, a memory stick, a secure digital (SD) memory card, and the like. In other embodiments, the processor 118 may access information from, and store data in, memory that is not physically located on the WTRU 102, such as on a server or a home computer (not shown).

[0260] The processor 118 may receive power from the power source 134, and may be configured to distribute and/or control the power to the other components in the WTRU 102. The power source 134 may be any suitable device for powering the WTRU 102. For example, the power source 134 may include one or more dry cell batteries (*e.g.*, nickel-cadmium (NiCd), nickel-zinc (NiZn), nickel metal hydride (NiMH), lithium-ion (Li-ion), *etc.*), solar cells, fuel cells, and the like.

[0261] The processor 118 may also be coupled to the GPS chipset 136, which may be configured to provide location information (*e.g.*, longitude and latitude) regarding the current location of the WTRU 102. In addition to, or in lieu of, the information from the GPS chipset 136, the WTRU 102 may receive location information over the air interface 115/116/117 from a base station (*e.g.*, base stations 114a, 114b) and/or determine its location based on the timing of the signals being received from two or more nearby base stations. It will be appreciated that the WTRU 102 may acquire location information by way of any suitable location-determination method while remaining consistent with an embodiment.

[0262] The processor 118 may further be coupled to other peripherals 138, which may include one or more software and/or hardware modules that provide additional features, functionality and/or wired or wireless connectivity. For example, the peripherals 138 may include an accelerometer, an e-compass, a satellite transceiver, a digital camera (for photographs or video), a universal serial bus (USB) port, a vibration device, a television transceiver, a hands free headset, a Bluetooth® module, a frequency modulated (FM) radio unit, a digital music player, a media player, a video game player module, an Internet browser, and the like.

[0263] FIG. 24C is a system diagram of the RAN 103 and the core network 106 according to an embodiment. As noted above, the RAN 103 may employ a UTRA radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 115. The RAN 103 may also be in communication with the core network 106. As shown in FIG. 24C, the RAN 103 may include Node-Bs 140a, 140b, 140c, which may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 115. The Node-Bs 140a, 140b, 140c may each be associated with a particular cell (not shown) within the RAN 103. The RAN 103 may also include RNCs 142a, 142b. It will be appreciated that the

RAN 103 may include any number of Node-Bs and RNCs while remaining consistent with an embodiment.

[0264] As shown in FIG. 24C, the Node-Bs 140a, 140b may be in communication with the RNC 142a. Additionally, the Node-B 140c may be in communication with the RNC142b. The Node-Bs 140a, 140b, 140c may communicate with the respective RNCs 142a, 142b via an Iub interface. The RNCs 142a, 142b may be in communication with one another via an Iur interface. Each of the RNCs 142a, 142b may be configured to control the respective Node-Bs 140a, 140b, 140c to which it is connected. In addition, each of the RNCs 142a, 142b may be configured to carry out or support other functionality, such as outer loop power control, load control, admission control, packet scheduling, handover control, macrodiversity, security functions, data encryption, and the like.

[0265] The core network 106 shown in FIG. 24C may include a media gateway (MGW) 144, a mobile switching center (MSC) 146, a serving GPRS support node (SGSN) 148, and/or a gateway GPRS support node (GGSN) 150. While each of the foregoing elements are depicted as part of the core network 106, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

[0266] The RNC 142a in the RAN 103 may be connected to the MSC 146 in the core network 106 via an IuCS interface. The MSC 146 may be connected to the MGW 144. The MSC 146 and the MGW 144 may provide the WTRUs 102a, 102b, 102c with access to circuit-switched networks, such as the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, 102c and land-line communications devices.

[0267] The RNC 142a in the RAN 103 may also be connected to the SGSN 148 in the core network 106 via an IuPS interface. The SGSN 148 may be connected to the GGSN 150. The SGSN 148 and the GGSN 150 may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, such as the Internet 110, to facilitate communications between and the WTRUs 102a, 102b, 102c and IP-enabled devices.

[0268] As noted above, the core network 106 may also be connected to the networks 112, which may include other wired or wireless networks that are owned and/or operated by other service providers.

[0269] FIG. 24D is a system diagram of the RAN 104 and the core network 107 according to an embodiment. As noted above, the RAN 104 may employ an E-UTRA radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 116. The RAN 104 may also be in communication with the core network 107.

[0270] The RAN 104 may include eNode-Bs 160a, 160b, 160c, though it will be appreciated that the RAN 104 may include any number of eNode-Bs while remaining consistent with an embodiment. The eNode-Bs 160a, 160b, 160c may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 116. In one embodiment, the eNode-Bs 160a, 160b, 160c may implement MIMO technology. Thus, the eNode-B 160a, for example, may use multiple antennas to transmit wireless signals to, and receive wireless signals from, the WTRU 102a.

[0271] Each of the eNode-Bs 160a, 160b, 160c may be associated with a particular cell (not shown) and may be configured to handle radio resource management decisions, handover decisions, scheduling of users in the uplink and/or downlink, and the like. As shown in FIG. 24D, the eNode-Bs 160a, 160b, 160c may communicate with one another over an X2 interface.

[0272] The core network 107 shown in FIG. 24D may include a mobility management gateway (MME) 162, a serving gateway 164, and a packet data network (PDN) gateway 166. While each of the foregoing elements are depicted as part of the core network 107, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

[0273] The MME 162 may be connected to each of the eNode-Bs 160a, 160b, 160c in the RAN 104 via an S1 interface and may serve as a control node. For example, the MME 162 may be responsible for authenticating users of the WTRUs 102a, 102b, 102c, bearer activation/deactivation, selecting a particular serving gateway during an initial attach of the WTRUs 102a, 102b, 102c, and the like. The MME 162 may also provide a control plane function for switching between the RAN 104 and other RANs (not shown) that employ other radio technologies, such as GSM or WCDMA.

[0274] The serving gateway 164 may be connected to each of the eNode-Bs 160a, 160b, 160c in the RAN 104 via the S1 interface. The serving gateway 164 may generally route and forward user data packets to/from the WTRUs 102a, 102b, 102c. The serving gateway 164 may also perform other functions, such as anchoring user planes during inter-eNode B handovers, triggering paging when downlink data is available for the WTRUs 102a, 102b, 102c, managing and storing contexts of the WTRUs 102a, 102b, 102c, and the like.

[0275] The serving gateway 164 may also be connected to the PDN gateway 166, which may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, such as the Internet 110, to facilitate communications between the WTRUs 102a, 102b, 102c and IP-enabled devices.

[0276] The core network 107 may facilitate communications with other networks. For example, the core network 107 may provide the WTRUs 102a, 102b, 102c with access to circuit-switched networks, such as the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, 102c and land-line communications devices. For example, the core network 107 may include, or may communicate with, an IP gateway (*e.g.*, an IP multimedia subsystem (IMS) server) that serves as an interface between the core network 107 and the PSTN 108. In addition, the core network 107 may provide the WTRUs 102a, 102b, 102c with access to the networks 112, which may include other wired or wireless networks that are owned and/or operated by other service providers.

[0277] FIG. 24E is a system diagram of the RAN 105 and the core network 109 according to an embodiment. The RAN 105 may be an access service network (ASN) that employs IEEE 802.16 radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 117. As will be further discussed below, the communication links between the different functional entities of the WTRUs 102a, 102b, 102c, the RAN 105, and the core network 109 may be defined as reference points.

[0278] As shown in FIG. 24E, the RAN 105 may include base stations 180a, 180b, 180c, and an ASN gateway 182, though it will be appreciated that the RAN 105 may include any number of base stations and ASN gateways while remaining consistent with an embodiment. The base stations 180a, 180b, 180c may each be associated with a particular cell (not shown) in the RAN 105 and may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 117. In one embodiment, the base stations 180a, 180b, 180c may implement MIMO technology. Thus, the base station 180a, for example, may use multiple antennas to transmit wireless signals to, and receive wireless signals from, the WTRU 102a. The base stations 180a, 180b, 180c may also provide mobility management functions, such as handoff triggering, tunnel establishment, radio resource management, traffic classification, quality of service (QoS) policy enforcement, and the like. The ASN gateway 182 may serve as a traffic aggregation point and may be responsible for paging, caching of subscriber profiles, routing to the core network 109, and the like.

[0279] The air interface 117 between the WTRUs 102a, 102b, 102c and the RAN 105 may be defined as an R1 reference point that implements the IEEE 802.16 specification. In addition, each of the WTRUs 102a, 102b, 102c may establish a logical interface (not shown) with the core network 109. The logical interface between the WTRUs 102a, 102b, 102c and the core network 109 may be defined as an R2 reference point, which may be used for authentication, authorization, IP host configuration management, and/or mobility management.

[0280] The communication link between each of the base stations 180a, 180b, 180c may be defined as an R8 reference point that includes protocols for facilitating WTRU handovers and the transfer of data between base stations. The communication link between the base stations 180a, 180b, 180c and the ASN gateway 182 may be defined as an R6 reference point. The R6 reference point may include protocols for facilitating mobility management based on mobility events associated with each of the WTRUs 102a, 102b, 102c.

[0281] As shown in FIG. 24E, the RAN 105 may be connected to the core network 109. The communication link between the RAN 105 and the core network 109 may defined as an R3 reference point that includes protocols for facilitating data transfer and mobility management capabilities, for example. The core network 109 may include a mobile IP home agent (MIP-HA) 184, an authentication, authorization, accounting (AAA) server 186, and a gateway 188. While each of the foregoing elements are depicted as part of the core network 109, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

[0282] The MIP-HA may be responsible for IP address management, and may enable the WTRUs 102a, 102b, 102c to roam between different ASNs and/or different core networks. The MIP-HA 184 may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, such as the Internet 110, to facilitate communications between the WTRUs 102a, 102b, 102c and IP-enabled devices. The AAA server 186 may be responsible for user authentication and for supporting user services. The gateway 188 may facilitate interworking with other networks. For example, the gateway 188 may provide the WTRUs 102a, 102b, 102c with access to circuit-switched networks, such as the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, 102c and land-line communications devices. In addition, the gateway 188 may provide the WTRUs 102a, 102b, 102c with access to the networks 112, which may include other wired or wireless networks that are owned and/or operated by other service providers.

[0283] Although not shown in FIG. 24E, it will be appreciated that the RAN 105 may be connected to other ASNs and the core network 109 may be connected to other core networks. The communication link between the RAN 105 the other ASNs may be defined as an R4 reference point, which may include protocols for coordinating the mobility of the WTRUs 102a, 102b, 102c between the RAN 105 and the other ASNs. The communication link between the core network 109 and the other core networks may be defined as an R5 reference, which may include protocols for facilitating interworking between home core networks and visited core networks.

[0284] Although features and elements are described above in particular combinations, one of ordinary skill in the art will appreciate that each feature or element can be used alone or in any combination with the other features and elements. In addition, the methods described herein may be implemented in a computer program, software, or firmware incorporated in a computer-readable medium for execution by a computer or processor. Examples of computer-readable media include electronic signals (transmitted over wired or wireless connections) and computer-readable storage media. Examples of computer-readable storage media include, but are not limited to, a read only memory (ROM), a random access memory (RAM), a register, cache memory, semiconductor memory devices, magnetic media such as internal hard disks and removable disks, magneto-optical media, and optical media such as CD-ROM disks, and digital versatile disks (DVDs). A processor in association with software may be used to implement a radio frequency transceiver for use in a WTRU, UE, terminal, base station, RNC, or any host computer.

CLAIMS

What is claimed is:

1. A wireless transmit/receive unit (WTRU) configured for wireless communication, the WTRU comprising:

    a memory; and

    a processor, the processor configured with at least:

        one or more search spaces, the one or more search spaces configured to provide for at least one of: a monitor of one or more Downlink (DL) control channels, or a receipt of the one or more DL control channels, at least one search space of the one or more search spaces corresponding to at least one reference signal of one or more reference signals, the processor configured at least to:

            monitor at least a part of a control region for at least one reference signal of the one or more reference signals;

            detect the at least one reference signal in the at least part of the control region; and

            monitor the at least one search space corresponding to the at least one reference signal for at least one DL control channel upon the detection of the at least one reference signal.

2. The WTRU of claim 1, wherein the processor is further configured to monitor the at least one search space corresponding to the at least one reference signal for at least one data channel upon the detection of the at least one reference signal.

3. The WTRU of claim 2, wherein the at least one search space has a duration.

4. The WTRU of claim 3, wherein the processor is further configured to determine a time location of the at least one data channel based on at least one of: the at least one reference signal, or the duration.

5. The WTRU of claim 1, wherein the at least one search space includes downlink control information (DCI), and the processor is further configured to monitor the at least one DL control channel based at least in part on the DCI.

6. The WTRU of claim 2, wherein the at least one search space includes downlink control information (DCI), and the processor is further configured to monitor the at least one data channel based at least in part on the DCI.

7. The WTRU of claim 6, wherein the processor is further configured to identify at least one beam for receipt of the at least one data channel based at least in part on the DCI.

8. The WTRU of claim 1, wherein the processor is further configured such that the at least part of the control region is one part of a number of parts of the control region.

9. The WTRU of claim 8, wherein the processor is further configured such that the number of parts of the control region is a function of a number of symbols configured for the control region.

10. The WTRU of claim 8, wherein the processor is further configured such that the number of parts of the control region is a function of a number of symbols used for the control region.

11. The WTRU of claim 1, further comprising a transceiver, the transceiver being configured to receive the one or more search spaces from a wireless communication system network node.

12. The WTRU of claim 1, wherein the processor is further configured such that the one or more search spaces are predefined.

13. The WTRU of claim 1, wherein the processor is further configured such that the at least one reference signal of the one or more reference signals is at least one of: a beam reference signal, or an antenna port reference signal.

14. The WTRU of claim 1, wherein the processor is further configured such that the at least one search space of the one or more search spaces is at least one of: a beam search space, or an antenna port search space.

15. The WTRU of claim 1, wherein the processor is further configured such that the at least one reference signal in the at least part of the control region is detected upon a strength of the at least one reference signal crossing a predetermined threshold.

16. The WTRU of claim 1, wherein the processor is further configured such that the at least one DL control channel is communicated via one or more Orthogonal Frequency Division Multiplexing (OFDM) symbols.

17. The WTRU of claim 16, wherein the processor is further configured such that the one or more OFDM symbols on which the at least one DL control channel is communicated is located in the control region.

18. The WTRU of claim of 17, wherein the processor is further configured to obtain a number of the one or more OFDM symbols in the control region via a Physical Control Format Indicator Channel (PCFICH).

19. The WTRU of claim 18, wherein the processor is further configured such that the PCFICH is obtained via a beam of a synchronization channel.

20. The WTRU of claim 18, wherein the processor is further configured such that the PCFICH is obtain via a beam of a Physical Broadcast Channel (PBCH).

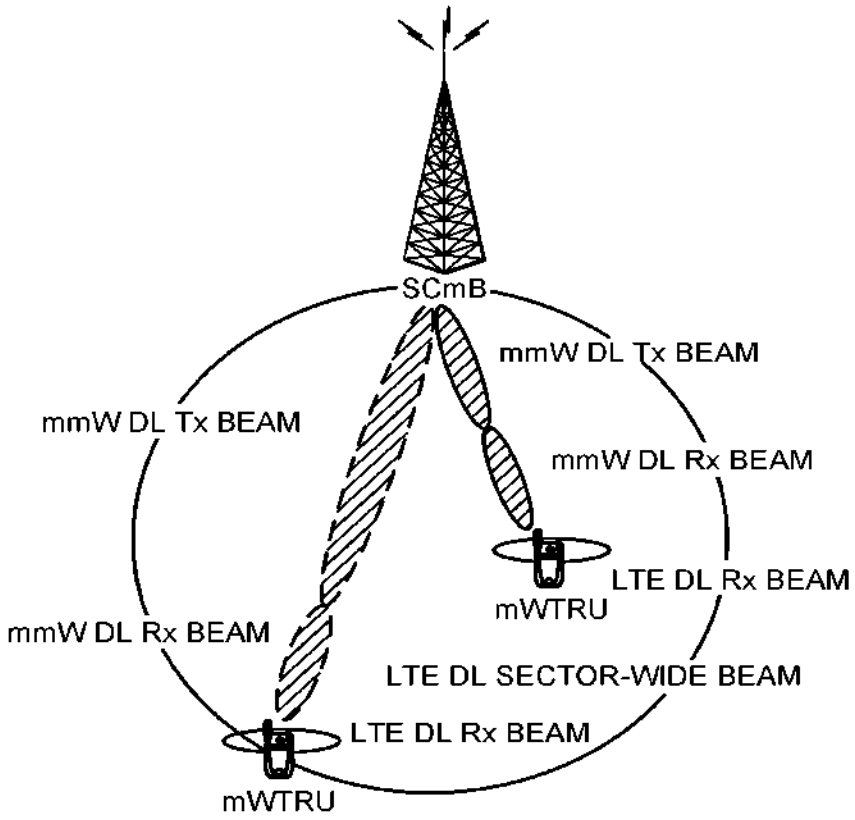

SCmB
mmW DL Tx BEAM
mmW DL Tx BEAM
mmW DL Rx BEAM
LTE DL Rx BEAM
mWTRU
mmW DL Rx BEAM
LTE DL SECTOR-WIDE BEAM
LTE DL Rx BEAM
mWTRU

FIG. 1

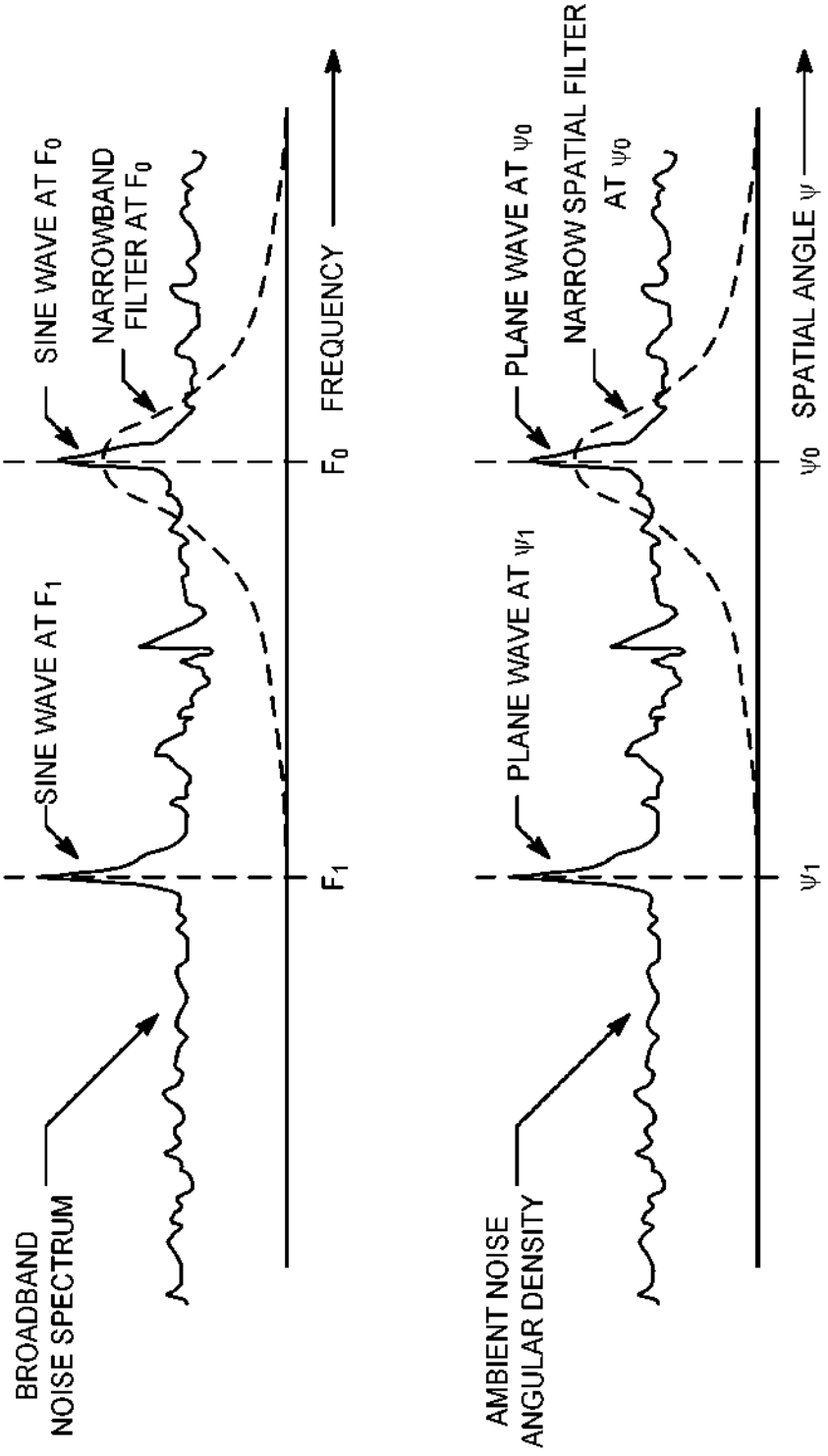

BROADBAND
NOISE SPECTRUM
SINE WAVE AT F_1
SINE WAVE AT F_0
NARROWBAND
FILTER AT F_0
F_1
F_0
FREQUENCY
AMBIENT NOISE
ANGULAR DENSITY
PLANE WAVE AT ψ_1
PLANE WAVE AT ψ_0
NARROW SPATIAL FILTER
AT ψ_0
ψ_1
ψ_0
SPATIAL ANGLE ψ

FIG. 2

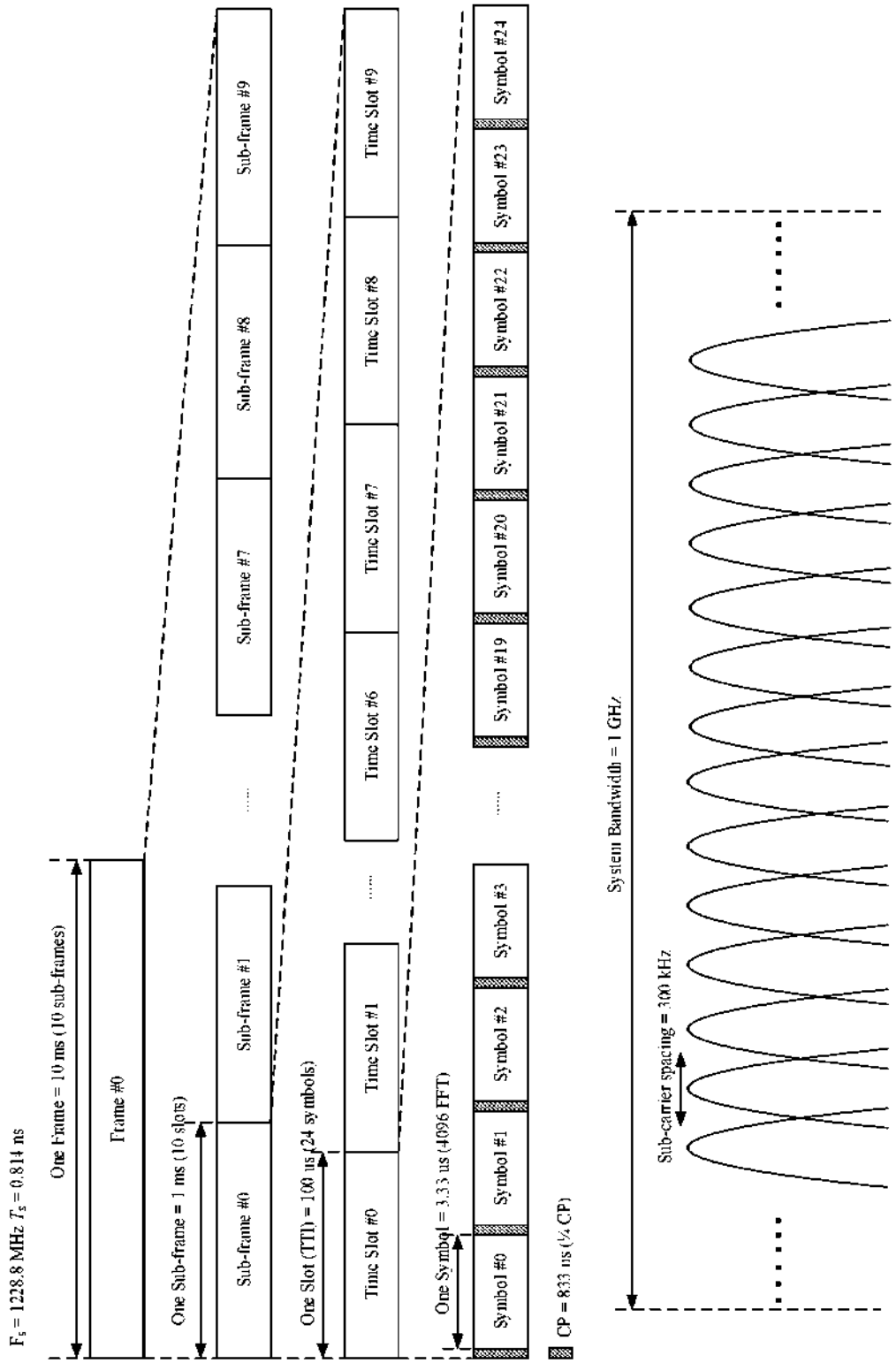

F_s = 1228.8 MHz T_s = 0.814 ns
One Frame = 10 ms (10 sub-frames)
Frame #0
One Sub-frame = 1 ms (10 slots)
Sub-frame #0
Sub-frame #1
Sub-frame #7
Sub-frame #8
Sub-frame #9
One Slot (TTI) = 100 us (24 symbols)
Time Slot #0
Time Slot #1
Time Slot #6
Time Slot #7
Time Slot #8
Time Slot #9
One Symbol = 3.33 us (4096 FFT)
Symbol #0
Symbol #1
Symbol #2
Symbol #3
Symbol #19
Symbol #20
Symbol #21
Symbol #22
Symbol #23
Symbol #24
CP = 833 ns (¼ CP)
System Bandwidth = 1 GHz
Sub-carrier spacing = 300 kHz

FIG. 3

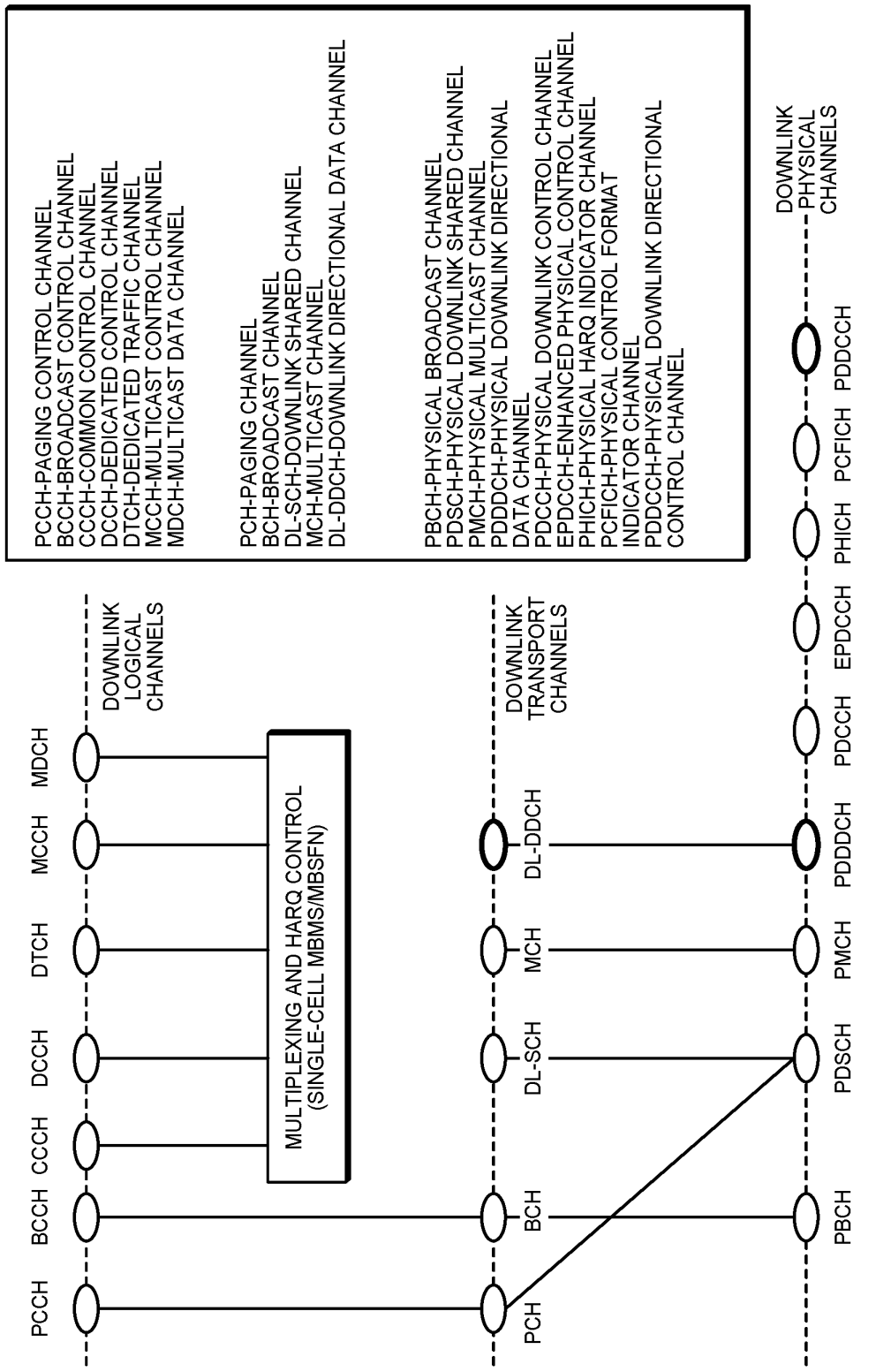

PCCH-PAGING CONTROL CHANNEL
BCCH-BROADCAST CONTROL CHANNEL
CCCH-COMMON CONTROL CHANNEL
DCCH-DEDICATED CONTROL CHANNEL
DTCH-DEDICATED TRAFFIC CHANNEL
MCCH-MULTICAST CONTROL CHANNEL
MDCH-MULTICAST DATA CHANNEL
PCH-PAGING CHANNEL
BCH-BROADCAST CHANNEL
DL-SCH-DOWNLINK SHARED CHANNEL
MCH-MULTICAST CHANNEL
DL-DDCH-DOWNLINK DIRECTIONAL DATA CHANNEL
PBCH-PHYSICAL BROADCAST CHANNEL
PDSCH-PHYSICAL DOWNLINK SHARED CHANNEL
PMCH-PHYSICAL MULTICAST CHANNEL
PDDDCH-PHYSICAL DOWNLINK DIRECTIONAL DATA CHANNEL
PDCCH-PHYSICAL DOWNLINK CONTROL CHANNEL
EPDCCH-ENHANCED PHYSICAL CONTROL CHANNEL
PHICH-PHYSICAL HARQ INDICATOR CHANNEL
PCFICH-PHYSICAL CONTROL FORMAT INDICATOR CHANNEL
PDDCCH-PHYSICAL DOWNLINK DIRECTIONAL CONTROL CHANNEL
DOWNLINK LOGICAL CHANNELS
DOWNLINK TRANSPORT CHANNELS
DOWNLINK PHYSICAL CHANNELS
MULTIPLEXING AND HARQ CONTROL (SINGLE-CELL MBMS/MBSFN)
PCCH
BCCH
CCCH
DCCH
DTCH
MCCH
MDCH
PCH
BCH
DL-SCH
MCH
DL-DDCH
PBCH
PDSCH
PMCH
PDDDCH
PDCCH
EPDCCH
PHICH
PCFICH
PDDCCH

FIG. 4

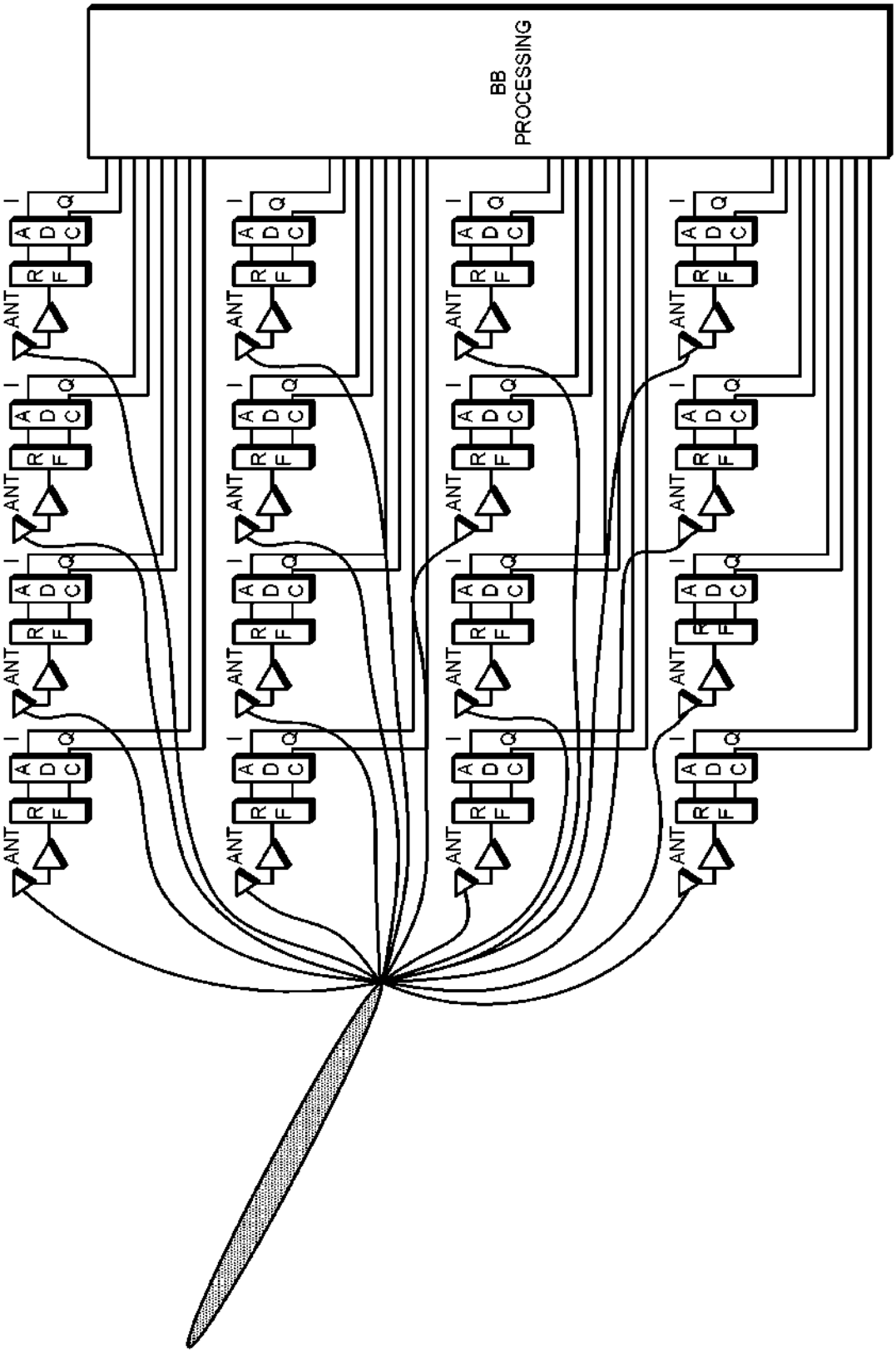


FIG. 5

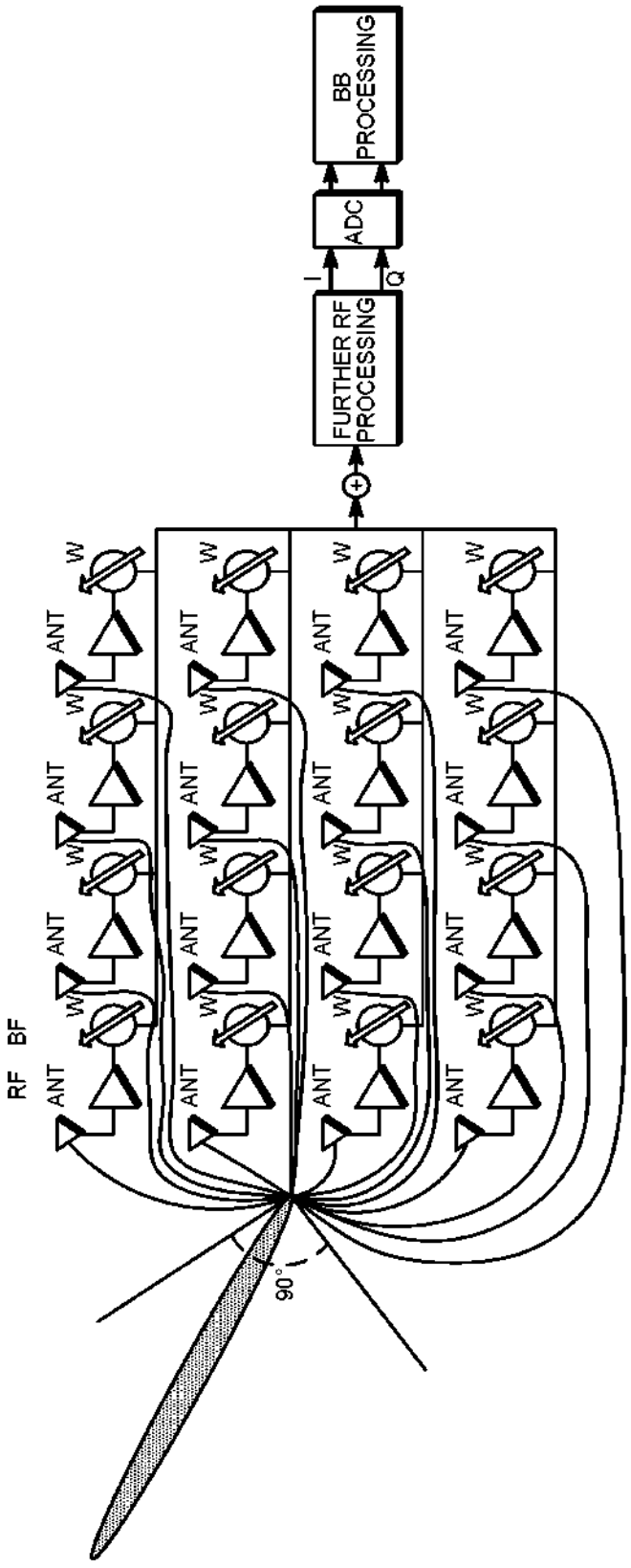


FIG. 6

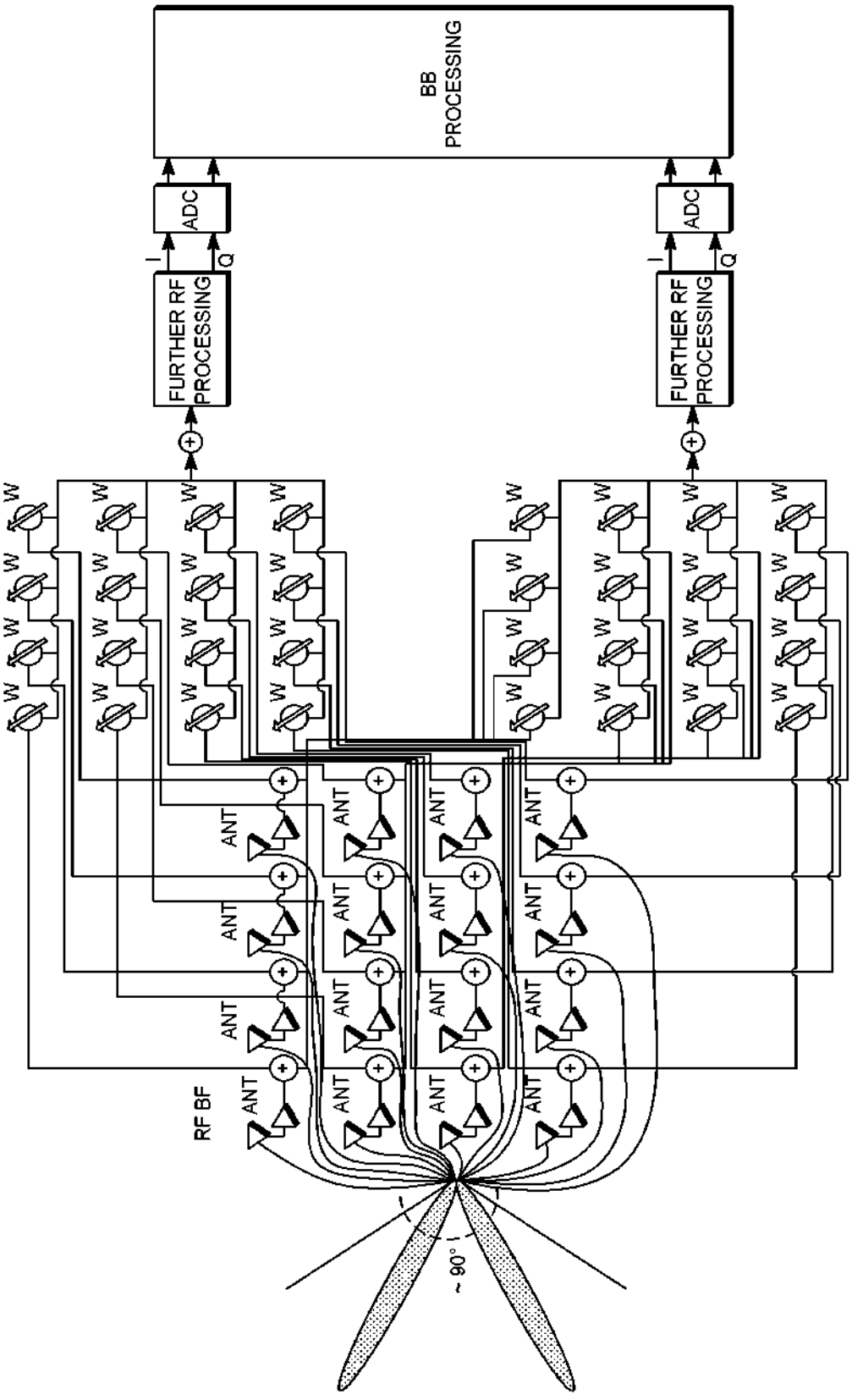

BB PROCESSING
ADC
ADC
I
Q
I
Q
FURTHER RF PROCESSING
FURTHER RF PROCESSING
W
ANT
RF BF
~ 90°

FIG. 7

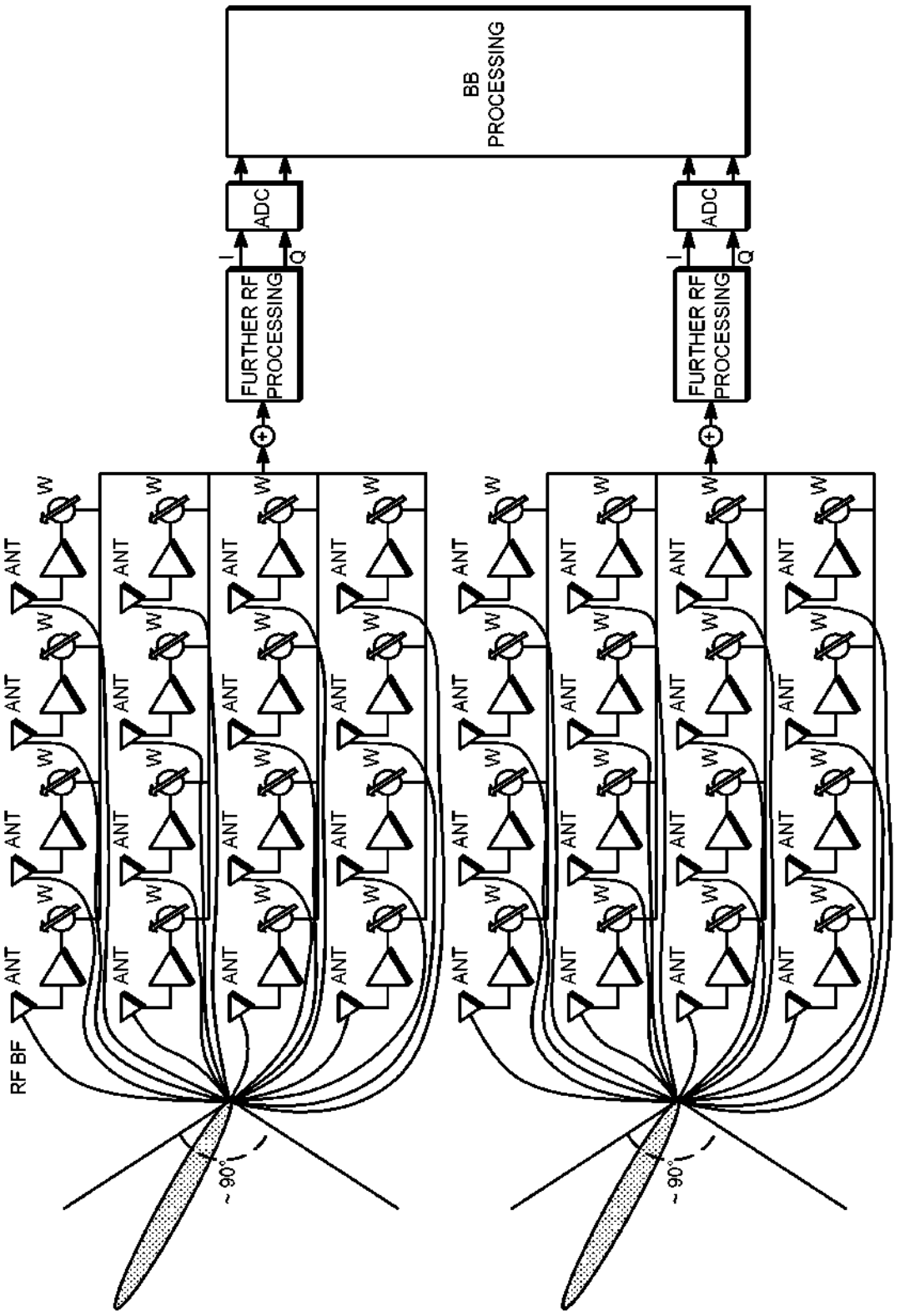

BB PROCESSING
ADC
ADC
I
Q
I
Q
FURTHER RF PROCESSING
FURTHER RF PROCESSING
RF BF
ANT
W
~90°
~90°

FIG. 8

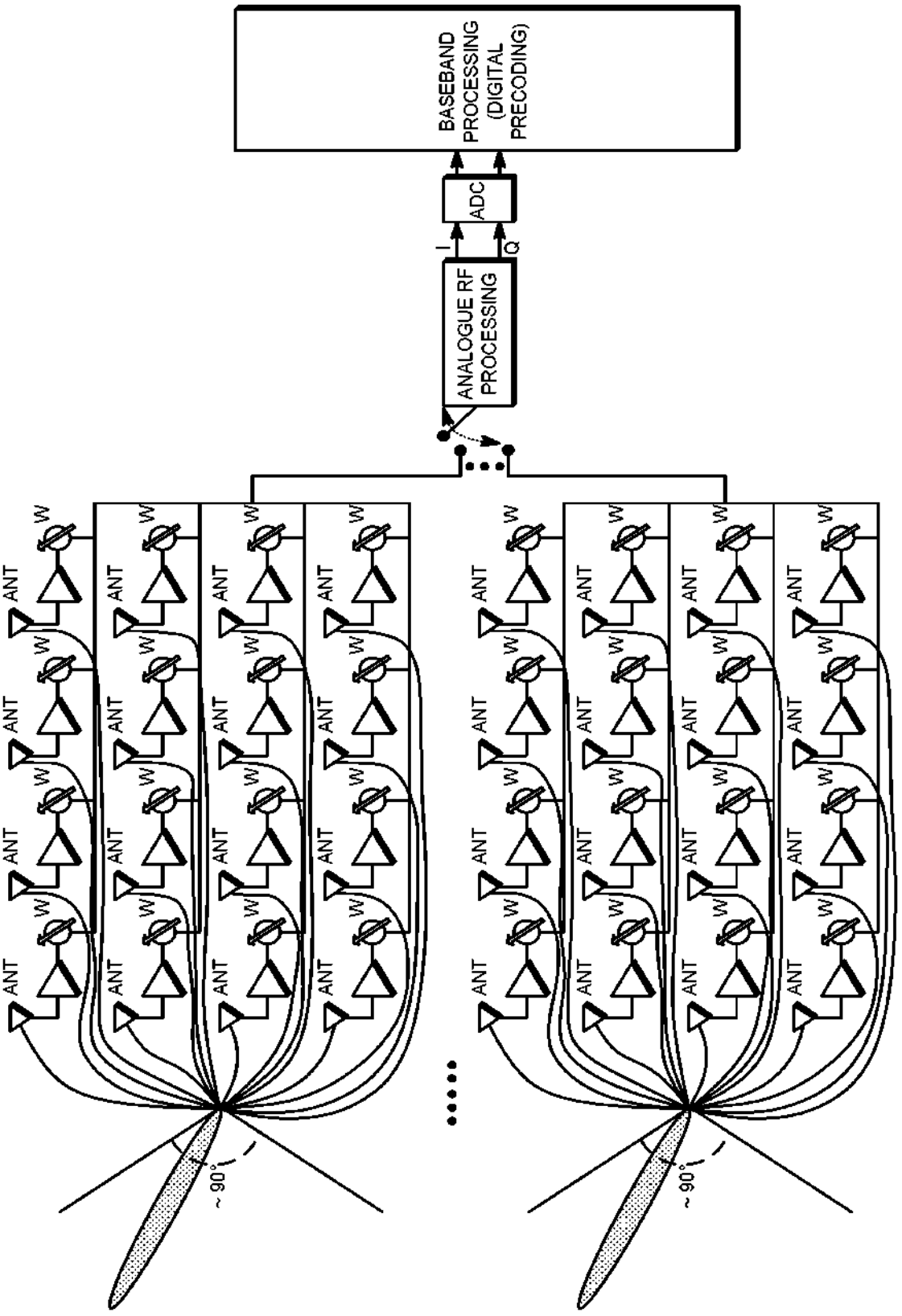

BASEBAND PROCESSING (DIGITAL PRECODING)
ADC
I
Q
ANALOGUE RF PROCESSING
ANT
W
~90°

FIG. 9

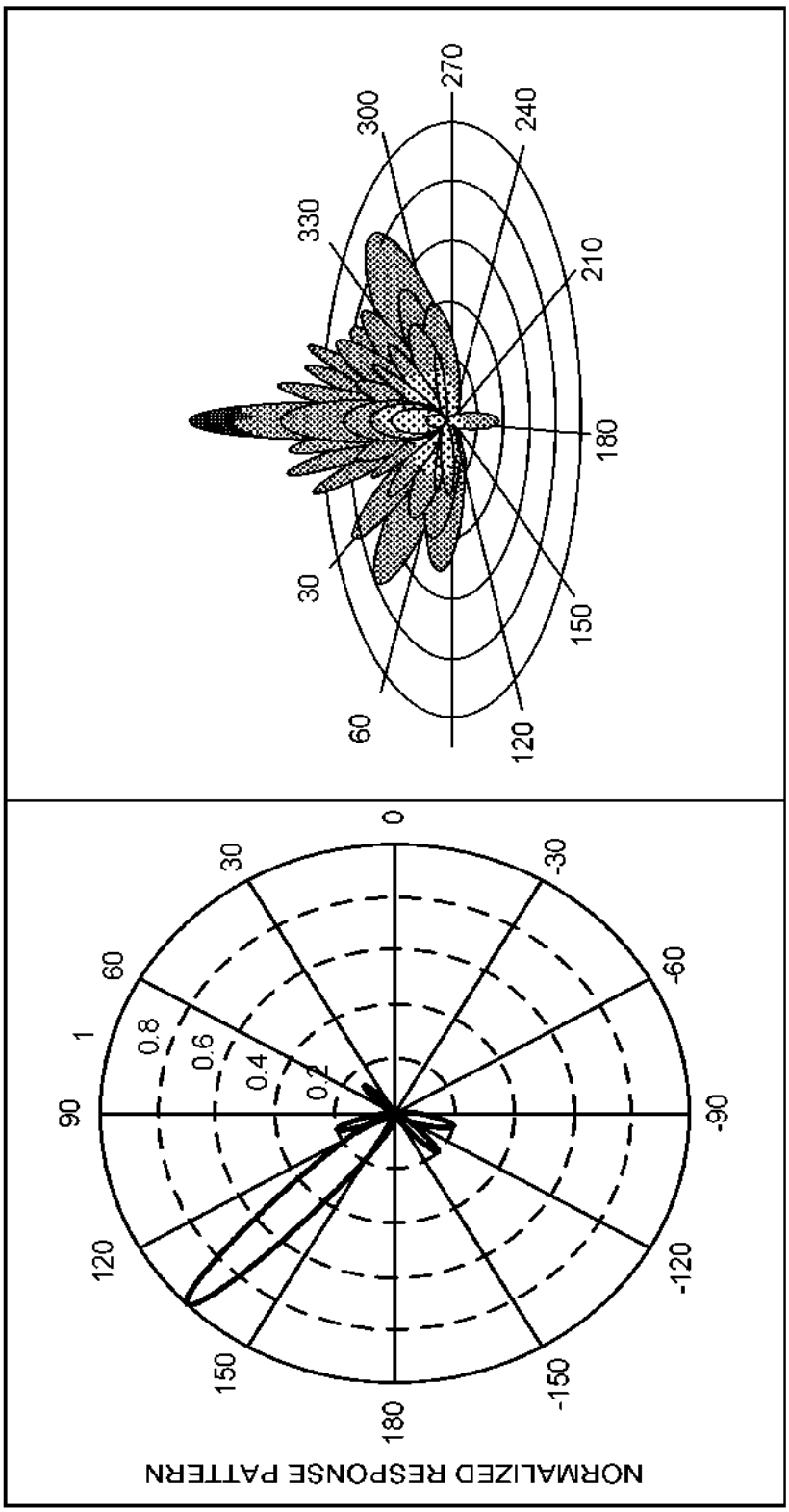

270
240
300
330
210
180
30
150
60
120
0
30
-30
60
-60
0.8
1
0.6
0.4
0.2
90
-90
120
-120
150
-150
180
NORMALIZED RESPONSE PATTERN

FIG. 10

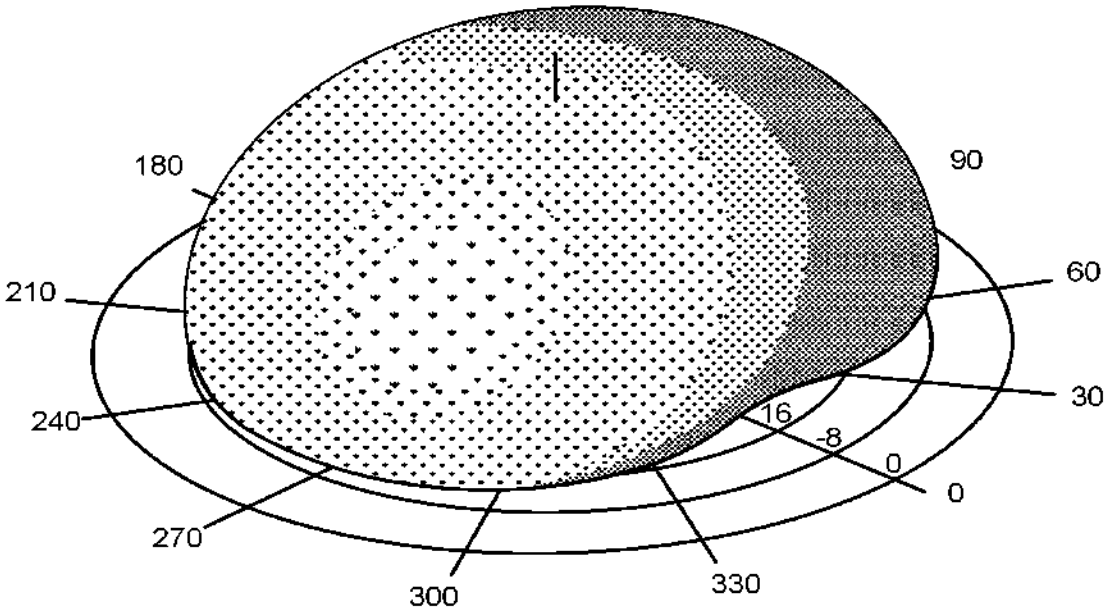


FIG. 11

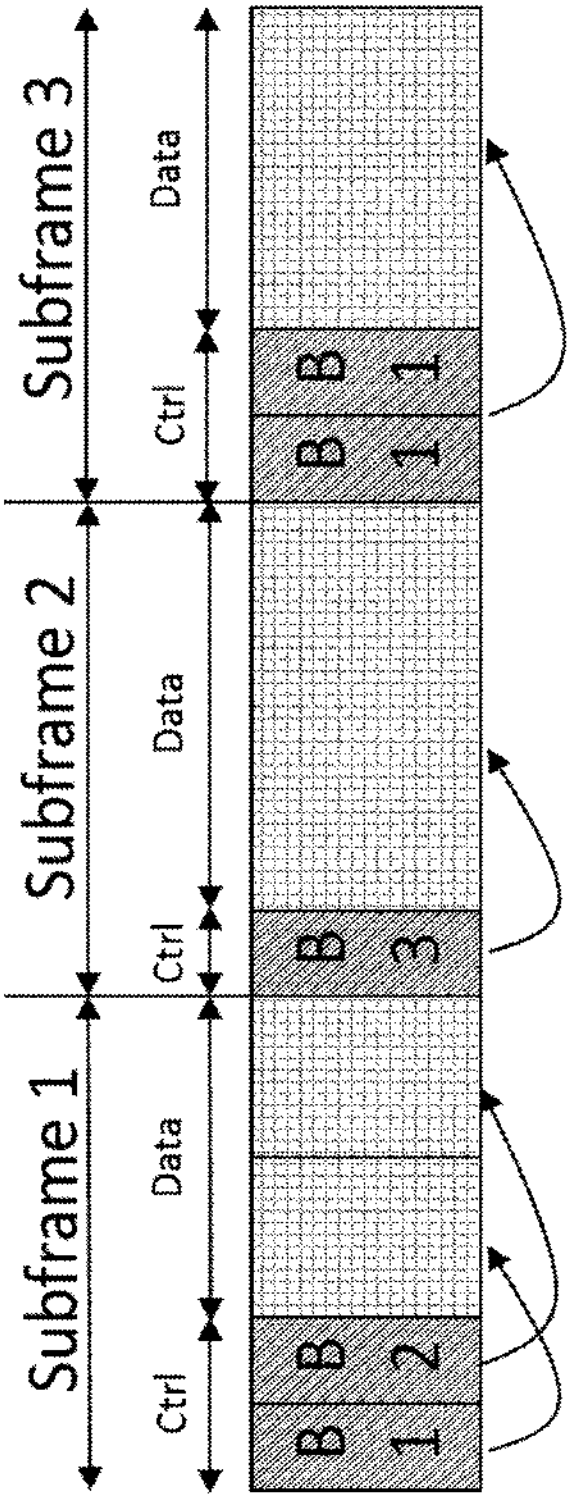

Subframe 1
Subframe 2
Subframe 3
Ctrl
Data
Ctrl
Data
Ctrl
Data
BB 1
BB 2
BB 3
BB 1

FIG. 12

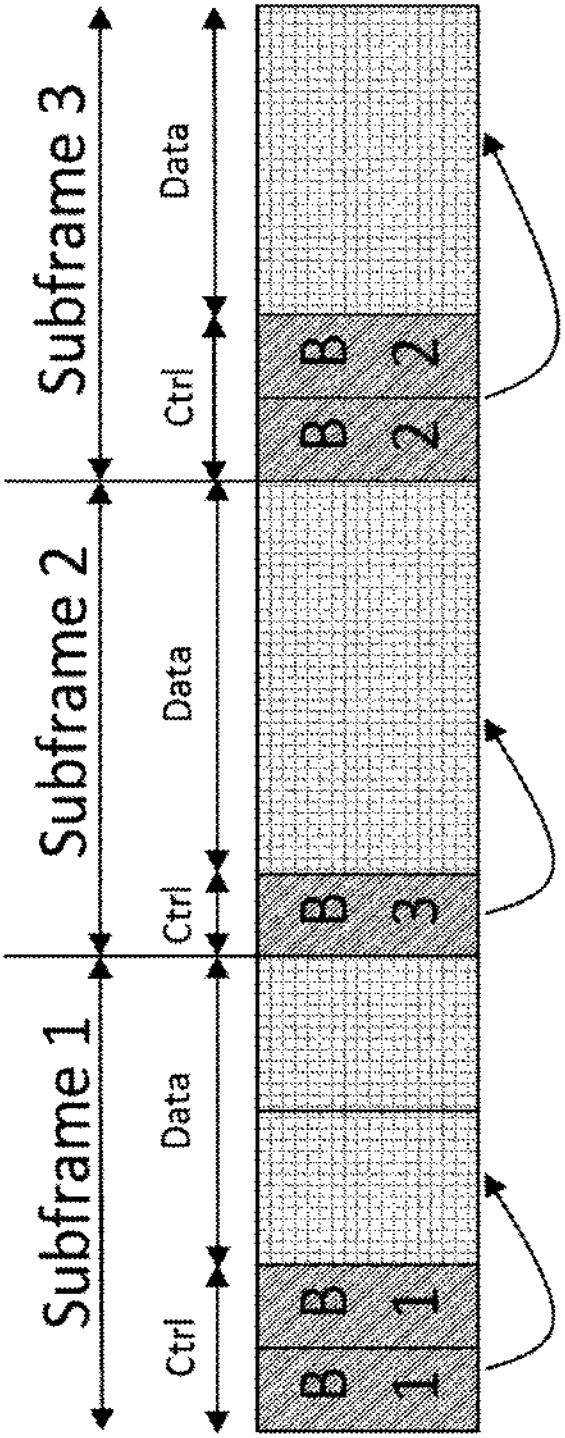

Subframe 1
Subframe 2
Subframe 3
Ctrl
Data
Ctrl
Data
Ctrl
Data
B 1
B 1
B 3
B 2
B 2

FIG. 13

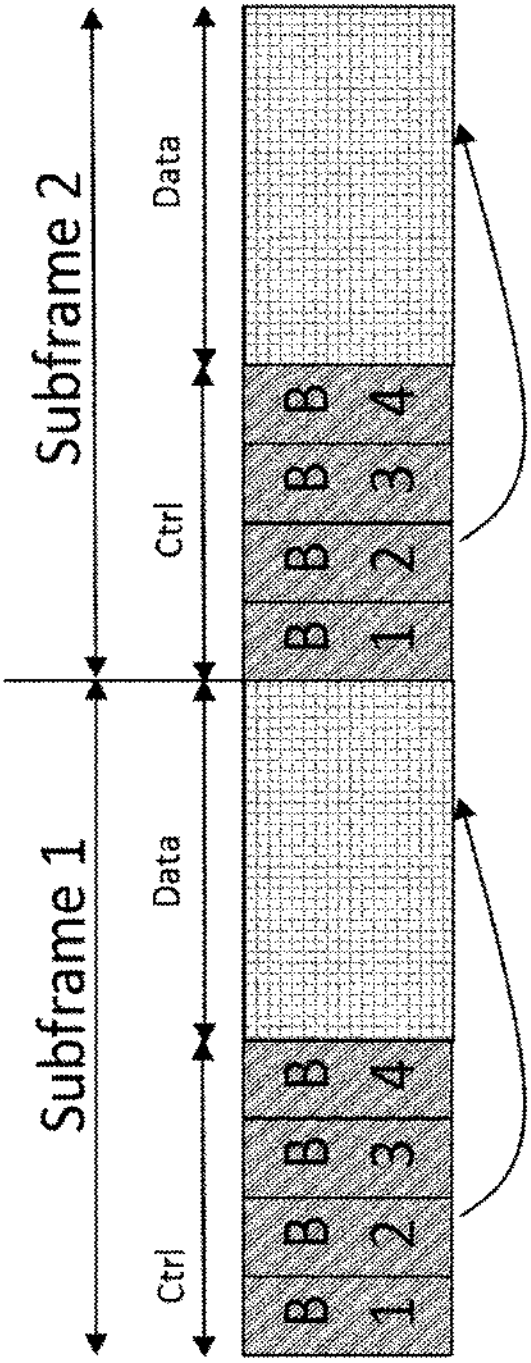

Subframe 2
Subframe 1
Data
Ctrl
Data
Ctrl
B B 1
B B 2
B B 3
B B 4
B B 1
B B 2
B B 3
B B 4

FIG. 14

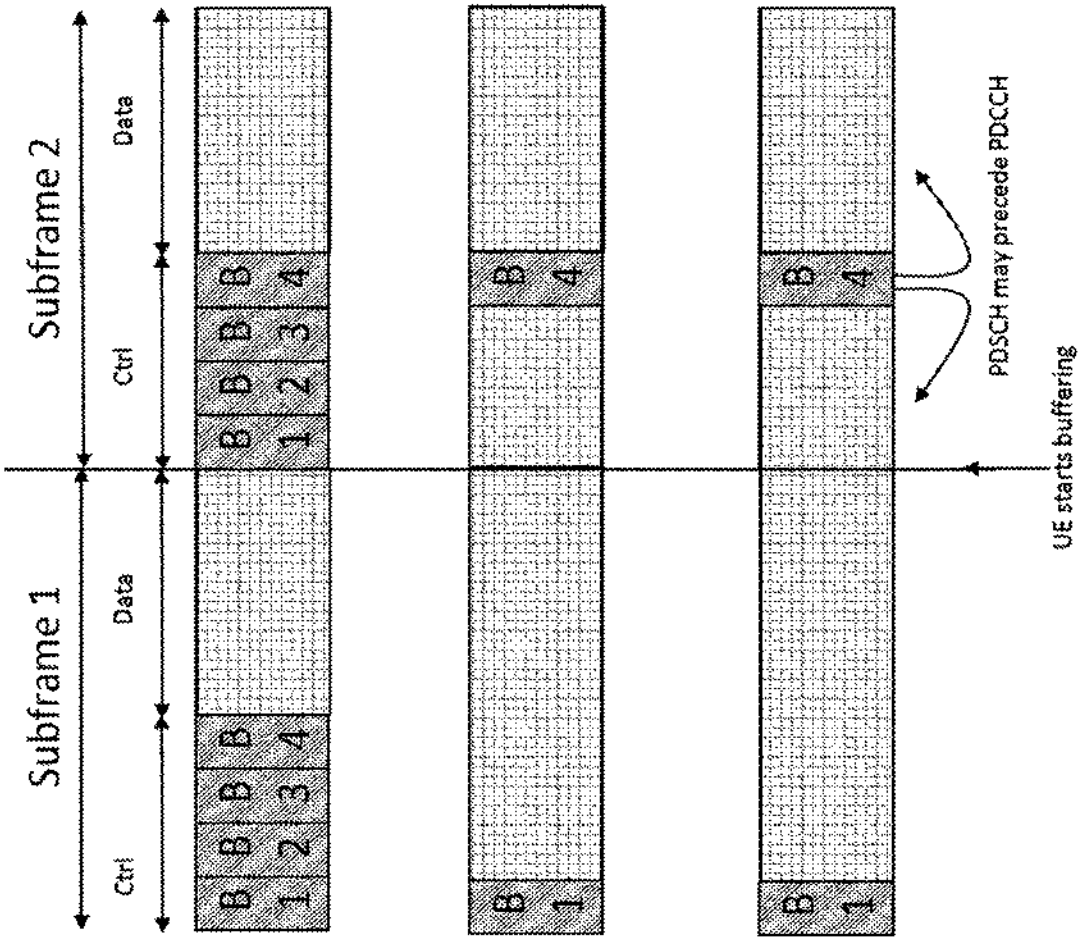

Subframe 2
Ctrl
Data
Subframe 1
Ctrl
Data
B 1
B 2
B 3
B 4
PDSCH may precede PDCCH
UE starts buffering

FIG. 15

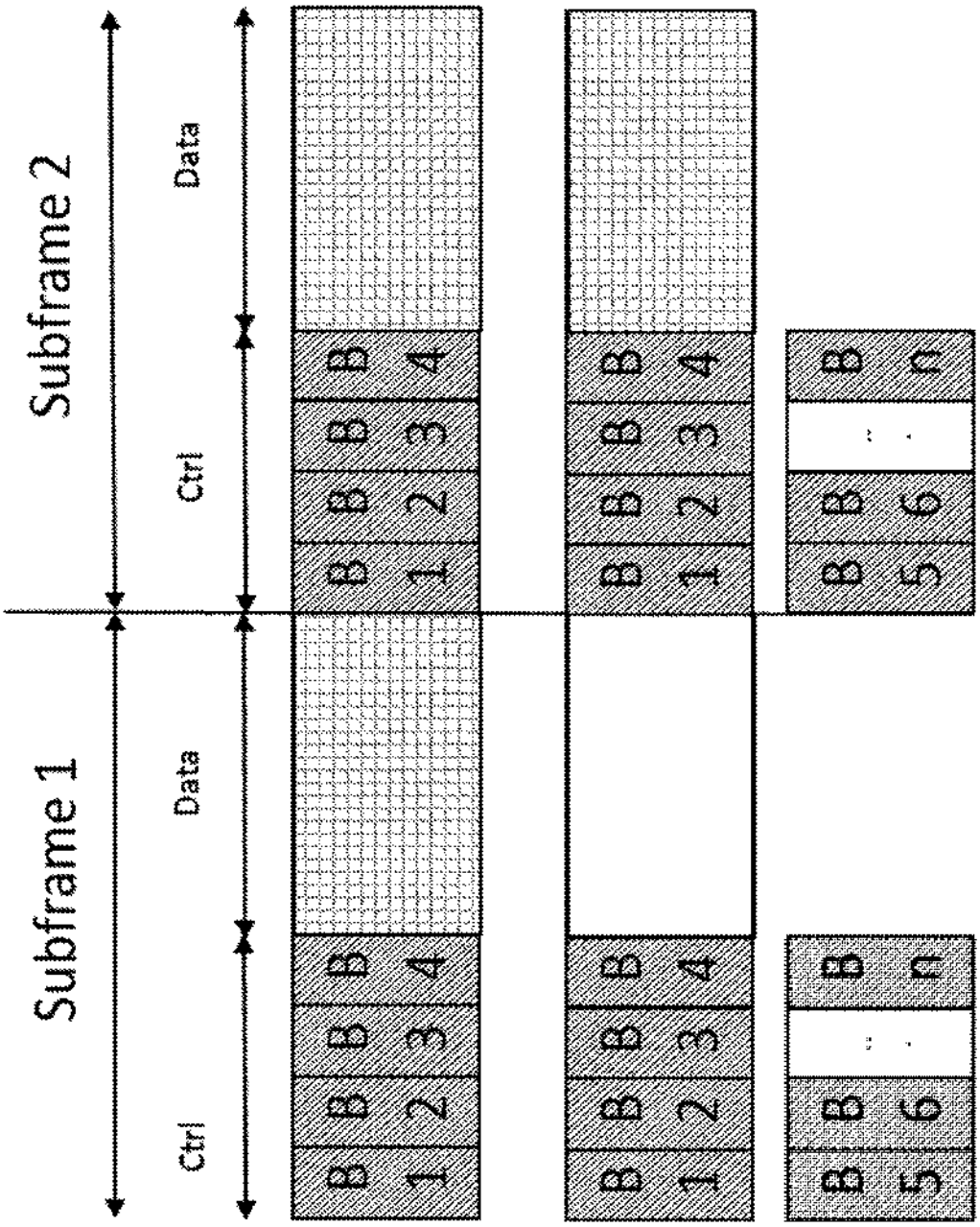


FIG. 16

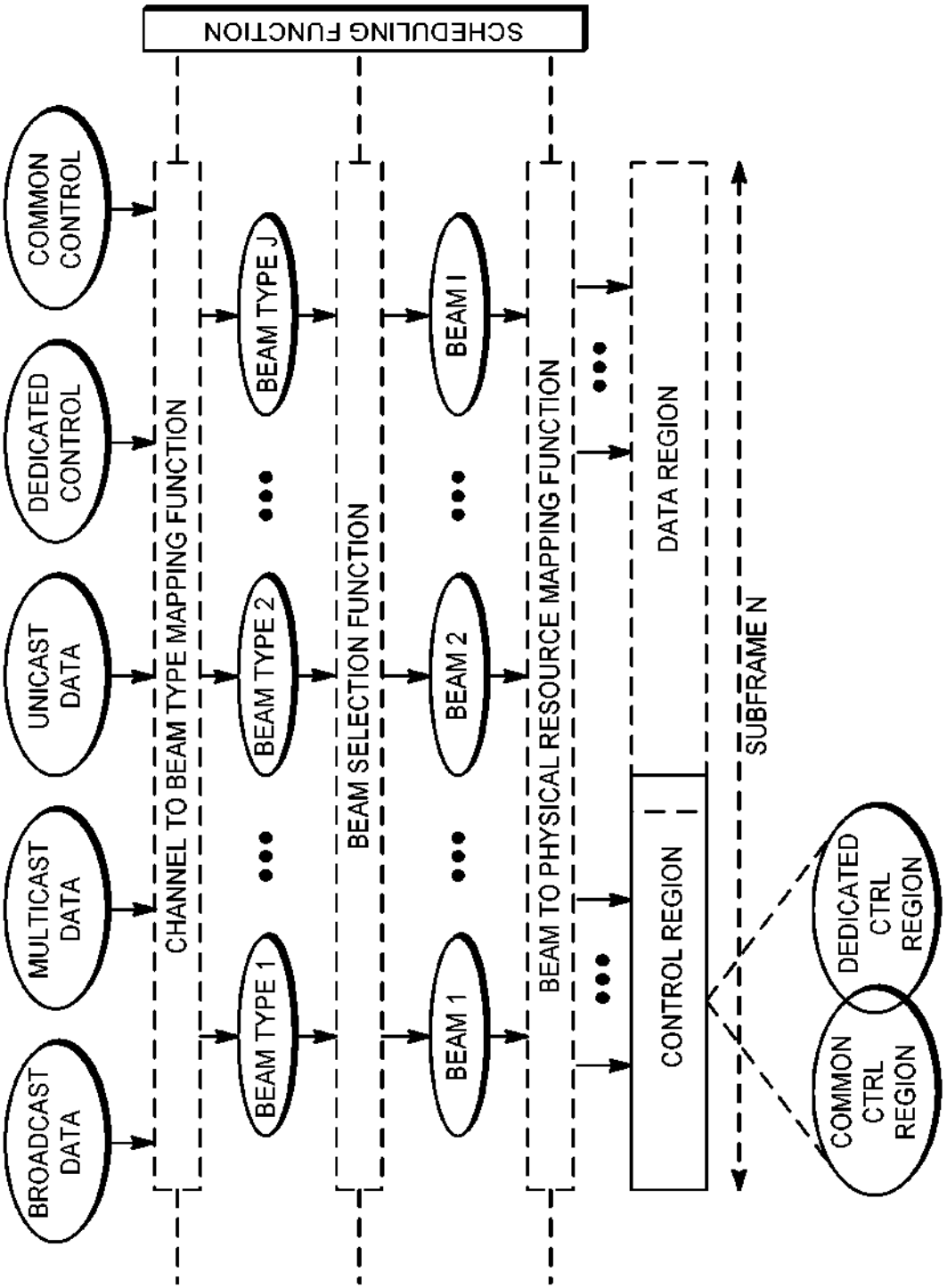

SCHEDULING FUNCTION
BROADCAST DATA
MULTICAST DATA
UNICAST DATA
DEDICATED CONTROL
COMMON CONTROL
CHANNEL TO BEAM TYPE MAPPING FUNCTION
BEAM TYPE 1
BEAM TYPE 2
BEAM TYPE J
BEAM SELECTION FUNCTION
BEAM 1
BEAM 2
BEAM I
BEAM TO PHYSICAL RESOURCE MAPPING FUNCTION
CONTROL REGION
DATA REGION
SUBFRAME N
COMMON CTRL REGION
DEDICATED CTRL REGION

FIG. 17

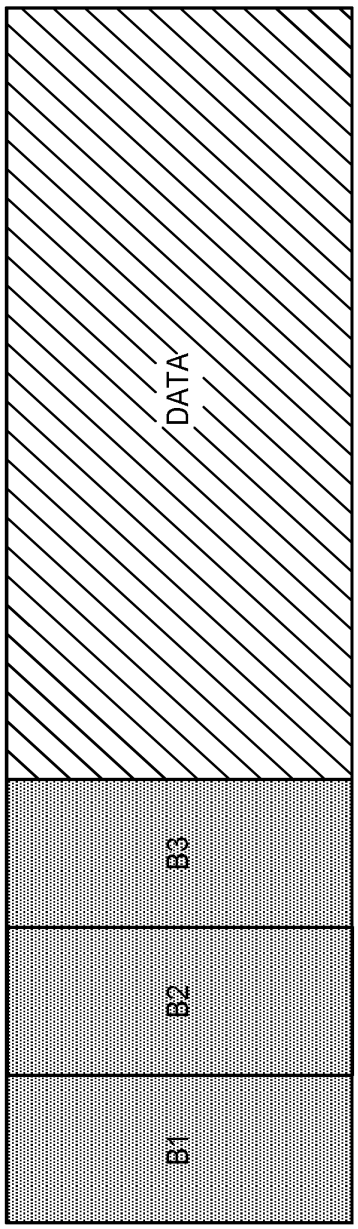


FIG. 18

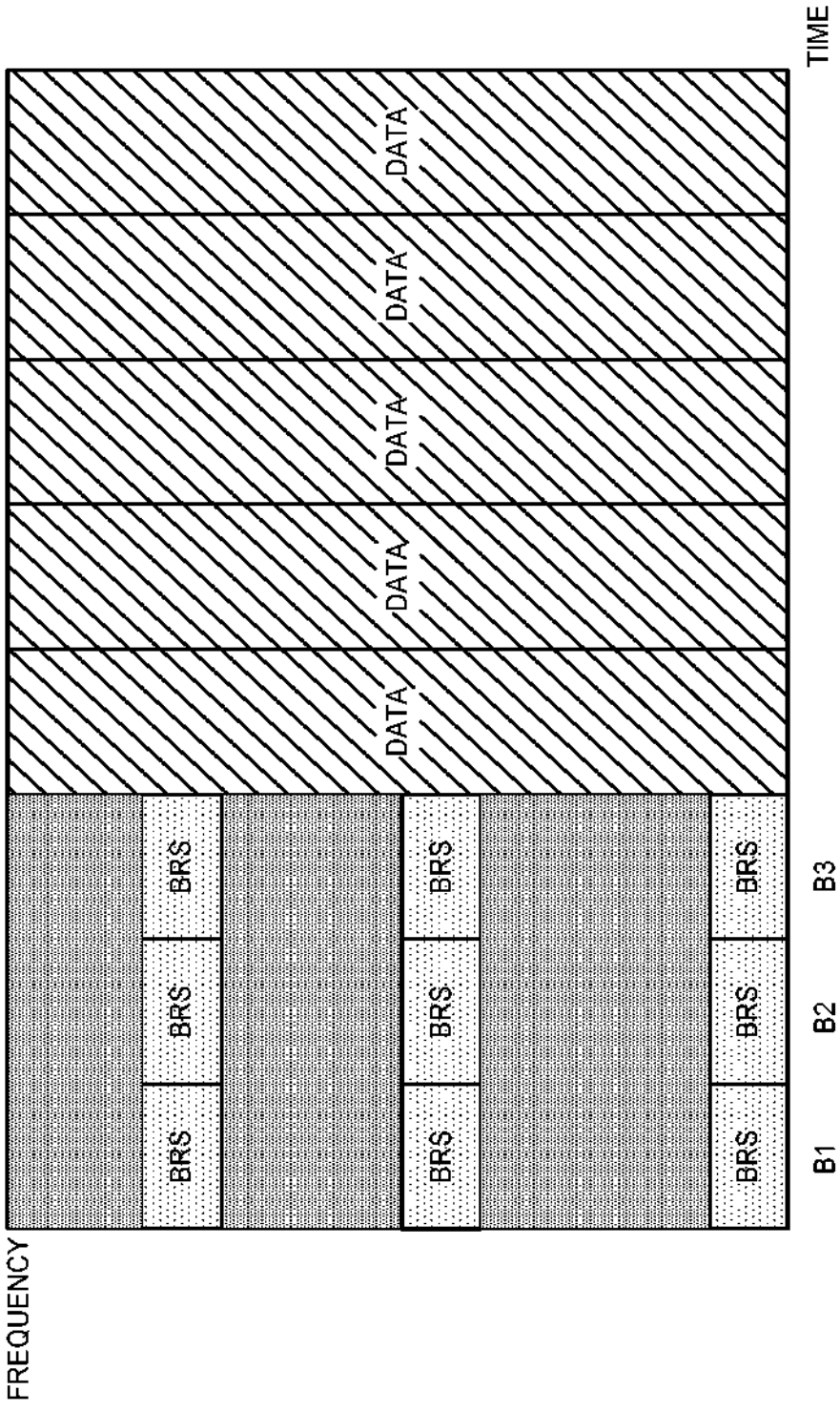


FIG. 19

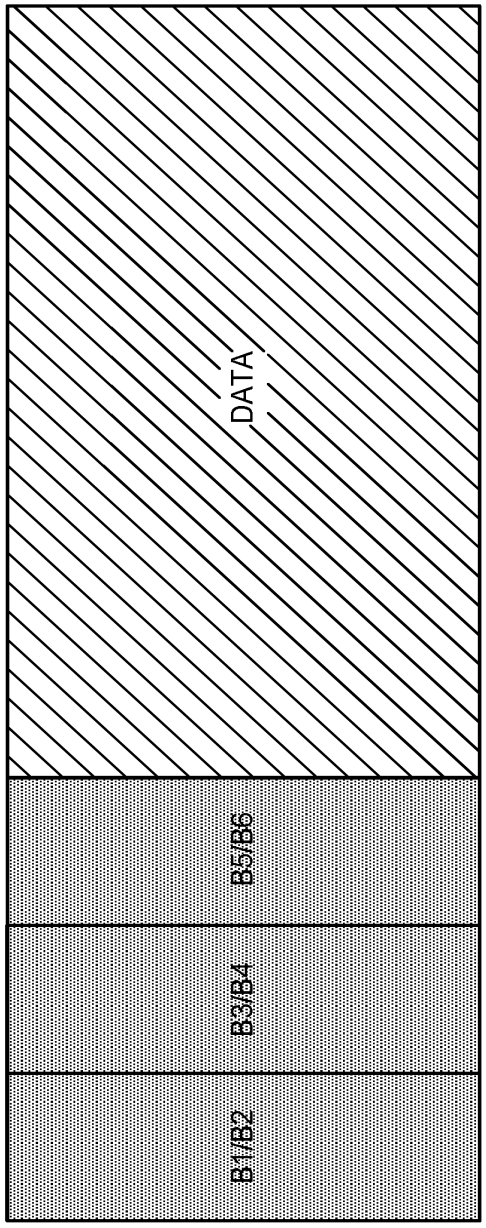


FIG. 20

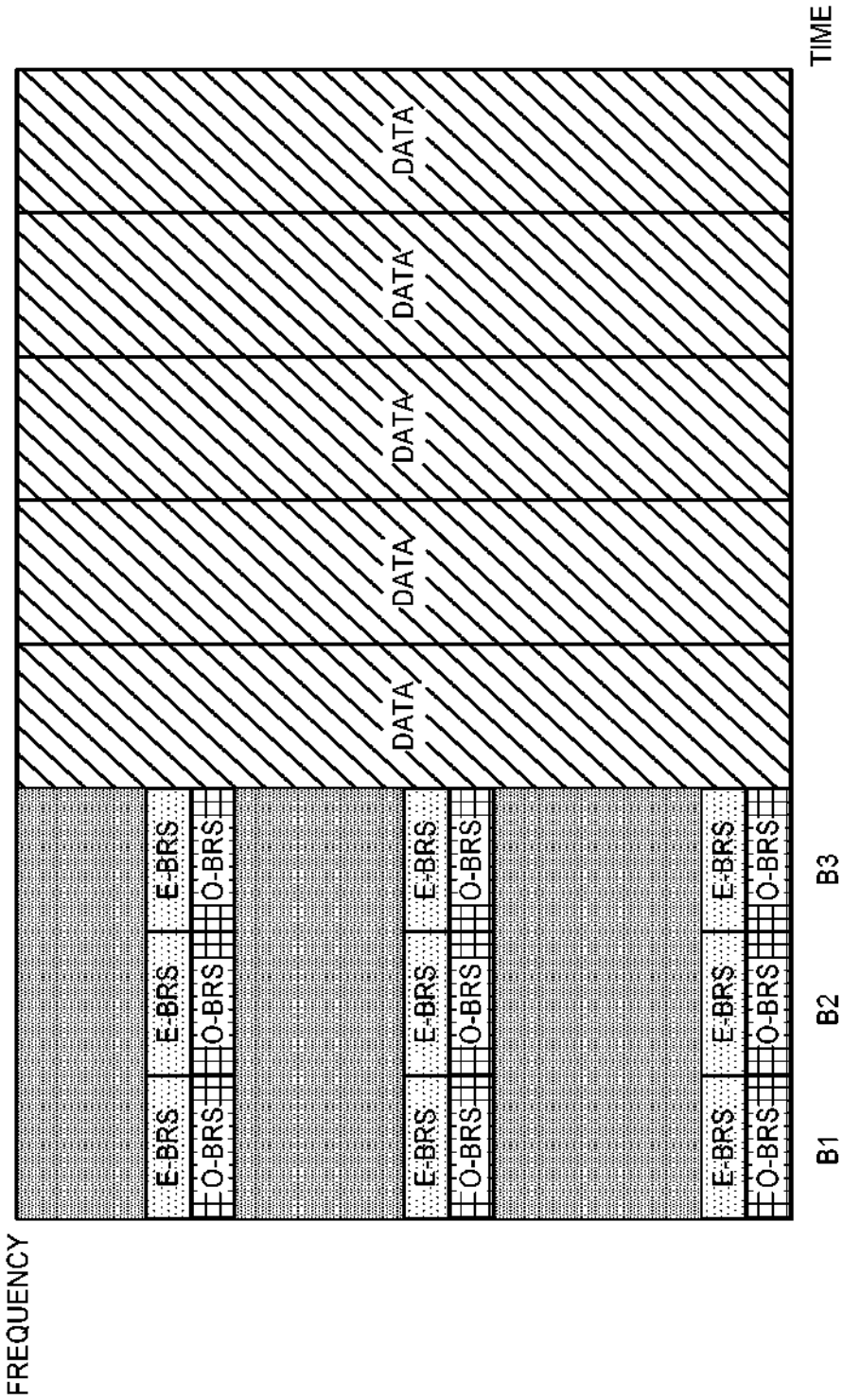


FIG. 21

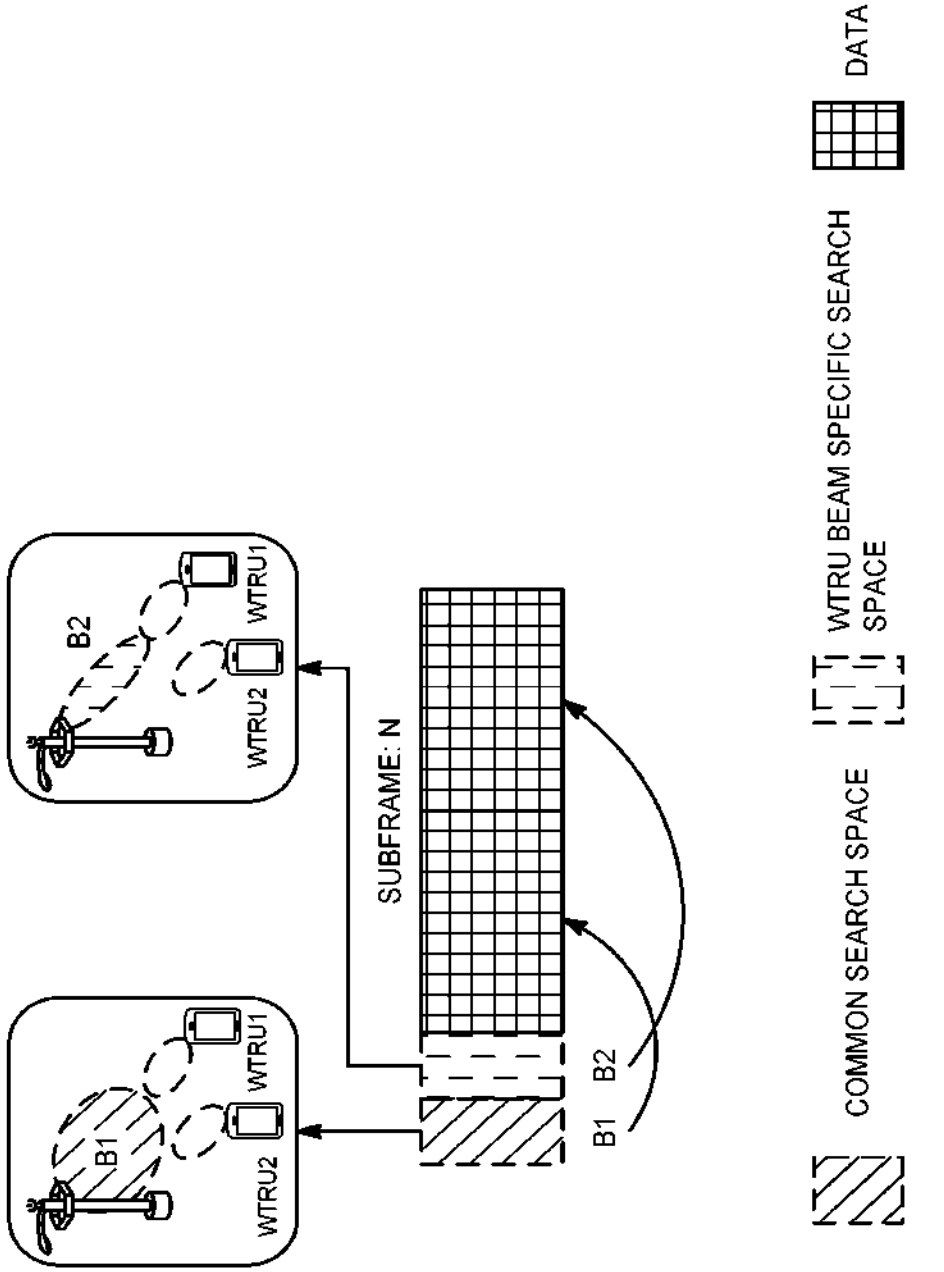

WTRU1
WTRU2
B2
WTRU1
WTRU2
B1
SUBFRAME: N
B1
B2
COMMON SEARCH SPACE
WTRU BEAM SPECIFIC SEARCH SPACE
DATA

FIG. 22

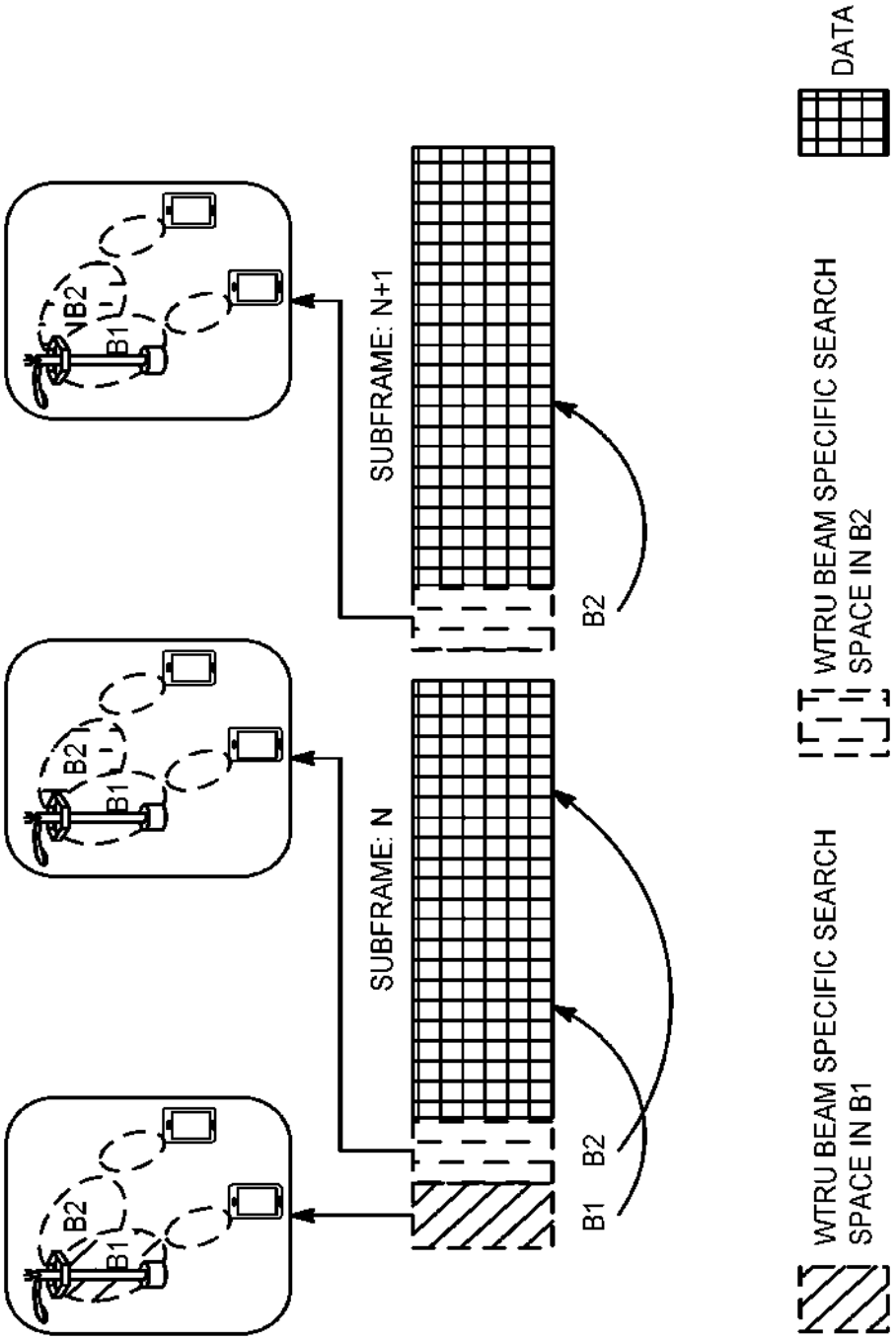

B2
B1
B2
B1
B2
B1
SUBFRAME: N
SUBFRAME: N+1
B1
B2
B2
DATA
WTRU BEAM SPECIFIC SEARCH
SPACE IN B2
WTRU BEAM SPECIFIC SEARCH
SPACE IN B1

FIG. 23

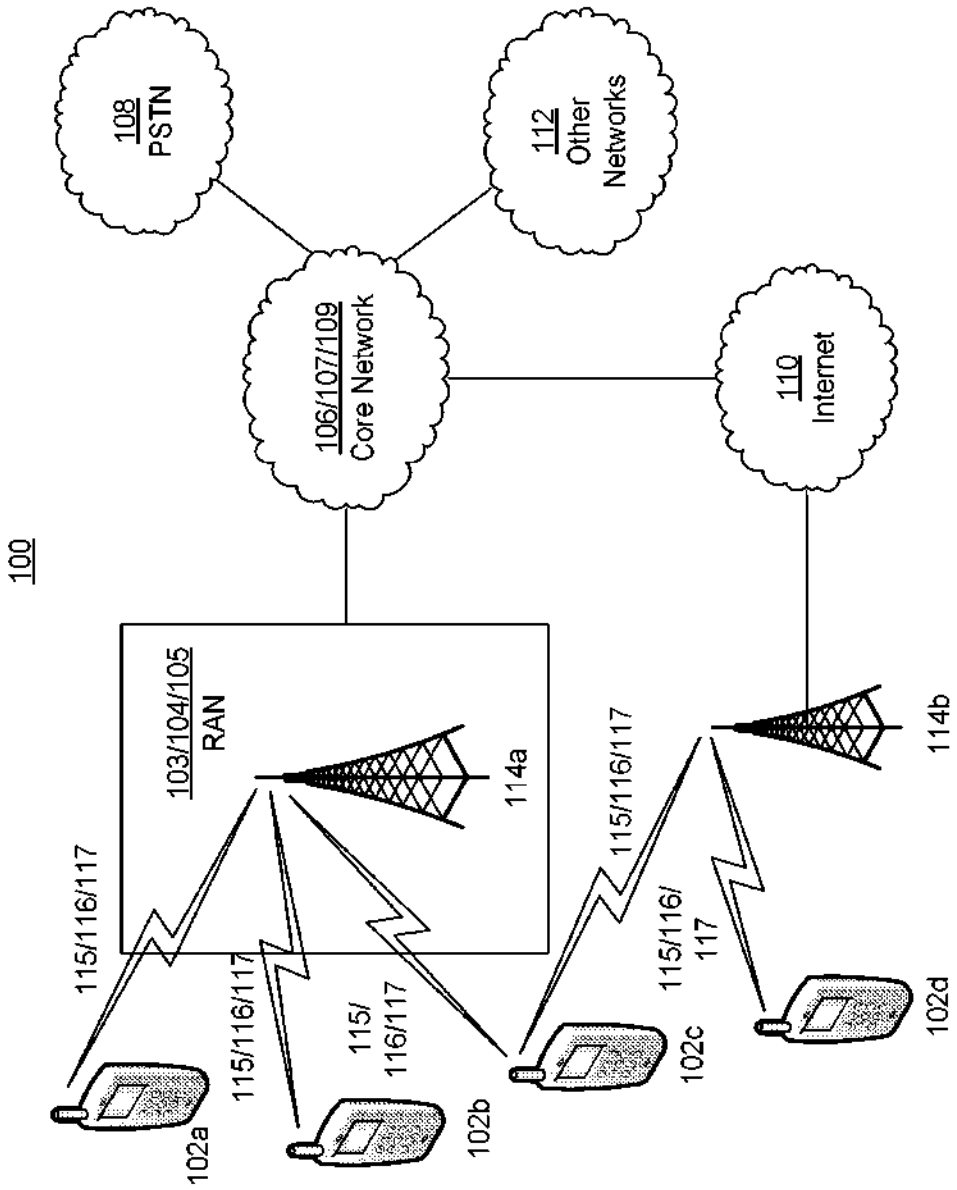

100
108
PSTN
112
Other
Networks
106/107/109
Core Network
110
Internet
103/104/105
RAN
114a
114b
115/116/117
115/116/117
115/
116/117
115/116/117
115/116/
117
102a
102b
102c
102d

FIG. 24A

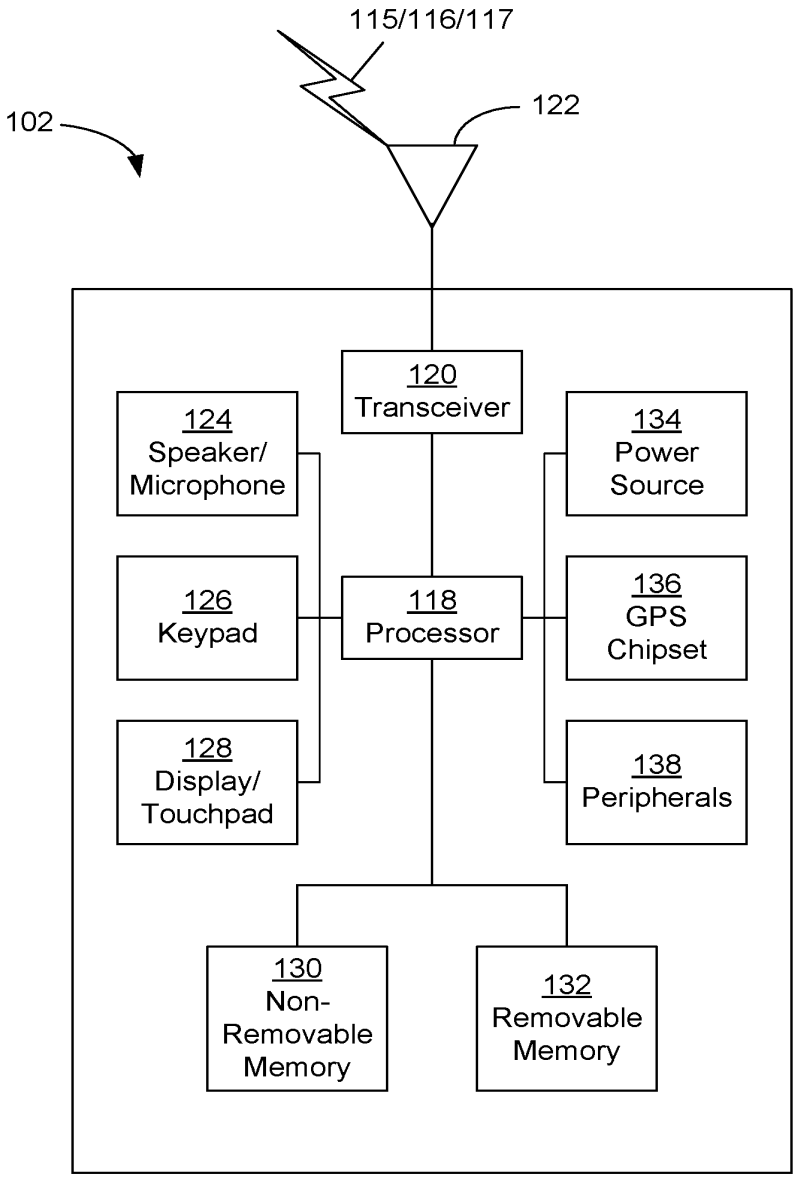

115/116/117
122
102
120
Transceiver
124
Speaker/
Microphone
134
Power
Source
126
Keypad
118
Processor
136
GPS
Chipset
128
Display/
Touchpad
138
Peripherals
130
Non-
Removable
Memory
132
Removable
Memory

FIG. 24B

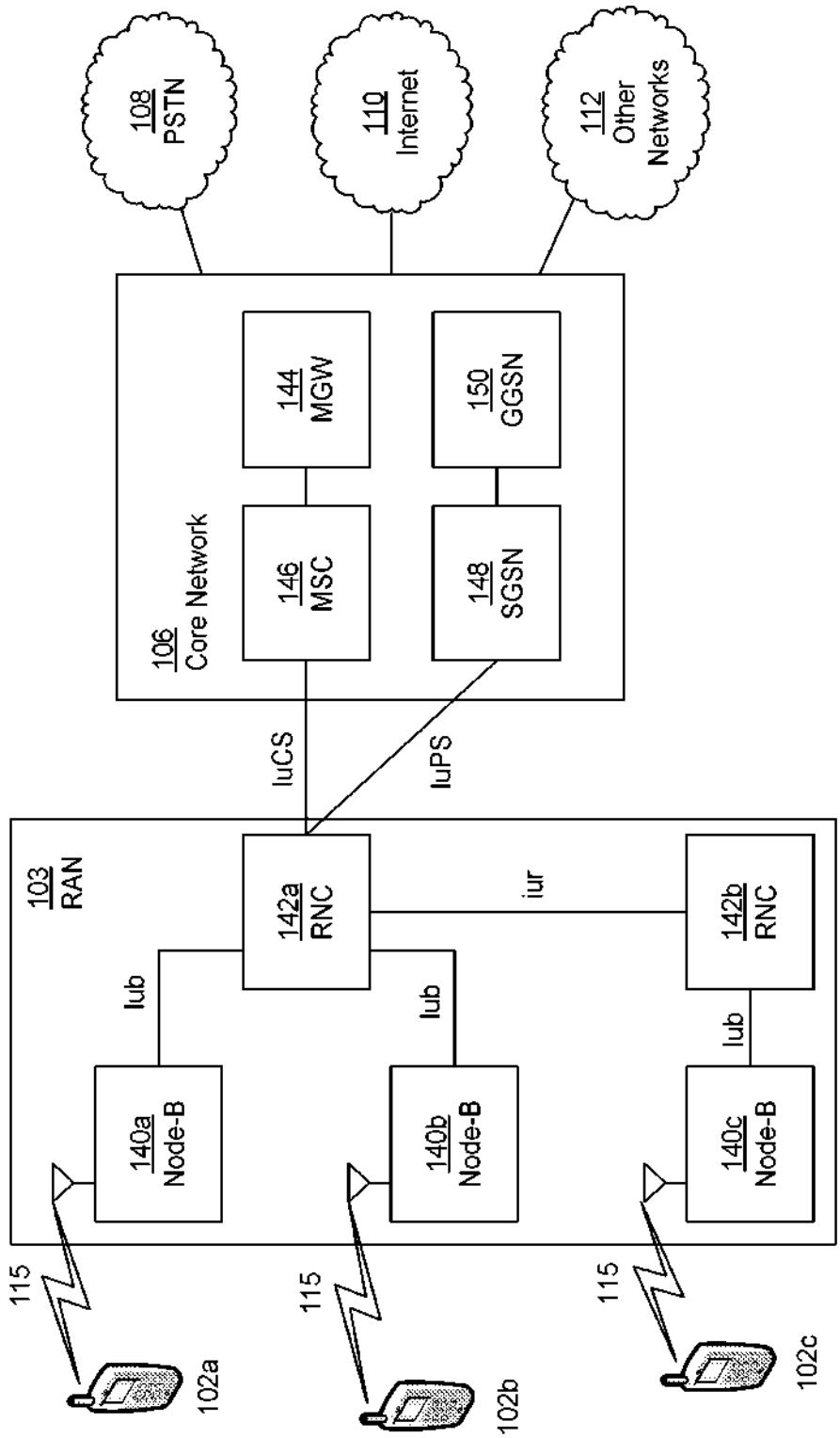

108 PSTN
110 Internet
112 Other Networks
106 Core Network
144 MGW
150 GGSN
146 MSC
148 SGSN
IuCS
IuPS
103 RAN
142a RNC
142b RNC
iur
Iub
Iub
Iub
140a Node-B
140b Node-B
140c Node-B
115
115
115
102a
102b
102c

FIG. 24C

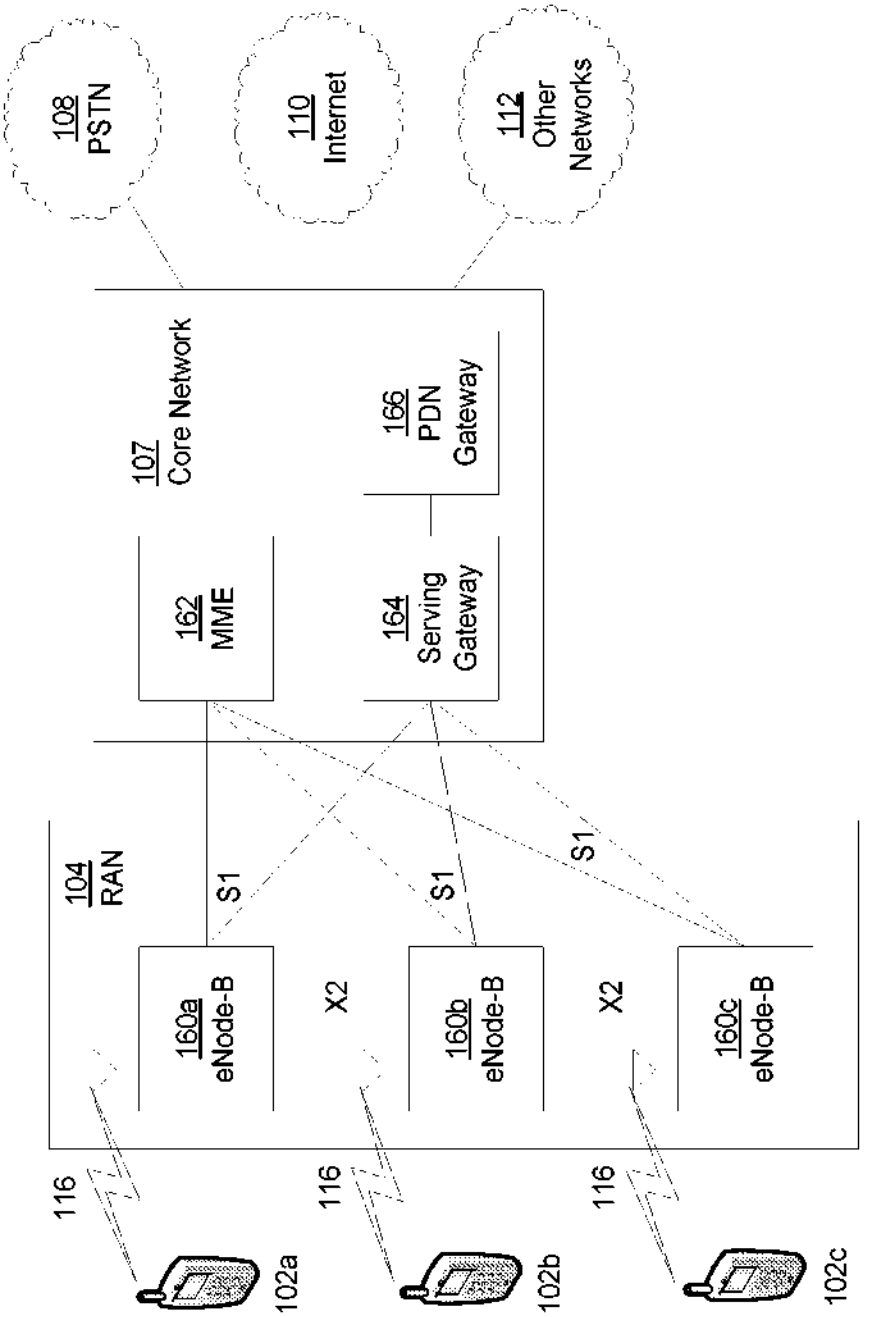

108 PSTN
110 Internet
112 Other Networks
107 Core Network
166 PDN Gateway
162 MME
164 Serving Gateway
104 RAN
S1
S1
S1
160a eNode-B
160b eNode-B
160c eNode-B
X2
X2
116
116
116
102a
102b
102c

FIG. 24D

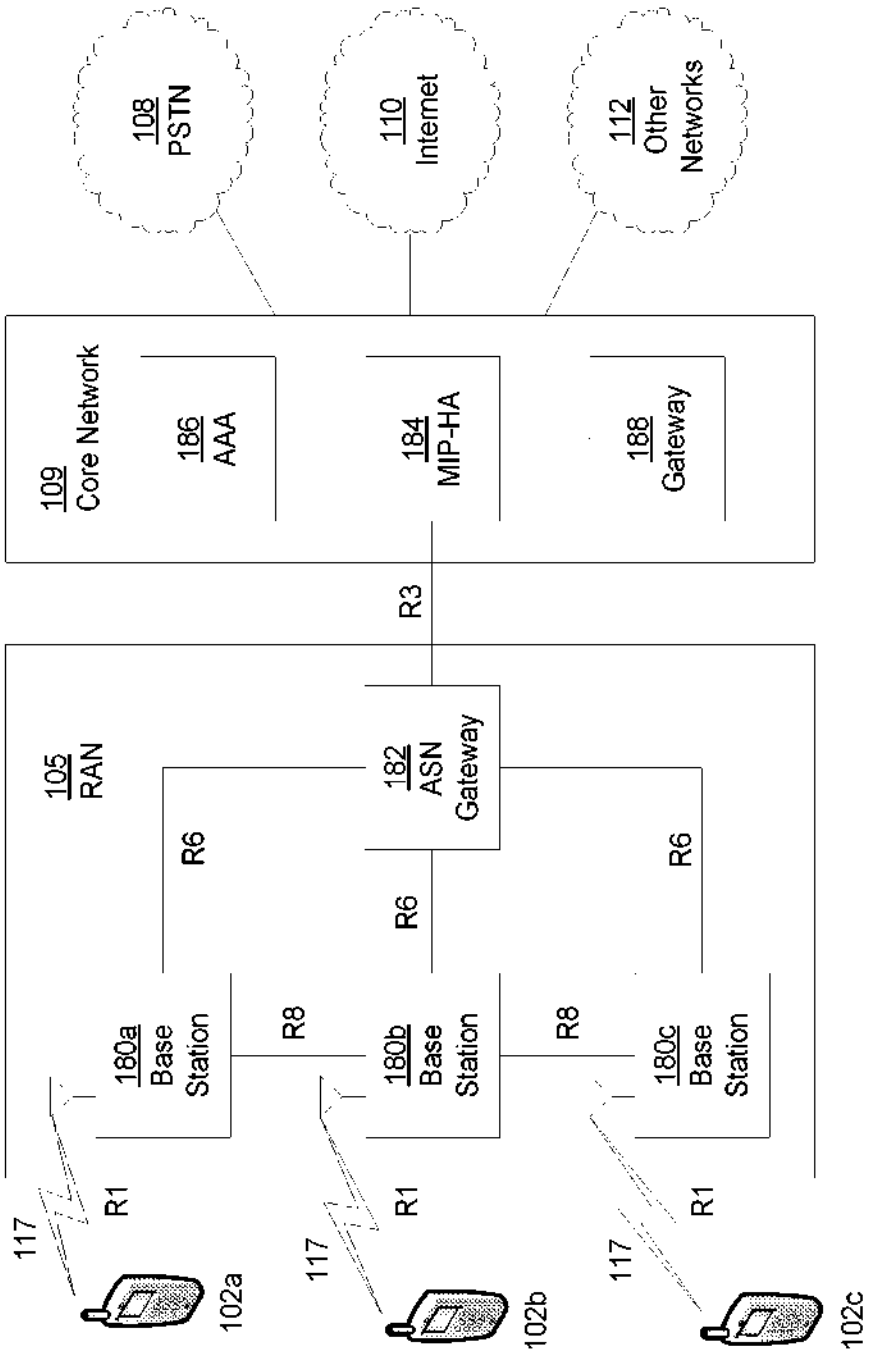

108 PSTN
110 Internet
112 Other Networks
109 Core Network
186 AAA
184 MIP-HA
188 Gateway
R3
105 RAN
182 ASN Gateway
R6
R6
R6
R8
R8
180a Base Station
180b Base Station
180c Base Station
R1
R1
R1
117
117
117
102a
102b
102c

FIG. 24E

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/061324

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04L5/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2013/058285 A1 (KOIVISTO TOMMI [FI] ET AL) 7 March 2013 (2013-03-07)	1-14, 16-20
A	figure 1 paragraph [0127] - paragraph [0132] paragraph [0142] -----	15
A	US 2014/177607 A1 (LI YING [US] ET AL) 26 June 2014 (2014-06-26) figures 10b, 10c paragraph [0122] - paragraph [0134] -----	1-20

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
2 February 2017	10/02/2017

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Hanus, Pavol

1

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2016/061324

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2013058285 A1	07-03-2013	NONE	
US 2014177607 A1	26-06-2014	CN 105122662 A	02-12-2015
		EP 2939349 A1	04-11-2015
		KR 20150100653 A	02-09-2015
		US 2014177607 A1	26-06-2014
		WO 2014104758 A1	03-07-2014

Form PCT/ISA/210 (patent family annex) (April 2005)

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	17950726
Filing Date	2022-09-22
First Named Inventor	Xiaobo ZHANG
Art Unit	2471
Examiner Name	AHMED ELALLAM
Attorney Docket Number	ZL0205-0004-US-CON3

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	6185432	B2	2001-02-06	Sridhar Vembu	
	2	7945222	B2	2011-05-17	Harel et al.	
	3	8027374	B2	2011-09-27	Wei Sun	
	4	8116693	B2	2012-02-14	Haim Harel	
	5	8654667	B2	2014-02-18	Bin Li	
	6	9131490	B2	2015-09-08	Sujuan Feng	
	7	9236992	B2	2016-01-12	Jae Hoon Chung	
	8	9264195	B2	2016-02-16	Jonghyun Park	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17950726
	Filing Date	2022-09-22
	First Named Inventor	Xiaobo ZHANG
	Art Unit	2471
	Examiner Name	AHMED ELALLAM
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17950726
	Filing Date	2022-09-22
	First Named Inventor	Xiaobo ZHANG
	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

	35	2018/227464	WO		2018-12-20	Wu et al.		☒
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	37	2016072770	WO		2016-05-12	Yunjung Yi		☒
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	1	3G Evolution: HSPA and LTE for Mobile Broadband, 2007, Erik Dahlman, Stefan Parkvall, Johan Skold, Per Beming dated	☒
	2	3GPP TR 25.892 version 6.0.0 release 6, June 28, 2004, 3rd Generation Partnership Project (3GPP) 3rd Generation	☒
	3	3GPP TR 36.873 version 12.2.0 release 12, July 3, 2015 , 3rd Generation Partnership Project (3GPP) 3rd Generation	☒
	4	3GPP TR 36.897 version 13.0.0 release 13, July 3, 2015 , 3rd Generation Partnership Project (3GPP) 3rd Generation	☒
	5	3GPP TR 37.840 version 12.1.0 release 12, January 6, 2014, 3rd Generation Partnership Project (3GPP) 3rd Generation	☒

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	6	3GPP TR 38.802 version 1.2.0 release 14, March 1, 2017, 3rd Generation Partnership Project (3GPP) 3rd Generation	☒
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	8	3GPP TS 36.133 version 12.8.0 release 12, 3rd Generation Partnership Project (3GPP), dated September 9, 2015	☒
	9	3GPP TS 36.133 version 13.2.0 release 13, 3rd Generation Partnership Project (3GPP), dated January 8, 2016	☒
	10	3GPP TS 36.211 version 12.3.0 release 12, 3rd Generation Partnership Project (3GPP), dated October 2, 2014	☒
	11	3GPP TS 36.211 version 12.5.0 release 12, 3rd Generation Partnership Project (3GPP), dated March 16, 2015	☒
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	17	3GPP TS 36.211 version 11.3.0 release 11, 3rd Generation Partnership Project (3GPP), dated June 26, 2013	☒
	18	3GPP TS 36.211 version 12.5.0 release 12, 3rd Generation Partnership Project (3GPP), dated March 16, 2015	☒
	19	3GPP TS 36.211 version 13.0.0 release 13, 3rd Generation Partnership Project (3GPP), dated January 5, 2016	☒
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	28	3GPP TS 36.212 version 14.2.0 release 14, 3rd Generation Partnership Project (3GPP), dated April 11, 2017	☒
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	30	3GPP TS 36.213 version 12.3.0 release 12, 3rd Generation Partnership Project (3GPP), dated October 2, 2014	☒
	31	3GPP TS 36.213 version 12.8.0 release 12, Project (3GPP) ETSI publication of 3rd Generation, dated May 3, 2016	☒
	32	3GPP TS 36.213 version 12.8.0 release 12 Annex A, 3rd Generation Partnership Project (3GPP), dated January 6, 2016	☒
	33	3GPP TS 36.213 version 12.8.0 release 12, Cover, 3rd Generation Partnership Project (3GPP), dated January 6, 2016	☒
	34	3GPP TS 36.213 version 12.8.0 release 12, Section 14, 3rd Generation Partnership Project (3GPP), dated January 6, 2016	☒
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	39	3GPP TS 36.214 version 12.0.0 release 12, 3rd Generation Partnership Project (3GPP), dated October 2, 2014	☒
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	43	3GPP TS 36.300 version 12.8.0 release 12, 3rd Generation Partnership Project (3GPP), dated January 4, 2016	☒
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	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

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Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

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☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/JIALIN ZHONG/	Date (YYYY-MM-DD)	2023-11-19
Name/Print	JIALIN ZHONG	Registration Number	62937

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KR20130130593A METHOD AND APPARATUS FOR MEASURING REFERENCE SIGNAL IN WIRELESS COMMUNICATION SYSTEM COMPRISING A PLURALITY BASE STATION USING A DISTRIBUTED ANTENNA

Applicants: SAMSUNG ELECTRONICS CO LTD [KR]

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Classifications:

IPC ***H04B7/04; H04J11/00;***

CPC **H04B17/24 (KR); H04B7/04 (US); H04B7/0417 (EP,CN,US); H04B7/0486 (US); H04B7/0626 (US); H04B7/063 (KR); H04B7/0639 (KR); H04L25/0224 (KR); H04W24/10 (EP,CN,US); H04W72/23 (US); H04W72/541 (US);** H04B7/022 (EP,CN,US); H04B7/063 (EP,CN,US); H04B7/0632 (EP,CN,US); H04B7/0639 (EP,CN,US); H04B7/0645 (EP,CN,US);

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METHOD AND APPARATUS FOR MEASURING REFERENCE SIGNAL IN WIRELESS COMMUNICATION SYSTEM COMPRISING A PLURALITY BASE STATION USING A DISTRIBUTED ANTENNA

Abstract

Normally, a cellular wireless mobile communication system is organized by constructing a plurality of cells in a restricted area. Base station equipment which manages mobile communication within the corresponding cell is located at the center of the cell area. The base station equipment provides a mobile communication service to an antenna which transmits a wireless signal and terminals located at the center of the cell. The system is called as a centralized antenna system (CAS) and is a normal type of the mobile communication system. A contrasting system is a distributed antenna system (DAS), uniformly distributes antennas to service areas of the cells, and can provide the improved mobile communication service. The present invention proposes an interference measuring method and an interference measuring apparatus for effective communication in the distributed antenna systems (DAS) distributed in the service area of each base station. [Reference numerals] (700) Base station determines the feedback setup of a terminal;(710) Is it RI/PMI report unavailable setup?;(720) Transmitting PDSCH to a terminal based on the CSI of a terminal measured by CSH-RS;(730) Is it CRS allocation for CSI measurement?;(740) Notifying a RS switch bit to a terminal by setting Z as 0;(750) Notifying a RS switch bit to a terminal by setting Z as 1;(760) Transmitting PDSCH to a terminal based on the CSI of a terminal measured by CRS;(770) Transmitting PDSCH to a terminal based on the CQI of a terminal measured by CSI-RS

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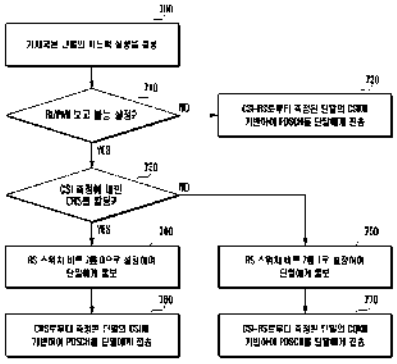
(54) 발명의 명칭 분산 안테나를 사용하는 복수 개의 기지국을 포함하는 무선통신 시스템에서 기준 신호 측정 방법 및 장치

(57) 요 약

일반적으로 셀룰러 무선 이동 통신 시스템은 한정된 지역에 복수개의 셀을 구축함으로서 이루어진다. 각 셀에는 해당 셀 내에서의 이동통신을 전담하는 기지국 장비가 셀 영역의 가운데에 위치하게 된다. 상기 기지국 장비로는 무선신호를 전송하는 안테나 및 신호처리 부분이 있으며 셀의 중앙에서 셀 내의 단말들에게 이동통신 서비스를 제공한다. 이와 같이 안테나가 셀의 중앙에 설치되는 시스템은 중앙 집중형 안테나 시스템 (Centralized Antenna System: CAS)이라고 하며 일반적인 이동통신 시스템이 이 형태이다.

이와 대비되는 시스템으로는 분산 안테나 시스템 (Distributed Antenna System: DAS)이 있으며 DAS의 경우 안테나들을 셀의 서비스영역에 골고루 분산함으로써 CAS와 대비하여 향상된 이동통신 서비스를 제공할 수 있다. 본 발명은 각 기지국의 서비스 영역에 분산되어 배치되어 있는 분산 안테나 시스템 (Distributed Antenna System: DAS)에서 효율적인 통신을 위한 간섭 측정 방법 및 장치를 제안한다.

대 표 도 도7



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특허청구의 범위

청구항 1

분산 안테나를 사용하는 복수 개의 기지국을 포함하는 이동통신 시스템에서 기준신호 측정 정보를 기지국이 단말에 통보하는 방법에 있어서,

상기 단말의 RI/PMI 보고 불능 설정 여부를 결정하는 단계;

상기 단말의 RI/PMI 보고 불능 설정 시, CRS 또는 CSI-RS 중 단말이 측정할 기준 신호를 결정하는 단계;

상기 결정된 기준 신호를 상기 단말에게 통보하는 단계;

상기 결정된 기준 신호를 측정하여 단말이 생성한 제1 채널 정보를 상기 단말로부터 수신하는 단계; 및

상기 제1 채널 정보에 기반하여 상기 단말에게 데이터를 전송하는 단계를 포함하는 것을 특징으로 하는 방법.

청구항 2

제1항에 있어서,

상기 단말의 RI/PMI 보고 설정 시, 상기 단말이 CSI-RS를 측정하도록 통보하는 단계;

상기 단말이 상기 CSI-RS를 측정하여 생성한 제2 채널 정보를 수신하는 단계; 및

상기 제2 채널 정보에 기반하여 상기 단말에게 데이터를 전송하는 단계를 포함하는 것을 특징으로 하는 방법.

청구항 3

제1항에 있어서, 상기 통보 단계는,

상기 단말이 측정하도록 결정된 기준 신호 정보를 비트 형식으로 지시하는 기준 신호 측정 정보를 상기 단말에게 통보하는 것을 특징으로 하는 방법.

청구항 4

제3항에 있어서, 상기 기준 신호 측정 정보는,

상위 시그널링 또는 물리계층 시그널링을 통해 상기 단말에게 전송되는 것을 특징으로 하는 방법.

청구항 5

제1항에 있어서, 상기 통보 단계는,

간섭 측정 자원을 상기 단말에게 통보하거나 또는 복수 개의 피드백을 상기 단말에게 통보하는 단계; 및

상기 단말이 CSI-RS를 측정하여 생성한 제3 채널 정보를 상기 단말로부터 수신하는 단계를 더 포함하는 것을 특징으로 하는 방법.

청구항 6

제1항에 있어서, 상기 데이터 전송 단계는,

특정 프리코더가 적용된 데이터를 상기 단말에 전송하는 것을 특징으로 하며,

상기 프리코더는, 상기 프리코더가 속한 집합 및 각 서브밴드에 적용될 프리코더가 미리 결정된 것을 특징으로 하는 방법.

청구항 7

분산 안테나를 사용하는 복수 개의 기지국을 포함하는 이동통신 시스템에서 단말의 하향링크 측정 방법에 있어서,

상기 단말의 RI/PMI 보고 불능 설정 여부에 대한 정보를 기지국으로부터 수신하는 단계;

상기 RI/PMI 보고 불능 설정 시, CRS 또는 CSI-RS 중 상기 단말이 측정하도록 결정된 기준 신호에 대한 정보를 상기 기지국으로부터 수신하는 단계;

상기 결정된 기준 신호를 측정하여 제1 채널 정보를 생성하고 상기 기지국으로 전송하는 단계; 및

상기 제1 채널 정보에 기반하여 전송되는 데이터를 상기 기지국으로부터 수신하는 단계를 포함하는 것을 특징으로 하는 하향링크 측정 방법.

청구항 8

제7항에 있어서,

상기 단말의 RI/PMI 보고 설정 시, 상기 CSI-RS를 측정하여 제2 채널 정보를 생성하는 단계; 및

상기 생성된 제2 채널 정보를 상기 기지국으로 전송하는 단계를 더 포함하는 것을 특징으로 하는 하향링크 측정 방법.

청구항 9

제7항에 있어서, 상기 기준 신호에 대한 정보 수신 단계는,

상기 단말이 측정하도록 결정된 기준 신호 정보를 비트 형식으로 지시하는 기준 신호 측정 정보를 수신하는 것을 특징으로 하는 하향링크 측정 방법.

청구항 10

제9항에 있어서, 상기 기준 신호 측정 정보는,

상위 시그널링 또는 물리계층 시그널링을 통해 상기 기지국으로부터 수신되는 것을 특징으로 하는 하향링크 측정 방법.

청구항 11

제7항에 있어서, 상기 기준 신호에 대한 정보 수신 단계는,

상기 기지국으로부터 간섭 측정 자원을 통보받거나 또는 복수 개의 피드백을 보고하도록 통보받는 경우, 상기 CSI-RS를 측정하여 제3 채널 정보를 생성하는 단계; 및

상기 생성된 제3 채널 정보를 상기 기지국으로 전송하는 단계를 더 포함하는 것을 특징으로 하는 하향링크 측정 방법.

청구항 12

제7항에 있어서, 상기 데이터 수신 단계는,

특정 프리코더가 적용된 데이터를 상기 기지국으로부터 수신하며,

상기 프리코더는, 상기 프리코더가 속한 집합 및 각 서브밴드에 적용될 프리코더가 미리 결정된 것을 특징으로 하는 하향링크 측정 방법.

청구항 13

분산 안테나를 사용하는 복수 개의 기지국을 포함하는 이동통신 시스템에서 기준 신호 측정 정보를 단말에 통보하는 기지국에 있어서,

상기 기준 신호 측정 정보 또는 데이터를 상기 단말에 전송하고, 상기 단말로부터 전송되는 채널 측정 정보를 수신하는 송수신부; 및

상기 단말의 RI/PMI 보고 불능 여부를 결정하고, 상기 단말의 RI/PMI 보고 불능 결정 시 CRS 또는 CSI-RS 중 단말이 측정할 기준 신호를 결정하며, 상기 결정된 기준 신호를 상기 단말에게 통보하고, 상기 결정된 기준 신호를 측정하여 단말이 생성한 제1 채널 정보를 상기 단말로부터 수신하며, 상기 제1 채널 정보에 기반하여 상기

단말에게 데이터를 전송하도록 제어하는 제어기를 포함하는 것을 특징으로 하는 기지국.

청구항 14

제13항에 있어서, 상기 제어기는,

상기 단말의 RI/PMI 보고 결정 시 상기 단말이 CSI-RS를 측정하도록 통보하고, 상기 단말이 상기 CSI-RS를 측정하여 생성한 제2 채널 정보를 수신하며, 상기 제2 채널 정보에 기반하여 상기 단말에게 데이터를 전송하도록 제어하는 것을 특징으로 하는 기지국.

청구항 15

제13항에 있어서, 상기 제어기는,

상기 단말이 측정하도록 결정된 기준 신호 정보를 비트 형식으로 지시하는 기준 신호 측정 정보를 생성하여 상기 단말에 통보하는 것을 특징으로 하는 기지국.

청구항 16

제15항에 있어서, 상기 기준 신호 측정 정보는,

상위 시그널링 또는 물리계층 시그널링을 통해 상기 단말에게 전송되는 것을 특징으로 하는 기지국.

청구항 17

제13항에 있어서, 상기 제어기는,

간섭 측정 자원을 상기 단말에게 통보하거나 또는 복수 개의 피드백을 상기 단말에게 통보하고, 상기 단말이 CSI-RS를 측정하여 생성한 제3 채널 정보를 상기 단말로부터 수신하도록 제어하는 것을 특징으로 하는 기지국.

청구항 18

제13항에 있어서, 상기 제어기는,

특정 프리코더가 적용된 데이터를 상기 단말에 전송하도록 제어하며,

상기 프리코더는, 상기 프리코더가 속한 집합 및 각 서브밴드에 적용될 프리코더가 미리 결정된 것을 특징으로 하는 기지국.

청구항 19

분산 안테나를 사용하는 복수 개의 기지국을 포함하는 이동통신 시스템에서 하향링크를 측정하여 보고하는 단말에 있어서,

기지국으로부터 전송되는 기준 신호 측정 정보 또는 데이터를 수신하고, 상기 단말이 측정한 채널 측정 정보를 상기 기지국으로 전송하는 송수신부; 및

상기 단말의 RI/PMI 보고 불능 설정 여부에 대한 정보를 기지국으로부터 수신하고, 상기 RI/PMI 보고 불능 설정 시 CRS 또는 CSI-RS 중 상기 단말이 측정하도록 결정된 기준 신호에 대한 정보를 상기 기지국으로부터 수신하며, 상기 결정된 기준 신호를 측정하여 제1 채널 정보를 생성하고 상기 기지국으로 전송하며, 상기 제1 채널 정보에 기반하여 전송되는 데이터를 상기 기지국으로부터 수신하도록 제어하는 제어기를 포함하는 것을 특징으로 하는 단말.

청구항 20

제19항에 있어서, 상기 제어기는,

상기 단말의 RI/PMI 보고 설정 시 상기 CSI-RS를 측정하여 제2 채널 정보를 생성하고, 상기 생성된 제2 채널 정보를 상기 기지국으로 전송하도록 제어하는 것을 특징으로 하는 단말.

청구항 21

제19항에 있어서, 상기 제어기는,

상기 단말이 측정하도록 결정된 기준 신호 정보를 비트 형식으로 지시하는 기준 신호 측정 정보를 수신하는 것을 특징으로 하는 단말.

청구항 22

제21항에 있어서, 상기 기준 신호 측정 정보는,

상위 시그널링 또는 물리계층 시그널링을 통해 상기 기지국으로부터 수신되는 것을 특징으로 하는 단말.

청구항 23

제19항에 있어서, 상기 제어기는,

상기 기지국으로부터 간섭 측정 자원을 통보받거나 또는 복수 개의 피드백을 보고하도록 통보받는 경우 상기 CSI-RS를 측정하여 제3 채널 정보를 생성하고, 상기 생성된 제3 채널 정보를 상기 기지국으로 전송하도록 제어하는 것을 특징으로 하는 단말.

청구항 24

제19항에 있어서, 상기 제어기는,

특정 프리코더가 적용된 데이터를 상기 기지국으로부터 수신하도록 제어하며,

상기 프리코더는, 상기 프리코더가 속한 집합 및 각 서브밴드에 적용될 프리코더가 미리 결정된 것을 특징으로 하는 단말.

명 세 서

기 술 분 야

[0001] 본 발명은 분산 안테나를 사용하는 복수 개의 기지국을 포함하는 무선통신 시스템에서 기준 신호 측정 방법 및 장치에 관한 것이다. 보다 구체적으로, 본 발명에서는 복수 개의 기지국이 존재하는 이동통신 시스템에서 각 기지국이 운용하는 안테나가 해당 기지국의 서비스 영역에 분산되어 배치되어 있는 분산 안테나 시스템(Distributed Antenna System: DAS)에서 하향링크에서 효과적인 통신을 위하여 단말에서 간섭측정을 수행하는 방법을 제안한다.

배 경 기 술

[0002] 이동통신 시스템은 초기의 음성 위주의 서비스를 제공하던 것에서 벗어나 데이터 서비스 및 멀티미디어 서비스 제공을 위해 고속, 고품질의 무선 패킷 데이터 통신 시스템으로 발전하고 있다. 최근 3GPP의 HSDPA(High Speed Downlink Packet Access), HSUPA(High Speed Uplink Packet Access), LTE (Long Term Evolution), LTE-A (Long Term Evolution Advanced), 3GPP2의 HRPD(High Rate Packet Data), 그리고 IEEE의 802.16 등 다양한 이동 통신 표준이 고속, 고품질의 무선 패킷 데이터 전송 서비스를 지원하기 위해 개발되었다. 특히 LTE 시스템은 고속 무선 패킷 데이터 전송을 효율적으로 지원하기 위하여 개발된 시스템으로 다양한 무선접속 기술을 활용하여 무선시스템 용량을 최대화한다. LTE-A 시스템은 LTE 시스템의 진보된 무선시스템으로 LTE와 비교하여 향상된 데이터 전송능력을 가지고 있다.

[0003] 상기 LTE는 일반적으로 3GPP 표준단체의 Release 8 또는 9에 해당하는 기지국 및 단말 장비를 의미하며 LTE-A는 3GPP 표준단체의 Release 10에 해당하는 기지국 및 단말 장비를 의미한다. 3GPP 표준단체에서는 LTE-A 시스템의 표준화 이후에도 이를 기반으로 하며 향상된 성능을 갖는 후속 Release에 대한 표준화를 진행하고 있다.

[0004] HSDPA, HSUPA, HRPD, LTE/LTE-A 등의 현존하는 3세대 및 4세대 무선 패킷 데이터 통신 시스템은 전송 효율을 개선하기 위해 적응 변조 및 부호(Adaptive Modulation and Coding, 이하 AMC) 방법과 채널 감응 스케줄링 방법 등의 기술을 이용한다. 상기의 AMC 방법을 활용하면 송신기는 채널 상태에 따라 전송하는 데이터의 양을 조절할 수 있다. 즉 채널 상태가 좋지 않으면 전송하는 데이터의 양을 줄여서 수신 오류 확률을 원하는 수준에 맞추고, 채널 상태가 좋으면 전송하는 데이터의 양을 늘려서 수신 오류 확률은 원하는 수준에 맞추면서도 많은 정보를 효과적으로 전송할 수 있다. 상기의 채널 감응 스케줄링 자원 관리 방법을 활용하면 송신기는 여러 사용자 중에서 채널 상태가 우수한 사용자를 선택적으로 서비스하기 때문에 한 사용자에게 채널을 할당하고 서비스해주는 것에 비해 시스템 용량이 증가한다. 이와 같은 용량 증가를 소위 다중 사용자 다이버시티(Multi-user

Diversity) 이득이라 한다. 요컨대 상기의 AMC 방법과 채널 감응 스케줄링 방법은 수신기로부터 부분적인 채널 상태 정보를 피드백(feedback) 받아서 가장 효율적이라고 판단되는 시점에 적절한 변조 및 부호 기법을 적용하는 방법이다.

[0005] 상기와 같은 AMC 방법은 MIMO (Multiple Input Multiple Output) 전송방식과 함께 사용될 경우 전송되는 신호의 spatial layer의 개수 또는 rank를 결정하는 기능도 포함할 수 있다. 이 경우 AMC 방법은 최적의 data rate를 결정하는데 단순히 부호화율과 변조방식만을 생각하지 않고 MIMO를 이용하여 몇 개의 layer로 전송할지도 고려하게 된다.

[0006] 최근 2세대와 3세대 이동 통신 시스템에서 사용되던 다중 접속 방식인 CDMA (Code Division Multiple Access)을 차세대 시스템에서 OFDMA(Orthogonal Frequency Division Multiple Access)으로 전환하려는 연구가 활발히 진행되고 있다. 3GPP와 3GPP2는 OFDMA를 사용하는 진화 시스템에 관한 표준화를 진행하기 시작하였다. CDMA 방식에 비해 OFDMA 방식에서 용량 증대를 기대할 수 있는 것으로 알려져 있다. OFDMA 방식에서 용량 증대를 낳는 여러 가지 원인 중의 하나가 주파수 축 상에서의 스케줄링(Frequency Domain Scheduling)을 수행할 수 있다는 것이다. 채널이 시간에 따라 변하는 특성에 따라 채널 감응 스케줄링 방법을 통해 용량 이득을 얻었듯이 채널이 주파수에 따라 다른 특성을 활용하면 더 많은 용량 이득을 얻을 수 있다.

[0007] 도 1은 LTE/LTE-A 시스템에서 시간 및 주파수 자원을 도시하는 도면이다.

[0008] 도 1에서 도시되는 바와 같이, eNB가 단말에게 전송하는 무선자원은 주파수 축 상에서는 RB (resource block) 단위로 나누어지며 시간 축 상에서는 서브프레임(subframe) 단위로 나누어진다. 상기 RB는 LTE/LTE-A 시스템에서 일반적으로 12개의 부반송파로 이루어지며 180kHz의 대역을 차지한다.

[0009] 반면 서브프레임은 LTE/LTE-A 시스템에서 일반적으로 14개의 OFDM 심볼구간으로 이루어지며 1 msec의 시간구간을 차지한다. LTE/LTE-A 시스템은 스케줄링을 수행함에 있어서 시간축에서는 서브프레임 단위로 자원을 할당할 수 있으며 주파수축에서는 RB 단위로 자원을 할당할 수 있다.

[0010] 도 2는 LTE/LTE-A 시스템에서 하향링크로 스케줄링 할 수 있는 최소 단위인 1 서브프레임 및 1 RB의 무선자원을 도시하는 도면이다.

[0011] 도 2에서 도시되는 바와 같이, 무선자원은 시간축 상에서 한 개의 서브프레임으로 이루어지며 주파수축상에서 한 개의 RB로 이루어진다. 이와 같은 무선자원은 주파수 영역에서 12개의 서브캐리어(subcarrier)(또는, 부반송파)로 이루어지며 시간영역에서 14개의 OFDM 심볼로 이루어져서 총 168개의 고유 주파수 및 시간 위치 갖도록 한다. LTE/LTE-A에서는 상기 도 2의 각각의 고유 주파수 및 시간 위치를 RE (resource element)라 한다.

[0012] 상기 도 2에 도시된 무선자원에는 다음과 같은 복수개의 서로 다른 종류의 신호가 전송될 수 있다.

[0013] 1. CRS (셀 특정 기준 신호, Cell Specific RS): 한 개의 셀(cell)에 속한 모든 단말을 위하여 주기적으로 전송되는 기준신호이며 복수개의 단말들이 공통적으로 이용할 수 있다.

[0014] 2. DMRS (복조 기준 신호, Demodulation Reference Signal): 특정 단말을 위하여 전송되는 기준신호이며 해당 단말에게 데이터를 전송할 경우에만 전송된다. DMRS는 총 8개의 DMRS 포트(port)들로 이루어질 수 있다. LTE/LTE-A에서는 port 7에서 port 14까지 DMRS port에 해당하며 port들은 CDM또는 FDM을 이용하여 서로 간섭을 발생시키지 않도록 직교성(orthogonality)을 유지한다.

[0015] 3. PDSCH (물리 하향링크 공유 채널, Physical Downlink Shared Channel): 하향링크로 전송되는 데이터 채널로 기지국이 단말에게 트래픽을 전송하기 위하여 이용하며 상기 도 2의 데이터 영역(data region)에서 기준신호가 전송되지 않는 RE를 이용하여 전송됨

[0016] 4. CSI-RS (채널 상태 정보 기준 신호, Channel Status Information Reference Signal): 한 개의 cell에 속한 단말들을 위하여 전송되는 기준신호를 채널상태를 측정하는데 이용됨. 한 개의 셀에는 복수개의 CSI-RS가 전송될 수 있음.

[0017] 5. 기타 제어채널 (PHICH, PCFICH, PDCCH): 단말이 PDSCH를 수신하는데 필요한 제어정보를 제공하거나 상향링크의 데이터 송신에 대한 HARQ를 운용하기 위한 ACK/NACK 전송

[0018] 상기 신호 외에 LTE-A 시스템에서는 다른 기지국의 전송하는 CSI-RS가 해당 셀의 단말들에게 간섭없이 수신될 수 있도록 뮤팅(muting)을 설정할 수 있다. 상기 muting은 CSI-RS가 전송될 수 있는 위치에서 적용될 수 있으며 일반적으로 단말은 해당 무선 자원을 건너뛰어 트래픽 신호를 수신한다. LTE-A 시스템에서 뮤팅은 또 다른 용어로 0 전력 CSI-RS((zero-power CSI-RS)라고 불리기도 한다. 뮤팅의 특성상 CSI-RS의 위치에 적용되며 전송전력이 송신되지 않기 때문이다.

[0019] 상기 도 2에서 도시되는 바와 같이, CSI-RS는 CSI-RS를 전송하는 안테나들 수에 따라 A, B, C, D, E, E, F, G, H, I, J로 표시된 위치의 일부를 이용하여 전송될 수 있다. 또한 뮤팅도 A, B, C, D, E, E, F, G, H, I, J로 표시된 위치의 일부에 적용될 수 있다. 특히 CSI-RS는 전송하는 안테나포트 수에 따라서 2개, 4개, 8개의 RE로 전송될 수 있다.

[0020] 안테나포트수가 2개일 경우 상기 도 2에서 특정 패턴의 절반에 CSI-RS가 전송되며 안테나포트수가 4개일 경우 특정 패턴의 전체에 CSI-RS가 전송되고 안테나포트수가 8개일 경우 두 개의 패턴을 이용하여 CSI-RS가 전송된다.

[0021] 반면 뮤팅의 경우 언제나 한 개의 패턴 단위로 이루어진다. 즉, 뮤팅은 복수개의 패턴에 적용될 수는 있지만 CSI-RS와 위치가 겹치지 않는 경우 한 개의 패턴의 일부에만 적용될 수는 없다. 단, CSI-RS의 위치와 뮤팅의 위치가 겹칠 경우에 한해서 한 개의 패턴의 일부에만 적용될 수 있다.

[0022] 두 개의 안테나포트에 대한 CSI-RS가 전송될 경우 CSI-RS는 시간축에서 연결된 두 개의 RE에서 두 안테나포트의 신호를 전송하며 각 안테나포트의 신호는 직교코드로 구분된다. 또한 네 개의 안테나포트에 대한 CSI-RS가 전송될 경우 두 개의 안테나포트를 위한 CSI-RS에 추가로 두 개의 RE를 더 이용하여 동일한 방법으로 추가로 두 개의 안테나포트에 대한 신호를 전송한다. 8개의 안테나포트에 대한 CSI-RS가 전송될 경우도 마찬가지이다.

[0023] 셀룰러 시스템에서 하향링크 채널 상태를 측정하기 위하여 기지국은 단말에게 기준신호 (reference signal, RS)를 전송해야 한다. 3GPP의 LTE-A (Long Term Evolution Advanced) 시스템의 경우 기지국이 전송하는 CRS 또는 CSI-RS (Channel Status Information Reference Signal)를 이용하여 단말은 기지국과 자신 사이의 채널 상태를 측정한다.

[0024] 상기 채널 상태는 기본적으로 몇 가지 요소가 고려되어야 하며 여기에는 하향링크에서의 간섭량이 포함된다. 상기 하향링크에서의 간섭량은 인접 기지국에 속한 안테나 의하여 발생되는 간섭신호 및 열잡음 등이 포함되며 단말이 하향링크의 채널 상황을 판단하는데 중요하다. 한 예로 송신안테나가 한 개인 기지국에서 수신안테나가 한 개의 단말로 전송할 경우 단말은 기지국에서 수신된 기준신호에서 하향링크로 수신할 수 있는 심볼당 에너지와 해당 심볼을 수신하는 구간에서 동시에 수신될 간섭량을 판단하여 Es/Io를 결정해야 한다. 결정된 Es/Io는 기지국으로 통보되어 기지국이 하향링크로 단말에게 어떤 데이터 전송속도로 전송을 수행할지를 판단할 수 있게 한다.

[0025] 일반적인 이동통신 시스템의 경우 각 셀의 중간 지점에 기지국 장비가 배치되며 해당 기지국 장비는 한정된 장소에 위치한 한 개 또는 복수개의 안테나를 이용하여 단말과 이동통신을 수행한다. 상기와 같이 한 개의 셀에 속한 안테나들이 동일한 위치에 배치된 이동통신 시스템을 CAS(Centralized Antenna System)이라고 한다. 반면 한 개의 셀에 속한 안테나(RRH: Remote Radio Head)들이 셀 내의 분산된 위치에 배치된 이동통신 시스템을 DAS (Distributed Antenna System: 분산안테나 시스템)이라고 한다.

[0026] 도 3은 일반적인 분산안테나 시스템에서 안테나의 분산된 위치에의 배치를 도시하는 도면이다.

[0027] 도 3에서 도시되는 바와 같이, 두 개의 셀 300과 셀 310은 분산안테나 시스템에 해당한다. 셀 300의 경우 다섯 개의 전송지점(transmission point)으로 이루어지며 한 개의 고출력 전송지점(320)과 네 개의 저출력 전송지점(340, 350, 360, 370)들로 이루어진다. 이 경우, 각각의 전송지점은 한 개 또는 복수개의 전송 안테나를 가질 수 있다.

[0028] 상기 고출력 전송지점은 셀영역 에 포함되는 전역에 최소한의 서비스를 제공할 수 있도록 하는 반면 분산된 저출력 전송지점들은 셀 내 제한된 영역에서 제한된 단말들에게 높은 데이터 속도를 기반으로 하는 서비스를 제공할 수 있다. 또한 저출력 전송지점들 및 고출력 전송지점은 330과 같이 모두 중앙제어기에 연결되어 중앙제어기

의 스케줄링 및 무선자원 할당에 따라 동작한다.

[0029] 상기 분산안테나 시스템에서 한 개의 지리적으로 분리된 전송지점 위치에는 한 개 또는 복수개의 안테나들이 배치될 수 있다. 분산안테나 시스템에서 동일한 전송지점에 배치된 안테나 또는 안테나들을 본 발명에서는 안테나 그룹 (RRH group)이라고도 한다. 상기 도 3과 같은 분산안테나 시스템에서 단말은 한 개의 지리적으로 분리된 안테나 그룹에서 신호를 수신하는 반면 나머지 안테나 그룹에서 전송되는 것은 간섭으로 작용한다.

[0030] 도 3과 같은 분산 안테나 시스템에서 CRS를 전송하기 위한 경우 한 개의 셀에 속한 모든 안테나들이 전송에 참여한다. 즉, 한 개의 셀에 속한 모든 안테나는 CRS를 위하여 CRS를 전송하거나 다른 안테나들이 CRS를 전송하는데 간섭을 발생시키지 않도록 CRS가 전송되는 RE 위치에서 다른 신호를 전송하지 않는다. 한 개의 셀에 속한 모든 안테나가 CRS를 위한 신호를 전송하는 경우 CRS를 기반으로 전송되는 데이터 신호는 셀에 속한 모든 안테나에서 전송된다.

[0031] 반면 한 개의 셀에 속한 일부 안테나들만 CRS를 위한 신호를 전송하는 경우 CRS를 위한 신호를 전송하지 않는 안테나들은 다른 안테나들에서 전송되는 CRS에 간섭을 발생시키지 않기 위하여 해당 CRS가 전송되는 RE 위치에서 다른 신호를 전송하지 않는다. 또한 CRS를 기반으로 전송되는 데이터 신호는 CRS를 전송하는 안테나들에서만 전송된다.

[0032] 반면 CSI-RS의 경우 한 개의 셀에 속한 안테나별로 다른 CSI-RS가 전송될 수 있다. 즉, 상기 도 3에서 동일한 CRS가 전송지점 320, 340, 350, 360, 370에서 전송되지만 CSI-RS는 전송지점 320, 340, 350, 360, 370마다 별도의 CSI-RS가 전송될 수 있다. 전송지점마다 다른 CSI-RS를 전송하는 방법으로는 상기 도 2에서 도시화된 복수개의 CSI-RS 전송위치 중 다른 것을 전송지점마다 할당하거나 동일한 전송위치를 이용하여 전송하되 전송지점마다 다른 scrambling을 적용하는 것이 있다.

[0033] LTE-A 시스템의 경우 단말은 하향링크의 채널상태에 대한 정보를 기지국에게 피드백하여 기지국의 하향링크 스케줄링에 활용할 수 있도록 한다. 즉, 단말은 하향링크로 기지국이 전송하는 기준신호를 측정하고 여기에서 추출한 정보를 LTE/LTE-A 표준에서 정의하는 형태로 기지국으로 피드백하는 것이다. LTE/LTE-A에서 단말이 피드백하는 정보로는 크게 다음의 세가지 정보가 있다.

[0034] - RI (랭크 지시자, Rank Indicator): 단말이 현재의 채널상태에서 수신할 수 있는 공간 레이어(spatial layer)의 개수

[0035] - PMI (프리코더 매트릭스 지시자, Precoder Matrix Indicator): 단말이 현재의 채널상태에서 선호하는 프리코딩 매트릭스(precoding matrix)에 대한 지시자

[0036] - CQI (채널 품질 지시자, Channel Quality Indicator): 단말이 현재의 채널상태에서 수신할 수 있는 최대 데이터 전송률 (data rate). CQI는 최대 데이터 전송률과 유사하게 활용될 수 있는 SINR, 최대의 오류정정 부호화율 (code rate) 및 변조 방식, 주파수당 데이터 효율 등으로 대체될 수 도 있음.

[0037] 상기 RI, PMI, CQI는 서로 연관되어 의미를 갖는다. 한 예로 LTE/LTE-A에서 지원하는 프리코딩 매트릭스 (precoding matrix)는 랭크(rank)별로 다르게 정의되어 있다. 때문에 RI가 1의 값을 가질 때 PMI 값 X와 RI가 2의 값을 가질 때 PMI 값 X는 다르게 해석이 된다. 또한 단말이 CQI를 결정할 때에도 자신이 기지국에 통보한 PMI와 X가 기지국에서 적용되었다는 가정을 한다. 즉, 단말이 RI_X, PMI_Y, CQI_Z를 기지국에 통보한 것은 랭크를 RI_X로 하고 프리코딩 을 PMI_Y로 할 때 CQI_Z에 해당하는 데이터 전송률을 해당 단말이 수신할 수 있다고 통보하는 것과 같다. 이와 같이 단말은 CQI를 계산할 때에 기지국에 어떤 전송방식을 수행할 지를 가정하여 해당 전송방식으로 실제 전송을 수행하였을 때 최적화된 성능을 얻을 수 있도록 한다.

[0038] LTE/LTE-A에서는 RI 및 PMI이 없이 CQI만을 피드백시키는 RI/PMI 불능 모드(이하, RI/PMI disabled mode)를 지원한다. 상기 RI/PMI disabled mode가 적용된 단말은 RI 및 PMI를 피드백하지 않고 CQI만을 기지국에게 피드백한다.

[0039] 도 4는 단말의 RI/PMI 보고(reporting)가 인에이블(enabled)된 상태와 RI/PMI reporting이 불능으로 설정(disabled)된 상태의 피드백을 도시하는 도면이다.

[0040] 도 4에서 도시되는 바와 같이, RI/PMI reporting이 enable된 상태에서 단말은 다음과 같이 RI, PMI, CQI를 전송한다.

[0041] - 400, 430의 위치에서 RI를 전송

[0042] - 410, 440의 위치에서 PMI를 전송

[0043] - 420, 450의 위치에서 CQI를 전송

[0044] 반면 RI/PMI가 disable된 상태에서 단말은 RI, PMI를 전송하지 않으며, 다만 CQI만을 460, 470의 위치에서 전송한다. RI/PMI를 disable시키는 것은 단말이 기지국으로 전송해야 하는 피드백 오버헤드를 감소시켜서 상향링크의 시스템 용량을 개선시키는 효과가 있으며 단말이 전송해야 하는 채널상태 정보량이 감소함에 따라 단말의 베터리 소모량을 감소시키는 효과도 있다.

[0045] LTE/LTE-A 시스템에서 RI/PMI reporting이 disable된 경우 단말은 언제나 CRS를 측정하여 CQI를 생성하게 되어 있다.

[0046] 상기에서 언급한 바와 같이 CQI를 생성하기 위해서 단말은 특정 전송방법을 가정해야 한다. LTE/LTE-A 시스템의 경우 RI/PMI가 disable될 경우 단말은 기지국이 두 개의 송신안테나를 가지면 SFBC (Space Frequency Block Code)에 따른 precoding이 적용된다는 가정하에서 CQI를 생성한다. 반면 기지국이 네 개의 송신안테나를 가지면 FSTD (Frequency Shift Time Diversity)에 다른 precoding이 적용된다는 가정하에서 CQI를 생성한다.

[0047] 상기와 같이 LTE/LTE-A에서 RI/PMI reporting이 disable된 경우 단말이 CRS를 측정하여 CQI를 생성하는 방법에는 두 가지의 주요 문제점이 있다.

[0048] <첫 번째 문제점>

[0049] CRS를 측정하기 때문에 상기 도 3과 같은 분산안테나 시스템에 적합하지 않다. CRS는 한 개의 cell내에 포함된 복수의 전송지점에서 동시 전송되기 때문에 CRS를 측정하여 얻어지는 CQI는 cell내의 모든 전송지점에서 동시에 단말에게 PDSCH를 전송하는 경우에만 정확하다. 일반적으로 분산안테나 시스템에서는 단말에게 상대적으로 가까운 전송지점에서만 PDSCH 전송을 수행한다. 이와 같이 가까운 전송지점에서만 PDSCH 전송을 수행할 경우 다른 전송지점들은 또 다른 단말에게 PDSCH 전송을 수행할 수 있기 때문에 시스템의 성능이 향상될 수 있다. 이와 같이 분산안테나 시스템에서 전송지점 별 하향 채널에 대한 정확한 CQI를 생성하기 위해서는 CRS가 아닌 CSI-RS를 측정해야 된다.

[0050] <두 번째 문제점>

[0051] CRS는 최대 4개의 송신안테나까지만 지원된다. 때문에 전송지점별 CRS 안테나 수가 2개 또는 4개일 때는 상기에서 언급한 바와 같이 SFBC 또는 FSTD에 따른 프리코딩 이 적용되지만 분산안테나 시스템에서 각 전송지점은 최대 8개의 안테나를 이용할 수 있다. 한 개의 전송지점이 8개의 안테나를 가질 경우 적용할 프리코딩이 정의되지 않았기 때문에 문제가 된다. 또한 상기의 SFBC 및 FSTD의 경우 CRS에 대해서만 정의되어 있기 때문에 CSI-RS에 적용하기에 어렵다.

[0052] 종래 기술에서 단말의 RI/PMI 보고가 불능(RI/PMI reporting이 disable)으로 설정된 경우에 CRS가 아닌 CSI-RS를 측정하여 CQI를 생성하는 방법으로 상기의 문제점을 해결할 수 있다.

[0053] 하지만 상기의 CRS를 측정하여 발생하는 문제는 종래 LTE/LTE-A 이동통신 시스템에서 언제나 발생되는 문제가 아닌 분산안테나 시스템이 구축되어 있을 경우에만 발생한다. 즉, 분산안테나 시스템이 구축되지 않았다면 단말은 RI/PMI reporting이 disable된 경우에 CRS를 측정하여 CQI를 생성하는 것이 시스템 성능관점에서 유리할 수 있다. 하지만 단말은 분산안테나 시스템이 구축되었는지 구축되지 않았는지 스스로 판단할 수 없기 때문에 독자적으로 CRS 또는 CSI-RS를 선택하여 측정할 수는 없다.

발명의 내용

해결하려는 과제

[0054] 본 발명의 목적은 LTE-A 시스템을 기반으로 하는 분산안테나 시스템에서 RI/PMI 보고가 불능으로 설정된 경우 정확한 CQI를 생성할 수 있도록 단말이 측정할 기준 신호를 기지국이 선택하여 단말에게 통보하는 방법 및 장치를 제공함에 있다. 또한 RI/PMI 보고가 불능으로 설정된 경우 단말이 CQI를 생성하기 위하여 가정하는 기지국의

전송방법을 정의한다.

과제의 해결 수단

[0055] 상기와 같은 문제점을 해결하기 위한 본 발명의 분산 안테나를 사용하는 복수 개의 기지국을 포함하는 이동통신 시스템에서 기준신호 측정 정보를 기지국이 단말에 통보하는 방법은 상기 단말의 RI/PMI 보고 불능 설정 여부를 결정하는 단계, 상기 단말의 RI/PMI 보고 불능 설정 시 CRS 또는 CSI-RS 중 단말이 측정할 기준 신호를 결정하는 단계, 상기 결정된 기준 신호를 상기 단말에게 통보하는 단계, 상기 결정된 기준 신호를 측정하여 단말이 생성한 제1 채널 정보를 상기 단말로부터 수신하는 단계, 및 상기 제1 채널 정보에 기반하여 상기 단말에게 데이터를 전송하는 단계를 포함하는 것을 특징으로 한다.

[0056] 또한, 본 발명의 분산 안테나를 사용하는 복수 개의 기지국을 포함하는 이동통신 시스템에서 단말의 하향링크 측정 방법은 상기 단말의 RI/PMI 보고 불능 설정 여부에 대한 정보를 기지국으로부터 수신하는 단계, 상기 RI/PMI 보고 불능 설정 시, CRS 또는 CSI-RS 중 상기 단말이 측정하도록 결정된 기준 신호에 대한 정보를 상기 기지국으로부터 수신하는 단계, 상기 결정된 기준 신호를 측정하여 제1 채널 정보를 생성하고 상기 기지국으로 전송하는 단계, 및 상기 제1 채널 정보에 기반하여 전송되는 데이터를 상기 기지국으로부터 수신하는 단계를 포함하는 것을 특징으로 한다.

[0057] 또한, 본 발명의 분산 안테나를 사용하는 복수 개의 기지국을 포함하는 이동통신 시스템에서 기준 신호 측정 정보를 단말에 통보하는 기지국은 상기 기준 신호 측정 정보 또는 데이터를 상기 단말에 전송하고, 상기 단말로부터 전송되는 채널 측정 정보를 수신하는 송수신부, 및 상기 단말의 RI/PMI 보고 불능 여부를 결정하고, 상기 단말의 RI/PMI 보고 불능 결정 시 CRS 또는 CSI-RS 중 단말이 측정할 기준 신호를 결정하며, 상기 결정된 기준 신호를 상기 단말에게 통보하고, 상기 결정된 기준 신호를 측정하여 단말이 생성한 제1 채널 정보를 상기 단말로부터 수신하며, 상기 제1 채널 정보에 기반하여 상기 단말에게 데이터를 전송하도록 제어하는 제어기를 포함하는 것을 특징으로 한다.

[0058] 그리고 본 발명의 분산 안테나를 사용하는 복수 개의 기지국을 포함하는 이동통신 시스템에서 하향링크를 측정하여 보고하는 단말은 기지국으로부터 전송되는 기준 신호 측정 정보 또는 데이터를 수신하고, 상기 단말이 측정한 채널 측정 정보를 상기 기지국으로 전송하는 송수신부, 및 상기 단말의 RI/PMI 보고 불능 설정 여부에 대한 정보를 기지국으로부터 수신하고, 상기 RI/PMI 보고 불능 설정 시 CRS 또는 CSI-RS 중 상기 단말이 측정하도록 결정된 기준 신호에 대한 정보를 상기 기지국으로부터 수신하며, 상기 결정된 기준 신호를 측정하여 제1 채널 정보를 생성하고 상기 기지국으로 전송하며, 상기 제1 채널 정보에 기반하여 전송되는 데이터를 상기 기지국으로부터 수신하도록 제어하는 제어부를 포함하는 것을 특징으로 한다.

발명의 효과

[0059] 본 발명의 실시예에 따르면 LTE-A 시스템을 기반으로 하는 분산안테나 시스템에서 RI/PMI 보고가 불능으로 설정된 경우 단말이 측정할 기준 신호를 기지국이 선택하여 단말에게 통보해준다. 이에 따라, 단말은 종래 시스템에서보다 보다 정확한 채널 측정 정보를 생성하여 기지국으로 피드백해줄 수 있다.

도면의 간단한 설명

[0060] 도 1은 LTE/LTE-A 시스템에서 시간 및 주파수 자원을 도시하는 도면.

도 2는 LTE/LTE-A 시스템에서 하향링크로 스케줄링 할 수 있는 최소 단위인 1 서브프레임 및 1 RB의 무선자원을 도시하는 도면.

도 3은 일반적인 분산안테나 시스템에서 안테나의 분산된 위치에의 배치를 도시하는 도면.

도 4는 단말의 RI/PMI 보고(reporting)가 인에이블(enabled)된 상태와 RI/PMI reporting이 불능으로 설정(disabled)된 상태의 피드백을 도시하는 도면.

도 5는 CRS를 측정하여 얻어지는 무선채널에 대한 CQI와 전송지점별 CSI-RS를 측정하여 얻어지는 무선채널에 대한 CQI를 비교하는 도면.

도 6은 상기 도 5의 분산안테나 시스템에서 CRS를 이용하여 CQI를 측정할 경우 발생하는 부정확한 CQI의 문제를 도시하는 도면.

도 7은 본 발명에서 제안하는 분산안테나 시스템에서 RI/PMI reporting이 disable된 상태에서 단말에게 어떤 RS를 이용하여 하향링크를 측정할지를 통보하는 기지국의 동작 순서를 도시하는 순서도.

도 8은 본 발명에서 제안하는 분산안테나 시스템에서 RI/PMI reporting이 disable된 상태에서 단말이 어떤 RS를 이용하여 하향링크를 측정할지를 판단하는 동작을 순서도로 도시한 도면.

도 9는 단말과 기지국이 주파수 영역에서 복수개의 프리코딩이 번갈아 가며 적용되는 실시예를 도시하는 도면.

도 10은 프리코더 후보집합에 포함된 프리코딩 들이 한 개의 서브프레임 내의 한 개의 RB 내에서 번갈아가며 적용되는 것을 도시하는 도면.

도 11은 본 발명의 실시예에 따른 기지국의 내부 구조를 도시하는 블록도.

도 12는 본 발명의 실시예에 따른 단말의 내부 구조를 도시하는 블록도.

도 13은 본 발명에서 제안하는 공간 시간/주파수 블록 코드의 적용을 위한 단말 수신기에서의 안테나 가상화를 설명하기 위한 도면

발명을 실시하기 위한 구체적인 내용

[0061] 이하 본 발명의 실시예를 첨부한 도면과 함께 상세히 설명한다. 또한 본 발명을 설명함에 있어서 관련된 공지 기능 혹은 구성에 대한 구체적인 설명이 본 발명의 요지를 불필요하게 흐릴 수 있다고 판단된 경우 그 상세한 설명은 생략한다. 그리고 후술되는 용어들은 본 발명에서의 기능을 고려하여 정의된 용어들로서 이는 사용자, 운용자의 의도 또는 관례 등에 따라 달라질 수 있다. 그러므로 그 정의는 본 명세서 전반에 걸친 내용을 토대로 내려져야 할 것이다.

[0062] 또한, 본 발명의 실시예들을 구체적으로 설명함에 있어서, OFDM 기반의 무선통신 시스템, 특히 3GPP EUTRA 표준을 주된 대상으로 할 것이지만, 본 발명의 주요한 요지는 유사한 기술적 배경 및 채널형태를 가지는 여타의 통신 시스템에도 본 발명의 범위를 크게 벗어나지 아니하는 범위에서 약간의 변형으로 적용 가능하며, 이는 본 발명의 기술분야에서 숙련된 기술적 지식을 가진 자의 판단으로 가능할 것이다.

[0063] 도 5는 CRS를 측정하여 얻어지는 무선채널에 대한 CQI와 전송지점별 CSI-RS를 측정하여 얻어지는 무선채널에 대한 CQI를 비교하는 도면이다.

[0064] 도 5에서 도시되는 바와 같이, cell 500의 경우 단말 (UE1)은 CRS를 측정하여 CQI를 생성한다. CRS는 cell내에 속한 모든 전송지점에서 동시에 전송되는 신호이기 때문에 단말이 CRS를 측정하여 CQI를 발생할 경우 해당 CQI에 맞는 PDSCH를 전송하기 위해서는 PDSCH 역시 모든 전송지점에서 송신되어야 한다. 즉, 상기 도 5에서 CRS를 측정하여 얻은 CQI에 따라 PDSCH를 전송하면서 PDSCH를 전송하는 전송지점을 cell내에 있는 특정 전송지점으로 제한시키는 것은 PDSCH 수신 성능을 충분히 보장시키지 못하는 단점을 발생시킨다.

[0065] 도 6은 상기 도 5의 분산안테나 시스템에서 CRS를 이용하여 CQI를 측정할 경우 발생하는 부정확한 CQI의 문제를 도시하는 도면이다.

[0066] 도 6에서 cell 600의 UE1은 상기 도 5에서와 같이 CRS를 측정하여 CQI를 발생하여 기지국에 통보한다. 반면 PDSCH는 한 개의 전송지점으로부터 수신한다. 도 6에서 도시되는 바와 같이, 분산안테나 시스템에서 CRS를 측정하여 CQI를 생성하고, 이에 대응하여 PDSCH를 한 개의 전송지점으로부터 수신할 경우 기지국에 통보한 CQI가 PDSCH를 전송하는 전송지점과 단말 사이의 무선채널의 상태를 정확히 반영시키지 못하기 때문에 성능을 저하시키게 된다는 문제점이 있다.

[0067] 반면 cell 610의 UE3과 UE4는 분산안테나 시스템에서 CRS가 아닌 전송지점별 CSI-RS를 측정하여 CQI를 생성하였기 때문에 기지국에 통보한 CQI가 PDSCH를 전송하는 각가의 전송지점과 단말 사이의 무선채널의 상태를 정확히 반영시키고 있다.

[0068] 본 발명은 분산안테나 시스템에서 단말의 RI/PMI reporting이 disable된 상기 도 5의 cell 510과 같이 전송지점별 CSI-RS를 측정하도록 하는 방법을 제공한다. 상기에서 언급한 바와 같이 단말이 속한 cell에 분산안테나 시스템이 구축되었느냐 여부에 따라 RI/PMI reporting이 disable되었을 때 CRS 또는 CSI-RS를 선택하여 측정하는

것이 성능관점에서 유리하다.

[0069] 본 발명에서는 단말의 RI/PMI reporting이 disable된 상태에서 단말이 CRS 또는 CSI-RS 중 어느 것을 측정하여 CQI를 생성하여 보고할지 여부에 대한 정보를 기지국이 단말에게 통보하는 방법을 제안한다. 상기 통보 방법은 후술하는 바와 같이 명시적(explicit)으로 통보할 수도 있고, 또는 암묵적(implicit)으로 통보할 수도 있다. 이에 대한 구체적인 설명은 하기 및 해당 부분에서 설명하도록 한다.

[0070] 단말이 측정할 기준 신호의 종류를 명시적으로 통보하는 방법에 대한 일 실시예로, 본 발명에서는 'RS_Switch 비트' 라는 제어정보(이하에서는 기준 신호 측정 정보라는 용어와 혼용하여 사용하기로 한다)를 제안한다.

[0071] 상기 RS_Switch 비트의 값에 따라 단말은 RI/PMI reporting이 disable된 상태에서 CRS 또는 CSI-RS를 측정하여 CQI를 생성한다. 한 예로 RI/PMI reporting이 disable되었을 때 단말은 기지국이 통보한 RS_Switch 비트의 값이 '0' 일 경우 CRS를 측정하여 CQI를 생성하는 반면 RS_Switch 비트의 값이 '1' 일 경우 CSI-RS를 측정하여 CQI를 생성한다. 이와 같은 방법은 LTE/LTE-A 시스템의 릴리즈 10과 그 이후 릴리즈들에서 지원되는 TM9 (Transmission Mode 9)(전송 모드 9)에서 적용될 수 있으며 이후에 추가되는 전송 모드 들에서도 적용될 수 있다.

[0072] 도 7은 본 발명에서 제안하는 분산안테나 시스템에서 RI/PMI reporting이 disable된 상태에서 단말에게 어떤 RS를 이용하여 하향링크를 측정할지를 통보하는 기지국의 동작 순서를 도시하는 순서도이다.

[0073] 도 7에서 도시되는 바와 같이, 기지국은 과정 700과 같이 단말에게 어떤 종류의 피드백을 설정할지를 결정한다. 상기 과정 700에서 고려되는 것 중 하나는 단말의 RI/PMI 보고 불능 설정 여부를 결정(RI/PMI reporting을 disable할지)하는 것을 포함할 수 있다..

[0074] 해당 단말의 RI/PMI reporting을 disable시키지 않는 것으로 과정 710에서 판단할 경우, 기지국은 과정 720과 같이 단말이 CSI-RS를 측정하여 생성한 CSI(RI, PMI, CQI)를 기반으로 PDSCH 전송을 수행한다. 이를 위해, 본 발명의 일 실시예에 따르면, 기지국은 단말의 RI/PMI 보고 설정 시, 상기 단말이 CSI-RS를 측정하도록 통보하고, 이에 대응하여 단말이 상기 CSI-RS를 측정하여 생성한 제2 채널 정보를 수신할 수 있다. 그러면 기지국은 제2 채널 정보에 기반하여 상기 단말에게 데이터 즉, PDSCH를 전송할 수 있다.

[0075] 반면 해당 단말의 RI/PMI reporting을 disable시키는 것으로 과정 710에서 판단할 경우, 기지국은 과정 730에서 해당 단말이 CRS를 측정하여 CQI를 생성시킬지 아니면 CSI-RS를 측정하여 CQI를 생성시킬지를 판단한다.

[0076] 상기 과정 730에서 단말이 CRS를 측정하여 CQI를 생성하는 것으로 기지국이 판단할 경우, 기지국은 과정 740과 같이 RS_Switch 비트(또는, 기준 신호 측정 정보, 이하 동일하다)를 '0' 으로 설정하여 단말에게 통보한다. 그리고 기지국은 과정 760로 진행하여 해당 단말이 CRS를 측정하여 생성한 CQI를 기반으로 PDSCH 전송을 수행한다.

[0077] 반면, 과정 730에서 단말이 CSI-RS를 측정하여 CQI를 생성하는 것으로 판단할 경우, 기지국은 과정 750과 같이 RS_Switch 비트를 '1' 로 설정하여 단말에게 통보한다. 그리고 기지국은 과정 770로 진행하여 해당 단말이 CSI-RS를 측정하여 생성한 CQI를 기반으로 PDSCH 전송을 수행한다.

[0078] 참고로, 기지국이 결정한 기준 신호 종류에 따라 단말이 해당 기준 신호를 측정하여 생성한 CQI를 제1 채널 정보라고 일컬을 수 있다.

[0079] 도 8은 본 발명에서 제안하는 분산안테나 시스템에서 RI/PMI reporting이 disable된 상태에서 단말이 어떤 RS를 이용하여 하향링크를 측정할지를 판단하는 동작을 순서도로 도시한 도면이다.

[0080] 도 8에서 도시되는 바와 같이, 단말은 과정 800과 같이 기지국에서 피드백 설정에 대한 제어정보를 수신한다. 본 발명의 일 실싱예에 따르면, 상기 제어 정보는 상기 단말의 RI/PMI 보고 불능 설정 여부를 포함할 수 있다.

[0081] 과정 810에서, 상기 제어정보를 통해 단말의 RI/PMI reporting이 disable되지 않았을 경우, 단말은 과정 820로 진행하여 CSI-RS를 측정하고 RI/PMI/CQI(제2 채널 정보)를 생성한다. 그리고 단말은 상기 측정 결과인 RI/PMI/CQI를 기지국으로 전송할 수 있다.

[0082] 반면 단말의 RI/PMI가 disable된 경우, 단말은 CRS 또는 CSI-RS 중 상기 단말이 측정하도록 결정된 기준 신호에 대한 정보를 상기 기지국으로부터 수신할 수 있다. 그리고 기지국은 상기 기준 신호에 대한 정보에 포함된 RS_Switch 비트에 따라 어떤 RS를 측정하여 CQI를 생성할지를 결정한다.

[0083] 보다 구체적으로, 단말은 수신한 RS_Switch 비트가 '0' 으로 설정되어 있을 경우 과정 840과 같이 CRS를 측정하여 CQI를 생성한다. 반면 단말은 수신한 RS_Switch 비트가 '1' 로 설정되어 있을 경우 과정 850과 같이 CSI-RS를 측정하여 CQI를 생성한다.

[0084] 참고로, 기지국이 결정한 기준 신호 종류에 따라 단말이 해당 기준 신호를 측정하여 생성한 CQI를 제1 채널 정보라고 일컬을 수 있다.

[0085] 일반적으로 RI/PMI reporting을 enable 또는 disable시킬지 여부는 네트워크의 구현여부에 따라 결정되며 이때 고려될 수 있는 요소 중 하나는 상기에서 언급한 바와 같이 분산안테나 시스템의 구축여부이다. 기지국은 네트워크의 구현에 최선인 RS를 선택하여 그 선택결과를 상기의 RS_Switch 비트를 이용하여 단말에게 통보한다. 상기 RS_Switch 비트는 상위 시그널링 또는 물리계층 시그널링을 이용하여 기지국에서 단말에게 전송된다.

[0086] RS_Switch 비트가 상위 시그널링을 이용하여 단말에게 통보될 경우 시스템 정보의 일부에 포함되어 불특정 다수의 단말에게 방송되는 형태 또는 특정 단말에게만 통보되는 유니캐스트(unicast) 형태로 전송될 수 있다. RS_Switch 비트가 물리계층 시그널링을 이용하여 단말에게 통보될 경우 LTE/LTE-A에서 지원하는 PDCCH 또는 E-PDCCH에 실리어 단말에게 전송될 수 있다.

[0087] 상기에서는 기지국이 RS_Switch 비트를 단말에게 직접적으로 전송하여 어느 RS를 측정하는지를 직접적(명시적, explicit)으로 통보하는 방법에 대하여 설명하였다.

[0088] 본 발명에서 제안하는 또 하나의 방법은 RS_Switch 비트의 전달과 같은 직접적인 지시 정보 없이 다른 제어 정보 또는 시스템 설정 정보를 활용하여 기지국이 단말에게 어느 RS를 사용할지를 간접적(implicit)으로 통보하는 것이다. RS_Switch 비트와 같은 직접적인 지시 정보 없이 어느 RS를 사용할지를 통보할 수 있는 방법으로는 다음의 두 가지가 있다.

[0089] <측정할 RS 종류에 대한 간접통보 방법1>

[0090] LTE/LTE-A 시스템에서 특정 셀(cell)이 분산안테나 시스템으로 구축될 경우 간섭측정을 위하여 별도의 간섭측정 자원이 단말에게 통보된다. 분산안테나 시스템으로 구현되지 않은 종래의 LTE/LTE-A 이동통신 시스템의 경우 단말이 CRS를 이용하여 간섭측정을 수행하지만 분산안테나 시스템에서는 CRS를 이용하여 간섭측정을 수행할 경우 잘못된 간섭량을 측정하게 되기 때문에 기지국이 단말에게 별도의 간섭측정 자원을 통보한다.

[0091] 이와 같은 특징을 활용하여 RS_Switch 비트와 같은 별도의 제어정보를 단말에게 전송할 필요 없이 기지국과 단말은 간섭측정 자원이 단말에게 통보되면 RI/PMI reporting이 disabling되더라도 CSI-RS를 측정하여 CQI를 생성하는 것으로 가정하는 방법을 이용하면 된다.

[0092] 즉, 단말은 RI/PMI reporting이 disabling되더라도 간섭측정 자원에 대한 시그널링을 통보 받은 상태라면 CSI-RS를 측정하여 CQI를 생성하고 기지국인 이를 기반으로 PDSCH를 전송한다. 반면 단말은 RI/PMI reporting이 disable되었지만 간섭측정 자원에 대한 시그널링을 통보 받지 못한 상태라면 CRS를 측정하여 CQI를 생성한다. 이와 같은 방법은 상위 시그널링 오버헤드를 증가시키지 않으면서도 기지국이 단말에게 어떤 RS를 측정할지를 통보할 수 있는 수단을 제공한다.

[0093] < 측정할 RS 종류에 대한 간접통보 방법2>

[0094] LTE/LTE-A 시스템에서 특정 셀(cell)이 분산안테나 시스템으로 구축될 경우 분산된 전송지점들 사이의 협력통신을 위하여 복수개의 피드백을 단말에게 설정할 수 있다. 일반적으로 한 개의 피드백이라 함은 RI/PMI reporting이 disable되지 않은 상태에서는 별도의 RI/PMI/CQI를 의미하며 RI/PMI/CQI가 disable된 상태에서는 별도의 CQI를 의미한다.

[0095] 즉, RI/PMI reporting이 disable된 상태에서 복수개의 피드백이 단말이 설정될 경우 단말은 두 개 이상의 서로 다른 전송지점 또는 간섭상황에 대한 CQI를 기지국으로 통보하도록 설정된다. 이와 같이 분산안테나 시스템에서는 복수개의 피드백이 설정된다는 것을 이용하여 RI/PMI reporting이 disable된 상태에서 RS_Switch 비트와 같은 별도의 제어정보를 단말에게 전송할 필요 없이 단말에게 어떤 RS를 이용할 지를 통보할 수 있다. 즉, 단말은 RI/PMI reporting이 disable된 상태에서 자신에게 복수개의 CQI가 설정될 경우에는 CSI-RS를 측정하여 CQI를 생성한다. 반면 단말은 RI/PMI reporting이 disable된 상태에서 자신에게 한 개의 CQI가 설정될 경우에는 CRS를

측정하여 CQI를 생성한다. 이와 같은 방법은 상위 시그널링 오버헤드를 증가시키지 않으면서도 기지국이 단말에게 어떤 RS를 측정할지를 통보할 수 있는 수단을 제공한다.

[0096] RI/PMI reporting이 disable될 경우 CQI를 단말이 생성하기 위해서 해결해야 하는 또 하나의 문제는 어떤 프리코딩(precoding)을 가정하여 CQI를 계산할 것인가 이다.

[0097] 구체적으로 기지국이 RI/PMI reporting이 disable될 경우 CSI-RS를 측정하여 CQI를 계산하라고 통보하였을 때 복수개의 CSI-RS 안테나 포트들 사이에 적용할 프리코딩이 단말과 기지국 사이에 공유되어야 한다. 상기 프리코딩이 공유되어야 하는 이유는 기지국이 단말이 적용한 프리코딩을 알고 있어야 단말이 요청한 CQI에 해당하는 MCS로 PDSCH를 전송하기 위해서 자신이 어떤 프리코딩을 적용해야 하는지를 알아야 하기 때문이다. 이와 같이 단말이 적용할 프리코딩을 결정하는 방법으로는 다음의 두 가지 방법이 가능할 수 있다.

[0098] <프리코딩 방법1>

[0099] 첫 번째 방법은 특정 프리코딩을 이용할 것을 단말과 기지국이 사전에 약속하는 것이다.

[0100] 이와 같은 특정 프리코딩은 PMI가 지정할 수 있는 복수개의 프리코딩들 중 한가지일 수 있다. 한 예로 기지국과 단말은 CSI-RS가 네 개의 안테나 포트를 가질 경우 $[+0.5\ +0.5\ +0.5\ +0.5]^{T}$이라고 가정하는 것이다. 이외에 기지국과 단말은 복수개의 프리코딩이 주어진 시간 또는 주파수 영역 내에서 번갈아 가며 적용된다고 가정할 수도 있다.

[0101] 도 9는 단말과 기지국이 주파수 영역에서 복수개의 프리코딩이 번갈아 가며 적용되는 실시예를 도시하는 도면이다.

[0102] 도 9에서 도시되는 바와 같이, 단말은 서브밴드(Subband) 0에서 서브밴드(Subband) 4까지 서로 다른 프리코더(precoder)가 적용된다고 가정하고 있다.

[0103] 이와 같은 서브밴드별 프리코딩의 적용은 기지국도 공유하고 있는 것이다. 단말은 상기의 서브밴드별 프리코딩을 가정하고 CQI를 생성한다. 이와 같이 주파수 또는 시간 영역에서 프리코더를 번갈아 가며 적용된다고 가정하고 CQI를 생성하는 것은 특정 한 개의 프리코더만 적용된다고 가정했을 경우와 비교하여 다이버시티(diversity) 효과가 존재한다. 여기서 다이버시티 효과라 함은 복수개의 프리코더를 가정하여 CQI를 단말이 피드백 함으로써 좋지 않은 프리코더 에 대해서만 연속적으로 CQI를 피드백하는 것을 방지하는 것이다.

[0104] 이와 같은 프리코더 다이버시티(precoder diversity)는 실제로 시스템의 성능을 개선시키는 효과가 있다. RI/PMI reporting이 disabling된 상태에서 상기의 프리코더 다이버시티 가 동작하기 위해서는 단말과 기지국 사이에 어떤 집합의 프리코더를 가정할지와 어떤 프리코더를 각 서브밴드에 적용할지를 기지국과 단말에 약속되어 있어야 한다.

[0105] 한 실시예로 기지국은 별도의 시그널링 없이 사전에 약속된 프리코더 집합을 서브밴드 인덱스(subband index)에 따라 각 서브밴드별로 가정할 수 있다. 즉, 서브밴드에 CQI를 생성할 때 가정할 프리코더는 다음의 수학식으로 결정된다.

[0106] <수학식1>

[0107] $\text{precoder index} = \text{subband index modulo } N_{\text{precoder}}$

[0108] 상기 수학식 1에서 N_{precoder}는 프리코더 다이버시티(precoder diversity)에 활용할 프리코더의 개수이다.

[0109] <프리코딩 방법2>

[0110] 단말이 적용할 프리코딩을 결정하기 위한 또 다른 방법에서는 기지국이 상위 시그널링을 이용하여 단말에게 프리코더 집합을 통보하고 단말은 상기의 수학식 1을 이용하여 각 서브밴드별로 어떤 프리코딩을 가정하여 CQI를 생성할지를 결정할 수 있다.

[0111] 상기에서는 주파수 영역에서 프리코딩을 번갈아 가며 가정하는 경우에 대하여 설명하였지만 동일한 방법이 시간 영역에서도 적용될 수 있다.

[0112] <프리코딩 방법3>

[0113] 상기에서는 프리코더 후보집합에 포함된 프리코딩들이 시간 또는 주파수 영역에서 번갈아 가며 적용된다는 가정하에서 단말이 CQI를 생성하였다. 이와 같은 방법외에도 단말은 프리코더 후보집합에 포함된 프리코딩들이 한 개의 subframe의 일부 RE들에서 번갈이 적용된다는 가정하에서 CQI를 생성할 수 있다.

[0114] 도 10은 이와 같이 프리코더 후보집합에 포함된 프리코딩들이 한 개의 서브프레임 내의 한 개의 RB내에서 번갈아 가며 적용되는 것을 도시한 것이다.

[0115] 도 10에서와 같이 단말은 OFDM 심볼마다 프리코더가 번갈아 가며 적용된다는 가정하고 CQI를 생성한다. 상기 도 10에서는 OFDM 심볼마다 프리코더가 번갈아 가며 적용되는 경우를 도시하였지만 이와 같은 방법 외에 한 개의 RB내의 RE들을 임의의 방법으로 복수 개의 그룹으로 나누고 각 그룹마다 프리코더를 번갈아 가며 적용하는 것도 가능하다.

[0116] 상기 프리코딩 방법 3에서 단말은 사전에 설정되어 있는 프리코더 집합 또는 기지국이 통보한 프리코더 집합을 상기 수학식 1과 유사한 방법을 이용하여 한 개의 RB내의 RE들마다 어떤 프리코딩을 가정할지를 판단한다.

[0117] 상기 프리코딩 방법 1, 방법 2, 방법 3 외에도 단말이 각 RE마다 공간 시간/주파수 블록 코드(Space time/frequency block code)를 가정하고 CQI를 생성하는 방법도 가능하다. 공간 시간/주파수 블록 코드(Space time/frequency block code)를 가정하고 CQI를 생성하는 방법에 대해서는 이하에서 구체적으로 기술하도록 한다.

[0118] <프리코딩 방법4>

[0119] Space time/frequency block code를 가정하고 CQI를 생성하는 방법에서는 단말이 시간, 주파수, 안테나 영역에서 규격화되어 있는 부호화 방식을 가정하여 CQI를 생성한다. Space time/frequency block code는 복수 개 무선채널의 효과를 평균화시키는 효과를 얻을 수 있도록 한다.

[0120] 현재 LTE/LTE-A에서 정의하고 있는 space time/frequency block code로는 송신안테나의 개수에 따라 하기의 수학식 2 및 수학식 3에서 도시되는 두 가지 종류의 space time/frequency block code가 적용될 수 있다. 송신안테나의 개수가 두 개일 경우 하기의 수학식 2에서 정의되는 space time/frequency block code가 적용된다.

[0121] <수학식 2>

[0122]
$$\begin{bmatrix} y^{(0)}(2i) \\ y^{(1)}(2i) \\ y^{(0)}(2i+1) \\ y^{(1)}(2i+1) \end{bmatrix} = \frac{1}{\sqrt{2}} \begin{bmatrix} 1 & 0 & j & 0 \\ 0 & -1 & 0 & j \\ 0 & 1 & 0 & j \\ 1 & 0 & -j & 0 \end{bmatrix} \begin{bmatrix} \mathrm{Re}\left(x^{(0)}(i)\right) \\ \mathrm{Re}\left(x^{(1)}(i)\right) \\ \mathrm{Im}\left(x^{(0)}(i)\right) \\ \mathrm{Im}\left(x^{(1)}(i)\right) \end{bmatrix}$$

[0123] 상기 수학식 2에서 y는 부화화된 신호이며 x는 부호화기에 입력되는 신호이다. 또한 i는 부호화기에 입력되는 신호의 순서를 나타내는 인덱스이다. 또한 Re(Z)는 복소수 Z의 실수성분을 의미하며 Im(Z)는 복소수 Z의 허수성분을 의미한다. 또한 $x^{(k)}(i)$ 및 $y^{(k)}(i)$에서 k는 안테나 포트 인덱스에 해당한다.

[0124] 송신안테나의 개수가 네 개일 경우 하기의 수학식 3에서 정의되는 space time/frequency block code가 적용된다.

[0125] <수학식3>

$$\begin{bmatrix} y^{(0)}(4i) \\ y^{(1)}(4i) \\ y^{(2)}(4i) \\ y^{(3)}(4i) \\ y^{(0)}(4i+1) \\ y^{(1)}(4i+1) \\ y^{(2)}(4i+1) \\ y^{(3)}(4i+1) \\ y^{(0)}(4i+2) \\ y^{(1)}(4i+2) \\ y^{(2)}(4i+2) \\ y^{(3)}(4i+2) \\ y^{(0)}(4i+3) \\ y^{(1)}(4i+3) \\ y^{(2)}(4i+3) \\ y^{(3)}(4i+3) \end{bmatrix} = \frac{1}{\sqrt{2}} \begin{bmatrix} 1 & 0 & 0 & 0 & j & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 & 0 & j & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & j & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & -j & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & j & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & -1 & 0 & 0 & 0 & j \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & j \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & -j & 0 \end{bmatrix} \begin{bmatrix} \mathrm{Re}\left(x^{(0)}(i)\right) \\ \mathrm{Re}\left(x^{(1)}(i)\right) \\ \mathrm{Re}\left(x^{(2)}(i)\right) \\ \mathrm{Re}\left(x^{(3)}(i)\right) \\ \mathrm{Im}\left(x^{(0)}(i)\right) \\ \mathrm{Im}\left(x^{(1)}(i)\right) \\ \mathrm{Im}\left(x^{(2)}(i)\right) \\ \mathrm{Im}\left(x^{(3)}(i)\right) \end{bmatrix}$$

[0126]

[0127] LTE/LTE-A 시스템에서 단말이 상기 수학식2 또는 수학식3과 같은 space time/frequency block code를 가정하고 CQI를 생성하는 경우, 발생할 수 있는 문제점은 현재 LTE/LTE-A 시스템의 경우 space time/frequency block code가 두 개 또는 네 개의 송신안테나에 대해서만 정의가 되어 있다는 점이다. 때문에 CSI-RS가 8개의 안테나 포트를 가질 경우 상기와 같은 space time/frequency block code를 가정하고 CQI를 생성하기 위해서는 별도의 방안이 필요하다.

[0128] 상기와 같이 CSI-RS가 8개의 안테나 포트를 가지는 경우에도 space time/frequency block code를 가정하고 CQI를 생성하도록 하기 위해, 본 발명에서는 단말이 자체적으로 안테나 가상화(virtualization)를 수행하는 방안을 제안한다.

[0129] 즉, CSI-RS의 안테나 포트수가 가정해야 하는 space time/frequency block code가 지원하는 송신안테나 수보다 적을 경우, 단말은 안테나 가상화(virtualization)를 통하여 해당 space time/frequency block code에 적합하도록 CSI-RS를 결합할 수 있다. 이하에서는 구체적인 예시를 들어, 단말의 안테나 가상화 방법에 대해 설명하도록 한다.

[0130] 예를 들어, 단말이 상기 수학식 2에서 도시되는 바와 같은 두 개의 안테나를 위한 space time/frequency block code를 이용할 수 있고 CSI-RS는 안테나 포트수가 8개인 경우를 가정한다. 이 경우, 단말은 8개의 안테나 포트를 갖는 CSI-RS를 수신하여 이를 2개의 송신안테나에 대한 수신신호로 안테나 가상화를 수행한다. 단말에서 안테나 가상화를 수행하는 방법은 미리 정해진 규칙에 따라 CSI-RS 안테나포트 별로 수신한 신호를 더하는 것이다. 한 예로, 단말은 CSI-RS 안테나포트 1, 2, 3, 4, 5, 6, 7, 8에 대한 수신신호가 각각 있을 경우 단말은 CSI-RS 안테나포트 1, 2, 3, 4의 수신신호를 결합하여 송신안테나 1에 대한 수신신호를 생성하고 CSI-RS 안테나포트 5, 6, 7, 8의 수신신호를 결합하여 송신안테나 2에 대한 수신신호를 생성한다. 그리고 단말은 상기 수학식 2에 따른 space time/frequency block code를 가정하여 CQI를 생성할 수 있다.

[0131] 또는 단말과 기지국의 약속에 따라, 1, 3, 5, 7의 수신신호를 결합하여 송신안테나 1에 대한 수신신호를 생성하고 CSI-RS 안테나포트 2, 4, 6, 8의 수신신호를 결합하여 송신안테나 2에 대한 수신신호를 생성할 수 도 있다.

[0132] 상기에서 더하기를 수행할 경우 각 안테나별 신호에 단말과 기지국 사이에 약속된 상수 값을 곱한 후 더하기를 수행하는 것도 가능하다.

[0133] 도 13은 본 발명에서 제안하는 공간 시간/주파수 블록 코드의 적용을 위한 단말 수신기에서의 안테나 가상화를 설명하기 위한 도면이다.

[0134] 상기 도 13에서 단말은 8개의 안테나 포트에 대한 CSI-RS를 RE 위치 1300(P1, P2), 1310(P5, P6), 1320(P3, P4), 1330(P7, P8)을 통해 수신한다.

[0135] 단말이 CQI를 생성하기 위하여 가정해야 하는 space time/frequency block code가 두 개의 송신안테나를 지원한

다고 가정할 경우, 단말은 상기 8개의 안테나 포트에 대한 CSI-RS의 수신신호를 안테나 가상화(antenna virtualization)를 통하여 결합하여 두 개의 송신안테나에 대한 수신신호로 변환한다. 즉, 상기 도 13에서 1300, 1310, 1320, 1330의 수신신호를 임의의 규칙에 따라 더하여 두 개의 송신안테나에 대한 수신신호를 생성한다.

[0136] 이 경우, 8개의 안테나 포트에 대한 CSI-RS 수신 신호를 두 개의 송신안테나에 대한 수신신호로 변환하기 위한 일 예로, 수신 신호를 OFDM 심볼 별로 더하는 방법을 고려해볼 수 있다. 상기 도 13에서 1300, 1310, 1320, 1330의 수신신호를 OFDM 심볼 별로 더할 경우, 두 개의 RE에 대한 신호를 얻을 수 있으며 이에 대하여 송신단에서 안테나포트를 구분하기 위하여 이용한 직교코드 두 개로 correlation을 취함으로서 두 개의 안테나포트에 대한 신호를 얻을 수 있다.

[0137] 또한 단말이 CQI를 생성하기 위하여 가정해야 하는 space time/frequency block code가 네 개의 송신안테나를 지원할 경우, 단말은 상기 8개의 안테나 포트에 대한 CSI-RS의 수신신호를 안테나 가상화(antenna virtualization)을 통하여 결합하여 네 개의 송신안테나에 대한 수신신호로 변환한다. 즉, 상기 도 13에서 1300, 1310, 1320, 1330의 수신신호를 사전에 정해진 규칙에 따라 더하여 두 개의 송신안테나에 대한 수신신호를 생성한다.

[0138] 이 경우, 8개의 안테나 포트에 대한 CSI-RS 수신 신호를 네 개의 송신안테나에 대한 수신신호로 변환하기 위한 일 예로, 상기 도 13의 1300, 1310, 1320, 1330을 두 쌍씩 더하여 네 개의 송신안테나에 대한 수신신호를 얻는 방법을 고려해볼 수 있다. 이와 같이 두 쌍씩 더하여 네 개의 송신안테나에 대한 수신신호를 얻는 경우 기지국과 단말은 각 쌍이 어느 위치의 CSI-RS 수신신호를 더하여 얻어지는지를 사전에 약속한대로 수행해야 한다. 즉, 단말과 기지국이 1300과 1320을 더하고 1310과 1330을 더하기로 약속한 경우 단말은 언제나 이와 같은 조합으로 수신신호를 더해야 한다.

[0139] 도 11는 본 발명의 실시예에 따른 기지국의 내부 구조를 도시하는 블록도이다.

[0140] 상기 도 11에서 기지국의 장치 1100인 제어기는 다음의 사항을 결정한다.

[0141] - RI/PMI reporting disable 여부 및 이와 관련된 대한 설정 정보를 단말에게 통보

[0142] - RI/PMI reporting이 disable되었을 경우 CRS와 CSI-RS 중 어느 것을 단말에게 측정하도록 할지 및 이와 관련된 설정 정보를 단말에게 통보

[0143] - RI/PMI reporting이 disable되었을 경우 주파수 및 시간영역에서 어떤 프리코딩을 가정하여 CQI를 생성할지 및 이와 관련된 설정 정보를 단말에게 통보

[0144] 상기의 결정 사항이 이루어지면 제어기 1100은 RI/PMI reporting과 관련된 설정 정보, 어떤 RS를 이용할지에 대한 설정 정보, 어떤 프리코딩 집합을 가정할지 등에 대한 설정 정보를 결정하고 전송신호를 생성한다. 상기 장치 1100에서 생성된 전송신호는 CRS 신호 생성기 1110 및 CSI-RS 신호 생성기 1120에서 생성된 전송신호와 함께 장치 1130 멀티플렉서(multiplexor)에서 주파수영역 또는 시간영역에서 먹싱(muxing)되어 장치 1140의 OFDMA 신호발생기를 이용하여 전송된다.

[0145] 상기한 제어기 1100가 수행하는 동작을 정리하면, 제어기1100는 상기 단말의 RI/PMI 보고 불능 여부를 결정하고, 상기 단말의 RI/PMI 보고 불능 결정 시 CRS 또는 CSI-RS 중 단말이 측정할 기준 신호를 결정하며, 상기 결정된 기준 신호를 상기 단말에게 통보하고, 상기 결정된 기준 신호를 측정하여 단말이 생성한 제1 채널 정보를 상기 단말로부터 수신하며, 상기 제1 채널 정보에 기반하여 상기 단말에게 데이터를 전송하도록 제어할 수 있다.

[0146] 한편, 제어기 1100는 상기 단말의 RI/PMI 보고 결정 시 상기 단말이 CSI-RS를 측정하도록 통보하고, 상기 단말이 상기 CSI-RS를 측정하여 생성한 제2 채널 정보를 수신하며, 상기 제2 채널 정보에 기반하여 상기 단말에게 데이터를 전송하도록 제어할 수 있다.

[0147] 본 발명의 일 실시예에 따르면, 제어기 1100는 상기 단말이 측정하도록 결정된 기준 신호 정보를 비트 형식으로 지시하는 기준 신호 측정 정보를 생성하여 상기 단말에 직접적으로 통보할 수 있다. 이 경우, 제어기 1100는 상위 시그널링 또는 물리계층 시그널링을 통해 상기 기준 신호 측정 정보를 단말에게 전송할 수 있다.

[0148] 한편, 본 발명의 다른 실시예에 따르면, 제어기 1100는 간섭 측정 자원을 상기 단말에게 통보하거나 또는 복수개의 피드백을 상기 단말에게 통보하고, 상기 단말이 CSI-RS를 측정하여 생성한 제3 채널 정보를 상기 단말로부

터 수신하도록 제어할 수도 있다. 이는 단말이 측정할 기준 신호의 종류를 간접적으로 단말에게 통보해주는 실시예에 대한 기술이다.

[0149] 또한, 제어기 1100는 특정 프리코더가 적용된 데이터를 상기 단말에 전송하도록 제어할 수 있다. 이 경우, 상기 프리코더는, 상기 프리코더가 속한 집합 및 각 서브밴드에 적용될 프리코더가 미리 결정된 것일 수 있다.

[0150] 도 12은 본 발명의 실시예에 따른 단말의 내부 구조를 도시하는 블록도이다.

[0151] 단말기는 장치 1200의 OFDMA 수신기를 통하여 기지국으로부터의 무선신호를 수신한다. 수신된 신호는 장치 1210의 디멀티플렉서(demultiplexor)에서 RI/PMI reporting관련 설정정보를 장치 1230의 제어기로 전달한다.

[0152] 상기 장치 1230의 제어기는 RI/PMI reporting이 disable될 경우 설정정보에 따라 어떤 RS를 이용할지, 어떤 프리코딩을 가정하고 CQI를 생성할지 등을 판단한다. 여기서 판단된 결과에 따라, RI/PMI reporting이 disable될 경우 제어기는 장치 1240의 CSI-RS 수신기에서 검출한 CSI-RS에 적절한 프리코딩을 가정하여 장치 1250(CQI 생성기)에서 CQI를 생성하거나 장치 1220의 CRS 수신기에서 검출한 CRS를 이용하여 장치 1250에서 CQI를 생성한다. 또한, RI/PMI reporting이 enable된 경우, 단말은 CSI-RS를 이용하여 장치 1240의 CSI-RS 수신기에서 검출한 CSI-RS를 이용하여 CQI를 장치 1250에서 생성한다.

[0153] 상기한 제어기 1230가 수행하는 동작을 정리하면, 상기 제어기 1230는 단말의 RI/PMI 보고 불능 설정 여부에 대한 정보를 기지국으로부터 수신하고, 상기 RI/PMI 보고 불능 설정 시 CRS 또는 CSI-RS 중 상기 단말이 측정하도록 결정된 기준 신호에 대한 정보를 상기 기지국으로부터 수신한다. 그리고 제어기 1230는 상기 결정된 기준 신호를 측정하여 제1 채널 정보를 생성하고 상기 기지국으로 전송한다. 그리고 제어기 1230는 상기 제1 채널 정보에 기반하여 전송되는 데이터를 상기 기지국으로부터 수신하도록 제어한다.

[0154] 한편, 제어기 1230는 단말의 RI/PMI 보고 설정 시 상기 CSI-RS를 측정하여 제2 채널 정보를 생성하고, 상기 생성된 제2 채널 정보를 상기 기지국으로 전송하도록 제어할 수 있다.

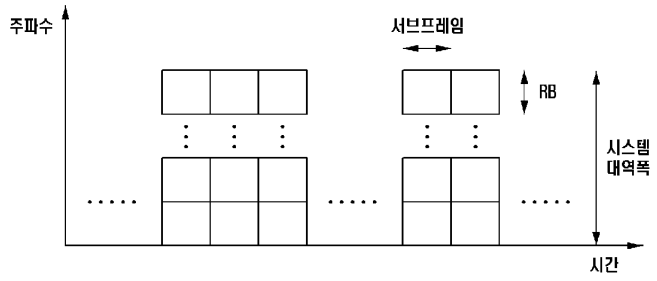
[0155] 본 발명의 일 실시예에 따르면, 제어기 1230는 상기 단말이 측정하도록 결정된 기준 신호 정보를 비트 형식으로 지시하는 기준 신호 측정 정보를 기지국으로부터 명시적으로 수신할 수 있다. 이 경우, 상기 기준 신호 측정 정보는 상위 시그널링 또는 물리계층 시그널링을 통해 상기 기지국으로부터 수신될 수 있다.

[0156] 반면, 본 발명의 다른 실시예에 따르면, 제어기 1230는 기지국으로부터 간섭 측정 자원을 통보받거나 또는 복수개의 피드백을 보고하도록 통보받는 경우, 이를 CSI-RS를 측정하라는 간접적 통보방법으로 인지하고, 상기 CSI-RS를 측정하여 제3 채널 정보를 생성할 수 있다.

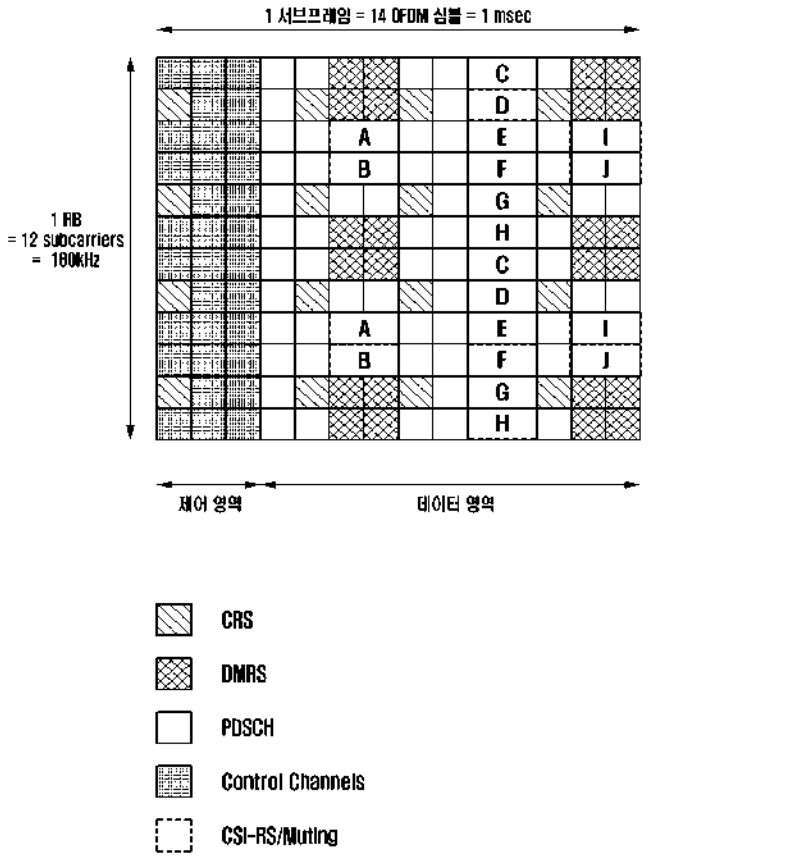
[0157] 본 명세서와 도면에 개시된 본 발명의 실시예들은 본 발명의 기술 내용을 쉽게 설명하고 본 발명의 이해를 돕기 위해 특정 예를 제시한 것일 뿐이며, 본 발명의 범위를 한정하고자 하는 것은 아니다. 여기에 개시된 실시예들 이외에도 본 발명의 기술적 사상에 바탕을 둔 다른 변형 예들이 실시 가능하다는 것은 본 발명이 속하는 기술 분야에서 통상의 지식을 가진 자에게 자명한 것이다.

도면

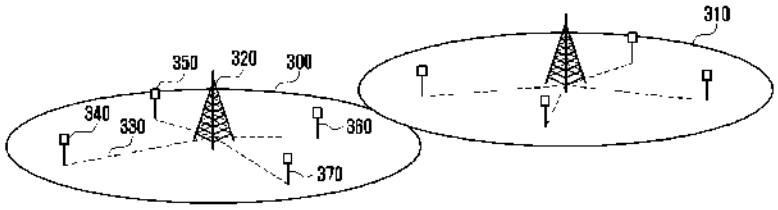
도면1



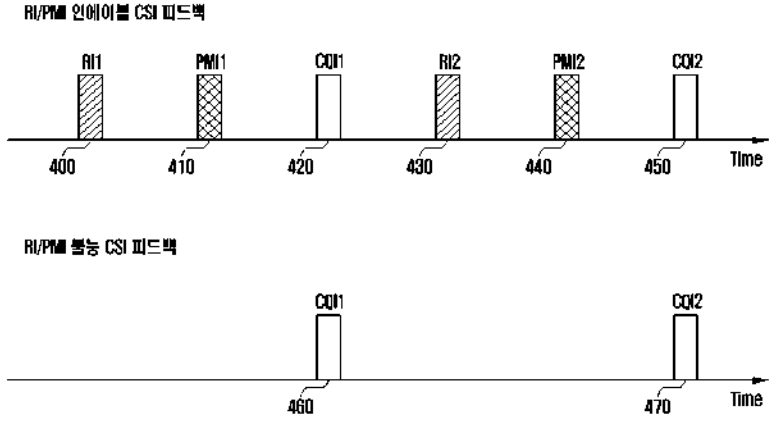
도면8


1 서브프레임 = 14 OFDM 심볼 = 1 msec
1 RB
= 12 subcarriers
= 180kHz
C
D
A
E
I
B
F
J
G
H
C
D
A
E
I
B
F
J
G
H
제어 영역
데이터 영역
CRS
DMRS
PDSCH
Control Channels
CSI-RS/Muting

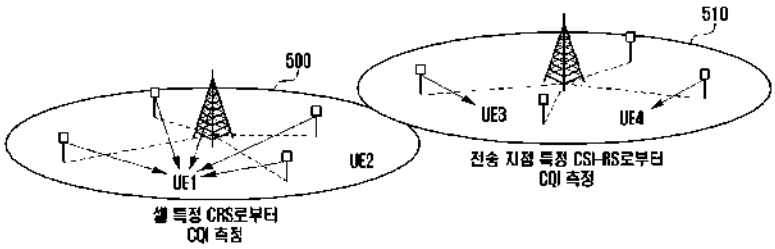
도면9


310
350
320
300
340
330
360
370

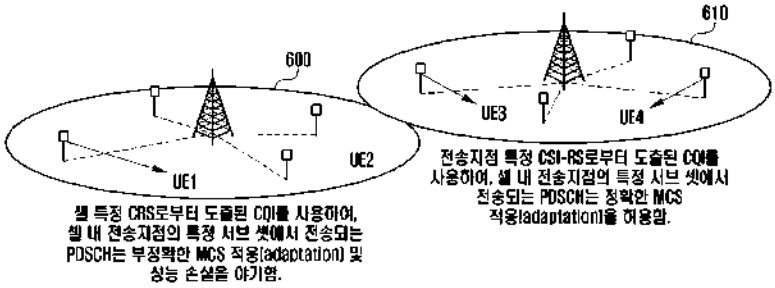
도 4


RI/PMI 인에이블 CSI 피드백
RI1
PMI1
CQI1
RI2
PMI2
CQI2
400
410
420
430
440
450
Time
RI/PMI 디스에이블 CSI 피드백
CQI1
CQI2
460
470
Time

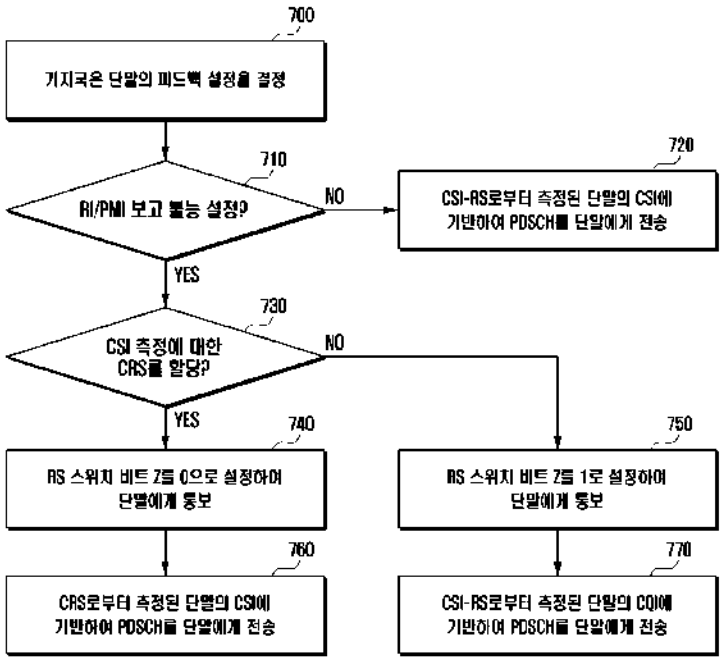
도 5


500
510
UE1
UE2
UE3
UE4
셀 특정 CRS로부터
CQI 측정
전송 지점 특정 CSI-RS로부터
CQI 측정

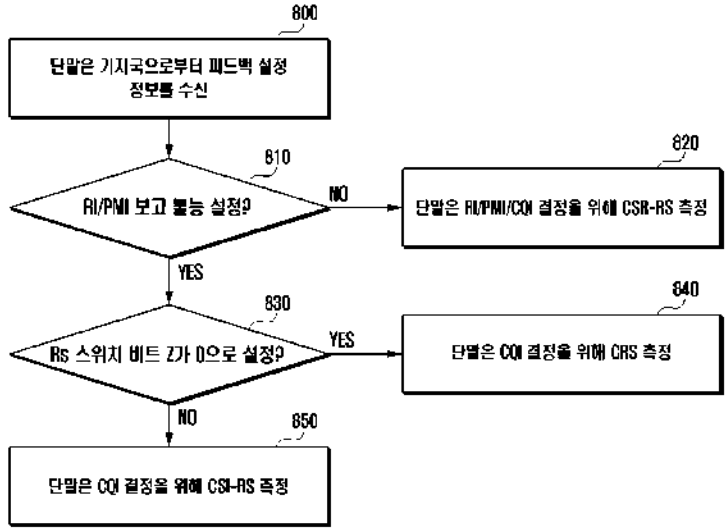
도 6


600
610
UE1
UE2
UE3
UE4
셀 특정 CRS로부터 도출된 CQI를 사용하여,
셀 내 전송지점의 특정 서브 셋에서 전송되는
PDSCH는 부정확한 MCS 적응(adaptation) 및
성능 손실을 야기함.
전송지점 특정 CSI-RS로부터 도출된 CQI를
사용하여, 셀 내 전송지점의 특정 서브 셋에서
전송되는 PDSCH는 정확한 MCS
적응(adaptation)을 허용함.

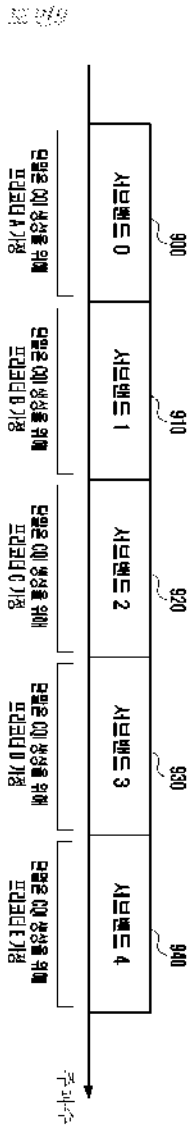
도면7


700
기지국은 단말의 피드백 설정을 결정
710
RI/PMI 보고 불능 설정?
NO
720
CSI-RS로부터 측정된 단말의 CSI에 기반하여 PDSCH를 단말에게 전송
YES
730
CSI 측정에 대한 CRS를 할당?
NO
YES
740
RS 스위치 비트 Z를 0으로 설정하여 단말에게 통보
750
RS 스위치 비트 Z를 1로 설정하여 단말에게 통보
760
CRS로부터 측정된 단말의 CSI에 기반하여 PDSCH를 단말에게 전송
770
CSI-RS로부터 측정된 단말의 CQI에 기반하여 PDSCH를 단말에게 전송

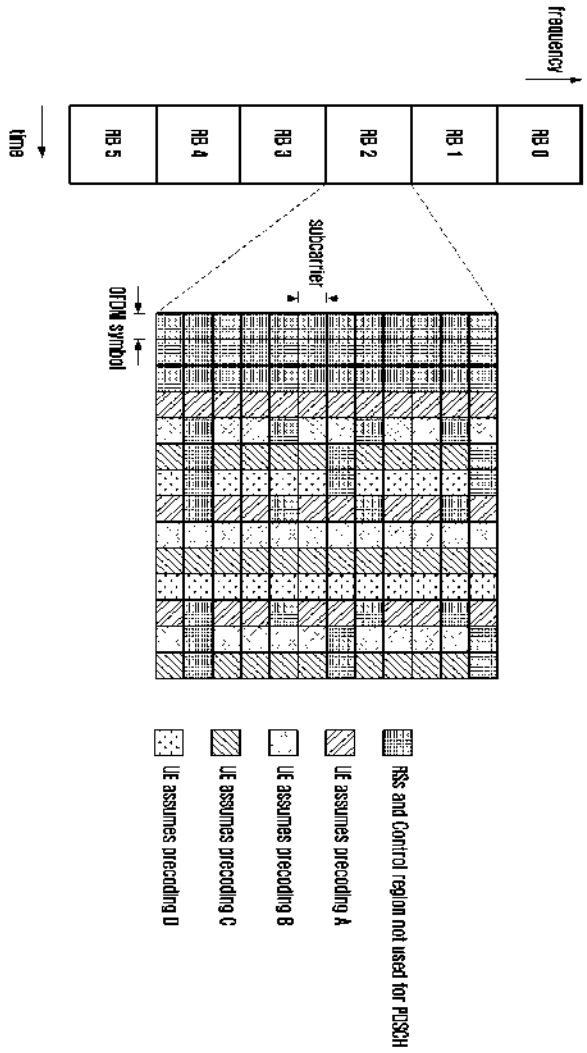
도면8


800
단말은 기지국으로부터 피드백 설정 정보를 수신
810
RI/PMI 보고 불능 설정?
NO
820
단말은 RI/PMI/CQI 결정을 위해 CSR-RS 측정
YES
830
Rs 스위치 비트 Z가 0으로 설정?
YES
840
단말은 CQI 결정을 위해 CRS 측정
NO
850
단말은 CQI 결정을 위해 CSI-RS 측정

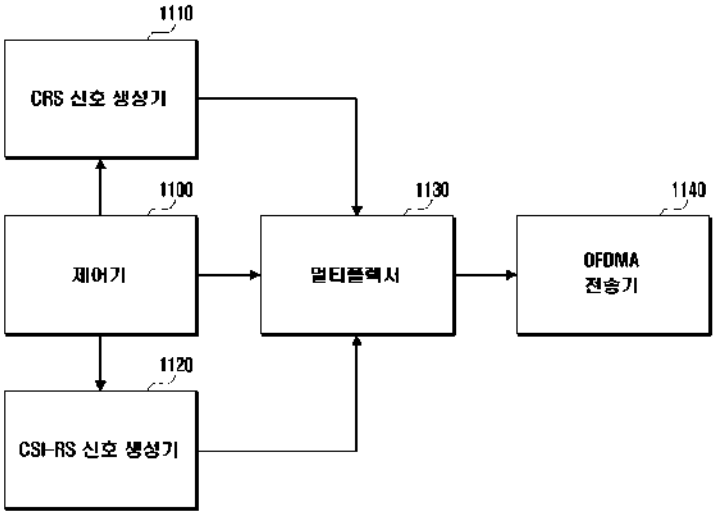
도면


서브프레임 0
서브프레임 1
서브프레임 2
서브프레임 3
서브프레임 4
900
910
920
930
940
하향링크 CC 상에서 제어 정보를 위한 영역
하향링크 CC 상에서 데이터 전송을 위한 영역
주파수

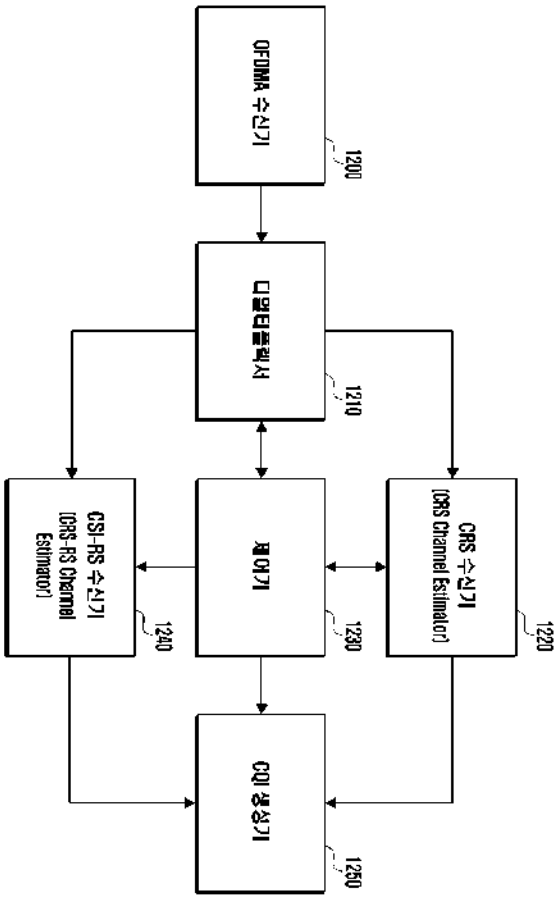
도면10


frequency
time
RB 0
RB 1
RB 2
RB 3
RB 4
RB 5
subcarrier
OFDM symbol
RSs and Control region not used for PDSCH
UE assumes precoding A
UE assumes precoding B
UE assumes precoding C
UE assumes precoding D

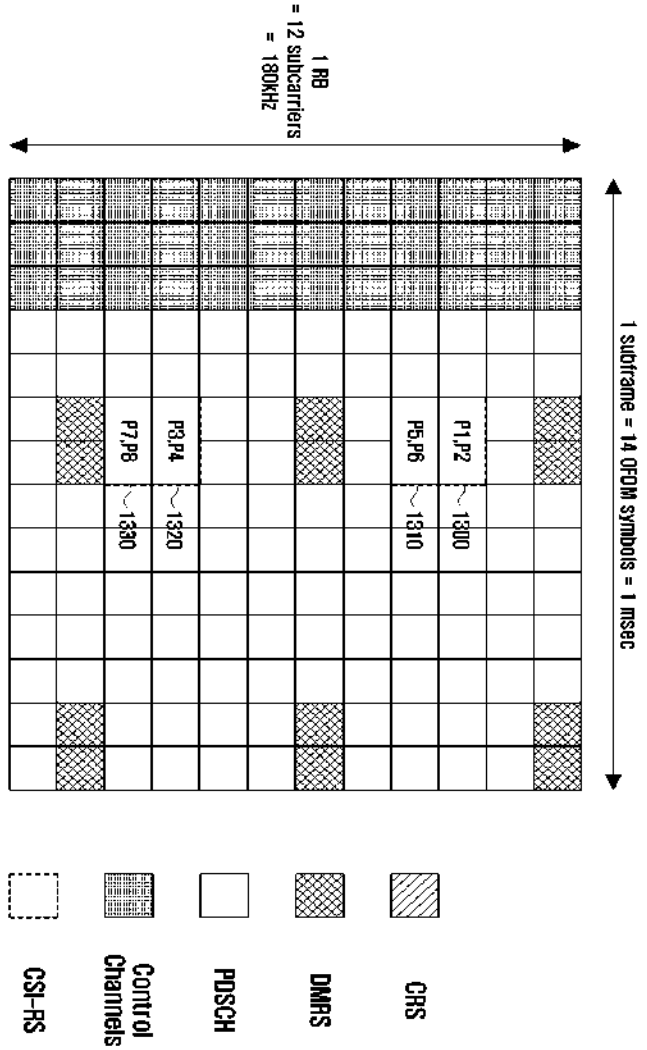
도면11


1110
CRS 신호 생성기
1100
제어기
1130
멀티플렉서
1140
OFDMA
전송기
1120
CSI-RS 신호 생성기

도면12


OFDMA 수신기
1200
디멀티플렉서
1210
CSI-RS 수신기
[CRS-RS Channel
Estimator]
1240
제어기
1230
CRS 수신기
[CRS Channel Estimator]
1220
CQI 생성기
1250

도면13


1 RB
= 12 subcarriers
= 180KHz
1 subframe = 14 OFDM symbols = 1 msec
P1,P2
~1300
P5,P6
~1310
P3,P4
~1320
P7,P8
~1330
CRS
DMRS
PDSCH
Control Channels
CSI-RS

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(54) Title: COMMUNICATION QUALITY MEASUREMENT METHOD AND DEVICE

(54) 发明名称 : 一种通信质量测量的方法和装置

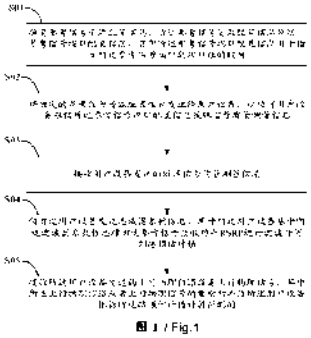


图 1 / Fig.1

501 Resource configuration information, wherein the reference signal resource configuration information comprises: reference signal port configuration information, and the reference signal port configuration information is used for indicating the mapping from a reference signal port to a port group

502 Sending the determined reference signal resource configuration information to a user equipment, so that the user equipment acquires signal quality measurement information according to the reference signal port configuration information

503 Receiving the signal quality measurement information sent by the user equipment

504 Sending filter coefficient information to the user equipment for the user equipment to filter reference signal receiving power (RSRP) based on the filter coefficient information and to obtain a path loss estimation value 505 Receiving an uplink physical channel or an uplink physical signal sent by the user equipment, wherein the transmitting power of the uplink physical channel or the uplink physical signal is obtained by the user equipment according to the calculation of the path loss estimation value

(57) **Abstract**: A method and device for indicating signal power. The method comprises: acquiring reference signal resource configuration information, wherein the reference signal resource configuration information at least comprises: reference signal port configuration information, and reference signal power information of at least one port group; or the reference signal resource configuration information at least comprises: the reference signal port configuration information, and a ratio of the power of a data channel with respect to the power of a reference signal in at least one port group; and sending the acquired reference signal resource configuration information to a user equipment. As a result, accurate signal quality measurement information or more accurate channel state information is acquired in a multi-antenna system.

(57) **摘要**: 一种用于指示信号功率的方法和装置，其中，该方法包括：获取参考信号资源配置信息，其中，所述参考信号资源配置信息至少包括：参考信号端口配置信息，和至少一个端口组的参考信号功率信息；或者，所述参考信号资源配置信息至少包括：参考信号端口配置信息，和至少一个端口组中的数据信道的功率相对于参考信号的功率的比值；将获取的参考信号资源配置信息发送给用户设备。使得在多天线系统中获取到准确的信号质量测量信息，或者获取到更准确的信道状态信息。

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RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG)。

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一种通信质量测量的方法和装置

技术领域

本发明涉及通信技术领域，特别涉及一种通信质量测量的方法和装置。

背景技术

在通信技术领域中，信号通常可以划分为两类，一类信号携带来自高层的信息，另一类信号则不携带来自高层的信息，该类信号通常用于辅助或者指示前一类信号的接收。信号的发射功率对于上述两类信号都是非常重要的参数，例如：参考信号的功率可以用于导出路径损耗估计值，该路径损耗估计值可以作为开环控制的一部分实现上行功率控制，或者作为小区（或者发射节点，或者接收节点）选择的基础。物理下行共享信道（PDSCH，Physical Downlink Shared CHannel）信号相对于参考信号（如：小区特定的参考信号（CRS，Cell-Specific Reference Signal）或者信道状态信息参考信号(CSI-RS, Channel State Information Reference Signal)的功率比值，可以用于导出信道状态信息（CSI，Channel State Information），便于实现调度和链路自适应。

在现有长期演进（LTE，Long Time Evolution） R8—R11版本中，与功率有关的参数是由基站或者网络侧确定，并通过高层信令通知给用户设备（UE，User Equipment）。由于传统基站天线配置具有固定的下倾角，上行和下行链路经历类似的路径损耗，从而下行路径损耗可以很好地用于估计上行路径损耗。因此，上述基站或者网络侧发送的功率有关的参数可以不区分天线端口，尤其是多个天线端口的情况，不区分天线端口的情况下，通过下行路径损耗可以很好地用于估计上行路径损耗。该技术对于传统基站天线配置特别是各个天线端口发射功率相同的情况可以很好的工作。另一方面，用户设备（User Equipment，UE）上报的本小区/节点或者邻小区/节点的参考信号接收功率（RSRP，Reference Signal Received Power）可以用于基站或者演进节点B（evolved Node，eNB）为UE选择服务小区或者节点。现有技术中RSRP是由不同天线口之间进行平均从而得到估计。

为了降低系统费用同时达到更高的系统容量和覆盖要求，有源天线系统（AAS，Active Antenna System）在实践中已广泛部署，目前即将启动的LTE R12标准正在考虑引入AAS系统之后对通信性能的增强。有别于传统的基站天线，

AAS进一步提供了天线垂直向的设计自由度，上行和下行链路可以采用独立的下倾角，并且，不同天线端口的功率可能不同。此外，对于AAS基站而言，即使相同数量的天线端口，其天线阵列结构也可能不同。从而相同编号的天线端口，在不同阵列结构的天线端口也可能有不同的发射功率。在这种情况下，现有技术中基于下行参考信号接收功率实现功率控制，或者小区/节点选择的方法将不再有效。现有技术中，无法正确区分天线口发射功率不同的情况，不能提供准确有效估计上行路径损耗，以及估计信道状态信息的技术方案。

发明内容

本发明实施例提供一种通信质量测量的方法和装置，克服了现有技术中不能在多天线系统中获取到准确的信号质量测量信息，或者获取到更准确的信道状态信息的问题。

第一方面，提供了一种通信质量测量的方法，包括：

确定参考信号资源配置信息，所述参考信号资源配置信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系；

将所述参考信号资源配置信息发送给用户设备，以使得所述用户设备根据所述参考信号端口配置信息获取信号质量测量信息。

在第一种可能的实现方式中，根据第一方面，所述参考信号资源配置信息还包括：至少两个端口组的参考信号功率信息，用于所述用户设备根据所述参考信号端口配置信息并结合所述至少两个端口组的参考信号功率信息，获取所述信号质量测量信息；

其中，所述至少两个端口组的参考信号功率信息，包括：

第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的比值；

或者，第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的差分。

在第二种可能的实现方式中，结合第一方面或第一种可能的实现方式，所述信号质量测量信息为参考信号接收功率 RSRP，所述方法还包括：

向所述用户设备发送滤波器系数信息，用于所述用户设备基于所述滤波器

系数信息对所述参考信号接收功率 RSRP 进行滤波并得到路损估计值。

在第三种可能的实现方式中，结合第二种可能的实现方式，所述方法还包括:

接收所述用户设备发送的上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率为所述用户设备根据所述路损估计值计算得到的。

在第四种可能的实现方式中，结合第一方面或第一种可能的实现方式，所述信号质量测量信息包括:

参考信号接收功率 RSRP，参考信号接收质量 RSRQ，或者参考信号强度指示 RSSI 其中任一项或者任意组合。

在第五种可能的实现方式中，结合第一方面或第一种可能的实现方式至第四种可能的实现方式的任意一种，其特征在于，所述方法还包括:

接收用户设备发送的所述信号质量测量信息。

第二方面，提供了一种通信质量测量的方法，包括:

接收基站发送的参考信号资源配置信息，所述参考信号资源配置信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系;

根据所述参考信号端口配置信息，得到至少一个端口组中的参考信号端口信息;

根据所述至少一个端口组中的参考信号端口信息获取信号质量测量信息。

在第一种可能的实现方式中，根据第二方面，所述根据所述参考信号端口配置信息，得到至少一个端口组中的参考信号端口信息包括:

根据所述参考信号端口配置信息，得到指定的一个端口组中的参考信号端口信息;

所述根据所述至少一个端口组中的参考信号端口信息获取信号质量测量信息包括:

根据所述指定的一个端口组中的参考信号端口信息获取所述信号质量测量信息。

在第二种可能的实现方式中，根据第一方面的第一种可能的实现方式，当

所述信号质量测量信息为参考信号接收功率 RSRP 时，所述根据所述指定的一个端口组中的参考信号端口信息获取所述信号质量测量信息，包括：

根据公式：$RSRP(r,p)=\frac{1}{K_s-1}\sum_{m=0}^{K_s-1}\hat{h}_p(m)\cdot\hat{h}_p(m+1)$ 得到第 r 个接收天线第 p 个端口的参考信号接收功率 $RSRP(r,p)$ 并通过组合 $RSRP(r,p)$ 得到所述 RSRP；其中，$\hat{h}_p(m)$ 为标号为 m 的参考信号 RE 上的信道估计；K_s 是在测量带宽内可利用的参考信号 RE 的样本总数；p 为所述指定的一个端口组中参考信号端口号，r 为接收天线的索引。

在第三种可能的实现方式中，结合第二方面，所述参考信号资源配置信息还包括：至少两个端口组的参考信号功率信息，用于所述用户设备根据所述参考信号端口配置信息并结合所述至少两个端口组的参考信号功率信息获取所述信号质量测量信息。

在第四种可能的实现方式中，结合第二方面第三中可能的实现方式，所述根据所述参考信号端口配置信息并结合至少两个端口组的参考信号功率信息获取信号质量测量信息，包括：

根据所述参考信号端口配置信息得到所述至少两个端口组对应的信号质量测量信息；

根据所述至少两个端口组的参考信号功率信息，对所得到的至少两个端口组对应的信号质量测量信息按端口组功率进行加权平均，得到所述信号质量测量信息。

在第五种可能的实现方式中，结合第二方面第四中可能的实现方式，所述根据所述至少两个端口组的参考信号功率信息，对所得到的至少两个端口组对应的信号质量测量信息按端口组功率进行加权平均，得到信号质量测量信息，包括：

根据公式：$SQ=\left(\sum_{g=0}^{n-1}p_g\cdot SQ_g\right)\Big/\left(\sum_{g=0}^{n-1}p_g\right)$，得到信号质量测量信息，

其中，SQ_g 为指定端口组的信号质量测量信息，其中，g 为指定端口组的编号，n 为指定端口组的个数，$n\geq 2$；p_g 为指定端口组的参考信号功率，其中，

指定端口组的参考信号功率根据所述至少两个端口组的参考信号功率信息得到。

在第六种可能的实现方式中，结合第二方面第二种可能的实现方式至第五种可能的实现方式的任意一种，所述至少两个端口组的参考信号功率信息，包括:

第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的比值;

或者，第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的差分。

在第七种可能的实现方式中，结合第二方面至第六种可能的实现方式的任意一种，所述方法还包括:

向基站发送所述信号质量测量信息。

在第八种可能的实现方式中，结合第二方面至第七种可能的实现方式的任意一种，所述信号质量测量信息为参考信号接收功率 RSRP，所述方法还包括:

接收基站发送的滤波器系数信息;

基于所述滤波器系数信息对所述参考信号接收功率 RSRP 进行滤波，并得到路损估计值。

在第九种可能的实现方式中，结合第二方面的第八种可能的实现方式，所述方法还包括:

向基站发送上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率根据所述路损估计值计算得到。

在第十种可能的实现方式中，结合第二方面，所述信号质量测量信息，包括: 参考信号接收功率 RSRP，参考信号强度指示 RSSI，或者参考信号接收质量 RSRQ。

第三方面，提供一种通信质量测量的方法，包括:

向用户设备发送参考信号资源配置信息，所述参考信号资源配置信息包括: 参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射关系，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功率比值;

接收用户设备发送的信道状态信息 CSI，其中，所述 CSI 为所述用户设备根据所述参考信号端口配置信息和所述功率比值信息得到。

在第一种可能的实现方式中，根据第三方面，在所述功率比值信息中：

所述至少一个端口组中的每个端口组内的各天线端口上数据信道相对于参考信号的功率比值都相同；

或者，所述至少一个端口组中的一个端口组内各个端口上的数据信道与其它端口组内各个端口的数据信道相对于参考信号的功率比值相同。

在第二种可能的实现方式中，根据第三方面或者第三方面第一种可能的实现方式，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的多套功率比值，

所述接收用户设备发送的信道状态信息 CSI，包括接收用户设备发送的多套信道状态信息 CSI，其中每一套信道状态信息 CSI 为所述用户设备根据所述多套功率比值中的一套功率比值得到的。

在第三种可能的实现方式中，结合第三方面或第一种可能的实现方式或第二种可能的实现方式，所述信道状态信息 CSI 包括：信道质量指示 CQI，预编码矩阵指示 PMI，或秩指示 RI 其中任意一个或者任意组合。

第四方面，提供了一种通信质量测量方法，所述方法包括：

接收基站发送的参考信号资源配置信息，所述参考信号资源配置信息包括：参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射关系，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功率比值；

根据所述参考信号端口配置信息和所述功率比值信息，得到所述至少一个端口组内每个天线端口上数据信道相对于参考信号的功率比值，

并根据所述每个天线端口上数据信道相对于参考信号的功率比值，得到信道状态信息 CSI；

向基站发送所述信道状态信息 CSI。

在第一种可能的实现方式中，根据第四方面，所述根据所述每个天线端口上数据信道相对于参考信号的功率比值，得到信道状态信息 CSI，包括：

根据所述每个天线端口上的参考信号得到所述每个天线端口对应的信道

测量值;

根据所述每个天线端口对应的信道测量值，和所述每个天线端口上数据信道相对于参考信号的功率比值，得到所述每个天线端口上数据信道的信道估计值;

根据所述每个天线端口上数据信道的信道估计值得到信道状态信息 CSI。

在第二种可能的实现方式中，结合第一种可能的实现方式，所述根据所述每个天线端口对应的信道测量值，和所述每个天线端口上数据信道相对于参考信号的功率比值，得到所述每个天线端口上数据信道的信道估计值，包括:

根据公式 $\hat{\mathbf{h}}_p = \sqrt{\rho_p}\mathbf{h}_p$ 得到天线端口 p 上数据信道的信道估计值;

其中，p 为所述天线端口的索引，ρ_p 为天线端口 p 上数据信道相对于参考信号的功率比值，$\mathbf{h}_p$ 为天线端口 p 对应的信道测量值，$\hat{\mathbf{h}}_p$ 为天线端口 p 上数据信道的信道估计值。

在第三种可能的实现方式中，结合第四方面或第一种可能的实现方式或第二种可能的实现方式，在所述功率比值信息中，

所述至少一个端口组中的每个端口组内的各天线端口上数据信道相对于参考信号的功率比值相同;

或者，所述至少一个端口组中的一个端口组内的各个端口上的数据信道与其它端口组内各个端口上的数据信道相对于参考信号的功率比值相同。

在第四种可能的实现方式中，结合第四方面，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的多套功率比值;

所述向基站发送所述信道状态信息 CSI，包括:

向基站发送所述多套信道状态信息 CSI，其中每一套信道状态信息 CSI 为根据所述多套功率比值中的一套功率比值得到的。

在第五种可能的实现方式中，结合第四方面或第一种可能的实现方式至第四种可能的实现方式的任意一种，所述信道状态信息 CSI 包括: 信道质量指示 CQI，预编码矩阵指示 PMI，或秩指示 RI 其中任意一个或者任意组合。

第五方面，提供了一种网络侧装置，所述网络侧装置包括: 确定单元，和第一发送单元;

所述确定单元，用于确定参考信号资源配置信息，所述参考信号资源配置

信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系；

所述第一发送单元，用于将所述确定单元确定的所述参考信号资源配置信息发送给用户设备，以使得所述用户设备根据所述参考信号端口配置信息获取信号质量测量信息。

在第一种可能的实现方式中，根据第五方面，所述确定单元确定的所述参考信号资源配置信息还包括：至少两个端口组的参考信号功率信息，用于所述用户设备根据所述参考信号端口配置信息并结合所述至少两个端口组的参考信号功率信息，获取所述信号质量测量信息；

其中，所述至少两个端口组的参考信号功率信息，包括：

第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的比值；

或者，第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的差分。

在第二种可能的实现方式中，结合第五方面或第一种可能的实现方式，当所述信号质量测量信息为参考信号接收功率 RSRP 时，所述第一发送单元还用于向所述用户设备发送滤波器系数信息，用于所述用户设备基于所述滤波器系数信息对所述参考信号接收功率 RSRP 进行滤波并得到路损估计值。

在第三种可能的实现方式中，结合第二种可能的实现方式，所述装置还包括：

第一接收单元，用于接收所述用户设备发送的上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率为所述用户设备根据所述路损估计值计算得到的。

在第四种可能的实现方式中，结合第五方面或第一种可能的实现方式，所述信号质量测量信息包括：

参考信号接收功率 RSRP，参考信号接收质量 RSRQ，或者参考信号强度指示 RSSI 其中任一项或者任意组合。

在第五种可能的实现方式中，结合第五方面或第一种可能的实现方式至第四种可能的实现方式的任意一种，其特征在于，所述装置还包括：第二接收单

元，

所述第二接收单元用于接收用户设备发送的所述信号质量测量信息。

第六方面，提供了一种用户设备，所述用户设备包括：第三接收单元，第一获取单元，和第二获取单元；

所述第三接收单元，用于接收基站发送的参考信号资源配置信息，所述参考信号资源配置信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系；

所述第一获取单元，用于根据所述第三接收单元接收的所述参考信号端口配置信息，得到至少一个端口组中的参考信号端口信息；

所述第二获取单元，用于根据所述第一获取单元得到所述至少一个端口组中的参考信号端口信息获取信号质量测量信息。

在第一种可能的实现方式中，根据第六方面，所述第一获取单元，具体用于根据所述第三接收单元接收的所述参考信号端口配置信息，得到指定的一个端口组中的参考信号端口信息；

所述第二获取单元，具体用于根据所述第一获取单元得到的所述指定的一个端口组中的参考信号端口信息获取所述信号质量测量信息。

在第二种可能的实现方式中，根据第六方面的第一种可能的实现方式，当所述信号质量测量信息为参考信号接收功率 RSRP 时，所述第二获取单元具体用于：

根据公式：$$RSRP(r,p)=\frac{1}{K_s-1}\sum_{m=0}^{K_s-1}\hat{h}_p(m)\cdot\hat{h}_p(m+1)$$ 得到第 r 个接收天线第 p 个端口的参考信号接收功率 $RSRP(r,p)$ 并通过组合 $RSRP(r,p)$ 得到所述 RSRP；其中，$\hat{h}_p(m)$ 为标号为 m 的参考信号 RE 上的信道估计；K_s 是在测量带宽内可利用的参考信号 RE 的样本总数；p 为所述指定的一个端口组中参考信号端口号，r 为接收天线的索引。

在第三种可能的实现方式中，结合第六方面，所述第三接收单元接收的所述参考信号资源配置信息还包括：至少两个端口组的参考信号功率信息，

所述第二获取单元还用于根据所述参考信号端口配置信息并结合所述至少两个端口组的参考信号功率信息获取所述信号质量测量信息。

在第四种可能的实现方式中，结合第六方面第三中可能的实现方式，所述第二获取单元具体用于：

根据所述参考信号端口配置信息得到所述至少两个端口组对应的信号质量测量信息；

根据所述至少两个端口组的参考信号功率信息，对所得到的至少两个端口组对应的信号质量测量信息按端口组功率进行加权平均，得到所述信号质量测量信息。

在第五种可能的实现方式中，结合第六方面第四中可能的实现方式，所述第二获取单元根据所述至少两个端口组的参考信号功率信息，对所得到的至少两个端口组对应的信号质量测量信息按端口组功率进行加权平均，得到所述信号质量测量信息，包括

根据公式：$SQ=\left(\sum_{g=0}^{n-1}p_g\cdot SQ_g\right)\Big/\left(\sum_{g=0}^{n-1}p_g\right)$，得到信号质量测量信息，

其中，SQ_g 为指定端口组的信号质量测量信息，其中，g 为指定端口组的编号，n 为指定端口组的个数，$n\geq 2$；p_g 为指定端口组的参考信号功率，其中，指定端口组的参考信号功率根据所述至少两个端口组的参考信号功率信息得到。

在第六种可能的实现方式中，结合第六方面第二种可能的实现方式至第五种可能的实现方式的任意一种，所述第三接收单元接收到的所述至少两个端口组的参考信号功率信息包括：

第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的比值；

或者，第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的差分。

在第七种可能的实现方式中，结合第六方面至第六种可能的实现方式的任意一种，所述用户设备还包括：第二发送单元，用于向基站发送所述信号质量

测量信息。

在第八种可能的实现方式中，结合第六方面至第七种可能的实现方式的任意一种，所述第三接收单元，还用于当所述信号质量测量信息为参考信号接收功率 RSRP，接收基站发送的滤波器系数信息；

所述用户设备还包括：第三获取单元，

所述第三获取单元，用于基于所述第三接收单元接收的所述滤波器系数信息对所述参考信号接收功率 RSRP 进行滤波，并得到路损估计值。

在第九种可能的实现方式中，结合第六方面的第八种可能的实现方式，所述用于装置还包括：第三发送单元，

所述第三发送单元，还用于向基站发送上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率根据所述路损估计值计算得到。

在第十种可能的实现方式中，结合第六方面，所述信号质量测量信息，包括：参考信号接收功率 RSRP，参考信号强度指示 RSSI，或者参考信号接收质量 RSRQ。

第七方面，提供了一种网络侧装置，所述装置包括：第四发送单元，第四接收单元；

所述第四发送单元，用于向用户设备发送参考信号资源配置信息，所述参考信号资源配置信息包括：参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射关系，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功率比值；

所述第四接收单元，用于接收用户设备发送的信道状态信息 CSI，其中，所述 CSI 为所述用户设备根据所述参考信号端口配置信息和所述功率比值信息得到。

在第一种可能的实现方式中，根据第七方面，在所述功率比值信息中：

所述至少一个端口组中的每个端口组内的各天线端口上数据信道相对于参考信号的功率比值都相同；

或者，所述至少一个端口组中的一个端口组内各个端口上的数据信道与其

它端口组内各个端口的数据信道相对于参考信号的功率比值相同;

在第二种可能的实现方式中,根据第七方面或者第七方面第一种可能的实现方式,所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的多套功率比值,

所述第四接收单元,具体用于接收用户设备发送的多套信道状态信息CSI,其中每一套信道状态信息CSI为所述用户设备根据所述多套功率比值中的一套功率比值得到的。

在第三种可能的实现方式中,结合第七方面或第一种可能的实现方式或第二种可能的实现方式,所述第四接收单元接收的所述信道状态信息CSI包括:信道质量指示CQI,预编码矩阵指示PMI,或秩指示RI其中任意一个或者任意组合。

第八方面,提供了一种用户设备,所述用户设备包括:第五接收单元,第四获取单元,第五获取单元,和第五发送单元;

所述第五接收单元,用于接收基站发送的参考信号资源配置信息,所述参考信号资源配置信息包括:参考信号端口配置信息和功率比值信息,其中,所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射关系,所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功率比值;

所述第四获取单元,用于根据所述第五接收单元接收的所述参考信号端口配置信息和所述功率比值信息,得到所述至少一个端口组内每个天线端口上数据信道相对于参考信号的功率比值;

所述第五获取单元,用于根据所述第四获取单元得到的所述每个天线端口上数据信道相对于参考信号的功率比值,得到信道状态信息CSI;

所述第五发送单元,用于向基站发送所述第五获取单元得到的所述信道状态信息CSI。

在第一种可能的实现方式中,根据第八方面,所述第五获取单元,具体用于:

根据所述每个天线端口上的参考信号得到所述每个天线端口对应的信道测量值;

根据所述每个天线端口对应的信道测量值，和所述每个天线端口上数据信道相对于参考信号的功率比值，得到所述每个天线端口上数据信道的信道估计值；

根据所述每个天线端口上数据信道的信道估计值得到信道状态信息 CSI。

在第二种可能的实现方式中，结合第一种可能的实现方式，所述第五获取单元根据所述每个天线端口对应的信道测量值，和所述每个天线端口上数据信道相对于参考信号的功率比值，得到所述每个天线端口上数据信道的信道估计值，包括：

根据公式 $\hat{\mathbf{h}}_p = \sqrt{\rho_p}\mathbf{h}_p$ 得到天线端口 p 上数据信道的信道估计值；

其中，p 为所述天线端口的索引，ρ_p 为天线端口 p 上数据信道相对于参考信号的功率比值，$\mathbf{h}_p$ 为天线端口 p 对应的信道测量值，$\hat{\mathbf{h}}_p$ 为天线端口 p 上数据信道的信道估计值。

在第三种可能的实现方式中，结合第八方面或第一种可能的实现方式或第二种可能的实现方式，在所述功率比值信息中，

所述至少一个端口组中的每个端口组内的各天线端口上数据信道相对于参考信号的功率比值相同；

或者，所述至少一个端口组中的一个端口组内的各个端口上的数据信道与其它端口组内各个端口上的数据信道相对于参考信号的功率比值相同。

在第四种可能的实现方式中，结合第八方面，所述第五接收单元接收的所述参考信号资源配置信息包括：参考信号端口配置信息和功率比值信息；

其中，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的多套功率比值；

所述第五发送单元，具体用于：

向基站发送所述多套信道状态信息 CSI，其中每一套信道状态信息 CSI 为根据所述多套功率比值中的一套功率比值得到的。

在第五种可能的实现方式中，结合第八方面或第一种可能的实现方式至第四种可能的实现方式的任意一种，所述第五获取单元得到的所述信道状态信息

CSI 包括：信道质量指示 CQI，预编码矩阵指示 PMI，或秩指示 RI 其中任意一个或者任意组合。

第九方面，提供了一种网络侧装置，所述网络侧装置包括：接收器、处理器和发射器；其中，

所述处理器，用于确定参考信号资源配置信息，所述参考信号资源配置信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系；

所述发射器，用于将所述参考信号资源配置信息发送给用户设备，以使得所述用户设备根据所述参考信号端口配置信息获取信号质量测量信息。

在第一种可能的实现方式中，根据第九方面，所述处理器确定的所述参考信号资源配置信息还包括：至少两个端口组的参考信号功率信息，用于所述用户设备根据所述参考信号端口配置信息并结合所述至少两个端口组的参考信号功率信息，获取所述信号质量测量信息；

其中，所述至少两个端口组的参考信号功率信息，包括：

第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的比值；

或者，第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的差分。

在第二种可能的实现方式中，结合第九方面或第一种可能的实现方式，当所述信号质量测量信息为参考信号接收功率 RSRP 时，所述发射器还用于向所述用户设备发送滤波器系数信息，用于所述用户设备基于所述滤波器系数信息对所述参考信号接收功率 RSRP 进行滤波并得到路损估计值。

在第三种可能的实现方式中，结合第二种可能的实现方式，所述接收器用于接收所述用户设备发送的上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率为所述用户设备根据所述路损估计值计算得到的。

在第四种可能的实现方式中，结合第九方面或第一种可能的实现方式，所述信号质量测量信息包括：

参考信号接收功率 RSRP，参考信号接收质量 RSRQ，或者参考信号强度

指示 RSSI 其中任一项或者任意组合。

在第五种可能的实现方式中，结合第九方面或第一种可能的实现方式至第四种可能的实现方式的任意一种，所述接收器还用于接收用户设备发送的所述信号质量测量信息。

第十方面，提供了一种用户设备，所述用户设备包括：接收器，处理器和发射器；

所述接收器，用于接收基站发送的参考信号资源配置信息，所述参考信号资源配置信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系；

所述处理器，用于根据所述参考信号端口配置信息，得到至少一个端口组中的参考信号端口信息；根据所述至少一个端口组中的参考信号端口信息获取信号质量测量信息。

在第一种可能的实现方式中，根据第十方面，所述处理器，具体用于：

根据所述参考信号端口配置信息，得到指定的一个端口组中的参考信号端口信息；

根据所述指定的一个端口组中的参考信号端口信息获取所述信号质量测量信息。

在第二种可能的实现方式中，根据第十方面的第一种可能的实现方式，当所述信号质量测量信息为参考信号接收功率 RSRP 时，所述处理器根据所述指定的一个端口组中的参考信号端口信息获取所述信号质量测量信息，包括：

根据公式：$RSRP(r,p)=\frac{1}{K_s-1}\sum_{m=0}^{K_s-1}\hat{h}_p(m)\cdot\hat{h}_p(m+1)$ 得到第 r 个接收天线第 p 个端口的参考信号接收功率 $RSRP(r,p)$ 并通过组合 $RSRP(r,p)$ 得到所述 RSRP；其中，$\hat{h}_p(m)$ 为标号为 m 的参考信号 RE 上的信道估计；K_s 是在测量带宽内可利用的参考信号 RE 的样本总数；p 为所述指定的一个端口组中参考信号端口号，r 为接收天线的索引。

在第三种可能的实现方式中，结合第十方面，所述接收器接收的所述参考

信号资源配置信息还包括：至少两个端口组的参考信号功率信息，用于所述用户设备根据所述参考信号端口配置信息并结合所述至少两个端口组的参考信号功率信息获取所述信号质量测量信息。

在第四种可能的实现方式中，结合第十方面第三中可能的实现方式，所述处理器根据所述参考信号端口配置信息并结合至少两个端口组的参考信号功率信息获取信号质量测量信息，包括：

根据所述参考信号端口配置信息得到所述至少两个端口组对应的信号质量测量信息；

根据所述至少两个端口组的参考信号功率信息，对所得到的至少两个端口组对应的信号质量测量信息按端口组功率进行加权平均，得到所述信号质量测量信息。

在第五种可能的实现方式中，结合第十方面第四中可能的实现方式，所述处理器根据所述至少两个端口组的参考信号功率信息，对所得到的至少两个端口组对应的信号质量测量信息按端口组功率进行加权平均，得到信号质量测量信息，包括：

根据公式：$SQ = \left(\sum_{g=0}^{n-1} p_g \cdot SQ_g \right) \Big/ \left(\sum_{g=0}^{n-1} p_g \right)$，得到信号质量测量信息，

其中，SQ_g 为指定端口组的信号质量测量信息，其中，g 为指定端口组的编号，n 为指定端口组的个数，$n \geq 2$；p_g 为指定端口组的参考信号功率，其中，指定端口组的参考信号功率根据所述至少两个端口组的参考信号功率信息得到。

在第六种可能的实现方式中，结合第十方面第二种可能的实现方式至第五种可能的实现方式的任意一种，所述接收器接收到的所述至少两个端口组的参考信号功率信息，包括：

第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的比值；

或者，第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的差分。

在第七种可能的实现方式中，结合第十方面至第六种可能的实现方式的任

意一种，所述发射器用于向基站发送所述信号质量测量信息。

在第八种可能的实现方式中，结合第十方面至第七种可能的实现方式的任意一种，当所述信号质量测量信息为参考信号接收功率 RSRP 时，所述接收器还用于接收基站发送的滤波器系数信息；

所述处理器，还用于基于所述滤波器系数信息对所述参考信号接收功率 RSRP 进行滤波，并得到路损估计值。

在第九种可能的实现方式中，结合第十方面的第八种可能的实现方式，所述发射器还用于向基站发送上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率根据所述路损估计值计算得到。

在第十种可能的实现方式中，结合第十方面，所述信号质量测量信息，包括：参考信号接收功率 RSRP，参考信号强度指示 RSSI，或者参考信号接收质量 RSRQ。

第十一方面，提供了一种网络侧装置，所述网络侧装置包括：发射器，和接收器，

所述发射器，用于向用户设备发送参考信号资源配置信息，所述参考信号资源配置信息包括：参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射关系，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功率比值；

所述接收器，用于接收用户设备发送的信道状态信息 CSI，其中，所述 CSI 为所述用户设备根据所述参考信号端口配置信息和所述功率比值信息得到。

在第一种可能的实现方式中，根据第十一方面，在所述功率比值信息中：

所述至少一个端口组中的每个端口组内的各天线端口上数据信道相对于参考信号的功率比值都相同；

或者，所述至少一个端口组中的一个端口组内各个端口上的数据信道与其它端口组内各个端口的数据信道相对于参考信号的功率比值相同。

在第二种可能的实现方式中，根据第十一方面或者第七方面第一种可能的实现方式，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的多套功率比值；

所述接收器接收用户设备发送的信道状态信息 CSI，包括：接收用户设备发送的多套信道状态信息 CSI，其中每一套信道状态信息 CSI 为所述用户设备根据所述多套功率比值中的一套功率比值得到的。

在第三种可能的实现方式中，结合第十一方面或第一种可能的实现方式或第二种可能的实现方式，所述接收器接收的所述信道状态信息 CSI 包括：信道质量指示 CQI，预编码矩阵指示 PMI，或秩指示 RI 其中任意一个或者任意组合。

第十二方面，提供了一种用户设备，所述用户设备包括：接收器，处理器，和发射器；

所述接收器，用于接收基站发送的参考信号资源配置信息，所述参考信号资源配置信息包括：参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射关系，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功率比值；

所述处理器，用于根据所述参考信号端口配置信息和所述功率比值信息，得到所述至少一个端口组内每个天线端口上数据信道相对于参考信号的功率比值，并根据所述每个天线端口上数据信道相对于参考信号的功率比值，得到信道状态信息 CSI；

所述发射器，用于向基站发送所述信道状态信息 CSI。

在第一种可能的实现方式中，根据第十二方面，所述处理器根据所述每个天线端口上数据信道相对于参考信号的功率比值，得到信道状态信息 CSI，包括：

根据所述每个天线端口上的参考信号得到所述每个天线端口对应的信道测量值；

根据所述每个天线端口对应的信道测量值，和所述每个天线端口上数据信道相对于参考信号的功率比值，得到所述每个天线端口上数据信道的信道估计值；

根据所述每个天线端口上数据信道的信道估计值得到信道状态信息 CSI。

在第二种可能的实现方式中，结合第一种可能的实现方式，所述处理器根据所述每个天线端口对应的信道测量值，和所述每个天线端口上数据信道相对

于参考信号的功率比值，得到所述每个天线端口上数据信道的信道估计值，包括:

根据公式$\hat{\mathbf{h}}_p = \sqrt{\rho_p}\mathbf{h}_p$得到天线端口 p 上数据信道的信道估计值；

其中，p为所述天线端口的索引，ρ_p为天线端口 p上数据信道相对于参考信号的功率比值，$\mathbf{h}_p$为天线端口 p对应的信道测量值，$\hat{\mathbf{h}}_p$为天线端口 p上数据信道的信道估计值。

在第三种可能的实现方式中，结合第十二方面或第一种可能的实现方式或第二种可能的实现方式，在所述功率比值信息中，

所述至少一个端口组中的每个端口组内的各天线端口上数据信道相对于参考信号的功率比值相同；

或者，所述至少一个端口组中的一个端口组内的各个端口上的数据信道与其它端口组内各个端口上的数据信道相对于参考信号的功率比值相同。

在第四种可能的实现方式中，结合第十二方面，所述所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的多套功率比值；

所述发射器具体用于:

向所述基站发送所述多套信道状态信息 CSI，其中每一套信道状态信息 CSI 为根据所述多套功率比值中的一套功率比值得到的。

在第五种可能的实现方式中，结合第十二方面或第一种可能的实现方式至第四种可能的实现方式的任意一种，所述处理器得到的所述信道状态信息 CSI 包括：信道质量指示 CQI，预编码矩阵指示 PMI，或秩指示 RI 其中任意一个或者任意组合。

本发明实施例提供一种通信质量测量的方法和装置，将参考信号资源配置信息发送给用户侧 UE，UE 可以根据其中一个端口组或者多个端口组的参考信号质量处理得到最终的信号质量测量信息，使得 UE 侧可以将端口根据不同的端口组进行区分，不同于现有技术中不能区分不同端口的发射功率的情况。因而，一方面，使得 UE 能够获取的信号质量测量信息，可以使得 UE 进行更为准确的小区选择和上行功率控制；另一方面，使得 UE 能够获取的信道状态信息，可以使得 UE 进行更为准确的调制与编码方案（MCS，Modulation and Coding Scheme)选择或者调度，从而提高系统的吞吐量。

附图说明

为了更清楚地说明本发明实施例或现有技术中的技术方案，下面将对实施例或现有技术描述中所需要使用的附图作简单地介绍，显而易见地，下面描述中的附图仅仅是本发明的一些实施例，对于本领域普通技术人员来讲，在不付出创造性劳动性的前提下，还可以根据这些附图获得其他的附图。

图 1 是本发明实施例一提供的一种通信质量测量的方法的流程图；

图 2 是本发明实施例二提供的一种通信质量测量的方法的流程图；

图 3 是不同的均匀线阵天线阵配置示意简图；

图 4 是不同的交叉极化天线阵配置示意简图；

图 5 是本发明实施例三提供的一种通信质量测量的方法的流程图；

图 6 是本发明实施例四提供的一种通信质量测量的方法的流程图；

图 7 是本发明实施例五提供的一种网络侧装置示意简图；

图 8 是本发明实施例六提供的一种用户设备示意简图；

图 9 是本发明实施例七提供的一种网络侧装置示意简图；

图 10 是本发明实施例八提供的一种用户设备示意简图；

图 11 是本发明实施例九提供的一种网络侧装置示意简图；

图 12 是本发明实施例十提供的一种用户设备示意简图；

图 13 是本发明实施例十一提供的一种网络侧装置示意简图；

图 14 是本发明实施例十二提供的一种用户设备示意简图。

具体实施方式

下面将结合本发明实施例中的附图，对本发明实施例中的技术方案进行清楚、完整地描述，显然，所描述的实施例仅仅是本发明一部分实施例，而不是全部的实施例。基于本发明中的实施例，本领域普通技术人员在没有作出创造性劳动前提下所获得的所有其他实施例，都属于本发明保护的范围。

实施例一

本发明实施例提供了一种通信质量测量的方法，如图 1 所示，所述方法包括:

步骤 S01，确定参考信号资源配置信息，所述参考信号资源配置信息包括:参考信号端口配置信息，其中所述参考信号端口配置信息用于指示所述参考信

号端口到端口组的映射;

其中，该操作具体可以是由基站或者网络侧（例如通用陆地无线接入(UTRAN， Universal Terrestrial Radio Access Network)）；或者演进的UTRAN(Evolved UTRAN)，或者演进节点 B（evolved node B）执行。

当所述参考信号资源配置信息包括：参考信号端口配置信息，可选的，参考信号资源配置信息还可以包括：至少一个端口组的参考信号功率信息时，将该参考信号资源配置信息发送给用户设备（UE，User Equipment），使得用户设备根据该参考信号资源配置信息获取信号质量测量信息，由于参考信号端口被分配到多个组，UE 可以根据其中一个端口组或者多个端口组的参考信号质量处理得到最终的信号质量测量信息，使得 UE 侧可以对端口根据不同的端口组进行区分，不同于现有技术中不能区分不同端口的发射功率的情况。因而，该方案获取的信号质量测量信息，可以使得 UE 进行更为准确的小区选择和上行功率控制。

还需要理解的是，对于所述参考信号资源配置信息中包括的参考信号端口配置信息的详细说明，可以参考实施例二中步骤 101 中的说明。

进一步，该参考信号资源配置信息还可以包括：参考信号配置或者参考信号子帧配置其中任一项。使得 UE 可以根据该信息接收参考信号。需要理解的是，但本发明实施例不限制参考信号配置或者参考信号子帧配置其中任一项一定是由参考信号资源配置信息下发给 UE 的，也可以是以其他信息的形式下发给 UE，需要指出的是，所述参考信号配置或者参考信号子帧配置还可以是预定义的，或者根据事先已知的参数如小区 ID 或者 UE ID 隐式导出，为基站或者 UE 所共知；本发明实施例不限制。

步骤 S02，将确定的参考信号资源配置信息发送给用户设备，以使得用户设备根据所述参考信号端口配置信息获取信号质量测量信息。

具体的，上述信号质量测量信息可以包括：

参考信号接收功率 RSRP，参考信号接收质量 RSRQ，或者参考信号强度指示 RSSI 其中任一项或者任意组合。

通过上述实施例一中说明的方法，该方法通过网络侧确定参考信号资源配置信息，并将该参考信号资源配置信息发送给用户侧，所述参考信号资源配置

信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射。所述方法可以避免逐端口指示参考信号功率相关信息从而减少信令开销之外，端口组内各个端口采用统一的功率指示而不同的端口组可以彼此独立指示其功率相关信息，充分利用了天线配置或者天线阵列的结构，从而可以使得系统能够根据天线配置或者天线阵列结构灵活选择参考信号功率相关信息；由于天线阵列可以具有对称的权重，利用该权重的对称性，可以降低波束赋形或者旁瓣抑制的设计复杂性。

进一步，将参考信号资源配置信息发送给用户侧 UE，UE 可以根据其中至少一个端口组的参考信号质量处理得到最终的信号质量测量信息，使得 UE 侧可以将端口根据不同的端口组进行区分，不同于现有技术中不能区分不同端口的发射功率的情况。使得 UE 能够获取的信号质量测量信息，可以使得 UE 进行更为准确的小区选择和上行功率控制。

可选的，所述方法还包括:

步骤 S03：接收用户设备发送的所述信号质量测量信息。

可选的，当信号质量测量信息为参考信号接收功率 RSRP，所述方法还包括:

步骤 S04：向所述用户设备发送滤波器系数信息，用于所述用户设备基于所述滤波器系数信息对所述参考信号接收功率 RSRP 进行滤波并得到路损估计值。

具体的，所述向用户设备发送滤波器系数信息，可以是与步骤 S02 中所述将所确定的参考信号资源配置信息发送给用户设备在同一时间发送，如在相同的子帧发送；也可以是与步骤 S02 中所述将所确定的参考信号资源配置信息发送给用户设备之前或者之后发送；所述滤波器系数信息与所述参考信号资源配置信息可以在相同或者不同的高层信令如 RRC 信令的信元（Information Element,简称 IE）或者下行控制信息（Downlink Control Information，简称 DCI）中发送。

可选的，所述方法还包括:

步骤 S05：接收所述用户设备发送的上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率为所述用户设备根据所述

路损估计值计算得到的。

可选的，所述参考信号资源配置信息还包括：至少两个端口组的参考信号功率信息，用于所述用户设备根据所述参考信号端口配置信息并结合所述至少两个端口组的参考信号功率信息，获取所述信号质量测量信息；

其中，所述至少两个端口组的参考信号功率信息，包括：

第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的比值；

或者，第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的差分。

可选的，所述参考信号端口配置信息为单索引，或者为双索引，或者为联合编码后的索引。

可选的，所述端口组的参考信号功率信息，至少包括：一个端口组中的各端口的参考信号功率相同。

其中，所述第一端口组为所述至少一个端口组中的一个端口组。

实施例二

本发明实施例提供了一种用于通信质量测量的方法，如图 2 所示，该方法包括：

步骤 101，接收基站发送的参考信号资源配置信息，所述参考信号资源配置信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系；

具体的，UE 接收参考信号资源配置信息，可以是 UE 通过高层信令(如：无线资源控制（RRC，Radio Resource Control）信令)或者动态信令(如：下行控制信息（DCI，Downlink Control Information）)，接收 eNB 通知的参考信号资源配置信息，或者基于小区标识（ID，Identity）得到参考信号的资源配置信息。所述高层信令可以通过物理下行共享信道（Physical Downlink Shared Channel，简称 PDSCH）等数据信道发送；所述动态信令如 DCI 通过物理下行控制信道（Physical Downlink Control Channel，简称 PDCCH）或者增强的 PDCCH（Enhanced PDCCH，简称 ePDCCH）等控制信道发送。

需要理解的是，参考信号端口配置信息，用于指示参考信号端口到端口组

的映射，参考信号端口到端口组中的映射关系可以是预定义的，为基站和用户设备所共知，因此，基站侧和用户设备侧都可以识别出该参考信号端口配置消息。

还需要理解的是，通过参考信号端口组与对应端口的映射关系信息和端口组的映射索引，可以唯一确定该端口组中包括的端口，如下表 1 至 3 中所示，在获知参考信号端口组与对应端口的映射关系信息和端口组的映射索引，设备可以获知对应的端口组中的端口。其中，端口组中包括的端口可以是预定义的，对于不同的索引，预定义的端口组可以根据规划得到。需要说明的是，一个参考信号端口与一个天线端口相对应，一个天线端口对应一个参考信号端口。天线信号端口的信道信息根据测量参考信号端口得到。因此，通常所述预定义的端口组可以根据天线端口阵列配置规划得到。

一个参考信号端口或者天线端口往往与一个物理天线，或者一个虚拟天线相对应，其中所说的虚拟天线可以通过多个物理天线的加权组合得到。实际的天线部署可能具有不同的天线配置和天线端口阵列形式。例如，图 3 所示为不同的均匀线阵（ULA，Uniform Linear Array）天线端口阵列配置。其中，天线端口阵列 A 为 2 行 4 列的均匀线阵,天线端口阵列 B 为 2 行 8 列的均匀线阵，天线端口阵列 C 为 4 行 4 列的均匀线阵；尽管天线端口阵列 B 与阵列 C 都具有 16 个端口，但是其阵列形式也不同。再如图 4 所示为不同的交叉极化（XPO ，Cross-polarization，）天线阵配置。其中，天线端口阵列 A 为 2 行 2 列的交叉极化天线阵，天线端口阵列 B 为 2 行 4 列的均匀线阵，天线端口阵列 C 为 4 行 2 列的均匀线阵，不同的极化天线可以处于相同的列；尽管天线端口阵列 B 与阵列 C 都具有 16 个端口，但是其阵列形式也不同。以下天线端口阵列简称天线阵列。

可选地，作为另一实施例，所述参考信号端口配置信息，包括参考信号端口数和映射索引，其中所述映射索引用于指示参考信号端口组与对应端口的映射。以如图 3 中的天线阵列 A 和如图 4 中的天线阵列 A 所示的 8 天线阵列为例，所述参考信号端口配置信息，包括参考信号端口数为 8 和映射索引为 0 或者 1。其中所述预定义的参考信号端口到端口组中的映射关系可以通过函数定义，也可以通过预定义的表格规定。例如表格 1 中所示，第一行可以是图 3

中天线阵列 A 的参考信号端口配置信息，该映射指示信息中包括：参考信号端口数为 8 个，映射索引为 0，端口组为 0 和 1 两组。表格 1 中第二行可以是图 4 中天线阵列 A 的参考信号端口配置信息，该映射指示信息中包括：参考信号端口数为 8 个，映射索引为 1，端口组为 0 和 1 两组。需要指出的是，本实施例中参考信号端口和参考信号端口组可以与天线端口和天线端口组互换。

表格 1-端口到端口组的映射

索引	端口到端口组的映射	
	0	1
0	0,3,4,7	1,2,5,6
1	0,1,4,5	2,3,6,7

进一步，当映射索引值为 0 时，端口组 0 包含参考信号端口（或者天线端口）0,3,4 和 7，端口组 1 包含参考信号端口（或者天线端口）1,2,5 和 6；当映射索引值为 1 时，端口组 0 包含参考信号端口（或者天线端口）0,1,4 和 5，端口组 1 包含参考信号端口（或者天线端口）2,3,6 和 7。

以如图 3 中的天线阵列 B 或者 C 和如图 4 中的天线阵列 B 或者 C 所示的 16 天线阵列为例，所述参考信号端口配置信息，包括参考信号端口数为 16 和映射索引为 0 或者 1 或者 2 或者 3。其中所述预定义的参考信号端口到端口组中的映射关系可以通过函数定义，也可以通过预定义的表格规定。例如表格 2 所示：

表格 2-端口到端口组的映射

索引	端口到端口组的映射			
	0	1	2	3
0	0,3,8,11	4,7,12,15	1,2,9,10	5,6,13,14
1	0,1,12,13	2,3,14,15	4,5,8,9	6,7,10,11

2	0,7,8,15	1,6,9,14	2,5,10,13	3,4,11,12
3	0,3,12,15	1,2,13,14	4,7,8,11	5,6,9,10

其中，图 3 中天线阵列 B 可以假设为表 2 中第一行，即映射索引值为 0，端口组 0 包含参考信号端口（或者天线端口）0,3,8 和 11，端口组 1 包含参考信号端口（或者天线端口）4,7,12 和 15，端口组 2 包含参考信号端口（或者天线端口）1,2,9 和 10，端口组 3 包含参考信号端口（或者天线端口）5,6,13 和 14。当映射索引值为 1 或 2 或 3 时，各个端口组包含的参考信号端口可以由上述表格依次类推。

可选的，作为另一实施例，所述参考信号端口配置信息，可以包括端口组映射双索引（m，n）。此时，所述预定义的参考信号端口到端口组中的映射关系可以通过函数定义，也可以通过预定义的表格规定。例如表格 3 所示：

表格 3-端口到端口组的映射

双索引 (m, n)	端口到端口组的映射			
	0	1	2	3
(2,4)	0,1,4,5	2,3,6,7	-	-
(2,8)	0,3,8,11	4,7,12,15	1,2,9,10	6,7,10,11
(4,4)	0,1,12,13	2,3,14,15	4,5,8,9	6,7,10,11

可选的，双索引(m，n)可以指示参考信号端口数为 m 和 n 的乘积。

进一步地，所述双索引信息，可以进行联合编码，例如，上述表格 3 中的双索引的联合编码，如表格 3a 或者 3b 所示。

表格 3a-端口到端口组的映射

双索引(m, n)的联合编码	双索引(m, n)	端口到端口组的映射			
		0	1	2	3
0	(2,4)	0,1,4,5	2,3,6,7	-	-
1	(2,8)	0,3,8,11	4,7,12,15	1,2,9,10	6,7,10,11
2	(4,4)	0,1,12,13	2,3,14,15	4,5,8,9	6,7,10,11

或者

表格 3b-端口到端口组的映射

映射索引	双索引(m, n)	端口到端口组的映射			
		0	1	2	3
0	(2,4)	0,1,4,5	2,3,6,7	-	-
1	(2,8)	0,3,8,11	4,7,12,15	1,2,9,10	6,7,10,11
2	(4,4)	0,1,12,13	2,3,14,15	4,5,8,9	6,7,10,11

可选的，端口组的划分可以是以 4 个参考信号端口（或者天线端口）为一个端口组。

需要进一步指出的是，端口组的划分也可以不限于含有 4 个参考信号端口的端口组，还可以是 2 或 8 个或者其他构成形式的端口组。同时，每个端口组内含有的参考信号端口号，也不限于上述取值，可以根据实际的天线配置或者部署灵活选择。上述预定义的端口组映射以及映射指示信息，可以使得系统能够自适应更多的天线配置和天线阵列部署。

可选的，所述参考信号资源配置信息还可以包括：参考信号配置，或者参

考信号子帧配置其中任意一项。所述参考信号配置可以包括：参考信号端口使用的子载波，或者正交频分复用（OFDM，Orthogonal Frequency Division Multiplexing）符号，或者码资源其中任意一项；所述参考信号子帧配置可以包括：参考信号端口占用的子帧位置，子帧周期，或者子帧偏移其中任意一项。需要指出的是，所述参考信号配置或者参考信号子帧配置还可以是预定义的，或者根据事先已知的参数如小区 ID 或者 UE ID 隐式导出，为基站或者 UE 所共知；本发明实施例不作限制。

步骤 102，根据所述参考信号端口配置信息，得到至少一个端口组中的参考信号端口信息；

步骤 103，根据所述至少一个端口组中的参考信号端口信息获取信号质量测量信息。

具体地，所述参考信号或者信号，具体可以包括小区特定参考信号 CSR；或者，信道状态信息参考信号（CSI-RS，Channel State Information Reference Signal）或者解调参考信号（DMRS， DeModulation Reference signal），但不限于当前的举例。

所述信号质量测量信息，可以为参考信号接收功率（RSRP，Reference Signal Received Power）或者参考信号接收质量（RSRQ，Reference Signal Received Quality）或者参考信号强度指示（RSSI，Reference Signal Strength Indicator），还可以是其它基于参考信号定义的信号质量测量信息。

本实施例以参考信号接收功率 RSRP 为例，详细说明其中一种实现，对于其他的实现方案本方案不做限制，且对于获取其他信号质量测量信息的方案也不做限制。

可选的，步骤 103 中根据所述参考信号端口配置信息，得到至少一个端口组中的参考信号端口信息可以包括：

根据所述参考信号端口配置信息，得到指定的一个端口组中的参考信号端口信息；

步骤 103 中所述根据所述至少一个端口组中的参考信号端口信息获取信号质量测量信息包括：

根据所述指定的一个端口组中的参考信号端口信息获取所述信号质量测

量信息。

以表 2 中的映射索引为 0 举例，此时端口组 0 含有的参考信号端口为 0，3，8 和 11。其中每个天线端口的复数 RSRP 测量可以为相邻两个参考信号资源单元（RE，Resource Element）的相关，其中，这里的相邻的两个 RE 可以是指频域上相邻的两个 RE，或者时域上相邻的两个 RE，或者是时频域上相邻的两个 RE。

$$RSRP(r,p)=\frac{1}{K_s-1}\sum_{m=0}^{K_s-1}\hat{h}_p(m)\cdot\hat{h}_p(m+1),p=0,3,8,11 \quad (1)$$

其中，$\hat{h}_p(m)$ 为标号为 m 的参考信号 RE 上的信道估计；K_s 是在测量带宽内可利用的参考信号 RE 的样本总数；p 为所述指定的一个端口组中参考信号端口号，r 为接收天线的索引。通过组合(combine) $RSRP(r,p)$ 可以得到天线端口组 0 对应的 RSRP，得到第 r 个接收天线第 p 个端口的参考信号接收功率 $RSRP(r,p)$ 并通过组合 $RSRP(r,p)$ 得到所述 RSRP。例如：上述 $RSRP(r,p)$ 对各个端口 p 和接收天线作线性（相关或者非相关）平均后取绝对值可以得到端口组 0 对应的 RSRP；或者上述 $RSRP(r,p)$ 对其中某一个端口 p 和各个接收天线作线性（相干或者非相关）平均后取绝对值可以得到端口组 0 对应的 RSRP。依次类推，也可以利用其它端口组的参考信号得到 RSRP。

本实施例步骤 103 中所述用于得到 RSRP 的端口组以及该端口组中的端口可以是预定义的（例如：端口组 0，以及端口组 0 中的端口 0，或者是端口组 0 中的端口 0 和 3，或者是该端口组 0 中的所有端口，或者其它）或者由基站 eNB 通过高层信令如 RRC 信令或者下行控制信息通知。以上基于一个端口组或者一个端口组中的部分或者全部端口得到 RSRP，不必逐端口测量 RSRP，可以降低 UE 的 RSRP 测量的实现复杂性，同时，端口组预定义或者通知，使得 UE 和 eNB 对测量的理解一致，从而保证 RSRP 测量的一致性。同时，不同的端口组可以彼此独立指示其功率，充分利用了图 3 和图 4 所示的天线配置和天线阵列的结构，可以适应天线结构的变化灵活指示，从而可以保证基站 eNB

能够自适应多种天线配置和天线阵列。

可选的，当步骤 101 中 UE 接收的参考信号资源配置信息中包括的一个或者多个端口组的参考信号功率信息，用作指示对应端口组中各个端口的参考信号功率。

以 16 个参考信号端口为例，4 端口组的参考信号功率可以如表 4 所示：

表格 4—端口组的参考信号功率表

端口组号	0	1	2	3
参考信号功率	p0	p1	p2	p3

此时，端口组 0 包含的参考信号端口的功率为 p0，端口组 1,2 和 3 中包含的参考信号端口的功率可以依次类推，分别为 p1 ,p2 和 p3。

或者，上述一个或者多个端口组的参考信号功率信息，还可以用其中一个端口组（例如端口组 0）的参考信号功率以及其它一个(例如端口组 1)或者多个端口组(例如端口组 1，2，3)相对于该端口组（例如端口组 0）的参考信号功率比值共同表示；例如端口组 0 的参考信号功率为 p0，端口组 1，2 和 3 相对于端口组 0 的参考信号功率比值分别为 ρ1, ρ2 和 ρ3。此时 UE 可以得到端口组 1，2 和 3 的参考信号功率分别为 p0*ρ1, p0 *ρ2 和 p0*ρ3。

此外，所述一个或者多个端口组的参考信号功率信息，还可以用于其中一个端口组（例如端口组 0）的参考信号功率以及其它一个(例如端口组 1)或者多个端口组(例如端口组 1，2，3)相对于该端口组（例如端口组 0）的参考信号功率的差分来表示；例如端口组 0 的参考信号功率为 p0，端口组 1，2 和 3 相对于端口组 0 的参考信号功率的差分分别为 d1,d2 和 d3。此时 UE 可以得到端口组 1，2 和 3 的参考信号功率分别为 p0+d1, p0+d2 和 p0+d3。

上述采用端口组分别指示参考信号功率信息，除了可以避免逐端口指示参考信号功率从而减少信令开销之外，端口组内各个端口采用统一的功率指示而不同的端口组可以彼此独立指示其功率，充分利用了天线配置或者天线阵列的结构，从而可以使得系统能够根据天线配置或者天线阵列结构灵活选择参考信号功率。同时，需要进一步指出的是，尽管端口组的划分不限于含有 4 个参考

信号端口的端口组，上述表格 1，2，3 中的端口组划分以及各个端口的构成可以进一步使得图 3 或者图 4 中的天线阵列具有关于阵列结构对称的功率，即各个端口相对于阵列可以具有对称的权重，利用该权重的对称性，可以降低波束赋形或者旁瓣抑制的设计复杂性。

进一步，以上所述参考信号功率也可以用每资源单元的能量（EPRE，Energy Per Resource Element）表示。

可选的，所述至少两个端口组的参考信号功率信息，包括：

第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的比值；

或者，第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的差分。

其中，上述可选的，根据所述参考信号端口配置信息并结合至少两个端口组的参考信号功率信息获取信号质量测量信息，包括：

根据所述参考信号端口配置信息得到所述至少两个端口组对应的信号质量测量信息；

根据所述至少两个端口组的参考信号功率信息，对所得到的至少两个端口组对应的信号质量测量信息按端口组功率进行加权平均，得到所述信号质量测量信息。

具体地，可以是通过多于一个端口组中的参考信号的接收功率组合得到。

以端口组 0，1，2，和 3 共 4 个端口组为例，可以基于上述得到一个端口组的 RSRP 的方法，分别得到端口组 0，1，2，和 3 对应的参考信号接收功率 $RSRP_g$， $g=0,1,2,3$。根据步骤 101 接收到的参考信号资源配置信息还包括：至少两个端口组的参考信号功率信息，用于所述用户设备根据所述参考信号端口配置信息并结合所述至少两个端口组的参考信号功率信息获取所述信号质量测量信息。

所述根据所述至少两个端口组的参考信号功率信息，对所得到的至少两个端口组对应的信号质量测量信息按端口组功率进行加权平均，得到信号质量测量信息，包括：

根据公式：$$SQ=\left(\sum_{g=0}^{n-1}p_g\cdot SQ_g\right)\Big/\left(\sum_{g=0}^{n-1}p_g\right) \quad (2)$$

得到信号质量测量信息，

其中，SQ_g 为指定端口组的信号质量测量信息，其中，g 为指定端口组的编号，n 为指定端口组的个数，$n\geq 2$；p_g 为指定端口组的参考信号功率，其中，指定端口组的参考信号功率根据所述至少两个端口组的参考信号功率信息得到。

以上所述多个端口组可以是全部端口组，也可以是部分端口组，因此，预置的端口信息可以是全部端口组，也可以是部分端口组。其中部分端口组可以是预先约定的（如端口组 0 和端口组 1）或者由基站 eNB 通过高层信令如 RRC 信令或者下行控制信息通知。以上多个端口组得到 RSRP，可以对各个端口组得到的 RSRP 进行平滑或者滤波等处理从而进一步提高了 RSRP 测量的精度，同时避免 UE 逐端口计算从而降低实现复杂性。此外端口组的配置，可以保证基站 eNB 能够自适应多种天线配置和天线阵列。

同样的，采用类似的方法，基于参考信号资源配置信息中的参考信号端口配置信息，以及参考信号配置或者子帧配置，接收基站发送的参考信号，UE 还可以进一步得到一个或者多个端口组的参考信号接收质量（RSRQ，Reference signal Received Quality）或者参考信号强度指示（RSSI）等信号质量测量信息。其中，RSSI 是接收的宽带总功率包括干扰和热噪声，RSRQ 为 RSRP 与 RSSI 的比。

进一步地，所述用于通信质量测量的方法，还可以包括：

步骤 104，所述 UE 向基站 eNB 上报所述信道质量测量信息，例如 RSRP，便于实现小区选择或者小区切换。

可选的，当所述信号质量测量信息为参考信号接收功率 RSRP，该通信质量测量的方法还可以包括：

步骤 105，接收基站发送的滤波器系数信息；

步骤 106，基于所述滤波器系数信息对所述参考信号接收功率 RSRP 进行滤波，并得到路损估计值。

具体的，所述用户设备接收基站发送的滤波器系数信息，可以是与步骤101 中所述接收参考信号资源配置信息在同一时间接收，如在相同的子帧接收；也可以是与步骤 101 中所述接收参考信号资源配置信息之前或者之后接收；所述滤波器系数信息与所述参考信号资源配置信息可以在相同或者不同的高层信令如 RRC 信令的信元（Information Element,简称 IE）或者下行控制信息（Downlink Control Information，简称 DCI）中接收。

具体地，如步骤 103 所述方法，可以获得一个或者多个端口组中的参考信号接收功率，例如可以得到端口组 0，1，2，和 3 对应的参考信号接收功率 $RSRP_g$，$g=0,1,2,3$ 。

所述路径损耗估计可以基于一个端口组的参考信号接收功率和对应的参考信号功率得到：

$PL(g)$ = 端口组 g 的参考信号功率 - 高层滤波的端口组 g 的 RSRP

其中 $PL(g)$ 表示基于端口组 g 得到的 PL 估计，其中高层滤波器参数由高层信令通知。可以利用其中一个端口组的 PL 得到，例如端口组 0；所述高层滤波的端口组 g 的 RSRP 利用高层信令通知的高层滤波器参数对端口组 g 的 RSRP 进行滤波得到。

以上所述用于得到 PL 估计的端口组可以是预定义的（如端口组 0）或者由基站 eNB 通过高层信令如 RRC 信令或者下行控制信息通知。以上基于一个端口组得到 PL 估计，可以降低 UE PL 估计的实现复杂性，同时，保证 PL 估计的一致性。同时端口组的配置，可以保证基站 eNB 能够自适应多种天线配置和天线阵列。

所述路径损耗估计也可以基于多个端口组的参考信号接收功率和对应的参考信号功率得到。具体地，所述 PL 估计可以是多个端口组得到 PL 估计的线性平均。

以上所述多个端口组可以是全部端口组，也可以是部分端口组。其中部分端口组可以是预先约定的（如端口组 0 和端口组 1）或者由基站 eNB 通过高层信令如 RRC 信令或者下行控制信息通知。以上多个端口组得到 PL 估计，可以进一步提高 PL 估计的精度，同时避免 UE 实现复杂性过高。此外端口组的配置，可以保证基站 eNB 能够自适应多种天线配置和天线阵列。

进一步地，所述用于通信质量测量的方法，还可以包括:

步骤 107，向基站发送上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率根据所述路损估计值计算得到。

所述物理信道可以是物理上行控制信道 PUCCH 或者物理上行共享 PUSCH 等；所述物理信号可以是侦听参考信号（SRS， Sounding Reference signal）或者用于上行物理信道的解调参考信号（DMRS， DeModulation R 俄 ference Signal）。

具体地，根据上述得到的路损估计，物理上行控制信道 PUCCH 的发射功率设置可以定义为如下式（3）:

$$P_{\mathrm{PUCCH}}(i)=\min\left\{P_{\mathrm{CMAX,c}}(i),P_{\mathrm{O_PUCCH}}+PL_c+h\left(n_{CQI},n_{HARQ},n_{SR}\right)+\Delta_{\mathrm{F_PUCCH}}(F)+\Delta_{TxD}(F')+g(i)\right\}$$

其中，$P_{\mathrm{CMAX,c}}(i)$ 是服务小区 c 子帧 i UE 上配置的最大发射功率，$P_{\mathrm{O_PUCCH}}$ 是一个由高层提供的小区特定参数 $P_{\mathrm{O_NOMINAL_PUCCH}}$ 和 UE 特定参数 $P_{\mathrm{O_UE_PUCCH}}$ 的和构成的参数。$h\left(n_{CQI},n_{HARQ},n_{SR}\right)$ 是一个依赖于 PUCCH 格式的值，其中 n_{CQI} 对应于 CQI 的信息比特数；对于参数 n_{SR}，如果子帧 i 为没有相关上行数据传输的 UE 配置调度请求（SR）则 $n_{SR}=1$ 否则 $n_{SR}=0$；参数 n_{HARQ} 是在子帧 i 发送的 HARQ-ACK 比特数. 参数 $\Delta_{\mathrm{F_PUCCH}}(F)$ 由高层提供，每一个 $\Delta_{\mathrm{F_PUCCH}}(F)$ 的取值对应于一个 PUCCH 格式（F）. 对于参数 $\Delta_{TxD}(F')$，如果 UE 被高层配置为在两个天线端口上发射 PUCCH，$\Delta_{TxD}(F')$ 的取值由高层提供，其中每种 PUCCH 格式 F' is 是预定义的，否则 $\Delta_{TxD}(F')=0$. $g(i)$ 是 UE 当前的 PUCCH 功率控制状态。PL_c 为 UE 针对小区 C 利用步骤 104 所述方法得到路径损耗的估计值。

再如，根据上述得到的路损估计，物理上行共享信道 PUSCH 的发射功率设置可以定义为如下式（4）:

$$P_{\mathrm{PUSCH,c}}(i)=\min\left\{P_{\mathrm{CMAX},c}(i),10\log_{10}(M_{\mathrm{PUSCH,c}}(i))+P_{\mathrm{O_PUSCH,c}}(j)+\alpha_c(j)\cdot PL_c+\Delta_{\mathrm{TF,c}}(i)+f_c(i)\right\}$$

其中，$P_{\mathrm{CMAX,c}}(i)$ 是服务小区 c 子帧 i UE 上配置的最大发射功率；$M_{\mathrm{PUSCH,c}}(i)$

是PUSCH 资源分配的带宽，用资源块RB表示，对子帧i和服务小区c有效。$P_{O_PUSCH,c}(j)$是一个由高层提供的分量$P_{O_NOMINAL_PUSCH,c}(j)$和分量$P_{O_UE_PUSCH,c}(j)$构成的参数，其中j=0,1。$\alpha_c \in \{0, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1\}$ 是一个3比特参数，由高层提供。$\Delta_{TF,c}(i)$是一个由高层信令确定的与传输格式相关的参数。$f_c(i)$ 是UE当前的PUSCH 功率控制调整状态。PL_c为UE针对小区C利用步骤104所述方法得到路径损耗的估计值。

再如，根据上述得到的路损估计，侦听参考信号SRS 的发射功率设置可以定义为如下式:

$$P_{SRS,c}(i) = \min\left\{ P_{CMAX,c}(i), P_{SRS_OFFSET,c}(m) + 10\log_{10}(M_{SRS,c}) + P_{O_PUSCH,c}(j) + \alpha_c(j)\cdot PL_c + f_c(i) \right\}$$

其中$P_{SRS_OFFSET,c}(m)$ 是服务小区c的高层半静态配置的参数，其中m=0和m=1。对于SRS传输触发类型0，则 m=0；触发类型1，则 m=1. $M_{SRS,c}$是服务小区c子帧 i的SRS传输带宽。$f_c(i)$ 是服务小区c的当前PUSCH功率控制调整状态。$P_{O_PUSCH,c}(j)$和$\alpha_c(j)$ 是预定义的参数，如LTE 36.213 中 5.1.1.1 节定义其中 $j=1$. PL_c为UE针对小区C利用步骤104所述方法得到路径损耗的估计值。

采用上述路损估计用于上行信道的开环控制，可以进一步提高功率控制的可靠性，同时，可以保证基站eNB能够自适应多种天线配置和天线阵列。

实施例三

本发明实施例提供一种用于通信质量测量的方法，如图5所示，所述方法包括:

步骤S21，确定参考信号资源配置信息，并向用户设备发送参考信号资源配置信息，所述参考信号资源配置信息包括：参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考

信号的功率比值。

当所述参考信号资源配置信息包括: 参考信号端口配置信息和功率比值信息，将该参考信号资源配置信息发送给用户设备（UE，User Equipment），使得用户设备根据该参考信号资源配置信息获取信道状态信息 CSI，由于参考信号端口被分配成多个组，UE 可以根据其中一个端口组或者多个端口组的参考信号质量处理得到最终的信号质量测量信息，使得 UE 侧可以将端口根据不同的端口组进行区分，不同于现有技术中不能区分不同端口的发射功率的情况。因而，该方案获取的信道状态信息，可以使得 UE 进行更为准确的调制与编码策略（MCS，Modulation and Coding Scheme)选择或者调度，从而提高系统的吞吐量。

步骤 S22，接收用户设备发送的信道状态信息 CSI，其中，所述 CSI 为所述用户设备根据所述参考信号端口配置信息和所述功率比值信息得到。

其中，所述信道状态信息 CSI 包括: 信道质量指示 CQI，预编码矩阵指示 PMI，或秩指示 RI 其中任意一个或者任意组合。

通过上述实施例三中说明的方法，该方法通过网络侧确定参考信号资源配置信息，并将该参考信号资源配置信息发送给用户侧，其中，所述参考信号资源配置信息至少包括: 端口组参考信号功率相关信息，以及参考信号端口配置信息，其中所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射。所述方法可以避免逐端口指示参考信号功率相关信息从而减少信令开销之外，端口组内各个端口采用统一的功率指示而不同的端口组可以彼此独立指示其功率相关信息，充分利用了天线配置或者天线阵列的结构，从而可以使得系统能够根据天线配置或者天线阵列结构灵活选择参考信号功率相关信息; 由于天线阵列可以具有对称的权重，利用该权重的对称性，可以降低波束赋形或者旁瓣抑制的设计复杂性。

进一步，将参考信号资源配置信息发送给用户侧 UE，UE 可以根据其中一个端口组或者多个端口组的参考信号质量处理得到最终的信号质量测量信息，使得 UE 侧可以将端口根据不同的端口组进行区分，不同于现有技术中不能区分不同端口的发射功率的情况。使得 UE 能够获取的信道状态信息，可以使得 UE 进行更为准确的调制与编码方案（MCS，Modulation and Coding

Scheme)选择或者调度，从而提高系统的吞吐量。

可选的，所述参考信号端口配置信息为单索引，或者为双索引，或者为联合编码后的索引。详细说明参考实施例一，此处不重述。

可选的，在步骤 S21 中所述功率比值信息中：

所述至少一个端口组中的每个端口组内的各天线端口上数据信道相对于参考信号的功率比值都相同；

或者，所述至少一个端口组中的一个端口组内各个端口上的数据信道与其它端口组内各个端口的数据信道相对于参考信号的功率比值相同。

可选的，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的多套功率比值，

所述接收用户设备发送的信道状态信息 CSI，包括接收用户设备发送的多套信道状态信息 CSI，其中每一套信道状态信息 CSI 为所述用户设备根据所述多套功率比值中的一套功率比值得到的。

其中，本实施例中所说的“多套”，是指采用多套取值；所述多套取值可以采用多套格式相同的信令。例如：

一种信令格式为：至少一个端口组中的各个端口的数据信道相对于参考信号的功率比值都相同，即端口组内各个端口间内功率相同；

另一种信令格式为：一个端口组内各个端口的数据信道与其它端口组内各个端口的数据信道相对于参考信号的功率比值相同，但端口组内各个端口间内功率不同；

上述例举了两种不同的信令格式，可以理解为对本实施例的具体举例，不应该理解对本实施例的限制。

实施例四

本发明实施例提供一种通信质量测量的方法，该方法与上述实施例二类似，不同之处在于，用户侧 UE 在接收到网络侧发送的参考信号资源配置信息后，将该信息用于获取信道状态信息，使得 UE 根据信道状态信息可以进行对应的调制与编码方案 MCS 选择或者资源调度。

如图 6 所示，所述方法包括：

步骤 201，接收基站发送的参考信号资源配置信息，所述参考信号资源配

置信息包括：参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功率比值；

其中，所述参考信号资源配置信息中包括的参考信号端口配置信息的详细说明，可以参考步骤 101 中的参考信号端口配置信息中的说明。即参考信号端口配置信息，用于指示参考信号端口到端口组的映射，参考信号端口到端口组中的映射关系是预定义的。

其中，所述数据信道可以是物理下行共享信道（PDSCH，Physical Downlink Shared Channel），也可以是用于传输控制信息的信道；数据信道的功率可以是每资源单元的能量（EPRE， Energy Per Resource Element）；

具体地，所述 UE 接收参考信号资源配置，可以是 UE 通过高层信令如无线资源控制（RRC， Radio Resource Control）信令或者动态信令如下行控制信息（DCI， Downlink Control Information）接收 eNB 通知的参考信号资源配置或者基于小区标识 ID 得到所述参考信号的资源配置。

具体地，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射。

一个参考信号端口往往与一个物理天线或者一个虚拟天线相对应，其中虚拟天线可以通过多个物理天线的加权组合得到。实际的天线部署可能具有不同的天线配置和天线阵列形式。需要指出的是，本实施例中参考信号端口和参考信号端口组可以与天线端口和天线端口组互换使用。

可选地，所述参考信号端口配置信息，用于指示所述参考信号端口到端口组的映射关系，可以包括参考信号端口数和映射索引，其中所述映射索引用于指示参考信号端口组与对应端口的映射。以如图 3 中的天线阵列 A 和如图 4 中的天线阵列 A 所示的 8 天线阵列为例，所述参考信号端口配置信息，包括参考信号端口数为 8 和映射索引为 0 或者 1。其中所述预定义的参考信号端口到端口组中的映射关系可以通过函数定义，也可以通过预定义的表格规定，如表 1 所示。

以如图 3 中的天线阵列 B 或者 C 和如图 4 中的天线阵列 B 或者 C 所示的 16 天线阵列为例，所述参考信号端口配置信息，包括参考信号端口数为 16 和

映射索引为 0 或者 1 或者 2 或者 3。其中所述预定义的参考信号端口到端口组中的映射关系可以通过函数定义，也可以通过预定义的表格规定，如表 2 所示。

具体地，所述参考信号端口配置信息，可以包括双索引（m, n）。此时，所述预定义的参考信号端口到端口组中的映射关系可以通过函数定义，也可以通过预定义的表格规定，如表 3 所示。

进一步地，双索引 (m, n) 可以指示参考信号端口数为 m 和 n 的乘积。

进一步地，所述双索引信息，可以进行联合编码，例如，上述表格 3 中的双索引的联合编码，如表格 3a 或者 3b 所示。

可选的，端口组的划分可以是以 4 个参考信号端口/天线端口为一个端口组。

需要进一步指出的是，端口组的划分不限于含有 4 个参考信号端口的端口组，还可以是 2 或 8 个或者其他构成形式的端口组。同时，每个端口组内含有的参考信号端口号，也不限于上述取值，可以根据实际的天线配置或者部署灵活选择。上述预定义的端口组映射以及映射指示信息，可以使得系统能够自适应更多的天线配置和天线阵列部署。

步骤 201 中在所述功率比值信息中，所述至少一个端口组中的每个端口组内的各天线端口上数据信道相对于参考信号的功率比值相同；以 16 个参考信号端口为例，假定数据信道为 PDSCH，功率对应于 EPRE，则 4 端口组的信号功率比值可以为：

表格 4-功率比值

端口组号	0	1	2	3
PDSCH EPRE 相对于参考信号 EPRE 的比值	ρ0	ρ1	ρ2	ρ3

进一步地，所述至少一个端口组内的各天线端口上数据信道相对于参考信号的功率比值相等。以表格 4 为例，其中端口组 0 中各个端口上的数据信道相对于参考信号的功率比值可以相等。

可选地，作为另一实施例，步骤 201 中在所述功率比值信息中，所述至少

一个端口组中的一个端口组内的各个端口上的数据信道与其它端口组内各个端口上的数据信道相对于参考信号的功率比值相同。

具体地，以 4 端口的端口组为例，例如端口组 0 的各个端口为 0,1,4,5；端口组 1 的各个端口为 2,3,6,7。端口组 0 中的数据信道相对于参考信号的功率比值如表格 4a 所示：

表格 4a-端口组 0 的功率比值

端口号	0	1	4	5
PDSCH EPRE 相对于参考信号 EPRE 的比值	ρ0	ρ1	ρ2	ρ3

端口组 0 内的各个端口与端口组 1 中各个端口对应的数据信道对于参考信号的功率比值相同，即端口组 1 的各个端口 2,3,6,7 对应的数据信道对于参考信号的功率比值分别为 ρ0，ρ1，ρ2 和 ρ3。

可选地，作为另一实施例，步骤 201 中所述一个或者一个以上端口组的数据信道相对于参考信号的功率比值可以包含多套取值。各套取值可以为如表格 4 或者 4a 所示的取值。

此外，所述参考信号资源配置信息还可以包括：参考信号配置，或者参考信号子帧配置其中任意一项。所述参考信号配置可以包括参考信号端口使用的子载波或者 OFDM 符号或者码资源；所述参考信号子帧配置可以包括参考信号端口占用的子帧位置、子帧周期或者子帧偏移。需要指出的是，所述参考信号配置或者参考信号子帧配置还可以是预定义的，或者根据事先已知的参数如小区 ID 或者 UE ID 隐式导出，为基站或者 UE 所共知；本发明实施例不作限制。

步骤 202，根据所述参考信号端口配置信息和所述功率比值信息，得到所述至少一个端口组内每个天线端口上数据信道相对于参考信号的功率比值；

步骤 203，根据所述每个天线端口上数据信道相对于参考信号的功率比值，得到信道状态信息 CSI；

具体地，根据所述每个天线端口上数据信道相对于参考信号的功率比值，得到信道状态信息 CSI，可以包括:

根据所述每个天线端口上的参考信号得到所述每个天线端口对应的信道测量值;

根据所述每个天线端口对应的信道测量值，和所述每个天线端口上数据信道相对于参考信号的功率比值，得到所述每个天线端口上数据信道的信道估计值;

根据所述每个天线端口上数据信道的信道估计值得到信道状态信息 CSI。

需要指出的是，本发明并不对得到所述至少一个端口组中的每个参考信号端口对应的信道测量值和得到所述至少一个端口组中的每个天线端口对应的数据信道相对于参考信号的功率比值的执行次序进行限定。

具体地，所述参考信号，具体可以包括小区特定参考信号 CSR; 或者，接收信道状态信息参考信号（CSI-RS，Channel State Information Reference Signal）或者解调参考信号（DMRS， DeModulation Reference signal）。

所述信道状态信息（CSI，Channel State Information），可以为信道质量指示（CQI，Channel Quality Indicator/Index）或者预编码矩阵指示（PMI，Precoding Matrix Indictor/Index）或者秩指示（RI，Rank Indicator），还可以是其它信道状态信息如预编码类型指示（PTI，Precoder Type Indicator）等。

具体地，UE基于PDSCH信号的EPRE相对于信道状态信息参考信号（CSI-RS，Channel State Information Reference Signal） EPRE的比值，计算信道状态信息时得到对应的PDSCH在天线端口上的发射功率。

以 16 个参考信号端口为例，假定步骤 201 中通知的参考信号端口配置信息，包括参考信号端口数为 16 和映射索引为 1，其映射关系如表 2 所示，功率比值如表 4 所示。则根据表 2 和表 4 可知，

参考信号端口 0,1,12 和 13 对应的 PDSCH 相对于参考信号的 EPRE 或者功率比值为 ρ0;

参考信号端口 2,3,14 和 15 对应的 PDSCH 相对于参考信号的 EPRE 或者功率比值为 ρ1;

参考信号端口 4,5,8 和 9 对应的 PDSCH 相对于参考信号的 EPRE 或者功

率比值为 ρ2；

参考信号端口 6,7,10 和 11 对应的 PDSCH 相对于参考信号的 EPRE 或者功率比值为 ρ3。

注意，所述参考信号端口与天线端口一一对应。

此外，所述UE根据所述参考信号资源配置信息接收参考信号，可以得到所述各个天线端口对应的信道测量值如下：

$$\mathbf{H}=\left[\mathbf{h}_0 \quad \mathbf{h}_1 \quad \cdots \quad \mathbf{h}_{15}\right]$$

其中，$\mathbf{h}_p, p=0,...,15$ 为天线端口 p 对应的信道测量值，所述测量值可以根据具体的参考信号如CSI RS等基于最小二乘法等方式得到，此为现有技术，不尽一步赘述。

根据上述各个天线端口对应的信道测量值，UE可以根据PDSCH相对于参考信号的EPRE或者功率比值得到各个天线端口上数据信道PDSCH的信道测量或者信道估计值为：

$$\hat{\mathbf{H}}=\left[\hat{\mathbf{h}}_0 \quad \hat{\mathbf{h}}_1 \quad \cdots \quad \hat{\mathbf{h}}_{15}\right]$$

其中，天线端口p上数据信道PDSCH的信道测量或者信道估计值 $\hat{\mathbf{h}}_p$ 为：

$$\hat{\mathbf{h}}_p=\sqrt{\rho_p}\mathbf{h}_p$$

其中，p 为所述天线端口的索引，ρ_p 为天线端口 p 上数据信道相对于参考信号的功率比值，$\mathbf{h}_p$ 为天线端口 p 对应的信道测量值，$\hat{\mathbf{h}}_p$ 为天线端口 p 上数据信道的信道估计值，即，

$$\hat{\mathbf{h}}_p=\begin{cases}\sqrt{\rho 0}\mathbf{h}_p, p=0,1,12,13\\ \sqrt{\rho 1}\mathbf{h}_p, p=2,3,14,15\\ \sqrt{\rho 2}\mathbf{h}_p, p=4,5,8,9\\ \sqrt{\rho 3}\mathbf{h}_p, p=6,7,10,11\end{cases}$$

则UE可以基于以下方程计算信道状态信息CSI如下方程（5）：

$$\mathbf{y} = \hat{\mathbf{H}}\mathbf{P}\mathbf{s} + \mathbf{n} \qquad (5)$$

其中，**P**为预编码矩阵，对于非预编码的系统，P为单位阵。**s**为发送的信息符号如调制符号，**n**为干扰和噪声矢量，**y**为接收信号。

根据上述方程（5）得到信道状态信息如信道质量指示（channel quality indicator, 简称CQI）或者预编码矩阵指示（PMI，Precoding Matrix Indicator/Index）/秩指示（RI，Rank Indicator/Index）其中任意一个或者任意组合。其中，根据上述方程（5）得到信道状态信息如CQI，或者PMI，或者RI的具体过程是已有技术，此处不再进一步赘述。

可选地，作为另一实施例，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的多套功率比值；

以16个参考信号端口为例，假定步骤201中通知的参考信号端口配置信息，包括参考信号端口数为16和映射索引为1，其映射关系如表2所示，功率比值如表4b所示。则根据表2和表4b可知，

参考信号端口0,1,12和13对应的PDSCH相对于参考信号的EPRE或者第一套功率比值为x0；

参考信号端口2,3,14和15对应的PDSCH相对于参考信号的EPRE或者第一套功率比值为x1；

参考信号端口4,5,8和9对应的PDSCH相对于参考信号的EPRE或者第一套功率比值为x2；

参考信号端口6,7,10和11对应的PDSCH相对于参考信号的EPRE或者第一套功率比值为x3；

参考信号端口0,1,12和13对应的PDSCH相对于参考信号的EPRE或者第二套功率比值为y0；

参考信号端口2,3,14和15对应的PDSCH相对于参考信号的EPRE或者第二套功率比值为y1；

参考信号端口4,5,8和9对应的PDSCH相对于参考信号的EPRE或者第二套功率比值为y2；

参考信号端口6,7,10和11对应的PDSCH相对于参考信号的EPRE或者第二套功率比值为y3。

表格 4b-端口组 0 的多套功率比值

端口号	0	1	4	5
PDSCH EPRE 相对于参考信号 EPRE 的第一套比值	x0	x1	x2	x3
PDSCH EPRE 相对于参考信号 EPRE 的第二比值	y0	y1	y2	y3

步骤 204，向基站发送所述信道状态信息 CSI;

具体地，可以通过物理上行控制信道 PUCCH 或物理上行共享信道 PUSCH 向基站发送所述信道状态信息。

可选地，所述向基站发送所述信道状态信息 CSI，包括：向基站发送所述多套信道状态信息 CSI，其中每一套信道状态信息 CSI 为根据所述多套功率比值中的一套功率比值得到的。

以 16 个参考信号端口为例，假定步骤 201 中通知的参考信号端口配置信息，包括参考信号端口数为 16 和映射索引为 1，其映射关系如表 2 所示，功率比值如表 4b 所示。则根据表 2 和表 4b 可知，UE 向基站发送两套信道状态信息 CSI。其中第一套 CSI 根据以下表格 4c 中第一套功率比值计算:

表格 4c 中端口组 0 的第一套功率比值

端口号	0	1	4	5
PDSCH EPRE 相对于参考信号 EPRE 的比值	x0	x1	x2	x3

其中，第二套 CSI 根据以下表格 4d 中第二套功率比值计算:

表格 4d 中端口组 0 的第二套功率比值

端口号	0	1	4	5
PDSCH EPRE 相对于参考信号 EPRE 的比值	y0	y1	y2	y3

上述采用端口组分别指示数据信道的功率相对于参考信号的功率的比值，除了可以减少信令开销之外，可以使得系统能够根据天线配置或者天线阵列结构灵活配置信号功率。同时，需要进一步指出的是，尽管端口组的划分不限于含有 4 个参考信号端口的端口组，上述表格 1，2，3 中的端口组划分以及各个端口的构成可以进一步使得图 3 或者图 4 中的天线阵列具有关于阵列结构对称的功率，即各个端口相对于阵列可以具有对称的权重，便于实现波束赋形或者旁瓣抑制。

实施例五

本发明实施例提供了一种网络侧装置，如图 7 所述，所述装置包括：确定单元 601，和第一发送单元 602;

所述确定单元 601，用于确定参考信号资源配置信息，所述参考信号资源配置信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系;

所述第一发送单元 602，用于将所述确定单元确定的所述参考信号资源配

置信息发送给用户设备，以使得所述用户设备根据所述参考信号端口配置信息获取信号质量测量信息。

本实施例说明的网络侧装置可以是网络侧的基站，其各单元功能的实现可以参照实施例一中相应步骤的描述，此处不重述。

通过上述实施例五中说明的装置，通过网络侧确定参考信号资源配置信息，并将该参考信号资源配置信息发送给用户侧，所述参考信号资源配置信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系。该装置可以避免逐端口指示参考信号功率相关信息从而减少信令开销之外，端口组内各个端口采用统一的功率指示而不同的端口组可以彼此独立指示其功率相关信息，充分利用了天线配置或者天线阵列的结构，从而可以使得系统能够根据天线配置或者天线阵列结构灵活选择参考信号功率相关信息；由于天线阵列可以具有对称的权重，利用该权重的对称性，可以降低波束赋形或者旁瓣抑制的设计复杂性。

进一步，将参考信号资源配置信息发送给用户侧 UE，UE 可以根据其中至少一个端口组的参考信号质量处理得到最终的信号质量测量信息，使得 UE 侧可以将端口根据不同的端口组进行区分，不同于现有技术中不能区分不同端口的发射功率的情况。使得 UE 能够获取的信号质量测量信息，可以使得 UE 进行更为准确的小区选择和上行功率控制。

可选的，所述确定单元 601 确定的所述参考信号资源配置信息还包括：至少两个端口组的参考信号功率信息，用于所述用户设备根据所述参考信号端口配置信息并结合所述至少两个端口组的参考信号功率信息，获取所述信号质量测量信息；

其中，所述至少两个端口组的参考信号功率信息，包括：

第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的比值；

或者，第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的差分。

可选的，当所述信号质量测量信息为参考信号接收功率 RSRP 时，所述第一发送单元 602 还用于向所述用户设备发送滤波器系数信息，用于所述用户设

备基于所述滤波器系数信息对所述参考信号接收功率 RSRP 进行滤波并得到路损估计值。

可选的，所述装置还包括:

第一接收单元 603，用于接收所述用户设备发送的上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率为所述用户设备根据所述路损估计值计算得到的。

可选的，所述信号质量测量信息包括:

参考信号接收功率 RSRP，参考信号接收质量 RSRQ，或者参考信号强度指示 RSSI 其中任一项或者任意组合。

可选的，所述装置还包括：第二接收单元 604，

所述第二接收单元用于接收用户设备发送的所述信号质量测量信息。

其中，第一接收单元 603 和第二接收单元 604 可以是集成在同一个实体模块中，或者可以理解为由同一模块实现，采用第一、第二接收单元的描述，是为了更好的理解该网络侧装置的中各模块之间的连接关系。

实施例六

本发明实施例提供了一种用户设备，如图 8 所示，该用户设备包括：第三接收单元 701，第一获取单元 702，和第二获取单元 703;

所述第三接收单元 701，用于接收基站发送的参考信号资源配置信息，所述参考信号资源配置信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系;

所述第一获取单元 702，用于根据所述第三接收单元接收的所述参考信号端口配置信息，得到至少一个端口组中的参考信号端口信息;

所述第二获取单元 703，用于根据所述第一获取单元得到所述至少一个端口组中的参考信号端口信息获取信号质量测量信息。

关于本实施例说明的用户设备，其各单元功能的实现可以参照实施例二中相应步骤的描述，此处不重述。

通过上述实施例七中说明的装置，该装置通过接收网络侧确定参考信号资源配置信息，其中，所述参考信号资源配置信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系。

所述装置可以避免逐端口指示参考信号功率相关信息从而减少信令开销之外，端口组内各个端口采用统一的功率指示而不同的端口组可以彼此独立指示其功率相关信息，充分利用了天线配置或者天线阵列的结构，从而可以使得系统能够根据天线配置或者天线阵列结构灵活选择参考信号功率相关信息；由于天线阵列可以具有对称的权重，利用该权重的对称性，可以降低波束赋形或者旁瓣抑制的设计复杂性。

进一步，将参考信号资源配置信息发送给用户侧 UE，UE 可以根据其中至少一个端口组的参考信号质量处理得到最终的信号质量测量信息，使得 UE 侧可以将端口根据不同的端口组进行区分，不同于现有技术中不能区分不同端口的发射功率的情况。使得 UE 能够获取的信号质量测量信息，可以使得 UE 进行更为准确的小区选择和上行功率控制。

可选的，所述第一获取单元 702，具体用于根据所述第三接收单元接收的所述参考信号端口配置信息，得到指定的一个端口组中的参考信号端口信息；

所述第二获取单元 703，具体用于根据所述第一获取单元得到的所述指定的一个端口组中的参考信号端口信息获取所述信号质量测量信息。

可选的，当所述信号质量测量信息为参考信号接收功率 RSRP 时，所述第二获取单元 703 具体用于：

根据公式：$$RSRP(r,p)=\frac{1}{K_s-1}\sum_{m=0}^{K_s-1}\hat{h}_p(m)\cdot\hat{h}_p(m+1)$$ 得到第 r 个接收天线第 p 个端口的参考信号接收功率 $RSRP(r,p)$ 并通过组合 $RSRP(r,p)$ 得到所述 RSRP；其中，$\hat{h}_p(m)$ 为标号为 m 的参考信号 RE 上的信道估计；K_s 是在测量带宽内可利用的参考信号 RE 的样本总数；p 为所述指定的一个端口组中参考信号端口号，r 为接收天线的索引。

可选的，所述第三接收单元 701 接收的所述参考信号资源配置信息还包括：至少两个端口组的参考信号功率信息，

所述第二获取单元还用于根据所述参考信号端口配置信息并结合所述至少两个端口组的参考信号功率信息获取所述信号质量测量信息。

可选的，所述第二获取单元 703 具体用于：

根据所述参考信号端口配置信息得到所述至少两个端口组对应的信号质量测量信息；

根据所述至少两个端口组的参考信号功率信息，对所得到的至少两个端口组对应的信号质量测量信息按端口组功率进行加权平均，得到所述信号质量测量信息。

可选的，所述第二获取单元 703 根据所述至少两个端口组的参考信号功率信息，对所得到的至少两个端口组对应的信号质量测量信息按端口组功率进行加权平均，得到所述信号质量测量信息，包括：

根据公式：$SQ = \left(\sum_{g=0}^{n-1} p_g \cdot SQ_g \right) \Big/ \left(\sum_{g=0}^{n-1} p_g \right)$，得到信号质量测量信息，

其中，SQ_g 为指定端口组的信号质量测量信息，其中，g 为指定端口组的编号，n 为指定端口组的个数，$n \geq 2$；p_g 为指定端口组的参考信号功率，其中，指定端口组的参考信号功率根据所述至少两个端口组的参考信号功率信息得到。

可选的，所述第三接收单元 701 接收到的所述至少两个端口组的参考信号功率信息包括：

第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的比值；

或者，第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的差分。

可选的，所述用户设备还包括：第二发送单元 704，用于向基站发送所述信号质量测量信息。

可选的，

所述第三接收单元 701，还用于当所述信号质量测量信息为参考信号接收功率 RSRP，接收基站发送的滤波器系数信息；

所述用户设备还包括：第三获取单元 705，

所述第三获取单元 705，用于基于所述第三接收单元接收的所述滤波器系

数信息对所述参考信号接收功率 RSRP 进行滤波，并得到路损估计值。

可选的，所述用于装置还包括：第三发送单元 706，

所述第三发送单元 706，还用于向基站发送上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率根据所述路损估计值计算得到。

其中，第三发送单元 706 和第二发送单元 704 具有可以由同一个实体模块实现，此次是便于理解的分开进行说明。

可选的，所述信号质量测量信息，包括：参考信号接收功率 RSRP，参考信号强度指示 RSSI，或者参考信号接收质量 RSRQ。

实施例七

本发明实施例提供了一种网络侧装置，如图 9 所示，所述装置包括：第四发送单元 801，第四接收单元 802;

所述第四发送单元 801，用于向用户设备发送参考信号资源配置信息，所述参考信号资源配置信息包括: 参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射关系，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功率比值;

所述第四接收单元 802，用于接收用户设备发送的信道状态信息 CSI，其中，所述 CSI 为所述用户设备根据所述参考信号端口配置信息和所述功率比值信息得到。

通过上述实施例七中说明的网络侧装置，该装置通过网络侧确定参考信号资源配置信息，并将该参考信号资源配置信息发送给用户侧，其中，参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射关系，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功率比值。该装置可以避免逐端口指示参考信号功率相关信息从而减少信令开销之外，端口组内各个端口采用统一的功率指示而不同的端口组可以彼此独立指示其功率相关信息，充分利用了天线配置或者天线阵列的结构，从而可以使得系统能够根据天线配置或者天线阵列结构灵活选择参考信号功率相关信息；由于天线阵列可以具有对称的权重，利用该

权重的对称性，可以降低波束赋形或者旁瓣抑制的设计复杂性。

进一步，将参考信号资源配置信息发送给用户侧 UE，UE 可以根据其中一个端口组或者多个端口组的参考信号质量处理得到最终的信号质量测量信息，使得 UE 侧可以将端口根据不同的端口组进行区分，不同于现有技术中不能区分不同端口的发射功率的情况。使得 UE 能够获取的信道状态信息，可以使得 UE 进行更为准确的调制与编码方案（MCS，Modulation and Coding Scheme)选择或者调度，从而提高系统的吞吐量。

可选的，在所述功率比值信息中：

所述至少一个端口组中的每个端口组内的各天线端口上数据信道相对于参考信号的功率比值都相同；

或者，所述至少一个端口组中的一个端口组内各个端口上的数据信道与其它端口组内各个端口的数据信道相对于参考信号的功率比值相同；

可选的，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的多套功率比值，

所述第四接收单元，具体用于接收用户设备发送的多套信道状态信息 CSI，其中每一套信道状态信息 CSI 为所述用户设备根据所述多套功率比值中的一套功率比值得到的。

可选的，所述第四接收单元接收的所述信道状态信息 CSI 包括：信道质量指示 CQI，预编码矩阵指示 PMI，或秩指示 RI 其中任意一个或者任意组合。

本实施例提供的网络侧装置，可以是网络侧的基站，其各单元功能的实现可以参照实施例三中相应步骤的描述，此处不重述。

实施例八

本发明实施例提供了一种用户设备，如图 10 所示，所述用户设备包括：第五接收单元 901，第四获取单元 902，第五获取单元 903，和第五发送单元 904；

所述第五接收单元 901，用于接收基站发送的参考信号资源配置信息，所述参考信号资源配置信息包括：参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射关系，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功

率比值;

所述第四获取单元 902，用于根据所述第五接收单元接收的所述参考信号端口配置信息和所述功率比值信息，得到所述至少一个端口组内每个天线端口上数据信道相对于参考信号的功率比值;

所述第五获取单元 903，用于根据所述第四获取单元得到的所述每个天线端口上数据信道相对于参考信号的功率比值，得到信道状态信息 CSI;

所述第五发送单元 904，用于向基站发送所述第五获取单元得到的所述信道状态信息 CSI。

本发明实施例提供了一种用户设备，该装置可以根据其中一个端口组或者多个端口组的参考信号质量处理得到最终的信号质量测量信息，使得 UE 侧可以将端口根据不同的端口组进行区分，不同于现有技术中不能区分不同端口的发射功率的情况。使得 UE 能够获取的信道状态信息，可以使得 UE 进行更为准确的调制与编码方案（MCS，Modulation and Coding Scheme)选择或者调度，从而提高系统的吞吐量。

可选的，所述第五获取单元，具体用于:

根据所述每个天线端口上的参考信号得到所述每个天线端口对应的信道测量值;

根据所述每个天线端口对应的信道测量值，和所述每个天线端口上数据信道相对于参考信号的功率比值，得到所述每个天线端口上数据信道的信道估计值;

根据所述每个天线端口上数据信道的信道估计值得到信道状态信息 CSI。

可选的，所述第五获取单元根据所述每个天线端口对应的信道测量值，和所述每个天线端口上数据信道相对于参考信号的功率比值，得到所述每个天线端口上数据信道的信道估计值，包括:

根据公式 $\hat{\mathbf{h}}_p = \sqrt{\rho_p}\mathbf{h}_p$ 得到天线端口 p 上数据信道的信道估计值;

其中，p 为所述天线端口的索引，ρ_p 为天线端口 p 上数据信道相对于参考信号的功率比值，$\mathbf{h}_p$ 为天线端口 p 对应的信道测量值，$\hat{\mathbf{h}}_p$ 为天线端口 p 上数据

信道的信道估计值。

可选的，在所述功率比值信息中，

所述至少一个端口组中的每个端口组内的各天线端口上数据信道相对于参考信号的功率比值相同；

或者，所述至少一个端口组中的一个端口组内的各个端口上的数据信道与其它端口组内各个端口上的数据信道相对于参考信号的功率比值相同。

可选的，所述第五接收单元接收的所述参考信号资源配置信息包括：参考信号端口配置信息和功率比值信息；

其中，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的多套功率比值；

所述第五发送单元，具体用于：

向基站发送所述多套信道状态信息 CSI，其中每一套信道状态信息 CSI 为根据所述多套功率比值中的一套功率比值得到的。

可选的，所述第五获取单元得到的所述信道状态信息 CSI 包括：信道质量指示 CQI，预编码矩阵指示 PMI，或秩指示 RI 其中任意一个或者任意组合。

本实施例提供的用户设备，其各单元功能的实现可以参照实施例四中相应步骤的描述，此处不重述。

实施例九

提供一种网络侧装置，能支持无线通信技术，且本实施例的通信设备中各个单元之间可以按照实施例一中所述的方法进行数据包的传输，结构示意图如图11所示，包括：分别连接到总线上的处理器21、接收器23和发射器24，

可选的，所示网络侧装置还可以包括：存储器20；

其中：

存储器20中用来储存从接收器23输入的数据，且还可以储存处理器21处理数据的必要文件等信息；接收器23和发射器24是通信设备与其它设备通信的端口。

其中，所述处理器 21，用于确定参考信号资源配置信息，所述参考信号资源配置信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系；

所述发射器 24，用于将所述参考信号资源配置信息发送给用户设备，以使得所述用户设备根据所述参考信号端口配置信息获取信号质量测量信息。

可选的，所述处理器 21 确定的所述参考信号资源配置信息还包括：至少两个端口组的参考信号功率信息，用于所述用户设备根据所述参考信号端口配置信息并结合所述至少两个端口组的参考信号功率信息，获取所述信号质量测量信息；

其中，所述至少两个端口组的参考信号功率信息，包括：

第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的比值；

或者，第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的差分。

可选的，当所述信号质量测量信息为参考信号接收功率 RSRP 时，所述发射器还用于向所述用户设备发送滤波器系数信息，用于所述用户设备基于所述滤波器系数信息对所述参考信号接收功率 RSRP 进行滤波并得到路损估计值。

可选的，所述接收器 23 用于接收所述用户设备发送的上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率为所述用户设备根据所述路损估计值计算得到的。

可选的，所述信号质量测量信息包括：

参考信号接收功率 RSRP，参考信号接收质量 RSRQ，或者参考信号强度指示 RSSI 其中任一项或者任意组合。

可选的，所述接收器 23 还用于接收用户设备发送的所述信号质量测量信息。

本实施例说明的网络侧装置可以是网络侧的基站，其各单元功能的实现可以参照实施例一中相应步骤的描述，此处不重述。

实施例十

本实施例提供一种用户设备，能支持无线通信技术，且本实施例的通信设备中各个单元之间可以按照实施例二中所述的方法进行数据包的传输，结构示意图如图12所示，包括：分别连接到总线上的处理器31、接收器33和发射器34，

可选的，所示网络侧装置还可以包括：存储器30;

其中：

存储器30中用来储存从接收器33输入的数据，且还可以储存处理器31处理数据的必要文件等信息；接收器33和发射器34是通信设备与其它设备通信的端口。

所述接收器 33，用于接收基站发送的参考信号资源配置信息，所述参考信号资源配置信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系；

所述处理器 31，用于根据所述参考信号端口配置信息，得到至少一个端口组中的参考信号端口信息；根据所述至少一个端口组中的参考信号端口信息获取信号质量测量信息。

可选的，所述处理器 31，具体用于：

根据所述参考信号端口配置信息，得到指定的一个端口组中的参考信号端口信息；

根据所述指定的一个端口组中的参考信号端口信息获取所述信号质量测量信息。

可选的，当所述信号质量测量信息为参考信号接收功率 RSRP 时，所述处理器根据所述指定的一个端口组中的参考信号端口信息获取所述信号质量测量信息，包括：

根据公式：$$RSRP(r,p)=\frac{1}{K_s-1}\sum_{m=0}^{K_s-1}\hat{h}_p(m)\cdot\hat{h}_p(m+1)$$ 得到第 r 个接收天线第 p 个端口的参考信号接收功率 $RSRP(r,p)$ 并通过组合 $RSRP(r,p)$ 得到所述 RSRP；其中，$\hat{h}_p(m)$ 为标号为 m 的参考信号 RE 上的信道估计；K_s 是在测量带宽内可利用的参考信号 RE 的样本总数；p 为所述指定的一个端口组中参考信号端口号，r 为接收天线的索引。

可选的，所述接收器 33 接收的所述参考信号资源配置信息还包括：至少

两个端口组的参考信号功率信息，用于所述用户设备根据所述参考信号端口配置信息并结合所述至少两个端口组的参考信号功率信息获取所述信号质量测量信息。

可选的，所述处理器 31 根据所述参考信号端口配置信息并结合至少两个端口组的参考信号功率信息获取信号质量测量信息，包括：

根据所述参考信号端口配置信息得到所述至少两个端口组对应的信号质量测量信息；

根据所述至少两个端口组的参考信号功率信息，对所得到的至少两个端口组对应的信号质量测量信息按端口组功率进行加权平均，得到所述信号质量测量信息。

可选的，所述处理器 31 根据所述至少两个端口组的参考信号功率信息，对所得到的至少两个端口组对应的信号质量测量信息按端口组功率进行加权平均，得到信号质量测量信息，包括：

根据公式：$SQ=\left(\sum_{g=0}^{n-1}p_g\cdot SQ_g\right)\Big/\left(\sum_{g=0}^{n-1}p_g\right)$，得到信号质量测量信息，

其中，SQ_g 为指定端口组的信号质量测量信息，其中，g 为指定端口组的编号，n 为指定端口组的个数，$n\geq 2$；p_g 为指定端口组的参考信号功率，其中，指定端口组的参考信号功率根据所述至少两个端口组的参考信号功率信息得到。

可选的，所述接收器 33 接收到的所述至少两个端口组的参考信号功率信息，包括：

第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的比值；

或者，第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的差分。

可选的，所述发射器 34 用于向基站发送所述信号质量测量信息。

可选的，当所述信号质量测量信息为参考信号接收功率 RSRP 时，所述接收器还用于接收基站发送的滤波器系数信息；

所述处理器 31，还用于基于所述滤波器系数信息对所述参考信号接收功

率 RSRP 进行滤波，并得到路损估计值。

可选的，所述发射器 34 还用于向基站发送上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率根据所述路损估计值计算得到。

可选的，所述信号质量测量信息，包括：参考信号接收功率 RSRP，参考信号强度指示 RSSI，或者参考信号接收质量 RSRQ。

实施例十一

提供一种网络侧装置，能支持无线通信技术，且本实施例的通信设备中各个单元之间可以按照实施例三中所述的方法进行数据包的传输，结构示意图如图13所示，包括：分别连接到总线上的处理器41、接收器43和发射器44，

可选的，所示网络侧装置还可以包括：存储器40;

其中：

存储器40中用来储存从接收器43输入的数据，且还可以储存处理器41处理数据的必要文件等信息；接收器43和发射器44是通信设备与其它设备通信的端口。

其中，所述发射器 44，用于向用户设备发送参考信号资源配置信息，所述参考信号资源配置信息包括：参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射关系，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功率比值;

所述接收器 43，用于接收用户设备发送的信道状态信息 CSI，其中，所述 CSI 为所述用户设备根据所述参考信号端口配置信息和所述功率比值信息得到。

可选的，在所述功率比值信息中：

所述至少一个端口组中的每个端口组内的各天线端口上数据信道相对于参考信号的功率比值都相同;

或者，所述至少一个端口组中的一个端口组内各个端口上的数据信道与其它端口组内各个端口的数据信道相对于参考信号的功率比值相同。

可选的，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的多套功率比值；

所述接收器接收用户设备发送的信道状态信息 CSI，包括：接收用户设备发送的多套信道状态信息 CSI，其中每一套信道状态信息 CSI 为所述用户设备根据所述多套功率比值中的一套功率比值得到的。

可选的，所述接收器接收的所述信道状态信息 CSI 包括：信道质量指示 CQI，预编码矩阵指示 PMI，或秩指示 RI 其中任意一个或者任意组合。

本实施例提供的网络侧装置，可以是网络侧的基站，其各单元功能的实现可以参照实施例三中相应步骤的描述，此处不重述。

实施例十二

本实施例提供一种用户设备，能支持无线通信技术，且本实施例的通信设备中各个单元之间可以按照实施例四中所述的方法进行数据包的传输，结构示意图如图14所示，包括：分别连接到总线上的处理器51、接收器53和发射器54，

可选的，所示网络侧装置还可以包括：存储器50；

其中，存储器50中用来储存从接收器53输入的数据，且还可以储存处理器51处理数据的必要文件等信息；接收器53和发射器54是通信设备与其它设备通信的端口。

所述接收器 53，用于接收基站发送的参考信号资源配置信息，所述参考信号资源配置信息包括：参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射关系，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功率比值；

所述处理器 51，用于根据所述参考信号端口配置信息和所述功率比值信息，得到所述至少一个端口组内每个天线端口上数据信道相对于参考信号的功率比值，并根据所述每个天线端口上数据信道相对于参考信号的功率比值，得到信道状态信息 CSI；

所述发射器 54，用于向基站发送所述信道状态信息 CSI。

可选的，所述处理器 51 根据所述每个天线端口上数据信道相对于参考信

号的功率比值，得到信道状态信息 CSI，包括：

根据所述每个天线端口上的参考信号得到所述每个天线端口对应的信道测量值；

根据所述每个天线端口对应的信道测量值，和所述每个天线端口上数据信道相对于参考信号的功率比值，得到所述每个天线端口上数据信道的信道估计值；

根据所述每个天线端口上数据信道的信道估计值得到信道状态信息 CSI。

可选的，所述处理器 51 根据所述每个天线端口对应的信道测量值，和所述每个天线端口上数据信道相对于参考信号的功率比值，得到所述每个天线端口上数据信道的信道估计值，包括：

根据公式 $\hat{\mathbf{h}}_p = \sqrt{\rho_p}\mathbf{h}_p$ 得到天线端口 p 上数据信道的信道估计值；

其中，p 为所述天线端口的索引，ρ_p 为天线端口 p 上数据信道相对于参考信号的功率比值，$\mathbf{h}_p$ 为天线端口 p 对应的信道测量值，$\hat{\mathbf{h}}_p$ 为天线端口 p 上数据信道的信道估计值。

可选的，在所述功率比值信息中，

所述至少一个端口组中的每个端口组内的各天线端口上数据信道相对于参考信号的功率比值相同；

或者，所述至少一个端口组中的一个端口组内的各个端口上的数据信道与其它端口组内各个端口上的数据信道相对于参考信号的功率比值相同。

可选的，所述所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的多套功率比值；

所述发射器具体用于：

向所述基站发送所述多套信道状态信息 CSI，其中每一套信道状态信息 CSI 为根据所述多套功率比值中的一套功率比值得到的。

可选的，所述处理器得到的所述信道状态信息 CSI 包括：信道质量指示 CQI，预编码矩阵指示 PMI，或秩指示 RI 其中任意一个或者任意组合。

本领域普通技术人员可以理解上述实施例的各种方法中的全部或部分步

骤是可以通过程序来指令相关的硬件来完成，该程序可以存储于一计算机可读存储介质中，存储介质可以包括：ROM、RAM、磁盘或光盘等。

以上对本发明实施例所提供的通信质量测量的方法和装置，进行了详细介绍，本文中应用了具体个例对本发明的原理及实施方式进行了阐述，以上实施例的说明只是用于帮助理解本发明的方法及其核心思想；同时，对于本领域的一般技术人员，依据本发明的思想，在具体实施方式及应用范围上均会有改变之处，综上所述，本说明书内容不应理解为对本发明的限制。

权 利 要 求

1、一种通信质量测量的方法，其特征在于，包括:

确定参考信号资源配置信息，所述参考信号资源配置信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系;

将所述参考信号资源配置信息发送给用户设备，以使得所述用户设备根据所述参考信号端口配置信息获取信号质量测量信息。

2、根据权利要求 1 所述的方法，其特征在于，所述参考信号资源配置信息还包括: 至少两个端口组的参考信号功率信息，用于所述用户设备根据所述参考信号端口配置信息并结合所述至少两个端口组的参考信号功率信息，获取所述信号质量测量信息;

其中，所述至少两个端口组的参考信号功率信息，包括:

第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的比值;

或者，第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的差分。

3、根据权利要求 1 或者 2 所述方法，其特征在于，所述信号质量测量信息为参考信号接收功率 RSRP，所述方法还包括:

向所述用户设备发送滤波器系数信息，用于所述用户设备基于所述滤波器系数信息对所述参考信号接收功率 RSRP 进行滤波并得到路损估计值。

4、根据权利 3 所述方法，其特征在于，所述方法还包括:

接收所述用户设备发送的上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率为所述用户设备根据所述路损估计值计算得到的。

5、根据权利要求 1 或者 2 所述方法，其特征在于，所述信号质量测量信息包括:

参考信号接收功率 RSRP，参考信号接收质量 RSRQ，或者参考信号强度指示 RSSI 其中任一项或者任意组合。

6、根据权利要求 1 至 5 任一项所述方法，其特征在于，所述方法还包括:

接收用户设备发送的所述信号质量测量信息。

7、一种通信质量测量的方法，其特征在于，包括:

接收基站发送的参考信号资源配置信息，所述参考信号资源配置信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系;

根据所述参考信号端口配置信息，得到至少一个端口组中的参考信号端口信息;

根据所述至少一个端口组中的参考信号端口信息获取信号质量测量信息。

8、根据权利要求 7 所述方法，其特征在于，所述根据所述参考信号端口配置信息，得到至少一个端口组中的参考信号端口信息包括:

根据所述参考信号端口配置信息，得到指定的一个端口组中的参考信号端口信息;

所述根据所述至少一个端口组中的参考信号端口信息获取信号质量测量信息包括:

根据所述指定的一个端口组中的参考信号端口信息获取所述信号质量测量信息。

9、根据权利要求 8 所述方法，其特征在于，当所述信号质量测量信息为参考信号接收功率 RSRP 时，所述根据所述指定的一个端口组中的参考信号端口信息获取所述信号质量测量信息，包括:

根据公式: $$RSRP(r,p)=\frac{1}{K_s-1}\sum_{m=0}^{K_s-1}\hat{h}_p(m)\cdot\hat{h}_p(m+1)$$ 得到第 r 个接收天线第 p 个端口的参考信号接收功率 $RSRP(r,p)$ 并通过组合 $RSRP(r,p)$ 得到所述 RSRP; 其中，$\hat{h}_p(m)$ 为标号为 m 的参考信号 RE 上的信道估计; K_s 是在测量带宽内可利用的参考信号 RE 的样本总数; p 为所述指定的一个端口组中参考信号端口号，r 为接收天线的索引。

10、根据权利要求 7 所述方法，其特征在于，所述参考信号资源配置信息

还包括：至少两个端口组的参考信号功率信息，用于所述用户设备根据所述参考信号端口配置信息并结合所述至少两个端口组的参考信号功率信息获取所述信号质量测量信息。

11、根据权利要求 10 所述方法，其特征在于，所述根据所述参考信号端口配置信息并结合至少两个端口组的参考信号功率信息获取信号质量测量信息，包括：

根据所述参考信号端口配置信息得到所述至少两个端口组对应的信号质量测量信息；

根据所述至少两个端口组的参考信号功率信息，对所得到的至少两个端口组对应的信号质量测量信息按端口组功率进行加权平均，得到所述信号质量测量信息。

12、根据权利要求 11 所述方法，其特征在于，所述根据所述至少两个端口组的参考信号功率信息，对所得到的至少两个端口组对应的信号质量测量信息按端口组功率进行加权平均，得到信号质量测量信息，包括：

根据公式：$SQ = \left(\sum_{g=0}^{n-1} p_g \cdot SQ_g \right) \Big/ \left(\sum_{g=0}^{n-1} p_g \right)$，得到信号质量测量信息，

其中，SQ_g 为指定端口组的信号质量测量信息，其中，g 为指定端口组的编号，n 为指定端口组的个数，$n \geq 2$；p_g 为指定端口组的参考信号功率，其中，指定端口组的参考信号功率根据所述至少两个端口组的参考信号功率信息得到。

13、根据权利要求 10 至 12 任一项所述的方法，其特征在于，所述至少两个端口组的参考信号功率信息，包括：

第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的比值；

或者，第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的差分。

14、根据权利要求 7 至 13 任一项所述的方法，其特征在于，所述方法还包括：

向基站发送所述信号质量测量信息。

15、根据权利要求 7 至 14 任一项所述方法，其特征在于，所述信号质量测量信息为参考信号接收功率 RSRP，所述方法还包括:

接收基站发送的滤波器系数信息;

基于所述滤波器系数信息对所述参考信号接收功率 RSRP 进行滤波，并得到路损估计值。

16、根据权利要求 15 所述方法，其特征在于，所述方法还包括:

向基站发送上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率根据所述路损估计值计算得到。

17、根据权利要求 7 所述方法，其特征在于，所述信号质量测量信息，包括: 参考信号接收功率 RSRP，参考信号强度指示 RSSI，或者参考信号接收质量 RSRQ。

18、一种通信质量测量的方法，其特征在于，包括:

向用户设备发送参考信号资源配置信息，所述参考信号资源配置信息包括: 参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射关系，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功率比值;

接收用户设备发送的信道状态信息 CSI，其中，所述 CSI 为所述用户设备根据所述参考信号端口配置信息和所述功率比值信息得到。

19、根据权利要求 18 所述的方法，其特征在于，在所述功率比值信息中:

所述至少一个端口组中的每个端口组内的各天线端口上数据信道相对于参考信号的功率比值都相同;

或者，所述至少一个端口组中的一个端口组内各个端口上的数据信道与其它端口组内各个端口的数据信道相对于参考信号的功率比值相同。

20、根据权利要求 18 或者 19 所述的方法，其特征在于，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的多套功率比值，

所述接收用户设备发送的信道状态信息 CSI，包括接收用户设备发送的多套信道状态信息 CSI，其中每一套信道状态信息 CSI 为所述用户设备根据所述多套功率比值中的一套功率比值得到的。

21、根据权利要求 18 至 20 任一项所述方法，其特征在于，所述信道状态

信息 CSI 包括：信道质量指示 CQI，预编码矩阵指示 PMI，或秩指示 RI 其中任意一个或者任意组合。

22、一种通信质量测量方法，其特征在于，所述方法包括:

接收基站发送的参考信号资源配置信息，所述参考信号资源配置信息包括: 参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射关系，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功率比值;

根据所述参考信号端口配置信息和所述功率比值信息，得到所述至少一个端口组内每个天线端口上数据信道相对于参考信号的功率比值，

并根据所述每个天线端口上数据信道相对于参考信号的功率比值，得到信道状态信息 CSI;

向基站发送所述信道状态信息 CSI。

23、根据权利要求 22 所述方法，其特征在于，所述根据所述每个天线端口上数据信道相对于参考信号的功率比值，得到信道状态信息 CSI，包括:

根据所述每个天线端口上的参考信号得到所述每个天线端口对应的信道测量值;

根据所述每个天线端口对应的信道测量值，和所述每个天线端口上数据信道相对于参考信号的功率比值，得到所述每个天线端口上数据信道的信道估计值;

根据所述每个天线端口上数据信道的信道估计值得到信道状态信息 CSI。

24、根据权利要求 23 所述方法，其特征在于，所述根据所述每个天线端口对应的信道测量值，和所述每个天线端口上数据信道相对于参考信号的功率比值，得到所述每个天线端口上数据信道的信道估计值，包括:

根据公式 $\hat{\mathbf{h}}_p = \sqrt{\rho_p}\mathbf{h}_p$ 得到天线端口 p 上数据信道的信道估计值;

其中，p 为所述天线端口的索引，ρ_p 为天线端口 p 上数据信道相对于参考信号的功率比值，$\mathbf{h}_p$ 为天线端口 p 对应的信道测量值，$\hat{\mathbf{h}}_p$ 为天线端口 p 上数据信道的信道估计值。

25、根据权利要求 22 至 24 任一项所述的方法，其特征在于，在所述功率比值信息中，

所述至少一个端口组中的每个端口组内的各天线端口上数据信道相对于参考信号的功率比值相同；

或者，所述至少一个端口组中的一个端口组内的各个端口上的数据信道与其它端口组内各个端口上的数据信道相对于参考信号的功率比值相同。

26、根据权利要求 22 所述的方法，其特征在于，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的多套功率比值；

所述向基站发送所述信道状态信息 CSI，包括：

向基站发送所述多套信道状态信息 CSI，其中每一套信道状态信息 CSI 为根据所述多套功率比值中的一套功率比值得到的。

27、根据权利要求 22 至 26 任一项所述方法，其特征在于，所述信道状态信息 CSI 包括：信道质量指示 CQI，预编码矩阵指示 PMI，或秩指示 RI 其中任意一个或者任意组合。

28、一种网络侧装置，其特征在于，所述网络侧装置包括：确定单元，和第一发送单元；

所述确定单元，用于确定参考信号资源配置信息，所述参考信号资源配置信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系；

所述第一发送单元，用于将所述确定单元确定的所述参考信号资源配置信息发送给用户设备，以使得所述用户设备根据所述参考信号端口配置信息获取信号质量测量信息。

29、根据权利要求 28 所述装置，其特征在于，所述确定单元确定的所述参考信号资源配置信息还包括：至少两个端口组的参考信号功率信息，用于所述用户设备根据所述参考信号端口配置信息并结合所述至少两个端口组的参考信号功率信息，获取所述信号质量测量信息；

其中，所述至少两个端口组的参考信号功率信息，包括：

第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的比值；

或者，第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的差分。

30、根据权利要求 28 或 29 所述装置，其特征在于，当所述信号质量测量信息为参考信号接收功率 RSRP 时，所述第一发送单元还用于向所述用户设备发送滤波器系数信息，用于所述用户设备基于所述滤波器系数信息对所述参考信号接收功率 RSRP 进行滤波并得到路损估计值。

31、根据权利要求 30 所述装置，其特征在于，所述装置还包括：

第一接收单元，用于接收所述用户设备发送的上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率为所述用户设备根据所述路损估计值计算得到的。

32、根据权利要求 28 或者 29 所述装置，其特征在于，所述信号质量测量信息包括：

参考信号接收功率 RSRP，参考信号接收质量 RSRQ，或者参考信号强度指示 RSSI 其中任一项或者任意组合。

33、根据权利要求 28 至 32 任一项所述装置，其特征在于，所述装置还包括：第二接收单元，

所述第二接收单元用于接收用户设备发送的所述信号质量测量信息。

34、一种用户设备，其特征在于，所述用户设备包括：第三接收单元，第一获取单元，和第二获取单元；

所述第三接收单元，用于接收基站发送的参考信号资源配置信息，所述参考信号资源配置信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系；

所述第一获取单元，用于根据所述第三接收单元接收的所述参考信号端口配置信息，得到至少一个端口组中的参考信号端口信息；

所述第二获取单元，用于根据所述第一获取单元得到所述至少一个端口组中的参考信号端口信息获取信号质量测量信息。

35、根据权利要求 34 所述用户设备，其特征在于，所述第一获取单元，具体用于根据所述第三接收单元接收的所述参考信号端口配置信息，得到指定的一个端口组中的参考信号端口信息；

所述第二获取单元，具体用于根据所述第一获取单元得到的所述指定的一个端口组中的参考信号端口信息获取所述信号质量测量信息。

36、根据权利要求 35 所述用户设备，其特征在于，当所述信号质量测量信息为参考信号接收功率 RSRP 时，所述第二获取单元具体用于：

根据公式：$RSRP(r,p)=\frac{1}{K_s-1}\sum_{m=0}^{K_s-1}\hat{h}_p(m)\cdot\hat{h}_p(m+1)$ 得到第 r 个接收天线第 p 个端口的参考信号接收功率 $RSRP(r,p)$ 并通过组合 $RSRP(r,p)$ 得到所述 RSRP；其中，$\hat{h}_p(m)$ 为标号为 m 的参考信号 RE 上的信道估计；K_s 是在测量带宽内可利用的参考信号 RE 的样本总数；p 为所述指定的一个端口组中参考信号端口号，r 为接收天线的索引。

37、根据权利要求 34 所述用户设备，其特征在于，所述第三接收单元接收的所述参考信号资源配置信息还包括：至少两个端口组的参考信号功率信息，

所述第二获取单元还用于根据所述参考信号端口配置信息并结合所述至少两个端口组的参考信号功率信息获取所述信号质量测量信息。

38、根据权利要求 37 所述用户设备，其特征在于，所述第二获取单元具体用于：

根据所述参考信号端口配置信息得到所述至少两个端口组对应的信号质量测量信息；

根据所述至少两个端口组的参考信号功率信息，对所得到的至少两个端口组对应的信号质量测量信息按端口组功率进行加权平均，得到所述信号质量测量信息。

39、根据权利要求 38 所述用户设备，其特征在于，所述第二获取单元根据所述至少两个端口组的参考信号功率信息，对所得到的至少两个端口组对应的信号质量测量信息按端口组功率进行加权平均，得到所述信号质量测量信息，包括：

根据公式：$SQ=\left(\sum_{g=0}^{n-1}p_g\cdot SQ_g\right)\Big/\left(\sum_{g=0}^{n-1}p_g\right)$，得到信号质量测量信息，

其中，SQ_g为指定端口组的信号质量测量信息，其中，g 为指定端口组的编号，n 为指定端口组的个数，$n \geq 2$；p_g为指定端口组的参考信号功率，其中，指定端口组的参考信号功率根据所述至少两个端口组的参考信号功率信息得到。

40、根据权利要求 37 至 39 任一项所述用户设备，其特征在于，所述第三接收单元接收到的所述至少两个端口组的参考信号功率信息包括：

第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的比值；

或者，第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的差分。

41、根据权利要求 34 至 40 任一项所述用户设备，其特征在于，所述用户设备还包括：第二发送单元，用于向基站发送所述信号质量测量信息。

42、根据权利要求 34 至 41 任一项所述用户设备，其特征在于，

所述第三接收单元，还用于当所述信号质量测量信息为参考信号接收功率 RSRP，接收基站发送的滤波器系数信息；

所述用户设备还包括：第三获取单元，

所述第三获取单元，用于基于所述第三接收单元接收的所述滤波器系数信息对所述参考信号接收功率 RSRP 进行滤波，并得到路损估计值。

43、根据权利要求 42 所述用户设备，其特征在于，所述用于装置还包括：第三发送单元，

所述第三发送单元，还用于向基站发送上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率根据所述路损估计值计算得到。

44、根据权利要求 42 所述用户设备，其特征在于，所述信号质量测量信息，包括：参考信号接收功率 RSRP，参考信号强度指示 RSSI，或者参考信号接收质量 RSRQ。

45、一种网络侧装置，其特征在于，所述装置包括：第四发送单元，第四接收单元；

所述第四发送单元，用于向用户设备发送参考信号资源配置信息，所述参

考信号资源配置信息包括：参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射关系，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功率比值；

所述第四接收单元，用于接收用户设备发送的信道状态信息 CSI，其中，所述 CSI 为所述用户设备根据所述参考信号端口配置信息和所述功率比值信息得到。

46、根据权利要求 45 所述装置，其特征在于，在所述功率比值信息中：

所述至少一个端口组中的每个端口组内的各天线端口上数据信道相对于参考信号的功率比值都相同；

或者，所述至少一个端口组中的一个端口组内各个端口上的数据信道与其它端口组内各个端口的数据信道相对于参考信号的功率比值相同。

47、根据权利要求 45 或 46 所述装置，其特征在于，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的多套功率比值，

所述第四接收单元，具体用于接收用户设备发送的多套信道状态信息 CSI，其中每一套信道状态信息 CSI 为所述用户设备根据所述多套功率比值中的一套功率比值得到的。

48、根据权利要求 45 或 47 所述装置，其特征在于，所述第四接收单元接收的所述信道状态信息 CSI 包括：信道质量指示 CQI，预编码矩阵指示 PMI，或秩指示 RI 其中任意一个或者任意组合。

49、一种用户设备，其特征在于，所述用户设备包括：第五接收单元，第四获取单元，第五获取单元，和第五发送单元；

所述第五接收单元，用于接收基站发送的参考信号资源配置信息，所述参考信号资源配置信息包括：参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射关系，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功率比值；

所述第四获取单元，用于根据所述第五接收单元接收的所述参考信号端口配置信息和所述功率比值信息，得到所述至少一个端口组内每个天线端口上数

据信道相对于参考信号的功率比值;

所述第五获取单元，用于根据所述第四获取单元得到的所述每个天线端口上数据信道相对于参考信号的功率比值，得到信道状态信息 CSI;

所述第五发送单元，用于向基站发送所述第五获取单元得到的所述信道状态信息 CSI。

50、根据权利要求 49 所述用户设备，其特征在于，所述第五获取单元，具体用于:

根据所述每个天线端口上的参考信号得到所述每个天线端口对应的信道测量值;

根据所述每个天线端口对应的信道测量值，和所述每个天线端口上数据信道相对于参考信号的功率比值，得到所述每个天线端口上数据信道的信道估计值;

根据所述每个天线端口上数据信道的信道估计值得到信道状态信息 CSI。

51、根据权利要求 50 所述用户设备，其特征在于，所述第五获取单元根据所述每个天线端口对应的信道测量值，和所述每个天线端口上数据信道相对于参考信号的功率比值，得到所述每个天线端口上数据信道的信道估计值，包括:

根据公式 $\hat{\mathbf{h}}_p = \sqrt{\rho_p}\mathbf{h}_p$ 得到天线端口 p 上数据信道的信道估计值;

其中，p 为所述天线端口的索引，ρ_p 为天线端口 p 上数据信道相对于参考信号的功率比值，$\mathbf{h}_p$ 为天线端口 p 对应的信道测量值，$\hat{\mathbf{h}}_p$ 为天线端口 p 上数据信道的信道估计值。

52、根据权利要求 49 至 51 任一项所述用户设备，其特在于，在所述功率比值信息中，

所述至少一个端口组中的每个端口组内的各天线端口上数据信道相对于参考信号的功率比值相同;

或者，所述至少一个端口组中的一个端口组内的各个端口上的数据信道与其它端口组内各个端口上的数据信道相对于参考信号的功率比值相同。

53、根据权利要求 49 所述用户设备，其特在于，所述第五接收单元接收的所述参考信号资源配置信息包括: 参考信号端口配置信息和功率比值信息;

其中，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的多套功率比值；

所述第五发送单元，具体用于：

向基站发送所述多套信道状态信息 CSI，其中每一套信道状态信息 CSI 为根据所述多套功率比值中的一套功率比值得到的。

54、根据权利要求 49 至 53 任一项所述用户设备，所述第五获取单元得到的所述信道状态信息 CSI 包括：信道质量指示 CQI，预编码矩阵指示 PMI，或秩指示 RI 其中任意一个或者任意组合。

55、一种网络侧装置，其特征在于，所述网络侧装置包括：接收器、处理器和发射器；其中，

所述处理器，用于确定参考信号资源配置信息，所述参考信号资源配置信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系；

所述发射器，用于将所述参考信号资源配置信息发送给用户设备，以使得所述用户设备根据所述参考信号端口配置信息获取信号质量测量信息。

56、根据权利要求 55 所述网络侧装置，其特征在于，所述处理器确定的所述参考信号资源配置信息还包括：至少两个端口组的参考信号功率信息，用于所述用户设备根据所述参考信号端口配置信息并结合所述至少两个端口组的参考信号功率信息，获取所述信号质量测量信息；

其中，所述至少两个端口组的参考信号功率信息，包括：

第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的比值；

或者，第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的差分。

57、根据权利要求 55 或 56 所述网络侧装置，其特征在于，当所述信号质量测量信息为参考信号接收功率 RSRP 时，所述发射器还用于向所述用户设备发送滤波器系数信息，用于所述用户设备基于所述滤波器系数信息对所述参考信号接收功率 RSRP 进行滤波并得到路损估计值。

58、根据权利要求 57 所述网络侧装置，其特征在于，所述接收器用于接

收所述用户设备发送的上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率为所述用户设备根据所述路损估计值计算得到的。

59、根据权利要求 55 或 56 所述网络侧装置，其特征在于，所述信号质量测量信息包括:

参考信号接收功率 RSRP，参考信号接收质量 RSRQ，或者参考信号强度指示 RSSI 其中任一项或者任意组合。

60、根据权利要求 55 或 59 所述网络侧装置，其特征在于，所述接收器还用于接收用户设备发送的所述信号质量测量信息。

61、一种用户设备，其特征在于，所述用户设备包括：接收器，处理器和发射器;

所述接收器，用于接收基站发送的参考信号资源配置信息，所述参考信号资源配置信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系;

所述处理器，用于根据所述参考信号端口配置信息，得到至少一个端口组中的参考信号端口信息;根据所述至少一个端口组中的参考信号端口信息获取信号质量测量信息。

62、根据权利要求 60 所述用户设备，其特征在于，所述处理器，具体用于:

根据所述参考信号端口配置信息，得到指定的一个端口组中的参考信号端口信息;

根据所述指定的一个端口组中的参考信号端口信息获取所述信号质量测量信息。

63、根据权利要求 62 所述用户设备，其特征在于，当所述信号质量测量信息为参考信号接收功率 RSRP 时，所述处理器根据所述指定的一个端口组中的参考信号端口信息获取所述信号质量测量信息，包括:

根据公式: $RSRP(r,p)=\frac{1}{K_s-1}\sum_{m=0}^{K_s-1}\hat{h}_p(m)\cdot\hat{h}_p(m+1)$ 得到第 r 个接收天线第 p 个端口的参考信号接收功率 $RSRP(r,p)$ 并通过组合 $RSRP(r,p)$ 得到所述 RSRP; 其中，$\hat{h}_p(m)$

为标号为 m 的参考信号 RE 上的信道估计；K_s是在测量带宽内可利用的参考信号 RE 的样本总数；p 为所述指定的一个端口组中参考信号端口号，r 为接收天线的索引。

64、根据权利要求 60 所述用户设备，其特征在于，所述接收器接收的所述参考信号资源配置信息还包括：至少两个端口组的参考信号功率信息，用于所述用户设备根据所述参考信号端口配置信息并结合所述至少两个端口组的参考信号功率信息获取所述信号质量测量信息。

65、根据权利要求 64 所述用户设备，其特征在于，所述处理器根据所述参考信号端口配置信息并结合至少两个端口组的参考信号功率信息获取信号质量测量信息，包括：

根据所述参考信号端口配置信息得到所述至少两个端口组对应的信号质量测量信息；

根据所述至少两个端口组的参考信号功率信息，对所得到的至少两个端口组对应的信号质量测量信息按端口组功率进行加权平均，得到所述信号质量测量信息。

66、根据权利要求 65 所述用户设备，其特征在于，所述处理器根据所述至少两个端口组的参考信号功率信息，对所得到的至少两个端口组对应的信号质量测量信息按端口组功率进行加权平均，得到信号质量测量信息，包括：

根据公式：$SQ=\left(\sum_{g=0}^{n-1}p_g\cdot SQ_g\right)\Big/\left(\sum_{g=0}^{n-1}p_g\right)$，得到信号质量测量信息，

其中，SQ_g为指定端口组的信号质量测量信息，其中，g 为指定端口组的编号，n 为指定端口组的个数，$n\geq 2$；p_g为指定端口组的参考信号功率，其中，指定端口组的参考信号功率根据所述至少两个端口组的参考信号功率信息得到。

67、根据权利要求 61 至 66 任一项所述用户设备，其特征在于，所述接收器接收到的所述至少两个端口组的参考信号功率信息，包括：

第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的比值；

或者，第一端口组的参考信号功率，以及剩余端口组中每一个端口组的参考信号功率相对于所述第一端口组的参考信号功率的差分。

68、根据权利要求 61 至 67 任一项所述用户设备，其特征在于，所述发射器用于向基站发送所述信号质量测量信息。

69、根据权利要求 61 至 68 任一项所述用户设备，其特征在于，当所述信号质量测量信息为参考信号接收功率 RSRP 时，所述接收器还用于接收基站发送的滤波器系数信息；

所述处理器，还用于基于所述滤波器系数信息对所述参考信号接收功率 RSRP 进行滤波，并得到路损估计值。

70、根据权利要求 69 所述用户设备，其特征在于，所述发射器还用于向基站发送上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率根据所述路损估计值计算得到。

71、根据权利要求 61 所述用户设备，其特征在于，所述信号质量测量信息，包括：参考信号接收功率 RSRP，参考信号强度指示 RSSI，或者参考信号接收质量 RSRQ。

72、一种网络侧装置，其特征在于，所述网络侧装置包括：发射器，和接收器，

所述发射器，用于向用户设备发送参考信号资源配置信息，所述参考信号资源配置信息包括：参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射关系，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功率比值；

所述接收器，用于接收用户设备发送的信道状态信息 CSI，其中，所述 CSI 为所述用户设备根据所述参考信号端口配置信息和所述功率比值信息得到。

73、根据权利要求 72 所述网络侧装置，其特征在于，在所述功率比值信息中：

所述至少一个端口组中的每个端口组内的各天线端口上数据信道相对于参考信号的功率比值都相同；

或者，所述至少一个端口组中的一个端口组内各个端口上的数据信道与其

它端口组内各个端口的数据信道相对于参考信号的功率比值相同。

74、根据权利要求 72 或 73 所述网络侧装置，其特征在于，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的多套功率比值；

所述接收器接收用户设备发送的信道状态信息 CSI，包括：接收用户设备发送的多套信道状态信息 CSI，其中每一套信道状态信息 CSI 为所述用户设备根据所述多套功率比值中的一套功率比值得到的。

75、根据权利要求 72 至 74 任一项所述网络侧装置，其特征在于，所述接收器接收的所述信道状态信息 CSI 包括：信道质量指示 CQI，预编码矩阵指示 PMI，或秩指示 RI 其中任意一个或者任意组合。

76、一种用户设备，其特征在于，所述用户设备包括：接收器，处理器，和发射器；

所述接收器，用于接收基站发送的参考信号资源配置信息，所述参考信号资源配置信息包括：参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射关系，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功率比值；

所述处理器，用于根据所述参考信号端口配置信息和所述功率比值信息，得到所述至少一个端口组内每个天线端口上数据信道相对于参考信号的功率比值，并根据所述每个天线端口上数据信道相对于参考信号的功率比值，得到信道状态信息 CSI；

所述发射器，用于向基站发送所述信道状态信息 CSI。

77、根据权利要求 76 所述用户设备，其特征在于，所述处理器根据所述每个天线端口上数据信道相对于参考信号的功率比值，得到信道状态信息 CSI，包括：

根据所述每个天线端口上的参考信号得到所述每个天线端口对应的信道测量值；

根据所述每个天线端口对应的信道测量值，和所述每个天线端口上数据信道相对于参考信号的功率比值，得到所述每个天线端口上数据信道的信道估计值；

根据所述每个天线端口上数据信道的信道估计值得到信道状态信息 CSI。

78、根据权利要求 77 所述用户设备，其特征在于，所述处理器根据所述每个天线端口对应的信道测量值，和所述每个天线端口上数据信道相对于参考信号的功率比值，得到所述每个天线端口上数据信道的信道估计值，包括：

根据公式 $\hat{\mathbf{h}}_p = \sqrt{\rho_p}\mathbf{h}_p$ 得到天线端口 p 上数据信道的信道估计值；

其中，p 为所述天线端口的索引，ρ_p 为天线端口 p 上数据信道相对于参考信号的功率比值，$\mathbf{h}_p$ 为天线端口 p 对应的信道测量值，$\hat{\mathbf{h}}_p$ 为天线端口 p 上数据信道的信道估计值。

79、根据权利要求 76 至 78 任一项所述用户设备，其特征在于，在所述功率比值信息中，

所述至少一个端口组中的每个端口组内的各天线端口上数据信道相对于参考信号的功率比值相同；

或者，所述至少一个端口组中的一个端口组内的各个端口上的数据信道与其它端口组内各个端口上的数据信道相对于参考信号的功率比值相同。

80、根据权利要求 76 所述用户设备，其特征在于，所述所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的多套功率比值；

所述发射器具体用于：

向所述基站发送所述多套信道状态信息 CSI，其中每一套信道状态信息 CSI 为根据所述多套功率比值中的一套功率比值得到的。

81、根据权利要求 76 至 80 任一项所述用户设备，其特征在于，所述处理器得到的所述信道状态信息 CSI 包括：信道质量指示 CQI，预编码矩阵指示 PMI，或秩指示 RI 其中任意一个或者任意组合。

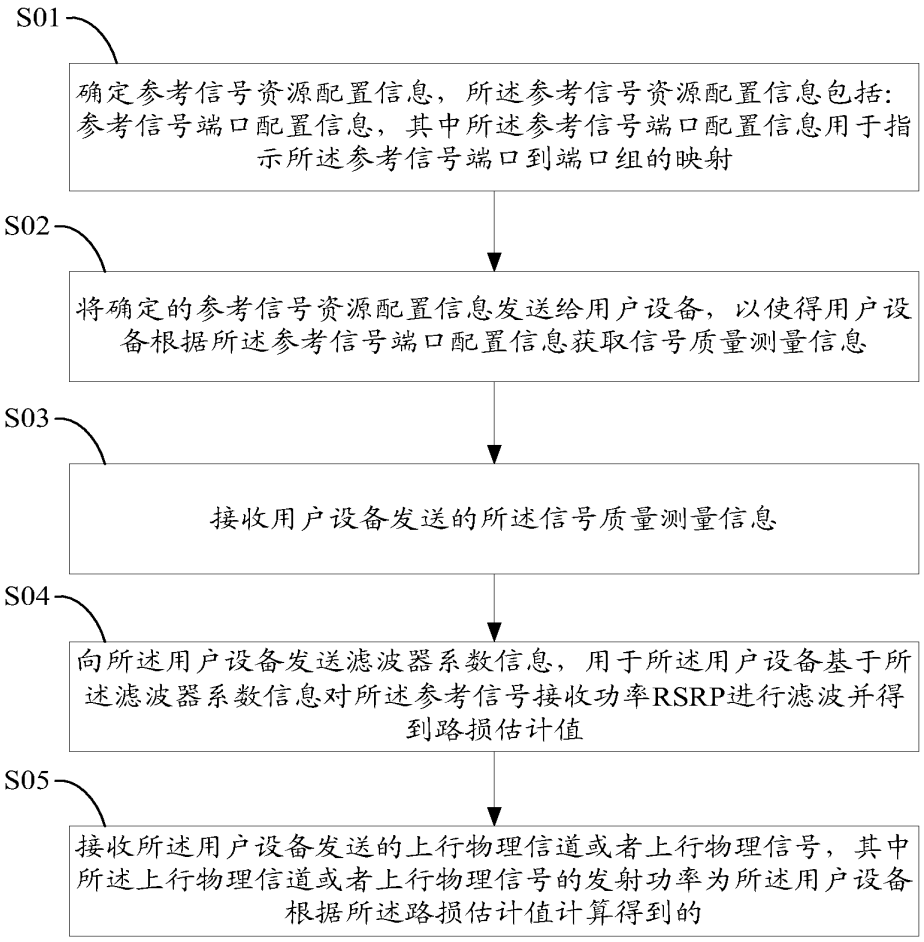

S01
确定参考信号资源配置信息，所述参考信号资源配置信息包括：参考信号端口配置信息，其中所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射
S02
将确定的参考信号资源配置信息发送给用户设备，以使得用户设备根据所述参考信号端口配置信息获取信号质量测量信息
S03
接收用户设备发送的所述信号质量测量信息
S04
向所述用户设备发送滤波器系数信息，用于所述用户设备基于所述滤波器系数信息对所述参考信号接收功率RSRP进行滤波并得到路损估计值
S05
接收所述用户设备发送的上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率为所述用户设备根据所述路损估计值计算得到的

图 1

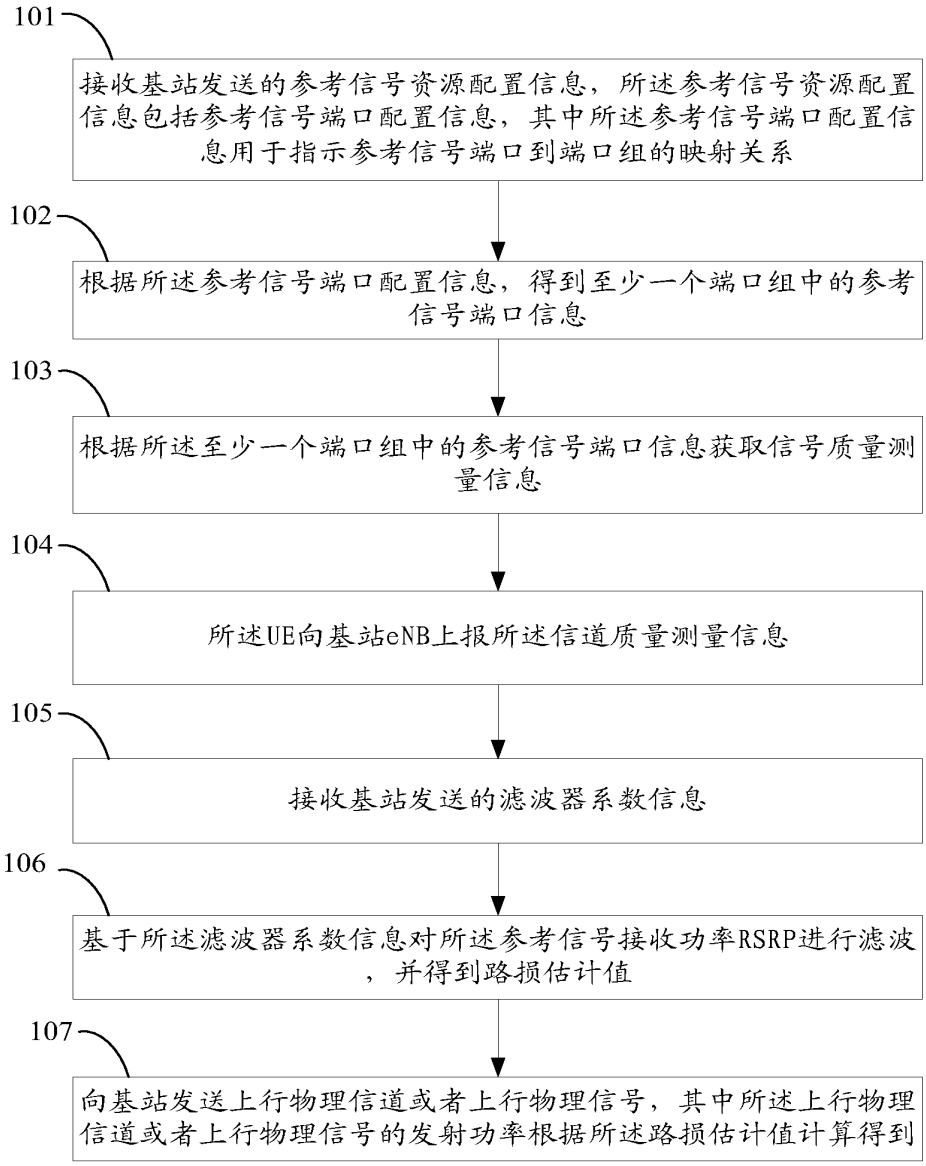

101
接收基站发送的参考信号资源配置信息，所述参考信号资源配置信息包括参考信号端口配置信息，其中所述参考信号端口配置信息用于指示参考信号端口到端口组的映射关系
102
根据所述参考信号端口配置信息，得到至少一个端口组中的参考信号端口信息
103
根据所述至少一个端口组中的参考信号端口信息获取信号质量测量信息
104
所述UE向基站eNB上报所述信道质量测量信息
105
接收基站发送的滤波器系数信息
106
基于所述滤波器系数信息对所述参考信号接收功率RSRP进行滤波，并得到路损估计值
107
向基站发送上行物理信道或者上行物理信号，其中所述上行物理信道或者上行物理信号的发射功率根据所述路损估计值计算得到

图 2

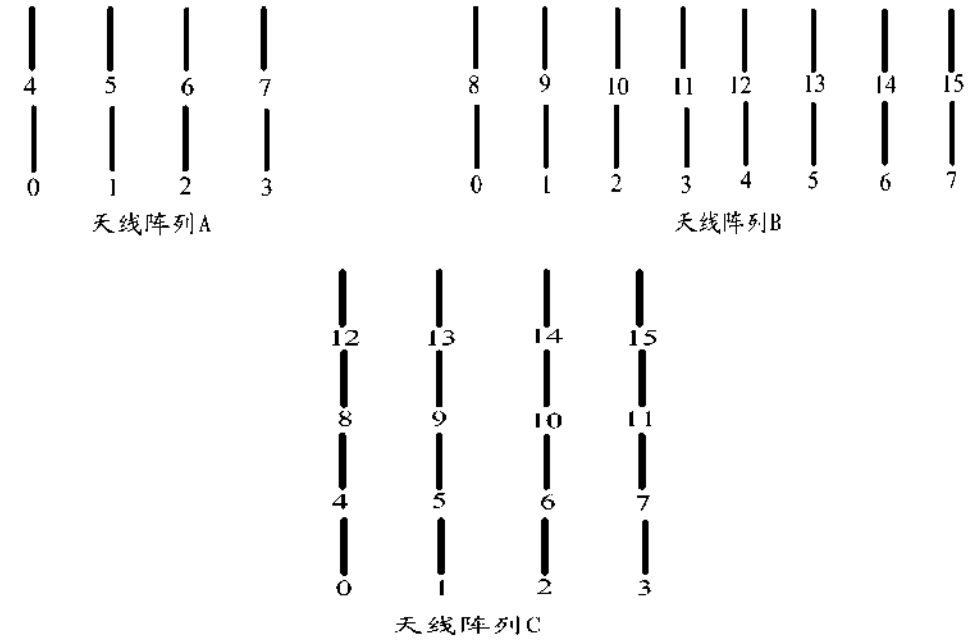

4 5 6 7
0 1 2 3
天线阵列A
8 9 10 11 12 13 14 15
0 1 2 3 4 5 6 7
天线阵列B
12 13 14 15
8 9 10 11
4 5 6 7
0 1 2 3
天线阵列C

图 3

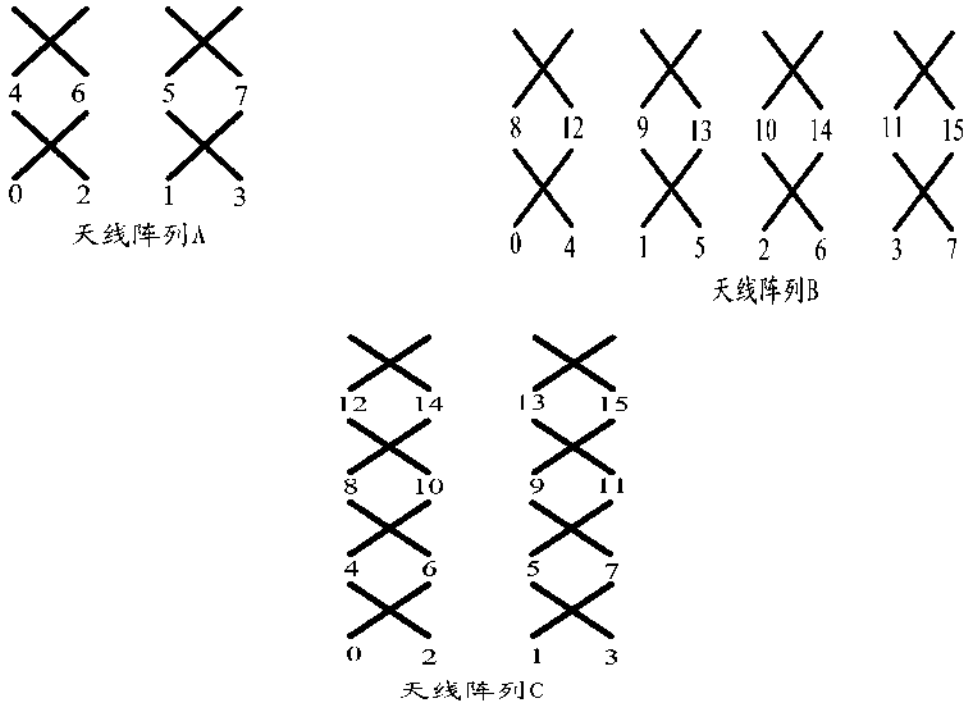

4 6 5 7
0 2 1 3
天线阵列A
8 12 9 13 10 14 11 15
0 4 1 5 2 6 3 7
天线阵列B
12 14 13 15
8 10 9 11
4 6 5 7
0 2 1 3
天线阵列C

图 4

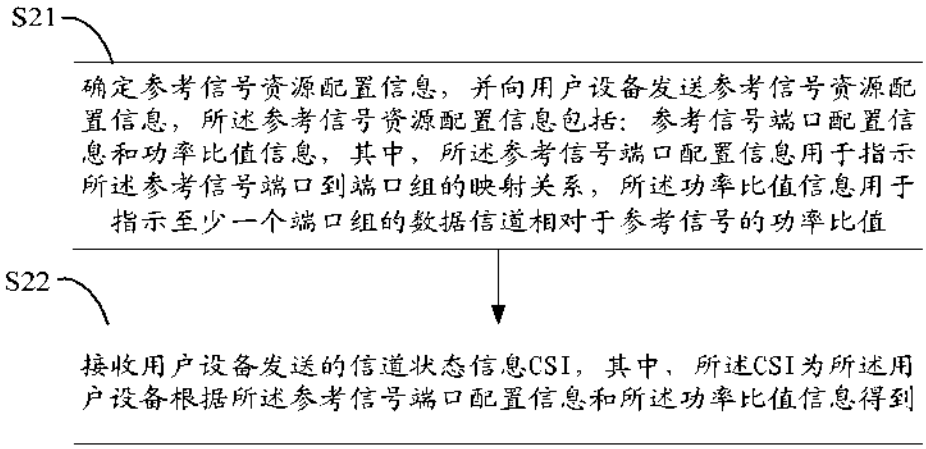

S21
确定参考信号资源配置信息，并向用户设备发送参考信号资源配置信息，所述参考信号资源配置信息包括：参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射关系，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功率比值
S22
接收用户设备发送的信道状态信息CSI，其中，所述CSI为所述用户设备根据所述参考信号端口配置信息和所述功率比值信息得到

图 5

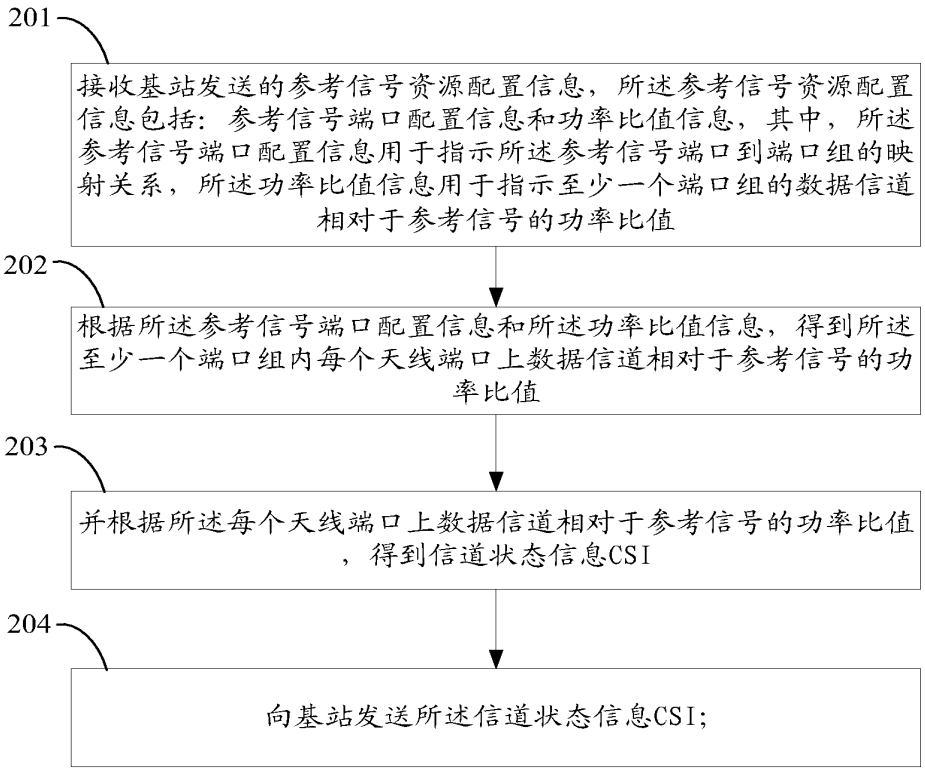

201
接收基站发送的参考信号资源配置信息，所述参考信号资源配置信息包括：参考信号端口配置信息和功率比值信息，其中，所述参考信号端口配置信息用于指示所述参考信号端口到端口组的映射关系，所述功率比值信息用于指示至少一个端口组的数据信道相对于参考信号的功率比值
202
根据所述参考信号端口配置信息和所述功率比值信息，得到所述至少一个端口组内每个天线端口上数据信道相对于参考信号的功率比值
203
并根据所述每个天线端口上数据信道相对于参考信号的功率比值，得到信道状态信息CSI
204
向基站发送所述信道状态信息CSI;

图 6

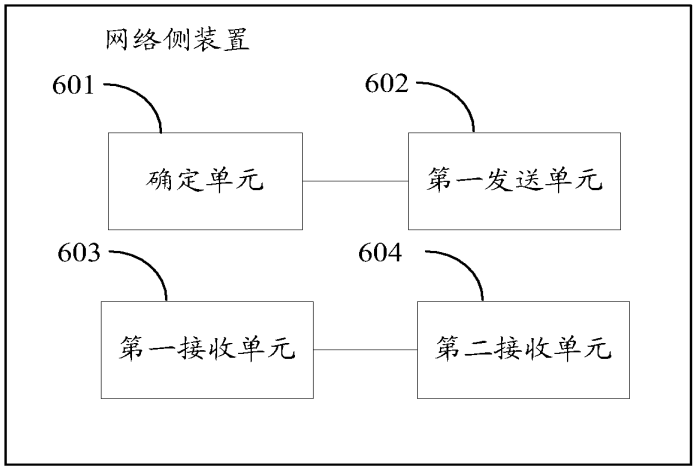

网络侧装置
601
确定单元
602
第一发送单元
603
第一接收单元
604
第二接收单元

图 7

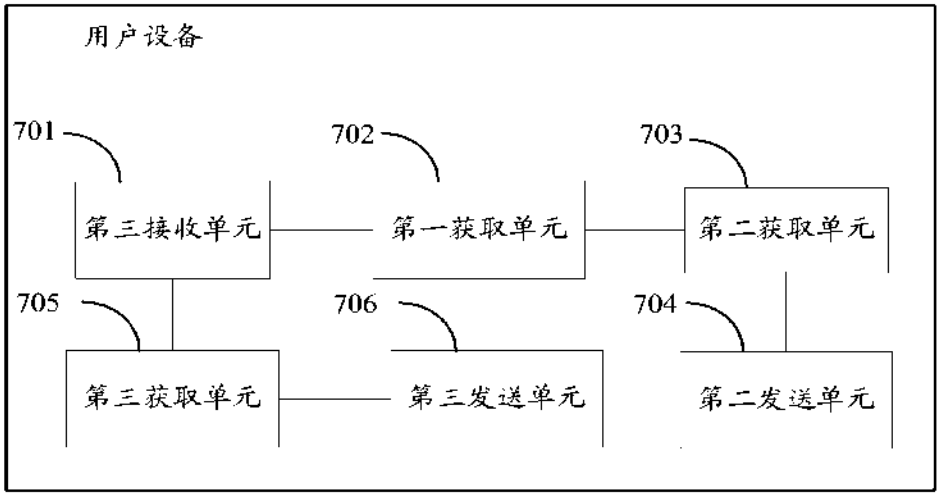

用户设备
701
702
703
第三接收单元
第一获取单元
第二获取单元
705
706
704
第三获取单元
第三发送单元
第二发送单元

图 8

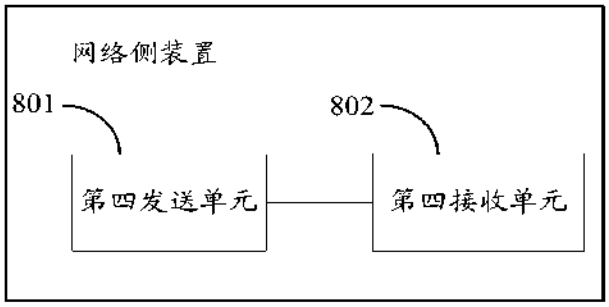

网络侧装置
801
802
第四发送单元
第四接收单元

图 9

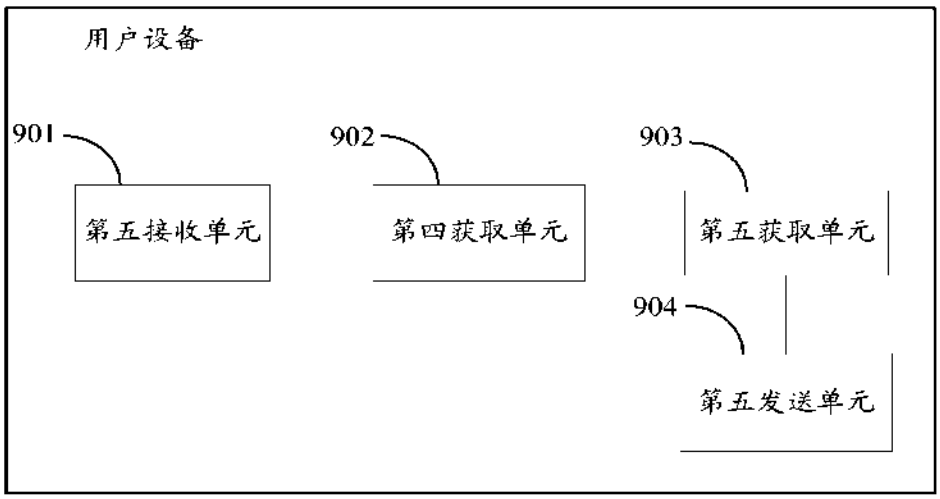

用户设备
901
第五接收单元
902
第四获取单元
903
第五获取单元
904
第五发送单元

图 10

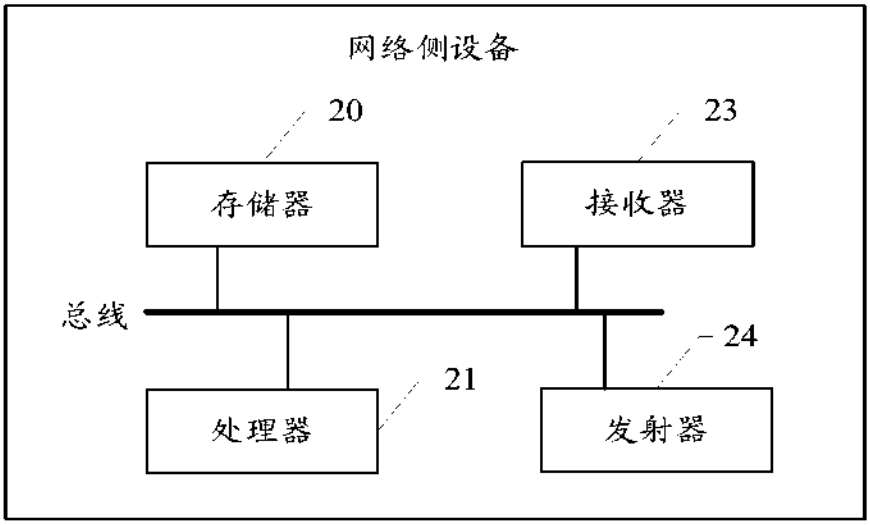

网络侧设备
20
存储器
23
接收器
总线
24
21
处理器
发射器

图 11

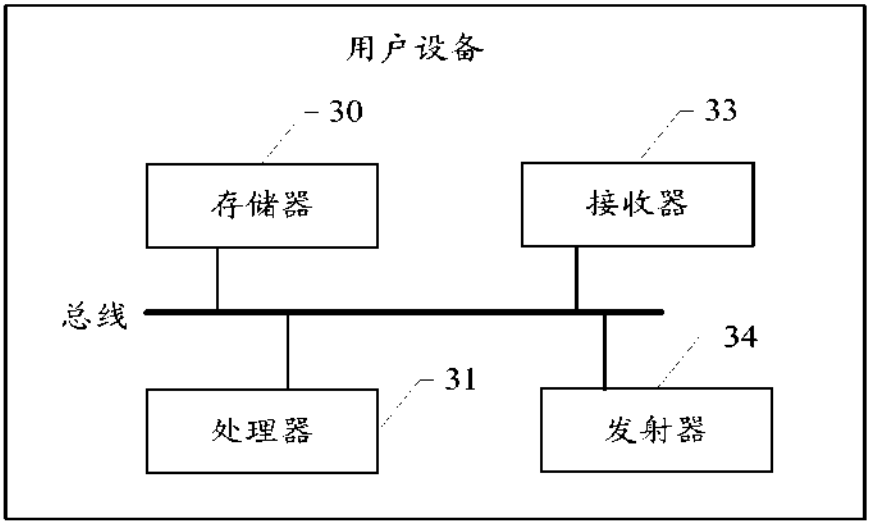

用户设备
30
33
存储器
接收器
总线
34
31
处理器
发射器

图 12

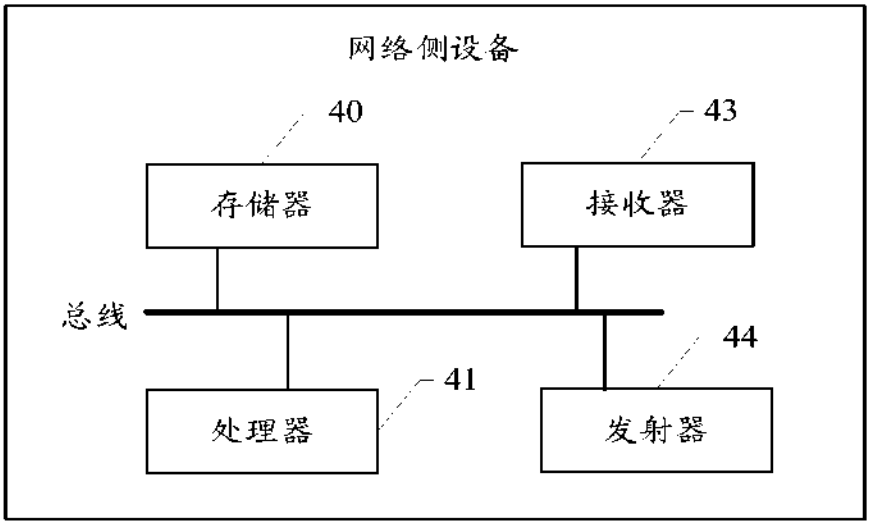

网络侧设备
40
43
存储器
接收器
总线
44
41
处理器
发射器

图 13

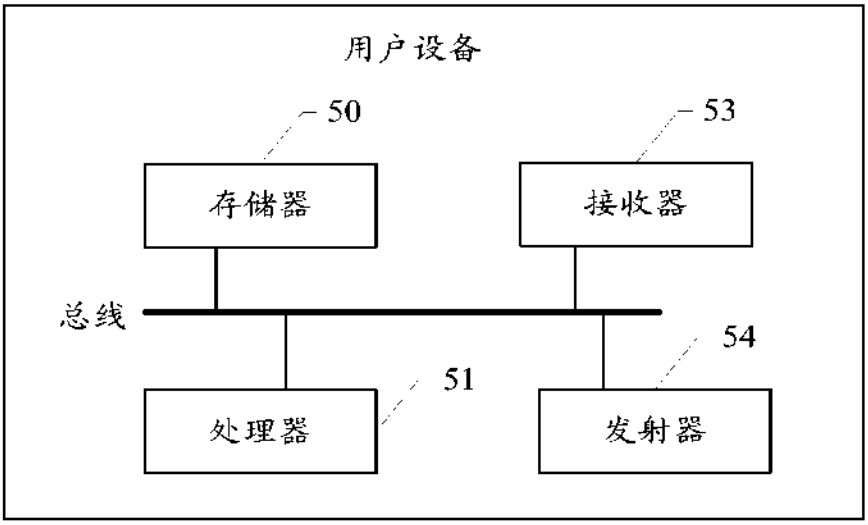


图 14

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2013/077477

A. CLASSIFICATION OF SUBJECT MATTER

H04W 24/00 (2009.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: H04W, H04L, H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNABS, CPRSABS, CNTXT, VEN, CNKI: RS, CSR, DMRS, CSI-RS, port, port group, map, CSI, channel quality, communication quality, pre-coding matrix indication, rank indication, pre-coding type indication, CQI, PMI, RI, PTI, power ratio, psrp, rsrq, rssi, reference signal received power, reference signal received quality, reference signal strength indicator; reference w signal, antenna w port, channel w state w information, channel w quality w indicator, channel w quality w index, power

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 102687438 A (LG ELECTRONICS INC.), 19 September 2012 (19.09.2012), claims 1, description, paragraphs 101-142	1, 3-9, 14, 28, 30-36, 41, 55, 57-63, 68
Y		2, 10-13, 15-27, 29, 37-40, 42-54, 56, 64-67, 69-81
Y	CN 102255689 A (ZTE CORP.), 23 November 2011 (23.11.2011), description, paragraphs 80-85 and 182	2, 10-13, 15-27, 29, 37-40, 42-54, 56, 64-67, 69-81

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 February 2014 (26.02.2014)	**13 March 2014 (13.03.2014)**
Name and mailing address of the ISA/CN: State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No.: (86-10) 62019451	Authorized officer **LIU, Jia** Telephone No.: (86-10) **62412046**

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2013/077477

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 102958147 A (HUAWEI TECHNOLOGIES CO., LTD.), 06 March 2013 (06.03.2013), the whole document	1-81
A	CN 102378114 A (CHINA MOBILE COMMUNICATIONS CORPORATION), 14 March 2012 (14.03.2012), the whole document	1-81

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2013/077477

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 102687438 A	19.09.2012	WO 2011087272 A2	21.07.2011
		AU 2011205920 A1	31.05.2012
		US 2012230290 A1	13.09.2012
		KR 20120127391 A	12.11.2012
		AU 2011205920 A2	20.12.2012
		WO 2011087272 A3	01.12.2011
		CA 2784034 A1	21.07.2011
		JP 2013517662 A	16.05.2013
		EP 2526639 A2	28.11.2012
CN 102255689 A	23.11.2011	WO 2013007088 A1	17.01.2013
CN 102958147 A	06.03.2013	WO 2013023551 A1	21.02.2013
CN 102378114 A	14.03.2012	None	

Form PCT/ISA/210 (patent family annex) (July 2009)

国际检索报告

国际申请号
PCT/CN2013/077477

A. 主题的分类

H04W 24/00 (2009.01) i

按照国际专利分类(IPC)或者同时按照国家分类和 IPC 两种分类

B. 检索领域

检索的最低限度文献(标明分类系统和分类号)

IPC: H04W, H04L, H04Q

包含在检索领域中的除最低限度文献以外的检索文献

在国际检索时查阅的电子数据库(数据库的名称，和使用的检索词（如使用）)

CNABS, CPRSABS, CNTXT, VEN, CNKI：参考信号，RS，CSR，DMRS，CSI-RS，端口，端口组，映射，CSI，信道状态信息，信道质量，通信质量，信道质量指示，预编码矩阵指示，秩指示、预编码类型指示，CQI，PMI，RI，PTI，功率比，psrp，rsrq，rssi，参考信号接收功率，参考信号接收质量，参考信号强度指示；reference w signal, antenna w port, channel w state w information, channel w quality w indicator, channel w quality w index, power

C. 相关文件

类　型*	引用文件，必要时，指明相关段落	相关的权利要求
X	CN 102687438 A (LG 电子株式会社) 19.9 月 2012(19.09.2012) 权利要求 1，说明书第 101 142 段	1、3-9、14、28、30-36、41、55、57-63、68
Y		2、10-13、15-27、29、37-40、42-54、56、64-67、69-81
Y	CN 102255689 A (中兴通讯股份有限公司) 23.11 月 2011(23.11.2011) 说明书第 80 85 段、第 182 段	2、10-13、15-27、29、37-40、42-54、56、64-67、69-81

☒ 其余文件在 C 栏的续页中列出。　　☒ 见同族专利附件。

* 引用文件的具体类型：

"A" 认为不特别相关的表示了现有技术一般状态的文件

"E" 在国际申请日的当天或之后公布的在先申请或专利

"L" 可能对优先权要求构成怀疑的文件，或为确定另一篇引用文件的公布日而引用的或者因其他特殊理由而引用的文件（如具体说明的）

"O" 涉及口头公开、使用、展览或其他方式公开的文件

"P" 公布日先于国际申请日但迟于所要求的优先权日的文件

"T" 在申请日或优先权日之后公布，与申请不相抵触，但为了理解发明之理论或原理的在后文件

"X" 特别相关的文件，单独考虑该文件，认定要求保护的发明不是新颖的或不具有创造性

"Y" 特别相关的文件，当该文件与另一篇或者多篇该类文件结合并且这种结合对于本领域技术人员为显而易见时，要求保护的发明不具有创造性

"&" 同族专利的文件

国际检索实际完成的日期	国际检索报告邮寄日期
26.2 月 2014（26.02.2014）	**13.3 月 2014 (13.03.2014)**
ISA/CN 的名称和邮寄地址： 中华人民共和国国家知识产权局 中国北京市海淀区蓟门桥西土城路 6 号 100088 传真号：　(86-10)62019451	受权官员 刘佳 电话号码：(86-10) **62412046**

PCT/ISA/210 表(第 2 页) (2009 年 7 月)

C(续). 相关文件

类 型	引用文件，必要时，指明相关段落	相关的权利要求
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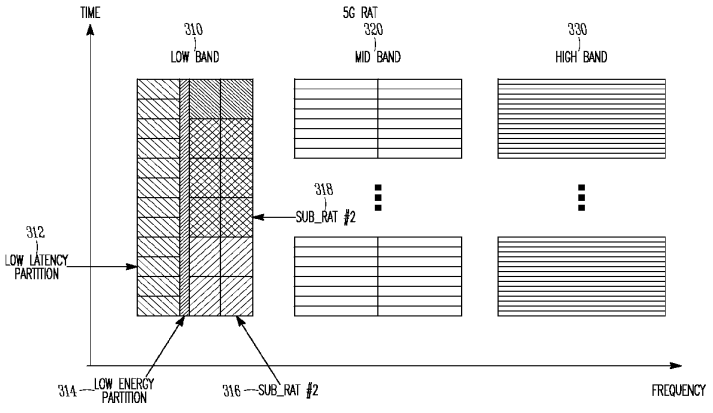


FIG. 3

(57) **Abstract**: An eNodeB (eNB), user equipment (UE) and method of providing a flexible Radio Access Technology (FRAT) are generally described. The information (resource allocation, partition information and numerology) of at least one of a plurality of RATs used by the eNB is provided to a UE. Each RAT has a flexible subcarrier spacing and symbol duration, which are integer multiples of a base subcarrier spacing and symbol duration, and is associated with at least one of different temporal and frequency resources. The symbol and/or frame structure of each RAT are independent. A Transmission Time Interval (TTI) boundary between the RATs is common, and the RATs comprise a common reference TTI duration. The information of the RATs is provided either via a different RAT than the RAT used by the UE for communication or via a dedicated carrier in the RAT used by the UE for communication.

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DEVICE, SYSTEM AND METHOD EMPLOYING UNIFIED FLEXIBLE 5G AIR INTERFACE

PRIORITY CLAIM

[0001] This application claims the benefit of priority to United States Provisional Patent Application Serial No. 62/114,733, filed February 11, 2015, and entitled "UNIFIED FLEXIBLE 5G NEW AIR INTERFACE DESIGN," which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] Embodiments pertain to radio access networks. Some embodiments relate to a unified communication framework using Radio Access Technologies (RAT) in 5th generation (5G) cellular networks.

BACKGROUND

[0003] The use of personal communication devices has increased astronomically over the last several decades. The penetration of mobile devices in modern society has continued to drive demand for a wide variety of networked devices in a number of disparate environments. The variety of available applications, especially video-related applications, has led to a concomitant increase in demand for increased bandwidth beyond that provided by Third Generation Partnership Project Long Term Evolution (3GPP LTE) and LTE advanced (LTE-A) systems.

[0004] The next generation wireless communication system, 5G, may provide access to information and sharing of data using a network that may be required to meet vastly different and sometimes conflicting performance dimensions and services driven by different services and use cases. It is therefore desirable that the next generation communication system be flexible and capable of providing high speed communications services for a wide ambit of devices under a multiplicity of circumstances.

BRIEF DESCRIPTION OF THE FIGURES

[0005] In the figures, which are not necessarily drawn to scale, like numerals may describe similar components in different views. Like numerals having different letter suffixes may represent different instances of similar components. The figures illustrate generally, by way of example, but not by way of limitation, various embodiments discussed in the present document.

[0006] FIG. 1 is a functional diagram of a 3GPP network in accordance with some embodiments.

[0007] FIG. 2 is a block diagram of a 3GPP device in accordance with some embodiments.

[0008] FIG. 3 illustrates one embodiment of a flexible Radio Access Technology (FRAT) of a 5G system in accordance with some embodiments.

[0009] FIG. 4 illustrates a unified frame structure in accordance with some embodiments.

[0010] FIG. 5 illustrates a Transmission Time Interval (TTI) boundary alignment in accordance with some embodiments.

[0011] FIG. 6 illustrates a symbol structure in accordance with some embodiments.

[0012] FIG. 7 illustrates frame structures within a TTI in accordance with some embodiments.

[0013] FIGS. 8A and 8B illustrate flowcharts of a uniform framework utilization method in accordance with some embodiments.

DETAILED DESCRIPTION OF THE INVENTION

[0014] The following description and the drawings sufficiently illustrate specific embodiments to enable those skilled in the art to practice them. Other embodiments may incorporate structural, logical, electrical, process, and other changes. Portions and features of some embodiments may be included in, or substituted for, those of other embodiments. Embodiments set forth in the claims encompass all available equivalents of those claims.

[0015] FIG. 1 is a functional diagram of a 3GPP network in accordance with some embodiments. The network may comprise a radio access network (RAN) (e.g., as depicted, the E-UTRAN or evolved universal terrestrial radio

access network) 100 and the core network 120 (e.g., shown as an evolved packet core (EPC)) coupled together through an S1 interface 115. For convenience and brevity sake, only a portion of the core network 120, as well as the RAN 100, is shown.

[0016] The core network 120 includes mobility management entity (MME) 122, serving gateway (serving GW) 124, and packet data network gateway (PDN GW) 126. The RAN 100 includes eNBs 104 (which may operate as base stations) for communicating with UE 102. The eNBs 104 may include macro eNBs and low power (LP) eNBs.

[0017] The MME is similar in function to the control plane of legacy Serving GPRS Support Nodes (SGSN). The MME manages mobility aspects in access such as gateway selection and tracking area list management. The serving GW 124 terminates the interface toward the RAN 100, and routes traffic packets (such as data packets or voice packets) between the RAN 100 and the core network 120. In addition, it may be a local mobility anchor point for inter-eNB handovers and also may provide an anchor for inter-3GPP mobility. Other responsibilities may include lawful intercept, charging, and some policy enforcement. The serving GW 124 and the MME 122 may be implemented in one physical node or separate physical nodes. The PDN GW 126 terminates a SGi interface toward the packet data network (PDN). The PDN GW 126 routes traffic packets between the EPC 120 and the external PDN, and may be a key node for policy enforcement and charging data collection. It may also provide an anchor point for mobility with non-LTE accesses. The external PDN can be any kind of IP network, as well as an IP Multimedia Subsystem (IMS) domain. The PDN GW 126 and the serving GW 124 may be implemented in one physical node or separated physical nodes.

[0018] The eNBs 104 (macro and micro) terminate the air interface protocol and may be the first point of contact for a UE 102. The eNBs 104 may communicate both with UEs 102 in a normal coverage mode and UEs 104 in one or more enhanced coverage modes. In some embodiments, an eNB 104 may fulfill various logical functions for the RAN 100 including but not limited to RNC (radio network controller functions) such as radio bearer management, uplink and downlink dynamic radio resource management and traffic packet

scheduling, and mobility management. In accordance with some embodiments, UEs 102 may be configured to communicate via orthogonal multiple access (OMA) communications such as Time Division Multiple Access (TDMA), Frequency Division Multiple Access (FDMA) Orthogonal FDMA (OFDMA), SC-FDMA or other communication signals with an eNB 104 over a multicarrier communication channel in accordance with the appropriate communication technique. The OFDM signals may comprise a plurality of orthogonal subcarriers. In accordance with some embodiments, UEs 102 may be configured to communicate via non-orthogonal multiple access (NOMA) signals.

[0019] The S1 interface 115 is the interface that separates the RAN 100 and the EPC 120. It is split into two parts: the S1-U, which carries traffic packets between the eNBs 104 and the serving GW 124, and the S1-MME, which is a signaling interface between the eNBs 104 and the MME 122.

[0020] With cellular networks, LP cells are typically used to extend coverage to indoor areas where outdoor signals do not reach well, or to add network capacity in areas with very dense phone usage, such as train stations. As used herein, the term low power (LP) eNB refers to any suitable relatively low power eNB for implementing a narrower cell (narrower than a macro cell) such as a femtocell, a picocell, or a micro cell. Femtocell eNBs are typically provided by a mobile network operator to its residential or enterprise customers. A femtocell is typically the size of a residential gateway or smaller and generally connects to the user's broadband line. Once plugged in, the femtocell connects to the mobile operator's mobile network and provides extra coverage in a range of typically 30 to 50 meters for residential femtocells. Thus, a LP eNB might be a femtocell eNB since it is coupled through the PDN GW 126. Similarly, a picocell is a wireless communication system typically covering a small area, such as in-building (offices, shopping malls, train stations, etc.), or more recently in-aircraft. A picocell eNB can generally connect through the X2 link to another eNB such as a macro eNB through its base station controller (BSC) functionality. Thus, LP eNB may be implemented with a picocell eNB since it is coupled to a macro eNB via an X2 interface. Picocell eNBs or other LP eNBs may incorporate some or all functionality of a macro eNB. In some cases, this may be referred to as an access point base station or enterprise femtocell.

[0021] As indicated in more detail below, communication over a 4G LTE network may be split up into 10ms frames, each of which may contain ten 1ms subframes. Each subframe of the frame, in turn, may contain two slots of 0.5ms. The eNB may schedule uplink and downlink transmissions over a variety of frequency bands. The allocation of resources in subframes used in one frequency band and may differ from those in another frequency band. Each slot of the subframe may contain 6-7 symbols, depending on the system used. In some embodiments, the subframe may contain 12 or 24 subcarriers. A resource grid may be used for downlink and uplink transmissions between an eNB and a UE. The resource grid may be a time-frequency grid, which is the physical resource in each slot. The smallest time-frequency unit in a resource grid may be denoted as a resource element (RE). Each column and each row of the resource grid may correspond to one OFDM symbol and one OFDM subcarrier, respectively. The resource grid may contain resource blocks (RBs) that describe the mapping of physical channels to resource elements and physical RBs (PRBs). A PRB may be the smallest unit of resources that can be allocated to a UE in the current 3GPP standard. A resource block may be 180 kHz wide in frequency and 1 slot long in time. In frequency, resource blocks may be either 12 x 15 kHz subcarriers or 24 x 7.5 kHz subcarriers wide. For most channels and signals, 12 subcarriers may be used per resource block, dependent on the system bandwidth. The duration of the resource grid in the time domain corresponds to one subframe or two resource blocks. Each resource grid may comprise 12 (subcarriers) *14 (symbols) =168 resource elements for normal cyclic prefix (CP) case. Several different physical channels may be conveyed using such resource blocks. As discussed in more detail below, in a 5G network, the sizes of the resource blocks, resource elements, and symbols, among others, may vary.

[0022] There may be several different physical downlink channels that are conveyed using such resource blocks, including the physical downlink control channel (PDCCH) and the physical downlink shared channel (PDSCH). Each subframe may contain a PDCCH, physical hybrid-ARQ indicator channel (PHICH), physical control format indicator channel (PCFICH) and the PDSCH. The PDCCH may normally occupy the first up to three symbols (four in the case

of narrow bandwidths of 1.4MHz) of each subframe and carry, among other things, information about the transport format and resource allocations related to the PDSCH channel and uplink scheduling grants for a physical uplink shared channel (PUSCH) transmission. The PHICH may be used to signal HARQ information in response to a PUSCH transmission. The PCFICH may inform the UE the control region size (e.g. one, two or three OFDM symbols) in each downlink subframe. The PDSCH may carry user data and higher layer signaling to a particular UE and occupy the remainder of the downlink subframe to avoid the resources in which downlink control channels (PDCCH/PHICH/PCFICH) are transmitted. Typically, downlink scheduling (assigning control and shared channel resource blocks to UEs within a cell) may be performed at the eNB based on channel quality information provided by the UEs, and then the downlink resource assignment information may be sent to a scheduled UE on the PDCCH used for (assigned to) PDSCH reception of the UE.

[0023] The PDCCH may contain downlink control information (DCI) in one of a number of formats that tell the UE where to find and how to decode the data, transmitted on PDSCH in the same subframe, from the resource grid. The DCI may provide details such as the number of resource blocks, resource allocation type, modulation scheme, transport block, redundancy version, coding rate etc. Each DCI format may have a cyclic redundancy code (CRC) and be scrambled with a Radio Network Temporary Identifier (RNTI) that identifies the target UE for which the PDSCH is intended. Use of the RNTI, which may be UE-specific, may limit decoding of the DCI information (and hence the corresponding PDSCH) to only the intended UE. The PDCCH may be located in any of a number of frequency/temporal regions, depending on whether the PDCCH is UE-Specific or common, as well as the aggregation level. The set of possible candidate locations for the PDCCH is defined in terms of search spaces. A search space is defined by a set of Control Channel Element (CCE) candidates with a number of aggregation level $L \in \{1,2,4,8\}$ where the UE may monitor to find its PDCCHs. A common search space may carry DCIs that are common for all UEs; for example, system information (using the SI-RNTI), paging (P-RNTI), PRACH responses (RA-RNTI), or UL TPC commands (TPC-PUCCH/PUSCH-RNTI). A UE-specific search space may carry DCIs for UE-

specific allocations using a Cell Radio-Network Temporary Identifier (C-RNTI) assigned to the UE, a semi-persistent scheduling (SPS C-RNTI), or an initial allocation (temporary C-RNTI). When configuring an SPS (either uplink or downlink), the SPS C-RNTI is provided by the eNB and the UE is configured by higher layers to decode a PDCCH with a CRC scrambled by the SPS C-RNTI. The UE may monitor the PDCCH having a CRC scrambled by the SPS C-RNTI in every subframe as the eNB can activate/re-activate/release the SPS at any time using a DCI format with a CRC scrambled by an SPS C-RNTI. The received DCI format with a CRC scrambled by the SPS C-RNTI can be a grant/assignment for a retransmission or for activation/re-activation/release of the SPS. 3GPP Technical Specification 36.213 has tabulated the validation procedure for activation/re-activation/release of SPS.

[0024] In addition to the PDCCH, an enhanced PDCCH (EPDCCH) may be used by the eNB and UE. The PDSCH may thus contain data in some of the resource blocks (RBs) and then EPDCCH contains the downlink control signals in others of the RBs of the bandwidth supported by the UE. Different UEs may have different EPDCCH configurations. The sets of RBs corresponding to EPDCCH may be configured, for example, by higher layer signaling such as Radio Resource Control (RRC) signaling for EPDCCH monitoring.

[0025] The Physical Uplink Control Channel (PUCCH) may be used by the UE to send Uplink Control Information (UCI) to the eNB. The PUCCH may be mapped to an UL control channel resource defined by an orthogonal cover code and two resource blocks (RBs), consecutive in time, with hopping potentially at the boundary between adjacent slots. The PUCCH may take several different formats, with the UCI containing information dependent on the format. Specifically, the PUCCH may contain a scheduling request (SR), acknowledgement responses/retransmission requests (ACK/NACK) or a Channel Quality Indication (CQI)/Channel State Information (CSI). The CQI/CSI may indicate to the eNB an estimate of the current downlink channel conditions as seen by the UE to aid channel-dependent scheduling and, if one MIMO transmission mode is configured to the UE, may include MIMO-related feedback (e.g. Precoder matrix indication, PMI).

[0026] FIG. 2 is a functional diagram of a 3GPP device in accordance with some embodiments. The device may be a UE or eNB, for example. In some embodiments, the eNB may be a stationary non-mobile device. The 3GPP device 200 may include physical layer circuitry 202 for transmitting and receiving signals using one or more antennas 201. The 3GPP device 200 may also include medium access control layer (MAC) circuitry 204 for controlling access to the wireless medium. The 3GPP device 200 may also include processing circuitry 206 and memory 208 arranged to perform the operations described herein.

[0027] In some embodiments, mobile devices or other devices described herein may be part of a portable wireless communication device, such as a personal digital assistant (PDA), a laptop or portable computer with wireless communication capability, a web tablet, a wireless telephone, a smartphone, a wireless headset, a pager, an instant messaging device, a digital camera, an access point, a television, a medical device (e.g., a heart rate monitor, a blood pressure monitor, etc.), or other device that may receive and/or transmit information wirelessly. In some embodiments, the mobile device or other device can be a UE 102 or eNB 104 configured to operate in accordance with 3GPP standards. In some embodiments, the mobile device or other device may be configured to operate according to other protocols or standards, including IEEE 802.11 or other IEEE standards. In some embodiments, the mobile device or other device may include one or more of a keyboard, a display, a non-volatile memory port, multiple antennas, a graphics processor, an application processor, speakers, and other mobile device elements. The display may be an LCD screen including a touch screen.

[0028] The antennas 201 may comprise one or more directional or omnidirectional antennas, including, for example, dipole antennas, monopole antennas, patch antennas, loop antennas, microstrip antennas or other types of antennas suitable for transmission of RF signals. In some multiple-input multiple-output (MIMO) embodiments, the antennas 201 may be effectively separated to take advantage of spatial diversity and the different channel characteristics that may result.

[0029] Although the 3GPP device 200 is illustrated as having several separate functional elements, one or more of the functional elements may be combined and may be implemented by combinations of software-configured elements, such as processing elements including digital signal processors (DSPs), and/or other hardware elements. For example, some elements may comprise one or more microprocessors, DSPs, field-programmable gate arrays (FPGAs), application specific integrated circuits (ASICs), radio-frequency integrated circuits (RFICs) and combinations of various hardware and logic circuitry for performing at least the functions described herein. In some embodiments, the functional elements may refer to one or more processes operating on one or more processing elements.

[0030] Embodiments may be implemented in one or a combination of hardware, firmware and software. Embodiments may also be implemented as instructions stored on a computer-readable storage device, which may be read and executed by at least one processor to perform the operations described herein. A computer-readable storage device may include any non-transitory mechanism for storing information in a form readable by a machine (e.g., a computer). For example, a computer-readable storage device may include read-only memory (ROM), random-access memory (RAM), magnetic disk storage media, optical storage media, flash-memory devices, and other storage devices and media. Some embodiments may include one or more processors and may be configured with instructions stored on a computer-readable storage device.

[0031] The term "machine readable medium" may include a single medium or multiple media (e.g., a centralized or distributed database, and/or associated caches and servers) configured to store one or more instructions. The term “machine readable medium” may include any medium that is capable of storing, encoding, or carrying instructions for execution by the 3GPP device 200 and that cause it to perform any one or more of the techniques of the present disclosure, or that is capable of storing, encoding or carrying data structures used by or associated with such instructions. The term “transmission medium” shall be taken to include any intangible medium that is capable of storing, encoding or carrying instructions for execution, and includes digital or analog

communications signals or other intangible medium to facilitate communication of such software.

[0032] As above, the upcoming 5G wireless communications technology systems may have a number of unique challenges, including carrying the inherent ability to provide different performances requirements for numerous different types of wireless devices. Higher data rates in particular may continue to drive network development and evolution for 5G system. It may be desirable for a 5G system to support a peak data rate of more than 10Gps and a minimum guaranteed user data rate of at least 100Mbps. In addition, it may be desirable for the 5G system to support the huge increase in variety and number of Internet of Things (IoT) and Machine-Type Communication (MTC)-type devices. MTC devices have been increasingly employed for different applications, using low operational power consumption and infrequent small burst transmissions. Moreover, it may be desirable for the 5G system to provide an extremely high level of reliable connectivity with guaranteed low latency, availability and reliability-of-service for mission critical MTC use cases.

[0033] In general, 5G systems may use a plurality of Radio Access Technologies (RATs), unlike previous 2G, 3G and 4G, systems. For example, an enormous amount of spectrum may be available through the use of higher frequency bands. In one example, the use of millimeter wave (mmWave) frequency bands ranging from 30 to 300GHz may provide the desired scalability, capacity and density for the 5G system. In this case, a new RAT may be defined for the mmWave band to achieve low latency and higher peak data rate. The RAT for mmWave band communications may differ from the RAT for one or more of the other frequency bands used to provide communication services. In some embodiments, the RATs may be used simultaneously by a single eNB for communications with different UEs.

[0034] In some embodiments, a 5G system may be provided that contains multiple RATs in a unified framework to support diverse applications, use cases and services and inter-networking in multiple frequency bands, including both licensed and unlicensed frequency bands. The RATs used in the licensed and unlicensed may be independent of each other. In some embodiments, flexible subcarrier spacing and symbol duration (i.e., configurable

numerology) may be provided across the frequency bands used in the 5G system. In addition, the 5G system may include mechanisms to multiplex multiple RATs, sub-RATs and other partitions in different or the same frequency resource or frequency bands.

[0035] The inter-networking in the unified frame structure may include, in some embodiments, a Transmission Time Interval (TTI) boundary alignment between multiple RATs may be provided to allow seamless scheduling, fallback and support of different RATs. In some embodiments, a TTI is the smallest unit of time in which the eNB is capable of scheduling any UE for uplink or downlink transmission. In some embodiments, the TTI boundary alignment may occur at a subframe or frame boundary. As used herein, a unified RAT with flexible air interface for the 5G system is referred to as a flexible Radio Access Technology (FRAT). A UE that communicates with an eNB operating using the FRAT may remain using a single air interface technology (i.e., RAT) or may switch between different RATs.

[0036] In some embodiments, a unified RAT with configurable numerologies may be used in the 5G system in which a base subcarrier spacing (Δf) and symbol duration (T) can be defined in the FRAT. In one example, to maintain the backward compatibility for existing LTE and LTE-Advanced systems, a base subcarrier spacing and symbol duration can be specified as Δf = 15KHz and T=66.7μs. Moreover, for convenience in some embodiments a single oscillator may be used, with the subcarrier spacing and symbol duration for different RATs specified as an integer number of the base subcarrier spacing and symbol duration, respectively.

[0037] Similarly, when a low latency use case and service is desired, a shortened symbol duration may be employed to reduce the latency by using larger subcarrier spacing. The subcarrier spacing and symbol duration may in this case be defined as $\Delta f_i = K*\Delta f$ and $T_i=(1/K)*T$. In one example, for frequency band between 6GHz and 30GHz, K can be chosen as 10, leading to a subcarrier spacing and symbol duration of 150KHz and 6.67μs, respectively. This may result in a 0.1ms TTI for low latency use case. In another example, for frequency bands below 6GHz, which includes the current LTE frequency range,

K can be selected by the network to be 2 or 4, and the corresponding subcarrier spacing and symbol duration changed proportional to the selected K value. Alternatively, the same subcarrier spacing and symbol duration can be defined for frequency bands below 6GHz (i.e., K =1), but a shorter TTI can be considered, e.g., with a fewer number of symbols, to support low latency use cases.

[0038] To efficiently support a massive number of MTC devices used in the 5G network, in other embodiments, the subcarrier spacing and symbol duration can be defined as $\Delta f_i = (1/K)*\Delta f$ and $T_i=K*T$. In such embodiments, K can be selected to be 10, and the subcarrier spacing and symbol duration 1.5KHz and 667μs, respectively. In this case, the subframe duration for MTC use cases can be defined to be 10ms, in the current generation LTE systems the length of a typical frame, rather than the typical 1ms. This may reduce the power consumption of MTC UEs by reducing the amount of time the MTC UE is active, thereby increasing the battery life of the MTC UEs.

[0039] A UE may be initially assigned the appropriate RAT by the eNB or other network device (such as the MME). In some embodiments, the UE may be configurable to communicate using any of the RATs, as indicated via the eNB, and can configure the subcarrier spacing and symbol duration accordingly. In some embodiments, the UE may be limited to communicating only using a subset of the RATs, and perhaps only a single RAT, e.g., when the UE is an MTC UE having a limited bandwidth and capabilities. The RAT may depend on the type of UE as well as the operating mode of the UE. For example, some UEs may change mode between a normal mode and an enhanced coverage mode in situations in which the link budget to the nearest serving eNB is worse than a typical link budget value in the network and additional link budget is to be obtained without increasing transmission power. Enhanced coverage mode may be employed by a variety of UEs, including a normal UE (e.g., a smartphone or the like), a machine-to-machine (M2M) UE or a stationary wireless UE (i.e., a UE that remains indefinitely in a single location) using MTC. The UE may determine whether additional link budget is desired, as well as how much additional link budget is desired, and enter an appropriate enhanced coverage mode (that provides the appropriate additional link budget). The different

enhanced coverage modes may correspond to different RATs. Some UEs, such as low cost, low complexity MTC UEs, further may be band limited and operate in a narrow bandwidth of e.g., to 1.4 MHz, for both control and data channels, leading to the ability to operate, e.g., in a single RAT unless the RAT is modified by the network.

[0040] FIG. 3 illustrates one embodiment of a FRAT of a 5G system in accordance with some embodiments. The FRAT 300 may contain one or more partitions in different frequency band regions 310, 320, 330. In one example, the low frequency band 310 may include frequencies used in 4G systems (up to 6 GHz), the mid-frequency band 320 may include higher frequencies (e.g., 6-30 GHz) and the high frequency band 330 may include the highest frequencies in the 5G system (e.g., mmWave, above 30 GHz). Although the RATs of only a low frequency band 310, a mid-frequency band 320, and a high frequency band 330 are shown, any number of RATs of different frequency bands may exist. The various RATs in frequency bands may each have a subcarrier spacing and symbol duration that is independent of the subcarrier spacing and symbol duration of another RAT in another frequency band (i.e., the RATs have configurable numerologies). Moreover, within each frequency band, one or more sub-RATs and partitions 312, 314, 316, 318 may be present with each sub-RAT or partition 312, 314, 316, 318 having a subcarrier spacing and symbol duration independent of the subcarrier spacing and symbol duration of another sub-RAT or partition 312, 314, 316, 318 and independent of the RAT in other frequency bands. As shown in FIG. 3, the sub_RATs 316, 318 in the low frequency band 310 may have the same subcarrier spacing and symbol duration and may be separated by frequency and/or time, while partitions 312, 314 may have different subcarrier spacings and symbol durations from each other and the sub_RATs 316, 318 and may be separated by frequency and/or time. Although the low frequency band 310 is shown as having multiple partitions 312, 314 and sub_RATs 316, 318, the mid frequency band 320 is shown as having two sub_RATs and the high frequency band 330 is shown as having no sub_RATs, the eNB may establish the number and type of RATs used within a particular frequency band differently.

[0041] In some embodiments, RATs and sub-RATs with same or different numerologies can be multiplexed. The multiplexing may be via Time-Division Multiplexing (TDM), Frequency-Division Multiplexing (FDM), code-division multiplex (CDM), spatial division multiplex (SDM), other possible orthogonal or non-orthogonal multiplexing schemes, or any combination thereof. For example, multiple RATs, sub-RATs or partitions with same or different numerologies can be multiplexed in a TDM manner. Each RAT, sub-RAT and partition may have a numerology, access scheme and modulation scheme that is independent of the numerology, access scheme and modulation scheme of the other RATs, sub-RATs and partitions. The numerologies, resource allocation and partition information in the time domain can be predefined or configured by higher layer signaling, e.g. via a Master Information Block (MIB), System Information Block (SIB) or UE-specific dedicated RRC signaling. If a MIB is used to indicate the partition configuration for multiple RATs, sub-RATs or partitions, the resource for the transmission physical broadcast channel (PBCH) used to carry the MIB may be predefined and known at the UEs. In some embodiments, the PBCH may be transmitted in a predetermined RAT, independent of the UE or number of RATs, sub-RATs or partitions supported. Once the UE receives the configuration information via the PBCH on the predetermined RAT, the UE may use a different RAT for further control and data communications; that is, the predetermined RAT and the RAT used by the UE to communicate may be independent.

[0042] In some embodiments, multiple RATs, sub-RATs or partitions with same or different numerologies can be multiplexed in a FDM manner. To minimize the interference between multiple RATs, sub-RATs or partitions with different numerologies, guard bands may be inserted at the edge of frequency resources allocated for the RATs, sub-RATs or partitions. Similar to the above, the numerologies and/or resource partition for multiple RATs, sub-RATs or partitions may be predefined or configured by high layer signaling via a MIB, SIB or UE-specific dedicated RRC signaling.

[0043] In embodiments in which numerologies and/or resource partition for multiple RATs, sub-RATs or partitions is predefined or dedicated carriers are allocated for different RATs, a dedicated downlink synchronization signal and

PBCHs may be transmitted on each RAT, sub-RAT or partition. In embodiments in which the numerologies and/or resource partition for multiple RATs, sub-RATs or partitions is configured using a MIB or SIB, a single MIB or SIB may be transmitted on one of the RAT, sub-RAT or partition. After successfully decoding the MIB or SIB, the UEs may be able to derive the resource information or numerologies for other RATs, sub-RATs or partitions. Thus, information provided from the eNB to the UE via a single transmission in a particular RAT, sub-RAT or partition may enable communications using different RATs, sub-RATs or partitions.

[0044] Particular RATs/sub-RATs/partitions may be used for different types of communications, with each having independently sized resource blocks. For example, as shown, the resources in a first partition 312 may be used for low-latency communications while the resources in a second partition 314 may be used for low energy communications. The first and second partitions 312, 314 may be multiplexed, as shown, using FDM such that the first and second partitions 312, 314 occupy the same time but different frequency resources. The first partition 312 may be associated with low latency communications in which the UE operates in a low latency mode and may have a short symbol duration and TTI, while the second partition 314 may be associated with low energy communications in which the UE operates in a low energy mode and may have a long symbol duration and TTI.

[0045] Other sub-RATs 316, 318 may similarly be FDM multiplexed with the first and second partitions 312, 314 and TDM multiplexed with each other. The sub-RATs 316, 318 may have a symbol duration and TTI between those associated with the first and second partitions 312, 314.

[0046] The RATs 320, 330 for the mid- and high- frequency band may be supported simultaneously with each other and the RAT 310 for low frequency band, while maintaining TTI boundary alignment between the different RATs 310, 320, 330. The RATs 320, 330 may similarly be FDM multiplexed with the first and second partitions 312, 314 and sub-RATs 316, 318. The RATs 320, 330 may have a symbol duration and TTI smaller than those associated with the first partition 312. As shown in FIG. 3, in some embodiments, the amount of temporal and/or frequency resources associated with the different RATs, sub-

RATs and partitions may differ among the different types, and the same type may be associated either with different amounts of temporal and/or frequency resources (e.g., as partitions 312, 314) or the same amount of temporal and/or frequency resources (e.g., as sub-RATs 316, 318). A given frequency and temporal range may be associated with a particular frame and symbol structure (as well as subcarrier spacing and symbol duration), with the frame and symbol structures of the frequency and temporal range independent of the frame and symbol structures of other frequency and temporal ranges.

[0047] FIG. 4 illustrates a unified frame structure in accordance with some embodiments. The unified frame structure contains frames 400, subframes 410, slots 420 and symbols 430. More specifically, each frame 400 may contain L subframes of equal duration and have an overall duration of X ms. Each subframe 410 may similarly comprise N slots of equal duration and have an overall duration of Y ms. Each slot may, in turn, comprise M symbols of equal duration. The slot and symbol durations may be different between subframes of different RATs depending on specific use cases, frequency bands and deployment scenarios. The frame structure of each of RAT may be independent of the frame structure of the other RATs. Thus, a particular RAT may have one or more of different L, N and/or M values, as well as different X and/or Y values, as the other RATs. This may also apply to the sub-RATs and partitions shown in FIG. 3.

[0048] FIG. 5 illustrates a Transmission Time Interval (TTI) boundary alignment in accordance with some embodiments. In some embodiments of the unified frame structure, it may be beneficial from a simplified design standpoint to periodically align the TTI boundary 530 between different RATs 510, 520, e.g., at a particular subframe or frame boundary after a predetermined number of subframes or frames. Thus, in some embodiments an integral number of TTIs 540 of a RAT 510 having a smaller TTI duration (low latency RAT) may be disposed within a single TTI 550 of a RAT 520 having a larger TTI duration. In the example shown in FIG. 5, the smaller TTI duration RAT 510 may have a TTI 540 of 0.1ms while the larger TTI RAT 520 may have a TTI 550 of 1ms. By implementing a TTI of 1ms, a low latency RAT TTI may align with the existing LTE specification TTI boundary. Having a common TTI boundary may support

cross-carrier/RAT scheduling for high frequency band RATs from low frequency band RATs based an anchor booster architecture. This is to say that, in some embodiments for cross-carrier/RAT scheduling, as shown a common PDCCH may be used to schedule other RATs, with the UE switching to a particular RAT to obtain the scheduling and then switching to another RAT to communicate and perhaps to obtain further scheduling information using that RAT. In some embodiments, the other RAT may contain a PDCCH for additional scheduling, while in other embodiments the other RAT may not contain a PDCCH, in which case the UE may periodically switch to the scheduling RAT to obtain scheduling information for the other RAT. In some embodiments, a UE may obtain initial scheduling information (e.g., when it initially powers on or otherwise accesses the eNB) from the initial RAT (e.g., a conventional 4G system RAT) and from then on, after switching to its assigned RAT, obtains scheduling information using that RAT. In other embodiments, each RAT may contain a PDCCH and scheduling is performed for the UE operating on the RAT. A licensed low frequency band RAT may provide reliable coverage for control signaling as an anchor cell, using the PDCCH shown in FIG. 5, while a high frequency band RAT may provide opportunistic boosting in data rate when channel conditions are favorable as booster cell.

[0049] FIG. 6 illustrates a symbol structure in accordance with some embodiments. FIG. 6 shows an OFDM symbol 610 and a unique word (UW) OFDM symbol 620. Each OFDM symbol 610 may contain a cyclic prefix (CP) 612 that comprises a replication of the initial portion of the OFDM symbol 610. The CP 612 may range in size from 1/4 to 1/32 of the symbol period 614. The CP 612 may be disposed at the end of the symbol or outside the symbol, depending on specific waveform, thereby creating a guard between the symbol and the adjacent symbol. In some embodiments, when OFDM downlink and SC-FDMA uplink waveforms are selected for a 5G RAT, the CP 612 may be inserted outside the symbol 610. In embodiments in which a UW OFDM symbol 620 or UW Discrete Fourier transform-Spread-Orthogonal Frequency Division Multiplexing (UW-DFT-s-OFDM) symbol is used, the UW 622 may be inserted within one symbol duration 624. The symbol structure may be independent for each of the RATs, such that whether or not a particular RAT a

CP or UW and whether the CP or UW is outside or within a symbol is independent of the symbol structure of any other RAT.

[0050] As shown in FIG. 6, the UW-OFDM 620 may be used to support different UW lengths based on different channel delay spreads while maintaining the same symbol duration (or FFT size). This enables both shorter UW 622 and longer UW 626 to be used in the same size symbol 624 as the UW 622, 624 is inserted within the FFT instead of being adding after the FFT size. The ability to maintain the same symbol duration may provide a greater flexibility to support a unified RAT design. In one example, using an OFDM symbol for a low frequency band (below 6GHz), a subcarrier spacing of 60KHz (i.e., K = 4, Δf =60KHz) may be used to achieve a 0.1ms TTI. This translates to OFDM symbols of T=16.7μs (66.7μs/K). Thus, 5 OFDM symbols may be able to be accommodated within one subframe (83.5μs) with a CP length of approximately 3.3μs (0.1ms - 83.5μs =16.5μs/5 CPs).

[0051] FIG. 7 illustrates frame structures within a TTI in accordance with some embodiments. In FIG. 7, various TTIs 710, 720, 730, 740 are illustrated in which the TTIs 710, 720, 730, 740 comprise UW-OFDM waveforms. The first TTI 710 shown in FIG. 7 may comprise a UW 712 and symbol 714 of typical length. In this example, the subcarrier spacing may be 15KHz and the symbol duration 716 may be 66.7μs. A total of 3 OFDM symbols 716 may be present in a TTI 710 of 200μs.

[0052] The second TTI 720 shown in FIG. 7 may comprise a low latency TTI 720 with short symbol duration. Such a TTI 720 can be used for use cases such as mission critical MTC applications and Vehicle–to-Vehicle applications, among others. The UW 722 and symbol 724 may each be smaller than the first TTI 710. In this example, the subcarrier spacing may be 30KHz and the symbol duration 726 may be 33.3μs. For a TTI 720 of the same length as the first TTI (e.g., 200μs), a total of 6 short OFDM symbols 726 may be present.

[0053] The third TTI 730 shown in FIG. 7 may comprise another low latency TTI 730 similar to the low latency TTI 720. The UW 732 and symbol 734 may each be smaller than the first TTI 710, the subcarrier spacing may be 30KHz and the symbol duration 736 may be 33.3μs. However, in this example

the TTI 730 may only be half the length as the first TTI (i.e., 100μs), corresponding to a total of 3 short OFDM symbols 736.

[0054] The fourth TTI 740 shown in FIG. 7 may comprise a low energy TTI 740, e.g., for use by MTC UEs. The UW 742 and symbol 744 may each have a longer duration smaller than the first TTI 710. In one example, the subcarrier spacing may be 5KHz and the symbol duration 746 may be 200μs. In this example, the TTI 740 may be 1ms, corresponding to a total of 5 long OFDM symbols 746.

[0055] The above TTIs 710, 720, 730, 740 may be FDM or TDM multiplexed based on the FRAT design. One or more of the UW-OFDM waveforms may be replaced by other waveforms so long as the same symbol duration is maintained. Other examples of OFDM waveforms may include ZT-OFDM and UW-DFTs-OFDM, among others. When different waveforms are used in the same carrier, multi-RATs can be supported where each RAT may have different waveform design. In some embodiments, existing LTE waveforms may be reused, i.e., OFDM waveforms may be used for downlink and SC-FDMA waveforms may be used for uplink communications. In some embodiments, OFDM may be used both downlink and uplink communications. In some embodiments, UW-based waveforms may be used both downlink and uplink communications. For example, UW-OFDM waveforms may be used for downlink communications and UW-DFT-s-OFDM waveforms may be used for uplink communications or either UW-OFDM or UW-DFT-s-OFDM waveforms may be used for both downlink and uplink communications. In some embodiment, filtered OFDM and filter-bank multiple carrier (FBMC) may be used. FBMC waveforms are produced using a nonrectangular sub-channel pulse shape in the time domain during OFDM-offset quadrature amplitude modulation (OQAM) transmission (in which the real part of QAM symbols are mapped to ½ of the multi-carrier symbols and the imaginary parts are mapped to an interlaced 1/2 of the multi-carrier symbols) and may lack a CP.

[0056] Tables 1-3 below illustrate various examples of 5G numerology.

Frequency Band	Subcarrier spacing	TTI	DL waveform	UL waveform

<3GHz (low power or MTC)	1.5KHz	10ms	OFDM	SC-FDMA
<3GHz	15KHz	1ms	OFDM	SC-FDMA
[3-6]GHz	75KHz	0.2ms	UW-OFDM	UW-DFT-s-OFDM
[6-30]GHz	480KHz	0.1ms	UW-OFDM	UW-DFT-s-OFDM
>30GHz	1.5MHz	0.1ms	DFT-s-OFDM	DFT-s-OFDM

Table 1: First 5G numerology example

Frequency Band	Subcarrier spacing	TTI	DL waveform	UL waveform
<3GHz (low power or MTC)	1.5KHz	10ms	UW-OFDM	UW-OFDM
<3GHz	15KHz	1ms	UW-OFDM	UW-OFDM
[3-6]GHz	75KHz	0.2ms	UW-OFDM	UW-OFDM
[6-30]GHz	480KHz	0.1ms	UW-DFT-s-OFDM	UW-DFT-s-OFDM
>30GHz	1.5MHz	0.1ms	OFDM	OFDM

Table 2: Second 5G numerology example

Frequency Band	Subcarrier spacing	TTI	DL waveform	UL waveform
<3GHz (low power or MTC)	1.5KHz	10ms	OFDM	OFDM
<3GHz	15KHz	1ms	OFDM	OFDM
[3,6]GHz	75KHz	0.2ms	OFDM	OFDM
[6,30]GHz	480KHz	0.1ms	UW-DFT-s-OFDM	UW-DFT-s-OFDM
>30GHz	1.5MHz	0.1ms	UW-DFT-s-OFDM	UW-DFT-s-OFDM

Table 3: Third 5G numerology example

[0057] FIGS. 8A and 8B illustrate flowcharts of a uniform framework utilization method in accordance with some embodiments. FIG. 8A in particular illustrates a flowchart of a uniform framework utilization method of an eNB such as the eNB shown in FIGS. 1 or 2 in accordance with some embodiments. As shown in FIG. 8A, the eNB may determine the unified framework at operation 802. The unified framework may include access scheme, modulation

scheme, frame structure, symbol structure, and configurable numerology including subcarrier spacing and symbol duration. The different frame and symbol structures may be associated with different temporal and/or frequency resources multiplexed respectively in a TDM or FDM manner.

[0058] At operation 804, the eNB may communicate specific unified framework configuration information of a particular RAT to one or more UEs serviced by the eNB. Different RAT information may be provided to different UEs attached to the eNB, in which different RATs may be associated with different frequency bands and/or time spans. The eNB may determine the configuration information to be provided to a particular UE based on the device type and/or data to be communicated between the UE and the eNB. The frequency bands may include both licensed and unlicensed frequency bands. The RAT information may include access and modulation scheme, frame and symbol structure, as well as numerology. The RAT information may also include resource allocation and partition information. The unified framework configuration information provided to each UE may be independent of the unified framework configuration information provided to any other UE. The RAT indicated by the eNB to the UE may be dependent on the type and/or operating mode of the UE.

[0059] The eNB may communicate with the UE at operation 806 using the RAT provided at operation 804. The information may include data and/or control information. For example, downlink communications from the eNB to the UE may include paging or control signals for channel estimation on the PDCCH and voice or video data from another UE on the PDSCH. The RAT information may be provided using a dedicated RAT that is different from the RAT used for communication with the UE or using a dedicated carrier on the RAT used for communication with the UE.

[0060] The eNB may, subsequent to communicating with the UE, receive an indication from the UE of a change of operating state of the UE at operation 808. The UE may, for example, be configured to operate in one or more of a normal mode, a low latency and low energy mode. The eNB may, at operation 804, assign the RAT to the UE based on the initial mode of the UE and

determine that an update of the operation mode of the UE has occurred at operation 808.

[0061] In response to determining at operation 808 that an update of the operation mode of the UE has occurred, the eNB may determine a new RAT and transmit the updated unified framework configuration information of the new RAT to the UE at operation 810. The new RAT may include a different frame and/or symbol structure and use a different frequency spectrum and/or time range. The eNB may then continue to communicate with the UE at operation 806.

[0062] FIG. 8B illustrates a uniform framework utilization method as performed by a UE in accordance with some embodiments. The UE may be the UE shown in FIGS. 1 or 2 and may attach to the eNB prior to communicating data. During the attachment, the UE may transmit the initial operation conditions to the eNB at operation 812. In particular, the UE may provide a UE type and/or operating mode during attachment. For example, the UE may be a MTC UE. The UE may moreover be configured to operate in a low latency and/or low energy mode. In some embodiments, a MTC UE may operate in an enhanced coverage, low energy mode.

[0063] In response to transmitting the operating conditions, unified framework configuration (RAT) information may be received by a particular UE at operation 814. The RAT information may be dependent on the type and/or operating mode of the UE. The RAT may be associated with a particular frequency band and/or time range. For example, when the UE operates in the low latency mode, a larger subcarrier spacing and shorter symbol duration may be indicated by the unified framework configuration information; while when the UE operates in the low energy mode, a smaller subcarrier spacing and longer symbol duration may be indicated by the unified framework configuration information.

[0064] Once the RAT received by the UE, the UE may then communicate using the RAT at operation 816. The UE may, for example, adjust FFT operating conditions and processing to meet the RAT information provided at operation 814. The UE may communicate with the eNB or may communicate directly with other UEs using device-to-device communication (D2D)

communication. The information may include uplink and downlink data and/or control information. For example, the information may include uplink communications of voice or video data for another UE or measurements of control signals for channel estimation.

[0065] The UE may, subsequent to communicating with the eNB, determine that a change of operating conditions is warranted at operation 818. For example, the UE may transition between the normal and enhanced coverage/low energy mode dependent on UE location, or between the normal and low latency mode dependent on the type of communication to transmit.

[0066] In response to determining that a change of operating conditions is warranted at operation 818, at operation 820 the UE may transmit an indication to the eNB indicating the change of operating state of the UE. The UE may instead determine that a change of operating conditions is desired at operation 820 and wait to change operating state until a new RAT is assigned to the UE.

[0067] In response to transmitting the indication at operation 820, the UE may return to operation 814 and receive a new RAT at operation 810. The new RAT may include a different frame and/or symbol structure and use a different frequency spectrum and/or time range. The eNB may then continue to communicate with the UE at operation 816.

[0068] Various examples of the disclosure are provided below. These examples are not intended to in any way limit the disclosure herein. In Example 1, user equipment (UE) may comprise processing circuitry configured to: configure a transceiver to receive a resource allocation from a network using a first Radio Access Technology (RAT), the first RAT selected from a plurality of RATs of a flexible RAT (FRAT) employed by the network, the plurality of RATs of the FRAT each comprising configurable numerology with flexible subcarrier spacing and symbol duration and associated with at least one of different temporal and frequency resources, the transceiver configurable to communicate using the plurality of RATs and configure the subcarrier spacing and symbol duration based on the numerology; and configure the transceiver to communicate using the first RAT.

[0069] In Example 2, the subject matter of Example 1 can optionally include that the processing circuitry is further configured to configure the transceiver to receive from an enhanced NodeB (eNB) higher layer signaling associated with the FRAT, the higher layer signaling indicating numerologies, resource allocation and partition information in at least one of a time and frequency domain.

[0070] In Example 3, the subject matter of one or any combination of Examples 1-2 can optionally include that the FRAT comprises a base subcarrier spacing and symbol duration, and at least one of the subcarrier spacing and symbol duration for different RATs of the FRAT is respectively specified as an integer number of the base subcarrier spacing or symbol duration.

[0071] In Example 4, the subject matter of one or any combination of Examples 1-3 can optionally include that the UE is a Machine-Type Communication (MTC) UE configured to operate in at least one of a low latency and low energy mode, and the first RAT comprises a larger subcarrier spacing and shorter symbol duration when the UE operates in the low latency mode and comprises a smaller subcarrier spacing and longer symbol duration when the UE operates in the low energy mode.

[0072] In Example 5, the subject matter of one or any combination of Examples 1-4 can optionally include that at least one of the plurality of RATs of the FRAT comprises at least one of a plurality of sub-RATs and partitions, each of the at least one of the plurality of sub-RATs and partitions comprising an independent configurable numerology with flexible subcarrier spacing and symbol duration and associated with at least one of different temporal and frequency resource, and the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are combined using at least one of a Time-Division Multiplexing (TDM), Frequency-Division Multiplexing (FDM), Code-Division Multiplexing (CDM), and Spatial Division Multiplexing (SDM).

[0073] In Example 6, the subject matter of one or any combination of Examples 1-6 can optionally include that the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are combined using TDM, and numerologies, resource allocation and partition information in a time domain are at least one of predefined or configured by higher-layer signaling via Master

Information Block (MIB), System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling, or the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are combined using FDM, guard bands are inserted at an edge of frequency resources allocated for the plurality of RATs and the at least one of the plurality of sub-RATs and partitions, and at least one of numerologies and resource partition for the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are at least one of predefined or configured by the higher-layer signaling.

[0074] In Example 7, the subject matter of one or any combination of Examples 1-6 can optionally include that a Transmission Time Interval (TTI) boundary between different RATs of the plurality of RATs is common, and the plurality of RATs comprise a common reference TTI duration.

[0075] In Example 8, the subject matter of one or any combination of Examples 1-7 can optionally include that a symbol structure of each of the plurality of RATs comprises a cyclic prefix (CP) or unique word (UW) outside or within a symbol, and the symbol structure of each of the plurality of RATs is independent of the symbol structure of the other RATs. ‘

[0076] In Example 9, the subject matter of one or any combination of Examples 1-8 can optionally include that the processing circuitry is further configured to configure the transceiver to communicate using Orthogonal Frequency-Division Multiplexing (OFDM) for downlink communications and one of Single Carrier Frequency-Division Multiple Access (SC-FDMA) and OFDM for uplink communications, and configure the transceiver to communicate using at least one of UW-OFDM and UW Discrete Fourier transform-Spread-Orthogonal Frequency Division Multiplexing (UW-DFT-s-OFDM).

[0077] In Example 10, the subject matter of one or any combination of Examples 1-9 can optionally include that a frame structure in each of the plurality of RATs comprises a frame comprising L subframes, each subframe comprising N slots, each slot comprising M symbols, and the frame structure of each of the plurality of RATs is independent of the frame structure of the other RATs.

[0078] In Example 11, the subject matter of one or any combination of Examples 1-10 can optionally include that the processing circuitry is further configured to configure the transceiver to receive numerologies, resource allocation and partition information via Master Information Block (MIB) carried by a physical broadcast channel (PBCH), a System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling in a second RAT, the first and second RATs being different.

[0079] In Example 12, the subject matter of one or any combination of Examples 1-11 can optionally include that the processing circuitry is configured to configure the transceiver to receive numerologies, resource allocation and partition information via a dedicated carrier in the first RAT, a dedicated carrier allocated for each of the plurality of RATs, and a dedicated downlink synchronization signal and physical broadcast channel (PBCH) is able to be received on each of the plurality of RATs.

[0080] In Example 13, the subject matter of one or any combination of Examples 1-12 can optionally include an antenna configured to transmit and receive communications between the transceiver and the eNB.

[0081] Example 14 comprises an apparatus of an eNode B (eNB) comprising processing circuitry configured to: configure a transceiver to transmit resource allocations for different Radio Access Technologies (RATs) to a plurality of user equipment (UE), at least two of the UEs associated with a different RAT, each RAT comprising an independent subcarrier spacing, symbol duration, frame structure and symbol structure; and configure the transceiver to communicate with each UE using the RAT associated with the UE.

[0082] In Example 15, the subject matter of Example 14 can optionally include that the processing circuitry is configured to configure the transceiver to transmit higher layer signaling indicating numerologies, resource allocation and partition information via Master Information Block (MIB) carried by a physical broadcast channel (PBCH), a System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling in a same RAT to each of the plurality of UEs.

[0083] In Example 16, the subject matter of one or any combination of Examples 14-15 can optionally include that the processing circuitry is

configured to configure the transceiver to transmit numerologies, resource allocation and partition information via a dedicated carrier allocated for each of the RATs, and a dedicated downlink synchronization signal and physical broadcast channel (PBCH) is able to be received on each of the RATs.

[0084] In Example 17, the subject matter of one or any combination of Examples 14-16 can optionally include that at least one of the subcarrier spacing and symbol duration for each of the RATs is respectively specified as an integer number of a base subcarrier spacing or symbol duration.

[0085] In Example 18, the subject matter of one or any combination of Examples 14-17 can optionally include that the RATs comprise a first RAT comprising a larger subcarrier spacing and shorter symbol duration configured for a UE operating in a low latency mode and a second RAT comprising a smaller subcarrier spacing and longer symbol duration configured for a UE operating in a low energy mode.

[0086] In Example 19, the subject matter of one or any combination of Examples 14-18 can optionally include that a Transmission Time Interval (TTI) boundary between the RATs is common, and the RATs comprise a common reference TTI duration.

[0087] In Example 20, the subject matter of one or any combination of Examples 14-19 can optionally include that a symbol structure of each of the RATs comprises a cyclic prefix (CP) or unique word (UW) outside or within a symbol, and the symbol structure of each of the RATs is independent of the symbol structure of the other RATs.

[0088] In Example 21, the subject matter of one or any combination of Examples 14-20 can optionally include that the processing circuitry is configured to at least one of: configure the transceiver to communicate using Orthogonal Frequency-Division Multiplexing (OFDM) for downlink communications and one of Single Carrier Frequency-Division Multiple Access (SC-FDMA) and OFDM for uplink communications, and configure the transceiver to communicate using at least one of UW-OFDM and UW Discrete Fourier transform-Spread-Orthogonal Frequency Division Multiplexing (UW-DFT-s-OFDM).

[0089] In Example 22 a non-transitory computer-readable storage medium that stores instructions for execution by one or more processors of a user equipment (UE) to configure the UE to communicate with an enhanced Node B (eNB), the one or more processors to configure the UE to: receive resource allocation, partition information and numerology, including subcarrier spacing and symbol duration, for a first Radio Access Technology (RAT) of a plurality of RATs used by the eNB, the UE configurable to configure the subcarrier spacing and symbol duration based on the numerology and to communicate using the plurality of RATs; and communicate using the first RAT.

[0090] In Example 23, the subject matter of Example 22 can optionally include that at least one of: a) at least one of the subcarrier spacing and symbol duration for the RATs is respectively specified as an integer number of a base subcarrier spacing or symbol duration, b) the UE is configured to operate in at least one of a low latency and low energy mode, and the first RAT comprises a larger subcarrier spacing and shorter symbol duration when the UE operates in the low latency mode and comprises a smaller subcarrier spacing and longer symbol duration when the UE operates in the low energy mode, and c) a Transmission Time Interval (TTI) boundary between the RATs is common, and the RATs comprise a common reference TTI duration.

[0091] In Example 24, the subject matter of one or any combination of Examples 22-23 can optionally include that at least one of: a) a symbol structure of each of the RATs comprises a cyclic prefix (CP) or unique word (UW) outside or within a symbol, and the symbol structure of each of the RATs is independent of the symbol structure of the other RATs, and b) a frame structure in each of the RATs comprises a frame comprising L subframes, each subframe comprising N slots, each slot comprising M symbols, and the frame structure of each of the RATs is independent of the frame structure of the other RATs.

[0092] In Example 25, the subject matter of one or any combination of Examples 22-24 can optionally include that the numerology, resource allocation and partition information is received via Master Information Block (MIB) carried by a physical broadcast channel (PBCH), a System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling in a second RAT, the first and second RATs being different.

[0093] Although an embodiment has been described with reference to specific example embodiments, it will be evident that various modifications and changes may be made to these embodiments without departing from the broader spirit and scope of the present disclosure. Accordingly, the specification and drawings are to be regarded in an illustrative rather than a restrictive sense. The accompanying drawings that form a part hereof show, by way of illustration, and not of limitation, specific embodiments in which the subject matter may be practiced. The embodiments illustrated are described in sufficient detail to enable those skilled in the art to practice the teachings disclosed herein. Other embodiments may be utilized and derived therefrom, such that structural and logical substitutions and changes may be made without departing from the scope of this disclosure. This Detailed Description, therefore, is not to be taken in a limiting sense, and the scope of various embodiments is defined only by the appended claims, along with the full range of equivalents to which such claims are entitled.

[0094] Such embodiments of the inventive subject matter may be referred to herein, individually and/or collectively, by the term “invention” merely for convenience and without intending to voluntarily limit the scope of this application to any single invention or inventive concept if more than one is in fact disclosed. Thus, although specific embodiments have been illustrated and described herein, it should be appreciated that any arrangement calculated to achieve the same purpose may be substituted for the specific embodiments shown. This disclosure is intended to cover any and all adaptations or variations of various embodiments. Combinations of the above embodiments, and other embodiments not specifically described herein, will be apparent to those of skill in the art upon reviewing the above description.

[0095] In this document, the terms "a" or "an" are used, as is common in patent documents, to include one or more than one, independent of any other instances or usages of "at least one" or "one or more." In this document, the term "or" is used to refer to a nonexclusive or, such that "A or B" includes "A but not B," "B but not A," and "A and B," unless otherwise indicated. In this document, the terms "including" and "in which" are used as the plain-English equivalents of the respective terms "comprising" and "wherein." Also, in the following claims, the

terms "including" and "comprising" are open-ended, that is, a system, UE, article, composition, formulation, or process that includes elements in addition to those listed after such a term in a claim are still deemed to fall within the scope of that claim. Moreover, in the following claims, the terms "first," "second," and "third," etc. are used merely as labels, and are not intended to impose numerical requirements on their objects.

[0096] The Abstract of the Disclosure is provided to comply with 37 C.F.R. §1.72(b), requiring an abstract that will allow the reader to quickly ascertain the nature of the technical disclosure. It is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims. In addition, in the foregoing Detailed Description, it can be seen that various features are grouped together in a single embodiment for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted as reflecting an intention that the claimed embodiments require more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive subject matter lies in less than all features of a single disclosed embodiment. Thus the following claims are hereby incorporated into the Detailed Description, with each claim standing on its own as a separate embodiment.

CLAIMS

What is claimed is:

1. User equipment (UE) comprising:

processing circuitry configured to:

configure a transceiver to receive a resource allocation from a network using a first Radio Access Technology (RAT), the first RAT selected from a plurality of RATs of a flexible RAT (FRAT) employed by the network, the plurality of RATs of the FRAT each comprising configurable numerology with flexible subcarrier spacing and symbol duration and associated with at least one of different temporal and frequency resources, the transceiver configurable to communicate using the plurality of RATs and configure the subcarrier spacing and symbol duration based on the numerology; and

configure the transceiver to communicate using the first RAT.

2. The UE of claim 1, wherein the processing circuitry is configured to:

configure the transceiver to receive from an enhanced NodeB (eNB) higher layer signaling associated with the FRAT, the higher layer signaling indicating numerologies, resource allocation and partition information in at least one of a time and frequency domain.

3. The UE of claim 1, wherein:

the FRAT comprises a base subcarrier spacing and symbol duration, and

at least one of the subcarrier spacing and symbol duration for different RATs of the FRAT is respectively specified as an integer number of the base subcarrier spacing or symbol duration.

4. The UE of claim 3, wherein:

the UE is a Machine-Type Communication (MTC) UE configured to operate in at least one of a low latency and low energy mode, and

the first RAT comprises a larger subcarrier spacing and shorter symbol duration when the UE operates in the low latency mode and comprises a smaller

subcarrier spacing and longer symbol duration when the UE operates in the low energy mode.

5. The UE of claim 1, wherein:

at least one of the plurality of RATs of the FRAT comprises at least one of a plurality of sub-RATs and partitions, each of the at least one of the plurality of sub-RATs and partitions comprising an independent configurable numerology with flexible subcarrier spacing and symbol duration and associated with at least one of different temporal and frequency resource, and

the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are combined using at least one of a Time-Division Multiplexing (TDM), Frequency-Division Multiplexing (FDM), Code-Division Multiplexing (CDM), and Spatial Division Multiplexing (SDM).

6. The UE of claim 5, wherein one of:

the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are combined using TDM, and numerologies, resource allocation and partition information in a time domain are at least one of predefined or configured by higher-layer signaling via Master Information Block (MIB), System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling, or

the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are combined using FDM, guard bands are inserted at an edge of frequency resources allocated for the plurality of RATs and the at least one of the plurality of sub-RATs and partitions, and at least one of numerologies and resource partition for the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are at least one of predefined or configured by the higher -layer signaling.

7. The UE of claim 1, wherein:

a Transmission Time Interval (TTI) boundary between different RATs of the plurality of RATs is common, and

the plurality of RATs comprise a common reference TTI duration.

8. The UE of claim 1, wherein:

a symbol structure of each of the plurality of RATs comprises a cyclic prefix (CP) or unique word (UW) outside or within a symbol, and

the symbol structure of each of the plurality of RATs is independent of the symbol structure of the other RATs.

9. The UE of claim 1, wherein the processing circuitry is configured to at least one of:

configure the transceiver to communicate using Orthogonal Frequency-Division Multiplexing (OFDM) for downlink communications and one of Single Carrier Frequency-Division Multiple Access (SC-FDMA) and OFDM for uplink communications, and

configure the transceiver to communicate using at least one of UW-OFDM and UW Discrete Fourier transform-Spread-Orthogonal Frequency Division Multiplexing (UW-DFT-s-OFDM).

10. The UE of claim 1, wherein:

a frame structure in each of the plurality of RATs comprises a frame comprising L subframes, each subframe comprising N slots, each slot comprising M symbols, and

the frame structure of each of the plurality of RATs is independent of the frame structure of the other RATs.

11. The UE of claim 1, wherein the processing circuitry is configured to:

configure the transceiver to receive numerologies, resource allocation and partition information via Master Information Block (MIB) carried by a physical broadcast channel (PBCH), a System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling in a second RAT, the first and second RATs being different.

12. The UE of claim 1, wherein:

the processing circuitry is configured to configure the transceiver to receive numerologies, resource allocation and partition information via a dedicated carrier in the first RAT, a dedicated carrier allocated for each of the plurality of RATs, and

a dedicated downlink synchronization signal and physical broadcast channel (PBCH) is able to be received on each of the plurality of RATs.

13. The UE of claim 1, further comprising an antenna configured to transmit and receive communications between the transceiver and the eNB.

14. An apparatus of an eNode B (eNB) comprising:

processing circuitry configured to:

configure a transceiver to transmit resource allocations for different Radio Access Technologies (RATs) to a plurality of user equipment (UE), at least two of the UEs associated with a different RAT, each RAT comprising an independent subcarrier spacing, symbol duration, frame structure and symbol structure; and

configure the transceiver to communicate with each UE using the RAT associated with the UE.

15. The apparatus of claim 14, wherein the processing circuitry is configured to:

configure the transceiver to transmit higher layer signaling indicating numerologies, resource allocation and partition information via Master Information Block (MIB) carried by a physical broadcast channel (PBCH), a System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling in a same RAT to each of the plurality of UEs.

16. The apparatus of claim 14, wherein the processing circuitry is configured to:

configure the transceiver to transmit numerologies, resource allocation and partition information via a dedicated carrier allocated for each of the RATs, and

a dedicated downlink synchronization signal and physical broadcast channel (PBCH) is able to be received on each of the RATs.

17. The apparatus of claim 14, wherein:

at least one of the subcarrier spacing and symbol duration for each of the RATs is respectively specified as an integer number of a base subcarrier spacing or symbol duration.

18. The apparatus of claim 14, wherein:

the RATs comprise a first RAT comprising a larger subcarrier spacing and shorter symbol duration configured for a UE operating in a low latency mode and a second RAT comprising a smaller subcarrier spacing and longer symbol duration configured for a UE operating in a low energy mode.

19. The apparatus of claim 14, wherein:

a Transmission Time Interval (TTI) boundary between the RATs is common, and

the RATs comprise a common reference TTI duration.

20. The apparatus of claim 14, wherein:

a symbol structure of each of the RATs comprises a cyclic prefix (CP) or unique word (UW) outside or within a symbol, and

the symbol structure of each of the RATs is independent of the symbol structure of the other RATs.

21. The apparatus of claim 14, wherein the processing circuitry is configured to at least one of:

configure the transceiver to communicate using Orthogonal Frequency-Division Multiplexing (OFDM) for downlink communications and one of Single Carrier Frequency-Division Multiple Access (SC-FDMA) and OFDM for uplink communications, and

configure the transceiver to communicate using at least one of UW-OFDM and UW Discrete Fourier transform-Spread-Orthogonal Frequency Division Multiplexing (UW-DFT-s-OFDM).

22. A non-transitory computer-readable storage medium that stores instructions for execution by one or more processors of a user equipment (UE) to configure the UE to communicate with an enhanced Node B (eNB), the one or more processors to configure the UE to:

receive resource allocation, partition information and numerology, including subcarrier spacing and symbol duration, for a first Radio Access Technology (RAT) of a plurality of RATs used by the eNB, the UE configurable to configure the subcarrier spacing and symbol duration based on the numerology and to communicate using the plurality of RATs; and

communicate using the first RAT.

23. The medium of claim 22, wherein at least one of:

a) at least one of the subcarrier spacing and symbol duration for the RATs is respectively specified as an integer number of a base subcarrier spacing or symbol duration,

b) the UE is configured to operate in at least one of a low latency and low energy mode, and

the first RAT comprises a larger subcarrier spacing and shorter symbol duration when the UE operates in the low latency mode and comprises a smaller subcarrier spacing and longer symbol duration when the UE operates in the low energy mode, and

c) a Transmission Time Interval (TTI) boundary between the RATs is common, and

the RATs comprise a common reference TTI duration.

24. The medium of claim 22, wherein at least one of:

a) a symbol structure of each of the RATs comprises a cyclic prefix (CP) or unique word (UW) outside or within a symbol, and

the symbol structure of each of the RATs is independent of the symbol structure of the other RATs, and

b) a frame structure in each of the RATs comprises a frame comprising L subframes, each subframe comprising N slots, each slot comprising M symbols, and

the frame structure of each of the RATs is independent of the frame structure of the other RATs.

25. The medium of claim 22, wherein:

the numerology, resource allocation and partition information is received via Master Information Block (MIB) carried by a physical broadcast channel (PBCH), a System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling in a second RAT, the first and second RATs being different.

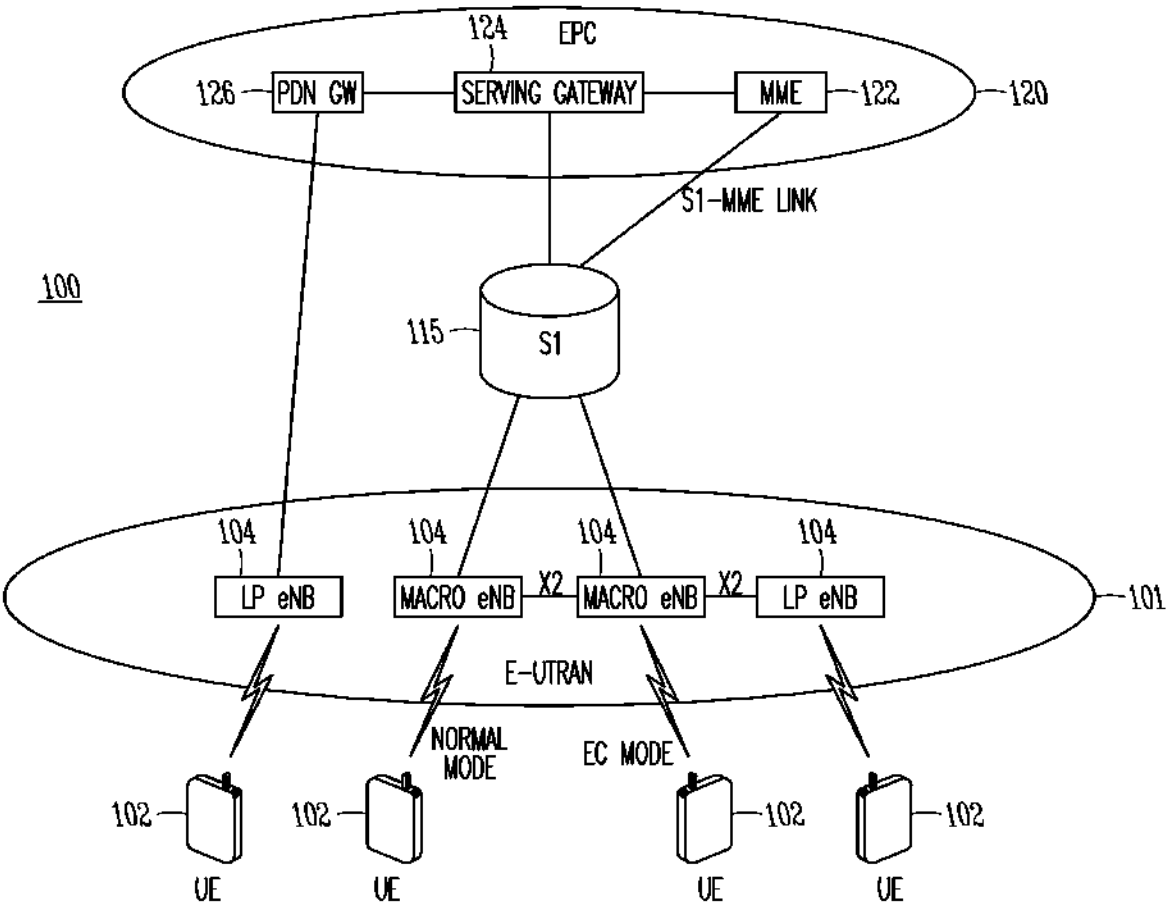

124
EPC
126
PDN GW
SERVING GATEWAY
MME
122
120
S1-MME LINK
100
115
S1
104
104
104
104
LP eNB
MACRO eNB
X2
MACRO eNB
X2
LP eNB
101
E-UTRAN
NORMAL MODE
EC MODE
102
102
102
102
UE
UE
UE
UE

FIG. 1

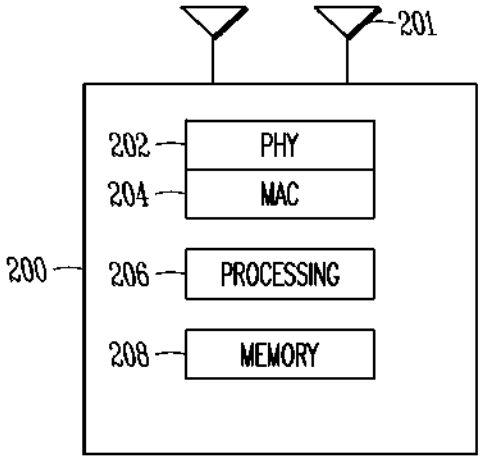


FIG. 2

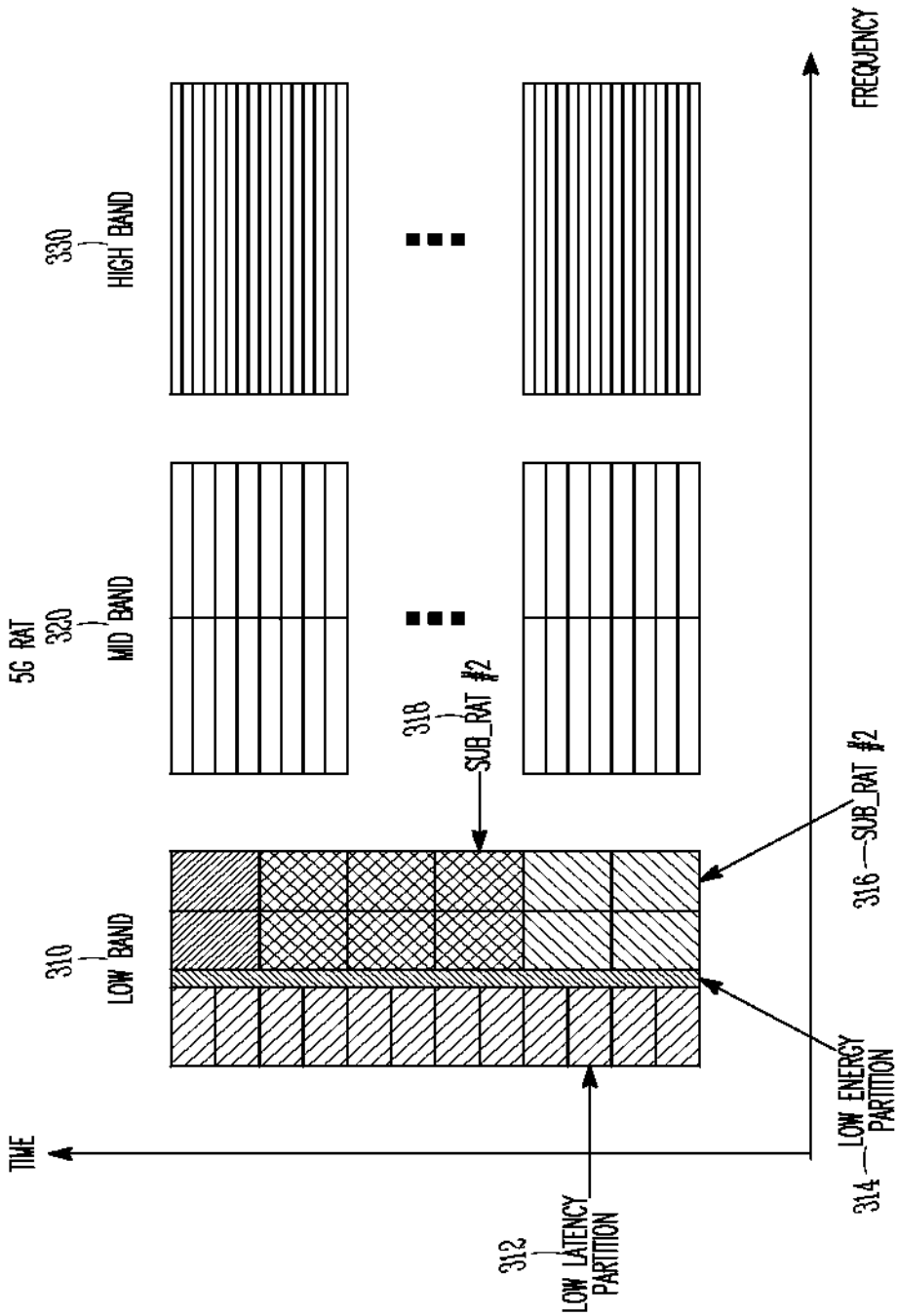

FREQUENCY
330
HIGH BAND
5G RAT
320
MID BAND
318
SUB_RAT #2
310
LOW BAND
316
SUB_RAT #2
TIME
314
LOW ENERGY PARTITION
312
LOW LATENCY PARTITION

FIG. 3

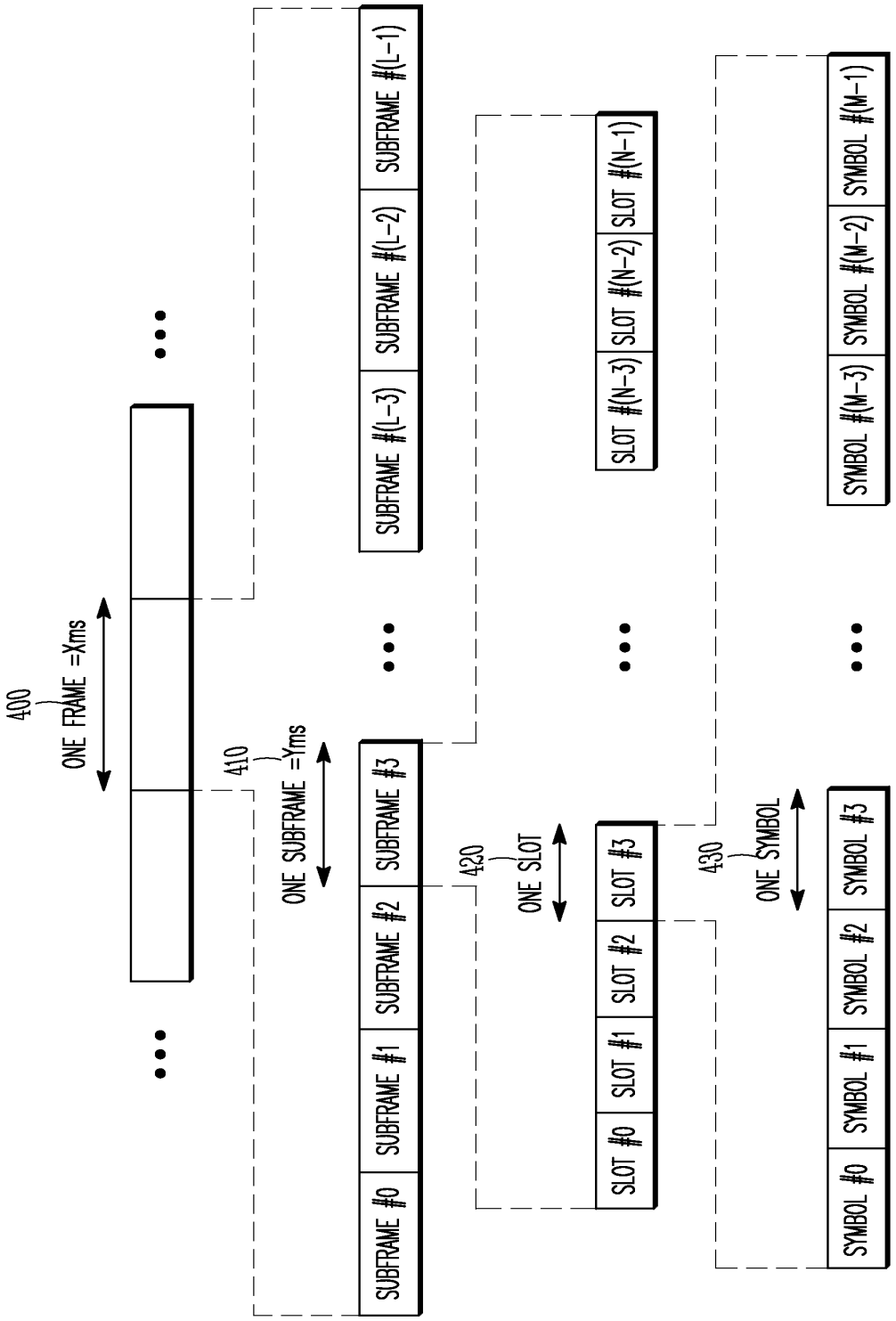

400
ONE FRAME =Xms
410
ONE SUBFRAME =Yms
SUBFRAME #0
SUBFRAME #1
SUBFRAME #2
SUBFRAME #3
SUBFRAME #(L-3)
SUBFRAME #(L-2)
SUBFRAME #(L-1)
420
ONE SLOT
SLOT #0
SLOT #1
SLOT #2
SLOT #3
SLOT #(N-3)
SLOT #(N-2)
SLOT #(N-1)
430
ONE SYMBOL
SYMBOL #0
SYMBOL #1
SYMBOL #2
SYMBOL #3
SYMBOL #(M-3)
SYMBOL #(M-2)
SYMBOL #(M-1)

FIG. 4

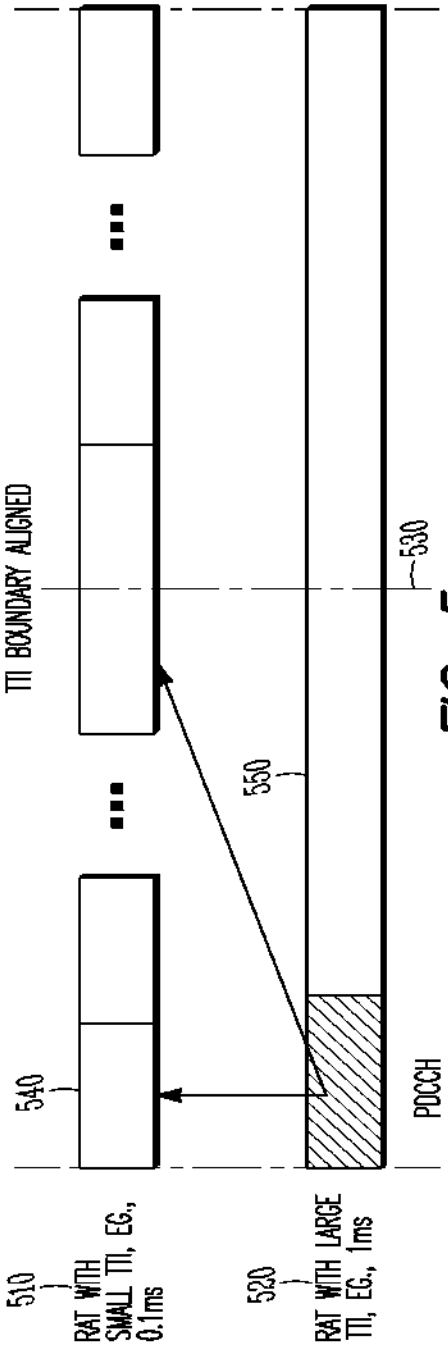

TTI BOUNDARY ALIGNED
530
550
540
PDCCH
510
RAT WITH SMALL TTI, EG., 0.1ms
520
RAT WITH LARGE TTI, EG., 1ms

FIG. 5

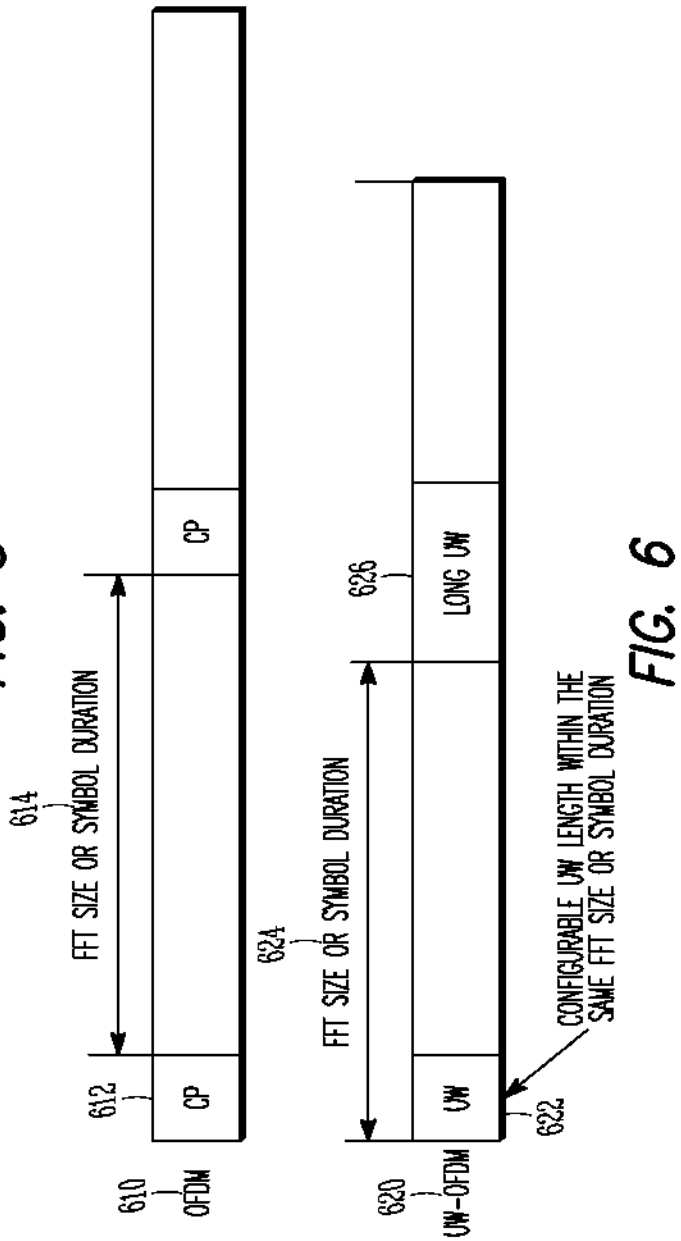

614
FFT SIZE OR SYMBOL DURATION
CP
612
610
OFDM
624
FFT SIZE OR SYMBOL DURATION
626
LONG UW
UW
622
620
UW-OFDM
CONFIGURABLE UW LENGTH WITHIN THE SAME FFT SIZE OR SYMBOL DURATION

FIG. 6

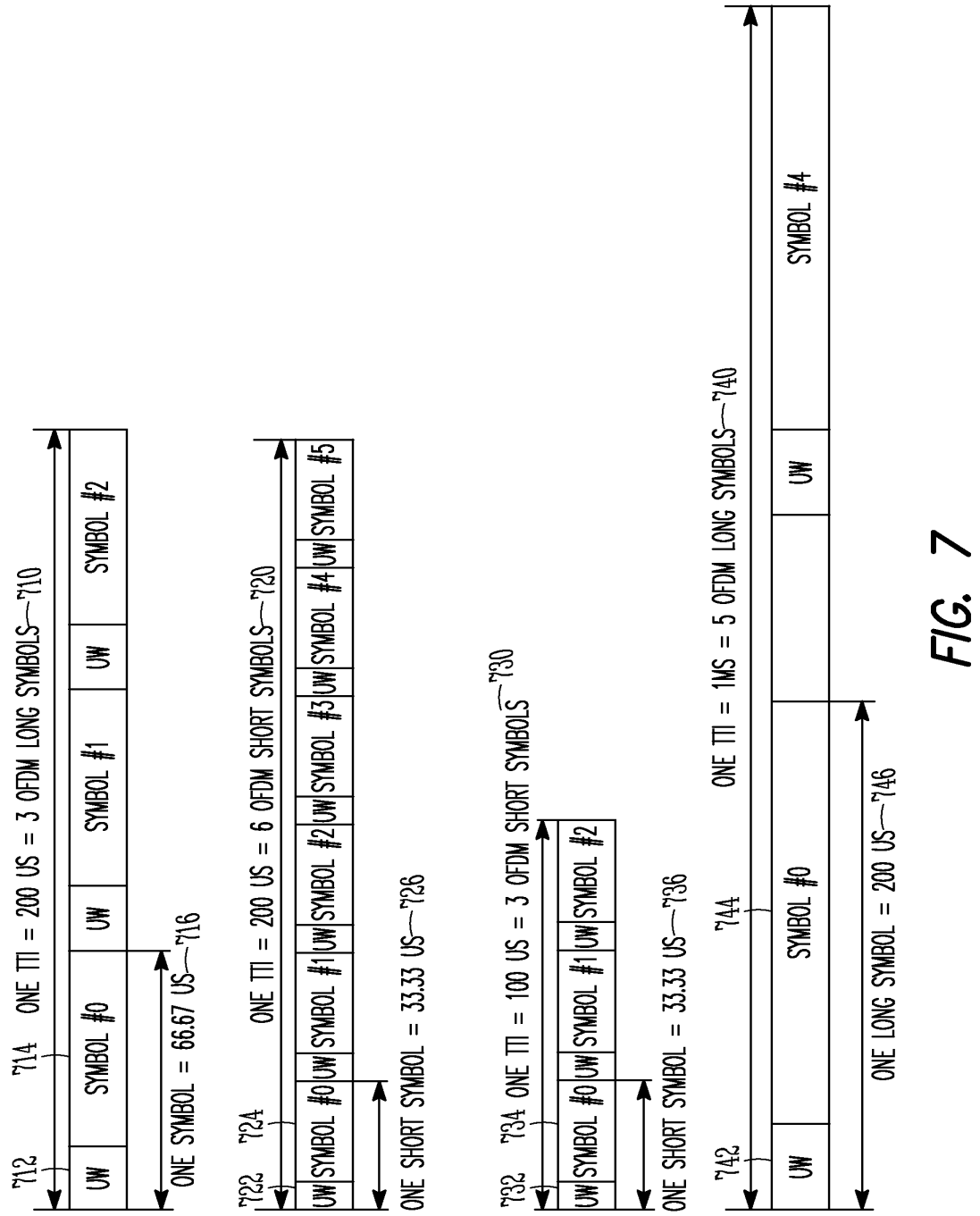

712
714
ONE TTI = 200 US = 3 OFDM LONG SYMBOLS
710
UW
SYMBOL #0
UW
SYMBOL #1
UW
SYMBOL #2
ONE SYMBOL = 66.67 US
716
722
724
ONE TTI = 200 US = 6 OFDM SHORT SYMBOLS
720
UW
SYMBOL #0
UW
SYMBOL #1
UW
SYMBOL #2
UW
SYMBOL #3
UW
SYMBOL #4
UW
SYMBOL #5
ONE SHORT SYMBOL = 33.33 US
726
732
734
ONE TTI = 100 US = 3 OFDM SHORT SYMBOLS
730
UW
SYMBOL #0
UW
SYMBOL #1
UW
SYMBOL #2
ONE SHORT SYMBOL = 33.33 US
736
742
744
ONE TTI = 1MS = 5 OFDM LONG SYMBOLS
740
UW
SYMBOL #0
UW
SYMBOL #4
ONE LONG SYMBOL = 200 US
746

FIG. 7

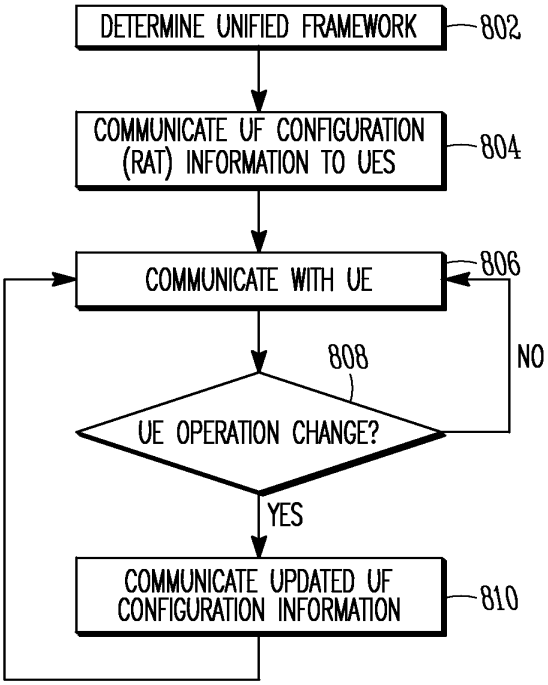

DETERMINE UNIFIED FRAMEWORK
802
COMMUNICATE UF CONFIGURATION (RAT) INFORMATION TO UES
804
COMMUNICATE WITH UE
806
808
UE OPERATION CHANGE?
NO
YES
COMMUNICATE UPDATED UF CONFIGURATION INFORMATION
810

FIG. 8A

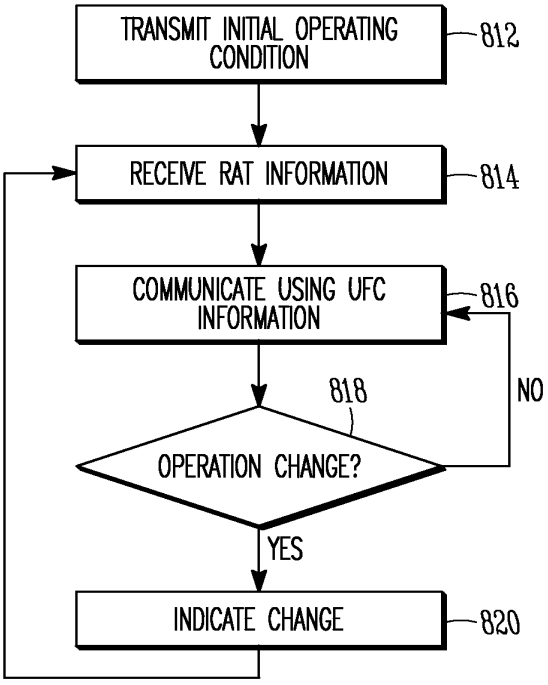

TRANSMIT INITIAL OPERATING CONDITION
812
RECEIVE RAT INFORMATION
814
COMMUNICATE USING UFC INFORMATION
816
818
OPERATION CHANGE?
NO
YES
INDICATE CHANGE
820

FIG. 8B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/044628

A. CLASSIFICATION OF SUBJECT MATTER

H04W 72/04(2009.01)i, H04W 92/10(2009.01)i, H04W 88/06(2009.01)i, H04W 88/08(2009.01)i, H04B 7/26(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W 72/04; H04L 5/00; H04Q 7/00; H04W 88/06; H04L 27/26; H04W 92/10; H04W 88/08; H04B 7/26

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: radio access technology (RAT), FRAT (flexible RAT), flexible subcarrier spacing and symbol duration, numerology, MTC, low latency, low energy, sub-RAT, partition, combination, TTI, unique word (UW), UW-OFDM, UW-DFT-s-OFDM, synchronization, broadcast

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2008-0130570 A1 (YOUNG-HO JUNG et al.) 5 June 2008 See paragraphs [0011], [0033]-[0045]; claims 1, 7; and figures 3-5.	1-25
Y	EEVA LAHETKANGAS et al., 'On the Flexible 5G Dense Deployment Air Interface for Mobile Broadband', In: 5G for Ubiquitous Connectivity (5GU), 2014 1st International Conference on, Page(s): 57-61, 26-28 November 2014 See pages 1-3; and figures 1, 4.	1-25
Y	US 2015-0029990 A1 (INTERDIGITAL PATENT HOLDINGS, INC.) 29 January 2015 See paragraphs [0066]-[0082]; and figure 1.	7,19
Y	US 2014-0140194 A1 (STEFAN FECHTEL) 22 May 2014 See paragraph [0024]; and figures 2A, 2B.	8,9,20,21
A	WO 2014-139562 A1 (NOKIA SOLUTIONS AND NETWORKS OY) 18 September 2014 See page 11, lines 19-32; claims 1, 8, 12; and figures 4, 5.	1-25

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 December 2015 (18.12.2015)	**21 December 2015 (21.12.2015)**

Name and mailing address of the ISA/KR
International Application Division
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Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2015/044628

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2008-0130570 A1	05/06/2008	KR 10-0969751 B1	13/07/2010
		KR 10-2008-0048293 A	02/06/2008
		US 8259667 B2	04/09/2012
US 2015-0029990 A1	29/01/2015	TW 201246857 A	16/11/2012
		US 2012-0230268 A1	13/09/2012
		US 8861461 B2	14/10/2014
		WO 2012-122170 A1	13/09/2012
US 2014-0140194 A1	22/05/2014	TW 201434298 A	01/09/2014
		WO 2014-079712 A1	30/05/2014
WO 2014-139562 A1	18/09/2014	None	

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International Bureau

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WIPO | PCT

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4 November 2016 (04.11.2016)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/250,791 4 November 2015 (04.11.2015) US

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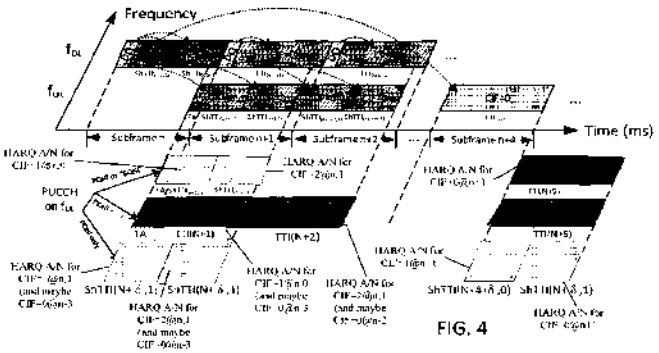


FIG. 4

(57) Abstract: A wireless transmit/receive unit, WTRU and methods of using a WTRU within a wireless communications network include communicating with a serving cell in the wireless communications network and determining, based on downlink control information whether the WTRU shall transmit with a first transmission time interval, TTI, length, using a first set of transmission resources, or a second TTI length, using a second set of transmission resources. Alternatively, determining based on said DCI, that the serving cell has indicated that the WTRU should use a first TTI on a physical uplink channel to communicate with the serving cell, or whether said DCI indicates that the WTRU should use a second TTI that is less than the first transmission time interval to communicate with the wireless communication network on the physical uplink channel or whether the WTRU should transmit using carrier aggregation.

DEVICE AND METHODS FOR MULTIPLEXING TRANSMISSIONS WITH DIFFERENT TTI DURATION

BACKGROUND

[0001] In a wireless communication network, such as a Long Term Evolution (LTE) system or New Radio (NR), a wireless transmit/receive unit (WTRU) device may access resources of the communication system. Latency associated with transmission of data in a communication system may have one or more latency components. A latency component may be the time to perform the transmission of a transport block, which time may be referred to as a Transmission Time Interval (TTI). Such TTI may be tied to a specific numerology associated with the transmission method and to a specific number of transmission symbols associated with the transmission. Other latency components may include processing time at a receiver, e.g., time decoding a transmission, transmission of feedback (e.g. ACK or NACK) and/or one or more retransmissions with one or more latency components.

SUMMARY

[0002] Systems, methods, and instrumentalities are disclosed for multiplexing transmissions with different durations, for example transmissions that are associated with different TTI lengths. Latency may be reduced (e.g., in an LTE system and/or in a NR system), for example, by multiplexing transmissions with different TTI durations or associated with different transmission numerologies. TTI duration may be modeled based on defining one or more cell(s) for a given carrier frequency, for example that may be associated with different TTI lengths and/or transmission durations. For example, the different transmission durations may be achieved by time-shifting one or more of the cells. In order to support signaling techniques that allow for concurrent and/or complementary scheduling of transmissions associated with different duration, a logical structure for the physical layer resources (e.g., a cell, a spectrum block, etc.) may configured to correspond to a secondary cell ("SCell"). A primary cell ("PCell") may logically maintain a first transmission duration (e.g., a first TTI length such as a legacy TTI length). The SCell may be configured with a second transmission duration (e.g., a second TTI length or a shortened TTI length). One or more of a PCell or an SCell may be configured with either the legacy or shortened TTI length (e.g., a shorter duration TTI (ShTTI).

[0003] By associating different TTI lengths with different cells, the LTE carrier aggregation framework can be utilized to support multiplexing of transmissions of different durations. For example, carrier aggregation signaling, including cross-carrier scheduling mechanisms, can be used to different scheduling grants and assignments of varying length. For example, a WTRU may determine a TTI duration (e.g., first or second TTI length) applicable to a transmission. For example, a WTRU may determine a TTI duration using cross-carrier scheduling. A WTRU may be configured to associate a given cell identity (e.g., servCellID) with a given transmission duration. Different cell identities (e.g., different servCellIDs) may be associated with different transmission durations/different TTI lengths. When a WTRU receives scheduling information applicable to a given cell identity, the WTRU may determine the associated TTI length based on the configuration received for that cell identity.

[0004] A WTRU may determine a TTI length and/or transmission duration based on one or more parameters and/or received fields. For example, a WTRU may associate a given TTI duration with a given transmission mode (TM). A TTI duration may be indicated by a Carrier Indicator Field (CIF), for example where certain values of the CIF are associated with SCells configured with a given TTI durations such as a ShTTI. The CIF may also be referred to as a Carrier Indicator Field (CIF). The TTI duration may be indicated by a field that indicates a set of resources such as a set of PRBs, a carrier, a serving cell of the WTRU's configuration, and/or a spectrum block. A TTI duration may be determined from an identity of a PRB subset associated with the transmissions and/or to a time-shifted cell within a subset of PRBs for a concerned carrier frequency. An applicable TTI duration and/or the identity of a slot/period applicable to a transmission within a subframe may be determined using a medium access control (MAC) Activation/Deactivation control element. MAC Activation/Deactivation CE may be used to toggle between first and second TTIs (e.g. legacy TTI and ShTTIs) or between slot-based ShTTIs and/or may be used to determine zero, one or more TTI (e.g. ShTTI) period(s) within a subframe.

[0005] HARQ processing may be performed according to a first behavior (e.g. legacy behavior) for one or more (e.g. each) time-shifted cell(s), although there may be exceptions. An exception may be timing-relationships, which may be scaled according to an applicable TTI duration. HARQ A/N feedback formats may use LTE Carrier Aggregation (CA) formats and/or (e.g. legacy) subframe-based timing relationships or a timing relationship associated with the HARQ process. Downlink Control Information (DCI) signaling may use a first (e.g. legacy) format, although, for example, interpretation of fields such as the CIF and/or fields that indicate the PRBs applicable for the transmission may be different than the interpretations of the first

(e.g. legacy) format. MAC activation/deactivation signaling may be applicable for time-shifted cells. DRX Timers associated with DRX may scale to HARQ A/N timing according to an applicable TTI duration and/or to the cell associated with an HARQ process. Physical random access channel (PRACH) resources and/or physical downlink control channel (PDCCH) order for RACH may or may not be supported for time-shifted SCells. Timing advance for uplink transmission may be time shifted, for example, according to a shift applied to the TTI associated with a cell. Time shift may be relative to PCell timing, e.g. a PCell may remain a DL timing reference for an SCell with the additional offset corresponding to the start of the ShTTI for those cells.

[0006] A method of using a wireless transmit/receive unit within a wireless communications network that is capable of aggregating different sets of physical layer resources (e.g., such as carrier aggregation, for example) may include communicating with a serving cell in the wireless communications network and determining that the serving cell has indicated that the WTRU should use a first transmission time interval on a physical uplink channel to communicate with the serving cell. The method may also include determining whether downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment) indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network (e.g., on the physical uplink channel). The method may further include communicating with the wireless communications network using the second transmission time interval.

[0007] The method may include determining that a downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment) indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network (e.g, on the physical uplink channel) comprises determining based on a carrier indicator field in received downlink control information.

[0008] The method may include communicating with the wireless communications network using the second transmission time interval comprises communicating with the serving cell using the second transmission time interval.

[0009] The method may include wherein communicating with the wireless communications network using the second transmission time interval includes communicating with a secondary cell using the second transmission time interval.

[0010] The method may include determining that a downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment) indicates that the WTRU should use a third

transmission time interval that is less than the first transmission time interval to communicate with a secondary cell in the wireless communications network. The shorten transmission time interval may correspond to at least one of at least one symbol or at least one resource block. The first transmission time interval may be one millisecond.

[0011] The method may include determining a time to transmit with the second transmission time interval based on the downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment). The time to transmit may defined by a time partition (e.g., a slot in a subframe and/or one or more time symbols, (e.g., OFDM symbols), an arrangement of symbols, a min-slot, or other time for a sub-carrier spacing).

[0012] The method may include determining whether a first downlink control information (e.g., using carrier aggregation fields such as the CIF) indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network (e.g., on the physical uplink channel) or whether the WTRU should transmit using carrier aggregation comprises determining with cross-carrier scheduling.

[0013] A wireless transmit/receive unit (WTRU) for use within a wireless communications network that is capable of carrier aggregation may have a processor having executable instructions that communicate with a serving cell in the wireless communications network and determine that the serving cell has indicated that the WTRU should use a first transmission time interval on an uplink channel (e.g., physical uplink channel) to communicate with the serving cell. The processor instructions may include determining whether a downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment) indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network (e.g., on the physical uplink channel). The WTRU processor instructions may include communicating with the wireless communications network using the second transmission time interval.

[0014] The WTRU processor instructions that determine that a first downlink control information (e.g, carrier aggregation field such as the CIF) indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network (e.g., on the physical uplink channel) may comprise determining based on a carrier indicator field in received downlink control information.

[0015] The WTRU processor executable instructions that communicate with the wireless communications network using the second transmission time interval may comprise communicating with the serving cell using the second transmission time interval.

[0016] The WTRU processor executable instructions that communicate with the wireless communications network using the second transmission time interval may comprise communicating with a secondary cell using the second transmission time interval.

[0017] The WTRU processor executable instructions may include determining that a downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment) indicates that the WTRU should use a third transmission time interval that is less than the first transmission time interval to communicate with a secondary cell in the wireless communications network. The shorten transmission time interval may correspond to at least one of at least one symbol or at least one resource block. The first transmission time interval may be one millisecond.

[0018] The WTRU processor executable instructions may include determining a time to transmit with the second transmission time interval based on the downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment). The time to transmit may be defined by a slot in a subframe.

[0019] The WTRU processor executable instructions that determine whether a downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment) indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network (e.g., on the physical uplink channel).

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] FIG. 1A is a system diagram of an example communications system in which disclosed subject matter may be implemented.

[0021] FIG. 1B is a system diagram of an example wireless transmit/receive unit (WTRU) that may be used in a communications system.

[0022] FIG. 1C is a system diagram of an example radio access network and an example core network that may be used in a communications system.

[0023] FIG. 1D is a system diagram of an example radio access network and an example core network that may be used in a communications system.

[0024] FIG. 1E is a system diagram of an example radio access network and an example core network that may be used in a communications system.

[0025] FIG. 2 shows an example of DL physical layer channels.

[0026] FIG. 3 shows an example of UL physical layer channels.

[0027] FIG. 4 is an example of scheduling with time-shifted cells.

DETAILED DESCRIPTION

[0028] A detailed description of illustrative embodiments will now be described with reference to the various figures. Although this description provides a detailed example of possible implementations, it should be noted that the details are intended to be exemplary and in no way limit the scope of the application.

[0029] FIG. 1A is a diagram of an example communications system 100 in which one or more disclosed embodiments may be implemented. The communications system 100 may be a multiple access system that provides content, for example voice, data, video, messaging, broadcast, etc., to multiple wireless users. The communications system 100 may enable multiple wireless users to access such content through the sharing of system resources, including wireless bandwidth. For example, the communications systems 100 may employ one or more channel access methods, for example code division multiple access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), orthogonal FDMA (OFDMA), single-carrier FDMA (SC-FDMA), and the like.

[0030] As shown in FIG. 1A, the communications system 100 may include wireless transmit/receive units (WTRUs) 102a, 102b, 102c, and/or 102d (which generally or collectively may be referred to as WTRU 102), a radio access network (RAN) 103/104/105, a core network 106/107/109, a public switched telephone network (PSTN) 108, the Internet 110, and other networks 112, though it will be appreciated that the disclosed embodiments contemplate any number of WTRUs, base stations, networks, and/or network elements. Each of the WTRUs 102a, 102b, 102c, 102d may be any type of device configured to operate and/or communicate in a wireless environment. By way of example, the WTRUs 102a, 102b, 102c, 102d may be configured to transmit and/or receive wireless signals and may include a user equipment (WTRU), a mobile station, a fixed or mobile subscriber unit, a pager, a cellular telephone, a personal digital assistant (PDA), a smartphone, a laptop, a netbook, a personal computer, a wireless sensor, consumer electronics, and the like.

[0031] The communications systems 100 may also include a base station 114a and a base station 114b. Each of the base stations 114a, 114b may be any type of device configured to wirelessly interface with at least one of the WTRUs 102a, 102b, 102c, 102d to facilitate access to

one or more communication networks, for example the core network 106/107/109, the Internet 110, and/or the networks 112. By way of example, the base stations 114a, 114b may be a base transceiver station (BTS), a Node-B, an eNode B, a Home Node B, a Home eNode B, a site controller, an access point (AP), a wireless router, and the like. While the base stations 114a, 114b are each depicted as a single element, it will be appreciated that the base stations 114a, 114b may include any number of interconnected base stations and/or network elements.

[0032] The base station 114a may be part of the RAN 103/104/105, which may also include other base stations and/or network elements (not shown), for example a base station controller (BSC), a radio network controller (RNC), relay nodes, etc. The base station 114a and/or the base station 114b may be configured to transmit and/or receive wireless signals within a particular geographic region, which may be referred to as a cell (not shown). The cell may further be divided into cell sectors. For example, the cell associated with the base station 114a may be divided into three sectors. Thus, in one embodiment, the base station 114a may include three transceivers, i.e., one for each sector of the cell. In an embodiment, the base station 114a may employ multiple-input multiple output (MIMO) technology and, therefore, may utilize multiple transceivers for each sector of the cell.

[0033] The base stations 114a, 114b may communicate with one or more of the WTRUs 102a, 102b, 102c, 102d over an air interface 115/116/117, which may be any suitable wireless communication link (e.g. radio frequency (RF), microwave, infrared (IR), ultraviolet (UV), visible light, etc.). The air interface 115/116/117 may be established using any suitable radio access technology (RAT).

[0034] More specifically, as noted above, the communications system 100 may be a multiple access system and may employ one or more channel access schemes, for example CDMA, TDMA, FDMA, OFDMA, SC-FDMA, and the like. For example, the base station 114a in the RAN 103/104/105 and the WTRUs 102a, 102b, 102c may implement a radio technology such as Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access (UTRA), which may establish the air interface 115/116/117 using wideband CDMA (WCDMA). WCDMA may include communication protocols such as High-Speed Packet Access (HSPA) and/or Evolved HSPA (HSPA+). HSPA may include High-Speed Downlink Packet Access (HSDPA) and/or High-Speed Uplink Packet Access (HSUPA).

[0035] In an embodiment, the base station 114a and the WTRUs 102a, 102b, 102c may implement a radio technology such as Evolved UMTS Terrestrial Radio Access (E-UTRA), which may establish the air interface 115/116/117 using Long Term Evolution (LTE) and/or LTE-Advanced (LTE-A).

[0036] In an embodiment, the base station 114a and the WTRUs 102a, 102b, 102c may implement radio technologies such as IEEE 802.16 (i.e., Worldwide Interoperability for Microwave Access (WiMAX)), CDMA2000, CDMA2000 1X, CDMA2000 EV-DO, Interim Standard 2000 (IS-2000), Interim Standard 95 (IS-95), Interim Standard 856 (IS-856), Global System for Mobile communications (GSM), Enhanced Data rates for GSM Evolution (EDGE), GSM EDGE (GERAN), New Radio (NR) and the like. The descriptions and example provided herein apply to any of the air interface and communications standards that have been implemented although the terminology may differ among them for the functional components.

[0037] The base station 114b in FIG. 1A may be a wireless router, Home Node B, Home eNode B, or access point, for example, and may utilize any suitable RAT for facilitating wireless connectivity in a localized area, for example a place of business, a home, a vehicle, a campus, and the like. In one embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.11 to establish a wireless local area network (WLAN). In an embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.15 to establish a wireless personal area network (WPAN). In yet an embodiment, the base station 114b and the WTRUs 102c, 102d may utilize a cellular-based RAT (e.g. WCDMA, CDMA2000, GSM, LTE, LTE-A, etc.) to establish a picocell or femtocell. As shown in FIG. 1A, the base station 114b may have a direct connection to the Internet 110. Thus, the base station 114b may not be required to access the Internet 110 via the core network 106/107/109.

[0038] The RAN 103/104/105 may be in communication with the core network 106/107/109, which may be any type of network configured to provide voice, data, applications, and/or voice over internet protocol (VoIP) services to one or more of the WTRUs 102a, 102b, 102c, 102d. For example, the core network 106/107/109 may provide call control, billing services, mobile location-based services, pre-paid calling, Internet connectivity, video distribution, etc., and/or perform high-level security functions, for example user authentication. Although not shown in FIG. 1A, it will be appreciated that the RAN 103/104/105 and/or the core network 106/107/109 may be in direct or indirect communication with other RANs that employ the same RAT as the RAN 103/104/105 or a different RAT. For example, in addition to being connected to the RAN 103/104/105, which may be utilizing an E-UTRA radio technology, the core network 106/107/109 may also be in communication with a RAN (not shown) employing a GSM radio technology.

[0039] The core network 106/107/109 may also serve as a gateway for the WTRUs 102a, 102b, 102c, 102d to access the PSTN 108, the Internet 110, and/or other networks 112. The

PSTN 108 may include circuit-switched telephone networks that provide plain old telephone service (POTS). The Internet 110 may include a global system of interconnected computer networks and devices that use common communication protocols, for example the transmission control protocol (TCP), user datagram protocol (UDP) and the internet protocol (IP) in the TCP/IP internet protocol suite. The networks 112 may include wired or wireless communications networks owned and/or operated by other service providers. For example, the networks 112 may include a core network connected to one or more RANs, which may employ the same RAT as the RAN 103/104/105 or a different RAT.

[0040] Some or all of the WTRUs 102a, 102b, 102c, 102d in the communications system 100 may include multi-mode capabilities, i.e., the WTRUs 102a, 102b, 102c, 102d may include multiple transceivers for communicating with different wireless networks over different wireless links. For example, the WTRU 102c shown in FIG. 1A may be configured to communicate with the base station 114a, which may employ a cellular-based radio technology, and with the base station 114b, which may employ an IEEE 802 radio technology.

[0041] FIG. 1B is a system diagram of an example WTRU 102. As shown in FIG. 1B, the WTRU 102 may include a processor 118, a transceiver 120, a transmit/receive element 122, a speaker/microphone 124, a keypad 126, a display/touchpad 128, non-removable memory 130, removable memory 132, a power source 134, a global positioning system (GPS) chipset 136, and other peripherals 138. It will be appreciated that the WTRU 102 may include any sub-combination of the foregoing elements while remaining consistent with an embodiment. Also, embodiments contemplate that the base stations 114a and 114b, and/or the nodes that base stations 114a and 114b may represent, for example but not limited to transceiver station (BTS), a Node-B, a site controller, an access point (AP), a home node-B, an evolved home node-B (eNodeB), a home evolved node-B (HeNB), a home evolved node-B gateway, and proxy nodes, among others, may include some or each of the elements depicted in FIG. 1B and described herein.

[0042] The processor 118 may be a general purpose processor, a special purpose processor, a conventional processor, a digital signal processor (DSP), a plurality of microprocessors, one or more microprocessors in association with a DSP core, a controller, a microcontroller, Application Specific Integrated Circuits (ASICs), Field Programmable Gate Array (FPGAs) circuits, any other type of integrated circuit (IC), a state machine, and the like. The processor 118 may perform signal coding, data processing, power control, input/output processing, and/or any other functionality that enables the WTRU 102 to operate in a wireless environment. The processor 118 may be coupled to the transceiver 120, which may be coupled to the

transmit/receive element 122. While FIG. 1B depicts the processor 118 and the transceiver 120 as separate components, it will be appreciated that the processor 118 and the transceiver 120 may be integrated together in an electronic package or chip.

[0043] The transmit/receive element 122 may be configured to transmit signals to, or receive signals from, a base station (e.g. the base station 114a) over the air interface 115/116/117. For example, in one embodiment, the transmit/receive element 122 may be an antenna configured to transmit and/or receive RF signals. In an embodiment, the transmit/receive element 122 may be an emitter/detector configured to transmit and/or receive IR, UV, or visible light signals, for example. In yet an embodiment, the transmit/receive element 122 may be configured to transmit and receive both RF and light signals. It will be appreciated that the transmit/receive element 122 may be configured to transmit and/or receive any combination of wireless signals.

[0044] In addition, although the transmit/receive element 122 is depicted in FIG. 1B as a single element, the WTRU 102 may include any number of transmit/receive elements 122. More specifically, the WTRU 102 may employ MIMO technology. Thus, in one embodiment, the WTRU 102 may include two or more transmit/receive elements 122 (e.g. multiple antennas) for transmitting and receiving wireless signals over the air interface 115/116/117.

[0045] The transceiver 120 may be configured to modulate the signals that are to be transmitted by the transmit/receive element 122 and to demodulate the signals that are received by the transmit/receive element 122. As noted above, the WTRU 102 may have multi-mode capabilities. Thus, the transceiver 120 may include multiple transceivers for enabling the WTRU 102 to communicate via multiple RATs, for example UTRA and IEEE 802.11, for example.

[0046] The processor 118 of the WTRU 102 may be coupled to, and may receive user input data from, the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128 (e.g. a liquid crystal display (LCD) display unit or organic light-emitting diode (OLED) display unit). The processor 118 may also output user data to the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128. In addition, the processor 118 may access information from, and store data in, any type of suitable memory, for example the non-removable memory 130 and/or the removable memory 132. The non-removable memory 130 may include random-access memory (RAM), read-only memory (ROM), a hard disk, or any other type of memory storage device. The removable memory 132 may include a subscriber identity module (SIM) card, a memory stick, a secure digital (SD) memory card, and the like. In an embodiment, the processor 118 may access information from, and store data in, memory that is not physically located on the WTRU 102, for example on a server or a home computer (not shown).

[0047] The processor 118 may receive power from the power source 134, and may be configured to distribute and/or control the power to the other components in the WTRU 102. The power source 134 may be any suitable device for powering the WTRU 102. For example, the power source 134 may include one or more dry cell batteries (e.g. nickel-cadmium (NiCd), nickel-zinc (NiZn), nickel metal hydride (NiMH), lithium-ion (Li-ion), etc.), solar cells, fuel cells, and the like.

[0048] The processor 118 may also be coupled to the GPS chipset 136, which may be configured to provide location information (e.g. longitude and latitude) regarding the current location of the WTRU 102. In addition to, or in lieu of, the information from the GPS chipset 136, the WTRU 102 may receive location information over the air interface 115/116/117 from a base station (e.g. base stations 114a, 114b) and/or determine its location based on the timing of the signals being received from two or more nearby base stations. It will be appreciated that the WTRU 102 may acquire location information by way of any suitable location-determination method while remaining consistent with an embodiment.

[0049] The processor 118 may further be coupled to other peripherals 138, which may include one or more software and/or hardware modules that provide additional features, functionality and/or wired or wireless connectivity. For example, the peripherals 138 may include an accelerometer, an e-compass, a satellite transceiver, a digital camera (for photographs or video), a universal serial bus (USB) port, a vibration device, a television transceiver, a hands free headset, a Bluetooth® module, a frequency modulated (FM) radio unit, a digital music player, a media player, a video game player module, an Internet browser, and the like.

[0050] FIG. 1C is a system diagram of the RAN 103 and the core network 106 according to an embodiment. As noted above, the RAN 103 may employ a UTRA radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 115. The RAN 103 may also be in communication with the core network 106. As shown in FIG. 1C, the RAN 103 may include Node-Bs 140a, 140b, 140c, which may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 115. The Node-Bs 140a, 140b, 140c may each be associated with a particular cell (not shown) within the RAN 103. The RAN 103 may also include RNCs 142a, 142b. It will be appreciated that the RAN 103 may include any number of Node-Bs and RNCs while remaining consistent with an embodiment.

[0051] As shown in FIG. 1C, the Node-Bs 140a, 140b may be in communication with the RNC 142a. Additionally, the Node-B 140c may be in communication with the RNC142b. The Node-Bs 140a, 140b, 140c may communicate with the respective RNCs 142a, 142b via an Iub interface. The RNCs 142a, 142b may be in communication with one another via an Iur interface.

Each of the RNCs 142a, 142b may be configured to control the respective Node-Bs 140a, 140b, 140c to which it is connected. In addition, each of the RNCs 142a, 142b may be configured to carry out or support other functionality, for example outer loop power control, load control, admission control, packet scheduling, handover control, macro diversity, security functions, data encryption, and the like.

[0052] The core network 106 shown in FIG. 1C may include a media gateway (MGW) 144, a mobile switching center (MSC) 146, a serving GPRS support node (SGSN) 148, and/or a gateway GPRS support node (GGSN) 150. While each of the foregoing elements are depicted as part of the core network 106, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

[0053] The RNC 142a in the RAN 103 may be connected to the MSC 146 in the core network 106 via an IuCS interface. The MSC 146 may be connected to the MGW 144. The MSC 146 and the MGW 144 may provide the WTRUs 102a, 102b, 102c with access to circuit-switched networks, for example the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, 102c and traditional land-line communications devices.

[0054] The RNC 142a in the RAN 103 may also be connected to the SGSN 148 in the core network 106 via an IuPS interface. The SGSN 148 may be connected to the GGSN 150. The SGSN 148 and the GGSN 150 may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, for example the Internet 110, to facilitate communications between and the WTRUs 102a, 102b, 102c and IP-enabled devices.

[0055] As noted above, the core network 106 may also be connected to the networks 112, which may include other wired or wireless networks that are owned and/or operated by other service providers.

[0056] FIG. 1D is a system diagram of the RAN 104 and the core network 107 according to an embodiment. As noted above, the RAN 104 may employ an E-UTRA radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 116. The RAN 104 may also be in communication with the core network 107.

[0057] The RAN 104 may include eNode-Bs 160a, 160b, 160c, though it will be appreciated that the RAN 104 may include any number of eNode-Bs while remaining consistent with an embodiment. The eNode-Bs 160a, 160b, 160c may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 116. In one embodiment, the eNode-Bs 160a, 160b, 160c may implement MIMO technology. Thus, the eNode-B 160a, for example, may use multiple antennas to transmit wireless signals to, and receive wireless signals from, the WTRU 102a.

[0058] Each of the eNode-Bs 160a, 160b, 160c may be associated with a particular cell (not shown) and may be configured to handle radio resource management decisions, handover decisions, scheduling of users in the uplink and/or downlink, and the like. As shown in FIG. 1D, the eNode-Bs 160a, 160b, 160c may communicate with one another over an X2 interface.

[0059] The core network 107 shown in FIG. 1D may include a mobility management gateway (MME) 162, a serving gateway 164, and a packet data network (PDN) gateway 166. While each of the foregoing elements are depicted as part of the core network 107, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

[0060] The MME 162 may be connected to each of the eNode-Bs 160a, 160b, 160c in the RAN 104 via an S1 interface and may serve as a control node. For example, the MME 162 may be responsible for authenticating users of the WTRUs 102a, 102b, 102c, bearer activation/deactivation, selecting a particular serving gateway during an initial attach of the WTRUs 102a, 102b, 102c, and the like. The MME 162 may also provide a control plane function for switching between the RAN 104 and other RANs (not shown) that employ other radio technologies, for example GSM or WCDMA.

[0061] The serving gateway 164 may be connected to each of the eNode-Bs 160a, 160b, 160c in the RAN 104 via the S1 interface. The serving gateway 164 may generally route and forward user data packets to/from the WTRUs 102a, 102b, 102c. The serving gateway 164 may also perform other functions, for example anchoring user planes during inter-eNode B handovers, triggering paging when downlink data is available for the WTRUs 102a, 102b, 102c, managing and storing contexts of the WTRUs 102a, 102b, 102c, and the like.

[0062] The serving gateway 164 may also be connected to the PDN gateway 166, which may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, for example the Internet 110, to facilitate communications between the WTRUs 102a, 102b, 102c and IP-enabled devices.

[0063] The core network 107 may facilitate communications with other networks. For example, the core network 107 may provide the WTRUs 102a, 102b, 102c with access to circuit-switched networks, for example the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, 102c and traditional land-line communications devices. For example, the core network 107 may include, or may communicate with, an IP gateway (e.g. an IP multimedia subsystem (IMS) server) that serves as an interface between the core network 107 and the PSTN 108. In addition, the core network 107 may provide the WTRUs 102a, 102b, 102c with access to

the networks 112, which may include other wired or wireless networks that are owned and/or operated by other service providers.

[0064] FIG. 1E is a system diagram of the RAN 105 and the core network 109 according to an embodiment. The RAN 105 may be an access service network (ASN) that employs IEEE 802.16 radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 117. As will be further discussed below, the communication links between the different functional entities of the WTRUs 102a, 102b, 102c, the RAN 105, and the core network 109 may be defined as reference points.

[0065] As shown in FIG. 1E, the RAN 105 may include base stations 180a, 180b, 180c, and an ASN gateway 182, though it will be appreciated that the RAN 105 may include any number of base stations and ASN gateways while remaining consistent with an embodiment. The base stations 180a, 180b, 180c may each be associated with a particular cell (not shown) in the RAN 105 and may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 117. In one embodiment, the base stations 180a, 180b, 180c may implement MIMO technology. Thus, the base station 180a, for example, may use multiple antennas to transmit wireless signals to, and receive wireless signals from, the WTRU 102a. The base stations 180a, 180b, 180c may also provide mobility management functions, for example handoff triggering, tunnel establishment, radio resource management, traffic classification, quality of service (QoS) policy enforcement, and the like. The ASN gateway 182 may serve as a traffic aggregation point and may be responsible for paging, caching of subscriber profiles, routing to the core network 109, and the like.

[0066] The air interface 117 between the WTRUs 102a, 102b, 102c and the RAN 105 may be defined as an R1 reference point that implements the IEEE 802.16 specification. In addition, each of the WTRUs 102a, 102b, 102c may establish a logical interface (not shown) with the core network 109. The logical interface between the WTRUs 102a, 102b, 102c and the core network 109 may be defined as an R2 reference point, which may be used for authentication, authorization, IP host configuration management, and/or mobility management.

[0067] The communication link between each of the base stations 180a, 180b, 180c may be defined as an R8 reference point that includes protocols for facilitating WTRU handovers and the transfer of data between base stations. The communication link between the base stations 180a, 180b, 180c and the ASN gateway 182 may be defined as an R6 reference point. The R6 reference point may include protocols for facilitating mobility management based on mobility events associated with each of the WTRUs 102a, 102b, 102c.

[0068] As shown in FIG. 1E, the RAN 105 may be connected to the core network 109. The communication link between the RAN 105 and the core network 109 may defined as an R3 reference point that includes protocols for facilitating data transfer and mobility management capabilities, for example. The core network 109 may include a mobile IP home agent (MIP-HA) 184, an authentication, authorization, accounting (AAA) server 186, and a gateway 188. While each of the foregoing elements are depicted as part of the core network 109, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

[0069] The MIP-HA may be responsible for IP address management, and may enable the WTRUs 102a, 102b, 102c to roam between different ASNs and/or different core networks. The MIP-HA 184 may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, for example the Internet 110, to facilitate communications between the WTRUs 102a, 102b, 102c and IP-enabled devices. The AAA server 186 may be responsible for user authentication and for supporting user services. The gateway 188 may facilitate interworking with other networks. For example, the gateway 188 may provide the WTRUs 102a, 102b, 102c with access to circuit-switched networks, for example the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, 102c and traditional land-line communications devices. In addition, the gateway 188 may provide the WTRUs 102a, 102b, 102c with access to the networks 112, which may include other wired or wireless networks that are owned and/or operated by other service providers.

[0070] Although not shown in FIG. 1E, it will be appreciated that the RAN 105 may be connected to other ASNs and the core network 109 may be connected to other core networks. The communication link between the RAN 105 the other ASNs may be defined as an R4 reference point, which may include protocols for coordinating the mobility of the WTRUs 102a, 102b, 102c between the RAN 105 and the other ASNs. The communication link between the core network 109 and the other core networks may be defined as an R5 reference, which may include protocols for facilitating interworking between home core networks and visited core networks.

[0071] Systems, methods, and instrumentalities are disclosed for multiplexing transmissions with different durations, for example such as transmission that utilize different TTI lengths. Latency reduction for some transmissions may achieved, for example, by multiplexing transmissions with different TTI durations. Although examples may be described with respect to multiplexing of an LTE legacy TTI (e.g., 1 ms) with a shortened TTI length (e.g., less than 1 ms), the techniques described herein may be generally applicable to the multiplexing of other

types of transmissions that are of different/varying lengths. For example, the examples may be described with respect to transmissions that contain one transport block (TB), but the examples may be equally applicable to transmissions that include a portion of a TB, transmissions that contain multiple TBs, etc. Thus, as may be appreciated, although specific examples herein may be described with respect to multiplexing transmissions associated with a "legacy" 1 ms TTI with transmissions that are less than 1 ms, these examples are not limited to the specific embodiments described and may be applied to transmissions of varying length that include varying amounts of data. Additionally, although examples may be described with respect to multiplexing shorter than 1 ms transmissions into a legacy LTE system that utilizes a legacy TTI length of 1 ms, the techniques may be applied to other types of transmission configurations, for example such as the NR system that may be utilized for 5G cellular communications.

[0072] Transmissions of different length may be realized in multiple ways and be consistent with this disclosure. For example, multiple TTI lengths may be defined, and the system may be configured to multiplex transmissions associated with the different TTI lengths over a common set of transmission resources. In example, rather than or in addition to defining different TTI lengths, transmissions of different durations may be supported, for example where one or more of the transmissions durations may or may not correspond to a TTI. Transmission duration may be defined in a number of ways, for example an amount of time over which the transmission occurs, (e.g., a specific duration or a time partition), a number of symbols over which the transmission occurs (e.g., 14 OFDM symbols, 12 OFDM symbols, 1 OFDM symbol, etc.), a slot, a minislot, a time partition for a sub-carrier spacing, and/or in terms of a specific numerology associated with the transmissions. For example, the numerology may be defined based on one or more of a sub-carrier spacing (e.g., different sub-carrier spacing may lead to different time durations for a symbol), a symbol length, a waveform type, etc.

[0073] Examples may also be described with respect to one or more cells. However, the techniques described herein may be equally applicable to other types of resource partitions. For example, in LTE cells may be defined based on certain OFDM time-frequency resources that are defined for a certain operating band for the cell. However, the multiplexing techniques described herein may be applied to physical resources that may or may not be defined using the cell construct. For example, the techniques described herein may apply of a subset of the physical resources in a cell and/or to physical resources that are not defined using the cell construct.

[0074] In order to TTI duration may be modeled using one or more time-shifted cell(s) for a given carrier frequency, e.g. in an LTE system such as a legacy LTE system. A "logical" cell structure may correspond to an SCell (e.g., a legacy SCell). A PCell may logically maintain

a TTI (e.g., a first TTI such as a legacy TTI that may be 1 ms) or may be (e.g. also) configured with a second duration TTI (e.g., a shorter duration TTI (ShTTI) that may be less than 1 ms).

[0075] In an example, a WTRU may determine a TTI duration (e.g. first or second TTI) applicable to a transmission. A determination may be, for example, a function of one or more facts, factors, and/or parameters. For example, a WTRU may determine a TTI duration using cross-carrier scheduling information. A WTRU may associate a certain TTI duration with a certain cell identity (e.g. servCellID). A WTRU may associate a certain TTI duration with certain a transmission mode (TM). A TTI duration may be indicated by a CIF included in DCI. For example, a first cell identity (e.g., servCellID = 1) may be associated with a first TTI duration and a second cell identity (e.g., servCellID = 2) may be associated with a second TTI duration. When the CIF field indicates that the received DCI is applicable to the first cell identity (e.g., CIF = '001' - servCellID = 1), the WTRU may determine that the scheduled transmission is associated with the first TTI duration. When the CIF field indicates that the received DCI is applicable to the second cell identity (e.g., CIF = '010' - servCellID = 2), the WTRU may determine that the scheduled transmission is associated with the second TTI duration. In this matter, carrier aggregation signaling methods may be reused/reinterpreted in order to support multiple TTI length.

[0076] A TTI duration may be determined from an identity of a PRB subset associated with the transmissions and/or to a time-shifted cell within a subset of PRBs for a concerned carrier frequency. An applicable TTI duration and/or the identity of a slot/period applicable to a transmission within a subframe may be determined using MAC Activation/Deactivation. MAC Activation/Deactivation may be used to toggle between first and second TTIs (e.g. between a legacy TTI and one or more ShTTIs). For example, a WTRU may utilize a first TTI length for a first cell prior to receiving MAC Activation/Deactivation control element. Upon receiving the MAC Activation/Deactivation control element for the first cell, the WTRU may toggle to a second TTI length. In an example, the MAC Activation/Deactivation control element may be used to toggle between different slots used for a ShTTI transmission in a legacy suframe. For example, the MAC Activation/Deactivation control element may be used to switch between the first and second slots for the shortened TTI transmission. MAC Activation/Deactivation may be used to determine zero, one or more ShTTIs period(s) within a subframe.

[0077] HARQ processing may remain according to a first behavior (e.g. legacy behavior) for one or more (e.g. each) time-shifted cell(s), although there may be exceptions. In an example, an exception may be timing-relationships, which may be scaled according to an applicable TTI duration. HARQ A/N feedback formats may use LTE Carrier Aggregation (CA)

formats and/or (e.g., legacy) subframe-based timing relationships or a timing relationship associated with the HARQ process. Downlink Control Information (DCI) signaling may use a first (e.g., legacy) format, although, for example, interpretation of fields such as the CIF and/or PRBs applicable for the transmission may be different than the first (e.g., legacy) format. MAC activation/deactivation signaling may be applicable for time-shifted cells. DRX Timers associated with DRX may scale to HARQ A/N timing according to an applicable TTI duration and/or to the cell associated with an HARQ process. PRACH resources and/or PDCCH order for RACH may or may not be supported for time-shifted SCells. Timing advance for uplink transmission may be time shifted, for example, according to a shift applied to the TTI associated with a cell. Time shift may be relative to PCell timing, e.g., a PCell may remain a DL timing reference for an SCell with the additional offset corresponding to the start of the ShTTI for those cells.

[0078] A device may access resources of a communication system. Latency associated with transmission of data may have one or more latency components. A latency component may be the time to perform the transmission of a transport block, which time may be referred to as a Transmission Time Interval (TTI). A latency component may be processing time at a receiver, e.g., time decoding a transmission. Receiver processing time may be tied to implementation complexity and may be accounted for using a fixed timing relationship between different events associated with the transmission of a data unit. A timing relationship may be fixed, for example, when time-division duplex (TDD) is used for a carrier and/or synchronous Hybrid ARQ (HARQ) operation (e.g., such as for LTE in the uplink).

[0079] There may be additional latency components, for example, when a transmission is not successfully decoded. For example, additional components may include transmission of feedback (e.g. HARQ ACK or NACK), processing time at the receiver and/or one or more retransmissions with one or more latency components.

[0080] Latency components may be measured in integer multiples of a basic time interval (BTI). For example, latency components may be measured in TTIs, e.g., in LTE.

[0081] Latency in wireless networks may be caused by multiple factors. Latency may be affected, e.g., at lower layers, by a need for highly reliable transmissions, which may be obtained using HARQ. One or more retransmissions may affect the latency of a transmission, for example, given that retransmissions may not be performed in adjacent time periods.

[0082] A WTRU may incur processing time, for example, for downlink (DL) transmission, to determine whether a transmission was decoded properly, which may lead to a time interval between reception of a DL transmission and transmission of an ACK or NACK. An eNB may

incur processing time, for example, to determine whether an ACK or NACK was transmitted by the WTRU and/or whether a retransmission is required. A similar consumption of processing time may occur for uplink (UL) transmissions. Processing times may be cumulative. There may be a tradeoff between latency and implementation complexity.

[0083] A system (e.g. LTE) may accommodate processing times in a timing relationship between a first transmission for a transport block and its corresponding ACK-NACK HARQ response for downlink and/or uplink operation and possible retransmission.

[0084] Time Division Duplex (TDD) and Frequency Division Duplex (FDD) DL scheduling timing may be the same, such that a WTRU may receive a scheduling grant for a DL transmission in the same subframe or transmission time interval (TTI).

[0085] A WTRU may transmit a corresponding Physical UL Shared Channel (PUSCH), e.g., in subframe n+4, for example, upon detection of a Physical DL Control Channel PDCCH or enhanced PDCCH (EPDCCH) with UL Downlink Control Information (DCI) format and/or Physical Hybrid ARQ Indicator Channel (PHICH) transmission in subframe n, e.g., in an FDD UL transmission intended for the WTRU. A HARQ ACK/NACK response for a DL or UL transmission in subframe n may be provided in subframe n+4.

[0086] A WTRU may transmit a corresponding PUSCH in subframe n+k, for example, upon detection of a (E)PDCCH with UL DCI format and/or PHICH transmission in subframe n, e.g., for a UL transmission in a TDD system intended for the WTRU. The value of k may depend on the TDD UL/DL configuration, the subframe where the UL DCI and/or PHICH was transmitted and/or the PHICH resource and the MSB or LSB of the UL index in the (E)PDCCH, e.g., in TDD UL/DL configuration 0. A HARQ ACK/NACK response for a DL or UL transmission in subframe n may be provided in subframe n+k, where k may depend on the value of n and the TDD UL/DL configuration. Bundling may be used to provide HARQ for multiple transmissions in one instance.

[0087] Processing time available to a WTRU may depend, for example, on the value of the timing advance or on the distance between the WTRU and the eNB. In an example, an LTE system may have a distance of 100km between a WTRU and an eNB, which may correspond to a (e.g. a maximum) timing advance of 0.67ms. In an example, there may be approximately 2.3 ms left for terminal processing. An eNB may have, for example, 3 ms processing time available, which may be on the same order as that of the terminal.

[0088] FIG. 2 shows an example of DL physical layer channels. In a DL example with reference to the example shown in FIG. 2, there may be three channel areas in a subframe to support DL Shared Channel (DL-SCH) and UL-SCH. Three channel areas may comprise a PDCCH (which may include Physical Control Format Indicator Channel (PCFICH) and PHICH),

a Physical DL Shared Channel (PDSCH) and an EPDCCH. An EPDCCH may include scheduling information for a WTRU while taking advantage of the benefits of the PDSCH region, such as beamforming gain and frequency domain Inter-Cell Interference Coordination (ICIC) and/or improving PDCCH capacity.

[0089] FIG. 3 shows an example of UL physical layer channels. In a UL example with reference to the example shown in FIG. 3, there may be two channel areas in a subframe to support DL-SCH and UL-SCH. Two channel areas may comprise a PUSCH and a PDSCH. These channel areas may be transmitted in different RBs in each time slot (e.g. frequency hopping of PUSCH), for example, to increase robustness in frequency selective channels.

[0090] A transmission time interval (TTI) duration may be based on and/or defined by one or more symbols. A TTI duration may be defined in terms of a number of OFDM symbols. For example, a TTI duration may be defined as an entire (legacy) subframe and/or a pair of physical resource blocks (PRBs). In the legacy 1 ms TTI length, there may be 14 OFDM symbols for normal cyclic prefix and 12 OFDM symbols for extended cyclic prefix. For example when multiplexing ShTTI transmissions with legacy TTI transmissions of 1 ms, a ShTTI may be made as short as a single ODFM symbol. Symbol-based categorization may be referred to as symbol-based TTI durations.

[0091] A TTI duration may be based on time-varying symbol duration. TTI durations may have a fixed number of symbols (e.g., 14 symbols) while symbol duration may vary in time. For example, variable time symbol-based TTI duration may be achieved by modifying subcarrier spacing. In an example, a first TTI duration may be achieved with a first subcarrier spacing and a second TTI duration may be achieved with a second subcarrier spacing. Different bandwidth portions (e.g. PRBs) of a carrier may support different subcarrier spacing, thus enabling different TTI duration for different bandwidth portions (e.g. PRBs). Multiplexing transmissions associated with different sub-carrier spacing and/or symbol duration may be applicable to 5G systems such as NR. Such techniques may also be used in LTE-Advanced.

[0092] A TTI duration may be based on a time slot. A TTI duration may be defined in terms of a time slot (e.g. 7 OFDM symbols for normal cyclic prefix and 6 OFDM symbols for extended cyclic prefix). For example, if a ShTTI is defined as the length of one slot, two ShTTI transmissions may be time multiplexed into a legacy 1 ms TTI length.

[0093] A TTI duration may be based on time. A TTI duration may be defined in terms of a time value (e.g. 1ms legacy TTI or a 100ms ShTTI).

[0094] A TTI duration may be based on a hybrid, such as a combination of forgoing TTI duration bases. In an example of a hybrid method of achieving variable TTI durations, a different number of symbols and different symbol durations may be used.

[0095] Latency may be improved. It may be beneficial to decrease the TTI duration of different channels. A decrease in TTI duration may enable a decrease in WTRU processing time and may permit a WTRU to begin processing data sooner. Such a scenario may enable a shorter HARQ timeline. Different channels may have different TTI durations. A TTI duration shorter than one subframe for one or more of the EPDCCH, PDSCH, PUCCH, PDSCH, etc. may be provided. Effective HARQ feedback for PDSCH and PUSCH transmissions using shorter than (e.g., legacy 1ms) subframe TTI durations may be provided. Shorter TTIs may be referred to as ShTTI.

[0096] ShTTI and/or a combination of TTI and ShTTI may be supported for a given WTRU, for example, to minimize the impact of other aspects related to WTRU transmissions, such as scheduling (e.g., formats of DCIs), HARQ (e.g., related processing/process identities), feedback formats and determination of an applicable TTI duration. For example, the configuration of ShTTIs and/or the signaling of DCI for ShTTIs may utilize certain signaling originally defined for purposes of carrier aggregation in order to limit the amount of complexity at the WTRU and/or facilitated TTI length multiplexing in a backwards compatible manner. One or more latency components may be reduced, for example, to minimize the impact on WTRU implementations.

[0097] A WTRU may (e.g., based on a determination) operate with a one or more TTI durations, such as subframe TTI duration (e.g., 1 ms), a timeslot TTI duration (e.g., 0.5 ms), a symbol-based TTI duration (e.g., one or more OFDM symbols in duration), and/or other shorter than 1 ms TTI durations. In an example, a WTRU may be configured to operate with specific but different TTI duration configuration in downlink and uplink. In an example, a WTRU may be configured to permit the same TTI duration configuration to be used in downlink and uplink for applicable transmissions. For example, if the WTRU receives a configuration that indicates a first cell is associated with a first TTI duration in the downlink, the WTRU may determine that the uplink TTI duration is also the first TTI duration unless the configuration indicates otherwise.

[0098] A TTI duration may be WTRU specific. A WTRU may operate with a TTI duration during a given period. A WTRU may be configured to operate according to one or more of a plurality of possible TTI durations and may operate with the one or more TTI durations for a specific period of time, e.g., based on an L3 (e.g., radio resource control (RRC)) reconfiguration. A TTI duration may be fixed (e.g. statically, semi-statically or dynamically) for a (e.g. every) transmission to and from a WTRU.

[0099] Multiple TTI durations may be concurrently configured and/or used. A WTRU may be configured to operate for transmissions of different TTI durations concurrently. Different TTI durations may be based on, for example, semi-static allocation (e.g. configuration of a subset of frames/subframes dedicated to different TTI durations based on a semi-persistent grant or assignment) and/or dynamic allocation (e.g. based on detection and/or reception of downlink control signaling).

[0100] A TTI duration may be cell/cell group (CG)-specific. Configuration may be applicable per cell of a WTRU's configuration, for a subset of cells of a WTRU's configuration, and/or for all cells of the same timing advance group (TAG) and/or all cells of the same cell group (CG). For example, upon adding a new cell, the TTI duration may be defined for the new cell. As an example, if the WTRU adds an SCell, the SCell configuration may indicated that the WTRU is to utilize a shortened TTI duration for the SCell. The HARQ instances associated with a specific MAC entity may be configured with a similar configuration for TTI duration. A similar or same configuration for TTI duration may be used, for example, for cells associated with the same channel(s) (e.g. PUCCH, PUSCH) for uplink control signaling.

[0101] TTI duration may be modeled using one or more time-shifted cell(s) for a given carrier frequency. Modeling may enable co-existence between WTRUs operating according to different TTI durations, e.g. in legacy LTE systems. A "logical" cell structure may correspond to the use of one or more serving cell(s). Serving cells may include secondary cells, such as an SCell type or a PSCell type defined for LTE CA. A PCell may logically maintain a first (e.g., legacy) TTI such as 1 ms or may be (e.g., also) configured as a ShTTI.

[0102] Multiple serving cells may be associated with a specific TTI duration. A WTRU may support multiple TTI durations based on one or more functions and/or characteristic associated to a serving cell.

[0103] A WTRU may determine the duration of a downlink control region, e.g., according to a first (e.g., legacy) behavior for LTE. A reception of PDCCH may be a first (e.g., legacy) behavior for downlink subframes. In an example, the first ShTTI in a subframe may include a control region, e.g., in case of slot-based operation, such as two slots of 7 symbols where the first slot include 1-3 symbols for PDCCH. In an example, the ShTTI duration may exclude the control region, e.g., in case of symbol-based ShTTIs. In an example, an offset in time or in symbol from the start of a subframe may be used to indicate the start of an ShTTI (e.g., in the DCI).

[0104] In an example, a WTRU may operate on a given carrier frequency (e.g., for downlink and/or uplink) according to at least one of the following: TTI duration per Transmission

Mode (TM), TTI duration per Serving Cell Identity (servCellID), and/or TTI duration per Serving Cell.

[0105] In an example of TTI duration per Transmission Mode (TM), a WTRU may be configured with multiple transmission modes (TM), e.g., one for each applicable TTI duration.

[0106] In an example of TTI duration per Serving Cell Identity (servCellID), a WTRU may be configured with multiple serving cell identities (e.g., servCellIDs), e.g., one for each applicable TTI duration.

[0107] In an example of TTI duration per Serving Cell, a WTRU may be configured with multiple serving cells for a given carrier frequency, e.g. one for each applicable TTI duration.

[0108] Combinations may be made using different types of serving cells. For example, a WTRU may be configured according to any of the following examples or other examples.

[0109] In a first case or example, a WTRU may be configured with one PCell and one SCell (or PSCell). A WTRU may perform a transmission associated with a PCell using a first ShTTI and a transmission associated with the SCell/PSCell using a second ShTTI. A WTRU may transmit Uplink Control Information (UCI) for a transmission associated with a specific cell using the uplink resources associated with the concerned cell (e.g., according to a first (e.g. legacy) behavior or processing time associated with the ShTTI), for example, when an SCell is configured with PUCCH resources or when the WTRU is configured with PSCell. A WTRU may perform the transmission of UCI using resources of the PCell (e.g., according to a first (e.g., legacy) behavior), for example, otherwise. In either case or other cases, a WTRU may transmit UCI using the TTI applicable to the uplink configuration of the concerned cell or according to the ShTTI applicable the received transmission.

[0110] In a second case or example, a WTRU may be configured with one PCell and two SCells. A WTRU may perform a transmissions associated with a PCell using a first TTI (e.g., a legacy 1ms TTI) and a transmission associated with an SCell using a second TTI (e.g., an ShTTI). A WTRU may transmit UCI for a transmission associated with a specific cell using the uplink resources associated with the concerned cell (e.g., according to a first (e.g., legacy) behavior or processing time associated with the ShTTI), for example, when an SCell is configured with PUCCH resources. A WTRU may perform the transmission of UCI using resources of the PCell (e.g., according to a first (e.g., legacy) behavior), for example, otherwise. In either case or other cases, a WTRU may transmit UCI using the TTI applicable to the uplink configuration of the concerned cell or according to the ShTTI applicable to the received transmission.

[0111] In a third case or example, a WTRU may be configured with one PCell and multiple SCells. A configuration may be a generalization of either of the first and second examples,

whereby more than two TTI durations may be supported (e.g., within a first (e.g., legacy) subframe).

[0112] In an example involving a PSCell, a different Cell Radio Network Temporary Identifier (C-RNTI) than that applicable for a PCell may indicate the duration of the TTI. Examples presented and other examples may be used separately or in combination. Other realizations and/or combinations are possible.

[0113] Examples for handling of downlink control region for case 1 with slot-based operation are described.

[0114] A WTRU may be configured with a (e.g., DL) control region of zero symbols for a serving cell used for the purpose of ShTTI, e.g., for the serving cell that corresponds to a second slot in case of slot-based operation. A WTRU may determine that a serving cell is configured for the purpose of ShTTI, for example, based on reception of signaling that indicates such value for the duration of the control region. A WTRU may determine that a serving cell is configured as an ShTTI for the second slot, for example, based on reception of signaling that indicates such value for the duration of the control region. A WTRU may determine that a PCell configuration is used for ShTTI for the first slot.

[0115] Different procedures or algorithms may be used to determine applicable TTI duration, e.g., independent of modeling. For example, a WTRU may determine the TTI duration (e.g. legacy duration such as 1ms or shorter (e.g., ShTTI)) applicable to a transmission as a function of one or more of the following: (a) a WTRU may determine TTI duration using cross-carrier scheduling; (b) a WTRU may associate a TTI duration with a serving cell identity; (c) a TTI duration may be indicated by a Carrier Indicator Field (CIF); (d) a TTI duration may be indicated by C-RNTI applicable to control signaling associated with the allocation of resources; (e) a TTI duration may be determined from the identity of a PRB subset applicable to the transmissions and/or to the time-shifted cell within the entire subset of PRBs for the carrier frequency; (f) a MAC Activation/Deactivation may be used to determine the applicable TTI duration and/or the identity of the slot/period applicable to a transmission within a subframe. A MAC Activation/Deactivation may be used, for example, to toggle between multiple TTIs (e.g. a legacy TTI and one or more ShTTIs), toggle between slot-based ShTTIs and/or to determine zero, one or more ShTTIs period(s) within a subframe.

[0116] HARQ processing may be used (e.g., according to a first (e.g., legacy) behavior) for time-shifted cell(s), although, in an example, timing-relationships may be scaled according to an applicable TTI duration. HARQ A/N feedback formats may reuse LTE CA formats, first (e.g., legacy) subframe-based timing relationships and/or timing relationship associated with the HARQ

process. DCI signaling may reuse a first (e.g., legacy) format, although, in an example, interpretation of fields such as the CIF and/or PRBs applicable for the transmission may be different. MAC activation/deactivation signaling may be applicable for time-shifted cells. DRX Timers associated with DRX may scale to HARQ A/N timing according to an applicable TTI duration and/or to the cell associated with the HARQ process. Physical Random Access Channel (PRACH) resources and/or PDCCH order for RACH may or may not be supported for time-shifted SCells. Timing advance for uplink transmission may be time shifted according to the shift applied to the TTI associated with a cell, for example, when such time shift is relative to the PCell timing (e.g., the PCell remains the DL timing reference for such SCell with the additional offset corresponding to the start of the ShTTI for those cells).

[0117] Any procedure or algorithm that may operate with or indicate a TTI duration may be applicable as a procedure or algorithm to operate with or to indicate a subcarrier spacing.

[0118] Support may be provided for transmissions with different TTI duration. A WTRU may be configured for operation with the LTE physical layer. A WTRU may be configured, for example, for operation according to a first (e.g., legacy) LTE behavior or for operation together with a 5gFLEX configuration, e.g., a configuration that supports a physical layer operating with other variants of potentially filtered OFDM transmissions, such as Universal Filtered OFDM (UF-OFDM), Filtered Based OFDM (FB-OFDM), etc.

[0119] In an example of LTE FDD, a radio frame may consist of 10 subframes of 1ms each with a TTI of 1ms. Each TTI may consist of two 0.5ms slots of 7 symbols for a configuration with a normal cyclic prefix. In the downlink, there may be 8 asynchronous HARQ processes numbered 0-7 that may be addressed by means of downlink DCI. In the uplink, there may be 8 synchronous HARQ processes per RTT, which identity may be tied to the subframe timing. A WTRU may be configured for 1 to 3 symbols at the beginning of the first slot used for control signaling (PDCCH). Control signaling may span the entire bandwidth for a given cell. A TTI duration may be fixed, e.g., at 1ms, as an aspect of the LTE physical layer.

[0120] Different cells of a WTRU's configuration may be (e.g. explicitly) associated with a TTI duration/offset shift. Support for different TTI durations may be realized, for example, by maintaining a unique association between a cell and a TTI duration in a WTRU's configuration. Timing associated with the cell (e.g. a cell of the LTE CA SCell type) may be shifted and/or offset in time with respect to the timing of a reference cell. A reference cell may be the PCell of the WTRU's configuration. The PCell may be considered to have a zero time shift, e.g., by default. In an example of dual connectivity, a PSCell may be considered to have a zero time shift (e.g., by

default), for example, when a secondary group of cells is configured and when the PSCell is used as the timing reference.

[0121] In an example, a time-shifted/TTI duration/offset shift may be associated with an identity. For example, a time-shifted cell may be configured with a serving cell identity, with an offset in time relative to the start of a cell-specific subframe (e.g. where timing may be based on the PCell used as a downlink timing reference) and with a TTI duration (e.g. shorter than a first (e.g. legacy) timing that may be referred to as a shorter TTI or ShTTI).

[0122] TTI duration may be a configuration aspect of a WTRU, such as part of a configured transmission mode associated with the physical layer configuration for the cell.

[0123] Cells using a timing relationship may be configured as part of the same timing advance group (TAG). Cells (e.g., SCells) in a secondary TAG (STAG) supporting ShTTIs may use one of the cells in the same TAG as a timing reference (e.g., a cell used may be a configuration aspect of a WTRU) or may use the PCell as the timing reference (e.g., otherwise).

[0124] Support may be provided for multiplexing transmissions in a cell and/or for a specific WTRU. Support for transmissions using different TTI duration may be for concurrent transmissions in the same cell. For example, transmission may correspond to a single TTI duration for each WTRU at any given time while some WTRUs may have different TTI duration than other WTRUs. Support may be for transmissions for a given WTRU within the same subframe (e.g., within a first (e.g., legacy) subframe such as 1 ms) where different transmissions may be performed according to different TTI durations by the concerned WTRU.

[0125] Procedures may be applicable for uplink and/or downlink transmission and may be a configuration aspect for a WTRU.

[0126] An ShTTI-based transmission mode (TM) and cell timing configuration may be provided. For example, a WTRU may be configured with a PCell (e.g., according to first (e.g., legacy) behavior). For example, a WTRU may operate on a PCell carrier frequency using a first TM (e.g., a TM in the range of 1-10) associated with a first TTI duration (e.g., legacy 1ms). The WTRU may receive a RRC Connection Reconfiguration message that may reconfigure the WTRU according to at least one of the following: the WTRU may reconfigure the PCell and/or may configure at least one SCell.

[0127] In an example of reconfiguring a PCell, the WTRU may reconfigure the PCell such that a second TTI (e.g., ShTTI) of a duration shorter than previously used by the WTRU for the PCell is supported. For example, the WTRU may reconfigure (or add) a TM associated to the PCell. For example, a TM (e.g., TM = 11) may be associated with a TTI duration different than previously used by the WTRU for the PCell.

[0128] For example, a WTRU may configure a TTI duration according to one of the following. In an example, an ShTTI duration may be equal to 1 slot (0.5ms). This may be applicable, for example, to the first case. In another example, an ShTTI may be a duration expressed as an integer multiple of 1 symbol. A duration may include the control region, for example, when the configuration includes a start offset for the ShTTI and such offset is equal to zero. In another example, an ShTTI may be a duration expressed as an integer value in time, e.g. 100 μs or 125μs. Whether an ShTTI duration may include the control region may be determined as a function the value of a start offset for the ShTTI when applicable. A control region may be a separate aspect of a WTRU's configuration for a cell when an offset is equal to a non-zero value.

[0129] For example, a TM may support transmissions in (e.g., only in) the first slot of a first (e.g., legacy) subframe for the concerned ShTTI duration. A WTRU may determine an aspect as a function of the type of cell (e.g., PCell) associated with the TM. A TM may support WTRU-specific demodulation reference signals (e.g., DM-RS) such that their location and density may be better suited for ShTTI operation.

[0130] In an example of reconfiguring a PCell, transmissions on the PCell using a first (e.g., legacy) TTI such as 1ms may be enabled. This may be applicable, for example, in the second case, e.g., when a WTRU may be configured such that PCell operation supports transmissions using a first (e.g. legacy) 1ms TTI and one or more SCells support operation using ShTTI.

[0131] A WTRU may configure a PCell with an additional cell identity to the PCell in the PCell's configuration such that DCI may indicate, for example, "CIF=0" for a transmission on PCell using a first TTI (e.g., 1ms) and "CIF=1" for a transmission on PCell using a second TTI (e.g. a slot-based ShTTI of 0.5ms or similar). This may be applicable, for example, in the first case.

[0132] In an example of reconfiguring at least one SCell, the WTRU may configure an SCell such that an associated TTI duration (e.g., ShTTI) is less than that of a first (e.g., legacy) subframe duration (e.g., less than 1ms). For example, the WTRU may configure a TM associated with the SCell. For example, a TM (e.g., TM = 11) may be associated with a TTI duration similar to that of the PCell (e.g., ShTTI). For example, a ShTTI duration may be equal to 1 slot (0.5ms). This may be applicable, for example, in the first case. A TM (e.g., TM = 11+x) may be (e.g. alternatively) associated with a TTI duration different than that of the PCell, for example, when the TTI duration of such SCell may differ from that of the PCell.

[0133] Combinations of slot-based TTI (e.g., 0.5ms for a PCell) and non slot-based TTIs (e.g., 5 SCells of 100ms each) may be applicable for a given WTRU. Another example may be of a WTRU configured with symbol-based TTIs such that a different number of symbols may be used for each of the control regions (e.g,. 3 symbols), the TTI duration for the PCell (e.g., 5 symbols)

and for a number of SCells of x symbols in duration (e.g., 3 SCells each 2 symbols in TTI duration). Other combinations and/or other values are possible.

[0134] Example procedures may be applicable to any of the cases described above. Procedures may be applicable for uplink and/or downlink transmission and may be a configuration aspect for a WTRU.

[0135] TTI duration may be determined as a function of a Carrier Indicator Field (CIF) in a DCI on PDCCH. A TTI duration may be signaled as a function of the indicated cell identity in the DCI (e.g., by CIF or similar for a given carrier frequency of the WTRU's configuration). A determination or indication may be achieved, for example, by associating a second identity with a cell of the WTRU's configuration or by duplication of a serving cell configuration for a given carrier frequency. The WTRU may determine that the DCI of a given transmission (e.g., PDDCH transmission, serving cell transmission, received downlink control information, or scheduling information) has indicated that the WTRU should use a first transmission time interval on a physical uplink channel to communicate with the serving cell. For example, the determination may be based on the CIF field of the DCI, as the CIF may refer to a serving cell identity that has been configured to utilize the first transmission time interval. In this manner, downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment) may be re-used for scheduling of transmissions associated with the first TTI length. Similarly, the WTRU may determine that the DCI of a given transmission (e.g., PDDCH transmission, serving cell transmission, received downlink control information, or scheduling information) has indicated that the WTRU should use a second transmission time interval on a physical uplink channel to communicate with a second serving cell. For example, the determination may be based on the CIF field of the DCI, as the CIF may refer to the second serving cell identity and the second serving cell may have been configured to utilize the second transmission time interval. One or more of the first or second transmission time intervals may correspond a shortened TTI that is less than the legacy transmission time interval. The first and second serving cells may configured to utilize the same frequency band and/or carrier frequency.

[0136] In an example using slot-based TTI duration, a WTRU may be configured with a PCell with CIF=0, an SCell with CIF=1 and an SCell with CIF=2 for a given carrier frequency. Both SCells may be configured with carrier aggregation cross-carrier scheduling such that scheduling information for the associated resources may be received on the PDCCH associated with the PCell. A WTRU may receive signaling that schedules a transmission on such PDCCH. A WTRU may determine that a TTI duration is according to first (e.g., legacy) operation (e.g., 1ms), for example, when the WTRU determines that the CIF applicable to the transmission is that

of the PCell. The WTRU may determine that the transmission is applicable to the first slot of the concerned subframe, for example, when the WTRU determines that the CIF=1. The WTRU may determine that the transmission is for the second slot of the concerned subframe, for example, when CIF=2.

[0137] Example procedures may be applicable to any of the cases described above. Procedures may be applicable for uplink and/or downlink transmission and may be a configuration aspect for a WTRU.

[0138] A start offset for ShTTI may be a function of CIF in the DCI on PDCCH. In an example, determination of the applicable location in time (e.g., slot in the subframe, applicable starting symbol and/or all applicable symbols or similar) may be enabled for a transmission, for example, when a TTI duration shorter than that of the subframe duration is configured for a given cell.

[0139] A start offset or applicable location in time may be based on signaling received by the WTRU. The WTRU may perform such determination as a function of the indicated cell identity in the DCI, e.g., by Carrier Indicator Field (CIF) or similar for a given carrier frequency of the WTRU's configuration. An indication or determination may be achieved, for example, by associating a specific offset in the subframe with an identity of a cell of the WTRU's configuration or by configuring multiple serving cells for a given carrier frequency each with a different identity and a different offset.

[0140] For example, an offset may indicate one of a first slot or a second slot of a cell-specific subframe or it may indicate an offset in terms of a starting symbol in a subframe or an offset in absolute time (e.g. 500ms). An offset may be applied from the start of a cell-specific subframe. An offset may implicitly indicate a TTI duration (or vice-versa).

[0141] Example procedures may be applicable to any of the cases described above. Procedures may be applicable for uplink and/or downlink transmission and may be a configuration aspect for a WTRU.

[0142] A TTI duration may be a function of PRB(s) for a transmission. In an example, a WTRU may be configured such that a number of PRBs (e.g. a subset of the total set of system-specific PRBs for the concerned carrier frequency) may be associated with a cell of the WTRU's configuration for which the WTRU is operating with shorter than 1ms TTI duration e.g. configured with ShTTI.

[0143] A WTRU may determine an applicable TTI duration as a function of the PRB(s) indicated by the scheduling information. A PRB may correspond to the starting PRB for the resource allocation for the transmission. A set of PRBs may correspond to a range of PRBs. A

WTRU may use the TTI duration associated with a set of PRB(s), for example, when such range includes (e.g., only includes) PRB(s) associated with the concerned set. A WTRU may (e.g., otherwise) use a different TTI duration (e.g., a first (e.g. legacy) TTI duration, such as 1ms, or a configured duration), for example, when such range includes PRBs associated with different sets of PRBs or when such range does not include PRBs associated with any such sets. Sets of PRBs may be a configuration aspect of a WTRU's configuration. For example, a serving cell may be associated with a set of one or more PRBs, for example, when a serving cell is configured for ShTTI operation for a carrier frequency. A WTRU may use the TTI duration associated with such a cell or associated with the concerned PRBs. Scheduling information may be received dynamically in a DCI on PDCCH. Scheduling information may be semi-statically configured. For example, an entire (e.g., system-specific) set of PRBs for a PCell configured with a first (e.g., legacy) operation may be 110 PRBs. A WTRU may (e.g., alternatively) be configured with one or more subsets of PRBs, where each set may be associated with a specific TTI duration.

[0144] A WTRU may (e.g., first) determine the cell configured with ShTTI applicable to the transmission and/or the duration of the TTI (e.g., determining as described herein) and may determine the set of applicable PRBs therefrom (e.g., determining using a configuration of sets of PRBs as discussed herein).

[0145] Example procedures (e.g., operation) may be applicable to any of the cases described above. Procedures may be applicable for uplink and/or downlink transmission and may be a configuration aspect for a WTRU. For example, a procedure may be associated with a transmission mode for downlink and/or uplink. For example, a procedure may be associated with a serving cell of the WTRU's configuration. For example, a WTRU may determine that a configuration is specific to a serving cell of a WTRU's configuration, e.g., a determination may be made that a TTI configuration applies to both DL and UL frequencies. For example, a WTRU may determine that a configuration is specific to a specific direction of a configuration for a given serving cell of the WTRU's configuration, e.g., a determination may be made that a TTI configuration is provided separately for the DL direction and for the UL direction.

[0146] A determination may be made about the start offset time for a transmission. Cell de-activation may control availability of ShTTI. In an example, a first (e.g., legacy) cell activation-deactivation mechanism (e.g., procedure or algorithm) may control the duration (e.g., first or second TTI such as a legacy TTI or an ShTTI duration) of a transmission, e.g., by activating and deactivating the transmission. A WTRU may associate an activation state with an ShTTI, a slot and/or a resource.

[0147] In an example, a WTRU configured using ShTTI cells may receive a first (e.g., legacy) MAC activation/deactivation control element. A WTRU may use the activation/deactivation element as a mechanism to determine the availability of the ShTTI. For example, a WTRU may use a first (e.g., 1ms) TTI duration, e.g., when the WTRU is configured with a single SCell with ShTTI and when the SCell is in a deactivated state when the WTRU determines that it needs to perform a transmission. A WTRU may (e.g., otherwise) use a second TTI duration (e.g., ShTTI) for a transmission, e.g., when the SCell is active. The WTRU may perform a transmission using the second TTI duration (e.g. ShTTI), for example, according to scheduling information independently of the scheduled slot. This example may be extended to apply to the case where a symbol-based TTI duration is used instead of a time duration such as transmission slots.

[0148] In an example where multiple SCells may be used to indicate slot-based transmissions, a WTRU may determine that a first TTI duration is applicable when all cells configured with ShTTI are in a deactivated state. A WTRU may determine (e.g., otherwise) the applicable slot based on the activation state associated with each SCell and associated with each slot. This example may be extended to apply to the case where a symbol-based TTI duration is used, e.g., instead of using time duration such as transmission slots.

[0149] A WTRU may transmit HARQ feedback and/or other Uplink Control Information (UCI) (e.g. CQI, PMI, RI or similar), for example, taking into consideration the configuration of the TTI duration.

[0150] A TTI duration applicable to the transmission of UCI may be a function of at least one of the following: scheduling information, configuration information, TTI applicable to a serving cell, a default configuration for UCI transmission, etc.

[0151] Scheduling information may indicate whether a WTRU has resources for a PUSCH transmission and (e.g., if so) the TTI duration associated with such transmission, which may be determined according to procedures described herein.

[0152] Configuration information may indicate whether a WTRU is configured for simultaneous PUSCH and PUCCH transmission.

[0153] A TTI may be applicable to a serving cell associated with a UCI transmission in the subframe for the concerned UCI transmission.

[0154] A TTI may be applicable (e.g., in duration and/or offset) to a serving cell associated with a UCI transmission in the subframe for a downlink transmission pertaining to the feedback (e.g., in case of HARQ A/N feedback).

[0155] A default configuration for the transmission of UCI may be, for example, for the transmission of UCI on PUCCH (e.g., always a first TTI such as 1 ms TTI on PCell).

[0156] Further examples are provided below.

[0157] An applicable resource may be a PUSCH or PUCCH resource. A WTRU may determine a physical channel to perform the transmission of UCI using any technique, procedure or algorithm. For example, a WTRU may determine that UCI may be included in a PUSCH transmission when the transmission is scheduled, when simultaneous PUSCH and PUCCH transmissions are not configured or on a PUCCH transmission (e.g., otherwise).

[0158] An applicable resource may be a PUSCH resource. A WTRU may perform the transmission of UCI on a PUSCH transmission according to a TTI duration associated with a PUSCH transmission, which may be determined using procedures described herein.

[0159] An applicable resource may be a PUCCH resource. A WTRU may determine that a PUCCH resource may be used for transmission of UCI according to any technique, procedure or algorithm applicable to LTE CA. For example, selection of a resource may be based on the first CCE of the DCI that scheduled a downlink transmission or based on a configuration (e.g. PUCCH format 3 or similar). Bundling and/or multiplexing may be applied, for example, when configured.

[0160] An applicable TTI may be function of the type of transmissions on the carrier frequency PUSCH or PUCCH. Transmission of UCI may use the principles of LTE CA whereby UCI corresponding to transmission on different cells, e.g., including time-shifted cells, maybe multiplexed on a single transmission using a format that supports the required number of information bits (e.g., PUCCH format 3).

[0161] A PUCCH transmission may be performed on a PCell with a first (e.g., 1 ms TTI), where the first TTI may be a fixed TTI. A WTRU may perform PUCCH transmission on resources of an applicable serving cell (e.g., a PCell) according to a TTI duration associated with a concerned (e.g., pertinent) PCell, which may be determined using procedures described herein. In an example, a WTRU may transmit HARQ feedback using a single PUCCH transmission, which may use resources associated with a PCell (e.g. using a 1ms TTI duration), for example, when a WTRU has HARQ A/N feedback to transmit for two slot-based time-shifted cells using PUCCH on the PCell according to a configuration for a given carrier frequency where the PCell uses a first (e.g., 1ms) TTI.

[0162] A PUCCH transmission may be performed on a PCell with alignment in time with TTI being reported. A WTRU may perform PUCCH transmission on resources of an applicable serving cell (e.g. a PCell) according to a TTI duration associated with transmission(s) for which feedback is transmitted. A WTRU may have, for example, HARQ A/N feedback to transmit for

two slot-based time-shifted cells using PUCCH on the PCell according to a configuration for a given carrier frequency. In an example, a WTRU may transmit in the first slot a HARQ feedback for a transmission associated with the first slot and may transmit the HARQ feedback for the other transmission in the second slot for the concerned subframe.

[0163] A PUCCH transmission may be performed on a PCell with TTI/ShTTI of the PCell. A WTRU may perform a PUCCH transmission on resources of an applicable serving cell (e.g. a PCell) according to a TTI duration associated with the PCell, which may be determined using procedures described herein. A PCell may be (e.g., otherwise) configured with a default TTI, such as a first (e.g., 1 ms) TTI or an ShTTI. A WTRU may have HARQ A/N feedback to transmit for two slot-based time-shifted cells using PUCCH on the PCell, e.g., according to a configuration for a given carrier frequency where the PCell uses ShTTI in the concerned subframe (e.g., based on a configuration aspect and/or an activation state such as ShTTI activated for a time-shifted SCell for the concerned subframe), In an example, a WTRU may transmit HARQ feedback using a single PUCCH transmission, which may use resources associated with the PCell using a ShTTI duration with an offset applicable to the PCell.

[0164] A WTRU may transmit HARQ A/N feedback, for example, based on an applicable WTRU processing time for a concerned (e.g., pertinent) HARQ process in a given subframe.

[0165] Processing time associated with a HARQ process may be specific to a TTI associated with a transmissions for a concerned process. Processing time may be specific to a serving cell, a transmission mode or may be indicated by DCI (e.g., from servCellID or CIF) associated with such transmissions for a concerned HARQ process. In an example, HARQ processing time may be the same for all HARQ processes associated with a serving cell configured with a specific TTI (e.g., an ShTTI). Processing time may be a fixed value (e.g., 1ms), a multiple of an ShTTI, etc. Processing time may be determined for a transmission using ShTTI in subframe, the first available occasion in subframe n+2, where an occasion may correspond to a PUCCH or a PUSCH transmission with duration according to a first TTI or second TTI (e.g., ShTTI).

[0166] Systems, methods, and instrumentalities have been disclosed for multiplexing transmissions with different TTI duration. Latency may be reduced (e.g., in an LTE system), for example, by multiplexing transmissions with different TTI durations. TTI duration may be modeled using one or more time-shifted cell(s) for a given carrier frequency. A "logical" cell structure may correspond to an SCell. A PCell may logically maintain a TTI (e.g,. a first TTI) or may be configured with a second duration TTI (e.g., a shorter duration TTI (ShTTI)).

[0167] In an example, a WTRU may determine a TTI duration (e.g., first or second TTI) applicable to a transmission. For example, a WTRU may determine a TTI duration using cross-

carrier scheduling. A WTRU may associate a TTI duration with a cell identity (e.g. servCellID). A WTRU may associate a TTI duration with a transmission mode (TM). A TTI duration may be indicated by Carrier Indicator Field (CIF). A TTI duration may be determined from an identity of a PRB subset applicable to transmissions and/or to a time-shifted cell within a subset of PRBs for a concerned carrier frequency. An applicable TTI duration and/or the identity of a slot/period applicable to a transmission within a subframe may be determined using MAC Activation/Deactivation. MAC Activation/Deactivation may be used to toggle between first and second TTIs (e.g. legacy TTI and ShTTIs) or between slot-based ShTTIs and/or may be used to determine zero, one or more TTI (e.g. ShTTI) period(s) within a subframe.

[0168] HARQ processing may be performed according to a first behavior (e.g. legacy behavior) for one or more (e.g. each) time-shifted cell(s), although there may be exceptions. An exception may be timing-relationships, which may be scaled according to an applicable TTI duration. HARQ A/N feedback formats may use LTE Carrier Aggregation (CA) formats and/or (e.g., legacy) subframe-based timing relationships or a timing relationship associated with the HARQ process. Downlink Control Information (DCI) signaling may use a first (e.g., legacy) format, although, for example, interpretation of fields such as the CIF and/or PRBs applicable for the transmission may be different than the first (e.g., legacy) format. MAC activation/deactivation signaling may be applicable for time-shifted cells. DRX Timers associated with DRX may scale to HARQ A/N timing according to an applicable TTI duration and/or to the cell associated with an HARQ process. PRACH resources and/or PDCCH order for RACH may or may not be supported for time-shifted SCells. Timing advance for uplink transmission may be time shifted, for example, according to a shift applied to the TTI associated with a cell. Time shift may be relative to PCell timing, e.g. a PCell may remain a DL timing reference for an SCell with the additional offset corresponding to the start of the ShTTI for those cells.

[0169] A different TTI may be used in LTE R14 and NR. Multiple serving cells may be configured on the same carrier for a single WTRU. There may be an association between a serving cell and a TTI duration (or more generally – a numerology-related aspect). A WTRU can be configured with multiple such cells on a given carrier to support (*e.g.*, dynamically) a change in transmission duration. A field in downlink control signaling (DCI), *e.g.*, on a downlink control channel (*e.g.*, PDCCH), such as the CIF field in a DCI, may be used to dynamically schedule specific TTI durations for same or later subframes, for UL or DL transmissions.

[0170] The WTRU may be configured with a plurality of transmission methods, where at least two of the configured transmission methods differ in at least the applicable TTI duration.

[0171] A transmission may be associated with a transmission timing (start offset) relative to a timing reference.

[0172] A WTRU transmission mode may be indicated in downlink control information (DCI) signaling.

[0173] WTRU transmissions may be configured for each of a plurality of PRBs in the WTRU's configuration. Each of a plurality of PRBs may correspond to a serving cell of the WTRU's configuration. Each of a plurality of PRBs may correspond to a given carrier.

[0174] An applicable transmission duration/timing may be determined from a serving cell ID indicated in DCI signaling.

[0175] The WTRU may determine the set of resources, transmission duration, and/or uplink control information for a transmission based on a previous combination of received downlink signaling and received transmission duration.

[0176] A WTRU may determine whether a control region (*e.g.*, single control region) (*e.g.*, single level PDCCH) or multiple control regions (*e.g.*, multi-level PDCCH) are applicable and whether they are a function of the PDCCH configuration applicable to the concerned cell(s). A WTRU can determine the location of CCEs with respect to the timing reference (*e.g.*, in support of either self-scheduling or cross-TTI scheduling).

[0177] A WTRU may support mini-slots (*e.g.*, 125usec), slots (*e.g.*, 0.5ms), subframe (*e.g.*, 1ms) and multi-slots (*e.g.*, Multiples of other durations), and transmission durations and use different (*e.g.*, shortened) TTI's based on these time allocations. This may provide a low latency mode, a throughput mode and/or a coverage mode.

[0178] FIG. 4 depicts a scheduling example with time shifted-cells. As shown, there is a frequency axis and a time axis. In Fig. 4, the time is measured in milliseconds and divided into subframes. Other time units can be used such as slots, minislots, symbols, and PRB lengths. The frequency axis shows downlink (DL) and uplink (UL) transmissions. The time axis shows subframes. N, n+1, N=3, etc.... As shown for the DL frequency, for one or more subframes, the WTRU may receive DCI. For subframe n, the DCI may indicate two allocations, for example two ShTTI allocations (*e.g.*, $ShTTI_{DL(n,0)}$ and $ShTTI_{DL(n,1)}$). As an example, setting the CIF equal to 1 may indicate that the allocation is for $ShTTI_{DL(n,0)}$ and setting the CIF equal to 2 may indicate the allocation is for $ShTTI_{DL(n,1)}$. Other values of the CIF may be used to indicate no ShTTI transmissions and/or different transmission durations. For example, the DCI in Subframe

n+1 may indicate that for DL subframe n+1, the transmission has a duration corresponding to the entire subframe by using the value CIF=0 (*see e.g.*, a $TTI_{DL(N+1)}$).

[0179] A similar signaling mechanism can be used for indicating different durations of uplink transmissions. For example, DCI in DL subframe n may indicate that the WTRU has recieved two uplink grants. For example, a first grant for subframe n+1 may be indicate a CIF=1, which may be configured to correspond to $ShTTI_{(n+an\ offset,0)}$, while a CIF equal to 2 may indicate a grant for $ShTTI_{(n+an\ offset,0)}$. Similarly, a different value of the CIF (*e.g.*, CIF = 0) in this example may indicate that the transmissions duration spans an entire legacy TTI as illustrated in FIG. 4. Thus, by associating different CIF values with different transmission durations, the DCI may be used to indicate different transmission durations by referencing the different CIF values. Although the CIF field is used for purposes of illustration, other DCI fields may be used and may have values mapped to/associated with transmissions of different duration.

[0180] FIG. 4 also shows for an example of the PUCCH on the uplink frequency. For the PCell or SCell there may be a HARQ A/N for CIF = 1 at (n, 0) and a HARQ A/N for CIF = 2 at n, 1. For the PCell, (*e.g.*, PCell only), there may be a HARQ A/N for CIF = 0 at (n, 0) or CIF = 0 at n-3. Also, for the PCell, (*e.g.*, PCell only), there may be a HARQ A/N for CIF = 1 at (n, 0) or CIF = 0 at n-3 for the $ShTTI_{(n+?,\ 0)}$ and HARQ A/N for CIF = 2 at (n, 1) or CIF = 0 at n-3 for the $ShTTI_{(n+?,\ 1)}$.

[0181] FIG. 4 shows an example with time shifted cells with an offset of symbols. In this example, the symbol offset is based on CIF. FIG. 4 shows a single HARQ addressing space per TTI duration and start offset in a given subframe. MAC activation/deactivation may be applied by a HARQ process space or CIF value. FIG. 4 also shows a UCI example with time-shifted cells. The first CCE of the DCI on the example channel, PDCCH, may be used for legacy PUCCH resource allocation at TTI or ShTTI. Configured LTE CA PUCCH, PUCCH on an SCell, and/or ARI may be used for UCI using different TTIs. As shown, the WTRU interprets the DCI TTI indication differently in the FIG. 4 example for SCells and PCells to use ShTTI for the SCells. FIG. 4 also shows an example of the frequency being the same for the PCell and SCell. The FIG. 4 example dynamically varies the scheduled TTI for a WTRU and uses the appropriate HARQ signaling. Also, resource allocation for associated control information is resolved and there is flexibility to adapt different time offsets in a subframe and with different ShTTIs.

[0182] Although features and elements are described above in particular combinations, one of ordinary skill in the art will appreciate that each feature or element may be used alone or in any combination with the other features and elements. In addition, the methods described herein

may be implemented in a computer program, software, or firmware incorporated in a computer-readable medium for execution by a computer or processor. Examples of computer-readable media include electronic signals (transmitted over wired or wireless connections) and computer-readable storage media. Examples of computer-readable storage media include, but are not limited to, a read only memory (ROM), a random access memory (RAM), a register, cache memory, semiconductor memory devices, magnetic media such as internal hard disks and removable disks, magneto-optical media, optical media such as CD-ROM disks, and digital versatile disks (DVDs). A processor in association with software may be used to implement a radio frequency transceiver for use in a WTRU, WTRU, terminal, base station, RNC, or any host computer.

CLAIMS

What Is Claimed:

1. A method implemented by a wireless transmit/receive unit (WTRU) for supporting transmissions of different durations, the method comprising:

receiving a first configuration associated with a first set of transmission resources, the first configuration indicating a first transmission time interval (TTI) length for use with the first set of transmission resources;

receiving a second configuration associated with a second set of transmission resources, the second configuration indicating a second transmission time interval (TTI) length for use with the second set of transmission resources;

receiving downlink control information (DCI), wherein the DCI comprises a field that indicates whether the DCI is applicable to first set of transmission resources or the second set of transmission resources; and

determining that a transmission associated with the DCI utilizes the first TTI length on condition that the field indicates that the DCI is applicable to the first set of transmission resources or that the transmission associated with the DCI utilizes the second TTI length on condition that the field indicates that the DCI is applicable to the second set of transmission resources.

2. The method of claim 1, wherein the first set of transmission resources correspond to a first serving cell and the second set of transmission resources correspond to a second serving cell.

3. The method of claim 2, wherein the field corresponds to a carrier indicator field.

4. The method of claim 2, wherein the first serving cell and the second serving cell are associated with the same carrier frequency.

5. The method of claim 2, wherein each of the first and second serving cells are configured as secondary cells (SCells).

6. The method of claim 2, wherein the first serving cell corresponds to a primary cell (PCell), the second serving cells is configured as a secondary cells (SCell), the first TTI length corresponds to 1 millisecond (ms), and the second TTI length corresponds to less than 1 ms.

7. The method of claim 1, wherein the DCI further comprises a physical resource block (PRB) assignment field, and the PRB assignment field is interpreted differently depending on whether the transmission is associated with the first TTI length or the second TTI length.

8. The method as in claim 1, wherein at least the second configuration is received via a radio resource control (RRC) message, and the DCI is received via a physical downlink control channel.

9. The method as in claim 1, wherein a hybrid automatic repeat request timing used for the transmission is dependent on whether the transmission is associated with the first TTI length or the second TTI length.

10. A method implemented by a wireless transmit/receive unit (WTRU) for supporting transmissions of different durations, the method comprising:

receiving downlink control information from a first serving cell in the wireless communications network;

determining that the received downlink control information indicates that the WTRU should use a first transmission time interval to transmit data information to the first serving cell;

determining whether the received downlink control information indicates that the WTRU should use a second transmission time interval that is different than the first transmission time interval to communicate with the wireless communication network on the physical uplink channel or whether the WTRU should transmit using carrier aggregation; and

communicating with the wireless communications network using the second transmission time interval.

11. The method of claim 10, wherein determining that the received downlink control information indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network on the physical uplink channel comprises determining based on a carrier indicator field in the received downlink control information.

12. The method of claim 10, wherein communicating with the wireless communications network using the second transmission time interval comprises communicating with the first serving cell using the second transmission time interval.

13. The method of claim 10, wherein communicating with the wireless communications network using the second transmission time interval comprises communicating with a secondary cell using the second transmission time interval.

14. The method of claim 10, further comprising determining that the WTRU should use a third transmission time interval that is less than the first transmission time interval to communicate with a secondary cell in the wireless communications network.

15. The method of claim 10, wherein the shorten transmission time interval corresponds to at least one of at least one symbol or at least one resource block.

16. The method of claim 10, wherein the first transmission time interval is one millisecond.

17. The method of claim 10, wherein the first transmission time interval is greater than the first transmission time interval.

18. The method of claim 10, wherein the first transmission time interval corresponds to a first sub-carrier spacing and the second transmission time interval corresponds to a second subcarrier spacing.

19. The method of claim 10, wherein the first transmission time interval corresponds to a first number of transmission symbols and the second transmission time interval corresponds to a second number of transmission symbols.

20. The method of claim 10, further comprising the WTRU communicating with the first serving cell and a second serving cell using the same carrier frequency.

21. The method of claim 10, further comprising determining a time to transmit with the second transmission time interval based on the received downlink control information.

22. The method of claim 21, wherein the time to transmit is defined by a slot in a subframe.

23. The method of claim 10, wherein determining whether the received downlink control information indicates that the WTRU should use a second transmission time interval that

is less than the first transmission time interval to communicate with the wireless communication network on the physical uplink channel or whether the WTRU should transmit using carrier aggregation comprises determining with cross-carrier scheduling.

24. A wireless transmit/receive unit (WTRU) for use within a wireless communications network that is capable of carrier aggregation, comprising:

a processor having executable instructions that:

determine that downlink control information from a first serving cell in the wireless communications network has been received;

determine that the received downlink control information indicates that the WTRU should use a first transmission time interval to transmit data information to the first serving cell;

determine whether the received downlink control information indicates that the WTRU should use a second transmission time interval that is different than the first transmission time interval to communicate with the wireless communication network on the physical uplink channel or whether the WTRU should transmit using carrier aggregation; and

communicate with the wireless communications network using the second transmission time interval.

25. The WTRU of claim 24, wherein the processor further comprises executable instructions that determine that the received downlink control information indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network on the physical uplink channel comprises determining based on a carrier indicator field in the received downlink control information.

26. The WTRU of claim 24, wherein the executable instructions that communicate with the wireless communications network using the second transmission time interval comprise communicating with the first serving cell using the second transmission time interval.

27. The WTRU of claim 24, wherein the executable instructions that communicate with the wireless communications network using the second transmission time interval comprise communicating with a secondary cell using the second transmission time interval.

28. The WTRU of claim 24, wherein the processor further comprises executable instructions that determine that the WTRU should use a third transmission time interval that is less than the first transmission time interval to communicate with a secondary cell in the wireless communications network.

29. The WTRU of claim 24, wherein the shorten transmission time interval corresponds to at least one of at least one symbol or at least one resource block.

30. The WTRU of claim 24, wherein the first transmission time interval is one millisecond.

31. The WTRU of claim 24, wherein the processor further comprises executable instructions that determine a time to transmit with the second transmission time interval based on the received downlink control information.

32. The WTRU of claim 31, wherein the time to transmit is defined by a slot in a subframe.

33. The WTRU of claim 24, wherein the executable instructions that determine whether the received downlink control information indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network on the physical uplink channel or whether the WTRU should transmit using carrier aggregation comprise determining with cross-carrier scheduling.

34. The WTRU of claim 24, wherein the first transmission time interval is greater than the first transmission time interval.

35. The method of claim 24, wherein the first transmission time interval corresponds to a first sub-carrier spacing and the second transmission time interval corresponds to a second subcarrier spacing.

36. The method of claim 24, wherein the first transmission time interval corresponds to a first number of transmission symbols and the second transmission time interval corresponds to a second number of transmission symbols.

37. The method of claim 24, further comprising the WTRU communicating with the first serving cell and a second serving cell using the same carrier frequency.

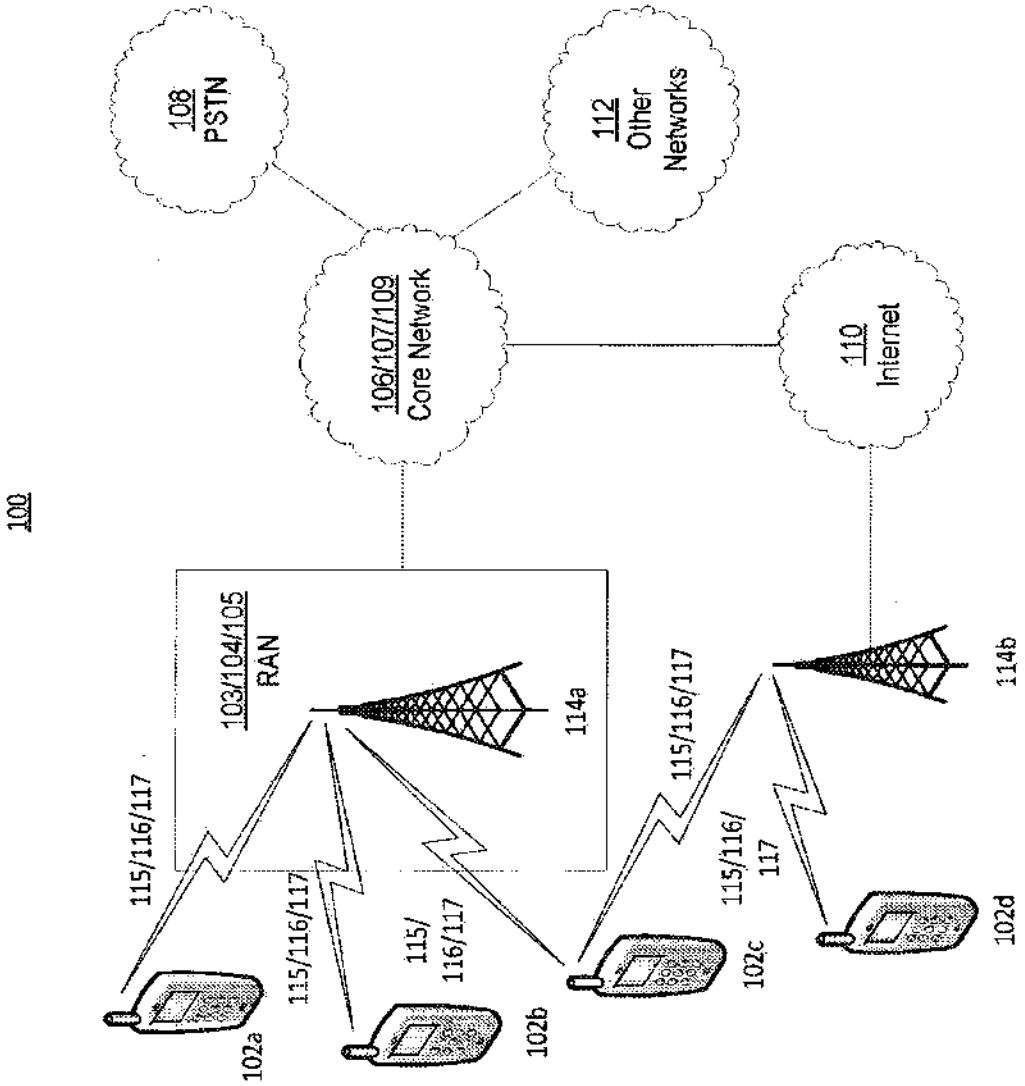

100
108 PSTN
112 Other Networks
106/107/109 Core Network
110 Internet
103/104/105 RAN
114a
114b
115/116/117
115/116/117
115/ 116/117
115/116/117
115/116/ 117
102a
102b
102c
102d

FIG. 1A

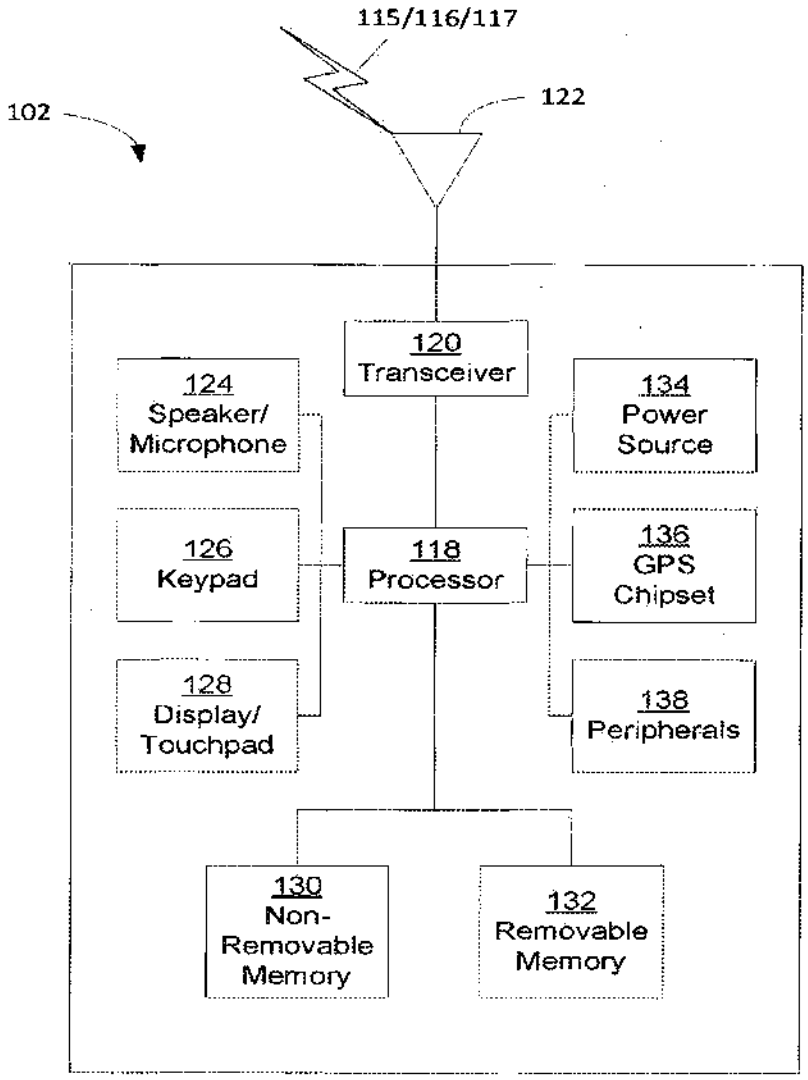

115/116/117
122
102
120
Transceiver
124
Speaker/
Microphone
134
Power
Source
126
Keypad
118
Processor
136
GPS
Chipset
128
Display/
Touchpad
138
Peripherals
130
Non-
Removable
Memory
132
Removable
Memory

FIG. 1B

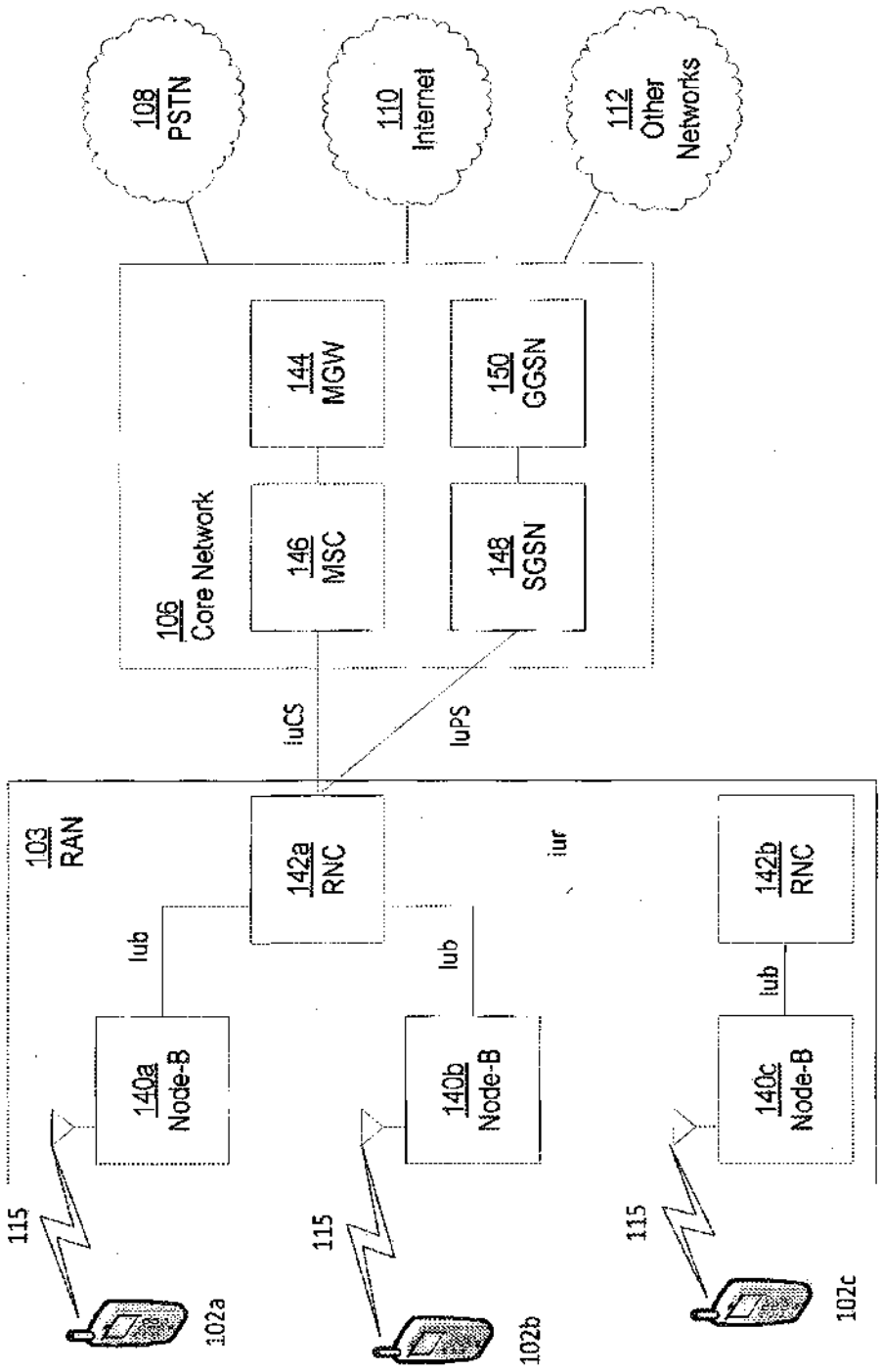

108 PSTN
110 Internet
112 Other Networks
106 Core Network
144 MGW
150 GGSN
146 MSC
148 SGSN
IuCS
IuPS
103 RAN
142a RNC
142b RNC
Iur
Iub
Iub
Iub
140a Node-B
140b Node-B
140c Node-B
115
115
115
102a
102b
102c

FIG. 1C

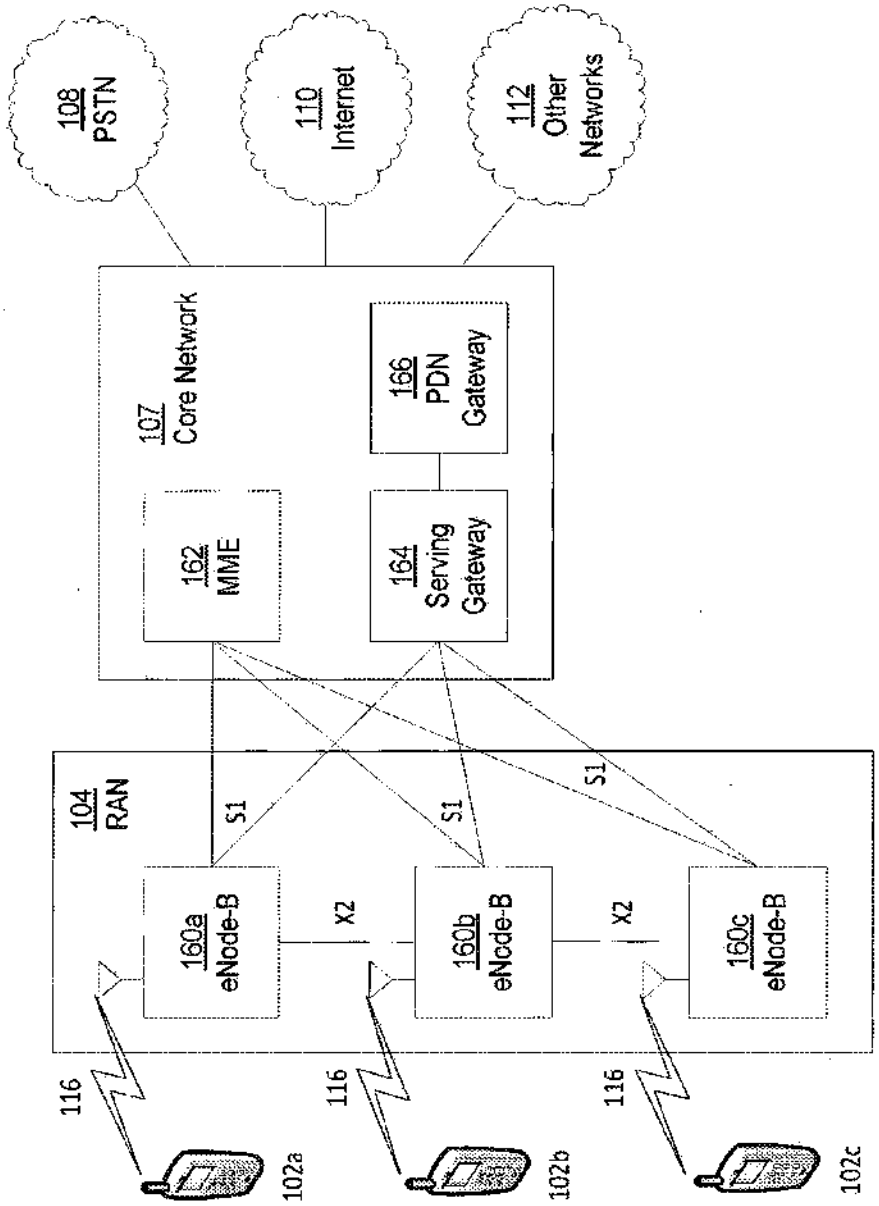

108 PSTN
110 Internet
112 Other Networks
107 Core Network
166 PDN Gateway
162 MME
164 Serving Gateway
104 RAN
S1
S1
S1
160a eNode-B
160b eNode-B
160c eNode-B
X2
X2
116
116
116
102a
102b
102c

FIG. 1D

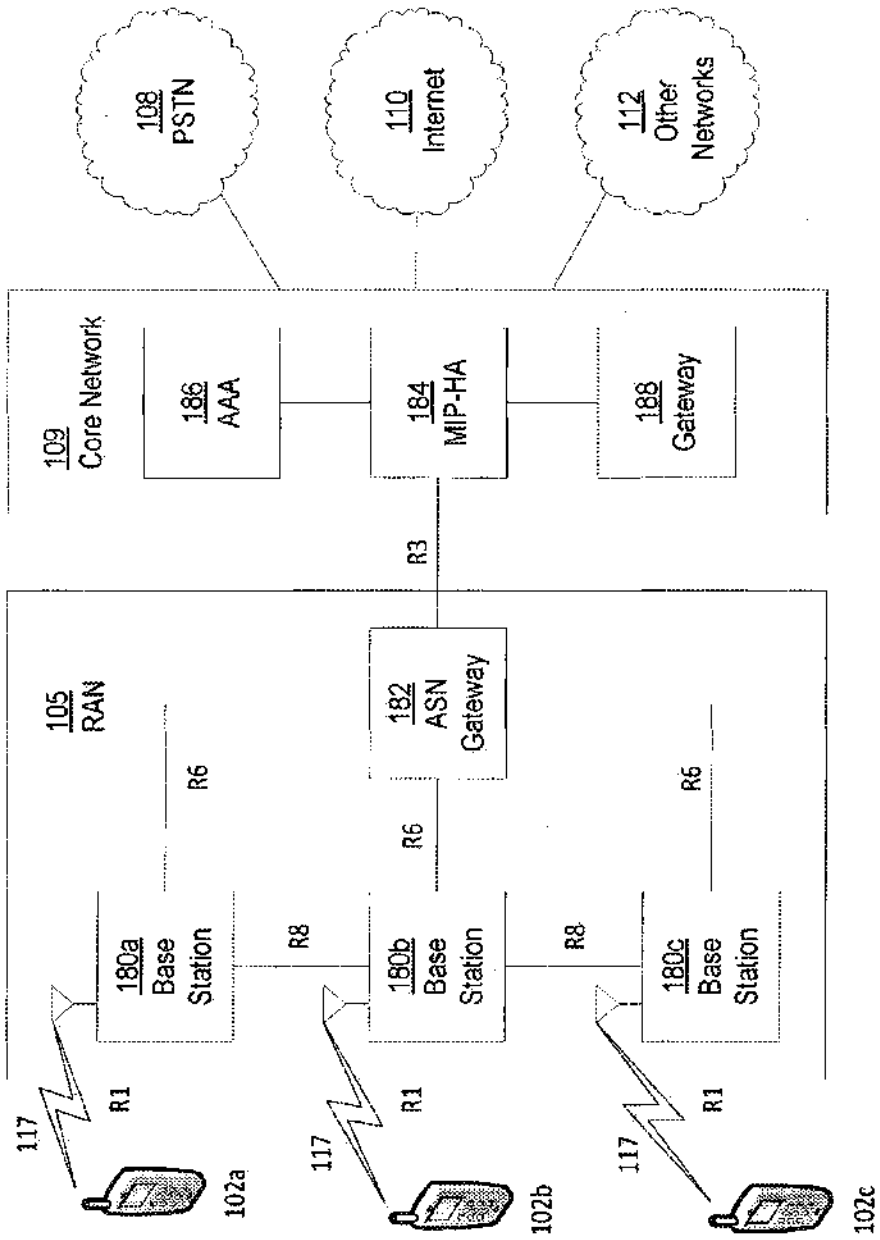

108 PSTN
110 Internet
112 Other Networks
109 Core Network
186 AAA
184 MIP-HA
188 Gateway
R3
105 RAN
182 ASN Gateway
R6
R6
R6
180a Base Station
180b Base Station
180c Base Station
R8
R8
R1
R1
R1
117
117
117
102a
102b
102c

FIG. 1E

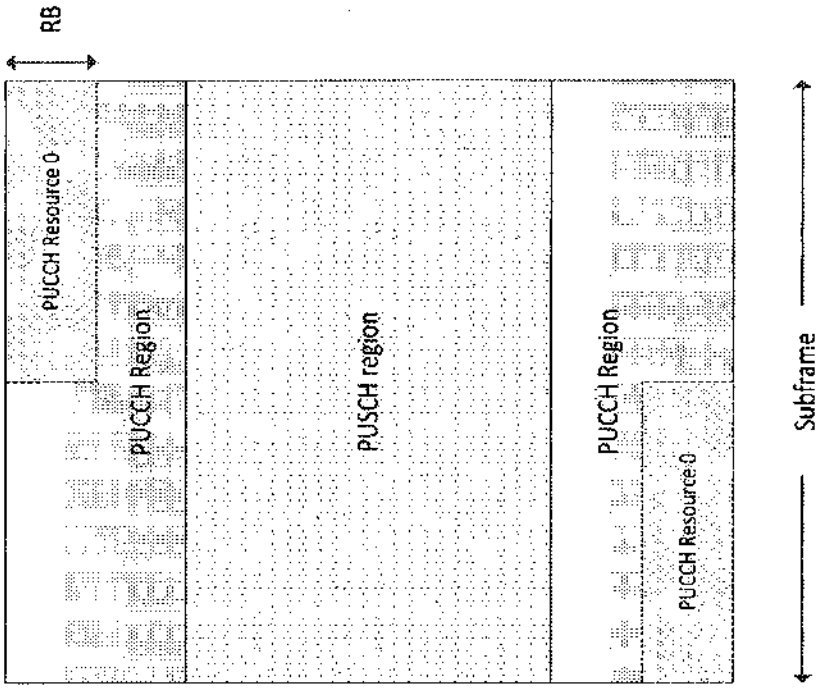

RB
PUCCH Resource 0
PUCCH Region
PUSCH region
PUCCH Region
PUCCH Resource 0
Subframe

FIG. 3

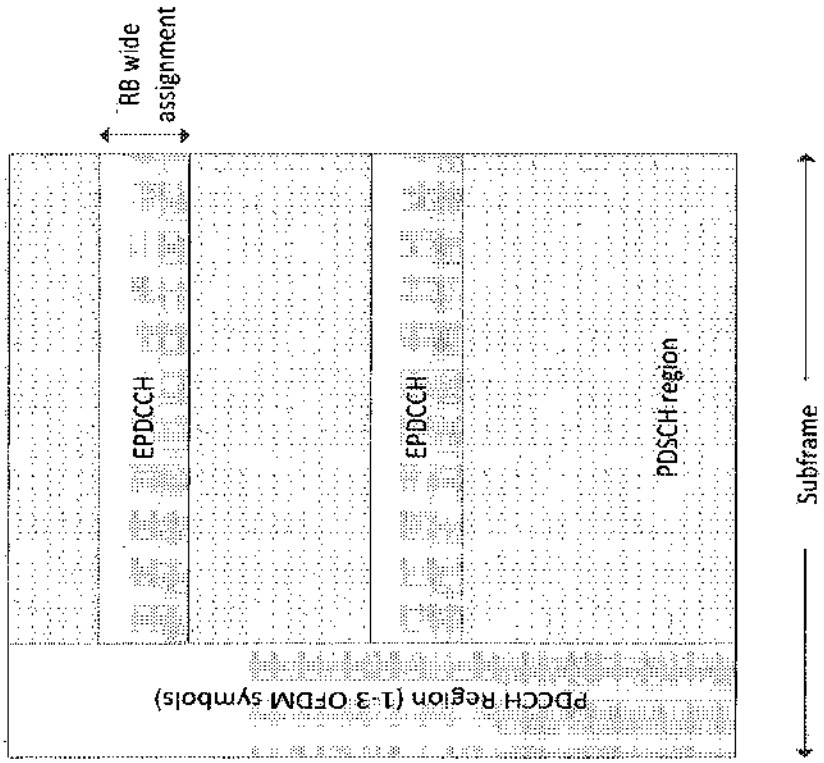

RB wide assignment
EPDCCH
EPDCCH
PDSCH region
PDCCH Region (1-3 OFDM symbols)
Subframe

FIG. 2

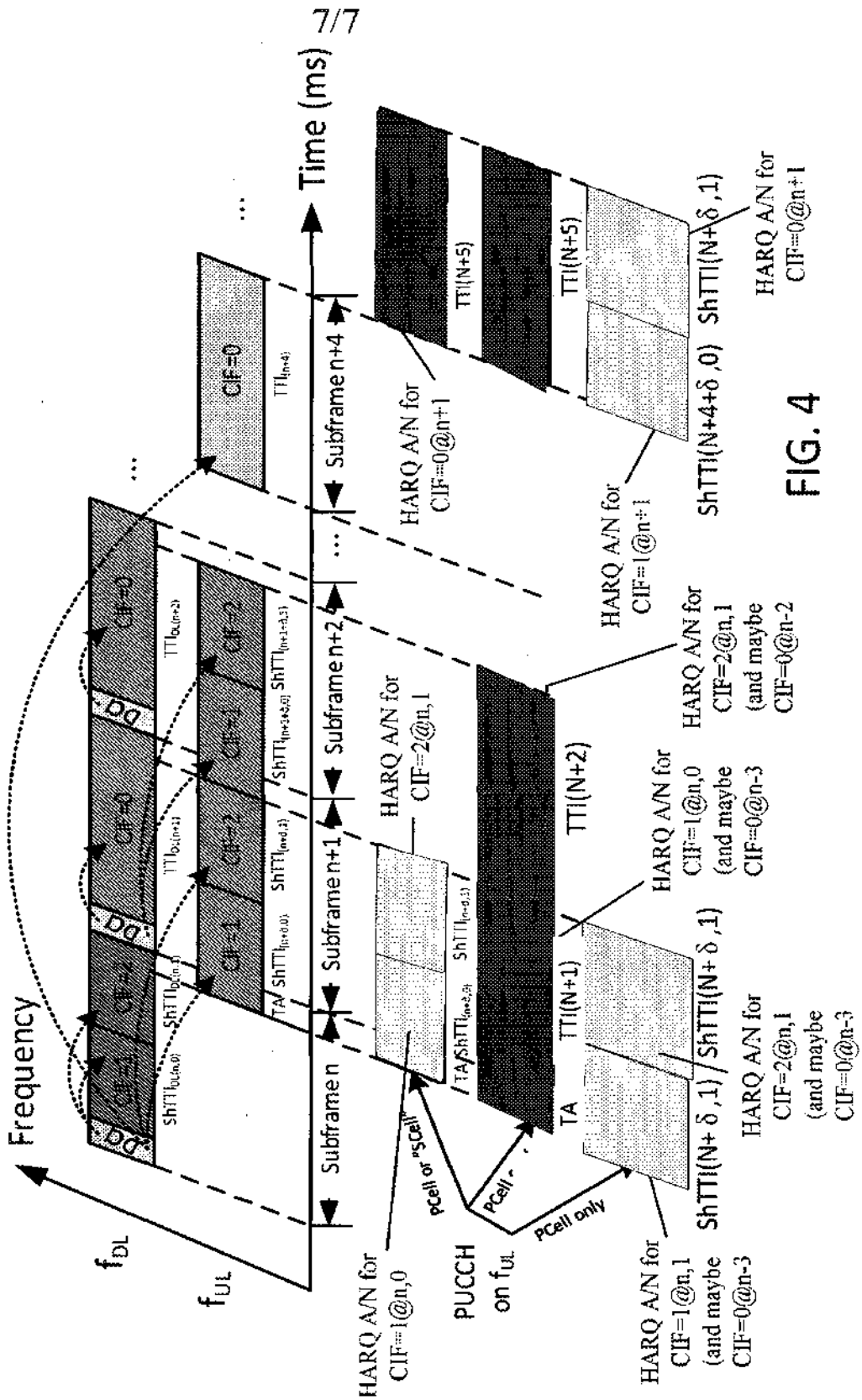

Frequency
Time (ms)
f_{DL}
f_{UL}
Subframe n
Subframe n+1
Subframe n+2
Subframe n+4
CIF=0
CIF=1
CIF=2
DTX
TA
TTI(N+1)
TTI(N+2)
TTI(N+5)
PUCCH on f_{UL}
PCell only
HARQ A/N for CIF=1@n,0
HARQ A/N for CIF=2@n,1
HARQ A/N for CIF=0@n+1
HARQ A/N for CIF=1@n,1 (and maybe CIF=0@n-3
HARQ A/N for CIF=1@n,0 (and maybe CIF=0@n-3
HARQ A/N for CIF=2@n,1 (and maybe CIF=0@n-2
HARQ A/N for CIF=1@n+1
HARQ A/N for CIF=0@n+1
ShTTI(N+δ,1)
ShTTI(N+4+δ,0)
ShTTI(N+δ,1)

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/060481

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W72/12
ADD. H04W28/06 H04L1/18

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2013/041138 A1 (NOKIA SIEMENS NETWORKS OY [FI]; HOLMA HARRI KALEVI [FI]; RAAF BERNHARD) 28 March 2013 (2013-03-28) pages 1,2 page 5, line 29 - page 9, line 35	1-37
X	US 2014/071954 A1 (AU KELVIN KAR KIN [CA] ET AL) 13 March 2014 (2014-03-13)	1,10,24
Y	paragraphs [0001] - [0005], [0022], [0023], [0025], [0027], [0028], [0030], [0032], [0033], [0034] - [0036]; figures 4-6,8,9 abstract	2-9, 11-23, 25-37

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 December 2016	11/01/2017

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Englund, Terese

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/060481

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	EP 2 816 858 A1 (ALCATEL LUCENT [FR]) 24 December 2014 (2014-12-24) abstract; figure 3 paragraphs [0006] - [0010], [0017] - [0021], [0026], [0035], [0041], [0045], [0049], [0063] - [0072] -----	1,10,24 2-9, 11-23, 25-37
X Y	WO 2015/139795 A1 (ERICSSON TELEFON AB L M [SE]) 24 September 2015 (2015-09-24) abstract page 5, lines 1-29 page 16, lines 13-30 -----	1 2-37
Y A	US 2015/256316 A1 (SEO DONGYOUN [KR] ET AL) 10 September 2015 (2015-09-10) abstract paragraphs [0005], [0008], [0010], [0033], [0036], [0052], [0053], [0094], [0105] - [0120], [179.183], [0190], [0202], [0205] paragraphs [0238] - [0248] -----	2-37 1
A	EP 2 341 678 A1 (PANASONIC CORP [JP]) 6 July 2011 (2011-07-06) abstract paragraphs [0001], [0003], [0019], [0020], [0030] -----	1-37
A	ITL: "On data transmission with partial TTI for LAA", 3GPP DRAFT; R1-153274, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. Fukuoka, Japan; 20150525 - 20150529 24 May 2015 (2015-05-24), XP050974055, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_ SYNC/RAN1/Docs/ [retrieved on 2015-05-24] chapter 2.1 -----	1-37
X,P	WO 2016/064048 A1 (LG ELECTRONICS INC [KR]) 28 April 2016 (2016-04-28) paragraphs [0191], [0344] - [0346]; claims 1-6 -----	1-37
E	WO 2016/190970 A1 (QUALCOMM INC [US]) 1 December 2016 (2016-12-01) paragraphs [0006] - [0011]; claims 1-4; figures 4-8 -----	1-37
	-/--	

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/060481

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X,P	WO 2016/064049 A1 (LG ELECTRONICS INC [KR]) 28 April 2016 (2016-04-28) paragraphs [0009] - [0016]; figures 1-24	1-37

1

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2016/060481

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2013041138 A1	28-03-2013	EP 2759085 A1	30-07-2014
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(54) 发明名称: 波束恢复方法及装置

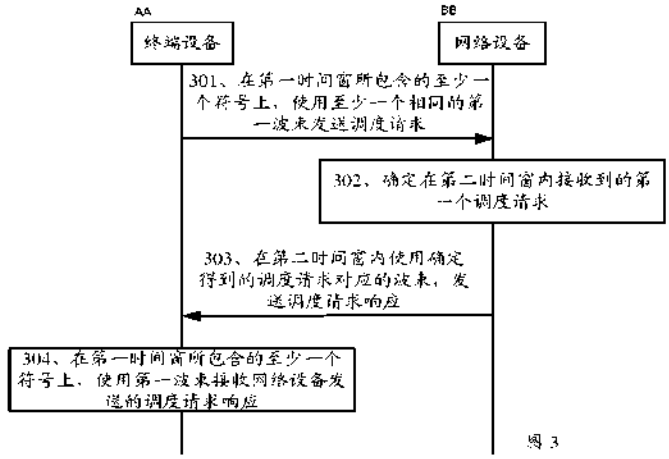


图 3

301 On at least one symbol comprised in a first time window, use at least one identical first beam to send a scheduling reques;
302 Determine a first scheduling request which is received within a second time window
303 Send a scheduling request response within the second time window by using a beam corresponding to the determined scheduling request
304 On at least one symbol comprised in the first time window, use the first beam to receive the scheduling request response which is sent by the network device
AA Terminal device
BB Network device

(57) Abstract: Disclosed in an embodiment of the present invention are a beam recovery method and device, the method comprising: a terminal device using at least one beam within a first time window to send to a network device a request which is used for recovering a beam, the request which is used for recovering a beam being a scheduling request or a beam failure recovery request; the terminal device using at least one beam within the first time window to receive a response to the request which is used for recovering a beam that is sent by the network device, the response to the request which is used for recovering a beam being a scheduling request response

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GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW。

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or a beam failure recovery request response. By using the embodiment of the present invention, the network device may perform beam recovery processing on multiple requests which are used for recovering a beam that are sent by the same terminal device, and beam recovery efficiency is increased.

(57) 摘要：本发明实施例公开了波束恢复方法及装置，所述方法包括：终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，用于恢复波束的请求为调度请求或者波束失败恢复请求；终端设备在第一时间窗内使用至少一个波束接收网络设备发送的用于波束恢复请求的响应，用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。采用本发明实施例，可实现网络设备针对同一终端设备发送的多个用于恢复波束的请求的波束恢复处理，提高波束恢复效率。

波束恢复方法及装置

技术领域

本申请涉及通信技术领域，尤其涉及波束恢复方法及装置。

背景技术

波束(beam)是一种通信资源，不同的波束可以认为是不同的通信资源。在移动通信系统中使用波束进行信息传输，即通过在空间上朝向特定的方向发送信号，可以实现更高的天线阵列增益。发射波束可以是指信号经天线发射出去后在空间不同方向上形成的信号强度的分布，接收波束可以是指从天线上接收到的无线信号在空间不同方向上的信号强度分布。一个波束对通常包括一个发送端的发射波束和一个接收端的接收波束。当下行控制信道关联的波束的性能下降到某个门限值时，该波束失效，即无法使用该波束进行信息传输，一旦波束失效，将触发波束恢复机制。

在长期演进（Long Term Evolution，LTE）系统中，在建立无线链路过程中的初始接入、在无线链路建立失败之后的链路重建或者采用基于上行测量的定位方法以进行定位等过程中可以采用随机接入方案，具体可以为：终端设备向网络设备发送调度请求（Scheduling Request，SR），以通知网络设备有终端设备试图接入；终端设备在预先配置的时间窗内监测控制信道，以接收网络设备下发的随机接入响应（Random Access Response，RAR）。上述随机接入方案仅针对网络设备接收到同一终端设备发送的一个 SR 的场景。

当下行链路（Down Link，DL）的波束对（Beam Pair Link，BPL）失效时，为了充分利用现有的资源，以及波束失效的持续时间远小于无线链路失效（Radio Link Failure，RLF）的时间窗长度，终端设备可以利用随机接入信道（Random Access Channel，RACH）资源在不同方向的多个波束上发射 SR，则网络设备在时间窗内可以接收到来自同一终端设备的多个 SR。而传统 LTE 中随机接入的处理流程仅针对网络设备收到同一终端设备发送的一个 SR 的场景，在网络设备收到同一终端设备发送的多个 SR 时如何进行随机接入处理，是目前亟需解决的问题。

发明内容

本发明实施例所要解决的技术问题在于，提供波束恢复方法及装置，可实现网络设备针对同一终端设备发送的多个用于恢复波束的请求的波束恢复处理，提高波束恢复效率。

第一方面，本发明实施例提供了一种波束恢复方法，终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求；终端设备在第一时间窗内使用至少一个波束接收网络设备发送的用于波束恢复请求的响应。

其中，用于恢复波束的请求可以为调度请求或者波束失败恢复请求（beam failure recovery request）。

其中，用于波束恢复请求的响应可以为调度请求响应或者波束失败恢复请求响应。

例如，当用于恢复波束的请求为调度请求时，用于波束恢复请求的响应可以为调度请求响应；当用于恢复波束的请求为波束失败恢复请求时，用于波束恢复请求的响应可以为

波束失败恢复请求响应。

其中，第一时间窗可以是网络设备对终端设备配置的时间窗，示例性的，第一时间窗可以包括 3 个符号或者 7 个符号等。

可选的，第一时间窗所包含的第一个符号可以为第一个配置有随机接入信道（Random Access Channel，RACH）资源的符号。

在该技术方案中，终端设备可以使用至少一个波束向网络设备发送用于恢复波束的请求，终端设备还可以在第一时间窗内使用上述至少一个波束接收网络设备发送的用于波束恢复请求的响应，则终端设备向网络设备发送的用于恢复波束的请求可以包括多个，以便提高波束恢复效率。

可选的，终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，具体可以为：终端设备在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送用于恢复波束的请求。

其中，第一波束可以是网络设备对终端设备配置的一个波束。

例如，终端设备可以在第一时间窗所包含的一个符号上，使用一个第一波束向网络设备发送用于恢复波束的请求。示例性的，第一时间窗包括 3 个符号，分别为第一符号、第二符号以及第三符号，若终端设备在第一时间窗中确定的一个符号为第一符号，则终端设备可以在第一时间窗所包含的第一符号上，使用第一波束向网络设备发送用于恢复波束的请求。

又如，终端设备可以在第一时间窗所包含的一个符号上，使用多个相同的第一波束向网络设备发送用于恢复波束的请求。示例性的，第一时间窗包括 3 个符号，分别为第一符号、第二符号以及第三符号，若终端设备在第一时间窗中确定的一个符号为第一符号，则终端设备可以在第一时间窗所包含的第一符号上，在不同方向上使用第一波束向网络设备发送用于恢复波束的请求。

又如，终端设备可以在第一时间窗所包含的多个符号上，使用一个第一波束向网络设备发送用于恢复波束的请求。示例性的，第一时间窗包括 3 个符号，分别为第一符号、第二符号以及第三符号，若终端设备在第一时间窗中确定的多个符号包括第二符号和第三符号，则终端设备可以在第一时间窗所包含的第二符号上，使用第一波束向网络设备发送用于恢复波束的请求，且在第一时间窗所包含的第三符号上，使用第一波束向网络设备发送用于恢复波束的请求。

又如，终端设备可以在第一时间窗所包含的多个符号上，使用多个相同的第一波束向网络设备发送用于恢复波束的请求。示例性的，第一时间窗包括 3 个符号，分别为第一符号、第二符号以及第三符号，若终端设备在第一时间窗中确定的多个符号包括第二符号和第三符号，则终端设备可以在第一时间窗所包含的第二符号上，使用第一波束向网络设备发送用于恢复波束的请求，且在第一时间窗所包含的第三符号上，使用第一波束向网络设备发送用于恢复波束的请求。

在该技术方案中，终端设备可以在一个符号上使用多个相同的第一波束向网络设备发送用于恢复波束的请求，或者在多个符号上使用一个或者多个相同的第一波束向网络设备发送用于恢复波束的请求，以实现同一终端设备向网络设备发送多个用于恢复波束的请求。

可选的，终端设备在第一时间窗内使用至少一个波束接收网络设备发送的用于波束恢复请求的响应，具体可以为：终端设备在第一时间窗所包含的至少一个符号上，使用第一波束接收用于波束恢复请求的响应。

在该技术方案中，终端设备在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送用于恢复波束的请求之后，可以在第一时间窗所包含的至少一个符号上，使用第一波束接收用于波束恢复请求的响应，可确保发送用于波束恢复的请求的波束和接收用于波束恢复请求的响应的波束为同一波束。

可选的，第一时间窗可以包括第一单元时间窗和第二单元时间窗，则终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，具体可以为：终端设备在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送用于恢复波束的请求。

其中，第一单元时间窗可以是网络设备对终端设备配置的时间窗，示例性的，第一单元时间窗可以包括 3 个符号或者 4 个符号等。

其中，第二单元时间窗可以是网络设备对终端设备配置的时间窗，示例性的，第二单元时间窗可以包括 4 个符号或者 5 个符号等。

其中，第二单元时间窗所包含的第一个符号为第一单元时间窗所包含的最后一个符号之后的第一个符号。例如第一单元时间窗包括 4 个符号，分别为符号 0、符号 1、符号 2 以及符号 3，符号 3 之后的第一个符号为符号 4，则终端设备可以确定第二单元时间窗所包含的第一个符号为符号 4。需要说明的是，本发明实施例中的第一单元时间窗包含但不限定 4 个符号，第一单元时间窗的长度和第二单元时间窗的长度可以相同，也可以不相同，具体不受本发明实施例的限定。

可选的，终端设备在第一时间窗内使用至少一个波束接收网络设备发送的用于波束恢复请求的响应，具体可以为：终端设备在第二单元时间窗所包含的至少一个符号上，使用第一波束接收用于波束恢复请求的响应。

在该技术方案中，终端设备在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送用于恢复波束的请求之后，终端设备可以在第二单元时间窗所包含的至少一个符号上，使用第一波束接收用于波束恢复请求的响应，可确保发送用于波束恢复的请求的波束和接收用于波束恢复请求的响应的波束为同一波束。

可选的，当在第一时间窗内未接收到用于波束恢复请求的响应时，终端设备可以确定网络设备对终端设备配置的第三时间窗，并在第三时间窗所包含的至少一个符号上，使用至少一个相同的第二波束向网络设备发送用于恢复波束的请求。

其中，第三时间窗可以是网络设备对终端设备配置的时间窗，示例性的，第三时间窗可以包括 3 个符号或者 5 个符号等。

在该技术方案中，终端设备在第一时间窗未检测到用于波束恢复请求的响应时，终端设备可以在第三时间窗使用第一波束以外的其他波束重新向网络设备发送用于恢复波束的请求，若终端设备在第三时间窗所包含的至少一个符号上使用第二波束接收到网络设备发送的用于波束恢复请求的响应，则可实现波束恢复，可提高波束恢复的可靠性。

可选的，第一时间窗可以包括第三单元时间窗和第四单元时间窗，则终端设备在第一

时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，具体可以为：终端设备在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备发送用于恢复波束的请求。

其中，第三单元时间窗可以是网络设备对终端设备配置的时间窗，示例性的，第一单元时间窗可以包括 3 个符号或者 5 个符号等。

其中，第四单元时间窗可以是网络设备对终端设备配置的时间窗，示例性的，第二单元时间窗可以包括 4 个符号或者 5 个符号等。

其中，第四单元时间窗所包含的第一个符号可以为第三单元时间窗所包含的最后一个符号之后的第一个符号。例如第三单元时间窗包括 4 个符号，分别为符号 0、符号 1、符号 2 以及符号 3，符号 3 之后的第一个符号为符号 4，则终端设备可以确定第四单元时间窗所包含的第一个符号为符号 4。需要说明的是，本发明实施例中的第三单元时间窗包含但不限定 4 个符号，第三单元时间窗的长度和第四单元时间窗的长度可以相同，也可以不相同，具体不受本发明实施例的限定。

其中，网络设备可以对终端设备配置最大波束数量，例如允许终端设备发送用于恢复波束的请求时所使用的波束的数量可以小于等于 5。需要说明的是，本发明实施例中的最大波束数量包含但不限于 5，例如，最大波束数量可以为 3，等等，具体不受本发明实施例的限制。

其中，第三单元时间窗所包含的符号的数量总和可以是根据网络设备对终端设备配置的最大波束数量确定的。例如，第三单元时间窗所包含的符号的数量总和与最大波束数量之间可以呈正比例关系。示例性的，最大波束数量为 5，则第三单元时间窗所包含的符号的数量总和可以为 5，即第三单元时间窗包含 5 个符号。

例如，终端设备可以在第三单元时间窗所包含的一个符号上，使用一个波束向网络设备发送用于恢复波束的请求。示例性的，第三单元时间窗包括 5 个符号，分别为第一符号、第二符号、第三符号、第四符号以及第五符号，若终端设备在第三单元时间窗中确定的一个符号为第一符号，则终端设备可以在第三单元时间窗所包含的第一符号上，使用波束 1 向网络设备发送用于恢复波束的请求。波束 1 可以为终端设备确定得到的一个波束，其中该波束可以是网络设备对终端设备配置的。

又如，终端设备可以在第三单元时间窗所包含的一个符号上，使用多个不同波束向网络设备发送用于恢复波束的请求。示例性的，第三单元时间窗包括 5 个符号，分别为第一符号、第二符号、第三符号、第四符号以及第五符号，若终端设备在第三单元时间窗中确定的一个符号为第一符号，则终端设备可以在第三单元时间窗所包含的第一符号上，在不同方向上分别使用波束 1~波束 5 中的多个波束向网络设备发送用于恢复波束的请求。其中，若网络设备对终端设备配置的最大波束数量为 5，则终端设备在第三单元时间窗所包含的第一符号上，可以使用大于等于 2 个且小于等于 5 个波束向网络设备发送用于恢复波束的请求。

又如，终端设备可以在第三单元时间窗所包含的多个符号上，使用一个波束向网络设备发送用于恢复波束的请求。示例性的，第三单元时间窗包括 5 个符号，分别为第一符号、第二符号、第三符号、第四符号以及第五符号，若终端设备在第三单元时间窗中确定的多

个符号包括第二符号和第三符号，则终端设备可以在第三单元时间窗所包含的第二符号上，使用波束 1 向网络设备发送用于恢复波束的请求，且在第三单元时间窗所包含的第三符号上，使用波束 1 向网络设备发送用于恢复波束的请求。

又如，终端设备可以在第三单元时间窗所包含的多个符号上，使用多个不同波束向网络设备发送用于恢复波束的请求。示例性的，第三单元时间窗包括 5 个符号，分别为第一符号、第二符号、第三符号、第四符号以及第五符号，若终端设备在第三单元时间窗中确定的多个符号包括第二符号和第三符号，则终端设备可以在第三单元时间窗所包含的第二符号上，在不同方向上分别使用波束 1~波束 5 中的多个波束向网络设备发送用于恢复波束的请求，且在第三单元时间窗所包含的第三符号上，在不同方向上分别使用波束 1~波束 5 中的多个波束向网络设备发送用于恢复波束的请求。

在该技术方案中，终端设备可以在一个符号上使用多个不同波束向网络设备发送用于恢复波束的请求，或者在多个符号上使用一个或者多个不同波束向网络设备发送用于恢复波束的请求，以实现同一终端设备向网络设备发送多个用于恢复波束的请求。

可选的，终端设备在第一时间窗内使用至少一个波束接收网络设备发送的用于波束恢复请求的响应，具体可以为：终端设备在第四单元时间窗所包含的至少一个符号上，使用至少一个不同的波束接收用于波束恢复请求的响应。

在该技术方案中，终端设备在第三单元时间窗所包含的至少一个符号上，使用至少一个不同波束向网络设备发送用于恢复波束的请求之后，终端设备可以在第四单元时间窗所包含的至少一个符号上，使用上述至少一个不同的波束接收用于波束恢复请求的响应，可确保发送用于波束恢复的请求的波束和接收用于波束恢复请求的响应的波束为同一波束。

可选的，终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，具体可以为：终端设备基于网络设备对终端设备配置的波束请求指示信息，在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，波束请求指示信息用于指示用于恢复波束的请求的发送方式。

例如，当波束请求指示信息用于指示用于恢复波束的请求的发送方式为在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束发送时，终端设备可以在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送用于恢复波束的请求，并在第一时间窗所包含的至少一个符号上，使用第一波束接收用于波束恢复请求的响应。

又如，当波束请求指示信息用于指示用于恢复波束的请求的发送方式为在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束发送时，终端设备可以在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送用于恢复波束的请求，并在第二单元时间窗所包含的至少一个符号上，使用第一波束接收用于波束恢复请求的响应。

又如，当波束请求指示信息用于指示用于恢复波束的请求的发送方式为在第三单元时间窗所包含的至少一个符号上，使用至少一个不同波束发送时，终端设备可以在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备发送用于恢复波束的请求，并在第四单元时间窗所包含的至少一个符号上，使用至少一个不同的波束接收用

于波束恢复请求的响应。

第二方面，本发明实施例提供了一种波束恢复方法，网络设备接收终端设备在第一时间窗内使用至少一个波束发送的用于恢复波束的请求，在第二时间窗内，在接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，并使用确定得到的用于恢复波束的请求对应的波束，向终端发送用于波束恢复请求的响应。

在该技术方案中，网络设备可以接收终端设备发送的多个用于恢复波束的请求，在接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，并使用确定得到的用于恢复波束的请求对应的波束，向终端发送用于波束恢复请求的响应，可实现网络设备针对同一终端设备发送的多个用于恢复波束的请求的波束恢复处理，提高波束恢复效率。

可选的，网络设备在接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，具体可以为：网络设备响应在第二时间窗内接收到的质量最好的波束所承载的用于恢复波束的请求。

例如，若终端设备在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备发送用于恢复波束的请求，则网络设备可以在第二时间窗内接收到的用于恢复波束的请求中确定质量最好的波束所承载的用于恢复波束的请求，并对确定得到的用于恢复波束的请求进行响应。

又如，若终端设备在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送用于恢复波束的请求，则网络设备可以在第二时间窗内接收到的用于恢复波束的请求中确定质量最好的波束所承载的用于恢复波束的请求，并对确定得到的用于恢复波束的请求进行响应。

可选的，网络设备在接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，具体可以为：网络设备响应在第二时间窗内接收到的第一个用于恢复波束的请求。

例如，若终端设备在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送用于恢复波束的请求，则网络设备可以在第二时间窗内接收到的用于恢复波束的请求中确定最先接收到的用于恢复波束的请求，并对确定得到的用于恢复波束的请求进行响应。

又如，若终端设备在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送用于恢复波束的请求，则网络设备可以在第二时间窗内接收到的用于恢复波束的请求中确定最先接收到的用于恢复波束的请求，并对确定得到的用于恢复波束的请求进行响应。

又如，若终端设备在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备发送用于恢复波束的请求，则网络设备可以在第二时间窗内接收到的用于恢复波束的请求中确定最先接收到的用于恢复波束的请求，并对确定得到的用于恢复波束的请求进行响应。

可选的，网络设备使用确定得到的用于恢复波束的请求对应的波束，向终端发送用于波束恢复请求的响应，具体可以为：网络设备在第二时间窗内使用确定得到的用于恢复波束的请求对应的波束，向终端设备发送用于波束恢复请求的响应。

可选的，网络设备使用确定得到的用于恢复波束的请求对应的波束，向终端发送用于波束恢复请求的响应，具体可以为：网络设备在第二时间窗之外使用确定得到的用于恢复波束的请求对应的波束，向终端设备发送用于波束恢复请求的响应。

第三方面，本发明实施例提供一种计算机存储介质，所述计算机存储介质存储有程序，所述程序执行时包括本发明实施例第一方面提供的波束恢复方法中全部或部分的步骤。

第四方面，本发明实施例提供一种计算机存储介质，所述计算机存储介质存储有程序，所述程序执行时包括本发明实施例第二方面提供的波束恢复方法中全部或部分的步骤。

第五方面，本发明实施例提供一种波束恢复装置，该波束恢复装置包括用于执行本发明实施例第一方面公开的波束恢复方法的模块。

第六方面，本发明实施例提供一种波束恢复装置，该波束恢复装置包括用于执行本发明实施例第二方面公开的波束恢复方法的模块。

第七方面，本发明实施例提供一种终端设备，其特征在于，包括处理器、存储器以及收发器，存储器中存储一组程序代码，且处理器调用存储器中存储的程序代码，用于执行以下操作：

在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求；在第一时间窗内使用至少一个波束接收网络设备发送的用于波束恢复请求的响应。

第八方面，本发明实施例提供一种网络设备，其特征在于，包括处理器、存储器以及收发器，存储器中存储一组程序代码，且处理器调用存储器中存储的程序代码，用于执行以下操作：

接收终端设备在第一时间窗内使用至少一个波束发送的用于恢复波束的请求；在第二时间窗内，在接收到的用于恢复波束的请求中确定一个用于恢复波束的请求；使用确定得到的用于恢复波束的请求对应的波束，向终端设备发送用于波束恢复请求的响应。

第九方面，本发明实施例提供一种波束恢复系统，包括本发明实施例第七方面公开的终端设备和本发明实施例第八方面公开的网络设备。

第十方面，本申请实施例提供了一种通信芯片，其中存储有指令，当其在终端设备上运行时，使得所述通信芯片执行上述第一方面的方法。

第十一方面，本申请实施例提供了一种通信芯片，其中存储有指令，当其在网络设备上运行时，使得所述通信芯片执行上述第二方面的方法。

附图说明

为了更清楚地说明本发明实施例或背景技术中的技术方案，下面将对本发明实施例或背景技术中所需要使用的附图进行说明。

图 1 是本发明实施例提供的一种波束恢复系统的架构示意图；

图 2A 是本发明实施例提供的一种信息传输的示意图；

图 2B 是本发明另一实施例提供的一种信息传输的示意图；

图 3 是本发明实施例提供的一种波束恢复方法的流程示意图；

图 4 是本发明另一实施例提供的一种信息传输的示意图；

图 5 是本发明另一实施例提供的一种波束恢复方法的流程示意图；

图 6 是本发明另一实施例提供的一种波束恢复方法的流程示意图；

图 7 是本发明另一实施例提供的一种信息传输的示意图；

图 8 是本发明另一实施例提供的一种波束恢复方法的流程示意图；

图 9 是本发明另一实施例提供的一种波束恢复方法的流程示意图；

图 10 是本发明另一实施例提供的一种信息传输的示意图；

图 11 是本发明另一实施例提供的一种波束恢复方法的流程示意图；

图 12 是本发明实施例提供的一种波束恢复装置的结构示意图；

图 13 是本发明实施例提供的一种终端设备的结构示意图；

图 14 是本发明另一实施例提供的一种波束恢复装置的结构示意图；

图 15 是本发明实施例提供的一种网络设备的结构示意图；

图 16 是本发明实施例提供的一种波束恢复系统的结构示意图。

具体实施方式

下面结合本发明实施例中的附图对本发明实施例进行描述。

为了更好的理解本发明实施例公开的一种波束恢复方法及装置，下面首先对本发明实施例适用的网络架构进行描述。请参见图 1，图 1 是本发明实施例公开的一种波束恢复系统的架构示意图。如图 1 所示，该波束恢复系统可以包括终端设备 10 以及网络设备 20。其中，终端设备 10 与网络设备 20 之间可以通过通信连接进行数据传输。

本发明实施例中的终端设备 10 可以称为用户设备（User Equipment，UE）、移动台、接入终端、用户单元、用户站、移动站、远方站、远程终端、移动设备、终端、无线通信设备、用户代理或用户装置等，其具体可以是 WLAN 中的站点（Station，ST）、蜂窝电话、无绳电话、会话启动协议（Session Initiation Protocol，SIP）电话、无线本地环路（Wireless Local Loop，WLL）站、个人数字处理（Personal Digital Assistant，PDA）、具有无线通信功能的手持设备、计算设备、连接到无线调制解调器的其它处理设备、车载设备、可穿戴设备、未来 5G 网络中的移动台以及未来演进的公共陆地移动网络（Public Land Mobile Network，PLMN）网络中的终端设备等中的任意一种。

本发明实施例中的网络设备 20 可以是能和终端设备 10 通信的设备。网络设备 20 可以是基站、中继站或接入点。基站可以是全球移动通信系统（Global System for Mobile Communication，GSM）或码分多址（Code Division Multiple Access，CDMA）网络中的基

站收发信台（Base Transceiver Station，BTS），也可以是宽带码分多址（Wideband Code Division Multiple Access，WCDMA）中的NB（NodeB），还可以是长期演进（Long Term Evolution，LTE）中的eNB或eNodeB（Evolutional NodeB）。网络设备20还可以是云无线接入网络（Cloud Radio Access Network，CRAN)场景下的无线控制器。网络设备20还可以是未来5G网络中的网络设备或者未来演进的PLMN网络中的网络设备。网络设备20还可以是可穿戴设备或车载设备。

应理解，本发明实施例的技术方案可以应用于各种通信系统，例如：GSM系统、CDMA系统、WCDMA系统、通用分组无线业务（General Packet Radio Service，GPRS）、LTE系统、LTE频分双工（Frequency Division Duplex，FDD）系统、LTE时分双工（Time Division Duplex，TDD）、通用移动通信系统（Universal Mobile Telecommunication System，UMTS）或全球互联微波接入（Worldwide Interoperability for Microwave Access，WiMAX）通信系统等。

本发明实施例中，能够和基站进行数据通信的设备均可以理解为终端设备10，本发明实施例将以一般意义上的终端设备来介绍；本发明实施例中，网络设备20可以通过信令对终端设备10配置允许的最大波束数量，则终端设备10可以使用小于等于最大波束数量的波束向网络设备20发送用于波束恢复的请求；本发明实施例中，网络设备20可以对终端设备10配置第一时间窗，其中第一时间窗可以包括一个子帧、一个时隙以及一个或多个符号中的任意一种，则终端设备10可以在第一时间窗使用至少一个波束向网络设备20发送用于波束恢复的请求；本发明实施例中，网络设备20可以对终端设备10配置第三时间窗，其中第三时间窗可以包括一个子帧、一个时隙以及一个或多个符号中的任意一种，则终端设备10在第一时间窗使用至少一个第一波束向网络设备20发送用于波束恢复的请求之后，当在第一时间窗内未接收到网络设备20发送的用于波束恢复请求的响应时，终端设备10可以在第三时间窗使用至少一个第二波束向网络设备发送用于恢复波束的请求；本发明实施例中，网络设备20可以配置网络设备20侧的第二时间窗，其中第二时间窗可以包括一个子帧、一个时隙以及一个或多个符号中的任意一种，则网络设备20接收到终端设备10在第一时间窗使用至少一个波束发送的用于波束恢复的请求之后，可以在第二时间窗，在接收到的用于波束恢复的请求中确定一个用于波束恢复的请求。

本发明实施例中，终端设备10至少有两种发送方式向网络设备20发送用于波束恢复的请求，以实现波束恢复。

第一种发送方式可以为：终端设备10在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备20发送用于恢复波束的请求，并在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备20发送的用于波束恢复请求的响应。

以图2A所示的信息传输的示意图为例，终端设备10在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束B4'向网络设备20发送用于恢复波束的请求。网络设备20按照接收RACH波束扫描方式检测终端设备10发送的用于恢复波束的请求，当网络设备20在第二时间窗内接收到终端设备10发送的用于波束恢复的请求时，网络设备20可以通过物理下行控制信道（Physical Downlink Control Channel，PDCCH）对该用于波束恢复的请求进行响应。当终端设备10在第一时间窗内未接收到网络设备20发送的用于恢

复波束请求的响应时，终端设备 10 可以在第二时间窗所包含的至少一个符号上，使用至少一个相同的第二波束 B5'向网络设备发送用于恢复波束的请求，当终端设备 10 在第二时间窗接收到网络设备 20 发送的用于波束恢复请求的响应时，终端设备 10 可以确定实现了波束恢复。

第二种发送方式可以为：若第一时间窗包括第三单元时间窗和第四单元时间窗，终端设备 10 可以在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备 20 发送用于恢复波束的请求，并在第四单元时间窗所包含的至少一个符号上，使用至少一个不同的波束接收网络设备 20 发送的用于波束恢复请求的响应。

以图 2B 所示的信息传输的示意图为例，终端设备 10 在第三单元时间窗所包含的至少一个符号上，使用多个不同的波束向网络设备 20 发送用于恢复波束的请求，网络设备 20 在第二时间窗内接收到终端设备 10 发送的多个用于恢复波束的请求之后，可以在多个用于恢复波束的请求中确定一个用于恢复波束的请求，网络设备 20 可以使用确定得到的一个用于恢复波束的请求对应的波束，向终端设备 10 发送用于波束恢复请求的响应。终端设备 10 可以按照波束扫描方式检测网络设备 20 发送的用于波束恢复请求的响应，当终端设备 10 接收到网络设备 20 发送的用于波束恢复请求的响应时，终端设备 10 可以确定实现了波束恢复。

相对第一种发送方式，本发明实施例通过第二种发送方式可以使用多个不同的波束向网络设备 20 发送用于恢复波束的请求，可减小时延，提高波束恢复效率。

基于图 1 所示的波束恢复系统的架构示意图，请参见图 3，图 3 是本发明实施例提供的一种波束恢复方法的流程示意图，该方法包括但不限于如下步骤：

步骤 S301：终端设备在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送调度请求。

具体地，当下行链路（Down Link，DL）的波束失效时，终端设备可以在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送调度请求。其中，第一波束可以是网络设备对终端设备配置的波束，例如波束 1。

例如，终端设备可以在第一时间窗中选取一个符号（例如符号 3），并在符号 3 上使用一个波束 1 向网络设备发送调度请求。又如，终端设备可以在第一时间窗中选取一个符号（例如符号 3），并在符号 3 上使用多个波束 1 向网络设备发送调度请求，即终端设备在符号 3 上，在不同方向上使用波束 1 向网络设备发送调度请求。又如，以图 4 所示的信息传输的示意图为例，终端设备可以在第一时间窗中选取多个符号（例如符号 3，符号 4），在符号 3 上使用一个波束 1 向网络设备发送调度请求，并在符号 4 上使用一个波束 1 向网络设备发送调度请求。又如，终端设备可以在第一时间窗中选取多个符号（例如符号 3，符号 4），在符号 3 上使用多个波束 1 向网络设备发送调度请求，并在符号 4 上使用多个波束 1 向网络设备发送调度请求。

本发明实施例中，终端设备在第一时间窗所包含的至少一个符号上，使用多个相同的第一波束向网络设备发送调度请求，可加大子载波间隔。

本发明实施例中，网络设备可以对终端设备配置第一时间窗。其中，第一时间窗的起

始时刻可以是配置有RACH资源的第一个符号，以图4所示的信息传输的示意图为例，配置有RACH资源的第一个符号为符号3，则终端设备可以确定第一时间窗的起始时刻为符号3。

其中，第一时间窗的长度可以是固定长度，例如7个符号，可选的，第一时间窗的长度也可以是网络设备配置的，例如3个符号或者5个符号等。

其中，网络设备可以向终端设备发送长度指示信息，以指示第一时间窗的长度。可选的，可以通过直接法指示第一时间窗的长度，例如长度指示信息为5，则终端设备可以确定第一时间窗的长度为5个符号。可选的，可以通过映射方式描述第一时间窗的长度，例如长度指示信息和第一时间窗的映射关系如表一所示：

表一

长度指示信息	第一时间窗的长度
00	3个符号
01	4个符号
10	5个符号
11	7个符号

通过表一可知，当长度指示信息为二进制00时，终端设备可以确定第一时间窗的长度为3个符号；当长度指示信息为二进制11时，终端设备可以确定第一时间窗的长度为7个符号。需要说明的是，本发明实施例中的长度指示信息和第一时间长度的映射关系包含但不局限于上述方式，研发人员可以结合不同场景进行修改，具体不受本发明实施例的限制。

其中，网络设备可以通过信令对终端设备配置第一时间窗，例如无线资源控制协议（Radio Resource Control，RRC）、媒体介入控制-控制元素协议（Media Access Control-Control Element，MAC-CE）或者下行控制信息协议（Downlink Control Information，DCI）等。

其中，网络设备可以通过向终端设备发送长度指示信息的方式，通知终端设备配置了第一时间窗。

步骤S302：网络设备确定在第二时间窗内接收到的第一个调度请求。

具体地，网络设备可以按照接收RACH波束扫描方式在第二时间窗内接收终端设备发送的调度请求，并确定在第二时间窗内接收到的第一个调度请求。

其中，网络设备可以配置网络设备侧的第二时间窗，第二时间窗所包含的第一个符号可以和第一单元时间窗所包含的第一个符号相同。

其中，第二时间窗的长度可以是固定长度，例如4个符号，可选的，第二时间窗的长度也可以是网络设备配置的，例如3个符号或者5个符号等。

步骤S303：网络设备在第二时间窗内使用确定得到的调度请求对应的波束，向终端设备发送调度请求响应。

具体实现中，网络设备可以获取承载确定得到的调度请求的波束，确定该波束所属波束对所包含的另一波束，在第二时间窗内使用确定得到的波束向终端设备发送调度请求响应。其中，波束对可以包括一个发送端的发射波束和一个接收端的接收波束。例如承载确

定得到的调度请求的波束为波束 1，波束 1 与波束 3 构成一个波束对，则网络设备可以在第二时间窗内使用波束 3 向终端设备发送调度请求响应。

以图 4 所示的信息传输的示意图为例，网络设备可以在第二时间窗所包含的符号 0 上，使用第一波束所属波束对所包含的另一波束向终端设备发送调度请求响应。

可选的，网络设备可以通过 PDCCH 向终端设备发送调度请求响应。例如，终端设备可以在同一子帧接收多个承载在不同 PDCCH 上的 DCI 消息。对于一个 PDCCH 所承载的 DCI 消息，每个 DCI 消息上可以附着一个 CRC。终端设备的 C-RNTI 可以被包含在 CRC 计算之中并隐式传输。则网络设备可以根据该终端设备的 C-RNTI，确定包含该 C-RNTI 的 CRC 所属的 DCI，进而确定承载该 DCI 的 PDCCH，通过确定得到的 PDCCH 向终端设备发送调度请求响应。其中，DCI 可以包括下行调度分配、上行调度请求、功率控制等。

可选的，网络设备可以通过 MAC-CE 向终端设备发送调度请求响应。例如，网络设备可以定义一个新的 MAC-CE，将该 MAC-CE 发送给终端设备，其中该 MAC-CE 可以携带调度请求响应。

可选的，网络设备可以通过 RRC 向终端设备发送调度请求响应。例如，网络设备可以定义一个新的 RRC IE，将该 RRC IE 发送给终端设备，其中该 RRC IE 可以携带调度请求响应。

可选的，网络设备可以通过物理下行共享信道（Physical Downlink Shared Channel，PDSCH）向终端设备发送调度请求响应。

步骤 S304：终端设备在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备发送的调度请求响应。

终端设备可以在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备发送的调度请求响应。例如，若终端设备在第一时间窗所包含的至少一个符号上，使用波束 1 向网络设备发送调度请求，则终端设备可以在第一时间窗所包含的至少一个符号上，使用波束 1 接收网络设备发送的调度请求响应。

相对传统的波束恢复方法中终端设备接收调度请求响应的接收时间与发送调度请求的发送时间间隔至少两个子帧，本发明实施例中终端设备接收调度请求响应的接收时间与发送调度请求的发送时间间隔最多第一时间窗，例如 7 个符号，可降低延迟，提高波束恢复的效率。

在图 3 所描述的方法中，终端设备在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送调度请求，网络设备确定在第二时间窗内接收到的第一个调度请求，网络设备在第二时间窗内使用确定得到的调度请求对应的波束，向终端设备发送调度请求响应，则终端设备在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备发送的调度请求响应，可实现网络设备针对同一终端设备发送的多个调度请求的波束恢复处理，提高波束恢复效率。

基于图 1 所示的波束恢复系统的架构示意图，请参见图 5，图 5 是本发明实施例提供的一种波束恢复方法的流程示意图，该方法包括但不限于如下步骤：

步骤 S501：终端设备在第一时间窗所包含的至少一个符号上，使用至少一个相同的第

一波束向网络设备发送波束失败恢复请求。

具体地，当 DL 波束失效时，终端设备可以在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送波束失败恢复请求。其中，第一波束可以是网络设备对终端设备配置的波束，例如波束 1。

例如，终端设备可以在第一时间窗中选取一个符号（例如符号 3），并在符号 3 上使用一个波束 1 向网络设备发送波束失败恢复请求。又如，终端设备可以在第一时间窗中选取一个符号（例如符号 3），并在符号 3 上使用多个波束 1 向网络设备发送波束失败恢复请求，即终端设备在符号 3 上，在不同方向上使用波束 1 向网络设备发送波束失败恢复请求。又如，以图 4 所示的信息传输的示意图为例，终端设备可以在第一时间窗中选取多个符号（例如符号 3，符号 4），在符号 3 上使用一个波束 1 向网络设备发送波束失败恢复请求，并在符号 4 上使用一个波束 1 向网络设备发送波束失败恢复请求。又如，终端设备可以在第一时间窗中选取多个符号（例如符号 3，符号 4），在符号 3 上使用多个波束 1 向网络设备发送波束失败恢复请求，并在符号 4 上使用多个波束 1 向网络设备发送波束失败恢复请求。

本发明实施例中，终端设备在第一时间窗所包含的至少一个符号上，使用多个相同的第一波束向网络设备发送波束失败恢复请求，可加大子载波间隔。

本发明实施例中，网络设备可以对终端设备配置第一时间窗。其中，第一时间窗的起始时刻可以是配置有 RACH 资源的第一个符号，以图 4 所示的信息传输的示意图为例，配置有 RACH 资源的第一个符号为符号 3，则终端设备可以确定第一时间窗的起始时刻为符号 3。

其中，第一时间窗的长度可以是固定长度，例如 7 个符号，可选的，第一时间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

其中，网络设备可以向终端设备发送长度指示信息，以指示第一时间窗的长度。可选的，可以通过直接法指示第一时间窗的长度，例如长度指示信息为 5，则终端设备可以确定第一时间窗的长度为 5 个符号。可选的，可以通过映射方式描述第一时间窗的长度，例如长度指示信息和第一时间窗的映射关系如表一所示。通过表一可知，当长度指示信息为二进制 00 时，终端设备可以确定第一时间窗的长度为 3 个符号；当长度指示信息为二进制 11 时，终端设备可以确定第一时间窗的长度为 7 个符号。需要说明的是，本发明实施例中的长度指示信息和第一时间长度的映射关系包含但不局限于上述方式，研发人员可以结合不同场景进行修改，具体不受本发明实施例的限制。

其中，网络设备可以通过信令对终端设备配置第一时间窗，例如无线资源控制协议（Radio Resource Control，RRC）、媒体介入控制-控制元素协议（Media Access Control-Control Element，MAC-CE）或者下行控制信息协议（Downlink Control Information，DCI）等。

其中，网络设备可以通过向终端设备发送长度指示信息的方式，通知终端设备配置了第一时间窗。

步骤 S502：网络设备确定在第二时间窗内接收到的第一个波束失败恢复请求。

具体地，网络设备可以按照接收 RACH 波束扫描方式在第二时间窗内接收终端设备发送的波束失败恢复请求，并确定在第二时间窗内接收到的第一个波束失败恢复请求。

其中，网络设备可以配置网络设备侧的第二时间窗，第二时间窗所包含的第一个符号可以和第一单元时间窗所包含的第一个符号相同。

其中，第二时间窗的长度可以是固定长度，例如 4 个符号，可选的，第二时间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

步骤 S503：网络设备在第二时间窗内使用确定得到的波束失败恢复请求对应的波束，向终端设备发送波束失败恢复请求响应。

具体实现中，网络设备可以获取承载确定得到的波束失败恢复请求的波束，确定该波束所属波束对所包含的另一波束，在第二时间窗内使用确定得到的波束向终端设备发送波束失败恢复请求响应。例如承载确定得到的波束失败恢复请求的波束为波束 1，波束 1 与波束 3 构成一个波束对，则网络设备可以在第二时间窗内使用波束 3 向终端设备发送波束失败恢复请求响应。

以图 4 所示的信息传输的示意图为例，网络设备可以在第二时间窗所包含的符号 0 上，使用第一波束所属波束对所包含的另一波束向终端设备发送波束失败恢复请求响应。

可选的，网络设备可以通过 PDCCH 向终端设备发送波束失败恢复请求响应。

可选的，网络设备可以通过 MAC-CE 向终端设备发送波束失败恢复请求响应。

可选的，网络设备可以通过 RRC 向终端设备发送波束失败恢复请求响应。

可选的，网络设备可以通过 PDSCH 向终端设备发送波束失败恢复请求响应。

步骤 S504：终端设备在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备发送的波束失败恢复请求响应。

终端设备可以在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备发送的波束失败恢复请求响应。例如，若终端设备在第一时间窗所包含的至少一个符号上，使用波束 1 向网络设备发送波束失败恢复请求，则终端设备可以在第一时间窗所包含的至少一个符号上，使用波束 1 接收网络设备发送的波束失败恢复请求响应。

相对传统的波束恢复方法中终端设备接收波束失败恢复请求响应的接收时间与发送波束失败恢复请求的发送时间间隔至少两个子帧，本发明实施例中终端设备接收波束失败恢复请求响应的接收时间与发送波束失败恢复请求的发送时间间隔最多第一时间窗，例如 7 个符号，可降低延迟，提高波束恢复的效率。

在图 5 所描述的方法中，终端设备在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送波束失败恢复请求，网络设备确定在第二时间窗内接收到的第一个波束失败恢复请求，网络设备在第二时间窗内使用确定得到的波束失败恢复请求对应的波束，向终端设备发送波束失败恢复请求响应，则终端设备在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备发送的波束失败恢复请求响应，可实现网络设备针对同一终端设备发送的多个波束失败恢复请求的波束恢复处理，提高波束恢复效率。

基于图 1 所示的波束恢复系统的架构示意图，请参见图 6，图 6 是本发明实施例提供的一种波束恢复方法的流程示意图，该方法包括但不限于如下步骤：

步骤 S601：终端设备在第一单元时间窗所包含的至少一个符号上，使用至少一个相同

的第一波束向网络设备发送调度请求。

具体地，当 DL 波束失效时，终端设备可以在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送调度请求。其中，第一波束可以是网络设备对终端设备配置的波束，例如波束 1。

例如，终端设备可以在第一单元时间窗中选取一个符号（例如符号 3），并在符号 3 上使用一个波束 1 向网络设备发送调度请求。又如，终端设备可以在第一单元时间窗中选取一个符号（例如符号 3），并在符号 3 上使用多个波束 1 向网络设备发送调度请求，即终端设备在符号 3 上，在不同方向上使用波束 1 向网络设备发送调度请求。又如，以图 7 所示的信息传输的示意图为例，终端设备可以在第一单元时间窗中选取多个符号（例如符号 3，符号 4），在符号 3 上使用一个波束 1 向网络设备发送调度请求，并在符号 4 上使用一个波束 1 向网络设备发送调度请求。又如，终端设备可以在第一单元时间窗中选取多个符号（例如符号 3，符号 4），在符号 3 上使用多个波束 1 向网络设备发送调度请求，并在符号 4 上使用多个波束 1 向网络设备发送调度请求。

本发明实施例中，终端设备在第一单元时间窗所包含的至少一个符号上，使用多个相同的第一波束向网络设备发送调度请求，可加大子载波间隔。

本发明实施例中，网络设备可以对终端设备配置第一单元时间窗。其中，第一单元时间窗的起始时刻可以是配置有 RACH 资源的第一个符号，以图 7 所示的信息传输的示意图为例，配置有 RACH 资源的第一个符号为符号 3，则终端设备可以确定第一单元时间窗的起始时刻为符号 3。

本发明实施例中，网络设备可以对终端设备配置第二单元时间窗。其中，第二单元时间窗所包含的第一个符号为第一单元时间窗所包含的最后一个符号之后的第一个符号，以图 7 所示的信息传输的示意图为例，第一单元时间窗所包含的最后一个符号为符号 6，则终端设备可以确定第二单元时间窗所包含的第一个符号为符号 0。

其中，第一单元时间窗的长度可以是固定长度，例如 4 个符号，可选的，第一单元时间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

其中，第二单元时间窗的长度可以是固定长度，例如 4 个符号，可选的，第二单元时间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

其中，网络设备可以向终端设备发送第一长度指示信息，以指示第一单元时间窗的长度。可选的，可以通过直接法指示第一单元时间窗的长度。可选的，可以通过映射方式描述第一单元时间窗的长度。

其中，网络设备可以向终端设备发送第二长度指示信息，以指示第二单元时间窗的长度。可选的，可以通过直接法指示第二单元时间窗的长度。可选的，可以通过映射方式描述第二单元时间窗的长度。

其中，网络设备可以通过信令对终端设备配置第一单元时间窗，例如 RRC、MAC-CE 或者 DCI 等。

其中，网络设备可以通过信令对终端设备配置第二单元时间窗，例如 RRC、MAC-CE 或者 DCI 等。

其中，网络设备可以通过向终端设备发送第一长度指示信息的方式，通知终端设备配

置了第一单元时间窗。

其中，网络设备可以通过向终端设备发送第二长度指示信息的方式，通知终端设备配置了第二单元时间窗。

步骤 S602：网络设备在第二时间窗内，在接收到的调度请求中确定一个调度请求。

具体地，网络设备可以按照接收 RACH 波束扫描方式在第二时间窗内接收终端设备发送的调度请求，并在接收到的调度请求中确定一个调度请求。

可选的，网络设备可以确定在第二时间窗内接收到的第一个调度请求。

可选的，网络设备可以确定在第二时间窗内接收到的质量大于预设质量阈值的波束所承载的调度请求。

可选的，网络设备可以确定在第二时间窗内接收到的质量最好的波束所承载的调度请求。

其中，网络设备可以配置网络设备侧的第二时间窗，第二时间窗所包含的第一个符号可以和第一单元时间窗所包含的第一个符号相同。

其中，第二时间窗的长度可以是固定长度，例如 4 个符号，可选的，第二时间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

步骤 S603：网络设备在第二时间窗之后使用确定得到的调度请求对应的波束，向终端设备发送调度请求响应。

具体实现中，网络设备可以获取承载确定得到的调度请求的波束，确定该波束所属波束对所包含的另一波束，在第二时间窗之后使用确定得到的波束向终端设备发送调度请求响应。例如承载确定得到的调度请求的波束为波束 1，波束 1 与波束 3 构成一个波束对，则网络设备可以在第二时间窗之后使用波束 3 向终端设备发送调度请求响应。

以图 7 所示的信息传输的示意图为例，终端设备可以在第二时间窗之后的第一个符号，即符号 0，使用第一波束所属波束对所包含的另一波束向终端设备发送调度请求响应。

可选的，网络设备可以通过 PDCCH 向终端设备发送调度请求响应。

可选的，网络设备可以通过 MAC-CE 向终端设备发送调度请求响应。

可选的，网络设备可以通过 RRC 向终端设备发送调度请求响应。

可选的，网络设备可以通过 PDSCH 向终端设备发送调度请求响应。

步骤 S604：终端设备在第二单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束接收网络设备发送的调度请求响应。

终端设备可以在第二单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束接收网络设备发送的调度请求响应。例如，若终端设备在第一单元时间窗所包含的至少一个符号上，使用波束 1 向网络设备发送调度请求，则终端设备可以在第二单元时间窗所包含的至少一个符号上，使用波束 1 接收网络设备发送的调度请求响应。

相对传统的波束恢复方法中终端设备接收调度请求响应的接收时间与发送调度请求的发送时间间隔至少两个子帧，本发明实施例中终端设备接收调度请求响应的接收时间与发送调度请求的发送时间间隔最多第一时间窗，例如 7 个符号，可降低延迟，提高波束恢复的效率。

在图 6 所描述的方法中，终端设备在第一时间窗所包含的至少一个符号上，使用至少

一个相同的第一波束向网络设备发送调度请求，网络设备确定在第一时间窗内接收到的第一个调度请求，网络设备在第一时间窗内使用确定得到的调度请求对应的波束，向终端设备发送调度请求响应，则终端设备在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备发送的调度请求响应，可实现网络设备针对同一终端设备发送的多个调度请求的波束恢复处理，提高波束恢复效率。

基于图 1 所示的波束恢复系统的架构示意图，请参见图 8，图 8 是本发明实施例提供的一种波束恢复方法的流程示意图，该方法包括但不限于如下步骤：

步骤 S801：终端设备在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送波束失败恢复请求。

具体地，当 DL 波束失效时，终端设备可以在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送波束失败恢复请求。其中，第一波束可以是网络设备对终端设备配置的波束，例如波束 1。

例如，终端设备可以在第一单元时间窗中选取一个符号（例如符号 3），并在符号 3 上使用一个波束 1 向网络设备发送波束失败恢复请求。又如，终端设备可以在第一单元时间窗中选取一个符号（例如符号 3），并在符号 3 上使用多个波束 1 向网络设备发送波束失败恢复请求，即终端设备在符号 3 上，在不同方向上使用波束 1 向网络设备发送波束失败恢复请求。又如，以图 7 所示的信息传输的示意图为例，终端设备可以在第一单元时间窗中选取多个符号（例如符号 3，符号 4），在符号 3 上使用一个波束 1 向网络设备发送波束失败恢复请求，并在符号 4 上使用一个波束 1 向网络设备发送波束失败恢复请求。又如，终端设备可以在第一单元时间窗中选取多个符号（例如符号 3，符号 4），在符号 3 上使用多个波束 1 向网络设备发送波束失败恢复请求，并在符号 4 上使用多个波束 1 向网络设备发送波束失败恢复请求。

本发明实施例中，终端设备在第一单元时间窗所包含的至少一个符号上，使用多个相同的第一波束向网络设备发送波束失败恢复请求，可加大子载波间隔。

本发明实施例中，网络设备可以对终端设备配置第一单元时间窗。其中，第一单元时间窗的起始时刻可以是配置有 RACH 资源的第一个符号，以图 7 所示的信息传输的示意图为例，配置有 RACH 资源的第一个符号为符号 3，则终端设备可以确定第一单元时间窗的起始时刻为符号 3。

本发明实施例中，网络设备可以对终端设备配置第二单元时间窗。其中，第二单元时间窗所包含的第一个符号为第一单元时间窗所包含的最后一个符号之后的第一个符号，以图 7 所示的信息传输的示意图为例，第一单元时间窗所包含的最后一个符号为符号 8，则终端设备可以确定第二单元时间窗所包含的第一个符号为符号 0。

其中，第一单元时间窗的长度可以是固定长度，例如 4 个符号，可选的，第一单元时间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

其中，第二单元时间窗的长度可以是固定长度，例如 4 个符号，可选的，第二单元时间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

其中，网络设备可以向终端设备发送第一长度指示信息，以指示第一单元时间窗的长

度。可选的，可以通过直接法指示第一单元时间窗的长度。可选的，可以通过映射方式描述第一单元时间窗的长度。

其中，网络设备可以向终端设备发送第二长度指示信息，以指示第二单元时间窗的长度。可选的，可以通过直接法指示第二单元时间窗的长度。可选的，可以通过映射方式描述第二单元时间窗的长度。

其中，网络设备可以通过信令对终端设备配置第一单元时间窗，例如 RRC、MAC-CE 或者 DCI 等。

其中，网络设备可以通过信令对终端设备配置第二单元时间窗，例如 RRC、MAC-CE 或者 DCI 等。

其中，网络设备可以通过向终端设备发送第一长度指示信息的方式，通知终端设备配置了第一单元时间窗。

其中，网络设备可以通过向终端设备发送第二长度指示信息的方式，通知终端设备配置了第二单元时间窗。

步骤 S802：网络设备在第二时间窗内，在接收到的波束失败恢复请求中确定一个波束失败恢复请求。

具体地，网络设备可以按照接收 RACH 波束扫描方式在第二时间窗内接收终端设备发送的波束失败恢复请求，并在接收到的波束失败恢复请求中确定一个波束失败恢复请求。

可选的，网络设备可以确定在第二时间窗内接收到的第一个波束失败恢复请求。

可选的，网络设备可以确定在第二时间窗内接收到的质量大于预设质量阈值的波束所承载的波束失败恢复请求。

可选的，网络设备可以确定在第二时间窗内接收到的质量最好的波束所承载的波束失败恢复请求。

其中，网络设备可以配置网络设备侧的第二时间窗，第二时间窗所包含的第一个符号可以和第一时间窗所包含的第一个符号相同。

其中，第二时间窗的长度可以是固定长度，例如 4 个符号，可选的，第二时间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

步骤 S803：网络设备在第二时间窗之后使用确定得到的波束失败恢复请求对应的波束，向终端设备发送波束失败恢复请求响应。

具体实现中，网络设备可以获取承载确定得到的波束失败恢复请求的波束，确定该波束所属波束对所包含的另一波束，在第二时间窗之后使用确定得到的波束向终端设备发送波束失败恢复请求响应。例如承载确定得到的波束失败恢复请求的波束为波束 1，波束 1 与波束 3 构成一个波束对，则网络设备可以在第二时间窗之后使用波束 3 向终端设备发送波束失败恢复请求响应。

以图 7 所示的信息传输的示意图为例，终端设备可以在第二时间窗之后的第一个符号上，使用第一波束所属波束对所包含的另一波束向终端设备发送波束失败恢复请求响应。

可选的，网络设备可以通过 PDCCH 向终端设备发送波束失败恢复请求响应。

可选的，网络设备可以通过 MAC-CE 向终端设备发送波束失败恢复请求响应。

可选的，网络设备可以通过 RRC 向终端设备发送波束失败恢复请求响应。

可选的，网络设备可以通过 PDSCH 向终端设备发送波束失败恢复请求响应。

步骤 S804：终端设备在第二单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束接收网络设备发送的波束失败恢复请求响应。

终端设备可以在第二单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束接收网络设备发送的波束失败恢复请求响应。例如，若终端设备在第一单元时间窗所包含的至少一个符号上，使用波束 1 向网络设备发送波束失败恢复请求，则终端设备可以在第二单元时间窗所包含的至少一个符号上，使用波束 1 接收网络设备发送的波束失败恢复请求响应。

相对传统的波束恢复方法中终端设备接收波束失败恢复请求响应的接收时间与发送波束失败恢复请求的发送时间间隔至少两个子帧，本发明实施例中终端设备接收波束失败恢复请求响应的接收时间与发送波束失败恢复请求的发送时间间隔最多第一时间窗，例如 7 个符号，可降低延迟，提高波束恢复的效率。

在图 8 所描述的方法中，终端设备在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送波束失败恢复请求，网络设备确定在第一时间窗内接收到的第一个波束失败恢复请求，网络设备在第一时间窗内使用确定得到的波束失败恢复请求对应的波束，向终端设备发送波束失败恢复请求响应，则终端设备在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备发送的波束失败恢复请求响应，可实现网络设备针对同一终端设备发送的多个波束失败恢复请求的波束恢复处理，提高波束恢复效率。

基于图 1 所示的波束恢复系统的架构示意图，请参见图 9，图 9 是本发明实施例提供的一种波束恢复方法的流程示意图，该方法包括但不限于如下步骤：

步骤 S901：终端设备在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备发送调度请求。

具体地，当 DL 波束失效时，终端设备可以在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备发送调度请求。其中，网络设备可以对终端设备配置允许的最大波束数量，则终端设备可以使用小于等于最大波束数量的波束向网络设备发送调度请求。

例如，终端设备可以在第三单元时间窗中选取一个符号（例如符号 3），并在符号 3 上使用一个波束 1 向网络设备发送调度请求。又如，终端设备可以在第三单元时间窗中选取一个符号（例如符号 3），并在符号 3 上使用多个不同波束向网络设备发送调度请求，示例性的，终端设备在符号 3 上，分别使用波束 1 和波束 2 向网络设备发送调度请求。又如，以图 10 所示的信息传输的示意图为例，终端设备可以在第三单元时间窗中选取多个符号（例如符号 3，符号 4），在符号 3 上使用一个波束 1 向网络设备发送调度请求，并在符号 4 上使用一个波束 1 向网络设备发送调度请求。又如，终端设备可以在第三单元时间窗中选取多个符号（例如符号 3，符号 4），在符号 3 上使用多个不同波束向网络设备发送调度请求，并在符号 4 上使用多个不同波束向网络设备发送调度请求。

本发明实施例中，终端设备在第三单元时间窗所包含的至少一个符号上，使用多个不

同波束向网络设备发送调度请求，可加大子载波间隔。

本发明实施例中，网络设备可通过 RRC、MAC-CE 或者 DCI 等信令对终端设备配置允许的最大波束数量。其中，同一小区所有终端设备可以配置相同的最大波束数量，或者终端设备集群所包含的所有终端设备可以配置相同的最大波束数量，或者不同终端设备可配置不同的最大波束数量，当不同终端设备配置不同的最大波束数量时，该终端设备需要向网络设备上报该终端设备的能力。其中，可以通过直接法指示最大波束数量。可选的，可以通过映射方法描述最大波束数量。

本发明实施例中，网络设备可以对终端设备配置第三单元时间窗。其中，第三单元时间窗的起始时刻可以是配置有 RACH 资源的第一个符号，以图 10 所示的信息传输的示意图为例，配置有 RACH 资源的第一个符号为符号 3，则终端设备可以确定第三单元时间窗的起始时刻为符号 3。

本发明实施例中，网络设备可以对终端设备配置第四单元时间窗。其中，第四单元时间窗所包含的第一个符号为第三单元时间窗所包含的最后一个符号之后的第一个符号，以图 10 所示的信息传输的示意图为例，第三单元时间窗所包含的最后一个符号为符号 6，则终端设备可以确定第四单元时间窗所包含的第一个符号为符号 0。

其中，第三单元时间窗的长度可以是固定长度，例如 4 个符号，可选的，第三单元时间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

其中，第四单元时间窗的长度可以是固定长度，例如 4 个符号，可选的，第四单元时间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

其中，网络设备可以向终端设备发送第三长度指示信息，以指示第三单元时间窗的长度。可选的，可以通过直接法指示第三单元时间窗的长度。可选的，可以通过映射方式描述第三单元时间窗的长度。

其中，网络设备可以向终端设备发送第四长度指示信息，以指示第四单元时间窗的长度。可选的，可以通过直接法指示第四单元时间窗的长度。可选的，可以通过映射方式描述第四单元时间窗的长度。

其中，网络设备可以通过信令对终端设备配置第三单元时间窗，例如 RRC、MAC-CE 或者 DCI 等。

其中，网络设备可以通过信令对终端设备配置第四单元时间窗，例如 RRC、MAC-CE 或者 DCI 等。

其中，网络设备可以通过向终端设备发送第三长度指示信息的方式，通知终端设备配置了第三单元时间窗。

其中，网络设备可以通过向终端设备发送第四长度指示信息的方式，通知终端设备配置了第四单元时间窗。

步骤 S902：网络设备在第二时间窗内，在接收到的调度请求中确定一个调度请求。

具体地，网络设备可以按照接收 RACH 波束扫描方式在第二时间窗内接收终端设备发送的调度请求，并在接收到的调度请求中确定一个调度请求。

可选的，网络设备可以确定在第二时间窗内接收到的第一个调度请求。

可选的，网络设备可以确定在第二时间窗内接收到的质量大于预设质量阈值的波束所

承载的调度请求。

可选的，网络设备可以确定在第二时间窗内接收到的质量最好的波束所承载的调度请求。

其中，网络设备可以配置网络设备侧的第二时间窗，第二时间窗所包含的第一个符号可以和第三单元时间窗所包含的第一个符号相同。

其中，第二时间窗的长度可以是固定长度，例如 4 个符号，可选的，第二时间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

步骤 S903：网络设备在第二时间窗之后使用确定得到的调度请求对应的波束，向终端设备发送调度请求响应。

具体实现中，网络设备可以获取承载确定得到的调度请求的波束，确定该波束所属波束对所包含的另一波束，在第二时间窗之后使用确定得到的波束向终端设备发送调度请求响应。例如承载确定得到的调度请求的波束为波束 1，波束 1 与波束 3 构成一个波束对，则网络设备可以在第二时间窗之后使用波束 3 向终端设备发送调度请求响应。

以图 10 所示的信息传输的示意图为例，终端设备可以在第二时间窗之后的第一个符号，即符号 0，使用第一波束所属波束对所包含的另一波束向终端设备发送调度请求响应，终端设备还可以在第二时间窗之后的第二个符号，即符号 1，使用第一波束所属波束对所包含的另一波束向终端设备发送调度请求响应。

可选的，网络设备可以通过 PDCCH 向终端设备发送调度请求响应。

可选的，网络设备可以通过 MAC-CE 向终端设备发送调度请求响应。

可选的，网络设备可以通过 RRC 向终端设备发送调度请求响应。

可选的，网络设备可以通过 PDSCH 向终端设备发送调度请求响应。

步骤 S904：终端设备在第四单元时间窗所包含的至少一个符号上，使用至少一个不同的波束接收网络设备发送的调度请求响应。

终端设备可以在第四单元时间窗所包含的至少一个符号上，使用至少一个不同的波束接收网络设备发送的调度请求响应。例如，若终端设备在第三单元时间窗所包含的至少一个符号上，分别使用波束 1 和波束 2 向网络设备发送调度请求，则终端设备可以在第四单元时间窗所包含的至少一个符号上，分别使用波束 1 和波束 2 接收网络设备发送的调度请求响应。

相对传统的波束恢复方法中终端设备接收调度请求响应的接收时间与发送调度请求的发送时间间隔至少两个子帧，本发明实施例中终端设备接收调度请求响应的接收时间与发送调度请求的发送时间间隔最多第一时间窗，例如 7 个符号，可降低延迟，提高波束恢复的效率。

在图 9 所描述的方法中，终端设备在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备发送调度请求，网络设备在第二时间窗内，在接收到的调度请求中确定一个调度请求，网络设备在第二时间窗之后使用确定得到的调度请求对应的波束，向终端设备发送调度请求响应，终端设备在第四单元时间窗所包含的至少一个符号上，使用至少一个不同的波束接收网络设备发送的调度请求响应，可实现网络设备针对同一终端设备发送的多个波束失败恢复请求的波束恢复处理，提高波束恢复效率。

基于图 1 所示的波束恢复系统的架构示意图，请参见图 11，图 11 是本发明实施例提供的一种波束恢复方法的流程示意图，该方法包括但不限于如下步骤：

步骤 S1101：终端设备在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备发送波束失败恢复请求。

具体地，当 DL 波束失效时，终端设备可以在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备发送波束失败恢复请求。其中，网络设备可以对终端设备配置允许的最大波束数量，则终端设备可以使用小于等于最大波束数量的波束向网络设备发送波束失败恢复请求。

例如，终端设备可以在第三单元时间窗中选取一个符号（例如符号 3），并在符号 3 上使用一个波束 1 向网络设备发送波束失败恢复请求。又如，终端设备可以在第三单元时间窗中选取一个符号（例如符号 3），并在符号 3 上使用多个不同波束向网络设备发送波束失败恢复请求，示例性的，终端设备在符号 3 上，分别使用波束 1 和波束 2 向网络设备发送波束失败恢复请求。又如，以图 10 所示的信息传输的示意图为例，终端设备可以在第三单元时间窗中选取多个符号（例如符号 3，符号 4），在符号 3 上使用一个波束 1 向网络设备发送波束失败恢复请求，并在符号 4 上使用一个波束 1 向网络设备发送波束失败恢复请求。又如，终端设备可以在第三单元时间窗中选取多个符号（例如符号 3，符号 4），在符号 3 上使用多个不同波束向网络设备发送波束失败恢复请求，并在符号 4 上使用多个不同波束向网络设备发送波束失败恢复请求。

本发明实施例中，终端设备在第三单元时间窗所包含的至少一个符号上，使用多个不同波束向网络设备发送波束失败恢复请求，可加大子载波间隔。

本发明实施例中，网络设备可通过 RRC、MAC-CE 或者 DCI 等信令对终端设备配置允许的最大波束数量。其中，同一小区所有终端设备可以配置相同的最大波束数量，或者终端设备集群所包含的所有终端设备可以配置相同的最大波束数量，或者不同终端设备可配置不同的最大波束数量，当不同终端设备配置不同的最大波束数量时，该终端设备需要向网络设备上报该终端设备的能力。其中，可以通过直接法指示最大波束数量。可选的，可以通过映射方法描述最大波束数量。

本发明实施例中，网络设备可以对终端设备配置第三单元时间窗。其中，第三单元时间窗的起始时刻可以是配置有 RACH 资源的第一个符号，以图 10 所示的信息传输的示意图为例，配置有 RACH 资源的第一个符号为符号 3，则终端设备可以确定第三单元时间窗的起始时刻为符号 3。

本发明实施例中，网络设备可以对终端设备配置第四单元时间窗。其中，第四单元时间窗所包含的第一个符号为第三单元时间窗所包含的最后一个符号之后的第一个符号，以图 10 所示的信息传输的示意图为例，第三单元时间窗所包含的最后一个符号为符号 6，则终端设备可以确定第四单元时间窗所包含的第一个符号为符号 0。

其中，第三单元时间窗的长度可以是固定长度，例如 4 个符号，可选的，第三单元时间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

其中，第四单元时间窗的长度可以是固定长度，例如 4 个符号，可选的，第四单元时

间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

其中，网络设备可以向终端设备发送第三长度指示信息，以指示第三单元时间窗的长度。可选的，可以通过直接法指示第三单元时间窗的长度。可选的，可以通过映射方式描述第三单元时间窗的长度。

其中，网络设备可以向终端设备发送第四长度指示信息，以指示第四单元时间窗的长度。可选的，可以通过直接法指示第四单元时间窗的长度。可选的，可以通过映射方式描述第四单元时间窗的长度。

其中，网络设备可以通过信令对终端设备配置第三单元时间窗，例如 RRC、MAC-CE 或者 DCI 等。

其中，网络设备可以通过信令对终端设备配置第四单元时间窗，例如 RRC、MAC-CE 或者 DCI 等。

其中，网络设备可以通过向终端设备发送第三长度指示信息的方式，通知终端设备配置了第三单元时间窗。

其中，网络设备可以通过向终端设备发送第四长度指示信息的方式，通知终端设备配置了第四单元时间窗。

步骤 S1102：网络设备在第二时间窗内，在接收到的波束失败恢复请求中确定一个波束失败恢复请求。

具体地，网络设备可以按照接收 RACH 波束扫描方式在第二时间窗内接收终端设备发送的波束失败恢复请求，并在接收到的波束失败恢复请求中确定一个波束失败恢复请求。

可选的，网络设备可以确定在第二时间窗内接收到的第一个波束失败恢复请求。

可选的，网络设备可以确定在第二时间窗内接收到的质量大于预设质量阈值的波束所承载的波束失败恢复请求。

可选的，网络设备可以确定在第二时间窗内接收到的质量最好的波束所承载的波束失败恢复请求。

其中，网络设备可以配置网络设备侧的第二时间窗，第二时间窗所包含的第一个符号可以和第三单元时间窗所包含的第一个符号相同。

其中，第二时间窗的长度可以是固定长度，例如 4 个符号，可选的，第二时间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

步骤 S1103：网络设备在第二时间窗之后使用确定得到的波束失败恢复请求对应的波束，向终端设备发送波束失败恢复请求响应。

具体实现中，网络设备可以获取承载确定得到的波束失败恢复请求的波束，确定该波束所属波束对所包含的另一波束，在第二时间窗之后使用确定得到的波束向终端设备发送波束失败恢复请求响应。例如承载确定得到的波束失败恢复请求的波束为波束 1，波束 1 与波束 3 构成一个波束对，则网络设备可以在第二时间窗之后使用波束 3 向终端设备发送波束失败恢复请求响应。

以图 10 所示的信息传输的示意图为例，终端设备可以在第二时间窗之后的第一个符号，即符号 0，使用第一波束所属波束对所包含的另一波束向终端设备发送波束失败恢复请求响应，终端设备还可以在第二时间窗之后的第二个符号，即符号 1，使用第一波束所

属波束对所包含的另一波束向终端设备发送波束失败恢复请求响应。

可选的，网络设备可以通过 PDCCH 向终端设备发送波束失败恢复请求响应。

可选的，网络设备可以通过 MAC-CE 向终端设备发送波束失败恢复请求响应。

可选的，网络设备可以通过 RRC 向终端设备发送波束失败恢复请求响应。

可选的，网络设备可以通过 PDSCH 向终端设备发送波束失败恢复请求响应。

步骤 S1104：终端设备在第四单元时间窗所包含的至少一个符号上，使用至少一个不同的波束接收网络设备发送的波束失败恢复请求响应。

终端设备可以在第四单元时间窗所包含的至少一个符号上，使用至少一个不同的波束接收网络设备发送的波束失败恢复请求响应。例如，若终端设备在第三单元时间窗所包含的至少一个符号上，分别使用波束 1 和波束 2 向网络设备发送波束失败恢复请求，则终端设备可以在第四单元时间窗所包含的至少一个符号上，分别使用波束 1 和波束 2 接收网络设备发送的波束失败恢复请求响应。

相对传统的波束恢复方法中终端设备接收波束失败恢复请求响应的接收时间与发送波束失败恢复请求的发送时间间隔至少两个子帧，本发明实施例中终端设备接收波束失败恢复请求响应的接收时间与发送波束失败恢复请求的发送时间间隔最多第一时间窗，例如 7 个符号，可降低延迟，提高波束恢复的效率。

在图 11 所描述的方法中，终端设备在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备发送波束失败恢复请求，网络设备在第二时间窗内，在接收到的波束失败恢复请求中确定一个波束失败恢复请求，网络设备在第二时间窗之后使用确定得到的波束失败恢复请求对应的波束，向终端设备发送波束失败恢复请求响应，终端设备在第四单元时间窗所包含的至少一个符号上，使用至少一个不同的波束接收网络设备发送的波束失败恢复请求响应，可实现网络设备针对同一终端设备发送的多个波束失败恢复请求的波束恢复处理，提高波束恢复效率。

上述详细阐述了本发明实施例的方法，下面提供了本发明实施例的装置。

请参见图 12，图 12 是本发明实施例提供的一种波束恢复装置的结构示意图，该波束恢复装置可以包括发送模块 1201 以及接收模块 1202，其中，各个模块的详细描述如下。

发送模块 1201，用于在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

接收模块 1202，用于在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

可选的，所述发送模块 1201，具体用于在所述第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

可选的，所述接收模块 1202，具体用于在所述第一时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

可选的，所述第一时间窗包括第一单元时间窗和第二单元时间窗，所述第二单元时间窗所包含的第一个符号为所述第一单元时间窗所包含的最后一个符号之后的第一个符号；

所述发送模块 1201，具体用于在所述第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

可选的，所述接收模块 1202，具体用于在所述第二单元时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

可选的，本发明实施例中的波束恢复装置还可以包括：

确定模块 1203，用于当在所述第一时间窗内未接收到所述用于波束恢复请求的响应时，所述波束恢复装置确定所述网络设备对所述波束恢复装置配置的第三时间窗；

所述发送模块 1201，还用于在所述第三时间窗所包含的至少一个符号上，使用至少一个相同的第二波束向所述网络设备发送所述用于恢复波束的请求。

可选的，所述第一时间窗包括第三单元时间窗和第四单元时间窗，所述第四单元时间窗所包含的第一个符号为所述第三单元时间窗所包含的最后一个符号之后的第一个符号；

所述发送模块 1201，具体用于在所述第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向所述网络设备发送所述用于恢复波束的请求。

可选的，所述接收模块 1202，具体用于在所述第四单元时间窗所包含的至少一个符号上，使用所述至少一个不同的波束接收所述用于波束恢复请求的响应。

可选的，所述发送模块 1201，具体用于基于所述网络设备对所述波束恢复装置配置的波束请求指示信息，在所述第一时间窗内使用所述至少一个波束向所述网络设备发送所述用于恢复波束的请求，所述波束请求指示信息用于指示所述用于恢复波束的请求的发送方式。

可选的，所述第一时间窗所包含的第一个符号为第一个配置有 RACH 资源的符号。

可选的，所述第一时间窗的长度是所述网络设备配置的。

可选的，所述第一时间窗所包含的符号的数量总和是根据所述网络设备对所述波束恢复装置配置的最大波束数量确定的。

需要说明的是，本发明实施例可具体参见图 3、5、6、8、9、11 所示实施例的相关描述，不再赘述。

本发明实施例中的波束恢复装置和方法实施例中的终端设备完全对应，由相应的模块执行相应的步骤，例如发送模块 1201 执行方法实施例中发送的步骤，接收模块 1202 执行方法实施例中接收的步骤，除发送接收外的其它步骤可以由确定模块 1203 或处理器执行。具体模块的功能可以参考相应的方法实施例，不再详述。

在图 12 所描述的波束恢复装置中，发送模块 1201 在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，接收模块 1202 在第一时间窗内使用至少一个波束接收网络设备发送的用于波束恢复请求的响应，可实现网络设备针对同一波束恢复装置发送的多个用于恢复波束的请求的波束恢复处理，提高波束恢复效率。

请参见图 13，图 13 是本发明实施例提供的一种终端设备，该终端设备包括处理器 1301、存储器 1302 以及收发器 1303，所述处理器 1301、存储器 1302 以及收发器 1303 通过总线相互连接。

存储器 1302 包括但不限于是随机存储记忆体（Random Access Memory，RAM）、只读

存储器（Read-Only Memory，ROM）、可擦除可编程只读存储器（Erasable Programmable Read Only Memory，EPROM）、或便携式只读存储器（Compact Disc Read-Only Memory，CD-ROM），该存储器 1302 用于存储相关指令及数据，例如用于恢复波束的请求等。收发器 1303 用于接收和发送数据，例如使用至少一个波束向网络设备发送用于恢复波束的请求，或者使用至少一个波束接收网络设备发送的用于波束恢复请求的响应等。存储器 1302 可以是一个单独的器件，也可以集成在处理器 1301 中。

处理器 1301 可以是一个或多个中央处理器（Central Processing Unit，CPU），或者一个或多个微控制单元（Microcontroller Unit，MCU）。在处理器 1301 是一个 CPU 的情况下，该 CPU 可以是单核 CPU，也可以是多核 CPU。其中，处理器 1301 可结合图 12 所示的波束恢复装置。

应理解，上述的收发器 1303 可以包括发射机和接收机。收发器 1303 还可以进一步包括天线，天线的数量可以为一个或多个。

上述的各个器件或部分器件可以集成到芯片中实现，如集成到基带芯片中实现。

该终端设备中的处理器 1301 用于读取所述存储器 1302 中存储的程序代码，执行以下操作：

通过收发器 1303 在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

通过收发器 1303 在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

可选的，处理器 1301 在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，具体可以为：

在所述第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

可选的，处理器 1301 在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，具体可以为：

在所述第一时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

可选的，所述第一时间窗包括第一单元时间窗和第二单元时间窗，所述第二单元时间窗所包含的第一个符号为所述第一单元时间窗所包含的最后一个符号之后的第一个符号；

处理器 1301 在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，具体可以为：

在所述第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

可选的，处理器 1301 在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，具体可以为：

在所述第二单元时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

可选的，处理器 1301 还可以执行以下操作：

当在所述第一时间窗内未接收到所述用于波束恢复请求的响应时，确定所述网络设备对所述终端设备配置的第三时间窗；

在所述第三时间窗所包含的至少一个符号上，使用至少一个相同的第二波束向所述网络设备发送所述用于恢复波束的请求。

可选的，所述第一时间窗包括第三单元时间窗和第四单元时间窗，所述第四单元时间窗所包含的第一个符号为所述第三单元时间窗所包含的最后一个符号之后的第一个符号；

处理器 1301 在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，具体可以为：

在所述第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向所述网络设备发送所述用于恢复波束的请求。

可选的，处理器 1301 在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，具体可以为：

在所述第四单元时间窗所包含的至少一个符号上，使用所述至少一个不同的波束接收所述用于波束恢复请求的响应。

可选的，处理器 1301 在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，具体可以为：

基于所述网络设备对所述终端设备配置的波束请求指示信息，在所述第一时间窗内使用所述至少一个波束向所述网络设备发送所述用于恢复波束的请求，所述波束请求指示信息用于指示所述用于恢复波束的请求的发送方式。

可选的，所述第一时间窗所包含的第一个符号为第一个配置有 RACH 资源的符号。

可选的，所述第一时间窗的长度是所述网络设备配置的。

可选的，所述第一时间窗所包含的符号的数量总和是根据所述网络设备对所述终端设备配置的最大波束数量确定的。

需要说明的是，本发明实施例可具体参见图 3、5、6、8、9、11 所示实施例的相关描述，不再赘述。

在图 13 所描述的终端设备中，处理器 1301 在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，并在第一时间窗内使用至少一个波束接收网络设备发送的用于波束恢复请求的响应，可实现网络设备针对同一终端设备发送的多个用于恢复波束的请求的波束恢复处理，提高波束恢复效率。

请参见图 14，图 14 是本发明实施例提供的一种波束恢复装置的结构示意图，该波束恢复装置可以包括接收模块 1401、确定模块 1402 以及发送模块 1403，其中，各个模块的详细描述如下。

接收模块 1401，用于接收终端设备在第一时间窗内使用至少一个波束发送的用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

确定模块 1402，用于在第二时间窗内，在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求；

发送模块 1403，用于使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

可选的，所述确定模块 1402，具体用于响应在所述第二时间窗内接收到的质量最好的波束所承载的用于恢复波束的请求，所述第二时间窗所包含的第一个符号与所述第一时间窗所包含的第一个符号相同。

可选的，所述确定模块 1402，具体用于响应在所述第二时间窗内接收到的第一个用于恢复波束的请求。

可选的，所述发送模块 1403，具体用于在所述第二时间窗内使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应。

可选的，所述发送模块 1403，具体用于在所述第二时间窗之外使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应。

需要说明的是，本发明实施例可具体参见图 3、5、6、8、9、11 所示实施例的相关描述，不再赘述。

本发明实施例中的波束恢复装置和方法实施例中的终端设备完全对应，由相应的模块执行相应的步骤，例如发送模块 1403 执行方法实施例中发送的步骤，接收模块 1401 执行方法实施例中接收的步骤，除发送接收外的其它步骤可以由确定模块 1402 或处理器执行。具体模块的功能可以参考相应的方法实施例，不再详述。

在图 14 所描述的波束恢复装置中，接收模块 1401 接收终端设备在第一时间窗内使用至少一个波束发送的用于恢复波束的请求，确定模块 1402 在第二时间窗内，在接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，发送模块 1403 使用确定得到的用于恢复波束的请求对应的波束，向终端设备发送用于波束恢复请求的响应，可实现网络设备针对同一波束恢复装置发送的多个用于恢复波束的请求的波束恢复处理，提高波束恢复效率。

请参见图 15，图 15 是本发明实施例提供的一种网络设备，该网络设备包括处理器 1501、存储器 1502 以及收发器 1503，所述处理器 1501、存储器 1502 以及收发器 1503 通过总线相互连接。

存储器 1502 包括但不限于是 RAM、ROM、EPROM、或 CD-ROM，该存储器 1502 用于存储相关指令及数据，例如用于恢复波束的请求等。收发器 1503 用于接收和发送数据，例如接收终端设备使用至少一个波束发送的用于恢复波束的请求，或者使用确定得到的用于恢复波束的请求对应的波束，向终端设备发送用于波束恢复请求的响应等。存储器 1502 可以是一个单独的器件，也可以集成在处理器 1501 中。

处理器 1501 可以是一个或多个 CPU，或者一个或多个 MCU。在处理器 1501 是一个 CPU 的情况下，该 CPU 可以是单核 CPU，也可以是多核 CPU。其中，处理器 1501 可结合图 14 所示的波束恢复装置。

应理解，上述的收发器 1503 可以包括发射机和接收机。收发器 1503 还可以进一步包括天线，天线的数量可以为一个或多个。

该网络设备中的处理器 1501 用于读取所述存储器 1502 中存储的程序代码，执行以下

操作：

通过收发器 1503 接收终端设备在第一时间窗内使用至少一个波束发送的用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

在第二时间窗内，在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求；

通过收发器 1503 使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

可选的，处理器 1501 在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，具体可以为：

响应在所述第二时间窗内接收到的质量最好的波束所承载的用于恢复波束的请求，所述第二时间窗所包含的第一个符号与所述第一时间窗所包含的第一个符号相同。

可选的，处理器 1501 在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，具体可以为：

响应在所述第二时间窗内接收到的第一个用于恢复波束的请求。

可选的，处理器 1501 使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，具体可以为：

在所述第二时间窗内使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应。

可选的，处理器 1501 使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，具体可以为：

在所述第二时间窗之外使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应。

在图 15 所描述的网络设备中，处理器 1501 接收终端设备在第一时间窗内使用至少一个波束发送的用于恢复波束的请求，在第二时间窗内，在接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，并使用确定得到的用于恢复波束的请求对应的波束，向终端设备发送用于波束恢复请求的响应，可实现网络设备针对同一终端设备发送的多个用于恢复波束的请求的波束恢复处理，提高波束恢复效率。

请参见图 16，图 16 是本发明实施例提供的一种波束恢复系统，该波束恢复系统可以包括图 13 所示的终端设备 1601 和图 15 所示的网络设备 1602，具体可以参见图 15、16 的描述，本发明实施例不再赘述。

本申请实施例还提供了一种通信芯片，其中存储有指令，当其在终端设备 1601 上运行时，使得所述通信芯片执行上述图 13 中的各种实现方式中终端设备对应的方法。

本申请实施例还提供了一种通信芯片，其中存储有指令，当其在网络设备 1602 上运行时，使得所述通信芯片执行上述图 15 中的各种实现方式中终端设备对应的方法。

上述各个方案的网络设备及终端设备具有实现上述方法中网络设备及终端设备执行的相应步骤的功能；所述功能可以通过硬件实现，也可以通过硬件执行相应的软件实现。所

述硬件或软件包括一个或多个与上述功能相对应的模块；例如发送模块可以由发射机替代，接收模块可以由接收机替代，其它模块，如处理模块等可以由处理器替代，分别执行各个方法实施例中的发送操作、接收操作以及相关的处理操作。

本领域普通技术人员可以理解实现上述实施例方法中的全部或部分流程，该流程可以由计算机程序来指令相关的硬件完成，该程序可存储于计算机可读取存储介质中，该程序在执行时，可包括如上述各方法实施例的流程。而前述的存储介质包括：ROM 或随机存储记忆体 RAM、磁碟或者光盘等各种可存储程序代码的介质。

在上述实施例中，可以全部或部分地通过软件、硬件、固件或者其任意组合来实现。当使用软件实现时，可以全部或部分地以计算机程序产品的形式实现。所述计算机程序产品包括一个或多个计算机指令。在计算机上加载和执行所述计算机程序指令时，全部或部分地产生按照本申请实施例所述的流程或功能。所述计算机可以是通用计算机、专用计算机、计算机网络、或者其他可编程装置。所述计算机指令可以存储在计算机可读存储介质中，或者从一个计算机可读存储介质向另一个计算机可读存储介质传输，例如，所述计算机指令可以从一个网站站点、计算机、服务器或数据中心通过有线（例如同轴电缆、光纤、数字用户线（DSL））或无线（例如红外、无线、微波等）方式向另一个网站站点、计算机、服务器或数据中心进行传输。所述计算机可读存储介质可以是计算机能够存取的任何可用介质或者是包含一个或多个可用介质集成的服务器、数据中心等数据存储设备。所述可用介质可以是磁性介质，(例如，软盘、硬盘、磁带)、光介质(例如，DVD)、或者半导体介质（例如固态硬盘 Solid State Disk (SSD)）等。

权 利 要 求

1、一种波束恢复方法，其特征在于，所述方法包括：

终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

所述终端设备在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

2、如权利要求 1 所述的方法，其特征在于，所述终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，包括：

所述终端设备在所述第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

3、如权利要求 2 所述的方法，其特征在于，所述终端设备在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，包括：

所述终端设备在所述第一时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

4、如权利要求 1 所述的方法，其特征在于，所述第一时间窗包括第一单元时间窗和第二单元时间窗，所述第二单元时间窗所包含的第一个符号为所述第一单元时间窗所包含的最后一个符号之后的第一个符号；

所述终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，包括：

所述终端设备在所述第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

5、如权利要求 4 所述的方法，其特征在于，所述终端设备在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，包括：

所述终端设备在所述第二单元时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

6、如权利要求 2~5 任一项所述的方法，其特征在于，所述方法还包括：

当在所述第一时间窗内未接收到所述用于波束恢复请求的响应时，所述终端设备确定所述网络设备对所述终端设备配置的第三时间窗；

所述终端设备在所述第三时间窗所包含的至少一个符号上，使用至少一个相同的第二波束向所述网络设备发送所述用于恢复波束的请求。

7、如权利要求 1 所述的方法，其特征在于，所述第一时间窗包括第三单元时间窗和第四单元时间窗，所述第四单元时间窗所包含的第一个符号为所述第三单元时间窗所包含的最后一个符号之后的第一个符号；

所述终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，包括：

所述终端设备在所述第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向所述网络设备发送所述用于恢复波束的请求。

8、如权利要求 7 所述的方法，其特征在于，所述终端设备在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，包括：

所述终端设备在所述第四单元时间窗所包含的至少一个符号上，使用所述至少一个不同的波束接收所述用于波束恢复请求的响应。

9、如权利要求 1~8 任一项所述的方法，其特征在于，所述终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，包括：

所述终端设备基于所述网络设备对所述终端设备配置的波束请求指示信息，在所述第一时间窗内使用所述至少一个波束向所述网络设备发送所述用于恢复波束的请求，所述波束请求指示信息用于指示所述用于恢复波束的请求的发送方式。

10、一种波束恢复方法，其特征在于，所述方法包括：

网络设备接收终端设备在第一时间窗内使用至少一个波束发送的用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

所述网络设备在第二时间窗内，在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求；

所述网络设备使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

11、如权利要求 10 所述的方法，其特征在于，所述网络设备在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，包括：

所述网络设备响应在所述第二时间窗内接收到的质量最好的波束所承载的用于恢复波束的请求，所述第二时间窗所包含的第一个符号与所述第一时间窗所包含的第一个符号相同。

12、如权利要求 10 所述的方法，其特征在于，所述网络设备在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，包括：

所述网络设备响应在所述第二时间窗内接收到的第一个用于恢复波束的请求。

13、如权利要求 10~12 任一项所述的方法，其特征在于，所述网络设备使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，包括：

所述网络设备在所述第二时间窗内使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应。

14、如权利要求 10~12 任一项所述的方法，其特征在于，所述网络设备使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，包括：

所述网络设备在所述第二时间窗之外使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应。

15、一种波束恢复装置，其特征在于，所述装置包括：

发送模块，用于在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

接收模块，用于在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

16、如权利要求 15 所述的装置，其特征在于，所述发送模块，具体用于：

在所述第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

17、如权利要求 16 所述的装置，其特征在于，

所述接收模块，具体用于在所述第一时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

18、如权利要求 15 所述的装置，其特征在于，所述第一时间窗包括第一单元时间窗和第二单元时间窗，所述第二单元时间窗所包含的第一个符号为所述第一单元时间窗所包含的最后一个符号之后的第一个符号；

所述发送模块，具体用于在所述第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

19、如权利要求 18 所述的装置，其特征在于，

所述接收模块，具体用于在所述第二单元时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

20、如权利要求 16~19 任一项所述的装置，其特征在于，所述装置还包括：

确定模块，用于当在所述第一时间窗内未接收到所述用于波束恢复请求的响应时，所述终端设备确定所述网络设备对所述终端设备配置的第三时间窗；

所述发送模块，还用于在所述第三时间窗所包含的至少一个符号上，使用至少一个相同的第二波束向所述网络设备发送所述用于恢复波束的请求。

21、如权利要求 15 所述的装置，其特征在于，所述第一时间窗包括第三单元时间窗和第四单元时间窗，所述第四单元时间窗所包含的第一个符号为所述第三单元时间窗所包含的最后一个符号之后的第一个符号；

所述发送模块，具体用于在所述第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向所述网络设备发送所述用于恢复波束的请求。

22、如权利要求 21 所述的装置，其特征在于，

所述接收模块，具体用于在所述第四单元时间窗所包含的至少一个符号上，使用所述至少一个不同的波束接收所述用于波束恢复请求的响应。

23、如权利要求 15~22 任一项所述的装置，其特征在于，

所述发送模块，具体用于基于所述网络设备对所述终端设备配置的波束请求指示信息，在所述第一时间窗内使用所述至少一个波束向所述网络设备发送所述用于恢复波束的请求，所述波束请求指示信息用于指示所述用于恢复波束的请求的发送方式。

24、一种波束恢复装置，其特征在于，所述装置包括：

接收模块，用于接收终端设备在第一时间窗内使用至少一个波束发送的用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

确定模块，用于在第二时间窗内，在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求；

发送模块，用于使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

25、如权利要求 24 所述的装置，其特征在于，

所述确定模块，具体用于响应在所述第二时间窗内接收到的质量最好的波束所承载的用于恢复波束的请求，所述第二时间窗所包含的第一个符号与所述第一时间窗所包含的第一个符号相同。

26、如权利要求 24 所述的装置，其特征在于，

所述确定模块，具体用于响应在所述第二时间窗内接收到的第一个用于恢复波束的请求。

27、如权利要求 24~26 任一项所述的装置，其特征在于，

所述发送模块，具体用于在所述第二时间窗内使用确定得到的用于恢复波束的请求对

应的波束，向所述终端设备发送用于波束恢复请求的响应。

28、如权利要求 24~26 任一项所述的装置，其特征在于，

所述发送模块，具体用于在所述第二时间窗之外使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应。

经修改的权利要求
国际局收到日：2018年08月17日（17.08.2018）

1、一种波束恢复方法，其特征在于，所述方法包括：

终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

所述终端设备在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

2、如权利要求 1 所述的方法，其特征在于，所述终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，包括：

所述终端设备在所述第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

3、如权利要求 2 所述的方法，其特征在于，所述终端设备在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，包括：

所述终端设备在所述第一时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

4、如权利要求 1 所述的方法，其特征在于，所述第一时间窗包括第一单元时间窗和第二单元时间窗，所述第二单元时间窗所包含的第一个符号为所述第一单元时间窗所包含的最后一个符号之后的第一个符号；

所述终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，包括：

所述终端设备在所述第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

5、如权利要求 4 所述的方法，其特征在于，所述终端设备在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，包括：

所述终端设备在所述第二单元时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

6、如权利要求 2~5 任一项所述的方法，其特征在于，所述方法还包括：

当在所述第一时间窗内未接收到所述用于波束恢复请求的响应时，所述终端设备确定所述网络设备对所述终端设备配置的第三时间窗；

所述终端设备在所述第三时间窗所包含的至少一个符号上，使用至少一个相同的第二波束向所述网络设备发送所述用于恢复波束的请求。

7、如权利要求 1 所述的方法，其特征在于，所述第一时间窗包括第三单元时间窗和第四单元时间窗，所述第四单元时间窗所包含的第一个符号为所述第三单元时间窗所包含的最后一个符号之后的第一个符号；

所述终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，包括：

所述终端设备在所述第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向所述网络设备发送所述用于恢复波束的请求。

8、如权利要求 7 所述的方法，其特征在于，所述终端设备在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，包括：

所述终端设备在所述第四单元时间窗所包含的至少一个符号上，使用所述至少一个不同的波束接收所述用于波束恢复请求的响应。

9、如权利要求 1~8 任一项所述的方法，其特征在于，所述终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，包括：

所述终端设备基于所述网络设备对所述终端设备配置的波束请求指示信息，在所述第一时间窗内使用所述至少一个波束向所述网络设备发送所述用于恢复波束的请求，所述波束请求指示信息用于指示所述用于恢复波束的请求的发送方式。

10、一种波束恢复方法，其特征在于，所述方法包括：

网络设备接收终端设备在第一时间窗内使用至少一个波束发送的用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

所述网络设备在第二时间窗内，在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求；

所述网络设备使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

11、如权利要求 10 所述的方法，其特征在于，所述网络设备在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，包括：

所述网络设备响应在所述第二时间窗内接收到的质量最好的波束所承载的用于恢复波束的请求，所述第二时间窗所包含的第一个符号与所述第一时间窗所包含的第一个符号相同。

12、如权利要求 10 所述的方法，其特征在于，所述网络设备在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，包括：

所述网络设备响应在所述第二时间窗内接收到的第一个用于恢复波束的请求。

13、如权利要求 10~12 任一项所述的方法，其特征在于，所述网络设备使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，包括：

所述网络设备在所述第二时间窗内使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应。

14、如权利要求 10~12 任一项所述的方法，其特征在于，所述网络设备使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，包括：

所述网络设备在所述第二时间窗之外使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应。

15、一种波束恢复装置，其特征在于，所述装置包括：

发送模块，用于在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

接收模块，用于在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

16、如权利要求 15 所述的装置，其特征在于，所述发送模块，具体用于：

在所述第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

17、如权利要求 16 所述的装置，其特征在于，

所述接收模块，具体用于在所述第一时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

18、如权利要求 15 所述的装置，其特征在于，所述第一时间窗包括第一单元时间窗和第二单元时间窗，所述第二单元时间窗所包含的第一个符号为所述第一单元时间窗所包含的最后一个符号之后的第一个符号；

所述发送模块，具体用于在所述第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

19、如权利要求 18 所述的装置，其特征在于，

所述接收模块，具体用于在所述第二单元时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

20、如权利要求 16~19 任一项所述的装置，其特征在于，所述装置还包括：

确定模块，用于当在所述第一时间窗内未接收到所述用于波束恢复请求的响应时，所述终端设备确定所述网络设备对所述终端设备配置的第三时间窗；

所述发送模块，还用于在所述第三时间窗所包含的至少一个符号上，使用至少一个相同的第二波束向所述网络设备发送所述用于恢复波束的请求。

21、如权利要求 15 所述的装置，其特征在于，所述第一时间窗包括第三单元时间窗和第四单元时间窗，所述第四单元时间窗所包含的第一个符号为所述第三单元时间窗所包含的最后一个符号之后的第一个符号；

所述发送模块，具体用于在所述第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向所述网络设备发送所述用于恢复波束的请求。

22、如权利要求 21 所述的装置，其特征在于，

所述接收模块，具体用于在所述第四单元时间窗所包含的至少一个符号上，使用所述至少一个不同的波束接收所述用于波束恢复请求的响应。

23、如权利要求 15~22 任一项所述的装置，其特征在于，

所述发送模块，具体用于基于所述网络设备对所述终端设备配置的波束请求指示信息，在所述第一时间窗内使用所述至少一个波束向所述网络设备发送所述用于恢复波束的请求，所述波束请求指示信息用于指示所述用于恢复波束的请求的发送方式。

24、一种波束恢复装置，其特征在于，所述装置包括：

接收模块，用于接收终端设备在第一时间窗内使用至少一个波束发送的用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

确定模块，用于在第二时间窗内，在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求；

发送模块，用于使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

25、如权利要求 24 所述的装置，其特征在于，

所述确定模块，具体用于响应在所述第二时间窗内接收到的质量最好的波束所承载的用于恢复波束的请求，所述第二时间窗所包含的第一个符号与所述第一时间窗所包含的第一个符号相同。

26、如权利要求 24 所述的装置，其特征在于，

所述确定模块，具体用于响应在所述第二时间窗内接收到的第一个用于恢复波束的请求。

27、如权利要求 24~26 任一项所述的装置，其特征在于，

所述发送模块，具体用于在所述第二时间窗内使用确定得到的用于恢复波束的请求对

应的波束，向所述终端设备发送用于波束恢复请求的响应。

28、如权利要求 24~26 任一项所述的装置，其特征在于，

所述发送模块，具体用于在所述第二时间窗之外使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应。

29、如权利要求 1 至 9 任一项所述的方法，其特征在于，所述用于恢复波束的请求通过随机接入信道 RACH 资源发送。

30、如权利要求 1 至 9 任一项所述的方法，其特征在于，所述用于波束恢复请求的响应通过物理下行控制信道 PDCCH 发送，所述 PDCCH 的循环冗余校验 CRC 由小区无线网络临时标识 C-RNTI 加扰。

31、如权利要求 4 或 5 所述的方法，其特征在于，所述第一单元时间窗的起始时刻是配置有 RACH 资源的第一个符号。

32、如权利要求 1 至 9 任一项所述的方法，其特征在于，该方法之前还包括：终端设备获取网络设备配置的用于发送恢复波束的请求时所使用的最大波束数量。

33、如权利要求 10 至 14 任一项所述的方法，其特征在于，该方法之前还包括：网络设备为终端设备配置用于发送恢复波束的请求时所使用的最大波束数量。

34、如权利要求 10 至 14 任一项所述的方法，其特征在于，所述用于恢复波束的请求通过随机接入信道 RACH 资源发送。

35、如权利要求 10 至 14 任一项所述的方法，其特征在于，所述用于波束恢复请求的响应通过物理下行控制信道 PDCCH 发送，所述 PDCCH 的循环冗余校验 CRC 由小区无线网络临时标识 C-RNTI 加扰。

36、如权利要求 15 至 23 任一项所述的装置，其特征在于，所述用于恢复波束的请求通过随机接入信道 RACH 资源发送。

37、如权利要求 15 至 23 任一项所述的装置，其特征在于，所述用于波束恢复请求的响应通过物理下行控制信道 PDCCH 发送，所述 PDCCH 的循环冗余校验 CRC 由小区无线网络临时标识 C-RNTI 加扰。

38、如权利要求 18 或 19 所述的装置，其特征在于，所述第一单元时间窗的起始时刻是配置有 RACH 资源的第一个符号。

39、如权利要求 15 至 13 任一项所述的装置，其特征在于，所述接收模块还用于：获取网络设备配置的用于发送恢复波束的请求时所使用的最大波束数量。

40、如权利要求 24 至 28 任一项所述的装置，其特征在于，所述确定模块还用于：为终端设备配置用于发送恢复波束的请求时所使用的最大波束数量。

41、如权利要求 24 至 28 任一项所述的装置，其特征在于，所述用于恢复波束的请求通过随机接入信道 RACH 资源发送。

42、如权利要求 24 至 28 任一项所述的装置，其特征在于，所述用于波束恢复请求的响应通过物理下行控制信道 PDCCH 发送，所述 PDCCH 的循环冗余校验 CRC 由小区无线网络临时标识 C-RNTI 加扰。

43、一种波束恢复装置，其特征在于，包括：存储器和处理器；所述处理器被配置为支持所述装置执行如权利要求 1 至 9 或 29-32 任一项所述的方法的功能，所述存储器用于保存所述装置的程序和数据。

44、一种波束恢复装置，其特征在于，包括：存储器和处理器；所述处理器被配置为支持所述装置执行如权利要求 10 至 14 或 33-35 任一项所述的方法的功能，所述存储器用于保存所述装置的程序和数据。

45、一种芯片系统，其特征在于，包括：处理器，所述处理器被配置为支持终端设备执行如权利要求 1 至 9 或 29-32 任一项所述的方法的功能。

46、如权利要求 45 所述的芯片系统，其特征在于，所述芯片系统还包括存储器，所述存储器用于保存所述终端设备的程序指令和数据。

47、一种芯片系统，其特征在于，包括：处理器，所述处理器被配置为支持网络设备执行如权利要求 10 至 14 或 33-35 任一项所述的方法的功能。

48、如权利要求 47 所述的芯片系统，其特征在于，所述芯片系统还包括存储器，所述存储器用于保存所述网络设备的程序指令和数据。

49、一种计算机存储介质，其特征在于，用于存储计算机程序，当所述计算机程序在终端设备上运行时，使得所述终端设备执行如权利要求 1 至 9 或 29-32 任一项所述的方法。

50、一种计算机存储介质，其特征在于，用于存储计算机程序，当所述计算机程序在

网络设备上运行时，使得所述网络设备执行如权利要求 10 至 14 或 33-35 任一项所述的方法。

51、一种计算机程序产品，其特征在于，当所述计算机程序产品在终端设备上运行时，使得所述终端设备执行如权利要求 1 至 9 或 29-32 任一项所述的方法。

52、一种计算机程序产品，其特征在于，当所述计算机程序产品在网络设备上运行时，使得所述网络设备执行如权利要求 10 至 14 或 33-35 任一项所述的方法。

53、一种波束恢复系统，其特征在于，所述波束恢复系统包括如权利要求 43 所述的波束恢复装置和如权利要求 44 所述的波束恢复装置。

54、一种波束恢复装置，用于实现如权利要求 1 至 9 或 29-32 任一项所述的方法步骤。

55、一种波束恢复装置，用于实现如权利要求 10 至 14 或 33-35 任一项所述的方法步骤。

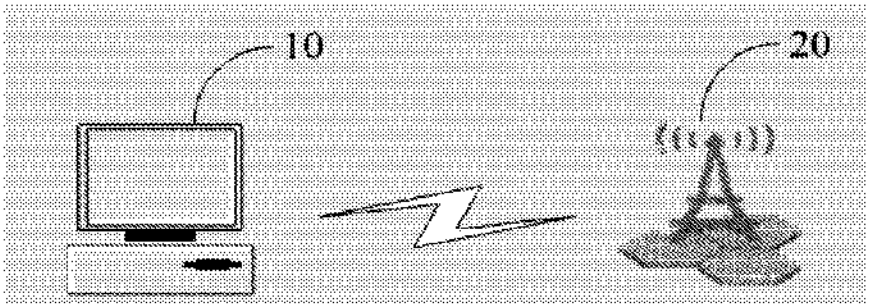

10
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图 1

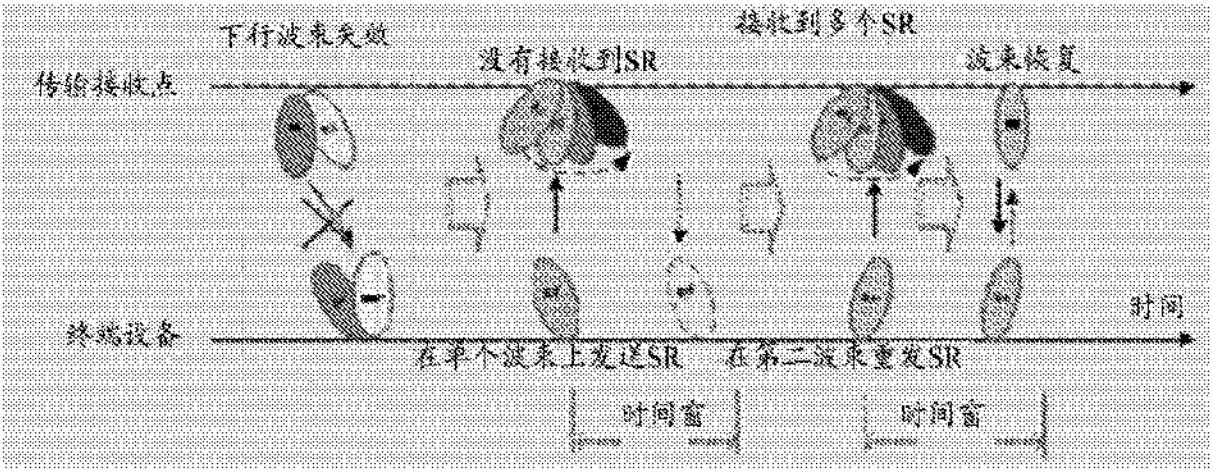

下行波束失效
接收到多个SR
传输接收点
没有接收到SR
波束恢复
时间
终端设备
在单个波束上发送SR
在第二波束重发SR
时间窗
时间窗

图 2A

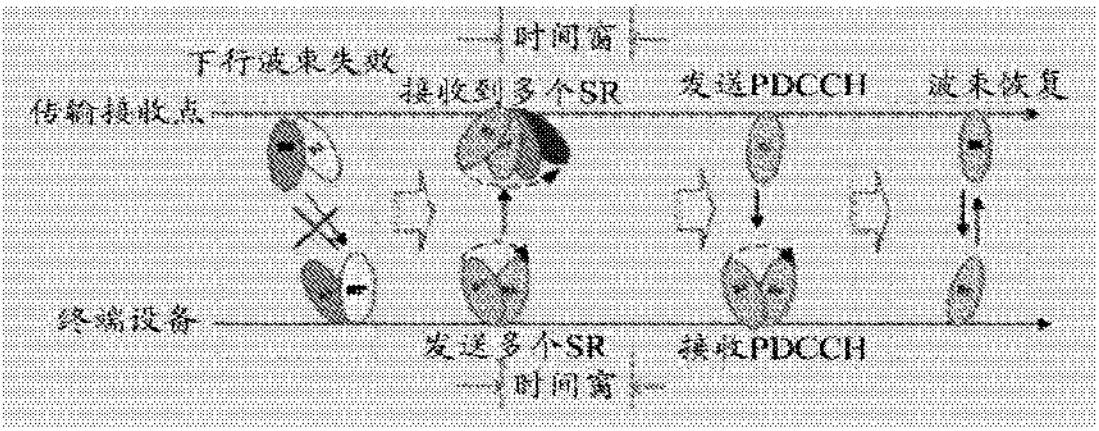

时间窗
下行波束失效
接收到多个SR
发送PDCCH
波束恢复
传输接收点
终端设备
发送多个SR
接收PDCCH
时间窗

图 2B

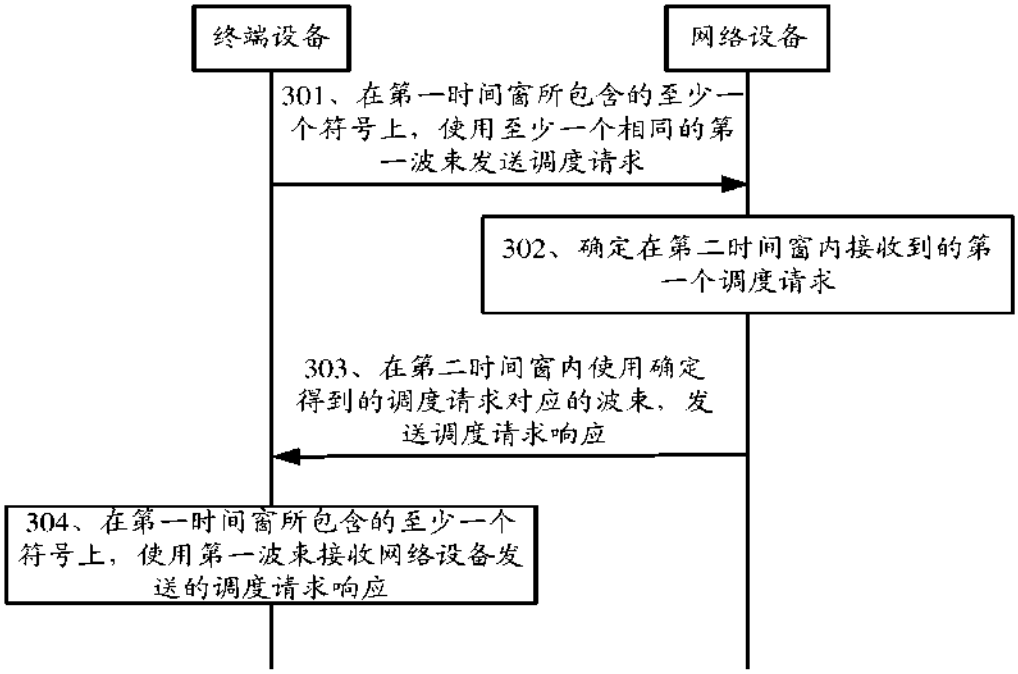

终端设备
网络设备
301、在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束发送调度请求
302、确定在第二时间窗内接收到的第一个调度请求
303、在第二时间窗内使用确定得到的调度请求对应的波束，发送调度请求响应
304、在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备发送的调度请求响应

图 3

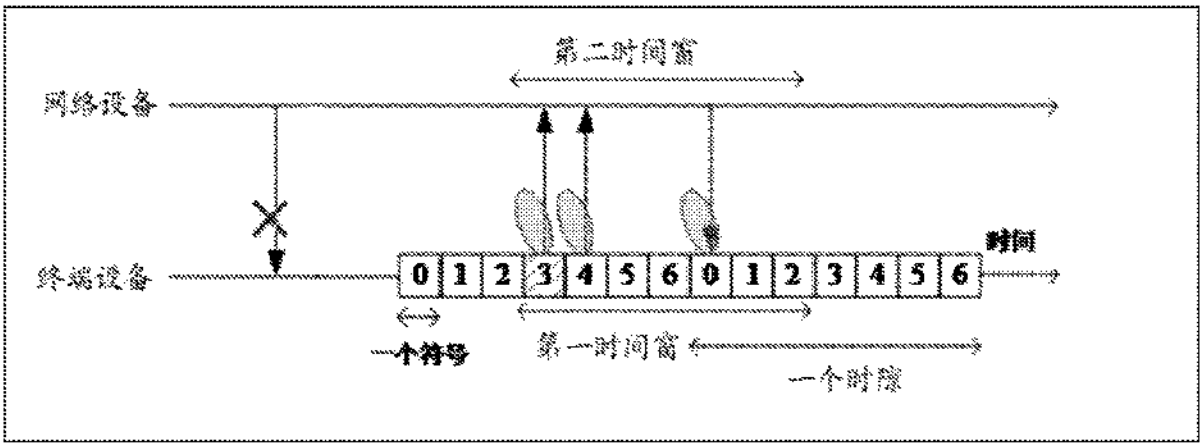

第二时间窗
网络设备
终端设备
0 1 2 3 4 5 6 0 1 2 3 4 5 6
时间
一个符号
第一时间窗
一个时隙

图 4

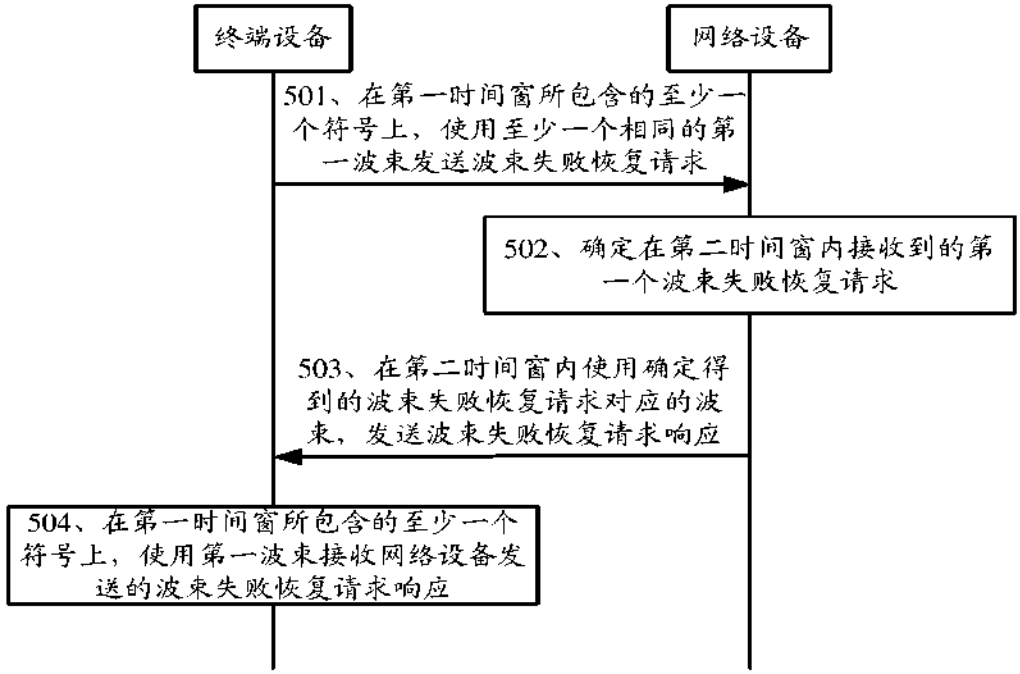

终端设备
网络设备
501、在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束发送波束失败恢复请求
502、确定在第二时间窗内接收到的第一个波束失败恢复请求
503、在第二时间窗内使用确定得到的波束失败恢复请求对应的波束，发送波束失败恢复请求响应
504、在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备发送的波束失败恢复请求响应

图 5

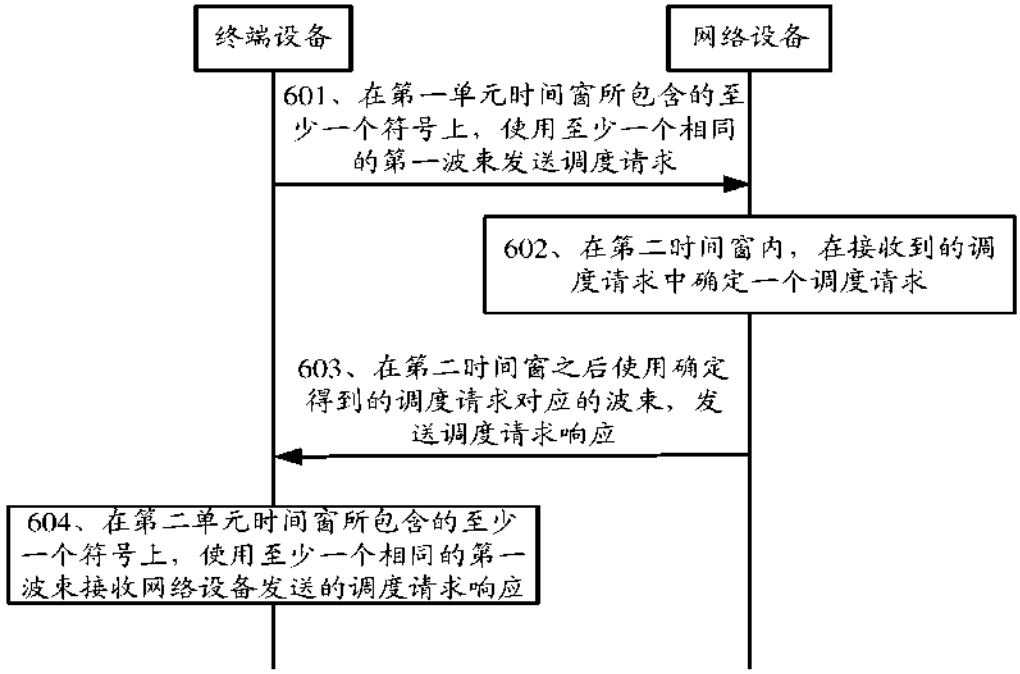

终端设备
网络设备
601、在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束发送调度请求
602、在第二时间窗内，在接收到的调度请求中确定一个调度请求
603、在第二时间窗之后使用确定得到的调度请求对应的波束，发送调度请求响应
604、在第二单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束接收网络设备发送的调度请求响应

图 6

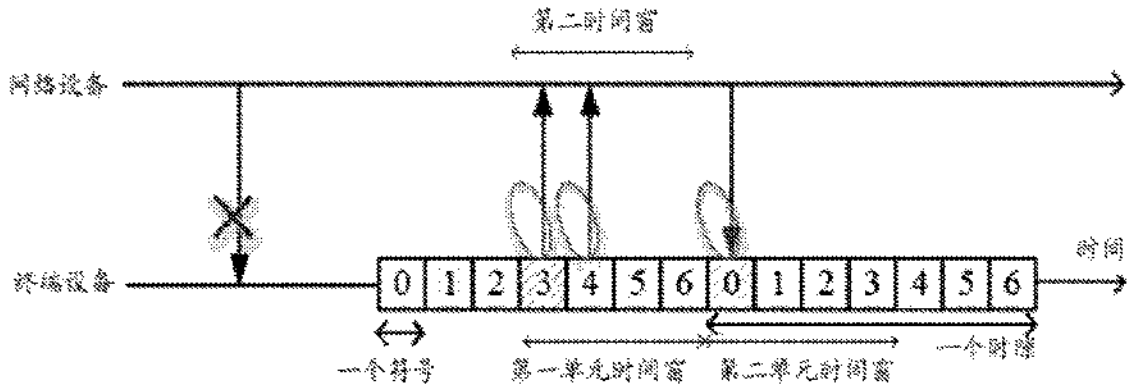

第二时间窗
网络设备
终端设备
0 1 2 3 4 5 6 0 1 2 3 4 5 6
时间
一个符号
第一单元时间窗
第二单元时间窗
一个时隙

图 7

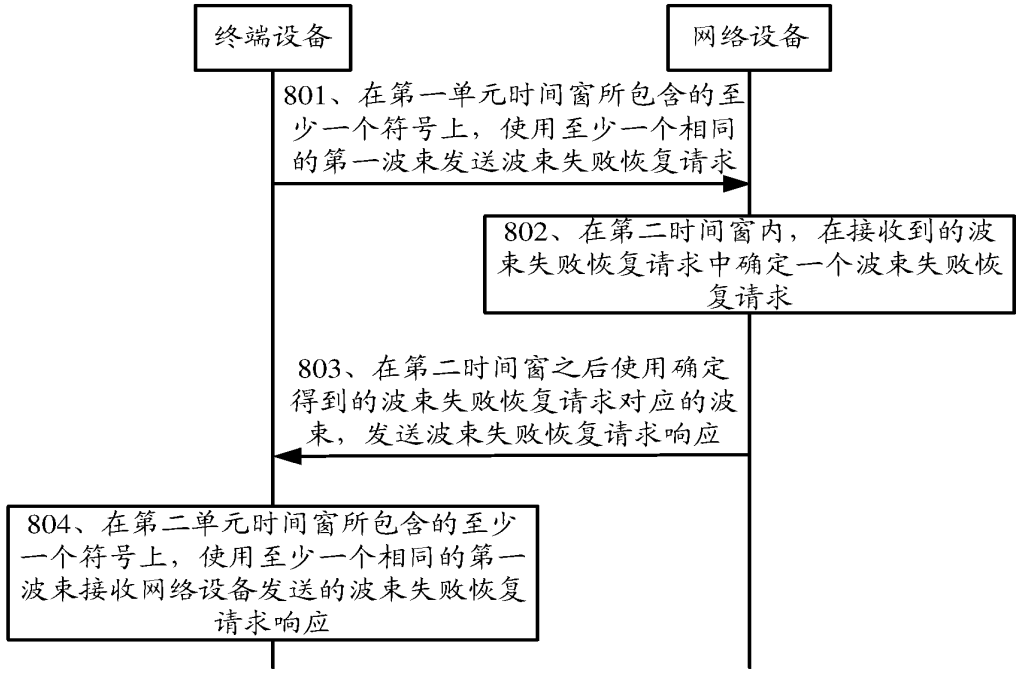

终端设备
网络设备
801、在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束发送波束失败恢复请求
802、在第二时间窗内，在接收到的波束失败恢复请求中确定一个波束失败恢复请求
803、在第二时间窗之后使用确定得到的波束失败恢复请求对应的波束，发送波束失败恢复请求响应
804、在第二单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束接收网络设备发送的波束失败恢复请求响应

图 8

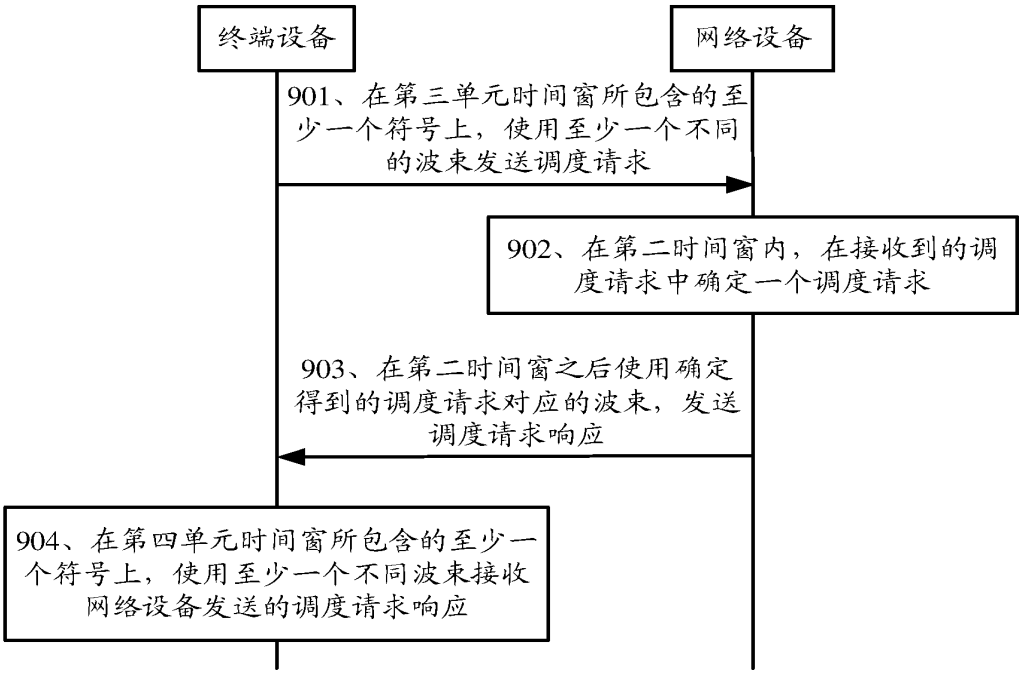

终端设备
网络设备
901、在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束发送调度请求
902、在第二时间窗内，在接收到的调度请求中确定一个调度请求
903、在第二时间窗之后使用确定得到的调度请求对应的波束，发送调度请求响应
904、在第四单元时间窗所包含的至少一个符号上，使用至少一个不同波束接收网络设备发送的调度请求响应

图 9

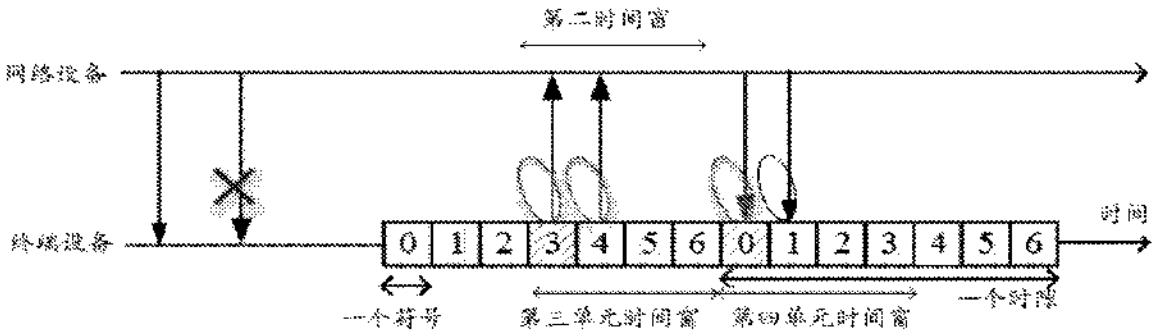

第二时间窗
网络设备
终端设备
0 1 2 3 4 5 6 0 1 2 3 4 5 6
时间
一个符号
第三单元时间窗
第四单元时间窗
一个时隙

图 10

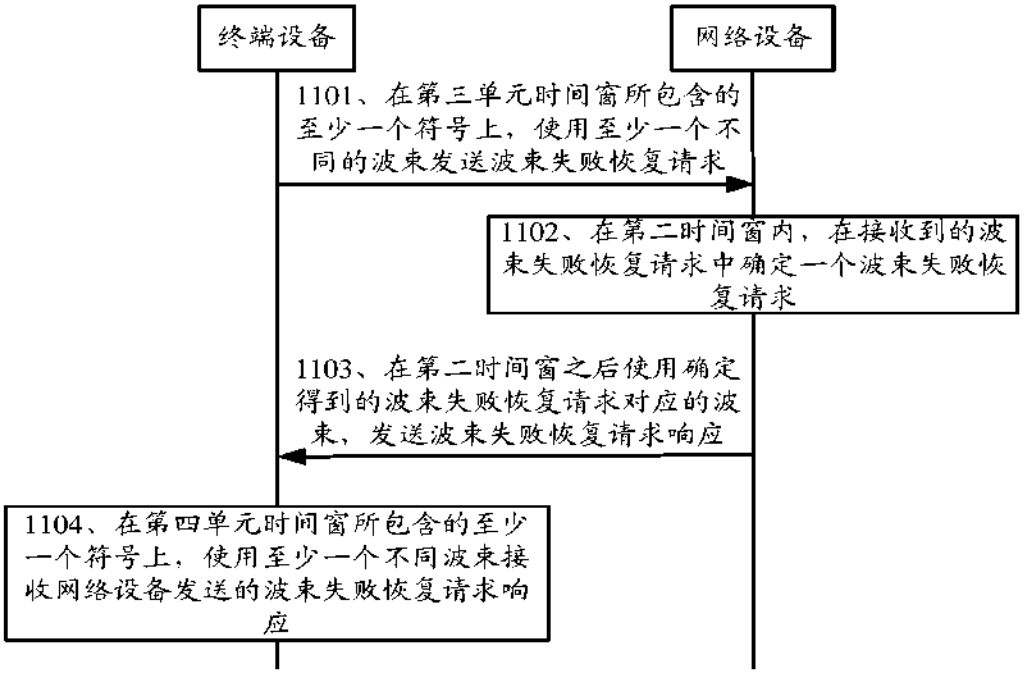

终端设备
网络设备
1101、在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束发送波束失败恢复请求
1102、在第二时间窗内，在接收到的波束失败恢复请求中确定一个波束失败恢复请求
1103、在第二时间窗之后使用确定得到的波束失败恢复请求对应的波束，发送波束失败恢复请求响应
1104、在第四单元时间窗所包含的至少一个符号上，使用至少一个不同波束接收网络设备发送的波束失败恢复请求响应

图 11

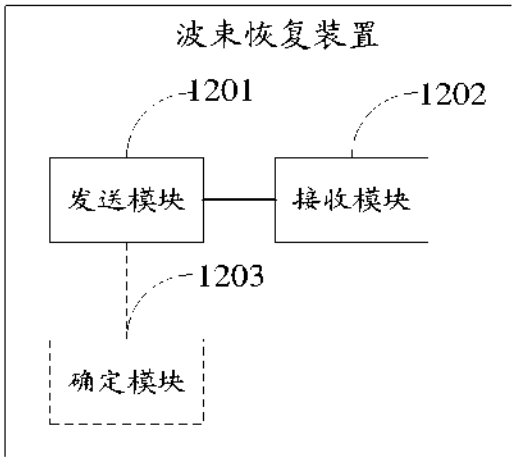

波束恢复装置
1201
1202
发送模块
接收模块
1203
确定模块

图 12

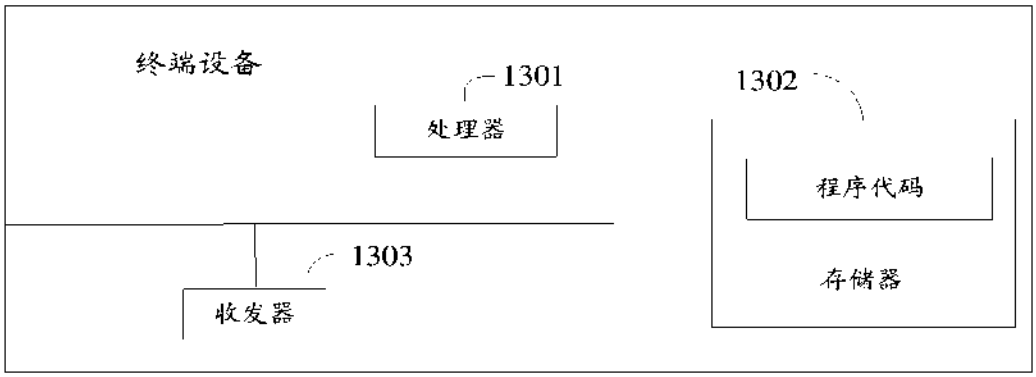


图 13

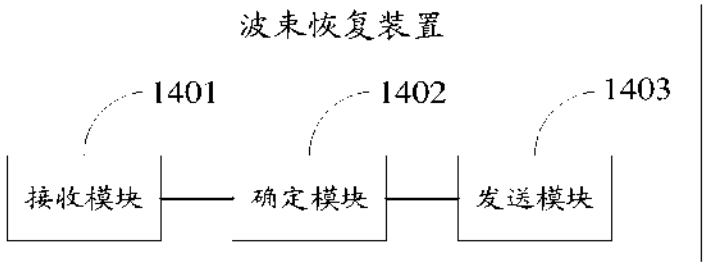


图 14

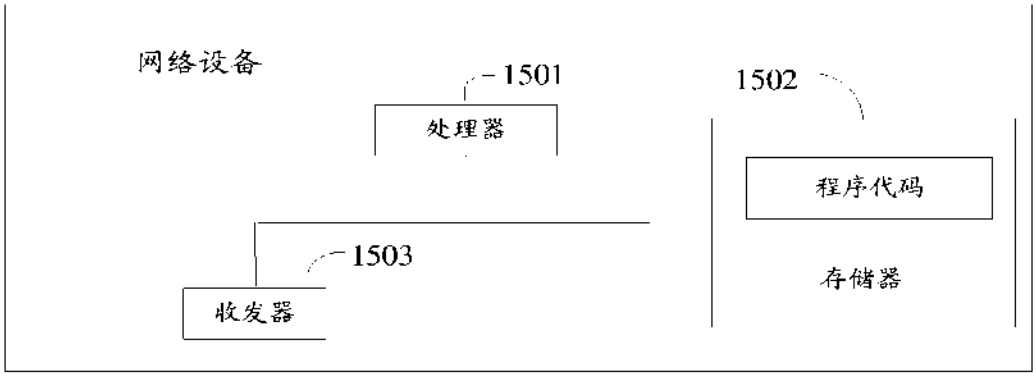


图 15

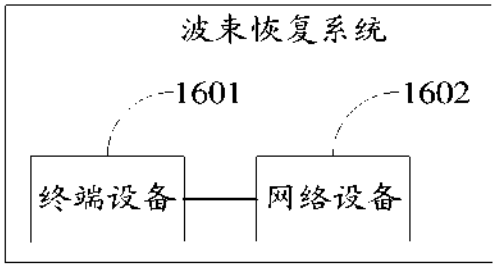


图 16

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2018/085733

A. CLASSIFICATION OF SUBJECT MATTER

H04B 7/0408 (2017.01) i; H04W 72/04 (2009.01) i; H04L 5/00 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04B, H04W, H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNABS; CNTXT; CNKI; VEN; USTXT; WOTXT; EPTXT; XP3GPP: 波束, 恢复, 时间窗, 调度请求, 响应; beam, recover, time 1w window, scheduling 1w request, SR, response

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	QUALCOMM INCORPORATED, Beam Recovery Request, 3GPP TSG-RAN WG 2 Meeting #97bis, R2-1703562, 07 April 2017 (07.04.2017), sections 1-2	1-28
Y	QUALCOM INCORPORATED, Beam Management, 3GPP TSG-RAN WG 2 Meeting #97bis, R2-1703564, 07 April 2017 (07.04.2017), sections 2.1-2.2	1-28
A	INTEL CORPORATION, Radio Link Monitoring, Beam Failure and Radio Link Failure, 3GPP TSG RAN WG 2 Meeting #97bis, R2-1703423, 07 April 2017 (07.04.2017), entire document	1-28
A	WO 2017022902 A1 (SAMSUNG ELECTRONICS CO., LTD.), 09 February 2017 (09.02.2017), entire document	1-28

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 July 2018	26 July 2018
Name and mailing address of the ISA State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No. (86-10) 62019451	Authorized officer LIU, Xin Telephone No. 86-010-62089141

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2018/085733

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
WO 2017022902 A1	09 February 2017	WO 2017022870 A1	09 February 2017
		EP 3332597 A1	13 June 2018
		CN 108141749 A	08 June 2018
		KR 20180036995 A	10 April 2018

Form PCT/ISA/210 (patent family annex) (January 2015)

国际检索报告

国际申请号
PCT/CN2018/085733

A. 主题的分类

H04B 7/0408(2017.01)i; H04W 72/04(2009.01)i; H04L 5/00(2006.01)i

按照国际专利分类(IPC)或者同时按照国家分类和IPC两种分类

B. 检索领域

检索的最低限度文献(标明分类系统和分类号)

H04B H04W H04L

包含在检索领域中的除最低限度文献以外的检索文献

在国际检索时查阅的电子数据库(数据库的名称，和使用的检索词（如使用）)

CNABS;CNTXT;CNKI,VEN;USTXT;WOTXT;EPTXT;XP3GPP:波束，恢复，时间窗，调度请求，响应; beam, recover, time lw window, scheduling lw request, SR, response

C. 相关文件

类 型*	引用文件，必要时，指明相关段落	相关的权利要求
Y	QUALCOMM INCORPORATED. "Beam recovery request" 3GPP TSG RAN WG2 Meeting #97bis, R2 1703562. 2017年 4月 7日 (2017-04-07), 第1 2节	1 28
Y	QUALCOMM INCORPORATED. "Beam management" 3GPP TSG-RAN WG2 Meeting #97bis, R2-1703564, 2017年 4月 7日 (2017-04-07), 第2.1-2.2节	1-28
A	INTEL CORPORATION. "Radio link monitoring, beam failure and radio link failure" 3GPP TSG RAN WG2 Meeting #97bis, R2-1703423, 2017年 4月 7日 (2017-04-07), 全文	1-28
A	WO 2017022902 A1 (SAMSUNG ELECTRONICS CO LTD) 2017年 2月 9日 (2017-02-09) 全文	1 28

☐ 其余文件在C栏的续页中列出。

☑ 见同族专利附件。

* 引用文件的具体类型:

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"L" 可能对优先权要求构成怀疑的文件，或为确定另一篇引用文件的公布日而引用的或者因其他特殊理由而引用的文件(如具体说明的)

"O" 涉及口头公开、使用、展览或其他方式公开的文件

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"X" 特别相关的文件，单独考虑该文件，认定要求保护的发明不是新颖的或不具有创造性

"Y" 特别相关的文件，当该文件与另一篇或者多篇该类文件结合并且这种结合对于本领域技术人员为显而易见时，要求保护的发明不具有创造性

"&" 同族专利的文件

国际检索实际完成的日期	国际检索报告邮寄日期
2018年 7月 11日	2018年 7月 26日
ISA/CN的名称和邮寄地址 中华人民共和国国家知识产权局(ISA/CN) 中国北京市海淀区蓟门桥西上城路6号 100088 传真号 (86-10)62019451	受权官员 刘欣 电话号码 86-010-62089141

表 PCT/ISA/210 (第2页) (2015年1月)

国际检索报告
关于同族专利的信息

国际申请号
PCT/CN2018/085733

检索报告引用的专利文件			公布日（年/月/日）	同族专利			公布日（年/月/日）
WO	2017022902	A1	2017年 2月 9日	WO	2017022870	A1	2017年 2月 9日
				EP	3332597	A1	2018年 6月 13日
				CN	108141749	A	2018年 6月 8日
				KR	20180036995	A	2018年 4月 10日

表 PCT/ISA/210（同族专利附件）（2015年1月）

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	17950726
Filing Date	2022-09-22
First Named Inventor	Xiaobo ZHANG
Art Unit	2471
Examiner Name	AHMED ELALLAM
Attorney Docket Number	ZL0205-0004-US-CON3

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	Application Number	17950726
	Filing Date	2022-09-22
	First Named Inventor	Xiaobo ZHANG
	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

	1	R1-1610145, Qualcomm, October 1, 2016	☒
	2	R1-1610239, Nokia, Alcatel-Lucent Shanghai Bell, September 30, 2016	☒
	3	R1-1611385, China Academy of Telecommunications Technology (CATT), November 5, 2016	☒
	4	R1-1611415, ZTE, ZTE Microelectronics, November 5, 2016	☒
	5	R1-1611417, ZTE, ZTE Microelectronics, November 5, 2016	☒
	6	R1-1612056, Qualcomm, November 5, 2016	☒
	7	R1-1612493, Samsung, November 4, 2016	☒
	8	R1-1612862, Nokia, Alcatel-Lucent Shanghai Bell, November 4, 2016	☒
	9	R4-161779, Qualcomm Incorporated, April 26, 2016	☒
	10	3GPP TR 36.897 V13.0.0 Release 13, 3rd Generation Partnership Project (3GPP), June 2015	☒
	11	R1-1704867, LG Electronics, March 25, 2017	☒

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	Application Number	17950726
	Filing Date	2022-09-22
	First Named Inventor	Xiaobo ZHANG
	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

	12	R1-1609662, Nokia, Alcatel-Lucent Shanghai Bell, September 30, 2016	☒
	13	R2-1703344, LG Electronics, March 24, 2017	☒
	14	3GPP R1-1704398, April 7, 2017	☒
	15	3GPP R1-1704877, April 7, 2017	☒
	16	R1-1609256, October 14, 2016	☒
	17	APEX BEAM TECHNOLOGIES LLC v. ONEPLUS TECHNOLOGY (SHENZHEN) CO., LTD., DEFENDANT'S INVALIDITY CONTENTIONS, Case No. 2:22-cv-00032-JRG, November 21, 2022	☒
	18	APEX BEAM TECHNOLOGIES LLC v. SAMSUNG ELECTRONICS CO., LTD., ET AL.,, DEFENDANT'S INVALIDITY CONTENTIONS, Case No. 2:22-cv-00188-JRG, March 2, 2023	☒
	19	APEX BEAM TECHNOLOGIES LLC v. ZTE CORPORATION, DEFENDANT'S INVALIDITY CONTENTIONS, Case No. 2:22-cv-00031-JRG-RSP, March 2, 2023	☒
	20	APEX BEAM TECHNOLOGIES LLC v. TCT MOBILE INTERNATIONAL LIMITED, DEFENDANTS' INITIAL INVALIDITY CONTENTIONS, Docket No. 2:21-cv-00438-JRG, November 9, 2023	☒
	21	SAMSUNG ELECTRONICS CO., LTD., AND SAMSUNG ELECTRONICS AMERICA, INC., v. APEX BEAM TECHNOLOGIES LLC, PETITION FOR INTER PARTES REVIEW, Case IPR2023-0059, February 28, 2023	☒

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	Application Number	17950726
	Filing Date	2022-09-22
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	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

EXAMINER SIGNATURE			
Examiner Signature		Date Considered	
*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.			

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	Application Number	17950726
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	First Named Inventor	Xiaobo ZHANG
	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

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☐ See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/JIALIN ZHONG/	Date (YYYY-MM-DD)	2023-11-19
Name/Print	JIALIN ZHONG	Registration Number	62937

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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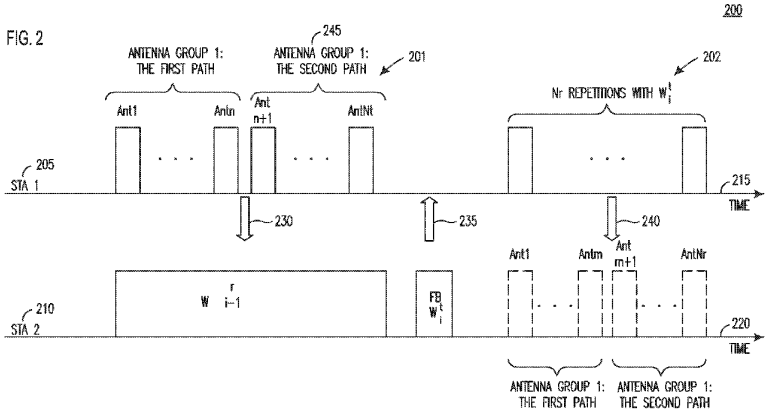
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(54) Title: BEAMFORMING METHODS AND METHODS FOR USING BEAMS



(57) Abstract: A method, apparatus, system, and computer readable medium may be used to perform beamforming. The method may include a first communication device sending a first plurality of beamforming training frames to a second communication device using a first beamforming weight vector; the first communication device receiving from the second communication device a second beamforming weight vector; and the first communication device sending a second plurality of beamforming training frames to the second communication device using the second beamforming weight vector. The apparatus, method, system, and computer readable media may use spatial diversity with beam switching, spatial diversity with a single beam, weighted multipath beamforming training, single user spatial multiplexing, and beamforming training for beam division multiple access (BDMA).

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BEAMFORMING METHODS AND METHODS FOR USING BEAMS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 61/724,679 filed on November 9, 2012, the contents of which are hereby incorporated by reference.

BACKGROUND

[0002] Some wireless communication networks support operation at very high and even extremely high carrier frequencies such as 60 GHz and millimeter wave (mmW) frequency bands. These extremely high carrier frequencies may support very high throughput such as up to 6 gigabits per second (Gbps). One of the challenges for wireless communication at very high or extremely high carrier frequencies is that a significant propagation loss may occur due to the high carrier frequency. As the carrier frequency increases, the carrier wavelength may decrease, and the propagation loss may increase as well.

[0003] At mmW frequency bands, the propagation loss may be severe. For example, the propagation loss may be on the order of 22 to 27 dB, relative to that observed in either the 2.4 GHz, or 5 GHz bands. Since the available spectrum is limited, however, and since users continue to demand more bandwidth, there is a need for effectively using very high and extremely high carrier frequencies for communication networks.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] FIG. 1A is a system diagram of an example communications system in which one or more disclosed embodiments may be implemented;

[0005] FIG. 1B is a system diagram of an example wireless transmit/receive unit (WTRU) that may be used within the communications system illustrated in FIG. 1A;

[0006] FIG. 1C is a system diagram of an example radio access network and an example core network that may be used within the communications system illustrated in FIG. 1A;

[0007] FIG. 1D is a diagram of an example WLAN with an AP and STA forming a BSS, and beamforming with multipath channels;

[0008] FIG. 1E is a diagram of another example WLAN with an AP and STA forming a BSS, and beamforming with multiple channels;

[0009] FIG. 2 is a diagram of an example of a method using two STAs to perform a multi-path beamforming method;

[0010] FIG. 3 is a diagram of an example of one iteration of the multi-path beamforming method using BRP transactions;

[0011] FIG. 4 is a diagram of an example frame format of a BRP packet;

[0012] FIG. 5 is a diagram of an example format of a BRP frame Action field;

[0013] FIG. 6 is a diagram of an example modified channel measurement feedback element;

[0014] FIG. 7 is a diagram of an example AP configured to perform a transmission using full size beamforming with STBC;

[0015] FIG. 8 is a diagram of an example AP configured to perform a transmission using partial size beamforming with STBC;

[0016] FIG. 9 is a diagram of an example transceiver architecture;

[0017] FIG. 10 is a diagram of another example transceiver architecture;

[0018] FIG. 11 is a diagram of an example beam division multiple access (BDMA) architecture;

[0019] FIG. 12 is a diagram of an example beamforming training method for BDMA;

[0020] FIG. 13 is a diagram of an example modified BRP procedure to implement a multi-stage iterative beamforming training method for BDMA;

[0021] FIG. 14 is a diagram of an example PHY layer frame format;

[0022] FIG. 15 is a diagram of an example beamforming training procedure using Eigen-beamforming based spatial multiplexing where the

communication devices may be configured to calibrate multiple transmit RF chains;

[0023] FIG. 16 is a diagram of an example beamforming training method for Type I devices and for Type II devices without calibration;

[0024] FIG. 17 is a diagram of an example beamforming training method for beam sweep based spatial multiplexing for Type I devices with calibration between two TX chains;

[0025] FIG. 18 is a diagram of an example beamforming training method for beam sweep based spatial multiplexing Type II devices and Type I devices without calibration;

[0026] FIG. 19 is a diagram of an example modified FBCK-TYPE subfield;

[0027] FIG. 20A is a diagram of an example PHY layer frame format;

[0028] FIG. 20B is a diagram of another example PHY layer frame format;

[0029] FIG. 20C is a diagram of another example PHY layer frame format;

[0030] FIG. 21 is a diagram of an example modified SSW training frames and sequence;

[0031] FIG. 22 is a diagram of an example SSWA frame format;

[0032] FIG. 23 is a diagram of an example early termination of the SLS training procedure; and

[0033] FIG. 24 is a diagram of an example multi-beam multi-DMG antenna SLS feedback method.

SUMMARY

[0034] A first communication device for beamforming may include a plurality of antennas and a processor. The processor may be configured to partition the antenna into at least a first group of antennas and a second group of antennas. The processor may be further configured to send a plurality of beamforming training frames to a second communication device using the

first group of antennas and the second group of antennas. The processor and/or a receiver may be configured to receive, from the second communication device, a first beamforming weight vector for sending signals on the first group of antennas and to receive a second beamforming weight vector for sending signals on the second group of antennas.

[0035] A method of beamforming training for beam division multiple access (BDMA) may include an AP transmitting Nt sequences modulated using Nt beamforming vectors. A first station may use a first previous beamforming vector to receive the Nt sequences and determine a first transmit beamforming weight from the AP to the first station based on the first previous beamforming vector and the received Nt sequences. The first station may send the determined first transmit beamforming weight to the AP. A second station may use a second previous beamforming vector to receive the Nt sequences and determine a second transmit beamforming weight from the AP to the first station based on the second previous beamforming vector and the received Nt sequences. The second station may send the determined second transmit beamforming weight to the AP, and the AP may transmit one or more sequences modulated based on the first transmit beamforming weight and the second transmit beamforming weight.

[0036] A method and apparatus may be used for spatial diversity with beam switching, spatial diversity with a single beam, weighted multipath beamforming training, single user spatial multiplexing, and for reduced beamforming training overhead.

DETAILED DESCRIPTION

[0037] FIG. 1A is a diagram of an example communications system 100 in which one or more disclosed embodiments may be implemented. The communications system 100 may be a multiple access system that provides content, such as voice, data, video, messaging, broadcast, etc., to multiple wireless users. The communications system 100 may enable multiple wireless users to access such content through the sharing of system resources,

including wireless bandwidth. For example, the communications systems 100 may employ one or more channel access methods, such as code division multiple access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), orthogonal FDMA (OFDMA), single-carrier FDMA (SC-FDMA), and the like.

[0038] As shown in FIG. 1A, the communications system 100 may include wireless transmit/receive units (WTRUs) 102a, 102b, 102c, 102d, a radio access network (RAN) 104, a core network 106, a public switched telephone network (PSTN) 108, the Internet 110, and other networks 112, though it will be appreciated that the disclosed embodiments contemplate any number of WTRUs, base stations, networks, and/or network elements. Each of the WTRUs 102a, 102b, 102c, 102d may be any type of device configured to operate and/or communicate in a wireless environment. By way of example, the WTRUs 102a, 102b, 102c, 102d may be configured to transmit and/or receive wireless signals and may include user equipment (UE), a mobile station, a fixed or mobile subscriber unit, a pager, a cellular telephone, a personal digital assistant (PDA), a smartphone, a laptop, a netbook, a personal computer, a wireless sensor, consumer electronics, and the like.

[0039] The communications systems 100 may also include a base station 114a and a base station 114b. Each of the base stations 114a, 114b may be any type of device configured to wirelessly interface with at least one of the WTRUs 102a, 102b, 102c, 102d to facilitate access to one or more communication networks, such as the core network 106, the Internet 110, and/or the networks 112. By way of example, the base stations 114a, 114b may be a base transceiver station (BTS), a Node-B, an eNode B, a Home Node B, a Home eNode B, a site controller, an access point (AP), a wireless router, and the like. While the base stations 114a, 114b are each depicted as a single element, it will be appreciated that the base stations 114a, 114b may include any number of interconnected base stations and/or network elements.

[0040] The base station 114a may be part of the RAN 104, which may also include other base stations and/or network elements (not shown), such as

a base station controller (BSC), a radio network controller (RNC), relay nodes, etc. The base station 114a and/or the base station 114b may be configured to transmit and/or receive wireless signals within a particular geographic region, which may be referred to as a cell (not shown). The cell may further be divided into cell sectors. For example, the cell associated with the base station 114a may be divided into three sectors. Thus, in one embodiment, the base station 114a may include three transceivers, i.e., one for each sector of the cell. In another embodiment, the base station 114a may employ multiple-input multiple output (MIMO) technology and, therefore, may utilize multiple transceivers for each sector of the cell.

[0041] The base stations 114a, 114b may communicate with one or more of the WTRUs 102a, 102b, 102c, 102d over an air interface 116, which may be any suitable wireless communication link (e.g., radio frequency (RF), microwave, infrared (IR), ultraviolet (UV), visible light, etc.). The air interface 116 may be established using any suitable radio access technology (RAT).

[0042] More specifically, as noted above, the communications system 100 may be a multiple access system and may employ one or more channel access schemes, such as CDMA, TDMA, FDMA, OFDMA, SC-FDMA, and the like. For example, the base station 114a in the RAN 104 and the WTRUs 102a, 102b, 102c may implement a radio technology such as Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access (UTRA), which may establish the air interface 116 using wideband CDMA (WCDMA). WCDMA may include communication protocols such as High-Speed Packet Access (HSPA) and/or Evolved HSPA (HSPA+). HSPA may include High-Speed Downlink Packet Access (HSDPA) and/or High-Speed Uplink Packet Access (HSUPA).

[0043] In another embodiment, the base station 114a and the WTRUs 102a, 102b, 102c may implement a radio technology such as Evolved UMTS Terrestrial Radio Access (E-UTRA), which may establish the air interface 116 using Long Term Evolution (LTE) and/or LTE-Advanced (LTE-A).

[0044] In other embodiments, the base station 114a and the WTRUs 102a, 102b, 102c may implement radio technologies such as IEEE 802.16 (i.e., Worldwide Interoperability for Microwave Access (WiMAX)), CDMA2000, CDMA2000 1X, CDMA2000 EV-DO, Interim Standard 2000 (IS-2000), Interim Standard 95 (IS-95), Interim Standard 856 (IS-856), Global System for Mobile communications (GSM), Enhanced Data rates for GSM Evolution (EDGE), GSM EDGE (GERAN), and the like.

[0045] The base station 114b in FIG. 1A may be a wireless router, Home Node B, Home eNode B, or access point, for example, and may utilize any suitable RAT for facilitating wireless connectivity in a localized area, such as a place of business, a home, a vehicle, a campus, and the like. In one embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.11 to establish a wireless local area network (WLAN). In another embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.15 to establish a wireless personal area network (WPAN). In yet another embodiment, the base station 114b and the WTRUs 102c, 102d may utilize a cellular-based RAT (e.g., WCDMA, CDMA2000, GSM, LTE, LTE-A, etc.) to establish a picocell or femtocell. As shown in FIG. 1A, the base station 114b may have a direct connection to the Internet 110. Thus, the base station 114b may not be required to access the Internet 110 via the core network 106.

[0046] The RAN 104 may be in communication with the core network 106, which may be any type of network configured to provide voice, data, applications, and/or voice over internet protocol (VoIP) services to one or more of the WTRUs 102a, 102b, 102c, 102d. For example, the core network 106 may provide call control, billing services, mobile location-based services, pre-paid calling, Internet connectivity, video distribution, etc., and/or perform high-level security functions, such as user authentication. Although not shown in FIG. 1A, it will be appreciated that the RAN 104 and/or the core network 106 may be in direct or indirect communication with other RANs that employ the same RAT as the RAN 104 or a different RAT. For example, in addition to

being connected to the RAN 104, which may be utilizing an E-UTRA radio technology, the core network 106 may also be in communication with another RAN (not shown) employing a GSM radio technology.

[0047] The core network 106 may also serve as a gateway for the WTRUs 102a, 102b, 102c, 102d to access the PSTN 108, the Internet 110, and/or other networks 112. The PSTN 108 may include circuit-switched telephone networks that provide plain old telephone service (POTS). The Internet 110 may include a global system of interconnected computer networks and devices that use common communication protocols, such as the transmission control protocol (TCP), user datagram protocol (UDP) and the internet protocol (IP) in the TCP/IP internet protocol suite. The networks 112 may include wired or wireless communications networks owned and/or operated by other service providers. For example, the networks 112 may include another core network connected to one or more RANs, which may employ the same RAT as the RAN 104 or a different RAT.

[0048] Some or all of the WTRUs 102a, 102b, 102c, 102d in the communications system 100 may include multi-mode capabilities, i.e., the WTRUs 102a, 102b, 102c, 102d may include multiple transceivers for communicating with different wireless networks over different wireless links. For example, the WTRU 102c shown in FIG. 1A may be configured to communicate with the base station 114a, which may employ a cellular-based radio technology, and with the base station 114b, which may employ an IEEE 802 radio technology.

[0049] FIG. 1B is a system diagram of an example WTRU 102. As shown in FIG. 1B, the WTRU 102 may include a processor 118, a transceiver 120, a transmit/receive element 122, a speaker/microphone 124, a keypad 126, a display/touchpad 128, non-removable memory 106, removable memory 132, a power source 134, a global positioning system (GPS) chipset 136, and other peripherals 138. It will be appreciated that the WTRU 102 may include any sub-combination of the foregoing elements while remaining consistent with an embodiment.

[0050] The processor 118 may be a general purpose processor, a special purpose processor, a conventional processor, a digital signal processor (DSP), a plurality of microprocessors, one or more microprocessors in association with a DSP core, a controller, a microcontroller, Application Specific Integrated Circuits (ASICs), Field Programmable Gate Array (FPGAs) circuits, any other type of integrated circuit (IC), a state machine, and the like. The processor 118 may perform signal coding, data processing, power control, input/output processing, and/or any other functionality that enables the WTRU 102 to operate in a wireless environment. The processor 118 may be coupled to the transceiver 120, which may be coupled to the transmit/receive element 122. While FIG. 1B depicts the processor 118 and the transceiver 120 as separate components, it will be appreciated that the processor 118 and the transceiver 120 may be integrated together in an electronic package or chip.

[0051] The transmit/receive element 122 may be configured to transmit signals to, or receive signals from, a base station (e.g., the base station 114a) over the air interface 116. For example, in one embodiment, the transmit/receive element 122 may be an antenna configured to transmit and/or receive RF signals. In another embodiment, the transmit/receive element 122 may be an emitter/detector configured to transmit and/or receive IR, UV, or visible light signals, for example. In yet another embodiment, the transmit/receive element 122 may be configured to transmit and receive both RF and light signals. It will be appreciated that the transmit/receive element 122 may be configured to transmit and/or receive any combination of wireless signals.

[0052] In addition, although the transmit/receive element 122 is depicted in FIG. 1B as a single element, the WTRU 102 may include any number of transmit/receive elements 122. More specifically, the WTRU 102 may employ MIMO technology. Thus, in one embodiment, the WTRU 102 may include two or more transmit/receive elements 122 (e.g., multiple antennas) for transmitting and receiving wireless signals over the air interface 116.

[0053] The transceiver 120 may be configured to modulate the signals that are to be transmitted by the transmit/receive element 122 and to demodulate the signals that are received by the transmit/receive element 122. As noted above, the WTRU 102 may have multi-mode capabilities. Thus, the transceiver 120 may include multiple transceivers for enabling the WTRU 102 to communicate via multiple RATs, such as UTRA and IEEE 802.11, for example.

[0054] The processor 118 of the WTRU 102 may be coupled to, and may receive user input data from, the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128 (e.g., a liquid crystal display (LCD) display unit or organic light-emitting diode (OLED) display unit). The processor 118 may also output user data to the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128. In addition, the processor 118 may access information from, and store data in, any type of suitable memory, such as the non-removable memory 106 and/or the removable memory 132. The non-removable memory 106 may include random-access memory (RAM), read-only memory (ROM), a hard disk, or any other type of memory storage device. The removable memory 132 may include a subscriber identity module (SIM) card, a memory stick, a secure digital (SD) memory card, and the like. In other embodiments, the processor 118 may access information from, and store data in, memory that is not physically located on the WTRU 102, such as on a server or a home computer (not shown).

[0055] The processor 118 may receive power from the power source 134, and may be configured to distribute and/or control the power to the other components in the WTRU 102. The power source 134 may be any suitable device for powering the WTRU 102. For example, the power source 134 may include one or more dry cell batteries (e.g., nickel-cadmium (NiCd), nickel-zinc (NiZn), nickel metal hydride (NiMH), lithium-ion (Li-ion), etc.), solar cells, fuel cells, and the like.

[0056] The processor 118 may also be coupled to the GPS chipset 136, which may be configured to provide location information (e.g., longitude and

latitude) regarding the current location of the WTRU 102. In addition to, or in lieu of, the information from the GPS chipset 136, the WTRU 102 may receive location information over the air interface 116 from a base station (e.g., base stations 114a, 114b) and/or determine its location based on the timing of the signals being received from two or more nearby base stations. It will be appreciated that the WTRU 102 may acquire location information by way of any suitable location-determination method while remaining consistent with an embodiment.

[0057] The processor 118 may further be coupled to other peripherals 138, which may include one or more software and/or hardware modules that provide additional features, functionality and/or wired or wireless connectivity. For example, the peripherals 138 may include an accelerometer, an e-compass, a satellite transceiver, a digital camera (for photographs or video), a universal serial bus (USB) port, a vibration device, a television transceiver, a hands free headset, a Bluetooth® module, a frequency modulated (FM) radio unit, a digital music player, a media player, a video game player module, an Internet browser, and the like.

[0058] FIG. 1C is a system diagram of the RAN 104 and the core network 106 according to an embodiment. As noted above, the RAN 104 may employ an E-UTRA radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 116. The RAN 104 may also be in communication with the core network 106.

[0059] The RAN 104 may include eNode-Bs 140a, 140b, 140c, though it will be appreciated that the RAN 104 may include any number of eNode-Bs while remaining consistent with an embodiment. The eNode-Bs 140a, 140b, 140c may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 116. In one embodiment, the eNode-Bs 140a, 140b, 140c may implement MIMO technology. Thus, the eNode-B 140a, for example, may use multiple antennas to transmit wireless signals to, and receive wireless signals from, the WTRU 102a.

[0060] Each of the eNode-Bs 140a, 140b, 140c may be associated with a particular cell (not shown) and may be configured to handle radio resource management decisions, handover decisions, scheduling of users in the uplink and/or downlink, and the like. As shown in FIG. 1C, the eNode-Bs 140a, 140b, 140c may communicate with one another over an X2 interface.

[0061] The core network 106 shown in FIG. 1C may include a mobility management gateway (MME) 142, a serving gateway 144, and a packet data network (PDN) gateway 146. While each of the foregoing elements are depicted as part of the core network 106, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

[0062] The MME 142 may be connected to each of the eNode-Bs 142a, 142b, 142c in the RAN 104 via an S1 interface and may serve as a control node. For example, the MME 142 may be responsible for authenticating users of the WTRUs 102a, 102b, 102c, bearer activation/deactivation, selecting a particular serving gateway during an initial attach of the WTRUs 102a, 102b, 102c, and the like. The MME 142 may also provide a control plane function for switching between the RAN 104 and other RANs (not shown) that employ other radio technologies, such as GSM or WCDMA.

[0063] The serving gateway 144 may be connected to each of the eNode Bs 140a, 140b, 140c in the RAN 104 via the S1 interface. The serving gateway 144 may generally route and forward user data packets to/from the WTRUs 102a, 102b, 102c. The serving gateway 144 may also perform other functions, such as anchoring user planes during inter-eNode B handovers, triggering paging when downlink data is available for the WTRUs 102a, 102b, 102c, managing and storing contexts of the WTRUs 102a, 102b, 102c, and the like.

[0064] The serving gateway 144 may also be connected to the PDN gateway 146, which may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, such as the Internet 110, to facilitate communications between the WTRUs 102a, 102b, 102c and IP-enabled devices. An access router (AR) 150 of a wireless local area network (WLAN)

155 may be in communication with the Internet 110. The AR 150 may facilitate communications between APs 160a, 160b, and 160c. The APs 160a, 160b, and 160c may be in communication with STAs 170a, 170b, and 170c.

[0065] The core network 106 may facilitate communications with other networks. For example, the core network 106 may provide the WTRUs 102a, 102b, 102c with access to circuit-switched networks, such as the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, 102c and traditional land-line communications devices. For example, the core network 106 may include, or may communicate with, an IP gateway (e.g., an IP multimedia subsystem (IMS) server) that serves as an interface between the core network 106 and the PSTN 108. In addition, the core network 106 may provide the WTRUs 102a, 102b, 102c with access to the networks 112, which may include other wired or wireless networks that are owned and/or operated by other service providers.

[0066] Fig. 1D is a diagram of an example use of beamforming in a WLAN 185. The WLAN 185 may include an AP 190 and an STA 192 forming a BSS. Fig. 1E is a diagram of an example use of beamforming using spatial diversity or multipath diversity in the WLAN 185. The WLAN 185 may include an AP 190 and an STA 192 forming a BSS. A WLAN in a Infrastructure Basic Service Set (BSS) mode has an Access Point (AP) 190 for the BSS and one or more stations (STAs) 192 associated with the AP. The AP 190 may have an access, or interface, to a Distribution System (DS) 195, or another type of wired/wireless network that carries traffic in and out of the BSS. Traffic to STAs that originates from outside the BSS may arrive through the AP to be delivered to the STAs. Traffic originating from STAs to destinations outside the BSS may be sent to the AP to be delivered to the respective destinations. Traffic between STAs within the BSS may also be sent through the AP where the source STA may send traffic to the AP and the AP may deliver the traffic to the destination STA. Such traffic between STAs within a BSS may be peer-to-peer traffic. Such peer-to-peer traffic may also be sent directly between the source and destination STAs with a direct link setup

(DLS) using an 802.11e DLS or an 802.11z tunneled DLS (TDLS). A WLAN using an Independent BSS (IBSS) mode has no AP, and/or STAs, communicating directly with each other. This mode of communication may be referred to as an "ad-hoc" mode of communication.

[0067] As used herein an STA 192 may include, but is not limited to, a WTRU 102, an AP, or a communication device. Using the 802.11 infrastructure mode of operation, the AP 190 may transmit a beacon on a fixed channel, usually the primary channel. This channel may be 20 MHz wide, and may be the operating channel of the BSS. This channel may also be used by the STAs to establish a connection with the AP. The fundamental channel access mechanism in an 802.11 system may be Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA). In this mode of operation, every STA, including the AP, may sense the primary channel. If the channel is detected to be busy, the STA may back off. Hence only one STA may transmit at any given time in a given BSS.

[0068] In an 802.11n example, High Throughput (HT) STAs may also use a 40 MHz wide channel for communication. This 40 MHz wide channel may be achieved by combining the primary 20 MHz channel, with an adjacent 20 MHz channel to form a 40 MHz wide contiguous channel. 802.11n may operate on the 2.4 GHz, and 5 GHz ISM bands.

[0069] In an 802.11ac example, Very High Throughput (VHT) STAs may support 20 MHz, 40 MHz, 80 MHz, and 160 MHz wide channels. The 40 MHz, and 80 MHz, channels may be formed by combining contiguous 20 MHz channels similar to 802.11n described above. A 160 MHz channel may be formed either by combining 8 contiguous 20 MHz channels, or by combining two non-contiguous 80 MHz channels, this may also be referred to as an 80+80 configuration. For the 80+80 configuration, the data, after channel encoding, is passed through a segment parser that may divide it into two streams. IFFT and time domain processing are done on each stream separately. The streams may then be mapped on two channels, and the data may be transmitted. At the receiver, this process may be reversed, and the combined data may be sent

to the MAC. 802.11ac may operate only on the 5 GHz ISM band, and consequently may not be backward compatible with 802.11n modes of operation in the 2.4 GHz ISM band. For the examples described herein, any combination of channels may be used, and should not be limited to contiguous and non-contiguous channels.

[0070] Sub 1 GHz modes of operation may be supported by 802.11af, and 802.11ah. For these specifications the channel operating bandwidths may be reduced relative to those used in 802.11n, and 802.11ac. 802.11af may support 5 MHz, 10 MHz and 20 MHz bandwidths in the TV White Space (TVWS) spectrum, and 802.11ah may support 1 MHz, 2 MHz, 4 MHz, 8 MHz, and 16 MHz bandwidths using a non-TVWS spectrum. A possible use case for 802.11ah may support Meter Type Control (MTC) devices in a macro coverage area. MTC devices may have limited capabilities including only support for limited bandwidths, but also may include a requirement for a very long battery life. 802.11ah may also be used for macro coverage as support for cellular offload to WiFi.

[0071] In 802.11ad, wide bandwidth spectrum at 60 GHz may be available, thus enabling very high throughput operation. 802.11ad may support up to 2 GHz operating bandwidths and the data rate may reach up to 6 Gbps. Since the propagation loss at 60 GHz may be more significant than at the 2.4 GHz, and 5 GHz bands, beamforming may be adopted in 802.11ad as a means to extend the coverage range. To support the receiver requirements for this band, the 802.11ac MAC layer may be modified in several areas. An important modification for the 802.11ad MAC layer may include procedures that allow channel estimation and training. These procedures may include omni, and beamformed modes of operation which do not exist in 802.11ac.

[0072] WLAN systems that support multiple channels and channel widths, such as 802.11n, 802.11ac, 802.11af, and 802.11ah, may include a channel designated as the primary channel. The primary channel may, but not necessarily, have a bandwidth equal to the largest common operating bandwidth supported by all STAs in the BSS. The bandwidth of the primary

channel may therefore be limited by the STA, of all the STAs operating in a BSS, which supports or enables the use of the smallest bandwidth operating mode. In the example of 802.11ah, the primary channel may be 1 MHz wide if there are STAs, for example, MTC type devices that only support a 1 MHz mode, even if the AP, and other STAs in the BSS, may support a 2 MHz, 4 MHz, 8 MHz, 16 MHz, or other channel bandwidth operating modes. All carrier sensing and NAV settings may depend on the status of the primary channel. For example, if the primary channel is busy due to a STA supporting only a 1 MHz operating mode, then the entire available frequency bands may be considered busy even though a majority of the frequency bands remain idle and available.

[0073] In the United States, for example, the available frequency bands that may be used by 802.11ah are from 902 MHz to 928 MHz. In Korea, for example, the available frequency bands may be from 917.5 MHz to 923.5 MHz, and in Japan, it may be from 916.5 MHz to 927.5 MHz. The total bandwidth available for 802.11ah may be 6 MHz to 26 MHz depending on the country.

[0074] One of the challenges for wireless communication over 60 GHz may include significant propagation loss due to the high frequency. As the wavelength decreases, the free space propagation loss may increase. To address the range limitation due to this propagation loss, 802.11ad may use beamforming to increase the Effective Radiated Power (ERP) of the transmissions. Since the wavelength is small, it may be possible to use a large antenna array to get a very high beamformed antenna gain. The beam in 802.11ad may be electronically steered to a particular STA, or group of STAs, during association with the STAs.

[0075] In order to support beamforming, the 802.11ad PHY and MAC specifications may be modified to support directional transmissions, and millimeter wave (mmW) antenna training procedures. A comprehensive beamforming training protocol may be defined in 802.11ad. The beamforming training protocol may include two components, for example a sector level sweep (SLS) procedure and a beam refinement protocol (BRP) procedure. The

SLS procedure may be used for transmit beamforming training. The BRP procedure may enable receive beamforming training and iterative refinement of both the transmit and receive beams.

[0076] In order to reduce implementation complexity, 802.11ad may support beam switching at both the AP and the STA. The beam switching at both the AP and the STA may be in contrast to more advanced multi-antenna schemes, and may assume that a single RF front-end is available at both ends. Problems related to link robustness and spectral efficiency may be of importance for enabling 802.11ad+ to address the current trend for a Carrier Grade WiFi service. A Carrier Grade WiFi service may be referred to as 5G Carrier Grade WiFi, may provide high air interference efficiency for multiple users, and a stable "cellular-like" quality. A 5G Carrier Grade WiFi system may support robust and dynamic deployments, for example dense deployments and flash crowds.

[0077] Although 802.11ad may address the need for a very high peak throughput, limitations due to the propagation environment are not adequately addressed in 802.11ad.

[0078] For mmW communications it may be necessary to handle a propagation loss due in part to the high free space propagation loss which may occur at mmW frequencies. For example, blockage of transmissions by the human body may attenuate a signal by 15 to 25 dB for hundreds of milliseconds.

[0079] While propagation loss of walls and other indoor obstacles may prevent the propagation of mmW through them, indoor Line of Site (LOS) propagation may occur indoors. LOS propagation may occur indoors either due to a direct line of sight transmission, or due to reflections off walls and other obstacles. It should be noted that non-negligible propagation loss at mmW frequencies may occur due to walls and other environmental factors. Beam switching may be used in 802.11ad to utilize signal diversity due to these reflections.

[0080] Some mmW communications may utilize a single beam for communications, for example, in 802.11ad. MIMO techniques, such as spatial multiplexing, may be employed to improve the spectral efficiency of the system, however it may be difficult to use these techniques in mmW systems due to the need for multiple symbol generation. Methods that improve the spectral efficiency of mmW systems, such as methods that enable the use of spatial multiplexing, may be needed in future mmW specifications which for example may be based on 802.11ad, and/or in mmW systems in general.

[0081] Beamforming training protocols, such as SLS and BRP, may be used to perform transmit/receive beamforming training and iterative beam refinement training. The beamforming training overhead and latency of these procedures, however, may be significant. For example, with the transmit beamforming training defined in SLS, the transmitter may need to transmit multiple sector sweep (SSW) frames that may be modulated by different beamforming sectors. Each device may have up to 64 different beam sectors. Each SSW frame may include a full PLCP header, which may include a preamble, one or more header blocks, and a MAC frame. In order to fully exploit the beamforming gain, transmit and receive training procedures at both peer devices may be required, and an iterative beam refinement may also be needed. These procedures may represent a significant overhead and hence methods that reduce this overhead may be needed in part to allow for a better user experience in mmW systems.

[0082] Referring back to FIGS. 1D and 1E, multipath propagation may be common in indoor communications links. Beam switching based beamforming algorithms utilized in the current 802.11ad specification may attempt to point the beam to the strongest path. As shown in FIG. 1D, a LOS path and a strong reflection path may exist between AP 190 and STA 192. After the beamforming training procedure, the beam with the best channel gain may be selected. This beam may be formed towards the strongest path among multiple propagation paths. However, human blockage may introduce an average 20 dB loss for 230 ms, which may prevent the 60GHz radio to

provide multi-Gigabit/sec data transmissions. It is therefore highly likely that the beamformed link may be dropped, and hence the transmitted packet during this period would be lost. Moreover, due to the loss of the packet, the system may have to repeat the beamforming training and then retransmit the packet over a potentially new beam.

[0083] Example beamforming schemes may exploit the spatial diversity such that the transmission is not dependent on only the strongest path. As shown in FIG. 1E, with two strong propagation paths, for example, a LOS path and a strong reflection path, a number of solutions may be possible including fast beam switching, wider beam and multi-beam methods.

[0084] Spatial diversity may be achieved with fast beam switching. In order to accomplish fast beam switching when the channel condition changes, it may be necessary that both AP and STA have an available list of weight vectors/beam identifiers. Example methods for obtaining a list of weight vectors/beam identifiers are disclosed below. There may be two possibilities for fast-beam switching including in-band signaling and out-of-band signaling. In-band beam switching may be used in some examples.

[0085] In an in-band beam switching example, the AP may be communicating with the STA using a beam set (Tx and Rx beams) B1. The AP and STA may have prioritized the beam sets according to the received SNR, or SINR, during the SLS and BRP phases. The STA may monitor one or more of the received SNR, SINR, Bit-Error-Rate (BER) or Packet Error Rate (PER), acknowledgement (ACK) statistics or a combination of these parameters. If, at the end of a packet reception, the STA determines that the channel quality is deteriorating, it may append a message to the ACK packet requesting the AP to switch to the next best beam set, for example B2, for the next transmitted packet. The assumption here is that the channel condition may be deteriorating, but not to the point that the data packet cannot be decoded correctly and hence an ACK may be sent.

[0086] In another example, alternative beam retransmission methods may be used. In 802.11 systems, and mmW systems in particular, if no ACK

is received, the data packet may be retransmitted. This retransmission may use the same beam that was used in the prior transmission. An example for an alternative procedure may be that if the AP does not receive an ACK, the AP may retransmit the data packet using the beam set B2 instead of the beam set B1. Since these beam sets may have been defined prior to this procedure, possibly during association of the STA with the AP, the procedure at the STA may use the corresponding receive beam set B2 for reception of the retransmission from the AP. In an example procedure, the AP and the STA may define an association of indices to beam sets, and subsequently use the beam set indices for identification of beam sets in the aforementioned procedures.

[0087] In an alternative, or additional example, the AP may cycle the data packet through the N best beam-sets. The STA may then perform a procedure wherein it receives N packets from the AP, and perform maximum-ratio-combining, selection combining, or a similar receive algorithm, on these packets. An ACK may then be determined and sent to the AP, for example, after all N transmissions have occurred, or as soon as the packet has been successfully received and decoded.

[0088] In an alternative, or additional example, the AP may also transmit the data packet through all of, or a subset of, the N beam-sets simultaneously. The remainder of the procedure described in the previous paragraph may then follow in a similar way.

[0089] A beam set may include the identification of a primary beam within the beam set. The primary beam may be used by transmission procedures at the AP, STA, or both, as the beam to be used for initial attempts at wireless communication. Alternatively, the primary beam may be used exclusively for transmission of control or scheduling information. More than one primary beam may be used for more than one STA wherein each primary beam may be associated with a particular STA.

[0090] In an alternative, or in addition to, the AP may also cycle through different modes of MIMO operation for each beam set, prior to

proceeding to the next beam set. For example, if the AP does not receive an ACK on beam set B1 it may select a more robust form of operation such as Space Time Block Coding (STBC), Space Frequency Block Coding (SFBC), or Cyclic Delay Diversity (CDD), before proceeding to transmit on the remaining beam sets B2 through BN.

[0091] In some examples, a first and second best beam transmission method may be used. For example, the STA may determine the two best beams, B1, B2, using a procedure similar to the above, and recommend these beam indices to the AP. In this example, for the remainder of the communication interval, the AP and the STA may assume that either, or both, beam indices may be used for wireless communication.

[0092] The AP may then determine to transmit on either beam during a particular transmission time interval (TTI) based on one or more criteria determined by the AP. Example criteria may include one or more of the received SNR, or SINR, Bit-Error-Rate (BER), or Packet Error Rate (PER), acknowledgement (ACK) statistics, or a combination of these criteria. The STA may respond to a message from the AP with an indication of the reception quality, or similar metric, for the beam that it used to receive the message from the AP. This indication or metric may be indicated in the response by the beam index.

[0093] Alternatively, if the STA does not provide an indication of the reception quality in its ACK and/or any other packet to the AP, the AP may determine that the reception quality was acceptable for one or more associated beams. If the STA indicates a poor reception quality to the AP for B1, it may assume that the next transmission from the AP will use the second best beam B2.

[0094] During communication with the STA, the AP may store the packet reception quality for each transmission, on each beam, in a memory, while using either beam. If a particular beam in the pair becomes unusable for further communication, the AP may identify a new first, or a second best beam for communication with the STA, while at the same time continuing

communication on the remaining beam of the original beam pair. Other combinations of the procedures described in this example may be possible. The above example is not limited to a pair of beams and may be extended to support any number of beams greater than one that the system may simultaneously support.

[0095] Some examples may use out of band beam switching. For example, the AP and STA may both have multi-band capability. In this example, the AP and the STA may communicate over either a 2.4 GHz or a 5 GHz link in addition to a directional 60 GHz link. The AP and the STA may use one or more of the sub-6 GHz links as an alternate link to signal to each other that the beam set needs to switch to the next best beam set at the beginning of the next data packet. This example procedure may allow for a fast beam switch to occur even if the packet currently being transmitted is not decoded correctly.

[0096] Some examples may implement spatial diversity using a single beam. For example, it may be possible that only one RF chain is available at both transmitter and receiver, such that only one data stream may be transmitted and received at the same time. This RF chain arrangement may be used in mmW systems. With one RF chain, devices may form one beam and transmit the data stream toward the direction specified by the beam. In this example, the devices may forming a beam pointing to a propagation path with the strongest channel gain. Multipath wireless channels, however, may introduce frequency selectivity. A beamforming weight may benefit some frequency tones, however, it may have a detrimental effect for one or more of the other set of frequency tones. Accordingly, there may be no guarantee that the weight pointing to the strongest propagation path will introduce the maximum beamforming gain for the entire frequency channel. Moreover, pointing in one beam direction may increase the system sensitivity to small changes in the multipath environment and may fail to provide robust communication.

[0097] FIG. 2 is a diagram of an example method 200 using two STAs to perform multi-path beamforming. The method may be a multi-stage iterative beamforming method as discussed below, and may include grouping two or more antennas. For example, FIG. 2 shows a first iteration 201 of the method and a second iteration 202 of the method.

[0098] The following articles disclose methods for beamforming. P. Xia, S. K. Yong, J. Oh and C. Ngo, "A practical SDMA protocol for 60GHz millimeter wave communications", Asilomar, 2008; and, P. Xia, S. K. Yong, J. Oh and C. Ngo, "Mulit-stage iterative antenna training for millimeter wave communications", Globecom, 2008, the entire contents of both are incorporated herein by reference.

[0099] Referring to FIG. 2, STA_1 205 and STA_2 210 are respectively shown on two time axes 215 and 220. In this example, STA_1 205 may transmit one or more training beamforming weights, and STA_2 210 may receive training beamforming weights 230, 240, and transmit beamforming weights 235 to STA_1 205. STA_1 205 and STA_2 210 may be, for example, WTRU, stations, electronic communication devices, or access points. The example in FIG. 2 shows STA_1 205 transmitting 230, 240 to only STA_2 210, however there may be more than one STA, which are not shown. STA_1 205 may be an AP or a non-AP STA. STA_2 210 may be an AP or a non-AP STA.

[0100] In each iteration of the method 201, 202, the AP, here STA_1 205, may transmit one or more training sequences over multiple time slots 230 and sweep the transmit beamforming weights. For example, STA_1 205 may be an AP or a non-AP STA. Note that only two iterations of the method 201, 202 are illustrated, but the method may have more than two iterations of the method 201, 202. STA_2 210 may calculate the best transmit beamforming weight vector according to an estimate of the received channel state. Note that the calculated transmit beamforming weight may not be one of the weights the transmitter STA_1 205 originally utilized. The method at STA_2 210 may then feedback this beamforming weight vector 235, or the estimated channel state vector, to the AP, here STA_1 205. The AP, here STA_1 205, may, or may not,

update the transmit beamforming weight it utilizes for a subsequent transmission to STA_2 210. The method may continue until packet transmissions are completed for the associated STAs, STA_2 210.

[0101] The AP, here STA_1 205, may group the antenna array into multiple sub-groups to point the beamforming weight to multiple paths. For example, if there are 36 antenna units and only the two strongest paths are used, then each sub-group may have 18 antenna units. Alternatively, if more antenna gain is anticipated from the strongest path, more antenna units may be assigned to the strongest path. The AP, here STA_1 205, may assign other antenna sub-group partitions depending on the requirements of the system. For example, more than two strongest paths may be used. The method in this example may steer the antenna array in the first sub-group to the strongest path, while the second sub-group may be steered to the second strongest path, and so on. This antenna group partition procedure may be performed by the AP, here STA_1 205, or STA_2 210, or both.

[0102] In another example, antenna group based multi-path beamforming may be performed. In this example, STA_1 205 may have Nt transmit antennas and STA_2 210 may have Nr receive antennas, and only the two strongest paths may be considered.

[0103] The transmitter, for example STA_1 205, may transmit Nt sequences 230. The Nt sequences 230 may be modulated using Nt orthogonal beamforming vectors. STA_1 205 may include a precoder, for example an identity precoder, and may be configured to transmit the first sequence using the first antenna, and transmit the second sequence using the second antenna, and so on. Other orthogonal precoding matrices may be utilized by STA_1 205.

[0104] The receiver, for example STA2 210, may receive the Nt sequences using the receive beamforming vector calculated in the last iteration, W_{i-1}^{r}. In some examples, W_{i-1}^{r} may be set to an initial value. STA2 210 may be configured to determine that the first n time slots correspond to transmit antenna 1 to antenna n, which may correspond to antenna group 1.

STA2 210 may utilize the training sequence transmitted in each time slot to estimate the strongest path of the propagation channel, and may denote the strongest channel path as H1. The received signal from the first n time slots may be expressed as $y_i^{11} = W_{i-1}^r(1:n)Hs + N$, where y may be the received symbol, s may be the sent symbol, N may be the additive Gaussian noise having a variance, and H may be the channel matrix between the transmitter STA1 205 and the receiver STA2 210. The receiver STA2 210 may use the correlation property of the training sequence to estimate the channel corresponding to the strongest propagation path, $\hat{H}_1^1$. Thus, the receiver STA2 210 may determine the best transmit beamforming weight corresponding to antenna group 1 and the strongest path, and may be represented as $(\hat{H}_1^1)'$. The size of the beamforming weight may be $n \times 1$.

[0105] The receiver, STA2 210, may be configured to determine that time slots n+1 to Nt correspond to transmit antenna n+1 to antenna Nt, and may correspond to antenna group 2 of STA1 205. The receiver, STA2 210, may utilize the training sequence transmitted in each time slot to estimate the second strongest path of the propagation channel, and may be denoted as H2. The received signal 245 from the Nt-(n+1)+1 time slots may be expressed as $y_i^{12} = W_{i-1}^r(n+1:Nt)Hs + N$. Since the signal may be transmitted using a sequence with a zero auto correlation (ZAC) property, STA2 210 may use a Rake receiver like method, where the strongest path may be removed, and the channel of the second strongest path may be determined. The second strongest path may be represented by $\hat{H}_2^1$. Thus the best transmit beamforming weight corresponding to antenna group 2 and the second strongest path may be $(\hat{H}_2^1)'$. The size of the transmit beamforming weight may be $(Nt - n) \times 1$.

[0106] The updated transmit beamforming weight for iteration i may be expressed as $W_i^t = [\hat{H}_1^1, \hat{H}_2^1]'$. STA2 210 may transmit W_i^t back to STA1 205 at 235. STA1 205 may use the received W_i^t to transmit 240 another set of beamforming training frames. STA1 205 may transmit Nr repetition of

training frames, where Nr may be the number of antenna(s) at STA2 205. STA2 205 may be configured to use this set of training frames to update the received beamforming weight. STA2 210 may use Nr antennas to receive the training frames sequentially. STA2 210 may also use other orthogonal beamforming weights to receive the Nr training frames. In this example, at STA2 210, antenna 1 to m may belong to the first antenna group, and may be used to point to the strongest propagation path, while antenna m+1 to Nr may belong to antenna group 2, and may correspond to the second strongest propagation path.

[0107] In one example, STA1 205 may use a mixed mode to transmit Nr repetitions of training frames with weight W_i^t. This example mixed mode method is shown in FIG. 2 as 202. The received signal through the Nr time slot may be expressed as $y_i = HW_i^t s + n$. The received signal from antenna group 1 may be $y_i^{21} = y_i(1:m)$. STA2 210 may use the correlation property of the training sequence to estimate the channel with the strongest propagation path, $\hat{H}_1^2$. The received signal from antenna group 2 may be $y_i^{22} = y_i(m+1:Nr)$, and STA2 210 may use correlation detection to remove the strongest path. STA2 210 may accordingly determine the estimated channel for the second strongest path, $\hat{H}_2^2$. STA2 210 may update the receive beamforming weight, which may be represented as $W_i^r = [\hat{H}_1^2, \hat{H}_2^2]'$. In FIG. 2, the reception of the signals is shown in dashed lines as an example illustration of the receiver operation while receiving a packet.

[0108] Alternatively, or in addition to, STA1 205 may use a sequential mode. STA1 205 may transmit m repetitions of training frames with antenna group 1, i.e., $W_1^{t1} = [\hat{H}_1^1, 0]'$. During the m training time slot, the receiver, for example STA2 210, may utilize antenna group 1 to receive the training frames. For example, STA2 210 may utilize antenna 1 to receive the first training frame, and antenna m to receive the mth training frame. The

received signal from these m frames may be expressed as $y_i^{21} = HW_i^{t1}s + n$. STA2 210 may estimate the channel corresponding to the strongest propagation path $\hat{H}_1^2$. STA1 205 may transmit Nr-m repetitions of training frames with antenna group 2 only, for example, $W_1^{t2} = [0, \hat{H}_2^1]'$. STA2 210 may utilize its antenna group 2 to receive the training frames. The received signal may be $y_i^{22} = HW_i^{t2}s + n$. STA2 210 may use a correlation method to determine the channel corresponding to the second strongest path, $\hat{H}_2^2$. STA2 210 may update the receive beamforming weight $W_i^r = [\hat{H}_1^2, \hat{H}_2^2]'$. In some examples, feedback channels corresponding to the strongest paths may be used directly by STA2 210 or STA1 205. Note that this mode is not illustrated in FIG. 2.

[0109] STA2 210 may send $W_i^r = [\hat{H}_1^2, \hat{H}_2^2]'$ to STA1 205 (not illustrated). In addition, the method may repeat for a number of times up to a threshold or until the method converges which may be determined by comparing a next value of the beamforming weights with a previous value of the beamforming weights and determining if the difference is less than a threshold value.

[0110] The initial beamforming weights for STA1 205 and STA2 210 may be set to initial values prior to beginning the method. STA1 205 and STA2 210 may determine the initial values in order to reduce the number iterations needed for the method to converge. The example method shown in FIG. 2 may be used for determining the two strongest paths. However, in other example embodiments, more than two paths may be determined by the STA1 205 and STA2 210.

[0111] Existing protocols may be modified to perform multi-path beamforming methods. For example, a multi-path beamforming method may be used in 802.11 and 802.11ad. For example, the multi-path beamforming method may be used in 802.11ad by using a modification of the beam refinement protocol (BRP) as disclosed in IEEE P802.11ad™/D9.0: Part 11, "Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications," the entire contents of which are herein incorporated by

reference. The multi-path beamforming method may be a multi-iteration multi-path beamforming training method.

[0112] A beam refinement transaction may be a set of BRP frames that include one or more beam refinement requests and responses. The multi-path beamforming method may be implemented by modifying current beamforming refinement protocols.

[0113] FIG. 3 is a diagram of an example of one iteration of the multi-path beamforming method 300 using BRP transactions. The beamforming initiator, STA1 305, may transmit a BRP frame 315 that indicates that the BRP frame 315 is a Transmit BRP Request frame. This indication may be performed by setting a field, for example, TX-TRN-REQ=1. A BRP frame with TX-TRN-REQ=1 315 may include a transmit training subfield (TRN-T) 320 appended to it. The responder, STA2 310 may reply with a Transmit BRP Feedback 325, for example, by setting TX-TRN-RSP=1. Moreover, STA2 310 may request a receive beamforming training by indicating Receive BRP Request frame in the same BRP frame, for example, by setting L_RX>0. In this example, the Receive BRP Request frame may be piggybacked on the Transmit BRP Response frame. L_RX may be a signal field used to indicate that the receiver requests a receive BRP training, and the transmitter may respond with a BRP train response followed by a TRN-R training field. STA1 305 may transmit a BRP frame 330 with a BRP train response, for example, by setting RX-TRN-RSP to 1. A BRP frame that includes an RX-Train-response that equals 1 may include a receive training subfield (TRN-R) 335 appended to it.

[0114] FIG. 4 is a diagram of an example frame format for a BRP packet 402. The BRP packet 402 may include a short training field (STF) 404, a channel estimation (CE) field 406, a Header field 408 and a data field 410. A training field 416 may be appended/prepended to the BRP packet 402 and may include an AGC training field 412 and a receiver/transmitter training subfield (TRN-R/T) 414. A BRP packet 402 may be transmitted using control PHY. Prior to the RTN-R/T training, there may be a signaling exchange to aid the

training procedure. This is the purpose of field 404, 406, 408, 410. A Packet Type field may be included in the PHY header, and it may indicate whether a TRN-R or a TRN-T subfield 414 is appended to the frame 402. A BRP frame 402 with a TRN-R/T 414 field appended may be referred to as a BRP-RX/TX packet 402. In a BRP-TX packet 402, the transmitter may change the TX beamforming weight configuration at the beginning of each AGC subfield 412. The set of beamforming weights used for the AGC subfields 412 may be the same as that used for the TRN-T subfield 414. In a BRP-RX packet 402, the transmitter may use the same transmit beamforming weight as in the preamble and data fields of the transmission data packet. The BRP frame may be an Action No ACK frame.

[0115] FIG. 5 is a diagram of an example format of a BRP frame Action field. The BRP frame Action field 500 may include a Category field 510, an Unprotected DMG Action field 520, a Dialog Token field 530, a BRP Request field 540, a DMG Beam Refinement element 550, and one or more Channel Measurement Feedback elements 5601…560n.

[0116] An 802.11ad beam refinement protocol may be modified as follows in order to accommodate a multi-path beamforming algorithm. For example, an initiator may determine the capabilities of the responder prior to initiating beamforming training with the responder. The multi-path multi-stage iterative beamforming training capability may be indicated in a DMG Capabilities element. A DMG Capabilities element may be present in Association Request, Association Response, Reassociation Request, Reassociation Response, Probe Request and Probe Response frames and may be present in DMG Beacon and Information request and response frames. A DMG Antenna Array Support field may include one or more bits that indicate that the STA is capable of forming sub-antenna groups and capable of performing the multi-path multi-stage beamforming training method.

[0117] Partitioning of antenna sub-groups at both initiator and responder may be signaled. Depending on the antenna grouping method, the

signaling may be different. For example, the antenna grouping may be performed uniformly or non-uniformly.

[0118] In a uniform antenna grouping example, assuming the total number of antennas is even, each antenna sub-group may have the same number of antenna elements, and hence only the number of antenna groups is required to indicate the partition of antenna sub-groups. For example if there are four antennas, and two groups, the number of groups, in this example two, may be sent back since the number of antennas per group will be known. The mapping between antenna element indices and sub-group indices may be predetermined and transmitted explicitly in a field of the BRP frame, for example, a BRP Request field. If the mapping is explicitly indicated in the BRP frame, the antenna sub-group index may be assigned to each antenna element.

[0119] In a non-uniform antenna grouping example, each antenna sub-group may have a different number of antenna elements. For example, the system may assign more antenna elements for the strongest path, so that the antenna gain from this sub-group may be larger. The mapping between antenna element indices and sub-group indices may be predetermined and transmitted explicitly in a field of the BRP frame, for example, in a BRP Request field.

[0120] Mapping between antenna sub-groups and channel propagation paths/taps may be predetermined. For example, antenna sub-group 1 may always map to the strongest path, and so on. Alternatively, the mapping may be defined in the BRP Request field.

[0121] The precoding matrix used by the initiator, for example, STA1 205, in the first part of each iteration may be predetermined and agreed by both initiator and responder. The first part of each iteration may be referred to as the transmit beamforming training part. In one example, a set of unitary precoding matrices may be predetermined. In this example, the initiator and responder may negotiate which matrix is utilized before performing the

beamforming training. For example, the precoding matrix index may be predetermined and transmitted in the BRP Request field.

[0122] The number of antennas at both initiator and responder side may be signaled. Number of antennas may be signaled, for example, in the PHY header, MAC header or BRP Request field.

[0123] FIG. 6 is a diagram of an example modified channel measurement feedback element 600. The channel measurement feedback element may include a signal-to-noise ratio (SNR) subfield 610, a channel measurement subfield 620, a tap delay subfield 630, and a sector ID order subfield 640. The presence of these subfields may depend on the values defined in the DMG Beam Refinement element. For example, the channel measurement subfield may be used to feed back up to Ntap channel measurements that correspond to a common set of relative tap delays defined in the tap delay subfield. Without the presence of the tap delay subfield, for example, the Ntaps channel taps may be interpreted as contiguous time samples, separated by Tc, where Tc may be the SC PHY chip time, and may be 0.57ns. In these exemplary multi-path beamforming methods, the channel measurements of the strongest propagation paths may be sent to STA1. In the example shown in FIG. 2, the strongest path/tap may be assigned for the first antenna sub-group, and the second strongest path/tap may be assigned for the second antenna sub-group and so on. If the multi-path beamforming method is indicated in the PHY header, MAC header or MAC body, the interpretation of the channel measurement may be modified when the tap delay subfield is not present. Therefore, protocols may be modified to accommodate examples of the multi-path beamforming method disclosed herein.

[0124] Weighted multi-path beamforming training methods may be performed. For example, a beamforming method for steering the beam towards multiple propagation paths may be performed. The strongest propagation paths/taps may be determined by a STA, and one or more beamforming weights may be determined to point to one or more of the propagation paths/taps. The beamforming weight for the kth strongest

propagation path may be represented as Wk, and the final beamforming weight may be expressed as $W = \sum_{k=1}^{K} \alpha_k W_k$, where K may be the number of channel propagation paths and α_k may be the weight, with $\sum \alpha_k = 1$.

[0125] Different methods may be used by the STA selecting α_k in one of the following ways. For example, propagation path selection may be based on: $\alpha_k = \begin{cases} 1 & k = m \\ 0 & k \neq m \end{cases}$. By this selection, the final beamforming weight vector may equal the weight vector directed towards the mth propagation path.

[0126] In an 802.11ad example, the channel propagation taps may be measured and fed back to the beamforming initiator, which may be STA1 205. According to the channel measurement of each tap, a channel gain may be estimated by the STA. Channel gain of the kth propagation path/tap may be represented as β_k. α_k may be represented as $\alpha_k = \lambda - \frac{1}{\beta_k}$, so that $\sum \alpha_k = 1$, $\lambda = \frac{1 + \sum 1/\beta_k}{K}$ may be satisfied. The propagation path with the larger channel gain may have a larger weight and may be determined by the STA to be the strongest propagation path.

[0127] A single data stream transmission may be performed with multi-beam capability devices. For example, multiple RF chains may be available at the AP. Accordingly, the AP may form multiple beams simultaneously. In this example, the STA may form only one RF chain. The AP and the STA may be configured to use an Nx1 virtual MIMO channel. The AP and the STA may be configured to use diversity methods, such as, for example, STBC, SFBC and CDD. These example methods may be performed by more than one AP and more than one STA. In addition, a STA may be an AP.

[0128] There may be at least two possible transmission procedures that implement RF front-end beamforming with digital domain STBC. One example transmission procedure may use full size beamforming with STBC.

Another example transmission procedure may use partial size beamforming with STBC.

[0129] FIG. 7 is a diagram of an example AP 700 configured to perform a transmission using full size beamforming with STBC. The AP 700 may include a coding/modulation unit 702, an STBC encoder 706, a plurality of DAC/upconverters 708, 710, and a plurality of antennas 716. In this example, the coding/modulation unit 702 may perform modulation and coding and pass the modulation symbols 704 to the STBC encoder 706. The STBC encoder 706 may generate two data streams 718, 720. The two data streams 718, 720 then be processed through two RF chains at the plurality of DAC/upconverters 708, 710, which may separately perform DAC and up conversion to the operating frequency band. At the RF front-end, two beamforming weight vectors W1 712 and W2 714 may be generated by AP. Each weight-vector may be of size Nt x 1. The first data stream 718 may be multiplied with the first weight vector W1 712, and the second data stream 720 may be multiplied with the second weight vector W2 514. The two data streams 718, 720 may then be summed together and transmitted through the Nt antennas 716. In some embodiments, the AP may be configured with more than two RF chains.

[0130] FIG. 8 is a diagram of an example AP 800 configured to perform a transmission using partial size beamforming with STBC. The AP 800 may include a coding/modulation unit 802, an STBC encoder 806, a plurality of DAC/upconverters 808, 810, and a plurality of sets of antennas 816, 817. In this example, the coding/modulation unit 802 may perform modulation and coding and pass the modulation symbols 804 to the STBC encoder 806. The STBC encoder 806 may generate two data streams 818, 820. The two data streams 818, 820 may then be processed through two RF chains at the plurality of DAC/upconverters 808, 810, which may separately perform DAC and up conversion to the operating frequency band. At the RF front-end, two beamforming weight vectors W1 812 and W2 814 may be generated. Each weight vector may be of size Nt/2 x 1. The first data stream 818 may be multiplied with the first weight vector W1 812, and the second data stream

820 may be multiplied with the second weight vector W2 814. The first data stream 818 may be transmitted through the first set of Nt/2 antennas 816 and the second data stream may be transmitted through the second set of Nt/2 antennas 817. In embodiments, AP may be configured with more than two RF chains.

[0131] The AP and/or the STA may be configured to send and receive multiple data streams. For example, the AP and/or the STA may be configured with multiple RF chains. In these examples, the AP may be configured to communicate with multiple STAs simultaneously. The AP may be configured to distinguish the multiple STAs by spatial domain beams, thus the method may be referred to as Beam Division Multiple Access (BDMA). The AP may need multiple RF chains to perform BDMA. For example, the AP may be configured to use spatial multiplexing methods for single STA transmission. The AP and STA may be configured to send more than one data stream at a time, which may increase the spectral efficiency of the system. Multiple RF chains may be needed at both AP and STA side.

[0132] FIG. 9 is a diagram of an example of transceiver architecture 900. The AP and/or STA may be configured as follows. The transceiver architecture 900 may include a transmitter side 902 and a receiver side 904. The transmitter side 902 may include one or more coding/modulation units 903, a plurality of DAC/upconverters 912, 914, a digital controller 917, one or more power amplifiers (PA)s 920, and a plurality of Nt antennas 925. Multiple data streams may be modulated and coded at baseband, and then converted from a digital domain to an analog domain through the digital controller 917. The streams 908, 910 may be upconverted to operation frequency band by the DAC/upconverters 912, 914. Two sets of DACs and upconverters are illustrated here, which implies that up to two data streams may be supported by the transmitter. Beamforming weights 915, 916 may be applied prior to applying the streams to the PAs 920. The beamforming weights 915, 916 may be prepared in a digital domain.

[0133] The transmitter 902, may be an AP or STA, an may be configured with Nt antennas 925. The Nt antennas 925 may be shared by two or more RF chains. When the transmitter 902 has two data streams $\{s_1, s_2\}$ to transmit, it may generate two beamforming weights $V^1 = (V_1^1, V_2^1, ..., V_{Nt}^1)^T$ 916 and $V^2 = (V_1^2, V_2^2, ..., V_{Nt}^2)^T$ 915. The two signal streams may be combined and transmitted through Nt transmit antennas 925, $s = V^1 s_1 + V^2 s_2$. The AP and STA may be similarly configured on the receiver side if multiple RF chains are presented. The receiver 904 may generate two sets of receive beamforming weights $U^1 = (U_1^1, U_2^1, ..., U_{Nr}^1)^T$ 936 and $U^2 = (U_1^2, U_2^2, ..., U_{Nr}^2)^T$ 935 and apply them in an analog domain. The weighted streams may be applied to a respective ADC/downconverter. The downconverted streams 908', 910' may be decoded and demodulated.

[0134] Communication devices, which may be, for example, APs or STAs, with the transceiver embodiment illustrated in FIG. 9 may be referred to as Type I. In some embodiments, the AP and/or STA may be configured with more than two RF chains where FIG. 9 may be extended to accommodate the more than two RF chains.

[0135] FIG. 10 is a diagram of another example transceiver architecture 1000. The transceiver architecture 1000 may include a transmitter side 1002 and a receiver side 1004. In this example, the AP and or the STA may be configured as follows. Each RF chain may have its own set of antennas 1048, 1050, respectively. The antennas may be deemed to have been partitioned or split into sub-groups based on the number of RF chains. Compared to Type I devices, in order to achieve the same antenna gain, N antenna elements may be required. Here N may be the number of RF chains. Communication devices, which may be, for example, APs or STA, with the transceiver architecture illustrated in FIG. 10 may be referred to as Type II. The beamforming weights in FIG. 10, may be tuned as a group by the digital controller logic, as indicated by the dashed lines.

[0136] FIG. 11 is a diagram of an example of beam division multiple access (BDMA) architecture 1100. The AP 1102 may be configured to transmit two packets to STA1 1106 and STA2 1104 simultaneously. The STAs 1106, 1104 may be configured to share the time-frequency resource by different RF front-end beams.

[0137] The AP 1102 may be configured to prepare MAC packets for both STA1 1106 and STA2 1104. The AP 1102 may encode and modulate the MAC packets and form separate PHY packets and up convert them to 60 GHz through separate RF chains. At the RF front-end, the AP 1102 may apply beamforming weight vector W1 to the first data stream and W2 to the second data stream. The AP transmits a combination of the two data streams. In this way, multiple RF chains may share the same set of antennas as shown in FIG. 9. Alternatively, the AP 1102 may be configured to implementation BDMA by dividing, grouping, or partitioning the set of antennas to sub-groups, and each RF chain control may be sent by the AP 1102 on one antenna sub-group as shown in FIG. 10.

[0138] The AP and STA may be configured to perform a beamforming training method for BDMA. The AP and/or STA may be configured to perform the beamforming training method sequentially with one or more STAs in communication with one another. The example beamforming training methods may be standardized, for example, and may be used in 802.11ad. The AP and/or STA may be configured to use orthogonality between training beams.

[0139] FIG. 12 is a diagram of an example beamforming training method 1200 for BDMA. This example may use a multi-stage iterative beamforming training algorithm for BDMA. In the example illustrated, the AP 1202 has Nt antennas, STA1 1204 has M1 antennas and STA2 1206 has M2 antennas.

[0140] The beamforming training method for BDMA may be performed iteratively. The AP 1202 may transmit Nt sequences 1208. The Nt sequences 1208 maybe modulated using Nt orthogonal beamforming vectors. The

example shown in FIG. 12 may be performed using a precoder, for example, an identity precoder. In this example, the first sequence may be transmitted using a first antenna ("Ant 1") 1208, and a second sequence may be transmitted using the second antenna, and so on until the Nt antenna ("Ant Nt") 1210. The AP 1202 may be configured to use other orthogonal precoding matrices, such as, for example, the Walsh Hadamard matrix or FFT matrix.

[0141] STA1 1204 may be configured to utilize the best receive beamforming vector 1212 calculated through the last iteration, W_{i-1}^{r1}, to receive the signals. In FIG. 12, the reception of the signals is shown in dashed lines as an example illustration of the receiver operation while receiving a packet. For example, the dashed box W_{i-1}^{r1} may indicate that the STA1 1204 should use receive beamforming vector W_{i-1}^{r1} to perform receive beamforming. Since the AP 1202 may have transmitted the signal through each antenna sequentially, STA1 1204 may receive a Nt x 1 effective MISO channel between AP 1202 and STA1 1204, $W_{i-1}^{r1}H_1$ at the end of the transmission due to the use of the receive beamformer. Equivalently, the received signal may be expressed in a matrix format: $y_{11} = W_{i-1}^{r1}H_1 s + n$, where y may be the received signal, s may be the sent signal, n may be Gaussian noise, W may be the weight used by STA1 1204, and H may be the channel matrix between AP 1202 and STA1 1204. Based on the received signal, STA1 1204 may calculate or determine the best transmit beamforming weight from AP 1202 to STA1 1204 which may be represented as $V_i^{r1} = \frac{y_{11}s'}{\|y_{11}s'\|}$.

[0142] Similarly, STA2 1206 may be configured to utilize W_{i-1}^{r2} to receive the signals, and the received signal may be expressed as $y_{12} = W_{i-1}^{r2}H_2 s + n$. The best transmit beamforming weight from AP 1202 to STA2 1206 may be represented as $V_i^{r2} = \frac{y_{12}s'}{\|y_{12}s'\|}$, which STA2 1206 may be configured to determine.

[0143] The method may continue with STA1 1204 sending V_i^{r1} 1222 to the AP 1202. STA2 1206 may send V_i^{r2} 1220 to the AP 1202. STA2 1206 may transmit the packet immediately after the transmission of STA1 1204, or STA2 1206 may wait for a polling frame transmitted from the AP 1202 (not illustrated) before transmitting the packet.

[0144] The method may continue with the AP 1202 calculating MU-MIMO weight W_i^{t1} and W_i^{t2} based on V_i^{r1} and V_i^{r2}. The AP 1202 may then implement a linear or non-linear MU-MIMO precoding algorithm for this weight update 1209.

[0145] The method may continue with the AP 1202 transmitting 1230 again with the best beamforming weights and each STA 1204, 1206 receiving with multiple receive antennas.

[0146] The method may continue with one of the following alternatives. In a first alternative, as illustrated in FIG. 12, the AP 1202 may transmit $W_i^{t1}s_1 + W_i^{t2}s_2$ for Max(M1,M2) times 1230. s_1 and s_2 may be orthogonal sequences, and may be known at AP 1202, STA1 1204 and STA2 1206. The AP 1202 may signal STA1 1204 and STA2 1206 about the assignment of s_1 and s_2. STA1 1204 may be configured to switch receive antennas to train the best receive beamforming weight W_i^{r1}. Similarly, STA2 1206 may train the best receive beamforming weight W_i^{r2}. STA1 1204 may use the orthogonal sequences to estimate the current signal (via cross correlation with s_1) and the current interference (via cross correlation with s_2). Thus, STA1 1204 may train its receive beamforming vectors by nulling the interference. Similarly, STA2 1206 may use the orthogonal sequences to estimate the current signal (via cross correlation with s_2) and the current interference (via cross correlation with s_1). Then, STA2 1206 may train its receive beamforming vectors by nulling the interference.

[0147] In a second alternative, the AP 1202 may transmit $W_i^{t1}s$ for M1 repetitions. STA1 1204 may switch between its M1 antennas to receive $W_i^{t1}s$, and at the same time, STA2 may monitor the transmission of $W_i^{t1}s$. AP 1202 may transmit $W_i^{t2}s$ for M2 repetitions and STA2 may switch between its M2 antennas to receive $W_i^{t2}s$ while STA1 1204 monitors the transmission of $W_i^{t2}s$.

[0148] The example beamforming training method for BDMA may not be successful. If the correlation between two STAs 1204, 1206 is high, the two STAs 1204, 1206 may not be distinguished by beams. This may lead to an unsuccessful beamforming training for BDMA. In this example, the AP 1202, and or STAs 1204, 1206, may be configured to provide information if BDMA may or may not be supported with the current configuration. The STAs 1204, 1206 may include the report of beamforming gain when they report V_i^{r1} and V_i^{r2} to the AP 1002. The beamforming gain may be defined as $\|y_{11}s'\|^2$ and $\|y_{12}s'\|^2$. Alternatively, or in addition, the STAs 1204, 1206 may report signal to interference ratio (SIR) during or at the end of the method. The STAs 1004, 1006 may determine or calculate the desired signal strength and interference signal strength with both example alternatives.

[0149] The BDMA training method may include performing BDMA training on each STA 1204, 1206 sequentially. This example method may be extended for more than two STAs.

[0150] Examples of the BDMA training method may be standardized. For example, the BDMA training method may be used with IEEE 802.11ad. In these examples, a service period (SP) may be a time period scheduled for service from one device to another device. The transmission during an SP duration may be scheduled by an AP. The BDMA training method may be scheduled by the AP if it is allocated in an SP duration. Examples of the BDMA training method may be used by modifying the BRP procedures.

[0151] FIG. 13 is a diagram of an example modified BRP procedure to implement a multi-stage iterative beamforming training method for BDMA 1300. In this example, AP 1302 may transmit a BRP frame 1320 that indicates a Transmit BDMA BRP Request. A Transmit BDMA BRP Request subfield may be defined in BRP Request field, and may indicate that the BRP frame is for transmit BDMA BRP training. Alternatively, a Transmit BRP Request may be used with TX-TRN-REQ=1 to indicate that the BRP frame is for transmit BRP training. A frame that is utilized for single user beamforming training or BDMA training may be indicated implicitly or explicitly in the MAC frame or PHY header.

[0152] STA1 1304 may reply with a Transmit BRP Feedback frame 1322 by setting TX-train-response=1. STA1 1304 may also request a receive beamforming training by indicating Receive BRP Request in the same Transmit BRP Feedback frame 1322 by setting L_RX>0.

[0153] AP 1302 may transmit a Polling frame 1324 to STA2 1304 to request BRP feedback. This step may be skipped if the frame length of BRP feedback frame is fixed and known by all the devices.

[0154] STA2 1306 may reply with a Transmit BRP Feedback frame 1326 by setting TX-train-response=1. STA2 1306 may also request a receive beamforming training by indicating Receive BRP Request in the same Transmit BRP Feedback frame 1326 by setting L_RX>0.

[0155] AP 1302 may transmit a BDMA BRP frame 1328 indicating a BRP train response by setting RX-Train-response to 1. A BRP frame with RX-Train-response equal to 1 may include a receive training subfield TRN-R 1330 appended to it. A BDMA BRP frame 1328 may indicate multiple receivers explicitly or implicitly in PHY header or MAC body.

[0156] The example in FIG. 13 shows that one AP 1302 may transmit to two STAs 1304, 1306. However, the BDMA transmission may be from one device to two devices irrespective of whether they are APs or STAs. Moreover, the AP 1302 may transmit to two or more STAs.

[0157] Examples of the method in FIG. 13 may include BDMA protection mechanisms. The feedback frame 1322 may include not only the best beam, but also the achievable SINR. If after a certain number of iterations, the achievable SINR is less than the target SNR, the BDMA method may be aborted. The number of iterations may be predetermined, determined statically, dynamically determined based on previous methods running, or in another way.

[0158] BDMA grouping may be indicated in some examples. The following examples may enable an indication of BDMA grouping by one or more communication devices. Using an SP, the BDMA grouping information may be indicated in an allocation field in an Extended Schedule Element. The Extended Schedule Element may be transmitted in a Beacon frame. The tuple, Source AID, Destination AID and Allocation ID may uniquely identify the allocation. The Source AID field may be set to the AID of the STA an may initiate channel access during the SP. The Destination AID field may indicate the AID of a STA that may be expected to communicate with the source STA during the allocation. The Allocation ID may identify an airtime allocation from a Source AID to a Destination AID. With BDMA transmission, more than one receiver may be indicated. One method may be to group BDMA transmitters and receivers, and assign each group a unique BDMA ID. Each STA corresponding to a BDMA ID may be assigned a User Position Array that may be used to distinguish the role of the STA. Therefore, the Destination AID may be replaced by the BDMA ID for BDMA transmissions. Alternatively, more than one Destination AID may be included in the allocation field. In this way, the order of the Destination AIDs may imply the role of one or more STAs in the BDMA transmission.

[0159] Since the BDMA transmission may be within the SP time slot, the communication device may not need to signal the BDMA transmission in the PHY header or MAC header. The MCS levels and Length field for each BDMA receiver may be signaled in PHY Header.

[0160] FIG. 14 is a diagram of an example PHY layer frame format 1400 that may be used in a BDMA transmission. N may represent the number of BDMA communication devices that may be signaled in the allocation field in Extended Schedule Element. The example PHY layer frame format 1400 may include an STF field 1410, one or more CE fields 1420, a header 1430, and a data field 1440. The one or more CE fields 1420 may be transmitted with a weight and a P matrix. The weight for the one or more CE fields may range from W1 to WN, for example, the first field may be transmitted with a weight W1, and the last CE field may be transmitted with a weight WN. The header 1430 and data field 1440 may be transmitted using BDMA and with all of the weights from W1 to WN.

[0161] Example embodiments may include performing BDMA in a contention based access period. For example, BDMA transmission protocols may be used by the communication device. Performing a BDMA transmission in a contention based access period may utilize the NDP announcement (NDPA) and NDP sequences for beamforming training. BDMA transmission may be performed after the NDP sequence exchanges. Alternatively, or in addition, the BDMA transmission may be delayed until the BDMA initiator, which may be a STA or an AP, acquires the media again.

[0162] In one example BDMA transmission procedure, one or more of the communication devices may be configured to use an NDPA period. In this example, an AP may transmit a message that indicates which STAs should participate in BDMA training. The NDPA frame may contain a STA info field to indicate the individual STA information. The NDPA frame may reserve a TXOP until the end of BDMA beamforming training by setting the duration period accordingly. Alternatively, the NDPA frame may reserve a TXOP until the end of the BDMA transmission.

[0163] In another example, an NDP period may be configured to allow training of transmit antennas at the AP. In this example, the STAs may perform measurements. In another example, a feedback period may be configured to allow STAs to take turns to feedback the best beam vectors as

well as the achievable SINRs. Moreover, STAs may also feedback the measured channels or the calculated transmit beamforming weight vectors.

[0164] In another example, a receiver training period may be configured to allow an AP to set its beamforming vectors. In this example, STAs may train their receive antennas.

[0165] In another example, the NDP period, feedback period, and receiver training period may be repeated for a number of iterations. A number of stopping criteria may be applied in this example. For example, if the achievable SINR meets expectation, the iteration may stop early. In these examples, BDMA transmissions may begin a certain inter-frame spacing after training is performed. ACK1 and ACK 2 may each be followed by a SIFs duration after BDMA transmission is performed.

[0166] In another example, one or more communication devices may be configured to indicate BDMA grouping. The following is an example of indicating grouping. BDMA grouping with contention based access period (CBAP) may be performed by using a BDMA ID. A BDMA ID management frame may be transmitted from an AP to a STA to indicate whether the STA belongs to one of the BDMA groups and the user position of the STA. The BDMA ID management frame may contain a Membership Status Array field and a User Position Array field. The BDMA ID may be included in BDMA related frames, such as BDMA training frames, BDMA transmission frames, or other similar frames.

[0167] One or more communication devices may be configured to perform a BDMA transmission method for CBAP that may be similar to that defined for SP. The BDMA transmission may be performed after the BDMA initiator, for example the AP, acquires a TXOP in the CBAP. The PHY layer frame format may be the same as illustrated FIG. 14. The transmission of BDMA in CBAP may not be scheduled by the AP. Accordingly, the BDMA ID may be included in the PHY header. The number of users or communication devices, N, may be indicated in the sequence exchange to acquire the TXOP

before a BDMA transmission. Alternatively, it may be implicitly indicated using a short training field (STF) and/or a channel estimation (CE) field.

[0168] In some examples, the communication devices may be configured to perform single user spatial multiplexing. In order to perform spatial multiplexing, both transmitter and receiver may have multiple RF chains. FIG. 9 and FIG. 10 are example transceiver configurations to perform single user spatial multiplexing. A communication device with the transceiver configuration shown in FIG. 9 may be referred to as a Type I device, i.e., where multiple RF chains share the same set of antenna elements. A communication device with the transceiver configuration shown in FIG. 10 may be referred to as a Type II communication device, i.e., where the antenna elements may be split into sub-groups, and each sub-group may correspond to one RF chain.

[0169] The communication devices may be configured to perform beamforming methods for spatial multiplexing. In this example, several beamforming methods may be used to perform spatial multiplexing transmission between a pair of communication devices. Two types of example beamforming methods may be used. The first example method may be referred to as Eigen-Beamforming based spatial multiplexing. In this example, the initiator/responder may estimate the channel over the air and calculate beamforming weights accordingly. The second example method may be referred to as beam sweep based spatial multiplexing. With this method, both initiator and responder may transmit and receive using pre-defined beam sectors. The beamforming beams may then be selected from these beam sectors.

[0170] The communication devices may be configured to perform an Eigen-Beamforming based spatial multiplexing method, where the communication devices may be configured as Type I devices with calibration. Type I devices may have multiple RF chains sharing the same set of antennas as discussed in conjunction with FIG. 9. If the communication devices are configured to calibrate the multiple transmit RF chains, the communication

devices may determine that the multiple RF chains are identical. Examples of non-calibrated or identical RF chains are discussed below.

[0171] FIG. 15 is a diagram of an example beamforming training procedure 1500 using Eigen-beamforming based spatial multiplexing where the Type I communication devices may be configured to calibrate the multiple transmit RF chains. An iterative example with two RF chains at both initiator and responder is shown in FIG. 15, however, the method may be extended to any number of RF chains. In this example, the transmitter (STA1) 1502 may have Nt antenna elements, and the receiver side (STA2) 1504 may have Nr antenna elements.

[0172] The beamforming training method may be performed iteratively. In each iteration, the transmit beamforming training may be performed and then the receive beamforming training may be performed. An example of a detailed method for Type I devices with calibration is described below.

[0173] For iteration i, STA1 1502 may act as an initiator, and may transmit Nt training sequences 1506 sweeping all the transmit antenna elements. The transmission may be performed using the first transmit RF chain (TX1) or the second transmit RF chain (TX2) of STA1 1502. In some examples, the two RF chains may be identical or differ by a scalar, or, in other examples, the two TX chains may be calibrated. Alternatively, STA1 1502 may also use an orthogonal precoding matrix to transmit the Nt training sequences.

[0174] STA2 (responder) 1504 may have two receive beamforming weights trained from previous iterations, and may be represented by W_{i-1}^{r1} and W_{i-1}^{r2}. If this is the first iteration of the method, STA2 1504 may randomly select two beamforming weights, or use Omni weights, or may determine the two beamforming weights in an alternate method. The first RF chain (RX1) may receive a signal that is the weighted combination of signals received from all the receive antenna elements. This weight may be the first receive beamforming weight W_{i-1}^{r1}. Similarly, the second RF chain (RX2) may receive a

signal that is the weighted combination of signals received from all the receive antenna elements. This weight may be the second receive beamforming weight W_{i-1}^{r2}. In FIG. 15, the reception of the signals is shown in dashed lines as an example illustration of the receiver operation while receiving a packet. For example, the dashed box W_{i-1}^{r1} may indicate that the STA1 1504 should use receive beamforming vector W_{i-1}^{r1} to perform receive beamforming. After conversion to the digital domain, STA2 1504 may estimate the effective channel by comparing the received sequence with the known transmitted sequence. For time slot k, STA2 1504 may estimate two channels using two RF chains $\begin{bmatrix} G_{k1} \\ G_{k2} \end{bmatrix}$. With Nt time slots, STA2 1504 may receive $\begin{bmatrix} G_{11} & \dots & G_{Nt1} \\ G_{12} & \dots & G_{Nt2} \end{bmatrix}$. Applying the inverse of the orthorgonal precoding matrix, STA2 1504 may obtain the channel from Nt transmit antenna elements to two RF chains as $H = \begin{bmatrix} H_{11} & \dots & H_{Nt1} \\ H_{12} & \dots & H_{Nt2} \end{bmatrix}$.

[0175] STA2 1504 may feedback the channel information or beamforming weights for multiple data streams to STA1 1502. STA2 1504 may calculate the transmit beamforming weights for spatial multiplexing and feedback 1508 the weights to STA1 1502. STA2 1504 may feedback the channel H to STA1 1502, and STA1 1502 then may determine or calculate the transmit beamforming weights 1510.

[0176] In some examples, the transmit beamforming weight method may be implementation dependent. For example, STA1 1502 and/or STA2 1504 may use linear or non-linear procoding algorithms.

[0177] The updated transmit beamforming weights for the ith iteration may be denoted as (W_i^{t1}, W_i^{t2}). STA1 1502 may transmit a training sequence Nr times with beamforming weight W_i^{t1} 1512. STA2 1504 may sweep through Nr receive antennas 1514, or apply an orthorgonal matrix. STA2 1504 then passes the received signal through the two RF chains. STA1 1502 may

transmit training sequences again Nr times with beamforming weight W_i^{t2} 1516. STA2 1504 may repeat a similar procedure with both RF chains 1518. The sweeping of the Nr receive antennas 1514 and 1518 is shown in dashed lines as an example illustration of receiver operation. For example, to receive Nr packets from the transmitter, the receiver may receive a first packet with the first receive antenna, a second packet with the second receive antenna, and so on, until it receives a last packet with the last receive antenna. STA2 1504 may estimate the channel and update the receive beamforming weight accordingly (not shown). The receive beamforming weight method may be implementation dependent.

[0178] The above method may be repeated until the method converges or certain criteria have been met that indicate that spatial multiplexing is not suitable for the pair of devices, for example, a set of failure criteria). There may be several ways to define failure criteria that indicate that the pair of devices are not suitable for spatial multiplexing. A first example of failure criteria may be that STA2 monitors the rank or condition number of a channel matrix while selecting a beamforming weight, and may feedback this information to STA1. A second example of failure criteria may be that STA2 monitors the rank or condition number of channel matrix while sweeping through Nr receive antennas or applying an orthogonal matrix, and feeds back this information to STA1. If the rank is less than the number of data streams expected to be supported, or the condition number is greater than a certain threshold, both STA1 and STA2 may determine that the maximum number of data streams supported may not meet the desired number. In this example, the pair of devices may determine to complete the training procedure, and perform RF selection at both transmitter and receiver later. For example, the pair of devices may terminate the training with a full set of RF chains, and return to perform beamforming training with a lesser number of RF chains. For example, after training, the devices may transmit with a lesser number of spatial streams.

[0179] A method of Eigen-beamforming for spatial multiplexing may be performed. The method may be for communication devices that are of Type I or Type II as discussed in conjunction with FIG. 9.

[0180] Type I devices may perform transmit RF chain training sequentially if the RF chains are not calibrated. Even though the RF chains share the same set of antenna elements and the physical channels over the air may be the same, the effective channels, which may be the combination of channel over the air and transmit/receive RF chains, may be measured and estimated.

[0181] Type II devices may split the antenna elements into sub-groups, and each sub-group has an RF chain. In these examples, there may be two RF chains and two sub-groups of antennas. The physical channel corresponding to RF chain 1 may be transmitted with antenna sub-group I, which may be different from that corresponding to RF chain 2 that may be transmitted with the other antenna sub-group. Because of this, the training for multiple transmit RF chains may be performed sequentially.

[0182] FIG. 16 is a diagram of an example beamforming training method 1600 for Eigen-beamforming based spatial multiplexing for Type I devices and for Type II devices without calibration. For iteration i, STA1 1602 (initiator) may transmit Nt repetitions of training sequences sweeping all the transmit antenna elements in a first antenna sub-group using the first transmit RF chain (TX1) 1606. Then STA1 1602 may transmit Nt repetitions of training sequences sweeping all the transmit antenna elements in the second antenna sub-group using the first transmit RF chain (TX2) 1608. STA1 1602 may also use an orthorgonal precoding matrix to transmit the Nt repetitions of training sequences. The first antenna sub-group may be the same as the second antenna sub-group for Type I devices, STA1 1602; while for Type II devices, STA1 1602, they may correspond to different antenna elements.

[0183] STA2 (responder) 1604 may have the two receive beamforming weights trained from the previous iterations. If this is the first iteration,

STA2 1604 may randomly select two beamforming weights, use Omni weights, or select the weights in an alternate manner. The first receive RF chain (RX1) may obtain a signal as the weighted combination of signals received from all antenna elements. The weight may be the first receive beamforming weight W_{i-1}^{r1}. Similarly, the second receive RF chain (RX2) may obtain a signal as the weighted combination of signals received from all the antenna elements. The weight may be the second receive beamforming weight W_{i-1}^{r2}. The sweeping of the Nr receive antennas 1616 and 1618 is shown in dashed lines as an example illustration of receiver operation. For example, to receive Nr packets from the transmitter, the receiver may receive a first packet with the first receive antenna, a second packet with the second receive antenna, and so on, until it receives a last packet with the last receive antenna. After converting them to baseband and digital domain, STA2 1604 may estimate the effective channel by comparing the received sequence with the known transmitted sequence. For time slot k, STA2 1604 may estimate two channels using two RF chains $\begin{bmatrix} G_{k1} \\ G_{k2} \end{bmatrix}$. With 2Nt time slot, STA2 may receive $\begin{bmatrix} G_{11} & \dots & G_{2Nt1} \\ G_{12} & \dots & G_{2Nt2} \end{bmatrix}$. The first half of the G matrix, $G_{TX1} = \begin{bmatrix} G_{11} & \dots & G_{Nt1} \\ G_{12} & \dots & G_{Nt2} \end{bmatrix}$, may correspond to TX1, and the second half of the G matrix, $G_{TX2} = \begin{bmatrix} G_{(Nt+1)1} & \dots & G_{2Nt1} \\ G_{(Nt+1)2} & \dots & G_{2Nt2} \end{bmatrix}$, may correspond to TX2. Applying the inverse of the orthorgonal precoding matrix to the first half and second half of G matrix respectively, STA2 1604 may obtain the channel from Nt transmit antenna elements with two transmit RF chains to two receive RF chains $H = \begin{bmatrix} H_{11} & \dots & H_{2Nt1} \\ H_{12} & \dots & H_{2Nt2} \end{bmatrix}$.

[0184] STA2 1604 may transmit channel information or beamforming weights for multiple data streams 1610 to STA1 1602. STA2 1604 may calculate the transmit beamforming weights to perform spatial multiplexing for STA1 1602, and transmit the weights 1610 to STA1 1602. STA2 1604 may

transmit the channel H 1610 to STA1 1602, and STA1 1602 then may determine or calculate the transmit beamforming weights for itself 1620.

[0185] For example, the transmit beamforming weight method may be implementation dependent, and linear or non-linear procoding methods may be used. The updated transmit beamforming weights for ith iteration may be denoted as (W_i^{t1}, W_i^{t2}). STA1 1602 may transmit training sequences Nr times with beamforming weight W_i^{t1} 1612. STA2 1604 may sweep through Nr receive antennas 1616, or apply an orthorgonal matrix. STA2 1604 may pass the received signal to two RF chains. STA1 1602 may transmit training sequences 1614 again for Nr times with beamforming weight W_i^{t2}. STA2 1604 may repeat the same procedure with both RF chains 1618. The sweeping of the Nr receive antennas 1616 and 1618 is shown in dashed lines as an example illustration of receiver operation. For example, to receive Nr packets from the transmitter, the receiver may receive a first packet with the first receive antenna, a second packet with the second receive antenna, and so on, until it receives a last packet with the last receive antenna. STA2 1604 may estimate the channel and update the receive beamforming weight 1622 accordingly.

[0186] For example, the receive beamforming weight method may be implementation dependent, and may be repeated for several iterations until the algorithm converges or certain criteria have been met that indicate that spatial multiplexing is not suitable for the pair of devices, STA1 1602 and STA2 1604.

[0187] There may be several ways to define failure criteria to indicate that the pair of devices are not suitable for spatial multiplexing. For example, the failure criteria may include STA2 monitoring the rank or condition number of channel matrix when selecting beamforming weights, and feeding back this information to STA1. A second example of a failure criteria may include STA2 monitoring the rank or condition number of channel matrix

while sweeping through Nr receive antennas or applying an orthogonal matrix, and feeding back this information to STA1.

[0188] If the rank is less than the number of data streams expected to be supported, or the condition number is greater than a certain threshold, both STA1 and STA2 may determine that the maximum number of data streams that may be supported does not meet the requirements. In this example, the pair of devices may determine to complete the training procedure, and perform RF selection at both transmitter and receiver later. Alternatively, the pair of devices may terminate the training with full set of RF chains, and return to performing beamforming training with a fewer number of RF chains. After training, they may transmit with a fewer number of spatial streams.

[0189] In some examples, methods for beam sweep based spatial multiplexing for Type I devices with calibration may be performed. For example, the method of beam sweep based spatial multiplexing may be similar to Eigen-Beamforming based spatial multiplexing. Examples using Eigen-Beamforming based spatial multiplexing may require that the channel estimate and the transmit/receive weights for spatial multiplexing may be determined based on the estimated channel, which may not necessarily be the same as one of the beams used for beamforming training. In beam sweep based spatial multiplexing, there may be no requirement for channel estimation. The device may select one or multiple beams from the set of beams used for beam sweep training. For example, implementation of beam sweep based beamforming may be easier than Eigen-Beamforming based beamforming. The performance of the beam sweep based methods may be sub-optimum compared to the Eigen-beamforming based methods.

[0190] FIG. 17 is a diagram of an example beamforming training method 1700 for beam sweep based spatial multiplexing for Type I devices with calibration between two TX chains. Referring to FIG. 17, for iteration i, STA1 (initiator) 1702 may transmit N repetitions of training sequences 1706 sweeping the transmit beams it intends to train. In these examples, N may

not necessarily be related to the number of transmit antennas. The transmission 1706 may be performed using the first transmit RF chain (TX1) or the second transmit RF chain (TX2). The two RF chains may be identical or different by a scalar. In some examples, the two TX chains may have been calibrated.

[0191] STA2 (responder) 1704 may have the two receive beams trained from the previous iterations. If this is the first iteration, STA2 1704 may randomly select two beams, use Omni weights, or select initial values in an alternate manner. The first receive RF chain (RX1) of STA2 1704 may obtain a signal as the weighted combination of signals received from all antenna elements. The weight may be the first receive beamforming weight W_{i-1}^{r1}. Similarly, the second receive RF chain (RX2) of STA2 1704 may obtain a signal as the weighted combination of signals received from all the antenna elements. The weight may be the second receive beamforming weight W_{i-1}^{r2}. $\{W_{i-1}^{r1}, W_{i-1}^{r2}\}$ may be the weights corresponding to beam indices $\{ID_{i-1}^{r1}, ID_{i-1}^{r2}\}$. After converting them to baseband and digital domain, STA2 1704 may measure the effective SNR or equivalent parameters. For time slot k, STA2 1704 may perform SNR measurements using two receive RF chains $\begin{bmatrix} SNR_{k1} \\ SNR_{k2} \end{bmatrix}$. With N time slots, STA2 1704 may receive $\begin{bmatrix} SNR_{11} & \dots & SNR_{N1} \\ SNR_{12} & \dots & SNR_{N2} \end{bmatrix}$. In FIG. 17, the reception of the signals is shown in dashed lines as an example illustration of the receiver operation while receiving a packet.

[0192] STA2 1704 may feedback two beam indices to STA1 1702. The beam selection method may be implementation dependent. For example, the STA2 1704 may choose the pair of indices (ID_i^{t1}, ID_i^{t2}) which may satisfy $ID_i^{t1} = \arg\max_k (SNR_{k1}^{TX} - SNR_{k2}^{TX})$, and $ID_i^{t2} = \arg\max_k (SNR_{k2}^{TX} - SNR_{k1}^{TX})$.

[0193] The updated transmit beam indices for the ith iteration may be (ID_i^{t1}, ID_i^{t2}). STA1 1702 may transmit a training sequence for M times with

beam ID_i^{t1} 1720. STA2 1704 may sweep through M receive beams with both receive RF chains (RX1 and RX2) 1722. STA1 1702 may transmits a training sequence again for M times with beamforming weight ID_i^{t2} 1724. STA2 1704 may repeat the similar procedure with both RF chains 1726. The sweeping of the receive antennas 1722 and 1726 is shown in dashed lines as an example illustration of receiver operation. For example, to receive packets from the transmitter, the receiver may receive a first packet with the first receive antenna, a second packet with the second receive antenna, and so on, until it receives a last packet with the last receive antenna. STA2 1704 may measure the SNR or equivalent parameters and update the receive beam index accordingly. The receive beam selection method may be implementation dependent. For example, M may be the number of receive beams STA2 1704 intends to train and it may not necessarily be related to a number of receive antennas at STA2 1704. The method may be repeated until the method converges or certain criteria have been met that indicates that spatial multiplexing is not suitable for the pair of devices.

[0194] Failure criteria may be defined in several different ways. For example, failure criteria may indicate that the pair of devices is not suitable for spatial multiplexing. In one example, the failure criteria may be defined as when STA2 1704 may record $\Delta_{11}^{SNR} = \max_k (SNR_{k1}^{TX} - SNR_{k2}^{TX})$ and $\Delta_{12}^{SNR} = \max_k (SNR_{k2}^{TX} - SNR_{k1}^{TX})$ when selecting beams, and feedback this information to STA1 1702. In another example, STA2 1704 may record $\Delta_{21}^{SNR} = \max_{1 \le k \le N} (SNR_{k1}^{RX} - SNR_{k2}^{RX})$ and $\Delta_{22}^{SNR} = \max_{N < k \le 2N} (SNR_{k2}^{RX} - SNR_{k1}^{RX})$ when sweeping beams, and feedback this information to STA1 1702.

[0195] If Δ_{ij}^{SNR} is smaller than a certain threshold, both STA1 1702 and STA2 1704 may determine that the channel cannot provide enough spatial diversity to support two data streams. In this example, STA1 1702 and STA2 1704 may determine to complete the training procedure, and perform RF selection at both transmitter and receiver. STA1 1702 and STA2 1704 may

terminate the training with two RF chains, and return to performing beamforming training with one RF chain. After training, they may transmit with a fewer number of spatial streams. For example, more than two data streams may be determined.

[0196] Beam sweep based spatial multiplexing for Type II devices and Type I devices without calibration may be performed. FIG. 18 is a diagram of an example beamforming training method 1800 for beam sweep based spatial multiplexing Type II devices and Type I devices without calibration.

[0197] For iteration i, STA1 (initiator) 1802 may transmit N repetition of training sequences sweeping all the transmit beams it intends to train using the first transmit RF chain (TX1) 1806. Then STA1 1802 may repeat the same procedure with the second RF chain (TX2) 1808. N may not necessarily be related to the number of transmit antennas. For example, the beam pattern used for TX1 may not be the same as that for TX2.

[0198] STA2 (responder) 1804 may have the two receive beams trained from the previous iterations. If this is the first iteration, STA2 1804 may randomly select two beams, use Omni weights, or select the two beams in a different way. The first receive RF chain (RX1) 1810 may obtain a signal as the weighted combination of signals received from all antenna elements. The weight may be the first receive beamforming weight W_{i-1}^{r1}. The second receive RF chain (RX2) 1812 may obtain a signal as the weighted combination of signals received from all the antenna elements. The weight may be the second receive beamforming weight W_{i-1}^{r2}. For example, $\{W_{i-1}^{r1}, W_{i-1}^{r2}\}$ may be the weights that correspond to beam indices $\{ID_{i-1}^{r1}, ID_{i-1}^{r2}\}$. After converting them to baseband and digital domain, STA2 1804 may measure the effective SNR or equivalent parameters. For time slot k, STA2 1804 may perform SNR measurements using two receive RF chains $\begin{bmatrix} SNR_{k1} \\ SNR_{k2} \end{bmatrix}$. With the first N time slot, STA2 1804 may receive $\begin{bmatrix} SNR_{11} & \dots & SNR_{N1} \\ SNR_{12} & \dots & SNR_{N2} \end{bmatrix}$, which may correspond to

TX1 of STA1 1802. With the last N time slots, STA2 1804 may receive $\begin{bmatrix} SNR_{(N+1)1} & \dots & SNR_{2N1} \\ SNR_{(N+1)2} & \dots & SNR_{2N2} \end{bmatrix}$, which may correspond to TX2 of STA1 1802. In FIG. 18, the reception of the signals is shown in dashed lines as an example illustration of the receiver operation while receiving a packet.

[0199] STA2 1804 may feedback two beam indices 1814 to STA1 1802. The beam selection method may be implementation dependent. For example, the STA2 1804 may select the pair of indices (ID_i^{t1}, ID_i^{t2}) which may satisfy $ID_i^{t1} = \arg\max_{1 \le k \le N} (SNR_{k1}^{TX} - SNR_{k2}^{TX})$ and $ID_i^{t2} = \arg\max_{N < k \le 2N} (SNR_{k2}^{TX} - SNR_{k1}^{TX})$.

[0200] The updated transmit beam indices for ith iteration may be (ID_i^{t1}, ID_i^{t2}). STA1 1802 may transmit a training sequence M times with beam ID_i^{t1} 1816. STA2 1804 may sweep through M receive beams with both receive RF chains (RX1 and RX2) 1818. STA1 1802 may transmit a training sequence again M times with beamforming weight ID_i^{t2} 1820. STA2 1804 may repeat the same procedure with both RF chains 1822. The sweeping of the receive antennas 1818 and 1822 is shown in dashed lines as an example illustration of receiver operation. For example, to receive packets from the transmitter, the receiver may receive a first packet with the first receive antenna, a second packet with the second receive antenna, and so on, until it receives a last packet with the last receive antenna. STA2 1804 may measure the SNR or equivalent parameters and update the receive beam index accordingly. The receive beam selection method may be implementation dependent. For example, M may be the number of receive beams STA2 1804 intends to train and may not necessarily be related to the number of receive antennas at STA2 1804.

[0201] The procedure may be repeated for several iterations until the method converges or certain criteria have been met that indicates that spatial multiplexing is not suitable for STA1 1802 and STA2 1804.

[0202] There may be several ways to define failure criteria that indicate that the pair of devices are not suitable for spatial multiplexing. For example, the failure criteria may be defined as when STA2 1804 may record $\Delta_{11}^{SNR} = \max_{1 \le k \le N} (SNR_{k1}^{TX} - SNR_{k2}^{TX})$ and $\Delta_{12}^{SNR} = \max_{N < k \le 2N} (SNR_{k2}^{TX} - SNR_{k1}^{TX})$ in when selecting beams, and feedback this information to STA1 1802. In another example failure criteria, STA2 1804 may record $\Delta_{21}^{SNR} = \max_{1 \le k \le N} (SNR_{k1}^{RX} - SNR_{k2}^{RX})$ and $\Delta_{22}^{SNR} = \max_{N < k \le 2N} (SNR_{k2}^{RX} - SNR_{k1}^{RX})$ in when sweeping beams, and feedback this information to STA1 1802.

[0203] If Δ_{ij}^{SNR} is smaller than a threshold, both STA1 1802 and STA2 1804 may determine that the channel cannot provide enough spatial diversity to support two data streams. In this example, the pair of devices may determine to complete the training procedure, and perform RF selection at both transmitter and receiver. Alternatively, the pair of devices may terminate the training with two RF chains, and return to performing beamforming training with one RF chain. After training, the pair of devices may transmit with a fewer number of spatial streams.

[0204] The beam refinement transaction discussed in conjunction with FIG. 3 may be used for Eigen-beamforming based spatial multiplexing methods disclosed above. Modifications may be applied to support spatial multiplexing. For example, a number of spatial streams may be defined. The number of data streams may be defined in a DMG beam refinement element. The FBCK-TYPE subfield in the DMG beam refinement element may be modified.

[0205] FIG. 19 is a diagram of an example modified FBCK-TYPE subfield 1900. The modified FBCK-TYPE subfield 1900 may be included in a DMG refinement element. The modified FBCK-TYPE subfield 1900 may include a SNR present field 1910, a channel measurement present field 1920, a tap delay present field 1930, a number of taps present field 1940, a number of measurement field 1950, a number of spatial streams field 1960, a sector ID order present field 1970, and a number of beams field 1980.

[0206] An initiator may determine the capabilities of the responder prior to initiating beamforming training with the responder by using an Eigen-beamforming based spatial multiplexing capability. The Beam sweep based spatial multiplexing capability may be indicated in a DMG capabilities element. The DMG capabilities element may be present in an association request, association response, re-association request, re-association response, probe request and probe response frames and may be present in DMG beacon and information request and response frames. One bit of Eigen-beamforming based spatial multiplexing indication and one bit of beam sweep spatial multiplexing capability may be used to indicate that the STA is capable of performing Eigen-beamforming based spatial multiplexing.

[0207] The type of beamforming training algorithm, such as Eigen-beamforming based and beam sweep based, may be indicated in DMG beam refinement element. In addition, transceiver architecture type, such as Type I and Type II may be indicated in a DMG capabilities element.

[0208] A precoding matrix utilized by the initiator in the first part of each iteration may be predefined and agreed on by both initiator and responder if Eigen-beamforming based spatial multiplexing is implemented. In this example, the initiator and responder may negotiate which matrix to utilize before the beamforming training. For example, the precoding matrix index may be defined and transmitted in a BRP request field. In addition, a set of unitary precoding matrices may be predetermined.

[0209] A number of antennas at both initiator and responder may be signaled if Eigen-beamforming based spatial multiplexing is implemented. The number of antennas may be signaled in the PHY header, MAC header or a BRP Request field.

[0210] A spatial multiplexing frame format may be implemented. For example, when a packet is transmitted using spatial multiplexing, an indication may be sent to inform the packet recipients that multiple streams were transmitted. The MCS may be redefined for a modulation/coding scheme and the number of spatial streams. In 802.11ad, for example, MCS 0 may be

the Control PHY; MCS 1-12 may be utilized for single carrier (SC) PHY; MCS 13-24 may be for OFDM PHY; and MCS 25-31 may be for low power SC PHY.

[0211] In examples with two data stream transmissions, the following may be defined for use by the communication devices. For example, MCS 32-43 may be for SC PHY, MCS 44-55 may be for OFDM PHY, and 56-62 may be for low power SC PHY. In some examples, the MCS mapping may not be the same as defined above.

[0212] Alternatively, the number of spatial streams may be indicated in a PHY header. In order to support multiple data streams, the PHY layer frame format may need to be modified.

[0213] FIGS. 20A, 20B, and 20C are diagrams of example PHY layer frame formats. With SC PHY, the data field may be composed of symbol blocks, while with OFDM PHY, the data field may be composed of OFDM symbols. The frame may be appended with TRN-T/R subfields, and may be utilized for beam refinement protocol.

[0214] Referring to FIG. 20A, short training field (STF) 2010, channel estimation field (CE) 2020 and PHY headers 2030 may be transmitted with a weight, W1 2040. The number of data streams supported, N, may be indicated in the PHY header. If more than one data stream will be transmitted, additional CE field(s) may be included. With N data streams, an extra N-1 CE field 2050 may be transmitted and weights W2 2060, ..., WN 2070 may be applied to each CE field. An orthogonal mapping matrix, such as the P matrix defined in 802.11n/ac, may be applied. If a cyclic shift delay (CSD) scheme is applied to spatial multiplexing, the same CSD parameters may be applied to the CE fields. The data field 2080 that follows may be transmitted using the spatial multiplexing scheme, and all of the weights (W1,...,WN) 2090 may be applied.

[0215] FIG. 20B is a diagram of another example preamble format for spatial multiplexing transmissions. This format is similar to FIG. 20A except that an AGC field 2015 may be inserted after additional CE fields and before the data field 2080. The AGC field 2015 may use the same sequence as an LTF

field, or it may be redesigned. The purpose of this AGC field 2015 may be for automatic gain control. The transmission of the AGC field 2015 may be in the same format as the data field 2080, i.e., weights (W1,...,WN) 2090 may be applied. The same CSD parameters may be applied to AGC field 2015 if CSD is utilized for data transmissions.

[0216] FIG. 20C is a diagram of another example preamble format for spatial multiplexing transmissions in which the number of data streams may be signaled implicitly. STF 2010 may be transmitted using all the weights (W1,...,WN) 2025. The first CE field 2020 following STF 2010 may be transmitted using the first weight W1 2040. The number of data streams may be implicitly indicated by using STF 2010 and the first CE field 2020. For example, several CE sequences may be defined, and each sequence may correspond to a certain number of data streams. Additional N-1 CE fields 2050 may follow the first CE field 2020 and transmitted with weights W2 2060 to WN 2070. The header 2035 may be transmitted with one of the weights or a combination of the weights similar to STF 2010. The spatial multiplexing transmission may be transmitted following the additional CE fields.

[0217] Beamforming training overhead and latency may be reduced. For example, sector sweep (SSW) frames and related training methods may be modified.

[0218] In the SLS procedures, SSW frames may be utilized for transmit and receive beamforming training. For example, the SSW frames may be transmitted in N time slots. For transmit beamforming training, SSW frames may be transmitted and multiple antenna sectors may be swept. The receiver may receive the SSW frames with the same antenna sector and feedback the best transmit sector ID to the transmitter. For example, for receive beamforming training, the same SSW frames may be repeated N times, and the receiver may sweep over multiple antenna sectors to receive. After the receive beamforming training, the receiver may select the best receive sector.

[0219] Each SSW frame may comprise a full PLCP header that may include a preamble, one or more header blocks, and a MAC frame. Since the

SSW frames may be utilized for beamforming training, they may be transmitted using the lowest data rate, for example, control PHY or MCS0 in 802.11ad. SSW frames may not contain data traffic, therefore SSW frame sequences may be beamforming training overhead.

[0220] FIG. 21 is a diagram of an example modified SSW training frames and sequence 2100. In this example, modified SSW training sequences may be utilized. A SSW announcement (SSWA) frame 2110 may be transmitted at the beginning of the SSW training sequences. The SSWA frame 2110 may contain all the information used to transmit by SSW frames. One or more N null SSW (NSSW) frames 2120 may follow the SSWA frame 2110 with a certain inter-frame spacing. NSSW frames 2120 may contain only preamble and PHY headers, and no MAC frame.

[0221] Figure 22 is a diagram of an example SSWA frame format 2200. The SSWA frame format 2200 may include a frame control field 2205, a duration field 2210, an RA field 2215, a TA field 2220, an SSW field 2225, an SSW feedback (FB) field 2230, and an FCS field 2235. The SSW field 2225 may include a direction subfield 2240, a DMG antenna ID 1 subfield 2245, a sector ID 1 subfield 2250, a sector ID N subfield 2255, a DMG antenna ID 2 subfield 2260, a sector ID 1 subfield 2265, a sector ID N2 subfield 2270, and an RXSS length subfield 2275. In this example, sector ID 1 subfield 2250 may be for DMG antenna ID 1, and sector ID 1 subfield 2265 may be for DMG antenna ID 2.

[0222] The direction subfield 2240 and the RXSS length subfield 2275 may be the same as in IEEE 802.11ad. The direction subfield 2240 may be set to 0 to indicate that the frame is transmitted by the beamforming initiator and set to 1 to indicate that the frame is transmitted by the beamforming responder. The RXSS Length subfield 2275 may be valid only when transmitted in a CBAP and may be reserved otherwise. The RXSS Length subfield 2275 may specify the length of a receive sector sweep as required by the transmitting STA, and may be defined in units of an SSW frame. The value of this field is in the range 0–62, with odd values being reserved.

[0223] DMG Antenna IDs and Sector IDs may be utilized to indicate the antenna pattern for the following NSSW frames. For example, the first NSSW frame may utilize DMG Antenna ID 1 and Sector ID 1 to transmit, and the second NSSW frame may utilize DMG Antenna ID 1 and Sector ID 2 to transmit, and so on. With DMG antenna ID k, there may be Nk sectors swept for this round of beamforming training. The total number of NSSW frames following this SSWA frame may be $\sum_{k=1}^{K} N_k$. K may be the number of DMG antennas trained with these SSWA-NSSW sequences.

[0224] The SSWA may be transmitted as follows. For example, the SSWA frame may carry all the MAC information necessary for beamforming training. It may be important that the receiver decodes the SSWA frame correctly. The SSWA frame may be transmitted using one of the following methods. For example, if the beamforming training is between two non-AP/PCP devices, the SSWA frame may be transmitted from AP to the two devices. In another example, if both the beamforming initiator and responder are multi-band capable, they may operate on multiple frequency bands simultaneously, and the SSWA frame may be transmitted on another frequency band. The SSWA frame may be transmitted with low data rate, spreading codes, or repetition schemes.

[0225] Some examples may use sub-optimum SLS training methods. In these examples, SLS training methods may be terminated early.

[0226] FIG. 23 is a diagram of an example early termination of the SLS training procedure. In this example, the initiator 2302 may have 4 beam sectors to train, and the countdown (CDOWN) number may equal 3 in the first training frame. In this example, sector 3 is shaded to illustrate that the initiator may use sector 3 for transmission in a first period, and sector 4 is shaded to illustrate that the initiator may use sector 4 for transmission in the second period. The initiator 2302 may continue transmitting training frames which are separated by inter-frame space duration 2T, for example. The responder 2304 may monitor the received training frames 2306. The dashed

"omni" circles in FIG. 23 are shown to illustrate that the receiver/responder may be in an omni-receiving mode. An omni-receiving mode may be enabled by an omni-directional receiving antenna. The first two "omni" circles are shown in dashed lines to illustrate that they are example receiver operations. The last "omni" circle is shown in indicating solid line to illustrate that this is an example transmitter operation, i.e., the feedback packet may be transmitted in an omni-transmitting mode, which may be enabled by an omni-directional transmitting antenna. Once the received SNR (or other parameters) is greater than a certain threshold, the responder 2304 may determine to terminate the training procedure by transmitting a feedback frame 2308. The feedback frame 2308 may be transmitted after a T duration from the end of a training frame transmitted by the initiator 2302. Thus the initiator 2302 may detect the transmission of this feedback and stop transmitting more training frames. This example may be used for both transmit and receive beamforming training.

[0227] A group based SLS training method may be performed. In this example, a STA may divide its sectors to groups. The partition of sectors may be implementation dependent. For example, the partition may be based on the direction of the sectors. The beamforming initiator may select one group to perform SLS training and wait for the feedback from the responder. Once the feedback from responder meets the expectation of the initiator, the beamforming initiator may determine to stop the beamforming training. Otherwise, the initiator may select another group to perform SLS training until one beam is selected or all the beams are swept.

[0228] Multi-beam, multi-DMG antenna sector level sweep feedback may be performed. In examples of the sector level sweep method, the receiver STA may report back the best beam only, for example, one sector of one DMG antenna. For example, a list of the best beams, such as multiple beams of multiple antennas may be reported. This may enable the communication link to track the relative performance of the beams over time and, if necessary, switch to a better beam without the need for retraining.

[0229] FIG. 24 is a diagram of an example multi-beam multi-DMG antenna SLS feedback method 2400. The following method 2400 may use a sector level sweep method that may report a list of best beams. In this example, the DMG transmitting STA1 2402 and receiving STA2 2404 may indicate their capability to support multi-sector, multi-DMG antenna Sector Sweep (SSW) feedback. This capability may be indicated by a bit in the DMG STA Capability Information field. STAs that do not have the capability may fall back to legacy transmission.

[0230] The STA initiating the sector sweep, for example STA1 2402, may transmit information to the responder STA, for example STA2 2404, indicating the number of beams to be fed back. The responder STA 2404 may also transmit information to initiator STA 2402 on the number of beams to be fed back. The metric to decide on the best beams may be implementation dependent. One signaling method may use a Transmit Sector Sweep frame for both the initiator and the responder may contain the number of beams to be fed back. A second signaling method may use a DMG beacon that may contain a field that indicates the number of beams to be fed back for all SSW feedback 2420. In a third signaling method, before a Sector Level Sweep procedure, the initiator and responder may exchange SLS setup frames indicating the number of beams to feed back. Quasi-omni may refer to a near omni-directional transmission or reception. For example, quasi-omni transmissions may be enabled by repeatedly transmitting the same information using multiple directional transmissions, as if it were transmitted using an omni-directional transmit antenna. Similarly, quasi-omni receptions may be enabled by repeatedly receiving the same packet using multiple directional receptions, as if it were received using an omni-directional receiving antenna.

[0231] Both STAs may implement the legacy initiator and responder sector level sweep procedures. The transmitter may feedback the best N beams. This may be by one of the following example methods. In a first example method, multiple SSW Feedback fields may be aggregated within an SSW feedback frame 2420. In a second example, a single SSW Feedback field

may be modified to enable feedback of multiple beams and DMG antennas and corresponding SNR Reports. In a third example, the best beam/antenna may be fed back during the SLS procedure and subsequent feedback of the additional N-1 beams with other transmissions, for example an ACK. In these examples, the number of antenna may be larger than the number radio frequency (RF) chains. In some examples, the number of antenna may be much larger than the number of RF chains.

EMBODIMENTS

1. A first communication device comprising:

a plurality of antennas;

a processor configured to partition the plurality of antennas;

a transmitter configured to transmit a plurality of frames to a second communication device;

and a receiver.

2. The first communication device of embodiment 1, wherein the processor is configured to partition the plurality of antennas into at least a first group of antennas and a second group of antennas.

3. The first communication device of embodiment 2, wherein the first group of antennas is associated with a first beam to a first station (STA).

4. The first communication device of embodiment 2 or 3, wherein the second group of antennas is associated with a second beam to a second station (STA).

5. The first communication device of any one of embodiments 2-4, wherein the first group of antennas is associated with a first beam to a first plurality of stations (STAs).

6. The first communication device of any one of embodiments 2-5, wherein the second group of antennas is associated with a second beam to a second plurality of stations (STAs).

7. The first communication device of any preceding embodiment, wherein the plurality of frames transmitted are beamforming training frames.

8. The first communication device of any preceding embodiment, wherein the plurality of frames are transmitted using the first group of antennas.

9. The first communication device of any preceding embodiment, wherein the plurality of frames are transmitted using the second group of antennas.

10. The first communication device of any preceding embodiment, wherein the receiver is configured to receive a first beamforming weight vector from the second communication device.

11. The first communication device of embodiment 10, wherein the first beamforming weight vector is for sending signals on the first group of antennas.

12. The first communication device of any preceding embodiment, wherein the receiver is configured to receive a second beamforming weight vector from the second communication device.

13. The first communication device of embodiment 12, wherein the second beamforming weight vector is for sending signals on the second group of antennas.

14. The first communication device of any one of embodiments 10-13, wherein the first beamforming weight vector is a strongest beam between the first communication device and the second communication device.

15. The first communication device of any one of embodiments 12-14, wherein the second beamforming weight vector is for a second strongest beam between the first communication device and the second communication device.

16. The first communication device of any preceding embodiment, wherein the first communication device is a wireless transmit/receive unit (WTRU).

17. The first communication device of any one of embodiments 1-15, wherein the first communication device is a station (STA).

18. The first communication device of any one of embodiments 1-15, wherein the first communication device is an access point (AP).

19. The first communication device of any one of embodiments 1-15, wherein the first communication device is a base station.

20. The first communication device of any preceding embodiment, wherein the second communication device is a wireless transmit/receive unit (WTRU).

21. The first communication device of any one of embodiments 1-19, wherein the second communication device is a station (STA).

22. The first communication device of any one of embodiments 1-19, wherein the second communication device is an access point (AP).

23. The first communication device of any one of embodiments 1-19, wherein the second communication device is a base station.

24. The first communication device of any one of embodiments 7-23, wherein the beamforming training frames are orthogonal beamforming vectors.

25. The first communication device of any preceding embodiment, wherein the transmitter is further configured to transmit a second set of beamforming training frames.

26. The first communication device of embodiment 25, wherein the second set of beamforming training frames is transmitted using the received first beamforming weight vector.

27. The first communication device of embodiment 25 or 26, wherein the second set of beamforming training frames is transmitted using the received second beamforming weight vector.

28. The first communication device of any preceding embodiment, wherein the receiver is further configured to receive a modified first beamforming weight vector.

29. The first communication device of embodiment 28, wherein the modified first weight vector is for sending signals on the first group of antenna.

30. The first communication device of any preceding embodiment, wherein the receiver is further configured to receive a modified second beamforming weight vector.

31. The first communication device of embodiment 30, wherein the modified second weight vector is for sending signals on the second group of antenna.

32. The first communication device of any preceding embodiment, wherein the first communication device comprises one or more radio frequency (RF) chains.

33. The first communication device of any preceding embodiment, wherein a number of the antenna is larger than a number of one or more radio frequency (RF) chains.

34. A first communication device comprising:

a plurality of antennas;

a receiver configured to receive a set of beamforming training frames;

a processor; and

a transmitter.

35. The first communication device of embodiment 34, wherein the processor is configured to determine a first transmit beamforming weight vector.

36. The first communication device of embodiment 35, wherein the first transmit beamforming weight vector corresponds to a first antenna group.

37. The first communication device of embodiment 36, wherein the first antenna group is for a second communication device.

38. The first communication device of any one of embodiments 34-37, wherein the processor is configured to determine a second transmit beamforming weight vector.

39. The first communication device of embodiment 38, wherein the second transmit beamforming weight vector corresponds to a second antenna group.

40. The first communication device of embodiment 39, wherein the second antenna group is for a second communication device.

41. The first communication device of any one of embodiments 34-40, wherein the transmitter is configured to transmit data using the first transmit beamforming weight vector to the second communication device to the second communication device.

42. The first communication device of any one of embodiments 34-41, wherein the transmitter is configured to transmit data using the second transmit data using the second transmit beamforming weight vector to the second communication device.

43. The first communication device of any one of embodiments 34-42, wherein the first communication device is a wireless transmit/receive unit (WTRU).

44. The first communication device of any one of embodiments 34-42, wherein the first communication device is a station (STA).

45. The first communication device of any one of embodiments 34-42, wherein the first communication device is an access point (AP).

46. The first communication device of any one of embodiments 34-42, wherein the first communication device is a base station.

47. The first communication device of any one of embodiments 34-46, wherein the second communication device is a wireless transmit/receive unit (WTRU).

48. The first communication device of any one of embodiments 34-46, wherein the second communication device is a station (STA).

49. The first communication device of any one of embodiments 34-46, wherein the second communication device is an access point (AP).

50. The first communication device of any one of embodiments 34-46, wherein the second communication device is a base station.

51. The first communication device of any one of embodiments 34-50, wherein the received beamforming training frames are orthogonal beamforming vectors.

52. The first communication device of any one of embodiments 34-51, wherein the transmitted beamforming weight vectors are orthogonal beamforming vectors.

53. A method for beamforming training for beam division multiple access (BDMA), the method comprising:

receiving a first transmit beamforming weight from a first station (STA), and receiving a second transmit beamforming weight from a second (STA);

transmitting Nt sequences modulated using Nt beamforming vectors, wherein the Nt sequences are modulated based on the first transmit beamforming weight and the second transmit beamforming weight.

54. The method of embodiment 53, wherein the Nt beamforming vectors are orthogonal.

55. A method for beamforming training for beam division multiple access (BDMA), the method comprising:

receiving a plurality of Nt sequences using a first previous beamforming vector;

determining a first transmit beamforming weight from an access point (AP) based on the first previous beamforming vector and the received plurality of Nt sequences; and

transmitting the determined first transmit beamforming weight to the AP.

56. A method for beamforming training for spatial multiplexing, the method comprising:

an initiator station having two radio frequency (RF) chains and having transmit antenna elements, the initiator station transmitting Nt known training sequences sweeping the transmit antenna elements;

a responder station having a first and a second RF chain and having receive antenna elements, and having a first and a second receive beamforming weight, the responder station receiving the first RF chain and receiving the second RF chain; and

the responder station estimating at least two channels by comparing the received first RF chain and the second RF chain to the Nt known training sequences.

57. The method of embodiment 56, wherein the first RF chain is the combination of signals received from the receive antenna elements weighted by the first receive beamforming weights

58. The method of embodiment 57, wherein the second RF chain is the combination of signals received from the receive antenna elements weighted by the second receive beamforming weights.

59. The method of any one of embodiments 56-58, wherein the transmitting Nt training sequences further comprises transmitting Nt training sequences over a first RF chain of the initiator.

60. The method of any one of embodiments 56-58, wherein the transmitting Nt training sequences further comprises transmitting Nt training sequences over a second RF chain of the initiator.

61. The method of any one of embodiments 56-58, wherein the transmitting Nt training sequences further comprises transmitting Nt training sequences over the first RF chain and the second RF chain.

62. The method of embodiment 61, wherein the first RF chain and the second RF chain are calibrated.

63. The method of any one of embodiments 56-62, wherein the transmitting Nt known training sequences sweeping the transmit antenna elements comprises the initiator station having two RF chains and having transmit antenna elements, transmitting Nt known training sequences sweeping the transmit antenna elements, wherein a number of the transmit antenna elements is larger than a number of RF chains.

64. The method of any one of embodiments 56-63, wherein the number of transmit antenna elements is at least six times larger than a number of RF chains.

65. The method of any one of embodiments 56-64 further comprising the responder transmitting the estimated two channels to the initiator.

66. A method for beamforming training for spatial multiplexing, the method comprising:

an initiator station having two or more radio frequency (RF) chains and having transmit antenna elements, the initiator station transmitting Nt known sequences sweeping the transmit antenna elements;

a responder station having a first and a second RF chain and having receive antenna elements, and having a first and a second receive beamforming weight, the responder station receiving the first RF chain and receiving the second RF chain; and

the responder estimating at least two channels by comparing the received first RF chain and the second RF chain to the known Nt training sequences.

67. The method of embodiment 66, wherein the first RF chain is a combination of signals received from the receive antenna elements weighted by the first receive beamforming weights.

68. The method of embodiment 66 or 67, wherein the second RF chain is the combination of signals received from the receive antenna elements weighted by the second receive beamforming weights.

69. A method for performing beamforming, the method comprising:

a first communication device transmitting a first plurality of beamforming training frames to a second communication device using a first beamforming vector;

the first communication device receiving from the second communication device a second beamforming weight vector; and

the first communication device transmitting a second plurality of beamforming training frames to the second communication device using the second beamforming vector.

70. The method of embodiment 69, wherein the first communication device transmits the first plurality of beamforming training frames to the second communication device using a first beamforming weight vector.

71. The method of embodiment 69 or 70, wherein the first communication device transmits a first portion of the first plurality of beamforming training frames using a first group of antenna and a first portion of the beamforming weights.

72. The method of any one of embodiments 69-71, wherein the first communication device transmits a second portion of the first plurality of beamforming training frames using a second group of antenna and a second portion of the beamforming weights.

73. A base station configured to perform any one of embodiments 53-72.

74. A base station configured to perform any portion of embodiments 53-72.

75. An integrated circuit configured to perform any one of embodiments 53-72.

76. An integrated circuit configured to perform any portion of embodiments 53-72.

77. A station (STA) configured to perform any one of embodiments 53-72.

78. A station (STA) configured to perform any portion of embodiments 53-72.

79. An access point (AP) configured to perform any one of embodiments 53-72.

80. An access point (AP) configured to perform any portion of embodiments 53-72.

81. A wireless transmit/receive unit (WTRU) configured to perform any one of embodiments 53-72.

82. A wireless transmit/receive unit (WTRU) configured to perform any portion of embodiments 53-72.

[0232] Although features and elements are described above in particular combinations, one of ordinary skill in the art will appreciate that each feature or element can be used alone or in any combination with the other features and elements. In addition, the methods described herein may be implemented in a computer program, software, or firmware incorporated in a computer-readable medium for execution by a computer or processor. Examples of computer-readable media include electronic signals (transmitted over wired or wireless connections) and computer-readable storage media. Examples of computer-readable storage media include, but are not limited to, a read only memory (ROM), a random access memory (RAM), a register, cache memory, semiconductor memory devices, magnetic media such as internal hard disks and removable disks, magneto-optical media, and optical media such as CD-ROM disks, and digital versatile disks (DVDs). A processor in association with software may be used to implement a radio frequency transceiver for use in a WTRU, UE, terminal, base station, RNC, or any host computer.

* * *

CLAIMS

What is claimed is:

1. A first communication device, the first communication device comprising:

a plurality of antennas;

a processor, wherein the processor is configured to partition the plurality of antennas into at least a first group of antennas and a second group of antennas, wherein the first group of antennas is associated with a first beam to a first station (STA) or a first plurality of STAs, and the second group of antennas is associated with a second beam to a second STA or a second plurality of STAs;

a transmitter configured to transmit, to a second communication device, a plurality of beamforming training frames using the first group of antennas and the second group of antennas; and

a receiver configured to receive from the second communication device a first beamforming weight vector for sending signals on the first group of antennas and to receive a second beamforming weight vector for sending signals on the second group of antennas.

2. The first communication device of claim 1, wherein the first beamforming weight vector is a strongest beam between the first communication device and the second communication device, and wherein the second beamforming weight vector is for a second strongest beam between the first communication device and the second communication device.

3. The first communication device of claim 1, wherein the first communication device and the second communication device are one of: a wireless transmit receive unit, a station, an access point, or a base station.

4. The first communication device of claim 1, wherein the beamforming training frames are orthogonal beamforming vectors.

5. The first communication device of claim 1, wherein the transmitter is further configured to transmit a second set of beamforming training frames using the received first beamforming weight vector and the second beamforming weight vector; and wherein the receiver is further configured to receive from the second communication device a modified first beamforming weight vector for sending signals on the first group of antenna and to receive a modified second beamforming weight vector for sending signals on the second group of antenna.

6. The first communication device of claim 1, wherein the first communication device comprises one or more radio frequency (RF) chains and wherein a number of the antenna is larger than a number of the one or more RF chains.

7. A first communication device, the first communication device comprising:

a plurality of antennas; and

a processor, wherein the plurality of antennas are configured to receive a set of beamforming training frames, and wherein the processor is configured to determine a first transmit beamforming weight vector corresponding to a first antenna group of a second communication device, and to determine a second transmit beamforming weight vector corresponding to a second antenna group of the second communication device; and

a transmitter configured to transmit data using the first transmit beamforming weight vector and to send data using the second transmit beamforming weight vector to the second communication device.

8. The first communication device of claim 7, wherein the first communication device and the second communication device are one of: a wireless transmit receive unit, a station, an access point, or a base station.

9. The first communication device of claim 7, wherein the received beamforming training frames are orthogonal beamforming vectors.

10. The first communication device of claim 7, wherein the transmitted beamforming weight vectors are orthogonal beamforming vectors.

11. A method for use in a first communication device, the method comprising:

partitioning, at the first communication device, a plurality of antennas into at least a first group of antennas and a second group of antennas, wherein the first group of antennas is associated with a first beam to a first station (STA) or a first plurality of STAs, and the second group of antennas is associated with a second beam to a second STA or a second plurality of STAs;

transmitting, to a second communication device, a plurality of beamforming training frames using the first group of antennas and the second group of antennas; and

receiving, from the second communication device, a first beamforming weight vector for transmitting signals on the first group of antennas and receiving a second beamforming weight vector for transmitting signals on the second group of antennas.

12. The method of claim 11, wherein the first beamforming weight vector is a strongest beam between the first communication device and the second communication device, and wherein the second beamforming weight vector is for a second strongest beam between the first communication device and the second communication device.

13. The method of claim 11, wherein the first communication device and the second communication device are one of: a wireless transmit receive unit, a STA, an access point (AP), or a base station.

14. The method of claim 11, wherein the beamforming training frames are orthogonal beamforming vectors.

15. The method of claim 11 further comprising:

transmitting a second set of beamforming training frames using the received first beamforming weight vector and the second beamforming weight vector; and

receiving from the second communication device a modified first beamforming weight vector for transmitting signals on the first group of antenna and receiving a modified second beamforming weight vector for transmitting signals on the second group of antenna.

16. The method of claim 11, wherein the first communication device comprises one or more radio frequency (RF) chains and wherein a number of the antenna is larger than a number of the one or more RF chains.

17. A method for use in a first communication device, the method comprising:

receiving a set of beamforming training frames;

determining a first transmit beamforming weight vector corresponding to a first antenna group of a second communication device, and to determining a second transmit beamforming weight vector corresponding to a second antenna group of the second communication device; and

transmitting data using the first transmit beamforming weight vector and transmitting data using the second transmit beamforming weight vector to the second communication device.

18. The method of claim 17, wherein the first communication device and the second communication device are one of: a wireless transmit receive unit, a station (STA), an access point (AP), or a base station.

19. The method of claim 17, wherein the received beamforming training frames are orthogonal beamforming vectors.

20. The method of claim 17, wherein the received beamforming training frames are orthogonal beamforming vectors.

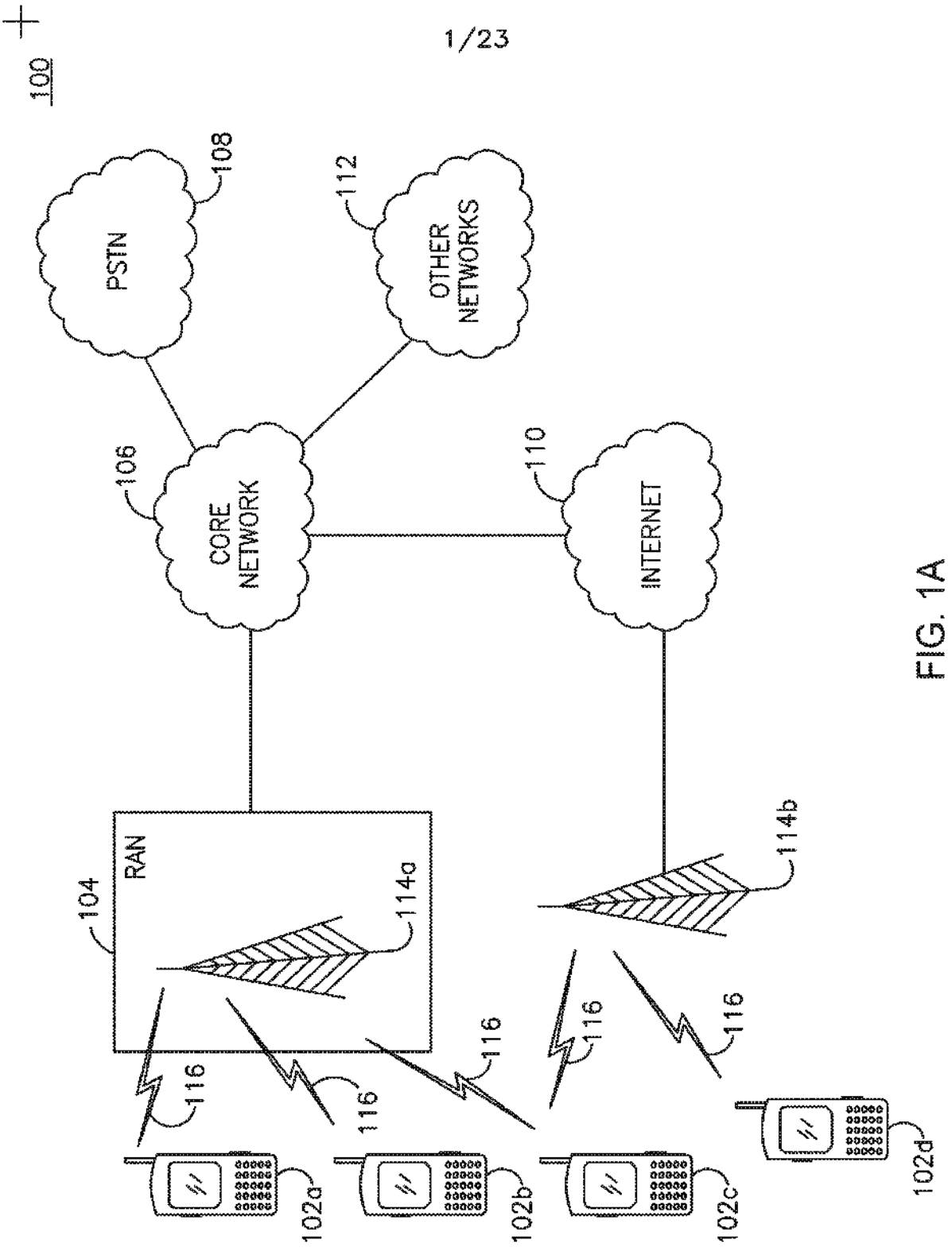

100
PSTN
108
OTHER NETWORKS
112
CORE NETWORK
106
INTERNET
110
RAN
104
114a
114b
116
116
116
116
116
102a
102b
102c
102d

FIG. 1A

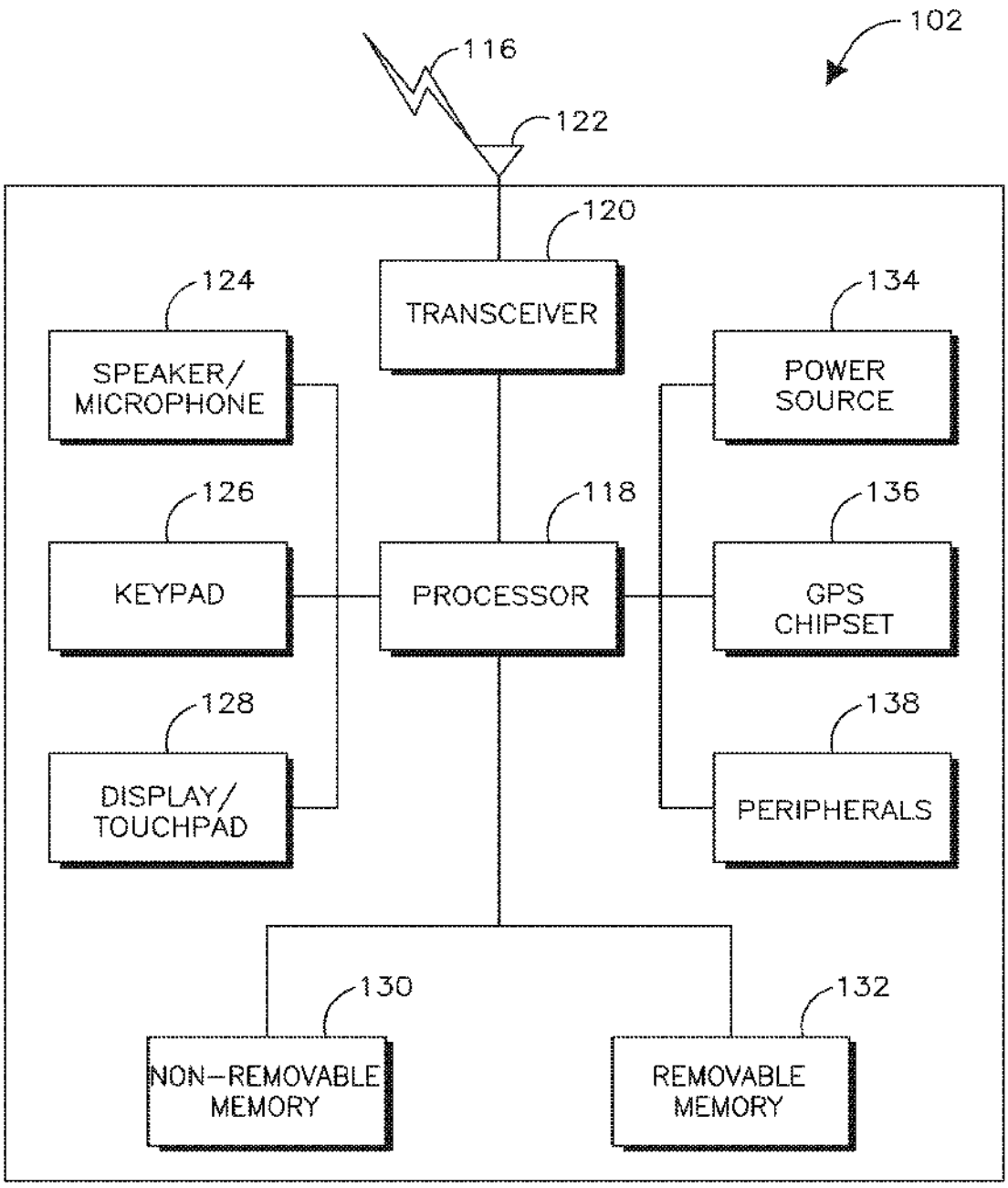

102
116
122
120
TRANSCEIVER
124
SPEAKER/
MICROPHONE
134
POWER
SOURCE
126
KEYPAD
118
PROCESSOR
136
GPS
CHIPSET
128
DISPLAY/
TOUCHPAD
138
PERIPHERALS
130
NON-REMOVABLE
MEMORY
132
REMOVABLE
MEMORY

FIG. 1B

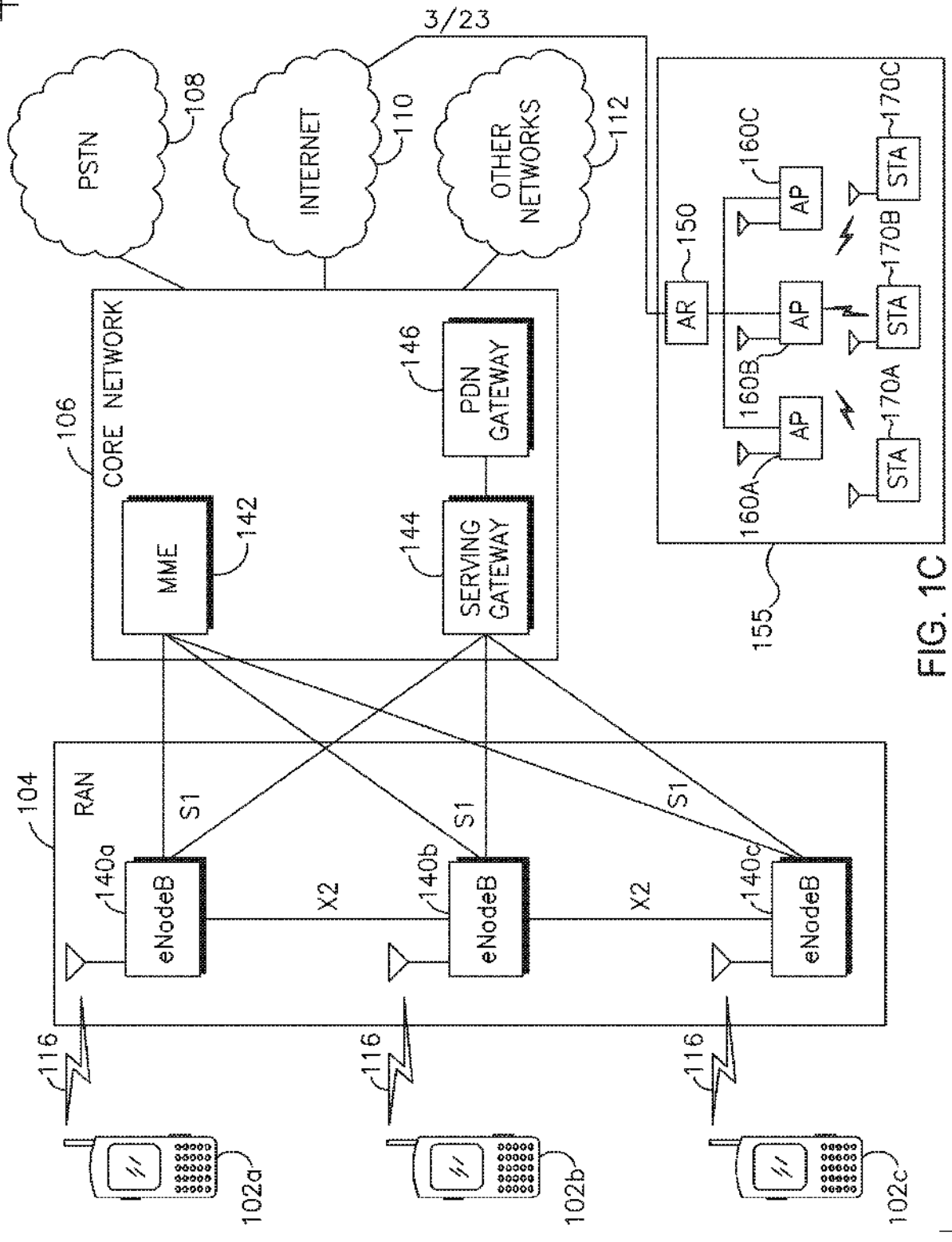

PSTN
108
INTERNET
110
OTHER NETWORKS
112
CORE NETWORK
106
MME
142
PDN GATEWAY
146
SERVING GATEWAY
144
AR
150
AP
160A
160B
160C
STA
170A
170B
170C
155
RAN
104
eNodeB
140a
140b
140c
S1
X2
116
102a
102b
102c

FIG. 1C

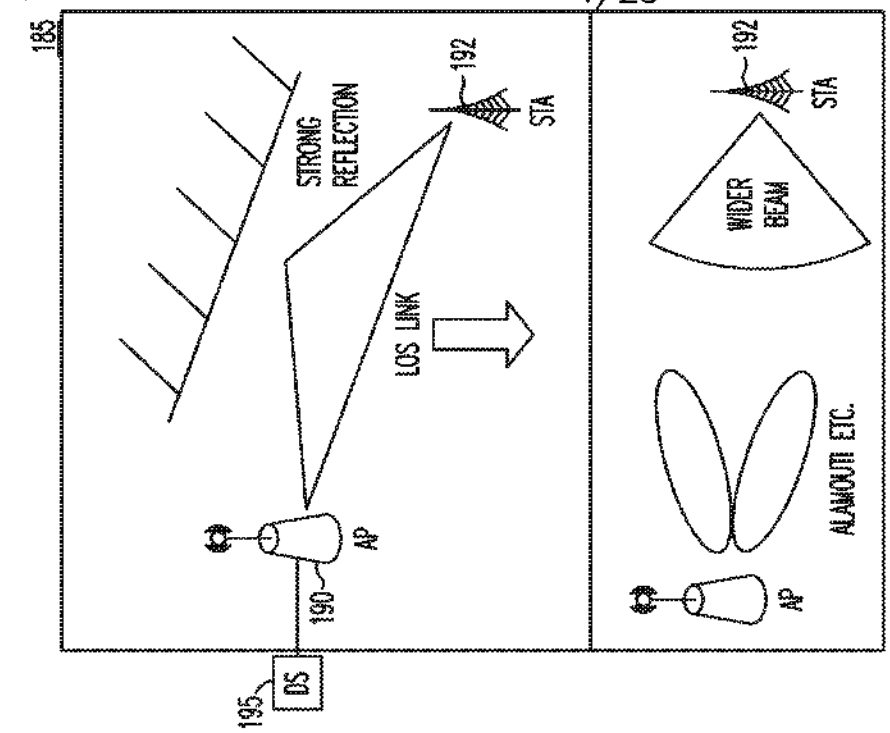

185
STRONG REFLECTION
192
STA
LOS LINK
AP
190
195
DS
WIDER BEAM
ALAMOUTI ETC.

FIG. 1E

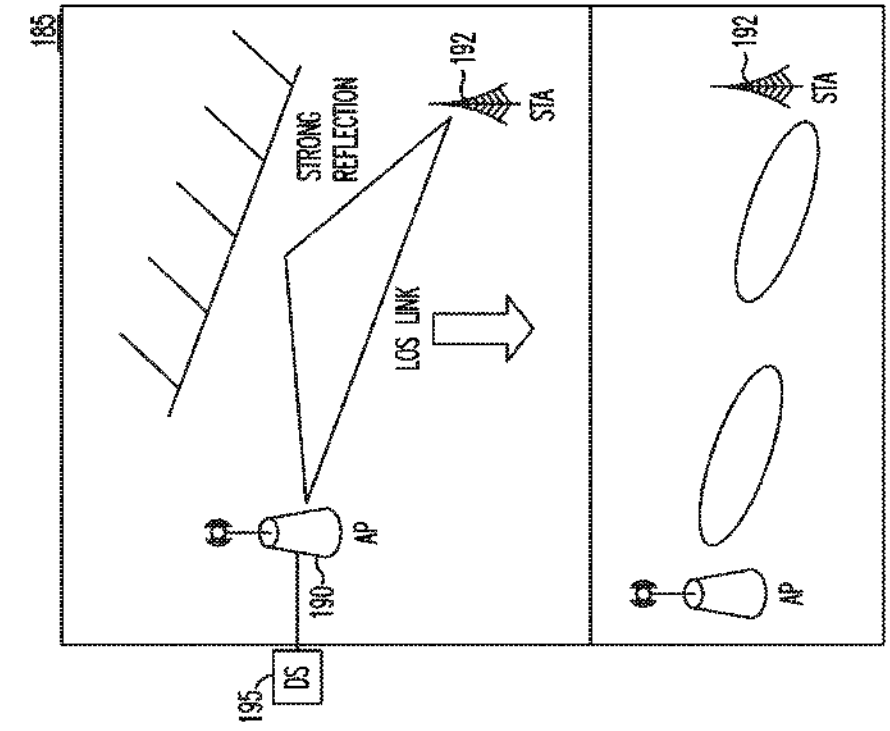

185
STRONG REFLECTION
192
STA
LOS LINK
AP
190
195
DS

FIG. 1D

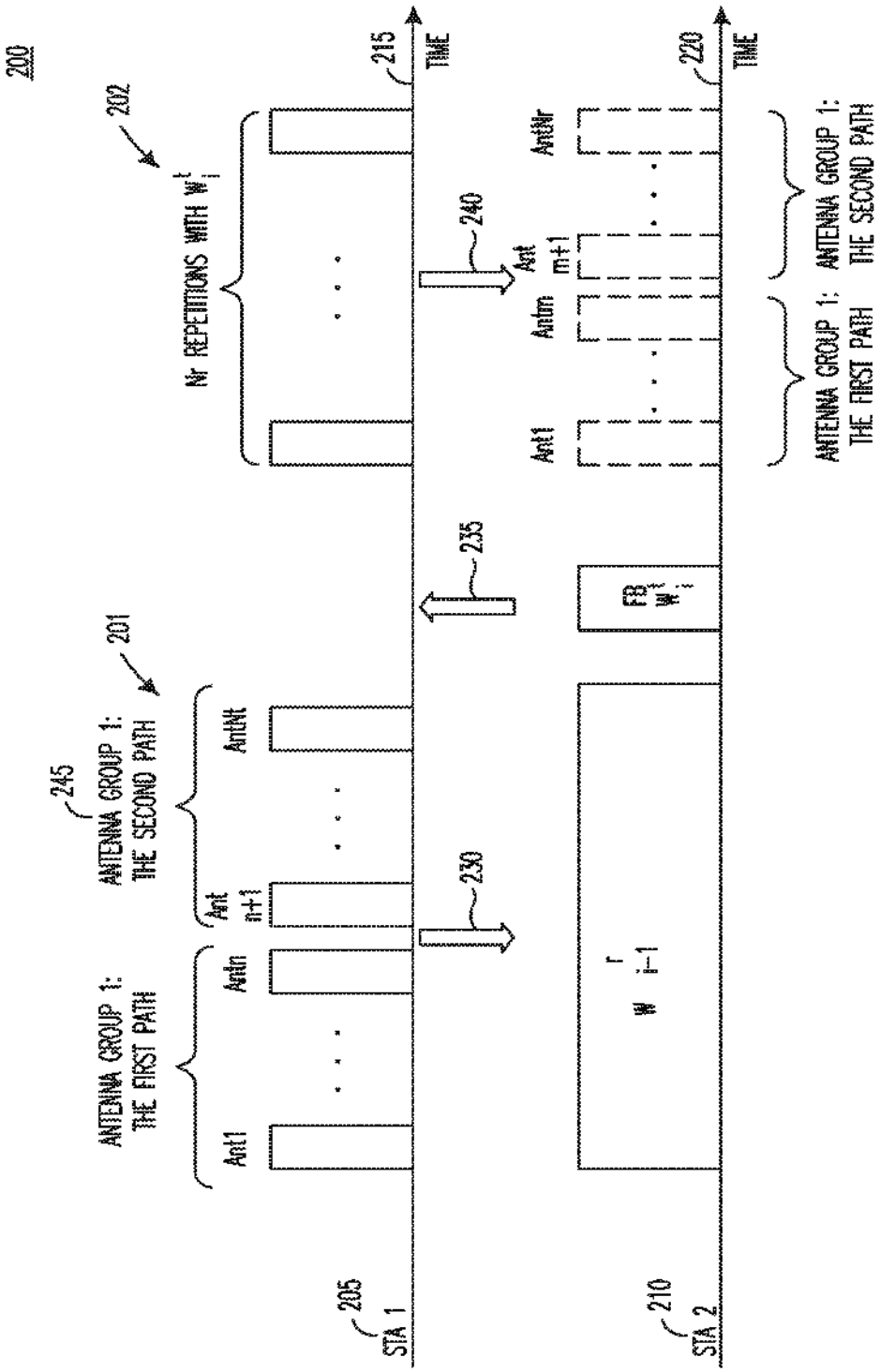

200
202
Nr REPETITIONS WITH W_i^1
215
TIME
240
Ant m+1
Antm
Ant1
AntNr
ANTENNA GROUP 1: THE FIRST PATH
ANTENNA GROUP 1: THE SECOND PATH
235
FB W_{i-1}^r
245
201
ANTENNA GROUP 1: THE SECOND PATH
ANTENNA GROUP 1: THE FIRST PATH
AntNt
Ant n+1
Antn
Ant1
230
W_{i-1}^r
205
STA 1
210
STA 2
220
TIME

FIG. 2

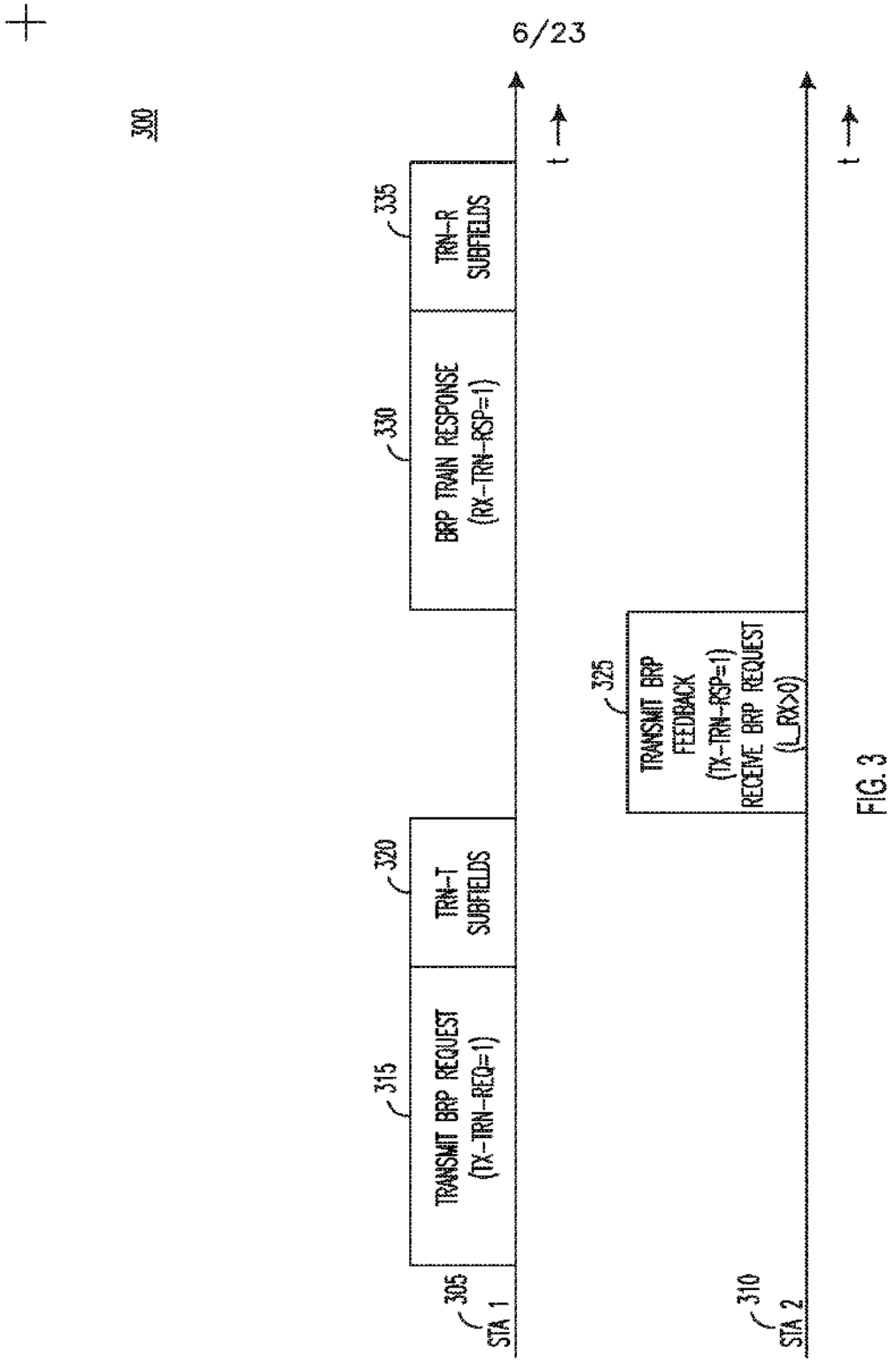

300
305
STA 1
310
STA 2
315
TRANSMIT BRP REQUEST
(TX-TRN-REQ=1)
320
TRN-T
SUBFIELDS
325
TRANSMIT BRP
FEEDBACK
(TX-TRN-RSP=1)
RECEIVE BRP REQUEST
(L_RX>0)
330
BRP TRAIN RESPONSE
(RX-TRN-RSP=1)
335
TRN-R
SUBFIELDS
t
t

FIG. 3

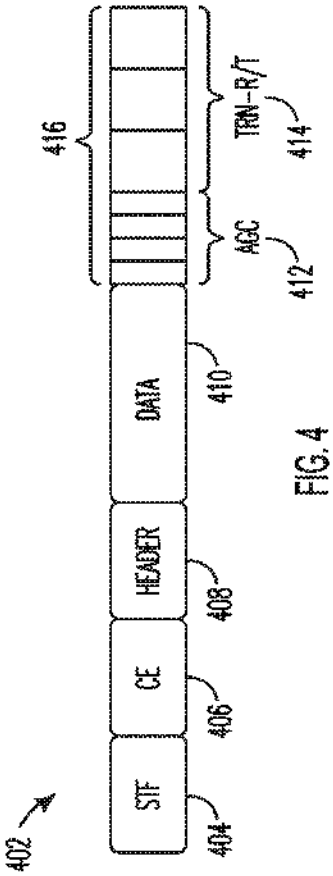


FIG. 4

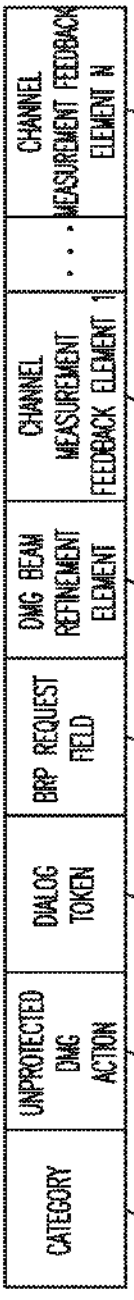


FIG. 5

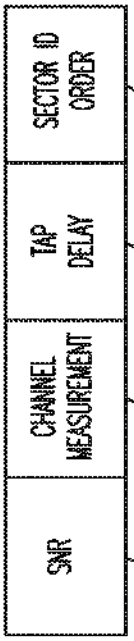


FIG. 6

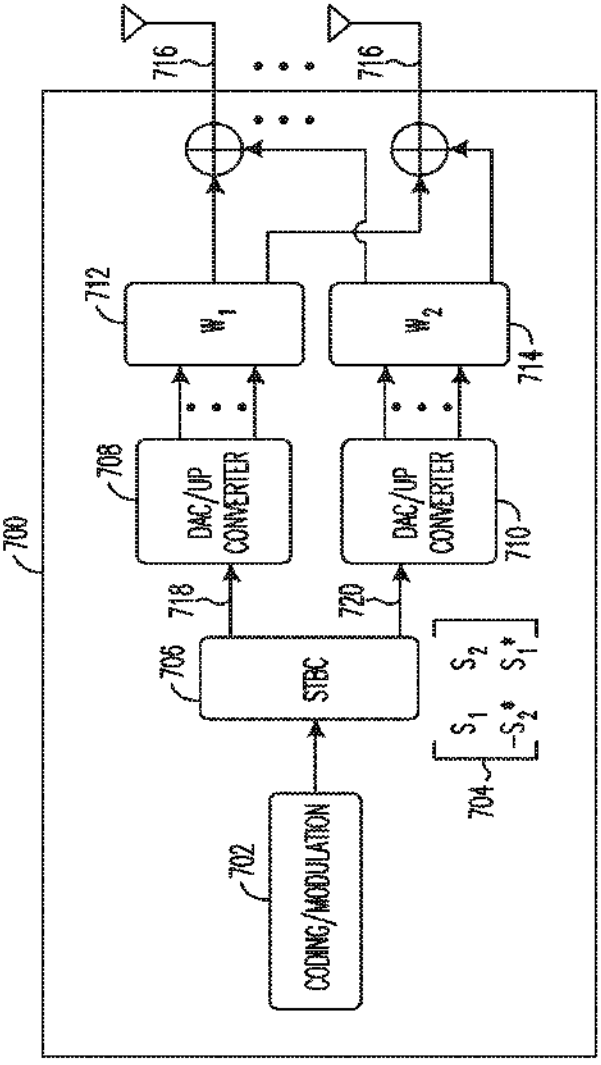

700
716
716
712
W_1
W_2
714
708
DAC/UP CONVERTER
DAC/UP CONVERTER
710
718
720
706
STBC
$\begin{bmatrix} S_1 & S_2 \\ -S_2^* & S_1^* \end{bmatrix}$
704
702
CODING/MODULATION

FIG. 7

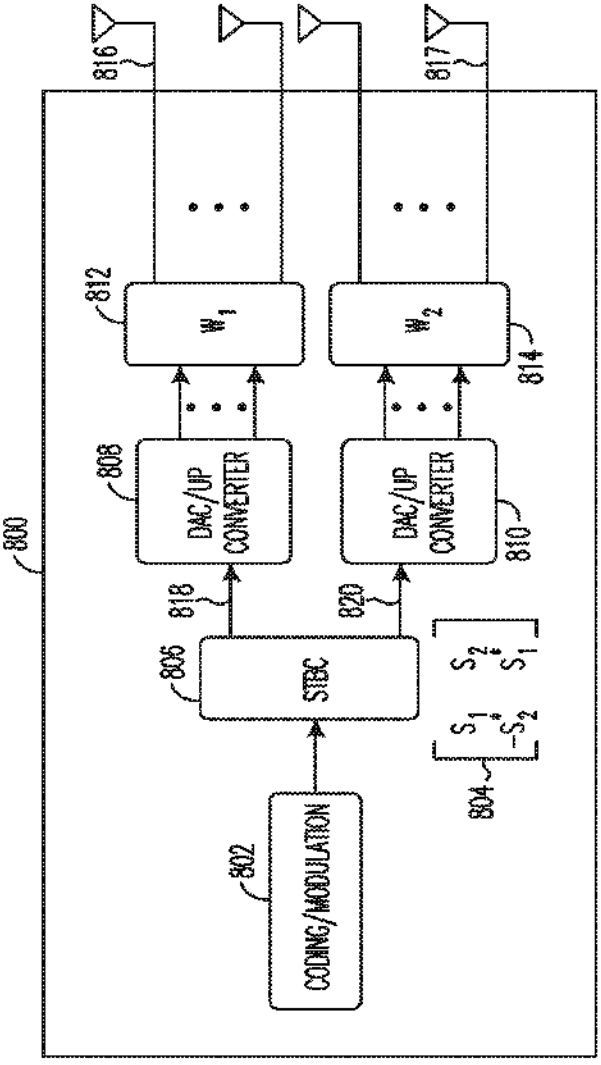

800
816
817
812
W_1
W_2
814
808
DAC/UP CONVERTER
DAC/UP CONVERTER
810
818
820
806
STBC
S_2 S_1^*
S_1 $-S_2^*$
804
802
CODING/MODULATION

FIG. 8

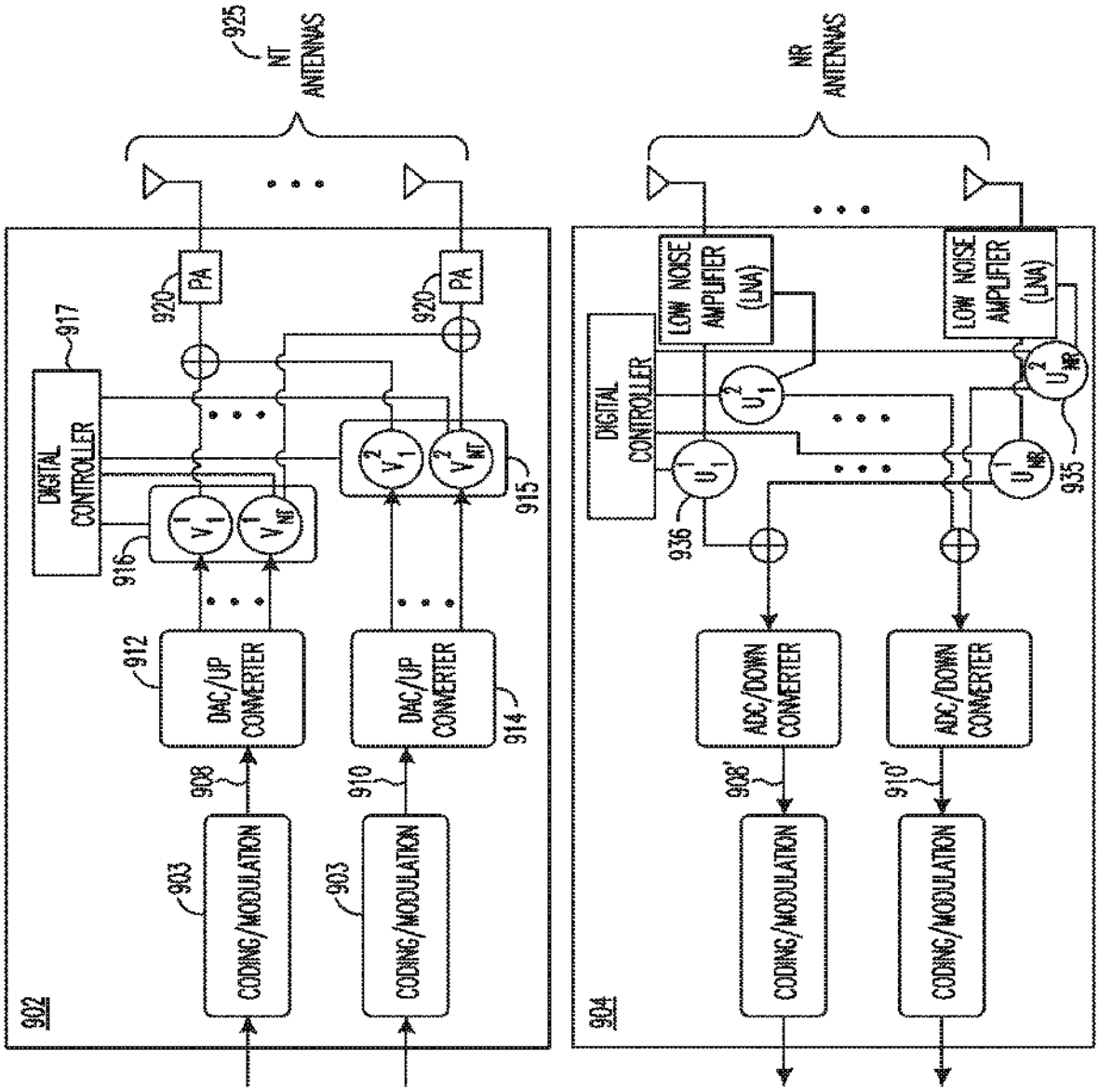

925
NT
ANTENNAS
NR
ANTENNAS
902
904
DIGITAL
CONTROLLER
917
916
915
920
PA
912
DAC/UP
CONVERTER
914
908
910
903
CODING/MODULATION
LOW NOISE
AMPLIFIER
(LNA)
936
935
ADC/DOWN
CONVERTER
908'
910'

FIG. 9

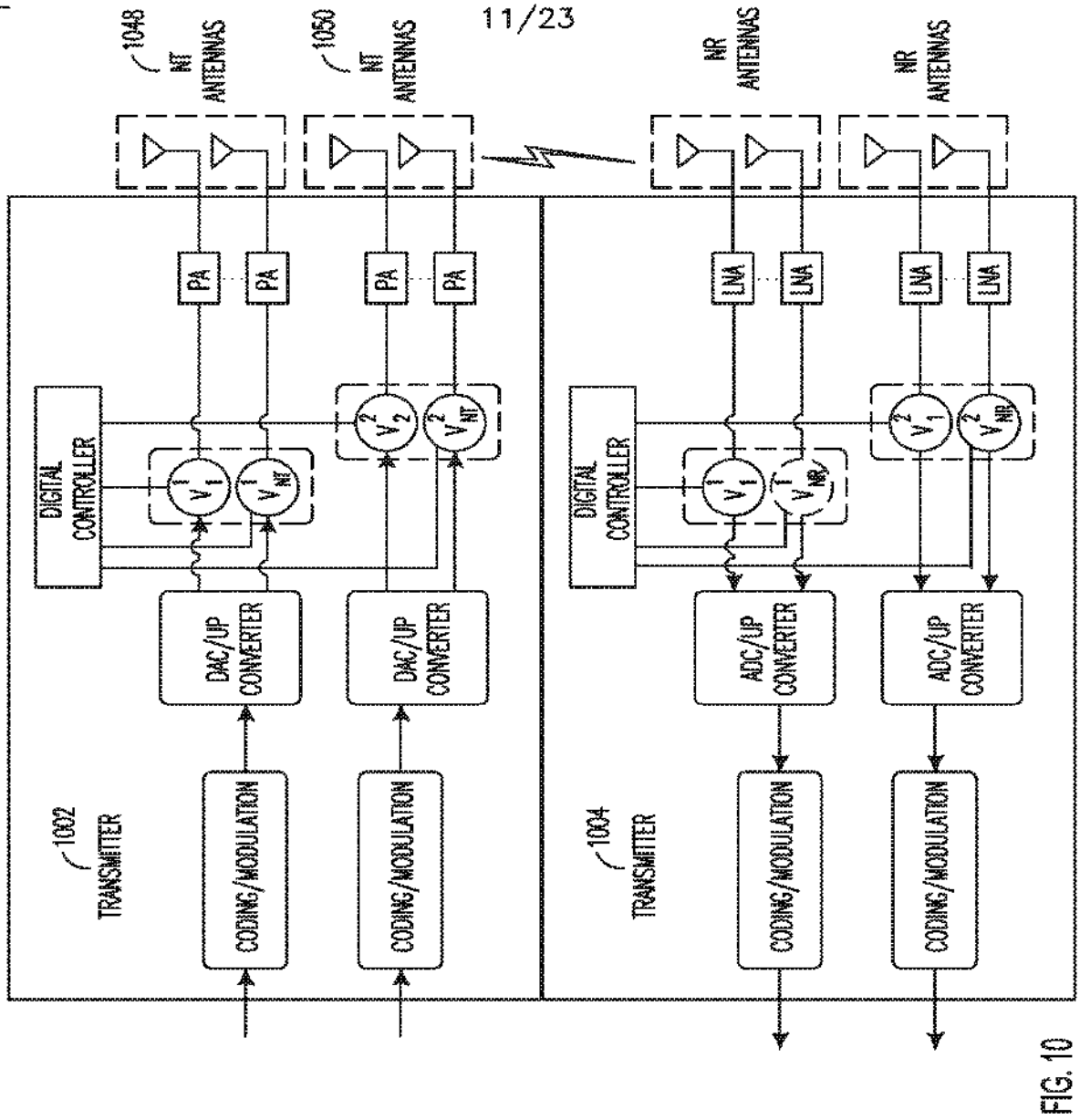

1048
NT ANTENNAS
1050
NT ANTENNAS
NR ANTENNAS
NR ANTENNAS
PA
PA
PA
PA
LNA
LNA
LNA
LNA
DIGITAL CONTROLLER
DIGITAL CONTROLLER
DAC/UP CONVERTER
DAC/UP CONVERTER
ADC/UP CONVERTER
ADC/UP CONVERTER
CODING/MODULATION
CODING/MODULATION
CODING/MODULATION
CODING/MODULATION
1002
TRANSMITTER
1004
TRANSMITTER

FIG. 10

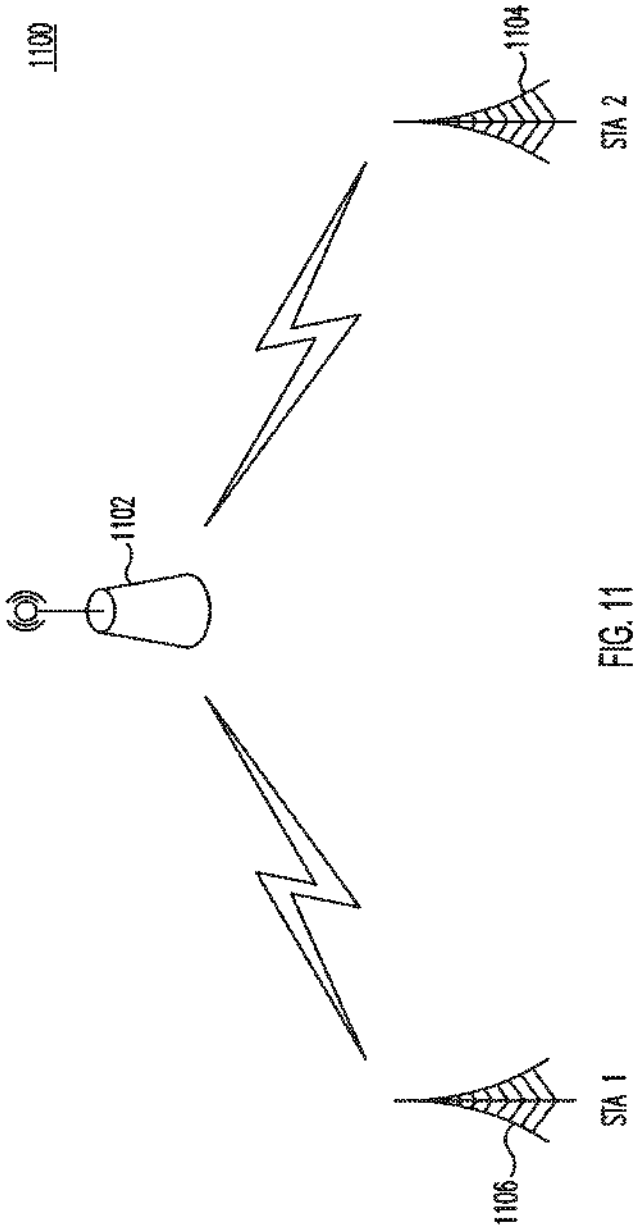


FIG. 11

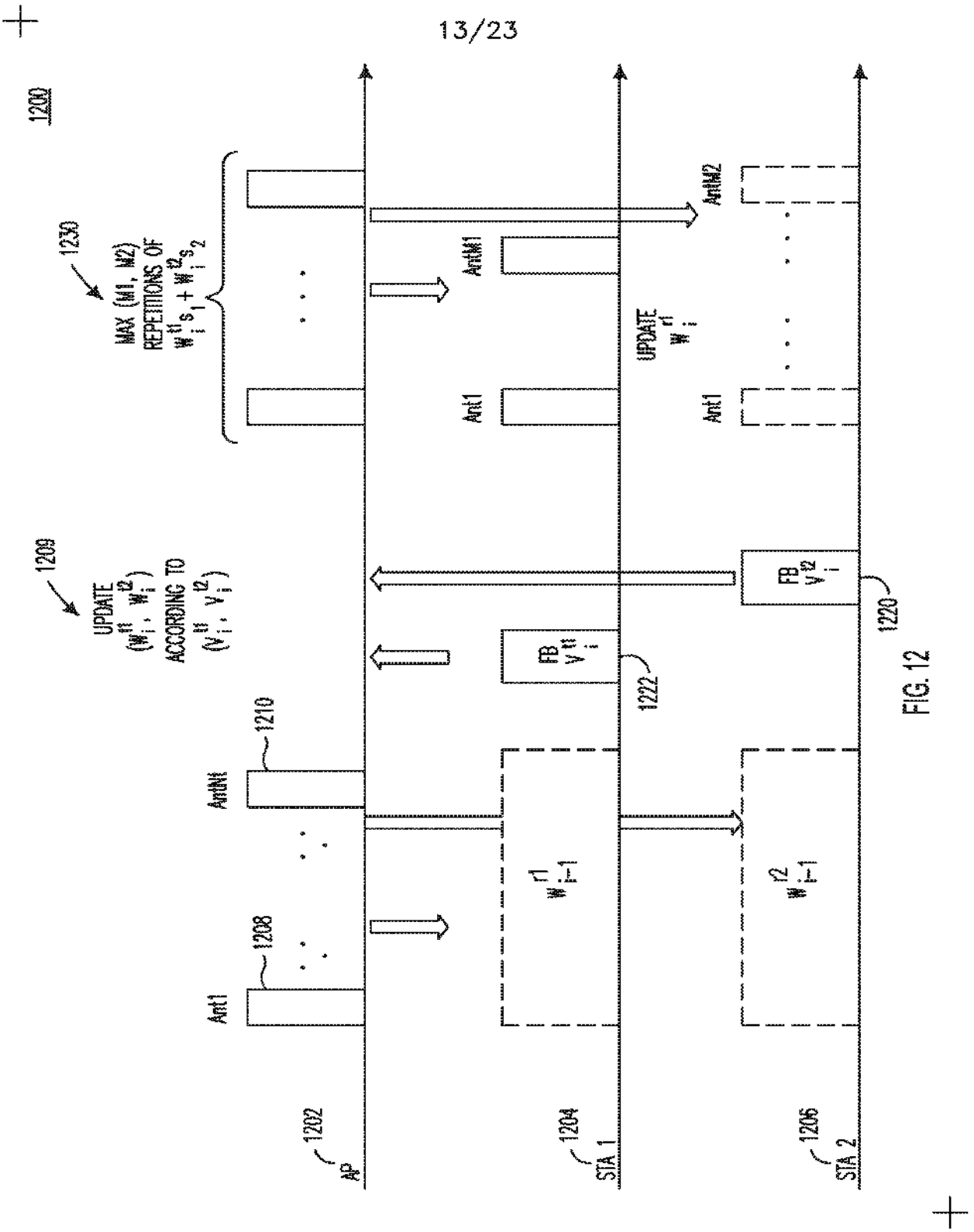

1200
1230
MAX (M1, M2) REPETITIONS OF
$W_i^{t1} s_1 + W_i^{t2} s_2$
1209
UPDATE
(W_i^{t1}, W_i^{t2})
ACCORDING TO
(V_i^{t1}, V_i^{t2})
Ant1
AntNt
1208
1210
$r1 W_{i-1}$
$r2 W_{i-1}$
FB V_i^{t1}
1222
FB V_i^{t2}
1220
Ant1
AntM1
Ant1
AntM2
UPDATE W_i^{r1}
1202
AP
1204
STA 1
1206
STA 2

FIG. 12

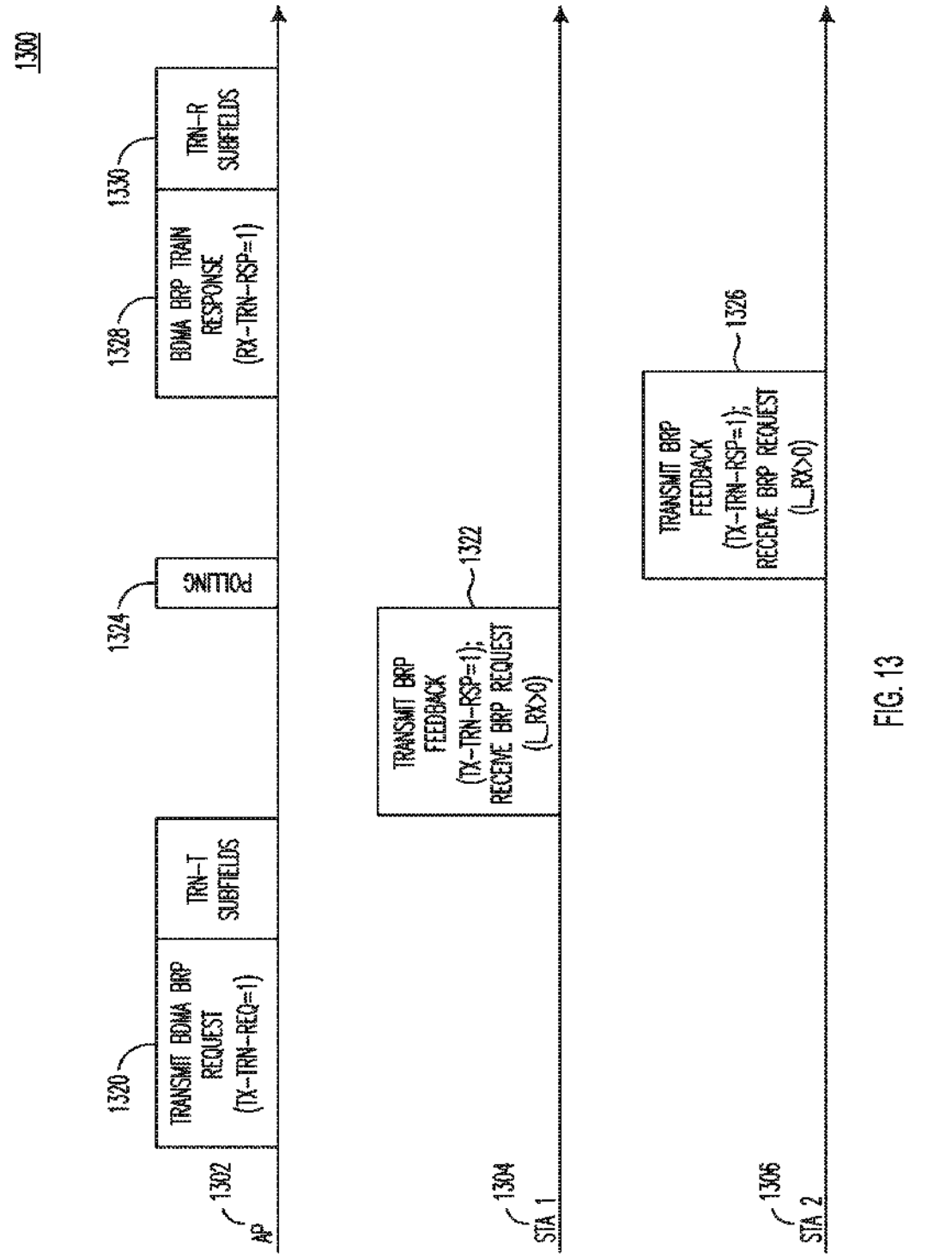

1300
AP
1302
STA 1
1304
STA 2
1306
TRANSMIT BDMA BRP REQUEST (TX-TRN-REQ=1)
1320
TRN-T SUBFIELDS
1324
BDMA BRP TRAIN RESPONSE (RX-TRN-RSP=1)
1328
TRN-R SUBFIELDS
1330
TRANSMIT BRP FEEDBACK (TX-TRN-RSP=1); RECEIVE BRP REQUEST (L_RX>0)
1322
TRANSMIT BRP FEEDBACK (TX-TRN-RSP=1); RECEIVE BRP REQUEST (L_RX>0)
1326

FIG. 13

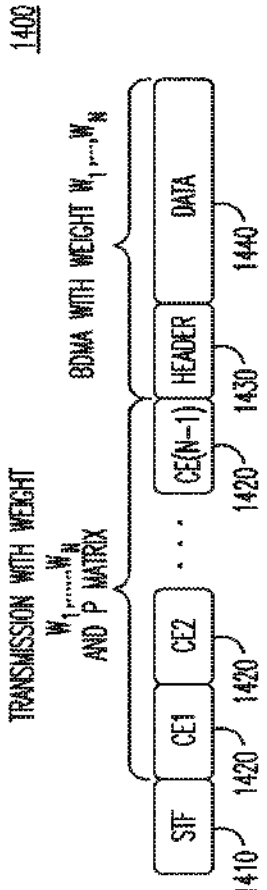

1400
TRANSMISSION WITH WEIGHT
$W_1,\ldots,W_N$
AND P MATRIX
BDMA WITH WEIGHT $W_1,\ldots,W_N$
STF
CE1
CE2
CE(N-1)
HEADER
DATA
1410
1420
1420
1420
1430
1440

FIG. 14

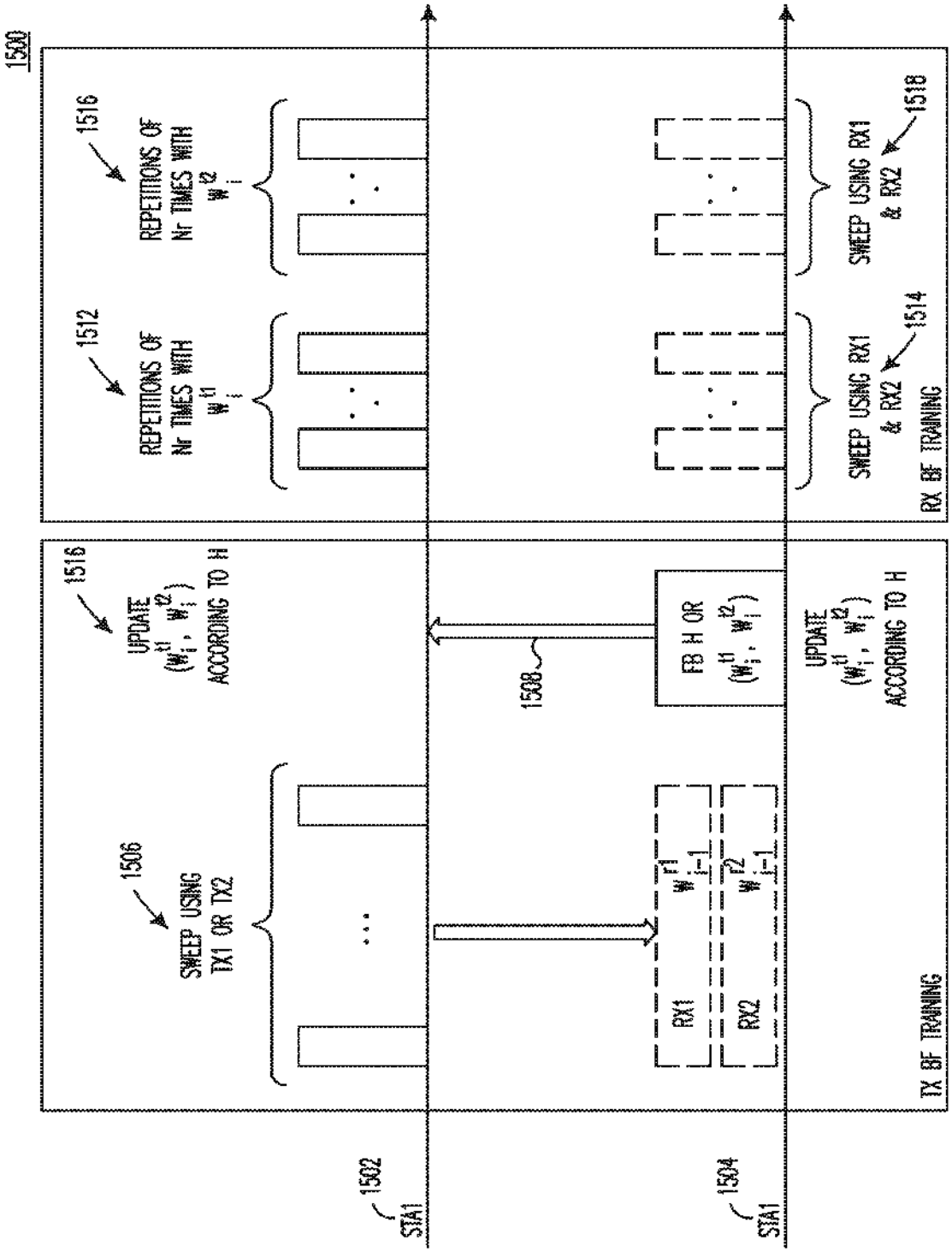

1500
1516
REPETITIONS OF Nr TIMES WITH W_i^{t2}
1512
REPETITIONS OF Nr TIMES WITH W_i^{t1}
SWEEP USING RX1 & RX2
1514
SWEEP USING RX1 & RX2
1518
RX BF TRAINING
1516
UPDATE (W_i^{t1}, W_i^{t2}) ACCORDING TO H
1506
SWEEP USING TX1 OR TX2
1508
FB H OR (W_i^{t1}, W_i^{t2})
UPDATE (W_i^{t1}, W_i^{t2}) ACCORDING TO H
RX1
W_{i-1}^{r1}
RX2
W_{i-1}^{r2}
TX BF TRAINING
1502
STA1
1504
STA1

FIG. 15

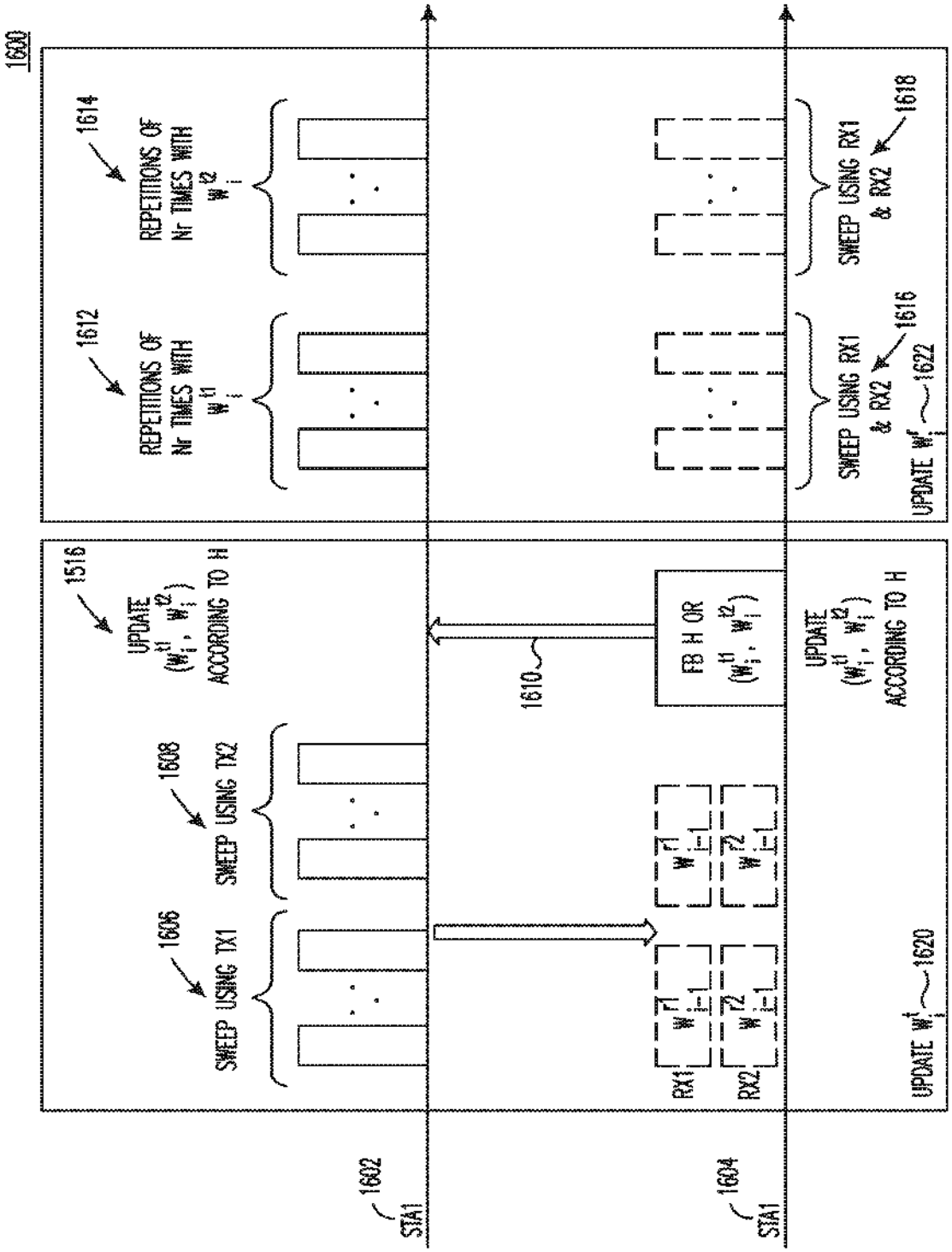

1600
1602
STA1
1604
STA1
1606
SWEEP USING TX1
1608
SWEEP USING TX2
1610
1612
REPETITIONS OF Nr TIMES WITH
1614
REPETITIONS OF Nr TIMES WITH
1516
UPDATE
ACCORDING TO H
FB H OR
RX1
RX2
1616
SWEEP USING RX1 & RX2
1618
SWEEP USING RX1 & RX2
1620
UPDATE
1622
UPDATE
ACCORDING TO H

FIG. 16

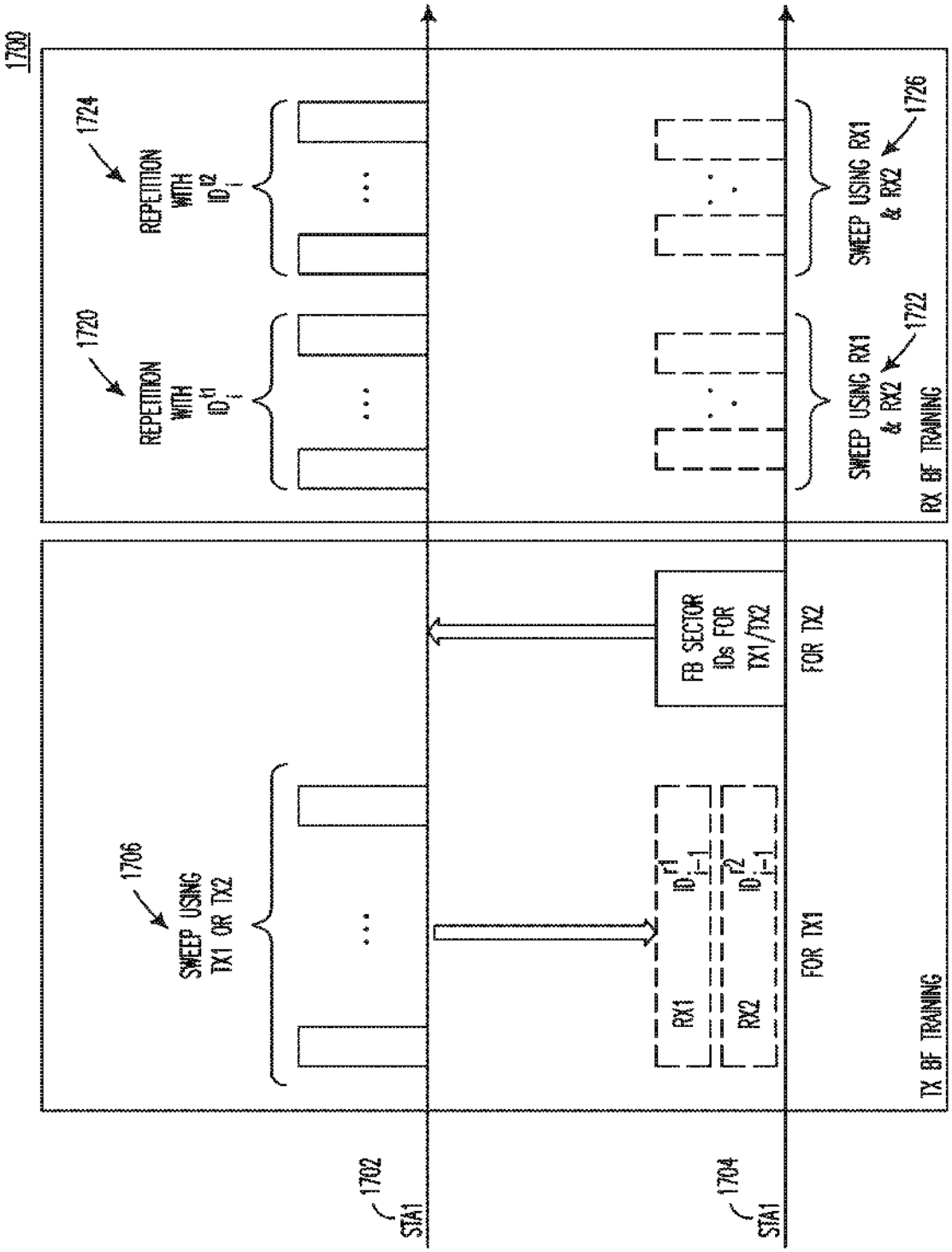

1700
1724
REPETITION WITH ID_i^{I2}
1720
REPETITION WITH ID_i^{I1}
SWEEP USING RX1 & RX2
1722
SWEEP USING RX1 & RX2
1726
RX BF TRAINING
1706
SWEEP USING TX1 OR TX2
RX1
RX2
ID_{i-1}^{r1}
ID_{i-1}^{r2}
FB SECTOR IDs FOR TX1/TX2
FOR TX1
FOR TX2
TX BF TRAINING
1702
STA1
1704
STA1

FIG. 17

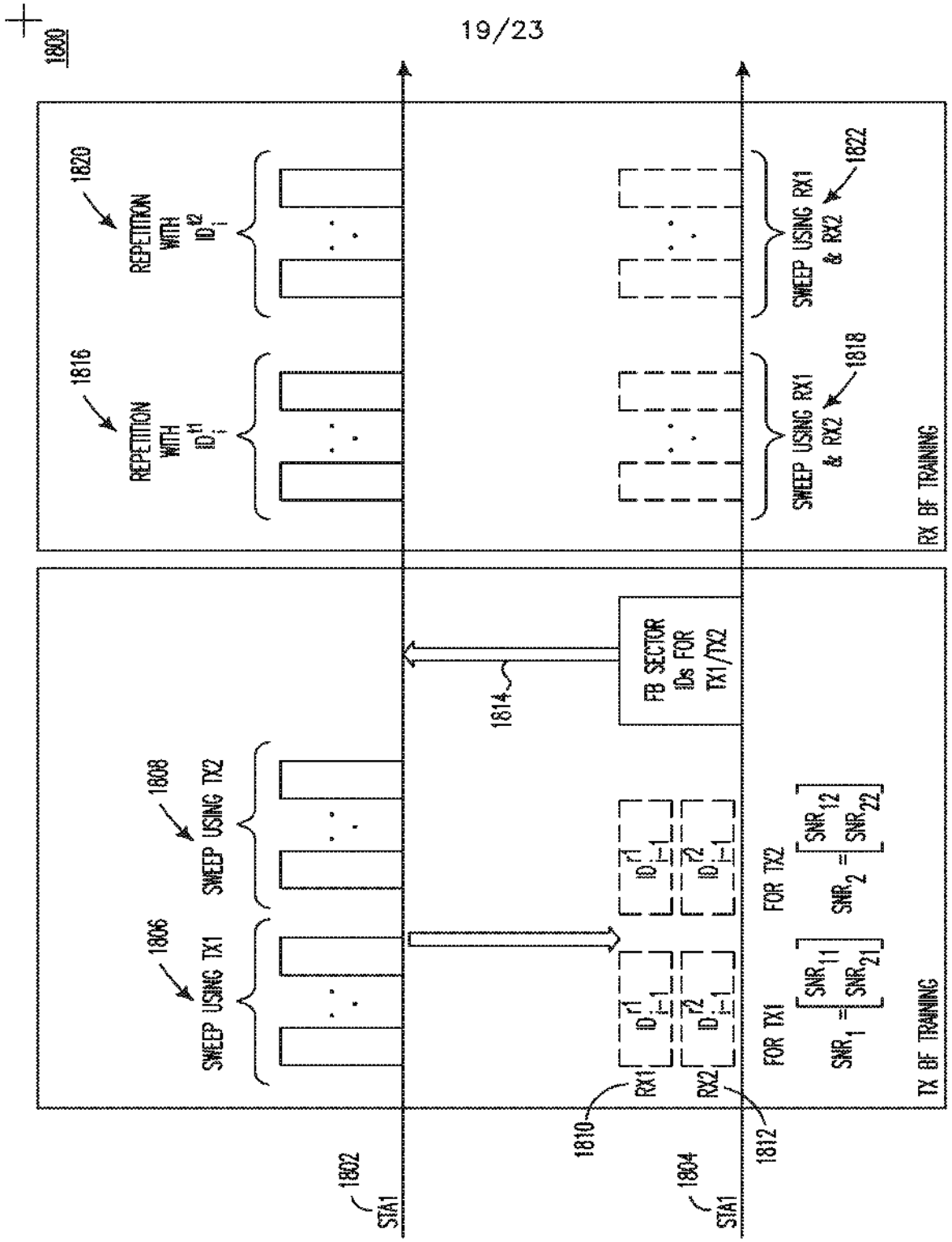

1800
1820
REPETITION WITH ID_i^{12}
1816
REPETITION WITH ID_i^{11}
SWEEP USING RX1 & RX2
1822
1818
RX BF TRAINING
1806
SWEEP USING TX1
1808
SWEEP USING TX2
1814
FB SECTOR IDs FOR TX1/TX2
ID_{i-1}^{r1}
ID_{i-1}^{r2}
RX1
RX2
1810
1812
FOR TX1
$SNR_1 = \begin{bmatrix} SNR_{11} \\ SNR_{21} \end{bmatrix}$
FOR TX2
$SNR_2 = \begin{bmatrix} SNR_{12} \\ SNR_{22} \end{bmatrix}$
TX BF TRAINING
1802
STA1
1804
STA1

FIG. 18

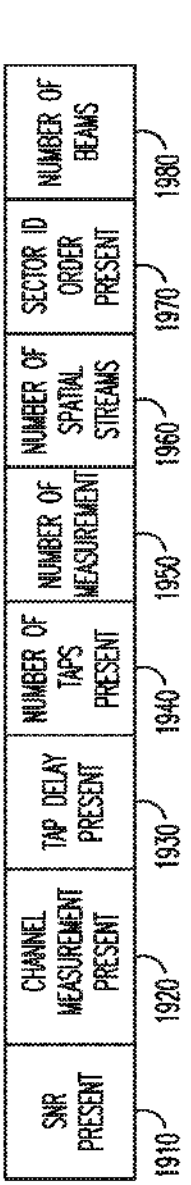


FIG. 19

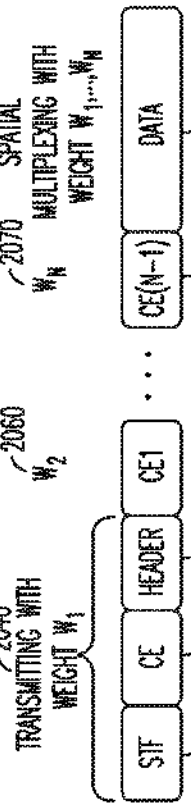


FIG. 20A

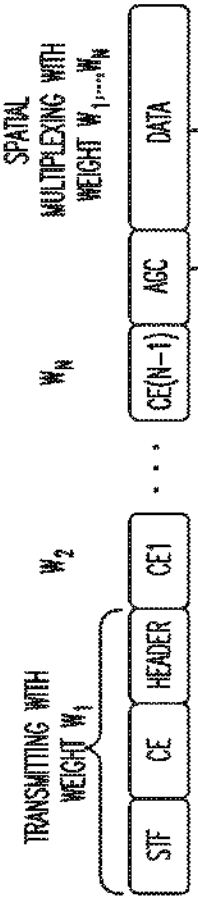


FIG. 20B



FIG. 20C

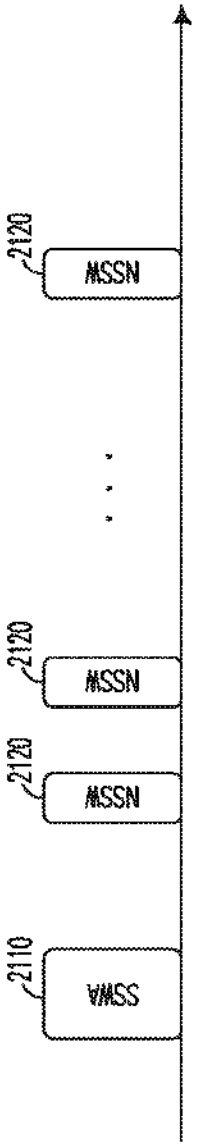

2100
2110
VMSS
2120
MSSN
2120
MSSN
2120
MSSN

FIG. 21

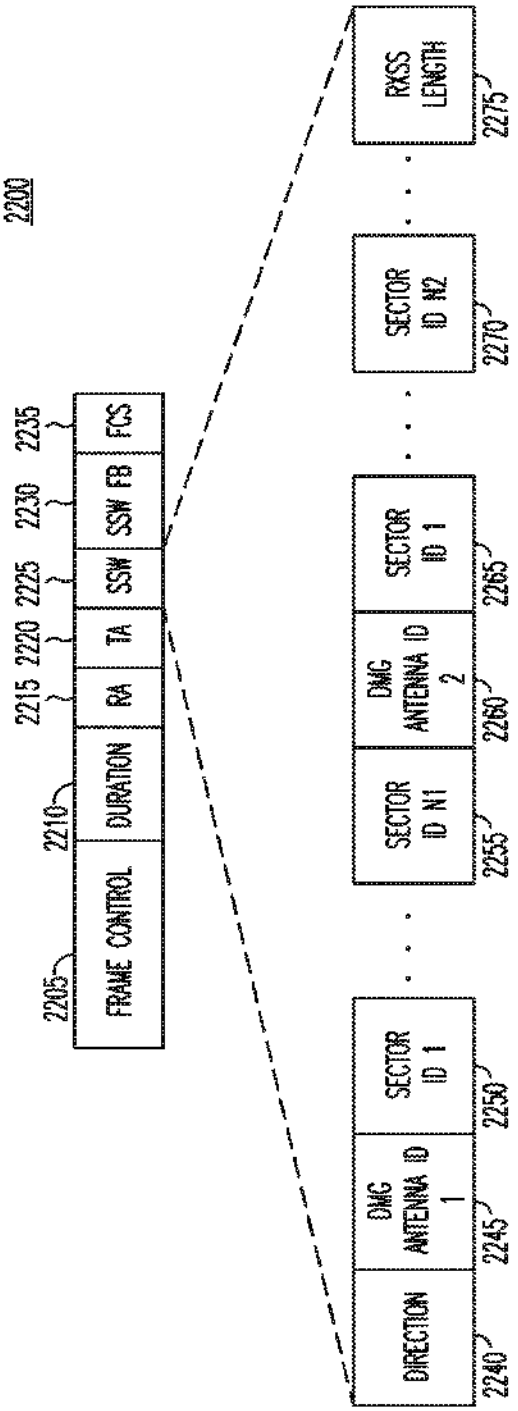

2200
2205
FRAME CONTROL
2210
DURATION
2215
RA
2220
TA
2225
SSW
2230
SSW FB
2235
FCS
2240
DIRECTION
2245
DMG ANTENNA ID 1
2250
SECTOR ID 1
2255
SECTOR ID N1
2260
DMG ANTENNA ID 2
2265
SECTOR ID 1
2270
SECTOR ID N2
2275
RXSS LENGTH

FIG. 22

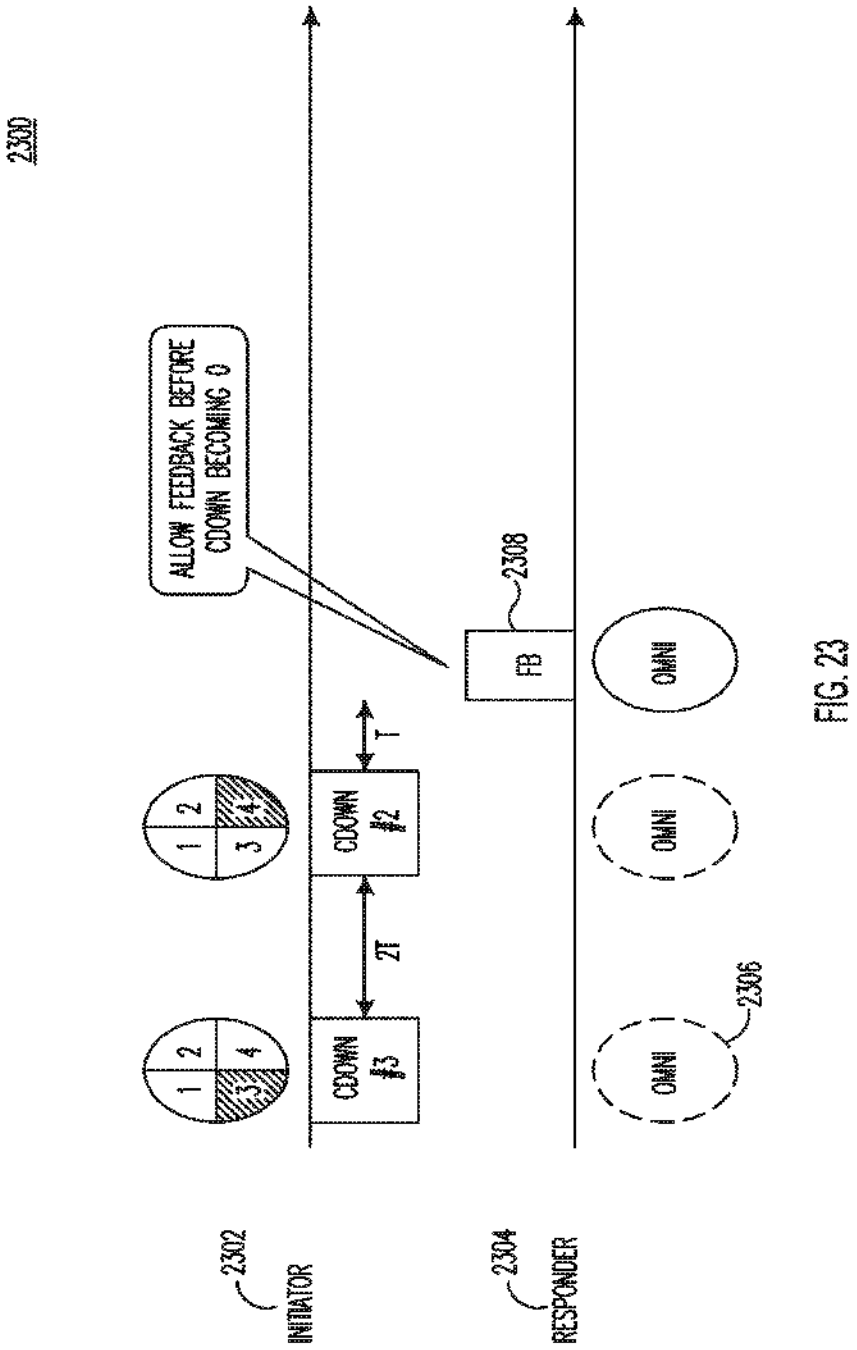

2300
ALLOW FEEDBACK BEFORE CDOWN BECOMING 0
2308
FB
OMNI
T
CDOWN #2
1 2 3 4
2T
CDOWN #3
1 2 3 4
OMNI
OMNI
2306
2302
INITIATOR
2304
RESPONDER

FIG. 23

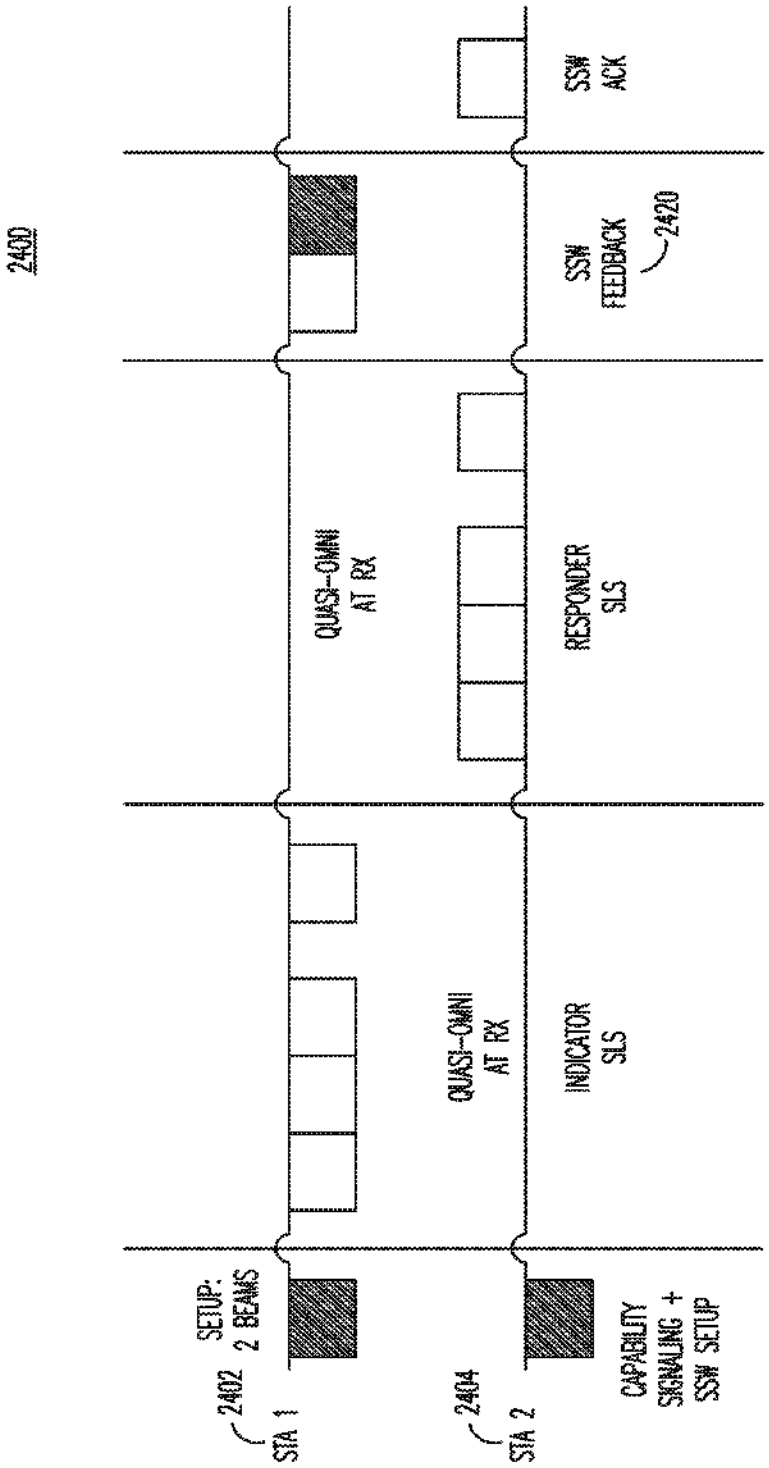

2400
SETUP: 2 BEAMS
2402
STA 1
QUASI-OMNI AT RX
QUASI-OMNI AT RX
2404
STA 2
INDICATOR SLS
CAPABILITY SIGNALING + SSW SETUP
RESPONDER SLS
SSW FEEDBACK
2420
SSW ACK

FIG. 24

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2013/069265

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04B7/04 H04B7/06
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2010/050874 A1 (ERICSSON TELEFON AB L M [SE]; RAHMAN MUHAMMAD IMADUR [SE]; JOENGREN GE) 6 May 2010 (2010-05-06) figures 1,5 page 9, line 1 - page 4, line 20 -----	1-20
X	WO 2009/093870 A2 (LG ELECTRONICS INC [KR]; JEON BEOM JIN [KR]) 30 July 2009 (2009-07-30) abstract paragraph [0001] - paragraph [0022] -----	1-20
X	WO 2009/102124 A2 (SAMSUNG ELECTRONICS CO LTD [KR]) 20 August 2009 (2009-08-20) abstract paragraph [0030] - paragraph [0057] ----- -/--	1-20

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 February 2014	27/02/2014

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Neeb, Christoph

3

Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 2 211 483 A1 (SONY CORP [JP]) 28 July 2010 (2010-07-28) paragraph [0026] - paragraph [0080] -----	1-20
A	US 2009/232010 A1 (LI GUOQING [US] ET AL) 17 September 2009 (2009-09-17) the whole document -----	1-20
A	ELDAD PERAHIA ET AL: "Gigabit wireless LANs", ACM SIGMOBILE MOBILE COMPUTING AND COMMUNICATIONS REVIEW, vol. 15, no. 3, 29 November 2011 (2011-11-29), page 23, XP055015658, ISSN: 1559-1662, DOI: 10.1145/2073290.2073294 section III -----	1-20
A	EP 1 266 463 B1 (NOKIA CORP [FI]) 21 June 2006 (2006-06-21) paragraph [0030] - paragraph [0050] -----	1-20

3

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2013/069265

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		EP 2351246 A1	03-08-2011
		US 2011205930 A1	25-08-2011
		WO 2010050874 A1	06-05-2010
WO 2009093870 A2	30-07-2009	CN 102017447 A	13-04-2011
		EP 2235845 A2	06-10-2010
		KR 20090081064 A	28-07-2009
		US 2010295730 A1	25-11-2010
		WO 2009093870 A2	30-07-2009
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		US 2009238156 A1	24-09-2009
		WO 2009102124 A2	20-08-2009
EP 2211483 A1	28-07-2010	CN 101789817 A	28-07-2010
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		CN 103237319 A	07-08-2013
		EP 2253081 A1	24-11-2010
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		US 7200368 B1	03-04-2007
		WO 0169814 A1	20-09-2001

Form PCT/ISA/210 (patent family annex) (April 2005)

(12) 특허협력조약에 의하여 공개된 국제출원

(19) 세계지식재산권기구
국제사무국

(43) 국제공개일
2016 년 8 월 4 일 (04.08.2016)

WIPO | PCT

(10) 국제공개번호
WO 2016/122257 A1

(51) 국제특허분류:
H04L 5/00 (2006.01) *H04B 7/02* (2006.01)
H04B 7/06 (2006.01)

(21) 국제출원번호: PCT/KR2016/001014

(22) 국제출원일: 2016 년 1 월 29 일 (29.01.2016)

(25) 출원언어: 한국어

(26) 공개언어: 한국어

(30) 우선권정보:
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10-2015-0018919 2015 년 2 월 6 일 (06.02.2015) KR
10-2015-0051184 2015 년 4 월 10 일 (10.04.2015) KR
10-2015-0064053 2015 년 5 월 7 일 (07.05.2015) KR
10-2015-0091400 2015 년 6 월 26 일 (26.06.2015) KR
10-2015-0105272 2015 년 7 월 24 일 (24.07.2015) KR
10-2015-0114925 2015 년 8 월 13 일 (13.08.2015) KR
10-2015-0114927 2015 년 8 월 13 일 (13.08.2015) KR
10-2016-0000596 2016 년 1 월 4 일 (04.01.2016) KR
10-2016-0004344 2016 년 1 월 13 일 (13.01.2016) KR
10-2016-0011000 2016 년 1 월 28 일 (28.01.2016) KR

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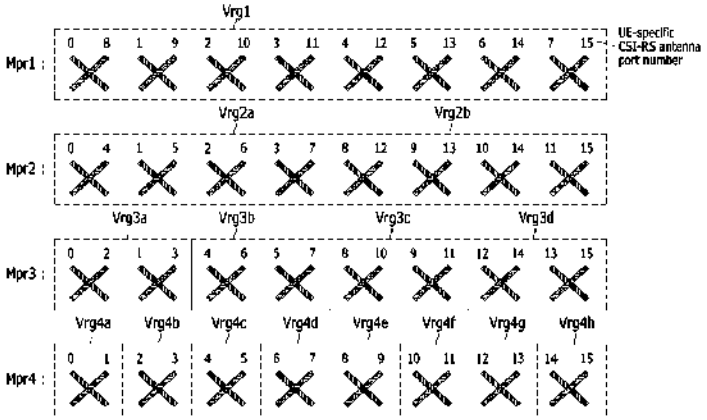
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(81) 지정국 (별도의 표시가 없는 한, 가능한 모든 종류의 국내 권리의 보호를 위하여): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE,

[다음 쪽 계속]

(54) Title: METHOD AND APPARATUS FOR TRANSMITTING DOWNLINK REFERENCE SIGNAL, AND METHOD AND APPARATUS FOR TRANSMITTING CONTROL INFORMATION IN MULTI-CELL COLLABORATIVE COMMUNICATION SYSTEM

(54) 발명의 명칭 : 하향링크 참조 신호를 전송하는 방법 및 장치, 그리고 다중 셀 협력 통신 시스템에서 제어 정보를 전송하는 방법 및 장치



(57) Abstract: Provided is a method for a base station to set channel state information (CSI)-reference signal (RS). The base station sets a CSI-RS antenna port for a terminal. For the terminal, the base station selects one of at least one port number mapping rule for mapping a port number to the CSI-RS antenna port. Further, the base station notifies the terminal of the selected port number mapping rule.

(57) 요약서: 기지국이 CSI(channel state information)-RS(reference signal)를 설정하는 방법이 제공된다. 상기 기지국은, 단말을 위한 CSI-RS 안테나 포트를 설정한다. 상기 기지국은, 상기 CSI-RS 안테나 포트에 포트 번호를 맵핑하기 위한 적어도 하나의 포트 번호 맵핑 규칙 중 하나를, 상기 단말을 위해 선택한다. 그리고 상기 기지국은, 상기 선택된 포트 번호 맵핑 규칙을 상기 단말에게 알린다.

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(84) 지정국 (별도의 표시가 없는 한, 가능한 모든 종류의 역내 권리의 보호를 위하여): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), 유라시아 (AM, AZ, BY, KG, KZ, RU, TJ, TM), 유럽 (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

공개:

— 국제조사보고서와 함께 (조약 제 21 조(3))

명세서

발명의 명칭: 하향링크 참조 신호를 전송하는 방법 및 장치, 그리고 다중 셀 협력 통신 시스템에서 제어 정보를 전송하는 방법 및 장치

기술분야

[1] 본 발명은 하향링크 참조 신호를 전송하는 방법 및 장치에 관한 것이다.

[2] 또한 본 발명은 채널 상태 정보를 측정하는 방법 및 장치에 관한 것이다.

[3] 또한 본 발명은 다중 셀 협력 통신 시스템에서 제어 정보를 전송하는 방법 및 장치에 관한 것이다.

배경기술

[4] 무선 통신 시스템의 다중 입출력(MIMO: multiple-input multiple-output) 방식은 복수의 송신 안테나와 복수의 수신 안테나를 사용하여 송수신하는 방법이다. MIMO 시스템에서 송수신 안테나 간 복수의 무선 채널 경로가 생성되며, 송수신단은 이를 분리 또는 병합함으로써, 데이터 전송 용량을 증대시키거나 전송 품질을 향상시킬 수 있다. MIMO 기법으로는 공간 다중화(spatial multiplexing) 기법과 공간 다이버시티(spatial diversity) 기법이 있다. LTE(long term evolution) 시스템에 도입된 하향링크 MIMO 기법으로는, 송신 다이버시티(transmit diversity), CDD (cyclic delay diversity), 빔포밍(beamforming) 및 공간 다중화 방식 등이 있다. 또한 동일 자원에서 동시에 복수의 단말에 데이터를 전송하는 다중 사용자 MIMO (MU-MIMO: multiuser MIMO) 기법이 지원된다.

[5] LTE 규격에서의 안테나 포트(antenna port)는 하나 또는 복수의 물리 안테나 요소(antenna element)의 가중치 합(weighted sum)에 의해 구현되는 논리적 안테나 단위로써, 주로 송신단에서 정의된다. 안테나 포트는 참조 신호(RS: reference signal)가 전송되는 기본 단위이기도 하다. 따라서 단말은 물리 안테나 요소가 아닌 각 안테나 포트에 대하여 채널을 추정하고 이를 기반으로 채널 상태 정보(CSI: channel state information) 측정 및 보고를 수행한다. LTE 하향링크 참조 신호인 CRS(cell-specific RS), URS(user equipment-specific RS), 및 CSI-RS에는 각기 다른 안테나 포트 번호가 부여된다. URS의 목적은 단말의 PDSCH(physical downlink shared channel) 복호를 위함이므로, URS는 DMRS(demodulation RS)로 부르기도 한다. CRS를 위한 안테나 포트 번호는 0번 내지 3번이고, URS를 위한 안테나 포트 번호는 7번 내지 14번, CSI-RS를 위한 안테나 포트 번호는 15번 내지 22번일 수 있다. 안테나 포트와 물리 안테나 요소(들) 간의 맵핑을 안테나 가상화(antenna virtualization)라고 한다. 단말은 기본적으로 각 안테나 포트에 어떤 가상화가 적용되었는지를 알 수 없다.

[6] CSI-RS는 단말이 CSI를 획득하기 위한 목적으로 기지국이 전송하는 하향링크 참조신호로써, LTE Release 10에서 도입되었다. CSI-RS는 후술할 ZP(zero-power)

CSI-RS와의 구별을 위해 NZP(non-zero-power) CSI-RS라 불려지기도 한다. 기존 Release 8/9 시스템에서는 단말의 CSI 획득을 위해 CRS가 이용되었으나, Release 10부터는 최대 8개의 레이어(layer)의 하향링크 전송을 지원하기 위해 기존의 CRS보다 낮은 밀도를 갖는 새로운 채널 추정용 참조신호의 도입이 필요하게 되었다. CSI-RS 설정 정보는 단말 특정적(user equipment-specific) RRC(radio resource control) 시그널링을 통해 단말에게 전송된다. 단말에게 설정 가능한 CSI-RS 안테나 포트 수는, Release 13 현재까지 1, 2, 4, 8, 12, 그리고 16이다. 각 CSI-RS 안테나 포트 수에 대하여, PRB(physical resource block) 페어(pair) 당 CSI-RS 전송이 차지하는 총 RE의 개수는, 2, 2, 4, 8, 12, 그리고 16이다.

[7] 시간 축에서의 CSI-RS 전송 주기는, 5, 10, 20, 40, 또는 80 ms 로 설정(configured)될 수 있다. 현재 규격에 의하면, 각 CSI-RS 안테나 포트는 주파수 축에서 12 자원 요소(RE: resource element)의 간격을 가진다.

[8] 한편, FD(full dimension)-MIMO(또는 3차원 MIMO) 시스템에서 기지국이 3차원 빔포밍을 수행하기 위해서는, 단말이 기존의 수평 축에 대한 CSI 뿐만 아니라 수직 축에 대한 CSI의 측정 및 보고를 수행할 필요가 있다. 2차원 안테나 배열의 크기가 큰 경우에, 단말에 설정 가능한 CSI-RS 안테나 포트 수를 늘리는 방법이 연구되고 있다.

[9] 또한 기존의 단말은 CSI-RS 안테나 포트 배열을 1차원으로만 인식한다. 단말이 CSI-RS 안테나 포트 배열을 2차원(2D: two dimensions) 또는 3차원(3D: three dimensions)으로 인식하는 방법이 필요하다.

발명의 상세한 설명

기술적 과제

[10] 본 발명이 해결하고자 하는 과제는, MIMO 무선 통신 시스템에서 CSI-RS를 설정하고 전송하는 방법 및 장치를 제공하는 것이다.

[11] 또한 본 발명이 해결하고자 하는 과제는, 단말에 설정 가능한 CSI-RS 안테나 포트 수를 늘리는 방법 및 장치를 제공하는 것이다.

[12] 또한 본 발명이 해결하고자 하는 과제는, CSI-RS 안테나 포트 배열을 1차원 또는 다차원으로 인식하는 방법 및 장치를 제공하는 것이다.

[13] 또한 본 발명이 해결하고자 하는 과제는, 무선 통신 시스템에서 CSI-RS 전송 오버헤드를 줄이기 위하여 다중 셀 협력 통신을 위한 제어 정보를 설정하는 방법 및 장치에 관한 것이다.

[14] 또한 본 발명이 해결하고자 하는 과제는, CSI-RS 자원으로써 설정될 수 있는 RE를 확장하는 방법 및 장치에 관한 것이다.

[15] 또한 본 발명이 해결하고자 하는 과제는, 상기 확장된 RE를 이용해 CSI-RS 를 전송하는 방법 및 장치에 관한 것이다.

과제 해결 수단

[16] 본 발명의 실시예에 따르면, 기지국이 CSI(channel state

information)-RS(reference signal)를 설정하는 방법이 제공된다. 상기 기지국의 CSI-RS 설정 방법은, 단말을 위한 CSI-RS 안테나 포트를 설정하는 단계; 상기 CSI-RS 안테나 포트에 포트 번호를 맵핑하기 위한 적어도 하나의 포트 번호 맵핑 규칙 중 하나를, 상기 단말을 위해 선택하는 단계; 및 상기 선택된 포트 번호 맵핑 규칙을 상기 단말에게 알리는 단계를 포함한다.

[17] 상기 단말을 위한 CSI-RS 안테나 포트를 설정하는 단계는, 상기 CSI-RS 안테나 포트가 제1 축, 제2 축, 및 제3 축 중 적어도 2개를 따라 배치되는 CSI-RS 안테나 포트 배열을 설정하는 단계를 포함할 수 있다.

[18] 상기 선택된 포트 번호 맵핑 규칙에 무관하게, 상기 제1 축, 상기 제2 축, 및 상기 제3 축에 포트 번호가 맵핑되는 축 순서는, 기 설정될 수 있다.

[19] 상기 단말을 위한 CSI-RS 안테나 포트를 설정하는 단계는, 상기 CSI-RS 안테나 포트 배열에 포함된 CSI-RS 안테나 포트 중에서 상기 제1 축으로 배치되는 CSI-RS 안테나 포트의 수, 상기 제2 축으로 배치되는 CSI-RS 안테나 포트의 수, 및 상기 제3 축으로 배치되는 CSI-RS 안테나 포트의 수 중 적어도 하나를, 상기 단말에게 전송하는 단계를 더 포함할 수 있다.

[20] 상기 단말을 위한 CSI-RS 안테나 포트를 설정하는 단계는, 상기 제1 축, 상기 제2 축, 및 상기 제3 축 중 하나의 축에 따라 배치되는 CSI-RS 안테나 포트의 수가 상기 단말에게 설정되는 전체 CSI-RS 안테나 포트의 수와 동일한 경우에, 상기 하나의 축에 따라 배치되는 CSI-RS 안테나 포트의 수를 상기 단말에게 전송하는 것을 생략하는 단계를 더 포함할 수 있다.

[21] 상기 단말을 위한 CSI-RS 안테나 포트를 설정하는 단계는, 상기 CSI-RS 안테나 포트 배열에 포함된 CSI-RS 안테나 포트 중에서 상기 제1 축으로 배치되는 CSI-RS 안테나 포트의 수와 상기 제3 축으로 배치되는 CSI-RS 안테나 포트의 수를 합하여, 제1 값을 구하는 단계; 및 상기 CSI-RS 안테나 포트 배열에 포함된 CSI-RS 안테나 포트 중에서 상기 제2 축으로 배치되는 CSI-RS 안테나 포트의 수 및 상기 제1 값 중 적어도 하나를, 상기 단말에게 전송하는 단계를 더 포함할 수 있다.

[22] 상기 선택된 포트 번호 맵핑 규칙은, 상기 단말에 의한 채널 추정 시에, 상기 단말로 하여금 상기 단말에게 설정된 전체 CSI-RS 안테나 포트를 상기 선택된 포트 번호 맵핑 규칙에 대응하는 개수 만큼의 CSI-RS 안테나 포트 그룹으로 나누도록 하고, 상기 CSI-RS 안테나 포트 그룹 별로 상기 각 CSI-RS 안테나 포트 그룹에 속하는 CSI-RS 안테나 포트에 상기 기 설정된 축 순서에 따라 포트 번호를 부여하도록 할 수 있다.

[23] 상기 각 CSI-RS 안테나 포트 그룹에 속하는 CSI-RS 안테나 포트의 수는, 상기 단말에게 설정되는 전체 CSI-RS 안테나 포트의 수의 약수일 수 있다.

[24] 상기 선택된 포트 번호 맵핑 규칙을 상기 단말에게 알리는 단계는, 상기 선택된 포트 번호 맵핑 규칙을 나타내는 비트 코드를, 상기 단말에게 전송하는 단계를 포함할 수 있다.

[25] 상기 선택된 포트 번호 맵핑 규칙을 상기 단말에게 알리는 단계는, 상기 선택된 포트 번호 맵핑 규칙에 따라 생성되는 상기 CSI-RS 안테나 포트 그룹의 개수를 나타내는 비트 코드를, 상기 단말에게 전송하는 단계를 포함할 수 있다.

[26] 상기 단말에게 설정되는 전체 CSI-RS 안테나의 수는 8개 보다 더 많을 수 있다.

[27] 상기 제1 축은 수평(horizontal) 축이고, 상기 제2 축은 수직(vertical) 축이고, 상기 제3 축은 편파(polarization) 축일 수 있다.

[28] 상기 기지국의 CSI-RS 설정 방법은, 제1 축, 제2 축, 및 제3 축에 포트 번호가 맵핑되는 축 순서들 중에서 하나를, 상기 단말을 위해 선택하는 단계; 및 상기 선택된 축 순서를 상기 단말에게 알리는 단계를 더 포함할 수 있다.

[29] 상기 단말을 위한 CSI-RS 안테나 포트를 설정하는 단계는, 상기 CSI-RS 안테나 포트가 상기 제1 축, 상기 제2 축, 및 상기 제3 축 중 적어도 2개를 따라 배치되는 CSI-RS 안테나 포트 배열을 설정하는 단계를 포함할 수 있다.

[30] 또한 본 발명의 다른 실시예에 따르면, 단말이 CSI(channel state information)를 측정하는 방법이 제공된다. 상기 단말의 CSI 측정 방법은, 기지국으로부터, CSI-RS(reference signal) 안테나 포트를 위한 제1 포트 번호 맵핑 규칙을 수신하는 단계; 상기 제1 포트 번호 맵핑 규칙에 기초해, 상기 CSI-RS 안테나 포트를 상기 제1 포트 번호 맵핑 규칙에 대응하는 개수 만큼의 CSI-RS 안테나 포트 그룹으로 나누는 단계; 상기 CSI-RS 안테나 포트 그룹 별로 상기 각 CSI-RS 안테나 포트 그룹에 속하는 CSI-RS 안테나 포트에 포트 번호를 부여하는 단계; 및 상기 포트 번호가 부여된 CSI-RS 안테나 포트에 대하여, 채널 추정을 수행하는 단계를 포함한다.

[31] 상기 단말의 CSI 측정 방법은, 상기 제1 포트 번호 맵핑 규칙과 다른 제2 포트 번호 맵핑 규칙에 따라, 상기 CSI-RS 안테나 포트에 포트 번호를 재부여하는 단계; 및 상기 포트 번호가 재부여된 CSI-RS 안테나 포트에 대하여, 상기 채널 추정의 결과에 기초해 CSI 측정을 수행하는 단계를 더 포함할 수 있다.

[32] 상기 제1 포트 번호 맵핑 규칙을 수신하는 단계는, 상기 제1 포트 번호 맵핑 규칙을 나타내는 비트 코드를 상기 기지국으로부터 수신하는 단계를 포함할 수 있다.

[33] 상기 CSI-RS 안테나 포트는 제1 축, 제2 축, 및 제3 축 중 적어도 2개를 따라 배치될 수 있다.

[34] 상기 CSI-RS 안테나 포트에 포트 번호를 부여하는 단계는, 상기 CSI-RS 안테나 포트 그룹 중에서 제1 CSI-RS 안테나 포트 그룹에 속하는 CSI-RS 안테나 포트에, 상기 제1 축, 상기 제2 축, 및 상기 제3 축에 포트 번호가 부여되는 축 순서에 따라 포트 번호를 부여하는 단계; 및 상기 CSI-RS 안테나 포트 그룹 중에서 제2 CSI-RS 안테나 포트 그룹에 속하는 CSI-RS 안테나 포트에, 상기 축 순서에 따라 포트 번호를 부여하는 단계를 포함할 수 있다.

[35] 상기 제2 CSI-RS 안테나 포트 그룹에 부여된 첫번째 포트 번호는, 상기 제1 CSI-RS 안테나 포트 그룹에 부여된 마지막 포트 번호 다음의 포트 번호일 수

있다.

[36] 또한 본 발명의 또 다른 실시예에 따르면, 단말이 CSI(channel state information)를 측정하는 방법이 제공된다. 상기 단말의 CSI 측정 방법은, 기지국으로부터, CSI-RS(reference signal) 안테나 포트를 설정받는 단계; 상기 기지국으로부터 상기 CSI-RS 안테나 포트에 대한 포트 번호 부여 여부 정보를 수신하는 단계; 상기 포트 번호 부여 정보에 기초해, 상기 CSI-RS 안테나 포트 중 일부에 포트 번호를 부여하는 단계; 및 상기 포트 번호가 부여된 CSI-RS 안테나 포트를 이용하여, CSI를 측정하는 단계를 포함한다.

[37] 상기 포트 번호 부여 여부 정보를 수신하는 단계는, 상기 CSI-RS 안테나 포트의 수만큼의 길이를 가지며 상기 CSI-RS 안테나 포트 별 포트 번호 부여 여부를 나타내는 비트맵을, 상기 기지국으로부터 수신하는 단계를 포함할 수 있다.

[38] 상기 CSI-RS 안테나 포트 중 일부에 포트 번호를 부여하는 단계는, 상기 비트맵에 속하는 비트 중에서 제1 값을 가지는 비트에 대응하는 CSI-RS 안테나 포트에 포트 번호를 부여하는 단계를 포함할 수 있다.

[39] 상기 포트 번호 부여 여부 정보를 수신하는 단계는, 상기 CSI-RS 안테나 포트의 수의 절반의 길이를 가지며 상기 CSI-RS 안테나 포트 쌍 별 포트 번호 부여 여부를 나타내는 비트맵을, 상기 기지국으로부터 수신하는 단계를 포함할 수 있다.

[40] 상기 CSI-RS 안테나 포트 중 일부에 포트 번호를 부여하는 단계는, 상기 비트맵에 속하는 비트 중에서 제1 값을 가지는 비트에 대응하는 CSI-RS 안테나 포트 쌍에 포트 번호를 부여하는 단계를 포함할 수 있다.

[41] 상기 CSI-RS 안테나 포트 쌍은, 동일한 RE(resource element)를 통해 전송되는 2개의 CSI-RS 안테나 포트를 포함할 수 있다.

[42] 상기 CSI-RS 안테나 포트는 CSI-RS 안테나 포트 배열에 포함되며 제1 축, 제2 축, 및 제3 축 중 적어도 2개에 따라 배치될 수 있다.

[43] 상기 포트 번호 부여 여부 정보를 수신하는 단계는, 상기 제1 축으로 배치되는 CSI-RS 안테나 포트의 수와 상기 제2 축으로 배치되는 CSI-RS 안테나 포트의 수를 합한 값 만큼의 길이를 가지며 상기 CSI-RS 안테나 포트 배열의 각 행과 각 열에 대한 포트 번호 부여 여부를 나타내는 비트맵을, 상기 기지국으로부터 수신하는 단계를 포함할 수 있다.

[44] 상기 단말의 CSI 측정 방법은, 상기 단말에게 설정된 전체 CSI-RS 안테나 포트를 위한 RE(resource element) 중에서 상기 포트 번호가 부여된 CSI-RS 안테나 포트를 위한 RE를 제외한 나머지에서 PDSCH(physical downlink shared channel)가 수신되는 것이 가능함을 가정하는 단계를 더 포함할 수 있다.

발명의 효과

[45] 본 발명의 실시예에 따르면, MIMO 안테나 통신 시스템에서 기지국은 채널 추정을 위해 단말에게 다수의 채널 추정용 RS 안테나 포트를 설정할 수 있고,

이를 단말에게 전송할 수 있다.

[46] 또한 본 발명의 실시예에 따르면, 단말에 설정 가능한 CSI-RS 안테나 포트 수를 늘릴 수 있다.

[47] 또한 본 발명의 실시예에 따르면, 단말은 CSI-RS 안테나 포트 배열을 1차원 또는 다차원(예, 2차원, 3차원)으로 인식할 수 있다. 즉, 단말은 자신에게 설정된 1차원 또는 다차원(예, 2차원, 3차원) CSI-RS 안테나 포트의 포트 번호를 인식할 수 있다.

[48] 또한 본 발명의 실시예에 따르면, 기지국은 CSI-RS를 효율적으로 설정할 수 있고 이를 통해 CSI-RS를 효율적으로 전송할 수 있다.

[49] 또한 본 발명의 실시예에 따르면, 단말의 CSI 보고를 위해 설정된 NZP(non-zero-power) CSI-RS 자원 영역의 일부를 해당 단말의 PDSCH(physical downlink shared channel) 수신을 위해 이용함으로써, CSI-RS 전송 오버헤드 문제를 해결할 수 있고, PDSCH 전송 자원의 감소로 인한 데이터 전송률 하락을 방지할 수 있다.

[50] 또한 본 발명의 실시예에 따르면, 기지국이 단말에게 PDSCH 레잇 매칭(rate matching) 정보 및 의사 동일 위치성(QCL: quasi-co-location) 정보를 설정할 수 있고, 이를 이용하여 기지국과 단말은 PDSCH 전송을 수행할 수 있다.

[51] 또한 본 발명의 실시예에 따르면, 주파수 축으로 인접한 복수의 PRB 페어를 이용하여 채널 추정용 RS(예, CSI-RS)를 설정함으로써, 채널 추정용 RS를 위한 자원 풀을 확장할 수 있다. 이를 통해, FD(full dimension)-MIMO 시스템에서 채널 추정용 RS를 효율적으로 전송할 수 있다.

도면의 간단한 설명

[52] 도 1은 CSI-RS 안테나 포트의 수가 2인 경우에 CSI-RS 자원 요소(RE: resource element)집합의 맵핑을 나타내는 도면이다.

[53] 도 2는 CSI-RS 안테나 포트의 수가 4인 경우에 CSI-RS RE 집합의 맵핑을 나타내는 도면이다.

[54] 도 3은 CSI-RS 안테나 포트의 수가 8인 경우에 CSI-RS RE 집합의 맵핑을 나타내는 도면이다.

[55] 도 4는 단말이 복수의 TP로부터 하향링크 협력 전송을 수신하는 경우를 나타내는 도면이다.

[56] 도 5는 3개의 TP가 하나의 서브프레임 내의 서로 다른 RE들을 이용하여 CSI-RS 자원을 설정하는 방법을 나타내는 도면이다.

[57] 도 6은 단말을 위한 PDSCH RE를 맵핑하는 방법을 나타내는 도면이다.

[58] 도 7은 본 발명의 실시예에 따른, 기지국이 방법 Ma110을 이용하는 경우에 단말을 위한 PDSCH RE를 맵핑하는 방법을 나타내는 도면이다.

[59] 도 8은 본 발명의 실시예에 따른, 3개의 TP가 2개의 서브프레임 내의 서로 다른 RE들을 이용하여 CSI-RS 자원을 설정하는 방법을 나타내는 도면이다.

[60] 도 9는 본 발명의 실시예에 따른, 방법 Mb100을 이용해 CSI-RS 자원을 설정하는 방법을 나타내는 도면이다.

[61] 도 10a 및 도 10b는 본 발명의 다른 실시예에 따른, 방법 Mb100을 이용해 CSI-RS 자원을 설정하는 방법을 나타내는 도면이다.

[62] 도 11은 본 발명의 또 다른 실시예에 따른, 방법 Mb100을 이용해 CSI-RS 자원을 설정하는 방법을 나타내는 도면이다.

[63] 도 12은 본 발명의 실시예에 따른, 방법 Mb200을 이용해 16개의 CSI-RS 안테나 포트에 대한 자원을 설정하는 방법을 나타내는 도면이다.

[64] 도 13a 및 도 13b는 본 발명의 실시예에 따른, 방법 Mb200을 이용해 12개의 CSI-RS 안테나 포트에 대한 자원을 설정하는 방법을 나타내는 도면이다.

[65] 도 14는 본 발명의 실시예에 따른, 방법 Mb200을 이용해 32개의 CSI-RS 안테나 포트에 대한 자원을 설정하는 방법을 나타내는 도면이다.

[66] 도 15은 본 발명의 다른 실시예에 따른, 방법 Mb200을 이용해 CSI-RS 자원을 설정하는 방법을 나타내는 도면이다.

[67] 도 16a 및 도 16b는 본 발명의 실시예에 따른, 방법 Mb201를 이용해 6개의 CSI-RS 안테나 포트에 대한 자원을 설정하는 방법을 나타내는 도면이다.

[68] 도 17는 본 발명의 실시예에 따른, 방법 Mb110을 이용해 컴포넌트 CSI-RS configuration를 집성하는 방법을 나타내는 도면이다.

[69] 도 18은 본 발명의 다른 실시예에 따른, 방법 Mb110을 이용해 복수의 컴포넌트 CSI-RS configuration를 집성하는 방법을 나타내는 도면이다.

[70] 도 19는 본 발명의 실시예에 따른, 방법 Mb130을 이용해 복수의 컴포넌트 CSI-RS configuration를 집성하는 방법을 나타내는 도면이다.

[71] 도 20는 본 발명의 실시예에 따른, 방법 Mb200의 PRB 번들링이 사용되는 경우에 복수의 컴포넌트 CSI-RS configuration를 집성하는 방법을 나타내는 도면이다.

[72] 도 21은 본 발명의 실시예에 따른, 번들링된 PRB 페어들의 인덱스를 시간적으로 교차시켜 CSI-RS를 전송하는 방법을 나타내는 도면이다.

[73] 도 22은 2차원 CSI-RS 안테나 포트 배열의 예를 나타내는 도면이다.

[74] 도 23a 및 도 23b는 본 발명의 실시예에 따른, 2차원 CSI-RS 안테나 포트 배열에 단말 특정적 CSI-RS 안테나 포트 번호가 맵핑되는 방법을 나타내는 도면이다.

[75] 도 24은 복수의 단말에게 서로 다른 CSI-RS 안테나 포트 집합을 설정하는 방법을 나타내는 도면이다.

[76] 도 25a는 복수의 단말에 대한 CSI-RS 자원 설정의 예를 나타내는 도면이다.

[77] 도 25b는 본 발명의 실시예에 따른, 단말에 설정된 CSI-RS 안테나 포트들의 포트 번호가 방법 Mc200에 의해 재배열됨으로써, 포트 번호와 RE들 간의 맵핑 관계가 기존과 달라지는 경우를 나타내는 도면이다.

[78] 도 26a 및 도 26b는 본 발명의 실시예에 따른, 방법 Mc220이 사용되는 경우에, 기지국이 단말에게 새로운 포트 번호 순열(sequence)을 알리기 위한 규칙(또는

정보)을 암시적인 시그널링을 통해 알려주는 경우를 나타내는 도면이다.

[79] 도 26c, 도 26d, 도 26e, 및 도 26f는 본 발명의 실시예에 따른, 방법 Mc221에 의해 기지국이 단말에게 도 26a에 예시된 포트 번호 맵핑 중 하나를 알려주는 경우에, 단말이 CSI-RS RE 집합을 구성하는 RE들에 CSI-RS 안테나 포트 번호들을 맵핑하는 경우를 나타내는 도면이다

[80] 도 27은 본 발명의 실시예에 따른, 방법 Mc220이 사용되는 경우에, 복수의 단말에 대한 CSI-RS 안테나 포트 번호 맵핑을 나타내는 도면이다.

[81] 도 28은 본 발명의 실시예에 따른, 방법 Mc220이 사용되는 경우에, 복수의 단말에 대한 CSI-RS 자원 설정을 나타내는 도면이다.

[82] 도 29a, 도 29b, 도 29c, 도 29d, 및 도 29e는 본 발명의 다른 실시예에 따른, 방법 Mc221을 위해 사용될 수 있는 복수의 안테나 포트 번호 맵핑 규칙을 나타내는 도면이다.

[83] 도 30는 본 발명의 실시예에 따른, 방법 Mc310이 사용되는 경우에, CSI-RS 자원 설정을 나타내는 도면이다.

[84] 도 31은 본 발명의 실시예에 따른, 방법 Mc310이 사용되는 경우에, CSI-RS 안테나 포트 번호 맵핑을 나타내는 도면이다.

[85] 도 32a, 도 32b, 및 도 32c는 방법 Mc300을 위한 다른 실시예를 나타내는 도면이다.

[86] 도 33a, 도 33b, 및 도 33c는 방법 Mc300을 위한 또 다른 실시예를 나타내는 도면이다.

[87] 도 34은 방법 Mc300을 위한 또 다른 실시예를 나타내는 도면이다.

[88] 도 35은 CSI-RS 안테나 포트의 2차원 십자 배열로써, 두 1차원 배열의 교차점에 CSI-RS 안테나 포트가 중복 할당되는 2차원 십자 배열을 나타내는 도면이다.

[89] 도 36는 CSI-RS 안테나 포트의 2차원 십자 배열로써, 두 1차원 배열의 교차점에 CSI-RS 안테나 포트가 중복 할당되지 않는 2차원 십자 배열을 나타내는 도면이다.

[90] 도 37은 본 발명의 실시예에 따른, 기지국을 나타내는 도면이다.

[91] 도 38은 본 발명의 실시예에 따른, 단말을 나타내는 도면이다.

발명의 실시를 위한 형태

[92] 아래에서는 첨부한 도면을 참고로 하여 본 발명의 실시예에 대하여 본 발명이 속하는 기술 분야에서 통상의 지식을 가진 자가 용이하게 실시할 수 있도록 상세히 설명한다. 그러나 본 발명은 여러 가지 상이한 형태로 구현될 수 있으며 여기에서 설명하는 실시예에 한정되지 않는다. 그리고 도면에서 본 발명을 명확하게 설명하기 위해서 설명과 관계없는 부분은 생략하였으며, 명세서 전체를 통하여 유사한 부분에 대해서는 유사한 도면 부호를 붙였다.

[93] 명세서 전체에서, 단말(terminal)은, 이동 단말(mobile terminal), 이동국(mobile station), 진보된 이동국(advanced mobile station), 고신뢰성 이동국(high reliability

mobile station), 가입자국(subscriber station), 휴대 가입자국(portable subscriber station), 접근 단말(access terminal), 사용자 장비(user equipment) 등을 지칭할 수도 있고, 단말, 이동 단말, 이동국, 진보된 이동국, 고신뢰성 이동국, 가입자국, 휴대 가입자국, 접근 단말, 사용자 장비 등의 전부 또는 일부의 기능을 포함할 수도 있다.

[94] 또한, 기지국(base station, BS)은, 진보된 기지국(advanced base station), 고신뢰성 기지국(high reliability base station), 노드B(node B), 고도화 노드B(evolved node B, eNodeB), 접근점(access point), 무선 접근국(radio access station), 송수신 기지국(base transceiver station), MMR(mobile multihop relay)-BS, 기지국 역할을 수행하는 중계기(relay station), 기지국 역할을 수행하는 고신뢰성 중계기(high reliability relay station), 리피터, 매크로 기지국, 소형 기지국 등을 지칭할 수도 있고, 기지국, 진보된 기지국, HR-BS, 노드B, eNodeB, 접근점, 무선 접근국, 송수신 기지국, MMR-BS, 중계기, 고신뢰성 중계기, 리피터, 매크로 기지국, 소형 기지국 등의 전부 또는 일부의 기능을 포함할 수도 있다.

[95] 한편, 본 명세서에서, 'A 또는 B'는, 'A', 'B', 또는 'A와 B 모두'를 포함할 수 있다.

[96]

[97] 1. 다중 셀 협력 통신 시스템에서 제어 정보를 전송하는 방법

[98] 셀 기반의 무선통신 시스템에서 셀 경계에 위치한 단말은, 일반적으로 인접 셀로부터 받는 간섭 신호로 인해 높은 전송률을 제공받는 데 한계를 가진다. 다중 셀 협력(CoMP: cooperative multi-point) 전송 기술은, 복수의 인접한 셀들 또는 전송 점(TP: transmission point)들이 서로 협력하여 셀 간 간섭을 완화하거나 회피함으로써, 셀 경계 단말의 데이터 전송률을 높이는 기술이다.

[99] 단말은 다중 셀 협력 전송을 위해, 자신이 속한 서빙 셀 뿐만 아니라 이웃 셀(들) 혹은 TP(들)에 대한 하향링크 채널 상태 정보(CSI: channel state information)를 측정하고, 이를 보고해야 할 수도 있다. 이를 위해, 기지국은 전송 모드(TM: transmission mode) 10으로 설정된 단말에게 복수의 CSI 프로세스 (process)를 설정할 수 있다. 하나의 CSI 프로세스는 채널 측정을 위한 CSI-RS(reference signal)와 간섭 측정을 위한 CSI-IM(interference measurement)의 자원 설정 정보를 포함하며, 각 CSI 프로세스로부터 유도된 CSI 정보는 독립적인 주기(periodicity)와 서브프레임 오프셋(subframe offset)에 따라 단말에 의해 기지국으로 보고된다.

[100] 한편, 기지국이 단말에게 설정된 모든 NZP CSI-RS 자원을 제외한 영역에서 PDSCH(physical downlink shared channel)를 전송하면, PDSCH 전송 자원의 감소로 인해 데이터 전송률이 떨어질 수도 있다. 이러한 CSI-RS 전송 오버헤드 문제는 FD(full dimension)-MIMO(multiple-input multiple-output) 시스템에서 더욱 두드러지나, 비단 이 경우에만 국한되지 않고, TP들이 기존 규격이 지원하는 범위 내에서 CSI-RS를 전송하는 경우에도 마찬가지로 해결해야 할 과제이다.

[101]

[102] 도 1은 CSI-RS 안테나 포트의 수가 2인 경우에 CSI-RS RE(resource element)집합(set)의 맵핑을 나타내는 도면이고, 도 2는 CSI-RS 안테나 포트의 수가 4인 경우에 CSI-RS RE 집합의 맵핑을 나타내는 도면이고, 도 3은 CSI-RS 안테나 포트의 수가 8인 경우에 CSI-RS RE 집합의 맵핑을 나타내는 도면이다.

[103] CSI-RS가 전송되는 자원 요소(RE: resource element)의 맵핑은 각 안테나 포트 수마다 미리 정해진 패턴을 따르고, 미리 정해진 CSI-RS 자원 풀(resource pool) 내에서 설정될 수 있다. CSI-RS 자원 설정(CSI-RS resource configuration, 이하 'CSI-RS configuration')은 노멀(normal) CP(cyclic prefix) 및 확장(extended) CP 각각에 대하여 정의되어 있다. 또한 CSI-RS configuration은 FDD(frequency division duplex)와 TDD(time division duplex) 모두에 설정 가능한 것과 TDD에만 설정될 수 있는 것으로 구분된다.

[104] 도 1 내지 도 3 각각은 노멀 CP가 설정되고 CSI-RS 안테나 포트 수가 2, 4, 또는 8인 경우에, CSI-RS configuration 0~19번에 대한 RE 맵핑을 나타낸다.

[105] 도 1 내지 도 3에 예시된 바와 같이, 하나의 하향링크 서브프레임은 2개의 타임 슬롯을 포함한다. 구체적으로 노멀 CP가 설정되는 경우에, 하나의 서브프레임은, 짝수의 타임 슬롯(이하 '슬롯0')과 슬롯0 이후의 홀수의 타임 슬롯(이하 ' 슬롯1')을 포함한다. 슬롯0과 슬롯1 각각은 시간 축으로 7개의 OFDM(Orthogonal Frequency Division Multiplexing) 심볼(0번~6번)과 주파수 축으로 12개의 부반송파(0번~11번)를 포함한다. 즉, 하나의 서브프레임 또는 PRB(physical resource block) 페어(pair) 내의 슬롯0과 슬롯1 각각에는 84개(=7x12)의 RE가 존재한다. 하나의 서브프레임 또는 PRB 페어 내의 RE 중 일부는 CRS 전송을 위한 RE로 설정될 수 있고, 일부는 DMRS(demodulation reference signal) 전송을 위한 RE로 설정될 수 있고, 일부는 CSI-RS 전송을 위한 RE로 설정될 수 있다. 예를 들어, 도 1에서 슬롯0의 OFDM 심볼 5번과 6번에 대응하며 부반송파 9번에 대응하는 2개의 RE에는, CSI-RS configuration 0번의 CSI-RS 안테나 포트 15번과 16번이 맵핑(설정)된다. 즉, CSI-RS configuration 0번~19번 각각을 위한 2개의 CSI-RS 안테나 포트(15번, 16번)는 2개의 RE에 맵핑된다. 이하에서는 설명의 편의를 위해서, 슬롯 내의 OFDM 심볼 n번에 대응하며 PRB 페어 내의 부반송파 k번에 대응하는 RE를, RE(n, k)라 한다.

[106] 다른 예를 들어, 도 2에서 슬롯1의 RE(2, 11)와 RE(3, 11)에는 CSI-RS configuration 1번의 CSI-RS 안테나 포트 15번과 16번이 맵핑되고, 슬롯1의 RE(2, 5)와 RE(3, 5)에는 CSI-RS configuration 1번의 CSI-RS 안테나 포트 17번과 18번이 맵핑된다. 즉, CSI-RS configuration 0번~9번 각각을 위한 4개의 CSI-RS 안테나 포트(15번~18번)는 4개의 RE에 맵핑된다.

[107] 또 다른 예를 들어, 도 3에서 슬롯0의 RE(5, 9)와 RE(6, 9)에는 CSI-RS configuration 0번의 CSI-RS 안테나 포트 15번과 16번이 맵핑되고, 슬롯0의 RE(5, 3)와 RE (6, 3)에는 CSI-RS configuration 0번의 CSI-RS 안테나 포트 17번과 18번이 맵핑되고, 슬롯0의 RE(5, 8)와 RE(6, 8)에는 CSI-RS configuration 0번을 위한

CSI-RS 안테나 포트 19번과 20번이 맵핑되고, 슬롯0의 RE(5, 2)와 RE(6, 2)에는 CSI-RS configuration 0번을 위한 CSI-RS 안테나 포트 21번과 22번이 맵핑된다. 즉, CSI-RS configuration 0번~4번 각각을 위한 8개의 CSI-RS 안테나 포트(15번~22번)는 8개의 RE에 맵핑된다.

[108] 한편, 동일한 RE를 통해 전송되는 CSI-RS 안테나 포트들(예, CSI-RS 안테나 포트 15번, 16번) 간에는 안테나 포트 간 다중화 방식으로써 코드 분할 다중화(CDM: Code Division Multiplexing)가 적용된다. 예를 들어, 도 1에서 슬롯0의 RE(5, 9)를 통해 CSI-RS 안테나 포트 15번과 16번이 전송되고, 슬롯0의 RE(6, 9)를 통해 CSI-RS 안테나 포트 15번과 16번이 전송된다. 이러한 경우에, 동일한 RE를 통해 전송되는 CSI-RS 안테나 포트 15번과 16번을 구별하기 위해서, CSI-RS 안테나 포트 15번과 16번 간에는 CDM이 적용된다.

[109] 한편, 서로 다른 RE를 통해 전송되는 CSI-RS 안테나 포트들(예, CSI-RS 안테나 포트 15번, 17번) 간에는 안테나 포트 간 다중화 방식으로써 주파수 분할 다중화(FDM: Frequency Division Multiplexing)가 적용된다. 예를 들어, 도 2에서 슬롯0의 RE(5, 9)와 RE(6, 9)를 통해 CSI-RS 안테나 포트 15번가 전송되고, 슬롯0의 RE(5, 3)와 RE(6, 3)를 통해 CSI-RS 안테나 포트 17번가 전송된다. 이러한 경우에, 서로 다른 RE를 통해 전송되는 CSI-RS 안테나 포트 15번과 17번을 구별하기 위해서, CSI-RS 안테나 포트 15번과 17번 간에는 FDM이 적용된다.

[110] 한편, 본 명세서의 도면들에 표기된 CSI-RS set A는 CSI-RS configuration A번을 의미하고, X, Y는 CSI-RS 안테나 포트의 번호를 나타낸다. 본 명세서의 도면들에 표기된 X_A, Y_A는 CSI-RS configuration A번에서의 CSI-RS 안테나 포트 X번과 Y번을 나타내거나, 또는 단말 A(단, UE-A는 UE-a, UE-b, UE-c, ...)를 위한 CSI-RS 안테나 포트 X번과 Y번을 나타낼 수 있다. 본 명세서에서, CSI-RS 안테나 포트 또는 CSI-RS 안테나 포트 X번이 전송된다는 것은, CSI-RS 안테나 포트의 CSI-RS 또는 CSI-RS 안테나 포트 X번의 CSI-RS가 전송된다는 것을 포함할 수 있다.

[111] 한편, 단말은 PDSCH 레잇 매칭(rate matching)을 수행할 때, ZP CSI-RS로 설정된 RE에 PDSCH가 맵핑되지 않음을 가정한다. ZP CSI-RS는 크게 두 가지 용도로 이용될 수 있다. 첫째로, 기지국은 인접 셀의 CSI-RS가 전송되는 RE에서 신호를 전송하지 않음으로써(즉, 해당 RE에 뮤팅(muting)을 적용함으로써), 인접 셀에 대한 단말의 CSI-RS 측정 성능을 향상시키고자 할 수 있다. 이 때, 기지국은 뮤팅이 적용되는 RE들을 단말에게 ZP CSI-RS 설정을 통해 알려줄 수 있다. 둘째로, 단말의 간섭 신호 측정을 위한 자원을 설정하기 위한 용도로, ZP CSI-RS가 설정될 수 있다. 현재 규격에 따르면, Release 12 TDD eIMTA(enhanced interference mitigation & traffic adaptation)가 설정된 단말을 제외하고는, 간섭 신호의 측정에 이용되는 CSI-IM 자원은 항상 단말에게 설정된 ZP CSI-RS 자원 영역 내에서만 설정될 수 있다.

[112] 한편, LTE 규격은 전송 모드(TM: transmission mode) 10의 CoMP 기반 PDSCH

전송을 위해, DCI(downlink control information) 포맷 2D 내에 PQI(PDSCH RE mapping and quasi-co-location indicator) 필드를 정의하였다. PQI 필드에 기초해, 단말은 DCI 포맷 2D를 통해 스케줄링되는 PDSCH의 RE 맵핑 정보와 PDSCH 안테나 포트의 의사 동일 위치성(QCL: quasi-co-location) 정보를 획득할 수 있다. PQI 필드는 2 비트로 구성되고, 아래의 표 1과 같이 비트열의 값에 따라 최대 4개의 파라미터 집합 (parameter set)을 지시(indicate)할 수 있다.

[113] [표1]

PQI field in DCI format 2D

Value of 'PDSCH RE Mapping and Quasi-Co-Location Indicator' field	Description
'00'	Parameter set 1 configured by higher layers
'01'	Parameter set 2 configured by higher layers
'10'	Parameter set 3 configured by higher layers
'11'	Parameter set 4 configured by higher layers

[114] 이하에서는, 상기 파라미터 집합을 PQI 파라미터 집합이라 부르기로 한다. 4개의 PQI 파라미터 집합 각각은 파라미터 crs-PortsCount-r11, 파라미터 crs-FreqShift-r11, 파라미터 mbsfn-SubframeConfigList-r11, 파라미터 csi-RS-ConfigZPId-r11, 파라미터 pdsch-Start-r11, 및 파라미터 qcl-CSI-RS-ConfigNZPId-r11을 포함할 수 있다. PQI 파라미터 집합은 RRC 시그널링을 통해 단말에게 설정될 수 있다.

[115] 한편, 기지국이 단말에게 DPS(dynamic point selection) 전송을 지원하고자 하는 경우에, 각 PQI 파라미터 집합은 서로 다른 셀 또는 TP(이하에서는 '셀 또는 TP'를 TP로 통칭함)에 대응될 수 있다. 이러한 DPS 전송에 대해서는, 도 4를 참고하여 자세히 설명한다.

[116]

[117] 도 4는 단말이 복수의 TP로부터 하향링크 협력 전송을 수신하는 경우를 나타내는 도면이다. 도 4에서는 설명의 편의를 위해, 기지국에 의해 제어되는 3개의 인접한 TP들(TP1, TP2, TP3)이 단말에 대한 신호 전송을 위해 협력하는 경우를 예시하였다.

[118] 기지국은 단말에 3개의 CSI 프로세스를 이용하여 각 TP(TP1~TP3)에 대한 CSI-RS 및 CSI-IM을 설정할 수 있고, 단말은 이에 따라 각 TP(TP1~TP3)에 대하여 독립적으로 CSI 측정 및 보고를 수행할 수 있다.

[119] 기지국은 단말이 보고한 CSI를 기반으로 TP(TP1~TP3) 중에서 단말에게 PDSCH를 전송할 TP를 선택하고, 선택된 TP를 통해 해당 단말을 위한 PDSCH를 전송한다. 이 때 기지국은 PDSCH 스케줄링 정보를 포함하는 DCI 포맷 2D의 PQI 필드를 통해, PDSCH를 전송하는 TP에 대응하는 PQI 파라미터 집합을

지시함으로써, 단말에게 해당 PDSCH가 어떤 TP로부터 전송되었는지를 암시적으로(implicitly) 알려줄 수 있다.

[120] 한편, 기지국은 TP들(TP1~TP3)이 전송하는 CSI-RS가 동일한 자원 상에 오버랩되어 전송되도록 설정할 수도 있고, 서로 간의 간섭을 회피하기 위해 서로 다른 자원에서 전송되도록 설정할 수도 있다. 후자의 경우에, 각 TP(TP1~TP3)는 CoMP 협력 집합 내 다른 TP들에 의해 CSI-RS가 전송되는 RE들을 ZP CSI-RS로써 설정하고 뮤팅을 수행함으로써, 단말의 CSI-RS 채널 추정 성능을 향상시킬 수 있다. 상기 DPS 전송에서 상기 후자의 경우를 위한 CSI-RS 자원 설정이 도 5에 예시되어 있다.

[121]

[122] 도 5는 3개의 TP(TP1~TP3)가 하나의 서브프레임 내의 서로 다른 RE들을 이용하여 CSI-RS 자원을 설정하는 방법을 나타내는 도면이다.

[123] 도 5에 예시된 바와 같이, 3개의 TP(TP1~TP3)의 NZP CSI-RS RE 집합들은 하나의 서브프레임 내에서 서로 다른 자원 영역에 설정된다. 도 5에서는 각 TP(TP1~TP3)의 CSI-RS 안테나 포트 수가 4인 경우를 예시하였다. 예를 들어, 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 3), 및 RE(6, 3)에는, TP(TP1)을 위한 CSI-RS 안테나 포트 15~18번이 맵핑된다. 다른 예를 들어, 슬롯1의 RE(2, 9), RE(3, 9), RE(2, 3), 및 RE(3, 3)에는, TP(TP2)을 위한 CSI-RS 안테나 포트 15~18번이 맵핑된다. 또 다른 예를 들어, 슬롯1의 RE(2, 8), RE(3, 8), RE(2, 2), 및 RE(3, 2)에는, TP(TP3)을 위한 CSI-RS 안테나 포트 15~18번이 맵핑된다.

[124]

[125] 도 6은 단말을 위한 PDSCH RE를 맵핑하는 방법을 나타내는 도면이다.

[126] 현재 규격에 의하면 전송 모드 10 기반의 하향링크 PDSCH를 수신하는 단말은 각 CSI 프로세스마다 설정된 NZP CSI-RS 자원 영역 모두에서 PDSCH 데이터가 전송되지 않음을 가정한다. 예를 들어, 단말이 도 5에 예시된 바와 같이, CRS, DMRS, 및 CSI-RS를 설정받은 경우에, 단말이 가정하는 PDSCH의 RE 맵핑은 도 6에 예시된 바와 같을 수 있다. 도 6에서는 PDCCH(physical downlink control channel) 영역의 OFDM 심볼 수가 3인 경우를 예시하였다. 구체적으로, 슬롯0의 OFDM 심볼 0~2번에 해당하는 RE들 중 일부는 CRS RE로써 설정되고, 나머지는 PDCCH RE로써 설정된다. 슬롯0의 OFDM 심볼 3~6번과 슬롯1의 0~6번에 해당하는 RE들 중 일부는 CRS RE로써, 일부는 DMRS RE로써, 일부는 CSI-RS RE로써, 나머지는 PDSCH RE로써 설정된다. 도 6에 예시된 바와 같이, 3개의 TP(TP1~TP3)의 CSI-RS RE 집합에는 PDSCH가 맵핑되지 않는다.

[127] 한편, FD-MIMO가 적용되는 시스템의 경우에, 대규모 안테나 배열 이득을 충분히 얻기 위해, CoMP 협력 집합에 속한 각 TP가 다수의 CSI-RS 안테나 포트를 전송하는 경우가 고려될 수 있다. 예를 들어, 도 4의 예시에서, 3개의 TP(TP1~TP3) 각각이 16, 32, 또는 64개의 CSI-RS 안테나 포트를 전송할 수 있다. 이 때, 각 TP(TP1~TP3)의 CSI-RS 전송 주기가 5 ms라고 하면, CSI-RS 전송

오버헤드가 하향링크 전체 자원 영역에서 차지하는 비중은 CSI-RS 포트 수가 16, 32, 64인 경우에, 각각 5.71%, 11.43%, 22.86%로 매우 큰 비중을 차지한다. 따라서 기존과 같이 단말에게 설정된 모든 NZP CSI-RS 자원을 제외한 영역에서 PDSCH를 전송하면, PDSCH 전송 자원의 감소로 인해 오히려 데이터 전송률이 떨어질 수 있다. 즉, 다중 셀 협력 전송 기법과 FD-MIMO의 결합이 제한적일 수 있다. 이러한 CSI-RS 전송 오버헤드 문제는 FD-MIMO 시스템에서 더욱 두드러지나, 비단 이 경우에만 국한되지 않고, TP들이 기존 규격이 지원하는 범위 내에서 CSI-RS를 전송하는 경우에도 마찬가지로 해결해야 할 과제이다.

[128] 이하에서는, 상기 문제점(예, CSI-RS 전송 오버헤드 문제 등)을 해결하기 위한 방법에 대해서 설명한다. 구체적으로, 단말의 CSI 보고를 위해 설정된 NZP CSI-RS 자원 영역의 일부가 해당 단말의 PDSCH 수신을 위해 이용될 수 있도록, 하향링크 제어 정보를 설계하는 방법 및 하향링크 제어 정보를 시그널링하는 방법에 대해서 설명한다. 더욱 구체적으로는, 아래의 방법 Ma100의 개념을 사용하기 위한 다양하고 구체적인 방법들에 대해서 설명한다.

[129] 방법 Ma100은 NZP CSI-RS configuration(또는 NZP CSI-RS ID)에 의해 단말에게 설정된 CSI-RS RE 집합에 단말이 수신하고자 하는 PDSCH가 맵핑되었는지 여부(이하 'PDSCH 맵핑 여부')를, 단말에게 알려주는 방법이다. NZP CSI-RS ID는 NZP CSI-RS configuration을 나타내는 식별자이다.

[130] Release 12 규격에 따르면, CSI 프로세스는 하나의 CSI-RS configuration을 포함하고, CSI-RS configuration은 고유의 NZP CSI-RS ID를 가진다. 한편, FD-MIMO를 위해 Release-13에 도입된 CSI 프로세스는, CSI 보고 유형에 따라 클래스-A와 클래스-B로 구분된다. 클래스-B의 CSI 보고를 위한 CSI 프로세스(이하 '클래스-B CSI 프로세스')는 복수의 NZP CSI-RS configuration을 포함할 수 있고, 클래스-B CSI 프로세스에 포함되는 각 NZP CSI-RS configuration은 고유의 NZP CSI-RS ID를 가진다.

[131] 방법 Ma100은 단말이 전송 모드(TM) 10으로 설정되어 있고 DCI 포맷 2D에 의해 스케줄링된 PDSCH를 수신하는 경우에 주로 적용될 수 있다. 방법 Ma100에서 PDSCH 맵핑 여부를 기지국이 단말에게 알려주는 데 이용될 수 있는 시그널링으로는, 물리계층 시그널링(예, 물리계층 제어 채널의 제어 필드 파라미터), MAC(media access control) 시그널링(예, MAC PDU(protocol data unit) 형태의 제어 정보, 또는 MAC 헤더 형태의 제어 정보), RRC 시그널링(예, RRC 제어 메시지 또는 IE(information element) 형태의 제어 파라미터) 등이 고려될 수 있다. 특히, 물리계층 시그널링 또는 MAC 시그널링 방식을 통한 제어 시그널링은, 해당 단말을 위한 스케줄링 정보와 함께 구성되거나 또는 동시에 전송되는 방법을 통하여 동적(dynamic) 자원 활용이 가능하다는 장점을 가질 수 있다. 또 다른 방법으로써, RRC 시그널링을 이용하여 단말에게 방법 Ma100의 적용 여부와 설정 정보를 알리고, 물리계층 시그널링 또는 MAC 시그널링을 통하여 CSI-RS RE 집합에 대한 PDSCH 맵핑 여부만을 알리는 방법이 사용될

수도 있다.

[132] 단말은 방법 Ma100에 기초해 어떤 NZP CSI-RS configuration에 의해 설정된 CSI-RS RE 집합에서 PDSCH를 수신하도록 지시받은 경우에, 해당 RE 집합에서 CSI-RS와 PDSCH가 혼합된 신호를 수신하는 것을 기대할 수 있다. 이 때, 단말은 CSI-RS와 PDSCH는 CoMP 협력 집합 내의 서로 다른 TP에서 각각 전송됨을 기대할 수 있다. 이는 규격에 명시적으로 정의될 수도 있으나, 규격에 명시적으로 드러내지 않고 단말이 방법 Ma100에 기초한 PDSCH 수신 지시에 의해 암시적으로 이를 알 수 있도록 하는 방법도 가능하다. 따라서 이 경우에, 단말은 해당 RE 집합에서 CSI-RS 기반 채널 추정과 PDSCH 데이터 검출 및 복호를 모두 수행할 수 있다. 이를 위해, 단말은 3가지 수신 방식들(동시(joint) 채널 추정 및 데이터 복호, SIC(successive interference cancellation)의 적용(단, CSI-RS 우선), SIC의 적용(단, PDSCH 우선)) 중 하나를 사용할 수 있다.

[133] 구체적으로, 단말이 동시 채널 추정 및 데이터 복호 방식을 사용하는 경우에, CSI-RS 기반 채널 추정과 PDSCH 데이터 복호를 동시에 한꺼번에(jointly) 수행할 수 있다. 또는 단말이 CSI-RS를 우선으로 하는 SIC 방식을 사용하는 경우에, 먼저 PDSCH 신호를 간섭으로 간주한 상태에서 CSI-RS 기반의 채널 추정을 수행하고, 다음으로 수신 신호에서 CSI-RS 신호를 제거한 후 PDSCH 복호를 수행할 수 있다. 또는 단말이 PDSCH를 우선으로 하는 SIC 방식을 사용하는 경우에, 먼저 CSI-RS 신호를 간섭으로 간주한 상태에서 PDSCH 데이터 복호를 수행하고, 다음으로 수신 신호에서 PDSCH 신호를 제거한 후 CSI-RS 기반의 채널 추정을 수행할 수 있다.

[134] 상술한 동시 채널 추정 및 데이터 복호 방법은, 채널 추정과 데이터 복호를 반복적(iterative)으로 수행하는 방법을 포함할 수 있다. 이 때, 단말은 첫 단계로 채널 추정을 먼저 수행할 수도 있고, 데이터 복호를 먼저 수행할 수도 있다. 상술한 3가지의 방식들 중 첫 번째 방식(동시 채널 추정 및 데이터 복호 방식) 및 두 번째 방식(CSI-RS를 우선으로 하는 SIC 방식)은, 다중 셀 협력 전송의 경우 외에도, 단말이 인접 셀로부터 강한 CSI-RS 간섭을 수신하는 경우에 PDSCH의 수신 성능 향상을 위해 적용될 수 있다. 그러나 다중 셀 협력 전송이 아닌 경우에는 기지국이 인접 셀(들)의 CSI-RS 설정 정보를 단말에게 별도의 시그널링을 통해 알려주고, 단말은 해당 인접 셀(들)로부터 수신하는 CSI-RS 간섭 신호를 이용하여 인접 셀(들)에 대한 채널 추정을 추가적으로 수행해야 하므로, 시그널링 오버헤드와 단말의 수신 복잡도가 증가할 수 있다. 반면에 다중 셀 협력 전송(특히, DPS)을 위해 다수의 CSI 프로세스를 설정받은 단말에 상기 3가지의 수신 방식들이 적용되는 경우에는, 별도의 CSI-RS configuration이 불필요하고 단말의 기존 동작 대비 복잡도 증가가 크지 않을 수 있다는 장점이 있다.

[135] 단말은 자신이 상술한 간섭 제거 수신 기능을 지원하는지 여부에 대한 캐퍼빌리티(capability) 정보를 기지국에게 전송할 수 있다. 기지국은 단말의

캐퍼빌리티 정보를 이용하여 해당 단말에 본 명세서에서 기술되는 방법들을 적용할지 여부를 판단할 수 있다.

[136] 한편, 방법 Ma100에서 CSI-RS RE 집합에 PDSCH가 맵핑되었는지의 여부를 기지국이 단말에게 지시자 전송을 통해 알려줄 수 있다. 이하에서는, 기지국이 단말에게 PDSCH 맵핑 여부를 알리기 위하여 단말에게 전송하는 지시자를, 맵핑 지시자라 한다. 한편, 기지국은 단말에게 PDSCH 맵핑 여부를 암시적인 시그널링을 통해 알려줄 수도 있다. 여기서 암시적인 시그널링을 통해 알려주는 방법은, 맵핑 지시자의 형태가 아닌 다른 형태의 시그널링, 또는 단말에게 다른 용도로 전송되는 시그널링을 이용하는 방법을 포함할 수 있다. 본 명세서에서, 맵핑 지시자를 설정하거나 전송한다는 것은, 상기 암시적인 시그널링을 통해 알려주는 것을 포함할 수 있다.

[137] 이 때 단말에게 PDSCH를 전송하는 TP는 PDSCH가 전송되는 RE에서 동시에 CSI-RS를 전송할 수 없으므로, 맵핑 지시자의 유효 범위는 CoMP 협력 집합 내의 TP들 중에서 단말에게 PDSCH를 전송하는 TP를 제외한 나머지 TP(들)에 대한 CSI-RS RE 집합(들)이 될 수 있다. 즉, 현재 규격에 따르면, 단말은 QCL type B로 설정된 경우에, DCI 포맷 2D에 의해 지시되는 PQI 파라미터 집합의 'qcl-CSI-RS-ConfigNZPId-r11'이 가리키는 하나의 NZP CSI-RS ID에 대응하는 CSI-RS RE 집합에는 상기 맵핑 지시자가 적용되지 않으며, 단말은 이 CSI-RS RE 집합에서 PDSCH를 수신하는 것을 기대하지 않을 수 있다.

[138] 한편, 하나의 PQI 파라미터 집합 내에서 PDSCH와 동일한 QCL이 가정되는 NZP CSI-RS ID는 향후 복수 개로 확장될 수 있다. 이 경우에, 상기 맵핑 지시자의 유효 범위는, 단말에 설정된 NZP CSI-RS ID(들) 중에서, DCI 포맷 2D에 의해 단말에 지시되는 PQI 파라미터 집합 내 QCL 가정을 위한 NZP CSI-RS ID(들) (이하 'QCL NZP CSI-RS ID(들)')을 제외한 나머지 NZP CSI-RS ID(들)에 대한 CSI-RS RE 집합(들)이 될 수 있다. 현재 규격에 따르면, QCL type B인 경우, QCL NZP CSI-RS ID는 'qcl-CSI-RS-ConfigNZPId-r11'이 가리키는 하나의 NZP CSI-RS ID를 의미한다. QCL NZP CSI-RS ID는 향후 복수의 NZP CSI-RS configuration에 대응될 수 있다. 이 경우에, 상기 맵핑 지시자의 유효 범위는, QCL NZP CSI-RS ID(들)에 대응되는 모든 CSI-RS configuration(들)을 제외한 나머지 CSI-RS configuration(들)에 대한 CSI-RS RE 집합(들)이 될 수 있다.

[139] 또한 QCL NZP CSI-RS ID에 대응하는 CSI-RS 자원 영역과 QCL NZP CSI-RS ID(들)을 제외한 다른 NZP CSI-RS ID에 대응하는 CSI-RS 자원 영역이 일부 또는 완전히 겹치는 경우에도, 단말은 QCL NZP CSI-RS ID에 대응하는 CSI-RS 자원 영역에서 PDSCH를 수신하는 것을 기대하지 않을 수 있다. 이 때, 다른 NZP CSI-RS ID에 대한 맵핑 지시자의 적용 범위는, 해당 CSI-RS 자원 영역에서 QCL NZP CSI-RS ID에 대응하는 CSI-RS 자원 영역을 제외한 나머지 영역이 될 수 있다.

[140] 또는, 단말에게 PDSCH를 전송하는 TP와 PDSCH를 전송하지 않는 TP를

구분하지 않고, CoMP 협력 집합 내의 모든 TP들을 맵핑 지시자의 유효 범위에 포함시키는 방법이 고려될 수도 있다. 즉, 단말은 QCL NZP CSI-RS ID(들)을 포함한 모든 NZP CSI-RS ID(들)에 대한 CSI-RS RE 집합(들)에서 맵핑 지시자에 의해 PDSCH를 수신하는 것을 가정할 수 있다. 이 경우에, 기지국은 어떤 TP에서도 CSI-RS와 PDSCH가 동일 자원 상에 맵핑되지 않도록 PDSCH를 스케줄링할 수 있다. 단말은 스케줄링받은 PDSCH의 자원이 CoMP 협력 집합에 포함되는 모든 TP의 CSI-RS 자원과 일부 또는 전부 오버랩되는 경우에, DCI의 설정 또는 수신 오류로 간주하고 해당 서브프레임에서 PDSCH를 수신하지 않을 수 있다. 또는 상기 경우에도, 단말은 맵핑 지시자에 따른 동작을 동일하게 수행함을 가정할 수도 있다.

[141] 이하에서는 RRC 시그널링에 의해 맵핑 지시자를 단말에 설정하는 방법에 대하여 설명한다.

[142] 방법 Ma110은, 맵핑 지시자가 PQI 파라미터 집합별로 설정될 수 있고, 하나의 맵핑 지시자는 단말에 설정된 NZP CSI-RS ID들에 대해서 공통적으로 적용되는 방법이다.

[143] 예를 들어, 방법 Ma110에서 맵핑 지시자는 1 비트일 수 있다. 기지국은 단말에게 1 비트의 맵핑 지시자를 통해, QCL NZP CSI-RS ID(들)을 제외한 나머지 NZP CSI-RS ID들에 대응하는 CSI-RS RE 집합에 대한 PDSCH RE 맵핑을 가정할 지 여부를 알려줄 수 있다. 또는, 기지국은 단말에게 1 비트의 맵핑 지시자를 통해, PQI 파라미터 집합별로, QCL NZP CSI-RS ID(들)을 포함한 모든 NZP CSI-RS ID들에 대응하는 CSI-RS RE 집합에 대한 PDSCH RE 맵핑을 가정할 지 여부를 알려줄 수 있다.

[144] 방법 Ma110에서 맵핑 지시자는 각 PQI 파라미터 집합 내에 포함되어 정의될 수 있다.

[145]

[146] 도 7은 본 발명의 실시예에 따른, 기지국이 방법 Ma110을 이용하는 경우에 단말을 위한 PDSCH RE를 맵핑하는 방법을 나타내는 도면이다.

[147] 설명의 편의를 위해서, 도 4의 DPS 전송에서 단말이 DCI 포맷 2D를 통해 TP(TP1)로부터 PDSCH를 수신하는 경우(즉, 단말에게 스케줄링된 PDSCH의 QCL 정보가 TP(TP1)가 전송하는 NZP CSI-RS의 ID를 포함하는 경우)를 가정하여 방법 Ma110을 설명한다.

[148] 단말이 TP(TP1)로부터 PDSCH를 수신하는 데 필요한 PDSCH RE 맵핑 정보와 QCL 정보가 PQI 파라미터 집합 1에 설정되었다고 가정하자. 기지국은 표 1에 따라 DCI 포맷 2D의 PQI 필드를 00으로 설정(configure)한다. 이 때, 기지국이 방법 Ma110을 사용하면, 단말이 TP(TP2)와 TP(TP3)가 전송하는 CSI-RS의 RE들에서 TP(TP1)의 PDSCH를 수신할 지 여부를, 맵핑 지시자를 통해 설정할 수 있다. 맵핑 지시자는 상술한 바와 같이 1 비트일 수 있고, RRC 시그널링에 의해 단말에 설정될 수 있다. 예를 들어, PQI 파라미터 집합 1에 대응되는 맵핑

지시자의 값이 0인 경우에, 단말은 TP(TP2)와 TP(TP3)에 의해 전송되는 CSI-RS의 RE들에 PDSCH가 맵핑되지 않았음을 가정하고, 도 6에 예시된 PDSCH RE 맵핑을 가정할 수 있다. 반대로 맵핑 지시자의 값이 1인 경우에, 단말은 TP(TP2)와 TP(TP3)에 의해 전송되는 CSI-RS의 RE들에 PDSCH가 맵핑되었음을 가정하고, 도 7에 예시된 PDSCH RE 맵핑을 가정할 수 있다. 구체적으로, 도 7에는 CSI-RS RE들 중에서 PDSCH를 전송하는 TP(TP1)를 위한 CSI-RS RE(예, 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 3), RE(6, 3))를 제외한 나머지 CSI-RS RE들이 PDSCH RE로써 설정되는 경우를 예시하였다. 즉, TP(TP2)를 위한 CSI-RS RE들(예, 슬롯1의 RE(2, 9), RE(3, 9), RE(2, 3), RE(3, 3))과 TP(TP3)를 위한 CSI-RS RE들(예, 슬롯1의 RE(2, 8), RE(3, 8), RE(2, 2), RE(3, 2))이, TP(TP1)의 PDSCH를 송수신하기 위한 RE로써 설정된다. 결국, PDSCH RE는 도 6에 예시된 PDSCH RE와 상기 8개의 RE들(예, RE(2, 9), RE(3, 9), RE(2, 8), RE(3, 8), RE(2, 3), RE(3, 3), RE(2, 2), RE(3, 2))을 포함한다. 상기 8개의 RE들(예, RE(2, 9), RE(3, 9), RE(2, 8), RE(3, 8), RE(2, 3), RE(3, 3), RE(2, 2), RE(3, 2))에서는, TP(TP2, TP3)의 CSI-RS와 TP(TP1)의 PDSCH가 송수신될 수 있다.

[149] 한편, 맵핑 지시자의 값이 1인 경우에, 단말은 해당 8개의 RE들(예, RE(2, 9), RE(3, 9), RE(2, 8), RE(3, 8), RE(2, 3), RE(3, 3), RE(2, 2), RE(3, 2))에서 CSI-RS 기반의 채널 추정과 PDSCH 수신을 모두 수행해야 하는 부담이 있으나, 기지국 그리고/또는 단말이 PDSCH에 대한 CSI-RS 간섭을 적절히 제어하는 경우에 PDSCH 수신 성능을 높이거나 전송 용량을 증대시킬 수 있다.

[150] 방법 Ma110의 다른 예로써, 맵핑 지시자의 값이 0인 경우에, 단말은 CoMP 협력 집합에 포함되는 모든 TP들(예, TP1, TP2, TP3)에 의해 전송되는 CSI-RS의 RE들(즉, 단말에 설정된 모든 NZP CSI-RS ID에 대한 CSI-RS RE 집합(들))에 PDSCH가 맵핑되지 않았음을 가정할 수 있다. 반대로 맵핑 지시자의 값이 1인 경우에, 단말은 CoMP 협력 집합에 포함되는 모든 TP들(예, TP1, TP2, TP3)에 의해 전송되는 CSI-RS의 RE들에 PDSCH가 맵핑되었음을 가정할 수 있다.

[151] 방법 Ma110에서, DCI 포맷 2D의 PQI 필드가 가리키는 PQI 파라미터 집합의 QCL NZP CSI-RS ID(들)을 포함하는 CSI 프로세스가 클래스-B CSI 프로세스인 경우에, 단말은 맵핑 지시자가 해당 클래스-B CSI 프로세스에 포함되는 모든 NZP CSI-RS ID들에 적용됨을 가정할 수 있다. 또는 상기 경우에, 단말은 맵핑 지시자가 해당 클래스-B CSI 프로세스에 포함되는 NZP CSI-RS ID들 중 일부에 적용됨을 가정할 수도 있다. 또는 상기 경우에, 단말은 맵핑 지시자가 해당 클래스-B CSI 프로세스에 포함되는 NZP CSI-RS ID들 중에 PQI 파라미터 집합 내에 설정된 QCL NZP CSI-RS ID(들)에만 적용됨을 가정할 수도 있다. 상기의 경우에, 단말은 맵핑 지시자가 적용되지 않는 NZP CSI-RS ID에 의해 설정된 CSI-RS RE 집합에는 맵핑 지시자의 값과 무관하게 항상 PDSCH가 전송되지 않음을 가정할 수도 있다.

[152] 방법 Ma111은, 맵핑 지시자가 PQI 파라미터 집합별로 설정될 수 있고, 하나의

PQI 파라미터 집합 내에서 맵핑 지시자는 NZP CSI-RS ID별로 설정될 수 있는 방법이다.

[153] 방법 Ma111은 방법 Ma110보다 더 세부적인 설정이 가능한 방법이다. 예를 들어, 맵핑 지시자는 1 비트일 수 있고, 맵핑 지시자는 단말에게 설정된 NZP CSI-RS ID 중에서 QCL NZP CSI-RS ID(들)을 제외한 나머지 NZP CSI-RS ID 각각을 위해 정의될 수 있다. 이 경우에, 각 PQI 파라미터 집합별 맵핑 지시자의 수는 상기 나머지 NZP CSI-RS ID들의 개수의 최대값일 수 있다. Release 12 규격에 따르면 단말은 최대 3개의 CSI 프로세스를 설정받을 수 있고, 하나의 CSI 프로세스는 하나의 NZP CSI-RS ID를 가질 수 있으므로, 맵핑 지시자의 수는 최대 2일 수 있다.

[154] Release 13 규격에 의하면, 클래스-B CSI 보고를 지원하는 단말은 CSI 프로세스당 NZP CSI-RS ID를 최대 8개까지 설정받을 수 있으므로, 이 경우에 PQI 파라미터 집합별 맵핑 지시자의 수는 최대 16일 수 있다.

[155] 또는 방법 Ma111에서, PQI 파라미터 집합별로, 맵핑 지시자는 단말에게 설정된 모든 NZP CSI-RS ID 각각을 위해 정의될 수 있다. 이 경우에, PQI 파라미터 집합별 맵핑 지시자의 수는 단말에게 설정된 NZP CSI-RS ID의 수와 같을 수 있다.

[156] 방법 Ma111에서 하나 또는 복수의 맵핑 지시자들은 각 PQI 파라미터 집합 내에 포함되어 정의될 수 있다. 예를 들어, 도 4의 DPS 전송에서 단말이 DCI 포맷 2D를 통해 TP(TP1)로부터 PDSCH를 수신하는 경우를 가정하면, 기지국은 단말을 위한 PQI 파라미터 집합 내에서 NZP CSI-RS ID 별로 맵핑 지시자를 설정함으로써, 해당 단말에게 PDSCH를 전송하지 않는 TP들(TP2, TP3)을 위한 CSI-RS RE 중에서 일부 TP(예, TP2)를 위한 CSI-RS RE를 PDSCH RE로써 설정하고 나머지 TP(예, TP3)를 위한 CSI-RS RE를 PDSCH RE로써 설정하지 않을 수 있다.

[157] 방법 Ma112는, 맵핑 지시자가 PQI 파라미터 집합별로 설정될 수 있고, 하나의 PQI 파라미터 집합 내에서 맵핑 지시자는 CSI 프로세스별로 설정될 수 있는 방법이다.

[158] 방법 Ma112에서, 예를 들어, 맵핑 지시자는 1 비트일 수 있고, 맵핑 지시자는 단말에게 설정된 CSI 프로세스 중에서 PQI 필드에 의해 지시되며 QCL NZP CSI-RS ID(들)을 포함하는 CSI 프로세스를 제외한 나머지 CSI 프로세스 각각을 위해 정의될 수 있다. 또는 방법 Ma112에서, PQI 파라미터 집합별로, 맵핑 지시자는 단말에 설정된 모든 CSI 프로세스 각각을 위해 정의될 수 있다. 클래스-B CSI 프로세스를 설정받은 단말에 대하여, 방법 Ma111은 PQI 파라미터 집합별로 다수의 맵핑 지시자를 설정해야 할 수도 있는 반면에, 방법 Ma112는 PQI 파라미터 집합별 맵핑 지시자의 수가 해당 캐리어 내에서 단말에 설정된 CSI 프로세스 수를 넘지 않는다.

[159] 방법 Ma113은, 맵핑 지시자가 모든 PQI 파라미터 집합과 모든 NZP CSI-RS

ID들에 공통적으로 적용되는 방법이다.

[160] 방법 Ma113은 단말이 DCI 포맷 2D의 PQI 필드 값과 무관하게, 단일 맵핑 지시자의 설정값을 따라 PDSCH 레잇 매칭(rate matching) 및 PDSCH 자원 요소 맵핑을 수행하는 방법이다. 이 때, 맵핑 지시자는 1 비트일 수 있다. 다중 셀 협력 통신은, 통상적으로 셀 경계(또는 TP 경계)의 단말이 복수의 TP들로부터 비슷한 장기(long-term) 채널 특성을 겪을 때 동적인 TP 선택에 의한 단기(short-term) 채널 선택 이득을 얻고자 하는 방법이다. 상기 맵핑 지시자가 반고정적인 RRC 시그널링에 의해 전송되는 경우에는, CSI-RS 간섭 제거 후의 PDSCH 수신 성능을 보장하는 것은 방법 Ma113으로 충분할 수 있다.

[161] 방법 Ma113에서도 마찬가지로, QCL NZP CSI-RS ID(들)에는 맵핑 지시자가 적용되지 않을 수 있다. 즉, 단말은 QCL NZP CSI-RS ID(들)에 대응하는 CSI-RS RE 집합에서는 PDSCH를 수신하는 것을 기대하지 않을 수 있다. 또는 방법 Ma113에서, QCL NZP CSI-RS ID(들)에도 맵핑 지시자가 동일하게 적용될 수 있다. 즉, 단말은 맵핑 지시자 값에 따라, QCL NZP CSI-RS ID(들)에 대응하는 CSI-RS RE 집합에서도 PDSCH를 수신하는 것을 기대할 수 있다.

[162] 한편, 방법 Ma113에서 맵핑 지시자는 PQI 파라미터 집합과 동일한 또는 상위 레벨의 정보에 포함될 수 있다.

[163] 한편, 상술한 바와 같이, 다중 셀 협력 전송이 아닌 경우에는 기지국이 인접 셀(들)의 CSI-RS configuration 정보를 단말에게 별도의 시그널링을 통해 알려주어야 하는데, 이러한 경우에, 기지국이 각 인접 셀에 대한 CSI-RS configuration마다 상기 맵핑 지시자를 정의하고 이를 CSI-RS configuration과 함께 단말에게 알려주는 방법이 사용될 수도 있다. 또는 방법 Ma113과 유사하게, 하나의 맵핑 지시자를 정의하고 이를 모든 인접 셀(들)에 대한 CSI-RS configuration에 공통적으로 적용하는 방법이 고려될 수도 있다.

[164] 이하에서는 물리계층 시그널링에 의해 맵핑 지시자를 단말에게 설정하는 방법에 대하여 설명한다.

[165] 방법 Ma120은, 단말의 PDSCH 스케줄링 정보를 포함하는 하향링크 DCI에 맵핑 지시자를 포함시키는 방법이다.

[166] 단말은 하향링크 DCI에 포함된 맵핑 지시자를 통해, 자신이 설정받은 CSI-RS RE 집합(들)에 PDSCH 데이터가 맵핑되었는지 여부를 동적으로 지시받을 수 있다. 기지국은 단말의 채널 상태에 따라, 단말이 서로 다른 TP에 의해 전송되는 CSI-RS와 PDSCH를 어떤 CSI-RS RE 집합에서 모두 성공적으로 수신할 수 있다고 판단되는 경우에, PDSCH 전송을 위해 해당 RE 집합을 추가로 이용하고, 그렇지 않다고 판단되는 경우에는, 해당 RE 집합에 PDSCH 데이터를 맵핑시키지 않을 수 있다.

[167] CoMP 전송인 경우(즉, 하향링크 DCI가 DCI 포맷 2D인 경우)에, 방법 Ma120에서 맵핑 지시자는 단말에게 설정된 NZP CSI-RS ID 중에서 QCL NZP CSI-RS ID(들)을 제외한 나머지 모든 NZP CSI-RS ID(들)을 위해 공통으로

정의되거나(방법 Ma110과 유사), 나머지 NZP CSI-RS ID 별로 각각 정의될 수 있다(방법 Ma111과 유사). 전자의 경우에 맵핑 지시자를 위한 필드는 1 비트일 수 있다. 또는 방법 Ma120에서 맵핑 지시자는 단말에게 설정된 NZP CSI-RS ID 중에서 QCL NZP CSI-RS ID(들)을 포함한 모든 NZP CSI-RS ID(들)을 위해 공통으로 정의되거나(방법 Ma110과 유사), 모든 NZP CSI-RS ID에 대하여 각각 정의될 수 있다(방법 Ma111과 유사). 전자의 경우에, 맵핑 지시자를 위한 필드는 1 비트일 수 있다.

[168] CoMP 전송이 아닌 경우에, 방법 Ma120에서 맵핑 지시자는 모든 인접 셀(들)의 NZP CSI-RS configuration을 위해 공통으로 정의되거나, 인접 셀의 NZP CSI-RS configuration 별로 각각 정의될 수 있다. 전자의 경우에 맵핑 지시자를 위한 필드는 1 비트일 수 있다.

[169] 방법 Ma120을 구성하는 또 다른 방법으로써, PDSCH 데이터를 맵핑시키고자 하는 RE 집합을 나타내는 NZP CSI-RS ID(들)의 집합, 또는 PDSCH 데이터를 맵핑시키지 않고자 하는 RE 집합을 나타내는 NZP CSI-RS ID(들)의 집합을 RRC 시그널링을 통해 미리 설정해 두고, DCI 내의 맵핑 지시자 필드(또는 이에 상응하는 필드)를 이용하여 단말에게 PDSCH 맵핑 여부를 상기 NZP CSI-RS ID 집합 단위로 동적으로 알려주는 방법이 있다. 상기 NZP CSI-RS ID 집합은 하나 또는 복수 개 설정될 수 있다. 설정 가능한 NZP CSI-RS ID 집합이 하나인 경우, DCI 내의 맵핑 지시자 필드는 1 비트로 충분할 수 있다. 설정 가능한 NZP CSI-RS ID 집합이 N개인 경우에, DCI 내의 맵핑 지시자 필드는 예를 들어 $\text{ceil}(\log_2(N+1))$ 비트를 필요로 할 수 있다. 여기서 ceil(.)는 소수점 이하 올림 연산을 의미한다.

[170] 상기 맵핑 지시자(또는 이에 상응하는 시그널링)에 기초한 방법들은, 단말이 복수의 CSI 프로세스에 의해 복수의 NZP CSI-RS ID를 설정받은 경우에만 적용 가능하도록, 제한될 수도 있다. 또는 상기 맵핑 지시자(또는 이에 상응하는 시그널링)에 기초한 방법들은, 단말이 설정받은 CSI 프로세스 수와 무관하게, 단말이 복수의 NZP CSI-RS ID를 설정받은 경우에만 적용 가능하도록, 제한될 수도 있다. 또는 상기 맵핑 지시자에 기초한 방법들은 단말이 QCL type B로 설정되는 경우에만 적용 가능하도록, 제한될 수도 있다. 단말이 QCL type A로 설정되는 경우에는, 상기 맵핑 지시자에 기초한 방법들의 적용이 불필요할 수 있다.

[171] 이하에서는 동일한 문제(예, CSI-RS 전송 오버헤드 문제 등)를 ZP CSI-RS를 이용하여 해결하는 방법에 대하여 설명한다.

[172] 방법 Ma130은, CoMP 협력 집합에 속한 TP들 중에서 PDSCH를 송신하는 TP를 제외한 나머지 TP(들)에 대해 설정된 CSI-RS RE 집합(들)에서, 단말이 PDSCH를 수신할 것을 기대하는 방법이다.

[173] 현재 규격에 의하면 단말은 하향링크 DCI 중에서 DCI 포맷 2D를 제외한 하향링크 DCI를 통해 PDSCH를 스케줄링받는 경우에, 단말은 서빙 셀에 의해 전송되는 CSI-RS의 RE들에서는 PDSCH가 전송되지 않고 인접 셀에 의해

전송되는 CSI-RS의 RE들에서는 해당 영역이 ZP CSI-RS로 설정되지 않는 한 PDSCH가 전송됨을 가정하므로, 단말은 이미 방법 Ma130을 따르고 있다. 그러나 단말이 DCI 포맷 2D를 통해 PDSCH를 스케줄링받는 경우에는, 단말은 자신이 설정받은 모든 NZP CSI-RS RE들을 제외한 자원 영역에 대해 PDSCH RE 맵핑을 수행하도록 되어 있다. 방법 Ma130이 사용되면, 단말은 후자의 경우에, 단말에게 설정된 NZP CSI-RS ID 중에서 DCI에 의해 지시되는 QCL NZP CSI-RS ID(들)을 제외한 나머지 NZP CSI-RS ID(들)에 대응하는 RE 집합(들)에서 해당 영역이 ZP CSI-RS로 설정되지 않는 한 PDSCH가 전송됨을 가정한다. 따라서 기지국은 단말에 설정된 어떤 CSI-RS RE 집합을 해당 단말로의 PDSCH 전송을 위해 이용하고자 하는 경우에, 해당 CSI-RS RE 집합을 ZP CSI-RS로 설정하지 않을 수 있고, 해당 CSI-RS RE 집합을 해당 단말로의 PDSCH 전송을 위해 이용하지 않고자 하는 경우에, 해당 CSI-RS RE 집합을 ZP CSI-RS로 설정할 수 있다. 도 4에 예시된 DPS 전송을 가정하면, 도 7에 예시된 PDSCH RE 맵핑은 전자의 경우(ZP CSI-RS로써 설정 안하는 경우)에 해당하고, 도 6에 예시된 PDSCH RE 맵핑은 후자의 경우(ZP CSI-RS로써 설정하는 경우)에 해당한다.

[174]

[175] 도 8은 본 발명의 실시예에 따른, 3개의 TP가 2개의 서브프레임 내의 서로 다른 RE들을 이용하여 CSI-RS 자원을 설정하는 방법을 나타내는 도면이다.

[176] DPS 전송에 참여하는 각 TP가 하나의 단말에 전송하는 CSI-RS들이 서로 다른 서브프레임에서 전송되도록 설정될 수도 있다. 이것은, 전송 모드(TM)가 10인 단말이 설정받은 복수의 NZP CSI-RS configuration들이 동일한 서브프레임 내에 설정되지 않은 경우에 대응한다.

[177] 구체적으로, 도 8에는 단말이 3개의 TP(TP1~TP3) 각각에 대하여 4개의 CSI-RS 안테나 포트(15~18번)를 2개의 인접한 서브프레임(서브프레임 n, 서브프레임 n+1)에 걸쳐 설정받은 경우를 예시하였다. 예를 들어, 서브프레임 n의 슬롯0에 속하는 RE(5, 9), RE(6, 9), RE(5, 3), 및 RE(6, 3)은 TP(TP1)을 위한 CSI-RS RE로써 설정되고, 서브프레임 n의 슬롯1에 속하는 RE(2, 9), RE(3, 9), RE(2, 3), 및 RE(3, 3)은 TP(TP2)을 위한 CSI-RS RE로써 설정되고, 서브프레임 n+1의 슬롯1에 속하는 RE(2, 8), RE(3, 8), RE(2, 2), 및 RE(3, 2)은 TP(TP3)을 위한 CSI-RS RE로써 설정된다.

[178] 단말이 DCI 포맷 2D를 통해 TP(TP1)로부터 PDSCH를 수신하는 경우를 가정하자. 방법 Ma130이 사용되면, 기지국은 단말이 TP(TP2)과 TP(TP3)에 의해 전송되 CSI-RS의 RE들에서 PDSCH를 수신할 지 여부를, ZP CSI-RS 설정을 통해 결정한다. 그러나 현재 규격에서 단말은 PQI 파라미터 집합별로 하나의 ZP CSI-RS configuration만을 설정받을 수 있다. 결국, 단말이 TP(TP2)와 TP(TP3)에 의해 전송되는 CSI-RS의 RE들 전부에서 PDSCH를 수신하지 않도록 설정하는 것은, 2개의 ZP CSI-RS configuration이 요구되므로, 현재 규격에서는 불가능하다.

[179] 한편, 향후 FD-MIMO를 지원하기 위한 다수의 CSI-RS 안테나 포트를 설정하는

방법으로써, 하나의 CSI 프로세스를 통해 하나 또는 복수의 NZP CSI-RS configuration들을 복수의 서브프레임에 걸쳐 설정하는 방법이 고려될 수 있다. 이 경우에도, 단말의 정확한 PDSCH 레잇 매칭(rate matching)을 위해서, PQI 파라미터 집합마다 복수의 ZP CSI-RS configuration을 설정하는 것이 필요할 수도 있다. 또는 방법 Ma130이 사용되지 않는 경우라 하더라도, 예를 들어, DPS 전송에 참여하는 TP가 복수의 단말에 대한 CSI-RS를 서로 다른 서브프레임에서 전송하는 경우에, 마찬가지로 복수의 ZP CSI-RS ID가 필요할 수도 있다.

[180] 방법 Ma131은, 각 PQI 파라미터 집합이 복수의 ZP CSI-RS ID를 포함하는 방법이다. ZP CSI-RS ID는 ZP CSI-RS configuration을 나타내는 식별자이다.

[181] ZP CSI-RS 설정 주기가 최소 5 ms임을 고려하면, 방법 Ma131에서 하나의 PQI 파라미터 집합에 포함될 수 있는 ZP CSI-RS ID의 수는, 최대 5개일 수 있다. 또는 RRC 시그널링 오버헤드를 고려하여, 하나의 PQI 파라미터 집합에 포함될 수 있는 ZP CSI-RS ID의 수는 2개 또는 3개로 제한될 수 있다.

[182] 한편, 기존 규격에서 하나의 단말이 설정받을 수 있는 Release 11 ZP CSI-RS ID는 최대 4개이므로, 방법 Ma131의 적용을 위해, 하나의 단말이 설정받을 수 있는 ZP CSI-RS ID의 수를 늘리는 방법이 고려될 수 있다. 이와 동시에, DPS 전송에 참여하는 TP의 수가 최대 3개라고 가정하면, 하나의 단말이 설정받을 수 있는 ZP CSI-RS ID의 수는 최대 15개일 수 있다.

[183] 방법 Ma132는, 하나의 ZP CSI-RS ID를 통해 복수의 서브프레임에 ZP CSI-RS를 설정하는 방법이다.

[184] 하나의 ZP CSI-RS ID에 대응하는 RE들의 집합을, ZP CSI-RS RE 집합이라 부르기로 한다. 이에 따르면, 기존 규격에서 하나의 ZP CSI-RS ID 또는 ZP CSI-RS RE 집합은 하나의 ZP CSI-RS configuration에 대응한다.

[185] 방법 Ma132는 각 PQI 파라미터 집합이 기존처럼 하나의 ZP CSI-RS ID만을 포함하되, 하나의 ZP CSI-RS ID가 복수의 ZP CSI-RS configuration 또는 하나의 ZP CSI-RS configuration list에 대응할 수 있도록 하는 방법이다. 예를 들어, 단말에게 설정된 하나의 ZP CSI-RS ID가 3개의 ZP CSI-RS configuration을 나타내는 경우에, 3개의 ZP CSI-RS configuration 각각은 3개의 서브프레임 각각에 적용될 수 있다.

[186] 한편, ZP CSI-RS configuration list에 포함되는 ZP CSI-RS configuration(들)은, 기존 규격의 ZP CSI-RS configuration과 동일할 수 있다. 또는 시그널링 오버헤드를 줄이기 위해, ZP CSI-RS configuration list에 포함되는 모든 configuration들이 동일한 주기성을 가진다고 가정되거나, ZP CSI-RS configuration list에 포함되는 configuration들 간의 상대적인 서브프레임 오프셋만을 단말에게 설정하는 방법이 고려될 수도 있다.

[187] ZP CSI-RS 설정 주기가 최소 5 ms임을 가정하면, 방법 Ma132에서 하나의 ZP CSI-RS ID에 대응하는 ZP CSI-RS configuration의 수는 최대 5일 수 있다.

[188] 방법 Ma132는, 기존의 ZP CSI-RS ID와 ZP CSI-RS configuration과의 관계를

그대로 유지한 채, ZP CSI-RS 그룹 ID를 정의하고, 하나의 ZP CSI-RS 그룹 ID가 복수의 ZP CSI-RS ID를 나타낼 수 있도록 하는 방법으로 해석될 수도 있다.

[189] 한편, 방법 Ma132와, 하나의 단말이 설정받을 수 있는 최대 ZP CSI-RS ID의 수를 늘리는 방법이 동시에 사용되는 방법도 고려될 수 있다. 또한 방법 Ma132와 방법 Ma131이 동시에 사용되는 방법도 고려될 수 있다.

[190] 방법 Ma133은, DRS(discovery reference signal) 설정을 위해 Release 12에서 도입된 ZP CSI-RS ID를 각 PQI 파라미터 집합에 포함시키는 방법이다.

[191] Release 12에서 도입된 DRS를 수신할 수 있는 단말은, 기존의 Release 11 ZP CSI-RS configuration에 더하여, DRS 설정을 위해 최대 5개의 ZP CSI-RS ID를 추가로 설정받을 수 있다. 따라서 방법 Ma133이 사용되는 경우에, 기지국은 DRS를 지원하는 Release 12 단말에게, 최대 9개의 ZP CSI-RS ID를 이용하여 PDSCH RE 맵핑 정보(또는 PDSCH 맵핑 여부 정보)를 동적으로 전송할 수 있다. 따라서 방법 Ma133은, 현재 규격에 정의되어 있는 ZP CSI-RS ID만으로도, 상기 문제점(예, CSI-RS 전송 오버헤드 문제 등)을 어느 정도 해결할 수 있다.

[192] 방법 Ma130, 방법 Ma131, 방법 Ma132, 또는 방법 Ma133의 ZP CSI-RS 설정 방법은, 단말의 CSI-RS 간섭 제거를 위한 시그널링 이외에 다른 용도로도 이용될 수 있다.

[193]

[194] 2. 하향링크 참조 신호를 전송하는 방법

[195] 2.1. CSI-RS 자원 설정

[196] 본 명세서에서, CSI-RS configuration이라 함은 CSI-RS 자원 설정 그 자체를 의미할 수도 있고, 경우에 따라서는 CSI-RS 자원 설정(resource configuration)에 의해 설정되는 CSI-RS 자원 구성(resource composition) 또는 CSI-RS RE 집합을 의미할 수도 있다.

[197] 노멀 CP에 대한 CSI-RS configuration은 아래의 표 2을 따른다.

[198] [표2]

노멀 CP에 대한 CSI-RS configuration

	CSI-RS configuration	Number of CSI reference signals configured					
		1 or 2		4		8	
		(k',l')	n_s mod 2	(k',l')	n_s mod 2	(k',l')	n_s mod 2
Frame structure type 1 and 2	0	(9,5)	0	(9,5)	0	(9,5)	0
	1	(11,2)	1	(11,2)	1	(11,2)	1
	2	(9,2)	1	(9,2)	1	(9,2)	1
	3	(7,2)	1	(7,2)	1	(7,2)	1
	4	(9,5)	1	(9,5)	1	(9,5)	1
	5	(8,5)	0	(8,5)	0		
	6	(10,2)	1	(10,2)	1		
	7	(8,2)	1	(8,2)	1		
	8	(6,2)	1	(6,2)	1		
	9	(8,5)	1	(8,5)	1		
	10	(3,5)	0				
	11	(2,5)	0				
	12	(5,2)	1				
	13	(4,2)	1				
	14	(3,2)	1				
	15	(2,2)	1				
	16	(1,2)	1				
	17	(0,2)	1				
	18	(3,5)	1				
	19	(2,5)	1				

Frame structure type 2 only	20	(11,1)	1	(11,1)	1	(11,1)	1
	21	(9,1)	1	(9,1)	1	(9,1)	1
	22	(7,1)	1	(7,1)	1	(7,1)	1
	23	(10,1)	1	(10,1)	1		
	24	(8,1)	1	(8,1)	1		
	25	(6,1)	1	(6,1)	1		
	26	(5,1)	1				
	27	(4,1)	1				
	28	(3,1)	1				
	29	(2,1)	1				
	30	(1,1)	1				
	31	(0,1)	1				

[199] 표 2에서 CSI-RS configuration 0~19번은 FDD와 TDD에 공통으로 적용될 수 있고, CSI-RS configuration 20~31번은 TDD에만 적용될 수 있다. TDD 시스템에서는 전송 모드(TM: transmission mode) 7로 설정된 단말을 위해 안테나 포트 5번의 DMRS가 전송될 가능성이 있으므로, 안테나 포트 5번의 DMRS와의 자원 오버랩을 피하기 위해, CSI-RS configuration 20~31번이 추가로 정의된다. 표 2에서 각각의 CSI-RS configuration이 가리키는 인덱스 쌍 (k',l')은 CSI-RS RE 집합의 기준점이 되는 RE를 의미한다. (k',l')을 기준으로 하나의 PRB 페어 내에서 CSI-RS RE 집합이 어떻게 정해지는 지는, 규격에 미리 정의되어 있다.

[200] 본 명세서에서 CSI-RS 패턴이라 함은, 각 CSI-RS 안테나 포트 수별로 CSI-RS 자원 풀 내에서 규격에 미리 정의된 CSI-RS 자원 구성을 의미하고, 경우에 따라서는 CSI-RS 안테나 포트의 주파수 축 자원 밀도까지를 포함할 수도 있다. 도 1 내지 도 3에 보이듯이, 현재 규격에는 1, 2, 4, 그리고 8개의 CSI-RS 안테나 포트에 대하여 CSI-RS 패턴이 정의되어 있다.

[201] 한편, Release 13에 도입된 12개 및 16개의 CSI-RS 안테나 포트에 대해서는, 하나의 고정된 CSI-RS 패턴이 정의된 것이 아니라, 기존의 4개 또는 8개의 CSI-RS 안테나 포트의 CSI-RS configuration을 복수 개 집성(aggregation)하여 자원을 구성하도록 되어 있다. 구체적으로, 12개의 CSI-RS 안테나 포트는 기존의 4개 안테나 포트의 CSI-RS configuration을 3개 집성하여 구성되고, 16개의 CSI-RS 안테나 포트는 기존의 8개 안테나 포트의 CSI-RS configuration을 2개 집성하여 구성된다. 본 명세서에서, CSI-RS 자원 집성의 요소로 이용되는 CSI-RS configuration을 '컴포넌트 CSI-RS configuration'이라 한다.

[202] 또한, 12개 및 16개의 CSI-RS 안테나 포트에 대해서는, length-2 CDM (이하 'CDM-2')와 length-4 CDM (이하 'CDM-4') 중 하나가 선택적으로 적용될 수 있다.

[203] 한편, Release 13에 도입된 단말의 CSI 보고 유형은 클래스-A와 클래스-B로 구분된다. 전송 모드(transmission mode)가 10인 경우, 기지국은 단말에게, CSI 프로세스 내의 CSI 보고 유형을 가리키는 파라미터를 이용하여 클래스-A 또는 클래스-B CSI 보고를 설정할 수 있다. 본 명세서에서는, 전송 모드를 구분하지 않고, 클래스-A CSI 보고를 위해 단말에 설정되는 CSI-RS 설정 파라미터들의 집합을 '제1 CSI-RS 설정'이라 하고, 클래스-B CSI 보고를 위해 단말에 설정되는 CSI-RS 설정 파라미터들의 집합을 '제2 CSI-RS 설정'이라 한다. 전송 모드가 10인 경우, 제1 CSI-RS 설정은 클래스-A CSI 보고를 위한 CSI 프로세스 내에서의 CSI-RS 설정 파라미터들의 집합을 의미하고, 제2 CSI-RS 설정은 클래스-B CSI 보고를 위한 CSI 프로세스 내에서의 CSI-RS 설정 파라미터들의 집합을 의미한다.

[204] 제1 CSI-RS 설정은 12개 또는 16개의 CSI-RS 안테나 포트의 자원 설정 정보를 포함할 수 있다. 즉, 제1 CSI-RS 설정은 12개 또는 16개의 CSI-RS 안테나 포트의 자원 집성을 위한 복수의 컴포넌트 CSI-RS configuration과 CDM 유형 (즉, CDM-2 또는 CDM-4)을 가리키는 파라미터를 포함할 수 있다. 제2 CSI-RS 설정은 하나 또는 복수의 CSI-RS configuration을 포함하고, 이 때 제2 CSI-RS 설정에 포함되는 각 CSI-RS configuration은 기존 1, 2, 4, 또는 8개의 CSI-RS 안테나 포트의 CSI-RS configuration이다. 하나의 제2 CSI-RS 설정 내에서, CSI-RS configuration들은 서로 다른 CSI-RS 안테나 포트 수를 가질 수 있고, 전송 모드가 10인 경우, 각기 다른 고유의 NZP CSI-RS ID를 가질 수 있다.

[205]

[206] 2.2. 제1 CSI-RS 설정을 확장하는 방법

[207] 제1 CSI-RS 설정은 8, 12, 그리고 16 이외의 CSI-RS 안테나 포트 수로 확장될 수 있다. 예를 들어, 제1 CSI-RS 설정은 16이 넘는 8의 배수인 CSI-RS 안테나 포트 수로 확장될 수 있다. 또는, 제1 CSI-RS 설정은 16이 넘는 4의 배수인 CSI-RS 안테나 포트 수로 확장될 수 있다. 또는, 제1 CSI-RS 설정은 16이 넘는 짝수인 CSI-RS 안테나 포트 수로 확장될 수 있다. 또는, 제1 CSI-RS 설정은 8 이상의 짝수인 CSI-RS 안테나 포트 수를 포함하도록 확장될 수 있다. 이 때, 설정 가능한 CSI-RS 안테나 포트 수는 N을 넘지 않도록 제한될 수 있다. 여기서 N은 16보다 큰 임의의 자연수이다. 예를 들어, N은 32 또는 64일 수 있다.

[208] 상기 새로운 CSI-RS 안테나 포트 수에 대해서도, 현재 규격과 마찬가지로, 복수의 컴포넌트 CSI-RS configuration을 집성하는 방법이 적용될 수 있다. 예를 들어, 20개의 CSI-RS 안테나 포트는 기존의 4개 안테나 포트의 CSI-RS configuration을 5개 집성하여 구성될 수 있고, 24개의 CSI-RS 안테나 포트는 기존의 4개 안테나 포트의 CSI-RS configuration을 6개 집성하여 구성되거나, 기존의 8개 안테나 포트의 CSI-RS configuration을 3개 집성하여 구성될 수 있다.

[209] 또는 상기 새로운 CSI-RS 안테나 포트 수의 일부 또는 전부, 그리고/또는 기존 CSI-RS 안테나 포트 수에 대해서, 컴포넌트 CSI-RS configuration별로 독립적인

CSI-RS 안테나 포트 수를 가지도록 하는 방법이 적용될 수 있다. 예를 들어, 20개의 CSI-RS 안테나 포트는 기존의 8개 안테나 포트의 CSI-RS configuration 2개와 기존의 4개 안테나 포트의 CSI-RS configuration 1개를 집성하여 구성될 수 있다.

[210] 또는 상기 새로운 CSI-RS 안테나 포트 수의 일부 또는 전부, 그리고/또는 기존 CSI-RS 안테나 포트 수에 대해서, 모든 컴포넌트 CSI-RS configuration이 동일한 CSI-RS 안테나 포트 수를 가지되, 이 중에서 하나의 컴포넌트 CSI-RS configuration에 대해서는 단말이 일부 CSI-RS 안테나 포트만을 수신하고 CSI 측정 및 보고에 이용할 것을 가정하는 방법이 적용될 수 있다. 예를 들어, 단말은 제1 CSI-RS 설정을 구성하는 컴포넌트 CSI-RS configuration(들) 중에 마지막 컴포넌트 CSI-RS configuration에 대해서 일부 CSI-RS 안테나 포트만을 가정할 수 있다. 예를 들어, 20개의 CSI-RS 안테나 포트는 기존의 8개 안테나 포트의 CSI-RS configuration을 3개 집성하여 구성하되, 마지막 컴포넌트 CSI-RS configuration에 대해서는 단말이 8개의 안테나 포트 중에서 4개(예, CSI-RS 안테나 포트 15~18번)만을 수신함을 가정할 수 있다. 단말이 일부 CSI-RS 안테나 포트만을 가정하는 컴포넌트 CSI-RS configuration에 대해서, 단말이 가정하는 CSI-RS 안테나 포트 수는 기지국에 의해 단말에게 시그널링될 수 있다.

[211] 본 명세서에서, 제1 CSI-RS 설정에 적용될 수 있는 방법들은, 상기 확장에 의한 새로운 CSI-RS 안테나 포트 수의 설정에도 동일하거나 유사하게 적용될 수 있음을 가정한다.

[212]

[213] 2.3. CSI-RS 자원 설정을 확장하는 방법

[214] 도 1 내지 도 3에 예시된 바와 같이, 현재의 LTE 규격에 따르면, 노멀 CP가 설정되는 경우에, 하나의 PRB 페어 내에서 CSI-RS 전송을 위해 이용될 수 있는 RE는 총 40개이다. 이하에서는, PRB 페어 내에서(또는 PRB 번들링(bundling)이 사용되는 경우에는 복수의 PRB 페어 내에서) CSI-RS 자원으로써 설정 가능한 RE들의 집합을, CSI-RS 자원 풀이라 한다. CSI-RS 자원 풀을 확장하는 것은 FD-MIMO 시스템에서 다수의 CSI-RS 안테나 포트를 전송하는 것에 도움이 될 수 있다. 하나의 서브프레임 내에서 CSI-RS 자원 풀을 확장하기 위한 방법으로써, 크게 두 가지 방법이 고려될 수 있다.

[215] 첫 번째 방법은 하나의 PRB 페어 내에서 CSI-RS 자원 풀에 포함되는 RE의 수를 늘리는 방법이다. 두 번째 방법은 하나의 PRB 페어 내 CSI-RS 자원 풀에 포함되는 RE 개수를 40개로 유지한 채, 주파수 축으로 인접한 복수의 PRB 페어를 번들링하여 CSI-RS 자원 풀을 확장하는 방법이다. 후자의 방법에 따르면, CSI-RS 자원 설정을 위해 이용될 수 있는 RE의 수가 늘어나는 반면에, 전체 시스템 대역폭 내에서 각 CSI-RS 안테나 포트에 할당되는 RE의 수는 줄어든다. 예를 들어, PRB 페어 번들이 2개의 인접한 PRB 페어를 포함하는 경우에, 하나의 PRB 페어 번들 내에서 CSI-RS 자원 풀은 총 80개의 RE를 포함하지만, 각 CSI-RS

안테나 포트의 시퀀스를 구성하는 심볼의 수는 기존 대비 절반으로 줄어든다. CSI-RS 안테나 포트별 주파수 축 RE의 밀도가 줄어들면, 단말의 채널 추정 시 이용 가능한 채널 샘플의 수가 줄어들게 되고, 이는 채널 특성과 채널 추정 알고리즘에 따라 채널 추정 성능에 영향을 미칠 수도 있다. 한편, 현재 규격에 의하면, 단말의 CSI 측정 및 보고는 적어도 서브밴드(subband) 단위로 수행되므로, 실제로 보고되는 CSI의 정확도나 스케줄러 성능의 열화는 미미할 수 있다.

[216] 이하에서는 상기 후자의 방법에 초점을 맞추어, CSI-RS 패턴을 확장하는 방법에 대하여 설명한다. 즉, PRB 페어 번들을 기본 단위로 하여, 기존의 CSI-RS 패턴을 다수의 안테나 포트로 확장하는 방법에 대하여 기술한다.

[217] 또한 1, 2, 4, 또는 8개의 CSI-RS 안테나 포트에 대해서도 PRB 번들링을 이용하여, 기존보다 CSI-RS 패턴이 더 낮은 주파수 축 밀도를 갖도록 하는 방법에 대해서도 설명한다. 또한 상기 확장된 CSI-RS 패턴들을 조합하여 단말에 설정하는 방법에 대해서도 설명한다. 이하에서 기술되는 방법들 각각을, 다음의 4가지 경우로 구분하여 순차적으로 설명한다. 첫 번째 경우를 위주로 기술하고, 나머지 경우들에 대해서는 간략히 설명하기로 한다.

[218] - 노멀 CP가 설정되는 경우에, FDD와 TDD에 모두 적용될 수 있는 CSI-RS 자원 설정

[219] - 노멀 CP가 설정되는 경우에, TDD에만 적용될 수 있는 CSI-RS 자원 설정

[220] - 확장 CP가 설정되는 경우에, FDD와 TDD에 모두 적용될 수 있는 CSI-RS 자원 설정

[221] - 확장 CP가 설정되는 경우에, TDD에만 적용될 수 있는 CSI-RS 자원 설정

[222] 한편, 본 발명의 실시예에 따른 방법들은, 안테나 가상화(virtualization) 방식에 따라 그 효과가 달라질 수 있다. 본 명세서에서 가상화라 함은 안테나 포트와 물리 안테나 요소(들) 간의 맵핑을 의미하며, 디지털 신호 처리 기반의 통신 시스템에서 안테나 가상화는 안테나 포트 가상화와 TXRU(transceiver unit) 가상화를 포함할 수 있다. 여기서 TXRU는, 입력 신호의 위상(phase)과 진폭(amplitude)을 독립적으로 제어하고 출력할 수 있는 RF 장치의 단위를 의미하고, 통상적으로 RF 체인이라 부르기도 한다. 안테나 포트 가상화는 안테나 포트와 TXRU(들) 간의 맵핑을 의미하고, TXRU 가상화는 TXRU와 물리 안테나 요소(들) 간의 맵핑을 의미한다. 단말은 기본적으로 각 안테나 포트에 적용된 가상화를 알 수 없다.

[223] 본 명세서에서 CSI-RS는 일반적으로 통용되듯이 NZP(non-zero-power) CSI-RS를 의미하고, ZP(zero-power) CSI-RS와는 구별되는 것으로 가정한다.

[224]

[225] <u>2.3.1. 노멀 CP가 설정되는 경우에, FDD와 TDD에 모두 적용될 수 있는 CSI-RS 자원 설정 방법</u>

[226] 첫째로, 노멀 CP가 설정되는 경우에, FDD와 TDD 프레임 구조에 공통적으로

적용되는 CSI-RS 자원 설정 방법에 대하여 기술한다.

[227] 제안하는 방법을 설명하기에 앞서, 먼저 PRB 페어 번들을 정의한다. 본 명세서에서 PRB 페어 번들(이하, 'PRB 번들')은 CSI-RS 패턴이 정의되는 기본 단위로써, 주파수 축에서 인접한 PRB 페어들의 묶음(또는 집합)을 의미한다. 즉, CSI-RS 패턴은 하나의 PRB 번들 내에서 정의되고, 이 CSI-RS 패턴이 전 대역에 걸쳐 복수의 PRB 번들에 동일하게 반복되어 맵핑된다. 이 때 PRB 번들의 크기, 즉 PRB 번들에 포함되는 PRB 페어의 개수를 N^bundle_RB로 정의하고, 전체 시스템 대역폭(system bandwidth)이 갖는 PRB 번들의 개수를 N^DL_bundle로 정의한다. 전 대역의 PRB 개수를 N^DL_RB라 하면, N^DL_bundle = ceil(N^DL_RB/N^bundle_RB)이 된다. 예를 들어, LTE 시스템에서 시스템 대역폭이 10 MHz인 경우에, N^DL_RB는 50이고, 이 때 PRB 번들의 크기를 3으로 설정하면 총 PRB 번들의 개수는 N^DL_bundle = ceil(50/3) = 17이고, 마지막 PRB 번들의 크기는 2가 된다. 기존 LTE 규격에 정의된 CSI-RS 패턴은 N^bundle_RB = 1인 경우에 해당한다.

[228]

[229] 이하에서는 PRB 번들링(단, N^bundle_RB > 1)에 대하여 설명한다. PRB 번들에 포함되는 복수의 PRB 페어를 이용하여, CSI-RS 패턴이 정의될 수 있다. 이러한 경우에, CSI-RS 패턴을 확장하는 방법으로써, 크게 방법 Mb100과 방법 Mb200이 고려될 수 있다.

[230] 방법 Mb100은, CSI-RS 패턴에 포함되는 CSI-RS 안테나 포트들의 RE 집합이 PRB 번들에 포함되는 복수의 PRB 페어들 중에서 하나의 PRB 페어 내에만 맵핑(설정)되는 방법이다.

[231] 방법 Mb100은 PRB 번들링이 미적용된 기존 규격의 CSI-RS 패턴을 재활용할 수 있다. 즉, 방법 Mb100은 1, 2, 4, 또는 8개의 CSI-RS 안테나 포트를 설정하고자 하는 경우에, 표 2을 이용한 기존의 CSI-RS configuration 시그널링을 재사용할 수 있다. 이 경우에, 기지국은 단말에게 PRB 번들의 크기(N^bundle_RB) 그리고/또는 PRB 번들 내 CSI-RS RE 집합이 맵핑되는 PRB 페어의 인덱스를 추가로 알려주어야 할 수 있다. 여기서 PRB 번들에 포함된 PRB 페어 중에서 CSI-RS RE 집합이 맵핑되는 PRB 페어의 인덱스는 0 이상 N^bundle_RB 미만의 정수로 표현될 수 있고, 이를 본 명세서에서 편의상 PRB shift라 한다. N^bundle_RB 그리고/또는 PRB shift는 미리 정해진 규칙에 의해 고정된 값을 가질 수도 있고, 단말별로 설정될 수도 있다.

[232] 전자의 예로써, N^bundle_RB는 CSI-RS 안테나 포트 수별로 미리 정해진 값을 가질 수 있다. 예를 들어, N^bundle_RB는 X개의 CSI-RS 안테나 포트 수까지는 1이고, X보다 큰 CSI-RS 안테나 포트 수에 대해서는 1보다 큰 값으로 정해질 수 있다. 여기서 X는 1 이상의 정수값으로 표현될 수 있다. 한편, 후자의 예로써, 단말이 전송 모드 10을 설정받은 경우, N^bundle_RB는 단말에 CSI 프로세스별로 설정될 수 있다.

[233]

[234] 도 9는 본 발명의 실시예에 따른, 방법 Mb100을 이용해 CSI-RS 자원을 설정하는 방법을 나타내는 도면이다.

[235] 구체적으로, 도 9에는 기지국이 2개의 PRB 페어에 번들링을 적용하고, 동일 서브프레임 내에서 단말들(UE-a, UE-b, UE-c, UE-d) 각각에게 8, 4, 2, 또는 1개의 CSI-RS 안테나 포트를 설정하는 경우가 예시되어 있다.

[236] 이 때, 모든 단말의 경우에 N^bundle_RB는 공통으로 2이고, 단말(UE-a)와 단말(UE-d)를 위한 PRB shift는 1이고, 단말(UE-b)와 단말(UE-c)를 위한 PRB shift는 0이다. PRB 번들의 크기가 2이므로, 도면에 예시된 모든 안테나 포트들의 주파수 축 밀도는 기존의 절반이 된다.

[237] 예를 들어, PRB 페어 1번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 5), RE(3, 5), RE(2, 10), RE(3, 10), RE(2, 4), 및 RE(3, 4)는 단말(UE-a)을 위한 CSI-RS RE(예, CSI-RS 안테나 포트 15~22번)로써 설정된다. PRB 페어 1번 내의 슬롯0의 RE(5, 3), 및 RE(6, 3)는 단말(UE-d)을 위한 CSI-RS RE(예, CSI-RS 안테나 포트 15번)로써 설정된다. PRB 페어 0번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 5), 및 RE(3, 5)는 단말(UE-b)을 위한 CSI-RS RE(예, CSI-RS 안테나 포트 15~18번)로써 설정된다. PRB 페어 0번 내의 슬롯0의 RE(5, 9), 및 RE(6, 9)는 단말(UE-c)을 위한 CSI-RS RE(예, CSI-RS 안테나 포트 15~16번)로써 설정된다. 본 명세서의 도면들에는 주파수 대역이 낮은 PRB 페어일수록 낮은 PRB 페어 인덱스를 가지는 것으로 예시되어 있으나, 반대로 주파수 대역이 높은 PRB 페어가 낮은 PRB 페어 인덱스를 가지는 것을 가정할 수도 있다.

[238] 방법 Mb100에 따르면, 하나의 PRB 페어 내 일부 RE들을 복수의 단말이 주파수 축에서 PRB 페어를 교대로 번갈아 가면서 사용할 수 있다. 도 9에 예시된 실시예에서, 단말(UE-a)와 단말(UE-b)는 슬롯1의 RE(2,5), RE(3,5), RE(2,11), 및 RE(3,11)을 사용한다.

[239] 방법 Mb100에서 PRB 번들의 크기(N^bundle_RB)는 임의의 자연수가 될 수 있다. 그러나 기지국이 너무 많은 수의 PRB 페어를 번들링하면 CSI 측정(measurement) 정확도가 떨어지므로, PRB 번들의 크기(N^bundle_RB)의 최대값이 적당한 값으로 미리 정의될 수도 있다. 예를 들어, PRB 번들의 크기가 서브밴드(subband)의 크기를 넘지 않도록(즉, N^bundle_RB가 하나의 서브밴드가 가지는 RB 개수 이하가 되도록), 제한될 수 있다. 또는 PRB 번들의 크기가 서브밴드의 크기의 약수만 가능하도록 제한될 수 있다. 또는 N^bundle_RB 값이 1과 2만 가능하도록 제한을 두는 방법도 고려될 수 있다.

[240] 전술하였듯이, 현재 규격에 의하면, CSI-RS 패턴은 1, 2, 4, 그리고 8개의 CSI-RS 안테나 포트에 대해서만 정의되어 있고, 12개 및 16개의 CSI-RS 안테나 포트는 복수의 컴포넌트 CSI-RS configuration을 집성하여 구성된다. 한편, 1, 2, 4, 그리고 8 이외의 CSI-RS 안테나 포트 수에 대하여, 상기 자원 집성에 의하지 않고, CSI-RS 패턴을 정의하는 방법이 고려될 수 있다. 이 경우에, 방법 Mb100은

현재의 CSI-RS 자원 풀로는 64개의 CSI-RS 안테나 포트에 적용될 수 없다는 제약을 가진다. 또한 기지국이 방법 Mb100을 이용해 32개의 CSI-RS 안테나 포트를 설정하고자 하는 경우에도, 하나의 PRB 페어 내에서 CDM-2와 FDM의 결합만으로는 CSI-RS 패턴이 정의될 수 없고, TDM 또는 length-4 이상의 CDM과의 결합을 통해서만 CSI-RS 패턴이 정의될 수 있으므로, CSI-RS 설정 및 전송을 위해 최소 4개의 OFDM 심볼이 필요하다. 따라서 32개의 CSI-RS 안테나 포트를 설정하는 경우는 16개 이하의 CSI-RS 안테나 포트를 설정하는 경우보다 오실레이터(oscillator)의 impairment로 인한 OFDM 심볼 간 phase drift 현상에 상대적으로 더 노출될 수 있다.

[241] 방법 Mb100의 장점 중 하나는 하나의 PRB 페어 내에서 기존의 CSI-RS 패턴이 동일하게 유지되므로, 기지국은 CSI-RS 전송 시에 PRB 번들링이 적용될 수 있는 단말과 PRB 번들링이 적용될 수 없는 기존(legacy) 단말이 일부 RE를 공유하도록 할 수 있다는 것이다.

[242]

[243] 도 10a 및 도 10b는 본 발명의 다른 실시예에 따른, 방법 Mb100을 이용해 CSI-RS 자원을 설정하는 방법을 나타내는 도면이다.

[244] 구체적으로 도 10a 및 도 10b에는, CSI-RS를 위해 PRB 번들링이 적용된 새로운 단말과 PRB 번들링을 적용받을 수 없는 기존 단말(또는 PRB 번들링이 적용되지 않은 새로운 단말)의 CSI-RS 설정이 자원을 공유하는 경우가 예시되어 있다.

[245] 도 10a에는 단말(UE-a)와 단말(UE-b)가 동일한 CSI-RS configuration에 의해 8개의 CSI-RS 안테나 포트를 설정받고, 단말(UE-a)에 대해서는 방법 Mb100에 의해 2개의 PRB 페어에 번들링이 적용된 경우가 예시되어 있다. 예를 들어, PRB 페어 0번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 5), RE(3, 5), RE(2, 4), 및 RE(3, 4)는 단말(UE-a)를 위한 CSI-RS RE로써 설정된다. 각 PRB 페어 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 5), RE(3, 5), RE(2, 4), 및 RE(3, 4)는 PRB 번들링을 적용받지 않은 단말(UE-b)를 위한 CSI-RS RE로써 설정된다. 결국, PRB 페어 0번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 5), RE(3, 5), RE(2, 4), 및 RE(3, 4)는 단말(UE-a)과 단말(UE-b)을 위한 CSI-RS RE로써 설정된다.

[246] 도 10b에는, 기지국이 단말(UE-a)에게 방법 Mb100을 이용해 2개의 PRB 페어의 번들링을 설정하고, PRB 페어 0번에 8개의 안테나 포트의 CSI-RS 패턴을 설정하고, 단말(UE-b)에게는 4개의 CSI-RS 안테나 포트를 PRB 번들링 없이 설정하는 경우가 예시되어 있다. 예를 들어, PRB 페어 0번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 5), RE(3, 5), RE(2, 4), 및 RE(3, 4)는 단말(UE-a)를 위한 CSI-RS RE로써 설정된다. 각 PRB 페어 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 5), 및 RE(3, 5)는 단말(UE-b)를 위한 CSI-RS RE로써 설정된다. 결국, PRB 페어 0번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 5), 및 RE(3, 5)는 단말(UE-a)과 단말(UE-b)을 위한 CSI-RS RE로써 설정된다.

[247] 도 10a 및 도 10b에 예시된 방법은 단말(UE-a)과 단말(UE-b)에 대한 CSI-RS 자원 설정이 일부 RE들을 공유함으로써, 두 단말(UE-a, UE-b)의 CSI-RS RE 집합 간에 교집합이 없도록 설정하는 방식에 비해, CSI-RS 전송 오버헤드를 줄일 수 있다.

[248]

[249] 도 11은 본 발명의 또 다른 실시예에 따른, 방법 Mb100을 이용해 CSI-RS 자원을 설정하는 방법을 나타내는 도면이다.

[250] 구체적으로 도 11에는 기지국이 복수의 단말에게 PRB 번들 내의 서로 다른 PRB 페어를 이용하여 CSI-RS 자원을 설정하고, 복수의 단말로 하여금 동일한 RE를 주파수 축에서 공유하도록 하는 방법이 예시되어 있다. 도 11에서 단말들(UE-a, UE-b, UE-c, UE-d)은 PRB 번들링을 설정받을 수 있는 단말이고, 각 단말(UE-a, UE-b, UE-c, UE-d)은 2개의 PRB 페어의 번들링을 설정받을 수 있다.

[251] 기지국은 단말(UE-a)와 단말(UE-b)에게 8개의 CSI-RS 안테나 포트를 위한 동일한 CSI-RS configuration과 N^bundle_RB = 2를 공통으로 설정하고, 단말(UE-a)을 위한 PRB shift는 0으로, 단말(UE-b)을 위한 PRB shift는 1로 설정한다. 예를 들어, PRB 페어 0번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)는 단말(UE-a)를 위한 CSI-RS RE로써 설정된다. PRB 페어 1번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)는 단말(UE-b)를 위한 CSI-RS RE로써 설정된다.

[252] 이 때, 단말(UE-a)와 단말(UE-b)를 위한 CSI-RS는 서로 다른 PRB 페어를 통해 전송되므로, 단말(UE-a)와 단말(UE-b)를 위한 CSI-RS에 서로 다른 가상화를 적용하는 것이 가능하다. 즉, 단말 특정적(user equipment-specific) CSI-RS 빔포밍이 가능하다. 이는, 단말(UE-a)와 단말(UE-b)가 가지는 채널이 빔 공간 내 또는 벡터 공간 내에서 서로 방향성이 다른 경우에, 유용하다.

[253] 기지국은 단말(UE-c)와 단말(UE-d)에게 2개의 CSI-RS 안테나 포트를 설정한다. 단말(UE-c)와 단말(UE-d)을 위한 CSI-RS 설정에 적용되는 원리는, 단말(UE-a) 및 단말(UE-b)의 예시와 동일하다. 예를 들어, PRB 페어 0번 내의 슬롯1의 RE(2, 11), 및 RE(3, 11)는 단말(UE-c)를 위한 CSI-RS RE로써 설정된다. PRB 페어 1번 내의 슬롯1의 RE(2, 11), 및 RE(3, 11)는 단말(UE-d)를 위한 CSI-RS RE로써 설정된다.

[254]

[255] 방법 Mb200은, CSI-RS 패턴에 포함되는 CSI-RS 안테나 포트들의 RE 집합이 PRB 번들에 포함되는 모든 PRB 페어들에 균일한 수(또는 최대한 균일한 수)로 맵핑되는 방법이다.

[256] 방법 Mb200에서 CSI-RS 안테나 포트들이 N^bundle_RB개의 PRB 페어들에 동일한 개수로 맵핑되기 위해서는, N^bundle_RB가 2의 지수승이어야 한다. 따라서 방법 Mb100에서 PRB 번들의 크기는 임의의 자연수가 되어도 무방한 데 반해, 방법 Mb200에서는 PRB 번들의 크기는 2의 지수승으로 제한되는 것이

효과적일 수 있다.

[257]

[258] 도 12는 본 발명의 실시예에 따른, 방법 Mb200을 이용해 16개의 CSI-RS 안테나 포트에 대한 자원을 설정하는 방법을 나타내는 도면이다.

[259] 구체적으로 도 12에는 2개의 PRB 페어가 번들링된 경우를 예시하고 있다.

[260] 도 12에 예시된 바와 같이, 기지국은 기존의 8개의 CSI-RS 패턴에 PRB 번들링과 안테나 포트 간 다중화(FDM)를 적용하고 주파수 축으로 2배만큼 CSI-RS 패턴을 확장하여, 16개의 CSI-RS 안테나 포트의 패턴을 설정할 수 있다.

[261] 이 때, 하나의 서브프레임 내에서 설정 가능한 CSI-RS configuration의 수는 5개(예, 0번 내지 4번)이다. 예를 들어, PRB 페어 0번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)와 PRB 페어 1번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)는, CSI-RS configuration 0번를 위한 CSI-RS RE(예, CSI-RS 안테나 포트 15~30번)로써 설정된다.

[262] 도 12에 예시된 실시예에 따르면, 방법 Mb100과 마찬가지로, 2개의 PRB 페어를 묶어 번들링한 만큼, 각 CSI-RS 안테나 포트의 주파수 축 자원 밀도는 절반으로 줄어든다.

[263]

[264] 도 13a 및 도 13b는 본 발명의 실시예에 따른, 방법 Mb200을 이용해 12개의 CSI-RS 안테나 포트에 대한 자원을 설정하는 방법을 나타내는 도면이다.

[265] 구체적으로 도 13a 및 도 13b에는 2개의 PRB 페어가 번들링된 경우를 예시하고 있다. CSI-RS 안테나 포트 수가 16인 경우와 달리, CSI-RS 안테나 포트 수가 12인 경우에는, 만약 기지국이 2개의 PRB 페어에 CSI-RS 안테나 포트를 균일하게 나누어 설정하고자 한다면, 하나의 PRB 페어 내에 6개의 CSI-RS 안테나 포트를 맵핑해야 한다. 이 경우에, 기존 규격상에 하나의 PRB 페어 내에서 설정되는 6개의 CSI-RS 안테나 포트에 대한 패턴이 정의되어 있지 않으므로, 6개의 CSI-RS 안테나 포트를 위한 새로운 패턴이 정의되어야 한다. 이를 피하기 위해, 12개의 CSI-RS 안테나 포트를 2개의 PRB 페어에 불균일하게 나누어 맵핑하는 방법이 고려될 수 있다.

[266] 도 13a 및 도 13b에는 기지국이 PRB 페어 0번과 1번 각각에 8개와 4개의 CSI-RS 안테나 포트를 맵핑하는 경우가 예시되어 있다.

[267] PRB 페어 0번에는 기존 규격상의 8개의 CSI-RS 안테나 포트에 대한 패턴이 적용되고, PRB 페어 1번에는 기존 규격상의 4개의 CSI-RS 안테나 포트에 대한 패턴이 적용된다.

[268] 이 때, 하나의 서브프레임 내에서 설정 가능한 CSI-RS configuration의 수는 5개(예, 0번 내지 4번)이다. 예를 들어, 도 13a에 예시된 실시예에서, PRB 페어 0번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)와 PRB 페어 1번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 3), 및 RE(6,

3)는, CSI-RS configuration 0번를 위한 CSI-RS RE(예, CSI-RS 안테나 포트 15~26번)로써 설정된다. 도 13b에 예시된 실시예에서, PRB 페어 0번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)와 PRB 페어 1번 내의 슬롯0의 RE(5, 8), RE(6, 8), RE(5, 2), 및 RE(6, 2)는, CSI-RS configuration 0번를 위한 CSI-RS RE(예, CSI-RS 안테나 포트 15~26번)로써 설정된다.

[269] 이 때 도 13a 및 도 13b에 예시된 CSI-RS 패턴들과 같이, PRB 페어 1번에 설정된 RE들의 집합이 PRB 페어 0번에 설정된 RE들의 집합에 포함되는 것은, 다른 단말들에 대한 ZP CSI-RS 설정에 효과적일 수 있다.

[270]

[271] 도 14는 본 발명의 실시예에 따른, 방법 Mb200을 이용해 32개의 CSI-RS 안테나 포트에 대한 자원을 설정하는 방법을 나타내는 도면이다.

[272] 구체적으로, 도 14에는 2개의 PRB 페어가 번들링되는 경우가 예시되어 있다.

[273] 기지국은 기존 규격상의 8개의 CSI-RS 안테나 포트의 패턴에 PRB 번들링과 안테나 포트 간 다중화(FDM)를 적용하고 주파수 축으로 CSI-RS 패턴을 4배만큼 확장하여, 32개의 CSI-RS 안테나 포트의 패턴을 설정할 수 있다.

[274] 이 때, 하나의 서브프레임 내에 설정 가능한 CSI-RS configuration의 수는 1개(예, 0번)이다. 예를 들어, 도 14에 예시된 실시예에서, PRB 페어 0번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 9), RE(3, 9), RE(2, 8), RE(3, 8), RE(2, 5), RE(3, 5), RE(2, 4), RE(3, 4), RE(2, 3), RE(3, 3), RE(2, 2), 및 RE(3, 2)와, PRB 페어 1번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 9), RE(3, 9), RE(2, 8), RE(3, 8), RE(2, 5), RE(3, 5), RE(2, 4), RE(3, 4), RE(2, 3), RE(3, 3), RE(2, 2), 및 RE(3, 2)는, CSI-RS configuration 0번를 위한 CSI-RS RE(예, CSI-RS 안테나 포트 15~46번)로써 설정된다.

[275] 한편, 도 12 내지 도 14에 예시된 실시예는 CSI-RS 패턴을 정의하는 특정 예시일 뿐이다. 기지국은 CSI-RS 자원 풀 내에서 다양한 CSI-RS 패턴들을, 방법 Mb200을 이용하는 상기 방법과 동일 또는 유사한 방법을 통해, 정의할 수 있다.

[276] 한편, 방법 Mb100과 마찬가지로, 방법 Mb200이 이용되는 경우에도, 1, 2, 4, 또는 8개의 CSI-RS 안테나 포트에 대하여 PRB 번들링이 적용될 수 있다.

[277]

[278] 도 15는 본 발명의 다른 실시예에 따른, 방법 Mb200을 이용해 CSI-RS 자원을 설정하는 방법을 나타내는 도면이다.

[279] 구체적으로 도 15에는 기지국이 2개의 PRB 페어를 번들링하여, 단말(UE-a, UE-b, UE-c, UE-d) 각각에게 8, 4, 2, 또는 1개의 CSI-RS 안테나 포트를 설정하는 경우가 예시되어 있다.

[280] 2, 4, 또는 8개 안테나 포트를 갖는 CSI-RS 패턴 각각은, 기존의 1, 2, 또는 4개 안테나 포트의 CSI-RS 패턴에 PRB 번들링과 안테나 포트 간 다중화(FDM)가 적용되고 주파수 축으로 CSI-RS 패턴이 2배 확장되는 형태로 정의될 수 있다.

예를 들어, PRB 페어 0번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 5), 및 RE(3, 5)와, PRB 페어 1번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 5), RE(3, 5)는 단말(UE-a)를 위한 CSI-RS RE(예, CSI-RS 안테나 포트 15~22번)로써 설정된다. PRB 페어 0번 내의 슬롯1의 RE(5, 8) 및 RE(6, 8)와, PRB 페어 1번 내의 슬롯1의 RE(5, 8) 및 RE(6, 8)는 단말(UE-b)를 위한 CSI-RS RE(예, CSI-RS 안테나 포트 15~18번)로써 설정된다. PRB 페어 0번 내의 슬롯0의 RE(5, 9) 및 RE(6, 9)와, PRB 페어 1번 내의 슬롯0의 RE(5, 9) 및 RE(6, 9)는 단말(UE-c)를 위한 CSI-RS RE(예, CSI-RS 안테나 포트 15~16번)로써 설정된다.

[281] 도 15에 예시된 단말(UE-a)와 단말(UE-b)에 대한 CSI-RS 자원 설정의 경우에, PRB 번들링이 적용되지 않은 8개 또는 4개 안테나 포트의 CSI-RS 자원 설정에 대비하여, CSI-RS 자원의 주파수 축 밀도가 절반으로 줄어든다. 이로 인해, CSI-RS 전송 오버헤드가 절반으로 줄어든다.

[282] 하지만 도 15에 예시된 단말(UE-d)에 대한 CSI-RS 자원 설정을 통해 알 수 있듯이, 단말에 설정되는 CSI-RS 안테나 포트의 수가 1이고 PRB 번들링이 사용되는 경우에는, 방법 Mb200의 원리가 적용될 수 없다. 이를 일반화하면, PRB 번들의 크기가 단말에 설정되는 CSI-RS 안테나 포트 수보다 크면, 방법 Mb200의 원리가 적용될 수 없다. 이 경우에는, 예외적으로, 방법 Mb100과 유사하게, CSI-RS RE 집합이 PRB 번들 내에서 하나의 PRB 페어에만 맵핑되도록 할 수 있다. 이 때, CSI-RS RE 집합이 맵핑되는 PRB 페어는 미리 정해질 수 있다. 예를 들어, 도 15에서, PRB 페어 0번 내의 슬롯0의 RE(5, 3) 및 RE(6, 3)는 단말(UE-d)를 위한 CSI-RS RE(예, CSI-RS 안테나 포트 15번)로써 설정된다.

[283] 또한 단말(UE-c)에 대한 CSI-RS 자원 설정을 통해 알 수 있듯이, 단말에 설정되는 CSI-RS 안테나 포트 수가 2인 경우에는, PRB 번들링이 사용되더라도 CSI-RS 전송 오버헤드의 감소가 없다. 즉, PRB 번들의 크기가 CSI-RS 안테나 포트 수와 동일하면, 방법 Mb200이 사용될 수는 있으나, 오버헤드 감소 효과가 없다. 이를 고려하여, PRB 번들의 크기(N^bundle_RB)가 단말에 설정하고자 하는 CSI-RS 안테나 포트 수보다 작은 값 또는 약수로만 설정되도록 제한을 두는 방법이 사용될 수도 있다.

[284] 한편, 방법 Mb200에서 PRB 번들의 크기(N^bundle_RB)가 CSI-RS 안테나 포트 수의 약수가아닌 경우에는, 모든 안테나 포트들이 PRB 번들 내에서 최대한 균일하게 맵핑되고 난 후에, 어떤 PRB 페어에서는 다른 PRB 페어(들)보다 더 적은 수의 RE에 안테나 포트들이 맵핑될 수 있다. 이 때, 모든 PRB 페어에서 동일한 수의 RE에 안테나 포트들이 맵핑되도록 하기 위하여, 더 적은 수의 RE가 맵핑된 PRB 페어(들)의 나머지 RE(들)에 CSI-RS 안테나 포트를 15번부터 다시 순차적으로 맵핑하는 방법이 고려될 수 있다. 또는 상기 나머지 RE(들)에 CSI-RS를 맵핑하지 않는 방법이 고려될 수 있다. 하지만 이러한 방법들은, CSI-RS 안테나 포트들 간 자원 할당의 불균형이나 비효율적 자원 할당으로 인한 채널 추정 성능 열화 등의 문제를 해결하기 어렵다. 따라서 방법 Mb200이

사용되는 경우에, PRB 번들의 크기(N^bundle_RB)는 CSI-RS 안테나 포트 수의 약수인 것이 좋다. PRB 번들의 크기(N^bundle_RB)는 2의 지수승으로만 설정되도록 제한되더라도, 대부분의 경우에 PRB 번들의 크기(N^bundle_RB)는 CSI-RS 안테나 포트 수의 약수가 되도록 설정하는 것이 가능하다.

[285] 방법 Mb200에 따르면, 동일한 RE에 PRB 번들에 포함되는 PRB 페어마다 서로 다른 CSI-RS 안테나 포트가 맵핑되므로, PRB 번들링이 적용될 수 있는 새로운 단말과 기존 단말이 NZP CSI-RS 전송 자원을 공유하는 것이 어렵다. 반면에, 방법 Mb200에 따르면 모든 PRB 페어들에 CSI-RS RE들의 수와 위치가 동일하게 설정되므로, 방법 Mb200은 기존 단말이 해당 RE들을 ZP CSI-RS로써 설정받고 PDSCH 레잇 매칭을 수행하는 데는 방법 Mb100보다 유리하다.

[286] 방법 Mb200에서도 PRB 번들의 크기(N^bundle_RB)의 최대값이 설정될 수 있다. PRB 번들의 크기(N^bundle_RB)가 하나의 서브밴드가 가지는 RB 개수를 넘지 않도록 제한될 수 있다. 또는 PRB 번들의 크기가 서브밴드의 크기의 약수만 가능하도록 제한될 수 있다. 또는 PRB 번들의 크기(N^bundle_RB)는 1과 2만이 가능하도록 제한될 수 있다.

[287] 방법 Mb201은, 방법 Mb200의 변형된 방법으로, PRB 번들을 따로 정의하지 않고, CSI-RS 안테나 포트들을 전체 시스템 대역상의 모든 PRB 페어들에 균일한 개수로 (또는 최대한 균일한 개수로) 맵핑하는 방법이다.

[288] 방법 Mb201은, 방법 Mb200의 특별한 경우(special case)로 해석될 수 있다. 즉, 방법 Mb201은, 방법 Mb200에서 PRB 번들의 크기가 시스템 대역폭과 동일하게 설정되는 경우(N^bundle_RB = N^DL_RB)와 동등하다. 그러나 이 경우에, 일반적으로 단말에 설정되는 CSI-RS 안테나 포트 수보다 훨씬 많은 수의 RE들이 전 대역에 걸쳐 존재하므로, 각 CSI-RS 안테나 포트를 복수의 RE들에 맵핑하는 규칙이 새로 정의되어야 할 수도 있다. 모든 CSI-RS 안테나 포트를 15번부터 시작하여 순차적으로 맵핑하는 것을 반복하는 방법이 사용될 수 있다. 이 때, 하나의 PRB 페어 내에서의 안테나 포트 맵핑 규칙으로는, 기존 1, 2, 4, 또는 8개의 CSI-RS 안테나 포트의 패턴을 따르는 방법이 사용될 수도 있고(도 16a), 또는 새로운 방법(도 16b)이 사용될 수도 있다. 이에 대하여, 도 16a 및 도 16b를 참고하여 설명한다.

[289]

[290] 도 16a 및 도 16b는 본 발명의 실시예에 따른, 방법 Mb201를 이용해 6개의 CSI-RS 안테나 포트에 대한 자원을 설정하는 방법을 나타내는 도면이다. 도 16a 및 도 16b에 예시된 실시예에서는 지금까지 기술된 실시예들과 달리, 주파수가 높은 PRB 페어일수록 낮은 PRB 페어 인덱스를 가진다.

[291] 구체적으로, 도 16a에는, 기존 1, 2, 4, 또는 8개의 CSI-RS 안테나 포트의 패턴을 따르는 방법이 사용되는 경우가 예시되어 있다. 각 PRB 페어 내에서 8개 안테나 포트에 대한 CSI-RS 패턴의 맵핑 순서가 사용된다. 예를 들어, PRB 페어 0번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 5), RE(3, 5), RE(2,

4), 및 RE(3, 4)는, CSI-RS RE(예, CSI-RS 안테나 포트 15~20번, CSI-RS 안테나 포트 15~16번)로써 설정된다. PRB 페어 1번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 5), RE(3, 5), RE(2, 4), 및 RE(3, 4)는, CSI-RS RE(예, CSI-RS 안테나 포트 17~20번, CSI-RS 안테나 포트 15~18번)로써 설정된다. PRB 페어 2번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 5), RE(3, 5), RE(2, 4), 및 RE(3, 4)는, CSI-RS RE(예, CSI-RS 안테나 포트 19~20번, CSI-RS 안테나 포트 15~20번)로써 설정된다.

[292] 도 16b에는 기존의 맵핑 규칙을 무시하는 새로운 방법이 사용되는 경우가 예시되어 있다. 예를 들어, PRB 페어 0번 내의 슬롯1의 RE(2, 10) 및 RE(3, 10)는 CSI-RS 안테나 포트 17~18번으로써 설정되고, PRB 페어 0번 내의 슬롯1의 RE(2, 5) 및 RE(3, 5)는 CSI-RS 안테나 포트 19~20번으로써 설정된다.

[293] 이와 같이, CSI-RS 안테나 포트 수가 2의 지수승이 아니면, 도 16a 및 도 16b에 예시된 바와 같이, 각 CSI-RS 안테나 포트 번호에 맵핑되는 RE들이 주파수 축으로 등간격으로 배치되지 않는 경우가 발생할 수 있다. 이로 인해, 채널 추정 성능의 열화 또는 복잡도 증가가 발생할 수 있다.

[294] 방법 Mb201은 방법 Mb200과 마찬가지로, PRB 번들링에 의해 확장된 새로운 CSI-RS 설정 자원이 기존 단말의 NZP CSI-RS 자원 설정과 공유되기가 어렵고, 새로운 설정 자원을 기존 단말이 ZP CSI-RS로써 설정받고 PDSCH 레잇 매칭을 수행하기에는 유리하다.

[295] 지금까지 PRB 번들링을 이용하여 CSI-RS 패턴을 주파수 축으로 확장 또는 변경하는 방법들을 기술하였다. 상기 방법들을 ZP CSI-RS의 설정에 동일하게 적용하여 ZP CSI-RS 자원 설정을 위해서도 PRB 번들링이 가능하도록 확장하는 방법이 고려될 수 있다. 예를 들어, ZP CSI-RS의 설정에 방법 Mb100가 적용되는 경우에, 기지국은 단말에게, 비트맵에 의해 지시되는 ZP CSI-RS RE 집합이 PRB 번들 내에서 어느 PRB 페어에 맵핑되는지를, 즉, PRB shift를 알려줄 수 있다. 또는, 하나의 ZP CSI-RS 설정이 복수의 비트맵을 포함할 수 있다. 이 때, 비트맵의 수는 PRB 번들의 크기(N^bundle_RB)와 동일하고, 비트맵과 PRB 페어가 일대일 맵핑될 수 있다. 다른 예를 들어, ZP CSI-RS의 설정에 방법 Mb200이 적용되는 경우에, PRB 번들의 크기는 2일 수 있다. 이 때, 비트맵의 길이는 기존 길이의 2배가 되고, 비트맵의 각 비트는, PRB 페어 0번과 1번에 공통으로, 표 2에서 2개의 CSI-RS 안테나 포트일 경우의 각 CSI-RS configuration이 가리키는 RE 집합에 대응될 수 있다. 즉, 비트맵의 각 비트는 PRB 페어 0번의 2개의 RE와 PRB 페어 1번의 2개의 RE에 대응될 수 있다.

[296] 상기와 같이 ZP CSI-RS 설정에 PRB 번들링이 적용됨으로써, 셀 간 간섭 제어 또는 간섭 측정(interference measurement)이 용이할 수 있다. 예를 들어, 인접 셀이 PRB 번들링된 NZP CSI-RS를 전송할 때, 서빙 셀은 단말에게 해당 자원을 동일한 PRB 번들링이 적용된 ZP CSI-RS로써 설정하여, 정확한 간섭 측정 또는 자원 낭비 없는 PDSCH 자원 할당이 가능하도록 할 수 있다.

[297] 한편, CSI-RS에 PRB 번들링이 적용되면 각 CSI-RS 안테나 포트의 주파수 축 RE 밀도가 줄어듦으로, CSI-RS 안테나 포트 별로 전송되어야 하는 CSI-RS 심볼의 개수가 줄어든다. 이 때, CSI-RS 시퀀스(sequence) 생성 및 심볼 맵핑에 대하여 두 가지 방법이 고려될 수 있다. 첫째는 각 안테나 포트 별로 줄어든 CSI-RS RE의 밀도에 맞추어 CSI-RS 시퀀스를 생성하고, 시퀀스를 구성하는 심볼들을 설정된 RE들에 주파수 축에서 순차적으로 맵핑하는 방법이다. 둘째는 각 안테나 포트 별로 기존과 동일한 길이의 CSI-RS 시퀀스를 생성하고, 시퀀스를 구성하는 심볼들을 설정된 RE들에 기존의 심볼과 PRB 페어 간 맵핑과 동일하게(즉, 띄엄띄엄) 맵핑하는 방법이다. 후자의 방법은, PRB 번들링이 적용될 수 있는 새로운 단말과 기존 단말이 CSI-RS 시퀀스를 공유하여 동일 자원 상에서 CSI-RS가 전송될 수 있다는 장점을 가진다.

[298] 한편, 방법 Mb100과 방법 Mb200에서는, 마지막 PRB 번들의 크기가 N^bundle_RB 보다 작을 수 있다. 예를 들어, 대역폭이 50 RB인 시스템의 경우에, CSI-RS의 PRB 번들 크기가 3으로 설정되면, 마지막 PRB 번들의 크기는 2가 된다. 마지막 PRB 번들에도 동일한 CSI-RS 패턴이 적용되되, PRB 페어의 부족으로 인해 맵핑될 자원이 존재하지 않는 CSI-RS 안테나 포트에 대해서는 맵핑을 생략하는 방법이 고려될 수 있다. 또는 마지막 PRB 번들에서는 CSI-RS를 전송하지 않는 방법이 고려될 수 있다.

[299] 한편, 지금까지 상술한 복수의 PRB 페어를 번들링하여 CSI-RS 자원을 설정하는 모든 방법은, 제2 CSI-RS 설정을 위해 적용될 수 있다. 제2 CSI-RS 설정은 하나 또는 복수의 CSI-RS configuration을 포함할 수 있는데, 이 때, 각 CSI-RS configuration별로 상술한 방법들이 적용될 수 있다. 즉, PRB 번들링의 적용 여부, PRB 번들의 크기, 그리고 PRB shift가 CSI-RS configuration별로 정의될 수 있다. 또는, PRB 번들링의 적용 여부, PRB 번들의 크기, 그리고 PRB shift 중 하나 또는 복수가 제2 CSI-RS 설정을 구성하는 모든 CSI-RS configuration에 공통으로 정의될 수 있다. 또는, PRB 번들링의 적용 여부, PRB 번들의 크기, 그리고 PRB shift 중 하나 또는 복수가 제2 CSI-RS 설정을 구성하는 CSI-RS configuration들 중 일부 CSI-RS configuration(들)의 집합에 공통으로 정의될 수 있다.

[300] 이하에서는 PRB 번들링을 적용하고 복수의 컴포넌트 CSI-RS configuration을 집성(aggregation)하여 단말에게 CSI-RS 자원을 설정하는 방법에 대하여 기술한다.

[301] 먼저 방법 Mb100을 위한 CSI-RS 자원 집성 방법에 대하여 기술한다. 가장 자유도가 높은 집성 방법은, 컴포넌트 CSI-RS configuration별로 PRB 번들의 크기를 독립적으로 설정하는 방법이지만, 이하에서는 집성되는 모든 컴포넌트 CSI-RS configuration들이 동일한 PRB 번들 크기를 가지는 경우만을 고려하기로 한다. CSI-RS 자원 집성의 경우에도, PRB 번들의 크기는 단말에 시그널링될 수도 있고, 미리 정해진 값을 따를 수도 있다. 이 때, PRB shift의 시그널링 유무에

따라 방법 Mb110 내지 방법 Mb130으로 구분될 수 있다.

[302] 방법 Mb110은, 컴포넌트 CSI-RS configuration 별로 PRB shift를 설정하는 방법이다.

[303] 방법 Mb110은, 방법 Mb120과 방법 Mb130에 비해 CSI-RS 자원 집성의 자유도가 높은 방법이다. 이 때, CSI-RS 자원 집성을 위한 파라미터는, 각 컴포넌트 CSI-RS configuration에 대한 CSI-RS 설정 정보 외에, 각 컴포넌트 CSI-RS configuration별 PRB shift를 포함하고, 모든 컴포넌트 CSI-RS configuration에 공통인 PRB 번들의 크기(N^bundle_RB)를 추가로 포함할 수도 있다.

[304] 각 컴포넌트 CSI-RS configuration을 위하여 설정 가능한 CSI-RS 안테나 포트 수는, Release 13 규격의 4 또는 8만을 포함할 수도 있고, 전술한 새로운 포트 수를 포함하여 4 또는 8 이외의 다른 포트 수(들)을 더 포함할 수도 있다.

[305] 안테나 포트 수가 1, 2, 4, 또는 8인 경우에, 컴포넌트 CSI-RS configuration은 기존 규격에 따른 CSI-RS configuration일 수 있고, 이외의 포트 수인 경우에, 컴포넌트 CSI-RS configuration은 새롭게 정의되는 CSI-RS configuration일 수 있다.

[306] PRB shift는 방법 Mb100에서 상술한 바와 같이, 0 이상 N^bundle_RB 미만의 정수 값으로 표현될 수 있다.

[307]

[308] 도 17은 본 발명의 실시예에 따른, 방법 Mb110을 이용해 복수의 컴포넌트 CSI-RS configuration을 집성하는 방법을 나타내는 도면이다.

[309] 단말(UE-e)에게는, 8개의 CSI-RS 안테나 포트를 포함하는 컴포넌트 CSI-RS configuration 2개가 집성되어 총 16개의 CSI-RS 안테나 포트가 설정된다. 예를 들어, PRB 페어 0번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)는, 단말(UE-e)을 위하여, 컴포넌트 CSI-RS configuration 0번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~22번)로써 설정된다. PRB 페어 1번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)는, 단말(UE-e)을 위하여, 컴포넌트 CSI-RS configuration 1번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~22번)로써 설정된다.

[310] 상술한 파라미터 예시에 따르면, 단말(UE-e)에게 전송되는 파라미터는, 각 컴포넌트 CSI-RS configuration의 CSI-RS 설정 정보 외에, 각 컴포넌트 CSI-RS configuration을 위한 PRB shift를 포함하고, 2인 PRB 번들의 크기(N^bundle_RB)를 추가로 포함할 수도 있다. 컴포넌트 CSI-RS configuration 0번을 위한 PRB shift는 0이고, 컴포넌트 CSI-RS configuration 1번을 위한 PRB shift는 1이다.

[311] 이 때, 단말(UE-e)을 위한 컴포넌트 CSI-RS configuration들(0번, 1번)의 안테나 포트 간 다중화 방식으로는, 두 개의 컴포넌트 CSI-RS configuration(0번, 1번)가 동일 OFDM 심볼 상에 할당되었으므로, FDM이 사용될 수 있다.

[312] 한편, 도 17에 예시된 실시예에서, 단말(UE-f)에게는, 2개의 컴포넌트 CSI-RS configuration이 집성되어 총 10개의 CSI-RS 안테나 포트가 설정된다. 예를 들어, PRB 페어 1번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 5), RE(3, 5), RE(2, 4), 및 RE(3, 4)는, 단말(UE-f)을 위하여, 컴포넌트 CSI-RS configuration 0번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~22번)로써 설정된다. PRB 페어 1번 내의 슬롯1의 RE(5, 9) 및 RE(6, 9)는, 단말(UE-f)을 위하여, 컴포넌트 CSI-RS configuration 1번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~16번)로써 설정된다.

[313] 단말(UE-f)에게 전송되는 파라미터는, 각 컴포넌트 CSI-RS configuration의 CSI-RS 설정 정보 외에, 각 컴포넌트 CSI-RS configuration을 위한 PRB shift를 포함하고, 2인 PRB 번들의 크기(N^bundle_RB)를 추가로 포함할 수도 있다. 컴포넌트 CSI-RS configuration 0번과 컴포넌트 CSI-RS configuration 1번을 위한 PRB shift는 모두 1이다.

[314] 이 때, 단말(UE-f)을 위한 두 개의 컴포넌트 CSI-RS configuration(0번, 1번)는 서로 다른 OFDM 심볼에 할당되었으므로, 컴포넌트 CSI-RS configuration들(0번, 1번)의 안테나 포트 간 다중화 방식으로는, FDM은 사용될 수 없고, TDM이 사용될 수 있다.

[315]

[316] 도 18은 본 발명의 다른 실시예에 따른, 방법 Mb110을 이용해 복수의 컴포넌트 CSI-RS configuration을 집성하는 방법을 나타내는 도면이다.

[317] 구체적으로 도 18에는, 하나의 단말(UE-e)에게, 3개의 컴포넌트 CSI-RS configuration(0번, 1번, 2번)이 집성되어 총 48개의 CSI-RS 안테나 포트가 설정되는 경우가 예시되어 있다.

[318] PRB 번들 크기(N^bundle_RB)는 2이고, 각 컴포넌트 CSI-RS configuration (0번~2번)의 안테나 포트 수는 16개이다. 예를 들어, PRB 페어 0번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)와 PRB 페어 0번 내의 슬롯1의 RE(2, 9), RE(3, 9), RE(2, 8), RE(3, 8), RE(2, 3), RE(3, 3), RE(2, 2), 및 RE(3, 2)는, 단말(UE-e)을 위하여, 컴포넌트 CSI-RS configuration 0번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~30번)로써 설정된다. PRB 페어 0번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 5), RE(3, 5), RE(2, 4), 및 RE(3, 4)와 PRB 페어 0번 내의 슬롯1의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)는, 단말(UE-e)을 위하여, 컴포넌트 CSI-RS configuration 1번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~30번)로써 설정된다. PRB 페어 1번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)와 PRB 페어 1번 내의 슬롯1의 RE(2, 9), RE(3, 9), RE(2, 8), RE(3, 8), RE(2, 3), RE(3, 3), RE(2, 2), 및 RE(3, 2)는, 단말(UE-e)을 위하여, 컴포넌트 CSI-RS configuration 2번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~30번)로써 설정된다.

[319]

[320] 방법 Mb120은, 모든 컴포넌트 CSI-RS configuration에 PRB shift를 동일한 값으로 설정하는 방법이다.

[321] 방법 Mb120은 방법 Mb110에 비해, 설정에 다소 제한을 가하는 대신에, 시그널링 오버헤드를 줄일 수 있는 방법이다. 방법 Mb120에 의하면 모든 컴포넌트 CSI-RS configuration의 CSI-RS RE들이 동일한 PRB 페어 상에 맵핑되므로, 다수의 CSI-RS 안테나 포트를 집성하는 것이 어려울 수 있다.

[322]

[323] 방법 Mb130은, PRB shift가 단말에 시그널링되지 않고 미리 정해진 규칙을 따르는 방법이다.

[324] 방법 Mb130은 방법 Mb110과 방법 Mb120에 비해, 설정에 다소 제한을 가하는 대신에, 시그널링 오버헤드를 줄일 수 있는 방법이다. 미리 정해진 집성 규칙을 위한 한 방법으로써, PRB shift는 각 컴포넌트 CSI-RS configuration의 인덱스의 함수로 정해지는 방법이 고려될 수 있다. 예를 들어, 각 컴포넌트 CSI-RS configuration을 위한 PRB shift는 해당 컴포넌트 CSI-RS configuration 인덱스를 PRB 번들의 크기(N^bundle_RB)로 모듈로(modulo) 연산을 취한 결과값에 의해 정해질 수 있다 (이하 '방법 Mb130-1'). 또는, PRB 번들의 크기(N^bundle_RB)는 컴포넌트 CSI-RS configuration의 수로 정해지고, 각 컴포넌트 CSI-RS configuration을 위한 PRB shift는 해당 컴포넌트 CSI-RS configuration의 인덱스로 정해질 수 있다 (이하 '방법 Mb130-2').

[325] 이 때, CSI-RS 자원 집성을 위한 파라미터는, 각 컴포넌트 CSI-RS configuration의 CSI-RS 설정 정보만을 포함하거나, 모든 컴포넌트 CSI-RS configuration에 공통인 PRB 번들의 크기(N^bundle_RB)를 추가로 포함할 수도 있다.

[326]

[327] 도 19는 본 발명의 실시예에 따른, 방법 Mb130을 이용해 복수의 컴포넌트 CSI-RS configuration을 집성하는 방법을 나타내는 도면이다.

[328] 단말(UE-e)에게는, 방법 Mb130-1에 의해, 3개의 컴포넌트 CSI-RS configuration이 집성되어 총 10개의 CSI-RS 안테나 포트가 설정된다. 예를 들어, PRB 페어 0번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 5), 및 RE(3, 5)는, 단말(UE-e)을 위하여, 컴포넌트 CSI-RS configuration 0번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~18번)로써 설정된다. PRB 페어 1번 내의 슬롯1의 RE(5, 9), RE(6, 9), RE(5, 3), 및 RE(6, 3)는, 단말(UE-e)을 위하여, 컴포넌트 CSI-RS configuration 1번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~18번)로써 설정된다. PRB 페어 0번 내의 슬롯1의 RE(5, 9) 및 RE(6, 9)는, 단말(UE-e)을 위하여, 컴포넌트 CSI-RS configuration 2번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~16번)로써 설정된다.

[329] 이 경우에, 컴포넌트 CSI-RS configuration 0번 내지 컴포넌트 CSI-RS

configuration 2번을 위한 PRB 번들의 크기(N^bundle_RB)는 모두 2이다. 또한, 컴포넌트 CSI-RS configuration 0번 내지 컴포넌트 CSI-RS configuration 2번을 위한 PRB shift는 해당 컴포넌트 CSI-RS configuration 인덱스를 PRB 번들의 크기(N^bundle_RB)로 모듈로 연산을 취한 결과값, 즉, 0, 1, 및 0으로 각각 정해진다.단말(UE-f)에게는, 방법 Mb130-2에 의해, 8개의 CSI-RS 안테나 포트를 포함하는 컴포넌트 CSI-RS configuration 2개가 집성되어 총 16개의 CSI-RS 안테나 포트가 설정된다. 예를 들어, PRB 페어 0번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)는, 단말(UE-f)을 위하여, 컴포넌트 CSI-RS configuration 0번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~22번)로써 설정된다. PRB 페어 1번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)는, 단말(UE-f)을 위하여, 컴포넌트 CSI-RS configuration 1번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~22번)로써 설정된다.

[330] 이 경우에, PRB 번들의 크기(N^bundle_RB)는 컴포넌트 CSI-RS configuration의 수인 2로 정해진다. 또한, 컴포넌트 CSI-RS configuration 0번과 컴포넌트 CSI-RS configuration 1번을 위한 PRB shift는 해당 컴포넌트 CSI-RS configuration 인덱스, 즉, 0과 1로 각각 정해진다.

[331]

[332] 다음으로 방법 Mb200을 위한 CSI-RS 자원 집성 방법에 대하여 기술한다.

[333] 상술한 바와 마찬가지로, 집성되는 모든 컴포넌트 CSI-RS configuration들이 동일한 PRB 번들 크기를 가진다고 가정하면, CSI-RS 자원 집성을 위한 파라미터는, 각 컴포넌트 CSI-RS configuration에 대한 CSI-RS 설정 정보만을 포함하거나, 모든 컴포넌트 CSI-RS configuration에 공통인 PRB 번들의 크기(N^bundle_RB)를 추가로 포함할 수도 있다.

[334]

[335] 도 20은 본 발명의 실시예에 따른, 방법 Mb200의 PRB 번들링이 사용되는 경우에 복수의 컴포넌트 CSI-RS configuration을 집성하는 방법을 나타내는 도면이다.

[336] 구체적으로 도 20에는 PRB 번들 크기(N^bundle_RB)는 2이고, 집성되는 컴포넌트 CSI-RS configuration의 수는 2인 경우가 예시되어 있다.

[337] 컴포넌트 CSI-RS configuration 0번과 1번 모두에는 방법 Mb200의 PRB 번들링에 의해 확장된 CSI-RS 패턴이 적용되고, 컴포넌트 CSI-RS configuration 0번과 1번은 모두 8개의 CSI-RS 안테나 포트 수를 가진다. 예를 들어, PRB 페어 0번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 3), 및 RE(6, 3)와 PRB 페어 1번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 3), 및 RE(6, 3)는, 단말(UE-e)을 위하여, 컴포넌트 CSI-RS configuration 0번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~22번)로써 설정된다. PRB 페어 0번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 5), 및 RE(3, 5)와 PRB 페어 1번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 5), 및

RE(3, 5)는, 단말(UE-e)을 위하여, 컴포넌트 CSI-RS configuration 1번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~22번)로써 설정된다.

[338] 한편, 지금까지 상술한 복수의 PRB 페어를 번들링하여 CSI-RS 자원을 설정하는 모든 방법에 대하여, 서로 다른 서브프레임들에 대하여, PRB 페어의 인덱스를 주기적으로 교차하여 CSI-RS를 전송하는 방법이 적용될 수 있다.

[339]

[340] 도 21은 본 발명의 실시예에 따른, 번들링된 PRB 페어들의 인덱스를 시간적으로 교차시켜 CSI-RS를 전송하는 방법을 나타내는 도면이다.

[341] 도 13a 및 도 13b에 예시된 바와 같이, 기지국이 방법 Mb200에 따라 2개의 PRB 페어를 번들링하여 단말에게 12개의 CSI-RS 안테나 포트를 설정하는 경우에, 기지국은 도 21에 예시된 바와 같이, CSI-RS 전송 서브프레임마다 PRB 페어의 위치를 교대로 바꾸어 CSI-RS를 전송할 수 있다.

[342] 구체적으로, CSI-RS 전송 주기를 T라고 가정하면, CSI-RS 전송 서브프레임 n+T 내의 PRB 페어 0번과 1번의 위치가 CSI-RS 전송 서브프레임 n 내의 PRB 페어 0번과 1번의 위치와 맞바뀐 형태로, CSI-RS가 전송될 수 있다.

[343] 이를 통해, 단말은 각 CSI-RS 안테나 포트에 대하여, 시스템 대역 내 모든 PRB 페어의 주파수 영역을 위한 채널 추정을 수행할 수 있으므로, CSI 측정 정확도가 향상될 수 있다.

[344] 한편, 지금까지 상술한 복수의 PRB 페어를 번들링하여 CSI-RS 자원을 집성하는 모든 방법은, 제1 CSI-RS 설정을 위해 적용될 수 있다. 또한, 전술하였듯이, 상술한 CSI-RS 자원 집성 방법들은 새로운 CSI-RS 안테나 포트 수의 설정을 위해서도 동일하거나 유사하게 적용될 수 있다.

[345] 한편, 방법 Mb100 및 방법 Mb100의 세부 방법들에 CDM-4를 적용하는 방법으로써, PRB 번들링이 적용되지 않는 기존 규격의 경우와 마찬가지로, 각각의 컴포넌트 CSI-RS configuration 내에서 CDM-4를 적용하는 방법이 사용될 수 있다. 이 경우에, 컴포넌트 CSI-RS configuration의 안테나 포트 수가 4 또는 8이라면, 기존 규격의 CDM-4 패턴이 동일하게 적용될 수 있다. 반면에, 방법 Mb200 및 방법 Mb200의 세부 방법들에 CDM-4를 적용하기 위하여, 각각의 컴포넌트 CSI-RS configuration 내에서 CDM-4가 적용되면, CDM-4 패턴을 구성하는 RE들 간의 주파수 축 거리가 멀어져 채널 추정 성능이 열화될 수 있다. 이 경우에, 하나의 CDM-4 패턴이 복수(예를 들면, 2개)의 컴포넌트 CSI-RS configuration들 간에 걸쳐서 정의되도록 하는 방법이 사용될 수 있다.

[346]

[347] 2.3.2. 노멀 CP가 설정되는 경우에, TDD에만 적용되는 CSI-RS 자원 설정 방법

[348] 표 2에서 CSI-RS configuration 20~31번에 대한 CSI-RS 패턴과 자원 맵핑은, 안테나 포트 5번의 DMRS 전송 자원과의 오버랩을 피하기 위해 설계되었다. 이 때, PRB 번들링이 적용되지 않은 하나의 PRB 페어 내의 CSI-RS 자원 풀은 24개의 RE들을 포함한다. 이 경우에도, 앞서 기술한 모든 PRB 번들링 방법들과

그 원리가 동일 또는 유사하게 적용될 수 있다. 다만, 하나의 PRB 페어 내에서 24개가 넘는 수의 CSI-RS 안테나 포트의 패턴을 정의하거나 24개가 넘는 수의 CSI-RS 안테나 포트를 집성하는 것은 불가능하다.

[349]

[350] 2.3.3. 확장 CP가 설정되는 경우에, FDD와 TDD에 공통적으로 적용될 수 있는 CSI-RS 자원 설정 방법

[351] 확장 CP가 설정되는 경우에 FDD와 TDD에 공통적으로 적용되는 CSI-RS configuration은, 기존 규격 상에서 0번부터 15번까지 총 16개이다. 하나의 PRB 페어 내의 CSI-RS 자원 풀은 32개의 RE들을 포함한다. 이 경우에도, 앞서 기술한 모든 PRB 번들링 방법들과 그 원리가 동일 또는 유사하게 적용될 수 있다.

[352]

[353] 2.3.4. 확장 CP가 설정되는 경우에, TDD에만 적용되는 CSI-RS 자원 설정 방법

[354] 확장 CP가 설정되는 경우에, 기존 규격상의 CSI-RS configuration 16~27번의 CSI-RS 자원 설정은, 안테나 포트 5번의 DMRS 전송 자원과의 오버랩을 최대한 피하도록 설계된다. 이 경우에 하나의 PRB 페어 내의 CSI-RS 자원 풀은 24개의 RE들을 포함한다. 이 경우에도, 앞서 기술한 모든 PRB 번들링 방법들과 그 원리가 동일 또는 유사하게 적용될 수 있다. 다만, 하나의 PRB 페어 내에서 24개가 넘는 수의 CSI-RS 안테나 포트의 패턴을 정의하거나 24개가 넘는 수의 CSI-RS 안테나 포트를 집성하는 것은 불가능하다.

[355]

[356] 한편, 지금까지 하향링크 RS가 CSI-RS인 경우를 예로 들어, 본 발명의 실시예를 설명하였으나, 이는 예시일 뿐이다. 본 발명의 실시예는, 하향링크 RS가 CSI-RS가 아닌 다른 RS인 경우에도 적용될 수 있다.

[357]

[358] 3. CSI-RS 안테나 포트 배열을 고려한 자원 설정 방법

[359] 단말은 기지국으로부터 시그널링받은 CSI-RS 설정 정보(예, CSI-RS 안테나 포트 수, RE 맵핑 정보)에 기초하여, 설정받은 각 CSI-RS 안테나 포트에 대하여 채널 추정(예, 채널 정보 획득)을 수행한다. 그리고 나서 단말은 CSI-RS 안테나 포트들에 대하여 획득한 채널 정보를 기초로 하여, CSI 측정 및 보고를 수행한다. 여기서 CSI 측정은, 단말이 채널 추정을 통해 획득한 하향링크 채널 정보를 이용하여 PMI(precoding matrix indicator), RI(rank indicator), 그리고/또는 CQI(channel quality indicator)를 결정하는 일련의 과정을 의미한다. 현재 규격에 의하면, 단말은 CSI를 측정할 때 자신이 기지국에 보고한 PMI에 대응하는 프리코딩 행렬의 각 행이 CSI-RS 안테나 포트에 15번부터 순차적으로 대응됨을 가정한다. 예를 들어, 단말이 4개의 CSI-RS 안테나 포트를 설정받은 경우에, 단말은 기지국에 의해 이용되는 프리코딩 행렬의 1행 내지 4행이 CSI-RS 안테나 포트 15번 내지 18번의 채널을 위한 프리코딩 가중치임을 가정하고 CSI를 측정한다. 이 때, 단말은 총 CSI-RS 안테나 포트 수만을 알고 있을 뿐, CSI-RS

안테나 포트들이 실제로 어떤 배치를 갖는지 명시적으로(explicitly) 알지 못한다.

[360] 한편, 상술한 바와 같이, FD-MIMO(또는 3차원 MIMO) 시스템에서 기지국이 3차원 빔포밍을 수행하기 위해서는, 단말이 기존의 수평 축에 대한 CSI 뿐만 아니라 수직 축에 대한 CSI에 대해서도 CSI 측정 및 보고를 수행할 필요가 있다.

[361] 이하에서는, CSI-RS 안테나 포트 번호를, 셀 특정적(cell-specific) CSI-RS 안테나 포트 번호와 단말 특정적(user equipment-specific) CSI-RS 안테나 포트 번호로 구분하여 기술한다. 셀 특정적 CSI-RS 안테나 포트 번호는 기지국에 의해 전송되는 모든 CSI-RS 안테나 포트에 대하여 기지국의 입장에서 매겨지는 번호를 의미하는 것으로 가정하고, 셀 특정적 CSI-RS 안테나 포트 번호는 0번부터 순차적으로 번호 매김되는 것으로 가정한다. 단말 특정적 CSI-RS 안테나 포트는 각 단말에 설정된 CSI-RS 안테나 포트에 대하여 각 단말의 입장에서 매겨지는 번호를 의미하는 것으로 가정한다. LTE 규격에는, 단말의 CSI-RS 안테나 포트 번호가 15번부터 순차적으로 번호 매김되는 것으로 정의되어 있으나, 이하에서는 설명의 편의를 위하여, 0번부터 순차적으로 번호 매김되는 것으로 가정한다. 본 명세서에서, CSI-RS 안테나 포트 번호가 셀 특정적인 경우 또는 단말 특정적인 경우로 명시되지 않은 경우, 이는 단말 특정적 CSI-RS 안테나 포트 번호를 의미함을 가정한다.

[362]

[363] 3.1. 2차원 CSI-RS 안테나 포트 배열 정보를 설정하는 방법

[364] 2차원 CSI-RS 안테나 포트 배열을 위해 제1 차원(first dimension)과 제2 차원(second dimension)이 정의될 수 있다. 일반적으로 2차원 CSI-RS 안테나 포트 배열을 위한 제1 차원과 제2 차원은, 2차원 공간 상에서 두 개의 서로 다른 임의의 방향성을 나타낼 수 있다. 예를 들어, 제1 차원과 제2 차원은, 수평(horizontal) 차원과 수직(vertical) 차원을 포함할 수 있다. 수평 차원과 수직 차원은, 2차원 공간 상에서 두 개의 직교하는 임의의 차원 또는 방향성을 나타낼 수 있다. 예를 들어, 상기 2차원 공간은 CSI-RS 안테나 포트들이 맵핑되는 물리 안테나 요소들로 구성되는 2차원 안테나 배열 평면일 수 있다. 수평 차원 및 수직 차원은, 수평 축 및 수직 축, 또는 수평 방향 및 수직 방향과 동일한 의미로 사용될 수 있다. 이하에서는, 설명의 편의를 위해서, CSI-RS 안테나 포트 배열을 위한 제1 차원과 제2 차원을 수평 축과 수직 축으로 부르기로 한다.

[365] 한편, CSI-RS 안테나 포트 배열은 단일 편파(polarization)를 가질 수도 있고, 다중 편파를 가질 수도 있다. 여기서, CSI-RS 안테나 포트의 편파라 함은, CSI-RS 안테나 포트가 맵핑되는 물리 안테나 요소(들)이 가지는 편파를 의미한다. 이 때, CSI-RS 안테나 포트 배열을 위해, 상술한 공간 차원과는 별도로, 편파 차원이 정의될 수 있다. 본 명세서에서, CSI-RS 안테나 포트 배열을 위한 편파 차원은, CSI-RS 안테나 포트들이 맵핑되는 물리 안테나 요소들의 편파(예, 0도 내지 180도)로 구성되는 차원을 의미한다. 이하에서는, CSI-RS 안테나 포트 배열을 위한 편파 차원을 편파 축으로 부르기로 한다.

[366]

[367] 도 22은 2차원 CSI-RS 안테나 포트 배열의 예를 나타내는 도면이다.

[368] 구체적으로 도 22에는, 수평 축, 수직 축, 및 편파 축으로의 CSI-RS 안테나 포트 수가 모두 2이고, CSI-RS 안테나 포트 번호가, 0번부터 시작하여 수평 축, 편파 축, 및 수직 축의 순서로 번호 매김된 경우가 예시되어 있다. 여기서, 편파 축의 서로 다른 CSI-RS 안테나 포트들은, 서로 다른 편파를 갖는 물리 안테나 요소(들)에 맵핑되는 CSI-RS 안테나 포트들을 의미한다.

[369] 또한, 도 22에서 편파 축으로 존재하는 2개의 CSI-RS 안테나 포트 각각이 +45도와 -45도의 막대(bar)로써 표현된 것은, 일반적으로 이중 편파 안테나 배열로써 사용되는 교차 편파(cross-polarization) 안테나 배열에서, 2개의 CSI-RS 안테나 포트들 각각이 +45도 편파 안테나 요소(들)과 -45도 편파 안테나 요소(들) 각각에 맵핑되는 것을 의미한다. 그러나, 본 명세서의 도면들에서 이중 편파를 가지는 CSI-RS 안테나 포트 배열의 편파 방향성이 +45도와 -45도인 것은 단지 예시일 뿐, 본 발명의 범위가 이들 예에 의하여 한정되지 않는다.

[370] 상술한 바와 같이, CSI-RS 안테나 포트와 물리 안테나 요소(들) 간의 맵핑을 안테나 가상화(virtualization)라 한다. 이하에서 설명되는 기술의 원리는, 특정 안테나 가상화 방식에 의해 제약을 받지 않으므로, 이하에서는 안테나 가상화 방식에 대해서는 구체적으로 기술하지 않기로 한다.

[371] 단말은 CSI 측정 및 보고를 위해 이용되는 코드북의 형태에 따라, CSI-RS 안테나 포트 배열에 대하여 단일 편파 또는 이중 편파를 가정할 수 있다. 현재 규격에 의하면, 단말은 Release 8에 도입된 2개 또는 4개의 송신 안테나 포트를 위한 코드북을 CSI 보고에 이용하는 경우, CSI-RS 안테나 포트 배열이 단일 편파임을 가정할 수 있다. 반면에, 단말은 Release 10에 도입된 8개의 송신 안테나 포트를 위한 코드북 또는 Release 12에 추가로 도입된 4개의 송신 안테나 포트를 위한 코드북을 CSI 보고에 이용하는 경우, CSI-RS 안테나 포트 배열이 이중 편파임을 가정할 수 있다. 상기 코드북들은 1차원 CSI-RS 안테나 포트 배열을 통해 얻어지는 1차원 CSI를 보고하는 데 적합하며, 이러한 코드북을 1차원 코드북이라 부르기로 한다.

[372] 한편, 상술한 바와 같이, FD-MIMO 시스템을 위해, 단말이 2차원 CSI를 기지국에 보고하는 것이 필요할 수 있다. 2차원 CSI를 보고하는 데 적합한 코드북을 2차원 코드북이라 부르기로 한다. 단말은 2차원 코드북을 이용해, 2차원 CSI 뿐만 아니라 1차원 CSI도 보고할 수 있다. 단말은 2차원 코드북을 CSI 보고에 이용하는 경우, 2차원 CSI-RS 안테나 포트 배열의 공간 정보를 알아야 할 수 있다. 또는 단말은, 기지국에 PMI를 보고하지 않도록 설정된 경우라 하더라도, CQI 그리고/또는 RI를 결정하기 위해, 2차원 CSI-RS 안테나 포트 배열의 공간 정보를 알아야 할 수도 있다. 이와 별도로, 단말은 2차원 CSI-RS 안테나 포트 배열의 편파 정보를 알아야 할 수도 있다.

[373] 이하에서는, 2차원 CSI-RS 안테나 포트 배열의 수평 축과 수직 축의 CSI-RS

안테나 포트 수를 각각 N_1과 N_2라 한다. 2차원 CSI-RS 안테나 포트 배열이 단일 편파인 경우, N_1과 N_2의 곱은 2차원 CSI-RS 안테나 포트 배열의 총 CSI-RS 안테나 포트 수와 동일하고, 2차원 CSI-RS 안테나 포트 배열이 이중 편파인 경우, N_1과 N_2의 곱은 2차원 CSI-RS 안테나 포트 배열의 총 CSI-RS 안테나 포트 수의 절반이다.

[374] 단말이 CSI-RS 안테나 포트 배열의 편파 정보를 획득하기 위한 방법으로, 기지국이 단말에게 CSI-RS 안테나 포트 배열이 단일 편파인지 이중 편파인지를 알려주는 방법이 고려될 수 있다. 이를 위해, 기지국은 단말에게 편파 정보(예, 1비트)를 명시적으로 시그널링할 수 있다. 또는, 기지국은 단말에게 편파 정보를 암시적으로 알려줄 수 있다. 예를 들어, 기지국은 단말에게 2차원 CSI-RS 안테나 포트 배열의 총 CSI-RS 안테나 포트 수를 알려주고, 추가로 N_1과 N_2의 곱을 알려줄 수 있다. 단말은 N_1과 N_2의 곱이 총 CSI-RS 안테나 포트 수와 일치하는 경우, CSI-RS 안테나 포트 배열이 단일 편파임을 가정하고, N_1과 N_2의 곱이 총 CSI-RS 안테나 포트 수의 절반인 경우, CSI-RS 안테나 포트 배열이 이중 편파임을 가정할 수 있다. 다른 방법은, 단말에 의해 가정되는 편파 축 CSI-RS 안테나 포트 수를 코드북별로 규격에 미리 정의하는 방법이다. 예를 들어, 단말이 2차원 코드북을 CSI 보고에 이용하도록 설정된 경우, 단말이 CSI-RS 안테나 포트 배열을 이중 편파로 가정하는 것이 규격에 명시될 수 있다. 또 다른 방법은, 단말에 의해 가정되는 편파 축 CSI-RS 안테나 포트 수를 규격에 정의하지 않고, 이를 단말이 코드북의 형태에 따라 적절한 값을 가정하도록 하는 방법이다. 예를 들어, 2차원 코드북이 이중 편파 (또는 교차 편파) 안테나 포트 배열에 대한 CSI 보고에 적합함이 규격에 정의되고, 단말은 2차원 코드북을 CSI 보고에 이용하도록 설정된 경우, CSI-RS 안테나 포트 배열이 이중 편파임을 가정할 수 있다.

[375] 한편, 단말이 2차원 CSI-RS 안테나 포트 배열의 공간 정보를 획득하기 위한 방법으로, 기지국이 단말에게 2차원 CSI-RS 안테나 포트 배열의 공간 정보를 알려주는 방법이 고려될 수 있다. 이를 위해, 기지국은 단말에게 2차원 CSI-RS 안테나 포트 배열의 공간 정보를 시그널링할 수 있다. 구체적으로, 기지국은 단말에게 N_1과 N_2를 시그널링할 수 있다. 또는, 기지국은 단말에게 N_1과 N_2의 곱을 시그널링하고, 추가로 N_1과 N_2 중 하나를 시그널링할 수 있다. 이 때, CSI-RS 안테나 포트 배열이 단일 편파인지 또는 이중 편파인지와는 무관하게, 상기 방법들이 사용될 수 있다. 여기서, 시그널링은 명시적인 시그널링과 암시적인 시그널링을 모두 포함할 수 있다.

[376] 예를 들어, 기지국이 단말에게 도 22에 예시된 8개의 CSI-RS 안테나 포트들을 설정하고자 하는 경우에, 기지국은 단말에게 N_1=2 및 N_2=2를 시그널링하고, CSI-RS 안테나 포트 배열이 이중 편파임을 추가로 알려줄 수 있다. 다른 예를 들어, 주어진 코드북에 의해 CSI-RS 안테나 포트 배열이 단일 편파인지 또는 이중 편파인지가 미리 정의되고, 기지국이 단말에게 N_1=2 및 N_2=2를 시그널링할

수 있다. 또 다른 예를 들어, 기지국은 단말에게 총 CSI-RS 안테나 포트 수가 8임을 알려주고, 추가로 N_1=2 및 N_2=2를 시그널링할 수 있다. 또 다른 예를 들어, 기지국은 단말에게 총 CSI-RS 안테나 포트 수가 8임을 알려주고, 추가로 N_1과 N_2의 곱이 4임을 알려줄 수 있다. 또 다른 예를 들어, 기지국은 단말에게 총 CSI-RS 안테나 포트 수가 8임을 알려주고, CSI-RS 안테나 포트 배열의 공간 축 또는 편파 축 배치 구조를 알려주지 않을 수 있다.

[377] 상술한 바와 같이 본 명세서에서, 기지국이 단말에게 정보를 전달하기 위한 시그널링은, 물리계층 시그널링(예, 물리계층 제어 채널의 제어 필드 파라미터), MAC 시그널링(예, MAC PDU 형태의 제어 정보, 또는 MAC 헤더 형태의 제어 정보), RRC 시그널링(예, RRC 제어 메시지 또는 IE 형태의 제어 파라미터) 등을 포함할 수 있다. 특히, 물리계층 시그널링 또는 MAC 시그널링 방식을 통한 제어 시그널링은, 해당 단말을 위한 스케줄링 정보와 함께 구성되거나 또는 동시에 전송되는 방법을 통하여 동적(dynamic) 자원 활용이 가능하다는 장점을 가질 수 있다.

[378] 이하에서는, 단말이 설정받은 CSI-RS 안테나 포트들로 구성되는 CSI-RS 안테나 포트 배열 상에 단말 특정적 CSI-RS 안테나 포트 번호들이 맵핑되는 방법에 대하여 기술한다. 설명의 편의를 위해, CSI-RS 안테나 포트 배열은 일반적으로 2차원임을 가정한다. 그러나, 본 명세서에서, 따로 언급이 없더라도, 2차원 CSI-RS 안테나 포트 배열은 1차원 CSI-RS 안테나 포트 배열을 포함할 수 있고, 2차원 CSI-RS 안테나 포트 배열에 적용되는 방법들은 1차원 CSI-RS 안테나 포트 배열에도 동일 또는 유사하게 적용될 수 있다.

[379] 단말 특정적 CSI-RS 안테나 포트 번호가 2차원 CSI-RS 안테나 포트 배열 상에서 수평 축, 수직 축, 및 편파 축에 어떤 순서로 맵핑되는지를 미리 정해두는 방법(이하 '방법 Mc100')이 사용될 수 있다. 방법 Mc100은 단말이 N_1 및 N_2 값을 알고, 추가로 2차원 CSI-RS 안테나 포트 배열이 단일 편파인지 이중 편파인지를 알고 있는 경우에 적용될 수 있다.

[380]

[381] 도 23a 및 도 23b는 본 발명의 실시예에 따른, 2차원 CSI-RS 안테나 포트 배열에 단말 특정적 CSI-RS 안테나 포트 번호가 맵핑되는 방법을 나타내는 도면이다.

[382] 도 23a 및 도 23b에는, 기지국이 방법 Mc100에 기초해 단말에게 도 22에 예시된 8개의 CSI-RS 안테나 포트를 설정하는 경우에, 해당 단말이 CSI-RS 안테나 포트 배열 상에서 인식하는 단말 특정적 CSI-RS 안테나 포트 번호가 예시되어 있다.

[383] 구체적으로, 도 23a에는 단말 특정적 CSI-RS 안테나 포트 번호가 수평 축, 편파 축, 및 수직 축의 순서로 증가하는 경우가 예시되어 있다. 도 23b에는 단말 특정적 CSI-RS 안테나 포트 번호가 수직 축, 수평 축, 및 편파 축의 순서로 증가하는 경우가 예시되어 있다.

[384] 한편, 단말 특정적 CSI-RS 안테나 포트 번호가 2차원 CSI-RS 안테나 포트 배열 상에서 수평 축 및 수직 축에 어떤 순서로 맵핑되는지를 미리 정해두는

방법(이하 '방법 Mc101')이 사용될 수 있다. 방법 Mc101은 단말이 2차원 CSI-RS 안테나 포트 배열이 단일 편파인지 또는 이중 편파인지를 모르는 경우에 적용될 수 있다. 이 때, 2차원 CSI-RS 안테나 포트 배열이 단일 편파인지 또는 이중 편파인지와 무관하게, N_1과 N_2의 곱은 2차원 CSI-RS 안테나 포트 배열의 총 CSI-RS 안테나 포트 수와 동일할 수 있다. 예를 들어, 단말 특정적 CSI-RS 안테나 포트 번호가 0번부터 시작하여, 수평 축에 먼저 순차적으로 맵핑되고, 다음으로 수직 축에 맵핑될 수 있다.

[385] 방법 Mc100과 방법 Mc101의 CSI-RS 안테나 포트 번호 맵핑 규칙은, 상기와 같이 명시적으로 정의될 수 있다. 또는, 단말이 수평 축 PMI와 수직 축 PMI를 나누어 보고하는 경우 또는 단말이 수평 축 PMI, 수직 축 PMI, 및 편파 축 PMI를 나누어 보고하는 경우에, 방법 Mc100과 방법 Mc101의 CSI-RS 안테나 포트 번호 맵핑 규칙은, CSI 측정 시 단말에 의해 가정되는 기지국 프리코딩에 대한 정의를 통해, 암시적으로 정의될 수도 있다. 즉, 단말은 CSI 측정을 수행할 때, 단말은 기지국이 아래의 수학식 1의 프리코딩을 적용함을 가정할 수 있다.

[386] [수식1]

$$\begin{bmatrix} y^{(0)}(i) \\ \vdots \\ y^{(P-1)}(i) \end{bmatrix} = W(i) \cdot \begin{bmatrix} x^{(0)}(i) \\ \vdots \\ x^{(V-1)}(i) \end{bmatrix}$$

[387] 수학식 1에서, $x^{(m)}(i)$ (단, m=0,…,V-1)는 i번째 시점에서 m번째 데이터 레이어(layer)를 통해 전송되는 데이터 심볼을 의미하고, $y^{(n)}(i)$ (단, n=0,…,P-1)는 i번째 시점에서 n번째 CSI-RS 안테나 포트를 통해 전송되는 프리코딩된 데이터 심볼을 의미하고, W(i)는 P개의 행과 V개의 열로 구성되는, i번째 시점에서의 프리코딩 행렬을 의미한다. 여기서, P는 CSI-RS 안테나 포트 수이고, V는 데이터 레이어의 수이다. 이 때, 단말이 보고하는 수평 축 PMI, 수직 축 PMI, 및 편파 축 PMI에 대응하는 프리코딩 행렬 각각을, $W_1(i)$, $W_2(i)$, $W_P(i)$라 정의한다. 여기서, 수평 축 PMI의 행렬 및 $W_1(i)$는, N_1개의 행과, 단말이 보고하는 수평 축 랭크(rank)와 동일한 개수의 열을 가진다. 수직 축 PMI의 행렬 및 $W_2(i)$는 N_2개의 행과, 단말이 보고하는 수직 축 랭크와 동일한 개수의 열을 가진다. 편파 축 PMI의 행렬 및 $W_P(i)$는, 1개 또는 2개의 행을 가지고(예, CSI-RS 안테나 배열이 단일 편파인 경우에 1개의 행을 가지고, CSI-RS 안테나 배열이 이중 편파인 경우에 2개의 행을 가지고), 단말이 보고하는 편파 축 랭크와 동일한 개수의 열을 가진다.

[388] 상기 정의에 기초하면, W(i)는 $W_1(i)$, $W_2(i)$, 및 $W_P(i)$의 크로네커 곱(Kronecker product)으로 표현되거나, W(i)는 $W_1(i)$와 $W_2(i)$의 크로네커 곱으로 표현될 수 있다. 예를 들어, 방법 Mc100에서 CSI-RS 안테나 포트 배열 상에 단말 특정적 CSI-RS 안테나 포트 번호가 수평 축, 편파 축, 및 수직 축의 순서로 맵핑되도록 하는 방법은, 아래의 수학식 2와 같은 크로네커 곱의 순서를 가지도록 수학식

1의 W(i)를 정의할 수 있다.

[389] [수식2]

$$W(i) = W_2(i) \otimes W_P(i) \otimes W_1(i)$$

[390] 다른 예를 들어, 방법 Mc101에서 CSI-RS 안테나 포트 배열 상에 단말 특정적 CSI-RS 안테나 포트 번호가 수평 축에 먼저, 수직 축에는 나중에 맵핑되도록 하는 방법은, 아래의 수학식 3과 같이 수학식 1의 W(i)를 정의할 수 있다.

[391] [수식3]

$$W(i) = W_2(i) \otimes W_1(i)$$

[392] 또 다른 예를 들어, 방법 Mc101에서 CSI-RS 안테나 포트 배열 상에 단말 특정적 CSI-RS 안테나 포트 번호가 수직 축에 먼저, 수평 축에는 나중에 맵핑되도록 하는 방법은, 아래의 수학식 4와 같이 수학식 1의 W(i)를 정의할 수 있다.

[393] [수식4]

$$W(i) = W_1(i) \otimes W_2(i)$$

[394] 한편, 단말이 수평 축 PMI와 수직 축 PMI를 나누어 보고하지 않고 하나의 통합(joint) PMI를 보고하는 경우에, 기지국의 프리코더를 수학식 2 내지 수학식 4와 같이 수평 축 프리코더와 수직 축 프리코더로 구분하는 것이 성립되지 않을 수 있다. 이 경우에는, W(i)의 행 인덱스 p (단, p=0, 1, …, P-1)와 수평 축 CSI-RS 포트 인덱스 p_1 (단, p_1=0, 1, …, N_1-1), 수직 축 CSI-RS 포트 인덱스 p_2 (단, p_2=0, 1, …, N_2-1), 그리고/또는 편파 축 CSI-RS 포트 인덱스 p_P (단, 단일 편파인 경우 p_P=0, 이중 편파인 경우 p_P=0, 1) 간의 관계를 정의하는 방법(수학식 5, 수학식 6)이 고려될 수 있다. 예를 들어, 방법 Mc100에 대하여, 단말은 아래의 수학식 5를 가정할 수 있다.

[395] [수식5]

$$p = N_2 N_1 p_P + N_2 p_1 + p_2$$

[396] 수학식 5에 따르면, 단말은 CSI-RS 안테나 포트 배열 상에 단말 특정적 CSI-RS 안테나 포트 번호가 수직 축, 수평 축, 및 편파 축의 순서로 맵핑됨을 가정할 수 있다.

[397] 또 다른 예를 들어, 방법 Mc101에 대하여, 단말은 아래의 수학식 6을 가정할 수 있다.

[398] [수식6]

$$p = N_2 p_1 + p_2$$

[399] 수학식 6에 따르면, 단말은 CSI-RS 안테나 포트 배열 상에 단말 특정적 CSI-RS 안테나 포트 번호가 수직 축 및 수평 축의 순서로 맵핑됨을 가정할 수 있다.

[400] 방법 Mc100 및 방법 Mc101과 다른 방법으로써, 복수의 CSI-RS 안테나 포트 번호 맵핑 규칙을 미리 정해두고, 기지국이 단말에게 복수의 CSI-RS 안테나 포트

번호 맵핑 규칙 중에서 어떤 것을 적용할지를 시그널링하는 방법(이하 '방법 Mc110')이 고려될 수 있다.

[401] 예를 들어, 기지국은 단말에게 1 비트의 시그널링을 통해, 미리 정의된 맵핑 규칙1 및 맵핑 규칙2 중 어느 것을 따를 것을 지시할 수 있다. 구체적으로, 맵핑 규칙1은 CSI-RS 안테나 포트 배열 상에 CSI-RS 안테나 포트 번호가 수평 축, 편파 축, 및 수직 축의 순서로 증가하는 규칙이고, 맵핑 규칙2는 CSI-RS 안테나 포트 배열 상에 CSI-RS 안테나 포트 번호가 수직 축, 수평 축, 및 편파 축의 순서로 증가하는 규칙일 수 있다.

[402]

[403] 3.2. CSI-RS 안테나 포트 번호를 재배열하는 방법

[404] 도 24은 복수의 단말에게 서로 다른 CSI-RS 안테나 포트 집합을 설정하는 방법을 나타내는 도면이다.

[405] FD-MIMO 시스템에서는, 송신 안테나 배열의 크기가 증가함에 따라, 기지국이 복수의 단말에게 서로 다른 CSI-RS 안테나 포트 수를 설정하거나, 복수의 단말에게 안테나 배열의 서로 다른 부분을 이용하여 데이터를 전송하고자 할 수 있다. 예를 들어, 기지국이 16개의 TXRU(transceiver unit)를 가지는 경우에, 다중 안테나를 활용한 성능 이득을 충분히 얻기 위해서는, 단말에게 16개의 CSI-RS 안테나 포트를 전송하는 것이 유리하다. 그러나 어떤 단말은 16개의 CSI-RS 안테나 포트를 설정받는 것이 불가능할 수도 있다. 16개의 CSI-RS 안테나 포트를 설정받는 것이 불가능한 단말로는, 저비용(low-cost) 단말, LTE Release 13 이전의 기존(legacy) 단말 등일 수 있다. 이 때, 예를 들어, 기지국은 도 24에 예시된 바와 같이, 복수의 단말에게 서로 다른 CSI-RS 안테나 포트 배열 또는 집합(set)을 설정할 수 있다. 즉, 기지국은 단말(UE-a)에게 16개의 CSI-RS 안테나 포트(셀 특정적 CSI-RS 안테나 포트 0번~15번)를 설정하고, 단말(UE-b)에게 4개의 CSI-RS 안테나 포트(셀 특정적 CSI-RS 안테나 포트 9번, 10번, 13번, 14번)를 설정할 수 있다.

[406]

[407] 도 25a는 복수의 단말에 대한 CSI-RS 자원 설정의 예를 나타내는 도면이다.

[408] 도 24에 도시된 예시에서, 단말(UE-a)와 단말(UE-b) 각각은 16개와 4개의 CSI-RS 안테나 포트에 대한 자원 설정을 필요로 한다. 이 때, 기지국은 도 25a에 예시된 자원 할당과 같이, 단말(UE-a)와 단말(UE-b)를 위한 CSI-RS 자원 설정에 서로 다른 RE 집합을 할당할 수 있다. 예를 들어, 기지국은 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 9), RE(3, 9), RE(2, 8), RE(3, 8), RE(2, 5), RE(3, 5), RE(2, 4), RE(3, 4), RE(2, 3), RE(3, 3), RE(2, 2), 및 RE(3, 2)를, 단말(UE-a)을 위한 CSI-RS RE(예, 단말 특정적 CSI-RS 안테나 포트 0~15번)로써 설정할 수 있다. 기지국은 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 3), 및 RE(6, 3)를, 단말(UE-b)을 위한 CSI-RS RE(예, 단말 특정적 CSI-RS 안테나 포트 0~3번)로써 설정할 수 있다.

[409] 도 24 및 도 25a에 예시된 방법은, 각 단말을 위한 CSI-RS에 서로 다른 가상화(virtualization)를 적용할 수 있다는 장점을 가지지만, CSI-RS 전송에 소요되는 RE의 수가 증가되는 단점을 가질 수 있다. 기지국은 CSI-RS 전송 오버헤드를 고려하여, 더 적은 안테나 포트 수가 할당된 단말(UE-b)을 위한 CSI-RS RE 집합이 단말(UE-a)을 위한 CSI-RS RE 집합에 포함되도록 설정할 수 있다. 다시 말하면, 기지국은 서로 다른 CSI-RS 안테나 포트 집합이 설정된 복수의 단말로 하여금 CSI-RS 전송 자원을 최대한 공유하도록 설정할 수 있다. 그러나 현재 규격에 의하면, 일부 경우를 제외하고는, 기지국이 상기와 같이 복수의 단말로 하여금 CSI-RS 전송 자원을 공유하도록 설정하는 것이 어렵다.

[410] 이하에서는 상기 문제(예, CSI-RS 전송 오버헤드, CSI-RS 전송 자원 공유)를 해결하기 위한 방법으로써, 단말에 설정된 CSI-RS 안테나 포트들의 포트 번호를 재배열(re-ordering)하는 방법 (이하 방법 'Mc200')에 대하여 기술한다.

[411] 방법 Mc200에서, CSI-RS 안테나 포트들의 포트 번호를 재배열한다고 함은, 단말이 CSI-RS configuration 시그널링에 의해 설정받은 CSI-RS 안테나 포트들의 단말 특정적 포트 번호를 기존 포트 번호라고 할 때, 기존 포트 번호들을 새로운 포트 번호들로 대체함을 의미한다. 예를 들어, 단말이 4개의 CSI-RS 안테나 포트를 설정받은 경우, 포트 번호를 1번, 3번, 0번, 및 2번으로 재배열한다고 함은, CSI-RS 안테나 포트들의 기존 포트 번호 0번 내지 3번을 각각 1번, 3번, 0번, 및 2번으로 대체함을 의미한다. 다른 예를 들어, 8개의 포트를 갖는 컴포넌트 CSI-RS configuration 2개가 집성되어 총 16개의 CSI-RS 안테나 포트가 단말에 설정되는 경우에, 포트 번호를 재배열한다고 함은, 컴포넌트 CSI-RS configuration 0번을 구성하는 CSI-RS 안테나 포트의 기존 포트 번호 0~7번 및 컴포넌트 CSI-RS configuration 1번을 구성하는 CSI-RS 안테나 포트의 기존 포트 번호 0~7번을 새로운 포트 번호들(0~15번)로 대체함을 의미한다.

[412] 기존 규격에서, 단말에 설정된 CSI-RS 안테나 포트들의 포트 번호와 해당 CSI-RS RE 집합을 구성하는 RE들 간의 맵핑 관계는 도 1 내지 도 3에 도시되어 있다. 예를 들어, 단말이 표 2에 따라 CSI-RS configuration 0번에 의해 4개의 CSI-RS 안테나 포트를 설정받은 경우, CSI-RS 안테나 포트 0번과 1번(도 2에서의 15번과 16번)은 슬롯0의 RE(5,9) 및 RE(6,9)에 맵핑되고, CSI-RS 안테나 포트 2번과 3번(도 2에서의 17번과 18번)은 슬롯0의 RE(5,3) 및 RE(6,3)에 맵핑된다. 다른 예를 들어, 단말이 표 2에 따라 CSI-RS configuration 1번에 의해 8개의 CSI-RS 안테나 포트를 설정받은 경우, CSI-RS 안테나 포트 0번과 1번(도 3에서의 15번과 16번)은 슬롯1의 RE(2,11) 및 RE(3,11)에 맵핑되고, CSI-RS 안테나 포트 2번과 3번(도 3에서의 17번과 18번)은 슬롯1의 RE(2,5) 및 RE(3,5)에 맵핑되고, CSI-RS 안테나 포트 4번과 5번(도 3에서의 19번과 20번)은 슬롯1의 RE(2,10) 및 RE(3,10)에 맵핑되고, CSI-RS 안테나 포트 6번과 7번(도 3에서의 21번과 22번)은 슬롯1의 RE(2,4) 및 RE(3,4)에 맵핑된다.

[413]

[414] 도 25b는 본 발명의 실시예에 따른, 단말에 설정된 CSI-RS 안테나 포트들의 포트 번호가 방법 Mc200에 의해 재배열됨으로써, 포트 번호와 RE들 간의 맵핑 관계가 기존과 달라지는 경우를 나타내는 도면이다.

[415] 구체적으로 도 25b에는, 단말(UE-a)에게 4개의 CSI-RS 안테나 포트가 설정되고, 방법 Mc200에 의해, CSI-RS 안테나 포트들의 포트 번호가 0번, 2번, 1번, 및 3번으로 재배열되는 경우가 예시되어 있다.

[416] 기존 포트 번호 0번 내지 3번이 새로운 포트 번호 0번, 2번, 1번, 및 3번으로 대체됨에 따라, 기존의 맵핑 관계에서 CSI-RS 안테나 포트 0번 내지 3번이 맵핑되었던 RE 각각에, CSI-SR 안테나 포트 0번, 2번, 1번, 및 3번이 각각 맵핑된다. 즉, CSI-RS 안테나 포트 0번과 2번은 슬롯0의 RE(5,9) 및 RE(6,9)에 맵핑되고, CSI-RS 안테나 포트 1번과 3번은 슬롯0의 RE(5,3) 및 RE(6,3)에 맵핑된다.

[417] 한편, 도 25b에는, 단말(UE-b)에게 8개의 CSI-RS 안테나 포트가 설정되고, 방법 Mc200에 의해, CSI-RS 안테나 포트들의 포트 번호가 0번, 1번, 4번, 5번, 2번, 3번, 6번, 및 7번으로 재배열되는 경우가 예시되어 있다.

[418] 기존 포트 번호 0번 내지 7번이 새로운 포트 번호 0번, 1번, 4번, 5번, 2번, 3번, 6번, 및 7번으로 대체됨에 따라, 기존의 맵핑 관계에서 CSI-RS 안테나 포트 0번 내지 7번이 맵핑되었던 RE 각각에, CSI-RS 안테나 포트 0번, 1번, 4번, 5번, 2번, 3번, 6번, 및 7번이 각각 맵핑된다. 즉, CSI-RS 안테나 포트 0번과 1번은 슬롯1의 RE(2,11) 및 RE(3,11)에 맵핑되고, CSI-RS 안테나 포트 2번과 3번은 슬롯1의 RE(2,10) 및 RE(3,10)에 맵핑되고, CSI-RS 안테나 포트 4번과 5번은 슬롯1의 RE(2,5) 및 RE(3,5)에 맵핑되고, CSI-RS 안테나 포트 6번과 7번은 슬롯1의 RE(2,4) 및 RE(3,4)에 맵핑된다.

[419] 방법 Mc200에서, 단말이 CSI-RS 안테나 포트들의 포트 번호 재배열 정보를 획득하는 방법으로써, 기지국이 단말에게 포트 번호 재배열 정보를 알려주는 방법이 고려될 수 있다. 예를 들어, 기지국은 기존 포트 번호들을 대체할 새로운 포트 번호들을 단말에게 명시적으로 알려줄 수 있다. 다른 예를 들어, 기지국은 단말이 기존 포트 번호들을 대체할 새로운 포트 번호들을 알 수 있도록 하는 재배열 규칙을 단말에게 알려줄 수 있다.

[420] 도 25b의 예에서, 기지국은 단말(UE-a)에게 CSI-RS 안테나 포트 번호의 재배열 정보로써 새로운 포트 번호들의 순열 (0, 2, 1, 3)을 알려줄 수 있다. 또는, 기지국은 단말(UE-a)이 새로운 포트 번호 순열이 (0, 2, 1, 3)임을 알 수 있도록 하는 재배열 규칙을 단말(UE-a)에게 알려줄 수 있다. 또한, 기지국은 단말(UE-b)에게 CSI-RS 안테나 포트 번호의 재배열 정보로써 새로운 포트 번호들의 순열 (0, 1, 4, 5, 2, 3, 6, 7)을 알려줄 수 있다. 또는, 기지국은 단말(UE-b)이 새로운 포트 번호 순열이 (0, 1, 4, 5, 2, 3, 6, 7)임을 알 수 있도록 하는 재배열 규칙을 단말(UE-b)에게 알려줄 수 있다.

[421]

[422] 방법 Mc210은, 단말에 설정되는 CSI-RS 안테나 포트들에 적용되는 새로운 포트 번호들의 순열로써 가능한 모든 경우의 수를 정의하고, 이 중에서 하나를 단말에게 시그널링하는 방법이다.

[423] 방법 Mc210에서, 새로운 포트 번호들의 순열은 기존 포트 번호들의 순열을 포함할 수 있다. 방법 Mc210은 단말에 설정되는 CSI-RS 안테나 포트들의 포트 번호를 임의의 순서로 배열할 수 있다는 장점을 가지나, 반면에 시그널링 오버헤드가 크다는 단점을 가진다. 단말에 설정된 CSI-RS 안테나 포트 수를 N이라 할 때, N개의 포트 번호를 순서를 고려하여 나열하는 방법은 총 N!가지이므로, 방법 Mc200에 따른 시그널링에 소요되는 비트 수는, ceil($\log_2$(N!))을 따른다. 여기서 연산 부호 '!'는 팩토리얼(factorial) 연산을 나타내고, 'ceil()'은 올림(ceiling) 연산을 의미한다. 또는, CSI-RS 설정에 CDM-2가 적용되는 경우에, CSI-RS 안테나 포트 쌍이 CDM에 의해 동일 자원 상에 맵핑되면, 방법 Mc210에 따른 시그널링에 소요되는 비트 수는 1비트만큼 절약될 수 있다.

[424]

[425] 방법 Mc220은, 단말에 설정되는 CSI-RS 안테나 포트들에 적용되는 새로운 포트 번호들의 순열 (또는 새로운 포트 번호들의 순열을 생성하기 위한 규칙이나 정보)을 하나 또는 복수 개 미리 정의하고, 이 중에서 하나를 단말에게 시그널링하는 방법이다.

[426] 방법 Mc220에서, 새로운 포트 번호들의 순열은 기존 포트 번호들의 순열을 포함할 수 있다. 방법 Mc210과 방법 Mc220은 새로운 포트 번호들의 순열을 단말에게 암시적인 방법으로 시그널링하는 방법을 포함할 수 있다. 암시적인 시그널링의 경우, 기지국은 단말에게 새로운 포트 번호 순열 그 자체가 아니라, 단말에게 새로운 포트 번호 순열을 알릴 수 있는 규칙이나 정보를 시그널링할 수 있다.

[427] 방법 Mc220은 방법 Mc210에 비해 적은 시그널링 오버헤드를 가지는 방법이다. 방법 Mc220에서, 적어도 하나의 포트 번호 순열 또는 포트 번호 순열 생성 규칙을 정함에 있어서, CSI-RS 안테나 포트 배열의 형태와 CSI-RS 안테나 포트 배열 상의 포트 번호 맵핑 규칙이 고려될 수 있다.

[428]

[429] 도 26a 및 도 26b는 본 발명의 실시예에 따른, 방법 Mc220이 사용되는 경우에, 기지국이 단말에게 새로운 포트 번호 순열(sequence)을 알리기 위한 규칙(또는 정보)을 암시적인 시그널링을 통해 알려주는 경우를 나타내는 도면이다.

[430] 구체적으로 도 26a 및 도 26b에는, 단말에 설정된 16개의 CSI-RS 안테나 포트들이, CSI-RS 안테나 포트 배열(수평 축 포트 수=8, 수직 축 포트 수=1, 교차 편파)을 구성하는 경우가 예시되어 있다.

[431] 도 26a에는 기지국이 단말에 설정하고자 하는 CSI-RS 안테나 포트 배열 상의 포트 번호 맵핑(Mpr1, Mpr2, Mpr3, Mpr4)이 예시되어 있다. 한편, 도 26b에는 단말이 CSI 측정 및 보고를 수행할 때 가정하는 포트 번호 맵핑이 예시되어 있다.

구체적으로, 도 26b에 예시된 맵핑에 적용된 규칙은, CSI-RS 안테나 포트 배열에 공간 축(또는 수평 축), 편파 축의 순서로 포트 번호를 맵핑하는 규칙이다. 이 때, 단말이 CSI 측정 및 보고를 수행할 때 가정하는 포트 번호 맵핑 규칙은, 상술한 방법들이 적용되어, 규격에 미리 정의될 수 있다.

[432] 도 26a에 예시된 포트 번호 맵핑(Mpr1, Mpr2, Mpr3, Mpr4)은, 총 CSI-RS 안테나 포트들(16개의 CSI-RS 안테나 포트)을 하나 또는 복수의 CSI-RS 안테나 포트 그룹으로 나누고, 각 CSI-RS 안테나 포트 그룹 내에서 특정 순서(예, 공간 축, 편파 축의 순서)로 CSI-RS 안테나 포트 번호를 맵핑하는 규칙이 적용된 것이다. 이 때, 각 CSI-RS 안테나 포트 그룹 내에서 포트 번호가 맵핑되는 축의 순서는, 단말이 CSI 측정 및 보고를 수행할 때 가정하는 포트 번호 맵핑 축의 순서와 동일할 수 있다. 구체적으로, 포트 번호 맵핑(Mpr1)의 경우, 16개의 CSI-RS 안테나 포트들이 하나의 CSI-RS 안테나 포트 그룹(Vrg1)으로 나뉜다. 포트 번호 맵핑(Mpr2)의 경우, 16개의 CSI-RS 안테나 포트들이 2개의 CSI-RS 안테나 포트 그룹(Vrg2a, Vrg2b)으로 나뉜다. 포트 번호 맵핑(Mpr3)의 경우, 16개의 CSI-RS 안테나 포트들이 4개의 CSI-RS 안테나 포트 그룹(Vrg3a, Vrg3b, Vrg3c, Vrg3d)으로 나뉜다. 포트 번호 맵핑(Mpr4)의 경우, 16개의 CSI-RS 안테나 포트들이 8개의 CSI-RS 안테나 포트 그룹(Vrg4a, Vrg4b, Vrg4c, Vrg4d, Vrg4e, Vrg4f, Vrg4g, Vrg4h)으로 나뉜다. 이 때, CSI-RS 안테나 포트 그룹의 수는, 공간 축 CSI-RS 안테나 포트 수인 8의 약수들일 수 있다.

[433] 방법 Mc220을 위한 암시적인 시그널링의 예로써, 기지국이 단말에게 적어도 하나의 포트 번호 맵핑들 중에서 하나를 알려주는 방법(이하 '방법 Mc221')이 고려될 수 있다. 예를 들어, 기지국은 단말에게 도 26a에 예시된 포트 번호 맵핑(Mpr1, Mpr2, Mpr3, Mpr4) 중 하나를 단말에게 알려줄 수 있다. 방법 Mc221이 사용되는 경우에, 단말은 기지국으로부터 설정받은 맵핑의 포트 번호들이 CSI 측정 및 보고를 수행할 때 가정하는 맵핑의 포트 번호들에 일치되도록 한다. 이를 위해, 단말은 기지국으로부터 설정받은 맵핑의 포트 번호를 기존 포트 번호로 간주하고, CSI 측정 및 보고를 수행할 때 가정하는 맵핑의 포트 번호를 새로운 포트 번호로 간주하여, 기존 포트 번호들을 새로운 포트 번호들로 재배열할 수 있다.

[434] 도 26a의 예시에서, 기지국이 방법 Mc221을 기초로 하여 단말에게 포트 번호 맵핑(Mpr1)을 알려준 경우에, 맵핑(Mpr1)의 기존 포트 번호가 새로운 포트 번호와 일치하므로, 단말은 CSI-RS 안테나 포트 번호를 재배열할 필요가 없다. 한편, 기지국이 단말에게 포트 번호 맵핑(Mpr2)을 알려준 경우에, 단말은 맵핑(Mpr2)과 도 26b의 맵핑 간의 관계에 따라, 기존 CSI-RS 안테나 포트 번호 0번 내지 15번을, 각각 0번, 1번, 2번, 3번, 8번, 9번, 10번, 11번, 4번, 5번, 6번, 7번, 12번, 13번, 14번, 및 15번으로 대체할 수 있다. 또는 기지국이 단말에게 포트 번호 맵핑(Mpr3)을 알려준 경우에, 단말은 맵핑(Mpr3)과 도 26b의 맵핑 간의 관계에 따라, 기존 CSI-RS 안테나 포트 번호 0번 내지 15번을, 각각 0번, 1번, 8번,

9번, 2번, 3번, 10번, 11번, 4번, 5번, 12번, 13번, 6번, 7번, 14번, 및 15번으로 대체할 수 있다. 또는 기지국이 단말에게 포트 번호 맵핑(Mpr4)을 알려준 경우에, 단말은 맵핑(Mpr4)과 도 26b의 맵핑 간의 관계에 따라, 기존 CSI-RS 안테나 포트 번호 0번 내지 15번을, 각각 0번, 8번, 1번, 9번, 2번, 10번, 3번, 11번, 4번, 12번, 5번, 13번, 6번, 14번, 7번, 및 15번으로 대체할 수 있다.

[435]

[436] 도 26c, 도 26d, 도 26e, 및 도 26f는, 본 발명의 실시예에 따른, 방법 Mc221에 의해 기지국이 단말에게 도 26a에 예시된 포트 번호 맵핑(Mpr1~Mpr4) 중 하나를 알려주는 경우에, 단말이 CSI-RS RE 집합을 구성하는 RE들에 CSI-RS 안테나 포트 번호들을 맵핑하는 경우를 나타내는 도면이다.

[437] 구체적으로, 도 26c 내지 도 26f에는, 8개의 포트를 갖는 컴포넌트 CSI-RS configuration 2개(0번, 1번)가 집성되어, 총 16개의 CSI-RS 안테나 포트가 단말에 설정된 경우가 예시되어 있다. 이 때, 각 컴포넌트 CSI-RS configuration에는 기존 규격상의 8개 포트에 대한 CSI-RS 패턴이 동일하게 적용되었다. 즉, 컴포넌트 CSI-RS configuration 0번은 CSI-RS RE 집합을 구성하는 RE로써, 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)를 포함한다. 컴포넌트 CSI-RS configuration 1번은 CSI-RS RE 집합을 구성하는 RE로써, 슬롯1의 RE(2, 9), RE(3, 9), RE(2, 8), RE(3, 8), RE(2, 3), RE(3, 3), RE(2, 2), 및 RE(3, 2)를 포함한다. 도 26c 내지 도 26f에서, 컴포넌트 CSI-RS configuration 0번에 대응되는 CSI-RS 안테나 포트 번호는 0~7번이고, 컴포넌트 CSI-RS configuration 1번에 대응되는 CSI-RS 안테나 포트 번호는 8~15번임을 가정한다.

[438] 도 26c에 예시된 포트-RE 맵핑은 단말이 포트 번호 맵핑(Mpr1)을 설정받은 경우에 대응하고, 도 26d에 예시된 포트-RE 맵핑은 단말이 포트 번호 맵핑(Mpr2)을 설정받은 경우에 대응하고, 도 26e에 예시된 포트-RE 맵핑은 단말이 포트 번호 맵핑(Mpr3)을 설정받은 경우에 대응하고, 도 26f에 예시된 포트-RE 맵핑은 단말이 포트 번호 맵핑(Mpr4)을 설정받은 경우에 대응한다.

[439] 예를 들어, 단말이 방법 Mc221에 의해 포트 번호 맵핑(Mpr1)을 설정받은 경우에, 도 26c에 예시된 포트-RE 맵핑을 따를 수 있다. 즉, 단말은 맵핑(Mpr1)을 설정받은 경우에, CSI-RS 안테나 포트 번호를 재배열할 필요가 없으므로, 각 컴포넌트 CSI-RS configuration별로 기존 규격상의 포트-RE 맵핑을 따를 수 있다.

[440] 다른 예를 들어, 단말이 방법 Mc221에 의해 포트 번호 맵핑(Mpr2)을 설정받은 경우에, 도 26d에 예시된 포트-RE 맵핑을 따를 수 있다. 즉, 단말은 맵핑(Mpr2)과 도 26b의 맵핑 간의 관계에 따라, 기존 포트 번호 4~5번이 맵핑되었던 슬롯0의 RE(5, 8) 및 RE(6, 8)에 포트 번호 8~9번이 맵핑되고, 기존 포트 번호 6~7번이 맵핑되었던 슬롯0의 RE(5, 2) 및 RE(6, 2)에 포트 번호 10~11번이 맵핑되고, 기존 포트 번호 8~9번이 맵핑되었던 슬롯1의 RE(2, 9) 및 RE(3, 9)에 포트 번호 4~5번이 맵핑되고, 기존 포트 번호 10~11번이 맵핑되었던 슬롯1의 RE(2, 3) 및 RE(3, 3)에 포트 번호 6~7번이 맵핑됨을 가정할 수 있다.

[441] 또 다른 예를 들어, 단말이 방법 Mc221에 의해 포트 번호 맵핑(Mpr3)을 설정받은 경우에, 도 26e에 예시된 포트-RE 맵핑을 따를 수 있다. 즉, 단말은 맵핑(Mpr3)과 도 26b의 맵핑 간의 관계에 따라, 기존 포트 번호 2~3번이 맵핑되었던 슬롯0의 RE(5, 3) 및 RE(6, 3)에 포트 번호 8~9번이 맵핑되고, 기존 포트 번호 4~5번이 맵핑되었던 슬롯0의 RE(5, 8) 및 RE(6, 8)에 포트 번호 2~3번이 맵핑되고, 기존 포트 번호 6~7번이 맵핑되었던 슬롯0의 RE(5, 2) 및 RE(6, 2)에 포트 번호 10~11번이 맵핑되고, 기존 포트 번호 8~9번이 맵핑되었던 슬롯1의 RE(2, 9) 및 RE(3, 9)에 포트 번호 4~5번이 맵핑되고, 기존 포트 번호 10~11번이 맵핑되었던 슬롯1의 RE(2, 3) 및 RE(3, 3)에 포트 번호 12~13번이 맵핑되고, 기존 포트 번호 12~13번이 맵핑되었던 슬롯1의 RE(2, 8) 및 RE(3, 8)에 포트 번호 6~7번이 맵핑됨을 가정할 수 있다.

[442] 또 다른 예를 들어, 단말이 방법 Mc221에 의해 포트 번호 맵핑(Mpr4)을 설정받은 경우에, 도 26f에 예시된 포트-RE 맵핑을 따를 수 있다. 즉, 단말은 맵핑(Mpr4)과 도 26b의 맵핑 간의 관계에 따라, 기존 포트 번호 0~1번이 맵핑되었던 슬롯0의 RE(5, 9) 및 RE(6, 9)에 포트 번호 0번과 8번이 맵핑되고, 기존 포트 번호 2~3번이 맵핑되었던 슬롯0의 RE(5, 3) 및 RE(6, 3)에 포트 번호 2번과 10번이 맵핑되고, 기존 포트 번호 4~5번이 맵핑되었던 슬롯0의 RE(5, 8) 및 RE(6, 8)에 포트 번호 1번과 9번이 맵핑되고, 기존 포트 번호 6~7번이 맵핑되었던 슬롯0의 RE(5, 2) 및 RE(6, 2)에 포트 번호 3번과 11번이 맵핑되고, 기존 포트 번호 8~9번이 맵핑되었던 슬롯1의 RE(2, 9) 및 RE(3, 9)에 포트 번호 4번과 12번이 맵핑되고, 기존 포트 번호 10~11번이 맵핑되었던 슬롯1의 RE(2, 3) 및 RE(3, 3)에 포트 번호 6번과 14번이 맵핑되고, 기존 포트 번호 12~13번이 맵핑되었던 슬롯1의 RE(2, 8) 및 RE(3, 8)에 포트 번호 5번과 13번이 맵핑되고, 기존 포트 번호 14~15번이 맵핑되었던 슬롯1의 RE(2, 2) 및 RE(3, 2)에 포트 번호 7번과 15번이 맵핑됨을 가정할 수 있다.

[443]

[444] 도 26a에 예시된 바와 같이, 단말에게 설정된 총 CSI-RS 안테나 포트 수를 하나 또는 복수의 CSI-RS 안테나 포트 그룹으로 나누고 각 그룹 내에서부터 포트 번호를 맵핑하는 규칙이 사용되는 경우에, 기지국이 단말에게 포트 번호 맵핑 그 자체를 알려주는 대신, CSI-RS 안테나 포트 그룹의 수(이하 '

$$N_{group}$$

')를 알려주는 방법(이하 '방법 Mc222')이 고려될 수 있다. 또는, 이와 동등한 효과를 얻기 위해, 기지국이 단말에게 CSI-RS 안테나 포트 그룹의 크기(즉, CSI-RS 안테나 포트 그룹별 CSI-RS 안테나 포트 수, 이하 '

$$N_{ports}^{group}$$

')를 알려주는 방법(이하 '방법 Mc223')이 고려될 수 있다.

[445] 예를 들어, 도 26a에 예시된 맵핑(Mpr1, Mpr2, Mpr3, Mpr4)이 이용되는 경우에, 기지국은 방법 Mc222를 기초로 하여, 단말에게

$$N_{group}$$

값으로써, 1, 2, 4, 및 8 중에서 하나를 알려줄 수 있다. 또는, 기지국은 방법 Mc223을 기초로 하여, 단말에게

$$N_{ports}^{group}$$

값으로써, 16, 8, 4, 및 2 중에서 하나를 알려줄 수 있다.

[446] 방법 Mc221에서, 기지국이 단말에게 알려줄 수 있는 포트 번호 맵핑의 가짓수가 하나라 하더라도, 기지국은 단말에게 포트 번호 맵핑을 알려줄 수 있다. 예를 들어, 방법 Mc221을 위해, 도 26a에 예시된 포트 번호 맵핑(Mpr1, Mpr2, Mpr3, Mpr4) 중에서 포트 번호 맵핑(Mpr2)만이 이용될 수 있다. 이 경우에, 기지국은 단말에게 포트 번호 맵핑(Mpr2) 정보를 시그널링할 수 있다. 또는 기지국은 방법 Mc222를 기초로 하여, 단말에게

$$N_{group}$$

값으로써 2를 알려줄 수 있다. 또는 기지국은 방법 Mc223을 기초로 하여, 단말에게

$$N_{ports}^{group}$$

값으로써 8을 알려줄 수 있다.

[447] 방법 Mc221에서, 기지국이 단말에게 알려줄 수 있는 포트 번호 맵핑의 가짓수가 하나인 경우에, 포트 번호 맵핑 또는 그 규칙은 단말에 설정된 CSI-RS 안테나 포트 수별로 다를 수 있다. 예를 들어, 도 26a에 예시된 맵핑 규칙이 사용된다면, 단말에 설정된 CSI-RS 안테나 포트 수가 16인 경우에

$$N_{ports}^{group}$$

값은 8이고, 단말에 설정된 CSI-RS 안테나 포트 수가 12인 경우에

$$N_{ports}^{group}$$

값은 4일 수 있다. 이 때, 기지국은 방법 Mc223을 기초로 하여, 단말에 설정된 CSI-RS 안테나 포트 수가 16인 경우, 단말에게

$$N_{ports}^{group}$$

값으로써 8을 알려주고, 단말에 설정된 CSI-RS 안테나 포트 수가 12인 경우, 단말에게

N_{ports}^{group}

값으로써 4를 알려줄 수 있다.

[448] 도 26a에 예시된 맵핑 규칙이 적용되는 경우, CSI-RS 안테나 포트 그룹의 수(N_{group})는 CSI-RS 자원 집성에 이용되는 컴포넌트 CSI-RS configuration의 수로 정해질 수 있다. 예를 들어, 도 26c 내지 도 26f에 예시된 바와 같이, 8개의 포트를 갖는 컴포넌트 CSI-RS configuration 2개가 집성되어 16개의 CSI-RS 안테나 포트가 단말에 설정되는 경우에, CSI-RS 안테나 포트 그룹의 수(N_{group})는 2일 수 있다. 다른 예를 들어, 4개의 포트를 갖는 컴포넌트 CSI-RS configuration 3개가 집성되어 12개의 CSI-RS 안테나 포트가 단말에 설정되는 경우에, CSI-RS 안테나 포트 그룹의 수(N_{group})는 3일 수 있다.

[449] 한편, 방법 Mc220 내지 방법 Mc223이 사용되는 경우에, 단말이 가정하는 포트-RE 맵핑은, 수학식 7로 표현될 수 있다. 수학식 7에서, p'은 각 CSI-RS 안테나 포트 그룹별 CSI-RS 안테나 포트 번호를 의미하고, p는 단말에 설정된 전체 CSI-RS 안테나 포트들에 대한 새로운 포트 번호를 의미하고, i는 CSI-RS 안테나 포트 그룹의 색인을 의미한다. 수학식 7에서, p'은 각 CSI-RS 안테나 포트 그룹별로 0부터 (N_{ports}^{group} -1)까지의 정수 값을 가지고, p는 0부터 (N_{group} * N_{ports}^{group} -1)까지의 정수 값을 가지고, i는 0부터 (N_{group}

-1)까지의 정수 값을 가진다.

[450] 예를 들어,

N_{ports}^{group}

개의 포트를 갖는 컴포넌트 CSI-RS configuration가

N_{group}

개 집성되어 단말에게 총 (

N_{group}

*

N_{ports}^{group}

)개의 CSI-RS 안테나 포트가 설정되는 경우에, p'은 각 컴포넌트 CSI-RS configuration별 CSI-RS 안테나 포트 번호이고, p는 집성된 CSI-RS 안테나 포트들에 대한 새로운 포트 번호일 수 있다.

[451] [수식7]

$$p = \begin{cases} p' + \frac{N_{ports}^{group}}{2} i, & \text{for } p' \in \left\{0, \cdots, \frac{N_{ports}^{group}}{2} - 1\right\} \\ p' + \frac{N_{ports}^{group}}{2}(i + N_{group} - 1), & \text{for } p' \in \left\{\frac{N_{ports}^{group}}{2}, \cdots, N_{ports}^{group} - 1\right\} \end{cases}$$

[452] 구체적으로, 기지국이 방법 Mc221을 기초로 하여 단말에게 도 26a에 예시된 포트 번호 맵핑(Mpr2, Mpr3, Mpr4)을 알려주는 경우에, 단말은 수학식 7에 따라 기존 포트 번호들을 새로운 포트 번호들로 대체할 수 있다. 포트 번호 맵핑(Mpr2)의 경우,

N_{group}

은 2이고,

N_{ports}^{group}

는 8이다. 포트 번호 맵핑(Mpr3)의 경우,

N_{group}

은 4이고,

N_{ports}^{group}

는 4이다. 포트 번호 맵핑(Mpr4)의 경우,

N_{group}

은 8이고,

N_{ports}^{group}

는 2이다.

[453] 예를 들어, 단말이 기지국으로부터 포트 번호 맵핑(Mpr2)을 설정받은 경우에, 단말에게 설정되는 16개의 CSI-RS 안테나 포트는, 8개의 포트를 갖는 컴포넌트 CSI-RS configuration이 2개 집성된 것임을 가정하자. 이 때, 상술한 바와 같이, 각 CSI-RS 안테나 포트 그룹은 각 컴포넌트 CSI-RS configuration에 대응될 수 있다. 단말은 수학식 7에 따라, 컴포넌트 CSI-RS configuration 0번의 기존 포트 번호 15~18번을 새로운 포트 번호 15~18번으로 유지하고, 컴포넌트 CSI-RS configuration 0번의 기존 포트 번호 19~22번을 새로운 포트 번호 23~26번으로 대체하고, 컴포넌트 CSI-RS configuration 1번의 기존 포트 번호 15~18번을 새로운 포트 번호 19~22번으로 대체하고, 컴포넌트 CSI-RS configuration 1번의 기존 포트 번호 19~22번을 새로운 포트 번호 27~30번으로 대체할 수 있다. 예를 들어, 단말은 도 26c에 예시된 바와 같이 CSI-RS 자원을 설정받은 경우에, 수학식 7에 따라, 도 26d에 예시된 포트-RE 맵핑을 가정할 수 있다.

[454] 한편, 방법 Mc222 및 방법 Mc223이 사용되는 경우에도, 단말은 수학식 7에 따라 기존 포트 번호들을 새로운 포트 번호들로 대체할 수 있다. 예를 들어, 기지국은 포트 번호 맵핑(Mpr2)을 단말에게 알리기 위한 방법으로써, 방법 Mc222를 기초로, 단말에게

N_{group}

값으로써 2를 알려줄 수 있다. 또는 기지국은 포트 번호 맵핑(Mpr2)을 단말에게 알리기 위한 방법으로써, 방법 Mc223을 기초로, 단말에게

N_{ports}^{group}

값으로써 8을 알려줄 수 있다. 상기 경우에도, 상술한 바와 같이, 단말은 수학식 7에 따라, 각 CSI-RS 안테나 포트 그룹별(또는 각 컴포넌트 CSI-RS configuration별) 기존 포트 번호들을, 새로운 포트 번호들로 대체할 수 있다.

[455]

[456] 도 27은 본 발명의 실시예에 따른, 방법 Mc220이 사용되는 경우에, 복수의 단말에 대한 CSI-RS 안테나 포트 번호 맵핑을 나타내는 도면이다.

[457] 방법 Mc220에 따르면, 기지국은 16개의 CSI-RS 안테나 포트를 설정받을 수 있는 단말을 위한 CSI-RS 자원 설정과 8개의 CSI-RS 안테나 포트를 설정받을 수

있는 단말을 위한 CSI-RS 자원 설정이 일부 RE들을 공유하도록 할 수 있다. 예를 들어, 도 27에 예시된 바와 같이, 기지국이 단말(UE-a)에게 16개의 CSI-RS 안테나 포트를 설정하고 단말(UE-b)에게 16개의 CSI-RS 안테나 포트 중 좌측 4개 열에 해당하는 8개의 CSI-RS 안테나 포트를 설정하고자 하는 경우에, 기지국은 상술한 방법 Mc221의 실시예에 따라, 단말(UE-a)에게 도 26b에 예시된 CSI-RS 안테나 포트 번호 맵핑(Mpr2)을 따를 것을 지시할 수 있다.

[458] 이를 통해, 16개의 CSI-RS 안테나 포트를 설정받은 단말(UE-a)의 8개의 CSI-RS 안테나 포트와 8개의 CSI-RS 안테나 포트를 설정받은 단말(UE-b)의 8개의 CSI-RS 안테나 포트는 동일한 RE에 맵핑될 수 있다.

[459]

[460] 도 28은 본 발명의 실시예에 따른, 방법 Mc220이 사용되는 경우에, 복수의 단말에 대한 CSI-RS 자원 설정을 나타내는 도면이다.

[461] 구체적으로 도 28에는, 도 27에 예시된 CSI-RS 안테나 포트 배열 상의 포트 번호 맵핑이 사용되는 경우에, 단말(UE-a)와 단말(UE-b)에 대한 CSI-RS RE 맵핑이 예시되어 있다. 이 때, 8개의 포트를 갖는 컴포넌트 CSI-RS configuration 2개가 집성되어 총 16개의 CSI-RS 안테나 포트가 단말(UE-a)에게 설정된 경우가 예시되어 있다. 예를 들어, 서브프레임 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 9), RE(3, 9), RE(2, 8), RE(3, 8), RE(2, 5), RE(3, 5), RE(2, 4), RE(3, 4), RE(2, 3), RE(3, 3), RE(2, 2), 및 RE(3, 2)는, 단말(UE-a)을 위한 CSI-RS RE(예, CSI-RS 안테나 포트 0~15번)로써 설정된다. 동일 서브프레임 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 5), RE(3, 5), RE(2, 4), 및 RE(3, 4)는, 단말(UE-b)을 위한 CSI-RS RE(예, CSI-RS 안테나 포트 0~7번)로써 설정된다.

[462] 단말(UE-a)은 CSI 측정 및 보고를 수행하는 경우에, 도 26b의 포트 번호 맵핑을 가정할 수 있다. 이러한 경우에, 단말(UE-a)은 도 27의 맵핑과 도 26b의 맵핑 간의 관계에 따라, 기존 포트 번호 4~5번이 맵핑되었던 슬롯1의 RE(2, 10) 및 RE(3, 10)에 포트 번호 8~9번이 맵핑되고, 기존 포트 번호 6~7번이 맵핑되었던 슬롯1의 RE(2, 4) 및 RE(3, 4)에 포트 번호 10~11번이 맵핑되고, 기존 포트 번호 8~9번이 맵핑되었던 슬롯1의 RE(2, 9) 및 RE(3, 9)에 포트 번호 4~5번이 맵핑되고, 기존 포트 번호 10~11번이 맵핑되었던 슬롯1의 RE(2, 3) 및 RE(3, 3)에 포트 번호 6~7번이 맵핑됨을 가정할 수 있다. 단말(UE-a)에 설정된 16개의 CSI-RS 안테나 포트(0~15번) 중에서 CSI-RS 안테나 포트 0~3번 및 8~11번은, 단말(UE-b)에 설정된 CSI-RS 안테나 포트 0~7번과 동일한 CSI-RS RE 집합을 공유할 수 있다. 즉, 동일 서브프레임 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 5), RE(3, 5), RE(2, 4), 및 RE(3, 4)는, 단말(UE-a)의 CSI-RS 안테나 포트 0~3번 및 8~11번과 단말(UE-b)의 CSI-RS 안테나 포트 0~7번에 의해 공유된다.

[463] 이는, 도 25a에 예시된 CSI-RS 자원 설정 방법에 비해, CSI-RS 전송 오버헤드를 1/3 절감시킬 수 있다. 이와 유사하게, 기지국이 단말(UE-a)에게 16개의 CSI-RS

안테나 포트를 설정하고 단말(UE-b)에게 4개 또는 2개의 CSI-RS 안테나 포트를 설정하고자 하는 경우에, 기지국은 상술한 방법 Mc220의 실시예에 따라, 단말(UE-a)에게 도 26a에 예시된 CSI-RS 안테나 포트 번호 맵핑 규칙(Mpr3) 또는 CSI-RS 안테나 포트 번호 맵핑 규칙(Mpr4)을 따를 것을 지시할 수 있다. 이 때, 단말(UE-b)는 16개의 CSI-RS 안테나 포트를 설정받을 수 없는 기존 단말일 수 있다.

[464] 도 26a 및 도 26b에 예시된 실시예는 16개의 CSI-RS 안테나 포트를 위한 방법이지만, 이는 예시일 뿐이고, 여기에 적용된 CSI-RS 안테나 포트 번호 맵핑의 원리는 다른 수의 CSI-RS 안테나 포트가 설정되는 경우에도 유사하게 적용될 수 있다. 이 때, CSI-RS 안테나 포트 수를 N이라 하면, CSI-RS 안테나 포트 번호 맵핑 또는 CSI-RS 안테나 포트 번호 맵핑 규칙을 N의 약수의 개수만큼 정의하는 방법이 고려될 수 있다. 한편, 단말이 1보다 큰 수직 축 CSI-RS 안테나 포트 수를 설정받은 경우에도, 도 26a 및 도 26b에 예시된 실시예와 같이, 수평 축 및 편파 축에 대해서만 상술한 방법이 적용될 수도 있다.

[465]

[466] 도 29a, 도 29b, 도 29c, 도 29d, 및 도 29e는 본 발명의 다른 실시예에 따른, 방법 Mc221을 위해 사용될 수 있는 복수의 안테나 포트 번호 맵핑 규칙을 나타내는 도면이다.

[467] 구체적으로 도 29a 내지 도 29e는 수평 축, 수직 축, 및 편파 축으로 구성된 16개의 CSI-RS 안테나 포트에 포트 번호 0~15번을 맵핑하는 방법을 나타낸다.

[468] 도 26b에 예시된 실시예에 적용된 원리와 유사하게, 도 29a 내지 도 29e에 예시된 CSI-RS 안테나 포트 그룹 맵핑 규칙은, 전체 CSI-RS 안테나 포트들을 하나 또는 복수의 CSI-RS 안테나 포트 그룹으로 나누고, 각 CSI-RS 안테나 포트 그룹 내에서 특정 순서(예, 수평 축, 편파 축, 및 수직 축의 순서)로 CSI-RS 안테나 포트 번호를 순차적으로 부여한다.

[469] 구체적으로, 도 29a에 예시된 포트 번호 맵핑의 경우에, 16개의 CSI-RS 안테나 포트들이 하나의 CSI-RS 안테나 포트 그룹(Vrg5)으로 나뉜다. 또는 도 29b에 예시된 포트 번호 맵핑의 경우에, 16개의 CSI-RS 안테나 포트들이 2개의 CSI-RS 안테나 포트 그룹(Vrg6a, Vrg6b)으로 나뉜다. 또는 도 29c에 예시된 포트 번호 맵핑의 경우에, 16개의 CSI-RS 안테나 포트들이 4개의 CSI-RS 안테나 포트 그룹(Vrg7a, Vrg7b, Vrg7c, Vrg7d)으로 나뉜다. 또는 도 29d에 예시된 포트 번호 맵핑의 경우에, 16개의 CSI-RS 안테나 포트들이 4개의 CSI-RS 안테나 포트 그룹(Vrg8a, Vrg8b, Vrg8c, Vrg8d)으로 나뉜다. 또는 도 29e에 예시된 포트 번호 맵핑의 경우에, 16개의 CSI-RS 안테나 포트들이 8개의 CSI-RS 안테나 포트 그룹(Vrg9a, Vrg9b, Vrg9c, Vrg9d, Vrg9e, Vrg9f, Vrg9g, Vrg9h)으로 나뉜다. 이 때, 도 29a 내지 도 29e에 예시된 CSI-RS 안테나 포트 그룹에 포함되는 CSI-RS 안테나 포트 수는, 16개, 8개, 4개, 4개, 또는 2개로써, 총 CSI-RS 안테나 포트 수인 16의 약수들일 수 있다.

[470] 방법 Mc221이 사용되는 경우에, 기지국은 16개의 CSI-RS 안테나 포트를 설정받은 단말에게, 도 29a 내지 도 29e에 예시된 CSI-RS 안테나 포트 번호 맵핑 중 하나를 알려줄 수 있다. 상술한 바와 같이, 단말은 기지국으로부터 설정받은 CSI-RS 안테나 포트 번호 맵핑(도 29a 내지 도 29e에 예시된 CSI-RS 안테나 포트 번호 맵핑 중 하나)와 CSI 측정 및 보고를 수행할 때 가정하는 포트 번호 맵핑 간의 관계를 고려하여, CSI-RS 안테나 포트 번호를 재배열할 수 있다.

[471] 예를 들어, 단말이 CSI 측정 및 보고를 수행할 때 도 29a에 예시된 포트 번호 맵핑을 가정하고, 단말이 기지국으로부터 도 29a 내지 도 29e에 예시된 CSI-RS 안테나 포트 번호 맵핑 중에서 도 29c에 예시된 CSI-RS 안테나 포트 번호 맵핑을 설정 받는 경우를 가정하자. 단말은 기지국으로부터 설정받은 도 29c에 예시된 맵핑의 CSI-RS 안테나 포트 번호들을 기존 포트 번호로 간주하고, CSI 측정 및 보고를 수행할 때 가정하는 도 29a에 예시된 맵핑의 CSI-RS 안테나 포트 번호들을 새로운 포트 번호로 간주하여, 기존 포트 번호들을 새로운 포트 번호들로 대체할 수 있다. 즉, 단말은 도 29c의 맵핑과 도 29a의 맵핑 간의 관계에 따라, 기존 CSI-RS 안테나 포트 번호 0번 내지 15번을, 각각 0번, 4번, 8번, 12번, 1번, 5번, 9번, 13번, 2번, 6번, 10번, 14번, 3번, 7번, 11번, 및 15번으로 대체할 수 있다.

[472] 다른 예를 들어, 방법 Mc221이 사용되는 경우에, 기지국은 16개의 CSI-RS 안테나 포트를 설정받은 단말에게, 도 29a 내지 도 29c에 예시된 CSI-RS 안테나 포트 번호 맵핑 중 하나를 알려줄 수 있다.

[473] 한편, 도 29a 내지 도 29e의 예시에서, 기지국은 방법 Mc222를 기초로 하여, 단말에게 CSI-RS 안테나 포트 그룹의 수로써, 1, 2, 4, 및 8 중에서 하나를 알려줄 수 있다. 또는, 기지국은 방법 Mc223을 기초로 하여, 단말에게 CSI-RS 안테나 포트 그룹의 크기로써, 16, 8, 4, 및 2 중에서 하나를 알려줄 수 있다. 도 29c에 예시된 맵핑을 위한 CSI-RS 안테나 포트 그룹의 수와 크기는 도 29d에 예시된 맵핑을 위한 CSI-RS 안테나 포트 그룹의 수와 크기와 동일하므로, 방법 Mc222 또는 방법 Mc223이 사용되는 경우에, 도 29c에 예시된 맵핑과 도 29d에 예시된 맵핑은 구별되지 못할 수 있다. 따라서, 방법 Mc222 또는 방법 Mc223이 사용되는 경우에는, 서로 다른 맵핑이 동일한 CSI-RS 안테나 포트 그룹의 수와 크기를 갖지 않도록 정의되는 것이 필요하다. 예를 들어, 방법 Mc222 또는 방법 Mc223을 위해, 도 29c에 예시된 맵핑과 도 29d에 예시된 맵핑 중에서 어느 하나만이 이용될 수 있다.

[474] 한편, 도 29a 내지 도 29e에 예시된 바와 같이, CSI-RS 안테나 포트들이 수평 축 및 편파 축 뿐만 아니라 수직 축으로도 배치되어 있는 경우에는, 도 26b에 예시된 실시예와 달리, CSI-RS 안테나 포트들을 그룹화하는 방법이 더 다양할 수 있다.

[475] 한편, 방법 Mc220은 CSI-RS 안테나 포트 그룹의 개념 없이 간단한 형태로도 실시될 수 있다. 예를 들어, 기지국은 CSI-RS 안테나 포트 번호 맵핑에 방법 Mc100을 위한 맵핑 순서들 중 어떤 맵핑 순서를 적용할지를, 단말에게 알려줄 수

있다. 즉, CSI-RS 안테나 포트 번호가 수평 축, 편파 축, 및 수직 축의 순서로 매겨지는 방법 Mc100를 위한 맵핑 순서와, CSI-RS 안테나 포트 번호가 수직 축, 수평 축, 및 편파 축의 순서로 매겨지는 방법 Mc100를 위한 맵핑 순서가 사전에 정의되고, 기지국은 1 비트의 시그널링을 통해, 상기 2개의 맵핑 순서들 중 하나를 사용할 것을 단말에게 지시할 수 있다.

[476] 방법 Mc220에 따르면, CSI-RS 안테나 포트 번호 맵핑의 수가 적을 때는 시그널링 오버헤드가 작으나, CSI-RS 안테나 포트 번호 맵핑의 수에 따라 시그널링 오버헤드가 밑이 2인 로그 함수에 비례하여 증가한다. 따라서, CSI-RS 안테나 포트 번호 맵핑의 수가 매우 많은 경우에, 방법 Mc220은 오히려 비효율적일 수 있다.

[477]

[478] 3.3. 다양한 CSI-RS 안테나 포트 수의 설정 방법

[479] 한편, 기지국은 1차원 또는 2차원의 다양한 안테나 형상 및 안테나 배열의 크기를 가질 수 있다. 다양한 크기의 송신 안테나 형상에 대하여, 단말이 효율적인 CSI 측정을 수행하기 위해서는, 단말이 다양한 CSI-RS 안테나 포트 수를 설정받을 수 있도록 하는 것이 중요하다. 예를 들어, 단말에게 기존 규격상의 1, 2, 4, 또는 8개의 CSI-RS 안테나 포트뿐만 아니라 3, 5, 6, 또는 7개의 CSI-RS 안테나 포트를 설정할 수 있도록 하는 방법이 고려될 수 있다. CSI-RS 안테나 포트 수를 확장하는 경우에도, 예를 들어, 단말에게 2의 지수승(예, 16개, 32개, 또는 64개 등)의 CSI-RS 안테나 포트 수만을 설정할 수 있도록 정하는 방법이 있을 수 있으나, 임의의 자연수 또는 임의의 짝수 등과 같이 더 다양한 CSI-RS 안테나 포트 수를 단말에게 설정할 수 있도록 정하는 방법도 고려될 수 있다. 단말에게 다양한 CSI-RS 안테나 포트 수를 설정 가능하도록 하기 위해서는, 기존의 CSI-RS 설정 방법이 확장 또는 개선되어야 할 수 있다.

[480] 지금까지 기술된 방법들의 경우, 단말은 자신이 설정받은 모든 CSI-RS 안테나 포트들을 이용하여 CSI 측정 및 보고를 수행한다. 이하에서는 단말이 자신이 설정받은 CSI-RS 안테나 포트들 중 일부만을 이용하여 CSI 측정 및 보고를 수행하도록 하는 방법(이하 '방법 Mc300')에 대하여 기술한다.

[481] 방법 Mc300에서, 기지국은 CSI-RS configuration 시그널링에 의해 단말에게 설정된 CSI-RS 안테나 포트들 중에서, 단말이 실제 CSI 측정 및 보고에 이용할 CSI-RS 안테나 포트들을 시그널링을 통해 단말에게 알려줄 수 있다. 본 명세서에서, 방법 Mc300에 의해 선택되며 단말의 CSI 측정 및 보고에 이용되는 CSI-RS 안테나 포트를, 유효 CSI-RS 안테나 포트로 부르기로 한다. 단말은 CSI 측정 및 보고를 위해, 유효 CSI-RS 안테나 포트들에만 포트 번호를 새로 부여할 수 있다. 이 때, 유효 CSI-RS 안테나 포트에 부여되는 포트 번호를, 유효 CSI-RS 안테나 포트 번호로 부르기로 한다.

[482] 방법 Mc300에서, CSI-RS configuration 시그널링에 의해 단말에게 설정될 수 있는 CSI-RS 안테나 포트 수는 제한적일 수 있다. 예를 들어, CSI-RS configuration

시그널링에 의해 단말에게 설정될 수 있는 CSI-RS 안테나 포트 수는 1, 2, 4, 그리고 8을 포함할 수 있다. 다른 예를 들어, CSI-RS configuration 시그널링에 의해 단말에게 설정될 수 있는 CSI-RS 안테나 포트 수는 1, 2, 4, 8, 12, 그리고 16을 포함할 수 있다. 반면에, 유효 CSI-RS 안테나 포트 수는 더 다양한 값을 가질 수 있다. 예를 들어, 기지국은 단말에게 기존 규격상의 CSI-RS configuration 시그널링을 이용하여 8개의 CSI-RS 안테나 포트를 설정하고, 방법 Mc300을 이용하여, 이 중에서 5개의 CSI-RS 안테나 포트들만을 유효 CSI-RS 안테나 포트로 설정할 수 있다.

[483] 방법 Mc300 중에서 기지국이 유효 CSI-RS 안테나 포트들을 단말에게 알려주는 방법에 대하여, 먼저 기술한다.

[484] 방법 Mc310은, 단말에게 설정된 CSI-RS 안테나 포트들 각각에 대한 유효성 여부를, 단말에게 알리는 방법이다.

[485] 단말에게 설정된 CSI-RS 안테나 포트 수를 N이라 할 때, 방법 Mc310을 위해, 단말에게 길이 N인 비트맵을 시그널링하는 방법이 사용될 수 있다. 단말은 비트맵에 포함되는 각 비트의 이진 정보를 통해, 각 CSI-RS 안테나 포트의 유효성 여부를 알 수 있다. 예를 들어, 단말(UE-a)이 도 25a에 예시된 바와 같이 CSI-RS를 설정받은 경우에, 기지국은 해당 단말(UE-a)에게 방법 Mc310에 따라, 1111100010100111의 비트맵을 시그널링할 수 있다. 이 때, 비트맵에 포함되는 각 비트가 1이면 해당 CSI-RS 안테나 포트가 유효함(즉, CSI 측정 및 보고에 이용됨)을 의미할 수 있고, 0이면 해당 CSI-RS 안테나 포트가 유효하지 않음을 의미할 수 있다. 비트맵의 MSB(most significant bit)는 방법 Mc300이 적용되기 전에 단말에게 설정된 CSI-RS 안테나 포트 0번(예, LTE 규격에서는 15번)에 대응하고, 비트맵의 LSB(least significant bit)으로 갈수록 CSI-RS 안테나 포트 번호가 증가함을 가정한다. 단말(UE-a)은 1111100010100111 비트맵의 수신을 통해, CSI-RS configuration 시그널링에 의해 원래 설정받은 총 16개의 CSI-RS 안테나 포트들 중에서 총 10개의 CSI-RS 안테나 포트들이 유효함을 인식할 수 있다. 여기서, 선택된 10개의 유효 CSI-RS 안테나 포트는 1111100010100111 비트맵의 비트들 중 1 값을 가지는 비트에 대응한다. 이 때, 10개의 유효 CSI-RS 안테나 포트들에 0번부터 9번까지의 유효 CSI-RS 안테나 포트 번호가 부여될 수 있다. 이 경우에, 단말(UE-a)에게 최종적으로 설정된 CSI-RS 안테나 포트들에 대한 RE 맵핑은, 도 30에 예시된 바와 같을 수 있다.

[486]

[487] 도 30는 본 발명의 실시예에 따른, 방법 Mc310이 사용되는 경우에, CSI-RS 자원 설정을 나타내는 도면이다.

[488] 서브프레임 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 9), RE(3, 9), RE(2, 5), RE(3, 5), RE(2, 3), RE(3, 3), RE(2, 2), 및 RE(3, 2)는, 단말(UE-a)을 위한 CSI-RS RE(예, 유효 CSI-RS 안테나 포트 0~9번)로써 설정된다. 특히, 서브프레임 내의 슬롯1의 RE(2, 10) 및 RE(3, 10)에는,

단말(UE-a)을 위한 하나의 유효 CSI-RS 안테나 포트(4번)가 맵핑되고, 서브프레임 내의 슬롯1의 RE(2, 9) 및 RE(3, 9)에는, 단말(UE-a)을 위한 하나의 유효 CSI-RS 안테나 포트(5번)가 맵핑된다. 단말(UE-a)은 상기 선택된 10개의 유효 CSI-RS 안테나 포트들(0~9번)만을 이용하여, CSI 측정 및 보고를 수행할 수 있다.

[489] 다른 예를 들어, 단말(UE-b)가 도 25a에 예시된 바와 같이 CSI-RS를 설정받은 경우에, 기지국은 단말(UE-b)에게 방법 Mc310에 따라, 1010 비트맵을 시그널링할 수 있다. 단말(UE-b)은 1010 비트맵의 수신을 통해, CSI-RS configuration 시그널링에 의해 원래 설정받은 총 4개의 CSI-RS 안테나 포트들 중에서 총 2개의 CSI-RS 안테나 포트들이 유효함을 인식할 수 있다. 여기서, 상기 선택된 2개의 유효 CSI-RS 안테나 포트는, 1010 비트맵의 비트들 중 1 값을 가지는 비트에 대응한다.

[490] 이 때, 단말(UE-b)은 상기 선택된 2개의 유효 CSI-RS 안테나 포트들에 0번과 1번의 포트 번호를 순차적으로 부여할 수 있다. 이 경우에, 단말(UE-b)에게 설정된 유효 CSI-RS 안테나 포트들에 대한 RE 맵핑은, 도 30에 예시된 바와 같을 수 있다. 예를 들어, 서브프레임 내의 슬롯0의 RE(5, 9) 및 RE(6, 9)에는, 단말(UE-b)을 위한 하나의 유효 CSI-RS 안테나 포트(0번)가 맵핑되고, 서브프레임 내의 슬롯0의 RE(5, 3) 및 RE(6, 3)에는, 단말(UE-b)을 위한 하나의 유효 CSI-RS 안테나 포트(1번)가 맵핑된다. 단말(UE-b)는 상기 선택된 2개의 유효 CSI-RS 안테나 포트들(0번, 1번)만을 이용하여, CSI 측정 및 보고를 수행할 수 있다.

[491] 한편, CSI-RS configuration에 의해 단말에게 설정되는 CSI-RS 안테나 포트들 중에서 CDM이 적용되는 2개의 CSI-RS 안테나 포트들(하나의 포트 쌍)은, 2개의 RE를 공유한다. 즉, 방법 Mc300이 적용되기 전의 CSI-RS configuration에 의한 CSI-RS 안테나 포트 2k번과 2k+1번(단, k=0, 1, 2,...)은 포트 쌍을 이루고, 동일 자원을 통해 전송될 수 있다. 이를 고려하여, 단말에게 설정된 CSI-RS 안테나 포트 수를 N이라 할 때, 방법 Mc310을 위해 단말에게 길이 N/2인 비트맵을 시그널링하는 방법이 사용될 수 있다. 이 때, 비트맵의 각 비트는 CDM을 통해 묶이는 각 CSI-RS 안테나 포트 쌍에 대한 유효성 여부를 의미할 수 있다. 예를 들어, 비트맵의 첫 번째 비트는 CSI-RS configuration에 의한 CSI-RS 안테나 포트 0번과 1번에 대응하고, 비트맵의 두 번째 비트는 CSI-RS configuration에 의한 CSI-RS 안테나 포트 2번과 3번에 대응할 수 있다.

[492] 방법 Mc320은, 단말에게 설정된 CSI-RS 안테나 포트 배열의 각 행(row)과 각 열(column)에 대한 유효성 여부를 알리는 방법이다.

[493] 방법 Mc310에서와 마찬가지로, 방법 Mc320을 위해, 단말에게 비트맵을 시그널링하는 방법이 사용될 수 있다. 단말에게 설정된 수평 축과 수직 축 CSI-RS 안테나 포트 수 각각을 N_1와 N_2라 할 때, 단말에게 시그널링되는 비트맵의 길이는 N_1와 N_2의 합이 될 수 있다. 예를 들어, 비트맵에서 N_2개의

최상위 비트들이 N_2개의 행에 대한 유효성 여부를 나타내고, 비트맵에서 N_1개의 최하위 비트들이 N_1개의 열에 대한 유효성 여부를 나타낸다고 가정하자. 만약 기지국이 단말에게 N_2=2 및 N_1=8로 설정하고 1011110000 비트맵을 단말에게 시그널링한 경우에, 단말은 1011110000 비트맵을 통해서, 단말에게 설정된 CSI-RS 안테나 포트 배열(2x8)에 속한 2개의 행 중에서 첫 번째 행이 선택되고, 해당 CSI-RS 안테나 포트 배열(2x8)에 속한 8개의 열 중에서 첫 번째 열 내지 네 번째 열이 선택되었음을 인식할 수 있다.

[494] 따라서, 단말에게 설정된 CSI-RS 안테나 포트들이 2차원 배열로 배치되어 있는 경우에, 방법 Mc320은 단말에게 전송되는 비트맵의 길이를 줄일 수 있다는 장점을 가진다. 반면에, 단말에게 설정된 CSI-RS 안테나 포트들이 1차원 배열로 배치되는 경우에는, 방법 Mc320에 따른 시그널링 오버헤드는 방법 Mc310에 따른 시그널링 오버헤드와 동일할 수 있다. 한편, 방법 Mc320에서 CSI-RS 안테나 포트 배열이 도 24 내지 도 29e에 예시된 바와 같이 교차 편파 배열인 경우에, 단말에게 시그널링되는 비트맵의 각 비트는 서로 다른 편파를 갖는 CSI-RS 안테나 포트 쌍(들)에 대응할 수 있다.

[495] 상술한 바와 같이, 방법 Mc300에서, 방법 Mc310 또는 방법 Mc320을 통해 단말이 유효 CSI-RS 안테나 포트들을 알고 나면, 단말은 유효 CSI-RS 안테나 포트들에 대하여 포트 번호를 새로 부여할 수 있다. 이 때, CSI-RS 안테나 포트 배열 상의 포트 번호 맵핑 규칙으로는, 상기 방법들(예, 방법 Mc100, 방법 Mc101, 방법 Mc200, 방법 Mc220 등)뿐만 아니라 이와 다른 방법들이 사용될 수 있다. 즉, 방법 Mc300을 위해, 방법 Mc310 또는 방법 Mc320의 시그널링 방법과 방법 Mc100 내지 방법 Mc220의 CSI-RS 안테나 포트 배열 상의 포트 번호 맵핑 방법이 결합되어 사용될 수 있다. 이에 대하여, 도 31을 참고하여 설명한다.

[496]

[497] 도 31은 본 발명의 실시예에 따른, 방법 Mc310이 사용되는 경우에, CSI-RS 안테나 포트 번호 맵핑을 나타내는 도면이다.

[498] 구체적으로, 도 31에는 기지국이 단말(UE-a)에게 16개의 CSI-RS 안테나 포트와 N_1=8 및 N_2=1을 설정하고, 방법 Mc310에 기초해 단말(UE-a)에게 1111100011111000 비트맵을 시그널링하는 경우가 예시되어 있다. 이 때, 도 31의 (a1)에 예시된 바와 같이, CSI-RS 안테나 포트 배열 상의 포트 번호(0~15번)는 수평 축 및 편파 축의 순서로 부여될 수 있다.

[499] 단말(UE-a)은 방법 Mc310에 의해 설정받은 총 10개의 유효 CSI-RS 안테나 포트들(포트 번호 0~4번, 포트 번호 8~12번)에, 유효 CSI-RS 안테나 포트 번호를 0번부터 9번까지 새롭게 맵핑할 수 있다. 예를 들어, 단말(UE-a)은 도 31의 (b1)에 예시된 바와 같이, 상기 선택된 10개의 유효 CSI-RS 안테나 포트에 수평 축 및 편파 축의 순서로 유효 CSI-RS 안테나 포트 번호(0~9번)를 부여할 수 있다. 단말(UE-a)은 10개의 유효 CSI-RS 안테나 포트(유효 포트 번호 0~9번)에 대하여 CSI 측정 및 보고를 수행할 수 있다.

[500] 한편, 방법 Mc300에서 기지국이 단말에게 CSI-RS를 전송하는 경우에, 기지국이 단말에게 CSI-RS configuration 시그널링을 통해 설정된 CSI-RS 안테나 포트(방법 Mc300이 적용되기 전의 CSI-RS 안테나 포트) 모두를 송신하는 방법(이하 '방법 Mc330')이 사용될 수 있다. 또는 방법 Mc300에서 기지국이 단말에게 CSI-RS를 전송하는 경우에, 기지국이 유효 CSI-RS 안테나 포트들(예, 비트맵의 비트들 중 1 값을 가지는 비트에 대응하는 CSI-RS 안테나 포트)만을 단말에게 전송하는 방법(이하 ' 방법 Mc331')이 사용될 수도 있다.

[501] 방법 Mc331이 사용되는 경우에, 유효 CSI-RS 안테나 포트들이 맵핑되는 RE들의 위치는, CSI-RS configuration 시그널링에 의한 RE 맵핑(방법 Mc300에 의해 CSI-RS 안테나 포트들이 선택되기 이전)을 따를 수 있다.

[502] 한편, 기존 규격에 따르면, 단말은 PDSCH RE 맵핑 및 PDSCH 레잇 매칭을 수행할 때, CSI-RS configuration 시그널링에 의해 설정받은 CSI-RS RE 집합에 PDSCH가 맵핑되지 않음을 가정한다. 방법 Mc300이 사용되는 경우에, PDSCH가 맵핑되지 않는 CSI-RS RE 집합이, CSI-RS configuration에 의해 단말에게 설정된 CSI-RS 안테나 포트들의 RE 집합(방법 Mc300이 사용되기 전의 CSI-RS RE 집합)과 방법 Mc300에 의한 유효 CSI-RS 안테나 포트들의 RE 집합 중 어느 것을 의미하는지 정의될 필요가 있다. 예를 들어, 도 30에 예시된 단말(UE-a)을 가정하자. CSI-RS RE 집합에 대한 전자의 정의에 따르면, 단말(UE-a)은 슬롯1의 RE(2, 4), RE(3, 4), RE(2, 8), 및 RE(3, 8)에서 PDSCH를 수신할 수 없다. CSI-RS RE 집합에 대한 후자의 정의에 따르면, 단말(UE-a)은 슬롯1의 RE(2, 4), RE(3, 4), RE(2, 8), 및 RE(3, 8)에서 PDSCH를 수신할 수 있다. CSI-RS RE 집합에 대한 전자의 정의를 이용하는 방법은, 기지국의 CSI-RS 전송에 방법 Mc330 또는 방법 Mc331이 적용되는 경우를 위해 고려될 수 있다. CSI-RS RE 집합에 대한 후자의 정의를 이용하는 방법은, 기지국의 CSI-RS 전송에 방법 Mc331이 적용되는 경우를 위해서 고려될 수 있다.

[503] 이하에서는 방법 Mc300의 다른 실시예들에 대하여 기술한다.

[504]

[505] 도 32a, 도 32b, 및 도 32c는 방법 Mc300을 위한 다른 실시예를 나타내는 도면이다.

[506] 도 32a 내지 도 32c에서 (a1)은 4개의 CSI-RS 안테나 포트가 1차원 교차 편파 배열로 배치되는 경우를 나타낸다. 여기서, 셀 특정적 CSI-RS 안테나 포트 번호는 수평 축 및 편파 축의 순서로 맵핑됨을 가정하였다.

[507] 이 때, 기지국은 단말(UE-c), 단말(UE-d), 및 단말(UE-e)로 하여금 각각 셀 특정적 CSI-RS 안테나 포트 0~3번, 셀 특정적 CSI-RS 안테나 포트 0번과 2번, 및 셀 특정적 CSI-RS 안테나 포트 1번과 3번에 대하여 CSI 측정 및 보고를 수행하도록 설정하고자 할 수 있다.

[508] 이를 위한 평범한(trivial) 방법은, 각 단말(UE-c, UE-d, UE-e)의 CSI-RS를 서로 다른 자원 영역에 겹치지 않도록 설정하는 것이다. 이 때, 단말들(UE-c, UE-d,

UE-e)을 위한 CSI-RS가 동일한 서브프레임에 설정됨을 가정하면, 하나의 PRB 페어 내에서 CSI-RS 전송을 위해 소요되는 총 RE의 수는 8개이다. 반면에 방법 Mc300과 방법 Mc310이 사용되면, 기지국은 3개의 단말들(UE-c, UE-d, UE-e)에 대한 CSI-RS 전송이 하나의 PRB 페어 내에서 4개의 RE들만을 차지하도록 설정할 수 있다. 구체적으로, 기지국은 단말(UE-c), 단말(UE-d), 및 단말(UE-e)에게 동일한 CSI-RS configuration 시그널링을 통해 4개의 CSI-RS 안테나 포트를 설정하고, 방법 Mc310에 따라, 단말(UE-c)에게 1111 비트맵을, 단말(UE-d)에게 1010 비트맵을, 단말(UE-e)에게 0101 비트맵을 추가로 시그널링할 수 있다.

[509] 1111 비트맵을 시그널링 받은 단말(UE-c)은 CSI-RS configuration 시그널링에 의해 설정받은 4개의 CSI-RS 안테나 포트들 모두에 유효 포트 번호(0~3번)를 부여할 수 있다. 결과적으로, 도 32a의 (b1)에 예시된 바와 같이, 단말(UE-c)은 수평 축의 길이가 2인 1차원 교차 편파 CSI-RS 안테나 포트 배열(Apa1a)에 대하여, CSI 측정 및 보고를 수행할 수 있다.

[510] 1010 비트맵을 시그널링 받은 단말(UE-d)은 CSI-RS configuration 시그널링에 의해 설정받은 4개의 CSI-RS 안테나 포트들 중 포트 0번과 2번에만 유효 포트 번호(0번, 1번)를 부여할 수 있다. 결과적으로, 도 32b의 (b2)에 예시된 바와 같이, 단말(UE-d)은 수평 축의 길이가 1인 교차 편파 CSI-RS 안테나 포트 배열(Apa1b)에 대하여, CSI 측정 및 보고를 수행할 수 있다.

[511] 0101 비트맵을 시그널링 받은 단말(UE-e)은 CSI-RS configuration 시그널링에 의해 설정받은 4개의 CSI-RS 안테나 포트들 중 포트 1번과 3번에만 유효 포트 번호(0번, 1번)를 부여할 수 있다. 결과적으로, 도 32c의 (b3)에 예시된 바와 같이, 단말(UE-e)은 수평 축의 길이가 1인 교차 편파 CSI-RS 안테나 포트 배열(Apa1c)에 대하여, CSI 측정 및 보고를 수행할 수 있다.

[512] 이와 같이, 방법 Mc300과 방법 Mc310에 따르면, CSI-RS 전송 오버헤드가 절반으로 줄어들 수 있고, 이를 통해, 결국 데이터 전송 용량 증대의 효과가 얻어질 수 있다.

[513]

[514] 도 33a, 도 33b, 및 도 33c는 방법 Mc300을 위한 또 다른 실시예를 나타내는 도면이다.

[515] 도 33a 내지 도 33c에서 (a1)은 4개의 CSI-RS 안테나 포트가 1차원 단일 편파 배열로 배치된 경우를 나타낸다.

[516] 이 때, 도 32a 내지 도 32c에 예시된 실시예에서와 동일하게, 기지국은 단말(UE-c), 단말(UE-d), 및 단말(UE-e)로 하여금 각각 셀 특정적 CSI-RS 안테나 포트 0번 내지 3번, 셀 특정적 CSI-RS 안테나 포트 0번과 2번, 및 셀 특정적 CSI-RS 안테나 포트 1번과 3번에 대하여 CSI 측정 및 보고를 수행하도록 설정하고자 할 수 있다.

[517] 이를 위해, 기지국은 방법 Mc300과 방법 Mc310을 사용하고, 도 32a 내지 도

32c에 예시된 실시예에서와 동일하게, CSI-RS 자원 설정 및 비트맵을 단말(UE-c, UE-d, UE-e) 각각에게 시그널링할 수 있다. 구체적으로, 기지국은 단말(UE-c, UE-d, UE-e)에게 동일한 CSI-RS configuration 시그널링을 통해 4개의 CSI-RS 안테나 포트를 설정하고, 단말(UE-c)에게 1111 비트맵을, 단말(UE-d)에게 1010 비트맵을, 단말(UE-e)에게 0101 비트맵을 추가로 시그널링할 수 있다.

[518] 1111 비트맵을 시그널링 받은 단말(UE-c)은 CSI-RS configuration 시그널링에 의해 설정받은 4개의 CSI-RS 안테나 포트들 모두에 유효 포트 번호(0~3번)를 부여할 수 있다. 그 결과로, 도 33a의 (b1)에 예시된 바와 같이, 단말(UE-c)은 길이 4인 1차원 단일 편파 CSI-RS 안테나 포트 배열(Apa2a)에 대하여, CSI 측정 및 보고를 수행할 수 있다.

[519] 1010 비트맵을 시그널링 받은 단말(UE-d)은 CSI-RS configuration 시그널링에 의해 설정받은 4개의 CSI-RS 안테나 포트들 중 포트 0번과 2번에만 유효 포트 번호(0번, 1번)를 부여할 수 있다. 그 결과로, 도 33b의 (b2)에 예시된 바와 같이, 단말(UE-d)은 길이 2인 1차원 단일 편파 CSI-RS 안테나 포트 배열(Apa2b)에 대하여, CSI 측정 및 보고를 수행할 수 있다.

[520] 0101 비트맵을 시그널링 받은 단말(UE-e)은 CSI-RS configuration 시그널링에 의해 설정받은 4개의 CSI-RS 안테나 포트들 중 포트 1번과 3번에만 유효 포트 번호(0번, 1번)를 부여할 수 있다. 그 결과로, 도 33c의 (b3)에 예시된 바와 같이, 단말(UE-e)은 길이 2인 1차원 단일 편파 CSI-RS 안테나 포트 배열(Apa2c)에 대하여, CSI 측정 및 보고를 수행할 수 있다.

[521] 이 때, 만약 CSI-RS 안테나 포트와 물리 안테나 요소(들) 간에 일대일 맵핑을 가정한다면, 단말(UE-d)와 단말(UE-e)에게 보이는 물리 안테나 요소들 간의 간격은 단말(UE-c)에게 보이는 물리 안테나 요소들 간 간격의 2배가 된다. 즉, 방법 Mc300과 방법 Mc310에 따르면, 복수의 단말은 공통의 CSI-RS 전송을 이용하여 서로 다른 안테나 간격을 갖는 안테나 배열에 대한 CSI 측정 및 보고를 수행할 수 있다. 상기 자원 설정의 효과는 도 32a 내지 도 32c에 예시된 실시예에서와 마찬가지로, 4개의 RE들만으로 얻어질 수 있다.

[522]

[523] 도 34은 방법 Mc300을 위한 또 다른 실시예를 나타내는 도면이다.

[524] 구체적으로 도 34에는, 16개의 CSI-RS 안테나 포트가 2차원 단일 편파 배열로 배치된 경우가 예시되어 있다. 이 때, 수평 축의 CSI-RS 안테나 포트 수는 8이고 수직 축의 CSI-RS 안테나 포트 수는 2이다. 여기서, 셀 특정적 CSI-RS 안테나 포트 번호는 수평 축 및 수직 축의 순서로 맵핑됨을 가정하였다.

[525] 기지국은 단말(UE-c)와 단말(UE-e)로 하여금 각각 8개의 열 중 좌측 4개의 열과 우측 4개의 열에 대하여 CSI 측정 및 보고를 수행하도록 하고, 단말(UE-d)로 하여금 셀 특정적 CSI-RS 안테나 포트 10~13번에 대하여 CSI 측정 및 보고를 수행하도록 하고자 할 수 있다.

[526] 방법 Mc300이 사용되면, 기지국은 총 16개의 RE들만을 이용하여 단말들(UE-c,

UE-d, UE-e)로 하여금 상기 CSI-RS 측정 및 보고 동작을 수행하도록 할 수 있다.

[527] 기지국이 선택된 CSI-RS 안테나 포트들을 단말에게 알려주기 위하여, 방법 Mc310을 사용할 수 있다. 이 경우에, 기지국은 단말들(UE-c, UE-d, UE-e)에게 동일한 CSI-RS configuration 시그널링을 통해 16개의 CSI-RS 안테나 포트를 설정하고, 단말(UE-c)에게 1111000011110000 비트맵을, 단말(UE-d)에게 0000000000111100 비트맵을, 단말(UE-e)에게 0000111100001111 비트맵을 시그널링할 수 있다.

[528] 한편, 기지국이 선택된 CSI-RS 안테나 포트들을 단말에게 알려주기 위하여, 방법 Mc320을 사용할 수도 있다. 이 경우에, 기지국은 단말들(UE-c, UE-d, UE-e)에게 동일한 CSI-RS configuration 시그널링을 통해 16개의 CSI-RS 안테나 포트를 설정하고, 단말(UE-c)에게 1111110000 비트맵을, 단말(UE-d)에게 0100111100 비트맵을, 단말(UE-e)에게 1100001111 비트맵을 시그널링할 수 있다. 여기서, 방법 Mc320에 따른 비트맵에서 N_2개의 최상위 비트들(좌측에 표기된 비트들)은 N_2개의 행에 대한 사용 여부(포트 번호 부여 여부)를 나타내고, 방법 Mc320에 따른 비트맵에서 N_1개의 최하위 비트들(우측에 표기된 비트들)은 N_1개의 열에 대한 사용 여부(포트 번호 부여 여부)를 나타내는 것으로 가정한다.

[529] 비트맵을 시그널링 받은 단말(UE-c)은 CSI-RS configuration 시그널링에 의해 설정받은 16개의 CSI-RS 안테나 포트들 중 1번째 내지 4번째 열에 대응하는 8개의 포트(포트 번호 0~3번, 8~11번)에만 유효 포트 번호(0~7번)를 부여할 수 있다. 그 결과로, 단말(UE-c)은 2차원 단일 편파 CSI-RS 안테나 포트 배열(Apa3a)에 대하여, CSI 측정 및 보고를 수행할 수 있다.

[530] 비트맵을 시그널링 받은 단말(UE-d)은 CSI-RS configuration 시그널링에 의해 설정받은 16개의 CSI-RS 안테나 포트들 중 4개의 포트(포트 번호 10~13번)에만 유효 포트 번호(0~3번)를 부여할 수 있다. 그 결과로, 단말(UE-d)은 1차원 단일 편파 CSI-RS 안테나 포트 배열(Apa3b)에 대하여, CSI 측정 및 보고를 수행할 수 있다.

[531] 비트맵을 시그널링 받은 단말(UE-e)은 CSI-RS configuration 시그널링에 의해 설정받은 16개의 CSI-RS 안테나 포트들 중 5번째 내지 8번째 열에 대응하는 8개의 포트(포트 번호 4~7번, 12~15번)에만 유효 포트 번호(0~7번)를 부여할 수 있다. 그 결과로, 단말(UE-e)은 2차원 단일 편파 CSI-RS 안테나 포트 배열(Apa3c)에 대하여, CSI 측정 및 보고를 수행할 수 있다.

[532] 한편, 방법 Mc300 및 방법 Mc300을 위한 세부 방법들은, 방법 Mc220 및 방법 Mc220을 위한 세부 방법들과 결합되어 사용될 수도 있다.

[533]

[534] 3.4. CSI-RS 안테나 포트의 2차원 십자 배열 구성

[535] 한편, 도 35 및 도 36에 예시된 바와 같이, 두 개의 1차원 CSI-RS 안테나 포트 배열이 각각 수평 축과 수직 축으로 나열되어 교차하는 구조를 가지는 2차원 CSI-RS 안테나 포트 배열이 고려될 수 있다.

[536] 도 35는 CSI-RS 안테나 포트의 2차원 십자 배열을 나타내는데, 구체적으로 두 1차원 배열의 교차점에 CSI-RS 안테나 포트가 중복 할당되는 2차원 십자 배열을 나타낸다.

[537] 도 35에 예시된 (Case-A)는, 두 1차원 배열의 교차점이 수평 배열의 첫번째 요소와 수직 배열의 첫번째 요소인 경우이다. 도 35에 예시된 (Case-B)는, 두 1차원 배열의 교차점이 수평 배열의 두번째 요소와 수직 배열의 첫번째 요소인 경우이다. 도 35의 (Case-A) 및 (Case-B)에는, 수평 배열에 CSI-RS 안테나 포트(0~3번)이 할당되고, 수직 배열에 CSI-RS 안테나 포트(4번, 5번)이 할당되는 경우가 예시되어 있다.

[538] 두 1차원 배열의 교차점에 CSI-RS 안테나 포트 번호가 중복 할당되는 경우에, 단말에게 설정되는 총 CSI-RS 안테나 포트 수는 N_2와 N_1의 합이다. 예를 들어, 도 35에 예시된 실시예에서, 단말에게 설정되는 총 CSI-RS 안테나 포트 수는 6(=2+4)이다.

[539]

[540] 도 36는 CSI-RS 안테나 포트의 2차원 십자 배열을 나타내는데, 구체적으로 두 1차원 배열의 교차점에 CSI-RS 안테나 포트가 중복 할당되지 않는 2차원 십자 배열을 나타낸다.

[541] 도 36에 예시된 (Case-A)는, 두 1차원 배열의 교차점이 수평 배열의 첫번째 요소와 수직 배열의 첫번째 요소인 경우이다. 도 36에 예시된 (Case-B)는, 두 1차원 배열의 교차점이 수평 배열의 두번째 요소와 수직 배열의 첫번째 요소인 경우이다. 도 36의 (Case-A) 및 (Case-B)에는, 수평 배열에 CSI-RS 안테나 포트(0~3번)이 할당되고, 수직 배열에 CSI-RS 안테나 포트(4번)이 할당되는 경우가 예시되어 있다.

[542] 두 1차원 배열의 교차점에 CSI-RS 안테나 포트 번호가 중복 할당되지 않고 하나만 할당되는 경우에, 단말에게 설정되는 총 CSI-RS 안테나 포트 수는 N_2+N_1-1 이다. 예를 들어, 도 36에 예시된 실시예에서, 단말에게 설정되는 총 CSI-RS 안테나 포트 수는 5(=2+4-1)이다.

[543] 한편, 이러한 십자 배열 구조는 2차원 또는 3차원 배열의 모든 원소들에 대하여 CSI-RS를 전송하는 구조에 비해, CSI-RS 전송을 위해 소요되는 오버헤드가 적다는 장점을 가진다. 하지만, 그만큼 단말이 CSI 측정을 위해 이용할 수 있는 채널 정보가 감소되므로, 실제 채널의 행(또는 열) 간 상관도(correlation)가 적은 환경에서는 채널 추정의 정확도가 떨어질 수 있다.

[544] CSI-RS 안테나 포트가 십자 배열로 구성되는 경우에도, 단말이 2차원 CSI-RS 안테나 포트 배열의 수평 축 및 수직 축 길이를 알고 있는 것이, CSI 측정 및 보고에 도움될 수 있다. 또한 이 경우에, 단말이 1차원 수직 배열과 1차원 수평 배열 간의 교차점 위치 또는 해당 교차점 위치에 할당된 CSI-RS 안테나 포트 번호를 아는 것이, CSI 측정 및 보고에 도움될 수 있다. 단말이 교차점에 관한 정보를 획득하기 위한 방법으로써, 두 가지 방법(방법 Mc500, 방법 Mc501)이

고려될 수 있다.

[545] 방법 Mc500은, 단말이 미리 정해진 규칙에 따라 수직 배열과 수평 배열의 교차점을 획득하는 방법이다. 방법 Mc501은, 수직 배열과 수평 배열의 교차점에 관한 정보를 기지국이 단말에게 전송하는 방법이다.

[546] 방법 Mc500에서 교차점은 미리 정해진 규칙에 따라 시간적으로(예, 서브프레임 마다, 주기적으로 등) 변할 수도 있고, 고정적일 수도 있다. 수평 축 및 수직 축 CSI-RS 안테나 포트 배열이 맵핑될 수 있는 전체 2차원 배열 공간을 열의 개수가 N_1이고 행의 개수가 N_2인 2차원 행렬로써 표현한다고 가정하면, 후자의 방법(교차점이 고정적임)은 예를 들어, 교차점의 위치를 2차원 행렬의 (1,1) 원소 지점으로 정해놓을 수 있다. 전자의 방법(교차점이 시간적으로 변함)은 예를 들어, 교차점의 위치가 수직 축에서 시간적으로 변하도록(즉, 교차점의 위치가 순차적으로 2차원 행렬의 (1,1), (2,1), ..., (N_2,1) 원소 지점이 되도록) 정할 수 있다.

[547] 한편, 도 36에 예시된 바와 같이, 교차점에 CSI-RS 안테나 포트 번호가 중복되지 않게 하나만 할당되는 경우에, 하나의 RB 페어 내에서 CSI-RS 전송을 위해 이용되는 RE가 1개 절약될 수 있다. 이를 위해, 단말에게 N_2+N_1-1개의 CSI-RS 안테나 포트를 설정하기 위한 방법이 필요할 수 있다. 그 방법 중 하나로써, 기지국이 단말에게 수평 축 또는 수직 축 CSI-RS 안테나 포트 수를 독립적으로 설정하는 경우에, 기지국은 단말에게 기존 설정을 동일하게 적용하되, 수평 축과 수직 축 방향 중 어느 한 방향의 CSI-RS 안테나 포트 수가 기존 설정에서의 해당 방향 포트 수보다 1만큼 적다는 것을 단말이 인식하도록 할 수 있다. 이 때, 기존 설정 대비 1개가 줄어든 N_2+N_1-1개의 CSI-RS 안테나 포트에 대한 포트 번호를 단말이 알아야 한다. 포트 번호 맵핑 규칙은 규격에 미리 정의될 수도 있고, 기지국이 단말에게 관련 정보를 시그널링할 수도 있다.

[548]

[549] 도 37은 본 발명의 실시예에 따른, 기지국(100)을 나타내는 도면이다.

[550] 기지국(100)은 프로세서(110), 메모리(120), 및 RF(radio frequency) 변환기(130)를 포함한다.

[551] 프로세서(110)는 본 명세서에서 기지국, 셀, 또는 TP와 관련하여 기술된 기능, 절차, 및 방법들을 구현하도록 구성될 수 있다. 또한, 프로세서(110)는 기지국(100)의 각 구성을 제어할 수 있다.

[552] 메모리(120)는 프로세서(110)와 연결되고, 프로세서(110)의 동작과 관련된 다양한 정보를 저장한다.

[553] RF 변환기(130)는 프로세서(110)와 연결되고, 무선 신호를 송신 또는 수신한다.

[554]

[555] 도 38은 본 발명의 실시예에 따른, 단말(200)을 나타내는 도면이다.

[556] 단말(200)은 프로세서(210), 메모리(220), 및 RF 변환기(230)를 포함한다.

[557] 프로세서(210)는 본 명세서에서 단말과 관련하여 기술된 기능, 절차, 및

방법들을 구현하도록 구성될 수 있다. 또한, 프로세서(210)는 단말(200)의 각 구성을 제어할 수 있다.

[558] 메모리(220)는 프로세서(210)와 연결되고, 프로세서(210)의 동작과 관련된 다양한 정보를 저장한다.

[559] RF 변환기(230)는 프로세서(210)와 연결되고, 무선 신호를 송신 또는 수신한다.

[560]

[561] 이상에서 본 발명의 실시예에 대하여 상세하게 설명하였지만 본 발명의 권리범위는 이에 한정되는 것은 아니고 다음의 청구범위에서 정의하고 있는 본 발명의 기본 개념을 이용한 당업자의 여러 변형 및 개량 형태 또한 본 발명의 권리범위에 속하는 것이다.

[562]

청구범위

[청구항 1] 기지국이 CSI(channel state information)-RS(reference signal)를 설정하는 방법으로서,
단말을 위한 CSI-RS 안테나 포트를 설정하는 단계;
상기 CSI-RS 안테나 포트에 포트 번호를 맵핑하기 위한 적어도 하나의 포트 번호 맵핑 규칙 중 하나를, 상기 단말을 위해 선택하는 단계; 및
상기 선택된 포트 번호 맵핑 규칙을 상기 단말에게 알리는 단계
를 포함하는 기지국의 CSI-RS 설정 방법.

[청구항 2] 제1항에 있어서,
상기 단말을 위한 CSI-RS 안테나 포트를 설정하는 단계는,
상기 CSI-RS 안테나 포트가 제1 축, 제2 축, 및 제3 축 중 적어도 2개를 따라 배치되는 CSI-RS 안테나 포트 배열을 설정하는 단계를 포함하고,
상기 선택된 포트 번호 맵핑 규칙에 무관하게, 상기 제1 축, 상기 제2 축, 및 상기 제3 축에 포트 번호가 맵핑되는 축 순서는 기 설정되는
기지국의 CSI-RS 설정 방법.

[청구항 3] 제2항에 있어서,
상기 단말을 위한 CSI-RS 안테나 포트를 설정하는 단계는,
상기 CSI-RS 안테나 포트 배열에 포함된 CSI-RS 안테나 포트 중에서 상기 제1 축으로 배치되는 CSI-RS 안테나 포트의 수, 상기 제2 축으로 배치되는 CSI-RS 안테나 포트의 수, 및 상기 제3 축으로 배치되는 CSI-RS 안테나 포트의 수 중 적어도 하나를, 상기 단말에게 전송하는 단계를 더 포함하는
기지국의 CSI-RS 설정 방법.

[청구항 4] 제2항에 있어서,
상기 단말을 위한 CSI-RS 안테나 포트를 설정하는 단계는,
상기 제1 축, 상기 제2 축, 및 상기 제3 축 중 하나의 축에 따라 배치되는 CSI-RS 안테나 포트의 수가 상기 단말에게 설정되는 전체 CSI-RS 안테나 포트의 수와 동일한 경우에, 상기 하나의 축에 따라 배치되는 CSI-RS 안테나 포트의 수를 상기 단말에게 전송하는 것을 생략하는 단계를 더 포함하는
기지국의 CSI-RS 설정 방법.

[청구항 5] 제2항에 있어서,
상기 단말을 위한 CSI-RS 안테나 포트를 설정하는 단계는,
상기 CSI-RS 안테나 포트 배열에 포함된 CSI-RS 안테나 포트 중에서 상기 제1 축으로 배치되는 CSI-RS 안테나 포트의 수와 상기 제3 축으로 배치되는 CSI-RS 안테나 포트의 수를 합하여, 제1 값을 구하는 단계; 및
상기 CSI-RS 안테나 포트 배열에 포함된 CSI-RS 안테나 포트 중에서 상기 제2 축으로 배치되는 CSI-RS 안테나 포트의 수 및 상기 제1 값 중 적어도

하나를, 상기 단말에게 전송하는 단계를 더 포함하는
기지국의 CSI-RS 설정 방법.

[청구항 6] 제2항에 있어서,
상기 선택된 포트 번호 맵핑 규칙은,
상기 단말에 의한 채널 추정 시에, 상기 단말로 하여금 상기 단말에게 설정된 전체 CSI-RS 안테나 포트를 상기 선택된 포트 번호 맵핑 규칙에 대응하는 개수 만큼의 CSI-RS 안테나 포트 그룹으로 나누도록 하고, 상기 CSI-RS 안테나 포트 그룹 별로 상기 각 CSI-RS 안테나 포트 그룹에 속하는 CSI-RS 안테나 포트에 상기 기 설정된 축 순서에 따라 포트 번호를 부여하도록 하는
기지국의 CSI-RS 설정 방법.

[청구항 7] 제6항에 있어서,
상기 각 CSI-RS 안테나 포트 그룹에 속하는 CSI-RS 안테나 포트의 수는 상기 단말에게 설정되는 전체 CSI-RS 안테나 포트의 수의 약수인
기지국의 CSI-RS 설정 방법.

[청구항 8] 제1항에 있어서,
상기 선택된 포트 번호 맵핑 규칙을 상기 단말에게 알리는 단계는,
상기 선택된 포트 번호 맵핑 규칙을 나타내는 비트 코드를, 상기 단말에게 전송하는 단계를 포함하는
기지국의 CSI-RS 설정 방법.

[청구항 9] 제6항에 있어서,
상기 선택된 포트 번호 맵핑 규칙을 상기 단말에게 알리는 단계는,
상기 선택된 포트 번호 맵핑 규칙에 따라 생성되는 상기 CSI-RS 안테나 포트 그룹의 개수를 나타내는 비트 코드를, 상기 단말에게 전송하는 단계를 포함하는
기지국의 CSI-RS 설정 방법.

[청구항 10] 제2항에 있어서,
상기 단말에게 설정되는 전체 CSI-RS 안테나의 수는 8개 보다 더 많고,
상기 제1 축은 수평(horizontal) 축이고, 상기 제2 축은 수직(vertical) 축이고, 상기 제3 축은 편파(polarization) 축인
기지국의 CSI-RS 설정 방법.

[청구항 11] 제1항에 있어서,
제1 축, 제2 축, 및 제3 축에 포트 번호가 맵핑되는 축 순서들 중에서 하나를, 상기 단말을 위해 선택하는 단계; 및
상기 선택된 축 순서를 상기 단말에게 알리는 단계를 더 포함하고,
상기 단말을 위한 CSI-RS 안테나 포트를 설정하는 단계는,
상기 CSI-RS 안테나 포트가 상기 제1 축, 상기 제2 축, 및 상기 제3 축 중 적어도 2개를 따라 배치되는 CSI-RS 안테나 포트 배열을 설정하는 단계를

포함하는
기지국의 CSI-RS 설정 방법.

[청구항 12] 단말이 CSI(channel state information)를 측정하는 방법으로서,
기지국으로부터, CSI-RS(reference signal) 안테나 포트를 위한 제1 포트 번호 맵핑 규칙을 수신하는 단계;
상기 제1 포트 번호 맵핑 규칙에 기초해, 상기 CSI-RS 안테나 포트를 상기 제1 포트 번호 맵핑 규칙에 대응하는 개수 만큼의 CSI-RS 안테나 포트 그룹으로 나누는 단계;
상기 CSI-RS 안테나 포트 그룹 별로 상기 각 CSI-RS 안테나 포트 그룹에 속하는 CSI-RS 안테나 포트에 포트 번호를 부여하는 단계; 및
상기 포트 번호가 부여된 CSI-RS 안테나 포트에 대하여, 채널 추정을 수행하는 단계
를 포함하는 단말의 CSI 측정 방법.

[청구항 13] 제12항에 있어서,
상기 제1 포트 번호 맵핑 규칙과 다른 제2 포트 번호 맵핑 규칙에 따라, 상기 CSI-RS 안테나 포트에 포트 번호를 재부여하는 단계; 및
상기 포트 번호가 재부여된 CSI-RS 안테나 포트에 대하여, 상기 채널 추정의 결과에 기초해 CSI 측정을 수행하는 단계
를 더 포함하는 단말의 CSI 측정 방법.

[청구항 14] 제12항에 있어서,
상기 제1 포트 번호 맵핑 규칙을 수신하는 단계는,
상기 제1 포트 번호 맵핑 규칙을 나타내는 비트 코드를 상기 기지국으로부터 수신하는 단계를 포함하는
단말의 CSI 측정 방법.

[청구항 15] 제12항에 있어서,
상기 CSI-RS 안테나 포트는 제1 축, 제2 축, 및 제3 축 중 적어도 2개를 따라 배치되고,
상기 CSI-RS 안테나 포트에 포트 번호를 부여하는 단계는,
상기 CSI-RS 안테나 포트 그룹 중에서 제1 CSI-RS 안테나 포트 그룹에 속하는 CSI-RS 안테나 포트에, 상기 제1 축, 상기 제2 축, 및 상기 제3 축에 포트 번호가 부여되는 축 순서에 따라 포트 번호를 부여하는 단계; 및
상기 CSI-RS 안테나 포트 그룹 중에서 제2 CSI-RS 안테나 포트 그룹에 속하는 CSI-RS 안테나 포트에, 상기 축 순서에 따라 포트 번호를 부여하는 단계를 포함하고,
상기 제2 CSI-RS 안테나 포트 그룹에 부여된 첫번째 포트 번호는 상기 제1 CSI-RS 안테나 포트 그룹에 부여된 마지막 포트 번호 다음의 포트 번호인
단말의 CSI 측정 방법.

[청구항 16] 단말이 CSI(channel state information)를 측정하는 방법으로서,

기지국으로부터, CSI-RS(reference signal) 안테나 포트를 설정받는 단계;
상기 기지국으로부터 상기 CSI-RS 안테나 포트에 대한 포트 번호 부여 여부 정보를 수신하는 단계;
상기 포트 번호 부여 정보에 기초해, 상기 CSI-RS 안테나 포트 중 일부에 포트 번호를 부여하는 단계; 및
상기 포트 번호가 부여된 CSI-RS 안테나 포트를 이용하여, CSI를 측정하는 단계
를 포함하는 단말의 CSI 측정 방법.

[청구항 17] 제16항에 있어서,
상기 포트 번호 부여 여부 정보를 수신하는 단계는,
상기 CSI-RS 안테나 포트의 수만큼의 길이를 가지며 상기 CSI-RS 안테나 포트 별 포트 번호 부여 여부를 나타내는 비트맵을, 상기 기지국으로부터 수신하는 단계를 포함하고,
상기 CSI-RS 안테나 포트 중 일부에 포트 번호를 부여하는 단계는,
상기 비트맵에 속하는 비트 중에서 제1 값을 가지는 비트에 대응하는 CSI-RS 안테나 포트에 포트 번호를 부여하는 단계를 포함하는
단말의 CSI 측정 방법.

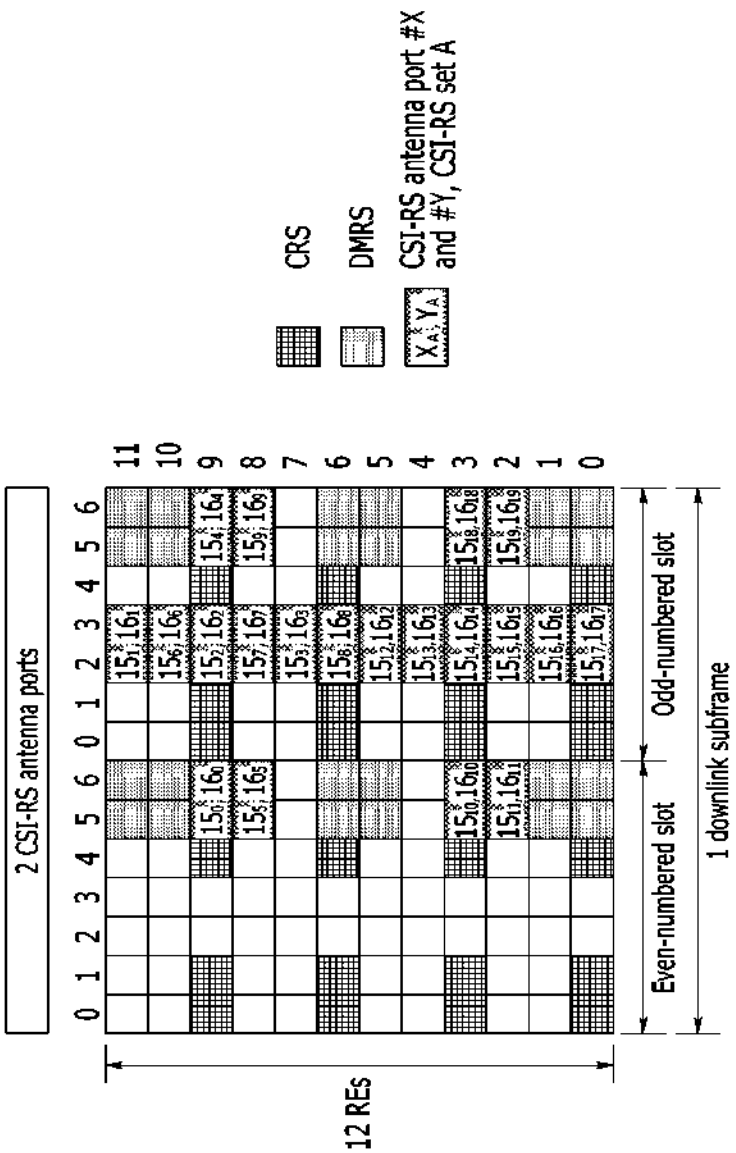
[청구항 18] 제16항에 있어서,
상기 포트 번호 부여 여부 정보를 수신하는 단계는,
상기 CSI-RS 안테나 포트의 수의 절반의 길이를 가지며 상기 CSI-RS 안테나 포트 쌍 별 포트 번호 부여 여부를 나타내는 비트맵을, 상기 기지국으로부터 수신하는 단계를 포함하고,
상기 CSI-RS 안테나 포트 중 일부에 포트 번호를 부여하는 단계는,
상기 비트맵에 속하는 비트 중에서 제1 값을 가지는 비트에 대응하는 CSI-RS 안테나 포트 쌍에 포트 번호를 부여하는 단계를 포함하고,
상기 CSI-RS 안테나 포트 쌍은 동일한 RE(resource element)를 통해 전송되는 2개의 CSI-RS 안테나 포트를 포함하는
단말의 CSI 측정 방법.

[청구항 19] 제16항에 있어서,
상기 CSI-RS 안테나 포트는 CSI-RS 안테나 포트 배열에 포함되며 제1 축, 제2 축, 및 제3 축 중 적어도 2개에 따라 배치되고,
상기 포트 번호 부여 여부 정보를 수신하는 단계는,
상기 제1 축으로 배치되는 CSI-RS 안테나 포트의 수와 상기 제2 축으로 배치되는 CSI-RS 안테나 포트의 수를 합한 값 만큼의 길이를 가지며 상기 CSI-RS 안테나 포트 배열의 각 행과 각 열에 대한 포트 번호 부여 여부를 나타내는 비트맵을, 상기 기지국으로부터 수신하는 단계를 포함하는
단말의 CSI 측정 방법.

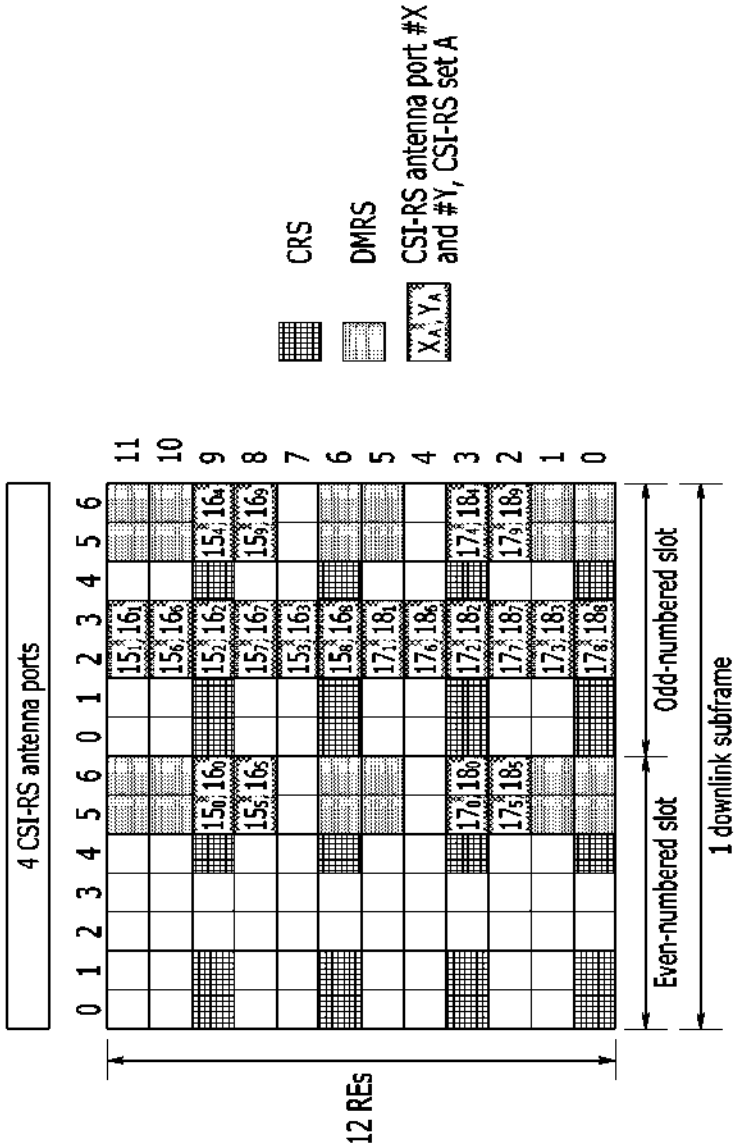
[청구항 20] 제16항에 있어서,

상기 단말에게 설정된 전체 CSI-RS 안테나 포트를 위한 RE(resource element) 중에서 상기 포트 번호가 부여된 CSI-RS 안테나 포트를 위한 RE를 제외한 나머지에서 PDSCH(physical downlink shared channel)가 수신되는 것이 가능함을 가정하는 단계
를 더 포함하는 단말의 CSI 측정 방법.

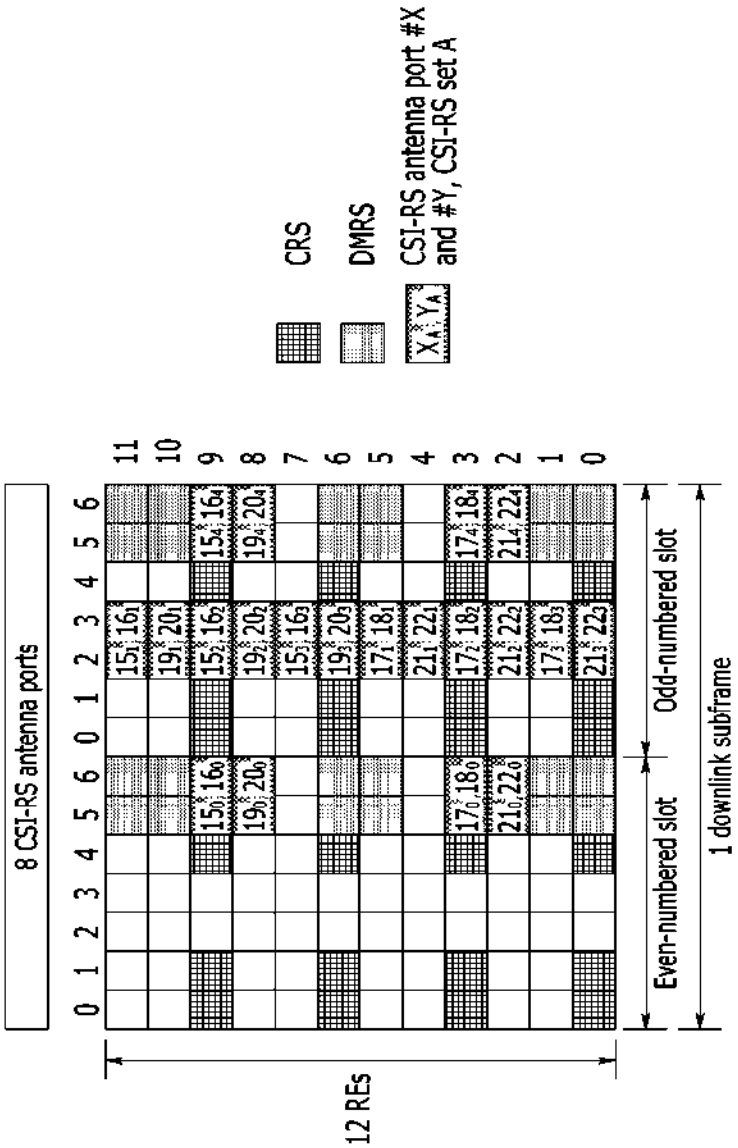
[도1]


CRS
DMRS
CSI-RS antenna port #X and #Y, CSI-RS set A
2 CSI-RS antenna ports
12 REs
Even-numbered slot
Odd-numbered slot
1 downlink subframe

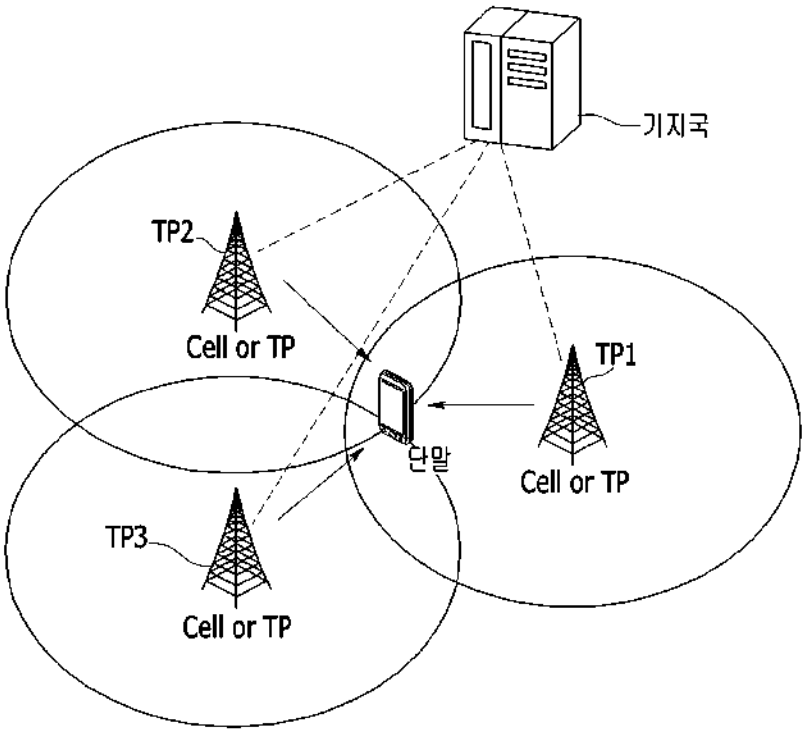
[도2]


CRS
DMRS
CSI-RS antenna port #X and #Y, CSI-RS set A
4 CSI-RS antenna ports
Even-numbered slot
Odd-numbered slot
1 downlink subframe
12 REs

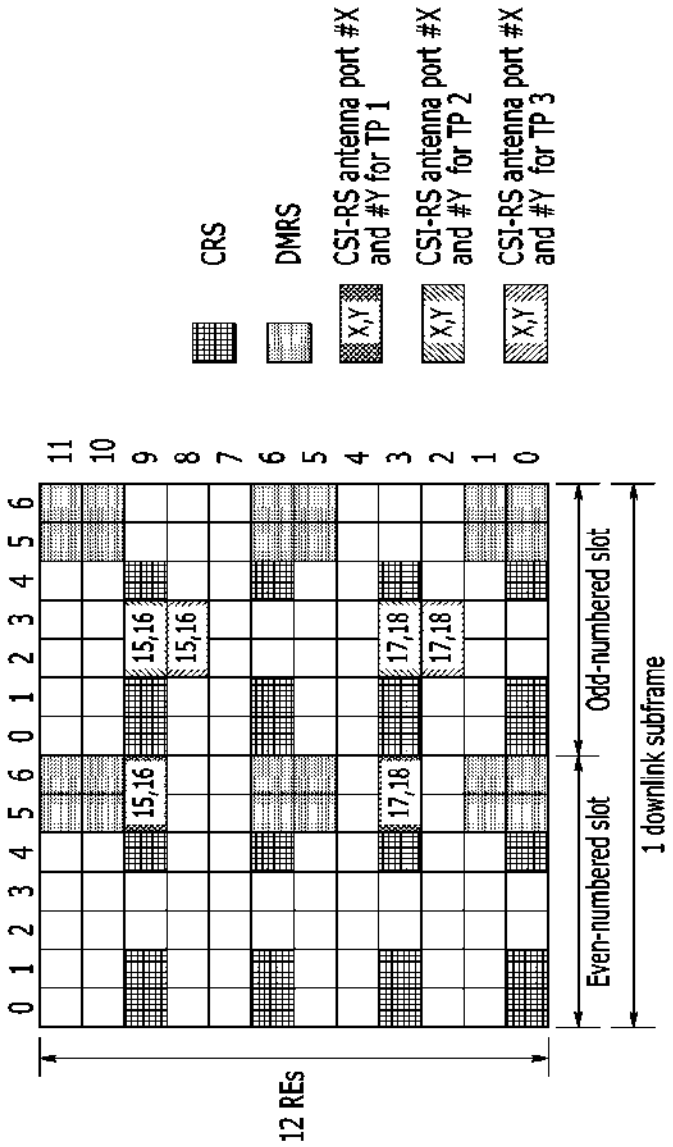
[도3]


CRS
DMRS
CSI-RS antenna port #X and #Y, CSI-RS set A
8 CSI-RS antenna ports
Even-numbered slot
Odd-numbered slot
1 downlink subframe
12 REs

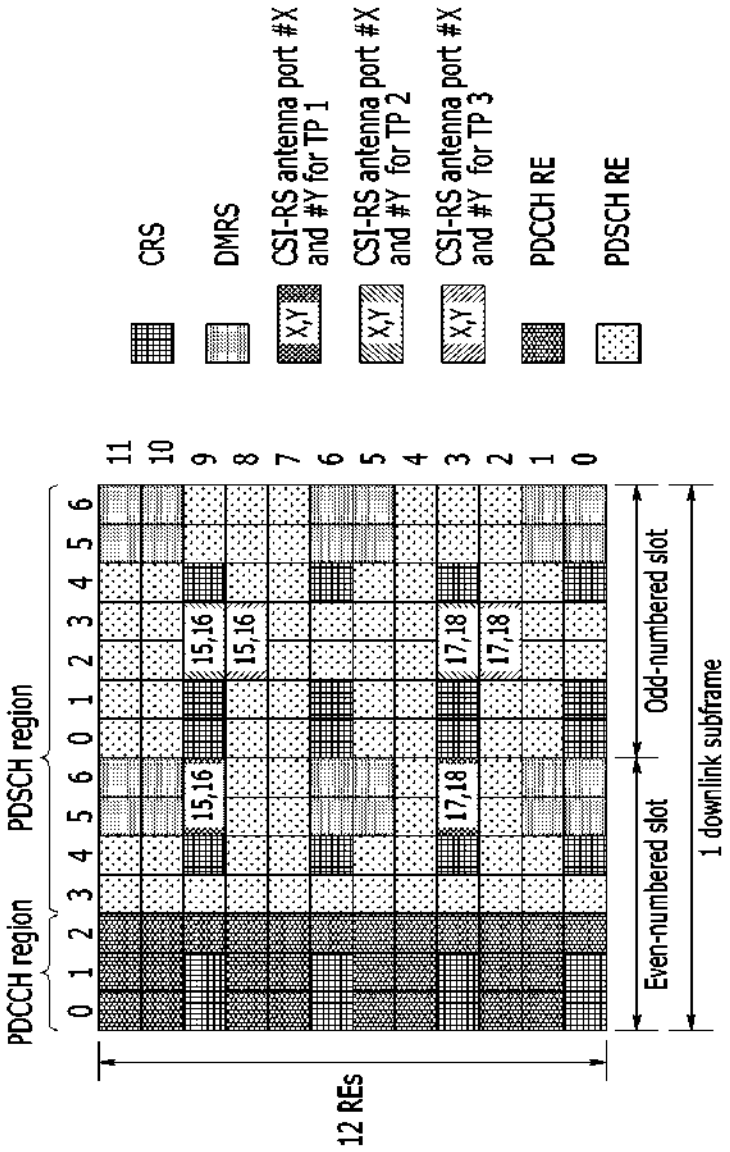
[도4]



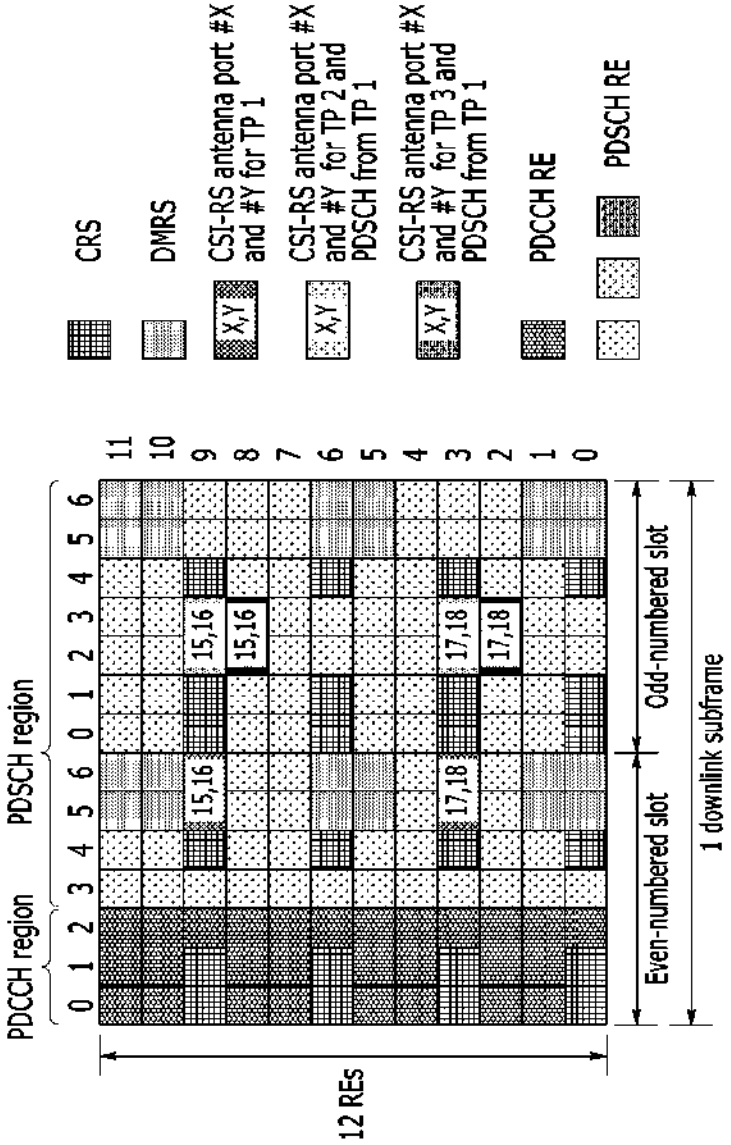
[도5]


CRS
DMRS
CSI-RS antenna port #X and #Y for TP 1
CSI-RS antenna port #X and #Y for TP 2
CSI-RS antenna port #X and #Y for TP 3
X,Y
15,16
17,18
Odd-numbered slot
Even-numbered slot
1 downlink subframe
12 REs

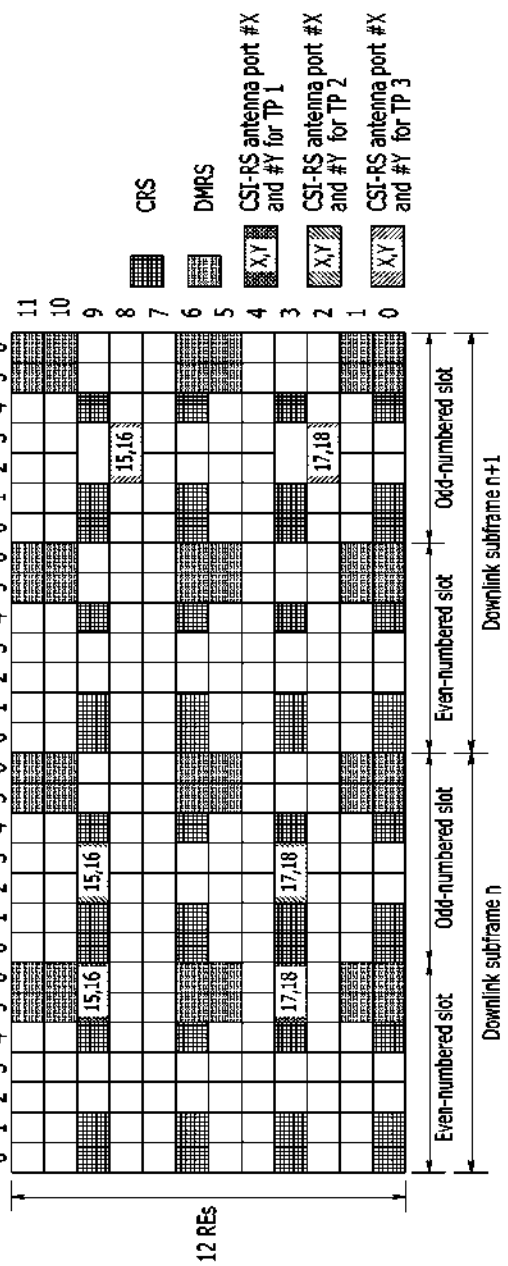
[도6]


CRS
DMRS
CSI-RS antenna port #X and #Y for TP 1
CSI-RS antenna port #X and #Y for TP 2
CSI-RS antenna port #X and #Y for TP 3
PDCCH RE
PDSCH RE
X,Y
11 10 9 8 7 6 5 4 3 2 1 0
PDCCH region
PDSCH region
0 1 2 3 4 5 6 0 1 2 3 4 5 6
15,16
17,18
Even-numbered slot
Odd-numbered slot
1 downlink subframe
12 REs

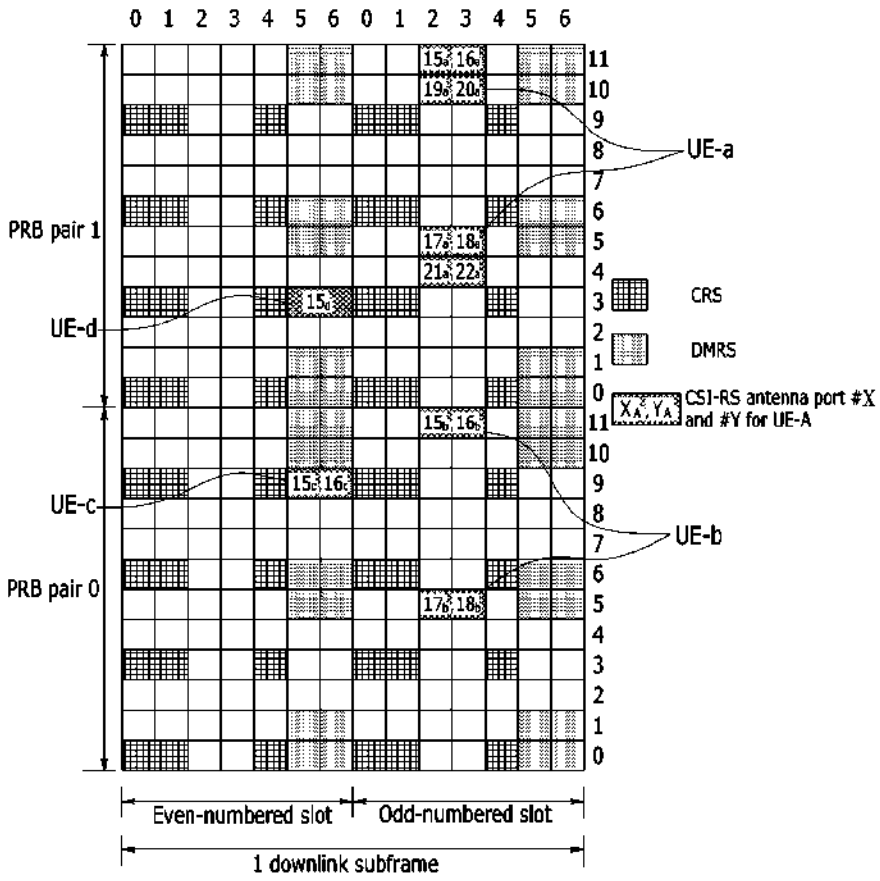
[도7]


CRS
DMRS
CSI-RS antenna port #X and #Y for TP 1
CSI-RS antenna port #X and #Y for TP 2 and PDSCH from TP 1
CSI-RS antenna port #X and #Y for TP 3 and PDSCH from TP 1
PDCCH RE
PDSCH RE
X,Y
PDCCH region
PDSCH region
0 1 2 3 4 5 6 0 1 2 3 4 5 6
11 10 9 8 7 6 5 4 3 2 1 0
15,16
15,16
15,16
17,18
17,18
17,18
Even-numbered slot
Odd-numbered slot
1 downlink subframe
12 REs

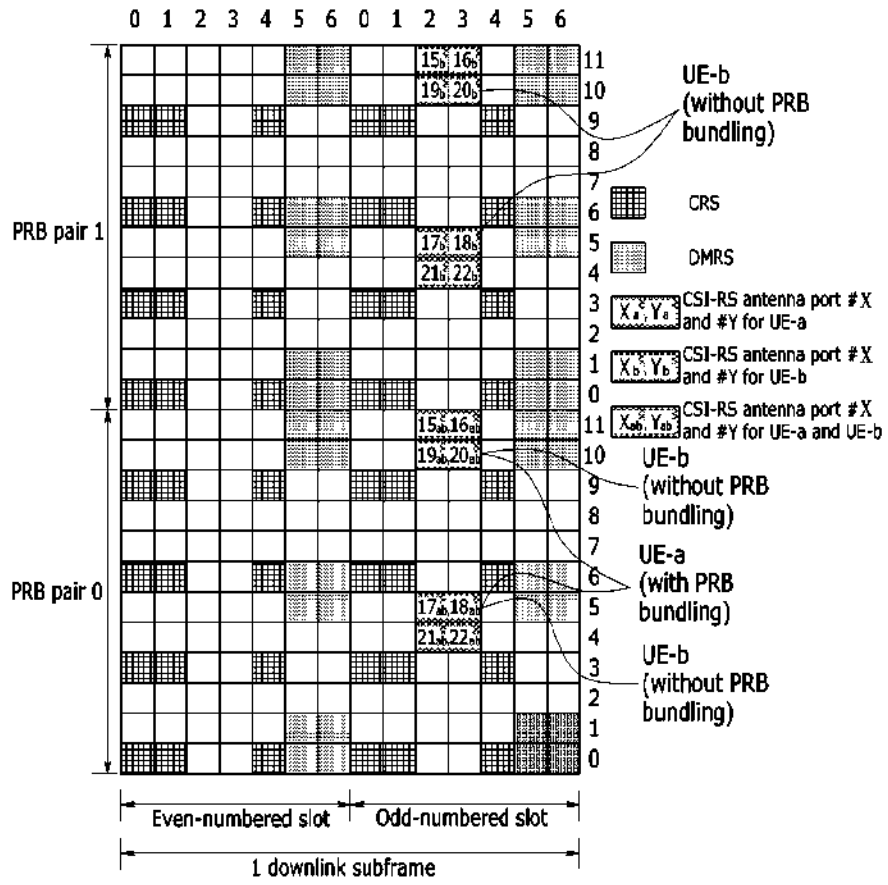
[도8]


CRS
DMRS
CSI-RS antenna port #X and #Y for TP 1
CSI-RS antenna port #X and #Y for TP 2
CSI-RS antenna port #X and #Y for TP 3
X,Y
15,16
17,18
12 REs
Even-numbered slot
Odd-numbered slot
Downlink subframe n
Downlink subframe n+1

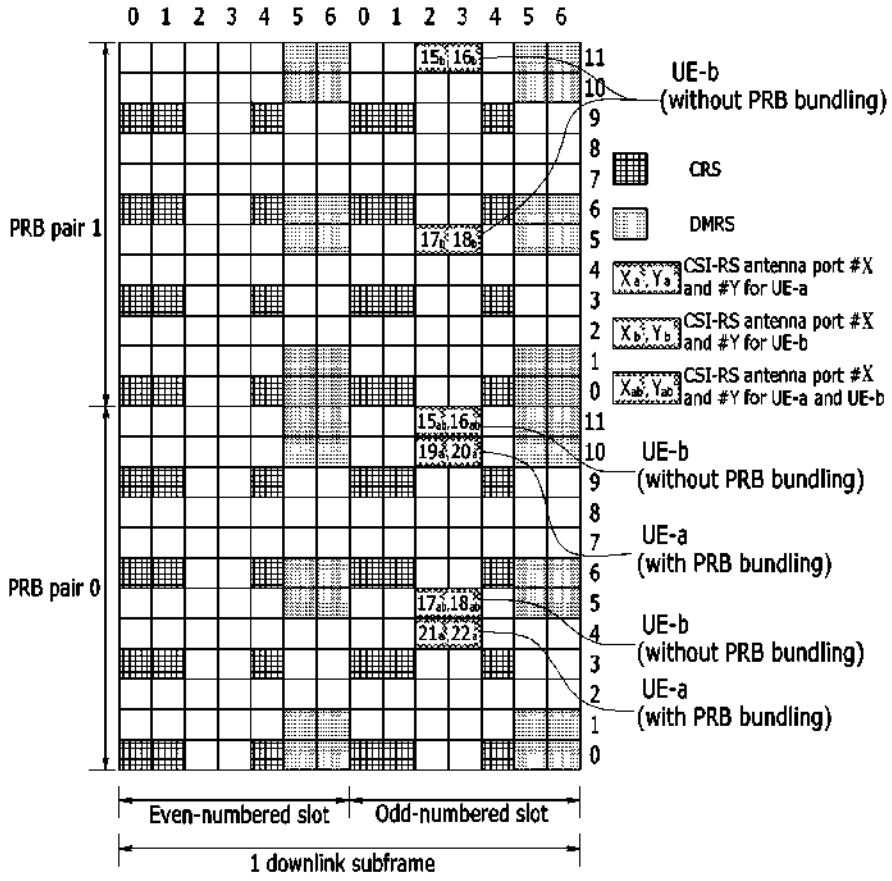
[도9]


0 1 2 3 4 5 6 0 1 2 3 4 5 6
PRB pair 1
PRB pair 0
UE-a
UE-b
UE-c
UE-d
CRS
DMRS
CSI-RS antenna port #X and #Y for UE-A
Even-numbered slot
Odd-numbered slot
1 downlink subframe

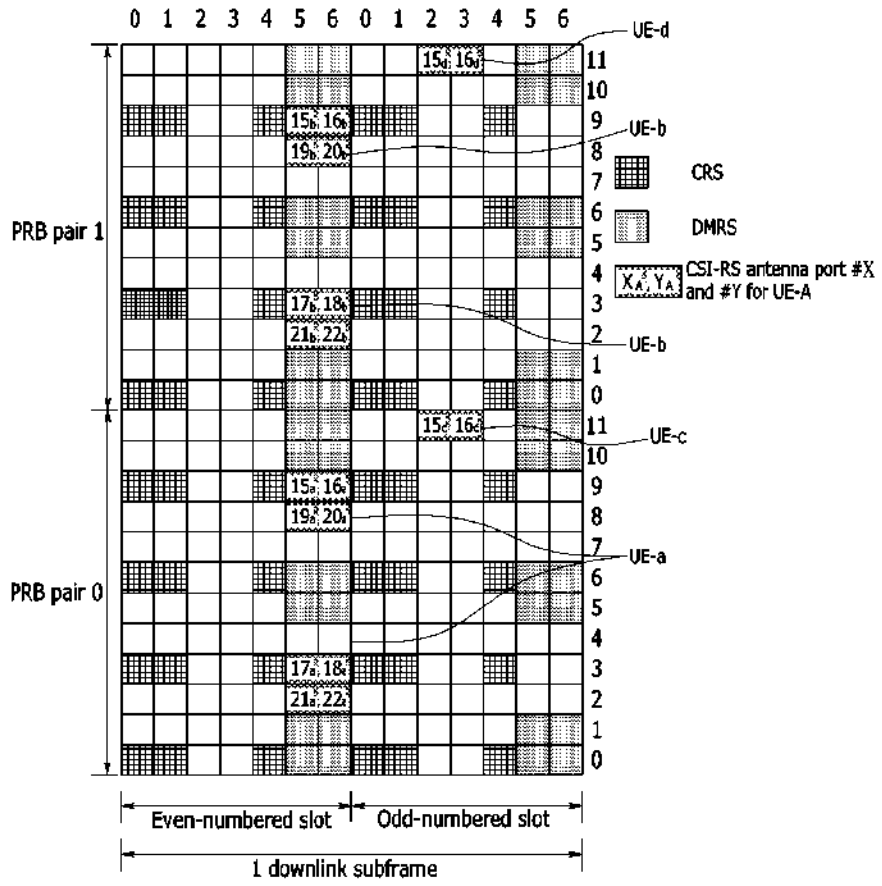
[도10a]


0 1 2 3 4 5 6 0 1 2 3 4 5 6
PRB pair 1
PRB pair 0
UE-b (without PRB bundling)
CRS
DMRS
CSI-RS antenna port #X and #Y for UE-a
CSI-RS antenna port #X and #Y for UE-b
CSI-RS antenna port #X and #Y for UE-a and UE-b
UE-b (without PRB bundling)
UE-a (with PRB bundling)
UE-b (without PRB bundling)
Even-numbered slot
Odd-numbered slot
1 downlink subframe

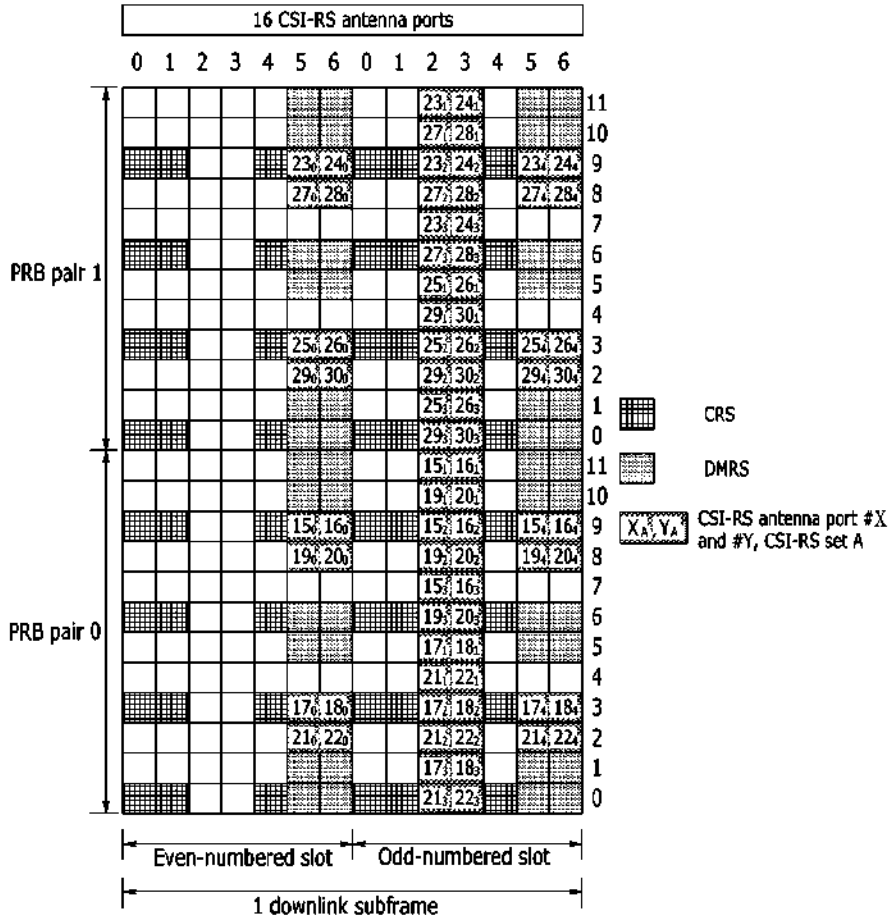
[도10b]


0 1 2 3 4 5 6 0 1 2 3 4 5 6
PRB pair 1
PRB pair 0
UE-b (without PRB bundling)
CRS
DMRS
CSI-RS antenna port #X and #Y for UE-a
CSI-RS antenna port #X and #Y for UE-b
CSI-RS antenna port #X and #Y for UE-a and UE-b
UE-b (without PRB bundling)
UE-a (with PRB bundling)
UE-b (without PRB bundling)
UE-a (with PRB bundling)
Even-numbered slot
Odd-numbered slot
1 downlink subframe

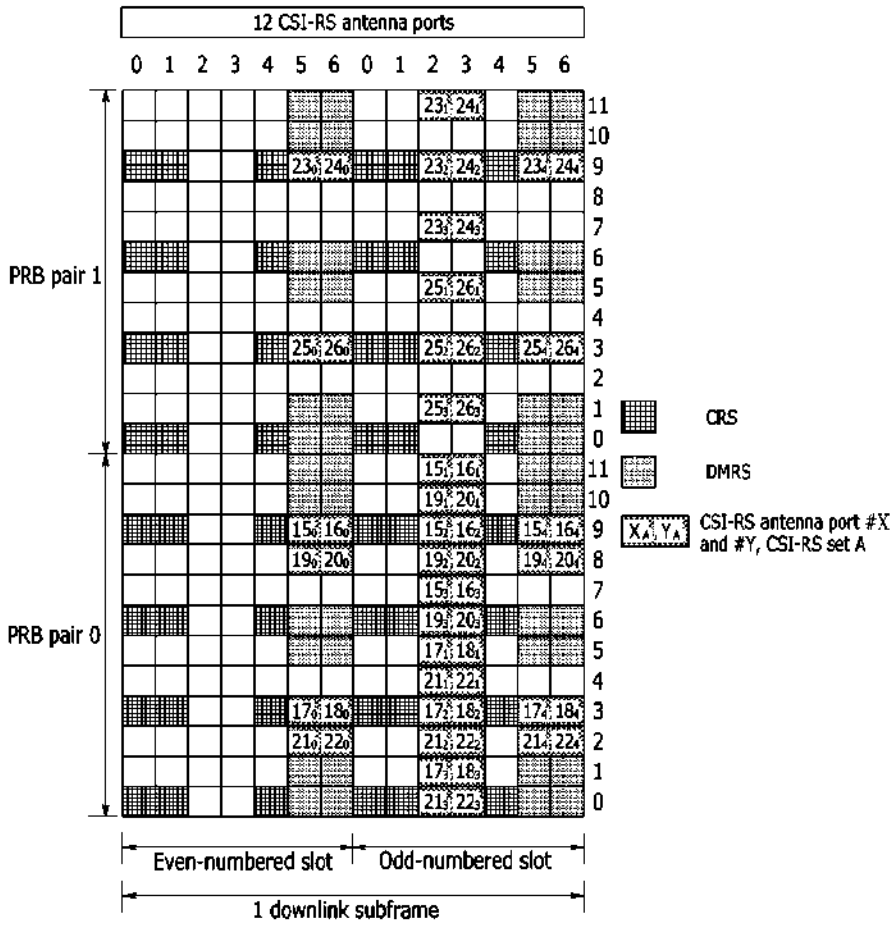
[도11]


0 1 2 3 4 5 6 0 1 2 3 4 5 6
UE-d
UE-b
CRS
DMRS
CSI-RS antenna port #X and #Y for UE-A
UE-b
UE-c
UE-a
PRB pair 1
PRB pair 0
Even-numbered slot
Odd-numbered slot
1 downlink subframe

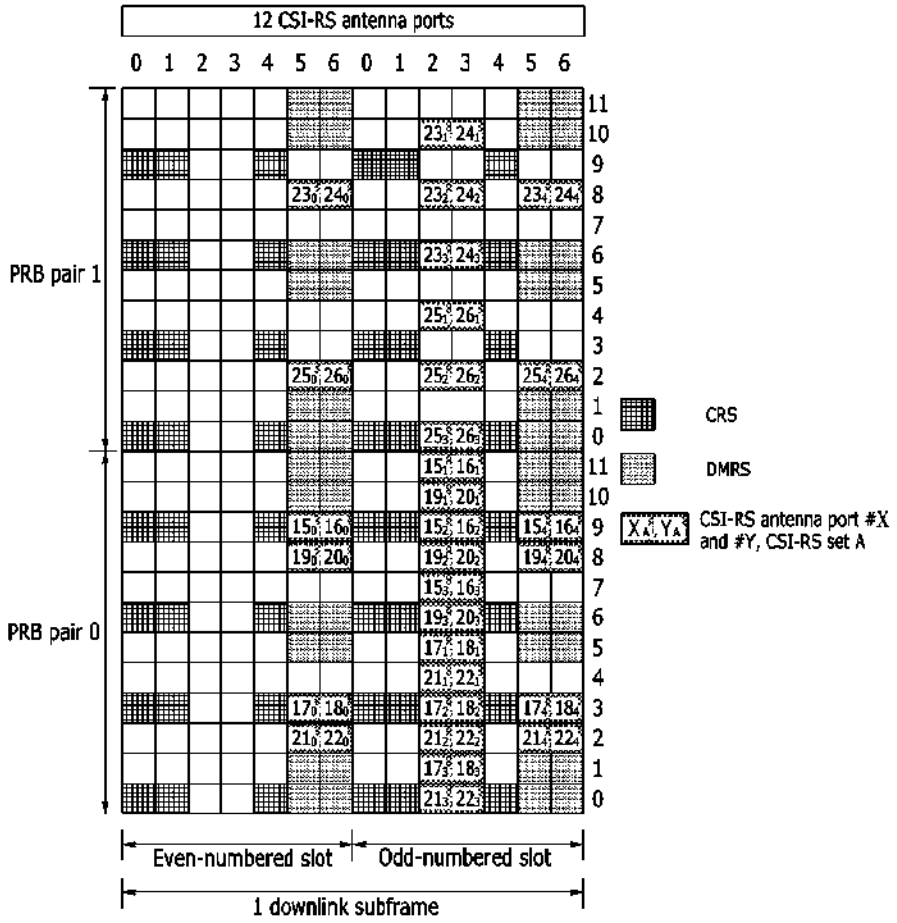
[도12]


16 CSI-RS antenna ports
0 1 2 3 4 5 6 0 1 2 3 4 5 6
PRB pair 1
PRB pair 0
11
10
9
8
7
6
5
4
3
2
1
0
CRS
DMRS
CSI-RS antenna port #X and #Y, CSI-RS set A
Even-numbered slot
Odd-numbered slot
1 downlink subframe

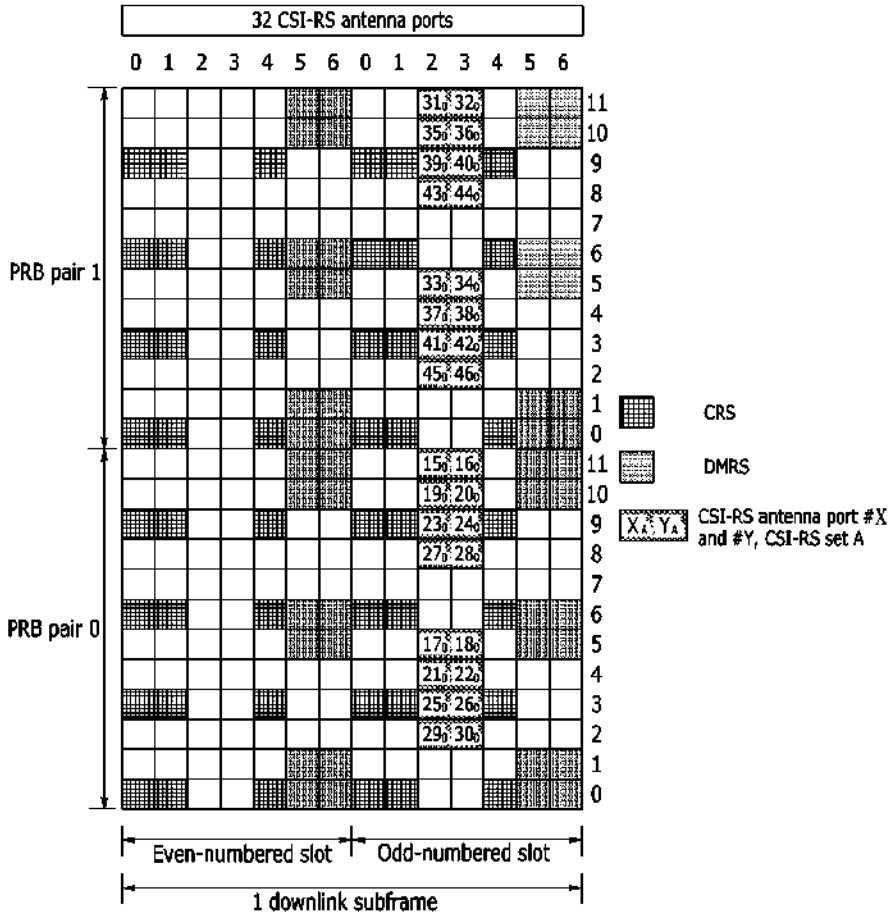
[도13a]


12 CSI-RS antenna ports
0 1 2 3 4 5 6 0 1 2 3 4 5 6
PRB pair 1
PRB pair 0
11 10 9 8 7 6 5 4 3 2 1 0 11 10 9 8 7 6 5 4 3 2 1 0
CRS
DMRS
CSI-RS antenna port #X and #Y, CSI-RS set A
Even-numbered slot
Odd-numbered slot
1 downlink subframe

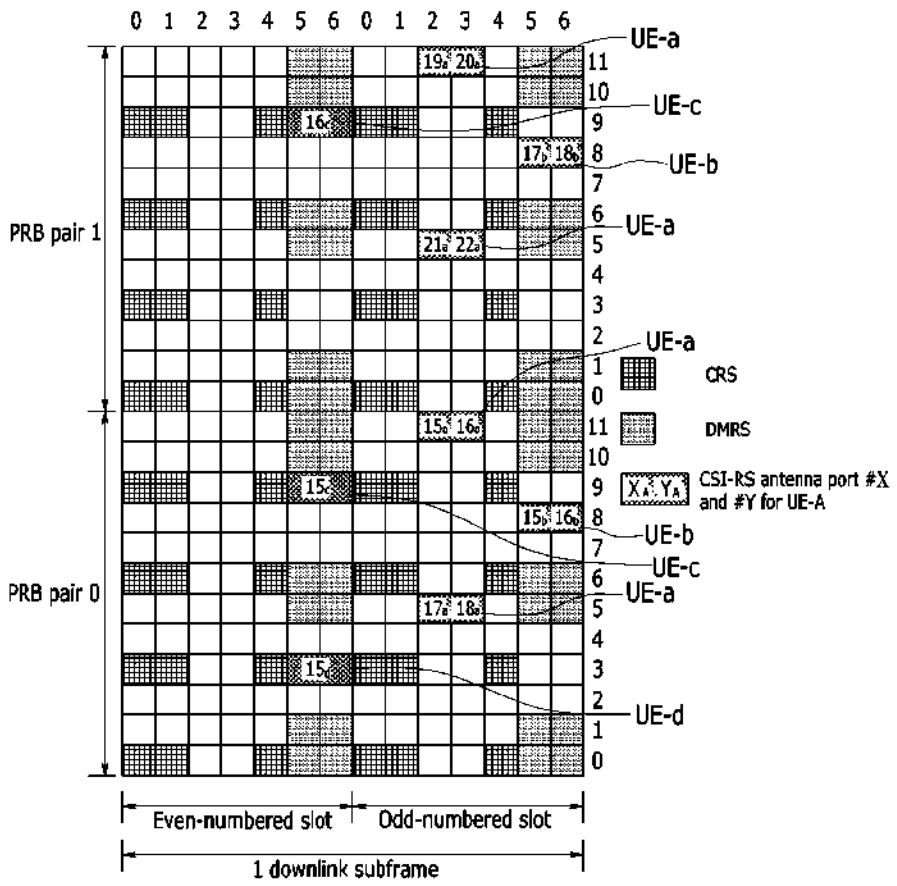
[도13b]


12 CSI-RS antenna ports
0 1 2 3 4 5 6 0 1 2 3 4 5 6
11
10
9
8
7
6
5
4
3
2
1
0
PRB pair 1
PRB pair 0
CRS
DMRS
CSI-RS antenna port #X and #Y, CSI-RS set A
Even-numbered slot
Odd-numbered slot
1 downlink subframe

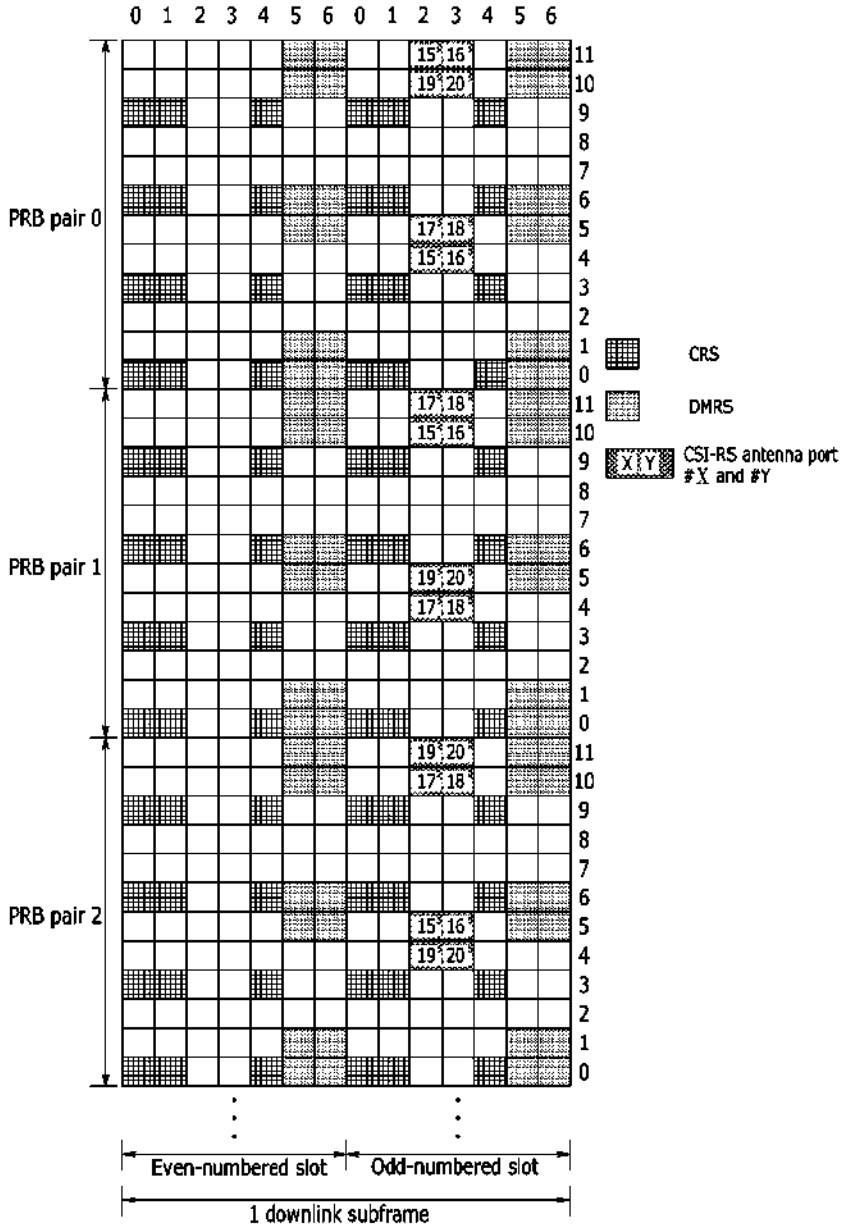
[도14]


32 CSI-RS antenna ports
0 1 2 3 4 5 6 0 1 2 3 4 5 6
PRB pair 1
PRB pair 0
Even-numbered slot
Odd-numbered slot
1 downlink subframe
CRS
DMRS
CSI-RS antenna port #X and #Y, CSI-RS set A

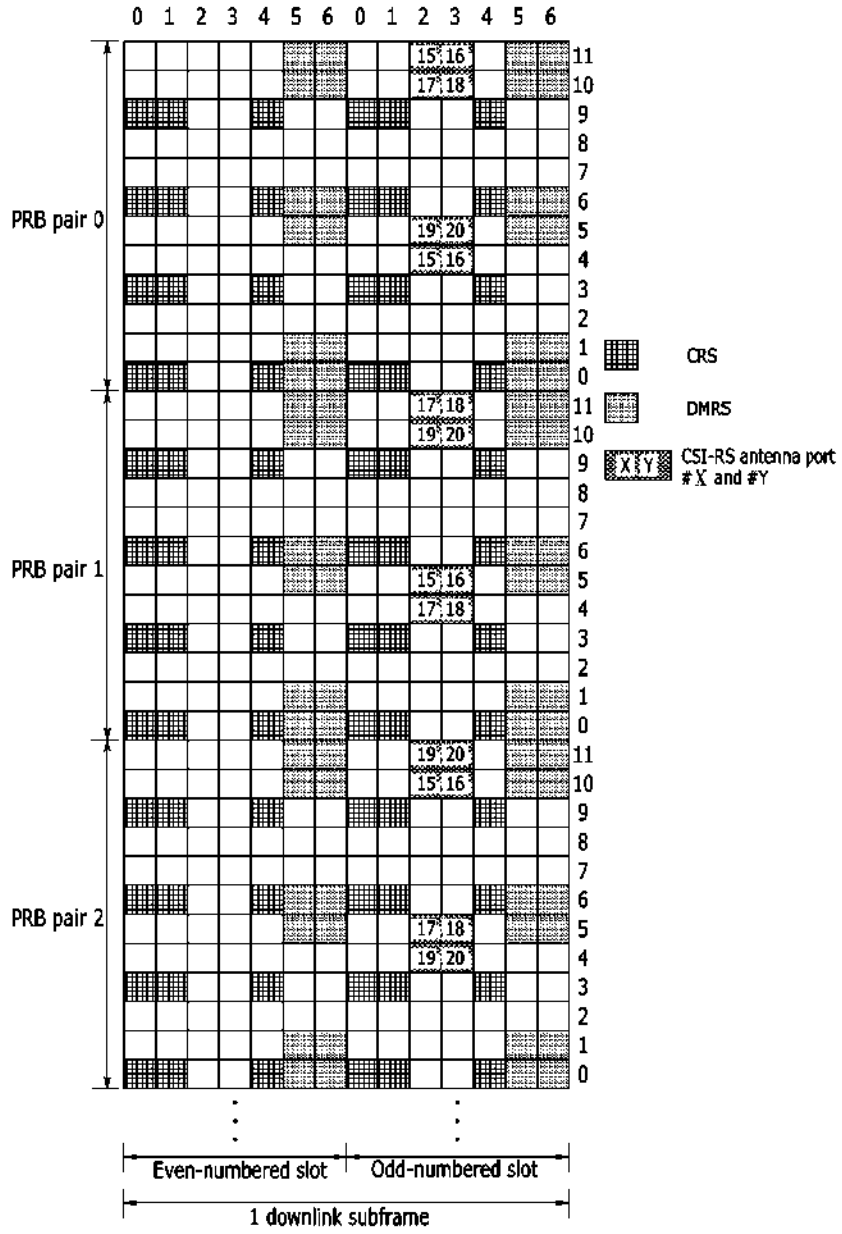
[도15]


0 1 2 3 4 5 6 0 1 2 3 4 5 6
UE-a
UE-c
UE-b
UE-a
UE-a
UE-b
UE-c
UE-a
UE-d
PRB pair 1
PRB pair 0
CRS
DMRS
CSI-RS antenna port #X and #Y for UE-A
Even-numbered slot
Odd-numbered slot
1 downlink subframe

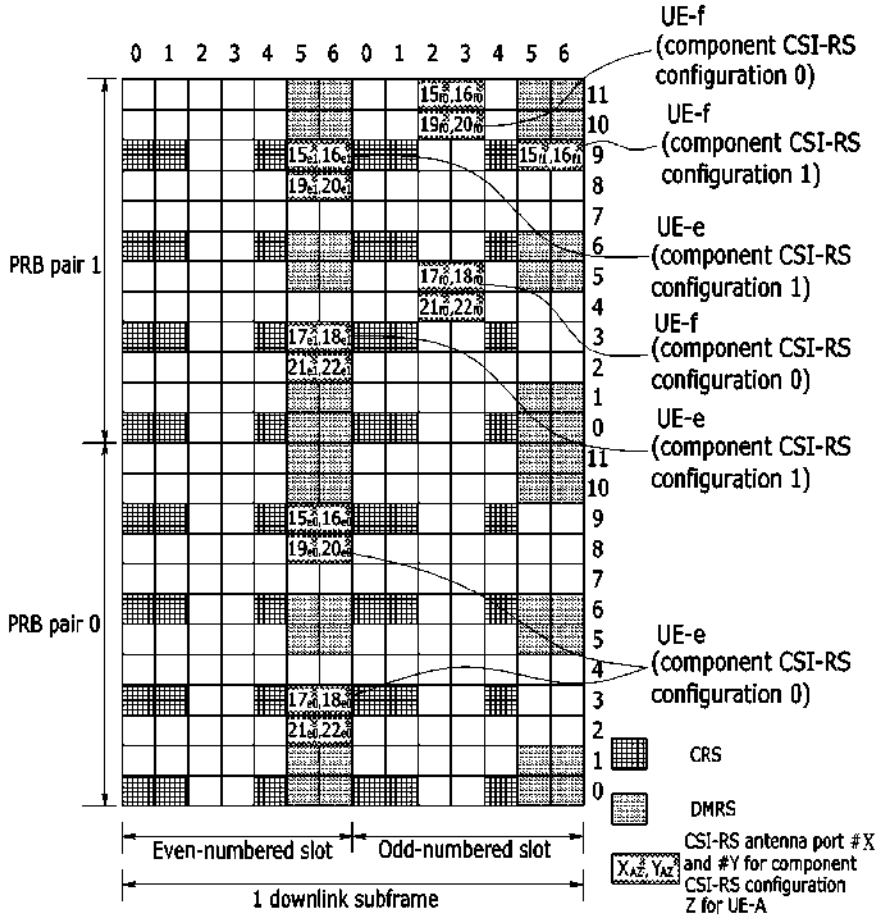
[도16a]


0 1 2 3 4 5 6 0 1 2 3 4 5 6
PRB pair 0
PRB pair 1
PRB pair 2
CRS
DMRS
CSI-RS antenna port #X and #Y
Even-numbered slot
Odd-numbered slot
1 downlink subframe

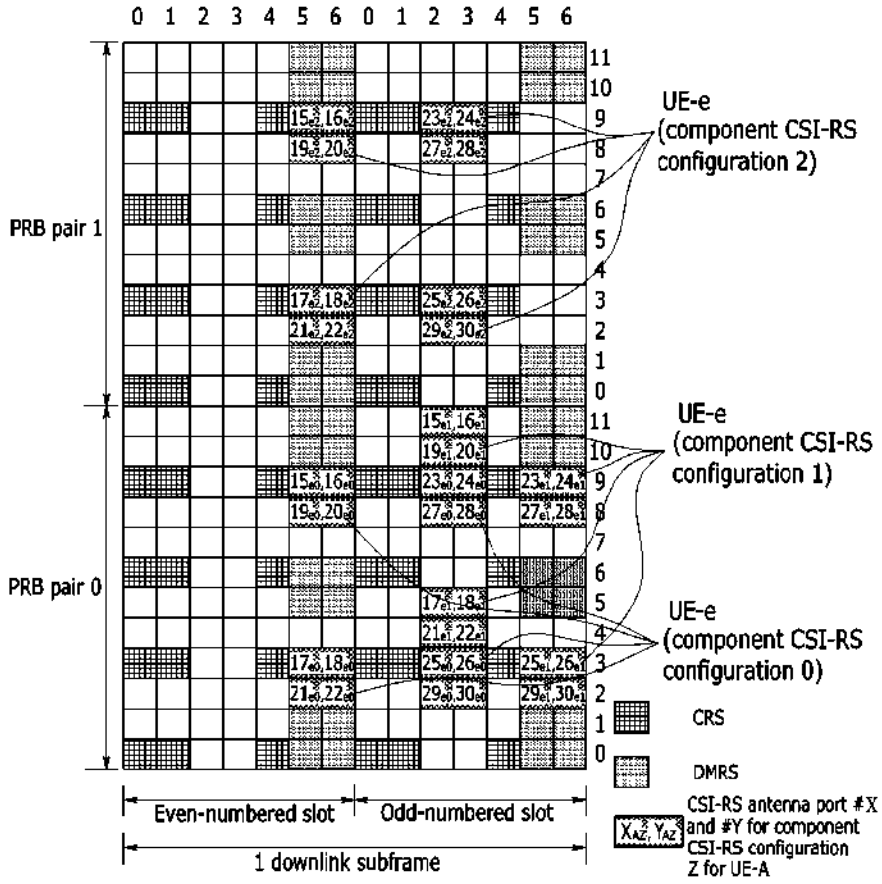
[도16b]


0 1 2 3 4 5 6 0 1 2 3 4 5 6
PRB pair 0
PRB pair 1
PRB pair 2
15 16
17 18
19 20
CRS
DMRS
X Y
CSI-RS antenna port #X and #Y
Even-numbered slot
Odd-numbered slot
1 downlink subframe

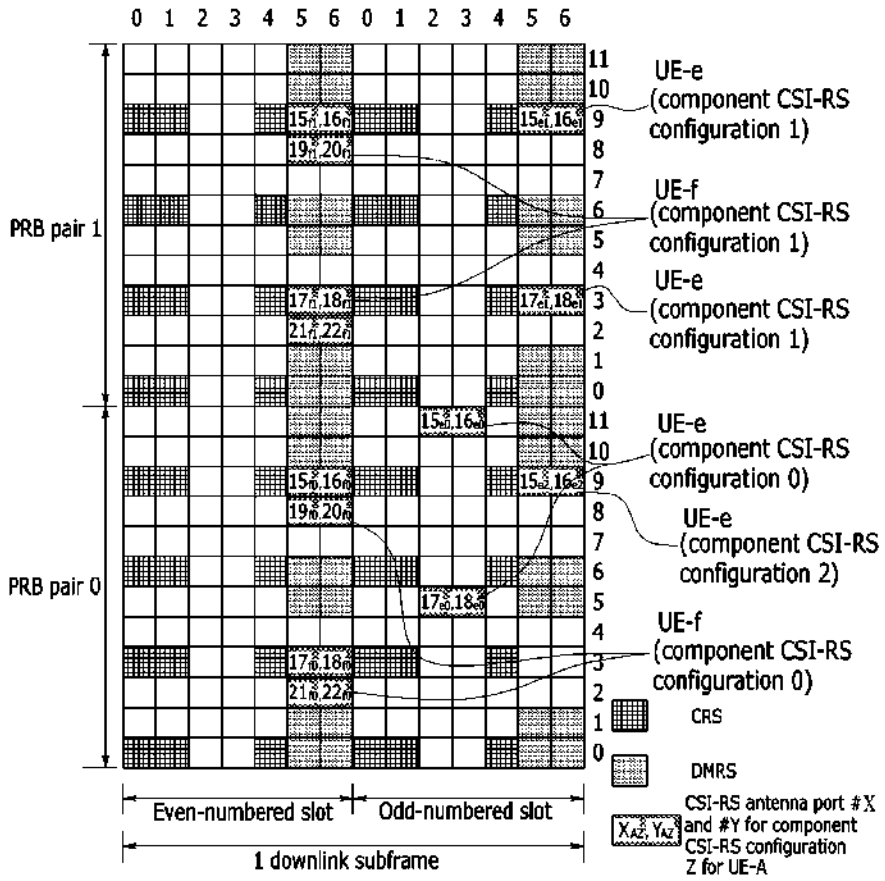
[도17]


0 1 2 3 4 5 6 0 1 2 3 4 5 6
PRB pair 1
PRB pair 0
UE-f (component CSI-RS configuration 0)
UE-f (component CSI-RS configuration 1)
UE-e (component CSI-RS configuration 1)
UE-f (component CSI-RS configuration 0)
UE-e (component CSI-RS configuration 1)
UE-e (component CSI-RS configuration 0)
CRS
DMRS
CSI-RS antenna port #X and #Y for component CSI-RS configuration Z for UE-A
Even-numbered slot
Odd-numbered slot
1 downlink subframe

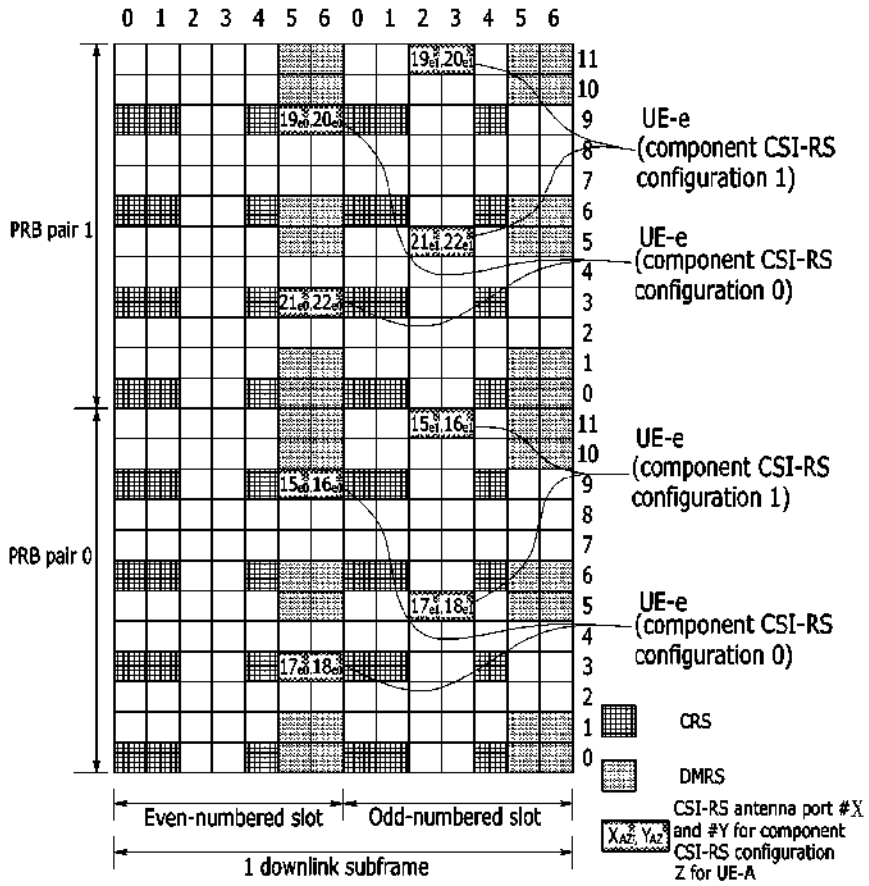
[도18]


0 1 2 3 4 5 6 0 1 2 3 4 5 6
11
10
9
8
7
6
5
4
3
2
1
0
PRB pair 1
PRB pair 0
UE-e
(component CSI-RS
configuration 2)
UE-e
(component CSI-RS
configuration 1)
UE-e
(component CSI-RS
configuration 0)
CRS
DMRS
CSI-RS antenna port #X
and #Y for component
CSI-RS configuration
Z for UE-A
Even-numbered slot
Odd-numbered slot
1 downlink subframe

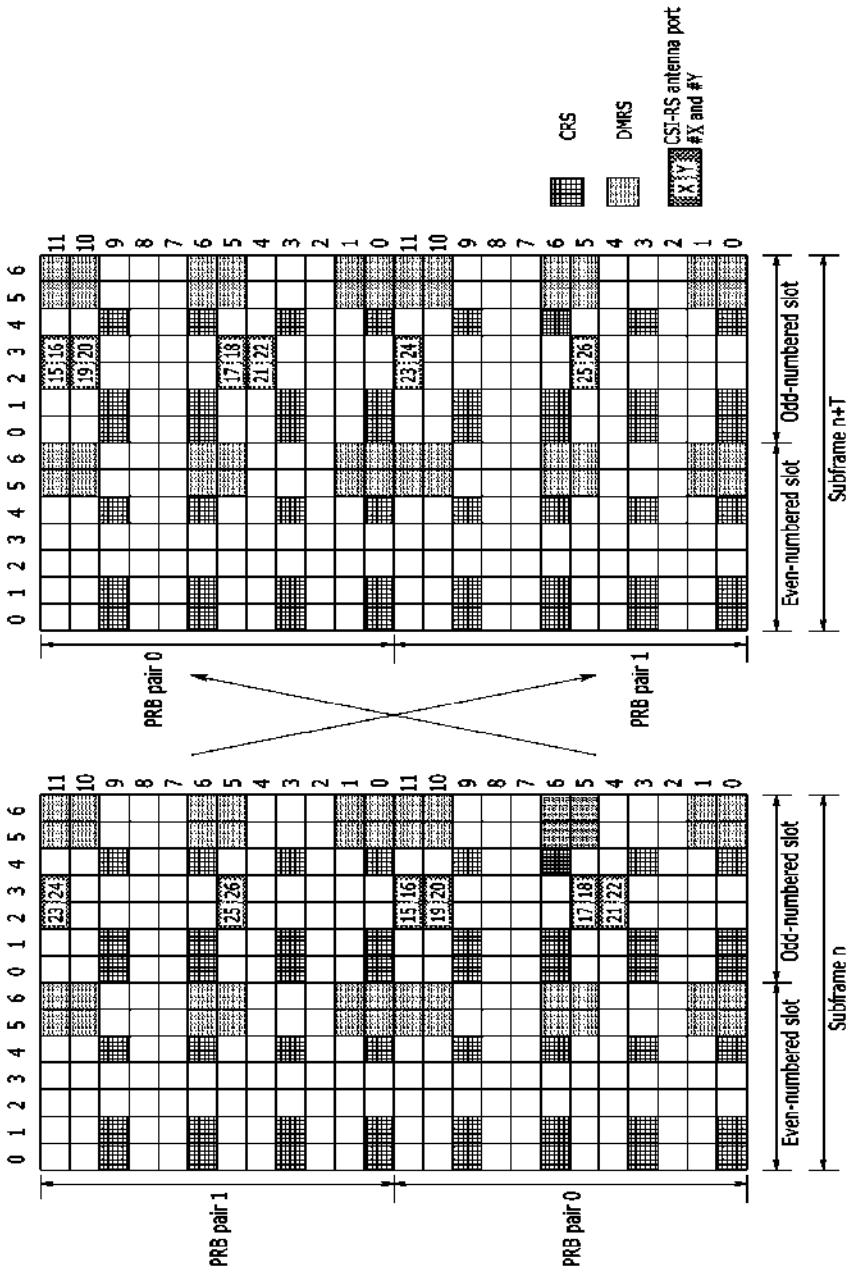
[도19]


0 1 2 3 4 5 6 0 1 2 3 4 5 6
PRB pair 1
PRB pair 0
UE-e (component CSI-RS configuration 1)
UE-f (component CSI-RS configuration 1)
UE-e (component CSI-RS configuration 1)
UE-e (component CSI-RS configuration 0)
UE-e (component CSI-RS configuration 2)
UE-f (component CSI-RS configuration 0)
CRS
DMRS
CSI-RS antenna port #X and #Y for component CSI-RS configuration Z for UE-A
Even-numbered slot
Odd-numbered slot
1 downlink subframe

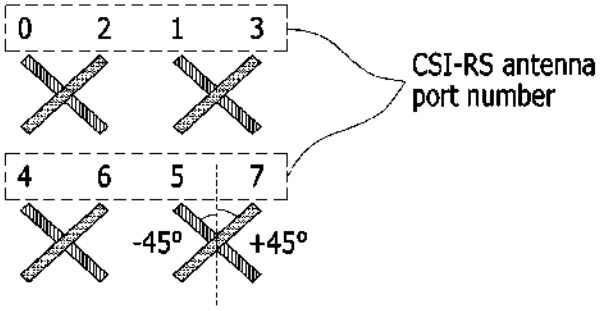
[도20]


0 1 2 3 4 5 6 0 1 2 3 4 5 6
PRB pair 1
PRB pair 0
UE-e (component CSI-RS configuration 1)
UE-e (component CSI-RS configuration 0)
UE-e (component CSI-RS configuration 1)
UE-e (component CSI-RS configuration 0)
CRS
DMRS
CSI-RS antenna port #X and #Y for component CSI-RS configuration Z for UE-A
Even-numbered slot
Odd-numbered slot
1 downlink subframe

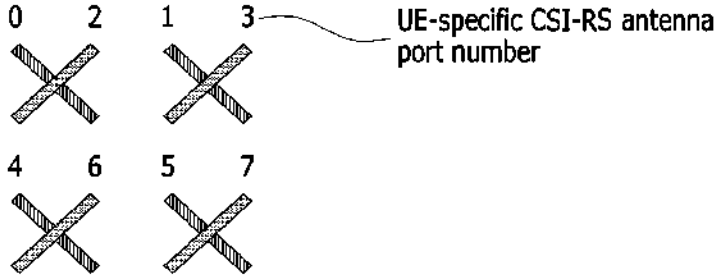
[도21]


CRS
DMRS
CSI-RS antenna port #X and #Y
PRB pair 0
PRB pair 1
PRB pair 1
PRB pair 0
Even-numbered slot
Odd-numbered slot
Subframe n+T
Even-numbered slot
Odd-numbered slot
Subframe n

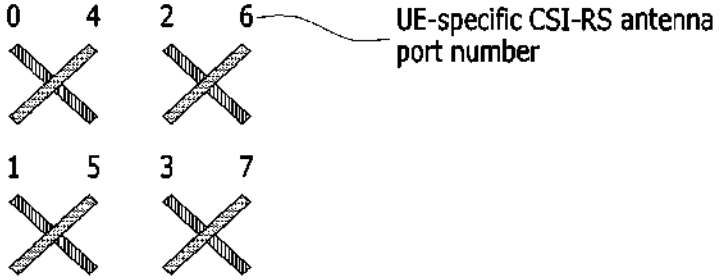
[도22]



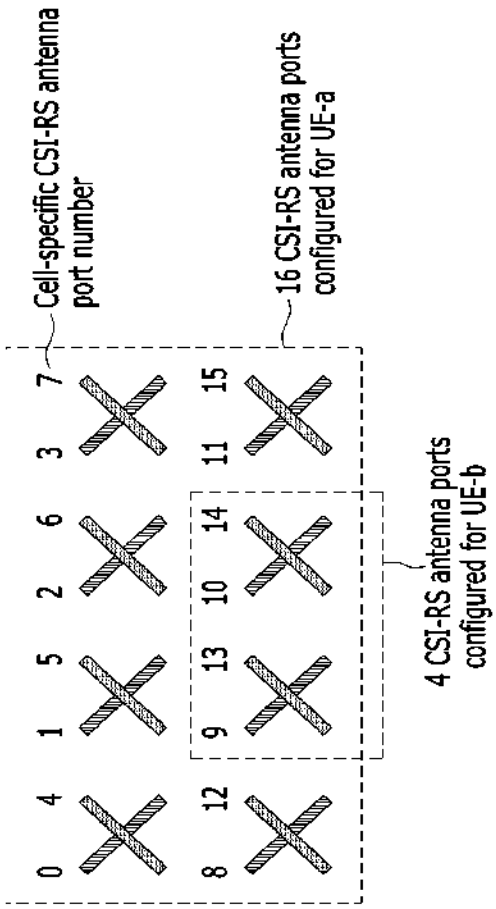
[도23a]



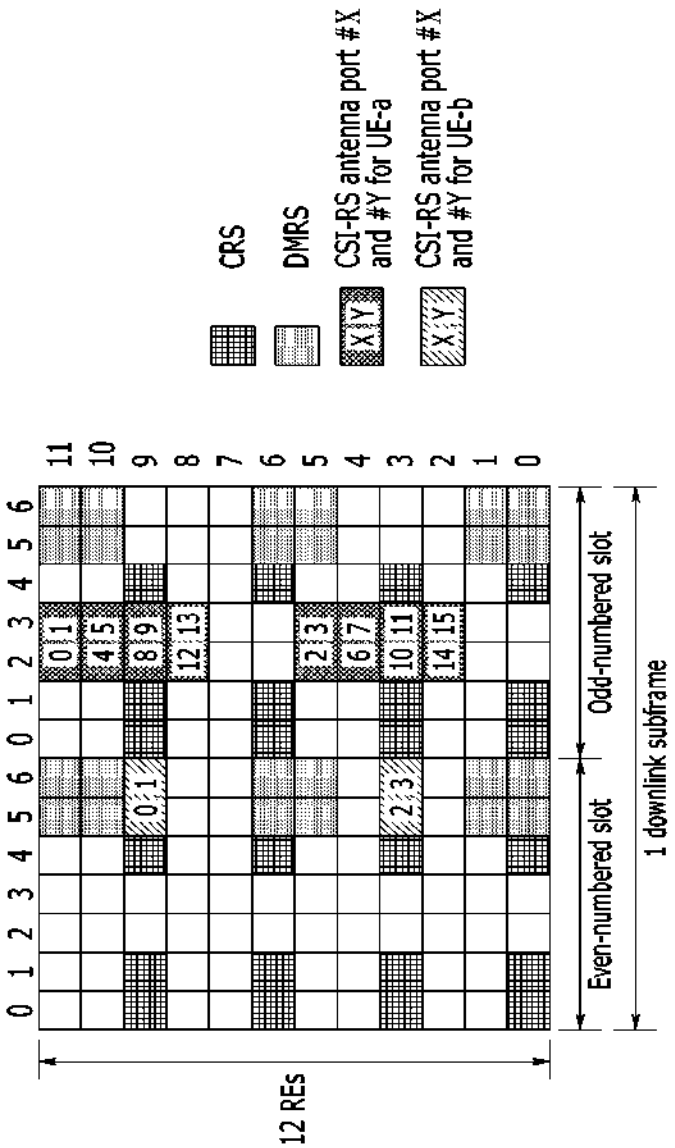
[도23b]



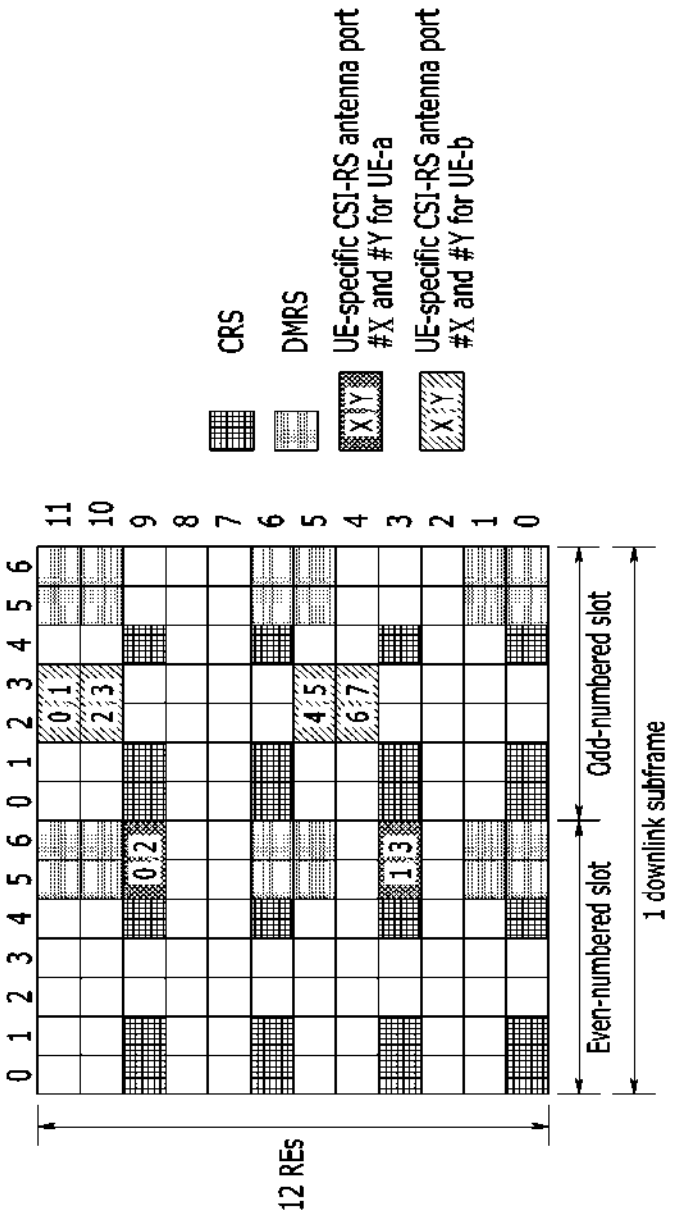
[도24]


Cell-specific CSI-RS antenna port number
16 CSI-RS antenna ports configured for UE-a
4 CSI-RS antenna ports configured for UE-b
0
4
8
12
1
5
9
13
2
6
10
14
3
7
11
15

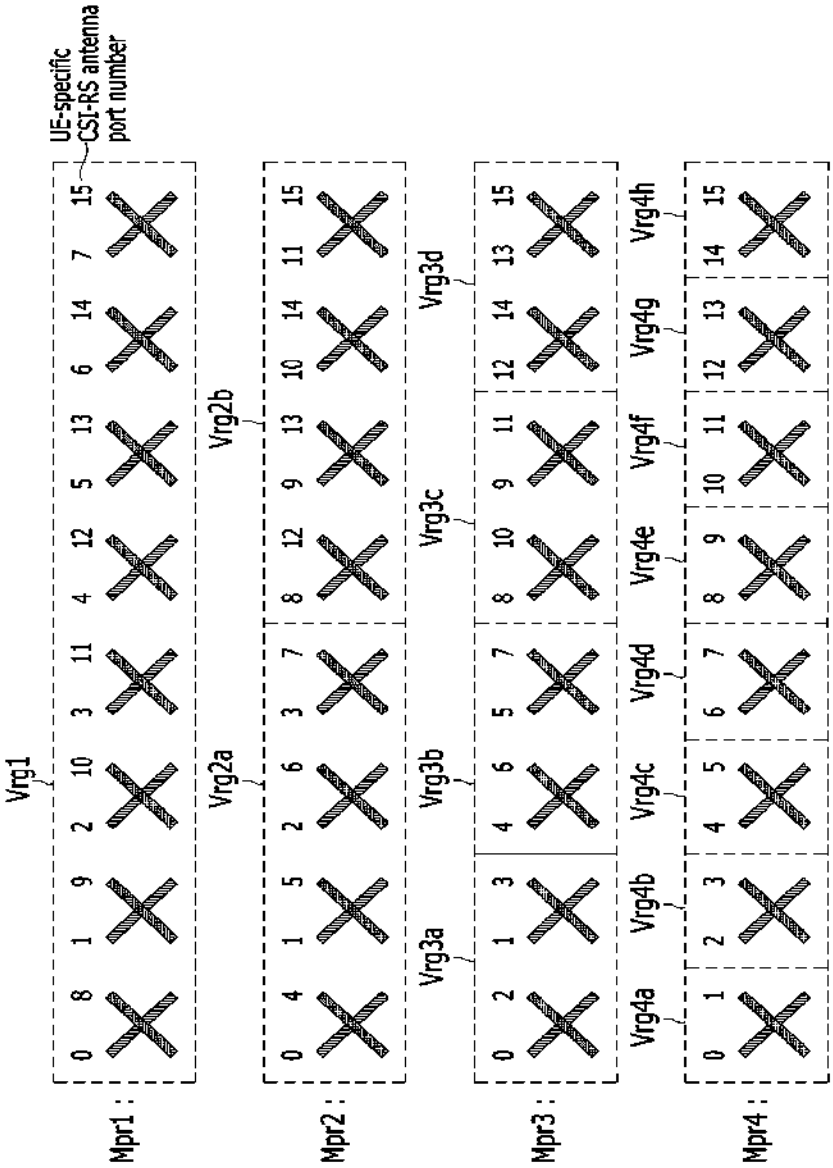
[도25a]


CRS
DMRS
CSI-RS antenna port #X and #Y for UE-a
CSI-RS antenna port #X and #Y for UE-b
X,Y
11 10 9 8 7 6 5 4 3 2 1 0
0 1 2 3 4 5 6
0,1 4,5 8,9 12,13
2,3 6,7 10,11 14,15
0,1 2,3
Odd-numbered slot
Even-numbered slot
1 downlink subframe
12 REs

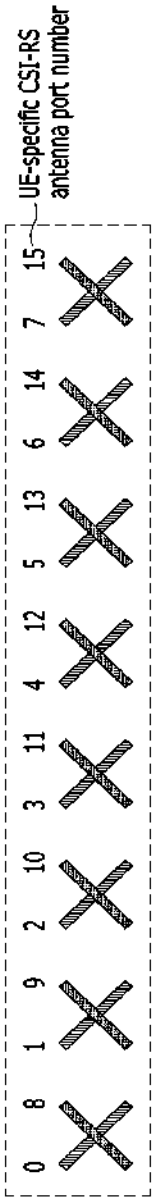
[도25b]


CRS
DMRS
UE-specific CSI-RS antenna port #X and #Y for UE-a
UE-specific CSI-RS antenna port #X and #Y for UE-b
Even-numbered slot
Odd-numbered slot
1 downlink subframe
12 REs

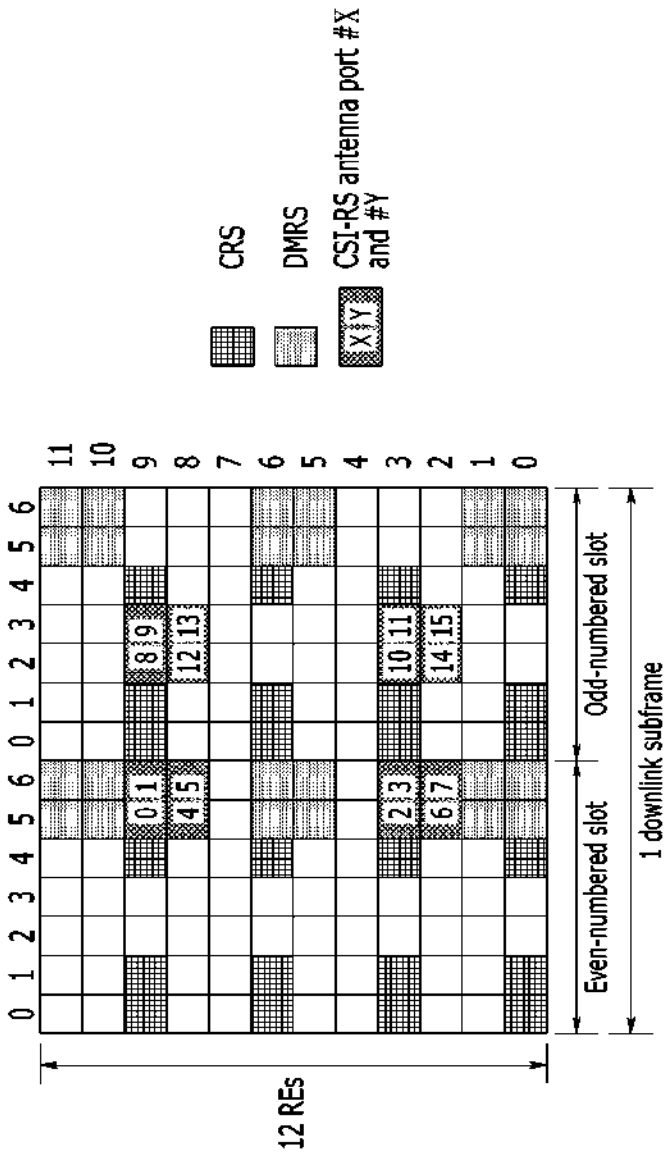
[도26a]


UE-specific CSI-RS antenna port number
Vrg1
Vrg2a
Vrg2b
Vrg3a
Vrg3b
Vrg3c
Vrg3d
Vrg4a
Vrg4b
Vrg4c
Vrg4d
Vrg4e
Vrg4f
Vrg4g
Vrg4h
Mpr1 :
Mpr2 :
Mpr3 :
Mpr4 :

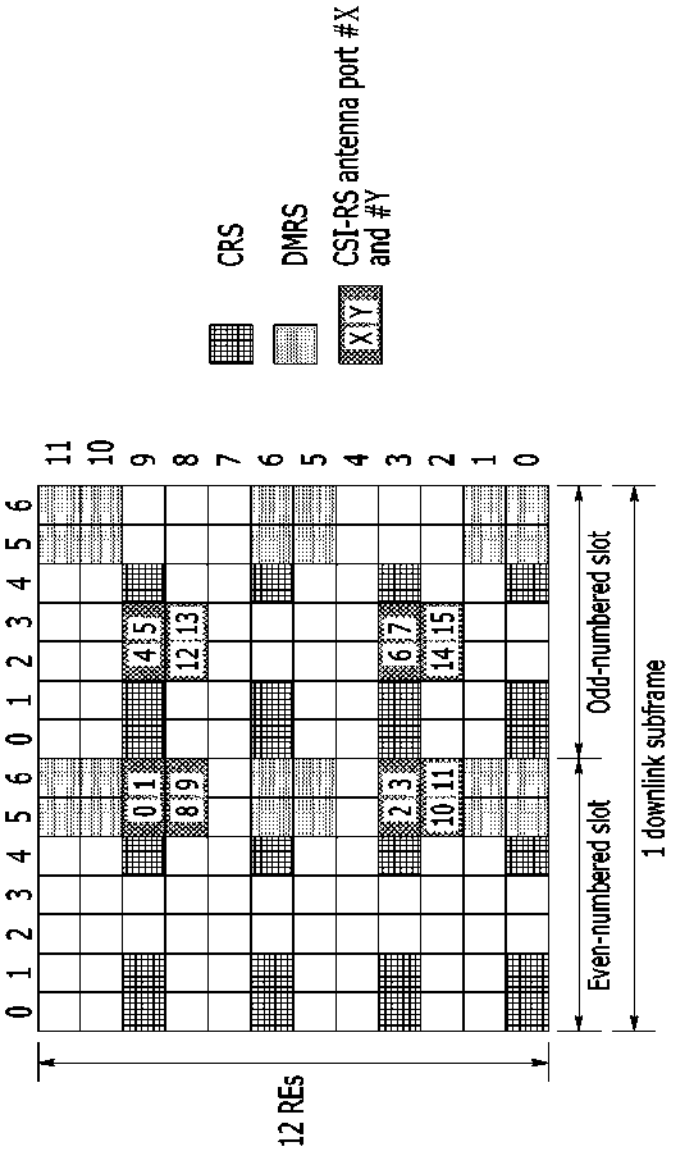
[도26b]


UE-specific CSI-RS antenna port number
15
7
14
6
13
5
12
4
11
3
10
2
9
1
8
0

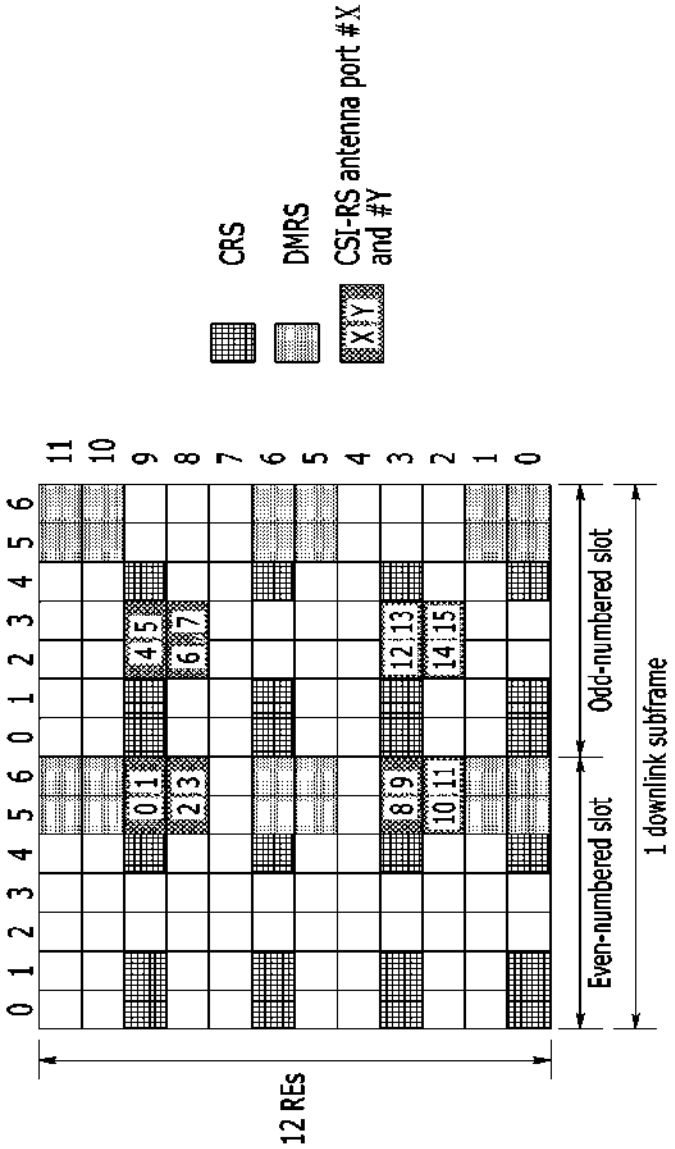
[도26c]


CRS
DMRS
CSI-RS antenna port #X and #Y
X Y
0 1 2 3 4 5 6
11 10 9 8 7 6 5 4 3 2 1 0
0 1
4 5
8 9
12 13
2 3
6 7
10 11
14 15
Even-numbered slot
Odd-numbered slot
1 downlink subframe
12 REs

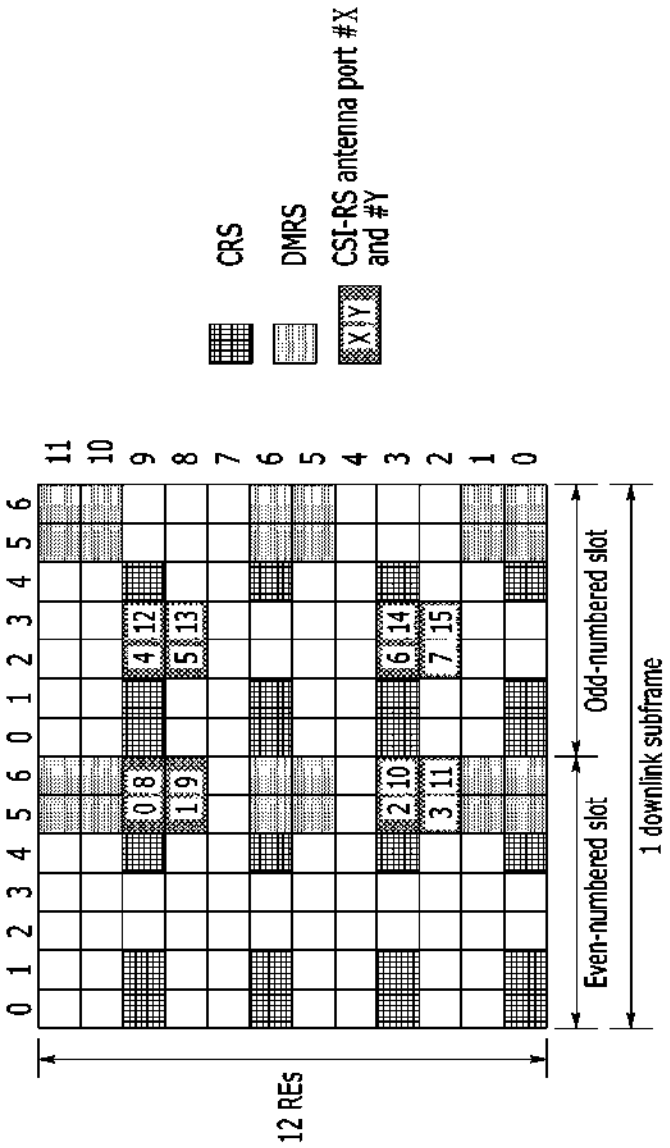
[도26d]


CRS
DMRS
CSI-RS antenna port #X and #Y
X Y
11 10 9 8 7 6 5 4 3 2 1 0
0 1 2 3 4 5 6
0 1
8 9
4 5
12 13
2 3
10 11
6 7
14 15
Even-numbered slot
Odd-numbered slot
1 downlink subframe
12 REs

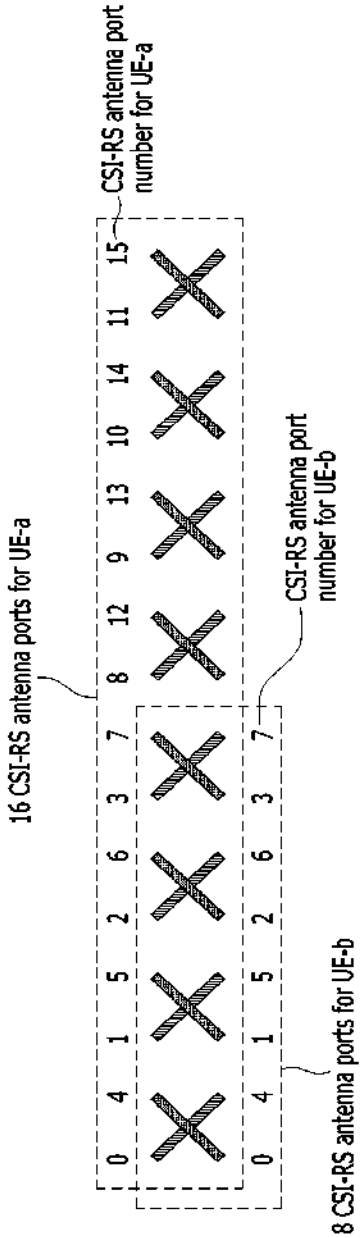
[도26c]


CRS
DMRS
CSI-RS antenna port #X and #Y
X Y
11 10 9 8 7 6 5 4 3 2 1 0
0 1 2 3 4 5 6
0 1
2 3
4 5
6 7
8 9
10 11
12 13
14 15
Odd-numbered slot
Even-numbered slot
1 downlink subframe
12 REs

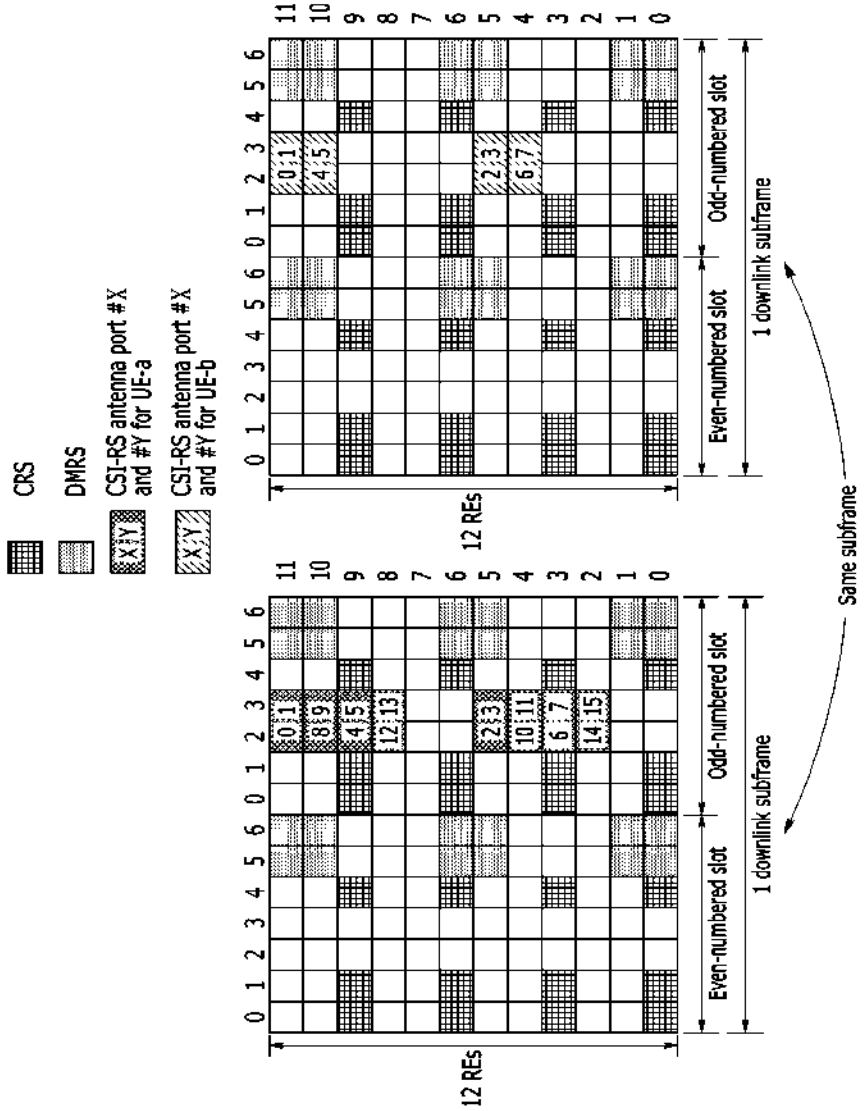
[도26f]


CRS
DMRS
CSI-RS antenna port #X and #Y
X Y
11 10 9 8 7 6 5 4 3 2 1 0
0 1 2 3 4 5 6
0 8
1 9
4 12
5 13
2 10
3 11
6 14
7 15
Odd-numbered slot
Even-numbered slot
1 downlink subframe
12 REs

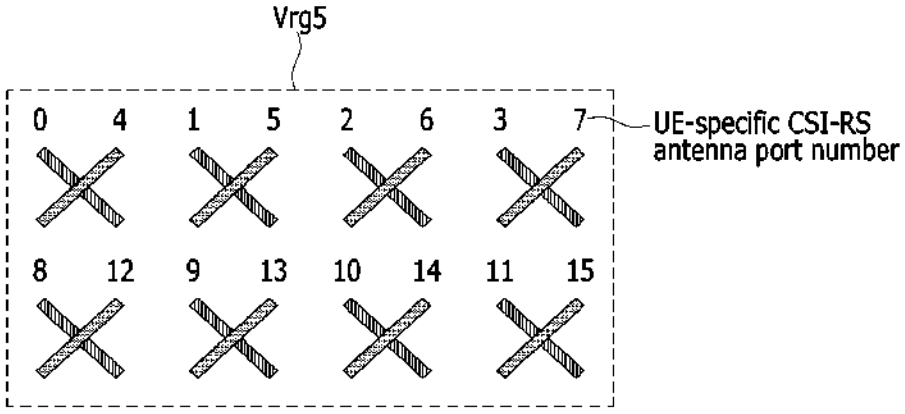
[도27]


CSI-RS antenna port number for UE-a
16 CSI-RS antenna ports for UE-a
CSI-RS antenna port number for UE-b
8 CSI-RS antenna ports for UE-b
0 4 1 5 2 6 3 7 8 12 9 13 10 14 11 15
0 4 1 5 2 6 3 7

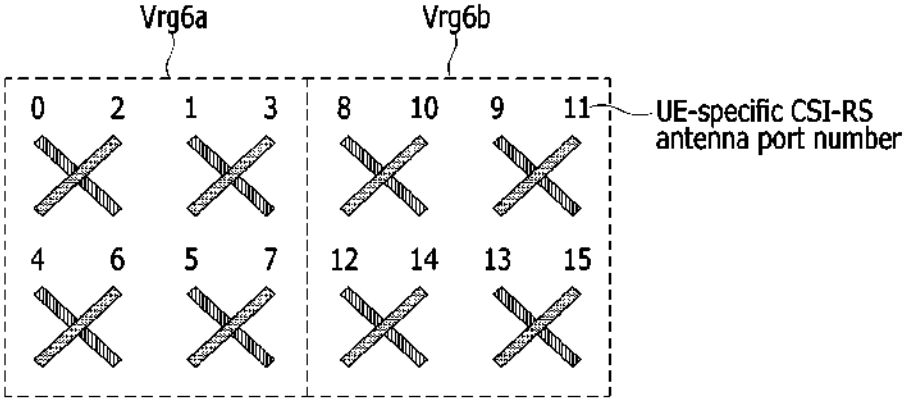
[도28]


CRS
DMRS
CSI-RS antenna port #X and #Y for UE-a
CSI-RS antenna port #X and #Y for UE-b
Odd-numbered slot
Even-numbered slot
1 downlink subframe
12 REs
Same subframe

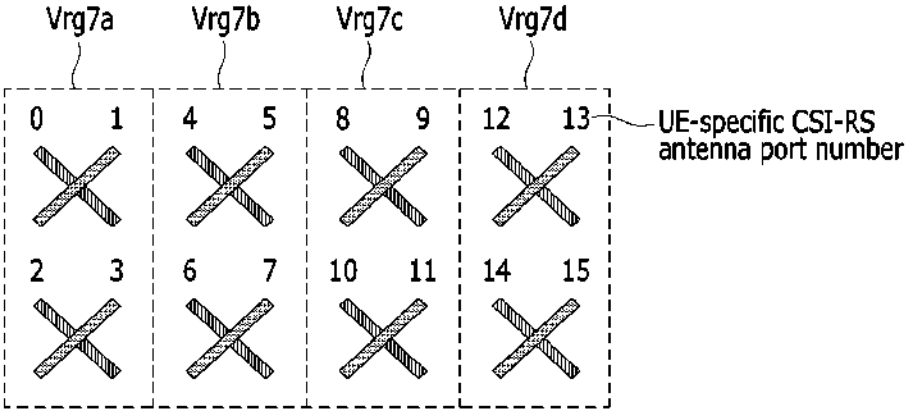
[도29a]


Vrg5
0 4 1 5 2 6 3 7
8 12 9 13 10 14 11 15
UE-specific CSI-RS antenna port number

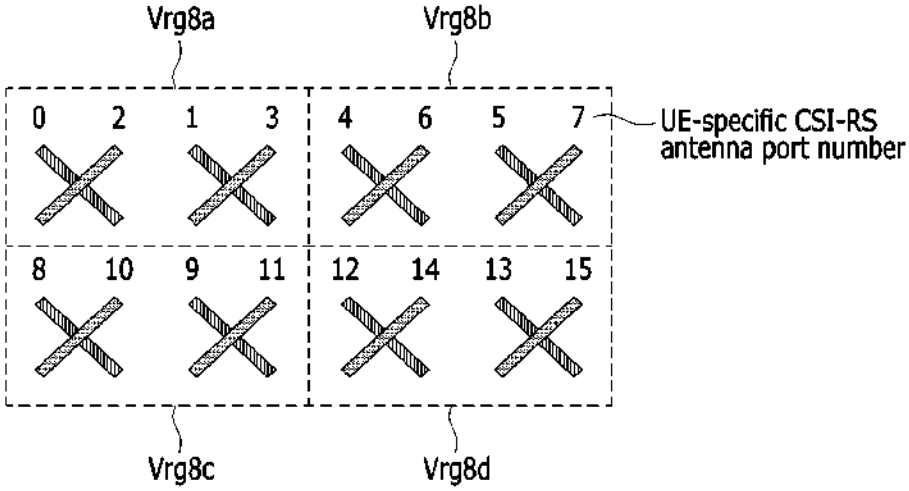
[도29b]



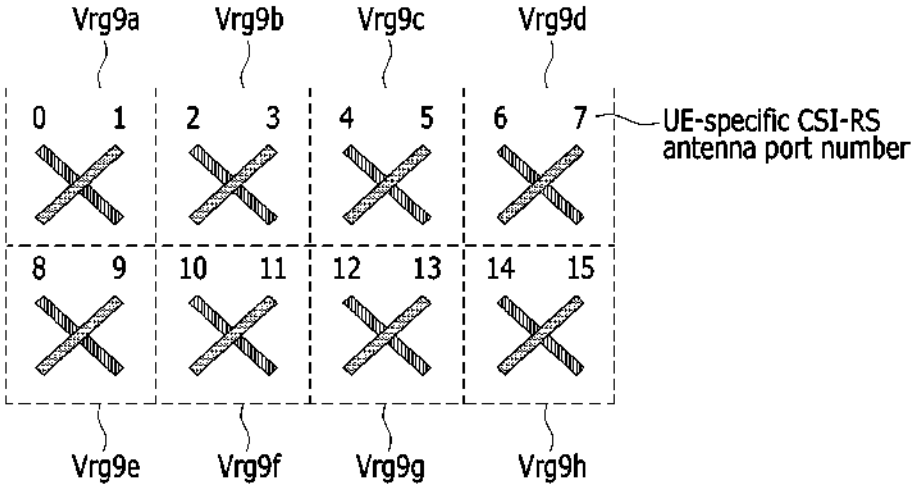
[도29c]



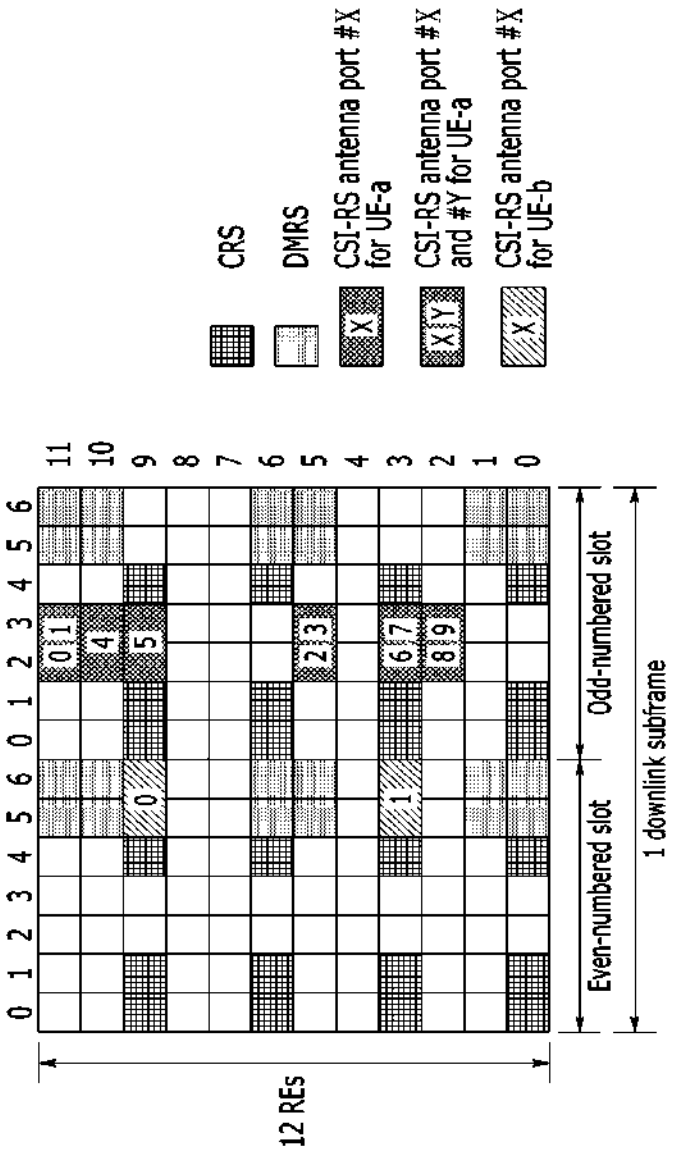
[도29d]



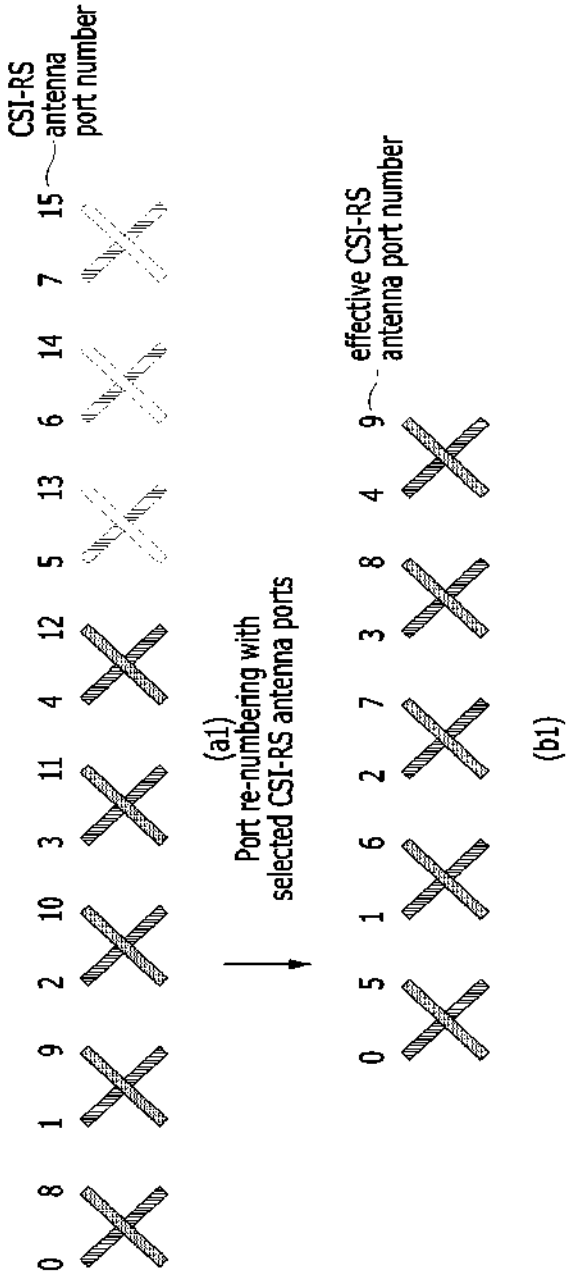
[도29c]


Vrg9a
Vrg9b
Vrg9c
Vrg9d
0 1
2 3
4 5
6 7
UE-specific CSI-RS antenna port number
8 9
10 11
12 13
14 15
Vrg9e
Vrg9f
Vrg9g
Vrg9h

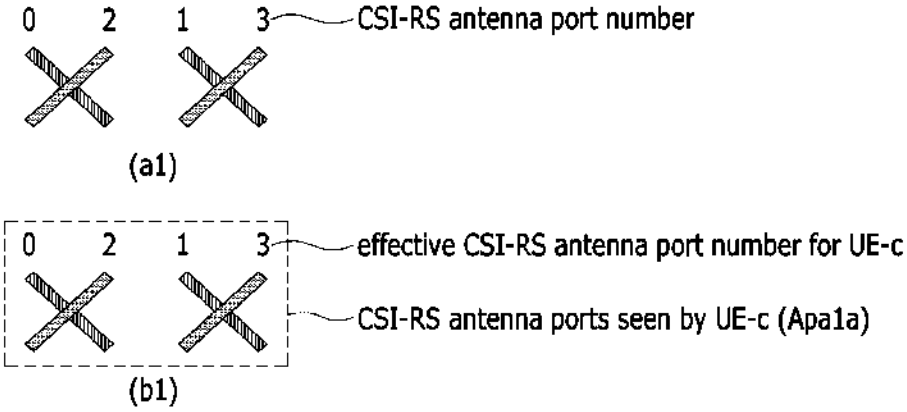
[도30]


CRS
DMRS
CSI-RS antenna port #X for UE-a
CSI-RS antenna port #X and #Y for UE-a
CSI-RS antenna port #X for UE-b
X
X Y
X
0 1 2 3 4 5 6 0 1 2 3 4 5 6
11 10 9 8 7 6 5 4 3 2 1 0
0 1 4 5 2 3 6 7 8 9
Even-numbered slot
Odd-numbered slot
1 downlink subframe
12 REs

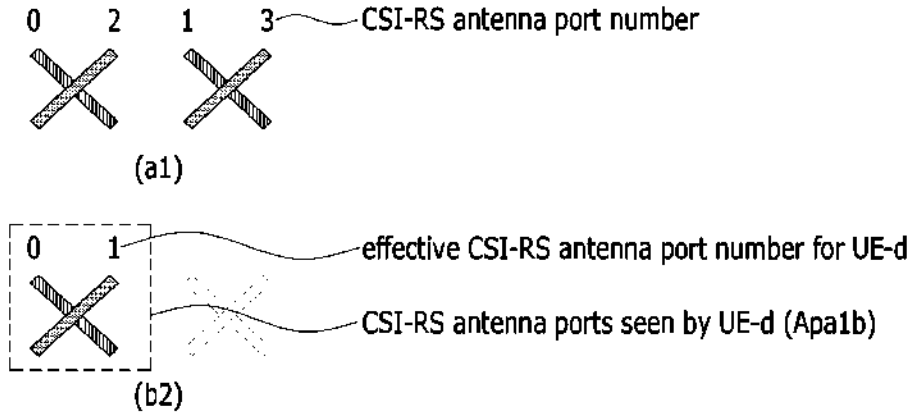
[도31]


CSI-RS antenna port number
0 8 1 9 2 10 3 11 4 12 5 13 6 14 7 15
(a1)
Port re-numbering with selected CSI-RS antenna ports
effective CSI-RS antenna port number
0 5 1 6 2 7 3 8 4 9
(b1)

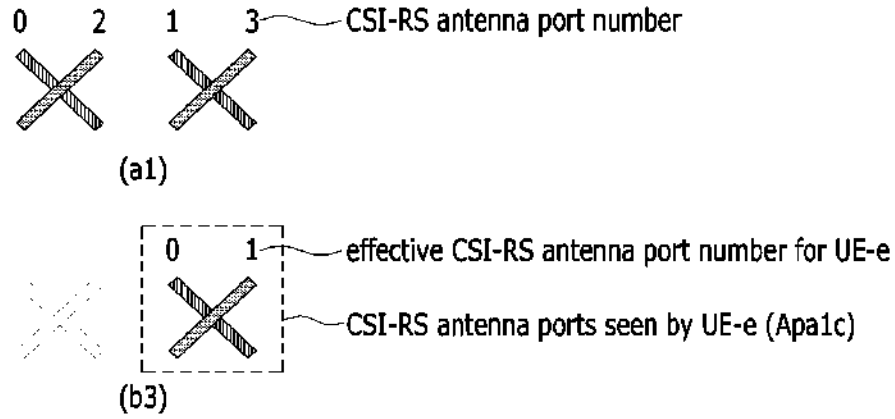
[도32a]



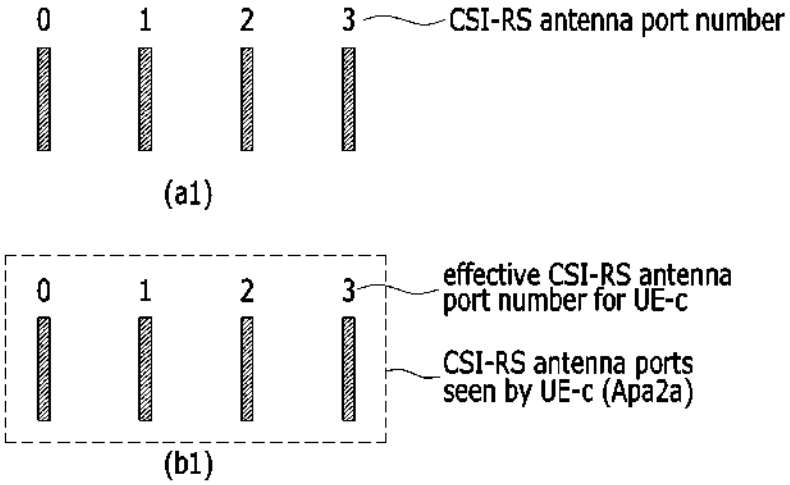
[도32b]



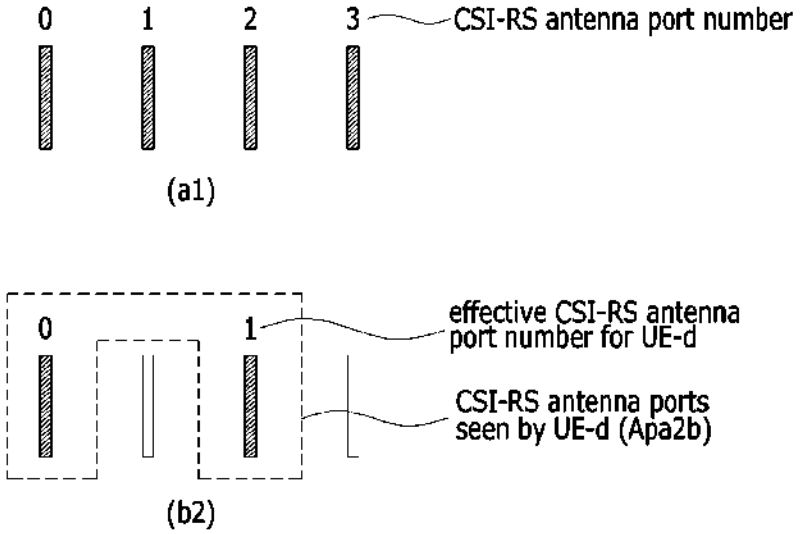
[도32c]



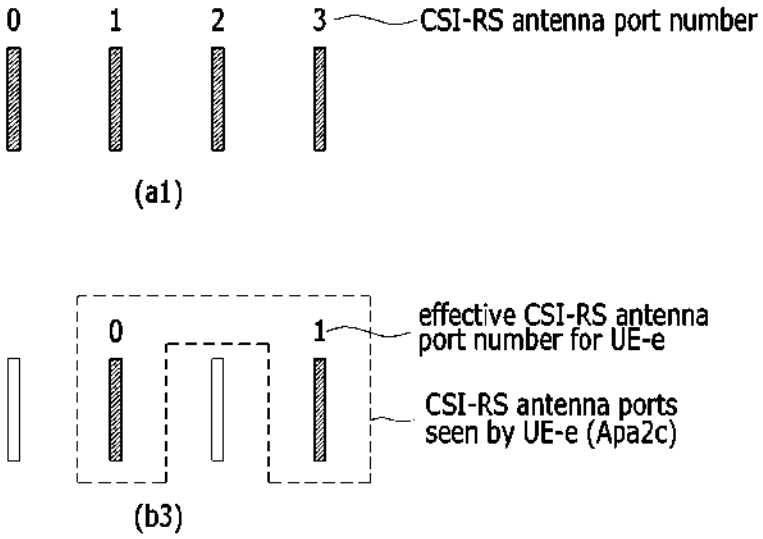
[도33a]


0
1
2
3
CSI-RS antenna port number
(a1)
0
1
2
3
effective CSI-RS antenna port number for UE-c
CSI-RS antenna ports seen by UE-c (Apa2a)
(b1)

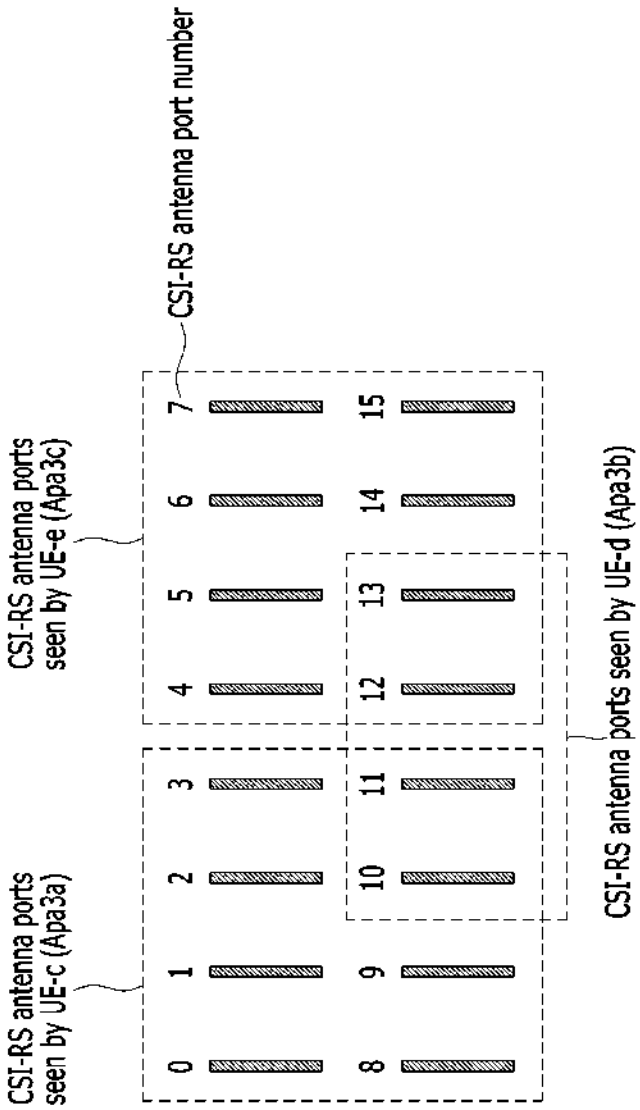
[도33b]


0
1
2
3
CSI-RS antenna port number
(a1)
0
1
effective CSI-RS antenna port number for UE-d
CSI-RS antenna ports seen by UE-d (Apa2b)
(b2)

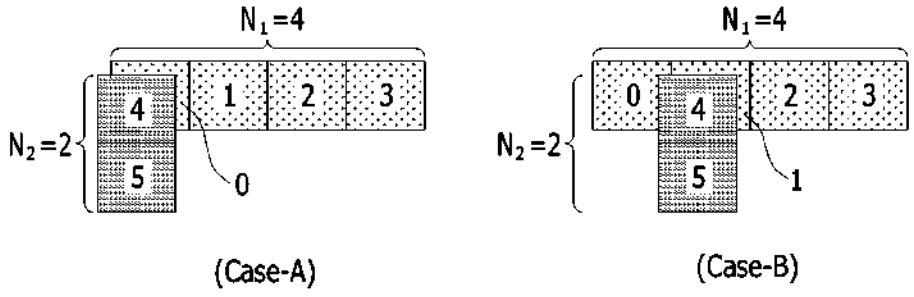
[도33c]


0
1
2
3
CSI-RS antenna port number
(a1)
0
1
effective CSI-RS antenna port number for UE-e
CSI-RS antenna ports seen by UE-e (Apa2c)
(b3)

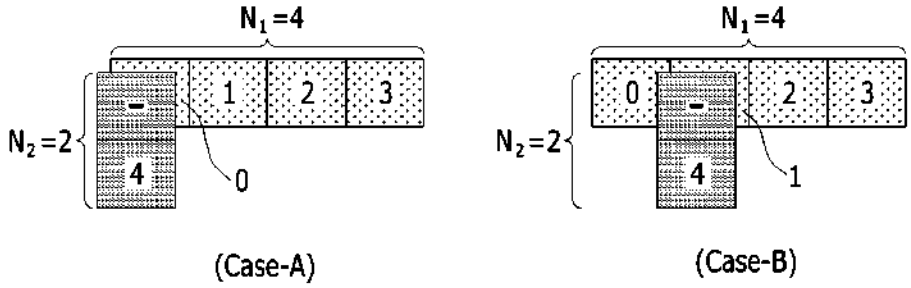
[도34]


CSI-RS antenna port number
CSI-RS antenna ports seen by UE-e (Apa3c)
CSI-RS antenna ports seen by UE-c (Apa3a)
CSI-RS antenna ports seen by UE-d (Apa3b)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

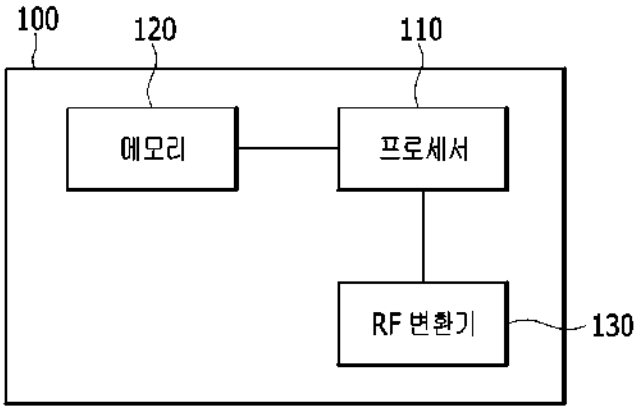
[도35]


N1=4
N2=2
4
1
2
3
5
0
(Case-A)
N1=4
N2=2
0
4
2
3
5
1
(Case-B)

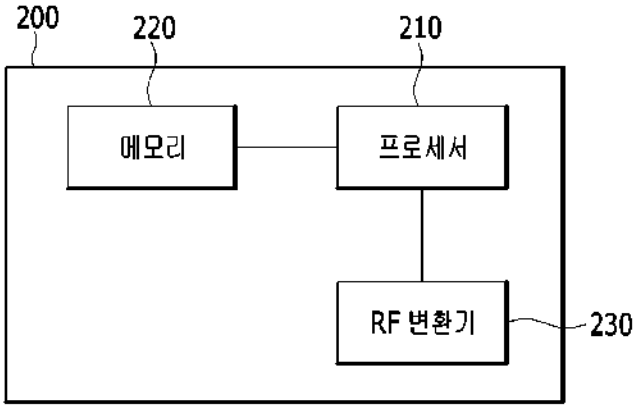
[도36]


N1=4
N2=2
1
2
3
4
0
(Case-A)
N1=4
N2=2
0
2
3
4
1
(Case-B)

[도37]


100
120
110
메모리
프로세서
RF 변환기
130

[도38]


200
220
210
메모리
프로세서
RF 변환기
230

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2016/001014

A. CLASSIFICATION OF SUBJECT MATTER

H04L 5/00(2006.01)i, H04B 7/06(2006.01)i, H04B 7/02(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04L 5/00; H04W 72/04; H04W 24/08; H04B 7/04; H04B 7/06; H04B 7/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Utility models and applications for Utility models: IPC as above
Japanese Utility models and applications for Utility models: IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS (KIPO internal) & Keywords: CSI-RS antenna port, port number mapping rule, the number of ports, CSI-RS antenna group, bit code, horizontal shaft, vertical shaft, polarization shaft, numbering, re-numbering, shaft order, port number state information, bitmap, PDSCH

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2014-0098689 A1 (INTERDIGITAL PATENT HOLDINGS, INC.) 10 April 2014 See paragraphs [0123]-[0234]; and figures 10A-14C.	1-20
A	WO 2014-069821 A1 (PANTECH CO., LTD.) 08 May 2014 See paragraphs [82]-[94]; and figures 6, 7.	1-20
A	WO 2014-161145 A1 (PANASONIC INTELLECTUAL PROPERTY CORPORATION OF AMERICA) 09 October 2014 See page 7, line 7-page 13, line 22; and figures 6-9	1-20
A	US 2014-0192917 A1 (SAMSUNG ELECTRONICS CO., LTD.) 10 July 2014 See paragraphs [0100]-[0120]; and figures 14-18.	1-20
A	US 2013-0100901 A1 (SAMSUNG ELECTRONICS CO., LTD.) 25 April 2013 See paragraphs [0082]-[0094]; and figures 5-7.	1-20

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
04 MAY 2016 (04.05.2016)	**04 MAY 2016 (04.05.2016)**
Name and mailing address of the ISA/KR Korean Intellectual Property Office Government Complex-Daejeon, 189 Seonsa-ro, Daejeon 302-701, Republic of Korea Facsimile No. 82-42-472-7140	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2016/001014

Patent document cited in search report	Publication date	Patent family member	Publication date
US 2014-0098689 A1	10/04/2014	EP 2901571 A1	05/08/2015
		JP 2015-536099 A	17/12/2015
		TW 201429182 A	16/07/2014
		WO 2014-052806 A1	03/04/2014
WO 2014-069821 A1	08/05/2014	KR 10-2014-0057005 A	12/05/2014
		US 2015-0288497 A1	08/10/2015
WO 2014-161145 A1	09/10/2014	CN 105191164 A	23/12/2015
		EP 2982049 A1	10/02/2016
US 2014-0192917 A1	10/07/2014	AU 2014-205792 A1	30/04/2015
		CN 104885499 A	02/09/2015
		EP 2944111 A1	18/11/2015
		KR 10-2015-0104556 A	15/09/2015
		US 9178583 B2	03/11/2015
		WO 2014-109557 A1	17/07/2014
US 2013-0100901 A1	25/04/2013	AU 2012-326774 A1	29/05/2014
		AU 2012-326774 A2	03/07/2014
		CA 2853003 A1	25/04/2013
		CN 104012016 A	27/08/2014
		EP 2584731 A2	24/04/2013
		EP 2584731 A3	03/09/2014
		JP 2015-501586 A	15/01/2015
		KR 10-2013-0043602 A	30/04/2013
		RU 2014120168 A	27/11/2015
		US 2015-0092729 A1	02/04/2015
		US 8913576 B2	16/12/2014
		WO 2013-058624 A1	25/04/2013

Form PCT/ISA/210 (patent family annex) (January 2015)

국 제 조 사 보 고 서

국제출원번호
PCT/KR2016/001014

A. 발명이 속하는 기술분류(국제특허분류(IPC))

H04L 5/00(2006.01)i, H04B 7/06(2006.01)i, H04B 7/02(2006.01)i

B. 조사된 분야

조사된 최소문헌(국제특허분류를 기재)

H04L 5/00; H04W 72/04; H04W 24/08; H04B 7/04; H04B 7/06; H04B 7/02

조사된 기술분야에 속하는 최소문헌 이외의 문헌

한국등록실용신안공보 및 한국공개실용신안공보: 조사된 최소문헌란에 기재된 IPC

일본등록실용신안공보 및 일본공개실용신안공보: 조사된 최소문헌란에 기재된 IPC

국제조사에 이용된 전산 데이터베이스(데이터베이스의 명칭 및 검색어(해당하는 경우))

eKOMPASS(특허청 내부 검색시스템) & 키워드: CSI-RS 안테나 포트, 포트 번호, 맵핑 규칙, 포트의 수, CSI-RS 안테나 그룹, 비트 코드, 수평 축, 수직 축, 편파 축, 번호 부여, 세부역, 축 순서, 포트 번호 부여 여부 정보, 비트맵, PDSCH

C. 관련 문헌

카테고리*	인용문헌명 및 관련 구절(해당하는 경우)의 기재	관련 청구항
A	US 2014-0098689 A1 (INTERDIGITAL PATENT HOLDINGS, INC.) 2014.04.10 단락 [0123]-[0234]; 및 도면 10A-14C 참조.	1-20
A	WO 2014-069821 A1 (주식회사 팬택) 2014.05.08 단락 [82]-[94]; 및 도면 6, 7 참조.	1-20
A	WO 2014-161145 A1 (PANASONIC INTELLECTUAL PROPERTY CORPORATION OF AMERICA) 2014.10.09 페이지 7, 라인 7 - 페이지 13, 라인 22; 및 도면 6-9 참조.	1-20
A	US 2014-0192917 A1 (SAMSUNG ELECTRONICS CO., LTD.) 2014.07.10 단락 [0100]-[0120]; 및 도면 14-18 참조.	1-20
A	US 2013-0100901 A1 (SAMSUNG ELECTRONICS CO., LTD.) 2013.04.25 단락 [0082]-[0094]; 및 도면 5-7 참조.	1-20

☐ 추가 문헌이 C(계속)이 기재되어 있습니다.

☒ 대응특허에 관한 별지를 참조하십시오.

* 인용된 문헌의 특별 카테고리

"A" 특별히 관련이 없는 것으로 보이는 일반적인 기술수준을 정의한 문헌

"E" 국제출원일보다 빠른 출원일 또는 우선일을 가지나 국제출원일 이후에 공개된 선출원 또는 특허 문헌

"L" 우선권 주장에 의문을 제기하는 문헌 또는 다른 인용문헌의 공개일 또는 다른 특별한 이유(이유를 명시)를 밝히기 위하여 인용된 문헌

"O" 구두 개시, 사용, 전시 또는 기타 수단을 언급하고 있는 문헌

"P" 우선일 이후에 공개되었으나 국제출원일 이전에 공개된 문헌

"T" 국제출원일 또는 우선일 후에 공개된 문헌으로, 출원과 상충하지 않으며 발명의 기초가 되는 원리나 이론을 이해하기 위해 인용된 문헌

"X" 특별한 관련이 있는 문헌. 해당 문헌 하나만으로 청구된 발명의 신규성 또는 진보성이 없는 것으로 본다.

"Y" 특별한 관련이 있는 문헌. 해당 문헌이 하나 이상의 다른 문헌과 조합하는 경우로 그 조합이 당업자에게 자명한 경우 청구된 발명은 진보성이 없는 것으로 본다.

"&" 동일한 대응특허문헌에 속하는 문헌

국제조사의 실제 완료일	국제조사보고서 발송일
2016년 05월 04일 (04.05.2016)	2016년 05월 04일 (04.05.2016)

ISA/KR의 명칭 및 우편주소
대한민국 특허청
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(54) METHOD, EQUIPMENT AND SYSTEM FOR COORDINATED MULTI-POINT TRANSMISSION/ RECEPTION

(57) A method, a device, and a system for CoMP coordinated multi-point transmission are disclosed, where the method includes: obtaining reference signal received power RSRP of a cell in a measurement set of a user equipment UE; determining that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold; and combining a cell whose RSRP is greater between the first cell and the second cell with the serving cell of the UE into a coordinated set of the UE, and performing coordinated multi-point transmission on the UE, thereby improving an effect of CoMP.

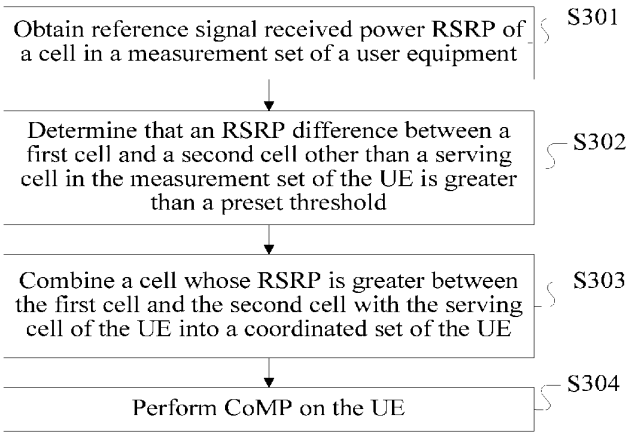


FIG. 3

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Description

TECHNICAL FIELD

[0001] The present invention relates to the field of network technologies, and in particular, to a method, a device, and a system for coordinated multi-point transmission.

BACKGROUND

[0002] CoMP (Coordinated Multi-point Transission/reception, coordinated multi-point transmission) is one of key technologies of LTE-A (Long Term Evolution-Advanced, long term evolution-advanced), and is used to expand coverage of a high data rate and increase average throughput of a system, thereby improving performance of a cell edge user.

[0003] FIG. 1 is a schematic diagram of a CoMP technology. CoMP is a cooperative sending and receiving technology, where one base station (for example, eNodeB x in FIG. 1) is connected to several access points (for example, Point x in FIG. 1), and one access point may include one or more antennas. Multiple users (User Equipment, UE for short) (UE x) may be served by one or more access points located at one same base station or different base stations. A coordination center controller may obtain information from a distributed access point, and allocate a resource to meet a QoS (Quality of Service, quality of service) requirement of a user, thereby maximizing performance of an entire network.

[0004] In the CoMP technology, signals of a serving cell and multiple coordination cells may be simultaneously sent or received, which is equivalent to increasing the number of antennas at a transmit end or a receive end, and demodulation performance is improved through a multiple input multiple output (Multiple Input Multiple Output, MIMO for short) receiver.

[0005] A main principle of uplink-based intra-eNodeB (Intra-eNodeB) CoMP is that, antennas in different cells of one same base station are used for receiving a signal of a certain user, and a combined gain and an interference suppression gain of the signal received by the multiple antennas may be obtained at the same time, and the combined gain of the signal is greater for a user closer to a boundary between two cells. By taking FIG. 2 as an example, a user is located at a boundary between cells, a Cell 0 and a Cell 1, and the Cell 1 is a serving cell for the user. When the user is closer to the boundary of the cell Cell 0, power of a signal of the user received by the cell Cell 0 is greater, and a combined gain of the signal is higher.

[0006] However, it is very complicated to implement CoMP for all users. Due to a limitation on a processing capability of a device at present, it is very difficult to implement this solution in practice. In a case of joint reception for some cells with excessively low signal to interference plus noise ratios (SINR), performance may decrease instead due to the influence of channel estimation. Therefore, how to select a CoMP coordinated set and which UEs are to be selected, where CoMP is performed on the UEs for optimization in terms of performance and complexity, become very important.

[0007] Currently, a mainstream solution in the prior art is to determine whether to perform CoMP on a UE by using whether a difference between RSRP (Reference Signal Receiving Power, reference signal received power) of a serving cell and RSRP of another neighboring cell is greater than a predetermined threshold. However, this selection manner does not take an interference factor into consideration, and in practice, interference on the serving cell and interference on another cell are usually very different. Therefore, a UE selected according to an RSRP difference between the serving cell and the another cell is usually not a UE for which a highest gain is obtained when CoMP is performed, which reduces an effect of CoMP.

SUMMARY

[0008] In view of this, embodiments of the present invention provide a method, a device, and a system for coordinated multi-point transmission, which can select a user equipment located at a cell overlapping area to perform coordinated multi-point transmission, thereby improving an effect of coordinated multi-point transmission.

[0009] To achieve the foregoing objectives, in one aspect, the present invention provides a method for CoMP coordinated multi-point transmission, where the method includes:

obtaining reference signal received power RSRP of a cell in a measurement set of a user equipment UE;
determining that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold; and
combining a cell whose RSRP is greater between the first cell and the second cell with the serving cell of the UE into a coordinated set of the UE, and performing coordinated multi-point transmission on the UE.

[0010] In another aspect, the present invention further provides a device for coordinated multi-point transmission, where the device includes:

an RSRP obtaining unit, configured to obtain reference signal received power RSRP of all cells in a measurement set of a user equipment UE;
a determining unit, configured to determine that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold;
a coordinated set joining unit, configured to combine a cell whose RSRP is greater between the first cell

and the second cell with the serving cell of the UE into a coordinated set of the UE; and

a transmitting unit, configured to perform coordinated multi-point transmission on the UE.

[0011] In still another aspect, the present invention further provides a system, including the device for coordinated multi-point transmission.

[0012] It can be seen that, in the method, the device, and the system for coordinated multi-point transmission provided by the embodiments of the present invention, whether to perform CoMP on a UE is determined based on whether two cells whose RSRP difference is greater than a threshold exist in a measurement set of the UE other than a serving cell. In the embodiments of the present invention, a UE near a cell overlapping area can be selected, and a relatively high gain can be obtained for such UE during CoMP, thereby improving an effect of CoMP.

BRIEF DESCRIPTION OF DRAWINGS

[0013] To describe the technical solutions in the embodiments of the present invention or in the prior art more clearly, the following briefly introduces accompanying drawings required for describing the embodiments or the prior art. Apparently, the accompanying drawings in the following description show merely some embodiments of the present invention, and a person of ordinary skill in the art may still derive other drawings according to these accompanying drawings without creative efforts.

FIG. 1 is a schematic diagram of a CoMP technology in the prior art;

FIG. 2 is a schematic diagram of a cell of an Intra-eNodeB CoMP technology;

FIG. 3 is a schematic flow chart of a method for coordinated multi-point transmission according to an embodiment of the present invention;

FIG. 4 is a schematic flow chart of a method for coordinated multi-point transmission according to another embodiment of the present invention;

FIG. 5 is a schematic diagram of an application scenario for a method for coordinated multi-point transmission according to an embodiment of the present invention;

FIG. 6 is a schematic structural diagram of a device for coordinated multi-point transmission according to an embodiment of the present invention; and

FIG. 7 is a schematic structural diagram of a device for coordinated multi-point transmission according to another embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

[0014] To make the objectives, technical solutions, and advantages of the embodiments of the present invention more comprehensible, the following clearly and completely describes the technical solutions in the embodiments of the present invention with reference to the accompanying drawings in the embodiments of the present invention. Apparently, the embodiments to be described are merely a part rather than all of the embodiments of the present invention. All other embodiments obtained by a person of ordinary skill in the art based on the embodiments of the present invention without creative efforts shall fall within the protection scope of the present invention.

[0015] FIG. 3 is a schematic flow chart of a method for coordinated multi-point transmission according to an embodiment of the present invention. An embodiment of the present invention provides a method for coordinated multi-point transmission, where, as shown in FIG. 3, the method includes:

Step S301: Obtain reference signal received power RSRP of a cell in a measurement set of a user equipment (UE).

[0016] Specific implementation of obtaining RSRP may adopt the prior art, for example, a method defined in the 3GPP 36.214 protocol. The present invention does not limit implementation of obtaining RSRP.

[0017] In addition, the measurement set may be determined by using the following method: A base station of a serving cell of the UE delivers a periodic measurement configuration to the UE. After receiving the periodic measurement configuration, the UE measures all available cells of a configured frequency to obtain signal quality, and reports the signal quality to the base station of the serving cell. The base station adds a cell whose signal quality exceeds a threshold set on a network to the measurement set of the UE. It may also be stipulated that cells whose signal quality ranks in the top several places are added to the measurement set of the UE, which is not limited by the present invention. Cells in the measurement set may belong to different base stations, or may belong to one same base station.

Step S302: Determine that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold. Subtraction may be performed on RSRP values of every two cells other than the serving cell in the measurement set of the UE to obtain an absolute value of an RSRP difference between two cells other than the serving cell in the measurement set, and the absolute value of the difference is compared with a threshold preset in advance.

[0018] For example, when there are two cells other than the serving cell of the UE in the measurement set, subtraction is performed on RSRP of the two cells for comparison with a preset threshold. It is assumed that there are three cells other than the serving cell of the UE

in the measurement set cell 1, cell 2, and cell 3. Subtraction is performed on RSRP values of every two cells of cell 1, cell 2, and cell 3 to obtain |RSRP cell 1 - RSRP cell 2|, |RSRP cell 1 - RSRP cell 3|, and |RSRP cell 3 - RSRP cell 2|, and the three values are compared with the preset threshold. As long as there is one of the three values which is greater than the preset threshold (or greater than or equal to the preset threshold, which is not limited in the present invention), CoMP may be performed on the UE.

When a first cell and a second cell that meet the foregoing condition exist, it indicates that the UE is located at an overlapping area of the serving cell and another cell, and a relatively high gain is obtained for the UE during CoMP.

Step S303: Combine a cell whose RSRP is greater between the first cell and the second cell with the serving cell of the UE into a coordinated set of the UE, and perform CoMP on the UE. A specific method for coordinated multi-point transmission may also be implemented through the prior art.

[0019] In the method provided by the embodiment, whether to perform CoMP on a UE is determined based on whether two cells whose RSRP difference is greater than a threshold exist in a measurement set of the UE other than a serving cell. Interference between cells other than the serving cell is usually close. Therefore, a UE near a cell overlapping area can be selected more accurately, and a relatively high gain can be obtained for such UE during CoMP, thereby improving an effect of CoMP.

[0020] FIG. 4 is a schematic flow chart of a method for coordinated multi-point transmission according to another embodiment of the present invention. As shown in FIG. 4, the method for coordinated multi-point transmission in embodiment 1 includes:

Step S401: Obtain reference signal received power (RSRP) of a cell in a measurement set of a UE.

[0021] For a specific method, reference may be similarly made to step S301 in the foregoing embodiment.

Step S402: Determine that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold.

For a specific method, reference may be similarly made to step S302 in the foregoing embodiment.

Step S403: Combine a cell whose RSRP is greater between the first cell and the second cell with the serving cell of the UE into a coordinated set of the UE.

For a specific method, reference may be similarly made to step S303 in the foregoing embodiment.

Step S404: After step S403, obtain a gain between a post-SINR (Posted-SINR) of the UE in the coordinated set and a post-SINR of the UE in the serving cell.

In a scenario where coverage is limited, a relative gain may be used as the gain in step S404. The relative gain may be determined according to the following formula:

$$\frac{\log_2(1+SINR_1)-\log_2(1+SINR_0)}{\log_2(1+SINR_0)},$$

where $SINR_0$ is the post-SINR of the UE in the serving cell of the UE, and $SINR_1$ is a post-SINR of the UE in a cell other than the serving cell in the coordinated set of the UE, where the cell other than the serving cell in the coordinated set of the UE may also be called a coordination cell of the UE; and

$\log_2(1+SINR_1)$ is throughput which is of the UE in the coordinated set of the UE and is determined according to the Shannon's formula, and $\log_2(1+SINR_0)$ is throughput which is of the UE in the serving cell of the UE and is determined according to the Shannon's formula.

[0022] In a scenario where a capacity is limited, an absolute gain may be used as the gain in step S404.

[0023] The absolute gain may be determined according to the following formula:

$$\log_2(1+SINR_1)-\log_2(1+SINR_0),$$

where $SINR_0$ is the post-SINR of the UE in the serving cell of the UE, and $SINR_1$ is the post-SINR of the UE in the cell other than the serving cell in the coordinated set of the UE; and

$\log_2(1+SINR_1)$ is the throughput which is of the UE in the coordinated set of the UE and is determined according to the Shannon's formula, and $\log_2(1+SINR_0)$ is the throughput which is of the UE in the serving cell of the UE and is determined according to the Shannon's formula.

Step S405: Perform CoMP on a UE whose gain is greater than the preset threshold.

In practice, alternatively, UEs may also be sorted according to gains obtained through calculation in step S404, and a UE with a highest gain is selected preferably for performing CoMP, until a processing resource is used up.

[0024] In the embodiment, by taking a case that a hardware resource is limited into consideration, it is possible that CoMP can be performed on only a part of UEs. After UEs near a cell overlapping area are selected through

step S401 to step S403, these UEs are sorted according to their gains, and CoMP is preferably performed on a UE with a highest gain, so that efficiency of CoMP may be fully improved with a limited resource.

[0025] It should be noted that, in the embodiment, the step for obtaining the gains of the UEs may be performed in each transmission time interval (TTI), or may be performed on each resource block (RB). Certainly, a granularity implemented in the step for obtaining the gains of the UEs may be divided according to another granularity.

[0026] In each of the foregoing embodiments, cells in the measurement set of the UE may belong to one same base station, or at least two cells may belong to different base stations.

[0027] If cells in the measurement set of the UE belong to one same base station, intra-eNodeB CoMP (Intra-eNodeB CoMP) is implemented when CoMP is performed on the UE.

[0028] If at least two cells in the measurement set of the UE belong to different base stations and the coordinated set of the UE also includes cells that belong to at least two base stations, inter-eNodeB CoMP is implemented when CoMP is performed on the UE.

[0029] Specific implementation of the method for coordinated multi-point transmission in the present invention is described in detail in the following through several specific examples.

[0030] Example 1: As shown in FIG. 5, it is assumed that a serving cell of a UE is Cell 0. In a measurement set of the UE, three cells are included, namely, a serving cell of the UE Cell0 and two other neighboring cells Cell 1 and Cell 2.

[0031] First, RSRP of Cell 0, Cell 1, and Cell 2 are obtained, and are marked as RSRP0, RSRP1, and RSRP2, respectively.

[0032] When it is determined that an absolute value of a difference between the RSRP1 and the RSRP2 is greater than a preset threshold, it indicates that the UE is located at a cell overlapping area. In FIG. 5, the UE is located at an overlapping area between cells Cell 0 and Cell 1, and a cell corresponding to a greater RSRP value between the RSRP1 and the RSRP2 and the serving cell Cell 0 are included in a coordinated set of the UE. For example, when the absolute value of the difference between the RSRP1 and the RSRP2 is greater than the preset threshold, and it may be measured that RSRP1> RSRP2 due to a fact the UE is closer to Cell1 than to Cell2, Cell 0 and Cell 1 are included in the coordinated set of the UE. Next, CoMP is performed on the UE.

[0033] Example 2: It is assumed that there are three UEs, which may be marked as UE1, UE2, and UE3 respectively, Cell0 is a serving cell of all the three UEs, and measurement sets all include Cell0 and other two neighboring cells Cell 1 and Cell 2.

[0034] First, a process as described in the foregoing example 1 for obtaining of RSPR and formation of a coordinated set of each UE is separately implemented for UE1, UE2, and UE3.

[0035] Next, a gain between a post-SINR of UE1 in the coordinated set of UE1 and a post-SINR of UE1 in the serving cell Cell0 of UE1 is calculated, and is marked as D1. A gain between a post-SINR of UE2 in the coordinated set of UE2 and a post-SINR of UE2 in the serving cell Cell0 of UE2 is calculated, and is marked as D2. A gain between a post-SINR of UE3 in the coordinated set of UE3 and a post-SINR of UE3 in the serving cell Cell0 of UE3 is calculated, and is marked as D3.

[0036] It is assumed that D2>D1>D3, and UE1, UE2, and UE3 are sorted according to order of their gains as follows: UE2, UE1, UE3.

[0037] CoMP is preferably performed on UE2, and then UE1. If a processing resource is used up after CoMP is performed on UE1, CoMP is not performed on UE3.

[0038] In addition, there may be multiple first cells and second cells that meet a condition in the foregoing embodiments, for example, in a scenario such as that a UE is located at a cell overlapping area between base stations, or a base station is divided into six cells. It is assumed that in a measurement set of a UE, five cells are included, namely, Cell 0, Cell 1, Cell 2, Cell 3, and Cell 4. Cell 0 is a serving cell of the UE. After measurement, RSRP of Cell 1, Cell 2, Cell 3, and Cell 4 are RSRP1, RSRP2, RSRP3, and RSRP4, respectively.

[0039] It is found through comparison that: An absolute value of a difference between the RSRP1 and the RSRP2 is greater than a preset threshold; an absolute value of a difference between the RSRP3 and the RSRP4 is also greater than the preset threshold. In a case that a hardware resource is sufficient, a cell whose RSRP is greater in each pair of cells whose RSRP difference is greater than the preset threshold and that meet a condition may be used as a coordination cell of the UE, and the coordination cell of the UE and the serving cell of the UE are included in a coordinated set of the UE. It is assumed that, in the foregoing example, there are two pairs of cells that meet the condition, namely, {cell1, cell2} and {cell3, cell4}, RSRP corresponding to the two pairs of cells may be respectively marked as {RSRP1, RSRP2} and {RSRP3, RSRP4}. It is assumed that, |RSRP1-RSRP2| and |RSRP3-RSRP4| are both greater than the preset threshold, and RSRP1>RSRP2 and RSRP3>RSRP4. In this case, RSRP1 and RSRP3 may both be used as coordination cells of the UE. In this way, the coordinated set of the UE includes Cell 0, Cell1, and Cell3.

[0040] However, sometimes, in a case that the hardware resource is insufficient, the number of coordination cells in the coordinated set of the UE is limited. In this case, cells whose RSRP is greater in each pair of the cells whose RSRP difference is greater than the preset threshold and that meet the condition need to be compared, and a cell whose RSRP is greater is preferably selected as the coordination cell of the UE. Alternatively, whether RSRP of a cell whose RSRP is greater among the cells whose RSRP difference is greater than the preset threshold is also greater than the preset threshold is determined through comparison, and then the cell whose

RSRP is greater is used as the coordination cell of the UE. For example, in the foregoing example, it is further assumed that, a difference between the RSRP1 and the RSRP3 of two first cells is also greater than the threshold. Then, only Cell1 whose RSRP is greater is used as the coordination cell of the UE. In this case, the coordinated set of the UE includes only Cell 0 and Cell1.

[0041] FIG. 6 is a schematic structural diagram of a device for coordinated multi-point transmission according to an embodiment of the present invention. As shown in FIG. 6, the device for coordinated multi-point transmission includes:

An RSRP obtaining unit 601 is configured to obtain reference signal received power RSRP of all cells in a measurement set of a user equipment UE.

[0042] A determining unit 602 is configured to determine that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold.

[0043] A transmitting unit 603 is configured to combine a cell whose RSRP is greater between the first cell and the second cell with the serving cell of the UE into a coordinated set of the UE, and perform coordinated multi-point transmission on the UE.

[0044] In practice, the device for coordinated multi-point transmission in the embodiment may be a base station.

[0045] Specific implementation of obtaining RSRP by the RSRP obtaining unit 601 may adopt the prior art, for example, a method defined in the 3GPP 36.214 protocol. The present invention does not limit implementation of obtaining RSRP. Cells in the measurement set may belong to different base stations or may belong to one same base station.

[0046] The determining unit 602 may perform subtraction on RSRP values of every two cells other than the serving cell in the measurement set of the UE to obtain an absolute value of an RSRP difference between two cells other than the serving cell in the measurement set, and compare the absolute value of the difference with the threshold preset in advance.

[0047] FIG. 7 is a schematic structural diagram of a device for coordinated multi-point transmission according to another embodiment of the present invention. As shown in FIG. 7, the device for coordinated multi-point transmission includes:

An RSRP obtaining unit 701 is configured to obtain reference signal received power RSRP of all cells in a measurement set of a user equipment UE. Specific implementation of obtaining RSRP by the RSRP obtaining unit 701 may adopt the prior art, for example, a method defined in the 3GPP 36.214 protocol. The present invention does not limit implementation of obtaining RSRP. Cells in the measurement set may belong to different base stations or may belong to one same base station.

[0048] A determining unit 702 is configured to determine that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold. The determining unit 702 may perform subtraction on RSRP values of every two cells other than the serving cell in the measurement set of the UE to obtain an absolute value of an RSRP difference between two cells other than the serving cell in the measurement set, and compare the absolute value of the difference with the threshold preset in advance.

[0049] A gain obtaining unit 703 is further included, where the gain obtaining unit 703 is configured to obtain a gain between a post-SINR of the UE in the coordinated set of the UE and a post-SINR of the UE in the serving cell of the UE.

[0050] Specifically, in a scenario where coverage is limited, the gain obtained by the gain obtaining unit 703 may be a relative gain, where the relative gain may be determined according to the following formula:

$$\frac{\log_2(1+SINR_1)-\log_2(1+SINR_0)}{\log_2(1+SINR_0)},$$

where $SINR_0$ is the post-SINR of the UE in the serving cell of the UE, and $SINR_1$ is a post-SINR of the UE in a cell other than the serving cell in the coordinated set of the UE, where the cell other than the serving cell in the coordinated set of the UE may also be called a coordination cell of the UE; and

$\log_2(1 + SINR_1)$ is throughput which is of the UE in the coordinated set of the UE and is determined according to the Shannon's formula, and $\log_2(1+SINR_0)$ is throughput which is of the UE in the serving cell of the UE and is determined according to the Shannon's formula.

[0051] In a scenario where a capacity is limited, the gain obtained by the gain obtaining unit 604 may be an absolute gain.

[0052] The absolute gain may be determined according to the following formula:

$$\log_2(1+SINR_1)-\log_2(1+SINR_0),$$

where $SINR_0$ is the post-SINR of the UE in the serving cell of the UE, and $SINR_1$ is the post-SINR of the UE in the cell other than the serving cell in the coordinated set of the UE; and

$\log_2(1 + SINR_1)$ is the throughput which is of the UE in the coordinated set of the UE and is determined according to the Shannon's formula, and

$\log_2(1+SINR_0)$ is the throughput which is of the UE in the serving cell of the UE and is determined according to the Shannon's formula.

[0053] A process of obtaining gains of UEs by the gain obtaining unit 703 may be performed in each transmission time interval (TTI), or may be performed on each resource block (RB). Certainly, a granularity implemented in the step for obtaining the gains of the UEs may be divided according to another granularity.

[0054] A transmitting unit 704 is specifically configured to select a UE whose gain is greater than a preset threshold to perform coordinated multi-point transmission.

[0055] The device for coordinated multi-point transmission in the embodiment may be a base station.

[0056] In addition, an embodiment of the present invention further provides a system, where the system includes the device for coordinated multi-point transmission in the foregoing device embodiments.

[0057] Exemplary implementation manners of the present invention are described in the foregoing. It should be noted that, a person of ordinary skill in the art may further make several modifications and variations without departing from the principle of the present invention, and these modifications and variations should also be construed as falling within the protection scope of the present invention.

Claims

1. A method for CoMP coordinated multi-point transmission, comprising:

   obtaining reference signal received power RSRP of a cell in a measurement set of a user equipment UE;
   determining that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold; and
   combining a cell whose RSRP is greater between the first cell and the second cell with the serving cell of the UE into a coordinated set of the UE, and performing coordinated multi-point transmission on the UE.

2. The method according to claim 1, further comprising:

   obtaining a gain between a post-SINR of the UE in the coordinated set and a post-SINR of the UE in the serving cell; wherein
   the performing coordinated multi-point transmission on the UE comprises:

   selecting the UE whose gain is greater than a preset threshold to perform coordinated multi-point transmission.

3. The method according to claim 2, wherein the gain is a relative gain or an absolute gain.

4. The method according to claim 2 or 3, wherein the obtaining a gain between a post-SINR of the UE in the coordinated set and a post-SINR of the UE in the serving cell comprises:

   obtaining, in each transmission time interval (TTI), the gain between the post-SINR of the UE in the coordinated set and the post-SINR of the UE in the serving cell.

5. The method according to claim 2 or 3, wherein the obtaining a gain between a post-SINR of the UE in the coordinated set and a post-SINR of the UE in the serving cell comprises:

   obtaining, on each resource block (RB), the gain between the post-SINR of the UE in the coordinated set and the post-SINR of the UE in the serving cell.

6. The method according to any one of claims 1 to 5, wherein,
   cells in the measurement set of the UE belong to one same base station, or
   at least two of cells in the measurement set of the UE belong to different base stations.

7. A device for coordinated multi-point transmission, comprising:

   an RSRP obtaining unit, configured to obtain reference signal received power RSRP of all cells in a measurement set of a user equipment UE;
   a determining unit, configured to determine that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold; and
   a transmitting unit, configured to combine a cell whose RSRP is greater between the first cell and the second cell with the serving cell of the UE into a coordinated set of the UE, and perform coordinated multi-point transmission on the UE.

8. The device according to claim 7, further comprising:

   a gain obtaining unit, configured to obtain a gain between a post-SINR of the UE in the coordinated set and a post-SINR of the UE in the serving cell; wherein
   the transmitting unit is specifically configured to select the UE whose gain is greater than a preset threshold to perform coordinated multi-point transmission.

9. The device according to claim 7, wherein the gain obtaining unit is specifically configured to obtain, in each transmission time interval (TTI), the gain between the post-SINR of the UE in the coordinated set and the post-SINR of the UE in the serving cell; or the gain obtaining unit is specifically configured to obtain, on each resource block (RB), the gain between the post-SINR of the UE in the coordinated set and the post-SINR of the UE in the serving cell.

10. The device according to any one of claims 7 to 9, wherein the device is a base station.

11. A system, comprising the device for coordinated multi-point transmission according to any one of claims 7 to 9.

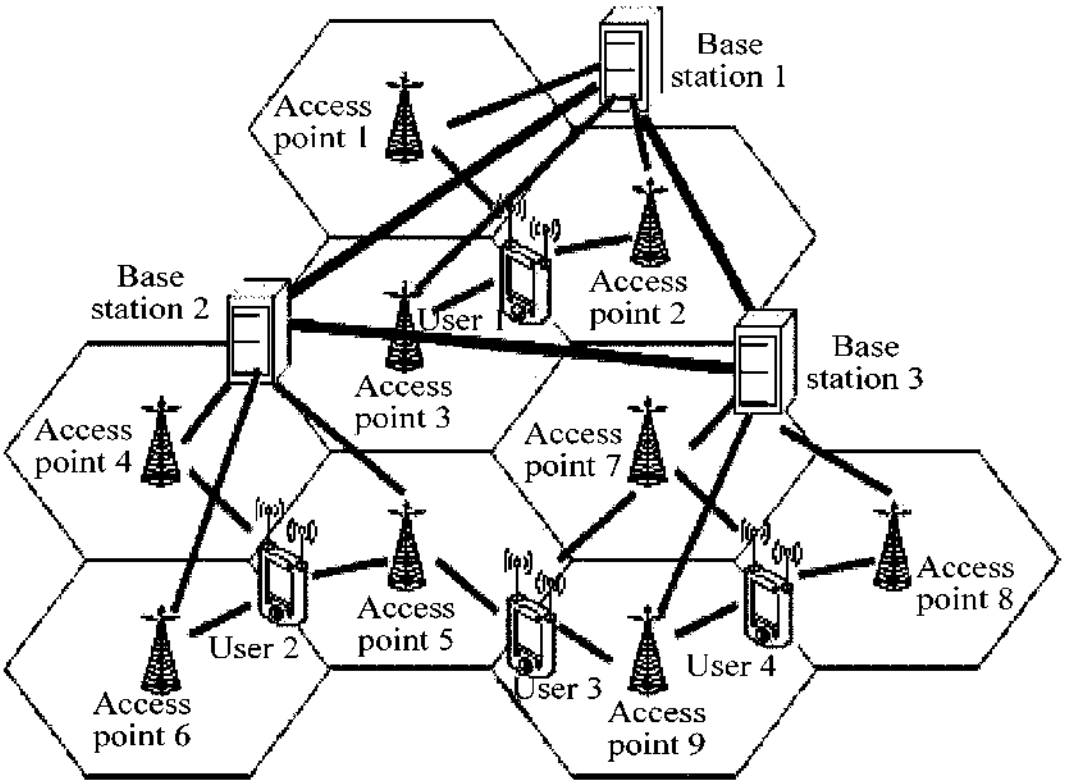

Base station 1
Access point 1
Base station 2
User 1
Access point 2
Base station 3
Access point 3
Access point 4
Access point 7
Access point 8
Access point 5
User 2
User 3
User 4
Access point 6
Access point 9

FIG. 1

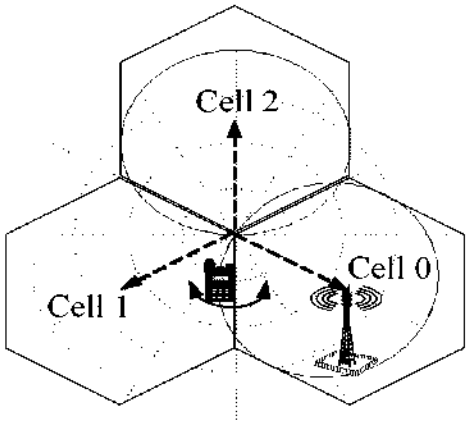

Cell 2
Cell 0
Cell 1

FIG. 2

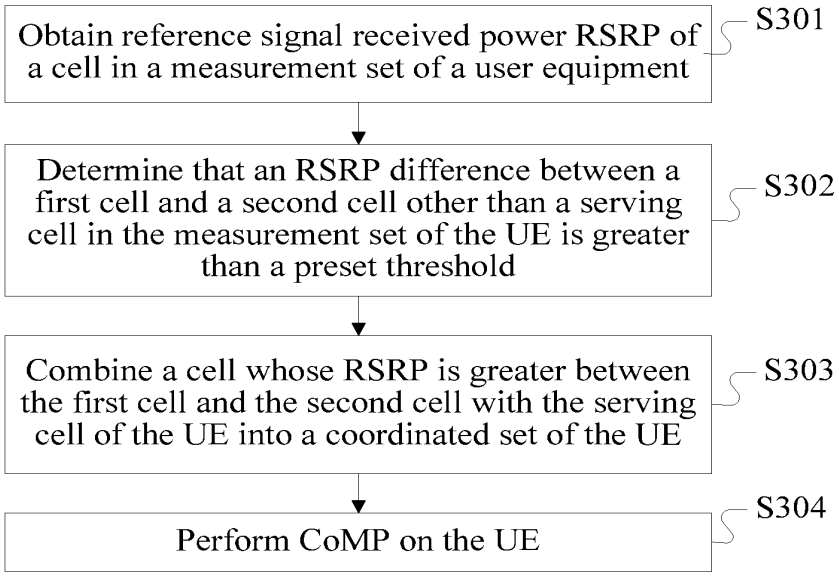

Obtain reference signal received power RSRP of a cell in a measurement set of a user equipment
S301
Determine that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold
S302
Combine a cell whose RSRP is greater between the first cell and the second cell with the serving cell of the UE into a coordinated set of the UE
S303
Perform CoMP on the UE
S304

FIG. 3

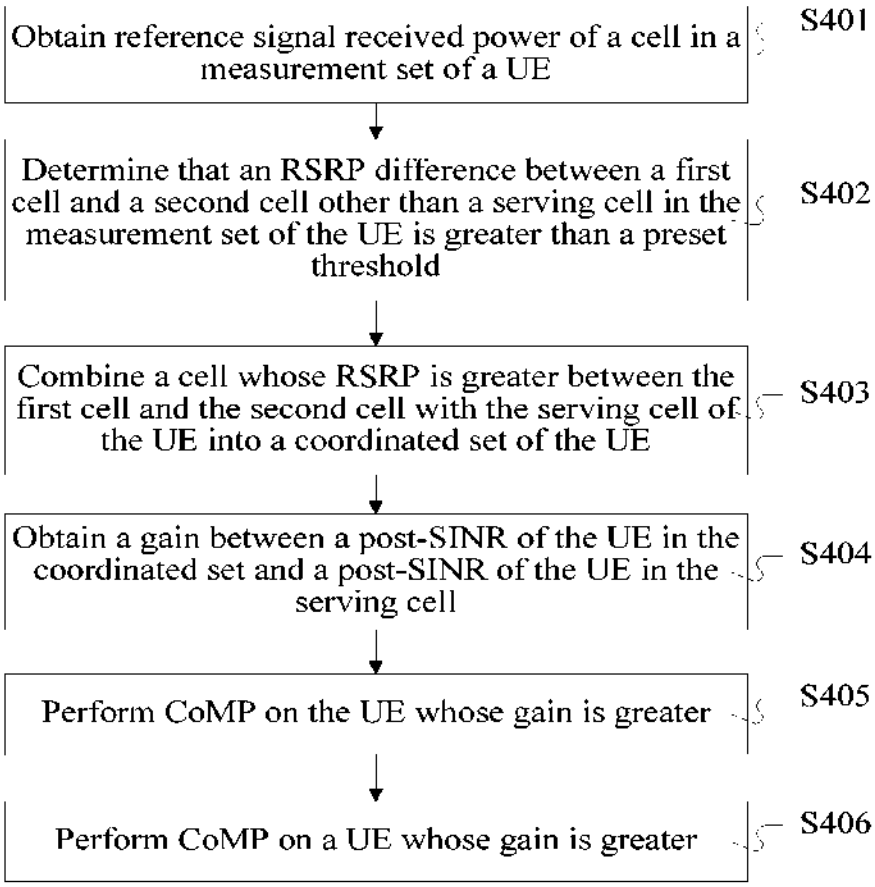

Obtain reference signal received power of a cell in a measurement set of a UE
S401
Determine that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold
S402
Combine a cell whose RSRP is greater between the first cell and the second cell with the serving cell of the UE into a coordinated set of the UE
S403
Obtain a gain between a post-SINR of the UE in the coordinated set and a post-SINR of the UE in the serving cell
S404
Perform CoMP on the UE whose gain is greater
S405
Perform CoMP on a UE whose gain is greater
S406

FIG. 4

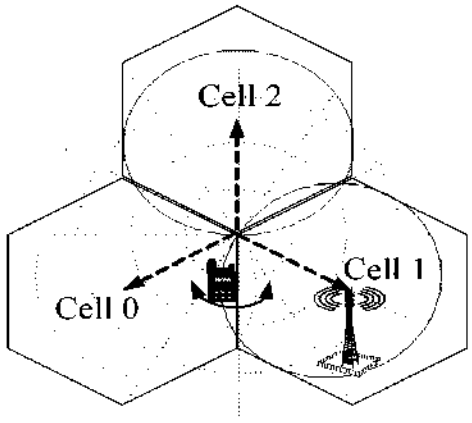

Cell 2
Cell 1
Cell 0

FIG. 5

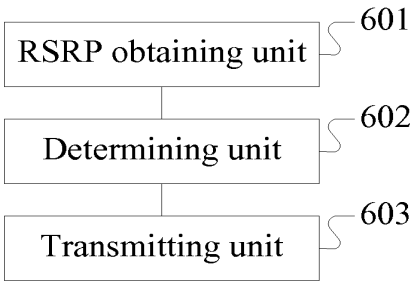

601
RSRP obtaining unit
602
Determining unit
603
Transmitting unit

FIG. 6

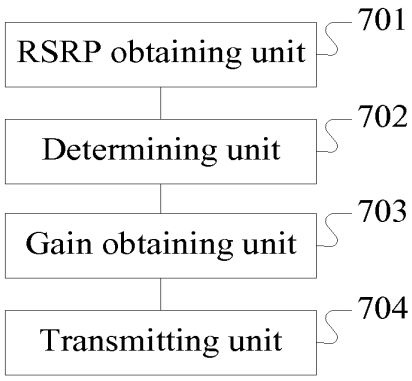

701
RSRP obtaining unit
702
Determining unit
703
Gain obtaining unit
704
Transmitting unit

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2011/077566

A. CLASSIFICATION OF SUBJECT MATTER

H04W 28/16 (2009.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: H04W, H04Q, H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNABS, CNTXT, CNKI: CoMP, coordinated multi-point, cell, transmission, reference signal received power, RSRP, quality, parameter, threshold, set

VEN, 3GPP: CoMP, coordinated multi-point transmission reception, cell?, RSRP, quality, parameter?, threshold?, set?

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 101895921 A (POTEVIO INSTITUTE OF TECHNOLOGY CO., LTD.), 24 November 2010 (24.11.2010), the whole document	1-11
A	CN 101873661 A (DATANG MOBILE COMMUNICATIONS EQUIPMENT CO., LTD.), 27 October 2010 (27.10.2010), the whole document	1-11
A	CN 102076096 A (SHANGHAI HUAWEI TECHNOLOGIES CO., LTD.), 25 May 2011 (25.05.2011), the whole document	1-11
A	CN 101815331 A (ZTE CORP.), 25 August 2010 (25.08.2010), the whole document	1-11

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 April 2012 (21.04.2012)	**03 May 2012 (03.05.2012)**
Name and mailing address of the ISA/CN: State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No.: (86-10) 62019451	Authorized officer **LV, Sihua** Telephone No.: (86-10) **62411386**

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2011/077566

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 101895921 A	24.11.2010	None	
CN 101873661 A	27.10.2010	None	
CN 102076096 A	25.05.2011	None	
CN 101815331 A	25.08.2010	None	

Form PCT/ISA/210 (patent family annex) (July 2009)

Espacenet

CN108809488A Message decoding method, sending end and receiving end

Applicants: CHINA ACADEMY TELECOMMUNICATIONS TECHNOLOGY

Inventors: CHEN RUNHUA,GAO QIUBIN,LI HUI

Classifications:

IPC ***H04L1/00;***

CPC **H04B7/0617 (CN,US); H04B7/0695 (EP,CN); H04B7/088 (EP,CN); H04L1/0036 (CN,KR); H04W74/006 (CN,US);**

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Application: CN201710307962A 2017-05-04

Publication: CN108809488A 2018-11-13

Published as: CN108809488A;**CN115395998A; EP3605986A1; EP3605986A4; EP3605986B1; EP4277157A2; JP2020520146A; JP6880237B2; KR102347904B1; KR20200003117A; TW201843962A; TWI715837B; US11039470B2; US2020059958A1; WO2018201861A1**

Message decoding method, sending end and receiving end

Abstract

The invention provides a message decoding method, a sending end and a receiving end. The method comprises the following steps: a receiving end receives a second message sent by a sending end and associated with the first message; the receiving end determines a target receiver parameter for decoding the first message according to the second message; and the receiving end decodes the first message sent by the sending end according to the target receiver parameter. Through the message decoding method provided by the embodiment of the invention, the receiving end can determine the receiver parameter according to the second message associated with the first message, and the message transmission performance can be improved.

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代理人 许静 黄灿

(51)Int.Cl.
H04L 1/00(2006.01)

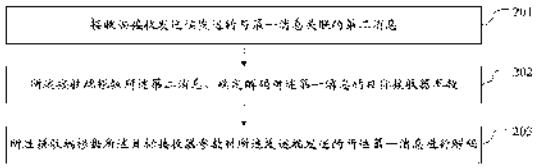
权利要求书5页 说明书20页 附图5页

(54)发明名称

一种消息解码方法、发送端和接收端

(57)摘要

本发明提供一种消息解码方法、发送端和接收端，该方法可包括：接收端接收发送端发送的与第一消息关联的第二消息；所述接收端根据所述第二消息，确定解码所述第一消息的目标接收器参数；所述接收端根据所述目标接收器参数对所述发送端发送的所述第一消息进行解码。这样本发明实施例可以实现接收端根据与第一消息关联的第二消息确定接收器参数，且还可以提高消息传输性能。



CN 108809488 A

1.一种消息解码方法，其特征在于，包括：

接收端接收发送端发送的与第一消息关联的第二消息；

所述接收端根据所述第二消息，确定解码所述第一消息的目标接收器参数；

所述接收端根据所述目标接收器参数对所述发送端发送的所述第一消息进行解码。

2.如权利要求1所述的方法，其特征在于，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端默认的接收器参数。

3.如权利要求2所述的方法，其特征在于，所述接收端默认的接收器参数包括：

所述接收端当前使用的接收器参数、所述接收端接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端向所述发送端上报时间最近的发送器参数对应的接收器参数。

4.如权利要求2所述的方法，其特征在于，所述参数指示信息显式或者隐式指示所述目标接收器参数。

5.如权利要求4所述的方法，其特征在于，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端选择的发送器参数，所述接收端将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

6.如权利要求1-5中任一项所述的方法，其特征在于，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

7.如权利要求6所述的方法，其特征在于，所述参数切换指示集对应的调度时间单位在时域上周期存在；和\或

所述参数切换指示集对应的调度时间单位由所述发送端半静态或半持续配置，并通知所述接收端。

8.如权利要求1-5中任一项所述的方法，其特征在于，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前，所述接收端根据所述目标接收器参数对所述第一消息进行解码，包括：

若所述第二消息包括参数指示信息，则所述接收端根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示信息，则所述接收端丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示信息，则所述接收端根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息不包括波束指示信息，则所述接收端根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段指示没有参数指示信息或者没有参数改变，则所述接收端根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

9.如权利要求1-5中任一项所述的方法，其特征在于，所述方法还包括：

所述接收端接收所述发送端发送的第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

10.如权利要求9所述的方法，其特征在于，所述第三消息用于指示M个时间单位内的第二消息是否包括参数指示信息，所述M为大于或者等于1的整数，所述M个时间单位连续或者不连续。

11.如权利要求1-5中任一项所述的方法，其特征在于，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

12.如权利要求11所述的方法，其特征在于，所述空域的接收器参数包括所述接收端的接收波束。

13.一种消息解码方法，其特征在于，包括：

发送端向接收端发送与第一消息关联的第二消息，所述第二消息用于所述接收端确定解码所述第一消息的目标接收器参数；

所述发送端向所述接收端发送所述第一消息。

14.如权利要求13所述的方法，其特征在于，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端默认的接收器参数。

15.如权利要求14所述的方法，其特征在于，所述接收端默认的接收器参数包括：

所述接收端当前使用的接收器参数、所述接收端接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端向所述发送端上报时间最近的发送器参数对应的接收器参数。

16.如权利要求14所述的方法，其特征在于，所述参数指示信息显式或者隐式指示所述目标接收器参数。

17.如权利要求16所述的方法，其特征在于，若所述参数指示信息隐式指示所述目标接

收器参数，则所述参数指示信息包括所述发送端选择的发送器参数，所述接收端将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

18.如权利要求13-17中任一项所述的方法，其特征在于，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

19.如权利要求18所述的方法，其特征在于，所述参数切换指示集对应的调度时间单位在时域上周期存在；和\或

所述参数切换指示集对应的调度时间单位由所述发送端半静态或半持续配置，并通知所述接收端。

20.如权利要求13-17中任一项所述的方法，其特征在于，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前。

21.如权利要求13-17中任一项所述的方法，其特征在于，所述方法还包括：

所述发送端向所述接收端发送第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

22.如权利要求21所述的方法，其特征在于，所述第三消息用于指示M个时间单位内的第二消息是否包括参数指示信息，所述M为大于或者等于1的整数，所述M个时间单位连续或者不连续。

23.如权利要求13-17中任一项所述的方法，其特征在于，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

24.如权利要求23所述的方法，其特征在于，所述空域的接收器参数包括所述接收端的接收波束。

25.一种接收端，其特征在于，包括：

第一接收模块，用于接收发送端发送的与第一消息关联的第二消息；

确定模块，用于根据所述第二消息，确定解码所述第一消息的目标接收器参数；

解码模块，用于根据所述目标接收器参数对所述发送端发送的所述第一消息进行解码。

26.如权利要求25所述的接收端，其特征在于，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端默认的接收器参数。

27.如权利要求25或26所述的接收端，其特征在于，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

28.如权利要求25或26所述的接收端，其特征在于，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前；

所述解码模块用于若所述第二消息包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示信息，则根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息不包括波束指示信息，则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示字段，且所述参数指示字段指示没有参数指示信息或者没有参数改变，则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

29.如权利要求25或26所述的接收端，其特征在于，所述接收端还包括：

第二接收模块，用于接收所述发送端发送的第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

30.一种发送端，其特征在于，包括：

第一发送模块，用于发送端向接收端发送与第一消息关联的第二消息，所述第二消息用于所述接收端确定解码所述第一消息的目标接收器参数；

第二发送模块，用于向所述接收端发送所述第一消息。

31.如权利要求30所述的发送端，其特征在于，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端默认的接收器参数。

32.如权利要求30或31所述的发送端，其特征在于，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

33.如权利要求30或31所述的发送端，其特征在于，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前。

34.如权利要求30或31所述的发送端，其特征在于，所述发送端还包括：

第二发送模块，用于向所述接收端发送第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

一种消息解码方法、发送端和接收端

技术领域

[0001] 本发明涉及通信技术领域，特别涉及一种消息解码方法、发送端和接收端。

背景技术

[0002] 随着通信技术的发展，目前通信设备均支持多天线系统，例如：支持高达128、256或者512个天线单元，以及高达128、256或者512个收发单元，每个天线单元连接一个收发单元。且目前通信设备还支持多波束，不同的波束的覆盖范围可以不同。这样发送端(例如：网络侧设备)在发送消息时，就可以在多个发送器参数(例如：发送波束)中选择相应的发送器参数进行发送，以提高通信性能。而接收端(例如：用户终端)如何选择相应的接收器参数(例如：接收波束)对发送端发送的消息进行解码目前还未明确。可见，接收端如何选择相应的接收器参数对发送端发送的消息进行解码是当前急需解决的技术问题。

发明内容

[0003] 本发明的目的在于提供一种消息解码方法、发送端和接收端，以解决接收端如何选择相应的接收器参数对发送端发送的消息进行解码的问题。

[0004] 为了达到上述目的，本发明实施例提供一种消息解码方法，包括：

[0005] 接收端接收发送端发送的与第一消息关联的第二消息；

[0006] 所述接收端根据所述第二消息，确定解码所述第一消息的目标接收器参数；

[0007] 所述接收端根据所述目标接收器参数对所述发送端发送的所述第一消息进行解码。

[0008] 可选的，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

[0009] 若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端默认的接收器参数。

[0010] 可选的，所述接收端默认的接收器参数包括：

[0011] 所述接收端当前使用的接收器参数、所述接收端接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端向所述发送端上报时间最近的发送器参数对应的接收器参数。

[0012] 可选的，所述参数指示信息显式或者隐式指示所述目标接收器参数。

[0013] 可选的，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端选择的发送器参数，所述接收端将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

[0014] 可选的，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

[0015] 若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所

述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

[0016] 可选的，所述参数切换指示集对应的调度时间单位在时域上周期存在；和\或

[0017] 所述参数切换指示集对应的调度时间单位由所述发送端半静态或半持续配置，并通知所述接收端。

[0018] 可选的，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前，所述接收端根据所述目标接收器参数对所述第一消息进行解码，包括：

[0019] 若所述第二消息包括参数指示信息，则所述接收端根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0020] 若所述第二消息包括参数指示信息，则所述接收端丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0021] 若所述第二消息包括参数指示信息，则所述接收端根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0022] 若所述第二消息不包括波束指示信息，则所述接收端根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码；或者

[0023] 若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0024] 若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0025] 若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0026] 若所述第二消息包括参数指示字段，且所述参数指示字段指示没有参数指示信息或者没有参数改变，则所述接收端根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

[0027] 可选的，所述方法还包括：

[0028] 所述接收端接收所述发送端发送的第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

[0029] 可选的，所述第三消息用于指示M个时间单位内的第二消息是否包括参数指示信息，所述M为大于或者等于1的整数，所述M个时间单位连续或者不连续。

[0030] 可选的，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

[0031] 可选的，所述空域的接收器参数包括所述接收端的接收波束。

[0032] 本发明实施例还提供一种消息解码方法，包括：

[0033] 发送端向接收端发送与第一消息关联的第二消息，所述第二消息用于所述接收端确定解码所述第一消息的目标接收器参数；

[0034] 所述发送端向所述接收端发送所述第一消息。

[0035] 可选的，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

[0036] 若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端默认的接收器参数。

[0037] 可选的，所述接收端默认的接收器参数包括：

[0038] 所述接收端当前使用的接收器参数、所述接收端接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端向所述发送端上报时间最近的发送器参数对应的接收器参数。

[0039] 可选的，所述参数指示信息显式或者隐式指示所述目标接收器参数。

[0040] 可选的，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端选择的发送器参数，所述接收端将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

[0041] 可选的，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

[0042] 若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

[0043] 可选的，所述参数切换指示集对应的调度时间单位在时域上周期存在；和\或

[0044] 所述参数切换指示集对应的调度时间单位由所述发送端半静态或半持续配置，并通知所述接收端。

[0045] 可选的，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前。

[0046] 可选的，所述方法还包括：

[0047] 所述发送端向所述接收端发送第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

[0048] 可选的，所述第三消息用于指示M个时间单位内的第二消息是否包括参数指示信息，所述M为大于或者等于1的整数，所述M个时间单位连续或者不连续。

[0049] 可选的，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

[0050] 可选的，所述空域的接收器参数包括所述接收端的接收波束。

[0051] 本发明实施例还提供一种接收端，包括：

[0052] 第一接收模块，用于接收发送端发送的与第一消息关联的第二消息；

[0053] 确定模块，用于根据所述第二消息，确定解码所述第一消息的目标接收器参数；

[0054] 解码模块，用于根据所述目标接收器参数对所述发送端发送的所述第一消息进行

解码。

[0055] 可选的，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

[0056] 若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端默认的接收器参数。

[0057] 可选的，所述接收端默认的接收器参数包括：

[0058] 所述接收端当前使用的接收器参数、所述接收端接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端向所述发送端上报时间最近的发送器参数对应的接收器参数。

[0059] 可选的，所述参数指示信息显式或者隐式指示所述目标接收器参数。

[0060] 可选的，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端选择的发送器参数，所述接收端将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

[0061] 可选的，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

[0062] 若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

[0063] 可选的，所述参数切换指示集对应的调度时间单位在时域上周期存在；和\或

[0064] 所述参数切换指示集对应的调度时间单位由所述发送端半静态或半持续配置，并通知所述接收端。

[0065] 可选的，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前；

[0066] 所述解码模块用于若所述第二消息包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0067] 所述解码模块用于若所述第二消息包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0068] 所述解码模块用于若所述第二消息包括参数指示信息，则根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0069] 所述解码模块用于若所述第二消息不包括波束指示信息，则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码；或者

[0070] 所述解码模块用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0071] 所述解码模块用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接

收器参数对所述第二部分内容进行解码;或者

[0072] 所述解码模块用于若所述第二消息包括参数指示字段,且所述参数指示字段包括参数指示信息,则根据默认的接收器参数对所述第一部分内容进行解码,以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码;或者

[0073] 所述解码模块用于若所述第二消息包括参数指示字段,且所述参数指示字段指示没有参数指示信息或者没有参数改变,则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

[0074] 可选的,所述接收端还包括:

[0075] 第二接收模块,用于接收所述发送端发送的第三消息,所述第三消息用于指示所述第二消息是否包括参数指示信息,且若所述第三消息指示所述第二消息包括参数指示信息,则所述第二消息与所述第一消息之间存在间隙,若所述第三消息指示所述第二消息不包括参数指示信息,则所述第二消息与所述第一消息之间不存在间隙。

[0076] 可选的,所述第三消息用于指示M个时间单位内的第二消息是否包括参数指示信息,所述M为大于或者等于1的整数,所述M个时间单位连续或者不连续。

[0077] 可选的,所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

[0078] 可选的,所述空域的接收器参数包括所述接收端的接收波束。

[0079] 本发明实施例还提供一种发送端,包括:

[0080] 第一发送模块,用于发送端向接收端发送与第一消息关联的第二消息,所述第二消息用于所述接收端确定解码所述第一消息的目标接收器参数;

[0081] 第二发送模块,用于向所述接收端发送所述第一消息。

[0082] 可选的,若所述第二消息包括参数指示信息,则所述目标接收器参数为所述参数指示信息指示的接收器参数;

[0083] 若所述第二消息不包括参数指示信息,则所述目标接收器参数为所述接收端默认的接收器参数。

[0084] 可选的,所述接收端默认的接收器参数包括:

[0085] 所述接收端当前使用的接收器参数、所述接收端接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端向所述发送端上报时间最近的发送器参数对应的接收器参数。

[0086] 可选的,所述参数指示信息显式或者隐式指示所述目标接收器参数。

[0087] 可选的,若所述参数指示信息隐式指示所述目标接收器参数,则所述参数指示信息包括所述发送端选择的发送器参数,所述接收端将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

[0088] 可选的,若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的,则所述第二消息包括参数指示信息,且所述第二消息与所述第一消息之间存在间隙;

[0089] 若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的,则所述第二消息不包括参数指示信息,且所述第二消息与所述第一消息之间不存在间隙。

[0090] 可选的,所述参数切换指示集对应的调度时间单位在时域上周期存在;和\或

[0091] 所述参数切换指示集对应的调度时间单位由所述发送端半静态或半持续配置,并

通知所述接收端。

[0092] 可选的，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前。

[0093] 可选的，所述发送端还包括：

[0094] 第二发送模块，用于向所述接收端发送第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

[0095] 可选的，所述第三消息用于指示M个时间单位内的第二消息是否包括参数指示信息，所述M为大于或者等于1的整数，所述M个时间单位连续或者不连续。

[0096] 可选的，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

[0097] 可选的，所述空域的接收器参数包括所述接收端的接收波束。

[0098] 本发明实施例还提供一种接收端，其特征在于，包括：处理器、收发机、存储器、用户接口和总线接口，其中：

[0099] 所述处理器，用于读取所述存储器中的程序，执行本发明实施例提供的接收端侧对应的消息解码方法中的步骤。

[0100] 本发明实施例还提供一种发送端，其特征在于，包括：处理器、收发机、存储器、用户接口和总线接口，其中：

[0101] 所述处理器，用于读取所述存储器中的程序，执行本发明实施例提供的发送侧对应的消息解码方法的步骤。

[0102] 本发明的上述技术方案至少具有如下有益效果：

[0103] 本发明实施例，接收端接收发送端发送的与第一消息关联的第二消息；所述接收端根据所述第二消息，确定解码所述第一消息的目标接收器参数；所述接收端根据所述目标接收器参数对所述发送端发送的所述第一消息进行解码。这样可以实现接收端根据与第一消息关联的第二消息确定接收器参数，且还可以提高消息传输性能。

附图说明

[0104] 图1为本发明实施例可应用的网络结构示意图；

[0105] 图2为本发明实施例提供的一种消息解码方法的流程图；

[0106] 图3为本发明实施例提供的一种消息发送的示意图；

[0107] 图4为本发明实施例提供的另一种消息发送的示意图；

[0108] 图5为本发明实施例提供的另一种消息发送的示意图；

[0109] 图6为本发明实施例提供的另一种消息发送的示意图；

[0110] 图7为本发明实施例提供的另一种消息解码方法的流程图；

[0111] 图8为本发明实施例提供的一种接收端的结构示意图；

[0112] 图9为本发明实施例提供的另一种接收端的结构示意图；

[0113] 图10为本发明实施例提供的一种发送端的结构示意图；

[0114] 图11为本发明实施例提供的另一种发送端的结构示意图；

[0115] 图12为本发明实施例提供的另一种接收端的结构示意图；

[0116] 图13为本发明实施例提供的另一种发送端的结构示意图。

具体实施方式

[0117] 为使本发明要解决的技术问题、技术方案和优点更加清楚，下面将结合附图及具体实施例进行详细描述。

[0118] 参见图1，图1为本发明实施例可应用的网络结构示意图，如图1所示，包括发送端11和接收端12，其中，发送端11可以是基站或者终端，而接收端12也可以是终端或者基站，例如：发送端11为基站，接收端12为终端，则可以实现终端与基站之间的通信，又或者发送端11为终端，则接收端12为基站，也可以实现终端与基站之间的通信，又或者发送端11为基站，接收端12也为基站，则可以实现基站与基站之间的通信，又或者发送端11为终端，接收端12也为终端，则可以实现终端与终端之间的通信。当然，本发明实施例中，并不限定发送端11只能是终端或者基站，例如：发送端11还可以是其他的网络侧设备，同理，接收端12也并不限定只是终端或者设备，例如：接收端12还可以是其他的网络侧设备，对此本发明实施例不作限定。其中，附图1，以发送端11为基站，接收端12为终端进行举例示意。终端可以是用户终端(User Equipment，UE)，例如：可以是手机、平板电脑(Tablet Personal Computer)、膝上型电脑(Laptop Computer)、个人数字助理(personal digital assistant，简称PDA)、移动上网装置(Mobile Internet Device，MID)或可穿戴式设备(Wearable Device)等终端侧设备，需要说明的是，在本发明实施例中并不限定终端的具体类型。基站可以是宏站，如LTE eNB、5G NR NB等；也可以是小站，如低功率节点(LPN：low power node)pico、femto等小站，或者可以是接入点(AP，access point)；基站也可以是中央单元(CU，central unit)与其管理和控制的多个传输接收点(TRP，Transmission Reception Point)共同组成的网络节点。另外，一个基站下有一个或多个小区(例如：不同的频点或扇区分裂)。需要说明的是，在本发明实施例中并不限定基站的具体类型。

[0119] 请参考图2，图2是本本发明实施例提供一种消息解码方法的流程图，如图2所示，包括以下步骤：

[0120] 201、接收端接收发送端发送的与第一消息关联的第二消息；

[0121] 202、所述接收端根据所述第二消息，确定解码所述第一消息的目标接收器参数；

[0122] 203、所述接收端根据所述目标接收器参数对所述发送端发送的所述第一消息进行解码。

[0123] 其中，上述第一消息可以是发送端需要向接收端发送的信号，例如：数据和/或控制消息等等，如上述第一消息可以是下行链路信号。另外，本发明实施例中，可以将第一消息定义为msg1。而上述第二消息可以理解为用于通知接收端接收器参考的消息，例如：控制消息或者调度消息等等，另外，本发明实施例中第二消息可以定义为msg2。

[0124] 上述根据所述第二消息，确定解码所述第一消息的目标接收器参数可以是，若上述第二消息中包括了参数指示信息，则确定该参数指示信息指示的接收器参数作为上述目标器参数，若上述第二消息中不包括参数指示信息，则确定默认的接收器参数作为上述目标器参数。即本发明实施例中，上述第二消息可以存在两种情况，一种是存在参数指示信息，该情况下接收端可能需要进行接收器参数切换，再对发送端发送的消息进行解码。另一

种是不存在参数指示信息，该情况下接收端可能不需要进行波束接收器参数切换，直接对接收端发送的消息进行解码。另外，目标接收器参数可以是接收端中接收器的相关参数，例如：接收波束、均衡器和接收滤波器等参数中的至少一项，对此本发明实施例不作限定。例如：以目标接收器参数为目标接收波束为例，上述确定解码所述第一消息的目标接收波束还可以是在接收端的多个接收波束(Rx波束)中选择一个或者多个接收波束。且接收端的多个接收器参数可以是与发送端无关的，或者接收端的多个接收器参数对于发送端来说也可以是已知的，例如：通过预配置或反馈通知发送端，对此本发明实施例不作限定。

[0125] 本发明实施例中，通过上述步骤就可以实现通过专门的第二消息向接收端通知发送端发送的第一消息的接收波束，从使接收端和发送端获得更准确的波束组合信息，支持多波束传输，以及提高波束传输性能。另外，本发明实施例可以用于在无线通信系统中的接收端的模拟波束切换，以及还可以用于接收端的数字波束切换等，对此本发明实施例不作限定。

[0126] 可选的，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

[0127] 若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端默认的接收器参数。

[0128] 该实施方式中，可以实现上述第二消息中包括或者不包括参数指示信息，若包括，则将参数指示信息指示的接收器参数作为上述目标接收器参数。其中，参数指示信息指示接收波束可以是与接收端当前使用的接收器参数为不同的接收器参数，这时接收端需要进行接收器参数切换。而使用默认的接收器参数，可以不进行切换，例如：默认的接收器参数就可以是接收端当前使用的接收器参数，以快速对发送端发送的消息进行解码。另外，本发明实施例中，第二消息中的参数指示信息可以是，第二消息中的参数指示字段，即第二消息中可以存在或者不存在该参数指示字段。

[0129] 例如：所述接收端默认的接收器参数包括：

[0130] 所述接收端当前使用的接收器参数、所述接收端接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端向所述发送端上报时间最近的发送器参数对应的接收器参数。

[0131] 该实施方式中，通过上述默认波束可以减少接收器参数的切换，例如：减少接收波束的切换，以提高传输性能，例如：第二消息与第一消息之间可以不存在间隙。

[0132] 另外，本发明实施例中，上述参数指示信息可以显式或者隐式指示所述目标接收器参数。例如：显式或者隐式指示所述目标接收波束。

[0133] 其中，显式指示可以理解为直接指示，例如：以接收波束举例，接收端具有一组L个预配置的接收波束，这些对于发送端可以是已知的。这样上述参数指示信息就式携带Log_2(L)位的字段，以指示接收端的推荐接收波束。在接收到第二消息后，接收端就可以机确定对应的接收波束用于解码msg1。而上述隐式指示可以理解为间接指示，例如：上述参数指示信息可以是指示发送波束(Tx波束)，通过指示的发送波束隐式指示该发送波束对应的接收波束。该实施方式中，通过上述显式或者隐式的方式可以实现灵活地向接收端指示接收波束，以提高系统的灵活性。

[0134] 可选的，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信

息包括所述发送端选择的发送器参数，所述接收端将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

[0135] 该实施方式中，可以实现通过发送器参数来隐式指示接收器参数，例如：以目标接收器参数为目标波束举例，发送端可以具有用于下行链路传输的M个候选发送波束。发送端配置M个参考符号(RS)资源，并将每个发送波束应用于相应的RS资源。对于每个RS资源，接收端可以测试一组候选接收波束，并确定每个RS资源(例如发送波束)的最佳接收波束。优选的，接收端可以将至少推荐的发送波束的信息反馈给发送端，例如，以推荐的RS资源的形式，但这一步是可选的。在发送第一消息之前，发送端以第二消息的方式发送其选定的发送波束的指示。接收端接收到第二消息后，获得所使用的发送波束的信息，并获得最佳的接收波束作为上述目标接收波束，该最佳的接收波束可以是从先前的测量已知并保存在接收端中。

[0136] 该实施方式中，可以实现通过发送器参数来隐式指示接收器参数，从而有利于接收端与发送端之间的传输。当然，在一些实施方式中，发送端可以是根据接收端返回的推荐信息自主选择相应的发送器参数，例如：发送波束。

[0137] 可选的，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

[0138] 若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

[0139] 该实施方式中，上述参数切换指示集(BSIS)对应的调度时间单位可以是子帧或者时隙(slots)等时间单位。且发送端和接收端对BSIS可以具有一致的认识。只有在BSIS对应的slot(这里以slot为例)中，第二消息才可能会携带参数指示信息，否则第二消息不携带波束指示信息。这意味着在BSIS对应的时隙之外的所有时隙中可以不执行接收器参数切换，例如：接收波束切换，而仅在周期性的选定时隙(例如BSIS中的时隙)中执行接收器参数切换。

[0140] 另外，由于第二消息包括参数指示信息时，所述第二消息与所述第一消息之间存在间隙，这样接收端可以是在该间隙切换进行接收器参数切换，例如：接收波束切换，从而不影响消息的传输。而所述第二消息不包括参数指示信息时，所述第二消息与所述第一消息之间可以不存在间隙，这样可以节约传输资源，因为该情况下，接收端可能是不需要进行接收器参数切换，例如：接收波束切换，进而第二消息和第一消息连续传输也不会影响接收端的解码。且上述第二消息和第一消息可以采用相同的频域资源发送的，或者采用相同的信道发送等，对此本发明实施例不作限定。

[0141] 例如：对于在BSIS中的时隙中发送的第二消息，携带波束指示信息。在这种情况下，同一时隙中的第一消息和第二消息之间有切换时间。否则对于BSIS外的时隙中的第二消息传输，发送端发送第二消息，而不携带波束指示字段。在这种情况下，接收端可以准备在第二消息之后立即接收第一消息(没有间隙)。例如：图3所示的第二个slot。另外，当尝试在每个时隙中接收到第二消息或者第一消息时，接收端可以根据假定存在或者不存在波束指示信息来解码第二消息。换句话说，在BSIS中的时隙中，第二消息可以携带参数指示信息，接收端尝试解码第二消息，假设有一个参数指示信息。在其他时隙中，接收器解码第二

消息，假设没有参数指示信息。在第二消息不携带参数指示信息的时隙中，接收端仍然可以选择一个接收器参数(例如：接收波束)来解码第一消息。接收端可以使用在最新的携带参数指示字段的第二消息中指示的接收器参数。如果没有接收到参数指示信息，则接收机可以使用默认的接收器参数来解码第一消息。

[0142] 可选的，所述参数切换指示集对应的调度时间单位在时域上周期存在；和\或

[0143] 所述参数切换指示集对应的调度时间单位由所述发送端半静态或半持续(semi-persistent)配置，并通知所述接收端。

[0144] 其中，上述参数切换指示集对应的调度时间单位在时域上周期存在可以是，上述参数切换指示集对应的调度时间单位具有周期性，例如：参数切换指示集在时域中可以周期性地具有预配置的周期和定时偏移，其中，该定时偏移可以是相对于另一个定时参考的偏移，如帧边界。例如，参数切换指示集可以具有10ms的周期，其指示在10个slots中的1个中发送的第二消息可能会携带参数指示信息，而其他9个slots中的第二消息不携带参数指示信息。上述参数切换指示集对应的调度时间单位由所述发送端半静态或半持续配置，并通知所述接收端可以是，发送端半静态或半持续配置，并通知接收端参数切换指示集的集合，即指示多个参数切换指示集。或者上述参数切换指示集可以由接收端获得，并作为推荐被反馈给发送端。发送端可以使用接收端推荐的参数切换指示集，或覆盖接收端推荐的参数切换指示集，并选择一个新的参数切换指示集。发送端可以需要向接收端指示是否确认接收端推荐的参数切换指示集，或者将其选择的参数切换指示集指示给接收端。

[0145] 可选的，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前，所述接收端根据所述目标接收器参数对所述第一消息进行解码，包括：

[0146] 若所述第二消息包括参数指示信息，则所述接收端根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0147] 若所述第二消息包括参数指示信息，则所述接收端丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0148] 若所述第二消息包括参数指示信息，则所述接收端根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0149] 若所述第二消息不包括波束指示信息，则所述接收端根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

[0150] 该实施方式中，所述第一消息分为时域上连续的第一部分内容和第二部分内容可以是接收端将第一消息分为两个部分，这里分为可以理解为将第一消息看作两个部分，因为，此时接收端还未接收到第一消息，不能对其进行拆分。

[0151] 例如：发送端可以发送携带与接收第一消息有关的下行调度信息的第二消息。第二消息可以携带或不携带参数指示信息，对此接收端可以没有先验知识。如果第二消息没有参数指示信息，则第二消息的有效载荷较小(表示为A位)。如果第二消息具有参数指示信息，则第二消息的有效载荷较大(表示为B位，其中B>A)。在发送端发送第二消息后，接收端可以尝试用盲解码第二消息。因为，接收端没有关于第二消息的有效载荷的先验信息，因此

需要基于不同的可能的第二消息有效载荷来执行盲解码。例如，接收端将执行假设有效载荷A位的第二消息的一次盲解码，以及假设B位的有效载荷的另一个第二消息的盲解码。这样根据第二消息的实际有效负载，两个盲解码之一将成功解码第二消息。之后，接收端就可以将第一消息分为第一部分内容和第二部分内容(part1and part 2)，第一部分内容在第二部分内容前面，并且在时域中为时分复用(TDM)。第一消息的第一部分部分紧随着第二消息，即两者没有间隙，第一消息的第二部分内容紧邻第一部分内容，例如：图4所示的第二个slot。

[0152] 另外，由于第一部分内容和第二部分内容属于同一消息，从而接收端可以分别对第一部分内容和第二部分内容执行符号级处理。

[0153] 该实施方式中，由于若所述第二消息包括参数指示信息时，则所述接收端使用所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码，其中，所述发送端未发送所述第一部分内容。例如：图4所示的第一个slot。这样可以提高接收端解码的准确性。

[0154] 另外，由于第二消息包括参数指示信息时，可以丢弃所述第一部分内容，以及使用所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码。即可以丢弃图4所示的第二个slot的第一部分内容，同样能够保证发送端与接收端之间的性能，因为，在该情况下发送端可以在第一部分内容中传输非重要信息，而在第二部分内容中传输重要信息。

[0155] 另外，由于第二消息包括参数指示信息时，可以使用默认的接收器参数对所述第一部分内容进行解码，以及使用所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码。这样可以实现接收到准备地解码第一部分部分和第二部分内容。

[0156] 另外，由于第二消息不包括参数指示信息，可以实现使用默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。即图4所示的第三个slot。

[0157] 另外，发送端和接收端可以将其对接收端上确切的第一消息解码行为的理解对齐。这可以由网络半静态地或半持续地配置给接收端，或者使用另一个动态控制消息动态地指示给接收端。

[0158] 可选的，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前，所述接收端根据所述目标接收器参数对所述发送端发送的所述第一消息进行解码，包括：

[0159] 若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0160] 若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0161] 若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0162] 若所述第二消息包括参数指示字段，且所述参数指示字段指示没有参数指示信息或者没有参数改变，则所述接收端根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

[0163] 该实施方式中，可以实现第二消息终具有参数指示字段，例如：波束指示字段，例如S比特位。且参数指示字段具有至少一个状态指示，即没有参数指示信息或者没有参数改变的状态指示，以及还可以指示用于解码第一消息的接收器参数的其他状态。因此，第二消息的有效载荷预先已知到发送端和接收端。例如对应于4个可能的接收器参数指示状态的S＝2。一个状态向接收机指示存在“没有参数指示信息或者没有参数改变”，而其他3个状态指示到接收机的接收器参数。

[0164] 另外，该实施方式中，关于第一消息的第一部分内容和第二部分内容可以参考上一实施方式中的相应描述，此处不作赘述。

[0165] 且关于第二消息中是否包括参数指示信息的情况，如何对第一部分内容和第二部分内容的解码，可以参见上述实施方式的相应描述，此处不作赘述，且可以达到相同的有益效率。

[0166] 可选的，所述方法还包括：

[0167] 所述接收端接收所述发送端发送的第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

[0168] 其中，上述第三消息可以定义为msg3，该实施方式中，通过第三消息通知接收端第二消息是否包括参数指示信息，更为具体的可以指示第二消息指示的接收器参数对于接收端是否存在接收器参数改变，这样可以实现当不存在接收器参数改变或者不包括参数指示信息时，接收端甚至可以不接收第二消息，直接使用当前的接收器参数对第一消息进行解码。另外，在一些实施方式中，第三消息可以具有固定有效载荷，其中第二消息中的参数指示信息的存在或者不存在对应于第三消息中的两个不同状态。例如，第三消息有1位表示第二消息是否携带参数指示信息。

[0169] 另外，本发明实施例中，上述第三消息可以对应于一个第二消息，即一个第三消息指示一个第二消息，例如：如图5所示。且第三消息、第二消息可以是以相同的调度时间单位(例如，时隙)发送，其中图5给出了一个示例。可以以不同的调度时间单位发送的第三消息和第二消息。如果第二消息有参数指示信息，第一消息和第二消息之间可以有一个间隙。如果第二消息没有参数指示，第一消息和第二消息之间可以没有间隙。

[0170] 可选的，所述第三消息用于指示M个时间单位内的第二消息是否包括参数指示信息，所述M为大于或者等于1的整数，所述M个时间单位连续或者不连续。

[0171] 该实施方式中，可以实现通过第三消息指示多个第二消息，例如：第三消息用于指示M个时隙中的M个第二消息是否包括参数指示信息，这样可以节省消息开销。另外，上述M的值和M个第二消息的时间位置可以预定义的半静态或半持续配置的，并且对发送端和接收端均是已知的。其中，图6示出了一个例子，其中M＝3。一旦接收到第三消息，该第三消息就向接收端指示相应的M个时隙中的第二消息是否携带参数指示信息。

[0172] 另外，第三消息可以是可以在每个调度时间单位(例如slots)或在由发送端预配

置的时隙的子集(例如,具有预先配置的传输周期和偏移)中被发送。对于后一种情况,发送端可以事先向接收端指示第三消息的发生。

[0173] 可选的,本发明实施例中,目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

[0174] 这样可以实现根据发送端的第二消息灵活选择时域、频域和空域中的至少一项的接收器参数,对第一消息进行解码。优先的,所述空域的接收器参数包括所述接收端的接收波束。这样可以实现接收端根据与第一消息关联的第二消息确定接收波束,且还可以提高波束传输性能。

[0175] 需要说明的是,本发明实施例介绍的多种可选的实施方式均可以相互结合实现,也可以单独实现,对此本发明实施例不作限定。

[0176] 本发明实施例,接收端接收发送端发送的与第一消息关联的第二消息;所述接收端根据所述第二消息,确定解码所述第一消息的目标接收器参数;所述接收端根据所述目标接收器参数对所述发送端发送的所述第一消息进行解码。这样可以实现接收端根据与第一消息关联的第二消息确定接收器参数,且还可以提高消息传输性能。

[0177] 请参阅图7,图7是本发明实施例提供的另一种消息解码方法的流程图,如图7所示,包括以下步骤:

[0178] 701、发送端向接收端发送与第一消息关联的第二消息,所述第二消息用于所述接收端确定解码所述第一消息的目标接收器参数;

[0179] 702、所述发送端向所述接收端发送所述第一消息。

[0180] 可选的,若所述第二消息包括参数指示信息,则所述目标接收器参数为所述参数指示信息指示的接收器参数;

[0181] 若所述第二消息不包括参数指示信息,则所述目标接收器参数为所述接收端默认的接收器参数。

[0182] 可选的,所述接收端默认的接收器参数包括:

[0183] 所述接收端当前使用的接收器参数、所述接收端接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端向所述发送端上报时间最近的发送器参数对应的接收器参数。

[0184] 可选的,所述参数指示信息显式或者隐式指示所述目标接收器参数。

[0185] 可选的,若所述参数指示信息隐式指示所述目标接收器参数,则所述参数指示信息包括所述发送端选择的发送器参数,所述接收端将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

[0186] 可选的,若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的,则所述第二消息包括参数指示信息,且所述第二消息与所述第一消息之间存在间隙;

[0187] 若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的,则所述第二消息不包括参数指示信息,且所述第二消息与所述第一消息之间不存在间隙。

[0188] 可选的,所述参数切换指示集对应的调度时间单位在时域上周期存在;和\或

[0189] 所述参数切换指示集对应的调度时间单位由所述发送端半静态或半持续配置,并通知所述接收端。

[0190] 可选的，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前。

[0191] 可选的，所述方法还包括：

[0192] 所述发送端向所述接收端发送第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

[0193] 可选的，所述第三消息用于指示M个时间单位内的第二消息是否包括参数指示信息，所述M为大于或者等于1的整数，所述M个时间单位连续或者不连续。

[0194] 可选的，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

[0195] 可选的，所述空域的接收器参数包括所述接收端的接收波束。

[0196] 需要说明的是，本实施例作为与图2所示的实施例中对应的发送端的实施方式，其具体的实施方式可以参见图2所示的实施例的相关说明，为了避免重复说明，本实施例不再赘述，且还可以达到相同有益效果。

[0197] 请参考图8，图8是本发明实施例提供一种接收端的结构图，如图8所示，接收端800包括：

[0198] 第一接收模块801，用于接收发送端发送的与第一消息关联的第二消息；

[0199] 确定模块802，用于根据所述第二消息，确定解码所述第一消息的目标接收器参数；

[0200] 解码模块803，用于根据所述目标接收器参数对所述发送端发送的所述第一消息进行解码。

[0201] 可选的，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

[0202] 若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端默认的接收器参数。

[0203] 可选的，所述接收端默认的接收器参数包括：

[0204] 所述接收端当前使用的接收器参数、所述接收端接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端向所述发送端上报时间最近的发送器参数对应的接收器参数。

[0205] 可选的，所述参数指示信息显式或者隐式指示所述目标接收器参数。

[0206] 可选的，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端选择的发送器参数，所述接收端将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

[0207] 可选的，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

[0208] 若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

[0209] 可选的，所述参数切换指示集对应的调度时间单位在时域上周期存在；和\或

[0210] 所述参数切换指示集对应的调度时间单位由所述发送端半静态或半持续配置，并通知所述接收端。

[0211] 可选的，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前；

[0212] 所述解码模块803用于若所述第二消息包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0213] 所述解码模块803用于若所述第二消息包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0214] 所述解码模块803用于若所述第二消息包括参数指示信息，则根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0215] 所述解码模块803用于若所述第二消息不包括波束指示信息，则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码；或者

[0216] 所述解码模块803用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0217] 所述解码模块803用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0218] 所述解码模块803用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0219] 所述解码模块803用于若所述第二消息包括参数指示字段，且所述参数指示字段指示没有参数指示信息或者没有参数改变，则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

[0220] 可选的，如图9所示，所述接收端800还包括：

[0221] 第二接收模块804，用于接收所述发送端发送的第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

[0222] 可选的，所述第三消息用于指示M个时间单位内的第二消息是否包括参数指示信息，所述M为大于或者等于1的整数，所述M个时间单位连续或者不连续。

[0223] 可选的，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

[0224] 可选的，所述空域的接收器参数包括所述接收端的接收波束。

[0225] 需要说明的是，本实施例中上述接收端800可以是本发明实施例中方法实施例中任意实施方式的接收端，本发明实施例中方法实施例中接收端的任意实施方式都可以被本

实施例中的上述接收端800所实现，以及达到相同的有益效果，此处不再赘述。

[0226] 请参阅图10，图10是本发明实施例提供的一种发送端的结构图，如图10所示，发送端1000包括：

[0227] 第一发送模块1001，用于发送端向接收端发送与第一消息关联的第二消息，所述第二消息用于所述接收端确定解码所述第一消息的目标接收器参数；

[0228] 第二发送模块1002，用于向所述接收端发送所述第一消息。

[0229] 可选的，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

[0230] 若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端默认的接收器参数。

[0231] 可选的，所述接收端默认的接收器参数包括：

[0232] 所述接收端当前使用的接收器参数、所述接收端接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端向所述发送端上报时间最近的发送器参数对应的接收器参数。

[0233] 可选的，所述参数指示信息显式或者隐式指示所述目标接收器参数。

[0234] 可选的，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端选择的发送器参数，所述接收端将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

[0235] 可选的，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

[0236] 若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

[0237] 可选的，所述参数切换指示集对应的调度时间单位在时域上周期存在；和\或

[0238] 所述参数切换指示集对应的调度时间单位由所述发送端半静态或半持续配置，并通知所述接收端。

[0239] 可选的，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前。

[0240] 可选的，如图11所示，所述发送端还包括：

[0241] 第二发送模块1003，用于向所述接收端发送第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

[0242] 可选的，所述第三消息用于指示M个时间单位内的第二消息是否包括参数指示信息，所述M为大于或者等于1的整数，所述M个时间单位连续或者不连续。

[0243] 可选的，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

[0244] 可选的，所述空域的接收器参数包括所述接收端的接收波束。

[0245] 需要说明的是，本实施例中上述发送端1000可以是本发明实施例中方法实施例中

任意实施方式的发送端，本发明实施例中方法实施例中发送端的任意实施方式都可以被本实施例中的上述发送端1000所实现，以及达到相同的有益效果，此处不再赘述。

[0246] 请参考图12，图12是本发明实施例提供的另一种接收端的结构图，如图12所示，该接收端包括：处理器1200、收发机1210、存储器1220、用户接口1230和总线接口，其中：

[0247] 处理器1200，用于读取存储器1220中的程序，执行下列过程：

[0248] 通过收发机1210接收端接收发送端发送的与第一消息关联的第二消息；

[0249] 根据所述第二消息，确定解码所述第一消息的目标接收器参数；

[0250] 根据所述目标接收器参数对所述发送端发送的所述第一消息进行解码。

[0251] 其中，收发机1210，用于在处理器1200的控制下接收和发送数据。

[0252] 在图12中，总线架构可以包括任意数量的互联的总线和桥，具体由处理器1200代表的一个或多个处理器和存储器1220代表的存储器的各种电路链接在一起。总线架构还可以将诸如外围设备、稳压器和功率管理电路等之类的各种其他电路链接在一起，这些都是本领域所公知的，因此，本文不再对其进行进一步描述。总线接口提供接口。收发机1210可以是多个元件，即包括发送机和接收机，提供用于在传输介质上与各种其他装置通信的单元。针对不同的用户设备，用户接口1230还可以是能够外接内接需要设备的接口，连接的设备包括但不限于小键盘、显示器、扬声器、麦克风、操纵杆等。

[0253] 处理器1200负责管理总线架构和通常的处理，存储器1220可以存储处理器1200在执行操作时所使用的数据。

[0254] 可选的，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

[0255] 若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端默认的接收器参数。

[0256] 可选的，所述接收端默认的接收器参数包括：

[0257] 所述接收端当前使用的接收器参数、所述接收端接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端向所述发送端上报时间最近的发送器参数对应的接收器参数。

[0258] 可选的，所述参数指示信息显式或者隐式指示所述目标接收器参数。

[0259] 可选的，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端选择的发送器参数，所述接收端将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

[0260] 可选的，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

[0261] 若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

[0262] 可选的，所述参数切换指示集对应的调度时间单位在时域上周期存在；和\或

[0263] 所述参数切换指示集对应的调度时间单位由所述发送端半静态或半持续配置，并通知所述接收端。

[0264] 可选的，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述

第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前，所述根据所述目标接收器参数对所述第一消息进行解码，包括：

[0265] 若所述第二消息包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0266] 若所述第二消息包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0267] 若所述第二消息包括参数指示信息，则根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0268] 若所述第二消息不包括波束指示信息，则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码；或者

[0269] 若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0270] 若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0271] 若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0272] 若所述第二消息包括参数指示字段，且所述参数指示字段指示没有参数指示信息或者没有参数改变，则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

[0273] 可选的，处理器1200还用于：

[0274] 通过收发机1210接收所述发送端发送的第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

[0275] 可选的，所述第三消息用于指示M个时间单位内的第二消息是否包括参数指示信息，所述M为大于或者等于1的整数，所述M个时间单位连续或者不连续。

[0276] 可选的，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

[0277] 可选的，所述空域的接收器参数包括所述接收端的接收波束。

[0278] 需要说明的是，本实施例中上述接收端可以是图1-图7所示的实施例中的终端，图1-图7所示实施例中接收端的任意实施方式都可以被本实施例中的上述接收所实现，以及达到相同的有益效果，此处不再赘述。

[0279] 请参考图13，图13是本发明实施提供的另一种发送端的结构图，如图13所示，该发送端包括：处理器1300、收发机1310、存储器1320、用户接口1330和总线接口，其中：

[0280] 处理器1300，用于读取存储器1320中的程序，执行下列过程：

[0281] 通过收发机1310向接收端发送与第一消息关联的第二消息，所述第二消息用于所

述接收端确定解码所述第一消息的目标接收器参数；

[0282] 通过收发机1310向所述接收端发送所述第一消息。

[0283] 其中，收发机1310，用于在处理器1300的控制下接收和发送数据。

[0284] 在图13中，总线架构可以包括任意数量的互联的总线和桥，具体由处理器1300代表的一个或多个处理器和存储器1320代表的存储器的各种电路链接在一起。总线架构还可以将诸如外围设备、稳压器和功率管理电路等之类的各种其他电路链接在一起，这些都是本领域所公知的，因此，本文不再对其进行进一步描述。总线接口提供接口。收发机1310可以是多个元件，即包括发送机和接收机，提供用于在传输介质上与各种其他装置通信的单元。针对不同的用户设备，用户接口1330还可以是能够外接内接需要设备的接口，连接的设备包括但不限于小键盘、显示器、扬声器、麦克风、操纵杆等。

[0285] 处理器1300负责管理总线架构和通常的处理，存储器1320可以存储处理器1300在执行操作时所使用的数据。

[0286] 可选的，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

[0287] 若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端默认的接收器参数。

[0288] 可选的，所述接收端默认的接收器参数包括：

[0289] 所述接收端当前使用的接收器参数、所述接收端接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端向所述发送端上报时间最近的发送器参数对应的接收器参数。

[0290] 可选的，所述参数指示信息显式或者隐式指示所述目标接收器参数。

[0291] 可选的，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端选择的发送器参数，所述接收端将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

[0292] 可选的，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

[0293] 若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

[0294] 可选的，所述参数切换指示集对应的调度时间单位在时域上周期存在；和\或

[0295] 所述参数切换指示集对应的调度时间单位由所述发送端半静态或半持续配置，并通知所述接收端。

[0296] 可选的，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前。

[0297] 可选的，处理器1300还用于：

[0298] 通过收发机1310向所述接收端发送第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数

指示信息，则所述第二消息与所述第一消息之间不存在间隙。

[0299] 可选的，所述第三消息用于指示M个时间单位内的第二消息是否包括参数指示信息，所述M为大于或者等于1的整数，所述M个时间单位连续或者不连续。

[0300] 可选的，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

[0301] 可选的，所述空域的接收器参数包括所述接收端的接收波束。

[0302] 需要说明的是，本实施例中上述发送端可以是图1-图7所示的实施例中的发送端，图1-图7所示实施例中发送端的任意实施方式都可以被本实施例中的上述发送端所实现，以及达到相同的有益效果，此处不再赘述。

[0303] 在本申请所提供的几个实施例中，应该理解到，所揭露方法和装置，可以通过其它的方式实现。例如，以上所描述的装置实施例仅仅是示意性的，例如，所述单元的划分，仅仅为一种逻辑功能划分，实际实现时可以有另外的划分方式，例如多个单元或组件可以结合或者可以集成到另一个系统，或一些特征可以忽略，或不执行。另一点，所显示或讨论的相互之间的耦合或直接耦合或通信连接可以是通过一些接口，装置或单元的间接耦合或通信连接，可以是电性，机械或其它的形式。

[0304] 另外，在本发明各个实施例中的各功能单元可以集成在一个处理单元中，也可以是各个单元单独物理包括，也可以两个或两个以上单元集成在一个单元中。上述集成的单元既可以采用硬件的形式实现，也可以采用硬件加软件功能单元的形式实现。

[0305] 上述以软件功能单元的形式实现的集成的单元，可以存储在一个计算机可读取存储介质中。上述软件功能单元存储在一个存储介质中，包括若干指令用以使得一台计算机设备(可以是个人计算机，服务器，或者网络设备等)执行本发明各个实施例所述收发方法的部分步骤。而前述的存储介质包括：U盘、移动硬盘、只读存储器(Read-Only Memory，简称ROM)、随机存取存储器(Random Access Memory，简称RAM)、磁碟或者光盘等各种可以存储程序代码的介质。

[0306] 以上所述是本发明的优选实施方式，应当指出，对于本技术领域的普通技术人员来说，在不脱离本发明所述原理的前提下，还可以作出若干改进和润饰，这些改进和润饰也应视为本发明的保护范围。

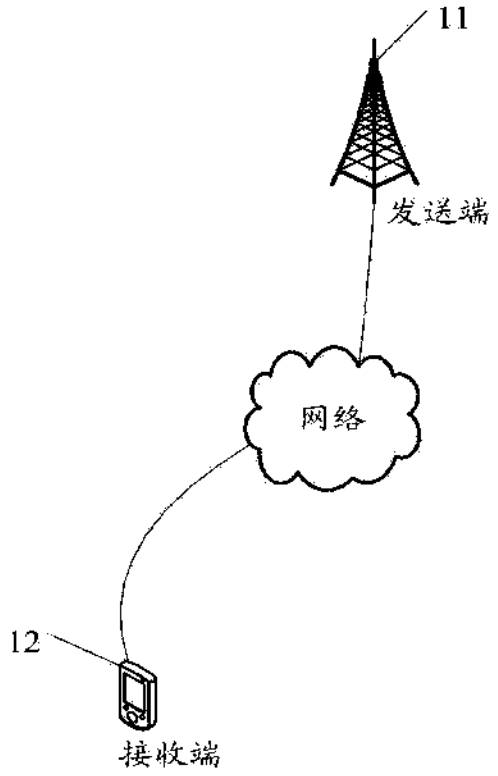

11
发送端
网络
12
接收端

图1

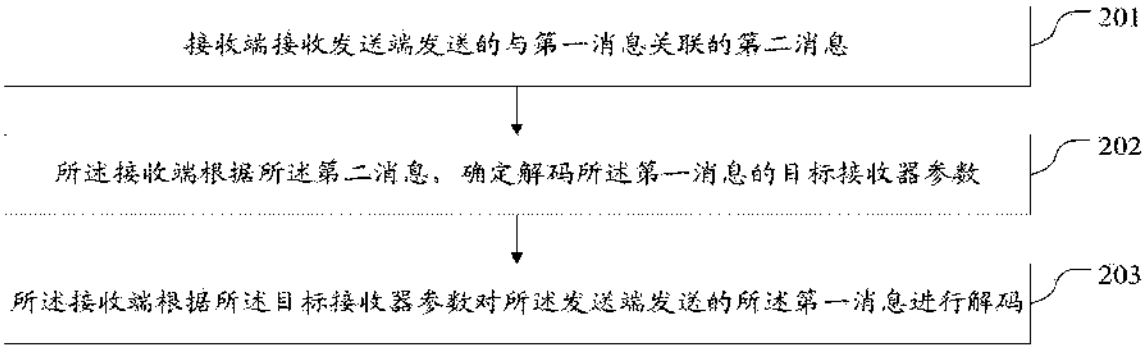

接收端接收发送端发送的与第一消息关联的第二消息
201
所述接收端根据所述第二消息，确定解码所述第一消息的目标接收器参数
202
所述接收端根据所述目标接收器参数对所述发送端发送的所述第一消息进行解码
203

图2

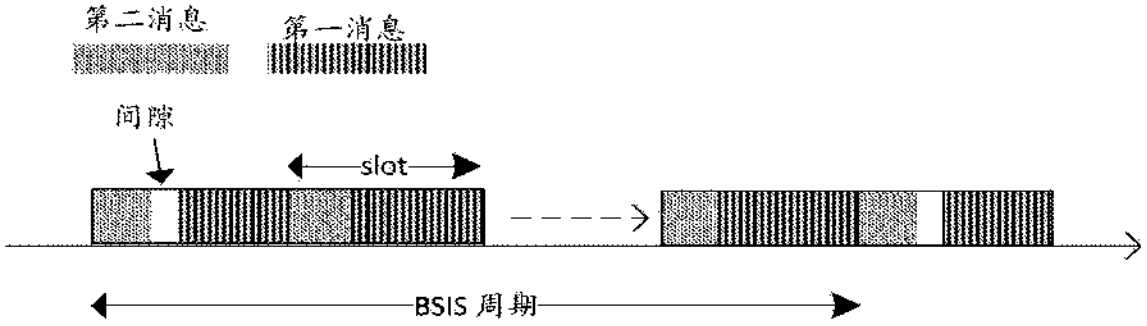

第二消息
第一消息
间隙
slot
BSIS 周期

图3

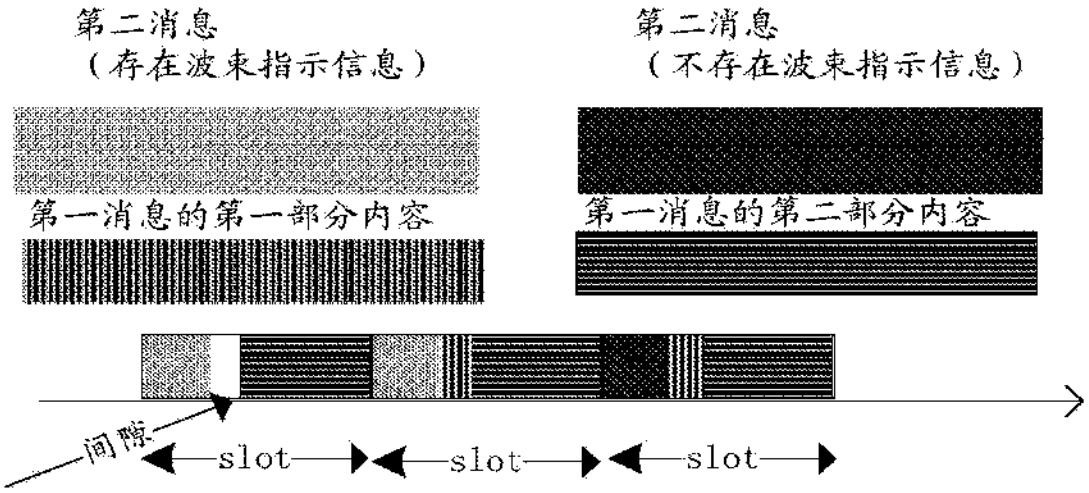

第二消息
（存在波束指示信息）
第二消息
（不存在波束指示信息）
第一消息的第一部分内容
第一消息的第二部分内容
间隙
slot
slot
slot

图4

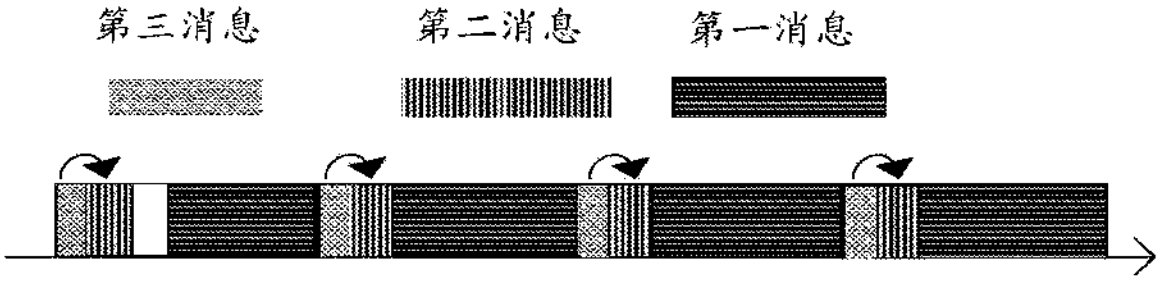

第三消息
第二消息
第一消息

图5

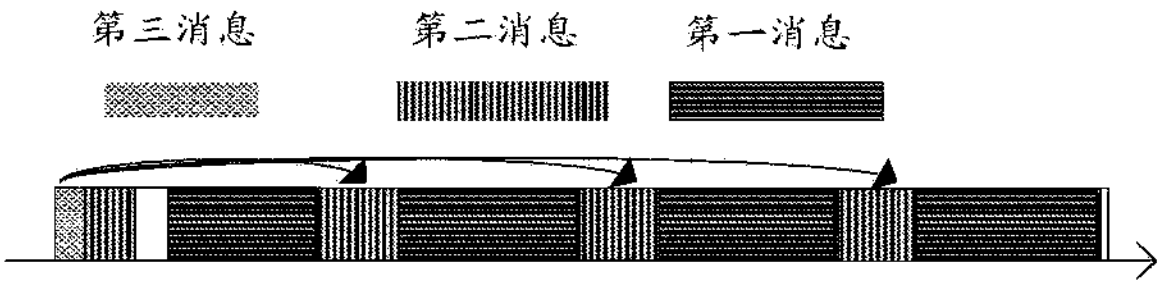

第三消息
第二消息
第一消息

图6

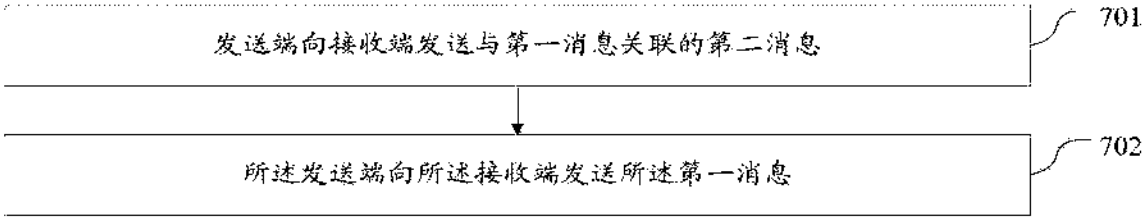

发送端向接收端发送与第一消息关联的第二消息
701
所述发送端向所述接收端发送所述第一消息
702

图7

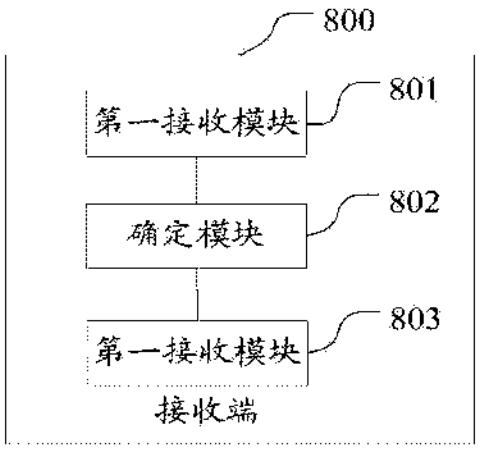

800
第一接收模块
801
确定模块
802
第一接收模块
803
接收端

图8

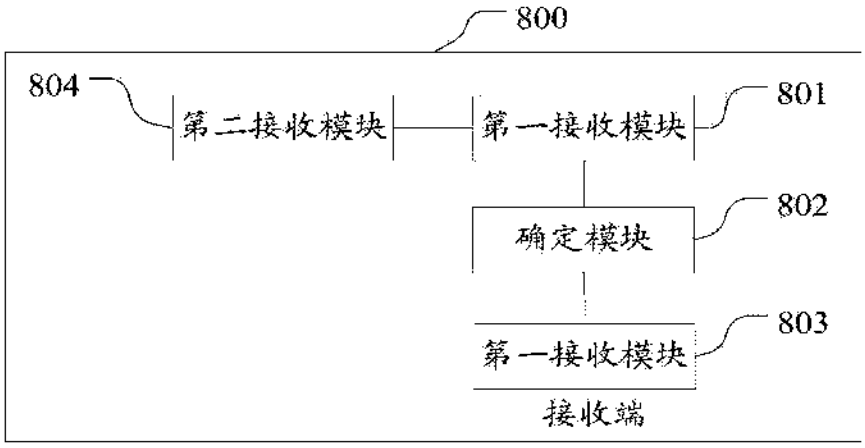

800
804
第二接收模块
第一接收模块
801
确定模块
802
第一接收模块
803
接收端

图9

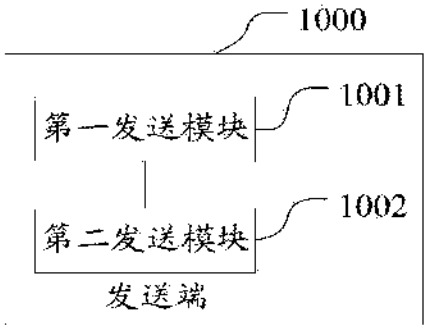

1000
第一发送模块
1001
第二发送模块
1002
发送端

图10

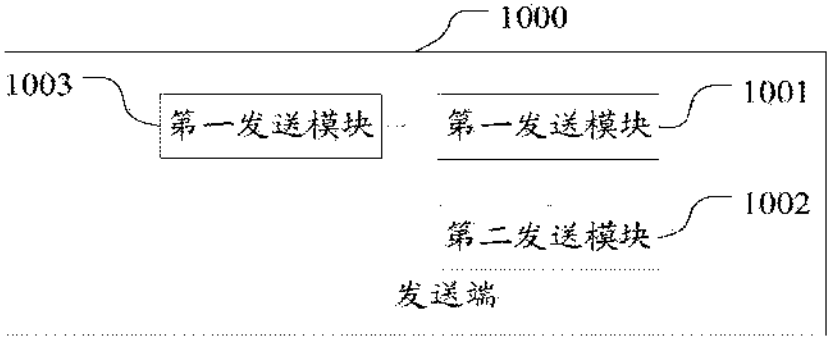

1000
1003
第一发送模块
第一发送模块
1001
第二发送模块
1002
发送端

图11

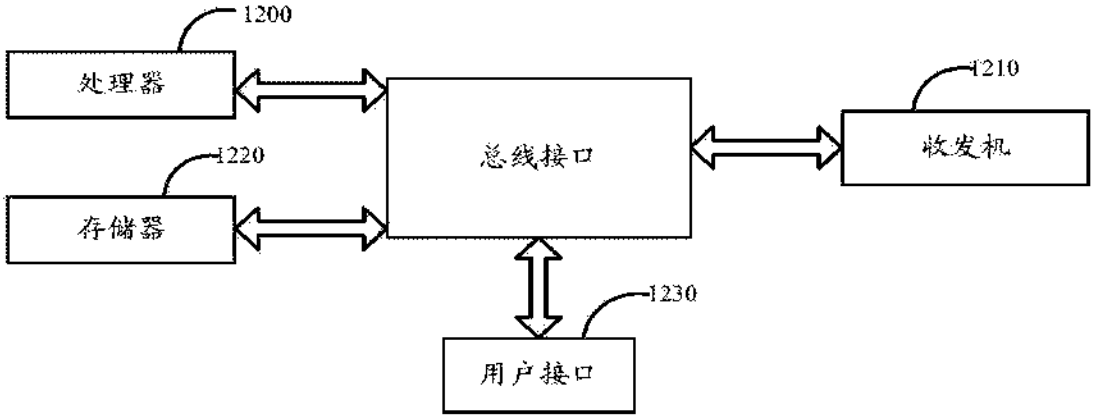

1200
处理器
1210
总线接口
收发机
1220
存储器
1230
用户接口

图12

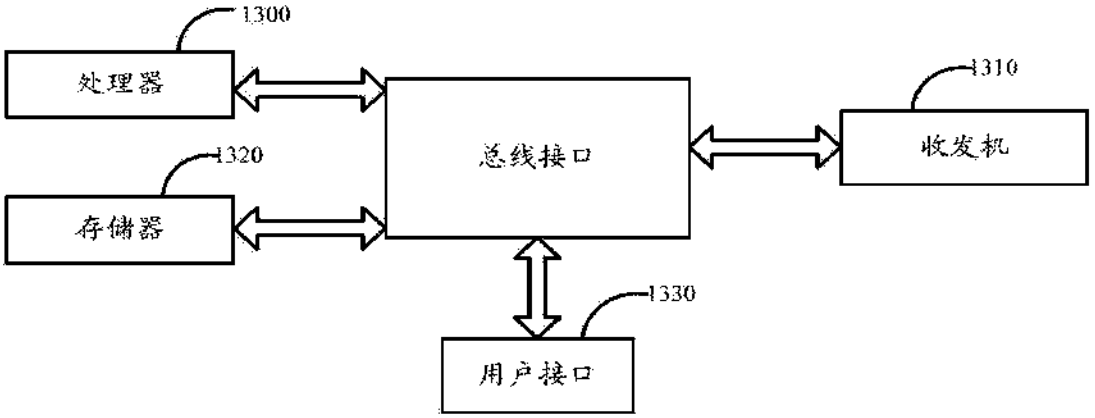

1300
处理器
1310
总线接口
收发机
1320
存储器
1330
用户接口

图13

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[Continued on next page]

(54) Title: ENODEB REFERENCE SIGNAL REDUCTION

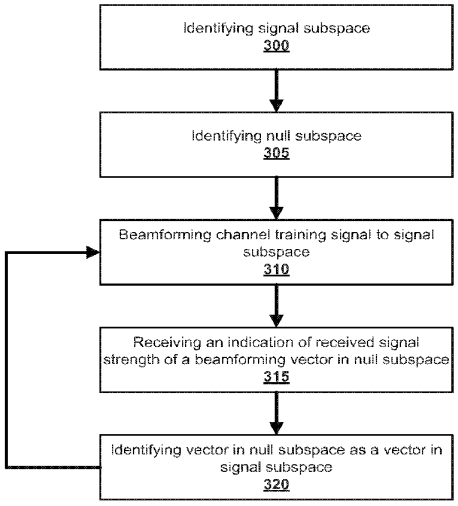


Figure 3

(57) Abstract: In embodiments, apparatuses, methods, and storage media may be described for reducing the overhead associated with the transmission of channel training signals from an eNodeB (eNB) of a wireless network. Specifically, the eNB may receive feedback from a user equipment (UE) regarding the received signal energy of a first and second beamformed signal produced with a first and second beamforming vector, respectively. The eNB may identify, based on the feedback of the received signal energy, a signal subspace and a null subspace. The eNB may then transmit a channel training signal to the signal subspace.

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EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

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— *of inventorship (Rule 4.17(iv))*

Published:

— *with international search report (Art. 21(3))*

— *with amended claims (Art. 19(1))*

ENODEB REFERENCE SIGNAL REDUCTION

Cross Reference to Related Application

The present application claims priority to U.S. Provisional Patent Application No. 61/806,821, filed March 29, 2013, entitled "Advanced Wireless Communication Systems and Techniques," the entire disclosure of which is hereby incorporated by reference in its entirety.

Field

Embodiments of the present invention relate generally to the technical field of channel training signals in wireless systems.

Background

The background description provided herein is for the purpose of generally presenting the context of the disclosure. Work of the presently named inventors, to the extent it is described in this background section, as well as aspects of the description that may not otherwise qualify as prior art at the time of filing, are neither expressly nor impliedly admitted as prior art against the present disclosure. Unless otherwise indicated herein, the approaches described in this section are not prior art to the claims in the present disclosure and are not admitted to be prior art by inclusion in this section.

Full dimension multiple-input-multiple-output (FD-MIMO) is a study item for the upcoming Release 12 of the third generation partnership project (3GPP) long term evolution (LTE) specifications. In FD-MIMO systems, the eNodeB (eNB) may have 16 or more different antenna elements that are configured for beamforming on one or more antenna ports to user equipment (UEs). Ideally, the throughput of the eNB in FD-MIMO systems may be expected to significantly increase with a large number of antenna elements.

However, in frequency division duplex (FDD) mode, beamforming may require channel training signals. Specifically, channel training signals may be reference signals that are sent by the eNB to each UE. The UE(s) may then respond with channel feedback based on the received channel training signals. This feedback may be used to identify the resources used to beamform one or more additional signals to the UE. Currently, the overhead associated with transmitting the channel training signals may increase linearly with the number of antenna elements. For large antenna arrays having, for example, 30 antenna elements, the overhead associated with transmitting the channel training signals may become prohibitive because the throughput gains realized through use of FD-MIMO

may be offset by the overhead incurred through transmission of the channel training signals.

Brief Description of the Drawings

Embodiments will be readily understood by the following detailed description in conjunction with the accompanying drawings. To facilitate this description, like reference numerals designate like structural elements. Embodiments are illustrated by way of example and not by way of limitation in the figures of the accompanying drawings.

Figure 1 schematically illustrates a high-level example of a network system comprising a UE and an eNB, in accordance with various embodiments.

Figure 2 depicts an example of different subspaces for FD-MIMO transmissions from an eNodeB (eNB) to a plurality of user equipment (UEs), in accordance with various embodiments.

Figure 3 depicts an example of a process flow for transmitting channel training signals, in accordance with various embodiments.

Figure 4 schematically illustrates an example system that may be used to practice various embodiments described herein.

Detailed Description

Apparatuses, methods, and storage media are described herein for reducing the overhead associated with the transmission of channel training signals such as the channel state information reference signal (CSI-RS). As described above, the number of antenna ports of an eNB may linearly increase with an increase in the number of antenna elements used by the eNB. This increase in antenna ports may increase transmissions of channel training signals, which in turn may increase resource overhead of the eNB.

The channel training signals may be shared between the antenna ports in order to reduce the resource overhead of the eNB. However, time sharing of the channel training signals may introduce latency or delay to transmissions of the eNB. As noted above, the channel training signals may be transmitted from the eNB, and the UE may feed back information related to the channel training signals, and more specifically the radio resources used to transmit the channel training signals. Based on the fed back information, the eNB may identify radio resources that should be used for further communication with the UE.

However, the latency introduced by time sharing of the channel training signals may be detrimental because the latency may be such that the radio resources in the cell may have changed significantly between the transmission of the channel training signal

and the identification of the channel resources to use to transmit further signals using the feedback based on the transmission of the channel training signal. In other words, the fed back information from a UE receiving the channel training signals may not necessarily correspond to the radio resources of the cell at the time of transmission of the additional signal(s) from the eNB. This change may be due to interference caused by multiple UEs, the UE moving, or other reasons. Therefore, time sharing of the channel training signals may reduce overall performance of the cell.

By contrast, the present disclosure may relate to selectively transmitting one or more channel training signals to particular signal subspaces. Specifically, the channel training signals may be beamformed to those signal subspaces. Typically, beamforming may include multiplying a signal by an antenna-specific or antenna-port specific weighting vector, which may be referred to as a beamforming vector. The beamforming vector may affect the phase of the signal, the amplitude of the signal, or some other characteristic of the signal. The weighted signal produced by this weighting may be referred to as a beamformed signal. By multiplying one or more antenna transmissions by the weighting vector, the beamformed signal may only be transmitted to a specific signal subspace.

Specifically, a signal subspace may be a vector space defined by a subset of the possible beamforming vectors. In other words, transmissions of the signal to the signal subspace may include weighting the signal by one or more beamforming vectors of the possible beamforming vectors to produce a beamformed signal, and transmitting the beamformed signal from the eNB. The signal subspace may be identified by identifying the beamforming vectors with which the UEs receive the signal with a relatively high signal energy. Specifically, as noted above, the eNB may initially transmit one or more training signals to one or more UEs, and receive feedback information from the UEs regarding the received signal. For example, the feedback may include information regarding strength or magnitude of the received signal energy, or the phase of the received signal. Based on that fedback information, the eNB may be able to identify the beamforming vectors that produce a relatively high amount of signal energy at the UEs. The identified beamforming vectors that produce a relatively high amount of signal energy at the UEs may then be used to identify the signal subspace on which the channel training signals should be transmitted. The eNB may then transmit the channel training signals to that signal subspace using the identified beamforming vectors.

The null subspace may then be identified as the remainder of the beamforming vectors that are not used for the beamforming signal transmission to the signal subspace.

In some embodiments an additional channel training signal may be beamformed to only a portion of the null subspace, as explained in greater detail below. In embodiments, the number of beamforming vectors used to generate a beamformed signal for the signal subspace may be significantly less than the number of beamforming vectors in the null subspace. Therefore, the transmission overhead of the eNB may be significantly reduced. For example, the dimension of the null space may be several times that of the signal subspace that is useful for data communications. Therefore, skipping the channel training in the entire null space may reduce the training overhead by multiple times. For example, simulations indicate that by not transmitting the channel training signal to the entire null subspace, the resource overhead of the cell may be reduced by up to 50% while the throughput of an FD-MIMO eNB with 16 antenna elements may only be reduced by 5%. The overhead reduction may be expected to increase significantly for eNBs with antenna arrays of 64 or 128 antenna elements. For example, an eNB with 128 antenna elements transmitting data to 10 UEs may need up to 128 antenna ports in legacy systems, while only needing up to 10 antennas ports (one antenna port per UE) in wireless cells of the present disclosure.

In some embodiments, and as described in further detail below, one or both of the signal and/or null subspaces may vary over time due to mobile channel variation. Because the eNB may identify or update the signal subspace and null subspace according to the feedback indications of training signals that were beamformed by the previous beamforming vectors, the currently updated signal subspace and null subspaces may not be exactly the same as the previous signal and null subspaces where the previous beamforming vectors are located. Therefore, in some embodiments, the newly identified subspace may not fully include the previous beamforming vector. However, since the channel variation may be relatively slow in many embodiments such that the subspaces are substantially correlated in time, i.e. very alike, the previous and the current signal and null subspace may be substantially the same.

In the following detailed description, reference is made to the accompanying drawings which form a part hereof wherein like numerals designate like parts throughout, and in which is shown by way of illustration embodiments that may be practiced. It is to be understood that other embodiments may be utilized and structural or logical changes may be made without departing from the scope of the present disclosure. Therefore, the following detailed description is not to be taken in a limiting sense.

Various operations may be described as multiple discrete actions or operations in

turn, in a manner that is most helpful in understanding the claimed subject matter. However, the order of description should not be construed as to imply that these operations are necessarily order dependent. In particular, these operations may not be performed in the order of presentation. Operations described may be performed in a different order than the described embodiment. Various additional operations may be performed and/or described operations may be omitted in additional embodiments.

For the purposes of the present disclosure, the phrases "A and/or B" and "A or B" mean (A), (B), or (A and B). For the purposes of the present disclosure, the phrase "A, B, and/or C" means (A), (B), (C), (A and B), (A and C), (B and C), or (A, B and C).

The description may use the phrases "in an embodiment," or "in embodiments," which may each refer to one or more of the same or different embodiments. Furthermore, the terms "comprising," "including," "having," and the like, as used with respect to embodiments of the present disclosure, are synonymous.

Figure 1 schematically illustrates a wireless communication network 100 in accordance with various embodiments. The wireless communication network 100 (hereinafter "network 100") may be an access network of a 3GPP LTE network such as evolved universal terrestrial radio access network (E-UTRAN). The network 100 may include an eNodeB (eNB, also referred to as an evolved NodeB) 105, configured to wirelessly communicate with a UE 110.

As shown in Figure 1, the UE 110 may include a transceiver module 120. The transceiver module 120 may be coupled with one or more of a plurality of antenna elements 125 of the UE 110 for communicating wirelessly with other components of the network 100, e.g., eNB 105 or another UE. The antenna elements 125 may be powered by a power amplifier 130 which may be a component of the transceiver module 120, as shown in Figure 1, or may be a separate component of the UE 110. In one embodiment, the power amplifier 130 provides the power for all transmissions on the antenna elements 125. In other embodiments, there may be multiple power amplifiers on the UE 110. The use of multiple antenna elements 125 may allow for the UE 110 to use transmit diversity techniques such as spatial orthogonal resource transmit diversity (SORTD), MIMO, or FD-MIMO. In certain embodiments the transceiver module 120 may contain both transmitter circuitry 155 and receiver circuitry 160. Specifically, the transmitter circuitry 155 may be configured to transmit a signal from the UE 110, for example using antenna elements 125. Similarly, the receiver circuitry 160 may be configured to receive a signal at the UE 110. Although Figure 1 depicts the transceiver module 120 including both the

transmitter circuitry 155 and the receiver circuitry 160, in other embodiments, the transceiver module 120 may be replaced by transmitter circuitry and receiver circuitry which are separate from one another (not shown). In other embodiments, the transceiver module 120 may be coupled with processor circuitry configured to alter, process, or transform signals or data received from, or sent to, the transceiver module 120 (not shown).

Similarly to the UE 110, the eNB 105 may include a transceiver module 140. The transceiver module 140 may be further coupled with one or more of a plurality of antenna elements 135 of the eNB 105 for communicating wirelessly with other components of the network 100, e.g., UE 110. The antenna elements 135 may be powered by a power amplifier 145 which may be a component of the transceiver module 140, as shown in Figure 1, or may be a separate component of the eNB 105. In one embodiment, the power amplifier 145 provides the power for all transmissions on the antenna elements 135. In other embodiments, there may be multiple power amplifiers on the eNB 105. The use of multiple antenna elements 135 may allow for the eNB 105 to use transmit diversity techniques such as SORTD, MIMO, or FD-MIMO. In certain embodiments the transceiver module 140 may contain both transmitter circuitry 165 and receiver circuitry 170 which may be similar to the transmitter circuitry 155 and receiver circuitry 160 described above. In other embodiments, the transceiver module 140 may be replaced by transmitter circuitry and receiver circuitry which are separate from one another (not shown). In other embodiments, the transceiver module 140 may be coupled with processor circuitry configured to alter, process, or transform signals or data received from, or sent to, the transceiver module 120 (not shown).

As noted above, an eNB such as eNB 105 may have a plurality of antenna ports, and each antenna port may correspond to one or more of the antenna elements 135. In embodiments the transceiver module 140 may additionally include, or otherwise be coupled with, a subspace identifier 150. As will be explained in additional detail below, the subspace identifier 150 may be configured to identify signal subspaces and/or null subspace(s) in the cell.

In embodiments, an antenna port may be perceived by a UE 110 over the air interface between the UE 110 and the eNB 105. In embodiments, one antenna port may be associated with one set of channel training symbols, for example the CSI-RS as described above. As will be described in further detail below, the UE 110 may measure the channel response of one or multiple antenna ports to generate feedback or make decisions. For

example, the UE 110 may measure the received power of antenna port 0 during a handover situation.

Therefore, in embodiments an antenna port may be the air interface perceived by UE 110. In embodiments herein, each antenna port may be formed by the eNB 105 using one or more (or all) antenna elements 135, with a beamforming weight assigned to each antenna element. In some embodiments, each antenna port may be associated with a set of beamforming weights, as described in further detail below. In embodiments described as examples below, the eNB 105 may form eight antenna ports using eight sets of weights, i.e. eight beamforming vectors. The eNB 105 may then let UEs in the cell know how the antenna ports are configured such that the UE can identify the resource in frequency and time allocated for the port.

In some embodiments, the eNB 105 may include a directional antenna with a narrow downtilt angle that uses multiple antenna elements with relatively fixed or constant beamforming weights. In the present disclosure, this directional antenna may be considered a single antenna element of the antenna elements 135 because the beamforming weights of the different antenna elements of the directional antenna may remain constant. Specifically, one or more of the antenna elements 135 may be omni-directional or unidirectional, and a directional antenna element of the antenna elements 135 may be physically implemented using multiple antenna elements with constant antenna weights.

Figure 2 depicts an example of a network 200 including an eNB 205, which may be similar to eNB 105, and UEs 210, 215, and 220, which may be similar to UE 110. Some of the UEs, for example UEs 210 and 220, may only include a single antenna element, while other UEs such as UE 215 may include two or more antenna elements. As can be seen, the eNB 205 may include a plurality of antenna elements 225 configured to transmit signals to, or receive signals from, UEs 210, 215, and 220. In the embodiment shown in Figure 2, the plurality of antenna elements 225 may include a first antenna element 230 through a sixteenth antenna element 235. In other embodiments, the eNB 205 may have more or less antenna elements in the plurality of antenna elements 225.

As used herein, "spaces" may refer to the vector spaces spanned by the antenna ports. For example, eNB 205 may have 16 antennas element in the plurality of antenna elements. If one antenna port is assigned to each antenna element in the plurality of antenna elements 225, then 16 antenna ports may be perceived by UEs 210, 215, and 220, and the dimension of the whole space may be 16. The 16 antenna ports may form a 16 by

1 vector space in linear algebra. The signal subspace may then be the "location" of the UEs in the whole space.

For example, the vector channel from the 16 antenna elements at the eNB to UE 210 may be denoted as $a = \begin{bmatrix} a_1 \\ \vdots \\ a_{16} \end{bmatrix}$, where a_i represents the channel response from the *i*th antenna element in the plurality of antenna elements 225 of eNB 205 to the receive antenna element of the UE 210. Similarly, the UE 215 may be equipped with two receive antenna elements and have two vector channels $b = \begin{bmatrix} b_1 \\ \vdots \\ b_{16} \end{bmatrix}$ and $c = \begin{bmatrix} c_1 \\ \vdots \\ c_{16} \end{bmatrix}$; and the UE 220 may have a vector channel $d = \begin{bmatrix} d_1 \\ \vdots \\ d_{16} \end{bmatrix}$. Because UE 215 has multiple vector channels, UE215 may have a matrix channel $\begin{bmatrix} b_1 & c_1 \\ \vdots & \vdots \\ b_{16} & c_{16} \end{bmatrix}$.

The signal subspace may be computed as follows as an example. Let the aggregated channel matrix of the active vector channels be $H = \begin{bmatrix} a_1 & b_1 & c_1 & d_1 \\ \vdots & \vdots & \vdots & \vdots \\ a_{16} & b_{16} & c_{16} & d_{16} \end{bmatrix}^T$. Let the singular value decomposition (SVD) of H be $H = U \begin{bmatrix} \sigma_1 & & & \\ & \sigma_2 & & \\ & & \sigma_3 & \\ & & & \sigma_4 \end{bmatrix} [v_1 \quad v_2 \quad v_3 \quad v_4]^H$, where σ_i represents the singular value of the ith eigen-mode; v_i is the corresponding beamforming vector of *i*th eigen-mode; and v_i is a 16 by 1 vector with complex values.

In this embodiment, the singular values may be ordered. Specifically, σ_i may be greater than or equal to σ_j for any $i < j$. If the eNB 205 is attempting to send a relatively high amount of signal to the aggregated UE side, which in this example may consist of the antenna elements of all three of the UEs 210, 215, and 220, using one antenna beam or one beamforming vector, then v_1 may be the beamforming vector because it corresponds to the largest singular value σ_1.

For this example, the dimension of the whole space may be 16 because there are 16 antenna elements in the plurality of antenna elements 225 of the eNB 200 and correspondingly 16 linearly independent channels to the receive antenna elements of each UE 210, 215, and 220. If the eNB 205 is configured to only use one antenna port for

channel training, then in this embodiment the eNB 205 may use the beamforming vector (or weight) v_1 for the antenna port. Namely, the *i*th entry of v_1 may be the beamforming weight for the *i*th antenna element of the eNB 205. Using v_1, the three UEs 210, 215, and 220 may receive the greatest amount of signal energy from the eNB 220 in total. Because in this example there may only be one beamformed signal, the three UEs 210, 215, and 220 may have to time share the beam. Similarly, if the eNB 205 is configured to use two antenna ports, then v_1 and v_2 or the linear combination of the two can be used as beamforming vectors for the two antenna ports for channel training.

The linear space spanned by vectors v_1 and v_2 within the whole space may be referred to as "subspace" or "signal subspace." If the eNB 205 sends two data streams over two beams, then there may exist two beamforming vectors within the signal subspace that can send the most energy to the aggregated UE side consisting of UEs 210, 215, and 220. The linear space within the whole space that is spanned by all the vectors orthogonal to the vectors in the signal subspace may be referred to as the null space (of the signal subspace). In this example, if eNB 205 uses two antenna ports, then the signal subspace may be spanned by v_1 and v_2 and any beamforming vectors orthogonal to v_1 and v_2 may be in the null space that may have 16-2=14 orthogonal vectors or dimensions. In other words, the null space may depend on the selection of the signal subspace. Note that in the example above v_3 and v_4 may be in the null space of v_1 and v_2 even though v_3 and v_4 may send energy to the aggregated UE side.

In the example above, the signal subspace is described with respect to beamforming vectors v_1 and v_2. However, as noted above in other embodiments the signal subspace may be described with respect to linear combinations of beamforming vectors v_1 and v_2. Specifically, as noted above beamforming vector v_1 may deliver the greatest amount of signal energy to UEs 210, 215, and 220. Beamforming vector v_2 may deliver the next greatest amount of signal energy to UEs 210, 215, and 220. In some embodiments, it may be desirable for one or more of UEs 210, 215, and 220 to perceive a relatively equal amount of signal energy from beamforming vectors v_1 and v_2. Therefore, in some embodiments beamforming vectors v_1 and v_2 may be added or subtracted from one another to produce one or more alternative beamforming vectors which may still be within the signal subspace defined by beamforming vectors v_1 and v_2, but produce a relatively equal amount of signal energy at one or more of UEs 210, 215, and 220.

Figure 3 depicts an example process 300 for identifying signal subspaces within a cell, and beamforming the channel training signal to the signal subspaces. Initially, the

signal subspace(s) may be identified at 300. In embodiments, and as described above, a signal subspace may be identified at 300 based on previous feedback(s) from the UEs 210, 215, and 220. Specifically, the eNB such as eNB 205 may transmit a pilot signal using each possible beamforming vector in the space. Each UE, for examples UEs 210, 215, and 220, may calculate the channel response of each beamforming vector as seen by the UE. The UE may then quantize the channel responses of all received beamforming vectors using vector or scalar quantization. To continue the example above with reference to Figure 2, four beamforming vectors (v_1, v_2, v_3, and v_4) may be selected by the eNB 205. Four pilot signals, one for each beamforming vector, may be transmitted from the eNB. If the UE has one receive antenna element, for example UEs 210 or 220, the channel response, which may indicate the received signal power of each beamformed pilot signal, of the eNB's four antenna ports may be a 4 by 1 vector with complex entries. The UE may then quantizes the 4 by 1 vector jointly using vector quantization i.e. codebook quantization. The index of the quantization codeword may then be fed back to the eNB.

If the UE has *m* receive antenna elements, for example UE 215 with two receive antenna elements, then the channel response of the four antenna ports may be a 4 by *m* matrix. The UE may select a desirable *k*-dimensional subspace of the 4 by *m* matrix, for example by using SVD. In embodiments, *k* may represent the number of spatial streams or rank that the UE desires. This *k*-dimensional subspace may in some embodiments be the best *k*-dimensional subspace, and may be based on the UE stepping through the available numbers of spatial streams for identifying the spatial stream that may maximize the throughput of the signal received by the UE from the eNB. The selected *k*-dimensional subspace may be quantized to produce a quantization index, and the quantization index may be fed back to the eNB. Additionally or alternatively, the eNB may be able to identify feedback information based on, for example, downlink or uplink sounding in time-division duplexing (TDD) mode. In some embodiments the feedback may be part of or associated with a rank indicator and/or precoding matrix indicator transmission of each UE.

In some embodiments the feedback may be based on an averaging function, a summation function, or some other mathematical function performed by the UE on a pilot or beamformed signal received from the eNB. As will be explained in greater detail below, in some embodiments the signal subspace may change based on changing conditions in the cell. Therefore, it may be desirable for the fedback information from the UE to be based only on one or more signals in a given time period such as a frame, a subframe, a plurality of frames, or some other time period in which the signal subspace is constant. Otherwise,

an averaging or summation function that spans a plurality of different signal subspaces may not be accurate.The combination of vectors received from the plurality of UEs may be used by the eNB to build the aggregated channel matrix *H* described above with respect to Figure 2.

The principal signal subspaces may be identified as corresponding to large singular values in the singular value decomposition of the fedback beamforming vectors. Specifically, as described above, the signal subspace may be identified as the signal subspace formed by the beamforming vectors that are capable of delivering the most signal power from the eNB to the UEs. A set of beamforming vectors that sufficiently covers the selected signal subspace may then be identified for additional transmissions of channel training signals from the eNB to the one or more UEs. In embodiments, each beamforming vector may be used for beamforming one channel training signal, for example a CSI-RS signal, using a given antenna port. In some embodiments, the beamforming vectors may or may not be orthogonal to one another. In some embodiments, set selection may be designed for feedback accuracy, a given feedback codebook, or based on the detection of channel variation.

Concurrently with, or subsequent to, the identification of the signal subspace at 300, the null subspace may be identified based on the singular value decomposition of the matrix formed by the fed back beamforming vectors received at the eNB from the UE. Specifically, the null subspace may be identified based on low singular values in the singular value decomposition formed by the fed back beamforming vectors received at the eNB from the UEs. Specifically, the null subspaces may correspond to beamforming vectors that produce relatively low signal power at the UEs. The eNB may then beamform one or more channel training signals, for example the CSI-RS, to the signal subspace at 310.

In some embodiments, after the signal subspace is identified at 300 and the null subspace is identified at 305, the strength of signals beamformed to the signal subspace may change. Specifically, a beamforming vector that produces a relatively high amount of signal energy at the UEs in the cell may instead begin to produce a relatively low amount of signal energy at the UEs. This may occur, for example, if a UE such as a mobile phone, personal digital assistant (PDA), laptop, or some other type of UE moves. Additionally or alternatively, the cell may experience a change in signal reflection, propagation, or interference. Based on this change in the strength of beamforming vectors, it may be desirable for the eNB to track variation in the channel or the cell. Specifically, UEs may

continuously provide feedback to the eNB, and it may be useful for the eNB to be able to dynamically modify this change in signal conditions in the cell based on the feedback from the UEs.

If the channel variation of a UE is within the signal subspace spanned by the current set of channel training signals, then the normal channel feedback procedures may be able to identify this change in the signal subspace. However, if a beamforming vector in the null subspace increases in strength, for example above the strength of a beamforming vector in the signal subspace, then there may be no feedback information from a UE that indicates this change in the beamforming vector of the null subspace because if the eNB is only beamforming signals to the signal subspace, then there may be no transmissions to the entire null subspace, or certain portions of the null subspace, by which the UE can feedback information to the eNB with regards to beamforming vectors in the null subspace.

In some embodiments it may therefore be desirable to identify whether the beamforming vectors of the signal subspace and the null subspace have changed. Therefore, in some embodiments, the eNB may receive an indication from a UE of a relatively high received signal strength of a beamforming vector in the null subspace at 315. Specifically, the eNB may occasionally beamform one or more channel training signals to the null subspace, and then analyze the singular values in the singular value decomposition formed by the fed back beamforming vectors received at the eNB from the UEs, as will be described in greater detail below. In some embodiments, because channel variation may usually be slow, the eNB may give processing priority to the beamforming feedback related to the signal subspace. Therefore, the channel training signals transmitted to the null subspace, for example by beamforming, may time share a single or a relatively low number of antenna ports so that the overhead that may result from the transmission of the channel training signals is reduced.

Based on the tracking the variation in the cell at 315, if the eNB receives feedback from one or more UEs that a transmission of a channel training signal using a beamforming vector in the null subspace has greater energy than a channel training signal beamformed using a beamforming vector in the signal subspace, then the eNB may identify the beamforming vector in the null subspace as part of the signal subspace at 320. The eNB may then return to beamforming the channel training signals in the signal subspace at 310.

To illustrate the process depicted in Figure 3 in more detail, the following specific

example may be useful. It will be understood that the following is merely an example and in other embodiments other values, equations, variables, or processes may be used. Generally, during the initial training phase, an eNB such as eNB 205 may receive feedback from one or more UEs in the cell. Based on that feedback, the signal subspace, which may contain almost all of the signal energy of the fed-back signals, and the null subspaces, which may contain a low amount or no signal energy of the fed-back signals, may be calculated at 300 and 305, respectively. The calculated information may then be used to configure future downlink training and reduce the signaling overhead by scanning the signal subspace for information from UEs with greater frequency than the null subspaces, as described above.

Initially, the variable k may represent the kth UE in a cell. t may represent a given orthogonal frequency division multiplexing (OFDM) symbol, and n may represent a subcarrier in the channel. Using this notation, the channel from an eNB to the kth UE may be written as $H_k[n,t] = \sum_{m=1}^{M} h_{k,m}[n,t]e_m = \sum_{m=1}^{M} g_{k,m}[n,t]w_m$. H_k may be, for example, a 16x1 vector in cells where the eNB includes 16 antenna elements, and there is only a single UE, and it may represent the spatial signature from the eNB to the UE that is obtained through uplink feedback. M may be the dimensionality of the channel, i.e. the number of subspaces in the cell. $h_{k,m}[n,t]$ may be the estimated channel, i.e. the channel response, for the kth UE on a given subcarrier n in OFDM symbol t. e_m may be a vector equal to, for example (0, 0, . . ., 0, 1, 0, 0, . . ., 0) with the 1 in the mth position and zeroes elsewhere, and represent the unit vector pointing to the mth direction. $g_{k,m}[n,t]$ may represent the channel coefficient for the kth UE in the mth dimension in OFDM symbol t and subcarrier n. w_m my represent the unit norm vector for the mth dimension, i.e. the normalization weighting factor.

As noted above, M may represent the dimensionality of the channel, i.e. the total number of subspaces in the cell. It may be desirable to compress the channel and reduce the dimensionality from M to $D < M$. In other words, all of the subspaces in the cell may have a dimensionality M, and the signal subspace may have a dimensionality $D < M$. In order to reduce the dimensionality of the channel, it may be desirable to find the optimal basis $w_1, \ldots, w_m$ such that $g_{k,m}[n]$ is approximately equal to 0 when $m > D$. Then, for $d = 1, 2, \ldots, D$, coefficients $g_{k,m}[n,t]$ may be given by $g_{k,d}[n,t] = w_d^H H_k[n,t]$.

One result of reducing the dimensionality from M to $D < M$ may be that, instead of

utilizing M reference signals to estimate the channel in the original M-dimensional space and feeding back that information, the eNB may only employ D reference signals. By beamforming these reference signals with the weights $w_1, \ldots, w_D$, each UE may estimate the coefficient $g_{k,m}[n]$ directly and send that information to the eNB.

By allowing the UE to estimate the coefficient $g_{k,m}[n]$ directly, the overhead of transmitting the channel training signals may be reduced by a factor of D/M. Additionally, because UEs may not need to actually know the beamforming vectors used to generate the beamformed signals in order to receive the beamformed signals, the process of reducing the dimensionality of the channel from M to D may be completely transparent to the UEs. In other words, the UEs may not receive an indication that channel training signals are being beamformed only to the signal subspace rather than to the full space of the cell. However, as described in further detail below, in some embodiments it may be useful for one or more of the UEs to receive an antenna port configuration schedule from the eNB so that the UE is able to identify, for feedback purposes, when the subspace configuration may remain relatively constant.

After receiving the feedback from the UE, the eNB may identify the signal and null subspaces in the cell. Specifically, the channel covariance matrix may be estimated at the end of the qth training phase (that is, the qth time that the channel training signals are transmitted from the eNB) as

$$R_q \approx \frac{1}{KTN}\sum_{k=1}^{K}\sum_{t=(q-1)T+1}^{qT}\sum_{n=1}^{N}\left(\frac{\hat{H}_k[t,n]}{\left\|\hat{H}_k[t,n]\right\|}\right)\left(\frac{\hat{H}_k[t,n]}{\left\|\hat{H}_k[t,n]\right\|}\right)^{H} = U_q \Lambda_q U_q^{H}$$

where R_q is the channel covariance matrix in the qth training phase. T may be the length of the training period for sample covariance matrix calculations at the eNB in terms of OFDM symbols. $\hat{H}_k$ may be the estimated channel for the kth UE. K may be the total number of UEs in the cell. N may be the total number of subcarriers used by the eNB. Superscript H may represent the transpose conjugate mathematical operation. U_q may be an M x M unitary matrix, and Λ_q may be a diagonal matrix of eigenvalues $\lambda_{q,1}, \ldots, \lambda_{q,D}$. In general, $U_q \Lambda_q U_q^{H}$ may be referred to as the SVD of the matrix formed by the fedback beamforming vectors received by the eNB from the UEs, and the eigenvalues may be the singular value corresponding to each eigenvector direction. An eigenvector may be a specific example of a beamforming vector. In other words, the eigenvalues from $\lambda_{q,1}$ to $\lambda_{q,D}$ may represent the strength of the signal received from signals beamformed using beamforming vectors in the signal subspaces, and the eigenvalues $\lambda_{q,D+1}$ to $\lambda_{q,M}$ may represent the strength of the

signals, or lack thereof, received from signals beamformed using beamforming vectors in the null subspaces. Without loss of generality, it may be assumed that $\lambda_{q,1} \geq \ldots \geq \lambda_{q,D} \geq \lambda_{q,D+1}$ which may be approximately equal to λ_M, which may be approximately equal to 0. Therefore, the basis for each signal subspace in the D-dimensional channel may be $\{u_{q,1}, \ldots, u_{q,D}\}$ where $u_{q,D}$ is the dth column of the unitary matrix U_q, that is the eigenvector corresponding to the dth strongest eigenvalue. These strongest eigenvectors may now be used to beamform reference signals to the signal subspace at 310.

However, as mentioned before, the signal subspace may change and one or more beamforming vectors in the null subspace may produce a better channel response than one or more beamforming vectors in the signal subspace. In order to track these movements, and the resultant changes in the channel, it may be desirable to occasionally scan at 315 one or more null subspaces that are orthogonal to the D-dimension signal subspace to identify new beamforming vector or vectors with components in the null subspaces that produce a better channel response than one or more beamforming vectors in the signal subspace. Specifically, the new beamforming vector may include two components. The first component may be in the existing subspace spanned by one or more vectors of the signal subspace. The other component may be in the null space, and may be viewed as a correction or adjustment to the component in the existing subspace. In embodiments, the correction component may be smaller than the component in the signal subspace. Because the basis for each signal subspace in the D-dimensional channel may be $\{u_{q,1}, \ldots, u_{q,D}\}$, the basis for each null subspace in the M-dimensional channel may be $\{u_{q,D+1}, \ldots, u_{q,M}\}$.

In order to scan the null subspaces, the eNB may beamform D-r reference signals with $u_{q,1}, \ldots, u_{q,D-r}$ and the remaining r reference signals may be beamformed with r vectors selected from $u_{q,D-r+1}, \ldots, u_{q,M}$ in order to cover the null subspaces of the M-dimensional space. UEs that receive one or more of the r reference signals may estimate and quantize their channel direction in the new space as $\tilde{g}_{k,d}[n,t] = \frac{u_{q,d}^{H} H_k[n,t]}{\left\| u_{q,d}^{H} H_k[n,t] \right\|}$ where $d = 1, 2, \ldots, D$. The estimated and quantized channel direction may be transmitted from the UE to the eNB along with a channel quality indicator (CQI) transmission (which may represent a signal to interference plus noise ratio (SINR)) to the eNB. The eNB may reconstruct the channel direction in the original M dimensional space as $\tilde{H}_k[t,n] \approx \sqrt{SINR_k[t,n]} \sum_{d=1}^{D-1} \tilde{g}_{k,d}[n,t] u_{k,d}$ to identify the relative strength of signals

received in the null subspace at 315. Based on these reconstructed channel directions, the eNB may be able to identify one or more of the beamforming vectors in the null subspaces as part of the signal subspace at 320.

Results of a simulated test using one embodiment of the present disclosure are presented below in Tables 1 and 2. In these simulations, it was assumed that an eNB such as eNB 205 included 16 antenna elements with eight antenna ports. The first seven antenna ports were selected to transmit channel training signals to the signal subspace, while the eighth antenna port was selected to periodically beamform a channel training signal to the null subspace. Specifically, the transmissions of the first seven channel training signals were weighted with the seven eigenvectors corresponding to the seven strongest eigenvalues to produce beamformed channel training signals. These seven eigenvectors may be considered to be in the signal subspace. The seven beamformed channel training signals were then respectively transmitted using the first seven antenna ports of the eNB. The eighth port was selected to time share the nine remaining eigenvectors, i.e. the beamforming vectors in the null subspace, that were orthogonal to the seven eigenvectors used to produce the beamformed channel training signals. Every five to ten frames, the eNB would update the first seven beamforming vectors, while the eighth eigenvector for tracking would be updated more often for time sharing the single port. In other words, while the first seven antenna ports transmitted the beamformed seven channel training signals produced by the seven strongest eigenvectors in each frame, the eighth port would sequentially transmit beamformed channel training signals produced using the ninth through sixteenth eigenvectors one at a time in respective frames (i.e. through time sharing of the eighth port).

Tables 1 and 2, below, depict simulated sample results for a 4x4 antenna configuration and a 16x1 antenna configuration, respectively. Specifically, Tables 1 and 2 depict the average cell throughput in Megabits per second (Mbps) and cell edge user throughput in kilobits per second per UE (kbps/UE). Tables 1 and 2 depicts results for a baseline measurement where the process of Figure 3 is not performed, a subspace tracking (SS) process with scalar quantization wherein the channel direction is quantized by a scalar quantizer with 3 bits per real dimension, an SS singular value decomposition (SVD) process wherein the channel direction is obtained by SVD, and a frequency division (FD) zero-forcing beamforming (ZFBF) process based on the instantaneous values of the effective channel where no channel compression is performed.

	Average Cell Throughput (Mbps)	Cell edge User Throughput (kbps/UE)
Baseline	19.57	671
SS, Scalar Quant.	23.29	757
SS, SVD	26.43	810
FD ZFBF, SVD	27.41	852

Table 1: Simulation Results for 4x4 Antenna Configuration

	Average Cell Throughput (Mbps)	Cell edge User Throughput (kbps/UE)
Baseline	19.57	671
SS, Scalar Quant.	31.46	1130
SS, SVD	36.76	1283
FD ZFBF, SVD	44.81	1591

Table 2: Simulation Results for 16x1 Antenna Configuration

In some embodiments, the process described above with respect to Figures 2 and 3 may cause the channel training signals to vary with time. For example, the channel reference signal (CRS) and CSI-RS may be beamformed on a vector that may vary with time. Therefore, in embodiments it may be useful for the UE to know the time boundary when the beamforming vectors of the channel training signals transmitted from the eNB in the signal subspace change. By knowing this time boundary, the UE may avoid providing feedback to the eNB regarding an average of the channel training signal across two different periods with two differently beamformed channel training signals.

Specifically, as noted above in some embodiments the signal subspace may change based on variations in the cell, positions of the UEs in the cell, or other factors.

Additionally, as described above the signal subspace may be constructed based on information fedback from UEs in the cell. However, if the signal conditions in the cell are changing, then based on this feedback the beamforming vectors in the signal subspace and the null subspace may change.

As noted above, in some embodiments the feedback may be based on one or more averaging, summation or some other mathematical operations of a UE of signals received from the eNB. However, in some embodiments if the beamforming vectors in the signal subspace and null subspace change, then information averaged over the change in signal subspace may not be desirable. Therefore, it may be useful for the UEs in the cell to not perform averaging or other mathematical operations that span two different signal subspace configurations. Specifically, in some embodiments the signal subspace may change with each radio frame, radio subframe, or plurality of radio frames, or according to some other time period. Therefore, an averaging, summation, or other mathematical operation of a UE may be limited to only a single time period rather than a plurality of time periods.

Therefore, in some embodiments the eNB may transmit an antenna port configuration schedule to one or more UEs. In some embodiments, the eNB may beamform the antenna port configuration schedule to one or more of the UEs, while in other embodiments the eNB may omnicast the antenna port configuration schedule to UEs in the cell. In some embodiments, the antenna port configuration schedule may include one or more of a start time at which the signal subspace configuration may remain constant, a duration at which the signal subspace configuration may remain constant, and/or an end time at which the signal subspace configuration may remain constant. In some embodiments the antenna port configuration schedule may be demarcated according to specific times, while in other embodiments the antenna port configuration schedule may indicate one or more known periods such as radio frames, subframes, etc. In some embodiments, the antenna port configuration schedule may include one or more of a start time at which the antenna port for the null space configuration may remain constant, a duration at which the null space configuration may remain constant, and/or an end time at which the null space may remain constant. In addition, the configuration information about how the large null space is stepped through by a small number of antenna ports may be sent by the eNB. By knowing the port scheduling of the null space, the UE may not average signals across two differently beamformed ports for the null space.

Embodiments of the present disclosure may be implemented into a system using

any suitable hardware and/or software to configure as desired. Figure 4 schematically illustrates an example system 400 that may be used to practice various embodiments described herein. Figure 4 illustrates, for one embodiment, an example system 400 having one or more processor(s) 405, system control module 410 coupled to at least one of the processor(s) 405, system memory 415 coupled to system control module 410, non-volatile memory (NVM)/storage 420 coupled to system control module 410, and one or more communications interface(s) 425 coupled to system control module 410.

In some embodiments, the system 400 may be capable of functioning as the UEs 110, 210, 215, or 220 as described herein. In other embodiments, the system 400 may be capable of functioning as the eNB 105 or 205 depicted in Figures 1 or 2 or any one of the other described embodiments. In some embodiments, the system 400 may include one or more computer-readable media (e.g., system memory or NVM/storage 420) having instructions and one or more processors (e.g., processor(s) 405) coupled with the one or more computer-readable media and configured to execute the instructions to implement a module to perform actions described herein.

System control module 410 for one embodiment may include any suitable interface controllers to provide for any suitable interface to at least one of the processor(s) 405 and/or to any suitable device or component in communication with system control module 410.

System control module 410 may include memory controller module 430 to provide an interface to system memory 415. The memory controller module 430 may be a hardware module, a software module, and/or a firmware module.

System memory 415 may be used to load and store data and/or instructions, for example, for system 400. System memory 415 for one embodiment may include any suitable volatile memory, such as suitable DRAM, for example. In some embodiments, the system memory 415 may include double data rate type four synchronous dynamic random-access memory (DDR4 SDRAM).

System control module 410 for one embodiment may include one or more input/output (I/O) controller(s) to provide an interface to NVM/storage 420 and communications interface(s) 425.

The NVM/storage 420 may be used to store data and/or instructions, for example. NVM/storage 420 may include any suitable non-volatile memory, such as flash memory, for example, and/or may include any suitable non-volatile storage device(s), such as one or more hard disk drive(s) (HDD(s)), one or more compact disc (CD) drive(s), and/or one or

more digital versatile disc (DVD) drive(s), for example.

The NVM/storage 420 may include a storage resource physically part of a device on which the system 400 may be installed or it may be accessible by, but not necessarily a part of, the device. For example, the NVM/storage 420 may be accessed over a network via the communications interface(s) 525.

Communications interface(s) 425 may provide an interface for system 400 to communicate over one or more network(s) and/or with any other suitable device. The system 400 may wirelessly communicate with the one or more components of the wireless network in accordance with any of one or more wireless network standards and/or protocols. In some embodiments the communications interface(s) 425 may include the transceiver module 140 and/or subspace identifier 150 of Figure 1.

For one embodiment, at least one of the processor(s) 405 may be packaged together with logic for one or more controller(s) of system control module 410, e.g., memory controller module 430. For one embodiment, at least one of the processor(s) 405 may be packaged together with logic for one or more controllers of system control module 410 to form a System in Package (SiP). For one embodiment, at least one of the processor(s) 405 may be integrated on the same die with logic for one or more controller(s) of system control module 410. For one embodiment, at least one of the processor(s) 405 may be integrated on the same die with logic for one or more controller(s) of system control module 410 to form a System on Chip (SoC).

In some embodiments the processor(s) 405 may include or otherwise be coupled with one or more of a graphics processor (GPU) (not shown), a digital signal processor (DSP) (not shown), wireless modem (not shown), digital camera or multimedia circuitry (not shown), sensor circuitry (not shown), display circuitry (not shown), and/or GPS circuitry (not shown).

In various embodiments, the system 400 may be, but is not limited to, a server, a workstation, a desktop computing device, or a mobile computing device (e.g., a laptop computing device, a handheld computing device, a tablet, a netbook, a smart phone, a gaming console, etc.). In various embodiments, the system 400 may have more or less components, and/or different architectures. For example, in some embodiments, the system 400 includes one or more of a camera, a keyboard, liquid crystal display (LCD) screen (including touch screen displays), non-volatile memory port, multiple antenna elements, graphics chip, application-specific integrated circuit (ASIC), and speakers.

Methods and apparatuses are provided herein for Example 1 may include an eNodeB (eNB) comprising: a plurality of antenna ports with a plurality of antenna elements; subspace identification circuitry coupled with the plurality of antenna elements, the subspace identification circuitry to: identify, based on feedback information, a plurality of beamforming weights for one or multiple antenna ports wherein a number of the antenna ports is less than a number of the plurality of antenna elements; and assign a beamforming weight in the plurality of beamforming weights to an antenna in the plurality of antenna elements; and transmitter circuitry coupled with the subspace identification circuitry, the transmitter circuitry to: beamform a channel training signal allocated for the antenna port with the beamforming weights; and transmit an antenna port configuration schedule from the plurality of antennas.

Example 2 may include the eNB of example 1, wherein the feedback information is based on downlink sounding, or uplink sounding, or a signal received from a user equipment (UE).

Example 3 may include the eNB of example 1, wherein the antenna port configuration schedule includes an indication of a time period where the beamforming weights will not change.

Example 4 may include the eNB of any of examples 1-3, wherein: the feedback information includes a first indication of a magnitude or phase of a first received signal of a first beamformed signal produced with a first beamforming vector and a second indication of a magnitude or phase of a second received signal of a second beamformed signal produced with a second beamforming vector; the subspace identification circuitry is further to identify a signal subspace that substantially includes the first beamforming vector based at least in part on the first indication, and a null subspace that substantially includes the second beamforming vector based at least in part on the second indication; and the transmitter circuitry is further to beamform the channel training signal to the signal subspace.

Example 5 may include the eNB of example 4, wherein the first received signal energy is higher than the second received signal energy.

Example 6 may include the eNB of example 4, wherein the channel training signal is a first channel training signal and the transmitter circuitry is further to beamform a second channel training signal to only a portion of the null subspace.

Example 7 may include the eNB of example 6, further comprising receiver circuitry coupled with the transmitter circuitry, the receiver circuitry to receive, in

response to the transmission of the additional training signal in the null subspace, a second feedback that includes a third indication of a magnitude or phase of a third received signal of a third beamformed signal produced with a third beamforming vector in the null subspace.

Example 8 may include the eNB of example 6, wherein the signal subspace is a first signal subspace and the subspace identification circuitry is further to identify a second signal subspace based at least in part on the third indication, wherein the second signal subspace includes the third beamforming vector.

Example 9 may include a method comprising: identifying, by an eNodeB (eNB), a first signal subspace in a space based at least in part on a first indication of a magnitude or a phase of a first received signal of a first beamforming signal using a first beamforming vector in the first signal subspace, the first signal subspace substantially including the first beamforming vector; identifying, by the eNB, a null subspace in the space based at least in part on a second indication of a magnitude or a phase of a second received signal of a second beamforming signal using a second beamforming vector in the null subspace, the null subspace substantially including the second beamforming vector; and beamforming, from an antenna port of the eNB, a channel training signal to the first signal subspace.

Example 10 may include the method of example 9, further comprising: receiving, by the eNB after the beamforming of the channel training signal, a third indication of a magnitude or a phase of a third received signal of a third beamforming signal using a third beamforming vector in the null subspace, the null subspace including a third beamforming vector; and identifying, by the eNB, a second signal subspace based at least in part on the third indication, the second signal subspace including the third beamforming vector.

Example 11 may include the method of example 10, wherein the channel training signal is a first channel training signal and the third indication is based at least in part on beamforming, by the eNB, a second channel training signal to at least a portion of the null subspace.

Example 12 may include the method of example 9, wherein the first signal subspace is based at least in part on a singular value decomposition of the first indication.

Example 13 may include the method of example 9, wherein the first received signal strength is greater than the second received signal strength.

Example 14 may include the method of any of examples 9-13, wherein the first indication, second indication, and third indication are received by the eNB from a user equipment (UE).

Example 15 may include the method of any of examples 9-13, wherein the antenna port includes a plurality of antenna elements of the eNB.

Example 16 may include the method of any of examples 9-13, wherein the channel training signal is a channel state information-reference signal (CSI-RS) signal.

Example 17 may include one or more computer readable media comprising instructions which, when executed by one or more processors of an eNodeB (eNB), cause the eNB to: identify a first signal subspace in a space based at least in part on a first indication of a magnitude or a phase of a first received signal of a first beamforming signal using a first beamforming vector in the signal subspace, the first signal subspace substantially including a first beamforming vector; identify a null subspace in the space based at least in part on a second indication of a magnitude or a phase of a second received signal of a second beamforming signal using a second beamforming vector in the null subspace, the null subspace substantially including the second beamforming vector; and beamform a channel training signal to the first signal subspace.

Example 18 may include the one or more computer readable media of example 17, further comprising instructions to: obtain, after the beamform of the channel training signal, a third indication of a magnitude or a phase of a third received signal of a third beamforming signal using a third beamforming vector in the null subspace, the null subspace including a third beamforming vector; and identify a second signal subspace based at least in part on the third indication, the second signal subspace including the third beamforming vector.

Example 19 may include the one or more computer readable media of examples 17 or 18, wherein the first received signal strength is greater than the second received signal strength.

Example 20 may include an eNodeB comprising: the one or more computer readable media of any of examples 17-19; and one or more processors coupled with the one or more computer-readable media and configured to execute the instructions.

Example 21 may include a method comprising: identifying, by an eNodeB (eNB) based on feedback information, a plurality of beamforming weights for one or multiple antenna ports, wherein the one or multiple antenna ports have a plurality of antenna elements, and a number of the antenna ports is less than a number of the plurality of antenna elements; assigning, by the eNB, a beamforming weight in the plurality of beamforming weights to an antenna in the plurality of antenna elements; beamforming, from the eNB, a channel training signal allocated for the antenna port with the

beamforming weights; and transmitting, from the eNB, an antenna port configuration schedule from the plurality of antennas.

Example 22 may include the method of example 21, wherein the feedback information is based on downlink sounding, or uplink sounding, or a signal received from a user equipment (UE).

Example 23 may include the method of example 21, wherein the antenna port configuration schedule includes an indication of a time period where the beamforming weights will not change.

Example 24 may include the method of any of examples 21-23, wherein the feedback information includes a first indication of a magnitude or phase of a first received signal of a first beamformed signal produced with a first beamforming vector and a second indication of a magnitude or phase of a second received signal of a second beamformed signal produced with a second beamforming vector and the method further comprises: identifying, by the eNB, a signal subspace that substantially includes the first beamforming vector based at least in part on the first indication, and a null subspace that substantially includes the second beamforming vector based at least in part on the second indication; and beamforming, from the eNB, the channel training signal to the signal subspace.

Example 25 may include the method of example 24, wherein the first received signal energy is higher than the second received signal energy.

Example 26 may include the method of example 24, wherein the channel training signal is a first channel training signal and the method further comprises beamforming, from the eNB, a second channel training signal to only a portion of the null subspace.

Example 27 may include the method of example 26, further comprising receiving, by the eNB and in response to the transmission of the additional training signal in the null subspace, a second feedback that includes a third indication of a magnitude or phase of a third received signal of a third beamformed signal produced with a third beamforming vector in the null subspace.

Example 28 may include the method of example 26, wherein the signal subspace is a first signal subspace and the method further comprising identifying, by the eNB, a second signal subspace based at least in part on the third indication, wherein the second signal subspace includes the third beamforming vector.

Example 29 may include an apparatus comprising: means to identify, based on feedback information, a plurality of beamforming weights for one or multiple antenna

ports, wherein the one or multiple antenna ports have a plurality of antenna elements, and a number of the antenna ports is less than a number of the plurality of antenna elements; means to assign a beamforming weight in the plurality of beamforming weights to an antenna in the plurality of antenna elements; means to beamform a channel training signal allocated for the antenna port with the beamforming weights; and means to transmit an antenna port configuration schedule from the plurality of antennas.

Example 30 may include the apparatus of example 29, wherein the feedback information is based on downlink sounding, or uplink sounding, or a signal received from a user equipment (UE).

Example 31 may include the apparatus of example 29, wherein the antenna port configuration schedule includes an indication of a time period where the beamforming weights will not change.

Example 32 may include the apparatus of any of examples 29-31, wherein the feedback information includes a first indication of a magnitude or phase of a first received signal of a first beamformed signal produced with a first beamforming vector and a second indication of a magnitude or phase of a second received signal of a second beamformed signal produced with a second beamforming vector and the apparatus further comprises: means to identify a signal subspace that substantially includes the first beamforming vector based at least in part on the first indication, and a null subspace that substantially includes the second beamforming vector based at least in part on the second indication; and means to beamform the channel training signal to the signal subspace.

Example 33 may include the apparatus of example 32, wherein the first received signal energy is higher than the second received signal energy.

Example 34 may include the apparatus of example 32, wherein the channel training signal is a first channel training signal and the apparatus further comprises means to beamform a second channel training signal to only a portion of the null subspace.

Example 35 may include the apparatus of example 34, further comprising means to receive, in response to the transmission of the additional training signal in the null subspace, a second feedback that includes a third indication of a magnitude or phase of a third received signal of a third beamformed signal produced with a third beamforming vector in the null subspace.

Example 36 may include the apparatus of example 34, wherein the signal subspace is a first signal subspace and the apparatus further comprises means to identify a second

signal subspace based at least in part on the third indication, wherein the second signal subspace includes the third beamforming vector.

Example 37 may include one or more computer readable media comprising instructions configured, upon execution of the instructions by a processor, to: identify, based on feedback information, a plurality of beamforming weights for one or multiple antenna ports, wherein the one or multiple antenna ports have a plurality of antenna elements, and a number of the antenna ports is less than a number of the plurality of antenna elements; assign a beamforming weight in the plurality of beamforming weights to an antenna in the plurality of antenna elements; beamform a channel training signal allocated for the antenna port with the beamforming weights; and transmit an antenna port configuration schedule from the plurality of antennas.

Example 38 may include the one or more computer readable media of example 37, wherein the feedback information is based on downlink sounding, or uplink sounding, or a signal received from a user equipment (UE).

Example 39 may include the one or more computer readable media of example 37, wherein the antenna port configuration schedule includes an indication of a time period where the beamforming weights will not change.

Example 40 may include the one or more computer readable media of any of examples 37-39, wherein the feedback information includes a first indication of a magnitude or phase of a first received signal of a first beamformed signal produced with a first beamforming vector and a second indication of a magnitude or phase of a second received signal of a second beamformed signal produced with a second beamforming vector and further comprising instructions to: identify a signal subspace that substantially includes the first beamforming vector based at least in part on the first indication, and a null subspace that substantially includes the second beamforming vector based at least in part on the second indication; and beamform the channel training signal to the signal subspace.

Example 41 may include the one or more computer readable media of example 40, wherein the first received signal energy is higher than the second received signal energy.

Example 42 may include the one or more computer readable media of example 40, wherein the channel training signal is a first channel training signal and further comprising instructions to beamform a second channel training signal to only a portion of the null subspace.

Example 43 may include the one or more computer readable media of example 42, further comprising instructions to receive, in response to the transmission of the additional training signal in the null subspace, a second feedback that includes a third indication of a magnitude or phase of a third received signal of a third beamformed signal produced with a third beamforming vector in the null subspace.

Example 44 may include the one or more computer readable media of example 42, wherein the signal subspace is a first signal subspace and further comprising instructions to identify a second signal subspace based at least in part on the third indication, wherein the second signal subspace includes the third beamforming vector.

Example 45 may include an apparatus comprising: means to identify a first signal subspace in a space based at least in part on a first indication of a magnitude or a phase of a first received signal of a first beamforming signal using a first beamforming vector in the first signal subspace, the first signal subspace substantially including the first beamforming vector; means to identify a null subspace in the space based at least in part on a second indication of a magnitude or a phase of a second received signal of a second beamforming signal using a second beamforming vector in the null subspace, the null subspace substantially including the second beamforming vector; and means to beamform, from an antenna port, a channel training signal to the first signal subspace.

Example 46 may include the apparatus of example 45, further comprising: means to receive, after the beamforming of the channel training signal, a third indication of a magnitude or a phase of a third received signal of a third beamforming signal using a third beamforming vector in the null subspace, the null subspace including a third beamforming vector; and means to identify a second signal subspace based at least in part on the third indication, the second signal subspace including the third beamforming vector.

Example 47 may include the apparatus of example 46, wherein the channel training signal is a first channel training signal and the third indication is based at least in part on a beamforming, by the eNB, of a second channel training signal to at least a portion of the null subspace.

Example 48 may include the apparatus of example 45, wherein the first signal subspace is based at least in part on a singular value decomposition of the first indication.

Example 49 may include the apparatus of example 45, wherein the first received signal strength is greater than the second received signal strength.

Example 50 may include the apparatus of any of examples 45-49, wherein the first indication, second indication, and third indication are received from a user equipment (UE).

Example 51 may include the apparatus of any of examples 45-49, wherein the antenna port includes a plurality of antenna elements of the eNB.

Example 52 may include the apparatus of any of examples 45-49, wherein the channel training signal is a channel state information-reference signal (CSI-RS) signal.

Example 53 may include an eNode B (eNB) comprising: subspace identification circuitry to: identify a first signal subspace in a space based at least in part on a first indication of a magnitude or a phase of a first received signal of a first beamforming signal using a first beamforming vector in the first signal subspace, the first signal subspace substantially including the first beamforming vector; and identify a null subspace in the space based at least in part on a second indication of a magnitude or a phase of a second received signal of a second beamforming signal using a second beamforming vector in the null subspace, the null subspace substantially including the second beamforming vector; and transmitter circuitry coupled with the subspace identification circuitry, the transmitter circuitry to beamform, from an antenna port of the eNB, a channel training signal to the first signal subspace.

Example 54 may include the eNB of example 53, further comprising: receiver circuitry coupled with the transmitter circuitry, the receiver circuitry to receive, after the beamforming of the channel training signal, a third indication of a magnitude or a phase of a third received signal of a third beamforming signal using a third beamforming vector in the null subspace, the null subspace including a third beamforming vector; and the subspace identification circuitry is further to identify a second signal subspace based at least in part on the third indication, the second signal subspace including the third beamforming vector.

Example 55 may include the eNB of example 54, wherein the channel training signal is a first channel training signal and the third indication is based at least in part on a beamforming, by the eNB, of a second channel training signal to at least a portion of the null subspace.

Example 56 may include the eNB of example 53, wherein the first signal subspace is based at least in part on a singular value decomposition of the first indication.

Example 57 may include the eNB of example 53, wherein the first received signal strength is greater than the second received signal strength.

Example 58 may include the eNB of any of examples 53-57, wherein the first indication, second indication, and third indication are received from a user equipment (UE).

Example 59 may include the eNB of any of examples 53-57, wherein the antenna port includes a plurality of antenna elements of the eNB.

Example 60 may include the eNB of any of examples 53-57, wherein the channel training signal is a channel state information-reference signal (CSI-RS) signal.

Although certain embodiments have been illustrated and described herein for purposes of description, this application is intended to cover any adaptations or variations of the embodiments discussed herein. Therefore, it is manifestly intended that embodiments described herein be limited only by the claims.

Where the disclosure recites "a" or "a first" element or the equivalent thereof, such disclosure includes one or more such elements, neither requiring nor excluding two or more such elements. Further, ordinal indicators (e.g., first, second or third) for identified elements are used to distinguish between the elements, and do not indicate or imply a required or limited number of such elements, nor do they indicate a particular position or order of such elements unless otherwise specifically stated.

Claims

What is claimed is:

1. An eNodeB (eNB) comprising:

a plurality of antenna ports with a plurality of antenna elements;

subspace identification circuitry coupled with the plurality of antenna elements, the subspace identification circuitry to:

identify, based on feedback information, a plurality of beamforming weights for one or multiple antenna ports wherein a number of the antenna ports is less than a number of the plurality of antenna elements; and

assign a beamforming weight in the plurality of beamforming weights to an antenna in the plurality of antenna elements; and

transmitter circuitry coupled with the subspace identification circuitry, the transmitter circuitry to:

beamform a channel training signal allocated for the antenna port with the beamforming weights; and

transmit an antenna port configuration schedule from the plurality of antennas.

2. The eNB of claim 1, wherein the feedback information is based on downlink sounding, or uplink sounding, or a signal received from a user equipment (UE).

3. The eNB of claim 1, wherein the antenna port configuration schedule includes an indication of a time period where the beamforming weights will not change.

4. The eNB of any of claims 1-3, wherein:

the feedback information includes a first indication of a magnitude or phase of a first received signal of a first beamformed signal produced with a first beamforming vector and a second indication of a magnitude or phase of a second received signal of a second beamformed signal produced with a second beamforming vector;

the subspace identification circuitry is further to identify a signal subspace that substantially includes the first beamforming vector based at least in part on the first indication, and a null subspace that substantially includes the second beamforming vector based at least in part on the second indication; and

the transmitter circuitry is further to beamform the channel training signal to the signal subspace.

5. The eNB of claim 4, wherein the first received signal energy is higher than the second received signal energy.

6. The eNB of claim 4, wherein the channel training signal is a first channel training signal and the transmitter circuitry is further to beamform a second channel training signal to only a portion of the null subspace.

7. The eNB of claim 6, further comprising receiver circuitry coupled with the transmitter circuitry, the receiver circuitry to receive, in response to the transmission of the additional training signal in the null subspace, a second feedback that includes a third indication of a magnitude or phase of a third received signal of a third beamformed signal produced with a third beamforming vector in the null subspace.

8. The eNB of claim 6, wherein the signal subspace is a first signal subspace and the subspace identification circuitry is further to identify a second signal subspace based at least in part on the third indication, wherein the second signal subspace includes the third beamforming vector.

9. A method comprising:

identifying, by an eNodeB (eNB), a first signal subspace in a space based at least in part on a first indication of a magnitude or a phase of a first received signal of a first beamforming signal using a first beamforming vector in the first signal subspace, the first signal subspace substantially including the first beamforming vector; and

identifying, by the eNB, a null subspace in the space based at least in part on a second indication of a magnitude or a phase of a second received signal of a second beamforming signal using a second beamforming vector in the null subspace, the null subspace substantially including the second beamforming vector; and

beamforming, from an antenna port of the eNB, a channel training signal to the first signal subspace.

10. The method of claim 9, further comprising:

receiving, by the eNB after the beamforming of the channel training signal, a third indication of a magnitude or a phase of a third received signal of a third beamforming signal using a third beamforming vector in the null subspace, the null subspace including a third beamforming vector; and

identifying, by the eNB, a second signal subspace based at least in part on the third indication, the second signal subspace including the third beamforming vector.

11. The method of claim 10, wherein the channel training signal is a first channel training signal and the third indication is based at least in part on beamforming, by the eNB, a second channel training signal to at least a portion of the null subspace.

12. The method of claim 9, wherein the first signal subspace is based at least in part on a singular value decomposition of the first indication.

13. The method of claim 9, wherein the first received signal strength is greater than the second received signal strength.

14. The method of any of claims 9-13, wherein the first indication, second indication, and third indication are received by the eNB from a user equipment (UE).

15. The method of any of claims 9-13, wherein the antenna port includes a plurality of antenna elements of the eNB.

16. The method of any of claims 9-13, wherein the channel training signal is a channel state information-reference signal (CSI-RS) signal.

17. One or more computer readable media comprising instructions which, when executed by one or more processors of an eNodeB (eNB), cause the eNB to:

identify a first signal subspace in a space based at least in part on a first indication of a magnitude or a phase of a first received signal of a first beamforming signal using a first beamforming vector in the signal subspace, the first signal subspace substantially including a first beamforming vector;

identify a null subspace in the space based at least in part on a second indication of a magnitude or a phase of a second received signal of a second beamforming signal using

a second beamforming vector in the null subspace, the null subspace substantially including the second beamforming vector; and

beamform a channel training signal to the first signal subspace.

18. The one or more computer readable media of claim 17, further comprising instructions to:

obtain, after the beamform of the channel training signal, a third indication of a magnitude or a phase of a third received signal of a third beamforming signal using a third beamforming vector in the null subspace, the null subspace including a third beamforming vector; and

identify a second signal subspace based at least in part on the third indication, the second signal subspace including the third beamforming vector.

19. The one or more computer readable media of claims 17 or 18, wherein the first received signal strength is greater than the second received signal strength.

20. An eNodeB comprising:

the one or more computer readable media of any of claims 17-19; and

one or more processors coupled with the one or more computer-readable media and configured to execute the instructions.

AMENDED CLAIMS
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1. An eNodeB (eNB) comprising:

a plurality of antenna ports with a plurality of antenna elements;

subspace identification circuitry coupled with the plurality of antenna elements, the subspace identification circuitry to:

identify, based on feedback information, a plurality of beamforming weights for one or multiple antenna ports wherein a number of the antenna ports is less than a number of the plurality of antenna elements; and

assign a beamforming weight in the plurality of beamforming weights to an antenna in the plurality of antenna elements; and

transmitter circuitry coupled with the subspace identification circuitry, the transmitter circuitry to:

beamform a channel training signal allocated for the antenna port with the beamforming weights; and

transmit an antenna port configuration schedule from the plurality of antennas.

2. The eNB of claim 1, wherein the feedback information is based on downlink sounding, or uplink sounding, or a signal received from a user equipment (UE).

3. The eNB of claim 1, wherein the antenna port configuration schedule includes an indication of a time period where the beamforming weights will not change.

4. The eNB of any of claims 1-3, wherein:

the feedback information includes a first indication of a magnitude or phase of a first received signal of a first beamformed signal produced with a first beamforming vector and a second indication of a magnitude or phase of a second received signal of a second beamformed signal produced with a second beamforming vector;

the subspace identification circuitry is further to identify a signal subspace that includes the first beamforming vector based at least in part on the first indication, and a null subspace that includes the second beamforming vector based at least in part on the second indication; and

the transmitter circuitry is further to beamform the channel training signal to the signal subspace.

5. The eNB of claim 4, wherein the first received signal magnitude is higher than the second received signal magnitude.

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6. The eNB of claim 4, wherein the channel training signal is a first channel training signal and the transmitter circuitry is further to beamform a second channel training signal to only a portion of the null subspace.

7. The eNB of claim 6, further comprising receiver circuitry coupled with the transmitter circuitry, the receiver circuitry to receive, in response to the transmission of the additional training signal in the null subspace, a second feedback that includes a third indication of a magnitude or phase of a third received signal of a third beamformed signal produced with a third beamforming vector in the null subspace.

8. The eNB of claim 6, wherein the signal subspace is a first signal subspace and the subspace identification circuitry is further to identify a second signal subspace based at least in part on the third indication, wherein the second signal subspace includes the third beamforming vector.

9. A method comprising:

identifying, by an eNodeB (eNB), a first signal subspace in a space based at least in part on a first indication of a magnitude or a phase of a first received signal of a first beamforming signal using a first beamforming vector in the first signal subspace, the first signal subspace including the first beamforming vector; and

identifying, by the eNB, a null subspace in the space based at least in part on a second indication of a magnitude or a phase of a second received signal of a second beamforming signal using a second beamforming vector in the null subspace, the null subspace including the second beamforming vector; and

beamforming, from an antenna port of the eNB, a channel training signal to the first signal subspace.

10. The method of claim 9, further comprising:

receiving, by the eNB after the beamforming of the channel training signal, a third indication of a magnitude or a phase of a third received signal of a third beamforming signal using a third beamforming vector in the null subspace, the null subspace including a third beamforming vector; and

identifying, by the eNB, a second signal subspace based at least in part on the third indication, the second signal subspace including the third beamforming vector.

11. The method of claim 10, wherein the channel training signal is a first channel training signal and the third indication is based at least in part on beamforming, by the eNB, a second channel training signal to at least a portion of the null subspace.

12. The method of claim 9, wherein the first signal subspace is based at least in part on a singular value decomposition of the first indication.

13. The method of claim 9, wherein the first received signal magnitude is greater than the second received signal magnitude.

14. The method of any of claims 9-13, wherein the first indication, second indication, and third indication are received by the eNB from a user equipment (UE).

15. The method of any of claims 9-13, wherein the antenna port includes a plurality of antenna elements of the eNB.

16. The method of any of claims 9-13, wherein the channel training signal is a channel state information-reference signal (CSI-RS) signal.

17. One or more computer readable media comprising instructions which, when executed by one or more processors of an eNodeB (eNB), cause the eNB to:

identify a first signal subspace in a space based at least in part on a first indication of a magnitude or a phase of a first received signal of a first beamforming signal using a first beamforming vector in the signal subspace, the first signal subspace including a first beamforming vector;

including the second beamforming vector; and

beamform a channel training signal to the first signal subspace.

18. The one or more computer readable media of claim 17, further comprising instructions to:

obtain, after the beamform of the channel training signal, a third indication of a magnitude or a phase of a third received signal of a third beamforming signal using a third beamforming vector in the null subspace, the null subspace including a third beamforming vector; and

identify a second signal subspace based at least in part on the third indication, the second signal subspace including the third beamforming vector.

19. The one or more computer readable media of claims 17 or 18, wherein the first received signal magnitude is greater than the second received signal magnitude.

20. An eNodeB comprising:

the one or more computer readable media of claims 17 or 18; and

one or more processors coupled with the one or more computer-readable media and configured to execute the instructions.

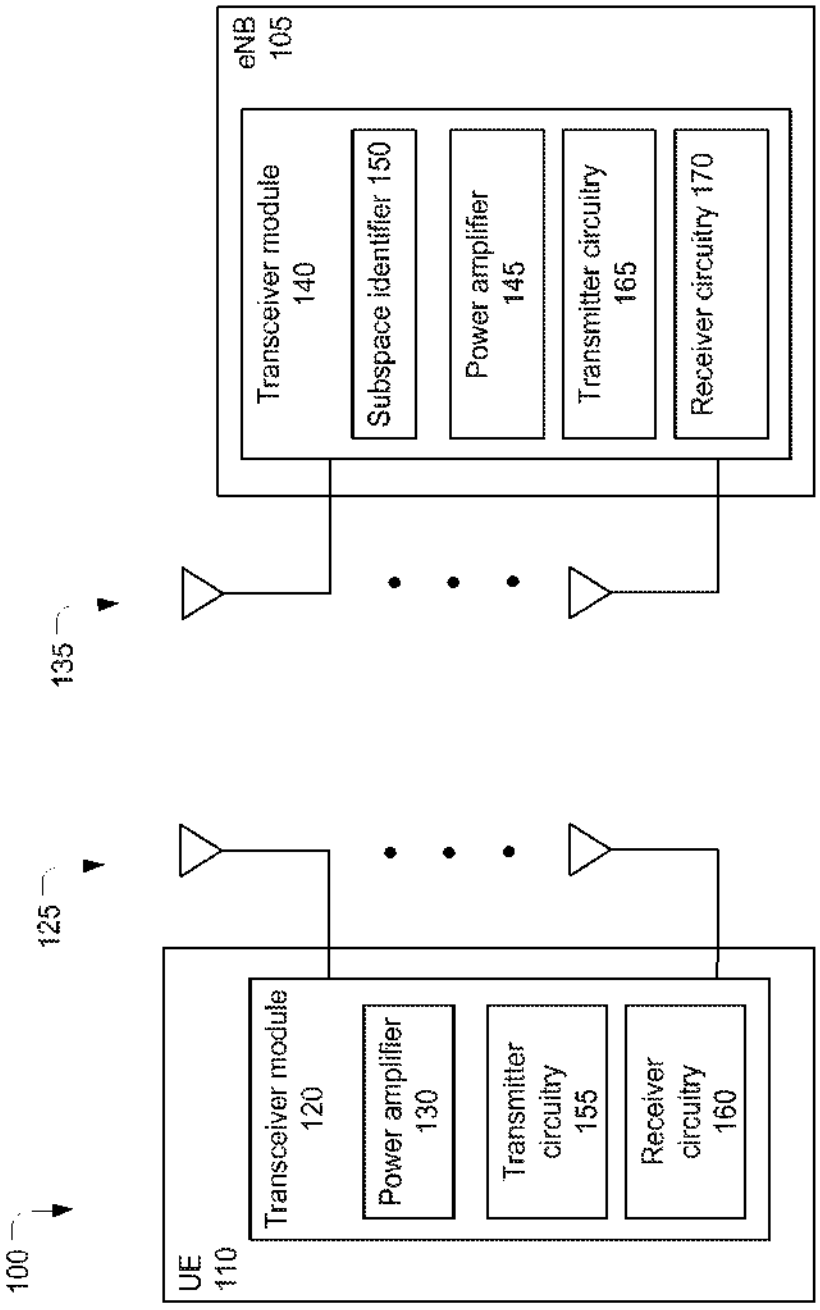

100
UE
110
Transceiver module
120
Power amplifier
130
Transmitter
circuitry
155
Receiver
circuitry
160
125
135
eNB
105
Transceiver module
140
Subspace identifier 150
Power amplifier
145
Transmitter circuitry
165
Receiver circuitry 170

Figure 1

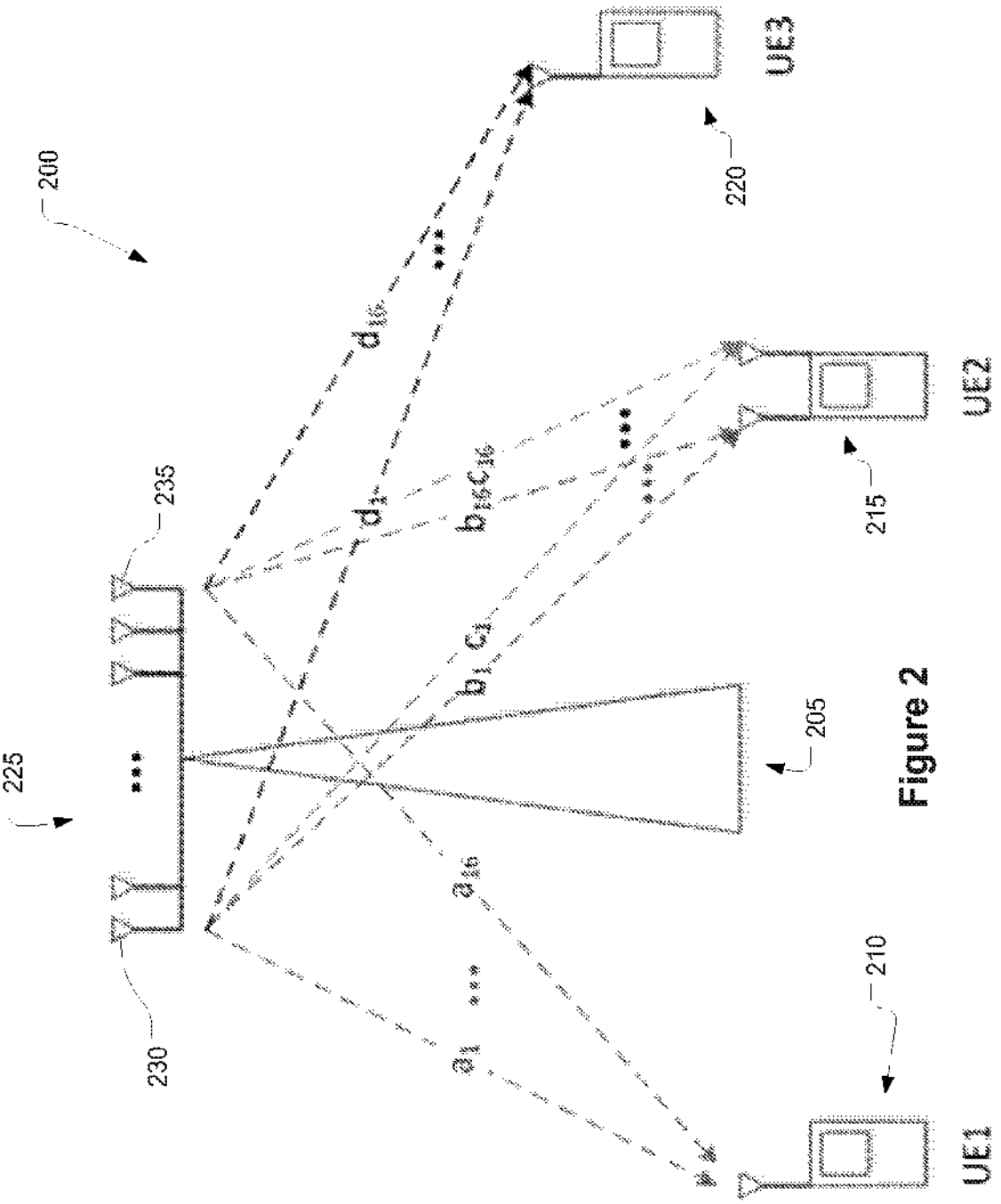


Figure 2

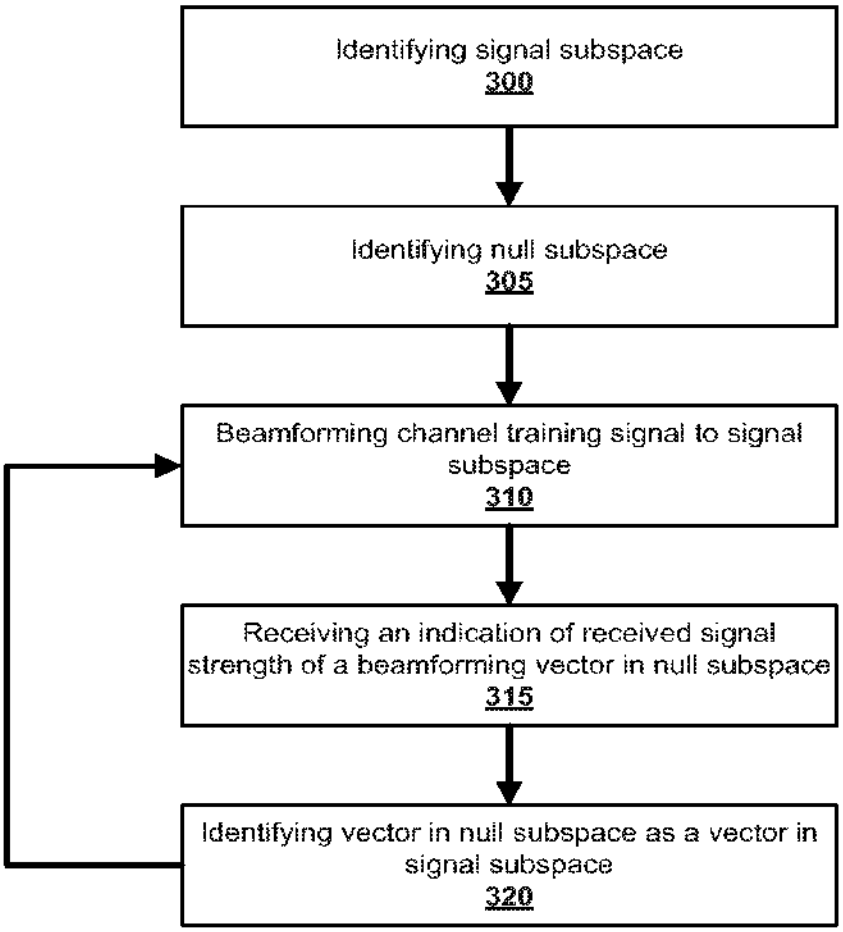

Identifying signal subspace
300
Identifying null subspace
305
Beamforming channel training signal to signal subspace
310
Receiving an indication of received signal strength of a beamforming vector in null subspace
315
Identifying vector in null subspace as a vector in signal subspace
320

Figure 3

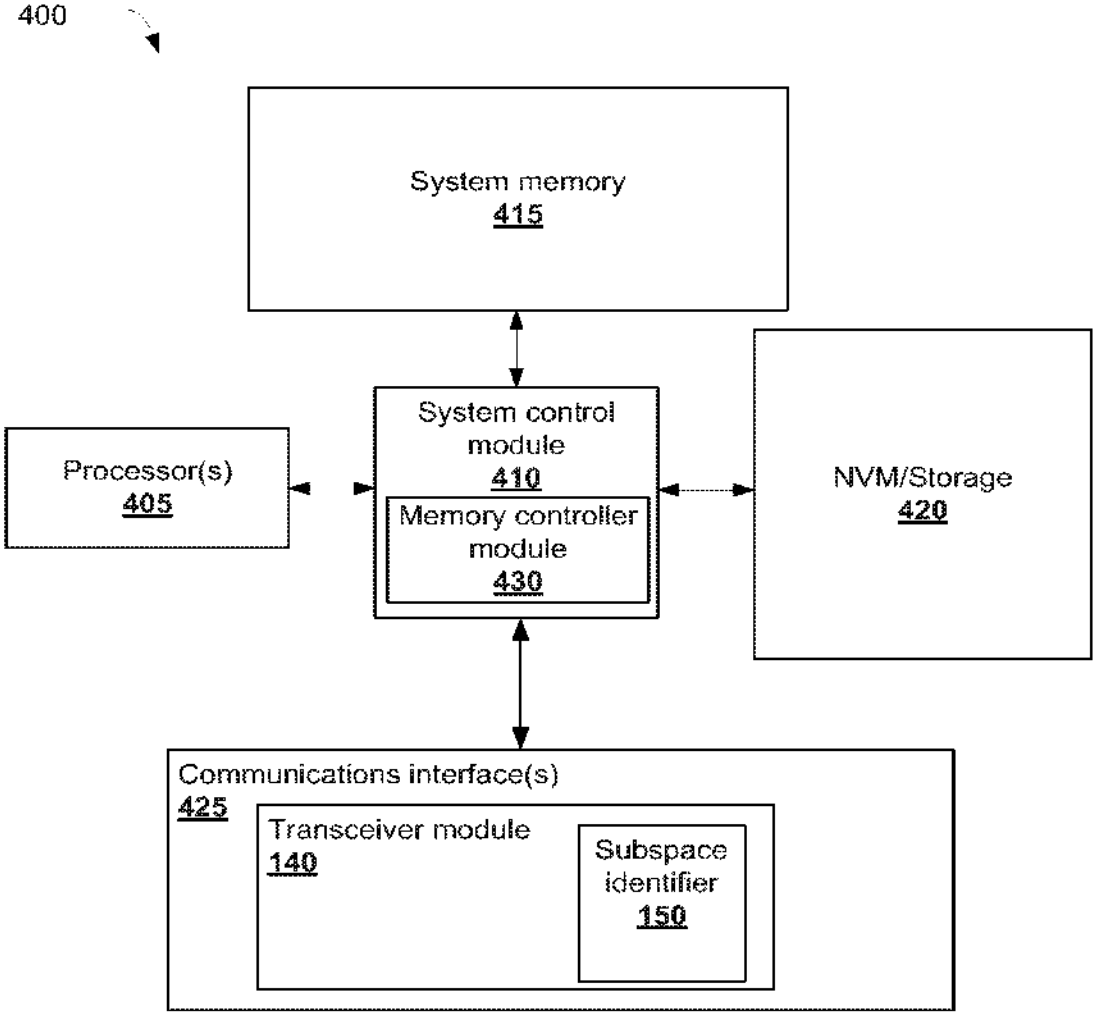

400
System memory
415
System control module
410
Memory controller module
430
Processor(s)
405
NVM/Storage
420
Communications interface(s)
425
Transceiver module
140
Subspace identifier
150

Figure 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/075463

A. CLASSIFICATION OF SUBJECT MATTER

H04B 7/06(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04B 7/06; H04B 7/00; H04B 7/02; H04B 17/00; H04M 1/00; H04Q 7/20; H04W 72/04; H04W 40/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: feedback, beamforming weight, channel training signal, beamform, antenna element, antenna port configuration schedule, signal subspace, null subspace, beamforming vector

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2009-0252250 A1 (ROBERT WENDELL HEATH, JR. et al.) 08 October 2009 See paragraphs 99-106, 115-125; and figs. 3, 5.	1-19
A	US 2009-0067375 A1 (WENDY C. WONG et al.) 12 March 2009 See paragraphs 31-99, 102-114; and figs. 2, 4.	1-19
A	US 2010-0075705 A1 (CORNELIUS VAN RENSBURG et al.) 25 March 2010 See paragraphs 50-67; and figs. 3, 4.	1-19
A	US 2013-0059619 A1 (TAE-YOUNG KIM et al.) 07 March 2013 See paragraphs 51-59, 83-91; and figs. 4, 7.	1-19
A	US 2011-0205963 A1 (YANG TANG et al.) 25 August 2011 See paragraphs 23-37, 50-58; and figs. 2a, 4.	1-19

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 March 2014 (18.03.2014)	**19 March 2014 (19.03.2014)**

Name and mailing address of the ISA/KR
International Application Division
Korean Intellectual Property Office
189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea
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Authorized officer
KANG, Hee Gok
Telephone No. +82-42-481-8264

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/075463

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 20
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required addtional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of any additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2013/075463

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2009-0252250 A1	08/10/2009	KR 10-2009-0105299 A	07/10/2009
		US 8165533 B2	24/04/2012
US 2009-0067375 A1	12/03/2009	CN 101384023 A	11/03/2009
		CN 101384023 B	31/10/2012
		EP 2034626 A2	11/03/2009
		EP 2034626 A3	20/11/2013
		US 8085653 B2	27/12/2011
US 2010-0075705 A1	25/03/2010	EP 2311192 A1	20/04/2011
		EP 2311192 A4	17/08/2011
		US 8315657 B2	20/11/2012
		WO 2010-033989 A1	25/03/2010
US 2013-0059619 A1	07/03/2013	KR 10-2013-0025102 A	11/03/2013
		WO 2013-032188 A2	07/03/2013
		WO 2013-032188 A3	25/04/2013
US 2011-0205963 A1	25/08/2011	None	

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13 November 2014 (13.11.2014)

(25) Filing Language: English

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(30) Priority Data:
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(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU,

[Continued on next page]

(54) Title: IDENTIFICATION OF DOWNLINK MESSAGES USING REPEATED TRANSMISSION

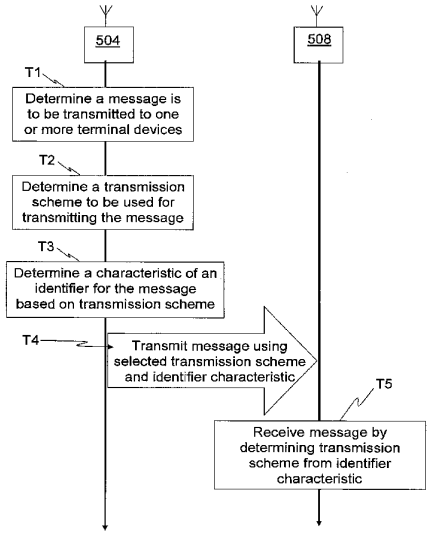


Fig. 9

(57) Abstract: A wireless telecommunication system comprises a base station arranged to communicate messages to one or more terminal devices over a radio interface. The radio interface has a radio frame structure comprising a plurality of subframes, wherein a message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes (e.g. one subframe) or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes (e.g. with repeat transmissions in a plurality of subframes). The message is transmitted in association with an identifier to indicate a terminal device to which the message is addressed. A characteristic for the identifier, for example a value or control region search space for the identifier, is dependent on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme. A terminal device to which the message is addressed determines the transmission scheme from the characteristic of the identifier and receives the message accordingly.

WO 2015/113664 A1

TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

IDENTIFICATION OF DOWNLINK MESSAGES USING REPEATED TRANSMISSION

BACKGROUND

Field

The present disclosure relates to telecommunications apparatus and methods. In particular, certain embodiments relate to schemes for communicating allocations of transmission resources of a shared channel in a wireless telecommunications system.

Description of Related Art

The "background" description provided herein is for the purpose of generally presenting the context of the disclosure. Work of the presently named inventors, to the extent it is described in this background section, as well as aspects of the description which may not otherwise qualify as prior art at the time of filing, are neither expressly or impliedly admitted as prior art against the present invention.

Mobile communication systems have evolved over the past ten years or so from the GSM System (Global System for Mobile communications) to the 3G system and now include packet data communications as well as circuit switched communications. The third generation partnership project (3GPP) is developing a fourth generation mobile communication system referred to as Long Term Evolution (LTE) in which a core network part has been evolved to form a more simplified architecture based on a merging of components of earlier mobile radio network architectures and a radio access interface which is based on Orthogonal Frequency Division Multiplexing (OFDM) on the downlink and Single Carrier Frequency Division Multiple Access (SC-FDMA) on the uplink.

Third and fourth generation mobile telecommunication systems, such as those based on the 3GPP defined UMTS and Long Term Evolution (LTE) architecture are becoming able to support more sophisticated services than simple voice and messaging services offered by previous generations of mobile telecommunication systems. For example, with the improved radio interface and enhanced data rates provided by LTE systems, a user is able to enjoy high data rate applications such as mobile video streaming and mobile video conferencing that would previously only have been available via a fixed line data connection. The demand to deploy third and fourth generation networks is therefore strong and there is a corresponding desire to extend the coverage available in such telecommunications systems (i.e. there is a desire to provide more reliable access to wireless telecommunications systems for terminal devices operating in coverage-limited locations).

A typical example of a coverage-limited terminal device might be a so-called machine type communication (MTC) device, such as a smart meter located in a customer's house and periodically transmitting information back to a central MTC server relating to the customer's consumption of a utility, such as gas, water, electricity and so on. Such a terminal device might operate in a coverage-limited location because, for example, it may be located in a basement or other location with relatively high penetration loss. Further information on characteristics of MTC-type devices can be found, for example, in the corresponding standards, such as ETSI TS 122 368 V10.530 (2011-07) / 3GPP TS 22.368 version 10.5.0 Release 10) [1]. Some typical characteristics of MTC type terminal devices / MTC type data might include, for example, characteristics such as low mobility, high delay tolerance, small data transmissions, infrequent transmission and group-based features, policing and addressing.

In some situations a terminal device in a coverage-limited situation in a particular communication cell served by a base station might be unable to receive communications from the base station unless specific provision is made for it to do so. One way to increase coverage in this situation would be for the base station to increase the power of its transmissions. However, a blanket increase in transmission power from a base station could be expected to give rise to increased interference in neighbouring communication cells. An alternative approach would be for the base station to in effect focus / concentrate its available transmission power budget into a subset of transmission resources (e.g. in terms of frequency) which are selected from within the base station's overall transmission resources and allocated for transmissions to coverage-limited terminal devices. However, this approach can again lead to increased interference in neighbouring cells and may in some cases require increased coordination among base stations to optimise performance.

Another approach for providing coverage extension is to rely on repeated transmissions of signalling in multiple subframes. A terminal device may then combine the signalling received for a plurality of repeated transmissions to increase the likelihood of successfully decoding the signalling, e.g. using chase combining / maximal ratio combining techniques. This repeated transmission approach may be applied for control signalling (e.g. sent on a physical downlink control channel such as PDCCH in LTE) and / or other signalling (e.g. sent on a physical downlink shared channel such as PDSCH in LTE).

One draw-back of a repeated transmission approach for providing coverage extension is a corresponding increase in the amount of transmission resources needed to communicate with terminal devices, particularly in the amount of transmission resources needed to provide control messages to the terminal devices, and the inventors have recognised how this issue can be especially significant for certain types of communications, as discussed further below. There is therefore a need for schemes which can allow for communications with terminal devices to be made over a number of subframes with a reduction in the overall amount of transmission resources needed to support this as compared to conventional techniques.

SUMMARY

According to a first aspect of the present disclosure, there is provided a method of operating a terminal device communicating with a base station in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the method comprises receiving a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel, determining a validity period for the control message, and receiving a plurality of other messages from the base station on the downlink data channel using the allocated transmission resources within the validity period for the control message.

According to a second aspect of the present disclosure, there is provided a terminal device for communicating with a base station in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the

downlink data channel, and wherein the terminal device comprises a controller unit and a transceiver unit configured to operate together to receive a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to receive a plurality of other messages from the base station on the downlink data channel using the allocated transmission resources within the validity period for the control message.

According to a third aspect of the present disclosure, there is provided circuitry for a terminal device communicating with a base station in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to cause the terminal device to receive a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to receive a plurality of other messages from the base station on the downlink data channel using the allocated transmission resources within the validity period for the control message

According to a forth aspect of the present disclosure, there is provided a method of operating a base station communicating with a terminal device in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the method comprises transmitting a control message to the terminal device conveying an indication of allocated transmission resources on the downlink data channel, determining a validity period for the control message, and transmitting a plurality of other messages to the terminal device on the downlink data channel using the allocated transmission resources within the validity period for the control message.

According to a fifth aspect of the present disclosure, there is provided a base station for communicating with a terminal device in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the base station comprises a controller unit and a transceiver unit configured to operate together to transmit a control message to the terminal device conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to transmit a plurality of other messages to the terminal device on the downlink data channel using the allocated transmission resources within the validity period for the control message.

According to a sixth aspect of the present disclosure, there is provided circuitry for a base station communicating with a terminal device in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the

downlink data channel, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to cause the base station to transmit a control message to the terminal device conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to transmit a plurality of other messages to the terminal device on the downlink data channel using the allocated transmission resources within the validity period for the control message.

According to a seventh aspect of the present disclosure, there is provided a method of operating a base station for communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein the method comprises selecting a characteristic for the identifier in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

According to an eighth aspect of the present disclosure, there is provided a base station for communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the base station comprises a controller unit and a transceiver unit configured to operate together such that the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein a characteristic for the identifier is selected in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

According to a ninth aspect of the present disclosure, there is provided circuitry for a base station communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the circuitry comprises a controller element and a transceiver element configured to operate together such that the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein a characteristic for the identifier is selected in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

According to a 10th aspect of the present disclosure, there is provided a method of operating a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission

resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the method comprises determining from an identifier associated with the message that the message is addressed to the terminal device, and further determining from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

According to an 11th aspect of the present disclosure, there is provided a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the terminal device comprises a controller unit and a transceiver unit configured to operate together to determine from an identifier associated with the message that the message is addressed to the terminal device, and to further determine from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

According to a twelfth aspect of the present disclosure, there is provided circuitry for a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to determine from an identifier associated with the message that the message is addressed to the terminal device, and to further determine from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

Further respective aspects and features are defined by the appended claims.

The foregoing paragraphs have been provided by way of general introduction, and are not intended to limit the scope of the following claims. The described embodiments, together with further advantages, will be best understood by reference to the following detailed description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the disclosure and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein like reference numerals designate identical or corresponding parts throughout the several views, and wherein:

Figure 1 provides a schematic diagram illustrating an example of a mobile telecommunication system;

Figure 2 provides a schematic diagram illustrating a LTE radio frame;

Figure 3 provides a schematic diagram illustrating an example of a LTE downlink radio subframe;

Figure 4 provides a schematic diagram illustrating a LTE "camp-on" procedure;

Figure 5 schematically represents a wireless telecommunications system according to an embodiment of the disclosure;

Figure 6 schematically represents a series of downlink subframes for communicating with a terminal device operating in the wireless telecommunications system of Figure 5;

Figure 7 schematically represents a series of downlink subframes for communicating with a terminal device operating in the wireless telecommunications system of Figure 5 in accordance with an embodiment of the disclosure;

Figure 8 is a signalling ladder diagram representing communications between a base station and a terminal device operating in accordance with an embodiment of the disclosure; and

Figure 9 is a signalling ladder diagram representing communications between a base station and a terminal device operating in accordance with another embodiment of the disclosure.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Figure 1 provides a schematic diagram illustrating some basic functionality of a mobile telecommunications network / system 100 operating in accordance with LTE principles and which may be adapted to implement embodiments of the disclosure as described further below. Various elements of Figure 1 and their respective modes of operation are well-known and defined in the relevant standards administered by the 3GPP (RTM) body and also described in many books on the subject, for example, Holma H. and Toskala A [2]. It will be appreciated that operational aspects of the telecommunications network which are not specifically described below may be implemented in accordance with any known techniques, for example according to the relevant standards.

The network 100 includes a plurality of base stations 101 connected to a core network 102. Each base station provides a coverage area 103 (i.e. a cell) within which data can be communicated to and from terminal devices 104. Data is transmitted from base stations 101 to terminal devices 104 within their respective coverage areas 103 via a radio downlink. Data is transmitted from terminal devices 104 to the base stations 101 via a radio uplink. The core network 102 routes data to and from the terminal devices 104 via the respective base stations 101 and provides functions such as authentication, mobility management, charging and so on. Terminal devices may also be referred to as mobile stations, user equipment (UE), user terminal, mobile radio, and so forth. Base stations may also be referred to as transceiver stations / nodeBs / e-nodeBs, and so forth.

Mobile telecommunications systems such as those arranged in accordance with the 3GPP defined Long Term Evolution (LTE) architecture use an orthogonal frequency division modulation (OFDM) based interface for the radio downlink (so-called OFDMA) and a single carrier frequency division multiple access scheme (SC-FDMA) on the radio uplink. Figure 2 shows a schematic diagram illustrating an OFDM based LTE downlink radio frame 201. The LTE downlink radio frame is transmitted from a LTE base station

(known as an enhanced Node B) and lasts 10 ms. The downlink radio frame comprises ten subframes, each subframe lasting 1 ms. A primary synchronisation signal (PSS) and a secondary synchronisation signal (SSS) are transmitted in the first and sixth subframes of the LTE frame. A physical broadcast channel (PBCH) is transmitted in the first subframe of the LTE frame.

Figure 3 is a schematic diagram of a grid which illustrates the structure of an example conventional downlink LTE subframe. The subframe comprises a predetermined number of symbols which are transmitted over a 1ms period. Each symbol comprises a predetermined number of orthogonal subcarriers distributed across the bandwidth of the downlink radio carrier.

The example subframe shown in Figure 3 comprises 14 symbols and 1200 subcarriers spread across a 20MHz bandwidth and in this example is the first subframe in a frame (hence it contains PBCH). The smallest allocation of physical resource for transmission in LTE is a resource block comprising twelve subcarriers transmitted over one subframe. For clarity, in Figure 3, each individual resource element is not shown, instead each individual box in the subframe grid corresponds to twelve subcarriers transmitted on one symbol.

Figure 3 shows in hatching resource allocations for four LTE terminals 340, 341, 342, 343. For example, the resource allocation 342 for a first LTE terminal (UE 1) extends over five blocks of twelve subcarriers (i.e. 60 subcarriers), the resource allocation 343 for a second LTE terminal (UE2) extends over six blocks of twelve subcarriers (i.e. 72 subcarriers), and so on.

Control channel data can be transmitted in a control region 300 (indicated by dotted-shading in Figure 3) of the subframe comprising the first "n" symbols of the subframe where "n" can vary between one and three symbols for channel bandwidths of 3MHz or greater and where "n" can vary between two and four symbols for a channel bandwidth of 1.4MHz. For the sake of providing a concrete example, the following description relates to host carriers with a channel bandwidth of 3MHz or greater so the maximum value of "n" will be 3 (as in the example of Figure 3). The data transmitted in the control region 300 includes data transmitted on the physical downlink control channel (PDCCH), the physical control format indicator channel (PCFICH) and the physical HARQ indicator channel (PHICH). These channels transmit physical layer control information. Control channel data can also or alternatively be transmitted in a second region of the subframe comprising a number of subcarriers for a time substantially equivalent to the duration of the subframe, or substantially equivalent to the duration of the subframe remaining after the "n" symbols. The data transmitted in this second region is transmitted on the enhanced physical downlink control channel (EPDCCH). This channel transmits physical layer control information which may be in addition to that transmitted on other physical layer control channels.

PDCCH and EPDCCH contain control data indicating which subcarriers of the subframe have been allocated to specific terminals (or all terminals or subset of terminals). This may be referred to as physical-layer control signalling / data. Thus, the PDCCH and/or EPDCCH data transmitted in the control region 300 of the subframe shown in Figure 3 would indicate that UE1 has been allocated the block of resources identified by reference numeral 342, that UE2 has been allocated the block of resources identified by reference numeral 343, and so on.

PCFICH contains control data indicating the size of the control region (i.e. between one and three symbols for channel bandwidths of 3 MHz or greater and between two and four symbols for channel bandwidths of 1.4 MHz).

PHICH contains HARQ (Hybrid Automatic Request) data indicating whether or not previously transmitted uplink data has been successfully received by the network.

Symbols in a central band 310 of the time-frequency resource grid are used for the transmission of information including the primary synchronisation signal (PSS), the secondary synchronisation signal (SSS) and the physical broadcast channel (PBCH). This central band 310 is typically 72 subcarriers wide (corresponding to a transmission bandwidth of 1.08 MHz). The PSS and SSS are synchronisation signals that once detected allow a LTE terminal device to achieve frame synchronisation and determine the physical layer cell identity of the enhanced Node B transmitting the downlink signal. The PBCH carries information about the cell, comprising a master information block (MIB) that includes parameters that LTE terminals use to properly access the cell. Data transmitted to terminals on the physical downlink shared channel (PDSCH), which may also be referred to as a downlink data channel, can be transmitted in other resource elements of the subframe. In general PDSCH conveys a combination of user-plane data and non-physical layer control-plane data (such as Radio Resource Control (RRC) and Non Access Stratum (NAS) signalling). The user-plane data and non-physical layer control-plane data conveyed on PDSCH may be referred to as higher layer data (i.e. data associated with a layer higher than the physical layer).

Figure 3 also shows a region of PDSCH containing system information and extending over a bandwidth of R344. A conventional LTE subframe will also include reference signals which are discussed further below but not shown in Figure 3 in the interests of clarity.

The number of subcarriers in a LTE channel can vary depending on the configuration of the transmission network. Typically this variation is from 72 sub carriers contained within a 1.4MHz channel bandwidth to 1200 subcarriers contained within a 20MHz channel bandwidth (as schematically shown in Figure 3). As is known in the art, data transmitted on the PDCCH, PCFICH and PHICH is typically distributed on the subcarriers across the entire bandwidth of the subframe to provide for frequency diversity. Therefore a conventional LTE terminal must be able to receive the entire channel bandwidth in order to receive and decode the control region.

Figure 4 illustrates a LTE “camp-on” process, that is, the process followed by a terminal so that it can decode downlink transmissions which are sent by a base station via a downlink channel. Using this process, the terminal can identify the parts of the transmissions that include system information for the cell and thus decode configuration information for the cell.

As can be seen in Figure 4, in a conventional LTE camp-on procedure, the terminal first synchronizes with the base station (step 400) using the PSS and SSS in the centre band and then decodes the PBCH (step 401). Once the terminal has performed steps 400 and 401, it is synchronized with the base station.

For each subframe, the terminal then decodes the PCFICH which is distributed across the entire bandwidth of carrier 320 (step 402). As discussed above, a LTE downlink carrier can be up to 20 MHz wide (1200 subcarriers) and a standard LTE-compliant terminal therefore has to have the capability to receive and decode transmissions on a 20 MHz bandwidth in order to decode the PCFICH. Accordingly, at the PCFICH decoding stage, with a 20MHz carrier band, the terminal operates at a larger bandwidth

(bandwidth of R320) than during steps 400 and 401 (bandwidth of R310) relating to synchronization and PBCH decoding.

The terminal then ascertains the PHICH locations (step 403) and decodes the PDCCH (step 404), in particular for identifying system information transmissions and for identifying its dedicated allocation grants. The allocation grants are used by the terminal to locate system information and to locate its data in the PDSCH. Both system information and dedicated allocations are transmitted on PDSCH and scheduled within the carrier band 320. Steps 403 and 404 also require a standard LTE-compliant terminal to operate on the entire bandwidth R320 of the carrier band. Allocation grants may also or alternatively be decoded from EPDCCH.

At steps 402 to 404, the terminal decodes information contained in the control region 300 of a subframe. As explained above, in LTE, the three control channels mentioned above (PCFICH, PHICH and PDCCH) can be found across the control region 300 of the carrier where the control region extends over the range R320 and occupies the first one, two or three OFDM symbols of each subframe as discussed above. In a subframe, typically the control channels do not use all the resource elements within the control region 300, but they are scattered across the entire region, such that a LTE terminal has to be able to simultaneously receive the entire control region 300 for decoding each of the three control channels.

The terminal can then decode the PDSCH (step 405) which contains system information or data transmitted for this terminal.

As explained above, in a LTE subframe the PDSCH generally occupies groups of resource elements which follow the control region. The data in the blocks of resource elements 340, 341, 342, 343 allocated to the different mobile communication terminals (UEs) and the system information data in the block of resources 344 shown in Figure 3 have a smaller bandwidth than the bandwidth of the entire carrier. To decode these blocks a terminal first receives the PDCCH spread across the frequency range R320 and/or the EPDCCH to determine if the (E)PDCCH indicates there are PDSCH resources in the subframe that need to be decoded by the UE. The intended recipient(s) for (E)PDCCH signalling in LTE is established through the use of radio network temporary identifiers (RNTI). (E)PDCCH signalling is addressed to a particular RNTI by using the RNTI to scramble cyclic redundancy check (CRC) bits associated with the (E)PDCCH signalling. Each connected UE in a cell is associated with a Cell RNTI (C-RNTI) that may be used to address PDCCH signalling to that particular UE. In addition there are other RNTIs defined and these may be used to simultaneously address groups of terminal devices. For example, a System Information RNTI (SI-RNTI) is defined and PDSCH transmissions comprising SI are allocated by (E)PDCCH signalling addressed to SI-RNTI. Various other RNTIs are defined for various other types of signalling. Some examples include a random-access RNTI (RA-RNTI), a Paging RNTI (P-RNTI), a Transmit Power Control Physical Uplink Control Channel RNTI (TPC-PUCCH-RNTI) and a Transmit Power Control Physical Uplink Shared Channel-RNTI (TPC-PUSCH-RNTI).

Thus, once a UE has received a downlink subframe, the UE searches for (E)PDCCH signalling associated with any RNTI that apply for the UE in the subframe to identify any corresponding allocations of transmission resources on PDSCH. If there is an allocation message addressed to the UE on (E)PDCCH the UE will proceed to decode the PDSCH in the relevant frequency range (if any) indicated by the PDCCH. So for example, UE 1 discussed above decodes the whole control region 300 to

determine its resource allocation and then extracts the relevant data from the corresponding resource block 342.

Figure 5 schematically shows a telecommunications system 500 according to an embodiment of the disclosure. The telecommunications system 500 in this example is based broadly on a LTE-type architecture. As such many aspects of the operation of the telecommunications system 500 are standard and well understood and not described here in detail in the interest of brevity. Operational aspects of the telecommunications system 500 which are not specifically described herein may be implemented in accordance with any known techniques, for example according to the established LTE-standards and known variations thereof.

The telecommunications system 500 comprises a core network part (evolved packet core) 502 coupled to a radio network part. The radio network part comprises a base station (evolved-nodeB) 504, a first terminal device 506 and a second terminal device 508. It will of course be appreciated that in practice the radio network part may comprise a plurality of base stations serving a larger number of terminal devices across various communication cells. However, only a single base station and two terminal devices are shown in Figure 5 in the interests of simplicity.

As with a conventional mobile radio network, the terminal devices 506, 508 are arranged to communicate data to and from the base station (transceiver station) 504. The base station is in turn communicatively connected to a serving gateway, S-GW, (not shown) in the core network part which is arranged to perform routing and management of mobile communications services to the terminal devices in the telecommunications system 500 via the base station 504. In order to maintain mobility management and connectivity, the core network part 502 also includes a mobility management entity (not shown) which manages the enhanced packet service, EPS, connections with the terminal devices 506, 508 operating in the communications system based on subscriber information stored in a home subscriber server, HSS. Other network components in the core network (also not shown for simplicity) include a policy charging and resource function, PCRF, and a packet data network gateway, PDN-GW, which provides a connection from the core network part 502 to an external packet data network, for example the Internet. As noted above, the operation of the various elements of the communications system 500 shown in Figure 5 may be broadly conventional apart from where modified to provide functionality in accordance with embodiments of the disclosure as discussed herein.

In this example, it is assumed the first terminal device 506 is a conventional smart-phone type terminal device communicating with the base station 504. Thus, and as is conventional, this first terminal device 506 comprises a transceiver unit 506a for transmission and reception of wireless signals and a controller unit 506b configured to control the smart phone 506. The controller unit 506b may comprise a processor unit which is suitably configured / programmed to provide the desired functionality using conventional programming / configuration techniques for equipment in wireless telecommunications systems. The transceiver unit 506a and the controller unit 506b are schematically shown in Figure 5 as separate elements. However, it will be appreciated that the functionality of these units can be provided in various different ways, for example using a single suitably programmed general purpose computer, or suitably configured application-specific integrated circuit(s) / circuitry. As will be appreciated the conventional terminal device 506 will in general comprise various other elements associated with its operating functionality.

In this example, it is assumed the second terminal device 508 is a machine-type communication (MTC) terminal device according to an embodiment of the disclosure and located in an area of restricted coverage. As discussed above, MTC devices may be typically characterised as semi-autonomous or autonomous wireless communication devices communicating small amounts of data. Examples include so-called smart meters which, for example, may be located in a customer's house and periodically transmit information back to a central MTC server data relating to the customer's consumption of a utility such as gas, water, electricity and so on. MTC devices may in some respects be seen as devices which can be supported by relatively low bandwidth communication channels having relatively low quality of service (QoS), for example in terms of latency. It is assumed here the MTC terminal device 508 in Figure 5 is such a device. It will, however, the appreciated that embodiments of the disclosure may also be implemented for other types of terminal device.

As with the smart phone 506, the MTC device 508 comprises a transceiver unit 508a for transmission and reception of wireless signals and a controller unit 508b configured to control the MTC device 508. The controller unit 508b may comprise a processor unit which is suitably configured / programmed to provide the desired functionality described herein using conventional programming / configuration techniques for equipment in wireless telecommunications systems. The transceiver unit 508a and the controller unit 508b are schematically shown in Figure 5 as separate elements for ease of representation. However, it will be appreciated that the functionality of these units can be provided in various different ways, for example using a single suitably programmed general purpose computer, or suitably configured application-specific integrated circuit(s) / circuitry, or using a plurality of discrete circuitry / processing elements for providing different elements of the desired functionality. It will be appreciated the MTC device 508 will in general comprise various other elements associated with its operating functionality in accordance with established wireless telecommunications techniques (e.g. a power source, possibly a user interface, and so forth).

The base station 504 comprises a transceiver unit 504a for transmission and reception of wireless signals and a controller unit 504b configured to control the base station 504. The controller unit 504b may comprise a processor unit which is suitably configured / programmed to provide the desired functionality described herein using conventional programming / configuration techniques for equipment in wireless telecommunications systems. The transceiver unit 504a and the controller unit 504b are schematically shown in Figure 5 as separate elements for ease of representation. However, it will be appreciated that the functionality of these units can be provided in various different ways, for example using a single suitably programmed general purpose computer, or suitably configured application-specific integrated circuit(s) / circuitry or using a plurality of discrete circuitry / processing elements for providing different elements of the desired functionality. It will be appreciated the base station 504 will in general comprise various other elements associated with its operating functionality. For example, the base station 504 will in general comprise a scheduling entity responsible for scheduling communications. The functionality of the scheduling entity may, for example, be subsumed by the controller unit 504b.

Thus, the base station 504 is configured to communicate data with the smart phone 506 over a first radio communication link 510 and communicate data with the MTC device 508 over a second radio communication link 512. Both radio links may be supported within a single radio frame structure associated with the base station 504. It is assumed here the base station 504 is configured to communicate with the smart phone 506 over the first radio communication link 510 in accordance with the

established principles of LTE-based communications and to communicate with the MTC-device 506 over the second radio communication link 512 in accordance with embodiments of the disclosure as described herein. It will be appreciated the base station may readily obtain information indicating the different classes of terminal device which are attached to the base station in accordance with conventional techniques. That is to say, the base station will be aware that the smart phone is of a device class that includes conventional smartphones and the MTC device is of a device class that includes MTC devices. Furthermore, the base station may establish using conventional techniques that the MTC device 508 is a device operating in a coverage limited situation such that steps are needed to increase the likelihood of the MTC device being able to decode downlink transmissions.

As noted above, in a LTE-based wireless telecommunications system some of the fundamental information required for a terminal device to operate in a cell is transmitted on PBCH in the Master Information Block (MIB). Other information regarding the system configuration is divided among System Information Blocks (SIBs) referred to as SIB1, SIB2, SIB3,...etc. (there are 16 SIBs defined as of Release 11 LTE). The SIBs are transmitted in system information (SI) messages, which, apart from SIB1, may contain multiple SIBs (termed first SI, second SI, etc.). There may be one or several SI messages transmitted at different periodicities. Each SI message may convey multiple SIBs suitable for scheduling with the same periodicity. The timings for SIB1 message transmissions are fixed on an 80 ms period and they occur in the fifth subframe of radio frames when System Frame Number (SFN) is a multiple of 8 (i.e. SFN mod 8 = 0). There are retransmissions of SIB1 messages provided in every other radio frame within the 80 ms period. The timings for other SIB transmission messages are configured in SIB1. The transmission resource allocations for the SI messages on PDSCH within a subframe are provided to terminal devices using PDCCH allocation messages addressed to SI-RNTI (System Information Radio Network Temporary Identifier - currently 0xFFFF in LTE). At higher layers, SI is carried on the logical broadcast control channel (BCCH).

In LTE the SI messages are transmitted within periodically occurring time domain windows (referred to as SI-windows) using dynamic scheduling. Each SI message is associated with a SI-window and the SI-windows of different SI messages do not overlap. That is, within one SI-window only the corresponding SI message is transmitted. The length of the SI-window is common for all SI messages, and is configurable. Within the SI-window, the corresponding SI message can be transmitted a number of times in any subframe other than MBSFN (multicast-broadcast single frequency network) subframes, uplink subframes in TDD (time division duplex), and subframe #5 of radio frames for which SFN (system frame number) mod 2 = 0. Terminal devices acquire the detailed time-domain scheduling (and other information, e.g. frequency-domain scheduling, transport format) from decoding SI-RNTI on PDCCH. A single SI-RNTI is used to address SystemInformationBlockType1 as well as all SI messages. SystemInformationBlockType1 configures the SI-window length and the transmission periodicity for the SI messages.

The system information in a cell may be changed, although typically this happens rarely with system information perhaps remaining unchanged for hours, days, or even weeks.

For changes of system information other than those related to EAB (Extended Access Barring), ETWS (Earthquake Tsunami Warning System) and CMAS (Commercial Mobile Alert System), there is a BCCH modification period defined (which may be referred to as a “SI modification period”). SI modification period boundaries are defined on radio frames for which SFN mod q = 0, for a cell-specific value of q.

When there is a change in system information, the new system information is transmitted from the start of a new SI modification period.

The general process for implementing a change in system information in a LTE-based network is described, for example, in Section 5.2.1.3 of ETSI TS 136 331 V11.4.0 (2013-07) / 3GPP TS 36.331 version 11.4.0 Release 11 [3]. In summary, a base station indicates a change of system information as follows.

1. When the network changes system information it notifies terminal devices about the change by transmitting a PDCCH resource allocation message addressed to the paging RNTI (P-RNTI). This directs the terminal devices to decode PDSCH resources containing a Paging message with a SystemInfoModification flag set to true. This may be done, for example, throughout one SI modification period. Both RRC_IDLE and RRC_CONNECTED terminal devices check for paging messages periodically. It may be noted that EAB alterations, ETWS and CMAS notifications may be separately modified with separate flags in a paging message (but can also be modified along with other SIBs).

2. In a following SI modification period, the network transmits the modified system information, and may increment a SystemInfoValueTag in SIB1. This value tag can indicate changes in any SIB, but it might not be used for EAB, ETWS, CMAS and some regularly changing SI parameters such as CDMA2000 system time. Terminal devices can use SystemInfoValueTag to verify if currently stored system information is still valid, for example on return from being out of coverage when the UE may have missed a system information change notification in paging.

More details on system information and changes in system information in a LTE-based system can be found in ETSI TS 136 331 V11.4.0 (2013-07) / 3GPP TS 36.331 version 11.4.0 Release 11 [3].

As discussed above, it has been proposed to improve coverage for terminal devices in a wireless telecommunications system by introducing repetitions of a transmission which a terminal device may combine to provide an increased likelihood of successful decoding.

Figure 6 schematically represents an approach for providing coverage extension through repeated transmissions for an SI message in accordance with existing techniques. Figure 6 schematically shows a sequence of LTE downlink subframes (labelled as subframes "A", "B", "C", …, "L" to aid explanation) with shading to schematically indicate which regions in which subframes are used to convey system information. The subframes represented in Figure 6 comprise four groups of three contiguous subframes with spaces between the groups as schematically indicated by dotted lines and discussed further below. Although not shown in Figure 6, the gaps between the groups comprise a continuing sequence of subframes used for other communications that are not relevant to the system information messaging considered here. As discussed above, each subframe comprises a control region 600 and a PDSCH region 602. The control regions 600 for the respective subframes are labelled in Figure 6 with the identification letter for the relevant subframe, i.e. as 600A, 600B, 600C, etc. The PDSCH regions for the respective subframes are similarly labelled in Figure 6 as 602A, 602B, 602C, etc. Each subframe represented in Figure 6 is in essence a simplified version of what is represented in Figure 3. Thus, the control regions 600 support the PCFICH, PHICH and PDCCH channels as discussed above while the PDSCH regions 602 support user-plane data and system information (among other things) and the EPDCCD if implemented. The most significant aspect of the control region 600 in the context of

embodiments of the present disclosure relate to the PDCCH and so for simplicity the control regions 600 may sometimes be referred to herein as PDCCH regions 600.

Before explaining the repeated transmissions approach to providing coverage extension represented in Figure 6 it is considered helpful to clarify some aspects of the terminology to be used herein. The term "repeat transmission" (and related terms) will be used to refer to a transmission in an individual subframe which is part of a sequence of transmissions that are being repeated for the purposes of providing coverage extension for a message being conveyed between a base station and a terminal device (such as a PDCCH message or a PDSCH message). Thus in a coverage extension context, the transmission of a (E)PDCCH message comprises a plurality of "repeat transmissions" on (E)PDCCH and the transmission of a PDSCH message comprises a plurality of "repeat transmissions" on PDSCH. The term "re-transmission" (and related terms) will be used to refer to the transmission of a message that has already been sent at least once before. These terms should be interpreted accordingly unless the context demands otherwise.

For the example repeat transmission approach to coverage extension represented in Figure 6 it is assumed for ease of representation the approach relies on providing only three repeat transmissions for each PDCCH message and each PDSCH message. It will, however, be appreciated that in practice larger numbers of repeat transmissions will typically be involved, for example there may be tens or hundreds of repeats comprising each message to provide a correspondingly higher degree of coverage extension. Furthermore, it will be appreciated that PDCCH messages and PDSCH messages may comprise different numbers of repeat transmissions (for example because different coding schemes are adopted meaning that different numbers of repeat transmissions are needed for a given probability of successful reception).

Thus, referring to Figure 6, subframes A, B and C are used to signal a PDCCH message addressed to SI-RNTI by sending three repeat PDCCH transmissions in the respective PDCCH regions 600A, 600B, 600C. Each PDCCH repeat transmission addressed to SI-RNTI in the PDCCH regions 600A, 600B, 600C in effect comprises a duplication of the same downlink control information which a terminal device can combine to seek to establish the content of the PDCCH message. For this example repeat-transmission based coverage extension scheme it is assumed a particular type of message subject to repeat transmissions is addressed to the same RNTI (e.g. SI-RNTI for a system information related type of messages) as if the same type of message were subject to conventional single-subframe transmission. However, as discussed further below, in accordance with certain embodiments of the disclosure identifiers having different characteristics (e.g. values) may be used for a given type of message depending on whether the messages to be sent in accordance with a first transmission scheme (e.g. using a conventional single subframe based transmission approach) or a second transmission scheme (e.g. using a repeat-transmission scheme for coverage extension). Furthermore, it will be appreciated the approach of using identifiers associated with a particular type of message having different characteristics according to what transmission scheme is to be used to transmit the message can be used in accordance with embodiments of the disclosure with or without the use of validity periods as disclosed herein.

The PDCCH message comprising the three repeat transmissions in the PDCCH regions of subframes A, B and C indicates resource blocks to be used for a subsequent PDSCH message comprising the transmission of system information. This PDSCH message itself comprises a plurality of repeat transmissions, and, in this example, are represented by shading in the PDSCH regions 602D, 602E and 602F of subframes D, E and F. The transmission resources, for example in terms of specific resource

elements, used to convey the repeat transmissions of the system information message in the PDSCH regions 602D, 602E and 602F are indicated in the corresponding PDCCH message addressed to SI-RNTI and comprising the repeat transmissions in PDCCH regions 600A, 600B, 600C in accordance with conventional resource allocation techniques in the context of coverage extension using repeat transmissions. Whilst the shading in Figure 6 schematically represents the same frequency resources being used for each repeat transmission in the respective PDSCH regions 602D, 602E and 602F of the subframes D, E, F, in principle the repeat-transmission approach may be configured to include frequency hopping for the different repeat transmissions comprising the PDSCH message sent in subframes D, E, F. The nature of any such frequency hopping may be pre-defined, for example it may be pre-specified according to an operating standard for the wireless telecommunications system, or it may be established in previous RRC (radio resource control) signalling, or it may be indicated in the PDCCH message.

As schematically represented in Figure 6 there is a gap between subframes C and D. This follows the currently-proposed approaches for repeat-transmission coverage extension whereby the transmission of a PDSCH message comprising a plurality of repeat transmissions does not start until after all repeat transmissions of the corresponding PDCCH message have been sent. This is to help reduce the buffering requirements at the terminal device. Furthermore, current proposals indicate there should be no overlap between the end of the repeat transmissions comprising the PDCCH message and the start of the repeat transmissions comprising the PDSCH message. It will, however, be appreciated the specific implementation of such aspects of a repeat transmission approach for providing coverage extension are not significant to the principles underlying the present disclosure. That is to say, the principles described herein may equally be implemented in association with other repeat transmission approaches (e.g. with repeat transmissions of PDCCH and its corresponding PDSCH occurring in the same subframe).

In subframes following the transmission of the system information message as schematically indicated in subframes D, E and F in Figure 6, the wireless telecommunications system continues to operate in accordance with its normal operating techniques until subframe G represented. Subframe G represents the beginning of another system information message. As noted above, system information messages can be regularly retransmitted in accordance with LTE techniques, and in this regard the system information message beginning at subframe G is considered in this example to be a re-transmission of the system information message transmitted using subframes A to F as discussed above. The specific timing of the re-transmission of system information (i.e. the timing of subframe G relative to subframe A) may follow any conventional system information re-transmission schedule. The principles underlying the re-transmission of the system information message starting from subframe G follow those described above. Thus, a PDCCH message addressed to SI-RNTI is sent using the PDCCH regions 600G, 600H and 600I of subframes G, H and I to allocate resources for a PDSCH message comprising three repeat transmissions in the PDSCH regions 602J, 602K and 602L in subframes J, K and L as indicated by shading in Figure 6. It may be noted in this example the frequencies of the resource elements for the re-transmission of the system information message on PDSCH in subframes J, K, L is different from that used in subframes D, E, F for the previous transmission, but this is not of any particular significance. Furthermore, the transmissions of the PDSCH message in subframes D, E, F, J, K, L may comprise different so-called redundancy versions of the PDSCH message comprising different combinations of information bits and redundancy bits arising from a forward error correction coding process.

It will be appreciated the transmission resources represented in Figure 6 which are not involved in the SI message signalling discussed above can be used for other communications in the network in the usual manner. In particular, it will be appreciated that although the entirety of the PDCCH regions associated with repeat transmissions of the PDCCH for the system information messages are shown shaded in Figure 6, this is merely to highlight those subframes in which a PDCCH for the system information messages is transmitted compared to those where it is not, and in practice these regions will comprise multiple PDCCH messages addressing different terminal devices for allocating resources for various different types of communication on PDSCH.

System information signalling in LTE is sent on what is approaching a more or less continuous basis. This means there is a considerable amount of PDSCH traffic for broadcasting system information messages comprising the SIBs. There is a corresponding requirement for PDCCH signalling to schedule the PDSCH resources for system information messages. The inventors have recognised that this can become a significant issue in a coverage extension scenario where a number of repetitions are expected, as illustrated in Figure 6. This is because for each PDSCH message comprising a plurality of PDSCH repeat transmissions (i.e. the PDSCH message sent using resources in subframes D, E and F and the PDSCH message sent using resources in subframes J, K and L) there is a corresponding SI-RNTI PDCCH message comprising a plurality of PDCCH repeat transmissions (i.e. the PDCCH message sent using resources in subframes A, B and C and the PDCCH message sent using resources in subframes G, H and I). With the potential for perhaps a hundred or more repeat transmissions to provide coverage extension to the edge of a base station's corresponding cell for system information messages a large fraction of the available control region resources will be needed to support this function following the approach of Figure 6. There is of course a corresponding increase in the use of PDSCH resources with the approach represented in Figure 6, but it is to be expected that in many situations it will be PDCCH resources that are more at a premium owing to the limited resources available in the control channel region for PDCCH and the priority typically given to PDSCH over EPDCCH in the PDSCH region. This is especially likely in networks supporting large numbers of MTC devices since these are likely to have a higher ratio of control signalling to data signalling as compared to the traffic profiles typically associated with conventional terminal devices. The increased PDCCH and/or EPDCCH resources needed to support repeat transmissions of system information messages could ultimately make it difficult to schedule unicast PDSCH transmissions to terminal devices operating within the system because of a lack an availability of control region resources to indicate the allocation of PDSCH resources and/or a lack of PDSCH region resource to indicate the allocation of PDSCH resources.

To address this type of issue there have been proposals to stop using PDCCH and EPDCCH messages resource allocations for PDSCH messages comprising system information (i.e. for system information messages). One proposal (described in the 3GPP document R1-135422, "On the need of PDCCH for SIB and other Common Channel", Mediatek, RAN1#75, San Francisco, November 2013 [4]) is to avoid providing any scheduling information in respect of system information-carrying PDSCH transmissions. Instead, a terminal device will be expected to perform blind searching of the PDSCH region to identify if there are any relevant system information transmissions. A drawback with this approach is a significant increase in the processing load required for terminal devices. To reduce the processing load required at the terminal device to a more manageable level the system information messages could be confined to a restricted subset of transmission resources comprising the PDSCH region. However, this approach still requires additional processing tasks to be performed by the terminal device and introduces reduced

scheduling flexibility. Another proposal (described in the 3GPP document R1-134207, "Coverage enhancement techniques for PBCH", Alcatel-Lucent, Alcatel-Lucent Shanghai Bell, RAN1#74bis, Guangzhou, October 2013 [5]) is to avoid using PDCCH messages to provide scheduling information in respect of system information-carrying PDSCH messages. Instead it is proposed that some of the spare bits currently available in the Master Information Block (MIB) in LTE are used for providing scheduling indications for system information messages. However, there are a limited number of spare bits available for this and so the approach does not allow for any significant degree of flexibility in scheduling system information messages, and furthermore the approach further reduces the number of spare bits available for other uses.

In view of these issues, the inventors have developed an alternative approach for reducing the amount of control signalling required to support resource allocations for higher-layer transmissions in a wireless telecommunications system. In particular, but not exclusively, the inventors have developed an approach which may be applied for reducing the amount of control-channel signalling required to support resource allocations for downlink messages, such as system information messages, and in particular for messages which may be subject to re-transmissions on a defined schedule and which may, in some cases, be sent using a repeat transmission approach to provide a degree of coverage extension.

Figure 7 is similar to, and represents various aspects that will be understood from, Figure 6, but shows an approach in accordance with certain embodiments of the present disclosure. Figure 8 is a signalling ladder diagram schematically representing modes of operation for the terminal device 508 and the base station 504 schematically represented in Figure 5 in accordance with some embodiments of the present disclosure for implementing an approach of the kind represented in Figure 7. In broad summary, some embodiments of the disclosure introduce the concept of a validity period for a PDCCH message to thereby indicate transmission resources that may be used for a plurality of PDSCH messages within the validity period. That is to say the control message transmitted on the PDCCH is considered valid for a period that is longer than the period needed to transmit a single PDSCH message (whether in one subframe or with repeat transmissions in a plurality of subframes to provide coverage extension). This means multiple PDSCH messages can in effect be scheduled using the control-region resources of only a single PDCCH message. There are various different ways in which the validity period may be established/determined, as discussed further below.

For the example represented in Figure 7, and as with Figure 6, it is assumed system information is being transmitted from a base station to a terminal device with a repeat transmission approach to providing coverage extension. Again the example approach to coverage extension represented in Figure 7 is assumed for ease of representation to rely on providing only three repeat transmissions for each PDCCH and PDSCH message. However, as noted above, it will be appreciated that in practice larger numbers of repeat transmissions will typically be involved, for example there may be tens or hundreds of repeats comprising each message to provide a correspondingly higher degree of coverage extension. Furthermore, it will be appreciated that PDCCH messages and PDSCH messages need not necessarily comprise the same number of repeat transmissions (for example different coding schemes may be adopted meaning that different numbers of repeat transmissions are appropriate to provide a desired probability of successful reception for each message).

Thus Figure 7 schematically represents an approach for providing coverage extension through repeated transmissions for a plurality of SI messages with reduced control signalling overhead in accordance with

an embodiment of the disclosure. Figure 7 schematically shows a sequence of LTE downlink subframes (labelled as subframes "O", "P", "Q", …, "Z" to aid explanation) with shading to schematically indicate which regions in which subframes are used to convey messages associated with the system information. The subframes represented in Figure 7 comprise four groups of three contiguous subframes with spaces between the groups as schematically indicated by dotted lines. Although not shown in Figure 7, the gaps between the groups comprise a continuing sequence of subframes used for other communications that are not relevant to the system information messaging considered here. As discussed above, each subframe comprises a control region 700 and a PDSCH region 702. The control regions 700 for the respective subframes are labelled in Figure 7 with the identification letter for the relevant subframe, i.e. as 700O, 700P, 700Q, etc. The PDSCH regions for the respective subframes are similarly labelled in Figure 6 as 702O, 702P, 702Q, etc.

As already noted above, aspects of the operation of a wireless telecommunications system in accordance with embodiments of the disclosure, for example as shown in Figure 7 and 8, which are not specifically described herein may be implemented in accordance with any conventional techniques. In this regard, insofar as the operation of embodiments of the disclosure follow conventional techniques the respective subframes represented in Figure 7 may be similar to that is represented in Figure 3. Thus, the control regions 700 support PCFICH, PHICH and PDCCH channels as discussed above while the PDSCH regions 702 support user-plane data and system information (among other things) and EPDCCH if implemented. The most significant aspect of the control region 700 in the context of embodiments of the present disclosure relate to the PDCCH and so for simplicity the control regions 700 may sometimes be referred to herein as PDCCH regions 700.

Thus referring to Figure 7 subframes O, P and Q are used to signal a PDCCH message addressed to SI-RNTI by sending three repeat PDCCH transmissions in the respective PDCCH regions 700O, 700P, 700Q. Each PDCCH repeat transmission addressed to SI-RNTI in the PDCCH regions 700O, 700P, 700Q in effect comprises a duplication of the same downlink control information which a terminal device can combine to seek to establish the content of the PDCCH message addressed to SI-RNTI in accordance with conventional techniques for coverage extension through repeat transmissions. For this example implementation of a repeat-transmission based coverage extension scheme it is again assumed a particular type of message subject to repeat transmissions is addressed to the same RNTI (e.g. SI-RNTI for a system information related type of messages) as if the same type of message were subject to conventional single-subframe transmission. However, as discussed further below, in accordance with certain embodiments of the disclosure identifiers having different characteristics (e.g. in terms of their value or control region search space) may be used for a given type of message depending on whether the messages to be sent in accordance with a first transmission scheme (e.g. using a conventional single subframe based transmission approach) or a second transmission scheme (e.g. using a repeat-transmission scheme for coverage extension). Furthermore, it will be appreciated the approach of using identifiers associated with a particular type of message having different characteristics according to the transmission scheme is to be used in accordance with embodiments of the disclosure may or may not also implement an approach using validity periods as disclosed herein.

The PDCCH message sent in subframes O, P and Q in Figure 7 differs from a conventional PDCCH message, for example of the kind transmitted in subframes A, B and C of Figure 6, in that it is associated with a validity period that is sufficient to span the transmission of a plurality of PDSCH messages. This is

different from the conventional approach in which a PDCCH message is simply associated with a single PDSCH message. The validity period for the PDCCH message is known to both the base station and the terminal device. For example, the validity period may be based on a defined standard for operations in accordance with an embodiment of the disclosure, whereby the base station and the terminal device can each determine the validity period from the defined standard. In other embodiments the base station may have flexibility to select the validity period, for example according to current scheduling requirements, and to communicate an indication of the validity period to the terminal device(s) to which the PDCCH message is addressed. Some example implementation of this approach are discussed further below.

The PDCCH message comprising the three repeat transmissions in the PDCCH regions of subframes O, P and Q indicate transmission resource blocks to be used for a subsequent PDSCH message comprising the transmission of system information. This PDSCH message itself comprises a plurality of repeat transmissions, and, in this example, are represented by shading in the PDSCH regions 702R, 702S and 702T of subframes D, E and F. The manner in which the PDCCH message indicates the corresponding PDSCH resources in subframes R, S and T may be in accordance with conventional techniques/signalling protocols. That is to say, the transmission resources, for example in terms of specific resource elements, used to convey the repeat transmissions of the system information message in the PDSCH regions 702R, 702S and 702T may be indicated in the corresponding PDCCH message addressed to SI-RNTI and comprising the repeat transmissions in PDCCH regions 700O, 700P, 700Q in accordance with conventional resource allocation techniques in the context of coverage extension using repeat transmissions. Whilst the shading in Figure 7 schematically represents the same frequency resources being used for each repeat transmission in the respective PDSCH regions 702R, 702S and 702T of the subframes R, S and T, in principle the repeat-transmission approach may be configured to include frequency hopping for the different repeat transmissions comprising the PDSCH message sent in subframes R, S and T. The nature of any such frequency hopping may be pre-defined, for example it may be pre-specified according to an operating standard for the wireless telecommunications system, or it may be established in previous RRC (radio resource control) signalling, or it may be indicated in the PDCCH message.

As schematically represented in Figure 7 there is a gap between subframes C and D. This again follows the currently-proposed approaches for repeat-transmission coverage extension whereby the transmission of a PDSCH message comprising a plurality of repeat transmissions does not start until after all repeat transmissions of the corresponding PDCCH message have been sent. Furthermore, some proposals indicate there should be no overlap between the end of the repeat transmissions comprising the PDCCH message and the start of the repeat transmissions comprising the PDSCH message. It will, however, be appreciated the specific implementation of such aspects of a repeat transmission approach for providing coverage extension are not significant to the principles underlying the present disclosure. That is to say, the principles described herein may equally be implemented in association with other repeat transmission approaches (e.g. with repeat transmissions of PDCCH and an associated PDSCH occurring in the same subframe).

Thus, the communication of the PDCCH message in subframes O, P and Q and the corresponding communication of the PDSCH message conveying system information in subframes R, S and T as represented in Figure 7 may follow the same general principles as the approach represented in Figure 6. Similarly, in subframes following the repeat-transmission approach for transmitting the system information

message as schematically indicated in subframes R, S and T in Figure 7, the wireless telecommunications system may continue to operate in accordance with its normal operating techniques for conveying other messages.

As noted above, system information messages are regularly retransmitted in accordance with LTE techniques, and the approach of Figure 7 differs from the approach of Figure 6 in respect of how a subsequent transmission of system information is scheduled on PDSCH in subframes X, Y and Z. In particular, the approach of Figure 7 differs from the approach of Figure 6 if the subsequent retransmission of system information occurs within the validity period associated with the previously-received PDCCH message in subframes O, P and Q initially sent in association with the previously-received system information message on PDSCH in subframes R, S and T. In LTE the transmission of system information follows a defined timing schedule, for example based on the system information window defined for the relevant system information. Thus, a base station and a terminal device are able to independently determine in which subframe a system information message will be transmitted on PDSCH (or which plurality of subframes in the case of coverage extension through repeat-transmissions as in this example). Thus, in the example of Figure 7, a terminal device to which the system information is addressed can determine that a system information message is to be transmitted in subframes X, Y and Z.

Referring back to Figure 6, the terminal device receiving the system information on PDSCH in subframes J, K and L can similarly determine in accordance with conventional techniques that the transmission will occur in these subframes. However, to determine the specific resources (e.g. in terms of specific OFDM carriers / resource blocks) on which the transmissions will occur within the relevant subframe(s) the terminal device must first receive the corresponding PDCCH allocation message sent in subframes G, H and I.

However, in the approach of Figure 7 in accordance with an embodiment of the present disclosure the resource allocation used for the PDSCH transmissions of the system information message on subframes X, Y and Z is determined from the previous resource allocation message sent on PDCCH in subframes O, P and Q. For example, in accordance with one approach the specific PDSCH resources (e.g. in terms of frequency) to be used for transmitting the subsequent system information message in subframes X,Y and Z are assumed to be the same as the specific PDSCH resources (e.g. in terms of frequency) used for transmitting the system information message in subframes R, S and T and indicated in the PDCCH message sent in subframes O, P and Q. However, it will be appreciated that other mappings can be adopted. For example, the frequencies to be used can be configured to shift in accordance with a predefined pattern for each retransmission within the validity period for the PDCCH message.

Thus, in accordance with an embodiment of the disclosure, and in contrast to the approach in the corresponding subframes in Figure 6, there is no PDCCH message sent in subframes U, V and W to support the system information message sent on PDSCH in subframes X, Y and Z. Instead it is determined that a previous PDCCH message remains valid (because its associated validity period has yet to expire), and the resources used for conveying the system information message on PDSCH in subframes X, Y and Z are derived from the previous PDCCH.

This approach has an advantage of freeing up the control-channel resources, in particular in subframes U, V and W for the example subframes represented in Figure 7. The approach can also help reduce the

amount of processing required by the terminal device (since the terminal device does not need to decode a separate PDCCH message for each and every PDSCH message). Furthermore the approach can reduce latency in situations that require high repetition numbers because there is no need to wait to receive a series of PDCCH repetitions before receiving each series of PDSCH repetitions.

It will be appreciated the transmission resources represented in Figure 7 that are not involved in the SI message signalling discussed above can be used for other communications in the network in the usual manner. In particular, it will be appreciated that although the entirety of the PDCCH regions associated with repeat transmissions of the PDCCH for the system information messages are shown shaded in Figure 7, this is merely to highlight those subframes in which a PDCCH for the system information messages is transmitted compared to those where it is not, and in practice these regions will comprise multiple PDCCH messages addressing different terminal devices for allocating resources for various different types of communication on PDSCH.

Thus, to summarise an approach in accordance with an embodiment of the disclosure as represented in Figure 7, and with reference to Figure 8, a base station 504 is transmitting system information messages to terminal devices, including terminal device 508, according to a pre-defined timing schedule. The predefined timing schedule may follow conventional LTE techniques for transmitting system information. It is assumed the processing represented in Figure 8 starts just prior to subframe O at the beginning of the series of subframes represented in Figure 7 and while there is no currently valid PDCCH message for the relevant system information. Thus, in a first step S1 in Figure 8 the base station determines a validity period that is to apply for an upcoming control-plane message that is to be transmitted to allocate resources for system information messages on PDSCH. The duration of a validity period for a given PDCCH message may be fixed / predetermined according to a specific implementation, for example by a network operator, or may be selectable by a base station according to current conditions. The validity period might be relatively short, for example it might only comprise the time required to transmit two PDSCH messages to provide a potential saving of one PDCCH message transmission. On the other hand, the validity period might be significant number, for example hundreds, thousands, tens of thousands, or even more subframes. In general a longer validity period may be preferred to reduce the number of PDCCH message transmissions, while an overly-long validity period may be considered to overly restrict scheduling flexibility. An appropriate validity period in a given situation may depend on current traffic conditions within a cell supported by a base station. For example, if a base station is currently supporting a large number of terminal devices it may be more appropriate to select a relatively long validity period to provide a correspondingly large saving in PDCCH message transmissions. However, if a base station is currently supporting only a small number of terminal devices with low traffic requirements (i.e. such that PDCCH congestion is not an overly significant concern), it may be more appropriate to select a relatively short validity period to provide a corresponding increase in scheduling flexibility (example to take better account of fluctuations in radio propagation conditions or traffic changes). In one example a current proportion of non-MTC traffic may be used to help determine an appropriate validity period for a repeated PDCCH. Generally speaking, the higher this proportion, the higher the proportion of non-delay-tolerant non-small-message terminal devices in the cell whose performance may be disrupted by a heavy use of control channel resources due to repeated PDCCH transmission. Therefore, as the proportion of relatively higher priority terminal devices (e.g. non-MTC terminal devices) increases, the base station may opt for longer PDCCH validity times, especially for use in association with SI-messages.

In step S2 the base station transmits a control-plane message, which can also be referred to as a control message (using repeat transmissions for coverage extension in this example) to allocate the resources for subsequent system information messages on PDSCH. This control message is received and decoded by the terminal device 508. This aspect of the operation may be based generally on conventional techniques, for example using a PDCCH message addressed to an SI-RNTI in LTE. Furthermore, the specific resources selected by the base station for allocation to the system information messages may be selected in accordance with established scheduling techniques in wireless communication systems. Thus, step S2 correspond with the transmissions made in subframes O, P and Q of Figure 7.

In step S3 the terminal device determines the validity period for the control-plane message received in step S2. There are various ways in which the terminal device may determine the validity period for the control-plane resource allocation message in accordance with various embodiments of the disclosure, and some examples are discussed further below.

In step S4 the base station proceeds to transmit a system information message (using repeat transmissions for coverage extension in this example) in accordance with the resource allocation identified by the control-plane (PDCCH) message of step S2. This aspect of the operation may be made broadly in accordance with conventional techniques. The terminal device seeks to receive and decode this system information message (SI message #1) in accordance with conventional techniques.

In step S5 the base station determines it is time to transmit another system information message (SI message #2) according to the predefined timing for periodic system information transmissions in the wireless telecommunications system. The base station further determines the validity period for the control-plane message sent in step S2 has not yet expired. Accordingly, the base station does not send any new control-plane message to support the new system information message that is about to be transmitted (SI message#2). Instead the base station proceeds to transmit the system information message (using repeat transmissions for coverage extension in this example) in accordance with resource allocations derived from the previously-sent control-plane (PDCCH) message of step S2. For example, the base station may be configured to simply use the same frequency resources for transmitting SI message #2 in step S5 as were used for transmitting SI message #1 in step S2. The terminal device likewise determines the expected transmission timing for the new system information message (SI message #2) from the predefined timing for system information transmissions and also determines the validity period for the previous control-plane message received in step S2 has not expired. Accordingly, the terminal device need not seek to receive a new control-plane message to indicate the PDSCH resources for the new system information message that is to be next transmitted (SI message#2). Instead the terminal device simply assumes the transmission is to be made in the relevant subframes (determined according to the predefined timing) on frequency resources derived from the previously-sent control-plane (PDCCH) message of step S2. Once the terminal device has determined the specific resources on which to expect the system information message in step S5 (SI message #2) it may proceed to receive and decode the system information message in accordance with conventional PDSCH transmission techniques.

As noted above the timing s for specific SI messages in LTE are based on SI windows. Conventionally it is the transmission of an associated PDCCH message addressed to the relevant system information RNTI which determines the precise subframe(s) in which the system information message PDSCH is transmitted. However, in accordance with certain embodiments of the disclosure there can be PDSCH

messages conveying system information in an SI windows without there being a corresponding PDCCH message in that SI window. There are a number of different ways in which a terminal device can determine the relevant subframe for a further PDSDH message transmitted within the validity period of a previously-received PDCCH message in accordance with embodiments of the disclosure. In one case, the base station may be configured to send the PDSCH message in a predefined subframe of the SI window. In principle this could be permanently fixed for all PDSCH system information messages at the cost of reduced scheduling flexibility. In another case the subframe(s) could be based on the subframe(s) used in association with the initial PDCCH message. For example, if the initial PDCCH indicates a system information message is to be sent in subframe number n (or starting in subframe n for repeat transitions for coverage extension) within a particular SI window, subsequent PDSCH messages within the validity period of the PDCCH might also be sent in (or start in) subframe n of the relevant SI window. In another example, the base station may retain the flexibility to send (or start sending when using repeat transmissions) the subsequent system information message in any subframe within the SI window. In this case a terminal device may check for a newly addressed PDCCH message in the subframes in the SI window in the normal way, and if a new PDCCH message is not found, the terminal device may decode the PDSCH resources indicated in accordance with a previously-received still valid PDCCH message in the same subframe(s) relative to the SI window as for the previous transmission. In principle, with sufficient processing power, the terminal device could simply seek to decode the relevant resources in all subframes of an SI window to see if an SI message can be decoded.

The process of the base station sending further system information messages, and the terminal device receiving the further information messages, based on transmission resource allocation information indicated in the control-plane message of step S2 may continue (as schematically indicated in step S6 for transmitting SI message #n) until the validity period for the control-plane message received in step S2 has expired, as schematically indicated in step S7.

Following step S7 the processing in effect cycles back to where it started prior to step S1. The base station may thus determine a new validity period for a new control message to be sent in a further step corresponding with step S2 (the base station determines that a new PDCCH message is required because the previous one has expired). Processing may then continue from this point in the manner discussed above.

Thus, the various example schemes represented in Figures 7 and 8, and described above, provide an approach in which control-plane messages, and in particular SI-messages, are associated with a validity period that extends for more than one message transmission of the associated PDSCH. For example, for SIBs in SI-messages, one SI-RNTI addressed PDCCH message can provide the control information for multiple transmissions of SIBs, and in general over multiple SI-windows. Similar operation for other types of message, for example messages addressed to other common search-space RNTIs, may be adopted in accordance with other examples. This kind of approach can help reduce control resource requirements, which can be especially important in the context of coverage extension where according to conventional techniques PDCCH (comprising multiple repeat transmissions) messages would have to be transmitted every time an SI-message (comprising multiple repeat transmissions) needed to be sent.

As noted above, SIBs in system information messages can in some cases remain unchanged for extended period, for example a few hours. A terminal device may thus combine system information message transmissions from across multiple SI-windows if it does not successfully decode an SI-

message at first attempt and with a sufficiently long validity period this can be achieved in accordance with the approaches described herein with reduced control signalling requirements than current schemes.

As noted above, there are various different ways in which the validity period for a PDCCH message may be established. In one simple example the period may be defined according to an operating standard of the wireless telecommunications system. Both the base station and the terminal device can in effect be hardwired with the validity period (or multiple validity periods associated with different types of messages). In another example the base station may have flexibility for determining a suitable validity period according to the implementation and traffic conditions at hand. In this case there are various different ways in which the validity period could be conveyed to a terminal device.

In one example the base station may be configured to convey a selected validity period to terminal devices by selecting a particular transmission characteristic, for example timing, for the PDCCH message with which the validity period is associated. According to current proposals for repeat transmission coverage extension in LTE, the starting subframe of a PDCCH message being transmitted in multiple subframes should be confined to a subset of subframes. This is because in some circumstances the terminal device may be required to blindly search over the possible numbers of repetitions the PDCCH might comprise. If it were allowed for a PDCCH messages comprising an arbitrary number of repeat transmissions to start in an arbitrary subframe this could be expected to give rise to significant complexity in the processing required of the terminal device. To address this there has been proposed an approach in which, for example, a PDCCH message comprising N repeats can only begin in subframes having a subframe number that is a multiple of N (i.e. 0, N, 2N, 3N,…). This reduces the set of possible repetition numbers the UE needs to consider per subframe. Thus, a similar approach could be used to convey information on PDCCH validity. This can be done by linking the validity period to the starting subframe number of the associated PDCCH message. For example, a PDCCH message commencing in subframe M might be taken to indicate a validity period corresponding to M SI-windows for the relevant system information. Thus, a terminal device can readily establish the relevant validity period from the timing of the relevant control-claim message. It may be noted that in some circumstances it may be preferable to assign longer PDCCH validity periods to PDSCH messages that comprise high numbers of repetitions.

In another example the base station may be configured to convey a selected validity period to terminal devices through explicit signalling, for example in the downlink control information (DCI) of the relevant PDCCH message. Thus, the DCI may comprise an indication of a number of subframes / radio frames corresponding to the validity period or may comprise an indication of a specific subframe / radio frame in which the validity period is to expire. In the application to the transmission of system information messages it may be preferable to indicate timings in respect of a number of SI-windows of validity.

In yet another example the terminal devices may be configured to simply assume the validity period for a given PDCCH message addressed to a given RNTI (e.g. SI-RNTI) extends until a subsequent PDCCH message addressed to the relevant RNTI is received. That is to say, the PDCCH message may be considered to remain valid until it is replaced by another PDCCH message. In this respect, in terms of the processing schematically represented in Figure 8, this corresponds with the terminal device determining the validity period for the control message (corresponding to step S3) at the same time at which the validity period expires (responding to step S7), with this being triggered by a new PDCCH message being received by the terminal device. In this approach a terminal device may thus monitor for a new PDCCH message addressed to the relevant RNTI in each subframe of each SI-window in the normal way until a

new PDCCH message is received to in effect define the end the validity period for the previous PDCCH message addressed to that RNTI.

Thus, one principle of the approaches described above in accordance with some embodiments of the disclosure is to associate a PDCCH message with a time defining its validity, that time being extensible beyond the time taken to convey a corresponding PDSCH message. A terminal device may thus assume the PDSCH resource allocation, MCS (modulation and coding scheme), TBS (transport block size), etc. in the DCI of the PDCCH message is valid for receiving multiple PDSCH messages during the PDCCH validity time. No further PDCCHs for multiple PDSCH messages need be sent during the validity time. Thus, in the case of SIB transmissions, the transmission of all SI-messages (including all transmissions within a SI-window of a particular SI-message), may be scheduled with a single transmission of SI-RNTI PDCCH with an appropriately configured validity period.

One particular situation in which approaches in accordance with the embodiments described above might be expected to be useful is where the transmissions are used to provide coverage extension on both PDCCH and PDSCH. However, similar principles can be applied where coverage extension is not being used, for example in respect of messages sent within single subframes.

Whilst the above-described embodiments have focused on system information messages, it will be appreciated that similar principles can be applied for other types of messages in wireless telecommunications systems, and especially for messages which rely on resource allocations occurring with some degree of predictable timing. For example, similar principles can be used for control signalling addressed to other common search space RNTIs, such as RA-RNTI and P-RNTI.

Thus a random access RNTI addressed PDCCH message received by a terminal device during an initial cell access may be associated with a validity period such that the transmission resources identified in association with the random access RNTI PDCCH message are taken to apply for later random access procedures in accordance with the principles set out above. The specific subframe of a RAR (random access response) window in which a subsequent RAR arrives can be established in a manner similar to that described above for system information within a predefined series of subframes comprising an SI-window

Similarly, a paging RNTI addressed PDCCH message may be associated with an extended validity in accordance with the principles described above. Thus a PDSCH resource allocation associated with a PDCCH message addressed to a paging RNTI transmitted in one subframe may be taken to indicate a PDSCH resource allocation in a subsequent subframe within a validity period associated with the PDCCH message. This may be especially appropriate for paging when a terminal device is in idle mode since there is a higher degree of predictability as to when paging messages may be sent according to a currently configured DRX, discontinuous reception, cycle. That is to say, the concept of PDDCH validity timers as discussed herein may be applied to the most recent P-RNTI PDCCH used to decode a paging message by an RRC_IDLE UE. An RRC_IDLE UE is only expected to monitor specific subframes for P-RNTI and is in DRX for other subframes. If the relevant PDCCH validity timer expires before a subsequent paging message is to be sent, the base station may provide a new P-RNTI PDCCH message to schedule the next paging message as normal. Otherwise the IDLE UE may assume the most recent such PDCCH is still valid. For an RRC_CONNECTED UE, there is less predictability as regards whether a particular subframe should contain P-RNTI PDCCH or not. For a connected mode terminal device the

principles described herein for paging messages might, for example, be used for subframes in which the UE would check for P-RNTI if it were in fact in IDLE mode. In other subframes the base station may send conventional paging signalling using PDCCH to page the UE in connected mode.

In a wireless telecommunications using repeat-transmissions for coverage extension there may be terminal devices which are not in coverage-limited locations and able to successfully decode individual ones of the PDCCH (or EPDCCH) repeat transmissions in each subframe. For example, and referring to Figure 7, a non-coverage-limited terminal device may be able to successfully decode the individual PDCCH repeat transmission in the control region 700O of subframe O. If this terminal device is not aware of the use of repeat-transmissions for coverage extension (for example because it is a legacy / conventional terminal device) it might be expected to assume the PDCCH information derived from the control region 700O subframe O applies to a system information transmission on PDSCH in the same subframe (i.e. in PDSCH region 702O). However, the terminal device would fail to receive the system information transmission (because it is not sent in accordance with this particular repeat-transmission protocol). Potentially this terminal device could seek to do this for each and every repeat transmission and so waste a considerable amount of processing effort needlessly decoding individual PDCCH repeat transmissions and associated PDSCH resources in the expectation of receiving system information messages which are not in fact being sent in those subframes. This is an issue which applies generally for repeat transmission approaches for coverage extension and is not specific to approaches based on validity periods as discussed herein.

Thus in accordance with certain embodiments of the disclosure an identifier (RNTI) having different characteristics (e.g. in terms of value or associated control region search space) may be associated with SI messages sent using a repeat transmission approach as compared to SI messages sent without using a repeat transmission approach. More generally, in a wireless telecommunications system supporting different transmission schemes for a given type (classification / category) of message (e.g. a message comprising a given radio resource control, RRC, information element, such as a system information related message or a paging request related message), a characteristic of an identifier associated with the message (i.e. an identifier to indicate which terminal device(s) the message is for) may be selected according to the transmission scheme used for the message. This approach may be implemented in accordance with certain embodiments of the disclosure regardless of whether the wireless telecommunications system also implements an approach using validity periods as described herein (i.e. the approach may be implemented in association with the principles of the repeat transmission scheme represented in Figure 6 as well as that represented in Figure 7). That is to say, the concept of associating a validity period with a control message and the concept of using different identifier characteristics according to a transmission scheme being used may be used together in combination or separately from one another in accordance with different embodiments of the disclosure.

A terminal device having the ability to receive transmissions using the repeat transmission approach can identify the transmissions as such directly from the associated identifier characteristic and receive the message accordingly. The characteristic for the identifier can be selected so that a terminal device not having the ability to receive transmissions using a repeat transmission approach, for example a legacy terminal device, does not recognise the message as being addressed to the terminal device, and so in effect ignores it. Such a terminal device may in effect ignore the message because, for example, the identifier has a value which is not recognised as a value relevant to the terminal device or because a search space for a control message conveying the identifier is not searched by the terminal device.

Thus, if in a particular implementation it is assumed that a repeat transmission approach to coverage extension is intended primarily for MTC-type devices, an MTC-specific system information radio network temporary identifier (MTC-SI-RNTI) may be established. PDCCH messages associated with repeat transmissions for conveying system information messages may thus be addressed to MTC-SI-RNTI instead of an SI-RNTI used for conveying system information that is not sent using repeat transmissions. More generally some embodiments of the disclosure propose introducing other repetition specific RNTIs to address messages that rely on repetitions for coverage extension to complement corresponding RNTIs in existing systems. Thus, system information messages to be sent in accordance with a non-repeat transmission technique may be associated with a conventional system information identifier (e.g. SI-RNTI) while system information messages to be sent in accordance with a repeat-transmission technique may be associated with a modified system information identifier (e.g. REPEAT-SI-RNTI).

Similar issues can arises for other common RNTIs associated with other types of message that may be sent using a repeat transmission approach. Thus corresponding RNTIs having different characteristics may also be established for these. For example, for each of SI-RNTI, P-RNTI, RA-RNTI, TPC-PUCCH-RNTI, TPC-PUSCH-RNTI and M-RNTI to be used for addressing non-repeat transmission messages, there may be established a corresponding RNTI having a different value to be used for addressing repeat-transmission messages (e.g. what might be generally referred to as REPEAT-RNTIs, such as REPEAT-SI-RNTI, REPEAT-P-RNTI, REPEAT-RA-RNTI, REPEAT-TPC-PUCCH-RNTI, REPEAT-TPC-PUSCH-RNTI and REPEAT-M-RNTI). Thus an approach in accordance with an embodiment of the disclosure may be used in association with messages selected from the group comprising: (i) a message associated with transmitting system information; (ii) a message associated with transmitting a paging message; (iii) a message associated with transmitting a random access response message; (iv) a message associated with transmitting power control information for an uplink control channel; (v) a message associated with transmitting power control information for an uplink data channel; and (vi) a message associated with a broadcast and / or multicast service. A similar approach can be taken for types of message associated with other common RNTIs which may be introduced in future.

In some implementations in which a message to be transmitted using a repeat-transmission approach in association with an identifier having a characteristic selected to indicate this, a component part of the message (e.g. a repeat transmission) may also be transmitted in one, or more, subframes in association with an identifier having a characteristic that would be used if the message were being transmitted using a conventional single-transmission approach. This will allow legacy terminal devices who are able to receive the message from only a single repeat transmission to in effect receive the message based on one of the repeat transmissions.

One advantage of associating identifiers for a given type of message with different characteristics based on the transmission scheme is the potential for more complete use of the available transmission resources. For example, referring to Figure 7, the initial SI-RNTI addressed PDCCH repeat transmission in the control region 700O of subframe O is part of a repeat transmission comprising three repeat transmissions in the respective control regions of subframes O, P and Q. This PDCCH message identifies resources (and other parameters) associated with a PDSCH message to be subsequently transmitted starting from subframe R as discussed above. As previously noted, it is expected for repeat-transmission based coverage extension there will be no PDSCH signalling associated with the PDCCH message until after the repeat transmissions comprising the PDCCH message had been made. In principle the PDSCH

transmission resources in the PDSCH regions 702O, 702P and 702Q of subframes O, P and Q corresponding to the resources allocated by the PDCCH message for use in subframe starting from subframe R could be used to support other transmissions. For example, the respective control regions 700O, 700P, 700R could include conventional single-subframe PDCCH messages allocating the relevant PDSCH transmission resources for another purpose, for example unicast data. However, it would be confusing for a legacy terminal device to decode a unicast PDCCH message and a SI PDCCH message resource allocation identifying the same resources in the same subframe. Thus by preventing the legacy terminal device from decoding the SI PDCCH signalling (through use of an appropriate distinguishing characteristic for the identifier as discussed herein), the legacy terminal device is free to receive unicast data on the relevant PDSCH resources (in association with an appropriately addressed PDCCH transmission indicating these resources).

In implementations in which the distinguishing characteristic for the identifier is its value (i.e. with one value, such as SI-RNTI, indicating conventional single-subframe transmission, and another value, such as REPEAT-SI-RNTI, indicating repeat-transmission coverage extension), the "new" REPEAT-RNTIs may be defined in accordance with an operating standard for the wireless telecommunications network in parallel with the corresponding RNTIs. For example, as noted above, in LTE the SI-RNTI has a fixed value 0xFFFF. In accordance with an embodiment of the disclosure a fixed value for a REPEAT-SI-RNTI may be selected from one of the currently reserved RNTIs in LTE (from 0xFFF4 to 0xFFC). Thus, if, for example, a value 0xFFF5 is allocated as REPEAT-SI-RNTI (i.e. an identifier for a system information related message sent using repeat transmissions), a PDCCH addressed to 0xFFFF can be identified as corresponding to a system information message sent without repetition whereas a PDCCH addressed to 0xFFF5 can be identified as corresponding to a system information message sent using repetition. A terminal device that is unaware of repetition will in effect ignore the PDCCH addressed to 0xFFF5 as this will not be recognised as a valid RNTI for the terminal device. Corresponding principles apply where EPDCCH is used.

In the above-described example the value of the RNTI is the characteristic used to distinguish between the different transmission schemes. However, in accordance with other embodiments of the disclosure, other characteristics can be used to distinguish identifiers to indicate different transmission schemes. For example, in LTE there are currently eight "spare" values that could be used as new REPEAT-RNTIs. This is a sufficient number of values to provide a corresponding RNTI to be used in association with a transmission scheme comprising repeat transmissions for all currently-existing common RNTIs. However, it may be considered preferable in some cases to avoid using these "spare" values so they remain free for other uses, or there may be a need for more REPEAT-RNTIs (for example, to provide multiple extra RNTI for a given type of message, e.g. a system information message, to indicate another aspect of the transmission scheme, for example the number of repeats). Thus, in accordance with some embodiments a REPEAT-RNTI may in fact have a value that is the same as its corresponding "conventional" RNTI (e.g. 0xFFFF for SI-RNTI and REPEAT-SI-RNTI) but be associated with a different search space. As is well known a terminal device will typically search a defined subset of control region resources to seek to identify any control messages associated with an identifier (RNTI) common to a plurality of terminal devices. The subset of control region resources is known as a search space and comprises a plurality of candidate PDCCH for the terminal device to check. This search space approach is taken to reduce the amount of processing required by the terminal device to seek to identify any relevant control messages. Thus, PDCCH signalling associated with the existing common RNTIs are constrained to a particular set of

candidate PDCCH comprising the common search space. In accordance with some embodiments of the disclosure the characteristic of the identifier which is used to distinguish the different potential transmission schemes may be based on the specific PDCCH resources used.

For example, a PDCCH message to be transmitted in accordance with a conventional single-subframe approach may be associated with an identifier, such as SI-RNTI, in the common search space in the usual way. However, a PDCCH message to be transmitted in accordance with a repeat-transmission approach may instead be associated with the same value of identifier, such as SI-RNTI, but transmitted on PDCCH resources outside the common search space. Thus in accordance with some implementations the distinguishing characteristic for the identifier based on the transmission scheme may be a search space with which the identifier is associated. Thus a PDCCH message addressed to SI-RNTI within a particular search space (e.g. the common search space in LTE) can be identified as corresponding to a system information message sent without repetition whereas a PDCCH transmission addressed to SI-RNTI outside the particular search space (e.g. outside the common search space in LTE) can be identified as corresponding to a system information message sent using repetition. A terminal device that is unaware of repetition will in effect ignore the PDCCH addressed to SI-RNTI outside the common search space as the terminal device will not search for the SI-RNTI outside the common search. Corresponding principles apply where EPDCCH is used. Thus in effect, identifiers associated with repeat transmissions may be associated with a newly-defined search space which is outside the search space used for the corresponding identifiers for conventional single-subframe transmissions. In some examples the new search space may support only a single aggregation level, for example an aggregation level 8 (the high aggregation level being appropriate in view of the coverage extension context). The new search space may be smaller (i.e. comprise fewer candidate PDCCH) than the search space for existing common RNTIs. This can help reduce the blind search load associated with the repeat transmissions comprising a message transmitted using a repeat transmission for coverage extension.

It will appreciated the advantages of establishing a new search space comprising a reduced number of candidate PDCCHs with a single relatively high aggregation level to be used in association with identifiers for repeat transmission messages can be applied even in circumstances where different identifier values are associated with the different transmission schemes. In such cases the repeat-specific identifier values may be selected from among the values that are available for use as identifiers in the wireless telecommunications system. In one example, as referred to above, a repeat-specific identifier values may simply match its corresponding non-repeat specific identify value (e.g. SI-RNTI) with the different search space in which a control message associated with the identifier is transmitted providing the distinguishing characteristic for the identifier for the selected transmission scheme. However, in another implementation the repeat-specific identifier values may be selected from, for example, identifiers available for other uses, for example in LTE from identifiers available for cell-specific RNTIs (which may range from 0x001 to 0xFFF3). This approach can in principle provide a relatively large number of repeat-specific identifiers. For example, one or more of the values normally used for C-RNTI can be in effect reserved as one or more repeat-specific RNTIs, such as REPEAT-SI-RNTI in the terminology used above, and likewise for types / classes / classifications of messages other than system information related messages, such as paging messages and random access a response messages etc. Thus a base station could in effect reserve (re-allocate) in its cell a number of RNTI values for one purpose as actually being for use as repeat-specific RNTIs. If any of the re-allocated subset of RNTIs comprising the repeat-specific RNTI is detected by a terminal device as addressing a PDCCH in the newly-defined search space, the terminal

device may be configured to interpret this as a repeat-specific RNTI. This may be based on the base station conveying in previous signalling to terminal devices that support repeat-transmission communications an indication of the relevant RNTI(s). Alternatively, or in addition, the relevant RNTI(s) may be defined in accordance with an operating standard of the network for reallocation within the new search space. If the PDCCH candidates comprising the new search space do not overlap with those of the pre-existing common search space and UE-specific search space used by legacy devices, then the RNTIs allocated as repeat-specific RNTIs within the new search space could continue to be used in the other search space without giving rise to the potential for confusion for legacy terminal devices. If, on the other hand, the PDCCH candidates comprising the new search space do overlap with those of the pre-existing common search space or UE-specific search space, then the base station may be configured to avoid allocating any of a currently re-allocated RNTI to terminal devices in accordance with the usual function for the RNTI (i.e. a C-RNTI reallocated for use as a repeat-specific identifier should not be allotted to a terminal device for use as a C-RNTI). This can be remedied as a straightforward matter of RNTI scheduling (for example, the base station can in effect simply treat the re-allocated RNTIs as being already allotted for use).

If multiple RNTI are made available for use for a given type of message, the particular RNTI selected for use in association with a particular message may be used to indicate a further characteristic of the message, for example a number of repeats or a specific PDCCH validity period where implemented. This can provide the base station with a simple mechanism for modifying the specific repeat and all validity period parameters associated with a particular message, thereby improving overall flexibility.

Determining which identifiers a terminal device should search for to seek to identify messages to be sent to the terminal device using a repeat transmission scheme can be done in accordance with the usual principles by linking it to transmission mode (TM) configuration. In one implementation the repeat-specific RNTIs provided in accordance with embodiments of the disclosure might apply in all transmission modes as the principles governing their use will in many respects be similar to conventional, search space RNTIs. There could also be a link with the category/type of the terminal device. For example, a new terminal device category identifier could be introduced (e.g. category 0) to indicate the terminal device is a particular type of terminal device, for example an MTC-based terminal device. The repeat-specific identifiers may then be considered to apply to all transmission modes for terminal devices of category 0 (if the repeat-transmission based scheme is limited to category 0 terminal devices), as well as for additional terminal device categories if the use of the repeat-transmission based scheme is more widely supported.

Figure 9 is a signalling ladder diagram schematically representing modes of operation for the terminal device 508 and the base station 504 schematically represented in Figure 5 in accordance with some embodiments of the present disclosure.

Processing begins in step T1 when the base station determines that a message is to be transmitted to one or more terminal devices. The message may, for example, be a broadcast message or a multicast message. The determination that a message is to be transmitted may be made in accordance with conventional operating procedures for the wireless communications system. For example, if the message is a system information message, step T1 may arise in accordance with a conventional timing schedule for transmitting system information messages. If the message is a paging message, step T1 may arise because an event has arisen which requires a terminal device to be paged. In this example it is assumed the message which is to be transmitted is a system information message which is relevant for (i.e.

address to an identifier associated with) terminal device 508. Furthermore, it is assumed the message may be transmitted in accordance with either one of a first transmission scheme using transmission resources in a first number of radio subframes (e.g. using conventional single-subframe transmission) or a second transmission scheme using transmission resources in a plurality radio subframes (e.g. using repeat-transmission for coverage extension).

In step T2 the base station determines which of the first and second transmission schemes are to be used for transmitting the message. That is to say, in this example, the base station determines whether or not a conventional single subframe approach or a repeat-transmission approach for coverage extension will be used for the message. There are a number of factors that may govern this determination, either individually or in combination. For example, the terminal devices in the wireless telecommunication system may comprise a first set of terminal devices and a second set of terminal devices step and T2 may be based on whether the one or more terminal devices to which the message is to be sent comprises terminal devices in the first or second sets. For example, the first set of terminal devices may comprise terminal devices that do not require coverage extension techniques to receive messages (or simply do not support coverage extension), whereas the second set of terminal devices may comprise terminal devices that do require coverage extension techniques to receive messages (and support repeat-transmission based coverage extension). Whether or not a specific terminal device requires coverage extension may, for example, be based on a measured radio propagation metric associated with the terminal device, for example a path loss, block error rate, a bit error rate, a packet error rate, a frame error rate, a symbol error rate, or negative or positive acknowledgement signalling rate (ACK/NACK) associated with communications with the terminal device. In another implementation the decision may take account of a specific identity or category for the one or more terminal devices to which the messages to be sent.

In step T3 the base station determines a characteristic of an identifier for the message based on the transmission scheme determined in step T2. This characteristic may be selected in accordance with any of the principles discussed above (e.g. use of different values for the identifier or different search spaces to be used with the identifier).

In step T4 the message is transmitted in accordance with the transmission scheme determined in step T2 and in association with an identifier, e.g. RNTI, having the characteristic determined in step T3. For example, the message may be transmitted in accordance with a repeat-transmission scheme as described herein with an identifier selected to have a characteristic to identify this, for example in accordance with any of the principles discussed above. In this regard the message may comprise one or other or both of a control message transmitted on a downlink control channel, e.g. a PDCCH message and another message transmitted on a downlink data channel, e.g. PDSCH (i.e. such that the identifier is transmitted separately from the message).

In step T5 the terminal device receives the transmitted signalling from the base station and determines the transmission scheme being used from the characteristic of the identifier. The terminal device may then proceed to receive and decode the message in accordance with the transmission scheme being used.

Thus, the process represented in Figure 9 demonstrates a mechanism by which a base station can readily indicates to terminal devices the transmission scheme being used for a given message. Once the terminal device has determined the transmission scheme, subsequent operation, for example in terms of

receiving the message, they be performed in accordance with conventional principles for receiving such messages. Furthermore, these techniques may be modified to incorporate a validity period approach such as discussed above.

Thus there has been described a wireless telecommunication system that comprises a base station and a terminal device communicating over a radio interface. The radio interface supports a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel (e.g. a physical downlink shared channel) for conveying other messages from the base station to the terminal device. The control messages convey information on resource allocations for the other messages on the downlink data channel. The other messages may comprise user-plane messages or control-plane messages. The terminal device is configured to receive a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel and determine a validity period for the control message. During the validity period for the control message the terminal device is configured to receive a plurality of the other messages from the base station on the downlink data channel using the allocated transmission resources.

There has also been described a wireless telecommunication system that comprises a base station arranged to communicate messages to one or more terminal devices over a radio interface. The radio interface has a radio frame structure comprising a plurality of subframes, wherein a message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes (e.g. one subframe) or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes (e.g. with repeat transmissions in a plurality of subframes). The message is transmitted in association with an identifier to indicate a terminal device to which the message is addressed. A characteristic for the identifier, for example a value or control region search space for the identifier, is dependent on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme. A terminal device to which the message is addressed determines the transmission scheme from the characteristic of the identifier and receives the message accordingly.

Further particular and preferred aspects of the present invention are set out in the accompanying independent and dependent claims. It will be appreciated that features of the dependent claims may be combined with features of the independent claims in combinations other than those explicitly set out in the claims.

Thus, the foregoing discussion discloses and describes merely exemplary embodiments of the present invention. As will be understood by those skilled in the art, the present invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. Accordingly, the disclosure of the present invention is intended to be illustrative, but not limiting of the scope of the invention, as well as other claims. The disclosure, including any readily discernible variants of the teachings herein, define, in part, the scope of the foregoing claim terminology such that no inventive subject matter is dedicated to the public.

Respective features of the present disclosure are defined by the following two groups of numbered paragraphs:

Group 1 of numbered paragraphs:

Paragraph 1. A method of operating a terminal device communicating with a base station in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the method comprises receiving a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel, determining a validity period for the control message, and receiving a plurality of other messages from the base station on the downlink data channel using the allocated transmission resources within the validity period for the control message.

Paragraph 2. The method of paragraph 1, wherein the other messages comprise system information messages.

Paragraph 3. The method of any preceding paragraph, wherein the system information messages comprise one or more system information blocks.

Paragraph 4. The method of any preceding paragraph, wherein the radio interface is based on a radio frame structure comprising a plurality of subframes, wherein each subframe comprises a control channel region for supporting the downlink control channel and a shared channel region for supporting the downlink data channel, and wherein respective ones of the control and / or the other messages comprise transmissions over a plurality of subframes.

Paragraph 5. The method of any preceding paragraph, wherein the validity period for the control message is determined in dependence on an identifier used in association with the control message.

Paragraph 6. The method of paragraph 5, wherein the identifier comprises an indication of one or more terminal devices to which the control message is addressed.

Paragraph 7. The method of any preceding paragraph, wherein the validity period for the control message is determined in dependence on a transmission characteristic of the control message.

Paragraph 8. The method of paragraph 7, wherein the transmission characteristic of the control message comprises a transmission time associated with the control message.

Paragraph 9. The method of any preceding paragraph, wherein the radio interface is based on a radio frame structure comprising a plurality of subframes, and wherein the timing of a subframe used to convey a first one of the plurality of other messages is used to determine the timing of a subframe used to convey a second one of the plurality of other messages within the validity period for the control message.

Paragraph 10. The method of any preceding paragraph, wherein the timing of a subframe used to convey the first one of the plurality of other messages relative to a first predefined range of subframes is used to determine the timing of a subframe used to convey the second one of the plurality of other messages relative to a second predefined range of subframes.

Paragraph 11. The method of any preceding paragraph, wherein the validity period is determined in dependence on a validity period indicator received in association with the control message.

Paragraph 12. The method of any preceding paragraph, wherein the validity period is determined in dependence on the time at which a subsequent control message is received.

Paragraph 13. The method of any preceding paragraph, wherein the other messages comprise random access response messages and / or paging messages..

Paragraph 14. A terminal device for communicating with a base station in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the terminal device comprises a controller unit and a transceiver unit configured to operate together to receive a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to receive a plurality of other messages from the base station on the downlink data channel using the allocated transmission resources within the validity period for the control message.

Paragraph 15. Circuitry for a terminal device communicating with a base station in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to cause the terminal device to receive a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to receive a plurality of other messages from the base station on the downlink data channel using the allocated transmission resources within the validity period for the control message

Paragraph 16. A method of operating a base station communicating with a terminal device in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the method comprises transmitting a control message to the terminal device conveying an indication of allocated transmission resources on the downlink data channel, determining a validity period for the control message, and transmitting a plurality of other messages to the terminal device on the downlink data channel using the allocated transmission resources within the validity period for the control message.

Paragraph 17. A base station for communicating with a terminal device in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the base station comprises a controller unit and a transceiver unit configured to operate together to transmit a control message to the terminal device conveying an indication of allocated transmission resources on the downlink data

channel, to determine a validity period for the control message, and to transmit a plurality of other messages to the terminal device on the downlink data channel using the allocated transmission resources within the validity period for the control message.

Paragraph 18. Circuitry for a base station communicating with a terminal device in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to cause the base station to transmit a control message to the terminal device conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to transmit a plurality of other messages to the terminal device on the downlink data channel using the allocated transmission resources within the validity period for the control message.

Group 2 of numbered paragraphs:

Paragraph 1. A method of operating a base station for communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein the method comprises selecting a characteristic for the identifier in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

Paragraph 2. The method of any preceding paragraph, wherein the first number of radio subframes comprises a single radio subframe and the second number of radio subframes comprises a plurality of radio subframes.

Paragraph 3. The method of any preceding paragraph, wherein terminal devices in the wireless telecommunications system comprise a first set of terminal devices and a second set of terminal devices, and wherein the method comprises determining whether to transmit the message in accordance with the first transmission scheme or the second transmission scheme in dependence on whether a terminal device to which the message is to be transmitted is a member of the first set of terminal devices or the second set of terminal devices.

Paragraph 4. The method of any preceding paragraph, wherein the method comprises determining whether to transmit the message in accordance with the first transmission scheme or the second transmission scheme in dependence on a radio propagation parameter associated with radio communications between the base station and a terminal device to which the message is to be transmitted.

Paragraph 5. The method of paragraph 4, wherein the radio propagation parameter is selected from the group comprising: a path loss; an error rate; a positive acknowledgment, ACK, signalling rate; and a negative acknowledgment signalling, NACK, rate.

Paragraph 6. The method of any preceding paragraph, wherein the method comprises determining whether to transmit the message in accordance with the first transmission scheme or the second transmission scheme in dependence on an identity and / or type of a terminal device to which the message is to be transmitted.

Paragraph 7. The method of any preceding paragraph, wherein the radio interface supports a downlink control channel for conveying control messages from the base station to terminal devices and a downlink data channel for conveying other messages from the base station to terminal devices, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the message comprises a control message transmitted on the downlink control channel.

Paragraph 8. The method of any preceding paragraph, wherein the radio interface supports a downlink control channel for conveying control messages from the base station to terminal devices and a downlink data channel for conveying other messages from the base station to terminal devices, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the message comprises one of the other messages transmitted on the downlink data channel.

Paragraph 9. The method of any preceding paragraph, wherein the identifier to indicate a terminal device to which the message is addressed is transmitted separately from the message.

1 Paragraph 0. The method of any preceding paragraph, wherein the identifier comprises a radio network temporary identifier, RNTI.

Paragraph 11. The method of any preceding paragraph, wherein the identifier is a common to a plurality of terminal devices.

Paragraph 12. The method of any preceding paragraph, wherein the message comprises a broadcast message.

Paragraph 13. The method of any preceding paragraph, wherein the message comprises a multicast message.

Paragraph 14. The method of any preceding paragraph, wherein for a given type of message the characteristic for the identifier is selected from a first predefined characteristic for the identifier associated with the given type of message and a second predefined characteristic for the identifier associated with the given type of message according to whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

Paragraph 15. The method of any preceding paragraph, wherein the message is selected from the group comprising: (i) a message associated with transmitting system information; (ii) a message associated with transmitting a paging message; (iii) a message associated with transmitting a random access response message; (iv) a message associated with transmitting power control information for an uplink control

channel; (v) a message associated with transmitting power control information for an uplink data channel; and (vi) a message associated with a broadcast and / or multicast service.

Paragraph 16. The method of any preceding paragraph, wherein for a message to be transmitted in accordance with the second transmission scheme, a component of the message transmitted in one of the second number of subframes is associated with a characteristic for the identifier corresponding to that which would be used if the message were to be transmitted in accordance with the first transmission scheme.

Paragraph 17. The method of any preceding paragraph, wherein the characteristic for the identifier comprises a value for the identifier.

Paragraph 18. The method of any preceding paragraph, wherein the characteristic for the identifier comprises a search space in which a terminal device searches using the identifier to determine if a message has been addressed to the terminal device.

Paragraph 19. The method of any preceding paragraph, wherein the method comprises selecting the characteristic for the identifier from a plurality of different characteristics associated with different types of message.

Paragraph 20. The method of any preceding paragraph, wherein the characteristic for the identifier to be selected for a message to be transmitted in accordance with the second transmission scheme is defined in accordance with an operating standard for the wireless telecommunications system.

Paragraph 21. The method of any preceding paragraph, further comprising the base station pre-defining the characteristic for the identifier to be selected for a message to be transmitted in accordance with the second transmission scheme.

Paragraph 22. The method of paragraph 21, wherein the pre-defining the characteristic for the identifier is a value for the identifier selected from among a plurality of values.

Paragraph 23. A base station for communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the base station comprises a controller unit and a transceiver unit configured to operate together such that the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein a characteristic for the identifier is selected in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

Paragraph 24. Circuitry for a base station communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the circuitry comprises a controller element and a transceiver element configured to operate together such that the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of

radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein a characteristic for the identifier is selected in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

Paragraph 25. A method of operating a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the method comprises determining from an identifier associated with the message that the message is addressed to the terminal device, and further determining from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

Paragraph 26. A terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the terminal device comprises a controller unit and a transceiver unit configured to operate together to determine from an identifier associated with the message that the message is addressed to the terminal device, and to further determine from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

Paragraph 27. Circuitry for a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to determine from an identifier associated with the message that the message is addressed to the terminal device, and to further determine from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

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5

CLAIMS

What is claimed is:

1. A method of operating a base station for communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein the method comprises selecting a characteristic for the identifier in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

2. The method of claim 1, wherein the first number of radio subframes comprises a single radio subframe and the second number of radio subframes comprises a plurality of radio subframes.

3. The method of claim 1, wherein terminal devices in the wireless telecommunications system comprise a first set of terminal devices and a second set of terminal devices, and wherein the method comprises determining whether to transmit the message in accordance with the first transmission scheme or the second transmission scheme in dependence on whether a terminal device to which the message is to be transmitted is a member of the first set of terminal devices or the second set of terminal devices.

4. The method of claim 1, wherein the method comprises determining whether to transmit the message in accordance with the first transmission scheme or the second transmission scheme in dependence on a radio propagation parameter associated with radio communications between the base station and a terminal device to which the message is to be transmitted.

5. The method of claim 4, wherein the radio propagation parameter is selected from the group comprising: a path loss; an error rate; a positive acknowledgment, ACK, signalling rate; and a negative acknowledgment signalling, NACK, rate.

6. The method of claim 1, wherein the method comprises determining whether to transmit the message in accordance with the first transmission scheme or the second transmission scheme in dependence on an identity and / or type of a terminal device to which the message is to be transmitted.

7. The method of claim 1, wherein the radio interface supports a downlink control channel for conveying control messages from the base station to terminal devices and a downlink data channel for conveying other messages from the base station to terminal devices, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the message comprises a control message transmitted on the downlink control channel.

8. The method of claim 1, wherein the radio interface supports a downlink control channel for conveying control messages from the base station to terminal devices and a downlink data channel for conveying other messages from the base station to terminal devices, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the message comprises one of the other messages transmitted on the downlink data channel.

9. The method of claim 1, wherein the identifier to indicate a terminal device to which the message is addressed is transmitted separately from the message.

10. The method of claim 1, wherein the identifier comprises a radio network temporary identifier, RNTI.

11. The method of claim 1, wherein the identifier is a common to a plurality of terminal devices.

12. The method of claim 1, wherein the message comprises a broadcast message.

13. The method of claim 1, wherein the message comprises a multicast message.

14. The method of claim 1, wherein for a given type of message the characteristic for the identifier is selected from a first predefined characteristic for the identifier associated with the given type of message and a second predefined characteristic for the identifier associated with the given type of message according to whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

15. The method of claim 1, wherein the message is selected from the group comprising: (i) a message associated with transmitting system information; (ii) a message associated with transmitting a paging message; (iii) a message associated with transmitting a random access response message; (iv) a message associated with transmitting power control information for an uplink control channel; (v) a message associated with transmitting power control information for an uplink data channel; and (vi) a message associated with a broadcast and / or multicast service.

16. The method of claim 1, wherein for a message to be transmitted in accordance with the second transmission scheme, a component of the message transmitted in one of the second number of subframes is associated with a characteristic for the identifier corresponding to that which would be used if the message were to be transmitted in accordance with the first transmission scheme.

17. The method of claim 1, wherein the characteristic for the identifier comprises a value for the identifier.

18. The method of claim 1, wherein the characteristic for the identifier comprises a search space in which a terminal device searches using the identifier to determine if a message has been addressed to the terminal device.

19. The method of claim 1, wherein the method comprises selecting the characteristic for the identifier from a plurality of different characteristics associated with different types of message.

20. The method of claim 1, wherein the characteristic for the identifier to be selected for a message to be transmitted in accordance with the second transmission scheme is defined in accordance with an operating standard for the wireless telecommunications system.

21. The method of claim 1, further comprising the base station pre-defining the characteristic for the identifier to be selected for a message to be transmitted in accordance with the second transmission scheme.

22. The method of claim 21, wherein the pre-defining the characteristic for the identifier is a value for the identifier selected from among a plurality of values.

23. A base station for communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the base station comprises a controller unit and a transceiver unit configured to operate together such that the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein a characteristic for the identifier is selected in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

24. Circuitry for a base station communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the circuitry comprises a controller element and a transceiver element configured to operate together such that the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein a characteristic for the identifier is selected in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

25. A method of operating a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the method comprises determining from an identifier associated with the message that the message is addressed to the terminal device, and further determining from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

26. A terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the terminal device comprises a controller unit and a transceiver unit configured to operate together to determine from an identifier associated with the message that the message is addressed to the terminal device, and to further determine from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

27. Circuitry for a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to determine from an identifier associated with the message that the message is addressed to the terminal device, and to further determine from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

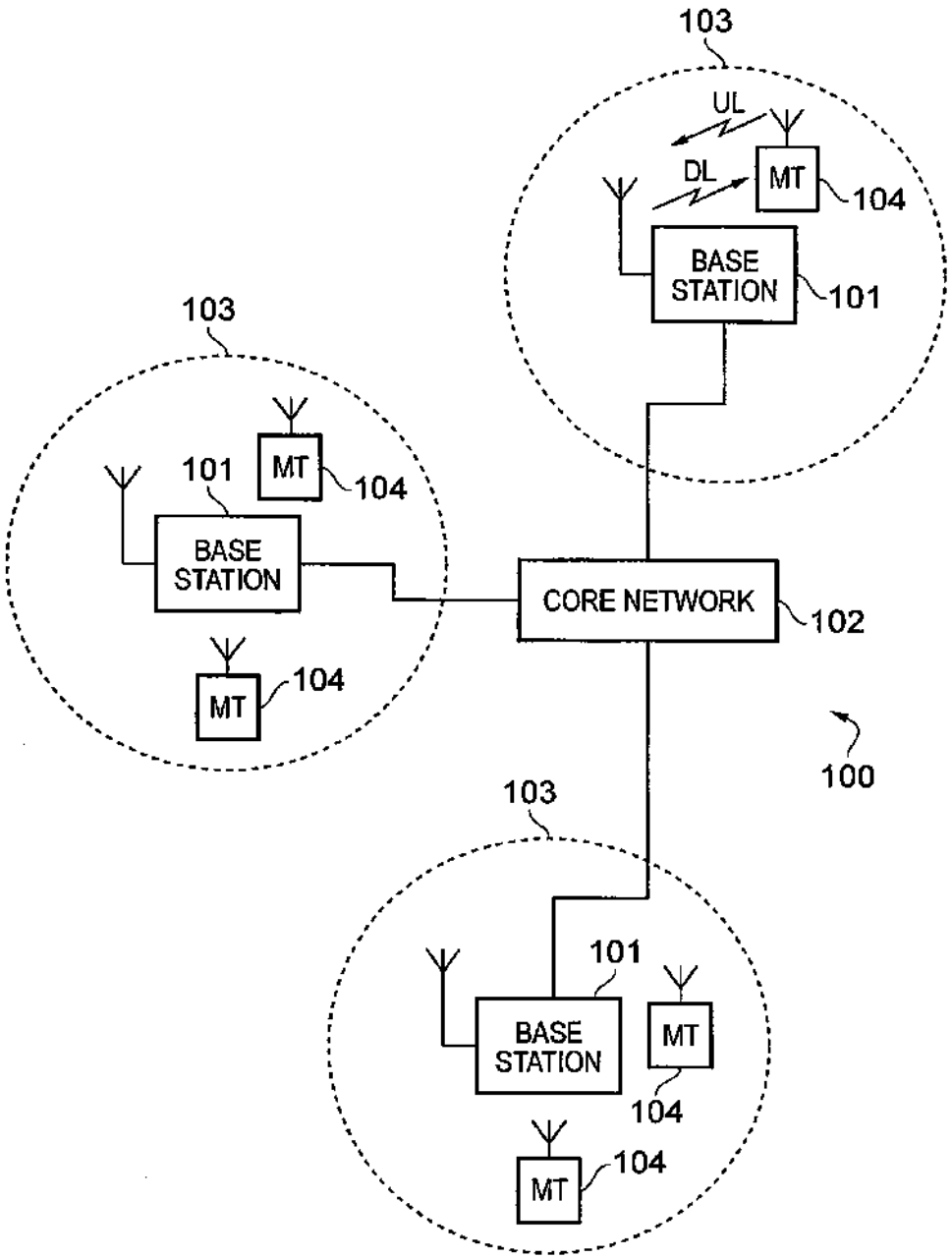

103
UL
DL
MT
104
BASE STATION
101
103
101
MT
104
BASE STATION
CORE NETWORK
102
MT
104
100
103
101
BASE STATION
MT
104
MT
104

FIG. 1

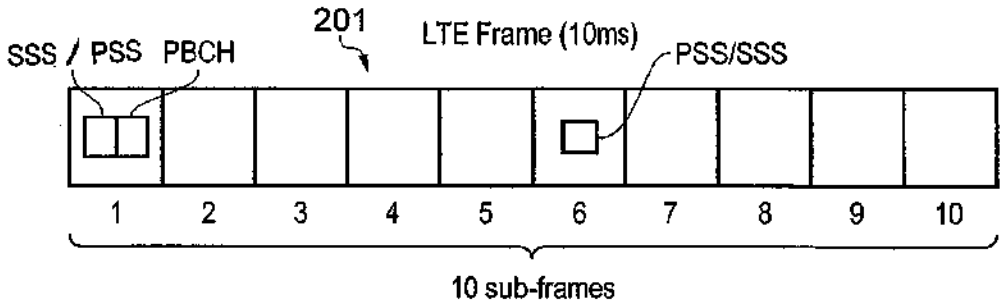

201
LTE Frame (10ms)
SSS / PSS
PBCH
PSS/SSS
1
2
3
4
5
6
7
8
9
10
10 sub-frames

FIG. 2

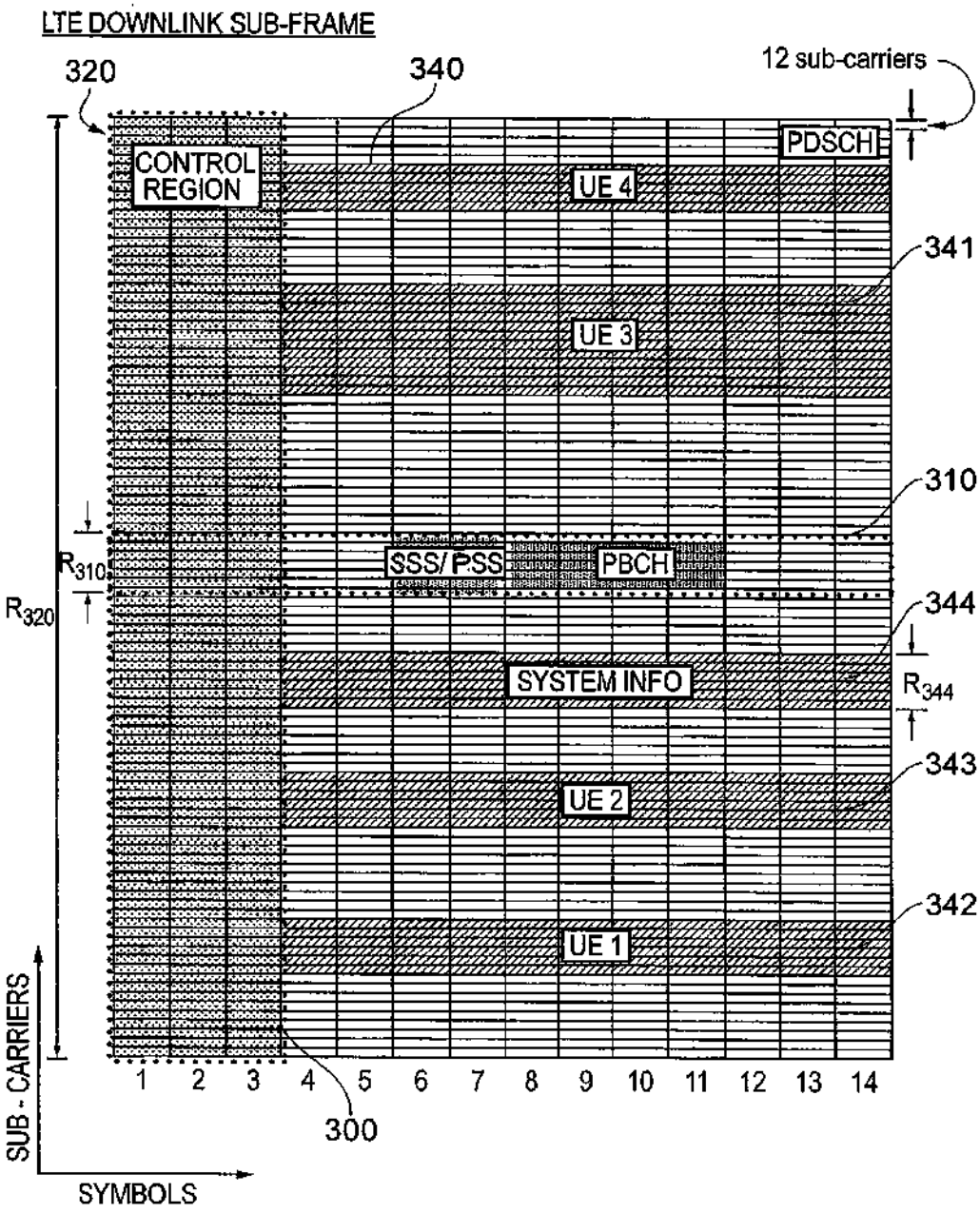

LTE DOWNLINK SUB-FRAME
320
340
12 sub-carriers
CONTROL REGION
PDSCH
UE 4
341
UE 3
310
R_{310}
SSS/ PSS
PBCH
R_{320}
344
SYSTEM INFO
R_{344}
343
UE 2
342
UE 1
SUB - CARRIERS
1 2 3 4 5 6 7 8 9 10 11 12 13 14
300
SYMBOLS

FIG. 3

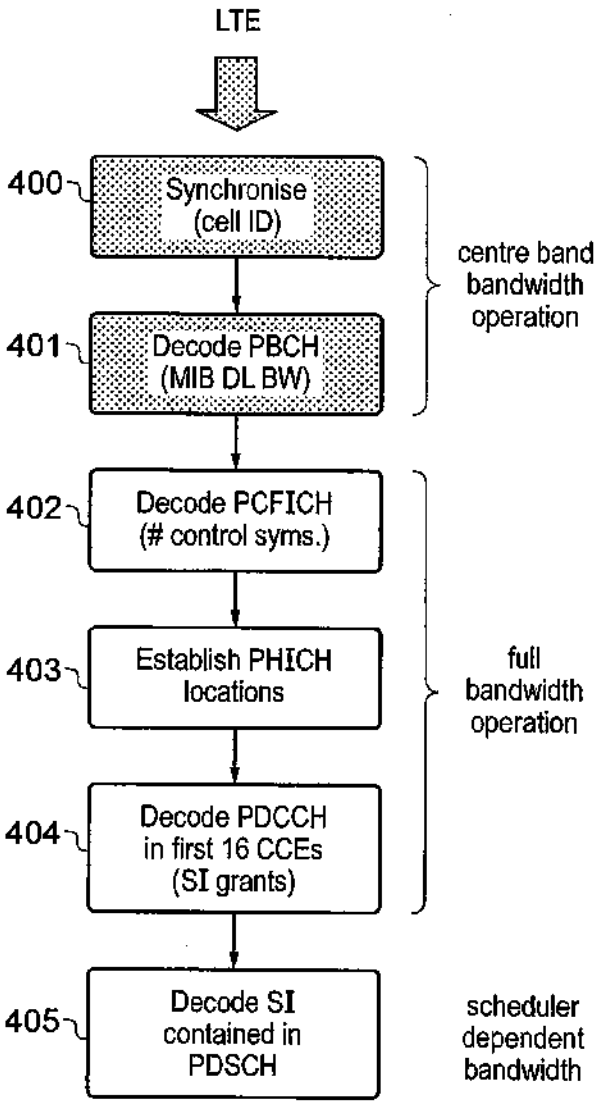

LTE
400
Synchronise (cell ID)
401
Decode PBCH (MIB DL BW)
centre band bandwidth operation
402
Decode PCFICH (# control syms.)
403
Establish PHICH locations
404
Decode PDCCH in first 16 CCEs (SI grants)
full bandwidth operation
405
Decode SI contained in PDSCH
scheduler dependent bandwidth

FIG. 4

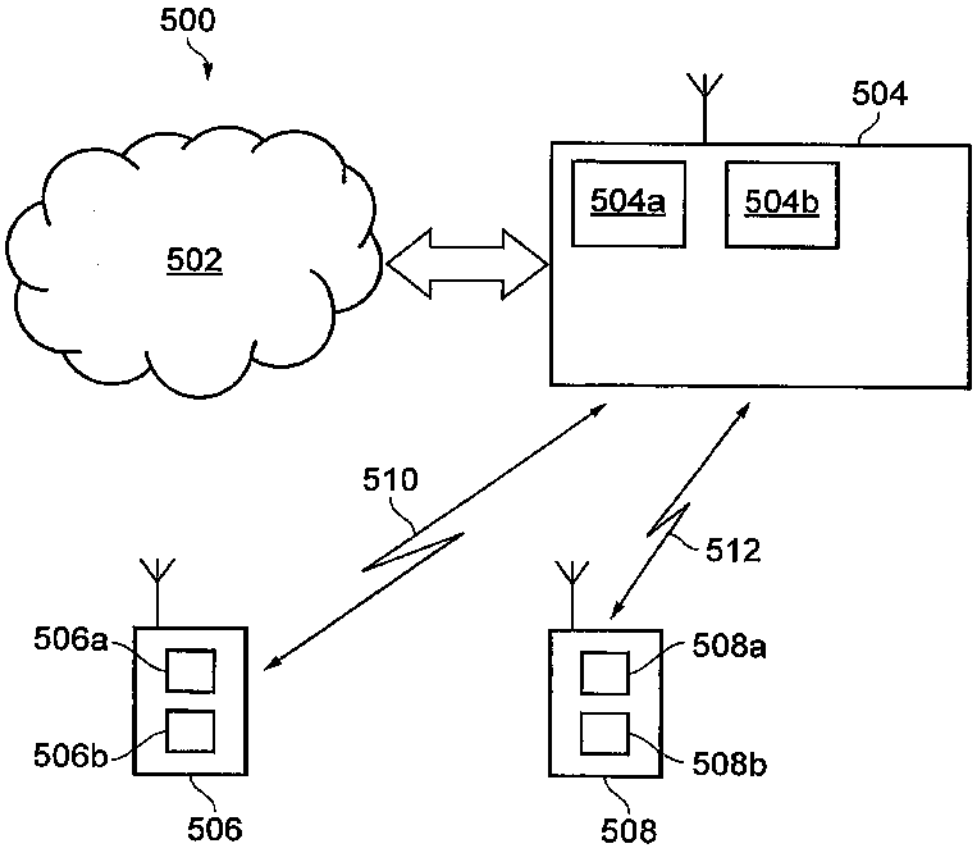


FIG. 5

Fig. 6

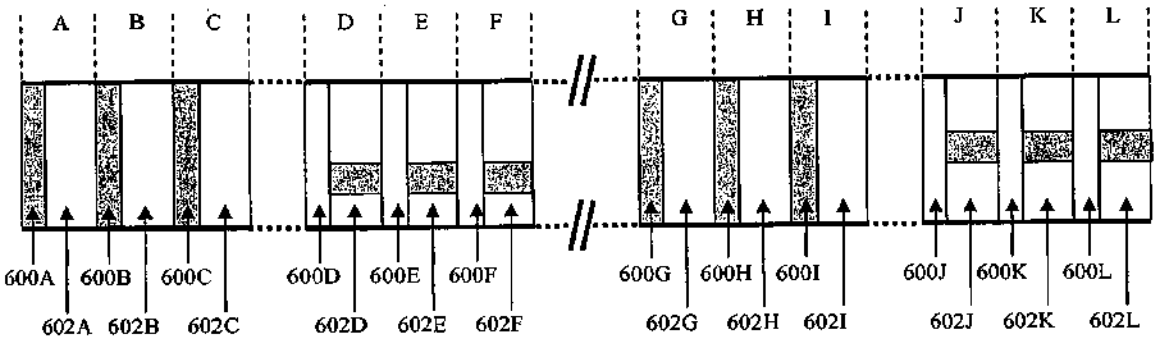
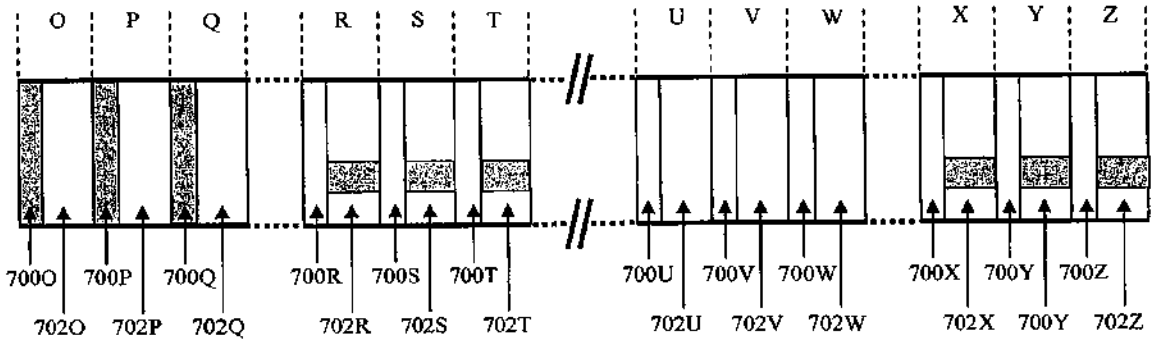

A
B
C
D
E
F
G
H
I
J
K
L
600A
600B
600C
600D
600E
600F
600G
600H
600I
600J
600K
600L
602A
602B
602C
602D
602E
602F
602G
602H
602I
602J
602K
602L

Fig. 7


O
P
Q
R
S
T
U
V
W
X
Y
Z
700O
700P
700Q
700R
700S
700T
700U
700V
700W
700X
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702V
702W
702X
702Y
702Z

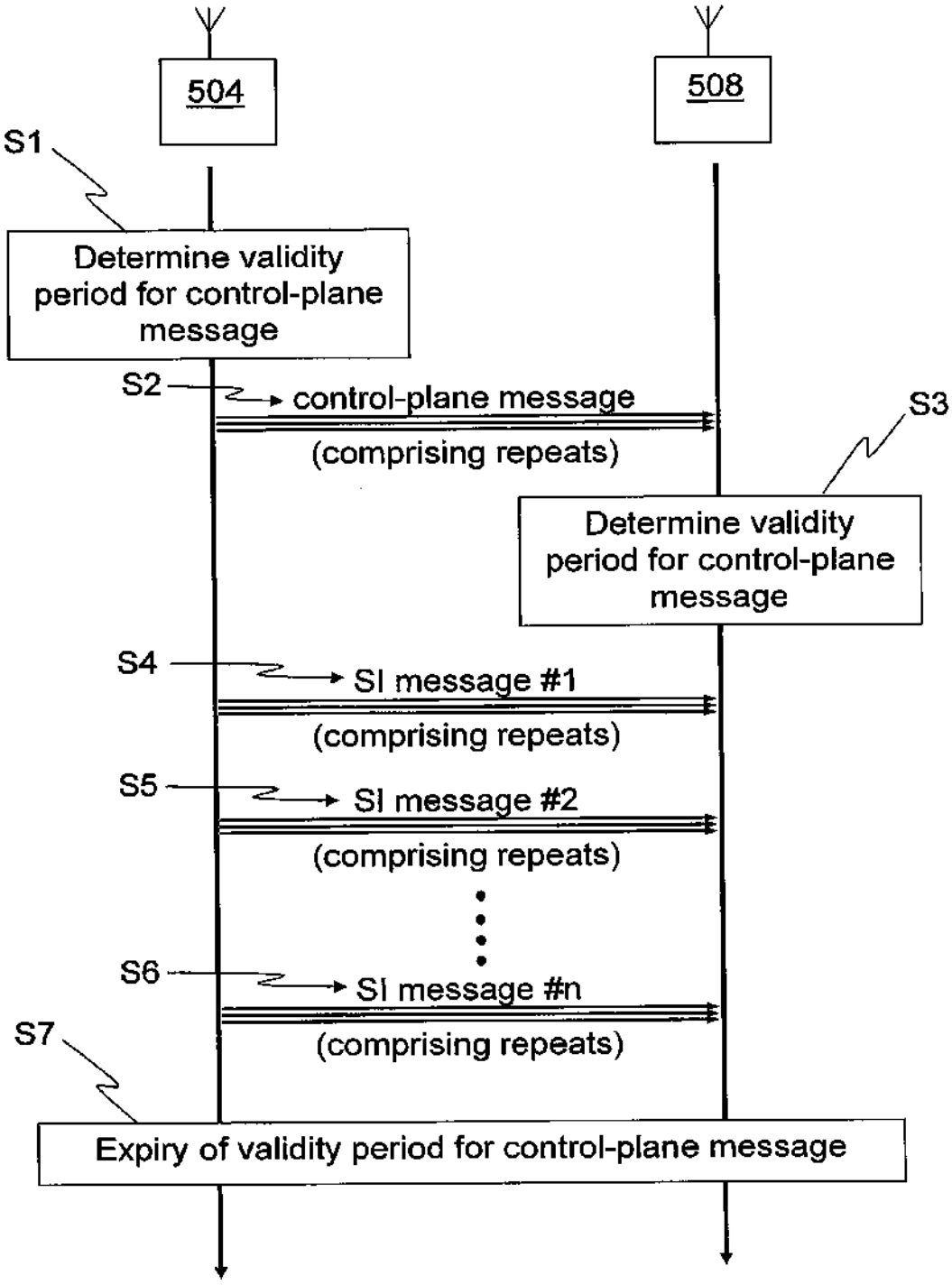

504
508
S1
Determine validity period for control-plane message
S2
control-plane message
(comprising repeats)
S3
Determine validity period for control-plane message
S4
SI message #1
(comprising repeats)
S5
SI message #2
(comprising repeats)
S6
SI message #n
(comprising repeats)
S7
Expiry of validity period for control-plane message

Fig. 8

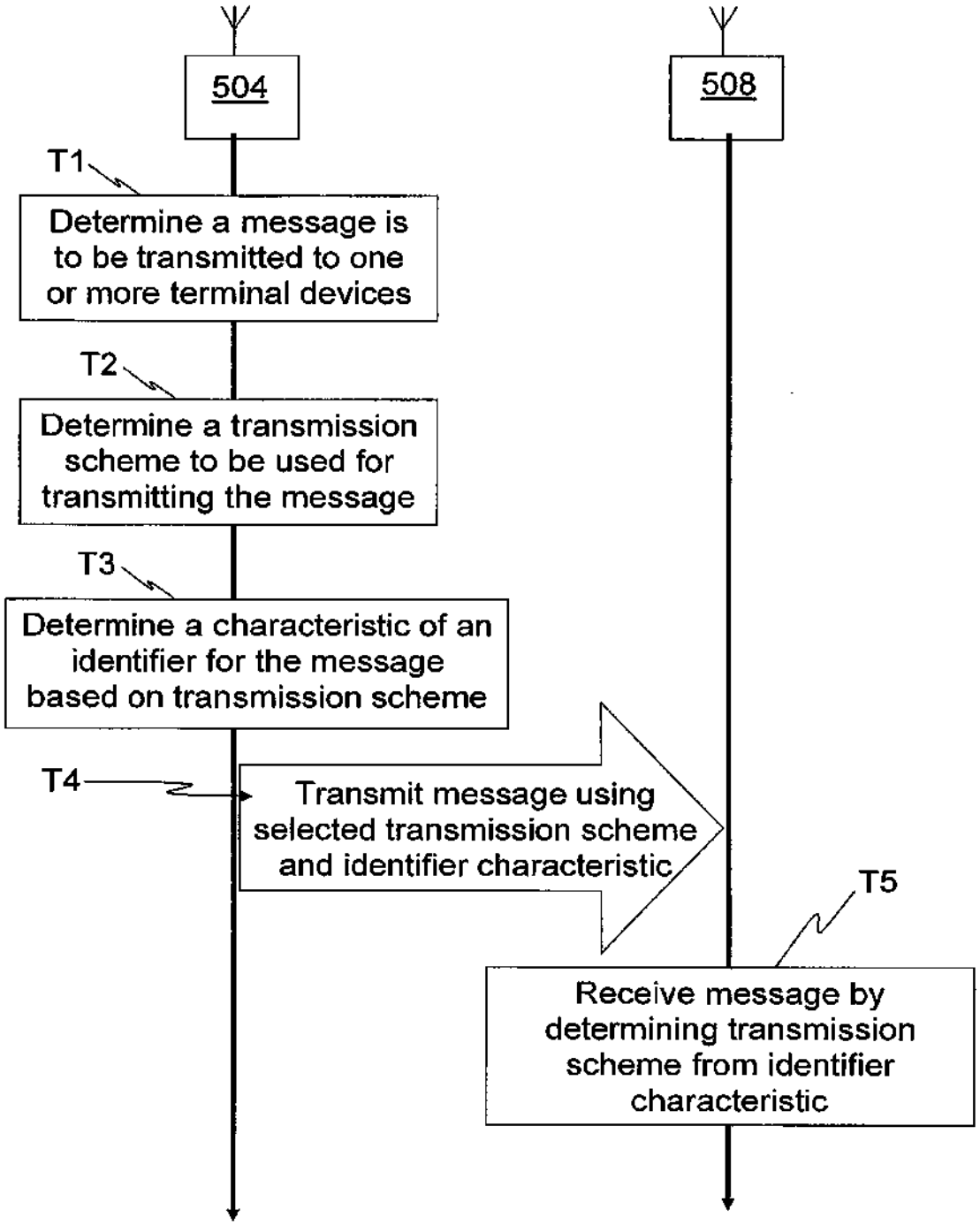

504
508
T1
Determine a message is to be transmitted to one or more terminal devices
T2
Determine a transmission scheme to be used for transmitting the message
T3
Determine a characteristic of an identifier for the message based on transmission scheme
T4
Transmit message using selected transmission scheme and identifier characteristic
T5
Receive message by determining transmission scheme from identifier characteristic

Fig. 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2014/074456

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W72/04
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W H04B H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2013/315159 A1 (XIA JINHUAN [CN] ET AL) 28 November 2013 (2013-11-28) paragraph [0005] - paragraph [0006] paragraph [0036]; figure 5 paragraph [0045]; figure 7 paragraph [0052] paragraph [0062]	1-27

X	EP 2 611 244 A2 (QUALCOMM INC [US]) 3 July 2013 (2013-07-03)	1,23-27
A	paragraph [0029]; figures 3,10 paragraph [0075]	2-22

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 February 2015	04/03/2015

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Cortés Gómez, F

1

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	Section 2.1 Section 2.5 -----	2-22
X	NTT DOCOMO: "Discussion on Multi-level PRACH Coverage Enhancement", 3GPP DRAFT; R1-135509 PRACH_COVERAGE, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. San Francisco, USA; 20131111 - 20131115 13 November 2013 (2013-11-13), XP050735182, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN/RAN1/Docs/ [retrieved on 2013-11-13]	1,23-27
A	Section 5 -----	2-22

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2014/074456

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International Bureau

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WIPO | PCT

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H04W 88/06 (2009.01)

(21) International Application Number:
PCT/US2015/044628

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11 August 2015 (11.08.2015)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
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(54) **Title**: DEVICE, SYSTEM AND METHOD EMPLOYING UNIFIED FLEXIBLE 5G AIR INTERFACE

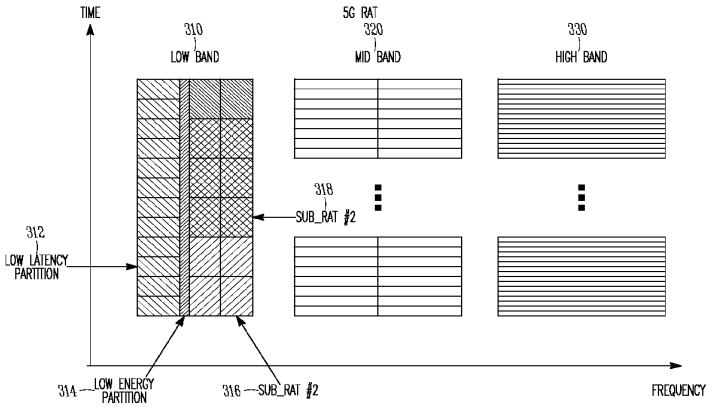


FIG. 3

(57) **Abstract**: An eNodeB (eNB), user equipment (UE) and method of providing a flexible Radio Access Technology (FRAT) are generally described. The information (resource allocation, partition information and numerology) of at least one of a plurality of RATs used by the eNB is provided to a UE. Each RAT has a flexible subcarrier spacing and symbol duration, which are integer multiples of a base subcarrier spacing and symbol duration, and is associated with at least one of different temporal and frequency resources. The symbol and/or frame structure of each RAT are independent. A Transmission Time Interval (TTI) boundary between the RATs is common, and the RATs comprise a common reference TTI duration. The information of the RATs is provided either via a different RAT than the RAT used by the UE for communication or via a dedicated carrier in the RAT used by the UE for communication.

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DEVICE, SYSTEM AND METHOD EMPLOYING UNIFIED FLEXIBLE 5G AIR INTERFACE

PRIORITY CLAIM

[0001] This application claims the benefit of priority to United States Provisional Patent Application Serial No. 62/114,733, filed February 11, 2015, and entitled "UNIFIED FLEXIBLE 5G NEW AIR INTERFACE DESIGN," which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] Embodiments pertain to radio access networks. Some embodiments relate to a unified communication framework using Radio Access Technologies (RAT) in 5th generation (5G) cellular networks.

BACKGROUND

[0003] The use of personal communication devices has increased astronomically over the last several decades. The penetration of mobile devices in modern society has continued to drive demand for a wide variety of networked devices in a number of disparate environments. The variety of available applications, especially video-related applications, has led to a concomitant increase in demand for increased bandwidth beyond that provided by Third Generation Partnership Project Long Term Evolution (3GPP LTE) and LTE advanced (LTE-A) systems.

[0004] The next generation wireless communication system, 5G, may provide access to information and sharing of data using a network that may be required to meet vastly different and sometimes conflicting performance dimensions and services driven by different services and use cases. It is therefore desirable that the next generation communication system be flexible and capable of providing high speed communications services for a wide ambit of devices under a multiplicity of circumstances.

BRIEF DESCRIPTION OF THE FIGURES

[0005] In the figures, which are not necessarily drawn to scale, like numerals may describe similar components in different views. Like numerals having different letter suffixes may represent different instances of similar components. The figures illustrate generally, by way of example, but not by way of limitation, various embodiments discussed in the present document.

[0006] FIG. 1 is a functional diagram of a 3GPP network in accordance with some embodiments.

[0007] FIG. 2 is a block diagram of a 3GPP device in accordance with some embodiments.

[0008] FIG. 3 illustrates one embodiment of a flexible Radio Access Technology (FRAT) of a 5G system in accordance with some embodiments.

[0009] FIG. 4 illustrates a unified frame structure in accordance with some embodiments.

[0010] FIG. 5 illustrates a Transmission Time Interval (TTI) boundary alignment in accordance with some embodiments.

[0011] FIG. 6 illustrates a symbol structure in accordance with some embodiments.

[0012] FIG. 7 illustrates frame structures within a TTI in accordance with some embodiments.

[0013] FIGS. 8A and 8B illustrate flowcharts of a uniform framework utilization method in accordance with some embodiments.

DETAILED DESCRIPTION OF THE INVENTION

[0014] The following description and the drawings sufficiently illustrate specific embodiments to enable those skilled in the art to practice them. Other embodiments may incorporate structural, logical, electrical, process, and other changes. Portions and features of some embodiments may be included in, or substituted for, those of other embodiments. Embodiments set forth in the claims encompass all available equivalents of those claims.

[0015] FIG. 1 is a functional diagram of a 3GPP network in accordance with some embodiments. The network may comprise a radio access network (RAN) (e.g., as depicted, the E-UTRAN or evolved universal terrestrial radio

access network) 100 and the core network 120 (e.g., shown as an evolved packet core (EPC)) coupled together through an S1 interface 115. For convenience and brevity sake, only a portion of the core network 120, as well as the RAN 100, is shown.

[0016] The core network 120 includes mobility management entity (MME) 122, serving gateway (serving GW) 124, and packet data network gateway (PDN GW) 126. The RAN 100 includes eNBs 104 (which may operate as base stations) for communicating with UE 102. The eNBs 104 may include macro eNBs and low power (LP) eNBs.

[0017] The MME is similar in function to the control plane of legacy Serving GPRS Support Nodes (SGSN). The MME manages mobility aspects in access such as gateway selection and tracking area list management. The serving GW 124 terminates the interface toward the RAN 100, and routes traffic packets (such as data packets or voice packets) between the RAN 100 and the core network 120. In addition, it may be a local mobility anchor point for inter-eNB handovers and also may provide an anchor for inter-3GPP mobility. Other responsibilities may include lawful intercept, charging, and some policy enforcement. The serving GW 124 and the MME 122 may be implemented in one physical node or separate physical nodes. The PDN GW 126 terminates a SGi interface toward the packet data network (PDN). The PDN GW 126 routes traffic packets between the EPC 120 and the external PDN, and may be a key node for policy enforcement and charging data collection. It may also provide an anchor point for mobility with non-LTE accesses. The external PDN can be any kind of IP network, as well as an IP Multimedia Subsystem (IMS) domain. The PDN GW 126 and the serving GW 124 may be implemented in one physical node or separated physical nodes.

[0018] The eNBs 104 (macro and micro) terminate the air interface protocol and may be the first point of contact for a UE 102. The eNBs 104 may communicate both with UEs 102 in a normal coverage mode and UEs 104 in one or more enhanced coverage modes. In some embodiments, an eNB 104 may fulfill various logical functions for the RAN 100 including but not limited to RNC (radio network controller functions) such as radio bearer management, uplink and downlink dynamic radio resource management and traffic packet

scheduling, and mobility management. In accordance with some embodiments, UEs 102 may be configured to communicate via orthogonal multiple access (OMA) communications such as Time Division Multiple Access (TDMA), Frequency Division Multiple Access (FDMA) Orthogonal FDMA (OFDMA), SC-FDMA or other communication signals with an eNB 104 over a multicarrier communication channel in accordance with the appropriate communication technique. The OFDM signals may comprise a plurality of orthogonal subcarriers. In accordance with some embodiments, UEs 102 may be configured to communicate via non-orthogonal multiple access (NOMA) signals.

[0019] The S1 interface 115 is the interface that separates the RAN 100 and the EPC 120. It is split into two parts: the S1-U, which carries traffic packets between the eNBs 104 and the serving GW 124, and the S1-MME, which is a signaling interface between the eNBs 104 and the MME 122.

[0020] With cellular networks, LP cells are typically used to extend coverage to indoor areas where outdoor signals do not reach well, or to add network capacity in areas with very dense phone usage, such as train stations. As used herein, the term low power (LP) eNB refers to any suitable relatively low power eNB for implementing a narrower cell (narrower than a macro cell) such as a femtocell, a picocell, or a micro cell. Femtocell eNBs are typically provided by a mobile network operator to its residential or enterprise customers. A femtocell is typically the size of a residential gateway or smaller and generally connects to the user's broadband line. Once plugged in, the femtocell connects to the mobile operator's mobile network and provides extra coverage in a range of typically 30 to 50 meters for residential femtocells. Thus, a LP eNB might be a femtocell eNB since it is coupled through the PDN GW 126. Similarly, a picocell is a wireless communication system typically covering a small area, such as in-building (offices, shopping malls, train stations, etc.), or more recently in-aircraft. A picocell eNB can generally connect through the X2 link to another eNB such as a macro eNB through its base station controller (BSC) functionality. Thus, LP eNB may be implemented with a picocell eNB since it is coupled to a macro eNB via an X2 interface. Picocell eNBs or other LP eNBs may incorporate some or all functionality of a macro eNB. In some cases, this may be referred to as an access point base station or enterprise femtocell.

[0021] As indicated in more detail below, communication over a 4G LTE network may be split up into 10ms frames, each of which may contain ten 1ms subframes. Each subframe of the frame, in turn, may contain two slots of 0.5ms. The eNB may schedule uplink and downlink transmissions over a variety of frequency bands. The allocation of resources in subframes used in one frequency band and may differ from those in another frequency band. Each slot of the subframe may contain 6-7 symbols, depending on the system used. In some embodiments, the subframe may contain 12 or 24 subcarriers. A resource grid may be used for downlink and uplink transmissions between an eNB and a UE. The resource grid may be a time-frequency grid, which is the physical resource in each slot. The smallest time-frequency unit in a resource grid may be denoted as a resource element (RE). Each column and each row of the resource grid may correspond to one OFDM symbol and one OFDM subcarrier, respectively. The resource grid may contain resource blocks (RBs) that describe the mapping of physical channels to resource elements and physical RBs (PRBs). A PRB may be the smallest unit of resources that can be allocated to a UE in the current 3GPP standard. A resource block may be 180 kHz wide in frequency and 1 slot long in time. In frequency, resource blocks may be either 12 x 15 kHz subcarriers or 24 x 7.5 kHz subcarriers wide. For most channels and signals, 12 subcarriers may be used per resource block, dependent on the system bandwidth. The duration of the resource grid in the time domain corresponds to one subframe or two resource blocks. Each resource grid may comprise 12 (subcarriers) *14 (symbols) =168 resource elements for normal cyclic prefix (CP) case. Several different physical channels may be conveyed using such resource blocks. As discussed in more detail below, in a 5G network, the sizes of the resource blocks, resource elements, and symbols, among others, may vary.

[0022] There may be several different physical downlink channels that are conveyed using such resource blocks, including the physical downlink control channel (PDCCH) and the physical downlink shared channel (PDSCH). Each subframe may contain a PDCCH, physical hybrid-ARQ indicator channel (PHICH), physical control format indicator channel (PCFICH) and the PDSCH. The PDCCH may normally occupy the first up to three symbols (four in the case

of narrow bandwidths of 1.4MHz) of each subframe and carry, among other things, information about the transport format and resource allocations related to the PDSCH channel and uplink scheduling grants for a physical uplink shared channel (PUSCH) transmission. The PHICH may be used to signal HARQ information in response to a PUSCH transmission. The PCFICH may inform the UE the control region size (e.g. one, two or three OFDM symbols) in each downlink subframe. The PDSCH may carry user data and higher layer signaling to a particular UE and occupy the remainder of the downlink subframe to avoid the resources in which downlink control channels (PDCCH/PHICH/PCFICH) are transmitted. Typically, downlink scheduling (assigning control and shared channel resource blocks to UEs within a cell) may be performed at the eNB based on channel quality information provided by the UEs, and then the downlink resource assignment information may be sent to a scheduled UE on the PDCCH used for (assigned to) PDSCH reception of the UE.

[0023] The PDCCH may contain downlink control information (DCI) in one of a number of formats that tell the UE where to find and how to decode the data, transmitted on PDSCH in the same subframe, from the resource grid. The DCI may provide details such as the number of resource blocks, resource allocation type, modulation scheme, transport block, redundancy version, coding rate etc. Each DCI format may have a cyclic redundancy code (CRC) and be scrambled with a Radio Network Temporary Identifier (RNTI) that identifies the target UE for which the PDSCH is intended. Use of the RNTI, which may be UE-specific, may limit decoding of the DCI information (and hence the corresponding PDSCH) to only the intended UE. The PDCCH may be located in any of a number of frequency/temporal regions, depending on whether the PDCCH is UE-Specific or common, as well as the aggregation level. The set of possible candidate locations for the PDCCH is defined in terms of search spaces. A search space is defined by a set of Control Channel Element (CCE) candidates with a number of aggregation level $L \in \{1,2,4,8\}$ where the UE may monitor to find its PDCCHs. A common search space may carry DCIs that are common for all UEs; for example, system information (using the SI-RNTI), paging (P-RNTI), PRACH responses (RA-RNTI), or UL TPC commands (TPC-PUCCH/PUSCH-RNTI). A UE-specific search space may carry DCIs for UE-

specific allocations using a Cell Radio-Network Temporary Identifier (C-RNTI) assigned to the UE, a semi-persistent scheduling (SPS C-RNTI), or an initial allocation (temporary C-RNTI). When configuring an SPS (either uplink or downlink), the SPS C-RNTI is provided by the eNB and the UE is configured by higher layers to decode a PDCCH with a CRC scrambled by the SPS C-RNTI. The UE may monitor the PDCCH having a CRC scrambled by the SPS C-RNTI in every subframe as the eNB can activate/re-activate/release the SPS at any time using a DCI format with a CRC scrambled by an SPS C-RNTI. The received DCI format with a CRC scrambled by the SPS C-RNTI can be a grant/assignment for a retransmission or for activation/re-activation/release of the SPS. 3GPP Technical Specification 36.213 has tabulated the validation procedure for activation/re-activation/release of SPS.

[0024] In addition to the PDCCH, an enhanced PDCCH (EPDCCH) may be used by the eNB and UE. The PDSCH may thus contain data in some of the resource blocks (RBs) and then EPDCCH contains the downlink control signals in others of the RBs of the bandwidth supported by the UE. Different UEs may have different EPDCCH configurations. The sets of RBs corresponding to EPDCCH may be configured, for example, by higher layer signaling such as Radio Resource Control (RRC) signaling for EPDCCH monitoring.

[0025] The Physical Uplink Control Channel (PUCCH) may be used by the UE to send Uplink Control Information (UCI) to the eNB. The PUCCH may be mapped to an UL control channel resource defined by an orthogonal cover code and two resource blocks (RBs), consecutive in time, with hopping potentially at the boundary between adjacent slots. The PUCCH may take several different formats, with the UCI containing information dependent on the format. Specifically, the PUCCH may contain a scheduling request (SR), acknowledgement responses/retransmission requests (ACK/NACK) or a Channel Quality Indication (CQI)/Channel State Information (CSI). The CQI/CSI may indicate to the eNB an estimate of the current downlink channel conditions as seen by the UE to aid channel-dependent scheduling and, if one MIMO transmission mode is configured to the UE, may include MIMO-related feedback (e.g. Precoder matrix indication, PMI).

[0026] FIG. 2 is a functional diagram of a 3GPP device in accordance with some embodiments. The device may be a UE or eNB, for example. In some embodiments, the eNB may be a stationary non-mobile device. The 3GPP device 200 may include physical layer circuitry 202 for transmitting and receiving signals using one or more antennas 201. The 3GPP device 200 may also include medium access control layer (MAC) circuitry 204 for controlling access to the wireless medium. The 3GPP device 200 may also include processing circuitry 206 and memory 208 arranged to perform the operations described herein.

[0027] In some embodiments, mobile devices or other devices described herein may be part of a portable wireless communication device, such as a personal digital assistant (PDA), a laptop or portable computer with wireless communication capability, a web tablet, a wireless telephone, a smartphone, a wireless headset, a pager, an instant messaging device, a digital camera, an access point, a television, a medical device (e.g., a heart rate monitor, a blood pressure monitor, etc.), or other device that may receive and/or transmit information wirelessly. In some embodiments, the mobile device or other device can be a UE 102 or eNB 104 configured to operate in accordance with 3GPP standards. In some embodiments, the mobile device or other device may be configured to operate according to other protocols or standards, including IEEE 802.11 or other IEEE standards. In some embodiments, the mobile device or other device may include one or more of a keyboard, a display, a non-volatile memory port, multiple antennas, a graphics processor, an application processor, speakers, and other mobile device elements. The display may be an LCD screen including a touch screen.

[0028] The antennas 201 may comprise one or more directional or omnidirectional antennas, including, for example, dipole antennas, monopole antennas, patch antennas, loop antennas, microstrip antennas or other types of antennas suitable for transmission of RF signals. In some multiple-input multiple-output (MIMO) embodiments, the antennas 201 may be effectively separated to take advantage of spatial diversity and the different channel characteristics that may result.

[0029] Although the 3GPP device 200 is illustrated as having several separate functional elements, one or more of the functional elements may be combined and may be implemented by combinations of software-configured elements, such as processing elements including digital signal processors (DSPs), and/or other hardware elements. For example, some elements may comprise one or more microprocessors, DSPs, field-programmable gate arrays (FPGAs), application specific integrated circuits (ASICs), radio-frequency integrated circuits (RFICs) and combinations of various hardware and logic circuitry for performing at least the functions described herein. In some embodiments, the functional elements may refer to one or more processes operating on one or more processing elements.

[0030] Embodiments may be implemented in one or a combination of hardware, firmware and software. Embodiments may also be implemented as instructions stored on a computer-readable storage device, which may be read and executed by at least one processor to perform the operations described herein. A computer-readable storage device may include any non-transitory mechanism for storing information in a form readable by a machine (e.g., a computer). For example, a computer-readable storage device may include read-only memory (ROM), random-access memory (RAM), magnetic disk storage media, optical storage media, flash-memory devices, and other storage devices and media. Some embodiments may include one or more processors and may be configured with instructions stored on a computer-readable storage device.

[0031] The term "machine readable medium" may include a single medium or multiple media (e.g., a centralized or distributed database, and/or associated caches and servers) configured to store one or more instructions. The term “machine readable medium” may include any medium that is capable of storing, encoding, or carrying instructions for execution by the 3GPP device 200 and that cause it to perform any one or more of the techniques of the present disclosure, or that is capable of storing, encoding or carrying data structures used by or associated with such instructions. The term “transmission medium” shall be taken to include any intangible medium that is capable of storing, encoding or carrying instructions for execution, and includes digital or analog

communications signals or other intangible medium to facilitate communication of such software.

[0032] As above, the upcoming 5G wireless communications technology systems may have a number of unique challenges, including carrying the inherent ability to provide different performances requirements for numerous different types of wireless devices. Higher data rates in particular may continue to drive network development and evolution for 5G system. It may be desirable for a 5G system to support a peak data rate of more than 10Gps and a minimum guaranteed user data rate of at least 100Mbps. In addition, it may be desirable for the 5G system to support the huge increase in variety and number of Internet of Things (IoT) and Machine-Type Communication (MTC)-type devices. MTC devices have been increasingly employed for different applications, using low operational power consumption and infrequent small burst transmissions. Moreover, it may be desirable for the 5G system to provide an extremely high level of reliable connectivity with guaranteed low latency, availability and reliability-of-service for mission critical MTC use cases.

[0033] In general, 5G systems may use a plurality of Radio Access Technologies (RATs), unlike previous 2G, 3G and 4G, systems. For example, an enormous amount of spectrum may be available through the use of higher frequency bands. In one example, the use of millimeter wave (mmWave) frequency bands ranging from 30 to 300GHz may provide the desired scalability, capacity and density for the 5G system. In this case, a new RAT may be defined for the mmWave band to achieve low latency and higher peak data rate. The RAT for mmWave band communications may differ from the RAT for one or more of the other frequency bands used to provide communication services. In some embodiments, the RATs may be used simultaneously by a single eNB for communications with different UEs.

[0034] In some embodiments, a 5G system may be provided that contains multiple RATs in a unified framework to support diverse applications, use cases and services and inter-networking in multiple frequency bands, including both licensed and unlicensed frequency bands. The RATs used in the licensed and unlicensed may be independent of each other. In some embodiments, flexible subcarrier spacing and symbol duration (i.e., configurable

numerology) may be provided across the frequency bands used in the 5G system. In addition, the 5G system may include mechanisms to multiplex multiple RATs, sub-RATs and other partitions in different or the same frequency resource or frequency bands.

[0035] The inter-networking in the unified frame structure may include, in some embodiments, a Transmission Time Interval (TTI) boundary alignment between multiple RATs may be provided to allow seamless scheduling, fallback and support of different RATs. In some embodiments, a TTI is the smallest unit of time in which the eNB is capable of scheduling any UE for uplink or downlink transmission. In some embodiments, the TTI boundary alignment may occur at a subframe or frame boundary. As used herein, a unified RAT with flexible air interface for the 5G system is referred to as a flexible Radio Access Technology (FRAT). A UE that communicates with an eNB operating using the FRAT may remain using a single air interface technology (i.e., RAT) or may switch between different RATs.

[0036] In some embodiments, a unified RAT with configurable numerologies may be used in the 5G system in which a base subcarrier spacing (Δf) and symbol duration (T) can be defined in the FRAT. In one example, to maintain the backward compatibility for existing LTE and LTE-Advanced systems, a base subcarrier spacing and symbol duration can be specified as Δf = 15KHz and T=66.7μs. Moreover, for convenience in some embodiments a single oscillator may be used, with the subcarrier spacing and symbol duration for different RATs specified as an integer number of the base subcarrier spacing and symbol duration, respectively.

[0037] Similarly, when a low latency use case and service is desired, a shortened symbol duration may be employed to reduce the latency by using larger subcarrier spacing. The subcarrier spacing and symbol duration may in this case be defined as $\Delta f_i = K*\Delta f$ and $T_i=(1/K)*T$. In one example, for frequency band between 6GHz and 30GHz, K can be chosen as 10, leading to a subcarrier spacing and symbol duration of 150KHz and 6.67μs, respectively. This may result in a 0.1ms TTI for low latency use case. In another example, for frequency bands below 6GHz, which includes the current LTE frequency range,

K can be selected by the network to be 2 or 4, and the corresponding subcarrier spacing and symbol duration changed proportional to the selected K value. Alternatively, the same subcarrier spacing and symbol duration can be defined for frequency bands below 6GHz (i.e., K =1), but a shorter TTI can be considered, e.g., with a fewer number of symbols, to support low latency use cases.

[0038] To efficiently support a massive number of MTC devices used in the 5G network, in other embodiments, the subcarrier spacing and symbol duration can be defined as $\Delta f_i = (1/K)*\Delta f$ and $T_i=K*T$. In such embodiments, K can be selected to be 10, and the subcarrier spacing and symbol duration 1.5KHz and 667μs, respectively. In this case, the subframe duration for MTC use cases can be defined to be 10ms, in the current generation LTE systems the length of a typical frame, rather than the typical 1ms. This may reduce the power consumption of MTC UEs by reducing the amount of time the MTC UE is active, thereby increasing the battery life of the MTC UEs.

[0039] A UE may be initially assigned the appropriate RAT by the eNB or other network device (such as the MME). In some embodiments, the UE may be configurable to communicate using any of the RATs, as indicated via the eNB, and can configure the subcarrier spacing and symbol duration accordingly. In some embodiments, the UE may be limited to communicating only using a subset of the RATs, and perhaps only a single RAT, e.g., when the UE is an MTC UE having a limited bandwidth and capabilities. The RAT may depend on the type of UE as well as the operating mode of the UE. For example, some UEs may change mode between a normal mode and an enhanced coverage mode in situations in which the link budget to the nearest serving eNB is worse than a typical link budget value in the network and additional link budget is to be obtained without increasing transmission power. Enhanced coverage mode may be employed by a variety of UEs, including a normal UE (e.g., a smartphone or the like), a machine-to-machine (M2M) UE or a stationary wireless UE (i.e., a UE that remains indefinitely in a single location) using MTC. The UE may determine whether additional link budget is desired, as well as how much additional link budget is desired, and enter an appropriate enhanced coverage mode (that provides the appropriate additional link budget). The different

enhanced coverage modes may correspond to different RATs. Some UEs, such as low cost, low complexity MTC UEs, further may be band limited and operate in a narrow bandwidth of e.g., to 1.4 MHz, for both control and data channels, leading to the ability to operate, e.g., in a single RAT unless the RAT is modified by the network.

[0040] FIG. 3 illustrates one embodiment of a FRAT of a 5G system in accordance with some embodiments. The FRAT 300 may contain one or more partitions in different frequency band regions 310, 320, 330. In one example, the low frequency band 310 may include frequencies used in 4G systems (up to 6 GHz), the mid-frequency band 320 may include higher frequencies (e.g., 6-30 GHz) and the high frequency band 330 may include the highest frequencies in the 5G system (e.g., mmWave, above 30 GHz). Although the RATs of only a low frequency band 310, a mid-frequency band 320, and a high frequency band 330 are shown, any number of RATs of different frequency bands may exist. The various RATs in frequency bands may each have a subcarrier spacing and symbol duration that is independent of the subcarrier spacing and symbol duration of another RAT in another frequency band (i.e., the RATs have configurable numerologies). Moreover, within each frequency band, one or more sub-RATs and partitions 312, 314, 316, 318 may be present with each sub-RAT or partition 312, 314, 316, 318 having a subcarrier spacing and symbol duration independent of the subcarrier spacing and symbol duration of another sub-RAT or partition 312, 314, 316, 318 and independent of the RAT in other frequency bands. As shown in FIG. 3, the sub_RATs 316, 318 in the low frequency band 310 may have the same subcarrier spacing and symbol duration and may be separated by frequency and/or time, while partitions 312, 314 may have different subcarrier spacings and symbol durations from each other and the sub_RATs 316, 318 and may be separated by frequency and/or time. Although the low frequency band 310 is shown as having multiple partitions 312, 314 and sub_RATs 316, 318, the mid frequency band 320 is shown as having two sub_RATs and the high frequency band 330 is shown as having no sub_RATs, the eNB may establish the number and type of RATs used within a particular frequency band differently.

[0041] In some embodiments, RATs and sub-RATs with same or different numerologies can be multiplexed. The multiplexing may be via Time-Division Multiplexing (TDM), Frequency-Division Multiplexing (FDM), code-division multiplex (CDM), spatial division multiplex (SDM), other possible orthogonal or non-orthogonal multiplexing schemes, or any combination thereof. For example, multiple RATs, sub-RATs or partitions with same or different numerologies can be multiplexed in a TDM manner. Each RAT, sub-RAT and partition may have a numerology, access scheme and modulation scheme that is independent of the numerology, access scheme and modulation scheme of the other RATs, sub-RATs and partitions. The numerologies, resource allocation and partition information in the time domain can be predefined or configured by higher layer signaling, e.g. via a Master Information Block (MIB), System Information Block (SIB) or UE-specific dedicated RRC signaling. If a MIB is used to indicate the partition configuration for multiple RATs, sub-RATs or partitions, the resource for the transmission physical broadcast channel (PBCH) used to carry the MIB may be predefined and known at the UEs. In some embodiments, the PBCH may be transmitted in a predetermined RAT, independent of the UE or number of RATs, sub-RATs or partitions supported. Once the UE receives the configuration information via the PBCH on the predetermined RAT, the UE may use a different RAT for further control and data communications; that is, the predetermined RAT and the RAT used by the UE to communicate may be independent.

[0042] In some embodiments, multiple RATs, sub-RATs or partitions with same or different numerologies can be multiplexed in a FDM manner. To minimize the interference between multiple RATs, sub-RATs or partitions with different numerologies, guard bands may be inserted at the edge of frequency resources allocated for the RATs, sub-RATs or partitions. Similar to the above, the numerologies and/or resource partition for multiple RATs, sub-RATs or partitions may be predefined or configured by high layer signaling via a MIB, SIB or UE-specific dedicated RRC signaling.

[0043] In embodiments in which numerologies and/or resource partition for multiple RATs, sub-RATs or partitions is predefined or dedicated carriers are allocated for different RATs, a dedicated downlink synchronization signal and

PBCHs may be transmitted on each RAT, sub-RAT or partition. In embodiments in which the numerologies and/or resource partition for multiple RATs, sub-RATs or partitions is configured using a MIB or SIB, a single MIB or SIB may be transmitted on one of the RAT, sub-RAT or partition. After successfully decoding the MIB or SIB, the UEs may be able to derive the resource information or numerologies for other RATs, sub-RATs or partitions. Thus, information provided from the eNB to the UE via a single transmission in a particular RAT, sub-RAT or partition may enable communications using different RATs, sub-RATs or partitions.

[0044] Particular RATs/sub-RATs/partitions may be used for different types of communications, with each having independently sized resource blocks. For example, as shown, the resources in a first partition 312 may be used for low-latency communications while the resources in a second partition 314 may be used for low energy communications. The first and second partitions 312, 314 may be multiplexed, as shown, using FDM such that the first and second partitions 312, 314 occupy the same time but different frequency resources. The first partition 312 may be associated with low latency communications in which the UE operates in a low latency mode and may have a short symbol duration and TTI, while the second partition 314 may be associated with low energy communications in which the UE operates in a low energy mode and may have a long symbol duration and TTI.

[0045] Other sub-RATs 316, 318 may similarly be FDM multiplexed with the first and second partitions 312, 314 and TDM multiplexed with each other. The sub-RATs 316, 318 may have a symbol duration and TTI between those associated with the first and second partitions 312, 314.

[0046] The RATs 320, 330 for the mid- and high- frequency band may be supported simultaneously with each other and the RAT 310 for low frequency band, while maintaining TTI boundary alignment between the different RATs 310, 320, 330. The RATs 320, 330 may similarly be FDM multiplexed with the first and second partitions 312, 314 and sub-RATs 316, 318. The RATs 320, 330 may have a symbol duration and TTI smaller than those associated with the first partition 312. As shown in FIG. 3, in some embodiments, the amount of temporal and/or frequency resources associated with the different RATs, sub-

RATs and partitions may differ among the different types, and the same type may be associated either with different amounts of temporal and/or frequency resources (e.g., as partitions 312, 314) or the same amount of temporal and/or frequency resources (e.g., as sub-RATs 316, 318). A given frequency and temporal range may be associated with a particular frame and symbol structure (as well as subcarrier spacing and symbol duration), with the frame and symbol structures of the frequency and temporal range independent of the frame and symbol structures of other frequency and temporal ranges.

[0047] FIG. 4 illustrates a unified frame structure in accordance with some embodiments. The unified frame structure contains frames 400, subframes 410, slots 420 and symbols 430. More specifically, each frame 400 may contain L subframes of equal duration and have an overall duration of X ms. Each subframe 410 may similarly comprise N slots of equal duration and have an overall duration of Y ms. Each slot may, in turn, comprise M symbols of equal duration. The slot and symbol durations may be different between subframes of different RATs depending on specific use cases, frequency bands and deployment scenarios. The frame structure of each of RAT may be independent of the frame structure of the other RATs. Thus, a particular RAT may have one or more of different L, N and/or M values, as well as different X and/or Y values, as the other RATs. This may also apply to the sub-RATs and partitions shown in FIG. 3.

[0048] FIG. 5 illustrates a Transmission Time Interval (TTI) boundary alignment in accordance with some embodiments. In some embodiments of the unified frame structure, it may be beneficial from a simplified design standpoint to periodically align the TTI boundary 530 between different RATs 510, 520, e.g., at a particular subframe or frame boundary after a predetermined number of subframes or frames. Thus, in some embodiments an integral number of TTIs 540 of a RAT 510 having a smaller TTI duration (low latency RAT) may be disposed within a single TTI 550 of a RAT 520 having a larger TTI duration. In the example shown in FIG. 5, the smaller TTI duration RAT 510 may have a TTI 540 of 0.1ms while the larger TTI RAT 520 may have a TTI 550 of 1ms. By implementing a TTI of 1ms, a low latency RAT TTI may align with the existing LTE specification TTI boundary. Having a common TTI boundary may support

cross-carrier/RAT scheduling for high frequency band RATs from low frequency band RATs based an anchor booster architecture. This is to say that, in some embodiments for cross-carrier/RAT scheduling, as shown a common PDCCH may be used to schedule other RATs, with the UE switching to a particular RAT to obtain the scheduling and then switching to another RAT to communicate and perhaps to obtain further scheduling information using that RAT. In some embodiments, the other RAT may contain a PDCCH for additional scheduling, while in other embodiments the other RAT may not contain a PDCCH, in which case the UE may periodically switch to the scheduling RAT to obtain scheduling information for the other RAT. In some embodiments, a UE may obtain initial scheduling information (e.g., when it initially powers on or otherwise accesses the eNB) from the initial RAT (e.g., a conventional 4G system RAT) and from then on, after switching to its assigned RAT, obtains scheduling information using that RAT. In other embodiments, each RAT may contain a PDCCH and scheduling is performed for the UE operating on the RAT. A licensed low frequency band RAT may provide reliable coverage for control signaling as an anchor cell, using the PDCCH shown in FIG. 5, while a high frequency band RAT may provide opportunistic boosting in data rate when channel conditions are favorable as booster cell.

[0049] FIG. 6 illustrates a symbol structure in accordance with some embodiments. FIG. 6 shows an OFDM symbol 610 and a unique word (UW) OFDM symbol 620. Each OFDM symbol 610 may contain a cyclic prefix (CP) 612 that comprises a replication of the initial portion of the OFDM symbol 610. The CP 612 may range in size from 1/4 to 1/32 of the symbol period 614. The CP 612 may be disposed at the end of the symbol or outside the symbol, depending on specific waveform, thereby creating a guard between the symbol and the adjacent symbol. In some embodiments, when OFDM downlink and SC-FDMA uplink waveforms are selected for a 5G RAT, the CP 612 may be inserted outside the symbol 610. In embodiments in which a UW OFDM symbol 620 or UW Discrete Fourier transform-Spread-Orthogonal Frequency Division Multiplexing (UW-DFT-s-OFDM) symbol is used, the UW 622 may be inserted within one symbol duration 624. The symbol structure may be independent for each of the RATs, such that whether or not a particular RAT a

CP or UW and whether the CP or UW is outside or within a symbol is independent of the symbol structure of any other RAT.

[0050] As shown in FIG. 6, the UW-OFDM 620 may be used to support different UW lengths based on different channel delay spreads while maintaining the same symbol duration (or FFT size). This enables both shorter UW 622 and longer UW 626 to be used in the same size symbol 624 as the UW 622, 624 is inserted within the FFT instead of being adding after the FFT size. The ability to maintain the same symbol duration may provide a greater flexibility to support a unified RAT design. In one example, using an OFDM symbol for a low frequency band (below 6GHz), a subcarrier spacing of 60KHz (i.e., K = 4, Δf =60KHz) may be used to achieve a 0.1ms TTI. This translates to OFDM symbols of T=16.7μs (66.7μs/K). Thus, 5 OFDM symbols may be able to be accommodated within one subframe (83.5μs) with a CP length of approximately 3.3μs (0.1ms - 83.5μs =16.5μs/5 CPs).

[0051] FIG. 7 illustrates frame structures within a TTI in accordance with some embodiments. In FIG. 7, various TTIs 710, 720, 730, 740 are illustrated in which the TTIs 710, 720, 730, 740 comprise UW-OFDM waveforms. The first TTI 710 shown in FIG. 7 may comprise a UW 712 and symbol 714 of typical length. In this example, the subcarrier spacing may be 15KHz and the symbol duration 716 may be 66.7μs. A total of 3 OFDM symbols 716 may be present in a TTI 710 of 200μs.

[0052] The second TTI 720 shown in FIG. 7 may comprise a low latency TTI 720 with short symbol duration. Such a TTI 720 can be used for use cases such as mission critical MTC applications and Vehicle–to-Vehicle applications, among others. The UW 722 and symbol 724 may each be smaller than the first TTI 710. In this example, the subcarrier spacing may be 30KHz and the symbol duration 726 may be 33.3μs. For a TTI 720 of the same length as the first TTI (e.g., 200μs), a total of 6 short OFDM symbols 726 may be present.

[0053] The third TTI 730 shown in FIG. 7 may comprise another low latency TTI 730 similar to the low latency TTI 720. The UW 732 and symbol 734 may each be smaller than the first TTI 710, the subcarrier spacing may be 30KHz and the symbol duration 736 may be 33.3μs. However, in this example

the TTI 730 may only be half the length as the first TTI (i.e., 100μs), corresponding to a total of 3 short OFDM symbols 736.

[0054] The fourth TTI 740 shown in FIG. 7 may comprise a low energy TTI 740, e.g., for use by MTC UEs. The UW 742 and symbol 744 may each have a longer duration smaller than the first TTI 710. In one example, the subcarrier spacing may be 5KHz and the symbol duration 746 may be 200μs. In this example, the TTI 740 may be 1ms, corresponding to a total of 5 long OFDM symbols 746.

[0055] The above TTIs 710, 720, 730, 740 may be FDM or TDM multiplexed based on the FRAT design. One or more of the UW-OFDM waveforms may be replaced by other waveforms so long as the same symbol duration is maintained. Other examples of OFDM waveforms may include ZT-OFDM and UW-DFTs-OFDM, among others. When different waveforms are used in the same carrier, multi-RATs can be supported where each RAT may have different waveform design. In some embodiments, existing LTE waveforms may be reused, i.e., OFDM waveforms may be used for downlink and SC-FDMA waveforms may be used for uplink communications. In some embodiments, OFDM may be used both downlink and uplink communications. In some embodiments, UW-based waveforms may be used both downlink and uplink communications. For example, UW-OFDM waveforms may be used for downlink communications and UW-DFT-s-OFDM waveforms may be used for uplink communications or either UW-OFDM or UW-DFT-s-OFDM waveforms may be used for both downlink and uplink communications. In some embodiment, filtered OFDM and filter-bank multiple carrier (FBMC) may be used. FBMC waveforms are produced using a nonrectangular sub-channel pulse shape in the time domain during OFDM-offset quadrature amplitude modulation (OQAM) transmission (in which the real part of QAM symbols are mapped to ½ of the multi-carrier symbols and the imaginary parts are mapped to an interlaced 1/2 of the multi-carrier symbols) and may lack a CP.

[0056] Tables 1-3 below illustrate various examples of 5G numerology.

Frequency Band	Subcarrier spacing	TTI	DL waveform	UL waveform

<3GHz (low power or MTC)	1.5KHz	10ms	OFDM	SC-FDMA
<3GHz	15KHz	1ms	OFDM	SC-FDMA
[3-6]GHz	75KHz	0.2ms	UW-OFDM	UW-DFT-s-OFDM
[6-30]GHz	480KHz	0.1ms	UW-OFDM	UW-DFT-s-OFDM
>30GHz	1.5MHz	0.1ms	DFT-s-OFDM	DFT-s-OFDM

Table 1: First 5G numerology example

Frequency Band	Subcarrier spacing	TTI	DL waveform	UL waveform
<3GHz (low power or MTC)	1.5KHz	10ms	UW-OFDM	UW-OFDM
<3GHz	15KHz	1ms	UW-OFDM	UW-OFDM
[3-6]GHz	75KHz	0.2ms	UW-OFDM	UW-OFDM
[6-30]GHz	480KHz	0.1ms	UW-DFT-s-OFDM	UW-DFT-s-OFDM
>30GHz	1.5MHz	0.1ms	OFDM	OFDM

Table 2: Second 5G numerology example

Frequency Band	Subcarrier spacing	TTI	DL waveform	UL waveform
<3GHz (low power or MTC)	1.5KHz	10ms	OFDM	OFDM
<3GHz	15KHz	1ms	OFDM	OFDM
[3,6]GHz	75KHz	0.2ms	OFDM	OFDM
[6,30]GHz	480KHz	0.1ms	UW-DFT-s-OFDM	UW-DFT-s-OFDM
>30GHz	1.5MHz	0.1ms	UW-DFT-s-OFDM	UW-DFT-s-OFDM

Table 3: Third 5G numerology example

[0057] FIGS. 8A and 8B illustrate flowcharts of a uniform framework utilization method in accordance with some embodiments. FIG. 8A in particular illustrates a flowchart of a uniform framework utilization method of an eNB such as the eNB shown in FIGS. 1 or 2 in accordance with some embodiments. As shown in FIG. 8A, the eNB may determine the unified framework at operation 802. The unified framework may include access scheme, modulation

scheme, frame structure, symbol structure, and configurable numerology including subcarrier spacing and symbol duration. The different frame and symbol structures may be associated with different temporal and/or frequency resources multiplexed respectively in a TDM or FDM manner.

[0058] At operation 804, the eNB may communicate specific unified framework configuration information of a particular RAT to one or more UEs serviced by the eNB. Different RAT information may be provided to different UEs attached to the eNB, in which different RATs may be associated with different frequency bands and/or time spans. The eNB may determine the configuration information to be provided to a particular UE based on the device type and/or data to be communicated between the UE and the eNB. The frequency bands may include both licensed and unlicensed frequency bands. The RAT information may include access and modulation scheme, frame and symbol structure, as well as numerology. The RAT information may also include resource allocation and partition information. The unified framework configuration information provided to each UE may be independent of the unified framework configuration information provided to any other UE. The RAT indicated by the eNB to the UE may be dependent on the type and/or operating mode of the UE.

[0059] The eNB may communicate with the UE at operation 806 using the RAT provided at operation 804. The information may include data and/or control information. For example, downlink communications from the eNB to the UE may include paging or control signals for channel estimation on the PDCCH and voice or video data from another UE on the PDSCH. The RAT information may be provided using a dedicated RAT that is different from the RAT used for communication with the UE or using a dedicated carrier on the RAT used for communication with the UE.

[0060] The eNB may, subsequent to communicating with the UE, receive an indication from the UE of a change of operating state of the UE at operation 808. The UE may, for example, be configured to operate in one or more of a normal mode, a low latency and low energy mode. The eNB may, at operation 804, assign the RAT to the UE based on the initial mode of the UE and

determine that an update of the operation mode of the UE has occurred at operation 808.

[0061] In response to determining at operation 808 that an update of the operation mode of the UE has occurred, the eNB may determine a new RAT and transmit the updated unified framework configuration information of the new RAT to the UE at operation 810. The new RAT may include a different frame and/or symbol structure and use a different frequency spectrum and/or time range. The eNB may then continue to communicate with the UE at operation 806.

[0062] FIG. 8B illustrates a uniform framework utilization method as performed by a UE in accordance with some embodiments. The UE may be the UE shown in FIGS. 1 or 2 and may attach to the eNB prior to communicating data. During the attachment, the UE may transmit the initial operation conditions to the eNB at operation 812. In particular, the UE may provide a UE type and/or operating mode during attachment. For example, the UE may be a MTC UE. The UE may moreover be configured to operate in a low latency and/or low energy mode. In some embodiments, a MTC UE may operate in an enhanced coverage, low energy mode.

[0063] In response to transmitting the operating conditions, unified framework configuration (RAT) information may be received by a particular UE at operation 814. The RAT information may be dependent on the type and/or operating mode of the UE. The RAT may be associated with a particular frequency band and/or time range. For example, when the UE operates in the low latency mode, a larger subcarrier spacing and shorter symbol duration may be indicated by the unified framework configuration information; while when the UE operates in the low energy mode, a smaller subcarrier spacing and longer symbol duration may be indicated by the unified framework configuration information.

[0064] Once the RAT received by the UE, the UE may then communicate using the RAT at operation 816. The UE may, for example, adjust FFT operating conditions and processing to meet the RAT information provided at operation 814. The UE may communicate with the eNB or may communicate directly with other UEs using device-to-device communication (D2D)

communication. The information may include uplink and downlink data and/or control information. For example, the information may include uplink communications of voice or video data for another UE or measurements of control signals for channel estimation.

[0065] The UE may, subsequent to communicating with the eNB, determine that a change of operating conditions is warranted at operation 818. For example, the UE may transition between the normal and enhanced coverage/low energy mode dependent on UE location, or between the normal and low latency mode dependent on the type of communication to transmit.

[0066] In response to determining that a change of operating conditions is warranted at operation 818, at operation 820 the UE may transmit an indication to the eNB indicating the change of operating state of the UE. The UE may instead determine that a change of operating conditions is desired at operation 820 and wait to change operating state until a new RAT is assigned to the UE.

[0067] In response to transmitting the indication at operation 820, the UE may return to operation 814 and receive a new RAT at operation 810. The new RAT may include a different frame and/or symbol structure and use a different frequency spectrum and/or time range. The eNB may then continue to communicate with the UE at operation 816.

[0068] Various examples of the disclosure are provided below. These examples are not intended to in any way limit the disclosure herein. In Example 1, user equipment (UE) may comprise processing circuitry configured to: configure a transceiver to receive a resource allocation from a network using a first Radio Access Technology (RAT), the first RAT selected from a plurality of RATs of a flexible RAT (FRAT) employed by the network, the plurality of RATs of the FRAT each comprising configurable numerology with flexible subcarrier spacing and symbol duration and associated with at least one of different temporal and frequency resources, the transceiver configurable to communicate using the plurality of RATs and configure the subcarrier spacing and symbol duration based on the numerology; and configure the transceiver to communicate using the first RAT.

[0069] In Example 2, the subject matter of Example 1 can optionally include that the processing circuitry is further configured to configure the transceiver to receive from an enhanced NodeB (eNB) higher layer signaling associated with the FRAT, the higher layer signaling indicating numerologies, resource allocation and partition information in at least one of a time and frequency domain.

[0070] In Example 3, the subject matter of one or any combination of Examples 1-2 can optionally include that the FRAT comprises a base subcarrier spacing and symbol duration, and at least one of the subcarrier spacing and symbol duration for different RATs of the FRAT is respectively specified as an integer number of the base subcarrier spacing or symbol duration.

[0071] In Example 4, the subject matter of one or any combination of Examples 1-3 can optionally include that the UE is a Machine-Type Communication (MTC) UE configured to operate in at least one of a low latency and low energy mode, and the first RAT comprises a larger subcarrier spacing and shorter symbol duration when the UE operates in the low latency mode and comprises a smaller subcarrier spacing and longer symbol duration when the UE operates in the low energy mode.

[0072] In Example 5, the subject matter of one or any combination of Examples 1-4 can optionally include that at least one of the plurality of RATs of the FRAT comprises at least one of a plurality of sub-RATs and partitions, each of the at least one of the plurality of sub-RATs and partitions comprising an independent configurable numerology with flexible subcarrier spacing and symbol duration and associated with at least one of different temporal and frequency resource, and the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are combined using at least one of a Time-Division Multiplexing (TDM), Frequency-Division Multiplexing (FDM), Code-Division Multiplexing (CDM), and Spatial Division Multiplexing (SDM).

[0073] In Example 6, the subject matter of one or any combination of Examples 1-6 can optionally include that the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are combined using TDM, and numerologies, resource allocation and partition information in a time domain are at least one of predefined or configured by higher-layer signaling via Master

Information Block (MIB), System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling, or the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are combined using FDM, guard bands are inserted at an edge of frequency resources allocated for the plurality of RATs and the at least one of the plurality of sub-RATs and partitions, and at least one of numerologies and resource partition for the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are at least one of predefined or configured by the higher-layer signaling.

[0074] In Example 7, the subject matter of one or any combination of Examples 1-6 can optionally include that a Transmission Time Interval (TTI) boundary between different RATs of the plurality of RATs is common, and the plurality of RATs comprise a common reference TTI duration.

[0075] In Example 8, the subject matter of one or any combination of Examples 1-7 can optionally include that a symbol structure of each of the plurality of RATs comprises a cyclic prefix (CP) or unique word (UW) outside or within a symbol, and the symbol structure of each of the plurality of RATs is independent of the symbol structure of the other RATs. ‘

[0076] In Example 9, the subject matter of one or any combination of Examples 1-8 can optionally include that the processing circuitry is further configured to configure the transceiver to communicate using Orthogonal Frequency-Division Multiplexing (OFDM) for downlink communications and one of Single Carrier Frequency-Division Multiple Access (SC-FDMA) and OFDM for uplink communications, and configure the transceiver to communicate using at least one of UW-OFDM and UW Discrete Fourier transform-Spread-Orthogonal Frequency Division Multiplexing (UW-DFT-s-OFDM).

[0077] In Example 10, the subject matter of one or any combination of Examples 1-9 can optionally include that a frame structure in each of the plurality of RATs comprises a frame comprising L subframes, each subframe comprising N slots, each slot comprising M symbols, and the frame structure of each of the plurality of RATs is independent of the frame structure of the other RATs.

[0078] In Example 11, the subject matter of one or any combination of Examples 1-10 can optionally include that the processing circuitry is further configured to configure the transceiver to receive numerologies, resource allocation and partition information via Master Information Block (MIB) carried by a physical broadcast channel (PBCH), a System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling in a second RAT, the first and second RATs being different.

[0079] In Example 12, the subject matter of one or any combination of Examples 1-11 can optionally include that the processing circuitry is configured to configure the transceiver to receive numerologies, resource allocation and partition information via a dedicated carrier in the first RAT, a dedicated carrier allocated for each of the plurality of RATs, and a dedicated downlink synchronization signal and physical broadcast channel (PBCH) is able to be received on each of the plurality of RATs.

[0080] In Example 13, the subject matter of one or any combination of Examples 1-12 can optionally include an antenna configured to transmit and receive communications between the transceiver and the eNB.

[0081] Example 14 comprises an apparatus of an eNode B (eNB) comprising processing circuitry configured to: configure a transceiver to transmit resource allocations for different Radio Access Technologies (RATs) to a plurality of user equipment (UE), at least two of the UEs associated with a different RAT, each RAT comprising an independent subcarrier spacing, symbol duration, frame structure and symbol structure; and configure the transceiver to communicate with each UE using the RAT associated with the UE.

[0082] In Example 15, the subject matter of Example 14 can optionally include that the processing circuitry is configured to configure the transceiver to transmit higher layer signaling indicating numerologies, resource allocation and partition information via Master Information Block (MIB) carried by a physical broadcast channel (PBCH), a System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling in a same RAT to each of the plurality of UEs.

[0083] In Example 16, the subject matter of one or any combination of Examples 14-15 can optionally include that the processing circuitry is

configured to configure the transceiver to transmit numerologies, resource allocation and partition information via a dedicated carrier allocated for each of the RATs, and a dedicated downlink synchronization signal and physical broadcast channel (PBCH) is able to be received on each of the RATs.

[0084] In Example 17, the subject matter of one or any combination of Examples 14-16 can optionally include that at least one of the subcarrier spacing and symbol duration for each of the RATs is respectively specified as an integer number of a base subcarrier spacing or symbol duration.

[0085] In Example 18, the subject matter of one or any combination of Examples 14-17 can optionally include that the RATs comprise a first RAT comprising a larger subcarrier spacing and shorter symbol duration configured for a UE operating in a low latency mode and a second RAT comprising a smaller subcarrier spacing and longer symbol duration configured for a UE operating in a low energy mode.

[0086] In Example 19, the subject matter of one or any combination of Examples 14-18 can optionally include that a Transmission Time Interval (TTI) boundary between the RATs is common, and the RATs comprise a common reference TTI duration.

[0087] In Example 20, the subject matter of one or any combination of Examples 14-19 can optionally include that a symbol structure of each of the RATs comprises a cyclic prefix (CP) or unique word (UW) outside or within a symbol, and the symbol structure of each of the RATs is independent of the symbol structure of the other RATs.

[0088] In Example 21, the subject matter of one or any combination of Examples 14-20 can optionally include that the processing circuitry is configured to at least one of: configure the transceiver to communicate using Orthogonal Frequency-Division Multiplexing (OFDM) for downlink communications and one of Single Carrier Frequency-Division Multiple Access (SC-FDMA) and OFDM for uplink communications, and configure the transceiver to communicate using at least one of UW-OFDM and UW Discrete Fourier transform-Spread-Orthogonal Frequency Division Multiplexing (UW-DFT-s-OFDM).

[0089] In Example 22 a non-transitory computer-readable storage medium that stores instructions for execution by one or more processors of a user equipment (UE) to configure the UE to communicate with an enhanced Node B (eNB), the one or more processors to configure the UE to: receive resource allocation, partition information and numerology, including subcarrier spacing and symbol duration, for a first Radio Access Technology (RAT) of a plurality of RATs used by the eNB, the UE configurable to configure the subcarrier spacing and symbol duration based on the numerology and to communicate using the plurality of RATs; and communicate using the first RAT.

[0090] In Example 23, the subject matter of Example 22 can optionally include that at least one of: a) at least one of the subcarrier spacing and symbol duration for the RATs is respectively specified as an integer number of a base subcarrier spacing or symbol duration, b) the UE is configured to operate in at least one of a low latency and low energy mode, and the first RAT comprises a larger subcarrier spacing and shorter symbol duration when the UE operates in the low latency mode and comprises a smaller subcarrier spacing and longer symbol duration when the UE operates in the low energy mode, and c) a Transmission Time Interval (TTI) boundary between the RATs is common, and the RATs comprise a common reference TTI duration.

[0091] In Example 24, the subject matter of one or any combination of Examples 22-23 can optionally include that at least one of: a) a symbol structure of each of the RATs comprises a cyclic prefix (CP) or unique word (UW) outside or within a symbol, and the symbol structure of each of the RATs is independent of the symbol structure of the other RATs, and b) a frame structure in each of the RATs comprises a frame comprising L subframes, each subframe comprising N slots, each slot comprising M symbols, and the frame structure of each of the RATs is independent of the frame structure of the other RATs.

[0092] In Example 25, the subject matter of one or any combination of Examples 22-24 can optionally include that the numerology, resource allocation and partition information is received via Master Information Block (MIB) carried by a physical broadcast channel (PBCH), a System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling in a second RAT, the first and second RATs being different.

[0093] Although an embodiment has been described with reference to specific example embodiments, it will be evident that various modifications and changes may be made to these embodiments without departing from the broader spirit and scope of the present disclosure. Accordingly, the specification and drawings are to be regarded in an illustrative rather than a restrictive sense. The accompanying drawings that form a part hereof show, by way of illustration, and not of limitation, specific embodiments in which the subject matter may be practiced. The embodiments illustrated are described in sufficient detail to enable those skilled in the art to practice the teachings disclosed herein. Other embodiments may be utilized and derived therefrom, such that structural and logical substitutions and changes may be made without departing from the scope of this disclosure. This Detailed Description, therefore, is not to be taken in a limiting sense, and the scope of various embodiments is defined only by the appended claims, along with the full range of equivalents to which such claims are entitled.

[0094] Such embodiments of the inventive subject matter may be referred to herein, individually and/or collectively, by the term “invention” merely for convenience and without intending to voluntarily limit the scope of this application to any single invention or inventive concept if more than one is in fact disclosed. Thus, although specific embodiments have been illustrated and described herein, it should be appreciated that any arrangement calculated to achieve the same purpose may be substituted for the specific embodiments shown. This disclosure is intended to cover any and all adaptations or variations of various embodiments. Combinations of the above embodiments, and other embodiments not specifically described herein, will be apparent to those of skill in the art upon reviewing the above description.

[0095] In this document, the terms "a" or "an" are used, as is common in patent documents, to include one or more than one, independent of any other instances or usages of "at least one" or "one or more." In this document, the term "or" is used to refer to a nonexclusive or, such that "A or B" includes "A but not B," "B but not A," and "A and B," unless otherwise indicated. In this document, the terms "including" and "in which" are used as the plain-English equivalents of the respective terms "comprising" and "wherein." Also, in the following claims, the

terms "including" and "comprising" are open-ended, that is, a system, UE, article, composition, formulation, or process that includes elements in addition to those listed after such a term in a claim are still deemed to fall within the scope of that claim. Moreover, in the following claims, the terms "first," "second," and "third," etc. are used merely as labels, and are not intended to impose numerical requirements on their objects.

[0096] The Abstract of the Disclosure is provided to comply with 37 C.F.R. §1.72(b), requiring an abstract that will allow the reader to quickly ascertain the nature of the technical disclosure. It is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims. In addition, in the foregoing Detailed Description, it can be seen that various features are grouped together in a single embodiment for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted as reflecting an intention that the claimed embodiments require more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive subject matter lies in less than all features of a single disclosed embodiment. Thus the following claims are hereby incorporated into the Detailed Description, with each claim standing on its own as a separate embodiment.

CLAIMS

What is claimed is:

1. User equipment (UE) comprising:

processing circuitry configured to:

configure a transceiver to receive a resource allocation from a network using a first Radio Access Technology (RAT), the first RAT selected from a plurality of RATs of a flexible RAT (FRAT) employed by the network, the plurality of RATs of the FRAT each comprising configurable numerology with flexible subcarrier spacing and symbol duration and associated with at least one of different temporal and frequency resources, the transceiver configurable to communicate using the plurality of RATs and configure the subcarrier spacing and symbol duration based on the numerology; and

configure the transceiver to communicate using the first RAT.

2. The UE of claim 1, wherein the processing circuitry is configured to:

configure the transceiver to receive from an enhanced NodeB (eNB) higher layer signaling associated with the FRAT, the higher layer signaling indicating numerologies, resource allocation and partition information in at least one of a time and frequency domain.

3. The UE of claim 1, wherein:

the FRAT comprises a base subcarrier spacing and symbol duration, and

at least one of the subcarrier spacing and symbol duration for different RATs of the FRAT is respectively specified as an integer number of the base subcarrier spacing or symbol duration.

4. The UE of claim 3, wherein:

the UE is a Machine-Type Communication (MTC) UE configured to operate in at least one of a low latency and low energy mode, and

the first RAT comprises a larger subcarrier spacing and shorter symbol duration when the UE operates in the low latency mode and comprises a smaller

subcarrier spacing and longer symbol duration when the UE operates in the low energy mode.

5. The UE of claim 1, wherein:

at least one of the plurality of RATs of the FRAT comprises at least one of a plurality of sub-RATs and partitions, each of the at least one of the plurality of sub-RATs and partitions comprising an independent configurable numerology with flexible subcarrier spacing and symbol duration and associated with at least one of different temporal and frequency resource, and

the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are combined using at least one of a Time-Division Multiplexing (TDM), Frequency-Division Multiplexing (FDM), Code-Division Multiplexing (CDM), and Spatial Division Multiplexing (SDM).

6. The UE of claim 5, wherein one of:

the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are combined using TDM, and numerologies, resource allocation and partition information in a time domain are at least one of predefined or configured by higher-layer signaling via Master Information Block (MIB), System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling, or

the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are combined using FDM, guard bands are inserted at an edge of frequency resources allocated for the plurality of RATs and the at least one of the plurality of sub-RATs and partitions, and at least one of numerologies and resource partition for the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are at least one of predefined or configured by the higher -layer signaling.

7. The UE of claim 1, wherein:

a Transmission Time Interval (TTI) boundary between different RATs of the plurality of RATs is common, and

the plurality of RATs comprise a common reference TTI duration.

8. The UE of claim 1, wherein:

a symbol structure of each of the plurality of RATs comprises a cyclic prefix (CP) or unique word (UW) outside or within a symbol, and

the symbol structure of each of the plurality of RATs is independent of the symbol structure of the other RATs.

9. The UE of claim 1, wherein the processing circuitry is configured to at least one of:

configure the transceiver to communicate using Orthogonal Frequency-Division Multiplexing (OFDM) for downlink communications and one of Single Carrier Frequency-Division Multiple Access (SC-FDMA) and OFDM for uplink communications, and

configure the transceiver to communicate using at least one of UW-OFDM and UW Discrete Fourier transform-Spread-Orthogonal Frequency Division Multiplexing (UW-DFT-s-OFDM).

10. The UE of claim 1, wherein:

a frame structure in each of the plurality of RATs comprises a frame comprising L subframes, each subframe comprising N slots, each slot comprising M symbols, and

the frame structure of each of the plurality of RATs is independent of the frame structure of the other RATs.

11. The UE of claim 1, wherein the processing circuitry is configured to:

configure the transceiver to receive numerologies, resource allocation and partition information via Master Information Block (MIB) carried by a physical broadcast channel (PBCH), a System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling in a second RAT, the first and second RATs being different.

12. The UE of claim 1, wherein:

the processing circuitry is configured to configure the transceiver to receive numerologies, resource allocation and partition information via a dedicated carrier in the first RAT, a dedicated carrier allocated for each of the plurality of RATs, and

a dedicated downlink synchronization signal and physical broadcast channel (PBCH) is able to be received on each of the plurality of RATs.

13. The UE of claim 1, further comprising an antenna configured to transmit and receive communications between the transceiver and the eNB.

14. An apparatus of an eNode B (eNB) comprising:

processing circuitry configured to:

configure a transceiver to transmit resource allocations for different Radio Access Technologies (RATs) to a plurality of user equipment (UE), at least two of the UEs associated with a different RAT, each RAT comprising an independent subcarrier spacing, symbol duration, frame structure and symbol structure; and

configure the transceiver to communicate with each UE using the RAT associated with the UE.

15. The apparatus of claim 14, wherein the processing circuitry is configured to:

configure the transceiver to transmit higher layer signaling indicating numerologies, resource allocation and partition information via Master Information Block (MIB) carried by a physical broadcast channel (PBCH), a System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling in a same RAT to each of the plurality of UEs.

16. The apparatus of claim 14, wherein the processing circuitry is configured to:

configure the transceiver to transmit numerologies, resource allocation and partition information via a dedicated carrier allocated for each of the RATs, and

a dedicated downlink synchronization signal and physical broadcast channel (PBCH) is able to be received on each of the RATs.

17. The apparatus of claim 14, wherein:

at least one of the subcarrier spacing and symbol duration for each of the RATs is respectively specified as an integer number of a base subcarrier spacing or symbol duration.

18. The apparatus of claim 14, wherein:

the RATs comprise a first RAT comprising a larger subcarrier spacing and shorter symbol duration configured for a UE operating in a low latency mode and a second RAT comprising a smaller subcarrier spacing and longer symbol duration configured for a UE operating in a low energy mode.

19. The apparatus of claim 14, wherein:

a Transmission Time Interval (TTI) boundary between the RATs is common, and

the RATs comprise a common reference TTI duration.

20. The apparatus of claim 14, wherein:

a symbol structure of each of the RATs comprises a cyclic prefix (CP) or unique word (UW) outside or within a symbol, and

the symbol structure of each of the RATs is independent of the symbol structure of the other RATs.

21. The apparatus of claim 14, wherein the processing circuitry is configured to at least one of:

configure the transceiver to communicate using Orthogonal Frequency-Division Multiplexing (OFDM) for downlink communications and one of Single Carrier Frequency-Division Multiple Access (SC-FDMA) and OFDM for uplink communications, and

configure the transceiver to communicate using at least one of UW-OFDM and UW Discrete Fourier transform-Spread-Orthogonal Frequency Division Multiplexing (UW-DFT-s-OFDM).

22. A non-transitory computer-readable storage medium that stores instructions for execution by one or more processors of a user equipment (UE) to configure the UE to communicate with an enhanced Node B (eNB), the one or more processors to configure the UE to:

receive resource allocation, partition information and numerology, including subcarrier spacing and symbol duration, for a first Radio Access Technology (RAT) of a plurality of RATs used by the eNB, the UE configurable to configure the subcarrier spacing and symbol duration based on the numerology and to communicate using the plurality of RATs; and

communicate using the first RAT.

23. The medium of claim 22, wherein at least one of:

a) at least one of the subcarrier spacing and symbol duration for the RATs is respectively specified as an integer number of a base subcarrier spacing or symbol duration,

b) the UE is configured to operate in at least one of a low latency and low energy mode, and

the first RAT comprises a larger subcarrier spacing and shorter symbol duration when the UE operates in the low latency mode and comprises a smaller subcarrier spacing and longer symbol duration when the UE operates in the low energy mode, and

c) a Transmission Time Interval (TTI) boundary between the RATs is common, and

the RATs comprise a common reference TTI duration.

24. The medium of claim 22, wherein at least one of:

a) a symbol structure of each of the RATs comprises a cyclic prefix (CP) or unique word (UW) outside or within a symbol, and

the symbol structure of each of the RATs is independent of the symbol structure of the other RATs, and

b) a frame structure in each of the RATs comprises a frame comprising L subframes, each subframe comprising N slots, each slot comprising M symbols, and

the frame structure of each of the RATs is independent of the frame structure of the other RATs.

25. The medium of claim 22, wherein:

the numerology, resource allocation and partition information is received via Master Information Block (MIB) carried by a physical broadcast channel (PBCH), a System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling in a second RAT, the first and second RATs being different.

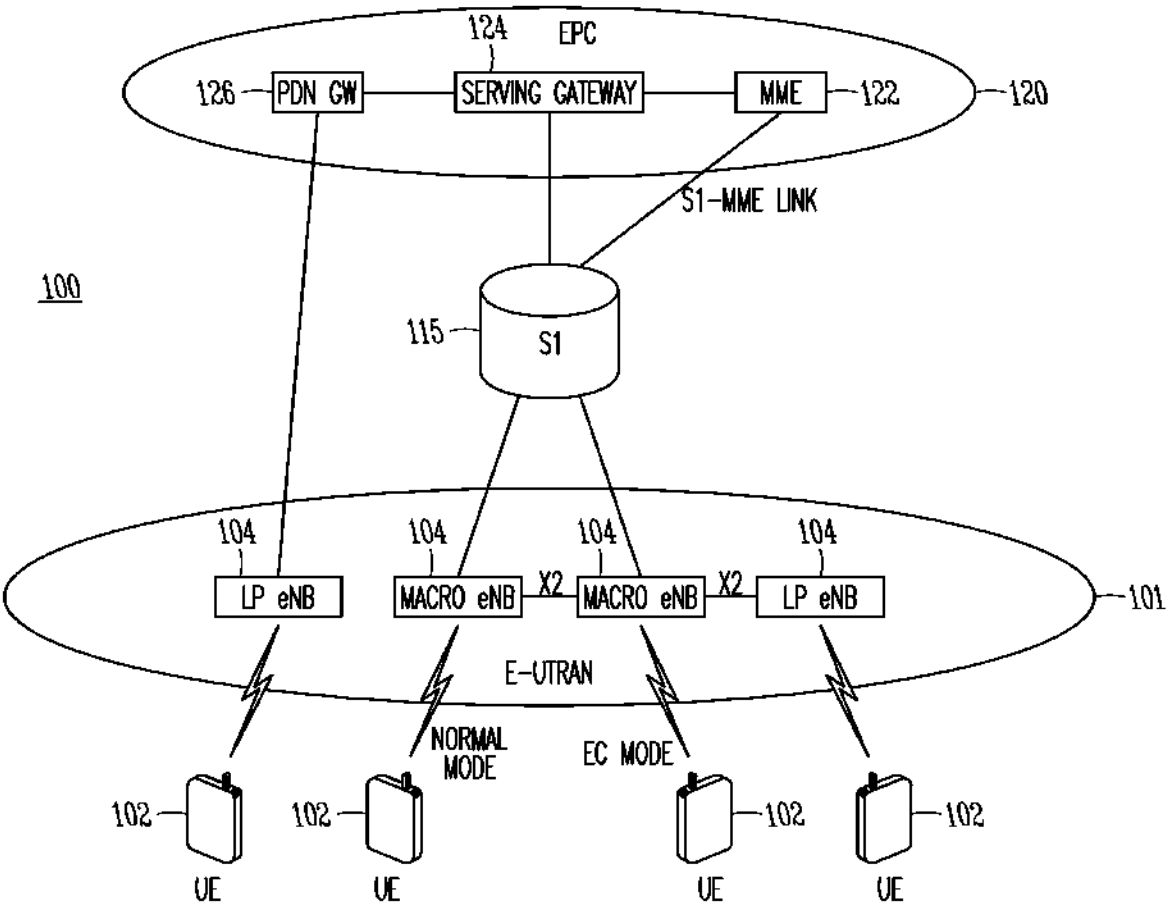

124
EPC
126
PDN GW
SERVING GATEWAY
MME
122
120
S1-MME LINK
100
115
S1
104
104
104
104
LP eNB
MACRO eNB
X2
MACRO eNB
X2
LP eNB
101
E-UTRAN
NORMAL MODE
EC MODE
102
102
102
102
UE
UE
UE
UE

FIG. 1

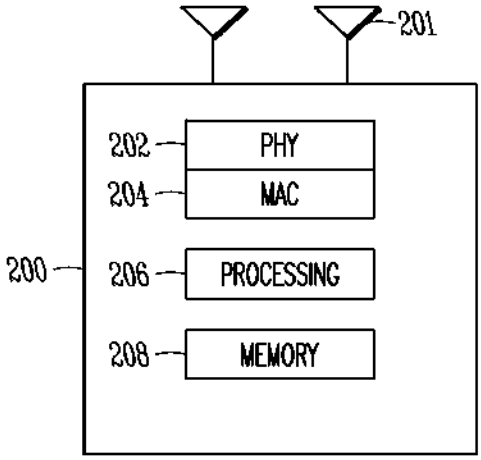


FIG. 2

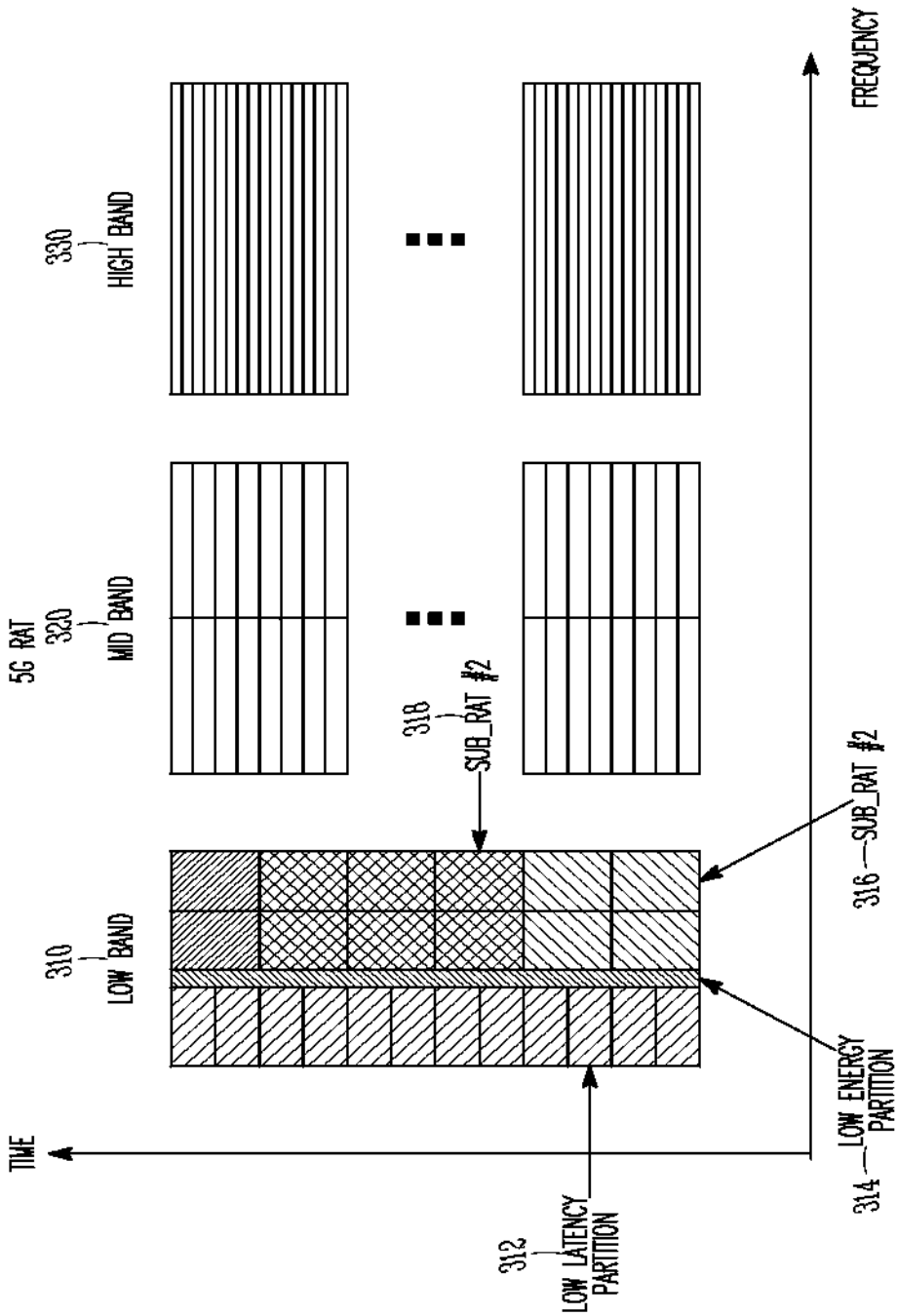

FREQUENCY
330
HIGH BAND
5G RAT
320
MID BAND
318
SUB_RAT #2
310
LOW BAND
316
SUB_RAT #2
TIME
314
LOW ENERGY PARTITION
312
LOW LATENCY PARTITION

FIG. 3

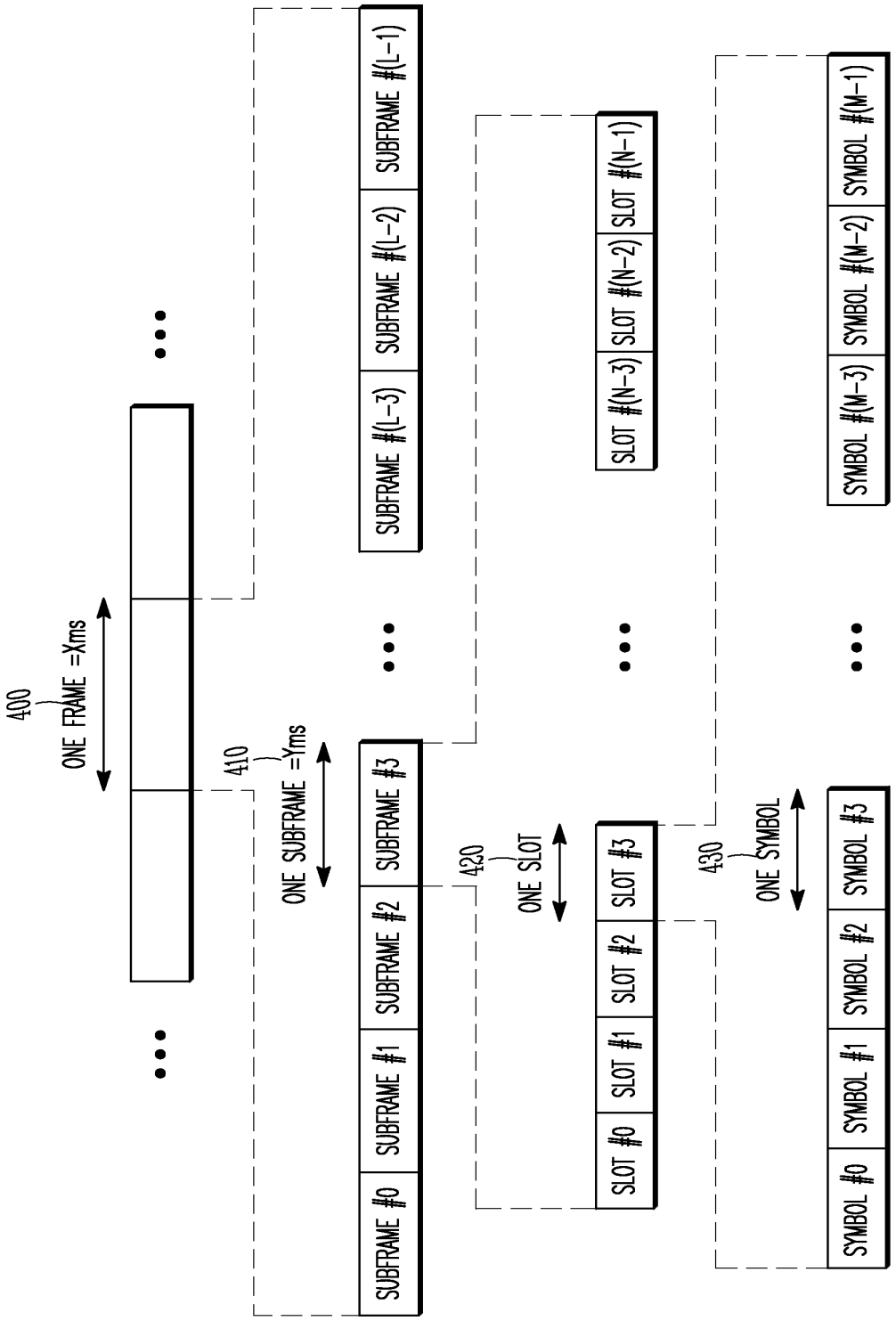

400
ONE FRAME =Xms
410
ONE SUBFRAME =Yms
SUBFRAME #0
SUBFRAME #1
SUBFRAME #2
SUBFRAME #3
SUBFRAME #(L-3)
SUBFRAME #(L-2)
SUBFRAME #(L-1)
420
ONE SLOT
SLOT #0
SLOT #1
SLOT #2
SLOT #3
SLOT #(N-3)
SLOT #(N-2)
SLOT #(N-1)
430
ONE SYMBOL
SYMBOL #0
SYMBOL #1
SYMBOL #2
SYMBOL #3
SYMBOL #(M-3)
SYMBOL #(M-2)
SYMBOL #(M-1)

FIG. 4

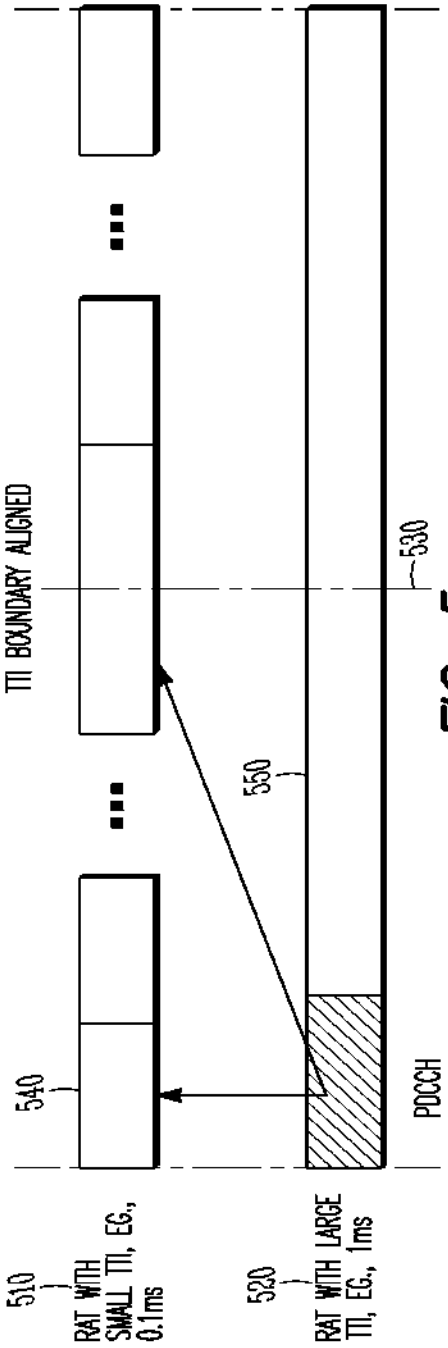

TTI BOUNDARY ALIGNED
530
550
540
PDCCH
510
RAT WITH SMALL TTI, EG., 0.1ms
520
RAT WITH LARGE TTI, EG., 1ms

FIG. 5

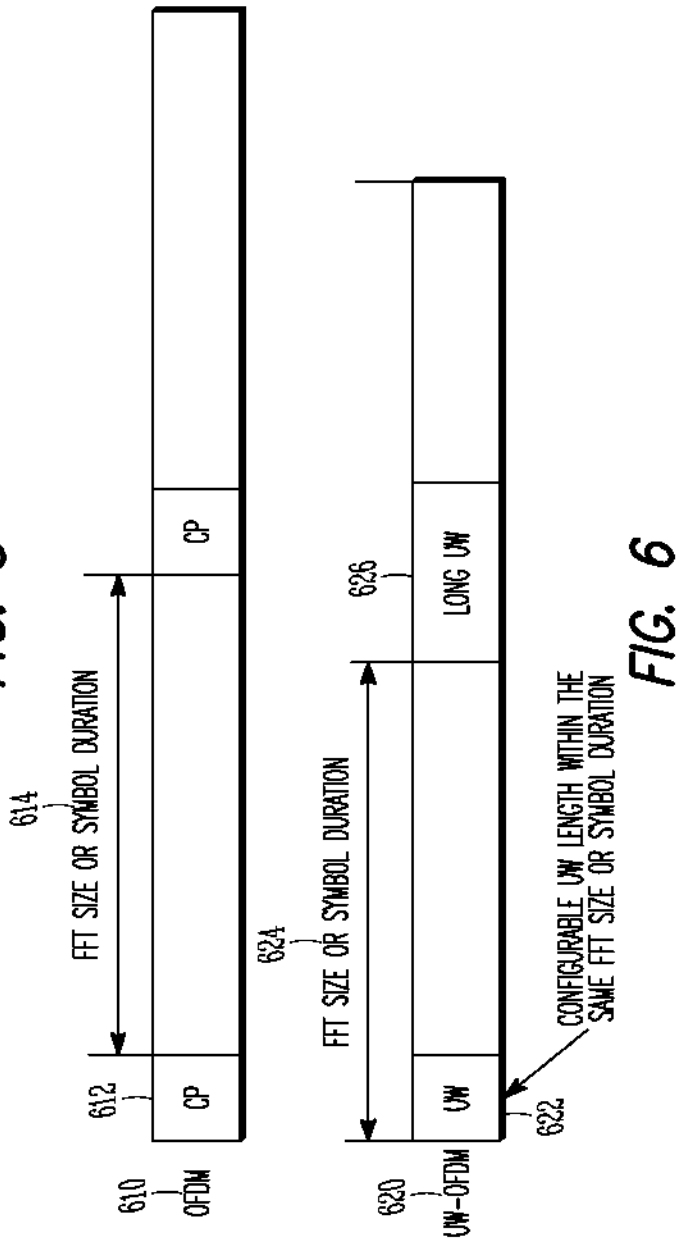

614
FFT SIZE OR SYMBOL DURATION
CP
612
610
OFDM
624
FFT SIZE OR SYMBOL DURATION
626
LONG UW
UW
622
620
UW-OFDM
CONFIGURABLE UW LENGTH WITHIN THE SAME FFT SIZE OR SYMBOL DURATION

FIG. 6

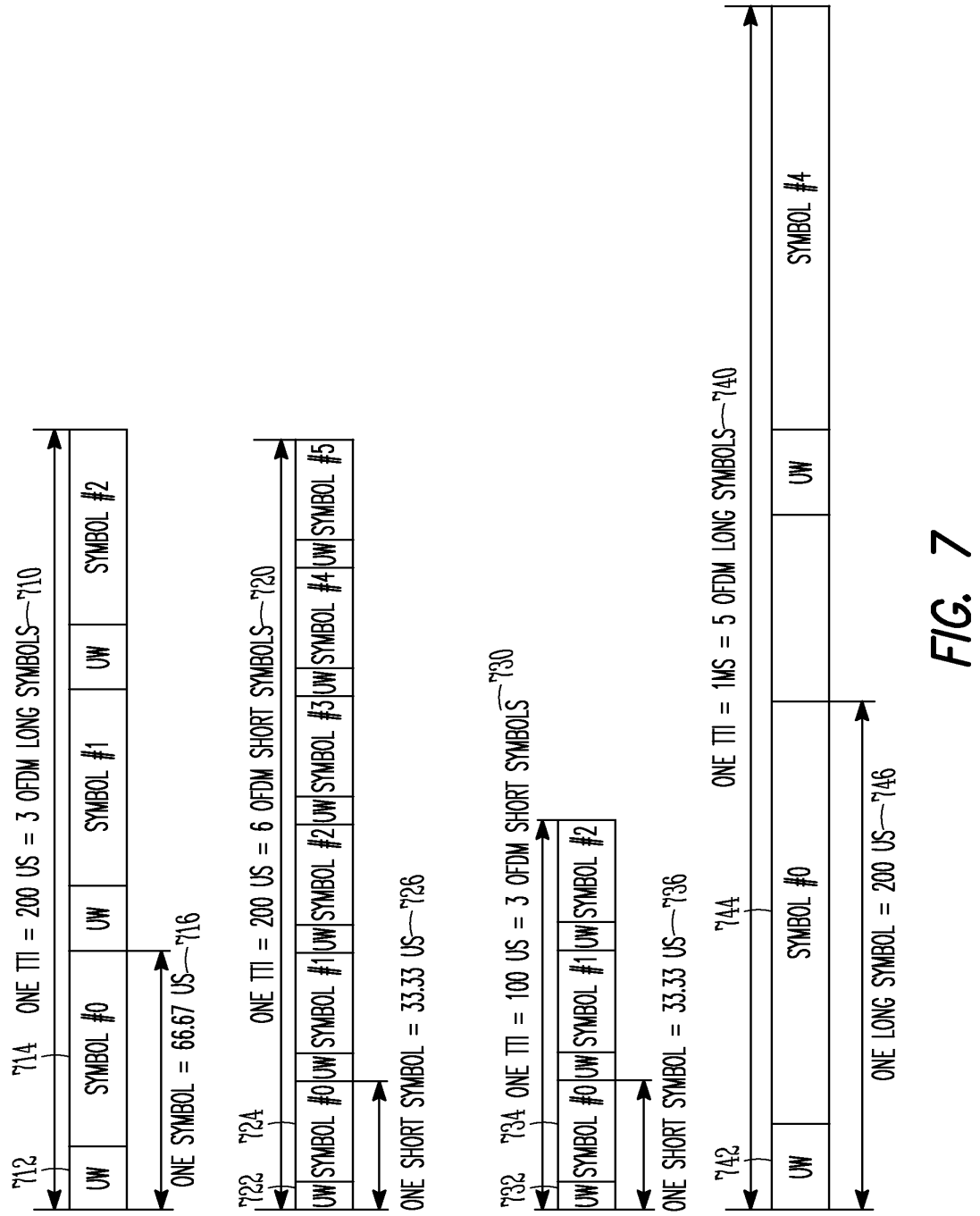

712
714
ONE TTI = 200 US = 3 OFDM LONG SYMBOLS
710
UW
SYMBOL #0
UW
SYMBOL #1
UW
SYMBOL #2
ONE SYMBOL = 66.67 US
716
722
724
ONE TTI = 200 US = 6 OFDM SHORT SYMBOLS
720
UW
SYMBOL #0
UW
SYMBOL #1
UW
SYMBOL #2
UW
SYMBOL #3
UW
SYMBOL #4
UW
SYMBOL #5
ONE SHORT SYMBOL = 33.33 US
726
732
734
ONE TTI = 100 US = 3 OFDM SHORT SYMBOLS
730
UW
SYMBOL #0
UW
SYMBOL #1
UW
SYMBOL #2
ONE SHORT SYMBOL = 33.33 US
736
742
744
ONE TTI = 1MS = 5 OFDM LONG SYMBOLS
740
UW
SYMBOL #0
UW
SYMBOL #4
ONE LONG SYMBOL = 200 US
746

FIG. 7

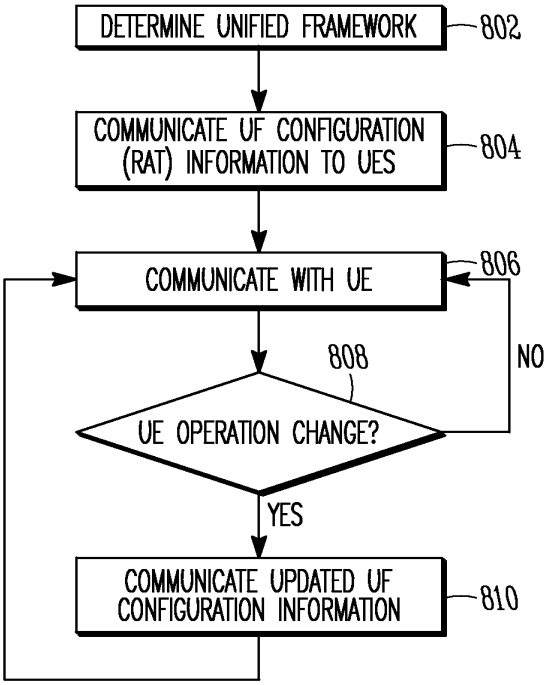

DETERMINE UNIFIED FRAMEWORK
802
COMMUNICATE UF CONFIGURATION (RAT) INFORMATION TO UES
804
COMMUNICATE WITH UE
806
808
UE OPERATION CHANGE?
NO
YES
COMMUNICATE UPDATED UF CONFIGURATION INFORMATION
810

FIG. 8A

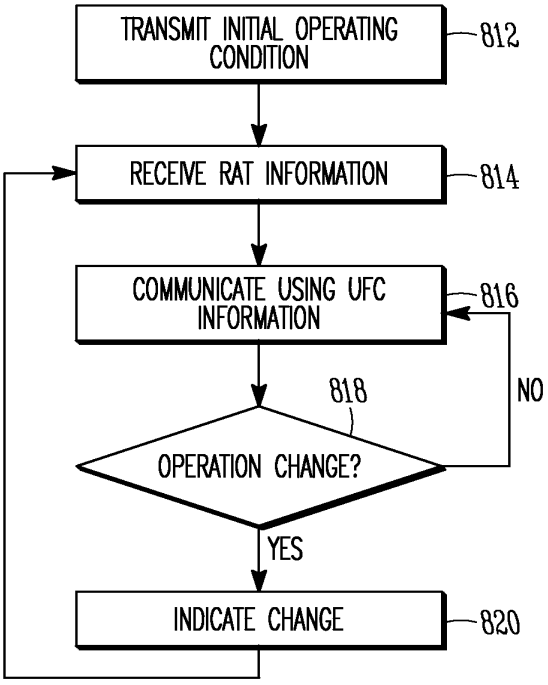

TRANSMIT INITIAL OPERATING CONDITION
812
RECEIVE RAT INFORMATION
814
COMMUNICATE USING UFC INFORMATION
816
818
OPERATION CHANGE?
NO
YES
INDICATE CHANGE
820

FIG. 8B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/044628

A. CLASSIFICATION OF SUBJECT MATTER

H04W 72/04(2009.01)i, H04W 92/10(2009.01)i, H04W 88/06(2009.01)i, H04W 88/08(2009.01)i, H04B 7/26(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W 72/04; H04L 5/00; H04Q 7/00; H04W 88/06; H04L 27/26; H04W 92/10; H04W 88/08; H04B 7/26

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: radio access technology (RAT), FRAT (flexible RAT), flexible subcarrier spacing and symbol duration, numerology, MTC, low latency, low energy, sub-RAT, partition, combination, TTI, unique word (UW), UW-OFDM, UW-DFT-s-OFDM, synchronization, broadcast

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2008-0130570 A1 (YOUNG-HO JUNG et al.) 5 June 2008 See paragraphs [0011], [0033]-[0045]; claims 1, 7; and figures 3-5.	1-25
Y	EEVA LAHETKANGAS et al., 'On the Flexible 5G Dense Deployment Air Interface for Mobile Broadband', In: 5G for Ubiquitous Connectivity (5GU), 2014 1st International Conference on, Page(s): 57-61, 26-28 November 2014 See pages 1-3; and figures 1, 4.	1-25
Y	US 2015-0029990 A1 (INTERDIGITAL PATENT HOLDINGS, INC.) 29 January 2015 See paragraphs [0066]-[0082]; and figure 1.	7,19
Y	US 2014-0140194 A1 (STEFAN FECHTEL) 22 May 2014 See paragraph [0024]; and figures 2A, 2B.	8,9,20,21
A	WO 2014-139562 A1 (NOKIA SOLUTIONS AND NETWORKS OY) 18 September 2014 See page 11, lines 19-32; claims 1, 8, 12; and figures 4, 5.	1-25

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 December 2015 (18.12.2015)	**21 December 2015 (21.12.2015)**

Name and mailing address of the ISA/KR
International Application Division
Korean Intellectual Property Office
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Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2015/044628

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2008-0130570 A1	05/06/2008	KR 10-0969751 B1	13/07/2010
		KR 10-2008-0048293 A	02/06/2008
		US 8259667 B2	04/09/2012
US 2015-0029990 A1	29/01/2015	TW 201246857 A	16/11/2012
		US 2012-0230268 A1	13/09/2012
		US 8861461 B2	14/10/2014
		WO 2012-122170 A1	13/09/2012
US 2014-0140194 A1	22/05/2014	TW 201434298 A	01/09/2014
		WO 2014-079712 A1	30/05/2014
WO 2014-139562 A1	18/09/2014	None	

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(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
11 May 2017 (11.05.2017)

WIPO | PCT

(10) International Publication Number
WO 2017/079530 A1

(51) International Patent Classification:
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H04W 28/06 (2009.01)

(21) International Application Number:
PCT/US2016/060481

(22) International Filing Date:
4 November 2016 (04.11.2016)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/250,791 4 November 2015 (04.11.2015) US

(71) Applicant: **INTERDIGITAL PATENT HOLDINGS, INC.** [US/US]; 200 Bellevue Parkway, Suite 300, Wilmington, DE 16809 (US).

(72) Inventor: **PELLETIER, Ghyslain**; 4650 Charlemagne, Montreal, QC H1X 3P2 (CA).

(74) Agents: **ROCCIA, Vincent** et al.; Condo Roccia Koptiw LLP, 1800 Jfk Blvd., Suite 1700, Philadelphia, PA 19103 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

(54) Title: DEVICE AND METHODS FOR MULTIPLEXING TRANSMISSIONS WITH DIFFERENT TTI DURATION

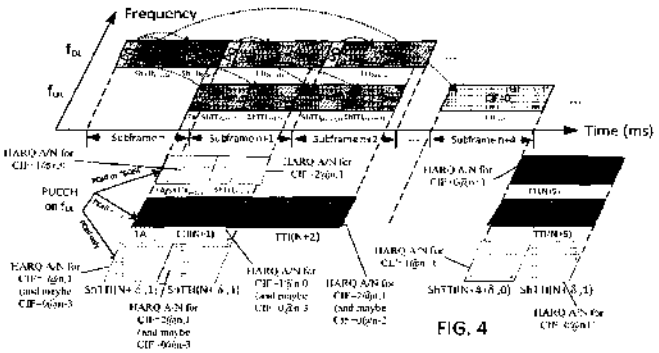


FIG. 4

(57) Abstract: A wireless transmit/receive unit, WTRU and methods of using a WTRU within a wireless communications network include communicating with a serving cell in the wireless communications network and determining, based on downlink control information whether the WTRU shall transmit with a first transmission time interval, TTI, length, using a first set of transmission resources, or a second TTI length, using a second set of transmission resources. Alternatively, determining based on said DCI, that the serving cell has indicated that the WTRU should use a first TTI on a physical uplink channel to communicate with the serving cell, or whether said DCI indicates that the WTRU should use a second TTI that is less than the first transmission time interval to communicate with the wireless communication network on the physical uplink channel or whether the WTRU should transmit using carrier aggregation.

WO 2017/079530 A1

DEVICE AND METHODS FOR MULTIPLEXING TRANSMISSIONS WITH DIFFERENT TTI DURATION

BACKGROUND

[0001] In a wireless communication network, such as a Long Term Evolution (LTE) system or New Radio (NR), a wireless transmit/receive unit (WTRU) device may access resources of the communication system. Latency associated with transmission of data in a communication system may have one or more latency components. A latency component may be the time to perform the transmission of a transport block, which time may be referred to as a Transmission Time Interval (TTI). Such TTI may be tied to a specific numerology associated with the transmission method and to a specific number of transmission symbols associated with the transmission. Other latency components may include processing time at a receiver, e.g., time decoding a transmission, transmission of feedback (e.g. ACK or NACK) and/or one or more retransmissions with one or more latency components.

SUMMARY

[0002] Systems, methods, and instrumentalities are disclosed for multiplexing transmissions with different durations, for example transmissions that are associated with different TTI lengths. Latency may be reduced (e.g., in an LTE system and/or in a NR system), for example, by multiplexing transmissions with different TTI durations or associated with different transmission numerologies. TTI duration may be modeled based on defining one or more cell(s) for a given carrier frequency, for example that may be associated with different TTI lengths and/or transmission durations. For example, the different transmission durations may be achieved by time-shifting one or more of the cells. In order to support signaling techniques that allow for concurrent and/or complementary scheduling of transmissions associated with different duration, a logical structure for the physical layer resources (e.g., a cell, a spectrum block, etc.) may configured to correspond to a secondary cell ("SCell"). A primary cell ("PCell") may logically maintain a first transmission duration (e.g., a first TTI length such as a legacy TTI length). The SCell may be configured with a second transmission duration (e.g., a second TTI length or a shortened TTI length). One or more of a PCell or an SCell may be configured with either the legacy or shortened TTI length (e.g., a shorter duration TTI (ShTTI).

[0003] By associating different TTI lengths with different cells, the LTE carrier aggregation framework can be utilized to support multiplexing of transmissions of different durations. For example, carrier aggregation signaling, including cross-carrier scheduling mechanisms, can be used to different scheduling grants and assignments of varying length. For example, a WTRU may determine a TTI duration (e.g., first or second TTI length) applicable to a transmission. For example, a WTRU may determine a TTI duration using cross-carrier scheduling. A WTRU may be configured to associate a given cell identity (e.g., servCellID) with a given transmission duration. Different cell identities (e.g., different servCellIDs) may be associated with different transmission durations/different TTI lengths. When a WTRU receives scheduling information applicable to a given cell identity, the WTRU may determine the associated TTI length based on the configuration received for that cell identity.

[0004] A WTRU may determine a TTI length and/or transmission duration based on one or more parameters and/or received fields. For example, a WTRU may associate a given TTI duration with a given transmission mode (TM). A TTI duration may be indicated by a Carrier Indicator Field (CIF), for example where certain values of the CIF are associated with SCells configured with a given TTI durations such as a ShTTI. The CIF may also be referred to as a Carrier Indicator Field (CIF). The TTI duration may be indicated by a field that indicates a set of resources such as a set of PRBs, a carrier, a serving cell of the WTRU's configuration, and/or a spectrum block. A TTI duration may be determined from an identity of a PRB subset associated with the transmissions and/or to a time-shifted cell within a subset of PRBs for a concerned carrier frequency. An applicable TTI duration and/or the identity of a slot/period applicable to a transmission within a subframe may be determined using a medium access control (MAC) Activation/Deactivation control element. MAC Activation/Deactivation CE may be used to toggle between first and second TTIs (e.g. legacy TTI and ShTTIs) or between slot-based ShTTIs and/or may be used to determine zero, one or more TTI (e.g. ShTTI) period(s) within a subframe.

[0005] HARQ processing may be performed according to a first behavior (e.g. legacy behavior) for one or more (e.g. each) time-shifted cell(s), although there may be exceptions. An exception may be timing-relationships, which may be scaled according to an applicable TTI duration. HARQ A/N feedback formats may use LTE Carrier Aggregation (CA) formats and/or (e.g. legacy) subframe-based timing relationships or a timing relationship associated with the HARQ process. Downlink Control Information (DCI) signaling may use a first (e.g. legacy) format, although, for example, interpretation of fields such as the CIF and/or fields that indicate the PRBs applicable for the transmission may be different than the interpretations of the first

(e.g. legacy) format. MAC activation/deactivation signaling may be applicable for time-shifted cells. DRX Timers associated with DRX may scale to HARQ A/N timing according to an applicable TTI duration and/or to the cell associated with an HARQ process. Physical random access channel (PRACH) resources and/or physical downlink control channel (PDCCH) order for RACH may or may not be supported for time-shifted SCells. Timing advance for uplink transmission may be time shifted, for example, according to a shift applied to the TTI associated with a cell. Time shift may be relative to PCell timing, e.g. a PCell may remain a DL timing reference for an SCell with the additional offset corresponding to the start of the ShTTI for those cells.

[0006] A method of using a wireless transmit/receive unit within a wireless communications network that is capable of aggregating different sets of physical layer resources (e.g., such as carrier aggregation, for example) may include communicating with a serving cell in the wireless communications network and determining that the serving cell has indicated that the WTRU should use a first transmission time interval on a physical uplink channel to communicate with the serving cell. The method may also include determining whether downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment) indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network (e.g., on the physical uplink channel). The method may further include communicating with the wireless communications network using the second transmission time interval.

[0007] The method may include determining that a downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment) indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network (e.g, on the physical uplink channel) comprises determining based on a carrier indicator field in received downlink control information.

[0008] The method may include communicating with the wireless communications network using the second transmission time interval comprises communicating with the serving cell using the second transmission time interval.

[0009] The method may include wherein communicating with the wireless communications network using the second transmission time interval includes communicating with a secondary cell using the second transmission time interval.

[0010] The method may include determining that a downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment) indicates that the WTRU should use a third

transmission time interval that is less than the first transmission time interval to communicate with a secondary cell in the wireless communications network. The shorten transmission time interval may correspond to at least one of at least one symbol or at least one resource block. The first transmission time interval may be one millisecond.

[0011] The method may include determining a time to transmit with the second transmission time interval based on the downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment). The time to transmit may defined by a time partition (e.g., a slot in a subframe and/or one or more time symbols, (e.g., OFDM symbols), an arrangement of symbols, a min-slot, or other time for a sub-carrier spacing).

[0012] The method may include determining whether a first downlink control information (e.g., using carrier aggregation fields such as the CIF) indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network (e.g., on the physical uplink channel) or whether the WTRU should transmit using carrier aggregation comprises determining with cross-carrier scheduling.

[0013] A wireless transmit/receive unit (WTRU) for use within a wireless communications network that is capable of carrier aggregation may have a processor having executable instructions that communicate with a serving cell in the wireless communications network and determine that the serving cell has indicated that the WTRU should use a first transmission time interval on an uplink channel (e.g., physical uplink channel) to communicate with the serving cell. The processor instructions may include determining whether a downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment) indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network (e.g., on the physical uplink channel). The WTRU processor instructions may include communicating with the wireless communications network using the second transmission time interval.

[0014] The WTRU processor instructions that determine that a first downlink control information (e.g, carrier aggregation field such as the CIF) indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network (e.g., on the physical uplink channel) may comprise determining based on a carrier indicator field in received downlink control information.

[0015] The WTRU processor executable instructions that communicate with the wireless communications network using the second transmission time interval may comprise communicating with the serving cell using the second transmission time interval.

[0016] The WTRU processor executable instructions that communicate with the wireless communications network using the second transmission time interval may comprise communicating with a secondary cell using the second transmission time interval.

[0017] The WTRU processor executable instructions may include determining that a downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment) indicates that the WTRU should use a third transmission time interval that is less than the first transmission time interval to communicate with a secondary cell in the wireless communications network. The shorten transmission time interval may correspond to at least one of at least one symbol or at least one resource block. The first transmission time interval may be one millisecond.

[0018] The WTRU processor executable instructions may include determining a time to transmit with the second transmission time interval based on the downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment). The time to transmit may be defined by a slot in a subframe.

[0019] The WTRU processor executable instructions that determine whether a downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment) indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network (e.g., on the physical uplink channel).

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] FIG. 1A is a system diagram of an example communications system in which disclosed subject matter may be implemented.

[0021] FIG. 1B is a system diagram of an example wireless transmit/receive unit (WTRU) that may be used in a communications system.

[0022] FIG. 1C is a system diagram of an example radio access network and an example core network that may be used in a communications system.

[0023] FIG. 1D is a system diagram of an example radio access network and an example core network that may be used in a communications system.

[0024] FIG. 1E is a system diagram of an example radio access network and an example core network that may be used in a communications system.

[0025] FIG. 2 shows an example of DL physical layer channels.

[0026] FIG. 3 shows an example of UL physical layer channels.

[0027] FIG. 4 is an example of scheduling with time-shifted cells.

DETAILED DESCRIPTION

[0028] A detailed description of illustrative embodiments will now be described with reference to the various figures. Although this description provides a detailed example of possible implementations, it should be noted that the details are intended to be exemplary and in no way limit the scope of the application.

[0029] FIG. 1A is a diagram of an example communications system 100 in which one or more disclosed embodiments may be implemented. The communications system 100 may be a multiple access system that provides content, for example voice, data, video, messaging, broadcast, etc., to multiple wireless users. The communications system 100 may enable multiple wireless users to access such content through the sharing of system resources, including wireless bandwidth. For example, the communications systems 100 may employ one or more channel access methods, for example code division multiple access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), orthogonal FDMA (OFDMA), single-carrier FDMA (SC-FDMA), and the like.

[0030] As shown in FIG. 1A, the communications system 100 may include wireless transmit/receive units (WTRUs) 102a, 102b, 102c, and/or 102d (which generally or collectively may be referred to as WTRU 102), a radio access network (RAN) 103/104/105, a core network 106/107/109, a public switched telephone network (PSTN) 108, the Internet 110, and other networks 112, though it will be appreciated that the disclosed embodiments contemplate any number of WTRUs, base stations, networks, and/or network elements. Each of the WTRUs 102a, 102b, 102c, 102d may be any type of device configured to operate and/or communicate in a wireless environment. By way of example, the WTRUs 102a, 102b, 102c, 102d may be configured to transmit and/or receive wireless signals and may include a user equipment (WTRU), a mobile station, a fixed or mobile subscriber unit, a pager, a cellular telephone, a personal digital assistant (PDA), a smartphone, a laptop, a netbook, a personal computer, a wireless sensor, consumer electronics, and the like.

[0031] The communications systems 100 may also include a base station 114a and a base station 114b. Each of the base stations 114a, 114b may be any type of device configured to wirelessly interface with at least one of the WTRUs 102a, 102b, 102c, 102d to facilitate access to

one or more communication networks, for example the core network 106/107/109, the Internet 110, and/or the networks 112. By way of example, the base stations 114a, 114b may be a base transceiver station (BTS), a Node-B, an eNode B, a Home Node B, a Home eNode B, a site controller, an access point (AP), a wireless router, and the like. While the base stations 114a, 114b are each depicted as a single element, it will be appreciated that the base stations 114a, 114b may include any number of interconnected base stations and/or network elements.

[0032] The base station 114a may be part of the RAN 103/104/105, which may also include other base stations and/or network elements (not shown), for example a base station controller (BSC), a radio network controller (RNC), relay nodes, etc. The base station 114a and/or the base station 114b may be configured to transmit and/or receive wireless signals within a particular geographic region, which may be referred to as a cell (not shown). The cell may further be divided into cell sectors. For example, the cell associated with the base station 114a may be divided into three sectors. Thus, in one embodiment, the base station 114a may include three transceivers, i.e., one for each sector of the cell. In an embodiment, the base station 114a may employ multiple-input multiple output (MIMO) technology and, therefore, may utilize multiple transceivers for each sector of the cell.

[0033] The base stations 114a, 114b may communicate with one or more of the WTRUs 102a, 102b, 102c, 102d over an air interface 115/116/117, which may be any suitable wireless communication link (e.g. radio frequency (RF), microwave, infrared (IR), ultraviolet (UV), visible light, etc.). The air interface 115/116/117 may be established using any suitable radio access technology (RAT).

[0034] More specifically, as noted above, the communications system 100 may be a multiple access system and may employ one or more channel access schemes, for example CDMA, TDMA, FDMA, OFDMA, SC-FDMA, and the like. For example, the base station 114a in the RAN 103/104/105 and the WTRUs 102a, 102b, 102c may implement a radio technology such as Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access (UTRA), which may establish the air interface 115/116/117 using wideband CDMA (WCDMA). WCDMA may include communication protocols such as High-Speed Packet Access (HSPA) and/or Evolved HSPA (HSPA+). HSPA may include High-Speed Downlink Packet Access (HSDPA) and/or High-Speed Uplink Packet Access (HSUPA).

[0035] In an embodiment, the base station 114a and the WTRUs 102a, 102b, 102c may implement a radio technology such as Evolved UMTS Terrestrial Radio Access (E-UTRA), which may establish the air interface 115/116/117 using Long Term Evolution (LTE) and/or LTE-Advanced (LTE-A).

[0036] In an embodiment, the base station 114a and the WTRUs 102a, 102b, 102c may implement radio technologies such as IEEE 802.16 (i.e., Worldwide Interoperability for Microwave Access (WiMAX)), CDMA2000, CDMA2000 1X, CDMA2000 EV-DO, Interim Standard 2000 (IS-2000), Interim Standard 95 (IS-95), Interim Standard 856 (IS-856), Global System for Mobile communications (GSM), Enhanced Data rates for GSM Evolution (EDGE), GSM EDGE (GERAN), New Radio (NR) and the like. The descriptions and example provided herein apply to any of the air interface and communications standards that have been implemented although the terminology may differ among them for the functional components.

[0037] The base station 114b in FIG. 1A may be a wireless router, Home Node B, Home eNode B, or access point, for example, and may utilize any suitable RAT for facilitating wireless connectivity in a localized area, for example a place of business, a home, a vehicle, a campus, and the like. In one embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.11 to establish a wireless local area network (WLAN). In an embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.15 to establish a wireless personal area network (WPAN). In yet an embodiment, the base station 114b and the WTRUs 102c, 102d may utilize a cellular-based RAT (e.g. WCDMA, CDMA2000, GSM, LTE, LTE-A, etc.) to establish a picocell or femtocell. As shown in FIG. 1A, the base station 114b may have a direct connection to the Internet 110. Thus, the base station 114b may not be required to access the Internet 110 via the core network 106/107/109.

[0038] The RAN 103/104/105 may be in communication with the core network 106/107/109, which may be any type of network configured to provide voice, data, applications, and/or voice over internet protocol (VoIP) services to one or more of the WTRUs 102a, 102b, 102c, 102d. For example, the core network 106/107/109 may provide call control, billing services, mobile location-based services, pre-paid calling, Internet connectivity, video distribution, etc., and/or perform high-level security functions, for example user authentication. Although not shown in FIG. 1A, it will be appreciated that the RAN 103/104/105 and/or the core network 106/107/109 may be in direct or indirect communication with other RANs that employ the same RAT as the RAN 103/104/105 or a different RAT. For example, in addition to being connected to the RAN 103/104/105, which may be utilizing an E-UTRA radio technology, the core network 106/107/109 may also be in communication with a RAN (not shown) employing a GSM radio technology.

[0039] The core network 106/107/109 may also serve as a gateway for the WTRUs 102a, 102b, 102c, 102d to access the PSTN 108, the Internet 110, and/or other networks 112. The

PSTN 108 may include circuit-switched telephone networks that provide plain old telephone service (POTS). The Internet 110 may include a global system of interconnected computer networks and devices that use common communication protocols, for example the transmission control protocol (TCP), user datagram protocol (UDP) and the internet protocol (IP) in the TCP/IP internet protocol suite. The networks 112 may include wired or wireless communications networks owned and/or operated by other service providers. For example, the networks 112 may include a core network connected to one or more RANs, which may employ the same RAT as the RAN 103/104/105 or a different RAT.

[0040] Some or all of the WTRUs 102a, 102b, 102c, 102d in the communications system 100 may include multi-mode capabilities, i.e., the WTRUs 102a, 102b, 102c, 102d may include multiple transceivers for communicating with different wireless networks over different wireless links. For example, the WTRU 102c shown in FIG. 1A may be configured to communicate with the base station 114a, which may employ a cellular-based radio technology, and with the base station 114b, which may employ an IEEE 802 radio technology.

[0041] FIG. 1B is a system diagram of an example WTRU 102. As shown in FIG. 1B, the WTRU 102 may include a processor 118, a transceiver 120, a transmit/receive element 122, a speaker/microphone 124, a keypad 126, a display/touchpad 128, non-removable memory 130, removable memory 132, a power source 134, a global positioning system (GPS) chipset 136, and other peripherals 138. It will be appreciated that the WTRU 102 may include any sub-combination of the foregoing elements while remaining consistent with an embodiment. Also, embodiments contemplate that the base stations 114a and 114b, and/or the nodes that base stations 114a and 114b may represent, for example but not limited to transceiver station (BTS), a Node-B, a site controller, an access point (AP), a home node-B, an evolved home node-B (eNodeB), a home evolved node-B (HeNB), a home evolved node-B gateway, and proxy nodes, among others, may include some or each of the elements depicted in FIG. 1B and described herein.

[0042] The processor 118 may be a general purpose processor, a special purpose processor, a conventional processor, a digital signal processor (DSP), a plurality of microprocessors, one or more microprocessors in association with a DSP core, a controller, a microcontroller, Application Specific Integrated Circuits (ASICs), Field Programmable Gate Array (FPGAs) circuits, any other type of integrated circuit (IC), a state machine, and the like. The processor 118 may perform signal coding, data processing, power control, input/output processing, and/or any other functionality that enables the WTRU 102 to operate in a wireless environment. The processor 118 may be coupled to the transceiver 120, which may be coupled to the

transmit/receive element 122. While FIG. 1B depicts the processor 118 and the transceiver 120 as separate components, it will be appreciated that the processor 118 and the transceiver 120 may be integrated together in an electronic package or chip.

[0043] The transmit/receive element 122 may be configured to transmit signals to, or receive signals from, a base station (e.g. the base station 114a) over the air interface 115/116/117. For example, in one embodiment, the transmit/receive element 122 may be an antenna configured to transmit and/or receive RF signals. In an embodiment, the transmit/receive element 122 may be an emitter/detector configured to transmit and/or receive IR, UV, or visible light signals, for example. In yet an embodiment, the transmit/receive element 122 may be configured to transmit and receive both RF and light signals. It will be appreciated that the transmit/receive element 122 may be configured to transmit and/or receive any combination of wireless signals.

[0044] In addition, although the transmit/receive element 122 is depicted in FIG. 1B as a single element, the WTRU 102 may include any number of transmit/receive elements 122. More specifically, the WTRU 102 may employ MIMO technology. Thus, in one embodiment, the WTRU 102 may include two or more transmit/receive elements 122 (e.g. multiple antennas) for transmitting and receiving wireless signals over the air interface 115/116/117.

[0045] The transceiver 120 may be configured to modulate the signals that are to be transmitted by the transmit/receive element 122 and to demodulate the signals that are received by the transmit/receive element 122. As noted above, the WTRU 102 may have multi-mode capabilities. Thus, the transceiver 120 may include multiple transceivers for enabling the WTRU 102 to communicate via multiple RATs, for example UTRA and IEEE 802.11, for example.

[0046] The processor 118 of the WTRU 102 may be coupled to, and may receive user input data from, the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128 (e.g. a liquid crystal display (LCD) display unit or organic light-emitting diode (OLED) display unit). The processor 118 may also output user data to the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128. In addition, the processor 118 may access information from, and store data in, any type of suitable memory, for example the non-removable memory 130 and/or the removable memory 132. The non-removable memory 130 may include random-access memory (RAM), read-only memory (ROM), a hard disk, or any other type of memory storage device. The removable memory 132 may include a subscriber identity module (SIM) card, a memory stick, a secure digital (SD) memory card, and the like. In an embodiment, the processor 118 may access information from, and store data in, memory that is not physically located on the WTRU 102, for example on a server or a home computer (not shown).

[0047] The processor 118 may receive power from the power source 134, and may be configured to distribute and/or control the power to the other components in the WTRU 102. The power source 134 may be any suitable device for powering the WTRU 102. For example, the power source 134 may include one or more dry cell batteries (e.g. nickel-cadmium (NiCd), nickel-zinc (NiZn), nickel metal hydride (NiMH), lithium-ion (Li-ion), etc.), solar cells, fuel cells, and the like.

[0048] The processor 118 may also be coupled to the GPS chipset 136, which may be configured to provide location information (e.g. longitude and latitude) regarding the current location of the WTRU 102. In addition to, or in lieu of, the information from the GPS chipset 136, the WTRU 102 may receive location information over the air interface 115/116/117 from a base station (e.g. base stations 114a, 114b) and/or determine its location based on the timing of the signals being received from two or more nearby base stations. It will be appreciated that the WTRU 102 may acquire location information by way of any suitable location-determination method while remaining consistent with an embodiment.

[0049] The processor 118 may further be coupled to other peripherals 138, which may include one or more software and/or hardware modules that provide additional features, functionality and/or wired or wireless connectivity. For example, the peripherals 138 may include an accelerometer, an e-compass, a satellite transceiver, a digital camera (for photographs or video), a universal serial bus (USB) port, a vibration device, a television transceiver, a hands free headset, a Bluetooth® module, a frequency modulated (FM) radio unit, a digital music player, a media player, a video game player module, an Internet browser, and the like.

[0050] FIG. 1C is a system diagram of the RAN 103 and the core network 106 according to an embodiment. As noted above, the RAN 103 may employ a UTRA radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 115. The RAN 103 may also be in communication with the core network 106. As shown in FIG. 1C, the RAN 103 may include Node-Bs 140a, 140b, 140c, which may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 115. The Node-Bs 140a, 140b, 140c may each be associated with a particular cell (not shown) within the RAN 103. The RAN 103 may also include RNCs 142a, 142b. It will be appreciated that the RAN 103 may include any number of Node-Bs and RNCs while remaining consistent with an embodiment.

[0051] As shown in FIG. 1C, the Node-Bs 140a, 140b may be in communication with the RNC 142a. Additionally, the Node-B 140c may be in communication with the RNC142b. The Node-Bs 140a, 140b, 140c may communicate with the respective RNCs 142a, 142b via an Iub interface. The RNCs 142a, 142b may be in communication with one another via an Iur interface.

Each of the RNCs 142a, 142b may be configured to control the respective Node-Bs 140a, 140b, 140c to which it is connected. In addition, each of the RNCs 142a, 142b may be configured to carry out or support other functionality, for example outer loop power control, load control, admission control, packet scheduling, handover control, macro diversity, security functions, data encryption, and the like.

[0052] The core network 106 shown in FIG. 1C may include a media gateway (MGW) 144, a mobile switching center (MSC) 146, a serving GPRS support node (SGSN) 148, and/or a gateway GPRS support node (GGSN) 150. While each of the foregoing elements are depicted as part of the core network 106, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

[0053] The RNC 142a in the RAN 103 may be connected to the MSC 146 in the core network 106 via an IuCS interface. The MSC 146 may be connected to the MGW 144. The MSC 146 and the MGW 144 may provide the WTRUs 102a, 102b, 102c with access to circuit-switched networks, for example the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, 102c and traditional land-line communications devices.

[0054] The RNC 142a in the RAN 103 may also be connected to the SGSN 148 in the core network 106 via an IuPS interface. The SGSN 148 may be connected to the GGSN 150. The SGSN 148 and the GGSN 150 may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, for example the Internet 110, to facilitate communications between and the WTRUs 102a, 102b, 102c and IP-enabled devices.

[0055] As noted above, the core network 106 may also be connected to the networks 112, which may include other wired or wireless networks that are owned and/or operated by other service providers.

[0056] FIG. 1D is a system diagram of the RAN 104 and the core network 107 according to an embodiment. As noted above, the RAN 104 may employ an E-UTRA radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 116. The RAN 104 may also be in communication with the core network 107.

[0057] The RAN 104 may include eNode-Bs 160a, 160b, 160c, though it will be appreciated that the RAN 104 may include any number of eNode-Bs while remaining consistent with an embodiment. The eNode-Bs 160a, 160b, 160c may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 116. In one embodiment, the eNode-Bs 160a, 160b, 160c may implement MIMO technology. Thus, the eNode-B 160a, for example, may use multiple antennas to transmit wireless signals to, and receive wireless signals from, the WTRU 102a.

[0058] Each of the eNode-Bs 160a, 160b, 160c may be associated with a particular cell (not shown) and may be configured to handle radio resource management decisions, handover decisions, scheduling of users in the uplink and/or downlink, and the like. As shown in FIG. 1D, the eNode-Bs 160a, 160b, 160c may communicate with one another over an X2 interface.

[0059] The core network 107 shown in FIG. 1D may include a mobility management gateway (MME) 162, a serving gateway 164, and a packet data network (PDN) gateway 166. While each of the foregoing elements are depicted as part of the core network 107, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

[0060] The MME 162 may be connected to each of the eNode-Bs 160a, 160b, 160c in the RAN 104 via an S1 interface and may serve as a control node. For example, the MME 162 may be responsible for authenticating users of the WTRUs 102a, 102b, 102c, bearer activation/deactivation, selecting a particular serving gateway during an initial attach of the WTRUs 102a, 102b, 102c, and the like. The MME 162 may also provide a control plane function for switching between the RAN 104 and other RANs (not shown) that employ other radio technologies, for example GSM or WCDMA.

[0061] The serving gateway 164 may be connected to each of the eNode-Bs 160a, 160b, 160c in the RAN 104 via the S1 interface. The serving gateway 164 may generally route and forward user data packets to/from the WTRUs 102a, 102b, 102c. The serving gateway 164 may also perform other functions, for example anchoring user planes during inter-eNode B handovers, triggering paging when downlink data is available for the WTRUs 102a, 102b, 102c, managing and storing contexts of the WTRUs 102a, 102b, 102c, and the like.

[0062] The serving gateway 164 may also be connected to the PDN gateway 166, which may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, for example the Internet 110, to facilitate communications between the WTRUs 102a, 102b, 102c and IP-enabled devices.

[0063] The core network 107 may facilitate communications with other networks. For example, the core network 107 may provide the WTRUs 102a, 102b, 102c with access to circuit-switched networks, for example the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, 102c and traditional land-line communications devices. For example, the core network 107 may include, or may communicate with, an IP gateway (e.g. an IP multimedia subsystem (IMS) server) that serves as an interface between the core network 107 and the PSTN 108. In addition, the core network 107 may provide the WTRUs 102a, 102b, 102c with access to

the networks 112, which may include other wired or wireless networks that are owned and/or operated by other service providers.

[0064] FIG. 1E is a system diagram of the RAN 105 and the core network 109 according to an embodiment. The RAN 105 may be an access service network (ASN) that employs IEEE 802.16 radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 117. As will be further discussed below, the communication links between the different functional entities of the WTRUs 102a, 102b, 102c, the RAN 105, and the core network 109 may be defined as reference points.

[0065] As shown in FIG. 1E, the RAN 105 may include base stations 180a, 180b, 180c, and an ASN gateway 182, though it will be appreciated that the RAN 105 may include any number of base stations and ASN gateways while remaining consistent with an embodiment. The base stations 180a, 180b, 180c may each be associated with a particular cell (not shown) in the RAN 105 and may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 117. In one embodiment, the base stations 180a, 180b, 180c may implement MIMO technology. Thus, the base station 180a, for example, may use multiple antennas to transmit wireless signals to, and receive wireless signals from, the WTRU 102a. The base stations 180a, 180b, 180c may also provide mobility management functions, for example handoff triggering, tunnel establishment, radio resource management, traffic classification, quality of service (QoS) policy enforcement, and the like. The ASN gateway 182 may serve as a traffic aggregation point and may be responsible for paging, caching of subscriber profiles, routing to the core network 109, and the like.

[0066] The air interface 117 between the WTRUs 102a, 102b, 102c and the RAN 105 may be defined as an R1 reference point that implements the IEEE 802.16 specification. In addition, each of the WTRUs 102a, 102b, 102c may establish a logical interface (not shown) with the core network 109. The logical interface between the WTRUs 102a, 102b, 102c and the core network 109 may be defined as an R2 reference point, which may be used for authentication, authorization, IP host configuration management, and/or mobility management.

[0067] The communication link between each of the base stations 180a, 180b, 180c may be defined as an R8 reference point that includes protocols for facilitating WTRU handovers and the transfer of data between base stations. The communication link between the base stations 180a, 180b, 180c and the ASN gateway 182 may be defined as an R6 reference point. The R6 reference point may include protocols for facilitating mobility management based on mobility events associated with each of the WTRUs 102a, 102b, 102c.

[0068] As shown in FIG. 1E, the RAN 105 may be connected to the core network 109. The communication link between the RAN 105 and the core network 109 may defined as an R3 reference point that includes protocols for facilitating data transfer and mobility management capabilities, for example. The core network 109 may include a mobile IP home agent (MIP-HA) 184, an authentication, authorization, accounting (AAA) server 186, and a gateway 188. While each of the foregoing elements are depicted as part of the core network 109, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

[0069] The MIP-HA may be responsible for IP address management, and may enable the WTRUs 102a, 102b, 102c to roam between different ASNs and/or different core networks. The MIP-HA 184 may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, for example the Internet 110, to facilitate communications between the WTRUs 102a, 102b, 102c and IP-enabled devices. The AAA server 186 may be responsible for user authentication and for supporting user services. The gateway 188 may facilitate interworking with other networks. For example, the gateway 188 may provide the WTRUs 102a, 102b, 102c with access to circuit-switched networks, for example the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, 102c and traditional land-line communications devices. In addition, the gateway 188 may provide the WTRUs 102a, 102b, 102c with access to the networks 112, which may include other wired or wireless networks that are owned and/or operated by other service providers.

[0070] Although not shown in FIG. 1E, it will be appreciated that the RAN 105 may be connected to other ASNs and the core network 109 may be connected to other core networks. The communication link between the RAN 105 the other ASNs may be defined as an R4 reference point, which may include protocols for coordinating the mobility of the WTRUs 102a, 102b, 102c between the RAN 105 and the other ASNs. The communication link between the core network 109 and the other core networks may be defined as an R5 reference, which may include protocols for facilitating interworking between home core networks and visited core networks.

[0071] Systems, methods, and instrumentalities are disclosed for multiplexing transmissions with different durations, for example such as transmission that utilize different TTI lengths. Latency reduction for some transmissions may achieved, for example, by multiplexing transmissions with different TTI durations. Although examples may be described with respect to multiplexing of an LTE legacy TTI (e.g., 1 ms) with a shortened TTI length (e.g., less than 1 ms), the techniques described herein may be generally applicable to the multiplexing of other

types of transmissions that are of different/varying lengths. For example, the examples may be described with respect to transmissions that contain one transport block (TB), but the examples may be equally applicable to transmissions that include a portion of a TB, transmissions that contain multiple TBs, etc. Thus, as may be appreciated, although specific examples herein may be described with respect to multiplexing transmissions associated with a "legacy" 1 ms TTI with transmissions that are less than 1 ms, these examples are not limited to the specific embodiments described and may be applied to transmissions of varying length that include varying amounts of data. Additionally, although examples may be described with respect to multiplexing shorter than 1 ms transmissions into a legacy LTE system that utilizes a legacy TTI length of 1 ms, the techniques may be applied to other types of transmission configurations, for example such as the NR system that may be utilized for 5G cellular communications.

[0072] Transmissions of different length may be realized in multiple ways and be consistent with this disclosure. For example, multiple TTI lengths may be defined, and the system may be configured to multiplex transmissions associated with the different TTI lengths over a common set of transmission resources. In example, rather than or in addition to defining different TTI lengths, transmissions of different durations may be supported, for example where one or more of the transmissions durations may or may not correspond to a TTI. Transmission duration may be defined in a number of ways, for example an amount of time over which the transmission occurs, (e.g., a specific duration or a time partition), a number of symbols over which the transmission occurs (e.g., 14 OFDM symbols, 12 OFDM symbols, 1 OFDM symbol, etc.), a slot, a minislot, a time partition for a sub-carrier spacing, and/or in terms of a specific numerology associated with the transmissions. For example, the numerology may be defined based on one or more of a sub-carrier spacing (e.g., different sub-carrier spacing may lead to different time durations for a symbol), a symbol length, a waveform type, etc.

[0073] Examples may also be described with respect to one or more cells. However, the techniques described herein may be equally applicable to other types of resource partitions. For example, in LTE cells may be defined based on certain OFDM time-frequency resources that are defined for a certain operating band for the cell. However, the multiplexing techniques described herein may be applied to physical resources that may or may not be defined using the cell construct. For example, the techniques described herein may apply of a subset of the physical resources in a cell and/or to physical resources that are not defined using the cell construct.

[0074] In order to TTI duration may be modeled using one or more time-shifted cell(s) for a given carrier frequency, e.g. in an LTE system such as a legacy LTE system. A "logical" cell structure may correspond to an SCell (e.g., a legacy SCell). A PCell may logically maintain

a TTI (e.g., a first TTI such as a legacy TTI that may be 1 ms) or may be (e.g. also) configured with a second duration TTI (e.g., a shorter duration TTI (ShTTI) that may be less than 1 ms).

[0075] In an example, a WTRU may determine a TTI duration (e.g. first or second TTI) applicable to a transmission. A determination may be, for example, a function of one or more facts, factors, and/or parameters. For example, a WTRU may determine a TTI duration using cross-carrier scheduling information. A WTRU may associate a certain TTI duration with a certain cell identity (e.g. servCellID). A WTRU may associate a certain TTI duration with certain a transmission mode (TM). A TTI duration may be indicated by a CIF included in DCI. For example, a first cell identity (e.g., servCellID = 1) may be associated with a first TTI duration and a second cell identity (e.g., servCellID = 2) may be associated with a second TTI duration. When the CIF field indicates that the received DCI is applicable to the first cell identity (e.g., CIF = '001' - servCellID = 1), the WTRU may determine that the scheduled transmission is associated with the first TTI duration. When the CIF field indicates that the received DCI is applicable to the second cell identity (e.g., CIF = '010' - servCellID = 2), the WTRU may determine that the scheduled transmission is associated with the second TTI duration. In this matter, carrier aggregation signaling methods may be reused/reinterpreted in order to support multiple TTI length.

[0076] A TTI duration may be determined from an identity of a PRB subset associated with the transmissions and/or to a time-shifted cell within a subset of PRBs for a concerned carrier frequency. An applicable TTI duration and/or the identity of a slot/period applicable to a transmission within a subframe may be determined using MAC Activation/Deactivation. MAC Activation/Deactivation may be used to toggle between first and second TTIs (e.g. between a legacy TTI and one or more ShTTIs). For example, a WTRU may utilize a first TTI length for a first cell prior to receiving MAC Activation/Deactivation control element. Upon receiving the MAC Activation/Deactivation control element for the first cell, the WTRU may toggle to a second TTI length. In an example, the MAC Activation/Deactivation control element may be used to toggle between different slots used for a ShTTI transmission in a legacy suframe. For example, the MAC Activation/Deactivation control element may be used to switch between the first and second slots for the shortened TTI transmission. MAC Activation/Deactivation may be used to determine zero, one or more ShTTIs period(s) within a subframe.

[0077] HARQ processing may remain according to a first behavior (e.g. legacy behavior) for one or more (e.g. each) time-shifted cell(s), although there may be exceptions. In an example, an exception may be timing-relationships, which may be scaled according to an applicable TTI duration. HARQ A/N feedback formats may use LTE Carrier Aggregation (CA)

formats and/or (e.g., legacy) subframe-based timing relationships or a timing relationship associated with the HARQ process. Downlink Control Information (DCI) signaling may use a first (e.g., legacy) format, although, for example, interpretation of fields such as the CIF and/or PRBs applicable for the transmission may be different than the first (e.g., legacy) format. MAC activation/deactivation signaling may be applicable for time-shifted cells. DRX Timers associated with DRX may scale to HARQ A/N timing according to an applicable TTI duration and/or to the cell associated with an HARQ process. PRACH resources and/or PDCCH order for RACH may or may not be supported for time-shifted SCells. Timing advance for uplink transmission may be time shifted, for example, according to a shift applied to the TTI associated with a cell. Time shift may be relative to PCell timing, e.g., a PCell may remain a DL timing reference for an SCell with the additional offset corresponding to the start of the ShTTI for those cells.

[0078] A device may access resources of a communication system. Latency associated with transmission of data may have one or more latency components. A latency component may be the time to perform the transmission of a transport block, which time may be referred to as a Transmission Time Interval (TTI). A latency component may be processing time at a receiver, e.g., time decoding a transmission. Receiver processing time may be tied to implementation complexity and may be accounted for using a fixed timing relationship between different events associated with the transmission of a data unit. A timing relationship may be fixed, for example, when time-division duplex (TDD) is used for a carrier and/or synchronous Hybrid ARQ (HARQ) operation (e.g., such as for LTE in the uplink).

[0079] There may be additional latency components, for example, when a transmission is not successfully decoded. For example, additional components may include transmission of feedback (e.g. HARQ ACK or NACK), processing time at the receiver and/or one or more retransmissions with one or more latency components.

[0080] Latency components may be measured in integer multiples of a basic time interval (BTI). For example, latency components may be measured in TTIs, e.g., in LTE.

[0081] Latency in wireless networks may be caused by multiple factors. Latency may be affected, e.g., at lower layers, by a need for highly reliable transmissions, which may be obtained using HARQ. One or more retransmissions may affect the latency of a transmission, for example, given that retransmissions may not be performed in adjacent time periods.

[0082] A WTRU may incur processing time, for example, for downlink (DL) transmission, to determine whether a transmission was decoded properly, which may lead to a time interval between reception of a DL transmission and transmission of an ACK or NACK. An eNB may

incur processing time, for example, to determine whether an ACK or NACK was transmitted by the WTRU and/or whether a retransmission is required. A similar consumption of processing time may occur for uplink (UL) transmissions. Processing times may be cumulative. There may be a tradeoff between latency and implementation complexity.

[0083] A system (e.g. LTE) may accommodate processing times in a timing relationship between a first transmission for a transport block and its corresponding ACK-NACK HARQ response for downlink and/or uplink operation and possible retransmission.

[0084] Time Division Duplex (TDD) and Frequency Division Duplex (FDD) DL scheduling timing may be the same, such that a WTRU may receive a scheduling grant for a DL transmission in the same subframe or transmission time interval (TTI).

[0085] A WTRU may transmit a corresponding Physical UL Shared Channel (PUSCH), e.g., in subframe n+4, for example, upon detection of a Physical DL Control Channel PDCCH or enhanced PDCCH (EPDCCH) with UL Downlink Control Information (DCI) format and/or Physical Hybrid ARQ Indicator Channel (PHICH) transmission in subframe n, e.g., in an FDD UL transmission intended for the WTRU. A HARQ ACK/NACK response for a DL or UL transmission in subframe n may be provided in subframe n+4.

[0086] A WTRU may transmit a corresponding PUSCH in subframe n+k, for example, upon detection of a (E)PDCCH with UL DCI format and/or PHICH transmission in subframe n, e.g., for a UL transmission in a TDD system intended for the WTRU. The value of k may depend on the TDD UL/DL configuration, the subframe where the UL DCI and/or PHICH was transmitted and/or the PHICH resource and the MSB or LSB of the UL index in the (E)PDCCH, e.g., in TDD UL/DL configuration 0. A HARQ ACK/NACK response for a DL or UL transmission in subframe n may be provided in subframe n+k, where k may depend on the value of n and the TDD UL/DL configuration. Bundling may be used to provide HARQ for multiple transmissions in one instance.

[0087] Processing time available to a WTRU may depend, for example, on the value of the timing advance or on the distance between the WTRU and the eNB. In an example, an LTE system may have a distance of 100km between a WTRU and an eNB, which may correspond to a (e.g. a maximum) timing advance of 0.67ms. In an example, there may be approximately 2.3 ms left for terminal processing. An eNB may have, for example, 3 ms processing time available, which may be on the same order as that of the terminal.

[0088] FIG. 2 shows an example of DL physical layer channels. In a DL example with reference to the example shown in FIG. 2, there may be three channel areas in a subframe to support DL Shared Channel (DL-SCH) and UL-SCH. Three channel areas may comprise a PDCCH (which may include Physical Control Format Indicator Channel (PCFICH) and PHICH),

a Physical DL Shared Channel (PDSCH) and an EPDCCH. An EPDCCH may include scheduling information for a WTRU while taking advantage of the benefits of the PDSCH region, such as beamforming gain and frequency domain Inter-Cell Interference Coordination (ICIC) and/or improving PDCCH capacity.

[0089] FIG. 3 shows an example of UL physical layer channels. In a UL example with reference to the example shown in FIG. 3, there may be two channel areas in a subframe to support DL-SCH and UL-SCH. Two channel areas may comprise a PUSCH and a PDSCH. These channel areas may be transmitted in different RBs in each time slot (e.g. frequency hopping of PUSCH), for example, to increase robustness in frequency selective channels.

[0090] A transmission time interval (TTI) duration may be based on and/or defined by one or more symbols. A TTI duration may be defined in terms of a number of OFDM symbols. For example, a TTI duration may be defined as an entire (legacy) subframe and/or a pair of physical resource blocks (PRBs). In the legacy 1 ms TTI length, there may be 14 OFDM symbols for normal cyclic prefix and 12 OFDM symbols for extended cyclic prefix. For example when multiplexing ShTTI transmissions with legacy TTI transmissions of 1 ms, a ShTTI may be made as short as a single ODFM symbol. Symbol-based categorization may be referred to as symbol-based TTI durations.

[0091] A TTI duration may be based on time-varying symbol duration. TTI durations may have a fixed number of symbols (e.g., 14 symbols) while symbol duration may vary in time. For example, variable time symbol-based TTI duration may be achieved by modifying subcarrier spacing. In an example, a first TTI duration may be achieved with a first subcarrier spacing and a second TTI duration may be achieved with a second subcarrier spacing. Different bandwidth portions (e.g. PRBs) of a carrier may support different subcarrier spacing, thus enabling different TTI duration for different bandwidth portions (e.g. PRBs). Multiplexing transmissions associated with different sub-carrier spacing and/or symbol duration may be applicable to 5G systems such as NR. Such techniques may also be used in LTE-Advanced.

[0092] A TTI duration may be based on a time slot. A TTI duration may be defined in terms of a time slot (e.g. 7 OFDM symbols for normal cyclic prefix and 6 OFDM symbols for extended cyclic prefix). For example, if a ShTTI is defined as the length of one slot, two ShTTI transmissions may be time multiplexed into a legacy 1 ms TTI length.

[0093] A TTI duration may be based on time. A TTI duration may be defined in terms of a time value (e.g. 1ms legacy TTI or a 100ms ShTTI).

[0094] A TTI duration may be based on a hybrid, such as a combination of forgoing TTI duration bases. In an example of a hybrid method of achieving variable TTI durations, a different number of symbols and different symbol durations may be used.

[0095] Latency may be improved. It may be beneficial to decrease the TTI duration of different channels. A decrease in TTI duration may enable a decrease in WTRU processing time and may permit a WTRU to begin processing data sooner. Such a scenario may enable a shorter HARQ timeline. Different channels may have different TTI durations. A TTI duration shorter than one subframe for one or more of the EPDCCH, PDSCH, PUCCH, PDSCH, etc. may be provided. Effective HARQ feedback for PDSCH and PUSCH transmissions using shorter than (e.g., legacy 1ms) subframe TTI durations may be provided. Shorter TTIs may be referred to as ShTTI.

[0096] ShTTI and/or a combination of TTI and ShTTI may be supported for a given WTRU, for example, to minimize the impact of other aspects related to WTRU transmissions, such as scheduling (e.g., formats of DCIs), HARQ (e.g., related processing/process identities), feedback formats and determination of an applicable TTI duration. For example, the configuration of ShTTIs and/or the signaling of DCI for ShTTIs may utilize certain signaling originally defined for purposes of carrier aggregation in order to limit the amount of complexity at the WTRU and/or facilitated TTI length multiplexing in a backwards compatible manner. One or more latency components may be reduced, for example, to minimize the impact on WTRU implementations.

[0097] A WTRU may (e.g., based on a determination) operate with a one or more TTI durations, such as subframe TTI duration (e.g., 1 ms), a timeslot TTI duration (e.g., 0.5 ms), a symbol-based TTI duration (e.g., one or more OFDM symbols in duration), and/or other shorter than 1 ms TTI durations. In an example, a WTRU may be configured to operate with specific but different TTI duration configuration in downlink and uplink. In an example, a WTRU may be configured to permit the same TTI duration configuration to be used in downlink and uplink for applicable transmissions. For example, if the WTRU receives a configuration that indicates a first cell is associated with a first TTI duration in the downlink, the WTRU may determine that the uplink TTI duration is also the first TTI duration unless the configuration indicates otherwise.

[0098] A TTI duration may be WTRU specific. A WTRU may operate with a TTI duration during a given period. A WTRU may be configured to operate according to one or more of a plurality of possible TTI durations and may operate with the one or more TTI durations for a specific period of time, e.g., based on an L3 (e.g., radio resource control (RRC)) reconfiguration. A TTI duration may be fixed (e.g. statically, semi-statically or dynamically) for a (e.g. every) transmission to and from a WTRU.

[0099] Multiple TTI durations may be concurrently configured and/or used. A WTRU may be configured to operate for transmissions of different TTI durations concurrently. Different TTI durations may be based on, for example, semi-static allocation (e.g. configuration of a subset of frames/subframes dedicated to different TTI durations based on a semi-persistent grant or assignment) and/or dynamic allocation (e.g. based on detection and/or reception of downlink control signaling).

[0100] A TTI duration may be cell/cell group (CG)-specific. Configuration may be applicable per cell of a WTRU's configuration, for a subset of cells of a WTRU's configuration, and/or for all cells of the same timing advance group (TAG) and/or all cells of the same cell group (CG). For example, upon adding a new cell, the TTI duration may be defined for the new cell. As an example, if the WTRU adds an SCell, the SCell configuration may indicated that the WTRU is to utilize a shortened TTI duration for the SCell. The HARQ instances associated with a specific MAC entity may be configured with a similar configuration for TTI duration. A similar or same configuration for TTI duration may be used, for example, for cells associated with the same channel(s) (e.g. PUCCH, PUSCH) for uplink control signaling.

[0101] TTI duration may be modeled using one or more time-shifted cell(s) for a given carrier frequency. Modeling may enable co-existence between WTRUs operating according to different TTI durations, e.g. in legacy LTE systems. A "logical" cell structure may correspond to the use of one or more serving cell(s). Serving cells may include secondary cells, such as an SCell type or a PSCell type defined for LTE CA. A PCell may logically maintain a first (e.g., legacy) TTI such as 1 ms or may be (e.g., also) configured as a ShTTI.

[0102] Multiple serving cells may be associated with a specific TTI duration. A WTRU may support multiple TTI durations based on one or more functions and/or characteristic associated to a serving cell.

[0103] A WTRU may determine the duration of a downlink control region, e.g., according to a first (e.g., legacy) behavior for LTE. A reception of PDCCH may be a first (e.g., legacy) behavior for downlink subframes. In an example, the first ShTTI in a subframe may include a control region, e.g., in case of slot-based operation, such as two slots of 7 symbols where the first slot include 1-3 symbols for PDCCH. In an example, the ShTTI duration may exclude the control region, e.g., in case of symbol-based ShTTIs. In an example, an offset in time or in symbol from the start of a subframe may be used to indicate the start of an ShTTI (e.g., in the DCI).

[0104] In an example, a WTRU may operate on a given carrier frequency (e.g., for downlink and/or uplink) according to at least one of the following: TTI duration per Transmission

Mode (TM), TTI duration per Serving Cell Identity (servCellID), and/or TTI duration per Serving Cell.

[0105] In an example of TTI duration per Transmission Mode (TM), a WTRU may be configured with multiple transmission modes (TM), e.g., one for each applicable TTI duration.

[0106] In an example of TTI duration per Serving Cell Identity (servCellID), a WTRU may be configured with multiple serving cell identities (e.g., servCellIDs), e.g., one for each applicable TTI duration.

[0107] In an example of TTI duration per Serving Cell, a WTRU may be configured with multiple serving cells for a given carrier frequency, e.g. one for each applicable TTI duration.

[0108] Combinations may be made using different types of serving cells. For example, a WTRU may be configured according to any of the following examples or other examples.

[0109] In a first case or example, a WTRU may be configured with one PCell and one SCell (or PSCell). A WTRU may perform a transmission associated with a PCell using a first ShTTI and a transmission associated with the SCell/PSCell using a second ShTTI. A WTRU may transmit Uplink Control Information (UCI) for a transmission associated with a specific cell using the uplink resources associated with the concerned cell (e.g., according to a first (e.g. legacy) behavior or processing time associated with the ShTTI), for example, when an SCell is configured with PUCCH resources or when the WTRU is configured with PSCell. A WTRU may perform the transmission of UCI using resources of the PCell (e.g., according to a first (e.g., legacy) behavior), for example, otherwise. In either case or other cases, a WTRU may transmit UCI using the TTI applicable to the uplink configuration of the concerned cell or according to the ShTTI applicable the received transmission.

[0110] In a second case or example, a WTRU may be configured with one PCell and two SCells. A WTRU may perform a transmissions associated with a PCell using a first TTI (e.g., a legacy 1ms TTI) and a transmission associated with an SCell using a second TTI (e.g., an ShTTI). A WTRU may transmit UCI for a transmission associated with a specific cell using the uplink resources associated with the concerned cell (e.g., according to a first (e.g., legacy) behavior or processing time associated with the ShTTI), for example, when an SCell is configured with PUCCH resources. A WTRU may perform the transmission of UCI using resources of the PCell (e.g., according to a first (e.g., legacy) behavior), for example, otherwise. In either case or other cases, a WTRU may transmit UCI using the TTI applicable to the uplink configuration of the concerned cell or according to the ShTTI applicable to the received transmission.

[0111] In a third case or example, a WTRU may be configured with one PCell and multiple SCells. A configuration may be a generalization of either of the first and second examples,

whereby more than two TTI durations may be supported (e.g., within a first (e.g., legacy) subframe).

[0112] In an example involving a PSCell, a different Cell Radio Network Temporary Identifier (C-RNTI) than that applicable for a PCell may indicate the duration of the TTI. Examples presented and other examples may be used separately or in combination. Other realizations and/or combinations are possible.

[0113] Examples for handling of downlink control region for case 1 with slot-based operation are described.

[0114] A WTRU may be configured with a (e.g., DL) control region of zero symbols for a serving cell used for the purpose of ShTTI, e.g., for the serving cell that corresponds to a second slot in case of slot-based operation. A WTRU may determine that a serving cell is configured for the purpose of ShTTI, for example, based on reception of signaling that indicates such value for the duration of the control region. A WTRU may determine that a serving cell is configured as an ShTTI for the second slot, for example, based on reception of signaling that indicates such value for the duration of the control region. A WTRU may determine that a PCell configuration is used for ShTTI for the first slot.

[0115] Different procedures or algorithms may be used to determine applicable TTI duration, e.g., independent of modeling. For example, a WTRU may determine the TTI duration (e.g. legacy duration such as 1ms or shorter (e.g., ShTTI)) applicable to a transmission as a function of one or more of the following: (a) a WTRU may determine TTI duration using cross-carrier scheduling; (b) a WTRU may associate a TTI duration with a serving cell identity; (c) a TTI duration may be indicated by a Carrier Indicator Field (CIF); (d) a TTI duration may be indicated by C-RNTI applicable to control signaling associated with the allocation of resources; (e) a TTI duration may be determined from the identity of a PRB subset applicable to the transmissions and/or to the time-shifted cell within the entire subset of PRBs for the carrier frequency; (f) a MAC Activation/Deactivation may be used to determine the applicable TTI duration and/or the identity of the slot/period applicable to a transmission within a subframe. A MAC Activation/Deactivation may be used, for example, to toggle between multiple TTIs (e.g. a legacy TTI and one or more ShTTIs), toggle between slot-based ShTTIs and/or to determine zero, one or more ShTTIs period(s) within a subframe.

[0116] HARQ processing may be used (e.g., according to a first (e.g., legacy) behavior) for time-shifted cell(s), although, in an example, timing-relationships may be scaled according to an applicable TTI duration. HARQ A/N feedback formats may reuse LTE CA formats, first (e.g., legacy) subframe-based timing relationships and/or timing relationship associated with the HARQ

process. DCI signaling may reuse a first (e.g., legacy) format, although, in an example, interpretation of fields such as the CIF and/or PRBs applicable for the transmission may be different. MAC activation/deactivation signaling may be applicable for time-shifted cells. DRX Timers associated with DRX may scale to HARQ A/N timing according to an applicable TTI duration and/or to the cell associated with the HARQ process. Physical Random Access Channel (PRACH) resources and/or PDCCH order for RACH may or may not be supported for time-shifted SCells. Timing advance for uplink transmission may be time shifted according to the shift applied to the TTI associated with a cell, for example, when such time shift is relative to the PCell timing (e.g., the PCell remains the DL timing reference for such SCell with the additional offset corresponding to the start of the ShTTI for those cells).

[0117] Any procedure or algorithm that may operate with or indicate a TTI duration may be applicable as a procedure or algorithm to operate with or to indicate a subcarrier spacing.

[0118] Support may be provided for transmissions with different TTI duration. A WTRU may be configured for operation with the LTE physical layer. A WTRU may be configured, for example, for operation according to a first (e.g., legacy) LTE behavior or for operation together with a 5gFLEX configuration, e.g., a configuration that supports a physical layer operating with other variants of potentially filtered OFDM transmissions, such as Universal Filtered OFDM (UF-OFDM), Filtered Based OFDM (FB-OFDM), etc.

[0119] In an example of LTE FDD, a radio frame may consist of 10 subframes of 1ms each with a TTI of 1ms. Each TTI may consist of two 0.5ms slots of 7 symbols for a configuration with a normal cyclic prefix. In the downlink, there may be 8 asynchronous HARQ processes numbered 0-7 that may be addressed by means of downlink DCI. In the uplink, there may be 8 synchronous HARQ processes per RTT, which identity may be tied to the subframe timing. A WTRU may be configured for 1 to 3 symbols at the beginning of the first slot used for control signaling (PDCCH). Control signaling may span the entire bandwidth for a given cell. A TTI duration may be fixed, e.g., at 1ms, as an aspect of the LTE physical layer.

[0120] Different cells of a WTRU's configuration may be (e.g. explicitly) associated with a TTI duration/offset shift. Support for different TTI durations may be realized, for example, by maintaining a unique association between a cell and a TTI duration in a WTRU's configuration. Timing associated with the cell (e.g. a cell of the LTE CA SCell type) may be shifted and/or offset in time with respect to the timing of a reference cell. A reference cell may be the PCell of the WTRU's configuration. The PCell may be considered to have a zero time shift, e.g., by default. In an example of dual connectivity, a PSCell may be considered to have a zero time shift (e.g., by

default), for example, when a secondary group of cells is configured and when the PSCell is used as the timing reference.

[0121] In an example, a time-shifted/TTI duration/offset shift may be associated with an identity. For example, a time-shifted cell may be configured with a serving cell identity, with an offset in time relative to the start of a cell-specific subframe (e.g. where timing may be based on the PCell used as a downlink timing reference) and with a TTI duration (e.g. shorter than a first (e.g. legacy) timing that may be referred to as a shorter TTI or ShTTI).

[0122] TTI duration may be a configuration aspect of a WTRU, such as part of a configured transmission mode associated with the physical layer configuration for the cell.

[0123] Cells using a timing relationship may be configured as part of the same timing advance group (TAG). Cells (e.g., SCells) in a secondary TAG (STAG) supporting ShTTIs may use one of the cells in the same TAG as a timing reference (e.g., a cell used may be a configuration aspect of a WTRU) or may use the PCell as the timing reference (e.g., otherwise).

[0124] Support may be provided for multiplexing transmissions in a cell and/or for a specific WTRU. Support for transmissions using different TTI duration may be for concurrent transmissions in the same cell. For example, transmission may correspond to a single TTI duration for each WTRU at any given time while some WTRUs may have different TTI duration than other WTRUs. Support may be for transmissions for a given WTRU within the same subframe (e.g., within a first (e.g., legacy) subframe such as 1 ms) where different transmissions may be performed according to different TTI durations by the concerned WTRU.

[0125] Procedures may be applicable for uplink and/or downlink transmission and may be a configuration aspect for a WTRU.

[0126] An ShTTI-based transmission mode (TM) and cell timing configuration may be provided. For example, a WTRU may be configured with a PCell (e.g., according to first (e.g., legacy) behavior). For example, a WTRU may operate on a PCell carrier frequency using a first TM (e.g., a TM in the range of 1-10) associated with a first TTI duration (e.g., legacy 1ms). The WTRU may receive a RRC Connection Reconfiguration message that may reconfigure the WTRU according to at least one of the following: the WTRU may reconfigure the PCell and/or may configure at least one SCell.

[0127] In an example of reconfiguring a PCell, the WTRU may reconfigure the PCell such that a second TTI (e.g., ShTTI) of a duration shorter than previously used by the WTRU for the PCell is supported. For example, the WTRU may reconfigure (or add) a TM associated to the PCell. For example, a TM (e.g., TM = 11) may be associated with a TTI duration different than previously used by the WTRU for the PCell.

[0128] For example, a WTRU may configure a TTI duration according to one of the following. In an example, an ShTTI duration may be equal to 1 slot (0.5ms). This may be applicable, for example, to the first case. In another example, an ShTTI may be a duration expressed as an integer multiple of 1 symbol. A duration may include the control region, for example, when the configuration includes a start offset for the ShTTI and such offset is equal to zero. In another example, an ShTTI may be a duration expressed as an integer value in time, e.g. 100 μs or 125μs. Whether an ShTTI duration may include the control region may be determined as a function the value of a start offset for the ShTTI when applicable. A control region may be a separate aspect of a WTRU's configuration for a cell when an offset is equal to a non-zero value.

[0129] For example, a TM may support transmissions in (e.g., only in) the first slot of a first (e.g., legacy) subframe for the concerned ShTTI duration. A WTRU may determine an aspect as a function of the type of cell (e.g., PCell) associated with the TM. A TM may support WTRU-specific demodulation reference signals (e.g., DM-RS) such that their location and density may be better suited for ShTTI operation.

[0130] In an example of reconfiguring a PCell, transmissions on the PCell using a first (e.g., legacy) TTI such as 1ms may be enabled. This may be applicable, for example, in the second case, e.g., when a WTRU may be configured such that PCell operation supports transmissions using a first (e.g. legacy) 1ms TTI and one or more SCells support operation using ShTTI.

[0131] A WTRU may configure a PCell with an additional cell identity to the PCell in the PCell's configuration such that DCI may indicate, for example, "CIF=0" for a transmission on PCell using a first TTI (e.g., 1ms) and "CIF=1" for a transmission on PCell using a second TTI (e.g. a slot-based ShTTI of 0.5ms or similar). This may be applicable, for example, in the first case.

[0132] In an example of reconfiguring at least one SCell, the WTRU may configure an SCell such that an associated TTI duration (e.g., ShTTI) is less than that of a first (e.g., legacy) subframe duration (e.g., less than 1ms). For example, the WTRU may configure a TM associated with the SCell. For example, a TM (e.g., TM = 11) may be associated with a TTI duration similar to that of the PCell (e.g., ShTTI). For example, a ShTTI duration may be equal to 1 slot (0.5ms). This may be applicable, for example, in the first case. A TM (e.g., TM = 11+x) may be (e.g. alternatively) associated with a TTI duration different than that of the PCell, for example, when the TTI duration of such SCell may differ from that of the PCell.

[0133] Combinations of slot-based TTI (e.g., 0.5ms for a PCell) and non slot-based TTIs (e.g., 5 SCells of 100ms each) may be applicable for a given WTRU. Another example may be of a WTRU configured with symbol-based TTIs such that a different number of symbols may be used for each of the control regions (e.g,. 3 symbols), the TTI duration for the PCell (e.g., 5 symbols)

and for a number of SCells of x symbols in duration (e.g., 3 SCells each 2 symbols in TTI duration). Other combinations and/or other values are possible.

[0134] Example procedures may be applicable to any of the cases described above. Procedures may be applicable for uplink and/or downlink transmission and may be a configuration aspect for a WTRU.

[0135] TTI duration may be determined as a function of a Carrier Indicator Field (CIF) in a DCI on PDCCH. A TTI duration may be signaled as a function of the indicated cell identity in the DCI (e.g., by CIF or similar for a given carrier frequency of the WTRU's configuration). A determination or indication may be achieved, for example, by associating a second identity with a cell of the WTRU's configuration or by duplication of a serving cell configuration for a given carrier frequency. The WTRU may determine that the DCI of a given transmission (e.g., PDDCH transmission, serving cell transmission, received downlink control information, or scheduling information) has indicated that the WTRU should use a first transmission time interval on a physical uplink channel to communicate with the serving cell. For example, the determination may be based on the CIF field of the DCI, as the CIF may refer to a serving cell identity that has been configured to utilize the first transmission time interval. In this manner, downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment) may be re-used for scheduling of transmissions associated with the first TTI length. Similarly, the WTRU may determine that the DCI of a given transmission (e.g., PDDCH transmission, serving cell transmission, received downlink control information, or scheduling information) has indicated that the WTRU should use a second transmission time interval on a physical uplink channel to communicate with a second serving cell. For example, the determination may be based on the CIF field of the DCI, as the CIF may refer to the second serving cell identity and the second serving cell may have been configured to utilize the second transmission time interval. One or more of the first or second transmission time intervals may correspond a shortened TTI that is less than the legacy transmission time interval. The first and second serving cells may configured to utilize the same frequency band and/or carrier frequency.

[0136] In an example using slot-based TTI duration, a WTRU may be configured with a PCell with CIF=0, an SCell with CIF=1 and an SCell with CIF=2 for a given carrier frequency. Both SCells may be configured with carrier aggregation cross-carrier scheduling such that scheduling information for the associated resources may be received on the PDCCH associated with the PCell. A WTRU may receive signaling that schedules a transmission on such PDCCH. A WTRU may determine that a TTI duration is according to first (e.g., legacy) operation (e.g., 1ms), for example, when the WTRU determines that the CIF applicable to the transmission is that

of the PCell. The WTRU may determine that the transmission is applicable to the first slot of the concerned subframe, for example, when the WTRU determines that the CIF=1. The WTRU may determine that the transmission is for the second slot of the concerned subframe, for example, when CIF=2.

[0137] Example procedures may be applicable to any of the cases described above. Procedures may be applicable for uplink and/or downlink transmission and may be a configuration aspect for a WTRU.

[0138] A start offset for ShTTI may be a function of CIF in the DCI on PDCCH. In an example, determination of the applicable location in time (e.g., slot in the subframe, applicable starting symbol and/or all applicable symbols or similar) may be enabled for a transmission, for example, when a TTI duration shorter than that of the subframe duration is configured for a given cell.

[0139] A start offset or applicable location in time may be based on signaling received by the WTRU. The WTRU may perform such determination as a function of the indicated cell identity in the DCI, e.g., by Carrier Indicator Field (CIF) or similar for a given carrier frequency of the WTRU's configuration. An indication or determination may be achieved, for example, by associating a specific offset in the subframe with an identity of a cell of the WTRU's configuration or by configuring multiple serving cells for a given carrier frequency each with a different identity and a different offset.

[0140] For example, an offset may indicate one of a first slot or a second slot of a cell-specific subframe or it may indicate an offset in terms of a starting symbol in a subframe or an offset in absolute time (e.g. 500ms). An offset may be applied from the start of a cell-specific subframe. An offset may implicitly indicate a TTI duration (or vice-versa).

[0141] Example procedures may be applicable to any of the cases described above. Procedures may be applicable for uplink and/or downlink transmission and may be a configuration aspect for a WTRU.

[0142] A TTI duration may be a function of PRB(s) for a transmission. In an example, a WTRU may be configured such that a number of PRBs (e.g. a subset of the total set of system-specific PRBs for the concerned carrier frequency) may be associated with a cell of the WTRU's configuration for which the WTRU is operating with shorter than 1ms TTI duration e.g. configured with ShTTI.

[0143] A WTRU may determine an applicable TTI duration as a function of the PRB(s) indicated by the scheduling information. A PRB may correspond to the starting PRB for the resource allocation for the transmission. A set of PRBs may correspond to a range of PRBs. A

WTRU may use the TTI duration associated with a set of PRB(s), for example, when such range includes (e.g., only includes) PRB(s) associated with the concerned set. A WTRU may (e.g., otherwise) use a different TTI duration (e.g., a first (e.g. legacy) TTI duration, such as 1ms, or a configured duration), for example, when such range includes PRBs associated with different sets of PRBs or when such range does not include PRBs associated with any such sets. Sets of PRBs may be a configuration aspect of a WTRU's configuration. For example, a serving cell may be associated with a set of one or more PRBs, for example, when a serving cell is configured for ShTTI operation for a carrier frequency. A WTRU may use the TTI duration associated with such a cell or associated with the concerned PRBs. Scheduling information may be received dynamically in a DCI on PDCCH. Scheduling information may be semi-statically configured. For example, an entire (e.g., system-specific) set of PRBs for a PCell configured with a first (e.g., legacy) operation may be 110 PRBs. A WTRU may (e.g., alternatively) be configured with one or more subsets of PRBs, where each set may be associated with a specific TTI duration.

[0144] A WTRU may (e.g., first) determine the cell configured with ShTTI applicable to the transmission and/or the duration of the TTI (e.g., determining as described herein) and may determine the set of applicable PRBs therefrom (e.g., determining using a configuration of sets of PRBs as discussed herein).

[0145] Example procedures (e.g., operation) may be applicable to any of the cases described above. Procedures may be applicable for uplink and/or downlink transmission and may be a configuration aspect for a WTRU. For example, a procedure may be associated with a transmission mode for downlink and/or uplink. For example, a procedure may be associated with a serving cell of the WTRU's configuration. For example, a WTRU may determine that a configuration is specific to a serving cell of a WTRU's configuration, e.g., a determination may be made that a TTI configuration applies to both DL and UL frequencies. For example, a WTRU may determine that a configuration is specific to a specific direction of a configuration for a given serving cell of the WTRU's configuration, e.g., a determination may be made that a TTI configuration is provided separately for the DL direction and for the UL direction.

[0146] A determination may be made about the start offset time for a transmission. Cell de-activation may control availability of ShTTI. In an example, a first (e.g., legacy) cell activation-deactivation mechanism (e.g., procedure or algorithm) may control the duration (e.g., first or second TTI such as a legacy TTI or an ShTTI duration) of a transmission, e.g., by activating and deactivating the transmission. A WTRU may associate an activation state with an ShTTI, a slot and/or a resource.

[0147] In an example, a WTRU configured using ShTTI cells may receive a first (e.g., legacy) MAC activation/deactivation control element. A WTRU may use the activation/deactivation element as a mechanism to determine the availability of the ShTTI. For example, a WTRU may use a first (e.g., 1ms) TTI duration, e.g., when the WTRU is configured with a single SCell with ShTTI and when the SCell is in a deactivated state when the WTRU determines that it needs to perform a transmission. A WTRU may (e.g., otherwise) use a second TTI duration (e.g., ShTTI) for a transmission, e.g., when the SCell is active. The WTRU may perform a transmission using the second TTI duration (e.g. ShTTI), for example, according to scheduling information independently of the scheduled slot. This example may be extended to apply to the case where a symbol-based TTI duration is used instead of a time duration such as transmission slots.

[0148] In an example where multiple SCells may be used to indicate slot-based transmissions, a WTRU may determine that a first TTI duration is applicable when all cells configured with ShTTI are in a deactivated state. A WTRU may determine (e.g., otherwise) the applicable slot based on the activation state associated with each SCell and associated with each slot. This example may be extended to apply to the case where a symbol-based TTI duration is used, e.g., instead of using time duration such as transmission slots.

[0149] A WTRU may transmit HARQ feedback and/or other Uplink Control Information (UCI) (e.g. CQI, PMI, RI or similar), for example, taking into consideration the configuration of the TTI duration.

[0150] A TTI duration applicable to the transmission of UCI may be a function of at least one of the following: scheduling information, configuration information, TTI applicable to a serving cell, a default configuration for UCI transmission, etc.

[0151] Scheduling information may indicate whether a WTRU has resources for a PUSCH transmission and (e.g., if so) the TTI duration associated with such transmission, which may be determined according to procedures described herein.

[0152] Configuration information may indicate whether a WTRU is configured for simultaneous PUSCH and PUCCH transmission.

[0153] A TTI may be applicable to a serving cell associated with a UCI transmission in the subframe for the concerned UCI transmission.

[0154] A TTI may be applicable (e.g., in duration and/or offset) to a serving cell associated with a UCI transmission in the subframe for a downlink transmission pertaining to the feedback (e.g., in case of HARQ A/N feedback).

[0155] A default configuration for the transmission of UCI may be, for example, for the transmission of UCI on PUCCH (e.g., always a first TTI such as 1 ms TTI on PCell).

[0156] Further examples are provided below.

[0157] An applicable resource may be a PUSCH or PUCCH resource. A WTRU may determine a physical channel to perform the transmission of UCI using any technique, procedure or algorithm. For example, a WTRU may determine that UCI may be included in a PUSCH transmission when the transmission is scheduled, when simultaneous PUSCH and PUCCH transmissions are not configured or on a PUCCH transmission (e.g., otherwise).

[0158] An applicable resource may be a PUSCH resource. A WTRU may perform the transmission of UCI on a PUSCH transmission according to a TTI duration associated with a PUSCH transmission, which may be determined using procedures described herein.

[0159] An applicable resource may be a PUCCH resource. A WTRU may determine that a PUCCH resource may be used for transmission of UCI according to any technique, procedure or algorithm applicable to LTE CA. For example, selection of a resource may be based on the first CCE of the DCI that scheduled a downlink transmission or based on a configuration (e.g. PUCCH format 3 or similar). Bundling and/or multiplexing may be applied, for example, when configured.

[0160] An applicable TTI may be function of the type of transmissions on the carrier frequency PUSCH or PUCCH. Transmission of UCI may use the principles of LTE CA whereby UCI corresponding to transmission on different cells, e.g., including time-shifted cells, maybe multiplexed on a single transmission using a format that supports the required number of information bits (e.g., PUCCH format 3).

[0161] A PUCCH transmission may be performed on a PCell with a first (e.g., 1 ms TTI), where the first TTI may be a fixed TTI. A WTRU may perform PUCCH transmission on resources of an applicable serving cell (e.g., a PCell) according to a TTI duration associated with a concerned (e.g., pertinent) PCell, which may be determined using procedures described herein. In an example, a WTRU may transmit HARQ feedback using a single PUCCH transmission, which may use resources associated with a PCell (e.g. using a 1ms TTI duration), for example, when a WTRU has HARQ A/N feedback to transmit for two slot-based time-shifted cells using PUCCH on the PCell according to a configuration for a given carrier frequency where the PCell uses a first (e.g., 1ms) TTI.

[0162] A PUCCH transmission may be performed on a PCell with alignment in time with TTI being reported. A WTRU may perform PUCCH transmission on resources of an applicable serving cell (e.g. a PCell) according to a TTI duration associated with transmission(s) for which feedback is transmitted. A WTRU may have, for example, HARQ A/N feedback to transmit for

two slot-based time-shifted cells using PUCCH on the PCell according to a configuration for a given carrier frequency. In an example, a WTRU may transmit in the first slot a HARQ feedback for a transmission associated with the first slot and may transmit the HARQ feedback for the other transmission in the second slot for the concerned subframe.

[0163] A PUCCH transmission may be performed on a PCell with TTI/ShTTI of the PCell. A WTRU may perform a PUCCH transmission on resources of an applicable serving cell (e.g. a PCell) according to a TTI duration associated with the PCell, which may be determined using procedures described herein. A PCell may be (e.g., otherwise) configured with a default TTI, such as a first (e.g., 1 ms) TTI or an ShTTI. A WTRU may have HARQ A/N feedback to transmit for two slot-based time-shifted cells using PUCCH on the PCell, e.g., according to a configuration for a given carrier frequency where the PCell uses ShTTI in the concerned subframe (e.g., based on a configuration aspect and/or an activation state such as ShTTI activated for a time-shifted SCell for the concerned subframe), In an example, a WTRU may transmit HARQ feedback using a single PUCCH transmission, which may use resources associated with the PCell using a ShTTI duration with an offset applicable to the PCell.

[0164] A WTRU may transmit HARQ A/N feedback, for example, based on an applicable WTRU processing time for a concerned (e.g., pertinent) HARQ process in a given subframe.

[0165] Processing time associated with a HARQ process may be specific to a TTI associated with a transmissions for a concerned process. Processing time may be specific to a serving cell, a transmission mode or may be indicated by DCI (e.g., from servCellID or CIF) associated with such transmissions for a concerned HARQ process. In an example, HARQ processing time may be the same for all HARQ processes associated with a serving cell configured with a specific TTI (e.g., an ShTTI). Processing time may be a fixed value (e.g., 1ms), a multiple of an ShTTI, etc. Processing time may be determined for a transmission using ShTTI in subframe, the first available occasion in subframe n+2, where an occasion may correspond to a PUCCH or a PUSCH transmission with duration according to a first TTI or second TTI (e.g., ShTTI).

[0166] Systems, methods, and instrumentalities have been disclosed for multiplexing transmissions with different TTI duration. Latency may be reduced (e.g., in an LTE system), for example, by multiplexing transmissions with different TTI durations. TTI duration may be modeled using one or more time-shifted cell(s) for a given carrier frequency. A "logical" cell structure may correspond to an SCell. A PCell may logically maintain a TTI (e.g,. a first TTI) or may be configured with a second duration TTI (e.g., a shorter duration TTI (ShTTI)).

[0167] In an example, a WTRU may determine a TTI duration (e.g., first or second TTI) applicable to a transmission. For example, a WTRU may determine a TTI duration using cross-

carrier scheduling. A WTRU may associate a TTI duration with a cell identity (e.g. servCellID). A WTRU may associate a TTI duration with a transmission mode (TM). A TTI duration may be indicated by Carrier Indicator Field (CIF). A TTI duration may be determined from an identity of a PRB subset applicable to transmissions and/or to a time-shifted cell within a subset of PRBs for a concerned carrier frequency. An applicable TTI duration and/or the identity of a slot/period applicable to a transmission within a subframe may be determined using MAC Activation/Deactivation. MAC Activation/Deactivation may be used to toggle between first and second TTIs (e.g. legacy TTI and ShTTIs) or between slot-based ShTTIs and/or may be used to determine zero, one or more TTI (e.g. ShTTI) period(s) within a subframe.

[0168] HARQ processing may be performed according to a first behavior (e.g. legacy behavior) for one or more (e.g. each) time-shifted cell(s), although there may be exceptions. An exception may be timing-relationships, which may be scaled according to an applicable TTI duration. HARQ A/N feedback formats may use LTE Carrier Aggregation (CA) formats and/or (e.g., legacy) subframe-based timing relationships or a timing relationship associated with the HARQ process. Downlink Control Information (DCI) signaling may use a first (e.g., legacy) format, although, for example, interpretation of fields such as the CIF and/or PRBs applicable for the transmission may be different than the first (e.g., legacy) format. MAC activation/deactivation signaling may be applicable for time-shifted cells. DRX Timers associated with DRX may scale to HARQ A/N timing according to an applicable TTI duration and/or to the cell associated with an HARQ process. PRACH resources and/or PDCCH order for RACH may or may not be supported for time-shifted SCells. Timing advance for uplink transmission may be time shifted, for example, according to a shift applied to the TTI associated with a cell. Time shift may be relative to PCell timing, e.g. a PCell may remain a DL timing reference for an SCell with the additional offset corresponding to the start of the ShTTI for those cells.

[0169] A different TTI may be used in LTE R14 and NR. Multiple serving cells may be configured on the same carrier for a single WTRU. There may be an association between a serving cell and a TTI duration (or more generally – a numerology-related aspect). A WTRU can be configured with multiple such cells on a given carrier to support (*e.g.*, dynamically) a change in transmission duration. A field in downlink control signaling (DCI), *e.g.*, on a downlink control channel (*e.g.*, PDCCH), such as the CIF field in a DCI, may be used to dynamically schedule specific TTI durations for same or later subframes, for UL or DL transmissions.

[0170] The WTRU may be configured with a plurality of transmission methods, where at least two of the configured transmission methods differ in at least the applicable TTI duration.

[0171] A transmission may be associated with a transmission timing (start offset) relative to a timing reference.

[0172] A WTRU transmission mode may be indicated in downlink control information (DCI) signaling.

[0173] WTRU transmissions may be configured for each of a plurality of PRBs in the WTRU's configuration. Each of a plurality of PRBs may correspond to a serving cell of the WTRU's configuration. Each of a plurality of PRBs may correspond to a given carrier.

[0174] An applicable transmission duration/timing may be determined from a serving cell ID indicated in DCI signaling.

[0175] The WTRU may determine the set of resources, transmission duration, and/or uplink control information for a transmission based on a previous combination of received downlink signaling and received transmission duration.

[0176] A WTRU may determine whether a control region (*e.g.*, single control region) (*e.g.*, single level PDCCH) or multiple control regions (*e.g.*, multi-level PDCCH) are applicable and whether they are a function of the PDCCH configuration applicable to the concerned cell(s). A WTRU can determine the location of CCEs with respect to the timing reference (*e.g.*, in support of either self-scheduling or cross-TTI scheduling).

[0177] A WTRU may support mini-slots (*e.g.*, 125usec), slots (*e.g.*, 0.5ms), subframe (*e.g.*, 1ms) and multi-slots (*e.g.*, Multiples of other durations), and transmission durations and use different (*e.g.*, shortened) TTI's based on these time allocations. This may provide a low latency mode, a throughput mode and/or a coverage mode.

[0178] FIG. 4 depicts a scheduling example with time shifted-cells. As shown, there is a frequency axis and a time axis. In Fig. 4, the time is measured in milliseconds and divided into subframes. Other time units can be used such as slots, minislots, symbols, and PRB lengths. The frequency axis shows downlink (DL) and uplink (UL) transmissions. The time axis shows subframes. N, n+1, N=3, etc.... As shown for the DL frequency, for one or more subframes, the WTRU may receive DCI. For subframe n, the DCI may indicate two allocations, for example two ShTTI allocations (*e.g.*, $ShTTI_{DL(n,0)}$ and $ShTTI_{DL(n,1)}$). As an example, setting the CIF equal to 1 may indicate that the allocation is for $ShTTI_{DL(n,0)}$ and setting the CIF equal to 2 may indicate the allocation is for $ShTTI_{DL(n,1)}$. Other values of the CIF may be used to indicate no ShTTI transmissions and/or different transmission durations. For example, the DCI in Subframe

n+1 may indicate that for DL subframe n+1, the transmission has a duration corresponding to the entire subframe by using the value CIF=0 (*see e.g.*, a $TTI_{DL(N+1)}$).

[0179] A similar signaling mechanism can be used for indicating different durations of uplink transmissions. For example, DCI in DL subframe n may indicate that the WTRU has recieved two uplink grants. For example, a first grant for subframe n+1 may be indicate a CIF=1, which may be configured to correspond to $ShTTI_{(n+an\ offset,0)}$, while a CIF equal to 2 may indicate a grant for $ShTTI_{(n+an\ offset,0)}$. Similarly, a different value of the CIF (*e.g.*, CIF = 0) in this example may indicate that the transmissions duration spans an entire legacy TTI as illustrated in FIG. 4. Thus, by associating different CIF values with different transmission durations, the DCI may be used to indicate different transmission durations by referencing the different CIF values. Although the CIF field is used for purposes of illustration, other DCI fields may be used and may have values mapped to/associated with transmissions of different duration.

[0180] FIG. 4 also shows for an example of the PUCCH on the uplink frequency. For the PCell or SCell there may be a HARQ A/N for CIF = 1 at (n, 0) and a HARQ A/N for CIF = 2 at n, 1. For the PCell, (*e.g.*, PCell only), there may be a HARQ A/N for CIF = 0 at (n, 0) or CIF = 0 at n-3. Also, for the PCell, (*e.g.*, PCell only), there may be a HARQ A/N for CIF = 1 at (n, 0) or CIF = 0 at n-3 for the $ShTTI_{(n+?,\ 0)}$ and HARQ A/N for CIF = 2 at (n, 1) or CIF = 0 at n-3 for the $ShTTI_{(n+?,\ 1)}$.

[0181] FIG. 4 shows an example with time shifted cells with an offset of symbols. In this example, the symbol offset is based on CIF. FIG. 4 shows a single HARQ addressing space per TTI duration and start offset in a given subframe. MAC activation/deactivation may be applied by a HARQ process space or CIF value. FIG. 4 also shows a UCI example with time-shifted cells. The first CCE of the DCI on the example channel, PDCCH, may be used for legacy PUCCH resource allocation at TTI or ShTTI. Configured LTE CA PUCCH, PUCCH on an SCell, and/or ARI may be used for UCI using different TTIs. As shown, the WTRU interprets the DCI TTI indication differently in the FIG. 4 example for SCells and PCells to use ShTTI for the SCells. FIG. 4 also shows an example of the frequency being the same for the PCell and SCell. The FIG. 4 example dynamically varies the scheduled TTI for a WTRU and uses the appropriate HARQ signaling. Also, resource allocation for associated control information is resolved and there is flexibility to adapt different time offsets in a subframe and with different ShTTIs.

[0182] Although features and elements are described above in particular combinations, one of ordinary skill in the art will appreciate that each feature or element may be used alone or in any combination with the other features and elements. In addition, the methods described herein

may be implemented in a computer program, software, or firmware incorporated in a computer-readable medium for execution by a computer or processor. Examples of computer-readable media include electronic signals (transmitted over wired or wireless connections) and computer-readable storage media. Examples of computer-readable storage media include, but are not limited to, a read only memory (ROM), a random access memory (RAM), a register, cache memory, semiconductor memory devices, magnetic media such as internal hard disks and removable disks, magneto-optical media, optical media such as CD-ROM disks, and digital versatile disks (DVDs). A processor in association with software may be used to implement a radio frequency transceiver for use in a WTRU, WTRU, terminal, base station, RNC, or any host computer.

CLAIMS

What Is Claimed:

1. A method implemented by a wireless transmit/receive unit (WTRU) for supporting transmissions of different durations, the method comprising:

receiving a first configuration associated with a first set of transmission resources, the first configuration indicating a first transmission time interval (TTI) length for use with the first set of transmission resources;

receiving a second configuration associated with a second set of transmission resources, the second configuration indicating a second transmission time interval (TTI) length for use with the second set of transmission resources;

receiving downlink control information (DCI), wherein the DCI comprises a field that indicates whether the DCI is applicable to first set of transmission resources or the second set of transmission resources; and

determining that a transmission associated with the DCI utilizes the first TTI length on condition that the field indicates that the DCI is applicable to the first set of transmission resources or that the transmission associated with the DCI utilizes the second TTI length on condition that the field indicates that the DCI is applicable to the second set of transmission resources.

2. The method of claim 1, wherein the first set of transmission resources correspond to a first serving cell and the second set of transmission resources correspond to a second serving cell.

3. The method of claim 2, wherein the field corresponds to a carrier indicator field.

4. The method of claim 2, wherein the first serving cell and the second serving cell are associated with the same carrier frequency.

5. The method of claim 2, wherein each of the first and second serving cells are configured as secondary cells (SCells).

6. The method of claim 2, wherein the first serving cell corresponds to a primary cell (PCell), the second serving cells is configured as a secondary cells (SCell), the first TTI length corresponds to 1 millisecond (ms), and the second TTI length corresponds to less than 1 ms.

7. The method of claim 1, wherein the DCI further comprises a physical resource block (PRB) assignment field, and the PRB assignment field is interpreted differently depending on whether the transmission is associated with the first TTI length or the second TTI length.

8. The method as in claim 1, wherein at least the second configuration is received via a radio resource control (RRC) message, and the DCI is received via a physical downlink control channel.

9. The method as in claim 1, wherein a hybrid automatic repeat request timing used for the transmission is dependent on whether the transmission is associated with the first TTI length or the second TTI length.

10. A method implemented by a wireless transmit/receive unit (WTRU) for supporting transmissions of different durations, the method comprising:

receiving downlink control information from a first serving cell in the wireless communications network;

determining that the received downlink control information indicates that the WTRU should use a first transmission time interval to transmit data information to the first serving cell;

determining whether the received downlink control information indicates that the WTRU should use a second transmission time interval that is different than the first transmission time interval to communicate with the wireless communication network on the physical uplink channel or whether the WTRU should transmit using carrier aggregation; and

communicating with the wireless communications network using the second transmission time interval.

11. The method of claim 10, wherein determining that the received downlink control information indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network on the physical uplink channel comprises determining based on a carrier indicator field in the received downlink control information.

12. The method of claim 10, wherein communicating with the wireless communications network using the second transmission time interval comprises communicating with the first serving cell using the second transmission time interval.

13. The method of claim 10, wherein communicating with the wireless communications network using the second transmission time interval comprises communicating with a secondary cell using the second transmission time interval.

14. The method of claim 10, further comprising determining that the WTRU should use a third transmission time interval that is less than the first transmission time interval to communicate with a secondary cell in the wireless communications network.

15. The method of claim 10, wherein the shorten transmission time interval corresponds to at least one of at least one symbol or at least one resource block.

16. The method of claim 10, wherein the first transmission time interval is one millisecond.

17. The method of claim 10, wherein the first transmission time interval is greater than the first transmission time interval.

18. The method of claim 10, wherein the first transmission time interval corresponds to a first sub-carrier spacing and the second transmission time interval corresponds to a second subcarrier spacing.

19. The method of claim 10, wherein the first transmission time interval corresponds to a first number of transmission symbols and the second transmission time interval corresponds to a second number of transmission symbols.

20. The method of claim 10, further comprising the WTRU communicating with the first serving cell and a second serving cell using the same carrier frequency.

21. The method of claim 10, further comprising determining a time to transmit with the second transmission time interval based on the received downlink control information.

22. The method of claim 21, wherein the time to transmit is defined by a slot in a subframe.

23. The method of claim 10, wherein determining whether the received downlink control information indicates that the WTRU should use a second transmission time interval that

is less than the first transmission time interval to communicate with the wireless communication network on the physical uplink channel or whether the WTRU should transmit using carrier aggregation comprises determining with cross-carrier scheduling.

24. A wireless transmit/receive unit (WTRU) for use within a wireless communications network that is capable of carrier aggregation, comprising:

a processor having executable instructions that:

determine that downlink control information from a first serving cell in the wireless communications network has been received;

determine that the received downlink control information indicates that the WTRU should use a first transmission time interval to transmit data information to the first serving cell;

determine whether the received downlink control information indicates that the WTRU should use a second transmission time interval that is different than the first transmission time interval to communicate with the wireless communication network on the physical uplink channel or whether the WTRU should transmit using carrier aggregation; and

communicate with the wireless communications network using the second transmission time interval.

25. The WTRU of claim 24, wherein the processor further comprises executable instructions that determine that the received downlink control information indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network on the physical uplink channel comprises determining based on a carrier indicator field in the received downlink control information.

26. The WTRU of claim 24, wherein the executable instructions that communicate with the wireless communications network using the second transmission time interval comprise communicating with the first serving cell using the second transmission time interval.

27. The WTRU of claim 24, wherein the executable instructions that communicate with the wireless communications network using the second transmission time interval comprise communicating with a secondary cell using the second transmission time interval.

28. The WTRU of claim 24, wherein the processor further comprises executable instructions that determine that the WTRU should use a third transmission time interval that is less than the first transmission time interval to communicate with a secondary cell in the wireless communications network.

29. The WTRU of claim 24, wherein the shorten transmission time interval corresponds to at least one of at least one symbol or at least one resource block.

30. The WTRU of claim 24, wherein the first transmission time interval is one millisecond.

31. The WTRU of claim 24, wherein the processor further comprises executable instructions that determine a time to transmit with the second transmission time interval based on the received downlink control information.

32. The WTRU of claim 31, wherein the time to transmit is defined by a slot in a subframe.

33. The WTRU of claim 24, wherein the executable instructions that determine whether the received downlink control information indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network on the physical uplink channel or whether the WTRU should transmit using carrier aggregation comprise determining with cross-carrier scheduling.

34. The WTRU of claim 24, wherein the first transmission time interval is greater than the first transmission time interval.

35. The method of claim 24, wherein the first transmission time interval corresponds to a first sub-carrier spacing and the second transmission time interval corresponds to a second subcarrier spacing.

36. The method of claim 24, wherein the first transmission time interval corresponds to a first number of transmission symbols and the second transmission time interval corresponds to a second number of transmission symbols.

37. The method of claim 24, further comprising the WTRU communicating with the first serving cell and a second serving cell using the same carrier frequency.

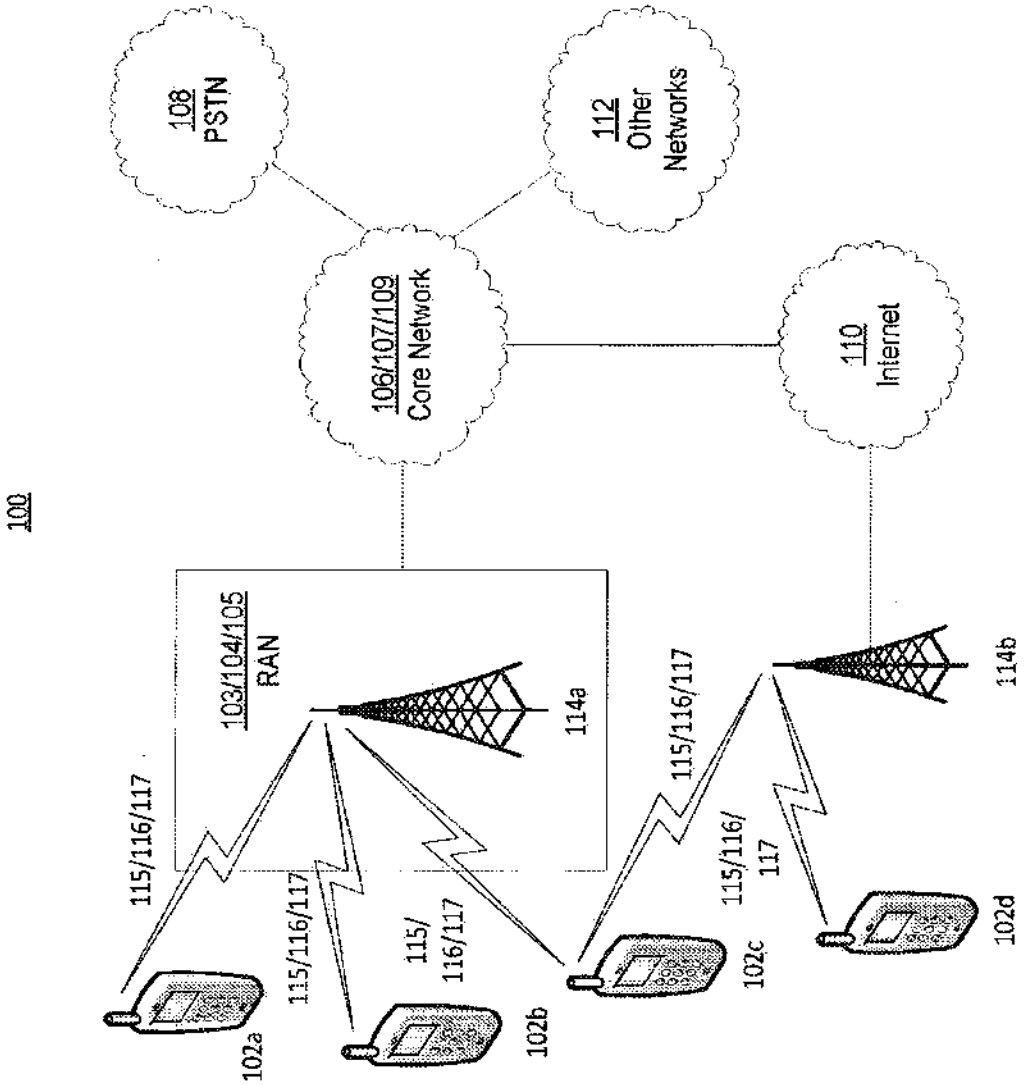

100
108 PSTN
112 Other Networks
106/107/109 Core Network
110 Internet
103/104/105 RAN
114a
114b
115/116/117
115/116/117
115/ 116/117
115/116/117
115/116/ 117
102a
102b
102c
102d

FIG. 1A

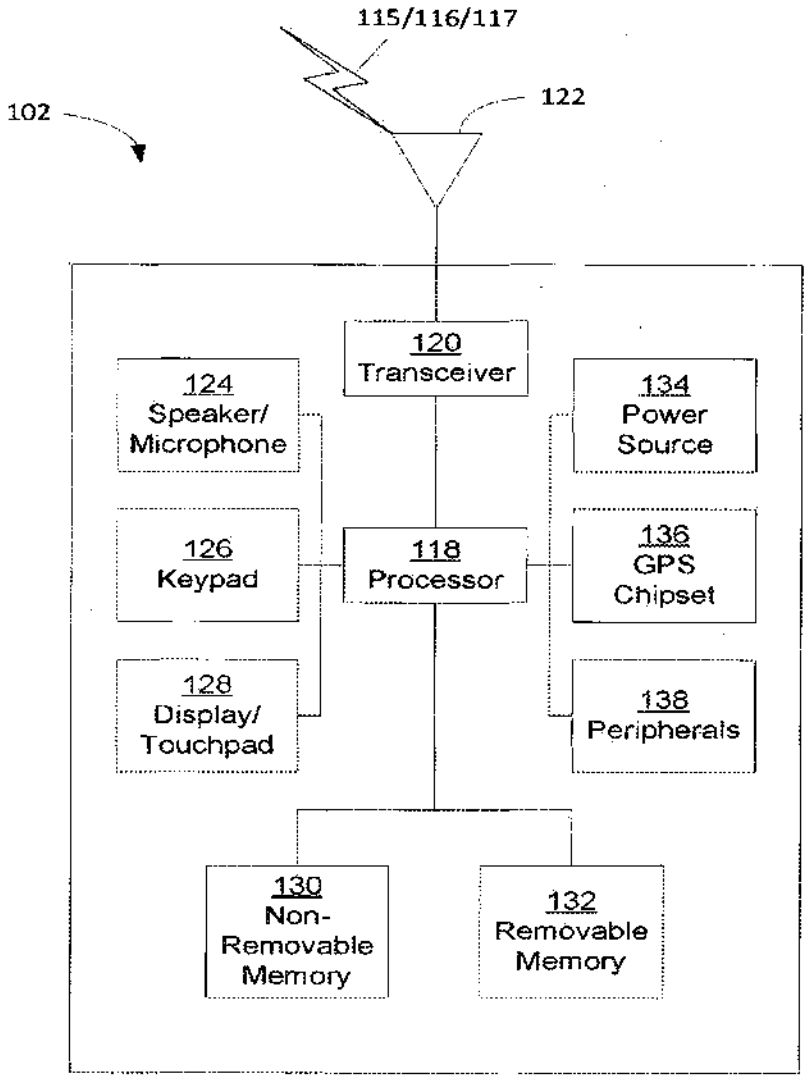

115/116/117
122
102
120
Transceiver
124
Speaker/
Microphone
134
Power
Source
126
Keypad
118
Processor
136
GPS
Chipset
128
Display/
Touchpad
138
Peripherals
130
Non-
Removable
Memory
132
Removable
Memory

FIG. 1B

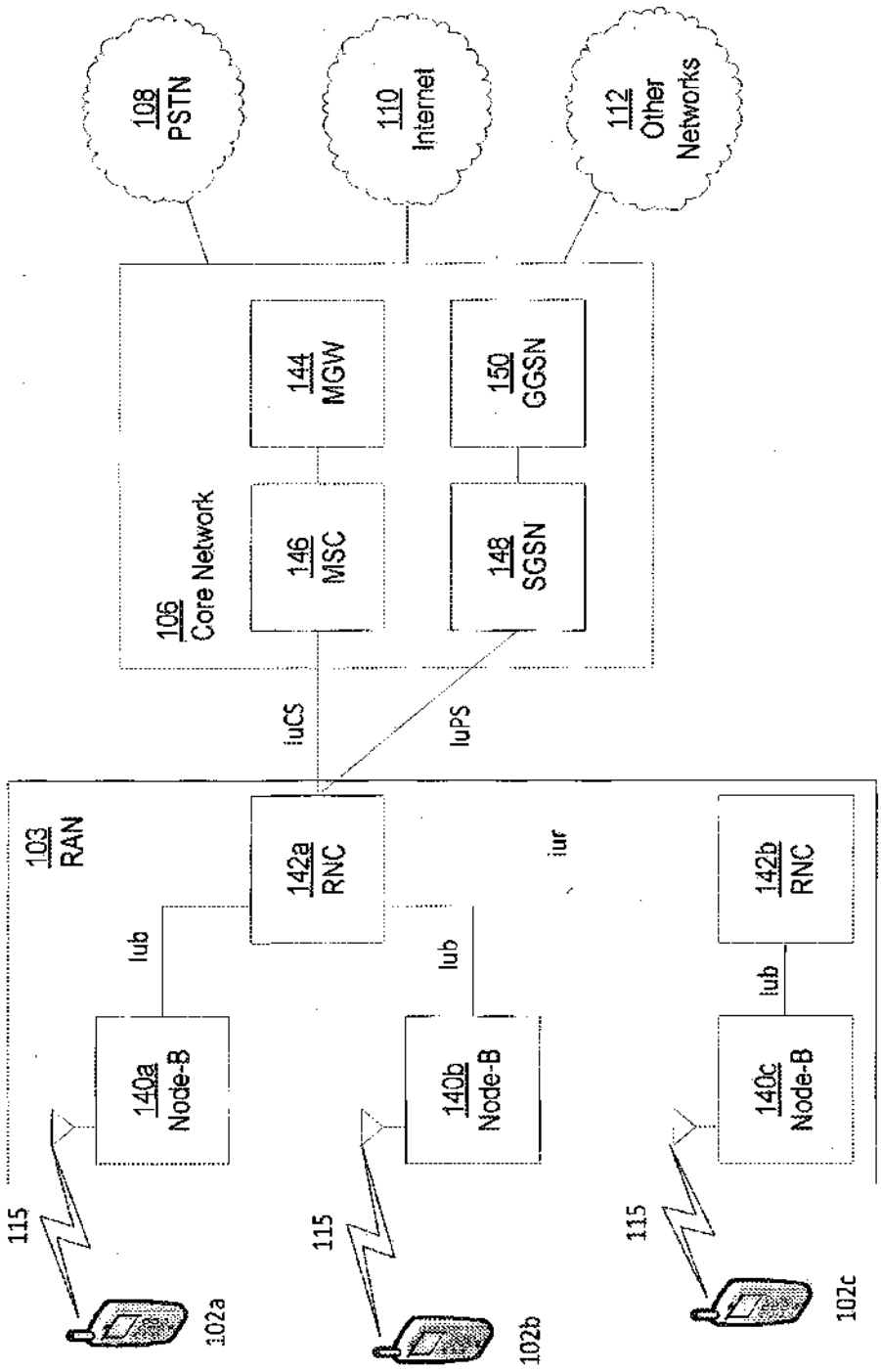

108 PSTN
110 Internet
112 Other Networks
106 Core Network
144 MGW
150 GGSN
146 MSC
148 SGSN
IuCS
IuPS
103 RAN
142a RNC
142b RNC
Iur
Iub
Iub
Iub
140a Node-B
140b Node-B
140c Node-B
115
115
115
102a
102b
102c

FIG. 1C

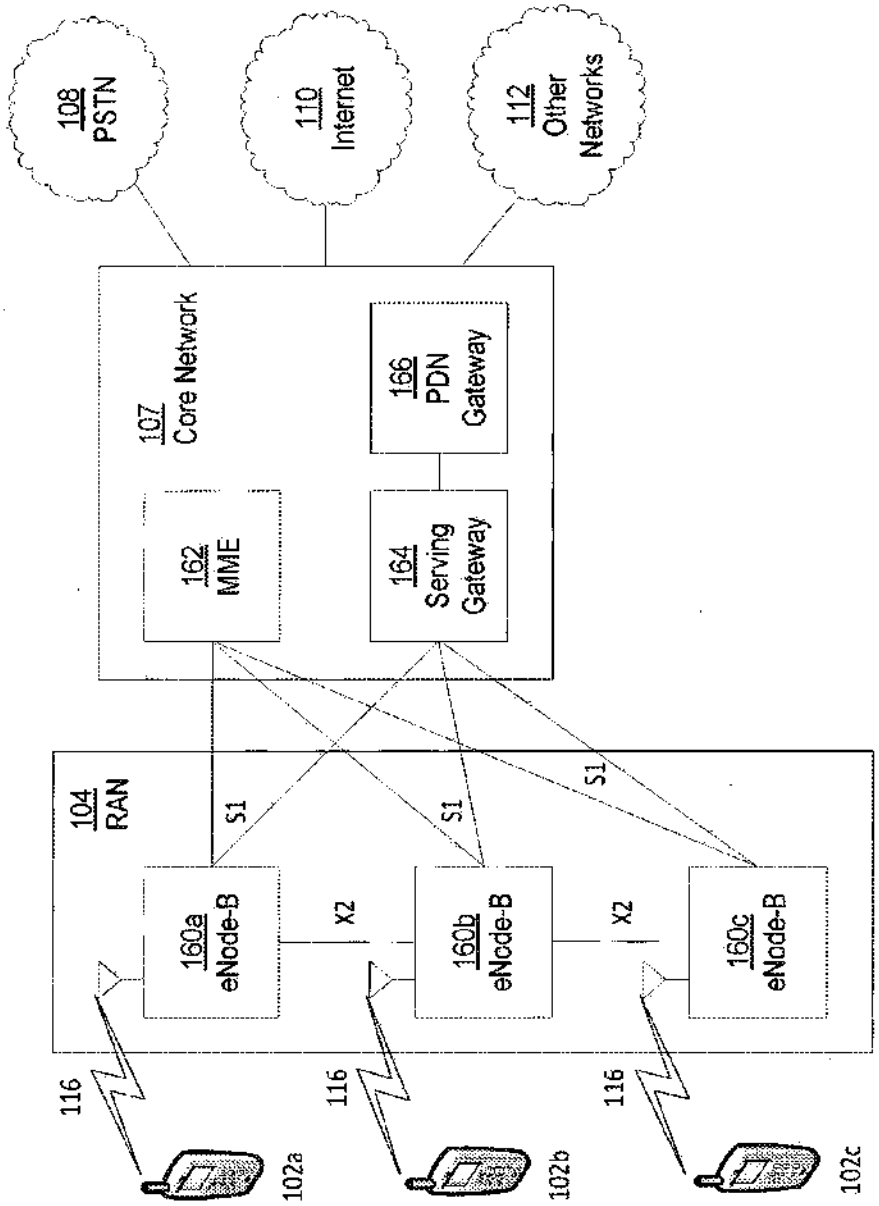

108 PSTN
110 Internet
112 Other Networks
107 Core Network
166 PDN Gateway
162 MME
164 Serving Gateway
104 RAN
S1
S1
S1
160a eNode-B
160b eNode-B
160c eNode-B
X2
X2
116
116
116
102a
102b
102c

FIG. 1D

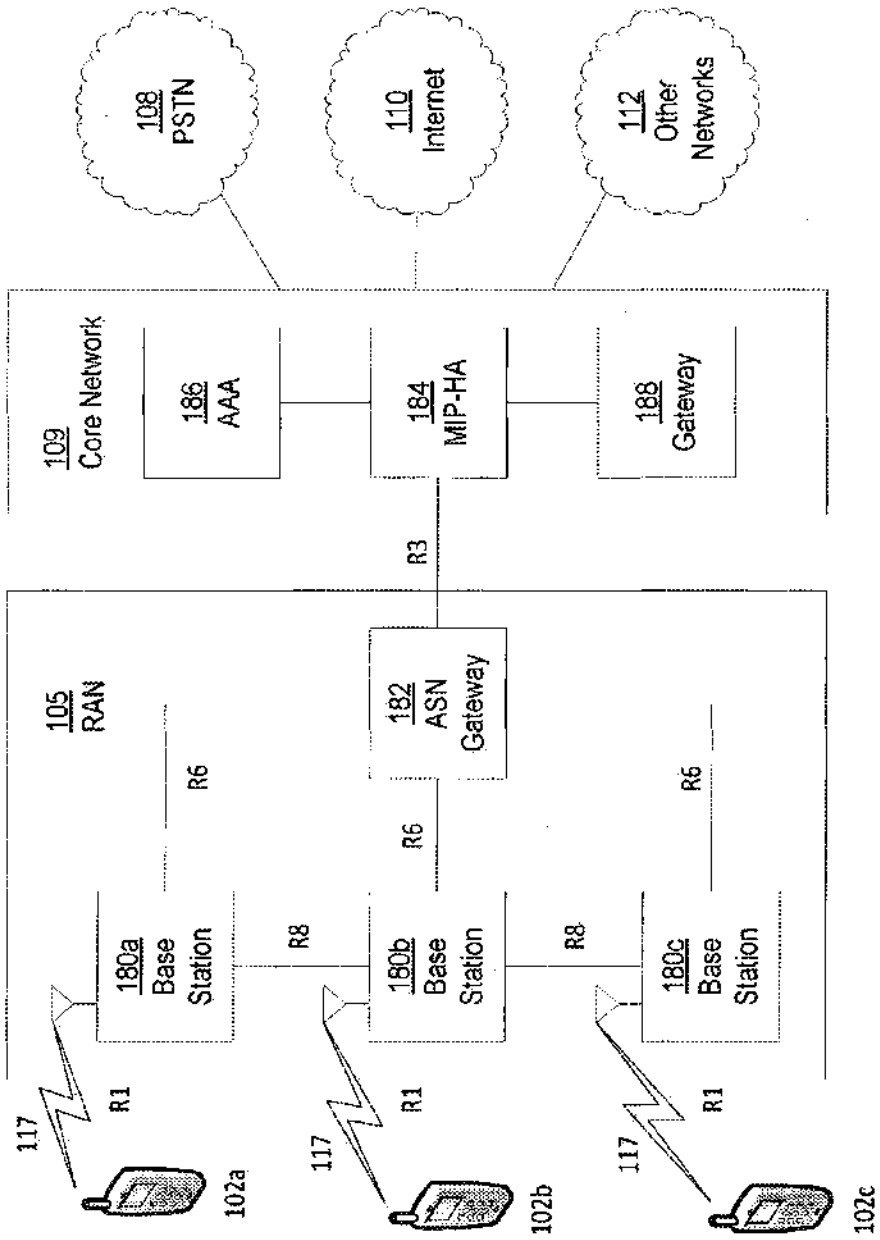

108 PSTN
110 Internet
112 Other Networks
109 Core Network
186 AAA
184 MIP-HA
188 Gateway
R3
105 RAN
182 ASN Gateway
R6
R6
R6
180a Base Station
180b Base Station
180c Base Station
R8
R8
R1
R1
R1
117
117
117
102a
102b
102c

FIG. 1E

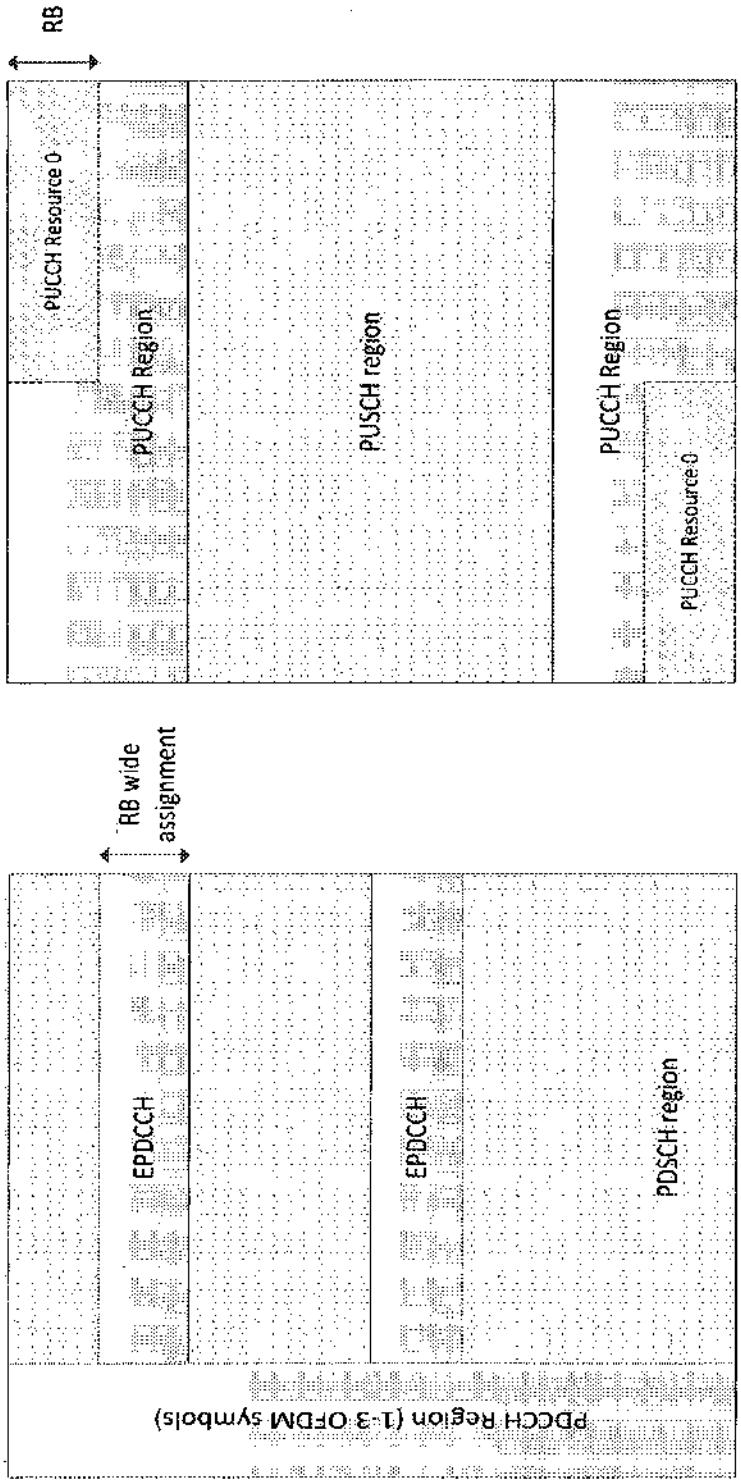

PDCCH Region (1-3 OFDM symbols)
EPDCCH
EPDCCH
PDSCH region
RB wide assignment
Subframe

FIG. 2

PUCCH Resource 0
PUCCH Region
PUSCH region
PUCCH Region
PUCCH Resource 0
RB
Subframe

FIG. 3

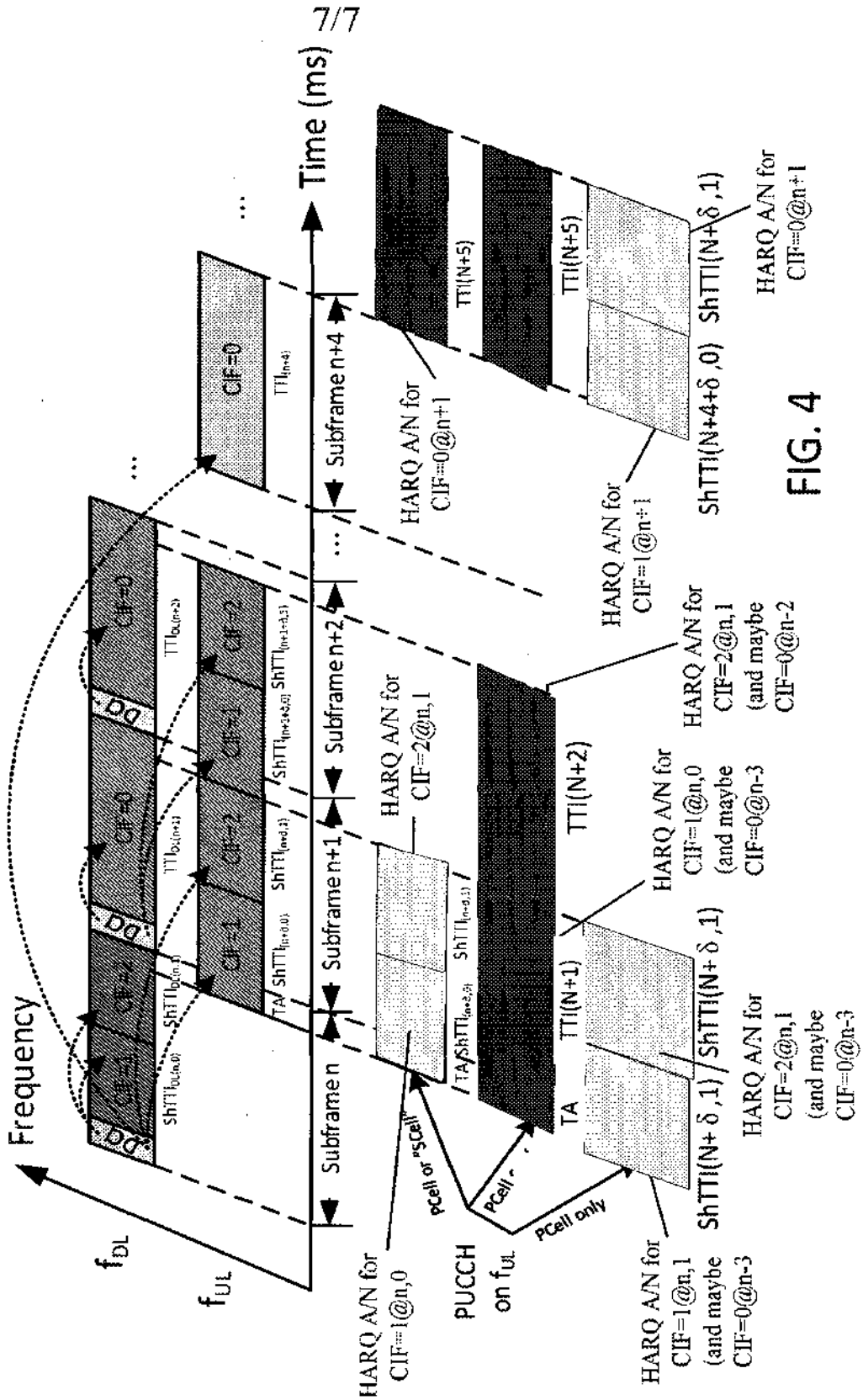

Frequency
Time (ms)
f_{DL}
f_{UL}
Subframe n
Subframe n+1
Subframe n+2
Subframe n+4
CIF=0
CIF=1
CIF=2
Dq
TTI(N+1)
TTI(N+2)
TTI(N+5)
TA
PUCCH on f_{UL}
PCell only
PCell or "SCell"
HARQ A/N for CIF=1@n,0
HARQ A/N for CIF=2@n,1
HARQ A/N for CIF=0@n+1
HARQ A/N for CIF=1@n,1 (and maybe CIF=0@n-3
HARQ A/N for CIF=1@n,0 (and maybe CIF=0@n-3
HARQ A/N for CIF=2@n,1 (and maybe CIF=0@n-2
HARQ A/N for CIF=1@n+1
HARQ A/N for CIF=0@n+1
ShTTI(N+δ ,1)
ShTTI(N+4+δ ,0)
ShTTI(N+δ ,1)

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/060481

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W72/12
ADD. H04W28/06 H04L1/18

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2013/041138 A1 (NOKIA SIEMENS NETWORKS OY [FI]; HOLMA HARRI KALEVI [FI]; RAAF BERNHARD) 28 March 2013 (2013-03-28) pages 1,2 page 5, line 29 - page 9, line 35	1-37
X	US 2014/071954 A1 (AU KELVIN KAR KIN [CA] ET AL) 13 March 2014 (2014-03-13)	1,10,24
Y	paragraphs [0001] - [0005], [0022], [0023], [0025], [0027], [0028], [0030], [0032], [0033], [0034] - [0036]; figures 4-6,8,9 abstract	2-9, 11-23, 25-37
	-/--	

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 December 2016	11/01/2017

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European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Englund, Terese

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	abstract; figure 3 paragraphs [0006] - [0010], [0017] - [0021], [0026], [0035], [0041], [0045], [0049], [0063] - [0072]	2-9, 11-23, 25-37
X	WO 2015/139795 A1 (ERICSSON TELEFON AB L M [SE]) 24 September 2015 (2015-09-24)	1
Y	abstract page 5, lines 1-29 page 16, lines 13-30	2-37
Y	US 2015/256316 A1 (SEO DONGYOUN [KR] ET AL) 10 September 2015 (2015-09-10)	2-37
A	abstract paragraphs [0005], [0008], [0010], [0033], [0036], [0052], [0053], [0094], [0105] - [0120], [179.183], [0190], [0202], [0205] paragraphs [0238] - [0248]	1
A	EP 2 341 678 A1 (PANASONIC CORP [JP]) 6 July 2011 (2011-07-06) abstract paragraphs [0001], [0003], [0019], [0020], [0030]	1-37
A	ITL: "On data transmission with partial TTI for LAA", 3GPP DRAFT; R1-153274, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. Fukuoka, Japan; 20150525 - 20150529 24 May 2015 (2015-05-24), XP050974055, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN1/Docs/ [retrieved on 2015-05-24] chapter 2.1	1-37
X,P	WO 2016/064048 A1 (LG ELECTRONICS INC [KR]) 28 April 2016 (2016-04-28) paragraphs [0191], [0344] - [0346]; claims 1-6	1-37
E	WO 2016/190970 A1 (QUALCOMM INC [US]) 1 December 2016 (2016-12-01) paragraphs [0006] - [0011]; claims 1-4; figures 4-8	1-37

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/060481

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X,P	WO 2016/064049 A1 (LG ELECTRONICS INC [KR]) 28 April 2016 (2016-04-28) paragraphs [0009] - [0016]; figures 1-24	1-37

1

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2016/060481

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		JP 5985009 B2	06-09-2016
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		WO 2016064059 A1	28-04-2016

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(43) 国际公布日
2018 年 11 月 8 日 (08.11.2018)

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H04W 72/04 (2009.01)

(21) 国际申请号: PCT/CN2018/085733

(22) 国际申请日: 2018 年 5 月 4 日 (04.05.2018)

(25) 申请语言: 中文

(26) 公布语言: 中文

(30) 优先权:
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(81) 指定国 (除另有指明, 要求每一种可提供的国家保护): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB,

(54) **Title:** BEAM RECOVERY METHOD AND DEVICE

(54) **发明名称:** 波束恢复方法及装置

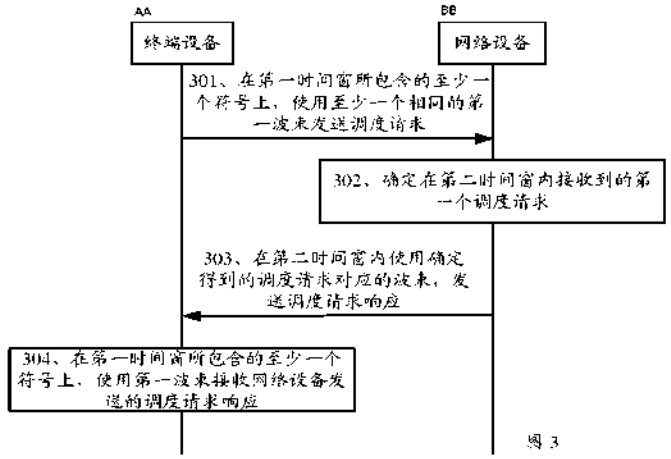


图 3

301 On at least one symbol comprised in a first time window, use at least one identical first beam to send a scheduling reques;
302 Determine a first scheduling request which is received within a second time window
303 Send a scheduling request response within the second time window by using a beam corresponding to the determined scheduling request
304 On at least one symbol comprised in the first time window, use the first beam to receive the scheduling request response which is sent by the network device
AA Terminal device
BB Network device

(57) **Abstract:** Disclosed in an embodiment of the present invention are a beam recovery method and device, the method comprising: a terminal device using at least one beam within a first time window to send to a network device a request which is used for recovering a beam, the request which is used for recovering a beam being a scheduling request or a beam failure recovery request; the terminal device using at least one beam within the first time window to receive a response to the request which is used for recovering a beam that is sent by the network device, the response to the request which is used for recovering a beam being a scheduling request response

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GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW。

(84) 指定国(除另有指明，要求每一种可提供的地区保护)：ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), 欧亚 (AM, AZ, BY, KG, KZ, RU, TJ, TM), 欧洲 (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG)。

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or a beam failure recovery request response. By using the embodiment of the present invention, the network device may perform beam recovery processing on multiple requests which are used for recovering a beam that are sent by the same terminal device, and beam recovery efficiency is increased.

(57) 摘要：本发明实施例公开了波束恢复方法及装置，所述方法包括：终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，用于恢复波束的请求为调度请求或者波束失败恢复请求；终端设备在第一时间窗内使用至少一个波束接收网络设备发送的用于波束恢复请求的响应，用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。采用本发明实施例，可实现网络设备针对同一终端设备发送的多个用于恢复波束的请求的波束恢复处理，提高波束恢复效率。

波束恢复方法及装置

技术领域

本申请涉及通信技术领域，尤其涉及波束恢复方法及装置。

背景技术

波束(beam)是一种通信资源，不同的波束可以认为是不同的通信资源。在移动通信系统中使用波束进行信息传输，即通过在空间上朝向特定的方向发送信号，可以实现更高的天线阵列增益。发射波束可以是指信号经天线发射出去后在空间不同方向上形成的信号强度的分布，接收波束可以是指从天线上接收到的无线信号在空间不同方向上的信号强度分布。一个波束对通常包括一个发送端的发射波束和一个接收端的接收波束。当下行控制信道关联的波束的性能下降到某个门限值时，该波束失效，即无法使用该波束进行信息传输，一旦波束失效，将触发波束恢复机制。

在长期演进（Long Term Evolution，LTE）系统中，在建立无线链路过程中的初始接入、在无线链路建立失败之后的链路重建或者采用基于上行测量的定位方法以进行定位等过程中可以采用随机接入方案，具体可以为：终端设备向网络设备发送调度请求（Scheduling Request，SR），以通知网络设备有终端设备试图接入；终端设备在预先配置的时间窗内监测控制信道，以接收网络设备下发的随机接入响应（Random Access Response，RAR）。上述随机接入方案仅针对网络设备接收到同一终端设备发送的一个 SR 的场景。

当下行链路（Down Link，DL）的波束对（Beam Pair Link，BPL）失效时，为了充分利用现有的资源，以及波束失效的持续时间远小于无线链路失效（Radio Link Failure，RLF）的时间窗长度，终端设备可以利用随机接入信道（Random Access Channel，RACH）资源在不同方向的多个波束上发射 SR，则网络设备在时间窗内可以接收到来自同一终端设备的多个 SR。而传统 LTE 中随机接入的处理流程仅针对网络设备收到同一终端设备发送的一个 SR 的场景，在网络设备收到同一终端设备发送的多个 SR 时如何进行随机接入处理，是目前亟需解决的问题。

发明内容

本发明实施例所要解决的技术问题在于，提供波束恢复方法及装置，可实现网络设备针对同一终端设备发送的多个用于恢复波束的请求的波束恢复处理，提高波束恢复效率。

第一方面，本发明实施例提供了一种波束恢复方法，终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求；终端设备在第一时间窗内使用至少一个波束接收网络设备发送的用于波束恢复请求的响应。

其中，用于恢复波束的请求可以为调度请求或者波束失败恢复请求（beam failure recovery request）。

其中，用于波束恢复请求的响应可以为调度请求响应或者波束失败恢复请求响应。

例如，当用于恢复波束的请求为调度请求时，用于波束恢复请求的响应可以为调度请求响应；当用于恢复波束的请求为波束失败恢复请求时，用于波束恢复请求的响应可以为

波束失败恢复请求响应。

其中，第一时间窗可以是网络设备对终端设备配置的时间窗，示例性的，第一时间窗可以包括 3 个符号或者 7 个符号等。

可选的，第一时间窗所包含的第一个符号可以为第一个配置有随机接入信道（Random Access Channel，RACH）资源的符号。

在该技术方案中，终端设备可以使用至少一个波束向网络设备发送用于恢复波束的请求，终端设备还可以在第一时间窗内使用上述至少一个波束接收网络设备发送的用于波束恢复请求的响应，则终端设备向网络设备发送的用于恢复波束的请求可以包括多个，以便提高波束恢复效率。

可选的，终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，具体可以为：终端设备在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送用于恢复波束的请求。

其中，第一波束可以是网络设备对终端设备配置的一个波束。

例如，终端设备可以在第一时间窗所包含的一个符号上，使用一个第一波束向网络设备发送用于恢复波束的请求。示例性的，第一时间窗包括 3 个符号，分别为第一符号、第二符号以及第三符号，若终端设备在第一时间窗中确定的一个符号为第一符号，则终端设备可以在第一时间窗所包含的第一符号上，使用第一波束向网络设备发送用于恢复波束的请求。

又如，终端设备可以在第一时间窗所包含的一个符号上，使用多个相同的第一波束向网络设备发送用于恢复波束的请求。示例性的，第一时间窗包括 3 个符号，分别为第一符号、第二符号以及第三符号，若终端设备在第一时间窗中确定的一个符号为第一符号，则终端设备可以在第一时间窗所包含的第一符号上，在不同方向上使用第一波束向网络设备发送用于恢复波束的请求。

又如，终端设备可以在第一时间窗所包含的多个符号上，使用一个第一波束向网络设备发送用于恢复波束的请求。示例性的，第一时间窗包括 3 个符号，分别为第一符号、第二符号以及第三符号，若终端设备在第一时间窗中确定的多个符号包括第二符号和第三符号，则终端设备可以在第一时间窗所包含的第二符号上，使用第一波束向网络设备发送用于恢复波束的请求，且在第一时间窗所包含的第三符号上，使用第一波束向网络设备发送用于恢复波束的请求。

又如，终端设备可以在第一时间窗所包含的多个符号上，使用多个相同的第一波束向网络设备发送用于恢复波束的请求。示例性的，第一时间窗包括 3 个符号，分别为第一符号、第二符号以及第三符号，若终端设备在第一时间窗中确定的多个符号包括第二符号和第三符号，则终端设备可以在第一时间窗所包含的第二符号上，使用第一波束向网络设备发送用于恢复波束的请求，且在第一时间窗所包含的第三符号上，使用第一波束向网络设备发送用于恢复波束的请求。

在该技术方案中，终端设备可以在一个符号上使用多个相同的第一波束向网络设备发送用于恢复波束的请求，或者在多个符号上使用一个或者多个相同的第一波束向网络设备发送用于恢复波束的请求，以实现同一终端设备向网络设备发送多个用于恢复波束的请求。

可选的，终端设备在第一时间窗内使用至少一个波束接收网络设备发送的用于波束恢复请求的响应，具体可以为：终端设备在第一时间窗所包含的至少一个符号上，使用第一波束接收用于波束恢复请求的响应。

在该技术方案中，终端设备在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送用于恢复波束的请求之后，可以在第一时间窗所包含的至少一个符号上，使用第一波束接收用于波束恢复请求的响应，可确保发送用于波束恢复的请求的波束和接收用于波束恢复请求的响应的波束为同一波束。

可选的，第一时间窗可以包括第一单元时间窗和第二单元时间窗，则终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，具体可以为：终端设备在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送用于恢复波束的请求。

其中，第一单元时间窗可以是网络设备对终端设备配置的时间窗，示例性的，第一单元时间窗可以包括 3 个符号或者 4 个符号等。

其中，第二单元时间窗可以是网络设备对终端设备配置的时间窗，示例性的，第二单元时间窗可以包括 4 个符号或者 5 个符号等。

其中，第二单元时间窗所包含的第一个符号为第一单元时间窗所包含的最后一个符号之后的第一个符号。例如第一单元时间窗包括 4 个符号，分别为符号 0、符号 1、符号 2 以及符号 3，符号 3 之后的第一个符号为符号 4，则终端设备可以确定第二单元时间窗所包含的第一个符号为符号 4。需要说明的是，本发明实施例中的第一单元时间窗包含但不限定 4 个符号，第一单元时间窗的长度和第二单元时间窗的长度可以相同，也可以不相同，具体不受本发明实施例的限定。

可选的，终端设备在第一时间窗内使用至少一个波束接收网络设备发送的用于波束恢复请求的响应，具体可以为：终端设备在第二单元时间窗所包含的至少一个符号上，使用第一波束接收用于波束恢复请求的响应。

在该技术方案中，终端设备在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送用于恢复波束的请求之后，终端设备可以在第二单元时间窗所包含的至少一个符号上，使用第一波束接收用于波束恢复请求的响应，可确保发送用于波束恢复的请求的波束和接收用于波束恢复请求的响应的波束为同一波束。

可选的，当在第一时间窗内未接收到用于波束恢复请求的响应时，终端设备可以确定网络设备对终端设备配置的第三时间窗，并在第三时间窗所包含的至少一个符号上，使用至少一个相同的第二波束向网络设备发送用于恢复波束的请求。

其中，第三时间窗可以是网络设备对终端设备配置的时间窗，示例性的，第三时间窗可以包括 3 个符号或者 5 个符号等。

在该技术方案中，终端设备在第一时间窗未检测到用于波束恢复请求的响应时，终端设备可以在第三时间窗使用第一波束以外的其他波束重新向网络设备发送用于恢复波束的请求，若终端设备在第三时间窗所包含的至少一个符号上使用第二波束接收到网络设备发送的用于波束恢复请求的响应，则可实现波束恢复，可提高波束恢复的可靠性。

可选的，第一时间窗可以包括第三单元时间窗和第四单元时间窗，则终端设备在第一

时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，具体可以为：终端设备在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备发送用于恢复波束的请求。

其中，第三单元时间窗可以是网络设备对终端设备配置的时间窗，示例性的，第一单元时间窗可以包括 3 个符号或者 5 个符号等。

其中，第四单元时间窗可以是网络设备对终端设备配置的时间窗，示例性的，第二单元时间窗可以包括 4 个符号或者 5 个符号等。

其中，第四单元时间窗所包含的第一个符号可以为第三单元时间窗所包含的最后一个符号之后的第一个符号。例如第三单元时间窗包括 4 个符号，分别为符号 0、符号 1、符号 2 以及符号 3，符号 3 之后的第一个符号为符号 4，则终端设备可以确定第四单元时间窗所包含的第一个符号为符号 4。需要说明的是，本发明实施例中的第三单元时间窗包含但不限定 4 个符号，第三单元时间窗的长度和第四单元时间窗的长度可以相同，也可以不相同，具体不受本发明实施例的限定。

其中，网络设备可以对终端设备配置最大波束数量，例如允许终端设备发送用于恢复波束的请求时所使用的波束的数量可以小于等于 5。需要说明的是，本发明实施例中的最大波束数量包含但不限于 5，例如，最大波束数量可以为 3，等等，具体不受本发明实施例的限制。

其中，第三单元时间窗所包含的符号的数量总和可以是根据网络设备对终端设备配置的最大波束数量确定的。例如，第三单元时间窗所包含的符号的数量总和与最大波束数量之间可以呈正比例关系。示例性的，最大波束数量为 5，则第三单元时间窗所包含的符号的数量总和可以为 5，即第三单元时间窗包含 5 个符号。

例如，终端设备可以在第三单元时间窗所包含的一个符号上，使用一个波束向网络设备发送用于恢复波束的请求。示例性的，第三单元时间窗包括 5 个符号，分别为第一符号、第二符号、第三符号、第四符号以及第五符号，若终端设备在第三单元时间窗中确定的一个符号为第一符号，则终端设备可以在第三单元时间窗所包含的第一符号上，使用波束 1 向网络设备发送用于恢复波束的请求。波束 1 可以为终端设备确定得到的一个波束，其中该波束可以是网络设备对终端设备配置的。

又如，终端设备可以在第三单元时间窗所包含的一个符号上，使用多个不同波束向网络设备发送用于恢复波束的请求。示例性的，第三单元时间窗包括 5 个符号，分别为第一符号、第二符号、第三符号、第四符号以及第五符号，若终端设备在第三单元时间窗中确定的一个符号为第一符号，则终端设备可以在第三单元时间窗所包含的第一符号上，在不同方向上分别使用波束 1~波束 5 中的多个波束向网络设备发送用于恢复波束的请求。其中，若网络设备对终端设备配置的最大波束数量为 5，则终端设备在第三单元时间窗所包含的第一符号上，可以使用大于等于 2 个且小于等于 5 个波束向网络设备发送用于恢复波束的请求。

又如，终端设备可以在第三单元时间窗所包含的多个符号上，使用一个波束向网络设备发送用于恢复波束的请求。示例性的，第三单元时间窗包括 5 个符号，分别为第一符号、第二符号、第三符号、第四符号以及第五符号，若终端设备在第三单元时间窗中确定的多

个符号包括第二符号和第三符号，则终端设备可以在第三单元时间窗所包含的第二符号上，使用波束 1 向网络设备发送用于恢复波束的请求，且在第三单元时间窗所包含的第三符号上，使用波束 1 向网络设备发送用于恢复波束的请求。

又如，终端设备可以在第三单元时间窗所包含的多个符号上，使用多个不同波束向网络设备发送用于恢复波束的请求。示例性的，第三单元时间窗包括 5 个符号，分别为第一符号、第二符号、第三符号、第四符号以及第五符号，若终端设备在第三单元时间窗中确定的多个符号包括第二符号和第三符号，则终端设备可以在第三单元时间窗所包含的第二符号上，在不同方向上分别使用波束 1~波束 5 中的多个波束向网络设备发送用于恢复波束的请求，且在第三单元时间窗所包含的第三符号上，在不同方向上分别使用波束 1~波束 5 中的多个波束向网络设备发送用于恢复波束的请求。

在该技术方案中，终端设备可以在一个符号上使用多个不同波束向网络设备发送用于恢复波束的请求，或者在多个符号上使用一个或者多个不同波束向网络设备发送用于恢复波束的请求，以实现同一终端设备向网络设备发送多个用于恢复波束的请求。

可选的，终端设备在第一时间窗内使用至少一个波束接收网络设备发送的用于波束恢复请求的响应，具体可以为：终端设备在第四单元时间窗所包含的至少一个符号上，使用至少一个不同的波束接收用于波束恢复请求的响应。

在该技术方案中，终端设备在第三单元时间窗所包含的至少一个符号上，使用至少一个不同波束向网络设备发送用于恢复波束的请求之后，终端设备可以在第四单元时间窗所包含的至少一个符号上，使用上述至少一个不同的波束接收用于波束恢复请求的响应，可确保发送用于波束恢复的请求的波束和接收用于波束恢复请求的响应的波束为同一波束。

可选的，终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，具体可以为：终端设备基于网络设备对终端设备配置的波束请求指示信息，在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，波束请求指示信息用于指示用于恢复波束的请求的发送方式。

例如，当波束请求指示信息用于指示用于恢复波束的请求的发送方式为在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束发送时，终端设备可以在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送用于恢复波束的请求，并在第一时间窗所包含的至少一个符号上，使用第一波束接收用于波束恢复请求的响应。

又如，当波束请求指示信息用于指示用于恢复波束的请求的发送方式为在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束发送时，终端设备可以在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送用于恢复波束的请求，并在第二单元时间窗所包含的至少一个符号上，使用第一波束接收用于波束恢复请求的响应。

又如，当波束请求指示信息用于指示用于恢复波束的请求的发送方式为在第三单元时间窗所包含的至少一个符号上，使用至少一个不同波束发送时，终端设备可以在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备发送用于恢复波束的请求，并在第四单元时间窗所包含的至少一个符号上，使用至少一个不同的波束接收用

于波束恢复请求的响应。

第二方面，本发明实施例提供了一种波束恢复方法，网络设备接收终端设备在第一时间窗内使用至少一个波束发送的用于恢复波束的请求，在第二时间窗内，在接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，并使用确定得到的用于恢复波束的请求对应的波束，向终端发送用于波束恢复请求的响应。

在该技术方案中，网络设备可以接收终端设备发送的多个用于恢复波束的请求，在接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，并使用确定得到的用于恢复波束的请求对应的波束，向终端发送用于波束恢复请求的响应，可实现网络设备针对同一终端设备发送的多个用于恢复波束的请求的波束恢复处理，提高波束恢复效率。

可选的，网络设备在接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，具体可以为：网络设备响应在第二时间窗内接收到的质量最好的波束所承载的用于恢复波束的请求。

例如，若终端设备在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备发送用于恢复波束的请求，则网络设备可以在第二时间窗内接收到的用于恢复波束的请求中确定质量最好的波束所承载的用于恢复波束的请求，并对确定得到的用于恢复波束的请求进行响应。

又如，若终端设备在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送用于恢复波束的请求，则网络设备可以在第二时间窗内接收到的用于恢复波束的请求中确定质量最好的波束所承载的用于恢复波束的请求，并对确定得到的用于恢复波束的请求进行响应。

可选的，网络设备在接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，具体可以为：网络设备响应在第二时间窗内接收到的第一个用于恢复波束的请求。

例如，若终端设备在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送用于恢复波束的请求，则网络设备可以在第二时间窗内接收到的用于恢复波束的请求中确定最先接收到的用于恢复波束的请求，并对确定得到的用于恢复波束的请求进行响应。

又如，若终端设备在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送用于恢复波束的请求，则网络设备可以在第二时间窗内接收到的用于恢复波束的请求中确定最先接收到的用于恢复波束的请求，并对确定得到的用于恢复波束的请求进行响应。

又如，若终端设备在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备发送用于恢复波束的请求，则网络设备可以在第二时间窗内接收到的用于恢复波束的请求中确定最先接收到的用于恢复波束的请求，并对确定得到的用于恢复波束的请求进行响应。

可选的，网络设备使用确定得到的用于恢复波束的请求对应的波束，向终端发送用于波束恢复请求的响应，具体可以为：网络设备在第二时间窗内使用确定得到的用于恢复波束的请求对应的波束，向终端设备发送用于波束恢复请求的响应。

可选的，网络设备使用确定得到的用于恢复波束的请求对应的波束，向终端发送用于波束恢复请求的响应，具体可以为：网络设备在第二时间窗之外使用确定得到的用于恢复波束的请求对应的波束，向终端设备发送用于波束恢复请求的响应。

第三方面，本发明实施例提供一种计算机存储介质，所述计算机存储介质存储有程序，所述程序执行时包括本发明实施例第一方面提供的波束恢复方法中全部或部分的步骤。

第四方面，本发明实施例提供一种计算机存储介质，所述计算机存储介质存储有程序，所述程序执行时包括本发明实施例第二方面提供的波束恢复方法中全部或部分的步骤。

第五方面，本发明实施例提供一种波束恢复装置，该波束恢复装置包括用于执行本发明实施例第一方面公开的波束恢复方法的模块。

第六方面，本发明实施例提供一种波束恢复装置，该波束恢复装置包括用于执行本发明实施例第二方面公开的波束恢复方法的模块。

第七方面，本发明实施例提供一种终端设备，其特征在于，包括处理器、存储器以及收发器，存储器中存储一组程序代码，且处理器调用存储器中存储的程序代码，用于执行以下操作：

在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求；在第一时间窗内使用至少一个波束接收网络设备发送的用于波束恢复请求的响应。

第八方面，本发明实施例提供一种网络设备，其特征在于，包括处理器、存储器以及收发器，存储器中存储一组程序代码，且处理器调用存储器中存储的程序代码，用于执行以下操作：

接收终端设备在第一时间窗内使用至少一个波束发送的用于恢复波束的请求；在第二时间窗内，在接收到的用于恢复波束的请求中确定一个用于恢复波束的请求；使用确定得到的用于恢复波束的请求对应的波束，向终端设备发送用于波束恢复请求的响应。

第九方面，本发明实施例提供一种波束恢复系统，包括本发明实施例第七方面公开的终端设备和本发明实施例第八方面公开的网络设备。

第十方面，本申请实施例提供了一种通信芯片，其中存储有指令，当其在终端设备上运行时，使得所述通信芯片执行上述第一方面的方法。

第十一方面，本申请实施例提供了一种通信芯片，其中存储有指令，当其在网络设备上运行时，使得所述通信芯片执行上述第二方面的方法。

附图说明

为了更清楚地说明本发明实施例或背景技术中的技术方案，下面将对本发明实施例或背景技术中所需要使用的附图进行说明。

图 1 是本发明实施例提供的一种波束恢复系统的架构示意图；

图 2A 是本发明实施例提供的一种信息传输的示意图；

图 2B 是本发明另一实施例提供的一种信息传输的示意图；

图 3 是本发明实施例提供的一种波束恢复方法的流程示意图；

图 4 是本发明另一实施例提供的一种信息传输的示意图；

图 5 是本发明另一实施例提供的一种波束恢复方法的流程示意图；

图 6 是本发明另一实施例提供的一种波束恢复方法的流程示意图；

图 7 是本发明另一实施例提供的一种信息传输的示意图；

图 8 是本发明另一实施例提供的一种波束恢复方法的流程示意图；

图 9 是本发明另一实施例提供的一种波束恢复方法的流程示意图；

图 10 是本发明另一实施例提供的一种信息传输的示意图；

图 11 是本发明另一实施例提供的一种波束恢复方法的流程示意图；

图 12 是本发明实施例提供的一种波束恢复装置的结构示意图；

图 13 是本发明实施例提供的一种终端设备的结构示意图；

图 14 是本发明另一实施例提供的一种波束恢复装置的结构示意图；

图 15 是本发明实施例提供的一种网络设备的结构示意图；

图 16 是本发明实施例提供的一种波束恢复系统的结构示意图。

具体实施方式

下面结合本发明实施例中的附图对本发明实施例进行描述。

为了更好的理解本发明实施例公开的一种波束恢复方法及装置，下面首先对本发明实施例适用的网络架构进行描述。请参见图 1，图 1 是本发明实施例公开的一种波束恢复系统的架构示意图。如图 1 所示，该波束恢复系统可以包括终端设备 10 以及网络设备 20。其中，终端设备 10 与网络设备 20 之间可以通过通信连接进行数据传输。

本发明实施例中的终端设备 10 可以称为用户设备（User Equipment，UE）、移动台、接入终端、用户单元、用户站、移动站、远方站、远程终端、移动设备、终端、无线通信设备、用户代理或用户装置等，其具体可以是 WLAN 中的站点（Station，ST）、蜂窝电话、无绳电话、会话启动协议（Session Initiation Protocol，SIP）电话、无线本地环路（Wireless Local Loop，WLL）站、个人数字处理（Personal Digital Assistant，PDA）、具有无线通信功能的手持设备、计算设备、连接到无线调制解调器的其它处理设备、车载设备、可穿戴设备、未来 5G 网络中的移动台以及未来演进的公共陆地移动网络（Public Land Mobile Network，PLMN）网络中的终端设备等中的任意一种。

本发明实施例中的网络设备 20 可以是能和终端设备 10 通信的设备。网络设备 20 可以是基站、中继站或接入点。基站可以是全球移动通信系统（Global System for Mobile Communication，GSM）或码分多址（Code Division Multiple Access，CDMA）网络中的基

站收发信台（Base Transceiver Station，BTS），也可以是宽带码分多址（Wideband Code Division Multiple Access，WCDMA）中的NB（NodeB），还可以是长期演进（Long Term Evolution，LTE）中的eNB或eNodeB（Evolutional NodeB）。网络设备20还可以是云无线接入网络（Cloud Radio Access Network，CRAN)场景下的无线控制器。网络设备20还可以是未来5G网络中的网络设备或者未来演进的PLMN网络中的网络设备。网络设备20还可以是可穿戴设备或车载设备。

应理解，本发明实施例的技术方案可以应用于各种通信系统，例如：GSM系统、CDMA系统、WCDMA系统、通用分组无线业务（General Packet Radio Service，GPRS）、LTE系统、LTE频分双工（Frequency Division Duplex，FDD）系统、LTE时分双工（Time Division Duplex，TDD）、通用移动通信系统（Universal Mobile Telecommunication System，UMTS）或全球互联微波接入（Worldwide Interoperability for Microwave Access，WiMAX）通信系统等。

本发明实施例中，能够和基站进行数据通信的设备均可以理解为终端设备10，本发明实施例将以一般意义上的终端设备来介绍；本发明实施例中，网络设备20可以通过信令对终端设备10配置允许的最大波束数量，则终端设备10可以使用小于等于最大波束数量的波束向网络设备20发送用于波束恢复的请求；本发明实施例中，网络设备20可以对终端设备10配置第一时间窗，其中第一时间窗可以包括一个子帧、一个时隙以及一个或多个符号中的任意一种，则终端设备10可以在第一时间窗使用至少一个波束向网络设备20发送用于波束恢复的请求；本发明实施例中，网络设备20可以对终端设备10配置第三时间窗，其中第三时间窗可以包括一个子帧、一个时隙以及一个或多个符号中的任意一种，则终端设备10在第一时间窗使用至少一个第一波束向网络设备20发送用于波束恢复的请求之后，当在第一时间窗内未接收到网络设备20发送的用于波束恢复请求的响应时，终端设备10可以在第三时间窗使用至少一个第二波束向网络设备发送用于恢复波束的请求；本发明实施例中，网络设备20可以配置网络设备20侧的第二时间窗，其中第二时间窗可以包括一个子帧、一个时隙以及一个或多个符号中的任意一种，则网络设备20接收到终端设备10在第一时间窗使用至少一个波束发送的用于波束恢复的请求之后，可以在第二时间窗，在接收到的用于波束恢复的请求中确定一个用于波束恢复的请求。

本发明实施例中，终端设备10至少有两种发送方式向网络设备20发送用于波束恢复的请求，以实现波束恢复。

第一种发送方式可以为：终端设备10在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备20发送用于恢复波束的请求，并在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备20发送的用于波束恢复请求的响应。

以图2A所示的信息传输的示意图为例，终端设备10在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束B4'向网络设备20发送用于恢复波束的请求。网络设备20按照接收RACH波束扫描方式检测终端设备10发送的用于恢复波束的请求，当网络设备20在第二时间窗内接收到终端设备10发送的用于波束恢复的请求时，网络设备20可以通过物理下行控制信道（Physical Downlink Control Channel，PDCCH）对该用于波束恢复的请求进行响应。当终端设备10在第一时间窗内未接收到网络设备20发送的用于恢

复波束请求的响应时，终端设备 10 可以在第二时间窗所包含的至少一个符号上，使用至少一个相同的第二波束 B5'向网络设备发送用于恢复波束的请求，当终端设备 10 在第二时间窗接收到网络设备 20 发送的用于波束恢复请求的响应时，终端设备 10 可以确定实现了波束恢复。

第二种发送方式可以为：若第一时间窗包括第三单元时间窗和第四单元时间窗，终端设备 10 可以在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备 20 发送用于恢复波束的请求，并在第四单元时间窗所包含的至少一个符号上，使用至少一个不同的波束接收网络设备 20 发送的用于波束恢复请求的响应。

以图 2B 所示的信息传输的示意图为例，终端设备 10 在第三单元时间窗所包含的至少一个符号上，使用多个不同的波束向网络设备 20 发送用于恢复波束的请求，网络设备 20 在第二时间窗内接收到终端设备 10 发送的多个用于恢复波束的请求之后，可以在多个用于恢复波束的请求中确定一个用于恢复波束的请求，网络设备 20 可以使用确定得到的一个用于恢复波束的请求对应的波束，向终端设备 10 发送用于波束恢复请求的响应。终端设备 10 可以按照波束扫描方式检测网络设备 20 发送的用于波束恢复请求的响应，当终端设备 10 接收到网络设备 20 发送的用于波束恢复请求的响应时，终端设备 10 可以确定实现了波束恢复。

相对第一种发送方式，本发明实施例通过第二种发送方式可以使用多个不同的波束向网络设备 20 发送用于恢复波束的请求，可减小时延，提高波束恢复效率。

基于图 1 所示的波束恢复系统的架构示意图，请参见图 3，图 3 是本发明实施例提供的一种波束恢复方法的流程示意图，该方法包括但不限于如下步骤：

步骤 S301：终端设备在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送调度请求。

具体地，当下行链路（Down Link，DL）的波束失效时，终端设备可以在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送调度请求。其中，第一波束可以是网络设备对终端设备配置的波束，例如波束 1。

例如，终端设备可以在第一时间窗中选取一个符号（例如符号 3），并在符号 3 上使用一个波束 1 向网络设备发送调度请求。又如，终端设备可以在第一时间窗中选取一个符号（例如符号 3），并在符号 3 上使用多个波束 1 向网络设备发送调度请求，即终端设备在符号 3 上，在不同方向上使用波束 1 向网络设备发送调度请求。又如，以图 4 所示的信息传输的示意图为例，终端设备可以在第一时间窗中选取多个符号（例如符号 3，符号 4），在符号 3 上使用一个波束 1 向网络设备发送调度请求，并在符号 4 上使用一个波束 1 向网络设备发送调度请求。又如，终端设备可以在第一时间窗中选取多个符号（例如符号 3，符号 4），在符号 3 上使用多个波束 1 向网络设备发送调度请求，并在符号 4 上使用多个波束 1 向网络设备发送调度请求。

本发明实施例中，终端设备在第一时间窗所包含的至少一个符号上，使用多个相同的第一波束向网络设备发送调度请求，可加大子载波间隔。

本发明实施例中，网络设备可以对终端设备配置第一时间窗。其中，第一时间窗的起

始时刻可以是配置有RACH资源的第一个符号，以图4所示的信息传输的示意图为例，配置有RACH资源的第一个符号为符号3，则终端设备可以确定第一时间窗的起始时刻为符号3。

其中，第一时间窗的长度可以是固定长度，例如7个符号，可选的，第一时间窗的长度也可以是网络设备配置的，例如3个符号或者5个符号等。

其中，网络设备可以向终端设备发送长度指示信息，以指示第一时间窗的长度。可选的，可以通过直接法指示第一时间窗的长度，例如长度指示信息为5，则终端设备可以确定第一时间窗的长度为5个符号。可选的，可以通过映射方式描述第一时间窗的长度，例如长度指示信息和第一时间窗的映射关系如表一所示：

表一

长度指示信息	第一时间窗的长度
00	3个符号
01	4个符号
10	5个符号
11	7个符号

通过表一可知，当长度指示信息为二进制00时，终端设备可以确定第一时间窗的长度为3个符号；当长度指示信息为二进制11时，终端设备可以确定第一时间窗的长度为7个符号。需要说明的是，本发明实施例中的长度指示信息和第一时间长度的映射关系包含但不局限于上述方式，研发人员可以结合不同场景进行修改，具体不受本发明实施例的限制。

其中，网络设备可以通过信令对终端设备配置第一时间窗，例如无线资源控制协议（Radio Resource Control，RRC）、媒体介入控制-控制元素协议（Media Access Control-Control Element，MAC-CE）或者下行控制信息协议（Downlink Control Information，DCI）等。

其中，网络设备可以通过向终端设备发送长度指示信息的方式，通知终端设备配置了第一时间窗。

步骤S302：网络设备确定在第二时间窗内接收到的第一个调度请求。

具体地，网络设备可以按照接收RACH波束扫描方式在第二时间窗内接收终端设备发送的调度请求，并确定在第二时间窗内接收到的第一个调度请求。

其中，网络设备可以配置网络设备侧的第二时间窗，第二时间窗所包含的第一个符号可以和第一单元时间窗所包含的第一个符号相同。

其中，第二时间窗的长度可以是固定长度，例如4个符号，可选的，第二时间窗的长度也可以是网络设备配置的，例如3个符号或者5个符号等。

步骤S303：网络设备在第二时间窗内使用确定得到的调度请求对应的波束，向终端设备发送调度请求响应。

具体实现中，网络设备可以获取承载确定得到的调度请求的波束，确定该波束所属波束对所包含的另一波束，在第二时间窗内使用确定得到的波束向终端设备发送调度请求响应。其中，波束对可以包括一个发送端的发射波束和一个接收端的接收波束。例如承载确

定得到的调度请求的波束为波束 1，波束 1 与波束 3 构成一个波束对，则网络设备可以在第二时间窗内使用波束 3 向终端设备发送调度请求响应。

以图 4 所示的信息传输的示意图为例，网络设备可以在第二时间窗所包含的符号 0 上，使用第一波束所属波束对所包含的另一波束向终端设备发送调度请求响应。

可选的，网络设备可以通过 PDCCH 向终端设备发送调度请求响应。例如，终端设备可以在同一子帧接收多个承载在不同 PDCCH 上的 DCI 消息。对于一个 PDCCH 所承载的 DCI 消息，每个 DCI 消息上可以附着一个 CRC。终端设备的 C-RNTI 可以被包含在 CRC 计算之中并隐式传输。则网络设备可以根据该终端设备的 C-RNTI，确定包含该 C-RNTI 的 CRC 所属的 DCI，进而确定承载该 DCI 的 PDCCH，通过确定得到的 PDCCH 向终端设备发送调度请求响应。其中，DCI 可以包括下行调度分配、上行调度请求、功率控制等。

可选的，网络设备可以通过 MAC-CE 向终端设备发送调度请求响应。例如，网络设备可以定义一个新的 MAC-CE，将该 MAC-CE 发送给终端设备，其中该 MAC-CE 可以携带调度请求响应。

可选的，网络设备可以通过 RRC 向终端设备发送调度请求响应。例如，网络设备可以定义一个新的 RRC IE，将该 RRC IE 发送给终端设备，其中该 RRC IE 可以携带调度请求响应。

可选的，网络设备可以通过物理下行共享信道（Physical Downlink Shared Channel，PDSCH）向终端设备发送调度请求响应。

步骤 S304：终端设备在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备发送的调度请求响应。

终端设备可以在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备发送的调度请求响应。例如，若终端设备在第一时间窗所包含的至少一个符号上，使用波束 1 向网络设备发送调度请求，则终端设备可以在第一时间窗所包含的至少一个符号上，使用波束 1 接收网络设备发送的调度请求响应。

相对传统的波束恢复方法中终端设备接收调度请求响应的接收时间与发送调度请求的发送时间间隔至少两个子帧，本发明实施例中终端设备接收调度请求响应的接收时间与发送调度请求的发送时间间隔最多第一时间窗，例如 7 个符号，可降低延迟，提高波束恢复的效率。

在图 3 所描述的方法中，终端设备在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送调度请求，网络设备确定在第二时间窗内接收到的第一个调度请求，网络设备在第二时间窗内使用确定得到的调度请求对应的波束，向终端设备发送调度请求响应，则终端设备在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备发送的调度请求响应，可实现网络设备针对同一终端设备发送的多个调度请求的波束恢复处理，提高波束恢复效率。

基于图 1 所示的波束恢复系统的架构示意图，请参见图 5，图 5 是本发明实施例提供的一种波束恢复方法的流程示意图，该方法包括但不限于如下步骤：

步骤 S501：终端设备在第一时间窗所包含的至少一个符号上，使用至少一个相同的第

一波束向网络设备发送波束失败恢复请求。

具体地，当 DL 波束失效时，终端设备可以在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送波束失败恢复请求。其中，第一波束可以是网络设备对终端设备配置的波束，例如波束 1。

例如，终端设备可以在第一时间窗中选取一个符号（例如符号 3），并在符号 3 上使用一个波束 1 向网络设备发送波束失败恢复请求。又如，终端设备可以在第一时间窗中选取一个符号（例如符号 3），并在符号 3 上使用多个波束 1 向网络设备发送波束失败恢复请求，即终端设备在符号 3 上，在不同方向上使用波束 1 向网络设备发送波束失败恢复请求。又如，以图 4 所示的信息传输的示意图为例，终端设备可以在第一时间窗中选取多个符号（例如符号 3，符号 4），在符号 3 上使用一个波束 1 向网络设备发送波束失败恢复请求，并在符号 4 上使用一个波束 1 向网络设备发送波束失败恢复请求。又如，终端设备可以在第一时间窗中选取多个符号（例如符号 3，符号 4），在符号 3 上使用多个波束 1 向网络设备发送波束失败恢复请求，并在符号 4 上使用多个波束 1 向网络设备发送波束失败恢复请求。

本发明实施例中，终端设备在第一时间窗所包含的至少一个符号上，使用多个相同的第一波束向网络设备发送波束失败恢复请求，可加大子载波间隔。

本发明实施例中，网络设备可以对终端设备配置第一时间窗。其中，第一时间窗的起始时刻可以是配置有 RACH 资源的第一个符号，以图 4 所示的信息传输的示意图为例，配置有 RACH 资源的第一个符号为符号 3，则终端设备可以确定第一时间窗的起始时刻为符号 3。

其中，第一时间窗的长度可以是固定长度，例如 7 个符号，可选的，第一时间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

其中，网络设备可以向终端设备发送长度指示信息，以指示第一时间窗的长度。可选的，可以通过直接法指示第一时间窗的长度，例如长度指示信息为 5，则终端设备可以确定第一时间窗的长度为 5 个符号。可选的，可以通过映射方式描述第一时间窗的长度，例如长度指示信息和第一时间窗的映射关系如表一所示。通过表一可知，当长度指示信息为二进制 00 时，终端设备可以确定第一时间窗的长度为 3 个符号；当长度指示信息为二进制 11 时，终端设备可以确定第一时间窗的长度为 7 个符号。需要说明的是，本发明实施例中的长度指示信息和第一时间长度的映射关系包含但不局限于上述方式，研发人员可以结合不同场景进行修改，具体不受本发明实施例的限制。

其中，网络设备可以通过信令对终端设备配置第一时间窗，例如无线资源控制协议（Radio Resource Control，RRC）、媒体介入控制-控制元素协议（Media Access Control-Control Element，MAC-CE）或者下行控制信息协议（Downlink Control Information，DCI）等。

其中，网络设备可以通过向终端设备发送长度指示信息的方式，通知终端设备配置了第一时间窗。

步骤 S502：网络设备确定在第二时间窗内接收到的第一个波束失败恢复请求。

具体地，网络设备可以按照接收 RACH 波束扫描方式在第二时间窗内接收终端设备发送的波束失败恢复请求，并确定在第二时间窗内接收到的第一个波束失败恢复请求。

其中，网络设备可以配置网络设备侧的第二时间窗，第二时间窗所包含的第一个符号可以和第一单元时间窗所包含的第一个符号相同。

其中，第二时间窗的长度可以是固定长度，例如 4 个符号，可选的，第二时间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

步骤 S503：网络设备在第二时间窗内使用确定得到的波束失败恢复请求对应的波束，向终端设备发送波束失败恢复请求响应。

具体实现中，网络设备可以获取承载确定得到的波束失败恢复请求的波束，确定该波束所属波束对所包含的另一波束，在第二时间窗内使用确定得到的波束向终端设备发送波束失败恢复请求响应。例如承载确定得到的波束失败恢复请求的波束为波束 1，波束 1 与波束 3 构成一个波束对，则网络设备可以在第二时间窗内使用波束 3 向终端设备发送波束失败恢复请求响应。

以图 4 所示的信息传输的示意图为例，网络设备可以在第二时间窗所包含的符号 0 上，使用第一波束所属波束对所包含的另一波束向终端设备发送波束失败恢复请求响应。

可选的，网络设备可以通过 PDCCH 向终端设备发送波束失败恢复请求响应。

可选的，网络设备可以通过 MAC-CE 向终端设备发送波束失败恢复请求响应。

可选的，网络设备可以通过 RRC 向终端设备发送波束失败恢复请求响应。

可选的，网络设备可以通过 PDSCH 向终端设备发送波束失败恢复请求响应。

步骤 S504：终端设备在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备发送的波束失败恢复请求响应。

终端设备可以在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备发送的波束失败恢复请求响应。例如，若终端设备在第一时间窗所包含的至少一个符号上，使用波束 1 向网络设备发送波束失败恢复请求，则终端设备可以在第一时间窗所包含的至少一个符号上，使用波束 1 接收网络设备发送的波束失败恢复请求响应。

相对传统的波束恢复方法中终端设备接收波束失败恢复请求响应的接收时间与发送波束失败恢复请求的发送时间间隔至少两个子帧，本发明实施例中终端设备接收波束失败恢复请求响应的接收时间与发送波束失败恢复请求的发送时间间隔最多第一时间窗，例如 7 个符号，可降低延迟，提高波束恢复的效率。

在图 5 所描述的方法中，终端设备在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送波束失败恢复请求，网络设备确定在第二时间窗内接收到的第一个波束失败恢复请求，网络设备在第二时间窗内使用确定得到的波束失败恢复请求对应的波束，向终端设备发送波束失败恢复请求响应，则终端设备在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备发送的波束失败恢复请求响应，可实现网络设备针对同一终端设备发送的多个波束失败恢复请求的波束恢复处理，提高波束恢复效率。

基于图 1 所示的波束恢复系统的架构示意图，请参见图 6，图 6 是本发明实施例提供的一种波束恢复方法的流程示意图，该方法包括但不限于如下步骤：

步骤 S601：终端设备在第一单元时间窗所包含的至少一个符号上，使用至少一个相同

的第一波束向网络设备发送调度请求。

具体地，当 DL 波束失效时，终端设备可以在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送调度请求。其中，第一波束可以是网络设备对终端设备配置的波束，例如波束 1。

例如，终端设备可以在第一单元时间窗中选取一个符号（例如符号 3），并在符号 3 上使用一个波束 1 向网络设备发送调度请求。又如，终端设备可以在第一单元时间窗中选取一个符号（例如符号 3），并在符号 3 上使用多个波束 1 向网络设备发送调度请求，即终端设备在符号 3 上，在不同方向上使用波束 1 向网络设备发送调度请求。又如，以图 7 所示的信息传输的示意图为例，终端设备可以在第一单元时间窗中选取多个符号（例如符号 3，符号 4），在符号 3 上使用一个波束 1 向网络设备发送调度请求，并在符号 4 上使用一个波束 1 向网络设备发送调度请求。又如，终端设备可以在第一单元时间窗中选取多个符号（例如符号 3，符号 4），在符号 3 上使用多个波束 1 向网络设备发送调度请求，并在符号 4 上使用多个波束 1 向网络设备发送调度请求。

本发明实施例中，终端设备在第一单元时间窗所包含的至少一个符号上，使用多个相同的第一波束向网络设备发送调度请求，可加大子载波间隔。

本发明实施例中，网络设备可以对终端设备配置第一单元时间窗。其中，第一单元时间窗的起始时刻可以是配置有 RACH 资源的第一个符号，以图 7 所示的信息传输的示意图为例，配置有 RACH 资源的第一个符号为符号 3，则终端设备可以确定第一单元时间窗的起始时刻为符号 3。

本发明实施例中，网络设备可以对终端设备配置第二单元时间窗。其中，第二单元时间窗所包含的第一个符号为第一单元时间窗所包含的最后一个符号之后的第一个符号，以图 7 所示的信息传输的示意图为例，第一单元时间窗所包含的最后一个符号为符号 6，则终端设备可以确定第二单元时间窗所包含的第一个符号为符号 0。

其中，第一单元时间窗的长度可以是固定长度，例如 4 个符号，可选的，第一单元时间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

其中，第二单元时间窗的长度可以是固定长度，例如 4 个符号，可选的，第二单元时间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

其中，网络设备可以向终端设备发送第一长度指示信息，以指示第一单元时间窗的长度。可选的，可以通过直接法指示第一单元时间窗的长度。可选的，可以通过映射方式描述第一单元时间窗的长度。

其中，网络设备可以向终端设备发送第二长度指示信息，以指示第二单元时间窗的长度。可选的，可以通过直接法指示第二单元时间窗的长度。可选的，可以通过映射方式描述第二单元时间窗的长度。

其中，网络设备可以通过信令对终端设备配置第一单元时间窗，例如 RRC、MAC-CE 或者 DCI 等。

其中，网络设备可以通过信令对终端设备配置第二单元时间窗，例如 RRC、MAC-CE 或者 DCI 等。

其中，网络设备可以通过向终端设备发送第一长度指示信息的方式，通知终端设备配

置了第一单元时间窗。

其中，网络设备可以通过向终端设备发送第二长度指示信息的方式，通知终端设备配置了第二单元时间窗。

步骤 S602：网络设备在第二时间窗内，在接收到的调度请求中确定一个调度请求。

具体地，网络设备可以按照接收 RACH 波束扫描方式在第二时间窗内接收终端设备发送的调度请求，并在接收到的调度请求中确定一个调度请求。

可选的，网络设备可以确定在第二时间窗内接收到的第一个调度请求。

可选的，网络设备可以确定在第二时间窗内接收到的质量大于预设质量阈值的波束所承载的调度请求。

可选的，网络设备可以确定在第二时间窗内接收到的质量最好的波束所承载的调度请求。

其中，网络设备可以配置网络设备侧的第二时间窗，第二时间窗所包含的第一个符号可以和第一单元时间窗所包含的第一个符号相同。

其中，第二时间窗的长度可以是固定长度，例如 4 个符号，可选的，第二时间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

步骤 S603：网络设备在第二时间窗之后使用确定得到的调度请求对应的波束，向终端设备发送调度请求响应。

具体实现中，网络设备可以获取承载确定得到的调度请求的波束，确定该波束所属波束对所包含的另一波束，在第二时间窗之后使用确定得到的波束向终端设备发送调度请求响应。例如承载确定得到的调度请求的波束为波束 1，波束 1 与波束 3 构成一个波束对，则网络设备可以在第二时间窗之后使用波束 3 向终端设备发送调度请求响应。

以图 7 所示的信息传输的示意图为例，终端设备可以在第二时间窗之后的第一个符号，即符号 0，使用第一波束所属波束对所包含的另一波束向终端设备发送调度请求响应。

可选的，网络设备可以通过 PDCCH 向终端设备发送调度请求响应。

可选的，网络设备可以通过 MAC-CE 向终端设备发送调度请求响应。

可选的，网络设备可以通过 RRC 向终端设备发送调度请求响应。

可选的，网络设备可以通过 PDSCH 向终端设备发送调度请求响应。

步骤 S604：终端设备在第二单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束接收网络设备发送的调度请求响应。

终端设备可以在第二单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束接收网络设备发送的调度请求响应。例如，若终端设备在第一单元时间窗所包含的至少一个符号上，使用波束 1 向网络设备发送调度请求，则终端设备可以在第二单元时间窗所包含的至少一个符号上，使用波束 1 接收网络设备发送的调度请求响应。

相对传统的波束恢复方法中终端设备接收调度请求响应的接收时间与发送调度请求的发送时间间隔至少两个子帧，本发明实施例中终端设备接收调度请求响应的接收时间与发送调度请求的发送时间间隔最多第一时间窗，例如 7 个符号，可降低延迟，提高波束恢复的效率。

在图 6 所描述的方法中，终端设备在第一时间窗所包含的至少一个符号上，使用至少

一个相同的第一波束向网络设备发送调度请求，网络设备确定在第一时间窗内接收到的第一个调度请求，网络设备在第一时间窗内使用确定得到的调度请求对应的波束，向终端设备发送调度请求响应，则终端设备在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备发送的调度请求响应，可实现网络设备针对同一终端设备发送的多个调度请求的波束恢复处理，提高波束恢复效率。

基于图 1 所示的波束恢复系统的架构示意图，请参见图 8，图 8 是本发明实施例提供的一种波束恢复方法的流程示意图，该方法包括但不限于如下步骤：

步骤 S801：终端设备在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送波束失败恢复请求。

具体地，当 DL 波束失效时，终端设备可以在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送波束失败恢复请求。其中，第一波束可以是网络设备对终端设备配置的波束，例如波束 1。

例如，终端设备可以在第一单元时间窗中选取一个符号（例如符号 3），并在符号 3 上使用一个波束 1 向网络设备发送波束失败恢复请求。又如，终端设备可以在第一单元时间窗中选取一个符号（例如符号 3），并在符号 3 上使用多个波束 1 向网络设备发送波束失败恢复请求，即终端设备在符号 3 上，在不同方向上使用波束 1 向网络设备发送波束失败恢复请求。又如，以图 7 所示的信息传输的示意图为例，终端设备可以在第一单元时间窗中选取多个符号（例如符号 3，符号 4），在符号 3 上使用一个波束 1 向网络设备发送波束失败恢复请求，并在符号 4 上使用一个波束 1 向网络设备发送波束失败恢复请求。又如，终端设备可以在第一单元时间窗中选取多个符号（例如符号 3，符号 4），在符号 3 上使用多个波束 1 向网络设备发送波束失败恢复请求，并在符号 4 上使用多个波束 1 向网络设备发送波束失败恢复请求。

本发明实施例中，终端设备在第一单元时间窗所包含的至少一个符号上，使用多个相同的第一波束向网络设备发送波束失败恢复请求，可加大子载波间隔。

本发明实施例中，网络设备可以对终端设备配置第一单元时间窗。其中，第一单元时间窗的起始时刻可以是配置有 RACH 资源的第一个符号，以图 7 所示的信息传输的示意图为例，配置有 RACH 资源的第一个符号为符号 3，则终端设备可以确定第一单元时间窗的起始时刻为符号 3。

本发明实施例中，网络设备可以对终端设备配置第二单元时间窗。其中，第二单元时间窗所包含的第一个符号为第一单元时间窗所包含的最后一个符号之后的第一个符号，以图 7 所示的信息传输的示意图为例，第一单元时间窗所包含的最后一个符号为符号 8，则终端设备可以确定第二单元时间窗所包含的第一个符号为符号 0。

其中，第一单元时间窗的长度可以是固定长度，例如 4 个符号，可选的，第一单元时间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

其中，第二单元时间窗的长度可以是固定长度，例如 4 个符号，可选的，第二单元时间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

其中，网络设备可以向终端设备发送第一长度指示信息，以指示第一单元时间窗的长

度。可选的，可以通过直接法指示第一单元时间窗的长度。可选的，可以通过映射方式描述第一单元时间窗的长度。

其中，网络设备可以向终端设备发送第二长度指示信息，以指示第二单元时间窗的长度。可选的，可以通过直接法指示第二单元时间窗的长度。可选的，可以通过映射方式描述第二单元时间窗的长度。

其中，网络设备可以通过信令对终端设备配置第一单元时间窗，例如 RRC、MAC-CE 或者 DCI 等。

其中，网络设备可以通过信令对终端设备配置第二单元时间窗，例如 RRC、MAC-CE 或者 DCI 等。

其中，网络设备可以通过向终端设备发送第一长度指示信息的方式，通知终端设备配置了第一单元时间窗。

其中，网络设备可以通过向终端设备发送第二长度指示信息的方式，通知终端设备配置了第二单元时间窗。

步骤 S802：网络设备在第二时间窗内，在接收到的波束失败恢复请求中确定一个波束失败恢复请求。

具体地，网络设备可以按照接收 RACH 波束扫描方式在第二时间窗内接收终端设备发送的波束失败恢复请求，并在接收到的波束失败恢复请求中确定一个波束失败恢复请求。

可选的，网络设备可以确定在第二时间窗内接收到的第一个波束失败恢复请求。

可选的，网络设备可以确定在第二时间窗内接收到的质量大于预设质量阈值的波束所承载的波束失败恢复请求。

可选的，网络设备可以确定在第二时间窗内接收到的质量最好的波束所承载的波束失败恢复请求。

其中，网络设备可以配置网络设备侧的第二时间窗，第二时间窗所包含的第一个符号可以和第一时间窗所包含的第一个符号相同。

其中，第二时间窗的长度可以是固定长度，例如 4 个符号，可选的，第二时间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

步骤 S803：网络设备在第二时间窗之后使用确定得到的波束失败恢复请求对应的波束，向终端设备发送波束失败恢复请求响应。

具体实现中，网络设备可以获取承载确定得到的波束失败恢复请求的波束，确定该波束所属波束对所包含的另一波束，在第二时间窗之后使用确定得到的波束向终端设备发送波束失败恢复请求响应。例如承载确定得到的波束失败恢复请求的波束为波束 1，波束 1 与波束 3 构成一个波束对，则网络设备可以在第二时间窗之后使用波束 3 向终端设备发送波束失败恢复请求响应。

以图 7 所示的信息传输的示意图为例，终端设备可以在第二时间窗之后的第一个符号上，使用第一波束所属波束对所包含的另一波束向终端设备发送波束失败恢复请求响应。

可选的，网络设备可以通过 PDCCH 向终端设备发送波束失败恢复请求响应。

可选的，网络设备可以通过 MAC-CE 向终端设备发送波束失败恢复请求响应。

可选的，网络设备可以通过 RRC 向终端设备发送波束失败恢复请求响应。

可选的，网络设备可以通过 PDSCH 向终端设备发送波束失败恢复请求响应。

步骤 S804：终端设备在第二单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束接收网络设备发送的波束失败恢复请求响应。

终端设备可以在第二单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束接收网络设备发送的波束失败恢复请求响应。例如，若终端设备在第一单元时间窗所包含的至少一个符号上，使用波束 1 向网络设备发送波束失败恢复请求，则终端设备可以在第二单元时间窗所包含的至少一个符号上，使用波束 1 接收网络设备发送的波束失败恢复请求响应。

相对传统的波束恢复方法中终端设备接收波束失败恢复请求响应的接收时间与发送波束失败恢复请求的发送时间间隔至少两个子帧，本发明实施例中终端设备接收波束失败恢复请求响应的接收时间与发送波束失败恢复请求的发送时间间隔最多第一时间窗，例如 7 个符号，可降低延迟，提高波束恢复的效率。

在图 8 所描述的方法中，终端设备在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向网络设备发送波束失败恢复请求，网络设备确定在第一时间窗内接收到的第一个波束失败恢复请求，网络设备在第一时间窗内使用确定得到的波束失败恢复请求对应的波束，向终端设备发送波束失败恢复请求响应，则终端设备在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备发送的波束失败恢复请求响应，可实现网络设备针对同一终端设备发送的多个波束失败恢复请求的波束恢复处理，提高波束恢复效率。

基于图 1 所示的波束恢复系统的架构示意图，请参见图 9，图 9 是本发明实施例提供的一种波束恢复方法的流程示意图，该方法包括但不限于如下步骤：

步骤 S901：终端设备在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备发送调度请求。

具体地，当 DL 波束失效时，终端设备可以在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备发送调度请求。其中，网络设备可以对终端设备配置允许的最大波束数量，则终端设备可以使用小于等于最大波束数量的波束向网络设备发送调度请求。

例如，终端设备可以在第三单元时间窗中选取一个符号（例如符号 3），并在符号 3 上使用一个波束 1 向网络设备发送调度请求。又如，终端设备可以在第三单元时间窗中选取一个符号（例如符号 3），并在符号 3 上使用多个不同波束向网络设备发送调度请求，示例性的，终端设备在符号 3 上，分别使用波束 1 和波束 2 向网络设备发送调度请求。又如，以图 10 所示的信息传输的示意图为例，终端设备可以在第三单元时间窗中选取多个符号（例如符号 3，符号 4），在符号 3 上使用一个波束 1 向网络设备发送调度请求，并在符号 4 上使用一个波束 1 向网络设备发送调度请求。又如，终端设备可以在第三单元时间窗中选取多个符号（例如符号 3，符号 4），在符号 3 上使用多个不同波束向网络设备发送调度请求，并在符号 4 上使用多个不同波束向网络设备发送调度请求。

本发明实施例中，终端设备在第三单元时间窗所包含的至少一个符号上，使用多个不

同波束向网络设备发送调度请求，可加大子载波间隔。

本发明实施例中，网络设备可通过 RRC、MAC-CE 或者 DCI 等信令对终端设备配置允许的最大波束数量。其中，同一小区所有终端设备可以配置相同的最大波束数量，或者终端设备集群所包含的所有终端设备可以配置相同的最大波束数量，或者不同终端设备可配置不同的最大波束数量，当不同终端设备配置不同的最大波束数量时，该终端设备需要向网络设备上报该终端设备的能力。其中，可以通过直接法指示最大波束数量。可选的，可以通过映射方法描述最大波束数量。

本发明实施例中，网络设备可以对终端设备配置第三单元时间窗。其中，第三单元时间窗的起始时刻可以是配置有 RACH 资源的第一个符号，以图 10 所示的信息传输的示意图为例，配置有 RACH 资源的第一个符号为符号 3，则终端设备可以确定第三单元时间窗的起始时刻为符号 3。

本发明实施例中，网络设备可以对终端设备配置第四单元时间窗。其中，第四单元时间窗所包含的第一个符号为第三单元时间窗所包含的最后一个符号之后的第一个符号，以图 10 所示的信息传输的示意图为例，第三单元时间窗所包含的最后一个符号为符号 6，则终端设备可以确定第四单元时间窗所包含的第一个符号为符号 0。

其中，第三单元时间窗的长度可以是固定长度，例如 4 个符号，可选的，第三单元时间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

其中，第四单元时间窗的长度可以是固定长度，例如 4 个符号，可选的，第四单元时间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

其中，网络设备可以向终端设备发送第三长度指示信息，以指示第三单元时间窗的长度。可选的，可以通过直接法指示第三单元时间窗的长度。可选的，可以通过映射方式描述第三单元时间窗的长度。

其中，网络设备可以向终端设备发送第四长度指示信息，以指示第四单元时间窗的长度。可选的，可以通过直接法指示第四单元时间窗的长度。可选的，可以通过映射方式描述第四单元时间窗的长度。

其中，网络设备可以通过信令对终端设备配置第三单元时间窗，例如 RRC、MAC-CE 或者 DCI 等。

其中，网络设备可以通过信令对终端设备配置第四单元时间窗，例如 RRC、MAC-CE 或者 DCI 等。

其中，网络设备可以通过向终端设备发送第三长度指示信息的方式，通知终端设备配置了第三单元时间窗。

其中，网络设备可以通过向终端设备发送第四长度指示信息的方式，通知终端设备配置了第四单元时间窗。

步骤 S902：网络设备在第二时间窗内，在接收到的调度请求中确定一个调度请求。

具体地，网络设备可以按照接收 RACH 波束扫描方式在第二时间窗内接收终端设备发送的调度请求，并在接收到的调度请求中确定一个调度请求。

可选的，网络设备可以确定在第二时间窗内接收到的第一个调度请求。

可选的，网络设备可以确定在第二时间窗内接收到的质量大于预设质量阈值的波束所

承载的调度请求。

可选的，网络设备可以确定在第二时间窗内接收到的质量最好的波束所承载的调度请求。

其中，网络设备可以配置网络设备侧的第二时间窗，第二时间窗所包含的第一个符号可以和第三单元时间窗所包含的第一个符号相同。

其中，第二时间窗的长度可以是固定长度，例如 4 个符号，可选的，第二时间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

步骤 S903：网络设备在第二时间窗之后使用确定得到的调度请求对应的波束，向终端设备发送调度请求响应。

具体实现中，网络设备可以获取承载确定得到的调度请求的波束，确定该波束所属波束对所包含的另一波束，在第二时间窗之后使用确定得到的波束向终端设备发送调度请求响应。例如承载确定得到的调度请求的波束为波束 1，波束 1 与波束 3 构成一个波束对，则网络设备可以在第二时间窗之后使用波束 3 向终端设备发送调度请求响应。

以图 10 所示的信息传输的示意图为例，终端设备可以在第二时间窗之后的第一个符号，即符号 0，使用第一波束所属波束对所包含的另一波束向终端设备发送调度请求响应，终端设备还可以在第二时间窗之后的第二个符号，即符号 1，使用第一波束所属波束对所包含的另一波束向终端设备发送调度请求响应。

可选的，网络设备可以通过 PDCCH 向终端设备发送调度请求响应。

可选的，网络设备可以通过 MAC-CE 向终端设备发送调度请求响应。

可选的，网络设备可以通过 RRC 向终端设备发送调度请求响应。

可选的，网络设备可以通过 PDSCH 向终端设备发送调度请求响应。

步骤 S904：终端设备在第四单元时间窗所包含的至少一个符号上，使用至少一个不同的波束接收网络设备发送的调度请求响应。

终端设备可以在第四单元时间窗所包含的至少一个符号上，使用至少一个不同的波束接收网络设备发送的调度请求响应。例如，若终端设备在第三单元时间窗所包含的至少一个符号上，分别使用波束 1 和波束 2 向网络设备发送调度请求，则终端设备可以在第四单元时间窗所包含的至少一个符号上，分别使用波束 1 和波束 2 接收网络设备发送的调度请求响应。

相对传统的波束恢复方法中终端设备接收调度请求响应的接收时间与发送调度请求的发送时间间隔至少两个子帧，本发明实施例中终端设备接收调度请求响应的接收时间与发送调度请求的发送时间间隔最多第一时间窗，例如 7 个符号，可降低延迟，提高波束恢复的效率。

在图 9 所描述的方法中，终端设备在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备发送调度请求，网络设备在第二时间窗内，在接收到的调度请求中确定一个调度请求，网络设备在第二时间窗之后使用确定得到的调度请求对应的波束，向终端设备发送调度请求响应，终端设备在第四单元时间窗所包含的至少一个符号上，使用至少一个不同的波束接收网络设备发送的调度请求响应，可实现网络设备针对同一终端设备发送的多个波束失败恢复请求的波束恢复处理，提高波束恢复效率。

基于图 1 所示的波束恢复系统的架构示意图，请参见图 11，图 11 是本发明实施例提供的一种波束恢复方法的流程示意图，该方法包括但不限于如下步骤：

步骤 S1101：终端设备在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备发送波束失败恢复请求。

具体地，当 DL 波束失效时，终端设备可以在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备发送波束失败恢复请求。其中，网络设备可以对终端设备配置允许的最大波束数量，则终端设备可以使用小于等于最大波束数量的波束向网络设备发送波束失败恢复请求。

例如，终端设备可以在第三单元时间窗中选取一个符号（例如符号 3），并在符号 3 上使用一个波束 1 向网络设备发送波束失败恢复请求。又如，终端设备可以在第三单元时间窗中选取一个符号（例如符号 3），并在符号 3 上使用多个不同波束向网络设备发送波束失败恢复请求，示例性的，终端设备在符号 3 上，分别使用波束 1 和波束 2 向网络设备发送波束失败恢复请求。又如，以图 10 所示的信息传输的示意图为例，终端设备可以在第三单元时间窗中选取多个符号（例如符号 3，符号 4），在符号 3 上使用一个波束 1 向网络设备发送波束失败恢复请求，并在符号 4 上使用一个波束 1 向网络设备发送波束失败恢复请求。又如，终端设备可以在第三单元时间窗中选取多个符号（例如符号 3，符号 4），在符号 3 上使用多个不同波束向网络设备发送波束失败恢复请求，并在符号 4 上使用多个不同波束向网络设备发送波束失败恢复请求。

本发明实施例中，终端设备在第三单元时间窗所包含的至少一个符号上，使用多个不同波束向网络设备发送波束失败恢复请求，可加大子载波间隔。

本发明实施例中，网络设备可通过 RRC、MAC-CE 或者 DCI 等信令对终端设备配置允许的最大波束数量。其中，同一小区所有终端设备可以配置相同的最大波束数量，或者终端设备集群所包含的所有终端设备可以配置相同的最大波束数量，或者不同终端设备可配置不同的最大波束数量，当不同终端设备配置不同的最大波束数量时，该终端设备需要向网络设备上报该终端设备的能力。其中，可以通过直接法指示最大波束数量。可选的，可以通过映射方法描述最大波束数量。

本发明实施例中，网络设备可以对终端设备配置第三单元时间窗。其中，第三单元时间窗的起始时刻可以是配置有 RACH 资源的第一个符号，以图 10 所示的信息传输的示意图为例，配置有 RACH 资源的第一个符号为符号 3，则终端设备可以确定第三单元时间窗的起始时刻为符号 3。

本发明实施例中，网络设备可以对终端设备配置第四单元时间窗。其中，第四单元时间窗所包含的第一个符号为第三单元时间窗所包含的最后一个符号之后的第一个符号，以图 10 所示的信息传输的示意图为例，第三单元时间窗所包含的最后一个符号为符号 6，则终端设备可以确定第四单元时间窗所包含的第一个符号为符号 0。

其中，第三单元时间窗的长度可以是固定长度，例如 4 个符号，可选的，第三单元时间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

其中，第四单元时间窗的长度可以是固定长度，例如 4 个符号，可选的，第四单元时

间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

其中，网络设备可以向终端设备发送第三长度指示信息，以指示第三单元时间窗的长度。可选的，可以通过直接法指示第三单元时间窗的长度。可选的，可以通过映射方式描述第三单元时间窗的长度。

其中，网络设备可以向终端设备发送第四长度指示信息，以指示第四单元时间窗的长度。可选的，可以通过直接法指示第四单元时间窗的长度。可选的，可以通过映射方式描述第四单元时间窗的长度。

其中，网络设备可以通过信令对终端设备配置第三单元时间窗，例如 RRC、MAC-CE 或者 DCI 等。

其中，网络设备可以通过信令对终端设备配置第四单元时间窗，例如 RRC、MAC-CE 或者 DCI 等。

其中，网络设备可以通过向终端设备发送第三长度指示信息的方式，通知终端设备配置了第三单元时间窗。

其中，网络设备可以通过向终端设备发送第四长度指示信息的方式，通知终端设备配置了第四单元时间窗。

步骤 S1102：网络设备在第二时间窗内，在接收到的波束失败恢复请求中确定一个波束失败恢复请求。

具体地，网络设备可以按照接收 RACH 波束扫描方式在第二时间窗内接收终端设备发送的波束失败恢复请求，并在接收到的波束失败恢复请求中确定一个波束失败恢复请求。

可选的，网络设备可以确定在第二时间窗内接收到的第一个波束失败恢复请求。

可选的，网络设备可以确定在第二时间窗内接收到的质量大于预设质量阈值的波束所承载的波束失败恢复请求。

可选的，网络设备可以确定在第二时间窗内接收到的质量最好的波束所承载的波束失败恢复请求。

其中，网络设备可以配置网络设备侧的第二时间窗，第二时间窗所包含的第一个符号可以和第三单元时间窗所包含的第一个符号相同。

其中，第二时间窗的长度可以是固定长度，例如 4 个符号，可选的，第二时间窗的长度也可以是网络设备配置的，例如 3 个符号或者 5 个符号等。

步骤 S1103：网络设备在第二时间窗之后使用确定得到的波束失败恢复请求对应的波束，向终端设备发送波束失败恢复请求响应。

具体实现中，网络设备可以获取承载确定得到的波束失败恢复请求的波束，确定该波束所属波束对所包含的另一波束，在第二时间窗之后使用确定得到的波束向终端设备发送波束失败恢复请求响应。例如承载确定得到的波束失败恢复请求的波束为波束 1，波束 1 与波束 3 构成一个波束对，则网络设备可以在第二时间窗之后使用波束 3 向终端设备发送波束失败恢复请求响应。

以图 10 所示的信息传输的示意图为例，终端设备可以在第二时间窗之后的第一个符号，即符号 0，使用第一波束所属波束对所包含的另一波束向终端设备发送波束失败恢复请求响应，终端设备还可以在第二时间窗之后的第二个符号，即符号 1，使用第一波束所

属波束对所包含的另一波束向终端设备发送波束失败恢复请求响应。

可选的，网络设备可以通过 PDCCH 向终端设备发送波束失败恢复请求响应。

可选的，网络设备可以通过 MAC-CE 向终端设备发送波束失败恢复请求响应。

可选的，网络设备可以通过 RRC 向终端设备发送波束失败恢复请求响应。

可选的，网络设备可以通过 PDSCH 向终端设备发送波束失败恢复请求响应。

步骤 S1104：终端设备在第四单元时间窗所包含的至少一个符号上，使用至少一个不同的波束接收网络设备发送的波束失败恢复请求响应。

终端设备可以在第四单元时间窗所包含的至少一个符号上，使用至少一个不同的波束接收网络设备发送的波束失败恢复请求响应。例如，若终端设备在第三单元时间窗所包含的至少一个符号上，分别使用波束 1 和波束 2 向网络设备发送波束失败恢复请求，则终端设备可以在第四单元时间窗所包含的至少一个符号上，分别使用波束 1 和波束 2 接收网络设备发送的波束失败恢复请求响应。

相对传统的波束恢复方法中终端设备接收波束失败恢复请求响应的接收时间与发送波束失败恢复请求的发送时间间隔至少两个子帧，本发明实施例中终端设备接收波束失败恢复请求响应的接收时间与发送波束失败恢复请求的发送时间间隔最多第一时间窗，例如 7 个符号，可降低延迟，提高波束恢复的效率。

在图 11 所描述的方法中，终端设备在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向网络设备发送波束失败恢复请求，网络设备在第二时间窗内，在接收到的波束失败恢复请求中确定一个波束失败恢复请求，网络设备在第二时间窗之后使用确定得到的波束失败恢复请求对应的波束，向终端设备发送波束失败恢复请求响应，终端设备在第四单元时间窗所包含的至少一个符号上，使用至少一个不同的波束接收网络设备发送的波束失败恢复请求响应，可实现网络设备针对同一终端设备发送的多个波束失败恢复请求的波束恢复处理，提高波束恢复效率。

上述详细阐述了本发明实施例的方法，下面提供了本发明实施例的装置。

请参见图 12，图 12 是本发明实施例提供的一种波束恢复装置的结构示意图，该波束恢复装置可以包括发送模块 1201 以及接收模块 1202，其中，各个模块的详细描述如下。

发送模块 1201，用于在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

接收模块 1202，用于在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

可选的，所述发送模块 1201，具体用于在所述第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

可选的，所述接收模块 1202，具体用于在所述第一时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

可选的，所述第一时间窗包括第一单元时间窗和第二单元时间窗，所述第二单元时间窗所包含的第一个符号为所述第一单元时间窗所包含的最后一个符号之后的第一个符号；

所述发送模块 1201，具体用于在所述第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

可选的，所述接收模块 1202，具体用于在所述第二单元时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

可选的，本发明实施例中的波束恢复装置还可以包括：

确定模块 1203，用于当在所述第一时间窗内未接收到所述用于波束恢复请求的响应时，所述波束恢复装置确定所述网络设备对所述波束恢复装置配置的第三时间窗；

所述发送模块 1201，还用于在所述第三时间窗所包含的至少一个符号上，使用至少一个相同的第二波束向所述网络设备发送所述用于恢复波束的请求。

可选的，所述第一时间窗包括第三单元时间窗和第四单元时间窗，所述第四单元时间窗所包含的第一个符号为所述第三单元时间窗所包含的最后一个符号之后的第一个符号；

所述发送模块 1201，具体用于在所述第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向所述网络设备发送所述用于恢复波束的请求。

可选的，所述接收模块 1202，具体用于在所述第四单元时间窗所包含的至少一个符号上，使用所述至少一个不同的波束接收所述用于波束恢复请求的响应。

可选的，所述发送模块 1201，具体用于基于所述网络设备对所述波束恢复装置配置的波束请求指示信息，在所述第一时间窗内使用所述至少一个波束向所述网络设备发送所述用于恢复波束的请求，所述波束请求指示信息用于指示所述用于恢复波束的请求的发送方式。

可选的，所述第一时间窗所包含的第一个符号为第一个配置有 RACH 资源的符号。

可选的，所述第一时间窗的长度是所述网络设备配置的。

可选的，所述第一时间窗所包含的符号的数量总和是根据所述网络设备对所述波束恢复装置配置的最大波束数量确定的。

需要说明的是，本发明实施例可具体参见图 3、5、6、8、9、11 所示实施例的相关描述，不再赘述。

本发明实施例中的波束恢复装置和方法实施例中的终端设备完全对应，由相应的模块执行相应的步骤，例如发送模块 1201 执行方法实施例中发送的步骤，接收模块 1202 执行方法实施例中接收的步骤，除发送接收外的其它步骤可以由确定模块 1203 或处理器执行。具体模块的功能可以参考相应的方法实施例，不再详述。

在图 12 所描述的波束恢复装置中，发送模块 1201 在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，接收模块 1202 在第一时间窗内使用至少一个波束接收网络设备发送的用于波束恢复请求的响应，可实现网络设备针对同一波束恢复装置发送的多个用于恢复波束的请求的波束恢复处理，提高波束恢复效率。

请参见图 13，图 13 是本发明实施例提供的一种终端设备，该终端设备包括处理器 1301、存储器 1302 以及收发器 1303，所述处理器 1301、存储器 1302 以及收发器 1303 通过总线相互连接。

存储器 1302 包括但不限于是随机存储记忆体（Random Access Memory，RAM）、只读

存储器（Read-Only Memory，ROM）、可擦除可编程只读存储器（Erasable Programmable Read Only Memory，EPROM）、或便携式只读存储器（Compact Disc Read-Only Memory，CD-ROM），该存储器 1302 用于存储相关指令及数据，例如用于恢复波束的请求等。收发器 1303 用于接收和发送数据，例如使用至少一个波束向网络设备发送用于恢复波束的请求，或者使用至少一个波束接收网络设备发送的用于波束恢复请求的响应等。存储器 1302 可以是一个单独的器件，也可以集成在处理器 1301 中。

处理器 1301 可以是一个或多个中央处理器（Central Processing Unit，CPU），或者一个或多个微控制单元（Microcontroller Unit，MCU）。在处理器 1301 是一个 CPU 的情况下，该 CPU 可以是单核 CPU，也可以是多核 CPU。其中，处理器 1301 可结合图 12 所示的波束恢复装置。

应理解，上述的收发器 1303 可以包括发射机和接收机。收发器 1303 还可以进一步包括天线，天线的数量可以为一个或多个。

上述的各个器件或部分器件可以集成到芯片中实现，如集成到基带芯片中实现。

该终端设备中的处理器 1301 用于读取所述存储器 1302 中存储的程序代码，执行以下操作：

通过收发器 1303 在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

通过收发器 1303 在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

可选的，处理器 1301 在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，具体可以为：

在所述第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

可选的，处理器 1301 在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，具体可以为：

在所述第一时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

可选的，所述第一时间窗包括第一单元时间窗和第二单元时间窗，所述第二单元时间窗所包含的第一个符号为所述第一单元时间窗所包含的最后一个符号之后的第一个符号；

处理器 1301 在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，具体可以为：

在所述第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

可选的，处理器 1301 在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，具体可以为：

在所述第二单元时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

可选的，处理器 1301 还可以执行以下操作：

当在所述第一时间窗内未接收到所述用于波束恢复请求的响应时，确定所述网络设备对所述终端设备配置的第三时间窗；

在所述第三时间窗所包含的至少一个符号上，使用至少一个相同的第二波束向所述网络设备发送所述用于恢复波束的请求。

可选的，所述第一时间窗包括第三单元时间窗和第四单元时间窗，所述第四单元时间窗所包含的第一个符号为所述第三单元时间窗所包含的最后一个符号之后的第一个符号；

处理器 1301 在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，具体可以为：

在所述第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向所述网络设备发送所述用于恢复波束的请求。

可选的，处理器 1301 在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，具体可以为：

在所述第四单元时间窗所包含的至少一个符号上，使用所述至少一个不同的波束接收所述用于波束恢复请求的响应。

可选的，处理器 1301 在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，具体可以为：

基于所述网络设备对所述终端设备配置的波束请求指示信息，在所述第一时间窗内使用所述至少一个波束向所述网络设备发送所述用于恢复波束的请求，所述波束请求指示信息用于指示所述用于恢复波束的请求的发送方式。

可选的，所述第一时间窗所包含的第一个符号为第一个配置有 RACH 资源的符号。

可选的，所述第一时间窗的长度是所述网络设备配置的。

可选的，所述第一时间窗所包含的符号的数量总和是根据所述网络设备对所述终端设备配置的最大波束数量确定的。

需要说明的是，本发明实施例可具体参见图 3、5、6、8、9、11 所示实施例的相关描述，不再赘述。

在图 13 所描述的终端设备中，处理器 1301 在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，并在第一时间窗内使用至少一个波束接收网络设备发送的用于波束恢复请求的响应，可实现网络设备针对同一终端设备发送的多个用于恢复波束的请求的波束恢复处理，提高波束恢复效率。

请参见图 14，图 14 是本发明实施例提供的一种波束恢复装置的结构示意图，该波束恢复装置可以包括接收模块 1401、确定模块 1402 以及发送模块 1403，其中，各个模块的详细描述如下。

接收模块 1401，用于接收终端设备在第一时间窗内使用至少一个波束发送的用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

确定模块 1402，用于在第二时间窗内，在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求；

发送模块 1403，用于使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

可选的，所述确定模块 1402，具体用于响应在所述第二时间窗内接收到的质量最好的波束所承载的用于恢复波束的请求，所述第二时间窗所包含的第一个符号与所述第一时间窗所包含的第一个符号相同。

可选的，所述确定模块 1402，具体用于响应在所述第二时间窗内接收到的第一个用于恢复波束的请求。

可选的，所述发送模块 1403，具体用于在所述第二时间窗内使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应。

可选的，所述发送模块 1403，具体用于在所述第二时间窗之外使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应。

需要说明的是，本发明实施例可具体参见图 3、5、6、8、9、11 所示实施例的相关描述，不再赘述。

本发明实施例中的波束恢复装置和方法实施例中的终端设备完全对应，由相应的模块执行相应的步骤，例如发送模块 1403 执行方法实施例中发送的步骤，接收模块 1401 执行方法实施例中接收的步骤，除发送接收外的其它步骤可以由确定模块 1402 或处理器执行。具体模块的功能可以参考相应的方法实施例，不再详述。

在图 14 所描述的波束恢复装置中，接收模块 1401 接收终端设备在第一时间窗内使用至少一个波束发送的用于恢复波束的请求，确定模块 1402 在第二时间窗内，在接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，发送模块 1403 使用确定得到的用于恢复波束的请求对应的波束，向终端设备发送用于波束恢复请求的响应，可实现网络设备针对同一波束恢复装置发送的多个用于恢复波束的请求的波束恢复处理，提高波束恢复效率。

请参见图 15，图 15 是本发明实施例提供的一种网络设备，该网络设备包括处理器 1501、存储器 1502 以及收发器 1503，所述处理器 1501、存储器 1502 以及收发器 1503 通过总线相互连接。

存储器 1502 包括但不限于是 RAM、ROM、EPROM、或 CD-ROM，该存储器 1502 用于存储相关指令及数据，例如用于恢复波束的请求等。收发器 1503 用于接收和发送数据，例如接收终端设备使用至少一个波束发送的用于恢复波束的请求，或者使用确定得到的用于恢复波束的请求对应的波束，向终端设备发送用于波束恢复请求的响应等。存储器 1502 可以是一个单独的器件，也可以集成在处理器 1501 中。

处理器 1501 可以是一个或多个 CPU，或者一个或多个 MCU。在处理器 1501 是一个 CPU 的情况下，该 CPU 可以是单核 CPU，也可以是多核 CPU。其中，处理器 1501 可结合图 14 所示的波束恢复装置。

应理解，上述的收发器 1503 可以包括发射机和接收机。收发器 1503 还可以进一步包括天线，天线的数量可以为一个或多个。

该网络设备中的处理器 1501 用于读取所述存储器 1502 中存储的程序代码，执行以下

操作：

通过收发器 1503 接收终端设备在第一时间窗内使用至少一个波束发送的用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

在第二时间窗内，在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求；

通过收发器 1503 使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

可选的，处理器 1501 在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，具体可以为：

响应在所述第二时间窗内接收到的质量最好的波束所承载的用于恢复波束的请求，所述第二时间窗所包含的第一个符号与所述第一时间窗所包含的第一个符号相同。

可选的，处理器 1501 在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，具体可以为：

响应在所述第二时间窗内接收到的第一个用于恢复波束的请求。

可选的，处理器 1501 使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，具体可以为：

在所述第二时间窗内使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应。

可选的，处理器 1501 使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，具体可以为：

在所述第二时间窗之外使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应。

在图 15 所描述的网络设备中，处理器 1501 接收终端设备在第一时间窗内使用至少一个波束发送的用于恢复波束的请求，在第二时间窗内，在接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，并使用确定得到的用于恢复波束的请求对应的波束，向终端设备发送用于波束恢复请求的响应，可实现网络设备针对同一终端设备发送的多个用于恢复波束的请求的波束恢复处理，提高波束恢复效率。

请参见图 16，图 16 是本发明实施例提供的一种波束恢复系统，该波束恢复系统可以包括图 13 所示的终端设备 1601 和图 15 所示的网络设备 1602，具体可以参见图 15、16 的描述，本发明实施例不再赘述。

本申请实施例还提供了一种通信芯片，其中存储有指令，当其在终端设备 1601 上运行时，使得所述通信芯片执行上述图 13 中的各种实现方式中终端设备对应的方法。

本申请实施例还提供了一种通信芯片，其中存储有指令，当其在网络设备 1602 上运行时，使得所述通信芯片执行上述图 15 中的各种实现方式中终端设备对应的方法。

上述各个方案的网络设备及终端设备具有实现上述方法中网络设备及终端设备执行的相应步骤的功能；所述功能可以通过硬件实现，也可以通过硬件执行相应的软件实现。所

述硬件或软件包括一个或多个与上述功能相对应的模块；例如发送模块可以由发射机替代，接收模块可以由接收机替代，其它模块，如处理模块等可以由处理器替代，分别执行各个方法实施例中的发送操作、接收操作以及相关的处理操作。

本领域普通技术人员可以理解实现上述实施例方法中的全部或部分流程，该流程可以由计算机程序来指令相关的硬件完成，该程序可存储于计算机可读取存储介质中，该程序在执行时，可包括如上述各方法实施例的流程。而前述的存储介质包括：ROM 或随机存储记忆体 RAM、磁碟或者光盘等各种可存储程序代码的介质。

在上述实施例中，可以全部或部分地通过软件、硬件、固件或者其任意组合来实现。当使用软件实现时，可以全部或部分地以计算机程序产品的形式实现。所述计算机程序产品包括一个或多个计算机指令。在计算机上加载和执行所述计算机程序指令时，全部或部分地产生按照本申请实施例所述的流程或功能。所述计算机可以是通用计算机、专用计算机、计算机网络、或者其他可编程装置。所述计算机指令可以存储在计算机可读存储介质中，或者从一个计算机可读存储介质向另一个计算机可读存储介质传输，例如，所述计算机指令可以从一个网站站点、计算机、服务器或数据中心通过有线（例如同轴电缆、光纤、数字用户线（DSL））或无线（例如红外、无线、微波等）方式向另一个网站站点、计算机、服务器或数据中心进行传输。所述计算机可读存储介质可以是计算机能够存取的任何可用介质或者是包含一个或多个可用介质集成的服务器、数据中心等数据存储设备。所述可用介质可以是磁性介质，(例如，软盘、硬盘、磁带)、光介质(例如，DVD)、或者半导体介质（例如固态硬盘 Solid State Disk (SSD)）等。

权 利 要 求

1、一种波束恢复方法，其特征在于，所述方法包括：

终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

所述终端设备在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

2、如权利要求 1 所述的方法，其特征在于，所述终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，包括：

所述终端设备在所述第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

3、如权利要求 2 所述的方法，其特征在于，所述终端设备在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，包括：

所述终端设备在所述第一时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

4、如权利要求 1 所述的方法，其特征在于，所述第一时间窗包括第一单元时间窗和第二单元时间窗，所述第二单元时间窗所包含的第一个符号为所述第一单元时间窗所包含的最后一个符号之后的第一个符号；

所述终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，包括：

所述终端设备在所述第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

5、如权利要求 4 所述的方法，其特征在于，所述终端设备在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，包括：

所述终端设备在所述第二单元时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

6、如权利要求 2~5 任一项所述的方法，其特征在于，所述方法还包括：

当在所述第一时间窗内未接收到所述用于波束恢复请求的响应时，所述终端设备确定所述网络设备对所述终端设备配置的第三时间窗；

所述终端设备在所述第三时间窗所包含的至少一个符号上，使用至少一个相同的第二波束向所述网络设备发送所述用于恢复波束的请求。

7、如权利要求 1 所述的方法，其特征在于，所述第一时间窗包括第三单元时间窗和第四单元时间窗，所述第四单元时间窗所包含的第一个符号为所述第三单元时间窗所包含的最后一个符号之后的第一个符号；

所述终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，包括：

所述终端设备在所述第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向所述网络设备发送所述用于恢复波束的请求。

8、如权利要求 7 所述的方法，其特征在于，所述终端设备在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，包括：

所述终端设备在所述第四单元时间窗所包含的至少一个符号上，使用所述至少一个不同的波束接收所述用于波束恢复请求的响应。

9、如权利要求 1~8 任一项所述的方法，其特征在于，所述终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，包括：

所述终端设备基于所述网络设备对所述终端设备配置的波束请求指示信息，在所述第一时间窗内使用所述至少一个波束向所述网络设备发送所述用于恢复波束的请求，所述波束请求指示信息用于指示所述用于恢复波束的请求的发送方式。

10、一种波束恢复方法，其特征在于，所述方法包括：

网络设备接收终端设备在第一时间窗内使用至少一个波束发送的用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

所述网络设备在第二时间窗内，在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求；

所述网络设备使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

11、如权利要求 10 所述的方法，其特征在于，所述网络设备在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，包括：

所述网络设备响应在所述第二时间窗内接收到的质量最好的波束所承载的用于恢复波束的请求，所述第二时间窗所包含的第一个符号与所述第一时间窗所包含的第一个符号相同。

12、如权利要求 10 所述的方法，其特征在于，所述网络设备在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，包括：

所述网络设备响应在所述第二时间窗内接收到的第一个用于恢复波束的请求。

13、如权利要求 10~12 任一项所述的方法，其特征在于，所述网络设备使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，包括：

所述网络设备在所述第二时间窗内使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应。

14、如权利要求 10~12 任一项所述的方法，其特征在于，所述网络设备使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，包括：

所述网络设备在所述第二时间窗之外使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应。

15、一种波束恢复装置，其特征在于，所述装置包括：

发送模块，用于在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

接收模块，用于在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

16、如权利要求 15 所述的装置，其特征在于，所述发送模块，具体用于：

在所述第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

17、如权利要求 16 所述的装置，其特征在于，

所述接收模块，具体用于在所述第一时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

18、如权利要求 15 所述的装置，其特征在于，所述第一时间窗包括第一单元时间窗和第二单元时间窗，所述第二单元时间窗所包含的第一个符号为所述第一单元时间窗所包含的最后一个符号之后的第一个符号；

所述发送模块，具体用于在所述第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

19、如权利要求 18 所述的装置，其特征在于，

所述接收模块，具体用于在所述第二单元时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

20、如权利要求 16~19 任一项所述的装置，其特征在于，所述装置还包括：

确定模块，用于当在所述第一时间窗内未接收到所述用于波束恢复请求的响应时，所述终端设备确定所述网络设备对所述终端设备配置的第三时间窗；

所述发送模块，还用于在所述第三时间窗所包含的至少一个符号上，使用至少一个相同的第二波束向所述网络设备发送所述用于恢复波束的请求。

21、如权利要求 15 所述的装置，其特征在于，所述第一时间窗包括第三单元时间窗和第四单元时间窗，所述第四单元时间窗所包含的第一个符号为所述第三单元时间窗所包含的最后一个符号之后的第一个符号；

所述发送模块，具体用于在所述第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向所述网络设备发送所述用于恢复波束的请求。

22、如权利要求 21 所述的装置，其特征在于，

所述接收模块，具体用于在所述第四单元时间窗所包含的至少一个符号上，使用所述至少一个不同的波束接收所述用于波束恢复请求的响应。

23、如权利要求 15~22 任一项所述的装置，其特征在于，

所述发送模块，具体用于基于所述网络设备对所述终端设备配置的波束请求指示信息，在所述第一时间窗内使用所述至少一个波束向所述网络设备发送所述用于恢复波束的请求，所述波束请求指示信息用于指示所述用于恢复波束的请求的发送方式。

24、一种波束恢复装置，其特征在于，所述装置包括：

接收模块，用于接收终端设备在第一时间窗内使用至少一个波束发送的用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

确定模块，用于在第二时间窗内，在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求；

发送模块，用于使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

25、如权利要求 24 所述的装置，其特征在于，

所述确定模块，具体用于响应在所述第二时间窗内接收到的质量最好的波束所承载的用于恢复波束的请求，所述第二时间窗所包含的第一个符号与所述第一时间窗所包含的第一个符号相同。

26、如权利要求 24 所述的装置，其特征在于，

所述确定模块，具体用于响应在所述第二时间窗内接收到的第一个用于恢复波束的请求。

27、如权利要求 24~26 任一项所述的装置，其特征在于，

所述发送模块，具体用于在所述第二时间窗内使用确定得到的用于恢复波束的请求对

应的波束，向所述终端设备发送用于波束恢复请求的响应。

28、如权利要求 24~26 任一项所述的装置，其特征在于，

所述发送模块，具体用于在所述第二时间窗之外使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应。

经修改的权利要求
国际局收到日：2018年08月17日（17.08.2018）

1、一种波束恢复方法，其特征在于，所述方法包括：

终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

所述终端设备在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

2、如权利要求 1 所述的方法，其特征在于，所述终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，包括：

所述终端设备在所述第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

3、如权利要求 2 所述的方法，其特征在于，所述终端设备在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，包括：

所述终端设备在所述第一时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

4、如权利要求 1 所述的方法，其特征在于，所述第一时间窗包括第一单元时间窗和第二单元时间窗，所述第二单元时间窗所包含的第一个符号为所述第一单元时间窗所包含的最后一个符号之后的第一个符号；

所述终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，包括：

所述终端设备在所述第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

5、如权利要求 4 所述的方法，其特征在于，所述终端设备在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，包括：

所述终端设备在所述第二单元时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

6、如权利要求 2~5 任一项所述的方法，其特征在于，所述方法还包括：

当在所述第一时间窗内未接收到所述用于波束恢复请求的响应时，所述终端设备确定所述网络设备对所述终端设备配置的第三时间窗；

所述终端设备在所述第三时间窗所包含的至少一个符号上，使用至少一个相同的第二波束向所述网络设备发送所述用于恢复波束的请求。

7、如权利要求 1 所述的方法，其特征在于，所述第一时间窗包括第三单元时间窗和第四单元时间窗，所述第四单元时间窗所包含的第一个符号为所述第三单元时间窗所包含的最后一个符号之后的第一个符号；

所述终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，包括：

所述终端设备在所述第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向所述网络设备发送所述用于恢复波束的请求。

8、如权利要求 7 所述的方法，其特征在于，所述终端设备在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，包括：

所述终端设备在所述第四单元时间窗所包含的至少一个符号上，使用所述至少一个不同的波束接收所述用于波束恢复请求的响应。

9、如权利要求 1~8 任一项所述的方法，其特征在于，所述终端设备在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，包括：

所述终端设备基于所述网络设备对所述终端设备配置的波束请求指示信息，在所述第一时间窗内使用所述至少一个波束向所述网络设备发送所述用于恢复波束的请求，所述波束请求指示信息用于指示所述用于恢复波束的请求的发送方式。

10、一种波束恢复方法，其特征在于，所述方法包括：

网络设备接收终端设备在第一时间窗内使用至少一个波束发送的用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

所述网络设备在第二时间窗内，在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求；

所述网络设备使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

11、如权利要求 10 所述的方法，其特征在于，所述网络设备在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，包括：

所述网络设备响应在所述第二时间窗内接收到的质量最好的波束所承载的用于恢复波束的请求，所述第二时间窗所包含的第一个符号与所述第一时间窗所包含的第一个符号相同。

12、如权利要求 10 所述的方法，其特征在于，所述网络设备在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求，包括：

所述网络设备响应在所述第二时间窗内接收到的第一个用于恢复波束的请求。

13、如权利要求 10~12 任一项所述的方法，其特征在于，所述网络设备使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，包括：

所述网络设备在所述第二时间窗内使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应。

14、如权利要求 10~12 任一项所述的方法，其特征在于，所述网络设备使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，包括：

所述网络设备在所述第二时间窗之外使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应。

15、一种波束恢复装置，其特征在于，所述装置包括：

发送模块，用于在第一时间窗内使用至少一个波束向网络设备发送用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

接收模块，用于在所述第一时间窗内使用所述至少一个波束接收所述网络设备发送的用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

16、如权利要求 15 所述的装置，其特征在于，所述发送模块，具体用于：

在所述第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

17、如权利要求 16 所述的装置，其特征在于，

所述接收模块，具体用于在所述第一时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

18、如权利要求 15 所述的装置，其特征在于，所述第一时间窗包括第一单元时间窗和第二单元时间窗，所述第二单元时间窗所包含的第一个符号为所述第一单元时间窗所包含的最后一个符号之后的第一个符号；

所述发送模块，具体用于在所述第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束向所述网络设备发送所述用于恢复波束的请求。

19、如权利要求 18 所述的装置，其特征在于，

所述接收模块，具体用于在所述第二单元时间窗所包含的至少一个符号上，使用所述第一波束接收所述用于波束恢复请求的响应。

20、如权利要求 16~19 任一项所述的装置，其特征在于，所述装置还包括：

确定模块，用于当在所述第一时间窗内未接收到所述用于波束恢复请求的响应时，所述终端设备确定所述网络设备对所述终端设备配置的第三时间窗；

所述发送模块，还用于在所述第三时间窗所包含的至少一个符号上，使用至少一个相同的第二波束向所述网络设备发送所述用于恢复波束的请求。

21、如权利要求 15 所述的装置，其特征在于，所述第一时间窗包括第三单元时间窗和第四单元时间窗，所述第四单元时间窗所包含的第一个符号为所述第三单元时间窗所包含的最后一个符号之后的第一个符号；

所述发送模块，具体用于在所述第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束向所述网络设备发送所述用于恢复波束的请求。

22、如权利要求 21 所述的装置，其特征在于，

所述接收模块，具体用于在所述第四单元时间窗所包含的至少一个符号上，使用所述至少一个不同的波束接收所述用于波束恢复请求的响应。

23、如权利要求 15~22 任一项所述的装置，其特征在于，

所述发送模块，具体用于基于所述网络设备对所述终端设备配置的波束请求指示信息，在所述第一时间窗内使用所述至少一个波束向所述网络设备发送所述用于恢复波束的请求，所述波束请求指示信息用于指示所述用于恢复波束的请求的发送方式。

24、一种波束恢复装置，其特征在于，所述装置包括：

接收模块，用于接收终端设备在第一时间窗内使用至少一个波束发送的用于恢复波束的请求，所述用于恢复波束的请求为调度请求或者波束失败恢复请求；

确定模块，用于在第二时间窗内，在所述接收到的用于恢复波束的请求中确定一个用于恢复波束的请求；

发送模块，用于使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应，所述用于波束恢复请求的响应为调度请求响应或者波束失败恢复请求响应。

25、如权利要求 24 所述的装置，其特征在于，

所述确定模块，具体用于响应在所述第二时间窗内接收到的质量最好的波束所承载的用于恢复波束的请求，所述第二时间窗所包含的第一个符号与所述第一时间窗所包含的第一个符号相同。

26、如权利要求 24 所述的装置，其特征在于，

所述确定模块，具体用于响应在所述第二时间窗内接收到的第一个用于恢复波束的请求。

27、如权利要求 24~26 任一项所述的装置，其特征在于，

所述发送模块，具体用于在所述第二时间窗内使用确定得到的用于恢复波束的请求对

应的波束，向所述终端设备发送用于波束恢复请求的响应。

28、如权利要求 24~26 任一项所述的装置，其特征在于，

所述发送模块，具体用于在所述第二时间窗之外使用确定得到的用于恢复波束的请求对应的波束，向所述终端设备发送用于波束恢复请求的响应。

29、如权利要求 1 至 9 任一项所述的方法，其特征在于，所述用于恢复波束的请求通过随机接入信道 RACH 资源发送。

30、如权利要求 1 至 9 任一项所述的方法，其特征在于，所述用于波束恢复请求的响应通过物理下行控制信道 PDCCH 发送，所述 PDCCH 的循环冗余校验 CRC 由小区无线网络临时标识 C-RNTI 加扰。

31、如权利要求 4 或 5 所述的方法，其特征在于，所述第一单元时间窗的起始时刻是配置有 RACH 资源的第一个符号。

32、如权利要求 1 至 9 任一项所述的方法，其特征在于，该方法之前还包括：终端设备获取网络设备配置的用于发送恢复波束的请求时所使用的最大波束数量。

33、如权利要求 10 至 14 任一项所述的方法，其特征在于，该方法之前还包括：网络设备为终端设备配置用于发送恢复波束的请求时所使用的最大波束数量。

34、如权利要求 10 至 14 任一项所述的方法，其特征在于，所述用于恢复波束的请求通过随机接入信道 RACH 资源发送。

35、如权利要求 10 至 14 任一项所述的方法，其特征在于，所述用于波束恢复请求的响应通过物理下行控制信道 PDCCH 发送，所述 PDCCH 的循环冗余校验 CRC 由小区无线网络临时标识 C-RNTI 加扰。

36、如权利要求 15 至 23 任一项所述的装置，其特征在于，所述用于恢复波束的请求通过随机接入信道 RACH 资源发送。

37、如权利要求 15 至 23 任一项所述的装置，其特征在于，所述用于波束恢复请求的响应通过物理下行控制信道 PDCCH 发送，所述 PDCCH 的循环冗余校验 CRC 由小区无线网络临时标识 C-RNTI 加扰。

38、如权利要求 18 或 19 所述的装置，其特征在于，所述第一单元时间窗的起始时刻是配置有 RACH 资源的第一个符号。

39、如权利要求 15 至 13 任一项所述的装置，其特征在于，所述接收模块还用于：获取网络设备配置的用于发送恢复波束的请求时所使用的最大波束数量。

40、如权利要求 24 至 28 任一项所述的装置，其特征在于，所述确定模块还用于：为终端设备配置用于发送恢复波束的请求时所使用的最大波束数量。

41、如权利要求 24 至 28 任一项所述的装置，其特征在于，所述用于恢复波束的请求通过随机接入信道 RACH 资源发送。

42、如权利要求 24 至 28 任一项所述的装置，其特征在于，所述用于波束恢复请求的响应通过物理下行控制信道 PDCCH 发送，所述 PDCCH 的循环冗余校验 CRC 由小区无线网络临时标识 C-RNTI 加扰。

43、一种波束恢复装置，其特征在于，包括：存储器和处理器；所述处理器被配置为支持所述装置执行如权利要求 1 至 9 或 29-32 任一项所述的方法的功能，所述存储器用于保存所述装置的程序和数据。

44、一种波束恢复装置，其特征在于，包括：存储器和处理器；所述处理器被配置为支持所述装置执行如权利要求 10 至 14 或 33-35 任一项所述的方法的功能，所述存储器用于保存所述装置的程序和数据。

45、一种芯片系统，其特征在于，包括：处理器，所述处理器被配置为支持终端设备执行如权利要求 1 至 9 或 29-32 任一项所述的方法的功能。

46、如权利要求 45 所述的芯片系统，其特征在于，所述芯片系统还包括存储器，所述存储器用于保存所述终端设备的程序指令和数据。

47、一种芯片系统，其特征在于，包括：处理器，所述处理器被配置为支持网络设备执行如权利要求 10 至 14 或 33-35 任一项所述的方法的功能。

48、如权利要求 47 所述的芯片系统，其特征在于，所述芯片系统还包括存储器，所述存储器用于保存所述网络设备的程序指令和数据。

49、一种计算机存储介质，其特征在于，用于存储计算机程序，当所述计算机程序在终端设备上运行时，使得所述终端设备执行如权利要求 1 至 9 或 29-32 任一项所述的方法。

50、一种计算机存储介质，其特征在于，用于存储计算机程序，当所述计算机程序在

网络设备上运行时，使得所述网络设备执行如权利要求 10 至 14 或 33-35 任一项所述的方法。

51、一种计算机程序产品，其特征在于，当所述计算机程序产品在终端设备上运行时，使得所述终端设备执行如权利要求 1 至 9 或 29-32 任一项所述的方法。

52、一种计算机程序产品，其特征在于，当所述计算机程序产品在网络设备上运行时，使得所述网络设备执行如权利要求 10 至 14 或 33-35 任一项所述的方法。

53、一种波束恢复系统，其特征在于，所述波束恢复系统包括如权利要求 43 所述的波束恢复装置和如权利要求 44 所述的波束恢复装置。

54、一种波束恢复装置，用于实现如权利要求 1 至 9 或 29-32 任一项所述的方法步骤。

55、一种波束恢复装置，用于实现如权利要求 10 至 14 或 33-35 任一项所述的方法步骤。

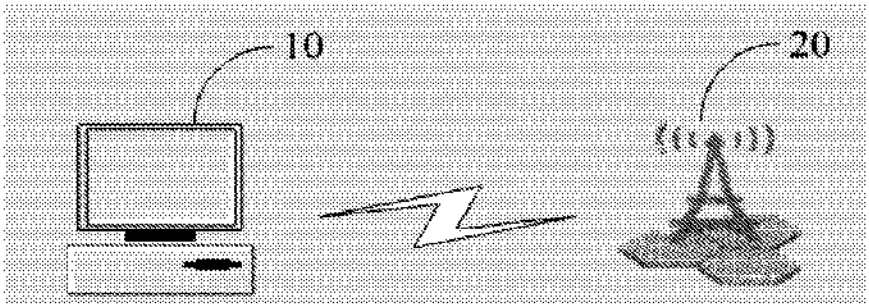

10
20

图 1

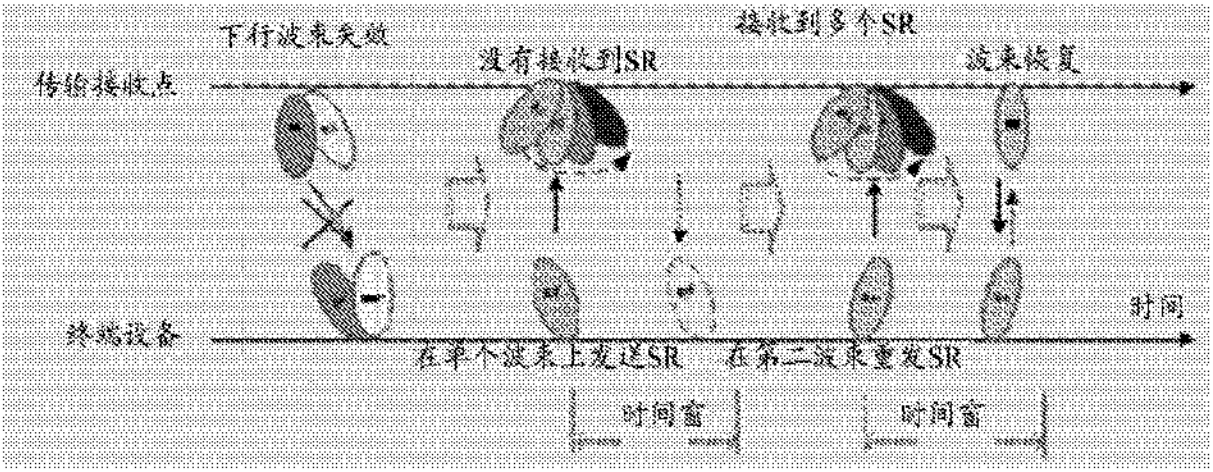

下行波束失效
接收到多个SR
没有接收到SR
波束恢复
传输接收点
时间
终端设备
在单个波束上发送SR
在第二波束重发SR
时间窗
时间窗

图 2A

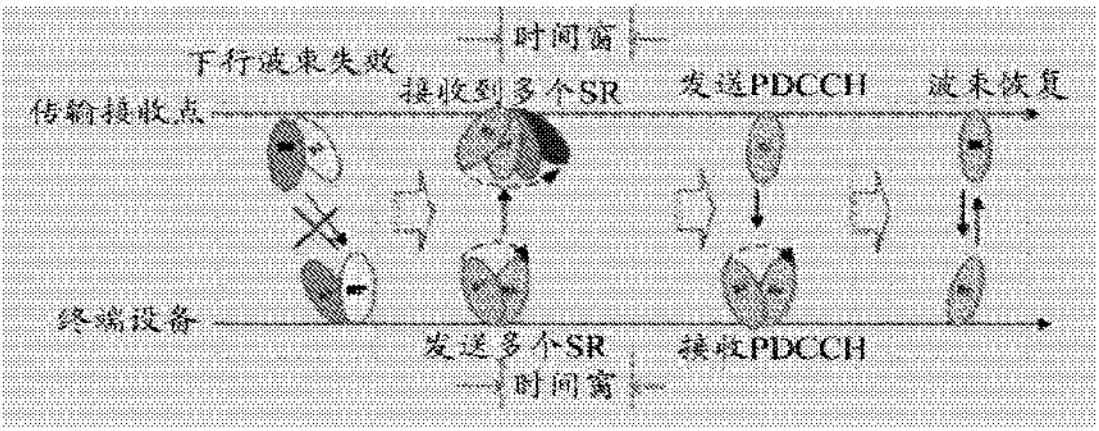

时间窗
下行波束失效
接收到多个SR
发送PDCCH
波束恢复
传输接收点
终端设备
发送多个SR
接收PDCCH
时间窗

图 2B

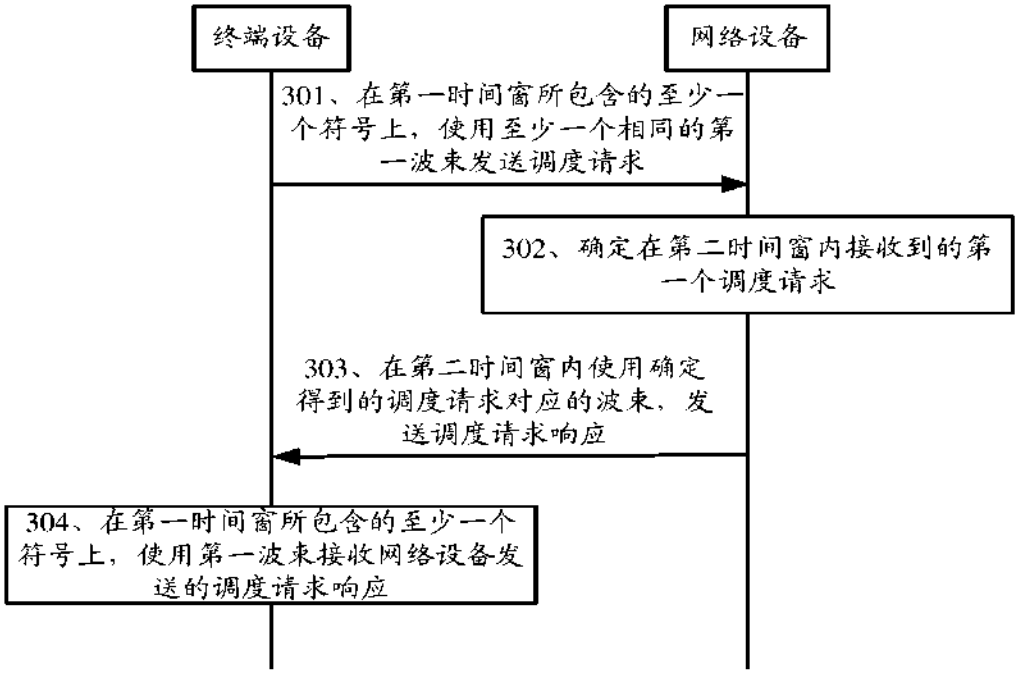

终端设备
网络设备
301、在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束发送调度请求
302、确定在第二时间窗内接收到的第一个调度请求
303、在第二时间窗内使用确定得到的调度请求对应的波束，发送调度请求响应
304、在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备发送的调度请求响应

图 3

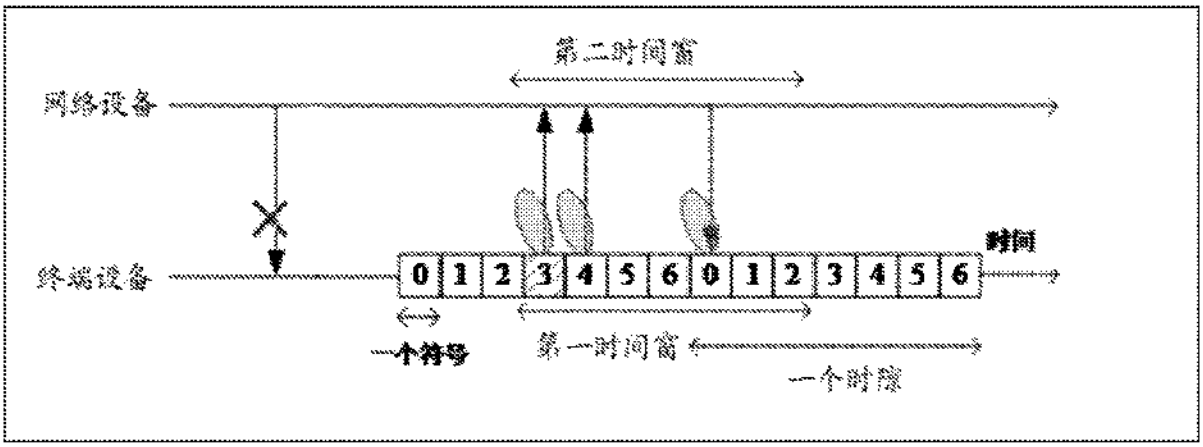

第二时间窗
网络设备
终端设备
0 1 2 3 4 5 6 0 1 2 3 4 5 6
时间
一个符号
第一时间窗
一个时隙

图 4

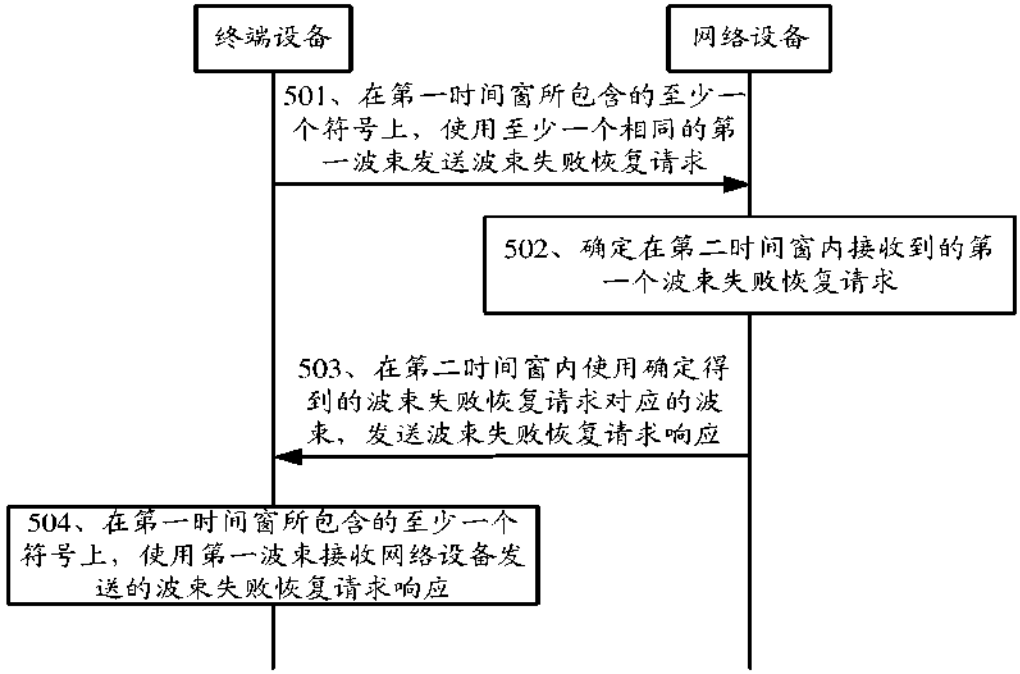

终端设备
网络设备
501、在第一时间窗所包含的至少一个符号上，使用至少一个相同的第一波束发送波束失败恢复请求
502、确定在第二时间窗内接收到的第一个波束失败恢复请求
503、在第二时间窗内使用确定得到的波束失败恢复请求对应的波束，发送波束失败恢复请求响应
504、在第一时间窗所包含的至少一个符号上，使用第一波束接收网络设备发送的波束失败恢复请求响应

图 5

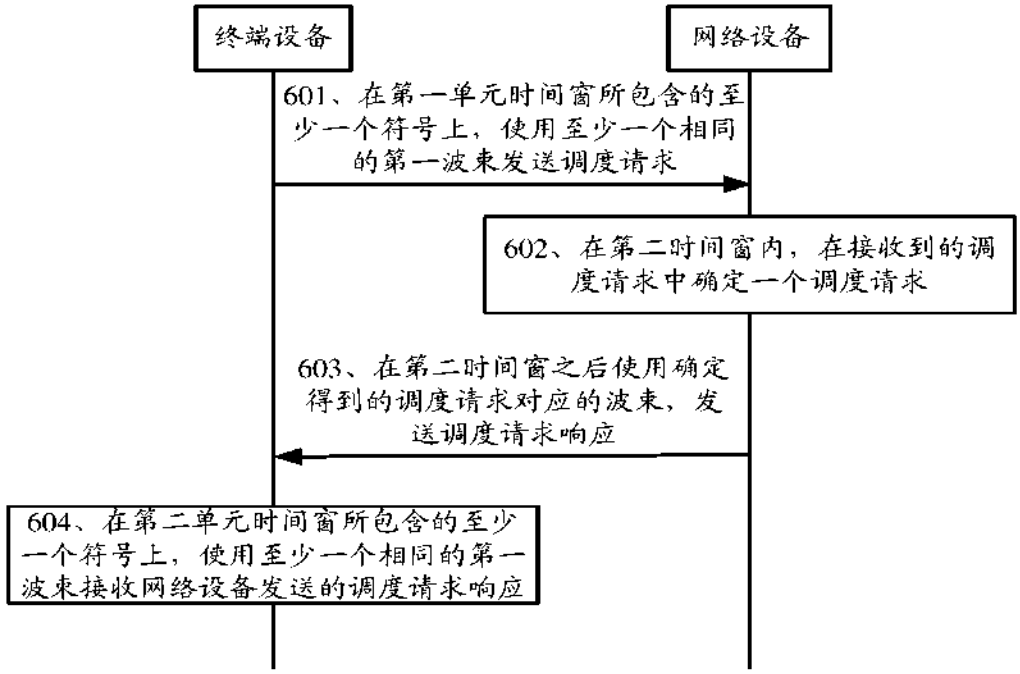

终端设备
网络设备
601、在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束发送调度请求
602、在第二时间窗内，在接收到的调度请求中确定一个调度请求
603、在第二时间窗之后使用确定得到的调度请求对应的波束，发送调度请求响应
604、在第二单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束接收网络设备发送的调度请求响应

图 6

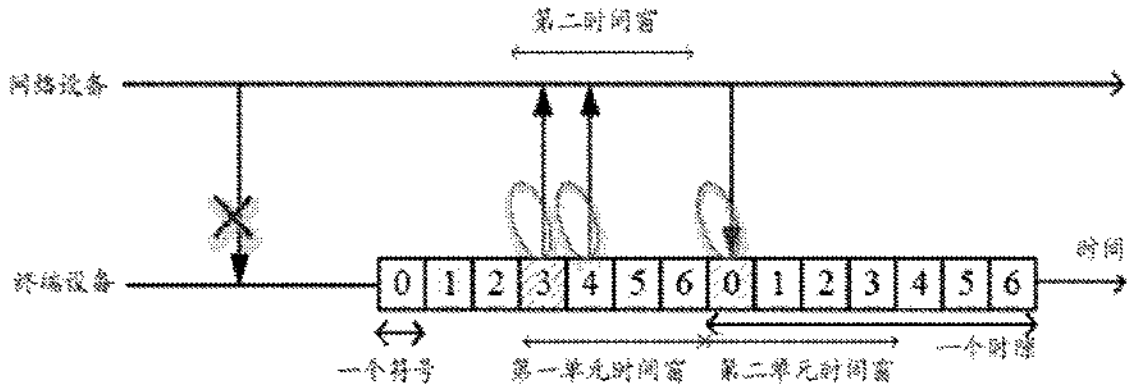

第二时间窗
网络设备
终端设备
0 1 2 3 4 5 6 0 1 2 3 4 5 6
时间
一个符号
第一单元时间窗
第二单元时间窗
一个时隙

图 7

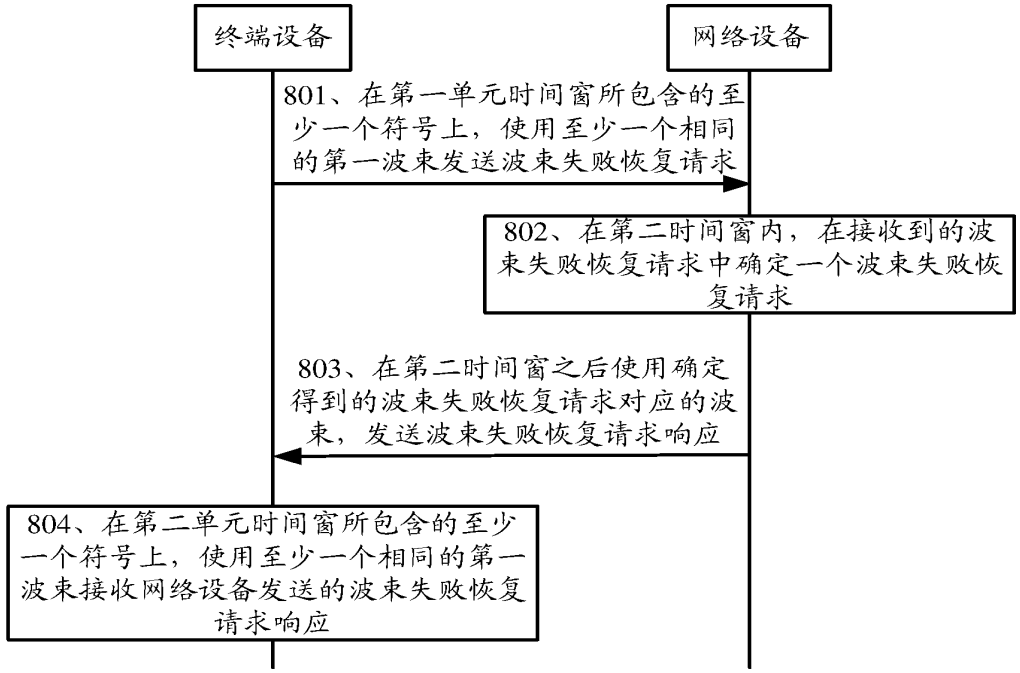

终端设备
网络设备
801、在第一单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束发送波束失败恢复请求
802、在第二时间窗内，在接收到的波束失败恢复请求中确定一个波束失败恢复请求
803、在第二时间窗之后使用确定得到的波束失败恢复请求对应的波束，发送波束失败恢复请求响应
804、在第二单元时间窗所包含的至少一个符号上，使用至少一个相同的第一波束接收网络设备发送的波束失败恢复请求响应

图 8

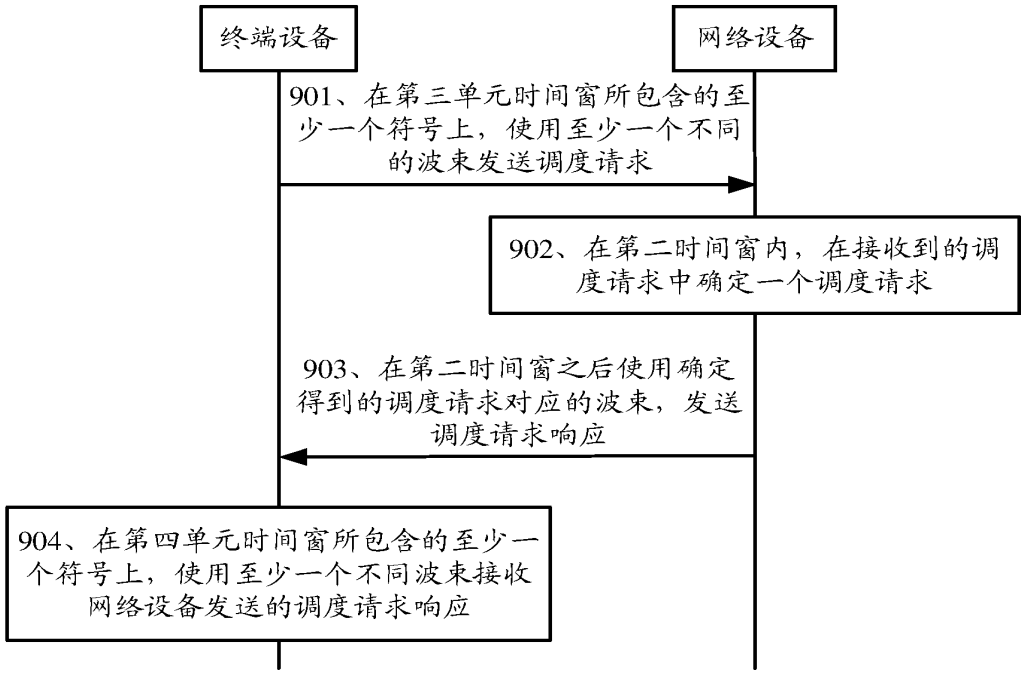

终端设备
网络设备
901、在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束发送调度请求
902、在第二时间窗内，在接收到的调度请求中确定一个调度请求
903、在第二时间窗之后使用确定得到的调度请求对应的波束，发送调度请求响应
904、在第四单元时间窗所包含的至少一个符号上，使用至少一个不同波束接收网络设备发送的调度请求响应

图 9

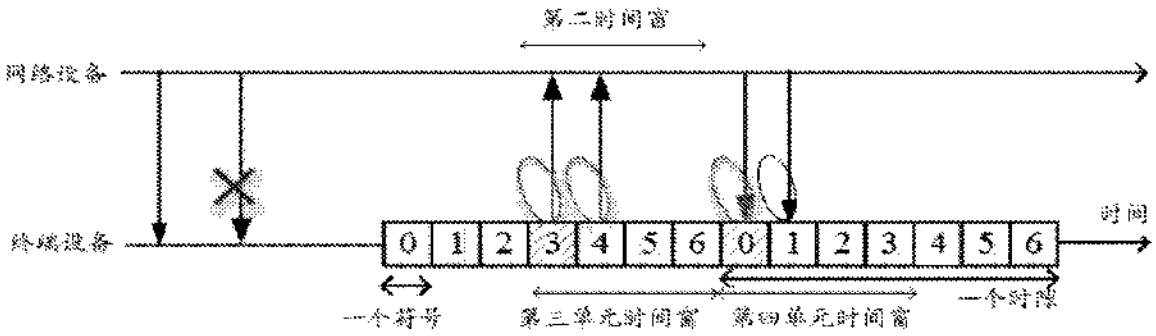

第二时间窗
网络设备
终端设备
时间
0 1 2 3 4 5 6 0 1 2 3 4 5 6
一个符号
第三单元时间窗
第四单元时间窗
一个时隙

图 10

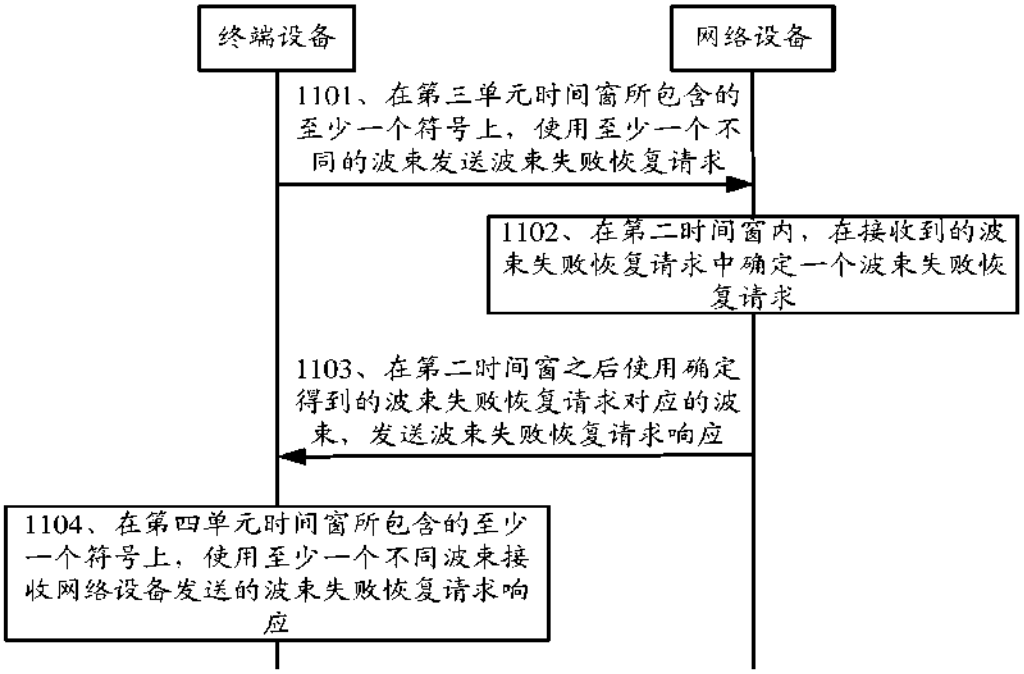

终端设备
网络设备
1101、在第三单元时间窗所包含的至少一个符号上，使用至少一个不同的波束发送波束失败恢复请求
1102、在第二时间窗内，在接收到的波束失败恢复请求中确定一个波束失败恢复请求
1103、在第二时间窗之后使用确定得到的波束失败恢复请求对应的波束，发送波束失败恢复请求响应
1104、在第四单元时间窗所包含的至少一个符号上，使用至少一个不同波束接收网络设备发送的波束失败恢复请求响应

图 11

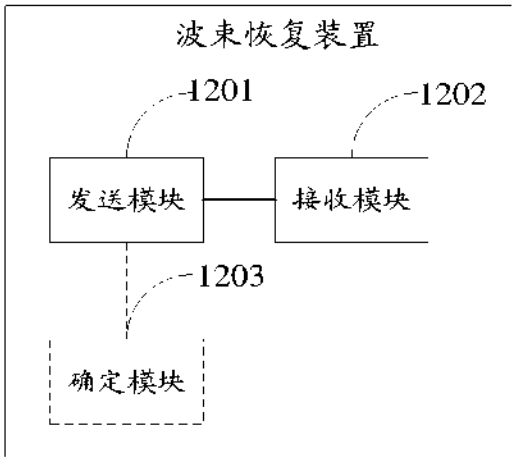

波束恢复装置
1201
1202
发送模块
接收模块
1203
确定模块

图 12

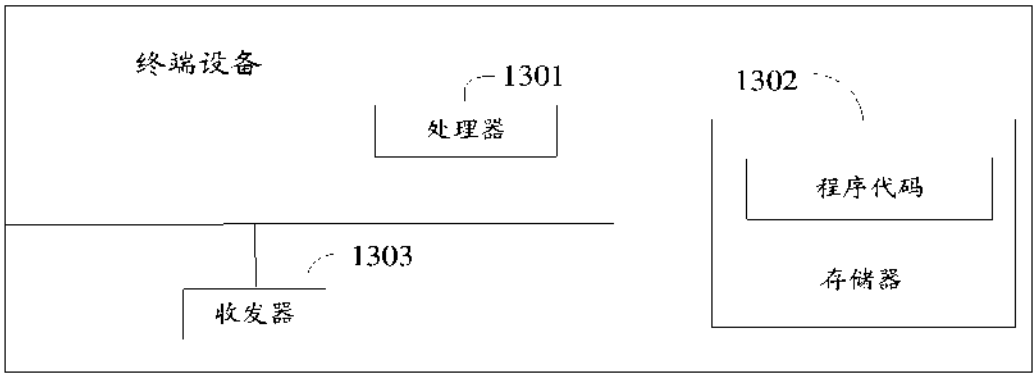


图 13

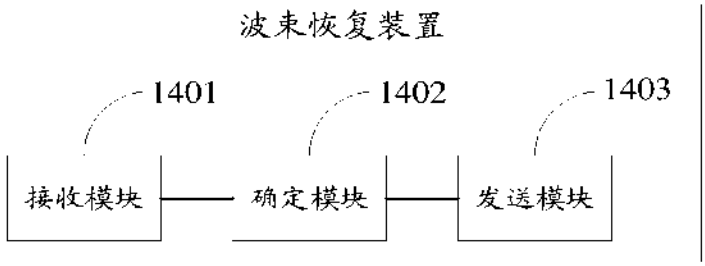


图 14

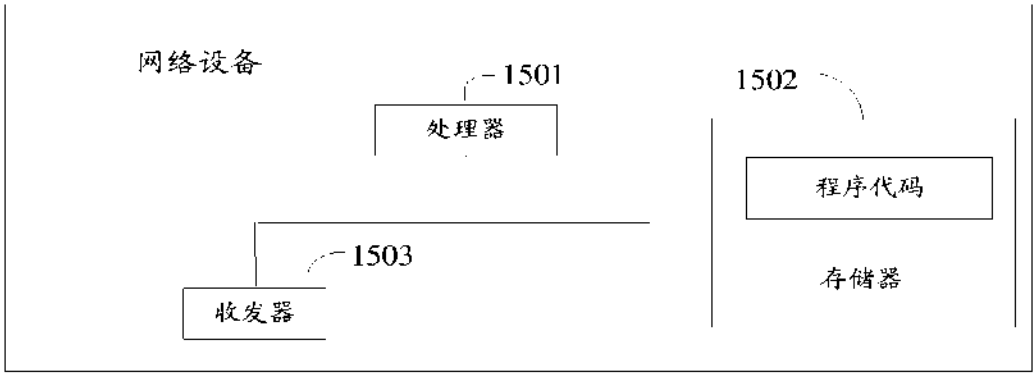


图 15

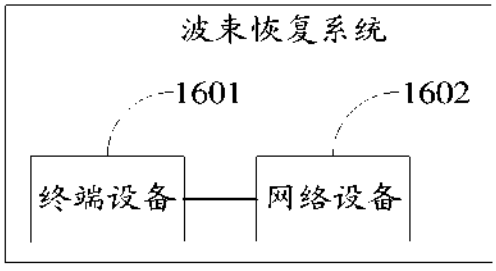


图 16

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2018/085733

A. CLASSIFICATION OF SUBJECT MATTER

H04B 7/0408 (2017.01) i; H04W 72/04 (2009.01) i; H04L 5/00 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04B, H04W, H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNABS; CNTXT; CNKI; VEN; USTXT; WOTXT; EPTXT; XP3GPP: 波束, 恢复, 时间窗, 调度请求, 响应; beam, recover, time 1w window, scheduling 1w request, SR, response

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	QUALCOMM INCORPORATED, Beam Recovery Request, 3GPP TSG-RAN WG 2 Meeting #97bis, R2-1703562, 07 April 2017 (07.04.2017), sections 1-2	1-28
Y	QUALCOM INCORPORATED, Beam Management, 3GPP TSG-RAN WG 2 Meeting #97bis, R2-1703564, 07 April 2017 (07.04.2017), sections 2.1-2.2	1-28
A	INTEL CORPORATION, Radio Link Monitoring, Beam Failure and Radio Link Failure, 3GPP TSG RAN WG 2 Meeting #97bis, R2-1703423, 07 April 2017 (07.04.2017), entire document	1-28
A	WO 2017022902 A1 (SAMSUNG ELECTRONICS CO., LTD.), 09 February 2017 (09.02.2017), entire document	1-28

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 July 2018	26 July 2018

Name and mailing address of the ISA	Authorized officer
State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No. (86-10) 62019451	LIU, Xin Telephone No. 86-010-62089141

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2018/085733

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
WO 2017022902 A1	09 February 2017	WO 2017022870 A1	09 February 2017
		EP 3332597 A1	13 June 2018
		CN 108141749 A	08 June 2018
		KR 20180036995 A	10 April 2018

Form PCT/ISA/210 (patent family annex) (January 2015)

国际检索报告

国际申请号
PCT/CN2018/085733

A. 主题的分类

H04B 7/0408(2017.01)i; H04W 72/04(2009.01)i; H04L 5/00(2006.01)i

按照国际专利分类(IPC)或者同时按照国家分类和IPC两种分类

B. 检索领域

检索的最低限度文献(标明分类系统和分类号)

H04B H04W H04L

包含在检索领域中的除最低限度文献以外的检索文献

在国际检索时查阅的电子数据库(数据库的名称，和使用的检索词（如使用）)

CNABS;CNTXT;CNKI,VEN;USTXT;WOTXT;EPTXT;XP3GPP:波束，恢复，时间窗，调度请求，响应; beam, recover, time lw window, scheduling lw request, SR, response

C. 相关文件

类 型*	引用文件，必要时，指明相关段落	相关的权利要求
Y	QUALCOMM INCORPORATED. "Beam recovery request" 3GPP TSG RAN WG2 Meeting #97bis, R2 1703562. 2017年 4月 7日 (2017-04-07), 第1 2节	1 28
Y	QUALCOMM INCORPORATED. "Beam management" 3GPP TSG-RAN WG2 Meeting #97bis, R2-1703564, 2017年 4月 7日 (2017-04-07), 第2.1-2.2节	1-28
A	INTEL CORPORATION. "Radio link monitoring, beam failure and radio link failure" 3GPP TSG RAN WG2 Meeting #97bis, R2-1703423, 2017年 4月 7日 (2017-04-07), 全文	1-28
A	WO 2017022902 A1 (SAMSUNG ELECTRONICS CO LTD) 2017年 2月 9日 (2017-02-09) 全文	1 28

☐ 其余文件在C栏的续页中列出。

☑ 见同族专利附件。

* 引用文件的具体类型:

"A" 认为不特别相关的表示了现有技术一般状态的文件

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"L" 可能对优先权要求构成怀疑的文件，或为确定另一篇引用文件的公布日而引用的或者因其他特殊理由而引用的文件（如具体说明的）

"O" 涉及口头公开、使用、展览或其他方式公开的文件

"P" 公布日先于国际申请日但迟于所要求的优先权日的文件

"T" 在申请日或优先权日之后公布，与申请不相抵触，但为了理解发明之理论或原理的在后文件

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"Y" 特别相关的文件，当该文件与另一篇或者多篇该类文件结合并且这种结合对于本领域技术人员为显而易见时，要求保护的发明不具有创造性

"&" 同族专利的文件

国际检索实际完成的日期	国际检索报告邮寄日期
2018年 7月 11日	2018年 7月 26日
ISA/CN的名称和邮寄地址 中华人民共和国国家知识产权局(ISA/CN) 中国北京市海淀区蓟门桥西上城路6号 100088 传真号 (86-10)62019451	受权官员 刘欣 电话号码 86-010-62089141

表 PCT/ISA/210 (第2页) (2015年1月)

国际检索报告
关于同族专利的信息

国际申请号
PCT/CN2018/085733

检索报告引用的专利文件			公布日（年/月/日）	同族专利			公布日（年/月/日）
WO	2017022902	A1	2017年 2月 9日	WO	2017022870	A1	2017年 2月 9日
				EP	3332597	A1	2018年 6月 13日
				CN	108141749	A	2018年 6月 8日
				KR	20180036995	A	2018年 4月 10日

表 PCT/ISA/210（同族专利附件）（2015年1月）

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	17950726
	Filing Date	2022-09-22
	First Named Inventor	Xiaobo ZHANG
	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]

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	Application Number	17950726
	Filing Date	2022-09-22
	First Named Inventor	Xiaobo ZHANG
	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

	1	R1-1610145, Qualcomm, October 1, 2016	☒
	2	R1-1610239, Nokia, Alcatel-Lucent Shanghai Bell, September 30, 2016	☒
	3	R1-1611385, China Academy of Telecommunications Technology (CATT), November 5, 2016	☒
	4	R1-1611415, ZTE, ZTE Microelectronics, November 5, 2016	☒
	5	R1-1611417, ZTE, ZTE Microelectronics, November 5, 2016	☒
	6	R1-1612056, Qualcomm, November 5, 2016	☒
	7	R1-1612493, Samsung, November 4, 2016	☒
	8	R1-1612862, Nokia, Alcatel-Lucent Shanghai Bell, November 4, 2016	☒
	9	R4-161779, Qualcomm Incorporated, April 26, 2016	☒
	10	3GPP TR 36.897 V13.0.0 Release 13, 3rd Generation Partnership Project (3GPP), June 2015	☒
	11	R1-1704867, LG Electronics, March 25, 2017	☒

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17950726
	Filing Date	2022-09-22
	First Named Inventor	Xiaobo ZHANG
	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

	12	R1-1609662, Nokia, Alcatel-Lucent Shanghai Bell, September 30, 2016	☒
	13	R2-1703344, LG Electronics, March 24, 2017	☒
	14	3GPP R1-1704398, April 7, 2017	☒
	15	3GPP R1-1704877, April 7, 2017	☒
	16	R1-1609256, October 14, 2016	☒
	17	APEX BEAM TECHNOLOGIES LLC v. ONEPLUS TECHNOLOGY (SHENZHEN) CO., LTD., DEFENDANT'S INVALIDITY CONTENTIONS, Case No. 2:22-cv-00032-JRG, November 21, 2022	☒
	18	APEX BEAM TECHNOLOGIES LLC v. SAMSUNG ELECTRONICS CO., LTD., ET AL.,, DEFENDANT'S INVALIDITY CONTENTIONS, Case No. 2:22-cv-00188-JRG, March 2, 2023	☒
	19	APEX BEAM TECHNOLOGIES LLC v. ZTE CORPORATION, DEFENDANT'S INVALIDITY CONTENTIONS, Case No. 2:22-cv-00031-JRG-RSP, March 2, 2023	☒
	20	APEX BEAM TECHNOLOGIES LLC v. TCT MOBILE INTERNATIONAL LIMITED, DEFENDANTS' INITIAL INVALIDITY CONTENTIONS, Docket No. 2:21-cv-00438-JRG, November 9, 2023	☒
	21	SAMSUNG ELECTRONICS CO., LTD., AND SAMSUNG ELECTRONICS AMERICA, INC., v. APEX BEAM TECHNOLOGIES LLC, PETITION FOR INTER PARTES REVIEW, Case IPR2023-0059, February 28, 2023	☒

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	Filing Date	2022-09-22
	First Named Inventor	Xiaobo ZHANG
	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

EXAMINER SIGNATURE			
Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	17950726
	Filing Date	2022-09-22
	First Named Inventor	Xiaobo ZHANG
	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/JIALIN ZHONG/	Date (YYYY-MM-DD)	2023-11-19
Name/Print	JIALIN ZHONG	Registration Number	62937

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

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4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

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6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

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(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
15 May 2014 (15.05.2014)

WIPO | PCT

(10) International Publication Number
WO 2014/074894 A1

(51) International Patent Classification:
H04B 7/04 (2006.01) *H04B 7/06* (2006.01)

(21) International Application Number:
PCT/US2013/069265

(22) International Filing Date:
8 November 2013 (08.11.2013)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
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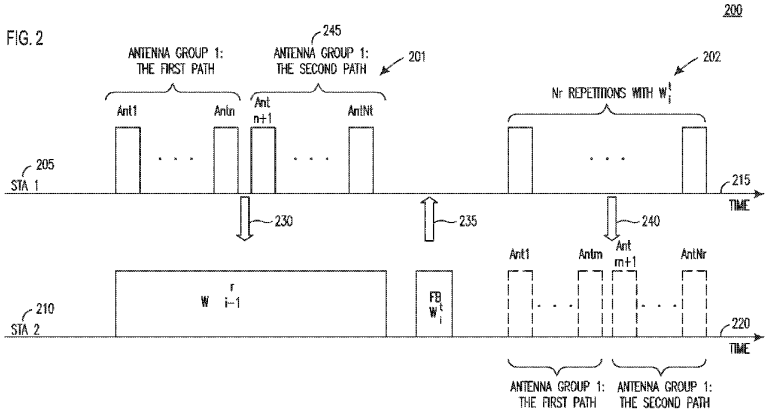
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(54) Title: BEAMFORMING METHODS AND METHODS FOR USING BEAMS



(57) Abstract: A method, apparatus, system, and computer readable medium may be used to perform beamforming. The method may include a first communication device sending a first plurality of beamforming training frames to a second communication device using a first beamforming weight vector; the first communication device receiving from the second communication device a second beamforming weight vector; and the first communication device sending a second plurality of beamforming training frames to the second communication device using the second beamforming weight vector. The apparatus, method, system, and computer readable media may use spatial diversity with beam switching, spatial diversity with a single beam, weighted multipath beamforming training, single user spatial multiplexing, and beamforming training for beam division multiple access (BDMA).

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BEAMFORMING METHODS AND METHODS FOR USING BEAMS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 61/724,679 filed on November 9, 2012, the contents of which are hereby incorporated by reference.

BACKGROUND

[0002] Some wireless communication networks support operation at very high and even extremely high carrier frequencies such as 60 GHz and millimeter wave (mmW) frequency bands. These extremely high carrier frequencies may support very high throughput such as up to 6 gigabits per second (Gbps). One of the challenges for wireless communication at very high or extremely high carrier frequencies is that a significant propagation loss may occur due to the high carrier frequency. As the carrier frequency increases, the carrier wavelength may decrease, and the propagation loss may increase as well.

[0003] At mmW frequency bands, the propagation loss may be severe. For example, the propagation loss may be on the order of 22 to 27 dB, relative to that observed in either the 2.4 GHz, or 5 GHz bands. Since the available spectrum is limited, however, and since users continue to demand more bandwidth, there is a need for effectively using very high and extremely high carrier frequencies for communication networks.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] FIG. 1A is a system diagram of an example communications system in which one or more disclosed embodiments may be implemented;

[0005] FIG. 1B is a system diagram of an example wireless transmit/receive unit (WTRU) that may be used within the communications system illustrated in FIG. 1A;

[0006] FIG. 1C is a system diagram of an example radio access network and an example core network that may be used within the communications system illustrated in FIG. 1A;

[0007] FIG. 1D is a diagram of an example WLAN with an AP and STA forming a BSS, and beamforming with multipath channels;

[0008] FIG. 1E is a diagram of another example WLAN with an AP and STA forming a BSS, and beamforming with multiple channels;

[0009] FIG. 2 is a diagram of an example of a method using two STAs to perform a multi-path beamforming method;

[0010] FIG. 3 is a diagram of an example of one iteration of the multi-path beamforming method using BRP transactions;

[0011] FIG. 4 is a diagram of an example frame format of a BRP packet;

[0012] FIG. 5 is a diagram of an example format of a BRP frame Action field;

[0013] FIG. 6 is a diagram of an example modified channel measurement feedback element;

[0014] FIG. 7 is a diagram of an example AP configured to perform a transmission using full size beamforming with STBC;

[0015] FIG. 8 is a diagram of an example AP configured to perform a transmission using partial size beamforming with STBC;

[0016] FIG. 9 is a diagram of an example transceiver architecture;

[0017] FIG. 10 is a diagram of another example transceiver architecture;

[0018] FIG. 11 is a diagram of an example beam division multiple access (BDMA) architecture;

[0019] FIG. 12 is a diagram of an example beamforming training method for BDMA;

[0020] FIG. 13 is a diagram of an example modified BRP procedure to implement a multi-stage iterative beamforming training method for BDMA;

[0021] FIG. 14 is a diagram of an example PHY layer frame format;

[0022] FIG. 15 is a diagram of an example beamforming training procedure using Eigen-beamforming based spatial multiplexing where the

communication devices may be configured to calibrate multiple transmit RF chains;

[0023] FIG. 16 is a diagram of an example beamforming training method for Type I devices and for Type II devices without calibration;

[0024] FIG. 17 is a diagram of an example beamforming training method for beam sweep based spatial multiplexing for Type I devices with calibration between two TX chains;

[0025] FIG. 18 is a diagram of an example beamforming training method for beam sweep based spatial multiplexing Type II devices and Type I devices without calibration;

[0026] FIG. 19 is a diagram of an example modified FBCK-TYPE subfield;

[0027] FIG. 20A is a diagram of an example PHY layer frame format;

[0028] FIG. 20B is a diagram of another example PHY layer frame format;

[0029] FIG. 20C is a diagram of another example PHY layer frame format;

[0030] FIG. 21 is a diagram of an example modified SSW training frames and sequence;

[0031] FIG. 22 is a diagram of an example SSWA frame format;

[0032] FIG. 23 is a diagram of an example early termination of the SLS training procedure; and

[0033] FIG. 24 is a diagram of an example multi-beam multi-DMG antenna SLS feedback method.

SUMMARY

[0034] A first communication device for beamforming may include a plurality of antennas and a processor. The processor may be configured to partition the antenna into at least a first group of antennas and a second group of antennas. The processor may be further configured to send a plurality of beamforming training frames to a second communication device using the

first group of antennas and the second group of antennas. The processor and/or a receiver may be configured to receive, from the second communication device, a first beamforming weight vector for sending signals on the first group of antennas and to receive a second beamforming weight vector for sending signals on the second group of antennas.

[0035] A method of beamforming training for beam division multiple access (BDMA) may include an AP transmitting Nt sequences modulated using Nt beamforming vectors. A first station may use a first previous beamforming vector to receive the Nt sequences and determine a first transmit beamforming weight from the AP to the first station based on the first previous beamforming vector and the received Nt sequences. The first station may send the determined first transmit beamforming weight to the AP. A second station may use a second previous beamforming vector to receive the Nt sequences and determine a second transmit beamforming weight from the AP to the first station based on the second previous beamforming vector and the received Nt sequences. The second station may send the determined second transmit beamforming weight to the AP, and the AP may transmit one or more sequences modulated based on the first transmit beamforming weight and the second transmit beamforming weight.

[0036] A method and apparatus may be used for spatial diversity with beam switching, spatial diversity with a single beam, weighted multipath beamforming training, single user spatial multiplexing, and for reduced beamforming training overhead.

DETAILED DESCRIPTION

[0037] FIG. 1A is a diagram of an example communications system 100 in which one or more disclosed embodiments may be implemented. The communications system 100 may be a multiple access system that provides content, such as voice, data, video, messaging, broadcast, etc., to multiple wireless users. The communications system 100 may enable multiple wireless users to access such content through the sharing of system resources,

including wireless bandwidth. For example, the communications systems 100 may employ one or more channel access methods, such as code division multiple access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), orthogonal FDMA (OFDMA), single-carrier FDMA (SC-FDMA), and the like.

[0038] As shown in FIG. 1A, the communications system 100 may include wireless transmit/receive units (WTRUs) 102a, 102b, 102c, 102d, a radio access network (RAN) 104, a core network 106, a public switched telephone network (PSTN) 108, the Internet 110, and other networks 112, though it will be appreciated that the disclosed embodiments contemplate any number of WTRUs, base stations, networks, and/or network elements. Each of the WTRUs 102a, 102b, 102c, 102d may be any type of device configured to operate and/or communicate in a wireless environment. By way of example, the WTRUs 102a, 102b, 102c, 102d may be configured to transmit and/or receive wireless signals and may include user equipment (UE), a mobile station, a fixed or mobile subscriber unit, a pager, a cellular telephone, a personal digital assistant (PDA), a smartphone, a laptop, a netbook, a personal computer, a wireless sensor, consumer electronics, and the like.

[0039] The communications systems 100 may also include a base station 114a and a base station 114b. Each of the base stations 114a, 114b may be any type of device configured to wirelessly interface with at least one of the WTRUs 102a, 102b, 102c, 102d to facilitate access to one or more communication networks, such as the core network 106, the Internet 110, and/or the networks 112. By way of example, the base stations 114a, 114b may be a base transceiver station (BTS), a Node-B, an eNode B, a Home Node B, a Home eNode B, a site controller, an access point (AP), a wireless router, and the like. While the base stations 114a, 114b are each depicted as a single element, it will be appreciated that the base stations 114a, 114b may include any number of interconnected base stations and/or network elements.

[0040] The base station 114a may be part of the RAN 104, which may also include other base stations and/or network elements (not shown), such as

a base station controller (BSC), a radio network controller (RNC), relay nodes, etc. The base station 114a and/or the base station 114b may be configured to transmit and/or receive wireless signals within a particular geographic region, which may be referred to as a cell (not shown). The cell may further be divided into cell sectors. For example, the cell associated with the base station 114a may be divided into three sectors. Thus, in one embodiment, the base station 114a may include three transceivers, i.e., one for each sector of the cell. In another embodiment, the base station 114a may employ multiple-input multiple output (MIMO) technology and, therefore, may utilize multiple transceivers for each sector of the cell.

[0041] The base stations 114a, 114b may communicate with one or more of the WTRUs 102a, 102b, 102c, 102d over an air interface 116, which may be any suitable wireless communication link (e.g., radio frequency (RF), microwave, infrared (IR), ultraviolet (UV), visible light, etc.). The air interface 116 may be established using any suitable radio access technology (RAT).

[0042] More specifically, as noted above, the communications system 100 may be a multiple access system and may employ one or more channel access schemes, such as CDMA, TDMA, FDMA, OFDMA, SC-FDMA, and the like. For example, the base station 114a in the RAN 104 and the WTRUs 102a, 102b, 102c may implement a radio technology such as Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access (UTRA), which may establish the air interface 116 using wideband CDMA (WCDMA). WCDMA may include communication protocols such as High-Speed Packet Access (HSPA) and/or Evolved HSPA (HSPA+). HSPA may include High-Speed Downlink Packet Access (HSDPA) and/or High-Speed Uplink Packet Access (HSUPA).

[0043] In another embodiment, the base station 114a and the WTRUs 102a, 102b, 102c may implement a radio technology such as Evolved UMTS Terrestrial Radio Access (E-UTRA), which may establish the air interface 116 using Long Term Evolution (LTE) and/or LTE-Advanced (LTE-A).

[0044] In other embodiments, the base station 114a and the WTRUs 102a, 102b, 102c may implement radio technologies such as IEEE 802.16 (i.e., Worldwide Interoperability for Microwave Access (WiMAX)), CDMA2000, CDMA2000 1X, CDMA2000 EV-DO, Interim Standard 2000 (IS-2000), Interim Standard 95 (IS-95), Interim Standard 856 (IS-856), Global System for Mobile communications (GSM), Enhanced Data rates for GSM Evolution (EDGE), GSM EDGE (GERAN), and the like.

[0045] The base station 114b in FIG. 1A may be a wireless router, Home Node B, Home eNode B, or access point, for example, and may utilize any suitable RAT for facilitating wireless connectivity in a localized area, such as a place of business, a home, a vehicle, a campus, and the like. In one embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.11 to establish a wireless local area network (WLAN). In another embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.15 to establish a wireless personal area network (WPAN). In yet another embodiment, the base station 114b and the WTRUs 102c, 102d may utilize a cellular-based RAT (e.g., WCDMA, CDMA2000, GSM, LTE, LTE-A, etc.) to establish a picocell or femtocell. As shown in FIG. 1A, the base station 114b may have a direct connection to the Internet 110. Thus, the base station 114b may not be required to access the Internet 110 via the core network 106.

[0046] The RAN 104 may be in communication with the core network 106, which may be any type of network configured to provide voice, data, applications, and/or voice over internet protocol (VoIP) services to one or more of the WTRUs 102a, 102b, 102c, 102d. For example, the core network 106 may provide call control, billing services, mobile location-based services, pre-paid calling, Internet connectivity, video distribution, etc., and/or perform high-level security functions, such as user authentication. Although not shown in FIG. 1A, it will be appreciated that the RAN 104 and/or the core network 106 may be in direct or indirect communication with other RANs that employ the same RAT as the RAN 104 or a different RAT. For example, in addition to

being connected to the RAN 104, which may be utilizing an E-UTRA radio technology, the core network 106 may also be in communication with another RAN (not shown) employing a GSM radio technology.

[0047] The core network 106 may also serve as a gateway for the WTRUs 102a, 102b, 102c, 102d to access the PSTN 108, the Internet 110, and/or other networks 112. The PSTN 108 may include circuit-switched telephone networks that provide plain old telephone service (POTS). The Internet 110 may include a global system of interconnected computer networks and devices that use common communication protocols, such as the transmission control protocol (TCP), user datagram protocol (UDP) and the internet protocol (IP) in the TCP/IP internet protocol suite. The networks 112 may include wired or wireless communications networks owned and/or operated by other service providers. For example, the networks 112 may include another core network connected to one or more RANs, which may employ the same RAT as the RAN 104 or a different RAT.

[0048] Some or all of the WTRUs 102a, 102b, 102c, 102d in the communications system 100 may include multi-mode capabilities, i.e., the WTRUs 102a, 102b, 102c, 102d may include multiple transceivers for communicating with different wireless networks over different wireless links. For example, the WTRU 102c shown in FIG. 1A may be configured to communicate with the base station 114a, which may employ a cellular-based radio technology, and with the base station 114b, which may employ an IEEE 802 radio technology.

[0049] FIG. 1B is a system diagram of an example WTRU 102. As shown in FIG. 1B, the WTRU 102 may include a processor 118, a transceiver 120, a transmit/receive element 122, a speaker/microphone 124, a keypad 126, a display/touchpad 128, non-removable memory 106, removable memory 132, a power source 134, a global positioning system (GPS) chipset 136, and other peripherals 138. It will be appreciated that the WTRU 102 may include any sub-combination of the foregoing elements while remaining consistent with an embodiment.

[0050] The processor 118 may be a general purpose processor, a special purpose processor, a conventional processor, a digital signal processor (DSP), a plurality of microprocessors, one or more microprocessors in association with a DSP core, a controller, a microcontroller, Application Specific Integrated Circuits (ASICs), Field Programmable Gate Array (FPGAs) circuits, any other type of integrated circuit (IC), a state machine, and the like. The processor 118 may perform signal coding, data processing, power control, input/output processing, and/or any other functionality that enables the WTRU 102 to operate in a wireless environment. The processor 118 may be coupled to the transceiver 120, which may be coupled to the transmit/receive element 122. While FIG. 1B depicts the processor 118 and the transceiver 120 as separate components, it will be appreciated that the processor 118 and the transceiver 120 may be integrated together in an electronic package or chip.

[0051] The transmit/receive element 122 may be configured to transmit signals to, or receive signals from, a base station (e.g., the base station 114a) over the air interface 116. For example, in one embodiment, the transmit/receive element 122 may be an antenna configured to transmit and/or receive RF signals. In another embodiment, the transmit/receive element 122 may be an emitter/detector configured to transmit and/or receive IR, UV, or visible light signals, for example. In yet another embodiment, the transmit/receive element 122 may be configured to transmit and receive both RF and light signals. It will be appreciated that the transmit/receive element 122 may be configured to transmit and/or receive any combination of wireless signals.

[0052] In addition, although the transmit/receive element 122 is depicted in FIG. 1B as a single element, the WTRU 102 may include any number of transmit/receive elements 122. More specifically, the WTRU 102 may employ MIMO technology. Thus, in one embodiment, the WTRU 102 may include two or more transmit/receive elements 122 (e.g., multiple antennas) for transmitting and receiving wireless signals over the air interface 116.

[0053] The transceiver 120 may be configured to modulate the signals that are to be transmitted by the transmit/receive element 122 and to demodulate the signals that are received by the transmit/receive element 122. As noted above, the WTRU 102 may have multi-mode capabilities. Thus, the transceiver 120 may include multiple transceivers for enabling the WTRU 102 to communicate via multiple RATs, such as UTRA and IEEE 802.11, for example.

[0054] The processor 118 of the WTRU 102 may be coupled to, and may receive user input data from, the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128 (e.g., a liquid crystal display (LCD) display unit or organic light-emitting diode (OLED) display unit). The processor 118 may also output user data to the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128. In addition, the processor 118 may access information from, and store data in, any type of suitable memory, such as the non-removable memory 106 and/or the removable memory 132. The non-removable memory 106 may include random-access memory (RAM), read-only memory (ROM), a hard disk, or any other type of memory storage device. The removable memory 132 may include a subscriber identity module (SIM) card, a memory stick, a secure digital (SD) memory card, and the like. In other embodiments, the processor 118 may access information from, and store data in, memory that is not physically located on the WTRU 102, such as on a server or a home computer (not shown).

[0055] The processor 118 may receive power from the power source 134, and may be configured to distribute and/or control the power to the other components in the WTRU 102. The power source 134 may be any suitable device for powering the WTRU 102. For example, the power source 134 may include one or more dry cell batteries (e.g., nickel-cadmium (NiCd), nickel-zinc (NiZn), nickel metal hydride (NiMH), lithium-ion (Li-ion), etc.), solar cells, fuel cells, and the like.

[0056] The processor 118 may also be coupled to the GPS chipset 136, which may be configured to provide location information (e.g., longitude and

latitude) regarding the current location of the WTRU 102. In addition to, or in lieu of, the information from the GPS chipset 136, the WTRU 102 may receive location information over the air interface 116 from a base station (e.g., base stations 114a, 114b) and/or determine its location based on the timing of the signals being received from two or more nearby base stations. It will be appreciated that the WTRU 102 may acquire location information by way of any suitable location-determination method while remaining consistent with an embodiment.

[0057] The processor 118 may further be coupled to other peripherals 138, which may include one or more software and/or hardware modules that provide additional features, functionality and/or wired or wireless connectivity. For example, the peripherals 138 may include an accelerometer, an e-compass, a satellite transceiver, a digital camera (for photographs or video), a universal serial bus (USB) port, a vibration device, a television transceiver, a hands free headset, a Bluetooth® module, a frequency modulated (FM) radio unit, a digital music player, a media player, a video game player module, an Internet browser, and the like.

[0058] FIG. 1C is a system diagram of the RAN 104 and the core network 106 according to an embodiment. As noted above, the RAN 104 may employ an E-UTRA radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 116. The RAN 104 may also be in communication with the core network 106.

[0059] The RAN 104 may include eNode-Bs 140a, 140b, 140c, though it will be appreciated that the RAN 104 may include any number of eNode-Bs while remaining consistent with an embodiment. The eNode-Bs 140a, 140b, 140c may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 116. In one embodiment, the eNode-Bs 140a, 140b, 140c may implement MIMO technology. Thus, the eNode-B 140a, for example, may use multiple antennas to transmit wireless signals to, and receive wireless signals from, the WTRU 102a.

[0060] Each of the eNode-Bs 140a, 140b, 140c may be associated with a particular cell (not shown) and may be configured to handle radio resource management decisions, handover decisions, scheduling of users in the uplink and/or downlink, and the like. As shown in FIG. 1C, the eNode-Bs 140a, 140b, 140c may communicate with one another over an X2 interface.

[0061] The core network 106 shown in FIG. 1C may include a mobility management gateway (MME) 142, a serving gateway 144, and a packet data network (PDN) gateway 146. While each of the foregoing elements are depicted as part of the core network 106, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

[0062] The MME 142 may be connected to each of the eNode-Bs 142a, 142b, 142c in the RAN 104 via an S1 interface and may serve as a control node. For example, the MME 142 may be responsible for authenticating users of the WTRUs 102a, 102b, 102c, bearer activation/deactivation, selecting a particular serving gateway during an initial attach of the WTRUs 102a, 102b, 102c, and the like. The MME 142 may also provide a control plane function for switching between the RAN 104 and other RANs (not shown) that employ other radio technologies, such as GSM or WCDMA.

[0063] The serving gateway 144 may be connected to each of the eNode Bs 140a, 140b, 140c in the RAN 104 via the S1 interface. The serving gateway 144 may generally route and forward user data packets to/from the WTRUs 102a, 102b, 102c. The serving gateway 144 may also perform other functions, such as anchoring user planes during inter-eNode B handovers, triggering paging when downlink data is available for the WTRUs 102a, 102b, 102c, managing and storing contexts of the WTRUs 102a, 102b, 102c, and the like.

[0064] The serving gateway 144 may also be connected to the PDN gateway 146, which may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, such as the Internet 110, to facilitate communications between the WTRUs 102a, 102b, 102c and IP-enabled devices. An access router (AR) 150 of a wireless local area network (WLAN)

155 may be in communication with the Internet 110. The AR 150 may facilitate communications between APs 160a, 160b, and 160c. The APs 160a, 160b, and 160c may be in communication with STAs 170a, 170b, and 170c.

[0065] The core network 106 may facilitate communications with other networks. For example, the core network 106 may provide the WTRUs 102a, 102b, 102c with access to circuit-switched networks, such as the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, 102c and traditional land-line communications devices. For example, the core network 106 may include, or may communicate with, an IP gateway (e.g., an IP multimedia subsystem (IMS) server) that serves as an interface between the core network 106 and the PSTN 108. In addition, the core network 106 may provide the WTRUs 102a, 102b, 102c with access to the networks 112, which may include other wired or wireless networks that are owned and/or operated by other service providers.

[0066] Fig. 1D is a diagram of an example use of beamforming in a WLAN 185. The WLAN 185 may include an AP 190 and an STA 192 forming a BSS. Fig. 1E is a diagram of an example use of beamforming using spatial diversity or multipath diversity in the WLAN 185. The WLAN 185 may include an AP 190 and an STA 192 forming a BSS. A WLAN in a Infrastructure Basic Service Set (BSS) mode has an Access Point (AP) 190 for the BSS and one or more stations (STAs) 192 associated with the AP. The AP 190 may have an access, or interface, to a Distribution System (DS) 195, or another type of wired/wireless network that carries traffic in and out of the BSS. Traffic to STAs that originates from outside the BSS may arrive through the AP to be delivered to the STAs. Traffic originating from STAs to destinations outside the BSS may be sent to the AP to be delivered to the respective destinations. Traffic between STAs within the BSS may also be sent through the AP where the source STA may send traffic to the AP and the AP may deliver the traffic to the destination STA. Such traffic between STAs within a BSS may be peer-to-peer traffic. Such peer-to-peer traffic may also be sent directly between the source and destination STAs with a direct link setup

(DLS) using an 802.11e DLS or an 802.11z tunneled DLS (TDLS). A WLAN using an Independent BSS (IBSS) mode has no AP, and/or STAs, communicating directly with each other. This mode of communication may be referred to as an "ad-hoc" mode of communication.

[0067] As used herein an STA 192 may include, but is not limited to, a WTRU 102, an AP, or a communication device. Using the 802.11 infrastructure mode of operation, the AP 190 may transmit a beacon on a fixed channel, usually the primary channel. This channel may be 20 MHz wide, and may be the operating channel of the BSS. This channel may also be used by the STAs to establish a connection with the AP. The fundamental channel access mechanism in an 802.11 system may be Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA). In this mode of operation, every STA, including the AP, may sense the primary channel. If the channel is detected to be busy, the STA may back off. Hence only one STA may transmit at any given time in a given BSS.

[0068] In an 802.11n example, High Throughput (HT) STAs may also use a 40 MHz wide channel for communication. This 40 MHz wide channel may be achieved by combining the primary 20 MHz channel, with an adjacent 20 MHz channel to form a 40 MHz wide contiguous channel. 802.11n may operate on the 2.4 GHz, and 5 GHz ISM bands.

[0069] In an 802.11ac example, Very High Throughput (VHT) STAs may support 20 MHz, 40 MHz, 80 MHz, and 160 MHz wide channels. The 40 MHz, and 80 MHz, channels may be formed by combining contiguous 20 MHz channels similar to 802.11n described above. A 160 MHz channel may be formed either by combining 8 contiguous 20 MHz channels, or by combining two non-contiguous 80 MHz channels, this may also be referred to as an 80+80 configuration. For the 80+80 configuration, the data, after channel encoding, is passed through a segment parser that may divide it into two streams. IFFT and time domain processing are done on each stream separately. The streams may then be mapped on two channels, and the data may be transmitted. At the receiver, this process may be reversed, and the combined data may be sent

to the MAC. 802.11ac may operate only on the 5 GHz ISM band, and consequently may not be backward compatible with 802.11n modes of operation in the 2.4 GHz ISM band. For the examples described herein, any combination of channels may be used, and should not be limited to contiguous and non-contiguous channels.

[0070] Sub 1 GHz modes of operation may be supported by 802.11af, and 802.11ah. For these specifications the channel operating bandwidths may be reduced relative to those used in 802.11n, and 802.11ac. 802.11af may support 5 MHz, 10 MHz and 20 MHz bandwidths in the TV White Space (TVWS) spectrum, and 802.11ah may support 1 MHz, 2 MHz, 4 MHz, 8 MHz, and 16 MHz bandwidths using a non-TVWS spectrum. A possible use case for 802.11ah may support Meter Type Control (MTC) devices in a macro coverage area. MTC devices may have limited capabilities including only support for limited bandwidths, but also may include a requirement for a very long battery life. 802.11ah may also be used for macro coverage as support for cellular offload to WiFi.

[0071] In 802.11ad, wide bandwidth spectrum at 60 GHz may be available, thus enabling very high throughput operation. 802.11ad may support up to 2 GHz operating bandwidths and the data rate may reach up to 6 Gbps. Since the propagation loss at 60 GHz may be more significant than at the 2.4 GHz, and 5 GHz bands, beamforming may be adopted in 802.11ad as a means to extend the coverage range. To support the receiver requirements for this band, the 802.11ac MAC layer may be modified in several areas. An important modification for the 802.11ad MAC layer may include procedures that allow channel estimation and training. These procedures may include omni, and beamformed modes of operation which do not exist in 802.11ac.

[0072] WLAN systems that support multiple channels and channel widths, such as 802.11n, 802.11ac, 802.11af, and 802.11ah, may include a channel designated as the primary channel. The primary channel may, but not necessarily, have a bandwidth equal to the largest common operating bandwidth supported by all STAs in the BSS. The bandwidth of the primary

channel may therefore be limited by the STA, of all the STAs operating in a BSS, which supports or enables the use of the smallest bandwidth operating mode. In the example of 802.11ah, the primary channel may be 1 MHz wide if there are STAs, for example, MTC type devices that only support a 1 MHz mode, even if the AP, and other STAs in the BSS, may support a 2 MHz, 4 MHz, 8 MHz, 16 MHz, or other channel bandwidth operating modes. All carrier sensing and NAV settings may depend on the status of the primary channel. For example, if the primary channel is busy due to a STA supporting only a 1 MHz operating mode, then the entire available frequency bands may be considered busy even though a majority of the frequency bands remain idle and available.

[0073] In the United States, for example, the available frequency bands that may be used by 802.11ah are from 902 MHz to 928 MHz. In Korea, for example, the available frequency bands may be from 917.5 MHz to 923.5 MHz, and in Japan, it may be from 916.5 MHz to 927.5 MHz. The total bandwidth available for 802.11ah may be 6 MHz to 26 MHz depending on the country.

[0074] One of the challenges for wireless communication over 60 GHz may include significant propagation loss due to the high frequency. As the wavelength decreases, the free space propagation loss may increase. To address the range limitation due to this propagation loss, 802.11ad may use beamforming to increase the Effective Radiated Power (ERP) of the transmissions. Since the wavelength is small, it may be possible to use a large antenna array to get a very high beamformed antenna gain. The beam in 802.11ad may be electronically steered to a particular STA, or group of STAs, during association with the STAs.

[0075] In order to support beamforming, the 802.11ad PHY and MAC specifications may be modified to support directional transmissions, and millimeter wave (mmW) antenna training procedures. A comprehensive beamforming training protocol may be defined in 802.11ad. The beamforming training protocol may include two components, for example a sector level sweep (SLS) procedure and a beam refinement protocol (BRP) procedure. The

SLS procedure may be used for transmit beamforming training. The BRP procedure may enable receive beamforming training and iterative refinement of both the transmit and receive beams.

[0076] In order to reduce implementation complexity, 802.11ad may support beam switching at both the AP and the STA. The beam switching at both the AP and the STA may be in contrast to more advanced multi-antenna schemes, and may assume that a single RF front-end is available at both ends. Problems related to link robustness and spectral efficiency may be of importance for enabling 802.11ad+ to address the current trend for a Carrier Grade WiFi service. A Carrier Grade WiFi service may be referred to as 5G Carrier Grade WiFi, may provide high air interference efficiency for multiple users, and a stable "cellular-like" quality. A 5G Carrier Grade WiFi system may support robust and dynamic deployments, for example dense deployments and flash crowds.

[0077] Although 802.11ad may address the need for a very high peak throughput, limitations due to the propagation environment are not adequately addressed in 802.11ad.

[0078] For mmW communications it may be necessary to handle a propagation loss due in part to the high free space propagation loss which may occur at mmW frequencies. For example, blockage of transmissions by the human body may attenuate a signal by 15 to 25 dB for hundreds of milliseconds.

[0079] While propagation loss of walls and other indoor obstacles may prevent the propagation of mmW through them, indoor Line of Site (LOS) propagation may occur indoors. LOS propagation may occur indoors either due to a direct line of sight transmission, or due to reflections off walls and other obstacles. It should be noted that non-negligible propagation loss at mmW frequencies may occur due to walls and other environmental factors. Beam switching may be used in 802.11ad to utilize signal diversity due to these reflections.

[0080] Some mmW communications may utilize a single beam for communications, for example, in 802.11ad. MIMO techniques, such as spatial multiplexing, may be employed to improve the spectral efficiency of the system, however it may be difficult to use these techniques in mmW systems due to the need for multiple symbol generation. Methods that improve the spectral efficiency of mmW systems, such as methods that enable the use of spatial multiplexing, may be needed in future mmW specifications which for example may be based on 802.11ad, and/or in mmW systems in general.

[0081] Beamforming training protocols, such as SLS and BRP, may be used to perform transmit/receive beamforming training and iterative beam refinement training. The beamforming training overhead and latency of these procedures, however, may be significant. For example, with the transmit beamforming training defined in SLS, the transmitter may need to transmit multiple sector sweep (SSW) frames that may be modulated by different beamforming sectors. Each device may have up to 64 different beam sectors. Each SSW frame may include a full PLCP header, which may include a preamble, one or more header blocks, and a MAC frame. In order to fully exploit the beamforming gain, transmit and receive training procedures at both peer devices may be required, and an iterative beam refinement may also be needed. These procedures may represent a significant overhead and hence methods that reduce this overhead may be needed in part to allow for a better user experience in mmW systems.

[0082] Referring back to FIGS. 1D and 1E, multipath propagation may be common in indoor communications links. Beam switching based beamforming algorithms utilized in the current 802.11ad specification may attempt to point the beam to the strongest path. As shown in FIG. 1D, a LOS path and a strong reflection path may exist between AP 190 and STA 192. After the beamforming training procedure, the beam with the best channel gain may be selected. This beam may be formed towards the strongest path among multiple propagation paths. However, human blockage may introduce an average 20 dB loss for 230 ms, which may prevent the 60GHz radio to

provide multi-Gigabit/sec data transmissions. It is therefore highly likely that the beamformed link may be dropped, and hence the transmitted packet during this period would be lost. Moreover, due to the loss of the packet, the system may have to repeat the beamforming training and then retransmit the packet over a potentially new beam.

[0083] Example beamforming schemes may exploit the spatial diversity such that the transmission is not dependent on only the strongest path. As shown in FIG. 1E, with two strong propagation paths, for example, a LOS path and a strong reflection path, a number of solutions may be possible including fast beam switching, wider beam and multi-beam methods.

[0084] Spatial diversity may be achieved with fast beam switching. In order to accomplish fast beam switching when the channel condition changes, it may be necessary that both AP and STA have an available list of weight vectors/beam identifiers. Example methods for obtaining a list of weight vectors/beam identifiers are disclosed below. There may be two possibilities for fast-beam switching including in-band signaling and out-of-band signaling. In-band beam switching may be used in some examples.

[0085] In an in-band beam switching example, the AP may be communicating with the STA using a beam set (Tx and Rx beams) B1. The AP and STA may have prioritized the beam sets according to the received SNR, or SINR, during the SLS and BRP phases. The STA may monitor one or more of the received SNR, SINR, Bit-Error-Rate (BER) or Packet Error Rate (PER), acknowledgement (ACK) statistics or a combination of these parameters. If, at the end of a packet reception, the STA determines that the channel quality is deteriorating, it may append a message to the ACK packet requesting the AP to switch to the next best beam set, for example B2, for the next transmitted packet. The assumption here is that the channel condition may be deteriorating, but not to the point that the data packet cannot be decoded correctly and hence an ACK may be sent.

[0086] In another example, alternative beam retransmission methods may be used. In 802.11 systems, and mmW systems in particular, if no ACK

is received, the data packet may be retransmitted. This retransmission may use the same beam that was used in the prior transmission. An example for an alternative procedure may be that if the AP does not receive an ACK, the AP may retransmit the data packet using the beam set B2 instead of the beam set B1. Since these beam sets may have been defined prior to this procedure, possibly during association of the STA with the AP, the procedure at the STA may use the corresponding receive beam set B2 for reception of the retransmission from the AP. In an example procedure, the AP and the STA may define an association of indices to beam sets, and subsequently use the beam set indices for identification of beam sets in the aforementioned procedures.

[0087] In an alternative, or additional example, the AP may cycle the data packet through the N best beam-sets. The STA may then perform a procedure wherein it receives N packets from the AP, and perform maximum-ratio-combining, selection combining, or a similar receive algorithm, on these packets. An ACK may then be determined and sent to the AP, for example, after all N transmissions have occurred, or as soon as the packet has been successfully received and decoded.

[0088] In an alternative, or additional example, the AP may also transmit the data packet through all of, or a subset of, the N beam-sets simultaneously. The remainder of the procedure described in the previous paragraph may then follow in a similar way.

[0089] A beam set may include the identification of a primary beam within the beam set. The primary beam may be used by transmission procedures at the AP, STA, or both, as the beam to be used for initial attempts at wireless communication. Alternatively, the primary beam may be used exclusively for transmission of control or scheduling information. More than one primary beam may be used for more than one STA wherein each primary beam may be associated with a particular STA.

[0090] In an alternative, or in addition to, the AP may also cycle through different modes of MIMO operation for each beam set, prior to

proceeding to the next beam set. For example, if the AP does not receive an ACK on beam set B1 it may select a more robust form of operation such as Space Time Block Coding (STBC), Space Frequency Block Coding (SFBC), or Cyclic Delay Diversity (CDD), before proceeding to transmit on the remaining beam sets B2 through BN.

[0091] In some examples, a first and second best beam transmission method may be used. For example, the STA may determine the two best beams, B1, B2, using a procedure similar to the above, and recommend these beam indices to the AP. In this example, for the remainder of the communication interval, the AP and the STA may assume that either, or both, beam indices may be used for wireless communication.

[0092] The AP may then determine to transmit on either beam during a particular transmission time interval (TTI) based on one or more criteria determined by the AP. Example criteria may include one or more of the received SNR, or SINR, Bit-Error-Rate (BER), or Packet Error Rate (PER), acknowledgement (ACK) statistics, or a combination of these criteria. The STA may respond to a message from the AP with an indication of the reception quality, or similar metric, for the beam that it used to receive the message from the AP. This indication or metric may be indicated in the response by the beam index.

[0093] Alternatively, if the STA does not provide an indication of the reception quality in its ACK and/or any other packet to the AP, the AP may determine that the reception quality was acceptable for one or more associated beams. If the STA indicates a poor reception quality to the AP for B1, it may assume that the next transmission from the AP will use the second best beam B2.

[0094] During communication with the STA, the AP may store the packet reception quality for each transmission, on each beam, in a memory, while using either beam. If a particular beam in the pair becomes unusable for further communication, the AP may identify a new first, or a second best beam for communication with the STA, while at the same time continuing

communication on the remaining beam of the original beam pair. Other combinations of the procedures described in this example may be possible. The above example is not limited to a pair of beams and may be extended to support any number of beams greater than one that the system may simultaneously support.

[0095] Some examples may use out of band beam switching. For example, the AP and STA may both have multi-band capability. In this example, the AP and the STA may communicate over either a 2.4 GHz or a 5 GHz link in addition to a directional 60 GHz link. The AP and the STA may use one or more of the sub-6 GHz links as an alternate link to signal to each other that the beam set needs to switch to the next best beam set at the beginning of the next data packet. This example procedure may allow for a fast beam switch to occur even if the packet currently being transmitted is not decoded correctly.

[0096] Some examples may implement spatial diversity using a single beam. For example, it may be possible that only one RF chain is available at both transmitter and receiver, such that only one data stream may be transmitted and received at the same time. This RF chain arrangement may be used in mmW systems. With one RF chain, devices may form one beam and transmit the data stream toward the direction specified by the beam. In this example, the devices may forming a beam pointing to a propagation path with the strongest channel gain. Multipath wireless channels, however, may introduce frequency selectivity. A beamforming weight may benefit some frequency tones, however, it may have a detrimental effect for one or more of the other set of frequency tones. Accordingly, there may be no guarantee that the weight pointing to the strongest propagation path will introduce the maximum beamforming gain for the entire frequency channel. Moreover, pointing in one beam direction may increase the system sensitivity to small changes in the multipath environment and may fail to provide robust communication.

[0097] FIG. 2 is a diagram of an example method 200 using two STAs to perform multi-path beamforming. The method may be a multi-stage iterative beamforming method as discussed below, and may include grouping two or more antennas. For example, FIG. 2 shows a first iteration 201 of the method and a second iteration 202 of the method.

[0098] The following articles disclose methods for beamforming. P. Xia, S. K. Yong, J. Oh and C. Ngo, "A practical SDMA protocol for 60GHz millimeter wave communications", Asilomar, 2008; and, P. Xia, S. K. Yong, J. Oh and C. Ngo, "Mulit-stage iterative antenna training for millimeter wave communications", Globecom, 2008, the entire contents of both are incorporated herein by reference.

[0099] Referring to FIG. 2, STA_1 205 and STA_2 210 are respectively shown on two time axes 215 and 220. In this example, STA_1 205 may transmit one or more training beamforming weights, and STA_2 210 may receive training beamforming weights 230, 240, and transmit beamforming weights 235 to STA_1 205. STA_1 205 and STA_2 210 may be, for example, WTRU, stations, electronic communication devices, or access points. The example in FIG. 2 shows STA_1 205 transmitting 230, 240 to only STA_2 210, however there may be more than one STA, which are not shown. STA_1 205 may be an AP or a non-AP STA. STA_2 210 may be an AP or a non-AP STA.

[0100] In each iteration of the method 201, 202, the AP, here STA_1 205, may transmit one or more training sequences over multiple time slots 230 and sweep the transmit beamforming weights. For example, STA_1 205 may be an AP or a non-AP STA. Note that only two iterations of the method 201, 202 are illustrated, but the method may have more than two iterations of the method 201, 202. STA_2 210 may calculate the best transmit beamforming weight vector according to an estimate of the received channel state. Note that the calculated transmit beamforming weight may not be one of the weights the transmitter STA_1 205 originally utilized. The method at STA_2 210 may then feedback this beamforming weight vector 235, or the estimated channel state vector, to the AP, here STA_1 205. The AP, here STA_1 205, may, or may not,

update the transmit beamforming weight it utilizes for a subsequent transmission to STA_2 210. The method may continue until packet transmissions are completed for the associated STAs, STA_2 210.

[0101] The AP, here STA_1 205, may group the antenna array into multiple sub-groups to point the beamforming weight to multiple paths. For example, if there are 36 antenna units and only the two strongest paths are used, then each sub-group may have 18 antenna units. Alternatively, if more antenna gain is anticipated from the strongest path, more antenna units may be assigned to the strongest path. The AP, here STA_1 205, may assign other antenna sub-group partitions depending on the requirements of the system. For example, more than two strongest paths may be used. The method in this example may steer the antenna array in the first sub-group to the strongest path, while the second sub-group may be steered to the second strongest path, and so on. This antenna group partition procedure may be performed by the AP, here STA_1 205, or STA_2 210, or both.

[0102] In another example, antenna group based multi-path beamforming may be performed. In this example, STA_1 205 may have Nt transmit antennas and STA_2 210 may have Nr receive antennas, and only the two strongest paths may be considered.

[0103] The transmitter, for example STA_1 205, may transmit Nt sequences 230. The Nt sequences 230 may be modulated using Nt orthogonal beamforming vectors. STA_1 205 may include a precoder, for example an identity precoder, and may be configured to transmit the first sequence using the first antenna, and transmit the second sequence using the second antenna, and so on. Other orthogonal precoding matrices may be utilized by STA_1 205.

[0104] The receiver, for example STA2 210, may receive the Nt sequences using the receive beamforming vector calculated in the last iteration, W_{i-1}^{r}. In some examples, W_{i-1}^{r} may be set to an initial value. STA2 210 may be configured to determine that the first n time slots correspond to transmit antenna 1 to antenna n, which may correspond to antenna group 1.

STA2 210 may utilize the training sequence transmitted in each time slot to estimate the strongest path of the propagation channel, and may denote the strongest channel path as H1. The received signal from the first n time slots may be expressed as $y_i^{11} = W_{i-1}^r(1:n)Hs + N$, where y may be the received symbol, s may be the sent symbol, N may be the additive Gaussian noise having a variance, and H may be the channel matrix between the transmitter STA1 205 and the receiver STA2 210. The receiver STA2 210 may use the correlation property of the training sequence to estimate the channel corresponding to the strongest propagation path, $\hat{H}_1^1$. Thus, the receiver STA2 210 may determine the best transmit beamforming weight corresponding to antenna group 1 and the strongest path, and may be represented as $(\hat{H}_1^1)'$. The size of the beamforming weight may be $n \times 1$.

[0105] The receiver, STA2 210, may be configured to determine that time slots n+1 to Nt correspond to transmit antenna n+1 to antenna Nt, and may correspond to antenna group 2 of STA1 205. The receiver, STA2 210, may utilize the training sequence transmitted in each time slot to estimate the second strongest path of the propagation channel, and may be denoted as H2. The received signal 245 from the Nt-(n+1)+1 time slots may be expressed as $y_i^{12} = W_{i-1}^r(n+1:Nt)Hs + N$. Since the signal may be transmitted using a sequence with a zero auto correlation (ZAC) property, STA2 210 may use a Rake receiver like method, where the strongest path may be removed, and the channel of the second strongest path may be determined. The second strongest path may be represented by $\hat{H}_2^1$. Thus the best transmit beamforming weight corresponding to antenna group 2 and the second strongest path may be $(\hat{H}_2^1)'$. The size of the transmit beamforming weight may be $(Nt - n) \times 1$.

[0106] The updated transmit beamforming weight for iteration i may be expressed as $W_i^t = [\hat{H}_1^1, \hat{H}_2^1]'$. STA2 210 may transmit W_i^t back to STA1 205 at 235. STA1 205 may use the received W_i^t to transmit 240 another set of beamforming training frames. STA1 205 may transmit Nr repetition of

training frames, where Nr may be the number of antenna(s) at STA2 205. STA2 205 may be configured to use this set of training frames to update the received beamforming weight. STA2 210 may use Nr antennas to receive the training frames sequentially. STA2 210 may also use other orthogonal beamforming weights to receive the Nr training frames. In this example, at STA2 210, antenna 1 to m may belong to the first antenna group, and may be used to point to the strongest propagation path, while antenna m+1 to Nr may belong to antenna group 2, and may correspond to the second strongest propagation path.

[0107] In one example, STA1 205 may use a mixed mode to transmit Nr repetitions of training frames with weight W_i^t. This example mixed mode method is shown in FIG. 2 as 202. The received signal through the Nr time slot may be expressed as $y_i = HW_i^t s + n$. The received signal from antenna group 1 may be $y_i^{21} = y_i(1:m)$. STA2 210 may use the correlation property of the training sequence to estimate the channel with the strongest propagation path, $\hat{H}_1^2$. The received signal from antenna group 2 may be $y_i^{22} = y_i(m+1:Nr)$, and STA2 210 may use correlation detection to remove the strongest path. STA2 210 may accordingly determine the estimated channel for the second strongest path, $\hat{H}_2^2$. STA2 210 may update the receive beamforming weight, which may be represented as $W_i^r = [\hat{H}_1^2, \hat{H}_2^2]'$. In FIG. 2, the reception of the signals is shown in dashed lines as an example illustration of the receiver operation while receiving a packet.

[0108] Alternatively, or in addition to, STA1 205 may use a sequential mode. STA1 205 may transmit m repetitions of training frames with antenna group 1, i.e., $W_1^{t1} = [\hat{H}_1^1, 0]'$. During the m training time slot, the receiver, for example STA2 210, may utilize antenna group 1 to receive the training frames. For example, STA2 210 may utilize antenna 1 to receive the first training frame, and antenna m to receive the mth training frame. The

received signal from these m frames may be expressed as $y_i^{21} = HW_i^{t1}s + n$. STA2 210 may estimate the channel corresponding to the strongest propagation path $\hat{H}_1^2$. STA1 205 may transmit Nr-m repetitions of training frames with antenna group 2 only, for example, $W_1^{t2} = [0, \hat{H}_2^1]'$. STA2 210 may utilize its antenna group 2 to receive the training frames. The received signal may be $y_i^{22} = HW_i^{t2}s + n$. STA2 210 may use a correlation method to determine the channel corresponding to the second strongest path, $\hat{H}_2^2$. STA2 210 may update the receive beamforming weight $W_i^r = [\hat{H}_1^2, \hat{H}_2^2]'$. In some examples, feedback channels corresponding to the strongest paths may be used directly by STA2 210 or STA1 205. Note that this mode is not illustrated in FIG. 2.

[0109] STA2 210 may send $W_i^r = [\hat{H}_1^2, \hat{H}_2^2]'$ to STA1 205 (not illustrated). In addition, the method may repeat for a number of times up to a threshold or until the method converges which may be determined by comparing a next value of the beamforming weights with a previous value of the beamforming weights and determining if the difference is less than a threshold value.

[0110] The initial beamforming weights for STA1 205 and STA2 210 may be set to initial values prior to beginning the method. STA1 205 and STA2 210 may determine the initial values in order to reduce the number iterations needed for the method to converge. The example method shown in FIG. 2 may be used for determining the two strongest paths. However, in other example embodiments, more than two paths may be determined by the STA1 205 and STA2 210.

[0111] Existing protocols may be modified to perform multi-path beamforming methods. For example, a multi-path beamforming method may be used in 802.11 and 802.11ad. For example, the multi-path beamforming method may be used in 802.11ad by using a modification of the beam refinement protocol (BRP) as disclosed in IEEE P802.11ad™/D9.0: Part 11, "Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications," the entire contents of which are herein incorporated by

reference. The multi-path beamforming method may be a multi-iteration multi-path beamforming training method.

[0112] A beam refinement transaction may be a set of BRP frames that include one or more beam refinement requests and responses. The multi-path beamforming method may be implemented by modifying current beamforming refinement protocols.

[0113] FIG. 3 is a diagram of an example of one iteration of the multi-path beamforming method 300 using BRP transactions. The beamforming initiator, STA1 305, may transmit a BRP frame 315 that indicates that the BRP frame 315 is a Transmit BRP Request frame. This indication may be performed by setting a field, for example, TX-TRN-REQ=1. A BRP frame with TX-TRN-REQ=1 315 may include a transmit training subfield (TRN-T) 320 appended to it. The responder, STA2 310 may reply with a Transmit BRP Feedback 325, for example, by setting TX-TRN-RSP=1. Moreover, STA2 310 may request a receive beamforming training by indicating Receive BRP Request frame in the same BRP frame, for example, by setting L_RX>0. In this example, the Receive BRP Request frame may be piggybacked on the Transmit BRP Response frame. L_RX may be a signal field used to indicate that the receiver requests a receive BRP training, and the transmitter may respond with a BRP train response followed by a TRN-R training field. STA1 305 may transmit a BRP frame 330 with a BRP train response, for example, by setting RX-TRN-RSP to 1. A BRP frame that includes an RX-Train-response that equals 1 may include a receive training subfield (TRN-R) 335 appended to it.

[0114] FIG. 4 is a diagram of an example frame format for a BRP packet 402. The BRP packet 402 may include a short training field (STF) 404, a channel estimation (CE) field 406, a Header field 408 and a data field 410. A training field 416 may be appended/prepended to the BRP packet 402 and may include an AGC training field 412 and a receiver/transmitter training subfield (TRN-R/T) 414. A BRP packet 402 may be transmitted using control PHY. Prior to the RTN-R/T training, there may be a signaling exchange to aid the

training procedure. This is the purpose of field 404, 406, 408, 410. A Packet Type field may be included in the PHY header, and it may indicate whether a TRN-R or a TRN-T subfield 414 is appended to the frame 402. A BRP frame 402 with a TRN-R/T 414 field appended may be referred to as a BRP-RX/TX packet 402. In a BRP-TX packet 402, the transmitter may change the TX beamforming weight configuration at the beginning of each AGC subfield 412. The set of beamforming weights used for the AGC subfields 412 may be the same as that used for the TRN-T subfield 414. In a BRP-RX packet 402, the transmitter may use the same transmit beamforming weight as in the preamble and data fields of the transmission data packet. The BRP frame may be an Action No ACK frame.

[0115] FIG. 5 is a diagram of an example format of a BRP frame Action field. The BRP frame Action field 500 may include a Category field 510, an Unprotected DMG Action field 520, a Dialog Token field 530, a BRP Request field 540, a DMG Beam Refinement element 550, and one or more Channel Measurement Feedback elements 5601…560n.

[0116] An 802.11ad beam refinement protocol may be modified as follows in order to accommodate a multi-path beamforming algorithm. For example, an initiator may determine the capabilities of the responder prior to initiating beamforming training with the responder. The multi-path multi-stage iterative beamforming training capability may be indicated in a DMG Capabilities element. A DMG Capabilities element may be present in Association Request, Association Response, Reassociation Request, Reassociation Response, Probe Request and Probe Response frames and may be present in DMG Beacon and Information request and response frames. A DMG Antenna Array Support field may include one or more bits that indicate that the STA is capable of forming sub-antenna groups and capable of performing the multi-path multi-stage beamforming training method.

[0117] Partitioning of antenna sub-groups at both initiator and responder may be signaled. Depending on the antenna grouping method, the

signaling may be different. For example, the antenna grouping may be performed uniformly or non-uniformly.

[0118] In a uniform antenna grouping example, assuming the total number of antennas is even, each antenna sub-group may have the same number of antenna elements, and hence only the number of antenna groups is required to indicate the partition of antenna sub-groups. For example if there are four antennas, and two groups, the number of groups, in this example two, may be sent back since the number of antennas per group will be known. The mapping between antenna element indices and sub-group indices may be predetermined and transmitted explicitly in a field of the BRP frame, for example, a BRP Request field. If the mapping is explicitly indicated in the BRP frame, the antenna sub-group index may be assigned to each antenna element.

[0119] In a non-uniform antenna grouping example, each antenna sub-group may have a different number of antenna elements. For example, the system may assign more antenna elements for the strongest path, so that the antenna gain from this sub-group may be larger. The mapping between antenna element indices and sub-group indices may be predetermined and transmitted explicitly in a field of the BRP frame, for example, in a BRP Request field.

[0120] Mapping between antenna sub-groups and channel propagation paths/taps may be predetermined. For example, antenna sub-group 1 may always map to the strongest path, and so on. Alternatively, the mapping may be defined in the BRP Request field.

[0121] The precoding matrix used by the initiator, for example, STA1 205, in the first part of each iteration may be predetermined and agreed by both initiator and responder. The first part of each iteration may be referred to as the transmit beamforming training part. In one example, a set of unitary precoding matrices may be predetermined. In this example, the initiator and responder may negotiate which matrix is utilized before performing the

beamforming training. For example, the precoding matrix index may be predetermined and transmitted in the BRP Request field.

[0122] The number of antennas at both initiator and responder side may be signaled. Number of antennas may be signaled, for example, in the PHY header, MAC header or BRP Request field.

[0123] FIG. 6 is a diagram of an example modified channel measurement feedback element 600. The channel measurement feedback element may include a signal-to-noise ratio (SNR) subfield 610, a channel measurement subfield 620, a tap delay subfield 630, and a sector ID order subfield 640. The presence of these subfields may depend on the values defined in the DMG Beam Refinement element. For example, the channel measurement subfield may be used to feed back up to Ntap channel measurements that correspond to a common set of relative tap delays defined in the tap delay subfield. Without the presence of the tap delay subfield, for example, the Ntaps channel taps may be interpreted as contiguous time samples, separated by Tc, where Tc may be the SC PHY chip time, and may be 0.57ns. In these exemplary multi-path beamforming methods, the channel measurements of the strongest propagation paths may be sent to STA1. In the example shown in FIG. 2, the strongest path/tap may be assigned for the first antenna sub-group, and the second strongest path/tap may be assigned for the second antenna sub-group and so on. If the multi-path beamforming method is indicated in the PHY header, MAC header or MAC body, the interpretation of the channel measurement may be modified when the tap delay subfield is not present. Therefore, protocols may be modified to accommodate examples of the multi-path beamforming method disclosed herein.

[0124] Weighted multi-path beamforming training methods may be performed. For example, a beamforming method for steering the beam towards multiple propagation paths may be performed. The strongest propagation paths/taps may be determined by a STA, and one or more beamforming weights may be determined to point to one or more of the propagation paths/taps. The beamforming weight for the kth strongest

propagation path may be represented as Wk, and the final beamforming weight may be expressed as $W = \sum_{k=1}^{K} \alpha_k W_k$, where K may be the number of channel propagation paths and α_k may be the weight, with $\sum \alpha_k = 1$.

[0125] Different methods may be used by the STA selecting α_k in one of the following ways. For example, propagation path selection may be based on: $\alpha_k = \begin{cases} 1 & k = m \\ 0 & k \neq m \end{cases}$. By this selection, the final beamforming weight vector may equal the weight vector directed towards the mth propagation path.

[0126] In an 802.11ad example, the channel propagation taps may be measured and fed back to the beamforming initiator, which may be STA1 205. According to the channel measurement of each tap, a channel gain may be estimated by the STA. Channel gain of the kth propagation path/tap may be represented as β_k. α_k may be represented as $\alpha_k = \lambda - \frac{1}{\beta_k}$, so that $\sum \alpha_k = 1$, $\lambda = \frac{1 + \sum 1/\beta_k}{K}$ may be satisfied. The propagation path with the larger channel gain may have a larger weight and may be determined by the STA to be the strongest propagation path.

[0127] A single data stream transmission may be performed with multi-beam capability devices. For example, multiple RF chains may be available at the AP. Accordingly, the AP may form multiple beams simultaneously. In this example, the STA may form only one RF chain. The AP and the STA may be configured to use an Nx1 virtual MIMO channel. The AP and the STA may be configured to use diversity methods, such as, for example, STBC, SFBC and CDD. These example methods may be performed by more than one AP and more than one STA. In addition, a STA may be an AP.

[0128] There may be at least two possible transmission procedures that implement RF front-end beamforming with digital domain STBC. One example transmission procedure may use full size beamforming with STBC.

Another example transmission procedure may use partial size beamforming with STBC.

[0129] FIG. 7 is a diagram of an example AP 700 configured to perform a transmission using full size beamforming with STBC. The AP 700 may include a coding/modulation unit 702, an STBC encoder 706, a plurality of DAC/upconverters 708, 710, and a plurality of antennas 716. In this example, the coding/modulation unit 702 may perform modulation and coding and pass the modulation symbols 704 to the STBC encoder 706. The STBC encoder 706 may generate two data streams 718, 720. The two data streams 718, 720 then be processed through two RF chains at the plurality of DAC/upconverters 708, 710, which may separately perform DAC and up conversion to the operating frequency band. At the RF front-end, two beamforming weight vectors W1 712 and W2 714 may be generated by AP. Each weight-vector may be of size Nt x 1. The first data stream 718 may be multiplied with the first weight vector W1 712, and the second data stream 720 may be multiplied with the second weight vector W2 514. The two data streams 718, 720 may then be summed together and transmitted through the Nt antennas 716. In some embodiments, the AP may be configured with more than two RF chains.

[0130] FIG. 8 is a diagram of an example AP 800 configured to perform a transmission using partial size beamforming with STBC. The AP 800 may include a coding/modulation unit 802, an STBC encoder 806, a plurality of DAC/upconverters 808, 810, and a plurality of sets of antennas 816, 817. In this example, the coding/modulation unit 802 may perform modulation and coding and pass the modulation symbols 804 to the STBC encoder 806. The STBC encoder 806 may generate two data streams 818, 820. The two data streams 818, 820 may then be processed through two RF chains at the plurality of DAC/upconverters 808, 810, which may separately perform DAC and up conversion to the operating frequency band. At the RF front-end, two beamforming weight vectors W1 812 and W2 814 may be generated. Each weight vector may be of size Nt/2 x 1. The first data stream 818 may be multiplied with the first weight vector W1 812, and the second data stream

820 may be multiplied with the second weight vector W2 814. The first data stream 818 may be transmitted through the first set of Nt/2 antennas 816 and the second data stream may be transmitted through the second set of Nt/2 antennas 817. In embodiments, AP may be configured with more than two RF chains.

[0131] The AP and/or the STA may be configured to send and receive multiple data streams. For example, the AP and/or the STA may be configured with multiple RF chains. In these examples, the AP may be configured to communicate with multiple STAs simultaneously. The AP may be configured to distinguish the multiple STAs by spatial domain beams, thus the method may be referred to as Beam Division Multiple Access (BDMA). The AP may need multiple RF chains to perform BDMA. For example, the AP may be configured to use spatial multiplexing methods for single STA transmission. The AP and STA may be configured to send more than one data stream at a time, which may increase the spectral efficiency of the system. Multiple RF chains may be needed at both AP and STA side.

[0132] FIG. 9 is a diagram of an example of transceiver architecture 900. The AP and/or STA may be configured as follows. The transceiver architecture 900 may include a transmitter side 902 and a receiver side 904. The transmitter side 902 may include one or more coding/modulation units 903, a plurality of DAC/upconverters 912, 914, a digital controller 917, one or more power amplifiers (PA)s 920, and a plurality of Nt antennas 925. Multiple data streams may be modulated and coded at baseband, and then converted from a digital domain to an analog domain through the digital controller 917. The streams 908, 910 may be upconverted to operation frequency band by the DAC/upconverters 912, 914. Two sets of DACs and upconverters are illustrated here, which implies that up to two data streams may be supported by the transmitter. Beamforming weights 915, 916 may be applied prior to applying the streams to the PAs 920. The beamforming weights 915, 916 may be prepared in a digital domain.

[0133] The transmitter 902, may be an AP or STA, an may be configured with Nt antennas 925. The Nt antennas 925 may be shared by two or more RF chains. When the transmitter 902 has two data streams $\{s_1, s_2\}$ to transmit, it may generate two beamforming weights $V^1 = (V_1^1, V_2^1, ..., V_{Nt}^1)^T$ 916 and $V^2 = (V_1^2, V_2^2, ..., V_{Nt}^2)^T$ 915. The two signal streams may be combined and transmitted through Nt transmit antennas 925, $s = V^1 s_1 + V^2 s_2$. The AP and STA may be similarly configured on the receiver side if multiple RF chains are presented. The receiver 904 may generate two sets of receive beamforming weights $U^1 = (U_1^1, U_2^1, ..., U_{Nr}^1)^T$ 936 and $U^2 = (U_1^2, U_2^2, ..., U_{Nr}^2)^T$ 935 and apply them in an analog domain. The weighted streams may be applied to a respective ADC/downconverter. The downconverted streams 908', 910' may be decoded and demodulated.

[0134] Communication devices, which may be, for example, APs or STAs, with the transceiver embodiment illustrated in FIG. 9 may be referred to as Type I. In some embodiments, the AP and/or STA may be configured with more than two RF chains where FIG. 9 may be extended to accommodate the more than two RF chains.

[0135] FIG. 10 is a diagram of another example transceiver architecture 1000. The transceiver architecture 1000 may include a transmitter side 1002 and a receiver side 1004. In this example, the AP and or the STA may be configured as follows. Each RF chain may have its own set of antennas 1048, 1050, respectively. The antennas may be deemed to have been partitioned or split into sub-groups based on the number of RF chains. Compared to Type I devices, in order to achieve the same antenna gain, N antenna elements may be required. Here N may be the number of RF chains. Communication devices, which may be, for example, APs or STA, with the transceiver architecture illustrated in FIG. 10 may be referred to as Type II. The beamforming weights in FIG. 10, may be tuned as a group by the digital controller logic, as indicated by the dashed lines.

[0136] FIG. 11 is a diagram of an example of beam division multiple access (BDMA) architecture 1100. The AP 1102 may be configured to transmit two packets to STA1 1106 and STA2 1104 simultaneously. The STAs 1106, 1104 may be configured to share the time-frequency resource by different RF front-end beams.

[0137] The AP 1102 may be configured to prepare MAC packets for both STA1 1106 and STA2 1104. The AP 1102 may encode and modulate the MAC packets and form separate PHY packets and up convert them to 60 GHz through separate RF chains. At the RF front-end, the AP 1102 may apply beamforming weight vector W1 to the first data stream and W2 to the second data stream. The AP transmits a combination of the two data streams. In this way, multiple RF chains may share the same set of antennas as shown in FIG. 9. Alternatively, the AP 1102 may be configured to implementation BDMA by dividing, grouping, or partitioning the set of antennas to sub-groups, and each RF chain control may be sent by the AP 1102 on one antenna sub-group as shown in FIG. 10.

[0138] The AP and STA may be configured to perform a beamforming training method for BDMA. The AP and/or STA may be configured to perform the beamforming training method sequentially with one or more STAs in communication with one another. The example beamforming training methods may be standardized, for example, and may be used in 802.11ad. The AP and/or STA may be configured to use orthogonality between training beams.

[0139] FIG. 12 is a diagram of an example beamforming training method 1200 for BDMA. This example may use a multi-stage iterative beamforming training algorithm for BDMA. In the example illustrated, the AP 1202 has Nt antennas, STA1 1204 has M1 antennas and STA2 1206 has M2 antennas.

[0140] The beamforming training method for BDMA may be performed iteratively. The AP 1202 may transmit Nt sequences 1208. The Nt sequences 1208 maybe modulated using Nt orthogonal beamforming vectors. The

example shown in FIG. 12 may be performed using a precoder, for example, an identity precoder. In this example, the first sequence may be transmitted using a first antenna ("Ant 1") 1208, and a second sequence may be transmitted using the second antenna, and so on until the Nt antenna ("Ant Nt") 1210. The AP 1202 may be configured to use other orthogonal precoding matrices, such as, for example, the Walsh Hadamard matrix or FFT matrix.

[0141] STA1 1204 may be configured to utilize the best receive beamforming vector 1212 calculated through the last iteration, W_{i-1}^{r1}, to receive the signals. In FIG. 12, the reception of the signals is shown in dashed lines as an example illustration of the receiver operation while receiving a packet. For example, the dashed box W_{i-1}^{r1} may indicate that the STA1 1204 should use receive beamforming vector W_{i-1}^{r1} to perform receive beamforming. Since the AP 1202 may have transmitted the signal through each antenna sequentially, STA1 1204 may receive a Nt x 1 effective MISO channel between AP 1202 and STA1 1204, $W_{i-1}^{r1}H_1$ at the end of the transmission due to the use of the receive beamformer. Equivalently, the received signal may be expressed in a matrix format: $y_{11} = W_{i-1}^{r1}H_1 s + n$, where y may be the received signal, s may be the sent signal, n may be Gaussian noise, W may be the weight used by STA1 1204, and H may be the channel matrix between AP 1202 and STA1 1204. Based on the received signal, STA1 1204 may calculate or determine the best transmit beamforming weight from AP 1202 to STA1 1204 which may be represented as $V_i^{r1} = \frac{y_{11}s'}{\|y_{11}s'\|}$.

[0142] Similarly, STA2 1206 may be configured to utilize W_{i-1}^{r2} to receive the signals, and the received signal may be expressed as $y_{12} = W_{i-1}^{r2}H_2 s + n$. The best transmit beamforming weight from AP 1202 to STA2 1206 may be represented as $V_i^{r2} = \frac{y_{12}s'}{\|y_{12}s'\|}$, which STA2 1206 may be configured to determine.

[0143] The method may continue with STA1 1204 sending V_i^{r1} 1222 to the AP 1202. STA2 1206 may send V_i^{r2} 1220 to the AP 1202. STA2 1206 may transmit the packet immediately after the transmission of STA1 1204, or STA2 1206 may wait for a polling frame transmitted from the AP 1202 (not illustrated) before transmitting the packet.

[0144] The method may continue with the AP 1202 calculating MU-MIMO weight W_i^{t1} and W_i^{t2} based on V_i^{r1} and V_i^{r2}. The AP 1202 may then implement a linear or non-linear MU-MIMO precoding algorithm for this weight update 1209.

[0145] The method may continue with the AP 1202 transmitting 1230 again with the best beamforming weights and each STA 1204, 1206 receiving with multiple receive antennas.

[0146] The method may continue with one of the following alternatives. In a first alternative, as illustrated in FIG. 12, the AP 1202 may transmit $W_i^{t1}s_1 + W_i^{t2}s_2$ for Max(M1,M2) times 1230. s_1 and s_2 may be orthogonal sequences, and may be known at AP 1202, STA1 1204 and STA2 1206. The AP 1202 may signal STA1 1204 and STA2 1206 about the assignment of s_1 and s_2. STA1 1204 may be configured to switch receive antennas to train the best receive beamforming weight W_i^{r1}. Similarly, STA2 1206 may train the best receive beamforming weight W_i^{r2}. STA1 1204 may use the orthogonal sequences to estimate the current signal (via cross correlation with s_1) and the current interference (via cross correlation with s_2). Thus, STA1 1204 may train its receive beamforming vectors by nulling the interference. Similarly, STA2 1206 may use the orthogonal sequences to estimate the current signal (via cross correlation with s_2) and the current interference (via cross correlation with s_1). Then, STA2 1206 may train its receive beamforming vectors by nulling the interference.

[0147] In a second alternative, the AP 1202 may transmit $W_i^{t1}s$ for M1 repetitions. STA1 1204 may switch between its M1 antennas to receive $W_i^{t1}s$, and at the same time, STA2 may monitor the transmission of $W_i^{t1}s$. AP 1202 may transmit $W_i^{t2}s$ for M2 repetitions and STA2 may switch between its M2 antennas to receive $W_i^{t2}s$ while STA1 1204 monitors the transmission of $W_i^{t2}s$.

[0148] The example beamforming training method for BDMA may not be successful. If the correlation between two STAs 1204, 1206 is high, the two STAs 1204, 1206 may not be distinguished by beams. This may lead to an unsuccessful beamforming training for BDMA. In this example, the AP 1202, and or STAs 1204, 1206, may be configured to provide information if BDMA may or may not be supported with the current configuration. The STAs 1204, 1206 may include the report of beamforming gain when they report V_i^{r1} and V_i^{r2} to the AP 1002. The beamforming gain may be defined as $\|y_{11}s'\|^2$ and $\|y_{12}s'\|^2$. Alternatively, or in addition, the STAs 1204, 1206 may report signal to interference ratio (SIR) during or at the end of the method. The STAs 1004, 1006 may determine or calculate the desired signal strength and interference signal strength with both example alternatives.

[0149] The BDMA training method may include performing BDMA training on each STA 1204, 1206 sequentially. This example method may be extended for more than two STAs.

[0150] Examples of the BDMA training method may be standardized. For example, the BDMA training method may be used with IEEE 802.11ad. In these examples, a service period (SP) may be a time period scheduled for service from one device to another device. The transmission during an SP duration may be scheduled by an AP. The BDMA training method may be scheduled by the AP if it is allocated in an SP duration. Examples of the BDMA training method may be used by modifying the BRP procedures.

[0151] FIG. 13 is a diagram of an example modified BRP procedure to implement a multi-stage iterative beamforming training method for BDMA 1300. In this example, AP 1302 may transmit a BRP frame 1320 that indicates a Transmit BDMA BRP Request. A Transmit BDMA BRP Request subfield may be defined in BRP Request field, and may indicate that the BRP frame is for transmit BDMA BRP training. Alternatively, a Transmit BRP Request may be used with TX-TRN-REQ=1 to indicate that the BRP frame is for transmit BRP training. A frame that is utilized for single user beamforming training or BDMA training may be indicated implicitly or explicitly in the MAC frame or PHY header.

[0152] STA1 1304 may reply with a Transmit BRP Feedback frame 1322 by setting TX-train-response=1. STA1 1304 may also request a receive beamforming training by indicating Receive BRP Request in the same Transmit BRP Feedback frame 1322 by setting L_RX>0.

[0153] AP 1302 may transmit a Polling frame 1324 to STA2 1304 to request BRP feedback. This step may be skipped if the frame length of BRP feedback frame is fixed and known by all the devices.

[0154] STA2 1306 may reply with a Transmit BRP Feedback frame 1326 by setting TX-train-response=1. STA2 1306 may also request a receive beamforming training by indicating Receive BRP Request in the same Transmit BRP Feedback frame 1326 by setting L_RX>0.

[0155] AP 1302 may transmit a BDMA BRP frame 1328 indicating a BRP train response by setting RX-Train-response to 1. A BRP frame with RX-Train-response equal to 1 may include a receive training subfield TRN-R 1330 appended to it. A BDMA BRP frame 1328 may indicate multiple receivers explicitly or implicitly in PHY header or MAC body.

[0156] The example in FIG. 13 shows that one AP 1302 may transmit to two STAs 1304, 1306. However, the BDMA transmission may be from one device to two devices irrespective of whether they are APs or STAs. Moreover, the AP 1302 may transmit to two or more STAs.

[0157] Examples of the method in FIG. 13 may include BDMA protection mechanisms. The feedback frame 1322 may include not only the best beam, but also the achievable SINR. If after a certain number of iterations, the achievable SINR is less than the target SNR, the BDMA method may be aborted. The number of iterations may be predetermined, determined statically, dynamically determined based on previous methods running, or in another way.

[0158] BDMA grouping may be indicated in some examples. The following examples may enable an indication of BDMA grouping by one or more communication devices. Using an SP, the BDMA grouping information may be indicated in an allocation field in an Extended Schedule Element. The Extended Schedule Element may be transmitted in a Beacon frame. The tuple, Source AID, Destination AID and Allocation ID may uniquely identify the allocation. The Source AID field may be set to the AID of the STA an may initiate channel access during the SP. The Destination AID field may indicate the AID of a STA that may be expected to communicate with the source STA during the allocation. The Allocation ID may identify an airtime allocation from a Source AID to a Destination AID. With BDMA transmission, more than one receiver may be indicated. One method may be to group BDMA transmitters and receivers, and assign each group a unique BDMA ID. Each STA corresponding to a BDMA ID may be assigned a User Position Array that may be used to distinguish the role of the STA. Therefore, the Destination AID may be replaced by the BDMA ID for BDMA transmissions. Alternatively, more than one Destination AID may be included in the allocation field. In this way, the order of the Destination AIDs may imply the role of one or more STAs in the BDMA transmission.

[0159] Since the BDMA transmission may be within the SP time slot, the communication device may not need to signal the BDMA transmission in the PHY header or MAC header. The MCS levels and Length field for each BDMA receiver may be signaled in PHY Header.

[0160] FIG. 14 is a diagram of an example PHY layer frame format 1400 that may be used in a BDMA transmission. N may represent the number of BDMA communication devices that may be signaled in the allocation field in Extended Schedule Element. The example PHY layer frame format 1400 may include an STF field 1410, one or more CE fields 1420, a header 1430, and a data field 1440. The one or more CE fields 1420 may be transmitted with a weight and a P matrix. The weight for the one or more CE fields may range from W1 to WN, for example, the first field may be transmitted with a weight W1, and the last CE field may be transmitted with a weight WN. The header 1430 and data field 1440 may be transmitted using BDMA and with all of the weights from W1 to WN.

[0161] Example embodiments may include performing BDMA in a contention based access period. For example, BDMA transmission protocols may be used by the communication device. Performing a BDMA transmission in a contention based access period may utilize the NDP announcement (NDPA) and NDP sequences for beamforming training. BDMA transmission may be performed after the NDP sequence exchanges. Alternatively, or in addition, the BDMA transmission may be delayed until the BDMA initiator, which may be a STA or an AP, acquires the media again.

[0162] In one example BDMA transmission procedure, one or more of the communication devices may be configured to use an NDPA period. In this example, an AP may transmit a message that indicates which STAs should participate in BDMA training. The NDPA frame may contain a STA info field to indicate the individual STA information. The NDPA frame may reserve a TXOP until the end of BDMA beamforming training by setting the duration period accordingly. Alternatively, the NDPA frame may reserve a TXOP until the end of the BDMA transmission.

[0163] In another example, an NDP period may be configured to allow training of transmit antennas at the AP. In this example, the STAs may perform measurements. In another example, a feedback period may be configured to allow STAs to take turns to feedback the best beam vectors as

well as the achievable SINRs. Moreover, STAs may also feedback the measured channels or the calculated transmit beamforming weight vectors.

[0164] In another example, a receiver training period may be configured to allow an AP to set its beamforming vectors. In this example, STAs may train their receive antennas.

[0165] In another example, the NDP period, feedback period, and receiver training period may be repeated for a number of iterations. A number of stopping criteria may be applied in this example. For example, if the achievable SINR meets expectation, the iteration may stop early. In these examples, BDMA transmissions may begin a certain inter-frame spacing after training is performed. ACK1 and ACK 2 may each be followed by a SIFs duration after BDMA transmission is performed.

[0166] In another example, one or more communication devices may be configured to indicate BDMA grouping. The following is an example of indicating grouping. BDMA grouping with contention based access period (CBAP) may be performed by using a BDMA ID. A BDMA ID management frame may be transmitted from an AP to a STA to indicate whether the STA belongs to one of the BDMA groups and the user position of the STA. The BDMA ID management frame may contain a Membership Status Array field and a User Position Array field. The BDMA ID may be included in BDMA related frames, such as BDMA training frames, BDMA transmission frames, or other similar frames.

[0167] One or more communication devices may be configured to perform a BDMA transmission method for CBAP that may be similar to that defined for SP. The BDMA transmission may be performed after the BDMA initiator, for example the AP, acquires a TXOP in the CBAP. The PHY layer frame format may be the same as illustrated FIG. 14. The transmission of BDMA in CBAP may not be scheduled by the AP. Accordingly, the BDMA ID may be included in the PHY header. The number of users or communication devices, N, may be indicated in the sequence exchange to acquire the TXOP

before a BDMA transmission. Alternatively, it may be implicitly indicated using a short training field (STF) and/or a channel estimation (CE) field.

[0168] In some examples, the communication devices may be configured to perform single user spatial multiplexing. In order to perform spatial multiplexing, both transmitter and receiver may have multiple RF chains. FIG. 9 and FIG. 10 are example transceiver configurations to perform single user spatial multiplexing. A communication device with the transceiver configuration shown in FIG. 9 may be referred to as a Type I device, i.e., where multiple RF chains share the same set of antenna elements. A communication device with the transceiver configuration shown in FIG. 10 may be referred to as a Type II communication device, i.e., where the antenna elements may be split into sub-groups, and each sub-group may correspond to one RF chain.

[0169] The communication devices may be configured to perform beamforming methods for spatial multiplexing. In this example, several beamforming methods may be used to perform spatial multiplexing transmission between a pair of communication devices. Two types of example beamforming methods may be used. The first example method may be referred to as Eigen-Beamforming based spatial multiplexing. In this example, the initiator/responder may estimate the channel over the air and calculate beamforming weights accordingly. The second example method may be referred to as beam sweep based spatial multiplexing. With this method, both initiator and responder may transmit and receive using pre-defined beam sectors. The beamforming beams may then be selected from these beam sectors.

[0170] The communication devices may be configured to perform an Eigen-Beamforming based spatial multiplexing method, where the communication devices may be configured as Type I devices with calibration. Type I devices may have multiple RF chains sharing the same set of antennas as discussed in conjunction with FIG. 9. If the communication devices are configured to calibrate the multiple transmit RF chains, the communication

devices may determine that the multiple RF chains are identical. Examples of non-calibrated or identical RF chains are discussed below.

[0171] FIG. 15 is a diagram of an example beamforming training procedure 1500 using Eigen-beamforming based spatial multiplexing where the Type I communication devices may be configured to calibrate the multiple transmit RF chains. An iterative example with two RF chains at both initiator and responder is shown in FIG. 15, however, the method may be extended to any number of RF chains. In this example, the transmitter (STA1) 1502 may have Nt antenna elements, and the receiver side (STA2) 1504 may have Nr antenna elements.

[0172] The beamforming training method may be performed iteratively. In each iteration, the transmit beamforming training may be performed and then the receive beamforming training may be performed. An example of a detailed method for Type I devices with calibration is described below.

[0173] For iteration i, STA1 1502 may act as an initiator, and may transmit Nt training sequences 1506 sweeping all the transmit antenna elements. The transmission may be performed using the first transmit RF chain (TX1) or the second transmit RF chain (TX2) of STA1 1502. In some examples, the two RF chains may be identical or differ by a scalar, or, in other examples, the two TX chains may be calibrated. Alternatively, STA1 1502 may also use an orthogonal precoding matrix to transmit the Nt training sequences.

[0174] STA2 (responder) 1504 may have two receive beamforming weights trained from previous iterations, and may be represented by W_{i-1}^{r1} and W_{i-1}^{r2}. If this is the first iteration of the method, STA2 1504 may randomly select two beamforming weights, or use Omni weights, or may determine the two beamforming weights in an alternate method. The first RF chain (RX1) may receive a signal that is the weighted combination of signals received from all the receive antenna elements. This weight may be the first receive beamforming weight W_{i-1}^{r1}. Similarly, the second RF chain (RX2) may receive a

signal that is the weighted combination of signals received from all the receive antenna elements. This weight may be the second receive beamforming weight W_{i-1}^{r2}. In FIG. 15, the reception of the signals is shown in dashed lines as an example illustration of the receiver operation while receiving a packet. For example, the dashed box W_{i-1}^{r1} may indicate that the STA1 1504 should use receive beamforming vector W_{i-1}^{r1} to perform receive beamforming. After conversion to the digital domain, STA2 1504 may estimate the effective channel by comparing the received sequence with the known transmitted sequence. For time slot k, STA2 1504 may estimate two channels using two RF chains $\begin{bmatrix} G_{k1} \\ G_{k2} \end{bmatrix}$. With Nt time slots, STA2 1504 may receive $\begin{bmatrix} G_{11} & \dots & G_{Nt1} \\ G_{12} & \dots & G_{Nt2} \end{bmatrix}$. Applying the inverse of the orthorgonal precoding matrix, STA2 1504 may obtain the channel from Nt transmit antenna elements to two RF chains as $H = \begin{bmatrix} H_{11} & \dots & H_{Nt1} \\ H_{12} & \dots & H_{Nt2} \end{bmatrix}$.

[0175] STA2 1504 may feedback the channel information or beamforming weights for multiple data streams to STA1 1502. STA2 1504 may calculate the transmit beamforming weights for spatial multiplexing and feedback 1508 the weights to STA1 1502. STA2 1504 may feedback the channel H to STA1 1502, and STA1 1502 then may determine or calculate the transmit beamforming weights 1510.

[0176] In some examples, the transmit beamforming weight method may be implementation dependent. For example, STA1 1502 and/or STA2 1504 may use linear or non-linear procoding algorithms.

[0177] The updated transmit beamforming weights for the ith iteration may be denoted as (W_i^{t1}, W_i^{t2}). STA1 1502 may transmit a training sequence Nr times with beamforming weight W_i^{t1} 1512. STA2 1504 may sweep through Nr receive antennas 1514, or apply an orthorgonal matrix. STA2 1504 then passes the received signal through the two RF chains. STA1 1502 may

transmit training sequences again Nr times with beamforming weight W_i^{t2} 1516. STA2 1504 may repeat a similar procedure with both RF chains 1518. The sweeping of the Nr receive antennas 1514 and 1518 is shown in dashed lines as an example illustration of receiver operation. For example, to receive Nr packets from the transmitter, the receiver may receive a first packet with the first receive antenna, a second packet with the second receive antenna, and so on, until it receives a last packet with the last receive antenna. STA2 1504 may estimate the channel and update the receive beamforming weight accordingly (not shown). The receive beamforming weight method may be implementation dependent.

[0178] The above method may be repeated until the method converges or certain criteria have been met that indicate that spatial multiplexing is not suitable for the pair of devices, for example, a set of failure criteria). There may be several ways to define failure criteria that indicate that the pair of devices are not suitable for spatial multiplexing. A first example of failure criteria may be that STA2 monitors the rank or condition number of a channel matrix while selecting a beamforming weight, and may feedback this information to STA1. A second example of failure criteria may be that STA2 monitors the rank or condition number of channel matrix while sweeping through Nr receive antennas or applying an orthogonal matrix, and feeds back this information to STA1. If the rank is less than the number of data streams expected to be supported, or the condition number is greater than a certain threshold, both STA1 and STA2 may determine that the maximum number of data streams supported may not meet the desired number. In this example, the pair of devices may determine to complete the training procedure, and perform RF selection at both transmitter and receiver later. For example, the pair of devices may terminate the training with a full set of RF chains, and return to perform beamforming training with a lesser number of RF chains. For example, after training, the devices may transmit with a lesser number of spatial streams.

[0179] A method of Eigen-beamforming for spatial multiplexing may be performed. The method may be for communication devices that are of Type I or Type II as discussed in conjunction with FIG. 9.

[0180] Type I devices may perform transmit RF chain training sequentially if the RF chains are not calibrated. Even though the RF chains share the same set of antenna elements and the physical channels over the air may be the same, the effective channels, which may be the combination of channel over the air and transmit/receive RF chains, may be measured and estimated.

[0181] Type II devices may split the antenna elements into sub-groups, and each sub-group has an RF chain. In these examples, there may be two RF chains and two sub-groups of antennas. The physical channel corresponding to RF chain 1 may be transmitted with antenna sub-group I, which may be different from that corresponding to RF chain 2 that may be transmitted with the other antenna sub-group. Because of this, the training for multiple transmit RF chains may be performed sequentially.

[0182] FIG. 16 is a diagram of an example beamforming training method 1600 for Eigen-beamforming based spatial multiplexing for Type I devices and for Type II devices without calibration. For iteration i, STA1 1602 (initiator) may transmit Nt repetitions of training sequences sweeping all the transmit antenna elements in a first antenna sub-group using the first transmit RF chain (TX1) 1606. Then STA1 1602 may transmit Nt repetitions of training sequences sweeping all the transmit antenna elements in the second antenna sub-group using the first transmit RF chain (TX2) 1608. STA1 1602 may also use an orthorgonal precoding matrix to transmit the Nt repetitions of training sequences. The first antenna sub-group may be the same as the second antenna sub-group for Type I devices, STA1 1602; while for Type II devices, STA1 1602, they may correspond to different antenna elements.

[0183] STA2 (responder) 1604 may have the two receive beamforming weights trained from the previous iterations. If this is the first iteration,

STA2 1604 may randomly select two beamforming weights, use Omni weights, or select the weights in an alternate manner. The first receive RF chain (RX1) may obtain a signal as the weighted combination of signals received from all antenna elements. The weight may be the first receive beamforming weight W_{i-1}^{r1}. Similarly, the second receive RF chain (RX2) may obtain a signal as the weighted combination of signals received from all the antenna elements. The weight may be the second receive beamforming weight W_{i-1}^{r2}. The sweeping of the Nr receive antennas 1616 and 1618 is shown in dashed lines as an example illustration of receiver operation. For example, to receive Nr packets from the transmitter, the receiver may receive a first packet with the first receive antenna, a second packet with the second receive antenna, and so on, until it receives a last packet with the last receive antenna. After converting them to baseband and digital domain, STA2 1604 may estimate the effective channel by comparing the received sequence with the known transmitted sequence. For time slot k, STA2 1604 may estimate two channels using two RF chains $\begin{bmatrix} G_{k1} \\ G_{k2} \end{bmatrix}$. With 2Nt time slot, STA2 may receive $\begin{bmatrix} G_{11} & \dots & G_{2Nt1} \\ G_{12} & \dots & G_{2Nt2} \end{bmatrix}$. The first half of the G matrix, $G_{TX1} = \begin{bmatrix} G_{11} & \dots & G_{Nt1} \\ G_{12} & \dots & G_{Nt2} \end{bmatrix}$, may correspond to TX1, and the second half of the G matrix, $G_{TX2} = \begin{bmatrix} G_{(Nt+1)1} & \dots & G_{2Nt1} \\ G_{(Nt+1)2} & \dots & G_{2Nt2} \end{bmatrix}$, may correspond to TX2. Applying the inverse of the orthorgonal precoding matrix to the first half and second half of G matrix respectively, STA2 1604 may obtain the channel from Nt transmit antenna elements with two transmit RF chains to two receive RF chains $H = \begin{bmatrix} H_{11} & \dots & H_{2Nt1} \\ H_{12} & \dots & H_{2Nt2} \end{bmatrix}$.

[0184] STA2 1604 may transmit channel information or beamforming weights for multiple data streams 1610 to STA1 1602. STA2 1604 may calculate the transmit beamforming weights to perform spatial multiplexing for STA1 1602, and transmit the weights 1610 to STA1 1602. STA2 1604 may

transmit the channel H 1610 to STA1 1602, and STA1 1602 then may determine or calculate the transmit beamforming weights for itself 1620.

[0185] For example, the transmit beamforming weight method may be implementation dependent, and linear or non-linear procoding methods may be used. The updated transmit beamforming weights for ith iteration may be denoted as (W_i^{t1}, W_i^{t2}). STA1 1602 may transmit training sequences Nr times with beamforming weight W_i^{t1} 1612. STA2 1604 may sweep through Nr receive antennas 1616, or apply an orthorgonal matrix. STA2 1604 may pass the received signal to two RF chains. STA1 1602 may transmit training sequences 1614 again for Nr times with beamforming weight W_i^{t2}. STA2 1604 may repeat the same procedure with both RF chains 1618. The sweeping of the Nr receive antennas 1616 and 1618 is shown in dashed lines as an example illustration of receiver operation. For example, to receive Nr packets from the transmitter, the receiver may receive a first packet with the first receive antenna, a second packet with the second receive antenna, and so on, until it receives a last packet with the last receive antenna. STA2 1604 may estimate the channel and update the receive beamforming weight 1622 accordingly.

[0186] For example, the receive beamforming weight method may be implementation dependent, and may be repeated for several iterations until the algorithm converges or certain criteria have been met that indicate that spatial multiplexing is not suitable for the pair of devices, STA1 1602 and STA2 1604.

[0187] There may be several ways to define failure criteria to indicate that the pair of devices are not suitable for spatial multiplexing. For example, the failure criteria may include STA2 monitoring the rank or condition number of channel matrix when selecting beamforming weights, and feeding back this information to STA1. A second example of a failure criteria may include STA2 monitoring the rank or condition number of channel matrix

while sweeping through Nr receive antennas or applying an orthogonal matrix, and feeding back this information to STA1.

[0188] If the rank is less than the number of data streams expected to be supported, or the condition number is greater than a certain threshold, both STA1 and STA2 may determine that the maximum number of data streams that may be supported does not meet the requirements. In this example, the pair of devices may determine to complete the training procedure, and perform RF selection at both transmitter and receiver later. Alternatively, the pair of devices may terminate the training with full set of RF chains, and return to performing beamforming training with a fewer number of RF chains. After training, they may transmit with a fewer number of spatial streams.

[0189] In some examples, methods for beam sweep based spatial multiplexing for Type I devices with calibration may be performed. For example, the method of beam sweep based spatial multiplexing may be similar to Eigen-Beamforming based spatial multiplexing. Examples using Eigen-Beamforming based spatial multiplexing may require that the channel estimate and the transmit/receive weights for spatial multiplexing may be determined based on the estimated channel, which may not necessarily be the same as one of the beams used for beamforming training. In beam sweep based spatial multiplexing, there may be no requirement for channel estimation. The device may select one or multiple beams from the set of beams used for beam sweep training. For example, implementation of beam sweep based beamforming may be easier than Eigen-Beamforming based beamforming. The performance of the beam sweep based methods may be sub-optimum compared to the Eigen-beamforming based methods.

[0190] FIG. 17 is a diagram of an example beamforming training method 1700 for beam sweep based spatial multiplexing for Type I devices with calibration between two TX chains. Referring to FIG. 17, for iteration i, STA1 (initiator) 1702 may transmit N repetitions of training sequences 1706 sweeping the transmit beams it intends to train. In these examples, N may

not necessarily be related to the number of transmit antennas. The transmission 1706 may be performed using the first transmit RF chain (TX1) or the second transmit RF chain (TX2). The two RF chains may be identical or different by a scalar. In some examples, the two TX chains may have been calibrated.

[0191] STA2 (responder) 1704 may have the two receive beams trained from the previous iterations. If this is the first iteration, STA2 1704 may randomly select two beams, use Omni weights, or select initial values in an alternate manner. The first receive RF chain (RX1) of STA2 1704 may obtain a signal as the weighted combination of signals received from all antenna elements. The weight may be the first receive beamforming weight W_{i-1}^{r1}. Similarly, the second receive RF chain (RX2) of STA2 1704 may obtain a signal as the weighted combination of signals received from all the antenna elements. The weight may be the second receive beamforming weight W_{i-1}^{r2}. $\{W_{i-1}^{r1}, W_{i-1}^{r2}\}$ may be the weights corresponding to beam indices $\{ID_{i-1}^{r1}, ID_{i-1}^{r2}\}$. After converting them to baseband and digital domain, STA2 1704 may measure the effective SNR or equivalent parameters. For time slot k, STA2 1704 may perform SNR measurements using two receive RF chains $\begin{bmatrix} SNR_{k1} \\ SNR_{k2} \end{bmatrix}$. With N time slots, STA2 1704 may receive $\begin{bmatrix} SNR_{11} & \dots & SNR_{N1} \\ SNR_{12} & \dots & SNR_{N2} \end{bmatrix}$. In FIG. 17, the reception of the signals is shown in dashed lines as an example illustration of the receiver operation while receiving a packet.

[0192] STA2 1704 may feedback two beam indices to STA1 1702. The beam selection method may be implementation dependent. For example, the STA2 1704 may choose the pair of indices (ID_i^{t1}, ID_i^{t2}) which may satisfy $ID_i^{t1} = \arg\max_k (SNR_{k1}^{TX} - SNR_{k2}^{TX})$, and $ID_i^{t2} = \arg\max_k (SNR_{k2}^{TX} - SNR_{k1}^{TX})$.

[0193] The updated transmit beam indices for the ith iteration may be (ID_i^{t1}, ID_i^{t2}). STA1 1702 may transmit a training sequence for M times with

beam ID_i^{t1} 1720. STA2 1704 may sweep through M receive beams with both receive RF chains (RX1 and RX2) 1722. STA1 1702 may transmits a training sequence again for M times with beamforming weight ID_i^{t2} 1724. STA2 1704 may repeat the similar procedure with both RF chains 1726. The sweeping of the receive antennas 1722 and 1726 is shown in dashed lines as an example illustration of receiver operation. For example, to receive packets from the transmitter, the receiver may receive a first packet with the first receive antenna, a second packet with the second receive antenna, and so on, until it receives a last packet with the last receive antenna. STA2 1704 may measure the SNR or equivalent parameters and update the receive beam index accordingly. The receive beam selection method may be implementation dependent. For example, M may be the number of receive beams STA2 1704 intends to train and it may not necessarily be related to a number of receive antennas at STA2 1704. The method may be repeated until the method converges or certain criteria have been met that indicates that spatial multiplexing is not suitable for the pair of devices.

[0194] Failure criteria may be defined in several different ways. For example, failure criteria may indicate that the pair of devices is not suitable for spatial multiplexing. In one example, the failure criteria may be defined as when STA2 1704 may record $\Delta_{11}^{SNR} = \max_k (SNR_{k1}^{TX} - SNR_{k2}^{TX})$ and $\Delta_{12}^{SNR} = \max_k (SNR_{k2}^{TX} - SNR_{k1}^{TX})$ when selecting beams, and feedback this information to STA1 1702. In another example, STA2 1704 may record $\Delta_{21}^{SNR} = \max_{1 \le k \le N} (SNR_{k1}^{RX} - SNR_{k2}^{RX})$ and $\Delta_{22}^{SNR} = \max_{N < k \le 2N} (SNR_{k2}^{RX} - SNR_{k1}^{RX})$ when sweeping beams, and feedback this information to STA1 1702.

[0195] If Δ_{ij}^{SNR} is smaller than a certain threshold, both STA1 1702 and STA2 1704 may determine that the channel cannot provide enough spatial diversity to support two data streams. In this example, STA1 1702 and STA2 1704 may determine to complete the training procedure, and perform RF selection at both transmitter and receiver. STA1 1702 and STA2 1704 may

terminate the training with two RF chains, and return to performing beamforming training with one RF chain. After training, they may transmit with a fewer number of spatial streams. For example, more than two data streams may be determined.

[0196] Beam sweep based spatial multiplexing for Type II devices and Type I devices without calibration may be performed. FIG. 18 is a diagram of an example beamforming training method 1800 for beam sweep based spatial multiplexing Type II devices and Type I devices without calibration.

[0197] For iteration i, STA1 (initiator) 1802 may transmit N repetition of training sequences sweeping all the transmit beams it intends to train using the first transmit RF chain (TX1) 1806. Then STA1 1802 may repeat the same procedure with the second RF chain (TX2) 1808. N may not necessarily be related to the number of transmit antennas. For example, the beam pattern used for TX1 may not be the same as that for TX2.

[0198] STA2 (responder) 1804 may have the two receive beams trained from the previous iterations. If this is the first iteration, STA2 1804 may randomly select two beams, use Omni weights, or select the two beams in a different way. The first receive RF chain (RX1) 1810 may obtain a signal as the weighted combination of signals received from all antenna elements. The weight may be the first receive beamforming weight W_{i-1}^{r1}. The second receive RF chain (RX2) 1812 may obtain a signal as the weighted combination of signals received from all the antenna elements. The weight may be the second receive beamforming weight W_{i-1}^{r2}. For example, $\{W_{i-1}^{r1}, W_{i-1}^{r2}\}$ may be the weights that correspond to beam indices $\{ID_{i-1}^{r1}, ID_{i-1}^{r2}\}$. After converting them to baseband and digital domain, STA2 1804 may measure the effective SNR or equivalent parameters. For time slot k, STA2 1804 may perform SNR measurements using two receive RF chains $\begin{bmatrix} SNR_{k1} \\ SNR_{k2} \end{bmatrix}$. With the first N time slot, STA2 1804 may receive $\begin{bmatrix} SNR_{11} & \dots & SNR_{N1} \\ SNR_{12} & \dots & SNR_{N2} \end{bmatrix}$, which may correspond to

TX1 of STA1 1802. With the last N time slots, STA2 1804 may receive $\begin{bmatrix} SNR_{(N+1)1} & \cdots & SNR_{2N1} \\ SNR_{(N+1)2} & \cdots & SNR_{2N2} \end{bmatrix}$, which may correspond to TX2 of STA1 1802. In FIG. 18, the reception of the signals is shown in dashed lines as an example illustration of the receiver operation while receiving a packet.

[0199] STA2 1804 may feedback two beam indices 1814 to STA1 1802. The beam selection method may be implementation dependent. For example, the STA2 1804 may select the pair of indices (ID_i^{t1}, ID_i^{t2}) which may satisfy $ID_i^{t1} = \arg\max_{1 \le k \le N} (SNR_{k1}^{TX} - SNR_{k2}^{TX})$ and $ID_i^{t2} = \arg\max_{N < k \le 2N} (SNR_{k2}^{TX} - SNR_{k1}^{TX})$.

[0200] The updated transmit beam indices for ith iteration may be (ID_i^{t1}, ID_i^{t2}). STA1 1802 may transmit a training sequence M times with beam ID_i^{t1} 1816. STA2 1804 may sweep through M receive beams with both receive RF chains (RX1 and RX2) 1818. STA1 1802 may transmit a training sequence again M times with beamforming weight ID_i^{t2} 1820. STA2 1804 may repeat the same procedure with both RF chains 1822. The sweeping of the receive antennas 1818 and 1822 is shown in dashed lines as an example illustration of receiver operation. For example, to receive packets from the transmitter, the receiver may receive a first packet with the first receive antenna, a second packet with the second receive antenna, and so on, until it receives a last packet with the last receive antenna. STA2 1804 may measure the SNR or equivalent parameters and update the receive beam index accordingly. The receive beam selection method may be implementation dependent. For example, M may be the number of receive beams STA2 1804 intends to train and may not necessarily be related to the number of receive antennas at STA2 1804.

[0201] The procedure may be repeated for several iterations until the method converges or certain criteria have been met that indicates that spatial multiplexing is not suitable for STA1 1802 and STA2 1804.

[0202] There may be several ways to define failure criteria that indicate that the pair of devices are not suitable for spatial multiplexing. For example, the failure criteria may be defined as when STA2 1804 may record $\Delta_{11}^{SNR} = \max_{1 \le k \le N} (SNR_{k1}^{TX} - SNR_{k2}^{TX})$ and $\Delta_{12}^{SNR} = \max_{N < k \le 2N} (SNR_{k2}^{TX} - SNR_{k1}^{TX})$ in when selecting beams, and feedback this information to STA1 1802. In another example failure criteria, STA2 1804 may record $\Delta_{21}^{SNR} = \max_{1 \le k \le N} (SNR_{k1}^{RX} - SNR_{k2}^{RX})$ and $\Delta_{22}^{SNR} = \max_{N < k \le 2N} (SNR_{k2}^{RX} - SNR_{k1}^{RX})$ in when sweeping beams, and feedback this information to STA1 1802.

[0203] If Δ_{ij}^{SNR} is smaller than a threshold, both STA1 1802 and STA2 1804 may determine that the channel cannot provide enough spatial diversity to support two data streams. In this example, the pair of devices may determine to complete the training procedure, and perform RF selection at both transmitter and receiver. Alternatively, the pair of devices may terminate the training with two RF chains, and return to performing beamforming training with one RF chain. After training, the pair of devices may transmit with a fewer number of spatial streams.

[0204] The beam refinement transaction discussed in conjunction with FIG. 3 may be used for Eigen-beamforming based spatial multiplexing methods disclosed above. Modifications may be applied to support spatial multiplexing. For example, a number of spatial streams may be defined. The number of data streams may be defined in a DMG beam refinement element. The FBCK-TYPE subfield in the DMG beam refinement element may be modified.

[0205] FIG. 19 is a diagram of an example modified FBCK-TYPE subfield 1900. The modified FBCK-TYPE subfield 1900 may be included in a DMG refinement element. The modified FBCK-TYPE subfield 1900 may include a SNR present field 1910, a channel measurement present field 1920, a tap delay present field 1930, a number of taps present field 1940, a number of measurement field 1950, a number of spatial streams field 1960, a sector ID order present field 1970, and a number of beams field 1980.

[0206] An initiator may determine the capabilities of the responder prior to initiating beamforming training with the responder by using an Eigen-beamforming based spatial multiplexing capability. The Beam sweep based spatial multiplexing capability may be indicated in a DMG capabilities element. The DMG capabilities element may be present in an association request, association response, re-association request, re-association response, probe request and probe response frames and may be present in DMG beacon and information request and response frames. One bit of Eigen-beamforming based spatial multiplexing indication and one bit of beam sweep spatial multiplexing capability may be used to indicate that the STA is capable of performing Eigen-beamforming based spatial multiplexing.

[0207] The type of beamforming training algorithm, such as Eigen-beamforming based and beam sweep based, may be indicated in DMG beam refinement element. In addition, transceiver architecture type, such as Type I and Type II may be indicated in a DMG capabilities element.

[0208] A precoding matrix utilized by the initiator in the first part of each iteration may be predefined and agreed on by both initiator and responder if Eigen-beamforming based spatial multiplexing is implemented. In this example, the initiator and responder may negotiate which matrix to utilize before the beamforming training. For example, the precoding matrix index may be defined and transmitted in a BRP request field. In addition, a set of unitary precoding matrices may be predetermined.

[0209] A number of antennas at both initiator and responder may be signaled if Eigen-beamforming based spatial multiplexing is implemented. The number of antennas may be signaled in the PHY header, MAC header or a BRP Request field.

[0210] A spatial multiplexing frame format may be implemented. For example, when a packet is transmitted using spatial multiplexing, an indication may be sent to inform the packet recipients that multiple streams were transmitted. The MCS may be redefined for a modulation/coding scheme and the number of spatial streams. In 802.11ad, for example, MCS 0 may be

the Control PHY; MCS 1-12 may be utilized for single carrier (SC) PHY; MCS 13-24 may be for OFDM PHY; and MCS 25-31 may be for low power SC PHY.

[0211] In examples with two data stream transmissions, the following may be defined for use by the communication devices. For example, MCS 32-43 may be for SC PHY, MCS 44-55 may be for OFDM PHY, and 56-62 may be for low power SC PHY. In some examples, the MCS mapping may not be the same as defined above.

[0212] Alternatively, the number of spatial streams may be indicated in a PHY header. In order to support multiple data streams, the PHY layer frame format may need to be modified.

[0213] FIGS. 20A, 20B, and 20C are diagrams of example PHY layer frame formats. With SC PHY, the data field may be composed of symbol blocks, while with OFDM PHY, the data field may be composed of OFDM symbols. The frame may be appended with TRN-T/R subfields, and may be utilized for beam refinement protocol.

[0214] Referring to FIG. 20A, short training field (STF) 2010, channel estimation field (CE) 2020 and PHY headers 2030 may be transmitted with a weight, W1 2040. The number of data streams supported, N, may be indicated in the PHY header. If more than one data stream will be transmitted, additional CE field(s) may be included. With N data streams, an extra N-1 CE field 2050 may be transmitted and weights W2 2060, ..., WN 2070 may be applied to each CE field. An orthogonal mapping matrix, such as the P matrix defined in 802.11n/ac, may be applied. If a cyclic shift delay (CSD) scheme is applied to spatial multiplexing, the same CSD parameters may be applied to the CE fields. The data field 2080 that follows may be transmitted using the spatial multiplexing scheme, and all of the weights (W1,...,WN) 2090 may be applied.

[0215] FIG. 20B is a diagram of another example preamble format for spatial multiplexing transmissions. This format is similar to FIG. 20A except that an AGC field 2015 may be inserted after additional CE fields and before the data field 2080. The AGC field 2015 may use the same sequence as an LTF

field, or it may be redesigned. The purpose of this AGC field 2015 may be for automatic gain control. The transmission of the AGC field 2015 may be in the same format as the data field 2080, i.e., weights (W1,...,WN) 2090 may be applied. The same CSD parameters may be applied to AGC field 2015 if CSD is utilized for data transmissions.

[0216] FIG. 20C is a diagram of another example preamble format for spatial multiplexing transmissions in which the number of data streams may be signaled implicitly. STF 2010 may be transmitted using all the weights (W1,...,WN) 2025. The first CE field 2020 following STF 2010 may be transmitted using the first weight W1 2040. The number of data streams may be implicitly indicated by using STF 2010 and the first CE field 2020. For example, several CE sequences may be defined, and each sequence may correspond to a certain number of data streams. Additional N-1 CE fields 2050 may follow the first CE field 2020 and transmitted with weights W2 2060 to WN 2070. The header 2035 may be transmitted with one of the weights or a combination of the weights similar to STF 2010. The spatial multiplexing transmission may be transmitted following the additional CE fields.

[0217] Beamforming training overhead and latency may be reduced. For example, sector sweep (SSW) frames and related training methods may be modified.

[0218] In the SLS procedures, SSW frames may be utilized for transmit and receive beamforming training. For example, the SSW frames may be transmitted in N time slots. For transmit beamforming training, SSW frames may be transmitted and multiple antenna sectors may be swept. The receiver may receive the SSW frames with the same antenna sector and feedback the best transmit sector ID to the transmitter. For example, for receive beamforming training, the same SSW frames may be repeated N times, and the receiver may sweep over multiple antenna sectors to receive. After the receive beamforming training, the receiver may select the best receive sector.

[0219] Each SSW frame may comprise a full PLCP header that may include a preamble, one or more header blocks, and a MAC frame. Since the

SSW frames may be utilized for beamforming training, they may be transmitted using the lowest data rate, for example, control PHY or MCS0 in 802.11ad. SSW frames may not contain data traffic, therefore SSW frame sequences may be beamforming training overhead.

[0220] FIG. 21 is a diagram of an example modified SSW training frames and sequence 2100. In this example, modified SSW training sequences may be utilized. A SSW announcement (SSWA) frame 2110 may be transmitted at the beginning of the SSW training sequences. The SSWA frame 2110 may contain all the information used to transmit by SSW frames. One or more N null SSW (NSSW) frames 2120 may follow the SSWA frame 2110 with a certain inter-frame spacing. NSSW frames 2120 may contain only preamble and PHY headers, and no MAC frame.

[0221] Figure 22 is a diagram of an example SSWA frame format 2200. The SSWA frame format 2200 may include a frame control field 2205, a duration field 2210, an RA field 2215, a TA field 2220, an SSW field 2225, an SSW feedback (FB) field 2230, and an FCS field 2235. The SSW field 2225 may include a direction subfield 2240, a DMG antenna ID 1 subfield 2245, a sector ID 1 subfield 2250, a sector ID N subfield 2255, a DMG antenna ID 2 subfield 2260, a sector ID 1 subfield 2265, a sector ID N2 subfield 2270, and an RXSS length subfield 2275. In this example, sector ID 1 subfield 2250 may be for DMG antenna ID 1, and sector ID 1 subfield 2265 may be for DMG antenna ID 2.

[0222] The direction subfield 2240 and the RXSS length subfield 2275 may be the same as in IEEE 802.11ad. The direction subfield 2240 may be set to 0 to indicate that the frame is transmitted by the beamforming initiator and set to 1 to indicate that the frame is transmitted by the beamforming responder. The RXSS Length subfield 2275 may be valid only when transmitted in a CBAP and may be reserved otherwise. The RXSS Length subfield 2275 may specify the length of a receive sector sweep as required by the transmitting STA, and may be defined in units of an SSW frame. The value of this field is in the range 0–62, with odd values being reserved.

[0223] DMG Antenna IDs and Sector IDs may be utilized to indicate the antenna pattern for the following NSSW frames. For example, the first NSSW frame may utilize DMG Antenna ID 1 and Sector ID 1 to transmit, and the second NSSW frame may utilize DMG Antenna ID 1 and Sector ID 2 to transmit, and so on. With DMG antenna ID k, there may be Nk sectors swept for this round of beamforming training. The total number of NSSW frames following this SSWA frame may be $\sum_{k=1}^{K} N_k$. K may be the number of DMG antennas trained with these SSWA-NSSW sequences.

[0224] The SSWA may be transmitted as follows. For example, the SSWA frame may carry all the MAC information necessary for beamforming training. It may be important that the receiver decodes the SSWA frame correctly. The SSWA frame may be transmitted using one of the following methods. For example, if the beamforming training is between two non-AP/PCP devices, the SSWA frame may be transmitted from AP to the two devices. In another example, if both the beamforming initiator and responder are multi-band capable, they may operate on multiple frequency bands simultaneously, and the SSWA frame may be transmitted on another frequency band. The SSWA frame may be transmitted with low data rate, spreading codes, or repetition schemes.

[0225] Some examples may use sub-optimum SLS training methods. In these examples, SLS training methods may be terminated early.

[0226] FIG. 23 is a diagram of an example early termination of the SLS training procedure. In this example, the initiator 2302 may have 4 beam sectors to train, and the countdown (CDOWN) number may equal 3 in the first training frame. In this example, sector 3 is shaded to illustrate that the initiator may use sector 3 for transmission in a first period, and sector 4 is shaded to illustrate that the initiator may use sector 4 for transmission in the second period. The initiator 2302 may continue transmitting training frames which are separated by inter-frame space duration 2T, for example. The responder 2304 may monitor the received training frames 2306. The dashed

"omni" circles in FIG. 23 are shown to illustrate that the receiver/responder may be in an omni-receiving mode. An omni-receiving mode may be enabled by an omni-directional receiving antenna. The first two "omni" circles are shown in dashed lines to illustrate that they are example receiver operations. The last "omni" circle is shown in indicating solid line to illustrate that this is an example transmitter operation, i.e., the feedback packet may be transmitted in an omni-transmitting mode, which may be enabled by an omni-directional transmitting antenna. Once the received SNR (or other parameters) is greater than a certain threshold, the responder 2304 may determine to terminate the training procedure by transmitting a feedback frame 2308. The feedback frame 2308 may be transmitted after a T duration from the end of a training frame transmitted by the initiator 2302. Thus the initiator 2302 may detect the transmission of this feedback and stop transmitting more training frames. This example may be used for both transmit and receive beamforming training.

[0227] A group based SLS training method may be performed. In this example, a STA may divide its sectors to groups. The partition of sectors may be implementation dependent. For example, the partition may be based on the direction of the sectors. The beamforming initiator may select one group to perform SLS training and wait for the feedback from the responder. Once the feedback from responder meets the expectation of the initiator, the beamforming initiator may determine to stop the beamforming training. Otherwise, the initiator may select another group to perform SLS training until one beam is selected or all the beams are swept.

[0228] Multi-beam, multi-DMG antenna sector level sweep feedback may be performed. In examples of the sector level sweep method, the receiver STA may report back the best beam only, for example, one sector of one DMG antenna. For example, a list of the best beams, such as multiple beams of multiple antennas may be reported. This may enable the communication link to track the relative performance of the beams over time and, if necessary, switch to a better beam without the need for retraining.

[0229] FIG. 24 is a diagram of an example multi-beam multi-DMG antenna SLS feedback method 2400. The following method 2400 may use a sector level sweep method that may report a list of best beams. In this example, the DMG transmitting STA1 2402 and receiving STA2 2404 may indicate their capability to support multi-sector, multi-DMG antenna Sector Sweep (SSW) feedback. This capability may be indicated by a bit in the DMG STA Capability Information field. STAs that do not have the capability may fall back to legacy transmission.

[0230] The STA initiating the sector sweep, for example STA1 2402, may transmit information to the responder STA, for example STA2 2404, indicating the number of beams to be fed back. The responder STA 2404 may also transmit information to initiator STA 2402 on the number of beams to be fed back. The metric to decide on the best beams may be implementation dependent. One signaling method may use a Transmit Sector Sweep frame for both the initiator and the responder may contain the number of beams to be fed back. A second signaling method may use a DMG beacon that may contain a field that indicates the number of beams to be fed back for all SSW feedback 2420. In a third signaling method, before a Sector Level Sweep procedure, the initiator and responder may exchange SLS setup frames indicating the number of beams to feed back. Quasi-omni may refer to a near omni-directional transmission or reception. For example, quasi-omni transmissions may be enabled by repeatedly transmitting the same information using multiple directional transmissions, as if it were transmitted using an omni-directional transmit antenna. Similarly, quasi-omni receptions may be enabled by repeatedly receiving the same packet using multiple directional receptions, as if it were received using an omni-directional receiving antenna.

[0231] Both STAs may implement the legacy initiator and responder sector level sweep procedures. The transmitter may feedback the best N beams. This may be by one of the following example methods. In a first example method, multiple SSW Feedback fields may be aggregated within an SSW feedback frame 2420. In a second example, a single SSW Feedback field

may be modified to enable feedback of multiple beams and DMG antennas and corresponding SNR Reports. In a third example, the best beam/antenna may be fed back during the SLS procedure and subsequent feedback of the additional N-1 beams with other transmissions, for example an ACK. In these examples, the number of antenna may be larger than the number radio frequency (RF) chains. In some examples, the number of antenna may be much larger than the number of RF chains.

EMBODIMENTS

1. A first communication device comprising:

a plurality of antennas;

a processor configured to partition the plurality of antennas;

a transmitter configured to transmit a plurality of frames to a second communication device;

and a receiver.

2. The first communication device of embodiment 1, wherein the processor is configured to partition the plurality of antennas into at least a first group of antennas and a second group of antennas.

3. The first communication device of embodiment 2, wherein the first group of antennas is associated with a first beam to a first station (STA).

4. The first communication device of embodiment 2 or 3, wherein the second group of antennas is associated with a second beam to a second station (STA).

5. The first communication device of any one of embodiments 2-4, wherein the first group of antennas is associated with a first beam to a first plurality of stations (STAs).

6. The first communication device of any one of embodiments 2-5, wherein the second group of antennas is associated with a second beam to a second plurality of stations (STAs).

7. The first communication device of any preceding embodiment, wherein the plurality of frames transmitted are beamforming training frames.

8. The first communication device of any preceding embodiment, wherein the plurality of frames are transmitted using the first group of antennas.

9. The first communication device of any preceding embodiment, wherein the plurality of frames are transmitted using the second group of antennas.

10. The first communication device of any preceding embodiment, wherein the receiver is configured to receive a first beamforming weight vector from the second communication device.

11. The first communication device of embodiment 10, wherein the first beamforming weight vector is for sending signals on the first group of antennas.

12. The first communication device of any preceding embodiment, wherein the receiver is configured to receive a second beamforming weight vector from the second communication device.

13. The first communication device of embodiment 12, wherein the second beamforming weight vector is for sending signals on the second group of antennas.

14. The first communication device of any one of embodiments 10-13, wherein the first beamforming weight vector is a strongest beam between the first communication device and the second communication device.

15. The first communication device of any one of embodiments 12-14, wherein the second beamforming weight vector is for a second strongest beam between the first communication device and the second communication device.

16. The first communication device of any preceding embodiment, wherein the first communication device is a wireless transmit/receive unit (WTRU).

17. The first communication device of any one of embodiments 1-15, wherein the first communication device is a station (STA).

18. The first communication device of any one of embodiments 1-15, wherein the first communication device is an access point (AP).

19. The first communication device of any one of embodiments 1-15, wherein the first communication device is a base station.

20. The first communication device of any preceding embodiment, wherein the second communication device is a wireless transmit/receive unit (WTRU).

21. The first communication device of any one of embodiments 1-19, wherein the second communication device is a station (STA).

22. The first communication device of any one of embodiments 1-19, wherein the second communication device is an access point (AP).

23. The first communication device of any one of embodiments 1-19, wherein the second communication device is a base station.

24. The first communication device of any one of embodiments 7-23, wherein the beamforming training frames are orthogonal beamforming vectors.

25. The first communication device of any preceding embodiment, wherein the transmitter is further configured to transmit a second set of beamforming training frames.

26. The first communication device of embodiment 25, wherein the second set of beamforming training frames is transmitted using the received first beamforming weight vector.

27. The first communication device of embodiment 25 or 26, wherein the second set of beamforming training frames is transmitted using the received second beamforming weight vector.

28. The first communication device of any preceding embodiment, wherein the receiver is further configured to receive a modified first beamforming weight vector.

29. The first communication device of embodiment 28, wherein the modified first weight vector is for sending signals on the first group of antenna.

30. The first communication device of any preceding embodiment, wherein the receiver is further configured to receive a modified second beamforming weight vector.

31. The first communication device of embodiment 30, wherein the modified second weight vector is for sending signals on the second group of antenna.

32. The first communication device of any preceding embodiment, wherein the first communication device comprises one or more radio frequency (RF) chains.

33. The first communication device of any preceding embodiment, wherein a number of the antenna is larger than a number of one or more radio frequency (RF) chains.

34. A first communication device comprising:

a plurality of antennas;

a receiver configured to receive a set of beamforming training frames;

a processor; and

a transmitter.

35. The first communication device of embodiment 34, wherein the processor is configured to determine a first transmit beamforming weight vector.

36. The first communication device of embodiment 35, wherein the first transmit beamforming weight vector corresponds to a first antenna group.

37. The first communication device of embodiment 36, wherein the first antenna group is for a second communication device.

38. The first communication device of any one of embodiments 34-37, wherein the processor is configured to determine a second transmit beamforming weight vector.

39. The first communication device of embodiment 38, wherein the second transmit beamforming weight vector corresponds to a second antenna group.

40. The first communication device of embodiment 39, wherein the second antenna group is for a second communication device.

41. The first communication device of any one of embodiments 34-40, wherein the transmitter is configured to transmit data using the first transmit beamforming weight vector to the second communication device to the second communication device.

42. The first communication device of any one of embodiments 34-41, wherein the transmitter is configured to transmit data using the second transmit data using the second transmit beamforming weight vector to the second communication device.

43. The first communication device of any one of embodiments 34-42, wherein the first communication device is a wireless transmit/receive unit (WTRU).

44. The first communication device of any one of embodiments 34-42, wherein the first communication device is a station (STA).

45. The first communication device of any one of embodiments 34-42, wherein the first communication device is an access point (AP).

46. The first communication device of any one of embodiments 34-42, wherein the first communication device is a base station.

47. The first communication device of any one of embodiments 34-46, wherein the second communication device is a wireless transmit/receive unit (WTRU).

48. The first communication device of any one of embodiments 34-46, wherein the second communication device is a station (STA).

49. The first communication device of any one of embodiments 34-46, wherein the second communication device is an access point (AP).

50. The first communication device of any one of embodiments 34-46, wherein the second communication device is a base station.

51. The first communication device of any one of embodiments 34-50, wherein the received beamforming training frames are orthogonal beamforming vectors.

52. The first communication device of any one of embodiments 34-51, wherein the transmitted beamforming weight vectors are orthogonal beamforming vectors.

53. A method for beamforming training for beam division multiple access (BDMA), the method comprising:

receiving a first transmit beamforming weight from a first station (STA), and receiving a second transmit beamforming weight from a second (STA);

transmitting Nt sequences modulated using Nt beamforming vectors, wherein the Nt sequences are modulated based on the first transmit beamforming weight and the second transmit beamforming weight.

54. The method of embodiment 53, wherein the Nt beamforming vectors are orthogonal.

55. A method for beamforming training for beam division multiple access (BDMA), the method comprising:

receiving a plurality of Nt sequences using a first previous beamforming vector;

determining a first transmit beamforming weight from an access point (AP) based on the first previous beamforming vector and the received plurality of Nt sequences; and

transmitting the determined first transmit beamforming weight to the AP.

56. A method for beamforming training for spatial multiplexing, the method comprising:

an initiator station having two radio frequency (RF) chains and having transmit antenna elements, the initiator station transmitting Nt known training sequences sweeping the transmit antenna elements;

a responder station having a first and a second RF chain and having receive antenna elements, and having a first and a second receive beamforming weight, the responder station receiving the first RF chain and receiving the second RF chain; and

the responder station estimating at least two channels by comparing the received first RF chain and the second RF chain to the Nt known training sequences.

57. The method of embodiment 56, wherein the first RF chain is the combination of signals received from the receive antenna elements weighted by the first receive beamforming weights

58. The method of embodiment 57, wherein the second RF chain is the combination of signals received from the receive antenna elements weighted by the second receive beamforming weights.

59. The method of any one of embodiments 56-58, wherein the transmitting Nt training sequences further comprises transmitting Nt training sequences over a first RF chain of the initiator.

60. The method of any one of embodiments 56-58, wherein the transmitting Nt training sequences further comprises transmitting Nt training sequences over a second RF chain of the initiator.

61. The method of any one of embodiments 56-58, wherein the transmitting Nt training sequences further comprises transmitting Nt training sequences over the first RF chain and the second RF chain.

62. The method of embodiment 61, wherein the first RF chain and the second RF chain are calibrated.

63. The method of any one of embodiments 56-62, wherein the transmitting Nt known training sequences sweeping the transmit antenna elements comprises the initiator station having two RF chains and having transmit antenna elements, transmitting Nt known training sequences sweeping the transmit antenna elements, wherein a number of the transmit antenna elements is larger than a number of RF chains.

64. The method of any one of embodiments 56-63, wherein the number of transmit antenna elements is at least six times larger than a number of RF chains.

65. The method of any one of embodiments 56-64 further comprising the responder transmitting the estimated two channels to the initiator.

66. A method for beamforming training for spatial multiplexing, the method comprising:

an initiator station having two or more radio frequency (RF) chains and having transmit antenna elements, the initiator station transmitting Nt known sequences sweeping the transmit antenna elements;

a responder station having a first and a second RF chain and having receive antenna elements, and having a first and a second receive beamforming weight, the responder station receiving the first RF chain and receiving the second RF chain; and

the responder estimating at least two channels by comparing the received first RF chain and the second RF chain to the known Nt training sequences.

67. The method of embodiment 66, wherein the first RF chain is a combination of signals received from the receive antenna elements weighted by the first receive beamforming weights.

68. The method of embodiment 66 or 67, wherein the second RF chain is the combination of signals received from the receive antenna elements weighted by the second receive beamforming weights.

69. A method for performing beamforming, the method comprising:

a first communication device transmitting a first plurality of beamforming training frames to a second communication device using a first beamforming vector;

the first communication device receiving from the second communication device a second beamforming weight vector; and

the first communication device transmitting a second plurality of beamforming training frames to the second communication device using the second beamforming vector.

70. The method of embodiment 69, wherein the first communication device transmits the first plurality of beamforming training frames to the second communication device using a first beamforming weight vector.

71. The method of embodiment 69 or 70, wherein the first communication device transmits a first portion of the first plurality of beamforming training frames using a first group of antenna and a first portion of the beamforming weights.

72. The method of any one of embodiments 69-71, wherein the first communication device transmits a second portion of the first plurality of beamforming training frames using a second group of antenna and a second portion of the beamforming weights.

73. A base station configured to perform any one of embodiments 53-72.

74. A base station configured to perform any portion of embodiments 53-72.

75. An integrated circuit configured to perform any one of embodiments 53-72.

76. An integrated circuit configured to perform any portion of embodiments 53-72.

77. A station (STA) configured to perform any one of embodiments 53-72.

78. A station (STA) configured to perform any portion of embodiments 53-72.

79. An access point (AP) configured to perform any one of embodiments 53-72.

80. An access point (AP) configured to perform any portion of embodiments 53-72.

81. A wireless transmit/receive unit (WTRU) configured to perform any one of embodiments 53-72.

82. A wireless transmit/receive unit (WTRU) configured to perform any portion of embodiments 53-72.

[0232] Although features and elements are described above in particular combinations, one of ordinary skill in the art will appreciate that each feature or element can be used alone or in any combination with the other features and elements. In addition, the methods described herein may be implemented in a computer program, software, or firmware incorporated in a computer-readable medium for execution by a computer or processor. Examples of computer-readable media include electronic signals (transmitted over wired or wireless connections) and computer-readable storage media. Examples of computer-readable storage media include, but are not limited to, a read only memory (ROM), a random access memory (RAM), a register, cache memory, semiconductor memory devices, magnetic media such as internal hard disks and removable disks, magneto-optical media, and optical media such as CD-ROM disks, and digital versatile disks (DVDs). A processor in association with software may be used to implement a radio frequency transceiver for use in a WTRU, UE, terminal, base station, RNC, or any host computer.

* * *

CLAIMS

What is claimed is:

1. A first communication device, the first communication device comprising:

a plurality of antennas;

a processor, wherein the processor is configured to partition the plurality of antennas into at least a first group of antennas and a second group of antennas, wherein the first group of antennas is associated with a first beam to a first station (STA) or a first plurality of STAs, and the second group of antennas is associated with a second beam to a second STA or a second plurality of STAs;

a transmitter configured to transmit, to a second communication device, a plurality of beamforming training frames using the first group of antennas and the second group of antennas; and

a receiver configured to receive from the second communication device a first beamforming weight vector for sending signals on the first group of antennas and to receive a second beamforming weight vector for sending signals on the second group of antennas.

2. The first communication device of claim 1, wherein the first beamforming weight vector is a strongest beam between the first communication device and the second communication device, and wherein the second beamforming weight vector is for a second strongest beam between the first communication device and the second communication device.

3. The first communication device of claim 1, wherein the first communication device and the second communication device are one of: a wireless transmit receive unit, a station, an access point, or a base station.

4. The first communication device of claim 1, wherein the beamforming training frames are orthogonal beamforming vectors.

5. The first communication device of claim 1, wherein the transmitter is further configured to transmit a second set of beamforming training frames using the received first beamforming weight vector and the second beamforming weight vector; and wherein the receiver is further configured to receive from the second communication device a modified first beamforming weight vector for sending signals on the first group of antenna and to receive a modified second beamforming weight vector for sending signals on the second group of antenna.

6. The first communication device of claim 1, wherein the first communication device comprises one or more radio frequency (RF) chains and wherein a number of the antenna is larger than a number of the one or more RF chains.

7. A first communication device, the first communication device comprising:

a plurality of antennas; and

a processor, wherein the plurality of antennas are configured to receive a set of beamforming training frames, and wherein the processor is configured to determine a first transmit beamforming weight vector corresponding to a first antenna group of a second communication device, and to determine a second transmit beamforming weight vector corresponding to a second antenna group of the second communication device; and

a transmitter configured to transmit data using the first transmit beamforming weight vector and to send data using the second transmit beamforming weight vector to the second communication device.

8. The first communication device of claim 7, wherein the first communication device and the second communication device are one of: a wireless transmit receive unit, a station, an access point, or a base station.

9. The first communication device of claim 7, wherein the received beamforming training frames are orthogonal beamforming vectors.

10. The first communication device of claim 7, wherein the transmitted beamforming weight vectors are orthogonal beamforming vectors.

11. A method for use in a first communication device, the method comprising:

partitioning, at the first communication device, a plurality of antennas into at least a first group of antennas and a second group of antennas, wherein the first group of antennas is associated with a first beam to a first station (STA) or a first plurality of STAs, and the second group of antennas is associated with a second beam to a second STA or a second plurality of STAs;

transmitting, to a second communication device, a plurality of beamforming training frames using the first group of antennas and the second group of antennas; and

receiving, from the second communication device, a first beamforming weight vector for transmitting signals on the first group of antennas and receiving a second beamforming weight vector for transmitting signals on the second group of antennas.

12. The method of claim 11, wherein the first beamforming weight vector is a strongest beam between the first communication device and the second communication device, and wherein the second beamforming weight vector is for a second strongest beam between the first communication device and the second communication device.

13. The method of claim 11, wherein the first communication device and the second communication device are one of: a wireless transmit receive unit, a STA, an access point (AP), or a base station.

14. The method of claim 11, wherein the beamforming training frames are orthogonal beamforming vectors.

15. The method of claim 11 further comprising:

transmitting a second set of beamforming training frames using the received first beamforming weight vector and the second beamforming weight vector; and

receiving from the second communication device a modified first beamforming weight vector for transmitting signals on the first group of antenna and receiving a modified second beamforming weight vector for transmitting signals on the second group of antenna.

16. The method of claim 11, wherein the first communication device comprises one or more radio frequency (RF) chains and wherein a number of the antenna is larger than a number of the one or more RF chains.

17. A method for use in a first communication device, the method comprising:

receiving a set of beamforming training frames;

determining a first transmit beamforming weight vector corresponding to a first antenna group of a second communication device, and to determining a second transmit beamforming weight vector corresponding to a second antenna group of the second communication device; and

transmitting data using the first transmit beamforming weight vector and transmitting data using the second transmit beamforming weight vector to the second communication device.

18. The method of claim 17, wherein the first communication device and the second communication device are one of: a wireless transmit receive unit, a station (STA), an access point (AP), or a base station.

19. The method of claim 17, wherein the received beamforming training frames are orthogonal beamforming vectors.

20. The method of claim 17, wherein the received beamforming training frames are orthogonal beamforming vectors.

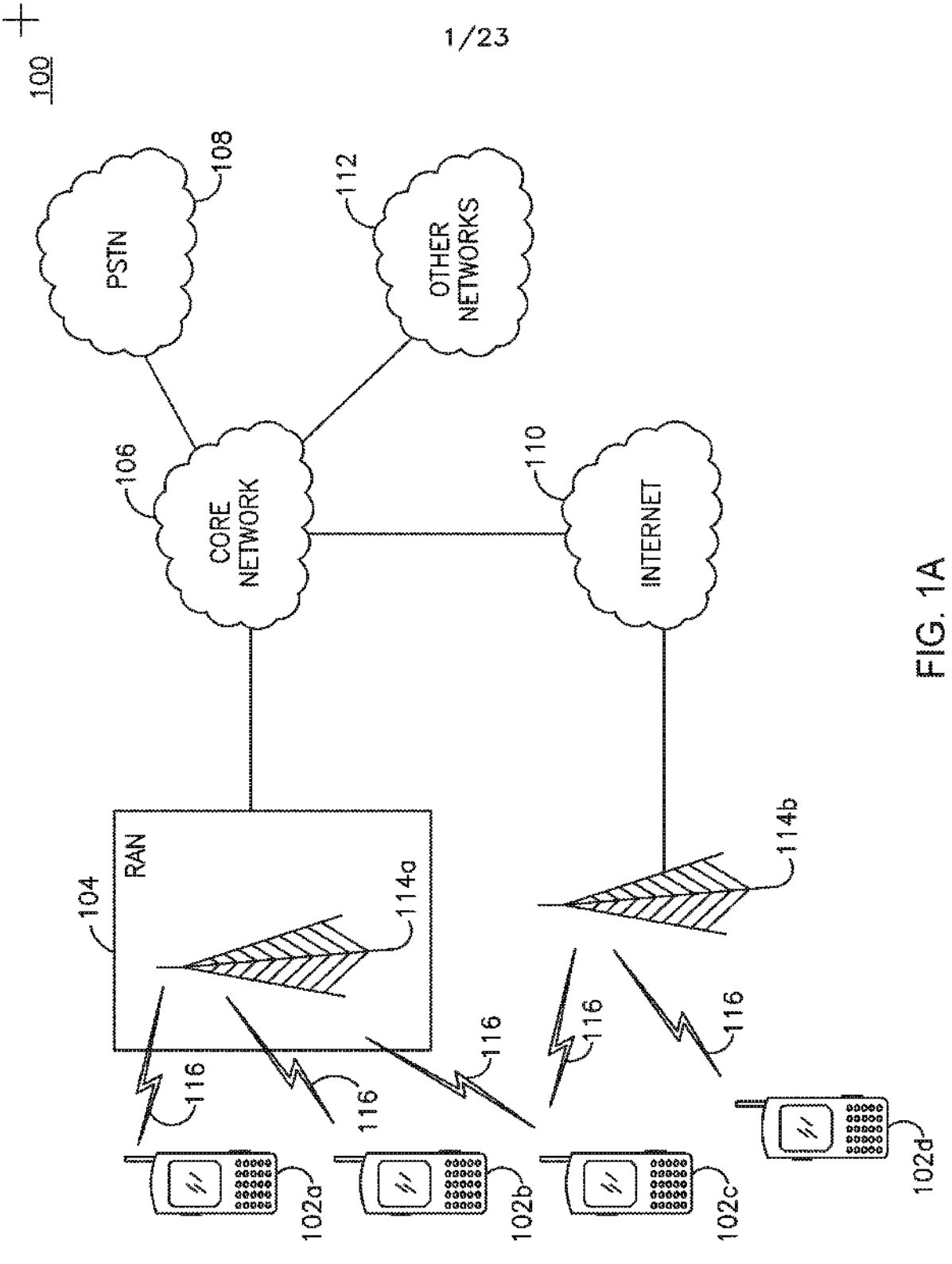

100
PSTN
108
OTHER NETWORKS
112
CORE NETWORK
106
INTERNET
110
RAN
104
114a
114b
116
116
116
116
102a
102b
102c
102d

FIG. 1A

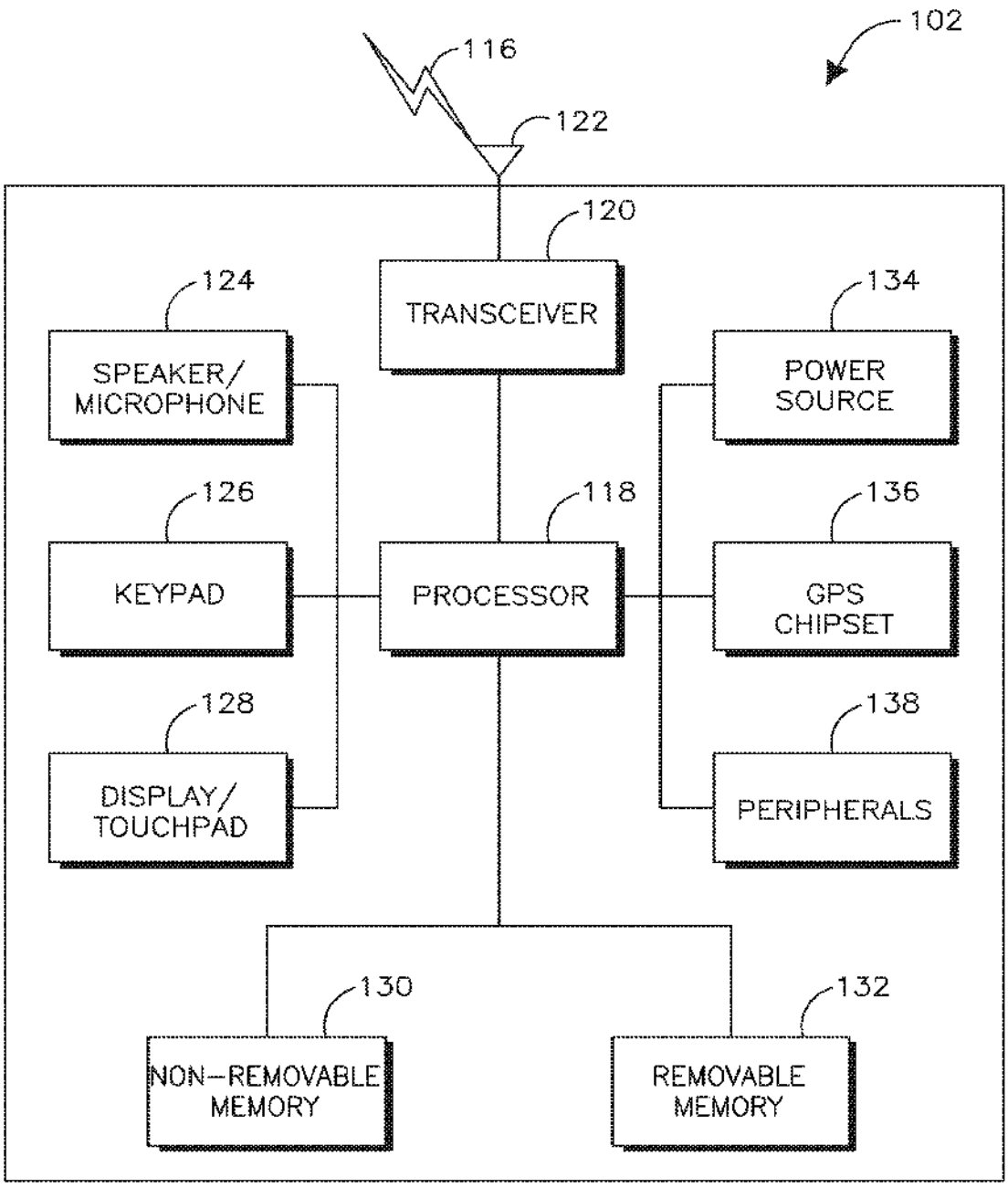

102
116
122
120
TRANSCEIVER
124
SPEAKER/
MICROPHONE
134
POWER
SOURCE
126
KEYPAD
118
PROCESSOR
136
GPS
CHIPSET
128
DISPLAY/
TOUCHPAD
138
PERIPHERALS
130
NON-REMOVABLE
MEMORY
132
REMOVABLE
MEMORY

FIG. 1B

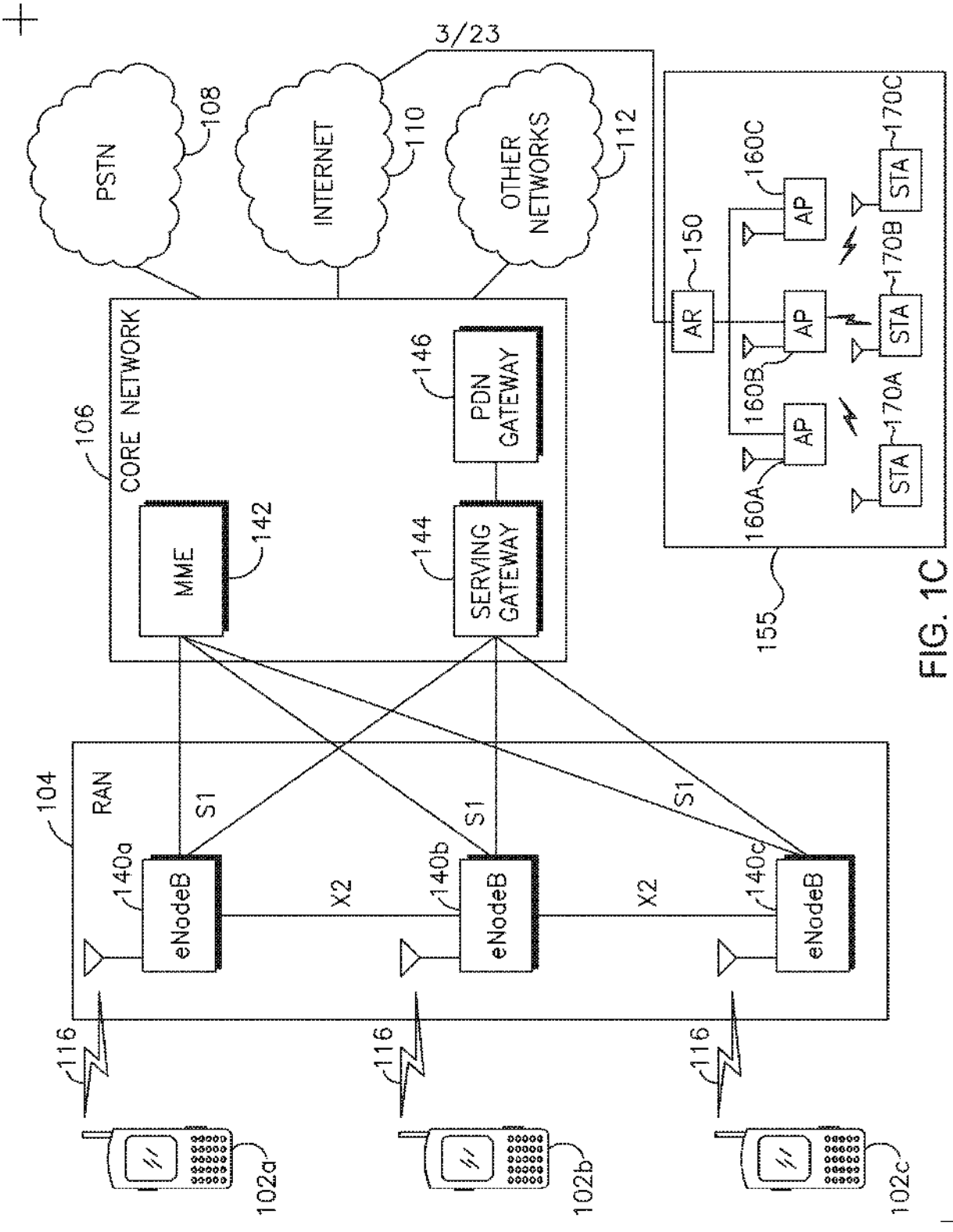

PSTN
108
INTERNET
110
OTHER NETWORKS
112
CORE NETWORK
106
MME
142
PDN GATEWAY
146
SERVING GATEWAY
144
AR
150
AP
160C
AP
160B
AP
160A
STA
170C
STA
170B
STA
170A
155
RAN
104
S1
S1
S1
X2
X2
eNodeB
140a
eNodeB
140b
eNodeB
140c
116
116
116
102a
102b
102c

FIG. 1C

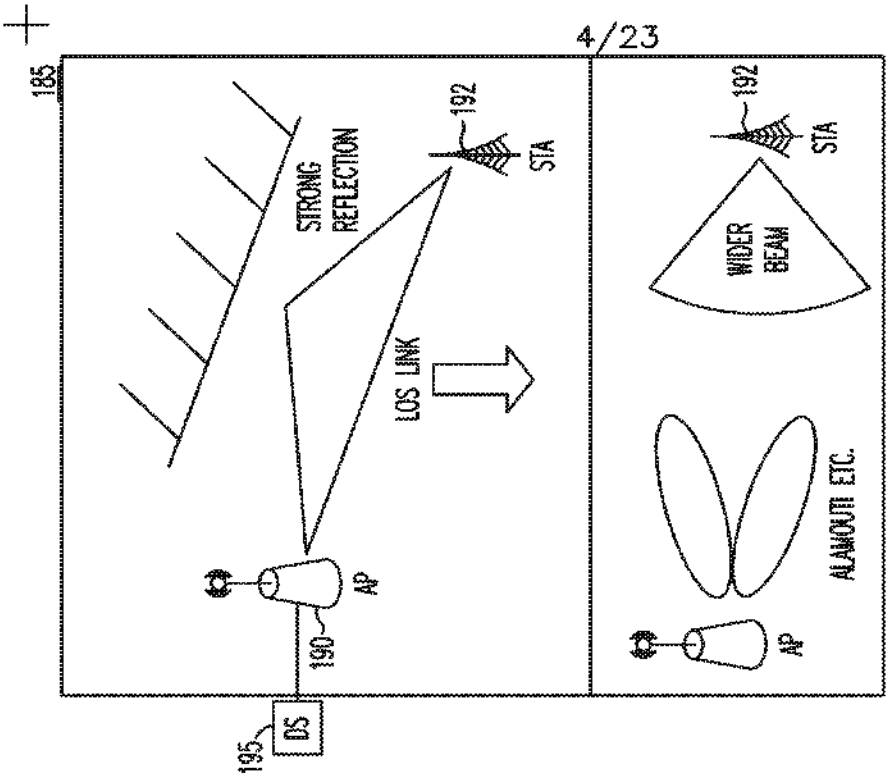

185
STRONG REFLECTION
192
STA
LOS LINK
AP
190
195
DS
WIDER BEAM
ALAMOUTI ETC.

FIG. 1E

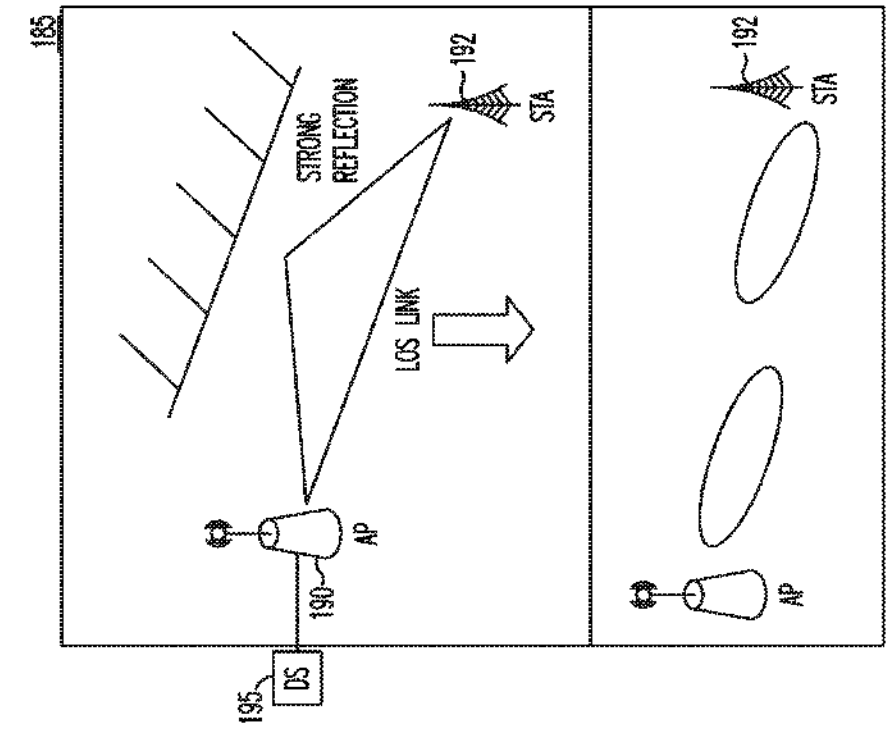

185
STRONG REFLECTION
192
STA
LOS LINK
AP
190
195
DS

FIG. 1D

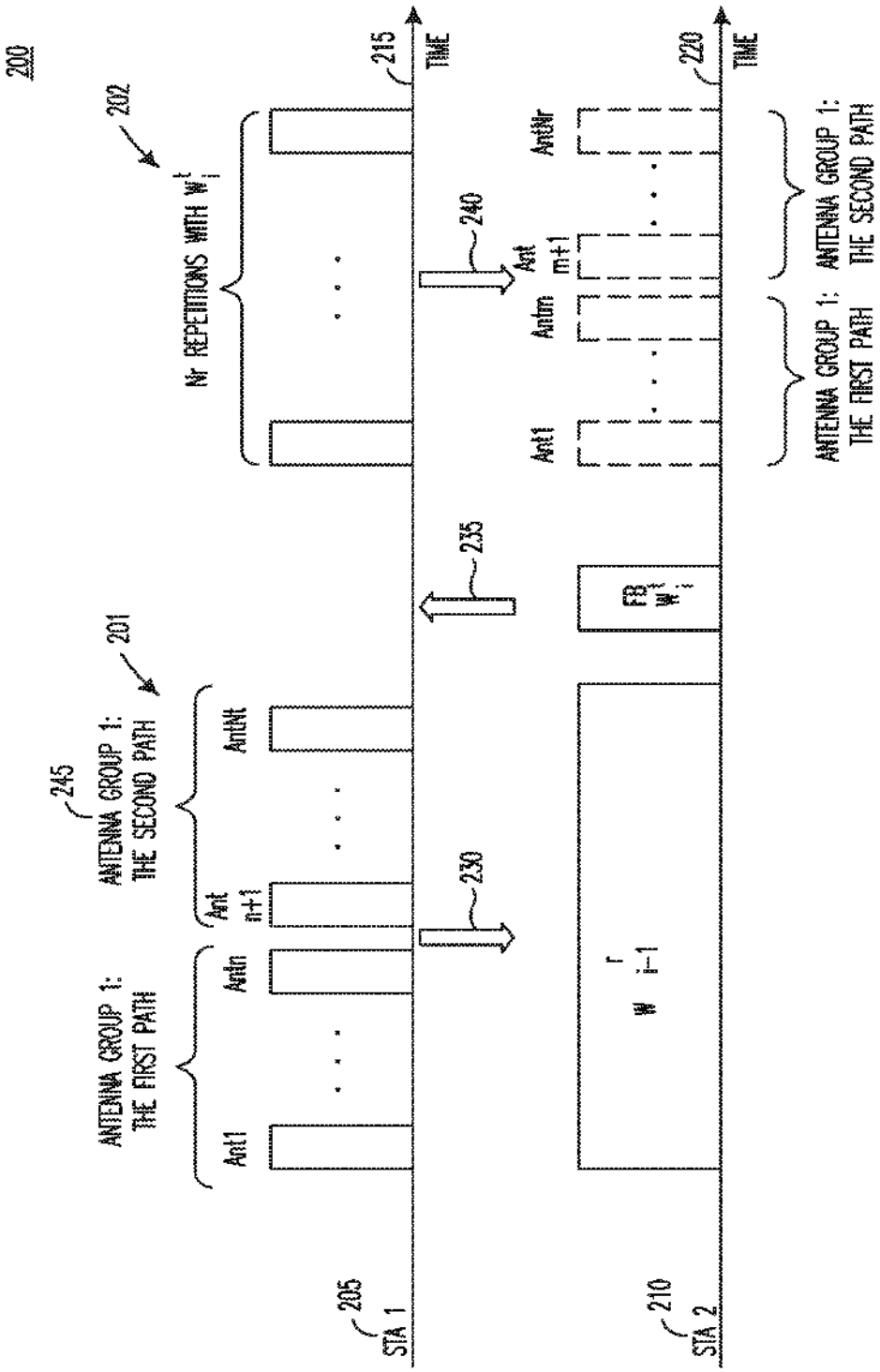

200
202
Nr REPETITIONS WITH W_i^1
215
TIME
240
Ant m+1
Antm
Antl
AntNr
ANTENNA GROUP 1: THE FIRST PATH
ANTENNA GROUP 1: THE SECOND PATH
ANTENNA GROUP 1: THE FIRST PATH
ANTENNA GROUP 1: THE SECOND PATH
245
201
Ant1
Antn
Ant n+1
AntNt
235
230
FB W_i^1
W_{i-1}^r
205
STA 1
210
STA 2
220
TIME

FIG. 2

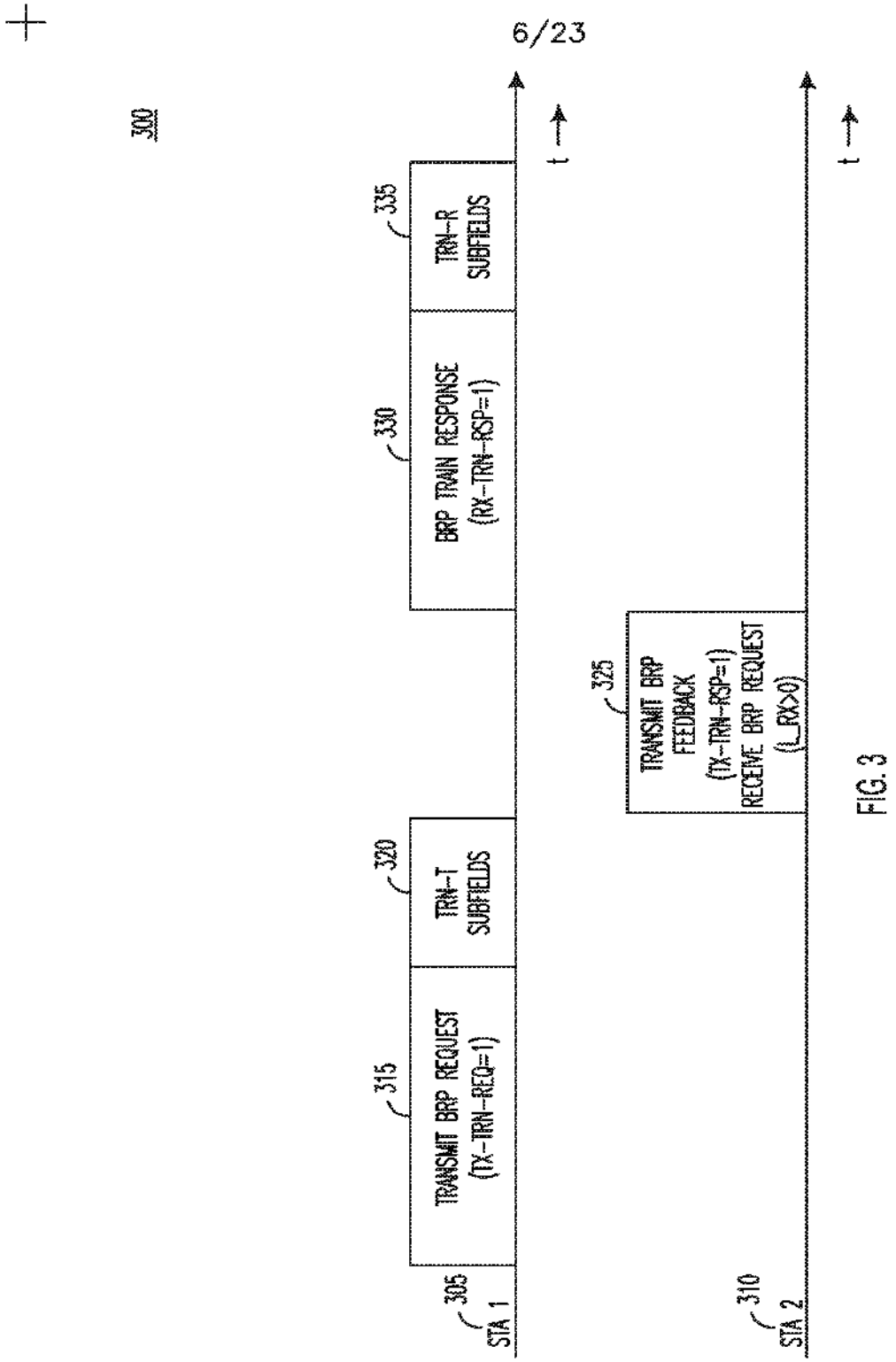

300
305
STA 1
310
STA 2
315
TRANSMIT BRP REQUEST
(TX-TRN-REQ=1)
320
TRN-T
SUBFIELDS
325
TRANSMIT BRP
FEEDBACK
(TX-TRN-RSP=1)
RECEIVE BRP REQUEST
(L_RX>0)
330
BRP TRAIN RESPONSE
(RX-TRN-RSP=1)
335
TRN-R
SUBFIELDS
t
t

FIG. 3

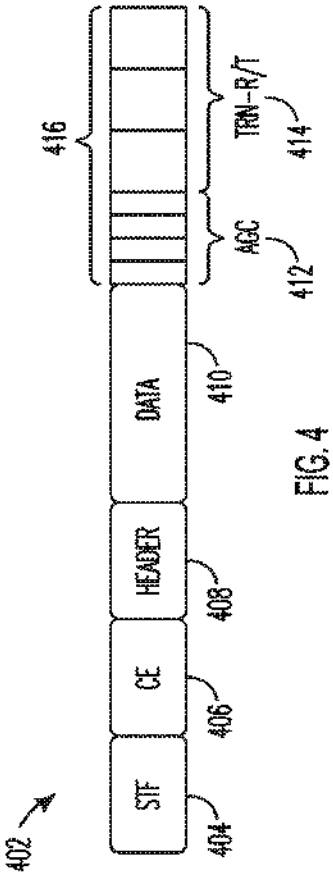


FIG. 4

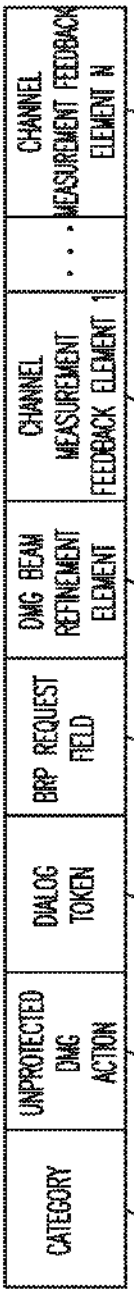


FIG. 5

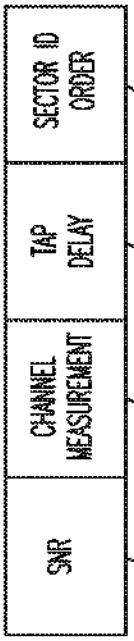


FIG. 6

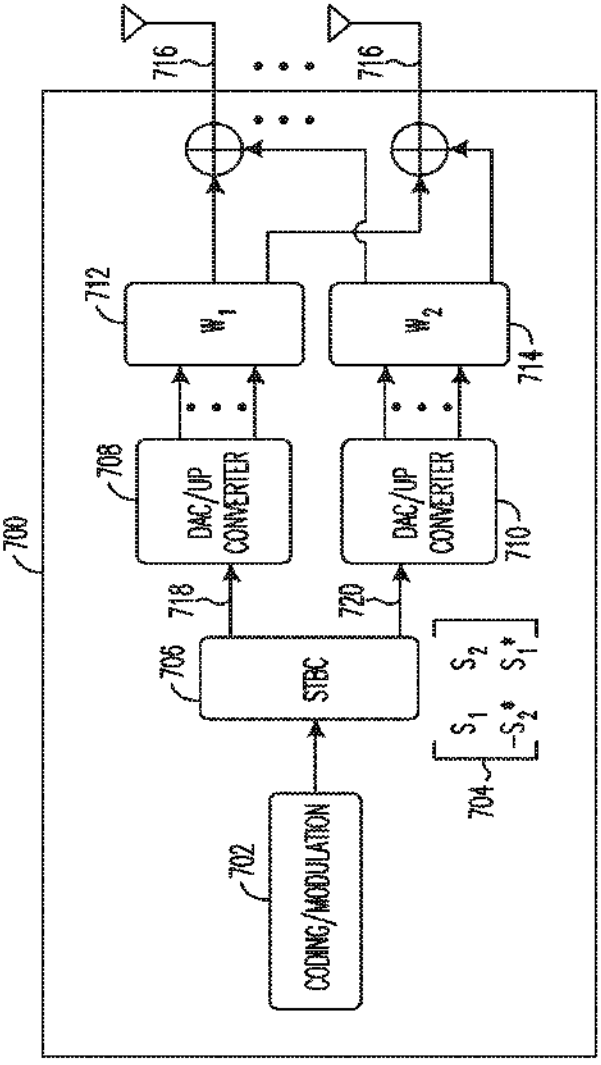

700
716
716
712
W_1
W_2
714
708
DAC/UP CONVERTER
DAC/UP CONVERTER
710
718
720
706
STBC
S_1 S_2
$-S_2^*$ S_1^*
704
702
CODING/MODULATION

FIG. 7

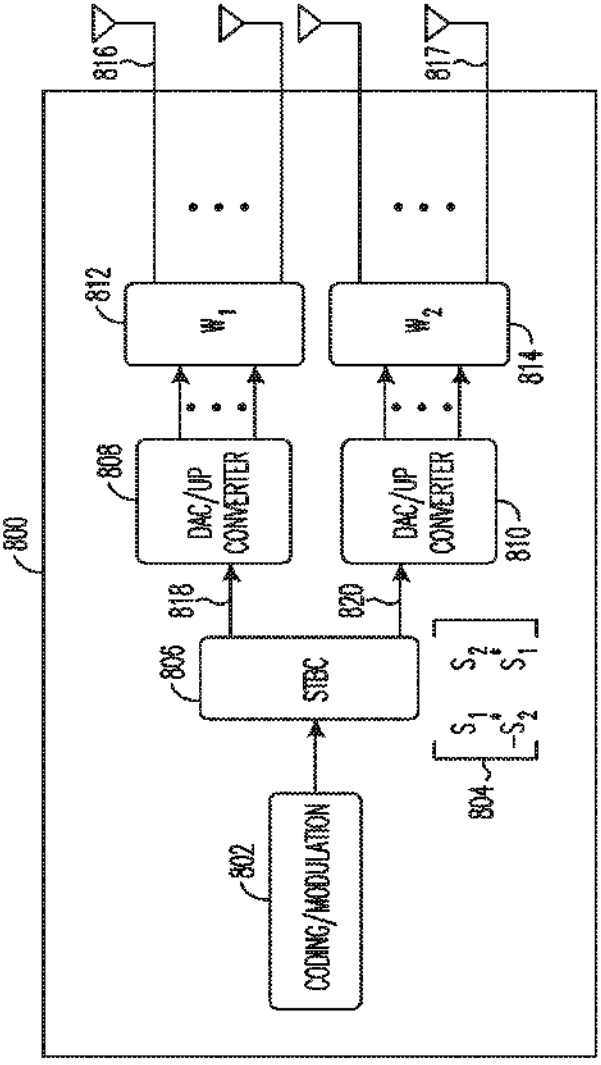

800
816
817
812
814
808
810
818
820
806
804
802
W_1
W_2
DAC/UP CONVERTER
DAC/UP CONVERTER
STBC
CODING/MODULATION
S_1 S_2
$-S_2^*$ S_1^*

FIG. 8

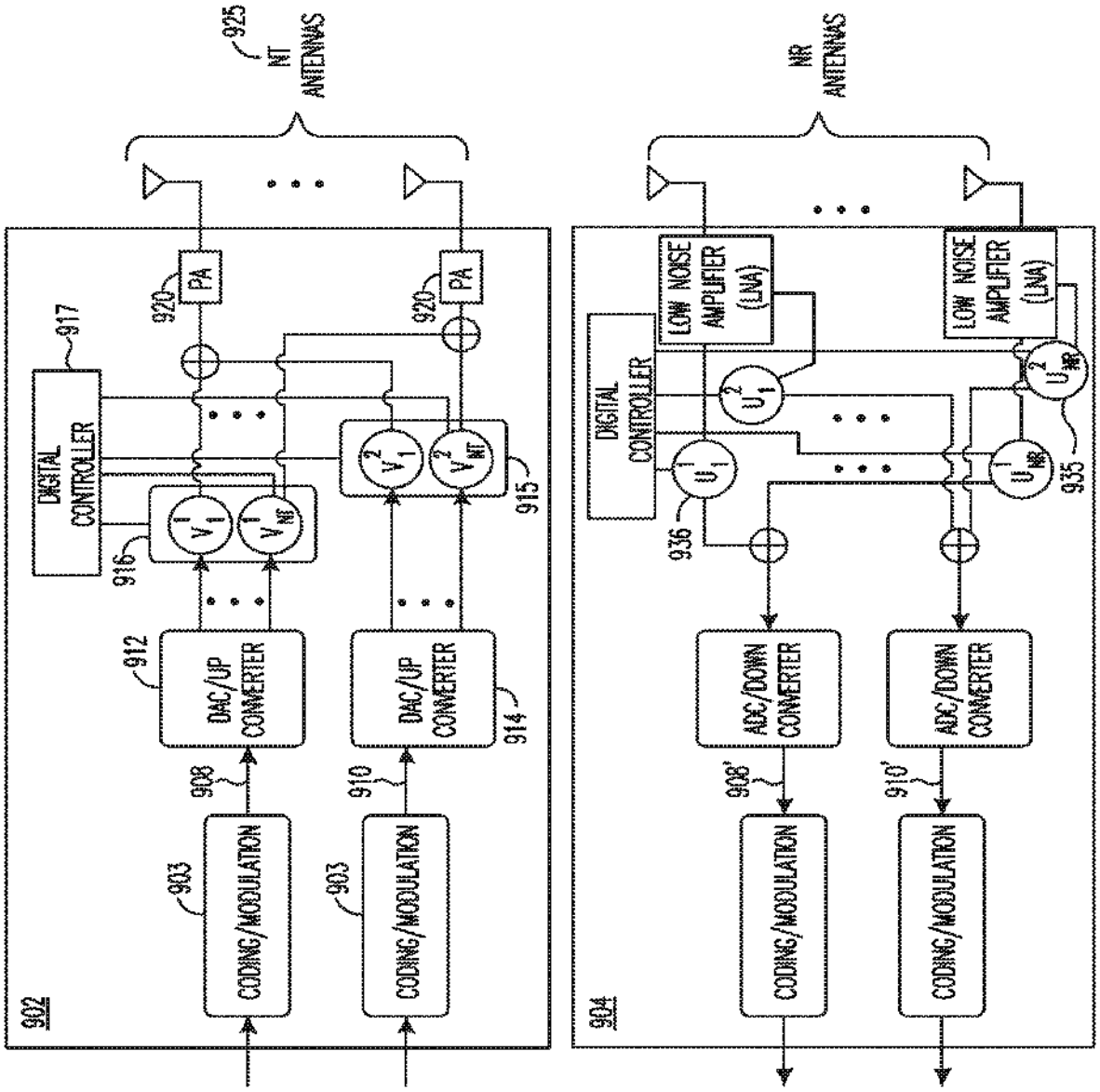

925
NT
ANTENNAS
NR
ANTENNAS
902
904
DIGITAL
CONTROLLER
917
916
915
920
PA
912
914
DAC/UP
CONVERTER
908
910
903
CODING/MODULATION
LOW NOISE
AMPLIFIER
(LNA)
936
935
ADC/DOWN
CONVERTER
908'
910'

FIG. 9

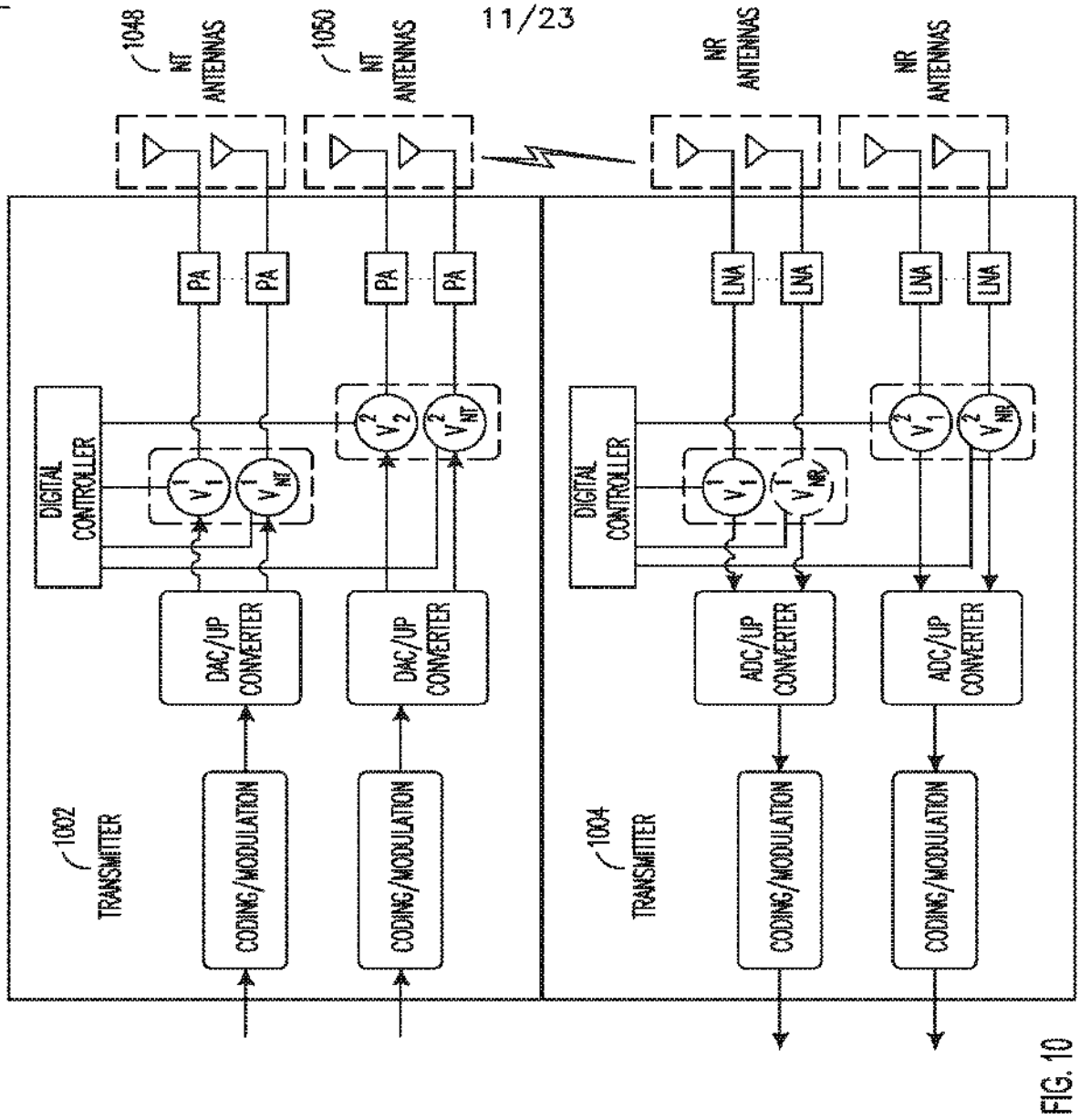

1048
NT ANTENNAS
1050
NT ANTENNAS
NR ANTENNAS
NR ANTENNAS
PA
PA
PA
PA
LNA
LNA
LNA
LNA
DIGITAL CONTROLLER
DIGITAL CONTROLLER
DAC/UP CONVERTER
DAC/UP CONVERTER
ADC/UP CONVERTER
ADC/UP CONVERTER
CODING/MODULATION
CODING/MODULATION
CODING/MODULATION
CODING/MODULATION
1002
TRANSMITTER
1004
TRANSMITTER

FIG. 10

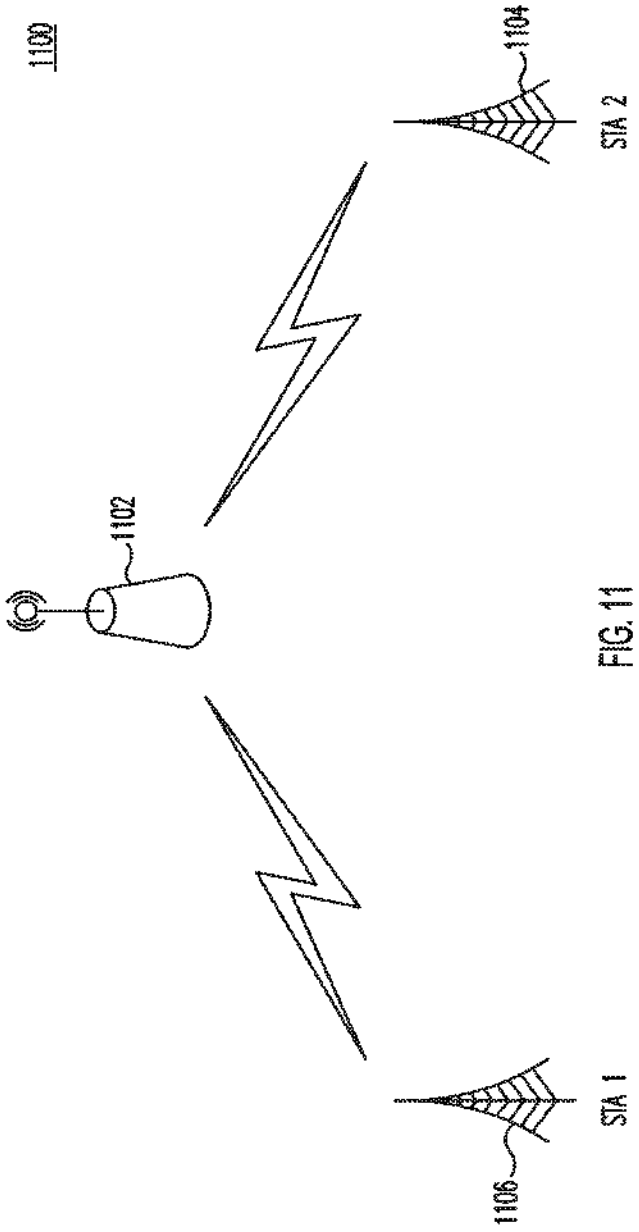


FIG. 11

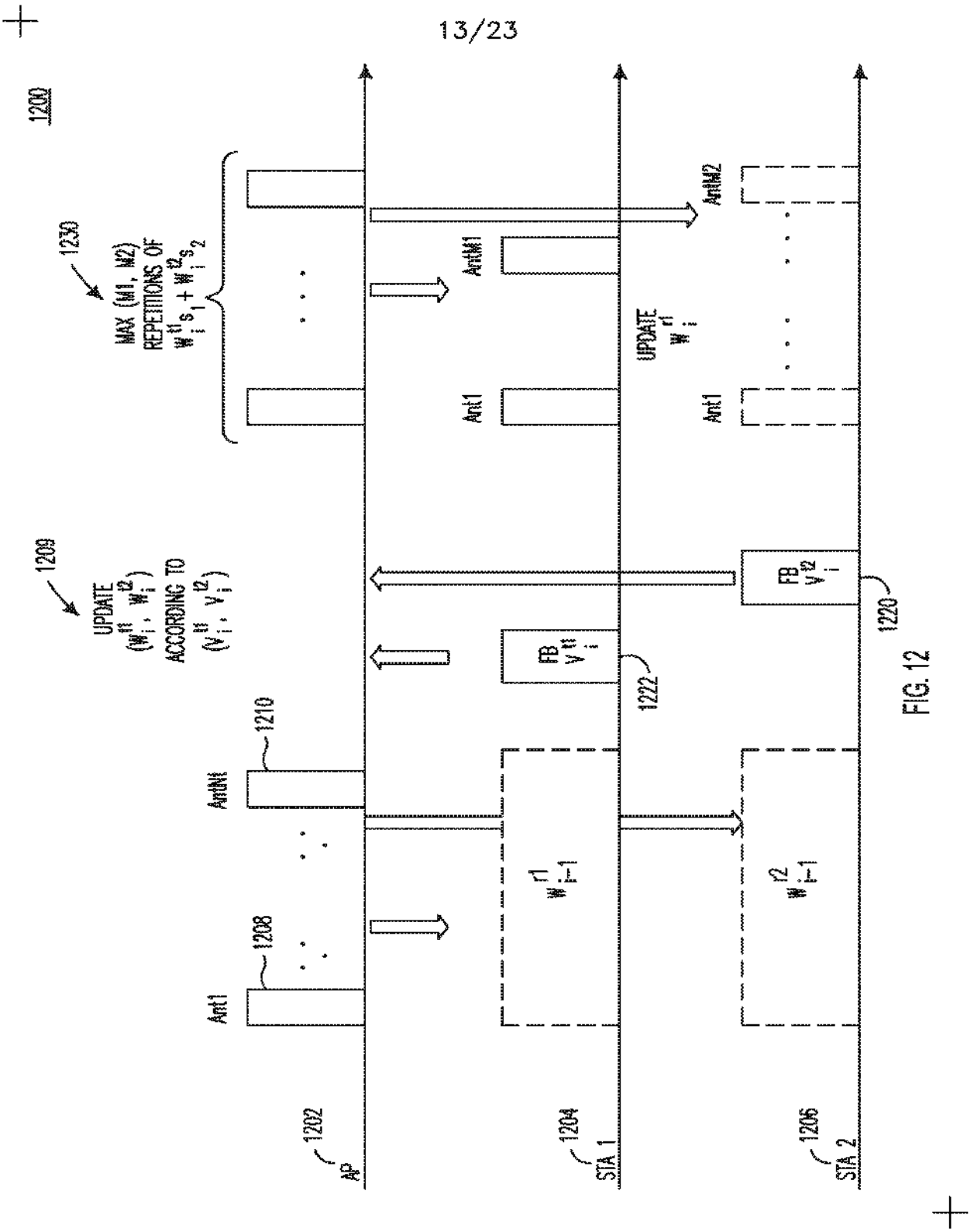

1200
1230
MAX (M1, M2)
REPETITIONS OF
$W_i^{t1} s_1 + W_i^{t2} s_2$
1209
UPDATE
(W_i^{t1}, W_i^{t2})
ACCORDING TO
(V_i^{t1}, V_i^{t2})
Ant1
1208
AntNt
1210
AntM1
AntM2
UPDATE
W_i^{r1}
W_{i-1}^{r1}
W_{i-1}^{r2}
FB
V_i^{t1}
1222
FB
V_i^{t2}
1220
1202
AP
1204
STA 1
1206
STA 2

FIG. 12

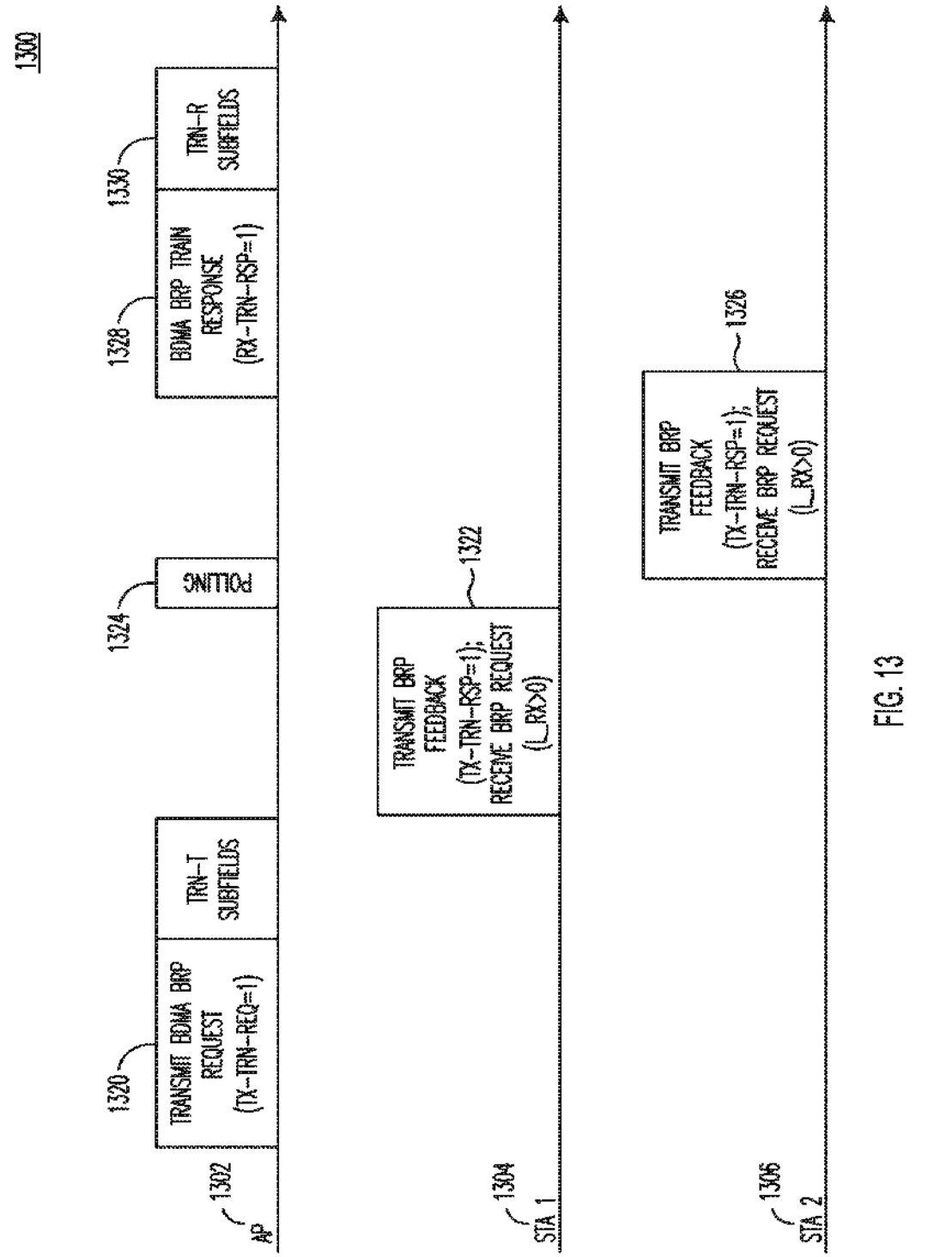

1300
1302
AP
1304
STA 1
1306
STA 2
1320
TRANSMIT BDMA BRP REQUEST (TX-TRN-REQ=1)
TRN-T SUBFIELDS
1322
TRANSMIT BRP FEEDBACK (TX-TRN-RSP=1); RECEIVE BRP REQUEST (L_RX>0)
1324
SWITCH
1326
TRANSMIT BRP FEEDBACK (TX-TRN-RSP=1); RECEIVE BRP REQUEST (L_RX>0)
1328
BDMA BRP TRAIN RESPONSE (RX-TRN-RSP=1)
1330
TRN-R SUBFIELDS

FIG. 13

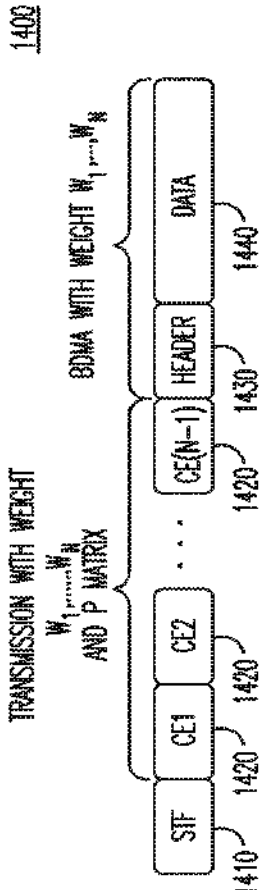

1400
TRANSMISSION WITH WEIGHT
$W_1,\ldots,W_N$
AND P MATRIX
BDMA WITH WEIGHT $W_1,\ldots,W_N$
STF
CE1
CE2
CE(N-1)
HEADER
DATA
1410
1420
1420
1420
1430
1440

FIG. 14

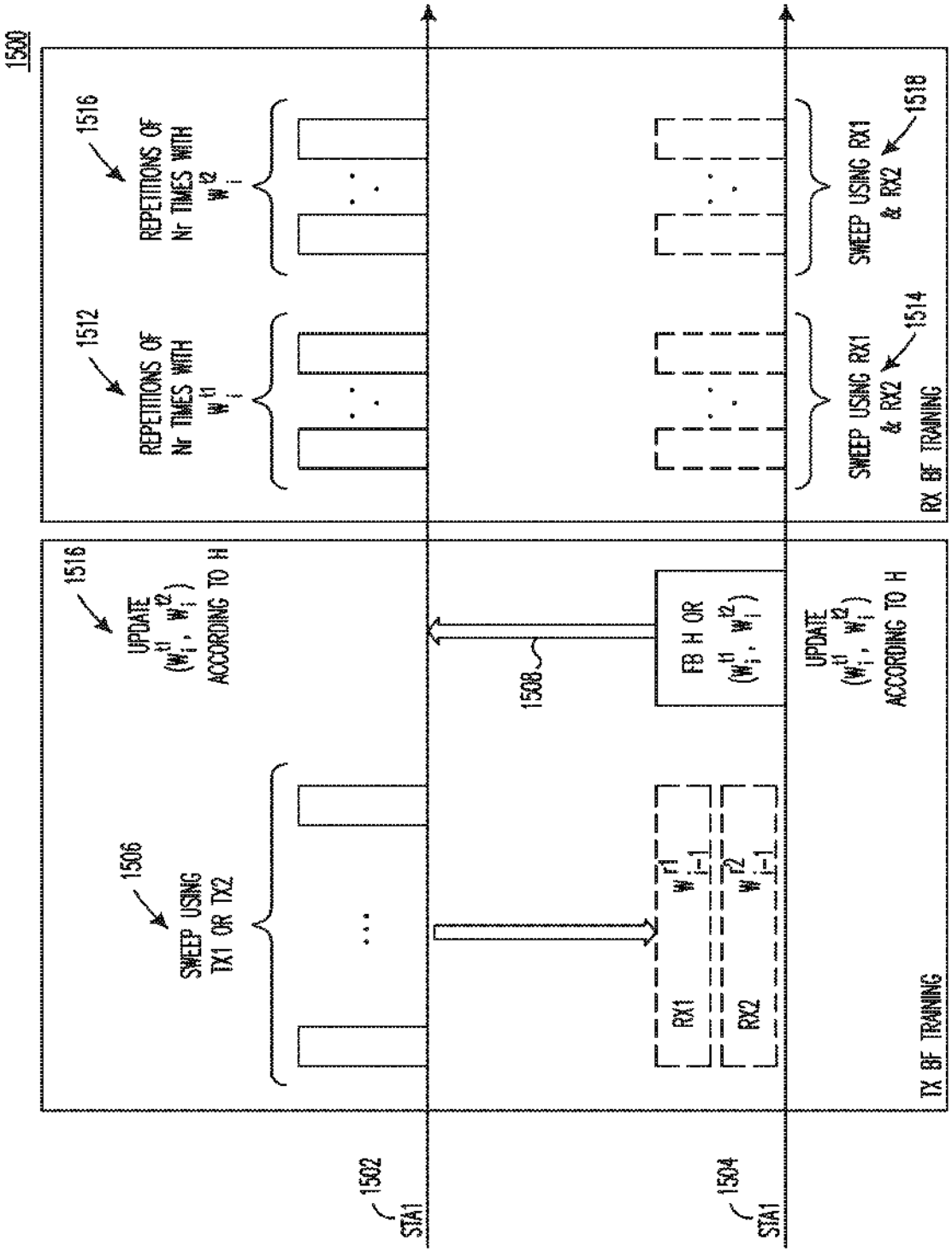

1500
1516
REPETITIONS OF Nr TIMES WITH W_i^{t2}
1512
REPETITIONS OF Nr TIMES WITH W_i^{t1}
SWEEP USING RX1 & RX2
1518
1514
RX BF TRAINING
1516
UPDATE (W_i^{t1}, W_i^{t2}) ACCORDING TO H
1506
SWEEP USING TX1 OR TX2
1508
FB H OR (W_i^{t1}, W_i^{t2})
UPDATE (W_i^{t1}, W_i^{t2}) ACCORDING TO H
RX1 W_{i-1}^{r1}
RX2 W_{i-1}^{r2}
TX BF TRAINING
1502
STA1
1504
STA1

FIG. 15

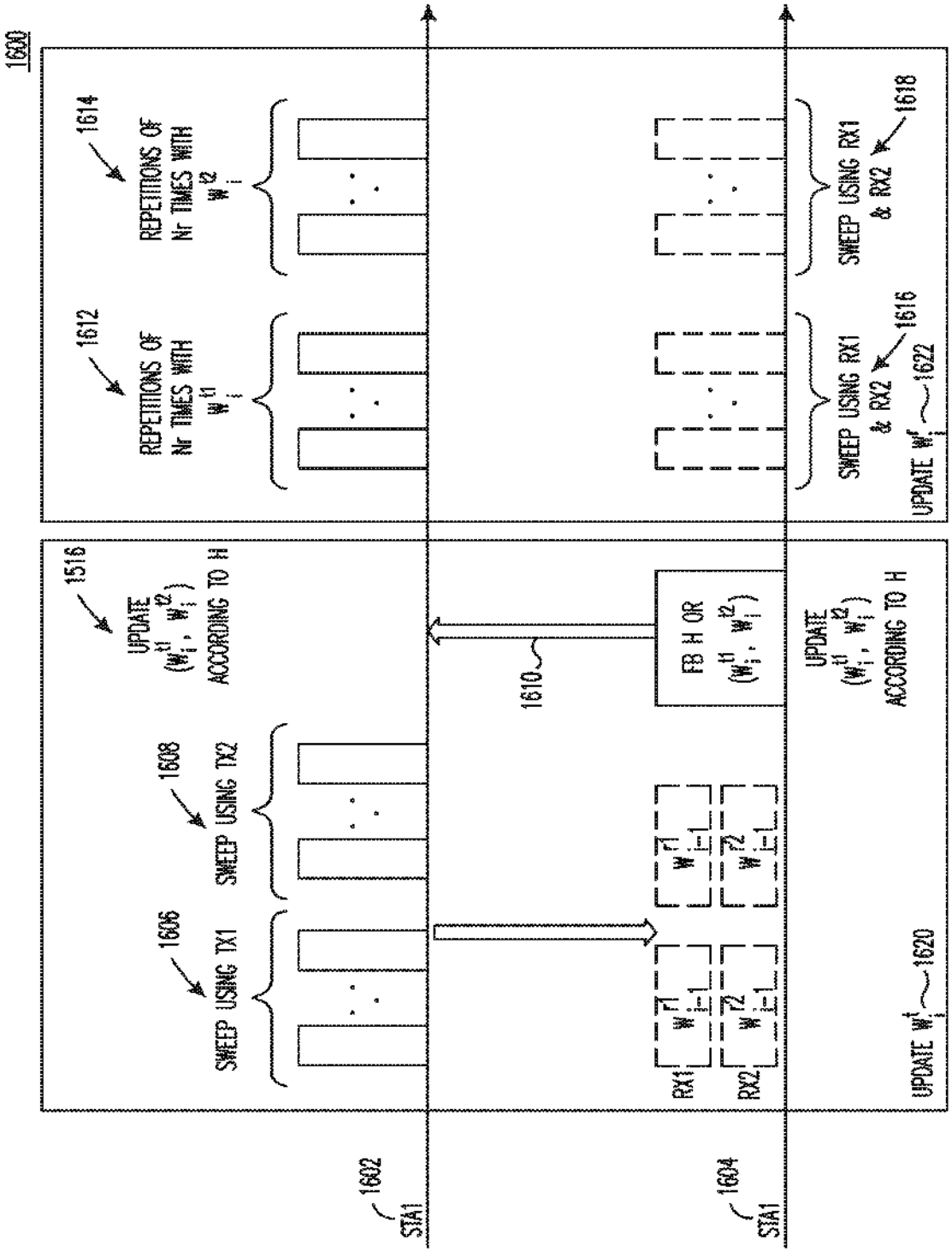

1600
1602
STA1
1604
STA1
1606
SWEEP USING TX1
1608
SWEEP USING TX2
1610
1612
REPETITIONS OF Nr TIMES WITH
1614
REPETITIONS OF Nr TIMES WITH
1616
SWEEP USING RX1 & RX2
1618
SWEEP USING RX1 & RX2
1620
UPDATE
1622
UPDATE
1516
UPDATE
ACCORDING TO H
FB H OR
RX1
RX2

FIG. 16

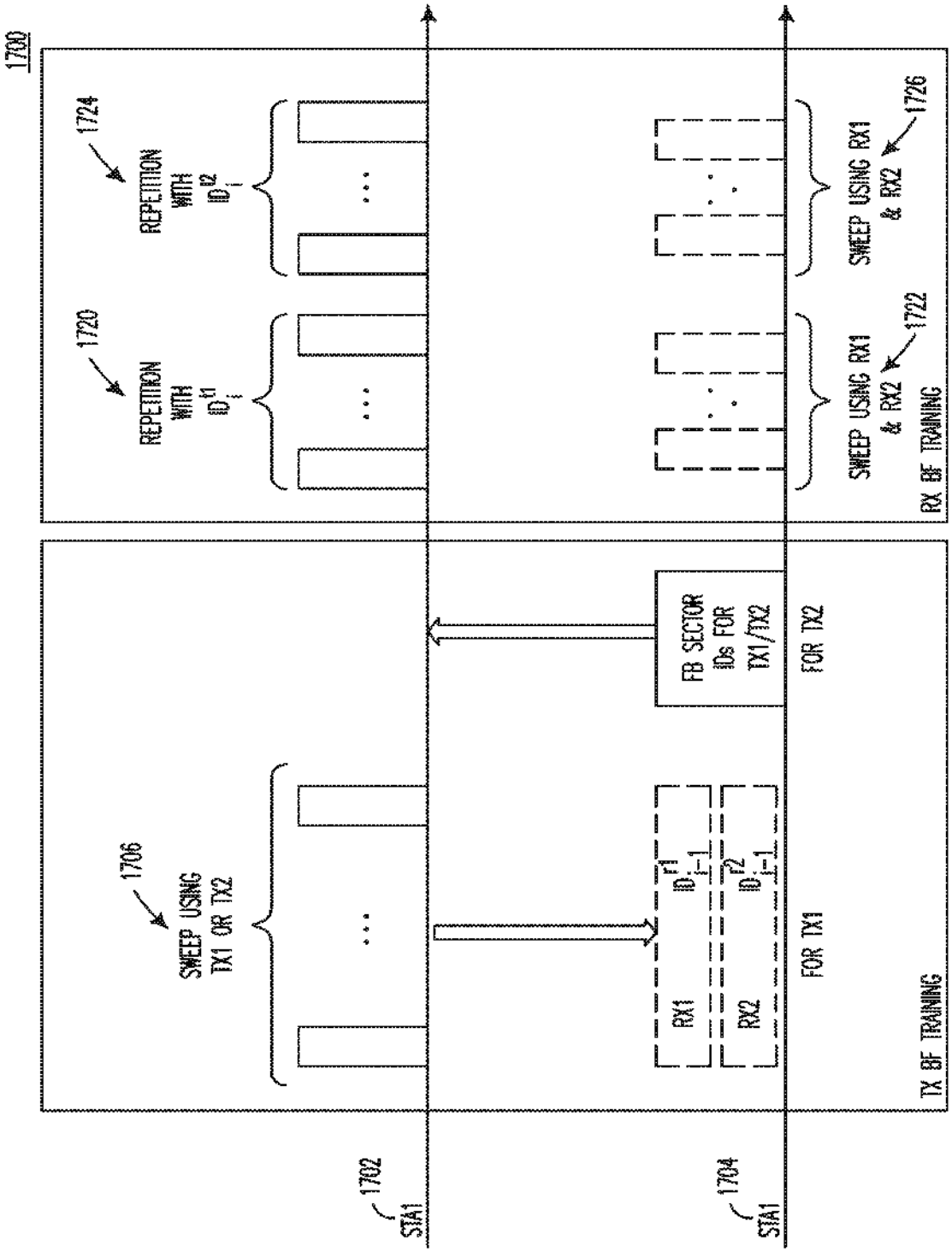

1700
1724
REPETITION WITH ID_i^{12}
1720
REPETITION WITH ID_i^{11}
SWEEP USING RX1 & RX2
1722
SWEEP USING RX1 & RX2
1726
RX BF TRAINING
1706
SWEEP USING TX1 OR TX2
RX1 ID_{i-1}^{r1}
RX2 ID_{i-1}^{r2}
FB SECTOR IDs FOR TX1/TX2
FOR TX1
FOR TX2
TX BF TRAINING
1702
STA1
1704
STA1

FIG. 17

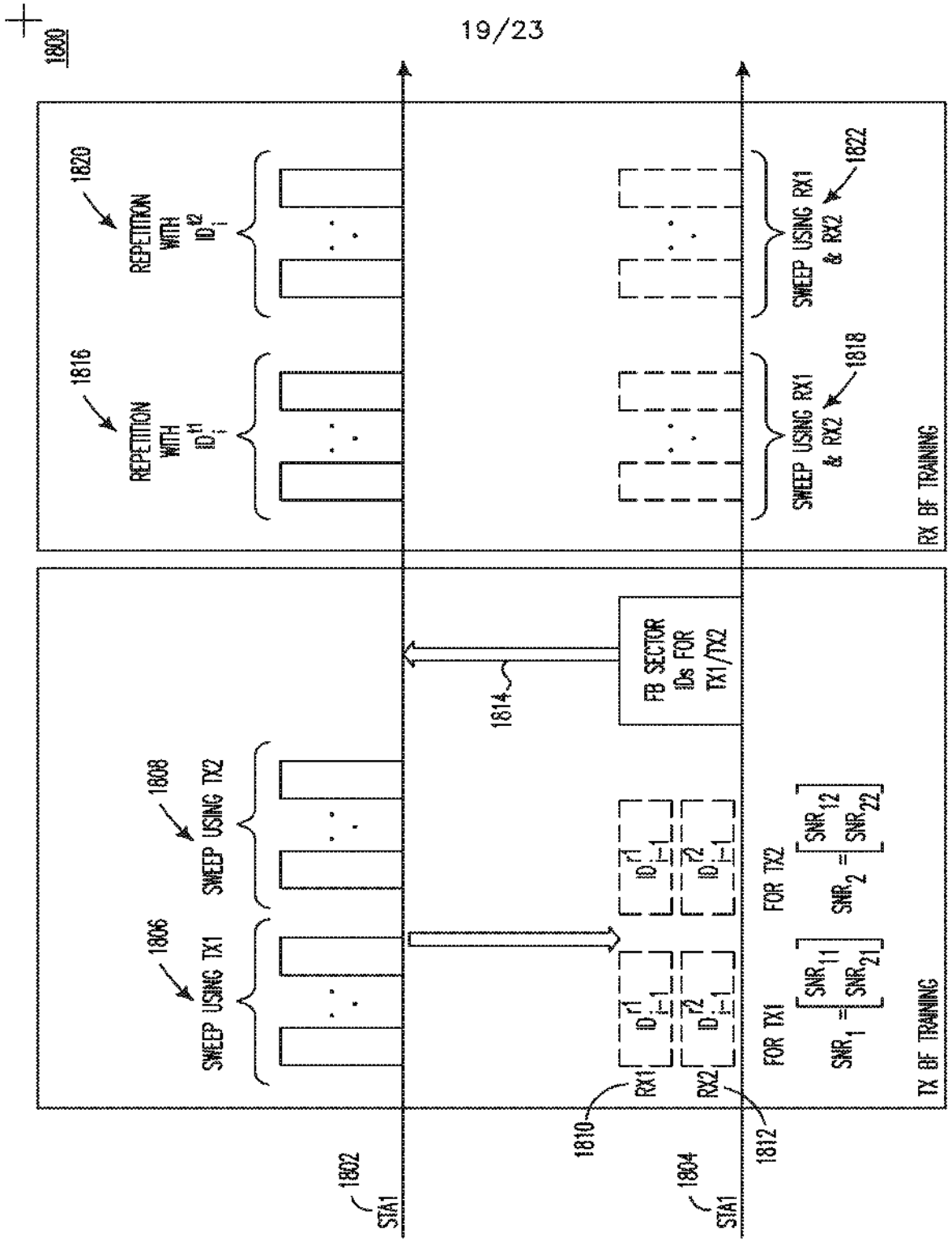

1800
1820
REPETITION WITH ID_i^{12}
1816
REPETITION WITH ID_i^{11}
SWEEP USING RX1 & RX2
1822
1818
RX BF TRAINING
1806
SWEEP USING TX1
1808
SWEEP USING TX2
1814
FB SECTOR IDs FOR TX1/TX2
ID_{i-1}^{r1}
ID_{i-1}^{r2}
RX1
RX2
1810
1812
FOR TX1
$SNR_1 = \begin{bmatrix} SNR_{11} \\ SNR_{21} \end{bmatrix}$
FOR TX2
$SNR_2 = \begin{bmatrix} SNR_{12} \\ SNR_{22} \end{bmatrix}$
TX BF TRAINING
1802
STA1
1804
STA1

FIG. 18

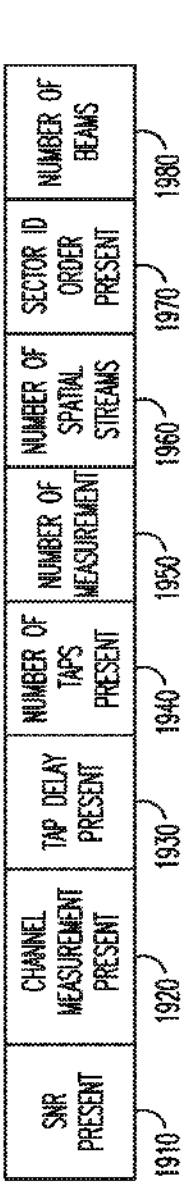


FIG. 19

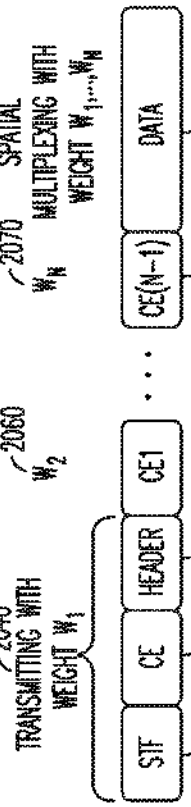


FIG. 20A

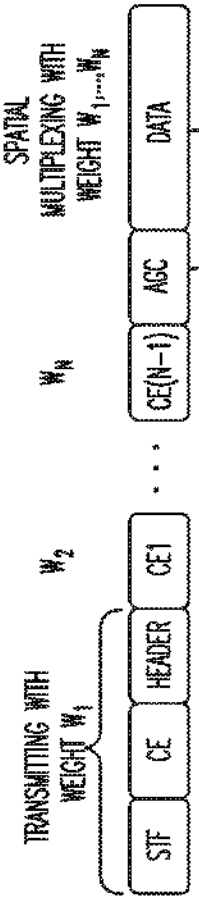


FIG. 20B

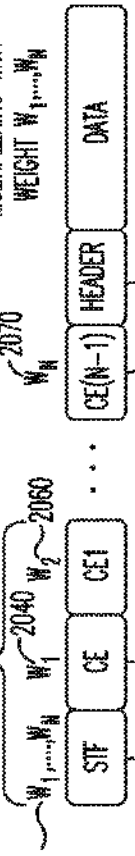


FIG. 20C

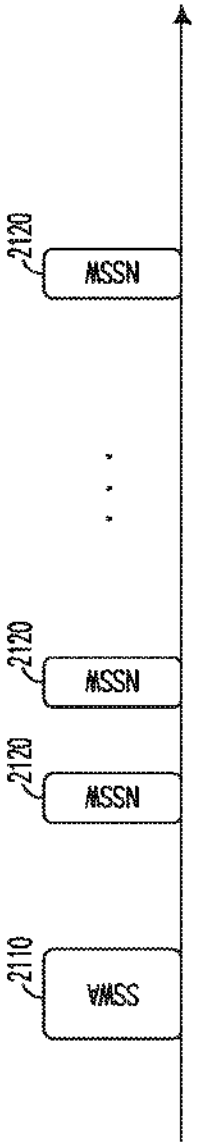

2100
2110
AMSS
2120
MSSN
2120
MSSN
2120
MSSN

FIG. 21

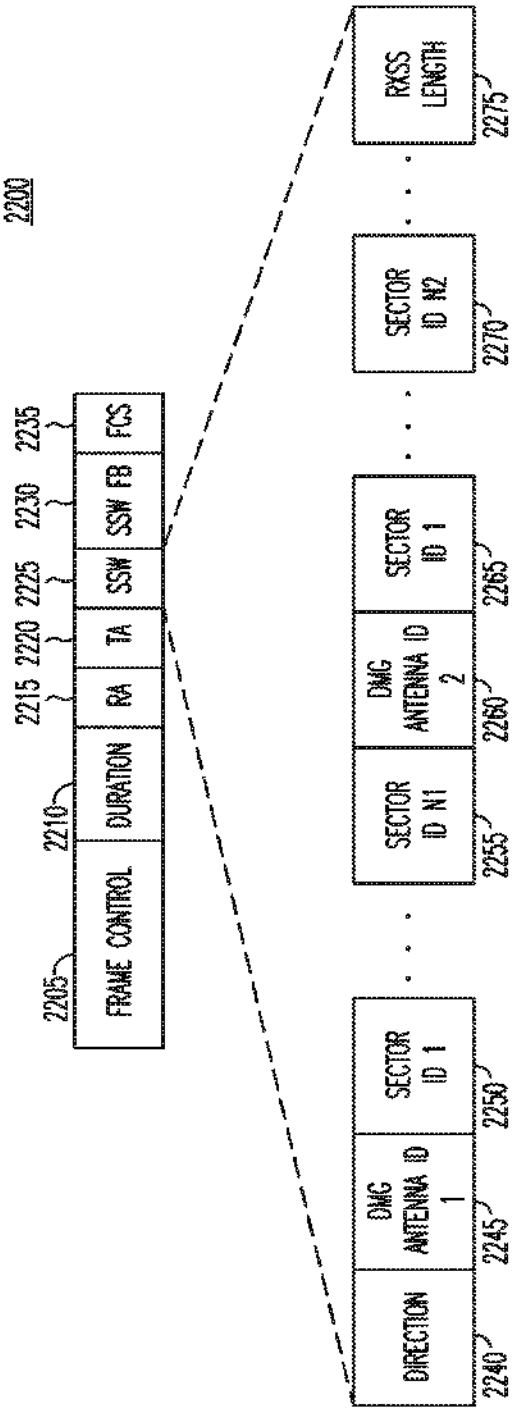

2200
2205
FRAME CONTROL
2210
DURATION
2215
RA
2220
TA
2225
SSW
2230
SSW FB
2235
FCS
2240
DIRECTION
2245
DMG ANTENNA ID 1
2250
SECTOR ID 1
2255
SECTOR ID N1
2260
DMG ANTENNA ID 2
2265
SECTOR ID 1
2270
SECTOR ID N2
2275
RXSS LENGTH

FIG. 22

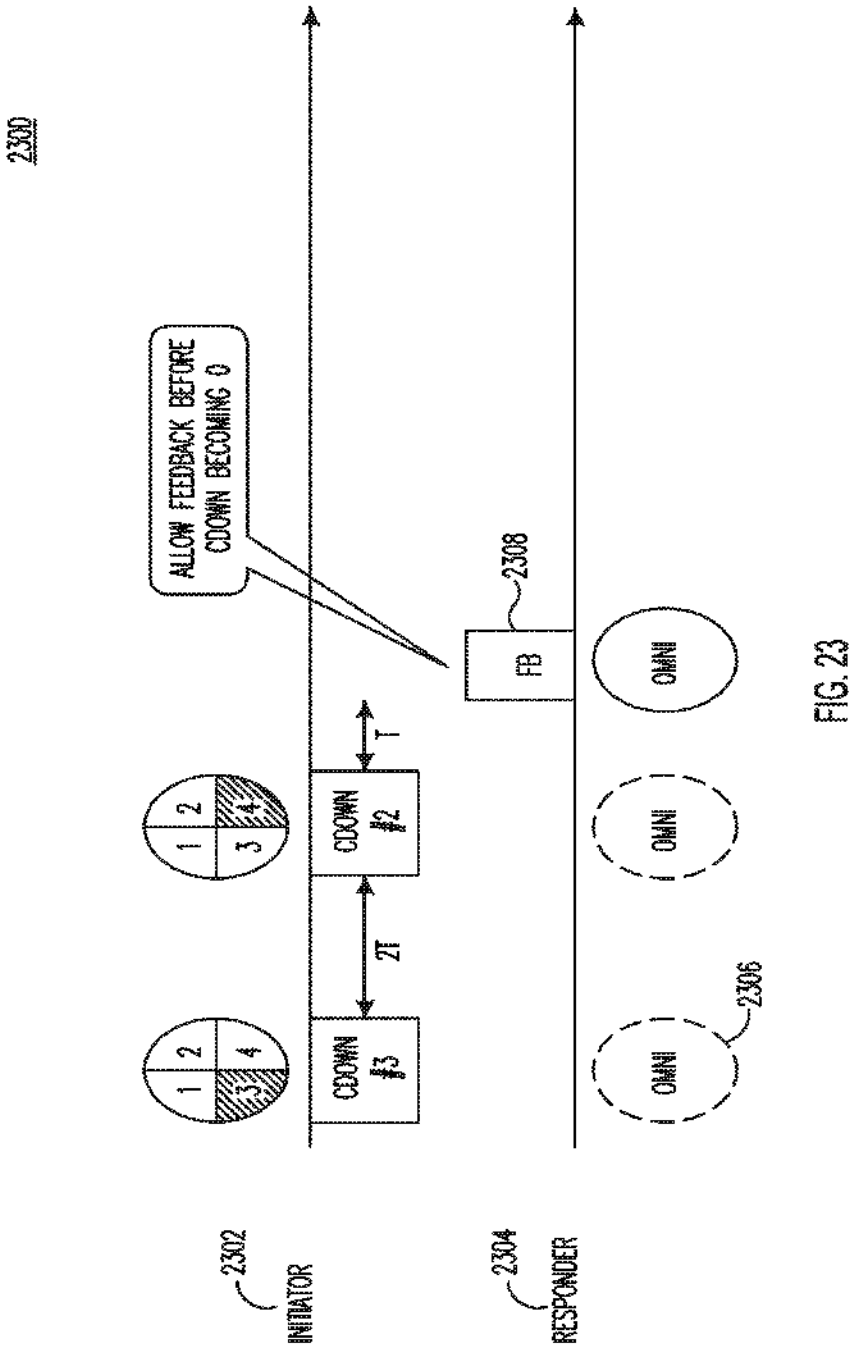

2300
ALLOW FEEDBACK BEFORE CDOWN BECOMING 0
2308
FB
OMNI
T
CDOWN #2
1 2 3 4
2T
CDOWN #3
1 2 3 4
OMNI
OMNI
2306
2302
INITIATOR
2304
RESPONDER

FIG. 23

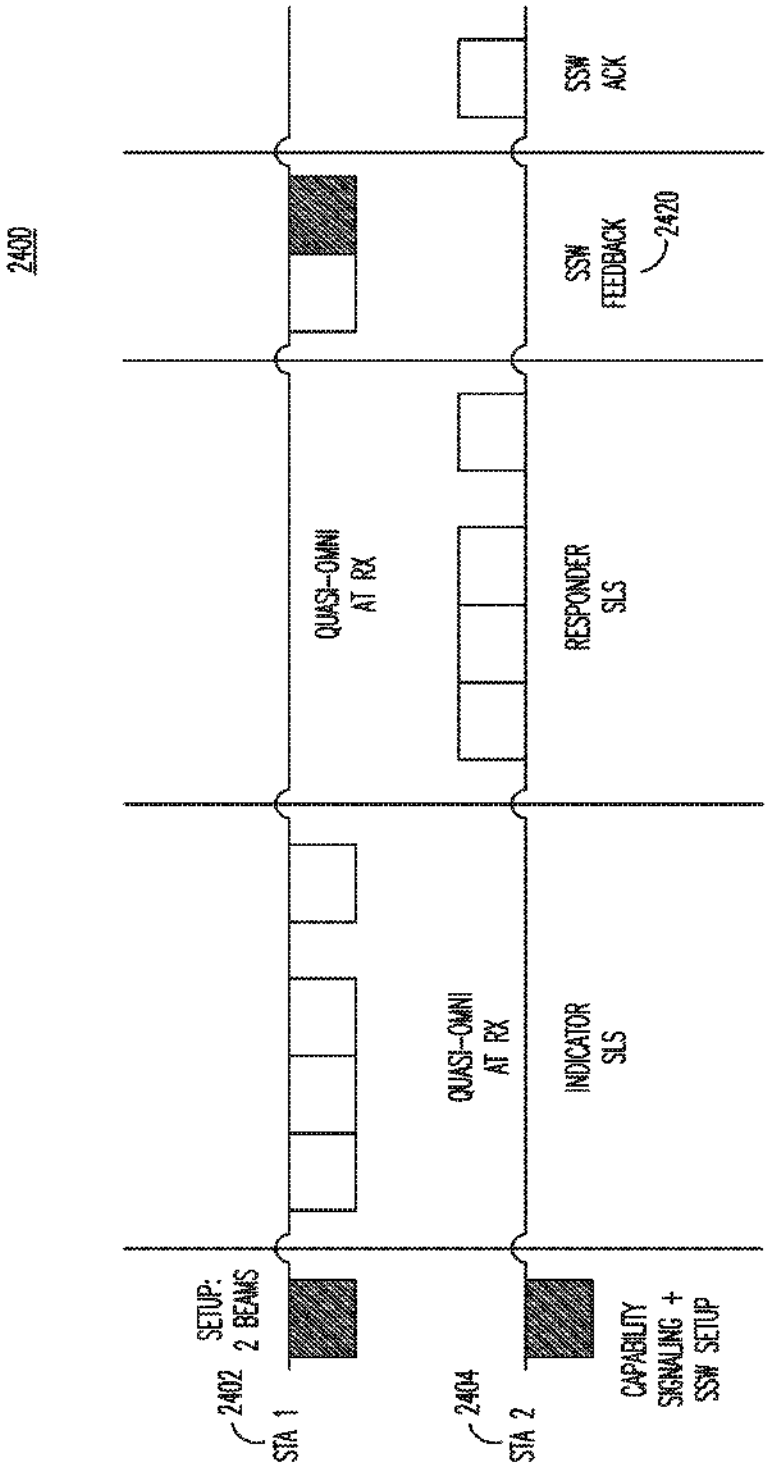

2400
SETUP: 2 BEAMS
2402
STA 1
QUASI-OMNI AT RX
QUASI-OMNI AT RX
2404
STA 2
INDICATOR SLS
CAPABILITY SIGNALING + SSW SETUP
RESPONDER SLS
SSW FEEDBACK
2420
SSW ACK

FIG. 24

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2013/069265

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04B7/04 H04B7/06
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2010/050874 A1 (ERICSSON TELEFON AB L M [SE]; RAHMAN MUHAMMAD IMADUR [SE]; JOENGREN GE) 6 May 2010 (2010-05-06) figures 1,5 page 9, line 1 - page 4, line 20 -----	1-20
X	WO 2009/093870 A2 (LG ELECTRONICS INC [KR]; JEON BEOM JIN [KR]) 30 July 2009 (2009-07-30) abstract paragraph [0001] - paragraph [0022] -----	1-20
X	WO 2009/102124 A2 (SAMSUNG ELECTRONICS CO LTD [KR]) 20 August 2009 (2009-08-20) abstract paragraph [0030] - paragraph [0057] ----- -/--	1-20

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"A" document defining the general state of the art which is not considered to be of particular relevance

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 February 2014	27/02/2014

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Neeb, Christoph

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2013/069265

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 2 211 483 A1 (SONY CORP [JP]) 28 July 2010 (2010-07-28) paragraph [0026] - paragraph [0080] -----	1-20
A	US 2009/232010 A1 (LI GUOQING [US] ET AL) 17 September 2009 (2009-09-17) the whole document -----	1-20
A	ELDAD PERAHIA ET AL: "Gigabit wireless LANs", ACM SIGMOBILE MOBILE COMPUTING AND COMMUNICATIONS REVIEW, vol. 15, no. 3, 29 November 2011 (2011-11-29), page 23, XP055015658, ISSN: 1559-1662, DOI: 10.1145/2073290.2073294 section III -----	1-20
A	EP 1 266 463 B1 (NOKIA CORP [FI]) 21 June 2006 (2006-06-21) paragraph [0030] - paragraph [0050] -----	1-20

3

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2013/069265

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		EP 2351246 A1	03-08-2011
		US 2011205930 A1	25-08-2011
		WO 2010050874 A1	06-05-2010
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		WO 2009102124 A2	20-08-2009
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		WO 0169814 A1	20-09-2001

Form PCT/ISA/210 (patent family annex) (April 2005)

(12) 특허협력조약에 의하여 공개된 국제출원

(19) 세계지식재산권기구
국제사무국

(43) 국제공개일
2016 년 8 월 4 일 (04.08.2016)

WIPO | PCT

(10) 국제공개번호
WO 2016/122257 A1

(51) 국제특허분류:
H04L 5/00 (2006.01) *H04B 7/02* (2006.01)
H04B 7/06 (2006.01)

(21) 국제출원번호: PCT/KR2016/001014

(22) 국제출원일: 2016 년 1 월 29 일 (29.01.2016)

(25) 출원언어: 한국어

(26) 공개언어: 한국어

(30) 우선권정보:
10-2015-0015603 2015 년 1 월 30 일 (30.01.2015) KR
10-2015-0018919 2015 년 2 월 6 일 (06.02.2015) KR
10-2015-0051184 2015 년 4 월 10 일 (10.04.2015) KR
10-2015-0064053 2015 년 5 월 7 일 (07.05.2015) KR
10-2015-0091400 2015 년 6 월 26 일 (26.06.2015) KR
10-2015-0105272 2015 년 7 월 24 일 (24.07.2015) KR
10-2015-0114925 2015 년 8 월 13 일 (13.08.2015) KR
10-2015-0114927 2015 년 8 월 13 일 (13.08.2015) KR
10-2016-0000596 2016 년 1 월 4 일 (04.01.2016) KR
10-2016-0004344 2016 년 1 월 13 일 (13.01.2016) KR
10-2016-0011000 2016 년 1 월 28 일 (28.01.2016) KR

(71) 출원인: 한국전자통신연구원 (ELECTRONICS AND TELECOMMUNICATIONS RESEARCH INSTITUTE) [KR/KR]; 34129 대전시 유성구 가정로 218, Daejeon (KR).

(72) 발명자: 문성현 (MOON, Sung-Hyun); 35201 대전시 서구 만년로 45, 103 동 709 호, Daejeon (KR). 김철순 (KIM, Cheulsoon); 34129 대전시 유성구 가정로 218, Daejeon (KR). 신우람 (SHIN, Wooram); 34127 대전시 유성구 죽동로 251, 307 동 1802 호, Daejeon (KR). 박기윤 (PARK, Gi Yoon); 34071 대전시 유성구 지족로 317, 106 동 1601 호, Daejeon (KR). 고영조 (KO, Young Jo); 35213 대전시 서구 청사서로 70, 102 동 706 호, Daejeon (KR). 남준영 (NAM, Junyoung); 34061 대전시 유성구 송림로 13, 106 동 1102 호, Daejeon (KR).

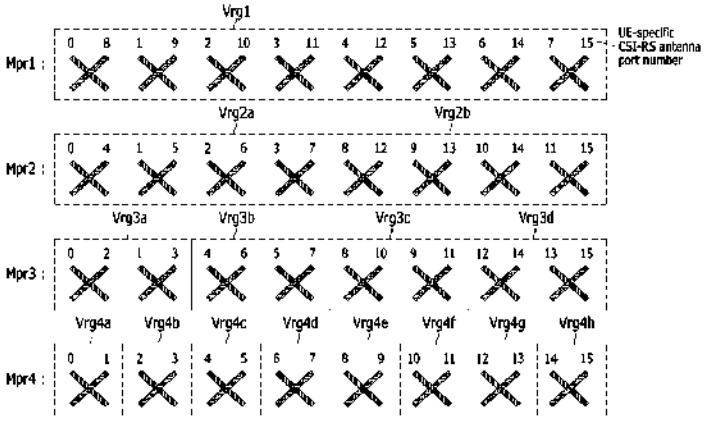
(74) 대리인: 팬코리아특허법인 (PANKOREA PATENT AND LAW FIRM); 06234 서울시 강남구 논현로 85 길 70, 13 층, Seoul (KR).

(81) 지정국 (별도의 표시가 없는 한, 가능한 모든 종류의 국내 권리의 보호를 위하여): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE,

[다음 쪽 계속]

(54) Title: METHOD AND APPARATUS FOR TRANSMITTING DOWNLINK REFERENCE SIGNAL, AND METHOD AND APPARATUS FOR TRANSMITTING CONTROL INFORMATION IN MULTI-CELL COLLABORATIVE COMMUNICATION SYSTEM

(54) 발명의 명칭 : 하향링크 참조 신호를 전송하는 방법 및 장치, 그리고 다중 셀 협력 통신 시스템에서 제어 정보를 전송하는 방법 및 장치



(57) Abstract: Provided is a method for a base station to set channel state information (CSI)-reference signal (RS). The base station sets a CSI-RS antenna port for a terminal. For the terminal, the base station selects one of at least one port number mapping rule for mapping a port number to the CSI-RS antenna port. Further, the base station notifies the terminal of the selected port number mapping rule.

(57) 요약서: 기지국이 CSI(channel state information)-RS(reference signal)를 설정하는 방법이 제공된다. 상기 기지국은, 단말을 위한 CSI-RS 안테나 포트를 설정한다. 상기 기지국은, 상기 CSI-RS 안테나 포트에 포트 번호를 맵핑하기 위한 적어도 하나의 포트 번호 맵핑 규칙 중 하나를, 상기 단말을 위해 선택한다. 그리고 상기 기지국은, 상기 선택된 포트 번호 맵핑 규칙을 상기 단말에게 알린다.

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명세서

발명의 명칭: 하향링크 참조 신호를 전송하는 방법 및 장치, 그리고 다중 셀 협력 통신 시스템에서 제어 정보를 전송하는 방법 및 장치

기술분야

[1] 본 발명은 하향링크 참조 신호를 전송하는 방법 및 장치에 관한 것이다.

[2] 또한 본 발명은 채널 상태 정보를 측정하는 방법 및 장치에 관한 것이다.

[3] 또한 본 발명은 다중 셀 협력 통신 시스템에서 제어 정보를 전송하는 방법 및 장치에 관한 것이다.

배경기술

[4] 무선 통신 시스템의 다중 입출력(MIMO: multiple-input multiple-output) 방식은 복수의 송신 안테나와 복수의 수신 안테나를 사용하여 송수신하는 방법이다. MIMO 시스템에서 송수신 안테나 간 복수의 무선 채널 경로가 생성되며, 송수신단은 이를 분리 또는 병합함으로써, 데이터 전송 용량을 증대시키거나 전송 품질을 향상시킬 수 있다. MIMO 기법으로는 공간 다중화(spatial multiplexing) 기법과 공간 다이버시티(spatial diversity) 기법이 있다. LTE(long term evolution) 시스템에 도입된 하향링크 MIMO 기법으로는, 송신 다이버시티(transmit diversity), CDD (cyclic delay diversity), 빔포밍(beamforming) 및 공간 다중화 방식 등이 있다. 또한 동일 자원에서 동시에 복수의 단말에 데이터를 전송하는 다중 사용자 MIMO (MU-MIMO: multiuser MIMO) 기법이 지원된다.

[5] LTE 규격에서의 안테나 포트(antenna port)는 하나 또는 복수의 물리 안테나 요소(antenna element)의 가중치 합(weighted sum)에 의해 구현되는 논리적 안테나 단위로써, 주로 송신단에서 정의된다. 안테나 포트는 참조 신호(RS: reference signal)가 전송되는 기본 단위이기도 하다. 따라서 단말은 물리 안테나 요소가 아닌 각 안테나 포트에 대하여 채널을 추정하고 이를 기반으로 채널 상태 정보(CSI: channel state information) 측정 및 보고를 수행한다. LTE 하향링크 참조 신호인 CRS(cell-specific RS), URS(user equipment-specific RS), 및 CSI-RS에는 각기 다른 안테나 포트 번호가 부여된다. URS의 목적은 단말의 PDSCH(physical downlink shared channel) 복호를 위함이므로, URS는 DMRS(demodulation RS)로 부르기도 한다. CRS를 위한 안테나 포트 번호는 0번 내지 3번이고, URS를 위한 안테나 포트 번호는 7번 내지 14번, CSI-RS를 위한 안테나 포트 번호는 15번 내지 22번일 수 있다. 안테나 포트와 물리 안테나 요소(들) 간의 맵핑을 안테나 가상화(antenna virtualization)라고 한다. 단말은 기본적으로 각 안테나 포트에 어떤 가상화가 적용되었는지를 알 수 없다.

[6] CSI-RS는 단말이 CSI를 획득하기 위한 목적으로 기지국이 전송하는 하향링크 참조신호로써, LTE Release 10에서 도입되었다. CSI-RS는 후술할 ZP(zero-power)

CSI-RS와의 구별을 위해 NZP(non-zero-power) CSI-RS라 불려지기도 한다. 기존 Release 8/9 시스템에서는 단말의 CSI 획득을 위해 CRS가 이용되었으나, Release 10부터는 최대 8개의 레이어(layer)의 하향링크 전송을 지원하기 위해 기존의 CRS보다 낮은 밀도를 갖는 새로운 채널 추정용 참조신호의 도입이 필요하게 되었다. CSI-RS 설정 정보는 단말 특정적(user equipment-specific) RRC(radio resource control) 시그널링을 통해 단말에게 전송된다. 단말에게 설정 가능한 CSI-RS 안테나 포트 수는, Release 13 현재까지 1, 2, 4, 8, 12, 그리고 16이다. 각 CSI-RS 안테나 포트 수에 대하여, PRB(physical resource block) 페어(pair) 당 CSI-RS 전송이 차지하는 총 RE의 개수는, 2, 2, 4, 8, 12, 그리고 16이다.

[7] 시간 축에서의 CSI-RS 전송 주기는, 5, 10, 20, 40, 또는 80 ms 로 설정(configured)될 수 있다. 현재 규격에 의하면, 각 CSI-RS 안테나 포트는 주파수 축에서 12 자원 요소(RE: resource element)의 간격을 가진다.

[8] 한편, FD(full dimension)-MIMO(또는 3차원 MIMO) 시스템에서 기지국이 3차원 빔포밍을 수행하기 위해서는, 단말이 기존의 수평 축에 대한 CSI 뿐만 아니라 수직 축에 대한 CSI의 측정 및 보고를 수행할 필요가 있다. 2차원 안테나 배열의 크기가 큰 경우에, 단말에 설정 가능한 CSI-RS 안테나 포트 수를 늘리는 방법이 연구되고 있다.

[9] 또한 기존의 단말은 CSI-RS 안테나 포트 배열을 1차원으로만 인식한다. 단말이 CSI-RS 안테나 포트 배열을 2차원(2D: two dimensions) 또는 3차원(3D: three dimensions)으로 인식하는 방법이 필요하다.

발명의 상세한 설명

기술적 과제

[10] 본 발명이 해결하고자 하는 과제는, MIMO 무선 통신 시스템에서 CSI-RS를 설정하고 전송하는 방법 및 장치를 제공하는 것이다.

[11] 또한 본 발명이 해결하고자 하는 과제는, 단말에 설정 가능한 CSI-RS 안테나 포트 수를 늘리는 방법 및 장치를 제공하는 것이다.

[12] 또한 본 발명이 해결하고자 하는 과제는, CSI-RS 안테나 포트 배열을 1차원 또는 다차원으로 인식하는 방법 및 장치를 제공하는 것이다.

[13] 또한 본 발명이 해결하고자 하는 과제는, 무선 통신 시스템에서 CSI-RS 전송 오버헤드를 줄이기 위하여 다중 셀 협력 통신을 위한 제어 정보를 설정하는 방법 및 장치에 관한 것이다.

[14] 또한 본 발명이 해결하고자 하는 과제는, CSI-RS 자원으로써 설정될 수 있는 RE를 확장하는 방법 및 장치에 관한 것이다.

[15] 또한 본 발명이 해결하고자 하는 과제는, 상기 확장된 RE를 이용해 CSI-RS 를 전송하는 방법 및 장치에 관한 것이다.

과제 해결 수단

[16] 본 발명의 실시예에 따르면, 기지국이 CSI(channel state

information)-RS(reference signal)를 설정하는 방법이 제공된다. 상기 기지국의 CSI-RS 설정 방법은, 단말을 위한 CSI-RS 안테나 포트를 설정하는 단계; 상기 CSI-RS 안테나 포트에 포트 번호를 맵핑하기 위한 적어도 하나의 포트 번호 맵핑 규칙 중 하나를, 상기 단말을 위해 선택하는 단계; 및 상기 선택된 포트 번호 맵핑 규칙을 상기 단말에게 알리는 단계를 포함한다.

[17] 상기 단말을 위한 CSI-RS 안테나 포트를 설정하는 단계는, 상기 CSI-RS 안테나 포트가 제1 축, 제2 축, 및 제3 축 중 적어도 2개를 따라 배치되는 CSI-RS 안테나 포트 배열을 설정하는 단계를 포함할 수 있다.

[18] 상기 선택된 포트 번호 맵핑 규칙에 무관하게, 상기 제1 축, 상기 제2 축, 및 상기 제3 축에 포트 번호가 맵핑되는 축 순서는, 기 설정될 수 있다.

[19] 상기 단말을 위한 CSI-RS 안테나 포트를 설정하는 단계는, 상기 CSI-RS 안테나 포트 배열에 포함된 CSI-RS 안테나 포트 중에서 상기 제1 축으로 배치되는 CSI-RS 안테나 포트의 수, 상기 제2 축으로 배치되는 CSI-RS 안테나 포트의 수, 및 상기 제3 축으로 배치되는 CSI-RS 안테나 포트의 수 중 적어도 하나를, 상기 단말에게 전송하는 단계를 더 포함할 수 있다.

[20] 상기 단말을 위한 CSI-RS 안테나 포트를 설정하는 단계는, 상기 제1 축, 상기 제2 축, 및 상기 제3 축 중 하나의 축에 따라 배치되는 CSI-RS 안테나 포트의 수가 상기 단말에게 설정되는 전체 CSI-RS 안테나 포트의 수와 동일한 경우에, 상기 하나의 축에 따라 배치되는 CSI-RS 안테나 포트의 수를 상기 단말에게 전송하는 것을 생략하는 단계를 더 포함할 수 있다.

[21] 상기 단말을 위한 CSI-RS 안테나 포트를 설정하는 단계는, 상기 CSI-RS 안테나 포트 배열에 포함된 CSI-RS 안테나 포트 중에서 상기 제1 축으로 배치되는 CSI-RS 안테나 포트의 수와 상기 제3 축으로 배치되는 CSI-RS 안테나 포트의 수를 합하여, 제1 값을 구하는 단계; 및 상기 CSI-RS 안테나 포트 배열에 포함된 CSI-RS 안테나 포트 중에서 상기 제2 축으로 배치되는 CSI-RS 안테나 포트의 수 및 상기 제1 값 중 적어도 하나를, 상기 단말에게 전송하는 단계를 더 포함할 수 있다.

[22] 상기 선택된 포트 번호 맵핑 규칙은, 상기 단말에 의한 채널 추정 시에, 상기 단말로 하여금 상기 단말에게 설정된 전체 CSI-RS 안테나 포트를 상기 선택된 포트 번호 맵핑 규칙에 대응하는 개수 만큼의 CSI-RS 안테나 포트 그룹으로 나누도록 하고, 상기 CSI-RS 안테나 포트 그룹 별로 상기 각 CSI-RS 안테나 포트 그룹에 속하는 CSI-RS 안테나 포트에 상기 기 설정된 축 순서에 따라 포트 번호를 부여하도록 할 수 있다.

[23] 상기 각 CSI-RS 안테나 포트 그룹에 속하는 CSI-RS 안테나 포트의 수는, 상기 단말에게 설정되는 전체 CSI-RS 안테나 포트의 수의 약수일 수 있다.

[24] 상기 선택된 포트 번호 맵핑 규칙을 상기 단말에게 알리는 단계는, 상기 선택된 포트 번호 맵핑 규칙을 나타내는 비트 코드를, 상기 단말에게 전송하는 단계를 포함할 수 있다.

[25] 상기 선택된 포트 번호 맵핑 규칙을 상기 단말에게 알리는 단계는, 상기 선택된 포트 번호 맵핑 규칙에 따라 생성되는 상기 CSI-RS 안테나 포트 그룹의 개수를 나타내는 비트 코드를, 상기 단말에게 전송하는 단계를 포함할 수 있다.

[26] 상기 단말에게 설정되는 전체 CSI-RS 안테나의 수는 8개 보다 더 많을 수 있다.

[27] 상기 제1 축은 수평(horizontal) 축이고, 상기 제2 축은 수직(vertical) 축이고, 상기 제3 축은 편파(polarization) 축일 수 있다.

[28] 상기 기지국의 CSI-RS 설정 방법은, 제1 축, 제2 축, 및 제3 축에 포트 번호가 맵핑되는 축 순서들 중에서 하나를, 상기 단말을 위해 선택하는 단계; 및 상기 선택된 축 순서를 상기 단말에게 알리는 단계를 더 포함할 수 있다.

[29] 상기 단말을 위한 CSI-RS 안테나 포트를 설정하는 단계는, 상기 CSI-RS 안테나 포트가 상기 제1 축, 상기 제2 축, 및 상기 제3 축 중 적어도 2개를 따라 배치되는 CSI-RS 안테나 포트 배열을 설정하는 단계를 포함할 수 있다.

[30] 또한 본 발명의 다른 실시예에 따르면, 단말이 CSI(channel state information)를 측정하는 방법이 제공된다. 상기 단말의 CSI 측정 방법은, 기지국으로부터, CSI-RS(reference signal) 안테나 포트를 위한 제1 포트 번호 맵핑 규칙을 수신하는 단계; 상기 제1 포트 번호 맵핑 규칙에 기초해, 상기 CSI-RS 안테나 포트를 상기 제1 포트 번호 맵핑 규칙에 대응하는 개수 만큼의 CSI-RS 안테나 포트 그룹으로 나누는 단계; 상기 CSI-RS 안테나 포트 그룹 별로 상기 각 CSI-RS 안테나 포트 그룹에 속하는 CSI-RS 안테나 포트에 포트 번호를 부여하는 단계; 및 상기 포트 번호가 부여된 CSI-RS 안테나 포트에 대하여, 채널 추정을 수행하는 단계를 포함한다.

[31] 상기 단말의 CSI 측정 방법은, 상기 제1 포트 번호 맵핑 규칙과 다른 제2 포트 번호 맵핑 규칙에 따라, 상기 CSI-RS 안테나 포트에 포트 번호를 재부여하는 단계; 및 상기 포트 번호가 재부여된 CSI-RS 안테나 포트에 대하여, 상기 채널 추정의 결과에 기초해 CSI 측정을 수행하는 단계를 더 포함할 수 있다.

[32] 상기 제1 포트 번호 맵핑 규칙을 수신하는 단계는, 상기 제1 포트 번호 맵핑 규칙을 나타내는 비트 코드를 상기 기지국으로부터 수신하는 단계를 포함할 수 있다.

[33] 상기 CSI-RS 안테나 포트는 제1 축, 제2 축, 및 제3 축 중 적어도 2개를 따라 배치될 수 있다.

[34] 상기 CSI-RS 안테나 포트에 포트 번호를 부여하는 단계는, 상기 CSI-RS 안테나 포트 그룹 중에서 제1 CSI-RS 안테나 포트 그룹에 속하는 CSI-RS 안테나 포트에, 상기 제1 축, 상기 제2 축, 및 상기 제3 축에 포트 번호가 부여되는 축 순서에 따라 포트 번호를 부여하는 단계; 및 상기 CSI-RS 안테나 포트 그룹 중에서 제2 CSI-RS 안테나 포트 그룹에 속하는 CSI-RS 안테나 포트에, 상기 축 순서에 따라 포트 번호를 부여하는 단계를 포함할 수 있다.

[35] 상기 제2 CSI-RS 안테나 포트 그룹에 부여된 첫번째 포트 번호는, 상기 제1 CSI-RS 안테나 포트 그룹에 부여된 마지막 포트 번호 다음의 포트 번호일 수

있다.

[36] 또한 본 발명의 또 다른 실시예에 따르면, 단말이 CSI(channel state information)를 측정하는 방법이 제공된다. 상기 단말의 CSI 측정 방법은, 기지국으로부터, CSI-RS(reference signal) 안테나 포트를 설정받는 단계; 상기 기지국으로부터 상기 CSI-RS 안테나 포트에 대한 포트 번호 부여 여부 정보를 수신하는 단계; 상기 포트 번호 부여 정보에 기초해, 상기 CSI-RS 안테나 포트 중 일부에 포트 번호를 부여하는 단계; 및 상기 포트 번호가 부여된 CSI-RS 안테나 포트를 이용하여, CSI를 측정하는 단계를 포함한다.

[37] 상기 포트 번호 부여 여부 정보를 수신하는 단계는, 상기 CSI-RS 안테나 포트의 수만큼의 길이를 가지며 상기 CSI-RS 안테나 포트 별 포트 번호 부여 여부를 나타내는 비트맵을, 상기 기지국으로부터 수신하는 단계를 포함할 수 있다.

[38] 상기 CSI-RS 안테나 포트 중 일부에 포트 번호를 부여하는 단계는, 상기 비트맵에 속하는 비트 중에서 제1 값을 가지는 비트에 대응하는 CSI-RS 안테나 포트에 포트 번호를 부여하는 단계를 포함할 수 있다.

[39] 상기 포트 번호 부여 여부 정보를 수신하는 단계는, 상기 CSI-RS 안테나 포트의 수의 절반의 길이를 가지며 상기 CSI-RS 안테나 포트 쌍 별 포트 번호 부여 여부를 나타내는 비트맵을, 상기 기지국으로부터 수신하는 단계를 포함할 수 있다.

[40] 상기 CSI-RS 안테나 포트 중 일부에 포트 번호를 부여하는 단계는, 상기 비트맵에 속하는 비트 중에서 제1 값을 가지는 비트에 대응하는 CSI-RS 안테나 포트 쌍에 포트 번호를 부여하는 단계를 포함할 수 있다.

[41] 상기 CSI-RS 안테나 포트 쌍은, 동일한 RE(resource element)를 통해 전송되는 2개의 CSI-RS 안테나 포트를 포함할 수 있다.

[42] 상기 CSI-RS 안테나 포트는 CSI-RS 안테나 포트 배열에 포함되며 제1 축, 제2 축, 및 제3 축 중 적어도 2개에 따라 배치될 수 있다.

[43] 상기 포트 번호 부여 여부 정보를 수신하는 단계는, 상기 제1 축으로 배치되는 CSI-RS 안테나 포트의 수와 상기 제2 축으로 배치되는 CSI-RS 안테나 포트의 수를 합한 값 만큼의 길이를 가지며 상기 CSI-RS 안테나 포트 배열의 각 행과 각 열에 대한 포트 번호 부여 여부를 나타내는 비트맵을, 상기 기지국으로부터 수신하는 단계를 포함할 수 있다.

[44] 상기 단말의 CSI 측정 방법은, 상기 단말에게 설정된 전체 CSI-RS 안테나 포트를 위한 RE(resource element) 중에서 상기 포트 번호가 부여된 CSI-RS 안테나 포트를 위한 RE를 제외한 나머지에서 PDSCH(physical downlink shared channel)가 수신되는 것이 가능함을 가정하는 단계를 더 포함할 수 있다.

발명의 효과

[45] 본 발명의 실시예에 따르면, MIMO 안테나 통신 시스템에서 기지국은 채널 추정을 위해 단말에게 다수의 채널 추정용 RS 안테나 포트를 설정할 수 있고,

이를 단말에게 전송할 수 있다.

[46] 또한 본 발명의 실시예에 따르면, 단말에 설정 가능한 CSI-RS 안테나 포트 수를 늘릴 수 있다.

[47] 또한 본 발명의 실시예에 따르면, 단말은 CSI-RS 안테나 포트 배열을 1차원 또는 다차원(예, 2차원, 3차원)으로 인식할 수 있다. 즉, 단말은 자신에게 설정된 1차원 또는 다차원(예, 2차원, 3차원) CSI-RS 안테나 포트의 포트 번호를 인식할 수 있다.

[48] 또한 본 발명의 실시예에 따르면, 기지국은 CSI-RS를 효율적으로 설정할 수 있고 이를 통해 CSI-RS를 효율적으로 전송할 수 있다.

[49] 또한 본 발명의 실시예에 따르면, 단말의 CSI 보고를 위해 설정된 NZP(non-zero-power) CSI-RS 자원 영역의 일부를 해당 단말의 PDSCH(physical downlink shared channel) 수신을 위해 이용함으로써, CSI-RS 전송 오버헤드 문제를 해결할 수 있고, PDSCH 전송 자원의 감소로 인한 데이터 전송률 하락을 방지할 수 있다.

[50] 또한 본 발명의 실시예에 따르면, 기지국이 단말에게 PDSCH 레잇 매칭(rate matching) 정보 및 의사 동일 위치성(QCL: quasi-co-location) 정보를 설정할 수 있고, 이를 이용하여 기지국과 단말은 PDSCH 전송을 수행할 수 있다.

[51] 또한 본 발명의 실시예에 따르면, 주파수 축으로 인접한 복수의 PRB 페어를 이용하여 채널 추정용 RS(예, CSI-RS)를 설정함으로써, 채널 추정용 RS를 위한 자원 풀을 확장할 수 있다. 이를 통해, FD(full dimension)-MIMO 시스템에서 채널 추정용 RS를 효율적으로 전송할 수 있다.

도면의 간단한 설명

[52] 도 1은 CSI-RS 안테나 포트의 수가 2인 경우에 CSI-RS 자원 요소(RE: resource element)집합의 맵핑을 나타내는 도면이다.

[53] 도 2는 CSI-RS 안테나 포트의 수가 4인 경우에 CSI-RS RE 집합의 맵핑을 나타내는 도면이다.

[54] 도 3은 CSI-RS 안테나 포트의 수가 8인 경우에 CSI-RS RE 집합의 맵핑을 나타내는 도면이다.

[55] 도 4는 단말이 복수의 TP로부터 하향링크 협력 전송을 수신하는 경우를 나타내는 도면이다.

[56] 도 5는 3개의 TP가 하나의 서브프레임 내의 서로 다른 RE들을 이용하여 CSI-RS 자원을 설정하는 방법을 나타내는 도면이다.

[57] 도 6은 단말을 위한 PDSCH RE를 맵핑하는 방법을 나타내는 도면이다.

[58] 도 7은 본 발명의 실시예에 따른, 기지국이 방법 Ma110을 이용하는 경우에 단말을 위한 PDSCH RE를 맵핑하는 방법을 나타내는 도면이다.

[59] 도 8은 본 발명의 실시예에 따른, 3개의 TP가 2개의 서브프레임 내의 서로 다른 RE들을 이용하여 CSI-RS 자원을 설정하는 방법을 나타내는 도면이다.

[60] 도 9는 본 발명의 실시예에 따른, 방법 Mb100을 이용해 CSI-RS 자원을 설정하는 방법을 나타내는 도면이다.

[61] 도 10a 및 도 10b는 본 발명의 다른 실시예에 따른, 방법 Mb100을 이용해 CSI-RS 자원을 설정하는 방법을 나타내는 도면이다.

[62] 도 11은 본 발명의 또 다른 실시예에 따른, 방법 Mb100을 이용해 CSI-RS 자원을 설정하는 방법을 나타내는 도면이다.

[63] 도 12은 본 발명의 실시예에 따른, 방법 Mb200을 이용해 16개의 CSI-RS 안테나 포트에 대한 자원을 설정하는 방법을 나타내는 도면이다.

[64] 도 13a 및 도 13b는 본 발명의 실시예에 따른, 방법 Mb200을 이용해 12개의 CSI-RS 안테나 포트에 대한 자원을 설정하는 방법을 나타내는 도면이다.

[65] 도 14는 본 발명의 실시예에 따른, 방법 Mb200을 이용해 32개의 CSI-RS 안테나 포트에 대한 자원을 설정하는 방법을 나타내는 도면이다.

[66] 도 15은 본 발명의 다른 실시예에 따른, 방법 Mb200을 이용해 CSI-RS 자원을 설정하는 방법을 나타내는 도면이다.

[67] 도 16a 및 도 16b는 본 발명의 실시예에 따른, 방법 Mb201를 이용해 6개의 CSI-RS 안테나 포트에 대한 자원을 설정하는 방법을 나타내는 도면이다.

[68] 도 17는 본 발명의 실시예에 따른, 방법 Mb110을 이용해 컴포넌트 CSI-RS configuration를 집성하는 방법을 나타내는 도면이다.

[69] 도 18은 본 발명의 다른 실시예에 따른, 방법 Mb110을 이용해 복수의 컴포넌트 CSI-RS configuration를 집성하는 방법을 나타내는 도면이다.

[70] 도 19는 본 발명의 실시예에 따른, 방법 Mb130을 이용해 복수의 컴포넌트 CSI-RS configuration를 집성하는 방법을 나타내는 도면이다.

[71] 도 20는 본 발명의 실시예에 따른, 방법 Mb200의 PRB 번들링이 사용되는 경우에 복수의 컴포넌트 CSI-RS configuration를 집성하는 방법을 나타내는 도면이다.

[72] 도 21은 본 발명의 실시예에 따른, 번들링된 PRB 페어들의 인덱스를 시간적으로 교차시켜 CSI-RS를 전송하는 방법을 나타내는 도면이다.

[73] 도 22은 2차원 CSI-RS 안테나 포트 배열의 예를 나타내는 도면이다.

[74] 도 23a 및 도 23b는 본 발명의 실시예에 따른, 2차원 CSI-RS 안테나 포트 배열에 단말 특정적 CSI-RS 안테나 포트 번호가 맵핑되는 방법을 나타내는 도면이다.

[75] 도 24은 복수의 단말에게 서로 다른 CSI-RS 안테나 포트 집합을 설정하는 방법을 나타내는 도면이다.

[76] 도 25a는 복수의 단말에 대한 CSI-RS 자원 설정의 예를 나타내는 도면이다.

[77] 도 25b는 본 발명의 실시예에 따른, 단말에 설정된 CSI-RS 안테나 포트들의 포트 번호가 방법 Mc200에 의해 재배열됨으로써, 포트 번호와 RE들 간의 맵핑 관계가 기존과 달라지는 경우를 나타내는 도면이다.

[78] 도 26a 및 도 26b는 본 발명의 실시예에 따른, 방법 Mc220이 사용되는 경우에, 기지국이 단말에게 새로운 포트 번호 순열(sequence)을 알리기 위한 규칙(또는

정보)을 암시적인 시그널링을 통해 알려주는 경우를 나타내는 도면이다.

[79] 도 26c, 도 26d, 도 26e, 및 도 26f는 본 발명의 실시예에 따른, 방법 Mc221에 의해 기지국이 단말에게 도 26a에 예시된 포트 번호 맵핑 중 하나를 알려주는 경우에, 단말이 CSI-RS RE 집합을 구성하는 RE들에 CSI-RS 안테나 포트 번호들을 맵핑하는 경우를 나타내는 도면이다

[80] 도 27은 본 발명의 실시예에 따른, 방법 Mc220이 사용되는 경우에, 복수의 단말에 대한 CSI-RS 안테나 포트 번호 맵핑을 나타내는 도면이다.

[81] 도 28은 본 발명의 실시예에 따른, 방법 Mc220이 사용되는 경우에, 복수의 단말에 대한 CSI-RS 자원 설정을 나타내는 도면이다.

[82] 도 29a, 도 29b, 도 29c, 도 29d, 및 도 29e는 본 발명의 다른 실시예에 따른, 방법 Mc221을 위해 사용될 수 있는 복수의 안테나 포트 번호 맵핑 규칙을 나타내는 도면이다.

[83] 도 30는 본 발명의 실시예에 따른, 방법 Mc310이 사용되는 경우에, CSI-RS 자원 설정을 나타내는 도면이다.

[84] 도 31은 본 발명의 실시예에 따른, 방법 Mc310이 사용되는 경우에, CSI-RS 안테나 포트 번호 맵핑을 나타내는 도면이다.

[85] 도 32a, 도 32b, 및 도 32c는 방법 Mc300을 위한 다른 실시예를 나타내는 도면이다.

[86] 도 33a, 도 33b, 및 도 33c는 방법 Mc300을 위한 또 다른 실시예를 나타내는 도면이다.

[87] 도 34은 방법 Mc300을 위한 또 다른 실시예를 나타내는 도면이다.

[88] 도 35은 CSI-RS 안테나 포트의 2차원 십자 배열로써, 두 1차원 배열의 교차점에 CSI-RS 안테나 포트가 중복 할당되는 2차원 십자 배열을 나타내는 도면이다.

[89] 도 36는 CSI-RS 안테나 포트의 2차원 십자 배열로써, 두 1차원 배열의 교차점에 CSI-RS 안테나 포트가 중복 할당되지 않는 2차원 십자 배열을 나타내는 도면이다.

[90] 도 37은 본 발명의 실시예에 따른, 기지국을 나타내는 도면이다.

[91] 도 38은 본 발명의 실시예에 따른, 단말을 나타내는 도면이다.

발명의 실시를 위한 형태

[92] 아래에서는 첨부한 도면을 참고로 하여 본 발명의 실시예에 대하여 본 발명이 속하는 기술 분야에서 통상의 지식을 가진 자가 용이하게 실시할 수 있도록 상세히 설명한다. 그러나 본 발명은 여러 가지 상이한 형태로 구현될 수 있으며 여기에서 설명하는 실시예에 한정되지 않는다. 그리고 도면에서 본 발명을 명확하게 설명하기 위해서 설명과 관계없는 부분은 생략하였으며, 명세서 전체를 통하여 유사한 부분에 대해서는 유사한 도면 부호를 붙였다.

[93] 명세서 전체에서, 단말(terminal)은, 이동 단말(mobile terminal), 이동국(mobile station), 진보된 이동국(advanced mobile station), 고신뢰성 이동국(high reliability

mobile station), 가입자국(subscriber station), 휴대 가입자국(portable subscriber station), 접근 단말(access terminal), 사용자 장비(user equipment) 등을 지칭할 수도 있고, 단말, 이동 단말, 이동국, 진보된 이동국, 고신뢰성 이동국, 가입자국, 휴대 가입자국, 접근 단말, 사용자 장비 등의 전부 또는 일부의 기능을 포함할 수도 있다.

[94] 또한, 기지국(base station, BS)은, 진보된 기지국(advanced base station), 고신뢰성 기지국(high reliability base station), 노드B(node B), 고도화 노드B(evolved node B, eNodeB), 접근점(access point), 무선 접근국(radio access station), 송수신 기지국(base transceiver station), MMR(mobile multihop relay)-BS, 기지국 역할을 수행하는 중계기(relay station), 기지국 역할을 수행하는 고신뢰성 중계기(high reliability relay station), 리피터, 매크로 기지국, 소형 기지국 등을 지칭할 수도 있고, 기지국, 진보된 기지국, HR-BS, 노드B, eNodeB, 접근점, 무선 접근국, 송수신 기지국, MMR-BS, 중계기, 고신뢰성 중계기, 리피터, 매크로 기지국, 소형 기지국 등의 전부 또는 일부의 기능을 포함할 수도 있다.

[95] 한편, 본 명세서에서, 'A 또는 B'는, 'A', 'B', 또는 'A와 B 모두'를 포함할 수 있다.

[96]

[97] 1. 다중 셀 협력 통신 시스템에서 제어 정보를 전송하는 방법

[98] 셀 기반의 무선통신 시스템에서 셀 경계에 위치한 단말은, 일반적으로 인접 셀로부터 받는 간섭 신호로 인해 높은 전송률을 제공받는 데 한계를 가진다. 다중 셀 협력(CoMP: cooperative multi-point) 전송 기술은, 복수의 인접한 셀들 또는 전송 점(TP: transmission point)들이 서로 협력하여 셀 간 간섭을 완화하거나 회피함으로써, 셀 경계 단말의 데이터 전송률을 높이는 기술이다.

[99] 단말은 다중 셀 협력 전송을 위해, 자신이 속한 서빙 셀 뿐만 아니라 이웃 셀(들) 혹은 TP(들)에 대한 하향링크 채널 상태 정보(CSI: channel state information)를 측정하고, 이를 보고해야 할 수도 있다. 이를 위해, 기지국은 전송 모드(TM: transmission mode) 10으로 설정된 단말에게 복수의 CSI 프로세스 (process)를 설정할 수 있다. 하나의 CSI 프로세스는 채널 측정을 위한 CSI-RS(reference signal)와 간섭 측정을 위한 CSI-IM(interference measurement)의 자원 설정 정보를 포함하며, 각 CSI 프로세스로부터 유도된 CSI 정보는 독립적인 주기(periodicity)와 서브프레임 오프셋(subframe offset)에 따라 단말에 의해 기지국으로 보고된다.

[100] 한편, 기지국이 단말에게 설정된 모든 NZP CSI-RS 자원을 제외한 영역에서 PDSCH(physical downlink shared channel)를 전송하면, PDSCH 전송 자원의 감소로 인해 데이터 전송률이 떨어질 수도 있다. 이러한 CSI-RS 전송 오버헤드 문제는 FD(full dimension)-MIMO(multiple-input multiple-output) 시스템에서 더욱 두드러지나, 비단 이 경우에만 국한되지 않고, TP들이 기존 규격이 지원하는 범위 내에서 CSI-RS를 전송하는 경우에도 마찬가지로 해결해야 할 과제이다.

[101]

[102] 도 1은 CSI-RS 안테나 포트의 수가 2인 경우에 CSI-RS RE(resource element)집합(set)의 맵핑을 나타내는 도면이고, 도 2는 CSI-RS 안테나 포트의 수가 4인 경우에 CSI-RS RE 집합의 맵핑을 나타내는 도면이고, 도 3은 CSI-RS 안테나 포트의 수가 8인 경우에 CSI-RS RE 집합의 맵핑을 나타내는 도면이다.

[103] CSI-RS가 전송되는 자원 요소(RE: resource element)의 맵핑은 각 안테나 포트 수마다 미리 정해진 패턴을 따르고, 미리 정해진 CSI-RS 자원 풀(resource pool) 내에서 설정될 수 있다. CSI-RS 자원 설정(CSI-RS resource configuration, 이하 'CSI-RS configuration')은 노멀(normal) CP(cyclic prefix) 및 확장(extended) CP 각각에 대하여 정의되어 있다. 또한 CSI-RS configuration은 FDD(frequency division duplex)와 TDD(time division duplex) 모두에 설정 가능한 것과 TDD에만 설정될 수 있는 것으로 구분된다.

[104] 도 1 내지 도 3 각각은 노멀 CP가 설정되고 CSI-RS 안테나 포트 수가 2, 4, 또는 8인 경우에, CSI-RS configuration 0~19번에 대한 RE 맵핑을 나타낸다.

[105] 도 1 내지 도 3에 예시된 바와 같이, 하나의 하향링크 서브프레임은 2개의 타임 슬롯을 포함한다. 구체적으로 노멀 CP가 설정되는 경우에, 하나의 서브프레임은, 짝수의 타임 슬롯(이하 '슬롯0')과 슬롯0 이후의 홀수의 타임 슬롯(이하 ' 슬롯1')을 포함한다. 슬롯0과 슬롯1 각각은 시간 축으로 7개의 OFDM(Orthogonal Frequency Division Multiplexing) 심볼(0번~6번)과 주파수 축으로 12개의 부반송파(0번~11번)를 포함한다. 즉, 하나의 서브프레임 또는 PRB(physical resource block) 페어(pair) 내의 슬롯0과 슬롯1 각각에는 84개(=7x12)의 RE가 존재한다. 하나의 서브프레임 또는 PRB 페어 내의 RE 중 일부는 CRS 전송을 위한 RE로 설정될 수 있고, 일부는 DMRS(demodulation reference signal) 전송을 위한 RE로 설정될 수 있고, 일부는 CSI-RS 전송을 위한 RE로 설정될 수 있다. 예를 들어, 도 1에서 슬롯0의 OFDM 심볼 5번과 6번에 대응하며 부반송파 9번에 대응하는 2개의 RE에는, CSI-RS configuration 0번의 CSI-RS 안테나 포트 15번과 16번이 맵핑(설정)된다. 즉, CSI-RS configuration 0번~19번 각각을 위한 2개의 CSI-RS 안테나 포트(15번, 16번)는 2개의 RE에 맵핑된다. 이하에서는 설명의 편의를 위해서, 슬롯 내의 OFDM 심볼 n번에 대응하며 PRB 페어 내의 부반송파 k번에 대응하는 RE를, RE(n, k)라 한다.

[106] 다른 예를 들어, 도 2에서 슬롯1의 RE(2, 11)와 RE(3, 11)에는 CSI-RS configuration 1번의 CSI-RS 안테나 포트 15번과 16번이 맵핑되고, 슬롯1의 RE(2, 5)와 RE(3, 5)에는 CSI-RS configuration 1번의 CSI-RS 안테나 포트 17번과 18번이 맵핑된다. 즉, CSI-RS configuration 0번~9번 각각을 위한 4개의 CSI-RS 안테나 포트(15번~18번)는 4개의 RE에 맵핑된다.

[107] 또 다른 예를 들어, 도 3에서 슬롯0의 RE(5, 9)와 RE(6, 9)에는 CSI-RS configuration 0번의 CSI-RS 안테나 포트 15번과 16번이 맵핑되고, 슬롯0의 RE(5, 3)와 RE (6, 3)에는 CSI-RS configuration 0번의 CSI-RS 안테나 포트 17번과 18번이 맵핑되고, 슬롯0의 RE(5, 8)와 RE(6, 8)에는 CSI-RS configuration 0번을 위한

CSI-RS 안테나 포트 19번과 20번이 맵핑되고, 슬롯0의 RE(5, 2)와 RE(6, 2)에는 CSI-RS configuration 0번을 위한 CSI-RS 안테나 포트 21번과 22번이 맵핑된다. 즉, CSI-RS configuration 0번~4번 각각을 위한 8개의 CSI-RS 안테나 포트(15번~22번)는 8개의 RE에 맵핑된다.

[108] 한편, 동일한 RE를 통해 전송되는 CSI-RS 안테나 포트들(예, CSI-RS 안테나 포트 15번, 16번) 간에는 안테나 포트 간 다중화 방식으로써 코드 분할 다중화(CDM: Code Division Multiplexing)가 적용된다. 예를 들어, 도 1에서 슬롯0의 RE(5, 9)를 통해 CSI-RS 안테나 포트 15번과 16번이 전송되고, 슬롯0의 RE(6, 9)를 통해 CSI-RS 안테나 포트 15번과 16번이 전송된다. 이러한 경우에, 동일한 RE를 통해 전송되는 CSI-RS 안테나 포트 15번과 16번을 구별하기 위해서, CSI-RS 안테나 포트 15번과 16번 간에는 CDM이 적용된다.

[109] 한편, 서로 다른 RE를 통해 전송되는 CSI-RS 안테나 포트들(예, CSI-RS 안테나 포트 15번, 17번) 간에는 안테나 포트 간 다중화 방식으로써 주파수 분할 다중화(FDM: Frequency Division Multiplexing)가 적용된다. 예를 들어, 도 2에서 슬롯0의 RE(5, 9)와 RE(6, 9)를 통해 CSI-RS 안테나 포트 15번가 전송되고, 슬롯0의 RE(5, 3)와 RE(6, 3)를 통해 CSI-RS 안테나 포트 17번가 전송된다. 이러한 경우에, 서로 다른 RE를 통해 전송되는 CSI-RS 안테나 포트 15번과 17번을 구별하기 위해서, CSI-RS 안테나 포트 15번과 17번 간에는 FDM이 적용된다.

[110] 한편, 본 명세서의 도면들에 표기된 CSI-RS set A는 CSI-RS configuration A번을 의미하고, X, Y는 CSI-RS 안테나 포트의 번호를 나타낸다. 본 명세서의 도면들에 표기된 X_A, Y_A는 CSI-RS configuration A번에서의 CSI-RS 안테나 포트 X번과 Y번을 나타내거나, 또는 단말 A(단, UE-A는 UE-a, UE-b, UE-c, ...)를 위한 CSI-RS 안테나 포트 X번과 Y번을 나타낼 수 있다. 본 명세서에서, CSI-RS 안테나 포트 또는 CSI-RS 안테나 포트 X번이 전송된다는 것은, CSI-RS 안테나 포트의 CSI-RS 또는 CSI-RS 안테나 포트 X번의 CSI-RS가 전송된다는 것을 포함할 수 있다.

[111] 한편, 단말은 PDSCH 레잇 매칭(rate matching)을 수행할 때, ZP CSI-RS로 설정된 RE에 PDSCH가 맵핑되지 않음을 가정한다. ZP CSI-RS는 크게 두 가지 용도로 이용될 수 있다. 첫째로, 기지국은 인접 셀의 CSI-RS가 전송되는 RE에서 신호를 전송하지 않음으로써(즉, 해당 RE에 뮤팅(muting)을 적용함으로써), 인접 셀에 대한 단말의 CSI-RS 측정 성능을 향상시키고자 할 수 있다. 이 때, 기지국은 뮤팅이 적용되는 RE들을 단말에게 ZP CSI-RS 설정을 통해 알려줄 수 있다. 둘째로, 단말의 간섭 신호 측정을 위한 자원을 설정하기 위한 용도로, ZP CSI-RS가 설정될 수 있다. 현재 규격에 따르면, Release 12 TDD eIMTA(enhanced interference mitigation & traffic adaptation)가 설정된 단말을 제외하고는, 간섭 신호의 측정에 이용되는 CSI-IM 자원은 항상 단말에게 설정된 ZP CSI-RS 자원 영역 내에서만 설정될 수 있다.

[112] 한편, LTE 규격은 전송 모드(TM: transmission mode) 10의 CoMP 기반 PDSCH

전송을 위해, DCI(downlink control information) 포맷 2D 내에 PQI(PDSCH RE mapping and quasi-co-location indicator) 필드를 정의하였다. PQI 필드에 기초해, 단말은 DCI 포맷 2D를 통해 스케줄링되는 PDSCH의 RE 맵핑 정보와 PDSCH 안테나 포트의 의사 동일 위치성(QCL: quasi-co-location) 정보를 획득할 수 있다. PQI 필드는 2 비트로 구성되고, 아래의 표 1과 같이 비트열의 값에 따라 최대 4개의 파라미터 집합 (parameter set)을 지시(indicate)할 수 있다.

[113] [표1]

PQI field in DCI format 2D

Value of 'PDSCH RE Mapping and Quasi-Co-Location Indicator' field	Description
'00'	Parameter set 1 configured by higher layers
'01'	Parameter set 2 configured by higher layers
'10'	Parameter set 3 configured by higher layers
'11'	Parameter set 4 configured by higher layers

[114] 이하에서는, 상기 파라미터 집합을 PQI 파라미터 집합이라 부르기로 한다. 4개의 PQI 파라미터 집합 각각은 파라미터 crs-PortsCount-r11, 파라미터 crs-FreqShift-r11, 파라미터 mbsfn-SubframeConfigList-r11, 파라미터 csi-RS-ConfigZPId-r11, 파라미터 pdsch-Start-r11, 및 파라미터 qcl-CSI-RS-ConfigNZPId-r11을 포함할 수 있다. PQI 파라미터 집합은 RRC 시그널링을 통해 단말에게 설정될 수 있다.

[115] 한편, 기지국이 단말에게 DPS(dynamic point selection) 전송을 지원하고자 하는 경우에, 각 PQI 파라미터 집합은 서로 다른 셀 또는 TP(이하에서는 '셀 또는 TP'를 TP로 통칭함)에 대응될 수 있다. 이러한 DPS 전송에 대해서는, 도 4를 참고하여 자세히 설명한다.

[116]

[117] 도 4는 단말이 복수의 TP로부터 하향링크 협력 전송을 수신하는 경우를 나타내는 도면이다. 도 4에서는 설명의 편의를 위해, 기지국에 의해 제어되는 3개의 인접한 TP들(TP1, TP2, TP3)이 단말에 대한 신호 전송을 위해 협력하는 경우를 예시하였다.

[118] 기지국은 단말에 3개의 CSI 프로세스를 이용하여 각 TP(TP1~TP3)에 대한 CSI-RS 및 CSI-IM을 설정할 수 있고, 단말은 이에 따라 각 TP(TP1~TP3)에 대하여 독립적으로 CSI 측정 및 보고를 수행할 수 있다.

[119] 기지국은 단말이 보고한 CSI를 기반으로 TP(TP1~TP3) 중에서 단말에게 PDSCH를 전송할 TP를 선택하고, 선택된 TP를 통해 해당 단말을 위한 PDSCH를 전송한다. 이 때 기지국은 PDSCH 스케줄링 정보를 포함하는 DCI 포맷 2D의 PQI 필드를 통해, PDSCH를 전송하는 TP에 대응하는 PQI 파라미터 집합을

지시함으로써, 단말에게 해당 PDSCH가 어떤 TP로부터 전송되었는지를 암시적으로(implicitly) 알려줄 수 있다.

[120] 한편, 기지국은 TP들(TP1~TP3)이 전송하는 CSI-RS가 동일한 자원 상에 오버랩되어 전송되도록 설정할 수도 있고, 서로 간의 간섭을 회피하기 위해 서로 다른 자원에서 전송되도록 설정할 수도 있다. 후자의 경우에, 각 TP(TP1~TP3)는 CoMP 협력 집합 내 다른 TP들에 의해 CSI-RS가 전송되는 RE들을 ZP CSI-RS로써 설정하고 뮤팅을 수행함으로써, 단말의 CSI-RS 채널 추정 성능을 향상시킬 수 있다. 상기 DPS 전송에서 상기 후자의 경우를 위한 CSI-RS 자원 설정이 도 5에 예시되어 있다.

[121]

[122] 도 5는 3개의 TP(TP1~TP3)가 하나의 서브프레임 내의 서로 다른 RE들을 이용하여 CSI-RS 자원을 설정하는 방법을 나타내는 도면이다.

[123] 도 5에 예시된 바와 같이, 3개의 TP(TP1~TP3)의 NZP CSI-RS RE 집합들은 하나의 서브프레임 내에서 서로 다른 자원 영역에 설정된다. 도 5에서는 각 TP(TP1~TP3)의 CSI-RS 안테나 포트 수가 4인 경우를 예시하였다. 예를 들어, 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 3), 및 RE(6, 3)에는, TP(TP1)을 위한 CSI-RS 안테나 포트 15~18번이 맵핑된다. 다른 예를 들어, 슬롯1의 RE(2, 9), RE(3, 9), RE(2, 3), 및 RE(3, 3)에는, TP(TP2)을 위한 CSI-RS 안테나 포트 15~18번이 맵핑된다. 또 다른 예를 들어, 슬롯1의 RE(2, 8), RE(3, 8), RE(2, 2), 및 RE(3, 2)에는, TP(TP3)을 위한 CSI-RS 안테나 포트 15~18번이 맵핑된다.

[124]

[125] 도 6은 단말을 위한 PDSCH RE를 맵핑하는 방법을 나타내는 도면이다.

[126] 현재 규격에 의하면 전송 모드 10 기반의 하향링크 PDSCH를 수신하는 단말은 각 CSI 프로세스마다 설정된 NZP CSI-RS 자원 영역 모두에서 PDSCH 데이터가 전송되지 않음을 가정한다. 예를 들어, 단말이 도 5에 예시된 바와 같이, CRS, DMRS, 및 CSI-RS를 설정받은 경우에, 단말이 가정하는 PDSCH의 RE 맵핑은 도 6에 예시된 바와 같을 수 있다. 도 6에서는 PDCCH(physical downlink control channel) 영역의 OFDM 심볼 수가 3인 경우를 예시하였다. 구체적으로, 슬롯0의 OFDM 심볼 0~2번에 해당하는 RE들 중 일부는 CRS RE로써 설정되고, 나머지는 PDCCH RE로써 설정된다. 슬롯0의 OFDM 심볼 3~6번과 슬롯1의 0~6번에 해당하는 RE들 중 일부는 CRS RE로써, 일부는 DMRS RE로써, 일부는 CSI-RS RE로써, 나머지는 PDSCH RE로써 설정된다. 도 6에 예시된 바와 같이, 3개의 TP(TP1~TP3)의 CSI-RS RE 집합에는 PDSCH가 맵핑되지 않는다.

[127] 한편, FD-MIMO가 적용되는 시스템의 경우에, 대규모 안테나 배열 이득을 충분히 얻기 위해, CoMP 협력 집합에 속한 각 TP가 다수의 CSI-RS 안테나 포트를 전송하는 경우가 고려될 수 있다. 예를 들어, 도 4의 예시에서, 3개의 TP(TP1~TP3) 각각이 16, 32, 또는 64개의 CSI-RS 안테나 포트를 전송할 수 있다. 이 때, 각 TP(TP1~TP3)의 CSI-RS 전송 주기가 5 ms라고 하면, CSI-RS 전송

오버헤드가 하향링크 전체 자원 영역에서 차지하는 비중은 CSI-RS 포트 수가 16, 32, 64인 경우에, 각각 5.71%, 11.43%, 22.86%로 매우 큰 비중을 차지한다. 따라서 기존과 같이 단말에게 설정된 모든 NZP CSI-RS 자원을 제외한 영역에서 PDSCH를 전송하면, PDSCH 전송 자원의 감소로 인해 오히려 데이터 전송률이 떨어질 수 있다. 즉, 다중 셀 협력 전송 기법과 FD-MIMO의 결합이 제한적일 수 있다. 이러한 CSI-RS 전송 오버헤드 문제는 FD-MIMO 시스템에서 더욱 두드러지나, 비단 이 경우에만 국한되지 않고, TP들이 기존 규격이 지원하는 범위 내에서 CSI-RS를 전송하는 경우에도 마찬가지로 해결해야 할 과제이다.

[128] 이하에서는, 상기 문제점(예, CSI-RS 전송 오버헤드 문제 등)을 해결하기 위한 방법에 대해서 설명한다. 구체적으로, 단말의 CSI 보고를 위해 설정된 NZP CSI-RS 자원 영역의 일부가 해당 단말의 PDSCH 수신을 위해 이용될 수 있도록, 하향링크 제어 정보를 설계하는 방법 및 하향링크 제어 정보를 시그널링하는 방법에 대해서 설명한다. 더욱 구체적으로는, 아래의 방법 Ma100의 개념을 사용하기 위한 다양하고 구체적인 방법들에 대해서 설명한다.

[129] 방법 Ma100은 NZP CSI-RS configuration(또는 NZP CSI-RS ID)에 의해 단말에게 설정된 CSI-RS RE 집합에 단말이 수신하고자 하는 PDSCH가 맵핑되었는지 여부(이하 'PDSCH 맵핑 여부')를, 단말에게 알려주는 방법이다. NZP CSI-RS ID는 NZP CSI-RS configuration을 나타내는 식별자이다.

[130] Release 12 규격에 따르면, CSI 프로세스는 하나의 CSI-RS configuration을 포함하고, CSI-RS configuration은 고유의 NZP CSI-RS ID를 가진다. 한편, FD-MIMO를 위해 Release-13에 도입된 CSI 프로세스는, CSI 보고 유형에 따라 클래스-A와 클래스-B로 구분된다. 클래스-B의 CSI 보고를 위한 CSI 프로세스(이하 '클래스-B CSI 프로세스')는 복수의 NZP CSI-RS configuration을 포함할 수 있고, 클래스-B CSI 프로세스에 포함되는 각 NZP CSI-RS configuration은 고유의 NZP CSI-RS ID를 가진다.

[131] 방법 Ma100은 단말이 전송 모드(TM) 10으로 설정되어 있고 DCI 포맷 2D에 의해 스케줄링된 PDSCH를 수신하는 경우에 주로 적용될 수 있다. 방법 Ma100에서 PDSCH 맵핑 여부를 기지국이 단말에게 알려주는 데 이용될 수 있는 시그널링으로는, 물리계층 시그널링(예, 물리계층 제어 채널의 제어 필드 파라미터), MAC(media access control) 시그널링(예, MAC PDU(protocol data unit) 형태의 제어 정보, 또는 MAC 헤더 형태의 제어 정보), RRC 시그널링(예, RRC 제어 메시지 또는 IE(information element) 형태의 제어 파라미터) 등이 고려될 수 있다. 특히, 물리계층 시그널링 또는 MAC 시그널링 방식을 통한 제어 시그널링은, 해당 단말을 위한 스케줄링 정보와 함께 구성되거나 또는 동시에 전송되는 방법을 통하여 동적(dynamic) 자원 활용이 가능하다는 장점을 가질 수 있다. 또 다른 방법으로써, RRC 시그널링을 이용하여 단말에게 방법 Ma100의 적용 여부와 설정 정보를 알리고, 물리계층 시그널링 또는 MAC 시그널링을 통하여 CSI-RS RE 집합에 대한 PDSCH 맵핑 여부만을 알리는 방법이 사용될

수도 있다.

[132] 단말은 방법 Ma100에 기초해 어떤 NZP CSI-RS configuration에 의해 설정된 CSI-RS RE 집합에서 PDSCH를 수신하도록 지시받은 경우에, 해당 RE 집합에서 CSI-RS와 PDSCH가 혼합된 신호를 수신하는 것을 기대할 수 있다. 이 때, 단말은 CSI-RS와 PDSCH는 CoMP 협력 집합 내의 서로 다른 TP에서 각각 전송됨을 기대할 수 있다. 이는 규격에 명시적으로 정의될 수도 있으나, 규격에 명시적으로 드러내지 않고 단말이 방법 Ma100에 기초한 PDSCH 수신 지시에 의해 암시적으로 이를 알 수 있도록 하는 방법도 가능하다. 따라서 이 경우에, 단말은 해당 RE 집합에서 CSI-RS 기반 채널 추정과 PDSCH 데이터 검출 및 복호를 모두 수행할 수 있다. 이를 위해, 단말은 3가지 수신 방식들(동시(joint) 채널 추정 및 데이터 복호, SIC(successive interference cancellation)의 적용(단, CSI-RS 우선), SIC의 적용(단, PDSCH 우선)) 중 하나를 사용할 수 있다.

[133] 구체적으로, 단말이 동시 채널 추정 및 데이터 복호 방식을 사용하는 경우에, CSI-RS 기반 채널 추정과 PDSCH 데이터 복호를 동시에 한꺼번에(jointly) 수행할 수 있다. 또는 단말이 CSI-RS를 우선으로 하는 SIC 방식을 사용하는 경우에, 먼저 PDSCH 신호를 간섭으로 간주한 상태에서 CSI-RS 기반의 채널 추정을 수행하고, 다음으로 수신 신호에서 CSI-RS 신호를 제거한 후 PDSCH 복호를 수행할 수 있다. 또는 단말이 PDSCH를 우선으로 하는 SIC 방식을 사용하는 경우에, 먼저 CSI-RS 신호를 간섭으로 간주한 상태에서 PDSCH 데이터 복호를 수행하고, 다음으로 수신 신호에서 PDSCH 신호를 제거한 후 CSI-RS 기반의 채널 추정을 수행할 수 있다.

[134] 상술한 동시 채널 추정 및 데이터 복호 방법은, 채널 추정과 데이터 복호를 반복적(iterative)으로 수행하는 방법을 포함할 수 있다. 이 때, 단말은 첫 단계로 채널 추정을 먼저 수행할 수도 있고, 데이터 복호를 먼저 수행할 수도 있다. 상술한 3가지의 방식들 중 첫 번째 방식(동시 채널 추정 및 데이터 복호 방식) 및 두 번째 방식(CSI-RS를 우선으로 하는 SIC 방식)은, 다중 셀 협력 전송의 경우 외에도, 단말이 인접 셀로부터 강한 CSI-RS 간섭을 수신하는 경우에 PDSCH의 수신 성능 향상을 위해 적용될 수 있다. 그러나 다중 셀 협력 전송이 아닌 경우에는 기지국이 인접 셀(들)의 CSI-RS 설정 정보를 단말에게 별도의 시그널링을 통해 알려주고, 단말은 해당 인접 셀(들)로부터 수신하는 CSI-RS 간섭 신호를 이용하여 인접 셀(들)에 대한 채널 추정을 추가적으로 수행해야 하므로, 시그널링 오버헤드와 단말의 수신 복잡도가 증가할 수 있다. 반면에 다중 셀 협력 전송(특히, DPS)을 위해 다수의 CSI 프로세스를 설정받은 단말에 상기 3가지의 수신 방식들이 적용되는 경우에는, 별도의 CSI-RS configuration이 불필요하고 단말의 기존 동작 대비 복잡도 증가가 크지 않을 수 있다는 장점이 있다.

[135] 단말은 자신이 상술한 간섭 제거 수신 기능을 지원하는지 여부에 대한 캐퍼빌리티(capability) 정보를 기지국에게 전송할 수 있다. 기지국은 단말의

캐퍼빌리티 정보를 이용하여 해당 단말에 본 명세서에서 기술되는 방법들을 적용할지 여부를 판단할 수 있다.

[136] 한편, 방법 Ma100에서 CSI-RS RE 집합에 PDSCH가 맵핑되었는지의 여부를 기지국이 단말에게 지시자 전송을 통해 알려줄 수 있다. 이하에서는, 기지국이 단말에게 PDSCH 맵핑 여부를 알리기 위하여 단말에게 전송하는 지시자를, 맵핑 지시자라 한다. 한편, 기지국은 단말에게 PDSCH 맵핑 여부를 암시적인 시그널링을 통해 알려줄 수도 있다. 여기서 암시적인 시그널링을 통해 알려주는 방법은, 맵핑 지시자의 형태가 아닌 다른 형태의 시그널링, 또는 단말에게 다른 용도로 전송되는 시그널링을 이용하는 방법을 포함할 수 있다. 본 명세서에서, 맵핑 지시자를 설정하거나 전송한다는 것은, 상기 암시적인 시그널링을 통해 알려주는 것을 포함할 수 있다.

[137] 이 때 단말에게 PDSCH를 전송하는 TP는 PDSCH가 전송되는 RE에서 동시에 CSI-RS를 전송할 수 없으므로, 맵핑 지시자의 유효 범위는 CoMP 협력 집합 내의 TP들 중에서 단말에게 PDSCH를 전송하는 TP를 제외한 나머지 TP(들)에 대한 CSI-RS RE 집합(들)이 될 수 있다. 즉, 현재 규격에 따르면, 단말은 QCL type B로 설정된 경우에, DCI 포맷 2D에 의해 지시되는 PQI 파라미터 집합의 'qcl-CSI-RS-ConfigNZPId-r11'이 가리키는 하나의 NZP CSI-RS ID에 대응하는 CSI-RS RE 집합에는 상기 맵핑 지시자가 적용되지 않으며, 단말은 이 CSI-RS RE 집합에서 PDSCH를 수신하는 것을 기대하지 않을 수 있다.

[138] 한편, 하나의 PQI 파라미터 집합 내에서 PDSCH와 동일한 QCL이 가정되는 NZP CSI-RS ID는 향후 복수 개로 확장될 수 있다. 이 경우에, 상기 맵핑 지시자의 유효 범위는, 단말에 설정된 NZP CSI-RS ID(들) 중에서, DCI 포맷 2D에 의해 단말에 지시되는 PQI 파라미터 집합 내 QCL 가정을 위한 NZP CSI-RS ID(들) (이하 'QCL NZP CSI-RS ID(들)')을 제외한 나머지 NZP CSI-RS ID(들)에 대한 CSI-RS RE 집합(들)이 될 수 있다. 현재 규격에 따르면, QCL type B인 경우, QCL NZP CSI-RS ID는 'qcl-CSI-RS-ConfigNZPId-r11'이 가리키는 하나의 NZP CSI-RS ID를 의미한다. QCL NZP CSI-RS ID는 향후 복수의 NZP CSI-RS configuration에 대응될 수 있다. 이 경우에, 상기 맵핑 지시자의 유효 범위는, QCL NZP CSI-RS ID(들)에 대응되는 모든 CSI-RS configuration(들)을 제외한 나머지 CSI-RS configuration(들)에 대한 CSI-RS RE 집합(들)이 될 수 있다.

[139] 또한 QCL NZP CSI-RS ID에 대응하는 CSI-RS 자원 영역과 QCL NZP CSI-RS ID(들)을 제외한 다른 NZP CSI-RS ID에 대응하는 CSI-RS 자원 영역이 일부 또는 완전히 겹치는 경우에도, 단말은 QCL NZP CSI-RS ID에 대응하는 CSI-RS 자원 영역에서 PDSCH를 수신하는 것을 기대하지 않을 수 있다. 이 때, 다른 NZP CSI-RS ID에 대한 맵핑 지시자의 적용 범위는, 해당 CSI-RS 자원 영역에서 QCL NZP CSI-RS ID에 대응하는 CSI-RS 자원 영역을 제외한 나머지 영역이 될 수 있다.

[140] 또는, 단말에게 PDSCH를 전송하는 TP와 PDSCH를 전송하지 않는 TP를

구분하지 않고, CoMP 협력 집합 내의 모든 TP들을 맵핑 지시자의 유효 범위에 포함시키는 방법이 고려될 수도 있다. 즉, 단말은 QCL NZP CSI-RS ID(들)을 포함한 모든 NZP CSI-RS ID(들)에 대한 CSI-RS RE 집합(들)에서 맵핑 지시자에 의해 PDSCH를 수신하는 것을 가정할 수 있다. 이 경우에, 기지국은 어떤 TP에서도 CSI-RS와 PDSCH가 동일 자원 상에 맵핑되지 않도록 PDSCH를 스케줄링할 수 있다. 단말은 스케줄링받은 PDSCH의 자원이 CoMP 협력 집합에 포함되는 모든 TP의 CSI-RS 자원과 일부 또는 전부 오버랩되는 경우에, DCI의 설정 또는 수신 오류로 간주하고 해당 서브프레임에서 PDSCH를 수신하지 않을 수 있다. 또는 상기 경우에도, 단말은 맵핑 지시자에 따른 동작을 동일하게 수행함을 가정할 수도 있다.

[141] 이하에서는 RRC 시그널링에 의해 맵핑 지시자를 단말에 설정하는 방법에 대하여 설명한다.

[142] 방법 Ma110은, 맵핑 지시자가 PQI 파라미터 집합별로 설정될 수 있고, 하나의 맵핑 지시자는 단말에 설정된 NZP CSI-RS ID들에 대해서 공통적으로 적용되는 방법이다.

[143] 예를 들어, 방법 Ma110에서 맵핑 지시자는 1 비트일 수 있다. 기지국은 단말에게 1 비트의 맵핑 지시자를 통해, QCL NZP CSI-RS ID(들)을 제외한 나머지 NZP CSI-RS ID들에 대응하는 CSI-RS RE 집합에 대한 PDSCH RE 맵핑을 가정할 지 여부를 알려줄 수 있다. 또는, 기지국은 단말에게 1 비트의 맵핑 지시자를 통해, PQI 파라미터 집합별로, QCL NZP CSI-RS ID(들)을 포함한 모든 NZP CSI-RS ID들에 대응하는 CSI-RS RE 집합에 대한 PDSCH RE 맵핑을 가정할 지 여부를 알려줄 수 있다.

[144] 방법 Ma110에서 맵핑 지시자는 각 PQI 파라미터 집합 내에 포함되어 정의될 수 있다.

[145]

[146] 도 7은 본 발명의 실시예에 따른, 기지국이 방법 Ma110을 이용하는 경우에 단말을 위한 PDSCH RE를 맵핑하는 방법을 나타내는 도면이다.

[147] 설명의 편의를 위해서, 도 4의 DPS 전송에서 단말이 DCI 포맷 2D를 통해 TP(TP1)로부터 PDSCH를 수신하는 경우(즉, 단말에게 스케줄링된 PDSCH의 QCL 정보가 TP(TP1)가 전송하는 NZP CSI-RS의 ID를 포함하는 경우)를 가정하여 방법 Ma110을 설명한다.

[148] 단말이 TP(TP1)로부터 PDSCH를 수신하는 데 필요한 PDSCH RE 맵핑 정보와 QCL 정보가 PQI 파라미터 집합 1에 설정되었다고 가정하자. 기지국은 표 1에 따라 DCI 포맷 2D의 PQI 필드를 00으로 설정(configure)한다. 이 때, 기지국이 방법 Ma110을 사용하면, 단말이 TP(TP2)와 TP(TP3)가 전송하는 CSI-RS의 RE들에서 TP(TP1)의 PDSCH를 수신할 지 여부를, 맵핑 지시자를 통해 설정할 수 있다. 맵핑 지시자는 상술한 바와 같이 1 비트일 수 있고, RRC 시그널링에 의해 단말에 설정될 수 있다. 예를 들어, PQI 파라미터 집합 1에 대응되는 맵핑

지시자의 값이 0인 경우에, 단말은 TP(TP2)와 TP(TP3)에 의해 전송되는 CSI-RS의 RE들에 PDSCH가 맵핑되지 않았음을 가정하고, 도 6에 예시된 PDSCH RE 맵핑을 가정할 수 있다. 반대로 맵핑 지시자의 값이 1인 경우에, 단말은 TP(TP2)와 TP(TP3)에 의해 전송되는 CSI-RS의 RE들에 PDSCH가 맵핑되었음을 가정하고, 도 7에 예시된 PDSCH RE 맵핑을 가정할 수 있다. 구체적으로, 도 7에는 CSI-RS RE들 중에서 PDSCH를 전송하는 TP(TP1)를 위한 CSI-RS RE(예, 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 3), RE(6, 3))를 제외한 나머지 CSI-RS RE들이 PDSCH RE로써 설정되는 경우를 예시하였다. 즉, TP(TP2)를 위한 CSI-RS RE들(예, 슬롯1의 RE(2, 9), RE(3, 9), RE(2, 3), RE(3, 3))과 TP(TP3)를 위한 CSI-RS RE들(예, 슬롯1의 RE(2, 8), RE(3, 8), RE(2, 2), RE(3, 2))이, TP(TP1)의 PDSCH를 송수신하기 위한 RE로써 설정된다. 결국, PDSCH RE는 도 6에 예시된 PDSCH RE와 상기 8개의 RE들(예, RE(2, 9), RE(3, 9), RE(2, 8), RE(3, 8), RE(2, 3), RE(3, 3), RE(2, 2), RE(3, 2))을 포함한다. 상기 8개의 RE들(예, RE(2, 9), RE(3, 9), RE(2, 8), RE(3, 8), RE(2, 3), RE(3, 3), RE(2, 2), RE(3, 2))에서는, TP(TP2, TP3)의 CSI-RS와 TP(TP1)의 PDSCH가 송수신될 수 있다.

[149] 한편, 맵핑 지시자의 값이 1인 경우에, 단말은 해당 8개의 RE들(예, RE(2, 9), RE(3, 9), RE(2, 8), RE(3, 8), RE(2, 3), RE(3, 3), RE(2, 2), RE(3, 2))에서 CSI-RS 기반의 채널 추정과 PDSCH 수신을 모두 수행해야 하는 부담이 있으나, 기지국 그리고/또는 단말이 PDSCH에 대한 CSI-RS 간섭을 적절히 제어하는 경우에 PDSCH 수신 성능을 높이거나 전송 용량을 증대시킬 수 있다.

[150] 방법 Ma110의 다른 예로써, 맵핑 지시자의 값이 0인 경우에, 단말은 CoMP 협력 집합에 포함되는 모든 TP들(예, TP1, TP2, TP3)에 의해 전송되는 CSI-RS의 RE들(즉, 단말에 설정된 모든 NZP CSI-RS ID에 대한 CSI-RS RE 집합(들))에 PDSCH가 맵핑되지 않았음을 가정할 수 있다. 반대로 맵핑 지시자의 값이 1인 경우에, 단말은 CoMP 협력 집합에 포함되는 모든 TP들(예, TP1, TP2, TP3)에 의해 전송되는 CSI-RS의 RE들에 PDSCH가 맵핑되었음을 가정할 수 있다.

[151] 방법 Ma110에서, DCI 포맷 2D의 PQI 필드가 가리키는 PQI 파라미터 집합의 QCL NZP CSI-RS ID(들)을 포함하는 CSI 프로세스가 클래스-B CSI 프로세스인 경우에, 단말은 맵핑 지시자가 해당 클래스-B CSI 프로세스에 포함되는 모든 NZP CSI-RS ID들에 적용됨을 가정할 수 있다. 또는 상기 경우에, 단말은 맵핑 지시자가 해당 클래스-B CSI 프로세스에 포함되는 NZP CSI-RS ID들 중 일부에 적용됨을 가정할 수도 있다. 또는 상기 경우에, 단말은 맵핑 지시자가 해당 클래스-B CSI 프로세스에 포함되는 NZP CSI-RS ID들 중에 PQI 파라미터 집합 내에 설정된 QCL NZP CSI-RS ID(들)에만 적용됨을 가정할 수도 있다. 상기의 경우에, 단말은 맵핑 지시자가 적용되지 않는 NZP CSI-RS ID에 의해 설정된 CSI-RS RE 집합에는 맵핑 지시자의 값과 무관하게 항상 PDSCH가 전송되지 않음을 가정할 수도 있다.

[152] 방법 Ma111은, 맵핑 지시자가 PQI 파라미터 집합별로 설정될 수 있고, 하나의

PQI 파라미터 집합 내에서 맵핑 지시자는 NZP CSI-RS ID별로 설정될 수 있는 방법이다.

[153] 방법 Ma111은 방법 Ma110보다 더 세부적인 설정이 가능한 방법이다. 예를 들어, 맵핑 지시자는 1 비트일 수 있고, 맵핑 지시자는 단말에게 설정된 NZP CSI-RS ID 중에서 QCL NZP CSI-RS ID(들)을 제외한 나머지 NZP CSI-RS ID 각각을 위해 정의될 수 있다. 이 경우에, 각 PQI 파라미터 집합별 맵핑 지시자의 수는 상기 나머지 NZP CSI-RS ID들의 개수의 최대값일 수 있다. Release 12 규격에 따르면 단말은 최대 3개의 CSI 프로세스를 설정받을 수 있고, 하나의 CSI 프로세스는 하나의 NZP CSI-RS ID를 가질 수 있으므로, 맵핑 지시자의 수는 최대 2일 수 있다.

[154] Release 13 규격에 의하면, 클래스-B CSI 보고를 지원하는 단말은 CSI 프로세스당 NZP CSI-RS ID를 최대 8개까지 설정받을 수 있으므로, 이 경우에 PQI 파라미터 집합별 맵핑 지시자의 수는 최대 16일 수 있다.

[155] 또는 방법 Ma111에서, PQI 파라미터 집합별로, 맵핑 지시자는 단말에게 설정된 모든 NZP CSI-RS ID 각각을 위해 정의될 수 있다. 이 경우에, PQI 파라미터 집합별 맵핑 지시자의 수는 단말에게 설정된 NZP CSI-RS ID의 수와 같을 수 있다.

[156] 방법 Ma111에서 하나 또는 복수의 맵핑 지시자들은 각 PQI 파라미터 집합 내에 포함되어 정의될 수 있다. 예를 들어, 도 4의 DPS 전송에서 단말이 DCI 포맷 2D를 통해 TP(TP1)로부터 PDSCH를 수신하는 경우를 가정하면, 기지국은 단말을 위한 PQI 파라미터 집합 내에서 NZP CSI-RS ID 별로 맵핑 지시자를 설정함으로써, 해당 단말에게 PDSCH를 전송하지 않는 TP들(TP2, TP3)을 위한 CSI-RS RE 중에서 일부 TP(예, TP2)를 위한 CSI-RS RE를 PDSCH RE로써 설정하고 나머지 TP(예, TP3)를 위한 CSI-RS RE를 PDSCH RE로써 설정하지 않을 수 있다.

[157] 방법 Ma112는, 맵핑 지시자가 PQI 파라미터 집합별로 설정될 수 있고, 하나의 PQI 파라미터 집합 내에서 맵핑 지시자는 CSI 프로세스별로 설정될 수 있는 방법이다.

[158] 방법 Ma112에서, 예를 들어, 맵핑 지시자는 1 비트일 수 있고, 맵핑 지시자는 단말에게 설정된 CSI 프로세스 중에서 PQI 필드에 의해 지시되며 QCL NZP CSI-RS ID(들)을 포함하는 CSI 프로세스를 제외한 나머지 CSI 프로세스 각각을 위해 정의될 수 있다. 또는 방법 Ma112에서, PQI 파라미터 집합별로, 맵핑 지시자는 단말에 설정된 모든 CSI 프로세스 각각을 위해 정의될 수 있다. 클래스-B CSI 프로세스를 설정받은 단말에 대하여, 방법 Ma111은 PQI 파라미터 집합별로 다수의 맵핑 지시자를 설정해야 할 수도 있는 반면에, 방법 Ma112는 PQI 파라미터 집합별 맵핑 지시자의 수가 해당 캐리어 내에서 단말에 설정된 CSI 프로세스 수를 넘지 않는다.

[159] 방법 Ma113은, 맵핑 지시자가 모든 PQI 파라미터 집합과 모든 NZP CSI-RS

ID들에 공통적으로 적용되는 방법이다.

[160] 방법 Ma113은 단말이 DCI 포맷 2D의 PQI 필드 값과 무관하게, 단일 맵핑 지시자의 설정값을 따라 PDSCH 레잇 매칭(rate matching) 및 PDSCH 자원 요소 맵핑을 수행하는 방법이다. 이 때, 맵핑 지시자는 1 비트일 수 있다. 다중 셀 협력 통신은, 통상적으로 셀 경계(또는 TP 경계)의 단말이 복수의 TP들로부터 비슷한 장기(long-term) 채널 특성을 겪을 때 동적인 TP 선택에 의한 단기(short-term) 채널 선택 이득을 얻고자 하는 방법이다. 상기 맵핑 지시자가 반고정적인 RRC 시그널링에 의해 전송되는 경우에는, CSI-RS 간섭 제거 후의 PDSCH 수신 성능을 보장하는 것은 방법 Ma113으로 충분할 수 있다.

[161] 방법 Ma113에서도 마찬가지로, QCL NZP CSI-RS ID(들)에는 맵핑 지시자가 적용되지 않을 수 있다. 즉, 단말은 QCL NZP CSI-RS ID(들)에 대응하는 CSI-RS RE 집합에서는 PDSCH를 수신하는 것을 기대하지 않을 수 있다. 또는 방법 Ma113에서, QCL NZP CSI-RS ID(들)에도 맵핑 지시자가 동일하게 적용될 수 있다. 즉, 단말은 맵핑 지시자 값에 따라, QCL NZP CSI-RS ID(들)에 대응하는 CSI-RS RE 집합에서도 PDSCH를 수신하는 것을 기대할 수 있다.

[162] 한편, 방법 Ma113에서 맵핑 지시자는 PQI 파라미터 집합과 동일한 또는 상위 레벨의 정보에 포함될 수 있다.

[163] 한편, 상술한 바와 같이, 다중 셀 협력 전송이 아닌 경우에는 기지국이 인접 셀(들)의 CSI-RS configuration 정보를 단말에게 별도의 시그널링을 통해 알려주어야 하는데, 이러한 경우에, 기지국이 각 인접 셀에 대한 CSI-RS configuration마다 상기 맵핑 지시자를 정의하고 이를 CSI-RS configuration과 함께 단말에게 알려주는 방법이 사용될 수도 있다. 또는 방법 Ma113과 유사하게, 하나의 맵핑 지시자를 정의하고 이를 모든 인접 셀(들)에 대한 CSI-RS configuration에 공통적으로 적용하는 방법이 고려될 수도 있다.

[164] 이하에서는 물리계층 시그널링에 의해 맵핑 지시자를 단말에게 설정하는 방법에 대하여 설명한다.

[165] 방법 Ma120은, 단말의 PDSCH 스케줄링 정보를 포함하는 하향링크 DCI에 맵핑 지시자를 포함시키는 방법이다.

[166] 단말은 하향링크 DCI에 포함된 맵핑 지시자를 통해, 자신이 설정받은 CSI-RS RE 집합(들)에 PDSCH 데이터가 맵핑되었는지 여부를 동적으로 지시받을 수 있다. 기지국은 단말의 채널 상태에 따라, 단말이 서로 다른 TP에 의해 전송되는 CSI-RS와 PDSCH를 어떤 CSI-RS RE 집합에서 모두 성공적으로 수신할 수 있다고 판단되는 경우에, PDSCH 전송을 위해 해당 RE 집합을 추가로 이용하고, 그렇지 않다고 판단되는 경우에는, 해당 RE 집합에 PDSCH 데이터를 맵핑시키지 않을 수 있다.

[167] CoMP 전송인 경우(즉, 하향링크 DCI가 DCI 포맷 2D인 경우)에, 방법 Ma120에서 맵핑 지시자는 단말에게 설정된 NZP CSI-RS ID 중에서 QCL NZP CSI-RS ID(들)을 제외한 나머지 모든 NZP CSI-RS ID(들)을 위해 공통으로

정의되거나(방법 Ma110과 유사), 나머지 NZP CSI-RS ID 별로 각각 정의될 수 있다(방법 Ma111과 유사). 전자의 경우에 맵핑 지시자를 위한 필드는 1 비트일 수 있다. 또는 방법 Ma120에서 맵핑 지시자는 단말에게 설정된 NZP CSI-RS ID 중에서 QCL NZP CSI-RS ID(들)을 포함한 모든 NZP CSI-RS ID(들)을 위해 공통으로 정의되거나(방법 Ma110과 유사), 모든 NZP CSI-RS ID에 대하여 각각 정의될 수 있다(방법 Ma111과 유사). 전자의 경우에, 맵핑 지시자를 위한 필드는 1 비트일 수 있다.

[168] CoMP 전송이 아닌 경우에, 방법 Ma120에서 맵핑 지시자는 모든 인접 셀(들)의 NZP CSI-RS configuration을 위해 공통으로 정의되거나, 인접 셀의 NZP CSI-RS configuration 별로 각각 정의될 수 있다. 전자의 경우에 맵핑 지시자를 위한 필드는 1 비트일 수 있다.

[169] 방법 Ma120을 구성하는 또 다른 방법으로써, PDSCH 데이터를 맵핑시키고자 하는 RE 집합을 나타내는 NZP CSI-RS ID(들)의 집합, 또는 PDSCH 데이터를 맵핑시키지 않고자 하는 RE 집합을 나타내는 NZP CSI-RS ID(들)의 집합을 RRC 시그널링을 통해 미리 설정해 두고, DCI 내의 맵핑 지시자 필드(또는 이에 상응하는 필드)를 이용하여 단말에게 PDSCH 맵핑 여부를 상기 NZP CSI-RS ID 집합 단위로 동적으로 알려주는 방법이 있다. 상기 NZP CSI-RS ID 집합은 하나 또는 복수 개 설정될 수 있다. 설정 가능한 NZP CSI-RS ID 집합이 하나인 경우, DCI 내의 맵핑 지시자 필드는 1 비트로 충분할 수 있다. 설정 가능한 NZP CSI-RS ID 집합이 N개인 경우에, DCI 내의 맵핑 지시자 필드는 예를 들어 $\text{ceil}(\log_2(N+1))$ 비트를 필요로 할 수 있다. 여기서 ceil(.)는 소수점 이하 올림 연산을 의미한다.

[170] 상기 맵핑 지시자(또는 이에 상응하는 시그널링)에 기초한 방법들은, 단말이 복수의 CSI 프로세스에 의해 복수의 NZP CSI-RS ID를 설정받은 경우에만 적용 가능하도록, 제한될 수도 있다. 또는 상기 맵핑 지시자(또는 이에 상응하는 시그널링)에 기초한 방법들은, 단말이 설정받은 CSI 프로세스 수와 무관하게, 단말이 복수의 NZP CSI-RS ID를 설정받은 경우에만 적용 가능하도록, 제한될 수도 있다. 또는 상기 맵핑 지시자에 기초한 방법들은 단말이 QCL type B로 설정되는 경우에만 적용 가능하도록, 제한될 수도 있다. 단말이 QCL type A로 설정되는 경우에는, 상기 맵핑 지시자에 기초한 방법들의 적용이 불필요할 수 있다.

[171] 이하에서는 동일한 문제(예, CSI-RS 전송 오버헤드 문제 등)를 ZP CSI-RS를 이용하여 해결하는 방법에 대하여 설명한다.

[172] 방법 Ma130은, CoMP 협력 집합에 속한 TP들 중에서 PDSCH를 송신하는 TP를 제외한 나머지 TP(들)에 대해 설정된 CSI-RS RE 집합(들)에서, 단말이 PDSCH를 수신할 것을 기대하는 방법이다.

[173] 현재 규격에 의하면 단말은 하향링크 DCI 중에서 DCI 포맷 2D를 제외한 하향링크 DCI를 통해 PDSCH를 스케줄링받는 경우에, 단말은 서빙 셀에 의해 전송되는 CSI-RS의 RE들에서는 PDSCH가 전송되지 않고 인접 셀에 의해

전송되는 CSI-RS의 RE들에서는 해당 영역이 ZP CSI-RS로 설정되지 않는 한 PDSCH가 전송됨을 가정하므로, 단말은 이미 방법 Ma130을 따르고 있다. 그러나 단말이 DCI 포맷 2D를 통해 PDSCH를 스케줄링받는 경우에는, 단말은 자신이 설정받은 모든 NZP CSI-RS RE들을 제외한 자원 영역에 대해 PDSCH RE 맵핑을 수행하도록 되어 있다. 방법 Ma130이 사용되면, 단말은 후자의 경우에, 단말에게 설정된 NZP CSI-RS ID 중에서 DCI에 의해 지시되는 QCL NZP CSI-RS ID(들)을 제외한 나머지 NZP CSI-RS ID(들)에 대응하는 RE 집합(들)에서 해당 영역이 ZP CSI-RS로 설정되지 않는 한 PDSCH가 전송됨을 가정한다. 따라서 기지국은 단말에 설정된 어떤 CSI-RS RE 집합을 해당 단말로의 PDSCH 전송을 위해 이용하고자 하는 경우에, 해당 CSI-RS RE 집합을 ZP CSI-RS로 설정하지 않을 수 있고, 해당 CSI-RS RE 집합을 해당 단말로의 PDSCH 전송을 위해 이용하지 않고자 하는 경우에, 해당 CSI-RS RE 집합을 ZP CSI-RS로 설정할 수 있다. 도 4에 예시된 DPS 전송을 가정하면, 도 7에 예시된 PDSCH RE 맵핑은 전자의 경우(ZP CSI-RS로써 설정 안하는 경우)에 해당하고, 도 6에 예시된 PDSCH RE 맵핑은 후자의 경우(ZP CSI-RS로써 설정하는 경우)에 해당한다.

[174]

[175] 도 8은 본 발명의 실시예에 따른, 3개의 TP가 2개의 서브프레임 내의 서로 다른 RE들을 이용하여 CSI-RS 자원을 설정하는 방법을 나타내는 도면이다.

[176] DPS 전송에 참여하는 각 TP가 하나의 단말에 전송하는 CSI-RS들이 서로 다른 서브프레임에서 전송되도록 설정될 수도 있다. 이것은, 전송 모드(TM)가 10인 단말이 설정받은 복수의 NZP CSI-RS configuration들이 동일한 서브프레임 내에 설정되지 않은 경우에 대응한다.

[177] 구체적으로, 도 8에는 단말이 3개의 TP(TP1~TP3) 각각에 대하여 4개의 CSI-RS 안테나 포트(15~18번)를 2개의 인접한 서브프레임(서브프레임 n, 서브프레임 n+1)에 걸쳐 설정받은 경우를 예시하였다. 예를 들어, 서브프레임 n의 슬롯0에 속하는 RE(5, 9), RE(6, 9), RE(5, 3), 및 RE(6, 3)은 TP(TP1)을 위한 CSI-RS RE로써 설정되고, 서브프레임 n의 슬롯1에 속하는 RE(2, 9), RE(3, 9), RE(2, 3), 및 RE(3, 3)은 TP(TP2)을 위한 CSI-RS RE로써 설정되고, 서브프레임 n+1의 슬롯1에 속하는 RE(2, 8), RE(3, 8), RE(2, 2), 및 RE(3, 2)은 TP(TP3)을 위한 CSI-RS RE로써 설정된다.

[178] 단말이 DCI 포맷 2D를 통해 TP(TP1)로부터 PDSCH를 수신하는 경우를 가정하자. 방법 Ma130이 사용되면, 기지국은 단말이 TP(TP2)과 TP(TP3)에 의해 전송되 CSI-RS의 RE들에서 PDSCH를 수신할 지 여부를, ZP CSI-RS 설정을 통해 결정한다. 그러나 현재 규격에서 단말은 PQI 파라미터 집합별로 하나의 ZP CSI-RS configuration만을 설정받을 수 있다. 결국, 단말이 TP(TP2)와 TP(TP3)에 의해 전송되는 CSI-RS의 RE들 전부에서 PDSCH를 수신하지 않도록 설정하는 것은, 2개의 ZP CSI-RS configuration이 요구되므로, 현재 규격에서는 불가능하다.

[179] 한편, 향후 FD-MIMO를 지원하기 위한 다수의 CSI-RS 안테나 포트를 설정하는

방법으로써, 하나의 CSI 프로세스를 통해 하나 또는 복수의 NZP CSI-RS configuration들을 복수의 서브프레임에 걸쳐 설정하는 방법이 고려될 수 있다. 이 경우에도, 단말의 정확한 PDSCH 레잇 매칭(rate matching)을 위해서, PQI 파라미터 집합마다 복수의 ZP CSI-RS configuration을 설정하는 것이 필요할 수도 있다. 또는 방법 Ma130이 사용되지 않는 경우라 하더라도, 예를 들어, DPS 전송에 참여하는 TP가 복수의 단말에 대한 CSI-RS를 서로 다른 서브프레임에서 전송하는 경우에, 마찬가지로 복수의 ZP CSI-RS ID가 필요할 수도 있다.

[180] 방법 Ma131은, 각 PQI 파라미터 집합이 복수의 ZP CSI-RS ID를 포함하는 방법이다. ZP CSI-RS ID는 ZP CSI-RS configuration을 나타내는 식별자이다.

[181] ZP CSI-RS 설정 주기가 최소 5 ms임을 고려하면, 방법 Ma131에서 하나의 PQI 파라미터 집합에 포함될 수 있는 ZP CSI-RS ID의 수는, 최대 5개일 수 있다. 또는 RRC 시그널링 오버헤드를 고려하여, 하나의 PQI 파라미터 집합에 포함될 수 있는 ZP CSI-RS ID의 수는 2개 또는 3개로 제한될 수 있다.

[182] 한편, 기존 규격에서 하나의 단말이 설정받을 수 있는 Release 11 ZP CSI-RS ID는 최대 4개이므로, 방법 Ma131의 적용을 위해, 하나의 단말이 설정받을 수 있는 ZP CSI-RS ID의 수를 늘리는 방법이 고려될 수 있다. 이와 동시에, DPS 전송에 참여하는 TP의 수가 최대 3개라고 가정하면, 하나의 단말이 설정받을 수 있는 ZP CSI-RS ID의 수는 최대 15개일 수 있다.

[183] 방법 Ma132는, 하나의 ZP CSI-RS ID를 통해 복수의 서브프레임에 ZP CSI-RS를 설정하는 방법이다.

[184] 하나의 ZP CSI-RS ID에 대응하는 RE들의 집합을, ZP CSI-RS RE 집합이라 부르기로 한다. 이에 따르면, 기존 규격에서 하나의 ZP CSI-RS ID 또는 ZP CSI-RS RE 집합은 하나의 ZP CSI-RS configuration에 대응한다.

[185] 방법 Ma132는 각 PQI 파라미터 집합이 기존처럼 하나의 ZP CSI-RS ID만을 포함하되, 하나의 ZP CSI-RS ID가 복수의 ZP CSI-RS configuration 또는 하나의 ZP CSI-RS configuration list에 대응할 수 있도록 하는 방법이다. 예를 들어, 단말에게 설정된 하나의 ZP CSI-RS ID가 3개의 ZP CSI-RS configuration을 나타내는 경우에, 3개의 ZP CSI-RS configuration 각각은 3개의 서브프레임 각각에 적용될 수 있다.

[186] 한편, ZP CSI-RS configuration list에 포함되는 ZP CSI-RS configuration(들)은, 기존 규격의 ZP CSI-RS configuration과 동일할 수 있다. 또는 시그널링 오버헤드를 줄이기 위해, ZP CSI-RS configuration list에 포함되는 모든 configuration들이 동일한 주기성을 가진다고 가정되거나, ZP CSI-RS configuration list에 포함되는 configuration들 간의 상대적인 서브프레임 오프셋만을 단말에게 설정하는 방법이 고려될 수도 있다.

[187] ZP CSI-RS 설정 주기가 최소 5 ms임을 가정하면, 방법 Ma132에서 하나의 ZP CSI-RS ID에 대응하는 ZP CSI-RS configuration의 수는 최대 5일 수 있다.

[188] 방법 Ma132는, 기존의 ZP CSI-RS ID와 ZP CSI-RS configuration과의 관계를

그대로 유지한 채, ZP CSI-RS 그룹 ID를 정의하고, 하나의 ZP CSI-RS 그룹 ID가 복수의 ZP CSI-RS ID를 나타낼 수 있도록 하는 방법으로 해석될 수도 있다.

[189] 한편, 방법 Ma132와, 하나의 단말이 설정받을 수 있는 최대 ZP CSI-RS ID의 수를 늘리는 방법이 동시에 사용되는 방법도 고려될 수 있다. 또한 방법 Ma132와 방법 Ma131이 동시에 사용되는 방법도 고려될 수 있다.

[190] 방법 Ma133은, DRS(discovery reference signal) 설정을 위해 Release 12에서 도입된 ZP CSI-RS ID를 각 PQI 파라미터 집합에 포함시키는 방법이다.

[191] Release 12에서 도입된 DRS를 수신할 수 있는 단말은, 기존의 Release 11 ZP CSI-RS configuration에 더하여, DRS 설정을 위해 최대 5개의 ZP CSI-RS ID를 추가로 설정받을 수 있다. 따라서 방법 Ma133이 사용되는 경우에, 기지국은 DRS를 지원하는 Release 12 단말에게, 최대 9개의 ZP CSI-RS ID를 이용하여 PDSCH RE 맵핑 정보(또는 PDSCH 맵핑 여부 정보)를 동적으로 전송할 수 있다. 따라서 방법 Ma133은, 현재 규격에 정의되어 있는 ZP CSI-RS ID만으로도, 상기 문제점(예, CSI-RS 전송 오버헤드 문제 등)을 어느 정도 해결할 수 있다.

[192] 방법 Ma130, 방법 Ma131, 방법 Ma132, 또는 방법 Ma133의 ZP CSI-RS 설정 방법은, 단말의 CSI-RS 간섭 제거를 위한 시그널링 이외에 다른 용도로도 이용될 수 있다.

[193]

[194] 2. 하향링크 참조 신호를 전송하는 방법

[195] 2.1. CSI-RS 자원 설정

[196] 본 명세서에서, CSI-RS configuration이라 함은 CSI-RS 자원 설정 그 자체를 의미할 수도 있고, 경우에 따라서는 CSI-RS 자원 설정(resource configuration)에 의해 설정되는 CSI-RS 자원 구성(resource composition) 또는 CSI-RS RE 집합을 의미할 수도 있다.

[197] 노멀 CP에 대한 CSI-RS configuration은 아래의 표 2을 따른다.

[198] [표2]

노멀 CP에 대한 CSI-RS configuration

	CSI-RS configuration	Number of CSI reference signals configured					
		1 or 2		4		8	
		(k',l')	n_s mod 2	(k',l')	n_s mod 2	(k',l')	n_s mod 2
Frame structure type 1 and 2	0	(9,5)	0	(9,5)	0	(9,5)	0
	1	(11,2)	1	(11,2)	1	(11,2)	1
	2	(9,2)	1	(9,2)	1	(9,2)	1
	3	(7,2)	1	(7,2)	1	(7,2)	1
	4	(9,5)	1	(9,5)	1	(9,5)	1
	5	(8,5)	0	(8,5)	0		
	6	(10,2)	1	(10,2)	1		
	7	(8,2)	1	(8,2)	1		
	8	(6,2)	1	(6,2)	1		
	9	(8,5)	1	(8,5)	1		
	10	(3,5)	0				
	11	(2,5)	0				
	12	(5,2)	1				
	13	(4,2)	1				
	14	(3,2)	1				
	15	(2,2)	1				
	16	(1,2)	1				
	17	(0,2)	1				
	18	(3,5)	1				
	19	(2,5)	1				

Frame structure type 2 only	20	(11,1)	1	(11,1)	1	(11,1)	1
	21	(9,1)	1	(9,1)	1	(9,1)	1
	22	(7,1)	1	(7,1)	1	(7,1)	1
	23	(10,1)	1	(10,1)	1		
	24	(8,1)	1	(8,1)	1		
	25	(6,1)	1	(6,1)	1		
	26	(5,1)	1				
	27	(4,1)	1				
	28	(3,1)	1				
	29	(2,1)	1				
	30	(1,1)	1				
	31	(0,1)	1				

[199] 표 2에서 CSI-RS configuration 0~19번은 FDD와 TDD에 공통으로 적용될 수 있고, CSI-RS configuration 20~31번은 TDD에만 적용될 수 있다. TDD 시스템에서는 전송 모드(TM: transmission mode) 7로 설정된 단말을 위해 안테나 포트 5번의 DMRS가 전송될 가능성이 있으므로, 안테나 포트 5번의 DMRS와의 자원 오버랩을 피하기 위해, CSI-RS configuration 20~31번이 추가로 정의된다. 표 2에서 각각의 CSI-RS configuration이 가리키는 인덱스 쌍 (k',l')은 CSI-RS RE 집합의 기준점이 되는 RE를 의미한다. (k',l')을 기준으로 하나의 PRB 페어 내에서 CSI-RS RE 집합이 어떻게 정해지는 지는, 규격에 미리 정의되어 있다.

[200] 본 명세서에서 CSI-RS 패턴이라 함은, 각 CSI-RS 안테나 포트 수별로 CSI-RS 자원 풀 내에서 규격에 미리 정의된 CSI-RS 자원 구성을 의미하고, 경우에 따라서는 CSI-RS 안테나 포트의 주파수 축 자원 밀도까지를 포함할 수도 있다. 도 1 내지 도 3에 보이듯이, 현재 규격에는 1, 2, 4, 그리고 8개의 CSI-RS 안테나 포트에 대하여 CSI-RS 패턴이 정의되어 있다.

[201] 한편, Release 13에 도입된 12개 및 16개의 CSI-RS 안테나 포트에 대해서는, 하나의 고정된 CSI-RS 패턴이 정의된 것이 아니라, 기존의 4개 또는 8개의 CSI-RS 안테나 포트의 CSI-RS configuration을 복수 개 집성(aggregation)하여 자원을 구성하도록 되어 있다. 구체적으로, 12개의 CSI-RS 안테나 포트는 기존의 4개 안테나 포트의 CSI-RS configuration을 3개 집성하여 구성되고, 16개의 CSI-RS 안테나 포트는 기존의 8개 안테나 포트의 CSI-RS configuration을 2개 집성하여 구성된다. 본 명세서에서, CSI-RS 자원 집성의 요소로 이용되는 CSI-RS configuration을 '컴포넌트 CSI-RS configuration'이라 한다.

[202] 또한, 12개 및 16개의 CSI-RS 안테나 포트에 대해서는, length-2 CDM (이하 'CDM-2')와 length-4 CDM (이하 'CDM-4') 중 하나가 선택적으로 적용될 수 있다.

[203] 한편, Release 13에 도입된 단말의 CSI 보고 유형은 클래스-A와 클래스-B로 구분된다. 전송 모드(transmission mode)가 10인 경우, 기지국은 단말에게, CSI 프로세스 내의 CSI 보고 유형을 가리키는 파라미터를 이용하여 클래스-A 또는 클래스-B CSI 보고를 설정할 수 있다. 본 명세서에서는, 전송 모드를 구분하지 않고, 클래스-A CSI 보고를 위해 단말에 설정되는 CSI-RS 설정 파라미터들의 집합을 '제1 CSI-RS 설정'이라 하고, 클래스-B CSI 보고를 위해 단말에 설정되는 CSI-RS 설정 파라미터들의 집합을 '제2 CSI-RS 설정'이라 한다. 전송 모드가 10인 경우, 제1 CSI-RS 설정은 클래스-A CSI 보고를 위한 CSI 프로세스 내에서의 CSI-RS 설정 파라미터들의 집합을 의미하고, 제2 CSI-RS 설정은 클래스-B CSI 보고를 위한 CSI 프로세스 내에서의 CSI-RS 설정 파라미터들의 집합을 의미한다.

[204] 제1 CSI-RS 설정은 12개 또는 16개의 CSI-RS 안테나 포트의 자원 설정 정보를 포함할 수 있다. 즉, 제1 CSI-RS 설정은 12개 또는 16개의 CSI-RS 안테나 포트의 자원 집성을 위한 복수의 컴포넌트 CSI-RS configuration과 CDM 유형 (즉, CDM-2 또는 CDM-4)을 가리키는 파라미터를 포함할 수 있다. 제2 CSI-RS 설정은 하나 또는 복수의 CSI-RS configuration을 포함하고, 이 때 제2 CSI-RS 설정에 포함되는 각 CSI-RS configuration은 기존 1, 2, 4, 또는 8개의 CSI-RS 안테나 포트의 CSI-RS configuration이다. 하나의 제2 CSI-RS 설정 내에서, CSI-RS configuration들은 서로 다른 CSI-RS 안테나 포트 수를 가질 수 있고, 전송 모드가 10인 경우, 각기 다른 고유의 NZP CSI-RS ID를 가질 수 있다.

[205]

[206] 2.2. 제1 CSI-RS 설정을 확장하는 방법

[207] 제1 CSI-RS 설정은 8, 12, 그리고 16 이외의 CSI-RS 안테나 포트 수로 확장될 수 있다. 예를 들어, 제1 CSI-RS 설정은 16이 넘는 8의 배수인 CSI-RS 안테나 포트 수로 확장될 수 있다. 또는, 제1 CSI-RS 설정은 16이 넘는 4의 배수인 CSI-RS 안테나 포트 수로 확장될 수 있다. 또는, 제1 CSI-RS 설정은 16이 넘는 짝수인 CSI-RS 안테나 포트 수로 확장될 수 있다. 또는, 제1 CSI-RS 설정은 8 이상의 짝수인 CSI-RS 안테나 포트 수를 포함하도록 확장될 수 있다. 이 때, 설정 가능한 CSI-RS 안테나 포트 수는 N을 넘지 않도록 제한될 수 있다. 여기서 N은 16보다 큰 임의의 자연수이다. 예를 들어, N은 32 또는 64일 수 있다.

[208] 상기 새로운 CSI-RS 안테나 포트 수에 대해서도, 현재 규격과 마찬가지로, 복수의 컴포넌트 CSI-RS configuration을 집성하는 방법이 적용될 수 있다. 예를 들어, 20개의 CSI-RS 안테나 포트는 기존의 4개 안테나 포트의 CSI-RS configuration을 5개 집성하여 구성될 수 있고, 24개의 CSI-RS 안테나 포트는 기존의 4개 안테나 포트의 CSI-RS configuration을 6개 집성하여 구성되거나, 기존의 8개 안테나 포트의 CSI-RS configuration을 3개 집성하여 구성될 수 있다.

[209] 또는 상기 새로운 CSI-RS 안테나 포트 수의 일부 또는 전부, 그리고/또는 기존 CSI-RS 안테나 포트 수에 대해서, 컴포넌트 CSI-RS configuration별로 독립적인

CSI-RS 안테나 포트 수를 가지도록 하는 방법이 적용될 수 있다. 예를 들어, 20개의 CSI-RS 안테나 포트는 기존의 8개 안테나 포트의 CSI-RS configuration 2개와 기존의 4개 안테나 포트의 CSI-RS configuration 1개를 집성하여 구성될 수 있다.

[210] 또는 상기 새로운 CSI-RS 안테나 포트 수의 일부 또는 전부, 그리고/또는 기존 CSI-RS 안테나 포트 수에 대해서, 모든 컴포넌트 CSI-RS configuration이 동일한 CSI-RS 안테나 포트 수를 가지되, 이 중에서 하나의 컴포넌트 CSI-RS configuration에 대해서는 단말이 일부 CSI-RS 안테나 포트만을 수신하고 CSI 측정 및 보고에 이용할 것을 가정하는 방법이 적용될 수 있다. 예를 들어, 단말은 제1 CSI-RS 설정을 구성하는 컴포넌트 CSI-RS configuration(들) 중에 마지막 컴포넌트 CSI-RS configuration에 대해서 일부 CSI-RS 안테나 포트만을 가정할 수 있다. 예를 들어, 20개의 CSI-RS 안테나 포트는 기존의 8개 안테나 포트의 CSI-RS configuration을 3개 집성하여 구성하되, 마지막 컴포넌트 CSI-RS configuration에 대해서는 단말이 8개의 안테나 포트 중에서 4개(예, CSI-RS 안테나 포트 15~18번)만을 수신함을 가정할 수 있다. 단말이 일부 CSI-RS 안테나 포트만을 가정하는 컴포넌트 CSI-RS configuration에 대해서, 단말이 가정하는 CSI-RS 안테나 포트 수는 기지국에 의해 단말에게 시그널링될 수 있다.

[211] 본 명세서에서, 제1 CSI-RS 설정에 적용될 수 있는 방법들은, 상기 확장에 의한 새로운 CSI-RS 안테나 포트 수의 설정에도 동일하거나 유사하게 적용될 수 있음을 가정한다.

[212]

[213] 2.3. CSI-RS 자원 설정을 확장하는 방법

[214] 도 1 내지 도 3에 예시된 바와 같이, 현재의 LTE 규격에 따르면, 노멀 CP가 설정되는 경우에, 하나의 PRB 페어 내에서 CSI-RS 전송을 위해 이용될 수 있는 RE는 총 40개이다. 이하에서는, PRB 페어 내에서(또는 PRB 번들링(bundling)이 사용되는 경우에는 복수의 PRB 페어 내에서) CSI-RS 자원으로써 설정 가능한 RE들의 집합을, CSI-RS 자원 풀이라 한다. CSI-RS 자원 풀을 확장하는 것은 FD-MIMO 시스템에서 다수의 CSI-RS 안테나 포트를 전송하는 것에 도움이 될 수 있다. 하나의 서브프레임 내에서 CSI-RS 자원 풀을 확장하기 위한 방법으로써, 크게 두 가지 방법이 고려될 수 있다.

[215] 첫 번째 방법은 하나의 PRB 페어 내에서 CSI-RS 자원 풀에 포함되는 RE의 수를 늘리는 방법이다. 두 번째 방법은 하나의 PRB 페어 내 CSI-RS 자원 풀에 포함되는 RE 개수를 40개로 유지한 채, 주파수 축으로 인접한 복수의 PRB 페어를 번들링하여 CSI-RS 자원 풀을 확장하는 방법이다. 후자의 방법에 따르면, CSI-RS 자원 설정을 위해 이용될 수 있는 RE의 수가 늘어나는 반면에, 전체 시스템 대역폭 내에서 각 CSI-RS 안테나 포트에 할당되는 RE의 수는 줄어든다. 예를 들어, PRB 페어 번들이 2개의 인접한 PRB 페어를 포함하는 경우에, 하나의 PRB 페어 번들 내에서 CSI-RS 자원 풀은 총 80개의 RE를 포함하지만, 각 CSI-RS

안테나 포트의 시퀀스를 구성하는 심볼의 수는 기존 대비 절반으로 줄어든다. CSI-RS 안테나 포트별 주파수 축 RE의 밀도가 줄어들면, 단말의 채널 추정 시 이용 가능한 채널 샘플의 수가 줄어들게 되고, 이는 채널 특성과 채널 추정 알고리즘에 따라 채널 추정 성능에 영향을 미칠 수도 있다. 한편, 현재 규격에 의하면, 단말의 CSI 측정 및 보고는 적어도 서브밴드(subband) 단위로 수행되므로, 실제로 보고되는 CSI의 정확도나 스케줄러 성능의 열화는 미미할 수 있다.

[216] 이하에서는 상기 후자의 방법에 초점을 맞추어, CSI-RS 패턴을 확장하는 방법에 대하여 설명한다. 즉, PRB 페어 번들을 기본 단위로 하여, 기존의 CSI-RS 패턴을 다수의 안테나 포트로 확장하는 방법에 대하여 기술한다.

[217] 또한 1, 2, 4, 또는 8개의 CSI-RS 안테나 포트에 대해서도 PRB 번들링을 이용하여, 기존보다 CSI-RS 패턴이 더 낮은 주파수 축 밀도를 갖도록 하는 방법에 대해서도 설명한다. 또한 상기 확장된 CSI-RS 패턴들을 조합하여 단말에 설정하는 방법에 대해서도 설명한다. 이하에서 기술되는 방법들 각각을, 다음의 4가지 경우로 구분하여 순차적으로 설명한다. 첫 번째 경우를 위주로 기술하고, 나머지 경우들에 대해서는 간략히 설명하기로 한다.

[218] - 노멀 CP가 설정되는 경우에, FDD와 TDD에 모두 적용될 수 있는 CSI-RS 자원 설정

[219] - 노멀 CP가 설정되는 경우에, TDD에만 적용될 수 있는 CSI-RS 자원 설정

[220] - 확장 CP가 설정되는 경우에, FDD와 TDD에 모두 적용될 수 있는 CSI-RS 자원 설정

[221] - 확장 CP가 설정되는 경우에, TDD에만 적용될 수 있는 CSI-RS 자원 설정

[222] 한편, 본 발명의 실시예에 따른 방법들은, 안테나 가상화(virtualization) 방식에 따라 그 효과가 달라질 수 있다. 본 명세서에서 가상화라 함은 안테나 포트와 물리 안테나 요소(들) 간의 맵핑을 의미하며, 디지털 신호 처리 기반의 통신 시스템에서 안테나 가상화는 안테나 포트 가상화와 TXRU(transceiver unit) 가상화를 포함할 수 있다. 여기서 TXRU는, 입력 신호의 위상(phase)과 진폭(amplitude)을 독립적으로 제어하고 출력할 수 있는 RF 장치의 단위를 의미하고, 통상적으로 RF 체인이라 부르기도 한다. 안테나 포트 가상화는 안테나 포트와 TXRU(들) 간의 맵핑을 의미하고, TXRU 가상화는 TXRU와 물리 안테나 요소(들) 간의 맵핑을 의미한다. 단말은 기본적으로 각 안테나 포트에 적용된 가상화를 알 수 없다.

[223] 본 명세서에서 CSI-RS는 일반적으로 통용되듯이 NZP(non-zero-power) CSI-RS를 의미하고, ZP(zero-power) CSI-RS와는 구별되는 것으로 가정한다.

[224]

[225] <u>2.3.1. 노멀 CP가 설정되는 경우에, FDD와 TDD에 모두 적용될 수 있는 CSI-RS 자원 설정 방법</u>

[226] 첫째로, 노멀 CP가 설정되는 경우에, FDD와 TDD 프레임 구조에 공통적으로

적용되는 CSI-RS 자원 설정 방법에 대하여 기술한다.

[227] 제안하는 방법을 설명하기에 앞서, 먼저 PRB 페어 번들을 정의한다. 본 명세서에서 PRB 페어 번들(이하, 'PRB 번들')은 CSI-RS 패턴이 정의되는 기본 단위로써, 주파수 축에서 인접한 PRB 페어들의 묶음(또는 집합)을 의미한다. 즉, CSI-RS 패턴은 하나의 PRB 번들 내에서 정의되고, 이 CSI-RS 패턴이 전 대역에 걸쳐 복수의 PRB 번들에 동일하게 반복되어 맵핑된다. 이 때 PRB 번들의 크기, 즉 PRB 번들에 포함되는 PRB 페어의 개수를 N^bundle_RB로 정의하고, 전체 시스템 대역폭(system bandwidth)이 갖는 PRB 번들의 개수를 N^DL_bundle로 정의한다. 전 대역의 PRB 개수를 N^DL_RB라 하면, N^DL_bundle = ceil(N^DL_RB/N^bundle_RB)이 된다. 예를 들어, LTE 시스템에서 시스템 대역폭이 10 MHz인 경우에, N^DL_RB는 50이고, 이 때 PRB 번들의 크기를 3으로 설정하면 총 PRB 번들의 개수는 N^DL_bundle = ceil(50/3) = 17이고, 마지막 PRB 번들의 크기는 2가 된다. 기존 LTE 규격에 정의된 CSI-RS 패턴은 N^bundle_RB = 1인 경우에 해당한다.

[228]

[229] 이하에서는 PRB 번들링(단, N^bundle_RB > 1)에 대하여 설명한다. PRB 번들에 포함되는 복수의 PRB 페어를 이용하여, CSI-RS 패턴이 정의될 수 있다. 이러한 경우에, CSI-RS 패턴을 확장하는 방법으로써, 크게 방법 Mb100과 방법 Mb200이 고려될 수 있다.

[230] 방법 Mb100은, CSI-RS 패턴에 포함되는 CSI-RS 안테나 포트들의 RE 집합이 PRB 번들에 포함되는 복수의 PRB 페어들 중에서 하나의 PRB 페어 내에만 맵핑(설정)되는 방법이다.

[231] 방법 Mb100은 PRB 번들링이 미적용된 기존 규격의 CSI-RS 패턴을 재활용할 수 있다. 즉, 방법 Mb100은 1, 2, 4, 또는 8개의 CSI-RS 안테나 포트를 설정하고자 하는 경우에, 표 2을 이용한 기존의 CSI-RS configuration 시그널링을 재사용할 수 있다. 이 경우에, 기지국은 단말에게 PRB 번들의 크기(N^bundle_RB) 그리고/또는 PRB 번들 내 CSI-RS RE 집합이 맵핑되는 PRB 페어의 인덱스를 추가로 알려주어야 할 수 있다. 여기서 PRB 번들에 포함된 PRB 페어 중에서 CSI-RS RE 집합이 맵핑되는 PRB 페어의 인덱스는 0 이상 N^bundle_RB 미만의 정수로 표현될 수 있고, 이를 본 명세서에서 편의상 PRB shift라 한다. N^bundle_RB 그리고/또는 PRB shift는 미리 정해진 규칙에 의해 고정된 값을 가질 수도 있고, 단말별로 설정될 수도 있다.

[232] 전자의 예로써, N^bundle_RB는 CSI-RS 안테나 포트 수별로 미리 정해진 값을 가질 수 있다. 예를 들어, N^bundle_RB는 X개의 CSI-RS 안테나 포트 수까지는 1이고, X보다 큰 CSI-RS 안테나 포트 수에 대해서는 1보다 큰 값으로 정해질 수 있다. 여기서 X는 1 이상의 정수값으로 표현될 수 있다. 한편, 후자의 예로써, 단말이 전송 모드 10을 설정받은 경우, N^bundle_RB는 단말에 CSI 프로세스별로 설정될 수 있다.

[233]

[234] 도 9는 본 발명의 실시예에 따른, 방법 Mb100을 이용해 CSI-RS 자원을 설정하는 방법을 나타내는 도면이다.

[235] 구체적으로, 도 9에는 기지국이 2개의 PRB 페어에 번들링을 적용하고, 동일 서브프레임 내에서 단말들(UE-a, UE-b, UE-c, UE-d) 각각에게 8, 4, 2, 또는 1개의 CSI-RS 안테나 포트를 설정하는 경우가 예시되어 있다.

[236] 이 때, 모든 단말의 경우에 N^bundle_RB는 공통으로 2이고, 단말(UE-a)와 단말(UE-d)를 위한 PRB shift는 1이고, 단말(UE-b)와 단말(UE-c)를 위한 PRB shift는 0이다. PRB 번들의 크기가 2이므로, 도면에 예시된 모든 안테나 포트들의 주파수 축 밀도는 기존의 절반이 된다.

[237] 예를 들어, PRB 페어 1번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 5), RE(3, 5), RE(2, 10), RE(3, 10), RE(2, 4), 및 RE(3, 4)는 단말(UE-a)을 위한 CSI-RS RE(예, CSI-RS 안테나 포트 15~22번)로써 설정된다. PRB 페어 1번 내의 슬롯0의 RE(5, 3), 및 RE(6, 3)는 단말(UE-d)을 위한 CSI-RS RE(예, CSI-RS 안테나 포트 15번)로써 설정된다. PRB 페어 0번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 5), 및 RE(3, 5)는 단말(UE-b)을 위한 CSI-RS RE(예, CSI-RS 안테나 포트 15~18번)로써 설정된다. PRB 페어 0번 내의 슬롯0의 RE(5, 9), 및 RE(6, 9)는 단말(UE-c)을 위한 CSI-RS RE(예, CSI-RS 안테나 포트 15~16번)로써 설정된다. 본 명세서의 도면들에는 주파수 대역이 낮은 PRB 페어일수록 낮은 PRB 페어 인덱스를 가지는 것으로 예시되어 있으나, 반대로 주파수 대역이 높은 PRB 페어가 낮은 PRB 페어 인덱스를 가지는 것을 가정할 수도 있다.

[238] 방법 Mb100에 따르면, 하나의 PRB 페어 내 일부 RE들을 복수의 단말이 주파수 축에서 PRB 페어를 교대로 번갈아 가면서 사용할 수 있다. 도 9에 예시된 실시예에서, 단말(UE-a)와 단말(UE-b)는 슬롯1의 RE(2,5), RE(3,5), RE(2,11), 및 RE(3,11)을 사용한다.

[239] 방법 Mb100에서 PRB 번들의 크기(N^bundle_RB)는 임의의 자연수가 될 수 있다. 그러나 기지국이 너무 많은 수의 PRB 페어를 번들링하면 CSI 측정(measurement) 정확도가 떨어지므로, PRB 번들의 크기(N^bundle_RB)의 최대값이 적당한 값으로 미리 정의될 수도 있다. 예를 들어, PRB 번들의 크기가 서브밴드(subband)의 크기를 넘지 않도록(즉, N^bundle_RB가 하나의 서브밴드가 가지는 RB 개수 이하가 되도록), 제한될 수 있다. 또는 PRB 번들의 크기가 서브밴드의 크기의 약수만 가능하도록 제한될 수 있다. 또는 N^bundle_RB 값이 1과 2만 가능하도록 제한을 두는 방법도 고려될 수 있다.

[240] 전술하였듯이, 현재 규격에 의하면, CSI-RS 패턴은 1, 2, 4, 그리고 8개의 CSI-RS 안테나 포트에 대해서만 정의되어 있고, 12개 및 16개의 CSI-RS 안테나 포트는 복수의 컴포넌트 CSI-RS configuration을 집성하여 구성된다. 한편, 1, 2, 4, 그리고 8 이외의 CSI-RS 안테나 포트 수에 대하여, 상기 자원 집성에 의하지 않고, CSI-RS 패턴을 정의하는 방법이 고려될 수 있다. 이 경우에, 방법 Mb100은

현재의 CSI-RS 자원 풀로는 64개의 CSI-RS 안테나 포트에 적용될 수 없다는 제약을 가진다. 또한 기지국이 방법 Mb100을 이용해 32개의 CSI-RS 안테나 포트를 설정하고자 하는 경우에도, 하나의 PRB 페어 내에서 CDM-2와 FDM의 결합만으로는 CSI-RS 패턴이 정의될 수 없고, TDM 또는 length-4 이상의 CDM과의 결합을 통해서만 CSI-RS 패턴이 정의될 수 있으므로, CSI-RS 설정 및 전송을 위해 최소 4개의 OFDM 심볼이 필요하다. 따라서 32개의 CSI-RS 안테나 포트를 설정하는 경우는 16개 이하의 CSI-RS 안테나 포트를 설정하는 경우보다 오실레이터(oscillator)의 impairment로 인한 OFDM 심볼 간 phase drift 현상에 상대적으로 더 노출될 수 있다.

[241] 방법 Mb100의 장점 중 하나는 하나의 PRB 페어 내에서 기존의 CSI-RS 패턴이 동일하게 유지되므로, 기지국은 CSI-RS 전송 시에 PRB 번들링이 적용될 수 있는 단말과 PRB 번들링이 적용될 수 없는 기존(legacy) 단말이 일부 RE를 공유하도록 할 수 있다는 것이다.

[242]

[243] 도 10a 및 도 10b는 본 발명의 다른 실시예에 따른, 방법 Mb100을 이용해 CSI-RS 자원을 설정하는 방법을 나타내는 도면이다.

[244] 구체적으로 도 10a 및 도 10b에는, CSI-RS를 위해 PRB 번들링이 적용된 새로운 단말과 PRB 번들링을 적용받을 수 없는 기존 단말(또는 PRB 번들링이 적용되지 않은 새로운 단말)의 CSI-RS 설정이 자원을 공유하는 경우가 예시되어 있다.

[245] 도 10a에는 단말(UE-a)와 단말(UE-b)가 동일한 CSI-RS configuration에 의해 8개의 CSI-RS 안테나 포트를 설정받고, 단말(UE-a)에 대해서는 방법 Mb100에 의해 2개의 PRB 페어에 번들링이 적용된 경우가 예시되어 있다. 예를 들어, PRB 페어 0번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 5), RE(3, 5), RE(2, 4), 및 RE(3, 4)는 단말(UE-a)를 위한 CSI-RS RE로써 설정된다. 각 PRB 페어 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 5), RE(3, 5), RE(2, 4), 및 RE(3, 4)는 PRB 번들링을 적용받지 않은 단말(UE-b)를 위한 CSI-RS RE로써 설정된다. 결국, PRB 페어 0번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 5), RE(3, 5), RE(2, 4), 및 RE(3, 4)는 단말(UE-a)과 단말(UE-b)을 위한 CSI-RS RE로써 설정된다.

[246] 도 10b에는, 기지국이 단말(UE-a)에게 방법 Mb100을 이용해 2개의 PRB 페어의 번들링을 설정하고, PRB 페어 0번에 8개의 안테나 포트의 CSI-RS 패턴을 설정하고, 단말(UE-b)에게는 4개의 CSI-RS 안테나 포트를 PRB 번들링 없이 설정하는 경우가 예시되어 있다. 예를 들어, PRB 페어 0번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 5), RE(3, 5), RE(2, 4), 및 RE(3, 4)는 단말(UE-a)를 위한 CSI-RS RE로써 설정된다. 각 PRB 페어 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 5), 및 RE(3, 5)는 단말(UE-b)를 위한 CSI-RS RE로써 설정된다. 결국, PRB 페어 0번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 5), 및 RE(3, 5)는 단말(UE-a)과 단말(UE-b)을 위한 CSI-RS RE로써 설정된다.

[247] 도 10a 및 도 10b에 예시된 방법은 단말(UE-a)과 단말(UE-b)에 대한 CSI-RS 자원 설정이 일부 RE들을 공유함으로써, 두 단말(UE-a, UE-b)의 CSI-RS RE 집합 간에 교집합이 없도록 설정하는 방식에 비해, CSI-RS 전송 오버헤드를 줄일 수 있다.

[248]

[249] 도 11은 본 발명의 또 다른 실시예에 따른, 방법 Mb100을 이용해 CSI-RS 자원을 설정하는 방법을 나타내는 도면이다.

[250] 구체적으로 도 11에는 기지국이 복수의 단말에게 PRB 번들 내의 서로 다른 PRB 페어를 이용하여 CSI-RS 자원을 설정하고, 복수의 단말로 하여금 동일한 RE를 주파수 축에서 공유하도록 하는 방법이 예시되어 있다. 도 11에서 단말들(UE-a, UE-b, UE-c, UE-d)은 PRB 번들링을 설정받을 수 있는 단말이고, 각 단말(UE-a, UE-b, UE-c, UE-d)은 2개의 PRB 페어의 번들링을 설정받을 수 있다.

[251] 기지국은 단말(UE-a)와 단말(UE-b)에게 8개의 CSI-RS 안테나 포트를 위한 동일한 CSI-RS configuration과 N^bundle_RB = 2를 공통으로 설정하고, 단말(UE-a)을 위한 PRB shift는 0으로, 단말(UE-b)을 위한 PRB shift는 1로 설정한다. 예를 들어, PRB 페어 0번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)는 단말(UE-a)를 위한 CSI-RS RE로써 설정된다. PRB 페어 1번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)는 단말(UE-b)를 위한 CSI-RS RE로써 설정된다.

[252] 이 때, 단말(UE-a)와 단말(UE-b)를 위한 CSI-RS는 서로 다른 PRB 페어를 통해 전송되므로, 단말(UE-a)와 단말(UE-b)를 위한 CSI-RS에 서로 다른 가상화를 적용하는 것이 가능하다. 즉, 단말 특정적(user equipment-specific) CSI-RS 빔포밍이 가능하다. 이는, 단말(UE-a)와 단말(UE-b)가 가지는 채널이 빔 공간 내 또는 벡터 공간 내에서 서로 방향성이 다른 경우에, 유용하다.

[253] 기지국은 단말(UE-c)와 단말(UE-d)에게 2개의 CSI-RS 안테나 포트를 설정한다. 단말(UE-c)와 단말(UE-d)을 위한 CSI-RS 설정에 적용되는 원리는, 단말(UE-a) 및 단말(UE-b)의 예시와 동일하다. 예를 들어, PRB 페어 0번 내의 슬롯1의 RE(2, 11), 및 RE(3, 11)는 단말(UE-c)를 위한 CSI-RS RE로써 설정된다. PRB 페어 1번 내의 슬롯1의 RE(2, 11), 및 RE(3, 11)는 단말(UE-d)를 위한 CSI-RS RE로써 설정된다.

[254]

[255] 방법 Mb200은, CSI-RS 패턴에 포함되는 CSI-RS 안테나 포트들의 RE 집합이 PRB 번들에 포함되는 모든 PRB 페어들에 균일한 수(또는 최대한 균일한 수)로 맵핑되는 방법이다.

[256] 방법 Mb200에서 CSI-RS 안테나 포트들이 N^bundle_RB개의 PRB 페어들에 동일한 개수로 맵핑되기 위해서는, N^bundle_RB가 2의 지수승이어야 한다. 따라서 방법 Mb100에서 PRB 번들의 크기는 임의의 자연수가 되어도 무방한 데 반해, 방법 Mb200에서는 PRB 번들의 크기는 2의 지수승으로 제한되는 것이

효과적일 수 있다.

[257]

[258] 도 12는 본 발명의 실시예에 따른, 방법 Mb200을 이용해 16개의 CSI-RS 안테나 포트에 대한 자원을 설정하는 방법을 나타내는 도면이다.

[259] 구체적으로 도 12에는 2개의 PRB 페어가 번들링된 경우를 예시하고 있다.

[260] 도 12에 예시된 바와 같이, 기지국은 기존의 8개의 CSI-RS 패턴에 PRB 번들링과 안테나 포트 간 다중화(FDM)를 적용하고 주파수 축으로 2배만큼 CSI-RS 패턴을 확장하여, 16개의 CSI-RS 안테나 포트의 패턴을 설정할 수 있다.

[261] 이 때, 하나의 서브프레임 내에서 설정 가능한 CSI-RS configuration의 수는 5개(예, 0번 내지 4번)이다. 예를 들어, PRB 페어 0번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)와 PRB 페어 1번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)는, CSI-RS configuration 0번를 위한 CSI-RS RE(예, CSI-RS 안테나 포트 15~30번)로써 설정된다.

[262] 도 12에 예시된 실시예에 따르면, 방법 Mb100과 마찬가지로, 2개의 PRB 페어를 묶어 번들링한 만큼, 각 CSI-RS 안테나 포트의 주파수 축 자원 밀도는 절반으로 줄어든다.

[263]

[264] 도 13a 및 도 13b는 본 발명의 실시예에 따른, 방법 Mb200을 이용해 12개의 CSI-RS 안테나 포트에 대한 자원을 설정하는 방법을 나타내는 도면이다.

[265] 구체적으로 도 13a 및 도 13b에는 2개의 PRB 페어가 번들링된 경우를 예시하고 있다. CSI-RS 안테나 포트 수가 16인 경우와 달리, CSI-RS 안테나 포트 수가 12인 경우에는, 만약 기지국이 2개의 PRB 페어에 CSI-RS 안테나 포트를 균일하게 나누어 설정하고자 한다면, 하나의 PRB 페어 내에 6개의 CSI-RS 안테나 포트를 맵핑해야 한다. 이 경우에, 기존 규격상에 하나의 PRB 페어 내에서 설정되는 6개의 CSI-RS 안테나 포트에 대한 패턴이 정의되어 있지 않으므로, 6개의 CSI-RS 안테나 포트를 위한 새로운 패턴이 정의되어야 한다. 이를 피하기 위해, 12개의 CSI-RS 안테나 포트를 2개의 PRB 페어에 불균일하게 나누어 맵핑하는 방법이 고려될 수 있다.

[266] 도 13a 및 도 13b에는 기지국이 PRB 페어 0번과 1번 각각에 8개와 4개의 CSI-RS 안테나 포트를 맵핑하는 경우가 예시되어 있다.

[267] PRB 페어 0번에는 기존 규격상의 8개의 CSI-RS 안테나 포트에 대한 패턴이 적용되고, PRB 페어 1번에는 기존 규격상의 4개의 CSI-RS 안테나 포트에 대한 패턴이 적용된다.

[268] 이 때, 하나의 서브프레임 내에서 설정 가능한 CSI-RS configuration의 수는 5개(예, 0번 내지 4번)이다. 예를 들어, 도 13a에 예시된 실시예에서, PRB 페어 0번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)와 PRB 페어 1번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 3), 및 RE(6,

3)는, CSI-RS configuration 0번를 위한 CSI-RS RE(예, CSI-RS 안테나 포트 15~26번)로써 설정된다. 도 13b에 예시된 실시예에서, PRB 페어 0번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)와 PRB 페어 1번 내의 슬롯0의 RE(5, 8), RE(6, 8), RE(5, 2), 및 RE(6, 2)는, CSI-RS configuration 0번를 위한 CSI-RS RE(예, CSI-RS 안테나 포트 15~26번)로써 설정된다.

[269] 이 때 도 13a 및 도 13b에 예시된 CSI-RS 패턴들과 같이, PRB 페어 1번에 설정된 RE들의 집합이 PRB 페어 0번에 설정된 RE들의 집합에 포함되는 것은, 다른 단말들에 대한 ZP CSI-RS 설정에 효과적일 수 있다.

[270]

[271] 도 14는 본 발명의 실시예에 따른, 방법 Mb200을 이용해 32개의 CSI-RS 안테나 포트에 대한 자원을 설정하는 방법을 나타내는 도면이다.

[272] 구체적으로, 도 14에는 2개의 PRB 페어가 번들링되는 경우가 예시되어 있다.

[273] 기지국은 기존 규격상의 8개의 CSI-RS 안테나 포트의 패턴에 PRB 번들링과 안테나 포트 간 다중화(FDM)를 적용하고 주파수 축으로 CSI-RS 패턴을 4배만큼 확장하여, 32개의 CSI-RS 안테나 포트의 패턴을 설정할 수 있다.

[274] 이 때, 하나의 서브프레임 내에 설정 가능한 CSI-RS configuration의 수는 1개(예, 0번)이다. 예를 들어, 도 14에 예시된 실시예에서, PRB 페어 0번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 9), RE(3, 9), RE(2, 8), RE(3, 8), RE(2, 5), RE(3, 5), RE(2, 4), RE(3, 4), RE(2, 3), RE(3, 3), RE(2, 2), 및 RE(3, 2)와, PRB 페어 1번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 9), RE(3, 9), RE(2, 8), RE(3, 8), RE(2, 5), RE(3, 5), RE(2, 4), RE(3, 4), RE(2, 3), RE(3, 3), RE(2, 2), 및 RE(3, 2)는, CSI-RS configuration 0번를 위한 CSI-RS RE(예, CSI-RS 안테나 포트 15~46번)로써 설정된다.

[275] 한편, 도 12 내지 도 14에 예시된 실시예는 CSI-RS 패턴을 정의하는 특정 예시일 뿐이다. 기지국은 CSI-RS 자원 풀 내에서 다양한 CSI-RS 패턴들을, 방법 Mb200을 이용하는 상기 방법과 동일 또는 유사한 방법을 통해, 정의할 수 있다.

[276] 한편, 방법 Mb100과 마찬가지로, 방법 Mb200이 이용되는 경우에도, 1, 2, 4, 또는 8개의 CSI-RS 안테나 포트에 대하여 PRB 번들링이 적용될 수 있다.

[277]

[278] 도 15는 본 발명의 다른 실시예에 따른, 방법 Mb200을 이용해 CSI-RS 자원을 설정하는 방법을 나타내는 도면이다.

[279] 구체적으로 도 15에는 기지국이 2개의 PRB 페어를 번들링하여, 단말(UE-a, UE-b, UE-c, UE-d) 각각에게 8, 4, 2, 또는 1개의 CSI-RS 안테나 포트를 설정하는 경우가 예시되어 있다.

[280] 2, 4, 또는 8개 안테나 포트를 갖는 CSI-RS 패턴 각각은, 기존의 1, 2, 또는 4개 안테나 포트의 CSI-RS 패턴에 PRB 번들링과 안테나 포트 간 다중화(FDM)가 적용되고 주파수 축으로 CSI-RS 패턴이 2배 확장되는 형태로 정의될 수 있다.

예를 들어, PRB 페어 0번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 5), 및 RE(3, 5)와, PRB 페어 1번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 5), RE(3, 5)는 단말(UE-a)를 위한 CSI-RS RE(예, CSI-RS 안테나 포트 15~22번)로써 설정된다. PRB 페어 0번 내의 슬롯1의 RE(5, 8) 및 RE(6, 8)와, PRB 페어 1번 내의 슬롯1의 RE(5, 8) 및 RE(6, 8)는 단말(UE-b)를 위한 CSI-RS RE(예, CSI-RS 안테나 포트 15~18번)로써 설정된다. PRB 페어 0번 내의 슬롯0의 RE(5, 9) 및 RE(6, 9)와, PRB 페어 1번 내의 슬롯0의 RE(5, 9) 및 RE(6, 9)는 단말(UE-c)를 위한 CSI-RS RE(예, CSI-RS 안테나 포트 15~16번)로써 설정된다.

[281] 도 15에 예시된 단말(UE-a)와 단말(UE-b)에 대한 CSI-RS 자원 설정의 경우에, PRB 번들링이 적용되지 않은 8개 또는 4개 안테나 포트의 CSI-RS 자원 설정에 대비하여, CSI-RS 자원의 주파수 축 밀도가 절반으로 줄어든다. 이로 인해, CSI-RS 전송 오버헤드가 절반으로 줄어든다.

[282] 하지만 도 15에 예시된 단말(UE-d)에 대한 CSI-RS 자원 설정을 통해 알 수 있듯이, 단말에 설정되는 CSI-RS 안테나 포트의 수가 1이고 PRB 번들링이 사용되는 경우에는, 방법 Mb200의 원리가 적용될 수 없다. 이를 일반화하면, PRB 번들의 크기가 단말에 설정되는 CSI-RS 안테나 포트 수보다 크면, 방법 Mb200의 원리가 적용될 수 없다. 이 경우에는, 예외적으로, 방법 Mb100과 유사하게, CSI-RS RE 집합이 PRB 번들 내에서 하나의 PRB 페어에만 맵핑되도록 할 수 있다. 이 때, CSI-RS RE 집합이 맵핑되는 PRB 페어는 미리 정해질 수 있다. 예를 들어, 도 15에서, PRB 페어 0번 내의 슬롯0의 RE(5, 3) 및 RE(6, 3)는 단말(UE-d)를 위한 CSI-RS RE(예, CSI-RS 안테나 포트 15번)로써 설정된다.

[283] 또한 단말(UE-c)에 대한 CSI-RS 자원 설정을 통해 알 수 있듯이, 단말에 설정되는 CSI-RS 안테나 포트 수가 2인 경우에는, PRB 번들링이 사용되더라도 CSI-RS 전송 오버헤드의 감소가 없다. 즉, PRB 번들의 크기가 CSI-RS 안테나 포트 수와 동일하면, 방법 Mb200이 사용될 수는 있으나, 오버헤드 감소 효과가 없다. 이를 고려하여, PRB 번들의 크기(N^bundle_RB)가 단말에 설정하고자 하는 CSI-RS 안테나 포트 수보다 작은 값 또는 약수로만 설정되도록 제한을 두는 방법이 사용될 수도 있다.

[284] 한편, 방법 Mb200에서 PRB 번들의 크기(N^bundle_RB)가 CSI-RS 안테나 포트 수의 약수가아닌 경우에는, 모든 안테나 포트들이 PRB 번들 내에서 최대한 균일하게 맵핑되고 난 후에, 어떤 PRB 페어에서는 다른 PRB 페어(들)보다 더 적은 수의 RE에 안테나 포트들이 맵핑될 수 있다. 이 때, 모든 PRB 페어에서 동일한 수의 RE에 안테나 포트들이 맵핑되도록 하기 위하여, 더 적은 수의 RE가 맵핑된 PRB 페어(들)의 나머지 RE(들)에 CSI-RS 안테나 포트를 15번부터 다시 순차적으로 맵핑하는 방법이 고려될 수 있다. 또는 상기 나머지 RE(들)에 CSI-RS를 맵핑하지 않는 방법이 고려될 수 있다. 하지만 이러한 방법들은, CSI-RS 안테나 포트들 간 자원 할당의 불균형이나 비효율적 자원 할당으로 인한 채널 추정 성능 열화 등의 문제를 해결하기 어렵다. 따라서 방법 Mb200이

사용되는 경우에, PRB 번들의 크기(N^bundle_RB)는 CSI-RS 안테나 포트 수의 약수인 것이 좋다. PRB 번들의 크기(N^bundle_RB)는 2의 지수승으로만 설정되도록 제한되더라도, 대부분의 경우에 PRB 번들의 크기(N^bundle_RB)는 CSI-RS 안테나 포트 수의 약수가 되도록 설정하는 것이 가능하다.

[285] 방법 Mb200에 따르면, 동일한 RE에 PRB 번들에 포함되는 PRB 페어마다 서로 다른 CSI-RS 안테나 포트가 맵핑되므로, PRB 번들링이 적용될 수 있는 새로운 단말과 기존 단말이 NZP CSI-RS 전송 자원을 공유하는 것이 어렵다. 반면에, 방법 Mb200에 따르면 모든 PRB 페어들에 CSI-RS RE들의 수와 위치가 동일하게 설정되므로, 방법 Mb200은 기존 단말이 해당 RE들을 ZP CSI-RS로써 설정받고 PDSCH 레잇 매칭을 수행하는 데는 방법 Mb100보다 유리하다.

[286] 방법 Mb200에서도 PRB 번들의 크기(N^bundle_RB)의 최대값이 설정될 수 있다. PRB 번들의 크기(N^bundle_RB)가 하나의 서브밴드가 가지는 RB 개수를 넘지 않도록 제한될 수 있다. 또는 PRB 번들의 크기가 서브밴드의 크기의 약수만 가능하도록 제한될 수 있다. 또는 PRB 번들의 크기(N^bundle_RB)는 1과 2만이 가능하도록 제한될 수 있다.

[287] 방법 Mb201은, 방법 Mb200의 변형된 방법으로, PRB 번들을 따로 정의하지 않고, CSI-RS 안테나 포트들을 전체 시스템 대역상의 모든 PRB 페어들에 균일한 개수로 (또는 최대한 균일한 개수로) 맵핑하는 방법이다.

[288] 방법 Mb201은, 방법 Mb200의 특별한 경우(special case)로 해석될 수 있다. 즉, 방법 Mb201은, 방법 Mb200에서 PRB 번들의 크기가 시스템 대역폭과 동일하게 설정되는 경우(N^bundle_RB = N^DL_RB)와 동등하다. 그러나 이 경우에, 일반적으로 단말에 설정되는 CSI-RS 안테나 포트 수보다 훨씬 많은 수의 RE들이 전 대역에 걸쳐 존재하므로, 각 CSI-RS 안테나 포트를 복수의 RE들에 맵핑하는 규칙이 새로 정의되어야 할 수도 있다. 모든 CSI-RS 안테나 포트를 15번부터 시작하여 순차적으로 맵핑하는 것을 반복하는 방법이 사용될 수 있다. 이 때, 하나의 PRB 페어 내에서의 안테나 포트 맵핑 규칙으로는, 기존 1, 2, 4, 또는 8개의 CSI-RS 안테나 포트의 패턴을 따르는 방법이 사용될 수도 있고(도 16a), 또는 새로운 방법(도 16b)이 사용될 수도 있다. 이에 대하여, 도 16a 및 도 16b를 참고하여 설명한다.

[289]

[290] 도 16a 및 도 16b는 본 발명의 실시예에 따른, 방법 Mb201를 이용해 6개의 CSI-RS 안테나 포트에 대한 자원을 설정하는 방법을 나타내는 도면이다. 도 16a 및 도 16b에 예시된 실시예에서는 지금까지 기술된 실시예들과 달리, 주파수가 높은 PRB 페어일수록 낮은 PRB 페어 인덱스를 가진다.

[291] 구체적으로, 도 16a에는, 기존 1, 2, 4, 또는 8개의 CSI-RS 안테나 포트의 패턴을 따르는 방법이 사용되는 경우가 예시되어 있다. 각 PRB 페어 내에서 8개 안테나 포트에 대한 CSI-RS 패턴의 맵핑 순서가 사용된다. 예를 들어, PRB 페어 0번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 5), RE(3, 5), RE(2,

4), 및 RE(3, 4)는, CSI-RS RE(예, CSI-RS 안테나 포트 15~20번, CSI-RS 안테나 포트 15~16번)로써 설정된다. PRB 페어 1번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 5), RE(3, 5), RE(2, 4), 및 RE(3, 4)는, CSI-RS RE(예, CSI-RS 안테나 포트 17~20번, CSI-RS 안테나 포트 15~18번)로써 설정된다. PRB 페어 2번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 5), RE(3, 5), RE(2, 4), 및 RE(3, 4)는, CSI-RS RE(예, CSI-RS 안테나 포트 19~20번, CSI-RS 안테나 포트 15~20번)로써 설정된다.

[292] 도 16b에는 기존의 맵핑 규칙을 무시하는 새로운 방법이 사용되는 경우가 예시되어 있다. 예를 들어, PRB 페어 0번 내의 슬롯1의 RE(2, 10) 및 RE(3, 10)는 CSI-RS 안테나 포트 17~18번으로써 설정되고, PRB 페어 0번 내의 슬롯1의 RE(2, 5) 및 RE(3, 5)는 CSI-RS 안테나 포트 19~20번으로써 설정된다.

[293] 이와 같이, CSI-RS 안테나 포트 수가 2의 지수승이 아니면, 도 16a 및 도 16b에 예시된 바와 같이, 각 CSI-RS 안테나 포트 번호에 맵핑되는 RE들이 주파수 축으로 등간격으로 배치되지 않는 경우가 발생할 수 있다. 이로 인해, 채널 추정 성능의 열화 또는 복잡도 증가가 발생할 수 있다.

[294] 방법 Mb201은 방법 Mb200과 마찬가지로, PRB 번들링에 의해 확장된 새로운 CSI-RS 설정 자원이 기존 단말의 NZP CSI-RS 자원 설정과 공유되기가 어렵고, 새로운 설정 자원을 기존 단말이 ZP CSI-RS로써 설정받고 PDSCH 레잇 매칭을 수행하기에는 유리하다.

[295] 지금까지 PRB 번들링을 이용하여 CSI-RS 패턴을 주파수 축으로 확장 또는 변경하는 방법들을 기술하였다. 상기 방법들을 ZP CSI-RS의 설정에 동일하게 적용하여 ZP CSI-RS 자원 설정을 위해서도 PRB 번들링이 가능하도록 확장하는 방법이 고려될 수 있다. 예를 들어, ZP CSI-RS의 설정에 방법 Mb100가 적용되는 경우에, 기지국은 단말에게, 비트맵에 의해 지시되는 ZP CSI-RS RE 집합이 PRB 번들 내에서 어느 PRB 페어에 맵핑되는지를, 즉, PRB shift를 알려줄 수 있다. 또는, 하나의 ZP CSI-RS 설정이 복수의 비트맵을 포함할 수 있다. 이 때, 비트맵의 수는 PRB 번들의 크기(N^bundle_RB)와 동일하고, 비트맵과 PRB 페어가 일대일 맵핑될 수 있다. 다른 예를 들어, ZP CSI-RS의 설정에 방법 Mb200이 적용되는 경우에, PRB 번들의 크기는 2일 수 있다. 이 때, 비트맵의 길이는 기존 길이의 2배가 되고, 비트맵의 각 비트는, PRB 페어 0번과 1번에 공통으로, 표 2에서 2개의 CSI-RS 안테나 포트일 경우의 각 CSI-RS configuration이 가리키는 RE 집합에 대응될 수 있다. 즉, 비트맵의 각 비트는 PRB 페어 0번의 2개의 RE와 PRB 페어 1번의 2개의 RE에 대응될 수 있다.

[296] 상기와 같이 ZP CSI-RS 설정에 PRB 번들링이 적용됨으로써, 셀 간 간섭 제어 또는 간섭 측정(interference measurement)이 용이할 수 있다. 예를 들어, 인접 셀이 PRB 번들링된 NZP CSI-RS를 전송할 때, 서빙 셀은 단말에게 해당 자원을 동일한 PRB 번들링이 적용된 ZP CSI-RS로써 설정하여, 정확한 간섭 측정 또는 자원 낭비 없는 PDSCH 자원 할당이 가능하도록 할 수 있다.

[297] 한편, CSI-RS에 PRB 번들링이 적용되면 각 CSI-RS 안테나 포트의 주파수 축 RE 밀도가 줄어듦으로, CSI-RS 안테나 포트 별로 전송되어야 하는 CSI-RS 심볼의 개수가 줄어든다. 이 때, CSI-RS 시퀀스(sequence) 생성 및 심볼 맵핑에 대하여 두 가지 방법이 고려될 수 있다. 첫째는 각 안테나 포트 별로 줄어든 CSI-RS RE의 밀도에 맞추어 CSI-RS 시퀀스를 생성하고, 시퀀스를 구성하는 심볼들을 설정된 RE들에 주파수 축에서 순차적으로 맵핑하는 방법이다. 둘째는 각 안테나 포트 별로 기존과 동일한 길이의 CSI-RS 시퀀스를 생성하고, 시퀀스를 구성하는 심볼들을 설정된 RE들에 기존의 심볼과 PRB 페어 간 맵핑과 동일하게(즉, 띄엄띄엄) 맵핑하는 방법이다. 후자의 방법은, PRB 번들링이 적용될 수 있는 새로운 단말과 기존 단말이 CSI-RS 시퀀스를 공유하여 동일 자원 상에서 CSI-RS가 전송될 수 있다는 장점을 가진다.

[298] 한편, 방법 Mb100과 방법 Mb200에서는, 마지막 PRB 번들의 크기가 N^bundle_RB 보다 작을 수 있다. 예를 들어, 대역폭이 50 RB인 시스템의 경우에, CSI-RS의 PRB 번들 크기가 3으로 설정되면, 마지막 PRB 번들의 크기는 2가 된다. 마지막 PRB 번들에도 동일한 CSI-RS 패턴이 적용되되, PRB 페어의 부족으로 인해 맵핑될 자원이 존재하지 않는 CSI-RS 안테나 포트에 대해서는 맵핑을 생략하는 방법이 고려될 수 있다. 또는 마지막 PRB 번들에서는 CSI-RS를 전송하지 않는 방법이 고려될 수 있다.

[299] 한편, 지금까지 상술한 복수의 PRB 페어를 번들링하여 CSI-RS 자원을 설정하는 모든 방법은, 제2 CSI-RS 설정을 위해 적용될 수 있다. 제2 CSI-RS 설정은 하나 또는 복수의 CSI-RS configuration을 포함할 수 있는데, 이 때, 각 CSI-RS configuration별로 상술한 방법들이 적용될 수 있다. 즉, PRB 번들링의 적용 여부, PRB 번들의 크기, 그리고 PRB shift가 CSI-RS configuration별로 정의될 수 있다. 또는, PRB 번들링의 적용 여부, PRB 번들의 크기, 그리고 PRB shift 중 하나 또는 복수가 제2 CSI-RS 설정을 구성하는 모든 CSI-RS configuration에 공통으로 정의될 수 있다. 또는, PRB 번들링의 적용 여부, PRB 번들의 크기, 그리고 PRB shift 중 하나 또는 복수가 제2 CSI-RS 설정을 구성하는 CSI-RS configuration들 중 일부 CSI-RS configuration(들)의 집합에 공통으로 정의될 수 있다.

[300] 이하에서는 PRB 번들링을 적용하고 복수의 컴포넌트 CSI-RS configuration을 집성(aggregation)하여 단말에게 CSI-RS 자원을 설정하는 방법에 대하여 기술한다.

[301] 먼저 방법 Mb100을 위한 CSI-RS 자원 집성 방법에 대하여 기술한다. 가장 자유도가 높은 집성 방법은, 컴포넌트 CSI-RS configuration별로 PRB 번들의 크기를 독립적으로 설정하는 방법이지만, 이하에서는 집성되는 모든 컴포넌트 CSI-RS configuration들이 동일한 PRB 번들 크기를 가지는 경우만을 고려하기로 한다. CSI-RS 자원 집성의 경우에도, PRB 번들의 크기는 단말에 시그널링될 수도 있고, 미리 정해진 값을 따를 수도 있다. 이 때, PRB shift의 시그널링 유무에

따라 방법 Mb110 내지 방법 Mb130으로 구분될 수 있다.

[302] 방법 Mb110은, 컴포넌트 CSI-RS configuration 별로 PRB shift를 설정하는 방법이다.

[303] 방법 Mb110은, 방법 Mb120과 방법 Mb130에 비해 CSI-RS 자원 집성의 자유도가 높은 방법이다. 이 때, CSI-RS 자원 집성을 위한 파라미터는, 각 컴포넌트 CSI-RS configuration에 대한 CSI-RS 설정 정보 외에, 각 컴포넌트 CSI-RS configuration별 PRB shift를 포함하고, 모든 컴포넌트 CSI-RS configuration에 공통인 PRB 번들의 크기(N^bundle_RB)를 추가로 포함할 수도 있다.

[304] 각 컴포넌트 CSI-RS configuration을 위하여 설정 가능한 CSI-RS 안테나 포트 수는, Release 13 규격의 4 또는 8만을 포함할 수도 있고, 전술한 새로운 포트 수를 포함하여 4 또는 8 이외의 다른 포트 수(들)을 더 포함할 수도 있다.

[305] 안테나 포트 수가 1, 2, 4, 또는 8인 경우에, 컴포넌트 CSI-RS configuration은 기존 규격에 따른 CSI-RS configuration일 수 있고, 이외의 포트 수인 경우에, 컴포넌트 CSI-RS configuration은 새롭게 정의되는 CSI-RS configuration일 수 있다.

[306] PRB shift는 방법 Mb100에서 상술한 바와 같이, 0 이상 N^bundle_RB 미만의 정수 값으로 표현될 수 있다.

[307]

[308] 도 17은 본 발명의 실시예에 따른, 방법 Mb110을 이용해 복수의 컴포넌트 CSI-RS configuration을 집성하는 방법을 나타내는 도면이다.

[309] 단말(UE-e)에게는, 8개의 CSI-RS 안테나 포트를 포함하는 컴포넌트 CSI-RS configuration 2개가 집성되어 총 16개의 CSI-RS 안테나 포트가 설정된다. 예를 들어, PRB 페어 0번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)는, 단말(UE-e)을 위하여, 컴포넌트 CSI-RS configuration 0번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~22번)로써 설정된다. PRB 페어 1번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)는, 단말(UE-e)을 위하여, 컴포넌트 CSI-RS configuration 1번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~22번)로써 설정된다.

[310] 상술한 파라미터 예시에 따르면, 단말(UE-e)에게 전송되는 파라미터는, 각 컴포넌트 CSI-RS configuration의 CSI-RS 설정 정보 외에, 각 컴포넌트 CSI-RS configuration을 위한 PRB shift를 포함하고, 2인 PRB 번들의 크기(N^bundle_RB)를 추가로 포함할 수도 있다. 컴포넌트 CSI-RS configuration 0번을 위한 PRB shift는 0이고, 컴포넌트 CSI-RS configuration 1번을 위한 PRB shift는 1이다.

[311] 이 때, 단말(UE-e)을 위한 컴포넌트 CSI-RS configuration들(0번, 1번)의 안테나 포트 간 다중화 방식으로는, 두 개의 컴포넌트 CSI-RS configuration(0번, 1번)가 동일 OFDM 심볼 상에 할당되었으므로, FDM이 사용될 수 있다.

[312] 한편, 도 17에 예시된 실시예에서, 단말(UE-f)에게는, 2개의 컴포넌트 CSI-RS configuration이 집성되어 총 10개의 CSI-RS 안테나 포트가 설정된다. 예를 들어, PRB 페어 1번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 5), RE(3, 5), RE(2, 4), 및 RE(3, 4)는, 단말(UE-f)을 위하여, 컴포넌트 CSI-RS configuration 0번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~22번)로써 설정된다. PRB 페어 1번 내의 슬롯1의 RE(5, 9) 및 RE(6, 9)는, 단말(UE-f)을 위하여, 컴포넌트 CSI-RS configuration 1번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~16번)로써 설정된다.

[313] 단말(UE-f)에게 전송되는 파라미터는, 각 컴포넌트 CSI-RS configuration의 CSI-RS 설정 정보 외에, 각 컴포넌트 CSI-RS configuration을 위한 PRB shift를 포함하고, 2인 PRB 번들의 크기(N^bundle_RB)를 추가로 포함할 수도 있다. 컴포넌트 CSI-RS configuration 0번과 컴포넌트 CSI-RS configuration 1번을 위한 PRB shift는 모두 1이다.

[314] 이 때, 단말(UE-f)을 위한 두 개의 컴포넌트 CSI-RS configuration(0번, 1번)는 서로 다른 OFDM 심볼에 할당되었으므로, 컴포넌트 CSI-RS configuration들(0번, 1번)의 안테나 포트 간 다중화 방식으로는, FDM은 사용될 수 없고, TDM이 사용될 수 있다.

[315]

[316] 도 18은 본 발명의 다른 실시예에 따른, 방법 Mb110을 이용해 복수의 컴포넌트 CSI-RS configuration을 집성하는 방법을 나타내는 도면이다.

[317] 구체적으로 도 18에는, 하나의 단말(UE-e)에게, 3개의 컴포넌트 CSI-RS configuration(0번, 1번, 2번)이 집성되어 총 48개의 CSI-RS 안테나 포트가 설정되는 경우가 예시되어 있다.

[318] PRB 번들 크기(N^bundle_RB)는 2이고, 각 컴포넌트 CSI-RS configuration (0번~2번)의 안테나 포트 수는 16개이다. 예를 들어, PRB 페어 0번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)와 PRB 페어 0번 내의 슬롯1의 RE(2, 9), RE(3, 9), RE(2, 8), RE(3, 8), RE(2, 3), RE(3, 3), RE(2, 2), 및 RE(3, 2)는, 단말(UE-e)을 위하여, 컴포넌트 CSI-RS configuration 0번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~30번)로써 설정된다. PRB 페어 0번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 5), RE(3, 5), RE(2, 4), 및 RE(3, 4)와 PRB 페어 0번 내의 슬롯1의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)는, 단말(UE-e)을 위하여, 컴포넌트 CSI-RS configuration 1번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~30번)로써 설정된다. PRB 페어 1번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)와 PRB 페어 1번 내의 슬롯1의 RE(2, 9), RE(3, 9), RE(2, 8), RE(3, 8), RE(2, 3), RE(3, 3), RE(2, 2), 및 RE(3, 2)는, 단말(UE-e)을 위하여, 컴포넌트 CSI-RS configuration 2번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~30번)로써 설정된다.

[319]

[320] 방법 Mb120은, 모든 컴포넌트 CSI-RS configuration에 PRB shift를 동일한 값으로 설정하는 방법이다.

[321] 방법 Mb120은 방법 Mb110에 비해, 설정에 다소 제한을 가하는 대신에, 시그널링 오버헤드를 줄일 수 있는 방법이다. 방법 Mb120에 의하면 모든 컴포넌트 CSI-RS configuration의 CSI-RS RE들이 동일한 PRB 페어 상에 맵핑되므로, 다수의 CSI-RS 안테나 포트를 집성하는 것이 어려울 수 있다.

[322]

[323] 방법 Mb130은, PRB shift가 단말에 시그널링되지 않고 미리 정해진 규칙을 따르는 방법이다.

[324] 방법 Mb130은 방법 Mb110과 방법 Mb120에 비해, 설정에 다소 제한을 가하는 대신에, 시그널링 오버헤드를 줄일 수 있는 방법이다. 미리 정해진 집성 규칙을 위한 한 방법으로써, PRB shift는 각 컴포넌트 CSI-RS configuration의 인덱스의 함수로 정해지는 방법이 고려될 수 있다. 예를 들어, 각 컴포넌트 CSI-RS configuration을 위한 PRB shift는 해당 컴포넌트 CSI-RS configuration 인덱스를 PRB 번들의 크기(N^bundle_RB)로 모듈로(modulo) 연산을 취한 결과값에 의해 정해질 수 있다 (이하 '방법 Mb130-1'). 또는, PRB 번들의 크기(N^bundle_RB)는 컴포넌트 CSI-RS configuration의 수로 정해지고, 각 컴포넌트 CSI-RS configuration을 위한 PRB shift는 해당 컴포넌트 CSI-RS configuration의 인덱스로 정해질 수 있다 (이하 '방법 Mb130-2').

[325] 이 때, CSI-RS 자원 집성을 위한 파라미터는, 각 컴포넌트 CSI-RS configuration의 CSI-RS 설정 정보만을 포함하거나, 모든 컴포넌트 CSI-RS configuration에 공통인 PRB 번들의 크기(N^bundle_RB)를 추가로 포함할 수도 있다.

[326]

[327] 도 19는 본 발명의 실시예에 따른, 방법 Mb130을 이용해 복수의 컴포넌트 CSI-RS configuration을 집성하는 방법을 나타내는 도면이다.

[328] 단말(UE-e)에게는, 방법 Mb130-1에 의해, 3개의 컴포넌트 CSI-RS configuration이 집성되어 총 10개의 CSI-RS 안테나 포트가 설정된다. 예를 들어, PRB 페어 0번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 5), 및 RE(3, 5)는, 단말(UE-e)을 위하여, 컴포넌트 CSI-RS configuration 0번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~18번)로써 설정된다. PRB 페어 1번 내의 슬롯1의 RE(5, 9), RE(6, 9), RE(5, 3), 및 RE(6, 3)는, 단말(UE-e)을 위하여, 컴포넌트 CSI-RS configuration 1번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~18번)로써 설정된다. PRB 페어 0번 내의 슬롯1의 RE(5, 9) 및 RE(6, 9)는, 단말(UE-e)을 위하여, 컴포넌트 CSI-RS configuration 2번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~16번)로써 설정된다.

[329] 이 경우에, 컴포넌트 CSI-RS configuration 0번 내지 컴포넌트 CSI-RS

configuration 2번을 위한 PRB 번들의 크기(N^bundle_RB)는 모두 2이다. 또한, 컴포넌트 CSI-RS configuration 0번 내지 컴포넌트 CSI-RS configuration 2번을 위한 PRB shift는 해당 컴포넌트 CSI-RS configuration 인덱스를 PRB 번들의 크기(N^bundle_RB)로 모듈로 연산을 취한 결과값, 즉, 0, 1, 및 0으로 각각 정해진다.단말(UE-f)에게는, 방법 Mb130-2에 의해, 8개의 CSI-RS 안테나 포트를 포함하는 컴포넌트 CSI-RS configuration 2개가 집성되어 총 16개의 CSI-RS 안테나 포트가 설정된다. 예를 들어, PRB 페어 0번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)는, 단말(UE-f)을 위하여, 컴포넌트 CSI-RS configuration 0번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~22번)로써 설정된다. PRB 페어 1번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)는, 단말(UE-f)을 위하여, 컴포넌트 CSI-RS configuration 1번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~22번)로써 설정된다.

[330] 이 경우에, PRB 번들의 크기(N^bundle_RB)는 컴포넌트 CSI-RS configuration의 수인 2로 정해진다. 또한, 컴포넌트 CSI-RS configuration 0번과 컴포넌트 CSI-RS configuration 1번을 위한 PRB shift는 해당 컴포넌트 CSI-RS configuration 인덱스, 즉, 0과 1로 각각 정해진다.

[331]

[332] 다음으로 방법 Mb200을 위한 CSI-RS 자원 집성 방법에 대하여 기술한다.

[333] 상술한 바와 마찬가지로, 집성되는 모든 컴포넌트 CSI-RS configuration들이 동일한 PRB 번들 크기를 가진다고 가정하면, CSI-RS 자원 집성을 위한 파라미터는, 각 컴포넌트 CSI-RS configuration에 대한 CSI-RS 설정 정보만을 포함하거나, 모든 컴포넌트 CSI-RS configuration에 공통인 PRB 번들의 크기(N^bundle_RB)를 추가로 포함할 수도 있다.

[334]

[335] 도 20은 본 발명의 실시예에 따른, 방법 Mb200의 PRB 번들링이 사용되는 경우에 복수의 컴포넌트 CSI-RS configuration을 집성하는 방법을 나타내는 도면이다.

[336] 구체적으로 도 20에는 PRB 번들 크기(N^bundle_RB)는 2이고, 집성되는 컴포넌트 CSI-RS configuration의 수는 2인 경우가 예시되어 있다.

[337] 컴포넌트 CSI-RS configuration 0번과 1번 모두에는 방법 Mb200의 PRB 번들링에 의해 확장된 CSI-RS 패턴이 적용되고, 컴포넌트 CSI-RS configuration 0번과 1번은 모두 8개의 CSI-RS 안테나 포트 수를 가진다. 예를 들어, PRB 페어 0번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 3), 및 RE(6, 3)와 PRB 페어 1번 내의 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 3), 및 RE(6, 3)는, 단말(UE-e)을 위하여, 컴포넌트 CSI-RS configuration 0번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~22번)로써 설정된다. PRB 페어 0번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 5), 및 RE(3, 5)와 PRB 페어 1번 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 5), 및

RE(3, 5)는, 단말(UE-e)을 위하여, 컴포넌트 CSI-RS configuration 1번의 CSI-RS RE(예, CSI-RS 안테나 포트 15~22번)로써 설정된다.

[338] 한편, 지금까지 상술한 복수의 PRB 페어를 번들링하여 CSI-RS 자원을 설정하는 모든 방법에 대하여, 서로 다른 서브프레임들에 대하여, PRB 페어의 인덱스를 주기적으로 교차하여 CSI-RS를 전송하는 방법이 적용될 수 있다.

[339]

[340] 도 21은 본 발명의 실시예에 따른, 번들링된 PRB 페어들의 인덱스를 시간적으로 교차시켜 CSI-RS를 전송하는 방법을 나타내는 도면이다.

[341] 도 13a 및 도 13b에 예시된 바와 같이, 기지국이 방법 Mb200에 따라 2개의 PRB 페어를 번들링하여 단말에게 12개의 CSI-RS 안테나 포트를 설정하는 경우에, 기지국은 도 21에 예시된 바와 같이, CSI-RS 전송 서브프레임마다 PRB 페어의 위치를 교대로 바꾸어 CSI-RS를 전송할 수 있다.

[342] 구체적으로, CSI-RS 전송 주기를 T라고 가정하면, CSI-RS 전송 서브프레임 n+T 내의 PRB 페어 0번과 1번의 위치가 CSI-RS 전송 서브프레임 n 내의 PRB 페어 0번과 1번의 위치와 맞바뀐 형태로, CSI-RS가 전송될 수 있다.

[343] 이를 통해, 단말은 각 CSI-RS 안테나 포트에 대하여, 시스템 대역 내 모든 PRB 페어의 주파수 영역을 위한 채널 추정을 수행할 수 있으므로, CSI 측정 정확도가 향상될 수 있다.

[344] 한편, 지금까지 상술한 복수의 PRB 페어를 번들링하여 CSI-RS 자원을 집성하는 모든 방법은, 제1 CSI-RS 설정을 위해 적용될 수 있다. 또한, 전술하였듯이, 상술한 CSI-RS 자원 집성 방법들은 새로운 CSI-RS 안테나 포트 수의 설정을 위해서도 동일하거나 유사하게 적용될 수 있다.

[345] 한편, 방법 Mb100 및 방법 Mb100의 세부 방법들에 CDM-4를 적용하는 방법으로써, PRB 번들링이 적용되지 않는 기존 규격의 경우와 마찬가지로, 각각의 컴포넌트 CSI-RS configuration 내에서 CDM-4를 적용하는 방법이 사용될 수 있다. 이 경우에, 컴포넌트 CSI-RS configuration의 안테나 포트 수가 4 또는 8이라면, 기존 규격의 CDM-4 패턴이 동일하게 적용될 수 있다. 반면에, 방법 Mb200 및 방법 Mb200의 세부 방법들에 CDM-4를 적용하기 위하여, 각각의 컴포넌트 CSI-RS configuration 내에서 CDM-4가 적용되면, CDM-4 패턴을 구성하는 RE들 간의 주파수 축 거리가 멀어져 채널 추정 성능이 열화될 수 있다. 이 경우에, 하나의 CDM-4 패턴이 복수(예를 들면, 2개)의 컴포넌트 CSI-RS configuration들 간에 걸쳐서 정의되도록 하는 방법이 사용될 수 있다.

[346]

[347] 2.3.2. 노멀 CP가 설정되는 경우에, TDD에만 적용되는 CSI-RS 자원 설정 방법

[348] 표 2에서 CSI-RS configuration 20~31번에 대한 CSI-RS 패턴과 자원 맵핑은, 안테나 포트 5번의 DMRS 전송 자원과의 오버랩을 피하기 위해 설계되었다. 이 때, PRB 번들링이 적용되지 않은 하나의 PRB 페어 내의 CSI-RS 자원 풀은 24개의 RE들을 포함한다. 이 경우에도, 앞서 기술한 모든 PRB 번들링 방법들과

그 원리가 동일 또는 유사하게 적용될 수 있다. 다만, 하나의 PRB 페어 내에서 24개가 넘는 수의 CSI-RS 안테나 포트의 패턴을 정의하거나 24개가 넘는 수의 CSI-RS 안테나 포트를 집성하는 것은 불가능하다.

[349]

[350] 2.3.3. 확장 CP가 설정되는 경우에, FDD와 TDD에 공통적으로 적용될 수 있는 CSI-RS 자원 설정 방법

[351] 확장 CP가 설정되는 경우에 FDD와 TDD에 공통적으로 적용되는 CSI-RS configuration은, 기존 규격 상에서 0번부터 15번까지 총 16개이다. 하나의 PRB 페어 내의 CSI-RS 자원 풀은 32개의 RE들을 포함한다. 이 경우에도, 앞서 기술한 모든 PRB 번들링 방법들과 그 원리가 동일 또는 유사하게 적용될 수 있다.

[352]

[353] 2.3.4. 확장 CP가 설정되는 경우에, TDD에만 적용되는 CSI-RS 자원 설정 방법

[354] 확장 CP가 설정되는 경우에, 기존 규격상의 CSI-RS configuration 16~27번의 CSI-RS 자원 설정은, 안테나 포트 5번의 DMRS 전송 자원과의 오버랩을 최대한 피하도록 설계된다. 이 경우에 하나의 PRB 페어 내의 CSI-RS 자원 풀은 24개의 RE들을 포함한다. 이 경우에도, 앞서 기술한 모든 PRB 번들링 방법들과 그 원리가 동일 또는 유사하게 적용될 수 있다. 다만, 하나의 PRB 페어 내에서 24개가 넘는 수의 CSI-RS 안테나 포트의 패턴을 정의하거나 24개가 넘는 수의 CSI-RS 안테나 포트를 집성하는 것은 불가능하다.

[355]

[356] 한편, 지금까지 하향링크 RS가 CSI-RS인 경우를 예로 들어, 본 발명의 실시예를 설명하였으나, 이는 예시일 뿐이다. 본 발명의 실시예는, 하향링크 RS가 CSI-RS가 아닌 다른 RS인 경우에도 적용될 수 있다.

[357]

[358] 3. CSI-RS 안테나 포트 배열을 고려한 자원 설정 방법

[359] 단말은 기지국으로부터 시그널링받은 CSI-RS 설정 정보(예, CSI-RS 안테나 포트 수, RE 맵핑 정보)에 기초하여, 설정받은 각 CSI-RS 안테나 포트에 대하여 채널 추정(예, 채널 정보 획득)을 수행한다. 그리고 나서 단말은 CSI-RS 안테나 포트들에 대하여 획득한 채널 정보를 기초로 하여, CSI 측정 및 보고를 수행한다. 여기서 CSI 측정은, 단말이 채널 추정을 통해 획득한 하향링크 채널 정보를 이용하여 PMI(precoding matrix indicator), RI(rank indicator), 그리고/또는 CQI(channel quality indicator)를 결정하는 일련의 과정을 의미한다. 현재 규격에 의하면, 단말은 CSI를 측정할 때 자신이 기지국에 보고한 PMI에 대응하는 프리코딩 행렬의 각 행이 CSI-RS 안테나 포트에 15번부터 순차적으로 대응됨을 가정한다. 예를 들어, 단말이 4개의 CSI-RS 안테나 포트를 설정받은 경우에, 단말은 기지국에 의해 이용되는 프리코딩 행렬의 1행 내지 4행이 CSI-RS 안테나 포트 15번 내지 18번의 채널을 위한 프리코딩 가중치임을 가정하고 CSI를 측정한다. 이 때, 단말은 총 CSI-RS 안테나 포트 수만을 알고 있을 뿐, CSI-RS

안테나 포트들이 실제로 어떤 배치를 갖는지 명시적으로(explicitly) 알지 못한다.

[360] 한편, 상술한 바와 같이, FD-MIMO(또는 3차원 MIMO) 시스템에서 기지국이 3차원 빔포밍을 수행하기 위해서는, 단말이 기존의 수평 축에 대한 CSI 뿐만 아니라 수직 축에 대한 CSI에 대해서도 CSI 측정 및 보고를 수행할 필요가 있다.

[361] 이하에서는, CSI-RS 안테나 포트 번호를, 셀 특정적(cell-specific) CSI-RS 안테나 포트 번호와 단말 특정적(user equipment-specific) CSI-RS 안테나 포트 번호로 구분하여 기술한다. 셀 특정적 CSI-RS 안테나 포트 번호는 기지국에 의해 전송되는 모든 CSI-RS 안테나 포트에 대하여 기지국의 입장에서 매겨지는 번호를 의미하는 것으로 가정하고, 셀 특정적 CSI-RS 안테나 포트 번호는 0번부터 순차적으로 번호 매김되는 것으로 가정한다. 단말 특정적 CSI-RS 안테나 포트는 각 단말에 설정된 CSI-RS 안테나 포트에 대하여 각 단말의 입장에서 매겨지는 번호를 의미하는 것으로 가정한다. LTE 규격에는, 단말의 CSI-RS 안테나 포트 번호가 15번부터 순차적으로 번호 매김되는 것으로 정의되어 있으나, 이하에서는 설명의 편의를 위하여, 0번부터 순차적으로 번호 매김되는 것으로 가정한다. 본 명세서에서, CSI-RS 안테나 포트 번호가 셀 특정적인 경우 또는 단말 특정적인 경우로 명시되지 않은 경우, 이는 단말 특정적 CSI-RS 안테나 포트 번호를 의미함을 가정한다.

[362]

[363] 3.1. 2차원 CSI-RS 안테나 포트 배열 정보를 설정하는 방법

[364] 2차원 CSI-RS 안테나 포트 배열을 위해 제1 차원(first dimension)과 제2 차원(second dimension)이 정의될 수 있다. 일반적으로 2차원 CSI-RS 안테나 포트 배열을 위한 제1 차원과 제2 차원은, 2차원 공간 상에서 두 개의 서로 다른 임의의 방향성을 나타낼 수 있다. 예를 들어, 제1 차원과 제2 차원은, 수평(horizontal) 차원과 수직(vertical) 차원을 포함할 수 있다. 수평 차원과 수직 차원은, 2차원 공간 상에서 두 개의 직교하는 임의의 차원 또는 방향성을 나타낼 수 있다. 예를 들어, 상기 2차원 공간은 CSI-RS 안테나 포트들이 맵핑되는 물리 안테나 요소들로 구성되는 2차원 안테나 배열 평면일 수 있다. 수평 차원 및 수직 차원은, 수평 축 및 수직 축, 또는 수평 방향 및 수직 방향과 동일한 의미로 사용될 수 있다. 이하에서는, 설명의 편의를 위해서, CSI-RS 안테나 포트 배열을 위한 제1 차원과 제2 차원을 수평 축과 수직 축으로 부르기로 한다.

[365] 한편, CSI-RS 안테나 포트 배열은 단일 편파(polarization)를 가질 수도 있고, 다중 편파를 가질 수도 있다. 여기서, CSI-RS 안테나 포트의 편파라 함은, CSI-RS 안테나 포트가 맵핑되는 물리 안테나 요소(들)이 가지는 편파를 의미한다. 이 때, CSI-RS 안테나 포트 배열을 위해, 상술한 공간 차원과는 별도로, 편파 차원이 정의될 수 있다. 본 명세서에서, CSI-RS 안테나 포트 배열을 위한 편파 차원은, CSI-RS 안테나 포트들이 맵핑되는 물리 안테나 요소들의 편파(예, 0도 내지 180도)로 구성되는 차원을 의미한다. 이하에서는, CSI-RS 안테나 포트 배열을 위한 편파 차원을 편파 축으로 부르기로 한다.

[366]

[367] 도 22은 2차원 CSI-RS 안테나 포트 배열의 예를 나타내는 도면이다.

[368] 구체적으로 도 22에는, 수평 축, 수직 축, 및 편파 축으로의 CSI-RS 안테나 포트 수가 모두 2이고, CSI-RS 안테나 포트 번호가, 0번부터 시작하여 수평 축, 편파 축, 및 수직 축의 순서로 번호 매김된 경우가 예시되어 있다. 여기서, 편파 축의 서로 다른 CSI-RS 안테나 포트들은, 서로 다른 편파를 갖는 물리 안테나 요소(들)에 맵핑되는 CSI-RS 안테나 포트들을 의미한다.

[369] 또한, 도 22에서 편파 축으로 존재하는 2개의 CSI-RS 안테나 포트 각각이 +45도와 -45도의 막대(bar)로써 표현된 것은, 일반적으로 이중 편파 안테나 배열로써 사용되는 교차 편파(cross-polarization) 안테나 배열에서, 2개의 CSI-RS 안테나 포트들 각각이 +45도 편파 안테나 요소(들)과 -45도 편파 안테나 요소(들) 각각에 맵핑되는 것을 의미한다. 그러나, 본 명세서의 도면들에서 이중 편파를 가지는 CSI-RS 안테나 포트 배열의 편파 방향성이 +45도와 -45도인 것은 단지 예시일 뿐, 본 발명의 범위가 이들 예에 의하여 한정되지 않는다.

[370] 상술한 바와 같이, CSI-RS 안테나 포트와 물리 안테나 요소(들) 간의 맵핑을 안테나 가상화(virtualization)라 한다. 이하에서 설명되는 기술의 원리는, 특정 안테나 가상화 방식에 의해 제약을 받지 않으므로, 이하에서는 안테나 가상화 방식에 대해서는 구체적으로 기술하지 않기로 한다.

[371] 단말은 CSI 측정 및 보고를 위해 이용되는 코드북의 형태에 따라, CSI-RS 안테나 포트 배열에 대하여 단일 편파 또는 이중 편파를 가정할 수 있다. 현재 규격에 의하면, 단말은 Release 8에 도입된 2개 또는 4개의 송신 안테나 포트를 위한 코드북을 CSI 보고에 이용하는 경우, CSI-RS 안테나 포트 배열이 단일 편파임을 가정할 수 있다. 반면에, 단말은 Release 10에 도입된 8개의 송신 안테나 포트를 위한 코드북 또는 Release 12에 추가로 도입된 4개의 송신 안테나 포트를 위한 코드북을 CSI 보고에 이용하는 경우, CSI-RS 안테나 포트 배열이 이중 편파임을 가정할 수 있다. 상기 코드북들은 1차원 CSI-RS 안테나 포트 배열을 통해 얻어지는 1차원 CSI를 보고하는 데 적합하며, 이러한 코드북을 1차원 코드북이라 부르기로 한다.

[372] 한편, 상술한 바와 같이, FD-MIMO 시스템을 위해, 단말이 2차원 CSI를 기지국에 보고하는 것이 필요할 수 있다. 2차원 CSI를 보고하는 데 적합한 코드북을 2차원 코드북이라 부르기로 한다. 단말은 2차원 코드북을 이용해, 2차원 CSI 뿐만 아니라 1차원 CSI도 보고할 수 있다. 단말은 2차원 코드북을 CSI 보고에 이용하는 경우, 2차원 CSI-RS 안테나 포트 배열의 공간 정보를 알아야 할 수 있다. 또는 단말은, 기지국에 PMI를 보고하지 않도록 설정된 경우라 하더라도, CQI 그리고/또는 RI를 결정하기 위해, 2차원 CSI-RS 안테나 포트 배열의 공간 정보를 알아야 할 수도 있다. 이와 별도로, 단말은 2차원 CSI-RS 안테나 포트 배열의 편파 정보를 알아야 할 수도 있다.

[373] 이하에서는, 2차원 CSI-RS 안테나 포트 배열의 수평 축과 수직 축의 CSI-RS

안테나 포트 수를 각각 N_1과 N_2라 한다. 2차원 CSI-RS 안테나 포트 배열이 단일 편파인 경우, N_1과 N_2의 곱은 2차원 CSI-RS 안테나 포트 배열의 총 CSI-RS 안테나 포트 수와 동일하고, 2차원 CSI-RS 안테나 포트 배열이 이중 편파인 경우, N_1과 N_2의 곱은 2차원 CSI-RS 안테나 포트 배열의 총 CSI-RS 안테나 포트 수의 절반이다.

[374] 단말이 CSI-RS 안테나 포트 배열의 편파 정보를 획득하기 위한 방법으로, 기지국이 단말에게 CSI-RS 안테나 포트 배열이 단일 편파인지 이중 편파인지를 알려주는 방법이 고려될 수 있다. 이를 위해, 기지국은 단말에게 편파 정보(예, 1비트)를 명시적으로 시그널링할 수 있다. 또는, 기지국은 단말에게 편파 정보를 암시적으로 알려줄 수 있다. 예를 들어, 기지국은 단말에게 2차원 CSI-RS 안테나 포트 배열의 총 CSI-RS 안테나 포트 수를 알려주고, 추가로 N_1과 N_2의 곱을 알려줄 수 있다. 단말은 N_1과 N_2의 곱이 총 CSI-RS 안테나 포트 수와 일치하는 경우, CSI-RS 안테나 포트 배열이 단일 편파임을 가정하고, N_1과 N_2의 곱이 총 CSI-RS 안테나 포트 수의 절반인 경우, CSI-RS 안테나 포트 배열이 이중 편파임을 가정할 수 있다. 다른 방법은, 단말에 의해 가정되는 편파 축 CSI-RS 안테나 포트 수를 코드북별로 규격에 미리 정의하는 방법이다. 예를 들어, 단말이 2차원 코드북을 CSI 보고에 이용하도록 설정된 경우, 단말이 CSI-RS 안테나 포트 배열을 이중 편파로 가정하는 것이 규격에 명시될 수 있다. 또 다른 방법은, 단말에 의해 가정되는 편파 축 CSI-RS 안테나 포트 수를 규격에 정의하지 않고, 이를 단말이 코드북의 형태에 따라 적절한 값을 가정하도록 하는 방법이다. 예를 들어, 2차원 코드북이 이중 편파 (또는 교차 편파) 안테나 포트 배열에 대한 CSI 보고에 적합함이 규격에 정의되고, 단말은 2차원 코드북을 CSI 보고에 이용하도록 설정된 경우, CSI-RS 안테나 포트 배열이 이중 편파임을 가정할 수 있다.

[375] 한편, 단말이 2차원 CSI-RS 안테나 포트 배열의 공간 정보를 획득하기 위한 방법으로, 기지국이 단말에게 2차원 CSI-RS 안테나 포트 배열의 공간 정보를 알려주는 방법이 고려될 수 있다. 이를 위해, 기지국은 단말에게 2차원 CSI-RS 안테나 포트 배열의 공간 정보를 시그널링할 수 있다. 구체적으로, 기지국은 단말에게 N_1과 N_2를 시그널링할 수 있다. 또는, 기지국은 단말에게 N_1과 N_2의 곱을 시그널링하고, 추가로 N_1과 N_2 중 하나를 시그널링할 수 있다. 이 때, CSI-RS 안테나 포트 배열이 단일 편파인지 또는 이중 편파인지와는 무관하게, 상기 방법들이 사용될 수 있다. 여기서, 시그널링은 명시적인 시그널링과 암시적인 시그널링을 모두 포함할 수 있다.

[376] 예를 들어, 기지국이 단말에게 도 22에 예시된 8개의 CSI-RS 안테나 포트들을 설정하고자 하는 경우에, 기지국은 단말에게 N_1=2 및 N_2=2를 시그널링하고, CSI-RS 안테나 포트 배열이 이중 편파임을 추가로 알려줄 수 있다. 다른 예를 들어, 주어진 코드북에 의해 CSI-RS 안테나 포트 배열이 단일 편파인지 또는 이중 편파인지가 미리 정의되고, 기지국이 단말에게 N_1=2 및 N_2=2를 시그널링할

수 있다. 또 다른 예를 들어, 기지국은 단말에게 총 CSI-RS 안테나 포트 수가 8임을 알려주고, 추가로 N_1=2 및 N_2=2를 시그널링할 수 있다. 또 다른 예를 들어, 기지국은 단말에게 총 CSI-RS 안테나 포트 수가 8임을 알려주고, 추가로 N_1과 N_2의 곱이 4임을 알려줄 수 있다. 또 다른 예를 들어, 기지국은 단말에게 총 CSI-RS 안테나 포트 수가 8임을 알려주고, CSI-RS 안테나 포트 배열의 공간 축 또는 편파 축 배치 구조를 알려주지 않을 수 있다.

[377] 상술한 바와 같이 본 명세서에서, 기지국이 단말에게 정보를 전달하기 위한 시그널링은, 물리계층 시그널링(예, 물리계층 제어 채널의 제어 필드 파라미터), MAC 시그널링(예, MAC PDU 형태의 제어 정보, 또는 MAC 헤더 형태의 제어 정보), RRC 시그널링(예, RRC 제어 메시지 또는 IE 형태의 제어 파라미터) 등을 포함할 수 있다. 특히, 물리계층 시그널링 또는 MAC 시그널링 방식을 통한 제어 시그널링은, 해당 단말을 위한 스케줄링 정보와 함께 구성되거나 또는 동시에 전송되는 방법을 통하여 동적(dynamic) 자원 활용이 가능하다는 장점을 가질 수 있다.

[378] 이하에서는, 단말이 설정받은 CSI-RS 안테나 포트들로 구성되는 CSI-RS 안테나 포트 배열 상에 단말 특정적 CSI-RS 안테나 포트 번호들이 맵핑되는 방법에 대하여 기술한다. 설명의 편의를 위해, CSI-RS 안테나 포트 배열은 일반적으로 2차원임을 가정한다. 그러나, 본 명세서에서, 따로 언급이 없더라도, 2차원 CSI-RS 안테나 포트 배열은 1차원 CSI-RS 안테나 포트 배열을 포함할 수 있고, 2차원 CSI-RS 안테나 포트 배열에 적용되는 방법들은 1차원 CSI-RS 안테나 포트 배열에도 동일 또는 유사하게 적용될 수 있다.

[379] 단말 특정적 CSI-RS 안테나 포트 번호가 2차원 CSI-RS 안테나 포트 배열 상에서 수평 축, 수직 축, 및 편파 축에 어떤 순서로 맵핑되는지를 미리 정해두는 방법(이하 '방법 Mc100')이 사용될 수 있다. 방법 Mc100은 단말이 N_1 및 N_2 값을 알고, 추가로 2차원 CSI-RS 안테나 포트 배열이 단일 편파인지 이중 편파인지를 알고 있는 경우에 적용될 수 있다.

[380]

[381] 도 23a 및 도 23b는 본 발명의 실시예에 따른, 2차원 CSI-RS 안테나 포트 배열에 단말 특정적 CSI-RS 안테나 포트 번호가 맵핑되는 방법을 나타내는 도면이다.

[382] 도 23a 및 도 23b에는, 기지국이 방법 Mc100에 기초해 단말에게 도 22에 예시된 8개의 CSI-RS 안테나 포트를 설정하는 경우에, 해당 단말이 CSI-RS 안테나 포트 배열 상에서 인식하는 단말 특정적 CSI-RS 안테나 포트 번호가 예시되어 있다.

[383] 구체적으로, 도 23a에는 단말 특정적 CSI-RS 안테나 포트 번호가 수평 축, 편파 축, 및 수직 축의 순서로 증가하는 경우가 예시되어 있다. 도 23b에는 단말 특정적 CSI-RS 안테나 포트 번호가 수직 축, 수평 축, 및 편파 축의 순서로 증가하는 경우가 예시되어 있다.

[384] 한편, 단말 특정적 CSI-RS 안테나 포트 번호가 2차원 CSI-RS 안테나 포트 배열 상에서 수평 축 및 수직 축에 어떤 순서로 맵핑되는지를 미리 정해두는

방법(이하 '방법 Mc101')이 사용될 수 있다. 방법 Mc101은 단말이 2차원 CSI-RS 안테나 포트 배열이 단일 편파인지 또는 이중 편파인지를 모르는 경우에 적용될 수 있다. 이 때, 2차원 CSI-RS 안테나 포트 배열이 단일 편파인지 또는 이중 편파인지와 무관하게, N_1과 N_2의 곱은 2차원 CSI-RS 안테나 포트 배열의 총 CSI-RS 안테나 포트 수와 동일할 수 있다. 예를 들어, 단말 특정적 CSI-RS 안테나 포트 번호가 0번부터 시작하여, 수평 축에 먼저 순차적으로 맵핑되고, 다음으로 수직 축에 맵핑될 수 있다.

[385] 방법 Mc100과 방법 Mc101의 CSI-RS 안테나 포트 번호 맵핑 규칙은, 상기와 같이 명시적으로 정의될 수 있다. 또는, 단말이 수평 축 PMI와 수직 축 PMI를 나누어 보고하는 경우 또는 단말이 수평 축 PMI, 수직 축 PMI, 및 편파 축 PMI를 나누어 보고하는 경우에, 방법 Mc100과 방법 Mc101의 CSI-RS 안테나 포트 번호 맵핑 규칙은, CSI 측정 시 단말에 의해 가정되는 기지국 프리코딩에 대한 정의를 통해, 암시적으로 정의될 수도 있다. 즉, 단말은 CSI 측정을 수행할 때, 단말은 기지국이 아래의 수학식 1의 프리코딩을 적용함을 가정할 수 있다.

[386] [수식1]

$$\begin{bmatrix} y^{(0)}(i) \\ \vdots \\ y^{(P-1)}(i) \end{bmatrix} = W(i) \cdot \begin{bmatrix} x^{(0)}(i) \\ \vdots \\ x^{(V-1)}(i) \end{bmatrix}$$

[387] 수학식 1에서, $x^{(m)}(i)$ (단, m=0,…,V-1)는 i번째 시점에서 m번째 데이터 레이어(layer)를 통해 전송되는 데이터 심볼을 의미하고, $y^{(n)}(i)$ (단, n=0,…,P-1)는 i번째 시점에서 n번째 CSI-RS 안테나 포트를 통해 전송되는 프리코딩된 데이터 심볼을 의미하고, W(i)는 P개의 행과 V개의 열로 구성되는, i번째 시점에서의 프리코딩 행렬을 의미한다. 여기서, P는 CSI-RS 안테나 포트 수이고, V는 데이터 레이어의 수이다. 이 때, 단말이 보고하는 수평 축 PMI, 수직 축 PMI, 및 편파 축 PMI에 대응하는 프리코딩 행렬 각각을, $W_1(i)$, $W_2(i)$, $W_P(i)$라 정의한다. 여기서, 수평 축 PMI의 행렬 및 $W_1(i)$는, N_1개의 행과, 단말이 보고하는 수평 축 랭크(rank)와 동일한 개수의 열을 가진다. 수직 축 PMI의 행렬 및 $W_2(i)$는 N_2개의 행과, 단말이 보고하는 수직 축 랭크와 동일한 개수의 열을 가진다. 편파 축 PMI의 행렬 및 $W_P(i)$는, 1개 또는 2개의 행을 가지고(예, CSI-RS 안테나 배열이 단일 편파인 경우에 1개의 행을 가지고, CSI-RS 안테나 배열이 이중 편파인 경우에 2개의 행을 가지고), 단말이 보고하는 편파 축 랭크와 동일한 개수의 열을 가진다.

[388] 상기 정의에 기초하면, W(i)는 $W_1(i)$, $W_2(i)$, 및 $W_P(i)$의 크로네커 곱(Kronecker product)으로 표현되거나, W(i)는 $W_1(i)$와 $W_2(i)$의 크로네커 곱으로 표현될 수 있다. 예를 들어, 방법 Mc100에서 CSI-RS 안테나 포트 배열 상에 단말 특정적 CSI-RS 안테나 포트 번호가 수평 축, 편파 축, 및 수직 축의 순서로 맵핑되도록 하는 방법은, 아래의 수학식 2와 같은 크로네커 곱의 순서를 가지도록 수학식

1의 W(i)를 정의할 수 있다.

[389] [수식2]

$$W(i) = W_2(i) \otimes W_P(i) \otimes W_1(i)$$

[390] 다른 예를 들어, 방법 Mc101에서 CSI-RS 안테나 포트 배열 상에 단말 특정적 CSI-RS 안테나 포트 번호가 수평 축에 먼저, 수직 축에는 나중에 맵핑되도록 하는 방법은, 아래의 수학식 3과 같이 수학식 1의 W(i)를 정의할 수 있다.

[391] [수식3]

$$W(i) = W_2(i) \otimes W_1(i)$$

[392] 또 다른 예를 들어, 방법 Mc101에서 CSI-RS 안테나 포트 배열 상에 단말 특정적 CSI-RS 안테나 포트 번호가 수직 축에 먼저, 수평 축에는 나중에 맵핑되도록 하는 방법은, 아래의 수학식 4와 같이 수학식 1의 W(i)를 정의할 수 있다.

[393] [수식4]

$$W(i) = W_1(i) \otimes W_2(i)$$

[394] 한편, 단말이 수평 축 PMI와 수직 축 PMI를 나누어 보고하지 않고 하나의 통합(joint) PMI를 보고하는 경우에, 기지국의 프리코더를 수학식 2 내지 수학식 4와 같이 수평 축 프리코더와 수직 축 프리코더로 구분하는 것이 성립되지 않을 수 있다. 이 경우에는, W(i)의 행 인덱스 p (단, p=0, 1, …, P-1)와 수평 축 CSI-RS 포트 인덱스 p_1 (단, p_1=0, 1, …, N_1-1), 수직 축 CSI-RS 포트 인덱스 p_2 (단, p_2=0, 1, …, N_2-1), 그리고/또는 편파 축 CSI-RS 포트 인덱스 p_P (단, 단일 편파인 경우 p_P=0, 이중 편파인 경우 p_P=0, 1) 간의 관계를 정의하는 방법(수학식 5, 수학식 6)이 고려될 수 있다. 예를 들어, 방법 Mc100에 대하여, 단말은 아래의 수학식 5를 가정할 수 있다.

[395] [수식5]

$$p = N_2 N_1 p_P + N_2 p_1 + p_2$$

[396] 수학식 5에 따르면, 단말은 CSI-RS 안테나 포트 배열 상에 단말 특정적 CSI-RS 안테나 포트 번호가 수직 축, 수평 축, 및 편파 축의 순서로 맵핑됨을 가정할 수 있다.

[397] 또 다른 예를 들어, 방법 Mc101에 대하여, 단말은 아래의 수학식 6을 가정할 수 있다.

[398] [수식6]

$$p = N_2 p_1 + p_2$$

[399] 수학식 6에 따르면, 단말은 CSI-RS 안테나 포트 배열 상에 단말 특정적 CSI-RS 안테나 포트 번호가 수직 축 및 수평 축의 순서로 맵핑됨을 가정할 수 있다.

[400] 방법 Mc100 및 방법 Mc101과 다른 방법으로써, 복수의 CSI-RS 안테나 포트 번호 맵핑 규칙을 미리 정해두고, 기지국이 단말에게 복수의 CSI-RS 안테나 포트

번호 맵핑 규칙 중에서 어떤 것을 적용할지를 시그널링하는 방법(이하 '방법 Mc110')이 고려될 수 있다.

[401] 예를 들어, 기지국은 단말에게 1 비트의 시그널링을 통해, 미리 정의된 맵핑 규칙1 및 맵핑 규칙2 중 어느 것을 따를 것을 지시할 수 있다. 구체적으로, 맵핑 규칙1은 CSI-RS 안테나 포트 배열 상에 CSI-RS 안테나 포트 번호가 수평 축, 편파 축, 및 수직 축의 순서로 증가하는 규칙이고, 맵핑 규칙2는 CSI-RS 안테나 포트 배열 상에 CSI-RS 안테나 포트 번호가 수직 축, 수평 축, 및 편파 축의 순서로 증가하는 규칙일 수 있다.

[402]

[403] 3.2. CSI-RS 안테나 포트 번호를 재배열하는 방법

[404] 도 24은 복수의 단말에게 서로 다른 CSI-RS 안테나 포트 집합을 설정하는 방법을 나타내는 도면이다.

[405] FD-MIMO 시스템에서는, 송신 안테나 배열의 크기가 증가함에 따라, 기지국이 복수의 단말에게 서로 다른 CSI-RS 안테나 포트 수를 설정하거나, 복수의 단말에게 안테나 배열의 서로 다른 부분을 이용하여 데이터를 전송하고자 할 수 있다. 예를 들어, 기지국이 16개의 TXRU(transceiver unit)를 가지는 경우에, 다중 안테나를 활용한 성능 이득을 충분히 얻기 위해서는, 단말에게 16개의 CSI-RS 안테나 포트를 전송하는 것이 유리하다. 그러나 어떤 단말은 16개의 CSI-RS 안테나 포트를 설정받는 것이 불가능할 수도 있다. 16개의 CSI-RS 안테나 포트를 설정받는 것이 불가능한 단말로는, 저비용(low-cost) 단말, LTE Release 13 이전의 기존(legacy) 단말 등일 수 있다. 이 때, 예를 들어, 기지국은 도 24에 예시된 바와 같이, 복수의 단말에게 서로 다른 CSI-RS 안테나 포트 배열 또는 집합(set)을 설정할 수 있다. 즉, 기지국은 단말(UE-a)에게 16개의 CSI-RS 안테나 포트(셀 특정적 CSI-RS 안테나 포트 0번~15번)를 설정하고, 단말(UE-b)에게 4개의 CSI-RS 안테나 포트(셀 특정적 CSI-RS 안테나 포트 9번, 10번, 13번, 14번)를 설정할 수 있다.

[406]

[407] 도 25a는 복수의 단말에 대한 CSI-RS 자원 설정의 예를 나타내는 도면이다.

[408] 도 24에 도시된 예시에서, 단말(UE-a)와 단말(UE-b) 각각은 16개와 4개의 CSI-RS 안테나 포트에 대한 자원 설정을 필요로 한다. 이 때, 기지국은 도 25a에 예시된 자원 할당과 같이, 단말(UE-a)와 단말(UE-b)를 위한 CSI-RS 자원 설정에 서로 다른 RE 집합을 할당할 수 있다. 예를 들어, 기지국은 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 9), RE(3, 9), RE(2, 8), RE(3, 8), RE(2, 5), RE(3, 5), RE(2, 4), RE(3, 4), RE(2, 3), RE(3, 3), RE(2, 2), 및 RE(3, 2)를, 단말(UE-a)을 위한 CSI-RS RE(예, 단말 특정적 CSI-RS 안테나 포트 0~15번)로써 설정할 수 있다. 기지국은 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 3), 및 RE(6, 3)를, 단말(UE-b)을 위한 CSI-RS RE(예, 단말 특정적 CSI-RS 안테나 포트 0~3번)로써 설정할 수 있다.

[409] 도 24 및 도 25a에 예시된 방법은, 각 단말을 위한 CSI-RS에 서로 다른 가상화(virtualization)를 적용할 수 있다는 장점을 가지지만, CSI-RS 전송에 소요되는 RE의 수가 증가되는 단점을 가질 수 있다. 기지국은 CSI-RS 전송 오버헤드를 고려하여, 더 적은 안테나 포트 수가 할당된 단말(UE-b)을 위한 CSI-RS RE 집합이 단말(UE-a)을 위한 CSI-RS RE 집합에 포함되도록 설정할 수 있다. 다시 말하면, 기지국은 서로 다른 CSI-RS 안테나 포트 집합이 설정된 복수의 단말로 하여금 CSI-RS 전송 자원을 최대한 공유하도록 설정할 수 있다. 그러나 현재 규격에 의하면, 일부 경우를 제외하고는, 기지국이 상기와 같이 복수의 단말로 하여금 CSI-RS 전송 자원을 공유하도록 설정하는 것이 어렵다.

[410] 이하에서는 상기 문제(예, CSI-RS 전송 오버헤드, CSI-RS 전송 자원 공유)를 해결하기 위한 방법으로써, 단말에 설정된 CSI-RS 안테나 포트들의 포트 번호를 재배열(re-ordering)하는 방법 (이하 방법 'Mc200')에 대하여 기술한다.

[411] 방법 Mc200에서, CSI-RS 안테나 포트들의 포트 번호를 재배열한다고 함은, 단말이 CSI-RS configuration 시그널링에 의해 설정받은 CSI-RS 안테나 포트들의 단말 특정적 포트 번호를 기존 포트 번호라고 할 때, 기존 포트 번호들을 새로운 포트 번호들로 대체함을 의미한다. 예를 들어, 단말이 4개의 CSI-RS 안테나 포트를 설정받은 경우, 포트 번호를 1번, 3번, 0번, 및 2번으로 재배열한다고 함은, CSI-RS 안테나 포트들의 기존 포트 번호 0번 내지 3번을 각각 1번, 3번, 0번, 및 2번으로 대체함을 의미한다. 다른 예를 들어, 8개의 포트를 갖는 컴포넌트 CSI-RS configuration 2개가 집성되어 총 16개의 CSI-RS 안테나 포트가 단말에 설정되는 경우에, 포트 번호를 재배열한다고 함은, 컴포넌트 CSI-RS configuration 0번을 구성하는 CSI-RS 안테나 포트의 기존 포트 번호 0~7번 및 컴포넌트 CSI-RS configuration 1번을 구성하는 CSI-RS 안테나 포트의 기존 포트 번호 0~7번을 새로운 포트 번호들(0~15번)로 대체함을 의미한다.

[412] 기존 규격에서, 단말에 설정된 CSI-RS 안테나 포트들의 포트 번호와 해당 CSI-RS RE 집합을 구성하는 RE들 간의 맵핑 관계는 도 1 내지 도 3에 도시되어 있다. 예를 들어, 단말이 표 2에 따라 CSI-RS configuration 0번에 의해 4개의 CSI-RS 안테나 포트를 설정받은 경우, CSI-RS 안테나 포트 0번과 1번(도 2에서의 15번과 16번)은 슬롯0의 RE(5,9) 및 RE(6,9)에 맵핑되고, CSI-RS 안테나 포트 2번과 3번(도 2에서의 17번과 18번)은 슬롯0의 RE(5,3) 및 RE(6,3)에 맵핑된다. 다른 예를 들어, 단말이 표 2에 따라 CSI-RS configuration 1번에 의해 8개의 CSI-RS 안테나 포트를 설정받은 경우, CSI-RS 안테나 포트 0번과 1번(도 3에서의 15번과 16번)은 슬롯1의 RE(2,11) 및 RE(3,11)에 맵핑되고, CSI-RS 안테나 포트 2번과 3번(도 3에서의 17번과 18번)은 슬롯1의 RE(2,5) 및 RE(3,5)에 맵핑되고, CSI-RS 안테나 포트 4번과 5번(도 3에서의 19번과 20번)은 슬롯1의 RE(2,10) 및 RE(3,10)에 맵핑되고, CSI-RS 안테나 포트 6번과 7번(도 3에서의 21번과 22번)은 슬롯1의 RE(2,4) 및 RE(3,4)에 맵핑된다.

[413]

[414] 도 25b는 본 발명의 실시예에 따른, 단말에 설정된 CSI-RS 안테나 포트들의 포트 번호가 방법 Mc200에 의해 재배열됨으로써, 포트 번호와 RE들 간의 맵핑 관계가 기존과 달라지는 경우를 나타내는 도면이다.

[415] 구체적으로 도 25b에는, 단말(UE-a)에게 4개의 CSI-RS 안테나 포트가 설정되고, 방법 Mc200에 의해, CSI-RS 안테나 포트들의 포트 번호가 0번, 2번, 1번, 및 3번으로 재배열되는 경우가 예시되어 있다.

[416] 기존 포트 번호 0번 내지 3번이 새로운 포트 번호 0번, 2번, 1번, 및 3번으로 대체됨에 따라, 기존의 맵핑 관계에서 CSI-RS 안테나 포트 0번 내지 3번이 맵핑되었던 RE 각각에, CSI-SR 안테나 포트 0번, 2번, 1번, 및 3번이 각각 맵핑된다. 즉, CSI-RS 안테나 포트 0번과 2번은 슬롯0의 RE(5,9) 및 RE(6,9)에 맵핑되고, CSI-RS 안테나 포트 1번과 3번은 슬롯0의 RE(5,3) 및 RE(6,3)에 맵핑된다.

[417] 한편, 도 25b에는, 단말(UE-b)에게 8개의 CSI-RS 안테나 포트가 설정되고, 방법 Mc200에 의해, CSI-RS 안테나 포트들의 포트 번호가 0번, 1번, 4번, 5번, 2번, 3번, 6번, 및 7번으로 재배열되는 경우가 예시되어 있다.

[418] 기존 포트 번호 0번 내지 7번이 새로운 포트 번호 0번, 1번, 4번, 5번, 2번, 3번, 6번, 및 7번으로 대체됨에 따라, 기존의 맵핑 관계에서 CSI-RS 안테나 포트 0번 내지 7번이 맵핑되었던 RE 각각에, CSI-RS 안테나 포트 0번, 1번, 4번, 5번, 2번, 3번, 6번, 및 7번이 각각 맵핑된다. 즉, CSI-RS 안테나 포트 0번과 1번은 슬롯1의 RE(2,11) 및 RE(3,11)에 맵핑되고, CSI-RS 안테나 포트 2번과 3번은 슬롯1의 RE(2,10) 및 RE(3,10)에 맵핑되고, CSI-RS 안테나 포트 4번과 5번은 슬롯1의 RE(2,5) 및 RE(3,5)에 맵핑되고, CSI-RS 안테나 포트 6번과 7번은 슬롯1의 RE(2,4) 및 RE(3,4)에 맵핑된다.

[419] 방법 Mc200에서, 단말이 CSI-RS 안테나 포트들의 포트 번호 재배열 정보를 획득하는 방법으로써, 기지국이 단말에게 포트 번호 재배열 정보를 알려주는 방법이 고려될 수 있다. 예를 들어, 기지국은 기존 포트 번호들을 대체할 새로운 포트 번호들을 단말에게 명시적으로 알려줄 수 있다. 다른 예를 들어, 기지국은 단말이 기존 포트 번호들을 대체할 새로운 포트 번호들을 알 수 있도록 하는 재배열 규칙을 단말에게 알려줄 수 있다.

[420] 도 25b의 예에서, 기지국은 단말(UE-a)에게 CSI-RS 안테나 포트 번호의 재배열 정보로써 새로운 포트 번호들의 순열 (0, 2, 1, 3)을 알려줄 수 있다. 또는, 기지국은 단말(UE-a)이 새로운 포트 번호 순열이 (0, 2, 1, 3)임을 알 수 있도록 하는 재배열 규칙을 단말(UE-a)에게 알려줄 수 있다. 또한, 기지국은 단말(UE-b)에게 CSI-RS 안테나 포트 번호의 재배열 정보로써 새로운 포트 번호들의 순열 (0, 1, 4, 5, 2, 3, 6, 7)을 알려줄 수 있다. 또는, 기지국은 단말(UE-b)이 새로운 포트 번호 순열이 (0, 1, 4, 5, 2, 3, 6, 7)임을 알 수 있도록 하는 재배열 규칙을 단말(UE-b)에게 알려줄 수 있다.

[421]

[422] 방법 Mc210은, 단말에 설정되는 CSI-RS 안테나 포트들에 적용되는 새로운 포트 번호들의 순열로써 가능한 모든 경우의 수를 정의하고, 이 중에서 하나를 단말에게 시그널링하는 방법이다.

[423] 방법 Mc210에서, 새로운 포트 번호들의 순열은 기존 포트 번호들의 순열을 포함할 수 있다. 방법 Mc210은 단말에 설정되는 CSI-RS 안테나 포트들의 포트 번호를 임의의 순서로 배열할 수 있다는 장점을 가지나, 반면에 시그널링 오버헤드가 크다는 단점을 가진다. 단말에 설정된 CSI-RS 안테나 포트 수를 N이라 할 때, N개의 포트 번호를 순서를 고려하여 나열하는 방법은 총 N!가지이므로, 방법 Mc200에 따른 시그널링에 소요되는 비트 수는, ceil($\log_2$(N!))을 따른다. 여기서 연산 부호 '!'는 팩토리얼(factorial) 연산을 나타내고, 'ceil()'은 올림(ceiling) 연산을 의미한다. 또는, CSI-RS 설정에 CDM-2가 적용되는 경우에, CSI-RS 안테나 포트 쌍이 CDM에 의해 동일 자원 상에 맵핑되면, 방법 Mc210에 따른 시그널링에 소요되는 비트 수는 1비트만큼 절약될 수 있다.

[424]

[425] 방법 Mc220은, 단말에 설정되는 CSI-RS 안테나 포트들에 적용되는 새로운 포트 번호들의 순열 (또는 새로운 포트 번호들의 순열을 생성하기 위한 규칙이나 정보)을 하나 또는 복수 개 미리 정의하고, 이 중에서 하나를 단말에게 시그널링하는 방법이다.

[426] 방법 Mc220에서, 새로운 포트 번호들의 순열은 기존 포트 번호들의 순열을 포함할 수 있다. 방법 Mc210과 방법 Mc220은 새로운 포트 번호들의 순열을 단말에게 암시적인 방법으로 시그널링하는 방법을 포함할 수 있다. 암시적인 시그널링의 경우, 기지국은 단말에게 새로운 포트 번호 순열 그 자체가 아니라, 단말에게 새로운 포트 번호 순열을 알릴 수 있는 규칙이나 정보를 시그널링할 수 있다.

[427] 방법 Mc220은 방법 Mc210에 비해 적은 시그널링 오버헤드를 가지는 방법이다. 방법 Mc220에서, 적어도 하나의 포트 번호 순열 또는 포트 번호 순열 생성 규칙을 정함에 있어서, CSI-RS 안테나 포트 배열의 형태와 CSI-RS 안테나 포트 배열 상의 포트 번호 맵핑 규칙이 고려될 수 있다.

[428]

[429] 도 26a 및 도 26b는 본 발명의 실시예에 따른, 방법 Mc220이 사용되는 경우에, 기지국이 단말에게 새로운 포트 번호 순열(sequence)을 알리기 위한 규칙(또는 정보)을 암시적인 시그널링을 통해 알려주는 경우를 나타내는 도면이다.

[430] 구체적으로 도 26a 및 도 26b에는, 단말에 설정된 16개의 CSI-RS 안테나 포트들이, CSI-RS 안테나 포트 배열(수평 축 포트 수=8, 수직 축 포트 수=1, 교차 편파)을 구성하는 경우가 예시되어 있다.

[431] 도 26a에는 기지국이 단말에 설정하고자 하는 CSI-RS 안테나 포트 배열 상의 포트 번호 맵핑(Mpr1, Mpr2, Mpr3, Mpr4)이 예시되어 있다. 한편, 도 26b에는 단말이 CSI 측정 및 보고를 수행할 때 가정하는 포트 번호 맵핑이 예시되어 있다.

구체적으로, 도 26b에 예시된 맵핑에 적용된 규칙은, CSI-RS 안테나 포트 배열에 공간 축(또는 수평 축), 편파 축의 순서로 포트 번호를 맵핑하는 규칙이다. 이 때, 단말이 CSI 측정 및 보고를 수행할 때 가정하는 포트 번호 맵핑 규칙은, 상술한 방법들이 적용되어, 규격에 미리 정의될 수 있다.

[432] 도 26a에 예시된 포트 번호 맵핑(Mpr1, Mpr2, Mpr3, Mpr4)은, 총 CSI-RS 안테나 포트들(16개의 CSI-RS 안테나 포트)을 하나 또는 복수의 CSI-RS 안테나 포트 그룹으로 나누고, 각 CSI-RS 안테나 포트 그룹 내에서 특정 순서(예, 공간 축, 편파 축의 순서)로 CSI-RS 안테나 포트 번호를 맵핑하는 규칙이 적용된 것이다. 이 때, 각 CSI-RS 안테나 포트 그룹 내에서 포트 번호가 맵핑되는 축의 순서는, 단말이 CSI 측정 및 보고를 수행할 때 가정하는 포트 번호 맵핑 축의 순서와 동일할 수 있다. 구체적으로, 포트 번호 맵핑(Mpr1)의 경우, 16개의 CSI-RS 안테나 포트들이 하나의 CSI-RS 안테나 포트 그룹(Vrg1)으로 나뉜다. 포트 번호 맵핑(Mpr2)의 경우, 16개의 CSI-RS 안테나 포트들이 2개의 CSI-RS 안테나 포트 그룹(Vrg2a, Vrg2b)으로 나뉜다. 포트 번호 맵핑(Mpr3)의 경우, 16개의 CSI-RS 안테나 포트들이 4개의 CSI-RS 안테나 포트 그룹(Vrg3a, Vrg3b, Vrg3c, Vrg3d)으로 나뉜다. 포트 번호 맵핑(Mpr4)의 경우, 16개의 CSI-RS 안테나 포트들이 8개의 CSI-RS 안테나 포트 그룹(Vrg4a, Vrg4b, Vrg4c, Vrg4d, Vrg4e, Vrg4f, Vrg4g, Vrg4h)으로 나뉜다. 이 때, CSI-RS 안테나 포트 그룹의 수는, 공간 축 CSI-RS 안테나 포트 수인 8의 약수들일 수 있다.

[433] 방법 Mc220을 위한 암시적인 시그널링의 예로써, 기지국이 단말에게 적어도 하나의 포트 번호 맵핑들 중에서 하나를 알려주는 방법(이하 '방법 Mc221')이 고려될 수 있다. 예를 들어, 기지국은 단말에게 도 26a에 예시된 포트 번호 맵핑(Mpr1, Mpr2, Mpr3, Mpr4) 중 하나를 단말에게 알려줄 수 있다. 방법 Mc221이 사용되는 경우에, 단말은 기지국으로부터 설정받은 맵핑의 포트 번호들이 CSI 측정 및 보고를 수행할 때 가정하는 맵핑의 포트 번호들에 일치되도록 한다. 이를 위해, 단말은 기지국으로부터 설정받은 맵핑의 포트 번호를 기존 포트 번호로 간주하고, CSI 측정 및 보고를 수행할 때 가정하는 맵핑의 포트 번호를 새로운 포트 번호로 간주하여, 기존 포트 번호들을 새로운 포트 번호들로 재배열할 수 있다.

[434] 도 26a의 예시에서, 기지국이 방법 Mc221을 기초로 하여 단말에게 포트 번호 맵핑(Mpr1)을 알려준 경우에, 맵핑(Mpr1)의 기존 포트 번호가 새로운 포트 번호와 일치하므로, 단말은 CSI-RS 안테나 포트 번호를 재배열할 필요가 없다. 한편, 기지국이 단말에게 포트 번호 맵핑(Mpr2)을 알려준 경우에, 단말은 맵핑(Mpr2)과 도 26b의 맵핑 간의 관계에 따라, 기존 CSI-RS 안테나 포트 번호 0번 내지 15번을, 각각 0번, 1번, 2번, 3번, 8번, 9번, 10번, 11번, 4번, 5번, 6번, 7번, 12번, 13번, 14번, 및 15번으로 대체할 수 있다. 또는 기지국이 단말에게 포트 번호 맵핑(Mpr3)을 알려준 경우에, 단말은 맵핑(Mpr3)과 도 26b의 맵핑 간의 관계에 따라, 기존 CSI-RS 안테나 포트 번호 0번 내지 15번을, 각각 0번, 1번, 8번,

9번, 2번, 3번, 10번, 11번, 4번, 5번, 12번, 13번, 6번, 7번, 14번, 및 15번으로 대체할 수 있다. 또는 기지국이 단말에게 포트 번호 맵핑(Mpr4)을 알려준 경우에, 단말은 맵핑(Mpr4)과 도 26b의 맵핑 간의 관계에 따라, 기존 CSI-RS 안테나 포트 번호 0번 내지 15번을, 각각 0번, 8번, 1번, 9번, 2번, 10번, 3번, 11번, 4번, 12번, 5번, 13번, 6번, 14번, 7번, 및 15번으로 대체할 수 있다.

[435]

[436] 도 26c, 도 26d, 도 26e, 및 도 26f는, 본 발명의 실시예에 따른, 방법 Mc221에 의해 기지국이 단말에게 도 26a에 예시된 포트 번호 맵핑(Mpr1~Mpr4) 중 하나를 알려주는 경우에, 단말이 CSI-RS RE 집합을 구성하는 RE들에 CSI-RS 안테나 포트 번호들을 맵핑하는 경우를 나타내는 도면이다.

[437] 구체적으로, 도 26c 내지 도 26f에는, 8개의 포트를 갖는 컴포넌트 CSI-RS configuration 2개(0번, 1번)가 집성되어, 총 16개의 CSI-RS 안테나 포트가 단말에 설정된 경우가 예시되어 있다. 이 때, 각 컴포넌트 CSI-RS configuration에는 기존 규격상의 8개 포트에 대한 CSI-RS 패턴이 동일하게 적용되었다. 즉, 컴포넌트 CSI-RS configuration 0번은 CSI-RS RE 집합을 구성하는 RE로써, 슬롯0의 RE(5, 9), RE(6, 9), RE(5, 8), RE(6, 8), RE(5, 3), RE(6, 3), RE(5, 2), 및 RE(6, 2)를 포함한다. 컴포넌트 CSI-RS configuration 1번은 CSI-RS RE 집합을 구성하는 RE로써, 슬롯1의 RE(2, 9), RE(3, 9), RE(2, 8), RE(3, 8), RE(2, 3), RE(3, 3), RE(2, 2), 및 RE(3, 2)를 포함한다. 도 26c 내지 도 26f에서, 컴포넌트 CSI-RS configuration 0번에 대응되는 CSI-RS 안테나 포트 번호는 0~7번이고, 컴포넌트 CSI-RS configuration 1번에 대응되는 CSI-RS 안테나 포트 번호는 8~15번임을 가정한다.

[438] 도 26c에 예시된 포트-RE 맵핑은 단말이 포트 번호 맵핑(Mpr1)을 설정받은 경우에 대응하고, 도 26d에 예시된 포트-RE 맵핑은 단말이 포트 번호 맵핑(Mpr2)을 설정받은 경우에 대응하고, 도 26e에 예시된 포트-RE 맵핑은 단말이 포트 번호 맵핑(Mpr3)을 설정받은 경우에 대응하고, 도 26f에 예시된 포트-RE 맵핑은 단말이 포트 번호 맵핑(Mpr4)을 설정받은 경우에 대응한다.

[439] 예를 들어, 단말이 방법 Mc221에 의해 포트 번호 맵핑(Mpr1)을 설정받은 경우에, 도 26c에 예시된 포트-RE 맵핑을 따를 수 있다. 즉, 단말은 맵핑(Mpr1)을 설정받은 경우에, CSI-RS 안테나 포트 번호를 재배열할 필요가 없으므로, 각 컴포넌트 CSI-RS configuration별로 기존 규격상의 포트-RE 맵핑을 따를 수 있다.

[440] 다른 예를 들어, 단말이 방법 Mc221에 의해 포트 번호 맵핑(Mpr2)을 설정받은 경우에, 도 26d에 예시된 포트-RE 맵핑을 따를 수 있다. 즉, 단말은 맵핑(Mpr2)과 도 26b의 맵핑 간의 관계에 따라, 기존 포트 번호 4~5번이 맵핑되었던 슬롯0의 RE(5, 8) 및 RE(6, 8)에 포트 번호 8~9번이 맵핑되고, 기존 포트 번호 6~7번이 맵핑되었던 슬롯0의 RE(5, 2) 및 RE(6, 2)에 포트 번호 10~11번이 맵핑되고, 기존 포트 번호 8~9번이 맵핑되었던 슬롯1의 RE(2, 9) 및 RE(3, 9)에 포트 번호 4~5번이 맵핑되고, 기존 포트 번호 10~11번이 맵핑되었던 슬롯1의 RE(2, 3) 및 RE(3, 3)에 포트 번호 6~7번이 맵핑됨을 가정할 수 있다.

[441] 또 다른 예를 들어, 단말이 방법 Mc221에 의해 포트 번호 맵핑(Mpr3)을 설정받은 경우에, 도 26e에 예시된 포트-RE 맵핑을 따를 수 있다. 즉, 단말은 맵핑(Mpr3)과 도 26b의 맵핑 간의 관계에 따라, 기존 포트 번호 2~3번이 맵핑되었던 슬롯0의 RE(5, 3) 및 RE(6, 3)에 포트 번호 8~9번이 맵핑되고, 기존 포트 번호 4~5번이 맵핑되었던 슬롯0의 RE(5, 8) 및 RE(6, 8)에 포트 번호 2~3번이 맵핑되고, 기존 포트 번호 6~7번이 맵핑되었던 슬롯0의 RE(5, 2) 및 RE(6, 2)에 포트 번호 10~11번이 맵핑되고, 기존 포트 번호 8~9번이 맵핑되었던 슬롯1의 RE(2, 9) 및 RE(3, 9)에 포트 번호 4~5번이 맵핑되고, 기존 포트 번호 10~11번이 맵핑되었던 슬롯1의 RE(2, 3) 및 RE(3, 3)에 포트 번호 12~13번이 맵핑되고, 기존 포트 번호 12~13번이 맵핑되었던 슬롯1의 RE(2, 8) 및 RE(3, 8)에 포트 번호 6~7번이 맵핑됨을 가정할 수 있다.

[442] 또 다른 예를 들어, 단말이 방법 Mc221에 의해 포트 번호 맵핑(Mpr4)을 설정받은 경우에, 도 26f에 예시된 포트-RE 맵핑을 따를 수 있다. 즉, 단말은 맵핑(Mpr4)과 도 26b의 맵핑 간의 관계에 따라, 기존 포트 번호 0~1번이 맵핑되었던 슬롯0의 RE(5, 9) 및 RE(6, 9)에 포트 번호 0번과 8번이 맵핑되고, 기존 포트 번호 2~3번이 맵핑되었던 슬롯0의 RE(5, 3) 및 RE(6, 3)에 포트 번호 2번과 10번이 맵핑되고, 기존 포트 번호 4~5번이 맵핑되었던 슬롯0의 RE(5, 8) 및 RE(6, 8)에 포트 번호 1번과 9번이 맵핑되고, 기존 포트 번호 6~7번이 맵핑되었던 슬롯0의 RE(5, 2) 및 RE(6, 2)에 포트 번호 3번과 11번이 맵핑되고, 기존 포트 번호 8~9번이 맵핑되었던 슬롯1의 RE(2, 9) 및 RE(3, 9)에 포트 번호 4번과 12번이 맵핑되고, 기존 포트 번호 10~11번이 맵핑되었던 슬롯1의 RE(2, 3) 및 RE(3, 3)에 포트 번호 6번과 14번이 맵핑되고, 기존 포트 번호 12~13번이 맵핑되었던 슬롯1의 RE(2, 8) 및 RE(3, 8)에 포트 번호 5번과 13번이 맵핑되고, 기존 포트 번호 14~15번이 맵핑되었던 슬롯1의 RE(2, 2) 및 RE(3, 2)에 포트 번호 7번과 15번이 맵핑됨을 가정할 수 있다.

[443]

[444] 도 26a에 예시된 바와 같이, 단말에게 설정된 총 CSI-RS 안테나 포트 수를 하나 또는 복수의 CSI-RS 안테나 포트 그룹으로 나누고 각 그룹 내에서부터 포트 번호를 맵핑하는 규칙이 사용되는 경우에, 기지국이 단말에게 포트 번호 맵핑 그 자체를 알려주는 대신, CSI-RS 안테나 포트 그룹의 수(이하 '

$$N_{group}$$

')를 알려주는 방법(이하 '방법 Mc222')이 고려될 수 있다. 또는, 이와 동등한 효과를 얻기 위해, 기지국이 단말에게 CSI-RS 안테나 포트 그룹의 크기(즉, CSI-RS 안테나 포트 그룹별 CSI-RS 안테나 포트 수, 이하 '

$$N_{ports}^{group}$$

')를 알려주는 방법(이하 '방법 Mc223')이 고려될 수 있다.

[445] 예를 들어, 도 26a에 예시된 맵핑(Mpr1, Mpr2, Mpr3, Mpr4)이 이용되는 경우에, 기지국은 방법 Mc222를 기초로 하여, 단말에게

$$N_{group}$$

값으로써, 1, 2, 4, 및 8 중에서 하나를 알려줄 수 있다. 또는, 기지국은 방법 Mc223을 기초로 하여, 단말에게

$$N_{ports}^{group}$$

값으로써, 16, 8, 4, 및 2 중에서 하나를 알려줄 수 있다.

[446] 방법 Mc221에서, 기지국이 단말에게 알려줄 수 있는 포트 번호 맵핑의 가짓수가 하나라 하더라도, 기지국은 단말에게 포트 번호 맵핑을 알려줄 수 있다. 예를 들어, 방법 Mc221을 위해, 도 26a에 예시된 포트 번호 맵핑(Mpr1, Mpr2, Mpr3, Mpr4) 중에서 포트 번호 맵핑(Mpr2)만이 이용될 수 있다. 이 경우에, 기지국은 단말에게 포트 번호 맵핑(Mpr2) 정보를 시그널링할 수 있다. 또는 기지국은 방법 Mc222를 기초로 하여, 단말에게

$$N_{group}$$

값으로써 2를 알려줄 수 있다. 또는 기지국은 방법 Mc223을 기초로 하여, 단말에게

$$N_{ports}^{group}$$

값으로써 8을 알려줄 수 있다.

[447] 방법 Mc221에서, 기지국이 단말에게 알려줄 수 있는 포트 번호 맵핑의 가짓수가 하나인 경우에, 포트 번호 맵핑 또는 그 규칙은 단말에 설정된 CSI-RS 안테나 포트 수별로 다를 수 있다. 예를 들어, 도 26a에 예시된 맵핑 규칙이 사용된다면, 단말에 설정된 CSI-RS 안테나 포트 수가 16인 경우에

$$N_{ports}^{group}$$

값은 8이고, 단말에 설정된 CSI-RS 안테나 포트 수가 12인 경우에

$$N_{ports}^{group}$$

값은 4일 수 있다. 이 때, 기지국은 방법 Mc223을 기초로 하여, 단말에 설정된 CSI-RS 안테나 포트 수가 16인 경우, 단말에게

$$N_{ports}^{group}$$

값으로써 8을 알려주고, 단말에 설정된 CSI-RS 안테나 포트 수가 12인 경우, 단말에게

N_{ports}^{group}

값으로써 4를 알려줄 수 있다.

[448] 도 26a에 예시된 맵핑 규칙이 적용되는 경우, CSI-RS 안테나 포트 그룹의 수(N_{group})는 CSI-RS 자원 집성에 이용되는 컴포넌트 CSI-RS configuration의 수로 정해질 수 있다. 예를 들어, 도 26c 내지 도 26f에 예시된 바와 같이, 8개의 포트를 갖는 컴포넌트 CSI-RS configuration 2개가 집성되어 16개의 CSI-RS 안테나 포트가 단말에 설정되는 경우에, CSI-RS 안테나 포트 그룹의 수(N_{group})는 2일 수 있다. 다른 예를 들어, 4개의 포트를 갖는 컴포넌트 CSI-RS configuration 3개가 집성되어 12개의 CSI-RS 안테나 포트가 단말에 설정되는 경우에, CSI-RS 안테나 포트 그룹의 수(N_{group})는 3일 수 있다.

[449] 한편, 방법 Mc220 내지 방법 Mc223이 사용되는 경우에, 단말이 가정하는 포트-RE 맵핑은, 수학식 7로 표현될 수 있다. 수학식 7에서, p'은 각 CSI-RS 안테나 포트 그룹별 CSI-RS 안테나 포트 번호를 의미하고, p는 단말에 설정된 전체 CSI-RS 안테나 포트들에 대한 새로운 포트 번호를 의미하고, i는 CSI-RS 안테나 포트 그룹의 색인을 의미한다. 수학식 7에서, p'은 각 CSI-RS 안테나 포트 그룹별로 0부터 (N_{ports}^{group} -1)까지의 정수 값을 가지고, p는 0부터 (N_{group} * N_{ports}^{group} -1)까지의 정수 값을 가지고, i는 0부터 (N_{group}

-1)까지의 정수 값을 가진다.

[450] 예를 들어,

N_{ports}^{group}

개의 포트를 갖는 컴포넌트 CSI-RS configuration가

N_{group}

개 집성되어 단말에게 총 (

N_{group}

*

N_{ports}^{group}

)개의 CSI-RS 안테나 포트가 설정되는 경우에, p'은 각 컴포넌트 CSI-RS configuration별 CSI-RS 안테나 포트 번호이고, p는 집성된 CSI-RS 안테나 포트들에 대한 새로운 포트 번호일 수 있다.

[451] [수식7]

$$p = \begin{cases} p' + \frac{N_{ports}^{group}}{2} i, & \text{for } p' \in \left\{0, \cdots, \frac{N_{ports}^{group}}{2} - 1\right\} \\ p' + \frac{N_{ports}^{group}}{2}(i + N_{group} - 1), & \text{for } p' \in \left\{\frac{N_{ports}^{group}}{2}, \cdots, N_{ports}^{group} - 1\right\} \end{cases}$$

[452] 구체적으로, 기지국이 방법 Mc221을 기초로 하여 단말에게 도 26a에 예시된 포트 번호 맵핑(Mpr2, Mpr3, Mpr4)을 알려주는 경우에, 단말은 수학식 7에 따라 기존 포트 번호들을 새로운 포트 번호들로 대체할 수 있다. 포트 번호 맵핑(Mpr2)의 경우,

N_{group}

은 2이고,

N_{ports}^{group}

는 8이다. 포트 번호 맵핑(Mpr3)의 경우,

N_{group}

은 4이고,

N_{ports}^{group}

는 4이다. 포트 번호 맵핑(Mpr4)의 경우,

N_{group}

은 8이고,

N_{ports}^{group}

는 2이다.

[453] 예를 들어, 단말이 기지국으로부터 포트 번호 맵핑(Mpr2)을 설정받은 경우에, 단말에게 설정되는 16개의 CSI-RS 안테나 포트는, 8개의 포트를 갖는 컴포넌트 CSI-RS configuration이 2개 집성된 것임을 가정하자. 이 때, 상술한 바와 같이, 각 CSI-RS 안테나 포트 그룹은 각 컴포넌트 CSI-RS configuration에 대응될 수 있다. 단말은 수학식 7에 따라, 컴포넌트 CSI-RS configuration 0번의 기존 포트 번호 15~18번을 새로운 포트 번호 15~18번으로 유지하고, 컴포넌트 CSI-RS configuration 0번의 기존 포트 번호 19~22번을 새로운 포트 번호 23~26번으로 대체하고, 컴포넌트 CSI-RS configuration 1번의 기존 포트 번호 15~18번을 새로운 포트 번호 19~22번으로 대체하고, 컴포넌트 CSI-RS configuration 1번의 기존 포트 번호 19~22번을 새로운 포트 번호 27~30번으로 대체할 수 있다. 예를 들어, 단말은 도 26c에 예시된 바와 같이 CSI-RS 자원을 설정받은 경우에, 수학식 7에 따라, 도 26d에 예시된 포트-RE 맵핑을 가정할 수 있다.

[454] 한편, 방법 Mc222 및 방법 Mc223이 사용되는 경우에도, 단말은 수학식 7에 따라 기존 포트 번호들을 새로운 포트 번호들로 대체할 수 있다. 예를 들어, 기지국은 포트 번호 맵핑(Mpr2)을 단말에게 알리기 위한 방법으로써, 방법 Mc222를 기초로, 단말에게

N_{group}

값으로써 2를 알려줄 수 있다. 또는 기지국은 포트 번호 맵핑(Mpr2)을 단말에게 알리기 위한 방법으로써, 방법 Mc223을 기초로, 단말에게

N_{ports}^{group}

값으로써 8을 알려줄 수 있다. 상기 경우에도, 상술한 바와 같이, 단말은 수학식 7에 따라, 각 CSI-RS 안테나 포트 그룹별(또는 각 컴포넌트 CSI-RS configuration별) 기존 포트 번호들을, 새로운 포트 번호들로 대체할 수 있다.

[455]

[456] 도 27은 본 발명의 실시예에 따른, 방법 Mc220이 사용되는 경우에, 복수의 단말에 대한 CSI-RS 안테나 포트 번호 맵핑을 나타내는 도면이다.

[457] 방법 Mc220에 따르면, 기지국은 16개의 CSI-RS 안테나 포트를 설정받을 수 있는 단말을 위한 CSI-RS 자원 설정과 8개의 CSI-RS 안테나 포트를 설정받을 수

있는 단말을 위한 CSI-RS 자원 설정이 일부 RE들을 공유하도록 할 수 있다. 예를 들어, 도 27에 예시된 바와 같이, 기지국이 단말(UE-a)에게 16개의 CSI-RS 안테나 포트를 설정하고 단말(UE-b)에게 16개의 CSI-RS 안테나 포트 중 좌측 4개 열에 해당하는 8개의 CSI-RS 안테나 포트를 설정하고자 하는 경우에, 기지국은 상술한 방법 Mc221의 실시예에 따라, 단말(UE-a)에게 도 26b에 예시된 CSI-RS 안테나 포트 번호 맵핑(Mpr2)을 따를 것을 지시할 수 있다.

[458] 이를 통해, 16개의 CSI-RS 안테나 포트를 설정받은 단말(UE-a)의 8개의 CSI-RS 안테나 포트와 8개의 CSI-RS 안테나 포트를 설정받은 단말(UE-b)의 8개의 CSI-RS 안테나 포트는 동일한 RE에 맵핑될 수 있다.

[459]

[460] 도 28은 본 발명의 실시예에 따른, 방법 Mc220이 사용되는 경우에, 복수의 단말에 대한 CSI-RS 자원 설정을 나타내는 도면이다.

[461] 구체적으로 도 28에는, 도 27에 예시된 CSI-RS 안테나 포트 배열 상의 포트 번호 맵핑이 사용되는 경우에, 단말(UE-a)와 단말(UE-b)에 대한 CSI-RS RE 맵핑이 예시되어 있다. 이 때, 8개의 포트를 갖는 컴포넌트 CSI-RS configuration 2개가 집성되어 총 16개의 CSI-RS 안테나 포트가 단말(UE-a)에게 설정된 경우가 예시되어 있다. 예를 들어, 서브프레임 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 9), RE(3, 9), RE(2, 8), RE(3, 8), RE(2, 5), RE(3, 5), RE(2, 4), RE(3, 4), RE(2, 3), RE(3, 3), RE(2, 2), 및 RE(3, 2)는, 단말(UE-a)을 위한 CSI-RS RE(예, CSI-RS 안테나 포트 0~15번)로써 설정된다. 동일 서브프레임 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 5), RE(3, 5), RE(2, 4), 및 RE(3, 4)는, 단말(UE-b)을 위한 CSI-RS RE(예, CSI-RS 안테나 포트 0~7번)로써 설정된다.

[462] 단말(UE-a)은 CSI 측정 및 보고를 수행하는 경우에, 도 26b의 포트 번호 맵핑을 가정할 수 있다. 이러한 경우에, 단말(UE-a)은 도 27의 맵핑과 도 26b의 맵핑 간의 관계에 따라, 기존 포트 번호 4~5번이 맵핑되었던 슬롯1의 RE(2, 10) 및 RE(3, 10)에 포트 번호 8~9번이 맵핑되고, 기존 포트 번호 6~7번이 맵핑되었던 슬롯1의 RE(2, 4) 및 RE(3, 4)에 포트 번호 10~11번이 맵핑되고, 기존 포트 번호 8~9번이 맵핑되었던 슬롯1의 RE(2, 9) 및 RE(3, 9)에 포트 번호 4~5번이 맵핑되고, 기존 포트 번호 10~11번이 맵핑되었던 슬롯1의 RE(2, 3) 및 RE(3, 3)에 포트 번호 6~7번이 맵핑됨을 가정할 수 있다. 단말(UE-a)에 설정된 16개의 CSI-RS 안테나 포트(0~15번) 중에서 CSI-RS 안테나 포트 0~3번 및 8~11번은, 단말(UE-b)에 설정된 CSI-RS 안테나 포트 0~7번과 동일한 CSI-RS RE 집합을 공유할 수 있다. 즉, 동일 서브프레임 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 5), RE(3, 5), RE(2, 4), 및 RE(3, 4)는, 단말(UE-a)의 CSI-RS 안테나 포트 0~3번 및 8~11번과 단말(UE-b)의 CSI-RS 안테나 포트 0~7번에 의해 공유된다.

[463] 이는, 도 25a에 예시된 CSI-RS 자원 설정 방법에 비해, CSI-RS 전송 오버헤드를 1/3 절감시킬 수 있다. 이와 유사하게, 기지국이 단말(UE-a)에게 16개의 CSI-RS

안테나 포트를 설정하고 단말(UE-b)에게 4개 또는 2개의 CSI-RS 안테나 포트를 설정하고자 하는 경우에, 기지국은 상술한 방법 Mc220의 실시예에 따라, 단말(UE-a)에게 도 26a에 예시된 CSI-RS 안테나 포트 번호 맵핑 규칙(Mpr3) 또는 CSI-RS 안테나 포트 번호 맵핑 규칙(Mpr4)을 따를 것을 지시할 수 있다. 이 때, 단말(UE-b)는 16개의 CSI-RS 안테나 포트를 설정받을 수 없는 기존 단말일 수 있다.

[464] 도 26a 및 도 26b에 예시된 실시예는 16개의 CSI-RS 안테나 포트를 위한 방법이지만, 이는 예시일 뿐이고, 여기에 적용된 CSI-RS 안테나 포트 번호 맵핑의 원리는 다른 수의 CSI-RS 안테나 포트가 설정되는 경우에도 유사하게 적용될 수 있다. 이 때, CSI-RS 안테나 포트 수를 N이라 하면, CSI-RS 안테나 포트 번호 맵핑 또는 CSI-RS 안테나 포트 번호 맵핑 규칙을 N의 약수의 개수만큼 정의하는 방법이 고려될 수 있다. 한편, 단말이 1보다 큰 수직 축 CSI-RS 안테나 포트 수를 설정받은 경우에도, 도 26a 및 도 26b에 예시된 실시예와 같이, 수평 축 및 편파 축에 대해서만 상술한 방법이 적용될 수도 있다.

[465]

[466] 도 29a, 도 29b, 도 29c, 도 29d, 및 도 29e는 본 발명의 다른 실시예에 따른, 방법 Mc221을 위해 사용될 수 있는 복수의 안테나 포트 번호 맵핑 규칙을 나타내는 도면이다.

[467] 구체적으로 도 29a 내지 도 29e는 수평 축, 수직 축, 및 편파 축으로 구성된 16개의 CSI-RS 안테나 포트에 포트 번호 0~15번을 맵핑하는 방법을 나타낸다.

[468] 도 26b에 예시된 실시예에 적용된 원리와 유사하게, 도 29a 내지 도 29e에 예시된 CSI-RS 안테나 포트 그룹 맵핑 규칙은, 전체 CSI-RS 안테나 포트들을 하나 또는 복수의 CSI-RS 안테나 포트 그룹으로 나누고, 각 CSI-RS 안테나 포트 그룹 내에서 특정 순서(예, 수평 축, 편파 축, 및 수직 축의 순서)로 CSI-RS 안테나 포트 번호를 순차적으로 부여한다.

[469] 구체적으로, 도 29a에 예시된 포트 번호 맵핑의 경우에, 16개의 CSI-RS 안테나 포트들이 하나의 CSI-RS 안테나 포트 그룹(Vrg5)으로 나뉜다. 또는 도 29b에 예시된 포트 번호 맵핑의 경우에, 16개의 CSI-RS 안테나 포트들이 2개의 CSI-RS 안테나 포트 그룹(Vrg6a, Vrg6b)으로 나뉜다. 또는 도 29c에 예시된 포트 번호 맵핑의 경우에, 16개의 CSI-RS 안테나 포트들이 4개의 CSI-RS 안테나 포트 그룹(Vrg7a, Vrg7b, Vrg7c, Vrg7d)으로 나뉜다. 또는 도 29d에 예시된 포트 번호 맵핑의 경우에, 16개의 CSI-RS 안테나 포트들이 4개의 CSI-RS 안테나 포트 그룹(Vrg8a, Vrg8b, Vrg8c, Vrg8d)으로 나뉜다. 또는 도 29e에 예시된 포트 번호 맵핑의 경우에, 16개의 CSI-RS 안테나 포트들이 8개의 CSI-RS 안테나 포트 그룹(Vrg9a, Vrg9b, Vrg9c, Vrg9d, Vrg9e, Vrg9f, Vrg9g, Vrg9h)으로 나뉜다. 이 때, 도 29a 내지 도 29e에 예시된 CSI-RS 안테나 포트 그룹에 포함되는 CSI-RS 안테나 포트 수는, 16개, 8개, 4개, 4개, 또는 2개로써, 총 CSI-RS 안테나 포트 수인 16의 약수들일 수 있다.

[470] 방법 Mc221이 사용되는 경우에, 기지국은 16개의 CSI-RS 안테나 포트를 설정받은 단말에게, 도 29a 내지 도 29e에 예시된 CSI-RS 안테나 포트 번호 맵핑 중 하나를 알려줄 수 있다. 상술한 바와 같이, 단말은 기지국으로부터 설정받은 CSI-RS 안테나 포트 번호 맵핑(도 29a 내지 도 29e에 예시된 CSI-RS 안테나 포트 번호 맵핑 중 하나)와 CSI 측정 및 보고를 수행할 때 가정하는 포트 번호 맵핑 간의 관계를 고려하여, CSI-RS 안테나 포트 번호를 재배열할 수 있다.

[471] 예를 들어, 단말이 CSI 측정 및 보고를 수행할 때 도 29a에 예시된 포트 번호 맵핑을 가정하고, 단말이 기지국으로부터 도 29a 내지 도 29e에 예시된 CSI-RS 안테나 포트 번호 맵핑 중에서 도 29c에 예시된 CSI-RS 안테나 포트 번호 맵핑을 설정 받는 경우를 가정하자. 단말은 기지국으로부터 설정받은 도 29c에 예시된 맵핑의 CSI-RS 안테나 포트 번호들을 기존 포트 번호로 간주하고, CSI 측정 및 보고를 수행할 때 가정하는 도 29a에 예시된 맵핑의 CSI-RS 안테나 포트 번호들을 새로운 포트 번호로 간주하여, 기존 포트 번호들을 새로운 포트 번호들로 대체할 수 있다. 즉, 단말은 도 29c의 맵핑과 도 29a의 맵핑 간의 관계에 따라, 기존 CSI-RS 안테나 포트 번호 0번 내지 15번을, 각각 0번, 4번, 8번, 12번, 1번, 5번, 9번, 13번, 2번, 6번, 10번, 14번, 3번, 7번, 11번, 및 15번으로 대체할 수 있다.

[472] 다른 예를 들어, 방법 Mc221이 사용되는 경우에, 기지국은 16개의 CSI-RS 안테나 포트를 설정받은 단말에게, 도 29a 내지 도 29c에 예시된 CSI-RS 안테나 포트 번호 맵핑 중 하나를 알려줄 수 있다.

[473] 한편, 도 29a 내지 도 29e의 예시에서, 기지국은 방법 Mc222를 기초로 하여, 단말에게 CSI-RS 안테나 포트 그룹의 수로써, 1, 2, 4, 및 8 중에서 하나를 알려줄 수 있다. 또는, 기지국은 방법 Mc223을 기초로 하여, 단말에게 CSI-RS 안테나 포트 그룹의 크기로써, 16, 8, 4, 및 2 중에서 하나를 알려줄 수 있다. 도 29c에 예시된 맵핑을 위한 CSI-RS 안테나 포트 그룹의 수와 크기는 도 29d에 예시된 맵핑을 위한 CSI-RS 안테나 포트 그룹의 수와 크기와 동일하므로, 방법 Mc222 또는 방법 Mc223이 사용되는 경우에, 도 29c에 예시된 맵핑과 도 29d에 예시된 맵핑은 구별되지 못할 수 있다. 따라서, 방법 Mc222 또는 방법 Mc223이 사용되는 경우에는, 서로 다른 맵핑이 동일한 CSI-RS 안테나 포트 그룹의 수와 크기를 갖지 않도록 정의되는 것이 필요하다. 예를 들어, 방법 Mc222 또는 방법 Mc223을 위해, 도 29c에 예시된 맵핑과 도 29d에 예시된 맵핑 중에서 어느 하나만이 이용될 수 있다.

[474] 한편, 도 29a 내지 도 29e에 예시된 바와 같이, CSI-RS 안테나 포트들이 수평 축 및 편파 축 뿐만 아니라 수직 축으로도 배치되어 있는 경우에는, 도 26b에 예시된 실시예와 달리, CSI-RS 안테나 포트들을 그룹화하는 방법이 더 다양할 수 있다.

[475] 한편, 방법 Mc220은 CSI-RS 안테나 포트 그룹의 개념 없이 간단한 형태로도 실시될 수 있다. 예를 들어, 기지국은 CSI-RS 안테나 포트 번호 맵핑에 방법 Mc100을 위한 맵핑 순서들 중 어떤 맵핑 순서를 적용할지를, 단말에게 알려줄 수

있다. 즉, CSI-RS 안테나 포트 번호가 수평 축, 편파 축, 및 수직 축의 순서로 매겨지는 방법 Mc100를 위한 맵핑 순서와, CSI-RS 안테나 포트 번호가 수직 축, 수평 축, 및 편파 축의 순서로 매겨지는 방법 Mc100를 위한 맵핑 순서가 사전에 정의되고, 기지국은 1 비트의 시그널링을 통해, 상기 2개의 맵핑 순서들 중 하나를 사용할 것을 단말에게 지시할 수 있다.

[476] 방법 Mc220에 따르면, CSI-RS 안테나 포트 번호 맵핑의 수가 적을 때는 시그널링 오버헤드가 작으나, CSI-RS 안테나 포트 번호 맵핑의 수에 따라 시그널링 오버헤드가 밑이 2인 로그 함수에 비례하여 증가한다. 따라서, CSI-RS 안테나 포트 번호 맵핑의 수가 매우 많은 경우에, 방법 Mc220은 오히려 비효율적일 수 있다.

[477]

[478] 3.3. 다양한 CSI-RS 안테나 포트 수의 설정 방법

[479] 한편, 기지국은 1차원 또는 2차원의 다양한 안테나 형상 및 안테나 배열의 크기를 가질 수 있다. 다양한 크기의 송신 안테나 형상에 대하여, 단말이 효율적인 CSI 측정을 수행하기 위해서는, 단말이 다양한 CSI-RS 안테나 포트 수를 설정받을 수 있도록 하는 것이 중요하다. 예를 들어, 단말에게 기존 규격상의 1, 2, 4, 또는 8개의 CSI-RS 안테나 포트뿐만 아니라 3, 5, 6, 또는 7개의 CSI-RS 안테나 포트를 설정할 수 있도록 하는 방법이 고려될 수 있다. CSI-RS 안테나 포트 수를 확장하는 경우에도, 예를 들어, 단말에게 2의 지수승(예, 16개, 32개, 또는 64개 등)의 CSI-RS 안테나 포트 수만을 설정할 수 있도록 정하는 방법이 있을 수 있으나, 임의의 자연수 또는 임의의 짝수 등과 같이 더 다양한 CSI-RS 안테나 포트 수를 단말에게 설정할 수 있도록 정하는 방법도 고려될 수 있다. 단말에게 다양한 CSI-RS 안테나 포트 수를 설정 가능하도록 하기 위해서는, 기존의 CSI-RS 설정 방법이 확장 또는 개선되어야 할 수 있다.

[480] 지금까지 기술된 방법들의 경우, 단말은 자신이 설정받은 모든 CSI-RS 안테나 포트들을 이용하여 CSI 측정 및 보고를 수행한다. 이하에서는 단말이 자신이 설정받은 CSI-RS 안테나 포트들 중 일부만을 이용하여 CSI 측정 및 보고를 수행하도록 하는 방법(이하 '방법 Mc300')에 대하여 기술한다.

[481] 방법 Mc300에서, 기지국은 CSI-RS configuration 시그널링에 의해 단말에게 설정된 CSI-RS 안테나 포트들 중에서, 단말이 실제 CSI 측정 및 보고에 이용할 CSI-RS 안테나 포트들을 시그널링을 통해 단말에게 알려줄 수 있다. 본 명세서에서, 방법 Mc300에 의해 선택되며 단말의 CSI 측정 및 보고에 이용되는 CSI-RS 안테나 포트를, 유효 CSI-RS 안테나 포트로 부르기로 한다. 단말은 CSI 측정 및 보고를 위해, 유효 CSI-RS 안테나 포트들에만 포트 번호를 새로 부여할 수 있다. 이 때, 유효 CSI-RS 안테나 포트에 부여되는 포트 번호를, 유효 CSI-RS 안테나 포트 번호로 부르기로 한다.

[482] 방법 Mc300에서, CSI-RS configuration 시그널링에 의해 단말에게 설정될 수 있는 CSI-RS 안테나 포트 수는 제한적일 수 있다. 예를 들어, CSI-RS configuration

시그널링에 의해 단말에게 설정될 수 있는 CSI-RS 안테나 포트 수는 1, 2, 4, 그리고 8을 포함할 수 있다. 다른 예를 들어, CSI-RS configuration 시그널링에 의해 단말에게 설정될 수 있는 CSI-RS 안테나 포트 수는 1, 2, 4, 8, 12, 그리고 16을 포함할 수 있다. 반면에, 유효 CSI-RS 안테나 포트 수는 더 다양한 값을 가질 수 있다. 예를 들어, 기지국은 단말에게 기존 규격상의 CSI-RS configuration 시그널링을 이용하여 8개의 CSI-RS 안테나 포트를 설정하고, 방법 Mc300을 이용하여, 이 중에서 5개의 CSI-RS 안테나 포트들만을 유효 CSI-RS 안테나 포트로 설정할 수 있다.

[483] 방법 Mc300 중에서 기지국이 유효 CSI-RS 안테나 포트들을 단말에게 알려주는 방법에 대하여, 먼저 기술한다.

[484] 방법 Mc310은, 단말에게 설정된 CSI-RS 안테나 포트들 각각에 대한 유효성 여부를, 단말에게 알리는 방법이다.

[485] 단말에게 설정된 CSI-RS 안테나 포트 수를 N이라 할 때, 방법 Mc310을 위해, 단말에게 길이 N인 비트맵을 시그널링하는 방법이 사용될 수 있다. 단말은 비트맵에 포함되는 각 비트의 이진 정보를 통해, 각 CSI-RS 안테나 포트의 유효성 여부를 알 수 있다. 예를 들어, 단말(UE-a)이 도 25a에 예시된 바와 같이 CSI-RS를 설정받은 경우에, 기지국은 해당 단말(UE-a)에게 방법 Mc310에 따라, 1111100010100111의 비트맵을 시그널링할 수 있다. 이 때, 비트맵에 포함되는 각 비트가 1이면 해당 CSI-RS 안테나 포트가 유효함(즉, CSI 측정 및 보고에 이용됨)을 의미할 수 있고, 0이면 해당 CSI-RS 안테나 포트가 유효하지 않음을 의미할 수 있다. 비트맵의 MSB(most significant bit)는 방법 Mc300이 적용되기 전에 단말에게 설정된 CSI-RS 안테나 포트 0번(예, LTE 규격에서는 15번)에 대응하고, 비트맵의 LSB(least significant bit)으로 갈수록 CSI-RS 안테나 포트 번호가 증가함을 가정한다. 단말(UE-a)은 1111100010100111 비트맵의 수신을 통해, CSI-RS configuration 시그널링에 의해 원래 설정받은 총 16개의 CSI-RS 안테나 포트들 중에서 총 10개의 CSI-RS 안테나 포트들이 유효함을 인식할 수 있다. 여기서, 선택된 10개의 유효 CSI-RS 안테나 포트는 1111100010100111 비트맵의 비트들 중 1 값을 가지는 비트에 대응한다. 이 때, 10개의 유효 CSI-RS 안테나 포트들에 0번부터 9번까지의 유효 CSI-RS 안테나 포트 번호가 부여될 수 있다. 이 경우에, 단말(UE-a)에게 최종적으로 설정된 CSI-RS 안테나 포트들에 대한 RE 맵핑은, 도 30에 예시된 바와 같을 수 있다.

[486]

[487] 도 30는 본 발명의 실시예에 따른, 방법 Mc310이 사용되는 경우에, CSI-RS 자원 설정을 나타내는 도면이다.

[488] 서브프레임 내의 슬롯1의 RE(2, 11), RE(3, 11), RE(2, 10), RE(3, 10), RE(2, 9), RE(3, 9), RE(2, 5), RE(3, 5), RE(2, 3), RE(3, 3), RE(2, 2), 및 RE(3, 2)는, 단말(UE-a)을 위한 CSI-RS RE(예, 유효 CSI-RS 안테나 포트 0~9번)로써 설정된다. 특히, 서브프레임 내의 슬롯1의 RE(2, 10) 및 RE(3, 10)에는,

단말(UE-a)을 위한 하나의 유효 CSI-RS 안테나 포트(4번)가 맵핑되고, 서브프레임 내의 슬롯1의 RE(2, 9) 및 RE(3, 9)에는, 단말(UE-a)을 위한 하나의 유효 CSI-RS 안테나 포트(5번)가 맵핑된다. 단말(UE-a)은 상기 선택된 10개의 유효 CSI-RS 안테나 포트들(0~9번)만을 이용하여, CSI 측정 및 보고를 수행할 수 있다.

[489] 다른 예를 들어, 단말(UE-b)가 도 25a에 예시된 바와 같이 CSI-RS를 설정받은 경우에, 기지국은 단말(UE-b)에게 방법 Mc310에 따라, 1010 비트맵을 시그널링할 수 있다. 단말(UE-b)은 1010 비트맵의 수신을 통해, CSI-RS configuration 시그널링에 의해 원래 설정받은 총 4개의 CSI-RS 안테나 포트들 중에서 총 2개의 CSI-RS 안테나 포트들이 유효함을 인식할 수 있다. 여기서, 상기 선택된 2개의 유효 CSI-RS 안테나 포트는, 1010 비트맵의 비트들 중 1 값을 가지는 비트에 대응한다.

[490] 이 때, 단말(UE-b)은 상기 선택된 2개의 유효 CSI-RS 안테나 포트들에 0번과 1번의 포트 번호를 순차적으로 부여할 수 있다. 이 경우에, 단말(UE-b)에게 설정된 유효 CSI-RS 안테나 포트들에 대한 RE 맵핑은, 도 30에 예시된 바와 같을 수 있다. 예를 들어, 서브프레임 내의 슬롯0의 RE(5, 9) 및 RE(6, 9)에는, 단말(UE-b)을 위한 하나의 유효 CSI-RS 안테나 포트(0번)가 맵핑되고, 서브프레임 내의 슬롯0의 RE(5, 3) 및 RE(6, 3)에는, 단말(UE-b)을 위한 하나의 유효 CSI-RS 안테나 포트(1번)가 맵핑된다. 단말(UE-b)는 상기 선택된 2개의 유효 CSI-RS 안테나 포트들(0번, 1번)만을 이용하여, CSI 측정 및 보고를 수행할 수 있다.

[491] 한편, CSI-RS configuration에 의해 단말에게 설정되는 CSI-RS 안테나 포트들 중에서 CDM이 적용되는 2개의 CSI-RS 안테나 포트들(하나의 포트 쌍)은, 2개의 RE를 공유한다. 즉, 방법 Mc300이 적용되기 전의 CSI-RS configuration에 의한 CSI-RS 안테나 포트 2k번과 2k+1번(단, k=0, 1, 2,…)은 포트 쌍을 이루고, 동일 자원을 통해 전송될 수 있다. 이를 고려하여, 단말에게 설정된 CSI-RS 안테나 포트 수를 N이라 할 때, 방법 Mc310을 위해 단말에게 길이 N/2인 비트맵을 시그널링하는 방법이 사용될 수 있다. 이 때, 비트맵의 각 비트는 CDM을 통해 묶이는 각 CSI-RS 안테나 포트 쌍에 대한 유효성 여부를 의미할 수 있다. 예를 들어, 비트맵의 첫 번째 비트는 CSI-RS configuration에 의한 CSI-RS 안테나 포트 0번과 1번에 대응하고, 비트맵의 두 번째 비트는 CSI-RS configuration에 의한 CSI-RS 안테나 포트 2번과 3번에 대응할 수 있다.

[492] 방법 Mc320은, 단말에게 설정된 CSI-RS 안테나 포트 배열의 각 행(row)과 각 열(column)에 대한 유효성 여부를 알리는 방법이다.

[493] 방법 Mc310에서와 마찬가지로, 방법 Mc320을 위해, 단말에게 비트맵을 시그널링하는 방법이 사용될 수 있다. 단말에게 설정된 수평 축과 수직 축 CSI-RS 안테나 포트 수 각각을 N_1와 N_2라 할 때, 단말에게 시그널링되는 비트맵의 길이는 N_1와 N_2의 합이 될 수 있다. 예를 들어, 비트맵에서 N_2개의

최상위 비트들이 N_2개의 행에 대한 유효성 여부를 나타내고, 비트맵에서 N_1개의 최하위 비트들이 N_1개의 열에 대한 유효성 여부를 나타낸다고 가정하자. 만약 기지국이 단말에게 N_2=2 및 N_1=8로 설정하고 1011110000 비트맵을 단말에게 시그널링한 경우에, 단말은 1011110000 비트맵을 통해서, 단말에게 설정된 CSI-RS 안테나 포트 배열(2x8)에 속한 2개의 행 중에서 첫 번째 행이 선택되고, 해당 CSI-RS 안테나 포트 배열(2x8)에 속한 8개의 열 중에서 첫 번째 열 내지 네 번째 열이 선택되었음을 인식할 수 있다.

[494] 따라서, 단말에게 설정된 CSI-RS 안테나 포트들이 2차원 배열로 배치되어 있는 경우에, 방법 Mc320은 단말에게 전송되는 비트맵의 길이를 줄일 수 있다는 장점을 가진다. 반면에, 단말에게 설정된 CSI-RS 안테나 포트들이 1차원 배열로 배치되는 경우에는, 방법 Mc320에 따른 시그널링 오버헤드는 방법 Mc310에 따른 시그널링 오버헤드와 동일할 수 있다. 한편, 방법 Mc320에서 CSI-RS 안테나 포트 배열이 도 24 내지 도 29e에 예시된 바와 같이 교차 편파 배열인 경우에, 단말에게 시그널링되는 비트맵의 각 비트는 서로 다른 편파를 갖는 CSI-RS 안테나 포트 쌍(들)에 대응할 수 있다.

[495] 상술한 바와 같이, 방법 Mc300에서, 방법 Mc310 또는 방법 Mc320을 통해 단말이 유효 CSI-RS 안테나 포트들을 알고 나면, 단말은 유효 CSI-RS 안테나 포트들에 대하여 포트 번호를 새로 부여할 수 있다. 이 때, CSI-RS 안테나 포트 배열 상의 포트 번호 맵핑 규칙으로는, 상기 방법들(예, 방법 Mc100, 방법 Mc101, 방법 Mc200, 방법 Mc220 등)뿐만 아니라 이와 다른 방법들이 사용될 수 있다. 즉, 방법 Mc300을 위해, 방법 Mc310 또는 방법 Mc320의 시그널링 방법과 방법 Mc100 내지 방법 Mc220의 CSI-RS 안테나 포트 배열 상의 포트 번호 맵핑 방법이 결합되어 사용될 수 있다. 이에 대하여, 도 31을 참고하여 설명한다.

[496]

[497] 도 31은 본 발명의 실시예에 따른, 방법 Mc310이 사용되는 경우에, CSI-RS 안테나 포트 번호 맵핑을 나타내는 도면이다.

[498] 구체적으로, 도 31에는 기지국이 단말(UE-a)에게 16개의 CSI-RS 안테나 포트와 N_1=8 및 N_2=1을 설정하고, 방법 Mc310에 기초해 단말(UE-a)에게 1111100011111000 비트맵을 시그널링하는 경우가 예시되어 있다. 이 때, 도 31의 (a1)에 예시된 바와 같이, CSI-RS 안테나 포트 배열 상의 포트 번호(0~15번)는 수평 축 및 편파 축의 순서로 부여될 수 있다.

[499] 단말(UE-a)은 방법 Mc310에 의해 설정받은 총 10개의 유효 CSI-RS 안테나 포트들(포트 번호 0~4번, 포트 번호 8~12번)에, 유효 CSI-RS 안테나 포트 번호를 0번부터 9번까지 새롭게 맵핑할 수 있다. 예를 들어, 단말(UE-a)은 도 31의 (b1)에 예시된 바와 같이, 상기 선택된 10개의 유효 CSI-RS 안테나 포트에 수평 축 및 편파 축의 순서로 유효 CSI-RS 안테나 포트 번호(0~9번)를 부여할 수 있다. 단말(UE-a)은 10개의 유효 CSI-RS 안테나 포트(유효 포트 번호 0~9번)에 대하여 CSI 측정 및 보고를 수행할 수 있다.

[500] 한편, 방법 Mc300에서 기지국이 단말에게 CSI-RS를 전송하는 경우에, 기지국이 단말에게 CSI-RS configuration 시그널링을 통해 설정된 CSI-RS 안테나 포트(방법 Mc300이 적용되기 전의 CSI-RS 안테나 포트) 모두를 송신하는 방법(이하 '방법 Mc330')이 사용될 수 있다. 또는 방법 Mc300에서 기지국이 단말에게 CSI-RS를 전송하는 경우에, 기지국이 유효 CSI-RS 안테나 포트들(예, 비트맵의 비트들 중 1 값을 가지는 비트에 대응하는 CSI-RS 안테나 포트)만을 단말에게 전송하는 방법(이하 ' 방법 Mc331')이 사용될 수도 있다.

[501] 방법 Mc331이 사용되는 경우에, 유효 CSI-RS 안테나 포트들이 맵핑되는 RE들의 위치는, CSI-RS configuration 시그널링에 의한 RE 맵핑(방법 Mc300에 의해 CSI-RS 안테나 포트들이 선택되기 이전)을 따를 수 있다.

[502] 한편, 기존 규격에 따르면, 단말은 PDSCH RE 맵핑 및 PDSCH 레잇 매칭을 수행할 때, CSI-RS configuration 시그널링에 의해 설정받은 CSI-RS RE 집합에 PDSCH가 맵핑되지 않음을 가정한다. 방법 Mc300이 사용되는 경우에, PDSCH가 맵핑되지 않는 CSI-RS RE 집합이, CSI-RS configuration에 의해 단말에게 설정된 CSI-RS 안테나 포트들의 RE 집합(방법 Mc300이 사용되기 전의 CSI-RS RE 집합)과 방법 Mc300에 의한 유효 CSI-RS 안테나 포트들의 RE 집합 중 어느 것을 의미하는지 정의될 필요가 있다. 예를 들어, 도 30에 예시된 단말(UE-a)을 가정하자. CSI-RS RE 집합에 대한 전자의 정의에 따르면, 단말(UE-a)은 슬롯1의 RE(2, 4), RE(3, 4), RE(2, 8), 및 RE(3, 8)에서 PDSCH를 수신할 수 없다. CSI-RS RE 집합에 대한 후자의 정의에 따르면, 단말(UE-a)은 슬롯1의 RE(2, 4), RE(3, 4), RE(2, 8), 및 RE(3, 8)에서 PDSCH를 수신할 수 있다. CSI-RS RE 집합에 대한 전자의 정의를 이용하는 방법은, 기지국의 CSI-RS 전송에 방법 Mc330 또는 방법 Mc331이 적용되는 경우를 위해 고려될 수 있다. CSI-RS RE 집합에 대한 후자의 정의를 이용하는 방법은, 기지국의 CSI-RS 전송에 방법 Mc331이 적용되는 경우를 위해서 고려될 수 있다.

[503] 이하에서는 방법 Mc300의 다른 실시예들에 대하여 기술한다.

[504]

[505] 도 32a, 도 32b, 및 도 32c는 방법 Mc300을 위한 다른 실시예를 나타내는 도면이다.

[506] 도 32a 내지 도 32c에서 (a1)은 4개의 CSI-RS 안테나 포트가 1차원 교차 편파 배열로 배치되는 경우를 나타낸다. 여기서, 셀 특정적 CSI-RS 안테나 포트 번호는 수평 축 및 편파 축의 순서로 맵핑됨을 가정하였다.

[507] 이 때, 기지국은 단말(UE-c), 단말(UE-d), 및 단말(UE-e)로 하여금 각각 셀 특정적 CSI-RS 안테나 포트 0~3번, 셀 특정적 CSI-RS 안테나 포트 0번과 2번, 및 셀 특정적 CSI-RS 안테나 포트 1번과 3번에 대하여 CSI 측정 및 보고를 수행하도록 설정하고자 할 수 있다.

[508] 이를 위한 평범한(trivial) 방법은, 각 단말(UE-c, UE-d, UE-e)의 CSI-RS를 서로 다른 자원 영역에 겹치지 않도록 설정하는 것이다. 이 때, 단말들(UE-c, UE-d,

UE-e)을 위한 CSI-RS가 동일한 서브프레임에 설정됨을 가정하면, 하나의 PRB 페어 내에서 CSI-RS 전송을 위해 소요되는 총 RE의 수는 8개이다. 반면에 방법 Mc300과 방법 Mc310이 사용되면, 기지국은 3개의 단말들(UE-c, UE-d, UE-e)에 대한 CSI-RS 전송이 하나의 PRB 페어 내에서 4개의 RE들만을 차지하도록 설정할 수 있다. 구체적으로, 기지국은 단말(UE-c), 단말(UE-d), 및 단말(UE-e)에게 동일한 CSI-RS configuration 시그널링을 통해 4개의 CSI-RS 안테나 포트를 설정하고, 방법 Mc310에 따라, 단말(UE-c)에게 1111 비트맵을, 단말(UE-d)에게 1010 비트맵을, 단말(UE-e)에게 0101 비트맵을 추가로 시그널링할 수 있다.

[509] 1111 비트맵을 시그널링 받은 단말(UE-c)은 CSI-RS configuration 시그널링에 의해 설정받은 4개의 CSI-RS 안테나 포트들 모두에 유효 포트 번호(0~3번)를 부여할 수 있다. 결과적으로, 도 32a의 (b1)에 예시된 바와 같이, 단말(UE-c)은 수평 축의 길이가 2인 1차원 교차 편파 CSI-RS 안테나 포트 배열(Apa1a)에 대하여, CSI 측정 및 보고를 수행할 수 있다.

[510] 1010 비트맵을 시그널링 받은 단말(UE-d)은 CSI-RS configuration 시그널링에 의해 설정받은 4개의 CSI-RS 안테나 포트들 중 포트 0번과 2번에만 유효 포트 번호(0번, 1번)를 부여할 수 있다. 결과적으로, 도 32b의 (b2)에 예시된 바와 같이, 단말(UE-d)은 수평 축의 길이가 1인 교차 편파 CSI-RS 안테나 포트 배열(Apa1b)에 대하여, CSI 측정 및 보고를 수행할 수 있다.

[511] 0101 비트맵을 시그널링 받은 단말(UE-e)은 CSI-RS configuration 시그널링에 의해 설정받은 4개의 CSI-RS 안테나 포트들 중 포트 1번과 3번에만 유효 포트 번호(0번, 1번)를 부여할 수 있다. 결과적으로, 도 32c의 (b3)에 예시된 바와 같이, 단말(UE-e)은 수평 축의 길이가 1인 교차 편파 CSI-RS 안테나 포트 배열(Apa1c)에 대하여, CSI 측정 및 보고를 수행할 수 있다.

[512] 이와 같이, 방법 Mc300과 방법 Mc310에 따르면, CSI-RS 전송 오버헤드가 절반으로 줄어들 수 있고, 이를 통해, 결국 데이터 전송 용량 증대의 효과가 얻어질 수 있다.

[513]

[514] 도 33a, 도 33b, 및 도 33c는 방법 Mc300을 위한 또 다른 실시예를 나타내는 도면이다.

[515] 도 33a 내지 도 33c에서 (a1)은 4개의 CSI-RS 안테나 포트가 1차원 단일 편파 배열로 배치된 경우를 나타낸다.

[516] 이 때, 도 32a 내지 도 32c에 예시된 실시예에서와 동일하게, 기지국은 단말(UE-c), 단말(UE-d), 및 단말(UE-e)로 하여금 각각 셀 특정적 CSI-RS 안테나 포트 0번 내지 3번, 셀 특정적 CSI-RS 안테나 포트 0번과 2번, 및 셀 특정적 CSI-RS 안테나 포트 1번과 3번에 대하여 CSI 측정 및 보고를 수행하도록 설정하고자 할 수 있다.

[517] 이를 위해, 기지국은 방법 Mc300과 방법 Mc310을 사용하고, 도 32a 내지 도

32c에 예시된 실시예에서와 동일하게, CSI-RS 자원 설정 및 비트맵을 단말(UE-c, UE-d, UE-e) 각각에게 시그널링할 수 있다. 구체적으로, 기지국은 단말(UE-c, UE-d, UE-e)에게 동일한 CSI-RS configuration 시그널링을 통해 4개의 CSI-RS 안테나 포트를 설정하고, 단말(UE-c)에게 1111 비트맵을, 단말(UE-d)에게 1010 비트맵을, 단말(UE-e)에게 0101 비트맵을 추가로 시그널링할 수 있다.

[518] 1111 비트맵을 시그널링 받은 단말(UE-c)은 CSI-RS configuration 시그널링에 의해 설정받은 4개의 CSI-RS 안테나 포트들 모두에 유효 포트 번호(0~3번)를 부여할 수 있다. 그 결과로, 도 33a의 (b1)에 예시된 바와 같이, 단말(UE-c)은 길이 4인 1차원 단일 편파 CSI-RS 안테나 포트 배열(Apa2a)에 대하여, CSI 측정 및 보고를 수행할 수 있다.

[519] 1010 비트맵을 시그널링 받은 단말(UE-d)은 CSI-RS configuration 시그널링에 의해 설정받은 4개의 CSI-RS 안테나 포트들 중 포트 0번과 2번에만 유효 포트 번호(0번, 1번)를 부여할 수 있다. 그 결과로, 도 33b의 (b2)에 예시된 바와 같이, 단말(UE-d)은 길이 2인 1차원 단일 편파 CSI-RS 안테나 포트 배열(Apa2b)에 대하여, CSI 측정 및 보고를 수행할 수 있다.

[520] 0101 비트맵을 시그널링 받은 단말(UE-e)은 CSI-RS configuration 시그널링에 의해 설정받은 4개의 CSI-RS 안테나 포트들 중 포트 1번과 3번에만 유효 포트 번호(0번, 1번)를 부여할 수 있다. 그 결과로, 도 33c의 (b3)에 예시된 바와 같이, 단말(UE-e)은 길이 2인 1차원 단일 편파 CSI-RS 안테나 포트 배열(Apa2c)에 대하여, CSI 측정 및 보고를 수행할 수 있다.

[521] 이 때, 만약 CSI-RS 안테나 포트와 물리 안테나 요소(들) 간에 일대일 맵핑을 가정한다면, 단말(UE-d)와 단말(UE-e)에게 보이는 물리 안테나 요소들 간의 간격은 단말(UE-c)에게 보이는 물리 안테나 요소들 간 간격의 2배가 된다. 즉, 방법 Mc300과 방법 Mc310에 따르면, 복수의 단말은 공통의 CSI-RS 전송을 이용하여 서로 다른 안테나 간격을 갖는 안테나 배열에 대한 CSI 측정 및 보고를 수행할 수 있다. 상기 자원 설정의 효과는 도 32a 내지 도 32c에 예시된 실시예에서와 마찬가지로, 4개의 RE들만으로 얻어질 수 있다.

[522]

[523] 도 34은 방법 Mc300을 위한 또 다른 실시예를 나타내는 도면이다.

[524] 구체적으로 도 34에는, 16개의 CSI-RS 안테나 포트가 2차원 단일 편파 배열로 배치된 경우가 예시되어 있다. 이 때, 수평 축의 CSI-RS 안테나 포트 수는 8이고 수직 축의 CSI-RS 안테나 포트 수는 2이다. 여기서, 셀 특정적 CSI-RS 안테나 포트 번호는 수평 축 및 수직 축의 순서로 맵핑됨을 가정하였다.

[525] 기지국은 단말(UE-c)와 단말(UE-e)로 하여금 각각 8개의 열 중 좌측 4개의 열과 우측 4개의 열에 대하여 CSI 측정 및 보고를 수행하도록 하고, 단말(UE-d)로 하여금 셀 특정적 CSI-RS 안테나 포트 10~13번에 대하여 CSI 측정 및 보고를 수행하도록 하고자 할 수 있다.

[526] 방법 Mc300이 사용되면, 기지국은 총 16개의 RE들만을 이용하여 단말들(UE-c,

UE-d, UE-e)로 하여금 상기 CSI-RS 측정 및 보고 동작을 수행하도록 할 수 있다.

[527] 기지국이 선택된 CSI-RS 안테나 포트들을 단말에게 알려주기 위하여, 방법 Mc310을 사용할 수 있다. 이 경우에, 기지국은 단말들(UE-c, UE-d, UE-e)에게 동일한 CSI-RS configuration 시그널링을 통해 16개의 CSI-RS 안테나 포트를 설정하고, 단말(UE-c)에게 1111000011110000 비트맵을, 단말(UE-d)에게 0000000000111100 비트맵을, 단말(UE-e)에게 0000111100001111 비트맵을 시그널링할 수 있다.

[528] 한편, 기지국이 선택된 CSI-RS 안테나 포트들을 단말에게 알려주기 위하여, 방법 Mc320을 사용할 수도 있다. 이 경우에, 기지국은 단말들(UE-c, UE-d, UE-e)에게 동일한 CSI-RS configuration 시그널링을 통해 16개의 CSI-RS 안테나 포트를 설정하고, 단말(UE-c)에게 1111110000 비트맵을, 단말(UE-d)에게 0100111100 비트맵을, 단말(UE-e)에게 1100001111 비트맵을 시그널링할 수 있다. 여기서, 방법 Mc320에 따른 비트맵에서 N_2개의 최상위 비트들(좌측에 표기된 비트들)은 N_2개의 행에 대한 사용 여부(포트 번호 부여 여부)를 나타내고, 방법 Mc320에 따른 비트맵에서 N_1개의 최하위 비트들(우측에 표기된 비트들)은 N_1개의 열에 대한 사용 여부(포트 번호 부여 여부)를 나타내는 것으로 가정한다.

[529] 비트맵을 시그널링 받은 단말(UE-c)은 CSI-RS configuration 시그널링에 의해 설정받은 16개의 CSI-RS 안테나 포트들 중 1번째 내지 4번째 열에 대응하는 8개의 포트(포트 번호 0~3번, 8~11번)에만 유효 포트 번호(0~7번)를 부여할 수 있다. 그 결과로, 단말(UE-c)은 2차원 단일 편파 CSI-RS 안테나 포트 배열(Apa3a)에 대하여, CSI 측정 및 보고를 수행할 수 있다.

[530] 비트맵을 시그널링 받은 단말(UE-d)은 CSI-RS configuration 시그널링에 의해 설정받은 16개의 CSI-RS 안테나 포트들 중 4개의 포트(포트 번호 10~13번)에만 유효 포트 번호(0~3번)를 부여할 수 있다. 그 결과로, 단말(UE-d)은 1차원 단일 편파 CSI-RS 안테나 포트 배열(Apa3b)에 대하여, CSI 측정 및 보고를 수행할 수 있다.

[531] 비트맵을 시그널링 받은 단말(UE-e)은 CSI-RS configuration 시그널링에 의해 설정받은 16개의 CSI-RS 안테나 포트들 중 5번째 내지 8번째 열에 대응하는 8개의 포트(포트 번호 4~7번, 12~15번)에만 유효 포트 번호(0~7번)를 부여할 수 있다. 그 결과로, 단말(UE-e)은 2차원 단일 편파 CSI-RS 안테나 포트 배열(Apa3c)에 대하여, CSI 측정 및 보고를 수행할 수 있다.

[532] 한편, 방법 Mc300 및 방법 Mc300을 위한 세부 방법들은, 방법 Mc220 및 방법 Mc220을 위한 세부 방법들과 결합되어 사용될 수도 있다.

[533]

[534] 3.4. CSI-RS 안테나 포트의 2차원 십자 배열 구성

[535] 한편, 도 35 및 도 36에 예시된 바와 같이, 두 개의 1차원 CSI-RS 안테나 포트 배열이 각각 수평 축과 수직 축으로 나열되어 교차하는 구조를 가지는 2차원 CSI-RS 안테나 포트 배열이 고려될 수 있다.

[536] 도 35는 CSI-RS 안테나 포트의 2차원 십자 배열을 나타내는데, 구체적으로 두 1차원 배열의 교차점에 CSI-RS 안테나 포트가 중복 할당되는 2차원 십자 배열을 나타낸다.

[537] 도 35에 예시된 (Case-A)는, 두 1차원 배열의 교차점이 수평 배열의 첫번째 요소와 수직 배열의 첫번째 요소인 경우이다. 도 35에 예시된 (Case-B)는, 두 1차원 배열의 교차점이 수평 배열의 두번째 요소와 수직 배열의 첫번째 요소인 경우이다. 도 35의 (Case-A) 및 (Case-B)에는, 수평 배열에 CSI-RS 안테나 포트(0~3번)이 할당되고, 수직 배열에 CSI-RS 안테나 포트(4번, 5번)이 할당되는 경우가 예시되어 있다.

[538] 두 1차원 배열의 교차점에 CSI-RS 안테나 포트 번호가 중복 할당되는 경우에, 단말에게 설정되는 총 CSI-RS 안테나 포트 수는 N_2와 N_1의 합이다. 예를 들어, 도 35에 예시된 실시예에서, 단말에게 설정되는 총 CSI-RS 안테나 포트 수는 6(=2+4)이다.

[539]

[540] 도 36는 CSI-RS 안테나 포트의 2차원 십자 배열을 나타내는데, 구체적으로 두 1차원 배열의 교차점에 CSI-RS 안테나 포트가 중복 할당되지 않는 2차원 십자 배열을 나타낸다.

[541] 도 36에 예시된 (Case-A)는, 두 1차원 배열의 교차점이 수평 배열의 첫번째 요소와 수직 배열의 첫번째 요소인 경우이다. 도 36에 예시된 (Case-B)는, 두 1차원 배열의 교차점이 수평 배열의 두번째 요소와 수직 배열의 첫번째 요소인 경우이다. 도 36의 (Case-A) 및 (Case-B)에는, 수평 배열에 CSI-RS 안테나 포트(0~3번)이 할당되고, 수직 배열에 CSI-RS 안테나 포트(4번)이 할당되는 경우가 예시되어 있다.

[542] 두 1차원 배열의 교차점에 CSI-RS 안테나 포트 번호가 중복 할당되지 않고 하나만 할당되는 경우에, 단말에게 설정되는 총 CSI-RS 안테나 포트 수는 N_2+N_1-1 이다. 예를 들어, 도 36에 예시된 실시예에서, 단말에게 설정되는 총 CSI-RS 안테나 포트 수는 5(=2+4-1)이다.

[543] 한편, 이러한 십자 배열 구조는 2차원 또는 3차원 배열의 모든 원소들에 대하여 CSI-RS를 전송하는 구조에 비해, CSI-RS 전송을 위해 소요되는 오버헤드가 적다는 장점을 가진다. 하지만, 그만큼 단말이 CSI 측정을 위해 이용할 수 있는 채널 정보가 감소되므로, 실제 채널의 행(또는 열) 간 상관도(correlation)가 적은 환경에서는 채널 추정의 정확도가 떨어질 수 있다.

[544] CSI-RS 안테나 포트가 십자 배열로 구성되는 경우에도, 단말이 2차원 CSI-RS 안테나 포트 배열의 수평 축 및 수직 축 길이를 알고 있는 것이, CSI 측정 및 보고에 도움될 수 있다. 또한 이 경우에, 단말이 1차원 수직 배열과 1차원 수평 배열 간의 교차점 위치 또는 해당 교차점 위치에 할당된 CSI-RS 안테나 포트 번호를 아는 것이, CSI 측정 및 보고에 도움될 수 있다. 단말이 교차점에 관한 정보를 획득하기 위한 방법으로써, 두 가지 방법(방법 Mc500, 방법 Mc501)이

고려될 수 있다.

[545] 방법 Mc500은, 단말이 미리 정해진 규칙에 따라 수직 배열과 수평 배열의 교차점을 획득하는 방법이다. 방법 Mc501은, 수직 배열과 수평 배열의 교차점에 관한 정보를 기지국이 단말에게 전송하는 방법이다.

[546] 방법 Mc500에서 교차점은 미리 정해진 규칙에 따라 시간적으로(예, 서브프레임 마다, 주기적으로 등) 변할 수도 있고, 고정적일 수도 있다. 수평 축 및 수직 축 CSI-RS 안테나 포트 배열이 맵핑될 수 있는 전체 2차원 배열 공간을 열의 개수가 N_1이고 행의 개수가 N_2인 2차원 행렬로써 표현한다고 가정하면, 후자의 방법(교차점이 고정적임)은 예를 들어, 교차점의 위치를 2차원 행렬의 (1,1) 원소 지점으로 정해놓을 수 있다. 전자의 방법(교차점이 시간적으로 변함)은 예를 들어, 교차점의 위치가 수직 축에서 시간적으로 변하도록(즉, 교차점의 위치가 순차적으로 2차원 행렬의 (1,1), (2,1), ..., (N_2,1) 원소 지점이 되도록) 정할 수 있다.

[547] 한편, 도 36에 예시된 바와 같이, 교차점에 CSI-RS 안테나 포트 번호가 중복되지 않게 하나만 할당되는 경우에, 하나의 RB 페어 내에서 CSI-RS 전송을 위해 이용되는 RE가 1개 절약될 수 있다. 이를 위해, 단말에게 N_2+N_1-1개의 CSI-RS 안테나 포트를 설정하기 위한 방법이 필요할 수 있다. 그 방법 중 하나로써, 기지국이 단말에게 수평 축 또는 수직 축 CSI-RS 안테나 포트 수를 독립적으로 설정하는 경우에, 기지국은 단말에게 기존 설정을 동일하게 적용하되, 수평 축과 수직 축 방향 중 어느 한 방향의 CSI-RS 안테나 포트 수가 기존 설정에서의 해당 방향 포트 수보다 1만큼 적다는 것을 단말이 인식하도록 할 수 있다. 이 때, 기존 설정 대비 1개가 줄어든 N_2+N_1-1개의 CSI-RS 안테나 포트에 대한 포트 번호를 단말이 알아야 한다. 포트 번호 맵핑 규칙은 규격에 미리 정의될 수도 있고, 기지국이 단말에게 관련 정보를 시그널링할 수도 있다.

[548]

[549] 도 37은 본 발명의 실시예에 따른, 기지국(100)을 나타내는 도면이다.

[550] 기지국(100)은 프로세서(110), 메모리(120), 및 RF(radio frequency) 변환기(130)를 포함한다.

[551] 프로세서(110)는 본 명세서에서 기지국, 셀, 또는 TP와 관련하여 기술된 기능, 절차, 및 방법들을 구현하도록 구성될 수 있다. 또한, 프로세서(110)는 기지국(100)의 각 구성을 제어할 수 있다.

[552] 메모리(120)는 프로세서(110)와 연결되고, 프로세서(110)의 동작과 관련된 다양한 정보를 저장한다.

[553] RF 변환기(130)는 프로세서(110)와 연결되고, 무선 신호를 송신 또는 수신한다.

[554]

[555] 도 38은 본 발명의 실시예에 따른, 단말(200)을 나타내는 도면이다.

[556] 단말(200)은 프로세서(210), 메모리(220), 및 RF 변환기(230)를 포함한다.

[557] 프로세서(210)는 본 명세서에서 단말과 관련하여 기술된 기능, 절차, 및

방법들을 구현하도록 구성될 수 있다. 또한, 프로세서(210)는 단말(200)의 각 구성을 제어할 수 있다.

[558] 메모리(220)는 프로세서(210)와 연결되고, 프로세서(210)의 동작과 관련된 다양한 정보를 저장한다.

[559] RF 변환기(230)는 프로세서(210)와 연결되고, 무선 신호를 송신 또는 수신한다.

[560]

[561] 이상에서 본 발명의 실시예에 대하여 상세하게 설명하였지만 본 발명의 권리범위는 이에 한정되는 것은 아니고 다음의 청구범위에서 정의하고 있는 본 발명의 기본 개념을 이용한 당업자의 여러 변형 및 개량 형태 또한 본 발명의 권리범위에 속하는 것이다.

[562]

청구범위

[청구항 1] 기지국이 CSI(channel state information)-RS(reference signal)를 설정하는 방법으로서,
단말을 위한 CSI-RS 안테나 포트를 설정하는 단계;
상기 CSI-RS 안테나 포트에 포트 번호를 맵핑하기 위한 적어도 하나의 포트 번호 맵핑 규칙 중 하나를, 상기 단말을 위해 선택하는 단계; 및
상기 선택된 포트 번호 맵핑 규칙을 상기 단말에게 알리는 단계
를 포함하는 기지국의 CSI-RS 설정 방법.

[청구항 2] 제1항에 있어서,
상기 단말을 위한 CSI-RS 안테나 포트를 설정하는 단계는,
상기 CSI-RS 안테나 포트가 제1 축, 제2 축, 및 제3 축 중 적어도 2개를 따라 배치되는 CSI-RS 안테나 포트 배열을 설정하는 단계를 포함하고,
상기 선택된 포트 번호 맵핑 규칙에 무관하게, 상기 제1 축, 상기 제2 축, 및 상기 제3 축에 포트 번호가 맵핑되는 축 순서는 기 설정되는
기지국의 CSI-RS 설정 방법.

[청구항 3] 제2항에 있어서,
상기 단말을 위한 CSI-RS 안테나 포트를 설정하는 단계는,
상기 CSI-RS 안테나 포트 배열에 포함된 CSI-RS 안테나 포트 중에서 상기 제1 축으로 배치되는 CSI-RS 안테나 포트의 수, 상기 제2 축으로 배치되는 CSI-RS 안테나 포트의 수, 및 상기 제3 축으로 배치되는 CSI-RS 안테나 포트의 수 중 적어도 하나를, 상기 단말에게 전송하는 단계를 더 포함하는
기지국의 CSI-RS 설정 방법.

[청구항 4] 제2항에 있어서,
상기 단말을 위한 CSI-RS 안테나 포트를 설정하는 단계는,
상기 제1 축, 상기 제2 축, 및 상기 제3 축 중 하나의 축에 따라 배치되는 CSI-RS 안테나 포트의 수가 상기 단말에게 설정되는 전체 CSI-RS 안테나 포트의 수와 동일한 경우에, 상기 하나의 축에 따라 배치되는 CSI-RS 안테나 포트의 수를 상기 단말에게 전송하는 것을 생략하는 단계를 더 포함하는
기지국의 CSI-RS 설정 방법.

[청구항 5] 제2항에 있어서,
상기 단말을 위한 CSI-RS 안테나 포트를 설정하는 단계는,
상기 CSI-RS 안테나 포트 배열에 포함된 CSI-RS 안테나 포트 중에서 상기 제1 축으로 배치되는 CSI-RS 안테나 포트의 수와 상기 제3 축으로 배치되는 CSI-RS 안테나 포트의 수를 합하여, 제1 값을 구하는 단계; 및
상기 CSI-RS 안테나 포트 배열에 포함된 CSI-RS 안테나 포트 중에서 상기 제2 축으로 배치되는 CSI-RS 안테나 포트의 수 및 상기 제1 값 중 적어도

하나를, 상기 단말에게 전송하는 단계를 더 포함하는
기지국의 CSI-RS 설정 방법.

[청구항 6] 제2항에 있어서,
상기 선택된 포트 번호 맵핑 규칙은,
상기 단말에 의한 채널 추정 시에, 상기 단말로 하여금 상기 단말에게 설정된 전체 CSI-RS 안테나 포트를 상기 선택된 포트 번호 맵핑 규칙에 대응하는 개수 만큼의 CSI-RS 안테나 포트 그룹으로 나누도록 하고, 상기 CSI-RS 안테나 포트 그룹 별로 상기 각 CSI-RS 안테나 포트 그룹에 속하는 CSI-RS 안테나 포트에 상기 기 설정된 축 순서에 따라 포트 번호를 부여하도록 하는
기지국의 CSI-RS 설정 방법.

[청구항 7] 제6항에 있어서,
상기 각 CSI-RS 안테나 포트 그룹에 속하는 CSI-RS 안테나 포트의 수는 상기 단말에게 설정되는 전체 CSI-RS 안테나 포트의 수의 약수인
기지국의 CSI-RS 설정 방법.

[청구항 8] 제1항에 있어서,
상기 선택된 포트 번호 맵핑 규칙을 상기 단말에게 알리는 단계는,
상기 선택된 포트 번호 맵핑 규칙을 나타내는 비트 코드를, 상기 단말에게 전송하는 단계를 포함하는
기지국의 CSI-RS 설정 방법.

[청구항 9] 제6항에 있어서,
상기 선택된 포트 번호 맵핑 규칙을 상기 단말에게 알리는 단계는,
상기 선택된 포트 번호 맵핑 규칙에 따라 생성되는 상기 CSI-RS 안테나 포트 그룹의 개수를 나타내는 비트 코드를, 상기 단말에게 전송하는 단계를 포함하는
기지국의 CSI-RS 설정 방법.

[청구항 10] 제2항에 있어서,
상기 단말에게 설정되는 전체 CSI-RS 안테나의 수는 8개 보다 더 많고,
상기 제1 축은 수평(horizontal) 축이고, 상기 제2 축은 수직(vertical) 축이고, 상기 제3 축은 편파(polarization) 축인
기지국의 CSI-RS 설정 방법.

[청구항 11] 제1항에 있어서,
제1 축, 제2 축, 및 제3 축에 포트 번호가 맵핑되는 축 순서들 중에서 하나를, 상기 단말을 위해 선택하는 단계; 및
상기 선택된 축 순서를 상기 단말에게 알리는 단계를 더 포함하고,
상기 단말을 위한 CSI-RS 안테나 포트를 설정하는 단계는,
상기 CSI-RS 안테나 포트가 상기 제1 축, 상기 제2 축, 및 상기 제3 축 중 적어도 2개를 따라 배치되는 CSI-RS 안테나 포트 배열을 설정하는 단계를

포함하는
기지국의 CSI-RS 설정 방법.

[청구항 12] 단말이 CSI(channel state information)를 측정하는 방법으로서,
기지국으로부터, CSI-RS(reference signal) 안테나 포트를 위한 제1 포트 번호 맵핑 규칙을 수신하는 단계;
상기 제1 포트 번호 맵핑 규칙에 기초해, 상기 CSI-RS 안테나 포트를 상기 제1 포트 번호 맵핑 규칙에 대응하는 개수 만큼의 CSI-RS 안테나 포트 그룹으로 나누는 단계;
상기 CSI-RS 안테나 포트 그룹 별로 상기 각 CSI-RS 안테나 포트 그룹에 속하는 CSI-RS 안테나 포트에 포트 번호를 부여하는 단계; 및
상기 포트 번호가 부여된 CSI-RS 안테나 포트에 대하여, 채널 추정을 수행하는 단계
를 포함하는 단말의 CSI 측정 방법.

[청구항 13] 제12항에 있어서,
상기 제1 포트 번호 맵핑 규칙과 다른 제2 포트 번호 맵핑 규칙에 따라, 상기 CSI-RS 안테나 포트에 포트 번호를 재부여하는 단계; 및
상기 포트 번호가 재부여된 CSI-RS 안테나 포트에 대하여, 상기 채널 추정의 결과에 기초해 CSI 측정을 수행하는 단계
를 더 포함하는 단말의 CSI 측정 방법.

[청구항 14] 제12항에 있어서,
상기 제1 포트 번호 맵핑 규칙을 수신하는 단계는,
상기 제1 포트 번호 맵핑 규칙을 나타내는 비트 코드를 상기 기지국으로부터 수신하는 단계를 포함하는
단말의 CSI 측정 방법.

[청구항 15] 제12항에 있어서,
상기 CSI-RS 안테나 포트는 제1 축, 제2 축, 및 제3 축 중 적어도 2개를 따라 배치되고,
상기 CSI-RS 안테나 포트에 포트 번호를 부여하는 단계는,
상기 CSI-RS 안테나 포트 그룹 중에서 제1 CSI-RS 안테나 포트 그룹에 속하는 CSI-RS 안테나 포트에, 상기 제1 축, 상기 제2 축, 및 상기 제3 축에 포트 번호가 부여되는 축 순서에 따라 포트 번호를 부여하는 단계; 및
상기 CSI-RS 안테나 포트 그룹 중에서 제2 CSI-RS 안테나 포트 그룹에 속하는 CSI-RS 안테나 포트에, 상기 축 순서에 따라 포트 번호를 부여하는 단계를 포함하고,
상기 제2 CSI-RS 안테나 포트 그룹에 부여된 첫번째 포트 번호는 상기 제1 CSI-RS 안테나 포트 그룹에 부여된 마지막 포트 번호 다음의 포트 번호인
단말의 CSI 측정 방법.

[청구항 16] 단말이 CSI(channel state information)를 측정하는 방법으로서,

기지국으로부터, CSI-RS(reference signal) 안테나 포트를 설정받는 단계;
상기 기지국으로부터 상기 CSI-RS 안테나 포트에 대한 포트 번호 부여 여부 정보를 수신하는 단계;
상기 포트 번호 부여 정보에 기초해, 상기 CSI-RS 안테나 포트 중 일부에 포트 번호를 부여하는 단계; 및
상기 포트 번호가 부여된 CSI-RS 안테나 포트를 이용하여, CSI를 측정하는 단계
를 포함하는 단말의 CSI 측정 방법.

[청구항 17] 제16항에 있어서,
상기 포트 번호 부여 여부 정보를 수신하는 단계는,
상기 CSI-RS 안테나 포트의 수만큼의 길이를 가지며 상기 CSI-RS 안테나 포트 별 포트 번호 부여 여부를 나타내는 비트맵을, 상기 기지국으로부터 수신하는 단계를 포함하고,
상기 CSI-RS 안테나 포트 중 일부에 포트 번호를 부여하는 단계는,
상기 비트맵에 속하는 비트 중에서 제1 값을 가지는 비트에 대응하는 CSI-RS 안테나 포트에 포트 번호를 부여하는 단계를 포함하는
단말의 CSI 측정 방법.

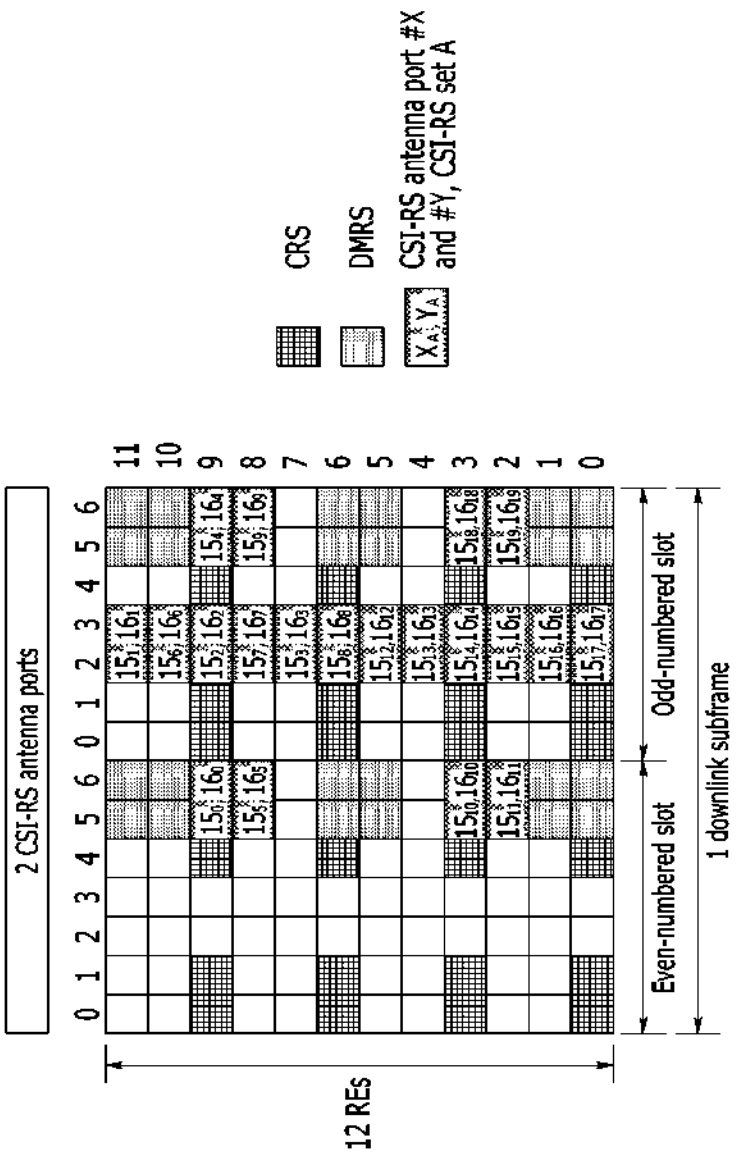
[청구항 18] 제16항에 있어서,
상기 포트 번호 부여 여부 정보를 수신하는 단계는,
상기 CSI-RS 안테나 포트의 수의 절반의 길이를 가지며 상기 CSI-RS 안테나 포트 쌍 별 포트 번호 부여 여부를 나타내는 비트맵을, 상기 기지국으로부터 수신하는 단계를 포함하고,
상기 CSI-RS 안테나 포트 중 일부에 포트 번호를 부여하는 단계는,
상기 비트맵에 속하는 비트 중에서 제1 값을 가지는 비트에 대응하는 CSI-RS 안테나 포트 쌍에 포트 번호를 부여하는 단계를 포함하고,
상기 CSI-RS 안테나 포트 쌍은 동일한 RE(resource element)를 통해 전송되는 2개의 CSI-RS 안테나 포트를 포함하는
단말의 CSI 측정 방법.

[청구항 19] 제16항에 있어서,
상기 CSI-RS 안테나 포트는 CSI-RS 안테나 포트 배열에 포함되며 제1 축, 제2 축, 및 제3 축 중 적어도 2개에 따라 배치되고,
상기 포트 번호 부여 여부 정보를 수신하는 단계는,
상기 제1 축으로 배치되는 CSI-RS 안테나 포트의 수와 상기 제2 축으로 배치되는 CSI-RS 안테나 포트의 수를 합한 값 만큼의 길이를 가지며 상기 CSI-RS 안테나 포트 배열의 각 행과 각 열에 대한 포트 번호 부여 여부를 나타내는 비트맵을, 상기 기지국으로부터 수신하는 단계를 포함하는
단말의 CSI 측정 방법.

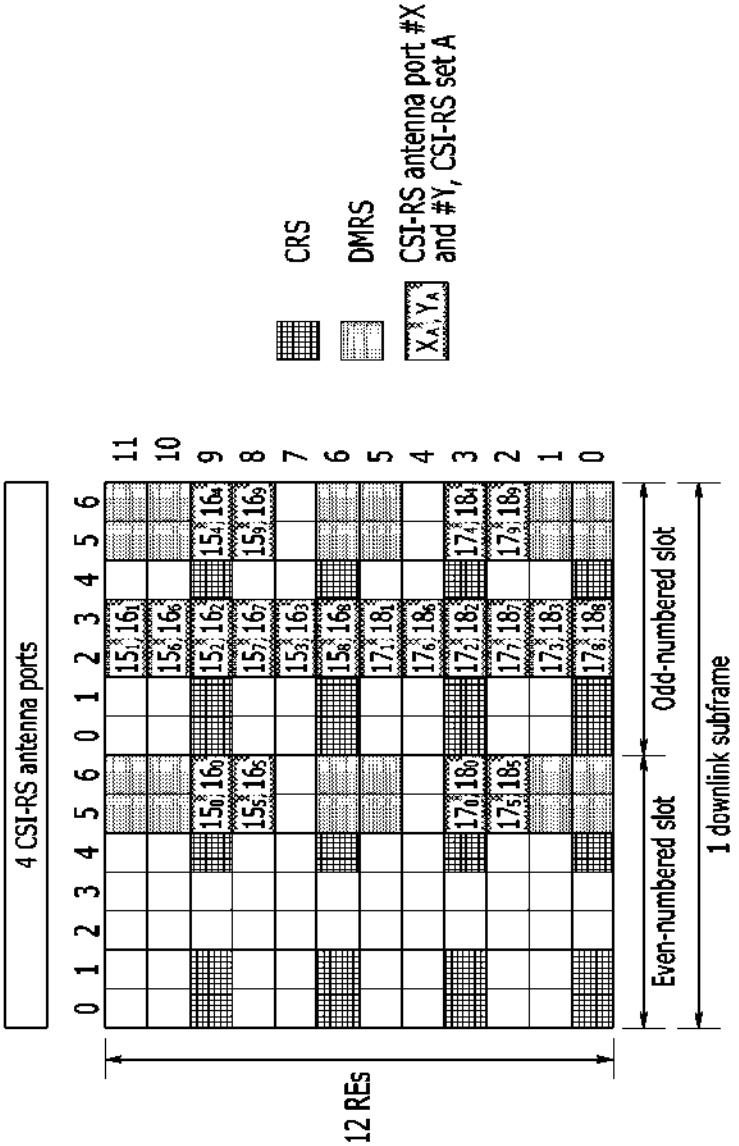
[청구항 20] 제16항에 있어서,

상기 단말에게 설정된 전체 CSI-RS 안테나 포트를 위한 RE(resource element) 중에서 상기 포트 번호가 부여된 CSI-RS 안테나 포트를 위한 RE를 제외한 나머지에서 PDSCH(physical downlink shared channel)가 수신되는 것이 가능함을 가정하는 단계
를 더 포함하는 단말의 CSI 측정 방법.

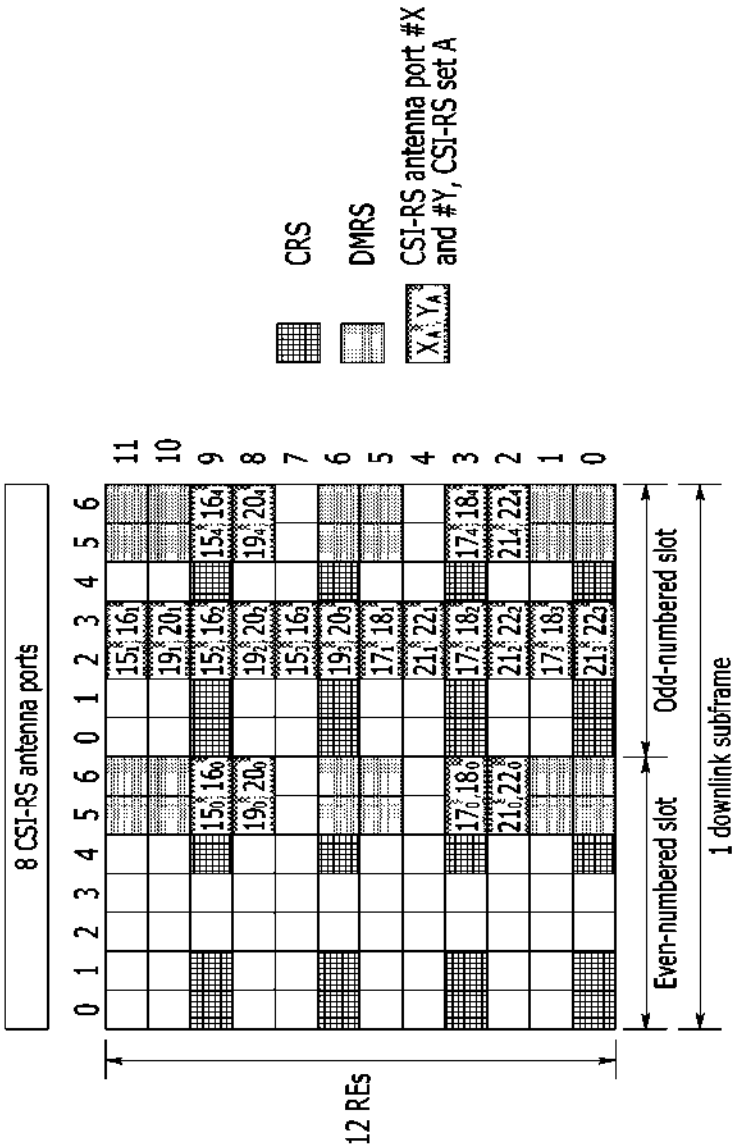
[도1]


CRS
DMRS
CSI-RS antenna port #X and #Y, CSI-RS set A
2 CSI-RS antenna ports
Even-numbered slot
Odd-numbered slot
1 downlink subframe
12 REs

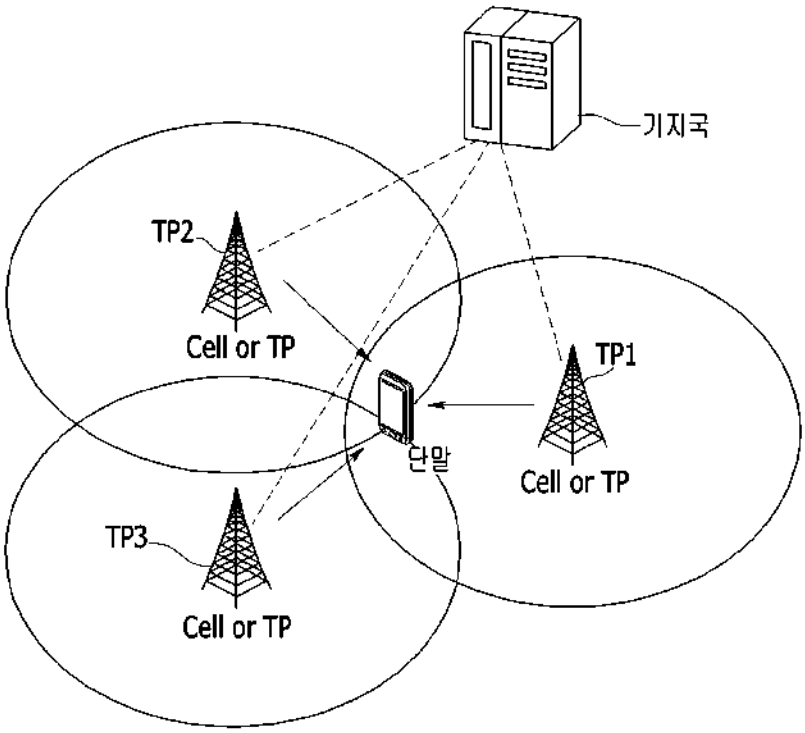
[도2]


CRS
DMRS
CSI-RS antenna port #X and #Y, CSI-RS set A
4 CSI-RS antenna ports
Even-numbered slot
Odd-numbered slot
1 downlink subframe
12 REs

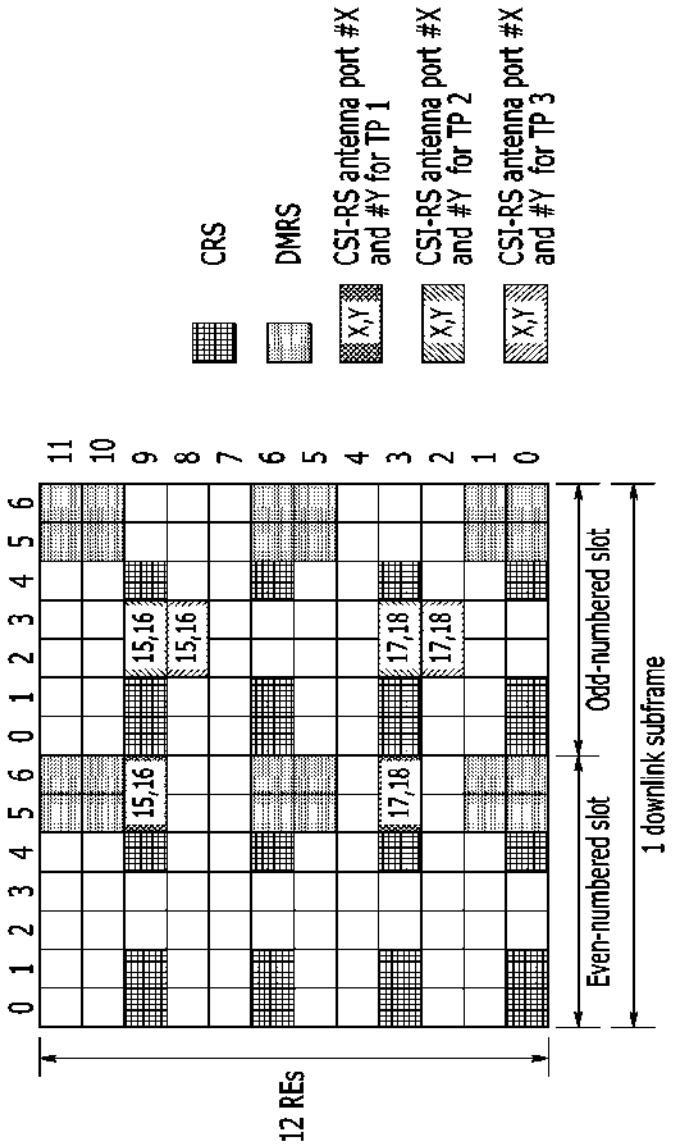
[도3]


CRS
DMRS
CSI-RS antenna port #X and #Y, CSI-RS set A
8 CSI-RS antenna ports
Even-numbered slot
Odd-numbered slot
1 downlink subframe
12 REs

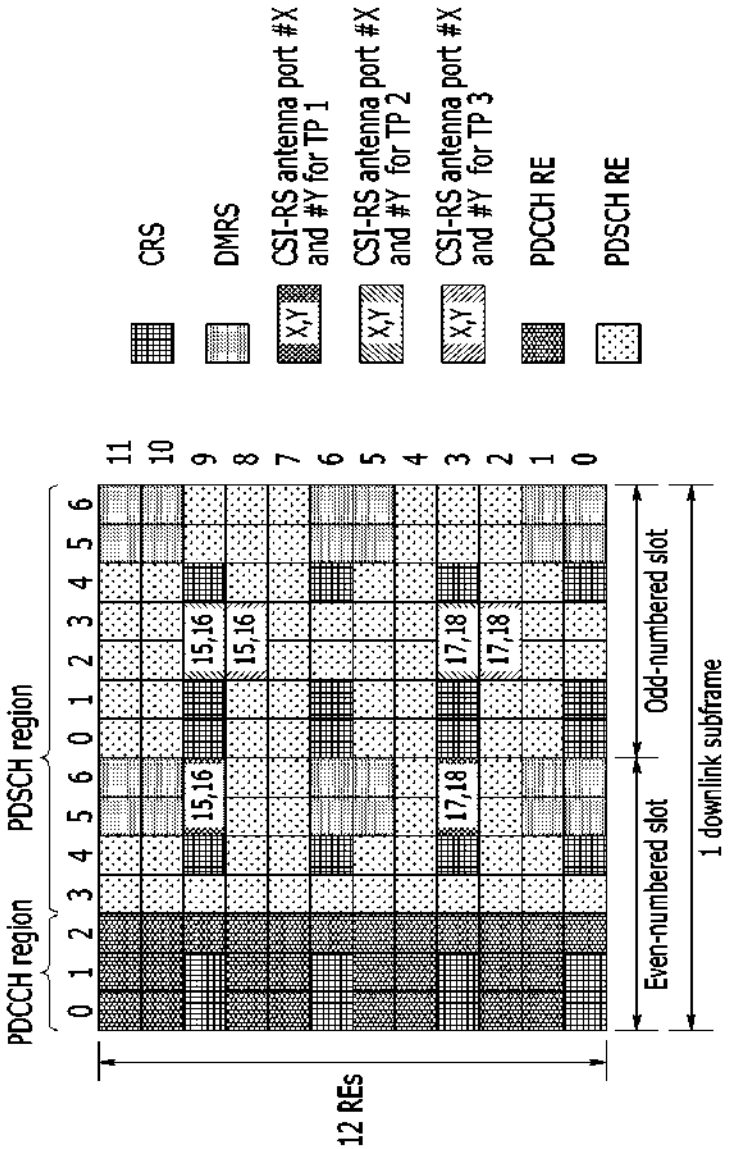
[도4]



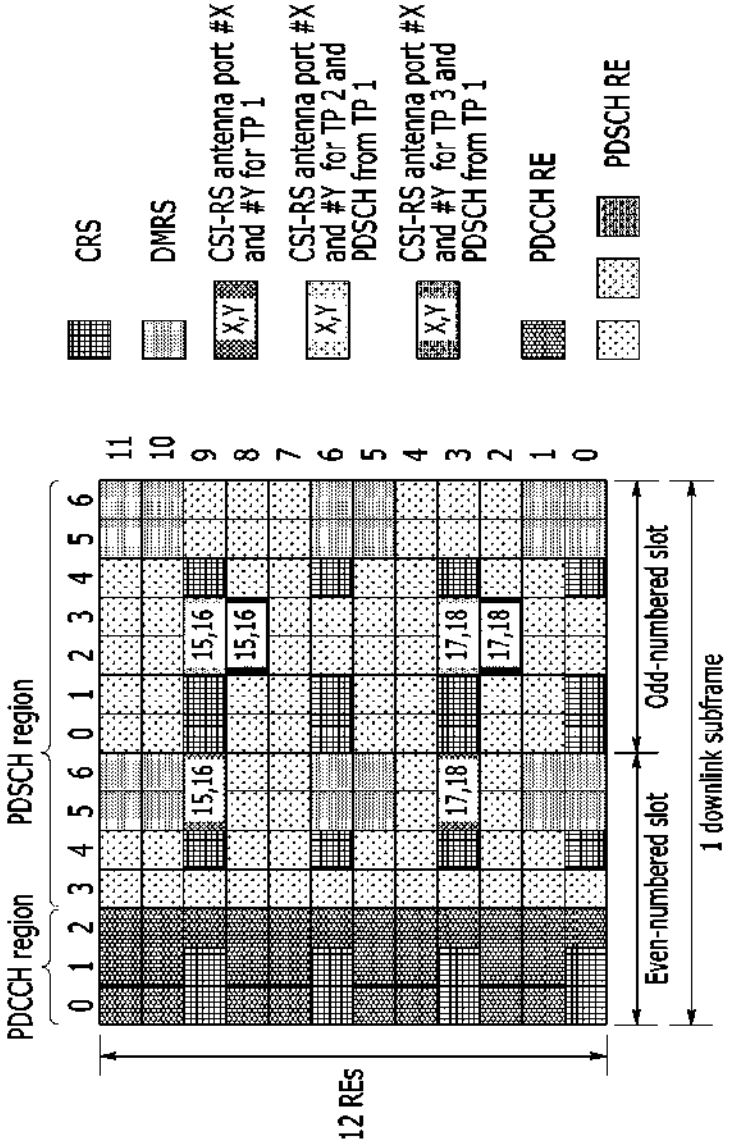
[도5]


CRS
DMRS
CSI-RS antenna port #X and #Y for TP 1
CSI-RS antenna port #X and #Y for TP 2
CSI-RS antenna port #X and #Y for TP 3
X,Y
11 10 9 8 7 6 5 4 3 2 1 0
0 1 2 3 4 5 6
15,16
17,18
Odd-numbered slot
Even-numbered slot
1 downlink subframe
12 REs

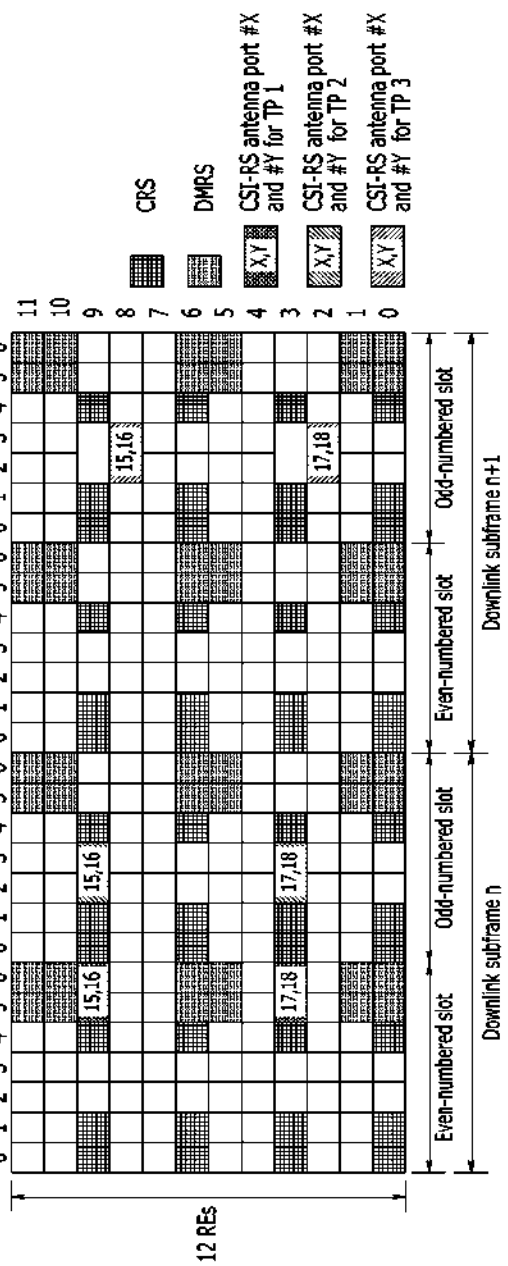
[도6]


CRS
DMRS
CSI-RS antenna port #X and #Y for TP 1
CSI-RS antenna port #X and #Y for TP 2
CSI-RS antenna port #X and #Y for TP 3
PDCCH RE
PDSCH RE
X,Y
PDCCH region
PDSCH region
0 1 2 3 4 5 6 0 1 2 3 4 5 6
11 10 9 8 7 6 5 4 3 2 1 0
15,16
17,18
12 REs
Even-numbered slot
Odd-numbered slot
1 downlink subframe

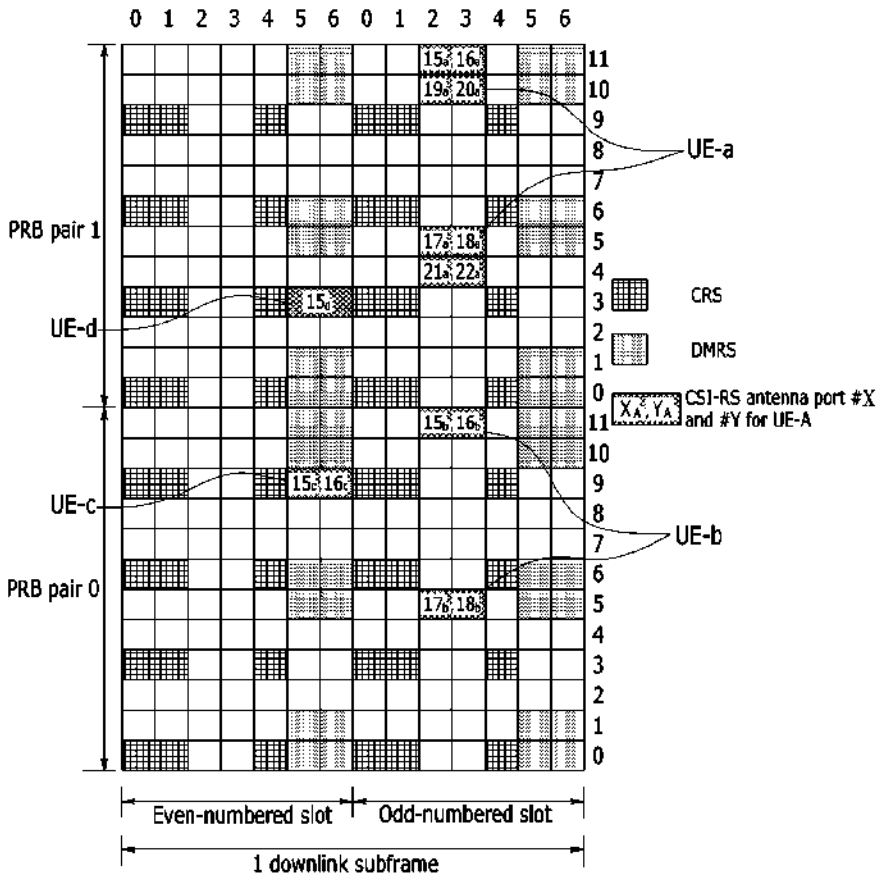
[도7]


CRS
DMRS
CSI-RS antenna port #X and #Y for TP 1
CSI-RS antenna port #X and #Y for TP 2 and PDSCH from TP 1
CSI-RS antenna port #X and #Y for TP 3 and PDSCH from TP 1
PDCCH RE
PDSCH RE
X,Y
PDCCH region
PDSCH region
15,16
17,18
Even-numbered slot
Odd-numbered slot
1 downlink subframe
12 REs

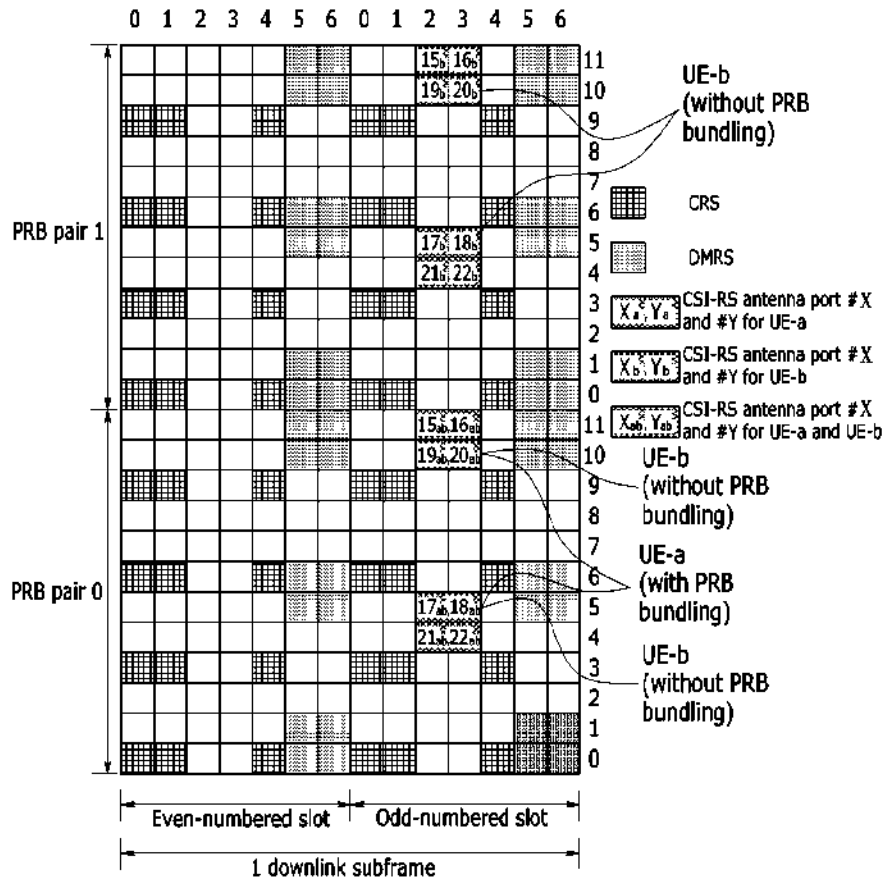
[도8]


CRS
DMRS
CSI-RS antenna port #X and #Y for TP 1
CSI-RS antenna port #X and #Y for TP 2
CSI-RS antenna port #X and #Y for TP 3
X,Y
15,16
17,18
12 REs
Even-numbered slot
Odd-numbered slot
Downlink subframe n
Downlink subframe n+1

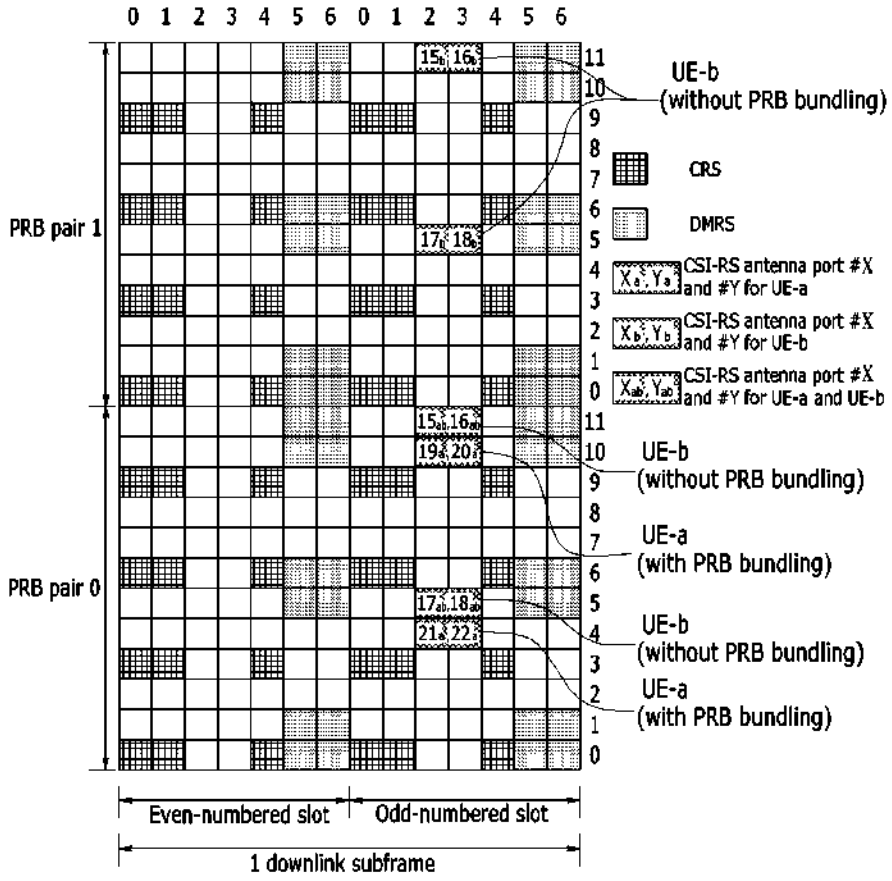
[도9]


0 1 2 3 4 5 6 0 1 2 3 4 5 6
11
10
9
8
7
6
5
4
3
2
1
0
11
10
9
8
7
6
5
4
3
2
1
0
UE-a
UE-b
UE-c
UE-d
PRB pair 1
PRB pair 0
CRS
DMRS
CSI-RS antenna port #X and #Y for UE-A
Even-numbered slot
Odd-numbered slot
1 downlink subframe

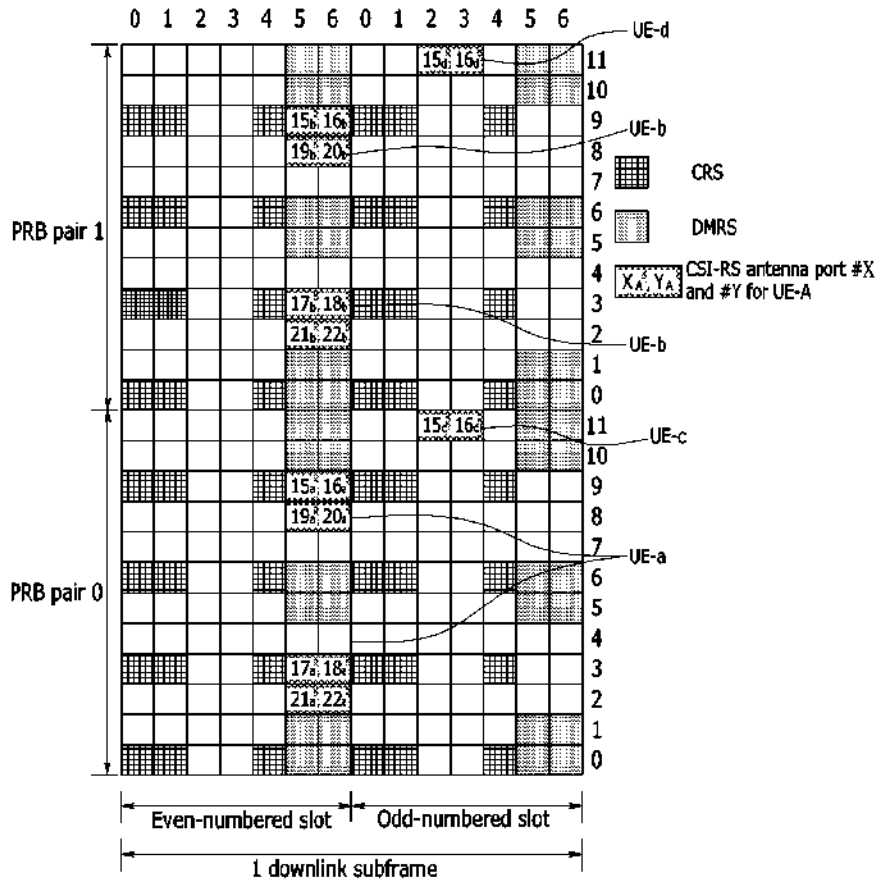
[도10a]


0 1 2 3 4 5 6 0 1 2 3 4 5 6
PRB pair 1
PRB pair 0
UE-b (without PRB bundling)
CRS
DMRS
CSI-RS antenna port #X and #Y for UE-a
CSI-RS antenna port #X and #Y for UE-b
CSI-RS antenna port #X and #Y for UE-a and UE-b
UE-b (without PRB bundling)
UE-a (with PRB bundling)
UE-b (without PRB bundling)
Even-numbered slot
Odd-numbered slot
1 downlink subframe

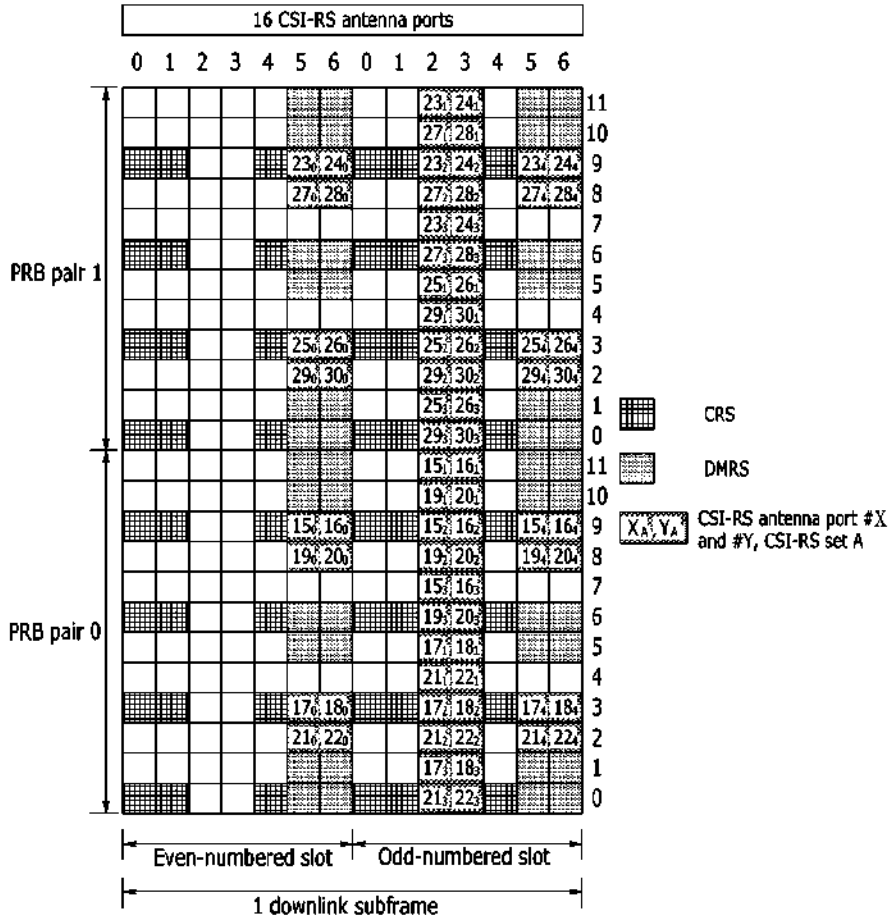
[도10b]


0 1 2 3 4 5 6 0 1 2 3 4 5 6
PRB pair 1
PRB pair 0
UE-b (without PRB bundling)
CRS
DMRS
CSI-RS antenna port #X and #Y for UE-a
CSI-RS antenna port #X and #Y for UE-b
CSI-RS antenna port #X and #Y for UE-a and UE-b
UE-b (without PRB bundling)
UE-a (with PRB bundling)
UE-b (without PRB bundling)
UE-a (with PRB bundling)
Even-numbered slot
Odd-numbered slot
1 downlink subframe

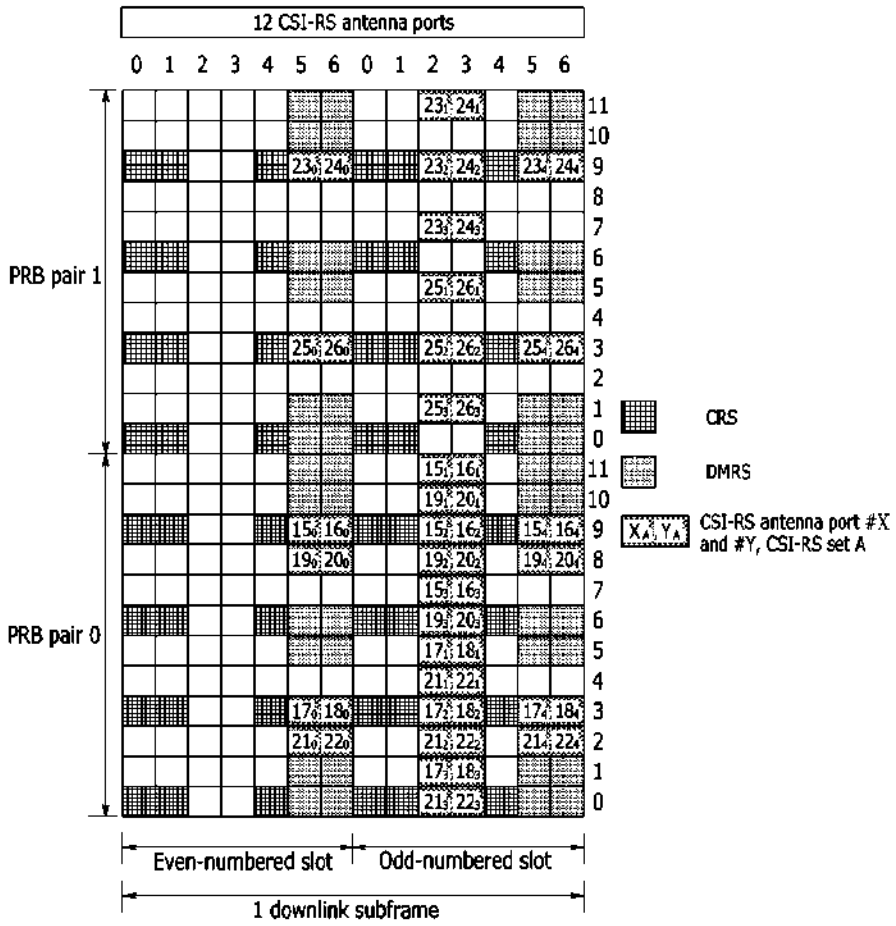
[도11]


0 1 2 3 4 5 6 0 1 2 3 4 5 6
UE-d
UE-b
CRS
DMRS
CSI-RS antenna port #X and #Y for UE-A
UE-b
UE-c
UE-a
PRB pair 1
PRB pair 0
Even-numbered slot
Odd-numbered slot
1 downlink subframe

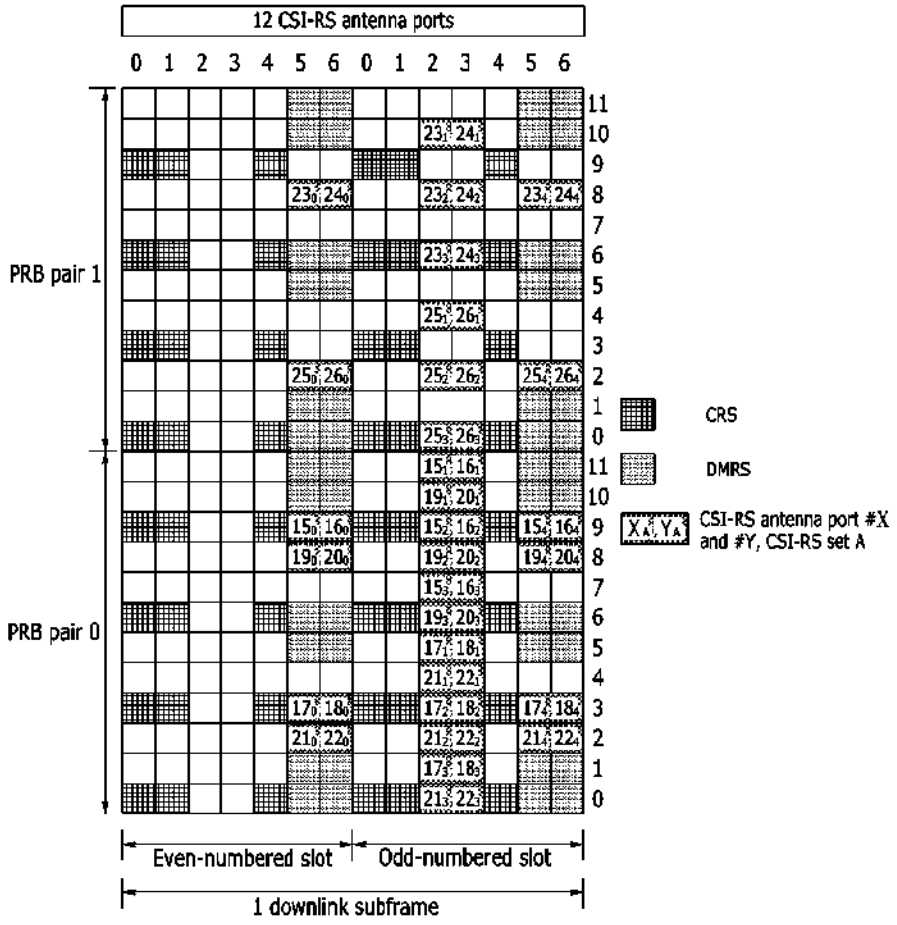
[도12]


16 CSI-RS antenna ports
0 1 2 3 4 5 6 0 1 2 3 4 5 6
PRB pair 1
PRB pair 0
11
10
9
8
7
6
5
4
3
2
1
0
CRS
DMRS
CSI-RS antenna port #X and #Y, CSI-RS set A
Even-numbered slot
Odd-numbered slot
1 downlink subframe

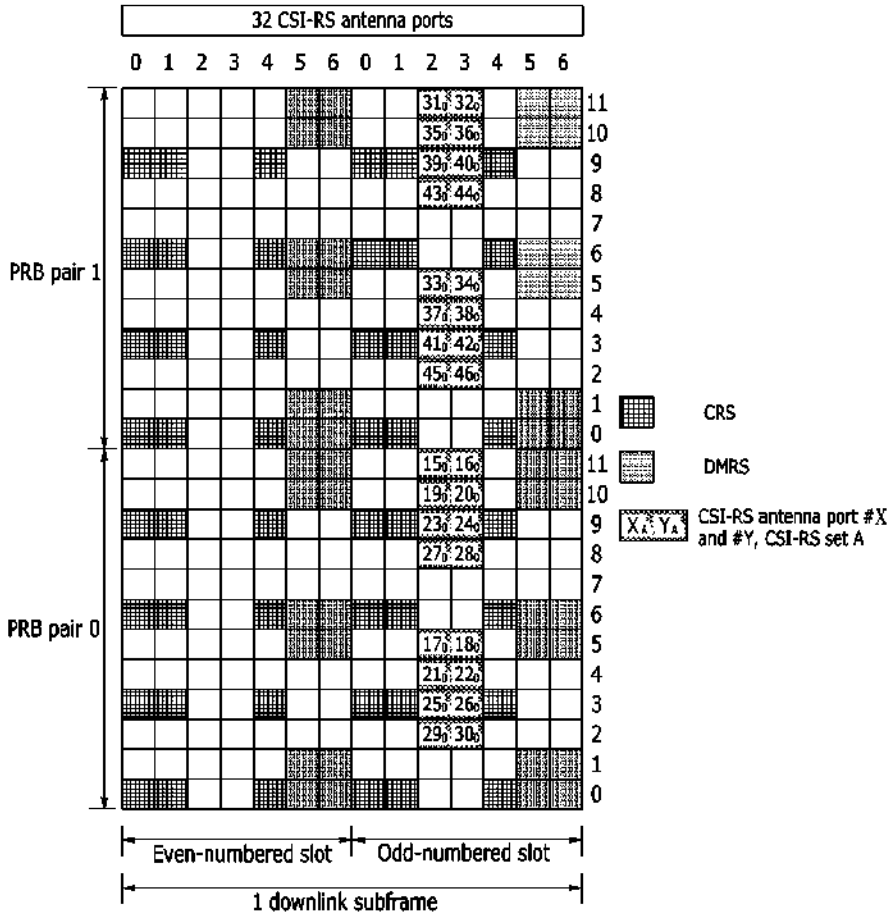
[도13a]


12 CSI-RS antenna ports
0 1 2 3 4 5 6 0 1 2 3 4 5 6
PRB pair 1
PRB pair 0
11 10 9 8 7 6 5 4 3 2 1 0 11 10 9 8 7 6 5 4 3 2 1 0
CRS
DMRS
CSI-RS antenna port #X and #Y, CSI-RS set A
Even-numbered slot
Odd-numbered slot
1 downlink subframe

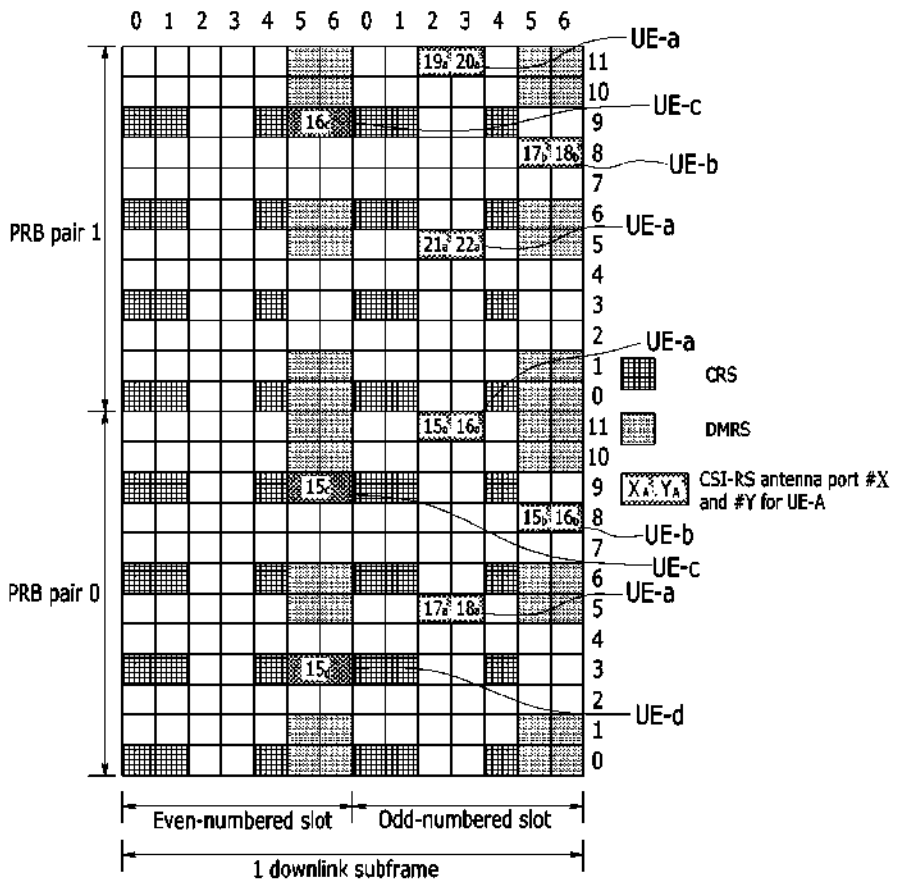
[도13b]


12 CSI-RS antenna ports
0 1 2 3 4 5 6 0 1 2 3 4 5 6
PRB pair 1
PRB pair 0
11 10 9 8 7 6 5 4 3 2 1 0
11 10 9 8 7 6 5 4 3 2 1 0
CRS
DMRS
CSI-RS antenna port #X and #Y, CSI-RS set A
Even-numbered slot
Odd-numbered slot
1 downlink subframe

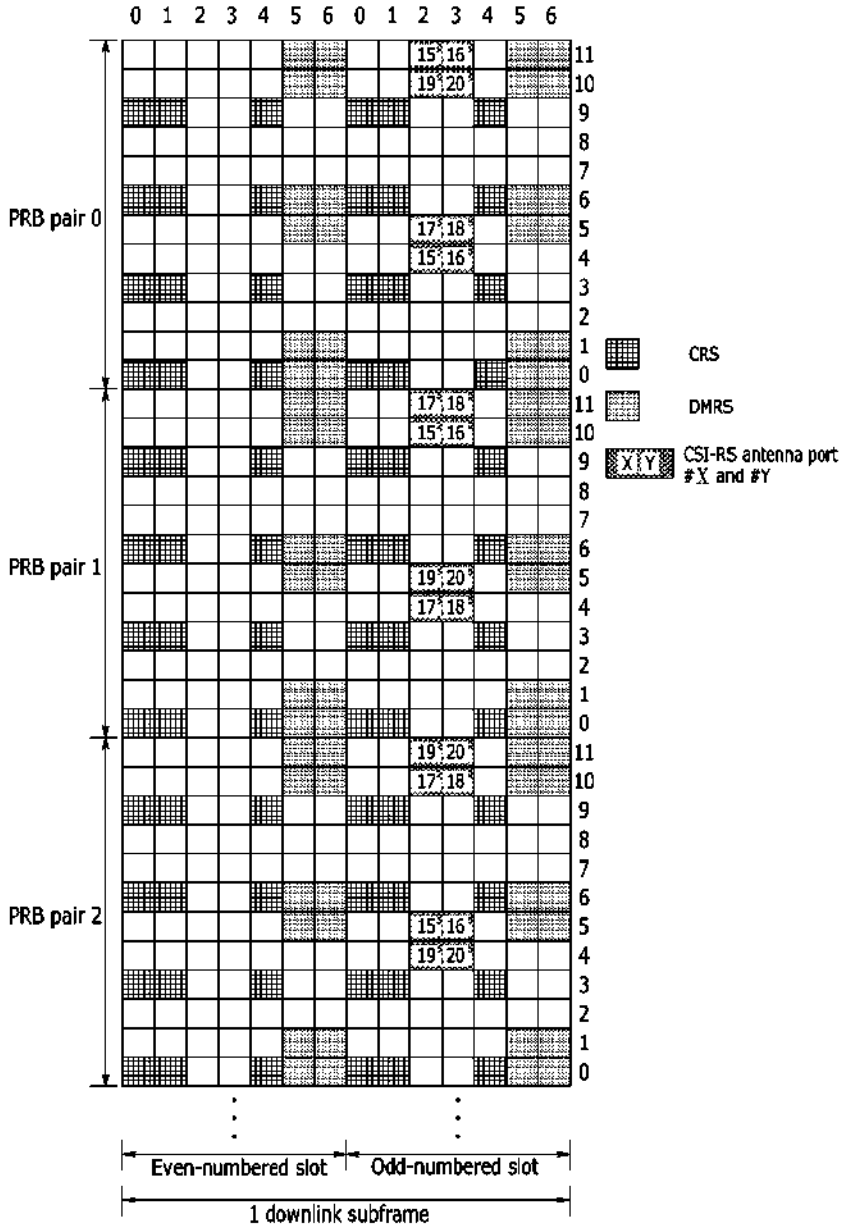
[도14]


32 CSI-RS antenna ports
0 1 2 3 4 5 6 0 1 2 3 4 5 6
PRB pair 1
PRB pair 0
Even-numbered slot
Odd-numbered slot
1 downlink subframe
CRS
DMRS
CSI-RS antenna port #X and #Y, CSI-RS set A

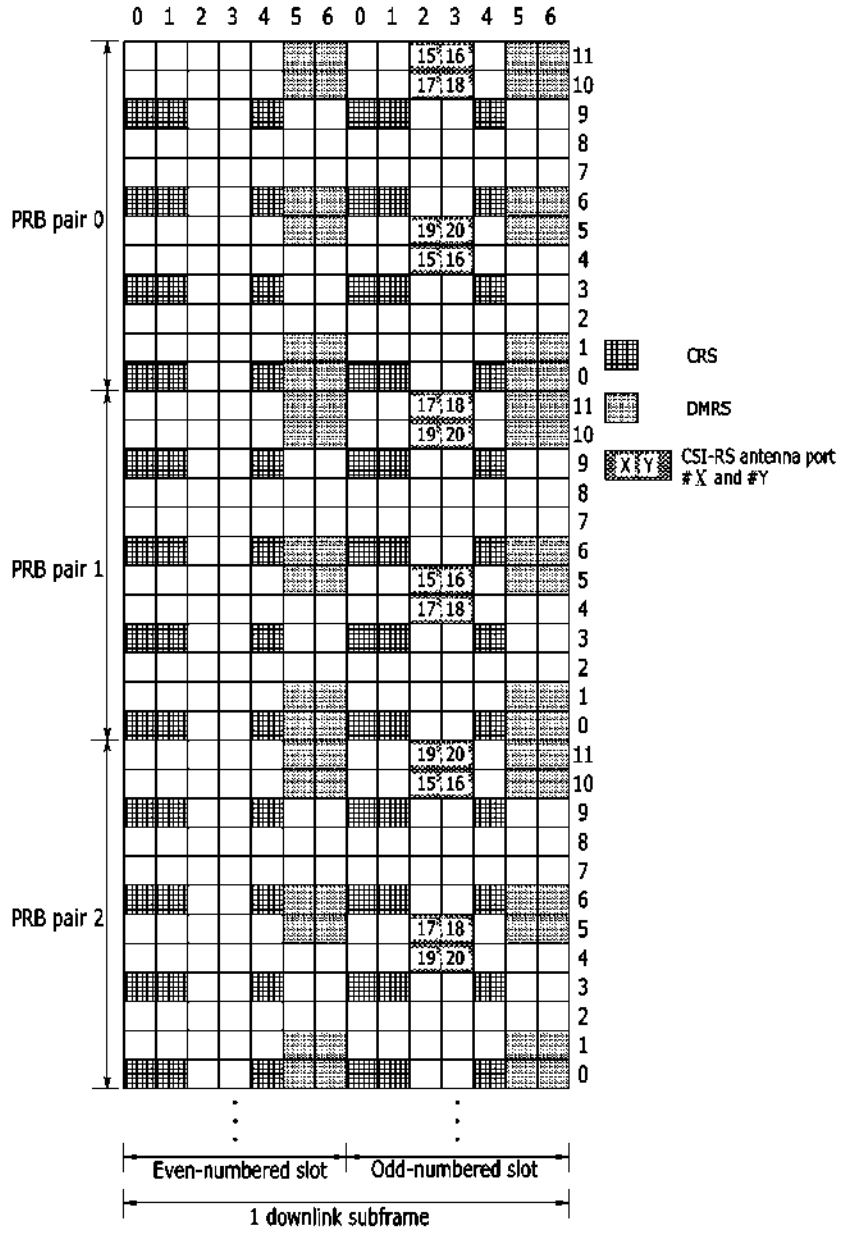
[도15]


0 1 2 3 4 5 6 0 1 2 3 4 5 6
UE-a
UE-c
UE-b
UE-a
UE-a
UE-b
UE-c
UE-a
UE-d
PRB pair 1
PRB pair 0
CRS
DMRS
CSI-RS antenna port #X and #Y for UE-A
Even-numbered slot
Odd-numbered slot
1 downlink subframe

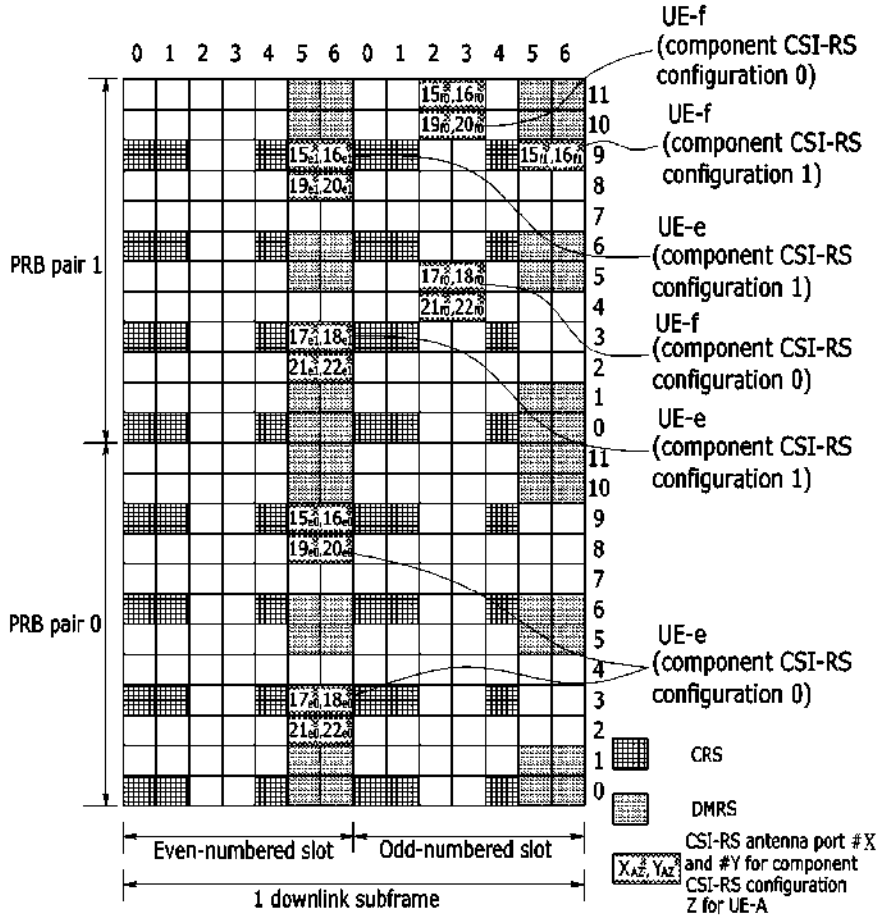
[도16a]


0 1 2 3 4 5 6 0 1 2 3 4 5 6
PRB pair 0
PRB pair 1
PRB pair 2
CRS
DMRS
X Y
CSI-RS antenna port #X and #Y
Even-numbered slot
Odd-numbered slot
1 downlink subframe

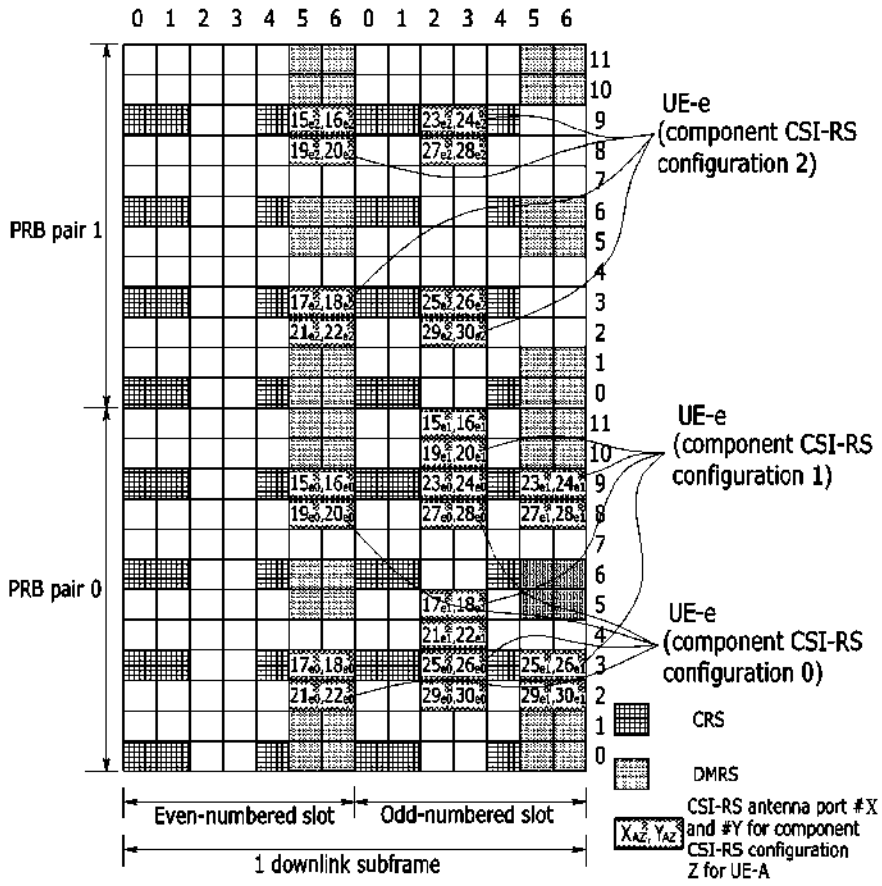
[도16b]


0 1 2 3 4 5 6 0 1 2 3 4 5 6
PRB pair 0
PRB pair 1
PRB pair 2
15, 16
17, 18
19, 20
CRS
DMRS
X, Y
CSI-RS antenna port #X and #Y
Even-numbered slot
Odd-numbered slot
1 downlink subframe

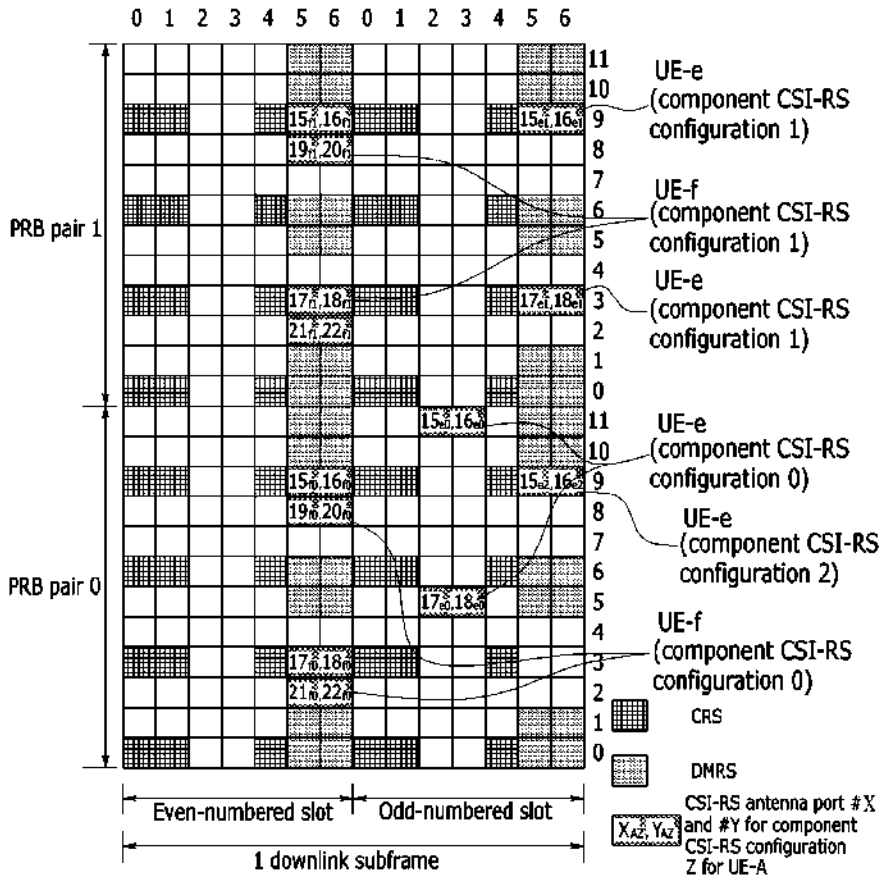
[도17]


0 1 2 3 4 5 6 0 1 2 3 4 5 6
PRB pair 1
PRB pair 0
UE-f (component CSI-RS configuration 0)
UE-f (component CSI-RS configuration 1)
UE-e (component CSI-RS configuration 1)
UE-f (component CSI-RS configuration 0)
UE-e (component CSI-RS configuration 1)
UE-e (component CSI-RS configuration 0)
CRS
DMRS
CSI-RS antenna port #X and #Y for component CSI-RS configuration Z for UE-A
Even-numbered slot
Odd-numbered slot
1 downlink subframe

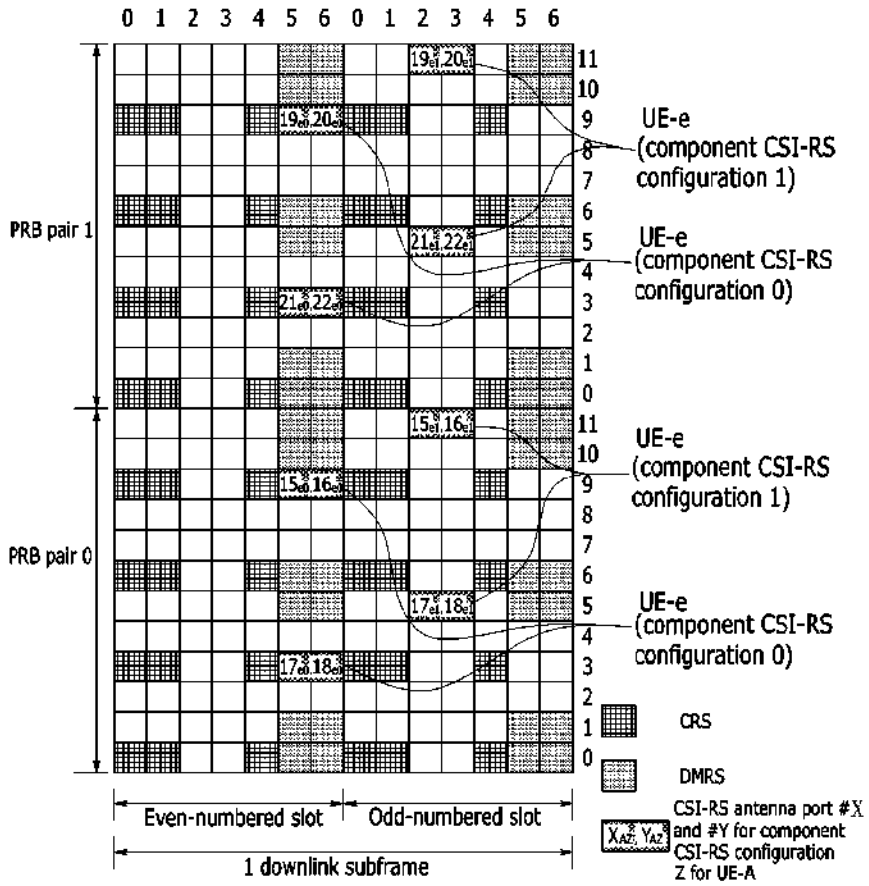
[도18]


0 1 2 3 4 5 6 0 1 2 3 4 5 6
11
10
9
8
7
6
5
4
3
2
1
0
PRB pair 1
PRB pair 0
UE-e
(component CSI-RS
configuration 2)
UE-e
(component CSI-RS
configuration 1)
UE-e
(component CSI-RS
configuration 0)
CRS
DMRS
CSI-RS antenna port #X
and #Y for component
CSI-RS configuration
Z for UE-A
Even-numbered slot
Odd-numbered slot
1 downlink subframe

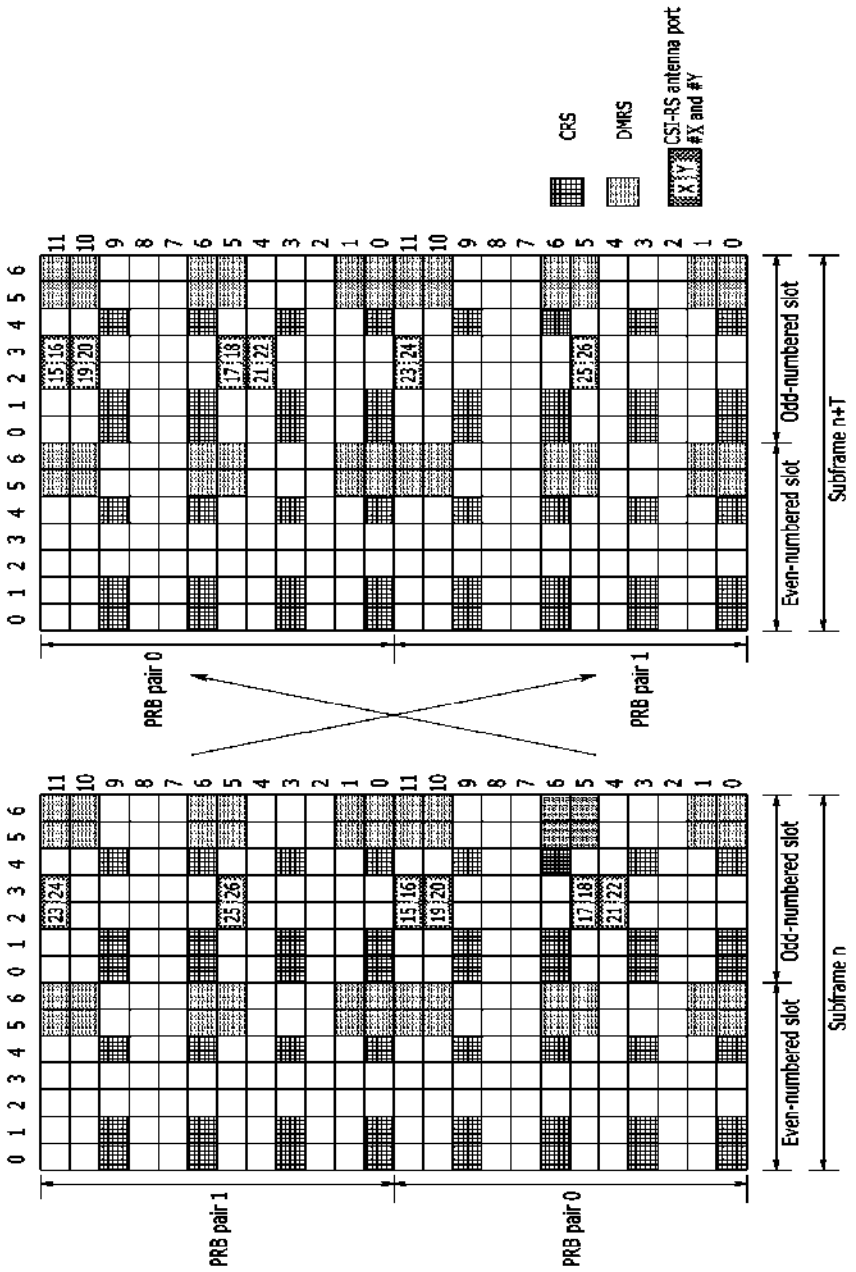
[도19]


0 1 2 3 4 5 6 0 1 2 3 4 5 6
PRB pair 1
PRB pair 0
UE-e (component CSI-RS configuration 1)
UE-f (component CSI-RS configuration 1)
UE-e (component CSI-RS configuration 1)
UE-e (component CSI-RS configuration 0)
UE-e (component CSI-RS configuration 2)
UE-f (component CSI-RS configuration 0)
CRS
DMRS
CSI-RS antenna port #X and #Y for component CSI-RS configuration Z for UE-A
Even-numbered slot
Odd-numbered slot
1 downlink subframe

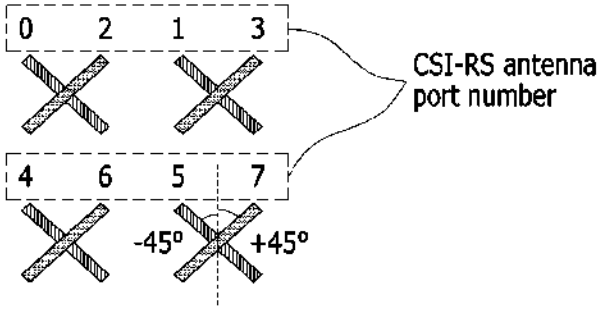
[도20]


0 1 2 3 4 5 6 0 1 2 3 4 5 6
PRB pair 1
PRB pair 0
UE-e (component CSI-RS configuration 1)
UE-e (component CSI-RS configuration 0)
UE-e (component CSI-RS configuration 1)
UE-e (component CSI-RS configuration 0)
CRS
DMRS
CSI-RS antenna port #X and #Y for component CSI-RS configuration Z for UE-A
Even-numbered slot
Odd-numbered slot
1 downlink subframe

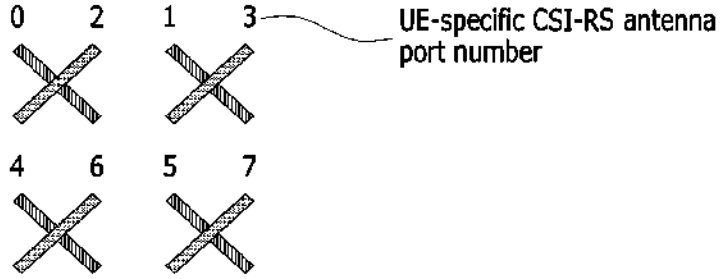
[도21]


CRS
DMRS
CSI-RS antenna port #X and #Y
PRB pair 0
PRB pair 1
PRB pair 1
PRB pair 0
Even-numbered slot
Odd-numbered slot
Subframe n+T
Even-numbered slot
Odd-numbered slot
Subframe n

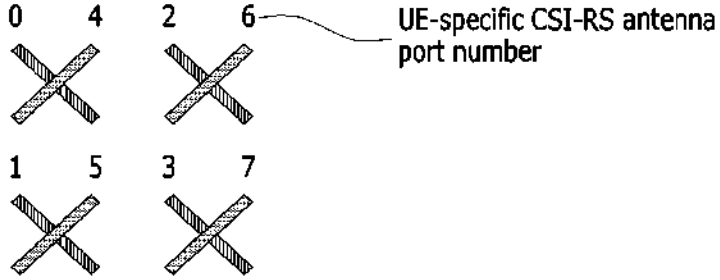
[도22]



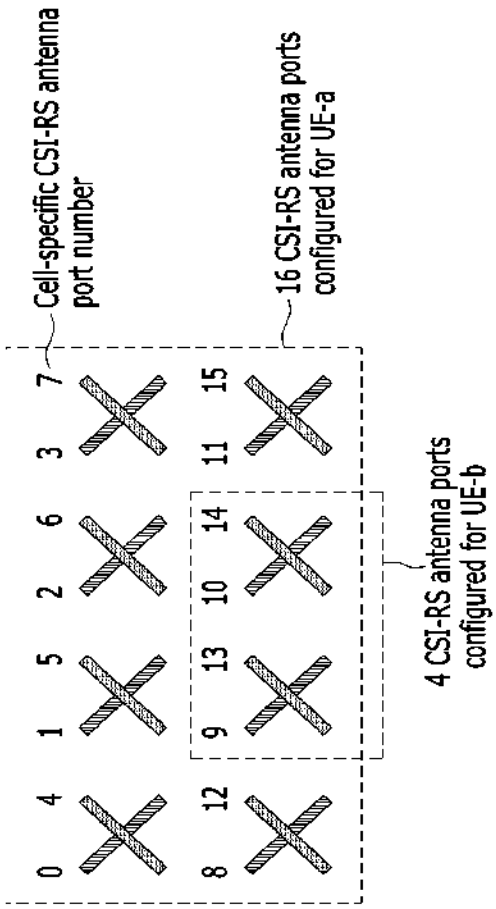
[도23a]



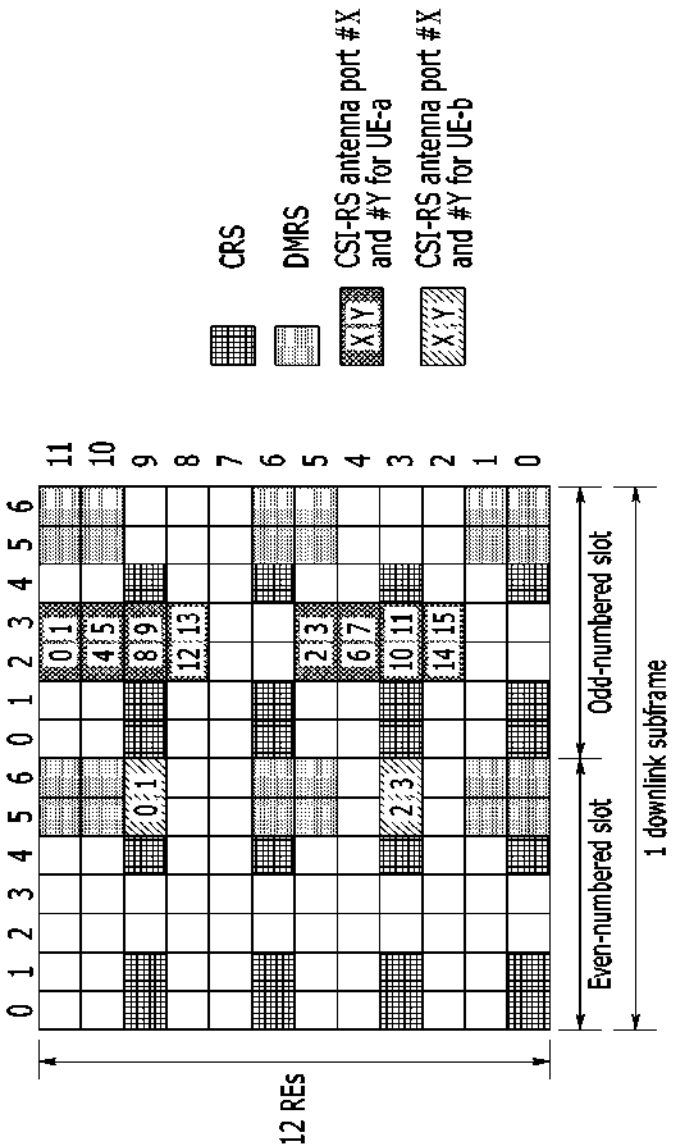
[도23b]



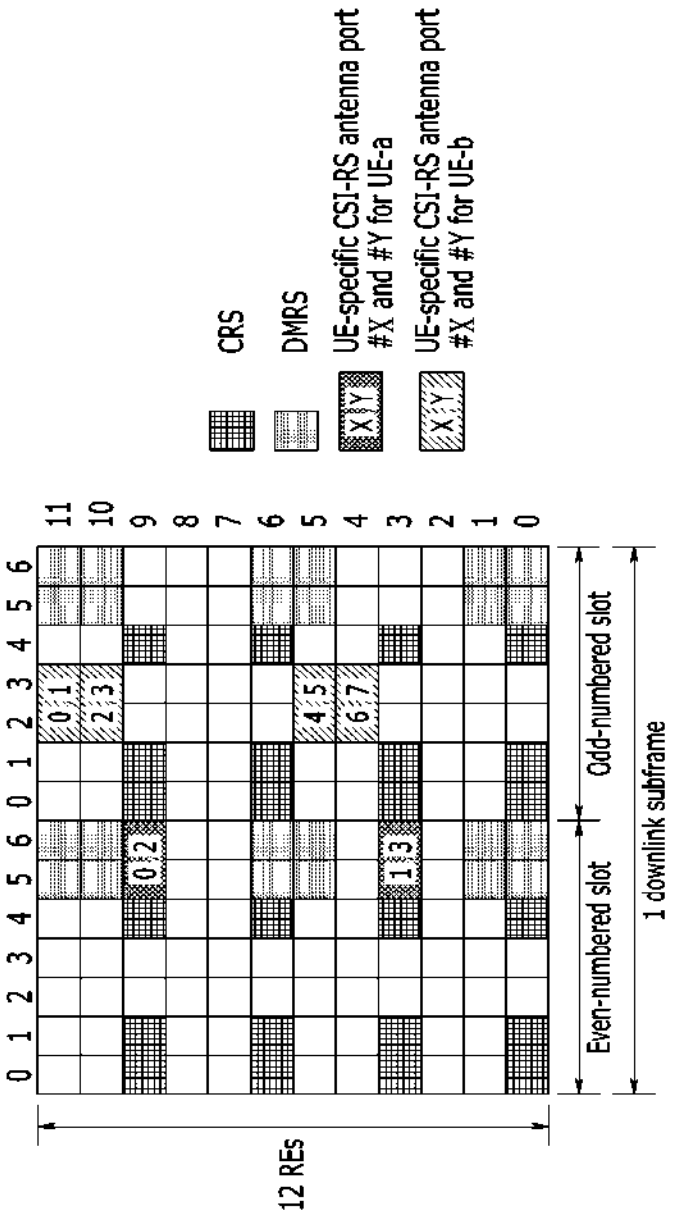
[도24]


Cell-specific CSI-RS antenna port number
16 CSI-RS antenna ports configured for UE-a
4 CSI-RS antenna ports configured for UE-b
0
4
8
12
1
5
9
13
2
6
10
14
3
7
11
15

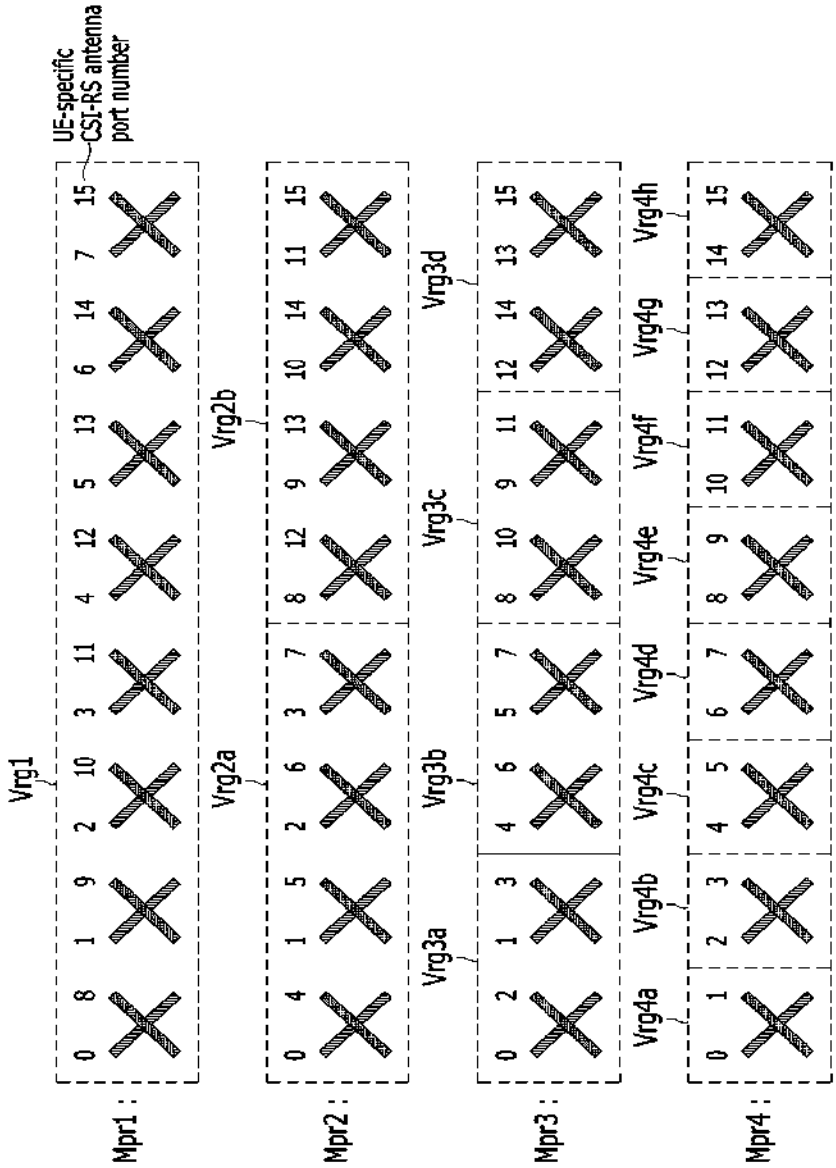
[도25a]


CRS
DMRS
CSI-RS antenna port #X and #Y for UE-a
CSI-RS antenna port #X and #Y for UE-b
X,Y
11 10 9 8 7 6 5 4 3 2 1 0
0 1 2 3 4 5 6
0,1 4,5 8,9 12,13
2,3 6,7 10,11 14,15
0,1 2,3
Odd-numbered slot
Even-numbered slot
1 downlink subframe
12 REs

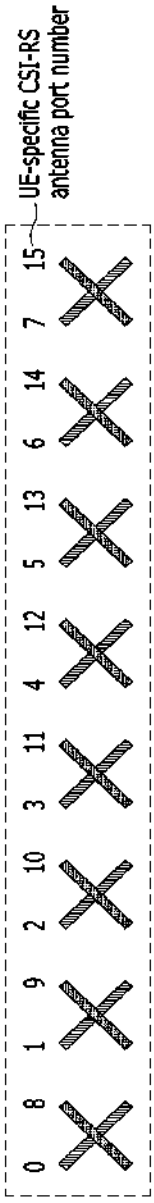
[도25b]


CRS
DMRS
UE-specific CSI-RS antenna port #X and #Y for UE-a
UE-specific CSI-RS antenna port #X and #Y for UE-b
Even-numbered slot
Odd-numbered slot
1 downlink subframe
12 REs

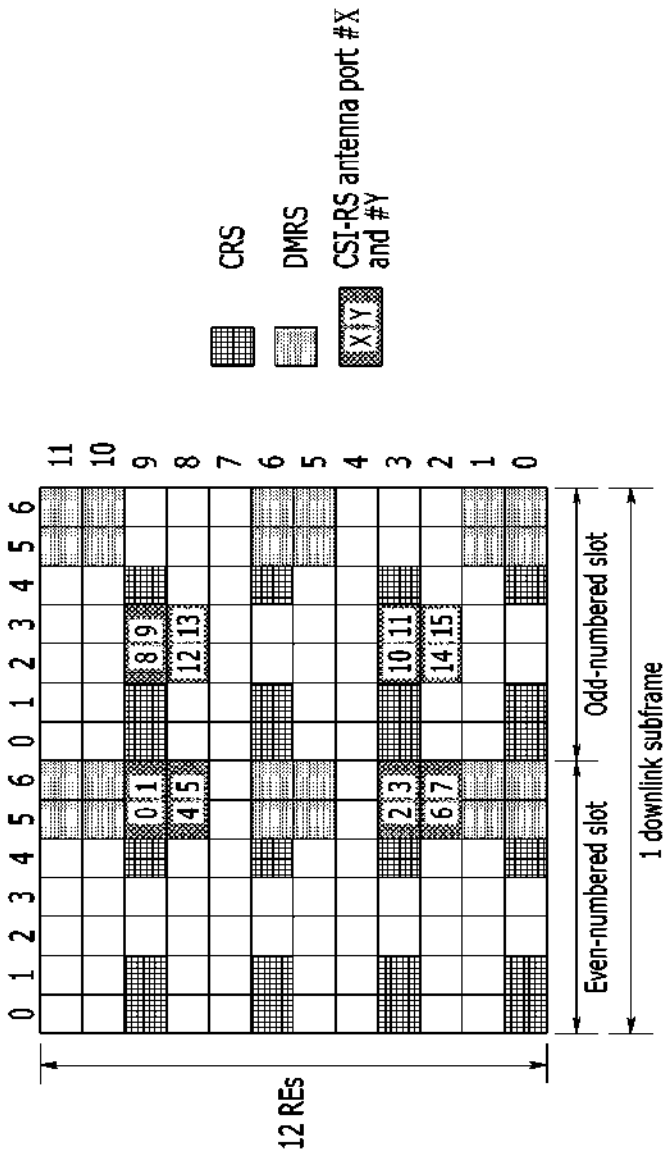
[도26a]


UE-specific CSI-RS antenna port number
Vrg1
Vrg2a
Vrg2b
Vrg3a
Vrg3b
Vrg3c
Vrg3d
Vrg4a
Vrg4b
Vrg4c
Vrg4d
Vrg4e
Vrg4f
Vrg4g
Vrg4h
Mpr1 :
Mpr2 :
Mpr3 :
Mpr4 :

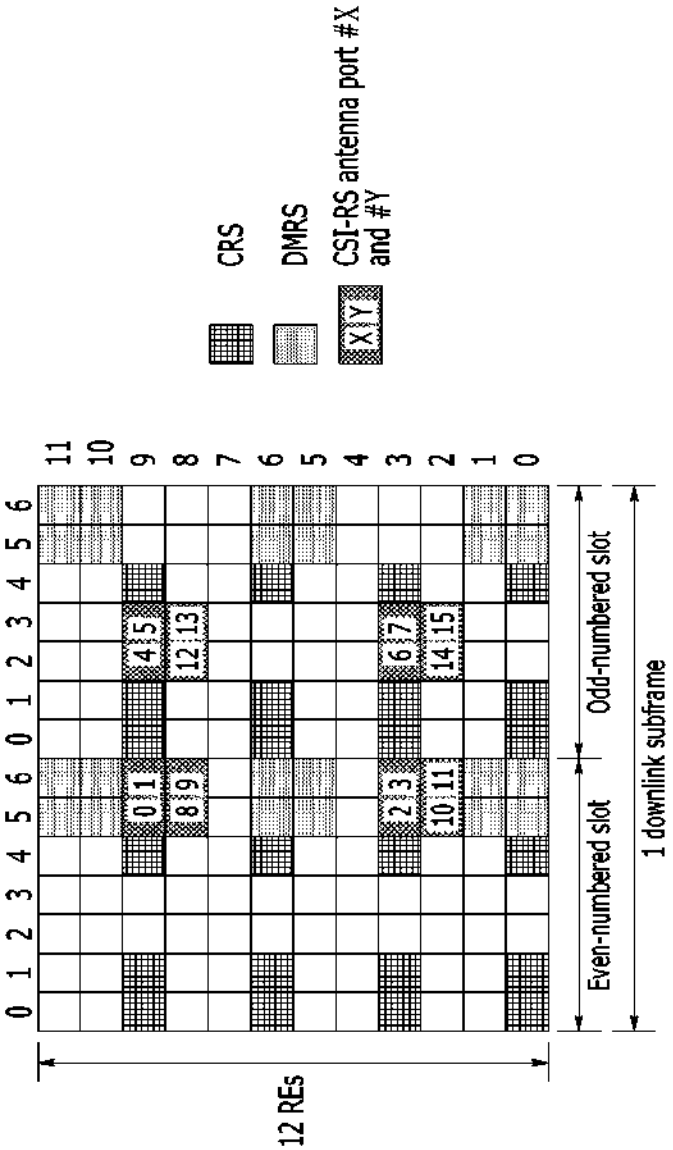
[도26b]


UE-specific CSI-RS antenna port number
15
7
14
6
13
5
12
4
11
3
10
2
9
1
8
0

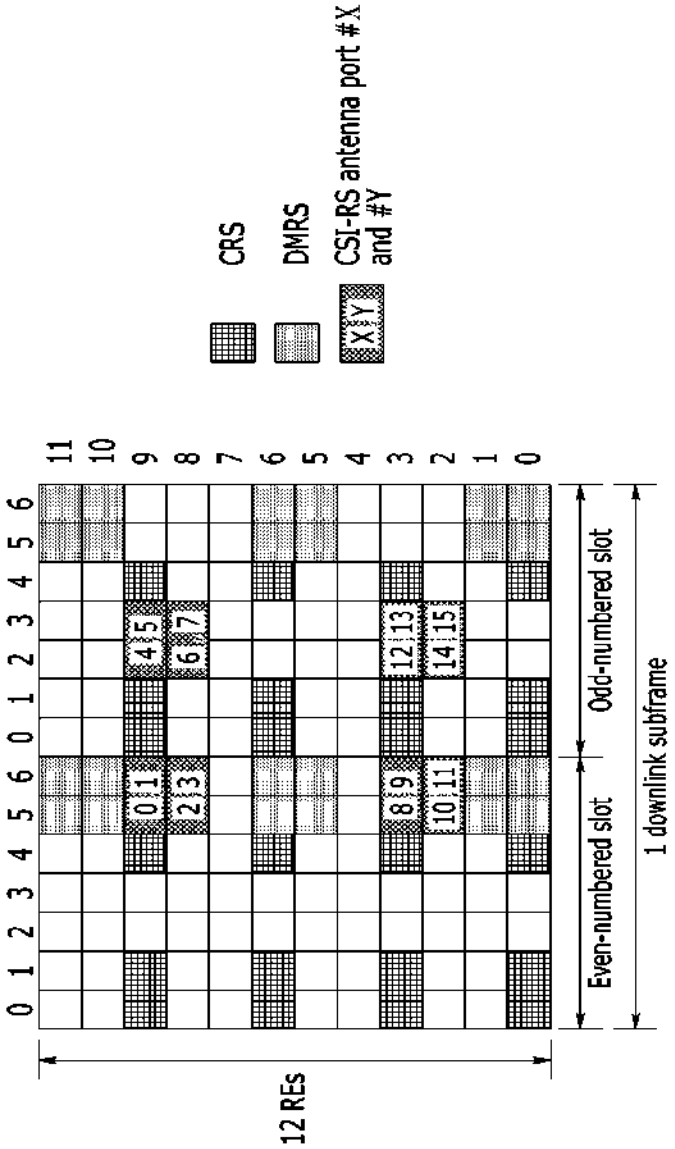
[도26c]


CRS
DMRS
CSI-RS antenna port #X and #Y
X Y
0 1 2 3 4 5 6
11 10 9 8 7 6 5 4 3 2 1 0
0 1
4 5
8 9
12 13
2 3
6 7
10 11
14 15
Even-numbered slot
Odd-numbered slot
1 downlink subframe
12 REs

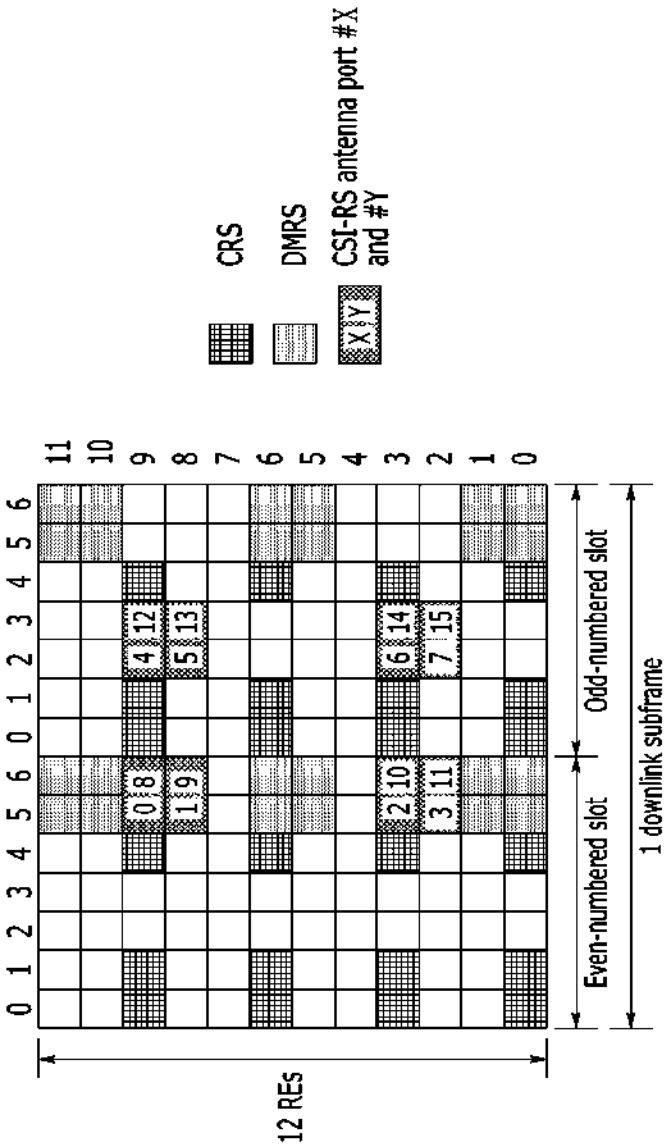
[도26d]


CRS
DMRS
CSI-RS antenna port #X and #Y
X Y
11 10 9 8 7 6 5 4 3 2 1 0
0 1 2 3 4 5 6
0 1
8 9
4 5
12 13
2 3
10 11
6 7
14 15
Even-numbered slot
Odd-numbered slot
1 downlink subframe
12 REs

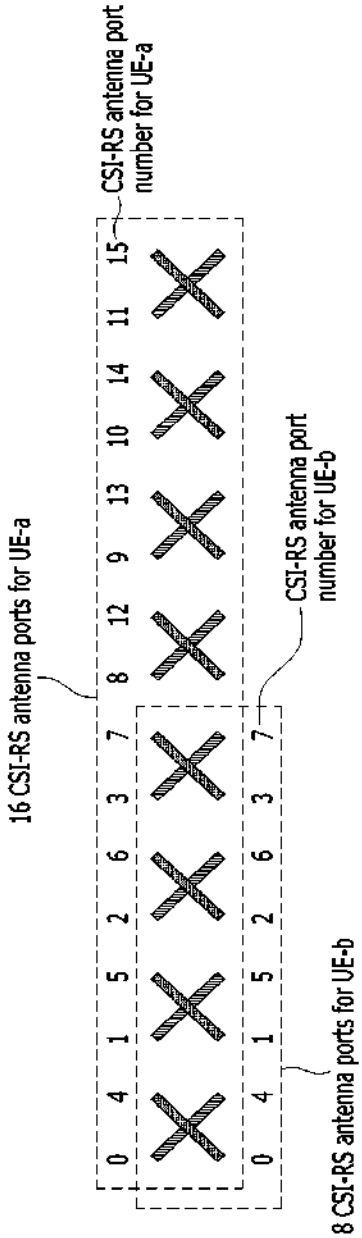
[도26c]


CRS
DMRS
CSI-RS antenna port #X and #Y
X Y
11 10 9 8 7 6 5 4 3 2 1 0
0 1 2 3 4 5 6
0 1
2 3
4 5
6 7
8 9
10 11
12 13
14 15
Odd-numbered slot
Even-numbered slot
1 downlink subframe
12 REs

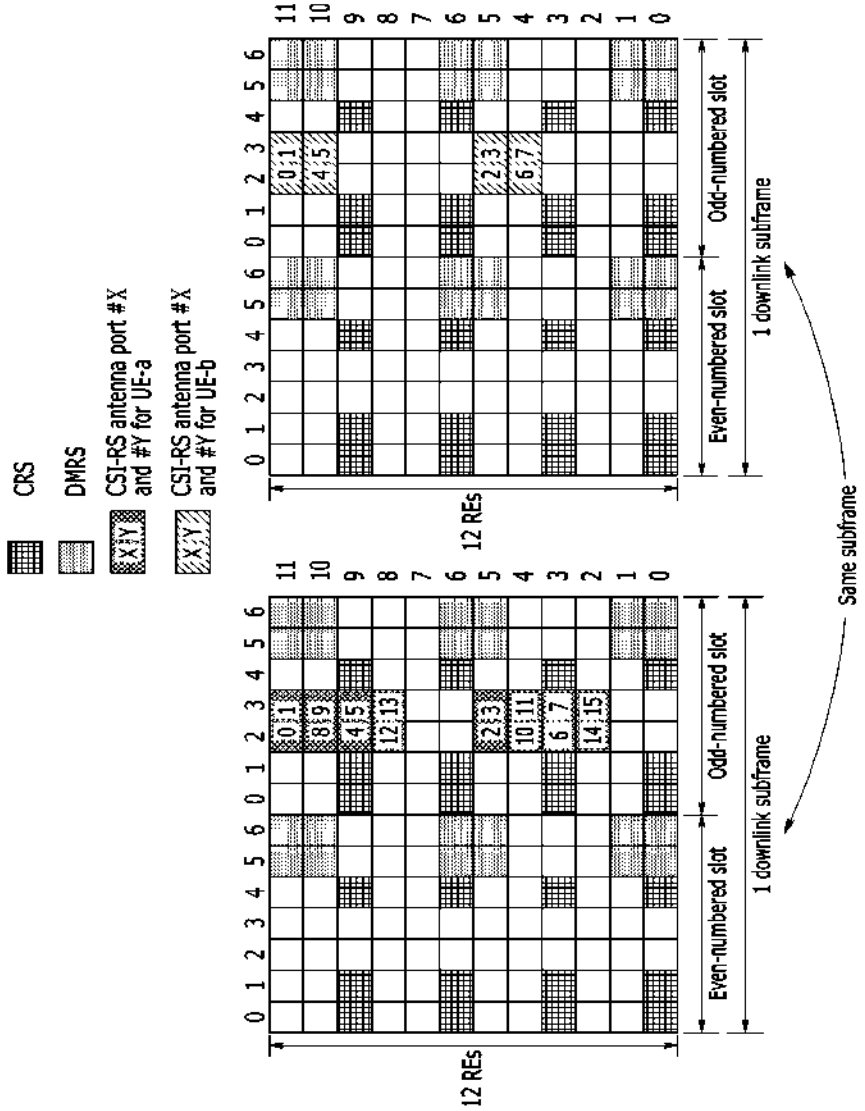
[도26f]


CRS
DMRS
CSI-RS antenna port #X and #Y
X Y
11 10 9 8 7 6 5 4 3 2 1 0
0 1 2 3 4 5 6
0 8
1 9
4 12
5 13
2 10
3 11
6 14
7 15
Odd-numbered slot
Even-numbered slot
1 downlink subframe
12 REs

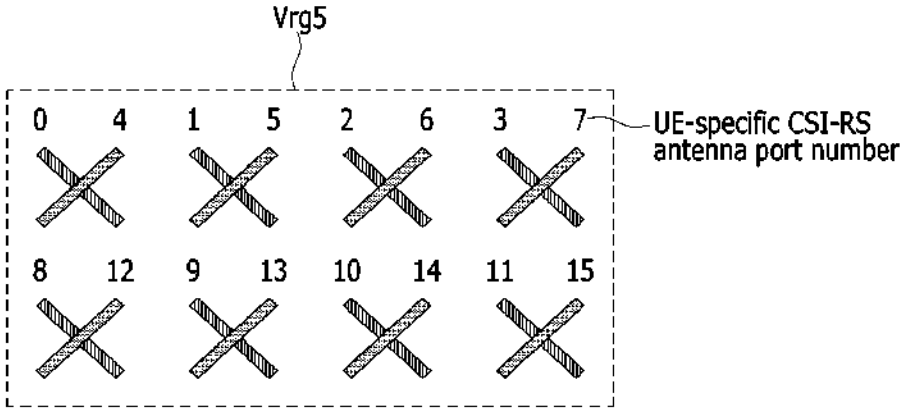
[도27]


CSI-RS antenna port number for UE-a
16 CSI-RS antenna ports for UE-a
CSI-RS antenna port number for UE-b
8 CSI-RS antenna ports for UE-b
0 4 1 5 2 6 3 7 8 12 9 13 10 14 11 15
0 4 1 5 2 6 3 7

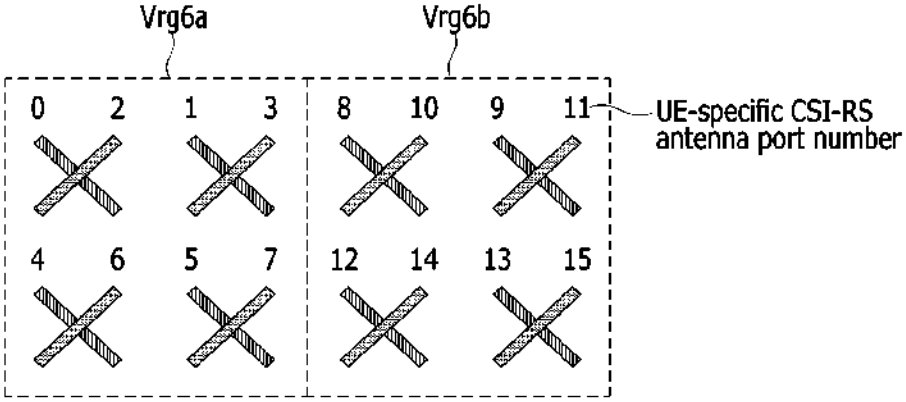
[도28]


CRS
DMRS
CSI-RS antenna port #X and #Y for UE-a
CSI-RS antenna port #X and #Y for UE-b
Odd-numbered slot
Even-numbered slot
1 downlink subframe
Same subframe
12 REs

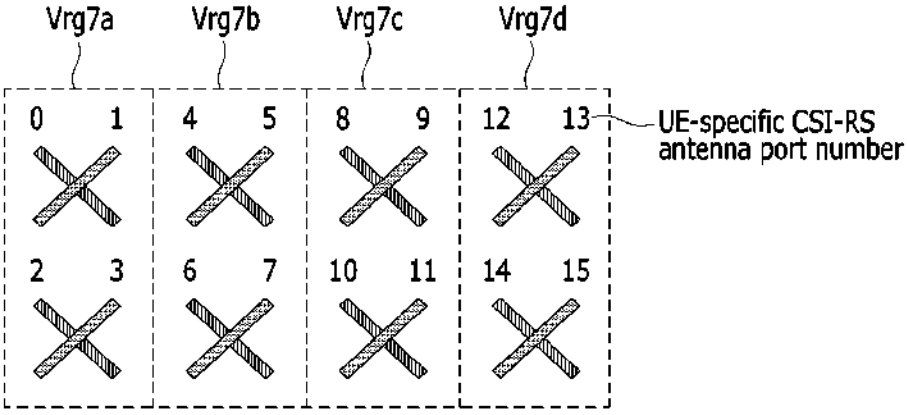
[도29a]


Vrg5
0 4 1 5 2 6 3 7
8 12 9 13 10 14 11 15
UE-specific CSI-RS antenna port number

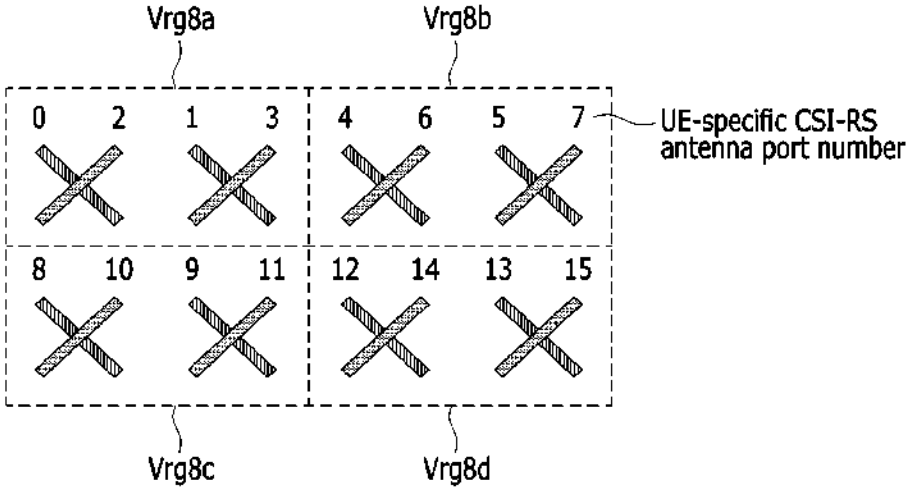
[도29b]



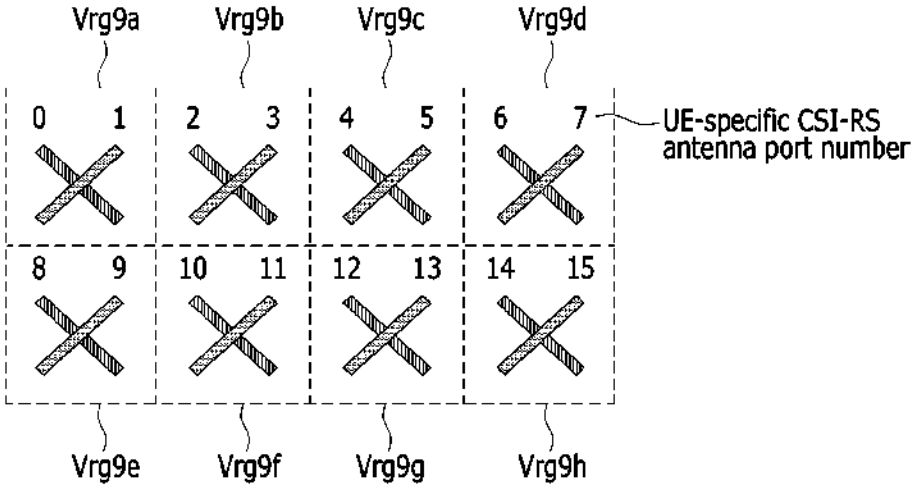
[도29c]



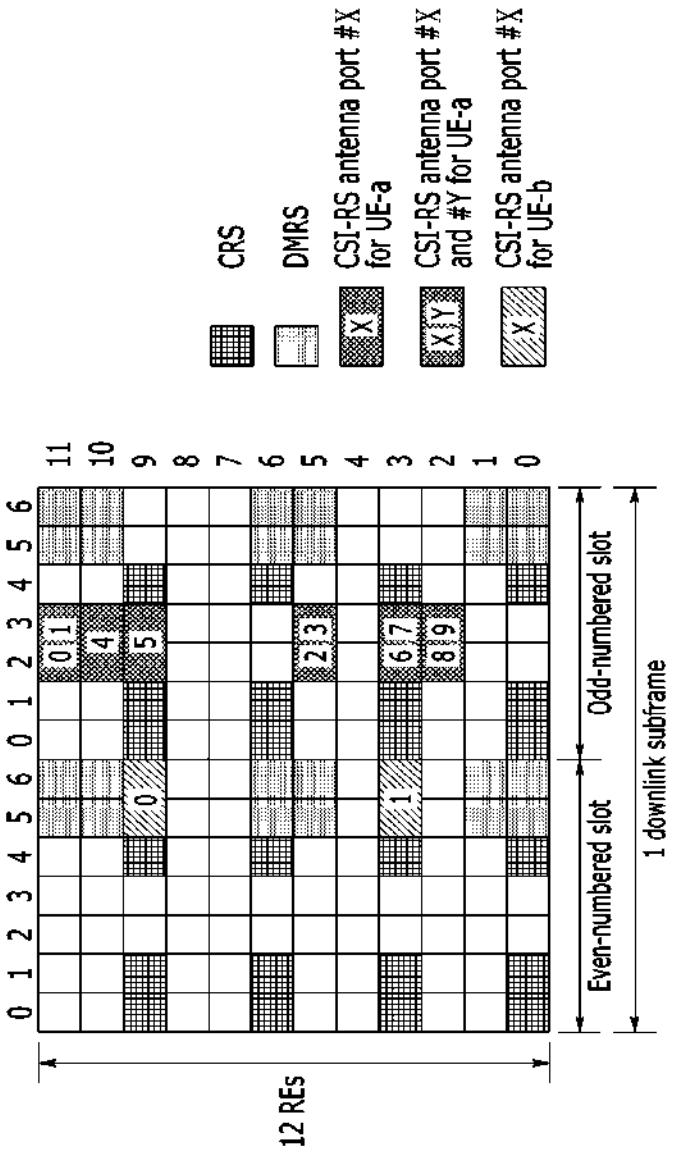
[도29d]



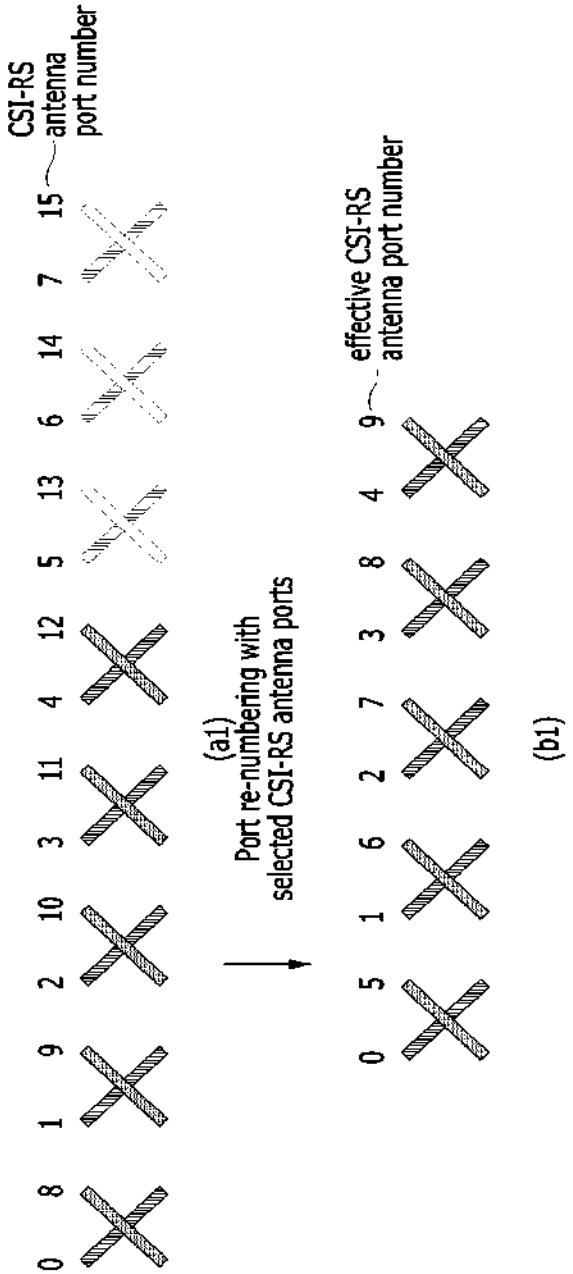
[도29c]


Vrg9a
Vrg9b
Vrg9c
Vrg9d
0 1
2 3
4 5
6 7
UE-specific CSI-RS antenna port number
8 9
10 11
12 13
14 15
Vrg9e
Vrg9f
Vrg9g
Vrg9h

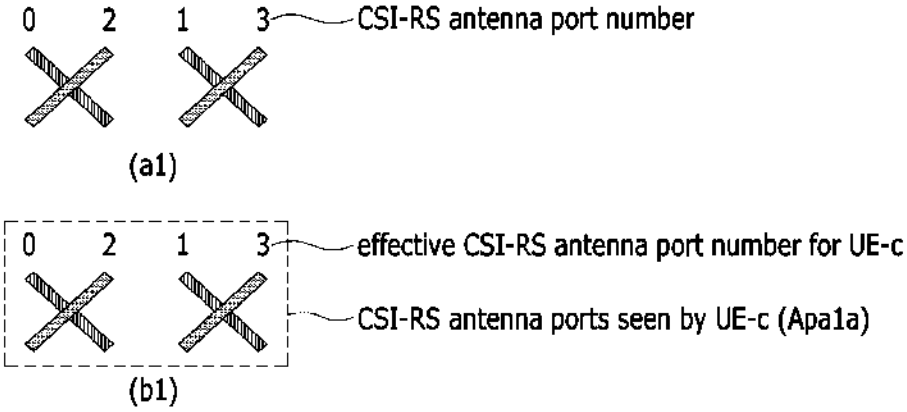
[도30]


CRS
DMRS
CSI-RS antenna port #X for UE-a
CSI-RS antenna port #X and #Y for UE-a
CSI-RS antenna port #X for UE-b
X
X Y
X
0 1 2 3 4 5 6 0 1 2 3 4 5 6
11 10 9 8 7 6 5 4 3 2 1 0
0 1 2 3 4 5
Odd-numbered slot
Even-numbered slot
1 downlink subframe
12 REs

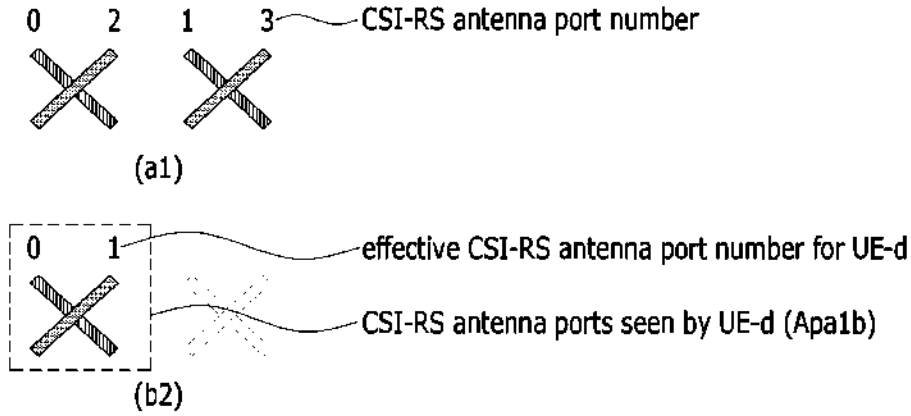
[도31]


CSI-RS antenna port number
0 8 1 9 2 10 3 11 4 12 5 13 6 14 7 15
(a1)
Port re-numbering with selected CSI-RS antenna ports
effective CSI-RS antenna port number
0 5 1 6 2 7 3 8 4 9
(b1)

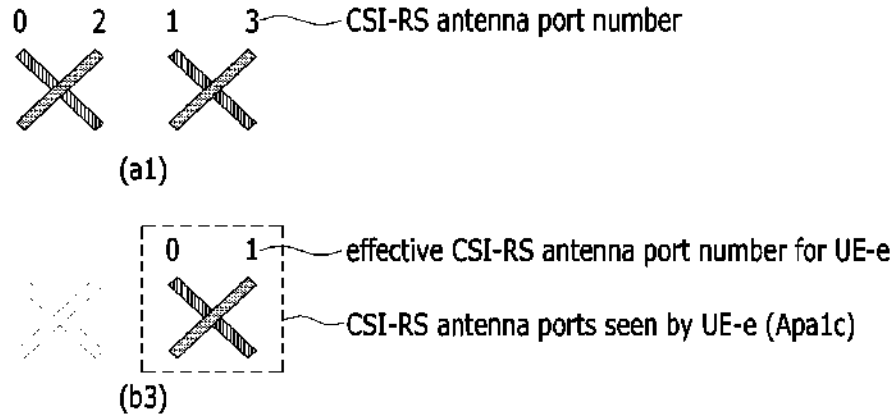
[도32a]



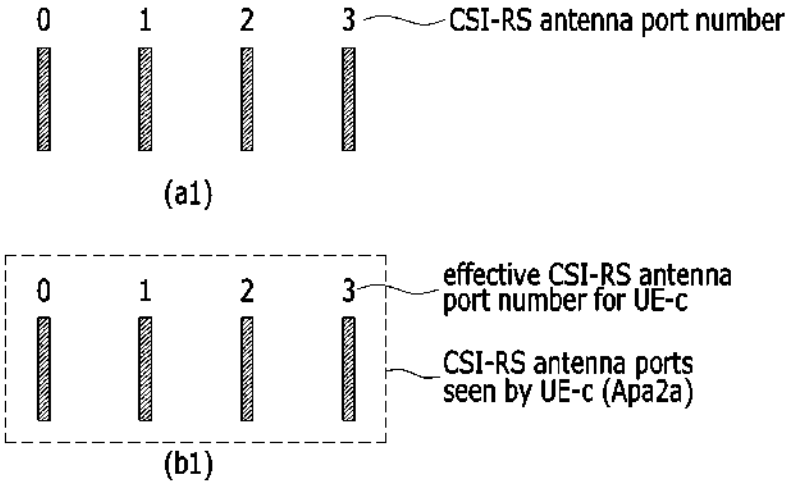
[도32b]



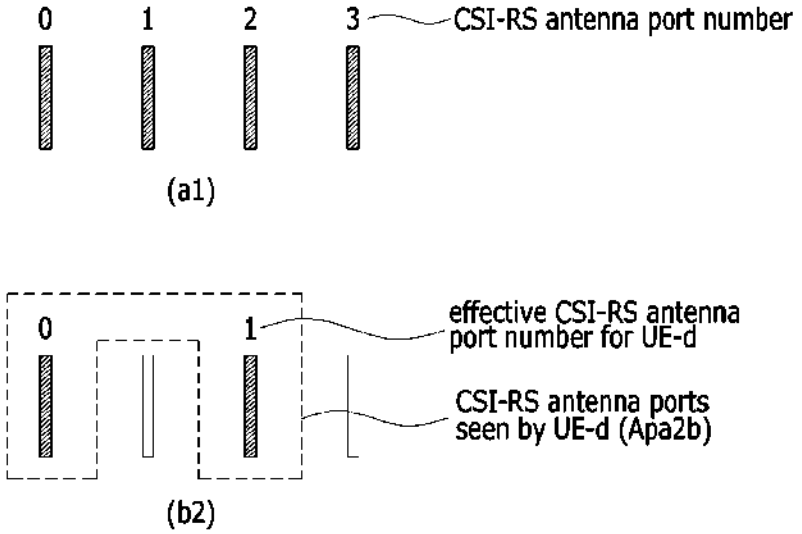
[도32c]



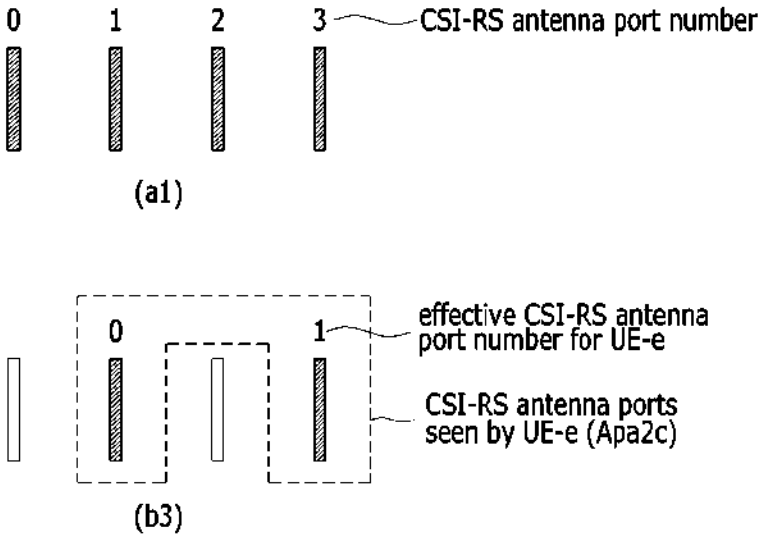
[도33a]


0
1
2
3
CSI-RS antenna port number
(a1)
0
1
2
3
effective CSI-RS antenna port number for UE-c
CSI-RS antenna ports seen by UE-c (Apa2a)
(b1)

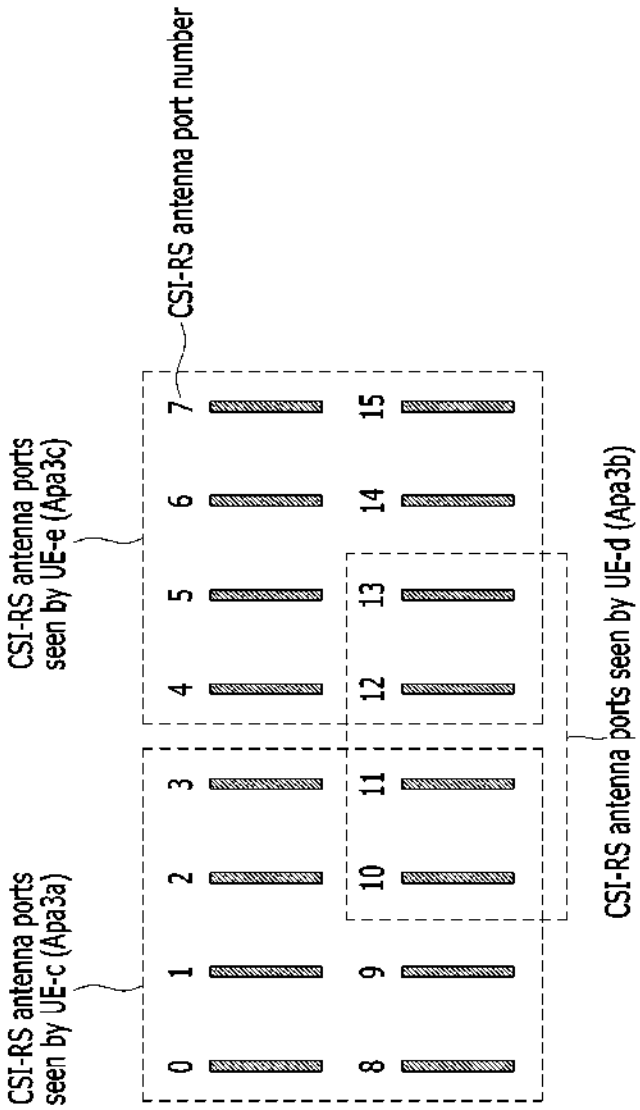
[도33b]


0
1
2
3
CSI-RS antenna port number
(a1)
0
1
effective CSI-RS antenna port number for UE-d
CSI-RS antenna ports seen by UE-d (Apa2b)
(b2)

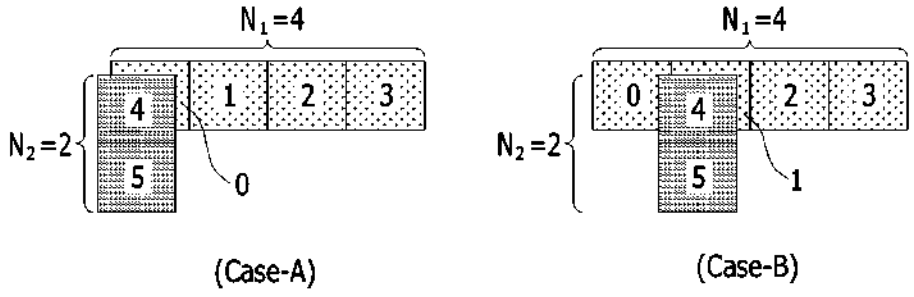
[도33c]


0
1
2
3
CSI-RS antenna port number
(a1)
0
1
effective CSI-RS antenna port number for UE-e
CSI-RS antenna ports seen by UE-e (Apa2c)
(b3)

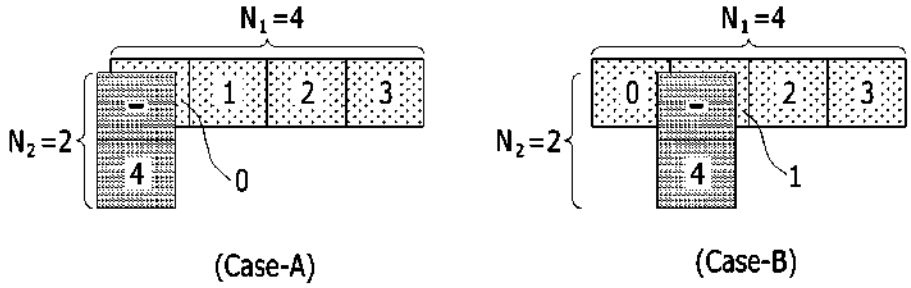
[도34]


CSI-RS antenna port number
CSI-RS antenna ports seen by UE-e (Apa3c)
CSI-RS antenna ports seen by UE-c (Apa3a)
CSI-RS antenna ports seen by UE-d (Apa3b)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

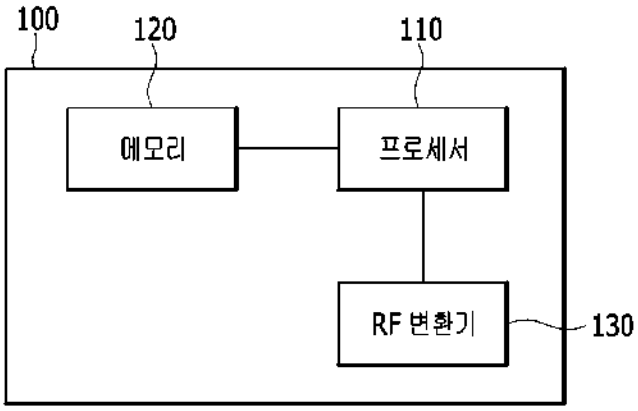
[도35]


N1=4
N2=2
4
1
2
3
5
0
(Case-A)
N1=4
N2=2
0
4
2
3
5
1
(Case-B)

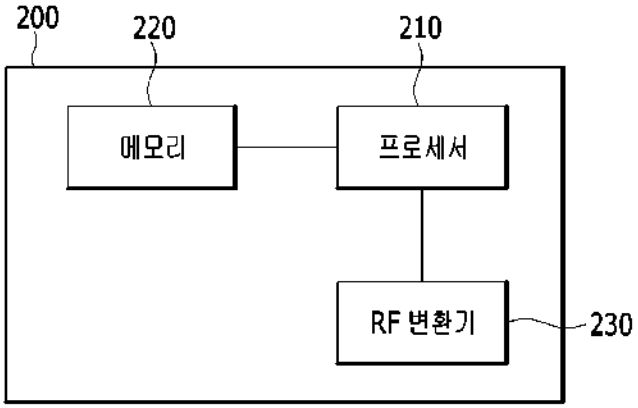
[도36]


N1=4
N2=2
1
2
3
4
0
(Case-A)
N1=4
N2=2
0
2
3
4
1
(Case-B)

[도37]


100
120
110
메모리
프로세서
RF 변환기
130

[도38]


200
220
210
메모리
프로세서
RF 변환기
230

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2016/001014

A. CLASSIFICATION OF SUBJECT MATTER

H04L 5/00(2006.01)i, H04B 7/06(2006.01)i, H04B 7/02(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04L 5/00; H04W 72/04; H04W 24/08; H04B 7/04; H04B 7/06; H04B 7/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Utility models and applications for Utility models: IPC as above
Japanese Utility models and applications for Utility models: IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS (KIPO internal) & Keywords: CSI-RS antenna port, port number mapping rule, the number of ports, CSI-RS antenna group, bit code, horizontal shaft, vertical shaft, polarization shaft, numbering, re-numbering, shaft order, port number state information, bitmap, PDSCH

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2014-0098689 A1 (INTERDIGITAL PATENT HOLDINGS, INC.) 10 April 2014 See paragraphs [0123]-[0234]; and figures 10A-14C.	1-20
A	WO 2014-069821 A1 (PANTECH CO., LTD.) 08 May 2014 See paragraphs [82]-[94]; and figures 6, 7.	1-20
A	WO 2014-161145 A1 (PANASONIC INTELLECTUAL PROPERTY CORPORATION OF AMERICA) 09 October 2014 See page 7, line 7-page 13, line 22; and figures 6-9	1-20
A	US 2014-0192917 A1 (SAMSUNG ELECTRONICS CO., LTD.) 10 July 2014 See paragraphs [0100]-[0120]; and figures 14-18.	1-20
A	US 2013-0100901 A1 (SAMSUNG ELECTRONICS CO., LTD.) 25 April 2013 See paragraphs [0082]-[0094]; and figures 5-7.	1-20

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
04 MAY 2016 (04.05.2016)	**04 MAY 2016 (04.05.2016)**
Name and mailing address of the ISA/KR Korean Intellectual Property Office Government Complex-Daejeon, 189 Seonsa-ro, Daejeon 302-701, Republic of Korea Facsimile No. 82-42-472-7140	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2016/001014

Patent document cited in search report	Publication date	Patent family member	Publication date
US 2014-0098689 A1	10/04/2014	EP 2901571 A1	05/08/2015
		JP 2015-536099 A	17/12/2015
		TW 201429182 A	16/07/2014
		WO 2014-052806 A1	03/04/2014
WO 2014-069821 A1	08/05/2014	KR 10-2014-0057005 A	12/05/2014
		US 2015-0288497 A1	08/10/2015
WO 2014-161145 A1	09/10/2014	CN 105191164 A	23/12/2015
		EP 2982049 A1	10/02/2016
US 2014-0192917 A1	10/07/2014	AU 2014-205792 A1	30/04/2015
		CN 104885499 A	02/09/2015
		EP 2944111 A1	18/11/2015
		KR 10-2015-0104556 A	15/09/2015
		US 9178583 B2	03/11/2015
		WO 2014-109557 A1	17/07/2014
US 2013-0100901 A1	25/04/2013	AU 2012-326774 A1	29/05/2014
		AU 2012-326774 A2	03/07/2014
		CA 2853003 A1	25/04/2013
		CN 104012016 A	27/08/2014
		EP 2584731 A2	24/04/2013
		EP 2584731 A3	03/09/2014
		JP 2015-501586 A	15/01/2015
		KR 10-2013-0043602 A	30/04/2013
		RU 2014120168 A	27/11/2015
		US 2015-0092729 A1	02/04/2015
		US 8913576 B2	16/12/2014
		WO 2013-058624 A1	25/04/2013

Form PCT/ISA/210 (patent family annex) (January 2015)

국 제 조 사 보 고 서

국제출원번호
PCT/KR2016/001014

A. 발명이 속하는 기술분류(국제특허분류(IPC))

H04L 5/00(2006.01)i, H04B 7/06(2006.01)i, H04B 7/02(2006.01)i

B. 조사된 분야

조사된 최소문헌(국제특허분류를 기재)

H04L 5/00; H04W 72/04; H04W 24/08; H04B 7/04; H04B 7/06; H04B 7/02

조사된 기술분야에 속하는 최소문헌 이외의 문헌

한국등록실용신안공보 및 한국공개실용신안공보: 조사된 최소문헌란에 기재된 IPC

일본등록실용신안공보 및 일본공개실용신안공보: 조사된 최소문헌란에 기재된 IPC

국제조사에 이용된 전산 데이터베이스(데이터베이스의 명칭 및 검색어(해당하는 경우))

eKOMPASS(특허청 내부 검색시스템) & 키워드: CSI-RS 안테나 포트, 포트 번호, 맵핑 규칙, 포트의 수, CSI-RS 안테나 그룹, 비트 코드, 수평 축, 수직 축, 편파 축, 번호 부여, 세부역, 축 순서, 포트 번호 부여 여부 정보, 비트맵, PDSCH

C. 관련 문헌

카테고리*	인용문헌명 및 관련 구절(해당하는 경우)의 기재	관련 청구항
A	US 2014-0098689 A1 (INTERDIGITAL PATENT HOLDINGS, INC.) 2014.04.10 단락 [0123]-[0234]; 및 도면 10A-14C 참조.	1-20
A	WO 2014-069821 A1 (주식회사 팬택) 2014.05.08 단락 [82]-[94]; 및 도면 6, 7 참조.	1-20
A	WO 2014-161145 A1 (PANASONIC INTELLECTUAL PROPERTY CORPORATION OF AMERICA) 2014.10.09 페이지 7, 라인 7 - 페이지 13, 라인 22; 및 도면 6-9 참조.	1-20
A	US 2014-0192917 A1 (SAMSUNG ELECTRONICS CO., LTD.) 2014.07.10 단락 [0100]-[0120]; 및 도면 14-18 참조.	1-20
A	US 2013-0100901 A1 (SAMSUNG ELECTRONICS CO., LTD.) 2013.04.25 단락 [0082]-[0094]; 및 도면 5-7 참조.	1-20

☐ 추가 문헌이 C(계속)이 기재되어 있습니다.

☒ 대응특허에 관한 별지를 참조하십시오.

* 인용된 문헌의 특별 카테고리

"A" 특별히 관련이 없는 것으로 보이는 일반적인 기술수준을 정의한 문헌

"E" 국제출원일보다 빠른 출원일 또는 우선일을 가지나 국제출원일 이후에 공개된 선출원 또는 특허 문헌

"L" 우선권 주장에 의문을 제기하는 문헌 또는 다른 인용문헌의 공개일 또는 다른 특별한 이유(이유를 명시)를 밝히기 위하여 인용된 문헌

"O" 구두 개시, 사용, 전시 또는 기타 수단을 언급하고 있는 문헌

"P" 우선일 이후에 공개되었으나 국제출원일 이전에 공개된 문헌

"T" 국제출원일 또는 우선일 후에 공개된 문헌으로, 출원과 상충하지 않으며 발명의 기초가 되는 원리나 이론을 이해하기 위해 인용된 문헌

"X" 특별한 관련이 있는 문헌. 해당 문헌 하나만으로 청구된 발명의 신규성 또는 진보성이 없는 것으로 본다.

"Y" 특별한 관련이 있는 문헌. 해당 문헌이 하나 이상의 다른 문헌과 조합하는 경우로 그 조합이 당업자에게 자명한 경우 청구된 발명은 진보성이 없는 것으로 본다.

"&" 동일한 대응특허문헌에 속하는 문헌

국제조사의 실제 완료일	국제조사보고서 발송일
2016년 05월 04일 (04.05.2016)	2016년 05월 04일 (04.05.2016)

ISA/KR의 명칭 및 우편주소
대한민국 특허청
(35208) 대전광역시 서구 청사로 189,
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(54) METHOD, EQUIPMENT AND SYSTEM FOR COORDINATED MULTI-POINT TRANSMISSION/ RECEPTION

(57) A method, a device, and a system for CoMP coordinated multi-point transmission are disclosed, where the method includes: obtaining reference signal received power RSRP of a cell in a measurement set of a user equipment UE; determining that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold; and combining a cell whose RSRP is greater between the first cell and the second cell with the serving cell of the UE into a coordinated set of the UE, and performing coordinated multi-point transmission on the UE, thereby improving an effect of CoMP.

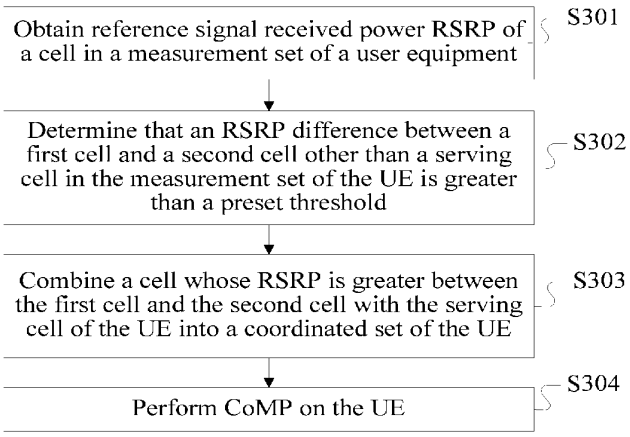


FIG. 3

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Description

TECHNICAL FIELD

[0001] The present invention relates to the field of network technologies, and in particular, to a method, a device, and a system for coordinated multi-point transmission.

BACKGROUND

[0002] CoMP (Coordinated Multi-point Transission/reception, coordinated multi-point transmission) is one of key technologies of LTE-A (Long Term Evolution-Advanced, long term evolution-advanced), and is used to expand coverage of a high data rate and increase average throughput of a system, thereby improving performance of a cell edge user.

[0003] FIG. 1 is a schematic diagram of a CoMP technology. CoMP is a cooperative sending and receiving technology, where one base station (for example, eNodeB x in FIG. 1) is connected to several access points (for example, Point x in FIG. 1), and one access point may include one or more antennas. Multiple users (User Equipment, UE for short) (UE x) may be served by one or more access points located at one same base station or different base stations. A coordination center controller may obtain information from a distributed access point, and allocate a resource to meet a QoS (Quality of Service, quality of service) requirement of a user, thereby maximizing performance of an entire network.

[0004] In the CoMP technology, signals of a serving cell and multiple coordination cells may be simultaneously sent or received, which is equivalent to increasing the number of antennas at a transmit end or a receive end, and demodulation performance is improved through a multiple input multiple output (Multiple Input Multiple Output, MIMO for short) receiver.

[0005] A main principle of uplink-based intra-eNodeB (Intra-eNodeB) CoMP is that, antennas in different cells of one same base station are used for receiving a signal of a certain user, and a combined gain and an interference suppression gain of the signal received by the multiple antennas may be obtained at the same time, and the combined gain of the signal is greater for a user closer to a boundary between two cells. By taking FIG. 2 as an example, a user is located at a boundary between cells, a Cell 0 and a Cell 1, and the Cell 1 is a serving cell for the user. When the user is closer to the boundary of the cell Cell 0, power of a signal of the user received by the cell Cell 0 is greater, and a combined gain of the signal is higher.

[0006] However, it is very complicated to implement CoMP for all users. Due to a limitation on a processing capability of a device at present, it is very difficult to implement this solution in practice. In a case of joint reception for some cells with excessively low signal to interference plus noise ratios (SINR), performance may decrease instead due to the influence of channel estimation. Therefore, how to select a CoMP coordinated set and which UEs are to be selected, where CoMP is performed on the UEs for optimization in terms of performance and complexity, become very important.

[0007] Currently, a mainstream solution in the prior art is to determine whether to perform CoMP on a UE by using whether a difference between RSRP (Reference Signal Receiving Power, reference signal received power) of a serving cell and RSRP of another neighboring cell is greater than a predetermined threshold. However, this selection manner does not take an interference factor into consideration, and in practice, interference on the serving cell and interference on another cell are usually very different. Therefore, a UE selected according to an RSRP difference between the serving cell and the another cell is usually not a UE for which a highest gain is obtained when CoMP is performed, which reduces an effect of CoMP.

SUMMARY

[0008] In view of this, embodiments of the present invention provide a method, a device, and a system for coordinated multi-point transmission, which can select a user equipment located at a cell overlapping area to perform coordinated multi-point transmission, thereby improving an effect of coordinated multi-point transmission.

[0009] To achieve the foregoing objectives, in one aspect, the present invention provides a method for CoMP coordinated multi-point transmission, where the method includes:

obtaining reference signal received power RSRP of a cell in a measurement set of a user equipment UE;
determining that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold; and
combining a cell whose RSRP is greater between the first cell and the second cell with the serving cell of the UE into a coordinated set of the UE, and performing coordinated multi-point transmission on the UE.

[0010] In another aspect, the present invention further provides a device for coordinated multi-point transmission, where the device includes:

an RSRP obtaining unit, configured to obtain reference signal received power RSRP of all cells in a measurement set of a user equipment UE;
a determining unit, configured to determine that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold;
a coordinated set joining unit, configured to combine a cell whose RSRP is greater between the first cell

and the second cell with the serving cell of the UE into a coordinated set of the UE; and

a transmitting unit, configured to perform coordinated multi-point transmission on the UE.

[0011] In still another aspect, the present invention further provides a system, including the device for coordinated multi-point transmission.

[0012] It can be seen that, in the method, the device, and the system for coordinated multi-point transmission provided by the embodiments of the present invention, whether to perform CoMP on a UE is determined based on whether two cells whose RSRP difference is greater than a threshold exist in a measurement set of the UE other than a serving cell. In the embodiments of the present invention, a UE near a cell overlapping area can be selected, and a relatively high gain can be obtained for such UE during CoMP, thereby improving an effect of CoMP.

BRIEF DESCRIPTION OF DRAWINGS

[0013] To describe the technical solutions in the embodiments of the present invention or in the prior art more clearly, the following briefly introduces accompanying drawings required for describing the embodiments or the prior art. Apparently, the accompanying drawings in the following description show merely some embodiments of the present invention, and a person of ordinary skill in the art may still derive other drawings according to these accompanying drawings without creative efforts.

FIG. 1 is a schematic diagram of a CoMP technology in the prior art;

FIG. 2 is a schematic diagram of a cell of an Intra-eNodeB CoMP technology;

FIG. 3 is a schematic flow chart of a method for coordinated multi-point transmission according to an embodiment of the present invention;

FIG. 4 is a schematic flow chart of a method for coordinated multi-point transmission according to another embodiment of the present invention;

FIG. 5 is a schematic diagram of an application scenario for a method for coordinated multi-point transmission according to an embodiment of the present invention;

FIG. 6 is a schematic structural diagram of a device for coordinated multi-point transmission according to an embodiment of the present invention; and

FIG. 7 is a schematic structural diagram of a device for coordinated multi-point transmission according to another embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

[0014] To make the objectives, technical solutions, and advantages of the embodiments of the present invention more comprehensible, the following clearly and completely describes the technical solutions in the embodiments of the present invention with reference to the accompanying drawings in the embodiments of the present invention. Apparently, the embodiments to be described are merely a part rather than all of the embodiments of the present invention. All other embodiments obtained by a person of ordinary skill in the art based on the embodiments of the present invention without creative efforts shall fall within the protection scope of the present invention.

[0015] FIG. 3 is a schematic flow chart of a method for coordinated multi-point transmission according to an embodiment of the present invention. An embodiment of the present invention provides a method for coordinated multi-point transmission, where, as shown in FIG. 3, the method includes:

Step S301: Obtain reference signal received power RSRP of a cell in a measurement set of a user equipment (UE).

[0016] Specific implementation of obtaining RSRP may adopt the prior art, for example, a method defined in the 3GPP 36.214 protocol. The present invention does not limit implementation of obtaining RSRP.

[0017] In addition, the measurement set may be determined by using the following method: A base station of a serving cell of the UE delivers a periodic measurement configuration to the UE. After receiving the periodic measurement configuration, the UE measures all available cells of a configured frequency to obtain signal quality, and reports the signal quality to the base station of the serving cell. The base station adds a cell whose signal quality exceeds a threshold set on a network to the measurement set of the UE. It may also be stipulated that cells whose signal quality ranks in the top several places are added to the measurement set of the UE, which is not limited by the present invention. Cells in the measurement set may belong to different base stations, or may belong to one same base station.

Step S302: Determine that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold. Subtraction may be performed on RSRP values of every two cells other than the serving cell in the measurement set of the UE to obtain an absolute value of an RSRP difference between two cells other than the serving cell in the measurement set, and the absolute value of the difference is compared with a threshold preset in advance.

[0018] For example, when there are two cells other than the serving cell of the UE in the measurement set, subtraction is performed on RSRP of the two cells for comparison with a preset threshold. It is assumed that there are three cells other than the serving cell of the UE

in the measurement set cell 1, cell 2, and cell 3. Subtraction is performed on RSRP values of every two cells of cell 1, cell 2, and cell 3 to obtain |RSRP cell 1 - RSRP cell 2|, |RSRP cell 1 - RSRP cell 3|, and |RSRP cell 3 - RSRP cell 2|, and the three values are compared with the preset threshold. As long as there is one of the three values which is greater than the preset threshold (or greater than or equal to the preset threshold, which is not limited in the present invention), CoMP may be performed on the UE.

When a first cell and a second cell that meet the foregoing condition exist, it indicates that the UE is located at an overlapping area of the serving cell and another cell, and a relatively high gain is obtained for the UE during CoMP.

Step S303: Combine a cell whose RSRP is greater between the first cell and the second cell with the serving cell of the UE into a coordinated set of the UE, and perform CoMP on the UE. A specific method for coordinated multi-point transmission may also be implemented through the prior art.

[0019] In the method provided by the embodiment, whether to perform CoMP on a UE is determined based on whether two cells whose RSRP difference is greater than a threshold exist in a measurement set of the UE other than a serving cell. Interference between cells other than the serving cell is usually close. Therefore, a UE near a cell overlapping area can be selected more accurately, and a relatively high gain can be obtained for such UE during CoMP, thereby improving an effect of CoMP.

[0020] FIG. 4 is a schematic flow chart of a method for coordinated multi-point transmission according to another embodiment of the present invention. As shown in FIG. 4, the method for coordinated multi-point transmission in embodiment 1 includes:

Step S401: Obtain reference signal received power (RSRP) of a cell in a measurement set of a UE.

[0021] For a specific method, reference may be similarly made to step S301 in the foregoing embodiment.

Step S402: Determine that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold.

For a specific method, reference may be similarly made to step S302 in the foregoing embodiment.

Step S403: Combine a cell whose RSRP is greater between the first cell and the second cell with the serving cell of the UE into a coordinated set of the UE.

For a specific method, reference may be similarly made to step S303 in the foregoing embodiment.

Step S404: After step S403, obtain a gain between a post-SINR (Posted-SINR) of the UE in the coordinated set and a post-SINR of the UE in the serving cell.

In a scenario where coverage is limited, a relative gain may be used as the gain in step S404. The relative gain may be determined according to the following formula:

$$\frac{\log_2(1+SINR_1)-\log_2(1+SINR_0)}{\log_2(1+SINR_0)},$$

where $SINR_0$ is the post-SINR of the UE in the serving cell of the UE, and $SINR_1$ is a post-SINR of the UE in a cell other than the serving cell in the coordinated set of the UE, where the cell other than the serving cell in the coordinated set of the UE may also be called a coordination cell of the UE; and

$\log_2(1+SINR_1)$ is throughput which is of the UE in the coordinated set of the UE and is determined according to the Shannon's formula, and $\log_2(1+SINR_0)$ is throughput which is of the UE in the serving cell of the UE and is determined according to the Shannon's formula.

[0022] In a scenario where a capacity is limited, an absolute gain may be used as the gain in step S404.

[0023] The absolute gain may be determined according to the following formula:

$$\log_2(1+SINR_1)-\log_2(1+SINR_0),$$

where $SINR_0$ is the post-SINR of the UE in the serving cell of the UE, and $SINR_1$ is the post-SINR of the UE in the cell other than the serving cell in the coordinated set of the UE; and

$\log_2(1+SINR_1)$ is the throughput which is of the UE in the coordinated set of the UE and is determined according to the Shannon's formula, and $\log_2(1+SINR_0)$ is the throughput which is of the UE in the serving cell of the UE and is determined according to the Shannon's formula.

Step S405: Perform CoMP on a UE whose gain is greater than the preset threshold.

In practice, alternatively, UEs may also be sorted according to gains obtained through calculation in step S404, and a UE with a highest gain is selected preferably for performing CoMP, until a processing resource is used up.

[0024] In the embodiment, by taking a case that a hardware resource is limited into consideration, it is possible that CoMP can be performed on only a part of UEs. After UEs near a cell overlapping area are selected through

step S401 to step S403, these UEs are sorted according to their gains, and CoMP is preferably performed on a UE with a highest gain, so that efficiency of CoMP may be fully improved with a limited resource.

[0025] It should be noted that, in the embodiment, the step for obtaining the gains of the UEs may be performed in each transmission time interval (TTI), or may be performed on each resource block (RB). Certainly, a granularity implemented in the step for obtaining the gains of the UEs may be divided according to another granularity.

[0026] In each of the foregoing embodiments, cells in the measurement set of the UE may belong to one same base station, or at least two cells may belong to different base stations.

[0027] If cells in the measurement set of the UE belong to one same base station, intra-eNodeB CoMP (Intra-eNodeB CoMP) is implemented when CoMP is performed on the UE.

[0028] If at least two cells in the measurement set of the UE belong to different base stations and the coordinated set of the UE also includes cells that belong to at least two base stations, inter-eNodeB CoMP is implemented when CoMP is performed on the UE.

[0029] Specific implementation of the method for coordinated multi-point transmission in the present invention is described in detail in the following through several specific examples.

[0030] Example 1: As shown in FIG. 5, it is assumed that a serving cell of a UE is Cell 0. In a measurement set of the UE, three cells are included, namely, a serving cell of the UE Cell0 and two other neighboring cells Cell 1 and Cell 2.

[0031] First, RSRP of Cell 0, Cell 1, and Cell 2 are obtained, and are marked as RSRP0, RSRP1, and RSRP2, respectively.

[0032] When it is determined that an absolute value of a difference between the RSRP1 and the RSRP2 is greater than a preset threshold, it indicates that the UE is located at a cell overlapping area. In FIG. 5, the UE is located at an overlapping area between cells Cell 0 and Cell 1, and a cell corresponding to a greater RSRP value between the RSRP1 and the RSRP2 and the serving cell Cell 0 are included in a coordinated set of the UE. For example, when the absolute value of the difference between the RSRP1 and the RSRP2 is greater than the preset threshold, and it may be measured that RSRP1> RSRP2 due to a fact the UE is closer to Cell1 than to Cell2, Cell 0 and Cell 1 are included in the coordinated set of the UE. Next, CoMP is performed on the UE.

[0033] Example 2: It is assumed that there are three UEs, which may be marked as UE1, UE2, and UE3 respectively, Cell0 is a serving cell of all the three UEs, and measurement sets all include Cell0 and other two neighboring cells Cell 1 and Cell 2.

[0034] First, a process as described in the foregoing example 1 for obtaining of RSPR and formation of a coordinated set of each UE is separately implemented for UE1, UE2, and UE3.

[0035] Next, a gain between a post-SINR of UE1 in the coordinated set of UE1 and a post-SINR of UE1 in the serving cell Cell0 of UE1 is calculated, and is marked as D1. A gain between a post-SINR of UE2 in the coordinated set of UE2 and a post-SINR of UE2 in the serving cell Cell0 of UE2 is calculated, and is marked as D2. A gain between a post-SINR of UE3 in the coordinated set of UE3 and a post-SINR of UE3 in the serving cell Cell0 of UE3 is calculated, and is marked as D3.

[0036] It is assumed that D2>D1>D3, and UE1, UE2, and UE3 are sorted according to order of their gains as follows: UE2, UE1, UE3.

[0037] CoMP is preferably performed on UE2, and then UE1. If a processing resource is used up after CoMP is performed on UE1, CoMP is not performed on UE3.

[0038] In addition, there may be multiple first cells and second cells that meet a condition in the foregoing embodiments, for example, in a scenario such as that a UE is located at a cell overlapping area between base stations, or a base station is divided into six cells. It is assumed that in a measurement set of a UE, five cells are included, namely, Cell 0, Cell 1, Cell 2, Cell 3, and Cell 4. Cell 0 is a serving cell of the UE. After measurement, RSRP of Cell 1, Cell 2, Cell 3, and Cell 4 are RSRP1, RSRP2, RSRP3, and RSRP4, respectively.

[0039] It is found through comparison that: An absolute value of a difference between the RSRP1 and the RSRP2 is greater than a preset threshold; an absolute value of a difference between the RSRP3 and the RSRP4 is also greater than the preset threshold. In a case that a hardware resource is sufficient, a cell whose RSRP is greater in each pair of cells whose RSRP difference is greater than the preset threshold and that meet a condition may be used as a coordination cell of the UE, and the coordination cell of the UE and the serving cell of the UE are included in a coordinated set of the UE. It is assumed that, in the foregoing example, there are two pairs of cells that meet the condition, namely, {cell1, cell2} and {cell3, cell4}, RSRP corresponding to the two pairs of cells may be respectively marked as {RSRP1, RSRP2} and {RSRP3, RSRP4}. It is assumed that, |RSRP1-RSRP2| and |RSRP3-RSRP4| are both greater than the preset threshold, and RSRP1>RSRP2 and RSRP3>RSRP4. In this case, RSRP1 and RSRP3 may both be used as coordination cells of the UE. In this way, the coordinated set of the UE includes Cell 0, Cell1, and Cell3.

[0040] However, sometimes, in a case that the hardware resource is insufficient, the number of coordination cells in the coordinated set of the UE is limited. In this case, cells whose RSRP is greater in each pair of the cells whose RSRP difference is greater than the preset threshold and that meet the condition need to be compared, and a cell whose RSRP is greater is preferably selected as the coordination cell of the UE. Alternatively, whether RSRP of a cell whose RSRP is greater among the cells whose RSRP difference is greater than the preset threshold is also greater than the preset threshold is determined through comparison, and then the cell whose

RSRP is greater is used as the coordination cell of the UE. For example, in the foregoing example, it is further assumed that, a difference between the RSRP1 and the RSRP3 of two first cells is also greater than the threshold. Then, only Cell1 whose RSRP is greater is used as the coordination cell of the UE. In this case, the coordinated set of the UE includes only Cell 0 and Cell1.

[0041] FIG. 6 is a schematic structural diagram of a device for coordinated multi-point transmission according to an embodiment of the present invention. As shown in FIG. 6, the device for coordinated multi-point transmission includes:

An RSRP obtaining unit 601 is configured to obtain reference signal received power RSRP of all cells in a measurement set of a user equipment UE.

[0042] A determining unit 602 is configured to determine that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold.

[0043] A transmitting unit 603 is configured to combine a cell whose RSRP is greater between the first cell and the second cell with the serving cell of the UE into a coordinated set of the UE, and perform coordinated multi-point transmission on the UE.

[0044] In practice, the device for coordinated multi-point transmission in the embodiment may be a base station.

[0045] Specific implementation of obtaining RSRP by the RSRP obtaining unit 601 may adopt the prior art, for example, a method defined in the 3GPP 36.214 protocol. The present invention does not limit implementation of obtaining RSRP. Cells in the measurement set may belong to different base stations or may belong to one same base station.

[0046] The determining unit 602 may perform subtraction on RSRP values of every two cells other than the serving cell in the measurement set of the UE to obtain an absolute value of an RSRP difference between two cells other than the serving cell in the measurement set, and compare the absolute value of the difference with the threshold preset in advance.

[0047] FIG. 7 is a schematic structural diagram of a device for coordinated multi-point transmission according to another embodiment of the present invention. As shown in FIG. 7, the device for coordinated multi-point transmission includes:

An RSRP obtaining unit 701 is configured to obtain reference signal received power RSRP of all cells in a measurement set of a user equipment UE. Specific implementation of obtaining RSRP by the RSRP obtaining unit 701 may adopt the prior art, for example, a method defined in the 3GPP 36.214 protocol. The present invention does not limit implementation of obtaining RSRP. Cells in the measurement set may belong to different base stations or may belong to one same base station.

[0048] A determining unit 702 is configured to determine that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold. The determining unit 702 may perform subtraction on RSRP values of every two cells other than the serving cell in the measurement set of the UE to obtain an absolute value of an RSRP difference between two cells other than the serving cell in the measurement set, and compare the absolute value of the difference with the threshold preset in advance.

[0049] A gain obtaining unit 703 is further included, where the gain obtaining unit 703 is configured to obtain a gain between a post-SINR of the UE in the coordinated set of the UE and a post-SINR of the UE in the serving cell of the UE.

[0050] Specifically, in a scenario where coverage is limited, the gain obtained by the gain obtaining unit 703 may be a relative gain, where the relative gain may be determined according to the following formula:

$$\frac{\log_2(1+SINR_1)-\log_2(1+SINR_0)}{\log_2(1+SINR_0)},$$

where $SINR_0$ is the post-SINR of the UE in the serving cell of the UE, and $SINR_1$ is a post-SINR of the UE in a cell other than the serving cell in the coordinated set of the UE, where the cell other than the serving cell in the coordinated set of the UE may also be called a coordination cell of the UE; and

$\log_2(1 + SINR_1)$ is throughput which is of the UE in the coordinated set of the UE and is determined according to the Shannon's formula, and $\log_2(1+SINR_0)$ is throughput which is of the UE in the serving cell of the UE and is determined according to the Shannon's formula.

[0051] In a scenario where a capacity is limited, the gain obtained by the gain obtaining unit 604 may be an absolute gain.

[0052] The absolute gain may be determined according to the following formula:

$$\log_2(1+SINR_1)-\log_2(1+SINR_0),$$

where $SINR_0$ is the post-SINR of the UE in the serving cell of the UE, and $SINR_1$ is the post-SINR of the UE in the cell other than the serving cell in the coordinated set of the UE; and

$\log_2(1 + SINR_1)$ is the throughput which is of the UE in the coordinated set of the UE and is determined according to the Shannon's formula, and

$\log_2(1+SINR_0)$ is the throughput which is of the UE in the serving cell of the UE and is determined according to the Shannon's formula.

[0053] A process of obtaining gains of UEs by the gain obtaining unit 703 may be performed in each transmission time interval (TTI), or may be performed on each resource block (RB). Certainly, a granularity implemented in the step for obtaining the gains of the UEs may be divided according to another granularity.

[0054] A transmitting unit 704 is specifically configured to select a UE whose gain is greater than a preset threshold to perform coordinated multi-point transmission.

[0055] The device for coordinated multi-point transmission in the embodiment may be a base station.

[0056] In addition, an embodiment of the present invention further provides a system, where the system includes the device for coordinated multi-point transmission in the foregoing device embodiments.

[0057] Exemplary implementation manners of the present invention are described in the foregoing. It should be noted that, a person of ordinary skill in the art may further make several modifications and variations without departing from the principle of the present invention, and these modifications and variations should also be construed as falling within the protection scope of the present invention.

Claims

1. A method for CoMP coordinated multi-point transmission, comprising:

   obtaining reference signal received power RSRP of a cell in a measurement set of a user equipment UE;
   determining that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold; and
   combining a cell whose RSRP is greater between the first cell and the second cell with the serving cell of the UE into a coordinated set of the UE, and performing coordinated multi-point transmission on the UE.

2. The method according to claim 1, further comprising:

   obtaining a gain between a post-SINR of the UE in the coordinated set and a post-SINR of the UE in the serving cell; wherein
   the performing coordinated multi-point transmission on the UE comprises:

   selecting the UE whose gain is greater than a preset threshold to perform coordinated multi-point transmission.

3. The method according to claim 2, wherein the gain is a relative gain or an absolute gain.

4. The method according to claim 2 or 3, wherein the obtaining a gain between a post-SINR of the UE in the coordinated set and a post-SINR of the UE in the serving cell comprises:

   obtaining, in each transmission time interval (TTI), the gain between the post-SINR of the UE in the coordinated set and the post-SINR of the UE in the serving cell.

5. The method according to claim 2 or 3, wherein the obtaining a gain between a post-SINR of the UE in the coordinated set and a post-SINR of the UE in the serving cell comprises:

   obtaining, on each resource block (RB), the gain between the post-SINR of the UE in the coordinated set and the post-SINR of the UE in the serving cell.

6. The method according to any one of claims 1 to 5, wherein,
   cells in the measurement set of the UE belong to one same base station, or
   at least two of cells in the measurement set of the UE belong to different base stations.

7. A device for coordinated multi-point transmission, comprising:

   an RSRP obtaining unit, configured to obtain reference signal received power RSRP of all cells in a measurement set of a user equipment UE;
   a determining unit, configured to determine that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold; and
   a transmitting unit, configured to combine a cell whose RSRP is greater between the first cell and the second cell with the serving cell of the UE into a coordinated set of the UE, and perform coordinated multi-point transmission on the UE.

8. The device according to claim 7, further comprising:

   a gain obtaining unit, configured to obtain a gain between a post-SINR of the UE in the coordinated set and a post-SINR of the UE in the serving cell; wherein
   the transmitting unit is specifically configured to select the UE whose gain is greater than a preset threshold to perform coordinated multi-point transmission.

9. The device according to claim 7, wherein the gain obtaining unit is specifically configured to obtain, in each transmission time interval (TTI), the gain between the post-SINR of the UE in the coordinated set and the post-SINR of the UE in the serving cell; or the gain obtaining unit is specifically configured to obtain, on each resource block (RB), the gain between the post-SINR of the UE in the coordinated set and the post-SINR of the UE in the serving cell.

10. The device according to any one of claims 7 to 9, wherein the device is a base station.

11. A system, comprising the device for coordinated multi-point transmission according to any one of claims 7 to 9.

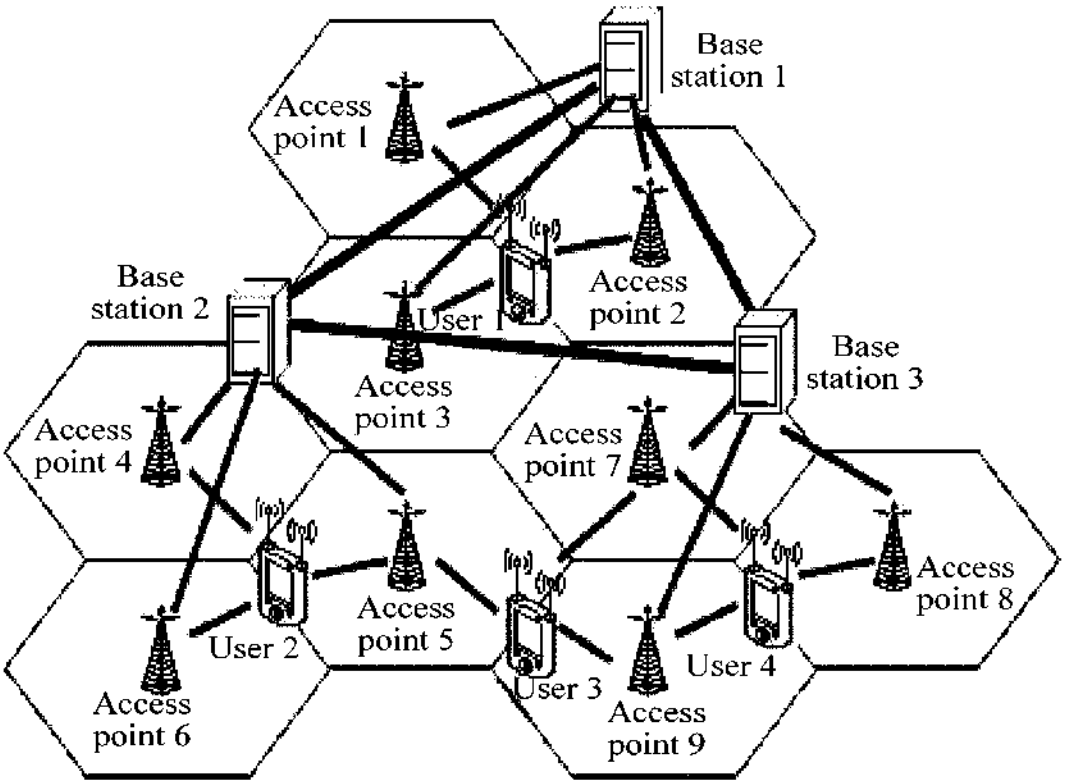

Base station 1
Access point 1
Base station 2
User 1
Access point 2
Base station 3
Access point 3
Access point 4
Access point 7
Access point 8
Access point 5
User 2
User 3
User 4
Access point 6
Access point 9

FIG. 1

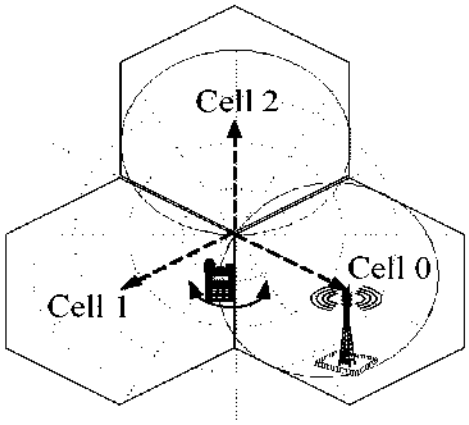

Cell 2
Cell 0
Cell 1

FIG. 2

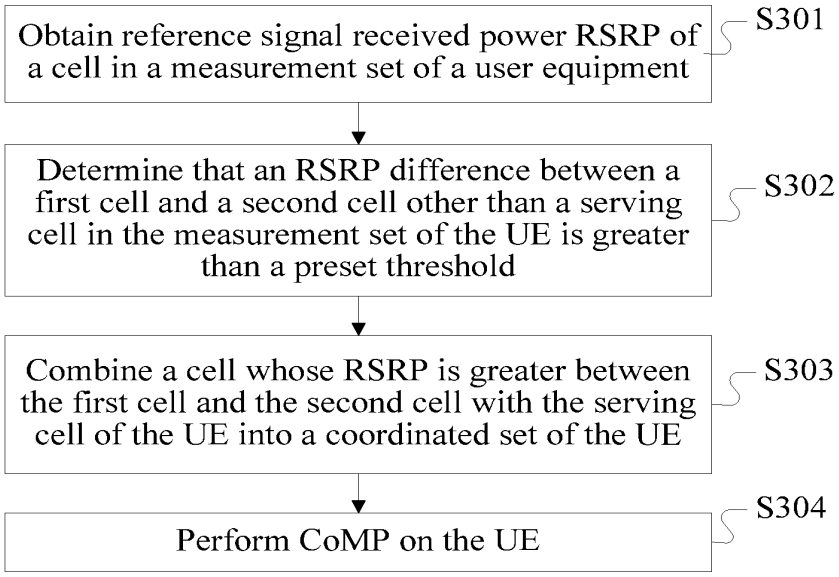

Obtain reference signal received power RSRP of a cell in a measurement set of a user equipment
S301
Determine that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold
S302
Combine a cell whose RSRP is greater between the first cell and the second cell with the serving cell of the UE into a coordinated set of the UE
S303
Perform CoMP on the UE
S304

FIG. 3

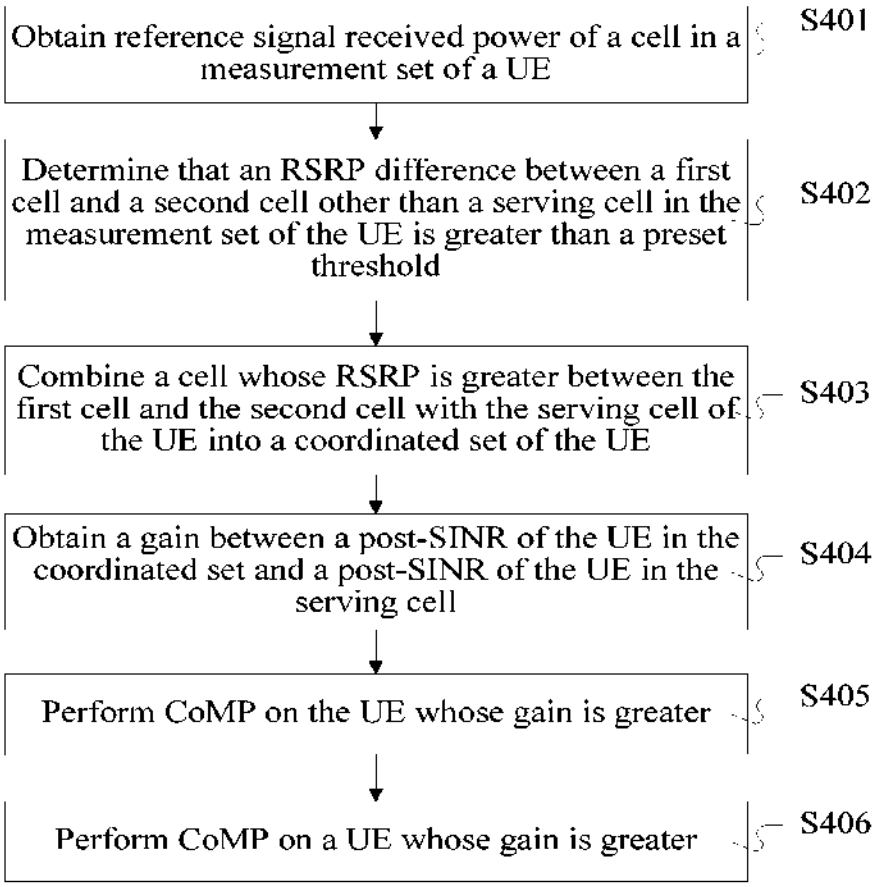

Obtain reference signal received power of a cell in a measurement set of a UE
S401
Determine that an RSRP difference between a first cell and a second cell other than a serving cell in the measurement set of the UE is greater than a preset threshold
S402
Combine a cell whose RSRP is greater between the first cell and the second cell with the serving cell of the UE into a coordinated set of the UE
S403
Obtain a gain between a post-SINR of the UE in the coordinated set and a post-SINR of the UE in the serving cell
S404
Perform CoMP on the UE whose gain is greater
S405
Perform CoMP on a UE whose gain is greater
S406

FIG. 4

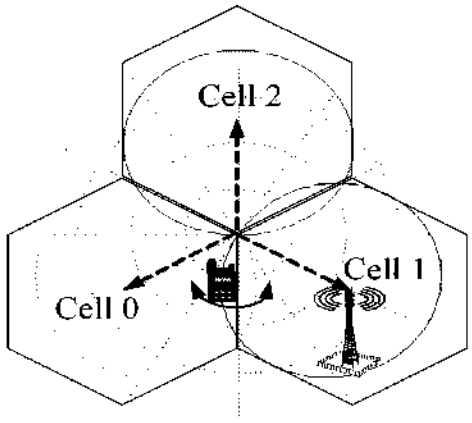

Cell 2
Cell 1
Cell 0

FIG. 5

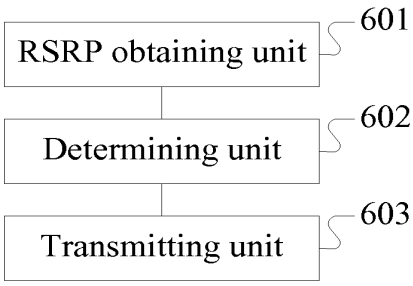

601
RSRP obtaining unit
602
Determining unit
603
Transmitting unit

FIG. 6

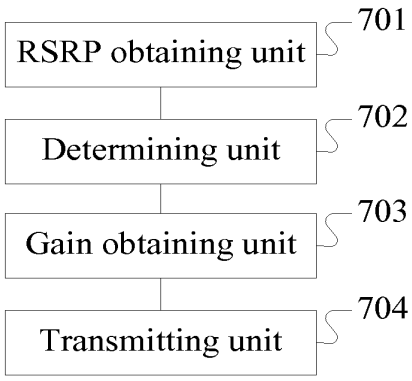

701
RSRP obtaining unit
702
Determining unit
703
Gain obtaining unit
704
Transmitting unit

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2011/077566

A. CLASSIFICATION OF SUBJECT MATTER

H04W 28/16 (2009.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: H04W, H04Q, H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNABS, CNTXT, CNKI: CoMP, coordinated multi-point, cell, transmission, reference signal received power, RSRP, quality, parameter, threshold, set

VEN, 3GPP: CoMP, coordinated multi-point transmission reception, cell?, RSRP, quality, parameter?, threshold?, set?

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 101895921 A (POTEVIO INSTITUTE OF TECHNOLOGY CO., LTD.), 24 November 2010 (24.11.2010), the whole document	1-11
A	CN 101873661 A (DATANG MOBILE COMMUNICATIONS EQUIPMENT CO., LTD.), 27 October 2010 (27.10.2010), the whole document	1-11
A	CN 102076096 A (SHANGHAI HUAWEI TECHNOLOGIES CO., LTD.), 25 May 2011 (25.05.2011), the whole document	1-11
A	CN 101815331 A (ZTE CORP.), 25 August 2010 (25.08.2010), the whole document	1-11

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 April 2012 (21.04.2012)	**03 May 2012 (03.05.2012)**
Name and mailing address of the ISA/CN: State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No.: (86-10) 62019451	Authorized officer **LV, Sihua** Telephone No.: (86-10) **62411386**

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2011/077566

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 101895921 A	24.11.2010	None	
CN 101873661 A	27.10.2010	None	
CN 102076096 A	25.05.2011	None	
CN 101815331 A	25.08.2010	None	

Form PCT/ISA/210 (patent family annex) (July 2009)

Espacenet

CN108809488A Message decoding method, sending end and receiving end

Applicants: CHINA ACADEMY TELECOMMUNICATIONS TECHNOLOGY

Inventors: CHEN RUNHUA,GAO QIUBIN,LI HUI

Classifications:

IPC ***H04L1/00;***

CPC **H04B7/0617 (CN,US); H04B7/0695 (EP,CN); H04B7/088 (EP,CN); H04L1/0036 (CN,KR); H04W74/006 (CN,US);**

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Application: CN201710307962A 2017-05-04

Publication: CN108809488A 2018-11-13

Published as: CN108809488A;**CN115395998A; EP3605986A1; EP3605986A4; EP3605986B1; EP4277157A2; JP2020520146A; JP6880237B2; KR102347904B1; KR20200003117A; TW201843962A; TWI715837B; US11039470B2; US2020059958A1; WO2018201861A1**

Message decoding method, sending end and receiving end

Abstract

The invention provides a message decoding method, a sending end and a receiving end. The method comprises the following steps: a receiving end receives a second message sent by a sending end and associated with the first message; the receiving end determines a target receiver parameter for decoding the first message according to the second message; and the receiving end decodes the first message sent by the sending end according to the target receiver parameter. Through the message decoding method provided by the embodiment of the invention, the receiving end can determine the receiver parameter according to the second message associated with the first message, and the message transmission performance can be improved.

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代理人 许静 黄灿

(51)Int.Cl.
H04L 1/00(2006.01)

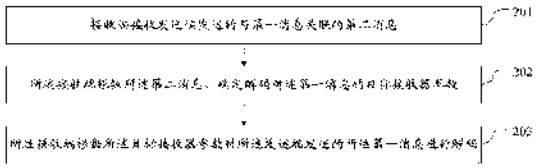
权利要求书5页 说明书20页 附图5页

(54)发明名称

一种消息解码方法、发送端和接收端

(57)摘要

本发明提供一种消息解码方法、发送端和接收端，该方法可包括：接收端接收发送端发送的与第一消息关联的第二消息；所述接收端根据所述第二消息，确定解码所述第一消息的目标接收器参数；所述接收端根据所述目标接收器参数对所述发送端发送的所述第一消息进行解码。这样本发明实施例可以实现接收端根据与第一消息关联的第二消息确定接收器参数，且还可以提高消息传输性能。



CN 108809488 A

1.一种消息解码方法，其特征在于，包括：

接收端接收发送端发送的与第一消息关联的第二消息；

所述接收端根据所述第二消息，确定解码所述第一消息的目标接收器参数；

所述接收端根据所述目标接收器参数对所述发送端发送的所述第一消息进行解码。

2.如权利要求1所述的方法，其特征在于，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端默认的接收器参数。

3.如权利要求2所述的方法，其特征在于，所述接收端默认的接收器参数包括：

所述接收端当前使用的接收器参数、所述接收端接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端向所述发送端上报时间最近的发送器参数对应的接收器参数。

4.如权利要求2所述的方法，其特征在于，所述参数指示信息显式或者隐式指示所述目标接收器参数。

5.如权利要求4所述的方法，其特征在于，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端选择的发送器参数，所述接收端将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

6.如权利要求1-5中任一项所述的方法，其特征在于，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

7.如权利要求6所述的方法，其特征在于，所述参数切换指示集对应的调度时间单位在时域上周期存在；和\或

所述参数切换指示集对应的调度时间单位由所述发送端半静态或半持续配置，并通知所述接收端。

8.如权利要求1-5中任一项所述的方法，其特征在于，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前，所述接收端根据所述目标接收器参数对所述第一消息进行解码，包括：

若所述第二消息包括参数指示信息，则所述接收端根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示信息，则所述接收端丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示信息，则所述接收端根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息不包括波束指示信息，则所述接收端根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

若所述第二消息包括参数指示字段，且所述参数指示字段指示没有参数指示信息或者没有参数改变，则所述接收端根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

9.如权利要求1-5中任一项所述的方法，其特征在于，所述方法还包括：

所述接收端接收所述发送端发送的第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

10.如权利要求9所述的方法，其特征在于，所述第三消息用于指示M个时间单位内的第二消息是否包括参数指示信息，所述M为大于或者等于1的整数，所述M个时间单位连续或者不连续。

11.如权利要求1-5中任一项所述的方法，其特征在于，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

12.如权利要求11所述的方法，其特征在于，所述空域的接收器参数包括所述接收端的接收波束。

13.一种消息解码方法，其特征在于，包括：

发送端向接收端发送与第一消息关联的第二消息，所述第二消息用于所述接收端确定解码所述第一消息的目标接收器参数；

所述发送端向所述接收端发送所述第一消息。

14.如权利要求13所述的方法，其特征在于，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端默认的接收器参数。

15.如权利要求14所述的方法，其特征在于，所述接收端默认的接收器参数包括：

所述接收端当前使用的接收器参数、所述接收端接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端向所述发送端上报时间最近的发送器参数对应的接收器参数。

16.如权利要求14所述的方法，其特征在于，所述参数指示信息显式或者隐式指示所述目标接收器参数。

17.如权利要求16所述的方法，其特征在于，若所述参数指示信息隐式指示所述目标接

收器参数，则所述参数指示信息包括所述发送端选择的发送器参数，所述接收端将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

18.如权利要求13-17中任一项所述的方法，其特征在于，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

19.如权利要求18所述的方法，其特征在于，所述参数切换指示集对应的调度时间单位在时域上周期存在；和\或

所述参数切换指示集对应的调度时间单位由所述发送端半静态或半持续配置，并通知所述接收端。

20.如权利要求13-17中任一项所述的方法，其特征在于，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前。

21.如权利要求13-17中任一项所述的方法，其特征在于，所述方法还包括：

所述发送端向所述接收端发送第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

22.如权利要求21所述的方法，其特征在于，所述第三消息用于指示M个时间单位内的第二消息是否包括参数指示信息，所述M为大于或者等于1的整数，所述M个时间单位连续或者不连续。

23.如权利要求13-17中任一项所述的方法，其特征在于，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

24.如权利要求23所述的方法，其特征在于，所述空域的接收器参数包括所述接收端的接收波束。

25.一种接收端，其特征在于，包括：

第一接收模块，用于接收发送端发送的与第一消息关联的第二消息；

确定模块，用于根据所述第二消息，确定解码所述第一消息的目标接收器参数；

解码模块，用于根据所述目标接收器参数对所述发送端发送的所述第一消息进行解码。

26.如权利要求25所述的接收端，其特征在于，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端默认的接收器参数。

27.如权利要求25或26所述的接收端，其特征在于，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

28.如权利要求25或26所述的接收端，其特征在于，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前；

所述解码模块用于若所述第二消息包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示信息，则根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息不包括波束指示信息，则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

所述解码模块用于若所述第二消息包括参数指示字段，且所述参数指示字段指示没有参数指示信息或者没有参数改变，则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

29.如权利要求25或26所述的接收端，其特征在于，所述接收端还包括：

第二接收模块，用于接收所述发送端发送的第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

30.一种发送端，其特征在于，包括：

第一发送模块，用于发送端向接收端发送与第一消息关联的第二消息，所述第二消息用于所述接收端确定解码所述第一消息的目标接收器参数；

第二发送模块，用于向所述接收端发送所述第一消息。

31.如权利要求30所述的发送端，其特征在于，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端默认的接收器参数。

32.如权利要求30或31所述的发送端，其特征在于，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

33.如权利要求30或31所述的发送端，其特征在于，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前。

34.如权利要求30或31所述的发送端，其特征在于，所述发送端还包括：

第二发送模块，用于向所述接收端发送第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

一种消息解码方法、发送端和接收端

技术领域

[0001] 本发明涉及通信技术领域，特别涉及一种消息解码方法、发送端和接收端。

背景技术

[0002] 随着通信技术的发展，目前通信设备均支持多天线系统，例如：支持高达128、256或者512个天线单元，以及高达128、256或者512个收发单元，每个天线单元连接一个收发单元。且目前通信设备还支持多波束，不同的波束的覆盖范围可以不同。这样发送端(例如：网络侧设备)在发送消息时，就可以在多个发送器参数(例如：发送波束)中选择相应的发送器参数进行发送，以提高通信性能。而接收端(例如：用户终端)如何选择相应的接收器参数(例如：接收波束)对发送端发送的消息进行解码目前还未明确。可见，接收端如何选择相应的接收器参数对发送端发送的消息进行解码是当前急需解决的技术问题。

发明内容

[0003] 本发明的目的在于提供一种消息解码方法、发送端和接收端，以解决接收端如何选择相应的接收器参数对发送端发送的消息进行解码的问题。

[0004] 为了达到上述目的，本发明实施例提供一种消息解码方法，包括：

[0005] 接收端接收发送端发送的与第一消息关联的第二消息；

[0006] 所述接收端根据所述第二消息，确定解码所述第一消息的目标接收器参数；

[0007] 所述接收端根据所述目标接收器参数对所述发送端发送的所述第一消息进行解码。

[0008] 可选的，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

[0009] 若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端默认的接收器参数。

[0010] 可选的，所述接收端默认的接收器参数包括：

[0011] 所述接收端当前使用的接收器参数、所述接收端接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端向所述发送端上报时间最近的发送器参数对应的接收器参数。

[0012] 可选的，所述参数指示信息显式或者隐式指示所述目标接收器参数。

[0013] 可选的，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端选择的发送器参数，所述接收端将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

[0014] 可选的，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

[0015] 若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所

述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

[0016] 可选的，所述参数切换指示集对应的调度时间单位在时域上周期存在；和\或

[0017] 所述参数切换指示集对应的调度时间单位由所述发送端半静态或半持续配置，并通知所述接收端。

[0018] 可选的，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前，所述接收端根据所述目标接收器参数对所述第一消息进行解码，包括：

[0019] 若所述第二消息包括参数指示信息，则所述接收端根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0020] 若所述第二消息包括参数指示信息，则所述接收端丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0021] 若所述第二消息包括参数指示信息，则所述接收端根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0022] 若所述第二消息不包括波束指示信息，则所述接收端根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码；或者

[0023] 若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0024] 若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0025] 若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0026] 若所述第二消息包括参数指示字段，且所述参数指示字段指示没有参数指示信息或者没有参数改变，则所述接收端根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

[0027] 可选的，所述方法还包括：

[0028] 所述接收端接收所述发送端发送的第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

[0029] 可选的，所述第三消息用于指示M个时间单位内的第二消息是否包括参数指示信息，所述M为大于或者等于1的整数，所述M个时间单位连续或者不连续。

[0030] 可选的，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

[0031] 可选的，所述空域的接收器参数包括所述接收端的接收波束。

[0032] 本发明实施例还提供一种消息解码方法，包括：

[0033] 发送端向接收端发送与第一消息关联的第二消息，所述第二消息用于所述接收端确定解码所述第一消息的目标接收器参数；

[0034] 所述发送端向所述接收端发送所述第一消息。

[0035] 可选的，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

[0036] 若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端默认的接收器参数。

[0037] 可选的，所述接收端默认的接收器参数包括：

[0038] 所述接收端当前使用的接收器参数、所述接收端接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端向所述发送端上报时间最近的发送器参数对应的接收器参数。

[0039] 可选的，所述参数指示信息显式或者隐式指示所述目标接收器参数。

[0040] 可选的，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端选择的发送器参数，所述接收端将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

[0041] 可选的，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

[0042] 若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

[0043] 可选的，所述参数切换指示集对应的调度时间单位在时域上周期存在；和\或

[0044] 所述参数切换指示集对应的调度时间单位由所述发送端半静态或半持续配置，并通知所述接收端。

[0045] 可选的，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前。

[0046] 可选的，所述方法还包括：

[0047] 所述发送端向所述接收端发送第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

[0048] 可选的，所述第三消息用于指示M个时间单位内的第二消息是否包括参数指示信息，所述M为大于或者等于1的整数，所述M个时间单位连续或者不连续。

[0049] 可选的，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

[0050] 可选的，所述空域的接收器参数包括所述接收端的接收波束。

[0051] 本发明实施例还提供一种接收端，包括：

[0052] 第一接收模块，用于接收发送端发送的与第一消息关联的第二消息；

[0053] 确定模块，用于根据所述第二消息，确定解码所述第一消息的目标接收器参数；

[0054] 解码模块，用于根据所述目标接收器参数对所述发送端发送的所述第一消息进行

解码。

[0055] 可选的，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

[0056] 若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端默认的接收器参数。

[0057] 可选的，所述接收端默认的接收器参数包括：

[0058] 所述接收端当前使用的接收器参数、所述接收端接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端向所述发送端上报时间最近的发送器参数对应的接收器参数。

[0059] 可选的，所述参数指示信息显式或者隐式指示所述目标接收器参数。

[0060] 可选的，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端选择的发送器参数，所述接收端将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

[0061] 可选的，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

[0062] 若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

[0063] 可选的，所述参数切换指示集对应的调度时间单位在时域上周期存在；和\或

[0064] 所述参数切换指示集对应的调度时间单位由所述发送端半静态或半持续配置，并通知所述接收端。

[0065] 可选的，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前；

[0066] 所述解码模块用于若所述第二消息包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0067] 所述解码模块用于若所述第二消息包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0068] 所述解码模块用于若所述第二消息包括参数指示信息，则根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0069] 所述解码模块用于若所述第二消息不包括波束指示信息，则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码；或者

[0070] 所述解码模块用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0071] 所述解码模块用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接

收器参数对所述第二部分内容进行解码;或者

[0072] 所述解码模块用于若所述第二消息包括参数指示字段,且所述参数指示字段包括参数指示信息,则根据默认的接收器参数对所述第一部分内容进行解码,以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码;或者

[0073] 所述解码模块用于若所述第二消息包括参数指示字段,且所述参数指示字段指示没有参数指示信息或者没有参数改变,则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

[0074] 可选的,所述接收端还包括:

[0075] 第二接收模块,用于接收所述发送端发送的第三消息,所述第三消息用于指示所述第二消息是否包括参数指示信息,且若所述第三消息指示所述第二消息包括参数指示信息,则所述第二消息与所述第一消息之间存在间隙,若所述第三消息指示所述第二消息不包括参数指示信息,则所述第二消息与所述第一消息之间不存在间隙。

[0076] 可选的,所述第三消息用于指示M个时间单位内的第二消息是否包括参数指示信息,所述M为大于或者等于1的整数,所述M个时间单位连续或者不连续。

[0077] 可选的,所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

[0078] 可选的,所述空域的接收器参数包括所述接收端的接收波束。

[0079] 本发明实施例还提供一种发送端,包括:

[0080] 第一发送模块,用于发送端向接收端发送与第一消息关联的第二消息,所述第二消息用于所述接收端确定解码所述第一消息的目标接收器参数;

[0081] 第二发送模块,用于向所述接收端发送所述第一消息。

[0082] 可选的,若所述第二消息包括参数指示信息,则所述目标接收器参数为所述参数指示信息指示的接收器参数;

[0083] 若所述第二消息不包括参数指示信息,则所述目标接收器参数为所述接收端默认的接收器参数。

[0084] 可选的,所述接收端默认的接收器参数包括:

[0085] 所述接收端当前使用的接收器参数、所述接收端接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端向所述发送端上报时间最近的发送器参数对应的接收器参数。

[0086] 可选的,所述参数指示信息显式或者隐式指示所述目标接收器参数。

[0087] 可选的,若所述参数指示信息隐式指示所述目标接收器参数,则所述参数指示信息包括所述发送端选择的发送器参数,所述接收端将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

[0088] 可选的,若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的,则所述第二消息包括参数指示信息,且所述第二消息与所述第一消息之间存在间隙;

[0089] 若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的,则所述第二消息不包括参数指示信息,且所述第二消息与所述第一消息之间不存在间隙。

[0090] 可选的,所述参数切换指示集对应的调度时间单位在时域上周期存在;和\或

[0091] 所述参数切换指示集对应的调度时间单位由所述发送端半静态或半持续配置,并

通知所述接收端。

[0092] 可选的，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前。

[0093] 可选的，所述发送端还包括：

[0094] 第二发送模块，用于向所述接收端发送第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

[0095] 可选的，所述第三消息用于指示M个时间单位内的第二消息是否包括参数指示信息，所述M为大于或者等于1的整数，所述M个时间单位连续或者不连续。

[0096] 可选的，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

[0097] 可选的，所述空域的接收器参数包括所述接收端的接收波束。

[0098] 本发明实施例还提供一种接收端，其特征在于，包括：处理器、收发机、存储器、用户接口和总线接口，其中：

[0099] 所述处理器，用于读取所述存储器中的程序，执行本发明实施例提供的接收端侧对应的消息解码方法中的步骤。

[0100] 本发明实施例还提供一种发送端，其特征在于，包括：处理器、收发机、存储器、用户接口和总线接口，其中：

[0101] 所述处理器，用于读取所述存储器中的程序，执行本发明实施例提供的发送侧对应的消息解码方法的步骤。

[0102] 本发明的上述技术方案至少具有如下有益效果：

[0103] 本发明实施例，接收端接收发送端发送的与第一消息关联的第二消息；所述接收端根据所述第二消息，确定解码所述第一消息的目标接收器参数；所述接收端根据所述目标接收器参数对所述发送端发送的所述第一消息进行解码。这样可以实现接收端根据与第一消息关联的第二消息确定接收器参数，且还可以提高消息传输性能。

附图说明

[0104] 图1为本发明实施例可应用的网络结构示意图；

[0105] 图2为本发明实施例提供的一种消息解码方法的流程图；

[0106] 图3为本发明实施例提供的一种消息发送的示意图；

[0107] 图4为本发明实施例提供的另一种消息发送的示意图；

[0108] 图5为本发明实施例提供的另一种消息发送的示意图；

[0109] 图6为本发明实施例提供的另一种消息发送的示意图；

[0110] 图7为本发明实施例提供的另一种消息解码方法的流程图；

[0111] 图8为本发明实施例提供的一种接收端的结构示意图；

[0112] 图9为本发明实施例提供的另一种接收端的结构示意图；

[0113] 图10为本发明实施例提供的一种发送端的结构示意图；

[0114] 图11为本发明实施例提供的另一种发送端的结构示意图；

[0115] 图12为本发明实施例提供的另一种接收端的结构示意图；

[0116] 图13为本发明实施例提供的另一种发送端的结构示意图。

具体实施方式

[0117] 为使本发明要解决的技术问题、技术方案和优点更加清楚，下面将结合附图及具体实施例进行详细描述。

[0118] 参见图1，图1为本发明实施例可应用的网络结构示意图，如图1所示，包括发送端11和接收端12，其中，发送端11可以是基站或者终端，而接收端12也可以是终端或者基站，例如：发送端11为基站，接收端12为终端，则可以实现终端与基站之间的通信，又或者发送端11为终端，则接收端12为基站，也可以实现终端与基站之间的通信，又或者发送端11为基站，接收端12也为基站，则可以实现基站与基站之间的通信，又或者发送端11为终端，接收端12也为终端，则可以实现终端与终端之间的通信。当然，本发明实施例中，并不限定发送端11只能是终端或者基站，例如：发送端11还可以是其他的网络侧设备，同理，接收端12也并不限定只是终端或者设备，例如：接收端12还可以是其他的网络侧设备，对此本发明实施例不作限定。其中，附图1，以发送端11为基站，接收端12为终端进行举例示意。终端可以是用户终端(User Equipment，UE)，例如：可以是手机、平板电脑(Tablet Personal Computer)、膝上型电脑(Laptop Computer)、个人数字助理(personal digital assistant，简称PDA)、移动上网装置(Mobile Internet Device，MID)或可穿戴式设备(Wearable Device)等终端侧设备，需要说明的是，在本发明实施例中并不限定终端的具体类型。基站可以是宏站，如LTE eNB、5G NR NB等；也可以是小站，如低功率节点(LPN：low power node)pico、femto等小站，或者可以是接入点(AP，access point)；基站也可以是中央单元(CU，central unit)与其管理和控制的多个传输接收点(TRP，Transmission Reception Point)共同组成的网络节点。另外，一个基站下有一个或多个小区(例如：不同的频点或扇区分裂)。需要说明的是，在本发明实施例中并不限定基站的具体类型。

[0119] 请参考图2，图2是本本发明实施例提供一种消息解码方法的流程图，如图2所示，包括以下步骤：

[0120] 201、接收端接收发送端发送的与第一消息关联的第二消息；

[0121] 202、所述接收端根据所述第二消息，确定解码所述第一消息的目标接收器参数；

[0122] 203、所述接收端根据所述目标接收器参数对所述发送端发送的所述第一消息进行解码。

[0123] 其中，上述第一消息可以是发送端需要向接收端发送的信号，例如：数据和/或控制消息等等，如上述第一消息可以是下行链路信号。另外，本发明实施例中，可以将第一消息定义为msg1。而上述第二消息可以理解为用于通知接收端接收器参考的消息，例如：控制消息或者调度消息等等，另外，本发明实施例中第二消息可以定义为msg2。

[0124] 上述根据所述第二消息，确定解码所述第一消息的目标接收器参数可以是，若上述第二消息中包括了参数指示信息，则确定该参数指示信息指示的接收器参数作为上述目标器参数，若上述第二消息中不包括参数指示信息，则确定默认的接收器参数作为上述目标器参数。即本发明实施例中，上述第二消息可以存在两种情况，一种是存在参数指示信息，该情况下接收端可能需要进行接收器参数切换，再对发送端发送的消息进行解码。另一

种是不存在参数指示信息，该情况下接收端可能不需要进行波束接收器参数切换，直接对接收端发送的消息进行解码。另外，目标接收器参数可以是接收端中接收器的相关参数，例如：接收波束、均衡器和接收滤波器等参数中的至少一项，对此本发明实施例不作限定。例如：以目标接收器参数为目标接收波束为例，上述确定解码所述第一消息的目标接收波束还可以是在接收端的多个接收波束(Rx波束)中选择一个或者多个接收波束。且接收端的多个接收器参数可以是与发送端无关的，或者接收端的多个接收器参数对于发送端来说也可以是已知的，例如：通过预配置或反馈通知发送端，对此本发明实施例不作限定。

[0125] 本发明实施例中，通过上述步骤就可以实现通过专门的第二消息向接收端通知发送端发送的第一消息的接收波束，从使接收端和发送端获得更准确的波束组合信息，支持多波束传输，以及提高波束传输性能。另外，本发明实施例可以用于在无线通信系统中的接收端的模拟波束切换，以及还可以用于接收端的数字波束切换等，对此本发明实施例不作限定。

[0126] 可选的，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

[0127] 若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端默认的接收器参数。

[0128] 该实施方式中，可以实现上述第二消息中包括或者不包括参数指示信息，若包括，则将参数指示信息指示的接收器参数作为上述目标接收器参数。其中，参数指示信息指示接收波束可以是与接收端当前使用的接收器参数为不同的接收器参数，这时接收端需要进行接收器参数切换。而使用默认的接收器参数，可以不进行切换，例如：默认的接收器参数就可以是接收端当前使用的接收器参数，以快速对发送端发送的消息进行解码。另外，本发明实施例中，第二消息中的参数指示信息可以是，第二消息中的参数指示字段，即第二消息中可以存在或者不存在该参数指示字段。

[0129] 例如：所述接收端默认的接收器参数包括：

[0130] 所述接收端当前使用的接收器参数、所述接收端接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端向所述发送端上报时间最近的发送器参数对应的接收器参数。

[0131] 该实施方式中，通过上述默认波束可以减少接收器参数的切换，例如：减少接收波束的切换，以提高传输性能，例如：第二消息与第一消息之间可以不存在间隙。

[0132] 另外，本发明实施例中，上述参数指示信息可以显式或者隐式指示所述目标接收器参数。例如：显式或者隐式指示所述目标接收波束。

[0133] 其中，显式指示可以理解为直接指示，例如：以接收波束举例，接收端具有一组L个预配置的接收波束，这些对于发送端可以是已知的。这样上述参数指示信息就式携带Log_2(L)位的字段，以指示接收端的推荐接收波束。在接收到第二消息后，接收端就可以机确定对应的接收波束用于解码msg1。而上述隐式指示可以理解为间接指示，例如：上述参数指示信息可以是指示发送波束(Tx波束)，通过指示的发送波束隐式指示该发送波束对应的接收波束。该实施方式中，通过上述显式或者隐式的方式可以实现灵活地向接收端指示接收波束，以提高系统的灵活性。

[0134] 可选的，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信

息包括所述发送端选择的发送器参数，所述接收端将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

[0135] 该实施方式中，可以实现通过发送器参数来隐式指示接收器参数，例如：以目标接收器参数为目标波束举例，发送端可以具有用于下行链路传输的M个候选发送波束。发送端配置M个参考符号(RS)资源，并将每个发送波束应用于相应的RS资源。对于每个RS资源，接收端可以测试一组候选接收波束，并确定每个RS资源(例如发送波束)的最佳接收波束。优选的，接收端可以将至少推荐的发送波束的信息反馈给发送端，例如，以推荐的RS资源的形式，但这一步是可选的。在发送第一消息之前，发送端以第二消息的方式发送其选定的发送波束的指示。接收端接收到第二消息后，获得所使用的发送波束的信息，并获得最佳的接收波束作为上述目标接收波束，该最佳的接收波束可以是从先前的测量已知并保存在接收端中。

[0136] 该实施方式中，可以实现通过发送器参数来隐式指示接收器参数，从而有利于接收端与发送端之间的传输。当然，在一些实施方式中，发送端可以是根据接收端返回的推荐信息自主选择相应的发送器参数，例如：发送波束。

[0137] 可选的，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

[0138] 若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

[0139] 该实施方式中，上述参数切换指示集(BSIS)对应的调度时间单位可以是子帧或者时隙(slots)等时间单位。且发送端和接收端对BSIS可以具有一致的认识。只有在BSIS对应的slot(这里以slot为例)中，第二消息才可能会携带参数指示信息，否则第二消息不携带波束指示信息。这意味着在BSIS对应的时隙之外的所有时隙中可以不执行接收器参数切换，例如：接收波束切换，而仅在周期性的选定时隙(例如BSIS中的时隙)中执行接收器参数切换。

[0140] 另外，由于第二消息包括参数指示信息时，所述第二消息与所述第一消息之间存在间隙，这样接收端可以是在该间隙切换进行接收器参数切换，例如：接收波束切换，从而不影响消息的传输。而所述第二消息不包括参数指示信息时，所述第二消息与所述第一消息之间可以不存在间隙，这样可以节约传输资源，因为该情况下，接收端可能是不需要进行接收器参数切换，例如：接收波束切换，进而第二消息和第一消息连续传输也不会影响接收端的解码。且上述第二消息和第一消息可以采用相同的频域资源发送的，或者采用相同的信道发送等，对此本发明实施例不作限定。

[0141] 例如：对于在BSIS中的时隙中发送的第二消息，携带波束指示信息。在这种情况下，同一时隙中的第一消息和第二消息之间有切换时间。否则对于BSIS外的时隙中的第二消息传输，发送端发送第二消息，而不携带波束指示字段。在这种情况下，接收端可以准备在第二消息之后立即接收第一消息(没有间隙)。例如：图3所示的第二个slot。另外，当尝试在每个时隙中接收到第二消息或者第一消息时，接收端可以根据假定存在或者不存在波束指示信息来解码第二消息。换句话说，在BSIS中的时隙中，第二消息可以携带参数指示信息，接收端尝试解码第二消息，假设有一个参数指示信息。在其他时隙中，接收器解码第二

消息，假设没有参数指示信息。在第二消息不携带参数指示信息的时隙中，接收端仍然可以选择一个接收器参数(例如：接收波束)来解码第一消息。接收端可以使用在最新的携带参数指示字段的第二消息中指示的接收器参数。如果没有接收到参数指示信息，则接收机可以使用默认的接收器参数来解码第一消息。

[0142] 可选的，所述参数切换指示集对应的调度时间单位在时域上周期存在；和\或

[0143] 所述参数切换指示集对应的调度时间单位由所述发送端半静态或半持续(semi-persistent)配置，并通知所述接收端。

[0144] 其中，上述参数切换指示集对应的调度时间单位在时域上周期存在可以是，上述参数切换指示集对应的调度时间单位具有周期性，例如：参数切换指示集在时域中可以周期性地具有预配置的周期和定时偏移，其中，该定时偏移可以是相对于另一个定时参考的偏移，如帧边界。例如，参数切换指示集可以具有10ms的周期，其指示在10个slots中的1个中发送的第二消息可能会携带参数指示信息，而其他9个slots中的第二消息不携带参数指示信息。上述参数切换指示集对应的调度时间单位由所述发送端半静态或半持续配置，并通知所述接收端可以是，发送端半静态或半持续配置，并通知接收端参数切换指示集的集合，即指示多个参数切换指示集。或者上述参数切换指示集可以由接收端获得，并作为推荐被反馈给发送端。发送端可以使用接收端推荐的参数切换指示集，或覆盖接收端推荐的参数切换指示集，并选择一个新的参数切换指示集。发送端可以需要向接收端指示是否确认接收端推荐的参数切换指示集，或者将其选择的参数切换指示集指示给接收端。

[0145] 可选的，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前，所述接收端根据所述目标接收器参数对所述第一消息进行解码，包括：

[0146] 若所述第二消息包括参数指示信息，则所述接收端根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0147] 若所述第二消息包括参数指示信息，则所述接收端丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0148] 若所述第二消息包括参数指示信息，则所述接收端根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0149] 若所述第二消息不包括波束指示信息，则所述接收端根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

[0150] 该实施方式中，所述第一消息分为时域上连续的第一部分内容和第二部分内容可以是接收端将第一消息分为两个部分，这里分为可以理解为将第一消息看作两个部分，因为，此时接收端还未接收到第一消息，不能对其进行拆分。

[0151] 例如：发送端可以发送携带与接收第一消息有关的下行调度信息的第二消息。第二消息可以携带或不携带参数指示信息，对此接收端可以没有先验知识。如果第二消息没有参数指示信息，则第二消息的有效载荷较小(表示为A位)。如果第二消息具有参数指示信息，则第二消息的有效载荷较大(表示为B位，其中B>A)。在发送端发送第二消息后，接收端可以尝试用盲解码第二消息。因为，接收端没有关于第二消息的有效载荷的先验信息，因此

需要基于不同的可能的第二消息有效载荷来执行盲解码。例如，接收端将执行假设有效载荷A位的第二消息的一次盲解码，以及假设B位的有效载荷的另一个第二消息的盲解码。这样根据第二消息的实际有效负载，两个盲解码之一将成功解码第二消息。之后，接收端就可以将第一消息分为第一部分内容和第二部分内容(partland part 2)，第一部分内容在第二部分内容前面，并且在时域中为时分复用(TDM)。第一消息的第一部分部分紧随着第二消息，即两者没有间隙，第一消息的第二部分内容紧邻第一部分内容，例如：图4所示的第二个slot。

[0152] 另外，由于第一部分内容和第二部分内容属于同一消息，从而接收端可以分别对第一部分内容和第二部分内容执行符号级处理。

[0153] 该实施方式中，由于若所述第二消息包括参数指示信息时，则所述接收端使用所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码，其中，所述发送端未发送所述第一部分内容。例如：图4所示的第一个slot。这样可以提高接收端解码的准确性。

[0154] 另外，由于第二消息包括参数指示信息时，可以丢弃所述第一部分内容，以及使用所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码。即可以丢弃图4所示的第二个slot的第一部分内容，同样能够保证发送端与接收端之间的性能，因为，在该情况下发送端可以在第一部分内容中传输非重要信息，而在第二部分内容中传输重要信息。

[0155] 另外，由于第二消息包括参数指示信息时，可以使用默认的接收器参数对所述第一部分内容进行解码，以及使用所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码。这样可以实现接收到准备地解码第一部分部分和第二部分内容。

[0156] 另外，由于第二消息不包括参数指示信息，可以实现使用默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。即图4所示的第三个slot。

[0157] 另外，发送端和接收端可以将其对接收端上确切的第一消息解码行为的理解对齐。这可以由网络半静态地或半持续地配置给接收端，或者使用另一个动态控制消息动态地指示给接收端。

[0158] 可选的，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前，所述接收端根据所述目标接收器参数对所述发送端发送的所述第一消息进行解码，包括：

[0159] 若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0160] 若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0161] 若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则所述接收端根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0162] 若所述第二消息包括参数指示字段，且所述参数指示字段指示没有参数指示信息或者没有参数改变，则所述接收端根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

[0163] 该实施方式中，可以实现第二消息终具有参数指示字段，例如：波束指示字段，例如S比特位。且参数指示字段具有至少一个状态指示，即没有参数指示信息或者没有参数改变的状态指示，以及还可以指示用于解码第一消息的接收器参数的其他状态。因此，第二消息的有效载荷预先已知到发送端和接收端。例如对应于4个可能的接收器参数指示状态的S＝2。一个状态向接收机指示存在“没有参数指示信息或者没有参数改变”，而其他3个状态指示到接收机的接收器参数。

[0164] 另外，该实施方式中，关于第一消息的第一部分内容和第二部分内容可以参考上一实施方式中的相应描述，此处不作赘述。

[0165] 且关于第二消息中是否包括参数指示信息的情况，如何对第一部分内容和第二部分内容的解码，可以参见上述实施方式的相应描述，此处不作赘述，且可以达到相同的有益效率。

[0166] 可选的，所述方法还包括：

[0167] 所述接收端接收所述发送端发送的第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

[0168] 其中，上述第三消息可以定义为msg3，该实施方式中，通过第三消息通知接收端第二消息是否包括参数指示信息，更为具体的可以指示第二消息指示的接收器参数对于接收端是否存在接收器参数改变，这样可以实现当不存在接收器参数改变或者不包括参数指示信息时，接收端甚至可以不接收第二消息，直接使用当前的接收器参数对第一消息进行解码。另外，在一些实施方式中，第三消息可以具有固定有效载荷，其中第二消息中的参数指示信息的存在或者不存在对应于第三消息中的两个不同状态。例如，第三消息有1位表示第二消息是否携带参数指示信息。

[0169] 另外，本发明实施例中，上述第三消息可以对应于一个第二消息，即一个第三消息指示一个第二消息，例如：如图5所示。且第三消息、第二消息可以是以相同的调度时间单位(例如，时隙)发送，其中图5给出了一个示例。可以以不同的调度时间单位发送的第三消息和第二消息。如果第二消息有参数指示信息，第一消息和第二消息之间可以有一个间隙。如果第二消息没有参数指示，第一消息和第二消息之间可以没有间隙。

[0170] 可选的，所述第三消息用于指示M个时间单位内的第二消息是否包括参数指示信息，所述M为大于或者等于1的整数，所述M个时间单位连续或者不连续。

[0171] 该实施方式中，可以实现通过第三消息指示多个第二消息，例如：第三消息用于指示M个时隙中的M个第二消息是否包括参数指示信息，这样可以节省消息开销。另外，上述M的值和M个第二消息的时间位置可以预定义的半静态或半持续配置的，并且对发送端和接收端均是已知的。其中，图6示出了一个例子，其中M＝3。一旦接收到第三消息，该第三消息就向接收端指示相应的M个时隙中的第二消息是否携带参数指示信息。

[0172] 另外，第三消息可以是可以在每个调度时间单位(例如slots)或在由发送端预配

置的时隙的子集(例如,具有预先配置的传输周期和偏移)中被发送。对于后一种情况,发送端可以事先向接收端指示第三消息的发生。

[0173] 可选的,本发明实施例中,目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

[0174] 这样可以实现根据发送端的第二消息灵活选择时域、频域和空域中的至少一项的接收器参数,对第一消息进行解码。优先的,所述空域的接收器参数包括所述接收端的接收波束。这样可以实现接收端根据与第一消息关联的第二消息确定接收波束,且还可以提高波束传输性能。

[0175] 需要说明的是,本发明实施例介绍的多种可选的实施方式均可以相互结合实现,也可以单独实现,对此本发明实施例不作限定。

[0176] 本发明实施例,接收端接收发送端发送的与第一消息关联的第二消息;所述接收端根据所述第二消息,确定解码所述第一消息的目标接收器参数;所述接收端根据所述目标接收器参数对所述发送端发送的所述第一消息进行解码。这样可以实现接收端根据与第一消息关联的第二消息确定接收器参数,且还可以提高消息传输性能。

[0177] 请参阅图7,图7是本发明实施例提供的另一种消息解码方法的流程图,如图7所示,包括以下步骤:

[0178] 701、发送端向接收端发送与第一消息关联的第二消息,所述第二消息用于所述接收端确定解码所述第一消息的目标接收器参数;

[0179] 702、所述发送端向所述接收端发送所述第一消息。

[0180] 可选的,若所述第二消息包括参数指示信息,则所述目标接收器参数为所述参数指示信息指示的接收器参数;

[0181] 若所述第二消息不包括参数指示信息,则所述目标接收器参数为所述接收端默认的接收器参数。

[0182] 可选的,所述接收端默认的接收器参数包括:

[0183] 所述接收端当前使用的接收器参数、所述接收端接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端向所述发送端上报时间最近的发送器参数对应的接收器参数。

[0184] 可选的,所述参数指示信息显式或者隐式指示所述目标接收器参数。

[0185] 可选的,若所述参数指示信息隐式指示所述目标接收器参数,则所述参数指示信息包括所述发送端选择的发送器参数,所述接收端将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

[0186] 可选的,若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的,则所述第二消息包括参数指示信息,且所述第二消息与所述第一消息之间存在间隙;

[0187] 若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的,则所述第二消息不包括参数指示信息,且所述第二消息与所述第一消息之间不存在间隙。

[0188] 可选的,所述参数切换指示集对应的调度时间单位在时域上周期存在;和\或

[0189] 所述参数切换指示集对应的调度时间单位由所述发送端半静态或半持续配置,并通知所述接收端。

[0190] 可选的，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前。

[0191] 可选的，所述方法还包括：

[0192] 所述发送端向所述接收端发送第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

[0193] 可选的，所述第三消息用于指示M个时间单位内的第二消息是否包括参数指示信息，所述M为大于或者等于1的整数，所述M个时间单位连续或者不连续。

[0194] 可选的，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

[0195] 可选的，所述空域的接收器参数包括所述接收端的接收波束。

[0196] 需要说明的是，本实施例作为与图2所示的实施例中对应的发送端的实施方式，其具体的实施方式可以参见图2所示的实施例的相关说明，为了避免重复说明，本实施例不再赘述，且还可以达到相同有益效果。

[0197] 请参考图8，图8是本发明实施例提供一种接收端的结构图，如图8所示，接收端800包括：

[0198] 第一接收模块801，用于接收发送端发送的与第一消息关联的第二消息；

[0199] 确定模块802，用于根据所述第二消息，确定解码所述第一消息的目标接收器参数；

[0200] 解码模块803，用于根据所述目标接收器参数对所述发送端发送的所述第一消息进行解码。

[0201] 可选的，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

[0202] 若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端默认的接收器参数。

[0203] 可选的，所述接收端默认的接收器参数包括：

[0204] 所述接收端当前使用的接收器参数、所述接收端接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端向所述发送端上报时间最近的发送器参数对应的接收器参数。

[0205] 可选的，所述参数指示信息显式或者隐式指示所述目标接收器参数。

[0206] 可选的，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端选择的发送器参数，所述接收端将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

[0207] 可选的，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

[0208] 若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

[0209] 可选的，所述参数切换指示集对应的调度时间单位在时域上周期存在；和\或

[0210] 所述参数切换指示集对应的调度时间单位由所述发送端半静态或半持续配置，并通知所述接收端。

[0211] 可选的，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前；

[0212] 所述解码模块803用于若所述第二消息包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0213] 所述解码模块803用于若所述第二消息包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0214] 所述解码模块803用于若所述第二消息包括参数指示信息，则根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0215] 所述解码模块803用于若所述第二消息不包括波束指示信息，则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码；或者

[0216] 所述解码模块803用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0217] 所述解码模块803用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0218] 所述解码模块803用于若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0219] 所述解码模块803用于若所述第二消息包括参数指示字段，且所述参数指示字段指示没有参数指示信息或者没有参数改变，则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

[0220] 可选的，如图9所示，所述接收端800还包括：

[0221] 第二接收模块804，用于接收所述发送端发送的第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

[0222] 可选的，所述第三消息用于指示M个时间单位内的第二消息是否包括参数指示信息，所述M为大于或者等于1的整数，所述M个时间单位连续或者不连续。

[0223] 可选的，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

[0224] 可选的，所述空域的接收器参数包括所述接收端的接收波束。

[0225] 需要说明的是，本实施例中上述接收端800可以是本发明实施例中方法实施例中任意实施方式的接收端，本发明实施例中方法实施例中接收端的任意实施方式都可以被本

实施例中的上述接收端800所实现，以及达到相同的有益效果，此处不再赘述。

[0226] 请参阅图10，图10是本发明实施例提供的一种发送端的结构图，如图10所示，发送端1000包括：

[0227] 第一发送模块1001，用于发送端向接收端发送与第一消息关联的第二消息，所述第二消息用于所述接收端确定解码所述第一消息的目标接收器参数；

[0228] 第二发送模块1002，用于向所述接收端发送所述第一消息。

[0229] 可选的，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

[0230] 若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端默认的接收器参数。

[0231] 可选的，所述接收端默认的接收器参数包括：

[0232] 所述接收端当前使用的接收器参数、所述接收端接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端向所述发送端上报时间最近的发送器参数对应的接收器参数。

[0233] 可选的，所述参数指示信息显式或者隐式指示所述目标接收器参数。

[0234] 可选的，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端选择的发送器参数，所述接收端将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

[0235] 可选的，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

[0236] 若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

[0237] 可选的，所述参数切换指示集对应的调度时间单位在时域上周期存在；和\或

[0238] 所述参数切换指示集对应的调度时间单位由所述发送端半静态或半持续配置，并通知所述接收端。

[0239] 可选的，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前。

[0240] 可选的，如图11所示，所述发送端还包括：

[0241] 第二发送模块1003，用于向所述接收端发送第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

[0242] 可选的，所述第三消息用于指示M个时间单位内的第二消息是否包括参数指示信息，所述M为大于或者等于1的整数，所述M个时间单位连续或者不连续。

[0243] 可选的，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

[0244] 可选的，所述空域的接收器参数包括所述接收端的接收波束。

[0245] 需要说明的是，本实施例中上述发送端1000可以是本发明实施例中方法实施例中

任意实施方式的发送端，本发明实施例中方法实施例中发送端的任意实施方式都可以被本实施例中的上述发送端1000所实现，以及达到相同的有益效果，此处不再赘述。

[0246] 请参考图12，图12是本发明实施例提供的另一种接收端的结构图，如图12所示，该接收端包括：处理器1200、收发机1210、存储器1220、用户接口1230和总线接口，其中：

[0247] 处理器1200，用于读取存储器1220中的程序，执行下列过程：

[0248] 通过收发机1210接收端接收发送端发送的与第一消息关联的第二消息；

[0249] 根据所述第二消息，确定解码所述第一消息的目标接收器参数；

[0250] 根据所述目标接收器参数对所述发送端发送的所述第一消息进行解码。

[0251] 其中，收发机1210，用于在处理器1200的控制下接收和发送数据。

[0252] 在图12中，总线架构可以包括任意数量的互联的总线和桥，具体由处理器1200代表的一个或多个处理器和存储器1220代表的存储器的各种电路链接在一起。总线架构还可以将诸如外围设备、稳压器和功率管理电路等之类的各种其他电路链接在一起，这些都是本领域所公知的，因此，本文不再对其进行进一步描述。总线接口提供接口。收发机1210可以是多个元件，即包括发送机和接收机，提供用于在传输介质上与各种其他装置通信的单元。针对不同的用户设备，用户接口1230还可以是能够外接内接需要设备的接口，连接的设备包括但不限于小键盘、显示器、扬声器、麦克风、操纵杆等。

[0253] 处理器1200负责管理总线架构和通常的处理，存储器1220可以存储处理器1200在执行操作时所使用的数据。

[0254] 可选的，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

[0255] 若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端默认的接收器参数。

[0256] 可选的，所述接收端默认的接收器参数包括：

[0257] 所述接收端当前使用的接收器参数、所述接收端接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端向所述发送端上报时间最近的发送器参数对应的接收器参数。

[0258] 可选的，所述参数指示信息显式或者隐式指示所述目标接收器参数。

[0259] 可选的，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端选择的发送器参数，所述接收端将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

[0260] 可选的，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

[0261] 若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

[0262] 可选的，所述参数切换指示集对应的调度时间单位在时域上周期存在；和\或

[0263] 所述参数切换指示集对应的调度时间单位由所述发送端半静态或半持续配置，并通知所述接收端。

[0264] 可选的，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述

第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前，所述根据所述目标接收器参数对所述第一消息进行解码，包括：

[0265] 若所述第二消息包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0266] 若所述第二消息包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0267] 若所述第二消息包括参数指示信息，则根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0268] 若所述第二消息不包括波束指示信息，则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码；或者

[0269] 若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0270] 若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则丢弃所述第一部分内容，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0271] 若所述第二消息包括参数指示字段，且所述参数指示字段包括参数指示信息，则根据默认的接收器参数对所述第一部分内容进行解码，以及根据所述参数指示信息指示的所述目标接收器参数对所述第二部分内容进行解码；或者

[0272] 若所述第二消息包括参数指示字段，且所述参数指示字段指示没有参数指示信息或者没有参数改变，则根据默认的接收器参数对所述第一部分内容和所述第二部分内容进行解码。

[0273] 可选的，处理器1200还用于：

[0274] 通过收发机1210接收所述发送端发送的第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数指示信息，则所述第二消息与所述第一消息之间不存在间隙。

[0275] 可选的，所述第三消息用于指示M个时间单位内的第二消息是否包括参数指示信息，所述M为大于或者等于1的整数，所述M个时间单位连续或者不连续。

[0276] 可选的，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

[0277] 可选的，所述空域的接收器参数包括所述接收端的接收波束。

[0278] 需要说明的是，本实施例中上述接收端可以是图1-图7所示的实施例中的终端，图1-图7所示实施例中接收端的任意实施方式都可以被本实施例中的上述接收所实现，以及达到相同的有益效果，此处不再赘述。

[0279] 请参考图13，图13是本发明实施提供的另一种发送端的结构图，如图13所示，该发送端包括：处理器1300、收发机1310、存储器1320、用户接口1330和总线接口，其中：

[0280] 处理器1300，用于读取存储器1320中的程序，执行下列过程：

[0281] 通过收发机1310向接收端发送与第一消息关联的第二消息，所述第二消息用于所

述接收端确定解码所述第一消息的目标接收器参数；

[0282] 通过收发机1310向所述接收端发送所述第一消息。

[0283] 其中，收发机1310，用于在处理器1300的控制下接收和发送数据。

[0284] 在图13中，总线架构可以包括任意数量的互联的总线和桥，具体由处理器1300代表的一个或多个处理器和存储器1320代表的存储器的各种电路链接在一起。总线架构还可以将诸如外围设备、稳压器和功率管理电路等之类的各种其他电路链接在一起，这些都是本领域所公知的，因此，本文不再对其进行进一步描述。总线接口提供接口。收发机1310可以是多个元件，即包括发送机和接收机，提供用于在传输介质上与各种其他装置通信的单元。针对不同的用户设备，用户接口1330还可以是能够外接内接需要设备的接口，连接的设备包括但不限于小键盘、显示器、扬声器、麦克风、操纵杆等。

[0285] 处理器1300负责管理总线架构和通常的处理，存储器1320可以存储处理器1300在执行操作时所使用的数据。

[0286] 可选的，若所述第二消息包括参数指示信息，则所述目标接收器参数为所述参数指示信息指示的接收器参数；

[0287] 若所述第二消息不包括参数指示信息，则所述目标接收器参数为所述接收端默认的接收器参数。

[0288] 可选的，所述接收端默认的接收器参数包括：

[0289] 所述接收端当前使用的接收器参数、所述接收端接收到的时间最近的第二消息指示的接收器参数、预先定义的接收器参数或者所述接收端向所述发送端上报时间最近的发送器参数对应的接收器参数。

[0290] 可选的，所述参数指示信息显式或者隐式指示所述目标接收器参数。

[0291] 可选的，若所述参数指示信息隐式指示所述目标接收器参数，则所述参数指示信息包括所述发送端选择的发送器参数，所述接收端将预先为所述发送器参数选择的接收器参数作为所述目标接收器参数。

[0292] 可选的，若所述第二消息是在预先确定的参数切换指示集对应的调度时间单位内接收到的，则所述第二消息包括参数指示信息，且所述第二消息与所述第一消息之间存在间隙；

[0293] 若所述第二消息是在所述参数切换指示集对应的调度时间单位外接收到的，则所述第二消息不包括参数指示信息，且所述第二消息与所述第一消息之间不存在间隙。

[0294] 可选的，所述参数切换指示集对应的调度时间单位在时域上周期存在；和\或

[0295] 所述参数切换指示集对应的调度时间单位由所述发送端半静态或半持续配置，并通知所述接收端。

[0296] 可选的，所述第一消息分为时域上连续的第一部分内容和第二部分内容，且所述第一部分内容在所述第二部分内容的前面，以及所述第一部分内容与所述第二消息在时域连续，所述第二消息在所述第一部分内容之前。

[0297] 可选的，处理器1300还用于：

[0298] 通过收发机1310向所述接收端发送第三消息，所述第三消息用于指示所述第二消息是否包括参数指示信息，且若所述第三消息指示所述第二消息包括参数指示信息，则所述第二消息与所述第一消息之间存在间隙，若所述第三消息指示所述第二消息不包括参数

指示信息，则所述第二消息与所述第一消息之间不存在间隙。

[0299] 可选的，所述第三消息用于指示M个时间单位内的第二消息是否包括参数指示信息，所述M为大于或者等于1的整数，所述M个时间单位连续或者不连续。

[0300] 可选的，所述目标接收器参数包括时域、频域和空域中的至少一项的接收器参数。

[0301] 可选的，所述空域的接收器参数包括所述接收端的接收波束。

[0302] 需要说明的是，本实施例中上述发送端可以是图1-图7所示的实施例中的发送端，图1-图7所示实施例中发送端的任意实施方式都可以被本实施例中的上述发送端所实现，以及达到相同的有益效果，此处不再赘述。

[0303] 在本申请所提供的几个实施例中，应该理解到，所揭露方法和装置，可以通过其它的方式实现。例如，以上所描述的装置实施例仅仅是示意性的，例如，所述单元的划分，仅仅为一种逻辑功能划分，实际实现时可以有另外的划分方式，例如多个单元或组件可以结合或者可以集成到另一个系统，或一些特征可以忽略，或不执行。另一点，所显示或讨论的相互之间的耦合或直接耦合或通信连接可以是通过一些接口，装置或单元的间接耦合或通信连接，可以是电性，机械或其它的形式。

[0304] 另外，在本发明各个实施例中的各功能单元可以集成在一个处理单元中，也可以是各个单元单独物理包括，也可以两个或两个以上单元集成在一个单元中。上述集成的单元既可以采用硬件的形式实现，也可以采用硬件加软件功能单元的形式实现。

[0305] 上述以软件功能单元的形式实现的集成的单元，可以存储在一个计算机可读取存储介质中。上述软件功能单元存储在一个存储介质中，包括若干指令用以使得一台计算机设备(可以是个人计算机，服务器，或者网络设备等)执行本发明各个实施例所述收发方法的部分步骤。而前述的存储介质包括：U盘、移动硬盘、只读存储器(Read-Only Memory，简称ROM)、随机存取存储器(Random Access Memory，简称RAM)、磁碟或者光盘等各种可以存储程序代码的介质。

[0306] 以上所述是本发明的优选实施方式，应当指出，对于本技术领域的普通技术人员来说，在不脱离本发明所述原理的前提下，还可以作出若干改进和润饰，这些改进和润饰也应视为本发明的保护范围。

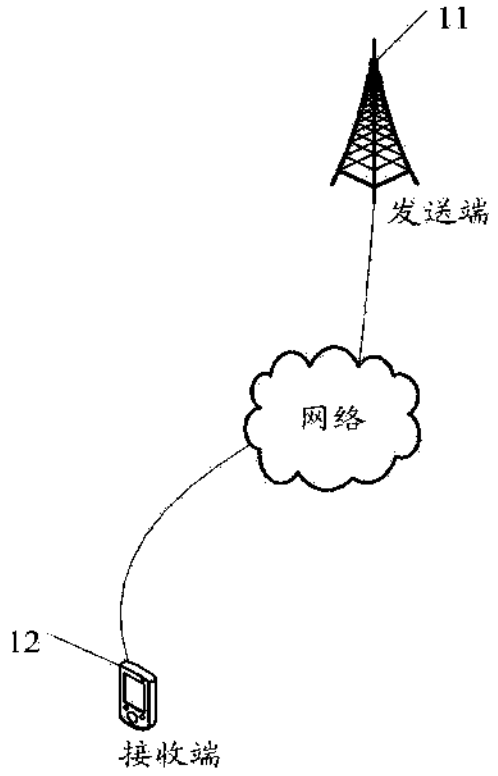

11
发送端
网络
12
接收端

图1

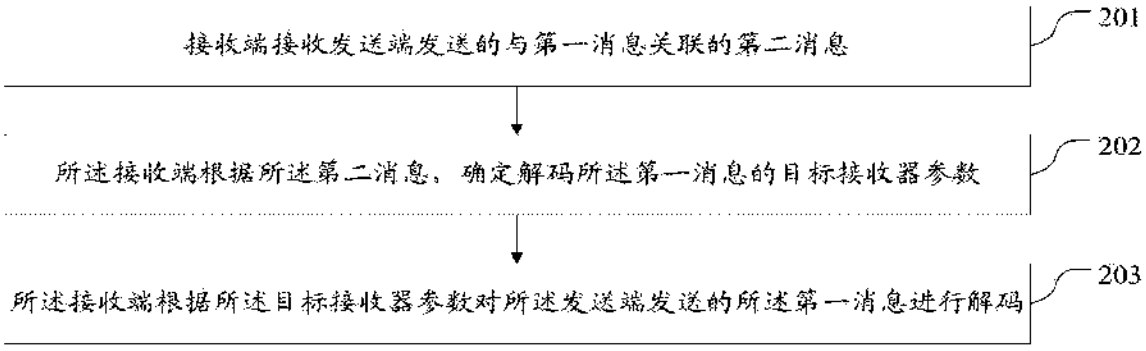

接收端接收发送端发送的与第一消息关联的第二消息
201
所述接收端根据所述第二消息，确定解码所述第一消息的目标接收器参数
202
所述接收端根据所述目标接收器参数对所述发送端发送的所述第一消息进行解码
203

图2

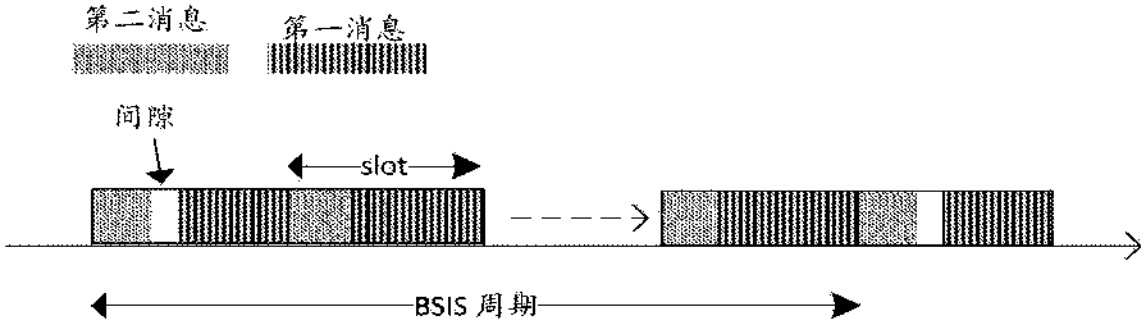

第二消息
第一消息
间隙
slot
BSIS 周期

图3

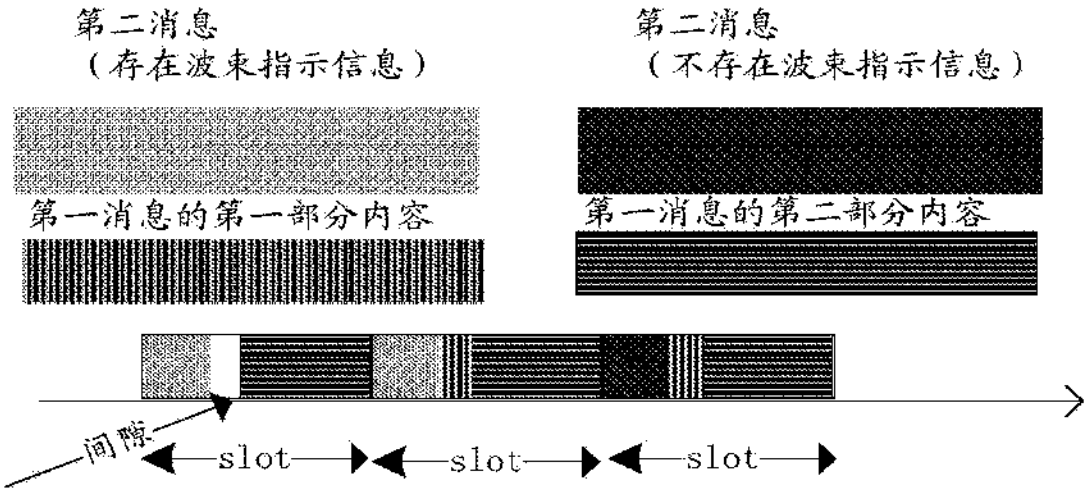

第二消息
（存在波束指示信息）
第二消息
（不存在波束指示信息）
第一消息的第一部分内容
第一消息的第二部分内容
间隙
slot
slot
slot

图4

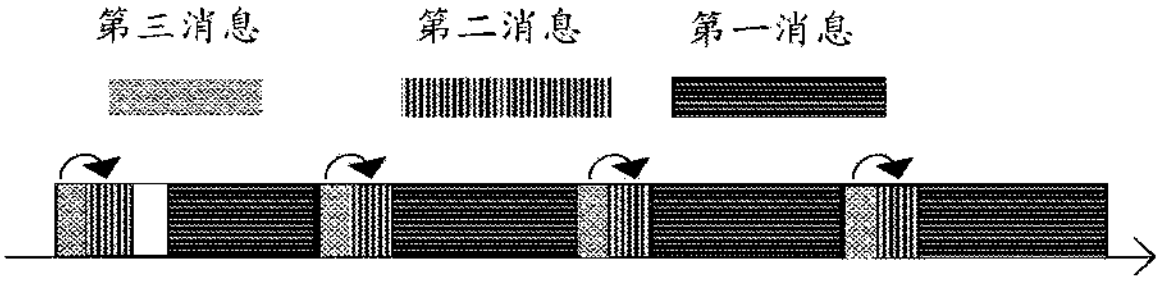

第三消息
第二消息
第一消息

图5

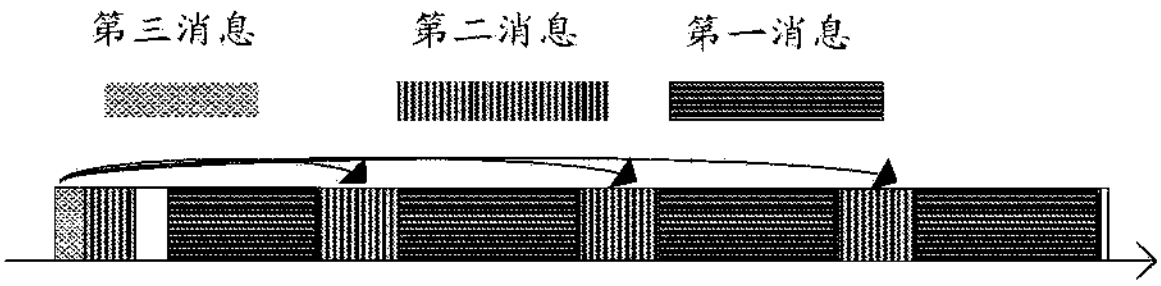

第三消息
第二消息
第一消息

图6

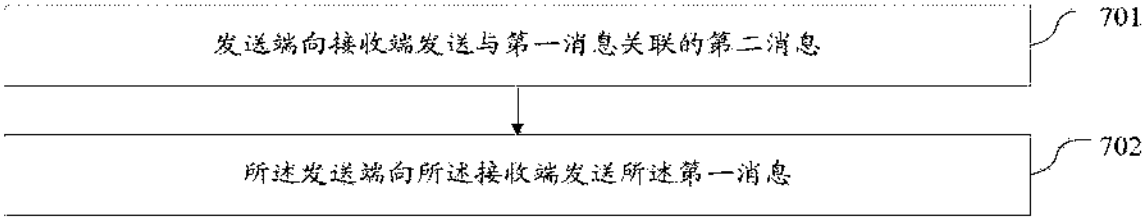

发送端向接收端发送与第一消息关联的第二消息
701
所述发送端向所述接收端发送所述第一消息
702

图7

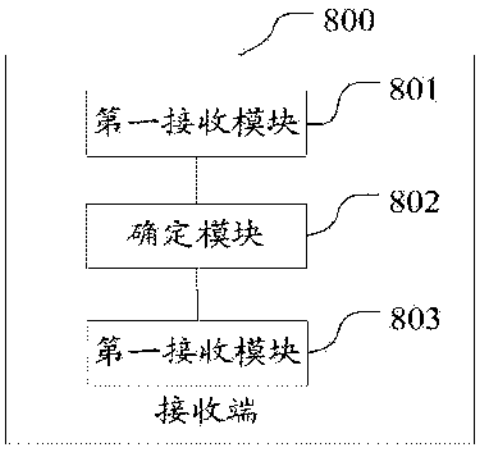

800
第一接收模块
801
确定模块
802
第一接收模块
803
接收端

图8

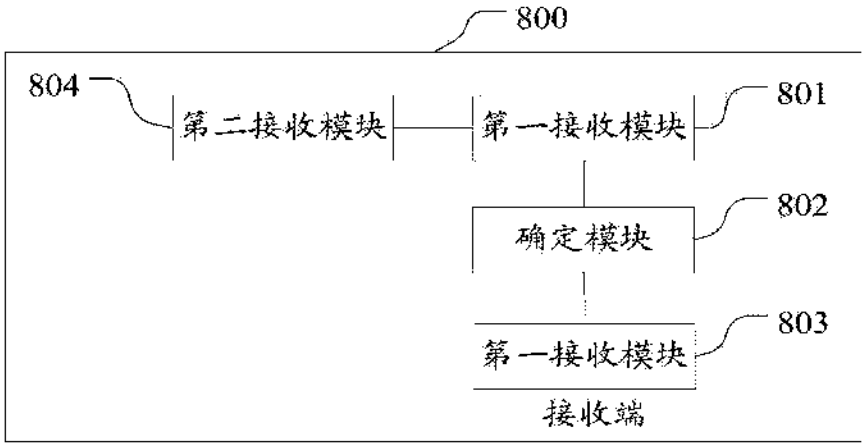

800
804
第二接收模块
第一接收模块
801
确定模块
802
第一接收模块
803
接收端

图9

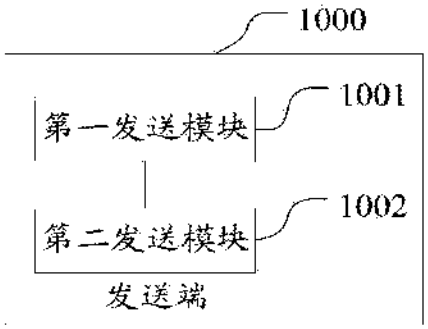

1000
第一发送模块
1001
第二发送模块
1002
发送端

图10

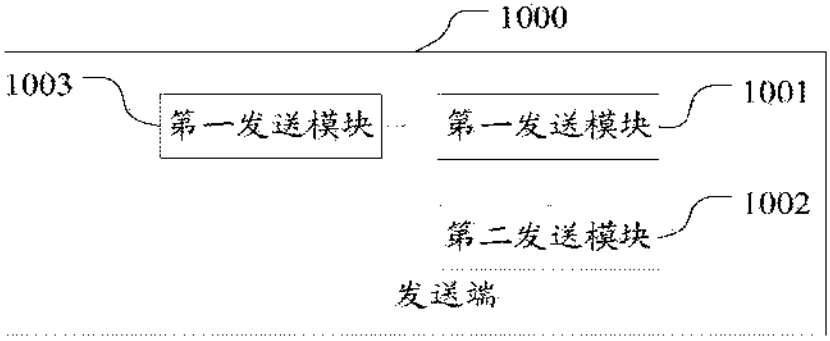

1000
1003
第一发送模块
第一发送模块
1001
第二发送模块
1002
发送端

图11

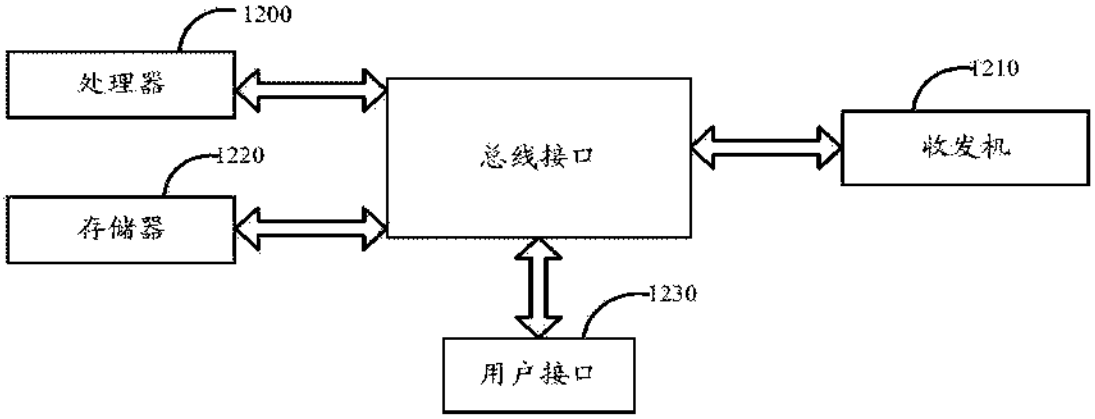

1200
处理器
1210
总线接口
收发机
1220
存储器
1230
用户接口

图12

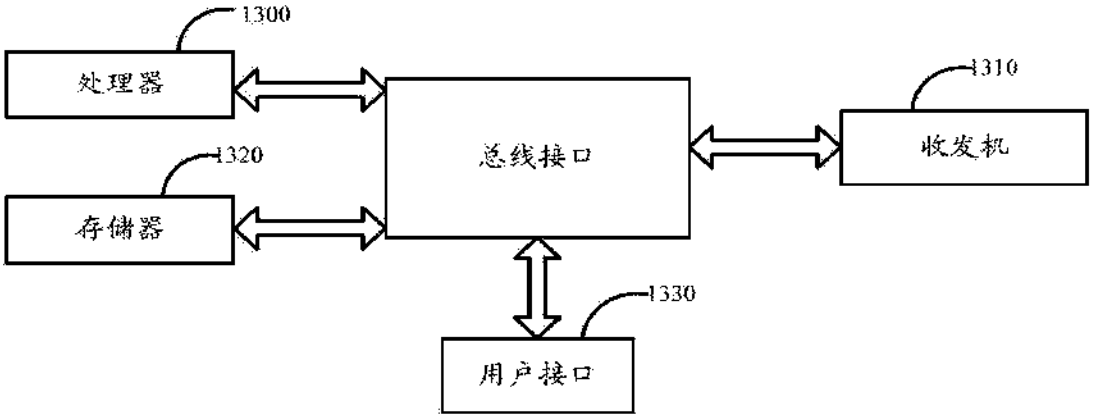

1300
处理器
1310
总线接口
收发机
1320
存储器
1330
用户接口

图13

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[Continued on next page]

(54) Title: ENODEB REFERENCE SIGNAL REDUCTION

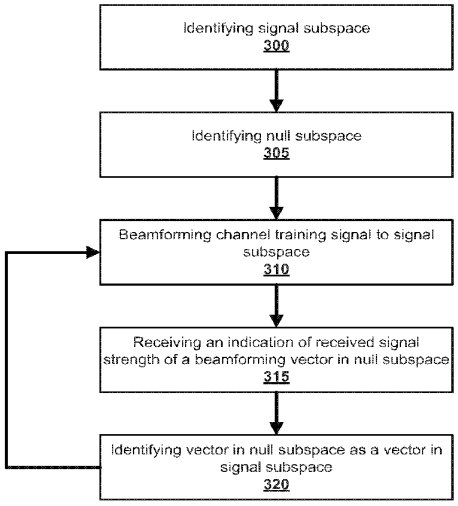


Figure 3

(57) Abstract: In embodiments, apparatuses, methods, and storage media may be described for reducing the overhead associated with the transmission of channel training signals from an eNodeB (eNB) of a wireless network. Specifically, the eNB may receive feedback from a user equipment (UE) regarding the received signal energy of a first and second beamformed signal produced with a first and second beamforming vector, respectively. The eNB may identify, based on the feedback of the received signal energy, a signal subspace and a null subspace. The eNB may then transmit a channel training signal to the signal subspace.

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EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *of inventorship (Rule 4.17(iv))*

Published:

— *with international search report (Art. 21(3))*

— *with amended claims (Art. 19(1))*

ENODEB REFERENCE SIGNAL REDUCTION

Cross Reference to Related Application

The present application claims priority to U.S. Provisional Patent Application No. 61/806,821, filed March 29, 2013, entitled "Advanced Wireless Communication Systems and Techniques," the entire disclosure of which is hereby incorporated by reference in its entirety.

Field

Embodiments of the present invention relate generally to the technical field of channel training signals in wireless systems.

Background

The background description provided herein is for the purpose of generally presenting the context of the disclosure. Work of the presently named inventors, to the extent it is described in this background section, as well as aspects of the description that may not otherwise qualify as prior art at the time of filing, are neither expressly nor impliedly admitted as prior art against the present disclosure. Unless otherwise indicated herein, the approaches described in this section are not prior art to the claims in the present disclosure and are not admitted to be prior art by inclusion in this section.

Full dimension multiple-input-multiple-output (FD-MIMO) is a study item for the upcoming Release 12 of the third generation partnership project (3GPP) long term evolution (LTE) specifications. In FD-MIMO systems, the eNodeB (eNB) may have 16 or more different antenna elements that are configured for beamforming on one or more antenna ports to user equipment (UEs). Ideally, the throughput of the eNB in FD-MIMO systems may be expected to significantly increase with a large number of antenna elements.

However, in frequency division duplex (FDD) mode, beamforming may require channel training signals. Specifically, channel training signals may be reference signals that are sent by the eNB to each UE. The UE(s) may then respond with channel feedback based on the received channel training signals. This feedback may be used to identify the resources used to beamform one or more additional signals to the UE. Currently, the overhead associated with transmitting the channel training signals may increase linearly with the number of antenna elements. For large antenna arrays having, for example, 30 antenna elements, the overhead associated with transmitting the channel training signals may become prohibitive because the throughput gains realized through use of FD-MIMO

may be offset by the overhead incurred through transmission of the channel training signals.

Brief Description of the Drawings

Embodiments will be readily understood by the following detailed description in conjunction with the accompanying drawings. To facilitate this description, like reference numerals designate like structural elements. Embodiments are illustrated by way of example and not by way of limitation in the figures of the accompanying drawings.

Figure 1 schematically illustrates a high-level example of a network system comprising a UE and an eNB, in accordance with various embodiments.

Figure 2 depicts an example of different subspaces for FD-MIMO transmissions from an eNodeB (eNB) to a plurality of user equipment (UEs), in accordance with various embodiments.

Figure 3 depicts an example of a process flow for transmitting channel training signals, in accordance with various embodiments.

Figure 4 schematically illustrates an example system that may be used to practice various embodiments described herein.

Detailed Description

Apparatuses, methods, and storage media are described herein for reducing the overhead associated with the transmission of channel training signals such as the channel state information reference signal (CSI-RS). As described above, the number of antenna ports of an eNB may linearly increase with an increase in the number of antenna elements used by the eNB. This increase in antenna ports may increase transmissions of channel training signals, which in turn may increase resource overhead of the eNB.

The channel training signals may be shared between the antenna ports in order to reduce the resource overhead of the eNB. However, time sharing of the channel training signals may introduce latency or delay to transmissions of the eNB. As noted above, the channel training signals may be transmitted from the eNB, and the UE may feed back information related to the channel training signals, and more specifically the radio resources used to transmit the channel training signals. Based on the fed back information, the eNB may identify radio resources that should be used for further communication with the UE.

However, the latency introduced by time sharing of the channel training signals may be detrimental because the latency may be such that the radio resources in the cell may have changed significantly between the transmission of the channel training signal

and the identification of the channel resources to use to transmit further signals using the feedback based on the transmission of the channel training signal. In other words, the fed back information from a UE receiving the channel training signals may not necessarily correspond to the radio resources of the cell at the time of transmission of the additional signal(s) from the eNB. This change may be due to interference caused by multiple UEs, the UE moving, or other reasons. Therefore, time sharing of the channel training signals may reduce overall performance of the cell.

By contrast, the present disclosure may relate to selectively transmitting one or more channel training signals to particular signal subspaces. Specifically, the channel training signals may be beamformed to those signal subspaces. Typically, beamforming may include multiplying a signal by an antenna-specific or antenna-port specific weighting vector, which may be referred to as a beamforming vector. The beamforming vector may affect the phase of the signal, the amplitude of the signal, or some other characteristic of the signal. The weighted signal produced by this weighting may be referred to as a beamformed signal. By multiplying one or more antenna transmissions by the weighting vector, the beamformed signal may only be transmitted to a specific signal subspace.

Specifically, a signal subspace may be a vector space defined by a subset of the possible beamforming vectors. In other words, transmissions of the signal to the signal subspace may include weighting the signal by one or more beamforming vectors of the possible beamforming vectors to produce a beamformed signal, and transmitting the beamformed signal from the eNB. The signal subspace may be identified by identifying the beamforming vectors with which the UEs receive the signal with a relatively high signal energy. Specifically, as noted above, the eNB may initially transmit one or more training signals to one or more UEs, and receive feedback information from the UEs regarding the received signal. For example, the feedback may include information regarding strength or magnitude of the received signal energy, or the phase of the received signal. Based on that fedback information, the eNB may be able to identify the beamforming vectors that produce a relatively high amount of signal energy at the UEs. The identified beamforming vectors that produce a relatively high amount of signal energy at the UEs may then be used to identify the signal subspace on which the channel training signals should be transmitted. The eNB may then transmit the channel training signals to that signal subspace using the identified beamforming vectors.

The null subspace may then be identified as the remainder of the beamforming vectors that are not used for the beamforming signal transmission to the signal subspace.

In some embodiments an additional channel training signal may be beamformed to only a portion of the null subspace, as explained in greater detail below. In embodiments, the number of beamforming vectors used to generate a beamformed signal for the signal subspace may be significantly less than the number of beamforming vectors in the null subspace. Therefore, the transmission overhead of the eNB may be significantly reduced. For example, the dimension of the null space may be several times that of the signal subspace that is useful for data communications. Therefore, skipping the channel training in the entire null space may reduce the training overhead by multiple times. For example, simulations indicate that by not transmitting the channel training signal to the entire null subspace, the resource overhead of the cell may be reduced by up to 50% while the throughput of an FD-MIMO eNB with 16 antenna elements may only be reduced by 5%. The overhead reduction may be expected to increase significantly for eNBs with antenna arrays of 64 or 128 antenna elements. For example, an eNB with 128 antenna elements transmitting data to 10 UEs may need up to 128 antenna ports in legacy systems, while only needing up to 10 antennas ports (one antenna port per UE) in wireless cells of the present disclosure.

In some embodiments, and as described in further detail below, one or both of the signal and/or null subspaces may vary over time due to mobile channel variation. Because the eNB may identify or update the signal subspace and null subspace according to the feedback indications of training signals that were beamformed by the previous beamforming vectors, the currently updated signal subspace and null subspaces may not be exactly the same as the previous signal and null subspaces where the previous beamforming vectors are located. Therefore, in some embodiments, the newly identified subspace may not fully include the previous beamforming vector. However, since the channel variation may be relatively slow in many embodiments such that the subspaces are substantially correlated in time, i.e. very alike, the previous and the current signal and null subspace may be substantially the same.

In the following detailed description, reference is made to the accompanying drawings which form a part hereof wherein like numerals designate like parts throughout, and in which is shown by way of illustration embodiments that may be practiced. It is to be understood that other embodiments may be utilized and structural or logical changes may be made without departing from the scope of the present disclosure. Therefore, the following detailed description is not to be taken in a limiting sense.

Various operations may be described as multiple discrete actions or operations in

turn, in a manner that is most helpful in understanding the claimed subject matter. However, the order of description should not be construed as to imply that these operations are necessarily order dependent. In particular, these operations may not be performed in the order of presentation. Operations described may be performed in a different order than the described embodiment. Various additional operations may be performed and/or described operations may be omitted in additional embodiments.

For the purposes of the present disclosure, the phrases "A and/or B" and "A or B" mean (A), (B), or (A and B). For the purposes of the present disclosure, the phrase "A, B, and/or C" means (A), (B), (C), (A and B), (A and C), (B and C), or (A, B and C).

The description may use the phrases "in an embodiment," or "in embodiments," which may each refer to one or more of the same or different embodiments. Furthermore, the terms "comprising," "including," "having," and the like, as used with respect to embodiments of the present disclosure, are synonymous.

Figure 1 schematically illustrates a wireless communication network 100 in accordance with various embodiments. The wireless communication network 100 (hereinafter "network 100") may be an access network of a 3GPP LTE network such as evolved universal terrestrial radio access network (E-UTRAN). The network 100 may include an eNodeB (eNB, also referred to as an evolved NodeB) 105, configured to wirelessly communicate with a UE 110.

As shown in Figure 1, the UE 110 may include a transceiver module 120. The transceiver module 120 may be coupled with one or more of a plurality of antenna elements 125 of the UE 110 for communicating wirelessly with other components of the network 100, e.g., eNB 105 or another UE. The antenna elements 125 may be powered by a power amplifier 130 which may be a component of the transceiver module 120, as shown in Figure 1, or may be a separate component of the UE 110. In one embodiment, the power amplifier 130 provides the power for all transmissions on the antenna elements 125. In other embodiments, there may be multiple power amplifiers on the UE 110. The use of multiple antenna elements 125 may allow for the UE 110 to use transmit diversity techniques such as spatial orthogonal resource transmit diversity (SORTD), MIMO, or FD-MIMO. In certain embodiments the transceiver module 120 may contain both transmitter circuitry 155 and receiver circuitry 160. Specifically, the transmitter circuitry 155 may be configured to transmit a signal from the UE 110, for example using antenna elements 125. Similarly, the receiver circuitry 160 may be configured to receive a signal at the UE 110. Although Figure 1 depicts the transceiver module 120 including both the

transmitter circuitry 155 and the receiver circuitry 160, in other embodiments, the transceiver module 120 may be replaced by transmitter circuitry and receiver circuitry which are separate from one another (not shown). In other embodiments, the transceiver module 120 may be coupled with processor circuitry configured to alter, process, or transform signals or data received from, or sent to, the transceiver module 120 (not shown).

Similarly to the UE 110, the eNB 105 may include a transceiver module 140. The transceiver module 140 may be further coupled with one or more of a plurality of antenna elements 135 of the eNB 105 for communicating wirelessly with other components of the network 100, e.g., UE 110. The antenna elements 135 may be powered by a power amplifier 145 which may be a component of the transceiver module 140, as shown in Figure 1, or may be a separate component of the eNB 105. In one embodiment, the power amplifier 145 provides the power for all transmissions on the antenna elements 135. In other embodiments, there may be multiple power amplifiers on the eNB 105. The use of multiple antenna elements 135 may allow for the eNB 105 to use transmit diversity techniques such as SORTD, MIMO, or FD-MIMO. In certain embodiments the transceiver module 140 may contain both transmitter circuitry 165 and receiver circuitry 170 which may be similar to the transmitter circuitry 155 and receiver circuitry 160 described above. In other embodiments, the transceiver module 140 may be replaced by transmitter circuitry and receiver circuitry which are separate from one another (not shown). In other embodiments, the transceiver module 140 may be coupled with processor circuitry configured to alter, process, or transform signals or data received from, or sent to, the transceiver module 120 (not shown).

As noted above, an eNB such as eNB 105 may have a plurality of antenna ports, and each antenna port may correspond to one or more of the antenna elements 135. In embodiments the transceiver module 140 may additionally include, or otherwise be coupled with, a subspace identifier 150. As will be explained in additional detail below, the subspace identifier 150 may be configured to identify signal subspaces and/or null subspace(s) in the cell.

In embodiments, an antenna port may be perceived by a UE 110 over the air interface between the UE 110 and the eNB 105. In embodiments, one antenna port may be associated with one set of channel training symbols, for example the CSI-RS as described above. As will be described in further detail below, the UE 110 may measure the channel response of one or multiple antenna ports to generate feedback or make decisions. For

example, the UE 110 may measure the received power of antenna port 0 during a handover situation.

Therefore, in embodiments an antenna port may be the air interface perceived by UE 110. In embodiments herein, each antenna port may be formed by the eNB 105 using one or more (or all) antenna elements 135, with a beamforming weight assigned to each antenna element. In some embodiments, each antenna port may be associated with a set of beamforming weights, as described in further detail below. In embodiments described as examples below, the eNB 105 may form eight antenna ports using eight sets of weights, i.e. eight beamforming vectors. The eNB 105 may then let UEs in the cell know how the antenna ports are configured such that the UE can identify the resource in frequency and time allocated for the port.

In some embodiments, the eNB 105 may include a directional antenna with a narrow downtilt angle that uses multiple antenna elements with relatively fixed or constant beamforming weights. In the present disclosure, this directional antenna may be considered a single antenna element of the antenna elements 135 because the beamforming weights of the different antenna elements of the directional antenna may remain constant. Specifically, one or more of the antenna elements 135 may be omni-directional or unidirectional, and a directional antenna element of the antenna elements 135 may be physically implemented using multiple antenna elements with constant antenna weights.

Figure 2 depicts an example of a network 200 including an eNB 205, which may be similar to eNB 105, and UEs 210, 215, and 220, which may be similar to UE 110. Some of the UEs, for example UEs 210 and 220, may only include a single antenna element, while other UEs such as UE 215 may include two or more antenna elements. As can be seen, the eNB 205 may include a plurality of antenna elements 225 configured to transmit signals to, or receive signals from, UEs 210, 215, and 220. In the embodiment shown in Figure 2, the plurality of antenna elements 225 may include a first antenna element 230 through a sixteenth antenna element 235. In other embodiments, the eNB 205 may have more or less antenna elements in the plurality of antenna elements 225.

As used herein, "spaces" may refer to the vector spaces spanned by the antenna ports. For example, eNB 205 may have 16 antennas element in the plurality of antenna elements. If one antenna port is assigned to each antenna element in the plurality of antenna elements 225, then 16 antenna ports may be perceived by UEs 210, 215, and 220, and the dimension of the whole space may be 16. The 16 antenna ports may form a 16 by

1 vector space in linear algebra. The signal subspace may then be the "location" of the UEs in the whole space.

For example, the vector channel from the 16 antenna elements at the eNB to UE 210 may be denoted as $a = \begin{bmatrix} a_1 \\ \vdots \\ a_{16} \end{bmatrix}$, where a_i represents the channel response from the *i*th antenna element in the plurality of antenna elements 225 of eNB 205 to the receive antenna element of the UE 210. Similarly, the UE 215 may be equipped with two receive antenna elements and have two vector channels $b = \begin{bmatrix} b_1 \\ \vdots \\ b_{16} \end{bmatrix}$ and $c = \begin{bmatrix} c_1 \\ \vdots \\ c_{16} \end{bmatrix}$; and the UE 220 may have a vector channel $d = \begin{bmatrix} d_1 \\ \vdots \\ d_{16} \end{bmatrix}$. Because UE 215 has multiple vector channels, UE215 may have a matrix channel $\begin{bmatrix} b_1 & c_1 \\ \vdots & \vdots \\ b_{16} & c_{16} \end{bmatrix}$.

The signal subspace may be computed as follows as an example. Let the aggregated channel matrix of the active vector channels be $H = \begin{bmatrix} a_1 & b_1 & c_1 & d_1 \\ \vdots & \vdots & \vdots & \vdots \\ a_{16} & b_{16} & c_{16} & d_{16} \end{bmatrix}^T$. Let the singular value decomposition (SVD) of H be $H = U \begin{bmatrix} \sigma_1 & & & \\ & \sigma_2 & & \\ & & \sigma_3 & \\ & & & \sigma_4 \end{bmatrix} [v_1 \quad v_2 \quad v_3 \quad v_4]^H$, where σ_i represents the singular value of the ith eigen-mode; v_i is the corresponding beamforming vector of *i*th eigen-mode; and v_i is a 16 by 1 vector with complex values.

In this embodiment, the singular values may be ordered. Specifically, σ_i may be greater than or equal to σ_j for any $i < j$. If the eNB 205 is attempting to send a relatively high amount of signal to the aggregated UE side, which in this example may consist of the antenna elements of all three of the UEs 210, 215, and 220, using one antenna beam or one beamforming vector, then v_1 may be the beamforming vector because it corresponds to the largest singular value σ_1.

For this example, the dimension of the whole space may be 16 because there are 16 antenna elements in the plurality of antenna elements 225 of the eNB 200 and correspondingly 16 linearly independent channels to the receive antenna elements of each UE 210, 215, and 220. If the eNB 205 is configured to only use one antenna port for

channel training, then in this embodiment the eNB 205 may use the beamforming vector (or weight) v_1 for the antenna port. Namely, the *i*th entry of v_1 may be the beamforming weight for the *i*th antenna element of the eNB 205. Using v_1, the three UEs 210, 215, and 220 may receive the greatest amount of signal energy from the eNB 220 in total. Because in this example there may only be one beamformed signal, the three UEs 210, 215, and 220 may have to time share the beam. Similarly, if the eNB 205 is configured to use two antenna ports, then v_1 and v_2 or the linear combination of the two can be used as beamforming vectors for the two antenna ports for channel training.

The linear space spanned by vectors v_1 and v_2 within the whole space may be referred to as "subspace" or "signal subspace." If the eNB 205 sends two data streams over two beams, then there may exist two beamforming vectors within the signal subspace that can send the most energy to the aggregated UE side consisting of UEs 210, 215, and 220. The linear space within the whole space that is spanned by all the vectors orthogonal to the vectors in the signal subspace may be referred to as the null space (of the signal subspace). In this example, if eNB 205 uses two antenna ports, then the signal subspace may be spanned by v_1 and v_2 and any beamforming vectors orthogonal to v_1 and v_2 may be in the null space that may have 16-2=14 orthogonal vectors or dimensions. In other words, the null space may depend on the selection of the signal subspace. Note that in the example above v_3 and v_4 may be in the null space of v_1 and v_2 even though v_3 and v_4 may send energy to the aggregated UE side.

In the example above, the signal subspace is described with respect to beamforming vectors v_1 and v_2. However, as noted above in other embodiments the signal subspace may be described with respect to linear combinations of beamforming vectors v_1 and v_2. Specifically, as noted above beamforming vector v_1 may deliver the greatest amount of signal energy to UEs 210, 215, and 220. Beamforming vector v_2 may deliver the next greatest amount of signal energy to UEs 210, 215, and 220. In some embodiments, it may be desirable for one or more of UEs 210, 215, and 220 to perceive a relatively equal amount of signal energy from beamforming vectors v_1 and v_2. Therefore, in some embodiments beamforming vectors v_1 and v_2 may be added or subtracted from one another to produce one or more alternative beamforming vectors which may still be within the signal subspace defined by beamforming vectors v_1 and v_2, but produce a relatively equal amount of signal energy at one or more of UEs 210, 215, and 220.

Figure 3 depicts an example process 300 for identifying signal subspaces within a cell, and beamforming the channel training signal to the signal subspaces. Initially, the

signal subspace(s) may be identified at 300. In embodiments, and as described above, a signal subspace may be identified at 300 based on previous feedback(s) from the UEs 210, 215, and 220. Specifically, the eNB such as eNB 205 may transmit a pilot signal using each possible beamforming vector in the space. Each UE, for examples UEs 210, 215, and 220, may calculate the channel response of each beamforming vector as seen by the UE. The UE may then quantize the channel responses of all received beamforming vectors using vector or scalar quantization. To continue the example above with reference to Figure 2, four beamforming vectors (v_1, v_2, v_3, and v_4) may be selected by the eNB 205. Four pilot signals, one for each beamforming vector, may be transmitted from the eNB. If the UE has one receive antenna element, for example UEs 210 or 220, the channel response, which may indicate the received signal power of each beamformed pilot signal, of the eNB's four antenna ports may be a 4 by 1 vector with complex entries. The UE may then quantizes the 4 by 1 vector jointly using vector quantization i.e. codebook quantization. The index of the quantization codeword may then be fed back to the eNB.

If the UE has *m* receive antenna elements, for example UE 215 with two receive antenna elements, then the channel response of the four antenna ports may be a 4 by *m* matrix. The UE may select a desirable *k*-dimensional subspace of the 4 by *m* matrix, for example by using SVD. In embodiments, *k* may represent the number of spatial streams or rank that the UE desires. This *k*-dimensional subspace may in some embodiments be the best *k*-dimensional subspace, and may be based on the UE stepping through the available numbers of spatial streams for identifying the spatial stream that may maximize the throughput of the signal received by the UE from the eNB. The selected *k*-dimensional subspace may be quantized to produce a quantization index, and the quantization index may be fed back to the eNB. Additionally or alternatively, the eNB may be able to identify feedback information based on, for example, downlink or uplink sounding in time-division duplexing (TDD) mode. In some embodiments the feedback may be part of or associated with a rank indicator and/or precoding matrix indicator transmission of each UE.

In some embodiments the feedback may be based on an averaging function, a summation function, or some other mathematical function performed by the UE on a pilot or beamformed signal received from the eNB. As will be explained in greater detail below, in some embodiments the signal subspace may change based on changing conditions in the cell. Therefore, it may be desirable for the fedback information from the UE to be based only on one or more signals in a given time period such as a frame, a subframe, a plurality of frames, or some other time period in which the signal subspace is constant. Otherwise,

an averaging or summation function that spans a plurality of different signal subspaces may not be accurate.The combination of vectors received from the plurality of UEs may be used by the eNB to build the aggregated channel matrix *H* described above with respect to Figure 2.

The principal signal subspaces may be identified as corresponding to large singular values in the singular value decomposition of the fedback beamforming vectors. Specifically, as described above, the signal subspace may be identified as the signal subspace formed by the beamforming vectors that are capable of delivering the most signal power from the eNB to the UEs. A set of beamforming vectors that sufficiently covers the selected signal subspace may then be identified for additional transmissions of channel training signals from the eNB to the one or more UEs. In embodiments, each beamforming vector may be used for beamforming one channel training signal, for example a CSI-RS signal, using a given antenna port. In some embodiments, the beamforming vectors may or may not be orthogonal to one another. In some embodiments, set selection may be designed for feedback accuracy, a given feedback codebook, or based on the detection of channel variation.

Concurrently with, or subsequent to, the identification of the signal subspace at 300, the null subspace may be identified based on the singular value decomposition of the matrix formed by the fed back beamforming vectors received at the eNB from the UE. Specifically, the null subspace may be identified based on low singular values in the singular value decomposition formed by the fed back beamforming vectors received at the eNB from the UEs. Specifically, the null subspaces may correspond to beamforming vectors that produce relatively low signal power at the UEs. The eNB may then beamform one or more channel training signals, for example the CSI-RS, to the signal subspace at 310.

In some embodiments, after the signal subspace is identified at 300 and the null subspace is identified at 305, the strength of signals beamformed to the signal subspace may change. Specifically, a beamforming vector that produces a relatively high amount of signal energy at the UEs in the cell may instead begin to produce a relatively low amount of signal energy at the UEs. This may occur, for example, if a UE such as a mobile phone, personal digital assistant (PDA), laptop, or some other type of UE moves. Additionally or alternatively, the cell may experience a change in signal reflection, propagation, or interference. Based on this change in the strength of beamforming vectors, it may be desirable for the eNB to track variation in the channel or the cell. Specifically, UEs may

continuously provide feedback to the eNB, and it may be useful for the eNB to be able to dynamically modify this change in signal conditions in the cell based on the feedback from the UEs.

If the channel variation of a UE is within the signal subspace spanned by the current set of channel training signals, then the normal channel feedback procedures may be able to identify this change in the signal subspace. However, if a beamforming vector in the null subspace increases in strength, for example above the strength of a beamforming vector in the signal subspace, then there may be no feedback information from a UE that indicates this change in the beamforming vector of the null subspace because if the eNB is only beamforming signals to the signal subspace, then there may be no transmissions to the entire null subspace, or certain portions of the null subspace, by which the UE can feedback information to the eNB with regards to beamforming vectors in the null subspace.

In some embodiments it may therefore be desirable to identify whether the beamforming vectors of the signal subspace and the null subspace have changed. Therefore, in some embodiments, the eNB may receive an indication from a UE of a relatively high received signal strength of a beamforming vector in the null subspace at 315. Specifically, the eNB may occasionally beamform one or more channel training signals to the null subspace, and then analyze the singular values in the singular value decomposition formed by the fed back beamforming vectors received at the eNB from the UEs, as will be described in greater detail below. In some embodiments, because channel variation may usually be slow, the eNB may give processing priority to the beamforming feedback related to the signal subspace. Therefore, the channel training signals transmitted to the null subspace, for example by beamforming, may time share a single or a relatively low number of antenna ports so that the overhead that may result from the transmission of the channel training signals is reduced.

Based on the tracking the variation in the cell at 315, if the eNB receives feedback from one or more UEs that a transmission of a channel training signal using a beamforming vector in the null subspace has greater energy than a channel training signal beamformed using a beamforming vector in the signal subspace, then the eNB may identify the beamforming vector in the null subspace as part of the signal subspace at 320. The eNB may then return to beamforming the channel training signals in the signal subspace at 310.

To illustrate the process depicted in Figure 3 in more detail, the following specific

example may be useful. It will be understood that the following is merely an example and in other embodiments other values, equations, variables, or processes may be used. Generally, during the initial training phase, an eNB such as eNB 205 may receive feedback from one or more UEs in the cell. Based on that feedback, the signal subspace, which may contain almost all of the signal energy of the fed-back signals, and the null subspaces, which may contain a low amount or no signal energy of the fed-back signals, may be calculated at 300 and 305, respectively. The calculated information may then be used to configure future downlink training and reduce the signaling overhead by scanning the signal subspace for information from UEs with greater frequency than the null subspaces, as described above.

Initially, the variable k may represent the kth UE in a cell. t may represent a given orthogonal frequency division multiplexing (OFDM) symbol, and n may represent a subcarrier in the channel. Using this notation, the channel from an eNB to the kth UE may be written as $H_k[n,t] = \sum_{m=1}^{M} h_{k,m}[n,t]e_m = \sum_{m=1}^{M} g_{k,m}[n,t]w_m$. H_k may be, for example, a 16x1 vector in cells where the eNB includes 16 antenna elements, and there is only a single UE, and it may represent the spatial signature from the eNB to the UE that is obtained through uplink feedback. M may be the dimensionality of the channel, i.e. the number of subspaces in the cell. $h_{k,m}[n,t]$ may be the estimated channel, i.e. the channel response, for the kth UE on a given subcarrier n in OFDM symbol t. e_m may be a vector equal to, for example (0, 0, . . ., 0, 1, 0, 0, . . ., 0) with the 1 in the mth position and zeroes elsewhere, and represent the unit vector pointing to the mth direction. $g_{k,m}[n,t]$ may represent the channel coefficient for the kth UE in the mth dimension in OFDM symbol t and subcarrier n. w_m my represent the unit norm vector for the mth dimension, i.e. the normalization weighting factor.

As noted above, M may represent the dimensionality of the channel, i.e. the total number of subspaces in the cell. It may be desirable to compress the channel and reduce the dimensionality from M to $D < M$. In other words, all of the subspaces in the cell may have a dimensionality M, and the signal subspace may have a dimensionality $D < M$. In order to reduce the dimensionality of the channel, it may be desirable to find the optimal basis $w_1, \ldots, w_m$ such that $g_{k,m}[n]$ is approximately equal to 0 when $m > D$. Then, for $d = 1, 2, \ldots, D$, coefficients $g_{k,m}[n,t]$ may be given by $g_{k,d}[n,t] = w_d^H H_k[n,t]$.

One result of reducing the dimensionality from M to $D < M$ may be that, instead of

utilizing M reference signals to estimate the channel in the original M-dimensional space and feeding back that information, the eNB may only employ D reference signals. By beamforming these reference signals with the weights $w_1, \ldots, w_D$, each UE may estimate the coefficient $g_{k,m}[n]$ directly and send that information to the eNB.

By allowing the UE to estimate the coefficient $g_{k,m}[n]$ directly, the overhead of transmitting the channel training signals may be reduced by a factor of D/M. Additionally, because UEs may not need to actually know the beamforming vectors used to generate the beamformed signals in order to receive the beamformed signals, the process of reducing the dimensionality of the channel from M to D may be completely transparent to the UEs. In other words, the UEs may not receive an indication that channel training signals are being beamformed only to the signal subspace rather than to the full space of the cell. However, as described in further detail below, in some embodiments it may be useful for one or more of the UEs to receive an antenna port configuration schedule from the eNB so that the UE is able to identify, for feedback purposes, when the subspace configuration may remain relatively constant.

After receiving the feedback from the UE, the eNB may identify the signal and null subspaces in the cell. Specifically, the channel covariance matrix may be estimated at the end of the qth training phase (that is, the qth time that the channel training signals are transmitted from the eNB) as

$$R_q \approx \frac{1}{KTN}\sum_{k=1}^{K}\sum_{t=(q-1)T+1}^{qT}\sum_{n=1}^{N}\left(\frac{\hat{H}_k[t,n]}{\left\|\hat{H}_k[t,n]\right\|}\right)\left(\frac{\hat{H}_k[t,n]}{\left\|\hat{H}_k[t,n]\right\|}\right)^{H} = U_q \Lambda_q U_q^{H}$$

where R_q is the channel covariance matrix in the qth training phase. T may be the length of the training period for sample covariance matrix calculations at the eNB in terms of OFDM symbols. $\hat{H}_k$ may be the estimated channel for the kth UE. K may be the total number of UEs in the cell. N may be the total number of subcarriers used by the eNB. Superscript H may represent the transpose conjugate mathematical operation. U_q may be an M x M unitary matrix, and Λ_q may be a diagonal matrix of eigenvalues $\lambda_{q,1}, \ldots, \lambda_{q,D}$. In general, $U_q \Lambda_q U_q^{H}$ may be referred to as the SVD of the matrix formed by the fedback beamforming vectors received by the eNB from the UEs, and the eigenvalues may be the singular value corresponding to each eigenvector direction. An eigenvector may be a specific example of a beamforming vector. In other words, the eigenvalues from $\lambda_{q,1}$ to $\lambda_{q,D}$ may represent the strength of the signal received from signals beamformed using beamforming vectors in the signal subspaces, and the eigenvalues $\lambda_{q,D+1}$ to $\lambda_{q,M}$ may represent the strength of the

signals, or lack thereof, received from signals beamformed using beamforming vectors in the null subspaces. Without loss of generality, it may be assumed that $\lambda_{q,1} \geq \ldots \geq \lambda_{q,D} \geq \lambda_{q,D+1}$ which may be approximately equal to λ_M, which may be approximately equal to 0. Therefore, the basis for each signal subspace in the D-dimensional channel may be $\{u_{q,1}, \ldots, u_{q,D}\}$ where $u_{q,D}$ is the dth column of the unitary matrix U_q, that is the eigenvector corresponding to the dth strongest eigenvalue. These strongest eigenvectors may now be used to beamform reference signals to the signal subspace at 310.

However, as mentioned before, the signal subspace may change and one or more beamforming vectors in the null subspace may produce a better channel response than one or more beamforming vectors in the signal subspace. In order to track these movements, and the resultant changes in the channel, it may be desirable to occasionally scan at 315 one or more null subspaces that are orthogonal to the D-dimension signal subspace to identify new beamforming vector or vectors with components in the null subspaces that produce a better channel response than one or more beamforming vectors in the signal subspace. Specifically, the new beamforming vector may include two components. The first component may be in the existing subspace spanned by one or more vectors of the signal subspace. The other component may be in the null space, and may be viewed as a correction or adjustment to the component in the existing subspace. In embodiments, the correction component may be smaller than the component in the signal subspace. Because the basis for each signal subspace in the D-dimensional channel may be $\{u_{q,1}, \ldots, u_{q,D}\}$, the basis for each null subspace in the M-dimensional channel may be $\{u_{q,D+1}, \ldots, u_{q,M}\}$.

In order to scan the null subspaces, the eNB may beamform D-r reference signals with $u_{q,1}, \ldots, u_{q,D-r}$ and the remaining r reference signals may be beamformed with r vectors selected from $u_{q,D-r+1}, \ldots, u_{q,M}$ in order to cover the null subspaces of the M-dimensional space. UEs that receive one or more of the r reference signals may estimate and quantize their channel direction in the new space as $\tilde{g}_{k,d}[n,t] = \frac{u_{q,d}^{H} H_k[n,t]}{\left\| u_{q,d}^{H} H_k[n,t] \right\|}$ where $d = 1, 2, \ldots, D$. The estimated and quantized channel direction may be transmitted from the UE to the eNB along with a channel quality indicator (CQI) transmission (which may represent a signal to interference plus noise ratio (SINR)) to the eNB. The eNB may reconstruct the channel direction in the original M dimensional space as $\tilde{H}_k[t,n] \approx \sqrt{SINR_k[t,n]} \sum_{d=1}^{D-1} \tilde{g}_{k,d}[n,t] u_{k,d}$ to identify the relative strength of signals

received in the null subspace at 315. Based on these reconstructed channel directions, the eNB may be able to identify one or more of the beamforming vectors in the null subspaces as part of the signal subspace at 320.

Results of a simulated test using one embodiment of the present disclosure are presented below in Tables 1 and 2. In these simulations, it was assumed that an eNB such as eNB 205 included 16 antenna elements with eight antenna ports. The first seven antenna ports were selected to transmit channel training signals to the signal subspace, while the eighth antenna port was selected to periodically beamform a channel training signal to the null subspace. Specifically, the transmissions of the first seven channel training signals were weighted with the seven eigenvectors corresponding to the seven strongest eigenvalues to produce beamformed channel training signals. These seven eigenvectors may be considered to be in the signal subspace. The seven beamformed channel training signals were then respectively transmitted using the first seven antenna ports of the eNB. The eighth port was selected to time share the nine remaining eigenvectors, i.e. the beamforming vectors in the null subspace, that were orthogonal to the seven eigenvectors used to produce the beamformed channel training signals. Every five to ten frames, the eNB would update the first seven beamforming vectors, while the eighth eigenvector for tracking would be updated more often for time sharing the single port. In other words, while the first seven antenna ports transmitted the beamformed seven channel training signals produced by the seven strongest eigenvectors in each frame, the eighth port would sequentially transmit beamformed channel training signals produced using the ninth through sixteenth eigenvectors one at a time in respective frames (i.e. through time sharing of the eighth port).

Tables 1 and 2, below, depict simulated sample results for a 4x4 antenna configuration and a 16x1 antenna configuration, respectively. Specifically, Tables 1 and 2 depict the average cell throughput in Megabits per second (Mbps) and cell edge user throughput in kilobits per second per UE (kbps/UE). Tables 1 and 2 depicts results for a baseline measurement where the process of Figure 3 is not performed, a subspace tracking (SS) process with scalar quantization wherein the channel direction is quantized by a scalar quantizer with 3 bits per real dimension, an SS singular value decomposition (SVD) process wherein the channel direction is obtained by SVD, and a frequency division (FD) zero-forcing beamforming (ZFBF) process based on the instantaneous values of the effective channel where no channel compression is performed.

	Average Cell Throughput (Mbps)	Cell edge User Throughput (kbps/UE)
Baseline	19.57	671
SS, Scalar Quant.	23.29	757
SS, SVD	26.43	810
FD ZFBF, SVD	27.41	852

Table 1: Simulation Results for 4x4 Antenna Configuration

	Average Cell Throughput (Mbps)	Cell edge User Throughput (kbps/UE)
Baseline	19.57	671
SS, Scalar Quant.	31.46	1130
SS, SVD	36.76	1283
FD ZFBF, SVD	44.81	1591

Table 2: Simulation Results for 16x1 Antenna Configuration

In some embodiments, the process described above with respect to Figures 2 and 3 may cause the channel training signals to vary with time. For example, the channel reference signal (CRS) and CSI-RS may be beamformed on a vector that may vary with time. Therefore, in embodiments it may be useful for the UE to know the time boundary when the beamforming vectors of the channel training signals transmitted from the eNB in the signal subspace change. By knowing this time boundary, the UE may avoid providing feedback to the eNB regarding an average of the channel training signal across two different periods with two differently beamformed channel training signals.

Specifically, as noted above in some embodiments the signal subspace may change based on variations in the cell, positions of the UEs in the cell, or other factors.

Additionally, as described above the signal subspace may be constructed based on information fedback from UEs in the cell. However, if the signal conditions in the cell are changing, then based on this feedback the beamforming vectors in the signal subspace and the null subspace may change.

As noted above, in some embodiments the feedback may be based on one or more averaging, summation or some other mathematical operations of a UE of signals received from the eNB. However, in some embodiments if the beamforming vectors in the signal subspace and null subspace change, then information averaged over the change in signal subspace may not be desirable. Therefore, it may be useful for the UEs in the cell to not perform averaging or other mathematical operations that span two different signal subspace configurations. Specifically, in some embodiments the signal subspace may change with each radio frame, radio subframe, or plurality of radio frames, or according to some other time period. Therefore, an averaging, summation, or other mathematical operation of a UE may be limited to only a single time period rather than a plurality of time periods.

Therefore, in some embodiments the eNB may transmit an antenna port configuration schedule to one or more UEs. In some embodiments, the eNB may beamform the antenna port configuration schedule to one or more of the UEs, while in other embodiments the eNB may omnicast the antenna port configuration schedule to UEs in the cell. In some embodiments, the antenna port configuration schedule may include one or more of a start time at which the signal subspace configuration may remain constant, a duration at which the signal subspace configuration may remain constant, and/or an end time at which the signal subspace configuration may remain constant. In some embodiments the antenna port configuration schedule may be demarcated according to specific times, while in other embodiments the antenna port configuration schedule may indicate one or more known periods such as radio frames, subframes, etc. In some embodiments, the antenna port configuration schedule may include one or more of a start time at which the antenna port for the null space configuration may remain constant, a duration at which the null space configuration may remain constant, and/or an end time at which the null space may remain constant. In addition, the configuration information about how the large null space is stepped through by a small number of antenna ports may be sent by the eNB. By knowing the port scheduling of the null space, the UE may not average signals across two differently beamformed ports for the null space.

Embodiments of the present disclosure may be implemented into a system using

any suitable hardware and/or software to configure as desired. Figure 4 schematically illustrates an example system 400 that may be used to practice various embodiments described herein. Figure 4 illustrates, for one embodiment, an example system 400 having one or more processor(s) 405, system control module 410 coupled to at least one of the processor(s) 405, system memory 415 coupled to system control module 410, non-volatile memory (NVM)/storage 420 coupled to system control module 410, and one or more communications interface(s) 425 coupled to system control module 410.

In some embodiments, the system 400 may be capable of functioning as the UEs 110, 210, 215, or 220 as described herein. In other embodiments, the system 400 may be capable of functioning as the eNB 105 or 205 depicted in Figures 1 or 2 or any one of the other described embodiments. In some embodiments, the system 400 may include one or more computer-readable media (e.g., system memory or NVM/storage 420) having instructions and one or more processors (e.g., processor(s) 405) coupled with the one or more computer-readable media and configured to execute the instructions to implement a module to perform actions described herein.

System control module 410 for one embodiment may include any suitable interface controllers to provide for any suitable interface to at least one of the processor(s) 405 and/or to any suitable device or component in communication with system control module 410.

System control module 410 may include memory controller module 430 to provide an interface to system memory 415. The memory controller module 430 may be a hardware module, a software module, and/or a firmware module.

System memory 415 may be used to load and store data and/or instructions, for example, for system 400. System memory 415 for one embodiment may include any suitable volatile memory, such as suitable DRAM, for example. In some embodiments, the system memory 415 may include double data rate type four synchronous dynamic random-access memory (DDR4 SDRAM).

System control module 410 for one embodiment may include one or more input/output (I/O) controller(s) to provide an interface to NVM/storage 420 and communications interface(s) 425.

The NVM/storage 420 may be used to store data and/or instructions, for example. NVM/storage 420 may include any suitable non-volatile memory, such as flash memory, for example, and/or may include any suitable non-volatile storage device(s), such as one or more hard disk drive(s) (HDD(s)), one or more compact disc (CD) drive(s), and/or one or

more digital versatile disc (DVD) drive(s), for example.

The NVM/storage 420 may include a storage resource physically part of a device on which the system 400 may be installed or it may be accessible by, but not necessarily a part of, the device. For example, the NVM/storage 420 may be accessed over a network via the communications interface(s) 525.

Communications interface(s) 425 may provide an interface for system 400 to communicate over one or more network(s) and/or with any other suitable device. The system 400 may wirelessly communicate with the one or more components of the wireless network in accordance with any of one or more wireless network standards and/or protocols. In some embodiments the communications interface(s) 425 may include the transceiver module 140 and/or subspace identifier 150 of Figure 1.

For one embodiment, at least one of the processor(s) 405 may be packaged together with logic for one or more controller(s) of system control module 410, e.g., memory controller module 430. For one embodiment, at least one of the processor(s) 405 may be packaged together with logic for one or more controllers of system control module 410 to form a System in Package (SiP). For one embodiment, at least one of the processor(s) 405 may be integrated on the same die with logic for one or more controller(s) of system control module 410. For one embodiment, at least one of the processor(s) 405 may be integrated on the same die with logic for one or more controller(s) of system control module 410 to form a System on Chip (SoC).

In some embodiments the processor(s) 405 may include or otherwise be coupled with one or more of a graphics processor (GPU) (not shown), a digital signal processor (DSP) (not shown), wireless modem (not shown), digital camera or multimedia circuitry (not shown), sensor circuitry (not shown), display circuitry (not shown), and/or GPS circuitry (not shown).

In various embodiments, the system 400 may be, but is not limited to, a server, a workstation, a desktop computing device, or a mobile computing device (e.g., a laptop computing device, a handheld computing device, a tablet, a netbook, a smart phone, a gaming console, etc.). In various embodiments, the system 400 may have more or less components, and/or different architectures. For example, in some embodiments, the system 400 includes one or more of a camera, a keyboard, liquid crystal display (LCD) screen (including touch screen displays), non-volatile memory port, multiple antenna elements, graphics chip, application-specific integrated circuit (ASIC), and speakers.

Methods and apparatuses are provided herein for Example 1 may include an eNodeB (eNB) comprising: a plurality of antenna ports with a plurality of antenna elements; subspace identification circuitry coupled with the plurality of antenna elements, the subspace identification circuitry to: identify, based on feedback information, a plurality of beamforming weights for one or multiple antenna ports wherein a number of the antenna ports is less than a number of the plurality of antenna elements; and assign a beamforming weight in the plurality of beamforming weights to an antenna in the plurality of antenna elements; and transmitter circuitry coupled with the subspace identification circuitry, the transmitter circuitry to: beamform a channel training signal allocated for the antenna port with the beamforming weights; and transmit an antenna port configuration schedule from the plurality of antennas.

Example 2 may include the eNB of example 1, wherein the feedback information is based on downlink sounding, or uplink sounding, or a signal received from a user equipment (UE).

Example 3 may include the eNB of example 1, wherein the antenna port configuration schedule includes an indication of a time period where the beamforming weights will not change.

Example 4 may include the eNB of any of examples 1-3, wherein: the feedback information includes a first indication of a magnitude or phase of a first received signal of a first beamformed signal produced with a first beamforming vector and a second indication of a magnitude or phase of a second received signal of a second beamformed signal produced with a second beamforming vector; the subspace identification circuitry is further to identify a signal subspace that substantially includes the first beamforming vector based at least in part on the first indication, and a null subspace that substantially includes the second beamforming vector based at least in part on the second indication; and the transmitter circuitry is further to beamform the channel training signal to the signal subspace.

Example 5 may include the eNB of example 4, wherein the first received signal energy is higher than the second received signal energy.

Example 6 may include the eNB of example 4, wherein the channel training signal is a first channel training signal and the transmitter circuitry is further to beamform a second channel training signal to only a portion of the null subspace.

Example 7 may include the eNB of example 6, further comprising receiver circuitry coupled with the transmitter circuitry, the receiver circuitry to receive, in

response to the transmission of the additional training signal in the null subspace, a second feedback that includes a third indication of a magnitude or phase of a third received signal of a third beamformed signal produced with a third beamforming vector in the null subspace.

Example 8 may include the eNB of example 6, wherein the signal subspace is a first signal subspace and the subspace identification circuitry is further to identify a second signal subspace based at least in part on the third indication, wherein the second signal subspace includes the third beamforming vector.

Example 9 may include a method comprising: identifying, by an eNodeB (eNB), a first signal subspace in a space based at least in part on a first indication of a magnitude or a phase of a first received signal of a first beamforming signal using a first beamforming vector in the first signal subspace, the first signal subspace substantially including the first beamforming vector; identifying, by the eNB, a null subspace in the space based at least in part on a second indication of a magnitude or a phase of a second received signal of a second beamforming signal using a second beamforming vector in the null subspace, the null subspace substantially including the second beamforming vector; and beamforming, from an antenna port of the eNB, a channel training signal to the first signal subspace.

Example 10 may include the method of example 9, further comprising: receiving, by the eNB after the beamforming of the channel training signal, a third indication of a magnitude or a phase of a third received signal of a third beamforming signal using a third beamforming vector in the null subspace, the null subspace including a third beamforming vector; and identifying, by the eNB, a second signal subspace based at least in part on the third indication, the second signal subspace including the third beamforming vector.

Example 11 may include the method of example 10, wherein the channel training signal is a first channel training signal and the third indication is based at least in part on beamforming, by the eNB, a second channel training signal to at least a portion of the null subspace.

Example 12 may include the method of example 9, wherein the first signal subspace is based at least in part on a singular value decomposition of the first indication.

Example 13 may include the method of example 9, wherein the first received signal strength is greater than the second received signal strength.

Example 14 may include the method of any of examples 9-13, wherein the first indication, second indication, and third indication are received by the eNB from a user equipment (UE).

Example 15 may include the method of any of examples 9-13, wherein the antenna port includes a plurality of antenna elements of the eNB.

Example 16 may include the method of any of examples 9-13, wherein the channel training signal is a channel state information-reference signal (CSI-RS) signal.

Example 17 may include one or more computer readable media comprising instructions which, when executed by one or more processors of an eNodeB (eNB), cause the eNB to: identify a first signal subspace in a space based at least in part on a first indication of a magnitude or a phase of a first received signal of a first beamforming signal using a first beamforming vector in the signal subspace, the first signal subspace substantially including a first beamforming vector; identify a null subspace in the space based at least in part on a second indication of a magnitude or a phase of a second received signal of a second beamforming signal using a second beamforming vector in the null subspace, the null subspace substantially including the second beamforming vector; and beamform a channel training signal to the first signal subspace.

Example 18 may include the one or more computer readable media of example 17, further comprising instructions to: obtain, after the beamform of the channel training signal, a third indication of a magnitude or a phase of a third received signal of a third beamforming signal using a third beamforming vector in the null subspace, the null subspace including a third beamforming vector; and identify a second signal subspace based at least in part on the third indication, the second signal subspace including the third beamforming vector.

Example 19 may include the one or more computer readable media of examples 17 or 18, wherein the first received signal strength is greater than the second received signal strength.

Example 20 may include an eNodeB comprising: the one or more computer readable media of any of examples 17-19; and one or more processors coupled with the one or more computer-readable media and configured to execute the instructions.

Example 21 may include a method comprising: identifying, by an eNodeB (eNB) based on feedback information, a plurality of beamforming weights for one or multiple antenna ports, wherein the one or multiple antenna ports have a plurality of antenna elements, and a number of the antenna ports is less than a number of the plurality of antenna elements; assigning, by the eNB, a beamforming weight in the plurality of beamforming weights to an antenna in the plurality of antenna elements; beamforming, from the eNB, a channel training signal allocated for the antenna port with the

beamforming weights; and transmitting, from the eNB, an antenna port configuration schedule from the plurality of antennas.

Example 22 may include the method of example 21, wherein the feedback information is based on downlink sounding, or uplink sounding, or a signal received from a user equipment (UE).

Example 23 may include the method of example 21, wherein the antenna port configuration schedule includes an indication of a time period where the beamforming weights will not change.

Example 24 may include the method of any of examples 21-23, wherein the feedback information includes a first indication of a magnitude or phase of a first received signal of a first beamformed signal produced with a first beamforming vector and a second indication of a magnitude or phase of a second received signal of a second beamformed signal produced with a second beamforming vector and the method further comprises: identifying, by the eNB, a signal subspace that substantially includes the first beamforming vector based at least in part on the first indication, and a null subspace that substantially includes the second beamforming vector based at least in part on the second indication; and beamforming, from the eNB, the channel training signal to the signal subspace.

Example 25 may include the method of example 24, wherein the first received signal energy is higher than the second received signal energy.

Example 26 may include the method of example 24, wherein the channel training signal is a first channel training signal and the method further comprises beamforming, from the eNB, a second channel training signal to only a portion of the null subspace.

Example 27 may include the method of example 26, further comprising receiving, by the eNB and in response to the transmission of the additional training signal in the null subspace, a second feedback that includes a third indication of a magnitude or phase of a third received signal of a third beamformed signal produced with a third beamforming vector in the null subspace.

Example 28 may include the method of example 26, wherein the signal subspace is a first signal subspace and the method further comprising identifying, by the eNB, a second signal subspace based at least in part on the third indication, wherein the second signal subspace includes the third beamforming vector.

Example 29 may include an apparatus comprising: means to identify, based on feedback information, a plurality of beamforming weights for one or multiple antenna

ports, wherein the one or multiple antenna ports have a plurality of antenna elements, and a number of the antenna ports is less than a number of the plurality of antenna elements; means to assign a beamforming weight in the plurality of beamforming weights to an antenna in the plurality of antenna elements; means to beamform a channel training signal allocated for the antenna port with the beamforming weights; and means to transmit an antenna port configuration schedule from the plurality of antennas.

Example 30 may include the apparatus of example 29, wherein the feedback information is based on downlink sounding, or uplink sounding, or a signal received from a user equipment (UE).

Example 31 may include the apparatus of example 29, wherein the antenna port configuration schedule includes an indication of a time period where the beamforming weights will not change.

Example 32 may include the apparatus of any of examples 29-31, wherein the feedback information includes a first indication of a magnitude or phase of a first received signal of a first beamformed signal produced with a first beamforming vector and a second indication of a magnitude or phase of a second received signal of a second beamformed signal produced with a second beamforming vector and the apparatus further comprises: means to identify a signal subspace that substantially includes the first beamforming vector based at least in part on the first indication, and a null subspace that substantially includes the second beamforming vector based at least in part on the second indication; and means to beamform the channel training signal to the signal subspace.

Example 33 may include the apparatus of example 32, wherein the first received signal energy is higher than the second received signal energy.

Example 34 may include the apparatus of example 32, wherein the channel training signal is a first channel training signal and the apparatus further comprises means to beamform a second channel training signal to only a portion of the null subspace.

Example 35 may include the apparatus of example 34, further comprising means to receive, in response to the transmission of the additional training signal in the null subspace, a second feedback that includes a third indication of a magnitude or phase of a third received signal of a third beamformed signal produced with a third beamforming vector in the null subspace.

Example 36 may include the apparatus of example 34, wherein the signal subspace is a first signal subspace and the apparatus further comprises means to identify a second

signal subspace based at least in part on the third indication, wherein the second signal subspace includes the third beamforming vector.

Example 37 may include one or more computer readable media comprising instructions configured, upon execution of the instructions by a processor, to: identify, based on feedback information, a plurality of beamforming weights for one or multiple antenna ports, wherein the one or multiple antenna ports have a plurality of antenna elements, and a number of the antenna ports is less than a number of the plurality of antenna elements; assign a beamforming weight in the plurality of beamforming weights to an antenna in the plurality of antenna elements; beamform a channel training signal allocated for the antenna port with the beamforming weights; and transmit an antenna port configuration schedule from the plurality of antennas.

Example 38 may include the one or more computer readable media of example 37, wherein the feedback information is based on downlink sounding, or uplink sounding, or a signal received from a user equipment (UE).

Example 39 may include the one or more computer readable media of example 37, wherein the antenna port configuration schedule includes an indication of a time period where the beamforming weights will not change.

Example 40 may include the one or more computer readable media of any of examples 37-39, wherein the feedback information includes a first indication of a magnitude or phase of a first received signal of a first beamformed signal produced with a first beamforming vector and a second indication of a magnitude or phase of a second received signal of a second beamformed signal produced with a second beamforming vector and further comprising instructions to: identify a signal subspace that substantially includes the first beamforming vector based at least in part on the first indication, and a null subspace that substantially includes the second beamforming vector based at least in part on the second indication; and beamform the channel training signal to the signal subspace.

Example 41 may include the one or more computer readable media of example 40, wherein the first received signal energy is higher than the second received signal energy.

Example 42 may include the one or more computer readable media of example 40, wherein the channel training signal is a first channel training signal and further comprising instructions to beamform a second channel training signal to only a portion of the null subspace.

Example 43 may include the one or more computer readable media of example 42, further comprising instructions to receive, in response to the transmission of the additional training signal in the null subspace, a second feedback that includes a third indication of a magnitude or phase of a third received signal of a third beamformed signal produced with a third beamforming vector in the null subspace.

Example 44 may include the one or more computer readable media of example 42, wherein the signal subspace is a first signal subspace and further comprising instructions to identify a second signal subspace based at least in part on the third indication, wherein the second signal subspace includes the third beamforming vector.

Example 45 may include an apparatus comprising: means to identify a first signal subspace in a space based at least in part on a first indication of a magnitude or a phase of a first received signal of a first beamforming signal using a first beamforming vector in the first signal subspace, the first signal subspace substantially including the first beamforming vector; means to identify a null subspace in the space based at least in part on a second indication of a magnitude or a phase of a second received signal of a second beamforming signal using a second beamforming vector in the null subspace, the null subspace substantially including the second beamforming vector; and means to beamform, from an antenna port, a channel training signal to the first signal subspace.

Example 46 may include the apparatus of example 45, further comprising: means to receive, after the beamforming of the channel training signal, a third indication of a magnitude or a phase of a third received signal of a third beamforming signal using a third beamforming vector in the null subspace, the null subspace including a third beamforming vector; and means to identify a second signal subspace based at least in part on the third indication, the second signal subspace including the third beamforming vector.

Example 47 may include the apparatus of example 46, wherein the channel training signal is a first channel training signal and the third indication is based at least in part on a beamforming, by the eNB, of a second channel training signal to at least a portion of the null subspace.

Example 48 may include the apparatus of example 45, wherein the first signal subspace is based at least in part on a singular value decomposition of the first indication.

Example 49 may include the apparatus of example 45, wherein the first received signal strength is greater than the second received signal strength.

Example 50 may include the apparatus of any of examples 45-49, wherein the first indication, second indication, and third indication are received from a user equipment (UE).

Example 51 may include the apparatus of any of examples 45-49, wherein the antenna port includes a plurality of antenna elements of the eNB.

Example 52 may include the apparatus of any of examples 45-49, wherein the channel training signal is a channel state information-reference signal (CSI-RS) signal.

Example 53 may include an eNode B (eNB) comprising: subspace identification circuitry to: identify a first signal subspace in a space based at least in part on a first indication of a magnitude or a phase of a first received signal of a first beamforming signal using a first beamforming vector in the first signal subspace, the first signal subspace substantially including the first beamforming vector; and identify a null subspace in the space based at least in part on a second indication of a magnitude or a phase of a second received signal of a second beamforming signal using a second beamforming vector in the null subspace, the null subspace substantially including the second beamforming vector; and transmitter circuitry coupled with the subspace identification circuitry, the transmitter circuitry to beamform, from an antenna port of the eNB, a channel training signal to the first signal subspace.

Example 54 may include the eNB of example 53, further comprising: receiver circuitry coupled with the transmitter circuitry, the receiver circuitry to receive, after the beamforming of the channel training signal, a third indication of a magnitude or a phase of a third received signal of a third beamforming signal using a third beamforming vector in the null subspace, the null subspace including a third beamforming vector; and the subspace identification circuitry is further to identify a second signal subspace based at least in part on the third indication, the second signal subspace including the third beamforming vector.

Example 55 may include the eNB of example 54, wherein the channel training signal is a first channel training signal and the third indication is based at least in part on a beamforming, by the eNB, of a second channel training signal to at least a portion of the null subspace.

Example 56 may include the eNB of example 53, wherein the first signal subspace is based at least in part on a singular value decomposition of the first indication.

Example 57 may include the eNB of example 53, wherein the first received signal strength is greater than the second received signal strength.

Example 58 may include the eNB of any of examples 53-57, wherein the first indication, second indication, and third indication are received from a user equipment (UE).

Example 59 may include the eNB of any of examples 53-57, wherein the antenna port includes a plurality of antenna elements of the eNB.

Example 60 may include the eNB of any of examples 53-57, wherein the channel training signal is a channel state information-reference signal (CSI-RS) signal.

Although certain embodiments have been illustrated and described herein for purposes of description, this application is intended to cover any adaptations or variations of the embodiments discussed herein. Therefore, it is manifestly intended that embodiments described herein be limited only by the claims.

Where the disclosure recites "a" or "a first" element or the equivalent thereof, such disclosure includes one or more such elements, neither requiring nor excluding two or more such elements. Further, ordinal indicators (e.g., first, second or third) for identified elements are used to distinguish between the elements, and do not indicate or imply a required or limited number of such elements, nor do they indicate a particular position or order of such elements unless otherwise specifically stated.

Claims

What is claimed is:

1. An eNodeB (eNB) comprising:

a plurality of antenna ports with a plurality of antenna elements;

subspace identification circuitry coupled with the plurality of antenna elements, the subspace identification circuitry to:

identify, based on feedback information, a plurality of beamforming weights for one or multiple antenna ports wherein a number of the antenna ports is less than a number of the plurality of antenna elements; and

assign a beamforming weight in the plurality of beamforming weights to an antenna in the plurality of antenna elements; and

transmitter circuitry coupled with the subspace identification circuitry, the transmitter circuitry to:

beamform a channel training signal allocated for the antenna port with the beamforming weights; and

transmit an antenna port configuration schedule from the plurality of antennas.

2. The eNB of claim 1, wherein the feedback information is based on downlink sounding, or uplink sounding, or a signal received from a user equipment (UE).

3. The eNB of claim 1, wherein the antenna port configuration schedule includes an indication of a time period where the beamforming weights will not change.

4. The eNB of any of claims 1-3, wherein:

the feedback information includes a first indication of a magnitude or phase of a first received signal of a first beamformed signal produced with a first beamforming vector and a second indication of a magnitude or phase of a second received signal of a second beamformed signal produced with a second beamforming vector;

the subspace identification circuitry is further to identify a signal subspace that substantially includes the first beamforming vector based at least in part on the first indication, and a null subspace that substantially includes the second beamforming vector based at least in part on the second indication; and

the transmitter circuitry is further to beamform the channel training signal to the signal subspace.

5. The eNB of claim 4, wherein the first received signal energy is higher than the second received signal energy.

6. The eNB of claim 4, wherein the channel training signal is a first channel training signal and the transmitter circuitry is further to beamform a second channel training signal to only a portion of the null subspace.

7. The eNB of claim 6, further comprising receiver circuitry coupled with the transmitter circuitry, the receiver circuitry to receive, in response to the transmission of the additional training signal in the null subspace, a second feedback that includes a third indication of a magnitude or phase of a third received signal of a third beamformed signal produced with a third beamforming vector in the null subspace.

8. The eNB of claim 6, wherein the signal subspace is a first signal subspace and the subspace identification circuitry is further to identify a second signal subspace based at least in part on the third indication, wherein the second signal subspace includes the third beamforming vector.

9. A method comprising:

identifying, by an eNodeB (eNB), a first signal subspace in a space based at least in part on a first indication of a magnitude or a phase of a first received signal of a first beamforming signal using a first beamforming vector in the first signal subspace, the first signal subspace substantially including the first beamforming vector; and

identifying, by the eNB, a null subspace in the space based at least in part on a second indication of a magnitude or a phase of a second received signal of a second beamforming signal using a second beamforming vector in the null subspace, the null subspace substantially including the second beamforming vector; and

beamforming, from an antenna port of the eNB, a channel training signal to the first signal subspace.

10. The method of claim 9, further comprising:

receiving, by the eNB after the beamforming of the channel training signal, a third indication of a magnitude or a phase of a third received signal of a third beamforming signal using a third beamforming vector in the null subspace, the null subspace including a third beamforming vector; and

identifying, by the eNB, a second signal subspace based at least in part on the third indication, the second signal subspace including the third beamforming vector.

11. The method of claim 10, wherein the channel training signal is a first channel training signal and the third indication is based at least in part on beamforming, by the eNB, a second channel training signal to at least a portion of the null subspace.

12. The method of claim 9, wherein the first signal subspace is based at least in part on a singular value decomposition of the first indication.

13. The method of claim 9, wherein the first received signal strength is greater than the second received signal strength.

14. The method of any of claims 9-13, wherein the first indication, second indication, and third indication are received by the eNB from a user equipment (UE).

15. The method of any of claims 9-13, wherein the antenna port includes a plurality of antenna elements of the eNB.

16. The method of any of claims 9-13, wherein the channel training signal is a channel state information-reference signal (CSI-RS) signal.

17. One or more computer readable media comprising instructions which, when executed by one or more processors of an eNodeB (eNB), cause the eNB to:

identify a first signal subspace in a space based at least in part on a first indication of a magnitude or a phase of a first received signal of a first beamforming signal using a first beamforming vector in the signal subspace, the first signal subspace substantially including a first beamforming vector;

identify a null subspace in the space based at least in part on a second indication of a magnitude or a phase of a second received signal of a second beamforming signal using

a second beamforming vector in the null subspace, the null subspace substantially including the second beamforming vector; and

beamform a channel training signal to the first signal subspace.

18. The one or more computer readable media of claim 17, further comprising instructions to:

obtain, after the beamform of the channel training signal, a third indication of a magnitude or a phase of a third received signal of a third beamforming signal using a third beamforming vector in the null subspace, the null subspace including a third beamforming vector; and

identify a second signal subspace based at least in part on the third indication, the second signal subspace including the third beamforming vector.

19. The one or more computer readable media of claims 17 or 18, wherein the first received signal strength is greater than the second received signal strength.

20. An eNodeB comprising:

the one or more computer readable media of any of claims 17-19; and

one or more processors coupled with the one or more computer-readable media and configured to execute the instructions.

AMENDED CLAIMS
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1. An eNodeB (eNB) comprising:

a plurality of antenna ports with a plurality of antenna elements;

subspace identification circuitry coupled with the plurality of antenna elements, the subspace identification circuitry to:

identify, based on feedback information, a plurality of beamforming weights for one or multiple antenna ports wherein a number of the antenna ports is less than a number of the plurality of antenna elements; and

assign a beamforming weight in the plurality of beamforming weights to an antenna in the plurality of antenna elements; and

transmitter circuitry coupled with the subspace identification circuitry, the transmitter circuitry to:

beamform a channel training signal allocated for the antenna port with the beamforming weights; and

transmit an antenna port configuration schedule from the plurality of antennas.

2. The eNB of claim 1, wherein the feedback information is based on downlink sounding, or uplink sounding, or a signal received from a user equipment (UE).

3. The eNB of claim 1, wherein the antenna port configuration schedule includes an indication of a time period where the beamforming weights will not change.

4. The eNB of any of claims 1-3, wherein:

the feedback information includes a first indication of a magnitude or phase of a first received signal of a first beamformed signal produced with a first beamforming vector and a second indication of a magnitude or phase of a second received signal of a second beamformed signal produced with a second beamforming vector;

the subspace identification circuitry is further to identify a signal subspace that includes the first beamforming vector based at least in part on the first indication, and a null subspace that includes the second beamforming vector based at least in part on the second indication; and

the transmitter circuitry is further to beamform the channel training signal to the signal subspace.

5. The eNB of claim 4, wherein the first received signal magnitude is higher than the second received signal magnitude.

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6. The eNB of claim 4, wherein the channel training signal is a first channel training signal and the transmitter circuitry is further to beamform a second channel training signal to only a portion of the null subspace.

7. The eNB of claim 6, further comprising receiver circuitry coupled with the transmitter circuitry, the receiver circuitry to receive, in response to the transmission of the additional training signal in the null subspace, a second feedback that includes a third indication of a magnitude or phase of a third received signal of a third beamformed signal produced with a third beamforming vector in the null subspace.

8. The eNB of claim 6, wherein the signal subspace is a first signal subspace and the subspace identification circuitry is further to identify a second signal subspace based at least in part on the third indication, wherein the second signal subspace includes the third beamforming vector.

9. A method comprising:

identifying, by an eNodeB (eNB), a first signal subspace in a space based at least in part on a first indication of a magnitude or a phase of a first received signal of a first beamforming signal using a first beamforming vector in the first signal subspace, the first signal subspace including the first beamforming vector; and

identifying, by the eNB, a null subspace in the space based at least in part on a second indication of a magnitude or a phase of a second received signal of a second beamforming signal using a second beamforming vector in the null subspace, the null subspace including the second beamforming vector; and

beamforming, from an antenna port of the eNB, a channel training signal to the first signal subspace.

10. The method of claim 9, further comprising:

receiving, by the eNB after the beamforming of the channel training signal, a third indication of a magnitude or a phase of a third received signal of a third beamforming signal using a third beamforming vector in the null subspace, the null subspace including a third beamforming vector; and

identifying, by the eNB, a second signal subspace based at least in part on the third indication, the second signal subspace including the third beamforming vector.

11. The method of claim 10, wherein the channel training signal is a first channel training signal and the third indication is based at least in part on beamforming, by the eNB, a second channel training signal to at least a portion of the null subspace.

12. The method of claim 9, wherein the first signal subspace is based at least in part on a singular value decomposition of the first indication.

13. The method of claim 9, wherein the first received signal magnitude is greater than the second received signal magnitude.

14. The method of any of claims 9-13, wherein the first indication, second indication, and third indication are received by the eNB from a user equipment (UE).

15. The method of any of claims 9-13, wherein the antenna port includes a plurality of antenna elements of the eNB.

16. The method of any of claims 9-13, wherein the channel training signal is a channel state information-reference signal (CSI-RS) signal.

17. One or more computer readable media comprising instructions which, when executed by one or more processors of an eNodeB (eNB), cause the eNB to:

identify a first signal subspace in a space based at least in part on a first indication of a magnitude or a phase of a first received signal of a first beamforming signal using a first beamforming vector in the signal subspace, the first signal subspace including a first beamforming vector;

including the second beamforming vector; and

beamform a channel training signal to the first signal subspace.

18. The one or more computer readable media of claim 17, further comprising instructions to:

obtain, after the beamform of the channel training signal, a third indication of a magnitude or a phase of a third received signal of a third beamforming signal using a third beamforming vector in the null subspace, the null subspace including a third beamforming vector; and

identify a second signal subspace based at least in part on the third indication, the second signal subspace including the third beamforming vector.

AMENDED SHEET (ARTICLE 19)

19. The one or more computer readable media of claims 17 or 18, wherein the first received signal magnitude is greater than the second received signal magnitude.

20. An eNodeB comprising:

the one or more computer readable media of claims 17 or 18; and

one or more processors coupled with the one or more computer-readable media and configured to execute the instructions.

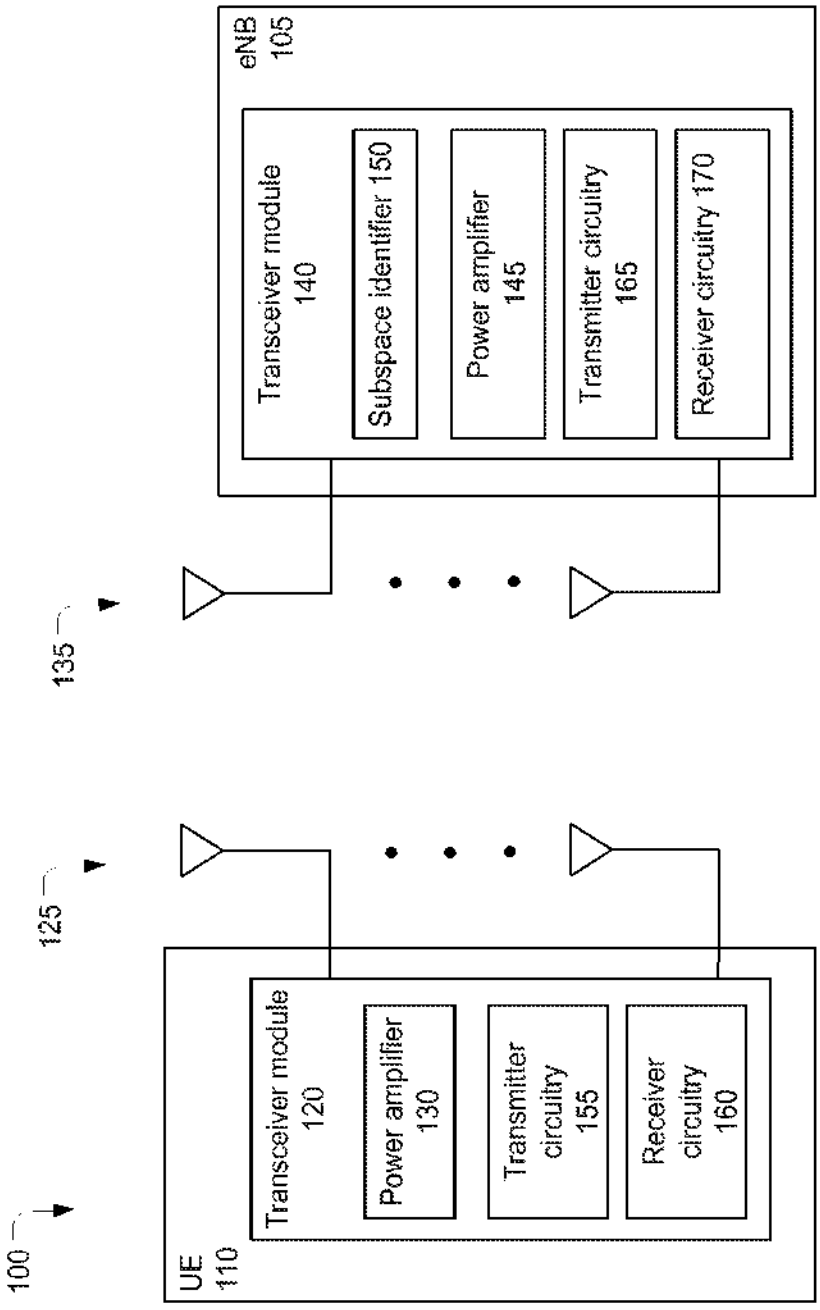

100
UE
110
Transceiver module
120
Power amplifier
130
Transmitter
circuitry
155
Receiver
circuitry
160
125
135
eNB
105
Transceiver module
140
Subspace identifier 150
Power amplifier
145
Transmitter circuitry
165
Receiver circuitry 170

Figure 1

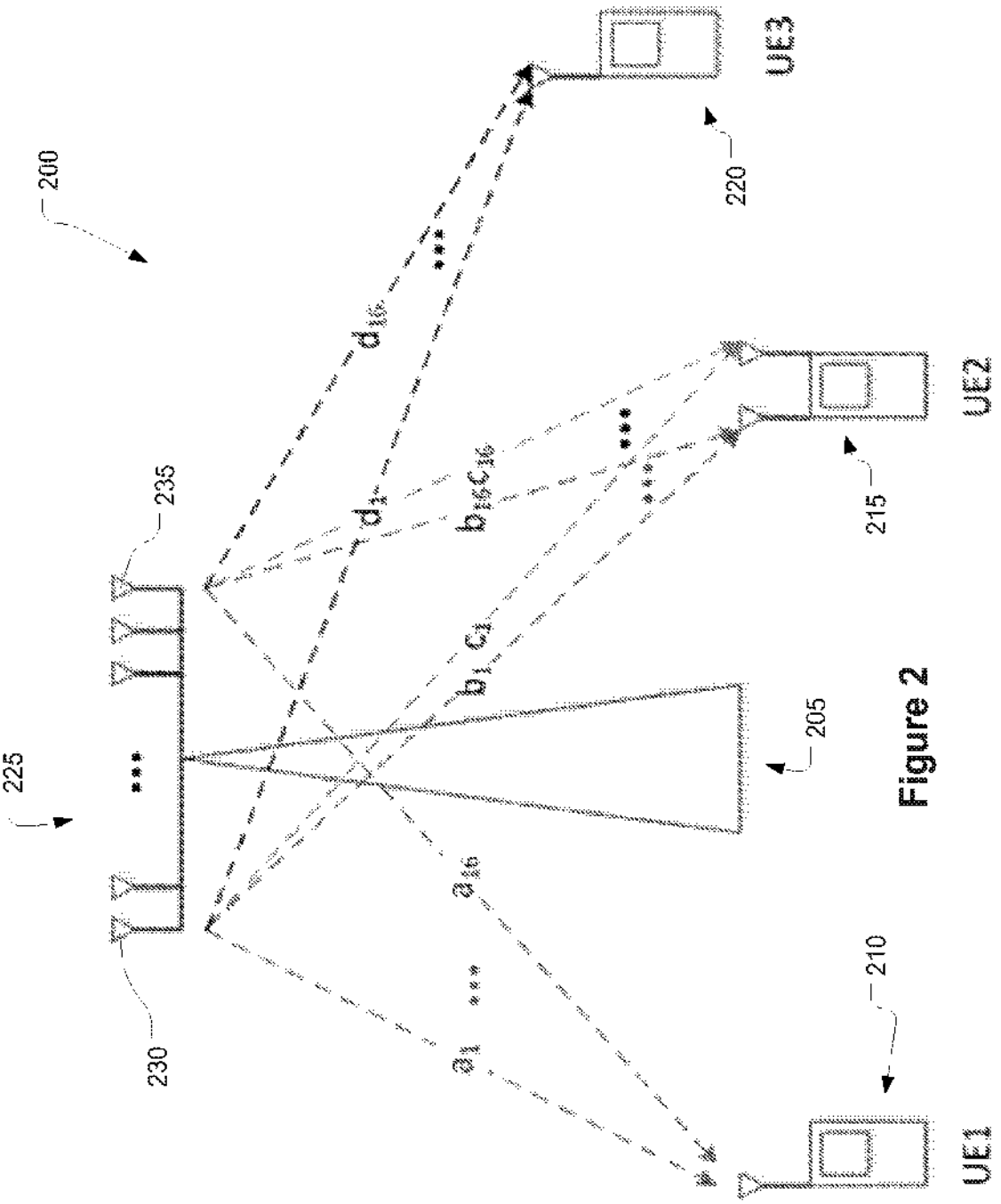


Figure 2

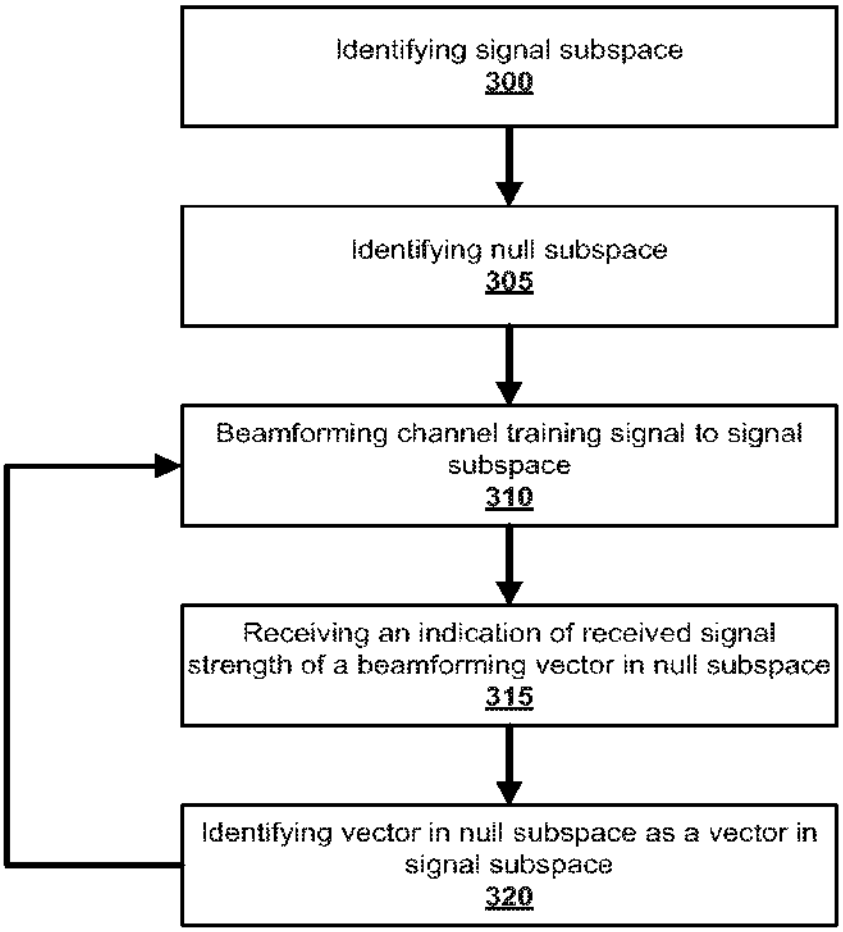

Identifying signal subspace
300
Identifying null subspace
305
Beamforming channel training signal to signal subspace
310
Receiving an indication of received signal strength of a beamforming vector in null subspace
315
Identifying vector in null subspace as a vector in signal subspace
320

Figure 3

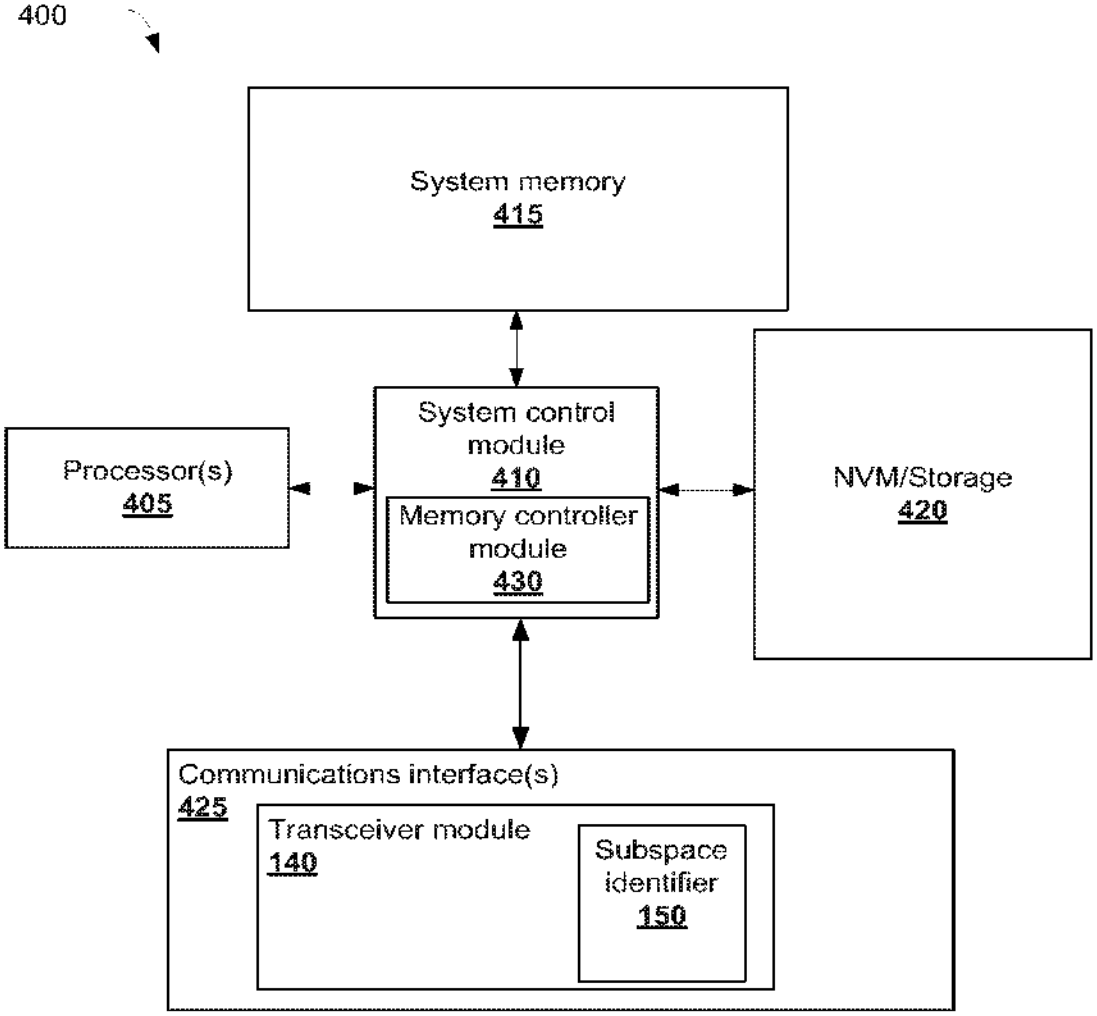

400
System memory
415
System control module
410
Memory controller module
430
Processor(s)
405
NVM/Storage
420
Communications interface(s)
425
Transceiver module
140
Subspace identifier
150

Figure 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/075463

A. CLASSIFICATION OF SUBJECT MATTER

H04B 7/06(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04B 7/06; H04B 7/00; H04B 7/02; H04B 17/00; H04M 1/00; H04Q 7/20; H04W 72/04; H04W 40/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: feedback, beamforming weight, channel training signal, beamform, antenna element, antenna port configuration schedule, signal subspace, null subspace, beamforming vector

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2009-0252250 A1 (ROBERT WENDELL HEATH, JR. et al.) 08 October 2009 See paragraphs 99-106, 115-125; and figs. 3, 5.	1-19
A	US 2009-0067375 A1 (WENDY C. WONG et al.) 12 March 2009 See paragraphs 31-99, 102-114; and figs. 2, 4.	1-19
A	US 2010-0075705 A1 (CORNELIUS VAN RENSBURG et al.) 25 March 2010 See paragraphs 50-67; and figs. 3, 4.	1-19
A	US 2013-0059619 A1 (TAE-YOUNG KIM et al.) 07 March 2013 See paragraphs 51-59, 83-91; and figs. 4, 7.	1-19
A	US 2011-0205963 A1 (YANG TANG et al.) 25 August 2011 See paragraphs 23-37, 50-58; and figs. 2a, 4.	1-19

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 March 2014 (18.03.2014)	**19 March 2014 (19.03.2014)**

Name and mailing address of the ISA/KR
International Application Division
Korean Intellectual Property Office
189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea
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Authorized officer
KANG, Hee Gok
Telephone No. +82-42-481-8264

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/075463

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 20
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required addtional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of any additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2013/075463

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2009-0252250 A1	08/10/2009	KR 10-2009-0105299 A	07/10/2009
		US 8165533 B2	24/04/2012
US 2009-0067375 A1	12/03/2009	CN 101384023 A	11/03/2009
		CN 101384023 B	31/10/2012
		EP 2034626 A2	11/03/2009
		EP 2034626 A3	20/11/2013
		US 8085653 B2	27/12/2011
US 2010-0075705 A1	25/03/2010	EP 2311192 A1	20/04/2011
		EP 2311192 A4	17/08/2011
		US 8315657 B2	20/11/2012
		WO 2010-033989 A1	25/03/2010
US 2013-0059619 A1	07/03/2013	KR 10-2013-0025102 A	11/03/2013
		WO 2013-032188 A2	07/03/2013
		WO 2013-032188 A3	25/04/2013
US 2011-0205963 A1	25/08/2011	None	

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13 November 2014 (13.11.2014)

(25) Filing Language: English

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(30) Priority Data:
14153280.4 30 January 2014 (30.01.2014) EP

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(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU,

[Continued on next page]

(54) Title: IDENTIFICATION OF DOWNLINK MESSAGES USING REPEATED TRANSMISSION

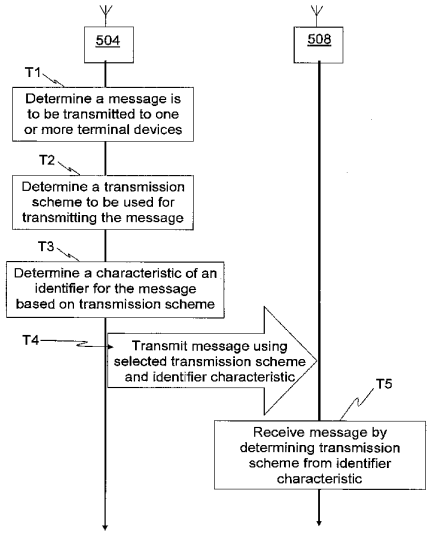


Fig. 9

(57) Abstract: A wireless telecommunication system comprises a base station arranged to communicate messages to one or more terminal devices over a radio interface. The radio interface has a radio frame structure comprising a plurality of subframes, wherein a message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes (e.g. one subframe) or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes (e.g. with repeat transmissions in a plurality of subframes). The message is transmitted in association with an identifier to indicate a terminal device to which the message is addressed. A characteristic for the identifier, for example a value or control region search space for the identifier, is dependent on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme. A terminal device to which the message is addressed determines the transmission scheme from the characteristic of the identifier and receives the message accordingly.

WO 2015/113664 A1

TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

IDENTIFICATION OF DOWNLINK MESSAGES USING REPEATED TRANSMISSION

BACKGROUND

Field

The present disclosure relates to telecommunications apparatus and methods. In particular, certain embodiments relate to schemes for communicating allocations of transmission resources of a shared channel in a wireless telecommunications system.

Description of Related Art

The "background" description provided herein is for the purpose of generally presenting the context of the disclosure. Work of the presently named inventors, to the extent it is described in this background section, as well as aspects of the description which may not otherwise qualify as prior art at the time of filing, are neither expressly or impliedly admitted as prior art against the present invention.

Mobile communication systems have evolved over the past ten years or so from the GSM System (Global System for Mobile communications) to the 3G system and now include packet data communications as well as circuit switched communications. The third generation partnership project (3GPP) is developing a fourth generation mobile communication system referred to as Long Term Evolution (LTE) in which a core network part has been evolved to form a more simplified architecture based on a merging of components of earlier mobile radio network architectures and a radio access interface which is based on Orthogonal Frequency Division Multiplexing (OFDM) on the downlink and Single Carrier Frequency Division Multiple Access (SC-FDMA) on the uplink.

Third and fourth generation mobile telecommunication systems, such as those based on the 3GPP defined UMTS and Long Term Evolution (LTE) architecture are becoming able to support more sophisticated services than simple voice and messaging services offered by previous generations of mobile telecommunication systems. For example, with the improved radio interface and enhanced data rates provided by LTE systems, a user is able to enjoy high data rate applications such as mobile video streaming and mobile video conferencing that would previously only have been available via a fixed line data connection. The demand to deploy third and fourth generation networks is therefore strong and there is a corresponding desire to extend the coverage available in such telecommunications systems (i.e. there is a desire to provide more reliable access to wireless telecommunications systems for terminal devices operating in coverage-limited locations).

A typical example of a coverage-limited terminal device might be a so-called machine type communication (MTC) device, such as a smart meter located in a customer's house and periodically transmitting information back to a central MTC server relating to the customer's consumption of a utility, such as gas, water, electricity and so on. Such a terminal device might operate in a coverage-limited location because, for example, it may be located in a basement or other location with relatively high penetration loss. Further information on characteristics of MTC-type devices can be found, for example, in the corresponding standards, such as ETSI TS 122 368 V10.530 (2011-07) / 3GPP TS 22.368 version 10.5.0 Release 10) [1]. Some typical characteristics of MTC type terminal devices / MTC type data might include, for example, characteristics such as low mobility, high delay tolerance, small data transmissions, infrequent transmission and group-based features, policing and addressing.

In some situations a terminal device in a coverage-limited situation in a particular communication cell served by a base station might be unable to receive communications from the base station unless specific provision is made for it to do so. One way to increase coverage in this situation would be for the base station to increase the power of its transmissions. However, a blanket increase in transmission power from a base station could be expected to give rise to increased interference in neighbouring communication cells. An alternative approach would be for the base station to in effect focus / concentrate its available transmission power budget into a subset of transmission resources (e.g. in terms of frequency) which are selected from within the base station's overall transmission resources and allocated for transmissions to coverage-limited terminal devices. However, this approach can again lead to increased interference in neighbouring cells and may in some cases require increased coordination among base stations to optimise performance.

Another approach for providing coverage extension is to rely on repeated transmissions of signalling in multiple subframes. A terminal device may then combine the signalling received for a plurality of repeated transmissions to increase the likelihood of successfully decoding the signalling, e.g. using chase combining / maximal ratio combining techniques. This repeated transmission approach may be applied for control signalling (e.g. sent on a physical downlink control channel such as PDCCH in LTE) and / or other signalling (e.g. sent on a physical downlink shared channel such as PDSCH in LTE).

One draw-back of a repeated transmission approach for providing coverage extension is a corresponding increase in the amount of transmission resources needed to communicate with terminal devices, particularly in the amount of transmission resources needed to provide control messages to the terminal devices, and the inventors have recognised how this issue can be especially significant for certain types of communications, as discussed further below. There is therefore a need for schemes which can allow for communications with terminal devices to be made over a number of subframes with a reduction in the overall amount of transmission resources needed to support this as compared to conventional techniques.

SUMMARY

According to a first aspect of the present disclosure, there is provided a method of operating a terminal device communicating with a base station in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the method comprises receiving a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel, determining a validity period for the control message, and receiving a plurality of other messages from the base station on the downlink data channel using the allocated transmission resources within the validity period for the control message.

According to a second aspect of the present disclosure, there is provided a terminal device for communicating with a base station in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the

downlink data channel, and wherein the terminal device comprises a controller unit and a transceiver unit configured to operate together to receive a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to receive a plurality of other messages from the base station on the downlink data channel using the allocated transmission resources within the validity period for the control message.

According to a third aspect of the present disclosure, there is provided circuitry for a terminal device communicating with a base station in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to cause the terminal device to receive a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to receive a plurality of other messages from the base station on the downlink data channel using the allocated transmission resources within the validity period for the control message

According to a forth aspect of the present disclosure, there is provided a method of operating a base station communicating with a terminal device in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the method comprises transmitting a control message to the terminal device conveying an indication of allocated transmission resources on the downlink data channel, determining a validity period for the control message, and transmitting a plurality of other messages to the terminal device on the downlink data channel using the allocated transmission resources within the validity period for the control message.

According to a fifth aspect of the present disclosure, there is provided a base station for communicating with a terminal device in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the base station comprises a controller unit and a transceiver unit configured to operate together to transmit a control message to the terminal device conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to transmit a plurality of other messages to the terminal device on the downlink data channel using the allocated transmission resources within the validity period for the control message.

According to a sixth aspect of the present disclosure, there is provided circuitry for a base station communicating with a terminal device in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the

downlink data channel, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to cause the base station to transmit a control message to the terminal device conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to transmit a plurality of other messages to the terminal device on the downlink data channel using the allocated transmission resources within the validity period for the control message.

According to a seventh aspect of the present disclosure, there is provided a method of operating a base station for communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein the method comprises selecting a characteristic for the identifier in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

According to an eighth aspect of the present disclosure, there is provided a base station for communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the base station comprises a controller unit and a transceiver unit configured to operate together such that the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein a characteristic for the identifier is selected in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

According to a ninth aspect of the present disclosure, there is provided circuitry for a base station communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the circuitry comprises a controller element and a transceiver element configured to operate together such that the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein a characteristic for the identifier is selected in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

According to a 10th aspect of the present disclosure, there is provided a method of operating a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission

resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the method comprises determining from an identifier associated with the message that the message is addressed to the terminal device, and further determining from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

According to an 11th aspect of the present disclosure, there is provided a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the terminal device comprises a controller unit and a transceiver unit configured to operate together to determine from an identifier associated with the message that the message is addressed to the terminal device, and to further determine from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

According to a twelfth aspect of the present disclosure, there is provided circuitry for a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to determine from an identifier associated with the message that the message is addressed to the terminal device, and to further determine from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

Further respective aspects and features are defined by the appended claims.

The foregoing paragraphs have been provided by way of general introduction, and are not intended to limit the scope of the following claims. The described embodiments, together with further advantages, will be best understood by reference to the following detailed description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the disclosure and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein like reference numerals designate identical or corresponding parts throughout the several views, and wherein:

Figure 1 provides a schematic diagram illustrating an example of a mobile telecommunication system;

Figure 2 provides a schematic diagram illustrating a LTE radio frame;

Figure 3 provides a schematic diagram illustrating an example of a LTE downlink radio subframe;

Figure 4 provides a schematic diagram illustrating a LTE "camp-on" procedure;

Figure 5 schematically represents a wireless telecommunications system according to an embodiment of the disclosure;

Figure 6 schematically represents a series of downlink subframes for communicating with a terminal device operating in the wireless telecommunications system of Figure 5;

Figure 7 schematically represents a series of downlink subframes for communicating with a terminal device operating in the wireless telecommunications system of Figure 5 in accordance with an embodiment of the disclosure;

Figure 8 is a signalling ladder diagram representing communications between a base station and a terminal device operating in accordance with an embodiment of the disclosure; and

Figure 9 is a signalling ladder diagram representing communications between a base station and a terminal device operating in accordance with another embodiment of the disclosure.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Figure 1 provides a schematic diagram illustrating some basic functionality of a mobile telecommunications network / system 100 operating in accordance with LTE principles and which may be adapted to implement embodiments of the disclosure as described further below. Various elements of Figure 1 and their respective modes of operation are well-known and defined in the relevant standards administered by the 3GPP (RTM) body and also described in many books on the subject, for example, Holma H. and Toskala A [2]. It will be appreciated that operational aspects of the telecommunications network which are not specifically described below may be implemented in accordance with any known techniques, for example according to the relevant standards.

The network 100 includes a plurality of base stations 101 connected to a core network 102. Each base station provides a coverage area 103 (i.e. a cell) within which data can be communicated to and from terminal devices 104. Data is transmitted from base stations 101 to terminal devices 104 within their respective coverage areas 103 via a radio downlink. Data is transmitted from terminal devices 104 to the base stations 101 via a radio uplink. The core network 102 routes data to and from the terminal devices 104 via the respective base stations 101 and provides functions such as authentication, mobility management, charging and so on. Terminal devices may also be referred to as mobile stations, user equipment (UE), user terminal, mobile radio, and so forth. Base stations may also be referred to as transceiver stations / nodeBs / e-nodeBs, and so forth.

Mobile telecommunications systems such as those arranged in accordance with the 3GPP defined Long Term Evolution (LTE) architecture use an orthogonal frequency division modulation (OFDM) based interface for the radio downlink (so-called OFDMA) and a single carrier frequency division multiple access scheme (SC-FDMA) on the radio uplink. Figure 2 shows a schematic diagram illustrating an OFDM based LTE downlink radio frame 201. The LTE downlink radio frame is transmitted from a LTE base station

(known as an enhanced Node B) and lasts 10 ms. The downlink radio frame comprises ten subframes, each subframe lasting 1 ms. A primary synchronisation signal (PSS) and a secondary synchronisation signal (SSS) are transmitted in the first and sixth subframes of the LTE frame. A physical broadcast channel (PBCH) is transmitted in the first subframe of the LTE frame.

Figure 3 is a schematic diagram of a grid which illustrates the structure of an example conventional downlink LTE subframe. The subframe comprises a predetermined number of symbols which are transmitted over a 1ms period. Each symbol comprises a predetermined number of orthogonal subcarriers distributed across the bandwidth of the downlink radio carrier.

The example subframe shown in Figure 3 comprises 14 symbols and 1200 subcarriers spread across a 20MHz bandwidth and in this example is the first subframe in a frame (hence it contains PBCH). The smallest allocation of physical resource for transmission in LTE is a resource block comprising twelve subcarriers transmitted over one subframe. For clarity, in Figure 3, each individual resource element is not shown, instead each individual box in the subframe grid corresponds to twelve subcarriers transmitted on one symbol.

Figure 3 shows in hatching resource allocations for four LTE terminals 340, 341, 342, 343. For example, the resource allocation 342 for a first LTE terminal (UE 1) extends over five blocks of twelve subcarriers (i.e. 60 subcarriers), the resource allocation 343 for a second LTE terminal (UE2) extends over six blocks of twelve subcarriers (i.e. 72 subcarriers), and so on.

Control channel data can be transmitted in a control region 300 (indicated by dotted-shading in Figure 3) of the subframe comprising the first "n" symbols of the subframe where "n" can vary between one and three symbols for channel bandwidths of 3MHz or greater and where "n" can vary between two and four symbols for a channel bandwidth of 1.4MHz. For the sake of providing a concrete example, the following description relates to host carriers with a channel bandwidth of 3MHz or greater so the maximum value of "n" will be 3 (as in the example of Figure 3). The data transmitted in the control region 300 includes data transmitted on the physical downlink control channel (PDCCH), the physical control format indicator channel (PCFICH) and the physical HARQ indicator channel (PHICH). These channels transmit physical layer control information. Control channel data can also or alternatively be transmitted in a second region of the subframe comprising a number of subcarriers for a time substantially equivalent to the duration of the subframe, or substantially equivalent to the duration of the subframe remaining after the "n" symbols. The data transmitted in this second region is transmitted on the enhanced physical downlink control channel (EPDCCH). This channel transmits physical layer control information which may be in addition to that transmitted on other physical layer control channels.

PDCCH and EPDCCH contain control data indicating which subcarriers of the subframe have been allocated to specific terminals (or all terminals or subset of terminals). This may be referred to as physical-layer control signalling / data. Thus, the PDCCH and/or EPDCCH data transmitted in the control region 300 of the subframe shown in Figure 3 would indicate that UE1 has been allocated the block of resources identified by reference numeral 342, that UE2 has been allocated the block of resources identified by reference numeral 343, and so on.

PCFICH contains control data indicating the size of the control region (i.e. between one and three symbols for channel bandwidths of 3 MHz or greater and between two and four symbols for channel bandwidths of 1.4 MHz).

PHICH contains HARQ (Hybrid Automatic Request) data indicating whether or not previously transmitted uplink data has been successfully received by the network.

Symbols in a central band 310 of the time-frequency resource grid are used for the transmission of information including the primary synchronisation signal (PSS), the secondary synchronisation signal (SSS) and the physical broadcast channel (PBCH). This central band 310 is typically 72 subcarriers wide (corresponding to a transmission bandwidth of 1.08 MHz). The PSS and SSS are synchronisation signals that once detected allow a LTE terminal device to achieve frame synchronisation and determine the physical layer cell identity of the enhanced Node B transmitting the downlink signal. The PBCH carries information about the cell, comprising a master information block (MIB) that includes parameters that LTE terminals use to properly access the cell. Data transmitted to terminals on the physical downlink shared channel (PDSCH), which may also be referred to as a downlink data channel, can be transmitted in other resource elements of the subframe. In general PDSCH conveys a combination of user-plane data and non-physical layer control-plane data (such as Radio Resource Control (RRC) and Non Access Stratum (NAS) signalling). The user-plane data and non-physical layer control-plane data conveyed on PDSCH may be referred to as higher layer data (i.e. data associated with a layer higher than the physical layer).

Figure 3 also shows a region of PDSCH containing system information and extending over a bandwidth of R344. A conventional LTE subframe will also include reference signals which are discussed further below but not shown in Figure 3 in the interests of clarity.

The number of subcarriers in a LTE channel can vary depending on the configuration of the transmission network. Typically this variation is from 72 sub carriers contained within a 1.4MHz channel bandwidth to 1200 subcarriers contained within a 20MHz channel bandwidth (as schematically shown in Figure 3). As is known in the art, data transmitted on the PDCCH, PCFICH and PHICH is typically distributed on the subcarriers across the entire bandwidth of the subframe to provide for frequency diversity. Therefore a conventional LTE terminal must be able to receive the entire channel bandwidth in order to receive and decode the control region.

Figure 4 illustrates a LTE “camp-on” process, that is, the process followed by a terminal so that it can decode downlink transmissions which are sent by a base station via a downlink channel. Using this process, the terminal can identify the parts of the transmissions that include system information for the cell and thus decode configuration information for the cell.

As can be seen in Figure 4, in a conventional LTE camp-on procedure, the terminal first synchronizes with the base station (step 400) using the PSS and SSS in the centre band and then decodes the PBCH (step 401). Once the terminal has performed steps 400 and 401, it is synchronized with the base station.

For each subframe, the terminal then decodes the PCFICH which is distributed across the entire bandwidth of carrier 320 (step 402). As discussed above, a LTE downlink carrier can be up to 20 MHz wide (1200 subcarriers) and a standard LTE-compliant terminal therefore has to have the capability to receive and decode transmissions on a 20 MHz bandwidth in order to decode the PCFICH. Accordingly, at the PCFICH decoding stage, with a 20MHz carrier band, the terminal operates at a larger bandwidth

(bandwidth of R320) than during steps 400 and 401 (bandwidth of R310) relating to synchronization and PBCH decoding.

The terminal then ascertains the PHICH locations (step 403) and decodes the PDCCH (step 404), in particular for identifying system information transmissions and for identifying its dedicated allocation grants. The allocation grants are used by the terminal to locate system information and to locate its data in the PDSCH. Both system information and dedicated allocations are transmitted on PDSCH and scheduled within the carrier band 320. Steps 403 and 404 also require a standard LTE-compliant terminal to operate on the entire bandwidth R320 of the carrier band. Allocation grants may also or alternatively be decoded from EPDCCH.

At steps 402 to 404, the terminal decodes information contained in the control region 300 of a subframe. As explained above, in LTE, the three control channels mentioned above (PCFICH, PHICH and PDCCH) can be found across the control region 300 of the carrier where the control region extends over the range R320 and occupies the first one, two or three OFDM symbols of each subframe as discussed above. In a subframe, typically the control channels do not use all the resource elements within the control region 300, but they are scattered across the entire region, such that a LTE terminal has to be able to simultaneously receive the entire control region 300 for decoding each of the three control channels.

The terminal can then decode the PDSCH (step 405) which contains system information or data transmitted for this terminal.

As explained above, in a LTE subframe the PDSCH generally occupies groups of resource elements which follow the control region. The data in the blocks of resource elements 340, 341, 342, 343 allocated to the different mobile communication terminals (UEs) and the system information data in the block of resources 344 shown in Figure 3 have a smaller bandwidth than the bandwidth of the entire carrier. To decode these blocks a terminal first receives the PDCCH spread across the frequency range R320 and/or the EPDCCH to determine if the (E)PDCCH indicates there are PDSCH resources in the subframe that need to be decoded by the UE. The intended recipient(s) for (E)PDCCH signalling in LTE is established through the use of radio network temporary identifiers (RNTI). (E)PDCCH signalling is addressed to a particular RNTI by using the RNTI to scramble cyclic redundancy check (CRC) bits associated with the (E)PDCCH signalling. Each connected UE in a cell is associated with a Cell RNTI (C-RNTI) that may be used to address PDCCH signalling to that particular UE. In addition there are other RNTIs defined and these may be used to simultaneously address groups of terminal devices. For example, a System Information RNTI (SI-RNTI) is defined and PDSCH transmissions comprising SI are allocated by (E)PDCCH signalling addressed to SI-RNTI. Various other RNTIs are defined for various other types of signalling. Some examples include a random-access RNTI (RA-RNTI), a Paging RNTI (P-RNTI), a Transmit Power Control Physical Uplink Control Channel RNTI (TPC-PUCCH-RNTI) and a Transmit Power Control Physical Uplink Shared Channel-RNTI (TPC-PUSCH-RNTI).

Thus, once a UE has received a downlink subframe, the UE searches for (E)PDCCH signalling associated with any RNTI that apply for the UE in the subframe to identify any corresponding allocations of transmission resources on PDSCH. If there is an allocation message addressed to the UE on (E)PDCCH the UE will proceed to decode the PDSCH in the relevant frequency range (if any) indicated by the PDCCH. So for example, UE 1 discussed above decodes the whole control region 300 to

determine its resource allocation and then extracts the relevant data from the corresponding resource block 342.

Figure 5 schematically shows a telecommunications system 500 according to an embodiment of the disclosure. The telecommunications system 500 in this example is based broadly on a LTE-type architecture. As such many aspects of the operation of the telecommunications system 500 are standard and well understood and not described here in detail in the interest of brevity. Operational aspects of the telecommunications system 500 which are not specifically described herein may be implemented in accordance with any known techniques, for example according to the established LTE-standards and known variations thereof.

The telecommunications system 500 comprises a core network part (evolved packet core) 502 coupled to a radio network part. The radio network part comprises a base station (evolved-nodeB) 504, a first terminal device 506 and a second terminal device 508. It will of course be appreciated that in practice the radio network part may comprise a plurality of base stations serving a larger number of terminal devices across various communication cells. However, only a single base station and two terminal devices are shown in Figure 5 in the interests of simplicity.

As with a conventional mobile radio network, the terminal devices 506, 508 are arranged to communicate data to and from the base station (transceiver station) 504. The base station is in turn communicatively connected to a serving gateway, S-GW, (not shown) in the core network part which is arranged to perform routing and management of mobile communications services to the terminal devices in the telecommunications system 500 via the base station 504. In order to maintain mobility management and connectivity, the core network part 502 also includes a mobility management entity (not shown) which manages the enhanced packet service, EPS, connections with the terminal devices 506, 508 operating in the communications system based on subscriber information stored in a home subscriber server, HSS. Other network components in the core network (also not shown for simplicity) include a policy charging and resource function, PCRF, and a packet data network gateway, PDN-GW, which provides a connection from the core network part 502 to an external packet data network, for example the Internet. As noted above, the operation of the various elements of the communications system 500 shown in Figure 5 may be broadly conventional apart from where modified to provide functionality in accordance with embodiments of the disclosure as discussed herein.

In this example, it is assumed the first terminal device 506 is a conventional smart-phone type terminal device communicating with the base station 504. Thus, and as is conventional, this first terminal device 506 comprises a transceiver unit 506a for transmission and reception of wireless signals and a controller unit 506b configured to control the smart phone 506. The controller unit 506b may comprise a processor unit which is suitably configured / programmed to provide the desired functionality using conventional programming / configuration techniques for equipment in wireless telecommunications systems. The transceiver unit 506a and the controller unit 506b are schematically shown in Figure 5 as separate elements. However, it will be appreciated that the functionality of these units can be provided in various different ways, for example using a single suitably programmed general purpose computer, or suitably configured application-specific integrated circuit(s) / circuitry. As will be appreciated the conventional terminal device 506 will in general comprise various other elements associated with its operating functionality.

In this example, it is assumed the second terminal device 508 is a machine-type communication (MTC) terminal device according to an embodiment of the disclosure and located in an area of restricted coverage. As discussed above, MTC devices may be typically characterised as semi-autonomous or autonomous wireless communication devices communicating small amounts of data. Examples include so-called smart meters which, for example, may be located in a customer's house and periodically transmit information back to a central MTC server data relating to the customer's consumption of a utility such as gas, water, electricity and so on. MTC devices may in some respects be seen as devices which can be supported by relatively low bandwidth communication channels having relatively low quality of service (QoS), for example in terms of latency. It is assumed here the MTC terminal device 508 in Figure 5 is such a device. It will, however, the appreciated that embodiments of the disclosure may also be implemented for other types of terminal device.

As with the smart phone 506, the MTC device 508 comprises a transceiver unit 508a for transmission and reception of wireless signals and a controller unit 508b configured to control the MTC device 508. The controller unit 508b may comprise a processor unit which is suitably configured / programmed to provide the desired functionality described herein using conventional programming / configuration techniques for equipment in wireless telecommunications systems. The transceiver unit 508a and the controller unit 508b are schematically shown in Figure 5 as separate elements for ease of representation. However, it will be appreciated that the functionality of these units can be provided in various different ways, for example using a single suitably programmed general purpose computer, or suitably configured application-specific integrated circuit(s) / circuitry, or using a plurality of discrete circuitry / processing elements for providing different elements of the desired functionality. It will be appreciated the MTC device 508 will in general comprise various other elements associated with its operating functionality in accordance with established wireless telecommunications techniques (e.g. a power source, possibly a user interface, and so forth).

The base station 504 comprises a transceiver unit 504a for transmission and reception of wireless signals and a controller unit 504b configured to control the base station 504. The controller unit 504b may comprise a processor unit which is suitably configured / programmed to provide the desired functionality described herein using conventional programming / configuration techniques for equipment in wireless telecommunications systems. The transceiver unit 504a and the controller unit 504b are schematically shown in Figure 5 as separate elements for ease of representation. However, it will be appreciated that the functionality of these units can be provided in various different ways, for example using a single suitably programmed general purpose computer, or suitably configured application-specific integrated circuit(s) / circuitry or using a plurality of discrete circuitry / processing elements for providing different elements of the desired functionality. It will be appreciated the base station 504 will in general comprise various other elements associated with its operating functionality. For example, the base station 504 will in general comprise a scheduling entity responsible for scheduling communications. The functionality of the scheduling entity may, for example, be subsumed by the controller unit 504b.

Thus, the base station 504 is configured to communicate data with the smart phone 506 over a first radio communication link 510 and communicate data with the MTC device 508 over a second radio communication link 512. Both radio links may be supported within a single radio frame structure associated with the base station 504. It is assumed here the base station 504 is configured to communicate with the smart phone 506 over the first radio communication link 510 in accordance with the

established principles of LTE-based communications and to communicate with the MTC-device 506 over the second radio communication link 512 in accordance with embodiments of the disclosure as described herein. It will be appreciated the base station may readily obtain information indicating the different classes of terminal device which are attached to the base station in accordance with conventional techniques. That is to say, the base station will be aware that the smart phone is of a device class that includes conventional smartphones and the MTC device is of a device class that includes MTC devices. Furthermore, the base station may establish using conventional techniques that the MTC device 508 is a device operating in a coverage limited situation such that steps are needed to increase the likelihood of the MTC device being able to decode downlink transmissions.

As noted above, in a LTE-based wireless telecommunications system some of the fundamental information required for a terminal device to operate in a cell is transmitted on PBCH in the Master Information Block (MIB). Other information regarding the system configuration is divided among System Information Blocks (SIBs) referred to as SIB1, SIB2, SIB3,...etc. (there are 16 SIBs defined as of Release 11 LTE). The SIBs are transmitted in system information (SI) messages, which, apart from SIB1, may contain multiple SIBs (termed first SI, second SI, etc.). There may be one or several SI messages transmitted at different periodicities. Each SI message may convey multiple SIBs suitable for scheduling with the same periodicity. The timings for SIB1 message transmissions are fixed on an 80 ms period and they occur in the fifth subframe of radio frames when System Frame Number (SFN) is a multiple of 8 (i.e. SFN mod 8 = 0). There are retransmissions of SIB1 messages provided in every other radio frame within the 80 ms period. The timings for other SIB transmission messages are configured in SIB1. The transmission resource allocations for the SI messages on PDSCH within a subframe are provided to terminal devices using PDCCH allocation messages addressed to SI-RNTI (System Information Radio Network Temporary Identifier - currently 0xFFFF in LTE). At higher layers, SI is carried on the logical broadcast control channel (BCCH).

In LTE the SI messages are transmitted within periodically occurring time domain windows (referred to as SI-windows) using dynamic scheduling. Each SI message is associated with a SI-window and the SI-windows of different SI messages do not overlap. That is, within one SI-window only the corresponding SI message is transmitted. The length of the SI-window is common for all SI messages, and is configurable. Within the SI-window, the corresponding SI message can be transmitted a number of times in any subframe other than MBSFN (multicast-broadcast single frequency network) subframes, uplink subframes in TDD (time division duplex), and subframe #5 of radio frames for which SFN (system frame number) mod 2 = 0. Terminal devices acquire the detailed time-domain scheduling (and other information, e.g. frequency-domain scheduling, transport format) from decoding SI-RNTI on PDCCH. A single SI-RNTI is used to address SystemInformationBlockType1 as well as all SI messages. SystemInformationBlockType1 configures the SI-window length and the transmission periodicity for the SI messages.

The system information in a cell may be changed, although typically this happens rarely with system information perhaps remaining unchanged for hours, days, or even weeks.

For changes of system information other than those related to EAB (Extended Access Barring), ETWS (Earthquake Tsunami Warning System) and CMAS (Commercial Mobile Alert System), there is a BCCH modification period defined (which may be referred to as a “SI modification period”). SI modification period boundaries are defined on radio frames for which SFN mod q = 0, for a cell-specific value of q.

When there is a change in system information, the new system information is transmitted from the start of a new SI modification period.

The general process for implementing a change in system information in a LTE-based network is described, for example, in Section 5.2.1.3 of ETSI TS 136 331 V11.4.0 (2013-07) / 3GPP TS 36.331 version 11.4.0 Release 11 [3]. In summary, a base station indicates a change of system information as follows.

1. When the network changes system information it notifies terminal devices about the change by transmitting a PDCCH resource allocation message addressed to the paging RNTI (P-RNTI). This directs the terminal devices to decode PDSCH resources containing a Paging message with a SystemInfoModification flag set to true. This may be done, for example, throughout one SI modification period. Both RRC_IDLE and RRC_CONNECTED terminal devices check for paging messages periodically. It may be noted that EAB alterations, ETWS and CMAS notifications may be separately modified with separate flags in a paging message (but can also be modified along with other SIBs).

2. In a following SI modification period, the network transmits the modified system information, and may increment a SystemInfoValueTag in SIB1. This value tag can indicate changes in any SIB, but it might not be used for EAB, ETWS, CMAS and some regularly changing SI parameters such as CDMA2000 system time. Terminal devices can use SystemInfoValueTag to verify if currently stored system information is still valid, for example on return from being out of coverage when the UE may have missed a system information change notification in paging.

More details on system information and changes in system information in a LTE-based system can be found in ETSI TS 136 331 V11.4.0 (2013-07) / 3GPP TS 36.331 version 11.4.0 Release 11 [3].

As discussed above, it has been proposed to improve coverage for terminal devices in a wireless telecommunications system by introducing repetitions of a transmission which a terminal device may combine to provide an increased likelihood of successful decoding.

Figure 6 schematically represents an approach for providing coverage extension through repeated transmissions for an SI message in accordance with existing techniques. Figure 6 schematically shows a sequence of LTE downlink subframes (labelled as subframes "A", "B", "C", …, "L" to aid explanation) with shading to schematically indicate which regions in which subframes are used to convey system information. The subframes represented in Figure 6 comprise four groups of three contiguous subframes with spaces between the groups as schematically indicated by dotted lines and discussed further below. Although not shown in Figure 6, the gaps between the groups comprise a continuing sequence of subframes used for other communications that are not relevant to the system information messaging considered here. As discussed above, each subframe comprises a control region 600 and a PDSCH region 602. The control regions 600 for the respective subframes are labelled in Figure 6 with the identification letter for the relevant subframe, i.e. as 600A, 600B, 600C, etc. The PDSCH regions for the respective subframes are similarly labelled in Figure 6 as 602A, 602B, 602C, etc. Each subframe represented in Figure 6 is in essence a simplified version of what is represented in Figure 3. Thus, the control regions 600 support the PCFICH, PHICH and PDCCH channels as discussed above while the PDSCH regions 602 support user-plane data and system information (among other things) and the EPDCCD if implemented. The most significant aspect of the control region 600 in the context of

embodiments of the present disclosure relate to the PDCCH and so for simplicity the control regions 600 may sometimes be referred to herein as PDCCH regions 600.

Before explaining the repeated transmissions approach to providing coverage extension represented in Figure 6 it is considered helpful to clarify some aspects of the terminology to be used herein. The term "repeat transmission" (and related terms) will be used to refer to a transmission in an individual subframe which is part of a sequence of transmissions that are being repeated for the purposes of providing coverage extension for a message being conveyed between a base station and a terminal device (such as a PDCCH message or a PDSCH message). Thus in a coverage extension context, the transmission of a (E)PDCCH message comprises a plurality of "repeat transmissions" on (E)PDCCH and the transmission of a PDSCH message comprises a plurality of "repeat transmissions" on PDSCH. The term "re-transmission" (and related terms) will be used to refer to the transmission of a message that has already been sent at least once before. These terms should be interpreted accordingly unless the context demands otherwise.

For the example repeat transmission approach to coverage extension represented in Figure 6 it is assumed for ease of representation the approach relies on providing only three repeat transmissions for each PDCCH message and each PDSCH message. It will, however, be appreciated that in practice larger numbers of repeat transmissions will typically be involved, for example there may be tens or hundreds of repeats comprising each message to provide a correspondingly higher degree of coverage extension. Furthermore, it will be appreciated that PDCCH messages and PDSCH messages may comprise different numbers of repeat transmissions (for example because different coding schemes are adopted meaning that different numbers of repeat transmissions are needed for a given probability of successful reception).

Thus, referring to Figure 6, subframes A, B and C are used to signal a PDCCH message addressed to SI-RNTI by sending three repeat PDCCH transmissions in the respective PDCCH regions 600A, 600B, 600C. Each PDCCH repeat transmission addressed to SI-RNTI in the PDCCH regions 600A, 600B, 600C in effect comprises a duplication of the same downlink control information which a terminal device can combine to seek to establish the content of the PDCCH message. For this example repeat-transmission based coverage extension scheme it is assumed a particular type of message subject to repeat transmissions is addressed to the same RNTI (e.g. SI-RNTI for a system information related type of messages) as if the same type of message were subject to conventional single-subframe transmission. However, as discussed further below, in accordance with certain embodiments of the disclosure identifiers having different characteristics (e.g. values) may be used for a given type of message depending on whether the messages to be sent in accordance with a first transmission scheme (e.g. using a conventional single subframe based transmission approach) or a second transmission scheme (e.g. using a repeat-transmission scheme for coverage extension). Furthermore, it will be appreciated the approach of using identifiers associated with a particular type of message having different characteristics according to what transmission scheme is to be used to transmit the message can be used in accordance with embodiments of the disclosure with or without the use of validity periods as disclosed herein.

The PDCCH message comprising the three repeat transmissions in the PDCCH regions of subframes A, B and C indicates resource blocks to be used for a subsequent PDSCH message comprising the transmission of system information. This PDSCH message itself comprises a plurality of repeat transmissions, and, in this example, are represented by shading in the PDSCH regions 602D, 602E and 602F of subframes D, E and F. The transmission resources, for example in terms of specific resource

elements, used to convey the repeat transmissions of the system information message in the PDSCH regions 602D, 602E and 602F are indicated in the corresponding PDCCH message addressed to SI-RNTI and comprising the repeat transmissions in PDCCH regions 600A, 600B, 600C in accordance with conventional resource allocation techniques in the context of coverage extension using repeat transmissions. Whilst the shading in Figure 6 schematically represents the same frequency resources being used for each repeat transmission in the respective PDSCH regions 602D, 602E and 602F of the subframes D, E, F, in principle the repeat-transmission approach may be configured to include frequency hopping for the different repeat transmissions comprising the PDSCH message sent in subframes D, E, F. The nature of any such frequency hopping may be pre-defined, for example it may be pre-specified according to an operating standard for the wireless telecommunications system, or it may be established in previous RRC (radio resource control) signalling, or it may be indicated in the PDCCH message.

As schematically represented in Figure 6 there is a gap between subframes C and D. This follows the currently-proposed approaches for repeat-transmission coverage extension whereby the transmission of a PDSCH message comprising a plurality of repeat transmissions does not start until after all repeat transmissions of the corresponding PDCCH message have been sent. This is to help reduce the buffering requirements at the terminal device. Furthermore, current proposals indicate there should be no overlap between the end of the repeat transmissions comprising the PDCCH message and the start of the repeat transmissions comprising the PDSCH message. It will, however, be appreciated the specific implementation of such aspects of a repeat transmission approach for providing coverage extension are not significant to the principles underlying the present disclosure. That is to say, the principles described herein may equally be implemented in association with other repeat transmission approaches (e.g. with repeat transmissions of PDCCH and its corresponding PDSCH occurring in the same subframe).

In subframes following the transmission of the system information message as schematically indicated in subframes D, E and F in Figure 6, the wireless telecommunications system continues to operate in accordance with its normal operating techniques until subframe G represented. Subframe G represents the beginning of another system information message. As noted above, system information messages can be regularly retransmitted in accordance with LTE techniques, and in this regard the system information message beginning at subframe G is considered in this example to be a re-transmission of the system information message transmitted using subframes A to F as discussed above. The specific timing of the re-transmission of system information (i.e. the timing of subframe G relative to subframe A) may follow any conventional system information re-transmission schedule. The principles underlying the re-transmission of the system information message starting from subframe G follow those described above. Thus, a PDCCH message addressed to SI-RNTI is sent using the PDCCH regions 600G, 600H and 600I of subframes G, H and I to allocate resources for a PDSCH message comprising three repeat transmissions in the PDSCH regions 602J, 602K and 602L in subframes J, K and L as indicated by shading in Figure 6. It may be noted in this example the frequencies of the resource elements for the re-transmission of the system information message on PDSCH in subframes J, K, L is different from that used in subframes D, E, F for the previous transmission, but this is not of any particular significance. Furthermore, the transmissions of the PDSCH message in subframes D, E, F, J, K, L may comprise different so-called redundancy versions of the PDSCH message comprising different combinations of information bits and redundancy bits arising from a forward error correction coding process.

It will be appreciated the transmission resources represented in Figure 6 which are not involved in the SI message signalling discussed above can be used for other communications in the network in the usual manner. In particular, it will be appreciated that although the entirety of the PDCCH regions associated with repeat transmissions of the PDCCH for the system information messages are shown shaded in Figure 6, this is merely to highlight those subframes in which a PDCCH for the system information messages is transmitted compared to those where it is not, and in practice these regions will comprise multiple PDCCH messages addressing different terminal devices for allocating resources for various different types of communication on PDSCH.

System information signalling in LTE is sent on what is approaching a more or less continuous basis. This means there is a considerable amount of PDSCH traffic for broadcasting system information messages comprising the SIBs. There is a corresponding requirement for PDCCH signalling to schedule the PDSCH resources for system information messages. The inventors have recognised that this can become a significant issue in a coverage extension scenario where a number of repetitions are expected, as illustrated in Figure 6. This is because for each PDSCH message comprising a plurality of PDSCH repeat transmissions (i.e. the PDSCH message sent using resources in subframes D, E and F and the PDSCH message sent using resources in subframes J, K and L) there is a corresponding SI-RNTI PDCCH message comprising a plurality of PDCCH repeat transmissions (i.e. the PDCCH message sent using resources in subframes A, B and C and the PDCCH message sent using resources in subframes G, H and I). With the potential for perhaps a hundred or more repeat transmissions to provide coverage extension to the edge of a base station's corresponding cell for system information messages a large fraction of the available control region resources will be needed to support this function following the approach of Figure 6. There is of course a corresponding increase in the use of PDSCH resources with the approach represented in Figure 6, but it is to be expected that in many situations it will be PDCCH resources that are more at a premium owing to the limited resources available in the control channel region for PDCCH and the priority typically given to PDSCH over EPDCCH in the PDSCH region. This is especially likely in networks supporting large numbers of MTC devices since these are likely to have a higher ratio of control signalling to data signalling as compared to the traffic profiles typically associated with conventional terminal devices. The increased PDCCH and/or EPDCCH resources needed to support repeat transmissions of system information messages could ultimately make it difficult to schedule unicast PDSCH transmissions to terminal devices operating within the system because of a lack an availability of control region resources to indicate the allocation of PDSCH resources and/or a lack of PDSCH region resource to indicate the allocation of PDSCH resources.

To address this type of issue there have been proposals to stop using PDCCH and EPDCCH messages resource allocations for PDSCH messages comprising system information (i.e. for system information messages). One proposal (described in the 3GPP document R1-135422, "On the need of PDCCH for SIB and other Common Channel", Mediatek, RAN1#75, San Francisco, November 2013 [4]) is to avoid providing any scheduling information in respect of system information-carrying PDSCH transmissions. Instead, a terminal device will be expected to perform blind searching of the PDSCH region to identify if there are any relevant system information transmissions. A drawback with this approach is a significant increase in the processing load required for terminal devices. To reduce the processing load required at the terminal device to a more manageable level the system information messages could be confined to a restricted subset of transmission resources comprising the PDSCH region. However, this approach still requires additional processing tasks to be performed by the terminal device and introduces reduced

scheduling flexibility. Another proposal (described in the 3GPP document R1-134207, "Coverage enhancement techniques for PBCH", Alcatel-Lucent, Alcatel-Lucent Shanghai Bell, RAN1#74bis, Guangzhou, October 2013 [5]) is to avoid using PDCCH messages to provide scheduling information in respect of system information-carrying PDSCH messages. Instead it is proposed that some of the spare bits currently available in the Master Information Block (MIB) in LTE are used for providing scheduling indications for system information messages. However, there are a limited number of spare bits available for this and so the approach does not allow for any significant degree of flexibility in scheduling system information messages, and furthermore the approach further reduces the number of spare bits available for other uses.

In view of these issues, the inventors have developed an alternative approach for reducing the amount of control signalling required to support resource allocations for higher-layer transmissions in a wireless telecommunications system. In particular, but not exclusively, the inventors have developed an approach which may be applied for reducing the amount of control-channel signalling required to support resource allocations for downlink messages, such as system information messages, and in particular for messages which may be subject to re-transmissions on a defined schedule and which may, in some cases, be sent using a repeat transmission approach to provide a degree of coverage extension.

Figure 7 is similar to, and represents various aspects that will be understood from, Figure 6, but shows an approach in accordance with certain embodiments of the present disclosure. Figure 8 is a signalling ladder diagram schematically representing modes of operation for the terminal device 508 and the base station 504 schematically represented in Figure 5 in accordance with some embodiments of the present disclosure for implementing an approach of the kind represented in Figure 7. In broad summary, some embodiments of the disclosure introduce the concept of a validity period for a PDCCH message to thereby indicate transmission resources that may be used for a plurality of PDSCH messages within the validity period. That is to say the control message transmitted on the PDCCH is considered valid for a period that is longer than the period needed to transmit a single PDSCH message (whether in one subframe or with repeat transmissions in a plurality of subframes to provide coverage extension). This means multiple PDSCH messages can in effect be scheduled using the control-region resources of only a single PDCCH message. There are various different ways in which the validity period may be established/determined, as discussed further below.

For the example represented in Figure 7, and as with Figure 6, it is assumed system information is being transmitted from a base station to a terminal device with a repeat transmission approach to providing coverage extension. Again the example approach to coverage extension represented in Figure 7 is assumed for ease of representation to rely on providing only three repeat transmissions for each PDCCH and PDSCH message. However, as noted above, it will be appreciated that in practice larger numbers of repeat transmissions will typically be involved, for example there may be tens or hundreds of repeats comprising each message to provide a correspondingly higher degree of coverage extension. Furthermore, it will be appreciated that PDCCH messages and PDSCH messages need not necessarily comprise the same number of repeat transmissions (for example different coding schemes may be adopted meaning that different numbers of repeat transmissions are appropriate to provide a desired probability of successful reception for each message).

Thus Figure 7 schematically represents an approach for providing coverage extension through repeated transmissions for a plurality of SI messages with reduced control signalling overhead in accordance with

an embodiment of the disclosure. Figure 7 schematically shows a sequence of LTE downlink subframes (labelled as subframes "O", "P", "Q", …, "Z" to aid explanation) with shading to schematically indicate which regions in which subframes are used to convey messages associated with the system information. The subframes represented in Figure 7 comprise four groups of three contiguous subframes with spaces between the groups as schematically indicated by dotted lines. Although not shown in Figure 7, the gaps between the groups comprise a continuing sequence of subframes used for other communications that are not relevant to the system information messaging considered here. As discussed above, each subframe comprises a control region 700 and a PDSCH region 702. The control regions 700 for the respective subframes are labelled in Figure 7 with the identification letter for the relevant subframe, i.e. as 700O, 700P, 700Q, etc. The PDSCH regions for the respective subframes are similarly labelled in Figure 6 as 702O, 702P, 702Q, etc.

As already noted above, aspects of the operation of a wireless telecommunications system in accordance with embodiments of the disclosure, for example as shown in Figure 7 and 8, which are not specifically described herein may be implemented in accordance with any conventional techniques. In this regard, insofar as the operation of embodiments of the disclosure follow conventional techniques the respective subframes represented in Figure 7 may be similar to that is represented in Figure 3. Thus, the control regions 700 support PCFICH, PHICH and PDCCH channels as discussed above while the PDSCH regions 702 support user-plane data and system information (among other things) and EPDCCH if implemented. The most significant aspect of the control region 700 in the context of embodiments of the present disclosure relate to the PDCCH and so for simplicity the control regions 700 may sometimes be referred to herein as PDCCH regions 700.

Thus referring to Figure 7 subframes O, P and Q are used to signal a PDCCH message addressed to SI-RNTI by sending three repeat PDCCH transmissions in the respective PDCCH regions 700O, 700P, 700Q. Each PDCCH repeat transmission addressed to SI-RNTI in the PDCCH regions 700O, 700P, 700Q in effect comprises a duplication of the same downlink control information which a terminal device can combine to seek to establish the content of the PDCCH message addressed to SI-RNTI in accordance with conventional techniques for coverage extension through repeat transmissions. For this example implementation of a repeat-transmission based coverage extension scheme it is again assumed a particular type of message subject to repeat transmissions is addressed to the same RNTI (e.g. SI-RNTI for a system information related type of messages) as if the same type of message were subject to conventional single-subframe transmission. However, as discussed further below, in accordance with certain embodiments of the disclosure identifiers having different characteristics (e.g. in terms of their value or control region search space) may be used for a given type of message depending on whether the messages to be sent in accordance with a first transmission scheme (e.g. using a conventional single subframe based transmission approach) or a second transmission scheme (e.g. using a repeat-transmission scheme for coverage extension). Furthermore, it will be appreciated the approach of using identifiers associated with a particular type of message having different characteristics according to the transmission scheme is to be used in accordance with embodiments of the disclosure may or may not also implement an approach using validity periods as disclosed herein.

The PDCCH message sent in subframes O, P and Q in Figure 7 differs from a conventional PDCCH message, for example of the kind transmitted in subframes A, B and C of Figure 6, in that it is associated with a validity period that is sufficient to span the transmission of a plurality of PDSCH messages. This is

different from the conventional approach in which a PDCCH message is simply associated with a single PDSCH message. The validity period for the PDCCH message is known to both the base station and the terminal device. For example, the validity period may be based on a defined standard for operations in accordance with an embodiment of the disclosure, whereby the base station and the terminal device can each determine the validity period from the defined standard. In other embodiments the base station may have flexibility to select the validity period, for example according to current scheduling requirements, and to communicate an indication of the validity period to the terminal device(s) to which the PDCCH message is addressed. Some example implementation of this approach are discussed further below.

The PDCCH message comprising the three repeat transmissions in the PDCCH regions of subframes O, P and Q indicate transmission resource blocks to be used for a subsequent PDSCH message comprising the transmission of system information. This PDSCH message itself comprises a plurality of repeat transmissions, and, in this example, are represented by shading in the PDSCH regions 702R, 702S and 702T of subframes D, E and F. The manner in which the PDCCH message indicates the corresponding PDSCH resources in subframes R, S and T may be in accordance with conventional techniques/signalling protocols. That is to say, the transmission resources, for example in terms of specific resource elements, used to convey the repeat transmissions of the system information message in the PDSCH regions 702R, 702S and 702T may be indicated in the corresponding PDCCH message addressed to SI-RNTI and comprising the repeat transmissions in PDCCH regions 700O, 700P, 700Q in accordance with conventional resource allocation techniques in the context of coverage extension using repeat transmissions. Whilst the shading in Figure 7 schematically represents the same frequency resources being used for each repeat transmission in the respective PDSCH regions 702R, 702S and 702T of the subframes R, S and T, in principle the repeat-transmission approach may be configured to include frequency hopping for the different repeat transmissions comprising the PDSCH message sent in subframes R, S and T. The nature of any such frequency hopping may be pre-defined, for example it may be pre-specified according to an operating standard for the wireless telecommunications system, or it may be established in previous RRC (radio resource control) signalling, or it may be indicated in the PDCCH message.

As schematically represented in Figure 7 there is a gap between subframes C and D. This again follows the currently-proposed approaches for repeat-transmission coverage extension whereby the transmission of a PDSCH message comprising a plurality of repeat transmissions does not start until after all repeat transmissions of the corresponding PDCCH message have been sent. Furthermore, some proposals indicate there should be no overlap between the end of the repeat transmissions comprising the PDCCH message and the start of the repeat transmissions comprising the PDSCH message. It will, however, be appreciated the specific implementation of such aspects of a repeat transmission approach for providing coverage extension are not significant to the principles underlying the present disclosure. That is to say, the principles described herein may equally be implemented in association with other repeat transmission approaches (e.g. with repeat transmissions of PDCCH and an associated PDSCH occurring in the same subframe).

Thus, the communication of the PDCCH message in subframes O, P and Q and the corresponding communication of the PDSCH message conveying system information in subframes R, S and T as represented in Figure 7 may follow the same general principles as the approach represented in Figure 6. Similarly, in subframes following the repeat-transmission approach for transmitting the system information

message as schematically indicated in subframes R, S and T in Figure 7, the wireless telecommunications system may continue to operate in accordance with its normal operating techniques for conveying other messages.

As noted above, system information messages are regularly retransmitted in accordance with LTE techniques, and the approach of Figure 7 differs from the approach of Figure 6 in respect of how a subsequent transmission of system information is scheduled on PDSCH in subframes X, Y and Z. In particular, the approach of Figure 7 differs from the approach of Figure 6 if the subsequent retransmission of system information occurs within the validity period associated with the previously-received PDCCH message in subframes O, P and Q initially sent in association with the previously-received system information message on PDSCH in subframes R, S and T. In LTE the transmission of system information follows a defined timing schedule, for example based on the system information window defined for the relevant system information. Thus, a base station and a terminal device are able to independently determine in which subframe a system information message will be transmitted on PDSCH (or which plurality of subframes in the case of coverage extension through repeat-transmissions as in this example). Thus, in the example of Figure 7, a terminal device to which the system information is addressed can determine that a system information message is to be transmitted in subframes X, Y and Z.

Referring back to Figure 6, the terminal device receiving the system information on PDSCH in subframes J, K and L can similarly determine in accordance with conventional techniques that the transmission will occur in these subframes. However, to determine the specific resources (e.g. in terms of specific OFDM carriers / resource blocks) on which the transmissions will occur within the relevant subframe(s) the terminal device must first receive the corresponding PDCCH allocation message sent in subframes G, H and I.

However, in the approach of Figure 7 in accordance with an embodiment of the present disclosure the resource allocation used for the PDSCH transmissions of the system information message on subframes X, Y and Z is determined from the previous resource allocation message sent on PDCCH in subframes O, P and Q. For example, in accordance with one approach the specific PDSCH resources (e.g. in terms of frequency) to be used for transmitting the subsequent system information message in subframes X,Y and Z are assumed to be the same as the specific PDSCH resources (e.g. in terms of frequency) used for transmitting the system information message in subframes R, S and T and indicated in the PDCCH message sent in subframes O, P and Q. However, it will be appreciated that other mappings can be adopted. For example, the frequencies to be used can be configured to shift in accordance with a predefined pattern for each retransmission within the validity period for the PDCCH message.

Thus, in accordance with an embodiment of the disclosure, and in contrast to the approach in the corresponding subframes in Figure 6, there is no PDCCH message sent in subframes U, V and W to support the system information message sent on PDSCH in subframes X, Y and Z. Instead it is determined that a previous PDCCH message remains valid (because its associated validity period has yet to expire), and the resources used for conveying the system information message on PDSCH in subframes X, Y and Z are derived from the previous PDCCH.

This approach has an advantage of freeing up the control-channel resources, in particular in subframes U, V and W for the example subframes represented in Figure 7. The approach can also help reduce the

amount of processing required by the terminal device (since the terminal device does not need to decode a separate PDCCH message for each and every PDSCH message). Furthermore the approach can reduce latency in situations that require high repetition numbers because there is no need to wait to receive a series of PDCCH repetitions before receiving each series of PDSCH repetitions.

It will be appreciated the transmission resources represented in Figure 7 that are not involved in the SI message signalling discussed above can be used for other communications in the network in the usual manner. In particular, it will be appreciated that although the entirety of the PDCCH regions associated with repeat transmissions of the PDCCH for the system information messages are shown shaded in Figure 7, this is merely to highlight those subframes in which a PDCCH for the system information messages is transmitted compared to those where it is not, and in practice these regions will comprise multiple PDCCH messages addressing different terminal devices for allocating resources for various different types of communication on PDSCH.

Thus, to summarise an approach in accordance with an embodiment of the disclosure as represented in Figure 7, and with reference to Figure 8, a base station 504 is transmitting system information messages to terminal devices, including terminal device 508, according to a pre-defined timing schedule. The predefined timing schedule may follow conventional LTE techniques for transmitting system information. It is assumed the processing represented in Figure 8 starts just prior to subframe O at the beginning of the series of subframes represented in Figure 7 and while there is no currently valid PDCCH message for the relevant system information. Thus, in a first step S1 in Figure 8 the base station determines a validity period that is to apply for an upcoming control-plane message that is to be transmitted to allocate resources for system information messages on PDSCH. The duration of a validity period for a given PDCCH message may be fixed / predetermined according to a specific implementation, for example by a network operator, or may be selectable by a base station according to current conditions. The validity period might be relatively short, for example it might only comprise the time required to transmit two PDSCH messages to provide a potential saving of one PDCCH message transmission. On the other hand, the validity period might be significant number, for example hundreds, thousands, tens of thousands, or even more subframes. In general a longer validity period may be preferred to reduce the number of PDCCH message transmissions, while an overly-long validity period may be considered to overly restrict scheduling flexibility. An appropriate validity period in a given situation may depend on current traffic conditions within a cell supported by a base station. For example, if a base station is currently supporting a large number of terminal devices it may be more appropriate to select a relatively long validity period to provide a correspondingly large saving in PDCCH message transmissions. However, if a base station is currently supporting only a small number of terminal devices with low traffic requirements (i.e. such that PDCCH congestion is not an overly significant concern), it may be more appropriate to select a relatively short validity period to provide a corresponding increase in scheduling flexibility (example to take better account of fluctuations in radio propagation conditions or traffic changes). In one example a current proportion of non-MTC traffic may be used to help determine an appropriate validity period for a repeated PDCCH. Generally speaking, the higher this proportion, the higher the proportion of non-delay-tolerant non-small-message terminal devices in the cell whose performance may be disrupted by a heavy use of control channel resources due to repeated PDCCH transmission. Therefore, as the proportion of relatively higher priority terminal devices (e.g. non-MTC terminal devices) increases, the base station may opt for longer PDCCH validity times, especially for use in association with SI-messages.

In step S2 the base station transmits a control-plane message, which can also be referred to as a control message (using repeat transmissions for coverage extension in this example) to allocate the resources for subsequent system information messages on PDSCH. This control message is received and decoded by the terminal device 508. This aspect of the operation may be based generally on conventional techniques, for example using a PDCCH message addressed to an SI-RNTI in LTE. Furthermore, the specific resources selected by the base station for allocation to the system information messages may be selected in accordance with established scheduling techniques in wireless communication systems. Thus, step S2 correspond with the transmissions made in subframes O, P and Q of Figure 7.

In step S3 the terminal device determines the validity period for the control-plane message received in step S2. There are various ways in which the terminal device may determine the validity period for the control-plane resource allocation message in accordance with various embodiments of the disclosure, and some examples are discussed further below.

In step S4 the base station proceeds to transmit a system information message (using repeat transmissions for coverage extension in this example) in accordance with the resource allocation identified by the control-plane (PDCCH) message of step S2. This aspect of the operation may be made broadly in accordance with conventional techniques. The terminal device seeks to receive and decode this system information message (SI message #1) in accordance with conventional techniques.

In step S5 the base station determines it is time to transmit another system information message (SI message #2) according to the predefined timing for periodic system information transmissions in the wireless telecommunications system. The base station further determines the validity period for the control-plane message sent in step S2 has not yet expired. Accordingly, the base station does not send any new control-plane message to support the new system information message that is about to be transmitted (SI message#2). Instead the base station proceeds to transmit the system information message (using repeat transmissions for coverage extension in this example) in accordance with resource allocations derived from the previously-sent control-plane (PDCCH) message of step S2. For example, the base station may be configured to simply use the same frequency resources for transmitting SI message #2 in step S5 as were used for transmitting SI message #1 in step S2. The terminal device likewise determines the expected transmission timing for the new system information message (SI message #2) from the predefined timing for system information transmissions and also determines the validity period for the previous control-plane message received in step S2 has not expired. Accordingly, the terminal device need not seek to receive a new control-plane message to indicate the PDSCH resources for the new system information message that is to be next transmitted (SI message#2). Instead the terminal device simply assumes the transmission is to be made in the relevant subframes (determined according to the predefined timing) on frequency resources derived from the previously-sent control-plane (PDCCH) message of step S2. Once the terminal device has determined the specific resources on which to expect the system information message in step S5 (SI message #2) it may proceed to receive and decode the system information message in accordance with conventional PDSCH transmission techniques.

As noted above the timing s for specific SI messages in LTE are based on SI windows. Conventionally it is the transmission of an associated PDCCH message addressed to the relevant system information RNTI which determines the precise subframe(s) in which the system information message PDSCH is transmitted. However, in accordance with certain embodiments of the disclosure there can be PDSCH

messages conveying system information in an SI windows without there being a corresponding PDCCH message in that SI window. There are a number of different ways in which a terminal device can determine the relevant subframe for a further PDSDH message transmitted within the validity period of a previously-received PDCCH message in accordance with embodiments of the disclosure. In one case, the base station may be configured to send the PDSCH message in a predefined subframe of the SI window. In principle this could be permanently fixed for all PDSCH system information messages at the cost of reduced scheduling flexibility. In another case the subframe(s) could be based on the subframe(s) used in association with the initial PDCCH message. For example, if the initial PDCCH indicates a system information message is to be sent in subframe number n (or starting in subframe n for repeat transitions for coverage extension) within a particular SI window, subsequent PDSCH messages within the validity period of the PDCCH might also be sent in (or start in) subframe n of the relevant SI window. In another example, the base station may retain the flexibility to send (or start sending when using repeat transmissions) the subsequent system information message in any subframe within the SI window. In this case a terminal device may check for a newly addressed PDCCH message in the subframes in the SI window in the normal way, and if a new PDCCH message is not found, the terminal device may decode the PDSCH resources indicated in accordance with a previously-received still valid PDCCH message in the same subframe(s) relative to the SI window as for the previous transmission. In principle, with sufficient processing power, the terminal device could simply seek to decode the relevant resources in all subframes of an SI window to see if an SI message can be decoded.

The process of the base station sending further system information messages, and the terminal device receiving the further information messages, based on transmission resource allocation information indicated in the control-plane message of step S2 may continue (as schematically indicated in step S6 for transmitting SI message #n) until the validity period for the control-plane message received in step S2 has expired, as schematically indicated in step S7.

Following step S7 the processing in effect cycles back to where it started prior to step S1. The base station may thus determine a new validity period for a new control message to be sent in a further step corresponding with step S2 (the base station determines that a new PDCCH message is required because the previous one has expired). Processing may then continue from this point in the manner discussed above.

Thus, the various example schemes represented in Figures 7 and 8, and described above, provide an approach in which control-plane messages, and in particular SI-messages, are associated with a validity period that extends for more than one message transmission of the associated PDSCH. For example, for SIBs in SI-messages, one SI-RNTI addressed PDCCH message can provide the control information for multiple transmissions of SIBs, and in general over multiple SI-windows. Similar operation for other types of message, for example messages addressed to other common search-space RNTIs, may be adopted in accordance with other examples. This kind of approach can help reduce control resource requirements, which can be especially important in the context of coverage extension where according to conventional techniques PDCCH (comprising multiple repeat transmissions) messages would have to be transmitted every time an SI-message (comprising multiple repeat transmissions) needed to be sent.

As noted above, SIBs in system information messages can in some cases remain unchanged for extended period, for example a few hours. A terminal device may thus combine system information message transmissions from across multiple SI-windows if it does not successfully decode an SI-

message at first attempt and with a sufficiently long validity period this can be achieved in accordance with the approaches described herein with reduced control signalling requirements than current schemes.

As noted above, there are various different ways in which the validity period for a PDCCH message may be established. In one simple example the period may be defined according to an operating standard of the wireless telecommunications system. Both the base station and the terminal device can in effect be hardwired with the validity period (or multiple validity periods associated with different types of messages). In another example the base station may have flexibility for determining a suitable validity period according to the implementation and traffic conditions at hand. In this case there are various different ways in which the validity period could be conveyed to a terminal device.

In one example the base station may be configured to convey a selected validity period to terminal devices by selecting a particular transmission characteristic, for example timing, for the PDCCH message with which the validity period is associated. According to current proposals for repeat transmission coverage extension in LTE, the starting subframe of a PDCCH message being transmitted in multiple subframes should be confined to a subset of subframes. This is because in some circumstances the terminal device may be required to blindly search over the possible numbers of repetitions the PDCCH might comprise. If it were allowed for a PDCCH messages comprising an arbitrary number of repeat transmissions to start in an arbitrary subframe this could be expected to give rise to significant complexity in the processing required of the terminal device. To address this there has been proposed an approach in which, for example, a PDCCH message comprising N repeats can only begin in subframes having a subframe number that is a multiple of N (i.e. 0, N, 2N, 3N,…). This reduces the set of possible repetition numbers the UE needs to consider per subframe. Thus, a similar approach could be used to convey information on PDCCH validity. This can be done by linking the validity period to the starting subframe number of the associated PDCCH message. For example, a PDCCH message commencing in subframe M might be taken to indicate a validity period corresponding to M SI-windows for the relevant system information. Thus, a terminal device can readily establish the relevant validity period from the timing of the relevant control-claim message. It may be noted that in some circumstances it may be preferable to assign longer PDCCH validity periods to PDSCH messages that comprise high numbers of repetitions.

In another example the base station may be configured to convey a selected validity period to terminal devices through explicit signalling, for example in the downlink control information (DCI) of the relevant PDCCH message. Thus, the DCI may comprise an indication of a number of subframes / radio frames corresponding to the validity period or may comprise an indication of a specific subframe / radio frame in which the validity period is to expire. In the application to the transmission of system information messages it may be preferable to indicate timings in respect of a number of SI-windows of validity.

In yet another example the terminal devices may be configured to simply assume the validity period for a given PDCCH message addressed to a given RNTI (e.g. SI-RNTI) extends until a subsequent PDCCH message addressed to the relevant RNTI is received. That is to say, the PDCCH message may be considered to remain valid until it is replaced by another PDCCH message. In this respect, in terms of the processing schematically represented in Figure 8, this corresponds with the terminal device determining the validity period for the control message (corresponding to step S3) at the same time at which the validity period expires (responding to step S7), with this being triggered by a new PDCCH message being received by the terminal device. In this approach a terminal device may thus monitor for a new PDCCH message addressed to the relevant RNTI in each subframe of each SI-window in the normal way until a

new PDCCH message is received to in effect define the end the validity period for the previous PDCCH message addressed to that RNTI.

Thus, one principle of the approaches described above in accordance with some embodiments of the disclosure is to associate a PDCCH message with a time defining its validity, that time being extensible beyond the time taken to convey a corresponding PDSCH message. A terminal device may thus assume the PDSCH resource allocation, MCS (modulation and coding scheme), TBS (transport block size), etc. in the DCI of the PDCCH message is valid for receiving multiple PDSCH messages during the PDCCH validity time. No further PDCCHs for multiple PDSCH messages need be sent during the validity time. Thus, in the case of SIB transmissions, the transmission of all SI-messages (including all transmissions within a SI-window of a particular SI-message), may be scheduled with a single transmission of SI-RNTI PDCCH with an appropriately configured validity period.

One particular situation in which approaches in accordance with the embodiments described above might be expected to be useful is where the transmissions are used to provide coverage extension on both PDCCH and PDSCH. However, similar principles can be applied where coverage extension is not being used, for example in respect of messages sent within single subframes.

Whilst the above-described embodiments have focused on system information messages, it will be appreciated that similar principles can be applied for other types of messages in wireless telecommunications systems, and especially for messages which rely on resource allocations occurring with some degree of predictable timing. For example, similar principles can be used for control signalling addressed to other common search space RNTIs, such as RA-RNTI and P-RNTI.

Thus a random access RNTI addressed PDCCH message received by a terminal device during an initial cell access may be associated with a validity period such that the transmission resources identified in association with the random access RNTI PDCCH message are taken to apply for later random access procedures in accordance with the principles set out above. The specific subframe of a RAR (random access response) window in which a subsequent RAR arrives can be established in a manner similar to that described above for system information within a predefined series of subframes comprising an SI-window

Similarly, a paging RNTI addressed PDCCH message may be associated with an extended validity in accordance with the principles described above. Thus a PDSCH resource allocation associated with a PDCCH message addressed to a paging RNTI transmitted in one subframe may be taken to indicate a PDSCH resource allocation in a subsequent subframe within a validity period associated with the PDCCH message. This may be especially appropriate for paging when a terminal device is in idle mode since there is a higher degree of predictability as to when paging messages may be sent according to a currently configured DRX, discontinuous reception, cycle. That is to say, the concept of PDDCH validity timers as discussed herein may be applied to the most recent P-RNTI PDCCH used to decode a paging message by an RRC_IDLE UE. An RRC_IDLE UE is only expected to monitor specific subframes for P-RNTI and is in DRX for other subframes. If the relevant PDCCH validity timer expires before a subsequent paging message is to be sent, the base station may provide a new P-RNTI PDCCH message to schedule the next paging message as normal. Otherwise the IDLE UE may assume the most recent such PDCCH is still valid. For an RRC_CONNECTED UE, there is less predictability as regards whether a particular subframe should contain P-RNTI PDCCH or not. For a connected mode terminal device the

principles described herein for paging messages might, for example, be used for subframes in which the UE would check for P-RNTI if it were in fact in IDLE mode. In other subframes the base station may send conventional paging signalling using PDCCH to page the UE in connected mode.

In a wireless telecommunications using repeat-transmissions for coverage extension there may be terminal devices which are not in coverage-limited locations and able to successfully decode individual ones of the PDCCH (or EPDCCH) repeat transmissions in each subframe. For example, and referring to Figure 7, a non-coverage-limited terminal device may be able to successfully decode the individual PDCCH repeat transmission in the control region 700O of subframe O. If this terminal device is not aware of the use of repeat-transmissions for coverage extension (for example because it is a legacy / conventional terminal device) it might be expected to assume the PDCCH information derived from the control region 700O subframe O applies to a system information transmission on PDSCH in the same subframe (i.e. in PDSCH region 702O). However, the terminal device would fail to receive the system information transmission (because it is not sent in accordance with this particular repeat-transmission protocol). Potentially this terminal device could seek to do this for each and every repeat transmission and so waste a considerable amount of processing effort needlessly decoding individual PDCCH repeat transmissions and associated PDSCH resources in the expectation of receiving system information messages which are not in fact being sent in those subframes. This is an issue which applies generally for repeat transmission approaches for coverage extension and is not specific to approaches based on validity periods as discussed herein.

Thus in accordance with certain embodiments of the disclosure an identifier (RNTI) having different characteristics (e.g. in terms of value or associated control region search space) may be associated with SI messages sent using a repeat transmission approach as compared to SI messages sent without using a repeat transmission approach. More generally, in a wireless telecommunications system supporting different transmission schemes for a given type (classification / category) of message (e.g. a message comprising a given radio resource control, RRC, information element, such as a system information related message or a paging request related message), a characteristic of an identifier associated with the message (i.e. an identifier to indicate which terminal device(s) the message is for) may be selected according to the transmission scheme used for the message. This approach may be implemented in accordance with certain embodiments of the disclosure regardless of whether the wireless telecommunications system also implements an approach using validity periods as described herein (i.e. the approach may be implemented in association with the principles of the repeat transmission scheme represented in Figure 6 as well as that represented in Figure 7). That is to say, the concept of associating a validity period with a control message and the concept of using different identifier characteristics according to a transmission scheme being used may be used together in combination or separately from one another in accordance with different embodiments of the disclosure.

A terminal device having the ability to receive transmissions using the repeat transmission approach can identify the transmissions as such directly from the associated identifier characteristic and receive the message accordingly. The characteristic for the identifier can be selected so that a terminal device not having the ability to receive transmissions using a repeat transmission approach, for example a legacy terminal device, does not recognise the message as being addressed to the terminal device, and so in effect ignores it. Such a terminal device may in effect ignore the message because, for example, the identifier has a value which is not recognised as a value relevant to the terminal device or because a search space for a control message conveying the identifier is not searched by the terminal device.

Thus, if in a particular implementation it is assumed that a repeat transmission approach to coverage extension is intended primarily for MTC-type devices, an MTC-specific system information radio network temporary identifier (MTC-SI-RNTI) may be established. PDCCH messages associated with repeat transmissions for conveying system information messages may thus be addressed to MTC-SI-RNTI instead of an SI-RNTI used for conveying system information that is not sent using repeat transmissions. More generally some embodiments of the disclosure propose introducing other repetition specific RNTIs to address messages that rely on repetitions for coverage extension to complement corresponding RNTIs in existing systems. Thus, system information messages to be sent in accordance with a non-repeat transmission technique may be associated with a conventional system information identifier (e.g. SI-RNTI) while system information messages to be sent in accordance with a repeat-transmission technique may be associated with a modified system information identifier (e.g. REPEAT-SI-RNTI).

Similar issues can arises for other common RNTIs associated with other types of message that may be sent using a repeat transmission approach. Thus corresponding RNTIs having different characteristics may also be established for these. For example, for each of SI-RNTI, P-RNTI, RA-RNTI, TPC-PUCCH-RNTI, TPC-PUSCH-RNTI and M-RNTI to be used for addressing non-repeat transmission messages, there may be established a corresponding RNTI having a different value to be used for addressing repeat-transmission messages (e.g. what might be generally referred to as REPEAT-RNTIs, such as REPEAT-SI-RNTI, REPEAT-P-RNTI, REPEAT-RA-RNTI, REPEAT-TPC-PUCCH-RNTI, REPEAT-TPC-PUSCH-RNTI and REPEAT-M-RNTI). Thus an approach in accordance with an embodiment of the disclosure may be used in association with messages selected from the group comprising: (i) a message associated with transmitting system information; (ii) a message associated with transmitting a paging message; (iii) a message associated with transmitting a random access response message; (iv) a message associated with transmitting power control information for an uplink control channel; (v) a message associated with transmitting power control information for an uplink data channel; and (vi) a message associated with a broadcast and / or multicast service. A similar approach can be taken for types of message associated with other common RNTIs which may be introduced in future.

In some implementations in which a message to be transmitted using a repeat-transmission approach in association with an identifier having a characteristic selected to indicate this, a component part of the message (e.g. a repeat transmission) may also be transmitted in one, or more, subframes in association with an identifier having a characteristic that would be used if the message were being transmitted using a conventional single-transmission approach. This will allow legacy terminal devices who are able to receive the message from only a single repeat transmission to in effect receive the message based on one of the repeat transmissions.

One advantage of associating identifiers for a given type of message with different characteristics based on the transmission scheme is the potential for more complete use of the available transmission resources. For example, referring to Figure 7, the initial SI-RNTI addressed PDCCH repeat transmission in the control region 700O of subframe O is part of a repeat transmission comprising three repeat transmissions in the respective control regions of subframes O, P and Q. This PDCCH message identifies resources (and other parameters) associated with a PDSCH message to be subsequently transmitted starting from subframe R as discussed above. As previously noted, it is expected for repeat-transmission based coverage extension there will be no PDSCH signalling associated with the PDCCH message until after the repeat transmissions comprising the PDCCH message had been made. In principle the PDSCH

transmission resources in the PDSCH regions 702O, 702P and 702Q of subframes O, P and Q corresponding to the resources allocated by the PDCCH message for use in subframe starting from subframe R could be used to support other transmissions. For example, the respective control regions 700O, 700P, 700R could include conventional single-subframe PDCCH messages allocating the relevant PDSCH transmission resources for another purpose, for example unicast data. However, it would be confusing for a legacy terminal device to decode a unicast PDCCH message and a SI PDCCH message resource allocation identifying the same resources in the same subframe. Thus by preventing the legacy terminal device from decoding the SI PDCCH signalling (through use of an appropriate distinguishing characteristic for the identifier as discussed herein), the legacy terminal device is free to receive unicast data on the relevant PDSCH resources (in association with an appropriately addressed PDCCH transmission indicating these resources).

In implementations in which the distinguishing characteristic for the identifier is its value (i.e. with one value, such as SI-RNTI, indicating conventional single-subframe transmission, and another value, such as REPEAT-SI-RNTI, indicating repeat-transmission coverage extension), the "new" REPEAT-RNTIs may be defined in accordance with an operating standard for the wireless telecommunications network in parallel with the corresponding RNTIs. For example, as noted above, in LTE the SI-RNTI has a fixed value 0xFFFF. In accordance with an embodiment of the disclosure a fixed value for a REPEAT-SI-RNTI may be selected from one of the currently reserved RNTIs in LTE (from 0xFFF4 to 0xFFC). Thus, if, for example, a value 0xFFF5 is allocated as REPEAT-SI-RNTI (i.e. an identifier for a system information related message sent using repeat transmissions), a PDCCH addressed to 0xFFFF can be identified as corresponding to a system information message sent without repetition whereas a PDCCH addressed to 0xFFF5 can be identified as corresponding to a system information message sent using repetition. A terminal device that is unaware of repetition will in effect ignore the PDCCH addressed to 0xFFF5 as this will not be recognised as a valid RNTI for the terminal device. Corresponding principles apply where EPDCCH is used.

In the above-described example the value of the RNTI is the characteristic used to distinguish between the different transmission schemes. However, in accordance with other embodiments of the disclosure, other characteristics can be used to distinguish identifiers to indicate different transmission schemes. For example, in LTE there are currently eight "spare" values that could be used as new REPEAT-RNTIs. This is a sufficient number of values to provide a corresponding RNTI to be used in association with a transmission scheme comprising repeat transmissions for all currently-existing common RNTIs. However, it may be considered preferable in some cases to avoid using these "spare" values so they remain free for other uses, or there may be a need for more REPEAT-RNTIs (for example, to provide multiple extra RNTI for a given type of message, e.g. a system information message, to indicate another aspect of the transmission scheme, for example the number of repeats). Thus, in accordance with some embodiments a REPEAT-RNTI may in fact have a value that is the same as its corresponding "conventional" RNTI (e.g. 0xFFFF for SI-RNTI and REPEAT-SI-RNTI) but be associated with a different search space. As is well known a terminal device will typically search a defined subset of control region resources to seek to identify any control messages associated with an identifier (RNTI) common to a plurality of terminal devices. The subset of control region resources is known as a search space and comprises a plurality of candidate PDCCH for the terminal device to check. This search space approach is taken to reduce the amount of processing required by the terminal device to seek to identify any relevant control messages. Thus, PDCCH signalling associated with the existing common RNTIs are constrained to a particular set of

candidate PDCCH comprising the common search space. In accordance with some embodiments of the disclosure the characteristic of the identifier which is used to distinguish the different potential transmission schemes may be based on the specific PDCCH resources used.

For example, a PDCCH message to be transmitted in accordance with a conventional single-subframe approach may be associated with an identifier, such as SI-RNTI, in the common search space in the usual way. However, a PDCCH message to be transmitted in accordance with a repeat-transmission approach may instead be associated with the same value of identifier, such as SI-RNTI, but transmitted on PDCCH resources outside the common search space. Thus in accordance with some implementations the distinguishing characteristic for the identifier based on the transmission scheme may be a search space with which the identifier is associated. Thus a PDCCH message addressed to SI-RNTI within a particular search space (e.g. the common search space in LTE) can be identified as corresponding to a system information message sent without repetition whereas a PDCCH transmission addressed to SI-RNTI outside the particular search space (e.g. outside the common search space in LTE) can be identified as corresponding to a system information message sent using repetition. A terminal device that is unaware of repetition will in effect ignore the PDCCH addressed to SI-RNTI outside the common search space as the terminal device will not search for the SI-RNTI outside the common search. Corresponding principles apply where EPDCCH is used. Thus in effect, identifiers associated with repeat transmissions may be associated with a newly-defined search space which is outside the search space used for the corresponding identifiers for conventional single-subframe transmissions. In some examples the new search space may support only a single aggregation level, for example an aggregation level 8 (the high aggregation level being appropriate in view of the coverage extension context). The new search space may be smaller (i.e. comprise fewer candidate PDCCH) than the search space for existing common RNTIs. This can help reduce the blind search load associated with the repeat transmissions comprising a message transmitted using a repeat transmission for coverage extension.

It will appreciated the advantages of establishing a new search space comprising a reduced number of candidate PDCCHs with a single relatively high aggregation level to be used in association with identifiers for repeat transmission messages can be applied even in circumstances where different identifier values are associated with the different transmission schemes. In such cases the repeat-specific identifier values may be selected from among the values that are available for use as identifiers in the wireless telecommunications system. In one example, as referred to above, a repeat-specific identifier values may simply match its corresponding non-repeat specific identify value (e.g. SI-RNTI) with the different search space in which a control message associated with the identifier is transmitted providing the distinguishing characteristic for the identifier for the selected transmission scheme. However, in another implementation the repeat-specific identifier values may be selected from, for example, identifiers available for other uses, for example in LTE from identifiers available for cell-specific RNTIs (which may range from 0x001 to 0xFFF3). This approach can in principle provide a relatively large number of repeat-specific identifiers. For example, one or more of the values normally used for C-RNTI can be in effect reserved as one or more repeat-specific RNTIs, such as REPEAT-SI-RNTI in the terminology used above, and likewise for types / classes / classifications of messages other than system information related messages, such as paging messages and random access a response messages etc. Thus a base station could in effect reserve (re-allocate) in its cell a number of RNTI values for one purpose as actually being for use as repeat-specific RNTIs. If any of the re-allocated subset of RNTIs comprising the repeat-specific RNTI is detected by a terminal device as addressing a PDCCH in the newly-defined search space, the terminal

device may be configured to interpret this as a repeat-specific RNTI. This may be based on the base station conveying in previous signalling to terminal devices that support repeat-transmission communications an indication of the relevant RNTI(s). Alternatively, or in addition, the relevant RNTI(s) may be defined in accordance with an operating standard of the network for reallocation within the new search space. If the PDCCH candidates comprising the new search space do not overlap with those of the pre-existing common search space and UE-specific search space used by legacy devices, then the RNTIs allocated as repeat-specific RNTIs within the new search space could continue to be used in the other search space without giving rise to the potential for confusion for legacy terminal devices. If, on the other hand, the PDCCH candidates comprising the new search space do overlap with those of the pre-existing common search space or UE-specific search space, then the base station may be configured to avoid allocating any of a currently re-allocated RNTI to terminal devices in accordance with the usual function for the RNTI (i.e. a C-RNTI reallocated for use as a repeat-specific identifier should not be allotted to a terminal device for use as a C-RNTI). This can be remedied as a straightforward matter of RNTI scheduling (for example, the base station can in effect simply treat the re-allocated RNTIs as being already allotted for use).

If multiple RNTI are made available for use for a given type of message, the particular RNTI selected for use in association with a particular message may be used to indicate a further characteristic of the message, for example a number of repeats or a specific PDCCH validity period where implemented. This can provide the base station with a simple mechanism for modifying the specific repeat and all validity period parameters associated with a particular message, thereby improving overall flexibility.

Determining which identifiers a terminal device should search for to seek to identify messages to be sent to the terminal device using a repeat transmission scheme can be done in accordance with the usual principles by linking it to transmission mode (TM) configuration. In one implementation the repeat-specific RNTIs provided in accordance with embodiments of the disclosure might apply in all transmission modes as the principles governing their use will in many respects be similar to conventional, search space RNTIs. There could also be a link with the category/type of the terminal device. For example, a new terminal device category identifier could be introduced (e.g. category 0) to indicate the terminal device is a particular type of terminal device, for example an MTC-based terminal device. The repeat-specific identifiers may then be considered to apply to all transmission modes for terminal devices of category 0 (if the repeat-transmission based scheme is limited to category 0 terminal devices), as well as for additional terminal device categories if the use of the repeat-transmission based scheme is more widely supported.

Figure 9 is a signalling ladder diagram schematically representing modes of operation for the terminal device 508 and the base station 504 schematically represented in Figure 5 in accordance with some embodiments of the present disclosure.

Processing begins in step T1 when the base station determines that a message is to be transmitted to one or more terminal devices. The message may, for example, be a broadcast message or a multicast message. The determination that a message is to be transmitted may be made in accordance with conventional operating procedures for the wireless communications system. For example, if the message is a system information message, step T1 may arise in accordance with a conventional timing schedule for transmitting system information messages. If the message is a paging message, step T1 may arise because an event has arisen which requires a terminal device to be paged. In this example it is assumed the message which is to be transmitted is a system information message which is relevant for (i.e.

address to an identifier associated with) terminal device 508. Furthermore, it is assumed the message may be transmitted in accordance with either one of a first transmission scheme using transmission resources in a first number of radio subframes (e.g. using conventional single-subframe transmission) or a second transmission scheme using transmission resources in a plurality radio subframes (e.g. using repeat-transmission for coverage extension).

In step T2 the base station determines which of the first and second transmission schemes are to be used for transmitting the message. That is to say, in this example, the base station determines whether or not a conventional single subframe approach or a repeat-transmission approach for coverage extension will be used for the message. There are a number of factors that may govern this determination, either individually or in combination. For example, the terminal devices in the wireless telecommunication system may comprise a first set of terminal devices and a second set of terminal devices step and T2 may be based on whether the one or more terminal devices to which the message is to be sent comprises terminal devices in the first or second sets. For example, the first set of terminal devices may comprise terminal devices that do not require coverage extension techniques to receive messages (or simply do not support coverage extension), whereas the second set of terminal devices may comprise terminal devices that do require coverage extension techniques to receive messages (and support repeat-transmission based coverage extension). Whether or not a specific terminal device requires coverage extension may, for example, be based on a measured radio propagation metric associated with the terminal device, for example a path loss, block error rate, a bit error rate, a packet error rate, a frame error rate, a symbol error rate, or negative or positive acknowledgement signalling rate (ACK/NACK) associated with communications with the terminal device. In another implementation the decision may take account of a specific identity or category for the one or more terminal devices to which the messages to be sent.

In step T3 the base station determines a characteristic of an identifier for the message based on the transmission scheme determined in step T2. This characteristic may be selected in accordance with any of the principles discussed above (e.g. use of different values for the identifier or different search spaces to be used with the identifier).

In step T4 the message is transmitted in accordance with the transmission scheme determined in step T2 and in association with an identifier, e.g. RNTI, having the characteristic determined in step T3. For example, the message may be transmitted in accordance with a repeat-transmission scheme as described herein with an identifier selected to have a characteristic to identify this, for example in accordance with any of the principles discussed above. In this regard the message may comprise one or other or both of a control message transmitted on a downlink control channel, e.g. a PDCCH message and another message transmitted on a downlink data channel, e.g. PDSCH (i.e. such that the identifier is transmitted separately from the message).

In step T5 the terminal device receives the transmitted signalling from the base station and determines the transmission scheme being used from the characteristic of the identifier. The terminal device may then proceed to receive and decode the message in accordance with the transmission scheme being used.

Thus, the process represented in Figure 9 demonstrates a mechanism by which a base station can readily indicates to terminal devices the transmission scheme being used for a given message. Once the terminal device has determined the transmission scheme, subsequent operation, for example in terms of

receiving the message, they be performed in accordance with conventional principles for receiving such messages. Furthermore, these techniques may be modified to incorporate a validity period approach such as discussed above.

Thus there has been described a wireless telecommunication system that comprises a base station and a terminal device communicating over a radio interface. The radio interface supports a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel (e.g. a physical downlink shared channel) for conveying other messages from the base station to the terminal device. The control messages convey information on resource allocations for the other messages on the downlink data channel. The other messages may comprise user-plane messages or control-plane messages. The terminal device is configured to receive a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel and determine a validity period for the control message. During the validity period for the control message the terminal device is configured to receive a plurality of the other messages from the base station on the downlink data channel using the allocated transmission resources.

There has also been described a wireless telecommunication system that comprises a base station arranged to communicate messages to one or more terminal devices over a radio interface. The radio interface has a radio frame structure comprising a plurality of subframes, wherein a message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes (e.g. one subframe) or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes (e.g. with repeat transmissions in a plurality of subframes). The message is transmitted in association with an identifier to indicate a terminal device to which the message is addressed. A characteristic for the identifier, for example a value or control region search space for the identifier, is dependent on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme. A terminal device to which the message is addressed determines the transmission scheme from the characteristic of the identifier and receives the message accordingly.

Further particular and preferred aspects of the present invention are set out in the accompanying independent and dependent claims. It will be appreciated that features of the dependent claims may be combined with features of the independent claims in combinations other than those explicitly set out in the claims.

Thus, the foregoing discussion discloses and describes merely exemplary embodiments of the present invention. As will be understood by those skilled in the art, the present invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. Accordingly, the disclosure of the present invention is intended to be illustrative, but not limiting of the scope of the invention, as well as other claims. The disclosure, including any readily discernible variants of the teachings herein, define, in part, the scope of the foregoing claim terminology such that no inventive subject matter is dedicated to the public.

Respective features of the present disclosure are defined by the following two groups of numbered paragraphs:

Group 1 of numbered paragraphs:

Paragraph 1. A method of operating a terminal device communicating with a base station in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the method comprises receiving a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel, determining a validity period for the control message, and receiving a plurality of other messages from the base station on the downlink data channel using the allocated transmission resources within the validity period for the control message.

Paragraph 2. The method of paragraph 1, wherein the other messages comprise system information messages.

Paragraph 3. The method of any preceding paragraph, wherein the system information messages comprise one or more system information blocks.

Paragraph 4. The method of any preceding paragraph, wherein the radio interface is based on a radio frame structure comprising a plurality of subframes, wherein each subframe comprises a control channel region for supporting the downlink control channel and a shared channel region for supporting the downlink data channel, and wherein respective ones of the control and / or the other messages comprise transmissions over a plurality of subframes.

Paragraph 5. The method of any preceding paragraph, wherein the validity period for the control message is determined in dependence on an identifier used in association with the control message.

Paragraph 6. The method of paragraph 5, wherein the identifier comprises an indication of one or more terminal devices to which the control message is addressed.

Paragraph 7. The method of any preceding paragraph, wherein the validity period for the control message is determined in dependence on a transmission characteristic of the control message.

Paragraph 8. The method of paragraph 7, wherein the transmission characteristic of the control message comprises a transmission time associated with the control message.

Paragraph 9. The method of any preceding paragraph, wherein the radio interface is based on a radio frame structure comprising a plurality of subframes, and wherein the timing of a subframe used to convey a first one of the plurality of other messages is used to determine the timing of a subframe used to convey a second one of the plurality of other messages within the validity period for the control message.

Paragraph 10. The method of any preceding paragraph, wherein the timing of a subframe used to convey the first one of the plurality of other messages relative to a first predefined range of subframes is used to determine the timing of a subframe used to convey the second one of the plurality of other messages relative to a second predefined range of subframes.

Paragraph 11. The method of any preceding paragraph, wherein the validity period is determined in dependence on a validity period indicator received in association with the control message.

Paragraph 12. The method of any preceding paragraph, wherein the validity period is determined in dependence on the time at which a subsequent control message is received.

Paragraph 13. The method of any preceding paragraph, wherein the other messages comprise random access response messages and / or paging messages..

Paragraph 14. A terminal device for communicating with a base station in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the terminal device comprises a controller unit and a transceiver unit configured to operate together to receive a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to receive a plurality of other messages from the base station on the downlink data channel using the allocated transmission resources within the validity period for the control message.

Paragraph 15. Circuitry for a terminal device communicating with a base station in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to cause the terminal device to receive a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to receive a plurality of other messages from the base station on the downlink data channel using the allocated transmission resources within the validity period for the control message

Paragraph 16. A method of operating a base station communicating with a terminal device in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the method comprises transmitting a control message to the terminal device conveying an indication of allocated transmission resources on the downlink data channel, determining a validity period for the control message, and transmitting a plurality of other messages to the terminal device on the downlink data channel using the allocated transmission resources within the validity period for the control message.

Paragraph 17. A base station for communicating with a terminal device in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the base station comprises a controller unit and a transceiver unit configured to operate together to transmit a control message to the terminal device conveying an indication of allocated transmission resources on the downlink data

channel, to determine a validity period for the control message, and to transmit a plurality of other messages to the terminal device on the downlink data channel using the allocated transmission resources within the validity period for the control message.

Paragraph 18. Circuitry for a base station communicating with a terminal device in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to cause the base station to transmit a control message to the terminal device conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to transmit a plurality of other messages to the terminal device on the downlink data channel using the allocated transmission resources within the validity period for the control message.

Group 2 of numbered paragraphs:

Paragraph 1. A method of operating a base station for communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein the method comprises selecting a characteristic for the identifier in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

Paragraph 2. The method of any preceding paragraph, wherein the first number of radio subframes comprises a single radio subframe and the second number of radio subframes comprises a plurality of radio subframes.

Paragraph 3. The method of any preceding paragraph, wherein terminal devices in the wireless telecommunications system comprise a first set of terminal devices and a second set of terminal devices, and wherein the method comprises determining whether to transmit the message in accordance with the first transmission scheme or the second transmission scheme in dependence on whether a terminal device to which the message is to be transmitted is a member of the first set of terminal devices or the second set of terminal devices.

Paragraph 4. The method of any preceding paragraph, wherein the method comprises determining whether to transmit the message in accordance with the first transmission scheme or the second transmission scheme in dependence on a radio propagation parameter associated with radio communications between the base station and a terminal device to which the message is to be transmitted.

Paragraph 5. The method of paragraph 4, wherein the radio propagation parameter is selected from the group comprising: a path loss; an error rate; a positive acknowledgment, ACK, signalling rate; and a negative acknowledgment signalling, NACK, rate.

Paragraph 6. The method of any preceding paragraph, wherein the method comprises determining whether to transmit the message in accordance with the first transmission scheme or the second transmission scheme in dependence on an identity and / or type of a terminal device to which the message is to be transmitted.

Paragraph 7. The method of any preceding paragraph, wherein the radio interface supports a downlink control channel for conveying control messages from the base station to terminal devices and a downlink data channel for conveying other messages from the base station to terminal devices, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the message comprises a control message transmitted on the downlink control channel.

Paragraph 8. The method of any preceding paragraph, wherein the radio interface supports a downlink control channel for conveying control messages from the base station to terminal devices and a downlink data channel for conveying other messages from the base station to terminal devices, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the message comprises one of the other messages transmitted on the downlink data channel.

Paragraph 9. The method of any preceding paragraph, wherein the identifier to indicate a terminal device to which the message is addressed is transmitted separately from the message.

1 Paragraph 0. The method of any preceding paragraph, wherein the identifier comprises a radio network temporary identifier, RNTI.

Paragraph 11. The method of any preceding paragraph, wherein the identifier is a common to a plurality of terminal devices.

Paragraph 12. The method of any preceding paragraph, wherein the message comprises a broadcast message.

Paragraph 13. The method of any preceding paragraph, wherein the message comprises a multicast message.

Paragraph 14. The method of any preceding paragraph, wherein for a given type of message the characteristic for the identifier is selected from a first predefined characteristic for the identifier associated with the given type of message and a second predefined characteristic for the identifier associated with the given type of message according to whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

Paragraph 15. The method of any preceding paragraph, wherein the message is selected from the group comprising: (i) a message associated with transmitting system information; (ii) a message associated with transmitting a paging message; (iii) a message associated with transmitting a random access response message; (iv) a message associated with transmitting power control information for an uplink control

channel; (v) a message associated with transmitting power control information for an uplink data channel; and (vi) a message associated with a broadcast and / or multicast service.

Paragraph 16. The method of any preceding paragraph, wherein for a message to be transmitted in accordance with the second transmission scheme, a component of the message transmitted in one of the second number of subframes is associated with a characteristic for the identifier corresponding to that which would be used if the message were to be transmitted in accordance with the first transmission scheme.

Paragraph 17. The method of any preceding paragraph, wherein the characteristic for the identifier comprises a value for the identifier.

Paragraph 18. The method of any preceding paragraph, wherein the characteristic for the identifier comprises a search space in which a terminal device searches using the identifier to determine if a message has been addressed to the terminal device.

Paragraph 19. The method of any preceding paragraph, wherein the method comprises selecting the characteristic for the identifier from a plurality of different characteristics associated with different types of message.

Paragraph 20. The method of any preceding paragraph, wherein the characteristic for the identifier to be selected for a message to be transmitted in accordance with the second transmission scheme is defined in accordance with an operating standard for the wireless telecommunications system.

Paragraph 21. The method of any preceding paragraph, further comprising the base station pre-defining the characteristic for the identifier to be selected for a message to be transmitted in accordance with the second transmission scheme.

Paragraph 22. The method of paragraph 21, wherein the pre-defining the characteristic for the identifier is a value for the identifier selected from among a plurality of values.

Paragraph 23. A base station for communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the base station comprises a controller unit and a transceiver unit configured to operate together such that the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein a characteristic for the identifier is selected in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

Paragraph 24. Circuitry for a base station communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the circuitry comprises a controller element and a transceiver element configured to operate together such that the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of

radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein a characteristic for the identifier is selected in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

Paragraph 25. A method of operating a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the method comprises determining from an identifier associated with the message that the message is addressed to the terminal device, and further determining from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

Paragraph 26. A terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the terminal device comprises a controller unit and a transceiver unit configured to operate together to determine from an identifier associated with the message that the message is addressed to the terminal device, and to further determine from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

Paragraph 27. Circuitry for a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to determine from an identifier associated with the message that the message is addressed to the terminal device, and to further determine from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

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[4] 3GPP document R1-135422, “On the need of PDCCH for SIB and other Common Channel”, Mediatek, RAN1#75, San Francisco, November 2013

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5

CLAIMS

What is claimed is:

1. A method of operating a base station for communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein the method comprises selecting a characteristic for the identifier in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

2. The method of claim 1, wherein the first number of radio subframes comprises a single radio subframe and the second number of radio subframes comprises a plurality of radio subframes.

3. The method of claim 1, wherein terminal devices in the wireless telecommunications system comprise a first set of terminal devices and a second set of terminal devices, and wherein the method comprises determining whether to transmit the message in accordance with the first transmission scheme or the second transmission scheme in dependence on whether a terminal device to which the message is to be transmitted is a member of the first set of terminal devices or the second set of terminal devices.

4. The method of claim 1, wherein the method comprises determining whether to transmit the message in accordance with the first transmission scheme or the second transmission scheme in dependence on a radio propagation parameter associated with radio communications between the base station and a terminal device to which the message is to be transmitted.

5. The method of claim 4, wherein the radio propagation parameter is selected from the group comprising: a path loss; an error rate; a positive acknowledgment, ACK, signalling rate; and a negative acknowledgment signalling, NACK, rate.

6. The method of claim 1, wherein the method comprises determining whether to transmit the message in accordance with the first transmission scheme or the second transmission scheme in dependence on an identity and / or type of a terminal device to which the message is to be transmitted.

7. The method of claim 1, wherein the radio interface supports a downlink control channel for conveying control messages from the base station to terminal devices and a downlink data channel for conveying other messages from the base station to terminal devices, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the message comprises a control message transmitted on the downlink control channel.

8. The method of claim 1, wherein the radio interface supports a downlink control channel for conveying control messages from the base station to terminal devices and a downlink data channel for conveying other messages from the base station to terminal devices, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the message comprises one of the other messages transmitted on the downlink data channel.

9. The method of claim 1, wherein the identifier to indicate a terminal device to which the message is addressed is transmitted separately from the message.

10. The method of claim 1, wherein the identifier comprises a radio network temporary identifier, RNTI.

11. The method of claim 1, wherein the identifier is a common to a plurality of terminal devices.

12. The method of claim 1, wherein the message comprises a broadcast message.

13. The method of claim 1, wherein the message comprises a multicast message.

14. The method of claim 1, wherein for a given type of message the characteristic for the identifier is selected from a first predefined characteristic for the identifier associated with the given type of message and a second predefined characteristic for the identifier associated with the given type of message according to whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

15. The method of claim 1, wherein the message is selected from the group comprising: (i) a message associated with transmitting system information; (ii) a message associated with transmitting a paging message; (iii) a message associated with transmitting a random access response message; (iv) a message associated with transmitting power control information for an uplink control channel; (v) a message associated with transmitting power control information for an uplink data channel; and (vi) a message associated with a broadcast and / or multicast service.

16. The method of claim 1, wherein for a message to be transmitted in accordance with the second transmission scheme, a component of the message transmitted in one of the second number of subframes is associated with a characteristic for the identifier corresponding to that which would be used if the message were to be transmitted in accordance with the first transmission scheme.

17. The method of claim 1, wherein the characteristic for the identifier comprises a value for the identifier.

18. The method of claim 1, wherein the characteristic for the identifier comprises a search space in which a terminal device searches using the identifier to determine if a message has been addressed to the terminal device.

19. The method of claim 1, wherein the method comprises selecting the characteristic for the identifier from a plurality of different characteristics associated with different types of message.

20. The method of claim 1, wherein the characteristic for the identifier to be selected for a message to be transmitted in accordance with the second transmission scheme is defined in accordance with an operating standard for the wireless telecommunications system.

21. The method of claim 1, further comprising the base station pre-defining the characteristic for the identifier to be selected for a message to be transmitted in accordance with the second transmission scheme.

22. The method of claim 21, wherein the pre-defining the characteristic for the identifier is a value for the identifier selected from among a plurality of values.

23. A base station for communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the base station comprises a controller unit and a transceiver unit configured to operate together such that the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein a characteristic for the identifier is selected in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

24. Circuitry for a base station communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the circuitry comprises a controller element and a transceiver element configured to operate together such that the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein a characteristic for the identifier is selected in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

25. A method of operating a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the method comprises determining from an identifier associated with the message that the message is addressed to the terminal device, and further determining from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

26. A terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the terminal device comprises a controller unit and a transceiver unit configured to operate together to determine from an identifier associated with the message that the message is addressed to the terminal device, and to further determine from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

27. Circuitry for a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to determine from an identifier associated with the message that the message is addressed to the terminal device, and to further determine from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

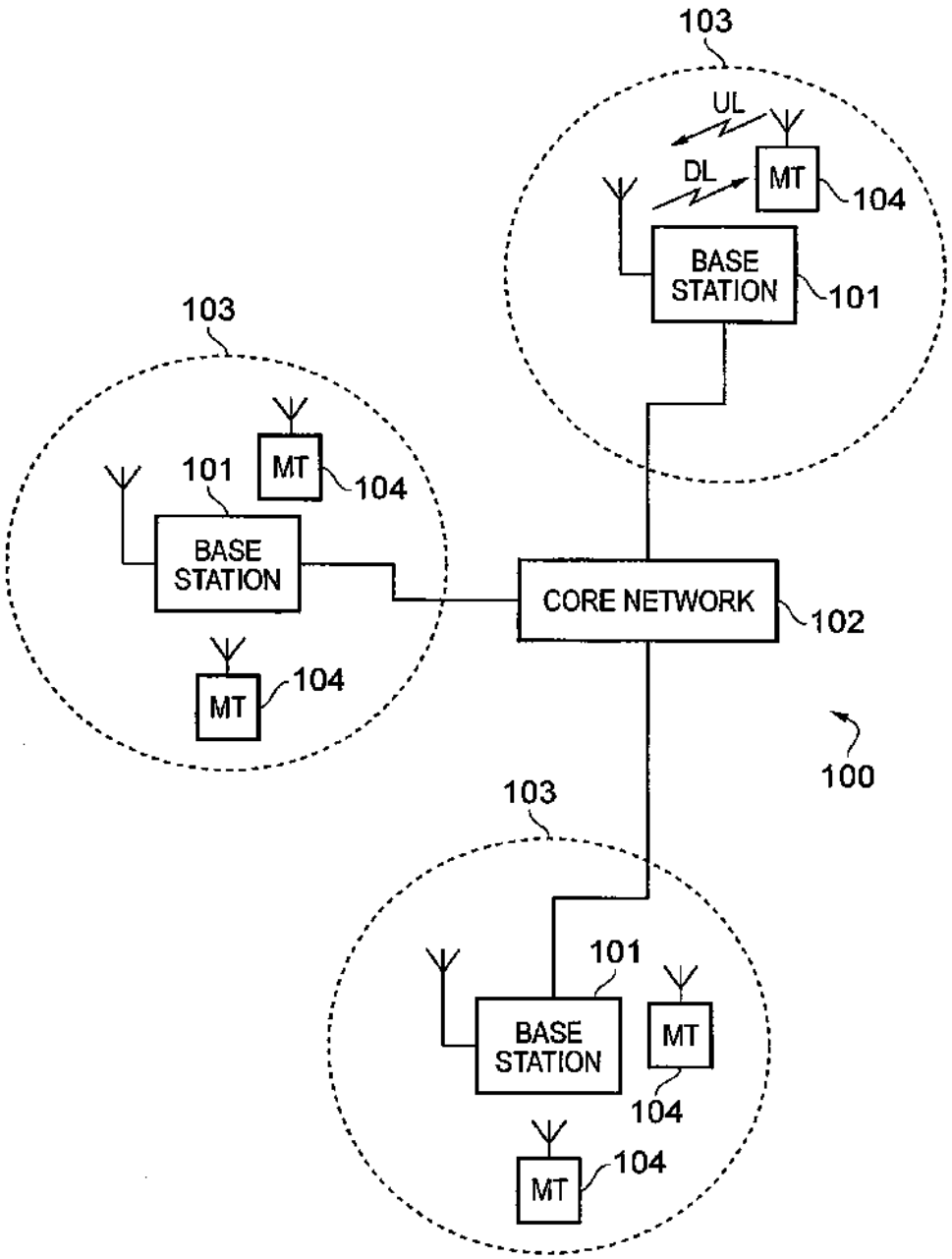

103
UL
DL
MT
104
BASE STATION
101
103
101
MT
104
BASE STATION
CORE NETWORK
102
MT
104
100
103
101
BASE STATION
MT
104
MT
104

FIG. 1

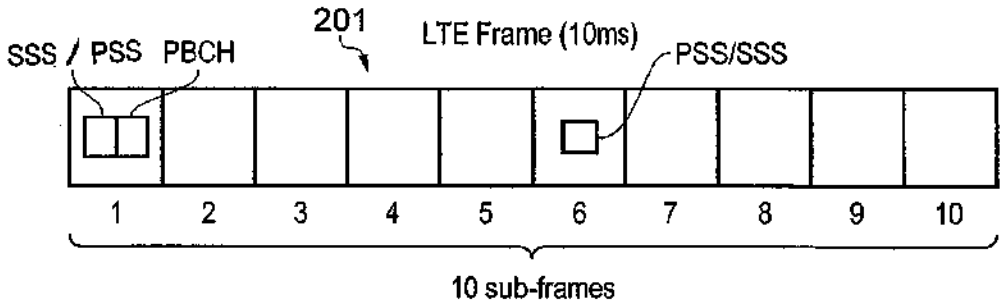

SSS / PSS
PBCH
201
LTE Frame (10ms)
PSS/SSS
1
2
3
4
5
6
7
8
9
10
10 sub-frames

FIG. 2

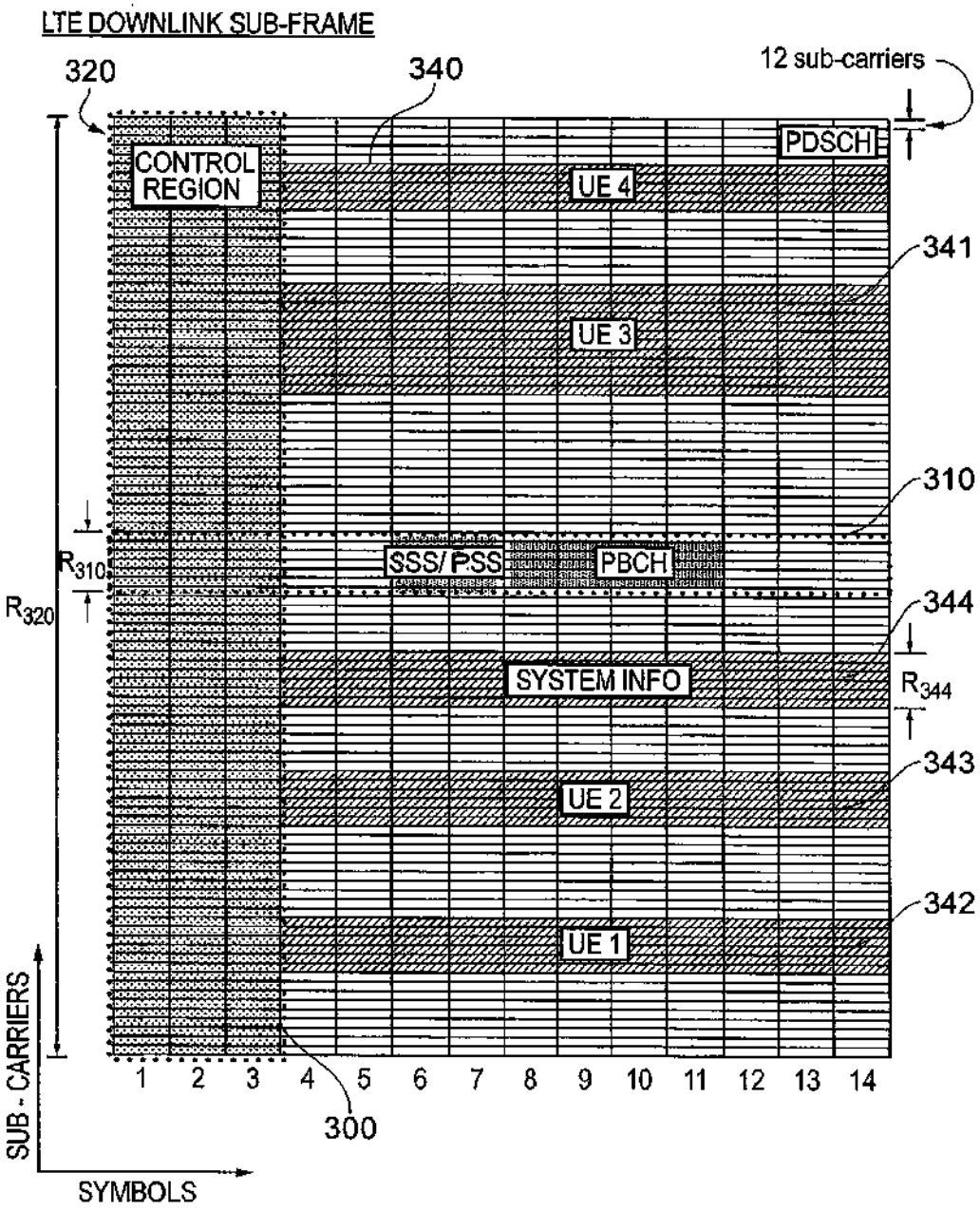

LTE DOWNLINK SUB-FRAME
320
340
12 sub-carriers
CONTROL REGION
PDSCH
UE 4
341
UE 3
310
R_{310}
SSS/ PSS
PBCH
R_{320}
344
SYSTEM INFO
R_{344}
343
UE 2
342
UE 1
SUB - CARRIERS
1 2 3 4 5 6 7 8 9 10 11 12 13 14
300
SYMBOLS

FIG. 3

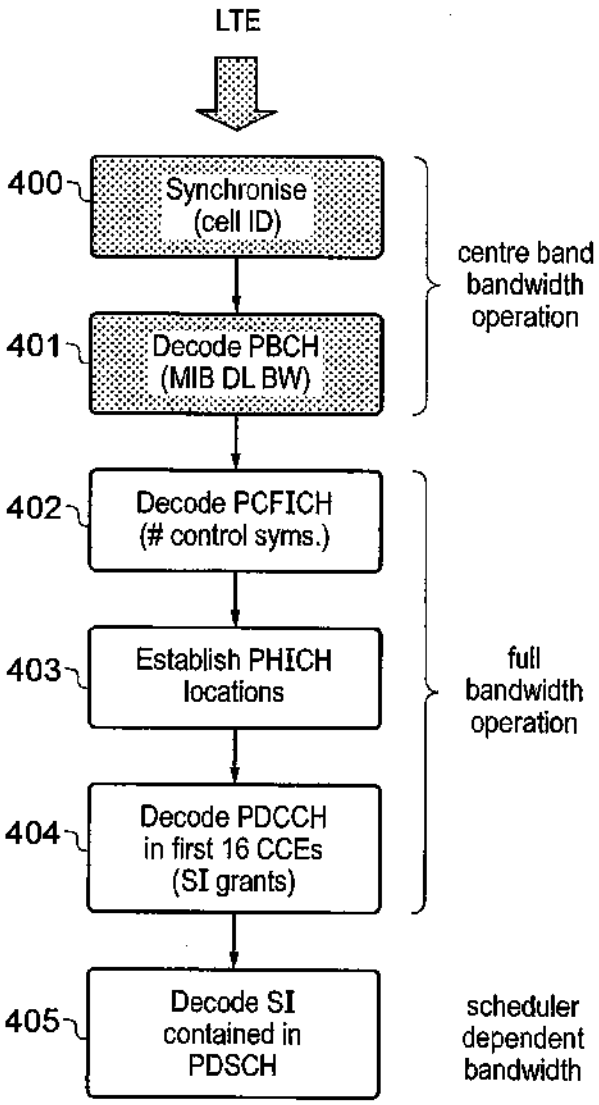

LTE
400
Synchronise (cell ID)
401
Decode PBCH (MIB DL BW)
centre band bandwidth operation
402
Decode PCFICH (# control syms.)
403
Establish PHICH locations
404
Decode PDCCH in first 16 CCEs (SI grants)
full bandwidth operation
405
Decode SI contained in PDSCH
scheduler dependent bandwidth

FIG. 4

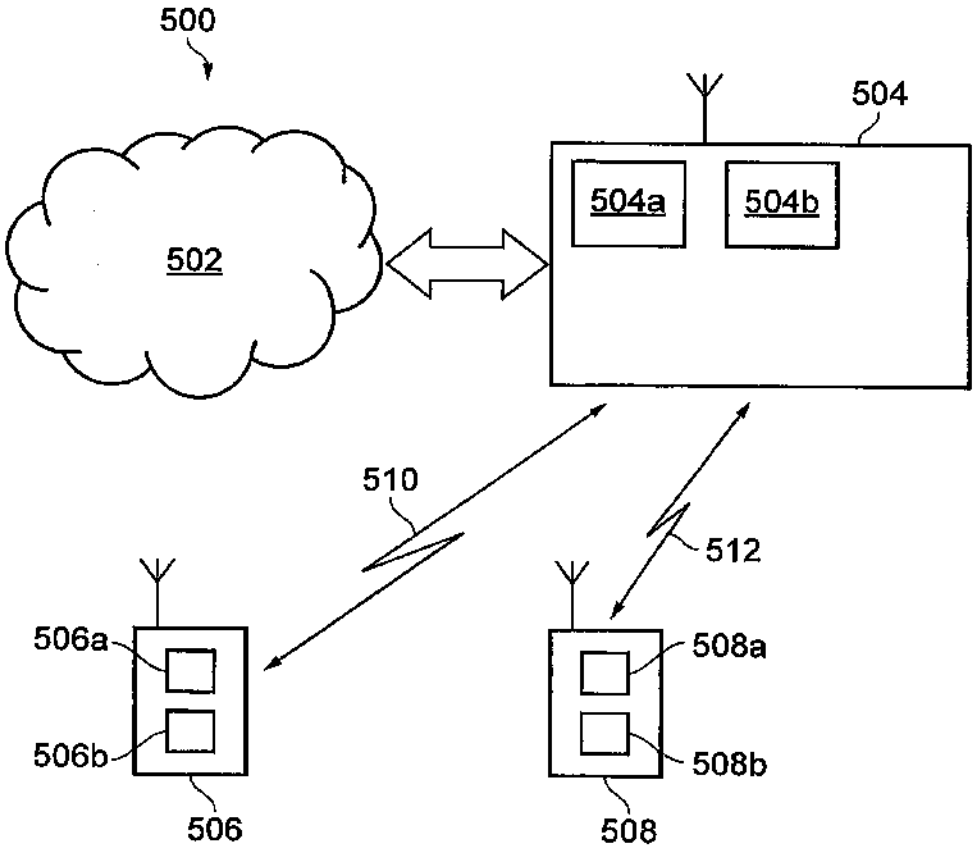


FIG. 5

Fig. 6

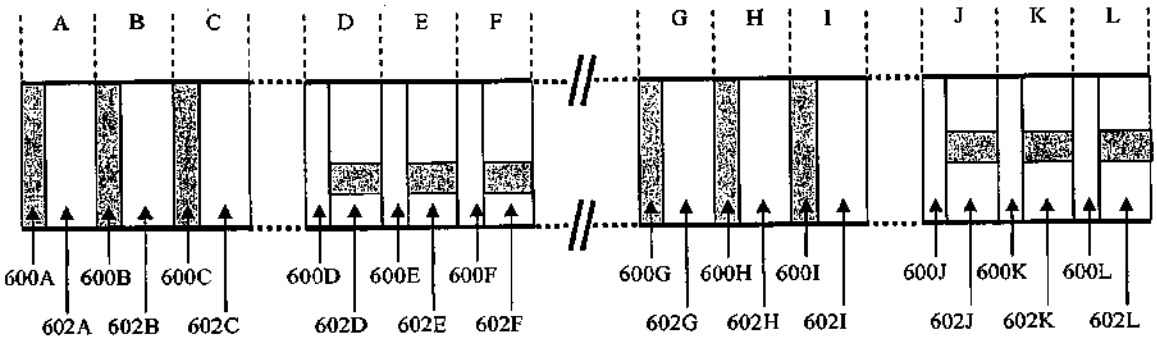
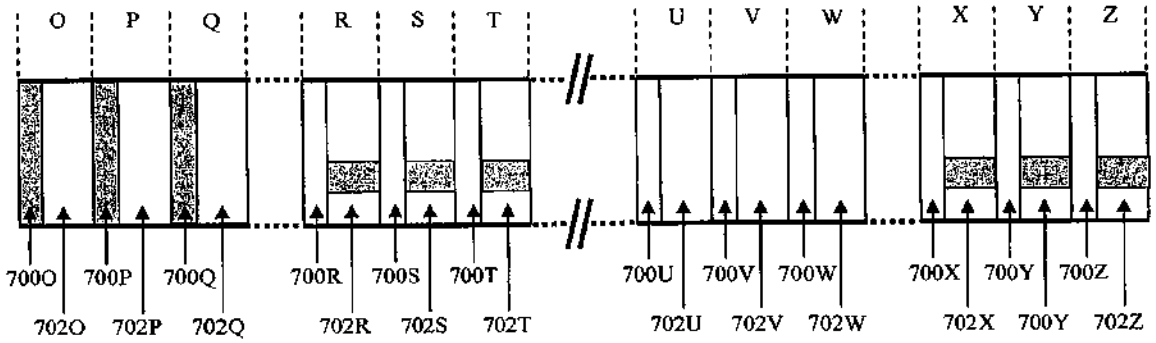

A
B
C
D
E
F
G
H
I
J
K
L
600A
600B
600C
600D
600E
600F
600G
600H
600I
600J
600K
600L
602A
602B
602C
602D
602E
602F
602G
602H
602I
602J
602K
602L

Fig. 7


O
P
Q
R
S
T
U
V
W
X
Y
Z
700O
700P
700Q
700R
700S
700T
700U
700V
700W
700X
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702V
702W
702X
702Y
702Z

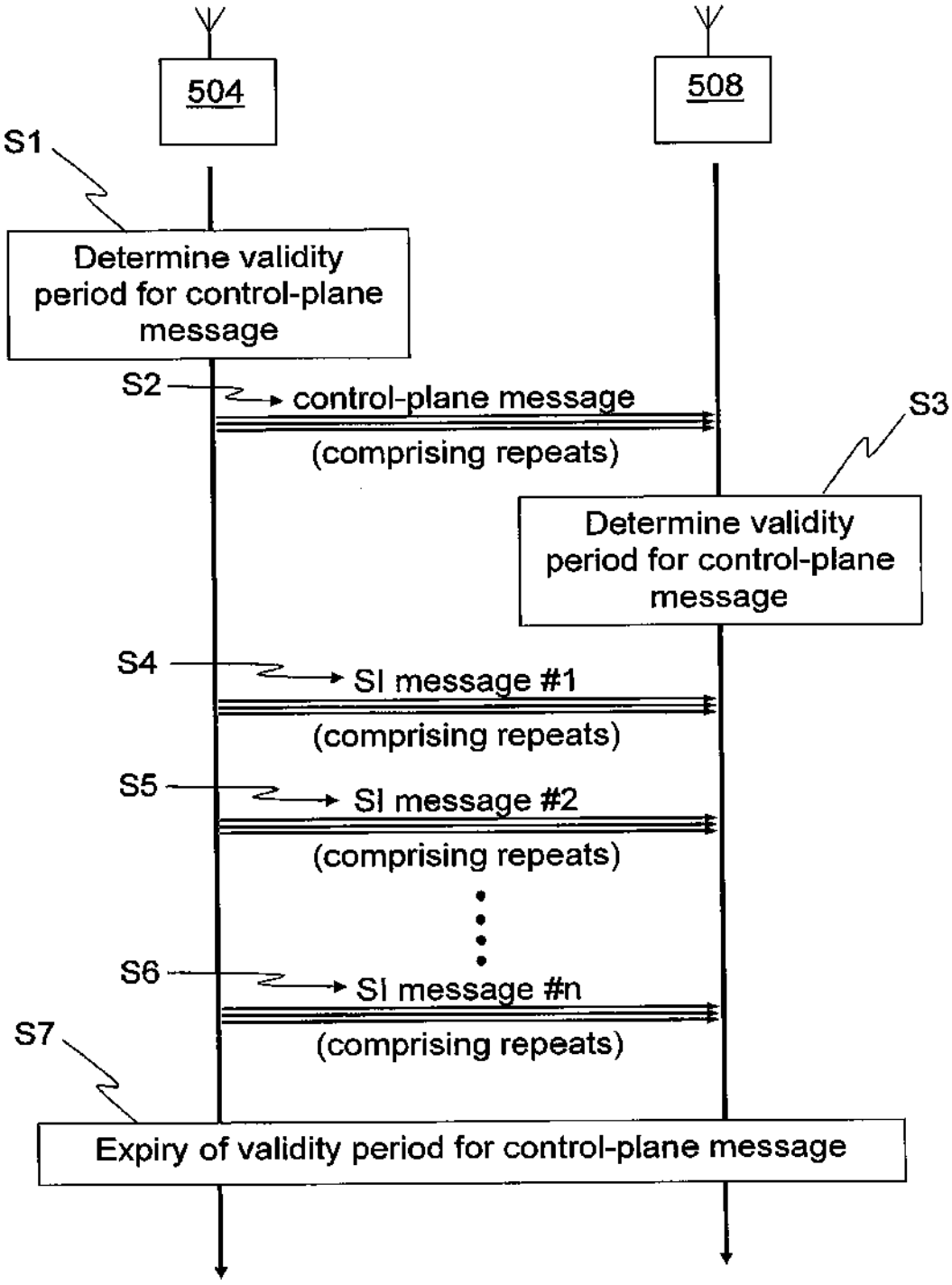

504
508
S1
Determine validity period for control-plane message
S2
control-plane message
(comprising repeats)
S3
Determine validity period for control-plane message
S4
SI message #1
(comprising repeats)
S5
SI message #2
(comprising repeats)
S6
SI message #n
(comprising repeats)
S7
Expiry of validity period for control-plane message

Fig. 8

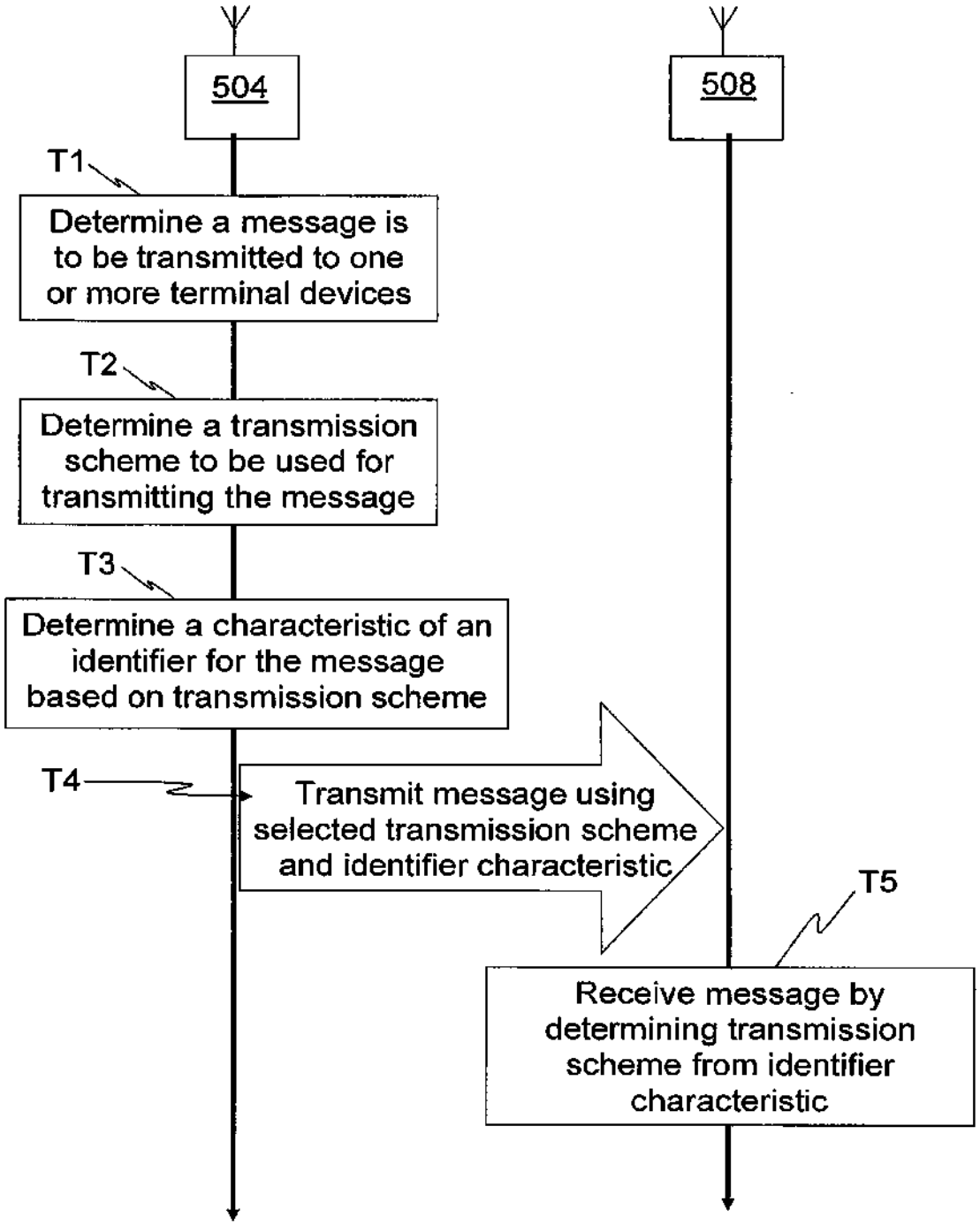

504
508
T1
Determine a message is to be transmitted to one or more terminal devices
T2
Determine a transmission scheme to be used for transmitting the message
T3
Determine a characteristic of an identifier for the message based on transmission scheme
T4
Transmit message using selected transmission scheme and identifier characteristic
T5
Receive message by determining transmission scheme from identifier characteristic

Fig. 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2014/074456

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W72/04
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W H04B H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2013/315159 A1 (XIA JINHUAN [CN] ET AL) 28 November 2013 (2013-11-28) paragraph [0005] - paragraph [0006] paragraph [0036]; figure 5 paragraph [0045]; figure 7 paragraph [0052] paragraph [0062]	1-27
X	EP 2 611 244 A2 (QUALCOMM INC [US]) 3 July 2013 (2013-07-03)	1,23-27
A	paragraph [0029]; figures 3,10 paragraph [0075]	2-22

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 February 2015	04/03/2015

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Cortés Gómez, F

1

Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	SONY: "PDSCH baseband bandwidth reduction for low complexity MTC UE", 3GPP DRAFT; R1-135763, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. San Francisco, USA; 20131111 - 20131115 13 November 2013 (2013-11-13), XP050735408, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN/RAN1/Docs/ [retrieved on 2013-11-13]	1,23-27
A	Section 2.1 Section 2.5 -----	2-22
X	NTT DOCOMO: "Discussion on Multi-level PRACH Coverage Enhancement", 3GPP DRAFT; R1-135509 PRACH_COVERAGE, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. San Francisco, USA; 20131111 - 20131115 13 November 2013 (2013-11-13), XP050735182, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN/RAN1/Docs/ [retrieved on 2013-11-13]	1,23-27
A	Section 5 -----	2-22

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2014/074456

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2013315159 A1	28-11-2013	CN 104335509 A	04-02-2015
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EP 2611244 A2	03-07-2013	AU 2009231819 A1	08-10-2009
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		PT 2346294 E	29-05-2013
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		TW 200948154 A	16-11-2009
		US 2009257449 A1	15-10-2009
		WO 2009124079 A1	08-10-2009

Doc Code: DIST.E.FILE **Document Description: Electronic Terminal Disclaimer - Filed**	PTO/SB/26 U.S. Patent and Trademark Office Department of Commerce

Electronic Petition Request	**TERMINAL DISCLAIMER TO OBVIATE A DOUBLE PATENTING REJECTION OVER A "PRIOR" PATENT**
Application Number	17950726
Filing Date	22-Sep-2022
First Named Inventor	Xiaobo ZHANG
Attorney Docket Number	ZL0205-0004-US-CON3
Title of Invention	METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

☒ Filing of terminal disclaimer does not obviate requirement for response under 37 CFR 1.111 to outstanding Office Action

☒ This electronic Terminal Disclaimer is not being used for a Joint Research Agreement.

Owner	Percent Interest
APEX BEAM TECHNOLOGIES LLC	100%

The owner(s) with percent interest listed above in the instant application hereby disclaims, except as provided below, the terminal part of the statutory term of any patent granted on the instant application which would extend beyond the expiration date of the full statutory term of prior patent number(s)

10462767

as the term of said prior patent is presently shortened by any terminal disclaimer. The owner hereby agrees that any patent so granted on the instant application shall be enforceable only for and during such period that it and the prior patent are commonly owned. This agreement runs with any patent granted on the instant application and is binding upon the grantee, its successors or assigns.

In making the above disclaimer, the owner does not disclaim the terminal part of the term of any patent granted on the instant application that would extend to the expiration date of the full statutory term of the prior patent, "as the term of said prior patent is presently shortened by any terminal disclaimer," in the event that said prior patent later:
- expires for failure to pay a maintenance fee;
- is held unenforceable;
- is found invalid by a court of competent jurisdiction;
- is statutorily disclaimed in whole or terminally disclaimed under 37 CFR 1.321;
- has all claims canceled by a reexamination certificate;
- is reissued; or
- is in any manner terminated prior to the expiration of its full statutory term as presently shortened by any terminal disclaimer.

◉ Terminal disclaimer fee under 37 CFR 1.20(d) is included with Electronic Terminal Disclaimer request.

○ I certify, in accordance with 37 CFR 1.4(d)(4), that the terminal disclaimer fee under 37 CFR 1.20(d) required for this terminal disclaimer has already been paid in the above-identified application.	
Applicant claims the following fee status: ◉ Small Entity ○ Micro Entity ○ Regular Undiscounted I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.	
THIS PORTION MUST BE COMPLETED BY THE SIGNATORY OR SIGNATORIES I certify, in accordance with 37 CFR 1.4(d)(4) that I am: ◉ An attorney or agent registered to practice before the Patent and Trademark Office who is of record in this application Registration Number 62937 ○ A sole inventor ○ A joint inventor; I certify that I am authorized to sign this submission on behalf of all of the inventors as evidenced by the power of attorney in the application ○ A joint inventor; all of whom are signing this request	
Signature	/Jialin Zhong/
Name	Jialin Zhong

*Statement under 37 CFR 3.73(b) is required if terminal disclaimer is signed by the assignee (owner).
Form PTO/SB/96 may be used for making this certification. See MPEP § 324.

Electronic Patent Application Fee Transmittal

Application Number:	17950726
Filing Date:	22-Sep-2022
Title of Invention:	METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING
First Named Inventor/Applicant Name:	Xiaobo ZHANG
Filer:	Jialin Zhong/Eddie Rowell
Attorney Docket Number:	ZL0205-0004-US-CON3

Filed as Small Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
STATUTORY OR TERMINAL DISCLAIMER	2814	1	170	170
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
			Total in USD ($)	**170**

Doc Code: DISQ.E.FILE
Document Description: Electronic Terminal Disclaimer – Approved

Application No.: 17950726

Filing Date: 22-Sep-2022

Applicant/Patent under Reexamination: ZHANG

Electronic Terminal Disclaimer filed on November 13, 2023

☒ APPROVED

This patent is subject to a terminal disclaimer

☐ DISAPPROVED

Approved/Disapproved by: Electronic Terminal Disclaimer automatically approved by EFS-Web

U.S. Patent and Trademark Office

Electronic Acknowledgement Receipt

EFS ID:	48820880
Application Number:	17950726
International Application Number:	
Confirmation Number:	6005
Title of Invention:	METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING
First Named Inventor/Applicant Name:	Xiaobo ZHANG
Customer Number:	155075
Filer:	Jialin Zhong/Eddie Rowell
Filer Authorized By:	Jialin Zhong
Attorney Docket Number:	ZL0205-0004-US-CON3
Receipt Date:	13-NOV-2023
Filing Date:	22-SEP-2022
Time Stamp:	12:21:54
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$170
RAM confirmation Number	E2023ACC21527903
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Terminal Disclaimer-Filed (Electronic)	eTerminal-Disclaimer.pdf	41326 e57ffdc750d7d98bb330a8ddd715e86730a0fa9a	no	2
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	38273 c24abca992152f8133f735d42e57efdf27dea12a	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	79599		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	17950726
Filing Date	2022-09-22
First Named Inventor	Xiaobo ZHANG
Art Unit	2471
Examiner Name	AHMED ELALLAM
Attorney Docket Number	ZL0205-0004-US-CON3

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1					

If you wish to add additional U.S. Patent citation information please click the Add button. Add

U.S.PATENT APPLICATION PUBLICATIONS Remove

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1					

If you wish to add additional U.S. Published Application citation information please click the Add button. Add

FOREIGN PATENT DOCUMENTS Remove

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1							

If you wish to add additional Foreign Patent Document citation information please click the Add button Add

NON-PATENT LITERATURE DOCUMENTS Remove

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17950726
	Filing Date	2022-09-22
	First Named Inventor	Xiaobo ZHANG
	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

	1	3GPP TSG RAN WG1 Meeting #89, R1-1707475, Discussion on DL beam management, dated May 2017	☒
	2	3GPP TSG RAN WG1 NR Ad-Hoc#2, R1-1710596, Discussion of beam recovery procedure, dated June 2017	☒
	3	Apex Beam Technologies LLC v. TCT MOBILE INTERNATIONAL LIMITED, DEFENDANTS' MOTION TO DISMISS PLAINTIFF'S FIRST AMENDED COMPLAINT FOR PATENT INFRINGEMENT, Case 2:21-cv-00438-JRG Document 32, dated 09/14/23	☒
	4	Apex Beam Technologies LLC v. TCT MOBILE INTERNATIONAL LIMITED, PLAINTIFF APEX BEAM TECHNOLOGIES LLC'S SUR-REPLY IN OPPOSITION TO DEFENDANTS' MOTION TO DISMISS, Case 2:21-cv-00438-JRG Document 39, dated 10/13/23	☒
	5	Apex Beam Technologies LLC v. TCT MOBILE INTERNATIONAL LIMITED, DEFENDANTS' REPLY IN SUPPORT OF DEFENDANTS' MOTION TO DISMISS PLAINTIFF'S FIRST AMENDED COMPLAINT, Case 2:21-cv-00438-JRG Document 34, dated 10/06/23	☒
	6	Apex Beam Technologies LLC v. TCT MOBILE INTERNATIONAL LIMITED, PLAINTIFF APEX BEAM TECHNOLOGIES LLC'S RESPONSE IN OPPOSITION TO DEFENDANTS' MOTION TO DISMISS, Case 2:21-cv-00438-JRG Document 33, dated 09/28/23	☒
	7	Apex Beam Technologies LLC v. Samsung Electronics Co., Ltd. et al., SAMSUNG ELECTRONICS CO., LTD. AND SAMSUNG ELECTRONICS AMERICA, INC.'S FIRST AMENDED ANSWER TO PLAINTIFF'S FIRST AMENDED COMPLAINT FOR PATENT INFRINGEMENT, Case 2:22-cv-00031-JRG-RSP Document 63, dated 09/28/23	☒
	8	Apex Beam Technologies LLC v. ZTE Corp., PLAINTIFF APEX BEAM TECHNOLOGIES LLC'S OPENING CLAIM CONSTRUCTION BRIEF, Case 2:22-cv-00031-JRG-RSP Document 69, dated 11/03/23	☒

If you wish to add additional non-patent literature document citation information please click the Add button Add

EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17950726
	Filing Date	2022-09-22
	First Named Inventor	Xiaobo ZHANG
	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/JIALIN ZHONG/	Date (YYYY-MM-DD)	2023-11-13
Name/Print	JIALIN ZHONG	Registration Number	62937

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Patent Application Fee Transmittal

Application Number:	17950726
Filing Date:	22-Sep-2022
Title of Invention:	METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING
First Named Inventor/Applicant Name:	Xiaobo ZHANG
Filer:	Jialin Zhong/Eddie Rowell
Attorney Docket Number:	ZL0205-0004-US-CON3

Filed as Small Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
SUBMISSION- INFORMATION DISCLOSURE STMT	2806	1	104	104
		Total in USD ($)		**104**

Electronic Acknowledgement Receipt

EFS ID:	48820861
Application Number:	17950726
International Application Number:	
Confirmation Number:	6005
Title of Invention:	METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING
First Named Inventor/Applicant Name:	Xiaobo ZHANG
Customer Number:	155075
Filer:	Jialin Zhong/Eddie Rowell
Filer Authorized By:	Jialin Zhong
Attorney Docket Number:	ZL0205-0004-US-CON3
Receipt Date:	13-NOV-2023
Filing Date:	22-SEP-2022
Time Stamp:	12:19:31
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$104
RAM confirmation Number	E2023ACC19537709
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		ZL0205-0004-US-CON3_Response_to_NFOA.pdf	31704 f32c2503104d77c6086ab79be396f391606c1d8f	yes	3

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Amendment/Request for Reconsideration-After Non-Final Rejection	1	1
	Applicant Arguments/Remarks Made in an Amendment	2	3

Warnings:

Information:

2	Information Disclosure Statement (IDS) Form (SB08)	ZL0205-0004-US-CON3_IDS.pdf	612833 5134c11b024ca9e629558fed0a63aad98a685725	no	4

Warnings:

Information:

A U.S. Patent Number Citation or a U.S. Publication Number Citation is required in the Information Disclosure Statement (IDS) form for autoloading of data into USPTO systems. You may remove the form to add the required data in order to correct the Informational Message if you are citing U.S. References. If you chose not to include U.S. References, the image of the form will be processed and be made available within the Image File Wrapper (IFW) system. However, no data will be extracted from this form. Any additional data such as Foreign Patent Documents or Non Patent Literature will be manually reviewed and keyed into USPTO systems.

3	Non Patent Literature	3GPP_1.pdf	375979 939d3fac783ca73dff7b5f186b4530f1c71006fb	no	10

Warnings:

Information:

4	Non Patent Literature	3GPP_2.pdf	52294 f23ebb3e7c4760404cfa19f3d026978bcdbf879d	no	5

Warnings:

Information:

5	Non Patent Literature	APEX_1.pdf	3505903 aeb9435f617cb26bb260db398733e5fe1d9c4a6d	no	12
Warnings:					
Information:					
6	Non Patent Literature	APEX_2.pdf	4488543 31d48a27d8facbd70b05f656b43e4b38cc039de6	no	14
Warnings:					
Information:					
7	Non Patent Literature	APEX_3.pdf	1983947 ffe460dcb674051baa85599429692103408 0a5bd	no	7
Warnings:					
Information:					
8	Non Patent Literature	APEX_4.pdf	4090412 305e6b3c8882d4ab1568173069ef198df52 8bd09	no	12
Warnings:					
Information:					
9	Non Patent Literature	APEX_5.pdf	13707743 ad2537668b187f0077528f19b682b23923fa b931	no	43
Warnings:					
Information:					
10	Non Patent Literature	APEX_6.pdf	11914897 ac26faf07dddef93949a04043b2dba1a09f8 4e8d	no	35
Warnings:					
Information:					
11	Fee Worksheet (SB06)	fee-info.pdf	38232 130f4e9c7253a7940f29fa1ecdb90a4b1574 2646	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	40802487	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:	)	Examiner: AHMED ELALLAM
Xiaobo ZHANG	)	Art Unit: 2471
Application No: 17/950,726	)	Confirmation No.: 6005
Filed: September 22, 2022	)	
For: METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING	)	

AMENDMENT

E-Filed via EFS-Web

Commissioner for Patents

P.O. Box 1450

Alexandria, VA 22313-1450

Sir/Madam:

In response to the non-final Office action mailed on November 9, 2023, applicant respectfully requests reconsideration in view of the following remarks.

Remarks begin on page 2 of this document.

REMARKS

Applicant respectfully requests reconsideration of this application.

Summary of the Office Action

Claims 1-24 are rejected on the ground of non-statutory double patenting as being unpatentable over claims 1-24 of U.S. Patent No. 10462767B2 (hereinafter Zhang'767).

Double Patenting Rejection

Claims 1-24 are rejected on the ground of non-statutory double patenting as being unpatentable over claims 1-20 of Zhang'767.

Applicant submits a terminal disclaimer and respectfully requests the withdrawal of the double patenting rejection of claims 1-24.

Applicant respectfully submits that the rejections have been overcome and that the claims are in condition for allowance. Accordingly, applicant respectfully requests the rejections be withdrawn and the claims be allowed.

The Examiner is requested to call the undersigned at (908) 591-2738 if there remains any issue with allowance of the case.

Please charge any shortage to our Deposit Account No. 60-2313.

Respectfully submitted,

ZHONG LAW, LLC
Attorneys/Agents for Applicants

Date: November 13, 2023

/ Jialin Zhong/
Jialin Zhong
Registration No. 62,937

51 JFK Parkway, First Floor West
Short Hills, New Jersey 07078

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/950,726	09/22/2022	Xiaobo ZHANG	ZL0205-0004-US-CON3	6005

155075 7590 11/09/2023

Zhong Law, LLC
51 JFK Parkway
1st Floor West
Short Hills, NJ 07078

EXAMINER	
ELALLAM, AHMED	

ART UNIT	PAPER NUMBER
2471	

NOTIFICATION DATE	DELIVERY MODE
11/09/2023	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

ip@remotedocket.com
szhao@zhong-law.com
zhong@zhong-law.com

Office Action Summary	Application No. 17/950,726	Applicant(s) ZHANG, Xiaobo	
	Examiner AHMED ELALLAM	Art Unit 2471	AIA (FITF) Status Yes

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☑ Responsive to communication(s) filed on 09/22/23.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL.** 2b) ☑ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5) ☑ Claim(s) 1-24 is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6) ☐ Claim(s) _____ is/are allowed.

7) ☑ Claim(s) 1-24 is/are rejected.

8) ☐ Claim(s) _____ is/are objected to.

9) ☐ Claim(s) _____ are subject to restriction and/or election requirement

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to **PPHfeedback@uspto.gov.**

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☑ The drawing(s) filed on 9/22/23 is/are: a)☑ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☑ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☑ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☑ Certified copies of the priority documents have been received in Application No. 15956742.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☑ Notice of References Cited (PTO-892)

2) ☑ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date 09/24/23.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date _____.

4) ☐ Other: _____.

Notice of Pre-AIA or AIA Status

1. The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

Double Patenting

2. The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise extension of the "right to exclude" granted by a patent and to prevent possible harassment by multiple assignees. A nonstatutory double patenting rejection is appropriate where the conflicting claims are not identical, but at least one examined application claim is not patentably distinct from the reference claim(s) because the examined application claim is either anticipated by, or would have been obvious over, the reference claim(s). See, e.g., *In re Berg*, 140 F.3d 1428, 46 USPQ2d 1226 (Fed. Cir. 1998); *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van Ornum*, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) or 1.321(d) may be used to overcome an actual or provisional rejection based on nonstatutory double patenting provided the reference application or patent either is shown to be commonly owned with the examined application, or claims an invention made as a result of activities undertaken within the scope of a joint research agreement. See MPEP § 717.02 for applications subject to examination under the first inventor to file provisions of the AIA as explained in MPEP § 2159.

See MPEP § 2146 *et seq.* for applications not subject to examination under the first inventor to file provisions of the AIA. A terminal disclaimer must be signed in compliance with 37 CFR 1.321(b).

The filing of a terminal disclaimer by itself is not a complete reply to a nonstatutory double patenting (NSDP) rejection. A complete reply requires that the terminal disclaimer be accompanied by a reply requesting reconsideration of the prior Office action. Even where the NSDP rejection is provisional the reply must be complete. See MPEP § 804, subsection I.B.1. For a reply to a non-final Office action, see 37 CFR 1.111(a). For a reply to final Office action, see 37 CFR 1.113(c). A request for reconsideration while not provided for in 37 CFR 1.113(c) may be filed after final for consideration. See MPEP §§ 706.07(e) and 714.13.

The USPTO Internet website contains terminal disclaimer forms which may be used. Please visit www.uspto.gov/patent/patents-forms. The actual filing date of the application in which the form is filed determines what form (e.g., PTO/SB/25, PTO/SB/26, PTO/AIA/25, or PTO/AIA/26) should be used. A web-based eTerminal Disclaimer may be filled out completely online using web-screens. An eTerminal Disclaimer that meets all requirements is auto-processed and approved immediately upon submission. For more information about eTerminal Disclaimers, refer to www.uspto.gov/patents/apply/applying-online/eterminal-disclaimer.

3. Claims 1-24 are rejected on the ground of nonstatutory double patenting as being unpatentable over claims of U.S. Patent No. 10462767 B2 . Although the claims at issue are not identical, they are not patentably distinct from each other because of the following:

The following table is presented herewith for ease of illustration:

Instant claims 1-24	Patented claims 1-20, US 10462767 B2
1. (Currently amended) A method in a User Equipment (UE) for paging, comprising: monitoring a first signaling in X time intervals; and receiving a first radio signal; wherein X is a positive integer; the first signaling is used for determining scheduling information for the first radio signal; the scheduling information comprises ~~at least one of~~ {occupied time- frequency resource, adopted Modulation Coding Scheme (MCS), and subcarrier spacing of subcarriers in occupied frequency domain resource; the first radio signal carries a paging message; the frequency domain resource used for transmitting the first signaling belongs to a first subband; the first subband comprises a positive integer number of consecutive subcarriers in frequency domain; and **location of the first subband in frequency domain is used for determining the X time intervals**.	1. A method in a User Equipment (UE) for paging, comprising: monitoring a first signaling in X time intervals; and receiving a first radio signal; wherein X is a positive integer; the first signaling is used for determining scheduling information for the first radio signal; the scheduling information comprises at least one of {occupied time-frequency resource, adopted Modulation Coding Scheme (MCS), subcarrier spacing of subcarriers in occupied frequency domain resource}; the first radio signal carries a paging message; the frequency domain resource used for transmitting the first signaling belongs to a first subband; the first subband comprises a positive integer number of consecutive subcarriers in frequency domain; and **at least one of** {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband} is used for determining the X time intervals.
2. (Original) The method according to claim 1, wherein any one of the X time intervals belongs to a first time window in time domain; the time length of the first time window is predefined; the first time window is divided into Y time intervals; the X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X; the subcarrier spacing of subcarriers included in the first subband is used for determining Y; and a feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals, the feature ID refers to a remainder when an International Mobile	2. The method according to claim 1, wherein any one of the X time intervals belongs to a first time window in time domain; the time length of the first time window is predefined; the first time window is divided into Y time intervals; the X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X; the subcarrier spacing of subcarriers included in the first subband is used for determining Y; and a feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals.

Subscriber Identification Number (IMSI) is divided by 1024.	
3. (Original) The method according to claim 2, wherein the first time window belongs to one of Z time windows, Z being an integer greater than 1; Z is predefined, or Z is configurable; any two of the Z time windows have an equal time length, any two of the Z time windows are orthogonal in time domain, any one of the Z time windows is a radio frame, Z is equal to the number of radio frames included in a Discontinuous Reception (DRX) cycle; and the feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.	3. The method according to claim 2, wherein the first time window belongs to one of Z time windows, Z being an integer greater than 1; Z is predefined, or Z is configurable; any two of the Z time windows have an equal time length; and the feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.
4. (Original) The method according to claim 3, further comprising: receiving a third signaling; wherein, the third signaling is used for configuring Z.	4. The method according to claim 1, further comprising: receiving a second radio signal; wherein the second radio signal is used for determining at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband}.
5. (Original) The method according to claim 1, further comprising: receiving a second radio signal; wherein the second radio signal is used for determining at least one of location of the first subband in frequency domain, or subcarrier spacing of subcarriers included in the first subband; the second radio signal carries Master Information Block (MIB) information, or the second radio signal carries System Information Block (SIB) information.	5. The method according to claim 1, further comprising: receiving a second signaling; wherein the second signaling is used for determining Q subbands, Q being a positive integer; the first subband belongs to one of the Q subbands; any one of the Q subbands comprises a positive integer number of consecutive subcarriers; and the feature ID of the monitor of the first signaling is used for determining the first subband in the Q subbands.
6. (Currently amended) A method in a base station for paging, comprising: transmitting a	6. A method in a base station for paging, comprising: transmitting a first signaling in a positive integer number of time intervals of X time intervals; and transmitting a first radio

first signaling in a positive integer number of time intervals of X time intervals; and transmitting a first radio signal; wherein X is a positive integer; the first signaling is used for determining scheduling information for the first radio signal; the scheduling information comprises ~~at least one of~~ {occupied time-frequency resource, adopted MCS, and subcarrier spacing of subcarriers in occupied frequency domain resource; the first radio signal carries a paging message; the frequency domain resource used for transmitting the first signaling belongs to a first subband; the first subband comprises a positive integer number of consecutive subcarriers in frequency domain; and location of the first subband in frequency domain is used for determining the X time intervals.	signal; wherein X is a positive integer; the first signaling is used for determining scheduling information for the first radio signal; the scheduling information comprises at least one of {occupied time-frequency resource, adopted MCS, subcarrier spacing of subcarriers in occupied frequency domain resource}; the first radio signal carries a paging message; the frequency domain resource used for transmitting the first signaling belongs to a first subband; the first subband comprises a positive integer number of consecutive subcarriers in frequency domain; and at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband} is used for determining the X time intervals.
7. (Original) The method according to claim 6, wherein any one of the X time intervals belongs to a first time window in time domain; the time length of the first time window is predefined; the first time window is divided into Y time intervals; the X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X; the subcarrier spacing of subcarriers included in the first subband is used for determining Y; and a feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals, the feature ID refers to a remainder when an International Mobile Subscriber Identification Number (IMSI) is divided by 1024.	7. The method according to claim 6, wherein any one of the X time intervals belongs to a first time window in time domain; the time length of the first time window is predefined; the first time window is divided into Y time intervals; the X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X; the subcarrier spacing of subcarriers included in the first subband is used for determining Y; and a feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals.
8. (Original) The method according to claim 7, wherein the first time window belongs to	8. The method according to claim 7, wherein the first time window belongs to one of Z time windows, Z being an integer greater than 1; Z is

one of Z time windows, Z being an integer greater than 1; Z is predefined, or Z is configurable; any two of the Z time windows have an equal time length, any two of the Z time windows are orthogonal in time domain, any one of the Z time windows is a radio frame, Z is equal to the number of radio frames included in a Discontinuous Reception (DRX) cycle; and the feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.	predefined, or Z is configurable; any two of the Z time windows have an equal time length; and the feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.
9. (Original) The method according to claim 8, further comprising: receiving a third signaling; wherein, the third signaling is used for configuring Z.	9. The method according to claim 6, further comprising: transmitting a second radio signal; wherein the second radio signal is used for determining at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband}.
10. (Original) The method according to claim 6, further comprising: transmitting a second radio signal; wherein the second radio signal is used for determining at least one of location of the first subband in frequency domain, or subcarrier spacing of subcarriers included in the first subband; the second radio signal carries Master Information Block (MIB) information, or the second radio signal carries System Information Block (SIB) information.	10. The method according to claim 6, further comprising: transmitting a second signaling; wherein the second signaling is used for determining Q subbands, Q being a positive integer; the first subband belongs to one of the Q subbands; any one of the Q subbands comprises a positive integer number of consecutive subcarriers; and the feature ID of the monitor of the first signaling is used for determining the first subband in the Q subbands.
11. (Currently amended) A UE for paging, comprising: a first receiver, to monitor a first signaling in X time intervals; and a second receiver, to receive a first radio signal; wherein X is a positive integer; the first signaling is used for determining scheduling information for the first radio signal; the	11. A UE for paging, comprising: a first receiver module, to monitor a first signaling in X time intervals; and a second receiver module, to receive a first radio signal; wherein X is a positive integer; the first signaling is used for determining scheduling information for the first radio signal; the scheduling information comprises at least one of {occupied time-frequency resource, adopted MCS, subcarrier spacing of subcarriers in occupied frequency

scheduling information comprises ~~at least one of~~ {occupied time- frequency resource, adopted MCS, and subcarrier spacing of subcarriers in occupied frequency domain resource; the first radio signal carries a paging message; the frequency domain resource used for transmitting the first signaling belongs to a first subband; the first subband comprises a positive integer number of consecutive subcarriers in frequency domain; and location of the first subband in frequency domain is used for determining the X time intervals.	domain resource}; the first radio signal carries a paging message; the frequency domain resource used for transmitting the first signaling belongs to a first subband; the first subband comprises a positive integer number of consecutive subcarriers in frequency domain; and at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband} is used for determining the X time intervals.
12. (Original) The UE according to claim 11, wherein any one of the X time intervals belongs to a first time window in time domain; the time length of the first time window is predefined; the first time window is divided into Y time intervals; the X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X; the subcarrier spacing of subcarriers included in the first subband is used for determining Y; and a feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals, the feature ID refers to a remainder when an International Mobile Subscriber Identification Number (IMSI) is divided by 1024.	12. The UE according to claim 11, wherein any one of the X time intervals belongs to a first time window in time domain; the time length of the first time window is predefined; the first time window is divided into Y time intervals; the X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X; the subcarrier spacing of subcarriers included in the first subband is used for determining Y; and a feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals.
13. (Original) The UE according to claim 12, wherein the first time window belongs to one of Z time windows, Z being an integer greater than 1; Z is predefined, or Z is configurable; any two of the Z time windows have an equal time length, any two of the Z time windows are orthogonal in time domain, any one of the Z time windows is a	13. The UE according to claim 12, wherein the first time window belongs to one of Z time windows, Z being an integer greater than 1; Z is predefined, or Z is configurable; any two of the Z time windows have an equal time length; and the feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.

radio frame, Z is equal to the number of radio frames included in a Discontinuous Reception (DRX) cycle; and the feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.	
14. (Original) The method according to claim 13, wherein the second receiver further receives a third signaling, the third signaling is used for configuring Z.	14. The UE according to claim 11, wherein the first receiver module further receives a second radio signal; the second radio signal is for determining at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband}.
15. (Original) The UE according to claim 11, wherein the first receiver further receives a second radio signal; the second radio signal is for determining at least one of location of the first subband in frequency domain, or subcarrier spacing of subcarriers included in the first subband; the second radio signal carries Master Information Block (MIB) information, or the second radio signal carries System Information Block (SIB) information.	15. The UE according to claim 11, wherein the first receiver module further receives a second signaling; the second signaling is for determining Q subbands, Q being a positive integer; the first subband belongs to one of the Q subbands; any one of the Q subbands comprises a positive integer number of consecutive subcarriers; and the feature ID of the monitor of the first signaling is used for determining the first subband in the Q subbands.
16. (Currently amended) A base station for paging, comprising: a first transmitter, to transmit a first signaling in a positive integer number of time intervals of X time intervals; and a second transmitter, to transmit a first radio signal; wherein X is a positive integer; the first signaling is used for determining scheduling information for the first radio signal; the scheduling information comprises ~~at least one of~~ {occupied time-frequency resource, adopted MCS, and subcarrier spacing of subcarriers in occupied frequency domain resource; the first radio signal	16. A base station for paging, comprising: a first transmitter module, to transmit a first signaling in a positive integer number of time intervals of X time intervals; and a second transmitter module, to transmit a first radio signal; wherein X is a positive integer; the first signaling is used for determining scheduling information for the first radio signal; the scheduling information comprises at least one of {occupied time-frequency resource, adopted MCS, subcarrier spacing of subcarriers in occupied frequency domain resource}; the first radio signal carries a paging message; the frequency domain resource used for transmitting the first signaling belongs to a first subband; the first subband comprises a positive integer number of

carries a paging message; the frequency domain resource used for transmitting the first signaling belongs to a first subband; the first subband comprises a positive integer number of consecutive subcarriers in frequency domain; and subcarrier spacing of subcarriers included in the first subband location of the first subband in frequency domain is used for determining the X time intervals.	consecutive subcarriers in frequency domain; and at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband} is used for determining the X time intervals.
17. (Original) The base station according to claim 16, wherein any one of the X time intervals belongs to a first time window in time domain; the time length of the first time window is predefined; the first time window is divided into Y time intervals; the X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X; the subcarrier spacing of subcarriers included in the first subband is used for determining Y; and a feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals, the feature ID refers to a remainder when an International Mobile Subscriber Identification Number (IMSI) is divided by 1024.	17. The base station according to claim 16, wherein any one of the X time intervals belongs to a first time window in time domain; the time length of the first time window is predefined; the first time window is divided into Y time intervals; the X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X; the subcarrier spacing of subcarriers included in the first subband is used for determining Y; and a feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals.
18. (Original) The base station according to claim 17, wherein the first time window belongs to one of Z time windows, Z being an integer greater than 1; Z is predefined, or Z is configurable; any two of the Z time windows have an equal time length, any two of the Z time windows are orthogonal in time domain, any one of the Z time windows is a radio frame, Z is equal to the number of	18. The base station according to claim 17, wherein the first time window belongs to one of Z time windows, Z being an integer greater than 1; Z is predefined, or Z is configurable; any two of the Z time windows have an equal time length; and the feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.

radio frames included in a Discontinuous Reception (DRX) cycle; and the feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows. 19. (Original) The method according to claim 18, wherein the second transmitter further transmits a third signaling, the third signaling is used for configuring Z. 20. (Original) The base station according to claim 16, wherein the first transmitter further transmits a second radio signal; the second radio signal is for determining at least one of location of the first subband in frequency domain, or subcarrier spacing of subcarriers included in the first subband; the second radio signal carries Master Information Block (MIB) information, or the second radio signal carries System Information Block (SIB) information. 21. (Previously presented) The method according to claim 1, wherein the location of the first subband in frequency domain and the subcarrier spacing of subcarriers included in the first subband are used for determining the X time intervals. 22. (Previously presented) The method according to claim 6, wherein the location of the first subband in frequency domain and the subcarrier spacing of subcarriers included in the first subband are used for determining the X time intervals. 23. (Previously presented) The UE according to claim 11, wherein the location of the first	19. The base station according to claim 16, wherein the first transmitter module further transmits a second radio signal; the second radio signal is for determining at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband}. 20. The base station according to claim 16, wherein the first transmitter module further transmits a second signaling; the second signaling is for determining Q subbands, Q being a positive integer; the first subband belongs to one of the Q subbands; any one of the Q subbands comprises a positive integer number of consecutive subcarriers; and the feature ID of the monitor of the first signaling is used for determining the first subband in the Q subbands

subband in frequency domain and the subcarrier spacing of subcarriers included in the first subband are used for determining the X time intervals. 24. (Previously presented) The base station according to claim 16, wherein the location of the first subband in frequency domain and the subcarrier spacing of subcarriers included in the first subband are used for determining the X time intervals.	

Regarding instant claim 1, the difference between instant claim 1 and patented claim 1 is that instant claim 1 has a narrow scope than patented claim by specifying "the scheduling information comprises occupied time- frequency resource, adopted MCS, **and** subcarrier spacing of subcarriers in occupied frequency domain resource", instead of "the scheduling information comprises **at least one of** (occupied time- frequency resource, adopted MCS, and subcarrier spacing of subcarriers in occupied frequency domain resource). Thus instant claim 1, is directed to better claiming the invention as presented in patented claim 1.

Independent instant claims 6, 11 and 16 are subject to similar remarks of narrowing the scope of respective patented claims 6, 11 and 16.

As to dependent claims sets {2-5, 21}, {7-10, 22}, {12-15, 23}, and {17-20, 24}, these claims are directed to substantially similar claimed subject matter of patented dependent claims 2-5, 7-10, 12-15, 17-20, with one of broadening and/or better claiming the invention.

Conclusion

4. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure. See attached Form pto-892.

5. Any inquiry concerning this communication or earlier communications from the examiner should be directed to AHMED ELALLAM whose telephone number is (571)272-3097. The examiner can normally be reached 9-5.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Chi Pham can be reached on 571-2723179. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of published or unpublished applications may be obtained from Patent Center. Unpublished application information in Patent Center is available to registered users. To file and manage patent submissions in Patent Center, visit: https://patentcenter.uspto.gov. Visit https://www.uspto.gov/patents/apply/patent-center for more information about Patent Center and https://www.uspto.gov/patents/docx for information about filing in DOCX format. For additional questions, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/AHMED ELALLAM/
Primary Examiner, Art Unit 2471
11/4/2023

Notice of References Cited	Application/Control No. 17/950,726	Applicant(s)/Patent Under Reexamination ZHANG, Xiaobo	
	Examiner AHMED ELALLAM	Art Unit 2471	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-10462767-B2	10-2019	Zhang; Xiaobo	H04W68/02	1/1
*	B	US-10966178-B2	03-2021	Zhang; Xiaobo	H04W68/02	1/1
*	C	US-11457426-B2	09-2022	Zhang; Xiaobo	H04L25/00	1/1
*	D	US-11063703-B2	07-2021	Yi; Yunjung	H04L5/0094	1/1
*	E	US-10856317-B2	12-2020	Ma; Jianglei	H04W72/21	1/1
*	F	US-11291078-B2	03-2022	Xiong; Gang	H04W80/08	1/1
	G					
	H					
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	K					
	L					
	M					

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/950,726	ZHANG, Xiaobo
	Examiner	Art Unit
	AHMED ELALLAM	2471

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

CLAIMS										
☐ Claims renumbered in the same order as presented by applicant					☐ CPA		☐ T.D.		☐ R.1.47	
CLAIM		DATE								
Final	Original	11/04/2023								
	1	✓								
	2	✓								
	3	✓								
	4	✓								
	5	✓								
	6	✓								
	7	✓								
	8	✓								
	9	✓								
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	19	✓								
	20	✓								
	21	✓								
	22	✓								
	23	✓								
	24	✓								

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/950,726	ZHANG, Xiaobo
	Examiner	Art Unit
	AHMED ELALLAM	2471

CPC - Searched*		
Symbol	Date	Examiner
H04W68/02 OR H04L1/1812 OR H04L5/0053 OR H04L25/00 OR H04W36/0088 OR H04W68/005 OR H04W72/23 OR H04L5/0007 OR H04L5/0044 OR H04L5/0008 OR H04L5/001 OR H04L27/2666 OR H04L27/2678 OR H04W72/0453	11/04/2023	AE

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
PE2E	11/04/2023	ae

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner

/AHMED ELALLAM/ Primary Examiner, Art Unit 2471	

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	17950726
Filing Date	2022-09-22
First Named Inventor	Xiaobo ZHANG
Art Unit	2471
Examiner Name	AHMED ELALLAM
Attorney Docket Number	ZL0205-0004-US-CON3

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	10135663	B2	2018-11-20	Huawei Technologies Co Ltd	
	2	10159097	B2	2018-12-18	Qualcomm Inc	
	3	10271295	B2	2019-04-23	InterDigital Patent Holdings Inc	
	4	10419177	B2	2019-09-17	Samsung Electronics Co Ltd	
	5	8644864	B2	2014-02-04	InterDigital Patent Holdings Inc	
	6	10135663	B2	2018-11-20	Huawei Technologies Co Ltd	
	7	10356778	B2	2019-07-16	Asustek Computer Inc	
	8	10448414	B2	2019-10-15	FG Innovation Co Ltd Sharp Corp	

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.E/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17950726
	Filing Date	2022-09-22
	First Named Inventor	Xiaobo ZHANG
	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

	9	10462739	B2	2019-10-29	Samsung Electronics Co Ltd	
	10	10660081	B2	2020-05-19	LG Electronics Inc	
	11	10660120	B2	2020-05-19	LG Electronics Inc	
	12	11051293	B2	2021-06-29	InterDigital Patent Holdings Inc	
	13	11197283	B2	2021-12-07	Huawei Technologies Co Ltd	
	14	11252717	B2	2022-02-15	Huawei Technologies Co Ltd	
	15	9131490	B2	2015-09-08	Feng et al	
	16	9380568	B2	2016-06-28	Harrison et al	

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Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20180054800	A1	2019-11-26	Samsung Electronics Co Ltd	

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	2	20180070341	A1	2022-02-15	Huawei Technologies Co Ltd	
	3	20180097678	A1	2020-02-04	Spreadtrum Communications Shanghai Co Ltd	
	4	20190109695	A1	2020-02-25	LG Electronics Inc	
	5	20140148204	A1	2014-12-09	InterDigital Patent Holdings Inc	
	6	20170279579	A1	2019-09-17	Samsung Electronics Co Ltd	
	7	20180279289	A1	2018-09-27	Huawei Technologies Co Ltd	
	8	20180279327	A1	2019-10-15	FG Innovation Co Ltd Sharp Corp	
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	10	20110038330	A1	2011-02-17	Luo et al	
	11	20110176519	A1	2011-07-21	Vitthaladevuni et al	
	12	20130308608	A1	2013-11-16	Hu et al	

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	13	20170331670	A1	2017-11-16	Parkvall et al	
	14	20120122495	A1	2012-05-17	Weng et al	
	15	20170094547	A1	2017-03-30	Yum et al	
	16	20100202382	A1	2010-08-12	Park et al	
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Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1	105813200	CN	A	2016-07-27	SHARP KK		☒
	2	106376050	CN	A	2017-02-01	YULONG COMPUTER TELECOMMUNICATION SCIENT SHENZHEN		☒
	3	2016107518	WO	A1	2016-07-07	SHARP KK		☒
	4	2018126401	WO	A1	2018-07-12	Liu et al		☒

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	5	2017052199	WO	A1	2017-03-30	You et al		☒
	6	2016136143	WO	A1	2016-09-01	Mallick et al		☒
	7	2018081913	WO	A1	2018-05-11	Liu et al		☒
	8	2017174469	WO	A1	2017-10-12	Wong et al		☒
	9	2017079574	WO	A1	2017-05-17	Lee et al		☒
	10	2015113664	WO	A1	2015-08-06	Webb et al		☒
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	12	2016130175	WO	A1	2016-08-18	Fwu et al		☒
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	15	2017171398	WO	A1	2017-10-05	Yi et al		☒

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	16	2017050184	WO	A1	2017-03-30	ZTE CORP		☒
	17	106231614	CN	A	2016-12-14	SHENZHEN GIONEE COMMUNICATION EQUIPMENT CO LTD		☒
	18	105979597	CN	A	2016-09-28	YULONG COMPUTER TELECOMMUNICATION SCIENTIFIC SHEN		☒
	19	108923896	CN	A	2021-03-26	ZHANG et al		☒

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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	1st Office Action received in Application No. 201710255811.X dated October 9, 2020	☐
	2	1st Search Report in Application No. 201710255811.X dated September27, 2020	☐
	3	Erik Dahlman et al., 4G LTE/LTE-Advanced for Mobile Broadband, 2011	☐
	4	Frank Schaich et al., Subcarrier Spacing - How to Make Use of This Degree of Freedom, 2016 IEEE 83rd Vehicular Technology Conference	☐
	5	Apex Beam Technologies LLC v. Samsung Electronics Co., Ltd. et al., Case No. 2:22-cv-00188-JRG, Dkt. No. 1, Complaint for Patent Infringement (E.D. Tex. June 1, 2022).	☐

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	Attorney Docket Number	ZL0205-0004-US-CON3

	6	Apex Beam Technologies LLC v. Samsung Electronics Co., Ltd. et al., Case No. 2:22-cv-00188-JRG, Plaintiff's Infringement Contentions Claim Chart for U.S. Patent No. 10,462,767, Jan. 5, 2023,	☐
	7	United States District Courts – National Judicial Caseload Profile, (retrieved Feb. 5, 2023)	☐
	8	Apex Beam Technologies LLC v. ZTE Corp., No. 2:22-cv-00031-JRG-RSP, Dkt. No. 37, Docket Control Order (E.D. Tex. Feb. 6, 2023)	☐
	9	Apex Beam Technologies LLC v. Samsung Electronics Co., Ltd. et al., Case No. 2:22-cv-00188-JRG, Plaintiff's Infringement Contentions Cover Pleading (E.D. Tex. Jan. 5, 2023)	☐
	10	3GPP TS 36.211 v11.3.0 ("Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Physical Channels and Modulation (Release 11)") (June 2013)	☐
	11	3GPP TS 36.304 v13.0.0 ("Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) procedures in idle mode (Release 13)") (December 2015)	☐
	12	3GPP TS 36.331 v13.0.0 ("Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification (Release 13)") (December 2015)	☐
	13	3GPP TSG RAN WG1 Meeting #88bis, RI-1704867, 2017-03-25.	☐
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	16	3GPP TSG RAN WG2 #97, RZ-1701727, 2017-02-04.	☐

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	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

	17	3GPP TSG RAN WG1 Meeting #86, RI-166881, 2016-08-13.	☐
	18	SAMSUNG ELECTRONICS CO., LTD., AND SAMSUNG ELECTRONICS AMERICA, INC., v. APEX BEAM TECHNOLOGIES LLC, Case IPR2023-00598, Patent No. 10,462,767, February 28, 2023	☐
	19	DECLARATION OF FRIEDHELM RODERMUND in support of a petition for inter partes review of Case IPR2023-00598, U.S. PATENT NO. 10,462,767, February 27, 2023	☐
	20	DECLARATION OF DR. HARRY V. BIMS in support of a petition for inter partes review, Case IPR2023-00598, Patent No. 10,462,767, February 27, 2023	☐
	21	DECISION of Inter Party Review, Case IPR2023-00598, 09-14-2023	☐
	22	Chinese Notification of Acceptance of Request for Invalidation and its translation, Patent No. 201710255811.X, 2023-01-03	☒
	23	Chinese Decision on invalidation Request and its translation, Patent No. 201710255811X, 2023-06-02	☒

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EXAMINER SIGNATURE

Examiner Signature	/AHMED ELALLAM/	Date Considered	11/04/2023

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

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	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☐ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/JIALIN ZHONG/	Date (YYYY-MM-DD)	2023-09-24
Name/Print	JIALIN ZHONG	Registration Number	62937

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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Bibliographic Data

Application No: 17/950,726

Foreign Priority claimed: (•) Yes ( ) No

35 USC 119 (a-d) conditions met: [✓] Yes [ ] No [ ] Met After Allowance

Verified and Acknowledged: /AHMED ELALLAM/ Examiner's Signature [ ] Initials

Title: METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
09/22/2022	340	2471	ZL0205-0004-US-CON3
RULE			

APPLICANTS

APEX BEAM TECHNOLOGIES LLC,

INVENTORS

Xiaobo ZHANG, Shanghai, CHINA

CONTINUING DATA Yes

This application is a CON of 17180885 02/22/2021 PAT 11457426

17180885 is a CON of 16577854 09/20/2019 PAT 10966178

16577854 is a CON of 15956742 04/18/2018 PAT 10462767

FOREIGN APPLICATIONS

CHINA CN201710255811.X 04/19/2017

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L385	1595	(paging page) same numerolog$4	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2023/11/04 07:31 PM
L386	81	L11 and sub$1band same sub$1carrier adj2 spacing	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2023/11/04 07:32 PM
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L388	43	(5G new adj radio numerolog$4) and sub$1band same sub$1carrier adj2 spacing and IMSI same ("1024" "4096" "16384" C-RNTI)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2023/11/04 07:32 PM
L390	746223	(H04W68/02 OR H04L1/1812 OR H04L5/0053 OR H04L25/00 OR H04W36/0088 OR H04W68/005 OR H04W72/23 OR H04L5/0007 OR H04L5/0044 OR H04L5/0008 OR H04L5/001 OR H04L27/2666 OR H04L27/2678 OR H04W72/0453).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2023/11/04 07:45 PM
L391	749	L390 AND numerolog$4 WITH (paging page)	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/11/04 07:46 PM
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L396	14	L395 AND schedul$4.clm.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/11/04 07:55 PM
L397	11	L395 AND (page paging).clm.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL,	OR	ON	ON	2023/11/04 08:09 PM

			NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L398	148	L391 AND (page paging).clm.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/11/04 08:09 PM
L399	51	L398 AND schedul$4.clm.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/11/04 08:10 PM
L400	11	L399 AND (mcs AND subcarrier near2 spacing).clm.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/11/04 08:10 PM
L401	11	L400 AND (@ad<= "20170419" @rlad<=	(US-PGPUB; USPAT; USOCR; FIT (AP, AT,	OR	ON	ON	2023/11/04 08:11 PM

		"20170419" @prad<= "20170419")	AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L402	7	(DCI AND (mcs AND subcarrier near2 spacing) AND (page paging)).clm.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/11/04 08:12 PM
L403	32	("10135663"|"10159097"|"10271295"|"10356778"|"10419177"|"10448414"|"10462739"|"10660081"|"10660120"|"11051293"|"11197283"|"11252717"|"20100202382"|"20110038330"|"20110176519"|"20120122495"|"20130308608"|"20140148204"|"20170094547"|"20170215170"|"20170279579"|"20170331670"|"20180054800"|"20180070341"|"20180097678"|"20180279289"|"20180279327"|"20190109695"|"20200099499"|"8644864"|"9131490"|"9380568").PN.	(US-PGPUB; USPAT)	OR	ON	ON	2023/11/04 08:16 PM
L406	0	L403 AND ((mcs AND subcarrier near2 spacing) AND (page paging)).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2023/11/04 08:17 PM
L407	11	((mcs AND subcarrier near2 spacing) AND (page paging)).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2023/11/04 08:17 PM

L408	7	L407 AND (monitor$4 AND interval).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2023/11/04 08:18 PM
L409	7	L407 AND (monitor$4).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2023/11/04 08:18 PM

PE2E SEARCH - Search History (Interference)

There are no Interference searches to show.

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APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
17/950,726	**09/24/2023 04:49:24 PM ET**	**ZL0205-0004-US-CON3**

Title of Invention

METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	6005	FILED BY	Jialin Zhong
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CUSTOMER #	155075	FIRST NAMED INVENTOR	Xiaobo ZHANG
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	-

Documents

TOTAL DOCUMENTS: 2

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
CN_Invalidation_Decision_and_Translation.pdf	22	Non Patent Literature	1545 KB
Notification_Acceptance_of_Request_for_nvalidation_and_translation.pdf	73	Non Patent Literature	10956 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)

CN_Invalidation_Decision_and_Translation.pdf	0C106400AC5C21FFEFFF0EFDA5CFE847493BD31504707DDA AC2B9F55A87CE77258E06446AB005235F97E83CB63EEBEFFD 5F800774DA5169989527C75325AAED0
Notification_Acceptance_of_Request_for_nvalidation_and_translation.pdf	0945EA4E78388F11E55EC278D881B350DE0C09C7638334BB6 D9E094174012DA6CFAC401FFDBA9F593F6D25164C1E17C142 D35A002604AC337F40F57FAA14DB73

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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Espacenet

CN106231614A Signal transmission method and related network element

Applicants: SHENZHEN GIONEE COMMUNICATION EQUIPMENT CO LTD

Inventors: WANG SANXIN

Classifications:

IPC ***H04W24/02; H04W72/04;***

CPC **H04W24/02 (CN); H04W72/0446 (CN); H04W72/0453 (CN);**

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Application: CN201610619821A·2016-07-30

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Signal transmission method and related network element

Abstract

The embodiment of the invention discloses a signal transmission method and a related network element. The method includes steps: when a new radio (NR) business is transmitted on a unauthorized frequency band, a base station performs a listen before talk (LBT) mechanism and determines whether remaining subframes exit in a resource block (RB); if yes, the base station selects the signal type applicable to the NR business on the remaining subframes according to the NR business type; and the base station sends a control signaling of the NR business to a terminal by employing the signal type of the NR business on the remaining subframes. According to the method and the related network element, the control signaling of the NR business is sent by employing the remaining subframes so that the utilization rate of channel resources can be increased.

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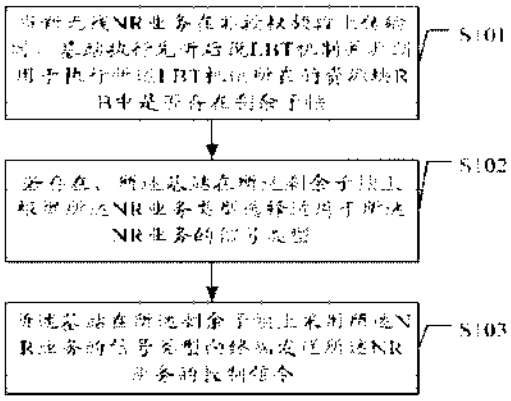
权利要求书3页 说明书12页 附图5页

(54)发明名称

一种信号传输方法及相关网元

(57)摘要

本发明实施例公开了一种信号传输方法及相关网元，其中的方法包括：当新无线NR业务在非授权频段上传输时，基站执行先听后说LBT机制并判断资源块RB中是否存在剩余子帧；若存在，所述基站在所述剩余子帧上根据所述NR业务类型选择适用于所述NR业务的信号类型；所述基站在所述剩余子帧上采用所述NR业务的信号类型的终端发送所述NR业务的控制信令。本发明实施例中，采用剩余子帧发送所述NR业务的控制信令，有利于提高信道资源利用率。



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1.一种信号传输方法，其特征在于，所述方法包括：

当新无线NR业务在非授权频段上传输时，基站执行先听后说LBT机制并判断用于执行所述LBT机制所在的资源块RB中是否存在剩余子帧；

若存在，所述基站在所述剩余子帧上根据所述NR业务类型选择适用于所述NR业务的信号类型；

所述基站在所述剩余子帧上采用所述NR业务的信号类型向终端发送所述NR业务的控制信令。

2.根据权利要求1所述的方法，其特征在于，所述基站在所述剩余子帧上根据所述NR业务类型选择适用于所述NR业务的信号类型，包括：

若所述NR业务类型为增强型移动宽带应用eMBB业务，则所述基站在所述剩余子帧上根据所述NR业务类型选择适用于所述eMBB业务的信号类型。

3.根据权利要求1所述的方法，其特征在于，所述基站在所述剩余子帧上根据所述NR业务类型选择适用于所述NR业务的信号类型，包括：

若所述NR业务类型为超可靠及低时延通信URLLC业务，则所述基站在所述剩余子帧上根据所述NR业务类型选择适用于所述URLLC业务的信号类型。

4.根据权利要求1所述的方法，其特征在于，所述基站在所述剩余子帧上根据所述NR业务类型选择适用于所述NR业务的信号类型，包括：

若所述NR业务类型为大量物联网通信mMTC业务，则所述基站在所述剩余子帧上根据所述NR业务类型选择适用于所述mMTC业务的信号类型。

5.根据权利要求1所述的方法，其特征在于，所述用于执行LBT机制的占用资源可以配置在帧或子帧位置上。

6.根据权利要求1所述的方法，其特征在于，所述执行LBT机制的信号类型与适用于所述NR业务的信号类型不同。

7.根据权利要求1所述的方法，其特征在于，所述适用于所述NR业务的信号类型是指所述基站根据所述NR业务类型所选择的与所述剩余子帧的子载波间隔，循环前缀长度和传输时间间隔TTI长度上的至少一种相匹配的NR业务的信号类型。

8.根据权利要求1-7任一项所述的方法，其特征在于，所述控制信令包括探测信号、信道探测的参考信号或同步信号。

9.一种信号传输方法，其特征在于，所述方法包括：

当新无线NR业务在非授权频段上传输时，终端执行先听后说LBT机制并判断用于执行所述LBT机制所在的资源块RB中是否存在剩余子帧；

若存在，所述终端向基站发送所述RB中存在剩余子帧的指示消息；

所述终端接收所述基站在所述剩余子帧上采用NR业务的信号类型发送的所述NR业务的控制信令，所述NR业务的信号类型由所述基站在所述剩余子帧上根据所述NR业务类型所选择。

10.根据权利要求9所述的方法，其特征在于，所述终端接收基站在所述剩余子帧上采用NR业务的信号类型发送的所述NR业务的控制信令，包括：

若所述NR业务类型为增强型移动宽带应用eMBB业务，则所述终端接收基站在所述剩余子帧上采用NR业务的信号类型发送的所述eMBB业务的控制信令。

11.根据权利要求9所述的方法，其特征在于，所述终端接收基站在所述剩余子帧上采用NR业务的信号类型发送的所述NR业务的控制信令，包括：

若所述NR业务类型为超可靠及低时延通信URLLC业务，则所述终端接收基站在所述剩余子帧上采用NR业务的信号类型发送的所述URLLC业务的控制信令。

12.根据权利要求9所述的方法，其特征在于，所述终端接收基站在所述剩余子帧上采用NR业务的信号类型发送的适用于所述NR业务的控制信令，包括：

若所述NR业务类型为大规物联网通信mMTC业务，则所述终端接收基站在所述剩余子帧上采用NR业务的信号类型发送的所述mMTC业务的控制信令。

13.根据权利要求9所述的方法，其特征在于，所述用于执行LBT机制的占用资源可以配置在预设子帧位置上。

14.根据权利要求9所述的方法，其特征在于，所述执行LBT机制的信号类型与适用于所述NR业务的信号类型不同。

15.根据权利要求9所述的方法，其特征在于，所述适用于所述NR业务的信号类型是指所述基站根据所述NR业务类型所选择的与所述剩余子帧的子载波间隔、循环前缀长度和传输时间间隔TTI长度中的至少一种相匹配的NR业务的信号类型。

16.根据权利要求9-15任一项所述的方法，其特征在于，所述控制信令包括保留信号、信道探测的参考信号或同步信号。

17.一种基站，其特征在于，所述基站包括：

判断单元，用于当新无线NR业务在上授权频段上传输时，执行先听后说LBT机制并判断资源块RB中是否存在剩余子帧；

选择单元，用于若存在所述剩余子帧，在所述剩余子帧上根据所述NR业务类型选择适用于所述NR业务的信号类型；

发送单元，用于在所述剩余子帧上采用所述NR业务的信号类型向终端发送所述NR业务的控制信令。

18.根据权利要求17所述的基站，其特征在于，所述选择单元具体用于：

若所述NR业务类型为增强型移动宽带应用eMBB业务，则在所述剩余子帧上根据所述NR业务类型选择适用于所述eMBB业务的信号类型。

19.根据权利要求17所述的基站，其特征在于，所述选择单元具体用于：

若所述NR业务类型为超可靠及低时延通信URLLC业务，则在所述剩余子帧上根据所述NR业务类型选择适用于所述URLLC业务的信号类型。

20.根据权利要求17所述的基站，其特征在于，所述选择单元具体用于：

若所述NR业务类型为大规物联网通信mMTC业务，则在所述剩余子帧上根据所述NR业务类型选择适用于所述mMTC业务的信号类型。

21.根据权利要求17所述的方法，其特征在于，所述用于执行LBT机制的占用资源可以配置在预设子帧位置上。

22.根据权利要求17所述的方法，其特征在于，所述执行LBT机制的信号类型与适用于所述NR业务的信号类型不同。

23.根据权利要求17所述的基站，其特征在于，所述适用于所述NR业务的信号类型是指根据所述NR业务类型所选择的与所述剩余子帧的子载波间隔、循环前缀长度和传输时间间

隙TTI长度中的至少一种相匹配的NR业务的信号类型。

21.根据权利要求17-23任一项所述的方法，其特征在于，所述控制信令包括保留信号、信道探测的参考信号或同步信号。

25.一种终端，其特征在于，所述终端包括：

判断单元，用于当新无线NR业务在上授权频段上传输时，执行先听后说LBT机制并判断资源块RB中是否存在剩余子帧；

发送单元，若存在所述剩余子帧，向基站发送所述RB中存在剩余子帧的指示消息；

接收单元，用于接收所述基站在所述剩余子帧上采用NR业务的信号类型发送的所述NR业务的控制信令，所述NR业务的信号类型由所述基站在所述剩余子帧上根据所述NR业务类型所选择。

26.根据权利要求25所述的终端，其特征在于，所述接收单元具体用于：

若所述NR业务类型为增强型移动宽带应用eMBB业务，则接收基站在所述剩余子帧上采用NR业务的信号类型发送的所述eMBB业务的控制信令。

27.根据权利要求25所述的终端，其特征在于，所述接收单元具体用于：

若所述NR业务类型为超可靠及低时延通信URLLC业务，则接收基站在所述剩余子帧上采用NR业务的信号类型发送的所述URLLC业务的控制信令。

28.根据权利要求25所述的终端，其特征在于，所述接收单元具体用于：

若所述NR业务类型为大量物联网通信mMTC业务，则接收基站在所述剩余子帧上采用NR业务的信号类型发送的所述mMTC业务的控制信令。

29.根据权利要求25所述的方法，其特征在于，所述用于执行LBT机制的与用资源可以配置在预设子帧位置上。

30.根据权利要求25所述的方法，其特征在于，所述执行LBT机制的信号类型与适用于所述NR业务的信号类型不同。

31.根据权利要求25所述的终端，其特征在于，所述适用于所述NR业务的信号类型是指根据所述NR业务类型所选择的与所述剩余子帧的子载波间隔，循环前缀长度和传输时间间隙TTI长度中的至少一种的NR业务的信号类型。

32.根据权利要求25-31任一项所述的终端，其特征在于，所述控制信令包括保留信号、信道探测的参考信号或同步信号。

一种信号传输方法及相关网元

技术领域

[0001] 本发明涉及通信技术领域，尤其涉及一种信号传输方法及相关网元。

背景技术

[0002] 无线通信网络的广泛部署可为用户提供各种通信服务，例如语音、视频、分组数据、消息传送、广播等。这些无线网络可以是能够通过共享可用的网络资源来支持多个用户的多址网络。这些多址网络的示例包括码分多址(Code Division Multiple Access,CDMA)网络、时分多址(Time Division Multiple Access,TDMA)网络、频分多址(Frequency Division Multiple Access,FDMA)网络、正交频分多址(Orthogonal Frequency Division Multiple Access,OFDMA)网络和单载波频分多址(Single-carrier Frequency Division Multiple Access,SC-FDMA)网络、以及下一代新无线(New Radio,NR)网络(例如5G)。

[0003] NR的提出带来了新的机遇和挑战，未来NR业务的三大主要应用场景和需求主要包括增强型移动宽带应用(Enhanced mobile broadband,eMBB)、超可靠及低时延通信(Ultra-reliable and low latency communications,URLLC)以及大规物联网通信(Massive machine type communications,mMTC)。针对增强型的移动宽带eMBB这种应用场景下，智能终端用户上网峰值速率要达到10Gbps甚至20Gbps，为虚拟现实、无处不在的视频直播和分享、随时随地的云接入等大带宽应用提供支持。针对大连接物联网mMTC这种场景下，5G网络需要支持100万一平方公里规模的人和物的连接。针对低时延、超可靠通信uRLLC这种场景要求5G网络的时延达到1毫秒，为智能制造、远程机械控制、辅助驾驶和自动驾驶等低时延业务提供强有力的支持。

[0004] 为进一步提高频谱资源的利用，第三代合作伙伴计划(3rd Generation Partnership Project,3GPP)引入了授权频谱辅助接入(Licensed Assisted Access,LAA)的概念，其可以借助长期演进(Long Term Evolution,LTE)甚至NR的授权频谱的帮助来处理非授权频段。同时，为确保LAA能够友好地与现有的接入技术共存，提出了一种先听后说(Listen Before Talk,LBT)机制来避免碰撞。若在非授权频谱上检测到信道处于空闲状态，才能占用该信道进行信号发送。在正常循环前缀(Cyclic Prefix,CP)情况下，一个资源块(Resource Block,RB)在时域上的最小长度是7个正交频分复用(Orthogonal Frequency Division Multiplexing,OFDM)符号，也就是0.5ms。非授权频段上，无线系统(包括后来的NR系统)在使用信道(或者使用RB)之前可以执行LBT机制，用以判断信道是否可用，而执行LBT的时间一般都是微秒级。非LBT事件的引入会产生新的频谱资源利用率的问题。

发明内容

[0005] 本发明实施例提供一种信号传输方法及相关网元，可提高频谱利用率。

[0006] 在第一方面，本发明实施例提供了一种信号传输方法，包括：

[0007] 当新无线NR业务在非授权频段上传输时，终端执行先听后说LBT机制，并判断资源块RB中是否存在剩余子帧；

[0008] 若存在，所述基站在所述剩余子帧上根据所述NR业务类型选择适用于所述NR业务的信号类型；

[0009] 所述基站在所述剩余子帧上采用所述NR业务的信号类型向终端发送所述NR业务的控制信令。

[0010] 在第二方面，本发明实施例提供了一种信号传输方法，包括：

[0011] 当新无线NR业务在非授权频段上传输时，终端执行先听后说LBT机制，并判断用于执行所述LBT机制所在的资源块RB中是否存在剩余子帧；

[0012] 若存在，所述终端向基站发送所述RB中存在剩余子帧的指示消息；

[0013] 所述终端接收所述基站在所述剩余子帧上采用NR业务的信号类型发送的所述NR业务的控制信令，所述NR业务的信号类型由所述基站在所述剩余子帧上根据所述NR业务类型所选择。

[0014] 在第三方面，本发明实施例提供了一种基站，包括：

[0015] 判断单元，用于当新无线NR业务在非授权频段上传输时，执行先听后说LBT机制并判断资源块RB中是否存在剩余子帧；

[0016] 选择单元，用于若存在所述剩余子帧，在所述剩余子帧上根据所述NR业务类型选择适用于所述NR业务的信号类型；

[0017] 发送单元，用于在所述剩余子帧上采用所述NR业务的信号类型向终端发送所述NR业务的控制指令。

[0018] 在第四方面，本发明实施例提供了一种终端，包括：

[0019] 判断单元，用于当新无线NR业务在非授权频段上传输时，执行先听后说LBT机制并判断资源块RB中是否存在剩余子帧；

[0020] 发送单元，用于若存在所述剩余子帧，向基站发送所述RB中存在剩余子帧的指示消息；

[0021] 接收单元，用于接收所述基站在所述剩余子帧上采用NR业务的信号类型发送的所述NR业务的控制信令，所述NR业务的信号类型由所述基站在所述剩余子帧上根据所述NR业务类型所选择。

[0022] 在NR系统中，因为LAA的引入，从而使得在非授权频段上的LBT机制可能只是占用了RB的部分时频位置，从而会出现RB中的OFDM符号的剩余的现象，此剩余的OFDM符号的利用率成为当前亟需讨论的问题。

[0023] 而本发明实施例，当新无线NR业务在非授权频段上传输时，基站执行先听后说LBT机制并判断是否存在剩余子帧，若存在，所述基站在所述剩余子帧上根据所述NR业务类型选择适用于所述NR业务的信号类型，并在所述剩余子帧上采用所述NR业务的信号类型向终端发送所述NR业务的控制信令，本发明实施例采用剩余子帧发送所述NR业务的控制信令，合理地使用了剩余子帧，提高了频谱利用率。

附图说明

[0024] 为了更清楚地说明本发明实施例技术方案，下面将对实施例描述中所需要使用的附图作简单地介绍，显而易见地，下面描述中的附图是本发明的一些实施例，对于本领域普通技术人员来讲，在不付出创造性劳动的前提下，还可以根据这些附图获得其他的附图。

[0025] 图1是本发明实施例提供的信号传输方法的第一实施例流程示意图；

[0026] 图1a是本发明实施例提供的发送NR业务的RB的结构示意图；

[0027] 图2是本发明实施例提供的信号传输方法的第二实施例流程示意图；

[0028] 图2a是本发明实施例提供的重授权频段的频段划分示意图；

[0029] 图2b是本发明实施例提供的发送eMBB业务的RB的结构示意图；

[0030] 图2c是本发明实施例提供的发送URLLC业务的RB的结构示意图；

[0031] 图2d是本发明实施例提供的发送mMTC业务的RB的结构示意图；

[0032] 图3是本发明实施例提供的信号传输方法的第三实施例流程示意图；

[0033] 图4是本发明实施例提供的基站的第一实施例结构示意图；

[0034] 图5是本发明实施例提供的基站的第二实施例结构示意图；

[0035] 图6是本发明实施例提供的终端的第一实施例结构示意图；

[0036] 图7是本发明实施例提供的终端的第二实施例结构示意图。

具体实施方式

[0037] 下面将结合本发明实施例中的附图，对本发明实施例中的技术方案进行清楚、完整地描述。显然，所描述的实施例是本发明一部分实施例，而不是全部的实施例。基于本发明中的实施例，本领域普通技术人员在没有做出创造性劳动前提下所获得的所有其他实施例，都属于本发明保护的范围。

[0038] 需要说明的是，在本发明实施例中使用的术语是仅仅出于描述特定实施例的目的，而非旨在限制本发明。在本发明实施例和所附权利要求书中所使用的单数形式的"一种"、"所述"和"该"也旨在包括多数形式，除非上下文清楚地表示其他含义。还应当理解，本文中使用的术语"和/或"是指并包含一个或多个相关联的列出项目的任何或所有可能组合。

[0039] 需要说明的是，在没有明示的特别说明的情况下，本发明各实施例中的各项技术特征可视为能够进行相互组合或者结合，只要该种组合或者结合不是因为技术的原因而无法实施，为了较为充分的说明本发明，一些示例性的、可选的、或者优选的特征在本发明各实施例中与其他技术特征结合在一起进行描述，但这种结合不是必须的，而应该理解该示例性的、可选的、或者优选的特征与其他的技术特征都是彼此可分离的或者独立的，只要该种可分离或者独立不是因为技术的原因而无法实施。方法实施例中的技术特征的一些功能性描述可以理解为执行该功能、方法或者步骤，装置实施例中的技术特征的一些功能性描述可以理解为使用该种装置来执行该功能、方法或者步骤。

[0040] 无线通信网络可以包括能够支持多个无线用户装置的通信的多个基站。无线用户装置可以通过下行链路和上行链路与基站进行通信。下行链路(或前向链路)是指从基站到无线用户装置的通信链路，而上行链路(或反向链路)是指从无线用户装置到基站的通信链路。

[0041] 无线用户设备(例如，蜂窝电话或者智能电话)可以利用无线通信系统来发射和接收数据以用于双路通信。无线用户设备可以包括用于数据发射的发射机以及用于数据接收的接收机。对于数据发射，发射机可以利用数据对发射本地振荡器(Local Oscillator，LO)信号进行调制以获得经过调制的射频(Radio Frequency，RF)信号，对经过调制的RF信号进行放

从以获得具有恰当发射功率级别的输出RF信号，并且经由天线来输出RF信号发射给基站。对于数据接收，接收机可以经由天线来获得所接收的RF信号，放大并利用接收LO信号将所接收的RF信号下变频。并且处理经下变频的信号以恢复由基站发送的数据。

[0042] 无线用户设备可以支持与不同无线电接入技术(Radio Access Technology,RAT)的多个无线系统的通信(例如LTE、LTE-A和NR)。每个无线系统可能具有某些特性和要求，能够高效地支持利用不同RAT的无线系统的同时通信。无线用户设备还可以被称为用户设备(User Equipment,UE)、移动台、终端、接入终端、用户单元、站点、等等。无线用户设备可以是蜂窝电话、智能电话、平板计算机、无线调制解调器、个人数字助理(Personal Digital Assistant,PDA)、手持式设备、膝上型计算机、智能本、上网本、无绳电话、无线本地回路(wireless local loop,WLL)站点、蓝牙设备、等等。无线用户设备可以能够与无线系统进行通信，还可以能够从广播站、一个或多个全球导航卫星系统(Global Navigation Satellite System,GNSS)中的卫星等接收信号。无线用户设备可以支持用于无线通信的一个或多个RAT，诸如GSM、WCDMA、cdma2000、LTE、LTE-A、802.11、等等。术语"无线电接入技术"、"RAT"、"无线电技术"、"空中接口"和"标准"经常可互换地被使用。

[0043] 需要说明的是，在LTE/LTE-A系统中，上、下行载波分别采用单载波频分多址(Single-carrier Frequency-Division Multiple Access,SC-FDMA)/OFDM以及循环前缀(Cyclic Prefix,CP)。在5G标准中，示例性的，可以对上下行载波进行统一，即上行链路与下行链路均采用OFDM以及CP。另外示例性的，5G中的RB可以被如下配置，1个资源块包含12个子载波，子载波间隔以15kHz为基准，子载波间隔可以是15kHz的N(N=2^n)倍，或者也可以固定为子载波间隔为75kHz。具体而言，传统LTE小区工作在频段上的带宽是由RB构成，RB分别具有固定的子载波间隔和符号长度，比如正常CP下，频域上的大小为180KHz(即：12个15KHz子载波间隔)，时域上，包括7个符号，一个符号的长度约等于71.5us。而在下一代移动通信技术中(例如NR系统中)，不同子载波可以基于业务类型不再具有固定的子载波间隔和固定的符号长度(可以动态变化)。为区别于传统LTE系统中的RB概念，NR系统新定义了"numerology"(参考数值)的概念，它主要包括子载波间隔、CP长度和TTI长度等。目前，NR系统共定义了三种业务类型，分别是eMBB、URLLC和mMTC，不同业务类型的"numerology"类型是可以不同，意味不同类型的子载波间隔、CP长度或TTI长度可能有所不同。示例性的，可以定义下一代移动通信将会支持最大为100MHz的单载波带宽。一个资源块RB在频域上的大小变为900KHz(即：12个75kHz子载波间隔)，而在时域上支持0.1ms。一个无线帧的长度是10ms，但是由50个子帧构成，每个子帧的长度为0.2ms。需要说明的是，本文通信所述的适用于所述NR业务的信号类型，可以是指包括载波间隔、CP长度和TTI长度等相关参数中的至少一种参数的配置。

[0044] 请参照图1和图1a，图1是本发明实施例提供的信号传输方法的第一实施例流程示意图，图1a是本发明实施例提供的发送NR业务的RB句结构示意图。本实施例中所描述的一种信号传输方法，包括步骤S101～S103：

[0045] S101，当新无线NR业务在非授权频段上传输时，基站执行先听后说LBT机制，并判断用于执行所述LBT机制所在的资源块RB中是否存在剩余子帧。

[0046] 具体实现中，当新无线NR业务在非授权频段上传输时，NR业务在占用信道之前都要执行LBT机制，通过能量感知的方式获取目标信道是否空闲。当信道处于空闲状态时，才

能使用该信道进行NR业务传输。由于LBT机制的时间一般微秒级的如LBT机制最短的执行时间是25us，而一个RB是0.5ms，基站一般以两个RB为单位即1ms来调度终端，LBT机制只是占用了RB的部分时频位置，所以，在执行完LBT机制之后，可能会出现剩余子帧。本发明实施例中，当基站需要采用非授权频段上向终端传输NR业务时，基站首先需要执行LBT机制，并在执行LBT机制之后判断RB中是否存在剩余子帧，如图1a所示为发送NR业务的RB的结构示意图，LBT机制的执行占用了1st部分的时频位置，其余的n2为剩余部分子帧，可以用于传输适用于所述NR业务的信号。本发明实施例中，若出现剩余子帧，则可以根据NR业务类型利用剩余子帧来发送与业务类型相匹配的相关控制信令或者是相匹配的数据业务相关指令。在上行链路中，上述LBT机制的执行过程和剩余子帧的判断过程也可以由终端来执行。

[0047] 作为检测目标信道是否处于空闲状态的一种示例性的方式，具体的，当有新无线NR业务需要在非授权频段上传输时，基站检测时间是否有其它设备正在目标信道发送数据，如果该目标载信道已被其它设备占用，可以在下一监听周期到来时继续监听，也可以不再监听；若监听到信道资源空闲，该基站可以立即占用该目标信道。信道占用时间可以是一个固定值，也可以在下一个信道检测位置前设定一个静默时间。优选的，若监听到信道资源繁忙，可以生成一个竞机数1作为退避时间，在这个退避时间内，继续监听目标信道，若检测到1次目标信道处于空闲状态，则退避时间结束，同时该基站就可以占几该目标信道。如果基站检测到信道状态为繁忙（例如已被其它设备占用），则在这个周期内设备不能占用信道，则该基站可以等到下一个周期的固定位置继续检测。

[0048] 作为检测目标信道是否处于空闲状态的另一种示例性的方式，具体的，当有新无线NR业务需要在非授权频段上传输时，触发初始检测，若基站初始检测到目标信道处于空闲状态，即可占用该目标信道，并在基站预先配置一个信道占用时间T；若基站初始检测到目标信道状态为非空闲，则可生成一个推迟周期(defer period)时间，如果在推迟周期时间还是检测到目标信道忙，则继续生成一个推迟周期时间，UE在此次检测时间检测到信道状态为空闲之后可以占用目标信道，占用目标信道时间为T。

[0049] S102，若存在，所述基站在所述剩余子帧上根据所述NR业务类型选择适用于所述NR业务的信号类型。

[0050] S103，所述基站在所述剩余子帧上采用所述NR业务的信号类型向终端发送所述NR业务的控制信令。

[0051] 具体实现中，NR业务类型可以包括eMBB、URLLC、mMTC等，基站可以根据上述业务类型选择与所述剩余子帧的子载波间隔、循环前缀长度和传输时间间隔(Transmission time interval，TTI)长度中至少一种相匹配的NR业务的信号，例如当NR业务类型为eMBB业务时，基站可以选择适用于eMBB业务所支持的参数取值如numerology类型或者频域资源组(Frequency resource group，FRG)类型的信号类型。FRG是指在一个NR载波上连续的或者非连续的频域资源上使用一个numerology类型的频域资源，而numerology类型主要与子载波间隔、循环前缀(Cyclic Prefix，CP)长度和TTI长度相关。所以，FRG的配置也理解为是包括子载波间隔、CP长度和TTI长度等相关参数中的至少一种参数的配置。

[0052] 基站可以在所述剩余子帧上采用所述NR业务的信号类型向终端发送所述NR业务的控制信令。本发明实施例中，控制信令可以包括保留信号，信道探测的参考信号或同步信号，其中，保留信号可以是未携带任何信息的信号，主要用于防止其它无线接入设备在此期

间占用该信道；参考信号主要用于对当前信道的信计以及信道质量的获取，也可在一定程度上防止其它无线接入设备在此期间占用该信道，它可以通过预设的序列生成，也可以以触发方式由基站发送；同步信号则可以防止终端与基站出现业务中断现象。

[0053] 本发明实施例，当NR业务在非授权频段上传输时，基站执行先听后说LBT机制并判断是否存在剩余子帧，若存在，所述基站根据所述NR业务类型选择适用于所述NR业务的信号类型，并在所述剩余子帧上采用所述NR业务的信号类型向终端发送所述NR业务的控制信令，本发明实施例采用剩余子帧发送所述NR业务的控制信令，合理使用了剩余子帧，有利于提高频谱利用率。

[0054] 请参照图2，图2是本发明实施例提供的信号传输方法的第一实施例流程示意图，本实施例中所描述的一种信号传输方法，包括步骤S201～S203。

[0055] S201，当新无线NR业务在非授权频段上传输时，基站执行先听后说LBT机制并判断用于执行所述LBT机制所在的资源块RB中是否存在剩余子帧。

[0056] 具体实现中，当新无线NR业务在非授权频段上传输时，NR业务在占用信道之前都要执行LBT机制，通过能量感知的方式获取目标信道是否空闲。当信道处于空闲状态时，才能使用该信道进行NR业务传输。由于LBT机制的时间一般微秒级的如LBT机制最短的执行时间是25us，而一个RB是0.5ms，基站一般以两个RB为单位即1ms来调度终端，LBT机制只是占用了RB的部分时频位置。所以，在执行完LBT机制之后，RB中可能会出现剩余子帧。在上行链路中，上述LBT机制的执行过程和剩余子帧的判断过程也可以由终端来执行。

[0057] 可选的，所述用于执行LBT机制的占用资源可以配置在预设子帧位置上。

[0058] 需要说明的是，下一代移动通信工作的频段可以包括非授权频段，也就是说，在无线通信系统的通信链路可以包括用于携带上行链路(UL)传输(例如，从UE116到eNB105)的上行链路和/或用于携带下行链路(DL)传输(例如，从基站到UE)的下行链路。UL传输还可以称为反向链路传输，而DL传输还可以称为前向链路传输。可以使用授权的频段(例如，LTE/LTE-A)、非授权的频段或两者来进行下行链路传输。类似地，可以使用授权的频段(例如，LTE/LTE-A)、非授权的频段或两者来进行上行链路传输。但是在非授权频段上，需要考虑到其它无线接入设备的存在，为了更好的与它们实现合理共存，LTE/LTE-A以及NR(例如，5G)系统需要遵守一些规则，比如LBT，即系统在使用非授权频段之前需要通过执行LBT机制用以判断目标信道是否可用。但是考虑到下一代移动通信系统中三种业务类型的特点，即为提高频谱利用率，三种业务类型所对应的"numerology"(数值参数)类型应有所不同。而对于非授权频段，在保证与其它异系统(诸如WiFi、蓝牙等)实现合理共存的同时，还要保证5G系统与LTE系统的兼容性。所以，针对这种情况，非授权频段会出现一种划分频段的情况，其示意图如图2a所示。可以看出，在子帧上被划分出一部分区域作为LBT区域，而另一部分区域作为不同NR类型业务(eMBB、URLLC、mMTC)的承载区域。考虑到LBT机制的执行时间处于微秒级别，所以，在对划分出来的LBT执行区域，可以以多子帧聚合的方式出现，即类似于LBT机制中基于帧结构设计的LBT机制(Frame Based Equipment，FBE)，基站或者终端会在预设若干个，每个无线帧中固定子帧的开头执行FBE；或者在每个无线帧中的一些固定子帧的开头执行FBE。所以，为提高非授权频段的频谱利用率，将划分出来用于执行LBT机制的占用资源，执行LBT机制的占用资源可以配置在预设子帧位置上，也可放在每个无线帧中固定子帧位置上，比如每个无线帧的第0号子帧和第5号子帧上。

[0059] 可选的，所述执行LBT机制的信号类型与适用于所述NR业务的信号类型不同。需要说明的是，考虑到尽可能保证LBT机制在适用于LTE/LTE-A业务的信号和适用于NR业务的信号两者中的兼容性，因此执行LBT机制的信号类型可以与传统的适用于LTE/LTE-A业务的信号保持一致，而与适用于NR业务的信号的类型不相同，此种设计被证明是有益的，可以在向前兼容的情形下同时考虑到新特性的引入，有利于提高频谱的利用效率。

[0060] S202，若存在上所述NR业务类型为增强型移动宽带应用eMBB业务，则从所述基站选择适用于所述eMBB业务的信号类型。

[0061] 具体实现中，为了使NR系统能够支持灵活和多种部署场景，不同"numerology(数值参数)"类型的子载波间隔和CP长度有所不同。同时，不同的"numerology(数值参数)"类型需具有可扩展性，以适应未来系统新增业务的需求，且不同的NR业务对于子帧结构的设计要求也不同。例如对于时延比较敏感的业务采用小数据包的发送或短周期TTI会比较适合。另外，同载波上不同频域范围内的"numerology(数值参数)"类型也可能不同。针对NR系统支持eMBB、URLLC、mMTC三大不同业务场景，业务具体分析如下：

[0062] eMBB主要工作在较宽的频段上，包括中高速的物联网通信(machine type communications,MTC)服务。该业务主要用于热点区域，以为终端用户提供较好的视频服务。通过设定合适的"numerology(数值参数)"类型以更好地适应该业务场景。例如可将该部分频段子载波间隔设置相对较大，以保证能够传输大带宽数业务。从频段特点来看，小于40GHz的频段上，最适合密集的城市宏小区场景中，高于40GHz以上的频段，比较适合室内或者微基站小区部署的城市密集场景。

[0063] URLLC场景主要面向车联网、工业控制等应用需求，其对时延要求和业务的可靠性要求较高。所以，可以适用于一些诸如室内和城市热点的微基站小区之中，例如部署大量小小区的场景中。不同于另外两种业务场景，可以将该场景的"numerology(数值参数)"类型中的TTI长度设置成短周期TTI最为适合。可以通过如下两种方式设置成短周期TTI：一种是在维持当前子载波间隔宽度的情况下，减少一个TTI内的符号数；一种是在维持相同TTI长度的情况下，增加每个符号的子载波间隔。

[0064] mMTC场景主要适用于以传感器和数据采集为主要的应用场景，例如环境监测、智能农业等。目前，它主要用于传输小流量数据包，其具有低功耗和低成本的特点，所以该业务场景的传输信道相对于前面两种业务场景而言，对频段宽度要求不是太高。因此，低于4GHz(如700MHz)的农村场景比较适合。其最佳典型场景和频谱设计可参见如下表1：

[0065]

使用场景	典型部属场景	典型频谱
eMBB	城市宏小区 密集城市场景（包括小小区）	< ~40GHz， > ~40GHz
URLLC mMTC	小小区/室内场景 农村场景	< ~40GHz < 1GHz（如700MHz）

[0066] 表1

[0067] 若所述NR业务类型为超可靠及低时延通信URLLC业务，则可以根据eMBB业务选择与所述剩余子帧的子载波间隔、循环前缀长度和TTI长度中至少一种相匹配的eMBB业务

的信号类型。

[0068] 可选的，若所述NR业务类型为超可靠及低时延通信URLLC业务，则所述基站可以选择适用于所述URLLC业务的信号类型。若存在剩余子帧且传输业务为URLLC业务，所述基站可以根据URLLC业务选择与所述剩余子帧的子载波间隔、循环前缀长度和TTI长度或者中至少一种相匹配的eMBB业务的信号类型。

[0069] 可选的，若所述NR业务类型为大量物联网通信mMTC业务，则所述基站选择适用于所述mMTC业务的信号类型。若存在剩余子帧且传输业务为mMTC业务时，可以根据mMTC业务选择与所述剩余子帧的子载波间隔、循环前缀长度和TTI长度中至少一种相匹配的mMTC业务的信号。

[0070] 其中，保留信号可以是未携带任何信息的信号，主要用于防止其它无线接入设备在此期间占用该信道；参考信号主要用于对当前信道的估计以及信道质量的获取，也可在一定程度上防止其它无线接入设备在此期间占用该信道，它可以通过预设的序列生成，也可以以触发方式由基站发送；同步信号则可以防止终端与基站出现业务中断现象。

[0071] S203、所述基站在所述剩余子帧上向终端发送适用于所述NR业务的控制指令。

[0072] 具体实现中，若已选择适用于所述NR业务的信号类型，可以在所述剩余子帧上发送适用于所述NR业务的信号。如图2b～2d所示，图2b是本发明实施例提供的发送eMBB业务的RB的结构示意图，图2c是本发明实施例提供的发送URLLC业务的RB的结构示意图，图2d是本发明实施例提供的发送mMTC业务的RB的结构示意图。RB一部分用于LBT机制的执行，另一部分根据不同的NR业务类型发送不同的信号，如eMBB业务的信号、URLLC业务的信号、mMTC业务的信号。其中，上述控制信令可以包括保留信号、信道探测的参考信号或同步信号。

[0073] 本发明实施例，当NR业务在非授权频段上传输时，执行先听后说LBT机制并判断是否存在剩余子帧，若存在且所述NR业务类型为增强型移动宽带应用eMBB业务，则选择适用于所述eMBB业务的信号类型，并在所述剩余子帧上采用所述NR业务的信号类型向终端发送适用于所述NR业务的控制信令，实现了NR业务和LAA共存，并通过合理使用剩余子帧发送NR业务的控制信令，提高了频谱利用率。

[0074] 请参照图3，图3是本发明实施例提供的信号传输方法的第一实施例流程示意图。本实施例中所描述的一种信号传输方法，包括步骤S301～S303。

[0075] S301、当新无线NR业务在非授权频段上传输时，终端执行先听后说LBT机制方法判断用于执行所述LBT机制所在的资源块RB中是否存在剩余子帧。

[0076] 具体实现请参考图1对应的方法实施例的步骤S101以及图2对应的方法实施例的步骤S201的具体解释，在此不再赘述。

[0077] 作为检测目标信道是否处于空闲状态的一种示例性的方式，具体的，当有新无线NR业务需要在非授权频段上传输时，终端检测周围是否有其它设备正在目标信道发送物理上行共享信道(Physical Uplink Shared Channel，PUSCH)数据。如果该目标某信道已被其它设备占用，可以在下一监听周期到来时继续监听，也可以根据指示不再监听；若监听到信道资源空闲，该终端也以立即占用该目标信道。信道占用时间是一个固定值，也可以在下一信道检测位置前设定一个计数时间。优选的，若监听到信道资源繁忙，可以生成一个随机数N作为退避时间，在这个退避时间内，继续监听目标信道，若检测到N次目标信道处于空闲状态，则退避时间结束，同时该终端就可以占用该目标信道。如果终端检测到信道状态为繁忙

(例如已被其它终端占用)，则在这个周期内设备不能占用信道，则该终端可以等到下一个周期的时间点位置继续检测。

[0078] 作为检测目标信道是否处于空闲状态的另一种示例性的方式，具体的，当有新无线NR业务需要在非授权频段上传输时，触发初始检测。若终端初始检测到目标信道处于空闲状态，即可占用该目标信道，并在基站预先配置一个信道占用时间T；若终端初始检测到目标信道状态为非空闲，则可生成一个推迟周期(defer period)时间，如果在推迟周期时间还是检测到目标信道忙，则继续生成一个推迟周期时间。终端在T次检测时间检测到信道状态为空闲之后可以占用目标信道，占用目标信道时间为T。

[0079] S302、若存在，所述终端向基站发送所述RB中存在剩余子帧的指示消息。

[0080] 具体实现中，若所在的RB中存在剩余子帧，则所述终端会向基站发送一个指示消息，该指示消息可以用于告知基站RB中存在剩余子帧，进一步的，该指示消息还可以触发基站在该剩余子帧上发送适用于所述NR业务的信号。

[0081] S303、所述终端接收所述基站在所述剩余子帧上采用NR业务的信号类型发送的所述NR业务的控制信令，所述NR业务的信号类型由所述基站在所述剩余子帧上根据所述NR业务类型所选择。

[0082] 具体实现中，基站获知RB中存在剩余子帧后，会根据NR业务类型选择适用于所述NR业务的信号类型，并在所述剩余子帧上采用NR业务的信号类型向终端发送所述NR业务的控制信令，具体过程请参见图1对应实施例的步骤S102～S103以及图2对应实施例的步骤S202～S203，在此不再赘述。所述终端可以接收所述基站在所述剩余子帧上采用NR业务的信号类型发送的所述NR业务的控制信令。

[0083] 可选的，若所述NR业务类型为增强型移动宽带应用eMBB业务，则所述终端接收基站在所述剩余子帧上采用NR业务的信号类型发送的所述eMBB业务的控制信令。

[0084] 可选的，若所述NR业务类型为超可靠及低时延通信URLLC业务，则所述终端接收基站在所述剩余子帧上采用NR业务的信号类型发送的所述URLLC业务的控制信令。

[0085] 可选的，若所述NR业务类型为大规模物联网通信mMTC业务，则所述终端接收基站在所述剩余子帧上采用NR业务的信号类型发送的所述mMTC业务的控制信令。

[0086] 可选的，所述适用于所述NR业务的信号类型是指所述基站根据所述NR业务类型所选择的与所述剩余子帧的子载波间隔，循环前缀长度和传输时间间隔TTI长度中的至少一种相匹配的NR业务的信号类型。

[0087] 可选的，所述控制信令包括保留信号、信道探测的参考信号或同步信号。

[0088] 上述可选步骤的具体实现请参考图2对应的方法实施例的具体解释，在此不再赘述。

[0089] 本发明实施例中，当新无线NR业务在非授权频段上传输时，终端执行先听后说LBT机制并判断用于执行所述LBT机制的所在的资源集RB中是否存在剩余子帧，若存在，所述终端接收基站在所述剩余子帧上采用NR业务的信号类型发送的所述NR业务的控制信令，所述NR业务的信号类型由所述基站在所述剩余子帧上根据所述NR业务类型所选择，实现了NR业务和LAA共存，并可以使基站在该剩余子帧上发送NR业务的控制信令，提高了频谱利用率。

[0090] 请参照图4，为本发明实施例提供的基站的第一实施例结构示意图。本发明实施例的基站包括：判断单元101、选择单元102和发送单元103

[0091] 判断单元101，用于当新无线NR业务在非授权频段上传输时，执行先听后说LBT机制并判断资源块RB中是否存在剩余子帧；

[0092] 选择单元102，用于若存在所述剩余子帧，在所述剩余子帧上根据所述NR业务类型选择适用于所述NR业务的信号类型；

[0093] 可选的，所述选择单元102具体用于若所述NR业务类型为增强型移动宽带应用eMBB业务，则在所述剩余子帧上根据所述NR业务类型选择适用于所述eMBB业务的信号类型。

[0094] 可选的，所述选择单元102具体用于若所述NR业务类型为超可靠及低时延通信URLLC业务，则在所述剩余子帧上根据所述NR业务类型选择适用于所述URLLC业务的信号类型。

[0095] 可选的，所述选择单元102具体用于若所述NR业务类型为大量物联网通信mMTC业务，则在所述剩余子帧上根据所述NR业务类型选择适用于所述mMTC业务的信号类型。

[0096] 发送单元103，用于在所述剩余子帧上采用所述NR业务的信号类型向终端发送所述NR业务的控制信令。

[0097] 可选的，所述适用于所述NR业务的信号类型是指根据所述NR业务类型所选择的与所述剩余子帧的子载波间隔，循环前缀长度和传输时间间隔TTI长度中的至少一种相匹配的NR业务的信号类型。

[0098] 可选的，所述控制信令包括保留信号，信道探测的参考信号或同步信号。

[0099] 上述实施例各个单元的具体解释请参见图一-图2所对应的方法实施例，在此不再赘述。

[0100] 请参照图5，是本发明实施例提供的基站的第二实施例结构示意图。本实施例中所描述的基站主要包括：至少一个输入设备1000和输出设备1001；至少一个处理器1002，例如CPU；可选的存储器1003，上述输入设备1000、输出设备1001、处理器1002和可选的存储器1003通过总线1004连接。

[0101] 上述存储器1003可以是高速RAM存储器，也可为非易失性存储器(non-volatile memory，NVM)，例如磁盘存储器。上述存储器1003可用于存储程序代码，上述处理器1002用于调用存储器1003中存储的程序代码，执行如下操作：

[0102] 上述处理器1002，用于当新无线NR业务在非授权频段上传输时，执行先听后说LBT机制并判断资源块RB中是否存在剩余子帧；

[0103] 上述处理器1002，还用于若存在，在所述剩余子帧上根据所述NR业务类型选择适用于所述NR业务的信号类型；

[0104] 上述处理器1002，还用于在所述剩余子帧上采用所述NR业务的信号类型向终端发送所述NR业务的控制信令。

[0105] 可选的，上述处理器1002，具体用于若所述NR业务类型为增强型移动宽带应用eMBB业务，则在所述剩余子帧上根据所述NR业务类型选择适用于所述eMBB业务的信号类型。

[0106] 上述处理器1002，具体用于若所述NR业务类型为超可靠及低时延通信URLLC业务，则在所述剩余子帧上根据所述NR业务类型选择适用于所述URLLC业务的信号类型。

[0107] 上述处理器1002，具体用于若所述NR业务类型为大量物联网通信mMTC业务，则在

所述剩余子帧上根据所述NR业务类型选择适用于所述mMTC业务的信号类型。

[0108] 其中，所述适用于所述NR业务的信号类型是指根据所述NR业务类型所选择的与所述剩余子帧的子载波间隔、循环前缀长度和传输时间间隔TTI长度中的至少一种相匹配的NR业务的信号类型。所述控制信令包括保留信号、信道探测的参考信号或同步信号。

[0109] 具体实现中，本发明实施例中所描述的输入设备1000、输出设备1001和处理器1002可执行本发明实施例提供的信号传输方法的第一实施例、第二实施例中所描述的实现方式，也可执行本发明实施例提供的基站中所描述的终实现方式，在此不再赘述。

[0110] 请参照图6，为本发明实施例提供的终端的第一实施例结构示意图。本发明实施例的终端包括：判断单元201、发送单元202和接收单元203。

[0111] 所述判断单元201，用于当新无线NR业务在非授权频段上传输时，执行先听后说LBT机制并判断资源块RB中是否存在剩余子帧；

[0112] 所述发送单元202，用于若存在所述剩余子帧，向基站发送所述RB中存在剩余子帧的指示消息；

[0113] 所述接收单元203，接收所述基站在所述剩余子帧上采用NR业务的信号类型发送的所述NR业务的控制信令，所述NR业务的信号类型由所述基站在所述剩余子帧上根据所述NR业务类型所选择。

[0114] 可选的，所述接收单元203具体用于若所述NR业务类型为增强型移动宽带应用eMBB业务，则接收基站在所述剩余子帧上采用NR业务的信号类型发送的所述eMBB业务的控制信令。

[0115] 可选的，所述接收单元203具体用于若所述NR业务类型为超可靠及低时延通信URLLC业务，则接收基站在所述剩余子帧上采用NR业务的信号类型发送的所述URLLC业务的控制信令。

[0116] 可选的，所述接收单元203具体用于若所述NR业务类型为大规物联网通信mMTC业务，则接收基站在所述剩余子帧上采用NR业务的信号类型发送的所述mMTC业务的控制信令。

[0117] 可选的，所述适用于所述NR业务的信号类型是指根据所述NR业务类型所选择的与所述剩余子帧的子载波间隔、循环前缀长度和传输时间间隔TTI长度中的至少一种相匹配的NR业务的信号类型。所述控制信令包括保留信号、信道探测的参考信号或同步信号。

[0118] 上述实施例各个单元的具体解释请参见图2所对应的方法实施例，在此不再赘述。

[0119] 请参照图7，是本发明实施例提供的终端的第二实施例结构示意图。本实施例中所描述的终端主要包括：至少一个输入设备2000和输出设备2001；至少一个处理器2002，例如CPU；可选的存储器2003。上述输入设备2000、输出设备2001、处理器2002和可选的存储器2003通过总线2004连接。

[0120] 上述存储器2003可以是高速RAM存储器，也可为NVM，例如磁盘存储器。上述存储器2003可用于存储程序代码，上述处理器2002用于调用存储器2003中存储的程序代码，执行如下操作：

[0121] 上述处理器2002，用于当新无线NR业务在非授权频段上传输时，执行先听后说LBT机制并判断资源块RB中是否存在剩余子帧；

[0122] 上述处理器2002，用于若存在所述剩余子帧，向基站发送所述RB中存在剩余子帧

的指示消息；

[0123] 上述处理器2002，还用于若存在所述剩余子帧，接收所述基站在所述剩余子帧上采用NR业务的信号类型发送的所述NR业务的控制信令，所述NR业务的信号类型由所述基站在所述剩余子帧上根据所述NR业务类型所选择；

[0124] 可选的，上述处理器2002，具体用于若所述NR业务类型为增强型移动宽带应用eMBB业务，则接收基站在所述剩余子帧上采用NR业务的信号类型发送的所述eMBB业务的控制信令。

[0125] 上述处理器2002，具体用于若所述NR业务类型为超可靠及低时延通信URLLC业务，则接收基站在所述剩余子帧上采用NR业务的信号类型发送的所述URLLC业务的控制信令。

[0126] 上述处理器2002，具体用于若所述NR业务类型为大规模物联网通信mMTC业务，则接收基站在所述剩余子帧上采用NR业务的信号类型发送的所述mMTC业务的控制信令。

[0127] 其中，所述适用于所述NR业务的信号类型是指根据所述NR业务类型所选择的与所述剩余子帧的子载波间隔、循环前缀长度和传输时间间隔TTI长度中的至少一种相匹配的NR业务的信号类型，所述控制信令包括参考信号、信道探测的参考信号或同步信号。

[0128] 具体实现中，本发明实施例中所描述的输入设备2000、输出设备2001和处理器2002可执行本发明实施例提供的信号传输方法的第二实施例中所描述的实现方式，也可执行本发明实施例提供的终端中所描述的终实现方式，在此不再赘述。

[0129] 本发明实施例方法中的步骤可以根据实际需要进行顺序调整、合并和删减。

[0130] 本发明实施例装置中的单元可以根据实际需要进行合并、划分和删减。

[0131] 本领域普通技术人员可以理解实现上述实施例方法中的全部或部分流程，是可以通过计算机程序来指令相关的硬件来完成，所述的程序可存储于一计算机可读取存储介质中，该程序在执行时，可包括如上述各方法的实施例的流程。其中，所述的存储介质可为磁碟、光盘、只读存储记忆体(Read-Only Memory，ROM)或随机存储记忆体(Random access Memory，RAM)等。

[0132] 以上所揭露的仅为本发明较佳实施例而已，当然不能以此来限定本发明之权利范围，因此依本发明权利要求所作的等同变化，仍属本发明所涵盖的范围。

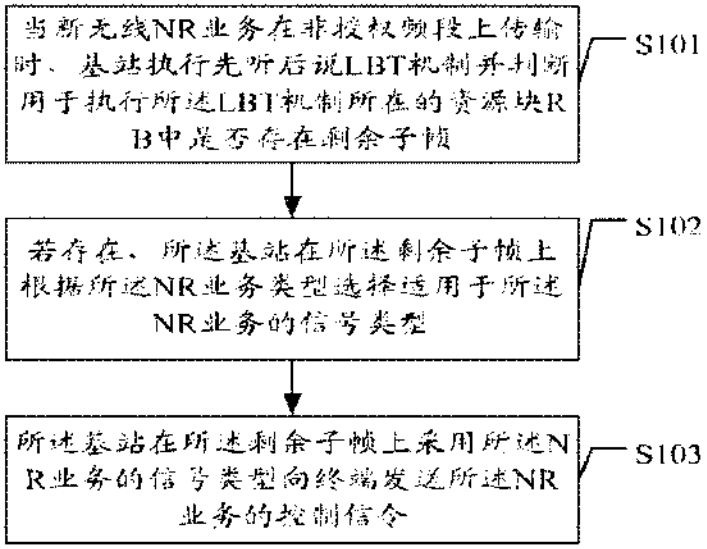

当新无线NR业务在非授权频段上传输时，基站执行先听后说LBT机制并判断用于执行所述LBT机制所在的资源块RB中是否存在剩余子帧
S101
若存在，所述基站在所述剩余子帧上根据所述NR业务类型选择适用于所述NR业务的信号类型
S102
所述基站在所述剩余子帧上采用所述NR业务的信号类型向终端发送所述NR业务的控制信令
S103

图1

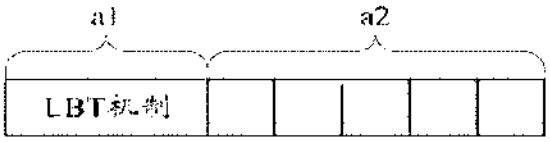

a1
a2
LBT机制

图1a

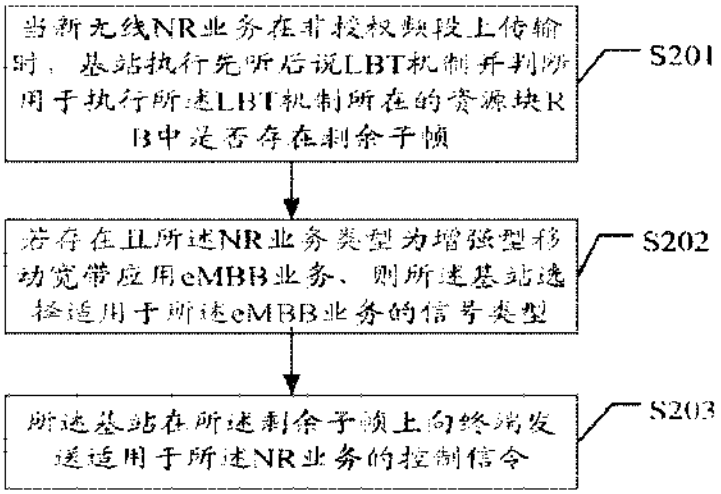

当新无线NR业务在非授权频段上传输时，基站执行先听后说LBT机制并判断用于执行所述LBT机制所在的资源块RB中是否存在剩余子帧
S201
若存在且所述NR业务类型为增强型移动宽带应用eMBB业务，则所述基站选择适用于所述eMBB业务的信号类型
S202
所述基站在所述剩余子帧上向终端发送适用于所述NR业务的控制信令
S203

图2

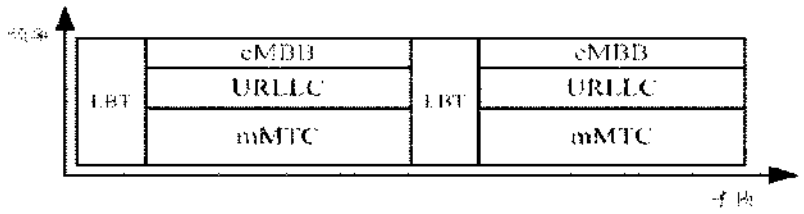

LBT
eMBB
URLLC
mMTC
LBT
eMBB
URLLC
mMTC

图2a

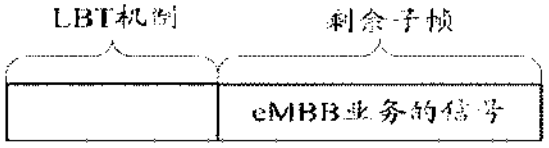

LBT机制
剩余子帧
eMBB业务的信号

图2b

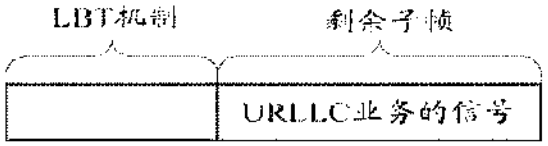

LBT机制
剩余子帧
URLLC业务的信号

图2c

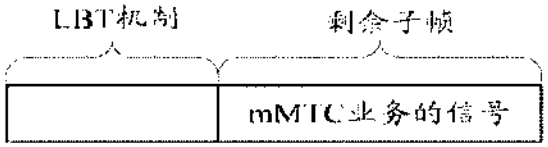

LBT机制
剩余子帧
mMTC业务的信号

图2d

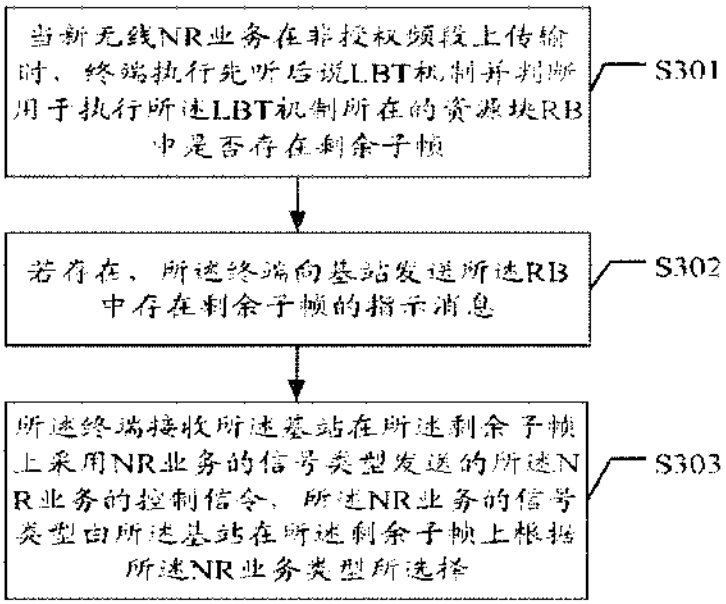

当新无线NR业务在非授权频段上传输时，终端执行先听后说LBT机制并判断用于执行所述LBT机制所在的资源块RB中是否存在剩余子帧
S301
若存在，所述终端向基站发送所述RB中存在剩余子帧的指示消息
S302
所述终端接收所述基站在所述剩余子帧上采用NR业务的信号类型发送的所述NR业务的控制信令，所述NR业务的信号类型由所述基站在所述剩余子帧上根据所述NR业务类型所选择
S303

图3

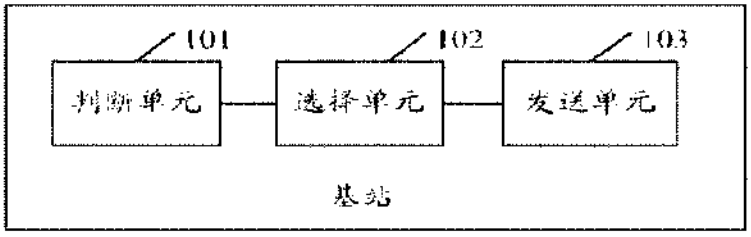

101
判断单元
102
选择单元
103
发送单元
基站

图1

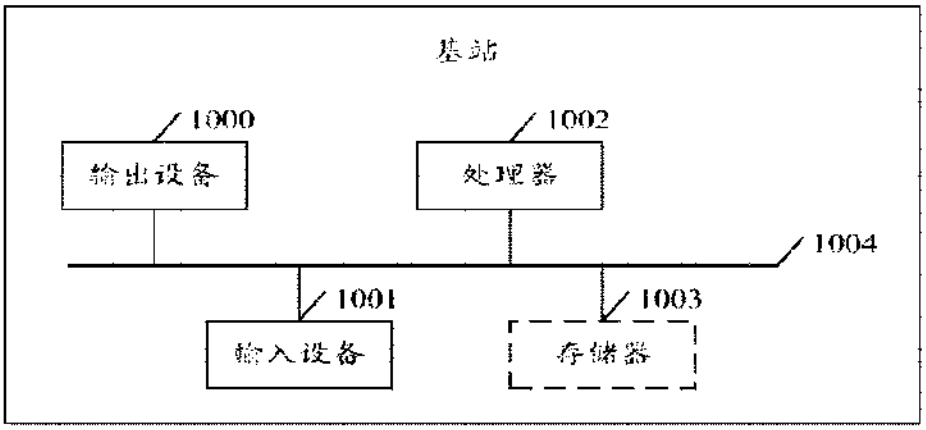

基站
1000
输出设备
1002
处理器
1004
1001
输入设备
1003
存储器

图5

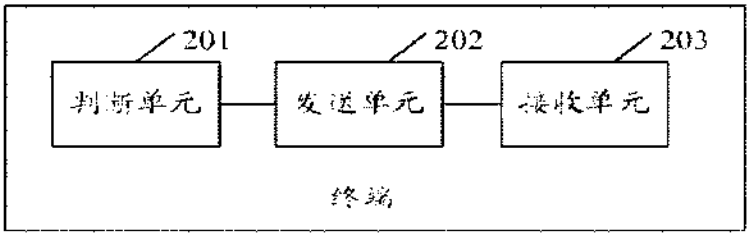

201
判断单元
202
发送单元
203
接收单元
终端

图6

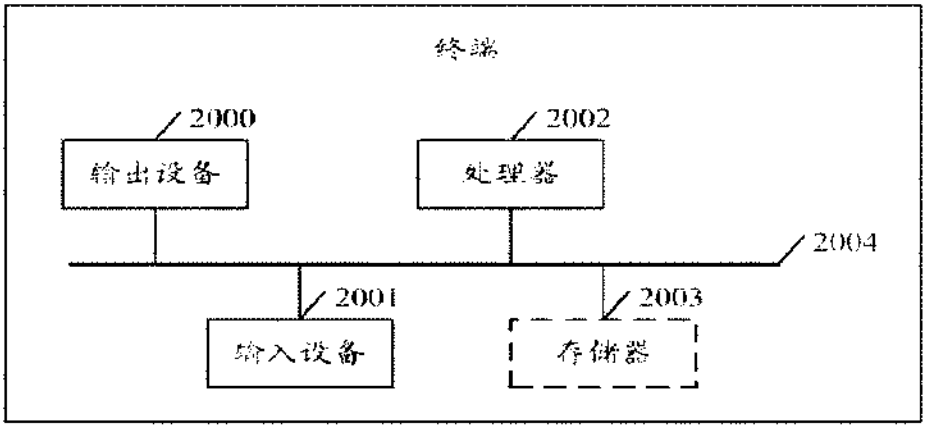


图7

(12) 按照专利合作条约所公布的国际申请

(19) 世界知识产权组织
国 际 局

(43) 国际公布日
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(81) 指定国 (除另有指明, 要求每一种可提供的国家保护): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW。

(84) 指定国 (除另有指明, 要求每一种可提供的地区保护): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), 欧亚 (AM, AZ, BY, KG, KZ, RU, TJ, TM), 欧洲 (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE,

[见续页]

(54) Title: METHOD FOR RECEIVING/SENDING PAGING MESSAGE AND RELATED NETWORK AND USER EQUIPMENT

(54) 发明名称: 寻呼消息的接收/发送方法及相关网络节点和用户设备

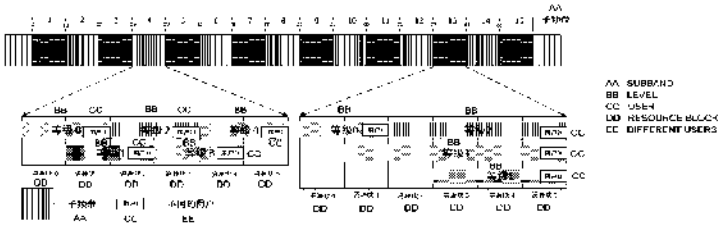


图10 / FIG. 10

(57) Abstract: The present invention provides a method for receiving/sending a paging message and a corresponding network node/user equipment. The method comprises: receiving an indication of a physical resource block set used to send a paging message, an index of the physical resource block set in a subframe being determined according to the level of the paging message; and receiving the paging message on the indicated physical resource block set. According to the technical solution, a paging message transmission mechanism for a coverage enhanced MTC user equipment and/or a low-complexity or low-cost MTC user equipment can be provided.

(57) 摘要: 本发明提供了寻呼消息接收/发送方法以及相应网络节点/用户设备。该方法包括: 接收对用于发送所述寻呼消息的物理资源块集的指示, 其中, 所述物理资源块集在子帧中的索引是根据所述寻呼消息的等级确定的; 以及在所指示的物理资源块集上接收所述寻呼消息。根据该技术方案, 可提供同时针对覆盖增强 MTC 用户设备和/或低复杂度或低成本的 MTC 用户设备的寻呼消息传输机制。

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IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG)。

本国际公布:

— 包括国际检索报告(条约第 21 条(3))。

寻呼消息的接收/发送方法及相关网络节点和用户设备

技术领域

本发明涉及无线通信技术领域。更具体地，本发明涉及寻呼消息的接收/发送方法以及相关网络节点/用户设备。

背景技术

第三代移动通信合作计划组织（3GPP）部署的长期演进项目（LTE）旨在提供日益多样化的未来移动通信服务，无线蜂窝通信日益成为大众生活和工作中不可或缺的一部分。在 3GPP LTE 的第一版（即 Release 8）中，引入了正交频分多址（OFDMA）和多天线（MIMO）技术。3GPP 的 Release 10 版本经国际电信联盟的评估和测试，正式成为了第四代全球移动通信标准 LTE-Advanced。在 LTE-Advanced 标准中，引入了载波聚合（CA）和中继技术，增强了上行/下行 MIMO 技术，同时支持异构网络（HetNet）的部署。

为了满足未来家庭设备通信的市场需求和规模庞大的物联网(IOT)部署，3GPP 决定在 LTE 及其升级版本中引入低成本机器间通信技术（MTC: Machine Type Communication），将 MTC 服务由目前的 GSM 网络支持迁移至 LTE 网络支持，并定义了若干种新的 LTE 用户设备(UE: User Equipment)的类型，其一称之为低成本 MTC 用户设备（Low-cost MTC UE），该 MTC 用户设备在现有 LTE 网络的所有双工模式中支持 MTC 服务，并具有这样的性能：1）单接收天线；2）下行和上行最大的传输模块大小（TBS: Transport Block Size）为 1000 比特；3a）下行链路数据信道的基带带宽降低为 1.4MHz，下行链路控制信道的带宽与网络侧系统带宽保持一致，上行链路信道带宽以及下行链路的射频部分与现有 LTE 网络中的用户设备保持一致；3b）下行/上行链路控制信道和数据信道的基带带宽降低为 1.4MHz。

MTC 是一种不需要人为参与的数据通信服务。大规模的 MTC 用户设备部署，可以用于安全、跟踪、付账、测量以及消费电子等领域，具体涉及的应用包括视频监控、供货链跟踪、智能电表，远程监控等。MTC 用户设备要求较低的功率消耗，支持较低的数据传输速率和较低的移动性。

目前 LTE 系统主要是针对人与人（H2H）的通信服务。因此，实现 MTC 服务的规模竞争优势及应用前景，关键环节在于 LTE 网络支持低成本的 MTC 设备能够低成本，低复杂性的工作。

一些 MTC 用户设备需要安装在居民楼地下室或者由绝缘箔片、金属护窗或者传统建筑物的厚墙保护的位置，相比较 LTE 网络中常规设备终端（如手机，平板电脑等），这些设备的空中接口将明显遭受更严重的穿透损失。3GPP 决定研究 LTE 网络提供 MTC 用户设备附加 20dB/15dB 覆盖增强服务的方案设计与性能评估，值得注意的是，位于糟糕网络覆盖区域的 MTC 用户设备具有这样的特点：非常低的数据传输速率，非常宽松的延时要求，以及有限的移动性。针对 MTC 用户设备特点，LTE 网络可以进一步优化一些信令和/或信道用以支持 MTC 用户设备。3GPP 要求为新定义的MTC用户设备以及其他运行MTC服务(如，非常宽松的延迟要求）的用户设备提供一定的 LTE 网络覆盖增强，其中，对于 LTE 频分双工（FDD）网络提供 15dB 的网络覆盖增强。另外，并不是所有的运用 MTC 服务的用户设备都需要相同网络覆盖增强。

在 2014 年 6 月举行的 3GPP RAN#64 次全会上，提出了一个新的面向 Rel-13 的低复杂性和覆盖增强的 MTC 的工作项目（参见非专利文献：RP-140990 New Work Item on Even Lower Complexity and Enhanced Coverage LTE UE for MTC，Ericsson，NSN）。在该工作项目的描述中，LTE Rel-13 系统需要支持上下行 1.4MHz 射频带宽的 MTC 用户设备（User Equipment，UE，以下称为窄带 MTC UE）工作在任意的系统带宽（例如 1.4MHz、3 MHz、5 MHz、10 MHz、15 MHz、20 MHz 等等）下，并且为该类 MTC 用户提供覆盖增强功能。在系统设计时，低成本 MTC 用户和覆盖增强 MTC 用户要采用统一的设计方案。降低 MTC 用户设备的能耗是该工作项目的主要目标之一。

针对 3GPP LTE 用户设备运行 MTC 业务并处于覆盖增强模式下，物理层信道如(E)PDCCH/PDSCH/PUCCH/PUSCH 的覆盖增强设计与配置是一个需要标准化的工作，根据 3GPP RAN1 #74 会议的讨论，在完成初始接入过后，任何一个需要重复传输的物理信道，其配置模式取决于基站端。而 MTC 用户设备合并解调大量重复数据会引入 2 至 10 秒的延迟。这样的延迟会增加MTC用户设备的耗电量。根据 3GPP RAN1 #74b 会议的决定，

对于需要覆盖增强的 MTC 用户设备数据信道的传输应在控制信道传输完成之后。因此为了减少用户设备的耗电量，对于需要覆盖增强的 MTC 用户设备的寻呼消息传输可以不需要控制信道。同时由于低复杂度 MTC 用户设备（Low complexity MTC UE）与覆盖增强的 MTC 用户设备具有相似的信息传输机制，需要设计一种同时针对覆盖增强 MTC 用户设备和/或低复杂度或低成本的 MTC 用户设备的寻呼消息传输机制。因此在 Rel-12 及其之后版本中，针对覆盖增强模式下 MTC 用户设备和/或低复杂度或低成本的 MTC 用户设备的寻呼消息传输需要重新标准化。

发明内容

本发明旨在提供同时针对例如覆盖增强 MTC 用户设备和/或低复杂度或低成本的 MTC 用户设备的寻呼消息传输机制。

根据本发明的一个方案，提供了一种用户设备接收寻呼消息的方法。该方法包括：接收对用于发送所述寻呼消息的物理资源块集的指示，其中，所述物理资源块集在子帧中的索引是根据所述寻呼消息的等级确定的；以及在所指示的物理资源块集上接收所述寻呼消息。

根据本发明的另一个方案，提供了一种网络节点发送寻呼消息的方法。该方法包括：根据所述寻呼消息的等级确定用于发送所述寻呼消息的物理资源块集在子帧中的索引；向作为所述寻呼消息的接收方的用户设备通知对所述物理资源块集的指示，以及在所确定的物理资源块集上发送所述寻呼消息。

根据本发明的另一个方案，提供了一种用户设备。该用户设备包括：接收单元，用于接收对用于发送所述寻呼消息的物理资源块集的指示，以及用于在所指示的物理资源块集上接收所述寻呼消息，其中，所述物理资源块集在子帧中的索引是根据所述寻呼消息的等级确定的。

根据本发明的另一个方案，提供了一种网络节点。该基站包括：块集索引确定单元，用于根据寻呼消息的等级确定用于发送所述寻呼消息的物理资源块集在子帧中的索引，以及发送单元，用于向作为所述寻呼消息的接收方的用户设备通知对所述块集索引确定单元确定的物理资源块集的指示，以及用于在所述确定的物理资源块集上发送所述寻呼消息。

本发明的上述方案简单易行，并且由于用于发送寻呼消息的物理资源块的参数（例如索引）取决于寻呼消息的等级，而该寻呼消息等级同样可用于对 MTC 用户设备进行覆盖增强，因此该方案同时适用于覆盖增强 MTC 用户设备和/或低复杂度或低成本的 MTC 用户设备的寻呼消息传输。

附图说明

通过下文结合附图的详细描述，本发明的上述和其它特征将会变得更加明显，其中：

图 1 示出了根据本发明的接收寻呼消息的方法的流程图；

图 2 示出了根据本发明的发送寻呼消息的方法的流程图；

图 3 示出了根据本发明的用于接收寻呼消息的用户设备的示意性框图；

图 4 示出了根据本发明的用于发送寻呼消息的基站的示意性框图；

图 5 示出了不同等级的寻呼消息的占用的相同大小资源块集的示意图；

图 6 示出了不同等级的寻呼消息与相应的资源块起始位置索引的对应关系的示意图；

图 7 示出了不同等级的寻呼消息的占用的不同大小资源块集的示意图；

图 8 示出了不同等级的寻呼消息与相应占用的资源块集的大小的对应关系的示意图；

图 9 示出了不同寻呼等级与相应的资源块起始位置索引的对应关系的另一示意图；以及

图 10 示出了将系统频带划分为多个子频带的示意图。

具体实施方式

以下将结合附图和具体实施例，对本发明所提出的针对需要额外覆盖增强的 MTC 用户设备或者低复杂度/低成本 MTC 用户设备的寻呼消息在频域资源上的发送/接收方法、网络节点和用户设备（UE）进行详细阐述。应当注意的是，虽然本发明是针对需要额外覆盖增强或者低复杂度/低成本 MTC 用户设备来阐述的，但其同样也适用于其他支持延迟容忍服务和/或需要一定覆盖增强的用户设备。应当注意的是，本发明不应局限于下文所述的具体实施例。另外，为了简便起见，省略了对与本发明没有直接关联的公知技术的详细描述，以防止对本发明的理解造成混淆。

下文以 LTE 移动通信系统及其后续的演进版本作为示例应用环境，具体描述了根据本发明的多个实施例。然而，需要指出的是，本发明不限于以下实施例，而是可适用于更多其它的无线通信系统，例如今后的 5G 蜂窝通信系统或现有的其他通信系统，只要其要求提供同时针对覆盖增强 MTC 用户设备和/或低复杂度或低成本的 MTC 用户设备的寻呼消息传输机制。

图 1 示出了根据本发明的一个实施例的寻呼消息接收方法。在图 1 的步骤 110 中，用户设备接收对用于发送寻呼消息的物理资源块集的指示，其中，物理资源块集在子帧中的索引是根据寻呼消息的等级确定的。在步骤 120 中，用户设备在所指示的物理资源块集上接收寻呼消息。

在本发明的一些实施例中，寻呼消息的等级是通过以下方式之一获得的：由基站通过广播系统信息和/或用户设备专用无线电资源控制信令配置；由网络侧通过 NAS 信令配置；以及由用户设备根据其测量结果确定。

在本发明的一些实施例中，物理资源块集在子帧中的索引是指物理资源块集的起始资源块在子帧中的索引。

在本发明的一些实施例中，物理资源块集的大小对于不同等级的寻呼消息而言是相同的。

在本发明的另一些实施例中，物理资源块集的大小根据寻呼消息的等级确定。

在本发明的一些实施例中，寻呼消息的等级还用于确定一个或多个物理下行共享信道，物理上行共享信道，物理下行控制信道和/或增强型物理下行控制信道，物理上行控制信道和物理随机接入信道的重复次数。

在本发明的一些实施例中，寻呼消息的等级还用于确定一个或多个物理下行共享信道，物理上行共享信道，物理下行控制信道和/或增强型物理下行控制信道，物理上行控制信道和物理随机接入信道的传输时间间隔捆绑大小。

在本发明的一些实施例中，接收对用于发送寻呼消息的物理资源块集的指示包括：通过广播系统信息和/或用户设备专用的无线电资源控制(UE dedicated Radio Resource Control)信令从基站接收物理资源块集在子帧中的索引和/或物理资源块集的大小；或通过非接入层（NAS）信令从网络侧设备接收物理资源块集在子帧中的索引和/或物理资源块集的大小。

在本发明的一些实施例中，该用户设备使用的系统带宽包括 6 个物理资源块。在该情况下，物理资源块集是系统带宽的子集

然而，也可能存在系统带宽大于 6 个物理资源块的情况。在本发明的一些实施例中，当系统带宽大于 6 个物理资源块时，系统带宽可包括多个子频带。该多个子频带中的每一个包含不多于 6 个的物理资源块。例如，在系统带宽中包含的物理资源块的数目能够被 6 整除时，该多个子频带中的每一个包含 6 个物理资源块。然而当系统带宽中包含的物理资源块的数目不能够被 6 整除时，该多个子频带中的一个子频带包含的物理资源块可以小于 6 个，而其他子频带可以均包含 6 个物理资源块。也可以存在其他的子频带分配方式，例如在其他通信系统中可以使用除 6 之外的其他物理资源块数目。只要寻呼消息对应的物理资源块的数目小于该子频带具有的资源块的总数目，便可以使用本文上述的方案确定该子频带中用于该寻呼消息的资源块集的起始位置索引和大小，本发明不受限于系统带宽/子频带中包含的具体资源块的数目。

在上述任一情况下，寻呼消息在多个子频带中由网络节点（例如基站或网络侧）确定的一个子频带上接收。

图 2 示出了根据本发明的一个实施例的网络节点侧的寻呼消息发送方法。在图 2 所示的流程图中，该方法包括：步骤 210，根据寻呼消息的等级确定用于发送寻呼消息的物理资源块集在子帧中的索引；步骤 220，向作为寻呼消息的接收方的用户设备通知对物理资源块集的指示；以及步骤 230，在所确定的物理资源块集上发送寻呼消息。

在本发明的一些实施例中，寻呼消息的等级是通过以下方式之一获得的：由网络节点预先存储，由上级网络节点通知（例如，在网络节点是基站的情况下，由网络侧通过 S1 寻呼消息指示）；以及用户设备根据其测量结果确定并通知网络节点。

在本发明的一些实施例中，物理资源块集在子帧中的索引是指物理资源块集的起始资源块在子帧中的索引。

在本发明的一些实施例中，物理资源块集的大小对于不同等级的寻呼消息而言是相同的。

在本发明的一些实施例中，物理资源块集的大小根据寻呼消息的等级确定。

在本发明的一些实施例中，寻呼消息的等级还用于确定一个或多个物理下行共享信道，物理上行共享信道，物理下行控制信道和/或增强型物理下行控制信道，物理上行控制信道和物理随机接入信道的重复次数。

在本发明的一些实施例中，寻呼消息的等级还用于确定一个或多个物理下行共享信道，物理上行共享信道，物理下行控制信道和/或增强型物理下行控制信道，物理上行控制信道和物理随机接入信道的传输时间间隔捆绑大小。

在本发明的一些实施例中，向作为寻呼消息的接收方的用户设备通知对物理资源块集的指示包括：如果网络节点是基站，通过广播系统信息和/或用户设备专用的无线电资源控制信令向用户设备发送物理资源块集在子帧中的索引和/或物理资源块集的大小；或如果网络节点是网络侧设备，通过非接入层信令向用户设备发送物理资源块集在子帧中的索引和/或物理资源块集的大小。然而本发明不限于此，例如基站也可以使用其他的群发机制（例如，多播机制等）来发送物理资源块集在子帧中的索引。

在本发明的一些实施例中，网络节点为用户设备分配的系统带宽包括 6 个物理资源块。在该情况下，物理资源块集是所述系统带宽的子集。

在本发明的一些实施例中，当网络节点为用户设备分配的系统带宽大于 6 个物理资源块时，将所述系统带宽划分为包含不多于 6 个物理资源块的多个子频带，以及确定所述多个子频带中要在其上向用户设备发送寻呼消息的一个子频带。

图 3 示出了用于根据本发明的实施例发送寻呼消息的用户设备。该用户设备至少包括：接收单元 310，用于接收对用于发送寻呼消息的物理资源块集的指示，且用于在所指示的物理资源块集上接收寻呼消息，其中，物理资源块集在子帧中的索引是根据寻呼消息的等级确定的。

在本发明的一些实施例中，寻呼消息的等级是由基站通过广播系统信息和/或用户设备专用无线电资源控制信令配置或由网络侧通过 NAS 信令配置，并通过接收单元 310 接收的。在本发明的另一些实施例中，用户设

备还包括用于测量信道状态的测量单元 320，以及用于根据测量单元的测量结果确定寻呼消息的等级的等级确定单元 330。

在本发明的一些实施例中，物理资源块集在子帧中的索引是指物理资源块集的起始资源块在子帧中的索引。

在本发明的一些实施例中，物理资源块集的大小对于不同等级的寻呼消息而言是相同的。

在本发明的一些实施例中，物理资源块集的大小由网络节点（根据不同的实现，可以是基站或网络侧设备，如移动性管理实体（MME））根据寻呼消息的等级确定，并通过广播系统信息和/或用户设备专用无线电资源控制信令由接收单元 310 接收。

对物理资源块集的指示可以包括物理资源块集在子帧中的索引以及物理资源块集的大小。在本发明的一些实施例中，接收单元 310 还用于通过广播系统信息和/或用户设备专用的无线电资源控制(UE dedicated RRC)信令从基站接收物理资源块集在子帧中的索引和/或物理资源块集的大小。或者在其他一些实施例中，接收单元 310 还用于通过非接入层信令从网络侧设备接收物理资源块集在子帧中的索引和/或物理资源块集的大小。

在本发明的一些实施例中，用户设备使用的系统带宽包括 6 个物理资源块，以及物理资源块集是所述系统带宽的子集。

在本发明的一些实施例中，当用户设备使用的系统带宽大于 6 个物理资源块时，系统带宽包括多个子频带，该多个子频带中的每一个包含不多于 6 个的物理资源块。在该情况下，寻呼消息由接收单元 310 在所述多个子频带中由网络节点（基站或网络侧）确定的一个子频带上接收。

在本发明的一些实施例中，用户设备还包括存储器 340，用于存储接收单元 310 接收到的各种信息，例如寻呼消息、物理资源块集的大小、物理资源块集在子帧中的索引以及其他用户设备接收到的信息等。存储器 350 还可以存储测量单元 320、等级确定单元 330 所使用或输出的信息，例如测量单元 320 的测量结果，在该情况下，等级确定单元 330 可从存储器 350 获得该测量结果。存储器 350 还可以存储发送单元 340 要发送的信息，例如等级确定单元 330 确定的寻呼消息的等级。

图 4 示出了根据本发明的实施例发送寻呼消息的网络节点。图 4 示出

的网络节点至少包括：块集索引确定单元 410，用于根据寻呼消息的等级确定用于发送寻呼消息的物理资源块集在子帧中的索引；以及发送单元 420，用于向作为寻呼消息的接收方的用户设备通知对块集索引确定单元 410 确定的物理资源块集的指示，以及用于在所确定的物理资源块集上发送寻呼消息。

在本发明的一些实施例中，网络节点还包括接收单元 430。其中，寻呼消息的等级由网络节点预先存储，或者由上级网络节点通知，或由用户设备根据其测量结果确定并通知网络节点，并由接收单元 430 接收。

在本发明的一些实施例中，物理资源块集在子帧中的索引是指物理资源块集的起始资源块在子帧中的索引。

在本发明的一些实施例中，物理资源块集的大小对于不同等级的寻呼消息而言是相同的。

在本发明的一些实施例中，网络节点还包括：块集大小确定单元 440，用于根据寻呼消息的等级确定物理资源块集的大小。

在本发明的一些实施例中，网络节点还包括：重复次数确定单元 450，用于根据寻呼消息的等级确定一个或多个物理下行共享信道，物理上行共享信道，物理下行控制信道和/或增强型物理下行控制信道，物理上行控制信道和物理随机接入信道的重复次数。

在本发明的一些实施例中，网络节点还包括：捆绑大小确定单元 460，用于根据寻呼消息的等级确定一个或多个物理下行共享信道，物理上行共享信道，物理下行控制信道和、或增强型物理下行控制信道，物理上行控制信道和物理随机接入信道的传输时间间隔捆绑大小。

在本发明的一些实施例中，如果网络节点是基站，发送单元 420 通过广播系统信息和/或用户设备专用的无线电资源控制(UE dedicated RRC)信令向用户设备发送物理资源块集在子帧中的索引和/或物理资源块集的大小；或者如果网络节点是网络侧设备，发送单元 420 通过非接入层信令向用户设备发送物理资源块集在子帧中的索引和/或物理资源块集的大小。

在本发明的一些实施例中，网络节点为用户设备分配的系统带宽包括 6 个物理资源块。在该情况下所述物理资源块集是系统带宽的子集。

在本发明的一些实施例中，网络节点还包括：子频带划分单元 470，用于当网络节点为用户设备分配的系统带宽大于 6 个物理资源块时，将所述系统带宽划分为包含不多于 6 个物理资源块的多个子频带；以及子频带确定单元 480，用于确定所述子频带划分单元 470 划分的所述多个子频带中要在其上向用户设备发送寻呼消息的一个子频带。

在本发明的一些实施例中，网络节点还包括存储器 490。存储器 490 可存储发送单元 420 要发送的信息，如寻呼消息，也可以存储接收单元 430 接收到的信息，例如接收单元 430 从网络侧（例如 MME）或用户设备接收到的寻呼消息的等级。存储器 490 还可以存储块集索引确定单元 410、块集大小确定单元 440、重复次数确定单元 450、捆绑大小确定单元 460、子频带划分单元 470、子频带确定单元 480 等单元所需的信息或输出的信息。

本发明的上述网络节点可以是基站，也可以是网络侧设备，例如网络侧的移动性管理实体（MME），当然，也可以是本领域技术人员通常使用来配置传输/移动性参数的任何网络侧设备。本发明不对此进行限制。

需要注意的是，在图 3 和图 4 中描述的用户设备和网络节点仅是为了使本领域技术人员更清楚地理解本发明而作的图，其中省略了一些对理解本发明不必要的模块/组件，本发明的保护范围不应受这些附图的具体细节所限制。此外，实际的设备中可以包括更多的模块/组件，如显示器、操作维护接口（对于图 4 中的网络节点）、输入输出接口等等。本发明不对这些进行限制。

下面将参考图 5 至图 10 来对图 1 和图 2 中示出的方法以及图 3 和图 4 中示出的设备进行更详细地阐述。需要注意的是，本发明中多数信息的确定和发送既可以由基站完成，也可以由网络侧设备完成。因此，除非特别说明，在本说明书中可以将术语基站、网络侧设备（如 MME）以及网络节点交换使用。此外，如上所述，虽然本发明主要针对需要额外覆盖增强或者低复杂度/低成本 MTC 用户设备来阐述的，但其同样也适用于其他支持延迟容忍服务和/或需要一定覆盖增强的用户设备。

对覆盖增强 MTC UE 而言，其上、下行物理信道需要多次重复发送，以满足信道的覆盖增强要求。处于不同地理位置的 UE 所需的信道覆盖增强程度不一样，导致处于不同地理位置的 UE 的物理信道所需重复发送的

次数不同。因此，可以将物理信道的覆盖增强程度分为若干个不同的覆盖增强等级。而不同覆盖增强等级的物理信道，其所需重复发送的次数不同。例如，可以将物理信道分为四个覆盖增强等级（CE0, CE1, CE2 和 CE3），每个覆盖增强等级对应物理信道所需的不同覆盖增强补偿，例如，CE0 指代的是覆盖增强等级 0，即不需要覆盖增强；CE1 指代的是覆盖增强等级 1，即需要例如 1~5dB 覆盖增强，其物理信道大致需要数次重复传输；CE2 指代的是覆盖增强等级 2，即需要例如 6~10dB 覆盖增强，其物理信道大致需要十数次重复传输；CE3 指代的是覆盖增强等级 3，即需要例如 11~15dB 覆盖增强，其物理信道大致需要数十次重复传输。然而，需要注意的是，本发明的技术方案不限于四个覆盖增强等级，而是可以根据需要采用更多或更少的覆盖增强等级。还需要注意的是，上述物理信道的重复次数仅是为了使本领域技术人员理解本发明而给出的示例，具体系统中使用的重复次数不限于上述次数，而是可以根据系统需求/限制（例如系统资源限制）选择更多或更少的次数。

由于寻呼消息对应的控制信道不传输，因此需要给出 MTC 用户设备的寻呼消息在频域上的位置。在本发明的技术方案中，网络节点（例如基站）将不同等级的寻呼消息映射到不同的资源块集（RBgroup）来指示寻呼消息在频域上的位置。在本文中，资源块集指的是寻呼消息在子帧上占用的物理资源块的集合。资源块集的大小是指寻呼消息在子帧上占用的资源块的数目。此处资源块集可以是物理资源块集（PRB group），也可以是虚拟资源块集（VRB group），物理资源块与虚拟资源块间的映射关系可参考 3GPP TS36.211 6.2.3.1，本发明不再进行赘述。在本发明的技术方案中，可以对多个资源块进行虚拟连续分配，即虚拟资源块集的集中式分配（virtual resource blocks of localized type）。此处虚拟资源块集的集中式分配指的是将虚拟资源块 n_{VRB} 直接映射到物理资源块 n_{PRB}。而虚拟资源块的大小与物理资源块的大小一致。

寻呼消息可以占用多个子帧，不同等级的寻呼消息占用的子帧数目可以不同。不同的用户设备占用的子帧也可以不同。例如，用户设备可根据用户 ID 在不同的子帧上接收寻呼消息，或通过 3GPP 协议中用于寻呼消息的时域复用的方法来进行子帧分配。在本发明的一些实施例中，需要确定确定两个参数，承载寻呼消息的物理资源块集的起始位置及连续分配的

资源块数目。然而在另一些实施例中，由于承载寻呼消息的物理资源块集的大小（即，连续分配的资源块数目）被预先确定，且对于不同等级的寻呼消息而言是相同的，仅需要确定物理资源块集的起始位置。

再次返回图 2，在图 2 的步骤 210 中，根据寻呼消息的等级确定用于发送寻呼消息的物理资源块集在子帧中的索引。该步骤由图 4 中的块集索引确定单元 410 执行。在本发明中，物理资源块集的起始位置与物理资源块集在子帧中的索引表达相同的概念，可相互交换使用。基于承载不同等级的寻呼消息的资源块集的大小是否一致，本发明提出了两种方案。网络节点和用户设备可同时支持两种方式或其中的一种。

图 5 示出了承载不同等级的寻呼消息的资源块集的大小一致的情况。如图 5 所示，系统带宽为 6 个物理资源块大小，且承载不同等级的寻呼消息的资源块集的大小是一样的，相应的资源块集的起始位置由基站和/或网络侧（例如 MME）配置，其原则可以是尽量利用子帧中的物理资源块，也可以是本领域技术人员可想到或通常使用的其他原则。在图 5 所示的示例中，资源块集的起始位置与不同等级的寻呼消息的关系可以是：覆盖增强等级 0 的寻呼消息对应的资源块集的起始位置索引为 0 或 4；覆盖增强等级 1 的寻呼消息对应的资源块集的起始位置索引为 1；覆盖增强等级 2 的寻呼消息对应的资源块集的起始位置索引为 2；覆盖增强等级 3 的寻呼消息对应的资源块集的起始位置索引为 3。在图 5 的示例中，相应的承载寻呼消息的资源块集的大小为例如 2 个资源块，然而在其他示例中也可以是更大或更小的其他数目，且可以采用与图 5 不同的索引分配模式。

寻呼消息的等级可以由基站通过广播信息和/或用户设备专用 RRC 信令配置给用户设备，或者可以由网络侧（例如 MME）通过 NAS 信令配置给用户设备。在一些示例中，寻呼消息的等级可以由用户设备根据自己的下行链路测量结果确定。例如，用户设备通过测量单元 320 执行信道测量，并使用等级确定单元 330 根据测量得到的下行信道的参考信号接收功率（RSRP）值与特定阈值比较。该特定阈值可以是在 3GPP 技术规范 TS36.104 中规定的阈值，可由用户设备通过接收单元 310 从基站/网络侧先行接收到的，并预先存储在用户设备的存储单元 350 中。如果大于或等于该阈值，则等级确定单元 330 确定寻呼消息等级为 0；小于该阈值 1~5dB，则确定寻呼消息等级为 1；小于该阈值 6~10dB，则确定寻呼消息等级为 2；

小于该阈值 11~15dB，则确定寻呼消息等级为 3。

可选地，在确定寻呼消息等级之后，用户设备/基站/网络侧可存储该寻呼消息等级，以用于下一次的资源块集起始位置确定或用于其他用途。

在块集索引确定单元 410 确定用于发送寻呼消息的物理资源块集在子帧中的索引之后，在步骤 220 中，网络节点向作为寻呼消息的接收方的用户设备通知对物理资源块集的指示。在一些实施例中，该对物理资源块集的指示可包括块集索引确定单元 410 确定的物理资源块集在子帧中的索引，并可选地包括物理资源块集的大小。然而在另一些实施例中，物理资源块集的大小已由被预先通知给了用户设备。

承载不同等级的寻呼消息的资源块的数目可以是预定的，并例如可由基站通过广播信息和/或用户设备专用 RRC 信令配置给用户设备。在其他一些示例中，承载不同等级的寻呼消息的资源块的数目可以由网络侧（例如，MME）通过 NAS 信令配置。此外，基站可通过广播系统信息和/或用户设备专用 RRC 信令通知物理资源块集在子帧中的索引；或网络侧（例如，MME）可通过 NAS 信令通知该索引。在本发明中，子帧中承载寻呼消息的资源块集的索引与这些资源块中起始资源块的索引表达相同的含义，可以互换使用。

在一些示例中，寻呼消息的等级可被基站的重复次数确定单元 450 用于确定一个或多个物理下行共享信道，物理上行共享信道，物理下行控制信道，物理上行控制信道和物理随机接入信道的重复次数。

在一些示例中，寻呼消息的等级可被基站的捆绑大小确定单元 460 用于确定一个或多个物理下行共享信道，物理上行共享信道，物理下行控制信道，物理上行控制信道和物理随机接入信道的 TTI bundle（Transmission Time Interval bundle: 传输时间间隔捆绑）大小。

图 6 示出了不同等级的寻呼消息与相应的资源块起始位置索引的对应关系的另一示意图。然而该图仅是为说明本发明而做出的示例，本发明不应被其所限制。例如，寻呼消息等级也可以对应于两个资源块起始位置，如索引 0 和 4，而不仅限于索引 0。

图 7 示出了承载不同等级的寻呼消息的资源块集的大小不一致的情况。如图 7 所示，系统带宽为 6 个物理资源块大小，且承载不同等级的寻呼消息的资源块集的大小是不一样的，相应的资源块集的起始位置由基站和/

或网络侧（例如，MME）配置，其原则可以是尽量利用子帧中的物理资源块，也可以是本领域技术人员可想到或通常使用的其他原则。在图 7 所示的示例中，资源块集的起始位置与不同等级的寻呼消息的关系可以是：覆盖增强等级 0 的寻呼消息对应的资源块集的起始位置索引为 0；覆盖增强等级 1 的寻呼消息对应的资源块集的起始位置索引为 3；覆盖增强等级 2 的寻呼消息对应的资源块集的起始位置索引为 2；覆盖增强等级 3 的寻呼消息对应的物理资源块集的起始位置索引为 1。

在图 7 示出的示例中，承载不同等级的寻呼消息的资源块集的大小不一致，因此需要对资源块集的大小进行确定。该操作可以由图 4 中的块集大小确定单元 440 执行。在一些示例中，承载不同等级的寻呼消息的资源块的数目可以是：覆盖增强等级 0 的寻呼消息对应的资源块的数目为 2；覆盖增强等级 1 的寻呼消息对应的资源块的数目为 3；覆盖增强等级 2 的寻呼消息对应的资源块的数目为 4；覆盖增强等级 3 的寻呼消息对应的资源块的数目为 5。当然，本领域技术人员也可以根据实际需求（例如系统资源限制等）选择不同的资源块集大小分配方案，理论上只要覆盖增强等级较高的寻呼消息对应更多数目的资源块即可。

图 7 所示情形的其他技术特征与图 5 所示情形相同，在此不再赘述。

图 8 示出了在承载不同等级的寻呼消息的资源块集的大小不一致的情况下，寻呼消息等级与资源块集大小的映射关系。图 9 示出了在承载不同等级的寻呼消息的资源块集的大小不一致的情况下，寻呼消息等级与资源块起始位置的映射关系。如上所述，这些映射关系都仅是为了说明本发明而做出的示例，本发明不应被其所限制。

在块集索引确定单元 410 确定用于发送寻呼消息的物理资源块集在子帧中的索引以及块集大小确定单元 440 确定该物理资源块集的大小之后，在步骤 220 中，网络节点向作为寻呼消息的接收方的用户设备通知对物理资源块集的指示。在一些实施例中，该对物理资源块集的指示可包括块集索引确定单元 410 确定的物理资源块集在子帧中的索引以及块集大小确定单元 440 确定的该物理资源块集的大小。

在步骤 230 中，网络单元的发送单元 420 在所确定的物理资源块集上发送寻呼消息。

然而，在 3GPP LTE 中，也可能存在系统带宽大于 6 个物理资源块的

情况。图 10 示出了在该情形下根据本发明的处理。如图 10 所示，当系统带宽大于 6 个物理资源块时，可将系统带宽分成多个子频带。在每一个子频带中依然可执行图 1-9 中所示的技术方案。在图 10 所示情况下，网络节点还需要通过发送单元 430 向用户设备通知子频带的划分。子频带可以是连续的 6 个物理资源块。同样地，子频带的划分可以由基站通过广播系统信息和/或用户设备专用无线电资源控制信令配置给用户设备，或者由网络侧（例如，MME）通过 NAS 信令配置给用户设备。

作为一般性的示例，可以假设系统带宽包含 M 个 PRB，并可被划分成 N 个子频带，其中 M 和 N 需满足 N = floor（M，6），即 N 是小于 M 除与 6 的最大自然数。这样整个系统带宽可划分为 N 个带宽大小为 6 个物理资源块的子频带和一个带宽大小为（M-6*N）个物理资源块的子频带。从上式可以看出，在 M 不是 6 的整倍数的情况下，可能包括子频带具有小于 6 个物理资源的情况。在这种情况下，只要寻呼消息对应的物理资源块的数目小于该子频带具有的资源块的总数目，依然可以使用本文上述的方案确定该子频带中用于该寻呼消息的资源块集的起始位置索引和大小，本发明不受限于系统带宽/子频带中包含的具体资源块的数目。

用户设备需要在一个子频带上接收寻呼消息，该子频带是在配置/确定物理资源块集在子帧中的索引和/或物理资源块的大小之前确定的。在本发明的一些实施例中，可以根据寻呼消息的等级来确定用户设备所使用的子频带。例如可通过以下公式：**[*index of sub-band*] = [*UE ID*] mod [*the number of sub-band*]**来确定用户设备所使用的子频带。其中 UE ID 可以是国际移动用户标识（IMSI，International Mobile Subscriber Identity），用于在核心网中唯一标识一个用户。该标识存储在 SIM 卡中。当然，在本发明的其他实施例中，本领域技术人员也可以使用唯一标识用户的其他可能的标识符，并对上式进行适应性修改，本发明不对此进行限制。

在用户设备侧，用户设备的接收单元 310 在步骤 110 中接收对用于发送寻呼消息的物理资源块集的指示。该指示可以包括其用于接收寻呼消息的物理资源块集在子帧中的索引。在一些情况下，该指示还可以包括物理资源块集的大小。而在另一些情况下，物理资源块集的大小已由网络节点确定并在之前发送给用户设备（例如，物理资源块集的大小对不同寻呼消息等级而言固定的情况下）。

然后，在步骤 120 中，用户设备可通过接收单元 310 在所指示的物理资源块集上接收寻呼消息。

当用户设备处于 RRC CONNECT 状态时，基站和/或网络侧（例如，MME）已经配置用户设备工作在一个子频带上接收数据。此时，当用户设备需要被寻呼时，该寻呼消息可在当前的子频带上传输，用于发送该寻呼消息的物理资源块集可通过根据本发明附图 1 至 9 中所述的方法来确定。

应该理解，本发明的上述实施例可以通过软件、硬件或者软件和硬件两者的结合来实现。例如，上述实施例中的基站和用户设备内部的各种组件可以通过多种器件来实现，这些器件包括但不限于：模拟电路器件、数字电路器件、数字信号处理（DSP）电路、可编程处理器、专用集成电路（ASIC）、现场可编程门阵列（FPGA）、可编程逻辑器件（CPLD），等等。

在本申请中，“基站”是指具有较大发射功率和较广覆盖面积的移动通信数据和控制交换中心，包括资源分配调度、数据接收发送等功能。“用户设备”是指用户移动终端，例如包括移动电话、笔记本等可以与基站或者微基站进行无线通信的终端设备。

此外，这里所公开的本发明的实施例可以在计算机程序产品上实现。更具体地，该计算机程序产品是如下的一种产品：具有计算机可读介质，计算机可读介质上编码有计算机程序逻辑，当在计算设备上执行时，该计算机程序逻辑提供相关的操作以实现本发明的上述技术方案。当在计算系统的至少一个处理器上执行时，计算机程序逻辑使得处理器执行本发明实施例所述的操作（方法）。本发明的这种设置典型地提供为设置或编码在例如光介质（例如 CD-ROM）、软盘或硬盘等的计算机可读介质上的软件、代码和/或其他数据结构、或者诸如一个或多个 ROM 或 RAM 或 PROM 芯片上的固件或微代码的其他介质、或一个或多个模块中的可下载的软件图像、共享数据库等。软件或固件或这种配置可安装在计算设备上，以使得计算设备中的一个或多个处理器执行本发明实施例所描述的技术方案。

尽管以上已经结合本发明的优选实施例示出了本发明，但是本领域的技术人员将会理解，在不脱离本发明的精神和范围的情况下，可以对本发明进行各种修改、替换和改变。因此，本发明不应由上述实施例来限定，而应由所附权利要求及其等价物来限定。

权 利 要 求

1. 一种用户设备接收寻呼消息的方法，包括：

接收对用于发送所述寻呼消息的物理资源块集的指示，其中，所述物理资源块集在子帧中的索引是根据所述寻呼消息的等级确定的；以及

在所指示的物理资源块集上接收所述寻呼消息。

2. 根据权利要求1所述的方法，其中，所述寻呼消息的等级是通过以下方式之一获得的：

由基站通过广播信息和/或用户设备专用无线电资源控制信令配置；

由网络侧通过NAS信令配置；以及

由所述用户设备根据其测量结果确定。

3. 根据权利要求1所述的方法，其中，所述物理资源块集在子帧中的索引是指所述物理资源块集的起始资源块在子帧中的索引。

4. 根据权利要求1所述的方法，其中，所述物理资源块集的大小对于不同等级的寻呼消息而言是相同的。

5. 根据权利要求1所述的方法，其中，所述物理资源块集的大小根据所述寻呼消息的等级确定。

6. 根据权利要求1所述的方法，其中，所述寻呼消息的等级还用于确定一个或多个物理下行共享信道，物理上行共享信道，物理下行控制信道和/或增强型物理下行控制信道，物理上行控制信道和物理随机接入信道的重复次数。

7. 根据权利要求1所述的方法，其中，所述寻呼消息的等级还用于确定一个或多个物理下行共享信道，物理上行共享信道，物理下行控制信道和/或增强型物理下行控制信道，物理上行控制信道和物理随机接入信道的传输时间间隔捆绑大小。

8. 根据权利要求1所述的方法，其中，接收对用于发送所述寻呼消息的物理资源块集的指示包括：

通过广播系统信息和/或用户设备专用无线电资源控制信令从基站接收所述物理资源块集在子帧中的索引和/或所述物理资源块集的大小；或

通过非接入层信令从网络侧设备接收所述物理资源块集在子帧中的

索引和/或所述物理资源块集的大小。

9. 根据权利要求1所述的方法，其中，所述用户设备使用的系统带宽包括6个物理资源块，以及所述物理资源块集是所述系统带宽的子集。

10. 根据权利要求1所述的方法，其中，当所述用户设备使用的系统带宽大于6个物理资源块时，所述系统带宽包括多个子频带，所述多个子频带中的每一个包含不多于6个的物理资源块，所述寻呼消息在所述多个子频带中由网络节点确定的一个子频带上接收。

11. 一种网络节点发送寻呼消息的方法，包括：

根据所述寻呼消息的等级确定用于发送所述寻呼消息的物理资源块集在子帧中的索引；

向作为所述寻呼消息的接收方的用户设备通知对所述物理资源块集的指示，以及

在所确定的物理资源块集上发送所述寻呼消息。

12. 根据权利要求11所述的方法，其中，所述寻呼消息的等级是通过以下方式之一获得的：

由所述网络节点预先存储；

由上级网络节点通知；或

用户设备根据其测量结果确定并通知所述网络节点。

13. 根据权利要求11所述的方法，其中，所述物理资源块集在子帧中的索引是指所述物理资源块集的起始资源块在子帧中的索引。

14. 根据权利要求11所述的方法，其中，所述物理资源块集的大小对于不同等级的寻呼消息而言是相同的。

15. 根据权利要求11所述的方法，其中，所述物理资源块集的大小根据所述寻呼消息的等级确定。

16. 根据权利要求11所述的方法，其中，所述寻呼消息的等级还用于确定一个或多个物理下行共享信道，物理上行共享信道，物理下行控制信道和/或增强型物理下行控制信道，物理上行控制信道和物理随机接入信道的重复次数。

17. 根据权利要求11所述的方法，其中，所述寻呼消息的等级还用于确定一个或多个物理下行共享信道，物理上行共享信道，物理下行控制信

道和/或增强型物理下行控制信道，物理上行控制信道和物理随机接入信道的传输时间间隔捆绑大小。

18. 根据权利要求11所述的方法，其中，向作为所述寻呼消息的接收方的用户设备通知对所述物理资源块集的指示包括：

如果所述网络节点是基站，通过广播系统信息和/或用户设备专用无线电资源控制信令向所述用户设备发送所述物理资源块集在子帧中的索引和/或所述物理资源块集的大小；或

如果所述网络节点是网络侧设备，通过非接入层信令向所述用户设备发送所述物理资源块集在子帧中的索引和/或所述物理资源块集的大小。

19. 根据权利要求11所述的方法，其中，所述网络节点为用户设备分配的系统带宽包括6个物理资源块，以及所述物理资源块集是所述系统带宽的子集。

20. 根据权利要求11所述的方法，还包括：当所述网络节点为用户设备分配的系统带宽大于6个物理资源块时，将所述系统带宽划分为包含不多于6个物理资源块的多个子频带，以及确定所述多个子频带中要在其上向所述用户设备发送寻呼消息的一个子频带。

21. 一种用户设备，包括：

接收单元，用于接收对用于发送所述寻呼消息的物理资源块集的指示，以及用于在所指示的物理资源块集上接收所述寻呼消息，其中，所述物理资源块集在子帧中的索引是根据所述寻呼消息的等级确定的。

22. 根据权利要求21所述的用户设备，其中，所述寻呼消息的等级是由基站通过广播信息和/或用户设备专用无线电资源控制信令配置或由网络侧通过NAS信令配置，并通过所述接收单元接收的；或者

所述用户设备还包括：

测量单元，用于测量信道状态；以及

等级确定单元，用于根据所述测量单元的测量结果确定所述寻呼消息的等级。

23. 根据权利要求21所述的用户设备，其中，所述物理资源块集在子帧中的索引是指所述物理资源块集的起始资源块在子帧中的索引。

24. 根据权利要求21所述的用户设备，其中，所述物理资源块集的大

小对于不同等级的寻呼消息而言是相同的。

25. 根据权利要求21所述的用户设备，其中，所述物理资源块集的大小由网络节点根据所述寻呼消息的等级确定，并通过广播信息和/或用户设备专用无线电资源控制信令由所述接收单元接收。

26. 根据权利要求21所述的用户设备，其中，对所述物理资源块集的指示包括所述物理资源块集在子帧中的索引以及所述物理资源块集的大小；以及

所述接收单元还用于通过广播系统信息和/或用户设备专用无线电资源控制信令从基站接收所述物理资源块集在子帧中的索引和/或所述物理资源块集的大小；或

所述接收单元还用于通过非接入层信令从网络侧设备接收所述物理资源块集在子帧中的索引和/或所述物理资源块集的大小。

27. 根据权利要求21所述的用户设备，其中，所述用户设备使用的系统带宽包括6个物理资源块，以及所述物理资源块集是所述系统带宽的子集。

28. 根据权利要求21所述的用户设备，其中，当所述用户设备使用的系统带宽大于6个物理资源块时，所述系统带宽包括多个子频带，所述多个子频带中的每一个包含不多于6个的物理资源块，所述寻呼消息由所述接收单元310在所述多个子频带中由网络节点确定的一个子频带上接收。

29. 一种网络节点，包括：

块集索引确定单元，用于根据寻呼消息的等级确定用于发送所述寻呼消息的物理资源块集在子帧中的索引；以及

发送单元，用于向作为所述寻呼消息的接收方的用户设备通知对所述块集索引确定单元确定的物理资源块集的指示，以及用于在所述确定的物理资源块集上发送所述寻呼消息。

30. 根据权利要求29所述的网络节点，还包括接收单元，

其中，所述寻呼消息的等级由所述网络节点预先存储，或者由上级网络节点通知，或者由用户设备根据其测量结果确定并通知所述网络节点，并由所述接收单元接收。

31. 根据权利要求29所述的网络节点，其中，所述物理资源块集在子

帧中的索引是指所述物理资源块集的起始资源块在子帧中的索引。

32 根据权利要求29所述的网络节点，其中，所述物理资源块集的大小对于不同等级的寻呼消息而言是相同的。

33. 根据权利要求29所述的网络节点，还包括：块集大小确定单元，用于根据所述寻呼消息的等级确定所述物理资源块集的大小。

34. 根据权利要求29所述的网络节点，还包括：重复次数确定单元，用于根据所述寻呼消息的等级确定一个或多个物理下行共享信道，物理上行共享信道，物理下行控制信道和/或增强型物理下行控制信道，物理上行控制信道和物理随机接入信道的重复次数。

35. 根据权利要求29所述的网络节点，还包括：捆绑大小确定单元，用于根据所述寻呼消息的等级确定一个或多个物理下行共享信道，物理上行共享信道，物理下行控制信道和/或增强型物理下行控制信道，物理上行控制信道和物理随机接入信道的传输时间间隔捆绑大小。

36. 根据权利要求29所述的网络节点，其中，对所述物理资源块集的指示包括所述物理资源块集在子帧中的索引以及所述物理资源块集的大小；以及

如果所述网络节点是基站，所述发送单元通过广播系统信息和/或用户设备专用无线电资源控制信令向用户设备发送所述物理资源块集在子帧中的索引和/或所述物理资源块集的大小；或

如果所述网络节点是网络侧设备，所述发送单元通过非接入层信令向用户设备发送所述物理资源块集在子帧中的索引和/或所述物理资源块集的大小。

37. 根据权利要求29所述的网络节点，其中，所述网络节点为用户设备分配的系统带宽包括6个物理资源块，以及所述物理资源块集是所述系统带宽的子集。

38. 根据权利要求29所述的网络节点，还包括：

子频带划分单元，用于当所述网络节点为用户设备分配的系统带宽大于6个物理资源块时，将所述系统带宽划分为包含不多于6个物理资源块的多个子频带；以及

子频带确定单元，用于确定所述子频带划分单元划分的所述多个子频

带中要在其上向用户设备发送寻呼消息的一个子频带。

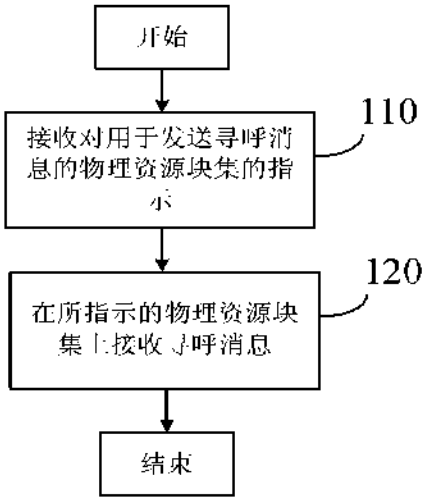

开始
接收对用于发送寻呼消息的物理资源块集的指示
110
在所指示的物理资源块集上接收寻呼消息
120
结束

图1

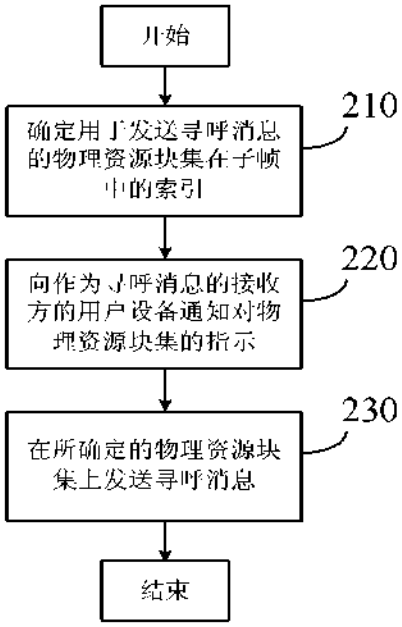

开始
确定用于发送寻呼消息的物理资源块集在子帧中的索引
210
向作为寻呼消息的接收方的用户设备通知对物理资源块集的指示
220
在所确定的物理资源块集上发送寻呼消息
230
结束

图2

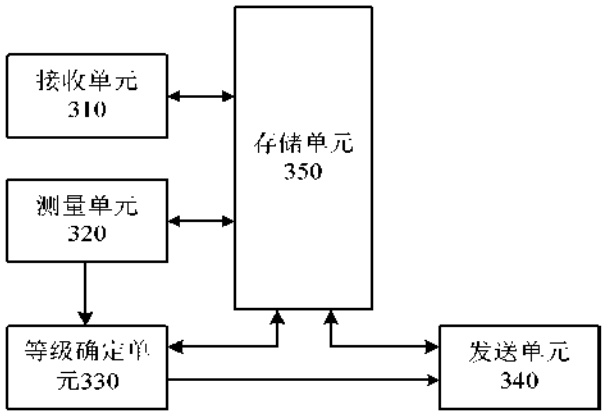

接收单元
310
测量单元
320
存储单元
350
等级确定单元330
发送单元
340

图3

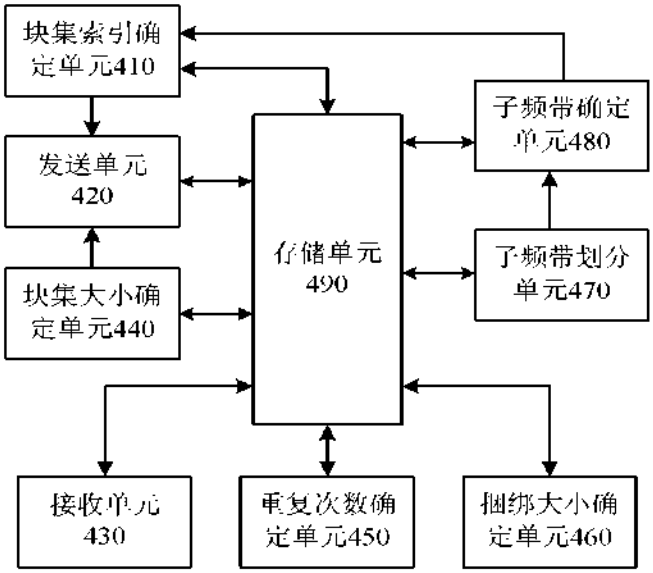

块集索引确定单元410
发送单元
420
块集大小确定单元440
存储单元
490
子频带确定单元480
子频带划分单元470
接收单元
430
重复次数确定单元450
捆绑大小确定单元460

图4

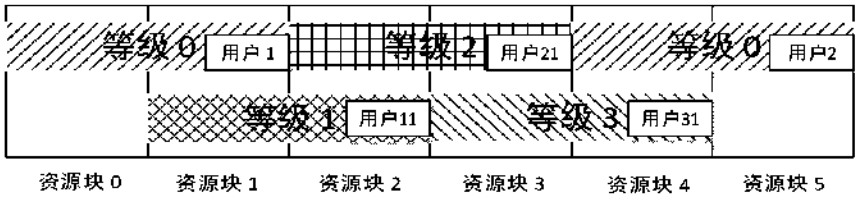


图5

寻呼消息等级	资源块起始位置
0	0
1	1
2	2
3	3

图6

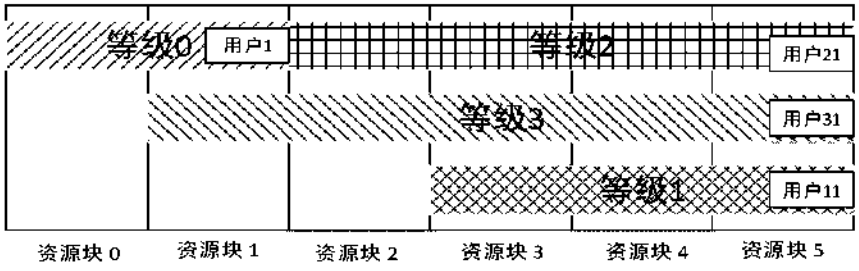


图7

寻呼消息等级	资源块集大小
0	2
1	3
2	4
3	5

图8

寻呼消息等级	资源块起始位置
0	0
1	3
2	2
3	1

图9

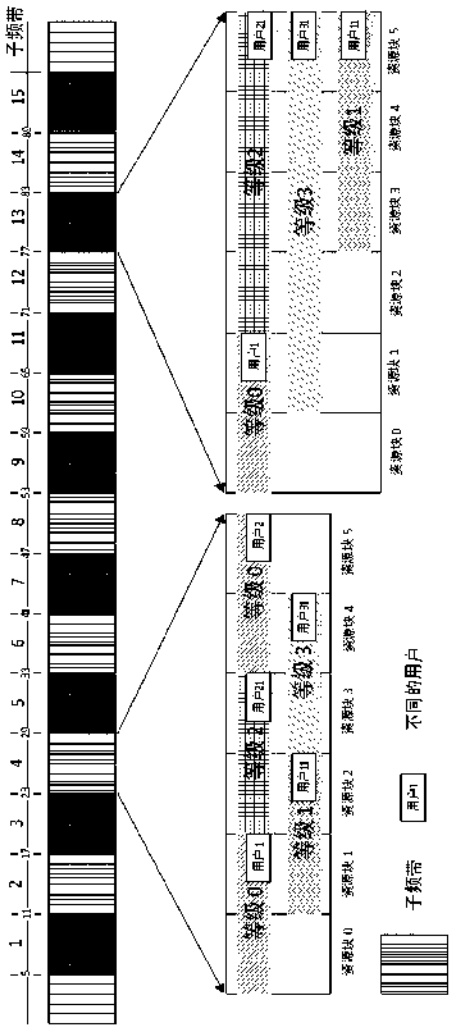

子频带
等级0
等级1
等级2
等级3
用户1
用户2
用户3
资源块0
资源块1
资源块2
资源块3
资源块4
资源块5
子频带
用户
不同的用户

图10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2015/099191

A. CLASSIFICATION OF SUBJECT MATTER

H04W 72/04 (2009.01) i; H04W 4/00 (2009.01) i; H04W 68/00 (2009.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04W; H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNPAT, CNKI, WPI, EPODOC, 3GPP: paging message, machine type, MTC, paging, coverage enhancement, machine type communication, level, physical resource block, instruction, indication, user equipment, network node, index

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 104137635 A (HUAWEI TECHNOLOGIES CO., LTD.), 05 November 2014 (05.11.2014), description, paragraphs [0170]-[0243]	1-38
A	CN 103517420 A (HUAWEI DEVICE CO., LTD.), 15 January 2014 (15.01.2014), the whole document	1-38
A	CN 102223412 A (VIA TELECOM, INC.), 19 October 2011 (19.10.2011), the whole document	1-38
A	US 2012064932 A1 (ELECTRONICS AND TELECOMMUNICATIONS RESEARCH INSTITUTE), 15 March 2012 (15.03.2012), the whole document	1-38

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 March 2016 (18.03.2016)	**29 March 2016 (29.03.2016)**
Name and mailing address of the ISA/CN: State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No.: (86-10) 62019451	Authorized officer **ZHANG, Qi** Telephone No.: (86-10) **62413262**

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2015/099191

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 104137635 A	05 November 2014	EP 2953409 A1	09 December 2015
		WO 2014131167 A1	04 September 2014
		US 2015365914 A1	17 December 2015
CN 103517420 A	15 January 2014	EP 2846594 A1	11 March 2015
		WO 2013185624 A1	19 December 2013
		US 2015092735 A1	02 April 2015
CN 102223412 A	19 October 2011	US 2011310769 A1	22 December 2011
US 2012064932 A1	15 March 2012	KR 20120028197 A	22 March 2012

Form PCT/ISA/210 (patent family annex) (July 2009)

国际检索报告

国际申请号
PCT/CN2015/099191

A. 主题的分类

H04W 72/04(2009.01)i; H04W 4/00(2009.01)i; H04W 68/00(2009.01)i

按照国际专利分类(IPC)或者同时按照国家分类和IPC两种分类

B. 检索领域

检索的最低限度文献(标明分类系统和分类号)

H04W; H04Q

包含在检索领域中的除最低限度文献以外的检索文献

在国际检索时查阅的电子数据库(数据库的名称，和使用的检索词（如使用）)

CNPAT, CNKI, WPI, EPODOC, 3GPP: 寻呼消息，覆盖增强，机器类型，MTC，等级，物理资源块，指示，用户设备，网络节点，索引, paging, coverage enhancement, machine type communication, level, physical resource block, instruction, indication, user equipment, network node, index

C. 相关文件

类 型*	引用文件，必要时，指明相关段落	相关的权利要求
X	CN 104137635 A (华为技术有限公司) 2014年 11月 5日 (2014-11-05) 说明书第[0170]-[0243]段	1-38
A	CN 103517420 A (华为终端有限公司) 2014年 1月 15日 (2014-01-15) 全文	1-38
A	CN 102223412 A (美商威睿电通公司) 2011年 10月 19日 (2011-10-19) 全文	1-38
A	US 2012064932 A1 (ELECTRONICS AND TELECOMMUNICATIONS RESEARCH INSTITUTE) 2012年 3月 15日 (2012-03-15) 全文	1-38

☐ 其余文件在C栏的续页中列出。

☑ 见同族专利附件。

* 引用文件的具体类型：

"A" 认为不特别相关的表示了现有技术一般状态的文件

"E" 在国际申请日的当天或之后公布的在先申请或专利

"L" 可能对优先权要求构成怀疑的文件，或为确定另一篇引用文件的公布日而引用的或者因其他特殊理由而引用的文件（如具体说明的）

"O" 涉及口头公开、使用、展览或其他方式公开的文件

"P" 公布日先于国际申请日但迟于所要求的优先权日的文件

"T" 在申请日或优先权日之后公布，与申请不相抵触，但为了理解发明之理论或原理的在后文件

"X" 特别相关的文件，单独考虑该文件，认定要求保护的发明不是新颖的或不具有创造性

"Y" 特别相关的文件，当该文件与另一篇或者多篇该类文件结合并且这种结合对于本领域技术人员为显而易见时，要求保护的发明不具有创造性

"&" 同族专利的文件

国际检索实际完成的日期	国际检索报告邮寄日期
2016年 3月 18日	2016年 3月 29日
ISA/CN的名称和邮寄地址 中华人民共和国国家知识产权局(ISA/CN) 中国北京市海淀区蓟门桥西土城路6号 100088 传真号 (86-10)62019451	受权官员 张琦 电话号码 (86-10)62413262

表 PCT/ISA/210 (第2页) (2009年7月)

国际检索报告
关于同族专利的信息

国际申请号
PCT/CN2015/099191

检索报告引用的专利文件			公布日（年/月/日）	同族专利			公布日（年/月/日）
CN	104137635	A	2014年 11月 5日	EP	2953409	A1	2015年 12月 9日
				WO	2014131167	A1	2014年 9月 4日
				US	2015365914	A1	2015年 12月 17日
CN	103517420	A	2014年 1月 15日	EP	2846594	A1	2015年 3月 11日
				WO	2013185624	A1	2013年 12月 19日
				US	2015092735	A1	2015年 4月 2日
CN	102223412	A	2011年 10月 19日	US	2011310769	A1	2011年 12月 22日
US	2012064932	A1	2012年 3月 15日	KR	20120028197	A	2012年 3月 22日

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(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

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9 February 2017 (09.02.2017)

WIPO | PCT

(10) International Publication Number
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PCT/US2015/066149

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16 December 2015 (16.12.2015)

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(30) **Priority Data**:
62/201,735 6 August 2015 (06.08.2015) US

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(72) **Inventors**: **XIONG, Gang**; 16682 NW Arizona Drive, Beaverton, OR 97006 (US). **HE, Hong**; 8F,Raycom Infotech Park A, No.2, KeXueYuan South Road, HaiDian District, Beijing, Heilongjiang 100190 (CN). **CHATTERJEE, Debdeep**; 725 Mariposa Avenue, Apt. 301, Mountain View, CA 94041 (US). **BENDLIN, Ralf**; 15447 NW Nightshade Drive, Portland, OR 97229 (US). **KECICIOGLU, Balkan**; MS JF3-336, 2111 NE 25th Avenue, Hillsboro, OR 97124 (US).

(74) **Agent**: **HAYMOND, Alex, W.**; Thorpe North & Western LLP, c/o CPA Global, P.O. Box 52050, Minneapolis, MN 55402 (US).

(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to the identity of the inventor (Rule 4.17(i))*

[Continued on next page]

(54) **Title**: PERFORMING MISSION CRITICAL COMMUNICATIONS AT A USER EQUIPMENT (UE)

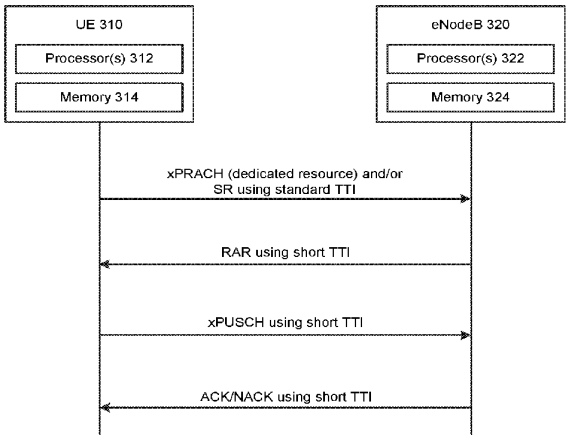


FIG. 3

(57) **Abstract**: Technology for a user equipment (UE) operable to perform mission critical communications with an eNodeB is disclosed. The UE can transmit a physical random access channel (PRACH) signal to the eNodeB that indicates a mission critical communication to be performed between the UE and the eNodeB. The PRACH signal can be transmitted in accordance with a first transmission time interval (TTI). The UE can receive a random access response (RAR) message from the eNodeB that includes a timing advance (TA) and a resource allocation for the mission critical communication. The RAR message can be transmitted from the eNodeB using a second TTI. The UE can perform the mission critical communication with the eNodeB in an uplink using the TA and the resource allocation indicated in the RAR message. The mission critical communication can be performed using a physical uplink shared channel (PUSCH) and in accordance with the second TTI.

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Published:

— *with international search report (Art. 21(3))*

PERFORMING MISSION CRITICAL COMMUNICATIONS AT A USER EQUIPMENT (UE)

BACKGROUND

[0001] Wireless mobile communication technology uses various standards and protocols to transmit data between a node (e.g., a transmission station) and a wireless device (e.g., a mobile device). Some wireless devices communicate using orthogonal frequency-division multiple access (OFDMA) in a downlink (DL) transmission and single carrier frequency division multiple access (SC-FDMA) in uplink (UL). Standards and protocols that use orthogonal frequency-division multiplexing (OFDM) for signal transmission include the third generation partnership project (3GPP) long term evolution (LTE), the Institute of Electrical and Electronics Engineers (IEEE) 1202.16 standard (e.g., 1202.16e, 1202.16m), which is commonly known to industry groups as WiMAX (Worldwide interoperability for Microwave Access), and the IEEE 1202.11 standard, which is commonly known to industry groups as WiFi.

[0002] In 3GPP radio access network (RAN) LTE systems, the node can be a combination of Evolved Universal Terrestrial Radio Access Network (E-UTRAN) Node Bs (also commonly denoted as evolved Node Bs, enhanced Node Bs, eNodeBs, or eNBs) and Radio Network Controllers (RNCs), which communicates with the wireless device, known as a user equipment (UE). The downlink (DL) transmission can be a communication from the node (e.g., eNodeB) to the wireless device (e.g., UE), and the uplink (UL) transmission can be a communication from the wireless device to the node.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] Features and advantages of the disclosure will be apparent from the detailed description which follows, taken in conjunction with the accompanying drawings, which together illustrate, by way of example, features of the disclosure; and, wherein:

[0004] FIG. 1 illustrates a flexible radio access technology (RAT) in accordance with an example;

[0005] FIG. 2 illustrates a subframe structure for low latency applications in accordance

with an example;

[0006] FIG. 3 illustrates a mission critical communication between a user equipment (UE) and an eNodeB in accordance with an example;

[0007] FIG. 4 illustrates a partition of a physical random access channel (PRACH) preamble resource in accordance with an example;

[0008] FIG. 5 illustrates a multiplexing of a physical random access channel (PRACH) signal and a scheduling request (SR) message in a repeated transmission in accordance with an example;

[0009] FIG. 6 illustrates a random access response (RAR) window for repeated transmissions between a user equipment (UE) and an eNodeB in accordance with an example;

[0010] FIGS. 7A to 7C illustrates a resource allocation of a primary partition and a secondary partition within a transmission time interval (TTI) in accordance with an example;

[0011] FIG. 8 illustrates a repeated transmission of a random access response (RAR) message using a short transmission time interval (TTI) in accordance with an example;

[0012] FIG. 9 depicts functionality of a user equipment (UE) operable to perform mission critical communications with an eNodeB in accordance with an example;

[0013] FIG. 10 depicts functionality of a base station operable to receive mission critical communications from a user equipment (UE) in accordance with an example;

[0014] FIG. 11 depicts a flowchart of a machine readable storage medium having instructions embodied thereon for performing mission critical communications between a user equipment (UE) and an eNodeB in accordance with an example;

[0015] FIG. 12 illustrates a diagram of a wireless device (e.g., UE) in accordance with an example; and

[0016] FIG. 13 illustrates a diagram of a wireless device (e.g., UE) in accordance with an example.

[0017] Reference will now be made to the exemplary embodiments illustrated, and specific language will be used herein to describe the same. It will nevertheless be

understood that no limitation of the scope of the technology is thereby intended.

DETAILED DESCRIPTION

[0018] Before the present technology is disclosed and described, it is to be understood that this technology is not limited to the particular structures, process actions, or materials disclosed herein, but is extended to equivalents thereof as would be recognized by those ordinarily skilled in the relevant arts. It should also be understood that terminology employed herein is used for the purpose of describing particular examples only and is not intended to be limiting. The same reference numerals in different drawings represent the same element. Numbers provided in flow charts and processes are provided for clarity in illustrating actions and operations and do not necessarily indicate a particular order or sequence.

EXAMPLE EMBODIMENTS

[0019] An initial overview of technology embodiments is provided below and then specific technology embodiments are described in further detail later. This initial summary is intended to aid readers in understanding the technology more quickly but is not intended to identify key features or essential features of the technology nor is it intended to limit the scope of the claimed subject matter.

[0020] The field of mobile communications has evolved significantly from early voice systems to today's highly sophisticated integrated communication platform. 4G Long Term Evolution (LTE) networks are deployed in more than 100 countries to provide services in various spectrum band allocations depending on spectrum regime. Recently, significant momentum has started to build around the idea of a next generation, i.e., fifth generation (5G) wireless communications technology.

[0021] A wide range of potential applications and services have been identified for the 5G system. Some examples include (1) enhanced mobile broadband, (2) massive machine type communications (MTC), and (3) ultra-reliable and low latency or mission critical communications. In enhanced mobile broadband, increased data rates is expected to be a key driver in network development and evolution for the 5G system. A peak data rate of more than 10 gigabits per second (Gbps) and a minimum guaranteed user data rate of at

least 100 megabits per second (Mbps) are envisioned for the 5G system. With respect to massive MTC, the support of a massive number of Internet of Things (IoT) or MTC devices is expected to be a key feature for the 5G system. MTC devices can be used for a wide variety of applications. MTC devices use low operational power consumption and are expected to communicate with infrequent small burst transmissions. Finally, with respect to ultra-reliable and low latency or mission critical communications, the support of mission critical MTC applications for the 5G system can necessitate a high level of reliable connectivity with guaranteed low latency, availability and reliability-of-service.

[0022] FIG. 1 illustrates an exemplary flexible radio access technology (RAT). The flexible RAT, also referred to as a 5G xRAT, can function to address the diverse features of the 5G system, such as the enhanced mobile broadband, massive MTC, and ultra-reliable and low latency or mission critical communications. The flexible RAT can define a unified framework that supports these diverse applications and services. In addition, the flexible RAT can support multiple frequency bands, multiple application/services, licensed/unlicensed frequency, and multiple RATs.

[0023] As shown in FIG. 1, the flexible RAT can be represented in two dimensions – frequency and time. Multiple RATs/sub-RATs/partitions or applications in the same frequency resources or frequency bands (or different frequency resources or frequency bands) can be multiplexed using time-division multiplexing (TDM), frequency-division multiplexing (FDM), code-division multiplexing (CDM), or a combination of the above.

[0024] In one example, the flexible RAT can include a medium/high frequency band, as well as a low frequency band. In the low frequency band, there can be a primary partition. The primary partition can be in accordance with a standard transmission time interval (TTI). As an example, the standard TTI can be for a Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) Release 8 orthogonal frequency division multiple access (OFDMA) frame structure. The standard TTI can be approximately one millisecond (ms) in duration. Furthermore, in the low frequency band, there can be a first secondary partition and a second secondary partition. The primary partition and the secondary partition can be in both time and frequency. The first secondary partition can be in accordance with a short TTI and the second secondary partition can be in accordance with a long TTI. In general, the short TTI can have a duration that is less than

the standard TTI, and the long TTI can have a duration that is greater than the standard TTI. As non-limiting examples, the short TTI can be approximately 0.1 to 0.2 ms in duration, and the long TTI can be approximately 5 ms in duration. In one example, the primary partition in the flexible RAT can be utilized for non-mission critical communications (e.g., voice, data), and the secondary partition in the flexible RAT can be utilized for mission critical communications.

[0025] In one example, for a carrier frequency below 6 Gigahertz (GHz), the primary partition can reuse existing LTE numerology, while the secondary partition can be designed to support low latency or mission critical MTC applications. In particular, the short TTI can enable the low latency for mission critical MTC communications. In addition, increased subcarrier spacing, e.g., 75 kilohertz (kHz), can be adopted for the secondary partition. In contrast, a 15 KHz subcarrier spacing can be utilized for the primary partition.

[0026] FIG. 2 illustrates an exemplary subframe structure for low latency applications. The subframe structure can be for a secondary partition in a low frequency band, and the secondary partition can be associated with a short TTI of approximately 0.1 to 0.2 ms in duration. In one example, the subframe structure for the secondary partition can be based on an orthogonal frequency division multiplexing (OFDM) waveform.

[0027] In the example shown in FIG. 2, a 0.2ms TTI can be achieved. Within one TTI, 12 OFDM symbols can be grouped together (e.g., symbol 0 to symbol 11). Each OFDM symbol can have a duration of 13.3 micro seconds (us). A cyclic prefix (CP) can be inserted between each OFDM symbol. A CP length can be approximately 3.3 us or 512 samples if a sampling rate is 153.6MHz.

[0028] As described in further detail below, a system and method for mission critical communications in a 5G system is described. The mission critical communication can be performed at a user equipment (UE) in a radio resource control (RRC) idle mode. In one example, the procedure can involve a "keep trying" mechanism in which transmissions are repeated to ensure robust communication. The repeated transmissions can provide the ultra-reliability for the mission critical communication. The procedure can involve using a short transmission time interval (TTI) for signaling between the UE and an eNodeB, thereby providing the low latency for the mission critical communication. In one

example, dedicated resources can be used for a 5G physical random access channel (xPRACH) transmission that triggers or indicates the mission critical communication. The xPRACH transmission can be combined with a contention based scheduling request (SR). In addition, the procedure can involve information content, resource allocation and transmission schemes for random access response (RAR) messages with respect to the mission critical communication.

[0029] FIG. 3 illustrates an exemplary mission critical communication between a user equipment (UE) 310 and an eNodeB 320. In one example, the UE 310 can be a mission critical machine type communication (MTC) device. The UE 310 can initially be in a radio resource control (RRC) idle mode. The UE can include one or more processors 312 and memory 314, and the eNodeB 320 can include one or more processors 322 and memory 324. The mission critical communication between the UE 310 and the eNodeB 320 can include four distinct actions. In a first action, the UE 310 can transmit a fifth generation (5G) physical random access channel (xPRACH) signal to the eNodeB 320 using a dedicated resource to indicate or trigger the mission critical communication. To enable faster uplink access and transmission, the xPRACH signal can be combined together with a scheduling request (SR) message. The xPRACH signal and/or SR message can be transmitted using a standard transmission time interval (TTI) in a primary partition. The standard TTI can be approximately one millisecond (ms) in duration. In addition, the dedicated resource can be represented in the form of an xPRACH preamble signature/sequence, time and frequency resource. In a second action, after successful detection of the xPRACH signal and/or decoding of the SR message, the eNodeB 320 can transmit a random access response (RAR) message using a short TTI in a secondary partition. The short TTI can be approximately 0.1 to 0.2 ms in duration. In general, the short TTI is associated with a time interval that is less than the standard TTI. In one example, the standard TTI can be referred to as a first TTI and the short TTI can be referred to as a second TTI, wherein the second TTI is associated with a time interval that is less than the first TTI. The RAR message may include a timing advance (TA), a resource allocation for an uplink transmission, etc. In a third action, after successfully decoding the RAR message, the UE 310 can transmit uplink data (i.e., the mission critical data) to the eNodeB 320 in a 5G physical uplink shared channel (xPUSCH) using the short TTI in the secondary partition. In other words, the mission critical communication

from the UE 310 to the eNodeB 320 is performed using the 5G xPUSCH and the short TTI. The uplink data in the xPUSCH can be transmitted on the allocated resource in the RAR message. In a fourth action, the eNodeB 320 can transmit acknowledgement (ACK) or negative acknowledgement (NACK) information to the UE 310. The ACK/NACK information can be transmitted in a 5G physical downlink control channel (xPDCCH) or a 5G physical hybrid-ARQ indicator channel (xPHICH) using the short TTI in the secondary partition. The four actions involved in performing the mission critical communication are described in further detail below.

[0030] In one configuration, a transmitter (e.g., the UE 310 or the eNodeB 320) can keep transmitting the signal until a response is received from a receiver (e.g., the eNodeB 320 or the UE 310). This "keep trying" mechanism can ensure high robustness of the reception, which is essential for the mission critical communication. For instance, in the first action, the UE 310 can continue transmitting the xPRACH signal on the dedicated resource until the UE 310 receives the RAR message from the eNodeB 320. The "keep trying" mechanism can be viewed as an early termination of a repeated transmission. In other words, the transmitter can terminate the repeated transmission when the transmitter receives a response/feedback from the receiver. In addition, a maximum repetition number for each action (e.g., actions 1-4 as described above) can be predefined or configured by higher layers via a 5G master information block (xMIB), a 5G system information block (xSIB) or dedicated RRC signaling. When the transmission reaches the maximum repetition number, the UE 310 can perform a random back-off on the xPRACH signal to re-initiate the mission critical communication.

[0031] In one configuration, for each action (e.g., actions 1-4 as described above), the transmitter can repeat the transmission using a fixed number of repetitions (K repetitions). The number of repetitions can be predefined or configured by higher layers via the xMIB, the xSIB or dedicated RRC signaling. In one example, the value of K can be configured as 1, which indicates that no repetition is used for the transmission. When the transmission reaches the fixed repetition number, the UE 310 can perform a random back-off on the xPRACH signal to re-initiate the mission critical communication, or the UE 310 can indicate a random access problem to upper layers in order to trigger corresponding procedure(s).

[0032] In one example, a combination of the above options can be considered for the transmission of channels and signals in each action (e.g., actions 1-4 as described above). In particular, the transmitter can keep sending the signal until the transmitter receives the response from the receiver, wherein each transmission occupies K repetitions. Similar to the above option, the number of repetitions (K) in each transmission can be predefined or configured by higher layers via the xMIB, the xSIB or dedicated RRC signaling.

[0033] In one configuration, a set of dedicated resources can be allocated for the transmission of the xPRACH signal from the UE to indicate or trigger the mission critical communication. The dedicated xPRACH resources can be multiplexed with resources for other applications (i.e., non-mission critical applications) using TDM or FDM or CDM, or a combination of the above. In addition, the partition of the set of dedicated resources for mission critical communications and the resources for other applications can be predefined or configured by higher layer via the xMIB, the xSIB or dedicated RRC signaling.

[0034] In one example, the xPRACH signal can be transmitted using the standard TTI (e.g., 1 ms duration) on the primary partition. Several options can be utilized to allocate the dedicated resource for the transmission of the xPRACH signal. For example, one or a plurality of signatures can be reserved for the xPRACH signal to indicate or trigger the mission critical communication. In addition, to handle the mission critical communication with different applications/services, one or a plurality of dedicated preamble signatures can be reserved for each specific event.

[0035] FIG. 4 illustrates an exemplary partition of a physical random access channel (PRACH) preamble resource. The PRACH preamble resource can include a fifth generation (5G) xPRACH preamble resource. The partition of the xPRACH preamble resource can be for mission critical applications, as well as other applications (i.e., non-mission critical applications). In other words, the xPRACH preamble resource can include a first resource for other applications and a second resource for mission critical applications. In addition, the partition of the xPRACH preamble resource can be associated with different applications and/or events. For example, the xPRACH preamble resource size or the number of reserved sequences for each event can be different. For instance, event #1 in the resource for mission critical applications can correspond to a

mission critical application for earthquake event, and one preamble signature can be reserved for event #1. Event #2 in the resource for mission critical applications can correspond to a mission-critical Vehicular to Vehicular (V2V) application, and five preamble signatures can be reserved for event #2.

[0036] In one example, one or a plurality of frequency resources can be allocated for the xPRACH signal to trigger the mission critical communication. When the UE transmits the xPRACH signal in the dedicated frequency resource, the eNodeB can transmit the corresponding RAR message using the short TTI on the secondary partition. The eNodeB can transmit the corresponding RAR message upon successful detection of xPRACH signal.

[0037] In one example, one or a plurality of time resources can be allocated for the xPRACH signal to trigger the mission critical communication. For example, the xPRACH signal for other applications (i.e., non-mission critical applications) can be transmitted in subframe 0, 2, 4, 6, 8 within one frame, while the xPRACH signal used to trigger the mission critical communication can be transmitted in subframe 1, 3, 5, 7, 9 within one frame.

[0038] In one example, a combination of TDM and/or FDM and/or CDM based multiplexed schemes can be used to separate the resource for mission critical applications and other applications (i.e., non-mission critical applications). For example, a combination of FDM and CDM multiplexing schemes can be utilized, i.e., one additional frequency resource can be reserved for mission critical applications, and within this dedicated frequency resource, different mission critical applications/services can be separated using different xPRACH preamble signatures.

[0039] In another example, a combination of TDM and CDM multiplexing schemes can be utilized. The xPRACH signal for the other application (i.e., a non-mission critical application) can be transmitted in subframe 0, 2, 4, 6, 8 within one frame, while the xPRACH signal used to trigger the mission critical communication can be transmitted in subframe 1, 3, 5, 7, 9 within one frame. Further, different mission critical applications/services can be separated using different xPRACH preamble signatures.

[0040] In one example, with respect to ultra-reliable and low latency communications, multiple mission critical devices can operate as a "single frequency network" (SFN),

which can improve a link level performance for mission critical communication. In this case, the eNodeB can treat multiple mission critical devices as a single mission critical device. For example, the eNodeB can transmit a single RAR message to multiple UEs, and in response, multiple UEs can transmit uplink data (i.e., mission critical data) simultaneously to the eNodeB on the same time and frequency resource.

[0041] In one example, in order to differentiate a typical operation from a "single frequency network" type of operation, different xPRACH resources can be allocated. For example, one event ID or dedicated xPRACH signature can be allocated for the "single frequency network" type of operation. In addition, when repeated transmissions of the xPRACH preamble are used, a starting subframe of the repeated xPRACH transmission can be predefined or configured by higher layers, thereby causing the eNodeB to perform efficient detection of the repeated xPRACH signal.

[0042] A more detailed description is now provided with respect to the first action shown in FIG. 3, in which the UE can transmit the 5G xPRACH signal and/or SR message to the eNodeB using dedicated resources to indicate or trigger the machine critical communication. The xPRACH signal transmission can be combined with a contention based scheduling request (SR) message to allow uplink access in a reduced amount of time, thereby fulfilling the latency constraints for mission critical communications. The contention based SR message can include the UE ID and buffer status report to enable uplink access in the reduced amount of time.

[0043] For mission critical applications, the SR message can be transmitted from the UE to the eNodeB as part of a random access channel (RACH) procedure, which allows for a reduction in connection establishment delay as compared to existing LTE systems. The SR message can be a fixed size and can include several parameters/fields. The SR message can include a mission critical MTC device ID, which can be the same as the UE ID or a different ID. The SR message can include an event ID to indicate an access cause when a same set of xPRACH sequences are allocated for multiple applications/services. The event ID can be included in the SR message to expedite access for the UE. The SR message can include a mission critical MTC device capability, which can include mission critical specific UE radio access capability information, such as carrier aggregation (CA) capability, i.e., component carrier (CC) index(s) that are supported by the UE (e.g., the

mission critical MTC device), supported multiple input multiple output (MIMO) capability, etc. The SR message can include a resource request and modulation and coding scheme (MCS) for an uplink transmission (e.g., mission critical data) from the UE. For example, the SR message can include the resource request in the time and frequency domain, e.g., physical resource block (PRB) index or numbers within one band, or symbol/slot/subframe/frame index or CC index(s) used for the uplink transmission. Alternatively, the UE can indicate the total amount of data for mission critical application and/or channel state information (CSI)/reference signaling measurements, which can subsequently be used for downlink MCS selection and open loop power control calculation.

[0044] In one example, when the resource request of PRB index and MCS are included in the SR message, the eNodeB can feedback 1 bit ACK/NACK information to the UE (or mission critical MTC device). Upon successful ACK detection, the UE can use the resource indicated in the SR message for uplink data transmission based on a predefined timing following a subframe in which the ACK/NACK information is detected.

[0045] In one example, the "keep trying" mechanism or repeated transmission can be employed when transmitting the xPRACH signal and/or SR message to the eNodeB. The same xPRACH preamble signature and the same SR information can be used for the transmission of the xPRACH signal and the SR message during the repetition, respectively. In addition, the SR message can occupy the resource allocated for the SR transmission to further enhance the link level performance.

[0046] In one example, UEs may not have the xPRACH/SR repetition capability, or the function may not be configured at the UE by the eNodeB. In this case, different xPRACH and/or SR resources can be used with respect to (1) an initial transmission that is shared among all UEs and (2) subsequent repeated transmission that is dedicated for UEs enabled with the xPRACH/SR repetition capability. In one example, the resource for the initial transmission of the xPRACH signal and SR message can be selected by the UE within a contention-based resource region, while the resources for subsequent repeated transmissions can be configured by higher-layers (e.g., broadcasted in the xSIB) within a contention-free resource region on the same partition or a different partition.

[0047] In one example, available sets of xPRACH or SR resources reserved for the UE

(e.g., a mission critical MTC device) can be divided into two different regions – a first region can be used for the xPRACH/SR transmission repetition and the second region can be reserved for the xPRACH/SR transmission without repetition. More specifically, an xPRACH signal or SR message can be repeatedly transmitted on a configurable or fixed consecutive xPRACH or SR resources within the first region according to a known pattern (e.g., TDM, CDM or FDM). The number of repetition times can be predefined or configured by higher layers for an individual UE. In addition, one-to-one mapping between the xPRACH repetition level and the xPRACH/SR resource set can be utilized. The UE can select an xPRACH/SR repetition level based on a measurement, such as a reference signal received power (RSRP), and the UE can transmit the xPRACH/SR using the xPRACH/SR resources set according to the selected xPRACH/SR repetition level.

[0048] FIG. 5 illustrates an exemplary multiplexing of a physical random access channel (PRACH) signal and a scheduling request (SR) message in a repeated transmission. The PRACH signal can include a fifth generation (5G) xPRACH signal. Various multiplexing mechanisms, such as time division multiplexing (TDM) or frequency division multiplexing (FDM), can be applied to the xPRACH signal and the SR message. As shown in FIG. 5, TDM multiplexing can be used for repeated transmissions of the xPRACH signal and the SR message, or FDM multiplexing can be used for repeated transmissions of the xPRACH signal and the SR message. In other words, TDM and FDM based multiplexing mechanisms can be applied to the "keep trying" mechanism for repeated transmissions. In addition, the SR message can be transmitted using all the available resource to achieve ultra-reliable communication.

[0049] In one example, with respect to transmission power control mechanism for the transmission of the xPRACH signal and/or the SR message, several options can be used. In one example, when (re)transmitting the xPRACH signal and/or SR message, a maximum transmit power can be used to ensure robust detection at the eNodeB. In another example, an existing power control mechanism can be applied for the transmission and retransmission of the xPRACH signal and/or SR message. In particular, for an initial transmission, the xPRACH transmission power can be set to an initial PRACH power, while for the retransmission, power ramping can be used to increase the actual transmission power.

[0050] In yet another example with respect to transmission power control, repetition level ramping can be applied for the transmission and retransmission of the xPRACH signal and/or SR message. Further, the repetition level ramping mechanism can be combined in conjunction with power ramping to further improve the performance. In one example, the repetition level can be doubled for each retransmission. In the initial transmission, the repetition level can be defined as K, while in the first retransmission, the repetition level can be set to 2K, etc. Additionally, if power ramping is applied on top of the repetition level ramping, the power ramping can be defined so as to account for an increase in the repetition level. Specifically, the power level for the first attempt at a subsequent repetition level can be reduced by a factor of 10*log(numRepL/numRepL-1), wherein numRepL and numRepL-1 are the number of repetitions configured for repetition levels L and L-1, respectively.

[0051] A more detailed description is now provided with respect to the second action shown in FIG. 3, in which the eNodeB can transmit the RAR message to the UE using the short TTI. After identifying the mission critical event based on detection of the xPRACH signal, the eNodeB can dynamically allocate the resource in a secondary partition, and the eNodeB can transmit the corresponding RAR message using the short TTI.

[0052] For mission critical MTC applications, a fixed relationship can be defined between the time (e.g., a last repetition/retransmission) of the xPRACH transmission and a time of the first transmission of the xPDCCH/xPDSCH signal (either scheduling or carrying the RAR message). Additionally, the frequency resource for the xPDCCH (if xPDCCH is not wideband) or xPDSCH can be determined as a function of at least the preamble sequence of the detected xPRACH signal, and possibly also the frequency location of the detected xPRACH signal. If additional flexibility is desired at the eNodeB, then for time-domain scheduling of the RAR message, a short RAR window can be defined in which the UE monitors for the first transmission of the xPDCCH/xPDSCH signal with the RAR message.

[0053] FIG. 6 illustrates an exemplary random access response (RAR) window for repeated transmissions between a user equipment (UE) and an eNodeB. When repeated transmissions are used for the xPRACH signal and/or SR message, the RAR window can be defined such that the UE (e.g., a mission critical MTC device) can monitor for the

RAR message within the RAR window. As shown in FIG. 6, the xPRACH signal and SR message can be transmitted in an uplink in accordance with a standard TTI (e.g., 1 ms in duration). After transmission of the xPRACH signal and SR message, the RAR window can be defined. During the RAR window, the UE can monitor a downlink for the RAR message. The UE can detect the RAR message during the RAR message, wherein the RAR message is transmitted in accordance with a short TTI. In one example, the position of the RAR window can be predefined or configured by higher layer via the xMIB, the xSIB or dedicated RRC signaling. In addition, the starting position of the RAR window can be defined relative to the starting of the last subframe of the repeated xPRACH signal and/or SR message transmission.

[0054] FIGS. 7A to 7C illustrates exemplary resource allocations of a primary partition and a secondary partition within a transmission time interval (TTI). The TTI can be a standard TTI with a duration of one millisecond (ms). Guard bands can be inserted between the primary and secondary partitions in a frequency domain in order to reduce inter-carrier interference.

[0055] As shown in FIG. 7A, a secondary partition using a short TTI (e.g., 0.1 to 0.2 ms) can be allocated after an xPDCCH region. The xPDCCH region can be in the primary partition using the standard TTI. When different numerologies, e.g., subcarrier spacing, are used for the primary and secondary partitions, a guard time may be inserted between the xPDCCH region using the standard TTI and the secondary partition using the short TTI. This option may avoid traffic interruption for the primary partition, as the eNodeB can schedule the downlink and uplink transmission via the xPDCCH within the primary partition.

[0056] As shown in FIG. 7B, a secondary partition using a short TTI (e.g., 0.1 to 0.2 ms) can be allocated after an xPDCCH region. The xPDCCH region can be in the primary partition using the standard TTI. Further, the secondary partition can occupy a full system bandwidth to enhance the link level performance. In this approach, guard times may not be inserted between the xPDCCH region using the standard TTI and the secondary partition using the short TTI.

[0057] As shown in FIG. 7C, a secondary partition using a short TTI (e.g., 0.1 to 0.2 ms) can span a standard TTI (e.g., 1 ms). In this approach, the secondary partition can occupy

a full system bandwidth to enhance the link level performance. In addition, a guard time may be inserted to reduce interference in a primary partition.

[0058] In one example, the resource allocation for the secondary partition can be predefined, or broadcasted in a mission critical specific xSIB message, or indicated in a downlink control information (DCI) format in the xPDCCH using the standard TTI in the primary partition. In the latter case, the UE (e.g., a mission critical MTC device) can monitor the xPDCCH with a cyclic redundancy check (CRC) scrambled by an existing random-access radio network temporary identifier (RA-RNTI) or a newly defined RA-RNTI for mission critical applications. The RA-RNTI can be predefined in the specification or defined as a function of at least one of: the time index, frequency index, preamble sequence, and repetition level used for the detected xPRACH transmission. Upon successful decoding of the xPDCCH signal, the UE can switch to a short TTI mode and decode the RAR message within the secondary partition.

[0059] FIG. 8 illustrates an exemplary repeated transmission of a random access response (RAR) message using a short transmission time interval (TTI). The "keep trying" mechanism or repeated transmissions of the RAR message can be used to improve the link level performance. The repeated RAR transmissions using the short TTI can occur within a secondary partition used for mission critical communication. As shown in FIG. 8, a preamble can be inserted before each transmission of the RAR message to improve a downlink synchronization accuracy, which is useful in view of the higher sampling rate used for the short TTI with large subcarrier spacing (e.g., 15 KHz). The preamble can utilize similar principles as compared to the 5G downlink synchronization channel (xSCH). To differentiate the preamble from the xSCH, independent root sequences can be employed when Zadoff-Chu (ZC) sequences are used for the xSCH.

[0060] In one example, the RAR message can include various parameters. For example, the RAR message can include a timing advance (TA). The eNodeB can estimate an initial TA from the xPRACH signal sent by the UE. The RAR message can include an UL grant for a subsequent uplink transmission. In addition, the UL grant can include a resource allocation of the secondary partition used for the subsequent uplink transmission. When the UE (e.g., a mission critical MTC device) supports carrier aggregation (CA), the resource allocation for multiple component carriers (CCs) can be included in the uplink

grant. The UL grant can include a modulation and coding scheme (MCS) and a power control parameter for the subsequent uplink transmission, as well as the number of repetitions used for the RAR transmission. In one example, the RAR message can include a mission critical MTC device ID, which can be used for contention resolution. The RAR message can include an event ID, which can be obtained from the SR message and used for contention resolution. In addition, the RAR message can include a random access preamble ID that is useful for contention resolution. The random access preamble ID can include a preamble index for the xPRACH transmission.

[0061] In one example, the RAR message can be transmitted in the secondary partition using the short TTI either: (1) on the xPDSCH scheduled by the xPDCCH, or (2) using the xPDCCH directly, or (3) using the xPDSCH directly. With respect to the first option, the xPDCCH can indicate the resource allocation and MCS for the transmission of the xPDSCH signal, while the xPDSCH carries the RAR message. With respect to the second option, the RAR message can be transmitted via the xPDCCH. In this case, the UE (e.g., a mission critical MTC device) can monitor the xPDCCH with the CRC scrambled by the RA-RNTI. With respect to the third option, the RAR message can be transmitted via the xPDSCH using the short TTI. When repeated transmissions or the "keep trying" mechanism is employed for the RAR message, TTI bundling and a predefined redundancy version (RV) pattern (e.g., [0 2 3 1]) can be used when turbo coding is adopted. Further, a scrambling seed for the transmission of the xPDSCH signal can be defined as a function of the RA-RNTI or a group ID with respect to a "single frequency network" (SFN) type of operation. In one example, the group ID can be specified as the event ID.

[0062] In one example, the UE (e.g., a mission critical MTC device) can monitor for the xPDSCH signal using fixed and known values of the MCS and a transport block size (TBS). If a UE processing complexity increase can be accommodated for mission critical devices, then a limited number of options for MCS and TBS for the xPDSCH can be configured, from which the UE can perform blind detection.

[0063] A more detailed description is now provided with respect to the third action shown in FIG. 3, in which the UE can transmit uplink data (i.e., mission critical data) to the eNodeB using the short TTI. A resource allocation for the uplink data transmission can be

indicated in the RAR message. In particular, the resource allocation can be associated with a secondary partition to be used for the uplink data transmission. Further, a scrambling seed for a transmission of the xPUSCH signal can be defined as a function of a mission critical MTC device ID or a group ID with respect to a "single frequency network" type of operation. In one example, the group ID can be specified as the event ID.

[0064] When the repeated transmission is used for the uplink transmission, a gap between the end of a last RAR transmission and a starting subframe of the uplink transmission can be predefined or configured by higher layers via the xMIB, the xSIB or dedicated RRC signaling. Alternatively, to allow additional flexibility, a delay parameter can be indicated in the UL grant of the RAR message, wherein the delay parameter can be of the order of one or more standard or short TTI(s).

[0065] In one example, to improve the robustness of the uplink transmission, the same information can be transmitted on multiple component carriers (CC) simultaneously, or transmitted repeatedly within a CC to fulfil the reliability constraint of the mission critical communication. Further, TTI bundling with a predefined redundancy version (RV) pattern can be employed for performance enhancement. For mission critical applications with small data packet transmissions, tail biting convolution coding (TBCC) can be used as a forward error correction (FEC) scheme as opposed to turbo coding.

[0066] A more detailed description is now provided with respect to the fourth action shown in FIG. 3, in which the eNodeB can transmit ACK/NACK information to the UE using the short TTI. The ACK/NACK can be transmitted via the xPDCCH or the xPHICH using the short TTI on the secondary partition. When repeated transmission are used for the ACK/NACK transmission, a gap between the end of a last uplink data transmission and a starting subframe of the ACK/NACK transmission can be predefined or configured by higher layers via the xMIB, the xSIB or dedicated RRC signaling.

[0067] In one example, when a NACK is received or an ACK is not received, the UE (e.g., a mission critical MTC device) can perform a retransmission of the uplink data. When a maximum number of retransmission is reached, the UE can perform a random back-off and re-initiate the procedure for mission critical communication. Alternatively, assuming that an uplink synchronization has been established via a mission critical

random access procedure, the UE can transmit a scheduling request (SR) using the short TTI on the secondary partition at a next available SR opportunity. In one example, periodically occurring SR opportunities can be defined in the secondary partition. The SR transmission can be based on a physical structure of the xPUSCH or xPUCCH, which are adapted for transmissions using short TTIs. The configuration of the SR opportunities in the secondary partition can be pre-defined or broadcasted using the xSIB. Alternatively, the configuration of the SR opportunities can be indicated via a combination of broadcasted information of system level configurations and UE-specific signaling of the actual configured SR resource periodicity carried in the RAR message.

[0068] In one example, with respect to the "single frequency network (SFN)" type of operation, multiple UEs that are closely co-located (i.e., located within a defined distance from each other) can transmit the xPRACH signal on the same xPRACH resource using the same xPRACH preamble, which can improve the xPRACH detection performance. In response to receiving the xPRACH signal from multiple UEs, the eNodeB can transmit a single RAR message that targets the multiple UEs. In addition, when one or more UEs successfully receive the RAR message, the UEs can transmit the xPUSCH signal simultaneously on the same resource, which can achieve SFN gain.

[0069] In one configuration, a system and method of ultra-reliable and low latency communications for a fifth generation (5G) system is described. A user equipment (UE) can transmit, to an eNodeB, a 5G Physical Random Access Channel (xPRACH) and/or a scheduling request (SR) message to trigger a mission critical communication. The xPRACH and/or SR can be transmitted on a dedicated resource using a standard transmission time interval (TTI) in a primary partition. The UE can receive a random access response (RAR) using a short TTI in a secondary partition. The UE can transmit uplink data to the eNodeB in a 5G physical uplink shared channel (xPUSCH) using the short TTI in the secondary partition. The UE can receive, from the eNodeB, acknowledgement (ACK) or negative acknowledgement (NACK) information in a 5G physical downlink control channel (xPDCCH) or a 5G Physical Hybrid-ARQ Indicator Channel (xPHICH) using the short TTI in the secondary partition.

[0070] In one configuration, a keep trying mechanism is employed between the UE and the eNodeB for ultra-reliable and low latency communication. A transmitter (e.g., the UE

or eNodeB) can keep sending a signal until a response is received from a receiver (e.g., the eNodeB or UE). A maximum repetition number for each transmission can be predefined or configured by higher layers via a 5G master information block (xMIB), a 5G system information block (xSIB) or dedicated RRC signaling.

[0071] In one configuration, a transmitter (e.g., the UE or eNodeB) can repeat the transmission using a fixed number of repetitions. The fixed number of repetitions can be predefined or configured by higher layers via the xMIB, the xSIB or dedicated RRC signaling.

[0072] In one configuration, a transmitter (e.g., the UE or eNodeB) can keep sending the signal until a response is received from a receiver (e.g., the eNodeB or UE). In addition, each transmission can occupy K repetitions, and K is predefined or configured by higher layers via the xMIB, the xSIB or dedicated RRC signaling.

[0073] In one configuration, a set of dedicated xPRACH resources for mission critical communications can be multiplexed with resources for non-mission critical applications using time division multiplexing (TDM) or frequency division multiplexing (FDM) or code division multiplexing (CDM) or a combination of above. In addition, a partition configuration can be predefined or configured by higher layer via the xMIB, the xSIB or dedicated RRC signaling.

[0074] In one configuration, one or more signatures can be reserved for the xPRACH to trigger the mission critical communication.

[0075] In one configuration, one or more time resources can be reserved for the xPRACH to trigger the mission critical communication.

[0076] In one configuration, one or more frequency resources can be reserved for the xPRACH to trigger the mission critical communication.

[0077] In one configuration, one or more xPRACH signatures or time resources or frequency resources can be reserved for "single frequency network" type of operations.

[0078] In one configuration, the SR message can have a fixed size, and the SR can include at least the following parameters or fields: a mission critical machine type communication (MTC) device identifier (ID), an event ID, a mission critical MTC device capability, a resource request, and a modulation and coding scheme (MCS) for

transmission of the uplink data from the UE to the eNodeB. In addition, the resource request can include a physical resource block (PRB) index or numbers within one band, or symbol/slot/subframe/frame index or component carrier (CC) index(s) used for the transmission of the uplink data.

[0079] In one configuration, a resource for an initial transmission of the xPRACH and SR is selected by a given UE within a contention-based resource region, and resources for subsequent repeated transmissions can be configured by higher-layers (e.g.. broadcasted in the xSIB) within a contention-free resource region on a same partition or a different partition.

[0080] In one configuration, a maximum transmit power can be utilized for the transmission and retransmission of the xPRACH signal and/or SR message.

[0081] In one configuration, existing power control mechanisms can be applied for the transmission and retransmission of the xPRACH signal and/or SR message.

[0082] In one configuration, repetition level ramping can be applied for the transmission and retransmission of the xPRACH signal and/or SR message.

[0083] In one configuration, the UE (e.g., a mission critical MTC device) can monitor a random access response (RAR) message within a RAR window. A position of the RAR window can be predefined or configured by higher layers via the xMIB, the xSIB or dedicated RRC signaling.

[0084] In one configuration, a resource allocation of a secondary partition or a RAR transmission is predefined, or broadcasted in a xSIB message, or indicated in a downlink control information (DCI) format in the xPDCCH using a standard TTI in the primary partition.

[0085] In one configuration, the secondary partition can be allocated after the xPDCCH region in the primary partition using the standard TTI (e.g., 1 ms). In addition, the secondary partition can occupy a full system bandwidth.

[0086] In one configuration, the secondary partition can span a standard TTI (e.g., 1 ms). In addition, the secondary partition can occupy a full system bandwidth.

[0087] In one configuration, a preamble can be inserted prior to the transmission of the RAR message. The preamble can be based on a 5G downlink synchronization channel

(xSCH).

[0088] In one configuration, the RAR message can include the following parameters or fields: a timing advance command (TA), an uplink grant, a mission critical MTC device ID, an event ID and a random access preamble ID. The uplink grant can further include a resource allocation of the secondary partition used for a subsequent uplink transmission.

[0089] In one configuration, the RAR message can be transmitted via the xPDSCH using a short TTI. When a repeated transmission mechanism (or "keep trying" mechanism) is employed, TTI bundling and a predefined redundancy version (RV) pattern can be used for the transmission of the RAR message when turbo coding is adopted. In addition, with respect to a "single frequency network" type of operation, a scrambling seed for the transmission of the xPDSCH can be defined as a function of a random access radio network temporary identifier (RA-RNTI), a group ID or an event ID.

[0090] In one configuration, the RAR message can be transmitted via the xPDCCH. The UE (e.g., a mission critical MTC device) can monitor the xPDCCH with a cyclic redundancy check (CRC) scrambled by an RA-RNTI.

[0091] In one configuration, the RAR message can be transmitted via the xPDSCH scheduled by the xPDCCH.

[0092] In one configuration, a gap between an end of a last RAR transmission and a starting subframe of the uplink transmission can be predefined or configured by higher layers via the xMIB, the xSIB or dedicated RRC signaling. In addition, a delay parameter in the order of standard or short TTI can indicated in the UL grant of the RAR message.

[0093] In one configuration, for the uplink transmission, the same information can be transmitted on multiple component carriers (CC) simultaneously or transmitted repeatedly over multiple sets of PRBs within a CC. In one example, TTI bundling with a predefined redundancy version (RV) pattern can be employed for the uplink transmission. In another example, a scrambling seed for the transmission of the xPUSCH can be defined as a function of a mission critical MTC device ID or a group ID for a "single frequency network" type of operation.

[0094] In one configuration, a gap between an end of the uplink data transmission and a starting subframe of the ACK/NACK transmission can be predefined or configured by

higher layers via the xMIB, the xSIB or dedicated RRC signaling.

[0095] In one configuration, when a negative acknowledgement (NACK) is received or an acknowledgement (ACK) is not received, the UE (e.g., a mission critical MTC device) can perform a retransmission of the uplink data. When a maximum number of retransmission is reached, the UE can perform a random back-off and re-initiate the procedure for mission critical communication.

[0096] Another example provides functionality 900 of a user equipment (UE) operable to perform mission critical communications with an eNodeB, as shown in the flow chart in FIG. 9. The UE can comprise one or more processors and memory configured to: transmit, from the UE to the eNodeB, a physical random access channel (PRACH) signal that indicates a mission critical communication to be performed between the UE and the eNodeB, wherein the PRACH signal is transmitted using dedicated PRACH resources and in accordance with a first transmission time interval (TTI), as in block 910. The UE can comprise one or more processors and memory configured to: receive, from the eNodeB, a random access response (RAR) message that includes a timing advance (TA) and a resource allocation for the mission critical communication, wherein the RAR message is transmitted from the eNodeB using a second TTI, wherein the second TTI is associated with a time interval that is less than the first TTI, as in block 920. The UE can comprise one or more processors and memory configured to: decode, at the UE, the RAR message to determine the TA and the resource allocation for the mission critical communication, as in block 930. The UE can comprise one or more processors and memory configured to: perform, at the UE, the mission critical communication with the eNodeB in an uplink using the TA and the resource allocation indicated in the RAR message, wherein the mission critical communication is performed using a physical uplink shared channel (PUSCH) and in accordance with the second TTI, as in block 940.

[0097] Another example provides functionality 1000 of a base station operable to receive mission critical communications from a user equipment (UE), as shown in the flow chart in FIG. 10. The base station can comprise one or more processors and memory configured to: receive, from the UE, a physical random access channel (PRACH) signal that indicates a mission critical communication to be performed between the eNodeB and the UE, wherein the PRACH signal is received using dedicated PRACH resources and in

accordance with a first transmission time interval (TTI), as in block 1010. The base station can comprise one or more processors and memory configured to: transmit, to the UE, a random access response (RAR) message that includes a timing advance (TA) and a resource allocation for the mission critical communication, wherein the RAR message is transmitted from the eNodeB using a second TTI, wherein the second TTI is associated with a time interval that is less than the first TTI, as in block 1020. The base station can comprise one or more processors and memory configured to: receive, from the UE, the mission critical communication on a physical uplink shared channel (PUSCH) and in accordance with the second TTI, wherein the UE is configured to perform the mission critical communication in an uplink using the TA and the resource allocation indicated in the RAR message, as in block 1030. The base station can comprise one or more processors and memory configured to: transmit, to the UE, an acknowledgement (ACK) or a negative acknowledgement (NACK) for the mission critical communication in a physical downlink control channel (PDCCH) or a physical hybrid-ARQ indicator channel (PHICH) channel in accordance with the second TTI, as in block 1040.

[0098] Another example provides at least one machine readable storage medium having instructions 1100 embodied thereon for performing mission critical communications between a user equipment (UE) and an eNodeB, as shown in the flow chart in FIG. 11. The instructions can be executed on a machine, where the instructions are included on at least one computer readable medium or one non-transitory machine readable storage medium. The instructions when executed perform: transmitting, using at least one processor of the UE, a physical random access channel (PRACH) signal to the eNodeB that indicates a mission critical communication to be performed between the UE and the eNodeB, wherein the PRACH signal is transmitted in accordance with a first transmission time interval (TTI), as in block 1110. The instructions when executed perform: receiving, using the at least one processor of the UE, a random access response (RAR) message from the eNodeB that includes a timing advance (TA) and a resource allocation for the mission critical communication, wherein the RAR message is transmitted from the eNodeB using a second TTI, wherein the second TTI is associated with a time interval that is less than the first TTI, as in block 1120. The instructions when executed perform: performing, using the at least one processor of the UE, the mission critical communication with the eNodeB in an uplink using the TA and the resource allocation

indicated in the RAR message, wherein the mission critical communication is performed using a physical uplink shared channel (PUSCH) and in accordance with the second TTI, as in block 1130. The instructions when executed perform: receiving, using the at least one processor of the UE, an acknowledgement (ACK) or a negative acknowledgement (NACK) from the eNodeB for the mission critical communication in a physical downlink control channel (PDCCH) or a physical hybrid-ARQ indicator channel (PHICH) channel in accordance with the second TTI, as in block 1140.

[0099] FIG. 12 provides an example illustration of a user equipment (UE) device 1200, such as a wireless device, a mobile station (MS), a mobile wireless device, a mobile communication device, a tablet, a handset, or other type of wireless device. The UE device 1200 can include one or more antennas configured to communicate with a node or transmission station, such as a base station (BS), an evolved Node B (eNB), a baseband unit (BBU), a remote radio head (RRH), a remote radio equipment (RRE), a relay station (RS), a radio equipment (RE), a remote radio unit (RRU), a central processing module (CPM), or other type of wireless wide area network (WWAN) access point. The UE device 1200 can be configured to communicate using at least one wireless communication standard including 3GPP LTE, WiMAX, High Speed Packet Access (HSPA), Bluetooth, and WiFi. The UE device 1200 can communicate using separate antennas for each wireless communication standard or shared antennas for multiple wireless communication standards. The UE device 1200 can communicate in a wireless local area network (WLAN), a wireless personal area network (WPAN), and/or a WWAN.

[00100] In some embodiments, the UE device 1200 may include application circuitry 1202, baseband circuitry 1204, Radio Frequency (RF) circuitry 1206, front-end module (FEM) circuitry 1208 and one or more antennas 1210, coupled together at least as shown.

[00101] The application circuitry 1202 may include one or more application processors. For example, the application circuitry 1202 may include circuitry such as, but not limited to, one or more single-core or multi-core processors. The processor(s) may include any combination of general-purpose processors and dedicated processors (e.g., graphics processors, application processors, etc.). The processors may be coupled with and/or may include a storage medium 1212, and may be configured to execute instructions stored in the storage medium 1212 to enable various applications and/or operating systems to run on the system.

[00102] The baseband circuitry 1204 may include circuitry such as, but not limited to, one or more single-core or multi-core processors. The baseband circuitry 1204 may include one or more baseband processors and/or control logic to process baseband signals received from a receive signal path of the RF circuitry 1206 and to generate baseband signals for a transmit signal path of the RF circuitry 1206. Baseband processing circuity 1204 may interface with the application circuitry 1202 for generation and processing of the baseband signals and for controlling operations of the RF circuitry 1206. For example, in some embodiments, the baseband circuitry 1204 may include a second generation (2G) baseband processor 1204a, third generation (3G) baseband processor 1204b, fourth generation (4G) baseband processor 1204c, and/or other baseband processor(s) 1204d for other existing generations, generations in development or to be developed in the future (e.g., fifth generation (5G), 6G, etc.). The baseband circuitry 1204 (e.g., one or more of baseband processors 1204a-d) may handle various radio control functions that enable communication with one or more radio networks via the RF circuitry 1206. The radio control functions may include, but are not limited to, signal modulation/demodulation, encoding/decoding, radio frequency shifting, etc. In some embodiments, modulation/demodulation circuitry of the baseband circuitry 1204 may include Fast-Fourier Transform (FFT), precoding, and/or constellation mapping/demapping functionality. In some embodiments, encoding/decoding circuitry of the baseband circuitry 1204 may include convolution, tail-biting convolution, turbo, Viterbi, and/or Low Density Parity Check (LDPC) encoder/decoder functionality. Embodiments of modulation/demodulation and encoder/decoder functionality are not limited to these examples and may include other suitable functionality in other embodiments.

[00103] In some embodiments, the baseband circuitry 1204 may include elements of a protocol stack such as, for example, elements of an evolved universal terrestrial radio access network (EUTRAN) protocol including, for example, physical (PHY), media access control (MAC), radio link control (RLC), packet data convergence protocol (PDCP), and/or radio resource control (RRC) elements. A central processing unit (CPU) 1204e of the baseband circuitry 1204 may be configured to run elements of the protocol stack for signaling of the PHY, MAC, RLC, PDCP and/or RRC layers. In some embodiments, the baseband circuitry may include one or more audio digital signal

processor(s) (DSP) 1204f. The audio DSP(s) 104f may be include elements for compression/decompression and echo cancellation and may include other suitable processing elements in other embodiments. Components of the baseband circuitry may be suitably combined in a single chip, a single chipset, or disposed on a same circuit board in some embodiments. In some embodiments, some or all of the constituent components of the baseband circuitry 1204 and the application circuitry 1202 may be implemented together such as, for example, on a system on a chip (SOC).

[00104] In some embodiments, the baseband circuitry 1204 may provide for communication compatible with one or more radio technologies. For example, in some embodiments, the baseband circuitry 1204 may support communication with an evolved universal terrestrial radio access network (EUTRAN) and/or other wireless metropolitan area networks (WMAN), a wireless local area network (WLAN), a wireless personal area network (WPAN). Embodiments in which the baseband circuitry 1204 is configured to support radio communications of more than one wireless protocol may be referred to as multi-mode baseband circuitry.

[00105] The RF circuitry 1206 may enable communication with wireless networks using modulated electromagnetic radiation through a non-solid medium. In various embodiments, the RF circuitry 1206 may include switches, filters, amplifiers, etc. to facilitate the communication with the wireless network. RF circuitry 1206 may include a receive signal path which may include circuitry to down-convert RF signals received from the FEM circuitry 1208 and provide baseband signals to the baseband circuitry 1204. RF circuitry 1206 may also include a transmit signal path which may include circuitry to up-convert baseband signals provided by the baseband circuitry 1204 and provide RF output signals to the FEM circuitry 1208 for transmission.

[00106] In some embodiments, the RF circuitry 1206 may include a receive signal path and a transmit signal path. The receive signal path of the RF circuitry 1206 may include mixer circuitry 1206a, amplifier circuitry 1206b and filter circuitry 1206c. The transmit signal path of the RF circuitry 1206 may include filter circuitry 1206c and mixer circuitry 1206a. RF circuitry 1206 may also include synthesizer circuitry 1206d for synthesizing a frequency for use by the mixer circuitry 1206a of the receive signal path and the transmit signal path. In some embodiments, the mixer circuitry 1206a of the receive signal path

may be configured to down-convert RF signals received from the FEM circuitry 1208 based on the synthesized frequency provided by synthesizer circuitry 1206d. The amplifier circuitry 1206b may be configured to amplify the down-converted signals and the filter circuitry 1206c may be a low-pass filter (LPF) or band-pass filter (BPF) configured to remove unwanted signals from the down-converted signals to generate output baseband signals. Output baseband signals may be provided to the baseband circuitry 1204 for further processing. In some embodiments, the output baseband signals may be zero-frequency baseband signals, although this is not a requirement. In some embodiments, mixer circuitry 1206a of the receive signal path may comprise passive mixers, although the scope of the embodiments is not limited in this respect.

[00107] In some embodiments, the mixer circuitry 1206a of the transmit signal path may be configured to up-convert input baseband signals based on the synthesized frequency provided by the synthesizer circuitry 1206d to generate RF output signals for the FEM circuitry 1208. The baseband signals may be provided by the baseband circuitry 1204 and may be filtered by filter circuitry 1206c. The filter circuitry 1206c may include a low-pass filter (LPF), although the scope of the embodiments is not limited in this respect.

[00108] In some embodiments, the mixer circuitry 1206a of the receive signal path and the mixer circuitry 1206a of the transmit signal path may include two or more mixers and may be arranged for quadrature down-conversion and/or up-conversion respectively. In some embodiments, the mixer circuitry 1206a of the receive signal path and the mixer circuitry 1206a of the transmit signal path may include two or more mixers and may be arranged for image rejection (e.g., Hartley image rejection). In some embodiments, the mixer circuitry 1206a of the receive signal path and the mixer circuitry 1206a may be arranged for direct down-conversion and/or direct up-conversion, respectively. In some embodiments, the mixer circuitry 1206a of the receive signal path and the mixer circuitry 1206a of the transmit signal path may be configured for super-heterodyne operation.

[00109] In some embodiments, the output baseband signals and the input baseband signals may be analog baseband signals, although the scope of the embodiments is not limited in this respect. In some alternate embodiments, the output baseband signals and the input baseband signals may be digital baseband signals. In these alternate embodiments, the RF circuitry 1206 may include analog-to-digital converter (ADC) and digital-to-analog

converter (DAC) circuitry and the baseband circuitry 1204 may include a digital baseband interface to communicate with the RF circuitry 1206.

[00110] In some dual-mode embodiments, a separate radio IC circuitry may be provided for processing signals for each spectrum, although the scope of the embodiments is not limited in this respect.

[00111] In some embodiments, the synthesizer circuitry 1206d may be a fractional-N synthesizer or a fractional N/N+1 synthesizer, although the scope of the embodiments is not limited in this respect as other types of frequency synthesizers may be suitable. For example, synthesizer circuitry 1206d may be a delta-sigma synthesizer, a frequency multiplier, or a synthesizer comprising a phase-locked loop with a frequency divider.

[00112] The synthesizer circuitry 1206d may be configured to synthesize an output frequency for use by the mixer circuitry 1206a of the RF circuitry 1206 based on a frequency input and a divider control input. In some embodiments, the synthesizer circuitry 1206d may be a fractional N/N+1 synthesizer.

[00113] In some embodiments, frequency input may be provided by a voltage controlled oscillator (VCO), although that is not a requirement. Divider control input may be provided by either the baseband circuitry 1204 or the applications processor 1202 depending on the desired output frequency. In some embodiments, a divider control input (e.g., N) may be determined from a look-up table based on a channel indicated by the applications processor 1202.

[00114] Synthesizer circuitry 1206d of the RF circuitry 1206 may include a divider, a delay-locked loop (DLL), a multiplexer and a phase accumulator. In some embodiments, the divider may be a dual modulus divider (DMD) and the phase accumulator may be a digital phase accumulator (DPA). In some embodiments, the DMD may be configured to divide the input signal by either N or N+1 (e.g., based on a carry out) to provide a fractional division ratio. In some example embodiments, the DLL may include a set of cascaded, tunable, delay elements, a phase detector, a charge pump and a D-type flip-flop. In these embodiments, the delay elements may be configured to break a VCO period up into Nd equal packets of phase, where Nd is the number of delay elements in the delay line. In this way, the DLL provides negative feedback to help ensure that the total delay through the delay line is one VCO cycle.

[00115] In some embodiments, synthesizer circuitry 1206d may be configured to generate a carrier frequency as the output frequency, while in other embodiments, the output frequency may be a multiple of the carrier frequency (e.g., twice the carrier frequency, four times the carrier frequency) and used in conjunction with quadrature generator and divider circuitry to generate multiple signals at the carrier frequency with multiple different phases with respect to each other. In some embodiments, the output frequency may be a LO frequency (fLO). In some embodiments, the RF circuitry 1206 may include an IQ/polar converter.

[00116] FEM circuitry 1208 may include a receive signal path which may include circuitry configured to operate on RF signals received from one or more antennas 1210, amplify the received signals and provide the amplified versions of the received signals to the RF circuitry 1206 for further processing. FEM circuitry 1208 may also include a transmit signal path which may include circuitry configured to amplify signals for transmission provided by the RF circuitry 1206 for transmission by one or more of the one or more antennas 1210.

[00117] In some embodiments, the FEM circuitry 1208 may include a TX/RX switch to switch between transmit mode and receive mode operation. The FEM circuitry may include a receive signal path and a transmit signal path. The receive signal path of the FEM circuitry may include a low-noise amplifier (LNA) to amplify received RF signals and provide the amplified received RF signals as an output (e.g., to the RF circuitry 1206). The transmit signal path of the FEM circuitry 1208 may include a power amplifier (PA) to amplify input RF signals (e.g., provided by RF circuitry 1206), and one or more filters to generate RF signals for subsequent transmission (e.g., by one or more of the one or more antennas 1210.

[00118] FIG. 13 provides an example illustration of the wireless device, such as a user equipment (UE), a mobile station (MS), a mobile wireless device, a mobile communication device, a tablet, a handset, or other type of wireless device. The wireless device can include one or more antennas configured to communicate with a node, macro node, low power node (LPN), or, transmission station, such as a base station (BS), an evolved Node B (eNB), a baseband processing unit (BBU), a remote radio head (RRH), a remote radio equipment (RRE), a relay station (RS), a radio equipment (RE), or other

type of wireless wide area network (WWAN) access point. The wireless device can be configured to communicate using at least one wireless communication standard such as, but not limited to, 3GPP LTE, WiMAX, High Speed Packet Access (HSPA), Bluetooth, and WiFi. The wireless device can communicate using separate antennas for each wireless communication standard or shared antennas for multiple wireless communication standards. The wireless device can communicate in a wireless local area network (WLAN), a wireless personal area network (WPAN), and/or a WWAN. The wireless device can also comprise a wireless modem. The wireless modem can comprise, for example, a wireless radio transceiver and baseband circuitry (e.g., a baseband processor). The wireless modem can, in one example, modulate signals that the wireless device transmits via the one or more antennas and demodulate signals that the wireless device receives via the one or more antennas.

[00119] FIG. 13 also provides an illustration of a microphone and one or more speakers that can be used for audio input and output from the wireless device. The display screen can be a liquid crystal display (LCD) screen, or other type of display screen such as an organic light emitting diode (OLED) display. The display screen can be configured as a touch screen. The touch screen can use capacitive, resistive, or another type of touch screen technology. An application processor and a graphics processor can be coupled to internal memory to provide processing and display capabilities. A non-volatile memory port can also be used to provide data input/output options to a user. The non-volatile memory port can also be used to expand the memory capabilities of the wireless device. A keyboard can be integrated with the wireless device or wirelessly connected to the wireless device to provide additional user input. A virtual keyboard can also be provided using the touch screen.

Examples

[00120] The following examples pertain to specific technology embodiments and point out specific features, elements, or actions that can be used or otherwise combined in achieving such embodiments.

[00121] Example 1 includes an apparatus of a user equipment (UE) operable to perform mission critical communications with an eNodeB, the apparatus comprising one or more processors and memory configured to: transmit, from the UE to the eNodeB, a physical

random access channel (PRACH) signal that indicates a mission critical communication to be performed between the UE and the eNodeB, wherein the PRACH signal is transmitted using dedicated PRACH resources and in accordance with a first transmission time interval (TTI); receive, from the eNodeB, a random access response (RAR) message that includes a timing advance (TA) and a resource allocation for the mission critical communication, wherein the RAR message is transmitted from the eNodeB using a second TTI, wherein the second TTI is associated with a time interval that is less than the first TTI; decode, at the UE, the RAR message to determine the TA and the resource allocation for the mission critical communication; and perform, at the UE, the mission critical communication with the eNodeB in an uplink using the TA and the resource allocation indicated in the RAR message, wherein the mission critical communication is performed using a physical uplink shared channel (PUSCH) and in accordance with the second TTI.

[00122] Example 2 includes the apparatus of Example 1, further configured to receive, from the eNodeB, an acknowledgement (ACK) or a negative acknowledgement (NACK) for the mission critical communication in a physical downlink control channel (PDCCH) or a physical hybrid-ARQ indicator channel (PHICH) channel in accordance with the second TTI.

[00123] Example 3 includes the apparatus of any of Examples 1-2, wherein the first TTI is for a Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) Release 8 orthogonal frequency division multiple access (OFDMA) frame structure and is approximately one millisecond (ms) and the second TTI is approximately 0.1 to 0.2 ms.

[00124] Example 4 includes the apparatus of any of Examples 1-3, wherein the first TTI is associated with a first partition of a low band and the second TTI is associated with a second partition of a low band, wherein the first partition is utilized for non-mission critical communications and the second partition is utilized for mission critical communications.

[00125] Example 5 includes the apparatus of any of Examples 1-4, wherein the UE is configured to: perform repeated transmissions of the PRACH signal to the eNodeB until the RAR message is received from the eNodeB; and perform repeated mission critical communications with the eNodeB until an acknowledgement (ACK) or a negative

acknowledgement (NACK) is received from the eNodeB, wherein a maximum number of repetitions for each transmission from the UE is predefined or configured by higher layers via one of: a master information block (MIB), a system information block (SIB) or dedicated radio resource control (RRC) signaling, wherein the UE performs a random back off and reinitiates a procedure for performing the mission critical communication when the maximum number of repetitions for a defined transmission is reached.

[00126] Example 6 includes the apparatus of any of Examples 1-5, wherein the UE is configured to: repeatedly transmit the PRACH signal to the eNodeB in accordance with a fixed number of repetitions; and repeatedly perform the mission critical communication with the eNodeB in accordance with a fixed number of repetitions, wherein the fixed number of repetitions for each transmission from the UE is predefined or configured by higher layers via one of: a master information block (MIB), a system information block (SIB) or dedicated radio resource control (RRC) signaling.

[00127] Example 7 includes the apparatus of any of Examples 1-6, wherein the dedicated PRACH resources for mission critical communications are multiplexed with PRACH resources for non-mission critical application using at least one of: time division multiplexing (TDM), frequency division multiplexing (FDM) and code division multiplexing (CDM).

[00128] Example 8 includes the apparatus of any of Examples 1-7, wherein a plurality of signatures, time resources and frequency resources are reserved for transmitting the PRACH signal from the UE to trigger the mission critical communication.

[00129] Example 9 includes the apparatus of any of Examples 1-8, wherein the PRACH signal is communicated to the eNodeB with a scheduling request (SR), wherein the SR includes at least one of: a mission critical machine type communication (MTC) device identifier (ID), an event ID, a mission critical MTC device capability, and a resource request and a modulation and coding scheme (MCS) for the mission critical communication in uplink from the UE.

[00130] Example 10 includes the apparatus of any of Examples 1-9, wherein the PRACH signal is transmitted from the UE to the eNodeB in accordance with a maximum transmit power.

[00131] Example 11 includes the apparatus of any of Examples 1-10, wherein the UE is

configured to receive the RAR message from the eNodeB by monitoring a RAR message window, wherein a position of the RAR message window is configured by higher layers via one of: a master information block (MIB), a system information block (SIB) or dedicated radio resource control (RRC) signaling.

[00132] Example 12 includes the apparatus of any of Examples 1-11, further configured to receive a preamble from the eNodeB prior to receiving the RAR message, wherein the preamble functions to improve a downlink synchronization accuracy.

[00133] Example 13 includes the apparatus of any of Examples 1-12, wherein the RAR message received at the UE includes at least one of: the timing advance (TA), an uplink grant that contains the resource allocation for the mission critical communication, a mission critical machine type communication (MTC) device identifier (ID), an event ID, and a random access preamble ID.

[00134] Example 14 includes the apparatus of any of Examples 1-13, wherein: the RAR message is received at the UE via a physical downlink control channel (PDCCH), wherein the UE is configured to monitor the PDCCH using a cyclic redundancy check (CRC) scrambled by a random-access radio network temporary identifier (RA-RNTI); or the RAR message is received at the UE via a physical downlink shared channel (PDSCH) that is scheduled by the PDCCH.

[00135] Example 15 includes the apparatus of any of Examples 1-14, wherein: a gap between a last subframe for a RAR message transmission and a starting subframe of the mission critical communication in uplink is predefined or configured by higher layers via one of: a master information block (MIB), a system information block (SIB) or dedicated radio resource control (RRC) signaling; and a gap between a last subframe of the mission critical communication in uplink and a starting subframe of an acknowledgement (ACK) or a negative acknowledgement (NACK) transmission is predefined or configured by higher layers via one of: the MIB, the SIB, or dedicated RRC signaling.

[00136] Example 16 includes the apparatus of any of Examples 1-15, wherein the UE includes at least one of an antenna, a touch sensitive display screen, a speaker, a microphone, a graphics processor, an application processor, a baseband processor, an internal memory, a non-volatile memory port, and combinations thereof.

[00137] Example 17 includes an apparatus of a base station operable to receive mission

critical communications from a user equipment (UE), the apparatus comprising one or more processors and memory configured to: receive, from the UE, a physical random access channel (PRACH) signal that indicates a mission critical communication to be performed between the eNodeB and the UE, wherein the PRACH signal is received using dedicated PRACH resources and in accordance with a first transmission time interval (TTI); transmit, to the UE, a random access response (RAR) message that includes a timing advance (TA) and a resource allocation for the mission critical communication, wherein the RAR message is transmitted from the eNodeB using a second TTI, wherein the second TTI is associated with a time interval that is less than the first TTI; receive, from the UE, the mission critical communication on a physical uplink shared channel (PUSCH) and in accordance with the second TTI, wherein the UE is configured to perform the mission critical communication in an uplink using the TA and the resource allocation indicated in the RAR message; and transmit, to the UE, an acknowledgement (ACK) or a negative acknowledgement (NACK) for the mission critical communication in a physical downlink control channel (PDCCH) or a physical hybrid-ARQ indicator channel (PHICH) channel in accordance with the second TTI.

[00138] Example 18 includes the apparatus of Example 17, wherein the first TTI is for a Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) Release 8 orthogonal frequency division multiple access (OFDMA) frame structure and is approximately one millisecond (ms) and is associated with a first partition of a low band, wherein the second TTI is approximately 0.1 to 0.2 ms and is associated with a second partition of a low band, wherein the first partition is utilized for non-mission critical communications and the second partition is utilized for mission critical communications.

[00139] Example 19 includes the apparatus of any of Examples 17-18, wherein the dedicated PRACH resources for mission critical communications are multiplexed with PRACH resources for non-mission critical application using at least one of: time division multiplexing (TDM), frequency division multiplexing (FDM) and code division multiplexing (CDM).

[00140] Example 20 includes the apparatus of any of Examples 17-19, wherein: the PRACH signal is received from the UE with a scheduling request (SR), wherein the SR includes at least one of: a mission critical machine type communication (MTC) device

identifier (ID), an event ID, a mission critical MTC device capability, and a resource request and a modulation and coding scheme (MCS) for the mission critical communication in uplink from the UE; and the RAR message transmitted to the UE includes at least one of: the timing advance (TA), an uplink grant that contains the resource allocation for the mission critical communication, a mission critical machine type communication (MTC) device identifier (ID), an event ID, and a random access preamble ID.

[00141] Example 21 includes the apparatus of any of Examples 17-20, wherein the RAR message is transmitted to the UE via a physical downlink control channel (PDCCH) or a physical downlink shared channel (PDSCH).

[00142] Example 22 includes at least one machine readable storage medium having instructions embodied thereon for performing mission critical communications between a user equipment (UE) and an eNodeB, the instructions when executed perform the following: transmitting, using at least one processor of the UE, a physical random access channel (PRACH) signal to the eNodeB that indicates a mission critical communication to be performed between the UE and the eNodeB, wherein the PRACH signal is transmitted in accordance with a first transmission time interval (TTI); receiving, using the at least one processor of the UE, a random access response (RAR) message from the eNodeB that includes a timing advance (TA) and a resource allocation for the mission critical communication, wherein the RAR message is transmitted from the eNodeB using a second TTI, wherein the second TTI is associated with a time interval that is less than the first TTI; performing, using the at least one processor of the UE, the mission critical communication with the eNodeB in an uplink using the TA and the resource allocation indicated in the RAR message, wherein the mission critical communication is performed using a physical uplink shared channel (PUSCH) and in accordance with the second TTI; and receiving, using the at least one processor of the UE, an acknowledgement (ACK) or a negative acknowledgement (NACK) from the eNodeB for the mission critical communication in a physical downlink control channel (PDCCH) or a physical hybrid-ARQ indicator channel (PHICH) channel in accordance with the second TTI.

[00143] Example 23 includes the at least one machine readable storage medium of Example 22, wherein the UE is configured to initiate performance of the mission critical

communication when in a radio resource control (RRC) idle mode.

[00144] Example 24 includes the at least one machine readable storage medium of any of Examples 22-23, wherein the first TTI is approximately one millisecond (ms) and is associated with a first partition of a low band, wherein the second TTI is approximately 0.1 to 0.2 ms and is associated with a second partition of a low band, wherein the first partition is utilized for non-mission critical communications and the second partition is utilized for mission critical communications.

[00145] Example 25 includes the at least one machine readable storage medium of any of Examples 22-24, further comprising instructions which when executed perform the following: performing repeated transmissions of the repeatedly transmit the PRACH signal to the eNodeB until the RAR message is received from the eNodeB; and performing repeated mission critical communications with the eNodeB until an acknowledgement (ACK) or a negative acknowledgement (NACK) is received from the eNodeB.

[00146] Various techniques, or certain aspects or portions thereof, may take the form of program code (i.e., instructions) embodied in tangible media, such as floppy diskettes, compact disc-read-only memory (CD-ROMs), hard drives, non-transitory computer readable storage medium, or any other machine-readable storage medium wherein, when the program code is loaded into and executed by a machine, such as a computer, the machine becomes an apparatus for practicing the various techniques. A non-transitory computer readable storage medium can be a computer readable storage medium that does not include signal. In the case of program code execution on programmable computers, the computing device may include a processor, a storage medium readable by the processor (including volatile and non-volatile memory and/or storage elements), at least one input device, and at least one output device. The volatile and non-volatile memory and/or storage elements may be a random-access memory (RAM), erasable programmable read only memory (EPROM), flash drive, optical drive, magnetic hard drive, solid state drive, or other medium for storing electronic data. The node and wireless device may also include a transceiver module (i.e., transceiver), a counter module (i.e., counter), a processing module (i.e., processor), and/or a clock module (i.e., clock) or timer module (i.e., timer). One or more programs that may implement or utilize

the various techniques described herein may use an application programming interface (API), reusable controls, and the like. Such programs may be implemented in a high level procedural or object oriented programming language to communicate with a computer system. However, the program(s) may be implemented in assembly or machine language, if desired. In any case, the language may be a compiled or interpreted language, and combined with hardware implementations.

[00147] As used herein, the term "circuitry" may refer to, be part of, or include an Application Specific Integrated Circuit (ASIC), an electronic circuit, a processor (shared, dedicated, or group), and/or memory (shared, dedicated, or group) that execute one or more software or firmware programs, a combinational logic circuit, and/or other suitable hardware components that provide the described functionality. In some embodiments, the circuitry may be implemented in, or functions associated with the circuitry may be implemented by, one or more software or firmware modules. In some embodiments, circuitry may include logic, at least partially operable in hardware.

[00148] It should be understood that many of the functional units described in this specification have been labeled as modules, in order to more particularly emphasize their implementation independence. For example, a module may be implemented as a hardware circuit comprising custom very-large-scale integration (VLSI) circuits or gate arrays, off-the-shelf semiconductors such as logic chips, transistors, or other discrete components. A module may also be implemented in programmable hardware devices such as field programmable gate arrays, programmable array logic, programmable logic devices or the like.

[00149] Modules may also be implemented in software for execution by various types of processors. An identified module of executable code may, for instance, comprise one or more physical or logical blocks of computer instructions, which may, for instance, be organized as an object, procedure, or function. Nevertheless, the executables of an identified module may not be physically located together, but may comprise disparate instructions stored in different locations which, when joined logically together, comprise the module and achieve the stated purpose for the module.

[00150] Indeed, a module of executable code may be a single instruction, or many instructions, and may even be distributed over several different code segments, among

different programs, and across several memory devices. Similarly, operational data may be identified and illustrated herein within modules, and may be embodied in any suitable form and organized within any suitable type of data structure. The operational data may be collected as a single data set, or may be distributed over different locations including over different storage devices, and may exist, at least partially, merely as electronic signals on a system or network. The modules may be passive or active, including agents operable to perform desired functions.

[00151] Reference throughout this specification to "an example" or “exemplary” means that a particular feature, structure, or characteristic described in connection with the example is included in at least one embodiment of the present technology. Thus, appearances of the phrases "in an example" or the word “exemplary” in various places throughout this specification are not necessarily all referring to the same embodiment.

[00152] As used herein, a plurality of items, structural elements, compositional elements, and/or materials may be presented in a common list for convenience. However, these lists should be construed as though each member of the list is individually identified as a separate and unique member. Thus, no individual member of such list should be construed as a de facto equivalent of any other member of the same list solely based on their presentation in a common group without indications to the contrary. In addition, various embodiments and example of the present technology may be referred to herein along with alternatives for the various components thereof. It is understood that such embodiments, examples, and alternatives are not to be construed as defacto equivalents of one another, but are to be considered as separate and autonomous representations of the present technology.

[00153] Furthermore, the described features, structures, or characteristics may be combined in any suitable manner in one or more embodiments. In the following description, numerous specific details are provided, such as examples of layouts, distances, network examples, etc., to provide a thorough understanding of embodiments of the technology. One skilled in the relevant art will recognize, however, that the technology can be practiced without one or more of the specific details, or with other methods, components, layouts, etc. In other instances, well-known structures, materials, or operations are not shown or described in detail to avoid obscuring aspects of the

technology.

[00154] While the forgoing examples are illustrative of the principles of the present technology in one or more particular applications, it will be apparent to those of ordinary skill in the art that numerous modifications in form, usage and details of implementation can be made without the exercise of inventive faculty, and without departing from the principles and concepts of the technology. Accordingly, it is not intended that the technology be limited, except as by the claims set forth below.

CLAIMS

What is claimed is:

1. An apparatus of a user equipment (UE) operable to perform mission critical communications with an eNodeB, the apparatus comprising one or more processors and memory configured to:

transmit, from the UE to the eNodeB, a physical random access channel (PRACH) signal that indicates a mission critical communication to be performed between the UE and the eNodeB, wherein the PRACH signal is transmitted using dedicated PRACH resources and in accordance with a first transmission time interval (TTI);

receive, from the eNodeB, a random access response (RAR) message that includes a timing advance (TA) and a resource allocation for the mission critical communication, wherein the RAR message is transmitted from the eNodeB using a second TTI, wherein the second TTI is associated with a time interval that is less than the first TTI;

decode, at the UE, the RAR message to determine the TA and the resource allocation for the mission critical communication; and

perform, at the UE, the mission critical communication with the eNodeB in an uplink using the TA and the resource allocation indicated in the RAR message, wherein the mission critical communication is performed using a physical uplink shared channel (PUSCH) and in accordance with the second TTI.

2. The apparatus of claim 1, further configured to receive, from the eNodeB, an acknowledgement (ACK) or a negative acknowledgement (NACK) for the mission critical communication in a physical downlink control channel (PDCCH) or a physical hybrid-ARQ indicator channel (PHICH) channel in accordance with the second TTI.

3. The apparatus of claim 1, wherein the first TTI is for a Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) Release 8 orthogonal frequency division multiple access (OFDMA) frame structure and is approximately one millisecond (ms) and the second TTI is approximately 0.1 to

0.2 ms.

4. The apparatus of claim 1, wherein the first TTI is associated with a first partition of a low band and the second TTI is associated with a second partition of a low band, wherein the first partition is utilized for non-mission critical communications and the second partition is utilized for mission critical communications.

5. The apparatus of any of claims 1 to 4, wherein the UE is configured to:

perform repeated transmissions of the PRACH signal to the eNodeB until the RAR message is received from the eNodeB; and

perform repeated mission critical communications with the eNodeB until an acknowledgement (ACK) or a negative acknowledgement (NACK) is received from the eNodeB,

wherein a maximum number of repetitions for each transmission from the UE is predefined or configured by higher layers via one of: a master information block (MIB), a system information block (SIB) or dedicated radio resource control (RRC) signaling,

wherein the UE performs a random back off and reinitiates a procedure for performing the mission critical communication when the maximum number of repetitions for a defined transmission is reached.

6. The apparatus of claim 1, wherein the UE is configured to:

repeatedly transmit the PRACH signal to the eNodeB in accordance with a fixed number of repetitions; and

repeatedly perform the mission critical communication with the eNodeB in accordance with a fixed number of repetitions,

wherein the fixed number of repetitions for each transmission from the UE is predefined or configured by higher layers via one of: a master information block (MIB), a system information block (SIB) or dedicated radio resource control (RRC) signaling.

7. The apparatus of claim 1, wherein the dedicated PRACH resources for mission critical communications are multiplexed with PRACH resources for non-mission critical application using at least one of: time division multiplexing (TDM), frequency division multiplexing (FDM) and code division multiplexing (CDM).

8. The apparatus of claim 1, wherein a plurality of signatures, time resources and frequency resources are reserved for transmitting the PRACH signal from the UE to trigger the mission critical communication.

9. The apparatus of claim 1, wherein the PRACH signal is communicated to the eNodeB with a scheduling request (SR), wherein the SR includes at least one of: a mission critical machine type communication (MTC) device identifier (ID), an event ID, a mission critical MTC device capability, and a resource request and a modulation and coding scheme (MCS) for the mission critical communication in uplink from the UE.

10. The apparatus of claim 1, wherein the PRACH signal is transmitted from the UE to the eNodeB in accordance with a maximum transmit power.

11. The apparatus of claim 1, wherein the UE is configured to receive the RAR message from the eNodeB by monitoring a RAR message window, wherein a position of the RAR message window is configured by higher layers via one of: a master information block (MIB), a system information block (SIB) or dedicated radio resource control (RRC) signaling.

12. The apparatus of claim 1, further configured to receive a preamble from the eNodeB prior to receiving the RAR message, wherein the preamble functions to improve a downlink synchronization accuracy.

13. The apparatus of claim 1, wherein the RAR message received at the UE includes at least one of: the timing advance (TA), an uplink grant that contains the resource allocation for the mission critical communication, a mission critical machine type

communication (MTC) device identifier (ID), an event ID, and a random access preamble ID.

14. The apparatus of claim 1, wherein:

the RAR message is received at the UE via a physical downlink control channel (PDCCH), wherein the UE is configured to monitor the PDCCH using a cyclic redundancy check (CRC) scrambled by a random-access radio network temporary identifier (RA-RNTI); or

the RAR message is received at the UE via a physical downlink shared channel (PDSCH) that is scheduled by the PDCCH.

15. The apparatus of any of claims 6 to 14, wherein:

a gap between a last subframe for a RAR message transmission and a starting subframe of the mission critical communication in uplink is predefined or configured by higher layers via one of: a master information block (MIB), a system information block (SIB) or dedicated radio resource control (RRC) signaling; and

a gap between a last subframe of the mission critical communication in uplink and a starting subframe of an acknowledgement (ACK) or a negative acknowledgement (NACK) transmission is predefined or configured by higher layers via one of: the MIB, the SIB, or dedicated RRC signaling.

16. The apparatus of claim 1, wherein the UE includes at least one of an antenna, a touch sensitive display screen, a speaker, a microphone, a graphics processor, an application processor, a baseband processor, an internal memory, a non-volatile memory port, and combinations thereof.

17. An apparatus of a base station operable to receive mission critical communications from a user equipment (UE), the apparatus comprising one or more processors and memory configured to:

receive, from the UE, a physical random access channel (PRACH) signal that indicates a mission critical communication to be performed between the

eNodeB and the UE, wherein the PRACH signal is received using dedicated PRACH resources and in accordance with a first transmission time interval (TTI);

transmit, to the UE, a random access response (RAR) message that includes a timing advance (TA) and a resource allocation for the mission critical communication, wherein the RAR message is transmitted from the eNodeB using a second TTI, wherein the second TTI is associated with a time interval that is less than the first TTI;

receive, from the UE, the mission critical communication on a physical uplink shared channel (PUSCH) and in accordance with the second TTI, wherein the UE is configured to perform the mission critical communication in an uplink using the TA and the resource allocation indicated in the RAR message; and

transmit, to the UE, an acknowledgement (ACK) or a negative acknowledgement (NACK) for the mission critical communication in a physical downlink control channel (PDCCH) or a physical hybrid-ARQ indicator channel (PHICH) channel in accordance with the second TTI.

18. The apparatus of claim 17, wherein the first TTI is for a Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) Release 8 orthogonal frequency division multiple access (OFDMA) frame structure and is approximately one millisecond (ms) and is associated with a first partition of a low band, wherein the second TTI is approximately 0.1 to 0.2 ms and is associated with a second partition of a low band, wherein the first partition is utilized for non-mission critical communications and the second partition is utilized for mission critical communications.

19. The apparatus of claim 17, wherein the dedicated PRACH resources for mission critical communications are multiplexed with PRACH resources for non-mission critical application using at least one of: time division multiplexing (TDM), frequency division multiplexing (FDM) and code division multiplexing (CDM).

20. The apparatus of any of claims 17 to 19, wherein:

the PRACH signal is received from the UE with a scheduling request (SR),

wherein the SR includes at least one of: a mission critical machine type communication (MTC) device identifier (ID), an event ID, a mission critical MTC device capability, and a resource request and a modulation and coding scheme (MCS) for the mission critical communication in uplink from the UE; and

the RAR message transmitted to the UE includes at least one of: the timing advance (TA), an uplink grant that contains the resource allocation for the mission critical communication, a mission critical machine type communication (MTC) device identifier (ID), an event ID, and a random access preamble ID.

21. The apparatus of claim 17, wherein the RAR message is transmitted to the UE via a physical downlink control channel (PDCCH) or a physical downlink shared channel (PDSCH).

22. At least one machine readable storage medium having instructions embodied thereon for performing mission critical communications between a user equipment (UE) and an eNodeB, the instructions when executed perform the following:

transmitting, using at least one processor of the UE, a physical random access channel (PRACH) signal to the eNodeB that indicates a mission critical communication to be performed between the UE and the eNodeB, wherein the PRACH signal is transmitted in accordance with a first transmission time interval (TTI);

receiving, using the at least one processor of the UE, a random access response (RAR) message from the eNodeB that includes a timing advance (TA) and a resource allocation for the mission critical communication, wherein the RAR message is transmitted from the eNodeB using a second TTI, wherein the second TTI is associated with a time interval that is less than the first TTI;

performing, using the at least one processor of the UE, the mission critical communication with the eNodeB in an uplink using the TA and the resource allocation indicated in the RAR message, wherein the mission critical communication is performed using a physical uplink shared channel (PUSCH) and in accordance with the second TTI; and

receiving, using the at least one processor of the UE, an acknowledgement

(ACK) or a negative acknowledgement (NACK) from the eNodeB for the mission critical communication in a physical downlink control channel (PDCCH) or a physical hybrid-ARQ indicator channel (PHICH) channel in accordance with the second TTI.

23. The at least one machine readable storage medium of claim 22, wherein the UE is configured to initiate performance of the mission critical communication when in a radio resource control (RRC) idle mode.

24. The at least one machine readable storage medium of claim 22, wherein the first TTI is approximately one millisecond (ms) and is associated with a first partition of a low band, wherein the second TTI is approximately 0.1 to 0.2 ms and is associated with a second partition of a low band, wherein the first partition is utilized for non-mission critical communications and the second partition is utilized for mission critical communications.

25. The at least one machine readable storage medium of any of claims 22 to 24, further comprising instructions which when executed perform the following:

performing repeated transmissions of the PRACH signal to the eNodeB until the RAR message is received from the eNodeB; and

performing repeated mission critical communications with the eNodeB until an acknowledgement (ACK) or a negative acknowledgement (NACK) is received from the eNodeB.

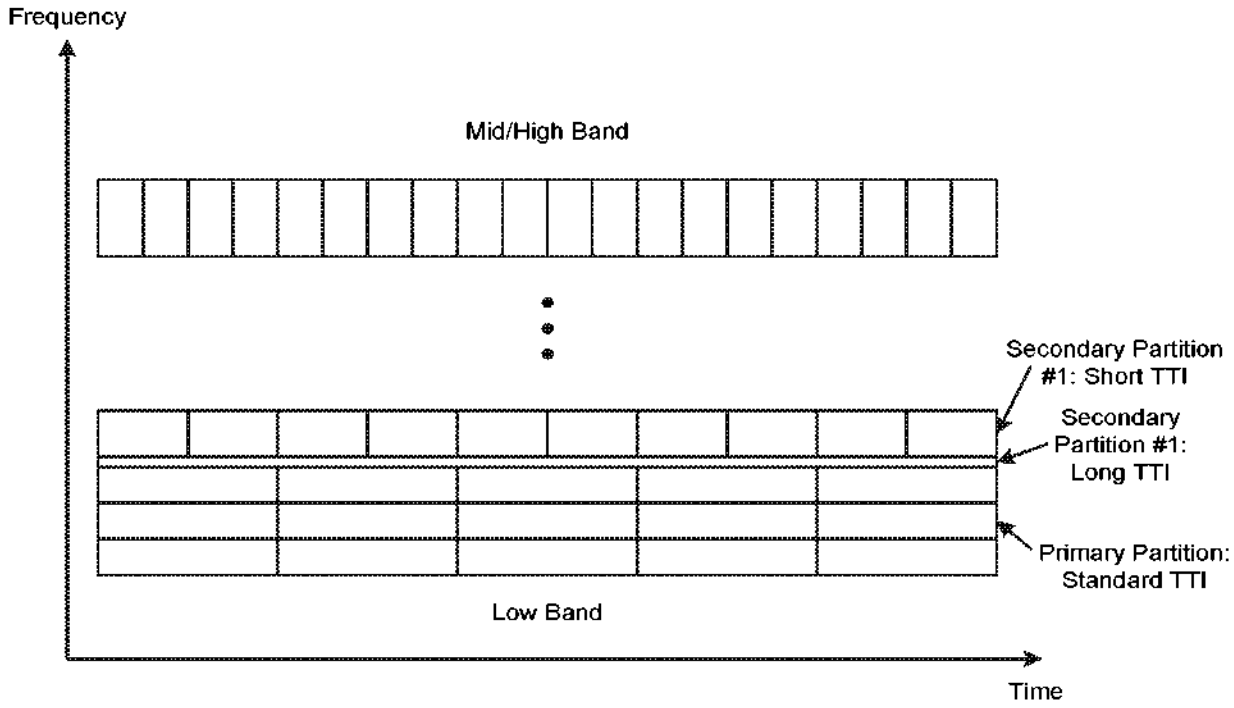

Frequency
Mid/High Band
Secondary Partition #1: Short TTI
Secondary Partition #1: Long TTI
Primary Partition: Standard TTI
Low Band
Time

FIG. 1

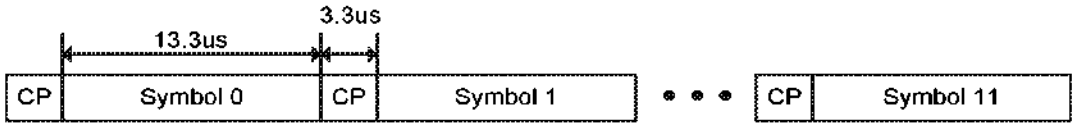

3.3us
13.3us
CP
Symbol 0
CP
Symbol 1
CP
Symbol 11

FIG. 2

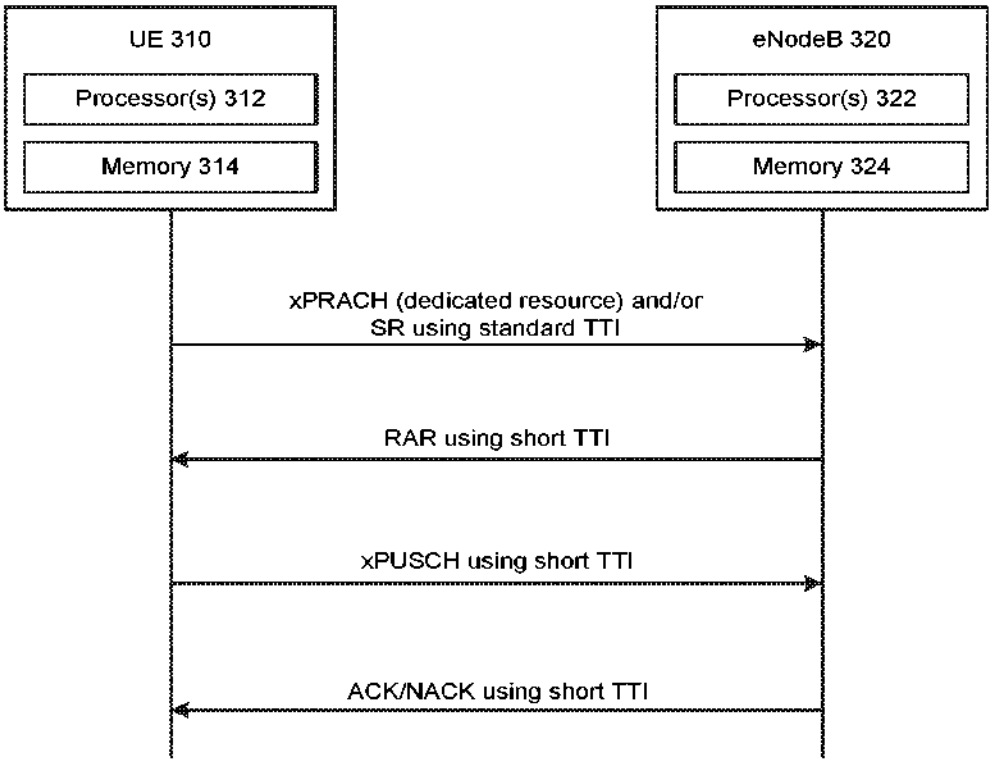

UE 310
Processor(s) 312
Memory 314
eNodeB 320
Processor(s) 322
Memory 324
xPRACH (dedicated resource) and/or
SR using standard TTI
RAR using short TTI
xPUSCH using short TTI
ACK/NACK using short TTI

FIG. 3

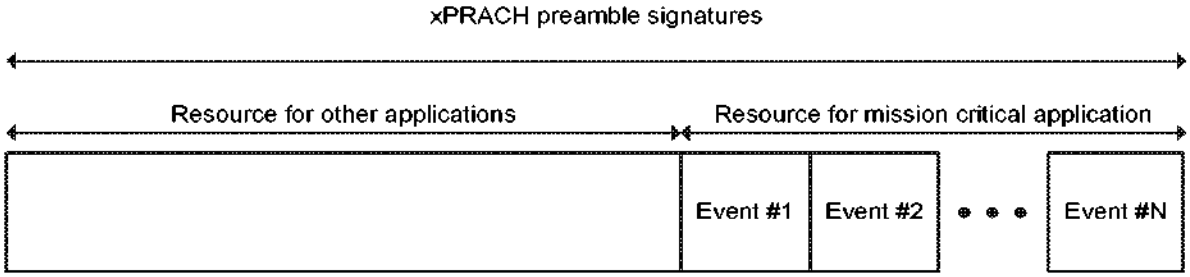

xPRACH preamble signatures
Resource for other applications
Resource for mission critical application
Event #1
Event #2
Event #N

FIG. 4

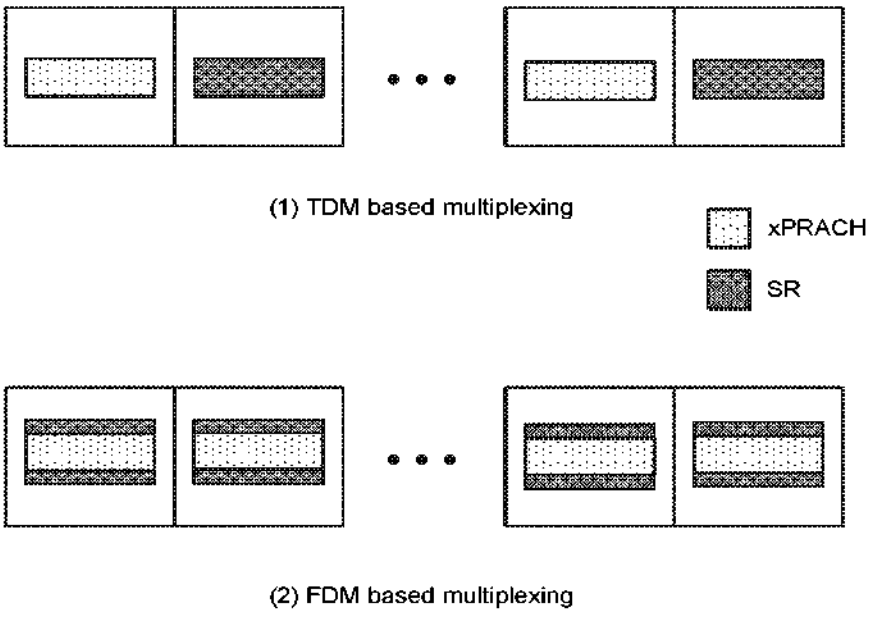

(1) TDM based multiplexing
xPRACH
SR
(2) FDM based multiplexing

FIG. 5

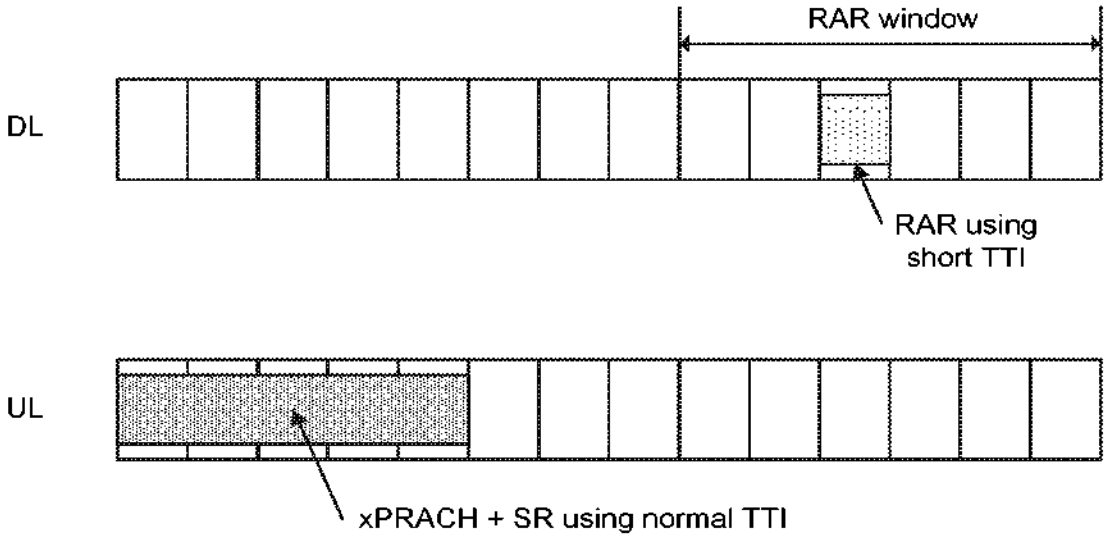

RAR window
DL
RAR using
short TTI
UL
xPRACH + SR using normal TTI

FIG. 6

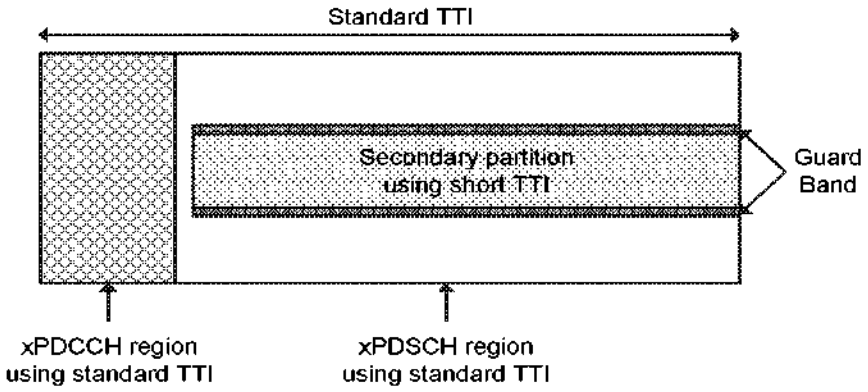


FIG. 7A

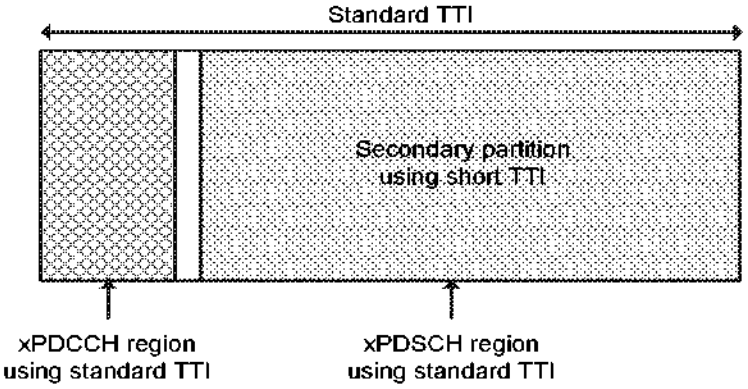


FIG. 7B

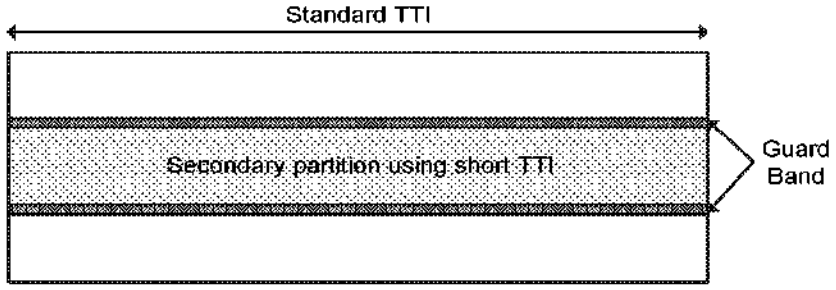


FIG. 7C

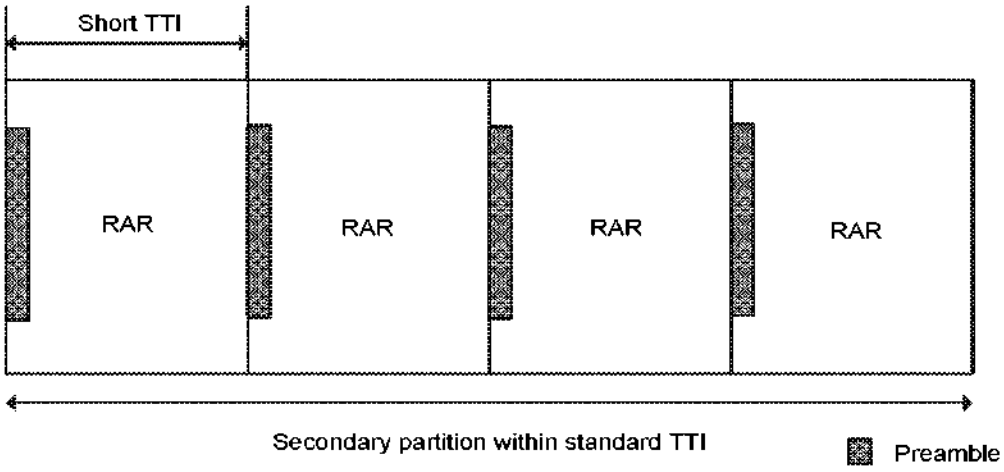

Short TTI
RAR
RAR
RAR
RAR
Secondary partition within standard TTI
Preamble

FIG. 8

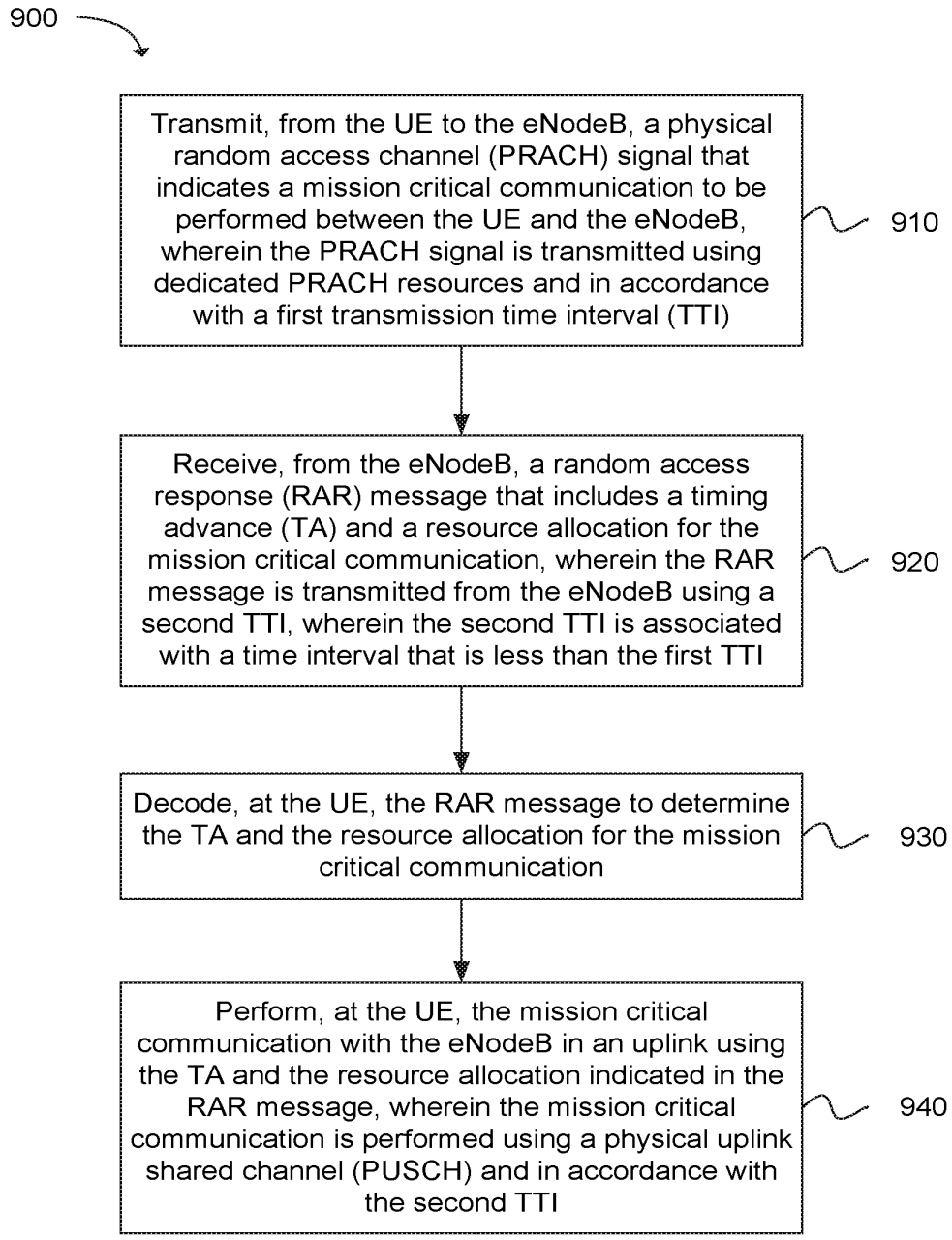

900
Transmit, from the UE to the eNodeB, a physical random access channel (PRACH) signal that indicates a mission critical communication to be performed between the UE and the eNodeB, wherein the PRACH signal is transmitted using dedicated PRACH resources and in accordance with a first transmission time interval (TTI)
910
Receive, from the eNodeB, a random access response (RAR) message that includes a timing advance (TA) and a resource allocation for the mission critical communication, wherein the RAR message is transmitted from the eNodeB using a second TTI, wherein the second TTI is associated with a time interval that is less than the first TTI
920
Decode, at the UE, the RAR message to determine the TA and the resource allocation for the mission critical communication
930
Perform, at the UE, the mission critical communication with the eNodeB in an uplink using the TA and the resource allocation indicated in the RAR message, wherein the mission critical communication is performed using a physical uplink shared channel (PUSCH) and in accordance with the second TTI
940

FIG. 9

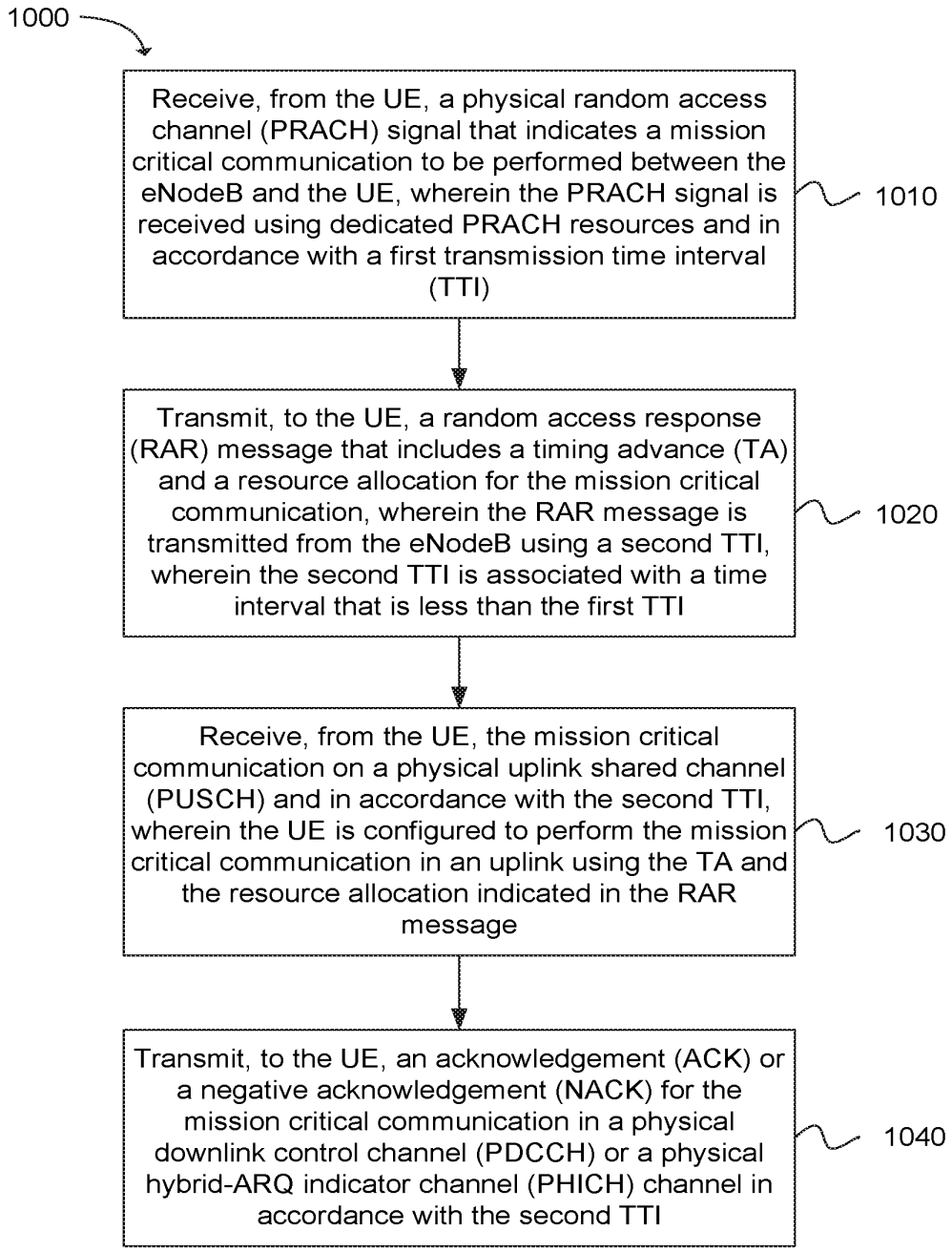

1000
Receive, from the UE, a physical random access channel (PRACH) signal that indicates a mission critical communication to be performed between the eNodeB and the UE, wherein the PRACH signal is received using dedicated PRACH resources and in accordance with a first transmission time interval (TTI)
1010
Transmit, to the UE, a random access response (RAR) message that includes a timing advance (TA) and a resource allocation for the mission critical communication, wherein the RAR message is transmitted from the eNodeB using a second TTI, wherein the second TTI is associated with a time interval that is less than the first TTI
1020
Receive, from the UE, the mission critical communication on a physical uplink shared channel (PUSCH) and in accordance with the second TTI, wherein the UE is configured to perform the mission critical communication in an uplink using the TA and the resource allocation indicated in the RAR message
1030
Transmit, to the UE, an acknowledgement (ACK) or a negative acknowledgement (NACK) for the mission critical communication in a physical downlink control channel (PDCCH) or a physical hybrid-ARQ indicator channel (PHICH) channel in accordance with the second TTI
1040

FIG. 10

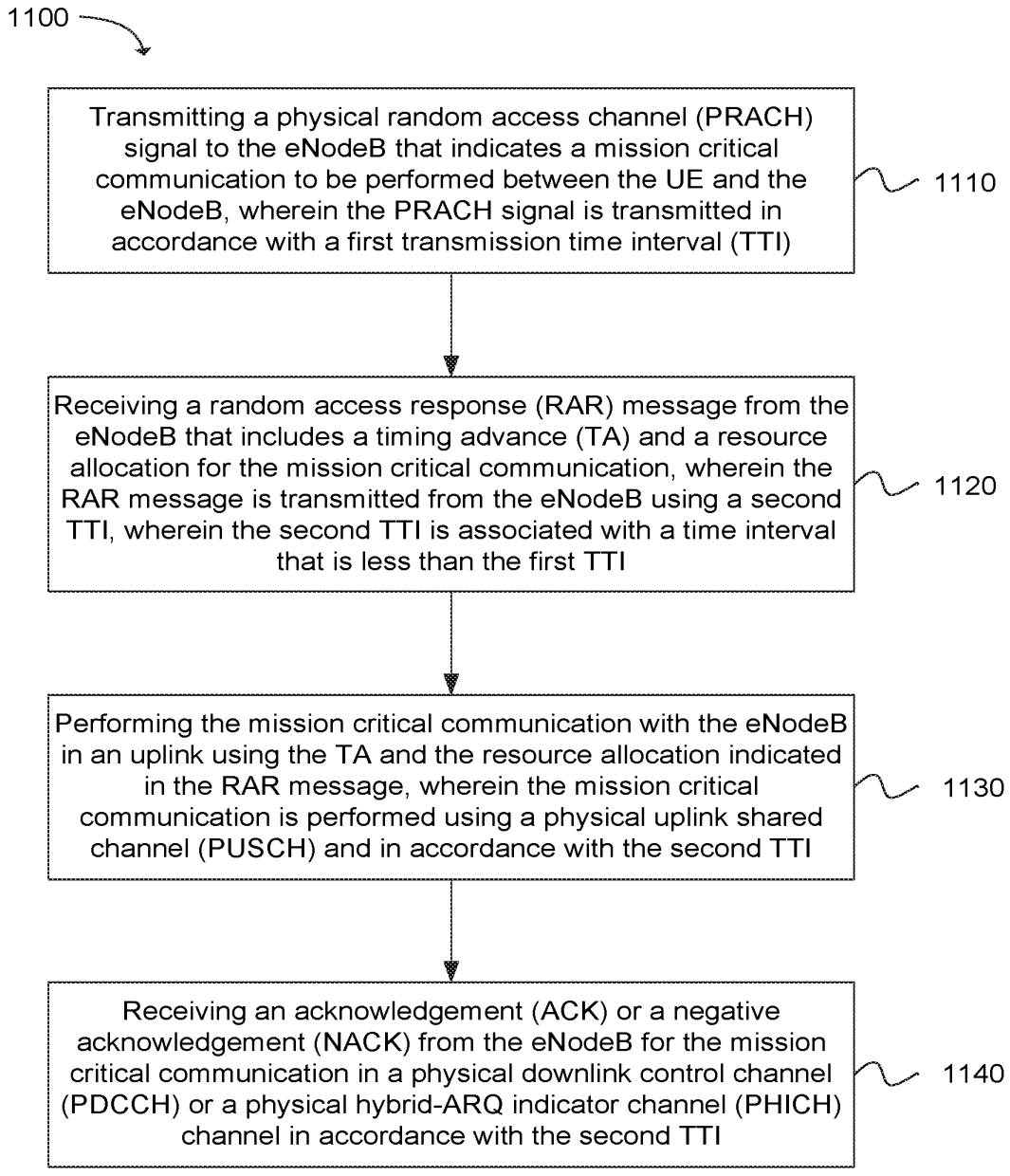

1100
Transmitting a physical random access channel (PRACH) signal to the eNodeB that indicates a mission critical communication to be performed between the UE and the eNodeB, wherein the PRACH signal is transmitted in accordance with a first transmission time interval (TTI)
1110
Receiving a random access response (RAR) message from the eNodeB that includes a timing advance (TA) and a resource allocation for the mission critical communication, wherein the RAR message is transmitted from the eNodeB using a second TTI, wherein the second TTI is associated with a time interval that is less than the first TTI
1120
Performing the mission critical communication with the eNodeB in an uplink using the TA and the resource allocation indicated in the RAR message, wherein the mission critical communication is performed using a physical uplink shared channel (PUSCH) and in accordance with the second TTI
1130
Receiving an acknowledgement (ACK) or a negative acknowledgement (NACK) from the eNodeB for the mission critical communication in a physical downlink control channel (PDCCH) or a physical hybrid-ARQ indicator channel (PHICH) channel in accordance with the second TTI
1140

FIG. 11

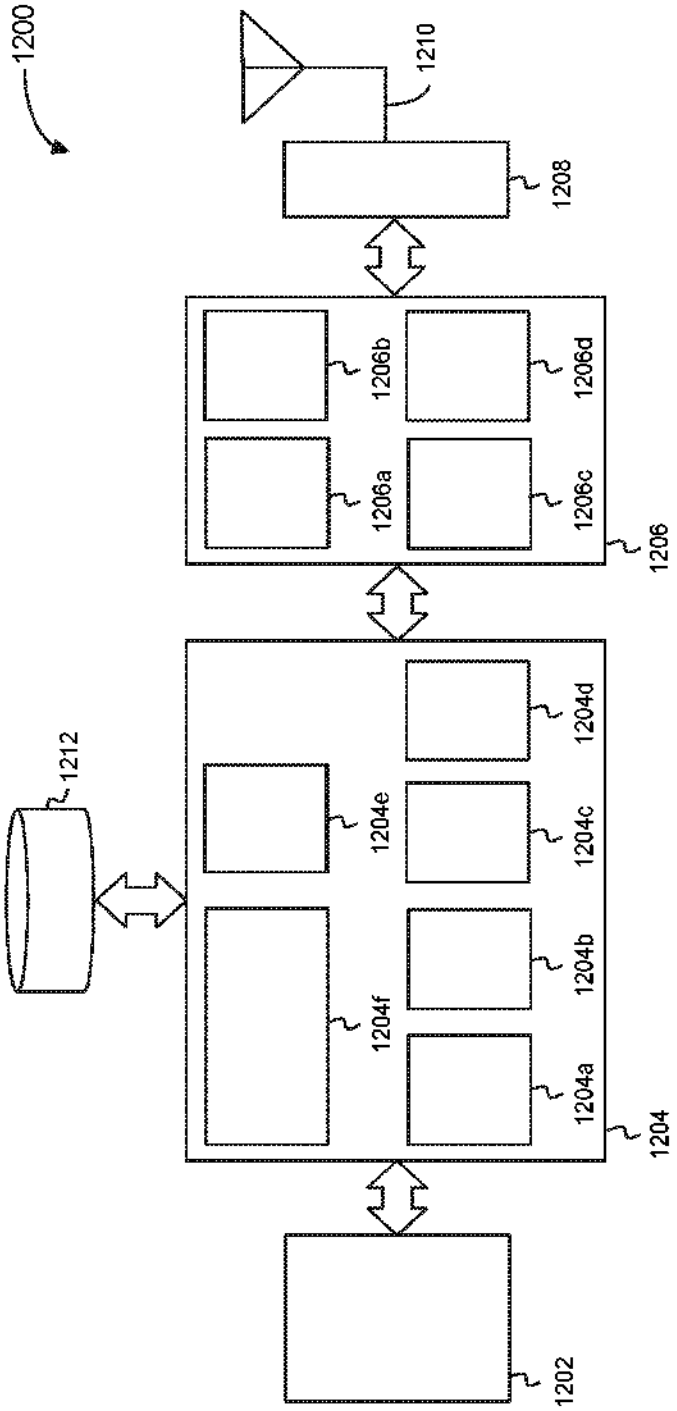

1200
1210
1208
1206b
1206d
1206a
1206c
1206
1212
1204d
1204e
1204c
1204f
1204b
1204a
1204
1202

FIG. 12

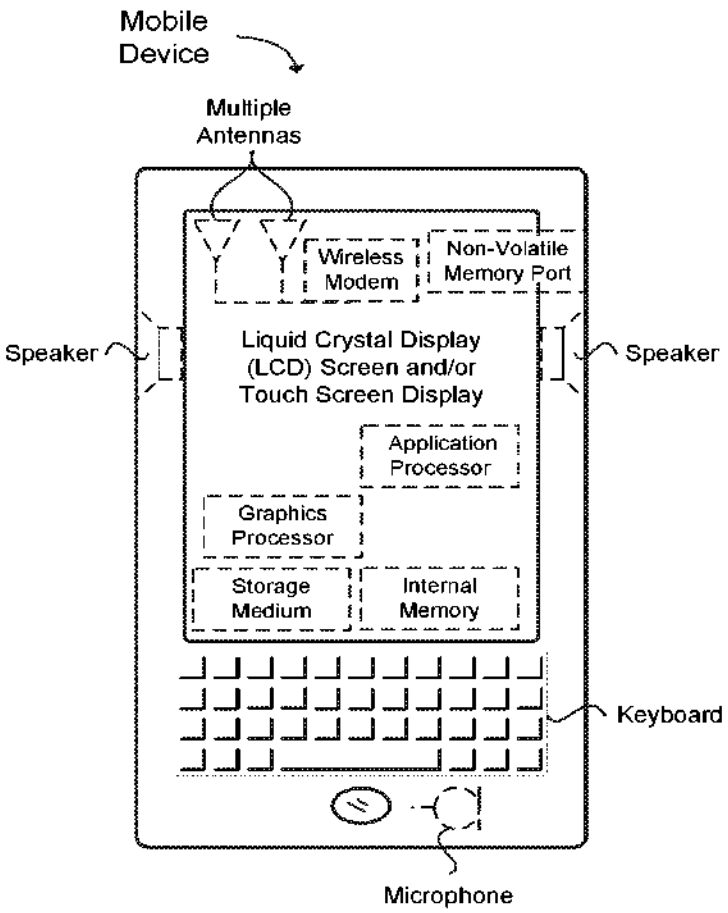

Mobile Device
Multiple Antennas
Wireless Modem
Non-Volatile Memory Port
Speaker
Liquid Crystal Display (LCD) Screen and/or Touch Screen Display
Speaker
Application Processor
Graphics Processor
Storage Medium
Internal Memory
Keyboard
Microphone

FIG. 13

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/066149

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W74/08 H04W72/04
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 2011/087274 A2 (SAMSUNG ELECTRONICS CO LTD [KR]; JEONG KYEONG-IN [KR]; KIM SOENG-HUN [) 21 July 2011 (2011-07-21) figures 2-4, 8-12 paragraphs [0005], [0006] paragraphs [0008], [0009], [0013], [0015] paragraphs [0018], [0019] paragraphs [0036] - [0042] paragraphs [0045] - [0057] paragraphs [0061] - [0072] paragraphs [0076], [0077], [0082] paragraphs [0114] - [0125] paragraphs [0126], [0127] paragraphs [0152], [0156], [0157] paragraphs [0168], [0170], [0177] paragraph [0191] -----	1-8, 10-19, 21-25 9,20

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
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Name and mailing address of the ISA/	Authorized officer
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Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	"3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2 (Release 12)", 3GPP STANDARD; 3GPP TS 36.300, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG2, no. V12.0.0, 10 January 2014 (2014-01-10), pages 1-208, XP050729408, [retrieved on 2014-01-10] Section 10.1.5; pages 73-77 -----	1-25
A	"3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Medium Access Control (MAC) protocol specification (Release 12)", 3GPP STANDARD; 3GPP TS 36.321, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG2, no. V12.0.0, 6 January 2014 (2014-01-06), pages 1-57, XP050729377, [retrieved on 2014-01-06] Section 5.1; pages 13-17 -----	1-25
A	"3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and modulation (Release 12)", 3GPP STANDARD; 3GPP TS 36.211, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG1, no. V12.0.0, 14 December 2013 (2013-12-14), pages 1-120, XP050729027, [retrieved on 2013-12-14] Section 5.7; pages 46-55 ----- -/--	1-25

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	MOTOROLA: "Synchronized Random Access Channel and Scheduling Request", 3GPP DRAFT; R1-062664 SYNCHRACH_SR, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG1, no. Seoul, Korea; 20061006, 6 October 2006 (2006-10-06), XP050103157, [retrieved on 2006-10-06] figure 3 Section 4 -----	9,20

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2015/066149

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2011087274 A2	21-07-2011	EP 2524564 A2	21-11-2012
		KR 20110083547 A	20-07-2011
		US 2012320842 A1	20-12-2012
		WO 2011087274 A2	21-07-2011

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(54) **Title**: DEVICE AND METHODS FOR MULTIPLEXING TRANSMISSIONS WITH DIFFERENT TTI DURATION

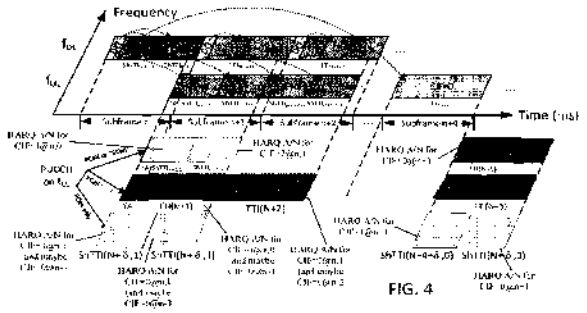


FIG. 4

(57) **Abstract**: A wireless transmit/receive unit, WTRU and methods of using a WTRU within a wireless communications network include communicating with a serving cell in the wireless communications network and determining, based on downlink control information whether the WTRU shall transmit with a first transmission time interval, TTI, length, using a first set of transmission resources, or a second TTI length, using a second set of transmission resources. Alternatively, determining based on said DCI, that the serving cell has indicated that the WTRU should use a first TTI on a physical uplink channel to communicate with the serving cell, or whether said DCI indicates that the WTRU should use a second TTI that is less than the first transmission time interval to communicate with the wireless communication network on the physical uplink channel or whether the WTRU should transmit using carrier aggregation.

DEVICE AND METHODS FOR MULTIPLEXING TRANSMISSIONS WITH DIFFERENT TTI DURATION

BACKGROUND

[0001] In a wireless communication network, such as a Long Term Evolution (LTE) system or New Radio (NR), a wireless transmit/receive unit (WTRU) device may access resources of the communication system. Latency associated with transmission of data in a communication system may have one or more latency components. A latency component may be the time to perform the transmission of a transport block, which time may be referred to as a Transmission Time Interval (TTI). Such TTI may be tied to a specific numerology associated with the transmission method and to a specific number of transmission symbols associated with the transmission. Other latency components may include processing time at a receiver, e.g., time decoding a transmission, transmission of feedback (e.g. ACK or NACK) and/or one or more retransmissions with one or more latency components.

SUMMARY

[0002] Systems, methods, and instrumentalities are disclosed for multiplexing transmissions with different durations, for example transmissions that are associated with different TTI lengths. Latency may be reduced (e.g., in an LTE system and/or in a NR system), for example, by multiplexing transmissions with different TTI durations or associated with different transmission numerologies. TTI duration may be modeled based on defining one or more cell(s) for a given carrier frequency, for example that may be associated with different TTI lengths and/or transmission durations. For example, the different transmission durations may be achieved by time-shifting one or more of the cells. In order to support signaling techniques that allow for concurrent and/or complementary scheduling of transmissions associated with different duration, a logical structure for the physical layer resources (e.g., a cell, a spectrum block, etc.) may configured to correspond to a secondary cell ("SCell"). A primary cell ("PCell") may logically maintain a first transmission duration (e.g., a first TTI length such as a legacy TTI length). The SCell may be configured with a second transmission duration (e.g., a second TTI length or a shortened TTI length). One or more of a PCell or an SCell may be configured with either the legacy or shortened TTI length (e.g., a shorter duration TTI (ShTTI).

[0003] By associating different TTI lengths with different cells, the LTE carrier aggregation framework can be utilized to support multiplexing of transmissions of different durations. For example, carrier aggregation signaling, including cross-carrier scheduling mechanisms, can be used to different scheduling grants and assignments of varying length. For example, a WTRU may determine a TTI duration (e.g., first or second TTI length) applicable to a transmission. For example, a WTRU may determine a TTI duration using cross-carrier scheduling. A WTRU may be configured to associate a given cell identity (e.g., servCellID) with a given transmission duration. Different cell identities (e.g., different servCellIDs) may be associated with different transmission durations/different TTI lengths. When a WTRU receives scheduling information applicable to a given cell identity, the WTRU may determine the associated TTI length based on the configuration received for that cell identity.

[0004] A WTRU may determine a TTI length and/or transmission duration based on one or more parameters and/or received fields. For example, a WTRU may associate a given TTI duration with a given transmission mode (TM). A TTI duration may be indicated by a Carrier Indicator Field (CIF), for example where certain values of the CIF are associated with SCells configured with a given TTI durations such as a ShTTI. The CIF may also be referred to as a Carrier Indicator Field (CIF). The TTI duration may be indicated by a field that indicates a set of resources such as a set of PRBs, a carrier, a serving cell of the WTRU's configuration, and/or a spectrum block. A TTI duration may be determined from an identity of a PRB subset associated with the transmissions and/or to a time-shifted cell within a subset of PRBs for a concerned carrier frequency. An applicable TTI duration and/or the identity of a slot/period applicable to a transmission within a subframe may be determined using a medium access control (MAC) Activation/Deactivation control element. MAC Activation/Deactivation CE may be used to toggle between first and second TTIs (e.g. legacy TTI and ShTTIs) or between slot-based ShTTIs and/or may be used to determine zero, one or more TTI (e.g. ShTTI) period(s) within a subframe.

[0005] HARQ processing may be performed according to a first behavior (e.g. legacy behavior) for one or more (e.g. each) time-shifted cell(s), although there may be exceptions. An exception may be timing-relationships, which may be scaled according to an applicable TTI duration. HARQ A/N feedback formats may use LTE Carrier Aggregation (CA) formats and/or (e.g. legacy) subframe-based timing relationships or a timing relationship associated with the HARQ process. Downlink Control Information (DCI) signaling may use a first (e.g. legacy) format, although, for example, interpretation of fields such as the CIF and/or fields that indicate the PRBs applicable for the transmission may be different than the interpretations of the first

(e.g. legacy) format. MAC activation/deactivation signaling may be applicable for time-shifted cells. DRX Timers associated with DRX may scale to HARQ A/N timing according to an applicable TTI duration and/or to the cell associated with an HARQ process. Physical random access channel (PRACH) resources and/or physical downlink control channel (PDCCH) order for RACH may or may not be supported for time-shifted SCells. Timing advance for uplink transmission may be time shifted, for example, according to a shift applied to the TTI associated with a cell. Time shift may be relative to PCell timing, e.g. a PCell may remain a DL timing reference for an SCell with the additional offset corresponding to the start of the ShTTI for those cells.

[0006] A method of using a wireless transmit/receive unit within a wireless communications network that is capable of aggregating different sets of physical layer resources (e.g., such as carrier aggregation, for example) may include communicating with a serving cell in the wireless communications network and determining that the serving cell has indicated that the WTRU should use a first transmission time interval on a physical uplink channel to communicate with the serving cell. The method may also include determining whether downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment) indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network (e.g., on the physical uplink channel). The method may further include communicating with the wireless communications network using the second transmission time interval.

[0007] The method may include determining that a downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment) indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network (e.g, on the physical uplink channel) comprises determining based on a carrier indicator field in received downlink control information.

[0008] The method may include communicating with the wireless communications network using the second transmission time interval comprises communicating with the serving cell using the second transmission time interval.

[0009] The method may include wherein communicating with the wireless communications network using the second transmission time interval includes communicating with a secondary cell using the second transmission time interval.

[0010] The method may include determining that a downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment) indicates that the WTRU should use a third

transmission time interval that is less than the first transmission time interval to communicate with a secondary cell in the wireless communications network. The shorten transmission time interval may correspond to at least one of at least one symbol or at least one resource block. The first transmission time interval may be one millisecond.

[0011] The method may include determining a time to transmit with the second transmission time interval based on the downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment). The time to transmit may defined by a time partition (e.g., a slot in a subframe and/or one or more time symbols, (e.g., OFDM symbols), an arrangement of symbols, a min-slot, or other time for a sub-carrier spacing).

[0012] The method may include determining whether a first downlink control information (e.g., using carrier aggregation fields such as the CIF) indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network (e.g., on the physical uplink channel) or whether the WTRU should transmit using carrier aggregation comprises determining with cross-carrier scheduling.

[0013] A wireless transmit/receive unit (WTRU) for use within a wireless communications network that is capable of carrier aggregation may have a processor having executable instructions that communicate with a serving cell in the wireless communications network and determine that the serving cell has indicated that the WTRU should use a first transmission time interval on an uplink channel (e.g., physical uplink channel) to communicate with the serving cell. The processor instructions may include determining whether a downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment) indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network (e.g., on the physical uplink channel). The WTRU processor instructions may include communicating with the wireless communications network using the second transmission time interval.

[0014] The WTRU processor instructions that determine that a first downlink control information (e.g, carrier aggregation field such as the CIF) indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network (e.g., on the physical uplink channel) may comprise determining based on a carrier indicator field in received downlink control information.

[0015] The WTRU processor executable instructions that communicate with the wireless communications network using the second transmission time interval may comprise communicating with the serving cell using the second transmission time interval.

[0016] The WTRU processor executable instructions that communicate with the wireless communications network using the second transmission time interval may comprise communicating with a secondary cell using the second transmission time interval.

[0017] The WTRU processor executable instructions may include determining that a downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment) indicates that the WTRU should use a third transmission time interval that is less than the first transmission time interval to communicate with a secondary cell in the wireless communications network. The shorten transmission time interval may correspond to at least one of at least one symbol or at least one resource block. The first transmission time interval may be one millisecond.

[0018] The WTRU processor executable instructions may include determining a time to transmit with the second transmission time interval based on the downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment). The time to transmit may be defined by a slot in a subframe.

[0019] The WTRU processor executable instructions that determine whether a downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment) indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network (e.g., on the physical uplink channel).

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] FIG. 1A is a system diagram of an example communications system in which disclosed subject matter may be implemented.

[0021] FIG. 1B is a system diagram of an example wireless transmit/receive unit (WTRU) that may be used in a communications system.

[0022] FIG. 1C is a system diagram of an example radio access network and an example core network that may be used in a communications system.

[0023] FIG. 1D is a system diagram of an example radio access network and an example core network that may be used in a communications system.

[0024] FIG. 1E is a system diagram of an example radio access network and an example core network that may be used in a communications system.

[0025] FIG. 2 shows an example of DL physical layer channels.

[0026] FIG. 3 shows an example of UL physical layer channels.

[0027] FIG. 4 is an example of scheduling with time-shifted cells.

DETAILED DESCRIPTION

[0028] A detailed description of illustrative embodiments will now be described with reference to the various figures. Although this description provides a detailed example of possible implementations, it should be noted that the details are intended to be exemplary and in no way limit the scope of the application.

[0029] FIG. 1A is a diagram of an example communications system 100 in which one or more disclosed embodiments may be implemented. The communications system 100 may be a multiple access system that provides content, for example voice, data, video, messaging, broadcast, etc., to multiple wireless users. The communications system 100 may enable multiple wireless users to access such content through the sharing of system resources, including wireless bandwidth. For example, the communications systems 100 may employ one or more channel access methods, for example code division multiple access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), orthogonal FDMA (OFDMA), single-carrier FDMA (SC-FDMA), and the like.

[0030] As shown in FIG. 1A, the communications system 100 may include wireless transmit/receive units (WTRUs) 102a, 102b, 102c, and/or 102d (which generally or collectively may be referred to as WTRU 102), a radio access network (RAN) 103/104/105, a core network 106/107/109, a public switched telephone network (PSTN) 108, the Internet 110, and other networks 112, though it will be appreciated that the disclosed embodiments contemplate any number of WTRUs, base stations, networks, and/or network elements. Each of the WTRUs 102a, 102b, 102c, 102d may be any type of device configured to operate and/or communicate in a wireless environment. By way of example, the WTRUs 102a, 102b, 102c, 102d may be configured to transmit and/or receive wireless signals and may include a user equipment (WTRU), a mobile station, a fixed or mobile subscriber unit, a pager, a cellular telephone, a personal digital assistant (PDA), a smartphone, a laptop, a netbook, a personal computer, a wireless sensor, consumer electronics, and the like.

[0031] The communications systems 100 may also include a base station 114a and a base station 114b. Each of the base stations 114a, 114b may be any type of device configured to wirelessly interface with at least one of the WTRUs 102a, 102b, 102c, 102d to facilitate access to

one or more communication networks, for example the core network 106/107/109, the Internet 110, and/or the networks 112. By way of example, the base stations 114a, 114b may be a base transceiver station (BTS), a Node-B, an eNode B, a Home Node B, a Home eNode B, a site controller, an access point (AP), a wireless router, and the like. While the base stations 114a, 114b are each depicted as a single element, it will be appreciated that the base stations 114a, 114b may include any number of interconnected base stations and/or network elements.

[0032] The base station 114a may be part of the RAN 103/104/105, which may also include other base stations and/or network elements (not shown), for example a base station controller (BSC), a radio network controller (RNC), relay nodes, etc. The base station 114a and/or the base station 114b may be configured to transmit and/or receive wireless signals within a particular geographic region, which may be referred to as a cell (not shown). The cell may further be divided into cell sectors. For example, the cell associated with the base station 114a may be divided into three sectors. Thus, in one embodiment, the base station 114a may include three transceivers, i.e., one for each sector of the cell. In an embodiment, the base station 114a may employ multiple-input multiple output (MIMO) technology and, therefore, may utilize multiple transceivers for each sector of the cell.

[0033] The base stations 114a, 114b may communicate with one or more of the WTRUs 102a, 102b, 102c, 102d over an air interface 115/116/117, which may be any suitable wireless communication link (e.g. radio frequency (RF), microwave, infrared (IR), ultraviolet (UV), visible light, etc.). The air interface 115/116/117 may be established using any suitable radio access technology (RAT).

[0034] More specifically, as noted above, the communications system 100 may be a multiple access system and may employ one or more channel access schemes, for example CDMA, TDMA, FDMA, OFDMA, SC-FDMA, and the like. For example, the base station 114a in the RAN 103/104/105 and the WTRUs 102a, 102b, 102c may implement a radio technology such as Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access (UTRA), which may establish the air interface 115/116/117 using wideband CDMA (WCDMA). WCDMA may include communication protocols such as High-Speed Packet Access (HSPA) and/or Evolved HSPA (HSPA+). HSPA may include High-Speed Downlink Packet Access (HSDPA) and/or High-Speed Uplink Packet Access (HSUPA).

[0035] In an embodiment, the base station 114a and the WTRUs 102a, 102b, 102c may implement a radio technology such as Evolved UMTS Terrestrial Radio Access (E-UTRA), which may establish the air interface 115/116/117 using Long Term Evolution (LTE) and/or LTE-Advanced (LTE-A).

[0036] In an embodiment, the base station 114a and the WTRUs 102a, 102b, 102c may implement radio technologies such as IEEE 802.16 (i.e., Worldwide Interoperability for Microwave Access (WiMAX)), CDMA2000, CDMA2000 1X, CDMA2000 EV-DO, Interim Standard 2000 (IS-2000), Interim Standard 95 (IS-95), Interim Standard 856 (IS-856), Global System for Mobile communications (GSM), Enhanced Data rates for GSM Evolution (EDGE), GSM EDGE (GERAN), New Radio (NR) and the like. The descriptions and example provided herein apply to any of the air interface and communications standards that have been implemented although the terminology may differ among them for the functional components.

[0037] The base station 114b in FIG. 1A may be a wireless router, Home Node B, Home eNode B, or access point, for example, and may utilize any suitable RAT for facilitating wireless connectivity in a localized area, for example a place of business, a home, a vehicle, a campus, and the like. In one embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.11 to establish a wireless local area network (WLAN). In an embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.15 to establish a wireless personal area network (WPAN). In yet an embodiment, the base station 114b and the WTRUs 102c, 102d may utilize a cellular-based RAT (e.g. WCDMA, CDMA2000, GSM, LTE, LTE-A, etc.) to establish a picocell or femtocell. As shown in FIG. 1A, the base station 114b may have a direct connection to the Internet 110. Thus, the base station 114b may not be required to access the Internet 110 via the core network 106/107/109.

[0038] The RAN 103/104/105 may be in communication with the core network 106/107/109, which may be any type of network configured to provide voice, data, applications, and/or voice over internet protocol (VoIP) services to one or more of the WTRUs 102a, 102b, 102c, 102d. For example, the core network 106/107/109 may provide call control, billing services, mobile location-based services, pre-paid calling, Internet connectivity, video distribution, etc., and/or perform high-level security functions, for example user authentication. Although not shown in FIG. 1A, it will be appreciated that the RAN 103/104/105 and/or the core network 106/107/109 may be in direct or indirect communication with other RANs that employ the same RAT as the RAN 103/104/105 or a different RAT. For example, in addition to being connected to the RAN 103/104/105, which may be utilizing an E-UTRA radio technology, the core network 106/107/109 may also be in communication with a RAN (not shown) employing a GSM radio technology.

[0039] The core network 106/107/109 may also serve as a gateway for the WTRUs 102a, 102b, 102c, 102d to access the PSTN 108, the Internet 110, and/or other networks 112. The

PSTN 108 may include circuit-switched telephone networks that provide plain old telephone service (POTS). The Internet 110 may include a global system of interconnected computer networks and devices that use common communication protocols, for example the transmission control protocol (TCP), user datagram protocol (UDP) and the internet protocol (IP) in the TCP/IP internet protocol suite. The networks 112 may include wired or wireless communications networks owned and/or operated by other service providers. For example, the networks 112 may include a core network connected to one or more RANs, which may employ the same RAT as the RAN 103/104/105 or a different RAT.

[0040] Some or all of the WTRUs 102a, 102b, 102c, 102d in the communications system 100 may include multi-mode capabilities, i.e., the WTRUs 102a, 102b, 102c, 102d may include multiple transceivers for communicating with different wireless networks over different wireless links. For example, the WTRU 102c shown in FIG. 1A may be configured to communicate with the base station 114a, which may employ a cellular-based radio technology, and with the base station 114b, which may employ an IEEE 802 radio technology.

[0041] FIG. 1B is a system diagram of an example WTRU 102. As shown in FIG. 1B, the WTRU 102 may include a processor 118, a transceiver 120, a transmit/receive element 122, a speaker/microphone 124, a keypad 126, a display/touchpad 128, non-removable memory 130, removable memory 132, a power source 134, a global positioning system (GPS) chipset 136, and other peripherals 138. It will be appreciated that the WTRU 102 may include any sub-combination of the foregoing elements while remaining consistent with an embodiment. Also, embodiments contemplate that the base stations 114a and 114b, and/or the nodes that base stations 114a and 114b may represent, for example but not limited to transceiver station (BTS), a Node-B, a site controller, an access point (AP), a home node-B, an evolved home node-B (eNodeB), a home evolved node-B (HeNB), a home evolved node-B gateway, and proxy nodes, among others, may include some or each of the elements depicted in FIG. 1B and described herein.

[0042] The processor 118 may be a general purpose processor, a special purpose processor, a conventional processor, a digital signal processor (DSP), a plurality of microprocessors, one or more microprocessors in association with a DSP core, a controller, a microcontroller, Application Specific Integrated Circuits (ASICs), Field Programmable Gate Array (FPGAs) circuits, any other type of integrated circuit (IC), a state machine, and the like. The processor 118 may perform signal coding, data processing, power control, input/output processing, and/or any other functionality that enables the WTRU 102 to operate in a wireless environment. The processor 118 may be coupled to the transceiver 120, which may be coupled to the

transmit/receive element 122. While FIG. 1B depicts the processor 118 and the transceiver 120 as separate components, it will be appreciated that the processor 118 and the transceiver 120 may be integrated together in an electronic package or chip.

[0043] The transmit/receive element 122 may be configured to transmit signals to, or receive signals from, a base station (e.g. the base station 114a) over the air interface 115/116/117. For example, in one embodiment, the transmit/receive element 122 may be an antenna configured to transmit and/or receive RF signals. In an embodiment, the transmit/receive element 122 may be an emitter/detector configured to transmit and/or receive IR, UV, or visible light signals, for example. In yet an embodiment, the transmit/receive element 122 may be configured to transmit and receive both RF and light signals. It will be appreciated that the transmit/receive element 122 may be configured to transmit and/or receive any combination of wireless signals.

[0044] In addition, although the transmit/receive element 122 is depicted in FIG. 1B as a single element, the WTRU 102 may include any number of transmit/receive elements 122. More specifically, the WTRU 102 may employ MIMO technology. Thus, in one embodiment, the WTRU 102 may include two or more transmit/receive elements 122 (e.g. multiple antennas) for transmitting and receiving wireless signals over the air interface 115/116/117.

[0045] The transceiver 120 may be configured to modulate the signals that are to be transmitted by the transmit/receive element 122 and to demodulate the signals that are received by the transmit/receive element 122. As noted above, the WTRU 102 may have multi-mode capabilities. Thus, the transceiver 120 may include multiple transceivers for enabling the WTRU 102 to communicate via multiple RATs, for example UTRA and IEEE 802.11, for example.

[0046] The processor 118 of the WTRU 102 may be coupled to, and may receive user input data from, the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128 (e.g. a liquid crystal display (LCD) display unit or organic light-emitting diode (OLED) display unit). The processor 118 may also output user data to the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128. In addition, the processor 118 may access information from, and store data in, any type of suitable memory, for example the non-removable memory 130 and/or the removable memory 132. The non-removable memory 130 may include random-access memory (RAM), read-only memory (ROM), a hard disk, or any other type of memory storage device. The removable memory 132 may include a subscriber identity module (SIM) card, a memory stick, a secure digital (SD) memory card, and the like. In an embodiment, the processor 118 may access information from, and store data in, memory that is not physically located on the WTRU 102, for example on a server or a home computer (not shown).

[0047] The processor 118 may receive power from the power source 134, and may be configured to distribute and/or control the power to the other components in the WTRU 102. The power source 134 may be any suitable device for powering the WTRU 102. For example, the power source 134 may include one or more dry cell batteries (e.g. nickel-cadmium (NiCd), nickel-zinc (NiZn), nickel metal hydride (NiMH), lithium-ion (Li-ion), etc.), solar cells, fuel cells, and the like.

[0048] The processor 118 may also be coupled to the GPS chipset 136, which may be configured to provide location information (e.g. longitude and latitude) regarding the current location of the WTRU 102. In addition to, or in lieu of, the information from the GPS chipset 136, the WTRU 102 may receive location information over the air interface 115/116/117 from a base station (e.g. base stations 114a, 114b) and/or determine its location based on the timing of the signals being received from two or more nearby base stations. It will be appreciated that the WTRU 102 may acquire location information by way of any suitable location-determination method while remaining consistent with an embodiment.

[0049] The processor 118 may further be coupled to other peripherals 138, which may include one or more software and/or hardware modules that provide additional features, functionality and/or wired or wireless connectivity. For example, the peripherals 138 may include an accelerometer, an e-compass, a satellite transceiver, a digital camera (for photographs or video), a universal serial bus (USB) port, a vibration device, a television transceiver, a hands free headset, a Bluetooth® module, a frequency modulated (FM) radio unit, a digital music player, a media player, a video game player module, an Internet browser, and the like.

[0050] FIG. 1C is a system diagram of the RAN 103 and the core network 106 according to an embodiment. As noted above, the RAN 103 may employ a UTRA radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 115. The RAN 103 may also be in communication with the core network 106. As shown in FIG. 1C, the RAN 103 may include Node-Bs 140a, 140b, 140c, which may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 115. The Node-Bs 140a, 140b, 140c may each be associated with a particular cell (not shown) within the RAN 103. The RAN 103 may also include RNCs 142a, 142b. It will be appreciated that the RAN 103 may include any number of Node-Bs and RNCs while remaining consistent with an embodiment.

[0051] As shown in FIG. 1C, the Node-Bs 140a, 140b may be in communication with the RNC 142a. Additionally, the Node-B 140c may be in communication with the RNC142b. The Node-Bs 140a, 140b, 140c may communicate with the respective RNCs 142a, 142b via an Iub interface. The RNCs 142a, 142b may be in communication with one another via an Iur interface.

Each of the RNCs 142a, 142b may be configured to control the respective Node-Bs 140a, 140b, 140c to which it is connected. In addition, each of the RNCs 142a, 142b may be configured to carry out or support other functionality, for example outer loop power control, load control, admission control, packet scheduling, handover control, macro diversity, security functions, data encryption, and the like.

[0052] The core network 106 shown in FIG. 1C may include a media gateway (MGW) 144, a mobile switching center (MSC) 146, a serving GPRS support node (SGSN) 148, and/or a gateway GPRS support node (GGSN) 150. While each of the foregoing elements are depicted as part of the core network 106, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

[0053] The RNC 142a in the RAN 103 may be connected to the MSC 146 in the core network 106 via an IuCS interface. The MSC 146 may be connected to the MGW 144. The MSC 146 and the MGW 144 may provide the WTRUs 102a, 102b, 102c with access to circuit-switched networks, for example the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, 102c and traditional land-line communications devices.

[0054] The RNC 142a in the RAN 103 may also be connected to the SGSN 148 in the core network 106 via an IuPS interface. The SGSN 148 may be connected to the GGSN 150. The SGSN 148 and the GGSN 150 may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, for example the Internet 110, to facilitate communications between and the WTRUs 102a, 102b, 102c and IP-enabled devices.

[0055] As noted above, the core network 106 may also be connected to the networks 112, which may include other wired or wireless networks that are owned and/or operated by other service providers.

[0056] FIG. 1D is a system diagram of the RAN 104 and the core network 107 according to an embodiment. As noted above, the RAN 104 may employ an E-UTRA radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 116. The RAN 104 may also be in communication with the core network 107.

[0057] The RAN 104 may include eNode-Bs 160a, 160b, 160c, though it will be appreciated that the RAN 104 may include any number of eNode-Bs while remaining consistent with an embodiment. The eNode-Bs 160a, 160b, 160c may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 116. In one embodiment, the eNode-Bs 160a, 160b, 160c may implement MIMO technology. Thus, the eNode-B 160a, for example, may use multiple antennas to transmit wireless signals to, and receive wireless signals from, the WTRU 102a.

[0058] Each of the eNode-Bs 160a, 160b, 160c may be associated with a particular cell (not shown) and may be configured to handle radio resource management decisions, handover decisions, scheduling of users in the uplink and/or downlink, and the like. As shown in FIG. 1D, the eNode-Bs 160a, 160b, 160c may communicate with one another over an X2 interface.

[0059] The core network 107 shown in FIG. 1D may include a mobility management gateway (MME) 162, a serving gateway 164, and a packet data network (PDN) gateway 166. While each of the foregoing elements are depicted as part of the core network 107, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

[0060] The MME 162 may be connected to each of the eNode-Bs 160a, 160b, 160c in the RAN 104 via an S1 interface and may serve as a control node. For example, the MME 162 may be responsible for authenticating users of the WTRUs 102a, 102b, 102c, bearer activation/deactivation, selecting a particular serving gateway during an initial attach of the WTRUs 102a, 102b, 102c, and the like. The MME 162 may also provide a control plane function for switching between the RAN 104 and other RANs (not shown) that employ other radio technologies, for example GSM or WCDMA.

[0061] The serving gateway 164 may be connected to each of the eNode-Bs 160a, 160b, 160c in the RAN 104 via the S1 interface. The serving gateway 164 may generally route and forward user data packets to/from the WTRUs 102a, 102b, 102c. The serving gateway 164 may also perform other functions, for example anchoring user planes during inter-eNode B handovers, triggering paging when downlink data is available for the WTRUs 102a, 102b, 102c, managing and storing contexts of the WTRUs 102a, 102b, 102c, and the like.

[0062] The serving gateway 164 may also be connected to the PDN gateway 166, which may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, for example the Internet 110, to facilitate communications between the WTRUs 102a, 102b, 102c and IP-enabled devices.

[0063] The core network 107 may facilitate communications with other networks. For example, the core network 107 may provide the WTRUs 102a, 102b, 102c with access to circuit-switched networks, for example the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, 102c and traditional land-line communications devices. For example, the core network 107 may include, or may communicate with, an IP gateway (e.g. an IP multimedia subsystem (IMS) server) that serves as an interface between the core network 107 and the PSTN 108. In addition, the core network 107 may provide the WTRUs 102a, 102b, 102c with access to

the networks 112, which may include other wired or wireless networks that are owned and/or operated by other service providers.

[0064] FIG. 1E is a system diagram of the RAN 105 and the core network 109 according to an embodiment. The RAN 105 may be an access service network (ASN) that employs IEEE 802.16 radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 117. As will be further discussed below, the communication links between the different functional entities of the WTRUs 102a, 102b, 102c, the RAN 105, and the core network 109 may be defined as reference points.

[0065] As shown in FIG. 1E, the RAN 105 may include base stations 180a, 180b, 180c, and an ASN gateway 182, though it will be appreciated that the RAN 105 may include any number of base stations and ASN gateways while remaining consistent with an embodiment. The base stations 180a, 180b, 180c may each be associated with a particular cell (not shown) in the RAN 105 and may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 117. In one embodiment, the base stations 180a, 180b, 180c may implement MIMO technology. Thus, the base station 180a, for example, may use multiple antennas to transmit wireless signals to, and receive wireless signals from, the WTRU 102a. The base stations 180a, 180b, 180c may also provide mobility management functions, for example handoff triggering, tunnel establishment, radio resource management, traffic classification, quality of service (QoS) policy enforcement, and the like. The ASN gateway 182 may serve as a traffic aggregation point and may be responsible for paging, caching of subscriber profiles, routing to the core network 109, and the like.

[0066] The air interface 117 between the WTRUs 102a, 102b, 102c and the RAN 105 may be defined as an R1 reference point that implements the IEEE 802.16 specification. In addition, each of the WTRUs 102a, 102b, 102c may establish a logical interface (not shown) with the core network 109. The logical interface between the WTRUs 102a, 102b, 102c and the core network 109 may be defined as an R2 reference point, which may be used for authentication, authorization, IP host configuration management, and/or mobility management.

[0067] The communication link between each of the base stations 180a, 180b, 180c may be defined as an R8 reference point that includes protocols for facilitating WTRU handovers and the transfer of data between base stations. The communication link between the base stations 180a, 180b, 180c and the ASN gateway 182 may be defined as an R6 reference point. The R6 reference point may include protocols for facilitating mobility management based on mobility events associated with each of the WTRUs 102a, 102b, 102c.

[0068] As shown in FIG. 1E, the RAN 105 may be connected to the core network 109. The communication link between the RAN 105 and the core network 109 may defined as an R3 reference point that includes protocols for facilitating data transfer and mobility management capabilities, for example. The core network 109 may include a mobile IP home agent (MIP-HA) 184, an authentication, authorization, accounting (AAA) server 186, and a gateway 188. While each of the foregoing elements are depicted as part of the core network 109, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

[0069] The MIP-HA may be responsible for IP address management, and may enable the WTRUs 102a, 102b, 102c to roam between different ASNs and/or different core networks. The MIP-HA 184 may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, for example the Internet 110, to facilitate communications between the WTRUs 102a, 102b, 102c and IP-enabled devices. The AAA server 186 may be responsible for user authentication and for supporting user services. The gateway 188 may facilitate interworking with other networks. For example, the gateway 188 may provide the WTRUs 102a, 102b, 102c with access to circuit-switched networks, for example the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, 102c and traditional land-line communications devices. In addition, the gateway 188 may provide the WTRUs 102a, 102b, 102c with access to the networks 112, which may include other wired or wireless networks that are owned and/or operated by other service providers.

[0070] Although not shown in FIG. 1E, it will be appreciated that the RAN 105 may be connected to other ASNs and the core network 109 may be connected to other core networks. The communication link between the RAN 105 the other ASNs may be defined as an R4 reference point, which may include protocols for coordinating the mobility of the WTRUs 102a, 102b, 102c between the RAN 105 and the other ASNs. The communication link between the core network 109 and the other core networks may be defined as an R5 reference, which may include protocols for facilitating interworking between home core networks and visited core networks.

[0071] Systems, methods, and instrumentalities are disclosed for multiplexing transmissions with different durations, for example such as transmission that utilize different TTI lengths. Latency reduction for some transmissions may achieved, for example, by multiplexing transmissions with different TTI durations. Although examples may be described with respect to multiplexing of an LTE legacy TTI (e.g., 1 ms) with a shortened TTI length (e.g., less than 1 ms), the techniques described herein may be generally applicable to the multiplexing of other

types of transmissions that are of different/varying lengths. For example, the examples may be described with respect to transmissions that contain one transport block (TB), but the examples may be equally applicable to transmissions that include a portion of a TB, transmissions that contain multiple TBs, etc. Thus, as may be appreciated, although specific examples herein may be described with respect to multiplexing transmissions associated with a "legacy" 1 ms TTI with transmissions that are less than 1 ms, these examples are not limited to the specific embodiments described and may be applied to transmissions of varying length that include varying amounts of data. Additionally, although examples may be described with respect to multiplexing shorter than 1 ms transmissions into a legacy LTE system that utilizes a legacy TTI length of 1 ms, the techniques may be applied to other types of transmission configurations, for example such as the NR system that may be utilized for 5G cellular communications.

[0072] Transmissions of different length may be realized in multiple ways and be consistent with this disclosure. For example, multiple TTI lengths may be defined, and the system may be configured to multiplex transmissions associated with the different TTI lengths over a common set of transmission resources. In example, rather than or in addition to defining different TTI lengths, transmissions of different durations may be supported, for example where one or more of the transmissions durations may or may not correspond to a TTI. Transmission duration may be defined in a number of ways, for example an amount of time over which the transmission occurs, (e.g., a specific duration or a time partition), a number of symbols over which the transmission occurs (e.g., 14 OFDM symbols, 12 OFDM symbols, 1 OFDM symbol, etc.), a slot, a minislot, a time partition for a sub-carrier spacing, and/or in terms of a specific numerology associated with the transmissions. For example, the numerology may be defined based on one or more of a sub-carrier spacing (e.g., different sub-carrier spacing may lead to different time durations for a symbol), a symbol length, a waveform type, etc.

[0073] Examples may also be described with respect to one or more cells. However, the techniques described herein may be equally applicable to other types of resource partitions. For example, in LTE cells may be defined based on certain OFDM time-frequency resources that are defined for a certain operating band for the cell. However, the multiplexing techniques described herein may be applied to physical resources that may or may not be defined using the cell construct. For example, the techniques described herein may apply of a subset of the physical resources in a cell and/or to physical resources that are not defined using the cell construct.

[0074] In order to TTI duration may be modeled using one or more time-shifted cell(s) for a given carrier frequency, e.g. in an LTE system such as a legacy LTE system. A "logical" cell structure may correspond to an SCell (e.g., a legacy SCell). A PCell may logically maintain

a TTI (e.g., a first TTI such as a legacy TTI that may be 1 ms) or may be (e.g. also) configured with a second duration TTI (e.g., a shorter duration TTI (ShTTI) that may be less than 1 ms).

[0075] In an example, a WTRU may determine a TTI duration (e.g. first or second TTI) applicable to a transmission. A determination may be, for example, a function of one or more facts, factors, and/or parameters. For example, a WTRU may determine a TTI duration using cross-carrier scheduling information. A WTRU may associate a certain TTI duration with a certain cell identity (e.g. servCellID). A WTRU may associate a certain TTI duration with certain a transmission mode (TM). A TTI duration may be indicated by a CIF included in DCI. For example, a first cell identity (e.g., servCellID = 1) may be associated with a first TTI duration and a second cell identity (e.g., servCellID = 2) may be associated with a second TTI duration. When the CIF field indicates that the received DCI is applicable to the first cell identity (e.g., CIF = '001' - servCellID = 1), the WTRU may determine that the scheduled transmission is associated with the first TTI duration. When the CIF field indicates that the received DCI is applicable to the second cell identity (e.g., CIF = '010' - servCellID = 2), the WTRU may determine that the scheduled transmission is associated with the second TTI duration. In this matter, carrier aggregation signaling methods may be reused/reinterpreted in order to support multiple TTI length.

[0076] A TTI duration may be determined from an identity of a PRB subset associated with the transmissions and/or to a time-shifted cell within a subset of PRBs for a concerned carrier frequency. An applicable TTI duration and/or the identity of a slot/period applicable to a transmission within a subframe may be determined using MAC Activation/Deactivation. MAC Activation/Deactivation may be used to toggle between first and second TTIs (e.g. between a legacy TTI and one or more ShTTIs). For example, a WTRU may utilize a first TTI length for a first cell prior to receiving MAC Activation/Deactivation control element. Upon receiving the MAC Activation/Deactivation control element for the first cell, the WTRU may toggle to a second TTI length. In an example, the MAC Activation/Deactivation control element may be used to toggle between different slots used for a ShTTI transmission in a legacy suframe. For example, the MAC Activation/Deactivation control element may be used to switch between the first and second slots for the shortened TTI transmission. MAC Activation/Deactivation may be used to determine zero, one or more ShTTIs period(s) within a subframe.

[0077] HARQ processing may remain according to a first behavior (e.g. legacy behavior) for one or more (e.g. each) time-shifted cell(s), although there may be exceptions. In an example, an exception may be timing-relationships, which may be scaled according to an applicable TTI duration. HARQ A/N feedback formats may use LTE Carrier Aggregation (CA)

formats and/or (e.g., legacy) subframe-based timing relationships or a timing relationship associated with the HARQ process. Downlink Control Information (DCI) signaling may use a first (e.g., legacy) format, although, for example, interpretation of fields such as the CIF and/or PRBs applicable for the transmission may be different than the first (e.g., legacy) format. MAC activation/deactivation signaling may be applicable for time-shifted cells. DRX Timers associated with DRX may scale to HARQ A/N timing according to an applicable TTI duration and/or to the cell associated with an HARQ process. PRACH resources and/or PDCCH order for RACH may or may not be supported for time-shifted SCells. Timing advance for uplink transmission may be time shifted, for example, according to a shift applied to the TTI associated with a cell. Time shift may be relative to PCell timing, e.g., a PCell may remain a DL timing reference for an SCell with the additional offset corresponding to the start of the ShTTI for those cells.

[0078] A device may access resources of a communication system. Latency associated with transmission of data may have one or more latency components. A latency component may be the time to perform the transmission of a transport block, which time may be referred to as a Transmission Time Interval (TTI). A latency component may be processing time at a receiver, e.g., time decoding a transmission. Receiver processing time may be tied to implementation complexity and may be accounted for using a fixed timing relationship between different events associated with the transmission of a data unit. A timing relationship may be fixed, for example, when time-division duplex (TDD) is used for a carrier and/or synchronous Hybrid ARQ (HARQ) operation (e.g., such as for LTE in the uplink).

[0079] There may be additional latency components, for example, when a transmission is not successfully decoded. For example, additional components may include transmission of feedback (e.g. HARQ ACK or NACK), processing time at the receiver and/or one or more retransmissions with one or more latency components.

[0080] Latency components may be measured in integer multiples of a basic time interval (BTI). For example, latency components may be measured in TTIs, e.g., in LTE.

[0081] Latency in wireless networks may be caused by multiple factors. Latency may be affected, e.g., at lower layers, by a need for highly reliable transmissions, which may be obtained using HARQ. One or more retransmissions may affect the latency of a transmission, for example, given that retransmissions may not be performed in adjacent time periods.

[0082] A WTRU may incur processing time, for example, for downlink (DL) transmission, to determine whether a transmission was decoded properly, which may lead to a time interval between reception of a DL transmission and transmission of an ACK or NACK. An eNB may

incur processing time, for example, to determine whether an ACK or NACK was transmitted by the WTRU and/or whether a retransmission is required. A similar consumption of processing time may occur for uplink (UL) transmissions. Processing times may be cumulative. There may be a tradeoff between latency and implementation complexity.

[0083] A system (e.g. LTE) may accommodate processing times in a timing relationship between a first transmission for a transport block and its corresponding ACK-NACK HARQ response for downlink and/or uplink operation and possible retransmission.

[0084] Time Division Duplex (TDD) and Frequency Division Duplex (FDD) DL scheduling timing may be the same, such that a WTRU may receive a scheduling grant for a DL transmission in the same subframe or transmission time interval (TTI).

[0085] A WTRU may transmit a corresponding Physical UL Shared Channel (PUSCH), e.g., in subframe n+4, for example, upon detection of a Physical DL Control Channel PDCCH or enhanced PDCCH (EPDCCH) with UL Downlink Control Information (DCI) format and/or Physical Hybrid ARQ Indicator Channel (PHICH) transmission in subframe n, e.g., in an FDD UL transmission intended for the WTRU. A HARQ ACK/NACK response for a DL or UL transmission in subframe n may be provided in subframe n+4.

[0086] A WTRU may transmit a corresponding PUSCH in subframe n+k, for example, upon detection of a (E)PDCCH with UL DCI format and/or PHICH transmission in subframe n, e.g., for a UL transmission in a TDD system intended for the WTRU. The value of k may depend on the TDD UL/DL configuration, the subframe where the UL DCI and/or PHICH was transmitted and/or the PHICH resource and the MSB or LSB of the UL index in the (E)PDCCH, e.g., in TDD UL/DL configuration 0. A HARQ ACK/NACK response for a DL or UL transmission in subframe n may be provided in subframe n+k, where k may depend on the value of n and the TDD UL/DL configuration. Bundling may be used to provide HARQ for multiple transmissions in one instance.

[0087] Processing time available to a WTRU may depend, for example, on the value of the timing advance or on the distance between the WTRU and the eNB. In an example, an LTE system may have a distance of 100km between a WTRU and an eNB, which may correspond to a (e.g. a maximum) timing advance of 0.67ms. In an example, there may be approximately 2.3 ms left for terminal processing. An eNB may have, for example, 3 ms processing time available, which may be on the same order as that of the terminal.

[0088] FIG. 2 shows an example of DL physical layer channels. In a DL example with reference to the example shown in FIG. 2, there may be three channel areas in a subframe to support DL Shared Channel (DL-SCH) and UL-SCH. Three channel areas may comprise a PDCCH (which may include Physical Control Format Indicator Channel (PCFICH) and PHICH),

a Physical DL Shared Channel (PDSCH) and an EPDCCH. An EPDCCH may include scheduling information for a WTRU while taking advantage of the benefits of the PDSCH region, such as beamforming gain and frequency domain Inter-Cell Interference Coordination (ICIC) and/or improving PDCCH capacity.

[0089] FIG. 3 shows an example of UL physical layer channels. In a UL example with reference to the example shown in FIG. 3, there may be two channel areas in a subframe to support DL-SCH and UL-SCH. Two channel areas may comprise a PUSCH and a PDSCH. These channel areas may be transmitted in different RBs in each time slot (e.g. frequency hopping of PUSCH), for example, to increase robustness in frequency selective channels.

[0090] A transmission time interval (TTI) duration may be based on and/or defined by one or more symbols. A TTI duration may be defined in terms of a number of OFDM symbols. For example, a TTI duration may be defined as an entire (legacy) subframe and/or a pair of physical resource blocks (PRBs). In the legacy 1 ms TTI length, there may be 14 OFDM symbols for normal cyclic prefix and 12 OFDM symbols for extended cyclic prefix. For example when multiplexing ShTTI transmissions with legacy TTI transmissions of 1 ms, a ShTTI may be made as short as a single ODFM symbol. Symbol-based categorization may be referred to as symbol-based TTI durations.

[0091] A TTI duration may be based on time-varying symbol duration. TTI durations may have a fixed number of symbols (e.g., 14 symbols) while symbol duration may vary in time. For example, variable time symbol-based TTI duration may be achieved by modifying subcarrier spacing. In an example, a first TTI duration may be achieved with a first subcarrier spacing and a second TTI duration may be achieved with a second subcarrier spacing. Different bandwidth portions (e.g. PRBs) of a carrier may support different subcarrier spacing, thus enabling different TTI duration for different bandwidth portions (e.g. PRBs). Multiplexing transmissions associated with different sub-carrier spacing and/or symbol duration may be applicable to 5G systems such as NR. Such techniques may also be used in LTE-Advanced.

[0092] A TTI duration may be based on a time slot. A TTI duration may be defined in terms of a time slot (e.g. 7 OFDM symbols for normal cyclic prefix and 6 OFDM symbols for extended cyclic prefix). For example, if a ShTTI is defined as the length of one slot, two ShTTI transmissions may be time multiplexed into a legacy 1 ms TTI length.

[0093] A TTI duration may be based on time. A TTI duration may be defined in terms of a time value (e.g. 1ms legacy TTI or a 100ms ShTTI).

[0094] A TTI duration may be based on a hybrid, such as a combination of forgoing TTI duration bases. In an example of a hybrid method of achieving variable TTI durations, a different number of symbols and different symbol durations may be used.

[0095] Latency may be improved. It may be beneficial to decrease the TTI duration of different channels. A decrease in TTI duration may enable a decrease in WTRU processing time and may permit a WTRU to begin processing data sooner. Such a scenario may enable a shorter HARQ timeline. Different channels may have different TTI durations. A TTI duration shorter than one subframe for one or more of the EPDCCH, PDSCH, PUCCH, PDSCH, etc. may be provided. Effective HARQ feedback for PDSCH and PUSCH transmissions using shorter than (e.g., legacy 1ms) subframe TTI durations may be provided. Shorter TTIs may be referred to as ShTTI.

[0096] ShTTI and/or a combination of TTI and ShTTI may be supported for a given WTRU, for example, to minimize the impact of other aspects related to WTRU transmissions, such as scheduling (e.g., formats of DCIs), HARQ (e.g., related processing/process identities), feedback formats and determination of an applicable TTI duration. For example, the configuration of ShTTIs and/or the signaling of DCI for ShTTIs may utilize certain signaling originally defined for purposes of carrier aggregation in order to limit the amount of complexity at the WTRU and/or facilitated TTI length multiplexing in a backwards compatible manner. One or more latency components may be reduced, for example, to minimize the impact on WTRU implementations.

[0097] A WTRU may (e.g., based on a determination) operate with a one or more TTI durations, such as subframe TTI duration (e.g., 1 ms), a timeslot TTI duration (e.g., 0.5 ms), a symbol-based TTI duration (e.g., one or more OFDM symbols in duration), and/or other shorter than 1 ms TTI durations. In an example, a WTRU may be configured to operate with specific but different TTI duration configuration in downlink and uplink. In an example, a WTRU may be configured to permit the same TTI duration configuration to be used in downlink and uplink for applicable transmissions. For example, if the WTRU receives a configuration that indicates a first cell is associated with a first TTI duration in the downlink, the WTRU may determine that the uplink TTI duration is also the first TTI duration unless the configuration indicates otherwise.

[0098] A TTI duration may be WTRU specific. A WTRU may operate with a TTI duration during a given period. A WTRU may be configured to operate according to one or more of a plurality of possible TTI durations and may operate with the one or more TTI durations for a specific period of time, e.g., based on an L3 (e.g., radio resource control (RRC)) reconfiguration. A TTI duration may be fixed (e.g. statically, semi-statically or dynamically) for a (e.g. every) transmission to and from a WTRU.

[0099] Multiple TTI durations may be concurrently configured and/or used. A WTRU may be configured to operate for transmissions of different TTI durations concurrently. Different TTI durations may be based on, for example, semi-static allocation (e.g. configuration of a subset of frames/subframes dedicated to different TTI durations based on a semi-persistent grant or assignment) and/or dynamic allocation (e.g. based on detection and/or reception of downlink control signaling).

[0100] A TTI duration may be cell/cell group (CG)-specific. Configuration may be applicable per cell of a WTRU's configuration, for a subset of cells of a WTRU's configuration, and/or for all cells of the same timing advance group (TAG) and/or all cells of the same cell group (CG). For example, upon adding a new cell, the TTI duration may be defined for the new cell. As an example, if the WTRU adds an SCell, the SCell configuration may indicated that the WTRU is to utilize a shortened TTI duration for the SCell. The HARQ instances associated with a specific MAC entity may be configured with a similar configuration for TTI duration. A similar or same configuration for TTI duration may be used, for example, for cells associated with the same channel(s) (e.g. PUCCH, PUSCH) for uplink control signaling.

[0101] TTI duration may be modeled using one or more time-shifted cell(s) for a given carrier frequency. Modeling may enable co-existence between WTRUs operating according to different TTI durations, e.g. in legacy LTE systems. A "logical" cell structure may correspond to the use of one or more serving cell(s). Serving cells may include secondary cells, such as an SCell type or a PSCell type defined for LTE CA. A PCell may logically maintain a first (e.g., legacy) TTI such as 1 ms or may be (e.g., also) configured as a ShTTI.

[0102] Multiple serving cells may be associated with a specific TTI duration. A WTRU may support multiple TTI durations based on one or more functions and/or characteristic associated to a serving cell.

[0103] A WTRU may determine the duration of a downlink control region, e.g., according to a first (e.g., legacy) behavior for LTE. A reception of PDCCH may be a first (e.g., legacy) behavior for downlink subframes. In an example, the first ShTTI in a subframe may include a control region, e.g., in case of slot-based operation, such as two slots of 7 symbols where the first slot include 1-3 symbols for PDCCH. In an example, the ShTTI duration may exclude the control region, e.g., in case of symbol-based ShTTIs. In an example, an offset in time or in symbol from the start of a subframe may be used to indicate the start of an ShTTI (e.g., in the DCI).

[0104] In an example, a WTRU may operate on a given carrier frequency (e.g., for downlink and/or uplink) according to at least one of the following: TTI duration per Transmission

Mode (TM), TTI duration per Serving Cell Identity (servCellID), and/or TTI duration per Serving Cell.

[0105] In an example of TTI duration per Transmission Mode (TM), a WTRU may be configured with multiple transmission modes (TM), e.g., one for each applicable TTI duration.

[0106] In an example of TTI duration per Serving Cell Identity (servCellID), a WTRU may be configured with multiple serving cell identities (e.g., servCellIDs), e.g., one for each applicable TTI duration.

[0107] In an example of TTI duration per Serving Cell, a WTRU may be configured with multiple serving cells for a given carrier frequency, e.g. one for each applicable TTI duration.

[0108] Combinations may be made using different types of serving cells. For example, a WTRU may be configured according to any of the following examples or other examples.

[0109] In a first case or example, a WTRU may be configured with one PCell and one SCell (or PSCell). A WTRU may perform a transmission associated with a PCell using a first ShTTI and a transmission associated with the SCell/PSCell using a second ShTTI. A WTRU may transmit Uplink Control Information (UCI) for a transmission associated with a specific cell using the uplink resources associated with the concerned cell (e.g., according to a first (e.g. legacy) behavior or processing time associated with the ShTTI), for example, when an SCell is configured with PUCCH resources or when the WTRU is configured with PSCell. A WTRU may perform the transmission of UCI using resources of the PCell (e.g., according to a first (e.g., legacy) behavior), for example, otherwise. In either case or other cases, a WTRU may transmit UCI using the TTI applicable to the uplink configuration of the concerned cell or according to the ShTTI applicable the received transmission.

[0110] In a second case or example, a WTRU may be configured with one PCell and two SCells. A WTRU may perform a transmissions associated with a PCell using a first TTI (e.g., a legacy 1ms TTI) and a transmission associated with an SCell using a second TTI (e.g., an ShTTI). A WTRU may transmit UCI for a transmission associated with a specific cell using the uplink resources associated with the concerned cell (e.g., according to a first (e.g., legacy) behavior or processing time associated with the ShTTI), for example, when an SCell is configured with PUCCH resources. A WTRU may perform the transmission of UCI using resources of the PCell (e.g., according to a first (e.g., legacy) behavior), for example, otherwise. In either case or other cases, a WTRU may transmit UCI using the TTI applicable to the uplink configuration of the concerned cell or according to the ShTTI applicable to the received transmission.

[0111] In a third case or example, a WTRU may be configured with one PCell and multiple SCells. A configuration may be a generalization of either of the first and second examples,

whereby more than two TTI durations may be supported (e.g., within a first (e.g., legacy) subframe).

[0112] In an example involving a PSCell, a different Cell Radio Network Temporary Identifier (C-RNTI) than that applicable for a PCell may indicate the duration of the TTI. Examples presented and other examples may be used separately or in combination. Other realizations and/or combinations are possible.

[0113] Examples for handling of downlink control region for case 1 with slot-based operation are described.

[0114] A WTRU may be configured with a (e.g., DL) control region of zero symbols for a serving cell used for the purpose of ShTTI, e.g., for the serving cell that corresponds to a second slot in case of slot-based operation. A WTRU may determine that a serving cell is configured for the purpose of ShTTI, for example, based on reception of signaling that indicates such value for the duration of the control region. A WTRU may determine that a serving cell is configured as an ShTTI for the second slot, for example, based on reception of signaling that indicates such value for the duration of the control region. A WTRU may determine that a PCell configuration is used for ShTTI for the first slot.

[0115] Different procedures or algorithms may be used to determine applicable TTI duration, e.g., independent of modeling. For example, a WTRU may determine the TTI duration (e.g. legacy duration such as 1ms or shorter (e.g., ShTTI)) applicable to a transmission as a function of one or more of the following: (a) a WTRU may determine TTI duration using cross-carrier scheduling; (b) a WTRU may associate a TTI duration with a serving cell identity; (c) a TTI duration may be indicated by a Carrier Indicator Field (CIF); (d) a TTI duration may be indicated by C-RNTI applicable to control signaling associated with the allocation of resources; (e) a TTI duration may be determined from the identity of a PRB subset applicable to the transmissions and/or to the time-shifted cell within the entire subset of PRBs for the carrier frequency; (f) a MAC Activation/Deactivation may be used to determine the applicable TTI duration and/or the identity of the slot/period applicable to a transmission within a subframe. A MAC Activation/Deactivation may be used, for example, to toggle between multiple TTIs (e.g. a legacy TTI and one or more ShTTIs), toggle between slot-based ShTTIs and/or to determine zero, one or more ShTTIs period(s) within a subframe.

[0116] HARQ processing may be used (e.g., according to a first (e.g., legacy) behavior) for time-shifted cell(s), although, in an example, timing-relationships may be scaled according to an applicable TTI duration. HARQ A/N feedback formats may reuse LTE CA formats, first (e.g., legacy) subframe-based timing relationships and/or timing relationship associated with the HARQ

process. DCI signaling may reuse a first (e.g., legacy) format, although, in an example, interpretation of fields such as the CIF and/or PRBs applicable for the transmission may be different. MAC activation/deactivation signaling may be applicable for time-shifted cells. DRX Timers associated with DRX may scale to HARQ A/N timing according to an applicable TTI duration and/or to the cell associated with the HARQ process. Physical Random Access Channel (PRACH) resources and/or PDCCH order for RACH may or may not be supported for time-shifted SCells. Timing advance for uplink transmission may be time shifted according to the shift applied to the TTI associated with a cell, for example, when such time shift is relative to the PCell timing (e.g., the PCell remains the DL timing reference for such SCell with the additional offset corresponding to the start of the ShTTI for those cells).

[0117] Any procedure or algorithm that may operate with or indicate a TTI duration may be applicable as a procedure or algorithm to operate with or to indicate a subcarrier spacing.

[0118] Support may be provided for transmissions with different TTI duration. A WTRU may be configured for operation with the LTE physical layer. A WTRU may be configured, for example, for operation according to a first (e.g., legacy) LTE behavior or for operation together with a 5gFLEX configuration, e.g., a configuration that supports a physical layer operating with other variants of potentially filtered OFDM transmissions, such as Universal Filtered OFDM (UF-OFDM), Filtered Based OFDM (FB-OFDM), etc.

[0119] In an example of LTE FDD, a radio frame may consist of 10 subframes of 1ms each with a TTI of 1ms. Each TTI may consist of two 0.5ms slots of 7 symbols for a configuration with a normal cyclic prefix. In the downlink, there may be 8 asynchronous HARQ processes numbered 0-7 that may be addressed by means of downlink DCI. In the uplink, there may be 8 synchronous HARQ processes per RTT, which identity may be tied to the subframe timing. A WTRU may be configured for 1 to 3 symbols at the beginning of the first slot used for control signaling (PDCCH). Control signaling may span the entire bandwidth for a given cell. A TTI duration may be fixed, e.g., at 1ms, as an aspect of the LTE physical layer.

[0120] Different cells of a WTRU's configuration may be (e.g. explicitly) associated with a TTI duration/offset shift. Support for different TTI durations may be realized, for example, by maintaining a unique association between a cell and a TTI duration in a WTRU's configuration. Timing associated with the cell (e.g. a cell of the LTE CA SCell type) may be shifted and/or offset in time with respect to the timing of a reference cell. A reference cell may be the PCell of the WTRU's configuration. The PCell may be considered to have a zero time shift, e.g., by default. In an example of dual connectivity, a PSCell may be considered to have a zero time shift (e.g., by

default), for example, when a secondary group of cells is configured and when the PSCell is used as the timing reference.

[0121] In an example, a time-shifted/TTI duration/offset shift may be associated with an identity. For example, a time-shifted cell may be configured with a serving cell identity, with an offset in time relative to the start of a cell-specific subframe (e.g. where timing may be based on the PCell used as a downlink timing reference) and with a TTI duration (e.g. shorter than a first (e.g. legacy) timing that may be referred to as a shorter TTI or ShTTI).

[0122] TTI duration may be a configuration aspect of a WTRU, such as part of a configured transmission mode associated with the physical layer configuration for the cell.

[0123] Cells using a timing relationship may be configured as part of the same timing advance group (TAG). Cells (e.g., SCells) in a secondary TAG (STAG) supporting ShTTIs may use one of the cells in the same TAG as a timing reference (e.g., a cell used may be a configuration aspect of a WTRU) or may use the PCell as the timing reference (e.g., otherwise).

[0124] Support may be provided for multiplexing transmissions in a cell and/or for a specific WTRU. Support for transmissions using different TTI duration may be for concurrent transmissions in the same cell. For example, transmission may correspond to a single TTI duration for each WTRU at any given time while some WTRUs may have different TTI duration than other WTRUs. Support may be for transmissions for a given WTRU within the same subframe (e.g., within a first (e.g., legacy) subframe such as 1 ms) where different transmissions may be performed according to different TTI durations by the concerned WTRU.

[0125] Procedures may be applicable for uplink and/or downlink transmission and may be a configuration aspect for a WTRU.

[0126] An ShTTI-based transmission mode (TM) and cell timing configuration may be provided. For example, a WTRU may be configured with a PCell (e.g., according to first (e.g., legacy) behavior). For example, a WTRU may operate on a PCell carrier frequency using a first TM (e.g., a TM in the range of 1-10) associated with a first TTI duration (e.g., legacy 1ms). The WTRU may receive a RRC Connection Reconfiguration message that may reconfigure the WTRU according to at least one of the following: the WTRU may reconfigure the PCell and/or may configure at least one SCell.

[0127] In an example of reconfiguring a PCell, the WTRU may reconfigure the PCell such that a second TTI (e.g., ShTTI) of a duration shorter than previously used by the WTRU for the PCell is supported. For example, the WTRU may reconfigure (or add) a TM associated to the PCell. For example, a TM (e.g., TM = 11) may be associated with a TTI duration different than previously used by the WTRU for the PCell.

[0128] For example, a WTRU may configure a TTI duration according to one of the following. In an example, an ShTTI duration may be equal to 1 slot (0.5ms). This may be applicable, for example, to the first case. In another example, an ShTTI may be a duration expressed as an integer multiple of 1 symbol. A duration may include the control region, for example, when the configuration includes a start offset for the ShTTI and such offset is equal to zero. In another example, an ShTTI may be a duration expressed as an integer value in time, e.g. 100 μs or 125μs. Whether an ShTTI duration may include the control region may be determined as a function the value of a start offset for the ShTTI when applicable. A control region may be a separate aspect of a WTRU's configuration for a cell when an offset is equal to a non-zero value.

[0129] For example, a TM may support transmissions in (e.g., only in) the first slot of a first (e.g., legacy) subframe for the concerned ShTTI duration. A WTRU may determine an aspect as a function of the type of cell (e.g., PCell) associated with the TM. A TM may support WTRU-specific demodulation reference signals (e.g., DM-RS) such that their location and density may be better suited for ShTTI operation.

[0130] In an example of reconfiguring a PCell, transmissions on the PCell using a first (e.g., legacy) TTI such as 1ms may be enabled. This may be applicable, for example, in the second case, e.g., when a WTRU may be configured such that PCell operation supports transmissions using a first (e.g. legacy) 1ms TTI and one or more SCells support operation using ShTTI.

[0131] A WTRU may configure a PCell with an additional cell identity to the PCell in the PCell's configuration such that DCI may indicate, for example, "CIF=0" for a transmission on PCell using a first TTI (e.g., 1ms) and "CIF=1" for a transmission on PCell using a second TTI (e.g. a slot-based ShTTI of 0.5ms or similar). This may be applicable, for example, in the first case.

[0132] In an example of reconfiguring at least one SCell, the WTRU may configure an SCell such that an associated TTI duration (e.g., ShTTI) is less than that of a first (e.g., legacy) subframe duration (e.g., less than 1ms). For example, the WTRU may configure a TM associated with the SCell. For example, a TM (e.g., TM = 11) may be associated with a TTI duration similar to that of the PCell (e.g., ShTTI). For example, a ShTTI duration may be equal to 1 slot (0.5ms). This may be applicable, for example, in the first case. A TM (e.g., TM = 11+x) may be (e.g. alternatively) associated with a TTI duration different than that of the PCell, for example, when the TTI duration of such SCell may differ from that of the PCell.

[0133] Combinations of slot-based TTI (e.g., 0.5ms for a PCell) and non slot-based TTIs (e.g., 5 SCells of 100ms each) may be applicable for a given WTRU. Another example may be of a WTRU configured with symbol-based TTIs such that a different number of symbols may be used for each of the control regions (e.g,. 3 symbols), the TTI duration for the PCell (e.g., 5 symbols)

and for a number of SCells of x symbols in duration (e.g., 3 SCells each 2 symbols in TTI duration). Other combinations and/or other values are possible.

[0134] Example procedures may be applicable to any of the cases described above. Procedures may be applicable for uplink and/or downlink transmission and may be a configuration aspect for a WTRU.

[0135] TTI duration may be determined as a function of a Carrier Indicator Field (CIF) in a DCI on PDCCH. A TTI duration may be signaled as a function of the indicated cell identity in the DCI (e.g., by CIF or similar for a given carrier frequency of the WTRU's configuration). A determination or indication may be achieved, for example, by associating a second identity with a cell of the WTRU's configuration or by duplication of a serving cell configuration for a given carrier frequency. The WTRU may determine that the DCI of a given transmission (e.g., PDDCH transmission, serving cell transmission, received downlink control information, or scheduling information) has indicated that the WTRU should use a first transmission time interval on a physical uplink channel to communicate with the serving cell. For example, the determination may be based on the CIF field of the DCI, as the CIF may refer to a serving cell identity that has been configured to utilize the first transmission time interval. In this manner, downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment) may be re-used for scheduling of transmissions associated with the first TTI length. Similarly, the WTRU may determine that the DCI of a given transmission (e.g., PDDCH transmission, serving cell transmission, received downlink control information, or scheduling information) has indicated that the WTRU should use a second transmission time interval on a physical uplink channel to communicate with a second serving cell. For example, the determination may be based on the CIF field of the DCI, as the CIF may refer to the second serving cell identity and the second serving cell may have been configured to utilize the second transmission time interval. One or more of the first or second transmission time intervals may correspond a shortened TTI that is less than the legacy transmission time interval. The first and second serving cells may configured to utilize the same frequency band and/or carrier frequency.

[0136] In an example using slot-based TTI duration, a WTRU may be configured with a PCell with CIF=0, an SCell with CIF=1 and an SCell with CIF=2 for a given carrier frequency. Both SCells may be configured with carrier aggregation cross-carrier scheduling such that scheduling information for the associated resources may be received on the PDCCH associated with the PCell. A WTRU may receive signaling that schedules a transmission on such PDCCH. A WTRU may determine that a TTI duration is according to first (e.g., legacy) operation (e.g., 1ms), for example, when the WTRU determines that the CIF applicable to the transmission is that

of the PCell. The WTRU may determine that the transmission is applicable to the first slot of the concerned subframe, for example, when the WTRU determines that the CIF=1. The WTRU may determine that the transmission is for the second slot of the concerned subframe, for example, when CIF=2.

[0137] Example procedures may be applicable to any of the cases described above. Procedures may be applicable for uplink and/or downlink transmission and may be a configuration aspect for a WTRU.

[0138] A start offset for ShTTI may be a function of CIF in the DCI on PDCCH. In an example, determination of the applicable location in time (e.g., slot in the subframe, applicable starting symbol and/or all applicable symbols or similar) may be enabled for a transmission, for example, when a TTI duration shorter than that of the subframe duration is configured for a given cell.

[0139] A start offset or applicable location in time may be based on signaling received by the WTRU. The WTRU may perform such determination as a function of the indicated cell identity in the DCI, e.g., by Carrier Indicator Field (CIF) or similar for a given carrier frequency of the WTRU's configuration. An indication or determination may be achieved, for example, by associating a specific offset in the subframe with an identity of a cell of the WTRU's configuration or by configuring multiple serving cells for a given carrier frequency each with a different identity and a different offset.

[0140] For example, an offset may indicate one of a first slot or a second slot of a cell-specific subframe or it may indicate an offset in terms of a starting symbol in a subframe or an offset in absolute time (e.g. 500ms). An offset may be applied from the start of a cell-specific subframe. An offset may implicitly indicate a TTI duration (or vice-versa).

[0141] Example procedures may be applicable to any of the cases described above. Procedures may be applicable for uplink and/or downlink transmission and may be a configuration aspect for a WTRU.

[0142] A TTI duration may be a function of PRB(s) for a transmission. In an example, a WTRU may be configured such that a number of PRBs (e.g. a subset of the total set of system-specific PRBs for the concerned carrier frequency) may be associated with a cell of the WTRU's configuration for which the WTRU is operating with shorter than 1ms TTI duration e.g. configured with ShTTI.

[0143] A WTRU may determine an applicable TTI duration as a function of the PRB(s) indicated by the scheduling information. A PRB may correspond to the starting PRB for the resource allocation for the transmission. A set of PRBs may correspond to a range of PRBs. A

WTRU may use the TTI duration associated with a set of PRB(s), for example, when such range includes (e.g., only includes) PRB(s) associated with the concerned set. A WTRU may (e.g., otherwise) use a different TTI duration (e.g., a first (e.g. legacy) TTI duration, such as 1ms, or a configured duration), for example, when such range includes PRBs associated with different sets of PRBs or when such range does not include PRBs associated with any such sets. Sets of PRBs may be a configuration aspect of a WTRU's configuration. For example, a serving cell may be associated with a set of one or more PRBs, for example, when a serving cell is configured for ShTTI operation for a carrier frequency. A WTRU may use the TTI duration associated with such a cell or associated with the concerned PRBs. Scheduling information may be received dynamically in a DCI on PDCCH. Scheduling information may be semi-statically configured. For example, an entire (e.g., system-specific) set of PRBs for a PCell configured with a first (e.g., legacy) operation may be 110 PRBs. A WTRU may (e.g., alternatively) be configured with one or more subsets of PRBs, where each set may be associated with a specific TTI duration.

[0144] A WTRU may (e.g., first) determine the cell configured with ShTTI applicable to the transmission and/or the duration of the TTI (e.g., determining as described herein) and may determine the set of applicable PRBs therefrom (e.g., determining using a configuration of sets of PRBs as discussed herein).

[0145] Example procedures (e.g., operation) may be applicable to any of the cases described above. Procedures may be applicable for uplink and/or downlink transmission and may be a configuration aspect for a WTRU. For example, a procedure may be associated with a transmission mode for downlink and/or uplink. For example, a procedure may be associated with a serving cell of the WTRU's configuration. For example, a WTRU may determine that a configuration is specific to a serving cell of a WTRU's configuration, e.g., a determination may be made that a TTI configuration applies to both DL and UL frequencies. For example, a WTRU may determine that a configuration is specific to a specific direction of a configuration for a given serving cell of the WTRU's configuration, e.g., a determination may be made that a TTI configuration is provided separately for the DL direction and for the UL direction.

[0146] A determination may be made about the start offset time for a transmission. Cell de-activation may control availability of ShTTI. In an example, a first (e.g., legacy) cell activation-deactivation mechanism (e.g., procedure or algorithm) may control the duration (e.g., first or second TTI such as a legacy TTI or an ShTTI duration) of a transmission, e.g., by activating and deactivating the transmission. A WTRU may associate an activation state with an ShTTI, a slot and/or a resource.

[0147] In an example, a WTRU configured using ShTTI cells may receive a first (e.g., legacy) MAC activation/deactivation control element. A WTRU may use the activation/deactivation element as a mechanism to determine the availability of the ShTTI. For example, a WTRU may use a first (e.g., 1ms) TTI duration, e.g., when the WTRU is configured with a single SCell with ShTTI and when the SCell is in a deactivated state when the WTRU determines that it needs to perform a transmission. A WTRU may (e.g., otherwise) use a second TTI duration (e.g., ShTTI) for a transmission, e.g., when the SCell is active. The WTRU may perform a transmission using the second TTI duration (e.g. ShTTI), for example, according to scheduling information independently of the scheduled slot. This example may be extended to apply to the case where a symbol-based TTI duration is used instead of a time duration such as transmission slots.

[0148] In an example where multiple SCells may be used to indicate slot-based transmissions, a WTRU may determine that a first TTI duration is applicable when all cells configured with ShTTI are in a deactivated state. A WTRU may determine (e.g., otherwise) the applicable slot based on the activation state associated with each SCell and associated with each slot. This example may be extended to apply to the case where a symbol-based TTI duration is used, e.g., instead of using time duration such as transmission slots.

[0149] A WTRU may transmit HARQ feedback and/or other Uplink Control Information (UCI) (e.g. CQI, PMI, RI or similar), for example, taking into consideration the configuration of the TTI duration.

[0150] A TTI duration applicable to the transmission of UCI may be a function of at least one of the following: scheduling information, configuration information, TTI applicable to a serving cell, a default configuration for UCI transmission, etc.

[0151] Scheduling information may indicate whether a WTRU has resources for a PUSCH transmission and (e.g., if so) the TTI duration associated with such transmission, which may be determined according to procedures described herein.

[0152] Configuration information may indicate whether a WTRU is configured for simultaneous PUSCH and PUCCH transmission.

[0153] A TTI may be applicable to a serving cell associated with a UCI transmission in the subframe for the concerned UCI transmission.

[0154] A TTI may be applicable (e.g., in duration and/or offset) to a serving cell associated with a UCI transmission in the subframe for a downlink transmission pertaining to the feedback (e.g., in case of HARQ A/N feedback).

[0155] A default configuration for the transmission of UCI may be, for example, for the transmission of UCI on PUCCH (e.g., always a first TTI such as 1 ms TTI on PCell).

[0156] Further examples are provided below.

[0157] An applicable resource may be a PUSCH or PUCCH resource. A WTRU may determine a physical channel to perform the transmission of UCI using any technique, procedure or algorithm. For example, a WTRU may determine that UCI may be included in a PUSCH transmission when the transmission is scheduled, when simultaneous PUSCH and PUCCH transmissions are not configured or on a PUCCH transmission (e.g., otherwise).

[0158] An applicable resource may be a PUSCH resource. A WTRU may perform the transmission of UCI on a PUSCH transmission according to a TTI duration associated with a PUSCH transmission, which may be determined using procedures described herein.

[0159] An applicable resource may be a PUCCH resource. A WTRU may determine that a PUCCH resource may be used for transmission of UCI according to any technique, procedure or algorithm applicable to LTE CA. For example, selection of a resource may be based on the first CCE of the DCI that scheduled a downlink transmission or based on a configuration (e.g. PUCCH format 3 or similar). Bundling and/or multiplexing may be applied, for example, when configured.

[0160] An applicable TTI may be function of the type of transmissions on the carrier frequency PUSCH or PUCCH. Transmission of UCI may use the principles of LTE CA whereby UCI corresponding to transmission on different cells, e.g., including time-shifted cells, maybe multiplexed on a single transmission using a format that supports the required number of information bits (e.g., PUCCH format 3).

[0161] A PUCCH transmission may be performed on a PCell with a first (e.g., 1 ms TTI), where the first TTI may be a fixed TTI. A WTRU may perform PUCCH transmission on resources of an applicable serving cell (e.g., a PCell) according to a TTI duration associated with a concerned (e.g., pertinent) PCell, which may be determined using procedures described herein. In an example, a WTRU may transmit HARQ feedback using a single PUCCH transmission, which may use resources associated with a PCell (e.g. using a 1ms TTI duration), for example, when a WTRU has HARQ A/N feedback to transmit for two slot-based time-shifted cells using PUCCH on the PCell according to a configuration for a given carrier frequency where the PCell uses a first (e.g., 1ms) TTI.

[0162] A PUCCH transmission may be performed on a PCell with alignment in time with TTI being reported. A WTRU may perform PUCCH transmission on resources of an applicable serving cell (e.g. a PCell) according to a TTI duration associated with transmission(s) for which feedback is transmitted. A WTRU may have, for example, HARQ A/N feedback to transmit for

two slot-based time-shifted cells using PUCCH on the PCell according to a configuration for a given carrier frequency. In an example, a WTRU may transmit in the first slot a HARQ feedback for a transmission associated with the first slot and may transmit the HARQ feedback for the other transmission in the second slot for the concerned subframe.

[0163] A PUCCH transmission may be performed on a PCell with TTI/ShTTI of the PCell. A WTRU may perform a PUCCH transmission on resources of an applicable serving cell (e.g. a PCell) according to a TTI duration associated with the PCell, which may be determined using procedures described herein. A PCell may be (e.g., otherwise) configured with a default TTI, such as a first (e.g., 1 ms) TTI or an ShTTI. A WTRU may have HARQ A/N feedback to transmit for two slot-based time-shifted cells using PUCCH on the PCell, e.g., according to a configuration for a given carrier frequency where the PCell uses ShTTI in the concerned subframe (e.g., based on a configuration aspect and/or an activation state such as ShTTI activated for a time-shifted SCell for the concerned subframe). In an example, a WTRU may transmit HARQ feedback using a single PUCCH transmission, which may use resources associated with the PCell using a ShTTI duration with an offset applicable to the PCell.

[0164] A WTRU may transmit HARQ A/N feedback, for example, based on an applicable WTRU processing time for a concerned (e.g., pertinent) HARQ process in a given subframe.

[0165] Processing time associated with a HARQ process may be specific to a TTI associated with a transmissions for a concerned process. Processing time may be specific to a serving cell, a transmission mode or may be indicated by DCI (e.g., from servCellID or CIF) associated with such transmissions for a concerned HARQ process. In an example, HARQ processing time may be the same for all HARQ processes associated with a serving cell configured with a specific TTI (e.g., an ShTTI). Processing time may be a fixed value (e.g., 1ms), a multiple of an ShTTI, etc. Processing time may be determined for a transmission using ShTTI in subframe, the first available occasion in subframe n+2, where an occasion may correspond to a PUCCH or a PUSCH transmission with duration according to a first TTI or second TTI (e.g., ShTTI).

[0166] Systems, methods, and instrumentalities have been disclosed for multiplexing transmissions with different TTI duration. Latency may be reduced (e.g., in an LTE system), for example, by multiplexing transmissions with different TTI durations. TTI duration may be modeled using one or more time-shifted cell(s) for a given carrier frequency. A "logical" cell structure may correspond to an SCell. A PCell may logically maintain a TTI (e.g,. a first TTI) or may be configured with a second duration TTI (e.g., a shorter duration TTI (ShTTI)).

[0167] In an example, a WTRU may determine a TTI duration (e.g., first or second TTI) applicable to a transmission. For example, a WTRU may determine a TTI duration using cross-

carrier scheduling. A WTRU may associate a TTI duration with a cell identity (e.g. servCellID). A WTRU may associate a TTI duration with a transmission mode (TM). A TTI duration may be indicated by Carrier Indicator Field (CIF). A TTI duration may be determined from an identity of a PRB subset applicable to transmissions and/or to a time-shifted cell within a subset of PRBs for a concerned carrier frequency. An applicable TTI duration and/or the identity of a slot/period applicable to a transmission within a subframe may be determined using MAC Activation/Deactivation. MAC Activation/Deactivation may be used to toggle between first and second TTIs (e.g. legacy TTI and ShTTIs) or between slot-based ShTTIs and/or may be used to determine zero, one or more TTI (e.g. ShTTI) period(s) within a subframe.

[0168] HARQ processing may be performed according to a first behavior (e.g. legacy behavior) for one or more (e.g. each) time-shifted cell(s), although there may be exceptions. An exception may be timing-relationships, which may be scaled according to an applicable TTI duration. HARQ A/N feedback formats may use LTE Carrier Aggregation (CA) formats and/or (e.g., legacy) subframe-based timing relationships or a timing relationship associated with the HARQ process. Downlink Control Information (DCI) signaling may use a first (e.g., legacy) format, although, for example, interpretation of fields such as the CIF and/or PRBs applicable for the transmission may be different than the first (e.g., legacy) format. MAC activation/deactivation signaling may be applicable for time-shifted cells. DRX Timers associated with DRX may scale to HARQ A/N timing according to an applicable TTI duration and/or to the cell associated with an HARQ process. PRACH resources and/or PDCCH order for RACH may or may not be supported for time-shifted SCells. Timing advance for uplink transmission may be time shifted, for example, according to a shift applied to the TTI associated with a cell. Time shift may be relative to PCell timing, e.g. a PCell may remain a DL timing reference for an SCell with the additional offset corresponding to the start of the ShTTI for those cells.

[0169] A different TTI may be used in LTE R14 and NR. Multiple serving cells may be configured on the same carrier for a single WTRU. There may be an association between a serving cell and a TTI duration (or more generally – a numerology-related aspect). A WTRU can be configured with multiple such cells on a given carrier to support (*e.g.*, dynamically) a change in transmission duration. A field in downlink control signaling (DCI), *e.g.*, on a downlink control channel (*e.g.*, PDCCH), such as the CIF field in a DCI, may be used to dynamically schedule specific TTI durations for same or later subframes, for UL or DL transmissions.

[0170] The WTRU may be configured with a plurality of transmission methods, where at least two of the configured transmission methods differ in at least the applicable TTI duration.

[0171] A transmission may be associated with a transmission timing (start offset) relative to a timing reference.

[0172] A WTRU transmission mode may be indicated in downlink control information (DCI) signaling.

[0173] WTRU transmissions may be configured for each of a plurality of PRBs in the WTRU's configuration. Each of a plurality of PRBs may correspond to a serving cell of the WTRU's configuration. Each of a plurality of PRBs may correspond to a given carrier.

[0174] An applicable transmission duration/timing may be determined from a serving cell ID indicated in DCI signaling.

[0175] The WTRU may determine the set of resources, transmission duration, and/or uplink control information for a transmission based on a previous combination of received downlink signaling and received transmission duration.

[0176] A WTRU may determine whether a control region (*e.g.*, single control region) (*e.g.*, single level PDCCH) or multiple control regions (*e.g.*, multi-level PDCCH) are applicable and whether they are a function of the PDCCH configuration applicable to the concerned cell(s). A WTRU can determine the location of CCEs with respect to the timing reference (*e.g.*, in support of either self-scheduling or cross-TTI scheduling).

[0177] A WTRU may support mini-slots (*e.g.*, 125usec), slots (*e.g.*, 0.5ms), subframe (*e.g.*, 1ms) and multi-slots (*e.g.*, Multiples of other durations), and transmission durations and use different (*e.g.*, shortened) TTI's based on these time allocations. This may provide a low latency mode, a throughput mode and/or a coverage mode.

[0178] FIG. 4 depicts a scheduling example with time shifted-cells. As shown, there is a frequency axis and a time axis. In Fig. 4, the time is measured in milliseconds and divided into subframes. Other time units can be used such as slots, minislots, symbols, and PRB lengths. The frequency axis shows downlink (DL) and uplink (UL) transmissions. The time axis shows subframes. N, n+1, N=3, etc.... As shown for the DL frequency, for one or more subframes, the WTRU may receive DCI. For subframe n, the DCI may indicate two allocations, for example two ShTTI allocations (*e.g.*, $ShTTI_{DL(n,0)}$ and $ShTTI_{DL(n,1)}$). As an example, setting the CIF equal to 1 may indicate that the allocation is for $ShTTI_{DL(n,0)}$ and setting the CIF equal to 2 may indicate the allocation is for $ShTTI_{DL(n,1)}$. Other values of the CIF may be used to indicate no ShTTI transmissions and/or different transmission durations. For example, the DCI in Subframe

n+1 may indicate that for DL subframe n+1, the transmission has a duration corresponding to the entire subframe by using the value CIF=0 (*see e.g.*, a $TTI_{DL(N+1)}$).

[0179] A similar signaling mechanism can be used for indicating different durations of uplink transmissions. For example, DCI in DL subframe n may indicate that the WTRU has recieved two uplink grants. For example, a first grant for subframe n+1 may be indicate a CIF=1, which may be configured to correspond to $ShTTI_{(n+an\ offset,0)}$, while a CIF equal to 2 may indicate a grant for $ShTTI_{(n+an\ offset,0)}$. Similarly, a different value of the CIF (*e.g.*, CIF = 0) in this example may indicate that the transmissions duration spans an entire legacy TTI as illustrated in FIG. 4. Thus, by associating different CIF values with different transmission durations, the DCI may be used to indicate different transmission durations by referencing the different CIF values. Although the CIF field is used for purposes of illustration, other DCI fields may be used and may have values mapped to/associated with transmissions of different duration.

[0180] FIG. 4 also shows for an example of the PUCCH on the uplink frequency. For the PCell or SCell there may be a HARQ A/N for CIF = 1 at (n, 0) and a HARQ A/N for CIF = 2 at n, 1. For the PCell, (*e.g.*, PCell only), there may be a HARQ A/N for CIF = 0 at (n, 0) or CIF = 0 at n-3. Also, for the PCell, (*e.g.*, PCell only), there may be a HARQ A/N for CIF = 1 at (n, 0) or CIF = 0 at n-3 for the $ShTTI_{(n+?,\ 0)}$ and HARQ A/N for CIF = 2 at (n, 1) or CIF = 0 at n-3 for the $ShTTI_{(n+?,\ 1)}$.

[0181] FIG. 4 shows an example with time shifted cells with an offset of symbols. In this example, the symbol offset is based on CIF. FIG. 4 shows a single HARQ addressing space per TTI duration and start offset in a given subframe. MAC activation/deactivation may be applied by a HARQ process space or CIF value. FIG. 4 also shows a UCI example with time-shifted cells. The first CCE of the DCI on the example channel, PDCCH, may be used for legacy PUCCH resource allocation at TTI or ShTTI. Configured LTE CA PUCCH, PUCCH on an SCell, and/or ARI may be used for UCI using different TTIs. As shown, the WTRU interprets the DCI TTI indication differently in the FIG. 4 example for SCells and PCells to use ShTTI for the SCells. FIG. 4 also shows an example of the frequency being the same for the PCell and SCell. The FIG. 4 example dynamically varies the scheduled TTI for a WTRU and uses the appropriate HARQ signaling. Also, resource allocation for associated control information is resolved and there is flexibility to adapt different time offsets in a subframe and with different ShTTIs.

[0182] Although features and elements are described above in particular combinations, one of ordinary skill in the art will appreciate that each feature or element may be used alone or in any combination with the other features and elements. In addition, the methods described herein

may be implemented in a computer program, software, or firmware incorporated in a computer-readable medium for execution by a computer or processor. Examples of computer-readable media include electronic signals (transmitted over wired or wireless connections) and computer-readable storage media. Examples of computer-readable storage media include, but are not limited to, a read only memory (ROM), a random access memory (RAM), a register, cache memory, semiconductor memory devices, magnetic media such as internal hard disks and removable disks, magneto-optical media, optical media such as CD-ROM disks, and digital versatile disks (DVDs). A processor in association with software may be used to implement a radio frequency transceiver for use in a WTRU, WTRU, terminal, base station, RNC, or any host computer.

CLAIMS

What Is Claimed:

1. A method implemented by a wireless transmit/receive unit (WTRU) for supporting transmissions of different durations, the method comprising:

receiving a first configuration associated with a first set of transmission resources, the first configuration indicating a first transmission time interval (TTI) length for use with the first set of transmission resources;

receiving a second configuration associated with a second set of transmission resources, the second configuration indicating a second transmission time interval (TTI) length for use with the second set of transmission resources;

receiving downlink control information (DCI), wherein the DCI comprises a field that indicates whether the DCI is applicable to first set of transmission resources or the second set of transmission resources; and

determining that a transmission associated with the DCI utilizes the first TTI length on condition that the field indicates that the DCI is applicable to the first set of transmission resources or that the transmission associated with the DCI utilizes the second TTI length on condition that the field indicates that the DCI is applicable to the second set of transmission resources.

2. The method of claim 1, wherein the first set of transmission resources correspond to a first serving cell and the second set of transmission resources correspond to a second serving cell.

3. The method of claim 2, wherein the field corresponds to a carrier indicator field.

4. The method of claim 2, wherein the first serving cell and the second serving cell are associated with the same carrier frequency.

5. The method of claim 2, wherein each of the first and second serving cells are configured as secondary cells (SCells).

6. The method of claim 2, wherein the first serving cell corresponds to a primary cell (PCell), the second serving cells is configured as a secondary cells (SCell), the first TTI length corresponds to 1 millisecond (ms), and the second TTI length corresponds to less than 1 ms.

7. The method of claim 1, wherein the DCI further comprises a physical resource block (PRB) assignment field, and the PRB assignment field is interpreted differently depending on whether the transmission is associated with the first TTI length or the second TTI length.

8. The method as in claim 1, wherein at least the second configuration is received via a radio resource control (RRC) message, and the DCI is received via a physical downlink control channel.

9. The method as in claim 1, wherein a hybrid automatic repeat request timing used for the transmission is dependent on whether the transmission is associated with the first TTI length or the second TTI length.

10. A method implemented by a wireless transmit/receive unit (WTRU) for supporting transmissions of different durations, the method comprising:

receiving downlink control information from a first serving cell in the wireless communications network;

determining that the received downlink control information indicates that the WTRU should use a first transmission time interval to transmit data information to the first serving cell;

determining whether the received downlink control information indicates that the WTRU should use a second transmission time interval that is different than the first transmission time interval to communicate with the wireless communication network on the physical uplink channel or whether the WTRU should transmit using carrier aggregation; and

communicating with the wireless communications network using the second transmission time interval.

11. The method of claim 10, wherein determining that the received downlink control information indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network on the physical uplink channel comprises determining based on a carrier indicator field in the received downlink control information.

12. The method of claim 10, wherein communicating with the wireless communications network using the second transmission time interval comprises communicating with the first serving cell using the second transmission time interval.

13. The method of claim 10, wherein communicating with the wireless communications network using the second transmission time interval comprises communicating with a secondary cell using the second transmission time interval.

14. The method of claim 10, further comprising determining that the WTRU should use a third transmission time interval that is less than the first transmission time interval to communicate with a secondary cell in the wireless communications network.

15. The method of claim 10, wherein the shorten transmission time interval corresponds to at least one of at least one symbol or at least one resource block.

16. The method of claim 10, wherein the first transmission time interval is one millisecond.

17. The method of claim 10, wherein the first transmission time interval is greater than the first transmission time interval.

18. The method of claim 10, wherein the first transmission time interval corresponds to a first sub-carrier spacing and the second transmission time interval corresponds to a second subcarrier spacing.

19. The method of claim 10, wherein the first transmission time interval corresponds to a first number of transmission symbols and the second transmission time interval corresponds to a second number of transmission symbols.

20. The method of claim 10, further comprising the WTRU communicating with the first serving cell and a second serving cell using the same carrier frequency.

21. The method of claim 10, further comprising determining a time to transmit with the second transmission time interval based on the received downlink control information.

22. The method of claim 21, wherein the time to transmit is defined by a slot in a subframe.

23. The method of claim 10, wherein determining whether the received downlink control information indicates that the WTRU should use a second transmission time interval that

is less than the first transmission time interval to communicate with the wireless communication network on the physical uplink channel or whether the WTRU should transmit using carrier aggregation comprises determining with cross-carrier scheduling.

24. A wireless transmit/receive unit (WTRU) for use within a wireless communications network that is capable of carrier aggregation, comprising:

a processor having executable instructions that:

determine that downlink control information from a first serving cell in the wireless communications network has been received;

determine that the received downlink control information indicates that the WTRU should use a first transmission time interval to transmit data information to the first serving cell;

determine whether the received downlink control information indicates that the WTRU should use a second transmission time interval that is different than the first transmission time interval to communicate with the wireless communication network on the physical uplink channel or whether the WTRU should transmit using carrier aggregation; and

communicate with the wireless communications network using the second transmission time interval.

25. The WTRU of claim 24, wherein the processor further comprises executable instructions that determine that the received downlink control information indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network on the physical uplink channel comprises determining based on a carrier indicator field in the received downlink control information.

26. The WTRU of claim 24, wherein the executable instructions that communicate with the wireless communications network using the second transmission time interval comprise communicating with the first serving cell using the second transmission time interval.

27. The WTRU of claim 24, wherein the executable instructions that communicate with the wireless communications network using the second transmission time interval comprise communicating with a secondary cell using the second transmission time interval.

28. The WTRU of claim 24, wherein the processor further comprises executable instructions that determine that the WTRU should use a third transmission time interval that is less than the first transmission time interval to communicate with a secondary cell in the wireless communications network.

29. The WTRU of claim 24, wherein the shorten transmission time interval corresponds to at least one of at least one symbol or at least one resource block.

30. The WTRU of claim 24, wherein the first transmission time interval is one millisecond.

31. The WTRU of claim 24, wherein the processor further comprises executable instructions that determine a time to transmit with the second transmission time interval based on the received downlink control information.

32. The WTRU of claim 31, wherein the time to transmit is defined by a slot in a subframe.

33. The WTRU of claim 24, wherein the executable instructions that determine whether the received downlink control information indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network on the physical uplink channel or whether the WTRU should transmit using carrier aggregation comprise determining with cross-carrier scheduling.

34. The WTRU of claim 24, wherein the first transmission time interval is greater than the first transmission time interval.

35. The method of claim 24, wherein the first transmission time interval corresponds to a first sub-carrier spacing and the second transmission time interval corresponds to a second subcarrier spacing.

36. The method of claim 24, wherein the first transmission time interval corresponds to a first number of transmission symbols and the second transmission time interval corresponds to a second number of transmission symbols.

37. The method of claim 24, further comprising the WTRU communicating with the first serving cell and a second serving cell using the same carrier frequency.

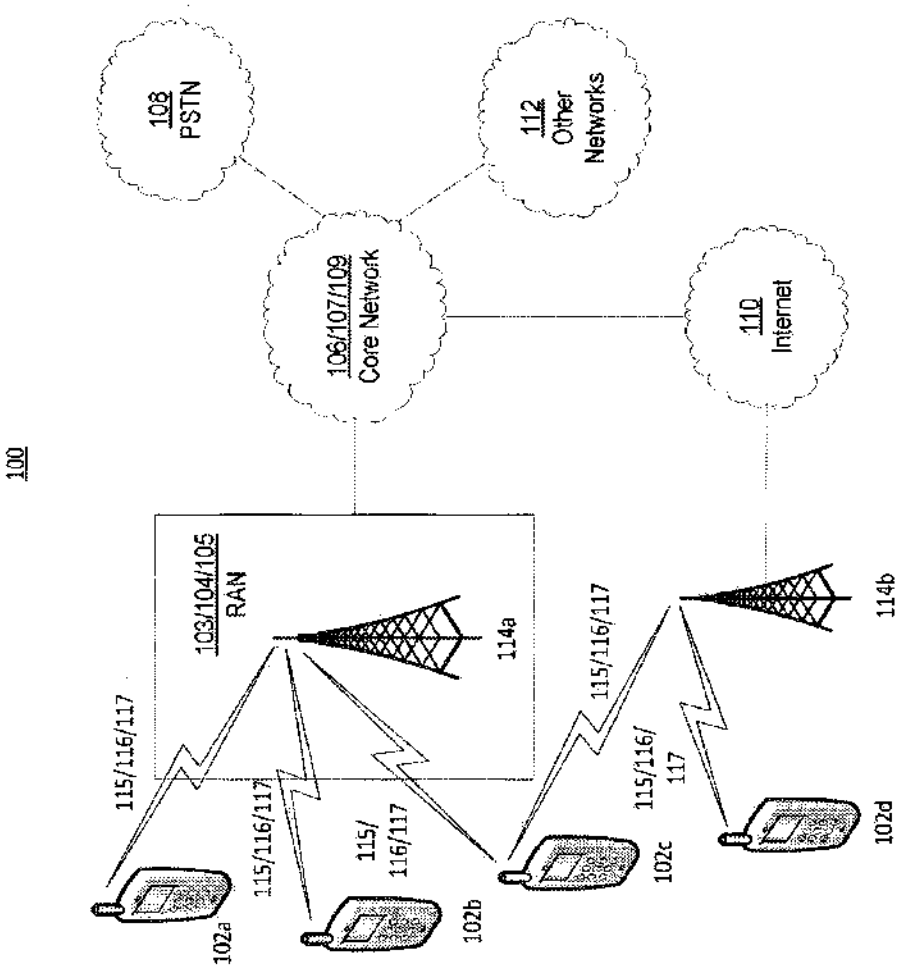

100
108 PSTN
112 Other Networks
106/107/109 Core Network
110 Internet
103/104/105 RAN
114a
114b
115/116/117
115/116/117
115/116/117
115/116/117
115/116/117
102a
102b
102c
102d

FIG. 1A

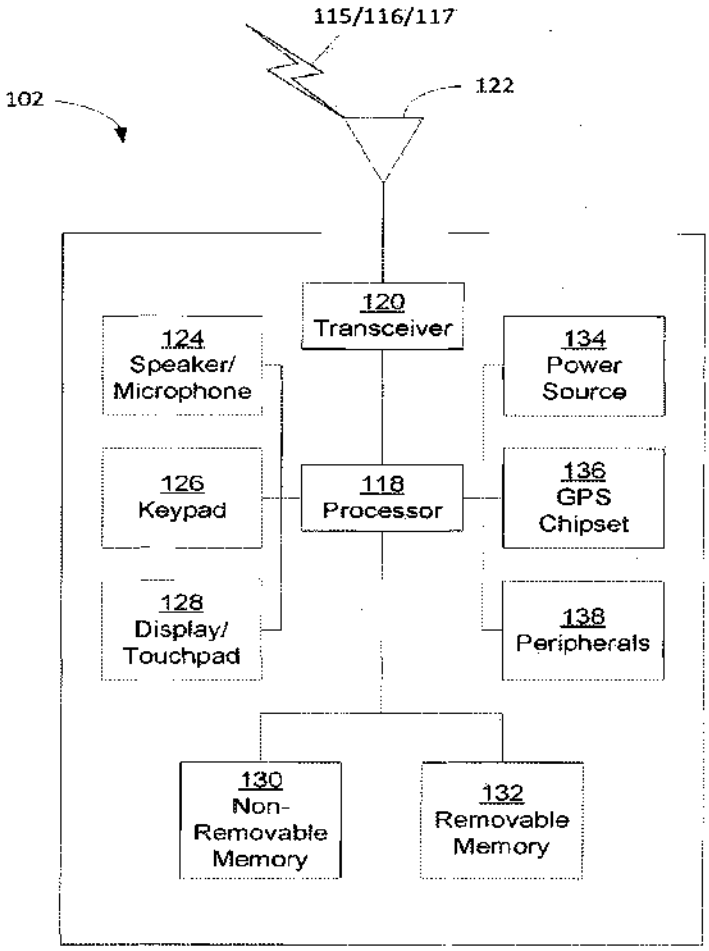

115/116/117
122
102
120
Transceiver
124
Speaker/
Microphone
134
Power
Source
126
Keypad
118
Processor
136
GPS
Chipset
128
Display/
Touchpad
138
Peripherals
130
Non-
Removable
Memory
132
Removable
Memory

FIG. 1B

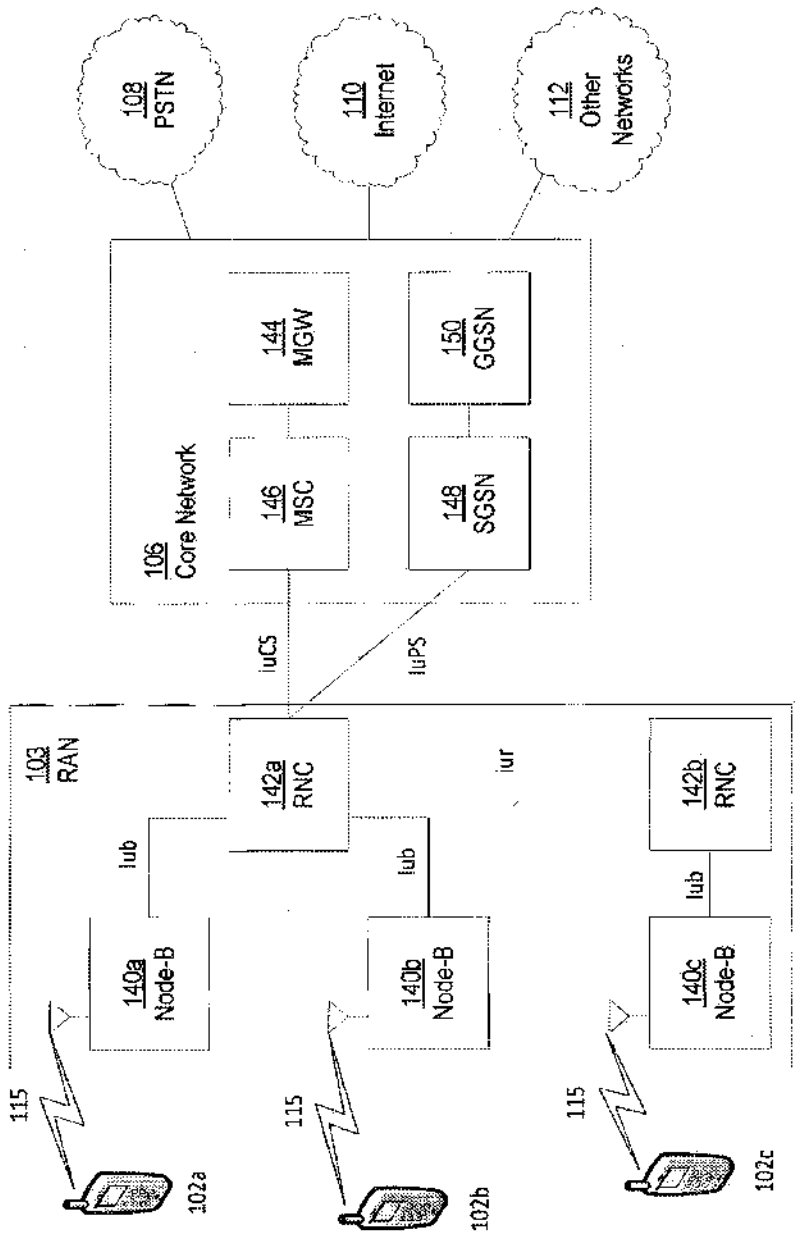

108 PSTN
110 Internet
112 Other Networks
106 Core Network
144 MGW
150 GGSN
146 MSC
148 SGSN
IuCS
IuPS
103 RAN
142a RNC
142b RNC
Iur
Iub
Iub
Iub
140a Node-B
140b Node-B
140c Node-B
115
115
115
102a
102b
102c

FIG. 1C

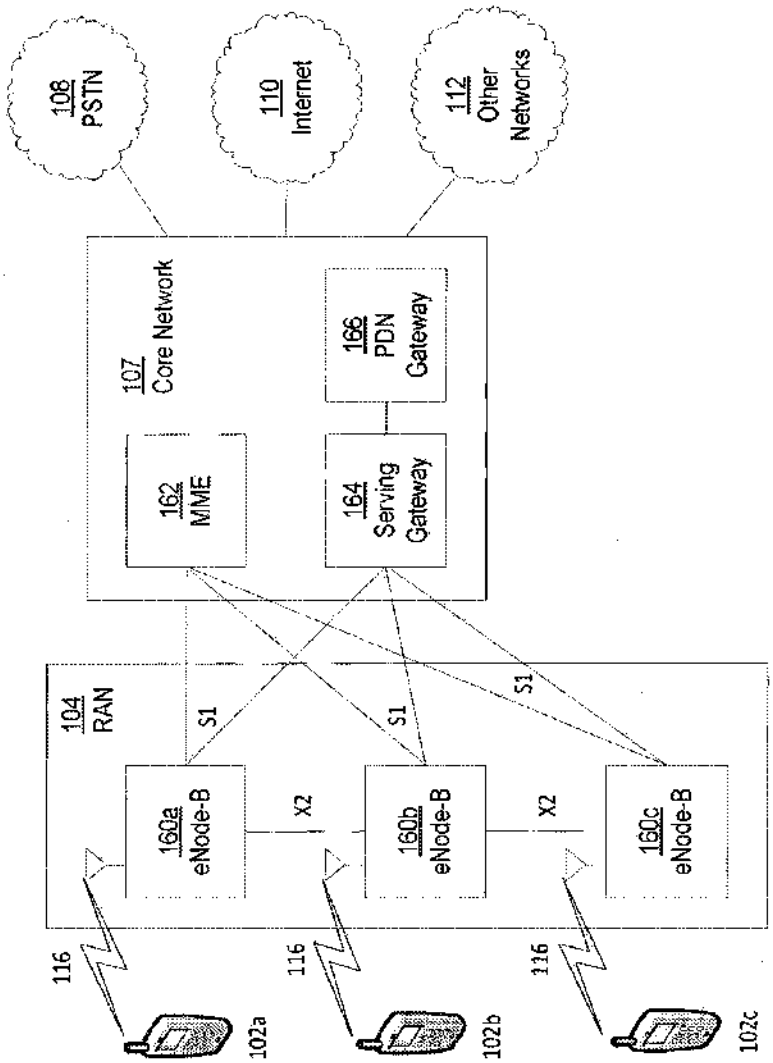

108
PSTN
110
Internet
112
Other
Networks
107
Core Network
166
PDN
Gateway
162
MME
164
Serving
Gateway
104
RAN
S1
S1
S1
160a
eNode-B
X2
160b
eNode-B
X2
160c
eNode-B
116
116
116
102a
102b
102c

FIG. 1D

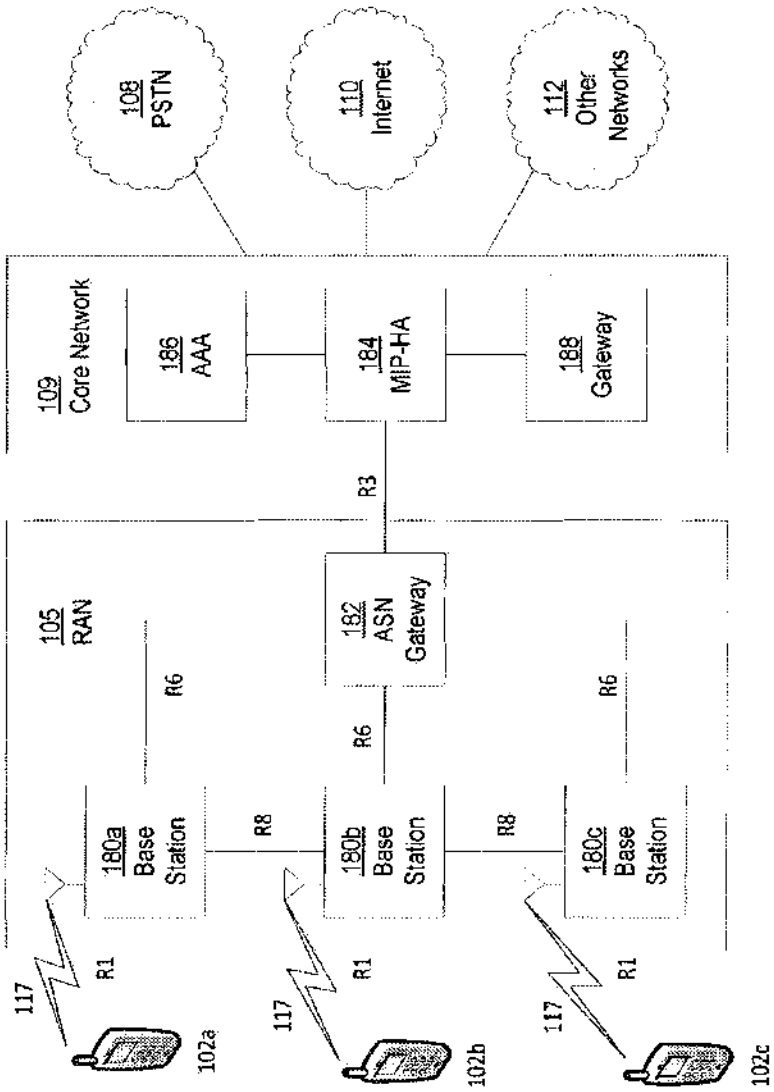

108 PSTN
110 Internet
112 Other Networks
109 Core Network
186 AAA
184 MIP-HA
188 Gateway
R3
105 RAN
182 ASN Gateway
R6
R6
R6
180a Base Station
180b Base Station
180c Base Station
R8
R8
R1
R1
R1
117
117
117
102a
102b
102c

FIG. 1E

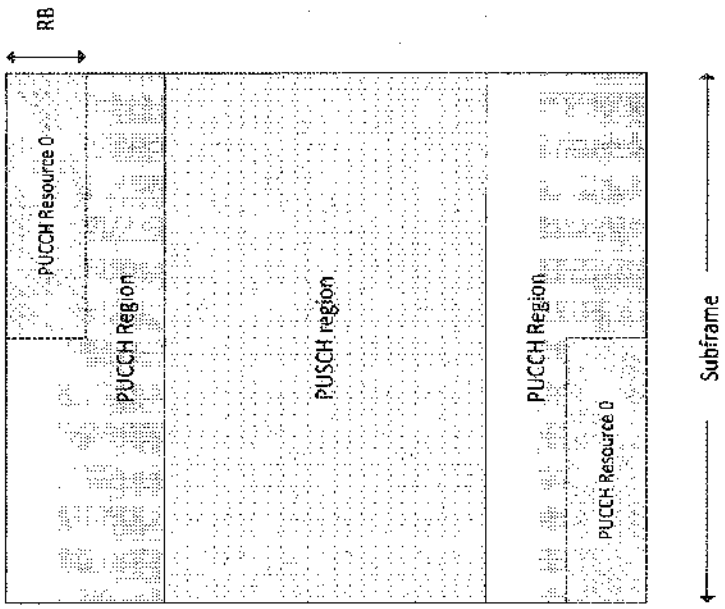

RB
PUCCH Resource 0
PUCCH Region
PUSCH region
PUCCH Region
PUCCH Resource 0
Subframe

FIG. 3

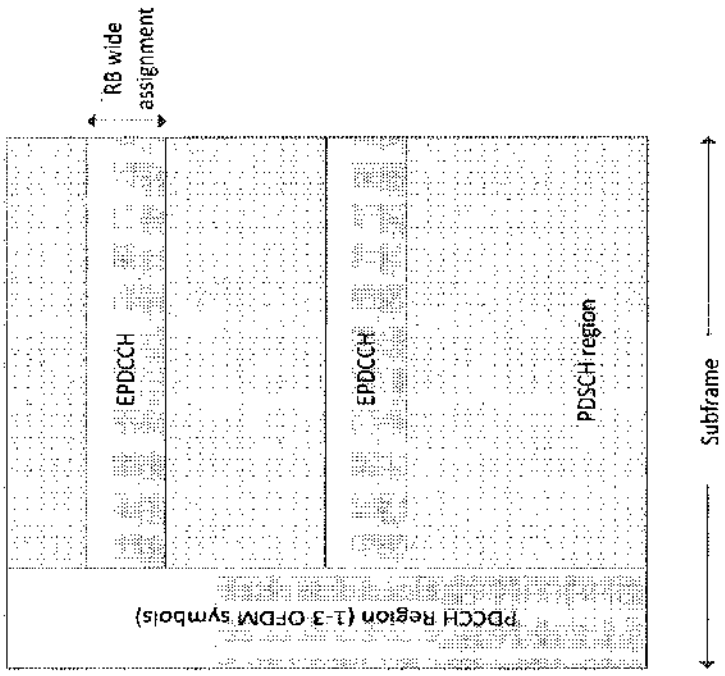

RB wide assignment
EPDCCH
EPDCCH
PDSCH region
PDCCH Region (1-3 OFDM symbols)
Subframe

FIG. 2

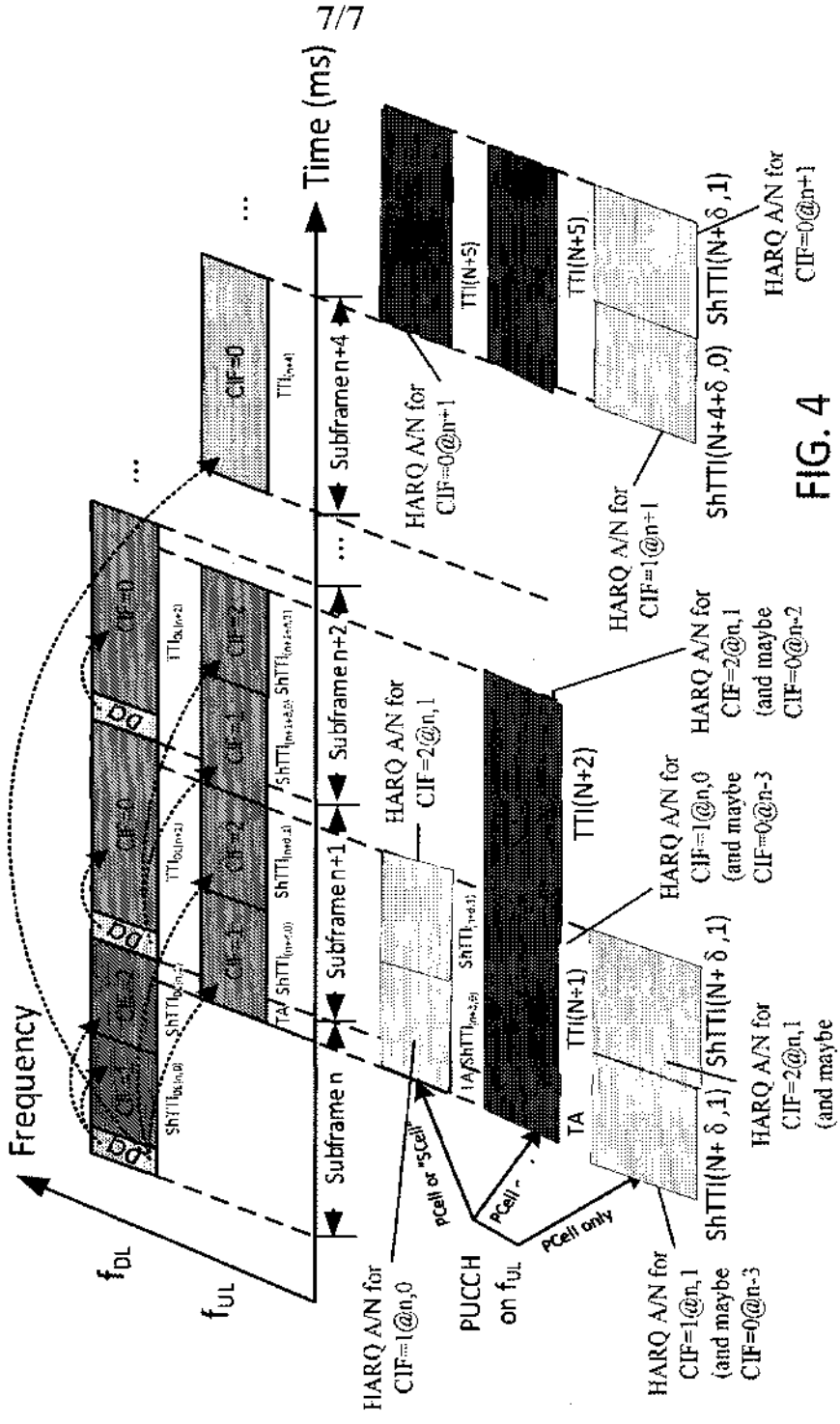

Frequency
Time (ms)
f_{DL}
f_{UL}
Subframe n
Subframe n+1
Subframe n+2
Subframe n+4
CIF=0
CIF=1
CIF=2
TTI(N+1)
TTI(N+2)
TTI(N+5)
TA
PUCCH on f_{UL}
PCell only
HARQ A/N for CIF=1@n,0
HARQ A/N for CIF=2@n,1
HARQ A/N for CIF=1@n,1 (and maybe CIF=0@n-3
HARQ A/N for CIF=2@n,1 (and maybe CIF=0@n-3
HARQ A/N for CIF=1@n,0 (and maybe CIF=0@n-3
HARQ A/N for CIF=2@n,1 (and maybe CIF=0@n-2
HARQ A/N for CIF=0@n+1
HARQ A/N for CIF=1@n+1
HARQ A/N for CIF=0@n+1
ShTTI(N+δ ,1)
ShTTI(N+4+δ ,0)
ShTTI(N+4+δ ,1)

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/060481

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W72/12
ADD. H04W28/06 H04L1/18

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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"P" document published prior to the international filing date but later than the priority date claimed

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Date of the actual completion of the international search	Date of mailing of the international search report
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Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/060481

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2016/060481

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(54) Title: METHOD AND DEVICE FOR PAGING A MACHINE TO MACHINE DEVICE

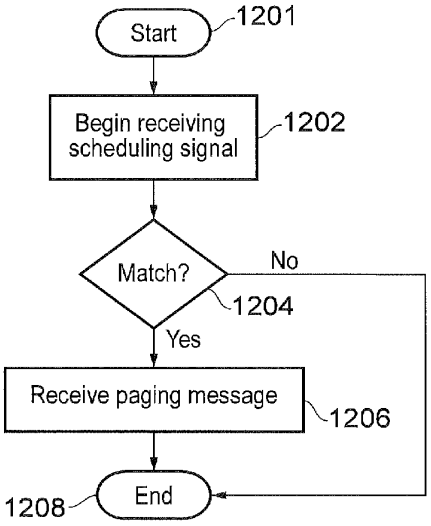


FIG. 12

(57) Abstract: A terminal device for use with a wireless telecommunications network comprising: a transceiver; and a controller. Receiving, during one of a plurality of periodic paging occasions associated with the terminal, a paging scheduling signal for one or more terminal devices, each paging occasion being associated with a value of a characteristic of the scheduling signal which is unique to that paging occasion. Determining whether the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the of periodic paging occasions associated with the terminal device; and control the transceiver to receive the paging message scheduled by the received scheduling message.

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METHOD AND DEVICE FOR PAGING A MACHINE TO MACHINE DEVICE

BACKGROUND

Field of Disclosure

The present disclosure relates to a terminal device, infrastructure equipment, methods and integrated circuitry for use with a wireless telecommunications network.

Description of Related Art

The "background" description provided herein is for the purpose of generally presenting the context of the disclosure. Work of the presently named inventors, to the extent it is described in this background section, as well as aspects of the description which may not otherwise qualify as prior art at the time of filing, are neither expressly or impliedly admitted as prior art against the present disclosure.

Third and fourth generation wireless communications systems, such as those based on the third generation project partnership (3GPP) defined UMTS and Long Term Evolution (LTE) architecture are able to support sophisticated services such as instant messaging, video calls as well as high speed internet access. For example, with the improved radio interface and enhanced data rates provided by LTE systems, a user is able to enjoy high data rate applications such as mobile video streaming and mobile video conferencing that would previously only have been available via a fixed line data connection. The demand to deploy third and fourth generation networks is therefore strong and the coverage area of these networks, i.e. geographic locations where access to the networks is possible, is expected to increase rapidly. However, whilst fourth generation networks can support communications at high data rate and low latencies from devices such as smart phones and tablet computers, it is expected that future wireless communications networks will need to support communications to and from a much wider range of devices, including reduced complexity devices, machine type communication devices, devices which require little or no mobility, high resolution video displays and virtual reality headsets. As such, supporting such a wide range of communications devices can represent a technical challenge for a wireless communications network.

A current technical area of interest to those working in the field of wireless and mobile communications is known as "The Internet of Things" or IoT for short. The 3GPP has proposed to develop technologies for supporting narrow band (NB)-IoT using an LTE or 4G wireless access interface and wireless infrastructure. Such IoT devices are expected to be low complexity and inexpensive devices requiring infrequent communication of relatively low bandwidth data. It is also expected that there will be an extremely large number of IoT devices which would need to be supported in a cell of the wireless

communications network. Furthermore such NB-IoT devices are likely to be deployed indoors and /or in remote locations making radio communications challenging.

SUMMARY OF THE DISCLOSURE

According to a first embodiment, the present technique provides a terminal device for use with a wireless telecommunications network, the terminal device comprising: a transceiver; and a controller operable: to control the transceiver to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging one or more terminal devices of the wireless telecommunications network, each periodic paging occasion associated with the terminal device being associated with a value of a characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network; to determine whether the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device; and if the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device, to control the transceiver to receive the paging message scheduled by the received scheduling message.

According to the first embodiment, the present technique also provides infrastructure equipment for use with a wireless telecommunications network, the infrastructure equipment comprising: a transceiver; and a controller operable: to control the transceiver to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device, wherein a value of a characteristic of the scheduling signal is associated with the one of the plurality of periodic paging occasions associated with the terminal device, each periodic paging occasion associated with the terminal device being associated with a value of the characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network.

According to a second embodiment, the present technique provides a terminal device for use with a wireless telecommunications network, the terminal device comprising: a transceiver; and a controller operable: to control the transceiver to begin receiving, during one of a plurality of periodic paging

occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging the terminal device; wherein the scheduling signal is repeatedly transmitted by the network a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin receiving the scheduling signal; and the controller is operable to control the transceiver to receive the repetitions of the scheduling signal over the predetermined plurality of separate time periods.

According to the second embodiment, the present technique also provides infrastructure equipment for use with a wireless telecommunications network, the infrastructure equipment comprising: a transceiver; and a controller operable: to control the transceiver to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device; wherein the controller is operable to control the transceiver to repeatedly transmit the scheduling signal a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin transmitting the scheduling signal.

The foregoing paragraphs have been provided by way of general introduction, and are not intended to limit the scope of the following claims. The described embodiments, together with further advantages, will be best understood by reference to the following detailed description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the disclosure and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein like reference numerals designate identical or corresponding parts throughout the several views, and wherein:

Figure 1 is a schematic block diagram illustrating an example of a mobile telecommunication system;

Figure 2 is a schematic representation illustrating a frame structure of a downlink of a wireless access interface according to an LTE standard;

Figure 3 is a schematic representation illustrating a frame structure of an uplink of wireless access interface according to an LTE standard;

Figure 4 is a schematic representation of a terminal device and infrastructure equipment;

Figure 5 is a schematic representation of an NB-PDCCH search space;

Figure 6 is a schematic representation of a plurality of paging occasions during which groups of UEs may search the NB-PDCCH search space;

Figure 7 is a schematic representation of an NB-PDCCH search space overlapping paging occasions associated with separate groups of UEs;

Figure 8 is a schematic representation an NB-PDCCH search space overlapping paging occasions associated with the same group of UEs;

Figure 9 is a schematic representation of segmentation of the NB-PDCCH according to a first example;

Figure 10 is a schematic representation of segmentation of the NB-PDCCH according to a second example;

Figure 11 is a schematic representation of segmentation of the NB-PDCCH according to a third example; and

Figure 12 illustrates a flow chart schematically showing a first method; and

Figure 13 illustrates a flow chart schematically showing a second method.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Conventional Communications System

Figure 1 provides a schematic diagram illustrating some basic functionality of a mobile telecommunications network / system 100 operating in accordance with LTE principles and which may be adapted to implement embodiments of the disclosure as described further below. Various elements of Figure 1 and their respective modes of operation are well-known and defined in the relevant standards administered by the 3GPP (RTM) body, and also described in many books on the subject, for example, Holma H. and Toskala A [1]. It will be appreciated that operational aspects of the telecommunications network which are not specifically described below may be implemented in accordance with any known techniques, for example according to the relevant standards.

The network 100 includes a plurality of base stations 101 connected to a core network 102. Each base station provides a coverage area 103 (i.e. a cell) within which data can be communicated to and from communications devices 104. Data is transmitted from base stations 101 to communications devices 104 within their respective coverage areas 103 via a radio downlink. Data is transmitted from communications devices 104 to the base stations 101 via a radio uplink. The uplink and downlink

communications are made using radio resources that are licenced for exclusive use by the operator of the network 100. The core network 102 routes data to and from the communications devices 104 via the respective base stations 101 and provides functions such as authentication, mobility management, charging and so on. Communications devices may also be referred to as mobile stations, user equipment (UE), user device, mobile radio, terminal device and so forth. Base stations may also be referred to as transceiver stations / infrastructure equipment / NodeBs / eNodeBs (eNB for short), and so forth.

Wireless communications systems such as those arranged in accordance with the 3GPP defined Long Term Evolution (LTE) architecture use an orthogonal frequency division modulation (OFDM) based interface for the radio downlink (so-called OFDMA) and a single carrier frequency division multiple access scheme (SC-FDMA) on the radio uplink.

Figure 2 provides a simplified schematic diagram of the structure of a downlink of a wireless access interface that may be provided by or in association with the eNB of Figure 1 when the communications system is operating in accordance with the LTE standard. In LTE systems the wireless access interface of the downlink from an eNB to a UE is based upon an orthogonal frequency division multiplexing (OFDM) access radio interface. In an OFDM interface the resources of the available bandwidth are divided in frequency into a plurality of orthogonal subcarriers and data is transmitted in parallel on a plurality of orthogonal subcarriers, where bandwidths between 1.4MHz and 20MHz bandwidth may be divided into 128 to 2048 orthogonal subcarriers for example. Each subcarrier bandwidth may take any value but in LTE it is conventionally fixed at 15kHz. However it has been proposed in the future [2][3] to provide also a reduced subcarrier spacing of 3.75 kHz for certain parts of the LTE wireless access interface for the uplink. As shown in Figure 2, the resources of the wireless access interface are also temporally divided into frames where a frame 200 lasts 10ms and is subdivided into 10 subframes 201 each with a duration of 1ms. Each subframe is formed from 14 OFDM symbols and is divided into two slots each of which comprise six or seven OFDM symbols depending on whether a normal or extended cyclic prefix is being utilised between OFDM symbols for the reduction of inter symbol interference. The resources within a slot may be divided into resources blocks 203 each comprising 12 subcarriers for the duration of one slot and the resources blocks further divided into resource elements 204 which span one subcarrier for one OFDM symbol, where each rectangle 204 represents a resource element. More details of the downlink structure of the LTE wireless access interface are provided in Annex 1.

Figure 3 provides a simplified schematic diagram of the structure of an uplink of an LTE wireless access interface that may be provided by or in association with the eNB of Figure 1. In LTE networks the uplink wireless access interface is based upon a single carrier frequency division multiplexing FDM (SC-FDM) interface and downlink and uplink wireless access interfaces may be provided by frequency division duplexing (FDD) or time division duplexing (TDD), where in TDD implementations subframes switch

between uplink and downlink subframes in accordance with predefined patterns. However, regardless of the form of duplexing used, a common uplink frame structure is utilised. The simplified structure of Figure 3 illustrates such an uplink frame in an FDD implementation. A frame 300 is divided in to 10 subframes 301 of 1ms duration where each subframe 301 comprises two slots 302 of 0.5ms duration. Each slot is then formed from seven OFDM symbols 303 where a cyclic prefix 304 is inserted between each symbol in a manner equivalent to that in downlink subframes. In Figure 3 a normal cyclic prefix is used and therefore there are seven OFDM symbols within a subframe, however, if an extended cyclic prefix were to be used, each slot would contain only six OFDM symbols. The resources of the uplink subframes are also divided into resource blocks and resource elements in a similar manner to downlink subframes. More details of the LTE uplink represented in Figure 3 are provided in Annex 1.

Narrowband Internet of Things

As explained above, it has been proposed to develop an adaptation of a mobile communications network to accommodate narrow band communications within an existing wireless access interface which has been developed to provide broadband wireless communications. For example, in 3GPP a project relating to improvements to LTE wireless access interfaces to provide for a Narrowband Internet of Things (NB-IoT) was agreed [2]. This project is aimed at improved indoor coverage, support for massive number of low throughput devices, low delay sensitivity, ultra-low device cost, low device power consumption and (optimised) network architecture. An example of such a device is a smart meter. It has been proposed that an NB-IoT communications system supports a bandwidth of only 180 kHz and can have three operational modes:

1. 'Stand-alone operation' utilizing for example the spectrum currently being used by GERAN systems as a replacement of one or more GSM carriers
2. 'Guard band operation' utilizing the unused resource blocks within a LTE carrier's guard-band
3. 'In-band operation' utilizing resource blocks within a normal LTE carrier

Figure 4 provides an example schematic block diagram of a terminal device or UE 104 and an infrastructure equipment or eNB 101 according to embodiments of the present technique. As shown in Figure 4, the UE 104 includes a transmitter 401 and a receiver 402 (which together form a transceiver) which are controlled by a controller 403. The UE 104 also comprises a storage medium 420 for storing data. Correspondingly, the eNB 101 includes a transmitter 411 and a receiver 412 (which together form a transceiver) which are controlled by a controller 413 (which can also implement a scheduler function). The eNB 101 also comprises a storage medium 422 for storing data. As explained above, the UE 104 transmits and receives signals to and from the eNB 101 via a wireless access interface provided by the

eNB as part of the wireless communications network. Each of the UE 104 and eNB 101 are configured to exchange signals with each other using NB-IoT.

One of the objectives of NB-IoT is to provide extended coverage of up to 20 dB. The main mechanism to extend coverage is to perform numerous repetitions of a message to be received at a receiving device, such that the receiver can accumulate the signal energy over the repetitive samples in order for it to have an increased signal-to-noise ratio (SNR), which increases the likelihood of successful decoding of the message at the receiving device. Such a mechanism is known as coverage enhancement (CE).

Coverage enhancement (CE) may have several levels. For example, it may provide one of 5 dB, 15 dB and 20 dB additional coverage enhancement. In NB-IoT, the CE levels may be referred to as the targeted MCL (Max Coupling Loss, the achievable coupling loss (accounting for, for example, path loss, feeder losses and/or antenna gains) between transmitter and receiver) of, for example, 144 dB, 154 dB and 164 dB (so that the higher the targeted MCL, the greater the additional coverage enhancement).

As previously mentioned, repetitions of a signal so that a receiver can accumulate energy of the signal over numerous repetitive samples is the basic method used for coverage enhancement. The number of repetitions required is dependent upon the CE level. Thus, a UE at a lower CE level, such as at 144 dB, MCL requires less repetition compared to one at a higher CE level, such as at 154 dB MCL. The power spectral density, PSD (mW/Hz) of a transmission also affects the number of repetitions required, that is, the larger the PSD, the less the required number of repetitions.

The NB-PDCCH (Narrow Band Physical Downlink Control Channel) is a control channel that is used to schedule downlink resources (downlink grant) and uplink resources (uplink grant) for a NB-PDSCH (Narrow Band Physical Downlink Shared Channel) and a NB-PUSCH (Narrow Band Physical Uplink Shared Channel) that carry data traffic. An NB-PDCCH search space consists of multiple NB-PDCCH candidates wherein each candidate has a specific starting time, set of subcarriers, a defined number of repetitions and an aggregation level (the aggregation level relating to the number of frequency resources occupied by the candidate such that when the candidate occupies a higher number of frequency resources, the aggregation level is higher, and when the candidate occupies a lower number of frequency resources, the aggregation level is lower). Candidates that have a larger number of repetitions and a higher aggregation level are more robust and can reach a UE at poorer coverage compared to candidates that have a smaller number of repetitions and a lower aggregation level.

The eNB uses one of the candidates in the search space to carry the NB-PDCCH. The UE is not aware which candidate is used and so it must blind decode all the candidates in the search space in order to find the candidate used by the eNB for the NB-PDCCH. An example of a typical NB-PDCCH search space is

shown in Figure 5. Here, the search space has 4 repetition levels {R1, R2, R3, R4} where R4 = 2×R3 = 4×R2 = 8×R1. It should be appreciated that an NB-PDCCH search space with other repetition levels is also possible. As an example the eNB can use any of the 15 candidates (labelled as C1 to C15) to carry the NB-PDCCH and the UE has to blind decode for all 15 candidates. The max repetition R_{MAX} (in Figure 5, R_{MAX} = R4) of the search space is assigned to the UE based on the UE's radio condition. Thus, for example, if the UE is in a poorer quality radio coverage location, then the eNB can configure a search space with a larger value of R_{MAX}, and if the UE is in a better quality radio coverage location, then the eNB can configure a search space with a smaller value of R_{MAX}. Typically, a set of NB-PDCCH search spaces is predefined in which each NB-PDCCH search space of the set consists of a set of candidates and a value of R_{MAX}. The UE is then assigned one NB-PDCCH search space in the set of NB-PDCCH search spaces. The maximum repetition R_{MAX} of an NB-PDCCH search space can be selected from the set of values {1, 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024, 2048}, for example.

In NB-IoT, paging is performed when a UE is in idle mode. More specifically, when in idle mode, the UE monitors an NB-PDCCH CSS (Common Search Space) which, in the case that a paging message is to be transmitted to the UE, contains an NB-PDCCH that schedules that paging message (the paging message being carried by an NB-PDSCH). In order to reduce power consumption, the UE monitors the NB-PDCCH CSS during each of a plurality of periodic Paging Occasions (PO) rather than constantly monitoring the NB-PDCCH CCS. The PO occurs periodically for a particular UE (or particular group of UEs), wherein the period is configured by the network, for example. In an embodiment, the network can configure multiple POs in which the specific PO that a UE monitors depends on an identifier of that that UE (UE-ID), for example, the UE's International Mobile Subscriber Identifity (IMSI). This enables the network to spread the paging load. For example in Figure 6, the eNB configures four POs where each PO has a period T_{PO}. The UE thus wakes up every T_{PO} ms to monitor for possible paging. The PO is assigned to the UE based on the UE's ID, using a **MOD** function of the number of POs, for example (thus, in the case of Figure 6, the PO assigned to a particular UE is given by UE_ID **MOD** 4).

As described previously, repetition of the paging CSS can reach 2048. A problem with this is that a PO can overlap another PO, causing confusion for UEs reading the PO. For example in Figure 7, two POs are configured. PO 1 begins at time t_1, where UE 1 belonging to this PO will start monitoring for NB-PDCCH in the paging CSS. This paging CSS ends at time t_3. If the repetition of NB-PDCCH is very long (for example, if the paging CSS ending at time t_3 has the structure shown in Figure 5, and the NB-PDDCH is received via the candidate C15 with the largest number of repetitions) , it will overlap into PO 2 at time t_2. At time t_2 UE 2 belonging to PO 2 will start monitoring for NB-PDCCH and will start to accumulate repetition samples from the NB-PDCCH intended for UE 1 (belong to PO 1). If UE 2 is in a better radio condition than UE 1, it may decode the NB-PDCCH and start to accumulate and decode the corresponding NB-PDSCH containing the paging message. UE 2 will not find any paging indication in

this paging message and would waste battery power accumulating and decoding the NB-PDSCH. This is because the paging message contains an identifier of each UE to be paged. If a paging message is not intended for UE 2, then the identifier of UE 2 will not be included in the paging message and thus UE 2 will not be paged. However, since UE 2 has received the NB-PDCCH during its paging occasion, it will still attempt to read the paging message scheduled by the NB-PDCCH by accumulating and decoding the NB-PDSCH, thus wasting battery power. It should be noted that the NB-PDSCH is also repeated.

It should also be appreciated that if the PO period T_{PO} is shorter than the NB-PDCCH repetition, the PO may overlap itself, as shown in an example in Figure 8, in which the NB-PDCCH for PO 1 starts at time t_1 but the repetition doesn't end till time t_4. It overlaps the next PO 1 at time t_3. In this scenario, the UE belonging to PO 1 is confused as to whether to continue accumulating samples from the previous PO 1 (started at time t_1) or start a new accumulation starting at time t_3. Furthermore, in an embodiment, the NB-PDSCH starting subframe is indicated in the downlink control information (DCI) of the NB-PDCCH, this NB-PDSCH starting subframe being defined relative to the end of the NB-PDCCH that schedules this NB-PDSCH. In order to determine the end of an NB-PDCCH transmission, the repetition of the NB-PDCCH is indicated in the DCI of that NB-PDCCH. For example, in Figure 5, if candidate C11 is used to carry the NB-PDCCH (including the DCI), then the NB-PDSCH scheduled by the NB-PDCCH will start at k subframes after time t_6 (t_6 marking the end of the NB-PDCCH carried by candidate C11) where k is indicated in the DCI. Since the UE can decode a message with less repetition when it has a good radio condition, however, the UE may decode C11 at time t_5 and mistake candidate C11 for candidate C5. The UE will thereby use the wrong reference point for the start of the NB-PDSCH. To avoid this, the repetition of the NB-PDCCH is indicated in the DCI so that the UE will not mistake candidate C11 for C5. However, this does not solve the problem shown in Figure 8 in which the search space overlaps itself. In this case, although the UE will know the repetition of the NB-PDCCH from the DCI information, the UE does not know whether the NP-PDCCH repetitions started at time t_1 or at time t_3. This causes confusion at the UE regarding the candidates.

In LTE Release-13 eMTC (enhanced Machine Type Communication), the POs are separated far apart so that they do not overlap. This is possible because the repetition used in this case is not as large as that used in NB-IoT. Furthermore, eMTC can use different narrowbands for different groups of UEs and avoid overlapping. In contrast, only the anchor NB-IoT can contain the paging CSS and paging message, and therefore problem of overlapping of the NB-PDCCH between different POs requires a new solution.

In an embodiment of the present technique, an indicator is used to distinguish one PO from another. The UE belonging to a PO then uses this indicator to determine whether the NB-PDCCH belongs to it or to another PO.

In one embodiment, the said indicator is a PO index in the DCI (carried by the NB-PDCCH). A new field in the DCI would indicate which PO the DCI (that is, the NB-PDCCH) belongs to. The UE, after accumulating the NB-PDCCH, will then decode the DCI and check the PO index to see whether it matches the PO that the UE belongs to.

In another embodiment, different versions of the same PO are also indicated in the DCI. This is to help overcome the issue of uncertainty at the UE regarding when the search space starts when a NB-PDCCH repetition is larger than the PO period T_{PO} (as described in Figure 8). For example, in Figure 8, PO 1 at time t_1 can be version 1 and PO 1 at time t_3 can be version 2, these versions being distinguishable from each other by the PO identifier in the DCI so the UE is clear where the search space starts. This helps to avoid confusion of the candidates in the search space.

In another embodiment the starting time of the CSS is indicated in the DCI. This is similar to indicating the PO index (which indirectly indicates the starting time of the CSS). After decoding the DCI, the UE will determine whether the starting time of the decoded NB-PDCCH belongs to the CSS that starts at its PO or another PO. If the CSS starts at a time belonging to another PO, the UE can discard the decoded DCI.

In another embodiment, a different P-RNTI (Paging Radio Network Temporary Identifier) is used for one or more of each respective PO and each respective PO version. The P-RNTI of each respective PO and/or each respective PO version can be signalled either explicitly or implicitly (that is, derived from a reference P-RNTI). For example, in the case that a different P-RNTI is used for each respective PO, the eNB may signal a single reference P-RNTI and PO 1 will use this P-RNTI, PO 2 will use this reference P-RNTI + 1, PO 3 will use P-RNTI + 2, and so on.

In another embodiment, a scrambling applied to the NB-PDCCH is dependent upon the PO. The UE then applies a descrambler depending upon which PO it belongs to. A different scrambling may be applied to each respective PO (so as to distinguish, for example, PO 1 from PO 2, but not distinguish between different versions of PO 1 or PO 2). Alternatively, or in addition, a different scrambling may be applied to each respective PO version (so that different versions of, for example, PO 1 or PO 2 may be distinguished from each other).

It will be appreciated that various features of these embodiments may be combined as appropriate. For example, it may be the case that each respective PO is distinguished by a different scrambling, but then each version of that PO is further distinguished in the DCI.

In another embodiment of the present technique, two or more different NB-PDCCH search spaces (that is, Common Search Spaces) are configured wherein at least one of these search spaces has max repetition $R1_{MAX}$ greater than the time between two adjacent POs T_S (thus potentially causing the overlapping issue described in Figure 7) whilst the remaining search spaces have max repetition $R2_{MAX}$ smaller than T_S. In this way the search space with $R1_{MAX}$ can be segmented and interleaved with search spaces with $R2_{MAX}$. An example is shown in Figure 9, where each PO is associated with one of two types of NB-PDCCH Common Search Space (CSS) with $R1_{MAX}$ and $R2_{MAX}$, respectively. CSS1 belongs to PO1, starts at time t_1 and has a max repetition of $R1_{MAX}$ where $R1_{MAX} > T_S$, (meaning that, if measures are not taken, then CSS1 will overlap with the adjacent PO (that is, PO2)). Using the method of an embodiment, CSS1 (belonging to the first version of PO1) is segmented into 3 segments, wherein the 1st segment starts at time t_1 and ends at time t_2. The 2nd segment occupies the time t_3 to t_4, which avoids overlapping CSS2 (belonging to the first version of PO2) between time t_2 and t_3. The 3rd segment occupies time t_5 to t_6, which avoids overlapping CSS3 (belonging to the second version of PO1) between time t_4 and t_5. The segments of CSS1 are therefore interleaved with CSS2 and CSS3. CSS3 and CSS4 belong to PO1 (the second and third versions of PO1, respectively) but with a smaller maximum repetition, that is, $R2_{MAX} < T_S$, and therefore do not overlap with any adjacent PO. CSS3 and CSS4 are thus not segmented. CSS5 belongs to PO2 (in particular, the second version of PO2), and since its max repetition is greater that T_S, it is segmented and interleaved in a similar manner as that for CSS1. The example in Figure 9 shows two types of CSS (that is, with two different max repetition values). However, it should be appreciated this method is also applicable for more than two different max repetition CSSs. Also, the segments of CSS1 can be interleaved using a different pattern, for example, interleaved with different CSSs such as CSS3 and CSS4 (as shown in Figure 10).

In an embodiment, different POs have different max CSS repetitions. For example, the CSS for PO1 may have repetition $R1_{MAX} > T_S$ whilst the CSS for PO2 may have max repetition $R2_{MAX} < T_S$. In this embodiment, the CSS for PO1 is segmented and interleaved with the un-segmented CSS for PO2.

In another embodiment, all CSSs have $R1_{MAX} > T_S$. Each CSS (with $R1_{MAX}$) is segmented and the segment occupies multiple POs. That is, the CSS is spread among multiple POs. An example is shown in Figure 11, where CSS1 (belonging to PO1) has $R1_{MAX} > T_S$ and is segmented into two segments. The first segment occupies time t_1 to t_2 and the 2nd segment occupies time t_4 to t_5. Similarly, CSS5 (belonging to PO2) has $R1_{MAX} > T_S$ and is segmented into two segments. The first segment occupies time t_2 to t_3 and the 2nd segment occupies time t_6 to t_7. It should be noted that the 2nd segment length of each of CSS1 and CSS2 is less than T_S in this example.

In another embodiment, the overlapping problem shown in Figure 8 can be overcome by ensuring the Paging Occasion period $T_{PO} >$ R1max. Note that this is easier to achieve than to ensure that $T_S > R1_{MAX}$,

since T_{PO} can be much larger than T_S (for example, up to 2560 subframes) and multiple different POs may fit within the T_{PO}.

In embodiments, the segments of the NB-PDCCH search space can be defined by a predetermined pattern, this pattern being configured by the network and, for example, transmitted to the UE 104 from the eNB 101 as system information (in the System Information Block (SIB), for example). In an embodiment, the pattern may vary depending on the number of repeats of the NB-PDCCH, an identifier of the CSS which is used, or any other parameter which the UE may discern from the CSS or NB-PDCCH. The relationship between the predetermined pattern and the CSS or NB-PDCCH may be determined and transmitted to the UE 104 by the eNB 101 and may be in the form of a lookup table of the like. In another embodiment, the pattern may be fixed for the set of paging occasions associated with the UE (again, information indicative of this fixed pattern may be determined and transmitted to the UE 104 by the eNB 101).

It will thus be appreciated that, in a first embodiment, the present technique provides a terminal device 104 for use with a wireless telecommunications network. The terminal device comprises a transceiver 401, 402 and a controller 403. The controller is operable to control the transceiver to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device (for example, the plurality of periodic paging occasions PO1 or PO2), a scheduling signal (carried by the NB-PDCCH, for example) scheduling a paging message for paging one or more terminal devices of the wireless telecommunications network. Each periodic paging occasion associated with the terminal device is associated with a value of a characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network. The controller is operable to determine whether the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device, and, if the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device, to control the transceiver to receive the paging message scheduled by the received scheduling message.

In one example, the characteristic of the scheduling signal is a paging occasion identifier identified by the scheduling signal. All periodic paging occasions associated with the terminal device may be associated with the same identifier of the scheduling signal (thus, for example, each paging occasion in the plurality of paging occasions PO1 may have the same index, each paging occasion in the plurality of paging occasions PO2 may have the same index, and so on). Alternatively, each periodic paging occasion

associated with the terminal device may be associated with an identifier of the scheduling signal which is different from the identifier of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device (thus, for example, each paging occasion in the plurality of paging occasions PO1 may have a version number which distinguishes it from the other paging occasions in the plurality PO1, each paging occasion in the plurality of paging occasions PO2 may have a version number which distinguishes it from the other paging occasions in the plurality PO1, and so on). Any suitable identifier may be used as the paging occasion identifier, including, for example, an identifier comprising one or more of a PO index, PO version number or P-RNTI number, as previously discussed.

In another example, the characteristic of the scheduling signal is a scrambling of the scheduling signal. All periodic paging occasions associated with the terminal device may be associated with the same scrambling of the scheduling signal (thus, for example, each paging occasion in the plurality of paging occasions PO1 may be associated with the same scrambling of the scheduling signal, each paging occasion in the plurality of paging occasions PO2 may be associated with the same scrambling of the scheduling signal, and so on). Alternatively, each periodic paging occasion associated with the terminal device may be associated with a scrambling of the scheduling signal which is different from the scrambling of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device (thus, for example, each paging occasion in the plurality of paging occasions PO1 may be associated with a different scrambling of the scheduling signal to the scrambling of the scheduling signal associated with the other paging occasions in the plurality PO1, each paging occasion in the plurality of paging occasions PO2 may be associated with a different scrambling of the scheduling signal to the scrambling of the scheduling signal associated with the other paging occasions in the plurality PO2, and so on).

In another example, the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate, and the controller is operable to control the transceiver to attempt to receive the scheduling signal from each candidate of the radio search space. For example, the radio search space may be a CSS and the scheduling signal may be the repeatedly transmitted NB-PDCCH. In this case the characteristic of the scheduling signal is a starting time of the radio search space indicated by the scheduling signal, and the controller is operable to determine, on the basis of the starting time of the radio search space and a starting time of the scheduling signal, whether the scheduling signal belongs to a radio search space with a starting time which matches the starting time of the one of the plurality of periodic paging occasions associated with the terminal device, wherein the controller determines a match when the scheduling signal is determined to belong to a radio search space

with a starting time which matches the starting time of the one of the plurality of periodic paging occasions associated with the terminal device.

In this first embodiment, the present technique also provides infrastructure equipment 101 for use with a wireless telecommunications network. The infrastructure equipment comprises a transceiver 411, 412 and a controller 413. The controller is operable to control the transceiver to begin transmitting, during the one of the plurality of periodic paging occasions associated with the terminal device 104, the scheduling signal scheduling the paging message for paging the terminal device in the way as described.

It will also be appreciated that, in a second embodiment, the present technique provides a terminal device 101for use with a wireless telecommunications network. The terminal device comprises a transceiver 401, 402 and a controller 403. The controller is operable to control the transceiver to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device (for example, the plurality of periodic paging occasions PO1 or PO2), a scheduling signal (carried by the NB-PDCCH, for example) scheduling a paging message for paging the terminal device. The scheduling signal is repeatedly transmitted by the network a predetermined number of times over a predetermined plurality of separate time periods (in other words, the periodic repeats of the scheduling signal are segmented, as shown in Figures 9 to 11, for example), each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin receiving the scheduling signal. The controller is operable to control the transceiver to receive the repetitions of the scheduling signal over the predetermined plurality of separate time periods.

In one example, the total time taken for the scheduling signal to be repeatedly transmitted by the network is greater than the time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated. Scheduling signals with a duration of that of CSS1 or CSS 5 (shown in Figures 9 to 11) are examples of such scheduling signals.

In one example, the plurality of periodic paging occasions associated with the terminal device are interleaved with the plurality of periodic paging occasions associated with any other terminal device of the wireless telecommunications network. This is shown, for example, in Figures 9 to 11, in which paging occasions belonging to the plurality PO1 are interleaved with paging occasions belonging to the plurality PO2.

In one example, the controller is operable to control the transceiver to receive a signal from the wireless telecommunications network indicative of the predetermined plurality of separate time periods. In this case, for example, information indicative of the predetermined plurality of separate time periods (in other words, the segmentation pattern of the repeatedly transmitted scheduling signal) is stored in the storage medium 422 of the infrastructure equipment 101 and is signalled to the terminal device 104 using the transceiver 411, 412. The transceiver 401, 402 of the terminal device then receives the signal and the information indicative of the predetermined plurality of separate time periods is stored in the storage medium 420.

In one example, the number of other terminal devices of the wireless telecommunications network with which a plurality of periodic paging occasions is associated is one or more, and the plurality of periodic paging occasions associated with the one or more other terminal devices is different to the plurality of periodic paging occasions associated with the terminal device. In this case, for example, there are at least two terminal devices in the wireless telecommunications network, wherein one terminal device is associated with the plurality of periodic paging occasions PO1 and the other terminal device is associated with the plurality of periodic paging occasions PO2, as shown in Figures 9 to 11. In another example, there may be no other terminal devices associated with a plurality of different periodic paging occasions (in which case, the only paging occasions present are those associated with the terminal device 104). It is noted that the present technique will still work in this case, in that if the terminal device knows the predetermined plurality of separate time periods over which the scheduling signal is repeatedly transmitted, the terminal device will know which paging occasion a particular set of repeats of the scheduling signal belongs to (thus avoiding the confusion arising from the situation shown in Figure 8, for example).

In this second embodiment, the present technique also provides infrastructure equipment 101 for use with a wireless telecommunications network. The infrastructure equipment comprises a transceiver 411, 412 and a controller 413. The controller is operable to control the transceiver to begin transmitting, during the one of the plurality of periodic paging occasions associated with a terminal device 104, the scheduling signal scheduling the paging message for paging the terminal device in the way as described.

Figure 12 illustrates a flow chart schematically showing a method according to the first embodiment of the present technique. The method starts at step 1201. At step 1202, the terminal device 104 begins receiving a scheduling signal during one of a plurality of periodic paging occasions associated with the terminal device. At step 1204, it is determined whether a value of a predetermined characteristic associated with each of the received scheduling signal and the one of the plurality of paging occasions matches. In the case that there is no match, the method ends at step 1208. On the other hand, in the case

that there is a match, the method moves on to step 1206, in which the terminal device receives a paging message scheduled by the scheduling signal. The method then ends at step 1208.

Figure 13 illustrates a flow chart schematically showing a method according to the second embodiment of the present technique. The method starts at step 1301. At step 1302, the terminal device 104 begins receiving a scheduling signal during one of a plurality of periodic paging occasions associated with the terminal device. At step 1303, the terminal device receives a predetermined number of repeats of the scheduling signal over a predetermined plurality of separate time periods. At step 1304, the terminal device receives a paging message scheduled by the scheduling signal. The method then ends at step 1305.

Features of various embodiments of the present technique are described by the following numbered clauses:

1. A terminal device for use with a wireless telecommunications network, the terminal device comprising:

a transceiver; and

a controller operable:

to control the transceiver to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging one or more terminal devices of the wireless telecommunications network, each periodic paging occasion associated with the terminal device being associated with a value of a characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network;

to determine whether the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device; and

if the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device, to control the transceiver to receive the paging message scheduled by the received scheduling message.

2. A terminal device according to clause 1, wherein the characteristic of the scheduling signal is a paging occasion identifier identified by the scheduling signal.

3. A terminal device according to clause 2, wherein all periodic paging occasions associated with the terminal device are associated with the same identifier of the scheduling signal.

4. A terminal device according to clause 2, wherein each periodic paging occasion associated with the terminal device is associated with an identifier of the scheduling signal which is different from the identifier of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device.

5. A terminal device according to clause 1, wherein the characteristic of the scheduling signal is a scrambling of the scheduling signal.

6. A terminal device according to clause 5, wherein all periodic paging occasions associated with the terminal device are associated with the same scrambling of the scheduling signal.

7. A terminal device according to clause 5, wherein each periodic paging occasion associated with the terminal device is associated with a scrambling of the scheduling signal which is different from the scrambling of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device.

8. A terminal device according to any preceding clause, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate, and wherein the controller is operable to control the transceiver to attempt to receive the scheduling signal from each candidate of the radio search space.

9. A terminal device according to clause 1, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate, and wherein the controller is operable to control the transceiver to attempt to receive the scheduling signal from each candidate of the radio search space, wherein the characteristic of the scheduling signal is a starting time of the radio search space indicated by the scheduling signal, and the controller is operable to determine, on the basis of the starting time of the radio search space and a starting time of the scheduling signal, whether the scheduling signal belongs to a radio search space with a starting time which matches the starting time of the one of the plurality of periodic paging occasions associated with the terminal device, wherein the controller determines a match when the scheduling signal is determined to belong to a

radio search space with a starting time which matches the starting time of the one of the plurality of periodic paging occasions associated with the terminal device.

10. A terminal device according to any preceding clause, wherein the terminal device is a Narrow Band Internet of Things (NB-IoT) terminal device and the scheduling signal is carried by a Narrow Band Physical Downlink Control Channel (NB-PDCCH).

11. Infrastructure equipment for use with a wireless telecommunications network, the infrastructure equipment comprising:

a transceiver; and

a controller operable:

to control the transceiver to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device, wherein a value of a characteristic of the scheduling signal is associated with the one of the plurality of periodic paging occasions associated with the terminal device, each periodic paging occasion associated with the terminal device being associated with a value of the characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network.

12. Infrastructure equipment according to clause 11, wherein the characteristic of the scheduling signal is a paging occasion identifier identified by the scheduling signal.

13. Infrastructure equipment according to clause 12, wherein all periodic paging occasions associated with the terminal device are associated with the same identifier of the scheduling signal.

14. Infrastructure equipment according to clause 12, wherein each periodic paging occasion associated with the terminal device is associated with an identifier of the scheduling signal which is different from the identifier of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device.

15. Infrastructure equipment according to clause 11, wherein the characteristic of the scheduling signal is a scrambling of the scheduling signal.

16. Infrastructure equipment according to clause 15, wherein all periodic paging occasions associated with the terminal device are associated with the same scrambling of the scheduling signal.

17. Infrastructure equipment according to clause 15, wherein each periodic paging occasion associated with the terminal device is associated with a scrambling of the scheduling signal which is different from the scrambling of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device.

18. Infrastructure equipment according to any one of clauses 11 to 17, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate.

19. Infrastructure equipment according to clause 11, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate, , wherein the characteristic of the scheduling signal is a starting time of the radio search space indicated by the scheduling signal, the starting time of the radio search space matching the starting time of the one of the plurality of periodic paging occasions associated with the terminal device.

20. Infrastructure equipment according to any one of clauses 11 to 19, wherein the terminal device is a Narrow Band Internet of Things (NB-IoT) terminal device and the scheduling signal is carried by a Narrow Band Physical Downlink Control Channel (NB-PDCCH).

21. A method of operating a terminal device for use with a wireless telecommunications network, the method comprising:

controlling a transceiver of the terminal device to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging one or more terminal devices of the wireless telecommunications network, each periodic paging occasion associated with the terminal device being associated with a value of a characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network;

determining whether the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device; and

if the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device, controlling the transceiver to receive the paging message scheduled by the received scheduling message.

22. A method of operating infrastructure equipment for use with a wireless telecommunications network, the method comprising:

controlling a transceiver of the infrastructure equipment to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device, wherein a value of a characteristic of the scheduling signal is associated with the one of the plurality of periodic paging occasions associated with the terminal device, each periodic paging occasion associated with the terminal device being associated with a value of the characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network.

23. Integrated circuitry for a terminal device for use with a wireless telecommunications network, the integrated circuitry comprising:

a transceiver element; and

a controller element operable:

to control the transceiver element to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging one or more terminal devices of the wireless telecommunications network, each periodic paging occasion associated with the terminal device being associated with a value of a characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network;

to determine whether the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device; and

if the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device, to control the transceiver element to receive the paging message scheduled by the received scheduling message.

24. Integrated circuitry for infrastructure equipment for use with a wireless telecommunications network, the integrated circuitry comprising:

a transceiver element; and

a controller element operable:

to control the transceiver element to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device, wherein a value of a characteristic of the scheduling signal is associated with the one of the plurality of periodic paging occasions associated with the terminal device, each periodic paging occasion associated with the terminal device being associated with a value of the characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network.

25. A wireless telecommunications network comprising a terminal device according to clause 1 and infrastructure equipment according to clause 11.

26. A terminal device for use with a wireless telecommunications network, the terminal device comprising:

a transceiver; and

a controller operable:

to control the transceiver to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the scheduling signal is repeatedly transmitted by the network a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin receiving the scheduling signal; and

the controller is operable to control the transceiver to receive the repetitions of the scheduling signal over the predetermined plurality of separate time periods.

27. A terminal device according to clause 26, wherein the total time taken for the scheduling signal to be repeatedly transmitted by the network is greater than the time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated.

28. A terminal device according to clause 26 or 27, wherein the plurality of periodic paging occasions associated with the terminal device are interleaved with the plurality of periodic paging occasions associated with any other terminal device of the wireless telecommunications network.

29. A terminal device according to any one of clauses 26 to 28, wherein the controller is operable to control the transceiver to receive a signal from the wireless telecommunications network indicative of the predetermined plurality of separate time periods.

30. A terminal device according to any one of clauses 26 to 29, wherein the number of other terminal devices of the wireless telecommunications network with which a plurality of periodic paging occasions is associated is one or more, and the plurality of periodic paging occasions associated with the one or more other terminal devices is different to the plurality of periodic paging occasions associated with the terminal device.

31. A terminal device according to any one of clauses 26 to 30, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate, and wherein the controller is operable to control the transceiver to attempt to receive the scheduling signal from each candidate of the radio search space.

32. A terminal device according to any one of clauses 26 to 31, wherein the terminal device is a Narrow Band Internet of Things (NB-IoT) terminal device and the scheduling signal is carried by a Narrow Band Physical Downlink Control Channel (NB-PDCCH).

33. Infrastructure equipment for use with a wireless telecommunications network, the infrastructure equipment comprising:

a transceiver; and

a controller operable:

to control the transceiver to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the controller is operable to control the transceiver to repeatedly transmit the scheduling signal a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin transmitting the scheduling signal.

34. Infrastructure equipment according to clause 33, wherein the total time taken for the scheduling signal to be repeatedly transmitted by the transceiver is greater than the time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated.

35. Infrastructure equipment according to clause 33 or 34, wherein the plurality of periodic paging occasions associated with the terminal device are interleaved with the plurality of periodic paging occasions associated with any other terminal device of the wireless telecommunications network.

36. Infrastructure equipment according to any one of claims 33 to 35, wherein the controller is operable to control the transceiver to transmit a signal to the terminal device indicative of the predetermined plurality of separate time periods.

37. Infrastructure equipment according to any one of clauses 33 to 36, wherein the number of other terminal devices of the wireless telecommunications network with which a plurality of periodic paging occasions is associated is one or more, and the plurality of periodic paging occasions associated with the one or more other terminal devices is different to the plurality of periodic paging occasions associated with the terminal device.

38. Infrastructure equipment according to any one of clauses 33 to 37, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate..

39. Infrastructure equipment according to any one of clauses 33 to 38, wherein the terminal device is a Narrow Band Internet of Things (NB-IoT) terminal device and the scheduling signal is carried by a Narrow Band Physical Downlink Control Channel (NB-PDCCH).

40. A method of operating a terminal device for use with a wireless telecommunications network, the method comprising:

controlling a transceiver of the terminal device to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the scheduling signal is repeatedly transmitted by the network a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin receiving the scheduling signal; and

transceiver is controlled to receive the repetitions of the scheduling signal over the predetermined plurality of separate time periods.

41. A method of operating infrastructure equipment for use with a wireless telecommunications network, the method comprising:

controlling a transceiver of the infrastructure equipment to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the transceiver is controlled to repeatedly transmit the scheduling signal a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin transmitting the scheduling signal.

42. Integrated circuitry for a terminal device for use with a wireless telecommunications network, the integrated circuitry comprising:

a transceiver element; and

a controller element operable:

to control the transceiver element to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the scheduling signal is repeatedly transmitted by the network a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver element is controlled to begin receiving the scheduling signal; and

the controller element is operable to control the transceiver element to receive the repetitions of the scheduling signal over the predetermined plurality of separate time periods.

43. Integrated circuitry for operating infrastructure equipment for use with a wireless telecommunications network, the integrated circuitry comprising:

a transceiver element; and

a controller element operable:

to control the transceiver element to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the controller element is operable to control the transceiver to repeatedly transmit the scheduling signal a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver element is controlled to begin transmitting the scheduling signal.

44. A wireless telecommunications network comprising a terminal device according to clause 26 and infrastructure equipment according to clause 33.

Numerous modifications and variations of the present disclosure are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the disclosure may be practiced otherwise than as specifically described herein.

In so far as embodiments of the disclosure have been described as being implemented, at least in part, by software-controlled data processing apparatus, it will be appreciated that a non-transitory machine-readable medium carrying such software, such as an optical disk, a magnetic disk, semiconductor memory or the like, is also considered to represent an embodiment of the present disclosure.

It will be appreciated that the above description for clarity has described embodiments with reference to different functional units, circuitry and/or processors. However, it will be apparent that any suitable distribution of functionality between different functional units, circuitry and/or processors may be used without detracting from the embodiments.

Described embodiments may be implemented in any suitable form including hardware, software, firmware or any combination of these. Described embodiments may optionally be implemented at least partly as computer software running on one or more data processors and/or digital signal processors. The elements and components of any embodiment may be physically, functionally and logically implemented in any suitable way. Indeed the functionality may be implemented in a single unit, in a plurality of units or as part of other functional units. As such, the disclosed embodiments may be implemented in a single unit or may be physically and functionally distributed between different units, circuitry and/or processors.

Although the present disclosure has been described in connection with some embodiments, it is not intended to be limited to the specific form set forth herein. Additionally, although a feature may appear to be described in connection with particular embodiments, one skilled in the art would recognize that various features of the described embodiments may be combined in any manner suitable to implement the technique.

Annex 1:

The simplified structure of the downlink of an LTE wireless access interface presented in Figure 2, also includes an illustration of each subframe 201, which comprises a control region 205 for the transmission of control data, a data region 206 for the transmission of user data , reference signals 207 and synchronisation signals which are interspersed in the control and data regions in accordance with a predetermined pattern. The control region 204 may contain a number of physical channels for the transmission of control data, such as a physical downlink control channel PDCCH, a physical control format indicator channel PCFICH and a physical HARQ indicator channel PHICH. The data region may contain a number of physical channel for the transmission of data, such as a physical downlink shared channel PDSCH and a physical broadcast channels PBCH. Although these physical channels provide a wide range of functionality to LTE systems, in terms of resource allocation and the present disclosure PDCCH and PDSCH are most relevant. Further information on the structure and functioning of the physical channels of LTE systems can be found in [1].

Resources within the PDSCH may be allocated by an eNodeB to UEs being served by the eNodeB. For example, a number of resource blocks of the PDSCH may be allocated to a UE in order that it may receive data that it has previously requested or data which is being pushed to it by the eNodeB, such as radio resource control RRC signalling. In Figure 2, UE1 has been allocated resources 208 of the data region 206, UE2 resources 209 and UE resources 210. UEs in a an LTE system may be allocated a fraction of the available resources of the PDSCH and therefore UEs are required to be informed of the location of their allocated resources within the PDCSH so that only relevant data within the PDSCH is detected and estimated. In order to inform the UEs of the location of their allocated communications resources, resource control information specifying downlink resource allocations is conveyed across the PDCCH in a form termed downlink control information DCI, where resource allocations for a PDSCH are communicated in a preceding PDCCH instance in the same subframe. During a resource allocation procedure, UEs thus monitor the PDCCH for DCI addressed to them and once such a DCI is detected, receive the DCI and detect and estimate the data from the relevant part of the PDSCH.

Each uplink subframe may include a plurality of different channels, for example a physical uplink shared channel PUSCH 305, a physical uplink control channel PUCCH 306, and a physical random access channel PRACH. The physical Uplink Control Channel PUCCH may carry control information such as ACK/NACK to the eNodeB for downlink transmissions, scheduling request indicators SRI for UEs wishing to be scheduled uplink resources, and feedback of downlink channel state information CSI for example. The PUSCH may carry UE uplink data or some uplink control data. Resources of the PUSCH are granted via PDCCH, such a grant being typically triggered by communicating to the network the amount of data ready to be transmitted in a buffer at the UE. The PRACH may be scheduled in any of the

resources of an uplink frame in accordance with a one of a plurality of PRACH patterns that may be signalled to UE in downlink signalling such as system information blocks. As well as physical uplink channels, uplink subframes may also include reference signals. For example, demodulation reference signals DMRS 307 and sounding reference signals SRS 308 may be present in an uplink subframe where the DMRS occupy the fourth symbol of a slot in which PUSCH is transmitted and are used for decoding of PUCCH and PUSCH data, and where SRS are used for uplink channel estimation at the eNodeB. Further information on the structure and functioning of the physical channels of LTE systems can be found in [1].

In an analogous manner to the resources of the PDSCH, resources of the PUSCH are required to be scheduled or granted by the serving eNodeB and thus if data is to be transmitted by a UE, resources of the PUSCH are required to be granted to the UE by the eNodeB. At a UE, PUSCH resource allocation is achieved by the transmission of a scheduling request or a buffer status report to its serving eNodeB. The scheduling request may be made, when there is insufficient uplink resource for the UE to send a buffer status report, via the transmission of Uplink Control Information UCI on the PUCCH when there is no existing PUSCH allocation for the UE, or by transmission directly on the PUSCH when there is an existing PUSCH allocation for the UE. In response to a scheduling request, the eNodeB is configured to allocate a portion of the PUSCH resource to the requesting UE sufficient for transferring a buffer status report and then inform the UE of the buffer status report resource allocation via a DCI in the PDCCH. Once or if the UE has PUSCH resource adequate to send a buffer status report, the buffer status report is sent to the eNodeB and gives the eNodeB information regarding the amount of data in an uplink buffer or buffers at the UE. After receiving the buffer status report, the eNodeB can allocate a portion of the PUSCH resources to the sending UE in order to transmit some of its buffered uplink data and then inform the UE of the resource allocation via a DCI in the PDCCH. For example, presuming a UE has a connection with the eNodeB, the UE will first transmit a PUSCH resource request in the PUCCH in the form of a UCI. The UE will then monitor the PDCCH for an appropriate DCI, extract the details of the PUSCH resource allocation, and transmit uplink data , at first comprising a buffer status report, and/or later comprising a portion of the buffered data, in the allocated resources.

Although similar in structure to downlink subframes, uplink subframes have a different control structure to downlink subframes, in particular the upper 309 and lower 310 subcarriers/frequencies/resource blocks of an uplink subframe are reserved for control signalling rather than the initial symbols of a downlink subframe. Furthermore, although the resource allocation procedure for the downlink and uplink are relatively similar, the actual structure of the resources that may be allocated may vary due to the different characteristics of the OFDM and SC-FDM interfaces that are used in the downlink and uplink respectively. In OFDM each subcarrier is individually modulated and therefore it is not necessary that frequency/subcarrier allocation are contiguous however, in SC-FDM subcarriers are modulation in

combination and therefore if efficient use of the available resources are to be made contiguous frequency allocations for each UE are preferable.

As a result of the above described wireless interface structure and operation, one or more UEs may communicate data to one another via a coordinating eNodeB, thus forming a conventional cellular telecommunications system. Although cellular communications system such as those based on the previously released LTE standards have been commercially successful, a number of disadvantages are associated with such centralised systems. For example, if two UEs which are in close proximity wish to communicate with each other, uplink and downlink resources sufficient to convey the data are required. Consequently, two portions of the system's resources are being used to convey a single portion of data. A second disadvantage is that an eNodeB is required if UEs, even when in close proximity, wish to communicate with one another. These limitations may be problematic when the system is experiencing high load or eNodeB coverage is not available, for instance in remote areas or when eNodeBs are not functioning correctly. Overcoming these limitations may increase both the capacity and efficiency of LTE networks but also lead to the creations of new revenue possibilities for LTE network operators.

References

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CLAIMS

1. A terminal device for use with a wireless telecommunications network, the terminal device comprising:

a transceiver; and

a controller operable:

to control the transceiver to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging one or more terminal devices of the wireless telecommunications network, each periodic paging occasion associated with the terminal device being associated with a value of a characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network;

to determine whether the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device; and

if the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device, to control the transceiver to receive the paging message scheduled by the received scheduling message.

2. A terminal device according to claim 1, wherein the characteristic of the scheduling signal is a paging occasion identifier identified by the scheduling signal.

3. A terminal device according to claim 2, wherein all periodic paging occasions associated with the terminal device are associated with the same identifier of the scheduling signal.

4. A terminal device according to claim 2, wherein each periodic paging occasion associated with the terminal device is associated with an identifier of the scheduling signal which is different from the identifier of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device.

5. A terminal device according to claim 1, wherein the characteristic of the scheduling signal is a scrambling of the scheduling signal.

6. A terminal device according to claim 5, wherein all periodic paging occasions associated with the terminal device are associated with the same scrambling of the scheduling signal.

7. A terminal device according to claim 5, wherein each periodic paging occasion associated with the terminal device is associated with a scrambling of the scheduling signal which is different from the scrambling of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device.

8. A terminal device according to claim 1, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate, and wherein the controller is operable to control the transceiver to attempt to receive the scheduling signal from each candidate of the radio search space.

9. A terminal device according to claim 1, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate, and wherein the controller is operable to control the transceiver to attempt to receive the scheduling signal from each candidate of the radio search space, wherein the characteristic of the scheduling signal is a starting time of the radio search space indicated by the scheduling signal, and the controller is operable to determine, on the basis of the starting time of the radio search space and a starting time of the scheduling signal, whether the scheduling signal belongs to a radio search space with a starting time which matches the starting time of the one of the plurality of periodic paging occasions associated with the terminal device, wherein the controller determines a match when the scheduling signal is determined to belong to a radio search space with a starting time which matches the starting time of the one of the plurality of periodic paging occasions associated with the terminal device.

10. A terminal device according to claim 1, wherein the terminal device is a Narrow Band Internet of Things (NB-IoT) terminal device and the scheduling signal is carried by a Narrow Band Physical Downlink Control Channel (NB-PDCCH).

11. Infrastructure equipment for use with a wireless telecommunications network, the infrastructure equipment comprising:

a transceiver; and

a controller operable:

to control the transceiver to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device, wherein a value of a characteristic of the scheduling signal is associated with the one of the plurality of periodic paging occasions associated with the terminal device, each periodic paging occasion associated with the terminal device being associated with a value of the characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network.

12. Infrastructure equipment according to claim 11, wherein the characteristic of the scheduling signal is a paging occasion identifier identified by the scheduling signal.

13. Infrastructure equipment according to claim 12, wherein all periodic paging occasions associated with the terminal device are associated with the same identifier of the scheduling signal.

14. Infrastructure equipment according to claim 12, wherein each periodic paging occasion associated with the terminal device is associated with an identifier of the scheduling signal which is different from the identifier of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device.

15. Infrastructure equipment according to claim 11, wherein the characteristic of the scheduling signal is a scrambling of the scheduling signal.

16. Infrastructure equipment according to claim 15, wherein all periodic paging occasions associated with the terminal device are associated with the same scrambling of the scheduling signal.

17. Infrastructure equipment according to claim 15, wherein each periodic paging occasion associated with the terminal device is associated with a scrambling of the scheduling signal which is different from the scrambling of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device.

18. Infrastructure equipment according to claim 11, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate.

19. Infrastructure equipment according to claim 11, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate, , wherein the characteristic of the scheduling signal is a starting time of the radio search space indicated by the scheduling signal, the starting time of the radio search space matching the starting time of the one of the plurality of periodic paging occasions associated with the terminal device.

20. Infrastructure equipment according to claim 11, wherein the terminal device is a Narrow Band Internet of Things (NB-IoT) terminal device and the scheduling signal is carried by a Narrow Band Physical Downlink Control Channel (NB-PDCCH).

21. A method of operating a terminal device for use with a wireless telecommunications network, the method comprising:

controlling a transceiver of the terminal device to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging one or more terminal devices of the wireless telecommunications network, each periodic paging occasion associated with the terminal device being associated with a value of a characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network;

determining whether the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device; and

if the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device, controlling the transceiver to receive the paging message scheduled by the received scheduling message.

22. A method of operating infrastructure equipment for use with a wireless telecommunications network, the method comprising:

controlling a transceiver of the infrastructure equipment to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device, wherein a value of a characteristic of the scheduling signal is associated with the one of the

plurality of periodic paging occasions associated with the terminal device, each periodic paging occasion associated with the terminal device being associated with a value of the characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network.

23. Integrated circuitry for a terminal device for use with a wireless telecommunications network, the integrated circuitry comprising:

a transceiver element; and

a controller element operable:

to control the transceiver element to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging one or more terminal devices of the wireless telecommunications network, each periodic paging occasion associated with the terminal device being associated with a value of a characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network;

to determine whether the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device; and

if the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device, to control the transceiver element to receive the paging message scheduled by the received scheduling message.

24. Integrated circuitry for infrastructure equipment for use with a wireless telecommunications network, the integrated circuitry comprising:

a transceiver element; and

a controller element operable:

to control the transceiver element to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device, wherein a value of a characteristic of the scheduling signal is associated with the one of the plurality of periodic paging occasions associated with the terminal device, each periodic paging occasion associated with the terminal device being associated with a value of the characteristic of the scheduling signal which is different from

a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network.

25. A wireless telecommunications network comprising a terminal device according to claim 1 and infrastructure equipment according to claim 11.

26. A terminal device for use with a wireless telecommunications network, the terminal device comprising:

a transceiver; and

a controller operable:

to control the transceiver to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the scheduling signal is repeatedly transmitted by the network a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin receiving the scheduling signal; and

the controller is operable to control the transceiver to receive the repetitions of the scheduling signal over the predetermined plurality of separate time periods.

27. A terminal device according to claim 26, wherein the total time taken for the scheduling signal to be repeatedly transmitted by the network is greater than the time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated.

28. A terminal device according to claim 26, wherein the plurality of periodic paging occasions associated with the terminal device are interleaved with the plurality of periodic paging occasions associated with any other terminal device of the wireless telecommunications network.

29. A terminal device according to claim 26, wherein the controller is operable to control the transceiver to receive a signal from the wireless telecommunications network indicative of the predetermined plurality of separate time periods.

30. A terminal device according to claim 26, wherein the number of other terminal devices of the wireless telecommunications network with which a plurality of periodic paging occasions is associated is one or more, and the plurality of periodic paging occasions associated with the one or more other terminal devices is different to the plurality of periodic paging occasions associated with the terminal device.

31. A terminal device according to claim 26, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate, and wherein the controller is operable to control the transceiver to attempt to receive the scheduling signal from each candidate of the radio search space.

32. A terminal device according to claim 26, wherein the terminal device is a Narrow Band Internet of Things (NB-IoT) terminal device and the scheduling signal is carried by a Narrow Band Physical Downlink Control Channel (NB-PDCCH).

33. Infrastructure equipment for use with a wireless telecommunications network, the infrastructure equipment comprising:

a transceiver; and

a controller operable:

to control the transceiver to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the controller is operable to control the transceiver to repeatedly transmit the scheduling signal a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin transmitting the scheduling signal.

34. Infrastructure equipment according to claim 33, wherein the total time taken for the scheduling signal to be repeatedly transmitted by the transceiver is greater than the time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated.

35. Infrastructure equipment according to claim 33, wherein the plurality of periodic paging occasions associated with the terminal device are interleaved with the plurality of periodic paging occasions associated with any other terminal device of the wireless telecommunications network.

36. Infrastructure equipment according to claim 33, wherein the controller is operable to control the transceiver to transmit a signal to the terminal device indicative of the predetermined plurality of separate time periods.

37. Infrastructure equipment according to claim 33, wherein the number of other terminal devices of the wireless telecommunications network with which a plurality of periodic paging occasions is associated is one or more, and the plurality of periodic paging occasions associated with the one or more other terminal devices is different to the plurality of periodic paging occasions associated with the terminal device.

38. Infrastructure equipment according to claim 33, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate..

39. Infrastructure equipment according to claim 33, wherein the terminal device is a Narrow Band Internet of Things (NB-IoT) terminal device and the scheduling signal is carried by a Narrow Band Physical Downlink Control Channel (NB-PDCCH).

40. A method of operating a terminal device for use with a wireless telecommunications network, the method comprising:

controlling a transceiver of the terminal device to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the scheduling signal is repeatedly transmitted by the network a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the

plurality of periodic paging occasions during which the transceiver is controlled to begin receiving the scheduling signal; and

transceiver is controlled to receive the repetitions of the scheduling signal over the predetermined plurality of separate time periods.

41. A method of operating infrastructure equipment for use with a wireless telecommunications network, the method comprising:

controlling a transceiver of the infrastructure equipment to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the transceiver is controlled to repeatedly transmit the scheduling signal a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin transmitting the scheduling signal.

42. Integrated circuitry for a terminal device for use with a wireless telecommunications network, the integrated circuitry comprising:

a transceiver element; and

a controller element operable:

to control the transceiver element to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the scheduling signal is repeatedly transmitted by the network a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver element is controlled to begin receiving the scheduling signal; and

the controller element is operable to control the transceiver element to receive the repetitions of the scheduling signal over the predetermined plurality of separate time periods.

43. Integrated circuitry for operating infrastructure equipment for use with a wireless telecommunications network, the integrated circuitry comprising:

a transceiver element; and

a controller element operable:

to control the transceiver element to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the controller element is operable to control the transceiver to repeatedly transmit the scheduling signal a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver element is controlled to begin transmitting the scheduling signal.

44. A wireless telecommunications network comprising a terminal device according to claim 26 and infrastructure equipment according to claim 33.

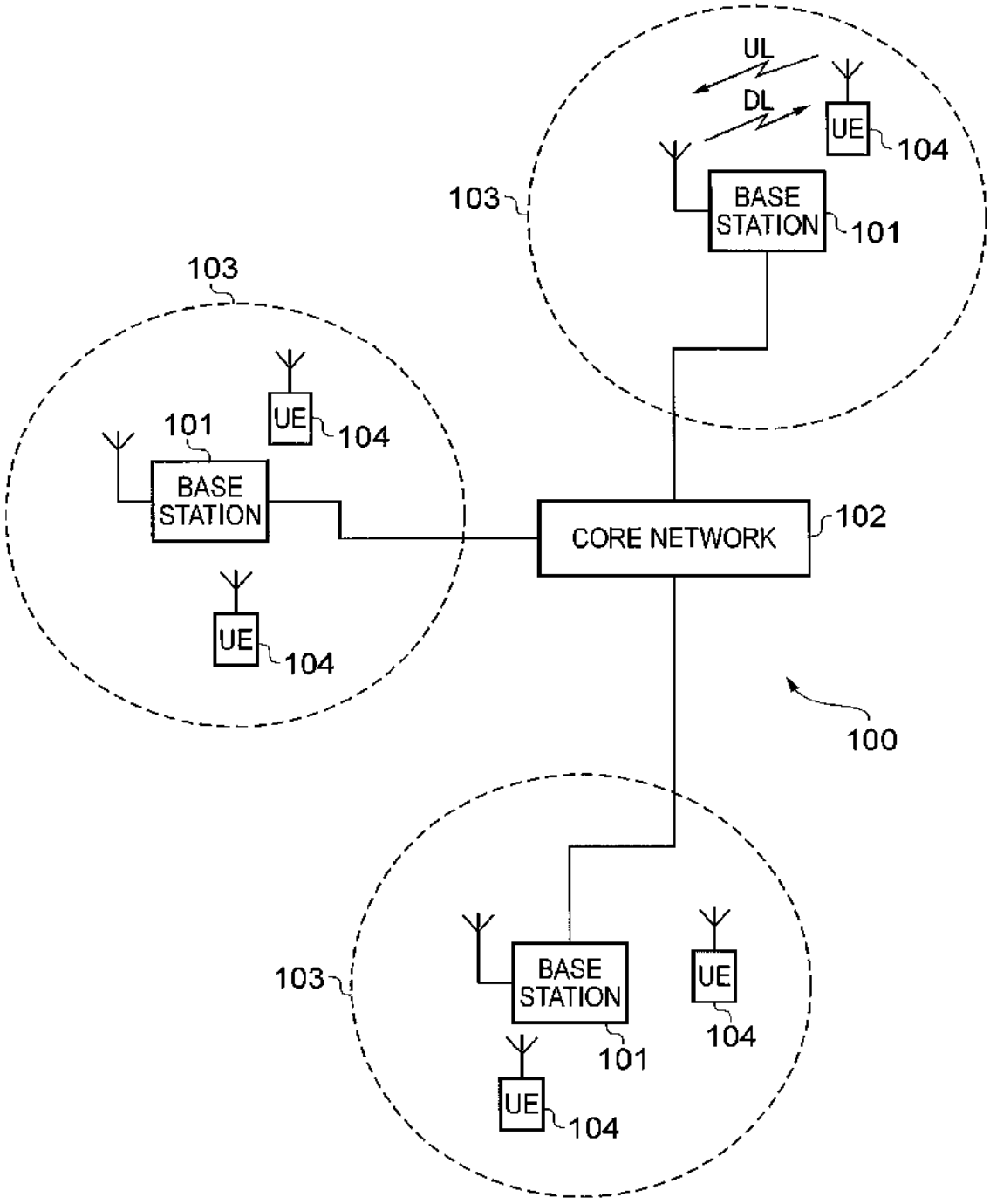

UL
DL
UE
104
103
BASE STATION
101
103
101
UE
104
BASE STATION
CORE NETWORK
102
UE
104
100
103
BASE STATION
UE
101
104
UE
104

FIG. 1

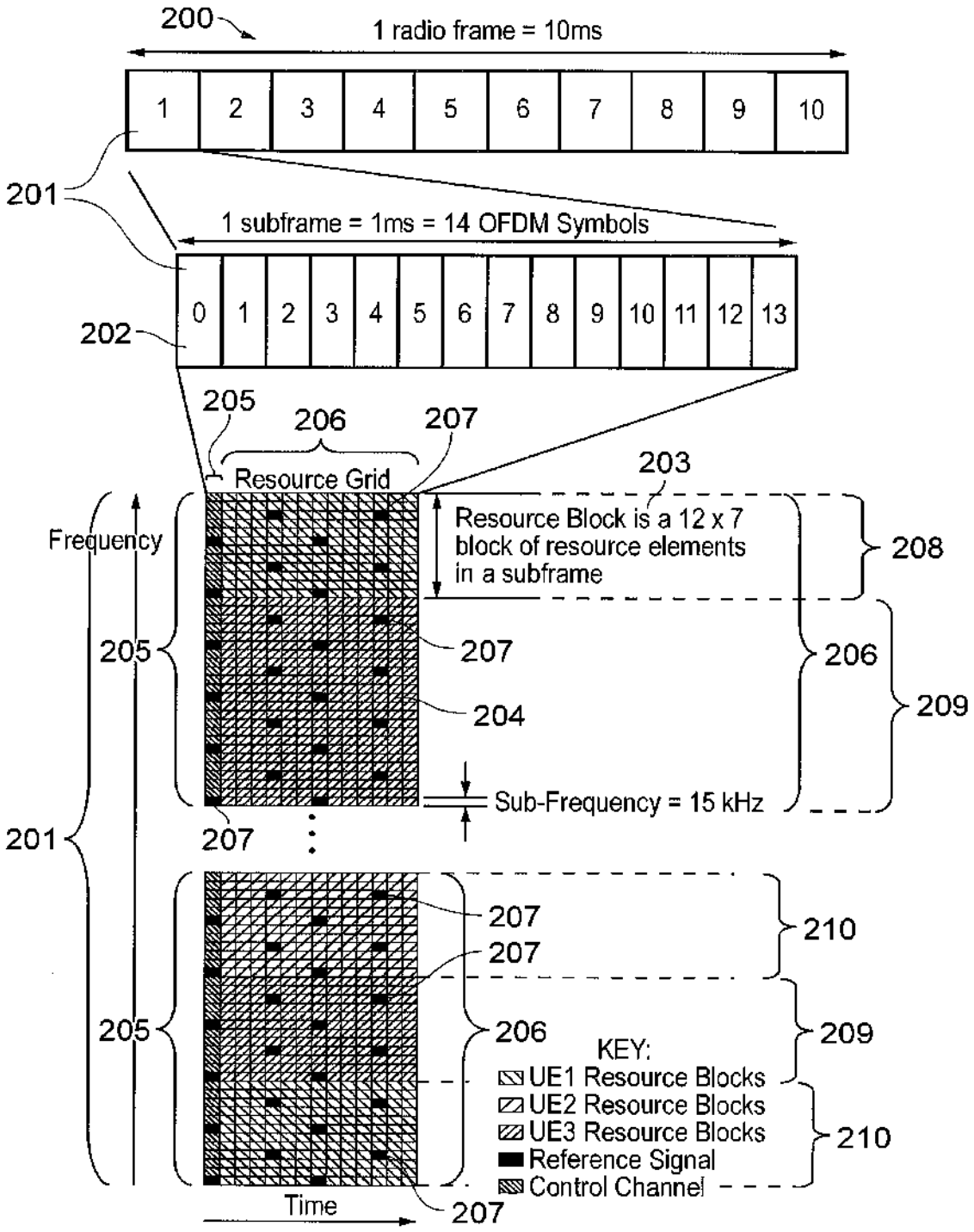

200
1 radio frame = 10ms
1
2
3
4
5
6
7
8
9
10
201
1 subframe = 1ms = 14 OFDM Symbols
0
1
2
3
4
5
6
7
8
9
10
11
12
13
202
205
206
207
Resource Grid
203
Frequency
Resource Block is a 12 x 7 block of resource elements in a subframe
208
205
207
206
209
204
Sub-Frequency = 15 kHz
201
207
207
207
210
205
206
209
KEY:
UE1 Resource Blocks
UE2 Resource Blocks
UE3 Resource Blocks
Reference Signal
Control Channel
210
Time
207

FIG. 2

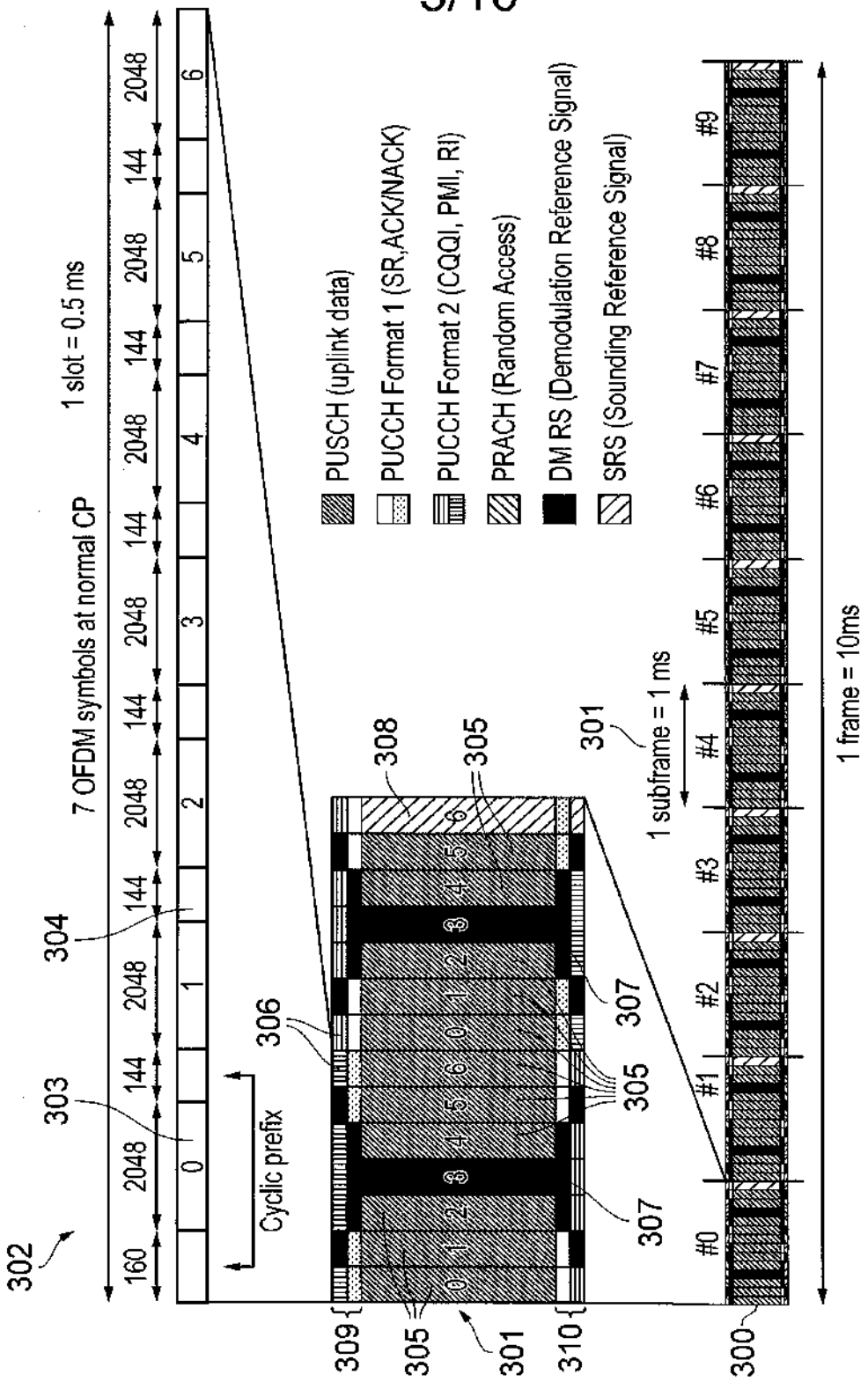

PUSCH (uplink data)
PUCCH Format 1 (SR,ACK/NACK)
PUCCH Format 2 (CQQI, PMI, RI)
PRACH (Random Access)
DM RS (Demodulation Reference Signal)
SRS (Sounding Reference Signal)
7 OFDM symbols at normal CP
1 slot = 0.5 ms
Cyclic prefix
1 subframe = 1 ms
1 frame = 10ms
302
303
304
305
306
307
308
309
310
300
301

FIG. 3

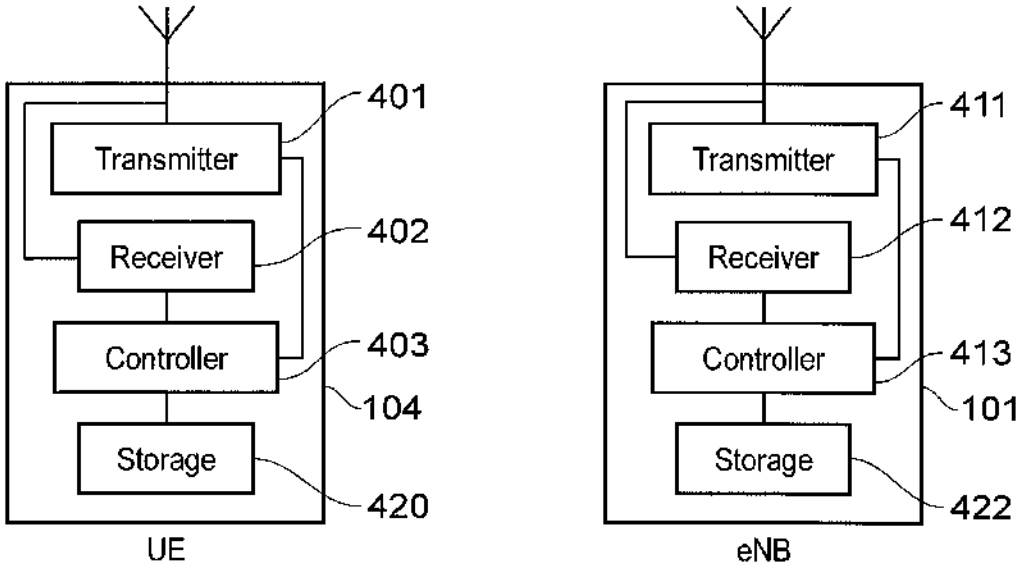

Transmitter
Receiver
Controller
Storage
401
402
403
104
420
UE
Transmitter
Receiver
Controller
Storage
411
412
413
101
422
eNB

FIG. 4

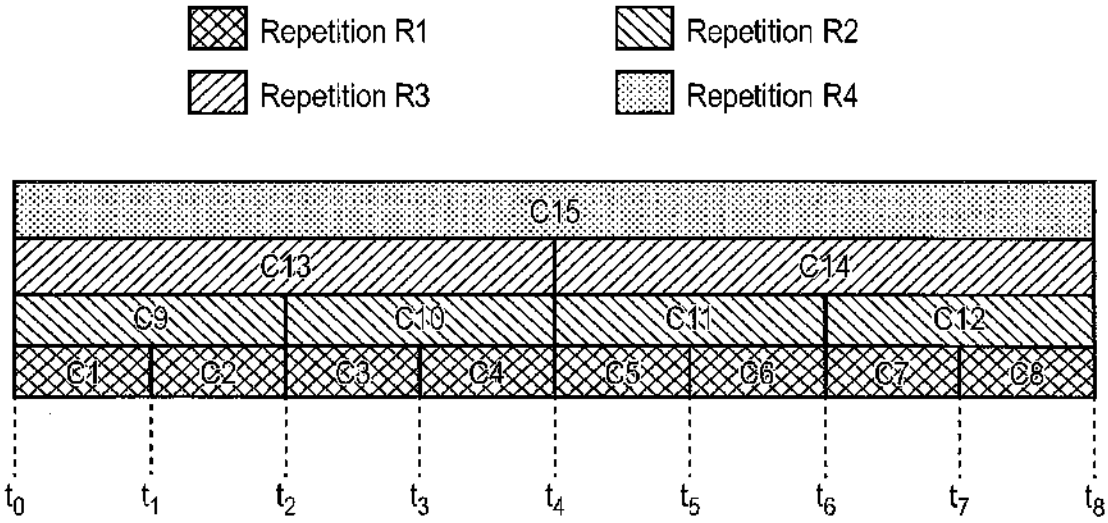

Repetition R1
Repetition R2
Repetition R3
Repetition R4
C15
C13
C14
C9
C10
C11
C12
C1
C2
C3
C4
C5
C6
C7
C8
t0
t1
t2
t3
t4
t5
t6
t7
t8

FIG. 5

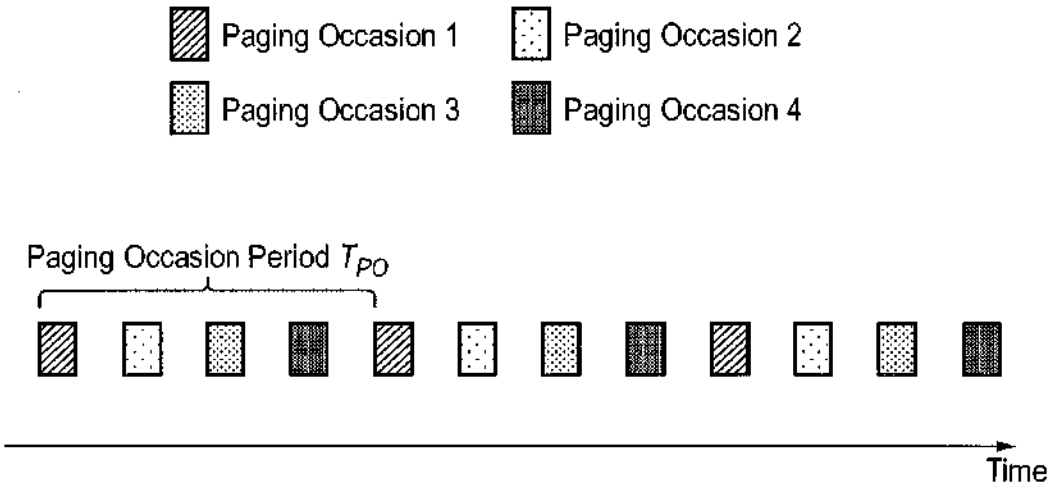

Paging Occasion 1
Paging Occasion 2
Paging Occasion 3
Paging Occasion 4
Paging Occasion Period T_{PO}
Time

FIG. 6

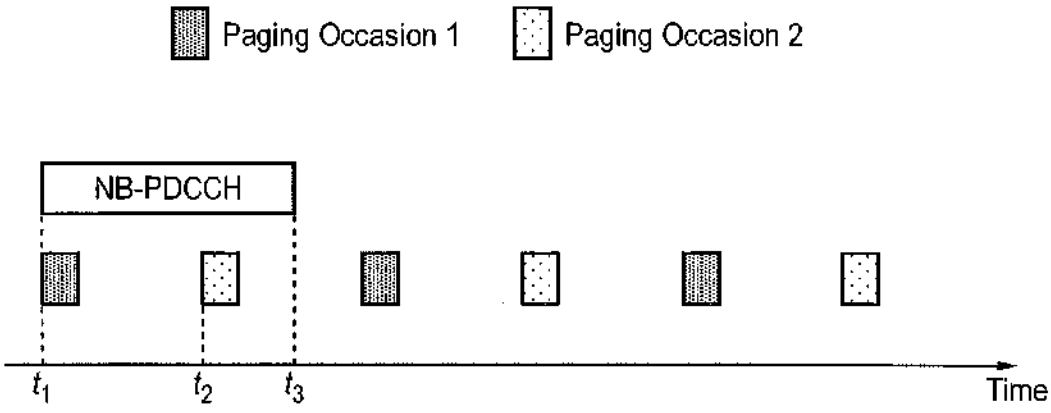

Paging Occasion 1
Paging Occasion 2
NB-PDCCH
t_1
t_2
t_3
Time

FIG. 7

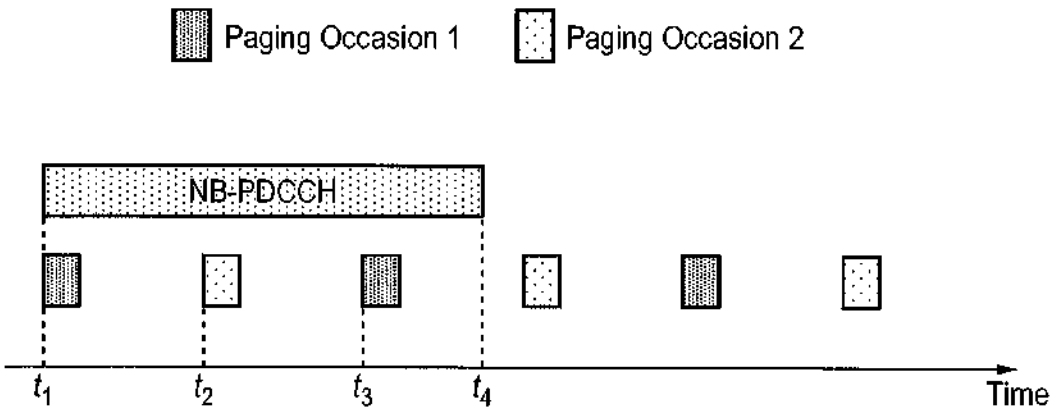

Paging Occasion 1
Paging Occasion 2
NB-PDCCH
t_1
t_2
t_3
t_4
Time

FIG. 8

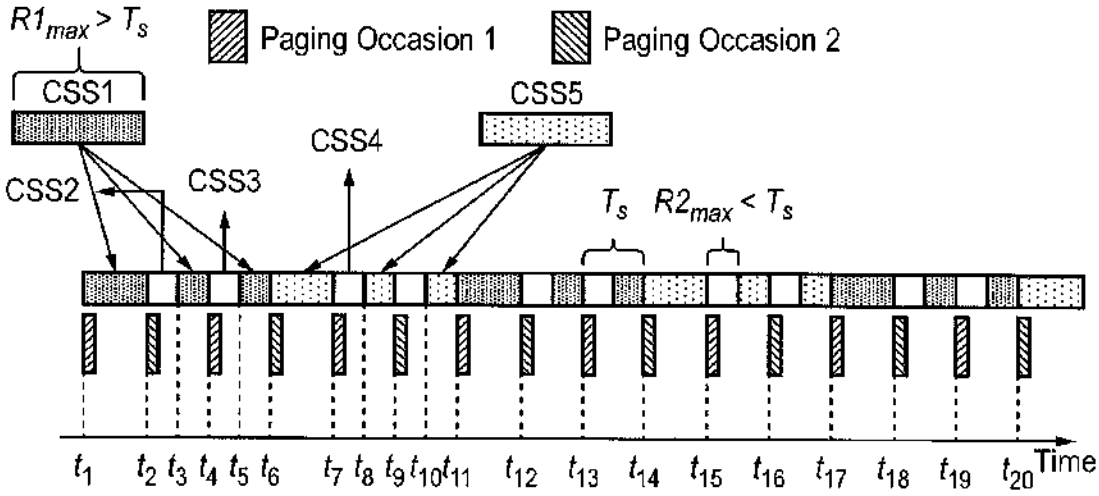

$R1_{max} > T_s$
Paging Occasion 1
Paging Occasion 2
CSS1
CSS5
CSS4
CSS2
CSS3
T_s
$R2_{max} < T_s$
t_1 t_2 t_3 t_4 t_5 t_6 t_7 t_8 t_9 t_{10} t_{11} t_{12} t_{13} t_{14} t_{15} t_{16} t_{17} t_{18} t_{19} t_{20}
Time

FIG. 9

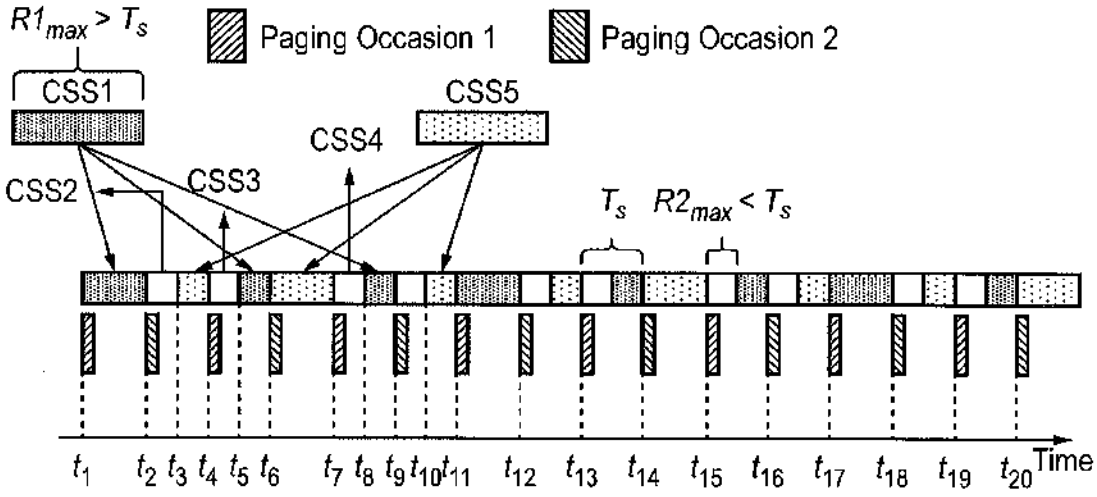

$R1_{max} > T_s$
Paging Occasion 1
Paging Occasion 2
CSS1
CSS5
CSS4
CSS2
CSS3
T_s
$R2_{max} < T_s$
t_1 t_2 t_3 t_4 t_5 t_6 t_7 t_8 t_9 t_{10} t_{11} t_{12} t_{13} t_{14} t_{15} t_{16} t_{17} t_{18} t_{19} t_{20} Time

FIG. 10

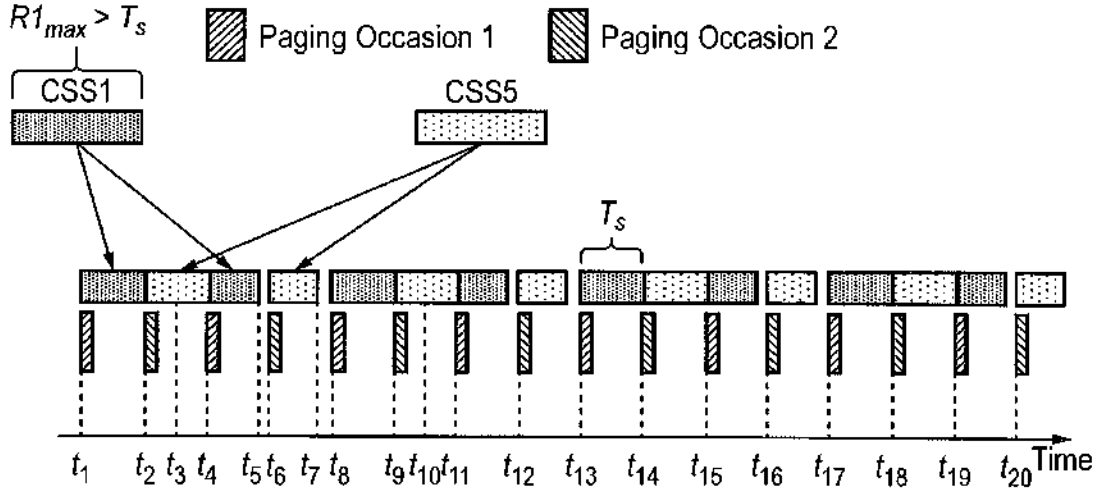

$R1_{max} > T_s$
Paging Occasion 1
Paging Occasion 2
CSS1
CSS5
T_s
t_1 t_2 t_3 t_4 t_5 t_6 t_7 t_8 t_9 t_{10} t_{11} t_{12} t_{13} t_{14} t_{15} t_{16} t_{17} t_{18} t_{19} t_{20} Time

FIG. 11

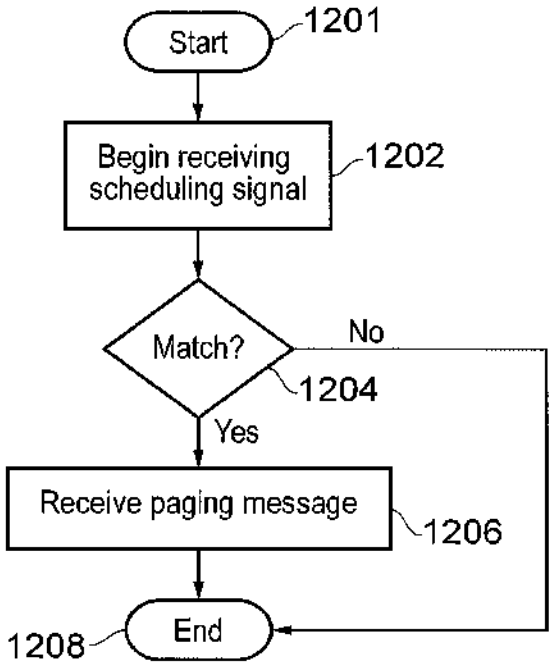

Start
1201
Begin receiving scheduling signal
1202
Match?
No
1204
Yes
Receive paging message
1206
End
1208

FIG. 12

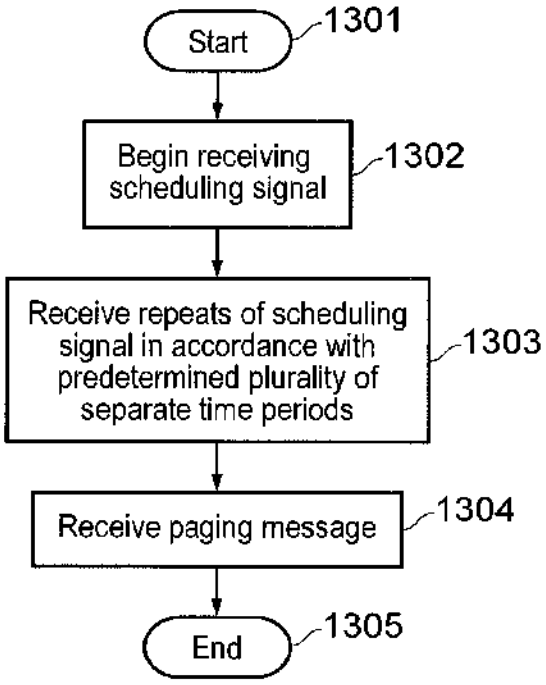

Start
1301
Begin receiving scheduling signal
1302
Receive repeats of scheduling signal in accordance with predetermined plurality of separate time periods
1303
Receive paging message
1304
End
1305

FIG. 13

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/057758

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W68/00
ADD. H04W4/00 H04W68/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 2 999 280 A2 (APPLE INC [US]) 23 March 2016 (2016-03-23) paragraphs [0100] - [0159] ----- -/--	1-25

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 July 2017	20/07/2017

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Bocking, Philip

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Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	ZTE: "Remaining Issues on NB-PDCCH Design of NB-IoT", 3GPP DRAFT; R1-160467 NB-PDCCH, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. St Julian's, Malta; 20160215 - 20160219 5 February 2016 (2016-02-05), XP051063789, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_84/Docs/ [retrieved on 2016-02-05] paragraphs [0004] - [05.2]; figures 4,7 -----	26-44
A	ERICSSON: "Paging and DRX in Idle mode in NB-IoT", 3GPP DRAFT; R2-161311 PAGING AND DRX IN IDLE MODE IN NB-IOT, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG2, no. St. Julian, Malta; 20160215 - 20160219 6 February 2016 (2016-02-06), XP051065779, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_93/Docs/ [retrieved on 2016-02-06] the whole document -----	1-44
A	ZTE: "Issues for PF/PO in NB-IOT", 3GPP DRAFT; R2-160411 ISSUES FOR PAGING IN NB-IOT-FINAL, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG2, no. Budapest, HU; 20160119 - 20160121 13 January 2016 (2016-01-13), XP051066437, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_AHs/2016_01_LTE_NB_IoT/Docs/ [retrieved on 2016-01-13] the whole document ----- -/--	1-44

2

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	INTEL CORPORATION: "Remaining open aspects on NBIOT Paging", 3GPP DRAFT; R2-160445_NB-IOT_PAGING_INTELV04, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG2, no. Budapest, HU; 20160119 - 20160121 18 January 2016 (2016-01-18), XP051054733, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN2/Docs/ [retrieved on 2016-01-18] the whole document -----	1-44
A	NOKIA NETWORKS: "Paging procedure for NB-IoT", 3GPP DRAFT; R2-160495 NB IOT PAGING PROCEDURE, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG2, no. Budapest, HU; 20160119 - 20160121 12 January 2016 (2016-01-12), XP051066428, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_AHs/2016_01_LTE_NB_IoT/Docs/ [retrieved on 2016-01-12] the whole document -----	1-44
A	ERICSSON: "Physical channels for paging in NB-IoT", 3GPP DRAFT; R2-160452 PHYSICAL CHANNELS FOR PAGING IN NB-IOT, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG2, no. Budapest, HU; 20160119 - 20160121 13 January 2016 (2016-01-13), XP051066469, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_AHs/2016_01_LTE_NB_IoT/Docs/ [retrieved on 2016-01-13] the whole document ----- -/--	1-44

2

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	ERICSSON: "NB-IoT - Paging", 3GPP DRAFT; R1-160084 - NB-IOT - PAGING, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. Budapest, HU; 20160118 - 20160120 12 January 2016 (2016-01-12), XP051064699, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_AH/LTE_NB-IoT_1601/Docs/ [retrieved on 2016-01-12] the whole document -----	1-44

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2017/057758

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-25

   Identification of paging/scheduling signal for a given mobile terminal

   ---

2. claims: 26-44

   Avoiding interference for paging where paging signals are transmitted multiple times (Coverage Enhancement)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2017/057758

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 2999280 A2	23-03-2016	CN 105392197 A	09-03-2016
		EP 2999280 A2	23-03-2016
		JP 2016052127 A	11-04-2016
		US 2016066296 A1	03-03-2016
		US 2017135067 A1	11-05-2017

Form PCT/ISA/210 (patent family annex) (April 2005)

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
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30 March 2017 (30.03.2017)

WIPO | PCT

(10) International Publication Number
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(22) International Filing Date:
21 September 2016 (21.09.2016)

(25) Filing Language: English

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(30) Priority Data:
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62/251,759 6 November 2015 (06.11.2015) US

(71) Applicant: **LG ELECTRONICS INC.** [KR/KR]; 128, Yeoui-daero, Yeongdeungpo-gu, Seoul 07336 (KR).

(72) Inventors: **YOU, Hyangsun**; IP Center, LG Electronics Inc., 19, Yangjae-daero 11gil, Seocho-gu, Seoul 06772 (KR). **YI, Yunjung**; IP Center, LG Electronics Inc., 19, Yangjae-daero 11gil, Seocho-gu, Seoul 06772 (KR).

(74) Agents: **KIM, Yong In** et al.; KBK & Associates, 7th Floor, 82 Olympic-ro, Songpa-ku, Seoul 05556 (KR).

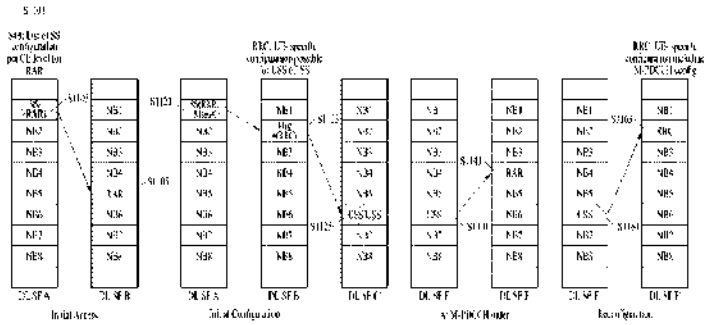
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(54) Title: METHOD AND USER EQUIPMENT FOR RECEIVING DOWNLINK CONTROL INFORMATION, AND METHOD AND BASE STATION FOR TRANSMITTING DOWNLINK CONTROL INFORMATION



(57) **Abstract:** A search space (hereinafter, CSS) for a control channel for scheduling a random access response may be configured by a system information block. A user equipment (UE) may attempt to receive a control channel for a random access response on the assumption that CSS is configured in accordance with a configuration based on the system information block. The UE may attempt to receive the control channel within a UE-specific search space (USS) by assuming that the USS is configured in accordance with the configuration of the CSS until a configuration for the USS is received.

WO 2017/052199 A1

Description

Title of Invention: METHOD AND USER EQUIPMENT FOR RECEIVING DOWNLINK CONTROL INFORMATION, AND METHOD AND BASE STATION FOR TRANSMITTING DOWNLINK CONTROL INFORMATION

Technical Field

[1] The present invention relates to a wireless communication system, and more particularly, to a method for transmitting or receiving downlink control information and a device therefor.

Background Art

[2] With appearance and spread of machine-to-machine (M2M) communication and a variety of devices such as smartphones and tablet PCs and technology demanding a large amount of data transmission, data throughput needed in a cellular network has rapidly increased. To satisfy such rapidly increasing data throughput, carrier aggregation technology, cognitive radio technology, etc. for efficiently employing more frequency bands and multiple input multiple output (MIMO) technology, multi-base station (BS) cooperation technology, etc. for raising data capacity transmitted on limited frequency resources have been developed.

[3] A general wireless communication system performs data transmission/reception through one downlink (DL) band and through one uplink (UL) band corresponding to the DL band (in case of a frequency division duplex (FDD) mode), or divides a prescribed radio frame into a UL time unit and a DL time unit in the time domain and then performs data transmission/reception through the UL/DL time unit (in case of a time division duplex (TDD) mode). A base station (BS) and a user equipment (UE) transmit and receive data and/or control information scheduled on a prescribed time unit basis, e.g. on a subframe basis. The data is transmitted and received through a data region configured in a UL/DL subframe and the control information is transmitted and received through a control region configured in the UL/DL subframe. To this end, various physical channels carrying radio signals are formed in the UL/DL subframe. In contrast, carrier aggregation technology serves to use a wider UL/DL bandwidth by aggregating a plurality of UL/DL frequency blocks in order to use a broader frequency band so that more signals relative to signals when a single carrier is used can be simultaneously processed.

[4] In addition, a communication environment has evolved into increasing density of nodes accessible by a user at the periphery of the nodes. A node refers to a fixed point

capable of transmitting/receiving a radio signal to/from the UE through one or more antennas. A communication system including high-density nodes may provide a better communication service to the UE through cooperation between the nodes.

Disclosure of Invention

Technical Problem

[5] Due to introduction of new radio communication technology, the number of user equipments (UEs) to which a BS should provide a service in a prescribed resource region increases and the amount of data and control information that the BS should transmit to the UEs increases. Since the amount of resources available to the BS for communication with the UE(s) is limited, a new method in which the BS efficiently receives/transmits uplink/downlink data and/or uplink/downlink control information using the limited radio resources is needed.

[6] The technical objects that can be achieved through the present invention are not limited to what has been particularly described hereinabove and other technical objects not described herein will be more clearly understood by persons skilled in the art from the following detailed description.

Solution to Problem

[7] A search space (hereinafter, CSS_RAR) for a control channel for scheduling a random access response may be configured by a system information block. A user equipment (UE) may attempt to receive a control channel for a random access response by assuming that CSS_RAR is configured in accordance with a configuration based on the system information block. If the UE receives the control channel for a random access response, the UE may receive the random access response to a random access preamble transmitted therefrom in accordance with control information carried by the control channel. The UE may attempt to receive a control channel within a UE-specific search space (hereinafter, USS) by assuming that the USS is configured in accordance with the configuration of the CSS until a configuration for the USS is received.

[8] In an aspect of the present invention, provided herein is a method for receiving, by a user equipment (UE), downlink control information (DCI) for the UE. The method comprises: receiving, by the UE, a common search space configuration for a common search space; receiving, by the UE, a first physical downlink control channel (PDCCH) scheduling a random access response; and receiving, by the UE, a second PDCCH carrying the DCI for the UE. The UE can monitor first PDCCH candidates of the common search space according to the common search space configuration in order to receive the first PDCCH. The UE can monitor second PDCCH candidates of a UE-specific search space in order to receive the second PDCCH. The UE can assume that configuration of the UE-specific search space is the same as that of the common search

space until the UE receives a UE-specific search space configuration.

[9] In another aspect of the present invention, provided herein is a method for transmitting, by a base station (BS), downlink control information (DCI) for a user equipment (UE). The method comprises: transmitting, by the BS, common search space configuration for a common search space; transmitting, by the BS to the UE, a first physical downlink control channel (PDCCH) scheduling a random access response; and transmitting, by the BS to the UE, a second PDCCH carrying the DCI for the UE. The BS can transmit the first PDCCH by using one of first PDCCH candidates of the common search space according to the common search space configuration. The BS can transmit the second PDCCH by using one of second PDCCH candidates of a UE-specific search space. The BS can configure the UE-specific search space according to the same configuration as the common search space configuration until the BS transmits a UE-specific search space configuration to the UE.

[10] In still another aspect of the present invention, provided herein a user equipment (UE) for receiving downlink control information (DCI) for the UE. The UE comprises a radio frequency (RF) unit and a processor connected to the RF unit. The processor can be configured to control the RF unit to receive common search space configuration for a common search space; control the RF unit to receive a first physical downlink control channel (PDCCH) scheduling a random access response; and control the RF unit to receive a second PDCCH carrying the DCI for the UE. The processor can be configured to monitor first PDCCH candidates of the common search space according to the common search space configuration in order to detect the firs PDCCH. The processor can be configured to monitor second PDCCH candidates of a UE-specific search space in order to detect the second PDCCH. The processor can be configured to assume that configuration of the UE-specific search space is the same as that of the common search space until the UE receives a UE-specific search space configuration.

[11] In a further aspect of the present invention, provided herein a base station (BS) for transmitting downlink control information (DCI) for a user equipment (UE). The BS comprises a radio frequency (RF) unit and a processor connected to the RF unit. The processor can be configured to control the RF unit to transmit common search space configuration for a common search space; control the RF unit to transmit a first physical downlink control channel (PDCCH) scheduling a random access response; and control the RF unit to transmit a second PDCCH carrying the DCI for the UE. The processor can be configured to control the RF unit to transmit the first PDCCH using one of first PDCCH candidates of the common search space according to the common search space configuration. The processor can be configured to control the RF unit to transmit the second PDCCH using one of second PDCCH candidates of a UE-specific search space. The processor can configure the UE-specific search space according to

the same as that of the common search space until the BS transmits a UE-specific search space configuration.

[12] In each aspect of the present invention, the common search space configuration can include information on a narrowband for the common search space. The second PDCCH candidates of the UE-specific search space can be configured on the same narrowband as the narrowband for the common search space until the UE-specific search space configuration is transmitted to the UE.

[13] In each aspect of the present invention, the common search space configuration can include information on a maximum number of repetitions for the first common search space. The second PDCCH candidates of the UE-specific search space can be configured based on the same number as the maximum number of repetitions for the common search space until the UE-specific search space configuration is transmitted to the UE.

[14] In each aspect of the present invention, the common search space configuration can include information on a first physical resource block (PRB) set for transmitting the first PDCCH. The same physical resource block set as the first PRB set can be used for the second PDCCH candidates until the UE-specific search space configuration is transmitted to the UE

[15] In each aspect of the present invention, the first PDCCH candidates of the common search space can be configured according to aggregation levels larger than or equal to 8 among a plurality of aggregation levels, whereas the second PDCCH candidates of the UE-specific search space can be configured according to the plurality of aggregation levels.

[16] In each aspect of the present invention, the UE can transmit a random access preamble using a physical random access channel (PRACH) resource. The UE can monitor the first PDCCH candidates in response to transmission of the random access preamble. The UE can receive the random access response according to control information carried by the first PDCCH. The BS can receive a random access preamble using a physical random access channel (PRACH) resource. The BS can transmit the first PDCCH in response to reception of the random access preamble. The BS can transmit the random access response according to control information carried by the first PDCCH.

[17] The above technical solutions are merely some parts of the embodiments of the present invention and various embodiments into which the technical features of the present invention are incorporated can be derived and understood by persons skilled in the art from the following detailed description of the present invention.

Advantageous Effects of Invention

[18] According to the present invention, uplink/downlink signals can be efficiently transmitted/received. Therefore, overall throughput of a radio communication system can be improved.

[19] According to one embodiment of the present invention, a low cost/complexity UE can perform communication with a BS at low cost while maintaining compatibility with a legacy system.

[20] According to one embodiment of the present invention, the UE can be implemented at low cost/complexity.

[21] According to one embodiment of the present invention, coverage can be enhanced.

[22] According to one embodiment of the present invention, the UE and the BS can perform communication with each other at a narrowband.

[23] It will be appreciated by persons skilled in the art that that the effects that can be achieved through the present invention are not limited to what has been particularly described hereinabove and other advantages of the present invention will be more clearly understood from the following detailed description.

Brief Description of Drawings

[24] The accompanying drawings, which are included to provide a further understanding of the invention, illustrate embodiments of the invention and together with the description serve to explain the principle of the invention.

[25] FIG. 1 illustrates the structure of a radio frame used in a wireless communication system.

[26] FIG. 2 illustrates the structure of a downlink (DL)/uplink (UL) slot in a wireless communication system.

[27] FIG. 3 illustrates a radio frame structure for transmission of a synchronization signal (SS).

[28] FIG. 4 illustrates the structure of a DL subframe used in a wireless communication system.

[29] FIG. 5 illustrates the structure of a UL subframe used in a wireless communication system.

[30] FIG. 6 illustrates an example of a signal band for MTC.

[31] FIG. 7 illustrates repeated transmission of a channel for coverage enhancement.

[32] FIG. 8 illustrates a configuration of a common search space (CSS) for paging according to the present invention.

[33] FIG. 9 illustrates a configuration of a common search space (CSS) for random access response (RAR) according to the present invention.

[34] FIG. 10 illustrates the example of the monitoring time region of USS and CSS.

[35] FIG. 11 illustrates a procedure of configuring a search space according to the present

invention.

[36] FIG. 12 illustrates a configuration of M-PDCCH repeated transmission according to the present invention.

[37] FIG. 13 is a block diagram illustrating elements of a transmitting device 10 and a receiving device 20 for implementing the present invention.

Mode for the Invention

[38] Reference will now be made in detail to the exemplary embodiments of the present invention, examples of which are illustrated in the accompanying drawings. The detailed description, which will be given below with reference to the accompanying drawings, is intended to explain exemplary embodiments of the present invention, rather than to show the only embodiments that can be implemented according to the invention. The following detailed description includes specific details in order to provide a thorough understanding of the present invention. However, it will be apparent to those skilled in the art that the present invention may be practiced without such specific details.

[39] In some instances, known structures and devices are omitted or are shown in block diagram form, focusing on important features of the structures and devices, so as not to obscure the concept of the present invention. The same reference numbers will be used throughout this specification to refer to the same or like parts.

[40] The following techniques, apparatuses, and systems may be applied to a variety of wireless multiple access systems. Examples of the multiple access systems include a code division multiple access (CDMA) system, a frequency division multiple access (FDMA) system, a time division multiple access (TDMA) system, an orthogonal frequency division multiple access (OFDMA) system, a single carrier frequency division multiple access (SC-FDMA) system, and a multicarrier frequency division multiple access (MC-FDMA) system. CDMA may be embodied through radio technology such as universal terrestrial radio access (UTRA) or CDMA2000. TDMA may be embodied through radio technology such as global system for mobile communications (GSM), general packet radio service (GPRS), or enhanced data rates for GSM evolution (EDGE). OFDMA may be embodied through radio technology such as institute of electrical and electronics engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20, or evolved UTRA (E-UTRA). UTRA is a part of a universal mobile telecommunications system (UMTS). 3rd generation partnership project (3GPP) long term evolution (LTE) is a part of evolved UMTS (E-UMTS) using E-UTRA. 3GPP LTE employs OFDMA in DL and SC-FDMA in UL. LTE-advanced (LTE-A) is an evolved version of 3GPP LTE. For convenience of description, it is assumed that the present invention is applied to 3GPP LTE/LTE-A. However, the

technical features of the present invention are not limited thereto. For example, although the following detailed description is given based on a mobile communication system corresponding to a 3GPP LTE/LTE-A system, aspects of the present invention that are not specific to 3GPP LTE/LTE-A are applicable to other mobile communication systems.

[41] For example, the present invention is applicable to contention based communication such as Wi-Fi as well as non-contention based communication as in the 3GPP LTE/LTE-A system in which an eNB allocates a DL/UL time/frequency resource to a UE and the UE receives a DL signal and transmits a UL signal according to resource allocation of the eNB. In a non-contention based communication scheme, an access point (AP) or a control node for controlling the AP allocates a resource for communication between the UE and the AP, whereas, in a contention based communication scheme, a communication resource is occupied through contention between UEs which desire to access the AP. The contention based communication scheme will now be described in brief. One type of the contention based communication scheme is carrier sense multiple access (CSMA). CSMA refers to a probabilistic media access control (MAC) protocol for confirming, before a node or a communication device transmits traffic on a shared transmission medium (also called a shared channel) such as a frequency band, that there is no other traffic on the same shared transmission medium. In CSMA, a transmitting device determines whether another transmission is being performed before attempting to transmit traffic to a receiving device. In other words, the transmitting device attempts to detect presence of a carrier from another transmitting device before attempting to perform transmission. Upon sensing the carrier, the transmitting device waits for another transmission device which is performing transmission to finish transmission, before performing transmission thereof. Consequently, CSMA can be a communication scheme based on the principle of "sense before transmit" or "listen before talk". A scheme for avoiding collision between transmitting devices in the contention based communication system using CSMA includes carrier sense multiple access with collision detection (CSMA/CD) and/or carrier sense multiple access with collision avoidance (CSMA/CA). CSMA/CD is a collision detection scheme in a wired local area network (LAN) environment. In CSMA/CD, a personal computer (PC) or a server which desires to perform communication in an Ethernet environment first confirms whether communication occurs on a network and, if another device carries data on the network, the PC or the server waits and then transmits data. That is, when two or more users (e.g. PCs, UEs, etc.) simultaneously transmit data, collision occurs between simultaneous transmission and CSMA/CD is a scheme for flexibly transmitting data by monitoring collision. A transmitting device using CSMA/CD adjusts data transmission thereof by sensing data transmission performed by another

device using a specific rule. CSMA/CA is a MAC protocol specified in IEEE 802.11 standards. A wireless LAN (WLAN) system conforming to IEEE 802.11 standards does not use CSMA/CD which has been used in IEEE 802.3 standards and uses CA, i.e. a collision avoidance scheme. Transmission devices always sense carrier of a network and, if the network is empty, the transmission devices wait for determined time according to locations thereof registered in a list and then transmit data. Various methods are used to determine priority of the transmission devices in the list and to re-configure priority. In a system according to some versions of IEEE 802.11 standards, collision may occur and, in this case, a collision sensing procedure is performed. A transmission device using CSMA/CA avoids collision between data transmission thereof and data transmission of another transmission device using a specific rule.

[42] In the present invention, a user equipment (UE) may be a fixed or mobile device. Examples of the UE include various devices that transmit and receive user data and/or various kinds of control information to and from a base station (BS). The UE may be referred to as a terminal equipment (TE), a mobile station (MS), a mobile terminal (MT), a user terminal (UT), a subscriber station (SS), a wireless device, a personal digital assistant (PDA), a wireless modem, a handheld device, etc. In addition, in the present invention, a BS generally refers to a fixed station that performs communication with a UE and/or another BS, and exchanges various kinds of data and control information with the UE and another BS. The BS may be referred to as an advanced base station (ABS), a node-B (NB), an evolved node-B (eNB), a base transceiver system (BTS), an access point (AP), a processing server (PS), etc. In describing the present invention, a BS will be referred to as an eNB.

[43] In the present invention, a node refers to a fixed point capable of transmitting/ receiving a radio signal through communication with a UE. Various types of eNBs may be used as nodes irrespective of the terms thereof. For example, a BS, a node B (NB), an e-node B (eNB), a pico-cell eNB (PeNB), a home eNB (HeNB), a relay, a repeater, etc. may be a node. In addition, the node may not be an eNB. For example, the node may be a radio remote head (RRH) or a radio remote unit (RRU). The RRH or RRU generally has a lower power level than a power level of an eNB. Since the RRH or RRU (hereinafter, RRH/RRU) is generally connected to the eNB through a dedicated line such as an optical cable, cooperative communication between RRH/ RRU and the eNB can be smoothly performed in comparison with cooperative communication between eNBs connected by a radio line. At least one antenna is installed per node. The antenna may mean a physical antenna or mean an antenna port, a virtual antennIn the present invention, a cell refers to a prescribed geographical area to which one or more nodes provide a communication service. Accordingly, in the present invention, communicating with a specific cell may mean communicating with an eNB

or a node which provides a communication service to the specific cell. In addition, a DL/UL signal of a specific cell refers to a DL/UL signal from/to an eNB or a node which provides a communication service to the specific cell. A node providing UL/DL communication services to a UE is called a serving node and a cell to which UL/DL communication services are provided by the serving node is especially called a serving cell. Furthermore, channel status/quality of a specific cell refers to channel status/ quality of a channel or communication link formed between an eNB or node which provides a communication service to the specific cell and a UE. The UE may measure DL channel state received from a specific node using cell-specific reference signal(s) (CRS(s)) transmitted on a CRS resource and/or channel state information reference signal(s) (CSI-RS(s)) transmitted on a CSI-RS resource, allocated by antenna port(s) of the specific node to the specific node. Detailed CSI-RS configuration may be understood with reference to 3GPP TS 36.211 and 3GPP TS 36.331 documents.

[44] Meanwhile, a 3GPP LTE/LTE-A system uses the concept of a cell in order to manage radio resources and a cell associated with the radio resources is distinguished from a cell of a geographic region.

[45] A "cell" of a geographic region may be understood as coverage within which a node can provide service using a carrier and a "cell" of a radio resource is associated with bandwidth (BW) which is a frequency range configured by the carrier. Since DL coverage, which is a range within which the node is capable of transmitting a valid signal, and UL coverage, which is a range within which the node is capable of receiving the valid signal from the UE, depends upon a carrier carrying the signal, the coverage of the node may be associated with coverage of the "cell" of a radio resource used by the node. Accordingly, the term "cell" may be used to indicate service coverage of the node sometimes, a radio resource at other times, or a range that a signal using a radio resource can reach with valid strength at other times. The "cell" of the radio resource will be described later in more detail.

[46] 3GPP LTE/LTE-A standards define DL physical channels corresponding to resource elements carrying information derived from a higher layer and DL physical signals corresponding to resource elements which are used by a physical layer but which do not carry information derived from a higher layer. For example, a physical downlink shared channel (PDSCH), a physical broadcast channel (PBCH), a physical multicast channel (PMCH), a physical control format indicator channel (PCFICH), a physical downlink control channel (PDCCH), and a physical hybrid ARQ indicator channel (PHICH) are defined as the DL physical channels, and a reference signal and a synchronization signal are defined as the DL physical signals. A reference signal (RS), also called a pilot, refers to a special waveform of a predefined signal known to both a BS and a UE. For example, a cell-specific RS (CRS), a UE-specific RS (UE-RS), a po-

sitioning RS (PRS), and channel state information RS (CSI-RS) may be defined as DL RSs. Meanwhile, the 3GPP LTE/LTE-A standards define UL physical channels corresponding to resource elements carrying information derived from a higher layer and UL physical signals corresponding to resource elements which are used by a physical layer but which do not carry information derived from a higher layer. For example, a physical uplink shared channel (PUSCH), a physical uplink control channel (PUCCH), and a physical random access channel (PRACH) are defined as the UL physical channels, and a demodulation reference signal (DM RS) for a UL control/data signal and a sounding reference signal (SRS) used for UL channel measurement are defined as the UL physical signals.

[47] In the present invention, a physical downlink control channel (PDCCH), a physical control format indicator channel (PCFICH), a physical hybrid automatic retransmit request indicator channel (PHICH), and a physical downlink shared channel (PDSCH) refer to a set of time-frequency resources or resource elements (REs) carrying downlink control information (DCI), a set of time-frequency resources or REs carrying a control format indicator (CFI), a set of time-frequency resources or REs carrying downlink acknowledgement (ACK)/negative ACK (NACK), and a set of time-frequency resources or REs carrying downlink data, respectively. In addition, a physical uplink control channel (PUCCH), a physical uplink shared channel (PUSCH) and a physical random access channel (PRACH) refer to a set of time-frequency resources or REs carrying uplink control information (UCI), a set of time-frequency resources or REs carrying uplink data and a set of time-frequency resources or REs carrying random access signals, respectively. In the present invention, in particular, a time-frequency resource or RE that is assigned to or belongs to PDCCH/PCFICH/PHICH/PDSCH/PUCCH/PUSCH/PRACH is referred to as PDCCH/PCFICH/PHICH/PDSCH/PUCCH/PUSCH/PRACH RE or PDCCH/PCFICH/PHICH/PDSCH/PUCCH/PUSCH/PRACH time-frequency resource, respectively. Therefore, in the present invention, PUCCH/PUSCH/PRACH transmission of a UE is conceptually identical to UCI/uplink data/random access signal transmission on PUSCH/PUCCH/PRACH, respectively. In addition, PDCCH/PCFICH/PHICH/PDSCH transmission of an eNB is conceptually identical to downlink data/DCI transmission on PDCCH/PCFICH/PHICH/PDSCH, respectively.

[48] Hereinafter, OFDM symbol/subcarrier/RE to or for which CRS/DMRS/CSI-RS/SRS/UE-RS/TRS is assigned or configured will be referred to as CRS/DMRS/CSI-RS/SRS/UE-RS/TRS symbol/carrier/subcarrier/RE. For example, an OFDM symbol to or for which a tracking RS (TRS) is assigned or configured is referred to as a TRS symbol, a subcarrier to or for which the TRS is assigned or configured is referred to as a TRS subcarrier, and an RE to or for which the TRS is

assigned or configured is referred to as a TRS RE. In addition, a subframe configured for transmission of the TRS is referred to as a TRS subframe. Moreover, a subframe in which a broadcast signal is transmitted is referred to as a broadcast subframe or a PBCH subframe and a subframe in which a synchronization signal (e.g. PSS and/or SSS) is transmitted is referred to a synchronization signal subframe or a PSS/SSS subframe. OFDM symbol/subcarrier/RE to or for which PSS/SSS is assigned or configured is referred to as PSS/SSS symbol/subcarrier/RE, respectively.

[49] In the present invention, a CRS port, a UE-RS port, a CSI-RS port, and a TRS port refer to an antenna port configured to transmit a CRS, an antenna port configured to transmit a UE-RS, an antenna port configured to transmit a CSI-RS, and an antenna port configured to transmit a TRS, respectively. Antenna ports configured to transmit CRSs may be distinguished from each other by the locations of REs occupied by the CRSs according to CRS ports, antenna ports configured to transmit UE-RSs may be distinguished from each other by the locations of REs occupied by the UE-RSs according to UE-RS ports, and antenna ports configured to transmit CSI-RSs may be distinguished from each other by the locations of REs occupied by the CSI-RSs according to CSI-RS ports. Therefore, the term CRS/UE-RS/CSI-RS/TRS ports may also be used to indicate a pattern of REs occupied by CRSs/UE-RSs/CSI-RSs/TRSs in a predetermined resource region. In the present invention, both a DMRS and a UE-RS refer to RSs for demodulation and, therefore, the terms DMRS and UE-RS are used to refer to RSs for demodulation.

[50] FIG. 1 illustrates the structure of a radio frame used in a wireless communication system.

[51] Specifically, FIG. 1(a) illustrates an exemplary structure of a radio frame which can be used in frequency division multiplexing (FDD) in 3GPP LTE/LTE-A and FIG. 1(b) illustrates an exemplary structure of a radio frame which can be used in time division multiplexing (TDD) in 3GPP LTE/LTE-A.

[52] Referring to FIG. 1, a 3GPP LTE/LTE-A radio frame is 10ms ($307,200T_s$) in duration. The radio frame is divided into 10 subframes of equal size. Subframe numbers may be assigned to the 10 subframes within one radio frame, respectively. Here, T_s denotes sampling time where T_s=1/(2048*15kHz). Each subframe is 1ms long and is further divided into two slots. 20 slots are sequentially numbered from 0 to 19 in one radio frame. Duration of each slot is 0.5ms. A time interval in which one subframe is transmitted is defined as a transmission time interval (TTI). Time resources may be distinguished by a radio frame number (or radio frame index), a subframe number (or subframe index), a slot number (or slot index), and the like.

[53] A radio frame may have different configurations according to duplex modes. In FDD mode for example, since DL transmission and UL transmission are discriminated

according to frequency, a radio frame for a specific frequency band operating on a carrier frequency includes either DL subframes or UL subframes. In TDD mode, since DL transmission and UL transmission are discriminated according to time, a radio frame for a specific frequency band operating on a carrier frequency includes both DL subframes and UL subframes.

[54] Table 1 shows an exemplary UL-DL configuration within a radio frame in TDD mode.

[55] [Table 1]

DL-UL configuration	Downlink-to-Uplink Switch-point periodicity	Subframe number									
		0	1	2	3	4	5	6	7	8	9
0	5ms	D	S	U	U	U	D	S	U	U	U
1	5ms	D	S	U	U	D	D	S	U	U	D
2	5ms	D	S	U	D	D	D	S	U	D	D
3	10ms	D	S	U	U	U	D	D	D	D	D
4	10ms	D	S	U	U	D	D	D	D	D	D
5	10ms	D	S	U	D	D	D	D	D	D	D
6	5ms	D	S	U	U	U	D	S	U	U	D

[56] In Table 1, D denotes a DL subframe, U denotes a UL subframe, and S denotes a special subframe. The special subframe includes three fields, i.e. downlink pilot time slot (DwPTS), guard period (GP), and uplink pilot time slot (UpPTS). DwPTS is a time slot reserved for DL transmission and UpPTS is a time slot reserved for UL transmission. Table 2 shows an example of the special subframe configuration.

[57] [Table 2]

Special subframe configuration	Normal cyclic prefix in downlink			Extended cyclic prefix in downlink		
	DwPTS	UpPTS		DwPTS	UpPTS	
		Normal cyclic prefix in uplink	Extended cyclic prefix in uplink		Normal cyclic prefix in uplink	Extended cyclic prefix in uplink
0	$6592 \cdot T_s$	$2192 \cdot T_s$	$2560 \cdot T_s$	$7680 \cdot T_s$	$2192 \cdot T_s$	$2560 \cdot T_s$
1	$19760 \cdot T_s$			$20480 \cdot T_s$		
2	$21952 \cdot T_s$			$23040 \cdot T_s$		
3	$24144 \cdot T_s$			$25600 \cdot T_s$		
4	$26336 \cdot T_s$			$7680 \cdot T_s$	$4384 \cdot T_s$	$5120 \cdot T_s$
5	$6592 \cdot T_s$	$4384 \cdot T_s$	$5120 \cdot T_s$	$20480 \cdot T_s$		
6	$19760 \cdot T_s$			$23040 \cdot T_s$		
7	$21952 \cdot T_s$			$12800 \cdot T_s$		
8	$24144 \cdot T_s$			-	-	-
9	$13168 \cdot T_s$			-	-	-

[58] FIG. 2 illustrates the structure of a DL/UL slot structure in a wireless communication system.

[59] Referring to FIG. 2, a slot includes a plurality of orthogonal frequency division multiplexing (OFDM) symbols in the time domain and includes a plurality of resource blocks (RBs) in the frequency domain. The OFDM symbol may refer to one symbol duration. Referring to FIG. 2, a signal transmitted in each slot may be expressed by a resource grid including $N^{DL/UL}_{RB} * N^{RB}_{sc}$ subcarriers and $N^{DL/UL}_{symb}$ OFDM symbols. N^{DL}_{RB} denotes the number of RBs in a DL slot and N^{UL}_{RB} denotes the number of RBs in a UL slot. N^{DL}_{RB} and N^{UL}_{RB} depend on a DL transmission bandwidth and a UL transmission bandwidth, respectively. N^{DL}_{symb} denotes the number of OFDM symbols in a DL slot, N^{UL}_{symb} denotes the number of OFDM symbols in a UL slot, and N^{RB}_{sc} denotes the number of subcarriers configuring one RB.

[60] An OFDM symbol may be referred to as an OFDM symbol, a single carrier frequency division multiplexing (SC-FDM) symbol, etc. according to multiple access schemes. The number of OFDM symbols included in one slot may be varied according to channel bandwidths and CP lengths. For example, in a normal cyclic prefix (CP) case, one slot includes 7 OFDM symbols. In an extended CP case, one slot includes 6

OFDM symbols. Although one slot of a subframe including 7 OFDM symbols is shown in FIG. 2 for convenience of description, embodiments of the present invention are similarly applicable to subframes having a different number of OFDM symbols. Referring to FIG. 2, each OFDM symbol includes $N^{DL/UL}_{RB} * N^{RB}_{sc}$ subcarriers in the frequency domain. The type of the subcarrier may be divided into a data subcarrier for data transmission, a reference signal (RS) subcarrier for RS transmission, and a null subcarrier for a guard band and a DC component. The null subcarrier for the DC component is unused and is mapped to a carrier frequency f_0 in a process of generating an OFDM signal or in a frequency up-conversion process. The carrier frequency is also called a center frequency f_c.

[61] One RB is defined as $N^{DL/UL}_{symb}$ (e.g. 7) consecutive OFDM symbols in the time domain and as N^{RB}_{sc} (e.g. 12) consecutive subcarriers in the frequency domain. For reference, a resource composed of one OFDM symbol and one subcarrier is referred to a resource element (RE) or tone. Accordingly, one RB includes $N^{DL/UL}_{symb} * N^{RB}_{sc}$ REs. Each RE within a resource grid may be uniquely defined by an index pair (k, l) within one slot. k is an index ranging from 0 to $N^{DL/UL}_{RB} * N^{RB}_{sc} - 1$ in the frequency domain, and l is an index ranging from 0 to $N^{DL/UL}_{symb} - 1$ in the time domain.

[62] Meanwhile, one RB is mapped to one physical resource block (PRB) and one virtual resource block (VRB). A PRB is defined as N^{DL}_{symb} (e.g. 7) consecutive OFDM or SC-FDM symbols in the time domain and N^{RB}_{sc} (e.g. 12) consecutive subcarriers in the frequency domain. Accordingly, one PRB is configured with $N^{DL/UL}_{symb} * N^{RB}_{sc}$ REs. In one subframe, two RBs each located in two slots of the subframe while occupying the same N^{RB}_{sc} consecutive subcarriers are referred to as a physical resource block (PRB) pair. Two RBs configuring a PRB pair have the same PRB number (or the same PRB index).

[63] FIG. 3 illustrates a radio frame structure for transmission of a synchronization signal (SS). Specifically, FIG. 3 illustrates a radio frame structure for transmission of an SS and a PBCH in frequency division duplex (FDD), wherein FIG. 3(a) illustrates transmission locations of an SS and a PBCH in a radio frame configured as a normal cyclic prefix (CP) and FIG. 3(b) illustrates transmission locations of an SS and a PBCH in a radio frame configured as an extended CP.

[64] If a UE is powered on or newly enters a cell, the UE performs an initial cell search procedure of acquiring time and frequency synchronization with the cell and detecting a physical cell identity N^{cell}_{ID} of the cell. To this end, the UE may establish synchronization with the eNB by receiving synchronization signals, e.g. a primary synchronization signal (PSS) and a secondary synchronization signal (SSS), from the eNB and obtain information such as a cell identity (ID).

[65] An SS will be described in more detail with reference to FIG. 3. An SS is categorized

into a PSS and an SSS. The PSS is used to acquire time-domain synchronization of OFDM symbol synchronization, slot synchronization, etc. and/or frequency-domain synchronization and the SSS is used to acquire frame synchronization, a cell group ID, and/or CP configuration of a cell (i.e. information as to whether a normal CP is used or an extended CP is used). Referring to FIG. 3, each of a PSS and an SSS is transmitted on two OFDM symbols of every radio frame. More specifically, SSs are transmitted in the first slot of subframe 0 and the first slot of subframe 5, in consideration of a global system for mobile communication (GSM) frame length of 4.6 ms for facilitation of inter-radio access technology (inter-RAT) measurement. Especially, a PSS is transmitted on the last OFDM symbol of the first slot of subframe 0 and on the last OFDM symbol of the first slot of subframe 5 and an SSS is transmitted on the second to last OFDM symbol of the first slot of subframe 0 and on the second to last OFDM symbol of the first slot of subframe 5. A boundary of a corresponding radio frame may be detected through the SSS. The PSS is transmitted on the last OFDM symbol of a corresponding slot and the SSS is transmitted on an OFDM symbol immediately before an OFDM symbol on which the PSS is transmitted. A transmit diversity scheme of an SS uses only a single antenna port and standards therefor are not separately defined. That is, a single antenna port transmission scheme or a transmission scheme transparent to a UE (e.g. precoding vector switching (PVS), time switched transmit diversity (TSTD), or cyclic delay diversity (CDD)) may be used for transmit diversity of an SS.

[66] Upon detecting a PSS, a UE may discern that a corresponding subframe is one of subframe 0 and subframe 5 because the PSS is transmitted every 5ms but the UE cannot discern whether the subframe is subframe 0 or subframe 5. Accordingly, the UE cannot recognize the boundary of a radio frame only by the PSS. That is, frame synchronization cannot be acquired only by the PSS. The UE detects the boundary of a radio frame by detecting an SSS which is transmitted twice in one radio frame with different sequences.

[67] The UE, which has determined time and frequency parameters necessary for demodulating a DL signal and transmitting a UL signal at an accurate time by performing a cell search procedure using PSS/SSS, can communicate with the eNB only after acquiring system information necessary for system configuration of the UE from the eNB.

[68] The system information is configured by a master information block (MIB) and system information blocks (SIBs). Each SIB includes a set of functionally associated parameters and is categorized into an MIB, SIB Type 1 (SIB 1), SIB Type 2 (SIB2), and SIB3 to SIB17 in accordance with the parameters.

[69] The MIB includes most frequently transmitted parameters which are essential for

initial access of the UE to a network of the eNB. The UE may receive the MIB through a broadcast channel (e.g. PBCH). The MIB includes a DL bandwidth (BW), PHICH configuration, and a system frame number (SFN). Accordingly, the UE may be explicitly aware of information about the DL BW, SFN, and PHICH configuration by receiving the MIB. Meanwhile, information which may be implicitly recognized by the UE through reception of the PBCH includes the number of transmit antenna ports of the eNB. Information about the number of transmit antennas of the eNB is implicitly signaled by masking (e.g. XOR operation) a sequence corresponding to the number of transmit antennas to a 16-bit cyclic redundancy check (CRC) used for error detection of the PBCH.

[70] The SIB1 includes parameters needed to determine if a specific cell is suitable for cell selection, as well as information about time-domain scheduling of the other SIBs. The SIB1 is received by the UE through broadcast signaling or dedicated signaling.

[71] DL carrier frequency and corresponding system bandwidth may be acquired by the MIB carried by the PBCH. UL carrier frequency and corresponding system bandwidth may be acquired by system information which is a DL signal. The UE which has received the MIB applies a DL BW value within the MIB to a UL-bandwidth (UL BW) until system information block type 2 (SystemInformationBlockType2, SIB2) is received if there is no valid system information stored in a corresponding cell. For example, the UE may identify a full UL system band, which may be used by itself for UL transmission, through UL-carrier frequency and UL-bandwidth information within the SIB2 by acquiring system information block type 2 (SystemInformationBlockType2, SIB2).

[72] In the frequency domain, a PSS/SSS and a PBCH are transmitted only in a total of 6 RBs, i.e. a total of 72 subcarriers, irrespective of actual system BW, wherein 3 RBs are in the left and the other 3 RBs are in the right centering on a DC subcarrier on corresponding OFDM symbols. Therefore, the UE is configured to detect or decode the SS and the PBCH irrespective of DL BW configured for the UE.

[73] After initial cell search, the UE may perform a random access procedure to complete access to the eNB. To this end, the UE may transmit a preamble through a physical random access channel (PRACH) and receive a response message to the preamble through a PDCCH and a PDSCH. In contention based random access, the UE may perform additional PRACH transmission and a contention resolution procedure of a PDCCH and a PDSCH corresponding to the PDCCH.

[74] After performing the aforementioned procedure, the UE may perform PDDCH/PDSCH reception and PUSCH/PUCCH transmission as general uplink/downlink transmission procedures.

[75] The random access procedure is also called RACH (random access channel)

procedure. The random access procedure is used for initial access, uplink synchronization adjustment, resource assignment, handover, etc. The random access procedure is classified into a contention-based process and a dedicated (i.e. non-contention-based) process. The contention-based random access procedure includes initial access and is normally used, whereas the dedicated random access procedure is limitedly used for handover. In the contention-based random access procedure, a UE randomly select a RACH preamble sequence. Accordingly, a plurality of UEs can simultaneously transmit the same RACH preamble sequence and thus a contention resolution procedure is not needed. In the dedicated random access procedure, a UE uses a RACH preamble sequence uniquely allocated thereto by an eNB. Accordingly, the UE can perform the random access procedure without colliding with other UEs.

[76] The contention-based random access procedure has the following four steps. Hereinafter, messages transmitted in steps 1 to 4 may be respectively referred to as Msg 1 to Msg 4.

[77] - Step 1: RACH preamble (via PRACH) (UE to eNB)

[78] - Step 2: Random access response (RAR) (via PDCCH and PDSCH) (eNB to UE)

[79] - Step 3: Layer 2/Layer 3 message (via PUSCH) (UE to eNB)

[80] - Step 4: Contention resolution message (eNB to UE)

[81] The dedicated random access procedure includes the following three steps. Hereinafter, uplink transmission (i.e. step 3) corresponding to a RAR may be performed as a part of the random access procedure. The dedicated random access procedure can be triggered using a PDCCH (hereinafter, referred to as PDCCH order) used for an eNB to command RACH preamble transmission.

[82] - Step 0: PACH preamble allocation through dedicated signaling (eNB to UE)

[83] - Step 1: RACH preamble (via PRACH) (UE to eNB)

[84] - Step 2: RAR (via PDCCH and PDSCH) (eNB to UE)

[85] After transmission of RACH preamble, the UE attempts to receive a random access response (RAR) within a predetermined time window. Specifically, the UE attempts to detect a PDCCH (hereinafter, referred to as RA-RNTI PDCCH) having an RA-RNTI (Random Access RNTI) (e.g., CRC is masked with RA-RNTI in the PDCCH) within the time window. The UE checks whether a RAR therefor is present in a PDSCH corresponding to the RA-RNTI PDCCH during RA-RNTI PDCCH detection. The RAR includes timing advance (TA) information indicating timing offset information for UL synchronization, UL resource allocation information (UL grant information), a temporary UE identifier (e.g., temporary cell-RNTI, TC-RNTI), etc. The UE can perform UL transmission (e.g., Msg3) in accordance with resource allocation information and TA value in the RAR. HARQ is applied to UL transmission corresponding to the RAR. Accordingly, the UE can receive acknowledgement information

(e.g., PHICH) corresponding to Msg 3 after transmission of Msg 3.

[86] The random access preamble, i.e., RACH preamble consists of a cyclic prefix of length T_{CP} and a sequence part of length T_{SEQ} in the physical layer. T_{CP} and T_{SEQ} depend on the frame structure and the random access configuration. The preamble format is controlled by higher layers. The following table shows examples of T_{CP} and T_{SEQ}.

[87] [Table 3]

Preamble format	T_{CP}	T_{SEQ}
0	$3168 \cdot T_s$	$24576 \cdot T_s$
1	$21024 \cdot T_s$	$24576 \cdot T_s$
2	$6240 \cdot T_s$	$2 \cdot 24576 \cdot T_s$
3	$21024 \cdot T_s$	$2 \cdot 24576 \cdot T_s$
4(see NOTE)	$448 \cdot T_s$	$4096 \cdot T_s$
NOTE: Frame structure type 2 and special subframe configuration with UpPTS lengths $4384 \cdot T_s$ and $5120 \cdot T_s$ only.		

[88] The random access preamble is transmitted in UL subframe(s). The transmission of a random access preamble is restricted to certain time and frequency resources. These resources are called PRACH resources. The PRACH resources, are enumerated in increasing order of the subframe number within the radio frame and the PRBs in the frequency domain such that index 0 correspond to the lowest numbered PRB and subframe within the radio frame. PRACH resources within the radio frame are indicated by a PRACH configuration index.

[89] For frame structure type 1 with preamble format 0-3, for each of the PRACH configurations there is at most one random access resource per subframe. The following table shows examples of the preamble formats and the subframes in which random access preamble transmission is allowed for a given configuration in frame structure type 1. The PRACH configuration index is given by a higher layer signal (transmitted by an eNB).

[90] [Table 4]

PRACH Configuration Index	Preamble Format	SFN	Subframe number	PRACH Configuration Index	Preamble Format	SFN	Subframe number
0	0	Even	1	32	2	Even	1
1	0	Even	4	33	2	Even	4
2	0	Even	7	34	2	Even	7
3	0	Any	1	35	2	Any	1
4	0	Any	4	36	2	Any	4
5	0	Any	7	37	2	Any	7
6	0	Any	1,6	38	2	Any	1,6
7	0	Any	2,7	39	2	Any	2,7
8	0	Any	3,8	40	2	Any	3,8
9	0	Any	1,4,7	41	2	Any	1,4,7
10	0	Any	2,5,8	42	2	Any	2,5,8
11	0	Any	3,6,9	43	2	Any	3,6,9
12	0	Any	0,2,4,6,8	44	2	Any	0,2,4,6,8
13	0	Any	1,3,5,7,9	45	2	Any	1,3,5,7,9
14	0	Any	0,1,2,3,4, 5,6,7,8.9	46	N/A	N/A	N/A
15	0	Even	9	47	2	Even	9
16	1	Even	1	48	3	Even	1
17	1	Even	4	49	3	Even	4
18	1	Even	7	50	3	Even	7
19	1	Any	1	51	3	Any	1
20	1	Any	4	52	3	Any	4
21	1	Any	7	53	3	Any	7
22	1	Any	1,6	54	3	Any	1,6
23	1	Any	2,7	55	3	Any	2,7
24	1	Any	3,8	56	3	Any	3,8
25	1	Any	1,4,7	57	3	Any	1,4,7

26	1	Any	2,5,8	58	3	Any	2,5,8
27	1	Any	3,6,9	59	3	Any	3,6,9
28	1	Any	0,2,4,6,8	60	N/A	N/A	N/A
29	1	Any	1,3,5,7,9	61	N/A	N/A	N/A
30	N/A	N/A	N/A	62	N/A	N/A	N/A
31	1	Even	9	63	3	Even	9

[91] In Table 4, SFN denotes a system frame number.

[92] The first PRB, n^{RA}_{PRB}, allocated to the PRACH opportunity considered for preamble formats 0, 1, 2 and 3 is defined by $n^{RA}_{PRB}=n^{RA}_{PRBoffset}$, where the PRACH frequency offset $n^{RA}_{PRBoffset}$ is a PRB configured by higher layers and satisfies $0\leq n^{RA}_{PRBoffset}\leq N^{UL}_{RB}-6$.

[93] In case of frame structure type 2 with preamble formats 0 to 4, a plurality of random access resources may exist within UL subframe (or UpPTS for preamble format 4) in accordance with UL/DL configuration. The random access resources for the frame structure type 2 are defined in accordance with PRACH configuration index (see 3GPP TS 36.211 standard document).

[94] FIG. 4 illustrates the structure of a DL subframe used in a wireless communication system.

[95] Referring to FIG. 4, A DL subframe is divided into a control region and a data region in the time domain. Referring to FIG. 4, a maximum of 3 (or 4) OFDM symbols located in a front part of a first slot of a subframe corresponds to the control region. Hereinafter, a resource region for PDCCH transmission in a DL subframe is referred to as a PDCCH region. OFDM symbols other than the OFDM symbol(s) used in the control region correspond to the data region to which a physical downlink shared channel (PDSCH) is allocated. Hereinafter, a resource region available for PDSCH transmission in the DL subframe is referred to as a PDSCH region.

[96] Examples of a DL control channel used in 3GPP LTE include a physical control format indicator channel (PCFICH), a physical downlink control channel (PDCCH), a physical hybrid ARQ indicator channel (PHICH), etc.

[97] The PCFICH is transmitted in the first OFDM symbol of a subframe and carries information about the number of OFDM symbols available for transmission of a control channel within a subframe. The PCFICH notifies the UE of the number of OFDM symbols used for the corresponding subframe every subframe. The PCFICH is located at the first OFDM symbol. The PCFICH is configured by four resource element groups (REGs), each of which is distributed within a control region on the basis of cell ID. One REG includes four REs.

[98] A set of OFDM symbols available for the PDCCH at a subframe is given by the following Table.

[99] [Table 5]

Subframe	Number of OFDM symbols for PDCCH when $N^{DL}_{RB}>10$	Number of OFDM symbols for PDCCH when $N^{DL}_{RB}\leq 10$
Subframe 1 and 6 for frame structure type 2	1, 2	2
MBSFN subframes on a carrier supporting PDSCH, configured with 1 or 2 cell-specific antenna ports	1, 2	2
MBSFN subframes on a carrier supporting PDSCH, configured with 4 cell-specific antenna ports	2	2
Subframes on a carrier not supporting PDSCH	0	0
Non-MBSFN subframes (except subframe 6 for frame structure type 2) configured with positioning reference signals	1, 2, 3	2, 3
All other cases	1, 2, 3	2, 3, 4

[100] A subset of downlink subframes within a radio frame on a carrier for supporting PDSCH transmission may be configured as MBSFN subframe(s) by a higher layer. Each MBSFN subframe is divided into a non-MBSFN region and an MBSFN region. The non-MBSFN region spans first one or two OFDM symbols, and its length is given by Table 5. The same CP as cyclic prefix (CP) used for subframe 0 is used for transmission within the non-MBSFN region of the MBSFN subframe. The MBSFN region within the MBSFN subframe is defined as OFDM symbols which are not used in the non-MBSFN region.

[101] The PCFICH carries a control format indicator (CFI), which indicates any one of values of 1 to 3. For a downlink system bandwidth $N^{DL}_{RB}>10$, the number 1, 2 or 3 of OFDM symbols which are spans of DCI carried by the PDCCH is given by the CFI. For a downlink system bandwidth $N^{DL}_{RB}\leq 10$, the number 2, 3 or 4 of OFDM symbols which are spans of DCI carried by the PDCCH is given by CFI+1. The CFI is coded in accordance with the following Table.

[102] [Table 6]

CFI	CFI code word<b_0, b_1, ..., b_{31}>
1	<0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1>
2	<1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0>
3	<1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1>
4(Reserved)	<0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0>

[103] The PHICH carries a HARQ (Hybrid Automatic Repeat Request) ACK/NACK (acknowledgment/negative-acknowledgment) signal as a response to UL transmission. The PHICH includes three REGs, and is scrambled cell-specifically. ACK/NACK is indicated by 1 bit, and the ACK/NACK of 1 bit is repeated three times. Each of the repeated ACK/NACK bits is spread with a spreading factor (SF) 4 or 2 and then mapped into a control region.

[104] The control information transmitted through the PDCCH will be referred to as downlink control information (DCI). The DCI includes resource allocation information for a UE or UE group and other control information. Transmit format and resource allocation information of a downlink shared channel (DL-SCH) are referred to as DL scheduling information or DL grant. Transmit format and resource allocation information of an uplink shared channel (UL-SCH) are referred to as UL scheduling information or UL grant. The size and usage of the DCI carried by one PDCCH are varied depending on DCI formats. The size of the DCI may be varied depending on a coding rate. In the current 3GPP LTE system, various formats are defined, wherein formats 0 and 4 are defined for a UL, and formats 1, 1A, 1B, 1C, 1D, 2, 2A, 2B, 2C, 3 and 3A are defined for a DL. Combination selected from control information such as a hopping flag, RB allocation, modulation coding scheme (MCS), redundancy version (RV), new data indicator (NDI), transmit power control (TPC), cyclic shift, cyclic shift demodulation reference signal (DM RS), UL index, channel quality information (CQI) request, DL assignment index, HARQ process number, transmitted precoding matrix indicator (TPMI), precoding matrix indicator (PMI) information is transmitted to the UE as the DCI. The following table shows examples of DCI formats.

[105] [Table 7]

DCI format	Description
0	Resource grants for the PUSCH transmissions (uplink)
1	Resource assignments for single codeword PDSCH transmissions
1A	Compact signaling of resource assignments for single codeword PDSCH
1B	Compact signaling of resource assignments for single codeword PDSCH
1C	Very compact resource assignments for PDSCH (e.g. paging/broadcast system information)
1D	Compact resource assignments for PDSCH using multi-user MIMO
2	Resource assignments for PDSCH for closed-loop MIMO operation
2A	Resource assignments for PDSCH for open-loop MIMO operation
2B	Resource assignments for PDSCH using up to 2 antenna ports with UE-specific reference signals
2C	Resource assignment for PDSCH using up to 8 antenna ports with UE-specific reference signals
3/3A	Power control commands for PUCCH and PUSCH with 2-bit/1-bit power adjustments
4	Scheduling of PUSCH in one UL Component Carrier with multi-antenna port transmission mode

[106] Other DCI formats in addition to the DCI formats defined in Table 7 may be defined.

[107] A plurality of PDCCHs may be transmitted within a control region. A UE may monitor the plurality of PDCCHs. An eNB determines a DCI format depending on the DCI to be transmitted to the UE, and attaches cyclic redundancy check (CRC) to the DCI. The CRC is masked (or scrambled) with an identifier (for example, a radio network temporary identifier (RNTI)) depending on usage of the PDCCH or owner of the PDCCH. For example, if the PDCCH is for a specific UE, the CRC may be masked with an identifier (for example, cell-RNTI (C-RNTI)) of the corresponding UE. If the PDCCH is for a paging message, the CRC may be masked with a paging identifier (for example, paging-RNTI (P-RNTI)). If the PDCCH is for system information (in more detail, system information block (SIB)), the CRC may be masked with system information RNTI (SI-RNTI). If the PDCCH is for a random access response, the CRC may be masked with a random access RNTI (RA-RNTI). For example, CRC masking

(or scrambling) includes XOR operation of CRC and RNTI at the bit level.

[108] Generally, a DCI format, which may be transmitted to the UE, is varied depending on a transmission mode configured for the UE. In other words, certain DCI format(s) corresponding to the specific transmission mode not all DCI formats may only be used for the UE configured to a specific transmission mode.

[109] For example, a transmission mode is semi-statically configured for the UE by a higher layer so that the UE may receive a PDSCH transmitted in accordance with one of a plurality of transmission modes which are previously defined. The UE attempts to decode a PDCCH using DCI formats only corresponding to its transmission mode. In other words, in order to maintain UE operation load according to blind decoding attempt, at a certain level or less, all DCI formats are not searched by the UE at the same time. Table 8 illustrates transmission modes for configuring multi-antenna technology and DCI formats for allowing a UE to perform blind decoding at the corresponding transmission mode. Particularly, Table 8 illustrates a relation between PDCCH and PDSCH configured by C-RNTI (Cell RNTI(Radio Network Temporary Identifier)).

[110] [Table 8]

Transmission mode	DCI format	Search Space	Transmission scheme of PDSCH corresponding to PDCCH
Mode 1	DCI format 1A	Common andUE specific by C-RNTI	Single-antenna port, port 0
	DCI format 1	UE specific by C-RNTI	Single-antenna port, port 0
Mode 2	DCI format 1A	Common andUE specific by C-RNTI	Transmit diversity
	DCI format 1	UE specific by C-RNTI	Transmit diversity
Mode 3	DCI format 1A	Common andUE specific by C-RNTI	Transmit diversity
	DCI format 2A	UE specific by C-RNTI	Large delay CDD or Transmit diversity
Mode 4	DCI format 1A	Common andUE specific by C-RNTI	Transmit diversity
	DCI format 2	UE specific by C-RNTI	Closed-loop spatial multiplexing or Transmit diversity
Mode 5	DCI format 1A	Common andUE specific by C-RNTI	Transmit diversity
	DCI format 1D	UE specific by C-RNTI	Multi-user MIMO
Mode 6	DCI format 1A	Common andUE specific by C-RNTI	Transmit diversity
	DCI format 1B	UE specific by C-RNTI	Closed-loop spatial multiplexing using a single transmission layer
Mode 7	DCI format	Common andUE	If the number of PBCH antenna ports

	1A	specific by C-RNTI	is one, Single-antenna port, port 0 is used, otherwise Transmit diversity
	DCI format 1	UE specific by C-RNTI	Single-antenna port, port 5
Mode 8	DCI format 1A	Common andUE specific by C-RNTI	If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used, otherwise Transmit diversity
	DCI format 2B	UE specific by C-RNTI	Dual layer transmission, port 7 and 8 or single-antenna port, port 7 or 8
Mode 9	DCI format 1A	Common andUE specific by C-RNTI	Non-MBSFN subframe: If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used, otherwise Transmit diversity.MBSFN subframe: Single-antenna port, port 7
	DCI format 2C	UE specific by C-RNTI	Up to 8 layer transmission, ports 7-14 or single-antenna port, port 7 or 8
Mode 10	DCI format 1A	Common andUE specific by C-RNTI	Non-MBSFN subframe: If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used, otherwise Transmit diversity.MBSFN subframe: Single-antenna port, port 7
	DCI format 2D	UE specific by C-RNTI	Up to 8 layer transmission, ports 7-14 or single antenna port, port 7 or 8

[111] Although transmission modes 1 to 10 are listed in Table 8, other transmission modes in addition to the transmission modes defined in Table 8 may be defined.

[112] Referring to Table 8, a UE configured to a transmission mode 9, for example, tries to decode PDCCH candidates of a UE-specific search space (USS) to a DCI format 1A, and tries to decode PDCCH candidates of a common search space (CSS) and the USS to a DCI format 2C. The UE may decode a PDSCH in accordance with DCI based on the DCI format successfully decoded. If DCI decoding from one of a plurality of PDCCH candidates to the DCI format 1A is successfully performed, the UE may decode the PDSCH by assuming that up to 8 layers from antenna ports 7 to 14 are transmitted thereto through the PDSCH, or may decode the PDSCH by assuming that a single layer from the antenna port 7 or 8 is transmitted thereto through the PDSCH.

[113] The PDCCH is allocated to first m number of OFDM symbol(s) within a subframe.

In this case, m is an integer equal to or greater than 1, and is indicated by the PCFICH.

[114] The PDCCH is transmitted on an aggregation of one or a plurality of continuous control channel elements (CCEs). The CCE is a logic allocation unit used to provide a coding rate based on the status of a radio channel to the PDCCH. The CCE corresponds to a plurality of resource element groups (REGs). For example, one CCE corresponds to nine resource element groups (REGs), and one REG corresponds to four REs. Four QPSK symbols are mapped to each REG. A resource element (RE) occupied by the reference signal (RS) is not included in the REG. Accordingly, the number of REGs within given OFDM symbols is varied depending on the presence of the RS. The REGs are also used for other downlink control channels (that is, PCFICH and PHICH).

[115] Assuming that the number of REGs not allocated to the PCFICH or the PHICH is N_{REG}, the number of available CCEs in a DL subframe for PDCCH(s) in a system is numbered from 0 to N_{CCE}—1, where $N_{CCE} = \text{floor}(N_{REG}/9)$.

[116] A PDCCH format and the number of DCI bits are determined in accordance with the number of CCEs. The CCEs are numbered and consecutively used. To simplify the decoding process, a PDCCH having a format including n CCEs may be initiated only on CCEs assigned numbers corresponding to multiples of n. The number of CCEs used for transmission of a specific PDCCH is determined by a network or the eNB in accordance with channel status. For example, one CCE may be required for a PDCCH for a UE (for example, adjacent to eNB) having a good downlink channel. However, in case of a PDCCH for a UE (for example, located near the cell edge) having a poor channel, eight CCEs may be required to obtain sufficient robustness. Additionally, a power level of the PDCCH may be adjusted to correspond to a channel status.

[117] In a 3GPP LTE/LTE-A system, a set of CCEs on which a PDCCH can be located for each UE is defined. A CCE set in which the UE can detect a PDCCH thereof is referred to as a PDCCH search space or simply as a search space (SS). An individual resource on which the PDCCH can be transmitted in the SS is called a PDCCH candidate. A set of PDCCH candidates that the UE is to monitor is defined in terms of SSs, where a search space $S^{(L)}_k$ at aggregation level $L \in \{1,2,4,8\}$ is defined by a set of PDCCH candidates. SSs for respective PDCCH formats may have different sizes and a dedicated SS and a common SS are defined. The dedicated SS is a UE-specific SS (USS) and is configured for each individual UE. The common SS (CSS) is configured for a plurality of UEs.

[118] The following table shows an example of aggregation levels for defining SS.

[119] [Table 9]

Search space $S^{(L)}_k$			Number of PDCCH candidates $M^{(L)}$
Type	Aggregation level L	Size [in CCEs]	
UE-specific	1	6	6
	2	12	6
	4	8	2
	8	16	2
Common	4	16	4
	8	16	2

[120] For each serving cell on which PDCCH is monitored, the CCEs corresponding to PDCCH candidates m of the search space $S^{(L)}_k$ are configured by "$L*\{Y_k+m'\}$ mod floor($N_{CCE,k}/L$}+i", where i=0,...,L—1. For the common search space $m'=m$. For the PDCCH UE specific search space, for the serving cell on which PDCCH is monitored, if the monitorng UE is configured with carrier indicator field then $m'=m+M^{(L)}*n_{CI}$ where n_{CI} is the carrier indicator field (CIF) value, else if the monitoring UE is not configured with carrier indicator field then $m'=m$, where m=0,1,...,$M^{(L)}$—1. $M^{(L)}$ is the number of PDCCH candidates to monitor at aggregation level L in the given search space. The carrier indication field value can be the same as a serving cell index (*ServCellIndex*). For the common search space, Y_k is set to 0 for the two aggregation levels L=4 and L=8. For the UE-specific search space $S^{(L)}_k$ at aggregation level D, the variable Y_k is defined by "$Y_k = (A\cdot Y_{k-1})$ mod D", where $Y_{-1}=n_{RNTI}\neq 0$, A=39827, D=65537 and k =floor($n_s/2$). n_s is the slot number within a radio frame.

[121] The eNB transmits an actual PDCCH (DCI) on a PDCCH candidate in a search space and the UE monitors the search space to detect the PDCCH (DCI). Here, monitoring implies attempting to decode each PDCCH in the corresponding SS according to all monitored DCI formats. The UE may detect a PDCCH thereof by monitoring a plurality of PDCCHs. Basically, the UE does not know the location at which a PDCCH thereof is transmitted. Therefore, the UE attempts to decode all PDCCHs of the corresponding DCI format for each subframe until a PDCCH having an ID thereof is detected and this process is referred to as blind detection (or blind decoding (BD)).

[122] For example, it is assumed that a specific PDCCH is CRC-masked with a radio network temporary identity (RNTI) 'A' and information about data transmitted using a radio resource 'B' (e.g. frequency location) and using transport format information 'C' (e.g. transmission block size, modulation scheme, coding information, etc.) is transmitted in a specific DL subframe. Then, the UE monitors the PDCCH using RNTI

information thereof. The UE having the RNTI 'A' receives the PDCCH and receives the PDSCH indicated by 'B' and 'C' through information of the received PDCCH.

[123] FIG. 5 illustrates the structure of a UL subframe used in a wireless communication system.

[124] Referring to FIG. 5, a UL subframe may be divided into a data region and a control region in the frequency domain. One or several PUCCHs may be allocated to the control region to deliver UCI. One or several PUSCHs may be allocated to the data region of the UE subframe to carry user data.

[125] In the UL subframe, subcarriers distant from a direct current (DC) subcarrier are used as the control region. In other words, subcarriers located at both ends of a UL transmission BW are allocated to transmit UCI. A DC subcarrier is a component unused for signal transmission and is mapped to a carrier frequency f_0 in a frequency up-conversion process. A PUCCH for one UE is allocated to an RB pair belonging to resources operating on one carrier frequency and RBs belonging to the RB pair occupy different subcarriers in two slots. The PUCCH allocated in this way is expressed by frequency hopping of the RB pair allocated to the PUCCH over a slot boundary. If frequency hopping is not applied, the RB pair occupies the same subcarriers.

[126] The PUCCH may be used to transmit the following control information.

[127] - Scheduling request (SR): SR is information used to request a UL-SCH resource and is transmitted using an on-off keying (OOK) scheme.

[128] - HARQ-ACK: HARQ-ACK is a response to a PDCCH and/or a response to a DL data packet (e.g. a codeword) on a PDSCH. HARQ-ACK indicates whether the PDCCH or PDSCH has been successfully received. 1-bit HARQ-ACK is transmitted in response to a single DL codeword and 2-bit HARQ-ACK is transmitted in response to two DL codewords. A HARQ-ACK response includes a positive ACK (simply, ACK), negative ACK (NACK), discontinuous transmission (DTX), or NACK/DRX. HARQ-ACK is used interchangeably with HARQ ACK/NACK and ACK/NACK.

[129] - Channel state information (CSI): CSI is feedback information for a DL channel. CSI may include channel quality information (CQI), a precoding matrix indicator (PMI), a precoding type indicator, and/or a rank indicator (RI). In the CSI, MIMO-related feedback information includes the RI and the PMI. The RI indicates the number of streams or the number of layers that the UE can receive through the same time-frequency resource. The PMI is a value reflecting a space characteristic of a channel, indicating an index of a preferred precoding matrix for DL signal transmission based on a metric such as an SINR. The CQI is a value of channel strength, indicating a received SINR that can be obtained by the UE generally when the eNB uses the PMI.

[130] A general wireless communication system performs data transmission/reception through one downlink (DL) band and through one uplink (UL) band corresponding to

the DL band (in case of a frequency division duplex (FDD) mode), or divides a prescribed radio frame into a UL time unit and a DL time unit in the time domain and then performs data transmission/reception through the UL/DL time unit (in case of a time division duplex (TDD) mode). Recently, to use a wider frequency band in recent wireless communication systems, introduction of carrier aggregation (or BW aggregation) technology that uses a wider UL/DL BW by aggregating a plurality of UL/DL frequency blocks has been discussed. A carrier aggregation (CA) is different from an orthogonal frequency division multiplexing (OFDM) system in that DL or UL communication is performed using a plurality of carrier frequencies, whereas the OFDM system carries a base frequency band divided into a plurality of orthogonal subcarriers on a single carrier frequency to perform DL or UL communication. Hereinbelow, each of carriers aggregated by carrier aggregation will be referred to as a component carrier (CC).

[131] For example, three 20MHz CCs may be aggregated on each of a UL and a DL to support a bandwidth of 60MHz. The respective CCs may be contiguous or non-contiguous in the frequency domain. For convenience, although it has been described that the bandwidth of UL CC and the bandwidth of DL CC are the same as each other and symmetric to each other, the bandwidth of each CC may be independently determined. Asymmetrical carrier aggregation in which the number of UL CCs is different from the number of DL CCs may be implemented. DL/UL CC limited to a specific UE may be referred to as a serving UL/DL CC configured for the specific UE.

[132] Meanwhile, the 3GPP LTE-A standard uses the concept of a cell to manage radio resources. The "cell" associated with the radio resources is defined by combination of downlink resources and uplink resources, that is, combination of DL CC and UL CC. The cell may be configured by downlink resources only, or may be configured by downlink resources and uplink resources. If carrier aggregation is supported, linkage between a carrier frequency of the downlink resources (or DL CC) and a carrier frequency of the uplink resources (or UL CC) may be indicated by system information. For example, combination of the DL resources and the UL resources may be indicated by linkage of system information block type 2 (SIB2). In this case, the carrier frequency means a center frequency of each cell or CC. A cell operating on a primary frequency may be referred to as a primary cell (Pcell) or PCC, and a cell operating on a secondary frequency may be referred to as a secondary cell (Scell) or SCC. The carrier corresponding to the Pcell on downlink will be referred to as a downlink primary CC (DL PCC), and the carrier corresponding to the Pcell on uplink will be referred to as an uplink primary CC (UL PCC). A Scell means a cell that may be configured after completion of radio resource control (RRC) connection establishment and used to provide additional radio resources. The Scell may form a set of serving cells for the UE

together with the Pcell in accordance with capabilities of the UE. The carrier corresponding to the Scell on the downlink will be referred to as downlink secondary CC (DL SCC), and the carrier corresponding to the Scell on the uplink will be referred to as uplink secondary CC (UL SCC). Although the UE is in RRC-CONNECTED state, if it is not configured by carrier aggregation or does not support carrier aggregation, a single serving cell configured by the Pcell only exists.

[133] The eNB may activate all or some of the serving cells configured in the UE or deactivate some of the serving cells for communication with the UE. The eNB may change the activated/deactivated cell, and may change the number of cells which is/are activated or deactivated. If the eNB allocates available cells to the UE cell-specifically or UE-specifically, at least one of the allocated cells is not deactivated unless cell allocation to the UE is fully reconfigured or unless the UE performs handover. Such a cell which is not deactivated unless CC allocation to the UE is fully reconfigured will be referred to as Pcell, and a cell which may be activated/deactivated freely by the eNB will be referred to as Scell. The Pcell and the Scell may be discriminated from each other on the basis of the control information. For example, specific control information may be set to be transmitted and received through a specific cell only. This specific cell may be referred to as the Pcell, and the other cell(s) may be referred to as Scell(s).

[134] A configured cell refers to a cell in which carrier aggregation is performed for a UE based on measurement report from another eNB or UE among cells of an eNB and is configured per UE. The cell configured for the UE may be a serving cell in terms of the UE. For the cell configured for the UE, i.e. the serving cell, resources for ACK/NACK transmission for PDSCH transmission are reserved in advance. An activated cell refers to a cell configured to be actually used for PDSCH/PUSCH transmission among cells configured for the UE and CSI reporting and SRS transmission for PDSCH/PUSCH transmission are performed in the activated cell. A deactivated cell refers to a cell configured not to be used for PDSCH/PUSCH transmission by the command of an eNB or the operation of a timer and, if a cell is deactivated, CSI reporting and SRS transmission are also stopped in the cell.

[135] For reference, a carrier indicator (CI) denotes a serving cell index (*ServCellIndex*), CI=0 is applied to Pcell. The serving cell index is a short ID used to identify a serving cell. For example, any one of integers from 0 to 'maximum number of carrier frequencies which can be configured for the UE at a time - 1' may be allocated to one serving cell as the serving cell index. That is, the serving cell index may be a logical index used to identify a specific serving cell among cells allocated to the UE rather than a physical index used to identify a specific carrier frequency among all carrier frequencies.

[136] Meanwhile, the 3GPP LTE-A standard uses the concept of a cell to manage radio

resources.

[137] The cell mentioned in the present invention means a cell of carrier aggregation which is combination of UL CC and DL CC unless specifically noted.

[138] Meanwhile, since one serving cell is only present in case of communication based on a single carrier, a PDCCH carrying UL/DL grant and corresponding PUSCH/PDSCH are transmitted on one cell. In other words, in case of FDD under a single carrier environment, a PDCCH for a DL grant for a PDSCH, which will be transmitted on a specific DL CC, is transmitted on the specific CC, and a PDCCH for a UL grant for a PUSCH, which will be transmitted on a specific UL CC, is transmitted on a DL CC linked to the specific UL CC. In case of TDD under a single carrier environment, a PDCCH for a DL grant for a PDSCH, which will be transmitted on a specific DL CC, is transmitted on the specific CC, and a PDCCH for a UL grant for a PUSCH, which will be transmitted on a specific UL CC, is transmitted on the specific CC.

[139] On the contrary, since a plurality of serving cells may be configured in a multi-carrier system, transmission of UL/DL grant through a serving cell having a good channel status may be allowed. In this way, if a cell carrying UL/DL grant which is scheduling information is different from a cell where UL/DL transmission corresponding to the UL/DL grant is performed, this will be referred to as cross-carrier scheduling.

[140] Hereinafter, the case where the cell is scheduled from itself and the case where the cell is scheduled from another cell will be referred to as self-CC scheduling and cross-CC scheduling, respectively.

[141] For data transmission rate enhancement and stable control signaling, the 3GPP LTE/LTE-A may support aggregation of a plurality of CCs and a cross carrier-scheduling operation based on the aggregation.

[142] If cross-carrier scheduling (or cross-CC scheduling) is applied, a PDCCH for downlink allocation for a DL CC B or DL CC C, that is, carrying a DL grant may be transmitted through a DL CC A, and a corresponding PDSCH may be transmitted through the DL CC B or DL CC C. For cross-CC scheduling, a carrier indicator field (CIF) may be introduced. The presence or absence of the CIF within the PDCCH may be semi-statically and UE-specifically (or UE-group-specifically) configured by higher layer signaling (e.g., RRC signaling).

[143] Meanwhile, if RRH technology, cross-carrier scheduling technology, etc. are introduced, the amount of PDCCH which should be transmitted by the eNB is gradually increased. However, since a size of a control region within which the PDCCH may be transmitted is the same as before, PDCCH transmission acts as a bottleneck of system throughput. Although channel quality may be improved by the introduction of the aforementioned multi-node system, application of various communication schemes, etc., the introduction of a new control channel is required to apply the legacy commu-

nication scheme and the carrier aggregation technology to a multi-node environment. Due to the need, a configuration of a new control channel in a data region (hereinafter, referred to as PDSCH region) not the legacy control region (hereinafter, referred to as PDCCH region) has been discussed. Hereinafter, the new control channel will be referred to as an enhanced PDCCH (hereinafter, referred to as EPDCCH).

[144] The EPDCCH may be configured within rear OFDM symbols starting from a configured OFDM symbol, instead of front OFDM symbols of a subframe. The EPDCCH may be configured using continuous frequency resources, or may be configured using discontinuous frequency resources for frequency diversity. By using the EPDCCH, control information per node may be transmitted to a UE, and a problem that a legacy PDCCH region may not be sufficient may be solved. For reference, the PDCCH may be transmitted through the same antenna port(s) as that(those) configured for transmission of a CRS, and a UE configured to decode the PDCCH may demodulate or decode the PDCCH by using the CRS. Unlike the PDCCH transmitted based on the CRS, the EPDCCH is transmitted based on the demodulation RS (hereinafter, DMRS). Accordingly, the UE decodes/demodulates the PDCCH based on the CRS and decodes/demodulates the EPDCCH based on the DMRS. The DMRS associated with EPDCCH is transmitted on the same antenna port $p \in \{107,108,109,110\}$ as the associated EPDCCH physical resource, is present for EPDCCH demodulation only if the EPDCCH transmission is associated with the corresponding antenna port, and is transmitted only on the PRB(s) upon which the corresponding EPDCCH is mapped. For example, the REs occupied by the UE-RS(s) of the antenna port 7 or 8 may be occupied by the DMRS(s) of the antenna port 107 or 108 on the PRB to which the EPDCCH is mapped, and the REs occupied by the UE-RS(s) of antenna port 9 or 10 may be occupied by the DMRS(s) of the antenna port 109 or 110 on the PRB to which the EPDCCH is mapped. In other words, a certain number of REs are used on each RB pair for transmission of the DMRS for demodulation of the EPDCCH regardless of the UE or cell if the type of EPDCCH and the number of layers are the same as in the case of the UE-RS for demodulation of the PDSCH.

[145] For each serving cell, higher layer signalling can configure a UE with one or two EPDCCH-PRB-sets for EPDCCH monitoring. The PRB-pairs corresponding to an EPDCCH-PRB-set are indicated by higher layers. Each EPDCCH-PRB-set consists of set of ECCEs numbered from 0 to $N_{ECCE,p,k}-1$, where $N_{ECCE,p,k}$ is the number of ECCEs in EPDCCH-PRB-set p of subframe k. Each EPDCCH-PRB-set can be configured for either localized EPDCCH transmission or distributed EPDCCH transmission.

[146] The UE shall monitor a set of EPDCCH candidates on one or more activated serving cells as configured by higher layer signaling for control information.

[147] The set of EPDCCH candidates to monitor are defined in terms of EPDCCH UE-

specific search spaces. For each serving cell, the subframes in which the UE monitors EPDCCH UE-specific search spaces are configured by higher layers.

[148] An EPDCCH UE-specific search space $ES^{(L)}_k$ at aggregation level $L\in\{1,2,4,8,16,32\}$ is defined by a set of EPDCCH candidates.

[149] For an EPDCCH-PRB-set p, the ECCEs corresponding to EPDCCH candidate m of the search space $ES^{(L)}_k$ are given by the following equation.

[150] [Math.1]

$$L\left\{(Y_{p,k}+\left\lfloor\frac{m\cdot N_{ECCE,p,k}}{L\cdot M_p^{(L)}}\right\rfloor+b)\bmod\left\lfloor N_{\mathrm{ECCE},p,k}/L\right\rfloor\right\}+i$$

[151] where $i=0,\ldots,L-1$. $b=n_{CI}$ if the UE is configured with a carrier indicator field for the serving cell on which EPDCCH is monitored, otherwise $b=0$. n_{CI} is the carrier indicator field (CIF) value, which is the same as a serving cell index (*ServCellIndex*). $m=0,1,\ldots,M^{(L)}_p-1$. $M^{(L)}_p$ is the number of EPDCCH candidates to monitor at aggregation level L in EPDDCH-PRB-set p. The variable $Y_{p,k}$ is defined by '$Y_{p,k}=(A_p\cdot Y_{p,k-1})\bmod D$', where $Y_{p,-1}=n_{RNTI}\neq 0$, $A_0=39827$, $A_1=39829$, $D=65537$ and $k=\mathrm{floor}(n_s/2)$. n_s is the slot number within a radio frame.

[152] A UE is not expected to monitor an EPDCCH candidate, if an ECCE corresponding to that EPDCCH candidate is mapped to a PRB pair that overlaps in frequency with a transmission of either PBCH or PSS/SSS in the same subframe.

[153] An EPDCCH is transmitted using an aggregation of one or several consecutive enhanced control channel elements (ECCEs). Each ECCE consists of multiple enhanced resource element groups (EREGs). EEREGs are used for defining the mapping of enhanced control channels to resource elements. There are 16 EREGs, numbered from 0 to 15, per physical resource block (PRB) pair. Number all resource elements (REs), except resource elements carrying DMRS (hereinafter EPDCCH DMRS) for demoduation of the EPDCCH, in a physical resource-block pair cyclically from 0 to 15 in an increasing order of first frequency, then time. Therefore all the REs, except REs carrying the EPDCCH DMRS, in the PRB pair has any one of numbers 0 to 15. All REs with number i in that PRB pair constitutes EREG number i.As described above, it is noted that EREGs are distributed on frequency and time axes within the PRB pair and an EPDCCH transmitted using aggregation of one or more ECCEs, each of which includes a plurality of EREGs, is also distributed on frequency and time axes within the PRB pair.

[154] The number of ECCEs used for one EPDCCH depends on the EPDCCH format as given by Table 10, the number of EREGs per ECCE is given by Table 11. Table 10 shows an example of supported EPDCCH formats, and Table 11 shows an example of

the number of EREGs per ECCE, N^{EREG}_{ECCE}. Both localized and distributed transmission is supported.

[155] [Table 10]

EPDCCH format	Number of ECCEs for one EPDCCH, N^{ECCE}_{EPDCCH}			
	Case A		Case B	
	Localized transmission	Distributed transmission	Localized transmission	Distributed transmission
0	2	2	1	1
1	4	4	2	2
2	8	8	4	4
3	16	16	8	8
4	-	32	-	16

[156] [Table 11]

Normal cyclic prefix			Extended cyclic prefix	
Normal subframe	Special subframe,configuration3, 4, 8	Special subframe,configuration1, 2, 6, 7, 9	Normal subframe	Special subframe,configuration1, 2, 3, 5, 6
4		8		

[157] An EPDCCH can use either localized or distributed transmission, differing in the mapping of ECCEs to EREGs and PRB pairs. One or two sets of PRB pairs which a UE shall monitor for EPDCCH transmissions can be configured. All EPDCCH candidates in EPDCCH set S_p (i.e., EPDCCH-PRB-set) use either only localized or only distributed transmission as configured by higher layers. Within EPDCCH set S_p in subframe k, the ECCEs available for transmission of EPDCCHs are numbered from 0 to $N_{ECCE,p,k}-1$. ECCE number n is corresponding to the following EREG(s):

[158] - EREGs numbered $(n \bmod N^{ECCE}_{RB})+jN^{ECCE}_{RB}$ in PRB index $\text{floor}(n/N^{ECCE}_{RB})$ for localized mapping, and

[159] - EREGs numbered $\text{floor}\ (n/N^{Sp}_{RB})+jN^{ECCE}_{RB}$ in PRB indices $(n+j\max(1,N^{Sp}_{RB}/N^{EREG}_{ECCE}))\bmod N^{Sp}_{RB}$ for distributed mapping.

[160] where $j=0,1,\ldots,N^{EREG}_{ECCE}-1$, N^{EREG}_{ECCE} is the number of EREGs per ECCE, and $N^{ECCE}_{RB}=16/N^{EREG}_{ECCE}$ is the number of ECCEs per RB pair. The PRB pairs constituting EPDCCH set S_p are assumed to be numbered in ascending order from 0 to $N^{Sp}_{RB}-1$.

[161] Case A in Table 10 applies when:

[162] - DCI formats 2, 2A, 2B, 2C or 2D is used and $N^{DL}_{RB}\geq 25$, or

[163] - any DCI format when n_{EPDCCH}<104 and normal cyclic prefix is used in normal subframes or special subframes with configuration 3, 4, 8.

[164] Otherwise case B is used. The quantity n_{EPDCCH} for a particular UE is defined as the number of downlink resource elements (k,l) in a PRB pair configured for possible EPDCCH transmission of EPDCCH set S_0 and and fulfilling all of the following criteria,

[165] - they are part of any one of the 16 EREGs in the physical resource-block pair,

[166] - they are assumed by the UE not to be used for CRSs or CSI-RSs,

[167] - the index l in a subframe fulfils $l \geq l_{EPDCCHStart}$.

[168] where $l_{EPDCCHStart}$ is given based on higher layer signaling '*epdcch*-StartSymbol-r11', higher layer signaling '*pdsch*-Start-r11', or CFI value carried by PCFICH.

[169] The mapping to resource elements (k,l) on antenna port p meeting the criteria above is in increasing order of first the index k and then the index l, starting with the first slot and ending with the second slot in a subframe.

[170] For localized transmission, the single antenna port p to use is given by Table 12 with $n' = n_{ECCE,low} \bmod N^{ECCE}_{RB} + n_{RNTI} \bmod \min(N^{ECCE}_{EPDCCH}, N^{ECCE}_{RB})$, where $n_{ECCE,low}$ is the lowest ECCE index used by this EPDCCH transmission in the EPDCCH set, n_{RNTI} corresponds to the RNTI associated with the EPDCCH transmission, and N^{ECCE}_{EPDCCH} is the number of ECCEs used for this EPDCCH.

[171] [Table 12]

n'	Normal cyclic prefix		Extended cyclic prefix
	Normal subframes,Special subframes,configurations3, 4, 8	Special subframes, configurations1, 2, 6, 7, 9	Any subframe
0	107	107	107
1	108	109	108
2	109	-	-
3	110	-	-

[172] For distributed transmission, each resource element in an EREG is associated with one out of two antenna ports in an alternating manner where $p \in \{107,109\}$ for normal cyclic prefix and $p \in \{107,108\}$ for extended cyclic prefix.

[173] Recently, machine type communication (MTC) has come to the fore as a significant communication standard issue. MTC refers to exchange of information between a machine and an eNB without involving persons or with minimal human intervention. For example, MTC may be used for data communication for measurement/

sensing/reporting such as meter reading, water level measurement, use of a surveillance camera, inventory reporting of a vending machine, etc. and may also be used for automatic application or firmware update processes for a plurality of UEs. In MTC, the amount of transmission data is small and UL/DL data transmission or reception (hereinafter, transmission/reception) occurs occasionally. In consideration of such properties of MTC, it would be better in terms of efficiency to reduce production cost and battery consumption of UEs for MTC (hereinafter, MTC UEs) according to data transmission rate. Since the MTC UE has low mobility, the channel environment thereof remains substantially the same. If an MTC UE is used for metering, reading of a meter, surveillance, and the like, the MTC UE is very likely to be located in a place such as a basement, a warehouse, and mountain regions which the coverage of a typical eNB does not reach. In consideration of the purposes of the MTC UE, it is better for a signal for the MTC UE to have wider coverage than the signal for the conventional UE (hereinafter, a legacy UE).

[174] When considering the usage of the MTC UE, there is a high probability that the MTC UE requires a signal of wide coverage compared with the legacy UE. Therefore, if the eNB transmits a PDCCH, a PDSCH, etc. to the MTC UE using the same scheme as a scheme of transmitting the PDCCH, the PDSCH, etc. to the legacy UE, the MTC UE has difficulty in receiving the PDCCH, the PDSCH, etc. Therefore, the present invention proposes that the eNB apply a coverage enhancement scheme such as subframe repetition (repetition of a subframe with a signal) or subframe bundling upon transmission of a signal to the MTC UE having a coverage issue so that the MTC UE can effectively receive a signal transmitted by the eNB. For example, the PDCCH and PDSCH may be transmitted to the MTC UE having the coverage issue in a plurality of subframes (e.g. about 100 subframes).

[175] FIG. 6 illustrates an example of signals band for MTC.

[176] As one method for reducing the cost of the MTC UE, an operation of the MTC UE may be performed at a reduced UE downlink and uplink bandwidth of 1.4 MHz, for example, regardless of an operating system bandwidth of a cell. At this time, a subband (narrowband) for operating the MTC UE may always be located at the center (e.g., 6 center PRBs) of a cell as shown in FIG. 6(a), or several subbands for MTC may be provided for one subframe to multiplex MTC UEs as shown in FIG. 6(b), whereby the UEs may use their respective subbands different from each other or the UEs use the same subband not the subband of 6 center PRBs.

[177] In this case, the MTC UE cannot receive a legacy PDCCH transmitted through a full system band normally, and transmission of PDCCH for the MTC UE from an OFDM symbol region within which the legacy PDCCH is transmitted may not be preferable due to multiplexing issue with a PDCCH transmitted to another UE. As one method for

solving this, it is required to introduce a control channel transmitted within a subband where MTC is operated for the MTC UE. As a downlink control channel for such a low-complexity MTC UE, the legacy EPDCCH may be used as it is. Or, M-PDCCH for the MTC UE which is a control channel of a modified type of the legacy PDCCH/ EPDCCH may be introduced. Hereinafter, in the present invention, the legacy EPDCCH or M-PDCCH for the low-complexity MTC UE or normal complexity MTC UE will be referred to as M-PDCCH. Also, MTC-EPDCCH is hereinafter used to refer to M-PDCCH.

[178] A data channel (e.g., PDSCH, PUSCH) and/or a control channel (e.g., M-PDCCH, PUCCH, PHICH) may be transmitted for coverage enhancement (CE) of the UE by using a repetition or TTI bundling scheme through multiple subframes. The control/ data channel may be transmitted by additionally using cross-subframe channel estimation and frequency (narrowband) hopping for CE. In this case, cross-subframe channel estimation means a channel estimation method means channel estimation using a reference signal within a subframe of a corresponding channel and a reference signal within neighboring subframe(s).

[179] The MTC UE may need CE of 15dB, for example. However, all MTC UEs do not exist in an environment that CE is needed. Also, the same requirements of QoS are not applied to all MTC UEs. For example, since devices such as sensor and meter have low mobility and are likely to be located in a shaded area even while having a small amount of data transmission and reception, the devices may need high CE. However, wearable devices such as smart watch may have mobility and are likely to be located in a place not a shaded area while having a relatively large amount of data transmission and reception. Therefore, all MTC UEs do not need CE of high level, and their requirement capability may be varied depending on their type.

[180] In the present invention, an operation for monitoring M-PDCCH by means of an MTC UE (which needs coverage enhancement (CE)) will be suggested. Hereinafter, M-PDCCH monitoring, search space monitoring, or M-PDCCH candidates monitoring may mean that reception or detection of M-PDCCH is attempted within a corresponding search space or from one of M-PDCCH candidates configuring the corresponding search space.

[181] In the following embodiments, the expression "assume" may mean that an entity for transmitting a channel transmits the channel to be suitable for the corresponding "assumption". An entity for receiving the channel may receive or decode the channel to be suitable for the corresponding "assumption" provided that the channel has been transmitted to be suitable for the corresponding "assumption".

[182] FIG. 7 illustrates repeated transmission of a channel for coverage enhancement.

[183] A search space for M-PDCCH may be configured over a plurality of downlink

subframes. For example, M-PDCCH search space having an aggregation level L and a repetition level R is defined by a set of M-PDCCH candidates. In this case, each M-PDCCH candidate may be repeated within a set of R number of consecutive downlink subframes. Referring to FIG. 7, in an example of maximum repetitions R_{max}=8 and a possible repetition level of $R \in \{1, 2, 4, 0\}$, a UE may attempt decoding of M-PDCCH by assuming that repetition of M-PDCCH (transmitted at an aggregation level L) exists in each of R number of consecutive downlink subframes. For example, the UE may attempt decoding of M-PDCCH by regarding signals received from each of 8 subframes as those of the same M-PDCCH in case of a repetition level $R = 8$ and attempt decoding of different M-PDCCHs in each of 8 subframes in case of a repetition level $R = 1$.

[184] In FIG. 7, repetition of a channel is performed over consecutive downlink subframes. However, a data channel and/or a control channel (hereinafter, data/control channel) transmitted to/from the MTC UE which needs CE may be transmitted by being repeated through non-consecutive subframes. For example, the control/data channel for a specific MTC UE may not be in all downlink subframes but may be restricted to some downlink subframes. Non-consecutive downlink subframes available at the MTC UE may be configured in such a manner that a downlink subframe group comprised of one or more consecutive downlink subframes is repeated with a periodicity greater than the number of subframes within the downlink subframe group. In other words, the data/control channel may be transmitted not in physically consecutive subframes, but transmitted in transmitted in each of physically non-consecutive subframes (excluding uplink subframes in case of downlink transmission, downlink subframes in case of uplink transmission, and/or subframes except subframe used for other purpose of use and cannot be used for data/control channel transmission). Use of non-consecutive (downlink or uplink) subframes for repeated transmission of the data/control channel of the MTC UE may increase transmission/reception latency. However, as time diversity effect is obtained in the time domain by use of non-consecutive subframes, the number of repetitions or the number of subframes used for channel transmission may be reduced as compared with transmission based on consecutive subframes. Therefore, overall system throughput may be increased. The embodiments of the present invention, which will be described later, suggest UE operation and transmission subframe during transmission/reception of a corresponding channel when a data/control channel transmitted from MTC UE is transmitted with repetition through consecutive subframes or non-consecutive subframes.

[185] In the following embodiments, each search space within an interval where a UE monitors M-PDCCH (CSS and/or USS) may be configured over one or more (consecutive or non-consecutive) downlink subframes. That is, a search space for

reception of the same M-PDCCH may be configured in each of one or more downlink subframes.

[186] For example, referring to FIG. 8, in case of no CE or CE having a repetition level = 1, each of CSSs of FIG. 8 may be CSS on which a respective M-PDCCH can be transmitted. At this time, a CSS starting subframe may mean a first subframe of paging occasions for allowing a UE to monitor M-PDCCH for a paging message. As another example, referring to FIG. 9, in case of no CE or CE having a repetition level = 1, each of CSSs of FIG. 9 may be CSS on which a respective M-PDCCH can be transmitted. At this time, a CSS starting subframe may mean a first subframe of a RAR window for allowing a UE to monitor M-PDCCH for scheduling RAR.

[187] In case of coverage enhancement (CE), M-PDCCH may be transmitted by being repeated once or multiple times. Therefore, a search space where M-PDCCH (hereinafter, paging M-PDCCH) will be monitored may be configured repeatedly over a plurality of downlink subframes, and a UE may attempt repeated reception of M-PDCCH within search spaces within the plurality of downlink subframes. If CE having a repetition level greater than 1 is applied, for example, each CSS shown in FIG. 8 may be a plurality of consecutive subframes that may have repetitions of M-PDCCH. If CE having a repetition level greater than 1 is applied, as another example, a plurality of CSSs within the same paging occasion shown in FIG. 8 may be CSSs for repetitions of the same M-PDCCH. If CE having a repetition level greater than 1 is applied, as still another example, a plurality of CSSs over a plurality of paging occasions shown in FIG. 8 may be CSSs for repetitions of the same M-PDCCH.

[188] ■ Section 1. M-PDCCH CSS for paging message scheduling

[189] In Section 1, details on M-PDCCH CSS for paging message scheduling are discussed.

[190] The paging message is used to notify UE(s) under RRC_IDLE and UE(s) under RRC_CONNECTED of system information modification.

[191] An eNB initiates a paging process by transmitting the paging message at a paging occasion of a UE. The eNB may address a plurality of UEs within the paging message by including a paging record (*PagingRecord*) per UE. The paging record may include information indicating NAS (non-access stratum) identifier of a UE which is paged and information indicating the origin of paging. One paging occasion means a subframe having P-RNTI transmitted on PDCCH/M-PDCCH addressing the paging message. A paging frame (PF) means one radio frame that includes one or a plurality of paging occasion(s).

[192] The UE may use discontinuous reception (DRX) in an idle mode to reduce power consumption. If DRX is used, the UE monitors only one paging occasion per DRX cycle.

[193] The paging message may be transmitted through a PDSCH, and the PDSCH carrying the paging message may be scheduled by PDCCH/M-PDCCH.

[194] For paging message scheduling, multiple narrowbands can be configured by eNB. Then, a narrowband location for a paging occasion monitoring of a UE is determined by at least UE ID at least for paging record(s). However, the narrowband location and paging occasion for common signal transmission (e.g., SI update, earthquake and tsunami warning system (ETWS), and/or commercial mobile alert system (CMAS)) is not determined yet. To reduce UE complexity, it would be beneficial to apply the same paging occasion and narrowband location for paging record(s) reception and other information reception such as SI update, ETWS, and CMAS. For example, the UE may attempt reception of M-PDCCH for scheduling the paging message on the same narrowband at the same paging occasion for SI update and reception of ETWS and CMAS instead of monitoring different paging occasions and/or different narrowbands for SI update and reception of ETWS and CMAS.

[195] FIG. 8 illustrates a configuration of a common search space (CSS) for paging according to the present invention.

[196] Under the assumption that a paging occasion is a time region for M-PDCCH monitoring for paging message scheduling, a UE can monitor a common search space (CSS) within a paging occasion to check paging message transmission. Depending on duration of paging occasion and period of CSS starting subframe, there can be multiple CSS monitoring opportunities within a paging occasion as shown in FIG. 8. The period and offset of CSS starting subframe location can be configured by eNB. In this case, offset k_{offset} of the CSS starting subframe may mean a difference from a reference subframe n (e.g., subframe 0) to a subframe $n+k_{offset}$ in which the CSS starting subframe is first applied.

[197] The composition of decoding candidates (i.e. M-PDCCH candidates) and a subset of $\{L, R\}$ for CSS for paging should be composed to supports all UEs with different CE levels. In this case, L indicates an aggregation level, and M-PDCCH of the aggregation level L is transmitted using aggregation of L number of M-CCEs. ECCE may be used as M-CCE, and CCE for MTC UE may newly be defined as M-CCE for MTC UE.

[198] To transmit paging message adapt to the target CE level, a subset of $\{L, R\}$ of CSS for paging needs to be composed to cover all range of CE levels or all range of repetition numbers. One simple configuration is $\{8, R1\}$, $\{16, R1\}$, $\{24, R1\}$, $\{24, R2\}$, $\{24, R3\}$, $\{24, R4\}$ where $R1 = 1$ and $R4$ is the maximum repetition level.

[199] In the present invention, a paging occasion may be defined as an interval where a UE monitors a paging M-PDCCH. For example, the UE may attempt reception of (same) paging M-PDCCH (or M-PDCCH scrambled by P-RNTI) within CSS(s) existing in the paging occasion or paging M-PDCCH search space(s) as shown in FIG. 8. Since the

paging M-PDCCH may be transmitted in any one of CSS(s) within the paging occasion, the UE continuously monitors the CSS(s) within the paging occasion. If the paging M-PDCCH (or M-PDCCH scrambled by P-RNTI) is received within the corresponding interval, the UE may receive a PDSCH carrying the corresponding paging message even though a paging message scheduled by the corresponding M-PDCCH, that is, a PDSCH carrying paging is transmitted outside a paging occasion interval.

[200] A duration of the paging occasion may be configured to be a multiple of the number of subframes configuring CSSs or search spaces on which the paging M-PDCCH is transmitted. For example, if the paging M-PDCCH search space is configured in each of R number of (consecutive or non-consecutive) downlink subframes, the paging occasion may be configured to have a duration of R*X number of subframes (where X is a positive integer).

[201] ■ Section 2. M-PDCCH CSS for RAR scheduling

[202] FIG. 9 illustrates a configuration of a common search space (CSS) for RAR according to the present invention.

[203] There would be multiple narrowbands for CSS for RAR scheduling, and the narrowband location of a UE for RAR monitoring is determined by PRACH resource set.

[204] After transmitting PRACH, a UE would try to receive RAR. Similar to paging occasion, there can be multiple CSS regions within a RAR window as depicted in Figure 9. So, the UE can monitor M-PDCCH scheduling RAR in CSS region(s) within the RAR window.

[205] A subset of $\{L, R\}$ and composition of decoding candidates of CSS for RAR can depend on CE level of corresponding PRACH resource set. For example, for each CE level, PRACH resource set(s) and available repetition level(s) may be configured. In this case, the UE may monitor a CSS, that is, M-PDCCH in accordance with a set of $\{L, R\}$ configured for a CE level associated with a PRACH resource used for a successful RACH procedure. Regardless of CSS and USS, same composition of decoding candidates and same subset of $\{L, R\}$ can be used for same CE level of the search space. For example, the UE may monitor a CSS and a USS in accordance with $\{L, R\}$ of the same set with respect to the same CE level.

[206] The present invention suggests that a RAR window interval should be defined as an interval where a UE monitor M-PDCCH (hereinafter, RAR M-PDCCH) for scheduling RAR. That is, as shown in FIG. 9, the UE may attempt reception of RAR M-PDCCH (e.g., M-PDCCH scheduled by RA-RNTI) on CSS(s) existing within a RAR window or a search space(s) (hereinafter, RAR M-PDCCH search space) on which RAR M-PDCCH is transmitted. If the UE receives RAR M-PDCCH within the corresponding interval, the UE may receive a PDSCH through which the corresponding RAR is

transmitted, even though RAR (e.g., PDSCH carrying RAR) scheduled by the corresponding M-PDCCH is transmitted outside the RAR window interval.

[207] A duration of the RAR window may be configured to become a multiple of the number of subframes configuring CSSs or RAR M-PDCCH search spaces. For example, if RAR M-PDCCH search space is configured in each of R number of (consecutive or non-consecutive) downlink subframes, the RAR window may be configured to have a duration of R*X number of subframes (in this case, X is a positive integer).

[208] ■ Section 3. M-PDCCH CSS for other purposes

[209] M-PDCCH CSS can be used to transmit DCIs for other purposes except paging message and RAR scheduling. For example, M-PDCCH CSS can be used for transmission of DCI for unicast data, DCI for TPC, DCI for enhanced interference management and traffic adaptation (eIMTA), and DCI for enhanced PHICH (EPHICH). If CSS is used to transmit these DCIs, the narrowband location, monitoring subframe location, and decoding candidates composition need to be specified. Hereinafter, the CSS will be referred to as CSS_regular or CSS_others.

[210] CSS for these purposes (i.e. CSS_regular) can be located in the same narrowband to USS. Then, a UE does not need to re-tune its operating frequency to monitor this CSS.

[211] To reconfigure CE level of a UE, the CSS needs to support the maximum CE level of the cell considering CE level reconfiguration message can be transmitted by this CSS. Therefore, CE level or a subset of $\{L, R\}$ composing the CSS should support all CE level of the cell.

[212] FIG. 10 illustrates the example of the monitoring time region of USS and CSS.

[213] Period of starting subframe for M-PDCCH USS monitoring and CSS monitoring can be configured independently. The period of CSS monitoring can be longer than the period of USS, since CE level of USS and CSS can be different and CSS can be occurred sparsely to reduce UE complexity.

[214] Referring to Math Figure 1 which is a hashing function, it is noted that $Y_{p,k}$ is varied depending on n_{RNTI} which is UE ID. In this way, CCE(s) or ECCE(s) configuring decoding candidates in the USS is(are) determined UE-specifically to be monitored by a specific UE. M-PDCCH CSS can be monitored by a group of MTC UEs. Therefore, for CSS, there should not be a hashing function to randomize the starting ECCE location composing a search space UE-specifically.

[215] ■ Section 4. Coverage enhancement level of CSS

[216] For transmission of a broadcast PDSCH (e.g., paging, RAR), CSSs for other purposes such as unicast data, TPC, eIMTA DCI and EPHICH may exist, and USS where a UE monitors unicast data may exist. Hereinafter, a coverage enhancement level of corresponding search spaces will be described.

[217] The present invention suggests that a plurality of SS types exist as follows in accordance with a coverage enhancement level supported by a search space or repetitions of M-PDCCH.

[218] - Method 1.

[219] In view of the UE, two types of search spaces (SSs) may exist as follows:

[220] * SS type 1: SS supporting all coverage enhancement levels or all repetitions of M-PDCCH, and

[221] * SS type 2: SS where the number of repetitions of M-PDCCH which is supported is varied depending on a coverage enhancement level of the UE.

[222] In this case, the UE may assume that CSS for paging and/or CSS_regular has SS type 1, and CSS and/or USS for RAR has SS type 2.

[223] Alternatively, as SS monitored by the UE, one SS having SS type 1 and one SS having SS type 2 may exist. CSS for paging and/or CSS_regular may be the same as SS having SS type 1, and CSS and/or USS for RAR may be the same as SS having SS type 2.

[224] - Method 2.

[225] When N number of coverage enhancement levels (or the number of repetitions of M-PDCCH) supported by a cell exist, in view of the cell, a plurality of SS types may exist as follows:

[226] * SS type 1: SS supporting coverage enhancement level 1 (or the number of repetitions R_1 of M-PDCCH),

[227] * SS type 2: SS supporting coverage enhancement level 2 (or the number of repetitions R_2 of M-PDCCH),

[228] ...

[229] * SS type N: SS supporting coverage enhancement level N (or the number of repetitions R_N of M-PDCCH),

[230] * SS type N+1: SS supporting all coverage enhancement levels (or all repetitions for M-PDCCH).

[231] In this case, SS supporting the coverage enhancement level n may mean SS supporting the coverage enhancement levels 1 to n or the maximum number of repetitions R_n of M-PDCCH.

[232] In this case, the UE may assume that the CSS for paging and CSS_regular has SS type N+1, and the CSS for RAR and/or USS has SS type k if the coverage enhancement level of the UE is k.

[233] ■ Section 5. Relationship between search spaces

[234] **CSS for paging (i.e., CSS_paging)**

[235] It is a CSS for paging monitoring in RRC_IDLE state. Since UEs in different CE levels monitor the same CSS for paging scheduling, it should be designed to cover all

the CE levels. CSS_paging are configured by SIB. In other words, the configuration of CSS_paging may be transmitted through SIB. The UE may identify the configuration of CSS_paging by reading SIB. The UE may monitor M-PDCCH candidates of CSS within subframe(s) and/or narrowband(s) according to the CSS_paging configuration.

[236] **CSS for** RAR corresponding to initial RACH procedure (i.e., CSS_RAR)

[237] Using CSS for RAR, a UE can monitor RAR, Msg3 (for retransmission), and Msg4. Though it can be considered to allow separate SS configurations for Msg3 re-transmission and Msg4 scheduling M-PDCCH from the SS configuration for RAR, given that those (i.e. RAR, Msg3 and Msg4) will be used only for initial access, the present invention proposes that the same configuration is used for initial RACH procedure. Required configurations for CSS_RAR can be configured by SIB per CE level. Then, in a UE perspective, configurations for CSS_RAR can be determined based on the CE level of PRACH resource set used for the latest PRACH transmission.

[238] **CSS for others (i.e., CSS_others or CSS_regular)**

[239] M-PDCCH CSS can be used to transmit DCIs for other purposes except paging message and initial RAR scheduling. For example, CSS is required to transmit TPC, unicast data for reconfiguration (such as CE level, transmission mode, USS reconfiguration), a DCI transmitting multiple HARQ-ACK corresponding to PUSCH to multiple UEs (if supported), transmit RAR corresponding to PRACH triggered by M-PDCCH order. CSS for these purposes can be located in the same narrowband to USS once a UE is connected to the network. Then, a UE does not need to re-tune its operating frequency to monitor this CSS. A UE can monitor CSS_others (i.e., CSS_regular) and USS simultaneously.

[240] If there is a complexity issue, TDM of CSS and USS monitoring can be considered. In other words, CSS and USS are time-division multiplexed, whereby the CSS and the USS may not be monitored at the same time.

[241] If CSS for other purposes are not defined, legacy PUCCH TPC via DCI format 3/3A cannot be supported. Then, if downlink traffic is occurred sparsely, it could be difficult to adopt PUCCH power since PUCCH TPC is accomplished by accumulated way. So, other way to handle this issue needs to be considered such as absolute PUCCH TPC via DL grant or unicast DCI for PUCCH TPC transmitted by USS. Thus, at least for CE mode A (for TCP and reconfiguration), CSS_others needs to be supported.

[242] **USS**

[243] USS is a search space for unicast data scheduling. Configurations for USS can be configured by SIB and Msg4. If necessary, reconfiguration can be utilized by radio resource control (RRC) layer (i.e. RRC signal). Configurations for USS also can be applied for CSS_others. In this case, individual configurations for CSS_others and USS may not be required.

[244] FIG. 11 illustrates a procedure of configuring a search space according to the present invention.

[245] Referring to FIG. 11, the UE may receive a list of search space (SS) configurations per CE level for RAR through SIB (S1101). The UE may transmit RACH preamble through PRACH by using a PRACH resource. PRACH resource(s) per CE level may be configured by SIB. The UE may monitor M-PDCCH for scheduling a response to the RACH preamble transmitted therefrom, that is, a response to transmission of the PRACH in a search space (S1103). The UE may assume that a search space for M-PDCCH scheduling the RAR depends on SS configuration (e.g., CSS_RAR configuration) received through the SIB. The UE which has received RAR M-PDCCH may receive RAR in accordance with DCI carried by the RAR M-PDCCH (S1105).

[246] Initial configuration for RAR, Msg3 and/or Msg4 may depend on SS configuration per CE level received (S1101) through SIB (S1121). The UE may monitor M-PDCCH for scheduling Msg4, which includes CSS configuration/reconfiguration and/or USS configuration/reconfiguration parameters, in the SS according to initial configuration through SIB (S1121). For example, the UE may monitor Msg4 M-PDCCH by assuming that the maximum number of repetitions, narrowband, PRB-set, etc. which are the same as those of CSS for RAR, are also applied to M-PDCCH (hereinafter, Msg4 M-PDCCH) for scheduling Msg4 (S1121). The UE which has received Msg4 M-PDCCH may receive Msg4 in accordance with DCI of the Msg4 M-PDCCH (S1123). The Msg4 may carry RRC message that includes UE-specific configuration for USS and/or CSS. In this case, the UE may monitor M-PDCCH by applying the UE-specific SS configuration instead of initial SS configuration (S1125).

[247] The UE may monitor M-PDCCH order within the CSS according to the UE-specific CSS configuration (S1141). The UE which has received the M-PDCCH order may receive RAR in accordance with scheduling information carried by the M-PDCCH order (S1143).

[248] The UE may monitor M-PDCCH for scheduling RRC message having UE-specific reconfiguration parameter(s) within the CSS according to the UE-specific CSS configuration (S1161). The UE-specific reconfiguration may include M-PDCCH configuration. The UE which has received the M-PDCCH may receive a PDSCH carrying the RRC message in accordance with scheduling information (that is, DCI) of the M-PDCCH (S1163). The UE may reconfigure M-PDCCH search space in accordance with the UE-specific reconfiguration.

[249] Table 13 illustrates parameters and configuration details required for search spaces. All or some of the parameters illustrated in Table 13 may be configured and/or re-configured in accordance with Table 13.

[250] [Table 13]

Parameters	Configuration details				Description
	CSS_paging	CSS_RAR	CSS_others	USS	
Subset of L	Fixed to {8, 16, 24}			{1, 2, 4, 8, 16, 24}	
R_{max}	Configurable by SIB.	Configured by SIB per CE level (configuration can be shared for CSS_RAR, CSS_others, USS).For CSS_others/USS, it can be reconfigured by RRC.			Subset of repetition numbers is determined based on R_{max}. Details are described in Subsection 5.1.
PRB-sets	Configured by SIB.	Configured by SIB per CE level specific and cell-specific.	Alt 1. Configured by Msg4 per UE.Alt 2. Configured by SIB per CE level (in this case, same configuration for CSS_RAR, CSS_others, USS).It can be reconfigured by RRC.		This configuration includes the number of PRB-sets, PRB size/ location of each PRB-set.
Transmission type	Configured by SIB per PRB-set.	Configured by SIB per PRB-set.	Alt 1. Configured by Msg4 per UE (the network ensures the same type is used beween CSS_others and USS in case both are monitored at the same time).Alt 2. Configured by SIB per CE level (in this case, same configuration for CSS_RAR, CSS_others, USS).It can be reconfigured by RRC.		
Narrowband	Determined	Based on	Default value can be		

	by UE ID among paging narrowbands configured by SIB.	PRACH resource set where RAR narrowband corresponding to each PRACH resource set is configured by SIB.	CSS_RAR's narrowband location. Configurable by Msg 4 per UEIt can be reconfigured by RRC.	
M-PDCCH monitoring starting	Alt 1. Configured by SIB per CE level.Alt 2. Configured by SIB regardless of CE level (one maximum value to reset monitoring starting subframe).			See FIG. 7 and Subsection 5.1.
M-PDCCH starting subframe	Determined by repetition number R per repetition number R.	Alt 1. Determined by R_{max} for CE Mode A, determined by repetition number R per repetition number R for CE Mode B.Alt 2. Determined by repetition number R per repetition number R.		See FIG. 7 and Subsection 5.1.

[251] In Table 13, a merged cell means that the configuration can be shared by corresponding search spaces, so individual configuration is not needed for each search space. For example, referring to Table 13, "Fixed to {8, 16, 24}" which is the description of a subset of an aggregation level L exists within a cell merged for CSS_paging, CSS_RAR and CSS_others (i.e., CSS_regular), and thus means that a corresponding parameter is not required to be configured individually for CSS_paging, CSS_RAR and CSS_others(i.e. CSS_reguar) and a common parameter is applied to CSS_paging, CSS_RAR and CSS_others. According to Table 13, the UE may attempt reception of M-PDCCH at an aggregation level $L\in\{8, 16, 24\}$ for CSS_paging, CSS_RAR and CSS_others, and may attempt reception of M-PDCCH at $L\in\{1, 2, 4, 8, 16, 24\}$ for the USS.

[252] Reconfigurable parameters in Table 13 mean that the same value as initial configuration or default configuration is applied until a corresponding parameter is reconfigured, whereby search space(s) is(are) configured.

[253] For example, referring to Table 13, the maximum number of repetitions R_{max} of M-PDCCH may be provided through SIB as a configuration for CSS_RAR. The UE may monitor CSS_RAR, CSS_others and/or USS by assuming that R_{max} included in the SIB is applied to CSS_RAR, CSS_others, and USS. That is, the UE may monitor rep-

etitions of M-PDCCH in SS within maximum R_{max} number of subframes. According to Table 13, since R_{max} for CSS_others and/or USS (hereinafter, CSS_others/USS) may be reconfigured, if R_{max} for CSS_others/USS is reconfigured by RRC signal, the UE may monitor CSS_others/USS in accordance with the reconfigured R_{max}. In other words, the UE may monitor CSS_others/USS in accordance with R_{max} for CSS_RAR until R_{max} for CSS_others/USS is received.

[254] For another example, referring to parameters of PRB-sets in Table 13, PRBs on which PRB-set(s) for CSS_RAR, that is, RAR M-PDCCH may be transmitted may be configured CE level-specifically and cell-specifically by SIB. Referring to Alt 2, these PRB-sets configured per CE level may be applied to CSS_others and USS by SIB. Since PRB-set parameter for CSS_others and USS may be reconfigured by RRC, the UE may monitor CSS_others/USS by applying PRB-set(s) for CSS_RAR until reconfiguration PRB-set parameter for CSS_others/USS is received, and may monitor CSS_others/USS by applying the reconfiguration PRB-set parameter if the reconfiguration PRB-set parameter for CSS_others/USS is received. For example, if PRB-set(s) of CSS_RAR are fixed to 6, the UE may monitor M-PDCCH USS by assuming all PRBs within a narrowband according to CSS_RAR configuration as PRB-set(s) for USS until configuration of separate PRB-set(s) for USS is received.

[255] For still another example, referring to a narrowband parameter of Table 13, a narrowband (hereinafter, RAR narrowband) having CSS_RAR may be determined based on a PRACH resource set. In this case, a corresponding RAR narrowband per PRACH resource set is configured by SIB. A default narrowband location of CSS_others and/or USS may be a narrowband location of CSS_RAR. A narrowband for CSS_others/USS may be configured per UE by Msg4, and may be reconfigured by RRC. Therefore, the UE may monitor CSS_others/USS on the same narrowband as that for CSS_RAR until a narrowband parameter for CSS_others/USS is received, and if Msg4 for CSS_others/USS or reconfiguration RRC message is received, may monitor CSS_others/USS on a narrowband according to the Msg4 or the RRC message.

[256] □ Subsection 5.1. Aggregation levels and repetition numbers

[257] Search space configuration parameters of Table 13 may be applied as follows in view of an aggregation level and the number of repetitions. For example, a subset (and/or starting subframe of M-PDCCH SS and/or starting subframe of M-PDCCH) of the number of repetitions R based on R_{max} may be determined in accordance with the following description.

[258] **CSS for paging (i.e., CSS_paging)**

[259] - Aggregation levels:

[260] Since data transmission scheduled by CSS is targeted to multicast/broadcast, similar

to PDCCH CSS, some high aggregation levels can be supported. Aggregation levels (ALs) {8, 16, 24} can be supported for normal CP and ALs {4, 8, 12} can be supported for extended CP.

[261] - Repetition numbers:

[262] A subset of R for CSS for paging monitoring depends on the maximum R (i.e., R_{max}) where R_{max} is configured by SIB. To support wide range of repetition numbers, the subset of R monitored for CSS_paging can be {$R_{max}/64$, $R_{max}/16$, $R_{max}/4$, R_{max}}.

[263] **CSS for** RAR corresponding to initial RACH procedure (i.e., CSS_RAR)

[264] - Aggregation levels:

[265] Similar to CSS_paging, ALs $L\in\{8, 16, 24\}$ can be supported for normal CP and ALs $L\in\{4, 8, 12\}$ can be supported for extended CP.

[266] - Repetition numbers:

[267] For CSS scheduling RAR, the subset of R depends on the maximum R (i.e., R_{max}) where R_{max} is configured by SIB per CE level. The subset of R monitored for CSS_RAR can be {$R_{max}/4$, $R_{max}/2$, R_{max}}.

[268] **CSS for others (i.e., CSS_others)**

[269] - Aggregation levels:

[270] Similar to CSS_paging, ALs $L\in\{8, 16, 24\}$ can be supported for normal CP and ALs $L\in\{4, 8, 12\}$ can be supported for extended CP.

[271] - Repetition numbers:

[272] For CSS_others, the subset of R depends on the maximum R (i.e., R_{max}) where R_{max} is configured by SIB per CE level or Msg4. R_{max} can be reconfigured by RRC if necessary. The subset of R monitored for CSS_others can be {$R_{max}/4$, $R_{max}/2$, R_{max}}. Or, to reduce UE complexity, the subset of R monitored for CSS_others can be {$R_{max}/2$, R_{max}}.

[273] **USS**

[274] - Aggregation levels:

[275] For CE Mode A, ALs $L\in\{1, 2, 4, 8, 16, 24\}$ are supported for normal CP. ALs $L\in\{1, 2, 4, 8, 12\}$ are supported for extended CP. For CE Mode B, ALs $L\in\{8, 16, 24\}$ is supported for normal CP. ALs $L\in\{4, 8, 12\}$ are supported for extended CP.

[276] - Repetition numbers:

[277] For USS, the subset of R depends on the maximum R (i.e., R_{max}) where R_{max} is configured by SIB per CE level or Msg4. R_{max} can be reconfigured by RRC if necessary. The subset of R monitored for USS can be {$R_{max}/4$, $R_{max}/2$, R_{max}}. Or, to support higher R to CSS_others for CE level reconfiguration reliably, subset of R monitored for USS can be {$R_{max}/8$, $R_{max}/4$, $R_{max}/2$}.

[278] ■ Section 6. Collision of M-PDCCH(s)

[279] If there are some subframes not available for downlink transmission, M-

PDCCH/PDSCH transmission or repetitions can be postponed till the next available subframe. It can be applied in case unavailable subframes are aligned between eNB and UE.

[280] FIG. 12 illustrates a configuration of M-PDCCH repeated transmission according to the present invention.

[281] If a small interval (e.g., cycle of starting subframe of M-PDCCH search space) of M-PDCCH search space is configured or a large number of invalid subframes, which cannot have M-PDCCH, are provided between M-PDCCH search space starting subframes, M-PDCCH2 transmission may not end until next starting subframe of the search space, in the same manner as M-PDCCH2 transmission of FIG. 12. That is, the subframes configuring two search spaces may be overlapped with each other. In this case, the UE may be in the status that the UE should perform monitoring for M-PDCCH transmitted in a previous search space and monitoring for M-PDCCH transmitted in a next search space. However, this operation may not be preferable due to buffer size and complexity issue of the UE. In this case, the UE may perform reception of M-PDCCH as follows.

[282] - Method 1. If a starting time (hereinafter, subframe #n) of next search space occurs before reception of M-PDCCH is ended, the UE may assume that the M-PDCCH is transmitted up to subframe #n-1 and is not transmitted in subframe #n. In this case, the UE may attempt reception of the M-PDCCH by using repetitions smaller than the number of expected repetitions of M-PDCCH.

[283] - Method 2. If a starting time (hereinafter, subframe #n) of next search space occurs before reception of M-PDCCH is ended, the UE may determine that the M-PDCCH that the UE is receiving is invalid, and may not perform reception of the corresponding M-PDCCH.

[284] - Method 3. If subframe(s) configuring two search spaces are overlapped with each other, the UE may determine that a search space existing at an earlier time is invalid, and may not perform reception of M-PDCCH for one of the two search space, which is first started in a time domain.

[285] FIG. 13 is a block diagram illustrating elements of a transmitting device 10 and a receiving device 20 for implementing the present invention.

[286] The transmitting device 10 and the receiving device 20 respectively include Radio Frequency (RF) units 13 and 23 capable of transmitting and receiving radio signals carrying information, data, signals, and/or messages, memories 12 and 22 for storing information related to communication in a wireless communication system, and processors 11 and 21 operationally connected to elements such as the RF units 13 and 23 and the memories 12 and 22 to control the elements and configured to control the memories 12 and 22 and/or the RF units 13 and 23 so that a corresponding device may

perform at least one of the above-described embodiments of the present invention.

[287] The memories 12 and 22 may store programs for processing and controlling the processors 11 and 21 and may temporarily store input/output information. The memories 12 and 22 may be used as buffers.

[288] The processors 11 and 21 generally control the overall operation of various modules in the transmitting device and the receiving device. Especially, the processors 11 and 21 may perform various control functions to implement the present invention. The processors 11 and 21 may be referred to as controllers, microcontrollers, microprocessors, or microcomputers. The processors 11 and 21 may be implemented by hardware, firmware, software, or a combination thereof. In a hardware configuration, application specific integrated circuits (ASICs), digital signal processors (DSPs), digital signal processing devices (DSPDs), programmable logic devices (PLDs), or field programmable gate arrays (FPGAs) may be included in the processors 11 and 21. Meanwhile, if the present invention is implemented using firmware or software, the firmware or software may be configured to include modules, procedures, functions, etc. performing the functions or operations of the present invention. Firmware or software configured to perform the present invention may be included in the processors 11 and 21 or stored in the memories 12 and 22 so as to be driven by the processors 11 and 21.

[289] The processor 11 of the transmitting device 10 performs predetermined coding and modulation for a signal and/or data scheduled to be transmitted to the outside by the processor 11 or a scheduler connected with the processor 11, and then transfers the coded and modulated data to the RF unit 13. For example, the processor 11 converts a data stream to be transmitted into K layers through demultiplexing, channel coding, scrambling, and modulation. The coded data stream is also referred to as a codeword and is equivalent to a transport block which is a data block provided by a MAC layer. One transport block (TB) is coded into one codeword and each codeword is transmitted to the receiving device in the form of one or more layers. For frequency up-conversion, the RF unit 13 may include N_t (where N_t is a positive integer) transmit antennas.

[290] A signal processing process of the receiving device 20 is the reverse of the signal processing process of the transmitting device 10. Under control of the processor 21, the RF unit 23 of the receiving device 20 receives radio signals transmitted by the transmitting device 10. The RF unit 23 may include N_r (where N_r is a positive integer) receive antennas and frequency down-converts each signal received through receive antennas into a baseband signal. The processor 21 decodes and demodulates the radio signals received through the receive antennas and restores data that the transmitting device 10 intended to transmit.

[291] The RF units 13 and 23 include one or more antennas. An antenna performs a function for transmitting signals processed by the RF units 13 and 23 to the exterior or receiving radio signals from the exterior to transfer the radio signals to the RF units 13 and 23. The antenna may also be called an antenna port. Each antenna may correspond to one physical antenna or may be configured by a combination of more than one physical antenna element. The signal transmitted from each antenna cannot be further deconstructed by the receiving device 20. An RS transmitted through a corresponding antenna defines an antenna from the view point of the receiving device 20 and enables the receiving device 20 to derive channel estimation for the antenna, irrespective of whether the channel represents a single radio channel from one physical antenna or a composite channel from a plurality of physical antenna elements including the antenna. That is, an antenna is defined such that a channel carrying a symbol of the antenna can be obtained from a channel carrying another symbol of the same antenna. An RF unit supporting a MIMO function of transmitting and receiving data using a plurality of antennas may be connected to two or more antennas.

[292] In the embodiments of the present invention, a UE operates as the transmitting device 10 in UL and as the receiving device 20 in DL. In the embodiments of the present invention, an eNB operates as the receiving device 20 in UL and as the transmitting device 10 in DL. Hereinafter, a processor, an RF unit, and a memory included in the UE will be referred to as a UE processor, a UE RF unit, and a UE memory, respectively, and a processor, an RF unit, and a memory included in the eNB will be referred to as an eNB processor, an eNB RF unit, and an eNB memory, respectively.

[293] The eNB processor of the present invention may configure or reconfigure CSS_paging in accordance with section 1, section 5 and/or section 6. The eNB processor may control the eNB RF unit to transmit SIB or RRC message, which includes configuration for CSS_paging, to the UE in accordance with section 1, section 5 and/or section 6. The eNB processor may control the eNB RF unit to transmit M-PDCCH for scheduling a paging message within CSS_paging according to CSS_paging configuration. The UE processor of the present invention may control the UE RF unit to receive configuration or reconfiguration information on CSS_paging from the eNB in accordance with section 1, section 5 and/or section 6. The UE may attempt reception of paging M-PDCCH from CSS_paging according to the CSS_paging configuration.

[294] The eNB processor of the present invention may configure or reconfigure CSS_RAR in accordance with section 2, section 5 and/or section 6. The eNB processor may control the eNB RF unit to transmit SIB or RRC message, which includes configuration for CSS_RAR, to the UE in accordance with section 2, section 5 and/or section 6. The eNB processor may control the eNB RF unit to transmit M-PDCCH for

scheduling RAR, Msg3 and/or Msg4 within a CSS according to CSS_RAR configuration. The UE processor of the present invention may control the UE RF unit to receive configuration or reconfiguration information on CSS_RAR from the eNB in accordance with section 2, section 5 and/or section 6. The UE may attempt reception of RAR M-MPDCCH, Msg3 M-PDCCH and/or Msg4 M-PDCCH from the CSS according to the CSS_RAR configuration.

[295] The eNB processor of the present invention may configure or reconfigure CSS_others in accordance with section 3, section 5 and/or section 6. The eNB processor may control the eNB RF unit to transmit SIB or RRC message, which includes configuration for CSS_others, to the UE in accordance with section 3, section 5 and/or section 6. The eNB processor may control the eNB RF unit to transmit M-PDCCH for other purpose within a CSS according to CSS_others configuration. The UE processor of the present invention may control the UE RF unit to receive configuration or reconfiguration information on CSS_others from the eNB in accordance with section 3, section 5 and/or section 6. The UE may attempt reception of M-PDCCH for other purpose from the CSS according to the CSS_others configuration.

[296] The eNB processor of the present invention may transmit initial configuration for CSS through SIB in accordance with section 6. The eNB processor may configure CSS and/or USS in accordance with the initial configuration until the other configuration (e.g., UE-specific configuration/reconfiguration) for SS is transmitted. The initial configuration may include a configuration (e.g., narrowband, PRB-set(s), starting subframe and/or period, and the number of maximum repetitions of SS) of time-frequency resources of SS. The eNB processor may transmit M-PDCCH in accordance with the initial configuration until the other configuration for SS is transmitted. For example, the eNB processor may control the eNB RF unit to transmit M-PDCCH by applying the number of repetitions R based on maximum R_{max} according to the initial configuration within the PRB-set according to the initial configuration on a narrowband according to the initial configuration. If the other configuration for SS is transmitted, the eNB processor may control the eNB RF unit to transmit M-PDCCH on the SS configured in accordance with the other configuration. The UE processor may receive the initial configuration for CSS through SIB in accordance with section 6. The UE processor may assume that CSS and/or USS is configured in accordance with the initial configuration until the other configuration (e.g., UE-specific configuration/reconfiguration) for SS is received. The UE processor may monitor M-PDCCH in accordance with the initial configuration until the other configuration for SS is transmitted. For example, the UE processor may control the UE RF unit to receive or monitor M-PDCCH by applying the number of repetitions R based on maximum R_{max} according to the initial configuration within the PRB-set according to the initial con-

figuration on a narrowband according to the initial configuration. If the other configuration for SS is received, the UE processor may control the UE RF unit to receive or monitor M-PDCCH on the SS configured in accordance with the other configuration.

[297] As described above, the detailed description of the preferred embodiments of the present invention has been given to enable those skilled in the art to implement and practice the invention. Although the invention has been described with reference to exemplary embodiments, those skilled in the art will appreciate that various modifications and variations can be made in the present invention without departing from the spirit or scope of the invention described in the appended claims. Accordingly, the invention should not be limited to the specific embodiments described herein, but should be accorded the broadest scope consistent with the principles and novel features disclosed herein.

Industrial Applicability

[298] The embodiments of the present invention are applicable to a BS, a UE, or other devices in a wireless communication system.

Claims

[Claim 1] A method for receiving, by a user equipment (UE), downlink control information (DCI) for the UE, the method comprising:
receiving, by the UE, a common search space configuration for a common search space;
receiving, by the UE, a first physical downlink control channel (PDCCH) scheduling a random access response by monitoring first PDCCH candidates of the common search space according to the common search space configuration; and
receiving, by the UE, a second PDCCH carrying the DCI for the UE by monitoring second PDCCH candidates of a UE-specific search space,
wherein the second PDCCH candidates of the UE-specific search space are monitored according to the same configuration as the common search space configuration until the UE receives a UE-specific search space configuration.

[Claim 2] The method according to claim 1,
wherein the common search space configuration includes information on a narrowband for the common search space, and
wherein the second PDCCH candidates of the UE-specific search space are monitored on the same narrowband as the narrowband for the common search space until the UE receives a UE-specific search space configuration.

[Claim 3] The method according to claim 1 or 2,
wherein the common search space configuration includes information on a maximum number of repetitions for the common common search space, and
wherein the second PDCCH candidates of the UE-specific search space are monitored based on the same number as the maximum number of repetitions for the common search space until the UE receives a UE-specific search space configuration.

[Claim 4] The method according to any one of claims 1 to 3,
wherein the common search space configuration includes information on a first physical resource block (PRB) set for monitoring the first PDCCH, and
wherein the same physical resource block set as the first PRB set is used for monitoring the second PDCCH candidates until the UE receives a UE-specific search space configuration.

[Claim 5] The method according to any one of claims 1 to 4,
wherein the first PDCCH candidates of the common search space are monitored according to aggregation levels larger than or equal to 8 among a plurality of aggregation levels, and the second PDCCH candidates of the UE-specific search space are monitored according to the plurality of aggregation levels.

[Claim 6] A method for transmitting, by a base station (BS), downlink control information (DCI) for a user equipment (UE), the method comprising:
transmitting, by the BS, common search space configuration for a common search space;
transmitting, by the BS to the UE, a first physical downlink control channel (PDCCH) scheduling a random access response by using one of first PDCCH candidates of the common search space according to the common search space configuration; and
transmitting, by the BS to the UE, a second PDCCH carrying the DCI for the UE by using one of second PDCCH candidates of a UE-specific search space,
wherein the second PDCCH candidates of the UE-specific search space are configured according to the same configuration as the common search space configuration until a UE-specific search space configuration is transmitted to the UE.

[Claim 7] The method according to claim 6,
wherein the common search space configuration includes information on a narrowband for the common search space, and
wherein the second PDCCH candidates of the UE-specific search space are configured on the same narrowband as the narrowband for the common search space until the UE-specific search space configuration is transmitted to the UE.

[Claim 8] The method according to claim 6 or 7,
wherein the common search space configuration includes information on a maximum number of repetitions for the first common search space, and
wherein the second PDCCH candidates of the UE-specific search space are configured based on the same number as the maximum number of repetitions for the common search space until the UE-specific search space configuration is transmitted to the UE.

[Claim 9] The method according to any one of claims 6 to 8,
wherein the common search space configuration includes information

on a first physical resource block (PRB) set for transmitting the first PDCCH, and
wherein the same physical resource block set as the first PRB set is used for the second PDCCH candidates until the UE-specific search space configuration is transmitted to the UE.

[Claim 10] The method according to any one of claims 6 to 9,
wherein the first PDCCH candidates of the common search space are configured according to aggregation levels larger than or equal to 8 among a plurality of aggregation levels, and the second PDCCH candidates of the UE-specific search space are configured according to the plurality of aggregation levels.

[Claim 11] A user equipment (UE) for receiving downlink control information (DCI) for the UE, the UE comprising:
a radio frequency (RF) unit, and
a processor connected to the RF unit, the processor configured to:
control the RF unit to receive common search space configuration for a common search space;
control the RF unit to receive a first physical downlink control channel (PDCCH) scheduling a random access response by monitoring first PDCCH candidates of the common search space according to the common search space configuration; and
control the RF unit to receive a second PDCCH carrying the DCI for the UE by monitoring second PDCCH candidates of a UE-specific search space,
wherein the second PDCCH candidates of the UE-specific search space are monitored according to the same configuration as the common search space configuration until the UE receives a UE-specific search space configuration.

[Claim 12] The UE according to claim 11,
wherein the common search space configuration includes information on a narrowband for the common search space, and
wherein the second PDCCH candidates of the UE-specific search space are monitored on the same narrowband as the narrowband for the common search space until the UE receives a UE-specific search space configuration.

[Claim 13] The UE according to claim 11 or 12,
wherein the common search space configuration includes information on a maximum number of repetitions for the common common search

space, and
wherein the second PDCCH candidates of the UE-specific search space are monitored based on the same number as the maximum number of repetitions for the common search space until the UE receives a UE-specific search space configuration.

[Claim 14] The UE according to any one of claims 11 to 13,
wherein the common search space configuration includes information on a first physical resource block (PRB) set for monitoring the first PDCCH, and
wherein the same physical resource block set as the first PRB set is used for monitoring the second PDCCH candidates until the UE receives a UE-specific search space configuration.

[Claim 15] The UE according to any one of claims 11 to 14,
wherein the first PDCCH candidates of the common search space are monitored according to aggregation levels larger than or equal to 8 among a plurality of aggregation levels, and the second PDCCH candidates of the UE-specific search space are monitored according to the plurality of aggregation levels.

[Claim 16] A base station (BS) for transmitting downlink control information (DCI) to a user equipment (UE), the BS comprising:
a radio frequency (RF) unit, and
a processor connected to the RF unit, the processor configured to:
control the RF unit to transmit common search space configuration for a common search space;
control the RF unit to transmit, to the UE, a first physical downlink control channel (PDCCH) scheduling a random access response by using one of first PDCCH candidates of the common search space according to the common search space configuration; and
control the RF unit to transmit, to the UE, a second PDCCH carrying the DCI for the UE by using one of second PDCCH candidates of a UE-specific search space,
wherein the second PDCCH candidates of the UE-specific search space are configured according to the same configuration as the common search space configuration until a UE-specific search space configuration is transmitted to the UE.

[Claim 17] The BS according to claim 16,
wherein the common search space configuration includes information on a narrowband for the common search space, and

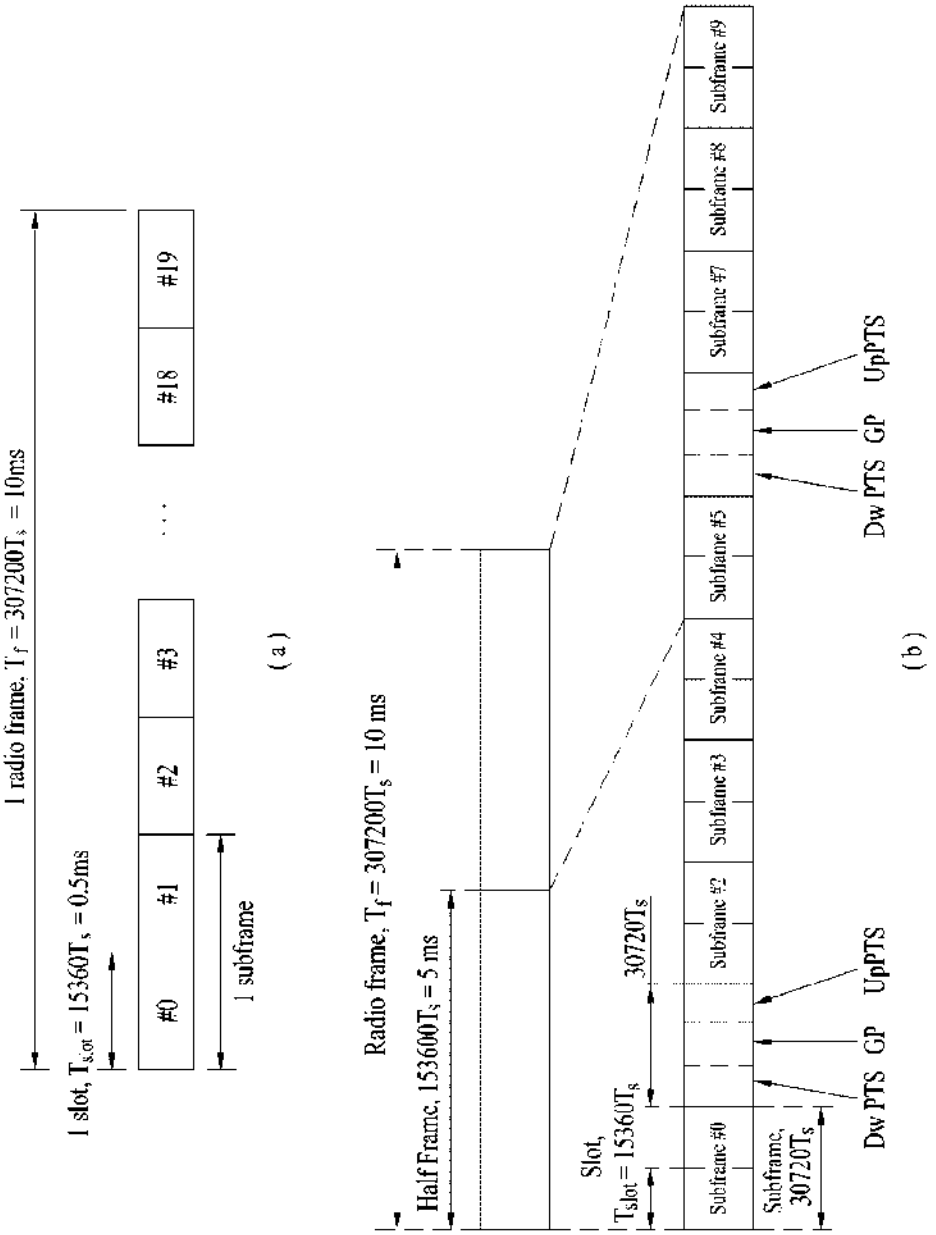
wherein the second PDCCH candidates of the UE-specific search space are configured on the same narrowband as the narrowband for the common search space until the UE-specific search space configuration is transmitted to the UE.

[Claim 18] The BS according to claim 16 or 17,
wherein the common search space configuration includes information on a maximum number of repetitions for the first common search space, and
wherein the second PDCCH candidates of the UE-specific search space are configured based on the same number as the maximum number of repetitions for the common search space until the UE-specific search space configuration is transmitted to the UE.

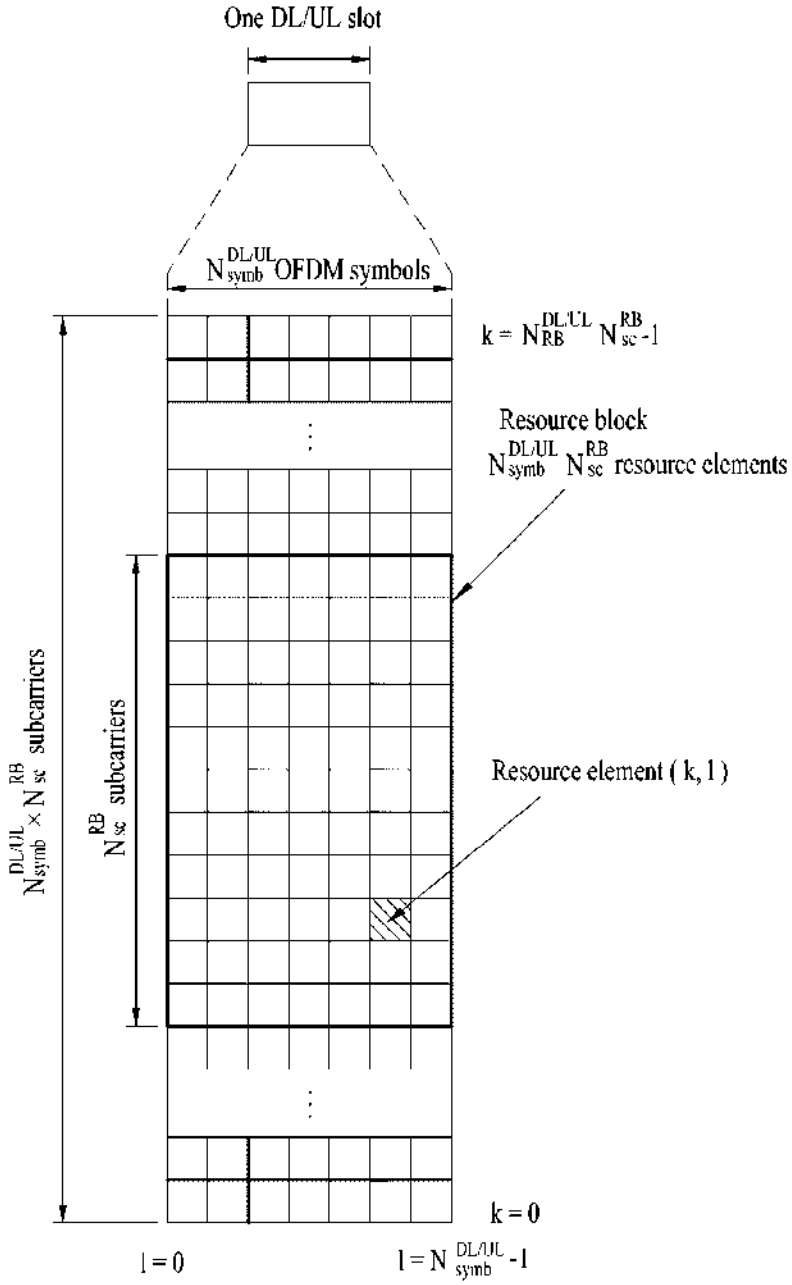
[Claim 19] The BS according to any one of claims 16 to 18,
wherein the common search space configuration includes information on a first physical resource block (PRB) set for transmitting the first PDCCH, and
wherein the same physical resource block set as the first PRB set is used for the second PDCCH candidates until the UE-specific search space configuration is transmitted to the UE.

[Claim 20] The BS according to any one of claims 16 to 19,
wherein the first PDCCH candidates of the common search space are configured according to aggregation levels larger than or equal to 8 among a plurality of aggregation levels, and the second PDCCH candidates of the UE-specific search space are configured according to the plurality of aggregation levels.

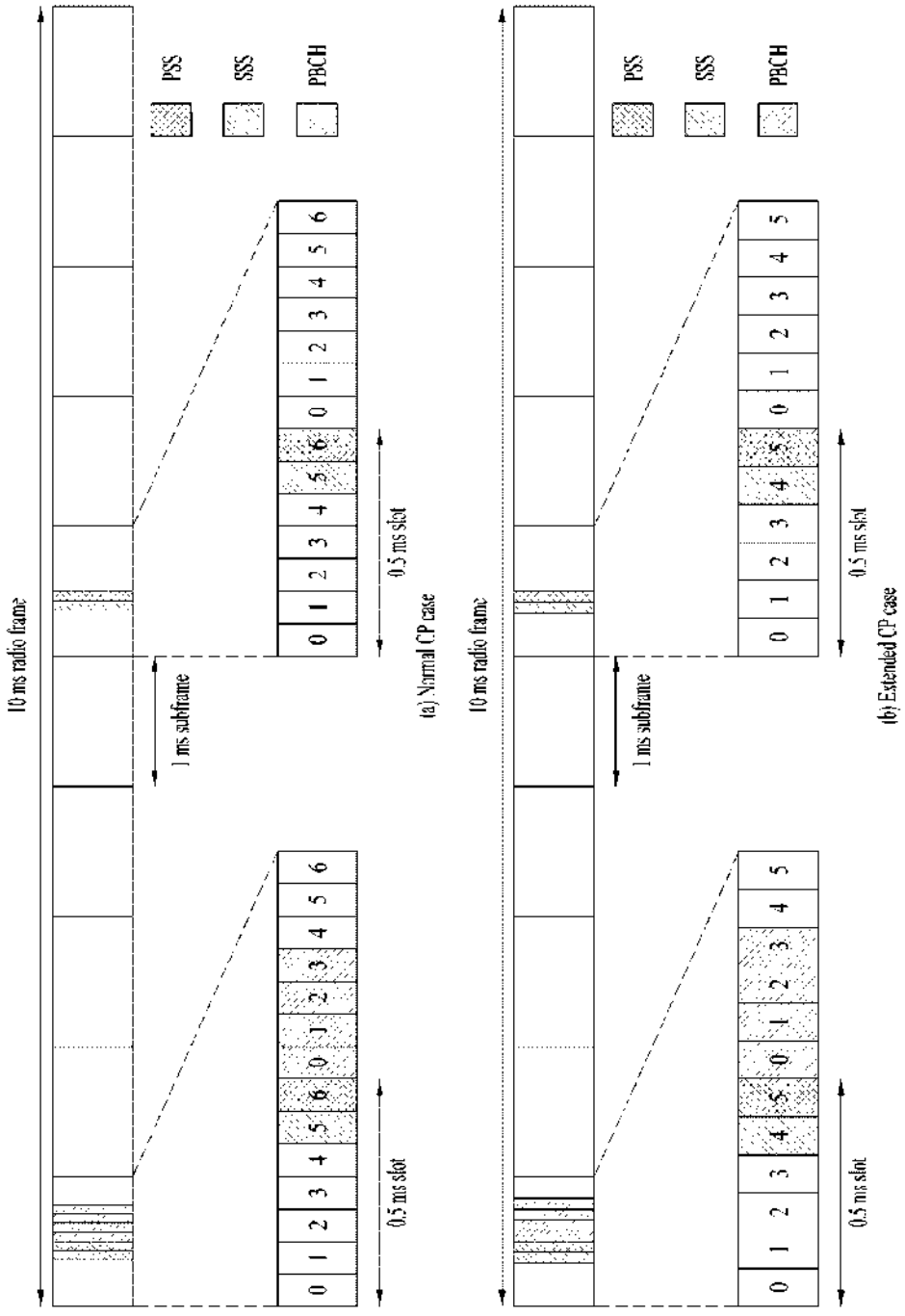
[Fig. 1]


1 radio frame, $T_f = 307200T_s = 10ms$
1 slot, $T_{slot} = 15360T_s = 0.5ms$
#0
#1
#2
#3
#18
#19
1 subframe
(a)
Radio frame, $T_f = 307200T_s = 10$ ms
Half Frame, $153600T_s = 5$ ms
Slot, $T_{slot} = 15360T_s$
$30720T_s$
Subframe #0
Subframe #2
Subframe #3
Subframe #4
Subframe #5
Subframe #7
Subframe #8
Subframe #9
Subframe, $30720T_s$
Dw PTS
GP
UpPTS
(b)

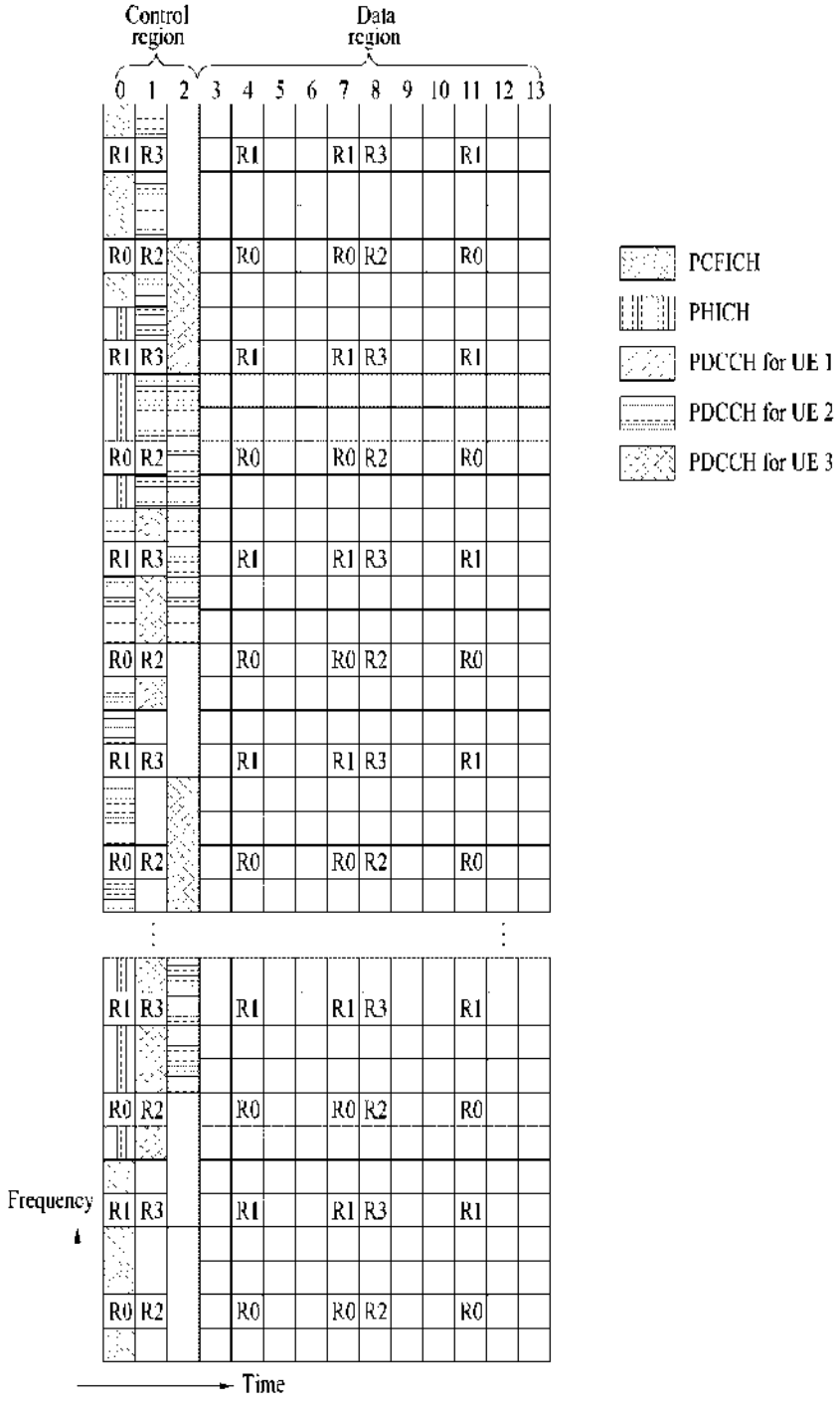
[Fig. 2]


One DL/UL slot
$N_{symb}^{DL/UL}$ OFDM symbols
$k = N_{RB}^{DL/UL} N_{sc}^{RB} - 1$
Resource block
$N_{symb}^{DL/UL} N_{sc}^{RB}$ resource elements
Resource element (k, l)
$N_{symb}^{DL/UL} \times N_{sc}^{RB}$ subcarriers
N_{sc}^{RB} subcarriers
k = 0
l = 0
$l = N_{symb}^{DL/UL} - 1$

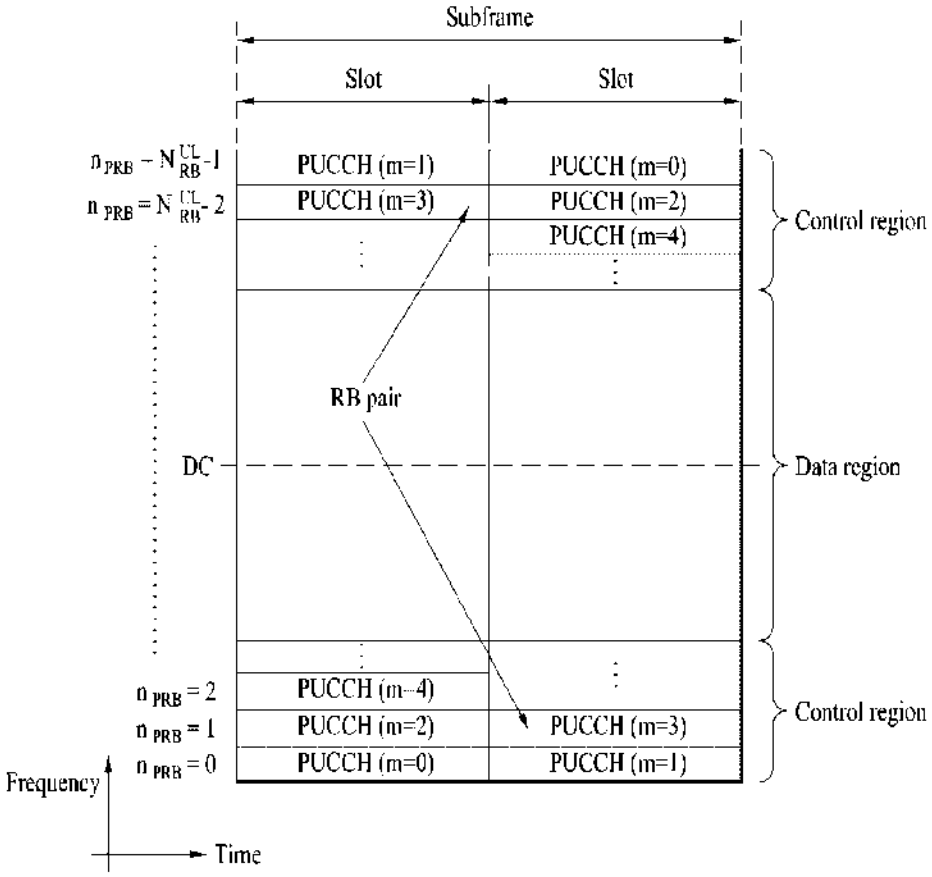
[Fig. 3]


PSS
SSS
PBCH
10 ms radio frame
1 ms subframe
0.5 ms slot
(a) Normal CP case
(b) Extended CP case

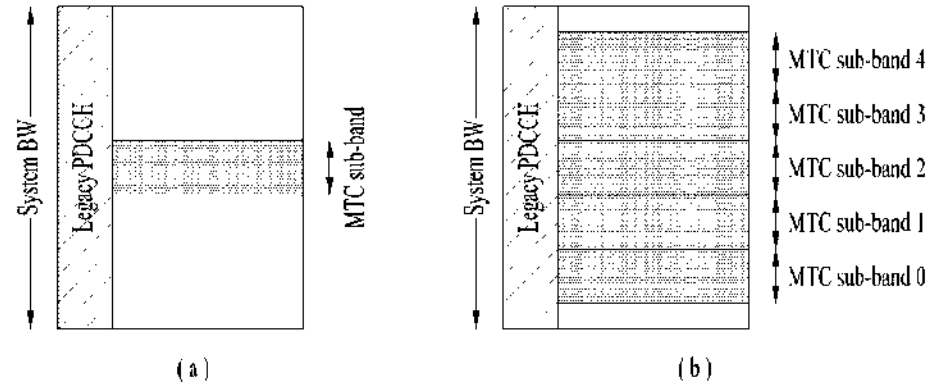
[Fig. 4]


Control region
Data region
0 1 2 3 4 5 6 7 8 9 10 11 12 13
R1 R3
R0 R2
PCFICH
PHICH
PDCCH for UE 1
PDCCH for UE 2
PDCCH for UE 3
Frequency
Time

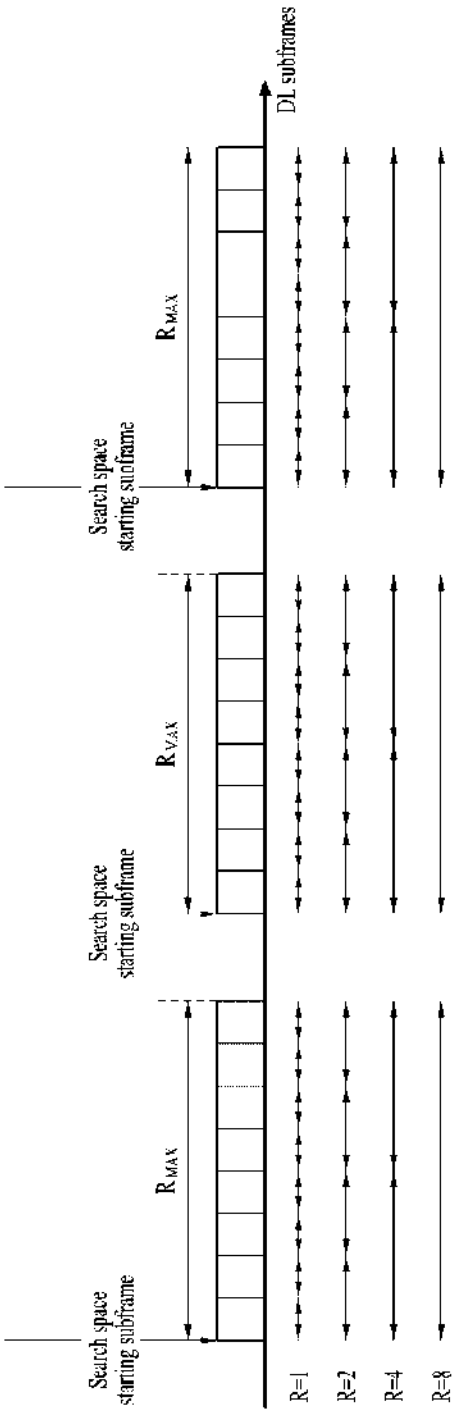
[Fig. 5]


Subframe
Slot
Slot
$n_{PRB} = N_{RB}^{UL} - 1$
$n_{PRB} = N_{RB}^{UL} - 2$
PUCCH (m=1)
PUCCH (m=0)
PUCCH (m=3)
PUCCH (m=2)
PUCCH (m=4)
Control region
RB pair
DC
Data region
$n_{PRB} = 2$
$n_{PRB} = 1$
$n_{PRB} = 0$
PUCCH (m=4)
PUCCH (m=2)
PUCCH (m=0)
PUCCH (m=3)
PUCCH (m=1)
Control region
Frequency
Time

[Fig. 6]


System BW
Legacy PDCCH
MTC sub-band
(a)
System BW
Legacy PDCCH
MTC sub-band 4
MTC sub-band 3
MTC sub-band 2
MTC sub-band 1
MTC sub-band 0
(b)

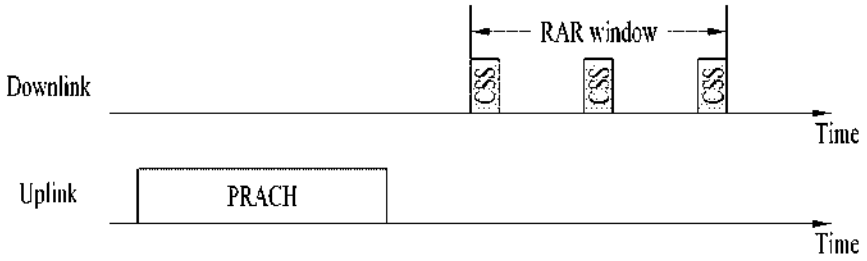
[Fig. 7]


DL subframes
Search space starting subframe
Search space starting subframe
Search space starting subframe
R_{MAX}
R_{MAX}
R_{MAX}
R=1
R=2
R=4
R=8

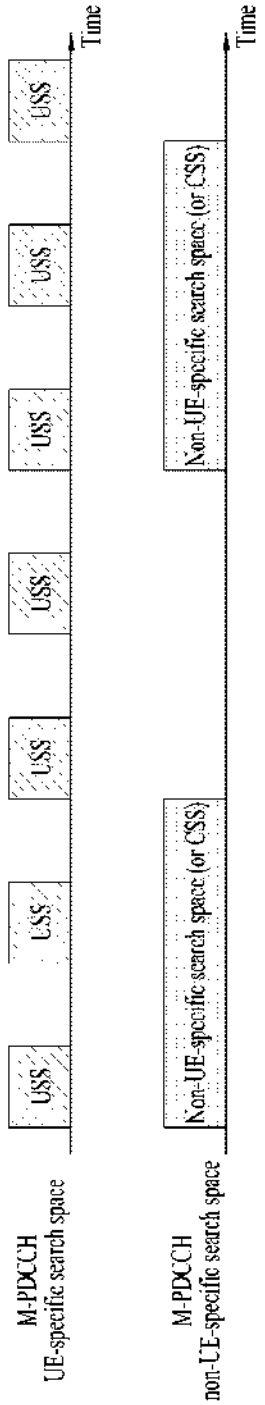
[Fig. 8]


Time
CSS
CSS
CSS
Paging occasion
CSS
CSS
CSS
Paging occasion

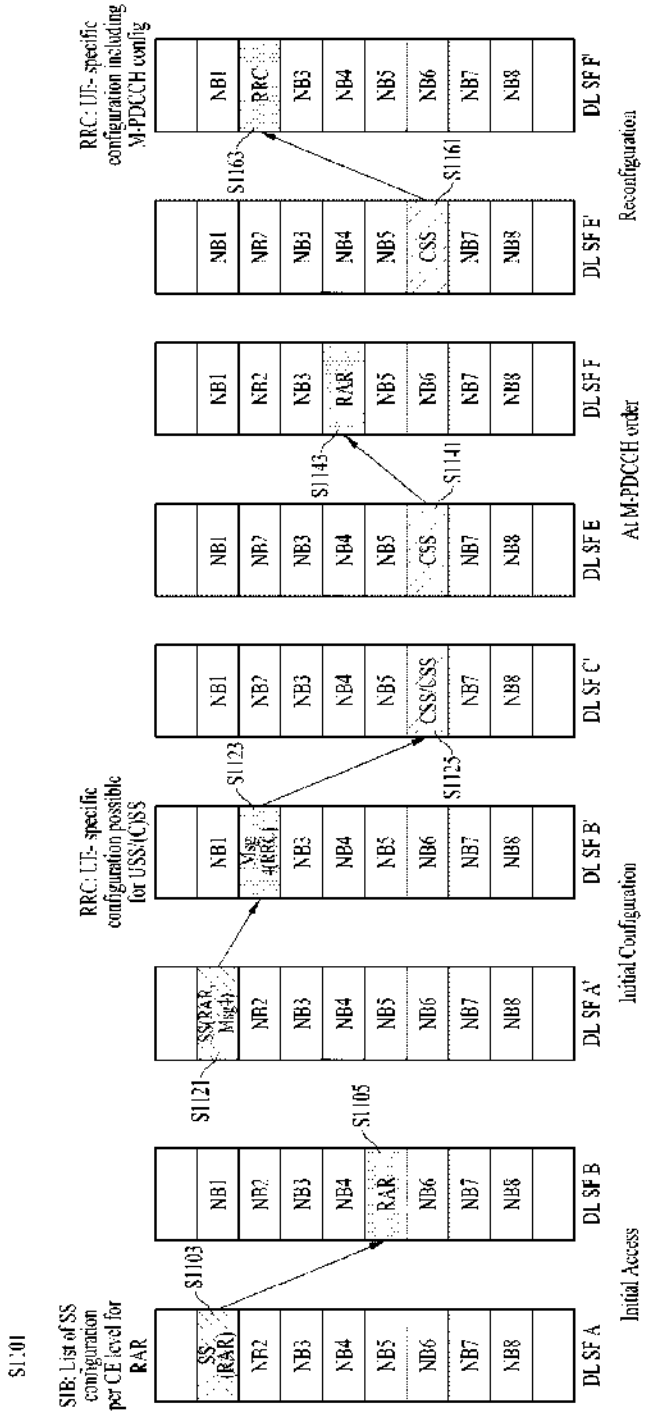
[Fig. 9]


RAR window
Downlink
CSS
CSS
CSS
Time
Uplink
PRACH
Time

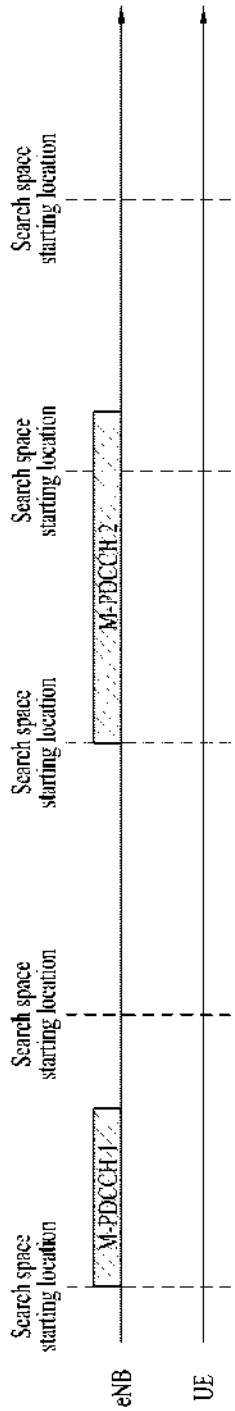
[Fig. 10]


M-PDCCH
UE-specific search space
USS
USS
USS
USS
USS
USS
USS
Time
M-PDCCH
non-UE-specific search space
Non-UE-specific search space (or CSS)
Non-UE-specific search space (or CSS)
Time

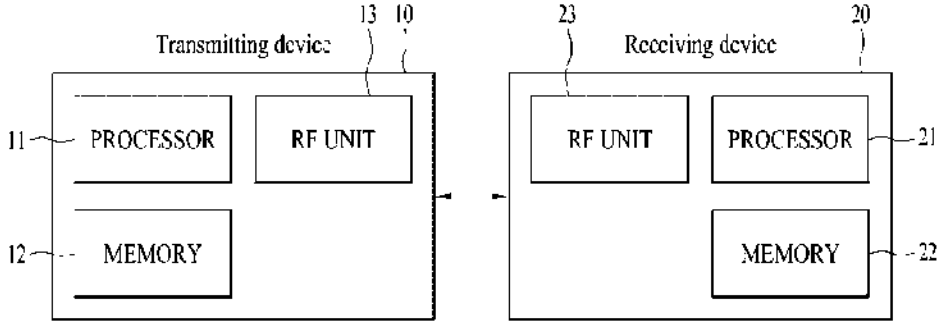
[Fig. 11]


S1101
SIB: List of SS configuration per CE level for RAR
DL SF A
SS (RAR)
NB2
NB3
NB4
NB5
NB6
NB7
NB8
Initial Access
S1103
DL SF B
NB1
NB2
NB3
NB4
RAR
NB6
NB7
NB8
S1105
S1121
DL SF A'
SS(RAR, Msg4)
Initial Configuration
RRC: UE- specific configuration possible for USS/CSS
DL SF B'
Msg 4(RRC)
S1123
S1125
DL SF C'
CSS/CSS
At M-PDCCH order
DL SF E
CSS
S1141
S1143
DL SF F
RAR
Reconfiguration
DL SF E'
S1161
S1163
RRC: UE- specific configuration including M-PDCCH config
DL SF F'
RRC

[Fig. 12]


Search space starting location
Search space starting location
Search space starting location
Search space starting location
M-PDCCH 1
M-PDCCH 2
eNB
UE

[Fig. 13]


Transmitting device
13
10
11
PROCESSOR
RF UNIT
12
MEMORY
Receiving device
23
20
RF UNIT
PROCESSOR
21
MEMORY
22

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2016/010542

A. CLASSIFICATION OF SUBJECT MATTER

H04L 5/00(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04L 5/00; H04W 72/04; H04W 24/08

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: common search space configuration, UE-specific search space, random access response, first PDCCH candidates, downlink control information, second PDCCH candidates, monitor, same configuration

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	ERICSSON, "EPDCCH initialization for MTC", R1 153731, 3GPP TSG RAN WG1 Meeting #82, Beijing, China, 15 August 2015 See sections 2.3.1; and fig. 1.	1,2,6,7,11,12,16,17
A		3-5,8-10,13-15,18-20
Y	LG ELECTRONICS, "Discussion on Resource configuration for low complexity MTC UEs", R1-154229, 3GPP TSG RAN WG1 Meeting #82, Beijing, China, 15 August 2015 See sections 2, 3; and figs. 2, 3.	1,2,6,7,11,12,16,17
A	ZTE, "Further considerations on M-PDCCH for MTC", R1-154432, 3GPP TSG RAN WG1 Meeting #82, Beijing, China, 15 August 2015 See sections 2-3.3.	1-20
A	US 2014-0307560 A1 (LG ELECTRONICS INC.) 16 October 2014 See paragraphs [0102]-[0149]; and figs. 6, 7.	1-20
A	US 2015-0181577 A1 (FUJITSU LIMITED) 25 June 2015 See paragraphs [0145]-[0153]; and fig. 7.	1-20

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 December 2016 (21.12.2016)	**22 December 2016 (22.12.2016)**

Name and mailing address of the ISA/KR	Authorized officer
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/KR2016/010542

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		EP 2779556 A2	17/09/2014
		EP 2779556 A4	05/08/2015
		EP 2779557 A2	17/09/2014
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		KR 10-1612207 B1	12/04/2016
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		WO 2013-066084 A2	10/05/2013
		WO 2013-066084 A3	27/06/2013
US 2015-0181577 A1	25/06/2015	CN 104704766 A	10/06/2015
		EP 2693677 A1	05/02/2014
		JP 2015-527840 A	17/09/2015
		KR 10-2015-0024926 A	09/03/2015
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Declarations under Rule 4.17:

— *as to the identity of the inventor (Rule 4.17(i))*

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(54) **Title**: DEVICE, SYSTEM AND METHOD EMPLOYING UNIFIED FLEXIBLE 5G AIR INTERFACE

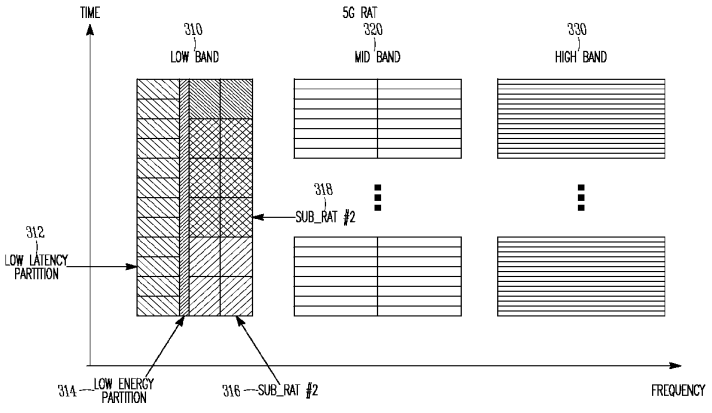


FIG. 3

(57) **Abstract**: An eNodeB (eNB), user equipment (UE) and method of providing a flexible Radio Access Technology (FRAT) are generally described. The information (resource allocation, partition information and numerology) of at least one of a plurality of RATs used by the eNB is provided to a UE. Each RAT has a flexible subcarrier spacing and symbol duration, which are integer multiples of a base subcarrier spacing and symbol duration, and is associated with at least one of different temporal and frequency resources. The symbol and/or frame structure of each RAT are independent. A Transmission Time Interval (TTI) boundary between the RATs is common, and the RATs comprise a common reference TTI duration. The information of the RATs is provided either via a different RAT than the RAT used by the UE for communication or via a dedicated carrier in the RAT used by the UE for communication.

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DEVICE, SYSTEM AND METHOD EMPLOYING UNIFIED FLEXIBLE 5G AIR INTERFACE

PRIORITY CLAIM

[0001] This application claims the benefit of priority to United States Provisional Patent Application Serial No. 62/114,733, filed February 11, 2015, and entitled "UNIFIED FLEXIBLE 5G NEW AIR INTERFACE DESIGN," which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] Embodiments pertain to radio access networks. Some embodiments relate to a unified communication framework using Radio Access Technologies (RAT) in 5th generation (5G) cellular networks.

BACKGROUND

[0003] The use of personal communication devices has increased astronomically over the last several decades. The penetration of mobile devices in modern society has continued to drive demand for a wide variety of networked devices in a number of disparate environments. The variety of available applications, especially video-related applications, has led to a concomitant increase in demand for increased bandwidth beyond that provided by Third Generation Partnership Project Long Term Evolution (3GPP LTE) and LTE advanced (LTE-A) systems.

[0004] The next generation wireless communication system, 5G, may provide access to information and sharing of data using a network that may be required to meet vastly different and sometimes conflicting performance dimensions and services driven by different services and use cases. It is therefore desirable that the next generation communication system be flexible and capable of providing high speed communications services for a wide ambit of devices under a multiplicity of circumstances.

BRIEF DESCRIPTION OF THE FIGURES

[0005] In the figures, which are not necessarily drawn to scale, like numerals may describe similar components in different views. Like numerals having different letter suffixes may represent different instances of similar components. The figures illustrate generally, by way of example, but not by way of limitation, various embodiments discussed in the present document.

[0006] FIG. 1 is a functional diagram of a 3GPP network in accordance with some embodiments.

[0007] FIG. 2 is a block diagram of a 3GPP device in accordance with some embodiments.

[0008] FIG. 3 illustrates one embodiment of a flexible Radio Access Technology (FRAT) of a 5G system in accordance with some embodiments.

[0009] FIG. 4 illustrates a unified frame structure in accordance with some embodiments.

[0010] FIG. 5 illustrates a Transmission Time Interval (TTI) boundary alignment in accordance with some embodiments.

[0011] FIG. 6 illustrates a symbol structure in accordance with some embodiments.

[0012] FIG. 7 illustrates frame structures within a TTI in accordance with some embodiments.

[0013] FIGS. 8A and 8B illustrate flowcharts of a uniform framework utilization method in accordance with some embodiments.

DETAILED DESCRIPTION OF THE INVENTION

[0014] The following description and the drawings sufficiently illustrate specific embodiments to enable those skilled in the art to practice them. Other embodiments may incorporate structural, logical, electrical, process, and other changes. Portions and features of some embodiments may be included in, or substituted for, those of other embodiments. Embodiments set forth in the claims encompass all available equivalents of those claims.

[0015] FIG. 1 is a functional diagram of a 3GPP network in accordance with some embodiments. The network may comprise a radio access network (RAN) (e.g., as depicted, the E-UTRAN or evolved universal terrestrial radio

access network) 100 and the core network 120 (e.g., shown as an evolved packet core (EPC)) coupled together through an S1 interface 115. For convenience and brevity sake, only a portion of the core network 120, as well as the RAN 100, is shown.

[0016] The core network 120 includes mobility management entity (MME) 122, serving gateway (serving GW) 124, and packet data network gateway (PDN GW) 126. The RAN 100 includes eNBs 104 (which may operate as base stations) for communicating with UE 102. The eNBs 104 may include macro eNBs and low power (LP) eNBs.

[0017] The MME is similar in function to the control plane of legacy Serving GPRS Support Nodes (SGSN). The MME manages mobility aspects in access such as gateway selection and tracking area list management. The serving GW 124 terminates the interface toward the RAN 100, and routes traffic packets (such as data packets or voice packets) between the RAN 100 and the core network 120. In addition, it may be a local mobility anchor point for inter-eNB handovers and also may provide an anchor for inter-3GPP mobility. Other responsibilities may include lawful intercept, charging, and some policy enforcement. The serving GW 124 and the MME 122 may be implemented in one physical node or separate physical nodes. The PDN GW 126 terminates a SGi interface toward the packet data network (PDN). The PDN GW 126 routes traffic packets between the EPC 120 and the external PDN, and may be a key node for policy enforcement and charging data collection. It may also provide an anchor point for mobility with non-LTE accesses. The external PDN can be any kind of IP network, as well as an IP Multimedia Subsystem (IMS) domain. The PDN GW 126 and the serving GW 124 may be implemented in one physical node or separated physical nodes.

[0018] The eNBs 104 (macro and micro) terminate the air interface protocol and may be the first point of contact for a UE 102. The eNBs 104 may communicate both with UEs 102 in a normal coverage mode and UEs 104 in one or more enhanced coverage modes. In some embodiments, an eNB 104 may fulfill various logical functions for the RAN 100 including but not limited to RNC (radio network controller functions) such as radio bearer management, uplink and downlink dynamic radio resource management and traffic packet

scheduling, and mobility management. In accordance with some embodiments, UEs 102 may be configured to communicate via orthogonal multiple access (OMA) communications such as Time Division Multiple Access (TDMA), Frequency Division Multiple Access (FDMA) Orthogonal FDMA (OFDMA), SC-FDMA or other communication signals with an eNB 104 over a multicarrier communication channel in accordance with the appropriate communication technique. The OFDM signals may comprise a plurality of orthogonal subcarriers. In accordance with some embodiments, UEs 102 may be configured to communicate via non-orthogonal multiple access (NOMA) signals.

[0019] The S1 interface 115 is the interface that separates the RAN 100 and the EPC 120. It is split into two parts: the S1-U, which carries traffic packets between the eNBs 104 and the serving GW 124, and the S1-MME, which is a signaling interface between the eNBs 104 and the MME 122.

[0020] With cellular networks, LP cells are typically used to extend coverage to indoor areas where outdoor signals do not reach well, or to add network capacity in areas with very dense phone usage, such as train stations. As used herein, the term low power (LP) eNB refers to any suitable relatively low power eNB for implementing a narrower cell (narrower than a macro cell) such as a femtocell, a picocell, or a micro cell. Femtocell eNBs are typically provided by a mobile network operator to its residential or enterprise customers. A femtocell is typically the size of a residential gateway or smaller and generally connects to the user's broadband line. Once plugged in, the femtocell connects to the mobile operator's mobile network and provides extra coverage in a range of typically 30 to 50 meters for residential femtocells. Thus, a LP eNB might be a femtocell eNB since it is coupled through the PDN GW 126. Similarly, a picocell is a wireless communication system typically covering a small area, such as in-building (offices, shopping malls, train stations, etc.), or more recently in-aircraft. A picocell eNB can generally connect through the X2 link to another eNB such as a macro eNB through its base station controller (BSC) functionality. Thus, LP eNB may be implemented with a picocell eNB since it is coupled to a macro eNB via an X2 interface. Picocell eNBs or other LP eNBs may incorporate some or all functionality of a macro eNB. In some cases, this may be referred to as an access point base station or enterprise femtocell.

[0021] As indicated in more detail below, communication over a 4G LTE network may be split up into 10ms frames, each of which may contain ten 1ms subframes. Each subframe of the frame, in turn, may contain two slots of 0.5ms. The eNB may schedule uplink and downlink transmissions over a variety of frequency bands. The allocation of resources in subframes used in one frequency band and may differ from those in another frequency band. Each slot of the subframe may contain 6-7 symbols, depending on the system used. In some embodiments, the subframe may contain 12 or 24 subcarriers. A resource grid may be used for downlink and uplink transmissions between an eNB and a UE. The resource grid may be a time-frequency grid, which is the physical resource in each slot. The smallest time-frequency unit in a resource grid may be denoted as a resource element (RE). Each column and each row of the resource grid may correspond to one OFDM symbol and one OFDM subcarrier, respectively. The resource grid may contain resource blocks (RBs) that describe the mapping of physical channels to resource elements and physical RBs (PRBs). A PRB may be the smallest unit of resources that can be allocated to a UE in the current 3GPP standard. A resource block may be 180 kHz wide in frequency and 1 slot long in time. In frequency, resource blocks may be either 12 x 15 kHz subcarriers or 24 x 7.5 kHz subcarriers wide. For most channels and signals, 12 subcarriers may be used per resource block, dependent on the system bandwidth. The duration of the resource grid in the time domain corresponds to one subframe or two resource blocks. Each resource grid may comprise 12 (subcarriers) *14 (symbols) =168 resource elements for normal cyclic prefix (CP) case. Several different physical channels may be conveyed using such resource blocks. As discussed in more detail below, in a 5G network, the sizes of the resource blocks, resource elements, and symbols, among others, may vary.

[0022] There may be several different physical downlink channels that are conveyed using such resource blocks, including the physical downlink control channel (PDCCH) and the physical downlink shared channel (PDSCH). Each subframe may contain a PDCCH, physical hybrid-ARQ indicator channel (PHICH), physical control format indicator channel (PCFICH) and the PDSCH. The PDCCH may normally occupy the first up to three symbols (four in the case

of narrow bandwidths of 1.4MHz) of each subframe and carry, among other things, information about the transport format and resource allocations related to the PDSCH channel and uplink scheduling grants for a physical uplink shared channel (PUSCH) transmission. The PHICH may be used to signal HARQ information in response to a PUSCH transmission. The PCFICH may inform the UE the control region size (e.g. one, two or three OFDM symbols) in each downlink subframe. The PDSCH may carry user data and higher layer signaling to a particular UE and occupy the remainder of the downlink subframe to avoid the resources in which downlink control channels (PDCCH/PHICH/PCFICH) are transmitted. Typically, downlink scheduling (assigning control and shared channel resource blocks to UEs within a cell) may be performed at the eNB based on channel quality information provided by the UEs, and then the downlink resource assignment information may be sent to a scheduled UE on the PDCCH used for (assigned to) PDSCH reception of the UE.

[0023] The PDCCH may contain downlink control information (DCI) in one of a number of formats that tell the UE where to find and how to decode the data, transmitted on PDSCH in the same subframe, from the resource grid. The DCI may provide details such as the number of resource blocks, resource allocation type, modulation scheme, transport block, redundancy version, coding rate etc. Each DCI format may have a cyclic redundancy code (CRC) and be scrambled with a Radio Network Temporary Identifier (RNTI) that identifies the target UE for which the PDSCH is intended. Use of the RNTI, which may be UE-specific, may limit decoding of the DCI information (and hence the corresponding PDSCH) to only the intended UE. The PDCCH may be located in any of a number of frequency/temporal regions, depending on whether the PDCCH is UE-Specific or common, as well as the aggregation level. The set of possible candidate locations for the PDCCH is defined in terms of search spaces. A search space is defined by a set of Control Channel Element (CCE) candidates with a number of aggregation level $L \in \{1,2,4,8\}$ where the UE may monitor to find its PDCCHs. A common search space may carry DCIs that are common for all UEs; for example, system information (using the SI-RNTI), paging (P-RNTI), PRACH responses (RA-RNTI), or UL TPC commands (TPC-PUCCH/PUSCH-RNTI). A UE-specific search space may carry DCIs for UE-

specific allocations using a Cell Radio-Network Temporary Identifier (C-RNTI) assigned to the UE, a semi-persistent scheduling (SPS C-RNTI), or an initial allocation (temporary C-RNTI). When configuring an SPS (either uplink or downlink), the SPS C-RNTI is provided by the eNB and the UE is configured by higher layers to decode a PDCCH with a CRC scrambled by the SPS C-RNTI. The UE may monitor the PDCCH having a CRC scrambled by the SPS C-RNTI in every subframe as the eNB can activate/re-activate/release the SPS at any time using a DCI format with a CRC scrambled by an SPS C-RNTI. The received DCI format with a CRC scrambled by the SPS C-RNTI can be a grant/assignment for a retransmission or for activation/re-activation/release of the SPS. 3GPP Technical Specification 36.213 has tabulated the validation procedure for activation/re-activation/release of SPS.

[0024] In addition to the PDCCH, an enhanced PDCCH (EPDCCH) may be used by the eNB and UE. The PDSCH may thus contain data in some of the resource blocks (RBs) and then EPDCCH contains the downlink control signals in others of the RBs of the bandwidth supported by the UE. Different UEs may have different EPDCCH configurations. The sets of RBs corresponding to EPDCCH may be configured, for example, by higher layer signaling such as Radio Resource Control (RRC) signaling for EPDCCH monitoring.

[0025] The Physical Uplink Control Channel (PUCCH) may be used by the UE to send Uplink Control Information (UCI) to the eNB. The PUCCH may be mapped to an UL control channel resource defined by an orthogonal cover code and two resource blocks (RBs), consecutive in time, with hopping potentially at the boundary between adjacent slots. The PUCCH may take several different formats, with the UCI containing information dependent on the format. Specifically, the PUCCH may contain a scheduling request (SR), acknowledgement responses/retransmission requests (ACK/NACK) or a Channel Quality Indication (CQI)/Channel State Information (CSI). The CQI/CSI may indicate to the eNB an estimate of the current downlink channel conditions as seen by the UE to aid channel-dependent scheduling and, if one MIMO transmission mode is configured to the UE, may include MIMO-related feedback (e.g. Precoder matrix indication, PMI).

[0026] FIG. 2 is a functional diagram of a 3GPP device in accordance with some embodiments. The device may be a UE or eNB, for example. In some embodiments, the eNB may be a stationary non-mobile device. The 3GPP device 200 may include physical layer circuitry 202 for transmitting and receiving signals using one or more antennas 201. The 3GPP device 200 may also include medium access control layer (MAC) circuitry 204 for controlling access to the wireless medium. The 3GPP device 200 may also include processing circuitry 206 and memory 208 arranged to perform the operations described herein.

[0027] In some embodiments, mobile devices or other devices described herein may be part of a portable wireless communication device, such as a personal digital assistant (PDA), a laptop or portable computer with wireless communication capability, a web tablet, a wireless telephone, a smartphone, a wireless headset, a pager, an instant messaging device, a digital camera, an access point, a television, a medical device (e.g., a heart rate monitor, a blood pressure monitor, etc.), or other device that may receive and/or transmit information wirelessly. In some embodiments, the mobile device or other device can be a UE 102 or eNB 104 configured to operate in accordance with 3GPP standards. In some embodiments, the mobile device or other device may be configured to operate according to other protocols or standards, including IEEE 802.11 or other IEEE standards. In some embodiments, the mobile device or other device may include one or more of a keyboard, a display, a non-volatile memory port, multiple antennas, a graphics processor, an application processor, speakers, and other mobile device elements. The display may be an LCD screen including a touch screen.

[0028] The antennas 201 may comprise one or more directional or omnidirectional antennas, including, for example, dipole antennas, monopole antennas, patch antennas, loop antennas, microstrip antennas or other types of antennas suitable for transmission of RF signals. In some multiple-input multiple-output (MIMO) embodiments, the antennas 201 may be effectively separated to take advantage of spatial diversity and the different channel characteristics that may result.

[0029] Although the 3GPP device 200 is illustrated as having several separate functional elements, one or more of the functional elements may be combined and may be implemented by combinations of software-configured elements, such as processing elements including digital signal processors (DSPs), and/or other hardware elements. For example, some elements may comprise one or more microprocessors, DSPs, field-programmable gate arrays (FPGAs), application specific integrated circuits (ASICs), radio-frequency integrated circuits (RFICs) and combinations of various hardware and logic circuitry for performing at least the functions described herein. In some embodiments, the functional elements may refer to one or more processes operating on one or more processing elements.

[0030] Embodiments may be implemented in one or a combination of hardware, firmware and software. Embodiments may also be implemented as instructions stored on a computer-readable storage device, which may be read and executed by at least one processor to perform the operations described herein. A computer-readable storage device may include any non-transitory mechanism for storing information in a form readable by a machine (e.g., a computer). For example, a computer-readable storage device may include read-only memory (ROM), random-access memory (RAM), magnetic disk storage media, optical storage media, flash-memory devices, and other storage devices and media. Some embodiments may include one or more processors and may be configured with instructions stored on a computer-readable storage device.

[0031] The term "machine readable medium" may include a single medium or multiple media (e.g., a centralized or distributed database, and/or associated caches and servers) configured to store one or more instructions. The term “machine readable medium” may include any medium that is capable of storing, encoding, or carrying instructions for execution by the 3GPP device 200 and that cause it to perform any one or more of the techniques of the present disclosure, or that is capable of storing, encoding or carrying data structures used by or associated with such instructions. The term “transmission medium” shall be taken to include any intangible medium that is capable of storing, encoding or carrying instructions for execution, and includes digital or analog

communications signals or other intangible medium to facilitate communication of such software.

[0032] As above, the upcoming 5G wireless communications technology systems may have a number of unique challenges, including carrying the inherent ability to provide different performances requirements for numerous different types of wireless devices. Higher data rates in particular may continue to drive network development and evolution for 5G system. It may be desirable for a 5G system to support a peak data rate of more than 10Gps and a minimum guaranteed user data rate of at least 100Mbps. In addition, it may be desirable for the 5G system to support the huge increase in variety and number of Internet of Things (IoT) and Machine-Type Communication (MTC)-type devices. MTC devices have been increasingly employed for different applications, using low operational power consumption and infrequent small burst transmissions. Moreover, it may be desirable for the 5G system to provide an extremely high level of reliable connectivity with guaranteed low latency, availability and reliability-of-service for mission critical MTC use cases.

[0033] In general, 5G systems may use a plurality of Radio Access Technologies (RATs), unlike previous 2G, 3G and 4G, systems. For example, an enormous amount of spectrum may be available through the use of higher frequency bands. In one example, the use of millimeter wave (mmWave) frequency bands ranging from 30 to 300GHz may provide the desired scalability, capacity and density for the 5G system. In this case, a new RAT may be defined for the mmWave band to achieve low latency and higher peak data rate. The RAT for mmWave band communications may differ from the RAT for one or more of the other frequency bands used to provide communication services. In some embodiments, the RATs may be used simultaneously by a single eNB for communications with different UEs.

[0034] In some embodiments, a 5G system may be provided that contains multiple RATs in a unified framework to support diverse applications, use cases and services and inter-networking in multiple frequency bands, including both licensed and unlicensed frequency bands. The RATs used in the licensed and unlicensed may be independent of each other. In some embodiments, flexible subcarrier spacing and symbol duration (i.e., configurable

numerology) may be provided across the frequency bands used in the 5G system. In addition, the 5G system may include mechanisms to multiplex multiple RATs, sub-RATs and other partitions in different or the same frequency resource or frequency bands.

[0035] The inter-networking in the unified frame structure may include, in some embodiments, a Transmission Time Interval (TTI) boundary alignment between multiple RATs may be provided to allow seamless scheduling, fallback and support of different RATs. In some embodiments, a TTI is the smallest unit of time in which the eNB is capable of scheduling any UE for uplink or downlink transmission. In some embodiments, the TTI boundary alignment may occur at a subframe or frame boundary. As used herein, a unified RAT with flexible air interface for the 5G system is referred to as a flexible Radio Access Technology (FRAT). A UE that communicates with an eNB operating using the FRAT may remain using a single air interface technology (i.e., RAT) or may switch between different RATs.

[0036] In some embodiments, a unified RAT with configurable numerologies may be used in the 5G system in which a base subcarrier spacing (Δf) and symbol duration (T) can be defined in the FRAT. In one example, to maintain the backward compatibility for existing LTE and LTE-Advanced systems, a base subcarrier spacing and symbol duration can be specified as Δf = 15KHz and T=66.7μs. Moreover, for convenience in some embodiments a single oscillator may be used, with the subcarrier spacing and symbol duration for different RATs specified as an integer number of the base subcarrier spacing and symbol duration, respectively.

[0037] Similarly, when a low latency use case and service is desired, a shortened symbol duration may be employed to reduce the latency by using larger subcarrier spacing. The subcarrier spacing and symbol duration may in this case be defined as $\Delta f_i = K*\Delta f$ and $T_i=(1/K)*T$. In one example, for frequency band between 6GHz and 30GHz, K can be chosen as 10, leading to a subcarrier spacing and symbol duration of 150KHz and 6.67μs, respectively. This may result in a 0.1ms TTI for low latency use case. In another example, for frequency bands below 6GHz, which includes the current LTE frequency range,

K can be selected by the network to be 2 or 4, and the corresponding subcarrier spacing and symbol duration changed proportional to the selected K value. Alternatively, the same subcarrier spacing and symbol duration can be defined for frequency bands below 6GHz (i.e., K =1), but a shorter TTI can be considered, e.g., with a fewer number of symbols, to support low latency use cases.

[0038] To efficiently support a massive number of MTC devices used in the 5G network, in other embodiments, the subcarrier spacing and symbol duration can be defined as $\Delta f_i = (1/K)*\Delta f$ and $T_i=K*T$. In such embodiments, K can be selected to be 10, and the subcarrier spacing and symbol duration 1.5KHz and 667μs, respectively. In this case, the subframe duration for MTC use cases can be defined to be 10ms, in the current generation LTE systems the length of a typical frame, rather than the typical 1ms. This may reduce the power consumption of MTC UEs by reducing the amount of time the MTC UE is active, thereby increasing the battery life of the MTC UEs.

[0039] A UE may be initially assigned the appropriate RAT by the eNB or other network device (such as the MME). In some embodiments, the UE may be configurable to communicate using any of the RATs, as indicated via the eNB, and can configure the subcarrier spacing and symbol duration accordingly. In some embodiments, the UE may be limited to communicating only using a subset of the RATs, and perhaps only a single RAT, e.g., when the UE is an MTC UE having a limited bandwidth and capabilities. The RAT may depend on the type of UE as well as the operating mode of the UE. For example, some UEs may change mode between a normal mode and an enhanced coverage mode in situations in which the link budget to the nearest serving eNB is worse than a typical link budget value in the network and additional link budget is to be obtained without increasing transmission power. Enhanced coverage mode may be employed by a variety of UEs, including a normal UE (e.g., a smartphone or the like), a machine-to-machine (M2M) UE or a stationary wireless UE (i.e., a UE that remains indefinitely in a single location) using MTC. The UE may determine whether additional link budget is desired, as well as how much additional link budget is desired, and enter an appropriate enhanced coverage mode (that provides the appropriate additional link budget). The different

enhanced coverage modes may correspond to different RATs. Some UEs, such as low cost, low complexity MTC UEs, further may be band limited and operate in a narrow bandwidth of e.g., to 1.4 MHz, for both control and data channels, leading to the ability to operate, e.g., in a single RAT unless the RAT is modified by the network.

[0040] FIG. 3 illustrates one embodiment of a FRAT of a 5G system in accordance with some embodiments. The FRAT 300 may contain one or more partitions in different frequency band regions 310, 320, 330. In one example, the low frequency band 310 may include frequencies used in 4G systems (up to 6 GHz), the mid-frequency band 320 may include higher frequencies (e.g., 6-30 GHz) and the high frequency band 330 may include the highest frequencies in the 5G system (e.g., mmWave, above 30 GHz). Although the RATs of only a low frequency band 310, a mid-frequency band 320, and a high frequency band 330 are shown, any number of RATs of different frequency bands may exist. The various RATs in frequency bands may each have a subcarrier spacing and symbol duration that is independent of the subcarrier spacing and symbol duration of another RAT in another frequency band (i.e., the RATs have configurable numerologies). Moreover, within each frequency band, one or more sub-RATs and partitions 312, 314, 316, 318 may be present with each sub-RAT or partition 312, 314, 316, 318 having a subcarrier spacing and symbol duration independent of the subcarrier spacing and symbol duration of another sub-RAT or partition 312, 314, 316, 318 and independent of the RAT in other frequency bands. As shown in FIG. 3, the sub_RATs 316, 318 in the low frequency band 310 may have the same subcarrier spacing and symbol duration and may be separated by frequency and/or time, while partitions 312, 314 may have different subcarrier spacings and symbol durations from each other and the sub_RATs 316, 318 and may be separated by frequency and/or time. Although the low frequency band 310 is shown as having multiple partitions 312, 314 and sub_RATs 316, 318, the mid frequency band 320 is shown as having two sub_RATs and the high frequency band 330 is shown as having no sub_RATs, the eNB may establish the number and type of RATs used within a particular frequency band differently.

[0041] In some embodiments, RATs and sub-RATs with same or different numerologies can be multiplexed. The multiplexing may be via Time-Division Multiplexing (TDM), Frequency-Division Multiplexing (FDM), code-division multiplex (CDM), spatial division multiplex (SDM), other possible orthogonal or non-orthogonal multiplexing schemes, or any combination thereof. For example, multiple RATs, sub-RATs or partitions with same or different numerologies can be multiplexed in a TDM manner. Each RAT, sub-RAT and partition may have a numerology, access scheme and modulation scheme that is independent of the numerology, access scheme and modulation scheme of the other RATs, sub-RATs and partitions. The numerologies, resource allocation and partition information in the time domain can be predefined or configured by higher layer signaling, e.g. via a Master Information Block (MIB), System Information Block (SIB) or UE-specific dedicated RRC signaling. If a MIB is used to indicate the partition configuration for multiple RATs, sub-RATs or partitions, the resource for the transmission physical broadcast channel (PBCH) used to carry the MIB may be predefined and known at the UEs. In some embodiments, the PBCH may be transmitted in a predetermined RAT, independent of the UE or number of RATs, sub-RATs or partitions supported. Once the UE receives the configuration information via the PBCH on the predetermined RAT, the UE may use a different RAT for further control and data communications; that is, the predetermined RAT and the RAT used by the UE to communicate may be independent.

[0042] In some embodiments, multiple RATs, sub-RATs or partitions with same or different numerologies can be multiplexed in a FDM manner. To minimize the interference between multiple RATs, sub-RATs or partitions with different numerologies, guard bands may be inserted at the edge of frequency resources allocated for the RATs, sub-RATs or partitions. Similar to the above, the numerologies and/or resource partition for multiple RATs, sub-RATs or partitions may be predefined or configured by high layer signaling via a MIB, SIB or UE-specific dedicated RRC signaling.

[0043] In embodiments in which numerologies and/or resource partition for multiple RATs, sub-RATs or partitions is predefined or dedicated carriers are allocated for different RATs, a dedicated downlink synchronization signal and

PBCHs may be transmitted on each RAT, sub-RAT or partition. In embodiments in which the numerologies and/or resource partition for multiple RATs, sub-RATs or partitions is configured using a MIB or SIB, a single MIB or SIB may be transmitted on one of the RAT, sub-RAT or partition. After successfully decoding the MIB or SIB, the UEs may be able to derive the resource information or numerologies for other RATs, sub-RATs or partitions. Thus, information provided from the eNB to the UE via a single transmission in a particular RAT, sub-RAT or partition may enable communications using different RATs, sub-RATs or partitions.

[0044] Particular RATs/sub-RATs/partitions may be used for different types of communications, with each having independently sized resource blocks. For example, as shown, the resources in a first partition 312 may be used for low-latency communications while the resources in a second partition 314 may be used for low energy communications. The first and second partitions 312, 314 may be multiplexed, as shown, using FDM such that the first and second partitions 312, 314 occupy the same time but different frequency resources. The first partition 312 may be associated with low latency communications in which the UE operates in a low latency mode and may have a short symbol duration and TTI, while the second partition 314 may be associated with low energy communications in which the UE operates in a low energy mode and may have a long symbol duration and TTI.

[0045] Other sub-RATs 316, 318 may similarly be FDM multiplexed with the first and second partitions 312, 314 and TDM multiplexed with each other. The sub-RATs 316, 318 may have a symbol duration and TTI between those associated with the first and second partitions 312, 314.

[0046] The RATs 320, 330 for the mid- and high- frequency band may be supported simultaneously with each other and the RAT 310 for low frequency band, while maintaining TTI boundary alignment between the different RATs 310, 320, 330. The RATs 320, 330 may similarly be FDM multiplexed with the first and second partitions 312, 314 and sub-RATs 316, 318. The RATs 320, 330 may have a symbol duration and TTI smaller than those associated with the first partition 312. As shown in FIG. 3, in some embodiments, the amount of temporal and/or frequency resources associated with the different RATs, sub-

RATs and partitions may differ among the different types, and the same type may be associated either with different amounts of temporal and/or frequency resources (e.g., as partitions 312, 314) or the same amount of temporal and/or frequency resources (e.g., as sub-RATs 316, 318). A given frequency and temporal range may be associated with a particular frame and symbol structure (as well as subcarrier spacing and symbol duration), with the frame and symbol structures of the frequency and temporal range independent of the frame and symbol structures of other frequency and temporal ranges.

[0047] FIG. 4 illustrates a unified frame structure in accordance with some embodiments. The unified frame structure contains frames 400, subframes 410, slots 420 and symbols 430. More specifically, each frame 400 may contain L subframes of equal duration and have an overall duration of X ms. Each subframe 410 may similarly comprise N slots of equal duration and have an overall duration of Y ms. Each slot may, in turn, comprise M symbols of equal duration. The slot and symbol durations may be different between subframes of different RATs depending on specific use cases, frequency bands and deployment scenarios. The frame structure of each of RAT may be independent of the frame structure of the other RATs. Thus, a particular RAT may have one or more of different L, N and/or M values, as well as different X and/or Y values, as the other RATs. This may also apply to the sub-RATs and partitions shown in FIG. 3.

[0048] FIG. 5 illustrates a Transmission Time Interval (TTI) boundary alignment in accordance with some embodiments. In some embodiments of the unified frame structure, it may be beneficial from a simplified design standpoint to periodically align the TTI boundary 530 between different RATs 510, 520, e.g., at a particular subframe or frame boundary after a predetermined number of subframes or frames. Thus, in some embodiments an integral number of TTIs 540 of a RAT 510 having a smaller TTI duration (low latency RAT) may be disposed within a single TTI 550 of a RAT 520 having a larger TTI duration. In the example shown in FIG. 5, the smaller TTI duration RAT 510 may have a TTI 540 of 0.1ms while the larger TTI RAT 520 may have a TTI 550 of 1ms. By implementing a TTI of 1ms, a low latency RAT TTI may align with the existing LTE specification TTI boundary. Having a common TTI boundary may support

cross-carrier/RAT scheduling for high frequency band RATs from low frequency band RATs based an anchor booster architecture. This is to say that, in some embodiments for cross-carrier/RAT scheduling, as shown a common PDCCH may be used to schedule other RATs, with the UE switching to a particular RAT to obtain the scheduling and then switching to another RAT to communicate and perhaps to obtain further scheduling information using that RAT. In some embodiments, the other RAT may contain a PDCCH for additional scheduling, while in other embodiments the other RAT may not contain a PDCCH, in which case the UE may periodically switch to the scheduling RAT to obtain scheduling information for the other RAT. In some embodiments, a UE may obtain initial scheduling information (e.g., when it initially powers on or otherwise accesses the eNB) from the initial RAT (e.g., a conventional 4G system RAT) and from then on, after switching to its assigned RAT, obtains scheduling information using that RAT. In other embodiments, each RAT may contain a PDCCH and scheduling is performed for the UE operating on the RAT. A licensed low frequency band RAT may provide reliable coverage for control signaling as an anchor cell, using the PDCCH shown in FIG. 5, while a high frequency band RAT may provide opportunistic boosting in data rate when channel conditions are favorable as booster cell.

[0049] FIG. 6 illustrates a symbol structure in accordance with some embodiments. FIG. 6 shows an OFDM symbol 610 and a unique word (UW) OFDM symbol 620. Each OFDM symbol 610 may contain a cyclic prefix (CP) 612 that comprises a replication of the initial portion of the OFDM symbol 610. The CP 612 may range in size from 1/4 to 1/32 of the symbol period 614. The CP 612 may be disposed at the end of the symbol or outside the symbol, depending on specific waveform, thereby creating a guard between the symbol and the adjacent symbol. In some embodiments, when OFDM downlink and SC-FDMA uplink waveforms are selected for a 5G RAT, the CP 612 may be inserted outside the symbol 610. In embodiments in which a UW OFDM symbol 620 or UW Discrete Fourier transform-Spread-Orthogonal Frequency Division Multiplexing (UW-DFT-s-OFDM) symbol is used, the UW 622 may be inserted within one symbol duration 624. The symbol structure may be independent for each of the RATs, such that whether or not a particular RAT a

CP or UW and whether the CP or UW is outside or within a symbol is independent of the symbol structure of any other RAT.

[0050] As shown in FIG. 6, the UW-OFDM 620 may be used to support different UW lengths based on different channel delay spreads while maintaining the same symbol duration (or FFT size). This enables both shorter UW 622 and longer UW 626 to be used in the same size symbol 624 as the UW 622, 624 is inserted within the FFT instead of being adding after the FFT size. The ability to maintain the same symbol duration may provide a greater flexibility to support a unified RAT design. In one example, using an OFDM symbol for a low frequency band (below 6GHz), a subcarrier spacing of 60KHz (i.e., K = 4, Δf =60KHz) may be used to achieve a 0.1ms TTI. This translates to OFDM symbols of T=16.7μs (66.7μs/K). Thus, 5 OFDM symbols may be able to be accommodated within one subframe (83.5μs) with a CP length of approximately 3.3μs (0.1ms - 83.5μs =16.5μs/5 CPs).

[0051] FIG. 7 illustrates frame structures within a TTI in accordance with some embodiments. In FIG. 7, various TTIs 710, 720, 730, 740 are illustrated in which the TTIs 710, 720, 730, 740 comprise UW-OFDM waveforms. The first TTI 710 shown in FIG. 7 may comprise a UW 712 and symbol 714 of typical length. In this example, the subcarrier spacing may be 15KHz and the symbol duration 716 may be 66.7μs. A total of 3 OFDM symbols 716 may be present in a TTI 710 of 200μs.

[0052] The second TTI 720 shown in FIG. 7 may comprise a low latency TTI 720 with short symbol duration. Such a TTI 720 can be used for use cases such as mission critical MTC applications and Vehicle–to-Vehicle applications, among others. The UW 722 and symbol 724 may each be smaller than the first TTI 710. In this example, the subcarrier spacing may be 30KHz and the symbol duration 726 may be 33.3μs. For a TTI 720 of the same length as the first TTI (e.g., 200μs), a total of 6 short OFDM symbols 726 may be present.

[0053] The third TTI 730 shown in FIG. 7 may comprise another low latency TTI 730 similar to the low latency TTI 720. The UW 732 and symbol 734 may each be smaller than the first TTI 710, the subcarrier spacing may be 30KHz and the symbol duration 736 may be 33.3μs. However, in this example

the TTI 730 may only be half the length as the first TTI (i.e., 100μs), corresponding to a total of 3 short OFDM symbols 736.

[0054] The fourth TTI 740 shown in FIG. 7 may comprise a low energy TTI 740, e.g., for use by MTC UEs. The UW 742 and symbol 744 may each have a longer duration smaller than the first TTI 710. In one example, the subcarrier spacing may be 5KHz and the symbol duration 746 may be 200μs. In this example, the TTI 740 may be 1ms, corresponding to a total of 5 long OFDM symbols 746.

[0055] The above TTIs 710, 720, 730, 740 may be FDM or TDM multiplexed based on the FRAT design. One or more of the UW-OFDM waveforms may be replaced by other waveforms so long as the same symbol duration is maintained. Other examples of OFDM waveforms may include ZT-OFDM and UW-DFTs-OFDM, among others. When different waveforms are used in the same carrier, multi-RATs can be supported where each RAT may have different waveform design. In some embodiments, existing LTE waveforms may be reused, i.e., OFDM waveforms may be used for downlink and SC-FDMA waveforms may be used for uplink communications. In some embodiments, OFDM may be used both downlink and uplink communications. In some embodiments, UW-based waveforms may be used both downlink and uplink communications. For example, UW-OFDM waveforms may be used for downlink communications and UW-DFT-s-OFDM waveforms may be used for uplink communications or either UW-OFDM or UW-DFT-s-OFDM waveforms may be used for both downlink and uplink communications. In some embodiment, filtered OFDM and filter-bank multiple carrier (FBMC) may be used. FBMC waveforms are produced using a nonrectangular sub-channel pulse shape in the time domain during OFDM-offset quadrature amplitude modulation (OQAM) transmission (in which the real part of QAM symbols are mapped to ½ of the multi-carrier symbols and the imaginary parts are mapped to an interlaced 1/2 of the multi-carrier symbols) and may lack a CP.

[0056] Tables 1-3 below illustrate various examples of 5G numerology.

Frequency Band	Subcarrier spacing	TTI	DL waveform	UL waveform

<3GHz (low power or MTC)	1.5KHz	10ms	OFDM	SC-FDMA
<3GHz	15KHz	1ms	OFDM	SC-FDMA
[3-6]GHz	75KHz	0.2ms	UW-OFDM	UW-DFT-s-OFDM
[6-30]GHz	480KHz	0.1ms	UW-OFDM	UW-DFT-s-OFDM
>30GHz	1.5MHz	0.1ms	DFT-s-OFDM	DFT-s-OFDM

Table 1: First 5G numerology example

Frequency Band	Subcarrier spacing	TTI	DL waveform	UL waveform
<3GHz (low power or MTC)	1.5KHz	10ms	UW-OFDM	UW-OFDM
<3GHz	15KHz	1ms	UW-OFDM	UW-OFDM
[3-6]GHz	75KHz	0.2ms	UW-OFDM	UW-OFDM
[6-30]GHz	480KHz	0.1ms	UW-DFT-s-OFDM	UW-DFT-s-OFDM
>30GHz	1.5MHz	0.1ms	OFDM	OFDM

Table 2: Second 5G numerology example

Frequency Band	Subcarrier spacing	TTI	DL waveform	UL waveform
<3GHz (low power or MTC)	1.5KHz	10ms	OFDM	OFDM
<3GHz	15KHz	1ms	OFDM	OFDM
[3,6]GHz	75KHz	0.2ms	OFDM	OFDM
[6,30]GHz	480KHz	0.1ms	UW-DFT-s-OFDM	UW-DFT-s-OFDM
>30GHz	1.5MHz	0.1ms	UW-DFT-s-OFDM	UW-DFT-s-OFDM

Table 3: Third 5G numerology example

[0057] FIGS. 8A and 8B illustrate flowcharts of a uniform framework utilization method in accordance with some embodiments. FIG. 8A in particular illustrates a flowchart of a uniform framework utilization method of an eNB such as the eNB shown in FIGS. 1 or 2 in accordance with some embodiments. As shown in FIG. 8A, the eNB may determine the unified framework at operation 802. The unified framework may include access scheme, modulation

scheme, frame structure, symbol structure, and configurable numerology including subcarrier spacing and symbol duration. The different frame and symbol structures may be associated with different temporal and/or frequency resources multiplexed respectively in a TDM or FDM manner.

[0058] At operation 804, the eNB may communicate specific unified framework configuration information of a particular RAT to one or more UEs serviced by the eNB. Different RAT information may be provided to different UEs attached to the eNB, in which different RATs may be associated with different frequency bands and/or time spans. The eNB may determine the configuration information to be provided to a particular UE based on the device type and/or data to be communicated between the UE and the eNB. The frequency bands may include both licensed and unlicensed frequency bands. The RAT information may include access and modulation scheme, frame and symbol structure, as well as numerology. The RAT information may also include resource allocation and partition information. The unified framework configuration information provided to each UE may be independent of the unified framework configuration information provided to any other UE. The RAT indicated by the eNB to the UE may be dependent on the type and/or operating mode of the UE.

[0059] The eNB may communicate with the UE at operation 806 using the RAT provided at operation 804. The information may include data and/or control information. For example, downlink communications from the eNB to the UE may include paging or control signals for channel estimation on the PDCCH and voice or video data from another UE on the PDSCH. The RAT information may be provided using a dedicated RAT that is different from the RAT used for communication with the UE or using a dedicated carrier on the RAT used for communication with the UE.

[0060] The eNB may, subsequent to communicating with the UE, receive an indication from the UE of a change of operating state of the UE at operation 808. The UE may, for example, be configured to operate in one or more of a normal mode, a low latency and low energy mode. The eNB may, at operation 804, assign the RAT to the UE based on the initial mode of the UE and

determine that an update of the operation mode of the UE has occurred at operation 808.

[0061] In response to determining at operation 808 that an update of the operation mode of the UE has occurred, the eNB may determine a new RAT and transmit the updated unified framework configuration information of the new RAT to the UE at operation 810. The new RAT may include a different frame and/or symbol structure and use a different frequency spectrum and/or time range. The eNB may then continue to communicate with the UE at operation 806.

[0062] FIG. 8B illustrates a uniform framework utilization method as performed by a UE in accordance with some embodiments. The UE may be the UE shown in FIGS. 1 or 2 and may attach to the eNB prior to communicating data. During the attachment, the UE may transmit the initial operation conditions to the eNB at operation 812. In particular, the UE may provide a UE type and/or operating mode during attachment. For example, the UE may be a MTC UE. The UE may moreover be configured to operate in a low latency and/or low energy mode. In some embodiments, a MTC UE may operate in an enhanced coverage, low energy mode.

[0063] In response to transmitting the operating conditions, unified framework configuration (RAT) information may be received by a particular UE at operation 814. The RAT information may be dependent on the type and/or operating mode of the UE. The RAT may be associated with a particular frequency band and/or time range. For example, when the UE operates in the low latency mode, a larger subcarrier spacing and shorter symbol duration may be indicated by the unified framework configuration information; while when the UE operates in the low energy mode, a smaller subcarrier spacing and longer symbol duration may be indicated by the unified framework configuration information.

[0064] Once the RAT received by the UE, the UE may then communicate using the RAT at operation 816. The UE may, for example, adjust FFT operating conditions and processing to meet the RAT information provided at operation 814. The UE may communicate with the eNB or may communicate directly with other UEs using device-to-device communication (D2D)

communication. The information may include uplink and downlink data and/or control information. For example, the information may include uplink communications of voice or video data for another UE or measurements of control signals for channel estimation.

[0065] The UE may, subsequent to communicating with the eNB, determine that a change of operating conditions is warranted at operation 818. For example, the UE may transition between the normal and enhanced coverage/low energy mode dependent on UE location, or between the normal and low latency mode dependent on the type of communication to transmit.

[0066] In response to determining that a change of operating conditions is warranted at operation 818, at operation 820 the UE may transmit an indication to the eNB indicating the change of operating state of the UE. The UE may instead determine that a change of operating conditions is desired at operation 820 and wait to change operating state until a new RAT is assigned to the UE.

[0067] In response to transmitting the indication at operation 820, the UE may return to operation 814 and receive a new RAT at operation 810. The new RAT may include a different frame and/or symbol structure and use a different frequency spectrum and/or time range. The eNB may then continue to communicate with the UE at operation 816.

[0068] Various examples of the disclosure are provided below. These examples are not intended to in any way limit the disclosure herein. In Example 1, user equipment (UE) may comprise processing circuitry configured to: configure a transceiver to receive a resource allocation from a network using a first Radio Access Technology (RAT), the first RAT selected from a plurality of RATs of a flexible RAT (FRAT) employed by the network, the plurality of RATs of the FRAT each comprising configurable numerology with flexible subcarrier spacing and symbol duration and associated with at least one of different temporal and frequency resources, the transceiver configurable to communicate using the plurality of RATs and configure the subcarrier spacing and symbol duration based on the numerology; and configure the transceiver to communicate using the first RAT.

[0069] In Example 2, the subject matter of Example 1 can optionally include that the processing circuitry is further configured to configure the transceiver to receive from an enhanced NodeB (eNB) higher layer signaling associated with the FRAT, the higher layer signaling indicating numerologies, resource allocation and partition information in at least one of a time and frequency domain.

[0070] In Example 3, the subject matter of one or any combination of Examples 1-2 can optionally include that the FRAT comprises a base subcarrier spacing and symbol duration, and at least one of the subcarrier spacing and symbol duration for different RATs of the FRAT is respectively specified as an integer number of the base subcarrier spacing or symbol duration.

[0071] In Example 4, the subject matter of one or any combination of Examples 1-3 can optionally include that the UE is a Machine-Type Communication (MTC) UE configured to operate in at least one of a low latency and low energy mode, and the first RAT comprises a larger subcarrier spacing and shorter symbol duration when the UE operates in the low latency mode and comprises a smaller subcarrier spacing and longer symbol duration when the UE operates in the low energy mode.

[0072] In Example 5, the subject matter of one or any combination of Examples 1-4 can optionally include that at least one of the plurality of RATs of the FRAT comprises at least one of a plurality of sub-RATs and partitions, each of the at least one of the plurality of sub-RATs and partitions comprising an independent configurable numerology with flexible subcarrier spacing and symbol duration and associated with at least one of different temporal and frequency resource, and the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are combined using at least one of a Time-Division Multiplexing (TDM), Frequency-Division Multiplexing (FDM), Code-Division Multiplexing (CDM), and Spatial Division Multiplexing (SDM).

[0073] In Example 6, the subject matter of one or any combination of Examples 1-6 can optionally include that the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are combined using TDM, and numerologies, resource allocation and partition information in a time domain are at least one of predefined or configured by higher-layer signaling via Master

Information Block (MIB), System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling, or the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are combined using FDM, guard bands are inserted at an edge of frequency resources allocated for the plurality of RATs and the at least one of the plurality of sub-RATs and partitions, and at least one of numerologies and resource partition for the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are at least one of predefined or configured by the higher-layer signaling.

[0074] In Example 7, the subject matter of one or any combination of Examples 1-6 can optionally include that a Transmission Time Interval (TTI) boundary between different RATs of the plurality of RATs is common, and the plurality of RATs comprise a common reference TTI duration.

[0075] In Example 8, the subject matter of one or any combination of Examples 1-7 can optionally include that a symbol structure of each of the plurality of RATs comprises a cyclic prefix (CP) or unique word (UW) outside or within a symbol, and the symbol structure of each of the plurality of RATs is independent of the symbol structure of the other RATs. ‘

[0076] In Example 9, the subject matter of one or any combination of Examples 1-8 can optionally include that the processing circuitry is further configured to configure the transceiver to communicate using Orthogonal Frequency-Division Multiplexing (OFDM) for downlink communications and one of Single Carrier Frequency-Division Multiple Access (SC-FDMA) and OFDM for uplink communications, and configure the transceiver to communicate using at least one of UW-OFDM and UW Discrete Fourier transform-Spread-Orthogonal Frequency Division Multiplexing (UW-DFT-s-OFDM).

[0077] In Example 10, the subject matter of one or any combination of Examples 1-9 can optionally include that a frame structure in each of the plurality of RATs comprises a frame comprising L subframes, each subframe comprising N slots, each slot comprising M symbols, and the frame structure of each of the plurality of RATs is independent of the frame structure of the other RATs.

[0078] In Example 11, the subject matter of one or any combination of Examples 1-10 can optionally include that the processing circuitry is further configured to configure the transceiver to receive numerologies, resource allocation and partition information via Master Information Block (MIB) carried by a physical broadcast channel (PBCH), a System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling in a second RAT, the first and second RATs being different.

[0079] In Example 12, the subject matter of one or any combination of Examples 1-11 can optionally include that the processing circuitry is configured to configure the transceiver to receive numerologies, resource allocation and partition information via a dedicated carrier in the first RAT, a dedicated carrier allocated for each of the plurality of RATs, and a dedicated downlink synchronization signal and physical broadcast channel (PBCH) is able to be received on each of the plurality of RATs.

[0080] In Example 13, the subject matter of one or any combination of Examples 1-12 can optionally include an antenna configured to transmit and receive communications between the transceiver and the eNB.

[0081] Example 14 comprises an apparatus of an eNode B (eNB) comprising processing circuitry configured to: configure a transceiver to transmit resource allocations for different Radio Access Technologies (RATs) to a plurality of user equipment (UE), at least two of the UEs associated with a different RAT, each RAT comprising an independent subcarrier spacing, symbol duration, frame structure and symbol structure; and configure the transceiver to communicate with each UE using the RAT associated with the UE.

[0082] In Example 15, the subject matter of Example 14 can optionally include that the processing circuitry is configured to configure the transceiver to transmit higher layer signaling indicating numerologies, resource allocation and partition information via Master Information Block (MIB) carried by a physical broadcast channel (PBCH), a System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling in a same RAT to each of the plurality of UEs.

[0083] In Example 16, the subject matter of one or any combination of Examples 14-15 can optionally include that the processing circuitry is

configured to configure the transceiver to transmit numerologies, resource allocation and partition information via a dedicated carrier allocated for each of the RATs, and a dedicated downlink synchronization signal and physical broadcast channel (PBCH) is able to be received on each of the RATs.

[0084] In Example 17, the subject matter of one or any combination of Examples 14-16 can optionally include that at least one of the subcarrier spacing and symbol duration for each of the RATs is respectively specified as an integer number of a base subcarrier spacing or symbol duration.

[0085] In Example 18, the subject matter of one or any combination of Examples 14-17 can optionally include that the RATs comprise a first RAT comprising a larger subcarrier spacing and shorter symbol duration configured for a UE operating in a low latency mode and a second RAT comprising a smaller subcarrier spacing and longer symbol duration configured for a UE operating in a low energy mode.

[0086] In Example 19, the subject matter of one or any combination of Examples 14-18 can optionally include that a Transmission Time Interval (TTI) boundary between the RATs is common, and the RATs comprise a common reference TTI duration.

[0087] In Example 20, the subject matter of one or any combination of Examples 14-19 can optionally include that a symbol structure of each of the RATs comprises a cyclic prefix (CP) or unique word (UW) outside or within a symbol, and the symbol structure of each of the RATs is independent of the symbol structure of the other RATs.

[0088] In Example 21, the subject matter of one or any combination of Examples 14-20 can optionally include that the processing circuitry is configured to at least one of: configure the transceiver to communicate using Orthogonal Frequency-Division Multiplexing (OFDM) for downlink communications and one of Single Carrier Frequency-Division Multiple Access (SC-FDMA) and OFDM for uplink communications, and configure the transceiver to communicate using at least one of UW-OFDM and UW Discrete Fourier transform-Spread-Orthogonal Frequency Division Multiplexing (UW-DFT-s-OFDM).

[0089] In Example 22 a non-transitory computer-readable storage medium that stores instructions for execution by one or more processors of a user equipment (UE) to configure the UE to communicate with an enhanced Node B (eNB), the one or more processors to configure the UE to: receive resource allocation, partition information and numerology, including subcarrier spacing and symbol duration, for a first Radio Access Technology (RAT) of a plurality of RATs used by the eNB, the UE configurable to configure the subcarrier spacing and symbol duration based on the numerology and to communicate using the plurality of RATs; and communicate using the first RAT.

[0090] In Example 23, the subject matter of Example 22 can optionally include that at least one of: a) at least one of the subcarrier spacing and symbol duration for the RATs is respectively specified as an integer number of a base subcarrier spacing or symbol duration, b) the UE is configured to operate in at least one of a low latency and low energy mode, and the first RAT comprises a larger subcarrier spacing and shorter symbol duration when the UE operates in the low latency mode and comprises a smaller subcarrier spacing and longer symbol duration when the UE operates in the low energy mode, and c) a Transmission Time Interval (TTI) boundary between the RATs is common, and the RATs comprise a common reference TTI duration.

[0091] In Example 24, the subject matter of one or any combination of Examples 22-23 can optionally include that at least one of: a) a symbol structure of each of the RATs comprises a cyclic prefix (CP) or unique word (UW) outside or within a symbol, and the symbol structure of each of the RATs is independent of the symbol structure of the other RATs, and b) a frame structure in each of the RATs comprises a frame comprising L subframes, each subframe comprising N slots, each slot comprising M symbols, and the frame structure of each of the RATs is independent of the frame structure of the other RATs.

[0092] In Example 25, the subject matter of one or any combination of Examples 22-24 can optionally include that the numerology, resource allocation and partition information is received via Master Information Block (MIB) carried by a physical broadcast channel (PBCH), a System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling in a second RAT, the first and second RATs being different.

[0093] Although an embodiment has been described with reference to specific example embodiments, it will be evident that various modifications and changes may be made to these embodiments without departing from the broader spirit and scope of the present disclosure. Accordingly, the specification and drawings are to be regarded in an illustrative rather than a restrictive sense. The accompanying drawings that form a part hereof show, by way of illustration, and not of limitation, specific embodiments in which the subject matter may be practiced. The embodiments illustrated are described in sufficient detail to enable those skilled in the art to practice the teachings disclosed herein. Other embodiments may be utilized and derived therefrom, such that structural and logical substitutions and changes may be made without departing from the scope of this disclosure. This Detailed Description, therefore, is not to be taken in a limiting sense, and the scope of various embodiments is defined only by the appended claims, along with the full range of equivalents to which such claims are entitled.

[0094] Such embodiments of the inventive subject matter may be referred to herein, individually and/or collectively, by the term “invention” merely for convenience and without intending to voluntarily limit the scope of this application to any single invention or inventive concept if more than one is in fact disclosed. Thus, although specific embodiments have been illustrated and described herein, it should be appreciated that any arrangement calculated to achieve the same purpose may be substituted for the specific embodiments shown. This disclosure is intended to cover any and all adaptations or variations of various embodiments. Combinations of the above embodiments, and other embodiments not specifically described herein, will be apparent to those of skill in the art upon reviewing the above description.

[0095] In this document, the terms "a" or "an" are used, as is common in patent documents, to include one or more than one, independent of any other instances or usages of "at least one" or "one or more." In this document, the term "or" is used to refer to a nonexclusive or, such that "A or B" includes "A but not B," "B but not A," and "A and B," unless otherwise indicated. In this document, the terms "including" and "in which" are used as the plain-English equivalents of the respective terms "comprising" and "wherein." Also, in the following claims, the

terms "including" and "comprising" are open-ended, that is, a system, UE, article, composition, formulation, or process that includes elements in addition to those listed after such a term in a claim are still deemed to fall within the scope of that claim. Moreover, in the following claims, the terms "first," "second," and "third," etc. are used merely as labels, and are not intended to impose numerical requirements on their objects.

[0096] The Abstract of the Disclosure is provided to comply with 37 C.F.R. §1.72(b), requiring an abstract that will allow the reader to quickly ascertain the nature of the technical disclosure. It is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims. In addition, in the foregoing Detailed Description, it can be seen that various features are grouped together in a single embodiment for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted as reflecting an intention that the claimed embodiments require more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive subject matter lies in less than all features of a single disclosed embodiment. Thus the following claims are hereby incorporated into the Detailed Description, with each claim standing on its own as a separate embodiment.

CLAIMS

What is claimed is:

1. User equipment (UE) comprising:

processing circuitry configured to:

configure a transceiver to receive a resource allocation from a network using a first Radio Access Technology (RAT), the first RAT selected from a plurality of RATs of a flexible RAT (FRAT) employed by the network, the plurality of RATs of the FRAT each comprising configurable numerology with flexible subcarrier spacing and symbol duration and associated with at least one of different temporal and frequency resources, the transceiver configurable to communicate using the plurality of RATs and configure the subcarrier spacing and symbol duration based on the numerology; and

configure the transceiver to communicate using the first RAT.

2. The UE of claim 1, wherein the processing circuitry is configured to:

configure the transceiver to receive from an enhanced NodeB (eNB) higher layer signaling associated with the FRAT, the higher layer signaling indicating numerologies, resource allocation and partition information in at least one of a time and frequency domain.

3. The UE of claim 1, wherein:

the FRAT comprises a base subcarrier spacing and symbol duration, and

at least one of the subcarrier spacing and symbol duration for different RATs of the FRAT is respectively specified as an integer number of the base subcarrier spacing or symbol duration.

4. The UE of claim 3, wherein:

the UE is a Machine-Type Communication (MTC) UE configured to operate in at least one of a low latency and low energy mode, and

the first RAT comprises a larger subcarrier spacing and shorter symbol duration when the UE operates in the low latency mode and comprises a smaller

subcarrier spacing and longer symbol duration when the UE operates in the low energy mode.

5. The UE of claim 1, wherein:

at least one of the plurality of RATs of the FRAT comprises at least one of a plurality of sub-RATs and partitions, each of the at least one of the plurality of sub-RATs and partitions comprising an independent configurable numerology with flexible subcarrier spacing and symbol duration and associated with at least one of different temporal and frequency resource, and

the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are combined using at least one of a Time-Division Multiplexing (TDM), Frequency-Division Multiplexing (FDM), Code-Division Multiplexing (CDM), and Spatial Division Multiplexing (SDM).

6. The UE of claim 5, wherein one of:

the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are combined using TDM, and numerologies, resource allocation and partition information in a time domain are at least one of predefined or configured by higher-layer signaling via Master Information Block (MIB), System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling, or

the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are combined using FDM, guard bands are inserted at an edge of frequency resources allocated for the plurality of RATs and the at least one of the plurality of sub-RATs and partitions, and at least one of numerologies and resource partition for the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are at least one of predefined or configured by the higher -layer signaling.

7. The UE of claim 1, wherein:

a Transmission Time Interval (TTI) boundary between different RATs of the plurality of RATs is common, and

the plurality of RATs comprise a common reference TTI duration.

8. The UE of claim 1, wherein:

a symbol structure of each of the plurality of RATs comprises a cyclic prefix (CP) or unique word (UW) outside or within a symbol, and

the symbol structure of each of the plurality of RATs is independent of the symbol structure of the other RATs.

9. The UE of claim 1, wherein the processing circuitry is configured to at least one of:

configure the transceiver to communicate using Orthogonal Frequency-Division Multiplexing (OFDM) for downlink communications and one of Single Carrier Frequency-Division Multiple Access (SC-FDMA) and OFDM for uplink communications, and

configure the transceiver to communicate using at least one of UW-OFDM and UW Discrete Fourier transform-Spread-Orthogonal Frequency Division Multiplexing (UW-DFT-s-OFDM).

10. The UE of claim 1, wherein:

a frame structure in each of the plurality of RATs comprises a frame comprising L subframes, each subframe comprising N slots, each slot comprising M symbols, and

the frame structure of each of the plurality of RATs is independent of the frame structure of the other RATs.

11. The UE of claim 1, wherein the processing circuitry is configured to:

configure the transceiver to receive numerologies, resource allocation and partition information via Master Information Block (MIB) carried by a physical broadcast channel (PBCH), a System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling in a second RAT, the first and second RATs being different.

12. The UE of claim 1, wherein:

the processing circuitry is configured to configure the transceiver to receive numerologies, resource allocation and partition information via a dedicated carrier in the first RAT, a dedicated carrier allocated for each of the plurality of RATs, and

a dedicated downlink synchronization signal and physical broadcast channel (PBCH) is able to be received on each of the plurality of RATs.

13. The UE of claim 1, further comprising an antenna configured to transmit and receive communications between the transceiver and the eNB.

14. An apparatus of an eNode B (eNB) comprising:

processing circuitry configured to:

configure a transceiver to transmit resource allocations for different Radio Access Technologies (RATs) to a plurality of user equipment (UE), at least two of the UEs associated with a different RAT, each RAT comprising an independent subcarrier spacing, symbol duration, frame structure and symbol structure; and

configure the transceiver to communicate with each UE using the RAT associated with the UE.

15. The apparatus of claim 14, wherein the processing circuitry is configured to:

configure the transceiver to transmit higher layer signaling indicating numerologies, resource allocation and partition information via Master Information Block (MIB) carried by a physical broadcast channel (PBCH), a System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling in a same RAT to each of the plurality of UEs.

16. The apparatus of claim 14, wherein the processing circuitry is configured to:

configure the transceiver to transmit numerologies, resource allocation and partition information via a dedicated carrier allocated for each of the RATs, and

a dedicated downlink synchronization signal and physical broadcast channel (PBCH) is able to be received on each of the RATs.

17. The apparatus of claim 14, wherein:

at least one of the subcarrier spacing and symbol duration for each of the RATs is respectively specified as an integer number of a base subcarrier spacing or symbol duration.

18. The apparatus of claim 14, wherein:

the RATs comprise a first RAT comprising a larger subcarrier spacing and shorter symbol duration configured for a UE operating in a low latency mode and a second RAT comprising a smaller subcarrier spacing and longer symbol duration configured for a UE operating in a low energy mode.

19. The apparatus of claim 14, wherein:

a Transmission Time Interval (TTI) boundary between the RATs is common, and

the RATs comprise a common reference TTI duration.

20. The apparatus of claim 14, wherein:

a symbol structure of each of the RATs comprises a cyclic prefix (CP) or unique word (UW) outside or within a symbol, and

the symbol structure of each of the RATs is independent of the symbol structure of the other RATs.

21. The apparatus of claim 14, wherein the processing circuitry is configured to at least one of:

configure the transceiver to communicate using Orthogonal Frequency-Division Multiplexing (OFDM) for downlink communications and one of Single Carrier Frequency-Division Multiple Access (SC-FDMA) and OFDM for uplink communications, and

configure the transceiver to communicate using at least one of UW-OFDM and UW Discrete Fourier transform-Spread-Orthogonal Frequency Division Multiplexing (UW-DFT-s-OFDM).

22. A non-transitory computer-readable storage medium that stores instructions for execution by one or more processors of a user equipment (UE) to configure the UE to communicate with an enhanced Node B (eNB), the one or more processors to configure the UE to:

receive resource allocation, partition information and numerology, including subcarrier spacing and symbol duration, for a first Radio Access Technology (RAT) of a plurality of RATs used by the eNB, the UE configurable to configure the subcarrier spacing and symbol duration based on the numerology and to communicate using the plurality of RATs; and

communicate using the first RAT.

23. The medium of claim 22, wherein at least one of:

a) at least one of the subcarrier spacing and symbol duration for the RATs is respectively specified as an integer number of a base subcarrier spacing or symbol duration,

b) the UE is configured to operate in at least one of a low latency and low energy mode, and

the first RAT comprises a larger subcarrier spacing and shorter symbol duration when the UE operates in the low latency mode and comprises a smaller subcarrier spacing and longer symbol duration when the UE operates in the low energy mode, and

c) a Transmission Time Interval (TTI) boundary between the RATs is common, and

the RATs comprise a common reference TTI duration.

24. The medium of claim 22, wherein at least one of:

a) a symbol structure of each of the RATs comprises a cyclic prefix (CP) or unique word (UW) outside or within a symbol, and

the symbol structure of each of the RATs is independent of the symbol structure of the other RATs, and

b) a frame structure in each of the RATs comprises a frame comprising L subframes, each subframe comprising N slots, each slot comprising M symbols, and

the frame structure of each of the RATs is independent of the frame structure of the other RATs.

25. The medium of claim 22, wherein:

the numerology, resource allocation and partition information is received via Master Information Block (MIB) carried by a physical broadcast channel (PBCH), a System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling in a second RAT, the first and second RATs being different.

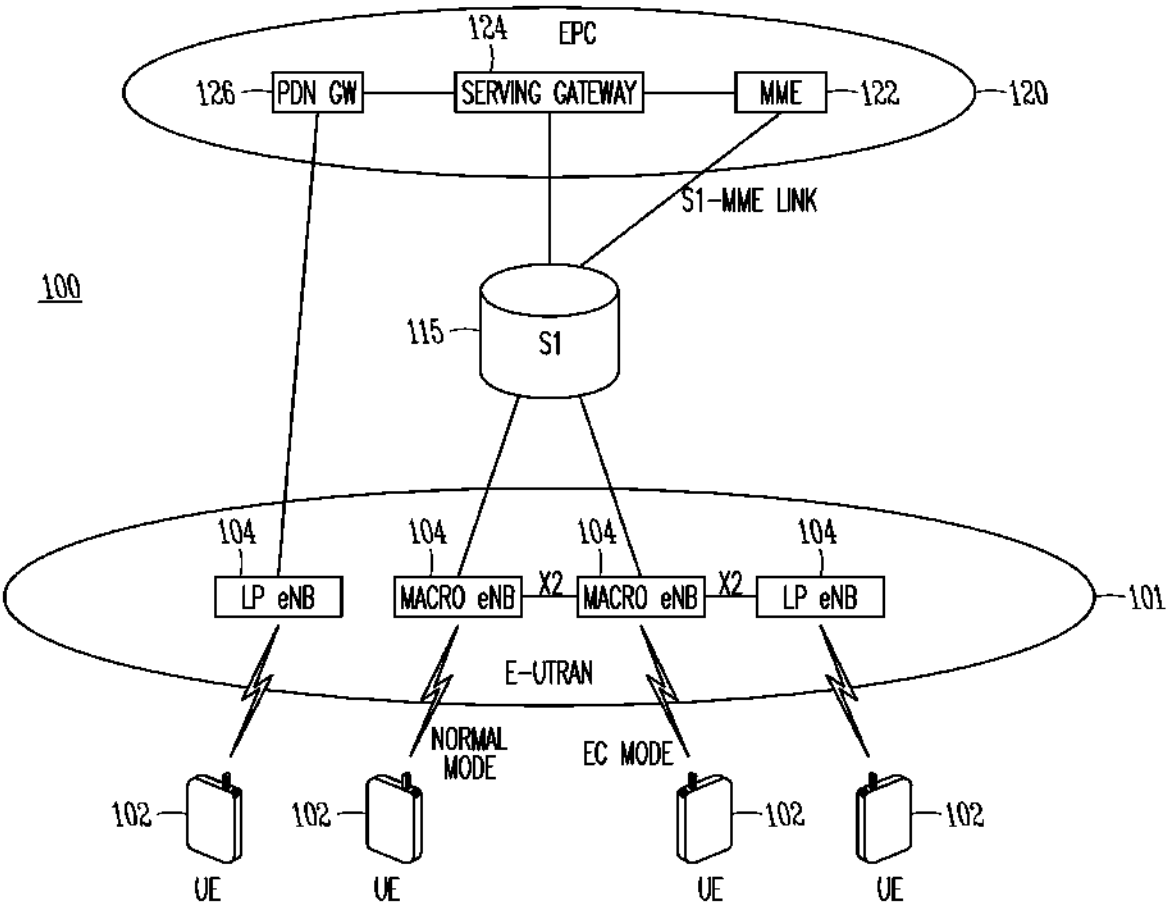

124
EPC
126
PDN GW
SERVING GATEWAY
MME
122
120
S1-MME LINK
100
115
S1
104
104
104
104
LP eNB
MACRO eNB
X2
MACRO eNB
X2
LP eNB
101
E-UTRAN
NORMAL MODE
EC MODE
102
102
102
102
UE
UE
UE
UE

FIG. 1

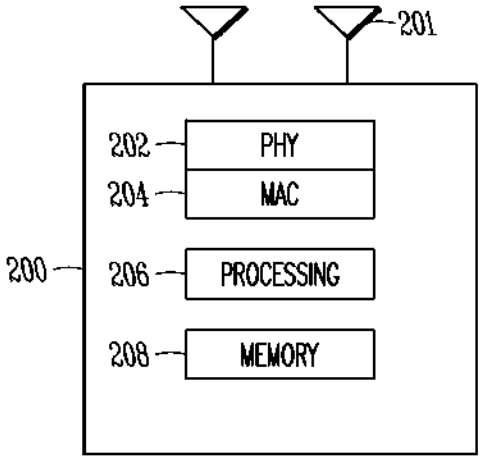


FIG. 2

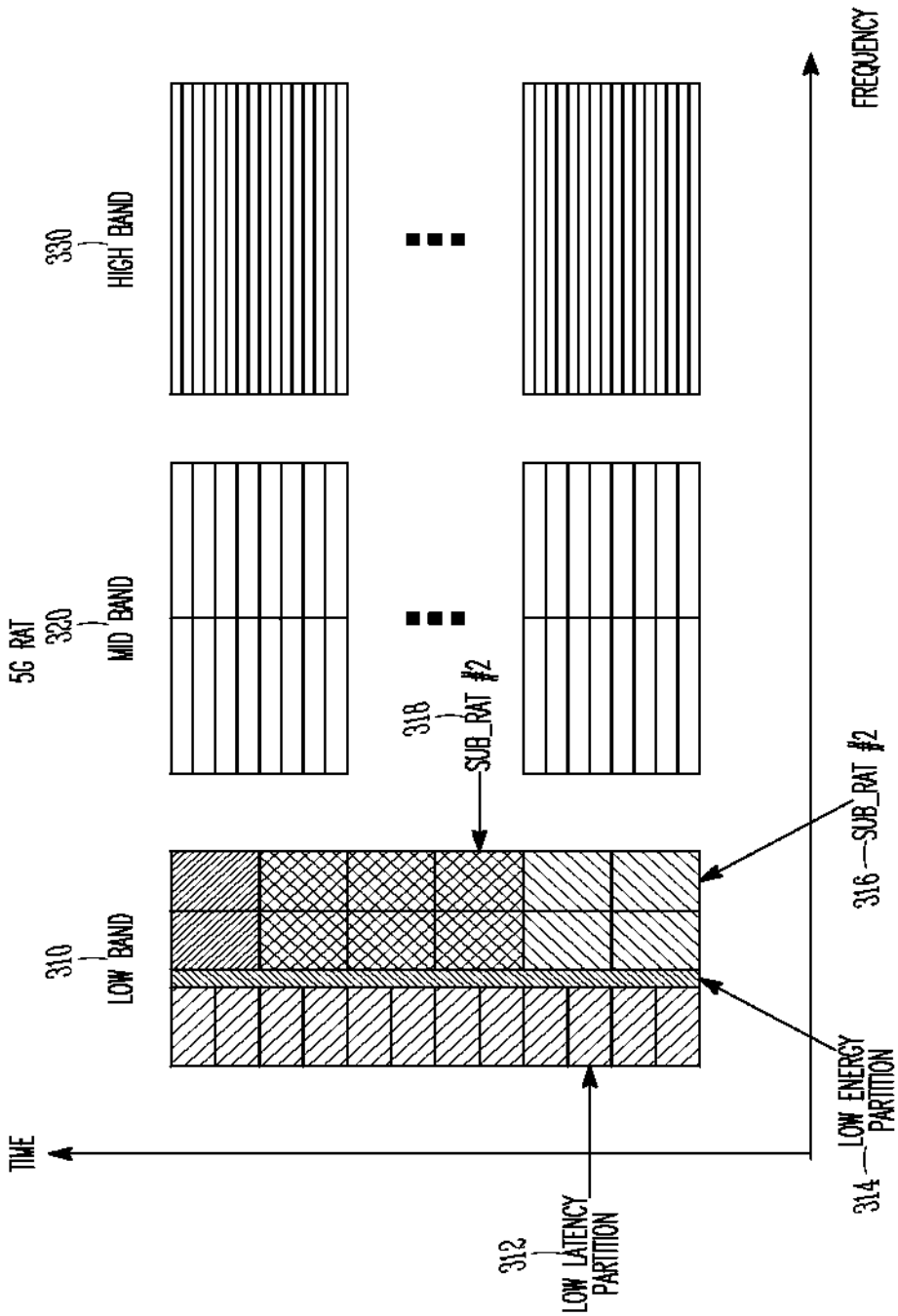

FREQUENCY
330
HIGH BAND
5G RAT
320
MID BAND
318
SUB_RAT #2
310
LOW BAND
316
SUB_RAT #2
TIME
314
LOW ENERGY PARTITION
312
LOW LATENCY PARTITION

FIG. 3

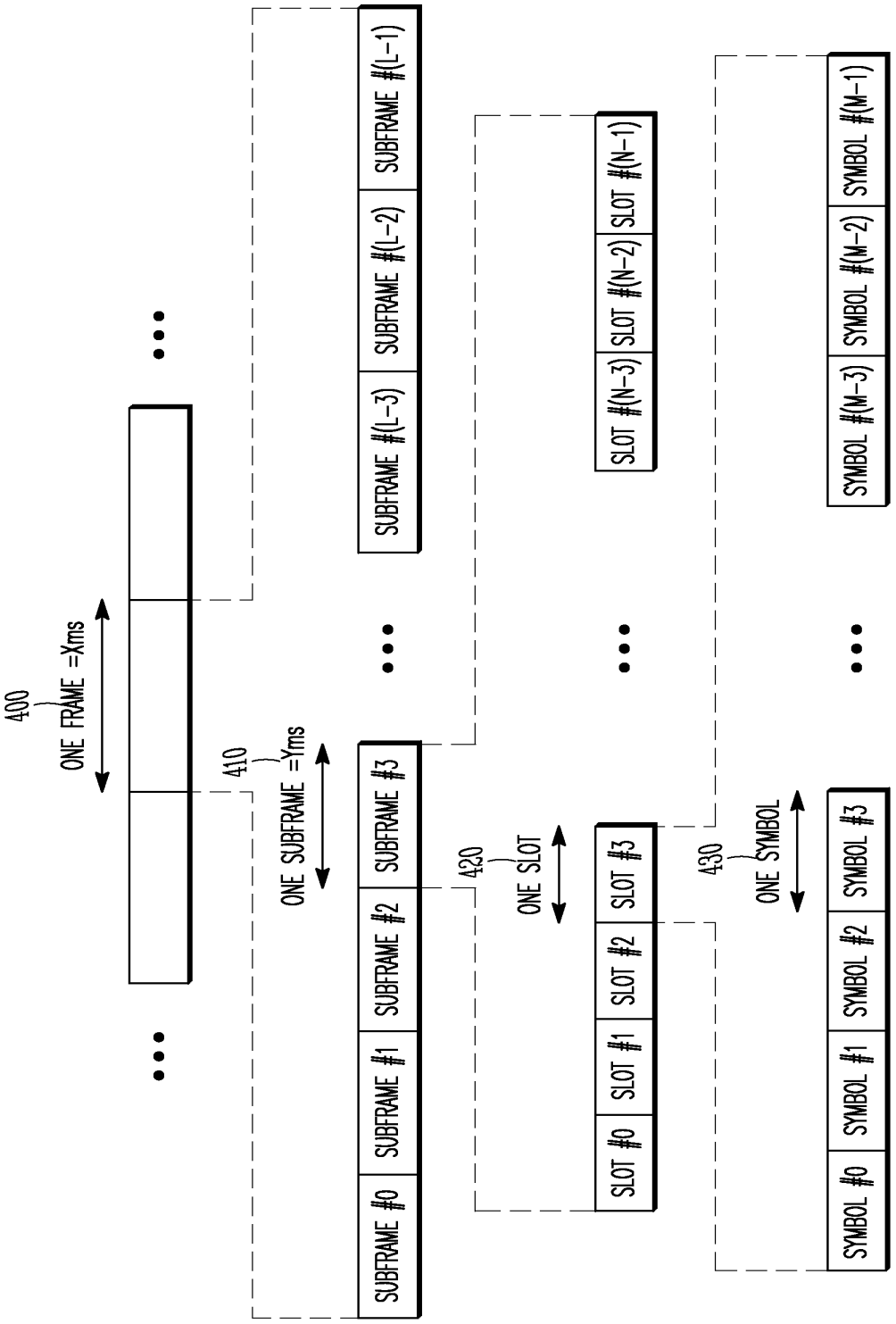

400
ONE FRAME =Xms
410
ONE SUBFRAME =Yms
SUBFRAME #0
SUBFRAME #1
SUBFRAME #2
SUBFRAME #3
SUBFRAME #(L-3)
SUBFRAME #(L-2)
SUBFRAME #(L-1)
420
ONE SLOT
SLOT #0
SLOT #1
SLOT #2
SLOT #3
SLOT #(N-3)
SLOT #(N-2)
SLOT #(N-1)
430
ONE SYMBOL
SYMBOL #0
SYMBOL #1
SYMBOL #2
SYMBOL #3
SYMBOL #(M-3)
SYMBOL #(M-2)
SYMBOL #(M-1)

FIG. 4

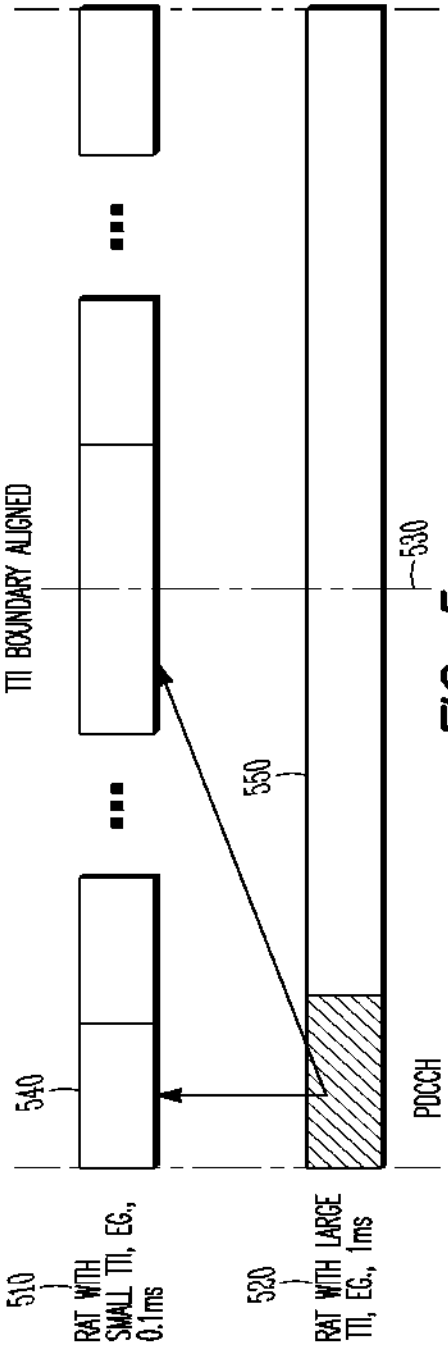

TTI BOUNDARY ALIGNED
530
550
540
PDCCH
510
RAT WITH SMALL TTI, EG., 0.1ms
520
RAT WITH LARGE TTI, EG., 1ms

FIG. 5

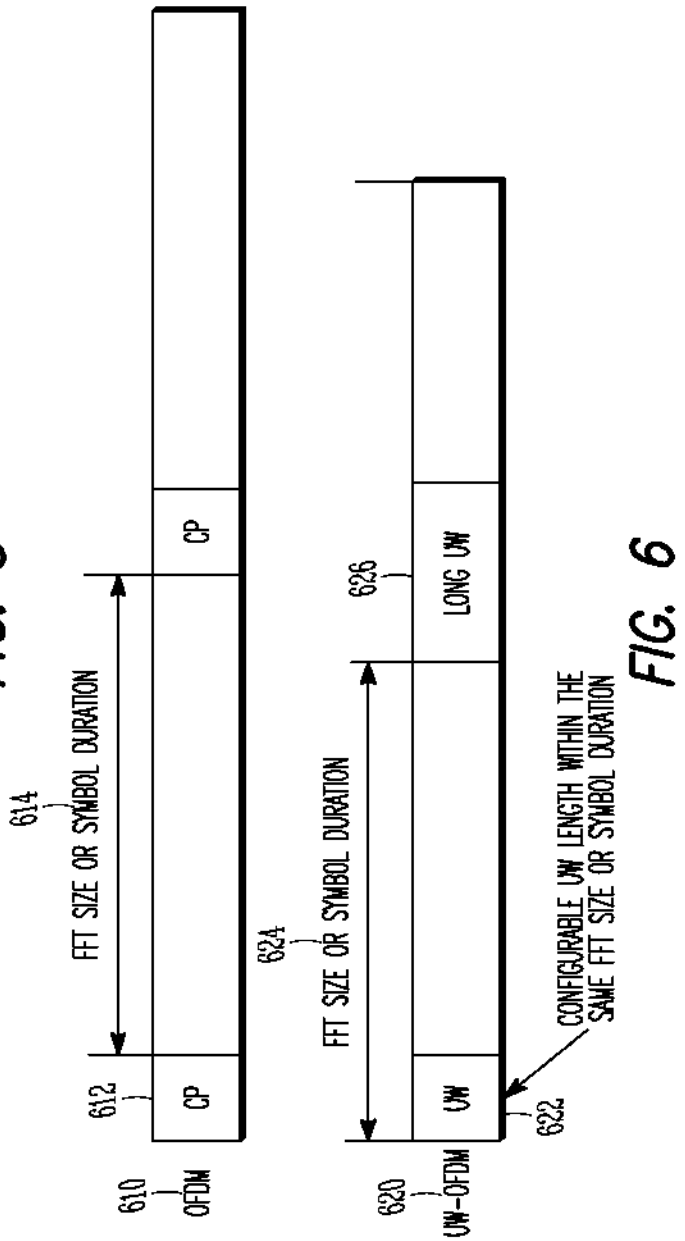

614
FFT SIZE OR SYMBOL DURATION
CP
612
OFDM
610
624
FFT SIZE OR SYMBOL DURATION
626
LONG UW
UW
622
CONFIGURABLE UW LENGTH WITHIN THE SAME FFT SIZE OR SYMBOL DURATION
UW-OFDM
620

FIG. 6


712
714 ONE TTI = 200 US = 3 OFDM LONG SYMBOLS—710
UW
SYMBOL #0
UW
SYMBOL #1
UW
SYMBOL #2
ONE SYMBOL = 66.67 US—716
722
724 ONE TTI = 200 US = 6 OFDM SHORT SYMBOLS—720
UW SYMBOL #0 UW SYMBOL #1 UW SYMBOL #2 UW SYMBOL #3 UW SYMBOL #4 UW SYMBOL #5
ONE SHORT SYMBOL = 33.33 US—726
732
734 ONE TTI = 100 US = 3 OFDM SHORT SYMBOLS—730
UW SYMBOL #0 UW SYMBOL #1 UW SYMBOL #2
ONE SHORT SYMBOL = 33.33 US—736
742
744 ONE TTI = 1MS = 5 OFDM LONG SYMBOLS—740
UW
SYMBOL #0
UW
SYMBOL #4
ONE LONG SYMBOL = 200 US—746

FIG. 7

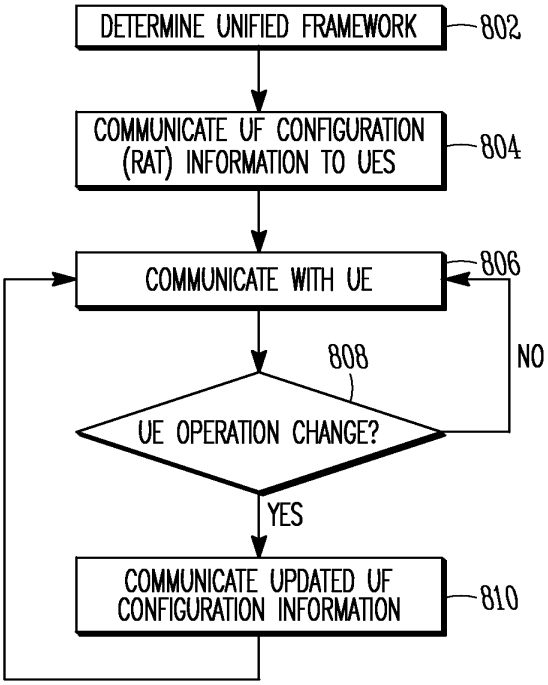

DETERMINE UNIFIED FRAMEWORK
802
COMMUNICATE UF CONFIGURATION (RAT) INFORMATION TO UES
804
COMMUNICATE WITH UE
806
808
UE OPERATION CHANGE?
NO
YES
COMMUNICATE UPDATED UF CONFIGURATION INFORMATION
810

FIG. 8A

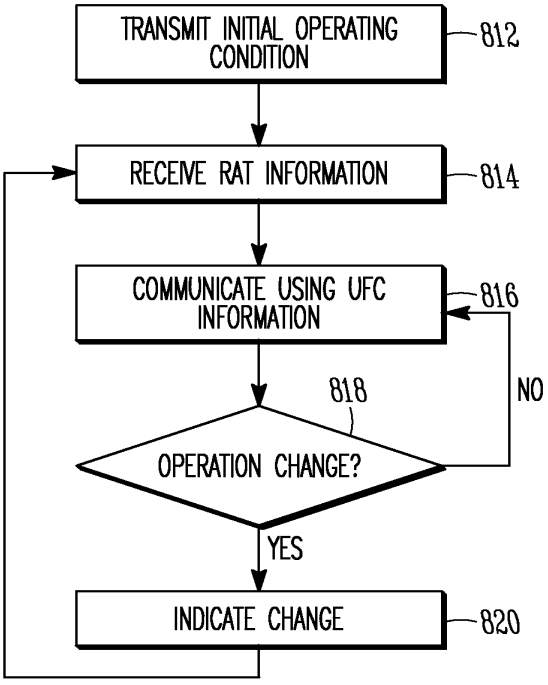

TRANSMIT INITIAL OPERATING CONDITION
812
RECEIVE RAT INFORMATION
814
COMMUNICATE USING UFC INFORMATION
816
818
OPERATION CHANGE?
NO
YES
INDICATE CHANGE
820

FIG. 8B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/044628

A. CLASSIFICATION OF SUBJECT MATTER

H04W 72/04(2009.01)i, H04W 92/10(2009.01)i, H04W 88/06(2009.01)i, H04W 88/08(2009.01)i, H04B 7/26(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W 72/04; H04L 5/00; H04Q 7/00; H04W 88/06; H04L 27/26; H04W 92/10; H04W 88/08; H04B 7/26

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: radio access technology (RAT), FRAT (flexible RAT), flexible subcarrier spacing and symbol duration, numerology, MTC, low latency, low energy, sub-RAT, partition, combination, TTI, unique word (UW), UW-OFDM, UW-DFT-s-OFDM, synchronization, broadcast

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2008-0130570 A1 (YOUNG-HO JUNG et al.) 5 June 2008 See paragraphs [0011], [0033]-[0045]; claims 1, 7; and figures 3-5.	1-25
Y	EEVA LAHETKANGAS et al., 'On the Flexible 5G Dense Deployment Air Interface for Mobile Broadband', In: 5G for Ubiquitous Connectivity (5GU), 2014 1st International Conference on, Page(s): 57-61, 26-28 November 2014 See pages 1-3; and figures 1, 4.	1-25
Y	US 2015-0029990 A1 (INTERDIGITAL PATENT HOLDINGS, INC.) 29 January 2015 See paragraphs [0066]-[0082]; and figure 1.	7,19
Y	US 2014-0140194 A1 (STEFAN FECHTEL) 22 May 2014 See paragraph [0024]; and figures 2A, 2B.	8,9,20,21
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☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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(54) Title: IDENTIFICATION OF DOWNLINK MESSAGES USING REPEATED TRANSMISSION

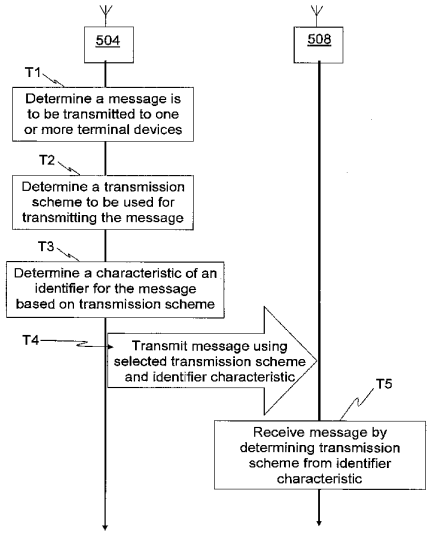


Fig. 9

(57) Abstract: A wireless telecommunication system comprises a base station arranged to communicate messages to one or more terminal devices over a radio interface. The radio interface has a radio frame structure comprising a plurality of subframes, wherein a message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes (e.g. one subframe) or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes (e.g. with repeat transmissions in a plurality of subframes). The message is transmitted in association with an identifier to indicate a terminal device to which the message is addressed. A characteristic for the identifier, for example a value or control region search space for the identifier, is dependent on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme. A terminal device to which the message is addressed determines the transmission scheme from the characteristic of the identifier and receives the message accordingly.

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IDENTIFICATION OF DOWNLINK MESSAGES USING REPEATED TRANSMISSION

BACKGROUND

Field

The present disclosure relates to telecommunications apparatus and methods. In particular, certain embodiments relate to schemes for communicating allocations of transmission resources of a shared channel in a wireless telecommunications system.

Description of Related Art

The "background" description provided herein is for the purpose of generally presenting the context of the disclosure. Work of the presently named inventors, to the extent it is described in this background section, as well as aspects of the description which may not otherwise qualify as prior art at the time of filing, are neither expressly or impliedly admitted as prior art against the present invention.

Mobile communication systems have evolved over the past ten years or so from the GSM System (Global System for Mobile communications) to the 3G system and now include packet data communications as well as circuit switched communications. The third generation partnership project (3GPP) is developing a fourth generation mobile communication system referred to as Long Term Evolution (LTE) in which a core network part has been evolved to form a more simplified architecture based on a merging of components of earlier mobile radio network architectures and a radio access interface which is based on Orthogonal Frequency Division Multiplexing (OFDM) on the downlink and Single Carrier Frequency Division Multiple Access (SC-FDMA) on the uplink.

Third and fourth generation mobile telecommunication systems, such as those based on the 3GPP defined UMTS and Long Term Evolution (LTE) architecture are becoming able to support more sophisticated services than simple voice and messaging services offered by previous generations of mobile telecommunication systems. For example, with the improved radio interface and enhanced data rates provided by LTE systems, a user is able to enjoy high data rate applications such as mobile video streaming and mobile video conferencing that would previously only have been available via a fixed line data connection. The demand to deploy third and fourth generation networks is therefore strong and there is a corresponding desire to extend the coverage available in such telecommunications systems (i.e. there is a desire to provide more reliable access to wireless telecommunications systems for terminal devices operating in coverage-limited locations).

A typical example of a coverage-limited terminal device might be a so-called machine type communication (MTC) device, such as a smart meter located in a customer's house and periodically transmitting information back to a central MTC server relating to the customer's consumption of a utility, such as gas, water, electricity and so on. Such a terminal device might operate in a coverage-limited location because, for example, it may be located in a basement or other location with relatively high penetration loss. Further information on characteristics of MTC-type devices can be found, for example, in the corresponding standards, such as ETSI TS 122 368 V10.530 (2011-07) / 3GPP TS 22.368 version 10.5.0 Release 10) [1]. Some typical characteristics of MTC type terminal devices / MTC type data might include, for example, characteristics such as low mobility, high delay tolerance, small data transmissions, infrequent transmission and group-based features, policing and addressing.

In some situations a terminal device in a coverage-limited situation in a particular communication cell served by a base station might be unable to receive communications from the base station unless specific provision is made for it to do so. One way to increase coverage in this situation would be for the base station to increase the power of its transmissions. However, a blanket increase in transmission power from a base station could be expected to give rise to increased interference in neighbouring communication cells. An alternative approach would be for the base station to in effect focus / concentrate its available transmission power budget into a subset of transmission resources (e.g. in terms of frequency) which are selected from within the base station's overall transmission resources and allocated for transmissions to coverage-limited terminal devices. However, this approach can again lead to increased interference in neighbouring cells and may in some cases require increased coordination among base stations to optimise performance.

Another approach for providing coverage extension is to rely on repeated transmissions of signalling in multiple subframes. A terminal device may then combine the signalling received for a plurality of repeated transmissions to increase the likelihood of successfully decoding the signalling, e.g. using chase combining / maximal ratio combining techniques. This repeated transmission approach may be applied for control signalling (e.g. sent on a physical downlink control channel such as PDCCH in LTE) and / or other signalling (e.g. sent on a physical downlink shared channel such as PDSCH in LTE).

One draw-back of a repeated transmission approach for providing coverage extension is a corresponding increase in the amount of transmission resources needed to communicate with terminal devices, particularly in the amount of transmission resources needed to provide control messages to the terminal devices, and the inventors have recognised how this issue can be especially significant for certain types of communications, as discussed further below. There is therefore a need for schemes which can allow for communications with terminal devices to be made over a number of subframes with a reduction in the overall amount of transmission resources needed to support this as compared to conventional techniques.

SUMMARY

According to a first aspect of the present disclosure, there is provided a method of operating a terminal device communicating with a base station in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the method comprises receiving a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel, determining a validity period for the control message, and receiving a plurality of other messages from the base station on the downlink data channel using the allocated transmission resources within the validity period for the control message.

According to a second aspect of the present disclosure, there is provided a terminal device for communicating with a base station in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the

downlink data channel, and wherein the terminal device comprises a controller unit and a transceiver unit configured to operate together to receive a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to receive a plurality of other messages from the base station on the downlink data channel using the allocated transmission resources within the validity period for the control message.

According to a third aspect of the present disclosure, there is provided circuitry for a terminal device communicating with a base station in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to cause the terminal device to receive a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to receive a plurality of other messages from the base station on the downlink data channel using the allocated transmission resources within the validity period for the control message

According to a forth aspect of the present disclosure, there is provided a method of operating a base station communicating with a terminal device in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the method comprises transmitting a control message to the terminal device conveying an indication of allocated transmission resources on the downlink data channel, determining a validity period for the control message, and transmitting a plurality of other messages to the terminal device on the downlink data channel using the allocated transmission resources within the validity period for the control message.

According to a fifth aspect of the present disclosure, there is provided a base station for communicating with a terminal device in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the base station comprises a controller unit and a transceiver unit configured to operate together to transmit a control message to the terminal device conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to transmit a plurality of other messages to the terminal device on the downlink data channel using the allocated transmission resources within the validity period for the control message.

According to a sixth aspect of the present disclosure, there is provided circuitry for a base station communicating with a terminal device in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the

downlink data channel, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to cause the base station to transmit a control message to the terminal device conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to transmit a plurality of other messages to the terminal device on the downlink data channel using the allocated transmission resources within the validity period for the control message.

According to a seventh aspect of the present disclosure, there is provided a method of operating a base station for communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein the method comprises selecting a characteristic for the identifier in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

According to an eighth aspect of the present disclosure, there is provided a base station for communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the base station comprises a controller unit and a transceiver unit configured to operate together such that the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein a characteristic for the identifier is selected in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

According to a ninth aspect of the present disclosure, there is provided circuitry for a base station communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the circuitry comprises a controller element and a transceiver element configured to operate together such that the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein a characteristic for the identifier is selected in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

According to a 10th aspect of the present disclosure, there is provided a method of operating a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission

resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the method comprises determining from an identifier associated with the message that the message is addressed to the terminal device, and further determining from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

According to an 11th aspect of the present disclosure, there is provided a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the terminal device comprises a controller unit and a transceiver unit configured to operate together to determine from an identifier associated with the message that the message is addressed to the terminal device, and to further determine from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

According to a twelfth aspect of the present disclosure, there is provided circuitry for a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to determine from an identifier associated with the message that the message is addressed to the terminal device, and to further determine from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

Further respective aspects and features are defined by the appended claims.

The foregoing paragraphs have been provided by way of general introduction, and are not intended to limit the scope of the following claims. The described embodiments, together with further advantages, will be best understood by reference to the following detailed description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the disclosure and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein like reference numerals designate identical or corresponding parts throughout the several views, and wherein:

Figure 1 provides a schematic diagram illustrating an example of a mobile telecommunication system;

Figure 2 provides a schematic diagram illustrating a LTE radio frame;

Figure 3 provides a schematic diagram illustrating an example of a LTE downlink radio subframe;

Figure 4 provides a schematic diagram illustrating a LTE "camp-on" procedure;

Figure 5 schematically represents a wireless telecommunications system according to an embodiment of the disclosure;

Figure 6 schematically represents a series of downlink subframes for communicating with a terminal device operating in the wireless telecommunications system of Figure 5;

Figure 7 schematically represents a series of downlink subframes for communicating with a terminal device operating in the wireless telecommunications system of Figure 5 in accordance with an embodiment of the disclosure;

Figure 8 is a signalling ladder diagram representing communications between a base station and a terminal device operating in accordance with an embodiment of the disclosure; and

Figure 9 is a signalling ladder diagram representing communications between a base station and a terminal device operating in accordance with another embodiment of the disclosure.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Figure 1 provides a schematic diagram illustrating some basic functionality of a mobile telecommunications network / system 100 operating in accordance with LTE principles and which may be adapted to implement embodiments of the disclosure as described further below. Various elements of Figure 1 and their respective modes of operation are well-known and defined in the relevant standards administered by the 3GPP (RTM) body and also described in many books on the subject, for example, Holma H. and Toskala A [2]. It will be appreciated that operational aspects of the telecommunications network which are not specifically described below may be implemented in accordance with any known techniques, for example according to the relevant standards.

The network 100 includes a plurality of base stations 101 connected to a core network 102. Each base station provides a coverage area 103 (i.e. a cell) within which data can be communicated to and from terminal devices 104. Data is transmitted from base stations 101 to terminal devices 104 within their respective coverage areas 103 via a radio downlink. Data is transmitted from terminal devices 104 to the base stations 101 via a radio uplink. The core network 102 routes data to and from the terminal devices 104 via the respective base stations 101 and provides functions such as authentication, mobility management, charging and so on. Terminal devices may also be referred to as mobile stations, user equipment (UE), user terminal, mobile radio, and so forth. Base stations may also be referred to as transceiver stations / nodeBs / e-nodeBs, and so forth.

Mobile telecommunications systems such as those arranged in accordance with the 3GPP defined Long Term Evolution (LTE) architecture use an orthogonal frequency division modulation (OFDM) based interface for the radio downlink (so-called OFDMA) and a single carrier frequency division multiple access scheme (SC-FDMA) on the radio uplink. Figure 2 shows a schematic diagram illustrating an OFDM based LTE downlink radio frame 201. The LTE downlink radio frame is transmitted from a LTE base station

(known as an enhanced Node B) and lasts 10 ms. The downlink radio frame comprises ten subframes, each subframe lasting 1 ms. A primary synchronisation signal (PSS) and a secondary synchronisation signal (SSS) are transmitted in the first and sixth subframes of the LTE frame. A physical broadcast channel (PBCH) is transmitted in the first subframe of the LTE frame.

Figure 3 is a schematic diagram of a grid which illustrates the structure of an example conventional downlink LTE subframe. The subframe comprises a predetermined number of symbols which are transmitted over a 1ms period. Each symbol comprises a predetermined number of orthogonal subcarriers distributed across the bandwidth of the downlink radio carrier.

The example subframe shown in Figure 3 comprises 14 symbols and 1200 subcarriers spread across a 20MHz bandwidth and in this example is the first subframe in a frame (hence it contains PBCH). The smallest allocation of physical resource for transmission in LTE is a resource block comprising twelve subcarriers transmitted over one subframe. For clarity, in Figure 3, each individual resource element is not shown, instead each individual box in the subframe grid corresponds to twelve subcarriers transmitted on one symbol.

Figure 3 shows in hatching resource allocations for four LTE terminals 340, 341, 342, 343. For example, the resource allocation 342 for a first LTE terminal (UE 1) extends over five blocks of twelve subcarriers (i.e. 60 subcarriers), the resource allocation 343 for a second LTE terminal (UE2) extends over six blocks of twelve subcarriers (i.e. 72 subcarriers), and so on.

Control channel data can be transmitted in a control region 300 (indicated by dotted-shading in Figure 3) of the subframe comprising the first "n" symbols of the subframe where "n" can vary between one and three symbols for channel bandwidths of 3MHz or greater and where "n" can vary between two and four symbols for a channel bandwidth of 1.4MHz. For the sake of providing a concrete example, the following description relates to host carriers with a channel bandwidth of 3MHz or greater so the maximum value of "n" will be 3 (as in the example of Figure 3). The data transmitted in the control region 300 includes data transmitted on the physical downlink control channel (PDCCH), the physical control format indicator channel (PCFICH) and the physical HARQ indicator channel (PHICH). These channels transmit physical layer control information. Control channel data can also or alternatively be transmitted in a second region of the subframe comprising a number of subcarriers for a time substantially equivalent to the duration of the subframe, or substantially equivalent to the duration of the subframe remaining after the "n" symbols. The data transmitted in this second region is transmitted on the enhanced physical downlink control channel (EPDCCH). This channel transmits physical layer control information which may be in addition to that transmitted on other physical layer control channels.

PDCCH and EPDCCH contain control data indicating which subcarriers of the subframe have been allocated to specific terminals (or all terminals or subset of terminals). This may be referred to as physical-layer control signalling / data. Thus, the PDCCH and/or EPDCCH data transmitted in the control region 300 of the subframe shown in Figure 3 would indicate that UE1 has been allocated the block of resources identified by reference numeral 342, that UE2 has been allocated the block of resources identified by reference numeral 343, and so on.

PCFICH contains control data indicating the size of the control region (i.e. between one and three symbols for channel bandwidths of 3 MHz or greater and between two and four symbols for channel bandwidths of 1.4 MHz).

PHICH contains HARQ (Hybrid Automatic Request) data indicating whether or not previously transmitted uplink data has been successfully received by the network.

Symbols in a central band 310 of the time-frequency resource grid are used for the transmission of information including the primary synchronisation signal (PSS), the secondary synchronisation signal (SSS) and the physical broadcast channel (PBCH). This central band 310 is typically 72 subcarriers wide (corresponding to a transmission bandwidth of 1.08 MHz). The PSS and SSS are synchronisation signals that once detected allow a LTE terminal device to achieve frame synchronisation and determine the physical layer cell identity of the enhanced Node B transmitting the downlink signal. The PBCH carries information about the cell, comprising a master information block (MIB) that includes parameters that LTE terminals use to properly access the cell. Data transmitted to terminals on the physical downlink shared channel (PDSCH), which may also be referred to as a downlink data channel, can be transmitted in other resource elements of the subframe. In general PDSCH conveys a combination of user-plane data and non-physical layer control-plane data (such as Radio Resource Control (RRC) and Non Access Stratum (NAS) signalling). The user-plane data and non-physical layer control-plane data conveyed on PDSCH may be referred to as higher layer data (i.e. data associated with a layer higher than the physical layer).

Figure 3 also shows a region of PDSCH containing system information and extending over a bandwidth of R344. A conventional LTE subframe will also include reference signals which are discussed further below but not shown in Figure 3 in the interests of clarity.

The number of subcarriers in a LTE channel can vary depending on the configuration of the transmission network. Typically this variation is from 72 sub carriers contained within a 1.4MHz channel bandwidth to 1200 subcarriers contained within a 20MHz channel bandwidth (as schematically shown in Figure 3). As is known in the art, data transmitted on the PDCCH, PCFICH and PHICH is typically distributed on the subcarriers across the entire bandwidth of the subframe to provide for frequency diversity. Therefore a conventional LTE terminal must be able to receive the entire channel bandwidth in order to receive and decode the control region.

Figure 4 illustrates a LTE “camp-on” process, that is, the process followed by a terminal so that it can decode downlink transmissions which are sent by a base station via a downlink channel. Using this process, the terminal can identify the parts of the transmissions that include system information for the cell and thus decode configuration information for the cell.

As can be seen in Figure 4, in a conventional LTE camp-on procedure, the terminal first synchronizes with the base station (step 400) using the PSS and SSS in the centre band and then decodes the PBCH (step 401). Once the terminal has performed steps 400 and 401, it is synchronized with the base station.

For each subframe, the terminal then decodes the PCFICH which is distributed across the entire bandwidth of carrier 320 (step 402). As discussed above, a LTE downlink carrier can be up to 20 MHz wide (1200 subcarriers) and a standard LTE-compliant terminal therefore has to have the capability to receive and decode transmissions on a 20 MHz bandwidth in order to decode the PCFICH. Accordingly, at the PCFICH decoding stage, with a 20MHz carrier band, the terminal operates at a larger bandwidth

(bandwidth of R320) than during steps 400 and 401 (bandwidth of R310) relating to synchronization and PBCH decoding.

The terminal then ascertains the PHICH locations (step 403) and decodes the PDCCH (step 404), in particular for identifying system information transmissions and for identifying its dedicated allocation grants. The allocation grants are used by the terminal to locate system information and to locate its data in the PDSCH. Both system information and dedicated allocations are transmitted on PDSCH and scheduled within the carrier band 320. Steps 403 and 404 also require a standard LTE-compliant terminal to operate on the entire bandwidth R320 of the carrier band. Allocation grants may also or alternatively be decoded from EPDCCH.

At steps 402 to 404, the terminal decodes information contained in the control region 300 of a subframe. As explained above, in LTE, the three control channels mentioned above (PCFICH, PHICH and PDCCH) can be found across the control region 300 of the carrier where the control region extends over the range R320 and occupies the first one, two or three OFDM symbols of each subframe as discussed above. In a subframe, typically the control channels do not use all the resource elements within the control region 300, but they are scattered across the entire region, such that a LTE terminal has to be able to simultaneously receive the entire control region 300 for decoding each of the three control channels.

The terminal can then decode the PDSCH (step 405) which contains system information or data transmitted for this terminal.

As explained above, in a LTE subframe the PDSCH generally occupies groups of resource elements which follow the control region. The data in the blocks of resource elements 340, 341, 342, 343 allocated to the different mobile communication terminals (UEs) and the system information data in the block of resources 344 shown in Figure 3 have a smaller bandwidth than the bandwidth of the entire carrier. To decode these blocks a terminal first receives the PDCCH spread across the frequency range R320 and/or the EPDCCH to determine if the (E)PDCCH indicates there are PDSCH resources in the subframe that need to be decoded by the UE. The intended recipient(s) for (E)PDCCH signalling in LTE is established through the use of radio network temporary identifiers (RNTI). (E)PDCCH signalling is addressed to a particular RNTI by using the RNTI to scramble cyclic redundancy check (CRC) bits associated with the (E)PDCCH signalling. Each connected UE in a cell is associated with a Cell RNTI (C-RNTI) that may be used to address PDCCH signalling to that particular UE. In addition there are other RNTIs defined and these may be used to simultaneously address groups of terminal devices. For example, a System Information RNTI (SI-RNTI) is defined and PDSCH transmissions comprising SI are allocated by (E)PDCCH signalling addressed to SI-RNTI. Various other RNTIs are defined for various other types of signalling. Some examples include a random-access RNTI (RA-RNTI), a Paging RNTI (P-RNTI), a Transmit Power Control Physical Uplink Control Channel RNTI (TPC-PUCCH-RNTI) and a Transmit Power Control Physical Uplink Shared Channel-RNTI (TPC-PUSCH-RNTI).

Thus, once a UE has received a downlink subframe, the UE searches for (E)PDCCH signalling associated with any RNTI that apply for the UE in the subframe to identify any corresponding allocations of transmission resources on PDSCH. If there is an allocation message addressed to the UE on (E)PDCCH the UE will proceed to decode the PDSCH in the relevant frequency range (if any) indicated by the PDCCH. So for example, UE 1 discussed above decodes the whole control region 300 to

determine its resource allocation and then extracts the relevant data from the corresponding resource block 342.

Figure 5 schematically shows a telecommunications system 500 according to an embodiment of the disclosure. The telecommunications system 500 in this example is based broadly on a LTE-type architecture. As such many aspects of the operation of the telecommunications system 500 are standard and well understood and not described here in detail in the interest of brevity. Operational aspects of the telecommunications system 500 which are not specifically described herein may be implemented in accordance with any known techniques, for example according to the established LTE-standards and known variations thereof.

The telecommunications system 500 comprises a core network part (evolved packet core) 502 coupled to a radio network part. The radio network part comprises a base station (evolved-nodeB) 504, a first terminal device 506 and a second terminal device 508. It will of course be appreciated that in practice the radio network part may comprise a plurality of base stations serving a larger number of terminal devices across various communication cells. However, only a single base station and two terminal devices are shown in Figure 5 in the interests of simplicity.

As with a conventional mobile radio network, the terminal devices 506, 508 are arranged to communicate data to and from the base station (transceiver station) 504. The base station is in turn communicatively connected to a serving gateway, S-GW, (not shown) in the core network part which is arranged to perform routing and management of mobile communications services to the terminal devices in the telecommunications system 500 via the base station 504. In order to maintain mobility management and connectivity, the core network part 502 also includes a mobility management entity (not shown) which manages the enhanced packet service, EPS, connections with the terminal devices 506, 508 operating in the communications system based on subscriber information stored in a home subscriber server, HSS. Other network components in the core network (also not shown for simplicity) include a policy charging and resource function, PCRF, and a packet data network gateway, PDN-GW, which provides a connection from the core network part 502 to an external packet data network, for example the Internet. As noted above, the operation of the various elements of the communications system 500 shown in Figure 5 may be broadly conventional apart from where modified to provide functionality in accordance with embodiments of the disclosure as discussed herein.

In this example, it is assumed the first terminal device 506 is a conventional smart-phone type terminal device communicating with the base station 504. Thus, and as is conventional, this first terminal device 506 comprises a transceiver unit 506a for transmission and reception of wireless signals and a controller unit 506b configured to control the smart phone 506. The controller unit 506b may comprise a processor unit which is suitably configured / programmed to provide the desired functionality using conventional programming / configuration techniques for equipment in wireless telecommunications systems. The transceiver unit 506a and the controller unit 506b are schematically shown in Figure 5 as separate elements. However, it will be appreciated that the functionality of these units can be provided in various different ways, for example using a single suitably programmed general purpose computer, or suitably configured application-specific integrated circuit(s) / circuitry. As will be appreciated the conventional terminal device 506 will in general comprise various other elements associated with its operating functionality.

In this example, it is assumed the second terminal device 508 is a machine-type communication (MTC) terminal device according to an embodiment of the disclosure and located in an area of restricted coverage. As discussed above, MTC devices may be typically characterised as semi-autonomous or autonomous wireless communication devices communicating small amounts of data. Examples include so-called smart meters which, for example, may be located in a customer's house and periodically transmit information back to a central MTC server data relating to the customer's consumption of a utility such as gas, water, electricity and so on. MTC devices may in some respects be seen as devices which can be supported by relatively low bandwidth communication channels having relatively low quality of service (QoS), for example in terms of latency. It is assumed here the MTC terminal device 508 in Figure 5 is such a device. It will, however, the appreciated that embodiments of the disclosure may also be implemented for other types of terminal device.

As with the smart phone 506, the MTC device 508 comprises a transceiver unit 508a for transmission and reception of wireless signals and a controller unit 508b configured to control the MTC device 508. The controller unit 508b may comprise a processor unit which is suitably configured / programmed to provide the desired functionality described herein using conventional programming / configuration techniques for equipment in wireless telecommunications systems. The transceiver unit 508a and the controller unit 508b are schematically shown in Figure 5 as separate elements for ease of representation. However, it will be appreciated that the functionality of these units can be provided in various different ways, for example using a single suitably programmed general purpose computer, or suitably configured application-specific integrated circuit(s) / circuitry, or using a plurality of discrete circuitry / processing elements for providing different elements of the desired functionality. It will be appreciated the MTC device 508 will in general comprise various other elements associated with its operating functionality in accordance with established wireless telecommunications techniques (e.g. a power source, possibly a user interface, and so forth).

The base station 504 comprises a transceiver unit 504a for transmission and reception of wireless signals and a controller unit 504b configured to control the base station 504. The controller unit 504b may comprise a processor unit which is suitably configured / programmed to provide the desired functionality described herein using conventional programming / configuration techniques for equipment in wireless telecommunications systems. The transceiver unit 504a and the controller unit 504b are schematically shown in Figure 5 as separate elements for ease of representation. However, it will be appreciated that the functionality of these units can be provided in various different ways, for example using a single suitably programmed general purpose computer, or suitably configured application-specific integrated circuit(s) / circuitry or using a plurality of discrete circuitry / processing elements for providing different elements of the desired functionality. It will be appreciated the base station 504 will in general comprise various other elements associated with its operating functionality. For example, the base station 504 will in general comprise a scheduling entity responsible for scheduling communications. The functionality of the scheduling entity may, for example, be subsumed by the controller unit 504b.

Thus, the base station 504 is configured to communicate data with the smart phone 506 over a first radio communication link 510 and communicate data with the MTC device 508 over a second radio communication link 512. Both radio links may be supported within a single radio frame structure associated with the base station 504. It is assumed here the base station 504 is configured to communicate with the smart phone 506 over the first radio communication link 510 in accordance with the

established principles of LTE-based communications and to communicate with the MTC-device 506 over the second radio communication link 512 in accordance with embodiments of the disclosure as described herein. It will be appreciated the base station may readily obtain information indicating the different classes of terminal device which are attached to the base station in accordance with conventional techniques. That is to say, the base station will be aware that the smart phone is of a device class that includes conventional smartphones and the MTC device is of a device class that includes MTC devices. Furthermore, the base station may establish using conventional techniques that the MTC device 508 is a device operating in a coverage limited situation such that steps are needed to increase the likelihood of the MTC device being able to decode downlink transmissions.

As noted above, in a LTE-based wireless telecommunications system some of the fundamental information required for a terminal device to operate in a cell is transmitted on PBCH in the Master Information Block (MIB). Other information regarding the system configuration is divided among System Information Blocks (SIBs) referred to as SIB1, SIB2, SIB3,...etc. (there are 16 SIBs defined as of Release 11 LTE). The SIBs are transmitted in system information (SI) messages, which, apart from SIB1, may contain multiple SIBs (termed first SI, second SI, etc.). There may be one or several SI messages transmitted at different periodicities. Each SI message may convey multiple SIBs suitable for scheduling with the same periodicity. The timings for SIB1 message transmissions are fixed on an 80 ms period and they occur in the fifth subframe of radio frames when System Frame Number (SFN) is a multiple of 8 (i.e. SFN mod 8 = 0). There are retransmissions of SIB1 messages provided in every other radio frame within the 80 ms period. The timings for other SIB transmission messages are configured in SIB1. The transmission resource allocations for the SI messages on PDSCH within a subframe are provided to terminal devices using PDCCH allocation messages addressed to SI-RNTI (System Information Radio Network Temporary Identifier - currently 0xFFFF in LTE). At higher layers, SI is carried on the logical broadcast control channel (BCCH).

In LTE the SI messages are transmitted within periodically occurring time domain windows (referred to as SI-windows) using dynamic scheduling. Each SI message is associated with a SI-window and the SI-windows of different SI messages do not overlap. That is, within one SI-window only the corresponding SI message is transmitted. The length of the SI-window is common for all SI messages, and is configurable. Within the SI-window, the corresponding SI message can be transmitted a number of times in any subframe other than MBSFN (multicast-broadcast single frequency network) subframes, uplink subframes in TDD (time division duplex), and subframe #5 of radio frames for which SFN (system frame number) mod 2 = 0. Terminal devices acquire the detailed time-domain scheduling (and other information, e.g. frequency-domain scheduling, transport format) from decoding SI-RNTI on PDCCH. A single SI-RNTI is used to address SystemInformationBlockType1 as well as all SI messages. SystemInformationBlockType1 configures the SI-window length and the transmission periodicity for the SI messages.

The system information in a cell may be changed, although typically this happens rarely with system information perhaps remaining unchanged for hours, days, or even weeks.

For changes of system information other than those related to EAB (Extended Access Barring), ETWS (Earthquake Tsunami Warning System) and CMAS (Commercial Mobile Alert System), there is a BCCH modification period defined (which may be referred to as a “SI modification period”). SI modification period boundaries are defined on radio frames for which SFN mod q = 0, for a cell-specific value of q.

When there is a change in system information, the new system information is transmitted from the start of a new SI modification period.

The general process for implementing a change in system information in a LTE-based network is described, for example, in Section 5.2.1.3 of ETSI TS 136 331 V11.4.0 (2013-07) / 3GPP TS 36.331 version 11.4.0 Release 11 [3]. In summary, a base station indicates a change of system information as follows.

1. When the network changes system information it notifies terminal devices about the change by transmitting a PDCCH resource allocation message addressed to the paging RNTI (P-RNTI). This directs the terminal devices to decode PDSCH resources containing a Paging message with a SystemInfoModification flag set to true. This may be done, for example, throughout one SI modification period. Both RRC_IDLE and RRC_CONNECTED terminal devices check for paging messages periodically. It may be noted that EAB alterations, ETWS and CMAS notifications may be separately modified with separate flags in a paging message (but can also be modified along with other SIBs).

2. In a following SI modification period, the network transmits the modified system information, and may increment a SystemInfoValueTag in SIB1. This value tag can indicate changes in any SIB, but it might not be used for EAB, ETWS, CMAS and some regularly changing SI parameters such as CDMA2000 system time. Terminal devices can use SystemInfoValueTag to verify if currently stored system information is still valid, for example on return from being out of coverage when the UE may have missed a system information change notification in paging.

More details on system information and changes in system information in a LTE-based system can be found in ETSI TS 136 331 V11.4.0 (2013-07) / 3GPP TS 36.331 version 11.4.0 Release 11 [3].

As discussed above, it has been proposed to improve coverage for terminal devices in a wireless telecommunications system by introducing repetitions of a transmission which a terminal device may combine to provide an increased likelihood of successful decoding.

Figure 6 schematically represents an approach for providing coverage extension through repeated transmissions for an SI message in accordance with existing techniques. Figure 6 schematically shows a sequence of LTE downlink subframes (labelled as subframes "A", "B", "C", …, "L" to aid explanation) with shading to schematically indicate which regions in which subframes are used to convey system information. The subframes represented in Figure 6 comprise four groups of three contiguous subframes with spaces between the groups as schematically indicated by dotted lines and discussed further below. Although not shown in Figure 6, the gaps between the groups comprise a continuing sequence of subframes used for other communications that are not relevant to the system information messaging considered here. As discussed above, each subframe comprises a control region 600 and a PDSCH region 602. The control regions 600 for the respective subframes are labelled in Figure 6 with the identification letter for the relevant subframe, i.e. as 600A, 600B, 600C, etc. The PDSCH regions for the respective subframes are similarly labelled in Figure 6 as 602A, 602B, 602C, etc. Each subframe represented in Figure 6 is in essence a simplified version of what is represented in Figure 3. Thus, the control regions 600 support the PCFICH, PHICH and PDCCH channels as discussed above while the PDSCH regions 602 support user-plane data and system information (among other things) and the EPDCCD if implemented. The most significant aspect of the control region 600 in the context of

embodiments of the present disclosure relate to the PDCCH and so for simplicity the control regions 600 may sometimes be referred to herein as PDCCH regions 600.

Before explaining the repeated transmissions approach to providing coverage extension represented in Figure 6 it is considered helpful to clarify some aspects of the terminology to be used herein. The term "repeat transmission" (and related terms) will be used to refer to a transmission in an individual subframe which is part of a sequence of transmissions that are being repeated for the purposes of providing coverage extension for a message being conveyed between a base station and a terminal device (such as a PDCCH message or a PDSCH message). Thus in a coverage extension context, the transmission of a (E)PDCCH message comprises a plurality of "repeat transmissions" on (E)PDCCH and the transmission of a PDSCH message comprises a plurality of "repeat transmissions" on PDSCH. The term "re-transmission" (and related terms) will be used to refer to the transmission of a message that has already been sent at least once before. These terms should be interpreted accordingly unless the context demands otherwise.

For the example repeat transmission approach to coverage extension represented in Figure 6 it is assumed for ease of representation the approach relies on providing only three repeat transmissions for each PDCCH message and each PDSCH message. It will, however, be appreciated that in practice larger numbers of repeat transmissions will typically be involved, for example there may be tens or hundreds of repeats comprising each message to provide a correspondingly higher degree of coverage extension. Furthermore, it will be appreciated that PDCCH messages and PDSCH messages may comprise different numbers of repeat transmissions (for example because different coding schemes are adopted meaning that different numbers of repeat transmissions are needed for a given probability of successful reception).

Thus, referring to Figure 6, subframes A, B and C are used to signal a PDCCH message addressed to SI-RNTI by sending three repeat PDCCH transmissions in the respective PDCCH regions 600A, 600B, 600C. Each PDCCH repeat transmission addressed to SI-RNTI in the PDCCH regions 600A, 600B, 600C in effect comprises a duplication of the same downlink control information which a terminal device can combine to seek to establish the content of the PDCCH message. For this example repeat-transmission based coverage extension scheme it is assumed a particular type of message subject to repeat transmissions is addressed to the same RNTI (e.g. SI-RNTI for a system information related type of messages) as if the same type of message were subject to conventional single-subframe transmission. However, as discussed further below, in accordance with certain embodiments of the disclosure identifiers having different characteristics (e.g. values) may be used for a given type of message depending on whether the messages to be sent in accordance with a first transmission scheme (e.g. using a conventional single subframe based transmission approach) or a second transmission scheme (e.g. using a repeat-transmission scheme for coverage extension). Furthermore, it will be appreciated the approach of using identifiers associated with a particular type of message having different characteristics according to what transmission scheme is to be used to transmit the message can be used in accordance with embodiments of the disclosure with or without the use of validity periods as disclosed herein.

The PDCCH message comprising the three repeat transmissions in the PDCCH regions of subframes A, B and C indicates resource blocks to be used for a subsequent PDSCH message comprising the transmission of system information. This PDSCH message itself comprises a plurality of repeat transmissions, and, in this example, are represented by shading in the PDSCH regions 602D, 602E and 602F of subframes D, E and F. The transmission resources, for example in terms of specific resource

elements, used to convey the repeat transmissions of the system information message in the PDSCH regions 602D, 602E and 602F are indicated in the corresponding PDCCH message addressed to SI-RNTI and comprising the repeat transmissions in PDCCH regions 600A, 600B, 600C in accordance with conventional resource allocation techniques in the context of coverage extension using repeat transmissions. Whilst the shading in Figure 6 schematically represents the same frequency resources being used for each repeat transmission in the respective PDSCH regions 602D, 602E and 602F of the subframes D, E, F, in principle the repeat-transmission approach may be configured to include frequency hopping for the different repeat transmissions comprising the PDSCH message sent in subframes D, E, F. The nature of any such frequency hopping may be pre-defined, for example it may be pre-specified according to an operating standard for the wireless telecommunications system, or it may be established in previous RRC (radio resource control) signalling, or it may be indicated in the PDCCH message.

As schematically represented in Figure 6 there is a gap between subframes C and D. This follows the currently-proposed approaches for repeat-transmission coverage extension whereby the transmission of a PDSCH message comprising a plurality of repeat transmissions does not start until after all repeat transmissions of the corresponding PDCCH message have been sent. This is to help reduce the buffering requirements at the terminal device. Furthermore, current proposals indicate there should be no overlap between the end of the repeat transmissions comprising the PDCCH message and the start of the repeat transmissions comprising the PDSCH message. It will, however, be appreciated the specific implementation of such aspects of a repeat transmission approach for providing coverage extension are not significant to the principles underlying the present disclosure. That is to say, the principles described herein may equally be implemented in association with other repeat transmission approaches (e.g. with repeat transmissions of PDCCH and its corresponding PDSCH occurring in the same subframe).

In subframes following the transmission of the system information message as schematically indicated in subframes D, E and F in Figure 6, the wireless telecommunications system continues to operate in accordance with its normal operating techniques until subframe G represented. Subframe G represents the beginning of another system information message. As noted above, system information messages can be regularly retransmitted in accordance with LTE techniques, and in this regard the system information message beginning at subframe G is considered in this example to be a re-transmission of the system information message transmitted using subframes A to F as discussed above. The specific timing of the re-transmission of system information (i.e. the timing of subframe G relative to subframe A) may follow any conventional system information re-transmission schedule. The principles underlying the re-transmission of the system information message starting from subframe G follow those described above. Thus, a PDCCH message addressed to SI-RNTI is sent using the PDCCH regions 600G, 600H and 600I of subframes G, H and I to allocate resources for a PDSCH message comprising three repeat transmissions in the PDSCH regions 602J, 602K and 602L in subframes J, K and L as indicated by shading in Figure 6. It may be noted in this example the frequencies of the resource elements for the re-transmission of the system information message on PDSCH in subframes J, K, L is different from that used in subframes D, E, F for the previous transmission, but this is not of any particular significance. Furthermore, the transmissions of the PDSCH message in subframes D, E, F, J, K, L may comprise different so-called redundancy versions of the PDSCH message comprising different combinations of information bits and redundancy bits arising from a forward error correction coding process.

It will be appreciated the transmission resources represented in Figure 6 which are not involved in the SI message signalling discussed above can be used for other communications in the network in the usual manner. In particular, it will be appreciated that although the entirety of the PDCCH regions associated with repeat transmissions of the PDCCH for the system information messages are shown shaded in Figure 6, this is merely to highlight those subframes in which a PDCCH for the system information messages is transmitted compared to those where it is not, and in practice these regions will comprise multiple PDCCH messages addressing different terminal devices for allocating resources for various different types of communication on PDSCH.

System information signalling in LTE is sent on what is approaching a more or less continuous basis. This means there is a considerable amount of PDSCH traffic for broadcasting system information messages comprising the SIBs. There is a corresponding requirement for PDCCH signalling to schedule the PDSCH resources for system information messages. The inventors have recognised that this can become a significant issue in a coverage extension scenario where a number of repetitions are expected, as illustrated in Figure 6. This is because for each PDSCH message comprising a plurality of PDSCH repeat transmissions (i.e. the PDSCH message sent using resources in subframes D, E and F and the PDSCH message sent using resources in subframes J, K and L) there is a corresponding SI-RNTI PDCCH message comprising a plurality of PDCCH repeat transmissions (i.e. the PDCCH message sent using resources in subframes A, B and C and the PDCCH message sent using resources in subframes G, H and I). With the potential for perhaps a hundred or more repeat transmissions to provide coverage extension to the edge of a base station's corresponding cell for system information messages a large fraction of the available control region resources will be needed to support this function following the approach of Figure 6. There is of course a corresponding increase in the use of PDSCH resources with the approach represented in Figure 6, but it is to be expected that in many situations it will be PDCCH resources that are more at a premium owing to the limited resources available in the control channel region for PDCCH and the priority typically given to PDSCH over EPDCCH in the PDSCH region. This is especially likely in networks supporting large numbers of MTC devices since these are likely to have a higher ratio of control signalling to data signalling as compared to the traffic profiles typically associated with conventional terminal devices. The increased PDCCH and/or EPDCCH resources needed to support repeat transmissions of system information messages could ultimately make it difficult to schedule unicast PDSCH transmissions to terminal devices operating within the system because of a lack an availability of control region resources to indicate the allocation of PDSCH resources and/or a lack of PDSCH region resource to indicate the allocation of PDSCH resources.

To address this type of issue there have been proposals to stop using PDCCH and EPDCCH messages resource allocations for PDSCH messages comprising system information (i.e. for system information messages). One proposal (described in the 3GPP document R1-135422, "On the need of PDCCH for SIB and other Common Channel", Mediatek, RAN1#75, San Francisco, November 2013 [4]) is to avoid providing any scheduling information in respect of system information-carrying PDSCH transmissions. Instead, a terminal device will be expected to perform blind searching of the PDSCH region to identify if there are any relevant system information transmissions. A drawback with this approach is a significant increase in the processing load required for terminal devices. To reduce the processing load required at the terminal device to a more manageable level the system information messages could be confined to a restricted subset of transmission resources comprising the PDSCH region. However, this approach still requires additional processing tasks to be performed by the terminal device and introduces reduced

scheduling flexibility. Another proposal (described in the 3GPP document R1-134207, "Coverage enhancement techniques for PBCH", Alcatel-Lucent, Alcatel-Lucent Shanghai Bell, RAN1#74bis, Guangzhou, October 2013 [5]) is to avoid using PDCCH messages to provide scheduling information in respect of system information-carrying PDSCH messages. Instead it is proposed that some of the spare bits currently available in the Master Information Block (MIB) in LTE are used for providing scheduling indications for system information messages. However, there are a limited number of spare bits available for this and so the approach does not allow for any significant degree of flexibility in scheduling system information messages, and furthermore the approach further reduces the number of spare bits available for other uses.

In view of these issues, the inventors have developed an alternative approach for reducing the amount of control signalling required to support resource allocations for higher-layer transmissions in a wireless telecommunications system. In particular, but not exclusively, the inventors have developed an approach which may be applied for reducing the amount of control-channel signalling required to support resource allocations for downlink messages, such as system information messages, and in particular for messages which may be subject to re-transmissions on a defined schedule and which may, in some cases, be sent using a repeat transmission approach to provide a degree of coverage extension.

Figure 7 is similar to, and represents various aspects that will be understood from, Figure 6, but shows an approach in accordance with certain embodiments of the present disclosure. Figure 8 is a signalling ladder diagram schematically representing modes of operation for the terminal device 508 and the base station 504 schematically represented in Figure 5 in accordance with some embodiments of the present disclosure for implementing an approach of the kind represented in Figure 7. In broad summary, some embodiments of the disclosure introduce the concept of a validity period for a PDCCH message to thereby indicate transmission resources that may be used for a plurality of PDSCH messages within the validity period. That is to say the control message transmitted on the PDCCH is considered valid for a period that is longer than the period needed to transmit a single PDSCH message (whether in one subframe or with repeat transmissions in a plurality of subframes to provide coverage extension). This means multiple PDSCH messages can in effect be scheduled using the control-region resources of only a single PDCCH message. There are various different ways in which the validity period may be established/determined, as discussed further below.

For the example represented in Figure 7, and as with Figure 6, it is assumed system information is being transmitted from a base station to a terminal device with a repeat transmission approach to providing coverage extension. Again the example approach to coverage extension represented in Figure 7 is assumed for ease of representation to rely on providing only three repeat transmissions for each PDCCH and PDSCH message. However, as noted above, it will be appreciated that in practice larger numbers of repeat transmissions will typically be involved, for example there may be tens or hundreds of repeats comprising each message to provide a correspondingly higher degree of coverage extension. Furthermore, it will be appreciated that PDCCH messages and PDSCH messages need not necessarily comprise the same number of repeat transmissions (for example different coding schemes may be adopted meaning that different numbers of repeat transmissions are appropriate to provide a desired probability of successful reception for each message).

Thus Figure 7 schematically represents an approach for providing coverage extension through repeated transmissions for a plurality of SI messages with reduced control signalling overhead in accordance with

an embodiment of the disclosure. Figure 7 schematically shows a sequence of LTE downlink subframes (labelled as subframes "O", "P", "Q", …, "Z" to aid explanation) with shading to schematically indicate which regions in which subframes are used to convey messages associated with the system information. The subframes represented in Figure 7 comprise four groups of three contiguous subframes with spaces between the groups as schematically indicated by dotted lines. Although not shown in Figure 7, the gaps between the groups comprise a continuing sequence of subframes used for other communications that are not relevant to the system information messaging considered here. As discussed above, each subframe comprises a control region 700 and a PDSCH region 702. The control regions 700 for the respective subframes are labelled in Figure 7 with the identification letter for the relevant subframe, i.e. as 700O, 700P, 700Q, etc. The PDSCH regions for the respective subframes are similarly labelled in Figure 6 as 702O, 702P, 702Q, etc.

As already noted above, aspects of the operation of a wireless telecommunications system in accordance with embodiments of the disclosure, for example as shown in Figure 7 and 8, which are not specifically described herein may be implemented in accordance with any conventional techniques. In this regard, insofar as the operation of embodiments of the disclosure follow conventional techniques the respective subframes represented in Figure 7 may be similar to that is represented in Figure 3. Thus, the control regions 700 support PCFICH, PHICH and PDCCH channels as discussed above while the PDSCH regions 702 support user-plane data and system information (among other things) and EPDCCH if implemented. The most significant aspect of the control region 700 in the context of embodiments of the present disclosure relate to the PDCCH and so for simplicity the control regions 700 may sometimes be referred to herein as PDCCH regions 700.

Thus referring to Figure 7 subframes O, P and Q are used to signal a PDCCH message addressed to SI-RNTI by sending three repeat PDCCH transmissions in the respective PDCCH regions 700O, 700P, 700Q. Each PDCCH repeat transmission addressed to SI-RNTI in the PDCCH regions 700O, 700P, 700Q in effect comprises a duplication of the same downlink control information which a terminal device can combine to seek to establish the content of the PDCCH message addressed to SI-RNTI in accordance with conventional techniques for coverage extension through repeat transmissions. For this example implementation of a repeat-transmission based coverage extension scheme it is again assumed a particular type of message subject to repeat transmissions is addressed to the same RNTI (e.g. SI-RNTI for a system information related type of messages) as if the same type of message were subject to conventional single-subframe transmission. However, as discussed further below, in accordance with certain embodiments of the disclosure identifiers having different characteristics (e.g. in terms of their value or control region search space) may be used for a given type of message depending on whether the messages to be sent in accordance with a first transmission scheme (e.g. using a conventional single subframe based transmission approach) or a second transmission scheme (e.g. using a repeat-transmission scheme for coverage extension). Furthermore, it will be appreciated the approach of using identifiers associated with a particular type of message having different characteristics according to the transmission scheme is to be used in accordance with embodiments of the disclosure may or may not also implement an approach using validity periods as disclosed herein.

The PDCCH message sent in subframes O, P and Q in Figure 7 differs from a conventional PDCCH message, for example of the kind transmitted in subframes A, B and C of Figure 6, in that it is associated with a validity period that is sufficient to span the transmission of a plurality of PDSCH messages. This is

different from the conventional approach in which a PDCCH message is simply associated with a single PDSCH message. The validity period for the PDCCH message is known to both the base station and the terminal device. For example, the validity period may be based on a defined standard for operations in accordance with an embodiment of the disclosure, whereby the base station and the terminal device can each determine the validity period from the defined standard. In other embodiments the base station may have flexibility to select the validity period, for example according to current scheduling requirements, and to communicate an indication of the validity period to the terminal device(s) to which the PDCCH message is addressed. Some example implementation of this approach are discussed further below.

The PDCCH message comprising the three repeat transmissions in the PDCCH regions of subframes O, P and Q indicate transmission resource blocks to be used for a subsequent PDSCH message comprising the transmission of system information. This PDSCH message itself comprises a plurality of repeat transmissions, and, in this example, are represented by shading in the PDSCH regions 702R, 702S and 702T of subframes D, E and F. The manner in which the PDCCH message indicates the corresponding PDSCH resources in subframes R, S and T may be in accordance with conventional techniques/signalling protocols. That is to say, the transmission resources, for example in terms of specific resource elements, used to convey the repeat transmissions of the system information message in the PDSCH regions 702R, 702S and 702T may be indicated in the corresponding PDCCH message addressed to SI-RNTI and comprising the repeat transmissions in PDCCH regions 700O, 700P, 700Q in accordance with conventional resource allocation techniques in the context of coverage extension using repeat transmissions. Whilst the shading in Figure 7 schematically represents the same frequency resources being used for each repeat transmission in the respective PDSCH regions 702R, 702S and 702T of the subframes R, S and T, in principle the repeat-transmission approach may be configured to include frequency hopping for the different repeat transmissions comprising the PDSCH message sent in subframes R, S and T. The nature of any such frequency hopping may be pre-defined, for example it may be pre-specified according to an operating standard for the wireless telecommunications system, or it may be established in previous RRC (radio resource control) signalling, or it may be indicated in the PDCCH message.

As schematically represented in Figure 7 there is a gap between subframes C and D. This again follows the currently-proposed approaches for repeat-transmission coverage extension whereby the transmission of a PDSCH message comprising a plurality of repeat transmissions does not start until after all repeat transmissions of the corresponding PDCCH message have been sent. Furthermore, some proposals indicate there should be no overlap between the end of the repeat transmissions comprising the PDCCH message and the start of the repeat transmissions comprising the PDSCH message. It will, however, be appreciated the specific implementation of such aspects of a repeat transmission approach for providing coverage extension are not significant to the principles underlying the present disclosure. That is to say, the principles described herein may equally be implemented in association with other repeat transmission approaches (e.g. with repeat transmissions of PDCCH and an associated PDSCH occurring in the same subframe).

Thus, the communication of the PDCCH message in subframes O, P and Q and the corresponding communication of the PDSCH message conveying system information in subframes R, S and T as represented in Figure 7 may follow the same general principles as the approach represented in Figure 6. Similarly, in subframes following the repeat-transmission approach for transmitting the system information

message as schematically indicated in subframes R, S and T in Figure 7, the wireless telecommunications system may continue to operate in accordance with its normal operating techniques for conveying other messages.

As noted above, system information messages are regularly retransmitted in accordance with LTE techniques, and the approach of Figure 7 differs from the approach of Figure 6 in respect of how a subsequent transmission of system information is scheduled on PDSCH in subframes X, Y and Z. In particular, the approach of Figure 7 differs from the approach of Figure 6 if the subsequent retransmission of system information occurs within the validity period associated with the previously-received PDCCH message in subframes O, P and Q initially sent in association with the previously-received system information message on PDSCH in subframes R, S and T. In LTE the transmission of system information follows a defined timing schedule, for example based on the system information window defined for the relevant system information. Thus, a base station and a terminal device are able to independently determine in which subframe a system information message will be transmitted on PDSCH (or which plurality of subframes in the case of coverage extension through repeat-transmissions as in this example). Thus, in the example of Figure 7, a terminal device to which the system information is addressed can determine that a system information message is to be transmitted in subframes X, Y and Z.

Referring back to Figure 6, the terminal device receiving the system information on PDSCH in subframes J, K and L can similarly determine in accordance with conventional techniques that the transmission will occur in these subframes. However, to determine the specific resources (e.g. in terms of specific OFDM carriers / resource blocks) on which the transmissions will occur within the relevant subframe(s) the terminal device must first receive the corresponding PDCCH allocation message sent in subframes G, H and I.

However, in the approach of Figure 7 in accordance with an embodiment of the present disclosure the resource allocation used for the PDSCH transmissions of the system information message on subframes X, Y and Z is determined from the previous resource allocation message sent on PDCCH in subframes O, P and Q. For example, in accordance with one approach the specific PDSCH resources (e.g. in terms of frequency) to be used for transmitting the subsequent system information message in subframes X,Y and Z are assumed to be the same as the specific PDSCH resources (e.g. in terms of frequency) used for transmitting the system information message in subframes R, S and T and indicated in the PDCCH message sent in subframes O, P and Q. However, it will be appreciated that other mappings can be adopted. For example, the frequencies to be used can be configured to shift in accordance with a predefined pattern for each retransmission within the validity period for the PDCCH message.

Thus, in accordance with an embodiment of the disclosure, and in contrast to the approach in the corresponding subframes in Figure 6, there is no PDCCH message sent in subframes U, V and W to support the system information message sent on PDSCH in subframes X, Y and Z. Instead it is determined that a previous PDCCH message remains valid (because its associated validity period has yet to expire), and the resources used for conveying the system information message on PDSCH in subframes X, Y and Z are derived from the previous PDCCH.

This approach has an advantage of freeing up the control-channel resources, in particular in subframes U, V and W for the example subframes represented in Figure 7. The approach can also help reduce the

amount of processing required by the terminal device (since the terminal device does not need to decode a separate PDCCH message for each and every PDSCH message). Furthermore the approach can reduce latency in situations that require high repetition numbers because there is no need to wait to receive a series of PDCCH repetitions before receiving each series of PDSCH repetitions.

It will be appreciated the transmission resources represented in Figure 7 that are not involved in the SI message signalling discussed above can be used for other communications in the network in the usual manner. In particular, it will be appreciated that although the entirety of the PDCCH regions associated with repeat transmissions of the PDCCH for the system information messages are shown shaded in Figure 7, this is merely to highlight those subframes in which a PDCCH for the system information messages is transmitted compared to those where it is not, and in practice these regions will comprise multiple PDCCH messages addressing different terminal devices for allocating resources for various different types of communication on PDSCH.

Thus, to summarise an approach in accordance with an embodiment of the disclosure as represented in Figure 7, and with reference to Figure 8, a base station 504 is transmitting system information messages to terminal devices, including terminal device 508, according to a pre-defined timing schedule. The predefined timing schedule may follow conventional LTE techniques for transmitting system information. It is assumed the processing represented in Figure 8 starts just prior to subframe O at the beginning of the series of subframes represented in Figure 7 and while there is no currently valid PDCCH message for the relevant system information. Thus, in a first step S1 in Figure 8 the base station determines a validity period that is to apply for an upcoming control-plane message that is to be transmitted to allocate resources for system information messages on PDSCH. The duration of a validity period for a given PDCCH message may be fixed / predetermined according to a specific implementation, for example by a network operator, or may be selectable by a base station according to current conditions. The validity period might be relatively short, for example it might only comprise the time required to transmit two PDSCH messages to provide a potential saving of one PDCCH message transmission. On the other hand, the validity period might be significant number, for example hundreds, thousands, tens of thousands, or even more subframes. In general a longer validity period may be preferred to reduce the number of PDCCH message transmissions, while an overly-long validity period may be considered to overly restrict scheduling flexibility. An appropriate validity period in a given situation may depend on current traffic conditions within a cell supported by a base station. For example, if a base station is currently supporting a large number of terminal devices it may be more appropriate to select a relatively long validity period to provide a correspondingly large saving in PDCCH message transmissions. However, if a base station is currently supporting only a small number of terminal devices with low traffic requirements (i.e. such that PDCCH congestion is not an overly significant concern), it may be more appropriate to select a relatively short validity period to provide a corresponding increase in scheduling flexibility (example to take better account of fluctuations in radio propagation conditions or traffic changes). In one example a current proportion of non-MTC traffic may be used to help determine an appropriate validity period for a repeated PDCCH. Generally speaking, the higher this proportion, the higher the proportion of non-delay-tolerant non-small-message terminal devices in the cell whose performance may be disrupted by a heavy use of control channel resources due to repeated PDCCH transmission. Therefore, as the proportion of relatively higher priority terminal devices (e.g. non-MTC terminal devices) increases, the base station may opt for longer PDCCH validity times, especially for use in association with SI-messages.

In step S2 the base station transmits a control-plane message, which can also be referred to as a control message (using repeat transmissions for coverage extension in this example) to allocate the resources for subsequent system information messages on PDSCH. This control message is received and decoded by the terminal device 508. This aspect of the operation may be based generally on conventional techniques, for example using a PDCCH message addressed to an SI-RNTI in LTE. Furthermore, the specific resources selected by the base station for allocation to the system information messages may be selected in accordance with established scheduling techniques in wireless communication systems. Thus, step S2 correspond with the transmissions made in subframes O, P and Q of Figure 7.

In step S3 the terminal device determines the validity period for the control-plane message received in step S2. There are various ways in which the terminal device may determine the validity period for the control-plane resource allocation message in accordance with various embodiments of the disclosure, and some examples are discussed further below.

In step S4 the base station proceeds to transmit a system information message (using repeat transmissions for coverage extension in this example) in accordance with the resource allocation identified by the control-plane (PDCCH) message of step S2. This aspect of the operation may be made broadly in accordance with conventional techniques. The terminal device seeks to receive and decode this system information message (SI message #1) in accordance with conventional techniques.

In step S5 the base station determines it is time to transmit another system information message (SI message #2) according to the predefined timing for periodic system information transmissions in the wireless telecommunications system. The base station further determines the validity period for the control-plane message sent in step S2 has not yet expired. Accordingly, the base station does not send any new control-plane message to support the new system information message that is about to be transmitted (SI message#2). Instead the base station proceeds to transmit the system information message (using repeat transmissions for coverage extension in this example) in accordance with resource allocations derived from the previously-sent control-plane (PDCCH) message of step S2. For example, the base station may be configured to simply use the same frequency resources for transmitting SI message #2 in step S5 as were used for transmitting SI message #1 in step S2. The terminal device likewise determines the expected transmission timing for the new system information message (SI message #2) from the predefined timing for system information transmissions and also determines the validity period for the previous control-plane message received in step S2 has not expired. Accordingly, the terminal device need not seek to receive a new control-plane message to indicate the PDSCH resources for the new system information message that is to be next transmitted (SI message#2). Instead the terminal device simply assumes the transmission is to be made in the relevant subframes (determined according to the predefined timing) on frequency resources derived from the previously-sent control-plane (PDCCH) message of step S2. Once the terminal device has determined the specific resources on which to expect the system information message in step S5 (SI message #2) it may proceed to receive and decode the system information message in accordance with conventional PDSCH transmission techniques.

As noted above the timing s for specific SI messages in LTE are based on SI windows. Conventionally it is the transmission of an associated PDCCH message addressed to the relevant system information RNTI which determines the precise subframe(s) in which the system information message PDSCH is transmitted. However, in accordance with certain embodiments of the disclosure there can be PDSCH

messages conveying system information in an SI windows without there being a corresponding PDCCH message in that SI window. There are a number of different ways in which a terminal device can determine the relevant subframe for a further PDSDH message transmitted within the validity period of a previously-received PDCCH message in accordance with embodiments of the disclosure. In one case, the base station may be configured to send the PDSCH message in a predefined subframe of the SI window. In principle this could be permanently fixed for all PDSCH system information messages at the cost of reduced scheduling flexibility. In another case the subframe(s) could be based on the subframe(s) used in association with the initial PDCCH message. For example, if the initial PDCCH indicates a system information message is to be sent in subframe number n (or starting in subframe n for repeat transitions for coverage extension) within a particular SI window, subsequent PDSCH messages within the validity period of the PDCCH might also be sent in (or start in) subframe n of the relevant SI window. In another example, the base station may retain the flexibility to send (or start sending when using repeat transmissions) the subsequent system information message in any subframe within the SI window. In this case a terminal device may check for a newly addressed PDCCH message in the subframes in the SI window in the normal way, and if a new PDCCH message is not found, the terminal device may decode the PDSCH resources indicated in accordance with a previously-received still valid PDCCH message in the same subframe(s) relative to the SI window as for the previous transmission. In principle, with sufficient processing power, the terminal device could simply seek to decode the relevant resources in all subframes of an SI window to see if an SI message can be decoded.

The process of the base station sending further system information messages, and the terminal device receiving the further information messages, based on transmission resource allocation information indicated in the control-plane message of step S2 may continue (as schematically indicated in step S6 for transmitting SI message #n) until the validity period for the control-plane message received in step S2 has expired, as schematically indicated in step S7.

Following step S7 the processing in effect cycles back to where it started prior to step S1. The base station may thus determine a new validity period for a new control message to be sent in a further step corresponding with step S2 (the base station determines that a new PDCCH message is required because the previous one has expired). Processing may then continue from this point in the manner discussed above.

Thus, the various example schemes represented in Figures 7 and 8, and described above, provide an approach in which control-plane messages, and in particular SI-messages, are associated with a validity period that extends for more than one message transmission of the associated PDSCH. For example, for SIBs in SI-messages, one SI-RNTI addressed PDCCH message can provide the control information for multiple transmissions of SIBs, and in general over multiple SI-windows. Similar operation for other types of message, for example messages addressed to other common search-space RNTIs, may be adopted in accordance with other examples. This kind of approach can help reduce control resource requirements, which can be especially important in the context of coverage extension where according to conventional techniques PDCCH (comprising multiple repeat transmissions) messages would have to be transmitted every time an SI-message (comprising multiple repeat transmissions) needed to be sent.

As noted above, SIBs in system information messages can in some cases remain unchanged for extended period, for example a few hours. A terminal device may thus combine system information message transmissions from across multiple SI-windows if it does not successfully decode an SI-

message at first attempt and with a sufficiently long validity period this can be achieved in accordance with the approaches described herein with reduced control signalling requirements than current schemes.

As noted above, there are various different ways in which the validity period for a PDCCH message may be established. In one simple example the period may be defined according to an operating standard of the wireless telecommunications system. Both the base station and the terminal device can in effect be hardwired with the validity period (or multiple validity periods associated with different types of messages). In another example the base station may have flexibility for determining a suitable validity period according to the implementation and traffic conditions at hand. In this case there are various different ways in which the validity period could be conveyed to a terminal device.

In one example the base station may be configured to convey a selected validity period to terminal devices by selecting a particular transmission characteristic, for example timing, for the PDCCH message with which the validity period is associated. According to current proposals for repeat transmission coverage extension in LTE, the starting subframe of a PDCCH message being transmitted in multiple subframes should be confined to a subset of subframes. This is because in some circumstances the terminal device may be required to blindly search over the possible numbers of repetitions the PDCCH might comprise. If it were allowed for a PDCCH messages comprising an arbitrary number of repeat transmissions to start in an arbitrary subframe this could be expected to give rise to significant complexity in the processing required of the terminal device. To address this there has been proposed an approach in which, for example, a PDCCH message comprising N repeats can only begin in subframes having a subframe number that is a multiple of N (i.e. 0, N, 2N, 3N,...). This reduces the set of possible repetition numbers the UE needs to consider per subframe. Thus, a similar approach could be used to convey information on PDCCH validity. This can be done by linking the validity period to the starting subframe number of the associated PDCCH message. For example, a PDCCH message commencing in subframe M might be taken to indicate a validity period corresponding to M SI-windows for the relevant system information. Thus, a terminal device can readily establish the relevant validity period from the timing of the relevant control-claim message. It may be noted that in some circumstances it may be preferable to assign longer PDCCH validity periods to PDSCH messages that comprise high numbers of repetitions.

In another example the base station may be configured to convey a selected validity period to terminal devices through explicit signalling, for example in the downlink control information (DCI) of the relevant PDCCH message. Thus, the DCI may comprise an indication of a number of subframes / radio frames corresponding to the validity period or may comprise an indication of a specific subframe / radio frame in which the validity period is to expire. In the application to the transmission of system information messages it may be preferable to indicate timings in respect of a number of SI-windows of validity.

In yet another example the terminal devices may be configured to simply assume the validity period for a given PDCCH message addressed to a given RNTI (e.g. SI-RNTI) extends until a subsequent PDCCH message addressed to the relevant RNTI is received. That is to say, the PDCCH message may be considered to remain valid until it is replaced by another PDCCH message. In this respect, in terms of the processing schematically represented in Figure 8, this corresponds with the terminal device determining the validity period for the control message (corresponding to step S3) at the same time at which the validity period expires (responding to step S7), with this being triggered by a new PDCCH message being received by the terminal device. In this approach a terminal device may thus monitor for a new PDCCH message addressed to the relevant RNTI in each subframe of each SI-window in the normal way until a

new PDCCH message is received to in effect define the end the validity period for the previous PDCCH message addressed to that RNTI.

Thus, one principle of the approaches described above in accordance with some embodiments of the disclosure is to associate a PDCCH message with a time defining its validity, that time being extensible beyond the time taken to convey a corresponding PDSCH message. A terminal device may thus assume the PDSCH resource allocation, MCS (modulation and coding scheme), TBS (transport block size), etc. in the DCI of the PDCCH message is valid for receiving multiple PDSCH messages during the PDCCH validity time. No further PDCCHs for multiple PDSCH messages need be sent during the validity time. Thus, in the case of SIB transmissions, the transmission of all SI-messages (including all transmissions within a SI-window of a particular SI-message), may be scheduled with a single transmission of SI-RNTI PDCCH with an appropriately configured validity period.

One particular situation in which approaches in accordance with the embodiments described above might be expected to be useful is where the transmissions are used to provide coverage extension on both PDCCH and PDSCH. However, similar principles can be applied where coverage extension is not being used, for example in respect of messages sent within single subframes.

Whilst the above-described embodiments have focused on system information messages, it will be appreciated that similar principles can be applied for other types of messages in wireless telecommunications systems, and especially for messages which rely on resource allocations occurring with some degree of predictable timing. For example, similar principles can be used for control signalling addressed to other common search space RNTIs, such as RA-RNTI and P-RNTI.

Thus a random access RNTI addressed PDCCH message received by a terminal device during an initial cell access may be associated with a validity period such that the transmission resources identified in association with the random access RNTI PDCCH message are taken to apply for later random access procedures in accordance with the principles set out above. The specific subframe of a RAR (random access response) window in which a subsequent RAR arrives can be established in a manner similar to that described above for system information within a predefined series of subframes comprising an SI-window

Similarly, a paging RNTI addressed PDCCH message may be associated with an extended validity in accordance with the principles described above. Thus a PDSCH resource allocation associated with a PDCCH message addressed to a paging RNTI transmitted in one subframe may be taken to indicate a PDSCH resource allocation in a subsequent subframe within a validity period associated with the PDCCH message. This may be especially appropriate for paging when a terminal device is in idle mode since there is a higher degree of predictability as to when paging messages may be sent according to a currently configured DRX, discontinuous reception, cycle. That is to say, the concept of PDDCH validity timers as discussed herein may be applied to the most recent P-RNTI PDCCH used to decode a paging message by an RRC_IDLE UE. An RRC_IDLE UE is only expected to monitor specific subframes for P-RNTI and is in DRX for other subframes. If the relevant PDCCH validity timer expires before a subsequent paging message is to be sent, the base station may provide a new P-RNTI PDCCH message to schedule the next paging message as normal. Otherwise the IDLE UE may assume the most recent such PDCCH is still valid. For an RRC_CONNECTED UE, there is less predictability as regards whether a particular subframe should contain P-RNTI PDCCH or not. For a connected mode terminal device the

principles described herein for paging messages might, for example, be used for subframes in which the UE would check for P-RNTI if it were in fact in IDLE mode. In other subframes the base station may send conventional paging signalling using PDCCH to page the UE in connected mode.

In a wireless telecommunications using repeat-transmissions for coverage extension there may be terminal devices which are not in coverage-limited locations and able to successfully decode individual ones of the PDCCH (or EPDCCH) repeat transmissions in each subframe. For example, and referring to Figure 7, a non-coverage-limited terminal device may be able to successfully decode the individual PDCCH repeat transmission in the control region 700O of subframe O. If this terminal device is not aware of the use of repeat-transmissions for coverage extension (for example because it is a legacy / conventional terminal device) it might be expected to assume the PDCCH information derived from the control region 700O subframe O applies to a system information transmission on PDSCH in the same subframe (i.e. in PDSCH region 702O). However, the terminal device would fail to receive the system information transmission (because it is not sent in accordance with this particular repeat-transmission protocol). Potentially this terminal device could seek to do this for each and every repeat transmission and so waste a considerable amount of processing effort needlessly decoding individual PDCCH repeat transmissions and associated PDSCH resources in the expectation of receiving system information messages which are not in fact being sent in those subframes. This is an issue which applies generally for repeat transmission approaches for coverage extension and is not specific to approaches based on validity periods as discussed herein.

Thus in accordance with certain embodiments of the disclosure an identifier (RNTI) having different characteristics (e.g. in terms of value or associated control region search space) may be associated with SI messages sent using a repeat transmission approach as compared to SI messages sent without using a repeat transmission approach. More generally, in a wireless telecommunications system supporting different transmission schemes for a given type (classification / category) of message (e.g. a message comprising a given radio resource control, RRC, information element, such as a system information related message or a paging request related message), a characteristic of an identifier associated with the message (i.e. an identifier to indicate which terminal device(s) the message is for) may be selected according to the transmission scheme used for the message. This approach may be implemented in accordance with certain embodiments of the disclosure regardless of whether the wireless telecommunications system also implements an approach using validity periods as described herein (i.e. the approach may be implemented in association with the principles of the repeat transmission scheme represented in Figure 6 as well as that represented in Figure 7). That is to say, the concept of associating a validity period with a control message and the concept of using different identifier characteristics according to a transmission scheme being used may be used together in combination or separately from one another in accordance with different embodiments of the disclosure.

A terminal device having the ability to receive transmissions using the repeat transmission approach can identify the transmissions as such directly from the associated identifier characteristic and receive the message accordingly. The characteristic for the identifier can be selected so that a terminal device not having the ability to receive transmissions using a repeat transmission approach, for example a legacy terminal device, does not recognise the message as being addressed to the terminal device, and so in effect ignores it. Such a terminal device may in effect ignore the message because, for example, the identifier has a value which is not recognised as a value relevant to the terminal device or because a search space for a control message conveying the identifier is not searched by the terminal device.

Thus, if in a particular implementation it is assumed that a repeat transmission approach to coverage extension is intended primarily for MTC-type devices, an MTC-specific system information radio network temporary identifier (MTC-SI-RNTI) may be established. PDCCH messages associated with repeat transmissions for conveying system information messages may thus be addressed to MTC-SI-RNTI instead of an SI-RNTI used for conveying system information that is not sent using repeat transmissions. More generally some embodiments of the disclosure propose introducing other repetition specific RNTIs to address messages that rely on repetitions for coverage extension to complement corresponding RNTIs in existing systems. Thus, system information messages to be sent in accordance with a non-repeat transmission technique may be associated with a conventional system information identifier (e.g. SI-RNTI) while system information messages to be sent in accordance with a repeat-transmission technique may be associated with a modified system information identifier (e.g. REPEAT-SI-RNTI).

Similar issues can arises for other common RNTIs associated with other types of message that may be sent using a repeat transmission approach. Thus corresponding RNTIs having different characteristics may also be established for these. For example, for each of SI-RNTI, P-RNTI, RA-RNTI, TPC-PUCCH-RNTI, TPC-PUSCH-RNTI and M-RNTI to be used for addressing non-repeat transmission messages, there may be established a corresponding RNTI having a different value to be used for addressing repeat-transmission messages (e.g. what might be generally referred to as REPEAT-RNTIs, such as REPEAT-SI-RNTI, REPEAT-P-RNTI, REPEAT-RA-RNTI, REPEAT-TPC-PUCCH-RNTI, REPEAT-TPC-PUSCH-RNTI and REPEAT-M-RNTI). Thus an approach in accordance with an embodiment of the disclosure may be used in association with messages selected from the group comprising: (i) a message associated with transmitting system information; (ii) a message associated with transmitting a paging message; (iii) a message associated with transmitting a random access response message; (iv) a message associated with transmitting power control information for an uplink control channel; (v) a message associated with transmitting power control information for an uplink data channel; and (vi) a message associated with a broadcast and / or multicast service. A similar approach can be taken for types of message associated with other common RNTIs which may be introduced in future.

In some implementations in which a message to be transmitted using a repeat-transmission approach in association with an identifier having a characteristic selected to indicate this, a component part of the message (e.g. a repeat transmission) may also be transmitted in one, or more, subframes in association with an identifier having a characteristic that would be used if the message were being transmitted using a conventional single-transmission approach. This will allow legacy terminal devices who are able to receive the message from only a single repeat transmission to in effect receive the message based on one of the repeat transmissions.

One advantage of associating identifiers for a given type of message with different characteristics based on the transmission scheme is the potential for more complete use of the available transmission resources. For example, referring to Figure 7, the initial SI-RNTI addressed PDCCH repeat transmission in the control region 700O of subframe O is part of a repeat transmission comprising three repeat transmissions in the respective control regions of subframes O, P and Q. This PDCCH message identifies resources (and other parameters) associated with a PDSCH message to be subsequently transmitted starting from subframe R as discussed above. As previously noted, it is expected for repeat-transmission based coverage extension there will be no PDSCH signalling associated with the PDCCH message until after the repeat transmissions comprising the PDCCH message had been made. In principle the PDSCH

transmission resources in the PDSCH regions 702O, 702P and 702Q of subframes O, P and Q corresponding to the resources allocated by the PDCCH message for use in subframe starting from subframe R could be used to support other transmissions. For example, the respective control regions 700O, 700P, 700R could include conventional single-subframe PDCCH messages allocating the relevant PDSCH transmission resources for another purpose, for example unicast data. However, it would be confusing for a legacy terminal device to decode a unicast PDCCH message and a SI PDCCH message resource allocation identifying the same resources in the same subframe. Thus by preventing the legacy terminal device from decoding the SI PDCCH signalling (through use of an appropriate distinguishing characteristic for the identifier as discussed herein), the legacy terminal device is free to receive unicast data on the relevant PDSCH resources (in association with an appropriately addressed PDCCH transmission indicating these resources).

In implementations in which the distinguishing characteristic for the identifier is its value (i.e. with one value, such as SI-RNTI, indicating conventional single-subframe transmission, and another value, such as REPEAT-SI-RNTI, indicating repeat-transmission coverage extension), the "new" REPEAT-RNTIs may be defined in accordance with an operating standard for the wireless telecommunications network in parallel with the corresponding RNTIs. For example, as noted above, in LTE the SI-RNTI has a fixed value 0xFFFF. In accordance with an embodiment of the disclosure a fixed value for a REPEAT-SI-RNTI may be selected from one of the currently reserved RNTIs in LTE (from 0xFFF4 to 0xFFC). Thus, if, for example, a value 0xFFF5 is allocated as REPEAT-SI-RNTI (i.e. an identifier for a system information related message sent using repeat transmissions), a PDCCH addressed to 0xFFFF can be identified as corresponding to a system information message sent without repetition whereas a PDCCH addressed to 0xFFF5 can be identified as corresponding to a system information message sent using repetition. A terminal device that is unaware of repetition will in effect ignore the PDCCH addressed to 0xFFF5 as this will not be recognised as a valid RNTI for the terminal device. Corresponding principles apply where EPDCCH is used.

In the above-described example the value of the RNTI is the characteristic used to distinguish between the different transmission schemes. However, in accordance with other embodiments of the disclosure, other characteristics can be used to distinguish identifiers to indicate different transmission schemes. For example, in LTE there are currently eight "spare" values that could be used as new REPEAT-RNTIs. This is a sufficient number of values to provide a corresponding RNTI to be used in association with a transmission scheme comprising repeat transmissions for all currently-existing common RNTIs. However, it may be considered preferable in some cases to avoid using these "spare" values so they remain free for other uses, or there may be a need for more REPEAT-RNTIs (for example, to provide multiple extra RNTI for a given type of message, e.g. a system information message, to indicate another aspect of the transmission scheme, for example the number of repeats). Thus, in accordance with some embodiments a REPEAT-RNTI may in fact have a value that is the same as its corresponding "conventional" RNTI (e.g. 0xFFFF for SI-RNTI and REPEAT-SI-RNTI) but be associated with a different search space. As is well known a terminal device will typically search a defined subset of control region resources to seek to identify any control messages associated with an identifier (RNTI) common to a plurality of terminal devices. The subset of control region resources is known as a search space and comprises a plurality of candidate PDCCH for the terminal device to check. This search space approach is taken to reduce the amount of processing required by the terminal device to seek to identify any relevant control messages. Thus, PDCCH signalling associated with the existing common RNTIs are constrained to a particular set of

candidate PDCCH comprising the common search space. In accordance with some embodiments of the disclosure the characteristic of the identifier which is used to distinguish the different potential transmission schemes may be based on the specific PDCCH resources used.

For example, a PDCCH message to be transmitted in accordance with a conventional single-subframe approach may be associated with an identifier, such as SI-RNTI, in the common search space in the usual way. However, a PDCCH message to be transmitted in accordance with a repeat-transmission approach may instead be associated with the same value of identifier, such as SI-RNTI, but transmitted on PDCCH resources outside the common search space. Thus in accordance with some implementations the distinguishing characteristic for the identifier based on the transmission scheme may be a search space with which the identifier is associated. Thus a PDCCH message addressed to SI-RNTI within a particular search space (e.g. the common search space in LTE) can be identified as corresponding to a system information message sent without repetition whereas a PDCCH transmission addressed to SI-RNTI outside the particular search space (e.g. outside the common search space in LTE) can be identified as corresponding to a system information message sent using repetition. A terminal device that is unaware of repetition will in effect ignore the PDCCH addressed to SI-RNTI outside the common search space as the terminal device will not search for the SI-RNTI outside the common search. Corresponding principles apply where EPDCCH is used. Thus in effect, identifiers associated with repeat transmissions may be associated with a newly-defined search space which is outside the search space used for the corresponding identifiers for conventional single-subframe transmissions. In some examples the new search space may support only a single aggregation level, for example an aggregation level 8 (the high aggregation level being appropriate in view of the coverage extension context). The new search space may be smaller (i.e. comprise fewer candidate PDCCH) than the search space for existing common RNTIs. This can help reduce the blind search load associated with the repeat transmissions comprising a message transmitted using a repeat transmission for coverage extension.

It will appreciated the advantages of establishing a new search space comprising a reduced number of candidate PDCCHs with a single relatively high aggregation level to be used in association with identifiers for repeat transmission messages can be applied even in circumstances where different identifier values are associated with the different transmission schemes. In such cases the repeat-specific identifier values may be selected from among the values that are available for use as identifiers in the wireless telecommunications system. In one example, as referred to above, a repeat-specific identifier values may simply match its corresponding non-repeat specific identify value (e.g. SI-RNTI) with the different search space in which a control message associated with the identifier is transmitted providing the distinguishing characteristic for the identifier for the selected transmission scheme. However, in another implementation the repeat-specific identifier values may be selected from, for example, identifiers available for other uses, for example in LTE from identifiers available for cell-specific RNTIs (which may range from 0x001 to 0xFFF3). This approach can in principle provide a relatively large number of repeat-specific identifiers. For example, one or more of the values normally used for C-RNTI can be in effect reserved as one or more repeat-specific RNTIs, such as REPEAT-SI-RNTI in the terminology used above, and likewise for types / classes / classifications of messages other than system information related messages, such as paging messages and random access a response messages etc. Thus a base station could in effect reserve (re-allocate) in its cell a number of RNTI values for one purpose as actually being for use as repeat-specific RNTIs. If any of the re-allocated subset of RNTIs comprising the repeat-specific RNTI is detected by a terminal device as addressing a PDCCH in the newly-defined search space, the terminal

device may be configured to interpret this as a repeat-specific RNTI. This may be based on the base station conveying in previous signalling to terminal devices that support repeat-transmission communications an indication of the relevant RNTI(s). Alternatively, or in addition, the relevant RNTI(s) may be defined in accordance with an operating standard of the network for reallocation within the new search space. If the PDCCH candidates comprising the new search space do not overlap with those of the pre-existing common search space and UE-specific search space used by legacy devices, then the RNTIs allocated as repeat-specific RNTIs within the new search space could continue to be used in the other search space without giving rise to the potential for confusion for legacy terminal devices. If, on the other hand, the PDCCH candidates comprising the new search space do overlap with those of the pre-existing common search space or UE-specific search space, then the base station may be configured to avoid allocating any of a currently re-allocated RNTI to terminal devices in accordance with the usual function for the RNTI (i.e. a C-RNTI reallocated for use as a repeat-specific identifier should not be allotted to a terminal device for use as a C-RNTI). This can be remedied as a straightforward matter of RNTI scheduling (for example, the base station can in effect simply treat the re-allocated RNTIs as being already allotted for use).

If multiple RNTI are made available for use for a given type of message, the particular RNTI selected for use in association with a particular message may be used to indicate a further characteristic of the message, for example a number of repeats or a specific PDCCH validity period where implemented. This can provide the base station with a simple mechanism for modifying the specific repeat and all validity period parameters associated with a particular message, thereby improving overall flexibility.

Determining which identifiers a terminal device should search for to seek to identify messages to be sent to the terminal device using a repeat transmission scheme can be done in accordance with the usual principles by linking it to transmission mode (TM) configuration. In one implementation the repeat-specific RNTIs provided in accordance with embodiments of the disclosure might apply in all transmission modes as the principles governing their use will in many respects be similar to conventional, search space RNTIs. There could also be a link with the category/type of the terminal device. For example, a new terminal device category identifier could be introduced (e.g. category 0) to indicate the terminal device is a particular type of terminal device, for example an MTC-based terminal device. The repeat-specific identifiers may then be considered to apply to all transmission modes for terminal devices of category 0 (if the repeat-transmission based scheme is limited to category 0 terminal devices), as well as for additional terminal device categories if the use of the repeat-transmission based scheme is more widely supported.

Figure 9 is a signalling ladder diagram schematically representing modes of operation for the terminal device 508 and the base station 504 schematically represented in Figure 5 in accordance with some embodiments of the present disclosure.

Processing begins in step T1 when the base station determines that a message is to be transmitted to one or more terminal devices. The message may, for example, be a broadcast message or a multicast message. The determination that a message is to be transmitted may be made in accordance with conventional operating procedures for the wireless communications system. For example, if the message is a system information message, step T1 may arise in accordance with a conventional timing schedule for transmitting system information messages. If the message is a paging message, step T1 may arise because an event has arisen which requires a terminal device to be paged. In this example it is assumed the message which is to be transmitted is a system information message which is relevant for (i.e.

address to an identifier associated with) terminal device 508. Furthermore, it is assumed the message may be transmitted in accordance with either one of a first transmission scheme using transmission resources in a first number of radio subframes (e.g. using conventional single-subframe transmission) or a second transmission scheme using transmission resources in a plurality radio subframes (e.g. using repeat-transmission for coverage extension).

In step T2 the base station determines which of the first and second transmission schemes are to be used for transmitting the message. That is to say, in this example, the base station determines whether or not a conventional single subframe approach or a repeat-transmission approach for coverage extension will be used for the message. There are a number of factors that may govern this determination, either individually or in combination. For example, the terminal devices in the wireless telecommunication system may comprise a first set of terminal devices and a second set of terminal devices step and T2 may be based on whether the one or more terminal devices to which the message is to be sent comprises terminal devices in the first or second sets. For example, the first set of terminal devices may comprise terminal devices that do not require coverage extension techniques to receive messages (or simply do not support coverage extension), whereas the second set of terminal devices may comprise terminal devices that do require coverage extension techniques to receive messages (and support repeat-transmission based coverage extension). Whether or not a specific terminal device requires coverage extension may, for example, be based on a measured radio propagation metric associated with the terminal device, for example a path loss, block error rate, a bit error rate, a packet error rate, a frame error rate, a symbol error rate, or negative or positive acknowledgement signalling rate (ACK/NACK) associated with communications with the terminal device. In another implementation the decision may take account of a specific identity or category for the one or more terminal devices to which the messages to be sent.

In step T3 the base station determines a characteristic of an identifier for the message based on the transmission scheme determined in step T2. This characteristic may be selected in accordance with any of the principles discussed above (e.g. use of different values for the identifier or different search spaces to be used with the identifier).

In step T4 the message is transmitted in accordance with the transmission scheme determined in step T2 and in association with an identifier, e.g. RNTI, having the characteristic determined in step T3. For example, the message may be transmitted in accordance with a repeat-transmission scheme as described herein with an identifier selected to have a characteristic to identify this, for example in accordance with any of the principles discussed above. In this regard the message may comprise one or other or both of a control message transmitted on a downlink control channel, e.g. a PDCCH message and another message transmitted on a downlink data channel, e.g. PDSCH (i.e. such that the identifier is transmitted separately from the message).

In step T5 the terminal device receives the transmitted signalling from the base station and determines the transmission scheme being used from the characteristic of the identifier. The terminal device may then proceed to receive and decode the message in accordance with the transmission scheme being used.

Thus, the process represented in Figure 9 demonstrates a mechanism by which a base station can readily indicates to terminal devices the transmission scheme being used for a given message. Once the terminal device has determined the transmission scheme, subsequent operation, for example in terms of

receiving the message, they be performed in accordance with conventional principles for receiving such messages. Furthermore, these techniques may be modified to incorporate a validity period approach such as discussed above.

Thus there has been described a wireless telecommunication system that comprises a base station and a terminal device communicating over a radio interface. The radio interface supports a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel (e.g. a physical downlink shared channel) for conveying other messages from the base station to the terminal device. The control messages convey information on resource allocations for the other messages on the downlink data channel. The other messages may comprise user-plane messages or control-plane messages. The terminal device is configured to receive a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel and determine a validity period for the control message. During the validity period for the control message the terminal device is configured to receive a plurality of the other messages from the base station on the downlink data channel using the allocated transmission resources.

There has also been described a wireless telecommunication system that comprises a base station arranged to communicate messages to one or more terminal devices over a radio interface. The radio interface has a radio frame structure comprising a plurality of subframes, wherein a message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes (e.g. one subframe) or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes (e.g. with repeat transmissions in a plurality of subframes). The message is transmitted in association with an identifier to indicate a terminal device to which the message is addressed. A characteristic for the identifier, for example a value or control region search space for the identifier, is dependent on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme. A terminal device to which the message is addressed determines the transmission scheme from the characteristic of the identifier and receives the message accordingly.

Further particular and preferred aspects of the present invention are set out in the accompanying independent and dependent claims. It will be appreciated that features of the dependent claims may be combined with features of the independent claims in combinations other than those explicitly set out in the claims.

Thus, the foregoing discussion discloses and describes merely exemplary embodiments of the present invention. As will be understood by those skilled in the art, the present invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. Accordingly, the disclosure of the present invention is intended to be illustrative, but not limiting of the scope of the invention, as well as other claims. The disclosure, including any readily discernible variants of the teachings herein, define, in part, the scope of the foregoing claim terminology such that no inventive subject matter is dedicated to the public.

Respective features of the present disclosure are defined by the following two groups of numbered paragraphs:

Group 1 of numbered paragraphs:

Paragraph 1. A method of operating a terminal device communicating with a base station in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the method comprises receiving a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel, determining a validity period for the control message, and receiving a plurality of other messages from the base station on the downlink data channel using the allocated transmission resources within the validity period for the control message.

Paragraph 2. The method of paragraph 1, wherein the other messages comprise system information messages.

Paragraph 3. The method of any preceding paragraph, wherein the system information messages comprise one or more system information blocks.

Paragraph 4. The method of any preceding paragraph, wherein the radio interface is based on a radio frame structure comprising a plurality of subframes, wherein each subframe comprises a control channel region for supporting the downlink control channel and a shared channel region for supporting the downlink data channel, and wherein respective ones of the control and / or the other messages comprise transmissions over a plurality of subframes.

Paragraph 5. The method of any preceding paragraph, wherein the validity period for the control message is determined in dependence on an identifier used in association with the control message.

Paragraph 6. The method of paragraph 5, wherein the identifier comprises an indication of one or more terminal devices to which the control message is addressed.

Paragraph 7. The method of any preceding paragraph, wherein the validity period for the control message is determined in dependence on a transmission characteristic of the control message.

Paragraph 8. The method of paragraph 7, wherein the transmission characteristic of the control message comprises a transmission time associated with the control message.

Paragraph 9. The method of any preceding paragraph, wherein the radio interface is based on a radio frame structure comprising a plurality of subframes, and wherein the timing of a subframe used to convey a first one of the plurality of other messages is used to determine the timing of a subframe used to convey a second one of the plurality of other messages within the validity period for the control message.

Paragraph 10. The method of any preceding paragraph, wherein the timing of a subframe used to convey the first one of the plurality of other messages relative to a first predefined range of subframes is used to determine the timing of a subframe used to convey the second one of the plurality of other messages relative to a second predefined range of subframes.

Paragraph 11. The method of any preceding paragraph, wherein the validity period is determined in dependence on a validity period indicator received in association with the control message.

Paragraph 12. The method of any preceding paragraph, wherein the validity period is determined in dependence on the time at which a subsequent control message is received.

Paragraph 13. The method of any preceding paragraph, wherein the other messages comprise random access response messages and / or paging messages..

Paragraph 14. A terminal device for communicating with a base station in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the terminal device comprises a controller unit and a transceiver unit configured to operate together to receive a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to receive a plurality of other messages from the base station on the downlink data channel using the allocated transmission resources within the validity period for the control message.

Paragraph 15. Circuitry for a terminal device communicating with a base station in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to cause the terminal device to receive a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to receive a plurality of other messages from the base station on the downlink data channel using the allocated transmission resources within the validity period for the control message

Paragraph 16. A method of operating a base station communicating with a terminal device in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the method comprises transmitting a control message to the terminal device conveying an indication of allocated transmission resources on the downlink data channel, determining a validity period for the control message, and transmitting a plurality of other messages to the terminal device on the downlink data channel using the allocated transmission resources within the validity period for the control message.

Paragraph 17. A base station for communicating with a terminal device in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the base station comprises a controller unit and a transceiver unit configured to operate together to transmit a control message to the terminal device conveying an indication of allocated transmission resources on the downlink data

channel, to determine a validity period for the control message, and to transmit a plurality of other messages to the terminal device on the downlink data channel using the allocated transmission resources within the validity period for the control message.

Paragraph 18. Circuitry for a base station communicating with a terminal device in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to cause the base station to transmit a control message to the terminal device conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to transmit a plurality of other messages to the terminal device on the downlink data channel using the allocated transmission resources within the validity period for the control message.

Group 2 of numbered paragraphs:

Paragraph 1. A method of operating a base station for communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein the method comprises selecting a characteristic for the identifier in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

Paragraph 2. The method of any preceding paragraph, wherein the first number of radio subframes comprises a single radio subframe and the second number of radio subframes comprises a plurality of radio subframes.

Paragraph 3. The method of any preceding paragraph, wherein terminal devices in the wireless telecommunications system comprise a first set of terminal devices and a second set of terminal devices, and wherein the method comprises determining whether to transmit the message in accordance with the first transmission scheme or the second transmission scheme in dependence on whether a terminal device to which the message is to be transmitted is a member of the first set of terminal devices or the second set of terminal devices.

Paragraph 4. The method of any preceding paragraph, wherein the method comprises determining whether to transmit the message in accordance with the first transmission scheme or the second transmission scheme in dependence on a radio propagation parameter associated with radio communications between the base station and a terminal device to which the message is to be transmitted.

Paragraph 5. The method of paragraph 4, wherein the radio propagation parameter is selected from the group comprising: a path loss; an error rate; a positive acknowledgment, ACK, signalling rate; and a negative acknowledgment signalling, NACK, rate.

Paragraph 6. The method of any preceding paragraph, wherein the method comprises determining whether to transmit the message in accordance with the first transmission scheme or the second transmission scheme in dependence on an identity and / or type of a terminal device to which the message is to be transmitted.

Paragraph 7. The method of any preceding paragraph, wherein the radio interface supports a downlink control channel for conveying control messages from the base station to terminal devices and a downlink data channel for conveying other messages from the base station to terminal devices, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the message comprises a control message transmitted on the downlink control channel.

Paragraph 8. The method of any preceding paragraph, wherein the radio interface supports a downlink control channel for conveying control messages from the base station to terminal devices and a downlink data channel for conveying other messages from the base station to terminal devices, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the message comprises one of the other messages transmitted on the downlink data channel.

Paragraph 9. The method of any preceding paragraph, wherein the identifier to indicate a terminal device to which the message is addressed is transmitted separately from the message.

1 Paragraph 0. The method of any preceding paragraph, wherein the identifier comprises a radio network temporary identifier, RNTI.

Paragraph 11. The method of any preceding paragraph, wherein the identifier is a common to a plurality of terminal devices.

Paragraph 12. The method of any preceding paragraph, wherein the message comprises a broadcast message.

Paragraph 13. The method of any preceding paragraph, wherein the message comprises a multicast message.

Paragraph 14. The method of any preceding paragraph, wherein for a given type of message the characteristic for the identifier is selected from a first predefined characteristic for the identifier associated with the given type of message and a second predefined characteristic for the identifier associated with the given type of message according to whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

Paragraph 15. The method of any preceding paragraph, wherein the message is selected from the group comprising: (i) a message associated with transmitting system information; (ii) a message associated with transmitting a paging message; (iii) a message associated with transmitting a random access response message; (iv) a message associated with transmitting power control information for an uplink control

channel; (v) a message associated with transmitting power control information for an uplink data channel; and (vi) a message associated with a broadcast and / or multicast service.

Paragraph 16. The method of any preceding paragraph, wherein for a message to be transmitted in accordance with the second transmission scheme, a component of the message transmitted in one of the second number of subframes is associated with a characteristic for the identifier corresponding to that which would be used if the message were to be transmitted in accordance with the first transmission scheme.

Paragraph 17. The method of any preceding paragraph, wherein the characteristic for the identifier comprises a value for the identifier.

Paragraph 18. The method of any preceding paragraph, wherein the characteristic for the identifier comprises a search space in which a terminal device searches using the identifier to determine if a message has been addressed to the terminal device.

Paragraph 19. The method of any preceding paragraph, wherein the method comprises selecting the characteristic for the identifier from a plurality of different characteristics associated with different types of message.

Paragraph 20. The method of any preceding paragraph, wherein the characteristic for the identifier to be selected for a message to be transmitted in accordance with the second transmission scheme is defined in accordance with an operating standard for the wireless telecommunications system.

Paragraph 21. The method of any preceding paragraph, further comprising the base station pre-defining the characteristic for the identifier to be selected for a message to be transmitted in accordance with the second transmission scheme.

Paragraph 22. The method of paragraph 21, wherein the pre-defining the characteristic for the identifier is a value for the identifier selected from among a plurality of values.

Paragraph 23. A base station for communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the base station comprises a controller unit and a transceiver unit configured to operate together such that the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein a characteristic for the identifier is selected in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

Paragraph 24. Circuitry for a base station communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the circuitry comprises a controller element and a transceiver element configured to operate together such that the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of

radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein a characteristic for the identifier is selected in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

Paragraph 25. A method of operating a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the method comprises determining from an identifier associated with the message that the message is addressed to the terminal device, and further determining from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

Paragraph 26. A terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the terminal device comprises a controller unit and a transceiver unit configured to operate together to determine from an identifier associated with the message that the message is addressed to the terminal device, and to further determine from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

Paragraph 27. Circuitry for a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to determine from an identifier associated with the message that the message is addressed to the terminal device, and to further determine from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

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CLAIMS

What is claimed is:

1. A method of operating a base station for communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein the method comprises selecting a characteristic for the identifier in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

2. The method of claim 1, wherein the first number of radio subframes comprises a single radio subframe and the second number of radio subframes comprises a plurality of radio subframes.

3. The method of claim 1, wherein terminal devices in the wireless telecommunications system comprise a first set of terminal devices and a second set of terminal devices, and wherein the method comprises determining whether to transmit the message in accordance with the first transmission scheme or the second transmission scheme in dependence on whether a terminal device to which the message is to be transmitted is a member of the first set of terminal devices or the second set of terminal devices.

4. The method of claim 1, wherein the method comprises determining whether to transmit the message in accordance with the first transmission scheme or the second transmission scheme in dependence on a radio propagation parameter associated with radio communications between the base station and a terminal device to which the message is to be transmitted.

5. The method of claim 4, wherein the radio propagation parameter is selected from the group comprising: a path loss; an error rate; a positive acknowledgment, ACK, signalling rate; and a negative acknowledgment signalling, NACK, rate.

6. The method of claim 1, wherein the method comprises determining whether to transmit the message in accordance with the first transmission scheme or the second transmission scheme in dependence on an identity and / or type of a terminal device to which the message is to be transmitted.

7. The method of claim 1, wherein the radio interface supports a downlink control channel for conveying control messages from the base station to terminal devices and a downlink data channel for conveying other messages from the base station to terminal devices, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the message comprises a control message transmitted on the downlink control channel.

8. The method of claim 1, wherein the radio interface supports a downlink control channel for conveying control messages from the base station to terminal devices and a downlink data channel for conveying other messages from the base station to terminal devices, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the message comprises one of the other messages transmitted on the downlink data channel.

9. The method of claim 1, wherein the identifier to indicate a terminal device to which the message is addressed is transmitted separately from the message.

10. The method of claim 1, wherein the identifier comprises a radio network temporary identifier, RNTI.

11. The method of claim 1, wherein the identifier is a common to a plurality of terminal devices.

12. The method of claim 1, wherein the message comprises a broadcast message.

13. The method of claim 1, wherein the message comprises a multicast message.

14. The method of claim 1, wherein for a given type of message the characteristic for the identifier is selected from a first predefined characteristic for the identifier associated with the given type of message and a second predefined characteristic for the identifier associated with the given type of message according to whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

15. The method of claim 1, wherein the message is selected from the group comprising: (i) a message associated with transmitting system information; (ii) a message associated with transmitting a paging message; (iii) a message associated with transmitting a random access response message; (iv) a message associated with transmitting power control information for an uplink control channel; (v) a message associated with transmitting power control information for an uplink data channel; and (vi) a message associated with a broadcast and / or multicast service.

16. The method of claim 1, wherein for a message to be transmitted in accordance with the second transmission scheme, a component of the message transmitted in one of the second number of subframes is associated with a characteristic for the identifier corresponding to that which would be used if the message were to be transmitted in accordance with the first transmission scheme.

17. The method of claim 1, wherein the characteristic for the identifier comprises a value for the identifier.

18. The method of claim 1, wherein the characteristic for the identifier comprises a search space in which a terminal device searches using the identifier to determine if a message has been addressed to the terminal device.

19. The method of claim 1, wherein the method comprises selecting the characteristic for the identifier from a plurality of different characteristics associated with different types of message.

20. The method of claim 1, wherein the characteristic for the identifier to be selected for a message to be transmitted in accordance with the second transmission scheme is defined in accordance with an operating standard for the wireless telecommunications system.

21. The method of claim 1, further comprising the base station pre-defining the characteristic for the identifier to be selected for a message to be transmitted in accordance with the second transmission scheme.

22. The method of claim 21, wherein the pre-defining the characteristic for the identifier is a value for the identifier selected from among a plurality of values.

23. A base station for communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the base station comprises a controller unit and a transceiver unit configured to operate together such that the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein a characteristic for the identifier is selected in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

24. Circuitry for a base station communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the circuitry comprises a controller element and a transceiver element configured to operate together such that the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein a characteristic for the identifier is selected in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

25. A method of operating a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the method comprises determining from an identifier associated with the message that the message is addressed to the terminal device, and further determining from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

26. A terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the terminal device comprises a controller unit and a transceiver unit configured to operate together to determine from an identifier associated with the message that the message is addressed to the terminal device, and to further determine from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

27. Circuitry for a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to determine from an identifier associated with the message that the message is addressed to the terminal device, and to further determine from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

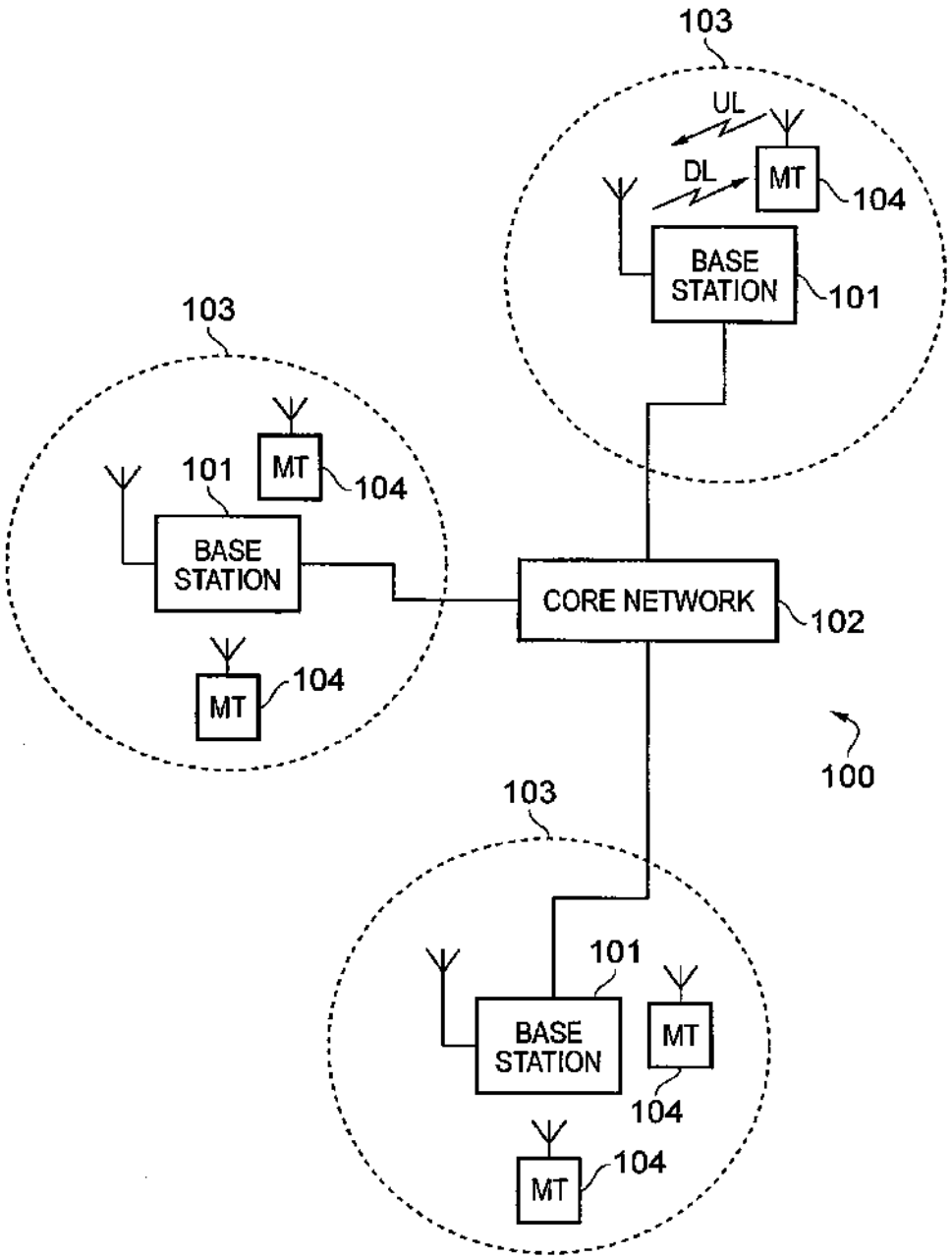

103
UL
DL
MT
104
BASE STATION
101
103
101
MT
104
BASE STATION
CORE NETWORK
102
MT
104
100
103
101
BASE STATION
MT
104
MT
104

FIG. 1

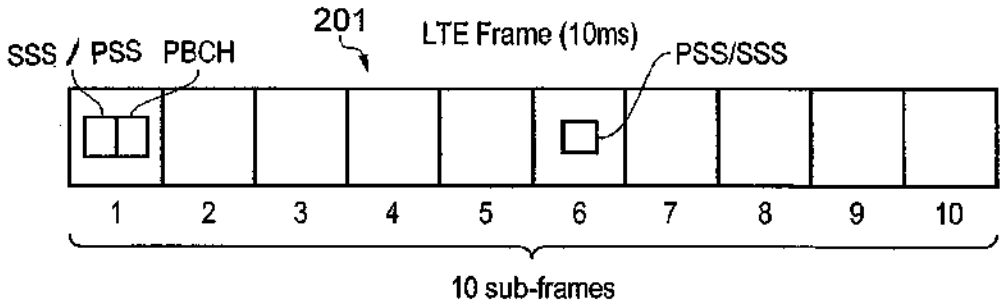

201
LTE Frame (10ms)
SSS / PSS
PBCH
PSS/SSS
1
2
3
4
5
6
7
8
9
10
10 sub-frames

FIG. 2

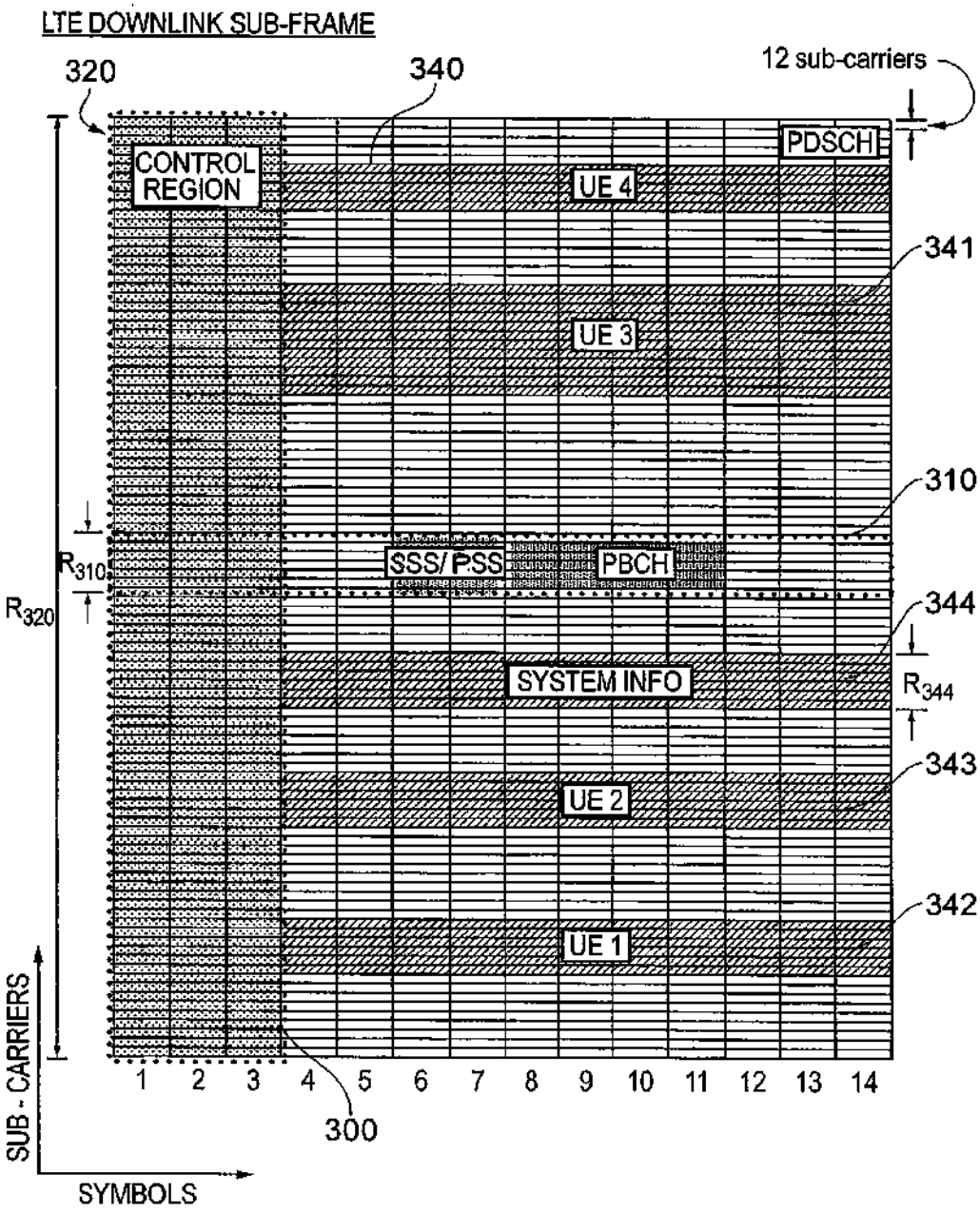

LTE DOWNLINK SUB-FRAME
320
340
12 sub-carriers
CONTROL REGION
PDSCH
UE 4
341
UE 3
310
R_{310}
SSS/ PSS
PBCH
R_{320}
344
SYSTEM INFO
R_{344}
343
UE 2
342
UE 1
SUB - CARRIERS
1 2 3 4 5 6 7 8 9 10 11 12 13 14
300
SYMBOLS

FIG. 3

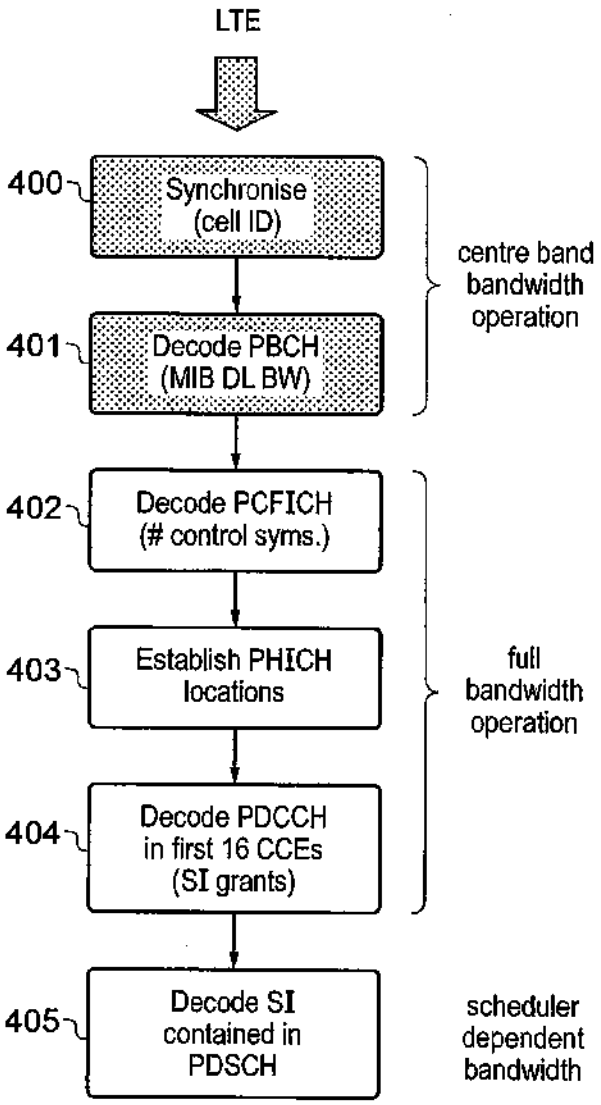

LTE
400
Synchronise (cell ID)
401
Decode PBCH (MIB DL BW)
centre band bandwidth operation
402
Decode PCFICH (# control syms.)
403
Establish PHICH locations
404
Decode PDCCH in first 16 CCEs (SI grants)
full bandwidth operation
405
Decode SI contained in PDSCH
scheduler dependent bandwidth

FIG. 4

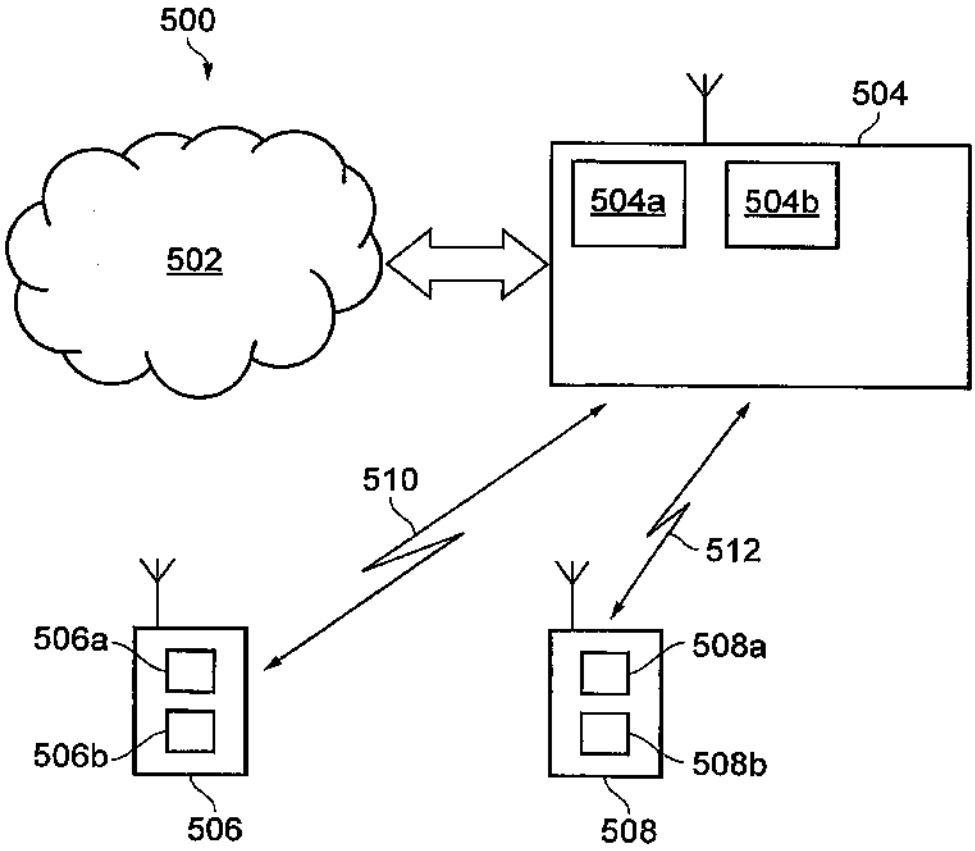


FIG. 5

Fig. 6

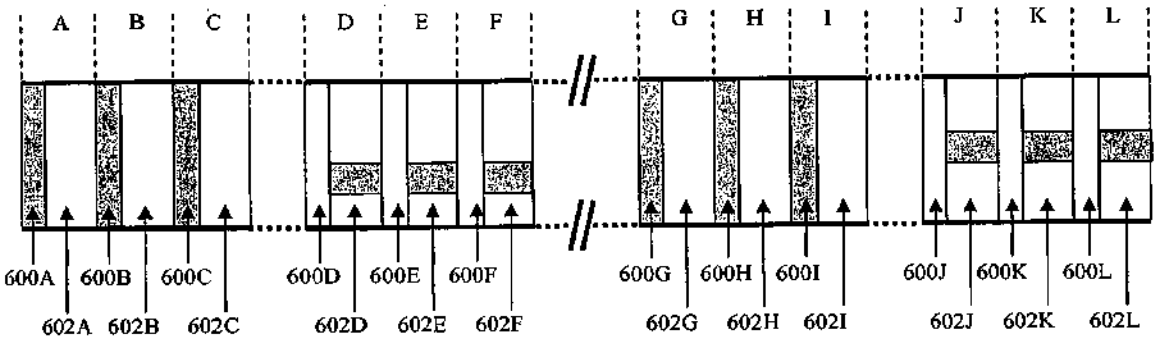
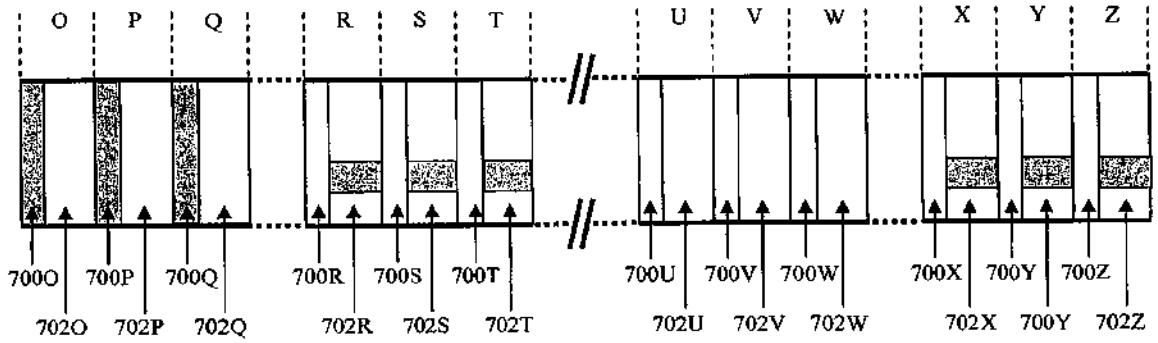

A
B
C
D
E
F
G
H
I
J
K
L
600A
600B
600C
600D
600E
600F
600G
600H
600I
600J
600K
600L
602A
602B
602C
602D
602E
602F
602G
602H
602I
602J
602K
602L

Fig. 7


O
P
Q
R
S
T
U
V
W
X
Y
Z
700O
700P
700Q
700R
700S
700T
700U
700V
700W
700X
700Y
700Z
702O
702P
702Q
702R
702S
702T
702U
702V
702W
702X
702Y
702Z

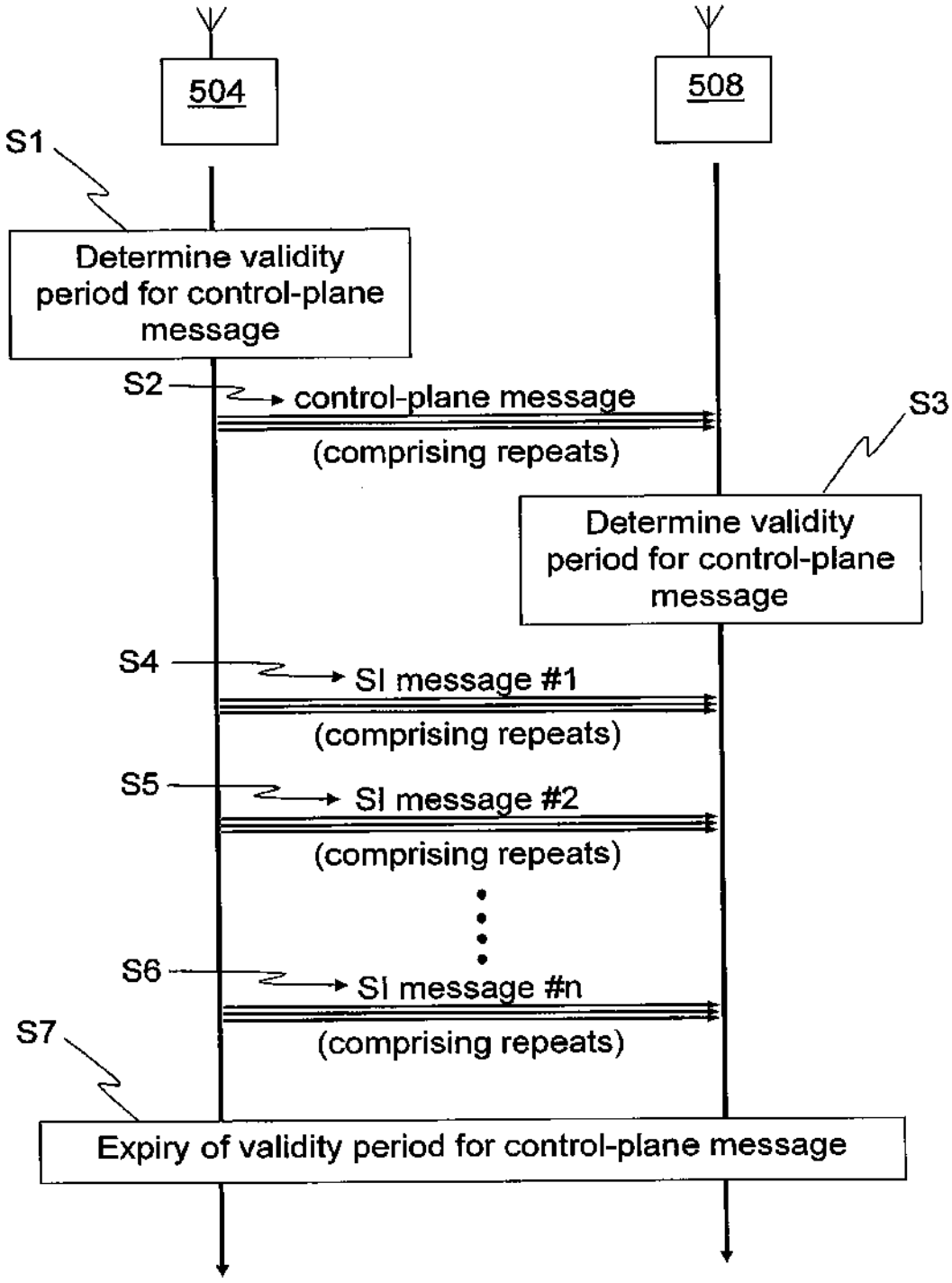

504
508
S1
Determine validity period for control-plane message
S2
control-plane message
(comprising repeats)
S3
Determine validity period for control-plane message
S4
SI message #1
(comprising repeats)
S5
SI message #2
(comprising repeats)
S6
SI message #n
(comprising repeats)
S7
Expiry of validity period for control-plane message

Fig. 8

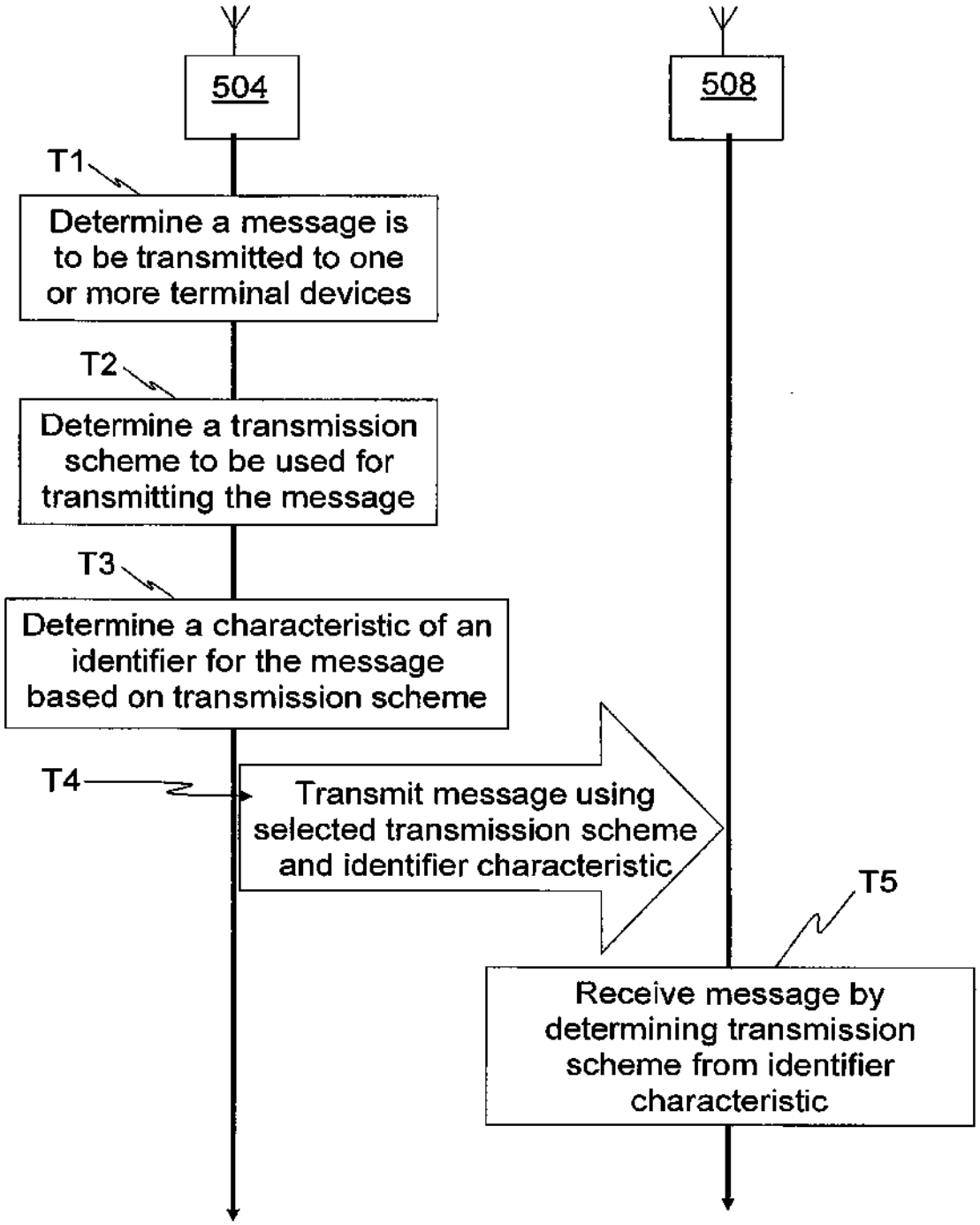

504
508
T1
Determine a message is to be transmitted to one or more terminal devices
T2
Determine a transmission scheme to be used for transmitting the message
T3
Determine a characteristic of an identifier for the message based on transmission scheme
T4
Transmit message using selected transmission scheme and identifier characteristic
T5
Receive message by determining transmission scheme from identifier characteristic

Fig. 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2014/074456

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W72/04
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W H04B H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2013/315159 A1 (XIA JINHUAN [CN] ET AL) 28 November 2013 (2013-11-28) paragraph [0005] - paragraph [0006] paragraph [0036]; figure 5 paragraph [0045]; figure 7 paragraph [0052] paragraph [0062]	1-27

X	EP 2 611 244 A2 (QUALCOMM INC [US]) 3 July 2013 (2013-07-03)	1,23-27
A	paragraph [0029]; figures 3,10 paragraph [0075]	2-22

	-/--	

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 February 2015	04/03/2015

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Cortés Gómez, F

1

Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	NTT DOCOMO: "Discussion on Multi-level PRACH Coverage Enhancement", 3GPP DRAFT; R1-135509 PRACH_COVERAGE, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. San Francisco, USA; 20131111 - 20131115 13 November 2013 (2013-11-13), XP050735182, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN/RAN1/Docs/ [retrieved on 2013-11-13]	1,23-27
A	Section 5 -----	2-22

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2014/074456

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		WO 2009124079 A1	08-10-2009

Form PCT/ISA/210 (patent family annex) (April 2005)

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H04L 27/26 (2006.01) *H04W 84/00* (2009.01)

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PCT/US2015/000466

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26 December 2015 (26.12.2015)

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(26) Publication Language: English

(30) Priority Data:
62/203,301 10 August 2015 (10.08.2015) US

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(74) Agent: **OLSON, Jared**; Ledell Ansari, LLP, c/o Cpa Global, P.O. Box 52050, Minneapolis, MN 55402 (US).

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(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

(54) **Title**: ENHANCED PHYSICAL SIGNAL STRUCTURE FOR LTE V2V COMMUNICATIONS

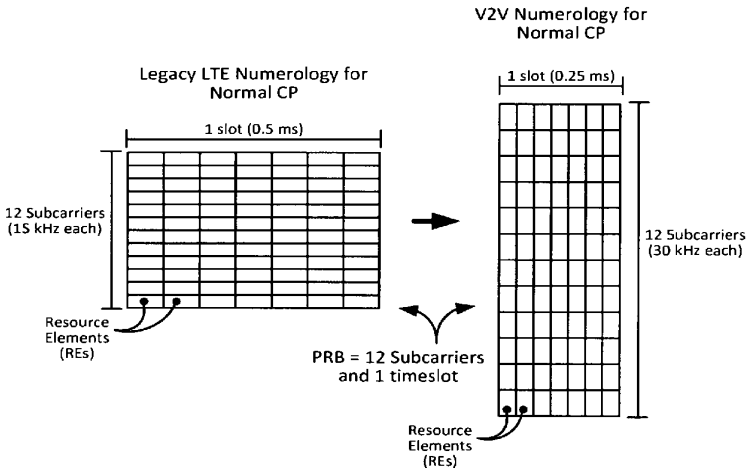


Fig. 4

(57) **Abstract**: A vehicle may wirelessly communicate with another vehicle via a physical channel (a vehicle-to-vehicle (V2V) channel) that is robust and reliable under high mobility propagation conditions. The physical channel may be created by modifying an existing long-term evolution (LTE) physical channel, such as an LTE sidelink (SL) channel. For instance, the V2V physical channel may be created by increasing, by a particular factor, the subcarrier spacing of legacy LTE channels (e.g., from 15 kilohertz (kHz) to 30 kHz). Additionally, a symbol duration and a fast Fourier transform (FFT) size for the V2V physical channel may each be reduced by the same factor. Doing so may enable the V2V physical channel to be implemented without significant modifications to other aspects of the LTE standard.

WO 2017/026983 A1

ENHANCED PHYSICAL SIGNAL STRUCTURE FOR LTE V2V COMMUNICATIONS

RELATED APPLICATIONS

The present application claims the benefit of U.S. Provisional Patent Application No. 62/203,301, which was filed on August 10, 2015, the contents of which are hereby incorporated by reference as though fully set forth herein.

BACKGROUND

The so-called "connected car concept" includes the idea that vehicles may be enabled to communicate wirelessly with one another. The 3GPP (3rd Generation Partnership Project) Long Term Evolution (LTE) communications standard has been proposed as the communication standard for implementing the connected car concept (also referred to as vehicle-to-vehicle (V2V) communications). V2V communications include one vehicle establishing a direct connection with one or multiple other vehicles.

Examples of such connections may include an LTE sidelink connection (also referred as direct connection, a proximity services (ProSe) connection, a device-to-device (D2D) connection, etc.). Once connected, vehicles may communicate a variety of information to each other, such as location information, velocity information, acceleration information, directional information, performance information, and more. Such information may be used to provide a variety of functionalities, such as preventing car accidents, determining driving conditions (e.g., traffic jams, icy roads, car accidents, etc.), determining optimal routes for driving from one location to another, etc.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments described herein will be readily understood by the following detailed description in conjunction with the accompanying drawings. To facilitate this description, like reference numerals may designate like structural elements. Embodiments are illustrated by way of example and not by way of limitation in the figures of the accompanying drawings.

Fig. 1 is a diagram of an example environment in which systems and/or methods described herein may be implemented;

Fig. 2 is a diagram illustrating an example process for sending information to another vehicle;

Fig. 3 is a diagram illustrating an example process for receiving information from another vehicle;

Fig. 4 is a diagram of an example physical resource block (PRB) of a legacy long term evolution (LTE) numerology and an example PRB of a vehicle-to-vehicle (V2V) numerology, under normal cyclic prefix (CP) conditions;

Fig. 5 is a diagram of an example PRB of a legacy LTE numerology and an example PRB of a V2V numerology, under extended CP conditions;

Fig. 6 is a diagram of example PRB pairs of a legacy LTE numerology and example PRB pairs of a V2V numerology, under normal CP conditions;

Fig. 7 is a diagram of example PRB pairs of a legacy LTE numerology and PRB pairs of a V2V numerology, under extended CP conditions;

Figs. 8A-8D are diagrams of example PRBs according to one or more embodiments described herein;

Figs. 9A-9D are diagrams of example PRBs according to one or more embodiments described herein;

Fig. 10 is a table of example characteristics of a legacy LTE numerology and a V2V numerology with 30 kilohertz (kHz) subcarrier spacing;

Fig. 11 is a table of example characteristics of a legacy LTE numerology and a V2V numerology with 60 kHz subcarrier spacing;

Fig. 12 is a table representing an example of legacy LTE and V2V transmission multiplexing; and

Fig. 13 illustrates, for one embodiment, example components of an electronic device.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The following detailed description refers to the accompanying drawings. The same reference numbers in different drawings may identify the same or similar elements. It is to be understood that other embodiments may be utilized and structural or logical changes may be made without departing from the scope of the present disclosure. Therefore, the following detailed description is not to be taken in a limiting sense, and the scope of embodiments defined by the appended claims and their equivalents.

As mentioned above, the 3GPP (3rd Generation Partnership Project) Long Term Evolution (LTE) communications standard has been proposed as the communication standard for vehicle-to-vehicle (V2V) communications. One reason behind the proposal is the reliability and high data rate capabilities of LTE technology. However, the current LTE standard includes

certain limitations when it comes to enabling vehicles to communicate with one another directly. For example, legacy LTE sidelink (SL) physical channels (also referred to as PC5 channels or device-to-device (D2D) channels) are considered to be used or enable V2V communications. At the same time, the legacy SL physical channels were designed with an assumption of substantially lower mobility conditions than the ones considered to be used for V2V communication (e.g., a scenario in which two vehicles are driving toward one another at 140 kilometers per hour (km/h) each). As a result, when subjected to wireless propagation in high mobility conditions (that may cause high Doppler fading and/or frequency shifts), legacy LTE physical channels may experience an unacceptably high block error rate (BLER) performance and/or use an unacceptably high signal-to-interference-noise ratio (SINR) to achieve reliable performance for V2V wireless communication.

Techniques described herein may be used to provide a physical channel (referred to herein as "V2V physical channel") of greater robustness and reliability when subjected to the high mobility conditions of V2V communications. For example, a V2V physical channel may have increased subcarrier spacing (e.g., 30 kilohertz (kHz) subcarriers) instead of the 15 kHz subcarrier spacing used in legacy LTE SL physical channels. The increased subcarrier spacing may improve physical channel robustness (particularly under high mobility wireless propagation effects) via a reduction of the impacts of frequency offset errors on the subcarriers orthogonality, reduced channel variations on the packet transmission duration, etc.

In some embodiments, the V2V physical channel may include additional alterations from current LTE SL physical channels. For example, the V2V physical channel may include a reduced symbol duration (e.g., a single-carrier frequency-division multiple access (SC-FDMA) symbol duration, etc.). The decrease in symbol duration may be proportional to the increased subcarrier spacing. For instance, if the subcarrier spacing of the V2V physical channel is twice as large as subcarrier spacing of a legacy LTE SL physical channel (e.g., 30 kHz instead of 15 kHz), the symbol duration for the V2V physical channel may be halved. Additionally, the decrease in symbol duration may be accompanied by a similar decrease (e.g., half) to a fast Fourier transform (FTT) size.

Additionally, since LTE air interfaces currently implement physical resource blocks (PRBs) as a fundamental unit of allocation for air interface resources, the techniques described herein may include one or more PRB formats for implementing the enhancements described above regarding modified subcarrier spacing and symbol duration of the V2V physical channels. For instance, a PRB of the V2V physical channel may

include time-domain changes, such as a change in the duration of each PRB and/or the number of slots per PRB. Similarly, a PRB of the V2V channel may include frequency-domain changes, such as the number of subcarriers per PRB, the PRB size in terms of frequency, etc. PRB formats may be discussed herein in terms of numerologies (e.g., legacy LTE numerologies and V2V numerologies), which may include a representation of subcarriers, slot durations, and resource elements (REs) of a PRB or PRB pair.

In some embodiments, the techniques described herein may be implemented within the context of cyclic prefixing (CP). For example, in the 3GPP LTE communication standard, CP may include copying a portion of one symbol (e.g., an end portion of the symbol) and adding the copied portion to a beginning portion of the symbol, such that the symbol begins and ends with the same portion. Doing so may, for example, reduce inter-symbol interference.

Fig. 1 is a diagram of an example environment 100 in which systems and/or methods described herein may be implemented. Environment 100 may include one or more vehicles with vehicle-to-X (V2X) devices 110, user equipment devices (UEs) 120, and network 130.

V2X device 110 may include a computing and communication device installed in a vehicle, such as a car, a truck, a sports utility vehicle (SUV), etc. V2X device 110 may be capable of gathering, processing, and communicating information regarding the vehicle in which V2X device 110 is installed. Examples of such information may include vehicle performance information, vehicle location information, vehicle usage information, vehicle status information, vehicle diagnostic information, etc. In some embodiments, V2X device 110 may be capable over gathering, processing, and communicating other types of information, such as information relating to a driver or passenger of the vehicle. V2X device 110 may be an example of user equipment device (UE) or another type of end terminal.

As shown, V2X device 110 may be capable of communicating with one or more networks or devices, such as UE 120, the V2X device of another vehicle, network 130, etc. In some embodiments, V2X device 110 may do so by establishing a connection that is based on a particular communications standard, such as the 3GPP LTE communication standard. For instance, V2X device 110 may establish a vehicle-to-pedestrian (V2P) connection with UE 120, which may include a D2D connection, an LTE SL connection, or other type of direct connection. V2X device 110 may also, or alternatively, establish a vehicle-to-infrastructure/network (V2I) connection with network 130. The V2I connection may include a standard connection with a base station (e.g., an evolved Node B (eNB)), a wireless access point (AP), or another device capable of enabling V2X device 110 to communicate with network 130.

As such, the "X" in "V2X device," may represent an ability of V2X device 110 to communicate with one or more types of devices (e.g., other V2X devices, UEs 120, a base station, a network access point (AP), etc.).

Additionally, or alternatively, V2X device 110 may establish a V2V connection with the V2X device of another vehicle. The V2V connection may include a D2D connection, an LTE SL connection, or other type of direct connection between UEs (e.g., a connection that does not, for example, include network 130). In some embodiments, V2X device 110 may be capable of communicating with other V2X devices using one or more of the techniques described herein. For example, V2X device 110 may be capable of using a V2V physical channel that ensure improved robustness and reliability when subjected to the high mobility conditions of V2V communications. The V2V physical channel may, for example, include greater subcarrier spacing and reduced symbol durations to, for example, improve demodulation performance including BLER reduction but still operating within the framework of an established communications standard (such as the 3GPP LTE communications standard).

UE 120 may include a portable computing and communication device, such as a personal digital assistant (PDA), a smart phone, a cellular phone, a laptop computer with connectivity to a cellular wireless network, a tablet computer, etc. UE 120 may also include non-portable computing devices, such as a desktop computer, a consumer or business appliance, or other devices that have the ability to connect to network 130. UE 120 may also include a computing and communication device that may be worn by a user (also referred to as wearable devices) as a watch, a fitness band, a necklace, glasses, an eyeglass, a ring, a belt, a headset, or another type of wearable device. As shown, UE 120 may establish a direct connection (e.g., a D2D connection) with V2X device 110. Additionally, UE 120 may communicate with V2X device 110 regarding the vehicle of V2X device 110, a driver or passenger of the vehicle, a user of UE 120, a location of the vehicle with respect to the user of UE 120, etc.

Network 130 may include one or more wired and/or wireless networks. For example, network 130 may include an LTE network. In some embodiments, network 130 may include one or more additional networks, such as a cellular network (e.g., a second generation (2G) network, a third generation (3G) network, a fourth generation (4G) network, a fifth generation (5G) network, a global system for mobile (GSM) network, a code division multiple access (CDMA) network, an evolution-data optimized (EVDO) network, or the like), a public land mobile network (PLMN), and/or another network. Additionally, or alternatively, network 150 may include a local area network (LAN), a wireless LAN (WLAN), a wide area network (WAN), a metropolitan network (MAN), the Public Switched Telephone Network (PSTN), an

ad hoc network, a managed IP network, a virtual private network (VPN), an intranet, the Internet, a fiber optic-based network, and/or a combination of these or other types of networks.

The quantity of devices and/or networks, illustrated in Fig. 1, is provided for explanatory purposes only. In practice, there may be additional devices and/or networks; fewer devices and/or networks; different devices and/or networks; or differently arranged devices and/or networks than illustrated in Fig. 1. Alternatively, or additionally, one or more of the devices of environment 100 may perform one or more functions described as being performed by another one or more of the devices of system 100. Furthermore, while "direct" connections are shown in Fig. 1, these connections should be interpreted as logical communication pathways, and in practice, one or more intervening devices (e.g., routers, gateways, modems, switches, hubs, etc.) may be present.

Additionally, while some of the techniques described herein may involve V2V communications as an example, the techniques described herein may be applied to various scenarios and/or other types of communications. For example, techniques described herein may be applicable to time division duplexing (TDD) or frequency division duplexing (FDD) communications. In some embodiments, techniques described herein may be applied to all of downlink (DL), uplink (UL), and sidelink (SL) communications, while other embodiments may only apply the techniques described herein to DL or UL or SL communications. Additionally, while the techniques described herein may be described within the context of the 3GPP LTE communications standard, the techniques may also be applied to other communication standards. Additionally, while examples provided herein may include enabling vehicles to communicate with one another more reliably, the techniques described herein may be applied to other scenarios as well (such as another system or device that may experience significant Doppler fading conditions when attempting to communicate wirelessly).

Fig. 2 is a diagram illustrating an example process 200 for sending information to another vehicle. Process 200 may be particularly appropriate for devices capable of wireless communications that may be subjected to high mobility propagation conditions (e.g., wireless propagation in high mobility conditions characterized by high Doppler fading and/or frequency shifts that may jeopardize the integrity or reliability of the wireless communications). Process 200 may be implemented by, for example, V2X device 110. Additionally, process 200 provides an example of how a V2V physical channel may be used; however, it should be noted that the V2V physical channel, as described herein, may

be used in additional and alternative ways, which may include fewer, additional, and/or alternative operations than the operations described below with reference to Fig. 2.

As shown, process 200 may include identifying a physical channel that is appropriate for communicating with another vehicle (block 210). For example, in some embodiments, V2X device 110 may be capable of using multiple physical channels for communicating with another vehicle. As described above, examples of such channels may include an LTE SL physical channel, a V2V physical channel (as described herein), etc. In some embodiments, V2X device 110 may identify the appropriate physical channel based on one or more factors.

Examples of such factors may include whether the physical channel will likely be subjected to high mobility propagation conditions. For instance, if the vehicle of the V2X device 110 and/or the other vehicle are traveling at a high speed, V2X device 110 may determine that communications between the vehicles are likely to be subjected to such conditions. As such, a V2V physical channel (as opposed to, for example, a legacy LTE SL channel) may be appropriate for communicating with the other vehicle.

Another example of a factor that may be considered by V2X device 110 may include the communication capabilities of the other vehicle. For example, V2X device 110 may determine the types of physical channels that the other vehicle is capable of using and select the most appropriate physical channel from on the physical channels that the other vehicle is capable of using. In some embodiments, determining the communication capabilities of the other vehicle may include determining what type of communications device is being implemented by the other vehicle (e.g., a V2X device or another type of communications device).

Additional examples of factors that may be used to identify an appropriate physical channel may include physical channel availability (e.g., whether V2X device is already using one or more physical channels), a measure of importance regarding the information (or type of information) that is to be sent to the other vehicle (e.g., less important information may be allocated with less reliable physical channels), a measure of importance of other information that is to communicated to a different vehicle, etc. In yet another example, V2X device may implement one or more rules for prioritizing which type of physical channel (e.g., an LTE SL channel, a V2V physical channel, etc.) should be implemented in light of one or more of the factors described above.

Process 200 may include generating information to communicate to the vehicle (block 220). For example, V2X device 110 may generate the information that is to be

transmitted to the other vehicle. Examples of such information may include vehicle performance information, vehicle location information, vehicle usage information, vehicle status information, vehicle diagnostic information, information relating to a driver or passenger of the vehicle, etc.

Process 200 may include processing the information based on the physical channel identified for communicating with the other vehicle (block 230). For example, V2X device 110 may arrange the information in accordance with a particular PRB format, which may be particular to the type of physical channel identified as the suitable for communicating with the other vehicle. For instance, if the identified physical channel corresponds to a currently available physical channel (such as an LTE LS physical channel), the information may be allocated to accommodate a format where a PRB includes 12 subcarriers (also referred to herein as frequency REs) with 15 kHz subcarrier spacing and 1 slot of 0.5 ms duration in time. However, if the identified physical channel corresponds to a V2V physical channel, the information may be allocated to accommodate a format where a PRB includes 12 subcarriers with 30 kHz subcarrier spacing and 1 slot of 0.25 ms duration in time. Alternatively, for V2V physical channel, the information may be allocated to accommodate a format where a PRB includes 12 subcarriers with 60 kHz subcarrier spacing and 1 slot of 0.125 ms duration in time. Additional examples of PRB formats are discussed below with reference to Figs. 4-9.

Process 200 may include using the physical channel to communicate information to vehicle (block 240). For example, V2X device 110 may use the physical channel identified as being appropriate for communicating with the vehicle to transmit the information to the vehicle. As described above, the physical channel may include a legacy channel (such as an LTE SL channel) or a V2V physical channel, and the information may be formatted in accordance with a format (e.g., a PRB format) that is particular to the physical channel used to transmit the information.

Fig. 3 is a diagram illustrating an example process 300 for receiving information from another vehicle. Process 300 may be particularly appropriate for devices capable of wireless communications that may be subjected to high mobility conditions (e.g., that may cause high Doppler fading and/or frequency shifts) during V2V communications. Process 300 may be implemented by, for example, V2X device 110.

As shown, process 300 may include receiving information from another vehicle via a physical channel (block 310). For example, V2X device 110 may be capable of using physical channels for communicating with another vehicle. As described above, examples

of such channels may include an LTE SL channel, a V2V physical channel, etc. The information sent and received between vehicles may include vehicle performance information, vehicle location information, vehicle usage information, vehicle status information, vehicle diagnostic information, information relating to a driver or passenger of the vehicle, etc.

Process 300 may include determining a physical channel type corresponding to the physical channel (block 320). For example, V2X device 110 may identify the type of physical channel (e.g., an LTE SL channel, a V2V channel, etc.) used to receive the information. In some embodiments, V2X device 110 may determine the manner in which the information is arranged in the physical channel based on the physical channel type may include. For example, if the physical channel corresponds to an LTE SL physical channel, the information may be formatted into PRBs that include 12 subcarriers with 15 kHz subcarrier spacing and 1 slot of 0.5 ms duration in time. In another example, if the physical channel corresponds to a V2V physical channel, the information may be formatted into PRBs that include 12 subcarriers with 30 kHz subcarrier spacing and 1 slot of 0.25 ms duration in time. Alternatively, for a V2V physical channel, the information may be allocated to accommodate a format where a PRB includes 12 subcarriers with 60 kHz subcarrier spacing and 1 slot of 0.125 ms duration in time. Additional examples of PRB formats are discussed below with reference to Figs. 4-9.

Process 300 may include interpreting the information based on the physical channel type of the physical channel (block 330). For example, V2X device 110 may interpret the information, received from another vehicle, based on a type of physical channel used to communicate the information. For instance, if the physical channel corresponds to an LTE LS physical channel, the information may be interpreted based on the assumption that the information was formatted into PRBs that include 12 subcarriers with 15 kHz subcarrier spacing and 1 slot of 0.5 ms duration in time. By contrast, if the physical channel corresponds to a V2V physical channel, the information may be interpreted based on the assumption that the information was formatted into PRBs that include 12 subcarriers with 30 kHz subcarrier spacing and 1 slot of 0.25 ms duration in time. Alternatively, for V2V physical channel, the information may be interpreted based on the assumption that the information was formatted into PRBs that include 12 subcarriers with 60 kHz subcarrier spacing and 1 slot of 0.125 ms duration in time.

Fig. 4 is a diagram of an example PRB of a legacy LTE numerology and an example PRB of a V2V numerology, under normal CP conditions. The legacy LTE numerology may correspond to a legacy LTE physical channel (e.g., an LTE SL channel), while the V2V

numerology may correspond to a V2V physical channel. A numerology, as discussed herein, may include parameters and characteristics of a physical channel (e.g., a legacy LTE SL channel or a V2V physical channel).

Such parameters and characteristics may include a bandwidth supported by the physical channel, a number of subcarriers per channel, a subcarrier spacing, a fast Fourier transform (FFT) size, a symbol duration, a slot duration, a subframe duration. Additional examples of numerological parameters and characteristics may include a direct, or indirect, description of a PRB and/or PRB pair of the physical channel, such as a number of subcarriers per PRB, a PRB duration (e.g., a number of slots per PRB), a number of resource elements (REs) per PRB, a number of symbols per PRB, etc.

Additionally, in the 3GPP LTE communication standard, CP may include copying a small portion of one symbol (e.g., an end portion of the symbol) and adding the copied portion to a beginning portion of the symbol, such that the symbol begins and ends with the same portion. Normal CP (as depicted in Figs. 4 and 6) may be implemented for wireless communications over shorter distances, while extended CP (as depicted in Figs. 5 and 7) may be implemented for wireless communications over longer distances. As such, normal CP may include a PRB of more symbols (or REs) per slot in time domain (e.g., 7), while extended CP may include a PRB of fewer symbols (or REs) per slot in time domain (e.g., 6).

As shown in Fig. 4, a PRB of the legacy LTE numerology for normal CP may include 12 subcarriers with 15 kHz subcarrier spacing, a slot of 0.5 ms in time domain comprising 7 consecutive symbols, and 84 REs in total. By contrast, the PRB of the V2V numerology for normal CP may include 12 subcarriers with 30 kHz subcarrier spacing, 1 slot of 0.25 ms in the time domain, comprising 7 consecutive symbols, and 84 REs in total. As such, each subcarrier of a V2V physical channel PRB may have twice as much subcarrier spacing as the subcarriers of the legacy LTE channel PRB; however, the duration of the slot of the V2V physical channel may be half the duration of the slot of the legacy LTE physical channel. As mentioned above, the decrease in slot duration may be accompanied by a similar decrease (e.g., a factor of 2, 4, etc.) to the FTT size associated with the V2V physical channel. Doing so may help ensure that the sampling time and/or sampling frequency of the V2V physical channel remains the same as the sampling time and sampling frequency of the legacy LTE channel.

For example, sampling time, as described herein, may include the basic time unit for the corresponding physical channel. For instance, in the 3GPP LTE communication standard, sampling time may be represented by "Ts" and may be equal to 1/(subcarrier spacing x FFT

size) (e.g., 1/(1500Hz x 2048)). By contrast, sampling frequency, as described herein, may include the basic frequency unit for a particular physical channel. For example, in the 3GPP LTE communication standard, sampling frequency may be represented by "Fs" and may be equal to subcarrier spacing (e.g., 15 kHz) multiplied by the number of FFT time samples (e.g., 2048).

As described above, a V2V channel may have increased subcarrier spacing (e.g., 30 kHz or 60 kHz instead of 15 kHz) but still be implemented within the LTE framework since decreasing symbol duration and FFT size proportionally may help ensure that sampling frequency and sampling time for the V2V channel are the same as the sampling frequency and sampling time of legacy LTE channels (e.g., an LTE SL channel). For example, since sampling time is equal to the inverse of subcarrier spacing multiplied by the corresponding FFT size, increasing the subcarrier spacing by a factor of two (e.g., from 15 kHz to 30 kHz) or four (e.g., from 15 kHz to 60 kHz) does not change the sampling time so long as the FFT size is reduced by the same factor (e.g., from 2048 to 1024 for factor of two or from 2048 to 512 for factor of four). The same can be said for sampling frequency since sampling frequency may be equal to subcarrier spacing multiplied by the corresponding FFT size. As such, the arrow depicted in Fig. 4 may represent that the techniques described herein may enable legacy LTE channels to be modified (or replaced) by V2V channels (which may be more robust and reliable in high mobility conditions (e.g., that may cause high Doppler fading and/or frequency shifts)) without affecting other aspects of the LTE communications standard.

For example, in some embodiments, the duration for a single subframe of a V2V channel may be set to 0.5 ms, such that the subframe may include 2 slots at 0.25 ms each. In such an implementation, relatively few (if any) modifications to the 3GPP LTE communication standard may implement the V2V channel since, for example, legacy LTE channels also include 2 slots per subframe. In other embodiments, the duration for a single subframe of the V2V channel may be set to 1.0 ms (for example), which may result in a subframe including 4 slots at 0.25 ms each. In such embodiments, certain modifications to the 3GPP LTE communications standard may be beneficial, such as modifications to the size of transport blocks, the transport block sizes (TBS) tables, etc.

Fig. 5 is a diagram of an example PRB of a legacy LTE numerology and an example PRB of a V2V numerology, under extended CP conditions. The legacy LTE numerology may correspond to a legacy LTE channel (e.g., an LTE SL channel), while the V2V numerology may correspond to a V2V channel. As shown, a PRB of the legacy LTE numerology for extended CP may include 12 subcarriers of 15 kHz each, a slot of 0.5 ms, and 72 REs (6 symbols or (REs)

per slot). By contrast, the PRB of the V2V numerology for normal CP may include 12 subcarriers of 30 kHz each, 1 slot of 0.25 ms, and 84 REs. As such, each subcarrier of a V2V channel PRB may include twice as much bandwidth as the subcarriers of the legacy LTE channel PRB; however, the slot of the V2V channel PRB may be half the duration of the slot of the legacy LTE channel PRB. As mentioned above, the decrease in slot duration may be accompanied by a similar decrease (e.g., a factor of 2, 4, etc.) to the FTT size associated with the V2V channel. The sampling frequency of the V2V channel may remain the same as the sampling frequency of the legacy LTE channel. As such, the arrow depicted in Fig. 5 may represent that the techniques described herein may enable legacy LTE channels to be modified (or replaced) by V2V channels (which may be more robust and reliable in high mobility conditions) without affecting other aspects of the LTE communications standard.

Fig. 6 is a diagram of example PRB pairs of a legacy LTE numerology and example PRB pairs of a V2V numerology, under normal CP conditions. As shown, the legacy LTE numerology and the V2V numerology may each include 4 PRBs, PRB 6.1 through PRB 6.4 and PRB 6.5 through 6.8, respectively. Each PRB of the legacy LTE numerology, and each PRB of the V2V numerology, may be similar to the corresponding PRBs discussed above with reference to Fig. 4. Additionally, the PRBs of Fig. 6 may corresponds to normal CP conditions since the PRB format includes 7 symbols (or REs) for each slot.

In the legacy LTE numerology, the PRB pairs may be differentiated from one another in the frequency domain, such that PRB 6.1 and PRB 6.2 include one pair (e.g., a 1st PRB pair) and PRB 6.3 and PRB 6.4 are another pair (e.g., a 2nd PRB pair). By contrast, in V2V numerology, the PRB pairs may be differentiated from one another in the time domain, such that PRB 6.5 and PRB 6.6 include one pair (e.g., a 1st PRB pair) and PRB 6.7 and PRB 6.8 are another pair (e.g., a 2nd PRB pair). Similar to the arrows in Fig. 4 and Fig. 5, the arrow depicted in Fig. 6 may represent that the techniques described herein may enable legacy LTE channels to be modified (or replaced) by V2V channels affecting other aspects of the LTE communications standard.

Fig. 7 is a diagram of example PRB pairs of a legacy LTE numerology and PRB pairs of a V2V numerology, under extended CP conditions. As shown, the legacy LTE numerology and the V2V numerology may each include 4 PRBs, PRB 7.1 through PRB 7.4 and PRB 7.5 through 7.8, respectively. Each PRB of the legacy LTE numerology, and each PRB of the V2V numerology, may be similar to the corresponding PRBs discussed above with reference to Fig. 5. Additionally, the PRBs of Fig. 7 may correspond to extended CP conditions since the PRB format includes 6 symbols (or REs) for each slot.

In the legacy LTE numerology, the PRB pairs may be differentiated from one another in the frequency domain, such that PRB 7.1 and PRB 7.2 include one pair (e.g., a 1st PRB pair) and PRB 6.3 and PRB 6.4 are another pair (e.g., a 2nd PRB pair). By contrast, in V2V numerology, the PRB pairs may be differentiated from one another in the time domain, such that PRB 7.5 and PRB 7.6 include one pair (e.g., a 1st PRB pair) and PRB 7.7 and PRB 7.8 are another pair (e.g., a 2nd PRB pair). Similar to the arrow in Fig. 6, the arrow depicted in Fig. 7 may represent that the techniques described herein may enable legacy LTE channels to be modified (or replaced) by V2V channels affecting other aspects of the LTE communications standard.

Figs. 8A-8D are diagrams of example PRBs according to one or more embodiments described herein. Additionally, the PRBs of Figs. 8A-8D may corresponds to normal CP conditions since each PRB includes 7 symbols per slot in time domain. The example PRB of Fig. 8A may correspond to the V2V channel PRB described above with reference to Fig. 4. The example PRBs of Fig. 8B may include a PRB pair (PRB 8.1 and PRB 8.2), similar to the V2V channel PRB pairs described above with reference to Fig. 5. Fig. 8C may include an example PRB that is similar to the PRB of Fig. 8A, except that the example PRB of Fig. 8C includes only 6 subcarriers (also, "REs in frequency" or "Frequency REs") of 30 kHz each. Similarly, Fig. 8D may include an example PRB pair (PRB 8.3 and PRB 8.4) that is similar to the PRB pair of Fig. 9B, except that the example PRBs of Fig. 8D include only 6 subcarriers with 30 kHz subcarrier spacing. In some embodiments, reducing the number of subcarriers per V2V channel may increase the number of transmission channels that may be used for V2V communications, which may in turn increase V2V system capacity (e.g., in a location with a high number of vehicles, such as a traffic jam on a freeway or major intersection).

Figs. 9A-9D are diagrams of example PRBs according to one or more embodiments described herein. Additionally, the PRBs of Figs. 9A-9D may correspond to extended CP conditions since each PRB includes 6 symbols per slot. The example PRB of Fig. 9A may correspond to the V2V channel PRB described above with reference to Fig. 5. The example PRBs of Fig. 9B may include a PRB pair (PRB 9.1 and PRB 9.2), similar to the V2V channel PRB pairs described above with reference to Fig. 5. Fig. 9C may include an example PRB that is similar to the PRB of Fig. 9A, except that the example PRB of Fig. 9C includes only 6 subcarriers (also, "REs in frequency" or "Frequency REs") of 30 kHz each. Similarly, Fig. 9D may include an example PRB pair (PRB 9.3 and PRB 9.4) that is similar to the PRB pair of Fig. 9B, except that the example PRBs of Fig. 9D include only 6 (instead of 12) subcarriers of 30 kHz each. As described above with reference to Figs. 8A-8D, in some embodiments, reducing

the number of subcarriers per V2V channel may increase the number of transmission channels that may be used for V2V communications, which may in turn increase the level of V2V system capacity (e.g., in a location with a high number of vehicles, such as a traffic jam on a freeway or major intersection).

Fig. 10 is a table of example characteristics of a legacy LTE numerology and a V2V numerology with 30 kHz subcarrier spacing. As shown, the table of Fig. 10 includes a Channel Characteristics column, a Legacy LTE Channel Numerology column, and a V2V Channel numerology column. Fig. 10 provides a non-limiting example of differences and similarities that may exists between a legacy LTE channel and a V2V channel.

For example, a legacy LTE channel may include a subcarrier spacing of 15 kHz, while a V2V channel may include a subcarrier spacing of 30 kHz. Both channels may support the same bandwidths; however, the channels may only support some of the same FTT sizes. For instance, only the legacy LTE channel may use FTT sizes of 1536 and 2048, and the V2V channel may use FTT sizes of 64 and 768. As such, the FFT size for the legacy LTE channel may include a lower limit of 128 for the 1.4 MHz bandwidth and an upper limit of 2048 for 20 MHz bandwidth, while the FFT size for the V2V channel (with 30 kHz subcarrier spacing), may include a lower limit of 64 for 1.4 MHz bandwidth and an upper limit of 1024 for the 20 MHz bandwidth. As described above, this is due to reducing the FTT sizes for the V2V channel by the same factor (e.g., "2") that was used to increase the subcarrier spacing of the V2V channel. The following table may represent a logical relationship between different BWs, legacy LTE FFT sizes, and V2V channel FFT sizes (when the subcarrier spacing for the V2V channel is 30 kHz).

Bandwidth (BW)	Nominal FFT Size	
	Legacy LTE Channel	V2V Channel with 30 kHz
1.4 MHz	128	64
3 MHz	256	128
5 MHz	512	256
10 MHz	1024	512
15 MHz	1536	768
20 MHz	2048	1024

Since the same factor was used to increase and decrease the subcarrier spacing and FFT size (respectively), both channels may have the same sampling time (Ts) of 32.55 nanoseconds

(ns) because sampling time may be calculated by taking the inverse of the product of the subcarrier spacing and the FFT size (e.g., Ts = 1/(subcarrier spacing x FFT size). In some embodiments, for similar reasons, both channels may also have the same sampling frequency (Fs) (e.g., Fs = subcarrier spacing x FFT size). As mentioned above, maintaining the same sampling time and sampling frequency as the legacy LTE channel may help ensure that the V2V channel can be implemented in an LTE environment without having to make significant adjustments to other aspects of the 3GPP LTE communication standard.

Similar to the change in FFT size, the symbol durations for the V2V channel may also be reduced by the same factor (e.g., "2") that was used to increase the subcarrier spacing of the V2V channel. As shown in Figs. 6-7, this may enable PRBs and PRB pairs to be formatted in a manner that enables the V2V channel to reduce the slot duration by half (e.g., from 0.5 ms to 0.25 ms) and output PRBs at the same rate as the legacy LTE channel, even though the subcarrier spacing for the V2V channel was doubled. Similar to maintaining the same sampling time and sampling frequency, maintaining a similar output rate as the legacy LTE channel, may help reduce the impact of the V2V channel on other aspects of the 3GPP LTE communication standard.

Additionally, the single subframe duration for the legacy LTE channel may be 1.0 ms, whereas the single subframe duration for the V2V channel may be 0.5 or 1.0 ms. A single subframe duration of 0.5 ms may enable the V2V channel to have two slots per subframe since the slot duration for the V2V channel was reduced to 0.25 ms. Additionally, since a PRB duration may be 0.25 ms (which corresponds to 1 slot), a 0.5 ms subframe may consist of one PRB pair (i.e., two 0.25 ms PRBs). In other words, the V2V channel may have a subframe-to-PRB-pair ratio of 1:1 when the subframe duration of the V2V channel is 0.5 ms, which may reduce the impact of the V2V channel on the 3GPP LTE communication standard since, for example, the legacy LTE channel also has a subframe-to-PRB-pair ratio of 1:1.

By contrast, a single subframe duration of 1.0 ms may enable the V2V channel to have four slots per subframe since the slot duration for the V2V channel was reduced to 0.25 ms. As such, the subframe may include four slots. In other words, a subframe duration of 1.0 ms, as opposed to the 0.5 ms subframe scenario above, may give rise to a relative increase in the amount of information that may be communicated in one subframe. As a result, implementing a 1.0 ms subframe may additional modifications to the 3GPP LTE communication standard, including changes to the design of physical channels, such as modifications to the size of transport blocks, the transport block sizes (TBS) tables, etc.

As shown in Fig. 10, whether the legacy LTE channel and the V2V channel have the same number of subcarriers per PRB may depend on the scenario or embodiment. For example, both channels may have 12 subcarriers for each PRB. Additionally, or alternatively, the V2V channel may have 6 subcarriers per PRB. In some embodiments, while allocating 6 subcarriers (instead of 12) to each PRB may decrease the rate at which a channel may transmit data, doing so may also increase the number of V2V channels that are available for V2X devices 110 to communicate with other V2X devices, UEs, etc. As such, allocating 6 subcarriers to each V2V channel may be beneficial in scenarios where V2V channels might not benefit from a high data rate connections and/or a vehicle with a V2X device is in a traffic jam, rush hour traffic, or in another situation involving a lot of V2X devices 110, UEs 110, etc., that within range of one another.

Fig. 11 is a table of example characteristics of a legacy LTE numerology and a V2V numerology with 60 kHz subcarrier spacing. As shown, the table of Fig. 11 includes a Channel Characteristics column, a Legacy LTE Channel Numerology column, and a V2V Channel numerology column. Fig. 11 provides a non-limiting example of differences and similarities that may exists between a legacy LTE channel and a V2V channel.

For example, a legacy LTE channel may include a subcarrier spacing of 15 kHz, while a V2V channel may include a subcarrier spacing of 60 kHz. Both channels may support the same bandwidths; however, the channels may only support some of the same FTT sizes. For instance, only the legacy LTE channel may support FTT sizes of 1024, 1536, and 2048, and only the V2V channel may support an FTT size of 32, 64, and 384. As such, the FFT size for the legacy LTE channel may include a lower limit of 128 and an upper limit of 2048, while the FFT size for the V2V channel (with 60 kHz subcarrier spacing), may include a lower limit of 32 kHz and an upper limit of 512 kHz. This may be due to reducing the FTT sizes for the V2V channel by the same factor (e.g., "4") that was used to increase the subcarrier spacing of the V2V channel. The following table may represent a logical relationship between different BWs, legacy LTE FFT sizes, and V2V channel FFT sizes (when the subcarrier spacing for the V2V channel is 30 kHz).

Bandwidth (BW)	Nominal FFT Size	
	Legacy LTE Channel	V2V Channel with 60 kHz
1.5 MHz	128	32
3 MHz	256	64
5 MHz	512	128
10 MHz	1024	256

15 MHz	1536	384
20 MHz	2048	512

Since the same factor was used to increase and decrease the subcarrier spacing and FFT size (respectively), both channels may have the same sampling time (Ts) of 32.55 nanoseconds (ns) because sampling time may be calculated by taking the inverse of the product of the subcarrier spacing and the FFT size (e.g., Ts = 1/(subcarrier spacing x FFT size). In some embodiments, for similar reasons, both channels may also have the same sampling frequency (Fs) (e.g., Fs = subcarrier spacing x FFT size). As mentioned above, maintaining the same sampling time and sampling frequency as the legacy LTE channel may help ensure that the V2V channel can be implemented in an LTE environment without having to make significant adjustments to other aspects of the 3GPP LTE communication standard.

Similar to the change in FFT size, the symbol durations for the V2V channel may also be reduced by the same factor (e.g., "4") that was used to increase the subcarrier spacing of the V2V channel. This may enable PRBs and PRB pairs to be formatted in a manner that enables the V2V channel to reduce the slot duration by one-fourth (e.g., from 1.0 ms to 0.125 ms) and output PRBs at the same rate as the legacy LTE channel, even though the subcarrier spacing for the V2V channel was quadrupled. Similar to maintaining the same sampling time and sampling frequency, maintaining a similar output rate as the legacy LTE channel, may help reduce the impact of the V2V channel on other aspects of the 3GPP LTE communication standard.

Additionally, the single subframe duration for the legacy LTE channel may be 1.0 ms, whereas the single subframe duration for the V2V channel may be 0.25 or 1.0 ms. A single subframe duration of 0.25 ms may enable the V2V channel to have two slots per subframe since the slot duration for the V2V channel was reduced to 0.125 ms. Additionally, since a PRB duration may be 0.125 ms (which corresponds to 1 slot), a 0.25 ms subframe may consist of one PRB pair (i.e., two 0.125 ms PRBs). In other words, the V2V channel may have a subframe-to-PRB-pair ratio of 1:1 when the subframe duration of the V2V channel is 0.25 ms, which may reduce the impact of the V2V channel on the 3GPP LTE communication standard since, for example, the legacy LTE channel also has a subframe-to-PRB-pair ratio of 1:1.

By contrast, a single subframe duration of 1.0 ms may enable the V2V channel to have eight slots per subframe since the slot duration for the V2V channel was reduced to 0.125 ms. As such, the subframe may include eight slots. In other words, a subframe duration of 1.0 ms, as opposed to the 0.25 ms subframe scenario above, may give rise to a relative increase in the amount of information that may be communicated in one subframe. As a result, implementing a

1.0 ms subframe may additional modifications to the 3GPP LTE communication standard, including changes to the design of physical channels, such as modifications to the size of transport blocks, the transport block sizes (TBS) tables, etc.

As shown in Fig. 11, whether the legacy LTE channel and the V2V channel have the same number of subcarriers per PRB may depend on the scenario or embodiment. For example, both channels may have 12 subcarriers for each PRB. Additionally, or alternatively, the V2V channel may have 3 or 6 subcarriers per PRB. In some embodiments, while allocating 3 or 6 subcarriers (instead of 12) to each PRB may decrease the rate at which a channel may transmit data, doing so may also increase the number of V2V channels that are available for V2X devices 110 to communicate with other V2X devices, UEs, etc. As such, allocating 3 or 6 subcarriers to each V2V channel may be beneficial in scenarios where V2V channels might not benefit from high data rate connections and/or a vehicle with a V2X device is in a traffic jam, rush hour traffic, or in another situation involving a lot of V2X devices 110, UEs 110, etc., that within range of one another.

Fig. 12 is a table representing an example of legacy LTE and V2V transmission multiplexing. As shown, Fig. 12 may include a vertical axis representing frequency and a horizontal axis representing time. V2V devices 110, UEs 110, etc., may support both legacy and V2V PHY numerologies (e.g. for cellular and V2V operation). Time domain multiplexing of legacy and V2V transmissions at one UE 110 may be used for these purposes. To facilitate efficient use of resources the minimum granularity for time domain multiplexing may be a multiple of legacy subframe granularity (e.g., 1.0 ms).

In one example, subframes for legacy LTE and V2V operation may be semi-statically, higher-layer configured, by an eNB (e.g., via radio resource control (RRC) protocol), on a per V2V device basis (or V2V device group basis). Semi-statically may include, for example, physical channels that are predefined by the eNB and assigned to a particular V2V device 210 or UE in a given scenario. In another example, subframes for legacy LTE and V2V operation may be dynamically assigned. In yet another example, subframes for legacy LTE and V2V operation may be specified by a communications standard (such as the 3GPP LTE communication standard).

A V2V transmissions (e.g., transmissions with a V2V numerology) may take place in either TDD or FDD modes. In the latter case, the transmissions may be configured in either a DL or a UL spectrum and can be configured independently (e.g., V2V transmissions on a UL spectrum may not impose use of V2V numerology in a DL spectrum in the same time resources).

In some embodiments, V2V device 110, UE 110, etc., may implement an autonomous selection capability for the numerology for the V2V transmissions (e.g., either a legacy LTE numerology or a V2V numerology) based on one or more instructions, conditions, or other criteria. As such, a V2V receiver (or another type of communication component) may either be informed on the type of the transmission in advance or may dynamically detect the transmission type. In embodiments where the transmission type is dynamically detected, a receiver (or another component of V2V device 110) may attempt to receive information under different hypothesis simultaneously (e.g., attempt to receive a signal under both a 15 kHz subcarrier spacing assumption and a 30 kHz subcarrier spacing assumptions)

As used herein, the term "circuitry" or "processing circuitry" may refer to, be part of, or include an Application Specific Integrated Circuit (ASIC), an electronic circuit, a processor (shared, dedicated, or group), and/or memory (shared, dedicated, or group) that execute one or more software or firmware programs, a combinational logic circuit, and/or other suitable hardware components that provide the described functionality. In some embodiments, the circuitry may be implemented in, or functions associated with the circuitry may be implemented by, one or more software or firmware modules. In some embodiments, circuitry may include logic, at least partially operable in hardware.

Embodiments described herein may be implemented into a system using any suitably configured hardware and/or software. Fig. 13 illustrates, for one embodiment, example components of an electronic device 1300. In embodiments, the electronic device 1300 may be a UE, an eNB, a WLAN AP, or some other appropriate electronic device. In some embodiments, the electronic device 1300 may include application circuitry 1302, baseband circuitry 1304, Radio Frequency (RF) circuitry 1306, front-end module (FEM) circuitry 1308 and one or more antennas 1360, coupled together at least as shown.

The application circuitry 1302 may include one or more application processors. For example, the application circuitry 1302 may include circuitry such as, but not limited to, one or more single-core or multi-core processors. The processor(s) may include any combination of general-purpose processors and dedicated processors (e.g., graphics processors, application processors, etc.). The processors may be coupled with and/or may include memory/storage, such as storage medium 1303, and may be configured to execute instructions stored in the memory/storage to enable various applications and/or operating systems to run on the system. In some implementations, storage medium 1303 may include a non-transitory computer-readable medium. Application circuitry 1302 may, in some embodiments, connect to or include one or more sensors, such as environmental sensors, cameras, etc.

Baseband circuitry 1304 may include circuitry such as, but not limited to, one or more single-core or multi-core processors. The baseband circuitry 1304 may include one or more baseband processors and/or control logic to process baseband signals received from a receive signal path of the RF circuitry 1306 and to generate baseband signals for a transmit signal path of the RF circuitry 1306. Baseband processing circuitry 1304 may interface with the application circuitry 1302 for generation and processing of the baseband signals and for controlling operations of the RF circuitry 1306. For example, in some embodiments, the baseband circuitry 1304 may include a second generation (2G) baseband processor 1304a, third generation (3G) baseband processor 1304b, fourth generation (4G) baseband processor 1304c, and/or other baseband processor(s) 1304d for other existing generations, generations in development or to be developed in the future (e.g., fifth generation (5G), 6G, etc.). The baseband circuitry 1304 (e.g., one or more of baseband processors 1304a-d) may handle various radio control functions that enable communication with one or more radio networks via the RF circuitry 1306. The radio control functions may include, but are not limited to, signal modulation/demodulation, encoding/decoding, radio frequency shifting, etc. In some implementations, baseband circuitry 1304 may be associated with storage medium 1303 or with another storage medium.

In some embodiments, modulation/demodulation circuitry of the baseband circuitry 1304 may include FFT, precoding, and/or constellation mapping/demapping functionality. In some embodiments, encoding/decoding circuitry of the baseband circuitry 1304 may include convolution, tail-biting convolution, turbo, Viterbi, and/or Low Density Parity Check (LDPC) encoder/decoder functionality. Embodiments of modulation/demodulation and encoder/decoder functionality are not limited to these examples and may include other suitable functionality in other embodiments. In some embodiments, the baseband circuitry 1304 may include elements of a protocol stack such as, for example, elements of an evolved universal terrestrial radio access network (E-UTRAN) protocol including, for example, physical (PHY), MAC, radio link control (RLC), packet data convergence protocol (PDCP), and/or radio resource control (RRC) elements. A central processing unit (CPU) 1304e of the baseband circuitry 1304 may be configured to run elements of the protocol stack for signaling of the PHY, MAC, RLC, PDCP and/or RRC layers. In some embodiments, the baseband circuitry may include one or more audio digital signal processor(s) (DSP) 1304f. The audio DSP(s) 1304f may be include elements for compression/decompression and echo cancellation and may include other suitable processing elements in other embodiments.

The baseband circuitry 1304 may further include memory/storage 1304g. The memory/storage 1304g may be used to load and store data and/or instructions for operations

performed by the processors of the baseband circuitry 1304. Memory/storage for one embodiment may include any combination of suitable volatile memory and/or non-volatile memory. The memory/storage 1304g may include any combination of various levels of memory/storage including, but not limited to, read-only memory (ROM) having embedded software instructions (e.g., firmware), random access memory (e.g., dynamic random access memory (DRAM)), cache, buffers, etc. The memory/storage 1304g may be shared among the various processors or dedicated to particular processors.

Components of the baseband circuitry may be suitably combined in a single chip, a single chipset, or disposed on a same circuit board in some embodiments. In some embodiments, some or all of the constituent components of the baseband circuitry 1304 and the application circuitry 1302 may be implemented together such as, for example, on a system on a chip (SOC).

In some embodiments, the baseband circuitry 1304 may provide for communication compatible with one or more radio technologies. For example, in some embodiments, the baseband circuitry 1304 may support communication with an E-UTRAN and/or other wireless metropolitan area networks (WMAN), a WLAN, a wireless personal area network (WPAN). Embodiments in which the baseband circuitry 1304 is configured to support radio communications of more than one wireless protocol may be referred to as multi-mode baseband circuitry.

RF circuitry 1306 may enable communication with wireless networks using modulated electromagnetic radiation through a non-solid medium. In various embodiments, the RF circuitry 1306 may include switches, filters, amplifiers, etc. to facilitate the communication with the wireless network. RF circuitry 1306 may include a receive signal path which may include circuitry to down-convert RF signals received from the FEM circuitry 1308 and provide baseband signals to the baseband circuitry 1304. RF circuitry 1306 may also include a transmit signal path which may include circuitry to up-convert baseband signals provided by the baseband circuitry 1304 and provide RF output signals to the FEM circuitry 1308 for transmission.

In some embodiments, the RF circuitry 1306 may include a receive signal path and a transmit signal path. The receive signal path of the RF circuitry 1306 may include mixer circuitry 1306a, amplifier circuitry 1306b and filter circuitry 1306c. The transmit signal path of the RF circuitry 1306 may include filter circuitry 1306c and mixer circuitry 1306a. RF circuitry 1306 may also include synthesizer circuitry 1306d for synthesizing a frequency for use by the mixer circuitry 1306a of the receive signal path and the transmit signal path. In some

embodiments, the mixer circuitry 1306a of the receive signal path may be configured to down-convert RF signals received from the FEM circuitry 1308 based on the synthesized frequency provided by synthesizer circuitry 1306d. The amplifier circuitry 1306b may be configured to amplify the down-converted signals and the filter circuitry 1306c may be a low-pass filter (LPF) or band-pass filter (BPF) configured to remove unwanted signals from the down-converted signals to generate output baseband signals.

Output baseband signals may be provided to the baseband circuitry 1304 for further processing. In some embodiments, the output baseband signals may be zero-frequency baseband signals. In some embodiments, mixer circuitry 1306a of the receive signal path may comprise passive mixers, although the scope of the embodiments is not limited in this respect.

In some embodiments, the mixer circuitry 1306a of the transmit signal path may be configured to up-convert input baseband signals based on the synthesized frequency provided by the synthesizer circuitry 1306d to generate RF output signals for the FEM circuitry 1308. The baseband signals may be provided by the baseband circuitry 1304 and may be filtered by filter circuitry 1306c. The filter circuitry 1306c may include a low-pass filter (LPF), although the scope of the embodiments is not limited in this respect.

In some embodiments, the mixer circuitry 1306a of the receive signal path and the mixer circuitry 1306a of the transmit signal path may include two or more mixers and may be arranged for quadrature downconversion and/or upconversion respectively. In some embodiments, the mixer circuitry 1306a of the receive signal path and the mixer circuitry 1306a of the transmit signal path may include two or more mixers and may be arranged for image rejection (e.g., Hartley image rejection). In some embodiments, the mixer circuitry 1306a of the receive signal path and the mixer circuitry 1306a may be arranged for direct downconversion and/or direct upconversion, respectively. In some embodiments, the mixer circuitry 1306a of the receive signal path and the mixer circuitry 1306a of the transmit signal path may be configured for super-heterodyne operation.

In some embodiments, the output baseband signals and the input baseband signals may be analog baseband signals, although the scope of the embodiments is not limited in this respect. In some alternate embodiments, the output baseband signals and the input baseband signals may be digital baseband signals. In these alternate embodiments, the RF circuitry 1306 may include analog-to-digital converter (ADC) and digital-to-analog converter (DAC) circuitry and the baseband circuitry 1304 may include a digital baseband interface to communicate with the RF circuitry 1306.

In some dual-mode embodiments, a separate radio IC circuitry may be provided for processing signals for each spectrum, although the scope of the embodiments is not limited in this respect.

In some embodiments, the synthesizer circuitry 1306d may be a fractional-N synthesizer or a fractional N/N+6 synthesizer, although the scope of the embodiments is not limited in this respect as other types of frequency synthesizers may be suitable. For example, synthesizer circuitry 1306d may be a delta-sigma synthesizer, a frequency multiplier, or a synthesizer comprising a phase-locked loop with a frequency divider.

The synthesizer circuitry 1306d may be configured to synthesize an output frequency for use by the mixer circuitry 1306a of the RF circuitry 1306 based on a frequency input and a divider control input. In some embodiments, the synthesizer circuitry 1306d may be a fractional N/N+6 synthesizer.

In some embodiments, frequency input may be provided by a voltage controlled oscillator (VCO. Divider control input may be provided by either the baseband circuitry 1304 or the applications processor 1302 depending on the desired output frequency. In some embodiments, a divider control input (e.g., N) may be determined from a look-up table based on a channel indicated by the applications processor 1302.

Synthesizer circuitry 1306d of the RF circuitry 1306 may include a divider, a delay-locked loop (DLL), a multiplexer and a phase accumulator. In some embodiments, the divider may be a dual modulus divider (DMD) and the phase accumulator may be a digital phase accumulator (DPA). In some embodiments, the DMD may be configured to divide the input signal by either N or N+6 (e.g., based on a carry out) to provide a fractional division ratio. In some example embodiments, the DLL may include a set of cascaded, tunable, delay elements, a phase detector, a charge pump and a D-type flip-flop. In these embodiments, the delay elements may be configured to break a VCO period up into Nd equal packets of phase, where Nd is the number of delay elements in the delay line. In this way, the DLL provides negative feedback to help ensure that the total delay through the delay line is one VCO cycle.

In some embodiments, synthesizer circuitry 1306d may be configured to generate a carrier frequency as the output frequency, while in other embodiments, the output frequency may be a multiple of the carrier frequency (e.g., twice the carrier frequency, four times the carrier frequency) and used in conjunction with quadrature generator and divider circuitry to generate multiple signals at the carrier frequency with multiple different phases with respect to each other. In some embodiments, the output frequency may be a LO frequency (fLO). In some embodiments, the RF circuitry 1306 may include an IQ/polar converter.

FEM circuitry 1308 may include a receive signal path which may include circuitry configured to operate on RF signals received from one or more antennas 1360, amplify the received signals and provide the amplified versions of the received signals to the RF circuitry 1306 for further processing. FEM circuitry 1308 may also include a transmit signal path which may include circuitry configured to amplify signals for transmission provided by the RF circuitry 1306 for transmission by one or more of the one or more antennas 1360.

In some embodiments, the FEM circuitry 1308 may include a TX/RX switch to switch between transmit mode and receive mode operation. The FEM circuitry may include a receive signal path and a transmit signal path. The receive signal path of the FEM circuitry may include a low-noise amplifier (LNA) to amplify received RF signals and provide the amplified received RF signals as an output (e.g., to the RF circuitry 1306). The transmit signal path of the FEM circuitry 1308 may include a power amplifier (PA) to amplify input RF signals (e.g., provided by RF circuitry 1306), and one or more filters to generate RF signals for subsequent transmission (e.g., by one or more of the one or more antennas 1360.

In some embodiments, the electronic device 1300 may include additional elements such as, for example, memory/storage, display, camera, sensors, and/or input/output (I/O) interface. In some embodiments, the electronic device of Fig. 13 may be configured to perform one or more methods, processes, and/or techniques such as those described herein.

A number of examples, relating to embodiments of the techniques described above, will next be given.

In a first example, a communication device may comprise: a radio frequency (RF) circuitry to communicate with other communication devices via a physical channel; and baseband circuitry to cause the RF circuitry to communicate with another communication device via the physical channel, the physical channel including: a single-carrier frequency-division multiple access (SC-FDMA) symbol duration (SC-FDMA) or an orthogonal frequency division multiplexing (OFDM) waveform, a subcarrier spacing of at least 30 kilohertz (kHz) in a frequency domain, and a symbol duration of 0.042 milliseconds (ms) or less in a time domain.

In example 2, the subject matter of example 1, or any of the examples herein, may further include wherein a physical resource block (PRB), corresponding to a signal of the physical channel, includes 12 subcarriers in a frequency domain with 30 kHz or with 60 kHz subcarrier spacing.

In example 3, the subject matter of example 1, or any of the examples herein, may further include wherein a PRB, corresponding to the physical channel, includes 6

subcarriers in frequency domain with 30 kHz subcarrier spacing or 3 subcarriers with 60 kHz subcarrier spacing.

In example 4, the subject matter of example 1, or any of the examples herein, may further include wherein two PRBs form a PRB pair, of the physical channel, that corresponds to two consecutive PRBs in a time-domain.

In example 5, the subject matter of example 1, or any of the examples herein, may further include wherein the physical channel corresponds to at least one of: a vehicle-to-vehicle (V2V) communication, a vehicular-to-infrastructure (V2I) communication, or a vehicular-to-pedestrian (V2P) communication.

In example 6, the subject matter of example 1, or any of the examples herein, may further include wherein the physical channel corresponds to at least one of: an long-term evolution (LTE) sidelink (SL) physical channels, an LTE downlink (DL) physical channels, or an LTE uplink (UL) physical channels.

In a seventh example, an apparatus for a wireless communication device may comprise: a radio (RF) circuitry to communicate with other communication devices via a physical channel; and a baseband circuitry to: use a physical channel, from a plurality of physical channel types, that is appropriate for communicating with the other wireless communication devices, the plurality of physical channel types including: a long-term evolution (LTE) physical channel, and a V2V physical channel that includes: a bandwidth that is at least as large as a bandwidth of the LTE physical channel; a subcarrier spacing that is greater, by a preselected factor, than a subcarrier spacing corresponding to the LTE physical channel, a fast Fourier transform (FFT) size that is less, by the preselected factor, than an FFT size corresponding to the LTE physical channel, a symbol duration that is less, by the preselected factor, than a symbol duration corresponding to the LTE physical channel, and a sampling frequency that is equal to a sampling frequency of the LTE physical channel, and a sampling time that is equal to a sampling time of the LTE physical channel; and communicate with the other wireless communication devices via the V2V physical channel.

In example 8, the subject matter of example 7, or any of the examples herein, may further include wherein the physical channel corresponds to at least one of: an LTE sidelink (SL) physical channels, an LTE downlink (DL) physical channels, or an LTE uplink (UL) physical channels.

In example 9, the subject matter of example 7, or any of the examples herein, may further include wherein the V2V physical channel includes physical resource blocks (PRBs) that

each include a number of subcarriers that is less than, or equal to, a number of subcarriers of the PRBs of the LTE physical channel.

In example 10, the subject matter of example 7, or any of the examples herein, may further include wherein: the subcarrier spacing for the V2V physical channel is 30 or 60 kilohertz (kHz); and the subcarrier spacing for the LTE physical channel is 15 kHz.

In example 11, the subject matter of example 7, or any of the examples herein, may further include wherein, for normal cyclic prefix (CP) conditions and extended CP conditions, a number of resource elements (REs) and a number of single-carrier frequency-division multiple access (SC-FDMA) or orthogonal frequency division multiplexing (OFDM) symbols per a physical resource block (PRB) of the V2V physical channel is equal to the number of REs and a number of SC-FDMA or OFDM symbols per PRB of the LTE physical channel.

In example 12, the subject matter of example 7, or any of the examples herein, may further include wherein application circuitry is to: communicate with a user equipment device (UE) of a vehicle via a vehicle-to-vehicle (V2V) connection, communicate with a UE of a user via a vehicle-to-pedestrian (V2P) connection, or communicate with a wireless telecommunications network via a vehicle-to-infrastructure (V2I) connection.

In example 13, the subject matter of example 7, or any of the examples herein, may further include wherein the baseband circuitry uses the type of physical channel that is appropriate for communicating with the other wireless communication device based on at least one of: a likelihood of communications, between the wireless communication device and the other wireless communication device being subjected to high mobility conditions, whether the other wireless communication device is capable of communicating via the LTE physical channel or the V2V physical channel, an availability, of the LTE physical channel or the V2V physical channel, for communicating with the other wireless communication device, a measure of importance regarding information that will be communicated to the other wireless communication device, or a preselected priority for communicating via the LTE physical channel or the V2V physical channel.

In example 14, the subject matter of example 7, or any of the examples herein, may further include wherein the baseband circuitry is configured, by via an eNB, to use the V2V physical channel or the LTE physical channel.

In example 15, the subject matter of example 7, or any of the examples herein, may further include wherein the baseband circuitry uses time-division multiplexing of the V2V physical channel and the LTE physical channel to communicate in different subframes.

In example 16, the subject matter of example 7, or any of the examples herein, may further include wherein subframes for the V2V physical channel and the LTE physical channel are semi-statically configured by an eNB.

In a seventeenth example, a wireless communication device as in the first or seventh examples, wherein a physical resource block (PRB), corresponding to the vehicle-to-vehicle (V2V) physical channel, includes: 7 consecutive single-carrier frequency-division multiple access (SC-FDMA) or orthogonal frequency division multiplexing (OFDM) symbols in time domain under normal cyclic prefix (CP) conditions, and 6 consecutive SC-FDMA or OFDM symbols in time domain under extended CP conditions.

In example 18, the subject matter of example 17, or any of the examples herein, may further include a subframe, corresponding to the V2V physical channel, includes two slots, a physical resource block (PRB), corresponding to the V2V physical channel, contains one slot; and a subframe duration, corresponding to the V2V physical channel, is equal to at least one of: 0.5 milliseconds (ms) and a slot duration is 0.25 ms when subcarrier spacing for the V2V physical channel is 30 kilohertz (kHz); or 0.25 milliseconds (ms) and a slot duration is 0.125 ms when subcarrier spacing for the V2V physical channel is 60 kilohertz (kHz).

In example 19, the subject matter of example 17, or any of the examples herein, may further include a subframe duration, corresponding to the vehicle-to-vehicle (V2V) physical channel, is equal to 1.0 ms, and the subframe, corresponding to the V2V physical channel, includes four slots with 0.25 ms duration and a physical resource block (PRB), corresponding to the V2V physical channel, contains two slots when subcarrier spacing for the V2V physical channel is 30 kilohertz (kHz), or the subframe, corresponding to the V2V physical channel, includes eight slots with 0.125 ms duration and a physical resource block (PRB), corresponding to the V2V physical channel, contains four slots when subcarrier spacing for the V2V physical channel is 60 kHz.

In a twentieth example, a computer readable medium may contain program instructions for causing one or more processors to: communicate with other communication devices via a physical channel, the physical channel including: a single-carrier frequency-division multiple access (SC-FDMA) symbol duration (SC-FDMA) or an orthogonal frequency division multiplexing (OFDM) waveform, a subcarrier spacing of at least 30 kilohertz (kHz) in a frequency domain, and a symbol duration of 0.042 milliseconds (ms) or less in a time domain.

In example 21, the subject matter of example 20, or any of the examples herein, may further include wherein a physical resource block (PRB), corresponding to a signal of the physical channel, includes 12 subcarriers in a frequency domain with 30 kHz or with 60 kHz subcarrier spacing.

In example 22, the subject matter of example 20, or any of the examples herein, may further include wherein a PRB, corresponding to the physical channel, includes 6 subcarriers in frequency domain with 30 kHz subcarrier spacing or 3 subcarriers with 60 kHz subcarrier spacing.

In example 23, the subject matter of example 20, or any of the examples herein, may further include wherein the physical channel corresponds to at least one of: a vehicle-to-vehicle (V2V) communication, a vehicular-to-infrastructure (V2I) communication, or a vehicular-to-pedestrian (V2P) communication.

In example 24, the subject matter of example 20, or any of the examples herein, may further include wherein the physical channel corresponds to at least one of: an LTE sidelink (SL) physical channels, an LTE downlink (DL) physical channels, or an LTE uplink (UL) physical channels.

In example 25, the subject matter of example 20, or any of the examples herein, may further include wherein two PRBs form a PRB pair, of the physical channel, that corresponds to two consecutive PRBs in a time-domain.

In a twenty-sixth example, a communication device may comprise: a means for communicating with other communication devices via a physical channel; and a means for causing the means for communicating to communicate with another communication device via the physical channel, the physical channel including: a single-carrier frequency-division multiple access (SC-FDMA) symbol duration (SC-FDMA) or an orthogonal frequency division multiplexing (OFDM) waveform, a subcarrier spacing of at least 30 kilohertz (kHz) in a frequency domain, and a symbol duration of 0.042 milliseconds (ms) or less in a time domain.

In example 27, the subject matter of example 26, or any of the examples herein, may further include wherein a physical resource block (PRB), corresponding to a signal of the physical channel, includes 12 subcarriers in a frequency domain with 30 kHz or with 60 kHz subcarrier spacing.

In example 28, the subject matter of example 26, or any of the examples herein, may further include wherein a PRB, corresponding to the physical channel, includes 6

subcarriers in frequency domain with 30 kHz subcarrier spacing or 3 subcarriers with 60 kHz subcarrier spacing.

In example 29, the subject matter of example 26, or any of the examples herein, may further include wherein two PRBs form a PRB pair, of the physical channel, that corresponds to two consecutive PRBs in a time-domain.

In the preceding specification, various embodiments have been described with reference to the accompanying drawings. It will, however, be evident that various modifications and changes may be made thereto, and additional embodiments may be implemented, without departing from the broader scope as set forth in the claims that follow. The specification and drawings are accordingly to be regarded in an illustrative rather than restrictive sense.

For example, while series of signals and/or operations have been described with regard to Figs. 3-4, the order of the signals and/or operations may be modified in other embodiments. Further, non-dependent signals may be performed in parallel.

It will be apparent that example aspects, as described above, may be implemented in many different forms of software, firmware, and hardware in the embodiments illustrated in the figures. The actual software code or specialized control hardware used to implement these aspects should not be construed as limiting. Thus, the operation and behavior of the aspects were described without reference to the specific software code--it being understood that software and control hardware could be designed to implement the aspects based on the description herein.

Further, certain portions may be implemented as "logic" that performs one or more functions. This logic may include hardware, such as an application-specific integrated circuit ("ASIC") or a field programmable gate array ("FPGA"), or a combination of hardware and software.

Even though particular combinations of features are recited in the claims and/or disclosed in the specification, these combinations are not intended to be limiting. In fact, many of these features may be combined in ways not specifically recited in the claims and/or disclosed in the specification.

No element, act, or instruction used in the present application should be construed as critical or essential unless explicitly described as such. An instance of the use of the term "and," as used herein, does not necessarily preclude the interpretation that the phrase "and/or" was intended in that instance. Similarly, an instance of the use of the term "or," as used herein, does not necessarily preclude the interpretation that the phrase "and/or" was intended in that instance. Also, as used herein, the article "a" is intended to include one or more items, and may be used

interchangeably with the phrase "one or more." Where only one item is intended, the terms "one," "single," "only," or similar language is used.

Samsung Exhibit 1026, Page 31 of 53

WHAT IS CLAIMED IS:

1. A communication device, comprising:

a radio frequency (RF) circuitry to communicate with other communication devices via a physical channel; and

baseband circuitry to cause the RF circuitry to communicate with another communication device via the physical channel, the physical channel including:

a single-carrier frequency-division multiple access (SC-FDMA) symbol duration (SC-FDMA) or an orthogonal frequency division multiplexing (OFDM) waveform,

a subcarrier spacing of at least 30 kilohertz (kHz) in a frequency domain, and

a symbol duration of 0.042 milliseconds (ms) or less in a time domain.

2. The communication device of claim 1, wherein a physical resource block (PRB), corresponding to a signal of the physical channel, includes 12 subcarriers in a frequency domain with 30 kHz or with 60 kHz subcarrier spacing.

3. The communication device of claim 1, wherein a PRB, corresponding to the physical channel, includes 6 subcarriers in frequency domain with 30 kHz subcarrier spacing or 3 subcarriers with 60 kHz subcarrier spacing.

4. The communication device of claim 1, wherein two PRBs form a PRB pair, of the physical channel, that corresponds to two consecutive PRBs in a time-domain.

5. The communication device of claim 1, wherein the physical channel corresponds to at least one of:

a vehicle-to-vehicle (V2V) communication,

a vehicular-to-infrastructure (V2I) communication, or

a vehicular-to-pedestrian (V2P) communication.

6. The communication device of claim 1, wherein the physical channel corresponds to at least one of:

an long-term evolution (LTE) sidelink (SL) physical channel,

an LTE downlink (DL) physical channel, or

an LTE uplink (UL) physical channel.

7. An apparatus for a wireless communication device, comprising:

a radio (RF) circuitry to communicate with other communication devices via a physical channel; and

a baseband circuitry to:

use a physical channel, from a plurality of physical channel types, that is appropriate for communicating with the other wireless communication devices, the plurality of physical channel types including:

a long-term evolution (LTE) physical channel, and

a V2V physical channel that includes:

a bandwidth that is at least as large as a bandwidth of the LTE physical channel;

a subcarrier spacing that is greater, by a preselected factor, than a subcarrier spacing corresponding to the LTE physical channel,

a fast Fourier transform (FFT) size that is less, by the preselected factor, than an FFT size corresponding to the LTE physical channel,

a symbol duration that is less, by the preselected factor, than a symbol duration corresponding to the LTE physical channel, and

a sampling frequency that is equal to a sampling frequency of the LTE physical channel, and

a sampling time that is equal to a sampling time of the LTE physical channel; and

communicate with the other wireless communication devices via the V2V physical channel.

8. The apparatus of claim 7, wherein the LTE physical channel and the V2V physical channel correspond to at least one of:

long-term evolution (LTE) sidelink (SL) physical channels,

LTE downlink (DL) physical channels, or

LTE uplink (UL) physical channels.

9. The apparatus of claim 7, wherein the V2V physical channel includes physical resource blocks (PRBs) that each include a number of subcarriers that is less than, or equal to, a number of subcarriers of the PRBs of the LTE physical channel.

10. The apparatus of claim 7, wherein:
the subcarrier spacing for the V2V physical channel is 30 or 60 kilohertz (kHz); and
the subcarrier spacing for the LTE physical channel is 15 kHz.

11. The apparatus of claim 7, wherein, for normal cyclic prefix (CP) conditions and extended CP conditions, a number of resource elements (REs) and a number of single-carrier frequency-division multiple access (SC-FDMA) or orthogonal frequency division multiplexing (OFDM) symbols per a physical resource block (PRB) of the V2V physical channel is equal to the number of REs and a number of SC-FDMA or OFDM symbols per PRB of the LTE physical channel.

12. The apparatus of claim 7, wherein application circuitry is to:
communicate with a user equipment device (UE) of a vehicle via a vehicle-to-vehicle (V2V) connection,
communicate with a UE of a user via a vehicle-to-pedestrian (V2P) connection, or
communicate with a wireless telecommunications network via a vehicle-to-infrastructure (V2I) connection.

13. The apparatus of claim 7, wherein the baseband circuitry uses the type of physical channel that is appropriate for communicating with the other wireless communication device based on at least one of:
a likelihood of communications, between the wireless communication device and the other wireless communication device being subjected to high mobility conditions,
whether the other wireless communication device is capable of communicating via the LTE physical channel or the V2V physical channel,
an availability, of the LTE physical channel or the V2V physical channel, for communicating with the other wireless communication device,
a measure of importance regarding information that will be communicated to the other wireless communication device, or

a preselected priority for communicating via the LTE physical channel or the V2V physical channel.

14. The apparatus of claim 7, wherein the baseband circuitry is configured, by via an eNB, to use the V2V physical channel or the LTE physical channel.

15. The apparatus of claim 7, wherein the baseband circuitry uses time-division multiplexing of the V2V physical channel and the LTE physical channel to communicate in different subframes.

16. The apparatus of either of claims 15, wherein subframes for the V2V physical channel and the LTE physical channel are semi-statically configured by an eNB.

17. A wireless communication device as in claims 1 or 7, wherein a physical resource block (PRB), corresponding to the vehicle-to-vehicle (V2V) physical channel, includes:

7 consecutive single-carrier frequency-division multiple access (SC-FDMA) or orthogonal frequency division multiplexing (OFDM) symbols in time domain under normal cyclic prefix (CP) conditions, and

6 consecutive SC-FDMA or OFDM symbols in time domain under extended CP conditions.

18. The wireless communication device of claim 17, wherein:

a subframe, corresponding to the V2V physical channel, includes two slots,

a physical resource block (PRB), corresponding to the V2V physical channel, contains one slot; and

a subframe duration, corresponding to the V2V physical channel, is equal to at least one of:

0.5 milliseconds (ms) and a slot duration is 0.25 ms when subcarrier spacing for the V2V physical channel is 30 kilohertz (kHz); or

0.25 milliseconds (ms) and a slot duration is 0.125 ms when subcarrier spacing for the V2V physical channel is 60 kilohertz (kHz).

19. The wireless communication device of claim 17, wherein:

a subframe duration, corresponding to the vehicle-to-vehicle (V2V) physical

channel, is equal to 1.0 ms, and

the subframe, corresponding to the V2V physical channel, includes four slots with 0.25 ms duration and a physical resource block (PRB), corresponding to the V2V physical channel, contains two slots when subcarrier spacing for the V2V physical channel is 30 kilohertz (kHz), or

the subframe, corresponding to the V2V physical channel, includes eight slots with 0.125 ms duration and a physical resource block (PRB), corresponding to the V2V physical channel, contains four slots when subcarrier spacing for the V2V physical channel is 60 kHz.

20. A computer readable medium containing program instructions for causing one or more processors to:

communicate with other communication devices via a physical channel, the physical channel including:

a single-carrier frequency-division multiple access (SC-FDMA) symbol duration (SC-FDMA) or an orthogonal frequency division multiplexing (OFDM) waveform,

a subcarrier spacing of at least 30 kilohertz (kHz) in a frequency domain, and

a symbol duration of 0.042 milliseconds (ms) or less in a time domain.

21. The computer readable medium of claim 20, wherein a physical resource block (PRB), corresponding to a signal of the physical channel, includes 12 subcarriers in a frequency domain with 30 kHz or with 60 kHz subcarrier spacing.

22. The computer readable medium of claim 20, wherein a PRB, corresponding to the physical channel, includes 6 subcarriers in frequency domain with 30 kHz subcarrier spacing or 3 subcarriers with 60 kHz subcarrier spacing.

23. The computer readable medium of claim 20, wherein the physical channel corresponds to at least one of:

a vehicle-to-vehicle (V2V) communication,

a vehicular-to-infrastructure (V2I) communication, or

a vehicular-to-pedestrian (V2P) communication.

24. The computer readable medium of claim 20, wherein the physical channel corresponds to at least one of:

an long-term evolution (LTE) sidelink (SL) physical channel,

an LTE downlink (DL) physical channel, or

an LTE uplink (UL) physical channel.

25. The computer readable medium of claim 20, wherein a PRB pair, of the physical channel, corresponds to two consecutive PRBs in a time-domain.

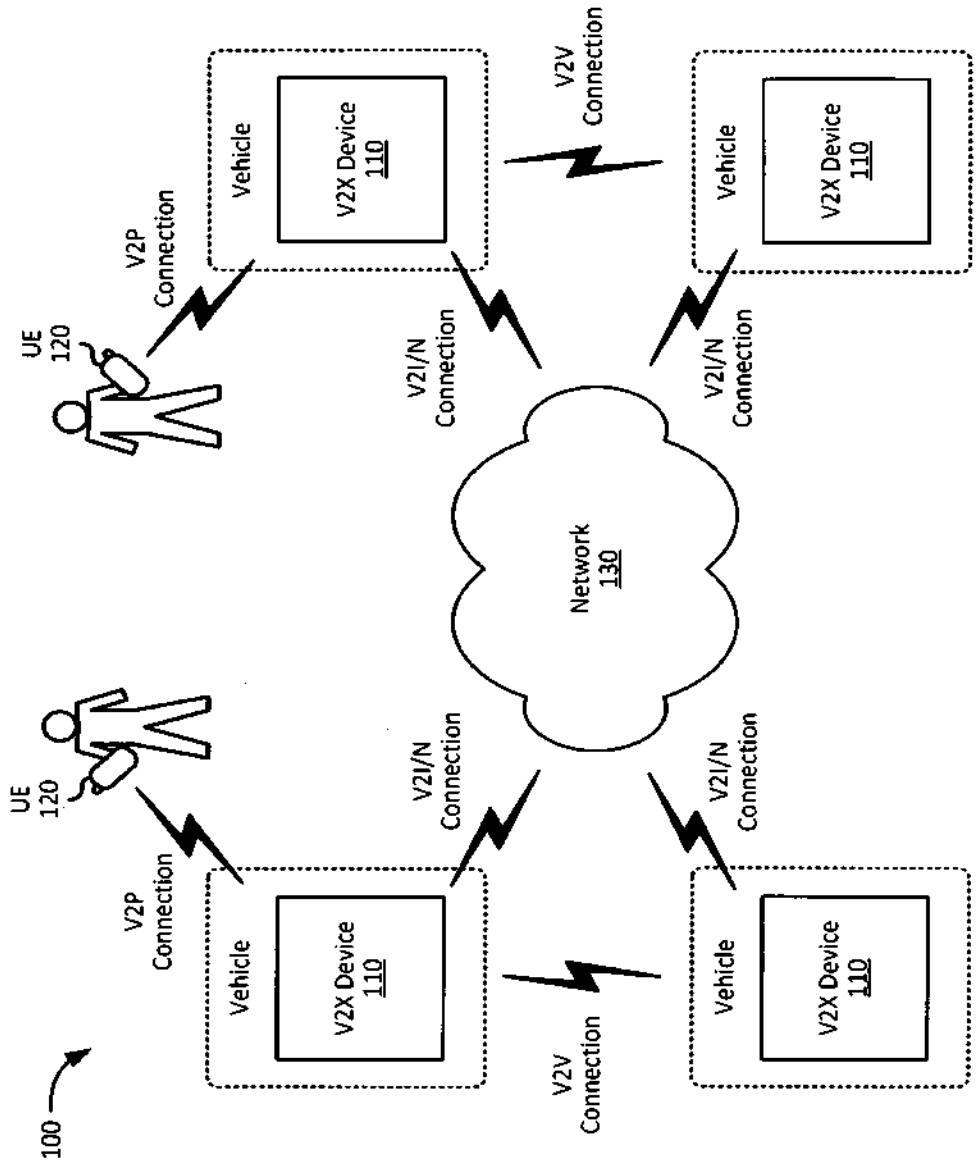

100
UE 120
UE 120
V2P Connection
V2P Connection
Vehicle
V2X Device 110
Vehicle
V2X Device 110
Vehicle
V2X Device 110
Vehicle
V2X Device 110
V2V Connection
V2V Connection
V2I/N Connection
V2I/N Connection
V2I/N Connection
V2I/N Connection
Network 130

Fig. 1

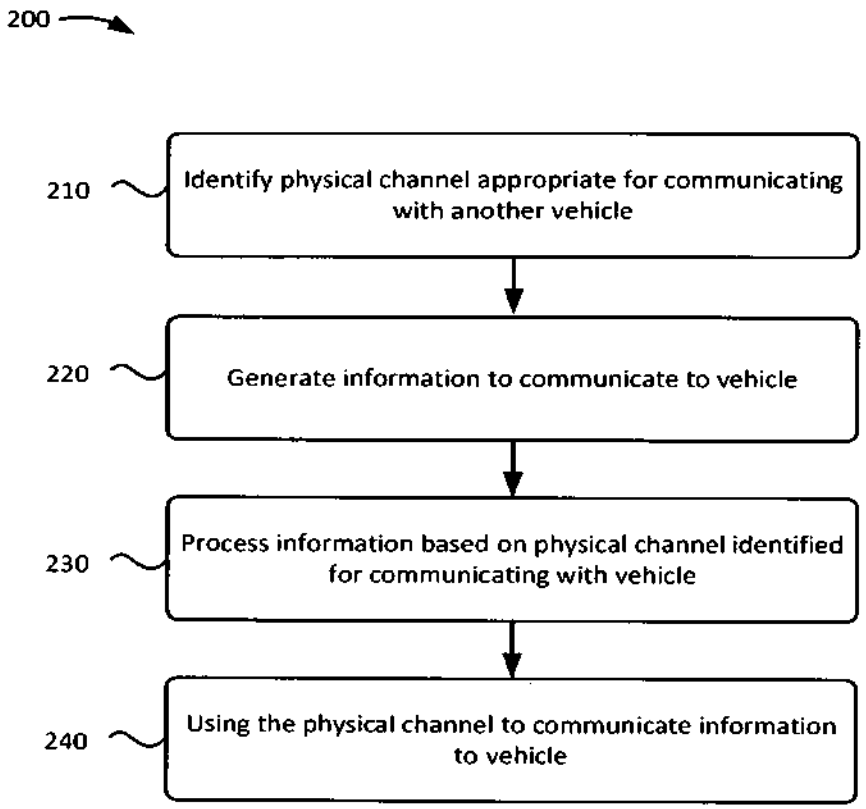

200
210
Identify physical channel appropriate for communicating with another vehicle
220
Generate information to communicate to vehicle
230
Process information based on physical channel identified for communicating with vehicle
240
Using the physical channel to communicate information to vehicle

Fig. 2

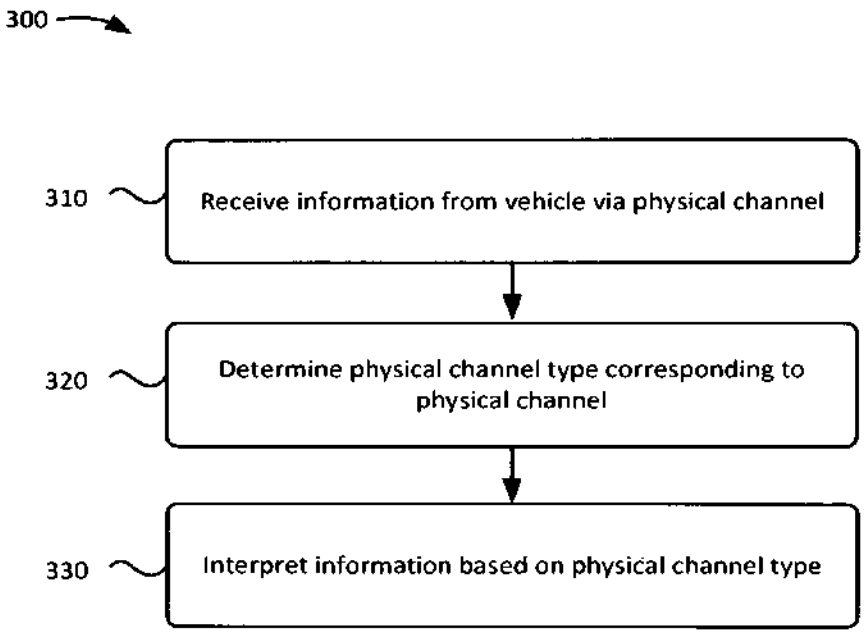

300
310
Receive information from vehicle via physical channel
320
Determine physical channel type corresponding to physical channel
330
Interpret information based on physical channel type

Fig. 3

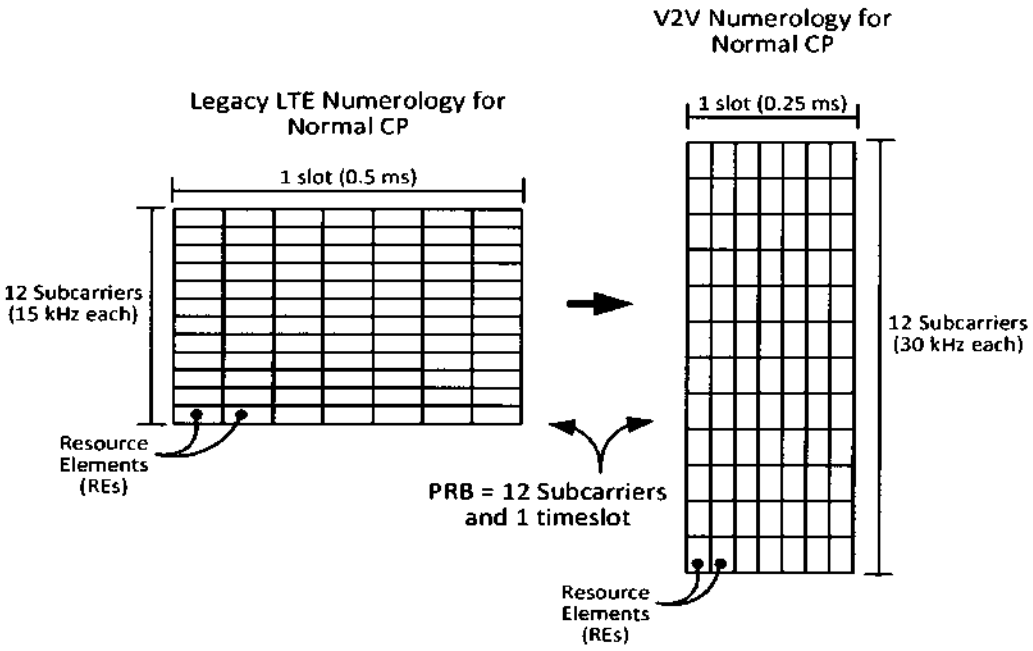

V2V Numerology for Normal CP
Legacy LTE Numerology for Normal CP
1 slot (0.25 ms)
1 slot (0.5 ms)
12 Subcarriers (15 kHz each)
12 Subcarriers (30 kHz each)
Resource Elements (REs)
PRB = 12 Subcarriers and 1 timeslot
Resource Elements (REs)

Fig. 4

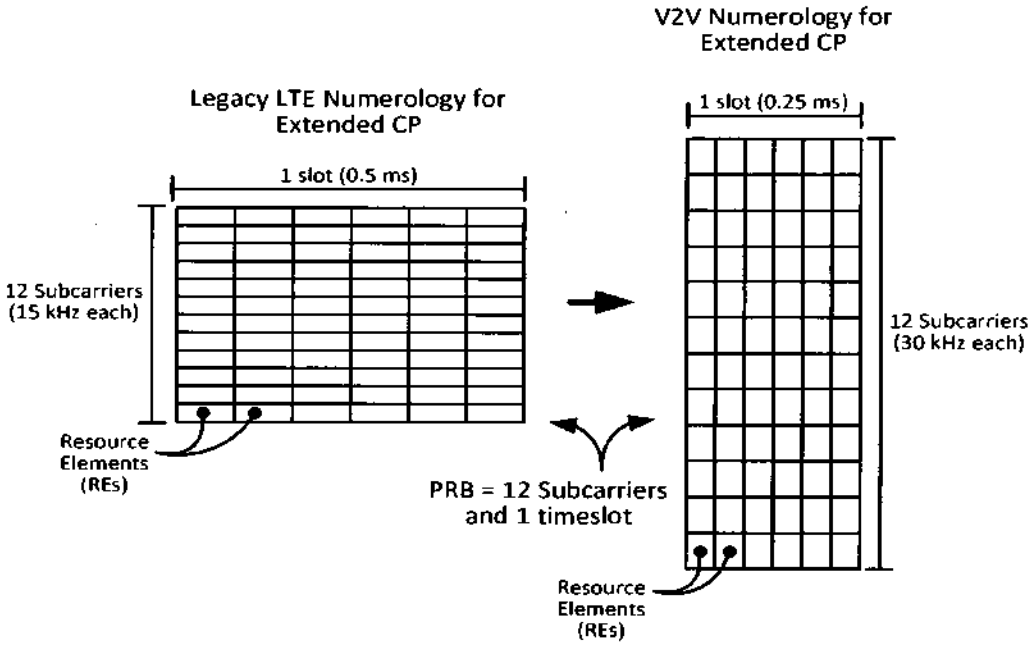

V2V Numerology for Extended CP
Legacy LTE Numerology for Extended CP
1 slot (0.25 ms)
1 slot (0.5 ms)
12 Subcarriers (15 kHz each)
12 Subcarriers (30 kHz each)
Resource Elements (REs)
PRB = 12 Subcarriers and 1 timeslot
Resource Elements (REs)

Fig. 5

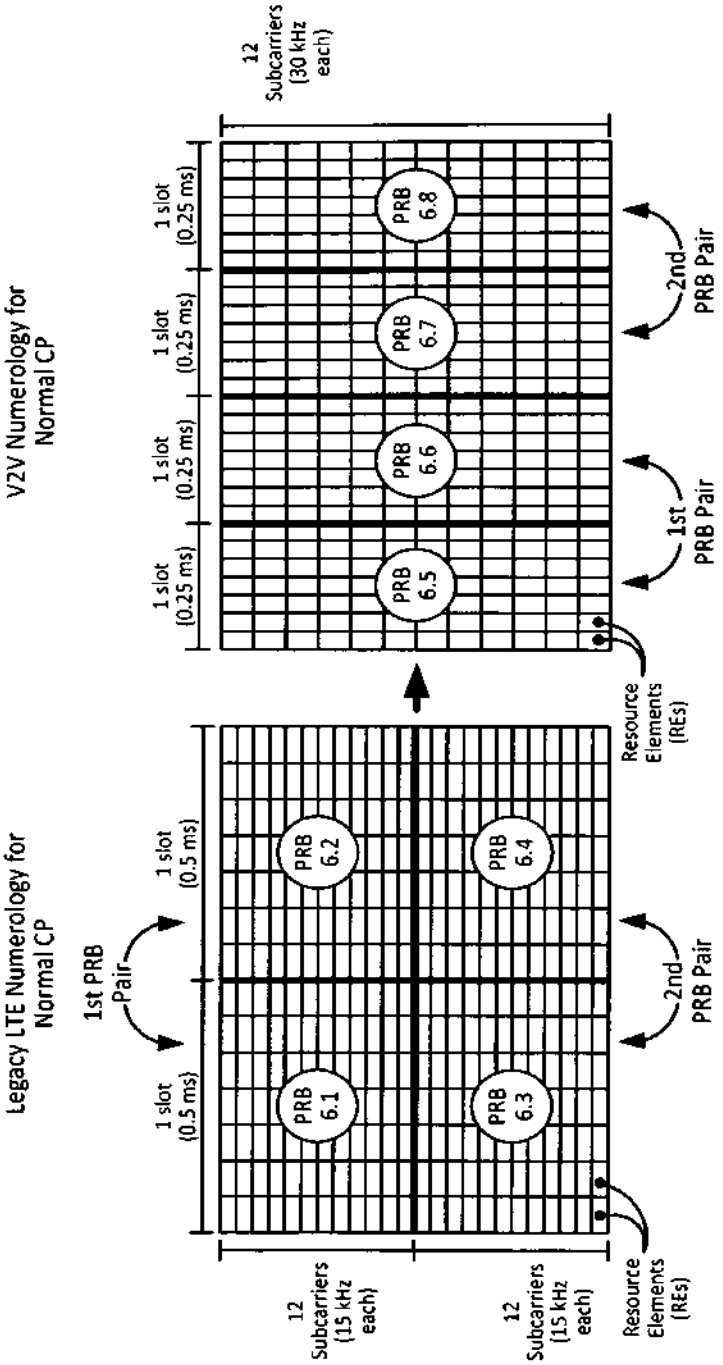

V2V Numerology for Normal CP
12 Subcarriers (30 kHz each)
1 slot (0.25 ms)
1 slot (0.25 ms)
1 slot (0.25 ms)
1 slot (0.25 ms)
PRB 6.5
PRB 6.6
PRB 6.7
PRB 6.8
1st PRB Pair
2nd PRB Pair
Resource Elements (REs)
Legacy LTE Numerology for Normal CP
1st PRB Pair
1 slot (0.5 ms)
1 slot (0.5 ms)
PRB 6.1
PRB 6.2
PRB 6.3
PRB 6.4
2nd PRB Pair
12 Subcarriers (15 kHz each)
12 Subcarriers (15 kHz each)
Resource Elements (REs)

Fig. 6

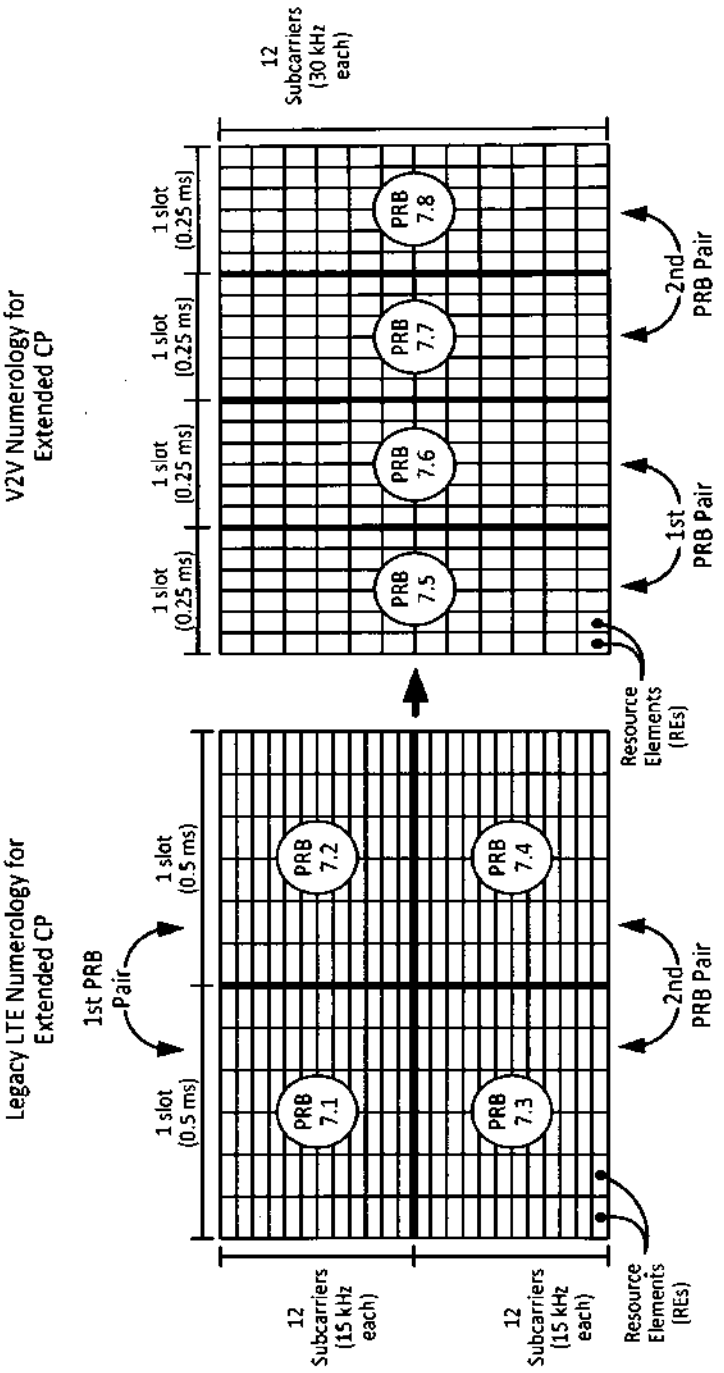

Legacy LTE Numerology for Extended CP
1st PRB Pair
1 slot (0.5 ms)
1 slot (0.5 ms)
PRB 7.1
PRB 7.2
PRB 7.3
PRB 7.4
2nd PRB Pair
12 Subcarriers (15 kHz each)
12 Subcarriers (15 kHz each)
Resource Elements (REs)
V2V Numerology for Extended CP
1 slot (0.25 ms)
1 slot (0.25 ms)
1 slot (0.25 ms)
1 slot (0.25 ms)
PRB 7.5
PRB 7.6
PRB 7.7
PRB 7.8
1st PRB Pair
2nd PRB Pair
12 Subcarriers (30 kHz each)
Resource Elements (REs)

Fig. 7

V2V Numerology for Normal CP

1 PRB = 12 Frequency REs and 1 timeslot

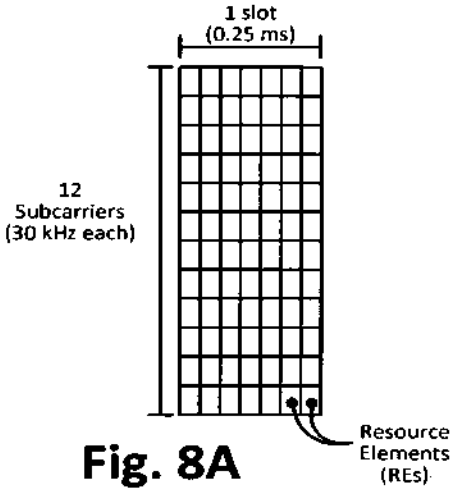


Fig. 8A

1 PRB Pair = 12 Frequency REs and 2 timeslots

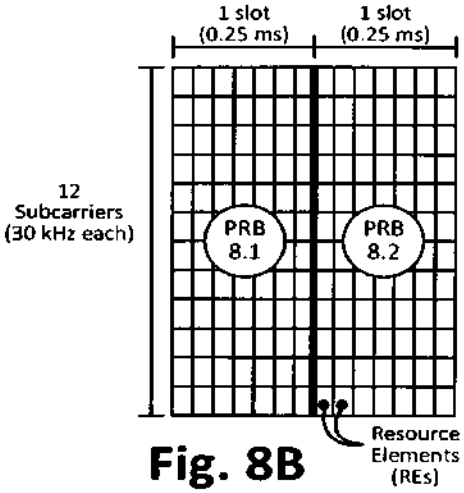


Fig. 8B

1 PRB = 6 Frequency REs and 1 timeslot

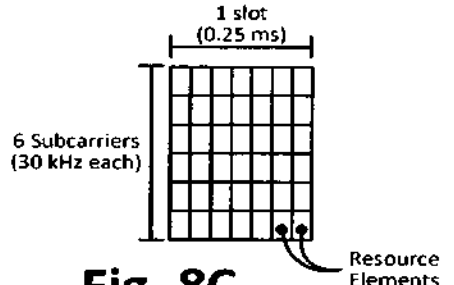


Fig. 8C

1 PRB Pair = 6 Frequency REs and 2 timeslots

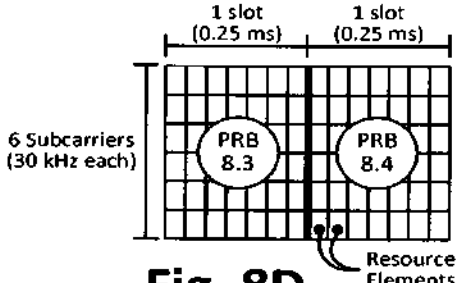


Fig. 8D

V2V Numerology for Extended CP

1 PRB = 12 Frequency Res and 1 timeslot

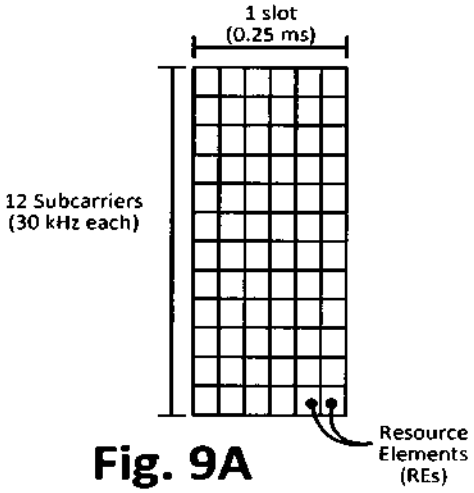


Fig. 9A

1 PRB Pair = 12 Frequency Res and 2 timeslots

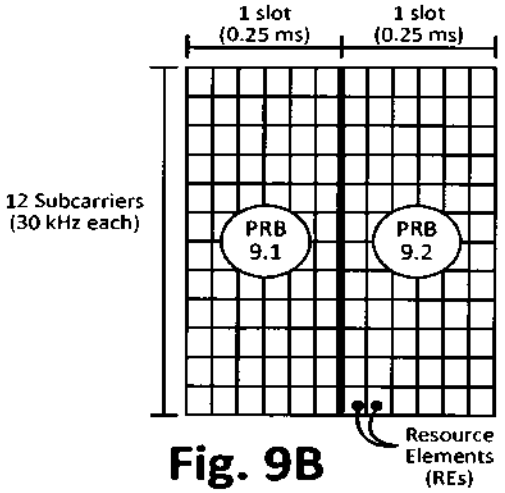


Fig. 9B

1 PRB = 6 Frequency REs and 1 timeslot

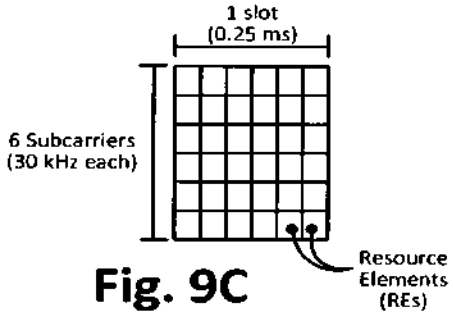


Fig. 9C

1 PRB Pair = 6 Frequency REs and 2 timeslots

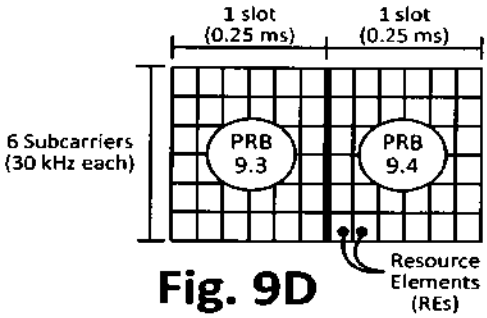


Fig. 9D

Channel Characteristic	Legacy LTE Channel Numerology	V2V Channel Numerology
Subcarrier Spacing	15 kHz	30 kHz
Supported Bandwidths	1.4, 3, 5, 10, 15, and 20 MHz	1.4, 3, 5, 10, 15, and 20 MHz
FFT Size	128, 256, 512, 1024, 1536, and 2048 MHz	64, 128, 256, 512, 768, and 1024 MHz
Sampling Time (Ts)	32.55 ns	32.55 ns
Symbol Duration (OFDM / SC-FDMA)	Normal CP, symbol 0: {(160+2048) x Ts) Normal CP, symbols 1-6: {(144+2048) x Ts) Extended CP: {(512+2048) x Ts)	Normal CP, symbol 0: {(160+2048) x Ts)/2 Normal CP, symbols 1-6: {(144+2048) x Ts)/2 Extended CP: {(512+2048) x Ts)/2
Single Timeslot Duration	0.5 ms (7 symbols for Normal CP) (6 symbols for Extended CP)	0.25 ms (7 symbols for Normal CP) (6 symbols for Extended CP
Single Subframe Duration	1.0 ms	0.5 or 1.0 ms
Subcarriers per PRB (Frequency REs)	12 subcarriers per PRB	6 or 12 subcarriers per PRB

Fig. 10

Channel Characteristic	Legacy LTE Channel Numerology	V2V Channel Numerology
Subcarrier Spacing	15 kHz	60 kHz
Supported Bandwidths	1.4, 3, 5, 10, 15, and 20 MHz	1.4, 3, 5, 10, 15, and 20 MHz
FFT Size	128, 256, 512, 1024, 1536, and 2048 MHz	64, 128, 256, 512, 768, and 1024 MHz
Sampling Time (Ts)	32.55 ns	32.55 ns
Symbol Duration (OFDM / SC-FDMA)	Normal CP, symbol 0: ((160+2048) x Ts) Normal CP, symbols 1-6: ((144+2048) x Ts) Extended CP: ((512+2048) x Ts)	Normal CP, symbol 0: ((160+2048) x Ts)/4 Normal CP, symbols 1-6: ((144+2048) x Ts)/4 Extended CP: ((512+2048) x Ts)/4
Single Timeslot Duration	0.5 ms (7 symbols for Normal CP) (6 symbols for Extended CP)	0.125 ms (7 symbols for Normal CP) (6 symbols for Extended CP
Single Subframe Duration	1.0 ms	0.5 or 1.0 ms
Subcarriers per PRB (Frequency REs)	12 subcarriers per PRB	3, 6, or 12 subcarriers per PRB

Fig. 11

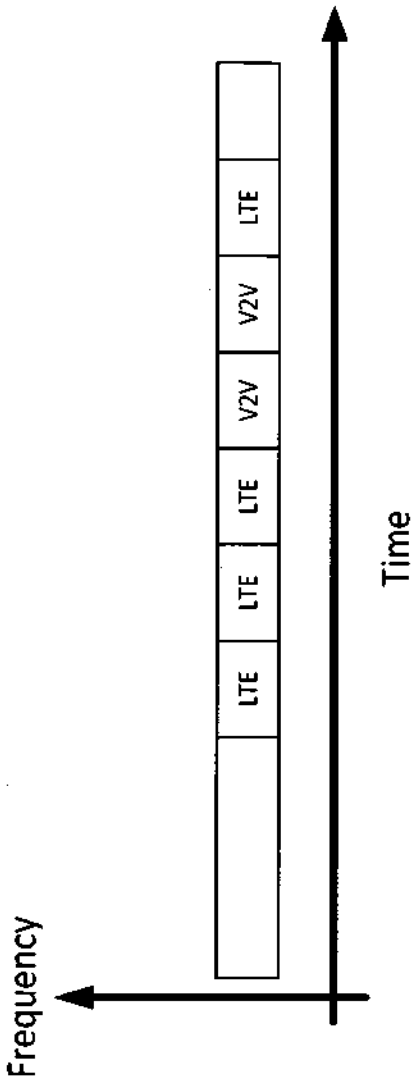


Fig. 12

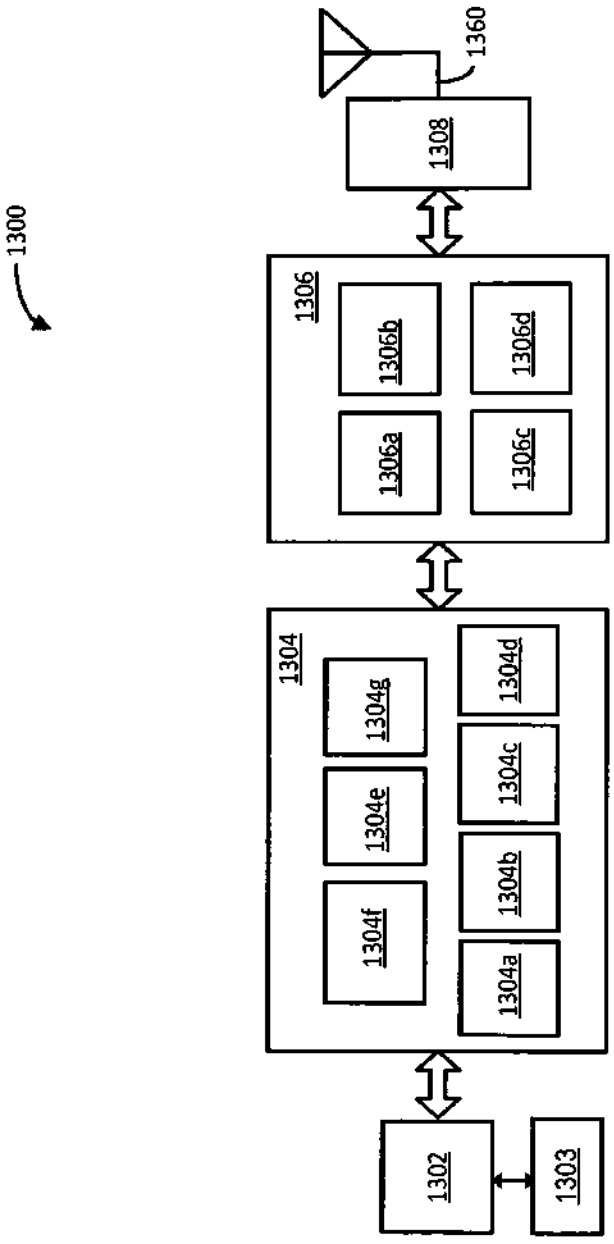

1300
1360
1308
1306
1306b
1306d
1306a
1306c
1304
1304g
1304d
1304e
1304c
1304f
1304b
1304a
1302
1303

Fig. 13

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/000466

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04L5/00 H04L27/26 H04W88/06 H04W84/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04L H04W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2014/065563 A1 (LG ELECTRONICS INC) 1 May 2014 (2014-05-01) the whole document -& US 2015/282178 A1 (KIM KITAE [KR] ET AL) 1 October 2015 (2015-10-01) paragraph [0010] paragraph [0023] paragraph [0045] - paragraph [0046] paragraph [0061] - paragraph [0065] paragraph [0082] paragraph [0094] paragraph [0110] - paragraph [0111] paragraph [0131] paragraph [0156] paragraph [0166] - paragraph [0177] figures 6,13,18 tables 1,4,6,8 ----- -/--	1-12,14, 17-25

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 April 2016	26/04/2016

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Tanbourgi, Ralph

3

Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2015/180622 A1 (YOO TAESANG [US] ET AL) 25 June 2015 (2015-06-25) paragraph [0007] paragraph [0012] paragraph [0054] - paragraph [0062] paragraph [0068] - paragraph [0080] paragraph [0140] - paragraph [0141] figures 2,3a,3c,8-10,12,13	1-25
A	Erik Dahlman ET AL: "Physical Transmission Resources (Chapter 9)" In: "4G: LTE/LTE-Advanced for Mobile Broadband (second edition) [Kindle Edition]", 7 October 2013 (2013-10-07), Academic Press, XP055167425, ISBN: 978-0-12-419997-2 pages 141-159, the whole document	1-25
A	Deliverable D2: "Document Number: ICT-317669-METIS/D2.4 Project Name: Mobile and wireless communications Enablers for the Twenty-twenty Information Society (METIS)", , 28 February 2015 (2015-02-28), XP055248907, Retrieved from the Internet: URL:https://www.metis2020.com/wp-content/uploads/deliverables/METIS_D2.4_v1.pdf [retrieved on 2016-02-10] Chapters 3 and 6	1-25

3

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2015/000466

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2014065563 A1	01-05-2014	CN 104854801 A	19-08-2015
		EP 2911321 A1	26-08-2015
		KR 20150091470 A	11-08-2015
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		WO 2014065563 A1	01-05-2014
US 2015282178 A1	01-10-2015	CN 104854801 A	19-08-2015
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Espacenet

CN108923896A Method for paging in user equipment, method for paging in base station, user equipment for paging and base station equipment for paging

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Method for paging in user equipment, method for paging in base station, user equipment for paging and base station equipment for paging

Abstract

The invention discloses a method for paging in user equipment, a method for paging in a base station, the user equipment for paging and base station equipment for paging. The user equipment first monitors first signaling in X time intervals respectively, and then receives a first radio signal. The X is a positive integer. The first signaling is used for determining scheduling information for the first radio signal. The scheduling information comprises at least one of {an occupied time-frequency resource, an employed MCS (Modulation Coding Scheme), and subcarrier spacing of subcarriers in an occupied frequency domain resource}. The first radio signal carries a paging message. The frequency domain resource for transmitting the first signaling belongs to a first subband. The first subband comprises a positive integer number of consecutive subcarriers in a frequency domain. At least one of {a location of the first subband in the frequency domain, and subcarrier spacing of the subcarriers included in the first subband} is used for determining the X time intervals. According to the methods, the user equipment and the base station equipment, paging capacity is kept, and moreover, power consumption of the user equipment is reduced.

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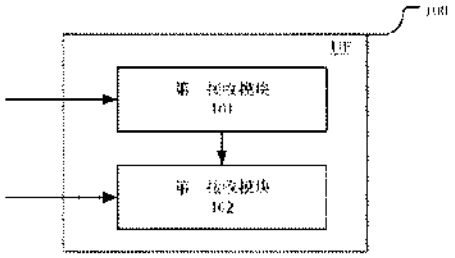
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(54) 发明名称

一种被用于寻呼的用户设备、基站中的方法和装置

(57) 摘要

本发明公开了一种被用于寻呼的用户设备、基站中的方法和装置。用户设备首先在X个时间间隔中分别监测第一信令，接着接收第一无线信号。其中，所述X是正整数，所述第一信令被用于确定所述第一无线信号的调度信息，所述调度信息包括所占用的时频资源，所采用的MCS，所占用的频域资源中的子载波的子载波间隔中至少之一，所述第一无线信号携带寻呼消息。传输所述第一信令所使用的频域资源属于第一子频带，所述第一子频带在频域包括正整数个连续的子载波，所述第一子频带在频域的位置，所述第一子频带中所包括的子载波的子载波间隔中至少之一被用于确定所述X个时间间隔。本发明可以在保持寻呼容量的同时降低用户设备功率消耗。



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1.一种用于寻呼的用户设备中的方法，其特征在于，包括如下步骤：

-步骤A.在X个时间间隔中分别监测第一信令；

-步骤B.接收第一无线信号；

其中，所述X是正整数，所述第一信令被用于确定所述第一无线信号的调度信息，所述调度信息包括所占用的时频资源、所采用的MCS中至少之一，所述第一无线信号携带寻呼消息；传输所述第一信令所使用的频域资源属于第一子频带，所述第一子频带在频域包括正整数个连续的子载波，所述第一子频带在频域的位置和所述第一子频带中所包括的子载波的子载波间隔被用于确定所述X个时间间隔。

2.根据权利要求1所述的方法，其特征在于，所述X个时间间隔中的任意一个时间间隔在时域都属于第一时间窗，所述第一时间窗的时间长度是预定义的，所述第一时间窗被分成Y个时间间隔，所述X个时间间隔是所述Y个时间间隔中的X个，所述Y是不小于X的正整数，所述第一子频带中所包括的子载波的子载波间隔被用于确定所述Y，所述第一信令的监测者的特征ID被用于在所述Y个时间间隔中确定所述X个时间间隔。

3.根据权利要求2所述的方法，其特征在于，所述第一时间窗属于Z个时间窗中之一，所述Z是大于1的整数；所述Z是预定义的；或者所述Z是可配置的；所述Z个时间窗中的任意两个时间窗的时间长度是相等的，所述第一信令的监测者的特征ID被用于在所述Z个时间窗中确定所述第一时间窗。

4.根据权利要求1至3中任一权利要求所述的方法，其特征在于，所述步骤A还包括如下步骤：

-步骤A0.接收第二无线信号；

其中，所述第二无线信号被用于确定所述第一子频带在频域的位置、所述第一子频带中所包括的子载波的子载波间隔中至少之一。

5.根据权利要求1至3中任一权利要求所述的方法，其特征在于，所述步骤A还包括如下步骤：

-步骤A1.接收第二信令；

其中，所述第二信令被用于确定Q个子频带，所述第一子频带属于所述Q个子频带中之一，所述Q个子频带中的任意一个子频带包括正整数个连续的子载波，所述第一信令的监测者的特征ID被用于在所述Q个子频带中确定所述第一子频带，所述Q是正整数。

6.根据权利要求4所述的方法，其特征在于，所述步骤A还包括如下步骤：

步骤A1.接收第二信令；

其中，所述第二信令被用于确定Q个子频带，所述第一子频带属于所述Q个子频带中之一，所述Q个子频带中的任意一个子频带包括正整数个连续的子载波，所述第一信令的监测者的特征ID被用于在所述Q个子频带中确定所述第一子频带，所述Q是正整数。

7.一种用于寻呼的基站中的方法，其特征在于，包括如下步骤：

-步骤A.在X个时间间隔中的正整数个时间间隔中分别发送第一信令；

-步骤B.发送第一无线信号；

其中，所述X是正整数，所述第一信令被用于确定所述第一无线信号的调度信息，所述调度信息包括所占用的时频资源、所采用的MCS中至少之一，所述第一无线信号携带寻呼消息；传输所述第一信令所使用的频域资源属于第一子频带，所述第一子频带在频域包括正

整数个连续的子载波，所述第一子频带在频域的位置和所述第一子频带中所包括的子载波的子载波间隔被用于确定所述X个时间间隔。

8.根据权利要求7所述的方法，其特征在于，所述X个时间间隔中的任意一个时间间隔在时域都属于第一时间窗，所述第一时间窗的时间长度是预定义的，所述第一时间窗被分成Y个时间间隔，所述X个时间间隔是所述Y个时间间隔中的X个，所述Y是不小于X的正整数，所述第一子频带中所包括的子载波的子载波间隔被用于确定所述Y，所述第一信令的监测者的特征ID被用于在所述Y个时间间隔中确定所述X个时间间隔。

9.根据权利要求8所述的方法，其特征在于，所述第一时间窗属于Z个时间窗中之一，所述Z是大于1的整数；所述Z是预定义的；或者所述Z是可配置的；所述Z个时间窗中的任意两个时间窗的时间长度是相等的，所述第一信令的监测者的特征ID被用于在所述Z个时间窗中确定所述第一时间窗。

10.根据权利要求7至9中任一权利要求所述的方法，其特征在于，所述步骤A还包括如下步骤：

-步骤A0.发送第二无线信号；

其中，所述第二无线信号被用于确定所述第一子频带在频域的位置、所述第一子频带中所包括的子载波的子载波间隔中至少之一。

11.根据权利要求7至9中任一权利要求所述的方法，其特征在于，所述步骤A还包括如下步骤：

-步骤A1.发送第二信令；

其中，所述第二信令被用于确定Q个子频带，所述第一子频带属于所述Q个子频带中之一，所述Q个子频带中的任意一个子频带包括正整数个连续的子载波，所述第一信令的监测者的特征ID被用于在所述Q个子频带中确定所述第一子频带，所述Q是正整数。

12.根据权利要求10所述的方法，其特征在于，所述步骤A还包括如下步骤：

-步骤A1.发送第二信令；

其中，所述第二信令被用于确定Q个子频带，所述第一子频带属于所述Q个子频带中之一，所述Q个子频带中的任意一个子频带包括正整数个连续的子载波，所述第一信令的监测者的特征ID被用于在所述Q个子频带中确定所述第一子频带，所述Q是正整数。

13.一种用于寻呼的用户设备，其特征在于，包括如下模块：

-第一接收模块：用于在X个时间间隔中分别监测第一信令；

-第二接收模块：用于接收第一无线信号；

其中，所述X是正整数，所述第一信令被用于确定所述第一无线信号的调度信息，所述调度信息包括所占用的时频资源、所采用的MCS中至少之一，所述第一无线信号携带寻呼消息；传输所述第一信令所使用的频域资源属于第一子频带，所述第一子频带在频域包括正整数个连续的子载波，所述第一子频带在频域的位置和所述第一子频带中所包括的子载波的子载波间隔被用于确定所述X个时间间隔。

14.根据权利要求13所述的用户设备，其特征在于，所述X个时间间隔中的任意一个时间间隔在时域都属于第一时间窗，所述第一时间窗的时间长度是预定义的，所述第一时间窗被分成Y个时间间隔，所述X个时间间隔是所述Y个时间间隔中的X个，所述Y是不小于X的正整数，所述第一子频带中所包括的子载波的子载波间隔被用于确定所述Y，所述第一信令

的监测者的特征ID被用于在所述Y个时间间隔中确定所述X个时间间隔。

15.根据权利要求14所述的用户设备，其特征在于，所述第一时间窗属于Z个时间窗中之一，所述Z是大于1的整数；所述Z是预定义的；或者所述Z是可配置的；所述Z个时间窗中的任意两个时间窗的时间长度是相等的，所述第一信令的监测者的特征ID被用于在所述Z个时间窗中确定所述第一时间窗。

16.根据权利要求13至15中任一权利要求所述的用户设备，其特征在于，所述第一接收模块还被用于接收第二无线信号；所述第二无线信号被用于确定所述第一子频带在频域的位置、所述第一子频带中所包括的子载波的子载波间隔中至少之一。

17.根据权利要求13至15中任一权利要求所述的用户设备，其特征在于，所述第一接收模块还被用于接收第二信令所述第二信令被用于确定Q个子频带，所述第一子频带属于所述Q个子频带中之一，所述Q个子频带中的任意一个子频带包括正整数个连续的子载波，所述第一信令的监测者的特征ID被用于在所述Q个子频带中确定所述第一子频带，所述Q是正整数。

18.根据权利要求16所述的用户设备，其特征在于，所述第一接收模块还被用于接收第二信令所述第二信令被用于确定Q个子频带，所述第一子频带属于所述Q个子频带中之一，所述Q个子频带中的任意一个子频带包括正整数个连续的子载波，所述第一信令的监测者的特征ID被用于在所述Q个子频带中确定所述第一子频带，所述Q是正整数。

19.一种用于寻呼的基站设备，其特征在于，包括如下模块：

-第一发送模块：用于在X个时间间隔中的正整数个时间间隔中分别发送第一信令；

第二发送模块：用于发送第一无线信号；

其中，所述X是正整数，所述第一信令被用于确定所述第一无线信号的调度信息，所述调度信息包括所占用的时频资源、所采用的MCS中至少之一，所述第一无线信号携带寻呼消息；传输所述第一信令所使用的频域资源属于第一子频带，所述第一子频带在频域包括正整数个连续的子载波，所述第一子频带在频域的位置和所述第一子频带中所包括的子载波的子载波间隔被用于确定所述X个时间间隔。

20.根据权利要求19所述的基站设备，其特征在于，所述X个时间间隔中的任意一个时间间隔在时域都属于第一时间窗，所述第一时间窗的时间长度是预定义的，所述第一时间窗被分成Y个时间间隔，所述X个时间间隔是所述Y个时间间隔中的X个，所述Y是不小于X的正整数，所述第一子频带中所包括的子载波的子载波间隔被用于确定所述Y，所述第一信令的监测者的特征ID被用于在所述Y个时间间隔中确定所述X个时间间隔。

21.根据权利要求20所述的基站设备，其特征在于，所述第一时间窗属于Z个时间窗中之一，所述Z是大于1的整数；所述Z是预定义的；或者所述Z是可配置的；所述Z个时间窗中的任意两个时间窗的时间长度是相等的，所述第一信令的监测者的特征ID被用于在所述Z个时间窗中确定所述第一时间窗。

22.根据权利要求19至21中任一权利要求所述的基站设备，其特征在于，所述第一发送模块还被用于发送第二无线信号；所述第二无线信号被用于确定所述第一子频带在频域的位置、所述第一子频带中所包括的子载波的子载波间隔中至少之一。

23.根据权利要求19至21中任一权利要求所述的基站设备，其特征在于，所述第一发送模块还被用于发送第二信令；所述第二信令被用于确定Q个子频带，所述第一子频带属于所

述Q个子频带中之一，所述Q个子频带中的任意一个子频带包括正整数个连续的子载波，所述第一信令的监测者的特征ID被用于在所述Q个子频带中确定所述第一子频带，所述Q是正整数。

24.根据权利要求22所述的基站设备，其特征在于，所述第一发送模块还被用于发送第二信令；所述第二信令被用于确定Q个子频带，所述第一子频带属于所述Q个子频带中之一，所述Q个子频带中的任意一个子频带包括正整数个连续的子载波，所述第一信令的监测者的特征ID被用于在所述Q个子频带中确定所述第一子频带，所述Q是正整数。

一种被用于寻呼的用户设备、基站中的方法和装置

技术领域

[0001] 本申请涉及无线通信系统中的传输方案，特别是涉及支持多种数理结构(Numerology)的通信系统中的寻呼传输的方法和装置。

背景技术

[0002] 未来无线通信系统的应用场景越来越多元化，不同的应用场景对系统提出了不同的性能要求。为了满足多种应用场景的不同的性能需求，在3GPP(3rd Generation Partner Project，第三代合作伙伴项目)RAN(Radio Access Network，无线接入网)#72次全会上决定对新空口技术(NR，New Radio)进行研究。在3GPP RAN#75次全会上通过了5G新空口技术(NR)的工作项目(WI，Working Item)的立项，开始对5G新空口技术进行标准化。

[0003] 为了能够灵活适应多种不同的应用场景，未来的无线通信系统，特别是5G NR将可以支持多种数理结构(Numerology)，多种数理结构是指多种子载波间隔，多种符号时间长度，多种CP(Cyclic Prefix，循环前缀)长度等。为了能够简化系统的设计与用户设备实现的复杂度，针对不同的数理结构，整个系统物理层设计最好能够采用一种统一结构。

发明内容

[0004] 在现有LTE系统中，寻呼的传输时机统一通过PF(Paging Frame，寻呼帧)和PO(Paging Occasion，寻呼机会)来定义，其中PF为有可能传输寻呼消息的无线帧，而PO用来确定在PF的帧中有可能传输寻呼消息的子帧。LTE中的无线帧的时间长度为固定的10毫秒，子帧的时间长度为固定的1毫秒。由于一个LTE网络一般采用单一的数理结构(Numerology)或者数理结构在一个网络中基本长时间不变，采用固定时长的PF和PO来定义寻呼的可能时间可以在保证寻呼容量和不增加用户设备(UE，User Equipment)功率消耗的前提下，简化系统设计。在5G NR下，由于支持不同的数理结构，在一个给定的时长内，比如1毫秒，可能包含了多个基本的调度单元(比如时隙，Slot)，如果沿用现有的寻呼时机的设计，在这个1毫秒内用户设备针对不同的数理结构要对寻呼消息进行不同次数的检测，因而导致在某些数理结构下的功率消耗的大大增加。同时也会导致寻呼容量因为不同的数理结构的采用而相差巨大。

[0005] 为了解决上述在5G NR中当采用多种数理结构(Numerology)时的寻呼的设计问题，本申请提供了解决方案。该方案依据寻呼所采用的数理结构来确定寻呼的传输时机，从而保证在不同的数理结构下用户设备监测寻呼消息的复杂度和功耗相差不大，同时寻呼的容量也保持基本不变。需要说明的是，在不冲突的情况下，本申请的UE(User Equipment，用户设备)中的实施例和实施例中的特征可以应用到基站中，反之亦然。进一步的，在不冲突的情况下，本申请的实施例和实施例中的特征可以任意相互组合。

[0006] 本申请公开了一种用于寻呼的用户设备中的方法，其中，包括如下步骤：

[0007] -步骤A.在X个时间间隔中分别监测第一信令；

[0008] -步骤B.接收第一无线信号。

[0009] 其中，所述X是正整数，所述第一信令被用于确定所述第一无线信号的调度信息，所述调度信息包括{所占用的时频资源，所采用的MCS，所占用的频域资源中的子载波的子载波间隔}中至少之一，所述第一无线信号携带寻呼消息。传输所述第一信令所使用的频域资源属于第一子频带，所述第一子频带在频域包括正整数个连续的子载波，{所述第一子频带在频域的位置，所述第一子频带中所包括的子载波的子载波间隔}中至少之一被用于确定所述X个时间间隔。

[0010] 作为一个实施例，采用所述方法，所述用于设备可以依据传输寻呼所采用的子载波间隔来确定监测传输寻呼的时间间隔，节省功耗。

[0011] 作为一个实施例，所述方法设计了基于不同的子载波间隔的一致的寻呼时机的计算方式，同时当采用不同的子载波间隔传输寻呼消息时，保持寻呼容量不变。

[0012] 作为一个实施例，所述寻呼消息包括被寻呼的用户设备的特征ID。

[0013] 作为一个实施例，在所述X个时间间隔中的每一个时间间隔中针对所述第一信令最多执行P次检测，所述P是正整数。

[0014] 作为一个实施例，所述X个时间间隔中的任意两个时间间隔的时间长度相等。

[0015] 作为一个实施例，所述X个时间间隔中存在两个时间间隔的时间长度不等。

[0016] 作为一个实施例，所述X个时间间隔中的任意一个时间间隔为一个时隙(Slot)。

[0017] 作为一个实施例，所述X个时间间隔中的任意两个时间间隔的时间长度相等，所述X个时间间隔中的每个时间间隔的时间长度和所述第一频带中所包括的子载波的子载波间隔有关。

[0018] 作为一个实施例，所述X个时间间隔中的任意一个时间间隔为M个OFDM(Orthogonal Frequency Division Multiplexing，正交频分复用)符号，所述M为小于14的正整数。

[0019] 作为一个实施例，所述X个时间间隔中的任意一个时间间隔为M个OFDM(Orthogonal Frequency Division Multiplexing，正交频分复用)符号，所述M为小于7的正整数。

[0020] 作为一个实施例，所述X个时间间隔中的任意两个时间间隔在时域正交，所述正交是指不存在一个时间单元同时属于所述X个时间间隔中的任意两个时间间隔。

[0021] 作为一个实施例，所述X个时间间隔中存在两个时间间隔在时域是离散的。

[0022] 作为一个实施例，所述第一信令是物理层信令。

[0023] 作为一个实施例，所述第一信令是DCI(Downlink Control Information，下行控制信息)。

[0024] 作为一个实施例，所述第一信令通过PDCCH(Physical Downlink Control Channel，物理下行控制信道)传输。

[0025] 作为一个实施例，所述第一信令通过NR-PDCCH(New Radio Physical Downl ink Control Channel，新空口物理下行控制信道)传输。

[0026] 作为一个实施例，所述第一信令通过PDCCH(Physical Downlink Control Channel，物理下行控制信道)传输，所述PDCCH在CSS(Common Search Space，公共搜索空间)中传输。

[0027] 作为一个实施例，所述第一信令通过PDCCH(Physical Downlink Control

Channel，物理下行控制信道)传输，所述PDCCH在USS(UE-Specific Search Space，UE特定搜索空间)中传输。

[0028] 作为一个实施例，所述第一信令通过PDCCH(Physical Downlink Control Channel，物理下行控制信道)传输，所述PDCCH的CRC(Cyclic Redundancy Check，循环冗余校验)经过P-RNTI(Paging Radio Network Temporary Identity，寻呼无线网络临时标识)加扰。

[0029] 作为一个实施例，所述MCS(Modulation Coding Scheme，调制编码方式)包括的调制方式为{QPSK，16QAM，64QAM，256QAM，1024QAM}中之一。

[0030] 作为一个实施例，所述子载波间隔等于15kHz乘以2的K次幂，所述K为整数。

[0031] 作为一个实施例，所述第一子频带(Subband)包括12的正整数倍个子载波。

[0032] 作为一个实施例，所述第一子频带中包括的所有子载波的子载波间隔都相等。

[0033] 作为一个实施例，所述所述第一子频带在频域的位置是指所述第一子频带在所处的载波(Carrier)中的位置。

[0034] 作为一个实施例，所述所述第一子频带在频域的位置是指所述第一子频带在所处的载波(Carrier)在频域的位置。

[0035] 作为一个实施例，所述所述第一子频带在频域的位置是指所述第一子频带在所处的载波(Carrier)中的子频带索引。

[0036] 作为一个实施例，所述所述第一子频带在频域的位置是指所述第一子频带在所处的频带(Band)所对应的频率资源中的位置。

[0037] 作为一个实施例，所述第一子频带在频域的位置，所述第一子频带中所包括的子载波的子载波间隔中至少之一被所述用户设备用于确定所述X个时间间隔。

[0038] 作为一个实施例，所述第一子频带在频域的位置，所述第一子频带中所包括的子载波的子载波间隔中至少之一被所述用户设备基于给定映射规则确定所述X个时间间隔。

[0039] 作为一个实施例，所述第一无线信号通过DL-SCH(Downlink Shared Channel，下行共享信道)传输。

[0040] 作为一个实施例，所述第一无线信号通过PDSCH(Physical Downlink Shared Channel，物理下行共享信道)传输。

[0041] 作为一个实施例，第一比特块依次经过调制映射器(Modulation Mapper)，层映射器(Layer Mapper)，预编码(Precoding)，资源粒子映射器(Resource Element Mapper)，OFDM信号发生(Generation)之后得到所述第一无线信号。所述第一比特块包括一个码块经过信道编码之后的输出。作为一个子实施例，所述码块是TB(Transport Block，传输块)。作为一个子实施例，所述码块是TB(Transport Block，传输块)中的一部分。

[0042] 具体的，根据本申请的一个方面，上述方法的特征在于，所述X个时间间隔中的任意一个时间间隔在时域都属于第一时间窗，所述第一时间窗的时间长度是预定义的，所述第一时间窗被分成Y个时间间隔，所述X个时间间隔是所述Y个时间间隔中的X个，所述Y是不小于X的正整数，所述所述第一子频带中所包括的子载波的子载波间隔被用于确定所述Y，所述第一信令的监测者的特征ID被用于在所述Y个时间间隔中确定所述X个时间间隔。

[0043] 作为一个实施例，所述第一时间窗的时间长度是固定不变的。

[0044] 作为一个实施例，所述第一时间窗中包括正整数个时域连续的多载波符号。作为

一个子实施例，所述多载波符号包括数据符号和CP(Cyclic Prefix，循环前缀)。

[0045] 作为一个实施例，所述所述第一时间窗的时间长度为1毫秒。

[0046] 作为一个实施例，所述所述第一时间窗的时间长度为10毫秒。

[0047] 作为一个实施例，所述第一时间窗为一个子帧(Subframe)。

[0048] 作为一个实施例，所述第一时间窗为一个无线帧(Radio Frame)。

[0049] 作为一个实施例，所述Y个时间间隔中的任意两个时间间隔的时间长度相等。

[0050] 作为一个实施例，所述Y个时间间隔中存在两个时间间隔的时间长度不等。

[0051] 作为一个实施例，所述Y大于所述X。

[0052] 作为一个实施例，所述Y与所述所述第一频带中所包括的子载波的子载波间隔成正比。

[0053] 作为一个实施例，所述所述第一频带中所包括的子载波的子载波间隔被所述用户设备用于确定所述Y。

[0054] 作为一个实施例，所述所述第一频带中所包括的子载波的子载波间隔被所述用户设备基于给定的映射关系确定所述Y。

[0055] 作为一个实施例，所述所述第一信令的监测者的特征ID被所述用户设备用于在所述Y个时间间隔中确定所述X个时间间隔。

[0056] 作为一个实施例，所述所述第一信令的监测者的特征ID被所述用户设备基于给定的映射关系在所述Y个时间间隔中确定所述X个时间间隔。

[0057] 作为一个实施例，所述特征ID指IMSI(International Mobile Subscriber Identification Number国际移动用户识别码)。

[0058] 作为一个实施例，所述特征ID指IMSI(International Mobile Subscriber Identification Number国际移动用户识别码)对1024的余数。

[0059] 作为一个实施例，所述特征ID指IMSI(International Mobile Subscriber Identification Number国际移动用户识别码)对4096的余数。

[0060] 作为一个实施例，所述特征ID指IMSI(International Mobile Subscriber Identification Number国际移动用户识别码)对16384的余数。

[0061] 作为一个实施例，所述特征ID是指C-RNTI(Cell Radio Network Temporary Identity，小区无线网络临时标识)。

[0062] 作为一个实施例，所述第一信令的发送小区的物理小区ID被用于在所述Y个时间间隔中确定所述X个时间间隔。

[0063] 具体的，根据本申请的一个方面，上述方法的特征在于，所述第一时间窗属于Z个时间窗中之一，所述Z是大于1的整数。所述Z是预定义的；或者所述Z是可配置的。所述Z个时间窗中的任意两个时间窗的时间长度是相等的，所述所述第一信令的监测者的特征ID被用于在所述Z个时间窗中确定所述第一时间窗。

[0064] 作为一个实施例，所述Z等于10。

[0065] 作为一个实施例，所述Z个时间窗中的任意两个时间窗在时域正交。

[0066] 作为一个实施例，所述Z个时间窗中的任意一个时间窗为一个子帧，所述Z等于10.

[0067] 作为一个实施例，所述Z个时间窗中的任意一个时间窗为一个无线帧，所述Z等于非连续接收周期(DRX(Discontinuous Reception)cycle)所包含的无线帧的数量。

[0068] 作为一个实施例，所述步骤A还包括如下步骤：

[0069] -步骤A2.接收第三信令。

[0070] 其中，所述第三信令被用于配置所述Z。

[0071] 作为一个实施例，所述所述第一信令的监测者的特征ID被所述用户设备用于在所述Z个时间窗中确定所述第一时间窗。

[0072] 作为一个实施例，所述所述第一信令的监测者的特征ID被所述用户设备基于给定的映射关系在所述Z个时间窗中确定所述第一时间窗。

[0073] 作为一个实施例，所述Z个时间窗中的任意一个时间窗为一个无线帧，所述第一时间窗由下式得到：

[0074] SFN mod Z=(Z div N)*(UE_ID mod N)

[0075] 其中，SFN为所述第一时间窗对应的无线帧的帧号，N=min(Z,nB)，nB等于{4Z,2Z,Z,Z/2,Z/4,Z/8,Z/16,Z/32,Z/64,Z/128,Z/256,Z/512,Z/1024}中之一。

[0076] 具体的，根据本申请的一个方面，上述方法的特征在于，所述步骤A还包括如下步骤：

[0077] -步骤A0.接收第二无线信号。

[0078] 其中，所述第二无线信号被用于确定{所述所述第一子频带在频域的位置，所述所述第一子频带中所包括的子载波的子载波间隔}中至少之一。

[0079] 作为一个实施例，所述第二无线信号包括主同步信号(PSS，Primary Synchronization Signal)。

[0080] 作为一个实施例，所述第二无线信号包括辅同步信号(SSS，Secondary Synchronization Signal)。

[0081] 作为一个实施例，所述第二无线信号通过BCH(Broadcast Channel，广播信道)传输。

[0082] 作为一个实施例，所述第二无线信号通过PBCH(Physical Broadcast Channel，物理广播信道)传输。

[0083] 作为一个实施例，所述第二无线信号通过PDSCH(Physical Downlink Shared Channel，物理下行共享信道)传输。

[0084] 作为一个实施例，所述第二无线信号携带MIB(Master Information Block，主信息块)信息。

[0085] 作为一个实施例，所述第二无线信号携带SIB(System Information Block，系统信息块)信息。

[0086] 作为一个实施例，所述第二无线信号所携带的信息是被周期性传输的。

[0087] 作为一个实施例，所述第二无线所携带的信息是按需(On-Demand)传输的。

[0088] 作为一个实施例，所述第二无线信号携带第一信息，所述第一信息被用于确定{所述所述第一子频带在频域的位置，所述所述第一子频带中所包括的子载波的子载波间隔}中至少之一。

[0089] 作为一个实施例，所述第二无线信号携带第一信息，所述第一信息指示{所述所述第一子频带在频域的位置，所述所述第一子频带中所包括的子载波的子载波间隔}中至少之一。

[0090] 作为一个实施例，所述第二无线信号被所述用户设备用于确定{所述所述第一子频带在频域的位置，所述所述第一子频带中所包括的子载波的子载波间隔}中至少之一。

[0091] 作为一个实施例，所述第二无线信号指示{所述所述第一子频带在频域的位置，所述所述第一子频带中所包括的子载波的子载波间隔}中至少之一。

[0092] 具体的，根据本申请的一个方面，上述方法的特征在于，所述步骤A还包括如下步骤：

[0093] -步骤A1.接收第二信令。

[0094] 其中，所述第二信令被用于确定Q个子频带，所述第一子频带属于所述Q个子频带中之一，所述Q个子频带中的任意一个子频带包括正整数个连续的子载波，所述所述第一信令的监测者的特征ID被用于在所述Q个子频带中确定所述第一子频带，所述Q是正整数。

[0095] 作为一个实施例，所述Q个子频带中的任意一个子频带所包括的子载波的子载波间隔都相等。

[0096] 作为一个实施例，所述Q个子频带中任意两个子频带中的子载波的子载波间隔不同。

[0097] 作为一个实施例，所述Q个子频带中存在两个子频带中的子载波的子载波间隔相同。

[0098] 作为一个实施例，所述Q个子频带中任意两个子频带的频域带宽相同。

[0099] 作为一个实施例，所述Q个子频带中存在两个子频带的频域带宽不相等。

[0100] 作为一个实施例，所述Q个子频带都属于同一个载波(Carrier)。

[0101] 作为一个实施例，所述Q个子频带中存在两个子频带属于不同的载波(Carrier)。

[0102] 作为一个实施例，所述第二信令是高层信令。

[0103] 作为一个实施例，所述第二信令是物理层信令。

[0104] 作为一个实施例，所述第二信令是通过BCH(Broadcast Channel，广播信道)传输的。

[0105] 作为一个实施例，所述第二信令是通过PBCH(Physical Broadcast Channel，物理广播信道)传输的。

[0106] 作为一个实施例，所述第二信令是通过PDSCH(Physical Downlink Shared Channel，物理下行共享信道)传输的。

[0107] 作为一个实施例，所述第二信令是RRC(Radio Resource Control，无线资源控制)信令。

[0108] 作为一个实施例，所述第二信令是SIB(System Information Block，系统信息块)。

[0109] 作为一个实施例，所述第二信令是通过DCI传输的。

[0110] 作为一个实施例，所述所述第一信令的监测者的特征ID被所述用户设备用于在所述Q个子频带中确定所述第一子频带。

[0111] 作为一个实施例，所述所述第一信令的监测者的特征ID被所述用户设备基于给定的映射关系在所述Q个子频带中确定所述第一子频带。

[0112] 本申请公开了一种用于寻呼的基站中的方法，其中，包括如下步骤：

[0113] -步骤A.在X个时间间隔中的正整数个时间间隔中分别发送第一信令；

[0114] -步骤B.发送第一无线信号。

[0115] 其中，所述X是正整数，所述第一信令被用于确定所述第一无线信号的调度信息，所述调度信息包括{所占用的时频资源，所采用的MCS，所占用的频域资源中的子载波的子载波间隔}中至少之一，所述第一无线信号携带寻呼消息。传输所述第一信令所使用的频域资源属于第一子频带，所述第一子频带在频域包括正整数个连续的子载波，{所述第一子频带在频域的位置，所述第一子频带中所包括的子载波的子载波间隔}中至少之一被用于确定所述X个时间间隔。

[0116] 具体的，根据本申请的一个方面，上述方法的特征在于，所述X个时间间隔中的任意一个时间间隔在时域都属于第一时间窗，所述第一时间窗的时间长度是预定义的，所述第一时间窗被分成Y个时间间隔，所述X个时间间隔是所述Y个时间间隔中的X个，所述Y是不小于X的正整数，所述所述第一子频带中所包括的子载波的子载波间隔被用于确定所述Y，所述第一信令的监测者的特征ID被用于在所述Y个时间间隔中确定所述X个时间间隔。

[0117] 具体的，根据本申请的一个方面，上述方法的特征在于，所述第一时间窗属于Z个时间窗中之一，所述Z是大于1的整数。所述Z是预定义的；或者所述Z是可配置的。所述Z个时间窗中的任意两个时间窗的时间长度是相等的，所述所述第一信令的监测者的特征ID被用于在所述Z个时间窗中确定所述第一时间窗。

[0118] 具体的，根据本申请的一个方面，上述方法的特征在于，所述步骤A还包括如下步骤：

[0119] -步骤A0.发送第二无线信号。

[0120] 其中，所述第二无线信号被用于确定{所述所述第一子频带在频域的位置，所述所述第一子频带中所包括的子载波的子载波间隔}中至少之一。

[0121] 具体的，根据本申请的一个方面，上述方法的特征在于，所述步骤A还包括如下步骤：

[0122] -步骤A1.发送第二信令。

[0123] 其中，所述第二信令被用于确定Q个子频带，所述第一子频带属于所述Q个子频带中之一，所述Q个子频带中的任意一个子频带包括正整数个连续的子载波，所述所述第一信令的监测者的特征ID被用于在所述Q个子频带中确定所述第一子频带，所述Q是正整数。

[0124] 本申请公开了一种用于寻呼的用户设备，其中，包括如下模块：

[0125] -第一接收模块：用于在X个时间间隔中分别监测第一信令；

[0126] -第二接收模块：用于接收第一无线信号。

[0127] 其中，所述X是正整数，所述第一信令被用于确定所述第一无线信号的调度信息，所述调度信息包括{所占用的时频资源，所采用的MCS，所占用的频域资源中的子载波的子载波间隔}中至少之一，所述第一无线信号携带寻呼消息。传输所述第一信令所使用的频域资源属于第一子频带，所述第一子频带在频域包括正整数个连续的子载波，{所述第一子频带在频域的位置，所述第一子频带中所包括的子载波的子载波间隔}中至少之一被用于确定所述X个时间间隔。

[0128] 具体的，根据本申请的一个方面，上述用户设备的特征在于，所述X个时间间隔中的任意一个时间间隔在时域都属于第一时间窗，所述第一时间窗的时间长度是预定义的，所述第一时间窗被分成Y个时间间隔，所述X个时间间隔是所述Y个时间间隔中的X个，所述Y

是不小于X的正整数，所述所述第一子频带中所包括的子载波的子载波间隔被用于确定所述Y，所述第一信令的监测者的特征ID被用于在所述Y个时间间隔中确定所述X个时间间隔。

[0129] 具体的，根据本申请的一个方面，上述用户设备的特征在于，所述第一时间窗属于Z个时间窗中之一，所述Z是大于1的整数。所述Z是预定义的；或者所述Z是可配置的。所述Z个时间窗中的任意两个时间窗的时间长度是相等的，所述所述第一信令的监测者的特征ID被用于在所述Z个时间窗中确定所述第一时间窗。

[0130] 具体的，根据本申请的一个方面，上述用户设备的特征在于，所述第一接收模块还被用于接收第二无线信号。所述第二无线信号被用于确定{所述所述第一子频带在频域的位置，所述所述第一子频带中所包括的子载波的子载波间隔}中至少之一。

[0131] 具体的，根据本申请的一个方面，上述用户设备的特征在于，所述第一接收模块还被用于接收第二信令。所述第二信令被用于确定Q个子频带，所述第一子频带属于所述Q个子频带中之一，所述Q个子频带中的任意一个子频带包括正整数个连续的子载波，所述所述第一信令的监测者的特征ID被用于在所述Q个子频带中确定所述第一子频带，所述Q是正整数。

[0132] 本申请公开了一种用于寻呼的基站设备，其中，包括如下模块：

[0133] -第一发送模块：用于在X个时间间隔中的正整数个时间间隔中分别发送第一信令；

[0134] -第二发送模块：用于发送第一无线信号。

[0135] 其中，所述X是正整数，所述第一信令被用于确定所述第一无线信号的调度信息，所述调度信息包括{所占用的时频资源，所采用的MCS，所占用的频域资源中的子载波的子载波间隔}中至少之一，所述第一无线信号携带寻呼消息。传输所述第一信令所使用的频域资源属于第一子频带，所述第一子频带在频域包括正整数个连续的子载波，{所述第一子频带在频域的位置，所述第一子频带中所包括的子载波的子载波间隔}中至少之一被用于确定所述X个时间间隔。

[0136] 具体的，根据本申请的一个方面，上述基站设备的特征在于，所述X个时间间隔中的任意一个时间间隔在时域都属于第一时间窗，所述第一时间窗的时间长度是预定义的，所述第一时间窗被分成Y个时间间隔，所述X个时间间隔是所述Y个时间间隔中的X个，所述Y是不小于X的正整数，所述所述第一子频带中所包括的子载波的子载波间隔被用于确定所述Y，所述第一信令的监测者的特征ID被用于在所述Y个时间间隔中确定所述X个时间间隔。

[0137] 具体的，根据本申请的一个方面，上述基站设备的特征在于，所述第一时间窗属于Z个时间窗中之一，所述Z是大于1的整数。所述Z是预定义的；或者所述Z是可配置的。所述Z个时间窗中的任意两个时间窗的时间长度是相等的，所述所述第一信令的监测者的特征ID被用于在所述Z个时间窗中确定所述第一时间窗。

[0138] 具体的，根据本申请的一个方面，上述基站设备的特征在于，所述第一发送模块还被用于发送第二无线信号。所述第二无线信号被用于确定{所述所述第一子频带在频域的位置，所述所述第一子频带中所包括的子载波的子载波间隔}中至少之一。

[0139] 具体的，根据本申请的一个方面，上述基站设备的特征在于，所述第一发送模块还被用于发送第二信令。所述第二信令被用于确定Q个子频带，所述第一子频带属于所述Q个子频带中之一，所述Q个子频带中的任意一个子频带包括正整数个连续的子载波，所述所述

第一信令的监测者的特征ID被用于在所述Q个子频带中确定所述第一子频带，所述Q是正整数。

附图说明

[0140] 通过阅读参照以下附图所作的对非限制性实施例所作的详细描述，本申请的其它特征、目的和优点将会变得更加明显：

[0141] 图1示出了根据本申请的一个实施例的无线信号传输流程图；

[0142] 图2示出了根据本申请的一个实施例的Z个时间窗和Q个子频带的关系的示意图；

[0143] 图3示出了根据本申请的一个实施例的第一时间窗与X个时间间隔的关系的示意图；

[0144] 图4示出了根据本申请的一个实施例的第一信令，第一无线信号和第二无线信号之间的关系的示意图；

[0145] 图5示出了根据本申请的一个实施例的用户设备(UE)中的处理装置的结构框图；

[0146] 图6示出了根据本申请的一个实施例的基站中的处理装置的结构框图；

具体实施方式

[0147] 下文将结合附图对本申请的技术方案作进一步详细说明，需要说明的是，在不冲突的情况下，本申请的实施例和实施例中的特征可以任意相互组合。

[0148] 实施例1

[0149] 实施例1示例了根据本申请的一个实施例的无线信号传输流程图，如附图1所示。附图1中，基站N1是UE U2的服务小区的维持基站，虚线框F1中标识的步骤是可选的。

[0150] 对于基站N1，在步骤S11中发送第二无线信号，在步骤S12中发送第二信令，在步骤S13中在X个时间间隔中的正整数个时间间隔中分别发送第一信令，在步骤S14中发送第一无线信号。

[0151] 对于UE U2，在步骤S21中接收第二无线信号，在步骤S22中接收第二信令，在步骤S23中在X个时间间隔中分别监测第一信令，在步骤S24中接收第一无线信号。

[0152] 在实施例1中，所述X是正整数，所述第一信令被用于确定所述第一无线信号的调度信息，所述调度信息包括{所占用的时频资源，所采用的MCS，所占用的频域资源中的子载波的子载波间隔}中至少之一，所述第一无线信号携带寻呼消息，传输所述第一信令所使用的频域资源属于第一子频带，所述第一子频带在频域包括正整数个连续的子载波，{所述第一子频带在频域的位置，所述第一子频带中所包括的子载波的子载波间隔}中至少之一被用于确定所述X个时间间隔。所述第二无线信号被用于确定{所述所述第一子频带在频域的位置，所述所述第一子频带中所包括的子载波的子载波间隔}中至少之一。所述第二信令被用于确定Q个子频带，所述第一子频带属于所述Q个子频带中之一，所述Q个子频带中的任意一个子频带包括正整数个连续的子载波，所述所述第一信令的监测者的特征ID被用于在所述Q个子频带中确定所述第一子频带，所述Q是正整数。

[0153] 在实施例1的子实施例1中，所述X个时间间隔中的任意一个时间间隔在时域都属于第一时间窗，所述第一时间窗的时间长度是预定义的，所述第一时间窗被分成Y个时间间隔，所述X个时间间隔是所述Y个时间间隔中的X个，所述Y是不小于X的正整数，所述所述第

一子频带中所包括的子载波的子载波间隔被用于确定所述Y，所述第一信令的监测者的特征ID被用于在所述Y个时间间隔中确定所述X个时间间隔。

[0154] 在实施例1的子实施例2中，所述第一时间窗属于Z个时间窗中之一，所述Z是大于1的整数。所述Z是预定义的；或者所述Z是可配置的。所述Z个时间窗中的任意两个时间窗的时间长度是相等的，所述所述第一信令的监测者的特征ID被用于在所述Z个时间窗中确定所述第一时间窗。

[0155] 在实施例1的子实施例3中，所述寻呼消息包括被寻呼的用户设备的特征ID。

[0156] 在实施例1的子实施例4中，所述MCS(Modulation Coding Scheme，调制编码方式)包括的调制方式为{QPSK，16QAM，64QAM，256QAM，1024QAM}中之一。

[0157] 在实施例1的子实施例5中，所述子载波间隔等于15kHz乘以2的K次幂，所述K为整数。

[0158] 在实施例1的子实施例6中，所述第一子频带(Subband)包括12的正整数倍个子载波。

[0159] 在实施例1的子实施例7中，所述第一子频带中包括的所有子载波的子载波间隔都相等。

[0160] 在实施例1的子实施例8中，所述所述第一子频带在频域的位置是指所述第一子频带在所处的载波(Carrier)中的位置。

[0161] 在实施例1的子实施例9中，所述所述第一子频带在频域的位置是指所述第一子频带所处的载波(Carrier)在频域的位置。

[0162] 在实施例1的子实施例10中，所述所述第一子频带在频域的位置是指所述第一子频带在所处的载波(Carrier)中的子频带索引。

[0163] 在实施例1的子实施例11中，所述所述第一子频带在频域的位置是指所述第一子频带在所处的频带(Band)所对应的频率资源中的位置。

[0164] 在实施例1的子实施例12中，所述第二信令是高层信令。

[0165] 在实施例1的子实施例13中，所述第二信令是物理层信令。

[0166] 在实施例1的子实施例14中，所述第二信令是通过BCH(Broadcast Channel，广播信道)传输的。

[0167] 在实施例1的子实施例15中，所述第二信令是通过PBCH(Physical Broadcast Channel，物理广播信道)传输的。

[0168] 在实施例1的子实施例16中，所述第二信令是通过PDSCH(Physical Downlink Shared Channel，物理下行共享信道)传输的。

[0169] 在实施例1的子实施例17中，所述第二信令是RRC(Radio Resource Control，无线资源控制)信令。

[0170] 在实施例1的子实施例18中，所述第二信令是SIB(System Information Block，系统信息块)。

[0171] 在实施例1的子实施例19中，所述第二信令是通过DCI传输的。

[0172] 实施例2

[0173] 实施例2示例了根据本申请的一个实施例的Z个时间窗和Q个子频带的关系的示意图，如附图2所示。附图2中，横轴代表时间，纵轴代表频率，每个矩形代表一个时间间隔，斜

线填充的矩形代表UE#1在时间窗#a中所监测的X1个时间间隔，十字线填充的矩形代表UE#2在时间窗#b中所监测的X2个时间间隔，斜线交叉线填充的矩形代表UE#3在时间窗#c中所监测的X3个时间间隔。

[0174] 在实施例2中，对于UE#1，在X1个时间间隔中分别监测第一信令，传输所述第一信令所使用的频域资源属于子频带#1，所述子频带#1在频域包括正整数个连续的子载波，所述子频带#1在频域的位置，所述子频带#1所包括的子载波的子载波间隔1中至少之一被用于确定所述X1个时间间隔。所述X1个时间间隔中的任意一个时间间隔在时域都属于时间窗#a，所述时间窗#a的时间长度是预定义的，所述时间窗#a被分成Y1个时间间隔，所述X1个时间间隔是所述Y1个时间间隔中的X1个，所述Y1是不小于X1的正整数，所述所述子频带#1中所包括的子载波的子载波间隔被用于确定所述Y1，所述UE#1的特征ID被用于在所述Y1个时间间隔中确定所述X1个时间间隔。所述时间窗#a属于Z个时间窗中之一，所述Z是大于1的整数。所述Z是预定义的；或者所述Z是可配置的。所述Z个时间窗中的任意两个时间窗的时间长度是相等的，所述所述UE#1的特征ID被用于在所述Z个时间窗中确定所述时间窗#a。所述子频带#1属于所述Q个子频带中之一，所述Q个子频带中的任意一个子频带包括正整数个连续的子载波，所述所述UE#1的特征ID被用于在所述Q个子频带中确定所述子频带#1，所述Q是正整数。

[0175] 在实施例2的子实施例1中，所述Z等于10。

[0176] 在实施例2的子实施例2中，所述Z个时间窗中的任意两个时间窗在时域正交。

[0177] 在实施例2的子实施例3中，所述Z个时间窗中的任意一个时间窗为一个子帧，所述Z等于10。

[0178] 在实施例2的子实施例4中，所述Z个时间窗中的任意一个时间窗为一个无线帧，所述Z等于非连续接收周期(DRX(Discontinuous Reception)cycle)所包含的无线帧的数量。

[0179] 在实施例2的子实施例5中，所述Z个时间窗中的任意一个时间窗为一个无线帧，所述时间窗#a由下式得到：

[0180] SFN mod Z=(Z div N)*(UE_ID mod N)

[0181] 其中，SFN为所述时间窗#a对应的无线帧的帧号，N=min(Z,nB)，nB等于{4Z,2Z,Z,Z/2,Z/4,Z/8,Z/16,Z/32,Z/64,Z/128,Z/256,Z/512,Z/1024}中之一。

[0182] 在实施例2的子实施例6中，所述Q个子频带中的任意一个子频带所包括的子载波的子载波间隔都相等。

[0183] 在实施例2的子实施例7中，所述Q个子频带中任意两个子频带中的子载波的子载波间隔不同。

[0184] 在实施例2的子实施例8中，所述Q个子频带中存在两个子频带中的子载波的子载波间隔相同。

[0185] 在实施例2的子实施例9中，所述Q个子频带中任意两个子频带的频域带宽相同。

[0186] 在实施例2的子实施例10中，所述Q个子频带中存在两个子频带的频域带宽不相等。

[0187] 在实施例2的子实施例11中，所述Q个子频带都属于同一个载波(Carrier)。

[0188] 在实施例2的子实施例12中，所述Q个子频带中存在两个子频带属于不同的载波(Carrier)。

[0189] 实施例3

[0190] 实施例3示例了根据本申请的一个实施例的第一时间窗与X个时间间隔的关系的示意图，如附图3所示。在附图3中，列出了依据不同的Y值和不同的UE的特征ID，X=1个时间间隔在第一时间窗中的索引。

[0191] 在实施例3中，UE在X个时间间隔中分别监测第一信令，所述X个时间间隔中的任意一个时间间隔在时域都属于第一时间窗，所述第一时间窗的时间长度是预定义的，所述第一时间窗被分成Y个时间间隔，所述X个时间间隔是所述Y个时间间隔中的X个，所述Y是不小于X的正整数，所述所述第一子频带中所包括的子载波的子载波间隔被用于确定所述Y，所述UE的特征ID被用于在所述Y个时间间隔中确定所述X个时间间隔。

[0192] 在实施例3的子实施例1中，在所述X个时间间隔中的每一个时间间隔中针对所述第一信令最多执行P次检测，所述P是正整数。

[0193] 在实施例3的子实施例2中，所述X个时间间隔中的任意两个时间间隔的时间长度相等。

[0194] 在实施例3的子实施例3中，所述X个时间间隔中存在两个时间间隔的时间长度不等。

[0195] 在实施例3的子实施例4中，所述X个时间间隔中的任意一个时间间隔为一个时隙(Slot)。

[0196] 在实施例3的子实施例5中，所述X个时间间隔中的任意两个时间间隔的时间长度相等，所述X个时间间隔中的每个时间间隔的时间长度和所述第一频带中所包括的子载波的子载波间隔有关。

[0197] 在实施例3的子实施例6中，所述X个时间间隔中的任意一个时间间隔为M个OFDM(Orthogonal Frequency Division Multiplexing，正交频分复用)符号，所述M为小于14的正整数。

[0198] 在实施例3的子实施例7中，所述X个时间间隔中的任意一个时间间隔为M个OFDM(Orthogonal Frequency Division Multiplexing，正交频分复用)符号，所述M为小于7的正整数。

[0199] 在实施例3的子实施例8中，所述X个时间间隔中的任意两个时间间隔在时域正交，所述正交是指不存在一个时间单元同时属于所述X个时间间隔中的任意两个时间间隔。

[0200] 在实施例3的子实施例9中，所述X个时间间隔中存在两个时间间隔在时域是离散的。

[0201] 在实施例3的子实施例10中，所述第一时间窗的时间长度是固定不变的。

[0202] 在实施例3的子实施例11中，所述第一时间窗中包括正整数个时域连续的多载波符号。作为一个子实施例，所述多载波符号包括数据符号和CP(Cyclic Prefix，循环前缀)。

[0203] 在实施例3的子实施例12中，所述所述第一时间窗的时间长度为1毫秒。

[0204] 在实施例3的子实施例13中，所述所述第一时间窗的时间长度为10毫秒。

[0205] 在实施例3的子实施例14中，所述第一时间窗为一个子帧(Subframe)。

[0206] 在实施例3的子实施例15中，所述第一时间窗为一个无线帧(Radio Frame)。

[0207] 在实施例3的子实施例16中，所述Y个时间间隔中的任意两个时间间隔的时间长度相等。

[0208] 在实施例3的子实施例17中，所述Y与所述所述第一频带中所包括的子载波的子载波间隔成正比。

[0209] 在实施例3的子实施例18中，所述特征ID指IMSI(International Mobile Subscriber Identification Number国际移动用户识别码)。

[0210] 在实施例3的子实施例19中，所述特征ID指IMSI(International Mobile Subscriber Identification Number国际移动用户识别码)对1024的余数。

[0211] 在实施例3的子实施例20中，所述特征ID指IMSI(International Mobile Subscriber Identification Number国际移动用户识别码)对4096的余数。

[0212] 在实施例3的子实施例21中，所述特征ID指IMSI(International Mobile Subscriber Identification Number国际移动用户识别码)对16384的余数。

[0213] 在实施例3的子实施例22中，所述特征ID是指C-RNTI(Cell Radio Network Temporary Identity，小区无线网络临时标识)。

[0214] 实施例4

[0215] 实施例4示例了根据本申请的一个实施例的第一信令，第一无线信号和第二无线信号之间的关系的示意图，如附图4所示。附图4中，横轴代表时间，纵轴代表频率，斜线填充的矩形代表传输第二无线信号所占用的时频资源，十字线填充的矩形代表传输第一信令所占用的时频资源，斜线交叉线填充的矩形代表传输第一无线信号所占用的时频资源，虚线箭头代表了特定的使用关系。

[0216] 在实施例4中，第一信令被用于确定第一无线信号的调度信息，所述调度信息包括{所占用的时频资源，所采用的MCS，所占用的频域资源中的子载波的子载波间隔}中至少之一，传输所述第一信令所使用的频域资源属于第一子频带，所述第一子频带在频域包括正整数个连续的子载波。第二无线信号被用于确定{所述第一子频带在频域的位置，所述第一子频带中所包括的子载波的子载波间隔}中至少之一。

[0217] 在实施例4的子实施例1中，所述第一信令是物理层信令。

[0218] 在实施例4的子实施例2中，所述第一信令是DCI(Downlink Control Information，下行控制信息)。

[0219] 在实施例4的子实施例3中，所述第一信令通过NR-PDCCH(New Radio Physical Downlink Control Channel，新空口物理下行控制信道)传输。

[0220] 在实施例4的子实施例4中，所述第一信令通过PDCCH(Physical Downlink Control Channel，物理下行控制信道)传输，所述PDCCH的CRC(Cyclic Redundancy Check，循环冗余校验)经过P-RNTI(Paging Radio Network Temporary Identity，寻呼无线网络临时标识)加扰。

[0221] 在实施例4的子实施例5中，所述第一无线信号通过DL-SCH(Downlink Shared Channel，下行共享信道)传输。

[0222] 在实施例4的子实施例6中，所述第一无线信号通过PDSCH(Physical Downlink Shared Channel，物理下行共享信道)传输。

[0223] 在实施例4的子实施例7中，第一比特块依次经过调制映射器(Modulation Mapper)，层映射器(Layer Mapper)，预编码(Precoding)，资源粒子映射器(Resource Element Mapper)，OFDM信号发生(Generation)之后得到所述第一无线信号。所述第一比特

块包括一个码块经过信道编码之后的输出。作为一个子实施例，所述码块是TB(Transport Block，传输块)。作为一个子实施例，所述码块是TB(Transport Block，传输块)中的一部分。

[0224] 在实施例4的子实施例8中，所述第一无线信号包括主同步信号(PSS，Primary Synchronization Signal)。

[0225] 在实施例4的子实施例9中，所述第一无线信号包括辅同步信号(SSS，Secondary Synchronization Signal)。

[0226] 在实施例4的子实施例10中，所述第二无线信号通过BCH(Broadcast Channel，广播信道)传输。

[0227] 在实施例4的子实施例11中，所述第二无线信号通过PBCH(Physical Broadcast Channel，物理广播信道)传输。

[0228] 在实施例4的子实施例12中，所述第二无线信号携带MIB(Master Information Block，主信息块)信息。

[0229] 在实施例4的子实施例13中，所述第二无线信号携带SIB(System Information Block，系统信息块)信息。

[0230] 在实施例4的子实施例14中，所述第二无线信号所携带的信息是被周期性传输的。

[0231] 在实施例4的子实施例15中，所述第二无线所携带的信息是按需(On-Demand)传输的。

[0232] 在实施例4的子实施例16中，所述第二无线信号携带第一信息，所述第一信息被用于确定{所述所述第一子频带在频域的位置，所述所述第一子频带中所包括的子载波的子载波间隔}中至少之一。

[0233] 在实施例4的子实施例17中，所述第二无线信号携带第一信息，所述第一信息指示{所述所述第一子频带在频域的位置，所述所述第一子频带中所包括的子载波的子载波间隔}中至少之一。

[0234] 实施例5

[0235] 实施例5示例了一个用户设备中的处理装置的结构框图，如附图5所示。附图5中，用户设备处理装置100主要由第一接收模块101和第二接收模块102组成。

[0236] 在实施例5中，第一接收模块101被用于在X个时间间隔中分别监测第一信令，第二接收模块102被用于接收第一无线信号。其中，所述X是正整数，所述第一信令被用于确定所述第一无线信号的调度信息，所述调度信息包括{所占用的时频资源，所采用的MCS，所占用的频域资源中的子载波的子载波间隔}中至少之一，所述第一无线信号携带寻呼消息。传输所述第一信令所使用的频域资源属于第一子频带，所述第一子频带在频域包括正整数个连续的子载波，{所述第一子频带在频域的位置，所述第一子频带中所包括的子载波的子载波间隔}中至少之一被用于确定所述X个时间间隔。

[0237] 在实施例5的子实施例1中，所述X个时间间隔中的任意一个时间间隔在时域都属于第一时间窗，所述第一时间窗的时间长度是预定义的，所述第一时间窗被分成Y个时间间隔，所述X个时间间隔是所述Y个时间间隔中的X个，所述Y是不小于X的正整数，所述所述第一子频带中所包括的子载波的子载波间隔被用于确定所述Y，所述第一信令的监测者的特征ID被用于在所述Y个时间间隔中确定所述X个时间间隔。

[0238] 在实施例5的子实施例2中，所述第一时间窗属于Z个时间窗中之一，所述Z是大于1的整数。所述Z是预定义的；或者所述Z是可配置的。所述Z个时间窗中的任意两个时间窗的时间长度是相等的，所述所述第一信令的监测者的特征ID被用于在所述Z个时间窗中确定所述第一时间窗。

[0239] 在实施例5的子实施例3中，第一接收模块101还被用于接收第二无线信号。所述第二无线信号被用于确定{所述所述第一子频带在频域的位置，所述所述第一子频带中所包括的子载波的子载波间隔}中至少之一。

[0240] 在实施例5的子实施例4中，第一接收模块101还被用于接收第二信令。所述第二信令被用于确定Q个子频带，所述第一子频带属于所述Q个子频带中之一，所述Q个子频带中的任意一个子频带包括正整数个连续的子载波，所述所述第一信令的监测者的特征ID被用于在所述Q个子频带中确定所述第一子频带，所述Q是正整数。

[0241] 实施例6

[0242] 实施例6示例了一个基站设备中的处理装置的结构框图，如附图6所示。在附图6中，基站处理装置200主要由第一发送模块201和第二发送模块202组成。

[0243] 在实施例6中，第一发送模块201被用于在X个时间间隔中的正整数个时间间隔中分别发送第一信令，第二发送模块202被用于发送第一无线信号。其中，所述X是正整数，所述第一信令被用于确定所述第一无线信号的调度信息，所述调度信息包括{所占用的时频资源，所采用的MCS，所占用的频域资源中的子载波的子载波间隔}中至少之一，所述第一无线信号携带寻呼消息。传输所述第一信令所使用的频域资源属于第一子频带，所述第一子频带在频域包括正整数个连续的子载波，{所述第一子频带在频域的位置，所述第一子频带中所包括的子载波的子载波间隔}中至少之一被用于确定所述X个时间间隔。

[0244] 在实施例6的子实施例1中，所述X个时间间隔中的任意一个时间间隔在时域都属于第一时间窗，所述第一时间窗的时间长度是预定义的，所述第一时间窗被分成Y个时间间隔，所述X个时间间隔是所述Y个时间间隔中的X个，所述Y是不小于X的正整数，所述所述第一子频带中所包括的子载波的子载波间隔被用于确定所述Y，所述第一信令的监测者的特征ID被用于在所述Y个时间间隔中确定所述X个时间间隔。

[0245] 在实施例6的子实施例2中，所述第一时间窗属于Z个时间窗中之一，所述Z是大于1的整数。所述Z是预定义的；或者所述Z是可配置的。所述Z个时间窗中的任意两个时间窗的时间长度是相等的，所述所述第一信令的监测者的特征ID被用于在所述Z个时间窗中确定所述第一时间窗。

[0246] 在实施例6的子实施例3中，第一发送模块201还被用于发送第二无线信号。所述第二无线信号被用于确定{所述所述第一子频带在频域的位置，所述所述第一子频带中所包括的子载波的子载波间隔}中至少之一。

[0247] 在实施例6的子实施例4中，第一发送模块201还被用于发送第二信令。所述第二信令被用于确定Q个子频带，所述第一子频带属于所述Q个子频带中之一，所述Q个子频带中的任意一个子频带包括正整数个连续的子载波，所述所述第一信令的监测者的特征ID被用于在所述Q个子频带中确定所述第一子频带，所述Q是正整数。

[0248] 本领域普通技术人员可以理解上述方法中的全部或部分步骤可以通过程序来指令相关硬件完成，所述程序可以存储于计算机可读存储介质中，如只读存储器，硬盘或者光

盘等。可选的，上述实施例的全部或部分步骤也可以使用一个或者多个集成电路来实现。相应的，上述实施例中的各模块单元，可以采用硬件形式实现，也可以由软件功能模块的形式实现，本申请不限于任何特定形式的软件和硬件的结合。本申请中的UE或者终端包括但不限于手机，平板电脑，笔记本，上网卡，低功耗设备，eMTC设备，NB-IoT设备，无人机，遥控飞机，车载通信设备等无线通信设备。本申请中的基站或者网络侧设备包括但不限于宏蜂窝基站，微蜂窝基站，家庭基站，中继基站，eNB，gNB，传输接收节点TRP等无线通信设备。

[0249] 以上所述，仅为本申请的较佳实施例而已，并非用于限定本申请的保护范围。凡在本申请的精神和原则之内，所做的任何修改，等同替换，改进等，均应包含在本申请的保护范围之内。

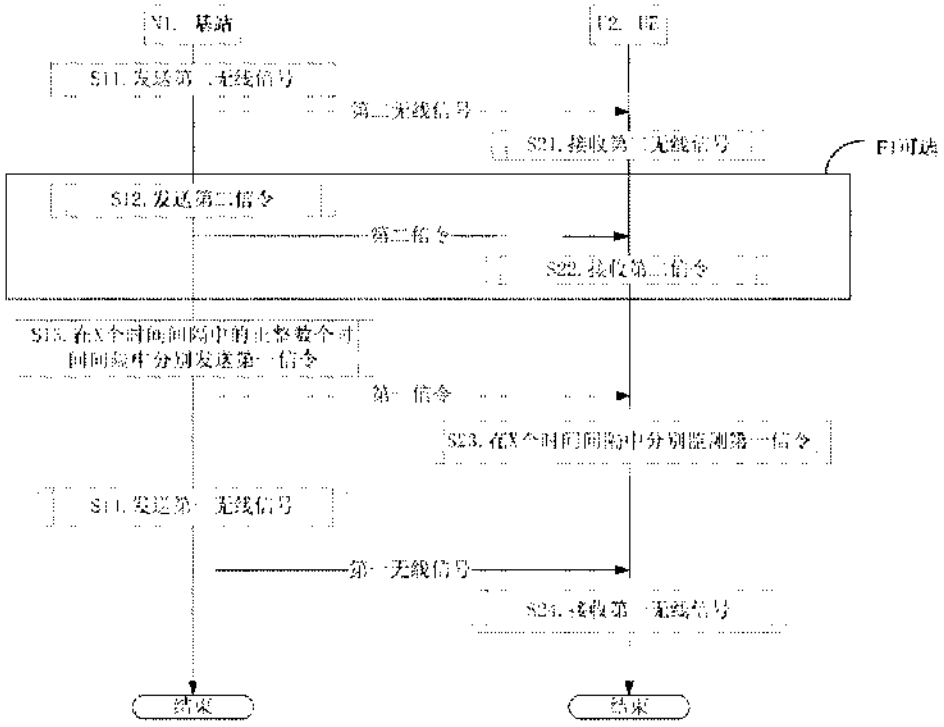

N1. 基站
F2. UE
S11. 发送第一无线信号
第二无线信号
S21. 接收第一无线信号
F1可选
S12. 发送第二信令
第二信令
S22. 接收第二信令
S13. 在X个时间间隔中的非零个时间间隔中分别发送第一信令
第一信令
S23. 在X个时间间隔中分别监测第一信令
S11. 发送第一无线信号
第一无线信号
S24. 接收第一无线信号
结束
结束

图1

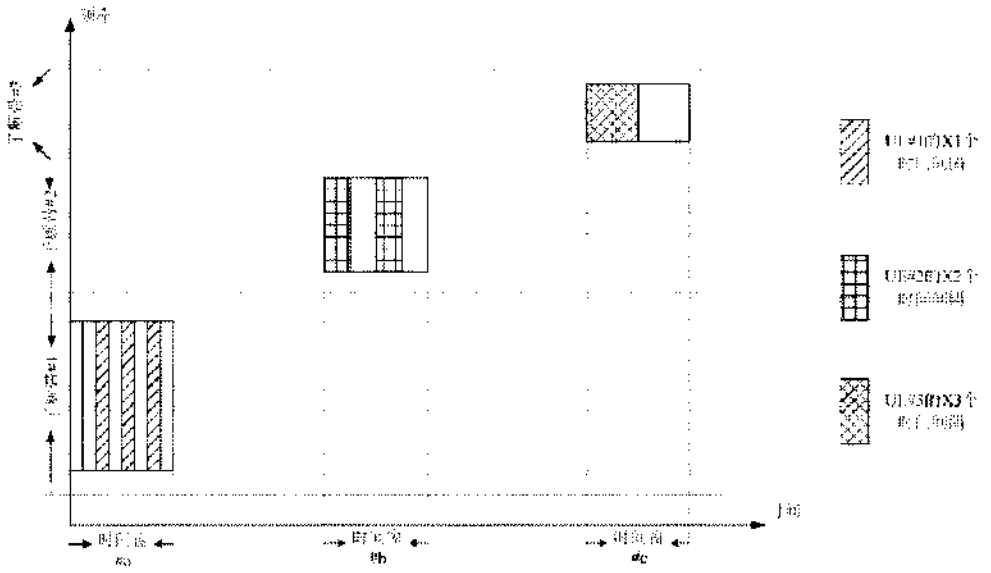


图2

	X=1 个时间间隔在第一时间窗中的索引			
	特征 ID = a	特征 ID = b	特征 ID = c	特征 ID = d
Y=1	0	0	0	0
Y=2	0	1	0	1
Y=4	0	1	2	3
Y=8	1	3	5	7
Y=16	2	6	10	14

图3

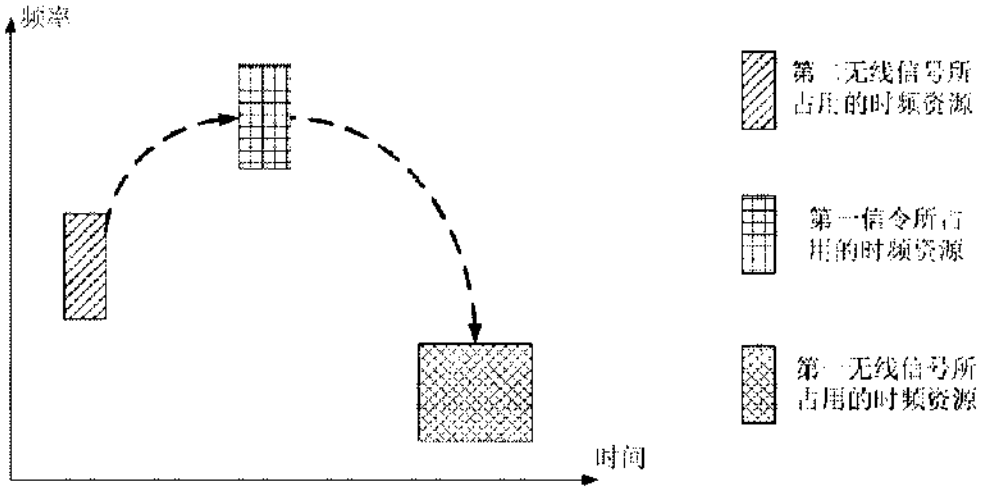

频率
时间
第二无线信号所占用的时频资源
第一信令所占用的时频资源
第一无线信号所占用的时频资源

图4

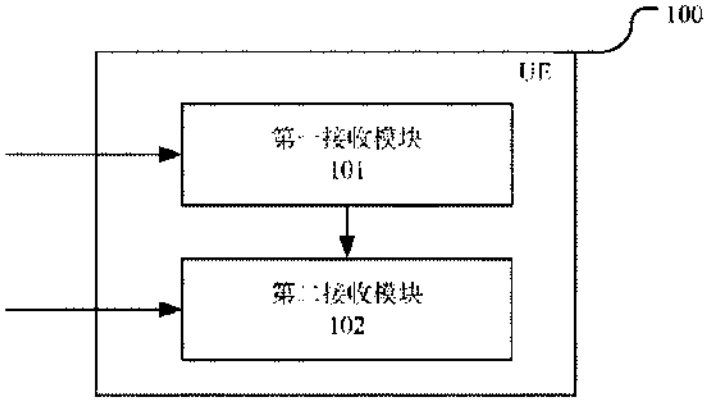

100
UE
第一接收模块
101
第二接收模块
102

图5

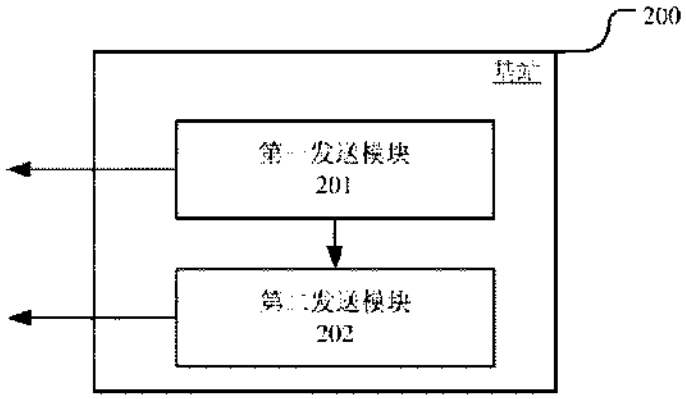


图6

Espacenet

CN108923896A Method for paging in user equipment, method for paging in base station, user equipment for paging and base station equipment for paging

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Method for paging in user equipment, method for paging in base station, user equipment for paging and base station equipment for paging

Abstract

The invention discloses a method for paging in user equipment, a method for paging in a base station, the user equipment for paging and base station equipment for paging. The user equipment first monitors first signaling in X time intervals respectively, and then receives a first radio signal. The X is a positive integer. The first signaling is used for determining scheduling information for the first radio signal. The scheduling information comprises at least one of {an occupied time-frequency resource, an employed MCS (Modulation Coding Scheme), and subcarrier spacing of subcarriers in an occupied frequency domain resource}. The first radio signal carries a paging message. The frequency domain resource for transmitting the first signaling belongs to a first subband. The first subband comprises a positive integer number of consecutive subcarriers in a frequency domain. At least one of {a location of the first subband in the frequency domain, and subcarrier spacing of the subcarriers included in the first subband} is used for determining the X time intervals. According to the methods, the user equipment and the base station equipment, paging capacity is kept, and moreover, power consumption of the user equipment is reduced.

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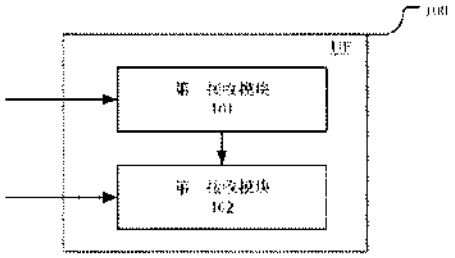
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一种被用于寻呼的用户设备、基站中的方法和装置

(57) 摘要

本发明公开了一种被用于寻呼的用户设备、基站中的方法和装置。用户设备首先在X个时间间隔中分别监测第一信令，接着接收第一无线信号。其中，所述X是正整数，所述第一信令被用于确定所述第一无线信号的调度信息，所述调度信息包括所占用的时频资源，所采用的MCS，所占用的频域资源中的子载波的子载波间隔中至少之一，所述第一无线信号携带寻呼消息。传输所述第一信令所使用的频域资源属于第一子频带，所述第一子频带在频域包括正整数个连续的子载波，所述第一子频带在频域的位置，所述第一子频带中所包括的子载波的子载波间隔中至少之一被用于确定所述X个时间间隔。本发明可以在保持寻呼容量的同时降低用户设备功率消耗。



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1.一种用于寻呼的用户设备中的方法，其特征在于，包括如下步骤：

-步骤A.在X个时间间隔中分别监测第一信令；

-步骤B.接收第一无线信号；

其中，所述X是正整数，所述第一信令被用于确定所述第一无线信号的调度信息，所述调度信息包括所占用的时频资源、所采用的MCS中至少之一，所述第一无线信号携带寻呼消息；传输所述第一信令所使用的频域资源属于第一子频带，所述第一子频带在频域包括正整数个连续的子载波，所述第一子频带在频域的位置和所述第一子频带中所包括的子载波的子载波间隔被用于确定所述X个时间间隔。

2.根据权利要求1所述的方法，其特征在于，所述X个时间间隔中的任意一个时间间隔在时域都属于第一时间窗，所述第一时间窗的时间长度是预定义的，所述第一时间窗被分成Y个时间间隔，所述X个时间间隔是所述Y个时间间隔中的X个，所述Y是不小于X的正整数，所述第一子频带中所包括的子载波的子载波间隔被用于确定所述Y，所述第一信令的监测者的特征ID被用于在所述Y个时间间隔中确定所述X个时间间隔。

3.根据权利要求2所述的方法，其特征在于，所述第一时间窗属于Z个时间窗中之一，所述Z是大于1的整数；所述Z是预定义的；或者所述Z是可配置的；所述Z个时间窗中的任意两个时间窗的时间长度是相等的，所述第一信令的监测者的特征ID被用于在所述Z个时间窗中确定所述第一时间窗。

4.根据权利要求1至3中任一权利要求所述的方法，其特征在于，所述步骤A还包括如下步骤：

-步骤A0.接收第二无线信号；

其中，所述第二无线信号被用于确定所述第一子频带在频域的位置、所述第一子频带中所包括的子载波的子载波间隔中至少之一。

5.根据权利要求1至3中任一权利要求所述的方法，其特征在于，所述步骤A还包括如下步骤：

-步骤A1.接收第二信令；

其中，所述第二信令被用于确定Q个子频带，所述第一子频带属于所述Q个子频带中之一，所述Q个子频带中的任意一个子频带包括正整数个连续的子载波，所述第一信令的监测者的特征ID被用于在所述Q个子频带中确定所述第一子频带，所述Q是正整数。

6.根据权利要求4所述的方法，其特征在于，所述步骤A还包括如下步骤：

步骤A1.接收第二信令；

其中，所述第二信令被用于确定Q个子频带，所述第一子频带属于所述Q个子频带中之一，所述Q个子频带中的任意一个子频带包括正整数个连续的子载波，所述第一信令的监测者的特征ID被用于在所述Q个子频带中确定所述第一子频带，所述Q是正整数。

7.一种用于寻呼的基站中的方法，其特征在于，包括如下步骤：

-步骤A.在X个时间间隔中的正整数个时间间隔中分别发送第一信令；

-步骤B.发送第一无线信号；

其中，所述X是正整数，所述第一信令被用于确定所述第一无线信号的调度信息，所述调度信息包括所占用的时频资源、所采用的MCS中至少之一，所述第一无线信号携带寻呼消息；传输所述第一信令所使用的频域资源属于第一子频带，所述第一子频带在频域包括正

整数个连续的子载波，所述第一子频带在频域的位置和所述第一子频带中所包括的子载波的子载波间隔被用于确定所述X个时间间隔。

8.根据权利要求7所述的方法，其特征在于，所述X个时间间隔中的任意一个时间间隔在时域都属于第一时间窗，所述第一时间窗的时间长度是预定义的，所述第一时间窗被分成Y个时间间隔，所述X个时间间隔是所述Y个时间间隔中的X个，所述Y是不小于X的正整数，所述第一子频带中所包括的子载波的子载波间隔被用于确定所述Y，所述第一信令的监测者的特征ID被用于在所述Y个时间间隔中确定所述X个时间间隔。

9.根据权利要求8所述的方法，其特征在于，所述第一时间窗属于Z个时间窗中之一，所述Z是大于1的整数；所述Z是预定义的；或者所述Z是可配置的；所述Z个时间窗中的任意两个时间窗的时间长度是相等的，所述第一信令的监测者的特征ID被用于在所述Z个时间窗中确定所述第一时间窗。

10.根据权利要求7至9中任一权利要求所述的方法，其特征在于，所述步骤A还包括如下步骤：

-步骤A0.发送第二无线信号；

其中，所述第二无线信号被用于确定所述第一子频带在频域的位置、所述第一子频带中所包括的子载波的子载波间隔中至少之一。

11.根据权利要求7至9中任一权利要求所述的方法，其特征在于，所述步骤A还包括如下步骤：

-步骤A1.发送第二信令；

其中，所述第二信令被用于确定Q个子频带，所述第一子频带属于所述Q个子频带中之一，所述Q个子频带中的任意一个子频带包括正整数个连续的子载波，所述第一信令的监测者的特征ID被用于在所述Q个子频带中确定所述第一子频带，所述Q是正整数。

12.根据权利要求10所述的方法，其特征在于，所述步骤A还包括如下步骤：

-步骤A1.发送第二信令；

其中，所述第二信令被用于确定Q个子频带，所述第一子频带属于所述Q个子频带中之一，所述Q个子频带中的任意一个子频带包括正整数个连续的子载波，所述第一信令的监测者的特征ID被用于在所述Q个子频带中确定所述第一子频带，所述Q是正整数。

13.一种用于寻呼的用户设备，其特征在于，包括如下模块：

-第一接收模块：用于在X个时间间隔中分别监测第一信令；

-第二接收模块：用于接收第一无线信号；

其中，所述X是正整数，所述第一信令被用于确定所述第一无线信号的调度信息，所述调度信息包括所占用的时频资源、所采用的MCS中至少之一，所述第一无线信号携带寻呼消息；传输所述第一信令所使用的频域资源属于第一子频带，所述第一子频带在频域包括正整数个连续的子载波，所述第一子频带在频域的位置和所述第一子频带中所包括的子载波的子载波间隔被用于确定所述X个时间间隔。

14.根据权利要求13所述的用户设备，其特征在于，所述X个时间间隔中的任意一个时间间隔在时域都属于第一时间窗，所述第一时间窗的时间长度是预定义的，所述第一时间窗被分成Y个时间间隔，所述X个时间间隔是所述Y个时间间隔中的X个，所述Y是不小于X的正整数，所述第一子频带中所包括的子载波的子载波间隔被用于确定所述Y，所述第一信令

的监测者的特征ID被用于在所述Y个时间间隔中确定所述X个时间间隔。

15.根据权利要求14所述的用户设备，其特征在于，所述第一时间窗属于Z个时间窗中之一，所述Z是大于1的整数；所述Z是预定义的；或者所述Z是可配置的；所述Z个时间窗中的任意两个时间窗的时间长度是相等的，所述第一信令的监测者的特征ID被用于在所述Z个时间窗中确定所述第一时间窗。

16.根据权利要求13至15中任一权利要求所述的用户设备，其特征在于，所述第一接收模块还被用于接收第二无线信号；所述第二无线信号被用于确定所述第一子频带在频域的位置、所述第一子频带中所包括的子载波的子载波间隔中至少之一。

17.根据权利要求13至15中任一权利要求所述的用户设备，其特征在于，所述第一接收模块还被用于接收第二信令所述第二信令被用于确定Q个子频带，所述第一子频带属于所述Q个子频带中之一，所述Q个子频带中的任意一个子频带包括正整数个连续的子载波，所述第一信令的监测者的特征ID被用于在所述Q个子频带中确定所述第一子频带，所述Q是正整数。

18.根据权利要求16所述的用户设备，其特征在于，所述第一接收模块还被用于接收第二信令所述第二信令被用于确定Q个子频带，所述第一子频带属于所述Q个子频带中之一，所述Q个子频带中的任意一个子频带包括正整数个连续的子载波，所述第一信令的监测者的特征ID被用于在所述Q个子频带中确定所述第一子频带，所述Q是正整数。

19.一种用于寻呼的基站设备，其特征在于，包括如下模块：

-第一发送模块：用于在X个时间间隔中的正整数个时间间隔中分别发送第一信令；

第二发送模块：用于发送第一无线信号；

其中，所述X是正整数，所述第一信令被用于确定所述第一无线信号的调度信息，所述调度信息包括所占用的时频资源、所采用的MCS中至少之一，所述第一无线信号携带寻呼消息；传输所述第一信令所使用的频域资源属于第一子频带，所述第一子频带在频域包括正整数个连续的子载波，所述第一子频带在频域的位置和所述第一子频带中所包括的子载波的子载波间隔被用于确定所述X个时间间隔。

20.根据权利要求19所述的基站设备，其特征在于，所述X个时间间隔中的任意一个时间间隔在时域都属于第一时间窗，所述第一时间窗的时间长度是预定义的，所述第一时间窗被分成Y个时间间隔，所述X个时间间隔是所述Y个时间间隔中的X个，所述Y是不小于X的正整数，所述第一子频带中所包括的子载波的子载波间隔被用于确定所述Y，所述第一信令的监测者的特征ID被用于在所述Y个时间间隔中确定所述X个时间间隔。

21.根据权利要求20所述的基站设备，其特征在于，所述第一时间窗属于Z个时间窗中之一，所述Z是大于1的整数；所述Z是预定义的；或者所述Z是可配置的；所述Z个时间窗中的任意两个时间窗的时间长度是相等的，所述第一信令的监测者的特征ID被用于在所述Z个时间窗中确定所述第一时间窗。

22.根据权利要求19至21中任一权利要求所述的基站设备，其特征在于，所述第一发送模块还被用于发送第二无线信号；所述第二无线信号被用于确定所述第一子频带在频域的位置、所述第一子频带中所包括的子载波的子载波间隔中至少之一。

23.根据权利要求19至21中任一权利要求所述的基站设备，其特征在于，所述第一发送模块还被用于发送第二信令；所述第二信令被用于确定Q个子频带，所述第一子频带属于所

述Q个子频带中之一，所述Q个子频带中的任意一个子频带包括正整数个连续的子载波，所述第一信令的监测者的特征ID被用于在所述Q个子频带中确定所述第一子频带，所述Q是正整数。

24.根据权利要求22所述的基站设备，其特征在于，所述第一发送模块还被用于发送第二信令；所述第二信令被用于确定Q个子频带，所述第一子频带属于所述Q个子频带中之一，所述Q个子频带中的任意一个子频带包括正整数个连续的子载波，所述第一信令的监测者的特征ID被用于在所述Q个子频带中确定所述第一子频带，所述Q是正整数。

一种被用于寻呼的用户设备、基站中的方法和装置

技术领域

[0001] 本申请涉及无线通信系统中的传输方案，特别是涉及支持多种数理结构(Numerology)的通信系统中的寻呼传输的方法和装置。

背景技术

[0002] 未来无线通信系统的应用场景越来越多元化，不同的应用场景对系统提出了不同的性能要求。为了满足多种应用场景的不同的性能需求，在3GPP(3rd Generation Partner Project，第三代合作伙伴项目)RAN(Radio Access Network，无线接入网)#72次全会上决定对新空口技术(NR，New Radio)进行研究。在3GPP RAN#75次全会上通过了5G新空口技术(NR)的工作项目(WI，Working Item)的立项，开始对5G新空口技术进行标准化。

[0003] 为了能够灵活适应多种不同的应用场景，未来的无线通信系统，特别是5G NR将可以支持多种数理结构(Numerology)，多种数理结构是指多种子载波间隔，多种符号时间长度，多种CP(Cyclic Prefix，循环前缀)长度等。为了能够简化系统的设计与用户设备实现的复杂度，针对不同的数理结构，整个系统物理层设计最好能够采用一种统一结构。

发明内容

[0004] 在现有LTE系统中，寻呼的传输时机统一通过PF(Paging Frame，寻呼帧)和PO(Paging Occasion，寻呼机会)来定义，其中PF为有可能传输寻呼消息的无线帧，而PO用来确定在PF的帧中有可能传输寻呼消息的子帧。LTE中的无线帧的时间长度为固定的10毫秒，子帧的时间长度为固定的1毫秒。由于一个LTE网络一般采用单一的数理结构(Numerology)或者数理结构在一个网络中基本长时间不变，采用固定时长的PF和PO来定义寻呼的可能时间可以在保证寻呼容量和不增加用户设备(UE，User Equipment)功率消耗的前提下，简化系统设计。在5G NR下，由于支持不同的数理结构，在一个给定的时长内，比如1毫秒，可能包含了多个基本的调度单元(比如时隙，Slot)，如果沿用现有的寻呼时机的设计，在这个1毫秒内用户设备针对不同的数理结构要对寻呼消息进行不同次数的检测，因而导致在某些数理结构下的功率消耗的大大增加。同时也会导致寻呼容量因为不同的数理结构的采用而相差巨大。

[0005] 为了解决上述在5G NR中当采用多种数理结构(Numerology)时的寻呼的设计问题，本申请提供了解决方案。该方案依据寻呼所采用的数理结构来确定寻呼的传输时机，从而保证在不同的数理结构下用户设备监测寻呼消息的复杂度和功耗相差不大，同时寻呼的容量也保持基本不变。需要说明的是，在不冲突的情况下，本申请的UE(User Equipment，用户设备)中的实施例和实施例中的特征可以应用到基站中，反之亦然。进一步的，在不冲突的情况下，本申请的实施例和实施例中的特征可以任意相互组合。

[0006] 本申请公开了一种用于寻呼的用户设备中的方法，其中，包括如下步骤：

[0007] -步骤A.在X个时间间隔中分别监测第一信令；

[0008] -步骤B.接收第一无线信号。

[0009] 其中，所述X是正整数，所述第一信令被用于确定所述第一无线信号的调度信息，所述调度信息包括{所占用的时频资源，所采用的MCS，所占用的频域资源中的子载波的子载波间隔}中至少之一，所述第一无线信号携带寻呼消息。传输所述第一信令所使用的频域资源属于第一子频带，所述第一子频带在频域包括正整数个连续的子载波，{所述第一子频带在频域的位置，所述第一子频带中所包括的子载波的子载波间隔}中至少之一被用于确定所述X个时间间隔。

[0010] 作为一个实施例，采用所述方法，所述用于设备可以依据传输寻呼所采用的子载波间隔来确定监测传输寻呼的时间间隔，节省功耗。

[0011] 作为一个实施例，所述方法设计了基于不同的子载波间隔的一致的寻呼时机的计算方式，同时当采用不同的子载波间隔传输寻呼消息时，保持寻呼容量不变。

[0012] 作为一个实施例，所述寻呼消息包括被寻呼的用户设备的特征ID。

[0013] 作为一个实施例，在所述X个时间间隔中的每一个时间间隔中针对所述第一信令最多执行P次检测，所述P是正整数。

[0014] 作为一个实施例，所述X个时间间隔中的任意两个时间间隔的时间长度相等。

[0015] 作为一个实施例，所述X个时间间隔中存在两个时间间隔的时间长度不等。

[0016] 作为一个实施例，所述X个时间间隔中的任意一个时间间隔为一个时隙(Slot)。

[0017] 作为一个实施例，所述X个时间间隔中的任意两个时间间隔的时间长度相等，所述X个时间间隔中的每个时间间隔的时间长度和所述第一频带中所包括的子载波的子载波间隔有关。

[0018] 作为一个实施例，所述X个时间间隔中的任意一个时间间隔为M个OFDM(Orthogonal Frequency Division Multiplexing，正交频分复用)符号，所述M为小于14的正整数。

[0019] 作为一个实施例，所述X个时间间隔中的任意一个时间间隔为M个OFDM(Orthogonal Frequency Division Multiplexing，正交频分复用)符号，所述M为小于7的正整数。

[0020] 作为一个实施例，所述X个时间间隔中的任意两个时间间隔在时域正交，所述正交是指不存在一个时间单元同时属于所述X个时间间隔中的任意两个时间间隔。

[0021] 作为一个实施例，所述X个时间间隔中存在两个时间间隔在时域是离散的。

[0022] 作为一个实施例，所述第一信令是物理层信令。

[0023] 作为一个实施例，所述第一信令是DCI(Downlink Control Information，下行控制信息)。

[0024] 作为一个实施例，所述第一信令通过PDCCH(Physical Downlink Control Channel，物理下行控制信道)传输。

[0025] 作为一个实施例，所述第一信令通过NR-PDCCH(New Radio Physical Downl ink Control Channel，新空口物理下行控制信道)传输。

[0026] 作为一个实施例，所述第一信令通过PDCCH(Physical Downlink Control Channel，物理下行控制信道)传输，所述PDCCH在CSS(Common Search Space，公共搜索空间)中传输。

[0027] 作为一个实施例，所述第一信令通过PDCCH(Physical Downlink Control

Channel，物理下行控制信道)传输，所述PDCCH在USS(UE-Specific Search Space，UE特定搜索空间)中传输。

[0028] 作为一个实施例，所述第一信令通过PDCCH(Physical Downlink Control Channel，物理下行控制信道)传输，所述PDCCH的CRC(Cyclic Redundancy Check，循环冗余校验)经过P-RNTI(Paging Radio Network Temporary Identity，寻呼无线网络临时标识)加扰。

[0029] 作为一个实施例，所述MCS(Modulation Coding Scheme，调制编码方式)包括的调制方式为{QPSK，16QAM，64QAM，256QAM，1024QAM}中之一。

[0030] 作为一个实施例，所述子载波间隔等于15kHz乘以2的K次幂，所述K为整数。

[0031] 作为一个实施例，所述第一子频带(Subband)包括12的正整数倍个子载波。

[0032] 作为一个实施例，所述第一子频带中包括的所有子载波的子载波间隔都相等。

[0033] 作为一个实施例，所述所述第一子频带在频域的位置是指所述第一子频带在所处的载波(Carrier)中的位置。

[0034] 作为一个实施例，所述所述第一子频带在频域的位置是指所述第一子频带在所处的载波(Carrier)在频域的位置。

[0035] 作为一个实施例，所述所述第一子频带在频域的位置是指所述第一子频带在所处的载波(Carrier)中的子频带索引。

[0036] 作为一个实施例，所述所述第一子频带在频域的位置是指所述第一子频带在所处的频带(Band)所对应的频率资源中的位置。

[0037] 作为一个实施例，所述第一子频带在频域的位置，所述第一子频带中所包括的子载波的子载波间隔中至少之一被所述用户设备用于确定所述X个时间间隔。

[0038] 作为一个实施例，所述第一子频带在频域的位置，所述第一子频带中所包括的子载波的子载波间隔中至少之一被所述用户设备基于给定映射规则确定所述X个时间间隔。

[0039] 作为一个实施例，所述第一无线信号通过DL-SCH(Downlink Shared Channel，下行共享信道)传输。

[0040] 作为一个实施例，所述第一无线信号通过PDSCH(Physical Downlink Shared Channel，物理下行共享信道)传输。

[0041] 作为一个实施例，第一比特块依次经过调制映射器(Modulation Mapper)，层映射器(Layer Mapper)，预编码(Precoding)，资源粒子映射器(Resource Element Mapper)，OFDM信号发生(Generation)之后得到所述第一无线信号。所述第一比特块包括一个码块经过信道编码之后的输出。作为一个子实施例，所述码块是TB(Transport Block，传输块)。作为一个子实施例，所述码块是TB(Transport Block，传输块)中的一部分。

[0042] 具体的，根据本申请的一个方面，上述方法的特征在于，所述X个时间间隔中的任意一个时间间隔在时域都属于第一时间窗，所述第一时间窗的时间长度是预定义的，所述第一时间窗被分成Y个时间间隔，所述X个时间间隔是所述Y个时间间隔中的X个，所述Y是不小于X的正整数，所述所述第一子频带中所包括的子载波的子载波间隔被用于确定所述Y，所述第一信令的监测者的特征ID被用于在所述Y个时间间隔中确定所述X个时间间隔。

[0043] 作为一个实施例，所述第一时间窗的时间长度是固定不变的。

[0044] 作为一个实施例，所述第一时间窗中包括正整数个时域连续的多载波符号。作为

一个子实施例，所述多载波符号包括数据符号和CP(Cyclic Prefix，循环前缀)。

[0045] 作为一个实施例，所述所述第一时间窗的时间长度为1毫秒。

[0046] 作为一个实施例，所述所述第一时间窗的时间长度为10毫秒。

[0047] 作为一个实施例，所述第一时间窗为一个子帧(Subframe)。

[0048] 作为一个实施例，所述第一时间窗为一个无线帧(Radio Frame)。

[0049] 作为一个实施例，所述Y个时间间隔中的任意两个时间间隔的时间长度相等。

[0050] 作为一个实施例，所述Y个时间间隔中存在两个时间间隔的时间长度不等。

[0051] 作为一个实施例，所述Y大于所述X。

[0052] 作为一个实施例，所述Y与所述所述第一频带中所包括的子载波的子载波间隔成正比。

[0053] 作为一个实施例，所述所述第一频带中所包括的子载波的子载波间隔被所述用户设备用于确定所述Y。

[0054] 作为一个实施例，所述所述第一频带中所包括的子载波的子载波间隔被所述用户设备基于给定的映射关系确定所述Y。

[0055] 作为一个实施例，所述所述第一信令的监测者的特征ID被所述用户设备用于在所述Y个时间间隔中确定所述X个时间间隔。

[0056] 作为一个实施例，所述所述第一信令的监测者的特征ID被所述用户设备基于给定的映射关系在所述Y个时间间隔中确定所述X个时间间隔。

[0057] 作为一个实施例，所述特征ID指IMSI(International Mobile Subscriber Identification Number国际移动用户识别码)。

[0058] 作为一个实施例，所述特征ID指IMSI(International Mobile Subscriber Identification Number国际移动用户识别码)对1024的余数。

[0059] 作为一个实施例，所述特征ID指IMSI(International Mobile Subscriber Identification Number国际移动用户识别码)对4096的余数。

[0060] 作为一个实施例，所述特征ID指IMSI(International Mobile Subscriber Identification Number国际移动用户识别码)对16384的余数。

[0061] 作为一个实施例，所述特征ID是指C-RNTI(Cell Radio Network Temporary Identity，小区无线网络临时标识)。

[0062] 作为一个实施例，所述第一信令的发送小区的物理小区ID被用于在所述Y个时间间隔中确定所述X个时间间隔。

[0063] 具体的，根据本申请的一个方面，上述方法的特征在于，所述第一时间窗属于Z个时间窗中之一，所述Z是大于1的整数。所述Z是预定义的；或者所述Z是可配置的。所述Z个时间窗中的任意两个时间窗的时间长度是相等的，所述所述第一信令的监测者的特征ID被用于在所述Z个时间窗中确定所述第一时间窗。

[0064] 作为一个实施例，所述Z等于10。

[0065] 作为一个实施例，所述Z个时间窗中的任意两个时间窗在时域正交。

[0066] 作为一个实施例，所述Z个时间窗中的任意一个时间窗为一个子帧，所述Z等于10.

[0067] 作为一个实施例，所述Z个时间窗中的任意一个时间窗为一个无线帧，所述Z等于非连续接收周期(DRX(Discontinuous Reception)cycle)所包含的无线帧的数量。

[0068] 作为一个实施例，所述步骤A还包括如下步骤：

[0069] 步骤A2.接收第三信令。

[0070] 其中，所述第三信令被用于配置所述Z。

[0071] 作为一个实施例，所述所述第一信令的监测者的特征ID被所述用户设备用于在所述Z个时间窗中确定所述第一时间窗。

[0072] 作为一个实施例，所述所述第一信令的监测者的特征ID被所述用户设备基于给定的映射关系在所述Z个时间窗中确定所述第一时间窗。

[0073] 作为一个实施例，所述Z个时间窗中的任意一个时间窗为一个无线帧，所述第一时间窗由下式得到：

[0074] SFN mod Z=(Z div N)*(UE_ID mod N)

[0075] 其中，SFN为所述第一时间窗对应的无线帧的帧号，N=min(Z,nB)，nB等于{4Z,2Z,Z,Z/2,Z/4,Z/8,Z/16,Z/32,Z/64,Z/128,Z/256,Z/512,Z/1024}中之一。

[0076] 具体的，根据本申请的一个方面，上述方法的特征在于，所述步骤A还包括如下步骤：

[0077] 步骤A0.接收第二无线信号。

[0078] 其中，所述第二无线信号被用于确定{所述所述第一子频带在频域的位置，所述所述第一子频带中所包括的子载波的子载波间隔}中至少之一。

[0079] 作为一个实施例，所述第二无线信号包括主同步信号(PSS，Primary Synchronization Signal)。

[0080] 作为一个实施例，所述第二无线信号包括辅同步信号(SSS，Secondary Synchronization Signal)。

[0081] 作为一个实施例，所述第二无线信号通过BCH(Broadcast Channel，广播信道)传输。

[0082] 作为一个实施例，所述第二无线信号通过PBCH(Physical Broadcast Channel，物理广播信道)传输。

[0083] 作为一个实施例，所述第二无线信号通过PDSCH(Physical Downlink Shared Channel，物理下行共享信道)传输。

[0084] 作为一个实施例，所述第二无线信号携带MIB(Master Information Block，主信息块)信息。

[0085] 作为一个实施例，所述第二无线信号携带SIB(System Information Block，系统信息块)信息。

[0086] 作为一个实施例，所述第二无线信号所携带的信息是被周期性传输的。

[0087] 作为一个实施例，所述第二无线所携带的信息是按需(On-Demand)传输的。

[0088] 作为一个实施例，所述第二无线信号携带第一信息，所述第一信息被用于确定{所述所述第一子频带在频域的位置，所述所述第一子频带中所包括的子载波的子载波间隔}中至少之一。

[0089] 作为一个实施例，所述第二无线信号携带第一信息，所述第一信息指示{所述所述第一子频带在频域的位置，所述所述第一子频带中所包括的子载波的子载波间隔}中至少之一。

[0090] 作为一个实施例，所述第二无线信号被所述用户设备用于确定{所述所述第一子频带在频域的位置，所述所述第一子频带中所包括的子载波的子载波间隔}中至少之一。

[0091] 作为一个实施例，所述第二无线信号指示{所述所述第一子频带在频域的位置，所述所述第一子频带中所包括的子载波的子载波间隔}中至少之一。

[0092] 具体的，根据本申请的一个方面，上述方法的特征在于，所述步骤A还包括如下步骤：

[0093] -步骤A1.接收第二信令。

[0094] 其中，所述第二信令被用于确定Q个子频带，所述第一子频带属于所述Q个子频带中之一，所述Q个子频带中的任意一个子频带包括正整数个连续的子载波，所述所述第一信令的监测者的特征ID被用于在所述Q个子频带中确定所述第一子频带，所述Q是正整数。

[0095] 作为一个实施例，所述Q个子频带中的任意一个子频带所包括的子载波的子载波间隔都相等。

[0096] 作为一个实施例，所述Q个子频带中任意两个子频带中的子载波的子载波间隔不同。

[0097] 作为一个实施例，所述Q个子频带中存在两个子频带中的子载波的子载波间隔相同。

[0098] 作为一个实施例，所述Q个子频带中任意两个子频带的频域带宽相同。

[0099] 作为一个实施例，所述Q个子频带中存在两个子频带的频域带宽不相等。

[0100] 作为一个实施例，所述Q个子频带都属于同一个载波(Carrier)。

[0101] 作为一个实施例，所述Q个子频带中存在两个子频带属于不同的载波(Carrier)。

[0102] 作为一个实施例，所述第二信令是高层信令。

[0103] 作为一个实施例，所述第二信令是物理层信令。

[0104] 作为一个实施例，所述第二信令是通过BCH(Broadcast Channel，广播信道)传输的。

[0105] 作为一个实施例，所述第二信令是通过PBCH(Physical Broadcast Channel，物理广播信道)传输的。

[0106] 作为一个实施例，所述第二信令是通过PDSCH(Physical Downlink Shared Channel，物理下行共享信道)传输的。

[0107] 作为一个实施例，所述第二信令是RRC(Radio Resource Control，无线资源控制)信令。

[0108] 作为一个实施例，所述第二信令是SIB(System Information Block，系统信息块)。

[0109] 作为一个实施例，所述第二信令是通过DCI传输的。

[0110] 作为一个实施例，所述所述第一信令的监测者的特征ID被所述用户设备用于在所述Q个子频带中确定所述第一子频带。

[0111] 作为一个实施例，所述所述第一信令的监测者的特征ID被所述用户设备基于给定的映射关系在所述Q个子频带中确定所述第一子频带。

[0112] 本申请公开了一种用于寻呼的基站中的方法，其中，包括如下步骤：

[0113] -步骤A.在X个时间间隔中的正整数个时间间隔中分别发送第一信令；

[0114] -步骤B.发送第一无线信号。

[0115] 其中，所述X是正整数，所述第一信令被用于确定所述第一无线信号的调度信息，所述调度信息包括所占用的时频资源，所采用的MCS，所占用的频域资源中的子载波的子载波间隔中至少之一，所述第一无线信号携带寻呼消息。传输所述第一信令所使用的频域资源属于第一子频带，所述第一子频带在频域包括正整数个连续的子载波，所述第一子频带在频域的位置，所述第一子频带中所包括的子载波的子载波间隔中至少之一被用于确定所述X个时间间隔。

[0116] 具体的，根据本申请的一个方面，上述方法的特征在于，所述X个时间间隔中的任意一个时间间隔在时域都属于第一时间窗，所述第一时间窗的时间长度是预定义的，所述第一时间窗被分成Y个时间间隔，所述X个时间间隔是所述Y个时间间隔中的X个，所述Y是不小于X的正整数，所述所述第一子频带中所包括的子载波的子载波间隔被用于确定所述Y，所述第一信令的监测者的特征ID被用于在所述Y个时间间隔中确定所述X个时间间隔。

[0117] 具体的，根据本申请的一个方面，上述方法的特征在于，所述第一时间窗属于Z个时间窗中之一，所述Z是大于1的整数。所述Z是预定义的；或者所述Z是可配置的。所述Z个时间窗中的任意两个时间窗的时间长度是相等的，所述所述第一信令的监测者的特征ID被用于在所述Z个时间窗中确定所述第一时间窗。

[0118] 具体的，根据本申请的一个方面，上述方法的特征在于，所述步骤A还包括如下步骤：

[0119] -步骤A0.发送第二无线信号。

[0120] 其中，所述第二无线信号被用于确定所述所述第一子频带在频域的位置，所述所述第一子频带中所包括的子载波的子载波间隔中至少之一。

[0121] 具体的，根据本申请的一个方面，上述方法的特征在于，所述步骤A还包括如下步骤：

[0122] -步骤A1.发送第二信令。

[0123] 其中，所述第二信令被用于确定Q个子频带，所述第一子频带属于所述Q个子频带中之一，所述Q个子频带中的任意一个子频带包括正整数个连续的子载波，所述所述第一信令的监测者的特征ID被用于在所述Q个子频带中确定所述第一子频带，所述Q是正整数。

[0124] 本申请公开了一种用于寻呼的用户设备，其中，包括如下模块：

[0125] -第一接收模块：用于在X个时间间隔中分别监测第一信令；

[0126] -第二接收模块：用于接收第一无线信号。

[0127] 其中，所述X是正整数，所述第一信令被用于确定所述第一无线信号的调度信息，所述调度信息包括所占用的时频资源，所采用的MCS，所占用的频域资源中的子载波的子载波间隔中至少之一，所述第一无线信号携带寻呼消息。传输所述第一信令所使用的频域资源属于第一子频带，所述第一子频带在频域包括正整数个连续的子载波，所述第一子频带在频域的位置，所述第一子频带中所包括的子载波的子载波间隔中至少之一被用于确定所述X个时间间隔。

[0128] 具体的，根据本申请的一个方面，上述用户设备的特征在于，所述X个时间间隔中的任意一个时间间隔在时域都属于第一时间窗，所述第一时间窗的时间长度是预定义的，所述第一时间窗被分成Y个时间间隔，所述X个时间间隔是所述Y个时间间隔中的X个，所述Y

是不小于X的正整数，所述所述第一子频带中所包括的子载波的子载波间隔被用于确定所述Y，所述第一信令的监测者的特征ID被用于在所述Y个时间间隔中确定所述X个时间间隔。

[0129] 具体的，根据本申请的一个方面，上述用户设备的特征在于，所述第一时间窗属于Z个时间窗中之一，所述Z是大于1的整数。所述Z是预定义的；或者所述Z是可配置的。所述Z个时间窗中的任意两个时间窗的时间长度是相等的，所述所述第一信令的监测者的特征ID被用于在所述Z个时间窗中确定所述第一时间窗。

[0130] 具体的，根据本申请的一个方面，上述用户设备的特征在于，所述第一接收模块还被用于接收第二无线信号。所述第二无线信号被用于确定{所述所述第一子频带在频域的位置，所述所述第一子频带中所包括的子载波的子载波间隔}中至少之一。

[0131] 具体的，根据本申请的一个方面，上述用户设备的特征在于，所述第一接收模块还被用于接收第二信令。所述第二信令被用于确定Q个子频带，所述第一子频带属于所述Q个子频带中之一，所述Q个子频带中的任意一个子频带包括正整数个连续的子载波，所述所述第一信令的监测者的特征ID被用于在所述Q个子频带中确定所述第一子频带，所述Q是正整数。

[0132] 本申请公开了一种用于寻呼的基站设备，其中，包括如下模块：

[0133] -第一发送模块：用于在X个时间间隔中的正整数个时间间隔中分别发送第一信令；

[0134] -第二发送模块：用于发送第一无线信号。

[0135] 其中，所述X是正整数，所述第一信令被用于确定所述第一无线信号的调度信息，所述调度信息包括{所占用的时频资源，所采用的MCS，所占用的频域资源中的子载波的子载波间隔}中至少之一，所述第一无线信号携带寻呼消息。传输所述第一信令所使用的频域资源属于第一子频带，所述第一子频带在频域包括正整数个连续的子载波，{所述第一子频带在频域的位置，所述第一子频带中所包括的子载波的子载波间隔}中至少之一被用于确定所述X个时间间隔。

[0136] 具体的，根据本申请的一个方面，上述基站设备的特征在于，所述X个时间间隔中的任意一个时间间隔在时域都属于第一时间窗，所述第一时间窗的时间长度是预定义的，所述第一时间窗被分成Y个时间间隔，所述X个时间间隔是所述Y个时间间隔中的X个，所述Y是不小于X的正整数，所述所述第一子频带中所包括的子载波的子载波间隔被用于确定所述Y，所述第一信令的监测者的特征ID被用于在所述Y个时间间隔中确定所述X个时间间隔。

[0137] 具体的，根据本申请的一个方面，上述基站设备的特征在于，所述第一时间窗属于Z个时间窗中之一，所述Z是大于1的整数。所述Z是预定义的；或者所述Z是可配置的。所述Z个时间窗中的任意两个时间窗的时间长度是相等的，所述所述第一信令的监测者的特征ID被用于在所述Z个时间窗中确定所述第一时间窗。

[0138] 具体的，根据本申请的一个方面，上述基站设备的特征在于，所述第一发送模块还被用于发送第二无线信号。所述第二无线信号被用于确定{所述所述第一子频带在频域的位置，所述所述第一子频带中所包括的子载波的子载波间隔}中至少之一。

[0139] 具体的，根据本申请的一个方面，上述基站设备的特征在于，所述第一发送模块还被用于发送第二信令。所述第二信令被用于确定Q个子频带，所述第一子频带属于所述Q个子频带中之一，所述Q个子频带中的任意一个子频带包括正整数个连续的子载波，所述所述

第一信令的监测者的特征ID被用于在所述Q个子频带中确定所述第一子频带，所述Q是正整数。

附图说明

[0140] 通过阅读参照以下附图所作的对非限制性实施例所作的详细描述，本申请的其它特征、目的和优点将会变得更加明显：

[0141] 图1示出了根据本申请的一个实施例的无线信号传输流程图；

[0142] 图2示出了根据本申请的一个实施例的Z个时间窗和Q个子频带的关系的示意图；

[0143] 图3示出了根据本申请的一个实施例的第一时间窗与X个时间间隔的关系的示意图；

[0144] 图4示出了根据本申请的一个实施例的第一信令，第一无线信号和第二无线信号之间的关系的示意图；

[0145] 图5示出了根据本申请的一个实施例的用户设备(UE)中的处理装置的结构框图；

[0146] 图6示出了根据本申请的一个实施例的基站中的处理装置的结构框图；

具体实施方式

[0147] 下文将结合附图对本申请的技术方案作进一步详细说明，需要说明的是，在不冲突的情况下，本申请的实施例和实施例中的特征可以任意相互组合。

[0148] 实施例1

[0149] 实施例1示例了根据本申请的一个实施例的无线信号传输流程图，如附图1所示。附图1中，基站N1是UE U2的服务小区的维持基站，虚线框F1中标识的步骤是可选的。

[0150] 对于基站N1，在步骤S11中发送第二无线信号，在步骤S12中发送第二信令，在步骤S13中在X个时间间隔中的正整数个时间间隔中分别发送第一信令，在步骤S14中发送第一无线信号。

[0151] 对于UE U2，在步骤S21中接收第二无线信号，在步骤S22中接收第二信令，在步骤S23中在X个时间间隔中分别监测第一信令，在步骤S24中接收第一无线信号。

[0152] 在实施例1中，所述X是正整数，所述第一信令被用于确定所述第一无线信号的调度信息，所述调度信息包括{所占用的时频资源，所采用的MCS，所占用的频域资源中的子载波的子载波间隔}中至少之一，所述第一无线信号携带寻呼消息，传输所述第一信令所使用的频域资源属于第一子频带，所述第一子频带在频域包括正整数个连续的子载波，{所述第一子频带在频域的位置，所述第一子频带中所包括的子载波的子载波间隔}中至少之一被用于确定所述X个时间间隔。所述第二无线信号被用于确定{所述所述第一子频带在频域的位置，所述所述第一子频带中所包括的子载波的子载波间隔}中至少之一。所述第二信令被用于确定Q个子频带，所述第一子频带属于所述Q个子频带中之一，所述Q个子频带中的任意一个子频带包括正整数个连续的子载波，所述所述第一信令的监测者的特征ID被用于在所述Q个子频带中确定所述第一子频带，所述Q是正整数。

[0153] 在实施例1的子实施例1中，所述X个时间间隔中的任意一个时间间隔在时域都属于第一时间窗，所述第一时间窗的时间长度是预定义的，所述第一时间窗被分成Y个时间间隔，所述X个时间间隔是所述Y个时间间隔中的X个，所述Y是不小于X的正整数，所述所述第

子频带中所包括的子载波的子载波间隔被用于确定所述Y，所述第一信令的监测者的特征ID被用于在所述Y个时间间隔中确定所述X个时间间隔。

[0154] 在实施例1的子实施例2中，所述第一时间窗属于Z个时间窗中之一，所述Z是大于1的整数。所述Z是预定义的；或者所述Z是可配置的。所述Z个时间窗中的任意两个时间窗的时间长度是相等的，所述所述第一信令的监测者的特征ID被用于在所述Z个时间窗中确定所述第一时间窗。

[0155] 在实施例1的子实施例3中，所述寻呼消息包括被寻呼的用户设备的特征ID。

[0156] 在实施例1的子实施例4中，所述MCS(Modulation Coding Scheme，调制编码方式)包括的调制方式为{QPSK，16QAM，64QAM，256QAM，1024QAM}中之一。

[0157] 在实施例1的子实施例5中，所述子载波间隔等于15kHz乘以2的K次幂，所述K为整数。

[0158] 在实施例1的子实施例6中，所述第一子频带(Subband)包括12的正整数倍个子载波。

[0159] 在实施例1的子实施例7中，所述第一子频带中包括的所有子载波的子载波间隔都相等。

[0160] 在实施例1的子实施例8中，所述所述第一子频带在频域的位置是指所述第一子频带在所处的载波(Carrier)中的位置。

[0161] 在实施例1的子实施例9中，所述所述第一子频带在频域的位置是指所述第一子频带所处的载波(Carrier)在频域的位置。

[0162] 在实施例1的子实施例10中，所述所述第一子频带在频域的位置是指所述第一子频带在所处的载波(Carrier)中的子频带索引。

[0163] 在实施例1的子实施例11中，所述所述第一子频带在频域的位置是指所述第一子频带在所处的频带(Band)所对应的频率资源中的位置。

[0164] 在实施例1的子实施例12中，所述第二信令是高层信令。

[0165] 在实施例1的子实施例13中，所述第二信令是物理层信令。

[0166] 在实施例1的子实施例14中，所述第二信令是通过BCH(Broadcast Channel，广播信道)传输的。

[0167] 在实施例1的子实施例15中，所述第二信令是通过PBCH(Physical Broadcast Channel，物理广播信道)传输的。

[0168] 在实施例1的子实施例16中，所述第二信令是通过PDSCH(Physical Downlink Shared Channel，物理下行共享信道)传输的。

[0169] 在实施例1的子实施例17中，所述第二信令是RRC(Radio Resource Control，无线资源控制)信令。

[0170] 在实施例1的子实施例18中，所述第二信令是SIB(System Information Block，系统信息块)。

[0171] 在实施例1的子实施例19中，所述第二信令是通过DCI传输的。

[0172] 实施例2

[0173] 实施例2示例了根据本申请的一个实施例的Z个时间窗和Q个子频带的关系的示意图，如附图2所示。附图2中，横轴代表时间，纵轴代表频率，每个矩形代表一个时间间隔，斜

线填充的矩形代表UE#1在时间窗#a中所监测的X1个时间间隔，十字线填充的矩形代表UE#2在时间窗#b中所监测的X2个时间间隔，斜线交叉线填充的矩形代表UE#3在时间窗#c中所监测的X3个时间间隔。

[0174] 在实施例2中，对于UE#1，在X1个时间间隔中分别监测第一信令，传输所述第一信令所使用的频域资源属于子频带#1，所述子频带#1在频域包括正整数个连续的子载波，所述子频带#1在频域的位置，所述子频带#1所包括的子载波的子载波间隔1中至少之一被用于确定所述X1个时间间隔。所述X1个时间间隔中的任意一个时间间隔在时域都属于时间窗#a，所述时间窗#a的时间长度是预定义的，所述时间窗#a被分成Y1个时间间隔，所述X1个时间间隔是所述Y1个时间间隔中的X1个，所述Y1是不小于X1的正整数，所述所述子频带#1中所包括的子载波的子载波间隔被用于确定所述Y1，所述UE#1的特征ID被用于在所述Y1个时间间隔中确定所述X1个时间间隔。所述时间窗#a属于Z个时间窗中之一，所述Z是大于1的整数。所述Z是预定义的；或者所述Z是可配置的。所述Z个时间窗中的任意两个时间窗的时间长度是相等的，所述所述UE#1的特征ID被用于在所述Z个时间窗中确定所述时间窗#a。所述子频带#1属于所述Q个子频带中之一，所述Q个子频带中的任意一个子频带包括正整数个连续的子载波，所述所述UE#1的特征ID被用于在所述Q个子频带中确定所述子频带#1，所述Q是正整数。

[0175] 在实施例2的子实施例1中，所述Z等于10。

[0176] 在实施例2的子实施例2中，所述Z个时间窗中的任意两个时间窗在时域正交。

[0177] 在实施例2的子实施例3中，所述Z个时间窗中的任意一个时间窗为一个子帧，所述Z等于10。

[0178] 在实施例2的子实施例4中，所述Z个时间窗中的任意一个时间窗为一个无线帧，所述Z等于非连续接收周期(DRX(Discontinuous Reception)cycle)所包含的无线帧的数量。

[0179] 在实施例2的子实施例5中，所述Z个时间窗中的任意一个时间窗为一个无线帧，所述时间窗#a由下式得到：

[0180] SFN mod Z=(Z div N)*(UE_ID mod N)

[0181] 其中，SFN为所述时间窗#a对应的无线帧的帧号，N=min(Z,nB)，nB等于{4Z,2Z,Z,Z/2,Z/4,Z/8,Z/16,Z/32,Z/64,Z/128,Z/256,Z/512,Z/1024}中之一。

[0182] 在实施例2的子实施例6中，所述Q个子频带中的任意一个子频带所包括的子载波的子载波间隔都相等。

[0183] 在实施例2的子实施例7中，所述Q个子频带中任意两个子频带中的子载波的子载波间隔不同。

[0184] 在实施例2的子实施例8中，所述Q个子频带中存在两个子频带中的子载波的子载波间隔相同。

[0185] 在实施例2的子实施例9中，所述Q个子频带中任意两个子频带的频域带宽相同。

[0186] 在实施例2的子实施例10中，所述Q个子频带中存在两个子频带的频域带宽不相等。

[0187] 在实施例2的子实施例11中，所述Q个子频带都属于同一个载波(Carrier)。

[0188] 在实施例2的子实施例12中，所述Q个子频带中存在两个子频带属于不同的载波(Carrier)。

[0189] 实施例3

[0190] 实施例3示例了根据本申请的一个实施例的第一时间窗与X个时间间隔的关系的示意图，如附图3所示。在附图3中，列出了依据不同的Y值和不同的UE的特征ID，X=1个时间间隔在第一时间窗中的索引。

[0191] 在实施例3中，UE在X个时间间隔中分别监测第一信令，所述X个时间间隔中的任意一个时间间隔在时域都属于第一时间窗，所述第一时间窗的时间长度是预定义的，所述第一时间窗被分成Y个时间间隔，所述X个时间间隔是所述Y个时间间隔中的X个，所述Y是不小于X的正整数，所述所述第一子频带中所包括的子载波的子载波间隔被用于确定所述Y，所述UE的特征ID被用于在所述Y个时间间隔中确定所述X个时间间隔。

[0192] 在实施例3的子实施例1中，在所述X个时间间隔中的每一个时间间隔中针对所述第一信令最多执行P次检测，所述P是正整数。

[0193] 在实施例3的子实施例2中，所述X个时间间隔中的任意两个时间间隔的时间长度相等。

[0194] 在实施例3的子实施例3中，所述X个时间间隔中存在两个时间间隔的时间长度不等。

[0195] 在实施例3的子实施例4中，所述X个时间间隔中的任意一个时间间隔为一个时隙(Slot)。

[0196] 在实施例3的子实施例5中，所述X个时间间隔中的任意两个时间间隔的时间长度相等，所述X个时间间隔中的每个时间间隔的时间长度和所述第一频带中所包括的子载波的子载波间隔有关。

[0197] 在实施例3的子实施例6中，所述X个时间间隔中的任意一个时间间隔为M个OFDM(Orthogonal Frequency Division Multiplexing，正交频分复用)符号，所述M为小于14的正整数。

[0198] 在实施例3的子实施例7中，所述X个时间间隔中的任意一个时间间隔为M个OFDM(Orthogonal Frequency Division Multiplexing，正交频分复用)符号，所述M为小于7的正整数。

[0199] 在实施例3的子实施例8中，所述X个时间间隔中的任意两个时间间隔在时域正交，所述正交是指不存在一个时间单元同时属于所述X个时间间隔中的任意两个时间间隔。

[0200] 在实施例3的子实施例9中，所述X个时间间隔中存在两个时间间隔在时域是离散的。

[0201] 在实施例3的子实施例10中，所述第一时间窗的时间长度是固定不变的。

[0202] 在实施例3的子实施例11中，所述第一时间窗中包括正整数个时域连续的多载波符号。作为一个子实施例，所述多载波符号包括数据符号和CP(Cyclic Prefix，循环前缀)。

[0203] 在实施例3的子实施例12中，所述所述第一时间窗的时间长度为1毫秒。

[0204] 在实施例3的子实施例13中，所述所述第一时间窗的时间长度为10毫秒。

[0205] 在实施例3的子实施例14中，所述第一时间窗为一个子帧(Subframe)。

[0206] 在实施例3的子实施例15中，所述第一时间窗为一个无线帧(Radio Frame)。

[0207] 在实施例3的子实施例16中，所述Y个时间间隔中的任意两个时间间隔的时间长度相等。

[0208] 在实施例3的子实施例17中，所述Y与所述所述第一频带中所包括的子载波的子载波间隔成正比。

[0209] 在实施例3的子实施例18中，所述特征ID指IMSI(International Mobile Subscriber Identification Number国际移动用户识别码)。

[0210] 在实施例3的子实施例19中，所述特征ID指IMSI(International Mobile Subscriber Identification Number国际移动用户识别码)对1024的余数。

[0211] 在实施例3的子实施例20中，所述特征ID指IMSI(International Mobile Subscriber Identification Number国际移动用户识别码)对4096的余数。

[0212] 在实施例3的子实施例21中，所述特征ID指IMSI(International Mobile Subscriber Identification Number国际移动用户识别码)对16384的余数。

[0213] 在实施例3的子实施例22中，所述特征ID是指C-RNTI(Cell Radio Network Temporary Identity，小区无线网络临时标识)。

[0214] 实施例4

[0215] 实施例4示例了根据本申请的一个实施例的第一信令，第一无线信号和第二无线信号之间的关系的示意图，如附图4所示。附图4中，横轴代表时间，纵轴代表频率，斜线填充的矩形代表传输第二无线信号所占用的时频资源，十字线填充的矩形代表传输第一信令所占用的时频资源，斜线交叉线填充的矩形代表传输第一无线信号所占用的时频资源，虚线箭头代表了特定的使用关系。

[0216] 在实施例4中，第一信令被用于确定第一无线信号的调度信息，所述调度信息包括{所占用的时频资源，所采用的MCS，所占用的频域资源中的子载波的子载波间隔}中至少之一，传输所述第一信令所使用的频域资源属于第一子频带，所述第一子频带在频域包括正整数个连续的子载波。第二无线信号被用于确定{所述第一子频带在频域的位置，所述第一子频带中所包括的子载波的子载波间隔}中至少之一。

[0217] 在实施例4的子实施例1中，所述第一信令是物理层信令。

[0218] 在实施例4的子实施例2中，所述第一信令是DCI(Downlink Control Information，下行控制信息)。

[0219] 在实施例4的子实施例3中，所述第一信令通过NR-PDCCH(New Radio Physical Downlink Control Channel，新空口物理下行控制信道)传输。

[0220] 在实施例4的子实施例4中，所述第一信令通过PDCCH(Physical Downlink Control Channel，物理下行控制信道)传输，所述PDCCH的CRC(Cyclic Redundancy Check，循环冗余校验)经过P-RNTI(Paging Radio Network Temporary Identity，寻呼无线网络临时标识)加扰。

[0221] 在实施例4的子实施例5中，所述第一无线信号通过DL-SCH(Downlink Shared Channel，下行共享信道)传输。

[0222] 在实施例4的子实施例6中，所述第一无线信号通过PDSCH(Physical Downlink Shared Channel，物理下行共享信道)传输。

[0223] 在实施例4的子实施例7中，第一比特块依次经过调制映射器(Modulation Mapper)，层映射器(Layer Mapper)，预编码(Precoding)，资源粒子映射器(Resource Element Mapper)，OFDM信号发生(Generation)之后得到所述第一无线信号。所述第一比特

块包括一个码块经过信道编码之后的输出。作为一个子实施例，所述码块是TB(Transport Block，传输块)。作为一个子实施例，所述码块是TB(Transport Block，传输块)中的一部分。

[0224] 在实施例4的子实施例8中，所述第一无线信号包括主同步信号(PSS，Primary Synchronization Signal)。

[0225] 在实施例4的子实施例9中，所述第一无线信号包括辅同步信号(SSS，Secondary Synchronization Signal)。

[0226] 在实施例4的子实施例10中，所述第二无线信号通过BCH(Broadcast Channel，广播信道)传输。

[0227] 在实施例4的子实施例11中，所述第二无线信号通过PBCH(Physical Broadcast Channel，物理广播信道)传输。

[0228] 在实施例4的子实施例12中，所述第二无线信号携带MIB(Master Information Block，主信息块)信息。

[0229] 在实施例4的子实施例13中，所述第二无线信号携带SIB(System Information Block，系统信息块)信息。

[0230] 在实施例4的子实施例14中，所述第二无线信号所携带的信息是被周期性传输的。

[0231] 在实施例4的子实施例15中，所述第二无线所携带的信息是按需(On-Demand)传输的。

[0232] 在实施例4的子实施例16中，所述第二无线信号携带第一信息，所述第一信息被用于确定{所述所述第一子频带在频域的位置，所述所述第一子频带中所包括的子载波的子载波间隔}中至少之一。

[0233] 在实施例4的子实施例17中，所述第二无线信号携带第一信息，所述第一信息指示{所述所述第一子频带在频域的位置，所述所述第一子频带中所包括的子载波的子载波间隔}中至少之一。

[0234] 实施例5

[0235] 实施例5示例了一个用户设备中的处理装置的结构框图，如附图5所示。附图5中，用户设备处理装置100主要由第一接收模块101和第二接收模块102组成。

[0236] 在实施例5中，第一接收模块101被用于在X个时间间隔中分别监测第一信令，第二接收模块102被用于接收第一无线信号。其中，所述X是正整数，所述第一信令被用于确定所述第一无线信号的调度信息，所述调度信息包括{所占用的时频资源，所采用的MCS，所占用的频域资源中的子载波的子载波间隔}中至少之一，所述第一无线信号携带寻呼消息。传输所述第一信令所使用的频域资源属于第一子频带，所述第一子频带在频域包括正整数个连续的子载波，{所述第一子频带在频域的位置，所述第一子频带中所包括的子载波的子载波间隔}中至少之一被用于确定所述X个时间间隔。

[0237] 在实施例5的子实施例1中，所述X个时间间隔中的任意一个时间间隔在时域都属于第一时间窗，所述第一时间窗的时间长度是预定义的，所述第一时间窗被分成Y个时间间隔，所述X个时间间隔是所述Y个时间间隔中的X个，所述Y是不小于X的正整数，所述所述第一子频带中所包括的子载波的子载波间隔被用于确定所述Y，所述第一信令的监测者的特征ID被用于在所述Y个时间间隔中确定所述X个时间间隔。

[0238] 在实施例5的子实施例2中，所述第一时间窗属于Z个时间窗中之一，所述Z是大于1的整数。所述Z是预定义的；或者所述Z是可配置的。所述Z个时间窗中的任意两个时间窗的时间长度是相等的，所述所述第一信令的监测者的特征ID被用于在所述Z个时间窗中确定所述第一时间窗。

[0239] 在实施例5的子实施例3中，第一接收模块101还被用于接收第二无线信号。所述第二无线信号被用于确定{所述所述第一子频带在频域的位置，所述所述第一子频带中所包括的子载波的子载波间隔}中至少之一。

[0240] 在实施例5的子实施例4中，第一接收模块101还被用于接收第二信令。所述第二信令被用于确定Q个子频带，所述第一子频带属于所述Q个子频带中之一，所述Q个子频带中的任意一个子频带包括正整数个连续的子载波，所述所述第一信令的监测者的特征ID被用于在所述Q个子频带中确定所述第一子频带，所述Q是正整数。

[0241] 实施例6

[0242] 实施例6示例了一个基站设备中的处理装置的结构框图，如附图6所示。在附图6中，基站处理装置200主要由第一发送模块201和第二发送模块202组成。

[0243] 在实施例6中，第一发送模块201被用于在X个时间间隔中的正整数个时间间隔中分别发送第一信令，第二发送模块202被用于发送第一无线信号。其中，所述X是正整数，所述第一信令被用于确定所述第一无线信号的调度信息，所述调度信息包括{所占用的时频资源，所采用的MCS，所占用的频域资源中的子载波的子载波间隔}中至少之一，所述第一无线信号携带寻呼消息。传输所述第一信令所使用的频域资源属于第一子频带，所述第一子频带在频域包括正整数个连续的子载波，{所述第一子频带在频域的位置，所述第一子频带中所包括的子载波的子载波间隔}中至少之一被用于确定所述X个时间间隔。

[0244] 在实施例6的子实施例1中，所述X个时间间隔中的任意一个时间间隔在时域都属于第一时间窗，所述第一时间窗的时间长度是预定义的，所述第一时间窗被分成Y个时间间隔，所述X个时间间隔是所述Y个时间间隔中的X个，所述Y是不小于X的正整数，所述所述第一子频带中所包括的子载波的子载波间隔被用于确定所述Y，所述第一信令的监测者的特征ID被用于在所述Y个时间间隔中确定所述X个时间间隔。

[0245] 在实施例6的子实施例2中，所述第一时间窗属于Z个时间窗中之一，所述Z是大于1的整数。所述Z是预定义的；或者所述Z是可配置的。所述Z个时间窗中的任意两个时间窗的时间长度是相等的，所述所述第一信令的监测者的特征ID被用于在所述Z个时间窗中确定所述第一时间窗。

[0246] 在实施例6的子实施例3中，第一发送模块201还被用于发送第二无线信号。所述第二无线信号被用于确定{所述所述第一子频带在频域的位置，所述所述第一子频带中所包括的子载波的子载波间隔}中至少之一。

[0247] 在实施例6的子实施例4中，第一发送模块201还被用于发送第二信令。所述第二信令被用于确定Q个子频带，所述第一子频带属于所述Q个子频带中之一，所述Q个子频带中的任意一个子频带包括正整数个连续的子载波，所述所述第一信令的监测者的特征ID被用于在所述Q个子频带中确定所述第一子频带，所述Q是正整数。

[0248] 本领域普通技术人员可以理解上述方法中的全部或部分步骤可以通过程序来指令相关硬件完成，所述程序可以存储于计算机可读存储介质中，如只读存储器，硬盘或者光

盘等。可选的，上述实施例的全部或部分步骤也可以使用一个或者多个集成电路来实现。相应的，上述实施例中的各模块单元，可以采用硬件形式实现，也可以由软件功能模块的形式实现，本申请不限于任何特定形式的软件和硬件的结合。本申请中的UE或者终端包括但不限于手机，平板电脑，笔记本，上网卡，低功耗设备，eMTC设备，NB-IoT设备，无人机，遥控飞机，车载通信设备等无线通信设备。本申请中的基站或者网络侧设备包括但不限于宏蜂窝基站，微蜂窝基站，家庭基站，中继基站，eNB，gNB，传输接收节点TRP等无线通信设备。

[0249] 以上所述，仅为本申请的较佳实施例而已，并非用于限定本申请的保护范围。凡在本申请的精神和原则之内，所做的任何修改，等同替换，改进等，均应包含在本申请的保护范围之内。

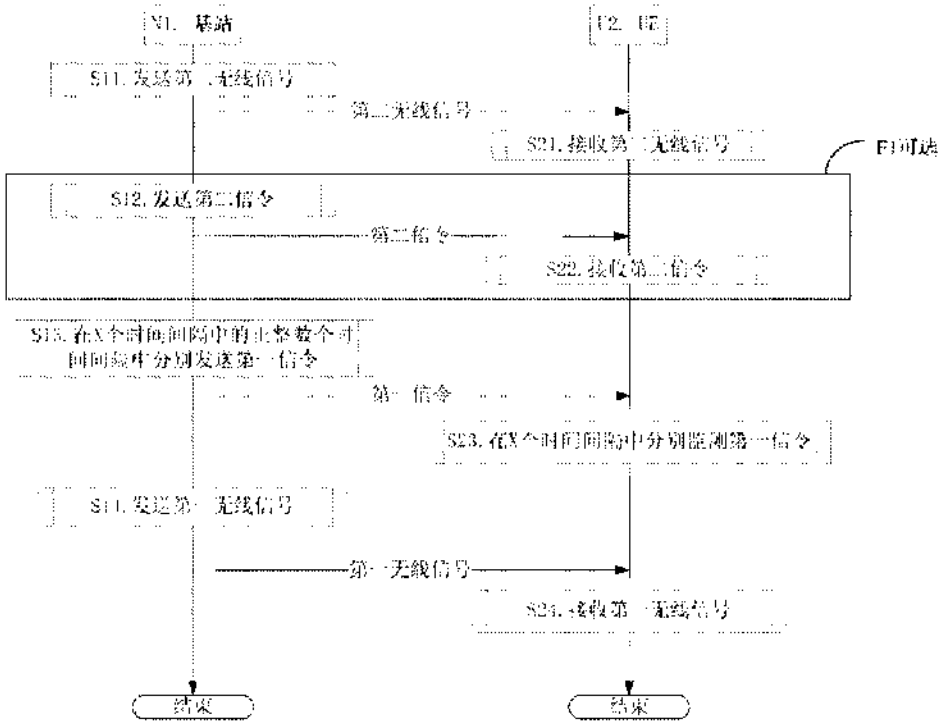

N1. 基站
F2. UE
S11. 发送第一无线信号
第二无线信号
S21. 接收第一无线信号
F1可选
S12. 发送第二信令
第二信令
S22. 接收第二信令
S13. 在X个时间间隔中的x个时间间隔中分别发送第一信令
第一信令
S23. 在X个时间间隔中分别监测第一信令
S11. 发送第一无线信号
第一无线信号
S24. 接收第一无线信号
结束
结束

图1

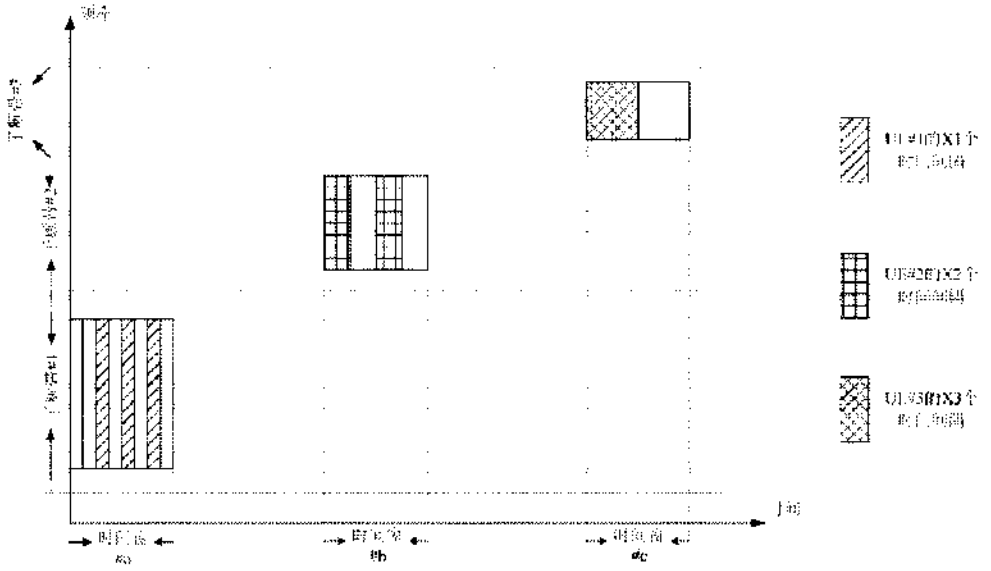


图2

	X=1 个时间间隔在第一时间窗中的索引			
	特征 ID = a	特征 ID = b	特征 ID = c	特征 ID = d
Y=1	0	0	0	0
Y=2	0	1	0	1
Y=4	0	1	2	3
Y=8	1	3	5	7
Y=16	2	6	10	14

图3

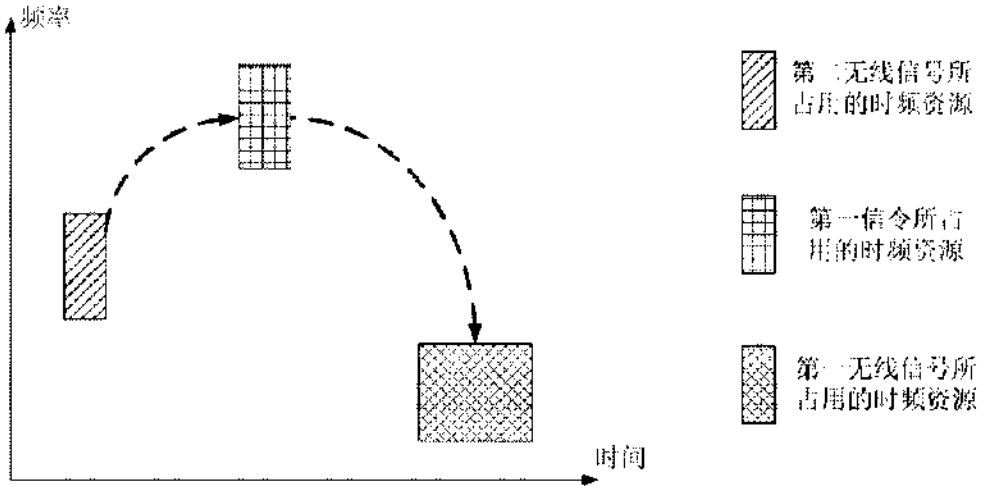

频率
时间
第二无线信号所占用的时频资源
第一信令所占用的时频资源
第一无线信号所占用的时频资源

图4

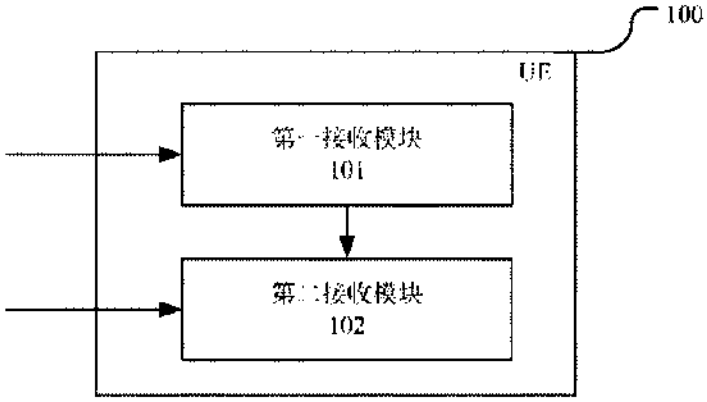

100
UE
第一接收模块
101
第二接收模块
102

图5

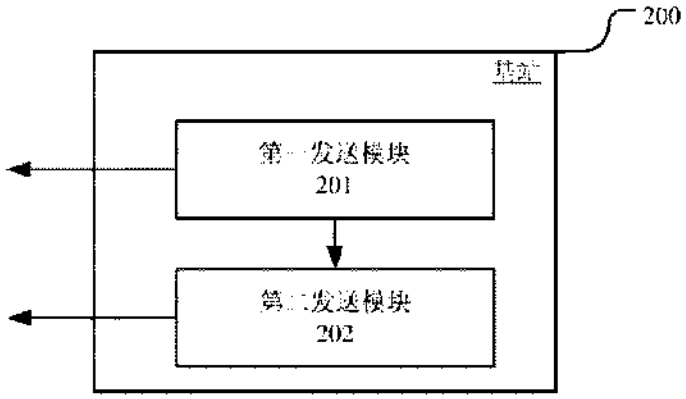


图6

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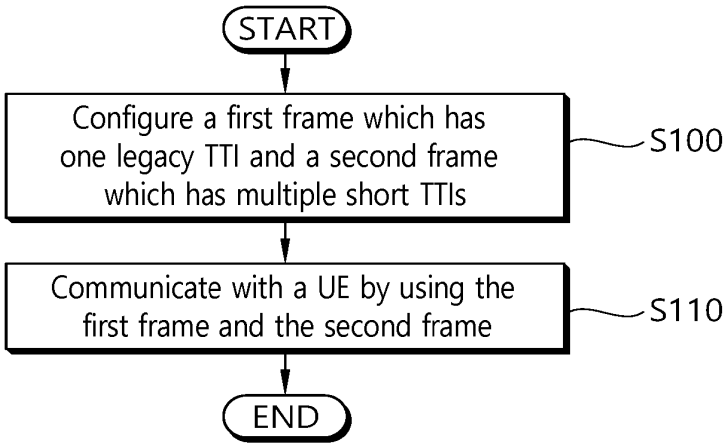
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(54) Title: METHOD AND APPARATUS FOR CONFIGURING FRAME STRUCTURE FOR NEW RADIO ACCESS TECHNOLOGY IN WIRELESS COMMUNICATION SYSTEM



(57) Abstract: A frame structure for a new radio access technology (RAT) is configured by a network node. The network node configures a first frame which has one legacy transmission time interval (TTI) and a second frame which has multiple short TTIs, and communicates with a user equipment (UE) by using at least one of the first frame and the second frame. The UE may be a one of a massive machine-type communication (mMTC) UE, an ultra-reliable and low latency communication (URLLC) UE or an enhanced vehicle-to-everything (eV2X) UE.

WO 2017/171398 A1

Description

Title of Invention: METHOD AND APPARATUS FOR CONFIGURING FRAME STRUCTURE FOR NEW RADIO ACCESS TECHNOLOGY IN WIRELESS COMMUNICATION SYSTEM

Technical Field

[1] The present invention relates to wireless communications, and more particularly, to a method and apparatus for configuring a frame structure for a new ratio access technology (RAT) in a wireless communication system.

Background Art

[2] 3rd generation partnership project (3GPP) long-term evolution (LTE) is a technology for enabling high-speed packet communications. Many schemes have been proposed for the LTE objective including those that aim to reduce user and provider costs, improve service quality, and expand and improve coverage and system capacity. The 3GPP LTE requires reduced cost per bit, increased service availability, flexible use of a frequency band, a simple structure, an open interface, and adequate power consumption of a terminal as an upper-level requirement.

[3] As more and more communication devices require more communication capacity, there is a need for improved mobile broadband communication over existing radio access technology. Also, massive machine type communications (MTC), which provides various services by connecting many devices and objects, is one of the major issues to be considered in the next generation communication. In addition, communication system design considering reliability/latency sensitive service/UE is being discussed. The introduction of next generation radio access technology considering enhanced mobile broadband communication, massive MTC, ultra-reliable and low latency communication (URLLC) is discussed. This new technology may be called new radio access technology (RAT) for convenience.

[4] In the new RAT, analog beamforming may be introduced. In case of millimeter wave (mmW), the wavelength is shortened so that a plurality of antennas can be installed in the same area. For example, in the 30 GHz band, a total of 100 antenna elements can be installed in a 2-dimension array of 0.5 lambda (wavelength) intervals on a panel of 5 by 5 cm with a wavelength of 1 cm. Therefore, in mmW, multiple antenna elements can be used to increase the beamforming gain to increase the coverage or increase the throughput.

[5] In this case, if a transceiver unit (TXRU) is provided so that transmission power and phase can be adjusted for each antenna element, independent beamforming is possible for each frequency resource. However, installing a TXRU on all 100 antenna elements

has a problem in terms of cost effectiveness. Therefore, a method of mapping a plurality of antenna elements to one TXRU and adjusting the direction of a beam using an analog phase shifter is considered. This analog beamforming method has a disadvantage that it cannot perform frequency selective beaming because it can make only one beam direction in all bands.

[6] A hybrid beamforming with B TXRUs, which is an intermediate form of digital beamforming and analog beamforming, and fewer than Q antenna elements, can be considered. In this case, although there is a difference depending on the connection method of the B TXRU and Q antenna elements, the direction of the beam that can be simultaneously transmitted is limited to B or less.

[7] For operating new RAT efficiently, various schemes have been discussed. Specifically, in perspective of using frequency/spectrum, some new features may need to be required. Further, new frame structure may also need to be required.

Disclosure of Invention

Technical Problem

[8] The present provides a method and apparatus for configuring a frame structure for a new ratio access technology (RAT) in a wireless communication system. The present invention discusses initial access procedure which can allow different use cases supported in the same spectrum, e.g. massive machine-type communication (mMTC) and enhanced mobile broadband (eMBB), for both below and above 6 GHz. The present invention discusses how to support multi/variable transmission time interval (TTI) operation for each channel including hybrid automatic repeat request acknowledgement (HARQ-ACK) operation.

Solution to Problem

[9] In an aspect, a method for configuring a frame structure for a new radio access technology (RAT) by a network node in a wireless communication system is provided. The method includes configuring a first frame which has one legacy transmission time interval (TTI) and a second frame which has multiple short TTIs, and communicating with a user equipment (UE) by using at least one of the first frame and the second frame.

[10] In another aspect, a network node for a new radio access technology (RAT) in a wireless communication system is provided. The network node includes a memory, a transceiver, and a processor, coupled to the memory and the transceiver, that configures a first frame which has one legacy transmission time interval (TTI) and a second frame which has multiple short TTIs, and controls the transceiver to communicate with a user equipment (UE) by using at least one of the first frame and the second frame.

Advantageous Effects of Invention

[11] New frame structure can be configured for new RAT.

Brief Description of Drawings

[12] FIG. 1 shows a wireless communication system.

[13] FIG. 2 shows structure of a radio frame of 3GPP LTE.

[14] FIG. 3 shows a resource grid for one downlink slot.

[15] FIG. 4 shows an example of subframe type for new RAT.

[16] FIG. 5 shows an example of a frame structure for a new RAT according to an embodiment of the present invention.

[17] FIG. 6 shows another example of a frame structure for a new RAT according to an embodiment of the present invention.

[18] FIG. 7 shows an example of nested frame structure for a new RAT according to an embodiment of the present invention.

[19] FIG. 8 shows an example of scheduling of multiple and different TTI via different TTI levels.

[20] FIG. 9 shows an example of overlapped short TTI in a nested frame structure for a new RAT according to an embodiment of the present invention.

[21] FIG. 10 shows another example of overlapped short TTI in a nested frame structure for a new RAT according to an embodiment of the present invention.

[22] FIG. 11 shows another example of a frame structure for a new RAT according to an embodiment of the present invention.

[23] FIG. 12 shows another example of a frame structure for a new RAT according to an embodiment of the present invention.

[24] FIG. 13 shows an example of a nested self-contained subframe according to an embodiment of the present invention.

[25] FIG. 14 shows another example of a frame structure for a new RAT according to an embodiment of the present invention.

[26] FIG. 15 shows another example of a frame structure for a new RAT according to an embodiment of the present invention.

[27] FIG. 16 shows an example of different subcarrier spacing between URLLC and eMBB which are multiplexed in a same carrier or frequency band.

[28] FIG. 17 shows an example of DM-RS sharing according to an embodiment of the present invention.

[29] FIG. 18 shows an example of PUSCH scheduling with DM-RS sharing according to an embodiment of the present invention.

[30] FIG. 19 shows an example of PUCCH scheduling without DM-RS sharing according to an embodiment of the present invention.

[31] FIG. 20 shows a method for configuring a frame structure for a new RAT by a network node according to an embodiment of the present invention.

[32] FIG. 21 shows a wireless communication system to implement an embodiment of the present invention.

Mode for the Invention

[33] Techniques, apparatus and systems described herein may be used in various wireless access technologies such as code division multiple access (CDMA), frequency division multiple access (FDMA), time division multiple access (TDMA), orthogonal frequency division multiple access (OFDMA), single carrier frequency division multiple access (SC-FDMA), etc. The CDMA may be implemented with a radio technology such as universal terrestrial radio access (UTRA) or CDMA2000. The TDMA may be implemented with a radio technology such as global system for mobile communications (GSM)/general packet radio service (GPRS)/enhanced data rates for GSM evolution (EDGE). The OFDMA may be implemented with a radio technology such as institute of electrical and electronics engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802-20, evolved-UTRA (E-UTRA) etc. The UTRA is a part of a universal mobile telecommunication system (UMTS). 3rd generation partnership project (3GPP) long term evolution (LTE) is a part of an evolved-UMTS (E-UMTS) using the E-UTRA. The 3GPP LTE employs the OFDMA in downlink (DL) and employs the SC-FDMA in uplink (UL). LTE-advance (LTE-A) is an evolution of the 3GPP LTE. For clarity, this application focuses on the 3GPP LTE/LTE-A. However, technical features of the present invention are not limited thereto.

[34] FIG. 1 shows a wireless communication system. The wireless communication system 10 includes at least one evolved NodeB (eNB) 11. Respective eNBs 11 provide a communication service to particular geographical areas 15a, 15b, and 15c (which are generally called cells). Each cell may be divided into a plurality of areas (which are called sectors). A user equipment (UE) 12 may be fixed or mobile and may be referred to by other names such as mobile station (MS), mobile terminal (MT), user terminal (UT), subscriber station (SS), wireless device, personal digital assistant (PDA), wireless modem, handheld device. The eNB 11 generally refers to a fixed station that communicates with the UE 12 and may be called by other names such as base station (BS), base transceiver system (BTS), access point (AP), etc.

[35] In general, a UE belongs to one cell, and the cell to which a UE belongs is called a serving cell. An eNB providing a communication service to the serving cell is called a serving eNB. The wireless communication system is a cellular system, so a different cell adjacent to the serving cell exists. The different cell adjacent to the serving cell is called a neighbor cell. An eNB providing a communication service to the neighbor cell

is called a neighbor eNB. The serving cell and the neighbor cell are relatively determined based on a UE.

[36] This technique can be used for DL or UL. In general, DL refers to communication from the eNB 11 to the UE 12, and UL refers to communication from the UE 12 to the eNB 11. In DL, a transmitter may be part of the eNB 11 and a receiver may be part of the UE 12. In UL, a transmitter may be part of the UE 12 and a receiver may be part of the eNB 11.

[37] The wireless communication system may be any one of a multiple-input multiple-output (MIMO) system, a multiple-input single-output (MISO) system, a single-input single-output (SISO) system, and a single-input multiple-output (SIMO) system. The MIMO system uses a plurality of transmission antennas and a plurality of reception antennas. The MISO system uses a plurality of transmission antennas and a single reception antenna. The SISO system uses a single transmission antenna and a single reception antenna. The SIMO system uses a single transmission antenna and a plurality of reception antennas. Hereinafter, a transmission antenna refers to a physical or logical antenna used for transmitting a signal or a stream, and a reception antenna refers to a physical or logical antenna used for receiving a signal or a stream.

[38] FIG. 2 shows structure of a radio frame of 3GPP LTE. Referring to FIG. 2, a radio frame includes 10 subframes. A subframe includes two slots in time domain. A time for transmitting one transport block by higher layer to physical layer (generally over one subframe) is defined as a transmission time interval (TTI). For example, one subframe may have a length of 1ms, and one slot may have a length of 0.5ms. One slot includes a plurality of orthogonal frequency division multiplexing (OFDM) symbols in time domain. Since the 3GPP LTE uses the OFDMA in the DL, the OFDM symbol is for representing one symbol period. The OFDM symbols may be called by other names depending on a multiple-access scheme. For example, when SC-FDMA is in use as a UL multi-access scheme, the OFDM symbols may be called SC-FDMA symbols. A resource block (RB) is a resource allocation unit, and includes a plurality of contiguous subcarriers in one slot. The structure of the radio frame is shown for exemplary purposes only. Thus, the number of subframes included in the radio frame or the number of slots included in the subframe or the number of OFDM symbols included in the slot may be modified in various manners.

[39] The wireless communication system may be divided into a frequency division duplex (FDD) scheme and a time division duplex (TDD) scheme. According to the FDD scheme, UL transmission and DL transmission are made at different frequency bands. According to the TDD scheme, UL transmission and DL transmission are made during different periods of time at the same frequency band. A channel response of the TDD scheme is substantially reciprocal. This means that a DL channel response and a UL

channel response are almost the same in a given frequency band. Thus, the TDD-based wireless communication system is advantageous in that the DL channel response can be obtained from the UL channel response. In the TDD scheme, the entire frequency band is time-divided for UL and DL transmissions, so a DL transmission by the eNB and a UL transmission by the UE cannot be simultaneously performed. In a TDD system in which a UL transmission and a DL transmission are discriminated in units of subframes, the UL transmission and the DL transmission are performed in different subframes. In a TDD system, to allow fast switching between DL and UL, UL and DL transmission may be performed within a same subframe/slot in time division multiplexing (TDM)/frequency division multiplexing (FDM) manner.

[40] FIG. 3 shows a resource grid for one downlink slot. Referring to FIG. 3, a DL slot includes a plurality of OFDM symbols in time domain. It is described herein that one DL slot includes 7 OFDM symbols, and one RB includes 12 subcarriers in frequency domain as an example. However, the present invention is not limited thereto. Each element on the resource grid is referred to as a resource element (RE). One RB includes 12×7 or 12×14 resource elements. The number NDL of RBs included in the DL slot depends on a DL transmit bandwidth. The structure of a UL slot may be same as that of the DL slot. The number of OFDM symbols and the number of subcarriers may vary depending on the length of a CP, frequency spacing, etc. For example, in case of a normal cyclic prefix (CP), the number of OFDM symbols is 7 or 14, and in case of an extended CP, the number of OFDM symbols is 6 or 12. One of 128, 256, 512, 1024, 1536, and 2048 may be selectively used as the number of subcarriers in one OFDM symbol.

[41] 5th generation mobile networks or 5th generation wireless systems, abbreviated 5G, are the proposed next telecommunications standards beyond the current 4G LTE/ international mobile telecommunications (IMT)-dvanced standards. 5G planning aims at higher capacity than current 4G LTE, allowing a higher density of mobile broadband users, and supporting device-to-device, ultra-reliable, and massive machine communications. 5G research and development also aims at lower latency than 4G equipment and lower battery consumption, for better implementation of the Internet of things. Hereinafter, 5G technology may be referred to as new radio access technology (RAT).

[42] In new RAT, utilizing a subframe in which downlink and uplink are contained may be considered. This scheme may be applied for paired spectrum and unpaired spectrum. The paired spectrum means that one carrier consists of two carriers. For example, in the paired spectrum, the one carrier may include a DL carrier and an UL carrier, which are paired with each other. In the paired spectrum, communication, such as DL, UL, device-to-device communication, and/or relay communication, may be

performed by utilizing the paired spectrum. The unpaired spectrum means that that one carrier consists of only one carrier, like the current 4G LTE. In the unpaired spectrum, communication, such as DL, UL, device-to-device communication, and/or relay communication, may be performed in the unpaired spectrum.

[43] Further in new RAT, the following subframe types may be considered to support the paired spectrum and the unpaired spectrum mentioned above.

[44] (1) Subframes including DL control and DL data

[45] (2) Subframes including DL control, DL data, and UL control

[46] (3) Subframes including DL control and UL data

[47] (4) Subframes including DL control, UL data, and UL control

[48] (5) Subframes including access signals or random access signals or other purposes.

[49] (6) Subframes including both DL/UL and all UL signals.

[50] However, the subframe types listed above are only exemplary, and other subframe types may also be considered.

[51] FIG. 4 shows an example of subframe type for new RAT. The subframe shown in FIG. 4 may be used in TDD system of new RAT, in order to minimize latency of data transmission. Referring to FIG. 4, the subframe contains 14 symbols in one TTI, like the current subframe. However, the subframe includes DL control channel in the first symbol, and UL control channel in the last symbol. The remaining symbols may be used for DL data transmission or for UL data transmission. According to this subframe structure, DL transmission and UL transmission may sequentially proceed in one subframe. Accordingly, DL data may be transmitted in the subframe, and UL acknowledgement/non-acknowledgement (ACK/NACK) may also be received in the subframe. In this manner, the subframe shown in FIG. 4 may be referred to as self-contained subframe. As a result, it may take less time to retransmit data when a data transmission error occurs, thereby minimizing the latency of final data transmission. In the self-contained subframe structure, a time gap may be required for the transition process from the transmission mode to the reception mode or from the reception mode to the transmission mode. For this purpose, some OFDM symbols at the time of switching from DL to UL in the subframe structure may be set to the guard period (GP).

[52] Hereinafter, the present invention discusses transmission mechanism and resources used for synchronization signals, physical broadcast channel (PBCH), system information block (SIB) and physical random access channel (PRACH) related procedure for the new RAT, particularly considering forward compatibility in which different UEs are supported with different requirements in terms of radio frequency (RF)/baseband processing capability, latency requirements, power requirements, etc. For example, enhanced mobile broadband (eMBB) high data rate UEs with massive internet-of-things (IoT_ devices with relatively lower data rate and extremely limited

RF/baseband capability may be supported, compared to regular UEs or eMBB high data UEs. However, the present invention which will be described below may be applied to LTE technology wherever applicable.

[53] To allow coexistence of different use cases, at least one of the following aspects may be considered.

[54] - Different RF/baseband bandwidth capability: For example, an IoT device may support only very limited bandwidth such as M MHz of bandwidth or P*one subcarrier spacing. For another example, an IoT device may support 12*one subcarrier spacing (e.g. 12 * 7.5 kHz = 90 kHz).

[55] - Different processing capability in terms of encoding/decoding: For example, an IoT device may not support high processing decoding, such as turbo decoder or low-density parity-check (LDPC). If any common channel is shared among different UEs, this may be taken into account. For this manner, separate SIB may be transmitted per each UE. Alternatively, one main SIB or PBCH may be shared and different branch from the common channel may be allowed.

[56] - Different number of possible concurrent UEs attempting to access the cell: For example, though IoT device may not access the cell frequently, there may be many IoT devices attempting accessing the cell given a time duration. Handling massive UEs may require separate PRACH resource configuration or handling of RACH procedure differently.

[57] - Different synchronization requirement: For example, an IoT device may be supported by joint transmission from multiple cells to improve coverage. This may require larger CP overhead compared to other high data rate UEs.

[58] - Different subcarrier spacing: Due to different synchronization requirement or multiplexing capacity requirements, different subcarrier spacing may be used.

[59] - Different coverage requirement: Depending on use case, coverage and the required repetition numbers may be different.

[60]

[61] 1. Synchronization signal for the new RAT according to an embodiment of the present invention is described.

[62] For example, due to different subcarrier spacing and/or different RF/baseband requirement, synchronization signals, such as primary synchronization signal (PSS)/secondary synchronization signal (SSS), for eMBB and massive machine-type communication (mMTC) UEs may be different from the legacy synchronization signal. For example, synchronization signals for eMBB UEs may be transmitted over larger than M MHz of the lowest bandwidth supported UEs sharing the same spectrum. In this case, at least one of following approaches may be considered.

[63] (1) The common synchronization signals over the minimum system bandwidth (e.g.

M MHz) may be transmitted, and the same density of PSS/SSS may also be transmitted. The density may be determined by the coverage that the network intends to support.

[64] (2) Base sequence of synchronization signal may be transmitted in the minimum system bandwidth with the minimum density required for general UEs. For general UEs, repetition in frequency domain may be considered. And for high coverage requiring UEs, repetition in time domain may be considered. For example, minimum system bandwidth may be 180 kHz with 15 kHz subcarrier spacing with 12 subcarriers, and the bandwidth used for general UEs may be 1.4 MHz which may be repeated 6 times in frequency domain. On the other hand, for high coverage requiring UEs, repetition over multiple subframes may be considered. When repetition occurs in frequency domain, different root sequence may be used (which may affect overall peak-to-average power (PAPR)) or orthogonal cover code (OCC) may be applied over repetitions in frequency domain. Similar mechanism may be applied to repetition in time domain as well. From a UE perspective, if the network supports its UE type, appropriate repetition in either frequency domain or time (or both) domain may be used. In terms of repetition in frequency domain, the repetition may be done consecutively or discontinuously over the frequency.

[65] (3) Base sequence of synchronization signal may be based on synchronization signal system bandwidth designed for general UEs (e.g. 72 subcarriers * subcarrier spacing). For example, if the system bandwidth is K*M MHz, the base sequence may be mapped over k OFDM symbols for UE with lower bandwidth capability. In terms of mapping, M1, M2...Mk may be mapped over K OFDM symbols. Assuming a center frequency of a carrier where synchronization signal is transmitted, center frequency of the system bandwidth/carrier may be the same as the center frequency of synchronization signal for general UEs. Thus, if the channel raster is the same between different UEs, it means that center frequency of synchronization signals for low bandwidth UEs may be offset from the center of general UEs' synchronization signal. This offset may be prefixed. Alternatively, center frequency of system bandwidth/carrier may be the same as the center frequency of synchronization signal for low bandwidth UEs.

[66] (4) Separate synchronization signal may be configured between two types of UEs: In this case, to allow synchronization signal transmissions from different UEs, it is necessary to reserve some frequency regions for different types of UEs. This means that some signals/channels such as beam reference signal (RS) or PBCH or SIB may not be mapped to those reserved regions. At least a few potential regions may be reserved for future use of different system deployment or supporting different types of UEs.

[67] For the reserved regions, the following approaches may be considered. Within the

reserved time resource, any cell-common and/or group-common channels/RS/signals may not be transmitted.

[68] - Frequency resource(s) is reserved: For example, to allow different subcarrier spacing, frequency resource may be reserved. For the reserved frequency resources, the resources aligned with channel raster of low bandwidth UEs or future UEs may be considered. Generally, the same channel raster assumption may be used regardless of UE type. Thus, some frequency location which are aligned with channel raster may be reserved for future uses or supporting some different types of UEs.

[69] - Time resource(s) is reserved: For example, similar to legacy multicast-broadcast single-frequency network (MBSFN) subframe configuration, different types of future use subframes may be considered. In such subframes, one or a few symbols may be still used for control (DL and/or UL) transmissions. Within the reserved time resource, any cell-common and/or group-common channels/RS/signals may not be transmitted.

[70] - Time/frequency resource(s) is reserved: Both time and frequency domain may be considered for the reserved resources.

[71] - Beam direction(s) is reserved: Certain resources associated with a certain beam may be reserved. This implies that subcarrier spacing and/or CP length may be different per beam direction. In case below 6 GHz, this may be associated with a certain channel state information (CSI) RS and its associated virtual cell.

[72] If different subcarrier spacing is used, it may be necessary to fix synchronization signal (if they are common across UEs with different applications/subcarrier spacing values)

[73]

[74] 2. Empty frequency/time resources

[75] It is expected that some resources should be reserved for potential new services in future. The reason of reserving some frequency/time resource is to allow potentially different numerology (such as subcarrier spacing/CP length) and/or potentially different frame structure. In this sense, it is important to not allocate any available resources in frequency and time domain to one specific application. For example, the system bandwidth may not be entirely used for transmission of cell-specific signals, such as reference signals and channels. Also, it may be desirable to reserve some resources over the entire frequency domain rather than reserving some resources at the edge of system bandwidth. In this sense, it may be generally desirable to transmit any cell-specific RS and/or channel in rather discontinuous frequency resources. For example, PBCH may be transmitted in PRBs which are rather distributed over the system bandwidth, assuming minimum bandwidth. For example, if the minimum bandwidth is 20 MHz, and the number of PRBs are 20 with 75 kHz subcarrier spacing and PBCH uses 6 PRBs in one TTI, instead of placing PBCH in a contiguous 6 PRBs,

PBCH may be transmitted over 1 PRB in every 3 PRBs (or 2 PRBs excluding some PRBs used for synchronization signals). By this way, at least one or a few PRBs between PBCH PRBs may be reserved for some other future uses. Since additional RS and/or channels (cell-specific) may be transmitted in one TTI or one OFDM symbol, it may be also desirable to have discontinuous transmission of such RS/channels as well. Overall, the idea is to reserve at least one or a few subcarriers/RBs between two consecutive cell-specific RS/channels for future uses. The location of cell specific RS/channels may be determined based on cell ID and/or subframe and/or radio frame and/or frame index.

[76] Alternatively, signal system bandwidth may be signaled in synchronization signal where different frequency region can be used for different applications. For example, transmission of cell-specific RS may be different based on system bandwidth.

[77]

[78] 3. Frame structure

[79] It is expected that different frame structure may be necessary for the new RAT. Particularly, different frame structure in which UL and DL may be present in every subframe or may change very frequently in the same carrier may be necessary for the new RAT. Different application may require different minimum size of DL or UL portions to support different latency and coverage requirements. For example, mMTC for high coverage case may require relatively long DL and UL portion so that one transmission can be successfully transmitted. Furthermore, due to different requirement on synchronization and tracking accuracy requirements, different subcarrier spacing and/or different CP length may be considered. In this sense, it is necessary to consider mechanisms to allow different frame structures coexisting in the same carrier and be operated by the same cell/eNB.

[80] For the convenience, it is assumed in the description below that a frame structure type 1 (FS1) and a frame structure type 2 (FS2) are configured and coexist in the same carrier. The FS1 may be a baseline frame structure used for such as for eMBB use cases or typical use cases. The FS2 may be used for some other applications such as mMTC, ultra-reliable and low latency communication (URLLC), an enhanced vehicle-to-everything (eV2X) communication. The network or a cell may support one or multiple frame structures at the same time. For the convenience, the present invention may discuss relationship between two frame structures. However, more than two frame structures may be supported simultaneously.

[81]

[82] A. FS2 for mMTC/URLLC in FDD case

[83] In this case, one TTI of FS2 may consist of a few (e.g. 'm') TTIs of FS1. For example, if one TTI of FS1 is X ms, one TTI of FS2 may be 'm'*X ms. For de-

termining 'm', at least one of the following approaches may be considered.

[84] - 'm' may be predetermined. 'm' may be different per frequency or frequency range or frequency bands. To support variable coverage level or repetition level, it may be desirable to have different 'm' per repetition level. 'm' may be 2^N , where N=0,...P.

[85] - 'm' may be determined based on subcarrier spacing used for mMTC. For example, if 15*K1 kHz subcarrier spacing is used for FS1, and 15 kHz subcarrier spacing is used for FS2, 'm' may be same as K1 or multiple of K1.

[86] - Combination of the above two approaches may also be considered.

[87] FIG. 5 shows an example of a frame structure for a new RAT according to an embodiment of the present invention. Referring to FIG. 5, it is shown that FS1 is the same as the conventional frame structure, as one TTI includes 14 symbols. That is, one TTI of FS1 is 1 ms. On the other hand, one TTI of FS2 is 'm' ms. 'm' may be predetermined. Or, 'm' may be determined based on subcarrier spacing used for mMTC.

[88] If different subcarrier spacing is used, it may be necessary to have a gap between two different subcarrier regions. Also, for transmission of synchronization signals, collision between FS1 OFDM symbol carrying PSS and/or SSS and FS2 OFDM symbol carrying PSS and/or SSS should be avoided. For this, FS1 and FS2 may be configured by TDM manner. For this, in terms of system information or master information block (MIB) signaling, a set of subframes not usable may be configured. In other words, the set of available subframes for each FS may be signaled by each system information carried in each FS respectively. However, a set of available TTIs/subframes may not reflect the case where one or a few OFDM symbols within one TTI should not be used. For example, one OFDM symbol of FS2 colliding with synchronization signal(s) of FS1 may be excluded/punctured/rate matched. One or a few patterns of available OFDM symbols per TTI may be configured and signaled per each FS or to FS2. For example, patterns may be {all OFDM symbols available}, {the first symbol is not available}, {the first symbol in each slot is not available}, etc.

[89] Alternatively, CP length of FS2 may be configured smaller than m*CP length of FS1. The remaining portion may be used for gap or blank region between FS1 and FS2.

[90] FIG. 6 shows another example of a frame structure for a new RAT according to an embodiment of the present invention. Referring to FIG. 6, like FIG. 5, one TTI of FS1 is 1 ms, and one TTI of FS2 is 'm' ms. However, CP length of FS2 is configured smaller than m*CP length of FS1, so gap occurs at the end of FS2. PSS/SSS of FS1 may be transmitted in gap of FS2, in order to avoid collision.

[91] Alternatively, when FS2 is constructed, additional gap may be considered, regardless of CP length, such that PSS/SSS (and also necessary system bandwidth wide signals such as CSI-RS, extended synchronization signal (ESS)) can be transmitted. In other

words, one or a few OFDM symbols may be reserved for some other purposes in FS2. For reservation, different CP may be configured so that the number of OFDM symbols within one TTI can be totally smaller than the size of one TTI (e.g. OFDM symbol size of 80 us*12 = 960 us in 1ms TTI leaves 40 us gap). Or, some OFDM symbols may be reserved for further uses. The future use or some other uses may include CSI-RS transmission, UL control transmission, DL control transmission, etc. Depending on reason of reservation, the gap may be formed in the beginning of each TTI (or multiple TTIs) or end of each TTI (or multiple TTIs). To support this, system bandwidth side signals of FS1, such as CSI-RS, ESS, PBCH, etc., may be transmitted in the beginning of TTI or ending of the TTI such that reservation on FS2 may be placed in the beginning or ending of TTI of FS2.

[92] Meanwhile, in order to reduce latency, short TTI which may be shorter than current TTI (i.e. 1ms) has been considered. For example, length of short TTI may be one of 1/2/3/4/7 symbols. When a short TTI is introduced for latency reduction in LTE, E-UTRAN may be configured with both normal TTI with 1ms and short TTI with a value less than 1ms, such as 1 symbol or 0.5ms. With keeping the current LTE frame structure, OFDM symbol length, subcarrier spacing, etc., reduction of TTI generally means smaller transport block size (TBS) contained in one TTI, and relatively larger control overhead if DCI size is kept as the same.

[93] When short TTI is adopted, and as a result, the number of OFDM symbols in reduced in one TTI (e.g. from 14 to 2) or subcarrier spacing increases (e.g. from 15 kHz to 60 kHz), a RB size may be different from the current RB size. For example, with subcarrier spacing of 60 kHz, one RB may include 12×8 resource elements, instead of 12×14 resource elements. For another example, when TTI length is 2 OFDM symbol length, one RB may include 12×2 resource elements. If short TTI is used, particularly with smaller number of OFDM symbols, larger RB size in frequency domain may be considered (e.g. one RB includes 48×2 resource elements).

[94] It is generally desirable to use short TTI for control. However, it may increase control overhead and thus decrease the overall performance benefit with short TTI operation. Thus, it may be desirable to support different TTI length per different application/packet.

[95] Hereinafter, as a proposal for FS2, a nested frame structure using short TTIs according to an embodiment of the present invention is described. It is assumed that "K" different levels (or lengths) of short TTIs is supported in the network. For example, level 1 may correspond to the legacy TTI length (e.g. 14 OFDM symbols with normal CP), which means 1 TTI in the network. Level 2 may correspond to 7 OFDM symbols, which means 2 TTIs in the network, and so on.

[96] FIG. 7 shows an example of nested frame structure for a new RAT according to an

embodiment of the present invention. Different TTI length may be used between FS1 and FS2. FIG. 7-(a) corresponds to level 1, in which one TTI includes 14 OFDM symbols. Level 1 may be called FS1. FIG. 7-(b) corresponds to level 2, in which one short TTI includes 7 OFDM symbols. That is, one TTI of FS1 includes two short TTIs of FS2. FIG. 7-(c) corresponds to level 3, in which one short TTI includes 3/4 OFDM symbols. That is, one TTI of FS1 includes 4 short TTIs of FS2. FIG. 7-(d) corresponds to level 4, in which one short TTI includes 1/2 OFDM symbols. That is, one TTI of FS1 includes eight short TTIs of FS2.

[97] Accordingly, depending on the needed number of short TTIs within one TTI (from 1 to 8, and 14), short TTIs may be placed. However, in FIG. 7-(c), instead of 4/3/4/3 OFDM symbols for short TTIs, 3/4/3/4 OFDM symbols or 3/4/4/3 OFDM symbols or 3/3/4/4 OFDM symbols or 4/4/3/3 OFDM symbols may be used. Similar rotation for 1/2 OFDM symbol may also be applied to FIG. 7-(d). In case of 1 OFDM symbol case, total of 14 short TTIs may be placed. Similar mechanisms may be applied to different OFDM symbols per TTI (e.g. 12 or 10). The proposed frame structure described above may allow that short TTI may be nested to the next level short TTI. In other words, one short TTI of one level may be divided to 2 short TTIs of the next level (except from 8 short TTIs to 14 short TTIs).

[98] In the proposed frame structure, the first one or two OFDM symbols of DL may be used for legacy control region, and the last OFDM symbol of UL may be reserved for sounding reference signal (SRS) transmission (or to minimize the impact by legacy SRS). In terms of SRS transmission for a short TTI supporting UE, the following two approaches may be considered.

[99] (1) If additional SRS configuration is given to short TTIs, a UE may transmit additional SRS according to short TTI configuration. If additional SRS transmission is considered, SRS may be transmitted in the last OFDM symbol of the configured short TTI for level 2 TTI structure. For level 3 and 4, the first OFDM symbol may be used for SRS except for the last short TTI in the legacy TTI. This additional SRS configuration may be cell-specific and may be configured per each TTI configuration. Thus, potentially multiple SRS configuration may be given. A UE configured with one level may perform rate matching or puncture in cell-specific SRS configuration of higher levels (i.e. shorter TTIs) to protect SRS. For example, if a UE is configured with level 2, and the cell also configures SRS for level 3, the UE may puncture or performing rate matching around SRS symbols of level 3.

[100] (2) Only legacy SRS configuration may be used, and additional SRS transmission in short TTI may not be used.

[101] More specifically, in FDD, option (2) above may be used. In TDD, option (1) may also be considered.

[102] With the nested frame structure, a UE supporting short TTI may be configured with multiple short TTI levels for control channel monitoring. For example, if level 4 is configured, the UE may monitor control channel in OFDM symbol 0 (possibly for legacy PDCCH), OFDM symbols 2, 4, 6, 7, 9, 11, and 14. In each short TTI, the multiple TTIs or variable TTI may schedule up to the maximum number of total short TTIs in the legacy TTI or multiple of the maximum short TTI numbers (e.g. 8 or 8*k in this example). For example, if a UE is scheduled with 4*sTTI in 2nd short TTI with level 2, PDSCH may be scheduled in 2nd, 3rd, 4th, 5th short TTIs, which in total of 7 OFDM symbols in length. The level may be determined by short TTI length used for control channel monitoring. More specifically, if the first short TTI schedules PDSCH, and the legacy PDCCH length is equal or larger than the size of short TTI, data may not be mapped to the fully overlapped short TTI. However, it may be counted for multiple TTIs scheduling. In other words, data may be rate matched, though it has been scheduled.

[103] It may be good to restrict the size of data channel only for a few cases (e.g. 1 symbol, 2 symbols, 4 symbols, 7 symbols and 12 symbols). It may be required by the network to schedule data properly not to vary the size of PDSCH in terms of OFDM symbols. For this, similar to ACK/NACK transmission, the timing from control channel to data channel may be considered. The timing from control channel to data channel may be signaled via number of short TTIs where short TTI length can be determined by sPDCCH TTI length (e.g. level 4). Alternatively, the basic short TTI length for ACK/NACK may also be determined by higher layer separately. In other words, a basic short TTI length or the level of short TTI used in DL and UL may be configured, respectively. Based on the basic short TTI length, multi/variable TTI scheduling which allows scheduling longer than the configured TTI length may be considered. If the first symbol is reserved for control channel in every short TTI, PDSCH may be rate matched in such OFDM symbols. Otherwise, data may be transmitted in the first control region of every short TTI as well, and data may be rate matched around its own scheduling DCI. Multi/variable TTI scheduling may be expanded to the next longer short TTI or level 1 TTI. If level 4 is used, data may not be scheduled in the same short TTI if the short TTI length is 1 OFDM symbol. For example, only 2 bits of 1, 2, 4, 8 multiple short TTIs may be scheduled in level 4 which allows PDSCH transmission ends aligned with the next higher level short TTI.

[104] FIG. 8 shows an example of scheduling of multiple and different TTI via different TTI levels. Referring to FIG. 8, legacy PDCCH may schedule PDSCH of level 1, 2, 3 and 4. PDCCH of each level may schedule PDSCH of each level. That is, PDCCH of level 2 may schedule PDSCH of level 2, PDCCH of level 3 may schedule PDSCH of level 3, and PDCCH of level 4 may schedule PDSCH of level 4.

[105] One drawback of the nested frame structure described above is that it leads different TTI lengths among short TTIs in the same level. To overcome this problem, partial overlap between two short TTIs may be considered.

[106] FIG. 9 shows an example of overlapped short TTI in a nested frame structure for a new RAT according to an embodiment of the present invention. That is, in the nested frame structure, short TTIs may be overlapped/shared to allow 2^N symbols per TTI. FIG. 9-(a) shows level 5 in which 16 short TTIs, instead of 14 short TTIs, are configured. In order to configure 16 short TTIs, fourth OFDM symbol are shared between TTI #3 and TTI #4, and eleventh OFDM symbol are shared between TTI #11 and TTI #12. FIG. 9-(b) shows level 4 in which 8 short TTIs are configured. In order to configure 8 short TTIs which has the same length, fourth OFDM symbol are shared between TTI #1 and TTI #2, and eleventh OFDM symbol are shared between TTI #5 and TTI #6. FIG. 9-(c) shows level 3 in which 4 short TTIs are configured. In order to configure 4 short TTIs which has the same length, fourth OFDM symbol are shared between TTI #0 and TTI #1, and eleventh OFDM symbol are shared between TTI #2 and TTI #3. 9-(d) shows level 2 in which 2 short TTIs are configured. In order to configure 2 short TTIs which has the length of 8 OFDM symbols, seventh and eighth OFDM symbols are shared between TTI #0 and TTI #1. The embodiment shown in FIG. 9 is only exemplary, and actual OFDM symbol which is shared between different short TTI may be changed. The idea is to allow some OFDM symbols overlapped among different short TTIs to align short TTI lengths.

[107] The drawback of the above approach is that control/data between two different short TTIs may be overlapped in the overlapped OFDM symbols, which may affect the overall FDM performance of control/data channels. However, if data and control is multiplexed by FDM, this overlap between control and data may be manageable if TDM between control and data is assumed. Alternatively, as the issue becomes more significant in level 2, overlap may not be considered in level 2.

[108] FIG. 10 shows another example of overlapped short TTI in a nested frame structure for a new RAT according to an embodiment of the present invention. Referring to FIG. 10, short TTI length may be configured as 7 actual OFDM symbols and fourth OFDM symbol may be mapped to #3 and #4 in each slot, respectively.

[109] The above approach may be applied to other levels as well. This may be explained that virtually there are 16 OFDM symbols which are mapped to physically 14 OFDM symbols. In this way, the design working for 16 OFDM symbols may be incorporated to 14 OFDM symbols cases (and vice versa). More specifically, in case from 16 OFDM symbols to 14 OFDM symbols, one OFDM symbol may be dropped between #3 and #4. In case from 14 OFDM symbols to 16 OFDM symbols, OFDM symbol #3 may be repeated. In terms of sharing OFDM symbol, at least in TDD, it is desirable to

use OFDM symbol #3 (in normal CP) in each slot may be preferable considering DM-RS position.

[110] When OFDM sharing is used, the number of OFDM symbols of multi/variable TTI scheduling may consider actual number of OFDM symbols in which multiple TTIs are spanning. In this sense, the total number of scheduled length may be smaller than multiple of short TTI length. This approach may allow that the number of OFDM symbols in each short TTI is 2^N, where N is 0, 1, 2...K depending on the necessity of latency and UE processing power requirement. In the overlapped short TTI with level 5 (e.g. TTI #3 and #4), it may be necessary to indicate which TTI is used for control and/or data channel, which may be differentiated via scrambling of control/data (some other means may also be considered). This may be particularly important when HARQ-ACK timing is determined based on 2^N number of OFDM symbols or the number of short TTIs in one the largest TTI size. For example, if TTI #3 schedules with gap of 2 TTI for sPDSCH, this may imply that PDSCH will be scheduled in TTI #5 (which is next OFDM symbol to TTI #3), thus, the gap may be in fact one short TTI. This may simplify the operation if system may require operating in multiple different levels of short TTI lengths. The similar concept may be used for UL as well. In UL, collision in the same resource between two short TTIs with level 5 may be considered as collision and transmission on one channel may be dropped per rule (if the network schedules collisions). For example, the rule may be configured based on uplink control channel information (UCI) priority or based on timing.

[111] For one example of the nested frame structure, if FS1 consists of 30 subframes, one subframe may be overlapped between two TTIs for FS2. If mMTC UE is scheduled in those overlapped TTIs, it may be counted only one as valid. Alternatively, instead of overlap of two TTIs, different TTI lengths may be configured. For example, level 2 of FS2 may have l TTIs with 2/2/2/2/1/2/2/2 in 1.5 ms range. Alternatively, reserve some resources may be reserved not used by mMTC devices. Those reserved resource blocks may be placed in any subframes consecutively or discontinuously. Alternatively, different levels may be defined by multiple of previous level's TTI length.

[112]

[113] B. Frame structure for mMTC in TDD case

[114] The above frame structure may be applied to a frame structure for mMTC in TDD. Additionally, in TDD, two different frame structures may be considered. One is a frame structure in which DL/UL switching may occur in a multiple TTI unit similar to current LTE TDD DL/UL configuration. The other is a frame structure that DL/UL switching may occur in every TTI to allow efficient DL and UL transmission and ACK/NACK transmission. For the latter case, DL control region and UL control region may need to be used for DL and UL, respectively, unless the network supports

full duplex capability. If the network does not support full duplex capability, thus, it may be necessary to align DL portions between FS1 and FS2. For this, the following two approaches may be considered.

[115] (1) FS1 configuration of DL/UL may be given to UEs of FS2, and UEs of FS2 may construct DL portion and UL portion according to DL/UL configuration of FS1. For example, if subcarrier spacing of FS2 is 2 times that of FS1, and the configuration of DL/UL configuration is DDDDDUUUUU (where D indicates subframes in which PDSCH may be transmitted, and U indicates subframes in which PUSCH may be transmitted), then DL and UL portion of FS2 may be constructed as DDSUU, where D indicates DL control and PDSCH portions can be used for DL and U indicates PUSCH portion and UL control portion can be used for UL.

[116] (2) FS2 configuration of DL/UL may be given to UEs of FS1, and UEs of FS1 may assume that subframe type (either PDSCH or PUSCH) may be determined by FS2 configuration, unless it's dynamically changed via scheduling or dynamic indication per each TTI. For example, assuming that the subcarrier spacing of FS2 is two times of that of FS1, FS2 may indicate DDDDDUUUUU. It may imply that default DL/UL configuration of FS1 is DDDDDDDDDDUUUUUUUUUU. More generally, a default DL/UL configuration of FS1 may be configured, and it may be overwritten by dynamic indication of subframe type change and/or via scheduling (e.g. DL grant or UL grant). Higher layer reconfiguration may also be considered.

[117] In terms of configuration of FS1 default DL/UL configuration type, a subset of TTIs/subframes with fixed D or U may be configured. Those fixed subframes may not change the subframe type either via dynamic singling or dynamic scheduling. For FS2, those fixed subframes may be at least used. For other subframes, additional configuration of subframe type and/or DL/UL configuration and/or availability for FS2 UEs' usage may be configured.

[118] Alternatively, In terms of configuration of FS1 default DL/UL configuration type, different types of subframe to FS1 UEs and FS2 UEs may be configured and FS1 UEs and FS2 UEs are multiplexed by FDM between DL and UL. FS1 UEs may be further classified between FS1 UEs with eMBB use cases and FS1 UEs with eV2X use cases. In other words, a subset of subframes with "D" type subframes may be fixed such that measurement signals and/or cell system bandwidth wide and/or cell specific signals/channels can be transmitted. For other subframes, the subframe type may be indicated as "U" from FS1 UE perspective such that sidelink resources can be configured/used in those resources, whereas the subframe type can be indicated as "D" from FS2 UE perspective. From the network perspective, the resource may be shared among FS1 and FS2 UEs and the network may transmit DL signals towards FS2 UEs. This may be applied to the same FS UEs depending on its communication/discovery types as well.

In other words, partial resources may be allocated for sidelink resources which can be multiplexed by FDM with DL resources in the same TTI. However, from a UE perspective, it may either perform DL or SL transmission.

[119]

[120] C. Frame structure for URLLC in TDD case

[121] The above frame structure with different subcarrier spacing may be applied to a frame structure for URLLC in TDD. If short TTI needs to be used for FS2, more DL/UL switching points within one TTI or different subframe type may be used. Or, if shorter OFDM symbol lengths are used for URLLC UEs for FS2, in one TTI of FS1, there may be different OFDM symbols used for DL and UL between FS1 and FS2.

[122] If the network does not support full duplex capability, it seems to be difficult to support different DL and UL in the same OFDM symbol duration. To minimize the impact, partial DL or UL transmission may be used in FS1. In partial DL or UL transmission, a UE may be scheduled with only one slot PDSCH or PUSCH transmission (if subcarrier spacing of FS2 is twice of FS1). In this case, the network may transmit data and then switch to UL and process URLCC uplink data. More generally, if FDM between FS1 and FS2 with different subcarrier spacing is used with potentially different UL/DL direction between FS1 and FS2, length of PDSCH or PUSCH scheduling and/or starting OFDM symbol index of PDSCH/PUSCH may be configured. Supporting partial PDSCH/PUSCH may be enabled by higher layer or dynamically indicated via common signaling or DCI or some signaling. Furthermore, FS2 needs to ensure DL control portion and UL control portion of FS1. Thus, first a few OFDM symbols may be used for DL control portion and last few OFDM symbols may be used for UL control portion. To minimize the DCI overhead, partial subframe length may be higher layer configured, and only starting position may be signaled. 0 or 1 may be used between partial and full TTI scheduling. Alternatively, it may also be combined with multiple TTI scheduling as well. Accordingly, partial TTI scheduling may be one of multi-TTI scheduling option.

[123] FIG. 11 shows another example of a frame structure for a new RAT according to an embodiment of the present invention. FIG. 11 shows examples of frame structures when short TTIs are used in TDD. This may be treated similar to the above case with FDD, assuming that the last short TTI or first short TTI may not be used and gap symbol may be punctured or rate matched. FIG. 11-(a) corresponds to level 1, i.e. FS1. FIG. 11-(b) corresponds to level 2 of FS2, in which one short TTI consists of 6 OFDM symbols. 2 short TTIs are configured in one TTI of FS1. FIG. 11-(c) corresponds to level 3 of FS2, in which one short TTI consists of 3 OFDM symbols. 4 short TTIs are configured in one TTI of FS1. FIG. 11-(d) corresponds to level 4 of FS2, in which one short TTI consists of 1/2 OFDM symbols. For DL, short TTIs having 2/1/2/1/2/1/2/1

OFDM symbols are configured, and for UL, short TTIs having 1/2/1/2/1/2/1/2 OFDM symbols are configured. 8 short TTIs are configured in one TTI of FS1. FIG. 11-(e) corresponds to level 4 of FS2, in which one short TTI consists of 2 OFDM symbols. 6 short TTIs are configured in one TTI of FS1.

[124] Meanwhile, similar to FDD case, different layout may also be possible. For example, if guard period or switching from DL to UL takes more than one OFDM symbol, portioning of short TTIs may be changed. Depending on the network capability, short TTI of FS2 may have different direction from FS1.

[125] For both FDD and TDD, in terms of scheduling, FS1 UE may also be scheduled with FS2, and where only data portion may be mapped over multiple TTIs of FS2. In terms of resource mapping, UEs of FS1 may be configured with the size of FS2 (if any), and the bitmap may indicate the data mapping to a set of short TTIs of FS2. For example, if a case of FIG. 11-(e) is used, bitmap of 6 bits may be used to indicate to which short TTIs FS1 UE PDSCH can be mapped. For example, [1 1 1 1 0 0] may indicate that PDSCH is mapped to first four short TTIs, is not mapped to the last two short TTIs. Depending on the latency requirement, different level of short TTIs may be used for each packet. In terms of scheduling, a UE supporting short TTI may monitor DL control region in the lowest level that the network supports (which may be signaled by SIB or higher layer), or the level may be configured per UE or per session or per application. It is also possible that short TTI transmission may start in the middle of longer TTI transmission. In this case, preemption of longer TTI transmission may also be possible. To minimize the impact from this preemption, the network may send a common signal in short TTI control region which indicates whether there is any short TTI transmission or not. Alternatively, a longer TTI UE may perform blind search on data. Alternatively, in the next longer TTI control, the network may indicate whether there was interrupt in the previous transmission or not, and if so, the network may further indicate which short TTIs have been used.

[126] In summary, the proposed frame structure may allow that shorter TTIs can be nested to the next level of short TTI. In other words, one TTI of one level may be divided to 2 short TTIs of the next level (except from 4 short TTIs to 6 short TTIs and 6 short TTIs to 12 short TTIs if nested frame structure for 8 short TTIs is not used, and if the nested frame structure is used, only exception from 8 short TTIs to 12 short TTIs). Similar to FDD case, the order between 1/2 in 8 short TTIs case may be changed. This nested frame structure may allow multi-TTI scheduling a bit easier. For example, the shortest TTI may be configured to allow potentially many control possibilities with multi-TTI scheduling to [1...N], where N is the level of the configured short TTI level.

[127] FIG. 12 shows another example of a frame structure for a new RAT according to an embodiment of the present invention. If DL and UL portion is equal within one TTI,

potentially limited number of levels may be supported for short TTIs. Referring to FIG. 12, only level 1, level 2, and level 3 are supported. FIG. 12-(a) corresponds to level 1, i.e. FS1. FIG. 12-(b) corresponds to level 2 of FS2, in which one short TTI consists of 6 OFDM symbols. 2 short TTIs are configured in one TTI of FS1. FIG. 12-(c) corresponds to level 3 of FS2. For level 3, short TTI size of 2 OFDM symbols may be considered (in total of 3 short TTIs per DL/UL) or 1/2/1/2 (or 2/1/2/1) short TTI lengths may be considered to support 4 short TTIs.

[128] UL switching symbol may be placed in any OFDM symbol in subframe with DL transmission. In other words, gap for DL to UL switching may be placed in any OFDM symbol which will be used by UE for switching. From DL perspective, the gap and UL symbols may be rate matched or punctured. From UL perspective, the gap and DL symbols may be rate matched or punctured.

[129]

[130] D. Frame structure for eV2X in FDD

[131] In this case, sharing among UEs transmitting towards the network needs to share UEs transmitting sidelink. The resource allocation mechanism or frame structure of eV2X UEs may be similar to other FS1 UEs. From a V2X UE perspective, if the same RF/ baseband capability of DL is used for both reception from the network and reception from other UEs, it may be necessary to separate DL resources between two transmission types.

[132] Similar mechanisms used in TDD case may be applied to FDD case as well, where sidelink resources may be configured in either DL or UL spectrum. The TTI length of sidelink may also be reduced to allow DL control reception and/or gap creation. Similar approach to place SL DL/UL control may be considered. In this case, if sidelink is only configured in UL spectrum, DL control may not be considered. If sidelink is configured in DL spectrum, UL control may not be considered. Alternatively, UL and DL spectrum may be used in a pair among different cells for different UEs. For example, a set of subframes may be fixed as DL or UL in each DL and UL spectrum. These configured subframes may not be configured as sidelink resources in either DL or UL spectrum. Other subframes in either DL or UL may be used for sidelink operation, like multi-carrier sidelink operation. Each UE may determine reception frequency and transmission frequency between DL and UL spectrum. Once it determines its direction, the UE will continue receiving or transmitting in one frequency and do opposite in the other frequency. In other words, other than fixed subframes, flexible subframes in either DL or UL may be used, like one carrier from a sidelink perspective similar to TDD case. More generally, TDD case may be applied in those flexible subframes, and DL carrier may include DL control in each TTI depending on configurations and UL carrier may include UL control in each TTI

depending on configuration.

[133]

[134] E. Frame structure for eV2X in TDD

[135] If TDD is used for eV2X, FS1 may be configured. Depending on its subframe type configuration of FS1, subset of UL portions may be used for sidelink operation (possibly except for UL control regions). Alternatively, a subset of subframes may be configured with subframe type, and the other subframes may be determined based on higher layer signaling and/or dynamic signaling. For example, non-DL subframe may be potentially allowed as sidelink capable subframes, then which subframes are usable for sidelink operation may be dynamically indicated by scheduling assignment (SA) transmission. In this case, to avoid any ambiguity, the SA may be transmitted in fixed UL subframe configured in MIB and/or SIB.

[136] IF DL control is potentially used in flexible subframes (i.e. flexible subframe is a subframe without configured subframe type via MIB and/or SIB), it may be desirable to avoid use of potential DL control portion in sidelink operation to minimize interference to other UEs, and potentially allow listening on DL control by eV2X UEs. In this case, DL control and potentially a gap to switch from DL to UL may be assigned in every flexible subframe. Alternatively, a subset of subframes with DL control may also be preconfigured, and a UE may assume that the first one or a few OFDM symbols may not be used for sidelink transmission in such subframes. To align resources among different cells, cells may be coordinated including DL control portions. Or, simply one or a few first OFDM symbols may always not be used for sidelink transmission in every TTI.

[137] Alternatively, subframe type for FS1 may be ignored and only sidelink resource information may be considered. For example, the network may perform FDM approaches between DL and UL between FS1 UEs receiving the data from the network and sidelink UEs.

[138] Whether to reserve DL control and UL control may be determined by at least one of the following approaches.

[139] - The network may configure the length of sidelink resource used in one TTI or the necessity of DL control and/or UL control region reservation. This may also allow flexible configuration of DL and UL control resource from network perspective. Only DL control portion may be reserved.

[140] - The UE may determine whether to reserve DL control and UL control depending on communication/discovery type. If the network controlled communication/discovery is used, DL control may be reserved. Otherwise, full TTI may be used for sidelink transmission. The gap may be used between DL and UL direction to minimize interference.

[141] - The resource may also include TTI size per each TTI in resource configuration.

[142] - It may be prefixed or follow a rule to determine the size.

[143] When each cell uses dynamic subframe type, different interference may be expected depending on subframe type on sidelink resources. In this sense, a subset of default UL subframes may be configured, and at least control channels of sidelink (such as SA) may be transmitted in those UL subframes. Those fixed UL subframes may be aligned among neighbor cells to minimize the interference among cells (similar concept may also be applied to DL as well).

[144] Also, ACK/NACK and control information for sidelink operations may be supported. Thus, sidelink DL control (configuration of sidelink resources, collision handling, etc., where all UEs except for the controlling UEs are supposed to listen) and ACK/NACK or feedback resource of sidelink (called sidelink UL control) should be placed somewhere. For this, at least one of the following options may be considered.

[145] - Option 1: Sidelink SL control may be multiplexed with DL/UL control by FDM (same direction): Or, the same OFDM symbol for DL control may be used for sidelink DL control and the same OFDM symbol for UL control may be used for sidelink UL control. It may follow the network configuration and the same configuration may be indicated to other UEs. This may be beneficial for relay nodes or UEs without network controlled operation. If this option is used, proper gap or interference mitigation between DL control and sidelink DL control may be assumed.

[146] - Option 2: Sidelink control FDM may be multiplexed with DL/UL control by FDM (opposite direction): Or, sidelink DL control may be placed in UL control region and sidelink UL control may be placed in SL DL control region to minimize the interference, assuming that interference from a UE to the network may be less significant to interference between UEs.

[147] - Option 3: Nested self-contained subframe

[148] FIG. 13 shows an example of a nested self-contained subframe according to an embodiment of the present invention. Referring to FIG. 13, sidelink DL control and/or sidelink UL control may be placed only in resources configured for sidelink operation. Depending on UE capability, gap from sidelink DL control to sidelink-transmit may be necessary. Depending on UE timing advance (TA) and other UL timing, gap between sidelink DL-receive to sidelink UL control may also be necessary. To allow a gap, it may be generally desirable not to use the last OFDM symbol for sidelink. In this case, either sidelink UL control or sidelink DL control may be placed in the second next to the last OFDM symbol.

[149] If the last OFDM symbol is used for UCI transmission toward to the network, it may not be used for the gap. To handle this case, a UE may create a gap by not receiving the next OFDM symbol if the next subframe is also used for sidelink. In this case,

sidelink UL control may be omitted and a UE may not receive sidelink DL control. To avoid such a case, if there is possibility of UCI transmission in the last OFDM symbol, it may be desirable to add one additional gap in the first OFDM symbol of the TTI.

[150] Overall, the followings may be considered for sidelink frame structure. TTI length of a sidelink may be at least 2 * gap OFDM symbols smaller than TTI length of host frame structure (e.g. if the gap size is 1 OFDM symbol, 2 OFDM symbols smaller than the FS1). Further, sidelink DL control and sidelink UL control may be placed in next to DL control and UL control (after and before) in the same TTI. If the gap is necessary to switch from sidelink DL/UL control to DL/UL control, the following order of priorities, UL control, sidelink DL/UL control, and DL control, may be used. If there is no sufficient gap is created by dropping lower priority, the next lower priority channel may be dropped.

[151]

[152] 4. Additional frame structure design for URLLC considering U-plane latency

[153] In the new RAT, scalable numerology may be considered. Some candidates of subcarrier spacing include 15 kHz, 30 kHz, 60 kHz, 120 kHz, etc. Among those, at least 15, 30, 60 kHz subcarrier spacing may be applied for under 6 GHz frequency band. Considering that the requirement of URLLC is 0.5ms for U-plane latency, some consideration on frame structure may be necessary. To minimize the overall U-plane latency, UL subframe boundary may be shifted. Assuming that data at L2/L3 queue may be scheduled to the next available subframe, the average latency may be 0.5*TTI. Assuming that UL subframe boundary is shifted by decoding latency of data channel, the latency to get the data at L2 at the destination side (without considering HARQ process) may be around 2*TTI.

[154]

[155] A. Frame structure for URLLC in FDD

[156] If HARQ process is considered, in FDD, since UL can be available anytime, the latency to encode ACK/NACK and TA may be added with HARQ retransmission latency. Overall, it may become 2.8*TTI (around 3*TTI).

[157] Table 1 shows an example of numerologies for normal CP and extended CP with 30 kHz spacing.

[158] [Table 1]

	eMBB - NCP	eMBB - ECP	URLLC - NCP	URLLC - ECP
OFDM symbol	33.34	33.34	33.34	33.34
Number of OFDM symbols in a TTI	14	12	4/3/4/3 in 0.5 ms	Option 1: 3 symbolsOption 2: 4 symbols
TTI length	0.5 ms	0.5 ms	0.1425/0.1075/0.1425/0.1075 ms	0.125 (with Option 1)0.16667 (with Option 2)
CP length	Half of LTE CP in NCP case	8.33us	Half of LTE CP in NCP case	8.33us

[159] Table 2 shows an example of numerologies for normal CP and extended CP with 15 kHz spacing.

[160] [Table 2]

	eMBB - NCP	eMBB - ECP	URLLC - NCP	URLLC - ECP
OFDM symbol	66.67 us	66.67 us	66.67 us	66.67 us
Number of OFDM symbols in a TTI	14	12	2	2 symbols
TTI length	1 ms	1 ms	0.143 ms	0.1667
CP length	Half of LTE CP in NCP case	Half of LTE CP in ECP case	Half of LTE CP in NCP case	Half of LTE CP in ECP case

[161] Table 3 shows an example of numerologies for normal CP and extended CP with 60 kHz spacing.

[162] [Table 3]

	eMBB - NCP	eMBB - ECP	URLLC - NCP	URLLC - ECP
OFDM symbol	16.67 us	16.67 us	16.67 us	16.67 us
Number of OFDM symbols in a TTI	14	10 (option 1)12 (option 2)	7	5 symbols (option 1)6 symbols (option 2)
TTI length	0.25 ms	0.25 ms	0.125 ms	0.125
CP length	Half of LTE CP in NCP case	8.33us (option 1)4.16 us (option 2)	Half of LTE CP in NCP case	8.33us (option 1)4.16 us (option 2)

[163] If 3 symbol short TTI is used (e.g. URLLC / 30 kHz / option 2), one short TTI may cross the slot boundary of eMBB subframe if slot is defined. More generally, short TTI may be defined over one or multiple subframes. One example is to aggregate two subframes and divide two subframe into multiple short TTIs (e.g. with 14 OFDM symbols of eMBB subframe, 4 OFDM symbol * 7 short TTIs may be constructed over two subframes for URLLC use case). In this case, where the short TTI starts (e.g. every even subframe or every odd subframe) needs to be clarified and may be defined in the specification or determined via initial access procedure.

[164]

[165] B. Frame structure for URLLC in TDD

[166] In TDD, since the ACK/NACK timing may be dependent on the availability of UL, if there is unavailable UL, the latency may be increased. Thus, to support low latency, in every short TTI, it is expected to have UL portion which can be dynamically created, whenever there is UL transmission. In TDD, if UL subframe boundary is shifted, UL transmission may occur in the middle of subframe. This may be handled by the network if the network and/or UE support (semi) full duplex capability. Or, larger delay budget may be assumed for TDD (e.g. 2 * TTI + TA without HARQ, 3 * TTI with HARQ). In TDD, even without subframe offset, as DL portion is relatively smaller compared to FDD, overall decoding latency may also be reduced (which in turn may lead less peak data rate with low latency). For TDD, the similar TTI length and the number of OFDM symbol per TTI may be considered.

[167] FIG. 14 shows another example of a frame structure for a new RAT according to an embodiment of the present invention. In FIG. 14, 2 OFDM symbol length frame structure is supported in TDD. In order to support 2 OFDM symbol length with 15 kHz or other subcarrier spacing, one OFDM symbol may be assumed for DL portion, and

double subcarrier spacing for uplink portion may be assumed (e.g. 30 kHz with 15 kHz DL subcarrier spacing) with keeping the same CP overhead for UL. The remaining part may be used for guard period (GP) including TA and DL/UL switching time.

[168] FIG. 15 shows another example of a frame structure for a new RAT according to an embodiment of the present invention. In FIG. 15, 3 OFDM symbol length frame structure is supported in TDD.

[169] For multiplexing of different use cases from the network perspective, different numerology or different subcarrier spacing may be used where the same CP may be still assumed between two different use cases. For this, 1 OFDM symbol for DL and 1 OFDM symbol for GP and 1 OFDM symbol for UL may be define in 3 OFDM symbol TTI length. Alternatively, similar to 2 OFDM symbol case, only UL portion may use different subcarrier spacing to allow more DL OFDM symbols available.

[170] More generally, this approach may be explained that URLLC can be utilized with extended CP with larger subcarrier spacing compared to eMBB to maintain the same level of CP. The remaining time may be applied towards GP between UL/DL switching and TA. Having larger GP in URLLC, TDD may be beneficial to allow more decoding time and UL transmission preparation. This case may be beneficial to reserve more processing time or allow larger GP which may be beyond one OFDM symbol length in 3 OFDM symbol short TTI case in TDD.

[171] FIG. 16 shows an example of different subcarrier spacing between URLLC and eMBB which are multiplexed in a same carrier or frequency band. From a UE perspective, each portion may be managed by individual transmission point or a cell such that initial access can be achieved separately per use cases. However, URLLC provided by shorter TTI with the same numerology with eMBB may also share the initial access procedure with host eMBB case. In this sense, via the initial access, whether to support short TTI or regular TTI may be informed.

[172] In determining UL portion for short TTI for URLLC, the portion or the number of OFDM symbol for UL portion in each short TTI may also depend on the necessity of demodulation RS (DM-RS) transmission. For example, if a UE requires to transmit DM-RS at least in one subframe in every 7 OFDM symbol, short TTIs within 7 OFDM symbol may not need to transmit DM-RS multiple times. In this sense, the first short TTI in every 7 OFDM symbol may have at least two OFDM symbols for UL portion and the remaining short TTIs may have one OFDM symbol for UL portion. Accordingly, dynamic determination of UL portion size may be supported depending on the necessity of DM-RS transmission in a given short TTI or not. This may also impact the behavior of DL reception, where a UE may puncture or not receiving the last DL OFDM symbol to shift UL portion one symbol forward. This may be restricted in case of 3 OFDM symbol short TTI. In this case, alternative approach is to transmit GP and

DM-RS in one OFDM symbol with different subcarrier spacing or by other means.

[173]

[174] 5. Above 6 GHz frequency

[175] The above description of the present invention may be applied for a frequency band below 6 GHz. The above description of the present invention may be applied for a frequency band above 6 GHz as well. In a frequency band above 6 GHz, analog beam may be used. In this case, the unit of beam switching may be used similar to one TTI mentioned for FS1 and FS2. However, the unit of beam switching for data transmission may be assumed for the unit size. For example, if beam switching occurs in every OFDM symbol for PSS/SSS or control channel transmission, whereas beam switching occurs only once per TTI for data transmission, the basic unit for beam switching may be 1 TTI. If beam switching for data transmission occurs in every 1/2 TTI, the basic unit for beam switching may be 1/2 TTI. When configuring sidelink resources, beam direction of each resource may be indicated such that UEs can communicate each other based on beam direction and based on each other's location information. The same size of subcarrier spacing among different applications may be used for frequencies above 6GHz.

[176]

[177] 7. DM-RS sharing

[178] For PUSCH, depending on coverage level, the network may configure the number of TTIs used for PUSCH transmission. As DM-RS for one OFDM symbol TTI in UL is very challenging (similar issue may be in DL as well, yet the problem may become more significant in UL due to SC-FDM characteristic and PAPR issue), the TTI of UL can be represented a bit differently in consideration of potentially DM-RS sharing among different TTIs.

[179] FIG. 17 shows an example of DM-RS sharing according to an embodiment of the present invention. FIG. 17-(a) shows a case of level 5 (i.e. 1 OFDM symbol short TTI) with discontinuous DM-RS. In this case, one symbol short TTIs share the DM-RS in the middle of legacy slot. Potentially different cyclic shift (CS) may be configured or preconfigured per each OFDM symbol to allow multiplexing of different TTIs. If a UE schedules more than one TTIs sharing the same DM-RS, it may continue using the first DM-RS scrambling/sequence of the first transmission among multiple TTIs. FIG. 17-(b) shows a case of level 4 (i.e. 2 OFDM symbols short TTI) with no DM-RS sharing.

[180] FIG. 17-(c) shows a case of level 4 (i.e. 2 OFDM symbols short TTI) for physical sidelink shard channel (PSSCH) with DM-RS sharing. FIG. 17-(d) also shows a case of level 4 (i.e. 2 OFDM symbols short TTI) for PSSCH with DM-RS sharing. For Level 4 with DM-RS sharing, there may be two different approaches.

[181] - Approach 1: DM-RS sharing does not occur between adjacent short TTIs with 2 OFDM symbols, and DM-RS sharing occurs between short TTIs with 1 OFDM symbol and 2 OFDM symbols. This approach corresponds to FIG. 17-(c).

[182] - Approach 2: DM-RS sharing occurs over all TTIs similar to level 5. One DM-RS symbol is shared by multiple short TTIs. This corresponds to FIG. 17-(d). Similar level 5, CS may be predefined or configured per OFDM symbol, and the first OFDM symbol mapped scrambling/CS/sequence is used if the short TTI size is larger than 1.

[183] FIG. 17-(e) shows a case of level 3 (i.e. 3/4 OFDM symbols short TTI) for physical uplink control channel (PUCCH) with no DM-RS sharing. FIG. 17-(f) shows a case of level 3 (i.e. 3/4 OFDM symbols short TTI) for PSSCH with DM-RS sharing. For level 3, if DM-RS sharing is considered, the fourth OFDM symbol in each slot may be used for DM-RS sharing.

[184] Additional DM-RS within a short TTI may be added which may or may not be shared among different short TTIs. For example, if PUCCH transmission is considered, with DM-RS sharing, additional DM-RS (the same DM-RS or with different CS) may be used in each TTI as well.

[185] FIG. 18 shows an example of PUSCH scheduling with DM-RS sharing according to an embodiment of the present invention. Referring to FIG. 18, PUSCHs of level 4 share DM-RS, and PUSCHs of level 3 with 2 short TTIs may also share DM-RS.

[186] FIG. 19 shows an example of PUCCH scheduling without DM-RS sharing according to an embodiment of the present invention. Referring to FIG. 19, there is no DM-RS sharing.

[187]

[188] 8. ACK/NACK transmission

[189] For ACK/NACK transmission or UCI transmission via PUCCH, the network may also indicate the number of TTIs used for ACK/NACK transmission or PUCCH transmission via DCI or higher layer signaling. As the coverage of ACK/NACK transmission may also be dependent on the number of ACK/NACK bits or UCI bits, it may be dynamically indicated by DL grant. For example, the timing and frequency offset of ACK/NACK transmission, and also the number of TTIs used for ACK/NACK transmission may be configured in DL grant. Or, the length may be determined by the number of UCI bits. The number of TTIs used for PUCCH may be semi-statically configured. In terms of baseline timing of ACK/NACK, (sPDSCH transmission duration + sPDSCH transmission duration (for decoding) or higher layer configured decoding latency + 2 * sTTI for UL for ACK/NACK preparation) may be assumed. If there is offset configured in the DL grant, the offset may be added to the baseline timing of ACK/NACK.

[190]

[191] 9. Short TTI indexing

[192] To indicate a short TTI within the largest TTI, assuming the largest TTI uses the subframe index, separate indexing of short TTI may be considered. In one subframe, K maximum short TTI may be placed. In terms of configuration of e.g. semi-persistent scheduling (SPS), CSI, etc., or any periodic configuration, periodicity may be represented by TTI length or multiple of TTIs. The periodicity may start from SFN=0 and subframe index = 0. Alternatively, periodicity may be represented in two level, i.e. periodicity in subframes and periodicity within a subframe.

[193]

[194] 10. Short TTI length for each channel

[195] There are a couple of aspects to determine right shot TTI length for each channel, e.g. the file size, system resource utilization, UE geometry, etc. Overall, smaller file size in a lighted loaded scenario for good coverage UEs may lead best performance gain, whereas very little or even worse performance may be expected with short TTI for poor coverage UEs with large file sizes. In this sense, it seems considerable to apply UE-specific TTI length at least based on UE geometry. However, the file size also impacts on the overall performance gain due to the associated protocol overhead and control overhead. In this sense, mechanisms to allow dynamic change of sPDSCH/sPUSCH may be beneficial to address the case where a UE has multiple transmission control protocol (TCP) sessions with different file sizes. As packets from different TCP sessions are not differentiable from the physical layer perspective, it may be beneficial to consider dynamic TTI length adaptation via DCI.

[196] To support this, the following overall approaches may be considered.

[197] (1) Dynamic TTI length for all channels: The TTI length of sPDCCH may be dynamically changed which are blindly monitored by a UE. Based on the scheduled sPDCCH, the UE may determine the TTI length for sPDSCH/sPUSCH. This approach however requires some mechanism to identify the length of sPDCCH. One approach is to assume that FDM between sPDCCH and sPDSCH is used such that sPDCCH is transmitted always over the entire short TTI. Or, explicit indication in DCI may be necessary.

[198] (2) Fixed TTI length for sPDCCH with dynamic indication via DCI: Alternatively, the TTI length used for sPDCCH may be higher layer configured, and the TTI length of scheduled sPDSCH or sPUSCH may be dynamically adapted by the signaling in DCI.

[199] The first approach may offer benefits to adapt sPDCCH resource in time domain (if sPDCCH and sPDSCH is multiplexed partially or fully by FDM). This however may be also achieved by different aggregation levels. Furthermore, it seems that both approaches may require potentially explicit indication via DCI. Thus, the clear benefits of

the first approach while it restricts the flexibility are not clear. In this sense, to simplify the UE blind decoding, refer the second approach may be preferred. In other words, supporting different TTI length for data channel may be supported by a multiple TTI scheduling manner.

[200] When variable/multi-TTI length scheduling is supported, the issue with multiplexing between sPDSCH with different TTI lengths may be also considered in terms of processing latency For example, if decoding latency is same as the length of sPDSCH, if longer TTI scheduling occurs before shorter TTI scheduling happens, the decoding or processing of following shorter TTI can be delayed (unless pre-emption is assumed). Thus, depending on the scheduling, the overall latency till ACK/NACK transmission can be changed. To address different cases, asynchronous HARQ-ACK feedback timing for sPDSCH may be considered as well where ACK/NCK timing can be signaled via DL scheduling DCI. Further, the shorter TTI of PUCCH transmission may reduce the overall coverage. This may be all right for good coverage UEs whereas it may impact on the cell edge UEs. In this sense, the TTI length for sPUCCH transmission may be semi-statically configured. Based on the semi-statically configured TTI length for sPDCCH and sPUCCH, timing of DL and UL may be respectively determined which are used for resources for DL and UL transmissions.

[201]

[202] FIG. 20 shows a method for configuring a frame structure for a new RAT by a network node according to an embodiment of the present invention. The present invention described above may be applied to this embodiment.

[203] In step S100, the network node configures a first frame which has one legacy TTI and a second frame which has multiple short TTIs. In step S110, the network node communicates with a UE by using at least one of the first frame and the second frame.

[204] The second frame may have the nested frame structure described above. The second frame may contain different number of short TTIs per a number of symbols in each short TTI. The number of symbols in each short TTI may be identical. In this case, at least one symbol may be shared between adjacent short TTIs.

[205] The second frame may contain at least one of a symbol for DL control, a symbol for UL control, a symbol for a sidelink DL control or a symbol for a sidelink UL control. The symbol for DL control may be placed in a first symbol of the second frame, and the symbol for UL control may be placed in a last symbol of the second frame. The symbol for sidelink DL control may be placed in a second last symbol of the second frame, and the symbol for sidelink UL control may be placed in a second symbol of the second frame. Further, a gap may be configured between the symbol for DL control and the symbol for sidelink UL control, or between the symbol for sidelink DL control and the symbol for UL control.

[206] A synchronization signal may be transmitted in a minimum system bandwidth with minimum density in the second frame. The synchronization signal may be shared among the first frame and the second frame. The synchronization signal may be repeated in a frequency domain or a time domain.

[207] The first frame and the second frame may be configured according to one of different baseband bandwidth capability, different processing capability, different number of possible UEs accessing a cell, different synchronization requirement, different subcarrier spacing or different coverage requirement. The UE may be a one of an mMTC UE, a URLL) UE or an eV2X UE.

[208] FIG. 21 shows a wireless communication system to implement an embodiment of the present invention.

[209] A network node 800 may include a processor 810, a memory 820 and a transceiver 830. The processor 810 may be configured to implement proposed functions, procedures and/or methods described in this description. Layers of the radio interface protocol may be implemented in the processor 810. The memory 820 is operatively coupled with the processor 810 and stores a variety of information to operate the processor 810. The transceiver 830 is operatively coupled with the processor 810, and transmits and/or receives a radio signal.

[210] A UE 900 may include a processor 910, a memory 920 and a transceiver 930. The processor 910 may be configured to implement proposed functions, procedures and/or methods described in this description. Layers of the radio interface protocol may be implemented in the processor 910. The memory 920 is operatively coupled with the processor 910 and stores a variety of information to operate the processor 910. The transceiver 930 is operatively coupled with the processor 910, and transmits and/or receives a radio signal.

[211] The processors 810, 910 may include application-specific integrated circuit (ASIC), other chipset, logic circuit and/or data processing device. The memories 820, 920 may include read-only memory (ROM), random access memory (RAM), flash memory, memory card, storage medium and/or other storage device. The transceivers 830, 930 may include baseband circuitry to process radio frequency signals. When the embodiments are implemented in software, the techniques described herein can be implemented with modules (e.g., procedures, functions, and so on) that perform the functions described herein. The modules can be stored in memories 820, 920 and executed by processors 810, 910. The memories 820, 920 can be implemented within the processors 810, 910 or external to the processors 810, 910 in which case those can be communicatively coupled to the processors 810, 910 via various means as is known in the art.

[212] In view of the exemplary systems described herein, methodologies that may be im-

plemented in accordance with the disclosed subject matter have been described with reference to several flow diagrams. While for purposed of simplicity, the methodologies are shown and described as a series of steps or blocks, it is to be understood and appreciated that the claimed subject matter is not limited by the order of the steps or blocks, as some steps may occur in different orders or concurrently with other steps from what is depicted and described herein. Moreover, one skilled in the art would understand that the steps illustrated in the flow diagram are not exclusive and other steps may be included or one or more of the steps in the example flow diagram may be deleted without affecting the scope of the present disclosure.

[213]

Claims

[Claim 1] A method for configuring a frame structure by a network node in a wireless communication system, the method comprising:
configuring a first frame which has one legacy transmission time interval (TTI) and a second frame which has multiple short TTIs; and
communicating with a user equipment (UE) by using at least one of the first frame and the second frame.

[Claim 2] The method of claim 1, wherein the second frame contains different number of short TTIs per a number of symbols in each short TTI.

[Claim 3] The method of claim 2, wherein the number of symbols in each short TTI is identical.

[Claim 4] The method of claim 3, wherein at least one symbol is shared between adjacent short TTIs.

[Claim 5] The method of claim 1, wherein the second frame contains at least one of a symbol for downlink (DL) control, a symbol for uplink (UL) control, a symbol for a sidelink DL control or a symbol for a sidelink UL control.

[Claim 6] The method of claim 5, wherein the symbol for DL control is placed in a first symbol of the second frame, and
wherein the symbol for UL control is placed in a last symbol of the second frame.

[Claim 7] The method of claim 5, wherein the symbol for sidelink DL control is placed in a second last symbol of the second frame, and
wherein the symbol for sidelink UL control is placed in a second symbol of the second frame.

[Claim 8] The method of claim 5, wherein a gap is configured between the symbol for DL control and the symbol for sidelink UL control, or between the symbol for sidelink DL control and the symbol for UL control.

[Claim 9] The method of claim 1, wherein a synchronization signal is transmitted in a minimum system bandwidth with minimum density in the second frame.

[Claim 10] The method of claim 9, wherein the synchronization signal is shared among the first frame and the second frame.

[Claim 11] The method of claim 9, wherein the synchronization signal is repeated in a frequency domain or a time domain.

[Claim 12] The method of claim 1, wherein the first frame and the second frame

are configured according to one of different baseband bandwidth capability, different processing capability, different number of possible UEs accessing a cell, different synchronization requirement, different subcarrier spacing or different coverage requirement.

[Claim 13] The method of claim 1, wherein the UE is a one of a massive machine-type communication (mMTC) UE, an ultra-reliable and low latency communication (URLLC) UE or an enhanced vehicle-to-everything (eV2X) UE.

[Claim 14] A network node in a wireless communication system, the network node comprising:

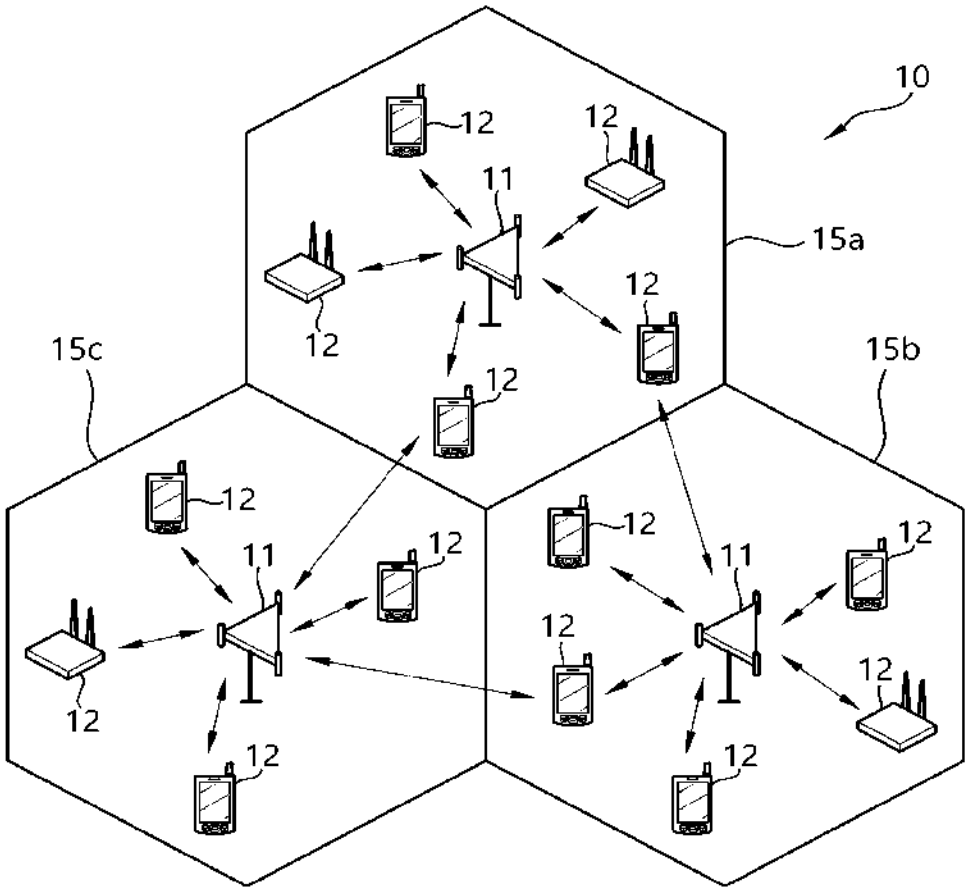
a memory;

a transceiver; and

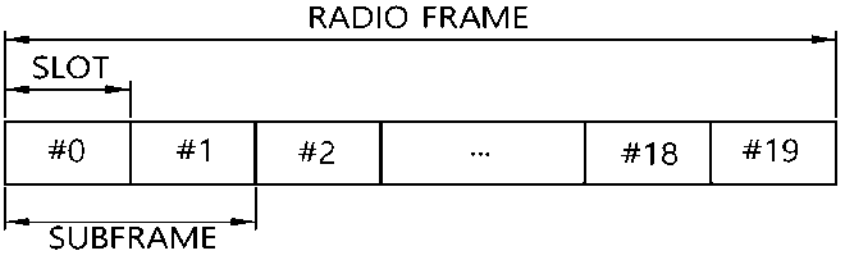
a processor, coupled to the memory and the transceiver, that:

configures a first frame which has one legacy transmission time interval (TTI) and a second frame which has multiple short TTIs, and controls the transceiver to communicate with a user equipment (UE) by using at least one of the first frame and the second frame.

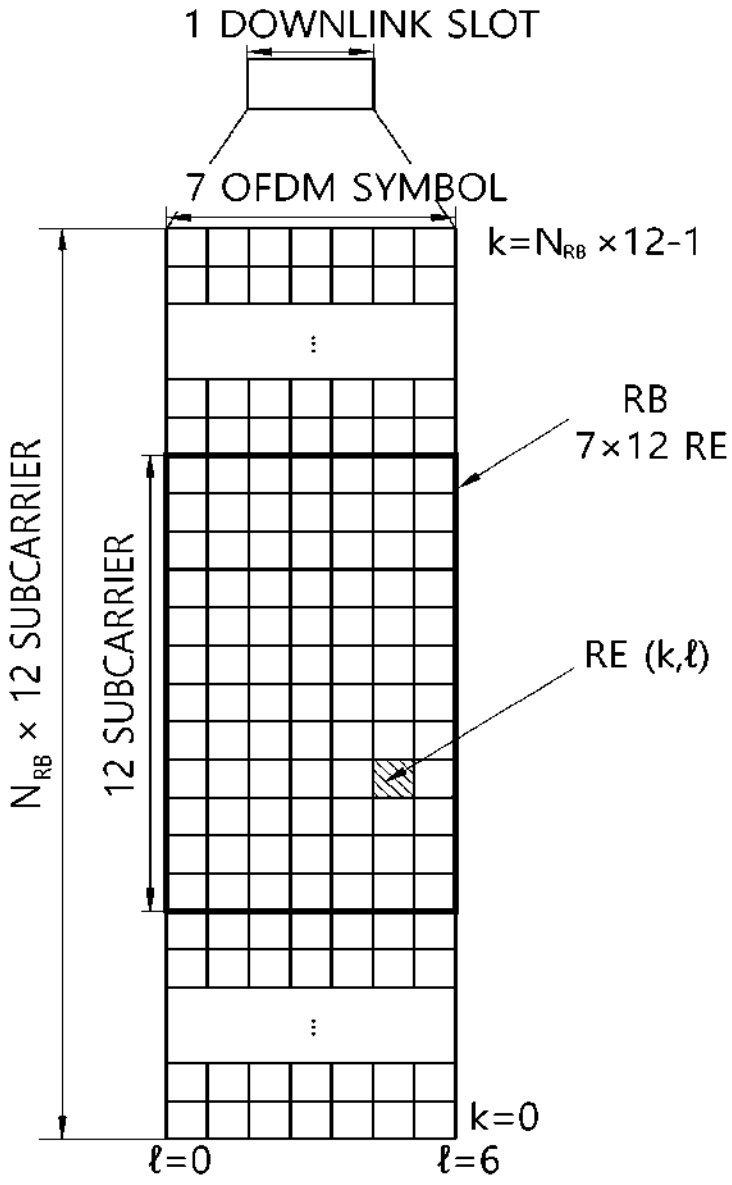
[Fig. 1]



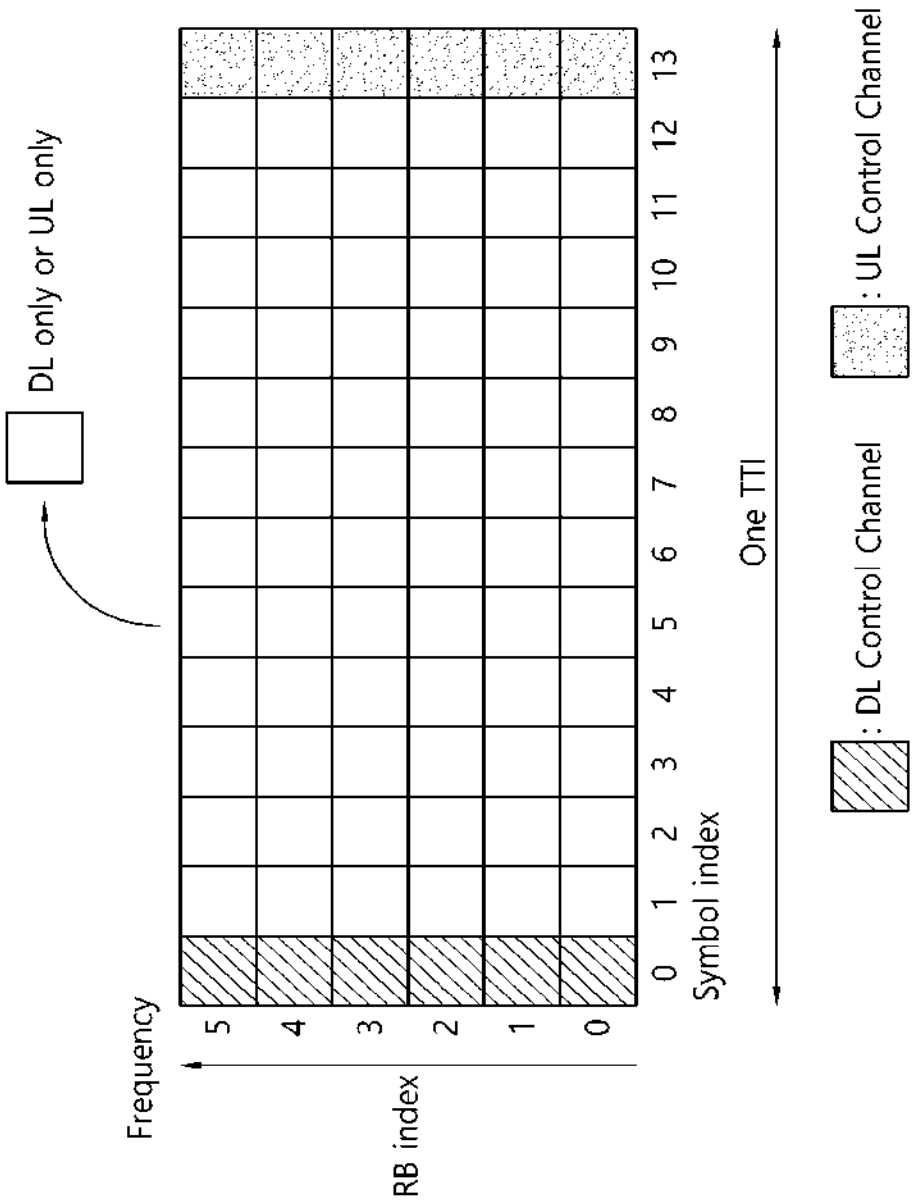
[Fig. 2]



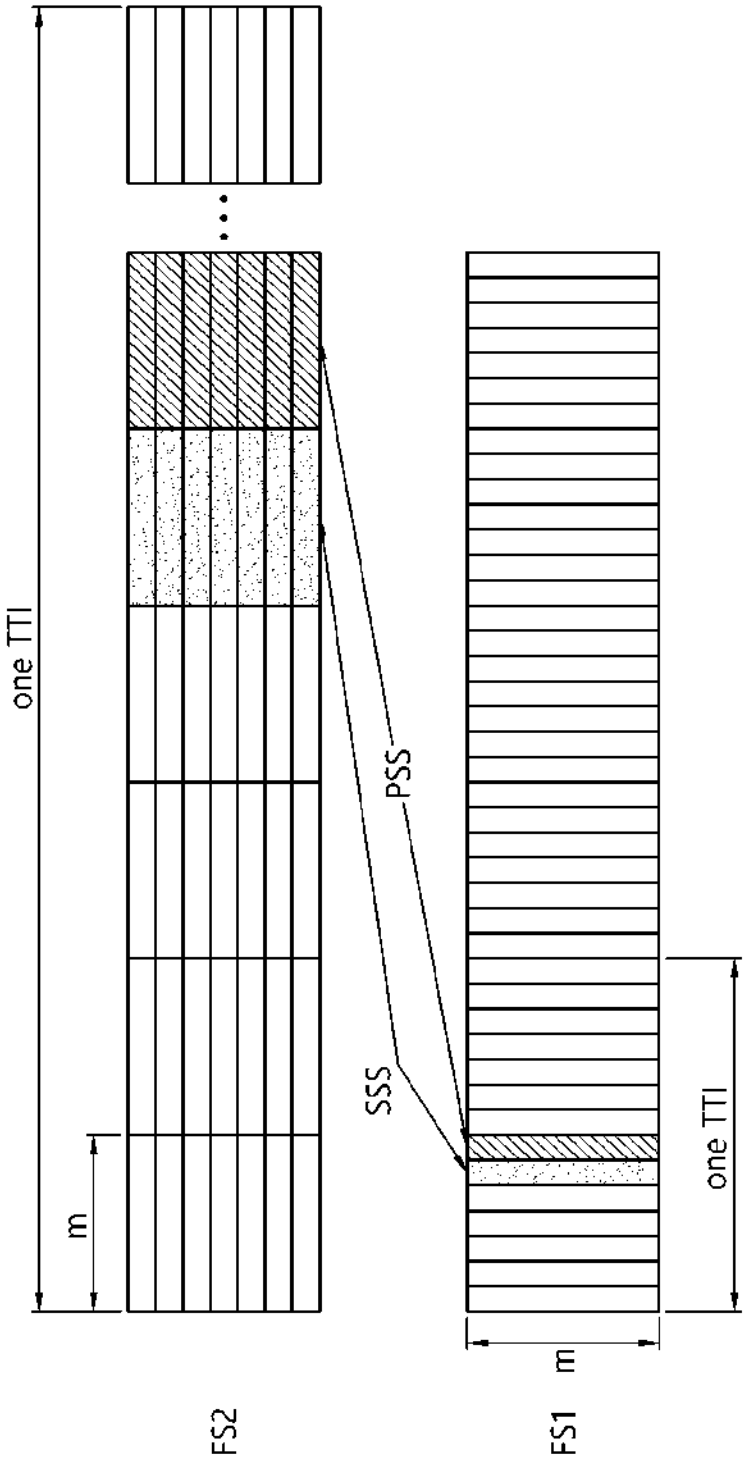
[Fig. 3]


1 DOWNLINK SLOT
7 OFDM SYMBOL
k=N_RB ×12-1
RB
7×12 RE
RE (k,ℓ)
N_RB × 12 SUBCARRIER
12 SUBCARRIER
k=0
ℓ=0
ℓ=6

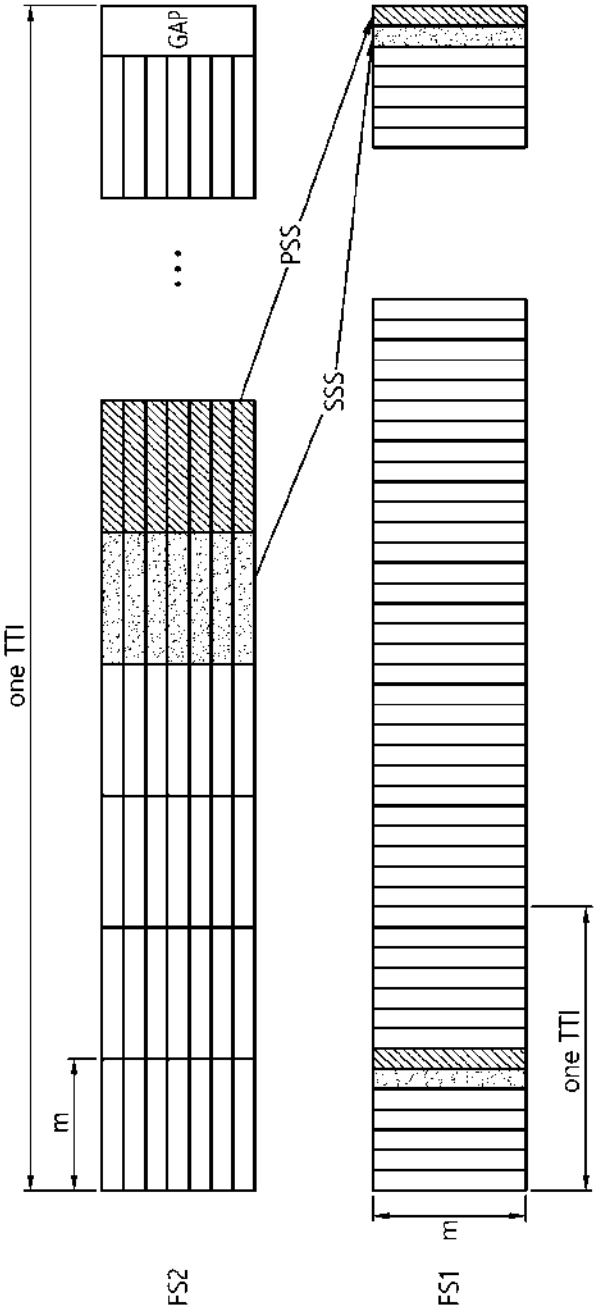
[Fig. 4]


DL only or UL only
Frequency
RB index
5
4
3
2
1
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13
Symbol index
One TTI
: DL Control Channel
: UL Control Channel

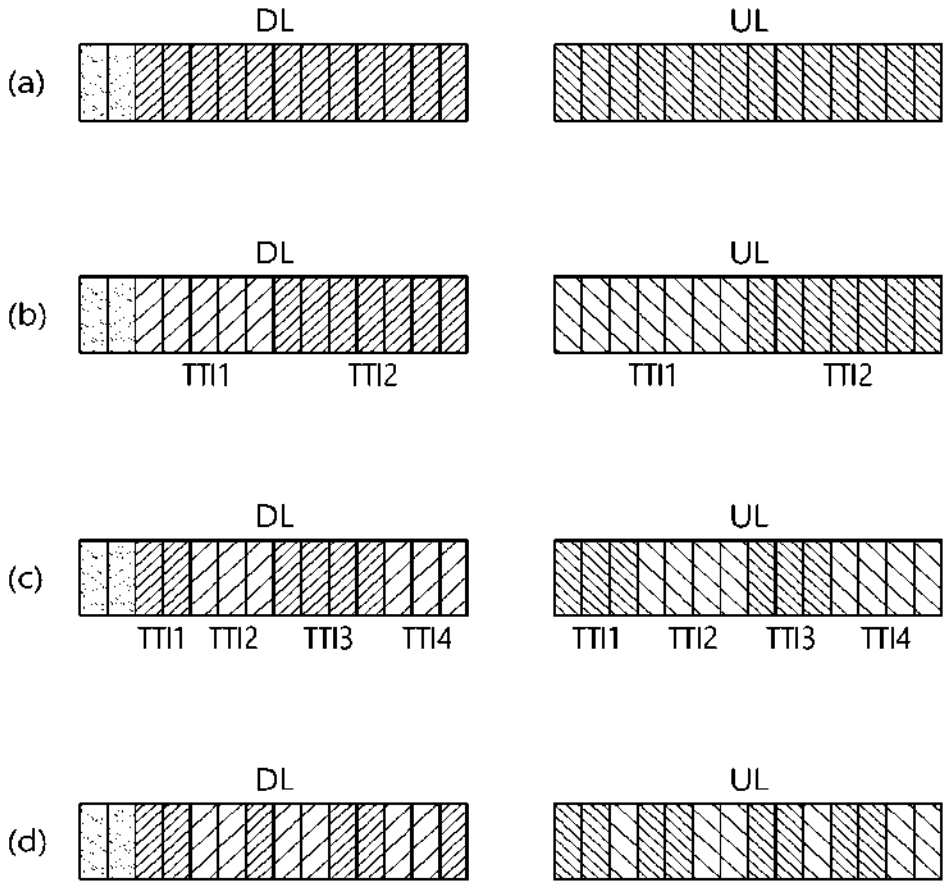
[Fig. 5]



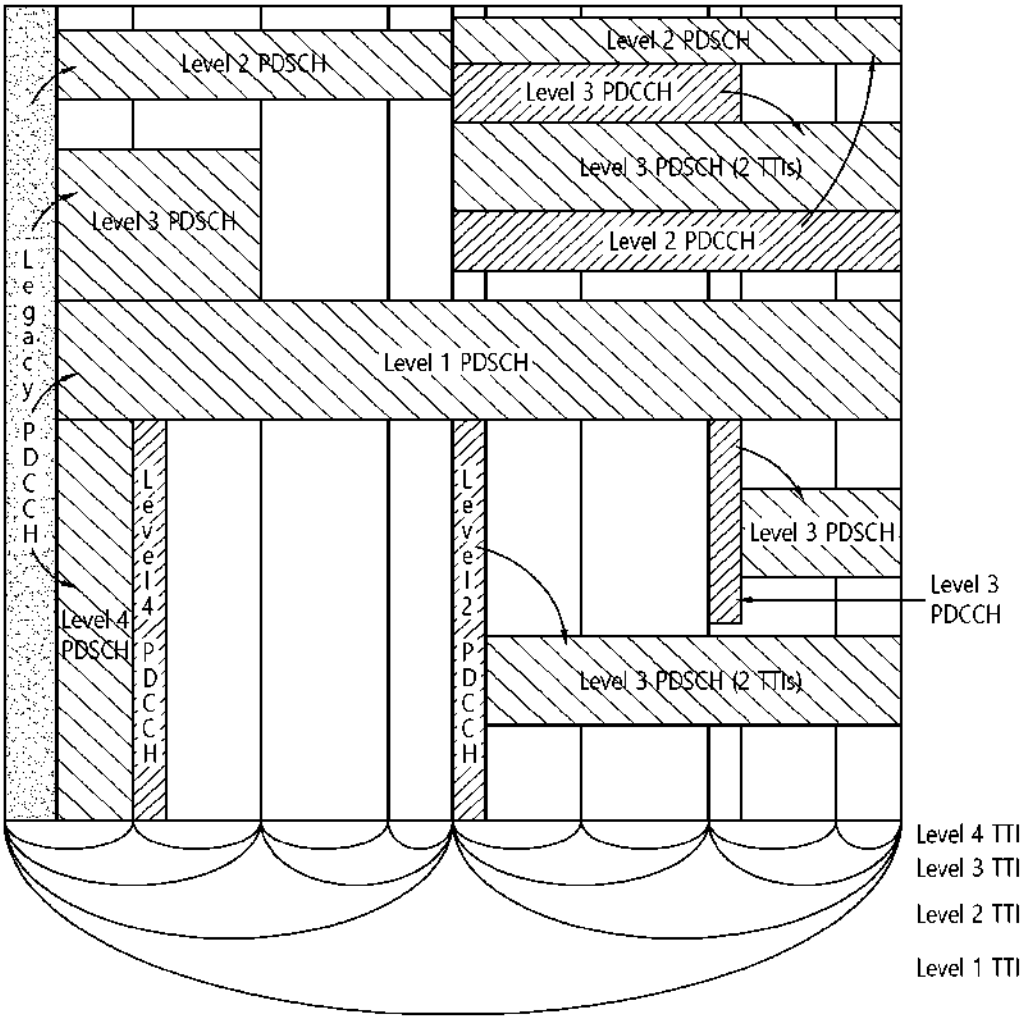
[Fig. 6]



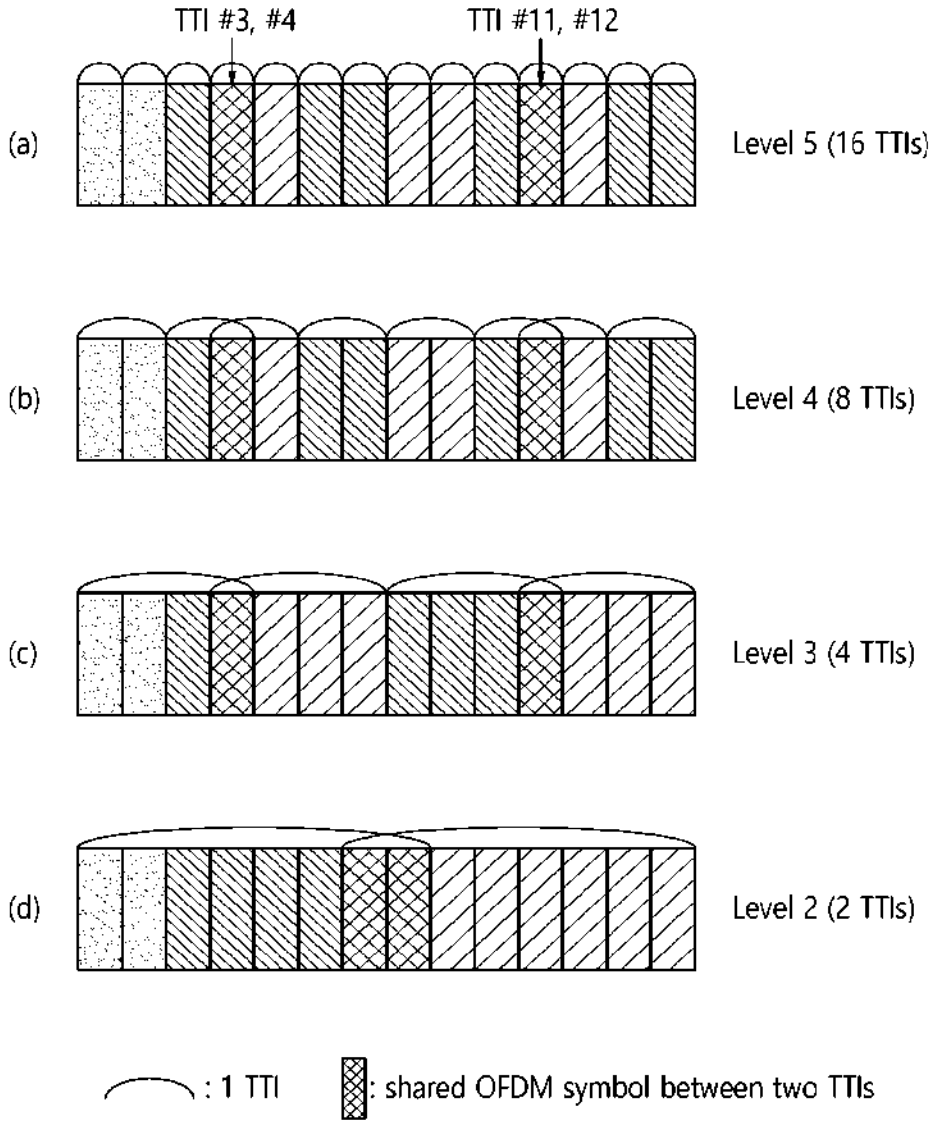
[Fig. 7]


DL
UL
(a)
DL
UL
(b)
TTI1
TTI2
TTI1
TTI2
DL
UL
(c)
TTI1
TTI2
TTI3
TTI4
TTI1
TTI2
TTI3
TTI4
DL
UL
(d)

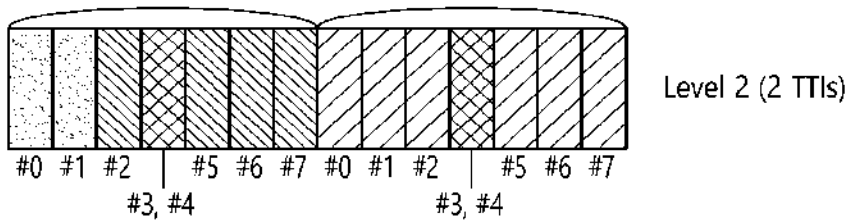
[Fig. 8]


Level 2 PDSCH
Level 2 PDSCH
Level 3 PDCCH
Level 3 PDSCH (2 TTIs)
Level 3 PDSCH
Level 2 PDCCH
Legacy PDCCH
Level 1 PDSCH
Level 4 PDSCH
Level 4 PDCCH
Level 2 PDCCH
Level 3 PDSCH
Level 3 PDCCH
Level 3 PDSCH (2 TTIs)
Level 4 TTI
Level 3 TTI
Level 2 TTI
Level 1 TTI

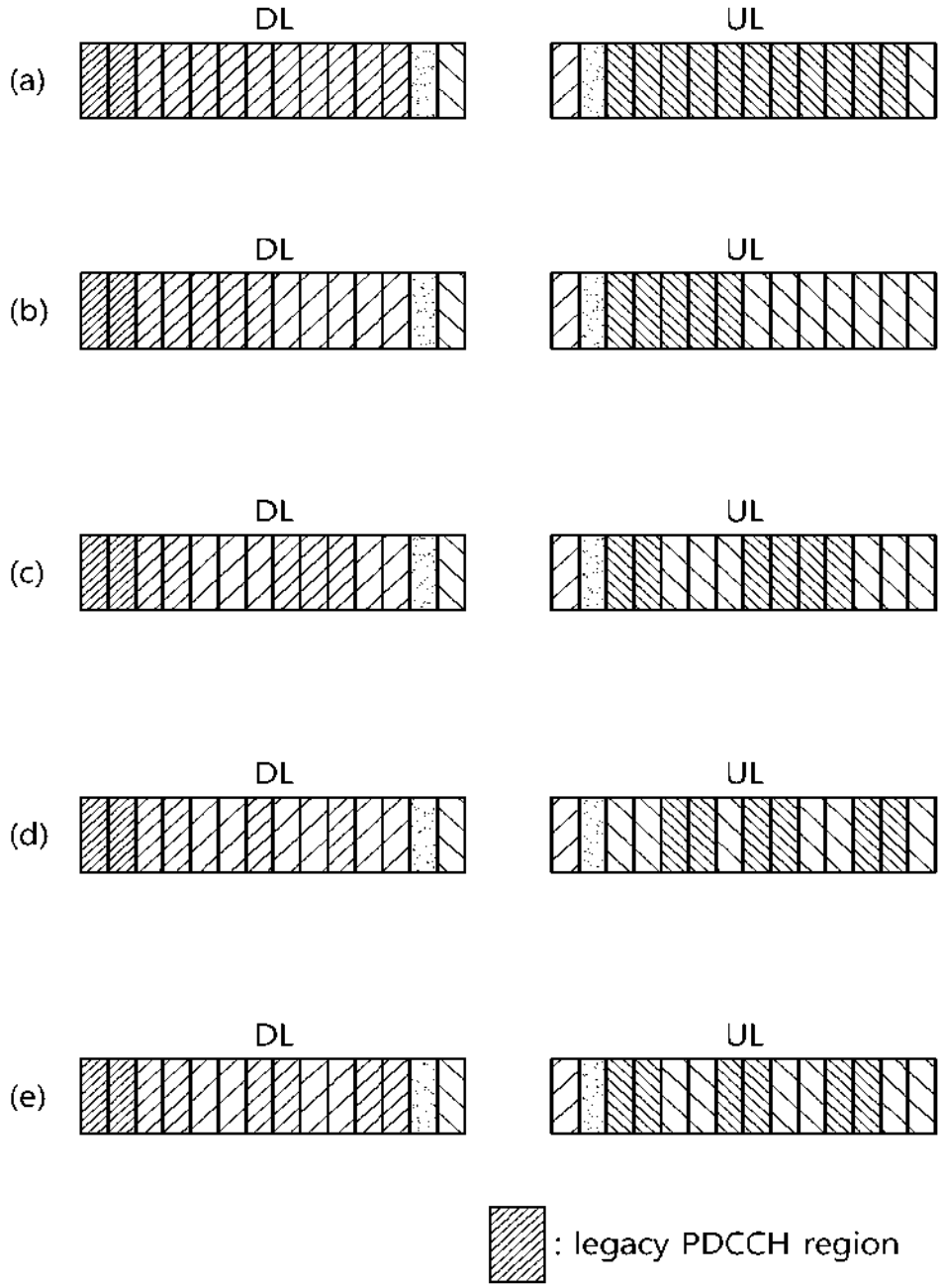
[Fig. 9]


TTI #3, #4
TTI #11, #12
(a)
Level 5 (16 TTIs)
(b)
Level 4 (8 TTIs)
(c)
Level 3 (4 TTIs)
(d)
Level 2 (2 TTIs)
: 1 TTI
: shared OFDM symbol between two TTIs

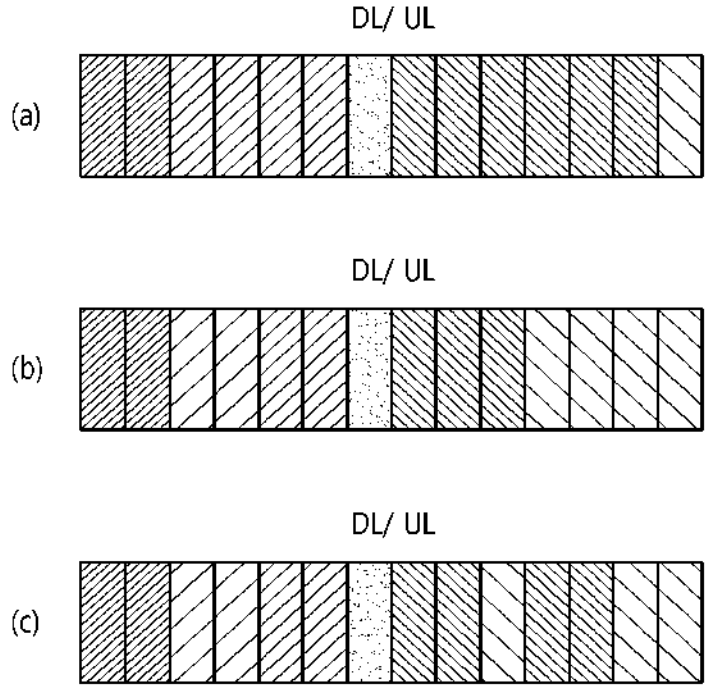
[Fig. 10]


Level 2 (2 TTIs)
#0 #1 #2 #5 #6 #7 #0 #1 #2 #5 #6 #7
#3, #4
#3, #4

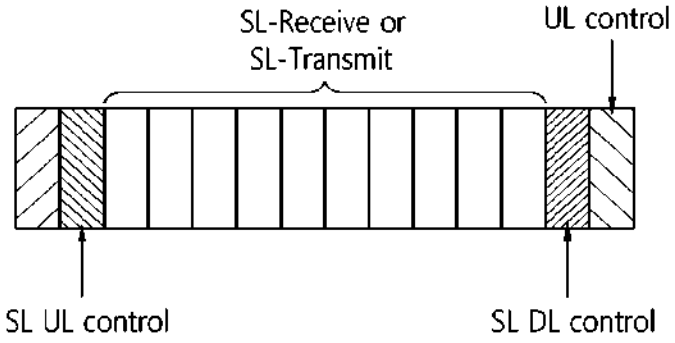
[Fig. 11]



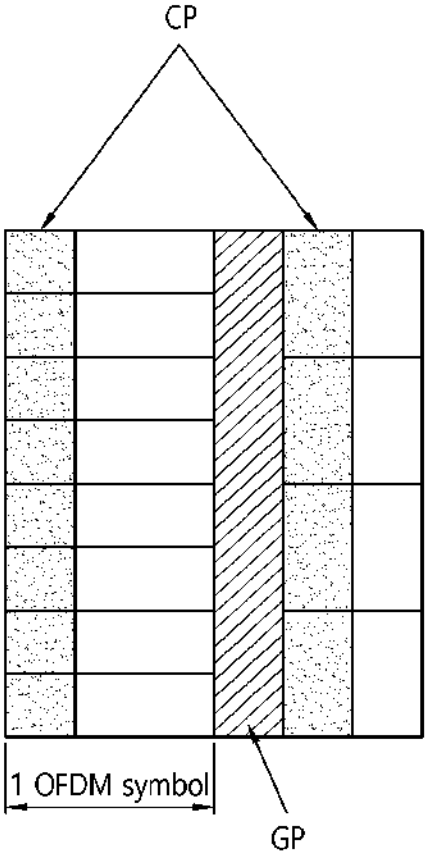
[Fig. 12]


DL/ UL
(a)
DL/ UL
(b)
DL/ UL
(c)

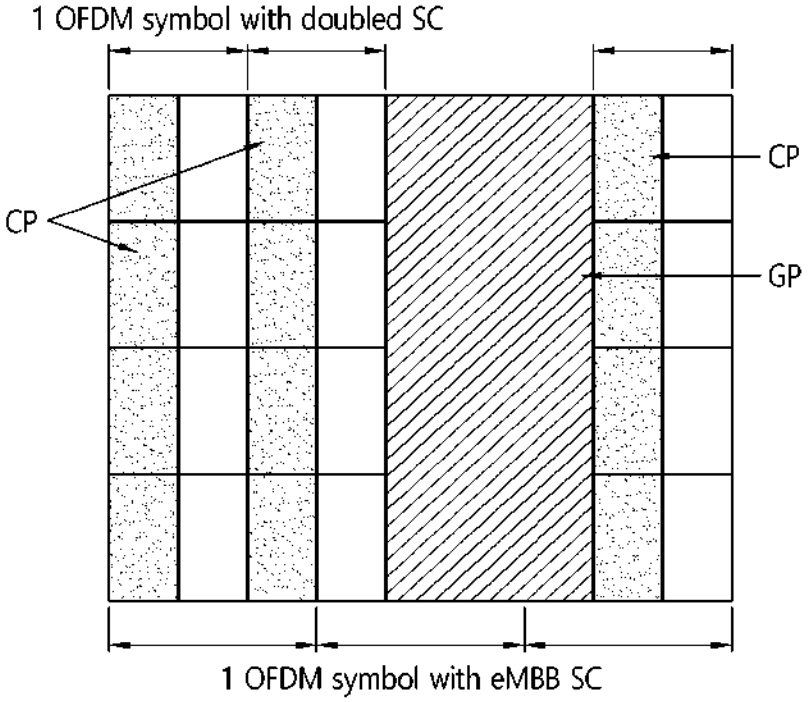
[Fig. 13]


SL-Receive or
SL-Transmit
UL control
SL UL control
SL DL control

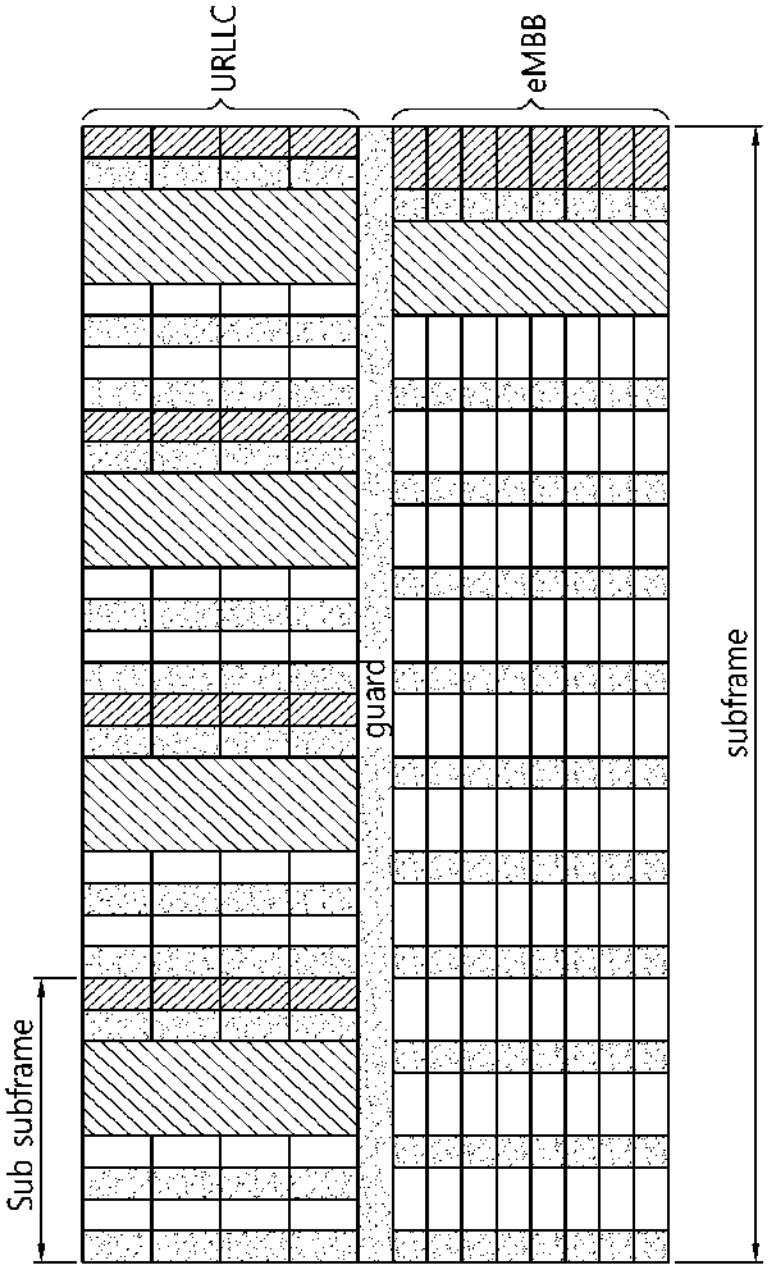
[Fig. 14]



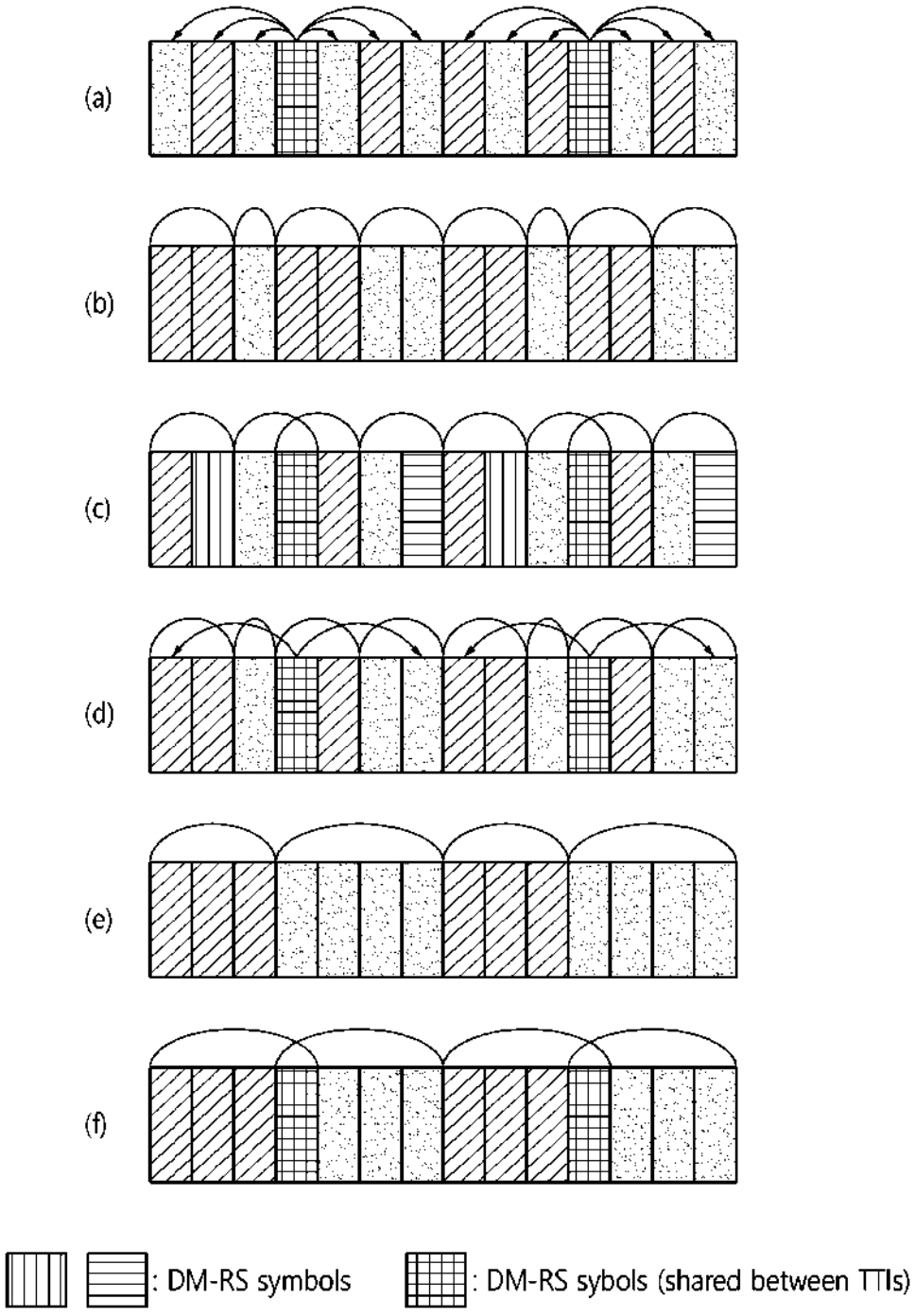
[Fig. 15]


1 OFDM symbol with doubled SC
CP
CP
GP
1 OFDM symbol with eMBB SC

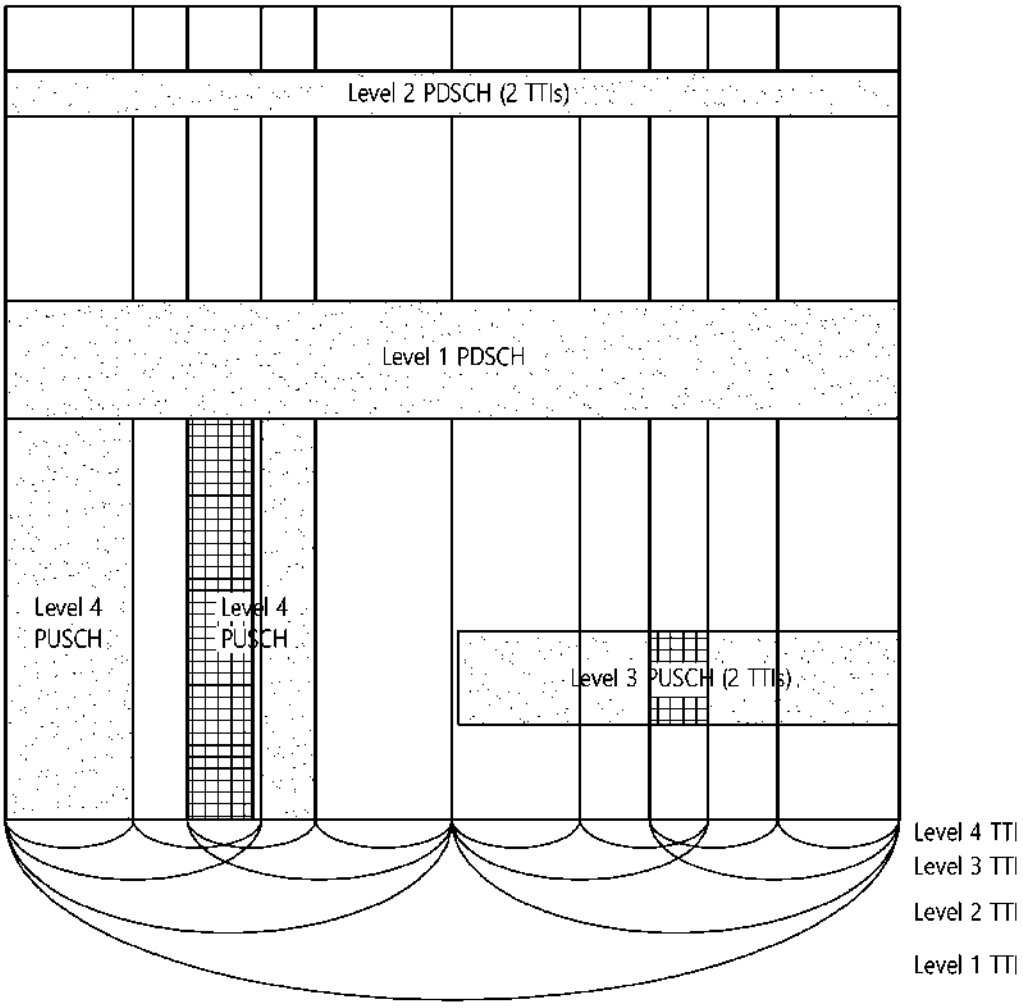
[Fig. 16]



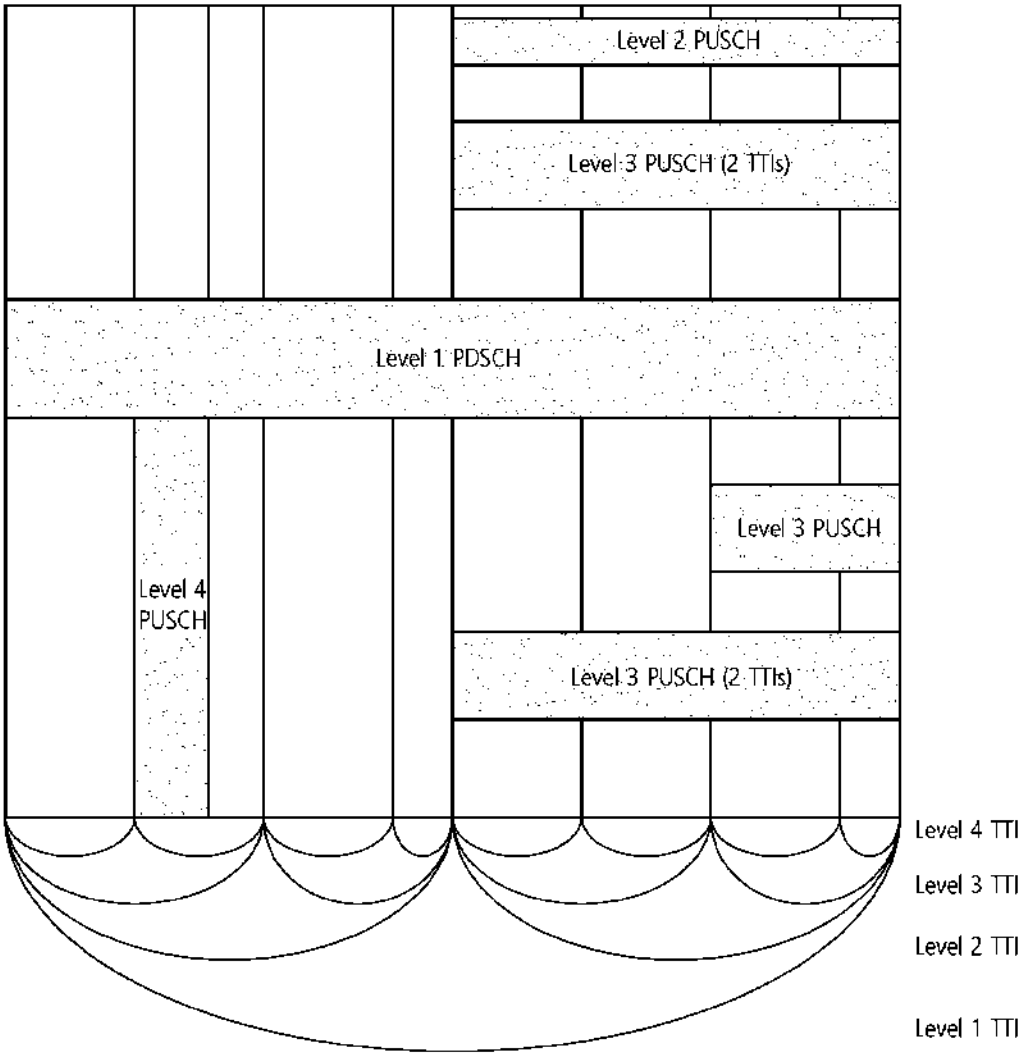
[Fig. 17]



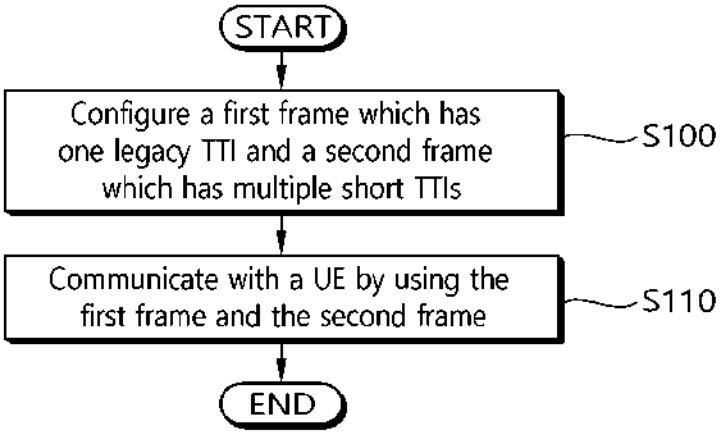
[Fig. 18]


Level 2 PDSCH (2 TTIs)
Level 1 PDSCH
Level 4 PUSCH
Level 4 PUSCH
Level 3 PUSCH (2 TTIs)
Level 4 TTI
Level 3 TTI
Level 2 TTI
Level 1 TTI

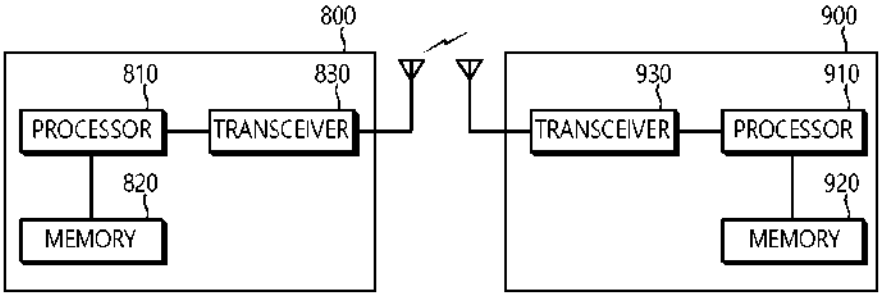
[Fig. 19]


Level 2 PUSCH
Level 3 PUSCH (2 TTIs)
Level 1 PDSCH
Level 3 PUSCH
Level 4 PUSCH
Level 3 PUSCH (2 TTIs)
Level 4 TTI
Level 3 TTI
Level 2 TTI
Level 1 TTI

[Fig. 20]


START
Configure a first frame which has one legacy TTI and a second frame which has multiple short TTIs
S100
Communicate with a UE by using the first frame and the second frame
S110
END

[Fig. 21]


800
810
830
PROCESSOR
TRANSCEIVER
820
MEMORY
900
930
910
TRANSCEIVER
PROCESSOR
920
MEMORY

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2017/003414

A. CLASSIFICATION OF SUBJECT MATTER

H04B 7/26(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04B 7/26; H04J 3/06; H04L 5/00; H04W 56/00; H04W 72/04; H04W 4/00; H04B 1/7073

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: legacy TTI, short TTIs, frames, symbols, synchronization signal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A		4,7-8,10
Y	US 2008-0080476 A1 (JOON-YOUNG CHO et al.) 03 April 2008 See paragraphs [0048]-[0054], [0071]; and figure 6.	1-3,5-6,9,11-14
Y	PETAR POPOVSKI et al., `Deliverable D6.3 Intermediate system evaluation results', ICT-317669-METIS/D6.3, Mobile and wireless communications Enablers for the Twenty-twenty Information Society, 01 August 2014 (https://www.metis2020.com/documents/deliverables/index.html) See page 66; and figure A.28.	5-6
Y	US 2014-0198772 A1 (TELEFONAKTIEBOLAGET L M ERICSSON (PUBL)) 17 July 2014 See paragraphs [0046]-[0058], [0073]; and figure 14.	9,11
Y	US 2015-0282178 A1 (LG ELECTRONICS INC.) 01 October 2015 See paragraphs [0136]-[0146]; claim 5; and figure 13.	12
Y	US 2013-0148564 A1 (HUAWEI TECHNOLOGIES CO., LTD.) 13 June 2013 See paragraphs [0006], [0039]-[0055]; claim 6; and figure 1.	13

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT

Information on patent family members

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Published:
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(54) Title: METHODS AND APPARATUSES FOR DOWNLINK CONTROL INFORMATION TRANSMISSION AND RECEIVING

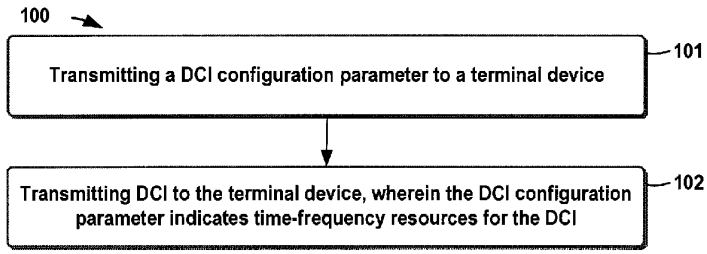


Fig. 1

(57) Abstract: Embodiments of the present disclosure relate to methods and apparatuses for downlink control information (DCI) transmission and receiving in a wireless communication system. A DCI configuration parameter can be first transmitted to a terminal device; and then DCI is transmitted to the terminal device, wherein the DCI configuration parameter indicates time-frequency resources for the DCI. With embodiments of the present disclosure, the UE could perform a flexible DCI monitoring according to the DCI configuration parameter and thus it may support the DCI monitoring occasion change due to numerology and scheduling unit size.

WO 2018/126401 A1

METHODS AND APPARATUSES FOR DOWNLINK CONTROL INFORMATION TRANSMISSION AND RECEIVING

FIELD OF THE INVENTION

[0001] The non-limiting and exemplary embodiments of the present disclosure generally relate to the field of wireless communication techniques, and more particularly relate to methods and apparatuses for downlink control information (DCI) transmission and receiving in a wireless communication system.

BACKGROUND OF THE INVENTION

[0002] New radio access system, which is called as new RAT (NR) system or network for short, is the next generation communication system. In Radio Access Network (RAN) #71 meeting for the third generation Partnership Project (3GPP) working group, study of NR system was approved. The NR system will consider frequency ranging up to 100Ghz with an object of a single technical framework addressing all usage scenarios, requirements and deployment scenarios defined in Technical Report TR 38.913, which include requirements such as enhanced mobile broadband, massive machine-type communications, ultra reliable and low latency communications.

[0003] Especially, in the NR network, different numerologies will coexist in the same carrier and a mini-slot will be introduced to carry Ultra-reliable low latency communication (URLLC) traffic. As a result, DCI monitoring may be performed per symbol based on the specific numerology. Thus, a terminal device like user equipment (UE) needs to know when to monitor the DCI for scheduling related operations.

[0004] In current LTE system, DCI monitoring is performed per subframe or per slot if the UE is in on duration of the discontinuous reception (DRX) active state. The DRX periodicity can be configured by higher layers.

[0005] However, with the current DCI monitoring solution in LTE, it cannot support the DCI monitoring occasion change due to numerology and scheduling unit size.

SUMMARY OF THE INVENTION

[0006] In patent cooperation treaty (PCT) application publication No. WO2016190970A1, there were proposed techniques for selecting data communications with shortened time duration wherein a two-stage grant for communication scheduling was introduced, the first stage grant could include an indication to activate/deactivate ultra-low latency (ULL) communication.

[0007] In US application US20160119969A1, there was proposed a solution for MAC enhancement for concurrent legacy and enhanced component carrier (ECC) operation, wherein a two stage Semi-Persistent Scheduling (SPS) solution was introduced and a first stage grant could contain parameters that may not change much over the course of a given SPS instance while the second stage grant could contain the actual resource for the SPS scheduling.

[0008] In another PCT application publication No. WO2016069270A1, there was proposed another two-stage PDCCH wherein a fast DCI could include a DCI flag and DCI format size indicator to indicate the existence and the size of the slow DCI in the same TTI.

[0009] However, none of the above solutions can address the problems as presented in the back ground.

[0010] To this end, in the present disclosure, there is provided a new solution for DCI transmission and receiving in a wireless communication system, to mitigate or at least alleviate at least part of the issues in the prior art.

[0011] According to a first aspect of the present disclosure, there is provided a DCI transmission in a wireless communication system. The method comprises transmitting a DCI configuration parameter to a terminal device; and transmitting DCI to the terminal device, wherein the DCI configuration parameter indicates time-frequency resources for the DCI.

[0012] According to a second aspect of the present disclosure, there is provided a method of DCI receiving in a wireless communication system. The method comprises receiving a DCI configuration parameter at a terminal device; and receiving DCI within time-frequency resources indicated by the DCI configuration parameter at the terminal device.

[0013] According to a third aspect of the present disclosure, there is provided

an apparatus of DCI transmission in a wireless communication system. The apparatus comprises: a parameter transmission module and a DCI transmission module. The parameter transmission module may be configured to transmit a DCI configuration parameter to a terminal device. The DCI transmission module may be configured to transmit DCI to the terminal device, wherein the DCI configuration parameter indicates time-frequency resources for the DCI

[0014] According to a fourth aspect of the present disclosure, there is provided an apparatus of DCI receiving in a wireless communication system. The apparatus comprises: a parameter receiving module and a DCI receiving module. The parameter receiving module may be configured to receive DCI configuration parameter at a terminal device. The DCI receiving module may be configured to receive DCI within time-frequency resources indicated by the DCI configuration parameter at the terminal device.

[0015] According to a fifth aspect of the present disclosure, there is provided a computer-readable storage media with computer program code embodied thereon, the computer program code configured to, when executed, cause an apparatus to perform actions in the method according to any embodiment in the first aspect.

[0016] According to a sixth aspect of the present disclosure, there is provided a computer-readable storage media with computer program code embodied thereon, the computer program code configured to, when executed, cause an apparatus to perform actions in the method according to any embodiment in the second aspect.

[0017] According to a seventh aspect of the present disclosure, there is provided a computer program product comprising a computer-readable storage media according to the fifth aspect.

[0018] According to an eighth aspect of the present disclosure, there is provided a computer program product comprising a computer-readable storage media according to the sixth aspect.

[0019] With embodiments of the present disclosure, a DCI configuration parameter can be first transmitted to the terminal device, and then the DCI is transmitted to the terminal device. Thus, the terminal device may monitor the transmitted DCI based on the received DCI configuration parameter, which means a flexible DCI monitoring solution and thus can support the DCI monitoring occasion change due to

numerology and scheduling unit size.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] The above and other features of the present disclosure will become more apparent through detailed explanation on the embodiments as illustrated in the embodiments with reference to the accompanying drawings, throughout which like reference numbers represent same or similar components and wherein:

[0021] Fig. 1 schematically illustrates a flow chart of a method of DCI transmission according to an example embodiment of the present disclosure;

[0022] Fig. 2 schematically illustrates DCI occurrence occasions with different numerologies according to example embodiments of the present disclosure;

[0023] Figs. 3A to 3C schematically illustrate DCI occurrence occasions at different levels according to examples embodiments of the present disclosure;

[0024] Figs. 4A and 4C schematically illustrate DCI occurrence occasions with frequency hopping according to example embodiment of the present disclosure;

[0025] Fig. 5A schematically illustrates a two-DCI solution for enhanced mobile broadband (eMBB) and URLLC multiplexing in which control and data are multiplexed in time domain according to an embodiment of the present disclosure;

[0026] Fig. 5B schematically illustrates a two-DCI solution for eMBB and URLLC multiplexing in which control and data are multiplexed in frequency domain according to an embodiment of the present disclosure;

[0027] Figs. 6A to 6D schematically illustrate two-DCI solutions for eMBB and URLLC multiplexing according to an embodiment of the present disclosure, wherein control region and data are multiplexed in time domain and the eMBB and the URLL are multiplexed in TDM, in TDM by symbol, in FDM, and in both FDM and TDM, respectively;

[0028] Figs. 7A to 7D schematically illustrate two-DCI solutions for eMBB and URLLC multiplexing according to an embodiment of the present disclosure, wherein control region and data are multiplexed in frequency domain and the eMBB and the URLL are multiplexed in TDM, in TDM by symbol, in FDM, and in both FDM and TDM, respectively;

[0029] Fig. 8 schematically illustrates a two-DCI solution for eMBB and

URLLC multiplexing according to an embodiment of the present disclosure, wherein two segments are used and the second segment is punctured or not punctured without re-transmission;

[0030] Fig. 9 schematically illustrates a two-DCI solution for eMBB and URLLC multiplexing according to an embodiment of the present disclosure, wherein two segments are used and the second segment is punctured with retransmission;

[0031] Fig. 10 schematically illustrates an example two-DCI division solution according to an embodiment of the present disclosure;

[0032] Fig. 11 schematically illustrates a flow chart of a method for DCI receiving according to an embodiment of the present disclosure;

[0033] Fig. 12 schematically illustrates a block diagram of an apparatus for DCI transmission according to an embodiment of the present disclosure;

[0034] Fig. 13 schematically illustrates a block diagram of an apparatus for DCI receiving according to an embodiment of the present disclosure; and

[0035] Fig. 14 further illustrates a simplified block diagram of an apparatus 1410 that may be embodied as or comprised in a serving node like a base station in a wireless network and an apparatus 1420 that may be embodied as or comprised in a terminal device like UE as described herein.

DETAILED DESCRIPTION OF EMBODIMENTS

[0036] Hereinafter, the solution as provided in the present disclosure will be described in details through embodiments with reference to the accompanying drawings. It should be appreciated that these embodiments are presented only to enable those skilled in the art to better understand and implement the present disclosure, not intended to limit the scope of the present disclosure in any manner.

[0037] In the accompanying drawings, various embodiments of the present disclosure are illustrated in block diagrams, flow charts and other diagrams. Each block in the flowcharts or blocks may represent a module, a program, or a part of code, which contains one or more executable instructions for performing specified logic functions, and in the present disclosure, a dispensable block is illustrated in a dotted line. Besides, although these blocks are illustrated in particular sequences for performing the steps of the methods, as a matter of fact, they may not necessarily be performed strictly

according to the illustrated sequence. For example, they might be performed in reverse sequence or simultaneously, which is dependent on natures of respective operations. It should also be noted that block diagrams and/or each block in the flowcharts and a combination of thereof may be implemented by a dedicated hardware-based system for performing specified functions/operations or by a combination of dedicated hardware and computer instructions.

[0038] Generally, all terms used in the claims are to be interpreted according to their ordinary meaning in the technical field, unless explicitly defined otherwise herein. All references to "a/an/the/said [element, device, component, means, step, etc.]" are to be interpreted openly as referring to at least one instance of said element, device, component, means, unit, step, etc., without excluding a plurality of such devices, components, means, units, steps, etc., unless explicitly stated otherwise. Besides, the indefinite article "a/an" as used herein does not exclude a plurality of such steps, units, modules, devices, and objects, and etc.

[0039] Additionally, in a context of the present disclosure, a user equipment (UE) may refer to a terminal, a Mobile Terminal (MT), a subscriber station, a portable subscriber station, Mobile Station (MS), or an Access Terminal (AT), and some or all of the functions of the UE, the terminal, the MT, the SS, the portable subscriber station, the MS, or the AT may be included. Furthermore, in the context of the present disclosure, the term "BS" may represent, e.g., a node B (NodeB or NB), an evolved NodeB (eNodeB or eNB), gNB (Node B in NR), a radio header (RH), a remote radio head (RRH), a relay, or a low power node such as a femto, a pico, and so on.

[0040] As mentioned hereinbefore, none of the prior arts can support the DCI monitoring occasion change due to numerology and scheduling unit size. Thus, in the present disclosure, there is proposed a new DCI transmission and receiving solution. In the proposed solution, a DCI configuration parameter can be first transmitted to the terminal device, and then the DCI is transmitted to the terminal device. Thus, the terminal device may monitor the DCI based on the received DCI configuration parameter, which means a flexible DCI monitoring solution and thus can support the DCI monitoring occasion change due to numerology and scheduling unit size.

[0041] Hereinafter, reference will be made to Figs. 1 to 14 to describe the DCI transmission and receiving solution.

[0042] Fig.1 schematically illustrates a flow chart of a method 100 of DCI transmission in a wireless communication system according to an embodiment of the present disclosure. The method 100 can be performed at a serving node, for example a BS, like a node B (NodeB or NB).

[0043] As illustrated in Fig. 1, first in step 101, a DCI configuration parameter is transmitted to a terminal device, and the DCI configuration parameter indicates time-frequency resources for a following DCI.

[0044] In an embodiment of the present disclosure, the DCI configuration parameter comprises at least one of: a numerology to be used; a valid duration for the DCI configuration parameter; a duration for a single DCI; and DCI occurrence occasions.

[0045] In NR system, different numerologies might be used, whereas different numerologies might use different transmission parameters, for example different subcarrier spacings. The different subcarrier spacings mean different symbol lengths. For example, for 15 kHz subcarrier spacing, its symbol will have a time length four times as that for 60 kHz subcarrier spacing, as illustrated in Fig. 2. Thus, the numerology to be used can be used to define a symbol.

[0046] The valid duration for the DCI configuration parameter indicates a duration in which the DCI configuration parameter is valid. The valid duration can be a number of symbols (for example, numerology specific) or a number of frames (for example numerology common). In an embodiment of the present disclosure, the values of the start of the valid duration can be an absolute value with respect to the reference numerology. For example, if the configuration signaling is received in symbol 7 of the subframe 2 of frame 6, the starting can be defined as symbol 0 of subframe 0 of frame 6. The definition of the absolute value can be predetermined or configured by a high layer signaling like RRC signaling. In another embodiment of the present disclosure, the first symbol carrying the configuration signaling can be used as the start of the valid duration no matter whether the configuration signaling is configured by DCI or by a RRC signaling.

[0047] The duration for a single DCI indicates the length of the DCI, it can be a number of symbols. Thus, parameter may indicate the length of DCI. It is also possible to use a predetermined length and in such a case, this parameter can be omitted.

[0048] DCI occurrence occasions indicate occasions at which DCI occurs in frames. In an embodiment of the present disclosure, the DCI occurrence occasions can be at a slot level, at subframe level (multi-slot), or at symbol level, as illustrated in Figs. 3A to 3C respectively.

[0049] The DCI occurrence occasions can be periodic. That is to say, the DCI monitoring will be performed periodically, for example every a predetermined number of slots, every a predetermined number of symbols. Fig 3A and Fig. 3B illustrate two examples of periodic DCI occurrence occasions. In Fig. 3A, the DCI occurrence occasions are per slot; in other words, the DCI monitoring is performed every slot, like in slots 0, 1,…,. In Fig. 3B, the DCI occurrence occasions are per multi-slot (e.g., 2 slots, a subframe); that is to say, the DCI monitoring can be performed per multi-slot. In such a case, the DCI occurrence occasions can be indicated by the periodicity and an offset of the DCI occurrence. The periodicity can be, for example, a predetermined number of symbols, slots, or frames.

[0050] Alternatively, the DCI occurrence occasions can also be aperiodic. Fig. 3C illustrates an aperiodic DCI occurrence occasion. In Fig. 3C, the DCI occurrence occasions are per symbol but aperiodic. In such a case, it may predefine a set of possible aperiodic patterns in specification or pre-configure the possible set of aperiodic patterns by a higher layer signaling. In the set of aperiodic patterns, each aperiodic pattern contains one or more symbols within a valid duration. In such a way, the network can inform the aperiodic pattern index to the terminal device in DCI configuration parameter.

[0051] It should be noticed that although the DCI occurrence occasions per slot and multi-slot in Fig.3A and 3B are periodic and the DCI occurrence occasions per symbol in Fig.3C is aperiodic, the present disclosure is not limited thereto. In fact, in each of the DCI occurrence occasions per slot, per multi-slot, per symbol, the DCI occurrence occasions can be periodic or aperiodic.

[0052] As another alternative, the DCI occurrence occasions can be a combination of periodic and aperiodic occasions. In other word, in a time period, it contains an aperiodic pattern including one or more symbols but the aperiodic pattern will repeat by the time period in the valid duration. In such a case, the DCI occurrence occasions can be indicated by the periodicity and the aperiodic pattern.

[0053] In another embodiment of the present disclosure, the DCI configuration parameter may comprise at least one of: frequency domain resource unit; and frequency hopping pattern.

[0054] The frequency domain resource unit indicates the resource unit to be used for DCI in the frequency domain, it could be a control channel element (CCE), a subband, a physical resource block (PRB), or physical resource group (REG). In addition, the frequency domain resource unit can be numerology common, which mean the frequency domain resource unit is same for all numerologies, or numerology specific, which mean that different numerologies might use different frequency domain resource units.

[0055] The frequency hopping pattern indicates a pattern in which the frequency hopping is used. This parameter is required when the frequency hopping pattern is used. An explicit signaling can be used to indicate the frequency resource in each DCI occurrence occasion. The hopping pattern can be a predetermined pattern which is known at both network and the terminal device, or a pattern configured by the network. The hopping pattern can be used to calculate the frequency resource position.

[0056] Figs. 4A to 4C illustrate use of frequency hopping in different DCI occurrence occasions according to embodiments of the present disclosure. DCI occurrence occasions as illustrated in Fig.4A to Fig. 4C are same with those in Fig. 3A to 3C in the time domain but in the frequency domain, the frequency hopping is used for the DCI occurrence occasions. It should be noticed that although the DCI occurrence occasions per slot and per multi-slot in Fig.4A and 4B are periodic and the DCI occurrence occasions per symbol in Fig.4C is aperiodic, the present disclosure is not limited thereto. In fact, in each of the DCI occurrence occasions per slot, per multi-slot, per symbol, the DCI occurrence occasions can be periodic or aperiodic.

[0057] Reference is made back to Fig. 1, in step 102, the DCI can be transmitted to the terminal device. With the DCI configuration parameter, the terminal device may learn the time-frequency resource for the DCI from the DCI configuration parameter and monitor the DCI within the time-frequency resource.

[0058] In an embodiment of the present disclosure, the DCI configuration parameter can be transmitted to the terminal device by a higher layer signaling like a

RRC signaling. That is to say, in the two-stage solution, for the first stage, the higher layer signaling can be used to transmit the DCI configuration indicating the time-frequency resource for the following DCI in the second stage.

[0059] In another embodiment of the present disclosure, the DCI configuration parameter can be transmitted to the terminal device dynamically by another DCI. In such a case, a first DCI is used to transmit the DCI configuration parameter for the following DCI. The actual data scheduling related information is located in the following DCI.

[0060] In addition, considering the payload size of the first DCI, it is also possible to use a combination of DCI and high layer signaling. That is to say, a part of DCI configuration parameter can be transmitted by DCI and another part of the DCI configuration parameter can be transmitted by a high layer signaling.

[0061] In the two stage DCI solution, the first DCI can be cell specific, beam specific, TRP specific, common for a UE group or UE specific. In an embodiment of the present disclosure, the DCI can be scrambled with a specific RNTI. The periodicity of the first DCI can be larger than the second DCI. The occurrence occasions of the first DCI can predetermined or configured by a higher layer signaling such a RRC signaling. The first DCI can be located in common search space. Or alternative, the first DCI can also be located in UE specific search space.

[0062] It shall be noted that there may be a valid duration for the DCI configuration parameter but there is no any restriction on DCI configuration parameter and scheduling unit size. For example, with slot-level DCI monitoring configuration, UE can also be configured with a scheduling unit starting and ending from the symbol boundary rather than a slot boundary. In such a case, the remaining blank symbols can be allocated to other UE with symbol level DCI monitoring configuration. Or alternatively, the remaining blank symbols can also be allocated to other UE with slot-level or multi-slot level DCI configuration.

[0063] In a further embodiment of the present disclosure, the DCI configuration parameter may comprise at least two sets of parameters, from which the terminal device can select a set of parameters based on its requested traffic types. In other words, DCI monitoring can be adapted at UE side after resource requirement by means of random access procedure/scheduling request (SR).

[0064] After a random access procedure, the terminal device starts DL/UL transmission/reception with the eNB. Thus, the DCI monitoring behavior can be based on the reason for random access. If URLLC scheduling request is the reason for random access, the DCI monitoring should be more frequent. If eMBB scheduling request is the reason for random access, the DCI monitoring can be less frequent. By providing two or more different sets of DCI configuration parameters predefined or configured by RRC signaling, the terminal device could choose the suitable parameter set based on its request traffic type. In such a way, it is possible for UE to perform DCI monitoring based on its required traffic type.

[0065] In another aspect of the present disclosure, there is also provided another two-DCI solution for different traffic type multiplexing. In these solutions, two DCIs are used, one of which can be called as prepositive control region (DCI), the other of which can be called as postpostive control region (DCI). The prepositive control region can be used to indicate resource that is allocated to a first traffic type (such as eMBB traffic) but is to be occupied by a second traffic type (such as URLLC traffic), the postpositive control region can be used to indicate resource that allocated to a first traffic type (such as eMBB traffic) but was already occupied by the second traffic type (such as abrupt URLLC traffic). Hereinafter, the URLLC traffic and the eMBB traffic will be taken as examples of different traffic types to describe the two-DCI solution; however, those skilled in the art can readily know that the present disclosure is not limited thereto.

[0066] In an embodiment of the present disclosure, the prepositive control region can include at least one of following fields:

- a field to indicate puncture or rate-matching around some time-frequency resource in a following pattern of time-frequency resource;
- a field to schedule on a following pattern of time-frequency resource (e.g. can be contiguous or non-contiguous symbols/frequency bands);
- a field to indicate re-transmission of previous punctured part;
- a field to indicate the end of one transmission block.

[0067] In an embodiment of the present disclosure, the postpositive region can include at least one of following fields:

- a field to indicate puncture or no puncture of some time-frequency

resources in the previous pattern of time-frequency resource

- a field to indicate re-transmission or no re-transmission of previous punctured part
- a field to indicate the end of one transmission block

[0068] It shall be noted that patterns of time-frequency resource in prepositive and postpositive control regions can be complementary. For example, the two patterns can compose a whole time-frequency resource of a region (subframe). Alternatively, the two patterns can be also partially overlapped.

[0069] Fig. 5A illustrates a two-DCI solution for different traffic type multiplexing according to an embodiment of the present disclosure. The resource of eMBB can be split into two parts as illustrated in Fig. 5, the first one is to be scheduled by the prepostive control region and the other one is to be scheduled by the postpostive control region. For some resources such as first several symbols, the scheduling of URLLC can be known, thus the eMBB UE can be indicated of rate-matching or puncture for the occupied resource in the prepositive control region if it is occupied by the URLLC. While, for some resources, for example when the URLLC occurs abruptly, the scheduling of URLLC cannot be known in the prepositive control region, and thus the eMBB UE can be indicated to puncture for the occupied resources in the postpositive control region.

[0070] In Fig. 5A, it is shown that the control regions and the data regions are multiplexed in the time domain. In another embodiment of the present disclosure, the control regions and data regions can be multiplexed in the frequency domain. Fig. 5B illustrates a two-DCI solution for different traffic type multiplexing according to an embodiment of the present disclosure. Fig. 5B is similar with Fig. 5A but differs in that in Fig. 5B, the control regions and data regions are multiplexed in the frequency domain.

[0071] It should also be noted that resource indicated to eMBB UE can be resource occupied by URLLC or resource reserved as empty for forward phase.

[0072] In addition, it shall also be noted that the split resource parts can also be multiplexed in many different ways, which will be described with reference to Fig. 6A to Fig. 7D.

[0073] Fig. 6A illustrates a two-DCI solution according to an embodiment of

the present disclosure, in which the control region and the data region are multiplexed in TDM and two split parts are multiplexed in time domain multiplexing (TDM). Fig. 6A is substantially same as that in Fig. 5A, and in the two DCI solution, the part scheduled by the prepostive control region is multiplexed with the part scheduled by the postpostive control region in TDM.

[0074] Fig. 6B illustrates another two-DCI solution according to an embodiment of the present disclosure, wherein the control region and the data region are multiplexed in TDM and the two split parts are multiplexed in TDM by symbols. Compared with that illustrated in Fig. 6A, in Fig. 6B, the part scheduled by the prepostive control region is multiplexed with the part scheduled by the postpostive control region also in TDM but by symbol; that is to say, in Fig. 6B, the symbols belonging to each part are not continuous.

[0075] Fig. 6C illustrates a further two-DCI solution according to an embodiment of the present disclosure, wherein the control region and the data region are multiplexed in TDM and the two split parts are multiplexed in frequency domain multiplexing (FDM). Different from that illustrated in Fig. 6A and Fig. 6B, in Fig. 6C the part scheduled by the prepostive control region is multiplexed with the part scheduled by the postpostive control region in FDM, i.e., they respectively occupy different frequency domain resources.

[0076] Fig. 6D illustrates a further two-DCI solution according to an embodiment of the present disclosure, wherein the control region and the data region are multiplexed in TDM and the two split parts are multiplexed in TDM and frequency domain multiplexing (FDM). As illustrated in Fig. 6D, the part scheduled by the prepostive control region is multiplexed with the part scheduled by the postpostive control region in a combination of TDM and FDM.

[0077] Figs. 7A to 7D illustrate two-DCI solutions according to an embodiment of the present disclosure, wherein the control region and the data region are multiplexed in FDM and two split parts are multiplexed in different manners respectively. In Fig. 7A, the two split parts are multiplexed in TDM; in Fig. 7B, the two split parts are multiplexed in TDM by symbol; in Fig. 7C, the two split parts are multiplexed in FDM; and Fig. 7D, the two split parts are multiplexed in TDM and FDM.

[0078] The two split parts can be decoded in any suitable manner. In an embodiment of the present disclosure, the two split part can be separately decoded. In another embodiment of the present disclosure, the two parts can be cascaded to decode, i.e. when UE receives the two parts, then it decodes them immediately or it decodes them after UE receiving the postpositive control region.

[0079] In a further embodiment of the present disclosure, the resource for eMBB can be split for several parts, wherein first parts are to be scheduled by the preposition control region and seconds parts are to be scheduled by the postpostive control region. The several parts are further divided into two segments in the time domain, i.e., segment 1 and segment 2. For some resources such as first several symbols, the scheduling of URLLC can be known, thus the eMBB UE can be indicated of rate-matching or puncture for the occupied resource in the prepositive control region if it is occupied by the URLLC. While, for some resources, for example when the URLLC occurs abruptly, the scheduling of URLLC cannot be known in the prepositive control region, and thus the eMBB UE can be indicated to puncturing or not puncturing for the occupied resources in the postpositive control region. For some resources in the second segment, they may be reserved for re-transmission or be punctured part of transmission in the first segment. This punctured part can be for example a subset of the first segment, and the remaining of the first segment can be used for new transmission. Fig. 8 illustrates a two-DCI solution wherein there is no re-transmission in the second segment; while Fig. 9 illustrates a two-DCI solution wherein, in the second segment, there is a re-transmission of punctured part of the first segment as indicated by blocks filled with cross lines.

[0080] In addition, similarly to solutions as illustrate in Figs. 6A to 7D, the first parts and the second parts can be multiplexed in time and/or frequency domain. Moreover, these parts can be cascaded to decode, i.e. when UE receives the two parts, then it decodes them immediately or it decodes them after UE receiving the postpositive control region.

[0081] In a further aspect of the present disclosure, one transmission block can also be split into several parts. The first part can be scheduled by, for example, prepositive control region, and the second part can be scheduled by, for example, postpositive control region. The UE can decode after receiving the whole transmission

block. The end of the transmission can be indicated in a control region. For example, UE may obtain frequency and time domain mapping for data, then obtain the mapping over resources preempted by URLLC, and after that it decodes the block.

[0082] In another embodiment of the present disclosure, preemption of URLLC can be indicated implicitly. For example, it is possible to use tracking RS to implicitly indicate preemption of URLLC. For example, if the tracking RS is interrupted on some symbols, this means these symbols are occupied by URLLC, and thus this can be used to indicate preemption of URLLC.

[0083] In a further embodiment of the present disclosure, DCI can be cascaded with K-stage DCI. For example, a first stage DCI contains resource allocation field; the second stage DCI contains information of MCS and other information for data transmission (which may also contain detailed information of resource allocation). In such a case, the UE can cascades the two-stage DCI for control information.

[0084] In addition, the first stage DCI can be shared by different UEs, e.g. URLLC UE and eMBB UE, as illustrated in Fig. 10. The URLLC UE could obtain the shared first stage DCI and the second stage DCI for control and/or data transmission. The eMBB UE could obtain the shared first stage DCI for the resource allocation for puncturing or rate-matching. The shared common DCI can be scrambled with shared RNTI, e.g. a resource allocation RNTI calculated considering the resource index.

[0085] In a further embodiment of the present disclosure, the first DCI can include full scheduling information; while the second DCI may include indication of the resource occupied by URLLC or not. In addition, the second DCI can be reduced for some cases. For example, when no MCS needed, the second DCI can be omitted. If the resource is semi-statically reserved for URLLC and known to eMBB UE, the resource allocation is no needed and the second DCI can be reduced as well. In another case, if the resource is known by eMBB UE, and the time-frequency of remaining resource is fixed, then only an indication is needed in the second DCI, which indicates whether the time-frequency resource is occupied. If yes, the resource is for re-transmission or just keeps punctured; if not, the resource will be used for new data transmission.

[0086] It shall be noted that although the aspects and embodiments are described separately, they can also be combined together to achieve more benefits.

[0087] Fig. 11 further schematically illustrates a flow chart of method for DCI receiving according to an example embodiment of the present disclosure. The method 1100 can be implemented at a terminal device, for example UE, or other like terminal devices.

[0088] As illustrated in Fig. 11, the method starts from step 11, in which the terminal device like UE receiving a DCI configuration parameter. The DCI configuration parameter indicates the time-frequency resources for the following DCI.

[0089] In an embodiment of the present disclosure, the DCI configuration parameter may comprise at least one of: numerology to be used; a valid duration for the DCI configuration parameters; a duration for a single DCI; DCI occurrence occasions.

[0090] In another embodiment of the present disclosure, the DCI configuration parameter may comprise at least one of: a frequency domain resource unit; and a frequency hopping pattern.

[0091] In a further embodiment of the present disclosure, the receiving DCI configuration parameter may comprise receiving the DCI configuration parameter in a higher layer signaling.

[0092] In a further embodiment of the present disclosure, the receiving DCI configuration parameter may comprise receiving the DCI configuration parameter in another DCI.

[0093] In addition, considering the payload size of the first DCI, it is also possible to use a combination of DCI and high layer signaling. That is to say, a part of DCI configuration parameter can be received by a first DCI and another part of the DCI configuration parameter can be transmitted by a high layer signaling.

[0094] The first DCI can be cell specific, beam specific, TRP specific, common for a UE group or UE specific. In an embodiment of the present disclosure, the DCI can be scrambled with a specific RNTI. The periodicity of the first DCI can be larger than the second DCI. The occurrence occasions of the first DCI can predetermined or configured by a higher layer signaling such a RRC signaling. The first DCI can be located in common search space. . Or alternative, the first DCI can also be located in UE specific search space.

[0095] Next, in step 1102, DCI is received within time-frequency resources indicated by the DCI configuration parameter at the terminal device. That is to say, at

the terminal device, the terminal device may perform DCI monitoring based on the DCI configuration parameter, which means a flexible DCI monitoring solution and thus can support the DCI monitoring occasion change due to numerology and scheduling unit size.

[0096] In a still further embodiment of the present disclosure, the DCI configuration parameter comprises at least two sets of parameters. In such a case, further in step 1103, the UE may select a set of parameters based on its requested traffic types. In other words, DCI monitoring can be adapted at UE side after resource requirement by means of random access procedure/SR.

[0097] After random access procedure, the terminal device starts DL/UL transmission/reception with the eNB. Thus, the DCI monitoring behavior can be based on the reason for random access. If URLLC scheduling request is the reason for random access, the DCI monitoring should be more frequent. If eMBB scheduling request is the reason for random access, the DCI monitoring can be less frequent. By providing two or more different sets of DCI configuration parameters predefined or configured by RRC signaling, the terminal device could choose the suitable parameter set based on its request traffic type. In such a way, it is possible for UE to perform DCI monitoring based on its required traffic type.

[0098] Besides, in the present disclosure, there are also provided apparatuses for DCI transmission and receiving at the serving node and terminal device in a wireless communication system respectively, which will be described next with reference to Figs. 12 and 13.

[0099] Fig. 12 schematically illustrates a block diagram of an apparatus 1200 for DCI transmission in a wireless communication system according to an embodiment of the present disclosure. The apparatus 1200 can be implemented at a serving node, for example a BS, like a node B (NodeB or NB).

[00100] As illustrated in Fig. 12, the apparatus 1200 may comprise a parameter transmission module 1201 and a DCI transmission module 1202. The parameter transmission module 1201 can be configured to transmit a DCI configuration parameter to a terminal device. The DCI transmission module 1202 can be configured to transmit DCI to the terminal device, wherein the DCI configuration parameter indicates time-frequency resources for the DCI.

[00101] In an embodiment of the present disclosure, the sequence position information may comprise any of: a numerology to be used; a valid duration for the DCI configuration parameters; a duration for a single DCI; DCI occurrence occasions; a frequency domain resource unit; and a frequency hopping pattern.

[00102] In another embodiment of the present disclosure, the parameter transmission module 1201 may be configured to transmit the DCI configuration parameter to the terminal device by a higher layer signaling.

[00103] In a further embodiment of the present disclosure, the parameter transmission module 1201 is configured to transmit the DCI configuration parameter to the terminal device dynamically by another DCI.

[00104] In a still further embodiment of the present disclosure, the another DCI may have a larger periodicity than the DCI.

[00105] In a yet further embodiment of the present disclosure, the DCI configuration parameter may comprise at least two sets of parameters, from which the terminal device can select a set of parameters based on its requested traffic type.

[00106] Fig. 13 further schematically illustrates a block diagram of an apparatus 1300 for DCI receiving in a wireless communication system according to an embodiment of the present disclosure. The apparatus 1300 can be implemented at a terminal device, for example UE, or other like terminal devices.

[00107] As illustrated in Fig. 13, the apparatus 1300 may include a parameter receiving module 1301 and a DCI receiving module 1302. The parameter receiving module 1301 may be configured to receive DCI configuration parameter at a terminal device. The DCI receiving module 1302 can be configured to receive DCI within time-frequency resources indicated by the DCI configuration parameter at a terminal device.

[00108] In an embodiment of the present disclosure, the sequence position information may comprise any of: a numerology to be used; a valid duration for the DCI configuration parameters; a duration for a single DCI; DCI occurrence occasions; a frequency domain resource unit; and a frequency hopping pattern.

[00109] In another embodiment of the present disclosure, the parameter receiving module 1301 may be further configured to receive the DCI configuration parameter in a higher layer signaling.

[00110] In another embodiment of the present disclosure, the parameter receiving module 1301 may be further configured to receive the DCI configuration parameter in another DCI.

[00111] In a still further embodiment of the present disclosure, the another DCI may have a larger periodicity than the DCI.

[00112] In a yet further embodiment of the present disclosure, the DCI configuration parameter may comprise at least two sets of parameters. In such a case, the apparatus 1300 may further comprise a parameter set selection module 1303. The apparatus 1300 may be configured to select a set of parameters based on a traffic type requested by the terminal device and wherein the time-frequency resources are those indicated by the selected set of parameters

[00113] Hereinbefore, the apparatuses 1200 and 1300 are described with reference to Figs. 12 and 13. It is noted that the apparatuses 1200 and 1300 may be configured to implement functionalities as described with reference to Figs. 1 to 11. Therefore, for details about the operations of modules in these apparatuses, one may refer to those descriptions made with respect to the respective steps of the methods with reference to Figs. 1 to 11.

[00114] It is further noted that the components of the apparatuses 1200 and 1300 may be embodied in hardware, software, firmware, and/or any combination thereof. For example, the components of apparatuses 1200 and 1300 may be respectively implemented by a circuit, a processor or any other appropriate selection device.

[00115] Those skilled in the art will appreciate that the aforesaid examples are only for illustration not limitation and the present disclosure is not limited thereto; one can readily conceive many variations, additions, deletions and modifications from the teaching provided herein and all these variations, additions, deletions and modifications fall the protection scope of the present disclosure.

[00116] In addition, in some embodiment of the present disclosure, apparatuses 1200 and 1300 may comprise at least one processor. The at least one processor suitable for use with embodiments of the present disclosure may include, by way of example, both general and special purpose processors already known or developed in the future. Apparatuses 1200 and 1300 may further comprise at least one memory.

The at least one memory may include, for example, semiconductor memory devices, e.g., RAM, ROM, EPROM, EEPROM, and flash memory devices. The at least one memory may be used to store program of computer executable instructions. The program can be written in any high-level and/or low-level compliable or interpretable programming languages. In accordance with embodiments, the computer executable instructions may be configured, with the at least one processor, to cause apparatuses 1200 and 1300 to at least perform operations according to the method as discussed with reference to Figs. 1 to 11 respectively.

[00117] Fig. 14 further illustrates a simplified block diagram of an apparatus 1410 that may be embodied as or comprised in a serving node like a base station in a wireless network and an apparatus 1420 that may be embodied as or comprised in a terminal device like UE as described herein.

[00118] The apparatus 1410 comprises at least one processor 1411, such as a data processor (DP) and at least one memory (MEM) 1412 coupled to the processor 1411. The apparatus 1410 may further comprise a transmitter TX and receiver RX 1413 coupled to the processor 1411, which may be operable to communicatively connect to the apparatus 1420. The MEM 1412 stores a program (PROG) 1414. The PROG 1414 may include instructions that, when executed on the associated processor 1411, enable the apparatus 1410 to operate in accordance with embodiments of the present disclosure, for example the method 100. A combination of the at least one processor 1411 and the at least one MEM 1412 may form processing means 1415 adapted to implement various embodiments of the present disclosure.

[00119] The apparatus 1420 comprises at least one processor 1421, such as a DP, and at least one MEM 1422 coupled to the processor 1421. The apparatus 1420 may further comprise a suitable TX/ RX 1423 coupled to the processor 1421, which may be operable for wireless communication with the apparatus 1410. The MEM 1422 stores a PROG 1424. The PROG 1424 may include instructions that, when executed on the associated processor 1421, enable the apparatus 1420 to operate in accordance with the embodiments of the present disclosure, for example to perform the method 1100. A combination of the at least one processor 1421 and the at least one MEM 1422 may form processing means 1425 adapted to implement various embodiments of the present disclosure.

[00120] Various embodiments of the present disclosure may be implemented by computer program executable by one or more of the processors 1411, 1421, software, firmware, hardware or in a combination thereof.

[00121] The MEMs 1412 and 1422 may be of any type suitable to the local technical environment and may be implemented using any suitable data storage technology, such as semiconductor based memory devices, magnetic memory devices and systems, optical memory devices and systems, fixed memory and removable memory, as non-limiting examples.

[00122] The processors 1411 and 1421 may be of any type suitable to the local technical environment, and may include one or more of general purpose computers, special purpose computers, microprocessors, digital signal processors DSPs and processors based on multicore processor architecture, as non-limiting examples.

[00123] In addition, the present disclosure may also provide a carrier containing the computer program as mentioned above, wherein the carrier is one of an electronic signal, optical signal, radio signal, or computer readable storage medium. The computer readable storage medium can be, for example, an optical compact disk or an electronic memory device like a RAM (random access memory), a ROM (read only memory), Flash memory, magnetic tape, CD-ROM, DVD, Blue-ray disc and the like.

[00124] The techniques described herein may be implemented by various means so that an apparatus implementing one or more functions of a corresponding apparatus described with one embodiment comprises not only prior art means, but also means for implementing the one or more functions of the corresponding apparatus described with the embodiment and it may comprise separate means for each separate function, or means that may be configured to perform two or more functions. For example, these techniques may be implemented in hardware (one or more apparatuses), firmware (one or more apparatuses), software (one or more modules), or combinations thereof. For a firmware or software, implementation may be made through modules (e.g., procedures, functions, and so on) that perform the functions described herein.

[00125] Exemplary embodiments herein have been described above with reference to block diagrams and flowchart illustrations of methods and apparatuses. It will be understood that each block of the block diagrams and flowchart illustrations, and combinations of blocks in the block diagrams and flowchart illustrations, respectively,

can be implemented by various means including computer program instructions. These computer program instructions may be loaded onto a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions which execute on the computer or other programmable data processing apparatus create means for implementing the functions specified in the flowchart block or blocks.

[00126] While this specification contains many specific implementation details, these should not be construed as limitations on the scope of any implementation or of what may be claimed, but rather as descriptions of features that may be specific to particular embodiments of particular implementations. Certain features that are described in this specification in the context of separate embodiments can also be implemented in combination in a single embodiment. Conversely, various features that are described in the context of a single embodiment can also be implemented in multiple embodiments separately or in any suitable sub-combination. Moreover, although features may be described above as acting in certain combinations and even initially claimed as such, one or more features from a claimed combination can in some cases be excised from the combination, and the claimed combination may be directed to a sub-combination or variation of a sub-combination.

[00127] It will be obvious to a person skilled in the art that, as the technology advances, the inventive concept can be implemented in various ways. The above described embodiments are given for describing rather than limiting the disclosure, and it is to be understood that modifications and variations may be resorted to without departing from the spirit and scope of the disclosure as those skilled in the art readily understand. Such modifications and variations are considered to be within the scope of the disclosure and the appended claims. The protection scope of the disclosure is defined by the accompanying claims.

WHAT IS CLAIMED IS:

1. A method of downlink control information (DCI) transmission in a wireless communication system, the method comprising:

transmitting a DCI configuration parameter to a terminal device; and

transmitting DCI to the terminal device, wherein the DCI configuration parameter indicates time-frequency resources for the DCI.

2. The method of Claim 1, wherein the DCI configuration parameter comprises at least one of:

a numerology to be used;

a valid duration for the DCI configuration parameter;

a duration for a single DCI; and

DCI occurrence occasions.

3. The method of Claim 1 or 2, wherein the DCI configuration parameter comprises at least one of:

a frequency domain resource unit; and

a frequency hopping pattern.

4. The method of any of Claims 1 to 3, wherein the transmitting DCI configuration parameter to a terminal device comprises transmitting the DCI configuration parameter to the terminal device by a higher layer signaling.

5. The method of any of Claims 1 to 4, wherein the transmitting DCI configuration parameter to a terminal device comprises transmitting the DCI configuration parameter to the terminal device dynamically by another DCI.

6. The method of Claim 5, wherein the another DCI has a larger periodicity than the DCI.

7. The method of any of Claims 1 to 6, wherein the DCI configuration parameter comprises at least two sets of parameters, from which the terminal device can select a

set of parameters based on its requested traffic type.

8. A method of downlink control information (DCI) receiving in a wireless communication system, the method comprising:

receiving a DCI configuration parameter at a terminal device; and

receiving DCI within time-frequency resources indicated by the DCI configuration parameter at the terminal device.

9. The method of Claim 8, wherein the DCI configuration parameter comprises at least one of:

a numerology to be used;

a valid duration for the DCI configuration parameters;

a duration for a single DCI;

DCI occurrence occasions;

a frequency domain resource unit; and

a frequency hopping pattern.

10. The method of Claim 8 or 9, wherein the receiving DCI configuration parameter comprises receiving the DCI configuration parameter in a higher layer signaling.

11. The method of any Claims 8 to 10, wherein the receiving DCI configuration parameter comprises receiving the DCI configuration parameter in another DCI.

12. The method of Claim 11, wherein the another DCI has a larger periodicity than the DCI.

13. The method of any of Claims 8 to 12, wherein the DCI configuration parameter comprises at least two sets of parameters, wherein the method further comprises selecting a set of parameters based on a traffic type requested by the terminal device and wherein the time-frequency resources are those indicated by the selected set of parameters.

14. An apparatus of downlink control information (DCI) transmission in a wireless communication system, the apparatus comprising:

a parameter transmission module configured to transmit a DCI configuration parameter to a terminal device; and

a DCI transmission module configured to transmit DCI to the terminal device, wherein the DCI configuration parameter indicates time-frequency resources for the DCI.

15. The apparatus of Claim 14, wherein the DCI configuration parameter comprises at least one of:

a numerology to be used;

a valid duration for the DCI configuration parameter;

a duration for a single DCI;

DCI occurrence occasions;

a frequency domain resource unit; and

a frequency hopping pattern .

16. The apparatus of Claim 14 or 15, wherein the parameter transmission module is further configured to transmit the DCI configuration parameter to the terminal device by a higher layer signaling.

17. The apparatus of any of Claims 14 to 16, wherein the parameter transmission module is further configured to transmit the DCI configuration parameter to the terminal device dynamically by another DCI.

18. The apparatus of Claim 17, wherein the another DCI has a larger periodicity than the DCI.

19. The apparatus of any of Claims 14 to 18, wherein the DCI configuration parameter comprises at least two sets of parameters, from which the terminal device can select a set of parameters based on its requested traffic type.

20. An apparatus of downlink control information (DCI) receiving in a wireless

communication system, the apparatus comprising:

a parameter receiving module configured to receive DCI configuration parameter at a terminal device; and

a DCI receiving module, configured to receive DCI within time-frequency resources indicated by the DCI configuration parameter at the terminal device.

21. The apparatus of Claim 20, wherein the DCI configuration parameter comprises at least one of:

a numerology to be used;

a valid duration for the DCI configuration parameters;

a duration for a single DCI;

DCI occurrence occasions;

a frequency domain resource unit; and

a frequency hopping pattern .

22. The apparatus of Claim 20 or 21, wherein the parameter receiving module is further configured to receive the DCI configuration parameter in a higher layer signaling.

23. The apparatus of any of Claims 20 to 22, wherein the parameter receiving module is further configured to receive the DCI configuration parameter in another DCI.

24. The apparatus of Claim 23, wherein the another DCI has a larger periodicity than the DCI.

25. The apparatus of any of Claims 20 to 24, wherein the DCI configuration parameter comprises at least two sets of parameters, wherein the apparatus further comprises a parameter set selection module, configured to select a set of parameters based on a traffic type requested by the terminal device and wherein the time-frequency resources are those indicated by the selected set of parameters.

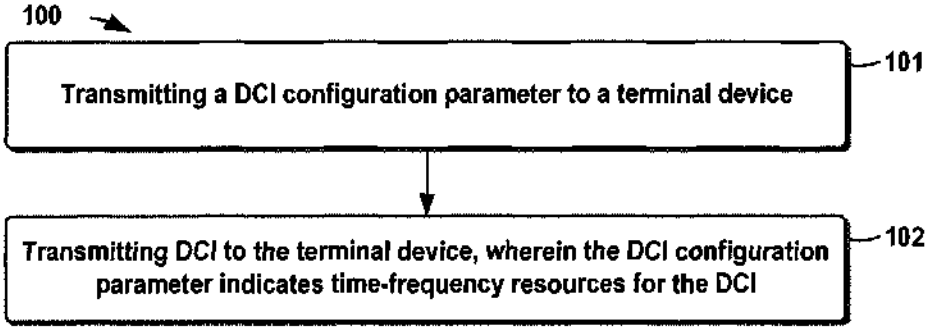


Fig. 1

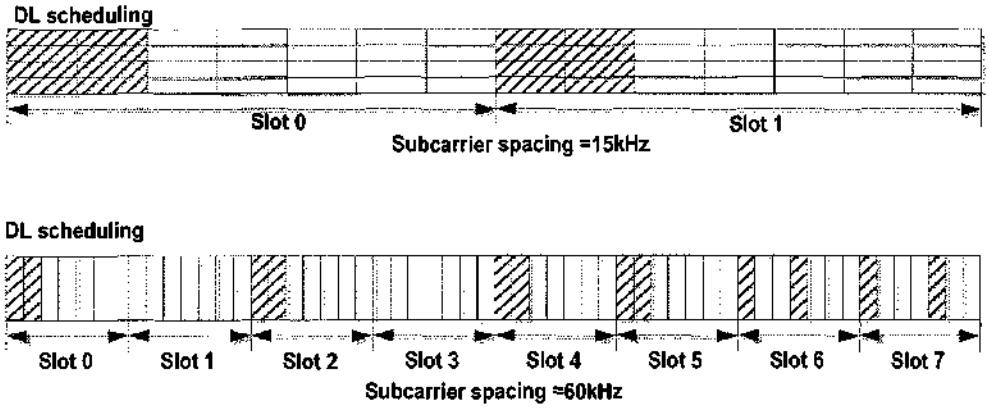


Fig. 2

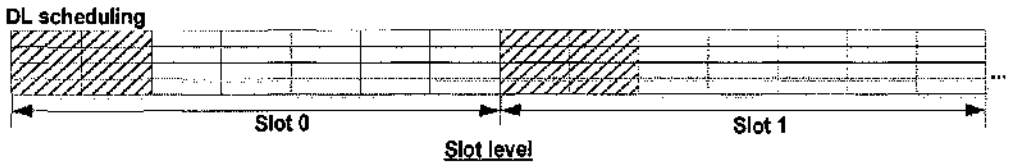


Fig. 3A

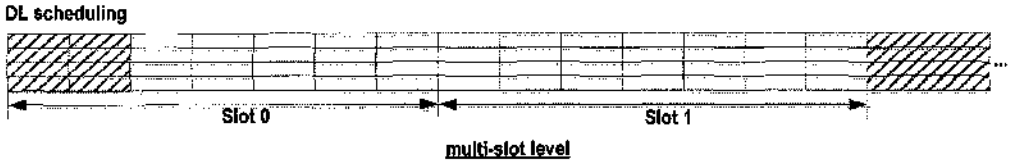


Fig. 3B

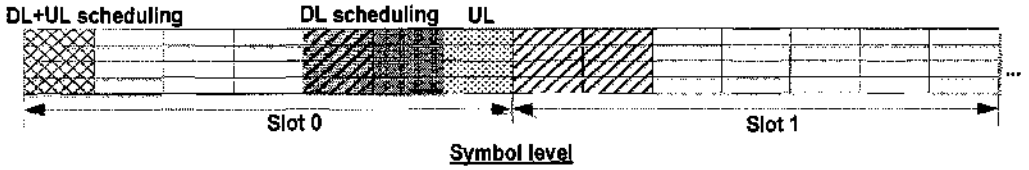


Fig. 3C

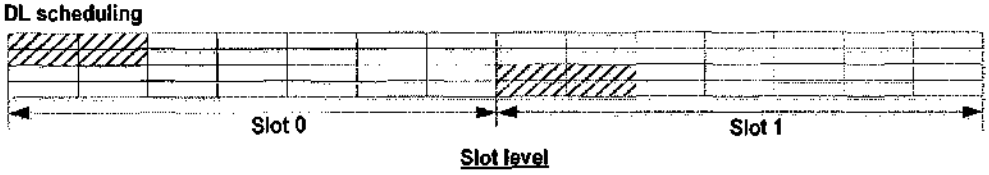


Fig. 4A

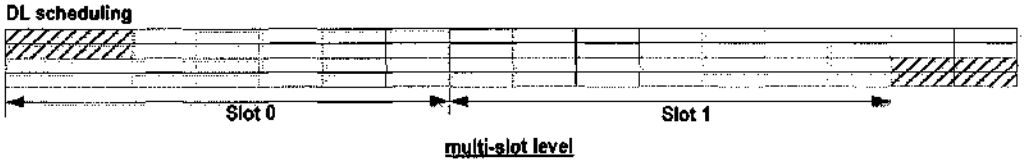


Fig. 4B

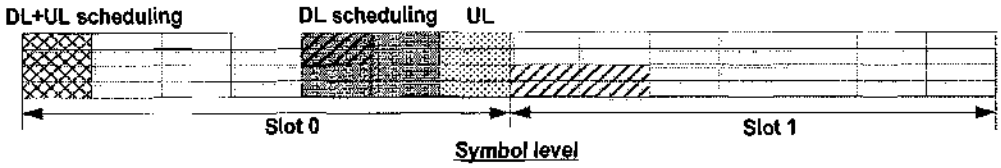


Fig. 4C

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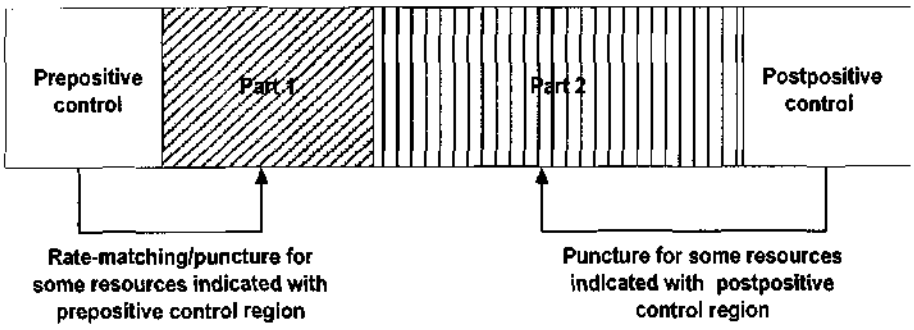


Fig. 5A

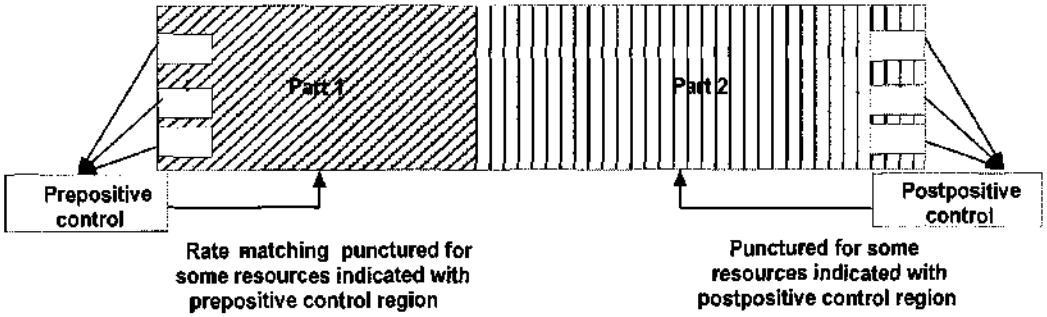
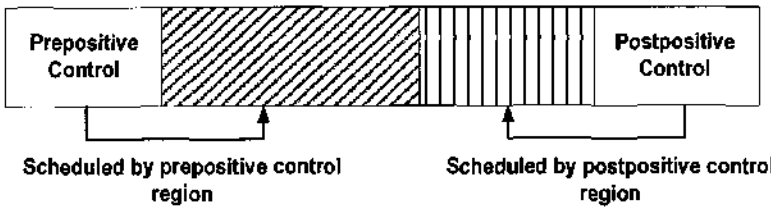
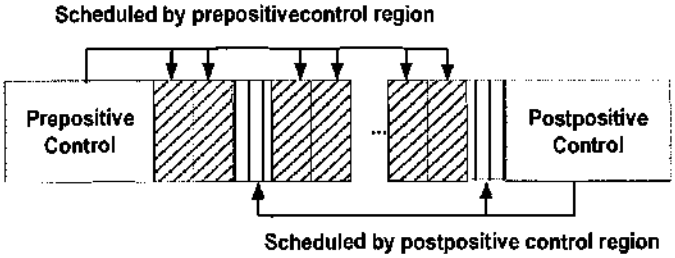


Fig. 5B



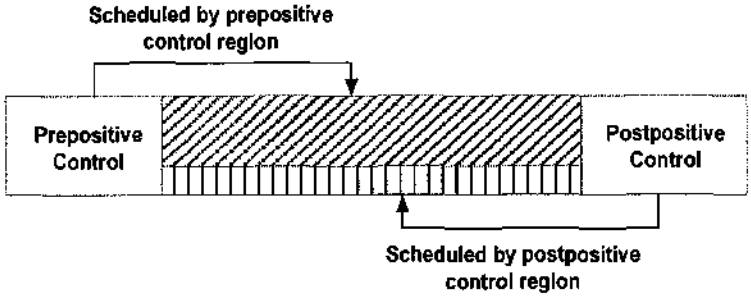
TDM

Fig. 6A



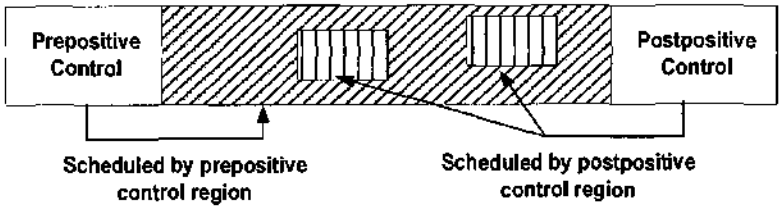
TDM by symbol

Fig. 6B



FDM

Fig. 6C



TDM and FDM

Fig. 6D

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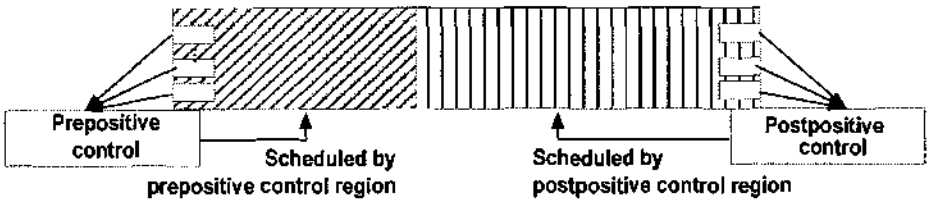


Fig. 7A

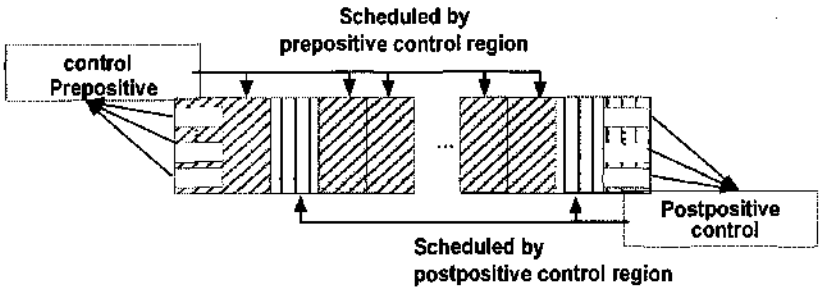


Fig. 7B

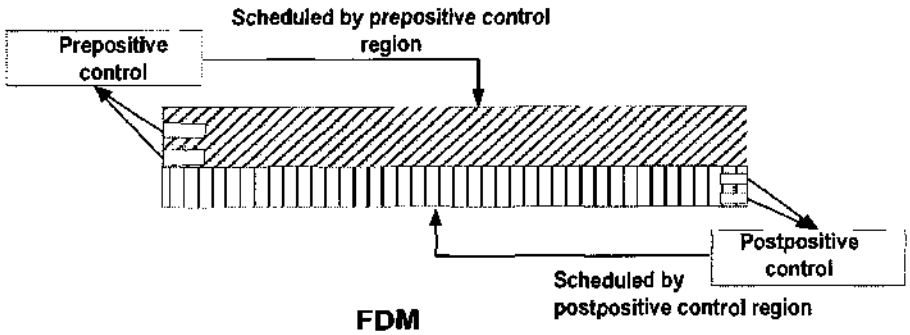
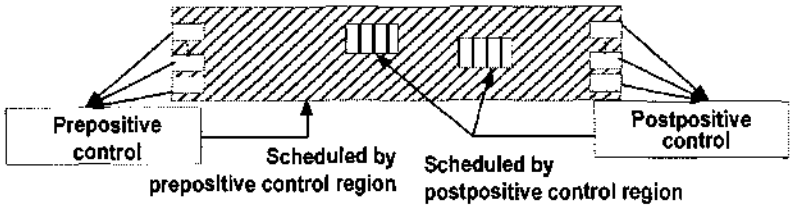


Fig. 7C



TDM and FDM

Fig. 7D

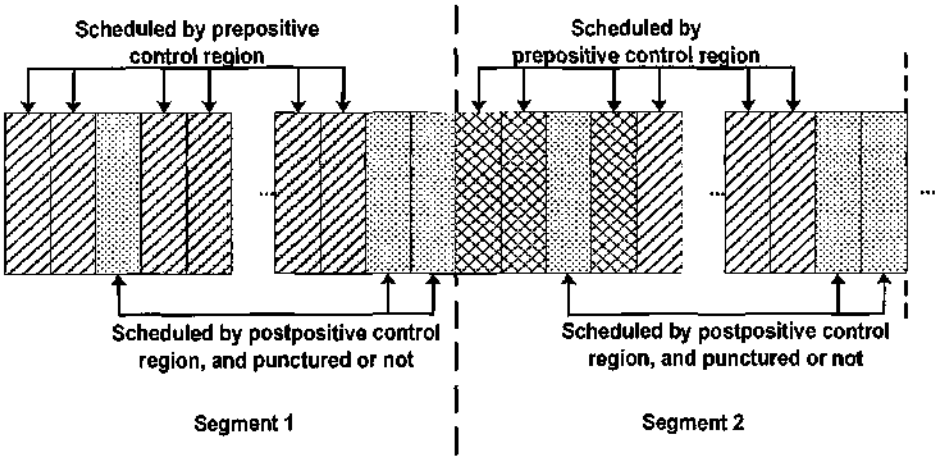


Fig. 8

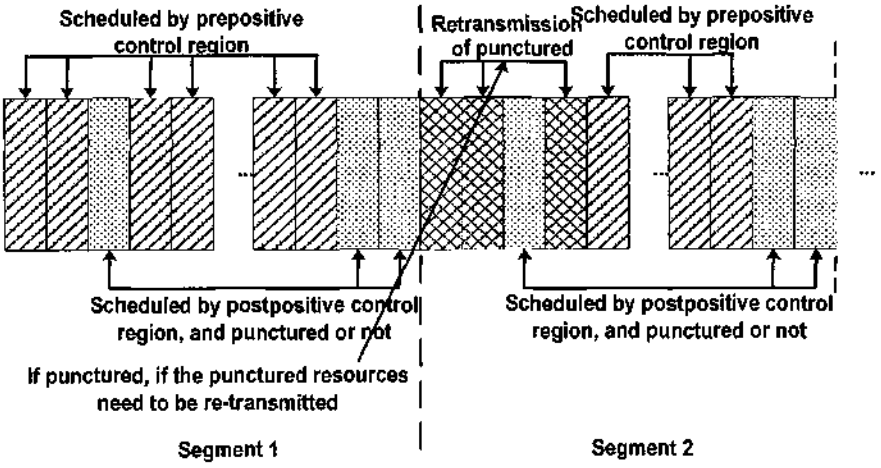


Fig. 9

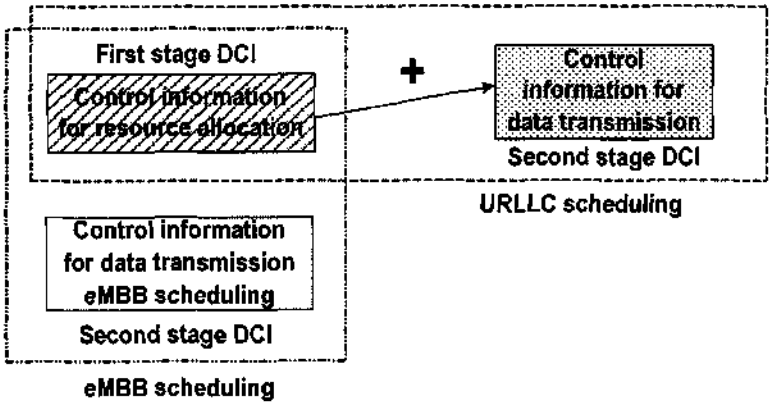


Fig. 10

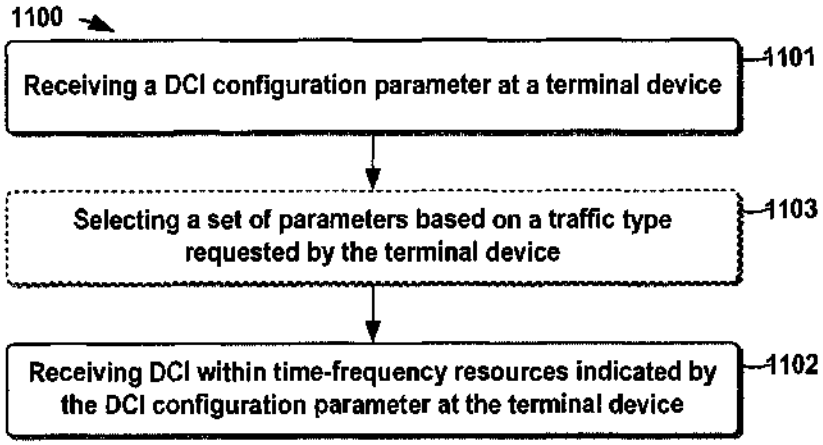


Fig. 11

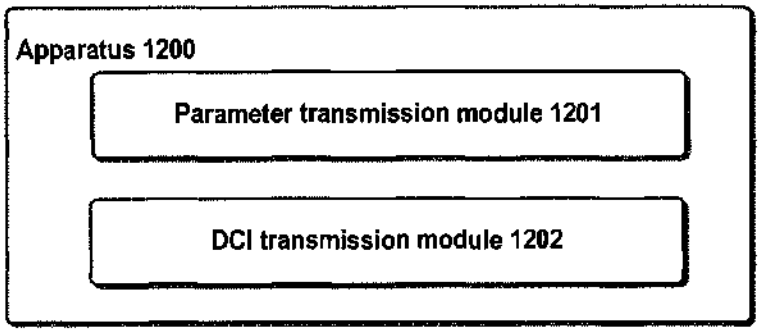


Fig. 12

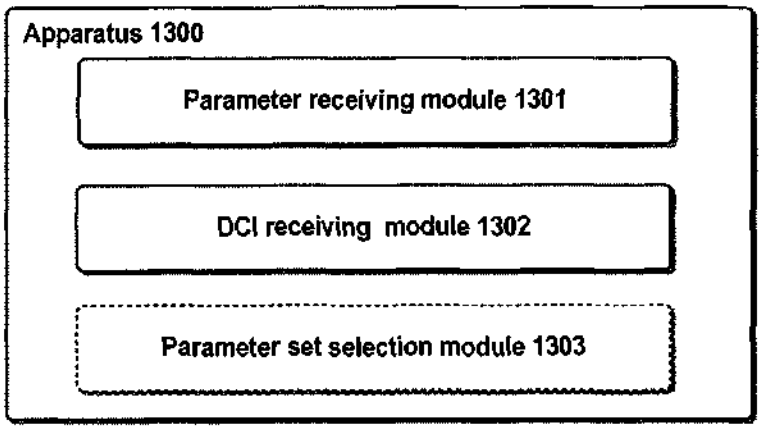

Apparatus 1300
Parameter receiving module 1301
DCI receiving module 1302
Parameter set selection module 1303

Fig. 13

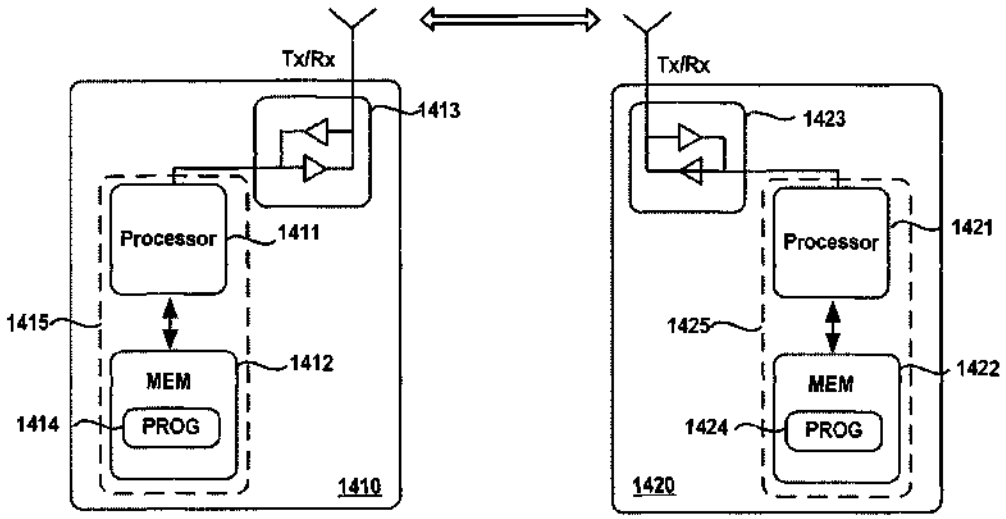

Tx/Rx
1413
Processor
1411
1415
MEM
1412
1414
PROG
1410
Tx/Rx
1423
Processor
1421
1425
MEM
1422
1424
PROG
1420

Fig. 14

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2017/070309

A. CLASSIFICATION OF SUBJECT MATTER

H04L 27/26(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04L,H04W,H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI,EPODOC,CNPAT,CNKI:downlink w control w information, DCI, configur+, parameter, time, frequency, resource+, indicat +, UE, user, transmit+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 106161312 A (CHINA MOBILE COMMUNICATIONS CORPORATION) 23 November 2016 (2016-11-23) description, paragraphs [0001], [0159]-[0166], [0217]-[0232]	1-25
A	CN 103095396 A (CHINA MOBILE COMMUNICATIONS CORPORATION) 08 May 2013 (2013-05-08) the whole document	1-25
A	US 2016345311 A1 (QUALCOMM INCORPORATED) 24 November 2016 (2016-11-24) the whole document	1-25
A	US 2016380737 A1 (LG ELECTRONICS INC.) 29 December 2016 (2016-12-29) the whole document	1-25

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particnlar relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
08 August 2017	**06 September 2017**
Name and mailing address of the ISA/CN **STATE INTELLECTUAL PROPERTY OFFICE OF THE P.R.CHINA** **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088** **China** Facsimile No. **(86-10)62019451**	Authorized officer **ZUO,Linzi** Telephone No. **(86-10)62413344**

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2017/070309

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	106161312	A	23 November 2016	WO	2016150224	A1	29 September 2016
CN	103095396	A	08 May 2013	无			
US	2016345311	A1	24 November 2016	WO	2016190970	A1	01 December 2016
US	2016380737	A1	29 December 2016	KR	101525746	B1	03 June 2015
				US	2015215095	A1	30 July 2015

Form PCT/ISA/210 (patent family annex) (July 2009)

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WIPO | PCT

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(51) International Patent Classification:
H04W 68/00 (2009.01) *H04L 5/00* (2006.01)
H04W 4/00 (2009.01)

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PCT/US2016/060554

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4 November 2016 (04.11.2016)

(25) Filing Language: English

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62/250,803 4 November 2015 (04.11.2015) US
62/290,790 3 February 2016 (03.02.2016) US
62/308,042 14 March 2016 (14.03.2016) US

(71) Applicant: **INTERDIGITAL PATENT HOLDINGS, INC.** [US/US]; 200 Bellevue Parkway, Suite 300, Wilmington, Delaware 19809 (US).

(72) Inventors: **LEE, Moon-il**; 2 Huntington Quadrangle, 4th Floor, South Wing, Melville, New York 11747-4508 (US). **STERN-BERKOWITZ, Janet A.**; 2 Huntington Quadrangle, 4th Floor, South Wing, Melville, New York 11747-4508 (US). **AHN, Jaehyun**; 5th F Bethel Building, 21-6 Teheran-ro 34gil, Gangnam-gu, Seoul 06222 (KR). **ADJAKPLE, Pascal, M.**; 2 Huntington Quadrangle, 4th Floor, South Wing, Melville, New York 11747-4508 (US).

(74) Agent: **DUNSAY, Jonathan M.**; Volpe and Koenig, P.C., 30 South 17th Street, United Plaza, Suite 1800, Philadelphia, PA 19103 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: METHODS AND MACHINE TYPE COMMUNICATION, MTC, DEVICE, IMPLEMENTING PAGING PROCEDURES FOR REDUCED BANDWITH MTC DEVICES

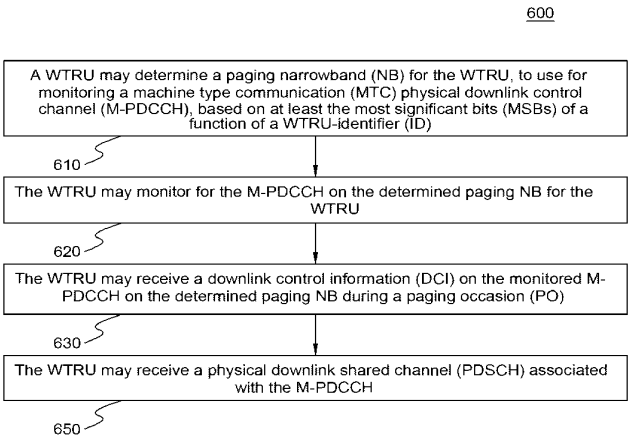


FIG. 6

(57) Abstract: Methods for paging for reduced bandwidth wireless transmit/receive units, WTRUs, in machine type communication, MTC, are provided. A WTRU determines (610) a paging narrowband, NB, for the WTRU, to use for monitoring an MTC physical downlink control channel, M-PDCCH, based on at least the most significant bits, MSBs, of a function of a WTRU-identifier, WTRU-ID. The WTRU monitors (620) for the M-PDCCH on the determined paging NB for the WTRU. The WTRU then receives (630) a downlink control information, DCI, on the monitored M-PDCCH on the determined paging NB during a paging occasion, PO.The WTRU then receives (650) a physical downlink shared channel, PDSCH, associated with the M-PDCCH. Alternatively, the WTRU monitors (420) the M-PDCCH in the M-PDCCH search space, wherein the M-PDCCH has a starting enahnced control channel element, ECCE, index for a WTRU group containing the WTR, and wherein the M-PDCCH includes (430) the DCI.

WO 2017/079574 A1

Published:

— *with international search report (Art. 21(3))*

METHODS AND MACHINE TYPE COMMUNICATION, MTC, DEVICE, IMPLEMENTING PAGING PROCEDURES FOR REDUCED BANDWITH MTC DEVICES

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 62/250,803 filed November 4, 2015, U.S. Provisional Application No. 62/290,790 filed February 3, 2016, and U.S. Provisional Application 62/308,042 filed March 14, 2016, the contents of which are hereby incorporated by reference herein.

BACKGROUND

[0002] As wireless communication systems such as Long Term Evolution (LTE) systems mature and their network deployment evolve, it may be beneficial for network operators to reduce the cost of the communication network, maintenance needs of the communication network or both. One technique to reduce the cost of the network may be to reduce the channel bandwidth and data rate used to communicate with devices.

[0003] For example, a portion of the channel bandwidth rather than the entire channel bandwidth may be supported by the devices in the network and/or the network itself when communicating with such devices. Current wireless communication systems, for example, LTE, have recently considered a bandwidth reduction for some devices including machine type communication (MTC) devices to some level, for example, 1.4 megahertz (MHz).

SUMMARY

[0004] Methods for paging for reduced bandwidth wireless transmit/receive units (WTRUs) in machine type communication (MTC) are provided. A WTRU may determine a paging narrowband (NB) for the WTRU, to use for monitoring an MTC physical downlink control channel (M-PDCCH), based on at least the most significant bits (MSBs) of a function of a WTRU-identifier (WTRU-ID). The WTRU may monitor for the M-PDCCH on the

determined paging NB for the WTRU. The WTRU may then receive a downlink control information (DCI) on the monitored M-PDCCH on the determined paging NB during a paging occasion (PO). The DCI may include a scrambled cyclic redundancy check (CRC). The CRC may be scrambled with a Paging Radio Network Temporary Identifier (P-RNTI). Also, the WTRU may receive a physical downlink shared channel (PDSCH) associated with the M-PDCCH.

[0005] In an example, the WTRU may determine the paging NB based on at least the 3 MSBs of a function of the WTRU-ID. In another example, the WTRU may determine the paging NB based on at least the 4 MSBs of a function of the WTRU-ID.

[0006] Further, the PDSCH may be scheduled by the DCI. In an example, the DCI may include a paging message. In another example, the DCI may include system information update related information. In a further example, the PDSCH may include a paging message. In an additional example, the PDSCH may include system information update related information.

[0007] In addition, a WTRU may monitor for a M-PDCCH in an M-PDCCH search space. The WTRU may receive an M-PDCCH in the M-PDCCH search space, wherein the M-PDCCH has a starting enhanced control channel element (ECCE) index for the WTRU group containing the WTRU. Further, the WTRU may decode the M-PDCCH, wherein the M-PDCCH includes a DCI. In addition, the WTRU may receive a PDSCH associated with the M-PDCCH.

[0008] Further, the WTRU may receive, decode, and/or demodulate the PDSCH based on the DCI, wherein the PDSCH includes a paging message. The WTRU may then change operations based on the paging message. For example, the WTRU may change from idle mode to connected mode based on the paging message. In an example, the ECCE aggregation level may be 16.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] A more detailed understanding may be had from the following description, given by way of example in conjunction with the accompanying drawings wherein:

[0010] FIG. 1A is a system diagram of an example communications system in which one or more disclosed embodiments may be implemented;

[0011] FIG. 1B is a system diagram of an example wireless transmit/receive unit (WTRU) that may be used within the communications system illustrated in FIG. 1A;

[0012] FIG. 1C is a system diagram of an example radio access network and an example core network that may be used within the communications system illustrated in FIG. 1A;

[0013] FIG. 2 is an exemplary timing diagram which illustrates hyper frames and paging within hyper frames;

[0014] FIG. 3 is an exemplary diagram which illustrates WTRU group-specific starting enhanced control channel element (ECCE) indexes;

[0015] FIG. 4 is a diagram of an example flow chart showing a WTRU receiving a machine type communication (MTC) physical downlink control channel (M-PDCCH) with a starting ECCE index based on the WTRU group of the WTRU;

[0016] FIG. 5 is an exemplary diagram which illustrates WTRU group-specific random ECCE ordering;

[0017] FIG. 6 is a diagram of an example flow chart showing a WTRU using a WTRU-ID to determine a paging narrowband (NB) to use for monitoring an M-PDCCH;

[0018] FIG. 7 is a diagram illustrating an example of code-block segment multiplexing in a physical downlink shared channel (PDSCH), which may be scheduled by an associated physical downlink control channel (PDCCH) in a paging occasion (PO); and

[0019] FIG. 8 is a diagram illustrating an example of code-block segments transmitted via multiple PDSCHs, which may be scheduled by an associated PDCCH in a PO.

DETAILED DESCRIPTION

[0020] FIG. 1A is a diagram of an example communications system 100 in which one or more disclosed embodiments may be implemented. The communications system 100 may be a multiple access system that provides content, such as voice, data, video, messaging, broadcast, etc., to multiple wireless users. The communications system 100 may enable multiple wireless users to access such content through the sharing of system resources, including wireless bandwidth. For example, the communications systems 100 may employ one or more channel access methods, such as code division multiple access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), orthogonal FDMA (OFDMA), single-carrier FDMA (SC-FDMA), and the like.

[0021] As shown in FIG. 1A, the communications system 100 may include wireless transmit/receive units (WTRUs) 102a, 102b, 102c, 102d, a radio access network (RAN) 104, a core network 106, a public switched telephone network (PSTN) 108, the Internet 110, and other networks 112, though it will be appreciated that the disclosed embodiments contemplate any number of WTRUs, base stations, networks, and/or network elements. Each of the WTRUs 102a, 102b, 102c, 102d may be any type of device configured to operate and/or communicate in a wireless environment. By way of example, the WTRUs 102a, 102b, 102c, 102d may be configured to transmit and/or receive wireless signals and may include user equipment (UE), a mobile station, a fixed or mobile subscriber unit, a pager, a cellular telephone, a personal digital assistant (PDA), a smartphone, a laptop, a netbook, a personal computer, a wireless sensor, consumer electronics, and the like.

[0022] The communications systems 100 may also include a base station 114a and a base station 114b. Each of the base stations 114a, 114b may be any type of device configured to wirelessly interface with at least one of the WTRUs 102a, 102b, 102c, 102d to facilitate access to one or more communication networks, such as the core network 106, the Internet 110, and/or the other networks 112. By way of example, the base stations 114a, 114b may be a base transceiver station (BTS), a Node-B, an eNode B, a Home

Node B, a Home eNode B, a site controller, an access point (AP), a wireless router, and the like. While the base stations 114a, 114b are each depicted as a single element, it will be appreciated that the base stations 114a, 114b may include any number of interconnected base stations and/or network elements.

[0023] The base station 114a may be part of the RAN 104, which may also include other base stations and/or network elements (not shown), such as a base station controller (BSC), a radio network controller (RNC), relay nodes, etc. The base station 114a and/or the base station 114b may be configured to transmit and/or receive wireless signals within a particular geographic region, which may be referred to as a cell (not shown). The cell may further be divided into cell sectors. For example, the cell associated with the base station 114a may be divided into three sectors. Thus, in one embodiment, the base station 114a may include three transceivers, i.e., one for each sector of the cell. In another embodiment, the base station 114a may employ multiple-input multiple-output (MIMO) technology and, therefore, may utilize multiple transceivers for each sector of the cell.

[0024] The base stations 114a, 114b may communicate with one or more of the WTRUs 102a, 102b, 102c, 102d over an air interface 116, which may be any suitable wireless communication link (for example, radio frequency (RF), microwave, infrared (IR), ultraviolet (UV), visible light, etc.). The air interface 116 may be established using any suitable radio access technology (RAT).

[0025] More specifically, as noted above, the communications system 100 may be a multiple access system and may employ one or more channel access schemes, such as CDMA, TDMA, FDMA, OFDMA, SC-FDMA, and the like. For example, the base station 114a in the RAN 104 and the WTRUs 102a, 102b, 102c may implement a radio technology such as Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access (UTRA), which may establish the air interface 116 using wideband CDMA (WCDMA). WCDMA may include communication protocols such as High-Speed Packet Access (HSPA) and/or Evolved HSPA (HSPA+). HSPA may include High-Speed Downlink Packet Access (HSDPA) and/or High-Speed Uplink Packet Access (HSUPA).

[0026] In another embodiment, the base station 114a and the WTRUs 102a, 102b, 102c may implement a radio technology such as Evolved UMTS Terrestrial Radio Access (E-UTRA), which may establish the air interface 116 using Long Term Evolution (LTE) and/or LTE-Advanced (LTE-A).

[0027] In other embodiments, the base station 114a and the WTRUs 102a, 102b, 102c may implement radio technologies such as IEEE 802.16 (i.e., Worldwide Interoperability for Microwave Access (WiMAX)), CDMA2000, CDMA2000 1X, CDMA2000 EV-DO, Interim Standard 2000 (IS-2000), Interim Standard 95 (IS-95), Interim Standard 856 (IS-856), Global System for Mobile communications (GSM), Enhanced Data rates for GSM Evolution (EDGE), GSM EDGE (GERAN), and the like.

[0028] The base station 114b in FIG. 1A may be a wireless router, Home Node B, Home eNode B, or access point, for example, and may utilize any suitable RAT for facilitating wireless connectivity in a localized area, such as a place of business, a home, a vehicle, a campus, and the like. In one embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.11 to establish a wireless local area network (WLAN). In another embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.15 to establish a wireless personal area network (WPAN). In yet another embodiment, the base station 114b and the WTRUs 102c, 102d may utilize a cellular-based RAT (for example, WCDMA, CDMA2000, GSM, LTE, LTE-A, etc.) to establish a picocell or femtocell. As shown in FIG. 1A, the base station 114b may have a direct connection to the Internet 110. Thus, the base station 114b may not be required to access the Internet 110 via the core network 106.

[0029] The RAN 104 may be in communication with the core network 106, which may be any type of network configured to provide voice, data, applications, and/or voice over internet protocol (VoIP) services to one or more of the WTRUs 102a, 102b, 102c, 102d. For example, the core network 106 may provide call control, billing services, mobile location-based services, pre-paid calling, Internet connectivity, video distribution, etc., and/or perform high-level security functions, such as user authentication. Although not shown in

FIG. 1A, it will be appreciated that the RAN 104 and/or the core network 106 may be in direct or indirect communication with other RANs that employ the same RAT as the RAN 104 or a different RAT. For example, in addition to being connected to the RAN 104, which may be utilizing an E-UTRA radio technology, the core network 106 may also be in communication with another RAN (not shown) employing a GSM radio technology.

[0030] The core network 106 may also serve as a gateway for the WTRUs 102a, 102b, 102c, 102d to access the PSTN 108, the Internet 110, and/or other networks 112. The PSTN 108 may include circuit-switched telephone networks that provide plain old telephone service (POTS). The Internet 110 may include a global system of interconnected computer networks and devices that use common communication protocols, such as the transmission control protocol (TCP), user datagram protocol (UDP) and the internet protocol (IP) in the TCP/IP internet protocol suite. The networks 112 may include wired or wireless communications networks owned and/or operated by other service providers. For example, the networks 112 may include another core network connected to one or more RANs, which may employ the same RAT as the RAN 104 or a different RAT.

[0031] Some or all of the WTRUs 102a, 102b, 102c, 102d in the communications system 100 may include multi-mode capabilities, i.e., the WTRUs 102a, 102b, 102c, 102d may include multiple transceivers for communicating with different wireless networks over different wireless links. For example, the WTRU 102c shown in FIG. 1A may be configured to communicate with the base station 114a, which may employ a cellular-based radio technology, and with the base station 114b, which may employ an IEEE 802 radio technology.

[0032] FIG. 1B is a system diagram of an example WTRU 102. As shown in FIG. 1B, the WTRU 102 may include a processor 118, a transceiver 120, a transmit/receive element 122, a speaker/microphone 124, a keypad 126, a display/touchpad 128, non-removable memory 130, removable memory 132, a power source 134, a global positioning system (GPS) chipset 136, and other peripherals 138. It will be appreciated that the WTRU 102 may include any

sub-combination of the foregoing elements while remaining consistent with an embodiment.

[0033] The processor 118 may be a general purpose processor, a special purpose processor, a conventional processor, a digital signal processor (DSP), a plurality of microprocessors, one or more microprocessors in association with a DSP core, a controller, a microcontroller, Application Specific Integrated Circuits (ASICs), Field Programmable Gate Array (FPGAs) circuits, any other type of integrated circuit (IC), a state machine, and the like. The processor 118 may perform signal coding, data processing, power control, input/output processing, and/or any other functionality that enables the WTRU 102 to operate in a wireless environment. The processor 118 may be coupled to the transceiver 120, which may be coupled to the transmit/receive element 122. While FIG. 1B depicts the processor 118 and the transceiver 120 as separate components, it will be appreciated that the processor 118 and the transceiver 120 may be integrated together in an electronic package or chip.

[0034] The transmit/receive element 122 may be configured to transmit signals to, or receive signals from, a base station (for example, the base station 114a) over the air interface 116. For example, in one embodiment, the transmit/receive element 122 may be an antenna configured to transmit and/or receive RF signals. In another embodiment, the transmit/receive element 122 may be an emitter/detector configured to transmit and/or receive IR, UV, or visible light signals, for example. In yet another embodiment, the transmit/receive element 122 may be configured to transmit and receive both RF and light signals. It will be appreciated that the transmit/receive element 122 may be configured to transmit and/or receive any combination of wireless signals.

[0035] In addition, although the transmit/receive element 122 is depicted in FIG. 1B as a single element, the WTRU 102 may include any number of transmit/receive elements 122. More specifically, the WTRU 102 may employ MIMO technology. Thus, in one embodiment, the WTRU 102 may include two or more transmit/receive elements 122 (for example, multiple

antennas) for transmitting and receiving wireless signals over the air interface 116.

[0036] The transceiver 120 may be configured to modulate the signals that are to be transmitted by the transmit/receive element 122 and to demodulate the signals that are received by the transmit/receive element 122. As noted above, the WTRU 102 may have multi-mode capabilities. Thus, the transceiver 120 may include multiple transceivers for enabling the WTRU 102 to communicate via multiple RATs, such as UTRA and IEEE 802.11, for example.

[0037] The processor 118 of the WTRU 102 may be coupled to, and may receive user input data from, the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128 (for example, a liquid crystal display (LCD) display unit or organic light-emitting diode (OLED) display unit). The processor 118 may also output user data to the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128. In addition, the processor 118 may access information from, and store data in, any type of suitable memory, such as the non-removable memory 130 and/or the removable memory 132. The non-removable memory 130 may include random-access memory (RAM), read-only memory (ROM), a hard disk, or any other type of memory storage device. The removable memory 132 may include a subscriber identity module (SIM) card, a memory stick, a secure digital (SD) memory card, and the like. In other embodiments, the processor 118 may access information from, and store data in, memory that is not physically located on the WTRU 102, such as on a server or a home computer (not shown).

[0038] The processor 118 may receive power from the power source 134, and may be configured to distribute and/or control the power to the other components in the WTRU 102. The power source 134 may be any suitable device for powering the WTRU 102. For example, the power source 134 may include one or more dry cell batteries (for example, nickel-cadmium (NiCd), nickel-zinc (NiZn), nickel metal hydride (NiMH), lithium-ion (Li-ion), etc.), solar cells, fuel cells, and the like.

[0039] The processor 118 may also be coupled to the GPS chipset 136, which may be configured to provide location information (for example, longitude and latitude) regarding the current location of the WTRU 102. In addition to, or in lieu of, the information from the GPS chipset 136, the WTRU 102 may receive location information over the air interface 116 from a base station (for example, base stations 114a, 114b) and/or determine its location based on the timing of the signals being received from two or more nearby base stations. It will be appreciated that the WTRU 102 may acquire location information by way of any suitable location-determination method while remaining consistent with an embodiment.

[0040] The processor 118 may further be coupled to other peripherals 138, which may include one or more software and/or hardware modules that provide additional features, functionality and/or wired or wireless connectivity. For example, the peripherals 138 may include an accelerometer, an e-compass, a satellite transceiver, a digital camera (for photographs or video), a universal serial bus (USB) port, a vibration device, a television transceiver, a hands free headset, a Bluetooth® module, a frequency modulated (FM) radio unit, a digital music player, a media player, a video game player module, an Internet browser, and the like.

[0041] FIG. 1C is a system diagram of the RAN 104 and the core network 106 according to an embodiment. As noted above, the RAN 104 may employ an E-UTRA radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 116. The RAN 104 may also be in communication with the core network 106.

[0042] The RAN 104 may include eNode-Bs 140a, 140b, 140c, though it will be appreciated that the RAN 104 may include any number of eNode-Bs while remaining consistent with an embodiment. The eNode-Bs 140a, 140b, 140c may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 116. In one embodiment, the eNode-Bs 140a, 140b, 140c may implement MIMO technology. Thus, the eNode-B 140a, for example, may use multiple antennas to transmit wireless signals to, and receive wireless signals from, the WTRU 102a.

[0043] Each of the eNode-Bs 140a, 140b, 140c may be associated with a particular cell (not shown) and may be configured to handle radio resource management decisions, handover decisions, scheduling of users in the uplink and/or downlink, and the like. As shown in FIG. 1C, the eNode-Bs 140a, 140b, 140c may communicate with one another over an X2 interface.

[0044] The core network 106 shown in FIG. 1C may include a mobility management entity gateway (MME) 142, a serving gateway 144, and a packet data network (PDN) gateway 146. While each of the foregoing elements are depicted as part of the core network 106, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

[0045] The MME 142 may be connected to each of the eNode-Bs 140a, 140b, 140c in the RAN 104 via an S1 interface and may serve as a control node. For example, the MME 142 may be responsible for authenticating users of the WTRUs 102a, 102b, 102c, bearer activation/deactivation, selecting a particular serving gateway during an initial attach of the WTRUs 102a, 102b, 102c, and the like. The MME 142 may also provide a control plane function for switching between the RAN 104 and other RANs (not shown) that employ other radio technologies, such as GSM or WCDMA.

[0046] The serving gateway 144 may be connected to each of the eNode Bs 140a, 140b, 140c in the RAN 104 via the S1 interface. The serving gateway 144 may generally route and forward user data packets to/from the WTRUs 102a, 102b, 102c. The serving gateway 144 may also perform other functions, such as anchoring user planes during inter-eNode B handovers, triggering paging when downlink data is available for the WTRUs 102a, 102b, 102c, managing and storing contexts of the WTRUs 102a, 102b, 102c, and the like.

[0047] The serving gateway 144 may also be connected to the PDN gateway 146, which may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, such as the Internet 110, to facilitate communications between the WTRUs 102a, 102b, 102c and IP-enabled devices.

[0048] The core network 106 may facilitate communications with other networks. For example, the core network 106 may provide the WTRUs 102a, 102b, 102c with access to circuit-switched networks, such as the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, 102c and traditional land-line communications devices. For example, the core network 106 may include, or may communicate with, an IP gateway (for example, an IP multimedia subsystem (IMS) server) that serves as an interface between the core network 106 and the PSTN 108. In addition, the core network 106 may provide the WTRUs 102a, 102b, 102c with access to the networks 112, which may include other wired or wireless networks that are owned and/or operated by other service providers.

[0049] Other network 112 may further be connected to an IEEE 802.11 based wireless local area network (WLAN) 160. The WLAN 160 may include an access router 165. The access router may contain gateway functionality. The access router 165 may be in communication with a plurality of access points (APs) 170a, 170b. The communication between access router 165 and APs 170a, 170b may be via wired Ethernet (IEEE 802.3 standards), or any type of wireless communication protocol. AP 170a is in wireless communication over an air interface with WTRU 102d.

[0050] As wireless communication systems such as LTE systems mature and their network deployment evolve, it may be beneficial for network operators to reduce the cost of the communication network, maintenance needs of the communication network or both. One technique to reduce the cost of the network may be to reduce the channel bandwidth and data rate used to communicate with devices. For example, a portion of the channel bandwidth rather than the entire channel bandwidth may be supported by the devices in the network and/or the network itself when communicating with such devices. Current wireless communication systems, for example, LTE, have recently considered a bandwidth reduction for some devices including machine type communication (MTC) devices to some level, for example, 1.4 megahertz (MHz). The considered level may enable more compatibility with legacy systems and reduce the time and/or cost of a new design, since, for

example LTE may already support operation with a system bandwidth of 1.4 MHz. Further bandwidth reduction, however, may be desirable for some devices, for example, smart watches and alarms, for example to reduce costs even further. Further reduction of the bandwidth, for example, on the order of 200 kilohertz (kHz), has been suggested. Additional system design may be needed to support operation with a reduced bandwidth which may be less compatible with legacy system operation.

[0051] A reduced bandwidth (BW) WTRU may be a WTRU which may support or may only support a certain limited BW, for example, RF BW or a certain limited number of resource blocks (RBs) in the downlink (DL) and/or uplink (UL), which may be independent of the BW of the eNode-B or cell with which the WTRU may communicate. For example, a reduced BW WTRU, which may also be referred to as a limited BW WTRU, may support or may only support a certain number of RBs, for example, 6 RBs or 1 RB, or a certain BW, for example, 1.4 MHz or 180 kHz, for transmission and/or reception. Such a WTRU may communicate with an eNode-B or cell for which the BW may be larger, for example, 20 MHz or 100 RBs.

[0052] An enhanced machine type communication (eMTC) WTRU may be a limited BW WTRU which may support a first number of RBs and/or a BW of a first bandwidth. A first number may be represented by N1 and a first bandwidth may be represented by B1. N1 may, for example, be 6 and B1 may, for example be 1.4 MHz. In an example, 6 RBs may correspond to a BW of 1.4 MHz. An eMTC WTRU may be used to represent a non-limiting example of a limited BW WTRU. Another WTRU which may be referred to as a narrowband LTE (NB-LTE) or narrowband internet of things (NB-IoT) WTRU may be a limited BW WTRU which may support a second number of RBs and/or a BW of a second bandwidth. A second number may be represented by N2 and a second bandwidth may be represented by B2. N2 may be less than N1. B2 may be less than B1. N2 may, for example, be 1 and B2 may, for example, be 180 kHz. In an example, 1 RB may correspond to a BW of 180 kHz. An NB-LTE WTRU and/or NB-IoT WTRU may be used to represent a non-limiting example of a limited BW WTRU. A narrowband (NB) WTRU may be used to

represent a non-limiting example of a WTRU or limited BW WTRU. WTRU, limited BW WTRU, BW limited WTRU, reduced BW WTRU, limited capability WTRU, low cost-MTC (LC-MTC) WTRU, low-complexity WTRU, MTC WTRU, eMTC WTRU, NB-IoT WTRU, eMTC, NB-IoT, and NB WTRU may be used interchangeably herein. An RB may be a physical RB (PRB). The terms RB and PRB may be used interchangeably herein.

[0053] A limited BW WTRU may use or require special procedures to operate in a portion of the full BW of the cell. Reduced bandwidth, limited bandwidth, and bandwidth limited may be used interchangeably herein. A WTRU which may support the full BW of a cell may be referred to as a full BW WTRU. BW may include a number of RBs and/or a location in a band such as the center of the band.

[0054] A WTRU may at least sometimes communicate, behave, or operate in a manner which may be consistent, or for example, at least partially consistent, with that of a full BW WTRU and may also at least sometimes, for example, some other times than when operating as a full BW WTRU, communicate, behave, or operate in a manner which may be consistent, or for example, at least partially consistent, with that of a reduced BW WTRU. For example, a WTRU which may support the full BW of a cell may communicate, behave, or operate in a manner which may be consistent, or for example, at least partially consistent with that of a reduced BW WTRU at certain times such as when it may be coverage limited or when it may operate in a coverage enhanced mode. A WTRU, such as this example WTRU, may be or may be considered a full BW WTRU at times and/or a reduced BW WTRU at times, for example at other times.

[0055] A WTRU may be or may be considered to be a reduced BW WTRU while it may, may need to, or may intend to behave or operate like, or for example, at least partially like, a reduced BW WTRU. A WTRU that may communicate, for example, with an eNode-B, behave, or operate in a manner which may be consistent, or for example, at least partially consistent with that of a reduced BW WTRU may be or may be considered to be a reduced BW WTRU, for example at least sometimes, such as when the WTRU may

communicate, behave, or operate in a manner which may be consistent, or for example, at least partially consistent, with that of a reduced BW WTRU.

[0056] It should be noted that the terms eNB, eNode-B and cell may be used interchangeably herein. Embodiments and examples described for reduced BW WTRUs may be applied to coverage limited WTRUs and vice versa.

[0057] Coverage limited and reduced BW WTRUs are examples of WTRUs which may use the example methods and procedures described herein. These coverage limited and reduced BW WTRUs are non-limiting examples of such example WTRUs. Application to a WTRU of any kind, with any capabilities, or reduced capabilities may still be consistent with the example methods and procedures described herein.

[0058] The term physical downlink control channel (PDCCH) may be replaced by enhanced PDCCH (EPDCCH), machine type communication (MTC) physical downlink control channel (M-PDCCH), or another DL control channel, and vice versa and still be consistent with the example methods and procedures described herein. The terms component carrier (CC) and serving cell may be used interchangeably herein. The terms WTRU, WTRU medium access control (MAC) entity, and MAC entity may be used interchangeably herein.

[0059] The terms a WTRU, a certain WTRU or certain WTRUs may be replaced by at least a WTRU, at least a certain WTRU or at least certain WTRUs and still be consistent with the example methods and procedures described herein. The phrase intended for may be replaced by at least intended for or intended for at least and still be consistent with the example methods and procedures described herein.

[0060] The example methods and procedures described herein may be described for a random access response (RAR), paging channel (PCH), or physical downlink shared channel (PDSCH) carrying or which may carry a RAR or PCH. These are used as non-limiting examples. RAR may be replaced by PCH or PCH PDSCH and vice versa and still be consistent with the example methods and procedures described herein. The channel or other

contents which may be carried by the PDSCH may be replaced with any channel or contents and still be consistent with the example methods and procedures described herein.

[0061] Example methods and procedures involving coverage enhancement (CE) are disclosed herein. A coverage enhanced WTRU may be a WTRU which may require coverage enhancement or a WTRU which may employ coverage enhancement techniques or may support a CE mode. The terms coverage limited WTRU and coverage enhanced WTRU may be used interchangeably herein. CE may refer to extending or improving coverage, for example for low data rate applications. CE may refer to extending or improving coverage, for example to enable communication with devices with reduced capabilities such as devices employing a single receiver or devices using a reduced bandwidth. CE may refer to extending or improving coverage, for example to enable communication with devices for which communication may be hampered such as indoor devices or devices in basements where penetration losses may impede communication. In at least some examples, CE may involve extending or improving coverage by reducing the data rate. In at least some examples, CE may involve extending or improving coverage by employing repetition techniques. In at least some examples, CE may be used for MTC applications. In at least some examples, CE may be used for NB or NB-IoT applications. The terms CE operation and coverage enhanced operation may be used interchangeably herein.

[0062] A repetitive transmission of a physical channel may be used for CE. The CE level may be determined based on the number of repetitions, for example, that may be needed or used to achieve the intended coverage improvement. The terms repetition number, number of repetitions, repetition level, and CE level may be used interchangeably herein.

[0063] A CE mode may be used with one or more CE levels, or for example, repetition levels. The CE levels or repetition levels supported within a CE mode may be changed dynamically.

[0064] An eMTC WTRU may be for example, a low-cost WTRU. An eMTC WTRU may be for example, a WTRU with limited or reduced

capabilities. Limited or reduced capabilities may include at least one of a limited or reduced BW capability, for example a BW using 6 RBs , low throughput performance, and a single RF chain at the receiver. An eMTC WTRU may be delay tolerant. An eMTC WTRU may be served in an LTE network which may or may not have a system BW larger than the eMTC supportable BW that may for example be a BW of 1.4 MHz.

[0065] An eMTC WTRU may support coverage enhanced operation. For example, two CE modes of operation may be supported such as CE mode-A and CE mode-B. Normal and small CE levels may be supported in CE mode-A, and medium and large CE levels may be supported in CE mode-B. Normal CE may be the same as normal operation or no CE, which may involve for example, no use of repetitions for CE.

[0066] An NB-IoT WTRU may be, for example, a low-cost WTRU. An NB-IoT WTRU may be, for example, a WTRU with limited or reduced capabilities that may, for example, be more limited or reduced more than the capabilities of an eMTC WTRU in at least one aspect. For example an NB-IoT WTRU may support or use a further reduced BW, for example, a BW of 1 RB, that may be smaller than the supportable BW for an eMTC WTRU.

[0067] An NB-IoT WTRU may, or may be intended to, support CE, for example, with up to 20 decibel (dB) CE, with a battery life that may be longer than the intended or expected battery life of an eMTC WTRU. An NB-IoT WTRU may be intended or expected to support a battery life such as 10 years. The population of NB-IoT WTRUs in a cell may be significantly larger than for other types of devices.

[0068] Example methods and procedures of paging are discussed herein. As used herein, paging may refer to network initiated connection setup. As used herein, paging may refer to a mechanism that a network may use to provide information such as system information modification information or warning system information, for example Earthquake and Tsunami Warning System (ETWS) information, to one or more WTRUs that may, for example, employ techniques for battery saving such as discontinuous reception (DRX). In some examples, paging may be used when a WTRU is in idle mode. In other

examples, paging may be used when a WTRU is in connected mode. A WTRU may, for example periodically, monitor a PDCCH for a DL control information (DCI) or DL assignment on a PDCCH masked with a Paging Radio Network Temporary Identifier (P-RNTI), for example in idle mode and/or in connected mode. When a WTRU detects or receives a DCI or DL assignment using a P-RNTI, the WTRU may demodulate the associated or indicated PDSCH RBs and/or may decode a Paging Channel (PCH) that may be carried on an associated or indicated PDSCH. A PDSCH which may carry PCH may be referred to as a PCH PDSCH. The terms paging, paging message, and PCH may be used interchangeably herein. As used herein, the terms downlink control channel, DL control channel for NB WTRU, M-PDCCH, PDCCH, NB PDCCH (NB-PDCCH), internet of things PDCCH (IoT-PDCCH), and NB IoT-PDCCH (NB-IoT-PDCCH) may be used interchangeably.

[0069] The paging frame (PF) and subframe within that PF, for example, the paging occasion (PO), that a WTRU may monitor for the paging channel, for example in idle mode, may be determined based on the WTRU identifier (ID), for example, WTRU_ID or UE_ID, and parameters which may be specified by the network. The parameters may include the Paging Cycle (PC) length, for example in frames, which may be the same as a discontinuous reception (DRX) cycle and another parameter, for example, nB, which together may enable the determination of the number of PF per PC and the number of PO per PF which may be in the cell. The WTRU ID, in an example, may be the WTRU international mobile subscriber identity (IMSI) mod 1024. The terms WTRU ID, WTRU-ID, and WTRU_ID may be used interchangeably herein.

[0070] From the network perspective, there may be multiple PFs per paging cycle and multiple POs within a PF, for example, more than one subframe per paging cycle may carry PDCCH masked with a P-RNTI. Additionally, from the WTRU perspective, a WTRU may monitor a PO per paging cycle, and such a PO may be determined based on the parameters specified herein, which may be provided to the WTRU via system information, dedicated signaling information, and the like. POs may include pages for one

or more specific WTRUs, or they may include system information change pages which may be directed to each of the WTRUs, multiple WTRUs, or all WTRUs. In idle mode, a WTRU may receive pages for reasons such as an incoming call or system information update changes.

[0071] In connected mode, a WTRU may receive pages related to system information change, for example, and the WTRU may not receive WTRU-specific pages such as those that may be used for an incoming call. As such, a WTRU in connected mode may not monitor a specific PO. Additionally, for frequency division duplex (FDD), the PO subframes may be limited to certain subframes such as subframes 0, 4, 5 and 9 and/or for time division duplex (TDD), the PO subframes may be limited to certain subframes such as subframes 0, 1, 5 and 6.

[0072] As used herein, DRX may refer to a WTRU monitoring for DL control signaling or a DL control channel at certain times, for example only at certain times, during a cycle. For example, a WTRU using DRX may monitor for a DL control channel during certain time periods, for example only during certain time periods. During other time periods, the WTRU may switch off at least part of its receiver circuitry and reduce power consumption. A time period may, for example, be a subframe. Example methods for operation using DRX are discussed herein.

[0073] In idle mode, for example, radio resource control (RRC) idle mode and/or evolved packet system (EPS) connection management (ECM) idle mode, a WTRU may monitor for or listen to a paging message to know about one or more of: an incoming call, a system information change, an Earthquake and Tsunami Warning System (ETWS) notification for ETWS capable WTRUs, a commercial mobile alert service (CMAS) notification and an extended access barring (EAB) parameters modification.

[0074] A WTRU may monitor PDCCH for P-RNTI discontinuously, for example to reduce battery consumption when there may be no pages for the WTRU. DRX may be or may include the process of monitoring PDCCH discontinuously. In idle mode, DRX may be or may include the process of

monitoring PDCCH discontinuously for P-RNTI, for example to monitor or listen for a paging message during RRC idle state.

[0075] The terms idle mode, idle state, RRC idle mode, RRC idle state, and RRC_IDLE mode or state may be used interchangeably herein. The terms RRC idle and ECM idle may be used interchangeably herein. DRX may also be enabled and/or used in connected mode. When in connected mode, if DRX is configured, the MAC entity may monitor the PDCCH discontinuously, for example using DRX operation. The terms connected mode, connected state, and RRC_CONNECTED mode or state may be used interchangeably herein.

[0076] Examples of operation in idle mode DRX are discussed herein. A WTRU may use one or more DRX parameters that may be broadcast, for example in a system information block (SIB) such as a SIB2, to determine the PF and/or PO to monitor for paging. The WTRU may, for example, alternatively, use one or more WTRU specific DRX cycle parameters that may be signaled to the WTRU, for example by the MME through non-access stratum (NAS) signaling.

[0077] Table 1 provides examples of DRX parameters including example ranges and an example source of the DRX parameter, for example, an eNode-B or an MME.

Table 1. Example DRX Cycle Parameters.

DRX parameter	Notation	Value Range	Configuring Network Node
WTRU Specific DRX cycle	TWTRU	32, 4, 128 and 256 radio frames where each radio frame may be 10 milliseconds (ms)	MME, for example, via NAS signaling
Cell specific DRX cycle	TCELL	32, 4, 128 and 256 radio frames	eNode-B, for example, via system information such as a SIB2
Number of POs per DRX cycle, for example, DRX cycle across all users in the cell	nB	4T, 2T, T, T/2, T/4, T/8, T/16, T/32 where T may be the DRX cycle of the WTRU, for example, TCELL or the smaller of TWTRU, if provided, and TCELL	eNode-B, for example, via system information such as a SIB2

[0078] The DRX cycle T of a WTRU may indicate the number of radio frames in the paging cycle. A larger value of T may result in less WTRU battery power consumption. A smaller value of T may increase WTRU battery power consumption. A DRX cycle may be cell specific or WTRU specific.

[0079] A DRX cycle provided by an eNode-B may be cell specific and may be provided to at least some, or for example all, WTRUs in a cell. The DRX cycle that may be provided by the eNode-B may be the default paging cycle. A DRX cycle provided by an MME may be WTRU specific. The WTRU may use the smaller of the default paging cycle and the WTRU specific DRX cycle as its DRX or paging cycle. An MME may provide a WTRU specific DRX cycle to a WTRU using NAS signaling, for example as 'WTRU specific DRX cycle'. An MME may provide a WTRU specific DRX cycle to an eNode-B in a PAGING S1 AP message, as 'Paging DRX', for example, for an MME initiated paging message that may be intended for the WTRU.

[0080] The WTRU and/or eNode-B may use the minimum of the default and WTRU specific DRX cycle. For example, T = Min (T_{WTRU}, T_{CELL}) in radio

frames. A WTRU with a DRX cycle of N (for example, 128) radio frames may wake up or may need to wake up every N x frame time (for example, every 1.28 seconds for a frame time of 10 ms) and look for a paging message.

[0081] The parameter nB may indicate the number of paging occasions or POs in a cell specific DRX cycle. The parameter may be cell specific. Configuration of the nB value may depend on the paging capacity that may be desired or used in a cell. A larger value of nB may be used, for example to increase paging capacity. A smaller value of nB may be used, for example for a smaller paging capacity.

[0082] The eNode-B and/or WTRU may calculate the WTRU's PFs according to the following relation: a PF is given by the following equation or occurs when SFN mod T = (T div N)*(WTRU_ID mod N), where N = min (T, nB) and div may represent division. The WTRU specific PO within the PF may be determined from a set of paging subframes. The set may be a function of predefined allowed subframes for paging and/or the number of POs per PF which may be a function of at least nB and/or T. The system frame number (SFN) may have a range of values such as 0 through 1023.

[0083] Examples of connected mode DRX are discussed herein. In connected mode, a PF and PO may be determined in a similar manner as in idle mode. The DRX cycle parameters may be different for idle and connected modes. A WTRU may monitor a PO, for example, any PO, in a PC in connected mode, for example to obtain system information change information.

[0084] Extended DRX (eDRX) is disclosed herein. It may be desirable to have extended or longer DRX cycles, for example for devices such as MTC devices. Extended or longer DRX cycles may be useful for some devices such as delay tolerant devices and may, for example, reduce battery consumption and/or increase battery life for those devices. A new time unit, for example, a hyper frame (HF), may be used, for example, with, as an extension of, or on top of radio frames and/or SFN timing, for example, legacy SFN timing.

[0085] FIG. 2 is an exemplary timing diagram which illustrates HFs and paging within HFs. One HF may include an SFN cycle, for example, 1024 radio frames or 10.24 s. A HF may have a Hyper-System Frame Number (H-

SFN). An H-SFN cycle may be 1024 SFN cycles. An H-SFN cycle may last 1024*1024*10 ms, for example, 174.76 minutes. In an example shown in timing diagram 200, HF 210 may have H-SFN 0 and may contain an SFN cycle of 1024 radio frames, from radio frame 0 through radio frame 1023. Likewise, HF 220 may have H-SFN 1023 and contain its own SFN cycle of 1024 radio frames. H-SFN cycle 230 may contain 1024 HFs, including HF 210 through HF 220.

[0086] An idle mode extended DRX (I-eDRX) cycle may include up to 256 H-SFN cycles and may, for example, last 256*1024*10 ms, for example, 43.69 minutes. The H-SFN may be broadcast by the cell. The H-SFN may increment at SFN cycle boundaries.

[0087] The H-SFN in which a WTRU may become reachable for paging may be referred to as a paging hyper frame (PH) or as the WTRU's PH. The PH may be applicable, or only applicable, in ECM-IDLE. The PH may be computed as a function of the extended DRX cycle and/or WTRU ID, for example, IMSI mod 1024. Within a PH, the determination of the PF and/or PO may follow the regular DRX rules and/or formulas. A WTRU's paging window (PW) may be the window or time span corresponding to the set of PFs in the WTRU's PH during which the WTRU may monitor for paging and/or may be paged. The PW may include a subset of the available PFs in the PH. In an example shown in timing diagram 200, PW 250 may include PF 260, PF 270 and PF 280. PF 260, PF 270 and PF 280 may be PFs within PH 290. eDRX cycle 295 may include PH 290. The PW may be signaled to the WTRU, for example by the MME in a NAS message. In a PF, a WTRU may monitor or only monitor one PO. Paging to a WTRU may be repeated in one or more of a WTRU's PFs in its PW, for example if the WTRU does not respond to a previous page.

[0088] A cell's support of idle mode extended DRX may be implicitly indicated by the broadcast of H-SFN. For long DRX cycles, it may be useful for the MME to have some awareness of when the WTRU may be become reachable, for example to avoid storing paging requests at the eNode-B for a long time. In connected mode, the DRX cycle may be extended up to the SFN

limit, for example, by extending the range of values for long DRX cycles to 10.24 seconds.

[0089] A large population of NB WTRUs may be multiplexed within a limited number of paging resources. If the distribution of WTRUs among paging resources is based on WTRU-ID, for example IMSI or IMSI modulo 1024, there may, for example still be a large number of WTRUs sharing the same paging resources in time and/or frequency, for example sharing the same PO and/or paging NB.

[0090] A NB WTRU may monitor M-PDCCH in a PO or each of its POs. If the M-PDCCH, or a DCI in the M-PDCCH, indicates the scheduling of an associated PDSCH for paging message, the NB WTRU may receive the associated PDSCH, for example, to check if there may be a paging message targeted to the NB WTRU.

[0091] Since a large number of NB WTRUs may share the same paging resources, a NB WTRU may receive the associated PDSCH when the paging message may not be targeted to the NB WTRU. The reception of an associated PDSCH that may not be intended for the WTRU may, for example, increase the WTRU's battery consumption unnecessarily. If the NB WTRU is in a CE level that may use a large number of repetitions, the impact to the WTRU may be worse, and may be, for example, significantly worse.

[0092] A NB WTRU may monitor M-PDCCH, for example in a PO or in each PO, in a NB WTRU specific or a NB WTRU group specific manner. The M-PDCCH may implicitly or explicitly indicate the necessity of receiving and/or decoding the M-PDCCH and/or an associated PDSCH, for example by a WTRU or group of WTRUs. For example, the M-PDCCH may implicitly or explicitly indicate the intended recipient or recipients of the M-PDCCH, an associated PDSCH, a page, a paging message or a PDSCH carrying a paging message or channel. Further, an implicit indication of paging reception, the need for paging reception, or the intended recipient or recipients of a M-PDCCH, a PDSCH, a page, a paging message or a PDSCH carrying a paging message or channel may be employed which uses one or more of: a scrambling indication; a scrambling sequence such as a scrambling sequence for M-

PDCCH randomization, a WTRU group-specific or WTRU-specific scrambling sequence, an information type specific scrambling sequence, or a scrambling sequence for paging reception; a starting enhanced control channel element (ECCE) index for M-PDCCH randomization, a bit interleaver for M-PDCCH randomization; and/or one or more Radio Network Temporary Identifiers (RNTIs).

[0093] In an example, a scrambling sequence may be used to randomize a bit sequence of an M-PDCCH. A WTRU that may use the same scrambling sequence to descramble the received bits may receive or may be able to receive the M-PDCCH. In an example, only a WTRU that may use the same scrambling sequence to descramble the received bits may receive or may be able to receive the M-PDCCH.

[0094] The bit sequence of an M-PDCCH may be a bit sequence before the modulation of M-PDCCH. For example, the bit sequence of an M-PDCCH may be a bit sequence after rate matching. A coded bit sequence may be an input bit sequence of the rate matching and an output bit sequence of the rate matching may be the bit sequence of an M-PDCCH. A DCI with cyclic redundancy check (CRC) scrambled by an RNTI may be an input bit sequence of the channel coding block and an output bit sequence may be a coded bit sequence.

[0095] The bit sequence of an M-PDCCH may be a bit sequence before the channel coding. For example, a DCI with CRC scrambled by an RNTI may be the bit sequence of an M-PDCCH.

[0096] For the RNTI, one or more of following examples may apply. The RNTI may be a P-RNTI, for example, if the DCI may be used for the paging. In another example, the RNTI may be a group-specific P-RNTI which may be associated with a scrambling sequence. In a further example, the RNTI may be the N least significant bits (LSBs) of a WTRU-ID that may be used for paging. N may be the number of CRC bits, which may be referred to as NCRC. For example, the 16 LSBs of a WTRU-ID, for example, IMSI or System Architecture Evolution (SAE)-Temporary Mobile Subscriber Identity (s-TMSI), may be used. The N bits used for the RNTI may be the same N bits that

correspond to WTRU-ID modulo (2^N), for example, IMSI modulo (2^N), where N may be 16.

[0097] In an example, a bit sequence of M-PDCCH $b(0),\ldots,b(M_{\text{bit}}-1)$ may be scrambled with a certain scrambling sequence, $c(i)$, where M_{bit} may be the number of bits in the bit sequence of an M-PDCCH. The result of a WTRU-specific or a WTRU group-specific scrambling sequence may be referred to as $\tilde{b}(0),\ldots,\tilde{b}(M_{\text{bit}}-1)$.

[0098] In an example, the $\tilde{b}(0),\ldots,\tilde{b}(M_{\text{bit}}-1)$ bit sequence may be determined based on $\tilde{b}(i)=(b(i)+c(i))\text{mod}2$, where mod2 may be modulo-2 operation. Further, the scrambling sequence $c(i)$ may be a Pseudo-random sequence that may be determined based on an initialization value, c_{init}, where i may be a bit index of the bit sequence.

[0099] The certain scrambling sequence may be determined based on at least one of whether the M-PDCCH or scrambling sequence may be WTRU-specific or WTRU group-specific, information type in the associated DCI and information type in the associated PDSCH. The initialization value (c_{init}) may be determined based on at least the WTRU-ID, at least the associated WTRU group number, at least the information type in the associated DCI, at least the information type in the associated PDSCH and/or an RNTI.

[0100] In an example, a WTRU which may monitor or attempt to decode a bit sequence of M-PDCCH may use its associated scrambling sequence. The associated scrambling sequence may be determined based on at least one of whether the M-PDCCH or scrambling sequence may be WTRU-specific or WTRU group-specific, and/or information type in the DCI. For example, the associated scrambling sequence may be determined based on the type of the information in the DCI for which the WTRU may be monitoring, such as WTRU-specific or WTRU group-specific paging. In an example, the WTRU may perform descrambling with an input bit sequence of the channel decoder. Also, the WTRU may perform descrambling with an output bit sequence of the channel decoder. In an example, if the bit sequence of M-PDCCH received at the WTRU receiver is $d(0),\ldots,d(M_{\text{bit}}-1)$, the $\tilde{d}(0),\ldots,\tilde{d}(M_{\text{bit}}-1)$ sequence may be

referred to as a descrambled bit sequence with the associated scrambling sequence $c(i)$. As an example, the WTRU may perform descrambling with $\tilde{d}(i) = (d(i) + c(i)) \bmod 2$.

[0101] A WTRU-specific scrambling sequence and/or a WTRU group-specific scrambling sequence may be provided and/or used. In an example, a WTRU-specific or WTRU group-specific scrambling sequence, for example a first scrambling sequence, may be used to scramble a bit sequence of an M-PDCCH, for example in a PO or each PO. In an example, a WTRU or a WTRU group that may use the same scrambling sequence, for example the first scrambling sequence, may decode or may be able to decode the M-PDCCH. For example only a WTRU or a WTRU group that may use the same scrambling sequence, for example the first scrambling sequence, may decode or may be able to decode the M-PDCCH.

[0102] In an example of using a WTRU group-specific scrambling sequence, N_g scrambling sequences may be used for N_g WTRU groups for a PO and a bit sequence of M-PDCCH intended or targeted for a WTRU group, for example a first WTRU group, within N_g WTRU groups may be scrambled with the corresponding scrambling sequence, for example a first scrambling sequence. In an example, the WTRU group using the corresponding scrambling sequence, for example the first scrambling sequence, may receive or may be able to receive the M-PDCCH. In a further example, only the WTRU group using the corresponding scrambling sequence, for example the first scrambling sequence, may receive or may be able to receive the M-PDCCH. The WTRU group-specific scrambling sequence may be determined based on at least one of following: a modulo operation that may, for example, be based on at least N_g and the WTRU-ID; a hashing function that may, for example, be based on N_g and the WTRU-ID; and the WTRU group number that may, for example, be determined based on at least a CE level.

[0103] A modulo operation may be used where the modulo operation may be based on at least N_g and the WTRU-ID (N_{WTRUID}). The WTRU group number (N_{group}) may be determined by WTRU-ID modulo N_g (for example

$N_{group} = (N_{WTRUID}) \bmod N_g$). A subframe number and/or a frame number (for example SFN) may be used. For example, $N_{group} = (N_{WTRUID} \cdot N_{Frame}) \bmod N_g$.

[0104] A hashing function may be used where the hashing function may be based on N_g and the WTRU-ID. In this case, for example, $N_{group} = (A \cdot N_{WTRUID}) \bmod N_g$, where the A may be a prime number (for example A = 39,827), or $N_{group} = ((A \cdot N_{WTRUID}) \bmod D) \bmod N_g$, where the D may be a prime number which may be different from A (for example D = 65,537). The hashing function may be based on a subframe number and/or a frame number.

[0105] The WTRU group number may be determined based on at least a CE level. For example, WTRUs with a first CE level (for example CE level-1) may be grouped as a first WTRU group and WTRUs with a second CE level (for example CE level-2) may be grouped as a second WTRU group.

[0106] The WTRU-ID may be at least one of an RNTI allocated for a WTRU, IMSI, and s-TMSI, and/or a part of at least one of the allocated RNTI, IMSI, and s-TMSI. For example, WTRU-ID may be IMSI modulo M or s-TMSI modulo N. M and/or N may be 1024. A and/or D may be a function of N_g. A and/or D may be fixed and/or configured, for example, by the eNode-B via signaling. A N_{WTRUID} may be the WTRU-ID or a portion of or function of the WTRUs IMSI or s-TMSI. For example N_{WTRUID} for a WTRU may be IMSI-10, or IMSI modulo X, where X may be a number less than or equal to 1024.

[0107] In an example of using a WTRU specific scrambling sequence, a WTRU specific scrambling sequence may be used for a bit sequence of M-PDCCH intended or targeted for a WTRU, where the WTRU specific scrambling sequence may be determined based on at least a WTRU-ID or a part of a WTRU-ID. In MME initiated paging, the WTRU-ID may be provided by the MME to the eNode-B in an S1 paging message or request.

[0108] In an example, the scrambling sequence may be determined based on the specific information type which may be carried in the DCI. For example, a first scrambling sequence may be used for a bit sequence of an M-PDCCH in which the DCI may carry a first information type and a second

scrambling sequence may be used for a bit sequence of an M-PDCCH in which the DCI may carry a second information type.

[0109] The first information type may include, but not be limited to, at least one or more system information update indications such as system information modification indication, an ETWS indication, a CMAS indication, and an EAB parameter modification indication. One or more system information indications may be a single bit to indicate the system information update or multiple bits to indicate the system information update of multiple SIs, for example, SIBs or SI-messages. An additional indicator may be included, for example, a flag bit to indicate a DCI format or a DCI type. The scrambling sequence for the first information type may be based on at least one of cell-specific parameters, such as for example, a physical cell-ID.

[0110] The second information type may be at least scheduling information of the associated PDSCH. The scrambling sequence for the second information type may be based on at least one of WTRU-specific parameters, such as for example, a WTRU-ID.

[0111] In another example, the scrambling sequence may be determined based on the information type carried in a DCI and/or WTRU-ID. For example, a first scrambling sequence may be used for a bit sequence of an M-PDCCH in which the DCI may carry a first information type, and a second scrambling sequence may be used for a bit sequence of an M-PDCCH in a which the DCI may carry a second information type. The first scrambling sequence may be predefined. The second scrambling sequence may be determined based on a WTRU-ID.

[0112] In an example, the PO for the first information type and the second information type may the same. Further, a WTRU may monitor M-PDCCH for both the first information type and the second information type. Also, a WTRU may monitor M-PDCCH for the first information type in a subset of POs or all POs. A WTRU may monitor M-PDCCH for the second information type in a subset of POs or all POs.

[0113] In another example, the PO for the first information type and the second information type may be different. The time and/or frequency location

of the PO for the first information type may be determined based on at least one cell-specific parameter. The cell-specific parameters may include, for example, a physical cell-ID, a system bandwidth, a subframe number, a frame number such as an SFN and the like. The time and/or frequency location of the PO for the second information type may be determined based on at least one WTRU-specific parameter, such as, for example, a WTRU-ID.

[0114] Examples which include the use of a scrambling sequence for paging reception are disclosed herein. A WTRU may determine a bit scrambling sequence, for example, an M-PDCCH bit scrambling sequence according to one or more examples described herein. In an example, the WTRU may monitor for an M-PDCCH in a PO. The WTRU may descramble the received signal or M-PDCCH using the bit scrambling sequence. The WTRU may determine if the descrambled M-PDCCH may carry a DCI masked with an RNTI that the WTRU may use for paging. The RNTI may be, for example, a P-RNTI. If the WTRU determines the DCI is masked with the RNTI, such as, for example, the P-RNTI, the WTRU may read the contents of the DCI to obtain one or more of system information update information and/or PDSCH scheduling information. The WTRU may use the scheduling information to receive an associated PDSCH that may carry one or more paging records or paging messages.

[0115] Examples using a starting ECCE index for M-PDCCH randomization are disclosed herein. In an example, an M-PDCCH search space may be used for monitoring for an M-PDCCH or a DCI, where the starting ECCE index, for example for monitoring, may be determined based on at least one WTRU-specific parameter. For example, a WTRU may use an M-PDCCH search space for monitoring for a an M-PDCCH or a DCI, where the starting ECCE index, for example for monitoring, may be determined based on at least one WTRU-specific parameter. As used herein, control channel element (CCE), ECCE and NB-IoT control channel element (NCCE) may be used interchangeably.

[0116] FIG. 3 is an exemplary diagram which illustrates WTRU group-specific starting ECCE indexes. Diagram 300 shows an example of ECCEs in a

subframe 310 at ECCE aggregation level 16. In other examples, other ECCE aggregation levels such as 1, 2, 4, 8 and 32 may be used. In an example shown in FIG. 3, a WTRU may use a different starting ECCE index depending upon the group the WTRU is in. For example, the WTRUs may be divided among four WTRU groups, numbered WTRU group #1 through WTRU group #4. WTRUs in WTRU group #1 may use a starting ECCE index 330 with a starting ECCE of 1, WTRUs in WTRU group #2 may use a starting ECCE index 350 with a starting ECCE of 5, WTRUs in WTRU group #3 may use a starting ECCE index 370 with a starting ECCE of 9, and WTRUs in WTRU group #4 may use a starting ECCE index 390 with a starting ECCE of 12.

[0117] FIG. 4 is a diagram of an example flow chart showing a WTRU receiving a machine type communication (MTC) physical downlink control channel (M-PDCCH) with a starting ECCE index based on the WTRU group of the WTRU. In an example shown in chart 400, a WTRU may monitor for an M-PDCCH in an M-PDCCH search space 410. The WTRU may monitor for the M-PDCCH using a starting ECCE index for the WTRU group containing the WTRU. The WTRU may then receive the M-PDCCH in the M-PDCCH search space, wherein the M-PDCCH may have a starting ECCE index for the WTRU group containing the WTRU 420. In an example corresponding to the WTRU groups shown in FIG. 3, the WTRU may be in WTRU group #2 and may therefore monitor for and/or receive an M-PDCCH with a starting ECCE index 350 of 5. Further, the WTRU may decode the M-PDCCH, wherein the M-PDCCH includes a DCI 430. The WTRU may receive a PDSCH associated with the M-PDCCH 440 or the DCI, for example a PDSCH scheduled by the M-PDCCH or the DCI. In an example, the WTRU may receive, decode, attempt to decode, demodulate, and/or attempt to demodulate the PDSCH based on the DCI, wherein the PDSCH may include a paging message. As a result, the WTRU may change its operation based on the paging message. For example, the WTRU may change from idle mode to connected mode based on the paging message. The WTRU may then begin to transmit and receive in connected mode. In another example, the WTRU may already be in connected

mode and may change its system operation based on system information change information in the page message.

[0118] In another example, an M-PDCCH search space may be used for a DCI monitoring, where the starting ECCE index and ordering (for example, an ascending order, a descending order, a random order and/or a predefined order) may be used to determine an M-PDCCH candidate. For example, if a number of ECCEs, $N_{ECCE,}$ is available in the search space and an ECCE aggregation level is the same as N_{ECCE} for an M-PDCCH candidate, one or more M-PDCCH candidates may be determined based on the starting ECCE index and/or ordering.

[0119] An M-PDCCH candidate may be defined or configured with N_{ECCE} ECCEs which may be aggregated in an ascending order, descending order, ascending order with a starting ECCE index, or descending order with a starting ECCE index. In an example, the starting ECCE index and/or ordering may be determined based on at least one WTRU-specific parameter. In a further example, the starting ECCE index and/or ordering may be determined based on at least information type carried in the DCI.

[0120] In another example, an M-PDCCH search space may be used for a DCI monitoring, where the ECCE aggregation may be based on a sequence. The sequence for the ECCE ordering may be determined based on at least one WTRU-specific parameter.

[0121] FIG. 5 is an exemplary diagram which illustrates WTRU group-specific random ECCE ordering. A sequence for the ECCE ordering may be determined based on at least one WTRU-specific parameter as shown in diagram 500. Similar to FIG. 3, FIG. 5 shows an example of ECCEs in a subframe 510, at ECCE aggregation level 16. In an example, a sequence may determine the ECCE ordering for ECCE aggregation. In a further example, the sequence for ECCE ordering may be determined based on at least one of: a WTRU-specific parameter, an information type carried in the DCI, an RNTI that may be used for CRC scrambling, a DCI format used and a CE level or repetition number such as, for example a repetition number of an M-PDCCH candidate.

[0122] In yet a further example, a set of random sequences may be predefined or configured, for example for a group of WTRUs. A sequence may correspond to a starting ECCE index. A sequence may correspond to ECCE aggregation ordering.

[0123] In an example shown in FIG. 5, a WTRU may use a different starting ECCE index depending upon a random sequence that may be defined, configured and/or used by or for the group the WTRU is in. For example, the WTRUs may be divided among four WTRU groups, numbered WTRU group #1 through WTRU group #4. WTRUs in WTRU group #1 may use a first random sequence 530 that may correspond to a starting ECCE index of 4, WTRUs in WTRU group #2 may use a second random sequence 550 that may correspond to a starting ECCE index of 5, WTRUs in WTRU group #3 may use a third random sequence 570 that may correspond to a starting ECCE index of 9, and WTRUs in WTRU group #4 may use a fourth random sequence 590 that may correspond to a starting ECCE index of 12. A random sequence, for example, within the set, may be determined based on at least one of: a WTRU-specific parameter, an information type carried in the DCI, an RNTI that may be used for CRC scrambling, a DCI format used, or a CE level or repetition number, such as, for example, a repetition number of an M-PDCCH candidate.

[0124] Examples using a bit interleaver for M-PDCCH randomization are disclosed herein. In an example, a bit sequence for an M-PDCCH may be interleaved with an interleaving sequence. The interleaving sequence may be a sequence with the length of the bit sequence. The bit positions may be interleaved based on the interleaving sequence. In an example, the interleaving sequence may be determined based on one or more of at least one WTRU-specific parameter, an information type carried in the DCI, an RNTI that may be used for CRC scrambling, a DCI format used, and a CE level or repetition number such as, for example a repetition number of an M-PDCCH candidate. In a further example, a WTRU may use the interleaving sequence to de-interleave the received bit sequence before it may attempt to decode the received bit sequence.

[0125] In an example, one or more RNTIs may be used for a DCI, for example to indicate to a WTRU whether to decode an associated PDSCH. For example, a cell-specific P-RNTI and one or more WTRU group specific P-RNTIs may be used. A WTRU may attempt to decode the M-PDCCH with the cell-specific P-RNTI and/or an associated WTRU group specific P-RNTI in a PO. In an example, a first P-RNTI may be used for a DCI carrying a first information type. In a further example, a second P-RNTI may be used for a DCI carrying a second information type. Also, in a PO, a WTRU may attempt to decode a DCI with the first P-RNTI and/or the second P-RNTI.

[0126] A first P-RNTI may be used for a DCI carrying a first information type. The first P-RNTI may be a cell-specific P-RNTI. The first information type may include but not be limited to at least one or more system information update indications such as a system information modification indication, an ETWS indication, a CMAS indication, and an EAB parameter modification indication. One or more system information indications may be a single bit to indicate the system information update or multiple bits to indicate the system information update of multiple SIs, such as, for example, SIBs or SI-messages. An additional indicator may be included, such as, for example a flag bit to indicate a DCI format or a DCI type. The first P-RNTI may be based on at least one cell-specific parameter, such as, for example a physical cell-ID.

[0127] A second P-RNTI may be used for a DCI carrying a second information type. A set of P-RNTIs may be predefined or configured for the second P-RNTI and one of the predefined or configured P-RNTIs may be determined in a WTRU-specific or a WTRU group specific manner. A modulo operation with a WTRU-ID and/or the number of P-RNTIs configured may be used to determine the associated P-RNTI. A hashing function may be used with a WTRU-ID and/or the number of P-RNTIs configured to determine the associated P-RNTI.

[0128] In a PO, a WTRU may attempt to decode a DCI with the first P-RNTI. The WTRU may also attempt to decode a DCI with the second P-RNTI which may be associated with the WTRU. If a WTRU may successfully decode a DCI with the first P-RNTI, then the WTRU may not monitor a DCI with the

second P-RNTI. If a WTRU may not successfully decode a DCI with the second P-RNTI, then the WTRU may assume that the associated PDSCH may not be scheduled.

[0129] An explicit indication of paging reception is disclosed herein including the use of: a paging occasion type; a monitoring indicator for a paging occasion, a paging type, a paging message, a paging window, among others; multiple monitoring indicators; and multiple monitoring indicators with explicit and implicit indications. In examples, one or more paging occasion types may be used, configured, or defined, for example for a RRC idle WTRU and/or a RRC connected WTRU.

[0130] A first paging occasion type may be used for a paging message transmission in which a WTRU may monitor for a paging message. The paging message may include one or more paging records and/or one or more system information update indications. In an example, the paging message may be carried in a DCI. In a further example, the paging message may be carried in a PDSCH and the scheduling information of the PDSCH may be provided in an associated DCI. Also, the paging message may be carried in a PDSCH without an associated DCI for the scheduling information. Further, the contents of the paging message may be indicated from the associated DCI. For example, a DCI may indicate the information type included in the paging message.

[0131] In an example, a second paging occasion type may be used for one or more system information update indications. In a further example, one or more paging occasion types may be located in a same time/frequency resource and monitored separately.

[0132] The time/frequency locations for one or more paging occasion types may be determined independently. A time/frequency location of a first paging occasion type may be determined based on at least one WTRU-specific parameter, such as, for example, a WTRU-ID. A time/frequency location of a second paging occasion type may be determined based on at least one cell-specific parameter, such as, for example, a physical cell-ID, (e)DRX cycle, system bandwidth and the like.

[0133] In an example, a DCI format or DCI contents may be different according to the paging occasion type. Further, an associated RNTI may be different according to the paging occasion type.

[0134] In an example, an indication for monitoring, for example, a monitoring indicator, of one or more of PO types may be transmitted in a broadcast channel, such as, for example, in a MIB, in a DCI in common search space and the like. For example, a broadcast channel may be transmitted in every x ms and one or more POs may be associated with a broadcast transmission. The broadcast transmission may indicate if a WTRU may need to monitor one or more POs associated with the broadcast transmission. A WTRU may attempt to decode or read a broadcast channel which may carry the monitoring indicator before it may monitor one or more POs. In an example, a monitoring indicator may be associated with one or more PO types. For example, the monitoring indicator may be associated with a first PO type. In a further example, the monitoring indicator may be associated only with a first PO type. In another example, the monitoring indicator may be associated with a second PO type. In a still further example, the monitoring indicator may be associated only with a second PO type. In an example, the monitoring indicator may be set to TRUE or FALSE. Based on the monitoring indicator, a WTRU may monitor a WTRU-group specific PO which may be determined based on at least one of a WTRU-specific parameter, such as, for example a WTRU-ID, or a cell-specific PO that may be determined based on at least one cell-specific parameter, such as, for example, a physical cell-ID.

[0135] A monitoring indicator may be associated with one or more POs. For example, a monitoring indicator may be associated with POs within a certain time window. If a WTRU receives the monitoring indicator, the WTRU may attempt to receive or monitor POs within the certain time window.

[0136] A monitoring indicator may indicate a WTRU group index and a WTRU group associated with the monitoring indicator may monitor the POs. In an example, the monitoring indicator may indicate which WTRU group may need to monitor POs. The WTRU group may include all WTRU groups for a system information update. In another example, the monitoring indicator

may have a number of states, such as four states and may indicate at least one of the states. The states may, for example include cell common paging, a first WTRU group, a second WTRU group, and a third WTRU group. In an example, the cell common page may be or occur in a cell-specific PO. A WTRU may monitor a PO or monitor for a page according to a monitoring indicator state.

[0137] A monitoring indicator may indicate a PO type and a WTRU may monitor POs corresponding to the PO type. In an example, a WTRU may receive a monitoring indicator which indicates a first PO type, and then the WTRU may monitor POs corresponding to the first PO type. Further, a WTRU may receive a monitoring indicator which indicates a first PO type, and then the WTRU may monitor POs corresponding to the first PO type only.

[0138] In another example, a monitoring indicator may be used with a WTRU group specific M-PDCCH scrambling sequence, a WTRU group specific RNTI, a WTRU group specific starting ECCE index, and/or a WTRU group specific interleaver. A monitoring indicator may be used to indicate if a WTRU may need to monitor POs associated with it and an implicit indication of paging reception schemes may be used in each PO. A WTRU may, for example, attempt to decode, receive, or monitor the monitoring indicator and, if the monitoring indicator indicates that the WTRU may need to monitor the POs, the WTRU may attempt to decode or monitor the POs, for an M-PDCCH, for example, with its associated scrambling sequence, starting ECCE index, RNTI, and/or interleaving sequence. Further, a WTRU may first attempt to decode, receive, or monitor the monitoring indicator and, if the monitoring indicator indicates that the WTRU may need to monitor the POs, the WTRU may attempt to decode or monitor the POs, for an M-PDCCH, for example, with its associated scrambling sequence, starting ECCE index, RNTI, and/or interleaving sequence.

[0139] In an example, one or more monitoring indicators may be used and a WTRU may determine if the WTRU may need to monitor, receive, or attempt to decode an M-PDCCH and/or a PDSCH carrying paging related information. A monitoring indicator may be used to determine if a WTRU

needs to monitor or attempt to decode a M-PDCCH in a PO, which may be referred to as a PO (paging occasion) monitoring indicator. A monitoring indicator may be used to determine if a WTRU needs to receive an associated PDSCH which may carry a paging message (PM), which may be referred to as a PM monitoring indicator. A monitoring indicator may be used to determine if a WTRU needs to monitor POs within a paging window (PW), which may be referred to as a PW monitoring indicator. A PW may include one or more POs for a WTRU. A PW may be defined or determined based on a number of POs. For example, a PW may be defined to include N_{PO} POs where N_{PO} may be a positive integer number.

[0140] A monitoring indicator may be used to determine if a WTRU needs to receive, attempt to decode, or monitor a subsequent monitoring indicator. A WTRU may receive a monitoring indicator before it may decode, monitor, attempt to decode, receive, or attempt to receive a signal, for example an M-PDCCH or a PDSCH, in a PO. Two monitoring indicators may be used and a first monitoring indicator may be a PO monitoring indicator and a second monitoring indicator may be a PM monitoring indicator. The first monitoring indicator may be transmitted in a broadcast channel. The second monitoring indicator may be transmitted in a DCI, for example in an M-PDCCH.

[0141] A PM monitoring indicator may be comprised of one or more bits to indicate at least one of the following: a presence of an associated PDSCH which may carry a paging message; a WTRU group index, or WTRU group ID, which may be associated with a paging message; and a type of information carried in a paging message.

[0142] In another example, one or more monitoring indicators may be used and each monitoring indicator may be used to indicate a WTRU group, a WTRU group index or a WTRU group ID. A WTRU which may be associated with a WTRU group, a WTRU group index or a WTRU group ID may need to monitor or receive a paging message, for example when a monitoring indicator for the WTRU group, the WTRU group index or the WTRU group ID indicates to monitor or read a paging message. A hierarchical WTRU group index may

be used, where a first WTRU group index may include a set of WTRUs or WTRU-IDs and a second WTRU group index may include a subset of WTRUs or WTRU-IDs within the set of WTRUs or WTRU-IDs indicated from the first WTRU group index. The first WTRU group index may be determined based on a WTRU-ID, for example, IMSI, and the second WTRU group index may be determined based on a different WTRU-ID, for example, s-TMSI. The first WTRU group index may be determined based on a modulo operation based on WTRU-ID and the number of WTRU groups for the first WTRU group index, and the second WTRU group index may be determined based on a hashing function with a WTRU-ID and the number of WTRU groups for the second WTRU group index.

[0143] A combination of a first monitoring indicator and a second monitoring indicator may be used to determine a WTRU group index. If N1 WTRU groups for a first monitoring indicator and N2 WTRU groups for a second monitoring indicator are used, the combined WTRU group may be indicated as N1 x N2 WTRU groups.

[0144] Examples of using multiple monitoring indicators for paging with explicit and implicit indications are discussed herein. In an example, one or more monitoring indicators may be used and a first monitoring indicator may be based on one or more explicit bits while a second monitoring indicator may be based on an RNTI. For example, a WTRU may receive or receive an indication from a PO monitoring indicator in a first channel and the WTRU may receive or receive an indication from a PM monitoring indicator in a second channel.

[0145] In an example, the first channel may be a broadcast channel and the second channel may be a physical downlink control channel, for example, an M-PDCCH. In another example, the first channel may be an M-PDCCH monitored in a cell-specific time/frequency resource, such as, for example, a common search space, and the second channel may be an M-PDCCH monitored in a WTRU-specific or WTRU-group specific time/frequency resource, such as, for example, a WTRU-specific or WTRU group-specific search space. In a further example, the PO monitoring indicator may be one or

more bits transmitted in a broadcast channel. Also, the PM monitoring indicator may be a set of RNTIs reserved for the PM monitoring indication.

[0146] Example methods for a WTRU to perform a paging NB determination are discussed herein. A WTRU may determine the NB to use for paging in its PO, for example based on at least one of its WTRU ID, the number of paging NBs, , and the DL system bandwidth. The WTRU ID may be an IMSI or an s-TMSI. An option is to use IMSI modulo 1024 to determine the NB, for example, since IMSI modulo 1024 may be used to determine the WTRU's PO. The number of paging NBs may be broadcast, may be received via broadcast signaling, and/or may be received via system information. A paging NB may be a NB that may be used for paging. In an example, a NB may be or may represent a set of RBs or subcarriers within a system BW.

[0147] The parameters used for paging may include DRX cycle, nB and the like. Depending on the parameters that may be used for paging and the number of NBs, the use of IMSI modulo 1024 to determine the NB, however, may result in some or all WTRUs in a given PO determining the same NB. This may defeat the purpose of having multiple NBs for paging.

[0148] Several example solutions are discussed herein for a WTRU to better determine a NB for paging. In an example solution, IMSI-10 may be used to represent IMSI modulo 1024 or the least significant 10 bits of an IMSI. For MME initiated paging of a WTRU, the MME may include the IMSI-10 and/or the s-TMSI for the WTRU in the S1 paging message to the eNode-B to request the page. When paging a WTRU, an eNode-B may know the IMSI-10 and/or the s-TMSI of the WTRU. The WTRU and/or eNode-B may use one or both of these values to determine the WTRU's NB for paging. For example, the WTRU and/or eNode-B may use one or both of these values to determine the WTRU's NB for paging in the WTRU's PO.

[0149] A function, such as a hashing function, that may be based on at least the WTRU ID may be used by a WTRU and/or eNode-B to determine the NB for paging. For example, the function may be based on at least IMSI-10 or IMSI modulo X. In an example, the hashing function may be based on at least IMSI-10 or IMSI modulo X.

[0150] For example, a function such as a hashing function may be used based on N_b and/or the WTRU ID. In an example, N_b may be the number of NBs. In a further example, N_b may be the number of NBs to use for paging or that may be used for paging. For example, the NB for a WTRU, NB_{WTRU}, may be determined, for example, by the WTRU and/or eNode-B according to:

$$NB_{WTRU} = (A \cdot N_{WTRUID}) \bmod N_b \quad \text{Equation (1)}$$

where the A may be a prime number, for example, A = 39827. In a further example, NB_{WTRU}, may be determined according to:

$$NB_{WTRU} = ((A \cdot N_{WTRUID}) \bmod D) \bmod N_b \quad \text{Equation (2)}$$

where D may be a prime number which may be different from A, for example, D = 65537.

[0151] A and/or D may be a function of N_b. A and/or D may be fixed and/or configured, for example, by the eNode-B via signaling. N_{WTRUID} may be the WTRU ID or a portion of or function of the WTRU's IMSI or s-TMSI. For example N_{WTRUID} for a WTRU may be IMSI-10, IMSI modulo X, where X may be a number less than or equal to 1024 or IMSI modulo Y, where Y may be a number less than or equal to 16,384. The number of NBs for paging may be provided by the eNode-B and/or received by the WTRU in signaling such as higher layer signaling which may be broadcast, for example, in system information.

[0152] Additional IMSI bits or an additional portion or function of the IMSI may be used by a WTRU and/or eNode-B to determine the NB for paging. The MME may include the additional bits in the S1 paging message to the eNode-B. The eNode-B may receive the additional bits and may use them to determine the NB in which to page the WTRU.

[0153] For example, the most significant B bits of IMSI modulo Z may be used to determine the NB for paging, where Z may be at least one of (2^B) x 1024, (2^C) x 1024 and a number less than or equal to 16,384. In an example, C may be a number or integer that may be different than B. Further, the B MSBs, for example the value of the B MSBs, MB, may be used to determine the NB, for example according to MB modulo N_b.

[0154] In an example, if there are up to 16 narrowbands for paging, B may be 4. The 4 MSBs of IMSI modulo 16,384 may be used to determine the NB for paging, where IMSI modulo 16,384 may be derived from IMSI modulo Z and Z = (2^B) x 1024. Since B may be 4, then (2^4) x 1024 = 16 x 1024 = 16,384. Further, since B may be 4, the 4 MSBs, M4, may be used to determine the NB, for example according to M4 modulo N_b. M4 may be used to represent the 4 MSBs or the value of the 4 MSBs.

[0155] In another example, B may be 3 and C may be 4. The 3 MSBs of IMSI modulo 16,384 may be used to determine the NB for paging, where IMSI modulo 16,384 may be derived from IMSI modulo Z and Z = (2^C) x 1024. Since C may 4, then (2^4) x 1024 = 16 x 1024 = 16,384. Further, since B may be 3, the 3 MSBs, M3, may be used to determine the NB, for example according to M3 modulo N_b. M3 may be used to represent the 3 MSBs or the value of the 3 MSBs.

[0156] In other examples, different numbers of narrowbands for paging may be used and still be consistent with the examples discussed herein. Further, in other examples, different values for B, for C or for both may be used.

[0157] The 14 bits, IMSI-14, that may correspond to IMSI modulo 16,384 may be used to determine the NB, for example according to IMSI-14 modulo N_b. Further, the 14 bits, IMSI-14, that may correspond to IMSI modulo 16,384 may be used to determine the NB, for example according to IMSI-14 modulo N_b modified by one or more other parameters.

[0158] FIG. 6 is a diagram of an example flow chart showing a WTRU using a WTRU-ID to determine a paging NB to use for monitoring an M-PDCCH. As shown in flow chart 600, a WTRU may determine a paging NB for the WTRU, to use for monitoring an M-PDCCH, based on at least the MSBs of a function of a WTRU-ID 610. The WTRU may monitor for the M-PDCCH on the determined paging NB for the WTRU 620. For example, the WTRU may monitor for the M-PDCCH on the determined paging NB in or during a PO that may be a PO of the WTRU. The WTRU may monitor for an M-PDCCH masked with a P-RNTI or for an M-PDCCH or DCI with a CRC scrambled

with a P-RNTI. The WTRU may then receive a DCI on the monitored M-PDCCH on the determined paging NB during a PO 630 that may be a PO of the WTRU. The DCI may include a CRC that may be scrambled with a P-RNTI. The WTRU may receive a physical downlink shared channel (PDSCH) associated with the M-PDCCH 650 or the DCI, for example a PDSCH scheduled by the M-PDCCH or the DCI. The WTRU may receive system information update related information and/or a paging message in or from the DCI or the PDSCH.

[0159] In a further example, the most significant N bits of IMSI-10 may be used to determine the NB for paging. N may be a function of the number of NBs configured or available, for example, in a PO, for paging.

[0160] In the embodiments and examples described herein, the term mobile subscriber identification number (MSIN) may be substituted for IMSI and vice versa and still be consistent with embodiments and examples disclosed herein. Further, various example numbers of digits may be used for MSIN and IMSI, including but not limited to 8, 10, 14, 16, 32, 64 and the like.

[0161] Examples of a WTRU determining a paging HF are discussed herein. Within a PH, WTRUs with the same IMSI modulo 1024 may determine the same PF and the same PO. Depending on the paging parameters, WTRUs may not be distributed well among the PFs and the PO.

[0162] IMSI may be comprised of decimal digits (0 through 9) and may include one or more of mobile country code (MCC), mobile network code (MNC) and MSIN. An IMSI may use binary-coded decimal (BCD) representation. IMSI may comprise 64 bits where each digit may by coded over 4 separate bits. The digits 0 to 9 may be encoded 0000 to 1001 and there may be two digits per octet. For the function IMSI modulo X, IMSI may be the decimal representation of the IMSI, the BCD representation of the IMSI, the hexadecimal representation of the IMSI, or another representation of the IMSI.

[0163] One or more of the examples described herein for the determination of a paging NB, for example, for and/or by a WTRU, may be applied to the determination of one or more of PH, PF, and PO, for example,

for and/or by a WTRU. A separate, for example, different function, aspect, or portion of the WTRU-ID, for example, IMSI or s-TMSI, may be used for each of PH and PF determination for and/or by a WTRU.

[0164] A $WTRU_ID_{PH}$ may represent the function, aspect, or portion of the WTRU-ID that may be used in the PH calculation. $WTRU_ID_{PF}$ may represent the function, aspect, or portion of the WTRU-ID that may be used in the PF calculation. $WTRU_ID_{PH}$-10 may represent $WTRU_ID_{PH}$ modulo 1024. $WTRU_ID_{PF}$-10 may represent $WTRU_ID_{PF}$ modulo 1024. For MME initiated paging of a WTRU, the MME may include $WTRU_ID_{PH}$-10 and/or $WTRU_ID_{PF}$-10 in the S1 paging message to the eNode-B to request the page.

[0165] A $WTRU_ID_{PH}$-10 and/or the $WTRU_ID_{PF}$-10 may be given to the eNode-B by the MME. A $WTRU_ID_{PH}$-10 and/or the $WTRU_ID_{PF}$-10 may be given to the eNode-B by the MME as a bit string of size 10. The bits may follow the normal binary representation or the BCD representation.

[0166] When paging a WTRU, an eNode-B may know $WTRU_ID_{PH}$-10 and/or $WTRU_ID_{PF}$-10. The WTRU and/or eNode-B may use one or both of these values to determine the WTRU's PH and/or PF. The WTRU and/or eNode-B may use $WTRU_ID_{PH}$-10 to determine the WTRU's PH or PHs for paging. The WTRU and/or eNode-B may use $WTRU_ID_{PF}$-10 to determine the WTRU's PF or PFs for paging.

[0167] In an example, $WTRU_ID_{PH}$ may be the WTRU's MSIN. MSIN may be the least N1, for example, 9, significant decimal digits of the IMSI in decimal representation, for example, if the concatenation of MCC and MNC is 6 digits. MSIN may be the least N2, for example, 10, significant decimal digits of the IMSI, for example, if the IMSI is 15 digits. $WTRU_ID_{PF}$ may be the WTRU's IMSI. $WTRU_ID_{PH}$-10 may be MSIN modulo 1024 and/or the $WTRU_ID_{PF}$-10 may be IMSI modulo 1024.

[0168] In another example, $WTRU_ID_{PH}$ may be the IMSI and $WTRU_ID_{PF}$ may be the MSIN. In another example, if the concatenation of the MCC and MNC part of the IMSI is an even number, the IMSI may be transformed such that the concatenation of the MCC and the MNC part of the

IMSI is an odd number. For example, one may be added or subtracted from the concatenation of the MCC and MNC part of the IMSI.

[0169] In another example, MSIN-10Q may be used to represent FLOOR [MSIN/1024] or (FLOOR [MSIN/1024]) modulo 1024. $WTRU_ID_{PH}$-10 may be MSIN-10Q.

[0170] Modified paging reception examples are disclosed herein. In an example, a WTRU may determine its PH, PF, and PO according to a set of rules, such as, for example, regular rules. The WTRU may receive and/or use additional configuration or information to determine when to monitor or skip monitoring for paging, for example, when to monitor or skip monitoring for a M-PDCCH masked with a paging RNTI, and/or receive or skip receiving an associated PDSCH or PCH.

[0171] At least some of the configuration and/or information may be provided by or received from an MME via NAS signaling or via an eNode-B via RRC signaling. The WTRU may maintain the configuration and/or information while in idle mode. A WTRU may monitor for paging in the PFs of its PW in one PH per I-eDRX cycle. In an example, a WTRU may be configured to skip its PH in one or more I-eDRX cycles and/or to skip one or more PFs in its PW.

[0172] In an example, whether the WTRU ID is an odd or even number may be used to determine whether a WTRU may read or receive, or may skip reading or receiving, a page in a PF and/or a PH. Reading and/or receiving a page may correspond to monitoring for M-PDCCH with a paging RNTI. Reading and/or receiving a page may correspond to receiving, decoding, and/or reading a PDSCH which may be associated with, indicated by, or allocated by an M-PDCCH with a paging RNTI. Reading and/or receiving a page may correspond to receiving, decoding, and/or reading a PDSCH that may carry a paging message. Skipping reading or receiving a page may be the same as not reading or receiving or not attempting to read or receive a page. Skipping reading or receiving a page may be the same as skipping one or more of a PO, PF or a PH.

[0173] A WTRU may read or monitor for a page, for example, in a PO, if WTRU ID is an odd number and skip reading or monitoring for a page, for example, in a PO, if WTRU ID is an even number, for example if reading and/or monitoring by a WTRU with an odd number WTRU ID is indicated. A WTRU may read or monitor for a page, for example, in a PO if the WTRU ID is an even number and skip reading or monitoring for a page, for example, in a PO if WTRU ID is an odd number, for example if reading and/or monitoring by a WTRU with an even number WTRU ID is indicated.

[0174] $WTRU_ID_{PH}$-10 and/or $WTRU_ID_{PF}$-10 may be substituted for WTRU ID and still be consistent with this disclosure. WTRU ID may be IMSI modulo 1024, MSIN modulo 1024, and/or FLOOR [MSIN/1024], among others.

[0175] Whether odd numbered WTRUs or even numbered WTRUs may receive a page in a PF or PO may be determined based on one or more of: a WTRU ID odd/even indicator; a PH odd/even indicator; and/or a PF odd/even indicator.

[0176] One bit may be used for an indicator. One state of the bit may be used to indicate even and the other state may be used to indicate odd. 0 may be used for even and 1 for odd or vice versa. One or more of the indicators may be signaled, for example, by the eNode-B, for example in the MIB, in a SIB, or in the M-PDCCH for paging.

[0177] A WTRU may read one or more of the indicators prior to at least one of its PHs and/or PFs and/or POs. The WTRU may read one or more of the indicators in an M-PDCCH for paging in one of its POs. The WTRU may determine the state of one or more of the indicators and based on the state or states the WTRU may determine whether to monitor for a page and/or receive a PDSCH that may carry a page. An indicator in the MIB may be used by a WTRU to determine whether to monitor for a paging M-PDCCH in one or more POs. An indicator in the M-PDCCH for paging may be used by a WTRU to determine whether to reads a PDSCH associated with the M-PDCCH that may carry a paging message.

[0178] For example, for WTRU ID odd/even = even and PH odd/even = odd, a WTRU with an even WTRU ID may read or monitor for a page in, for

example, only in, an odd numbered PH. The WTRU may skip reading or monitoring for a page in an even numbered PH. A WTRU with an odd WTRU ID may skip reading or monitoring for a page when WTRU odd/even is set to even, for example, in one or more, for example, both odd and even PHs.

[0179] In an example, (0,0) may mean the WTRU ID is even and PH is even, (1,0) may mean the WTRU ID is odd and PH is even, (0,1) may mean the WTRU ID is even and PH is odd, and (1,1) may mean the WTRU ID and PH are odd. The eNode-B may use one of these codes as a paging reading indicator, for example, at any time.

[0180] In another example, a single bit for odd/even WTRU ID may be used. A WTRU with an even WTRU ID may read or monitor for a page when WTRU odd/even is set to even and may skip reading or monitoring for a page when WTRU odd/even is set to odd. A WTRU with an odd WTRU ID may read or monitor for a page when WTRU odd/even is set to odd and may skip reading or monitoring for a page when WTRU odd/even is set to even.

[0181] The eNode-B may signal some or all of the bits of the current value of the paging reading indicator in the MIB, or in the SIB or in M-PDCCH (or PDCCH). The WTRU may make the determination to skip a PH based on the value of the paging indicator signaled by the eNode-B. The WTRU may make the determination to skip a PF based on the value of the paging reading indicator.

[0182] The eNode-B may use a paging reading indicator to indicate to one or more WTRUs to skip or read a page in a PH and/or PF. The eNode-B may use separate paging reading indicators to indicate to skip or read a page in a PF and to skip or read pages in all the PFs in a PH.

[0183] Odd/even indication may be replaced by a group ID that may represent another way to distinguish groups. More bits may be used as is appropriate. For example, there may be 4 groups and the least significant 2 bits of the WTRU ID may be used for the determination of which WTRUs may read or monitor for pages.

[0184] In a PO, multiple paging messages intended for multiple WTRUs may be multiplexed into a transport block and jointly coded by a channel

coder, where the WTRUs may have a different coverage level, thus requiring repetitions targeting for a worst coverage case. This may result in resource waste for paging transmissions.

[0185] In an example, multiple paging messages may be separately coded as code-block segments within a PDSCH transmission. For example, a PDSCH, for example, an NB-PDSCH carrying one or more paging message(s) may be scheduled by an associated PDCCH, for example, an NB-PDCCH, in each PO. The paging messages multiplexed in the PDSCH may be split into one or more code-block segments.

[0186] Each code-block segment may be coded separately by a channel code, for example, a turbo code, convolutional code, or block code. Each code-block segment may be attached with a CRC. A code-block segment may be associated with one or more paging messages. A code-block segment may be associated with one or more coverage levels. A code-block segment may be associated with a WTRU-ID. The WTRU-ID used for PO determination and code-block segment determination may be different. For example, the PO may be determined based on a first WTRU-ID, for example, IMSI-10, while the code-block segment may be determined based on a second WTRU-ID, for example, s-TMSI.

[0187] FIG. 7 is a diagram illustrating an example of code-block segment multiplexing in a PDSCH which may be scheduled by an associated PDCCH in a PO. The paging message, paging information, and paging record may be used interchangeably. As shown in diagram 700, code-block segments 710, 720 and 780 may be each associated with one or more respective coverage levels or CE levels. For example, code-block segment 710 may be associated with CE level 1, code-block segment 720 may be associated with CE level 2 and code-block segment 780 may be associated with CE level 3.

[0188] A PDSCH carrying one or more paging messages may be transmitted over multiple subframes. The number of subframes used for the PDSCH transmission may be indicated from the associated PDCCH. The number of subframes for the PDSCH transmission may be determined based on the transport block size, where the transport block size may include all

code-block segments multiplexed in the PDSCH. The number of repetitions may be indicated from the associated PDCCH. For example, the number of subframes Ns for the PDSCH transmission may be determined as a function of the transport block size and the number of repetitions Nrep may be indicated from the associated PDCCH. The total number of subframes used for the PDSCH transmission including repetitions may be Ns x Nrep.

[0189] A NB-subframe may include one of more subframes. The NB-subframe length may be determined based on the transport block size of the PDSCH transmission.

[0190] A code-block segment may be transmitted within an NB-subframe, where the NB-subframe length, for example, as a number of subframes, TTIs, ms, or the like, may be determined based on the size of the code-block segment. Multiple code-block segments may be multiplexed in a PDSCH. In an example shown in FIG. 7, code-block segments 710, 720 and 780 may be multiplexed in PDSCH 790. In an example, if Nc code-block segments are multiplexed in a PDSCH, the PDSCH may be transmitted over Nc NB-subframes. A NB-subframe length associated with a code-block segment may be determined based on the code-block segment size. The size of code-block segments may be indicated in the associated PDCCH. Based on the code-block segment sizes, a WTRU may determine the NB-subframe length of each code-block segment.

[0191] One or more code-block segments may be multiplexed in a PDSCH and the time/frequency resource locations for each code-block segment may be predefined. A WTRU may monitor all code-block segments within the PDSCH or a WTRU may monitor a subset of code-block segments. Each code-block segment may be associated with a CE level and a WTRU with a certain CE level may monitor, attempt to decode, or receive a code-block segment associated with the CE level. Each code-block segment may be associated with a WTRU-ID or a WTRU-group ID, and a WTRU may monitor, attempt to decode, or receive a code-block segment associated with the WTRU-ID or a WTRU-group ID.

[0192] In an example, multiple paging messages may be separately coded as code-block segments and each code-block segment may be transmitted in a PDSCH. For example, if Nc code-block segments are transmitted, the Nc PDSCHs may be transmitted and the Nc PDSCHs may be scheduled in an associated PDCCH in a PO. Each PDSCH carrying a code-block segment may be transmitted in one or more subframes. The starting subframe of each PDSCH carrying a code-block segment may be determined based on the last subframe of the associated PDCCH. Alternatively, the starting subframe of each PDSCH carrying a code-block segment may be determined based on the last subframe of the associated PDCCH and the size of the code-block segment. The number of subframes for a PDSCH carrying a code-block segment may be determined based on the size of the code-block segment. The size of the code-block segment may be a number of bits for the code-block segment after coding and rate-matching.

[0193] FIG. 8 is a diagram illustrating an example of code-block segments transmitted via multiple PDSCHs which may be scheduled by an associated PDCCH in a PO. An associated PDCCH transmitted in a PO may schedule one or more PDSCHs carrying paging messages. A PDSCH may be associated with a code-block segment.

[0194] As shown in diagram 800, code-block segments 810, 820 and 860 may be each associated with one or more respective coverage levels or CE levels, in a manner similar to that in FIG. 7. For example, code-block segment 810 may be associated with CE level 1, code-block segment 820 may be associated with CE level 2 and code-block segment 860 may be associated with CE level 3. However, in FIG. 8, each different respective PDSCH may be associated with each different respective code-block segment. For example, code-block segment 810 may be associated with PDSCH 870, code-block segment 820 may be associated with PDSCH 880 and code-block segment 860 may be associated with PDSCH 890.

[0195] The PDSCHs may be multiplexed in the time domain. For example, the PDSCHs may be transmitted in a different time (e.g., different

time window). The starting subframe of the PDSCHs may be predetermined based on the last subframe of the associated PDCCH.

[0196] In another example, the PDSCHs carrying code-block segments may be transmitted without an associated PDCCH. In each PO, one or more time windows may be configured, used, or allocated and a WTRU may attempt to decode, monitor, or receive a PDSCH carrying a code-block segment in a time window. The code-block segment size for a PDSCH may be predefined. One or more code-block segment sizes may be used and a WTRU may attempt to decode all candidate code-block segment sizes. The time windows for PDSCHs may be non-overlapped. Each time window may be associated with a CE level or WRTU-ID.

[0197] In another example, one or more PDSCHs carrying code-block segments may be transmitted and a first PDSCH may be scheduled by an associated PDCCH and the subsequent PDSCH(s) may be scheduled based on the previous PDSCH. An indication may be transmitted in a PDSCH to indicate whether a subsequent PDSCH carrying code-block segment may follow or may be transmitted. The indication may be based on a sequence masked in the CRC. For example, if the CRC is masked with a first sequence, there may not be a subsequent PDSCH while if the CRC is masked with a second sequence, there may be a subsequent PDSCH. The indication may be a bit transmitted in a code-block segment. A scheduling information may be transmitted with the indication. The first PDSCH may be based on the highest CE level, for example, a largest repetition number, and a subsequent PDSCH may be based on a lower CE level. The terms code-block segment and paging message may be interchangeably used herein.

[0198] The following examples include sending a direct indication in a paging DCI without PDSCH scheduling. When an eNode-B updates, or changes, a frequency location of an anchor RB, for example an anchor PRB, which may contain a synchronization signal and/or broadcasting signals such as a NB master information block (NB-MIB) and/or a NB-SIB, the eNode-B may need to indicate the update, or changes, via paging for WTRUs that are in RRC idle mode. If the indication bits are transmitted in a paging message, the

resource overhead may be increased significantly since the eNode-B may need to send this signal in all POs.

[0199] In an example, a WTRU may monitor or attempt to decode a DCI located in a NB-PDCCH search space. The NB-PDCCH may be in a PO. The NB-PDCCH and/or the PO may be intended for the WTRU. The DCI may carry one or more information types. The terms information type and DCI contents may be used interchangeably herein. One or more of following example parameters may apply.

[0200] A first information type may be scheduling information of the associated PDSCH carrying a paging message. A second information type may be a direct indication which may be related to a system configuration. The second information type may not include scheduling information of the associated PDSCH.

[0201] The information type related to system configuration may include at least one of following parameters or indications: a system information update indication; a public warning indication, such as an ETWS or a CMAS indication; an access barring parameter, such as an EAB parameter modification indication; scheduling information of one or more SIBs, where one or more SIBs may be transmitted without an associated DL control channel (NB-PDCCH); configuration information related to the anchor RB, for example the anchor PRB, for NB-IoT; a same-physical cell-ID (PCI) indicator, which may indicate if the PCI for a cell-specific reference signal (CRS) port and the PCI for an NB reference signal (NB-RS) are the same; and a valueTag, which may include one or more bits to indicate which SIB or SIBs are updated.

[0202] The scheduling information of a SIB or SIBs may include at least one of the following parameters: transport block size (TBS), frequency location, frequency hopping related information, and coverage level, which may be, for example, a repetition number. As described herein, an anchor RB, for example an anchor PRB, may include or may include transmission of at least one of the following: a synchronization signal (for example, a NB primary synchronization signal (NB-PSS), a NB secondary synchronization signal NB-

SSS and the like), a broadcast signal (for example, an NB physical broadcast channel (NB-PBCH), an NB-SIB and the like), and a NB-PDCCH common search space. The configuration information for an anchor RB, for example an anchor PRB, may include at least one of the following parameters: a RB location, for example a PRB location, within a system bandwidth, a raster offset, and a PCI of the NB-Sync.

[0203] In an example, the information type for the DCI may be determined based on a flag field in the DCI. For example, the flag field may indicate the information type carried. In another example, the information type for the DCI may be determined based on a RNTI used for the DCI. A first RNTI (e.g., P-RNTI-1) may be used if the DCI carries scheduling information of a corresponding PDSCH. A second RNTI (e.g., P-RNTI-2) may be used if the DCI carries direct information such as one or more indications related to a system configuration. In other examples, the information type for the DCI may be determined based on a scrambling sequence used for the DCI or a starting ECCE index used.

[0204] In examples, an eNode-B may page one or more WTRUs to indicate or provide a broadcast transmission or a multicast transmission. For example, for a downlink burst transmission to a group of WTRUs or all WTRUs in a cell, such as, for example, for or to perform a software upgrade of one or more NB-IoT devices, an eNode-B may page or may need to page the group of WTRUs or all WTRUs in the cell. For example, the eNode-B may need to page the group of WTRUs or all WTRUs in the cell if the WTRUs are in RRC idle. The eNode-B may need to transmit the downlink burst for each WTRU via WTRU-dedicated resources. This may result in inefficient resource utilization and WTRU battery consumption. A downlink burst transmission may be used herein as a non-limiting example of a broadcast or multicast transmission.

[0205] In an example, a common PO may be used for a downlink burst transmission. For example, a DCI scrambled with a certain RNTI, such as, for example, a downlink burst RNTI (DB-RNTI), may be monitored by a WTRU in

a PDCCH search space in the common PO. The DCI may schedule a PDSCH carrying a downlink burst traffic.

[0206] A WTRU may monitor or attempt to decode the DCI in a PDCCH search space. The PDCCH search space may be located in a certain time/frequency resource configured or used for the common PO. The time/frequency resource for a common PO may be determined based on at least one of the following parameters: system parameters, such as, for example, system bandwidth, physical cell-ID, duplex mode, TDD subframe configuration; subframe number and/or radio frame number, for example SFN; WTRU-ID, such as, for example, full or partial information of IMSI, s-TMSI and the like; operation mode, such as, for example, in-band, guard-band, and stand-alone operation; one or more coverage levels, which may be represented by, for example, repetition numbers; WTRU category and/or WTRU capabilities; and paging NBs, which may be configured or determined.

[0207] The DCI may activate and/or deactivate the PDSCH transmission for downlink burst transmission. The PDSCH may be transmitted in predefined time/frequency resources. The predefined time/frequency resources may be transmitted with a duty cycle.

[0208] In an example, a scheduling information of the downlink burst may be transmitted in a broadcast channel or in system information, such as, for example, in a MIB or a SIB. A WTRU may receive an indication or may be indicated, triggered, or informed to read the broadcast channel or the system information. The indication may be signaled in a paging message or as a direct indication in a DCI for paging. The scheduling information of the downlink burst may be transmitted in a broadcast channel or in system information. A WTRU may receive or attempt to decode the broadcast channel or system information if the WTRU receives a system information update indication.

[0209] In an example, an ordered PDSCH transmission may be used for the downlink burst transmission. For example, downlink burst traffic may be split into *N*_burst transport blocks and may be numbered in an increasing order. Each transport block may be transmitted in a PDSCH transmission. Scheduling information for the downlink burst transmission may indicate the

number of transport blocks, represented by, for example *N*_burst, for the downlink burst transmission. Scheduling information for a PDSCH carrying one or more downlink burst transport blocks may indicate the ordering number of the PDSCH.

[0210] Each transport block may be transmitted in a certain time and/or frequency resource. A transport block with a certain transport block number may be associated with a certain subframe number, a certain SFN and/or a certain hyper frame number. Therefore, a WTRU may determine, assume, or understand which transport block may be transmitted in a certain time/frequency resource for the burst transmission. If a WTRU fails to receive a subset of the transport blocks of the *N*_burst transport blocks, the WTRU may receive the failed transport blocks in a next downlink burst transmission. A transport block with a certain transport block number may be associated with a certain frequency resource. The certain time/frequency resources may be configured via higher layer signaling.

[0211] Each PDSCH carrying a transport block may be transmitted with a repetition, where the repetition number may be indicated in the scheduling information. The repetition number may include a value of "1" as a no repetition case.

[0212] In an example, a WTRU that fails to receive one or more PDSCH transmissions for a downlink burst transmission may perform one or more of following actions. The WTRU may attempt to receive the failed PDSCH transmission in a following transmission or a following transmission window. A maximum number of attempts may be predefined or configured by higher layers. The maximum number of attempts may include a value of "1".

[0213] If the WTRU fails to receive one or more PDSCH transmissions after the maximum number of attempts, the WTRU may attempt to change operation mode, such as, for example, from RRC idle mode to RRC connected mode, and/or the WTRU may initiate a random access or random access channel (RACH) procedure.

[0214] In another example, a WTRU that fails to receive one or more PDSCH transmissions for a downlink burst transmission may perform one or

more of the following actions. The WTRU may send a corresponding hybrid automatic repeat request acknowledgement (HARQ-ACK) transmission in an associated HARQ-ACK resource. A HARQ transmission for reception failure may be a negative acknowledgement (NACK). A subset of physical random access channel (PRACH) resources may be reserved as an associated HARQ-ACK resource for the downlink burst transmission. For example, a WTRU may send a HARQ transmission that may be a NACK on a PRACH resource when it fails to receive one or more PDSCH transmissions for a downlink burst transmission. A set of physical uplink control channel (PUCCH) resources may be configured, indicated, or used for HARQ transmission, for example for NACK transmission. For example, a WTRU may send a HARQ transmission that may be a NACK on a PUCCH resource that may be configured or indicated when it fails to receive one or more PDSCH transmissions for a downlink burst transmission.

[0215] Although features and elements are described above in particular combinations, one of ordinary skill in the art will appreciate that each feature or element can be used alone or in any combination with the other features and elements. In addition, the methods described herein may be implemented in a computer program, software, or firmware incorporated in a computer-readable medium for execution by a computer or processor. Examples of computer-readable media include electronic signals (transmitted over wired or wireless connections) and computer-readable storage media. Examples of computer-readable storage media include, but are not limited to, a read only memory (ROM), a random access memory (RAM), a register, cache memory, semiconductor memory devices, magnetic media such as internal hard disks and removable disks, magneto-optical media, and optical media such as CD-ROM disks, and digital versatile disks (DVDs). A processor in association with software may be used to implement a radio frequency transceiver for use in a WTRU, UE, terminal, base station, RNC, or any host computer.

* * *

CLAIMS

What is claimed is:

1. A method performed in a machine type communication (MTC) wireless transmit/receive unit (WTRU), the method comprising:

determining, by the WTRU, a paging narrowband (NB) for the WTRU, to use for monitoring an MTC physical downlink control channel (M-PDCCH), based on at least the most significant bits (MSBs) of a function of a WTRU-identifier (WTRU-ID);

monitoring, by the WTRU, for the M-PDCCH on the determined paging NB for the WTRU;

receiving, by the WTRU, a downlink control information (DCI) on the monitored M-PDCCH on the determined paging NB during a paging occasion (PO); and

receiving, by the WTRU, a physical downlink shared channel (PDSCH) associated with the M-PDCCH.

2. The method of claim 1, wherein the WTRU determines the paging NB based on at least the 3 MSBs of a function of the WTRU-ID.

3. The method of claim 1, wherein the WTRU determines the paging NB based on at least the 4 MSBs of a function of the WTRU-ID.

4. The method of claim 1, wherein the DCI includes a cyclic redundancy check (CRC) that is scrambled with a Paging Radio Network Temporary Identifier (P-RNTI).

5. The method of claim 1, wherein the PDSCH is scheduled by the DCI.

6. The method of claim 1, wherein the DCI includes system information update related information.

7. The method of claim 1, where in the PDSCH includes system information update related information.

8. The method of claim 1, wherein the PDSCH includes a paging message.

9. The method of claim 1, wherein the WTRU-ID is a WTRU international mobile subscriber identity (IMSI).

10. The method of claim 9, wherein the function includes IMSI mod 16,384.

11. The method of claim 1, wherein determining the paging NB for the WTRU is further based on a number of NBs for paging.

12. A machine type communication (MTC) wireless transmit/receive unit (WTRU), the WTRU comprising:

a processor configured to determine a paging narrowband (NB) for the WTRU, to use for monitoring an MTC physical downlink control channel (M-PDCCH), based on at least the most significant bits (MSBs) of a function of a WTRU-identifier (WTRU-ID);

a transceiver operatively coupled to the processor, the transceiver and processor configured to monitor for the M-PDCCH on the determined paging NB for the WTRU;

the transceiver and processor configured to receive a downlink control information (DCI) on the monitored M-PDCCH on the determined paging NB during a paging occasion (PO); and

the transceiver and processor configured to receive a physical downlink shared channel (PDSCH) associated with the M-PDCCH.

13. The WTRU of claim 12, wherein the WTRU determines the paging NB based on at least the 3 MSBs of a function of the WTRU-ID.

14. The WTRU of claim 12, wherein the WTRU determines the paging NB based on at least the 4 MSBs of a function of the WTRU-ID.

15. The WTRU of claim 12, wherein the DCI includes a cyclic redundancy check (CRC) that is scrambled with a Paging Radio Network Temporary Identifier (P-RNTI).

16. The WTRU of claim 12, wherein the PDSCH is scheduled by the DCI.

17. The WTRU of claim 12, wherein the DCI includes system information update related information.

18. The WTRU of claim 12, wherein the PDSCH includes system information update related information.

19. The WTRU of claim 12, wherein the PDSCH includes a paging message.

20. The WTRU of claim 12, wherein the WTRU-ID is a WTRU international mobile subscriber identity (IMSI).

21. The WTRU of claim 20, wherein the function includes IMSI mod 16,384.

22. The WTRU of claim 12, wherein the determining the paging NB for the WTRU is further based on a number of NBs for paging.

23. A method performed in a machine type communication (MTC) wireless transmit/receive unit (WTRU), the method comprising:

monitoring, by the WTRU, for an MTC physical downlink control channel (M-PDCCH) in an M-PDCCH search space;

receiving, by the WTRU, an M-PDCCH in the M-PDCCH search space, wherein the M-PDCCH has a starting enhanced control channel element (ECCE) index for a WTRU group containing the WTRU;

decoding, by the WTRU, the M-PDCCH, wherein the M-PDCCH includes a downlink control information (DCI); and

receiving, by the WTRU, a physical downlink shared channel (PDSCH) associated with the M-PDCCH.

24. The method of claim 23, further comprising:

demodulating, by the WTRU, the PDSCH based on the DCI, wherein the PDSCH includes a paging message.

25. The method of claim 24, wherein the WTRU changes operations based on the paging message.

26. The method of claim 25, wherein the WTRU changing operations includes the WTRU changing from idle mode to connected mode based on the paging message.

27. The method of claim 23, wherein an ECCE aggregation level is 16.

28. The method of claim 23, further comprising:

receiving, by the WTRU, the PDSCH based on the DCI, wherein the PDSCH includes a paging message.

29. The method of claim 23, further comprising:

decoding, by the WTRU, the PDSCH based on the DCI, wherein the PDSCH includes a paging message.

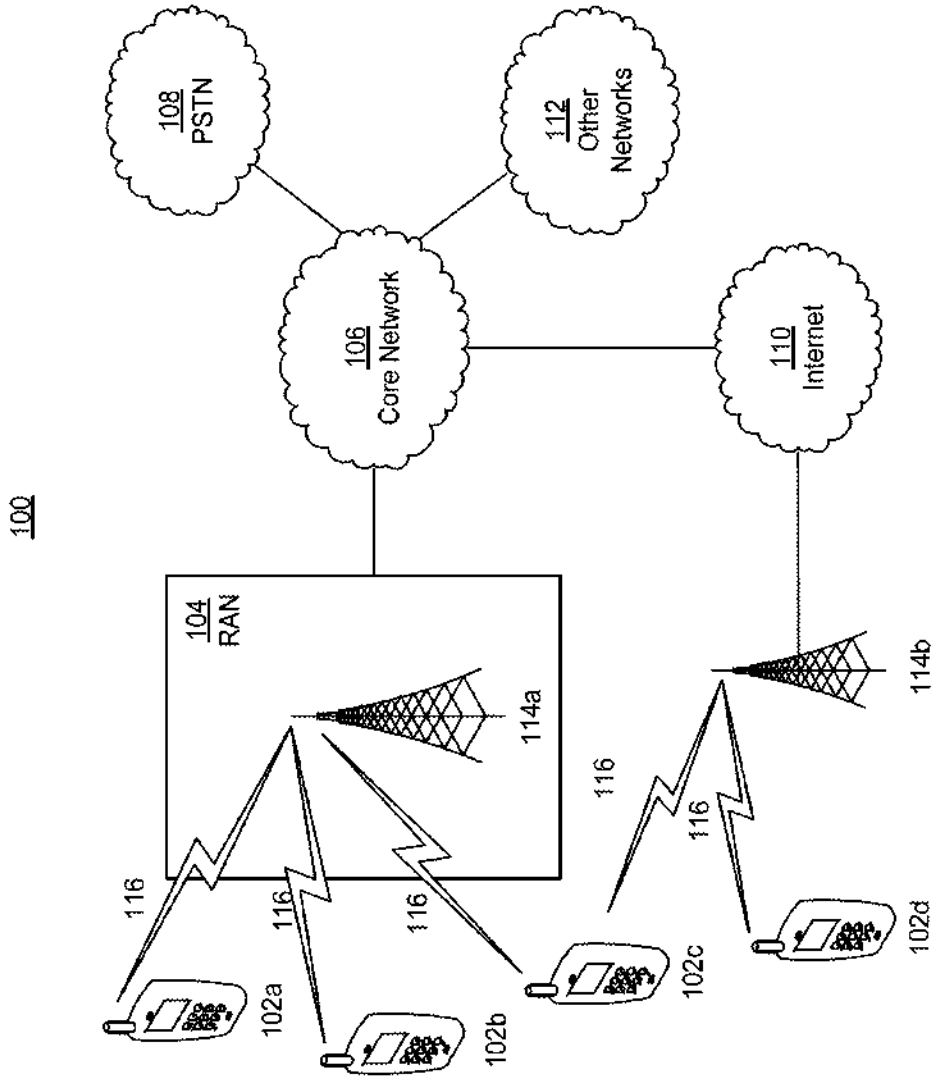

100
108 PSTN
112 Other Networks
106 Core Network
110 Internet
104 RAN
114a
114b
116
102a
102b
102c
102d

FIG. 1A

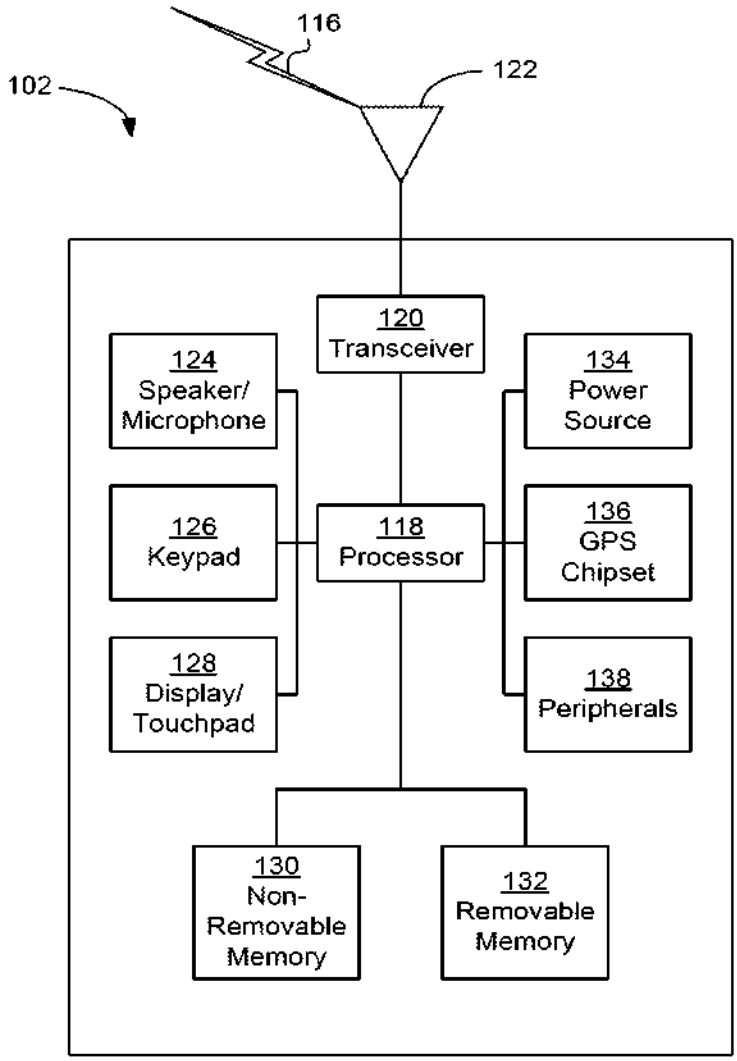

116
122
102
120
Transceiver
124
Speaker/
Microphone
134
Power
Source
126
Keypad
118
Processor
136
GPS
Chipset
128
Display/
Touchpad
138
Peripherals
130
Non-
Removable
Memory
132
Removable
Memory

FIG. 1B

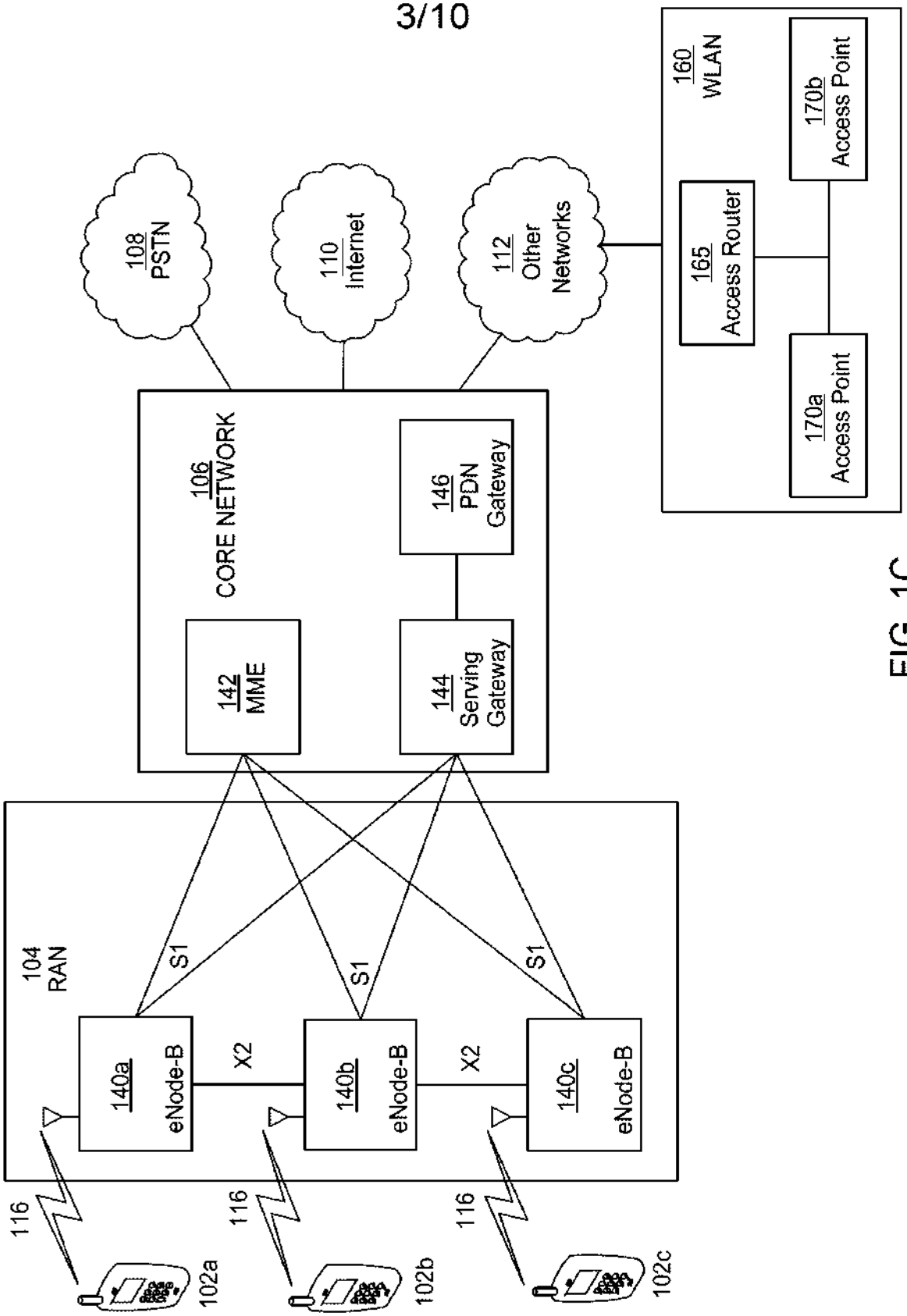

108 PSTN
110 Internet
112 Other Networks
160 WLAN
165 Access Router
170b Access Point
170a Access Point
106 CORE NETWORK
146 PDN Gateway
142 MME
144 Serving Gateway
104 RAN
S1
S1
S1
140a eNode-B
X2
140b eNode-B
X2
140c eNode-B
116
116
116
102a
102b
102c

FIG. 1C

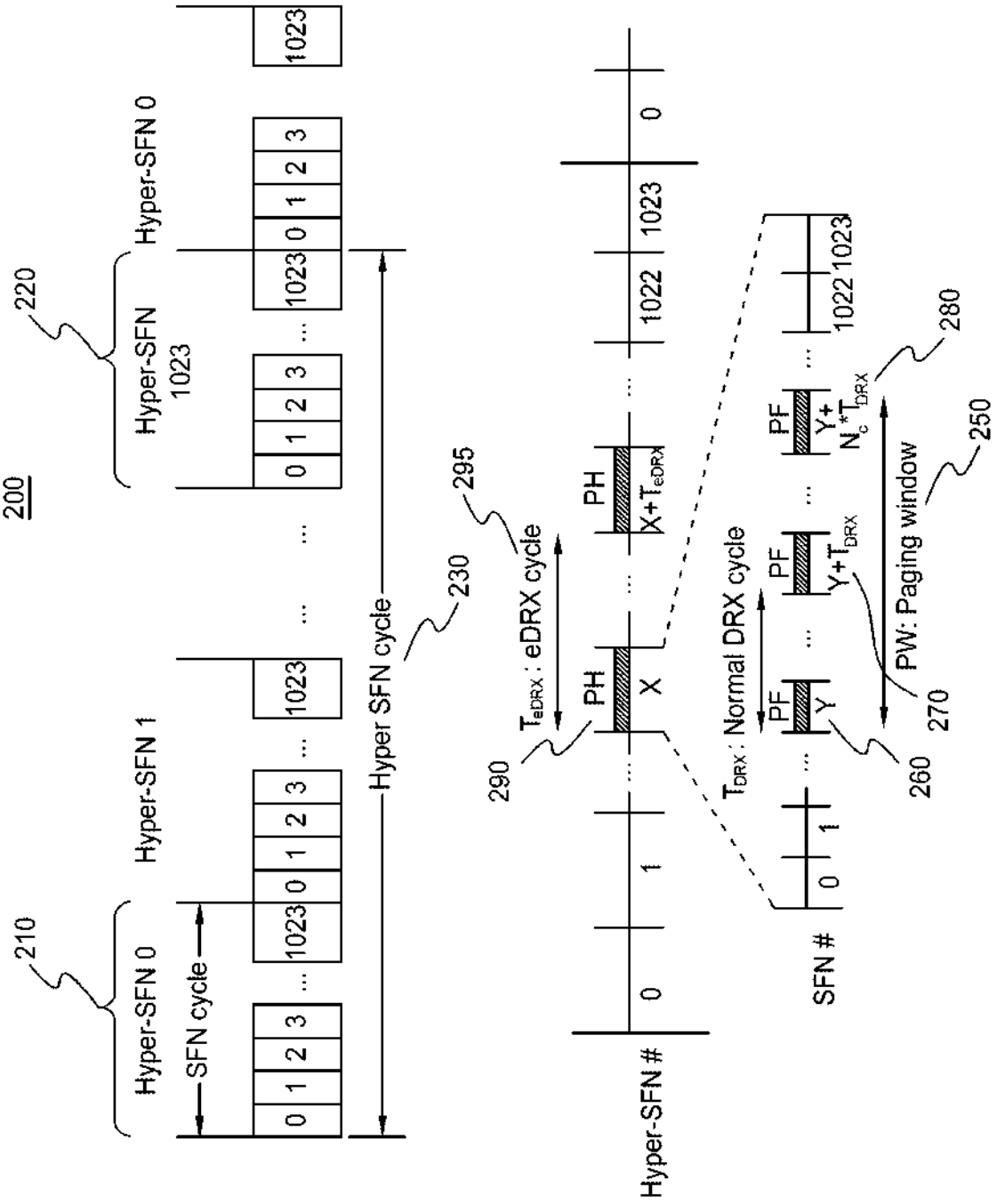

200
210
Hyper-SFN 0
SFN cycle
0 1 2 3 ... 1023
Hyper-SFN 1
0 1 2 3 ... 1023
220
Hyper-SFN 0
Hyper-SFN 1023
0 1 2 3 ... 1023
Hyper SFN cycle
230
295
290
T_{eDRX} : eDRX cycle
Hyper-SFN #
0 1 ... PH X ... PH X+T_{eDRX} ... 1022 1023
0
T_{DRX} : Normal DRX cycle
SFN #
0 1 ... PF Y ... PF Y+T_{DRX} ... PF Y+N_c*T_{DRX} ... 1022 1023
260
270
PW: Paging window
280
250

FIG. 2

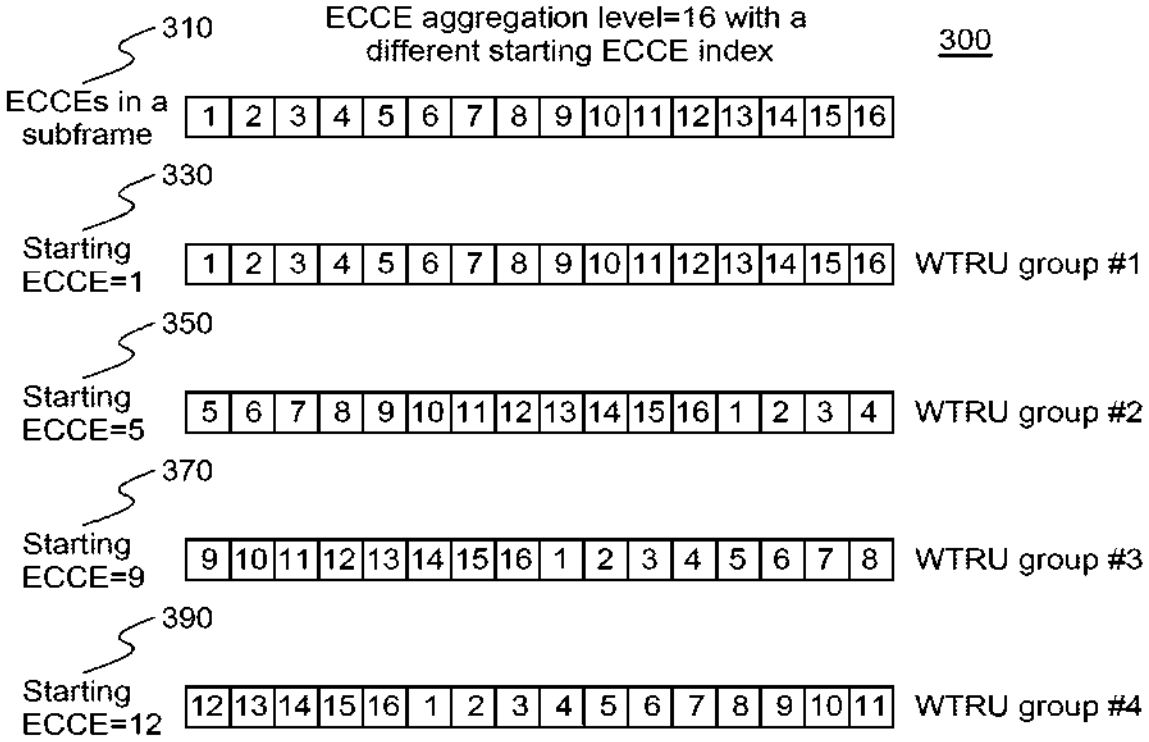

ECCE aggregation level=16 with a different starting ECCE index
300
310
ECCEs in a subframe
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
330
Starting ECCE=1
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
WTRU group #1
350
Starting ECCE=5
5 6 7 8 9 10 11 12 13 14 15 16 1 2 3 4
WTRU group #2
370
Starting ECCE=9
9 10 11 12 13 14 15 16 1 2 3 4 5 6 7 8
WTRU group #3
390
Starting ECCE=12
12 13 14 15 16 1 2 3 4 5 6 7 8 9 10 11
WTRU group #4

FIG. 3

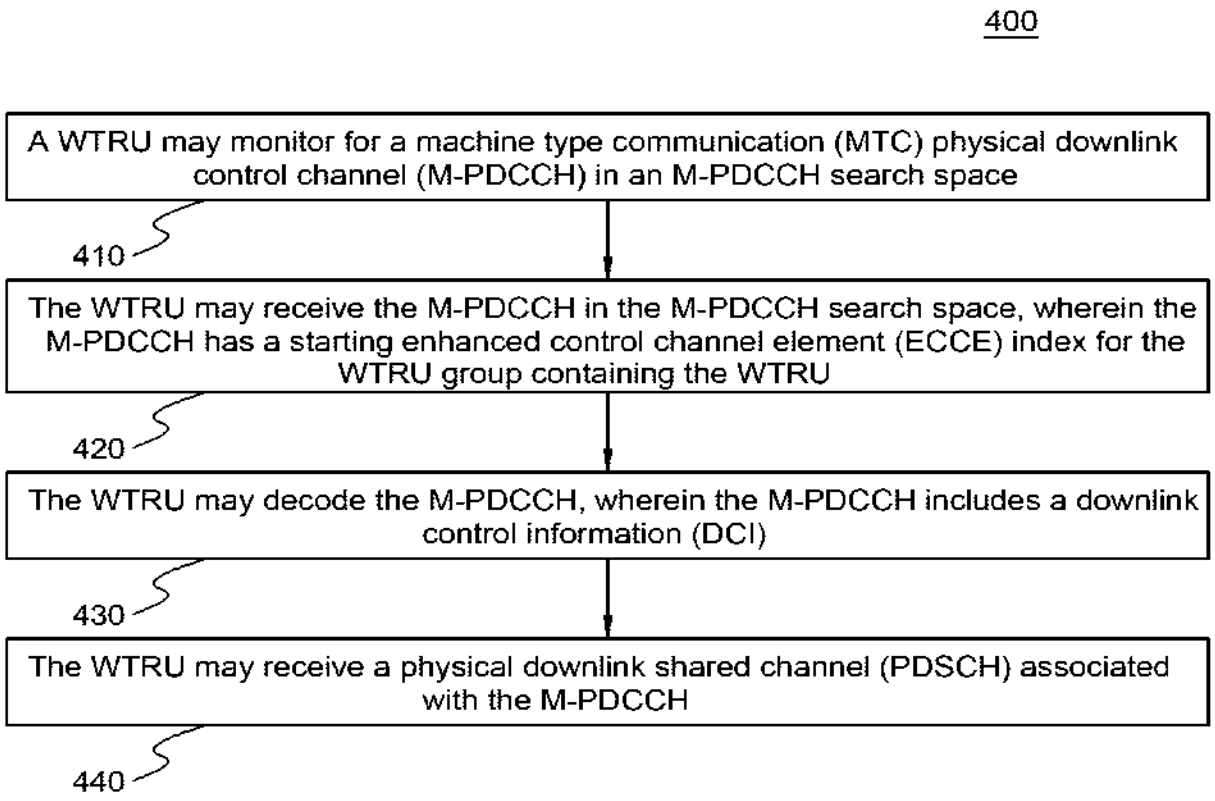

400
A WTRU may monitor for a machine type communication (MTC) physical downlink control channel (M-PDCCH) in an M-PDCCH search space
410
The WTRU may receive the M-PDCCH in the M-PDCCH search space, wherein the M-PDCCH has a starting enhanced control channel element (ECCE) index for the WTRU group containing the WTRU
420
The WTRU may decode the M-PDCCH, wherein the M-PDCCH includes a downlink control information (DCI)
430
The WTRU may receive a physical downlink shared channel (PDSCH) associated with the M-PDCCH
440

FIG. 4

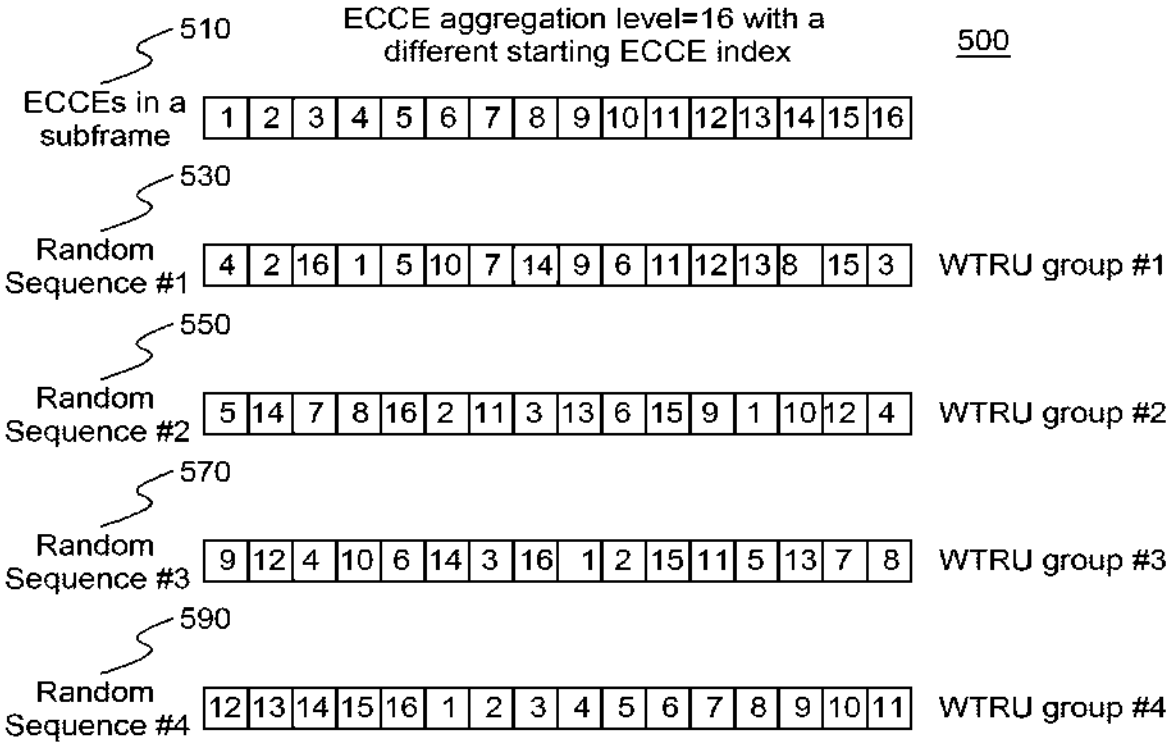

510
ECCE aggregation level=16 with a different starting ECCE index
500
ECCEs in a subframe
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
530
Random Sequence #1
4 2 16 1 5 10 7 14 9 6 11 12 13 8 15 3
WTRU group #1
550
Random Sequence #2
5 14 7 8 16 2 11 3 13 6 15 9 1 10 12 4
WTRU group #2
570
Random Sequence #3
9 12 4 10 6 14 3 16 1 2 15 11 5 13 7 8
WTRU group #3
590
Random Sequence #4
12 13 14 15 16 1 2 3 4 5 6 7 8 9 10 11
WTRU group #4

FIG. 5

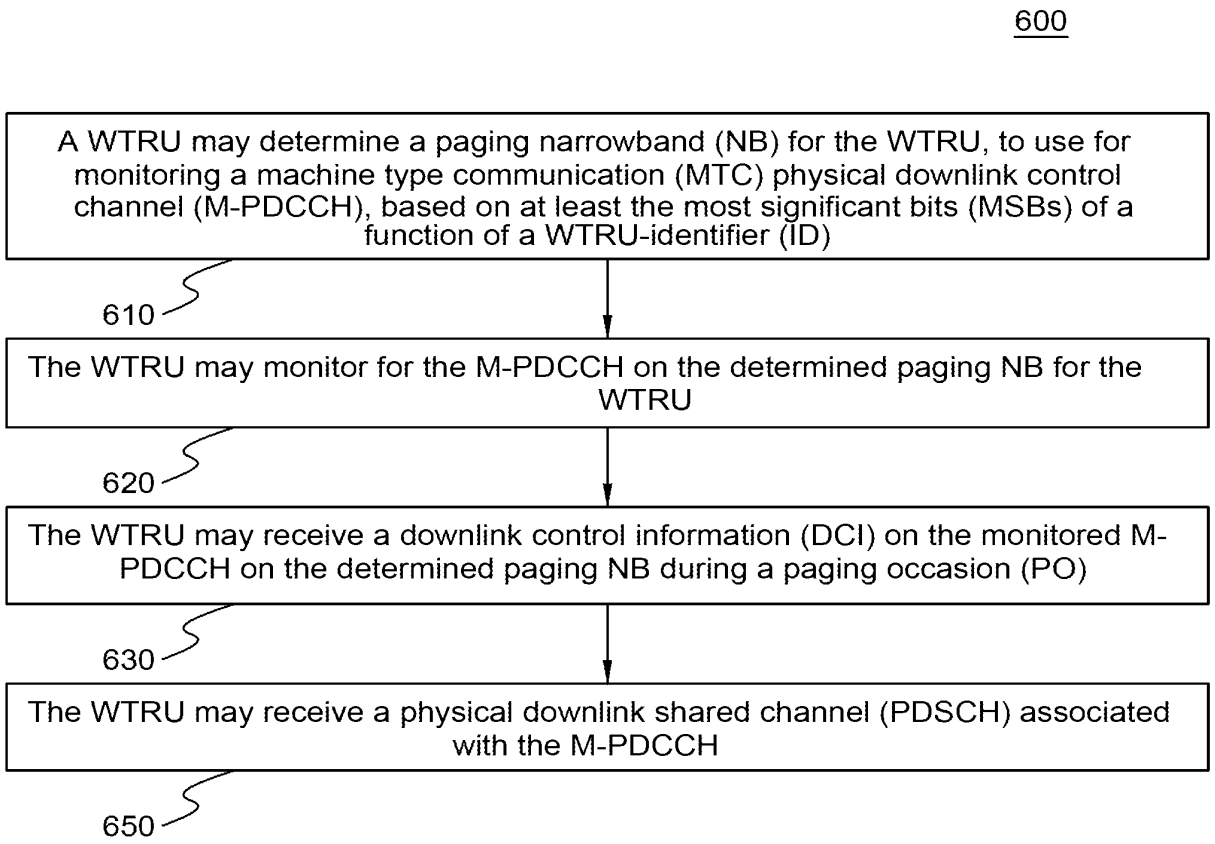

600
A WTRU may determine a paging narrowband (NB) for the WTRU, to use for monitoring a machine type communication (MTC) physical downlink control channel (M-PDCCH), based on at least the most significant bits (MSBs) of a function of a WTRU-identifier (ID)
610
The WTRU may monitor for the M-PDCCH on the determined paging NB for the WTRU
620
The WTRU may receive a downlink control information (DCI) on the monitored M-PDCCH on the determined paging NB during a paging occasion (PO)
630
The WTRU may receive a physical downlink shared channel (PDSCH) associated with the M-PDCCH
650

FIG. 6

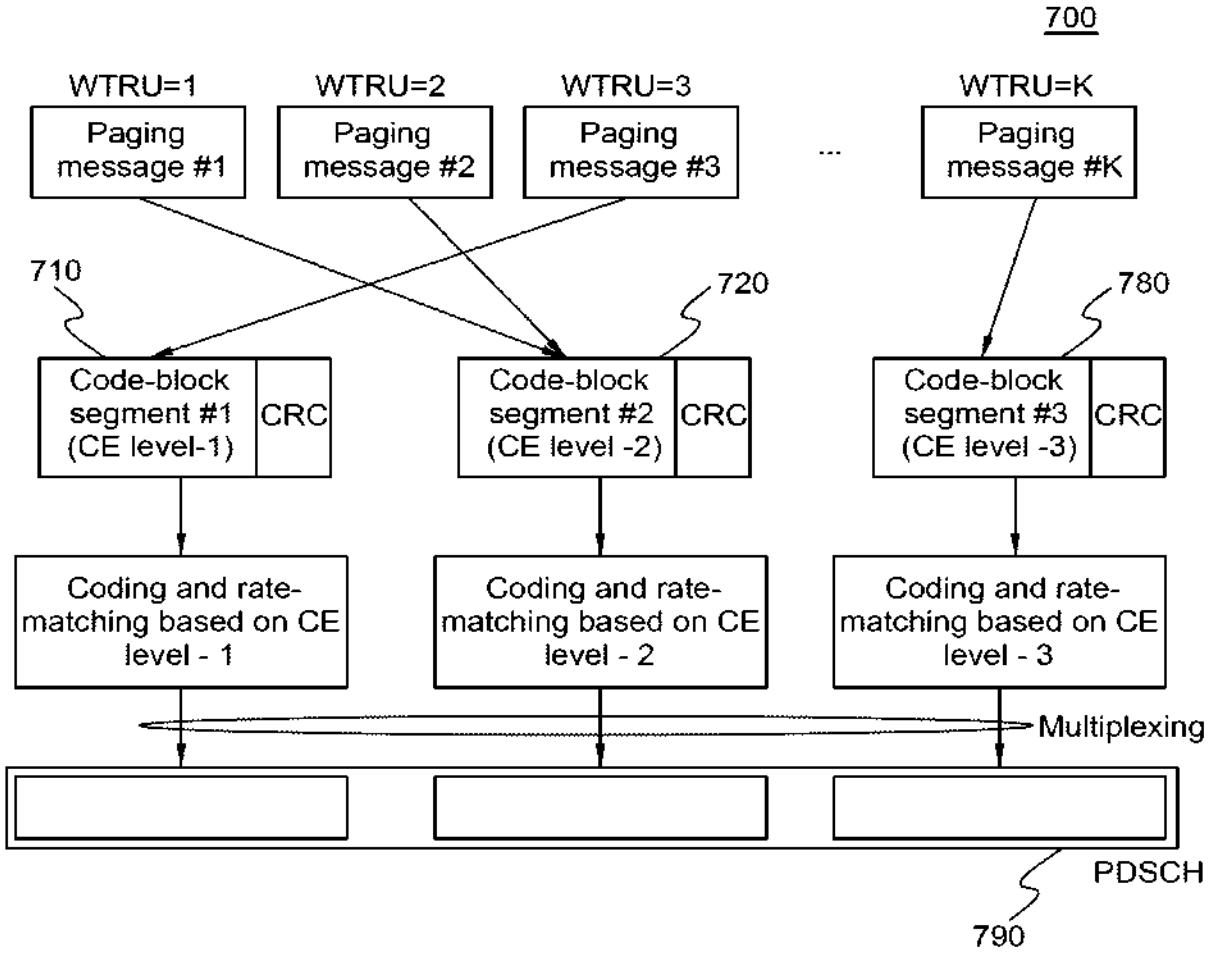

700
WTRU=1
WTRU=2
WTRU=3
WTRU=K
Paging message #1
Paging message #2
Paging message #3
...
Paging message #K
710
720
780
Code-block segment #1 (CE level-1)
CRC
Code-block segment #2 (CE level -2)
CRC
Code-block segment #3 (CE level -3)
CRC
Coding and rate-matching based on CE level - 1
Coding and rate-matching based on CE level - 2
Coding and rate-matching based on CE level - 3
Multiplexing
PDSCH
790

FIG. 7

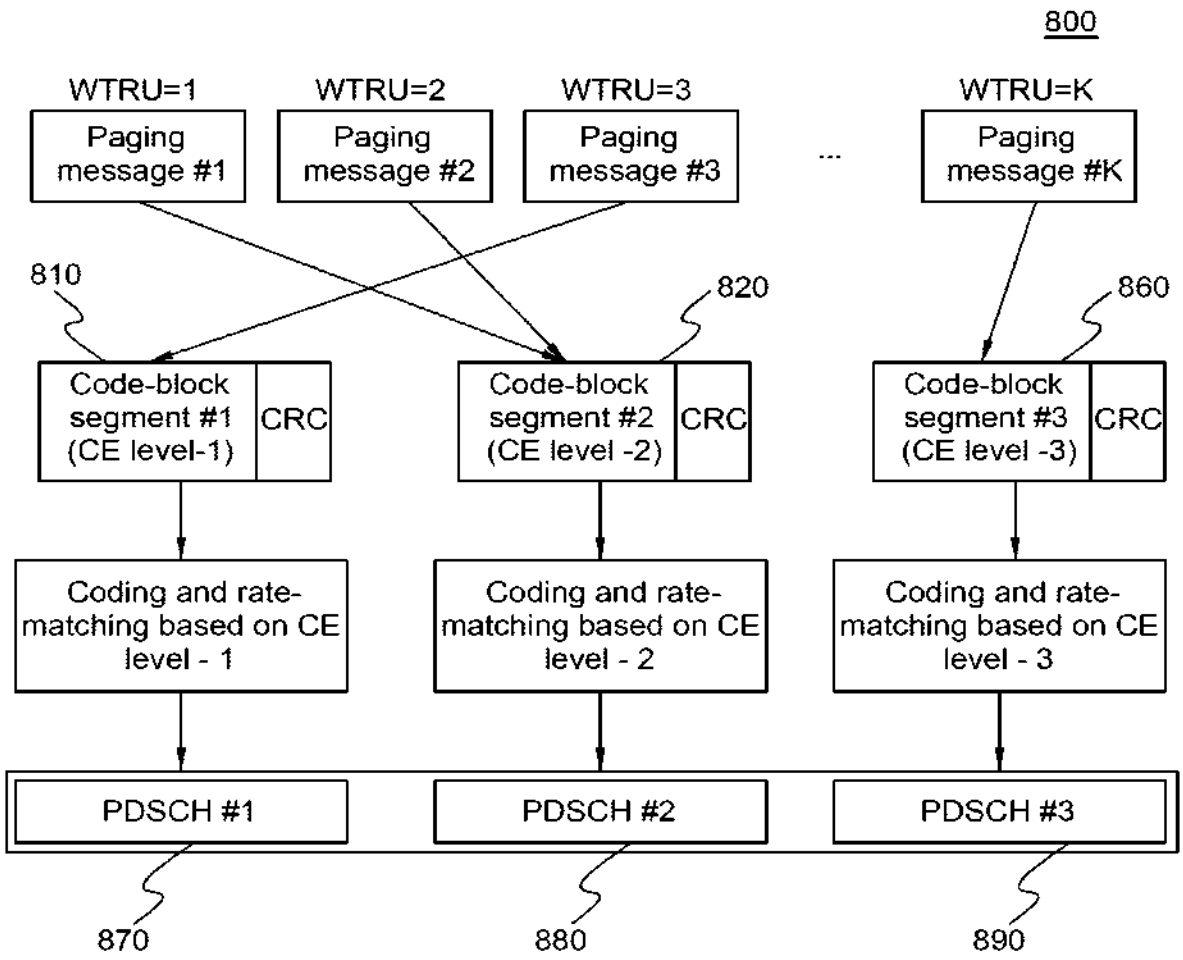

800
WTRU=1
WTRU=2
WTRU=3
WTRU=K
Paging message #1
Paging message #2
Paging message #3
...
Paging message #K
810
820
860
Code-block segment #1 (CE level-1)
CRC
Code-block segment #2 (CE level -2)
CRC
Code-block segment #3 (CE level -3)
CRC
Coding and rate-matching based on CE level - 1
Coding and rate-matching based on CE level - 2
Coding and rate-matching based on CE level - 3
PDSCH #1
PDSCH #2
PDSCH #3
870
880
890

FIG. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/060554

A. CLASSIFICATION OF SUBJECT MATTER
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ADD. H04W4/00 H04L5/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2014/069946 A1 (LG ELECTRONICS INC [KR]) 8 May 2014 (2014-05-08) abstract paragraphs [0008] - [0014], [0048], [0051], [0052], [0060], [0061], [0076], [0093], [0095], [0096], [0100] - [0101] paragraphs [0121] - [0123], [0127], [0130] - [0133]; claim 1 ----- -/--	1-29

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
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Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Englund, Terese

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	US 2013/194931 A1 (LEE MOON-IL [US] ET AL) 1 August 2013 (2013-08-01) abstract paragraphs [0004], [0005], [0038] - [0041], [0044], [0120], [0149], [0196] - [0201], [0203], [0204], [0209] paragraphs [0221] - [0222], [0224], [0226], [0244], [0245], [0248] - [0251], [0254], [0255] paragraphs [0262], [0269] - [0270], [0276]	1-29
X	US 2015/146692 A1 (YI YUNJUNG [KR] ET AL) 28 May 2015 (2015-05-28) paragraphs [0054], [0055], [0063], [0064], [0065], [0070], [0074], [0076], [0079] - [0083], [0106], [0116], [0151]	1-29
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2

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2016/060554

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		WO 2014069946 A1	08-05-2014
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		WO 2011100497 A1	18-08-2011

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(74) Agents: **TOKUDA, Yoshiaki** et al.; c/o Panasonic Corporation, 1006, Oaza Kadoma, Kadoma-shi, Osaka, 5718501 (JP).

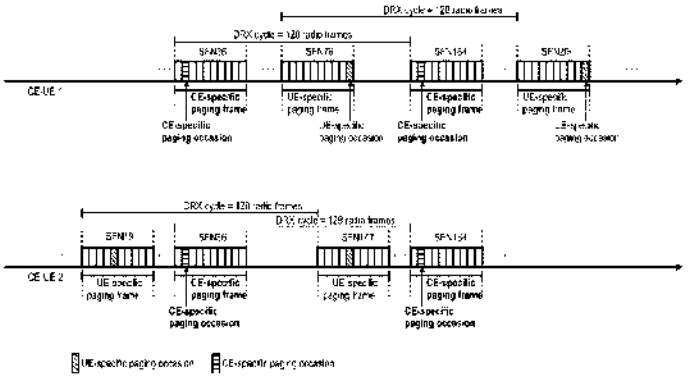
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(54) **Title**: IMPROVED PAGING PROCEDURES FOR USER EQUIPMENTS REQUIRING COVERAGE EXTENSION



(57) **Abstract**: The present disclosure relates to a method for paging coverage extension UEs in a cell controlled by a radio base station. At least one regularly-occurring coverage-extension-specific paging possibility (CE-specific paging possibility), is defined for paging CE UEs. The CE-UEs in the cell regularly monitor the at least one CE-specific paging possibility. When the radio base station determines to page all the user equipments in the cell, it pages the CE user equipments in the cell at the CE-specific paging possibility, using a coverage extension technique. The present disclosure also relates to a method for paging a CE UE, which performs radio measurements by the CE-capable user equipment to determine whether coverage extension is necessary. The radio base station is informed about whether the CE-capable user equipment needs coverage extension or not and then pages the CE UEs applying or not applying a CE technique depending on whether coverage extension is necessary or not.

WO 2016/136143 A1

Description

Title of Invention: IMPROVED PAGING PROCEDURES FOR USER EQUIPMENTS REQUIRING COVERAGE EXTENSION

Technical Field

[0001] The present disclosure relates to methods for paging one or several user equipments in a cell of a radio base station, where the user equipment(s) do require coverage extension to be reliably paged. The present disclosure is also providing the user equipment and radio base station for participating in the methods described herein.

Background

[0002] Long Term Evolution (LTE)

Third-generation mobile systems (3G) based on WCDMA radio-access technology are being deployed on a broad scale all around the world. A first step in enhancing or evolving this technology entails introducing High-Speed Downlink Packet Access (HSDPA) and an enhanced uplink, also referred to as High Speed Uplink Packet Access (HSUPA), giving a radio access technology that is highly competitive.

[0003] In order to be prepared for further increasing user demands and to be competitive against new radio access technologies, 3GPP introduced a new mobile communication system which is called Long Term Evolution (LTE). LTE is designed to meet the carrier needs for high speed data and media transport as well as high capacity voice support for the next decade. The ability to provide high bit rates is a key measure for LTE.

[0004] The work item (WI) specification on Long-Term Evolution (LTE) called Evolved UMTS Terrestrial Radio Access (UTRA) and UMTS Terrestrial Radio Access Network (UTRAN) is finalized as Release 8 (LTE Rel. 8). The LTE system represents efficient packet-based radio access and radio access networks that provide full IP-based functionalities with low latency and low cost. In LTE, scalable multiple transmission bandwidths are specified such as 1.4, 3.0, 5.0, 10.0, 15.0, and 20.0 MHz, in order to achieve flexible system deployment using a given spectrum. In the downlink, Orthogonal Frequency Division Multiplexing (OFDM) based radio access was adopted because of its inherent immunity to multipath interference (MPI) due to a low symbol rate, the use of a cyclic prefix (CP) and its affinity to different transmission bandwidth arrangements. Single-carrier frequency division multiple access (SC-FDMA) based radio access was adopted in the uplink, since provisioning of wide area coverage was prioritized over improvement in the peak data rate considering the restricted transmit power of the user equipment (UE). Many key packet radio access techniques are employed including multiple-input multiple-output

(MIMO) channel transmission techniques and a highly efficient control signaling structure is achieved in LTE Rel. 8/9.

[0005] LTE architecture

The overall architecture is shown in Fig. 1 and a more detailed representation of the E-UTRAN architecture is given in Fig. 2. The E-UTRAN consists of an eNodeB, providing the E-UTRA user plane (PDCP/RLC/MAC/PHY) and control plane (RRC) protocol terminations towards the user equipment (UE). The eNodeB (eNB) hosts the Physical (PHY), Medium Access Control (MAC), Radio Link Control (RLC) and Packet Data Control Protocol (PDCP) layers that include the functionality of user-plane header-compression and encryption. It also offers Radio Resource Control (RRC) functionality corresponding to the control plane. It performs many functions including radio resource management, admission control, scheduling, enforcement of negotiated uplink Quality of Service (QoS), cell information broadcast, ciphering/ deciphering of user and control plane data, and compression/ decompression of downlink/uplink user plane packet headers. The eNodeBs are interconnected with each other by means of the X2 interface.

[0006] The eNodeBs are also connected by means of the S1 interface to the EPC (Evolved Packet Core), more specifically to the MME (Mobility Management Entity) by means of the S1-MME and to the Serving Gateway (SGW) by means of the S1-U. The S1 interface supports a many-to-many relation between MMEs/Serving Gateways and eNodeBs. The SGW routes and forwards user data packets, while also acting as the mobility anchor for the user plane during inter-eNodeB handovers and as the anchor for mobility between LTE and other 3GPP technologies (terminating S4 interface and relaying the traffic between 2G/3G systems and PDN GW). For idle state user equipments, the SGW terminates the downlink data path and triggers paging when downlink data arrives for the user equipment. It manages and stores user equipment contexts, e.g. parameters of the IP bearer service, network internal routing information. It also performs replication of the user traffic in case of lawful interception.

[0007] The MME is the key control-node for the LTE access-network. It is responsible for idle mode user equipment tracking and paging procedure including retransmissions. It is involved in the bearer activation/deactivation process and is also responsible for choosing the SGW for a user equipment at the initial attach and at time of intra-LTE handover involving Core Network (CN) node relocation. It is responsible for authenticating the user (by interacting with the HSS). The Non-Access Stratum (NAS) signaling terminates at the MME and it is also responsible for generation and allocation of temporary identities to user equipments. It checks the authorization of the user equipment to camp on the service provider's Public Land Mobile Network (PLMN) and enforces user equipment roaming restrictions. The MME is the ter-

mination point in the network for ciphering/integrity protection for NAS signaling and handles the security key management. Lawful interception of signaling is also supported by the MME. The MME also provides the control plane function for mobility between LTE and 2G/3G access networks with the S3 interface terminating at the MME from the SGSN. The MME also terminates the S6a interface towards the home HSS for roaming user equipments.

[0008] LTE RRC states

LTE is based on only two main states: "RRC_IDLE" and "RRC_CONNECTED".

[0009] In RRC_IDLE the radio is not active, but an ID is assigned and tracked by the core network. More specifically, a mobile terminal in RRC_IDLE performs cell selection and reselection – in other words, it decides on which cell to camp. The cell (re)selection process takes into account the priority of each applicable frequency of each applicable Radio Access Technology (RAT), the radio link quality and the cell status (i.e. whether a cell is barred or reserved). An RRC_IDLE mobile terminal monitors a paging channel to detect incoming calls, and also acquires system information. The system information mainly consists of parameters by which the network (E-UTRAN) can control the cell (re)selection process and also how the mobile terminal accesses the network. RRC specifies the control signalling applicable for a mobile terminal in RRC_IDLE, namely paging and system information. The mobile terminal behaviour in RRC_IDLE is specified in more detail e.g. in TS 36.304, current version 12.0.0(NPL 1), chapter 4 "General description of Idle mode" incorporated herein by reference.

[0010] In RRC_CONNECTED the mobile terminal has an active radio operation with contexts in the eNodeB. The E-UTRAN allocates radio resources to the mobile terminal to facilitate the transfer of (unicast) data via shared data channels. To support this operation, the mobile terminal monitors an associated control channel which is used to indicate the dynamic allocation of the shared transmission resources in time and frequency. The mobile terminal provides the network with reports of its buffer status and of the downlink channel quality, as well as neighbouring cell measurement information to enable E-UTRAN to select the most appropriate cell for the mobile terminal. These measurement reports include cells using other frequencies or RATs. The UE also receives system information, consisting mainly of information required to use the transmission channels. To extend its battery lifetime, a UE in RRC_CONNECTED may be configured with a Discontinuous Reception (DRX) cycle. RRC is the protocol by which the E-UTRAN controls the UE behaviour in RRC_CONNECTED.

[0011] The various functions of the mobile terminal in RRC Protocol for and including Connected Mode are described in 3GPP TS 36.331, current version 12.4.1(NPL 2), in

Ch. 4 "Functions", incorporated herein by reference.

[0012] Paging

The present application will differentiate between two types of paging, namely the paging initiated from the non-access stratum (NAS) (termed exemplarily in the following "Paging-NAS") and the paging initiated from the eNodeB (termed exemplarily in the following "Paging-eNB"). Paging-NAS relates to the paging of a particular UE e.g. when paging a UE in connection with an incoming data connection e.g. a mobile-terminating (MT) call. On the other hand, paging-eNB relates to the paging of all the UEs in the cell, and e.g. is used to inform them about a system information change, ETWS message (Earthquake and Tsunami Warning System), CMAS message (Commercial Mobile Alert System) etc. Furthermore, depending on whether the UE is in RRC idle or connected state, the actual paging messages are transmitted differently to the UE. However, the two paging procedures have a lot in common too.

[0013] In general, the UE in RRC_Idle state monitors for paging to detect incoming calls, system information change, for ETWS capable UEs, ETWS notification, and for CMAS capable UEs, CMAS notification. The UE in RRC_Connected state monitors for paging and/or System Information Block Type 1 contents to detect system information change, for ETWS capable UEs, ETWS notification, and for CMAS capable UEs, CMAS notification (see 3GPP TS 36.331, current version v12.4.1, subclause 4.2.1, incorporated herein by reference).

The general paging procedure for transmitting the paging message from EUTRAN to the UE is defined in TS 36.331, current version 12.4.1, subclause 5.3.2 incorporated herein by reference, describing that the purpose of the paging procedure is:

[0014] - to transmit paging information to a UE in RRC_IDLE (Paging-NAS) and/ or;

- to inform UEs in RRC_IDLE and UEs in RRC_CONNECTED about a system information change (Paging-eNB) and/ or;

- to inform about an ETWS primary notification and/ or ETWS secondary notification (Paging-eNB) and/ or;

- to inform about a CMAS notification (Paging-eNB).

[0015] The paging information received in the UE is provided to upper layers, which in response e.g. may the initiate RRC connection establishment to receive an incoming call.

[0016] E-UTRAN performs the paging procedure by transmitting the Paging message at the UE's paging occasion as specified in TS 36.304. E-UTRAN may address multiple UEs within a Paging message by including one PagingRecord for each UE.

[0017] To receive paging messages from E-UTRAN, UEs in idle mode monitor the PDCCH channel for an RNTI value used to indicate paging: the P-RNTI (Paging radio network

temporary identity) which is a common RNTI, i.e. not allocated to any UE explicitly. The UE only needs to monitor the PDCCH channel at certain UE-specific paging possibilities, i.e. at specific subframes within specific radio frames as will be discussed in more detail in the following. The E-UTRAN configures which of the radio frames and subframes can be used for paging in its cell. Each cell broadcasts a default paging cycle Tc, and in addition, upper layers may use dedicated signaling to configure a UE-specific paging cycle TUE; if both are configured, the UE applies the lowest value for the DRX cycle T of the UE.

[0018] In order to explain the procedure for paging as currently defined for LTE-A, the following exemplary cases A, B, and C are defined, as taken from the book LTE – The UMTS Long Term Evolution – From Theory to Practice, Edited by: Stefania Sesia, Issam Toufik, and Matthew Baker, Second Edition, ISBN 9780470660256, section 3.4(NPL 3).

[0019] [Table 1]

Case	UE_ID	T_C	T_{UE}	T	nB	N	Ns	PF	i_s	PO
A	147	256	256	256	64	64	1	76	0	9
B	147	256	128	128	32	32	1	76	0	9
C	147	256	128	128	256	128	2	19	1	4

[0020] The following parameters are used in said respect:

- "TC" is the cell-specific default paging cycle, and can be 32, 64, 128, or 256 radio frames,

- "TUE" is the UE-specific paging cycle of the UE, and can be 32, 64, 128, or 256 radio frames,

- "N" is the number of paging frames within the paging cycle of the UE, and is min (T, nB),

- Ns is the number of paging subframes in a radio frame that may be used for paging, and is max (1, nB/T),

[0021] - nB is the number of paging subframes per paging cycle (across all UEs in the cell), and can be 4T, 2T, T, T/2, T/4, T/8, T/16, T/32; the parameter determines to a large extent the paging capability of the eNB across all UEs in the cell. In general, if nB is set equal to or larger than T, all radio frames may be used for paging (see also parameter N), and there are nB/T POs per PF (see also parameter Ns). In turn, if nB is set lower than T, only a fraction nB/T of the radio frames may be used for paging (see also parameter N), and there is one PO per PF (see also parameter Ns).

[0022] - "T" is the DRX cycle of the UE (also termed paging cycle), is min of TC and TUE,

and specifies how frequently a UE monitors for paging, where a shorter DRX cycle decreases the time for paging but increases battery consumption.

[0023] For example, for cases A and B E-UTRAN has configured one out of every four radio frames and specifically one subframe in each of those radio frames, to be used for paging (see T, Ns, respectively). For case C, there are two subframes in each radio frame that can be used for paging, i.e. Ns=2, and 128 paging frames within the UE's paging cycle, i.e. N=128, available for paging the UEs in the cell. Furthermore, for case B, there are 32 paging frames within the UE's paging cycle (N=32). Across these generally-available paging opportunities configured by the eNB, the paging possibilities for paging the UEs are distributed based on the UE identity.

[0024] In said respect, the particular radio frame and subframe used for paging a particular UE is calculated as follows. A Paging Occasion (PO) is a subframe where there may be a P-RNTI (Paging radio network temporary identity) transmitted on PDCCH addressing the paging message. A Paging Frame (PF) is a radio frame, which may contain one or multiple Paging Occasion(s). In the context of this patent application, the term paging possibility shall refer to the combination of the paging frame and paging subframe.

[0025] The paging frames and paging occasions are defined for example in 3GPP TS 36.304, current version 12.0.0, subclause 7, incorporated herein by reference. Accordingly, the paging frame number (SFN) is calculated according to the following formula:

SFN mod T = (T div N)*(UE_ID mod N)

where UE_ID is IMSI mod 1024.

[0026] When assuming an UE_ID of 147 for all three cases A, B, and C, calculating the above formula results in the paging frame 76 for cases A and B, and paging frame 19 for case C. Furthermore, i_s would be calculated to be 0 for cases A and B, and be 1 for case C.

[0027] The paging occasion has values in the range of [0, 1, ... 9], as in LTE there are 10 subframes within one radio frame. The paging occasion number is selected from a preconfigured table based on the parameters Ns and i_s calculated according to the following formula:

i_s= floor(UE_ID / N) mod Ns.

[0028] The following table is taken from TS 36.304, current version 12.0.0, and is used to determine the Paging Occasion for a particular UE, based on the above parameters Ns and i_s. The following table is intended for FDD.

[0029]

[Table 2]

	PO when i_s=0	PO when i_s=1	PO when i_s=2	PO when i_s=3
1	9	N/A	N/A	N/A
2	4	9	N/A	N/A
4	0	4	5	9

[0030] Therefore, for case A and B, with Ns=1 and i_s=0, the table would yield the subframe number 9, such that the UE for cases A and B would be paged regularly in subframe 9 of radio frame 76 of every paging cycle; i.e. for case A next radio frame 332 and for case B next radio frame 204 etc. For case C, the UE would be paged regularly in subframe 4 of radio frame 19 of every paging cycle, i.e. next radio frame 147 etc.

[0031] The paging frame and paging occasion for the above-discussed cases B and C, is exemplarily depicted in Fig. 3.

[0032] Paging-NAS

For instance, in order to re-establish a connection towards a UE in idle mode, the MME - having been informed e.g. by the UE's P/SGW - sends a paging request message to all eNBs that are part of the so-called tracking area(s) to which the UE belongs and within which the UE can move without having to perform the Tracking Area Update (TAU) procedure (except the periodic TAU procedure).

[0033] When receiving the paging request, the eNodeB(s) of the tracking area(s) then broadcast(s) another paging message over the radio interface in the cells The UE is notified about the paging based on the P-RNTI on the PDCCH and then receives the paging message transmitted over the PDSCH, in the radio resources as indicated by the PDCCH paging notification. When the UE in RRC idle receives the paging message/ signal, it transfers from IDLE to CONNECTED state and establishes an RRC connection with that eNB where it is camped in IDLE mode (e.g. the UE initiates the RRC connection establishment procedure).

[0034] A system overview and message exchange is exemplarily illustrated in Fig. 4, assuming that the UE to be paged by the MME (as triggered by the SGW) is registered at tracking areas TAC1 and TAC3. Consequently, the MME will provide the S1AP paging request to the eNBs of those tracking areas, which in turn will transmit a page at the UE-specific paging possibility (i.e. the PDCCH notification) and then the paging message on the PDSCH resources. The UE is consequently notified about the paging, receives the paging message on the PDSCH, and after confirming its own identity in the paging message, processes the paging message and responds to the paging by e.g. by sending a service request to the MME.

[0035] In the current LTE system, the paging message transmitted from the MME to the eNB, and its content, are defined e.g. by 3GPP TS 36.413, current version 12.4.0(NPL 4), in sub-clauses 8.5 and 9.1.6, incorporated herein by reference. The paging message from the MME to the eNB contains amongst other the following information:

[0036] - UE_ID Index Value: known as UE_ID, which is calculated by (IMSI mod 1024). Correspondingly, the UE_ID may have values in the range of [0, 1 ... 1023].

[0037] - UE Paging Identity: can be the IMSI (as stored on the SIM card) or the SAE-Temporary Mobile subscriber ID (S-TMSI) assigned to the UE during the attach procedure. The UE Paging Identity is transmitted from the eNB to the UE in a paging message over the radio interface (i.e. Uu interface).

[0038] - Paging DRX cycle: is the Discontinuous Reception (DRX) cycle configured in the UE (using NAS signalling) or the default DRX cycle broadcast in the System Information Block (SIB). The default DRX cycle is also known as Paging Cycle in the RadioResourceConfigCommon SIB. The UE may use discontinued reception in IDLE mode in order to reduce power consumption. The DRX cycle is a time interval between monitoring Paging Occurrences for a specific UE. The values of the default DRX/paging cycle broadcast in the SIB are 32, 64, 128 or 256 radio frames.

- UE radio Capability for paging: including the radio access capabilities of the UE, including the coverage extension capability.

[0039] The paging message transmitted from the eNodeB is broadcast in a defined paging possibility as explained above. Paging possibilities are known to the eNodeB and the UE so that they send/listen to the paging message at the same time.

[0040] When Discontinues Reception (DRX) is used, the UE needs only to monitor one PO per DRX cycle.

[0041] As mentioned before, the paging initiated by the non-access stratum (NAS) is UE specific. Consequently, the UE is paged by using the IMSI (or S-TMSI) of the UE as paging identity in the paging message sent in the PDSCH. Therefore, for each UE a separate paging message has to be transmitted from the MME to the eNB(s), which has then to be broadcast from the corresponding eNB(s).

[0042] The paging message transmitted from the eNodeB to the UE is defined in TS 36.331, current version 12.4.1, subclause 6.2.2 Message definition, section "Paging", incorporated herein by reference. This message may contain the following:

[0043] - cmas-Indication: if present, indication of a CMAS notification

- cn-Domain: indicates the origin of paging

- eab-ParamModification: if present, indication of an EAB parameter (SIB14) modification

- etws-Indication: if present, indication often ETWS primary/secondary notification

- imsi: The International Mobile Subscriber Identity, a globally unique permanent

subscriber identity; can also be part of the Paging UE-Identity below

- systemInfoModification: if present, indication of a BCCH modification, other than SIB10-SIB12, SIB14

- ue-Identity: provides the NAS identity of the UE that is being paged

[0044] In the above description, it has been assumed that the UE is in an idle state when receiving the paging, such that the paging message is sent to the UE addressed to the P-RNTI on PDCCH at the UE-specific paging possibilities (based on IMSI of this UE) where the UE verifies that the paging message is indeed intended for it by checking the IDs in the included paging records.

[0045] However, also UEs in RRC connected state may be paged. In this case a downlink information transfer (DLInformationTransfer), containing the paging related information from the NAS, is sent to the UE addressed to the C-RNTI (Cell-RNTI, a unique ID used for identifying RRC connection and scheduling dedicated to a particular UE) on the PDCCH. The DLInformationTransfer message is used for the downlink transfer of NAS or non-3GPP dedicated information. The RRC layer is transparent for this information. For more information, reference is made to TS 36.331, current version 12.4.1, subclause 5.6.1 "DL information transfer" and 6.2.2 "Message definitions" section DLInformationTransfer, incorporate herein by reference.

[0046] Paging from eNB

One of the reasons for an eNodeB to page the UE is a change of system information. In general a change of system information only occurs at specific radio frames, thus implementing the concept of a modification period. System information may be transmitted a number of times with the same content within a modification period. When the network changes (some of) the system information, it first notifies the UEs about this change, which may be done throughout a modification period. In the next modification period, the network then transmits the updated system information. Upon receiving a change notification, the UE acquires the new system information immediately from the start of the next modification period. A paging message is used to inform the UEs in RRC idle and UEs in RRC connected state about a system information change (as mentioned e.g. in TS 36.304, current version 12.0.0, subclause 6.1). If the UE receives a paging message including the systemInfoModification, it knows that the system information will change at the next modification period and boundary. In said case, the UE does not need to check for the UE_ID (not included in the paging message), in view of the presence of the systemInfoModification. Further information in said respect can be found in TS 36.331, current version 12.4.1, subclause 5.2.1.3, incorporated herein by reference.

[0047] Another reason for the eNodeB to page the UEs is an ETWS (Earthquake and Tsunami Warning system) notification, where the paging message is used to inform

ETWS-capable UEs in RRC idle and in RRC connected state about the presence of an ETWS primary/secondary notification. Further information in said respect can be found in TS 36.331, current version 12.4.1, subclause 5.2.1.4, incorporated herein by reference. The paging message may also be used to inform CMAS-capable UEs in RRC idle and RRC connected state about the presence of one or more CMAS (Commercial Mobile Alert System) notifications. Further information in said respect can be found in TS 36.331, current version 12.4.1, subclause 5.2.1.5, incorporated herein by reference. Still another reason for the eNB to page UEs in its cell relates e.g. to Enhanced Access Barring for MTC devices, EAB, as explained for example in TS 36.331, current version 12.4.1, subclause 5.2.1.6 incorporated herein by reference.

[0048] For UEs in both RRC connected and idle state the eNB sends a paging notification to the UE(s) addressed to the P-RNTI on the PDCCH at all possible paging occasions (e.g. at subframes 0, 4, 5, and 9) and at all possible paging frames (e.g. N different radio frames in total, calculated according to SFN mod T=T/N (UE_ID mod N) for every possible "UE_ID mod N" value) irrespective of the IMSI of a particular UE in the cell. By transmitting the paging message at all possible paging possibilities within a paging cycle, the eNB ensures that all the UEs receive the paging message. The detailed definitions for determining the paging occasions and paging frames are given above.

[0049] Machine Type Communication (MTC)

As LTE deployments evolve, operators strive to reduce the cost of overall network maintenance by minimizing the number of RATs. In this respect, Machine-Type Communications (MTC) devices is a market that is likely to continue expanding in the future.

[0050] Many MTC devices are targeting low-end (low cost, low data rate) applications that can be handled adequately by GSM/GPRS. Owing to the low cost of these devices and good coverage of GSM/GPRS, there is very little motivation for MTC device suppliers to use modules supporting the LTE radio interface.

[0051] As more and more MTC devices are deployed in the field, this naturally increases the reliance on GSM/GPRS networks. This will cost operators not only in terms of maintaining multiple RATs, but also prevent operators reaping the maximum benefit out of their spectrum (given the non-optimal spectrum efficiency of GSM/GPRS). With users and traffic becoming denser, using more spectral-efficient technologies, such as Long Term Evolution (LTE), allow the operators to utilize their spectrum in a much more efficient way.

[0052] Given the likely high number of MTC devices, the overall resource they will need for service provision may be correspondingly significant, and inefficiently assigned (for further details on objectives for MTC, see for example 3GPP, RP-111112, Vodafone:

"Provision of low-cost MTC UEs based on LTE"(NPL 5), section 4, available at http://www.3gpp.org and incorporated herein by reference).

[0053] Approaches to lower the cost of LTE presently regard the volume of products as the primary reason. The impact of volume can be seen in two possible ways, depending on how low-cost MTC is developed. Firstly, if low-cost MTC may be very similar to mainline LTE and included in LTE chipsets, MTC has the benefit of the volume of LTE. Secondly, a low-cost MTC based on LTE may have significantly lower cost than mainline LTE. Although it appears not to have the volume benefit of LTE, the volume of MTC devices can be even larger due to a potentially greater number of supported MTC applications and scenarios.

[0054] In this respect, the following approaches to lower the cost of LTE, i.e. defining low-cost MTC are discussed and found to have significant UE cost impact (for further details on low-cost MTC devices, see for example 3GPP, R1-112912, Huawei, HiSilicon, CMCC: "Overview on low-cost MTC UEs based on LTE"(NPL 6), section 4, available at http://www.3gpp.org and incorporated herein by reference):

[0055] - Reduction in supported bandwidth for the low-cost LTE: The low cost of 1.4 MHz (6 RB) downlink bandwidth could cover most application scenarios of MTC. However, 3 MHz (15 RB) or 5 MHz (25 RB) could be considered given that the complexity does not increase much. Given that the uplink may have a larger requirement for MTC services, the possibility of reduced transmit power, and small baseband complexity (relative to downlink reception), any reduction in minimum transmission bandwidth in the UE should be carefully justified.

[0056] - Modified PDCCH-related design for the low-cost LTE to simplify the PDCCH blind decoding and give efficient channel access for a large number of MTC devices. A reduction in maximum bandwidth (e.g., 1.4MHz) decreases PDCCH blind decoding naturally.

[0057] - Protocol simplification including HARQ consideration, MAC, RLC and RRC protocol. Signaling reduction between low duty cycle MTC devices and the base station.

- Transmission modes down-selection to maintain coverage and balance complexity.

[0058] Further considerations on low-cost MTC devices relate to an improved indoor coverage. A number of applications require indoor deployment of Machine Type Communication, MTC, devices, e.g. in an apartment basement, or on indoor equipment that may be close to the ground floor etc. These UEs would experience significantly greater penetration losses on the radio interface than normal LTE devices. This effectively means that indoor coverage should be readily available and reliable: i.e. should provide a significant improvement on existing coverage.

[0059] Additionally, regarding the power consumption of low-cost MTC devices it is noted

that many applications require devices to have up to ten years of battery life. In this respect, presently available Power Save Modes appear not sufficient to achieve the envisaged battery life. In this respect, it is anticipated that further techniques are proposed to significantly cut down the power usage of MTC devices e.g. by optimizing signaling exchanges in the system, in order to realize battery life of up to ten years.

[0060] Enhanced Coverage mode (EC mode)

For improving indoor coverage (for low-cost MTC devices), recent developments have focused on an Enhanced Coverage, EC, mode that is applicable to UEs e.g. operating delay tolerant MTC applications. Another term is "Coverage Extension". The corresponding Work Item in 3GPP Release 12 "Low cost & enhanced coverage MTC UE for LTE" came to the conclusion that further complexity reduction of LTE devices for MTC can be achieved if additional complexity reduction techniques are supported, as apparent from the study report TR 36.888. The study report TR 36.888 concluded that a coverage improvement target of 15-20 dB for both FDD and TDD in comparison to a normal LTE footprint could be achieved to support the use cases where MTC devices are deployed in challenging locations, e.g. deep inside buildings, and to compensate for gain loss caused by complexity-reduction techniques. MTC coverage enhancements are now expected to be introduced in 3GPP Release 13.

[0061] The general objective is to specify a new UE for MTC operation in LTE that allows for enhanced coverage and lower power consumption. Some of the additional objectives are given below:

- Reduced UE bandwidth of 1.4 MHz in downlink and uplink.

-- Bandwidth reduced UEs should be able to operate within any system bandwidth.

-- Frequency multiplexing of bandwidth reduced UEs and non-MTC UEs should be supported.

-- The UE only needs to support 1.4 MHz RF bandwidth in downlink and uplink.

-- The allowed re-tuning time supported by specification (e.g. ~0 ms, 1 ms) should be determined by RAN4.

[0062] - Reduced maximum transmit power.

-- The maximum transmit power of the new UE power class should be determined by RAN4 and should support an integrated PA implementation.

[0063] - Reduced support for downlink transmission modes.

[0064] - The following further UE processing relaxations can also be considered within this work item:

-- Reduced maximum transport block size for unicast and/or broadcast signalling.

-- Reduced support for simultaneous reception of multiple transmissions.

-- Relaxed transmit and/or receive EVM requirement including restricted modulation scheme. Reduced physical control channel processing (e.g. reduced number of blind

decoding attempts).

-- Reduced physical data channel processing (e.g. relaxed downlink HARQ time line or reduced number of HARQ processes).

-- Reduced support for CQI/CSI reporting modes.

[0065] A relative LTE coverage improvement - corresponding to 15 dB for FDD - for the UE category/type defined above and other UEs operating delay-tolerant MTC applications with respect to their respective normal coverage shall be possible. At least some of the following techniques, which shall be applicable for both FDD and TDD, can be considered to achieve this:

[0066] - Subframe bundling techniques with HARQ for physical data channels (e.g. PDSCH, PUSCH)

- Elimination of use of control channels (e.g. PCFICH, PDCCH)

- Repetition techniques for control channels (e.g. PBCH, PRACH, (E)PDCCH)

- Either elimination or repetition techniques (e.g. PBCH, PHICH, PUCCH)

- Uplink PSD boosting with smaller granularity than 1 PRB

- Resource allocation using EPDCCH with cross-subframe scheduling and repetition (EPDCCH-less operation can also be considered)

[0067] - New physical channel formats with repetition for SIB/RAR/Paging

- A new SIB for bandwidth reduced and/or coverage enhanced UEs

- Increased reference symbol density and frequency hopping techniques

- Relaxed "probability of missed detection" for PRACH and initial UE system acquisition time for PSS/SSS/PBCH/SIBs can be considered as long as the UE power consumption impact can be kept on a reasonable level.

- Spreading: Spreading refers to spreading of information across resources including time-frequency domain resources or even spreading using Scrambling (or Channelization) codes.

[0068] There can be also other techniques than those listed above.

The amount of coverage enhancement should be configurable per cell and/or per UE and/or per channel and/or group of channels, such that different levels of coverage enhancements exist. The different levels of coverage enhancement could mean different level of CE techniques being applied to support the CE-device transmission and reception. Relevant UE measurements and reporting to support this functionality should be defined.

[0069] For more details, see for example 3GPP RP-141865 "Revised WI: Further LTE Physical Layer Enhancements for MTC"(NPL 7) sourced by Ericsson, available at http://www.3gpp.org and incorporated herein by reference.

[0070] Notably, coverage enhancements of 15/ 20 dB for UEs in the Enhanced Coverage mode with respect to their nominal coverage means that the UEs have to be capable of

receiving extremely low signal strengths. This applies not only to the initial scanning operation, the cell search and the cell selection operation but also the subsequent communication scheme to be performed by the UE.

[0071] Early attempts to define the Enhanced Coverage mode have focused on modifications of the radio transmissions. In this respect, discussions have focused on repeated transmissions as being the main technique to improve the coverage. Repetitions can be applied to every channel for coverage improvement.

[0072] An exemplary implementation of these repeated transmissions prescribes that the same data is transmitted across multiple sub-frames. Yet, it will become immediately apparent that these repeated transmissions will use more resource blocks (time-frequency) resources than required for normal coverage UEs.

Citation List

Non Patent Literature

[0073] NPL 1: 3GPP TS 36.304, "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) procedures in idle mode", version 12.0.0

NPL 2: 3GPP TS 36.331, "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification", version 12.4.1

NPL 3: Theory to Practice, Edited by: Stefania Sesia, Issam Toufik, and Matthew Baker, Second Edition, ISBN 9780470660256, section 3.4

NPL 4: 3GPP TS 36.413, "Evolved Universal Terrestrial Radio Access Network (E-UTRAN); S1 Application Protocol (S1AP) ", version 12.4.0

NPL 5: 3GPP, RP-111112, Vodafone: "Provision of low-cost MTC UEs based on LTE"

NPL 6: 3GPP, R1-112912, Huawei, HiSilicon, CMCC: "Overview on low-cost MTC UEs based on LTE"

NPL 7: 3GPP RP-141865 "Revised WI: Further LTE Physical Layer Enhancements for MTC"

NPL 8: 3GPP TS 36.214, "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer; Measurements", version 10.1.0

Summary

[0074] One non-limiting and exemplary embodiment provides an improved method for paging all user equipments in a cell, particularly involving user equipments which need coverage extension. Another non-limiting and exemplary embodiment provides an improved method for paging one user equipment in a cell, particularly a user equipment which needs coverage extension.

The independent claims provide non-limiting and exemplary embodiments. Advantageous embodiments are subject to the dependent claims.

According to a first aspect, the present disclosure improves the paging procedure by which a radio base station can page the user equipments in its cell, particularly for the case where the paging shall also reach user equipments which require coverage extension, i.e. user equipments that are in poor radio conditions but support coverage extension techniques as explained in the background section. The first aspect refers to the case were paging is initiated by the radio base station and shall reach all user equipments in the cell of the radio base station; in other words, the paging is not UE specific but cell specific, and can be for example used so as to broadcast a warning message or to inform UEs about an imminent system information change.

[0075] Consequently, the paging must reach user equipments that require coverage extension as well as "normal" user equipments which do not require coverage extension. One main idea of the first aspect is the definition of a coverage-extension-specific paging possibility, which is specifically defined for those user equipments that support coverage extension techniques, and more precisely which need coverage extension to be reliably reached. Correspondingly, the CE-UEs not only monitor the UE-specific paging possibility, calculated based on their identities, but additionally monitor a (at least one) different paging possibility dedicated to achieve coverage extension paging. Both CE-user equipments in idle and connected state can be configured to monitor this CE-specific paging possibility. Consequently, in order to reach those CE-UEs, the radio base station pages the CE-UEs at said CE-specific paging possibility, and uses one of the plurality of available techniques (e.g. repetition or increased transmission power) for extending the coverage of the paging and thus to reliably reach the CE-UE.

[0076] Like a usual UE-specific paging possibility, this CE-specific paging possibility is defined by a particular radio frame number and subframe number, and occurs regularly e.g. at every paging cycle.

[0077] Since the CE-specific paging possibility shall preferably only be monitored by CE-UEs, the radio base station still needs to reach the other non-CE-UEs and can thus, as described in the background section, perform the paging at all possible paging possibilities of a paging cycle, so as to reach all UEs in the cell. In this case the radio base station would not use a coverage extension technique, since the radio base station can be sure that the CE-UEs will be reached by the paging at the CE-specific paging possibility and not for all possible.

[0078] One advantage of the above-described first aspect is that, by providing one dedicated paging possibility for CE-UEs, downlink resources can be saved. The coverage extension techniques, which can be a heavy burden to the radio base station(s) are applied in a very limited manner, namely for just one paging possibility.

[0079] One set of variants of the first aspect differs as to how this CE-specific paging pos-

sibility is defined. In general, it can be said that the CE-specific paging possibility must be known to both the CE-UE(s) and the radio base station(s), so as to ensure that the paging can be successful. However, how exactly the CE-specific paging possibility is defined can vary. One solution is that the radio frame number and the subframe number of the CE-specific paging possibility is fixed beforehand such that corresponding information can be e.g. pre-stored at the radio base station and the CE-UE (e.g. in the USIM), or the radio base station can broadcast same in its cell. Another possible solution is that a plurality of possible paging subframes, generally configured for the system by the radio base station, is divided to be used either as a UE-specific paging subframe or as a CE-specific paging subframe. By correspondingly configuring the paging parameter(s) (e.g. nB) of normal UEs and CE-UEs it is possible that CE-UEs are assigned e.g. one normal UE-specific paging subframe and one CE-specific paging subframe. Still another solution is based on an additional CE-specific UE identity that is assigned exclusively to CE-UEs and which can be used for calculating the CE-specific paging possibility; in addition, as in the prior art, the UE-specific paging possibility is calculated based on the usual identity of the CE-UE (e.g. IMSI).

[0080] According to a second aspect, the paging procedure by which a radio base station pages a user equipment which requires coverage extension in its cell is improved. This second aspect refers to the case where the paging is initiated in the core network (NAS) and is destined to a single UE (or a very limited number of UEs), in contrast to the first aspect dealing with cell-wide paging initiated by the eNB. The paging which is directed at a particular CE-UE shall reliably reach the CE-UE, and thus the radio base station shall use one appropriate coverage extension technique for the CE paging. In order to avoid unnecessary CE paging from the radio base station, the CE-capable UEs will implement a measurement and reporting procedure according to which the radio base station is informed as to the current CE status of the UE. The radio base station will thus only perform a CE paging for a CE-capable UE that is indeed currently in the CE status, i.e. currently requiring coverage extension. CE-UEs, although CE capable, will not be paged with a coverage extension technique, if the status of the CE-capable UE, informed to the radio base station, indicates that no coverage extension is actually required by this CE-capable UE at the moment.

[0081] Appropriate radio measurements are regularly performed by the CE-capable UE(s) to determine whether coverage extension is necessary or not at the moment. The measurements could also be triggered by the radio base station or a core network entity when being interested in the current CE status. These measurements could include e.g. at least one of RSRQ, RSRP, channel quality, block error rate, or any other suitable measurement parameter. Appropriate threshold(s) can be defined to which the CE-capable UE(s) compare(s) the measurement results to determine whether it requires or

not coverage extension.

[0082] Consequently, a particular CE-capable UE can change it CE-status, i.e. toggle between being a CE-UE (i.e. indeed requiring coverage extension) and a non-CE-UE (i.e. supporting CE but not requiring CE at the moment).

[0083] The radio base station is kept updated on the current CE status of the CE-capable UE and thus (should) knows at the time of paging whether coverage extension is indeed necessary or not for the paging. In order to limit uplink traffic, the informing of the radio base station could be limited to the cases where the CE status of the CE-capable UE is changed, i.e. from non-CE-UE to CE-UE and vice versa. Of course it should also be possible for the CE-capable UE to measure and report such information/ measurements periodically even in the absence of said toggling. In this case, the eNB could, based on its implementation, perform some averaging of the received information including measurement reports and determine that a toggling of CE state is indeed helpful. The step of informing may be done, e.g. directly between the CE-capable UE and the radio base station, e.g. for CE-capable UEs that are in connected state and thus may provide the corresponding CE status to the radio base station. Alternatively, the CE-capable UE may report to a core network entity, which in turn may inform the radio base station, at the latest when triggering for paging; this may be done e.g. for those cases where the CE-capable UE is in idle state and thus has no active connection with the radio base station.

[0084] Correspondingly, the paging for CE-UE is performed by the radio base station by using a CE technique, whereas paging for a non-CE-UE is performed without using a CE technique. The CE-capable UE appropriately receives the CE paging or normal paging.

[0085] Correspondingly, in one general first aspect, the techniques disclosed here feature a method for paging all user equipments in a cell controlled by a radio base station in a mobile communication system. At least one regularly-occurring coverage-extension-specific paging possibility, in short CE-specific paging possibility, is defined for paging user equipments that require coverage extension, in short CE user equipments. The radio base station is capable to use one of a plurality of techniques for achieving a coverage extension for a CE user equipment. The CE user equipments in the cell regularly monitor the at least one CE-specific paging possibility. When the radio base station determines to page all the user equipments in the cell, the radio base station pages the CE user equipments in the cell at the CE-specific paging possibility, using one of the plurality of techniques for achieving the coverage extension.

[0086] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, a plurality of UE-specific paging possibilities is defined for paging a specific user equipment in the cell of the radio base station. The

CE user equipments and non-CE user equipments each monitor a respective UE-specific paging possibility out of the plurality of UE-specific paging possibilities. The radio base station — upon determining to page all the user equipments in the cell - additionally performs paging at all of the plurality of UE-specific paging possibilities without using one of the plurality of techniques for achieving coverage extension. According to a further example, each of the plurality of UE-specific paging possibilities is different from the at least one CE-specific paging possibility.

[0087] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, each of the at least one CE-specific paging possibility refers to radio resources of a control channel defined by a radio frame number and subframe number and is repeated every paging cycle. The at least one CE-specific paging possibility is only monitored by CE user equipments. For example, the at least one CE-specific paging possibility is monitored by CE user equipments in idle state and CE user equipments in connected state.

[0088] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, the step of paging includes transmitting by the radio base station a first paging notification at radio resources of a control channel specified by the at least one CE-specific paging possibility, and includes transmitting by the radio base station a second paging message at radio resources of another channel specified by the first paging notification. For example, the technique for achieving the coverage extension is applied to both steps of transmitting the first paging notification and of transmitting the second paging message.

[0089] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, the plurality of techniques for achieving the coverage extension comprise at least one of a repetition technique where a message is repeated by the radio base station for a pre-configured number of times, an increase in transmission power, where a message is transmitted by the radio base station with an increased transmission power, a bundling technique where a .same message is transmitted in a plurality of consecutive subframes, and a spreading technique where a message is transmitted by a larger resource, e.g. via a larger frequency-time resource or channelization code.

[0090] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, the step of determining by the radio base station to page all user equipments in the cell is triggered by a change of system information applicable to the cell controlled by the radio base station or by the presence of a message, e.g. a warning message, to be broadcast in the cell controlled by the radio base station.

[0091] According to an advantageous variant of the first aspect which can be used in

addition or alternatively to the above, each of the at least one CE-specific paging possibility refers to radio resources of a control channel defined by a radio frame number and a subframe number which are pre-configured such that the radio frame number and the subframe number are fixed for the CE-specific paging possibility. For example, information to determine the pre-configured radio frame number and the pre-configured subframe number is stored in a Universal Subscriber Identity Module, USIM, of the CE user equipment, or broadcast by the radio base station in the cell. Further exemplary, the pre-configured subframe number is 1, 2, 3, 6, 7, or 8.

[0092] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, a plurality of paging possibilities are defined for paging in the cell of the radio base station, wherein a first value of at least one parameter for calculating the UE-specific paging possibility is different from a second value of the at least one parameter for calculating a CE-specific paging possibility such that the plurality of paging possibilities are divided to be used either as the CE-specific paging possibility or the UE-specific paging possibility. CE user equipments are configured to use the first value of the at least one parameter for calculating the UE-specific paging possibility and to use the second value of the at least one parameter for calculating the CE-specific paging possibility. Non-CE user equipments are configured to use the first value of the at least one parameter for calculating the UE-specific paging possibility and to not calculate the CE-specific paging possibility.

[0093] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, 6, wherein CE user equipments are assigned a CE-specific user equipment identity based on which the CE-specific paging possibility is calculated by the radio base station and the CE user equipments. For example, the CE-specific user equipment identity is the same for all CE-configured user equipments, and the CE-specific user equipment identity is stored in a Universal Subscriber Identity Module, USIM, of the CE user equipment or broadcast by the radio base station in the cell. Further for example, a plurality of different levels of coverage extension is defined, and wherein for each level of coverage extension a different CE-specific user equipment identity is defined.

[0094] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, wherein a plurality of different levels of coverage extension is defined, and wherein for each level of coverage extension a different CE-specific paging possibility is defined for paging the CE user equipments configured for that level of coverage extension.

[0095] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, the radio base station determines whether there are CE user equipments in idle state in its cell by performing a counting procedure

where the CE user equipments in idle state inform the radio base station about their presence in the cell controlled by the radio base station. For example, the determination is only performed in case there are no CE user equipments in connected state in the cell.

[0096] Correspondingly, in one general first aspect, the techniques disclosed here feature a user equipment located in a cell controlled by a radio base station in a mobile communication system. The user equipment, in short CE user equipment, requires coverage extension, wherein at least one regularly-occurring coverage-extension-specific paging possibility, in short CE-specific paging possibility, is defined for the CE user equipment. The radio base station is capable to use one of a plurality of techniques for achieving a coverage extension for the CE user equipment. A processor of the CE user equipment regularly monitors the at least one CE-specific paging possibility. A receiver of the CE user equipment receives a paging from the radio base station at the CE-specific paging possibility, using one of the plurality of techniques for achieving the coverage extension.

[0097] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, a plurality of UE-specific paging possibilities is defined for paging a specific user equipment in the cell of the radio base station. The processor of the CE user equipment monitors a respective UE-specific paging possibility out of the plurality of UE-specific paging possibilities. In a further example, each of the plurality of UE-specific paging possibilities is different from the at least one CE-specific paging possibility.

[0098] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, wherein each of the at least one CE-specific paging possibility refers to radio resources of a control channel defined by a radio frame number and subframe number and is repeated every paging cycle. In a further example, the at least one CE-specific paging possibility is monitored by the CE user equipment when in idle state and when in connected state.

[0099] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, the receiver receiving the paging includes: receiving a first paging notification at radio resources of a control channel specific by the at least one CE-specific paging possibility, and includes receiving a second paging message at radio resources of another channel specific by the first paging notification. In a further example, the technique for achieving the coverage extension is used by the CE user equipment to both receive the first paging notification and receive the second paging message.

[0100] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, each of the at least one CE-specific paging pos-

sibility refers to radio resources of a control channel defined by a radio frame number and a subframe number which are pre-configured such that the radio frame number and the subframe number are fixed for the CE-specific paging possibility. In a further example, a memory of the CE user equipment is adapted to store information to determine the pre-configured radio frame number and the pre-configured subframe number. Exemplarily, the memory is a Universal Subscriber Identity Module, USIM, of the CE user equipment. Or, the receiver of the CE user equipment receives information to determine the pre-configured radio frame number and the pre-configured subframe number, broadcast by the radio base station in the cell.

[0101] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, the CE user equipment is assigned a CE-specific user equipment identity, wherein the processor of the CE user equipment is adapted to calculate the CE-specific paging possibility based on the CE-specific user equipment identity. Exemplarily, the CE-specific user equipment identity is the same for all CE-configured user equipments. In a further example, a plurality of different levels of coverage extension is defined. For each level of coverage extension a different CE-specific user equipment identity is defined.

[0102] Correspondingly, in one general first aspect, the techniques disclosed here feature a radio base station for paging all user equipments in a cell controlled by the radio base station in a mobile communication system. At least one regularly-occurring coverage-extension-specific paging possibility, in short CE-specific paging possibility, is defined for paging user equipments that require coverage extension, in short CE user equipments. The radio base station is capable to use one of a plurality of techniques for achieving a coverage extension for a CE user equipment. A processor of the radio base station determines whether to page all the user equipments in the cell. A transmitter of the radio base station pages the CE user equipments in the cell at the CE-specific paging possibility, using one of the plurality of techniques for achieving the coverage extension.

[0103] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, a plurality of UE-specific paging possibilities are defined for paging a specific user equipment in the cell of the radio base station, wherein transmitter of the radio base station – upon the processor determining to page all the user equipments in the cell – additionally pages at all of the plurality of UE-specific paging possibilities without using one of the plurality of techniques for achieving coverage extension. For example, each of the plurality of UE-specific paging possibilities is different from the at least one CE-specific paging possibility.

[0104] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, the transmitter of the radio base station is

adapted to transmit a first paging notification at radio resources of a control channel specified by the at least one CE-specific paging possibility, and to transmit a second paging message at radio resources of another channel specified by the first paging notification. Exemplarily, the technique for achieving the coverage extension is applied to both the transmitting of the first paging notification and the transmitting of the second paging message.

[0105] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, the processor determines to page all the user equipments in the cell when being triggered by a change of system information applicable to the cell controlled by the radio base station or by the presence of a message, e.g. a warning message, to be broadcast in the cell controlled by the radio base station.

[0106] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, each of the at least one CE-specific paging possibility refers to radio resources of a control channel defined by a radio frame number and a subframe number which are pre-configured such that the radio frame number and the subframe number are fixed for the CE-specific paging possibility. Exemplarily, information to determine the pre-configured radio frame number and the pre-configured subframe number is stored in the radio base station, wherein the transmitter of the radio base station broadcasts the information to determine the pre-configured radio frame number and subframe number.

[0107] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, a CE-specific user equipment identity is assigned to the CE user equipments, wherein the processor of the radio base station is adapted to calculate the CE-specific paging possibility based on the CE-specific user equipment identity. Exemplarily, the transmitter of the radio base station is adapted to broadcast the CE-specific user equipment identity in the cell.

[0108] According to an advantageous variant of the first aspect which can be used in addition or alternatively to the above, the processor of the radio base station determines whether there are CE user equipments in idle state in its cell by performing a counting procedure. Exemplarily, the determination is only performed in case there are no CE user equipments in connected state in the cell.

[0109] Correspondingly, in one general second aspect, the techniques disclosed here feature a method for paging a user equipment in a cell controlled by a radio base station in a mobile communication system. The user equipment supports coverage extension techniques, wherein the radio base station is capable to use one of a plurality of techniques for achieving a coverage extension for the CE-capable user equipment. Radio measurements are performed by the CE-capable user equipment, which determines whether coverage extension is necessary or not, based on the results of the

radio measurements. The radio base station is informed about whether the CE-capable user equipment needs coverage extension or not, based on the determination result. When paging the CE-capable user equipment, the radio base station applies or not applies one of the plurality of techniques for achieving coverage extension depending on whether coverage extension is necessary or not for the CE-capable user equipment.

[0110] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the radio measurements performed by the CE-capable user equipment include measurements of a Reference Signal Received Power, RSRP, and/or Reference Signal Received Quality, RSRQ, and/or a channel quality, and/or a block error rate and/ or HARQ operating point.

[0111] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the step of determining whether coverage extension is necessary comprises the step of comparing by the CE-capable user equipment the result of the radio measurements with a first threshold to determine whether coverage extension is necessary. For example, the comparison determines that coverage extension is necessary when the result of the radio measurements falls below the first threshold. The step further comprises comparing by the CE-capable user equipment the result of the radio measurements with a second threshold to determine whether coverage extension is not necessary. For example, the comparison determines that coverage extension is not necessary when the result of the radio measurement exceeds the second threshold.

[0112] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the step of informing the radio base station about the CE-capable user equipment needing coverage extension or not, includes the steps of either transmitting by the CE-capable user equipment information about whether the CE-capable user equipment needs coverage extension or not to the radio base station. In this case, for example the CE-capable user equipment is in a connected state. In a further example, it is avoided that the CE-capable user equipment is changing into the idle state by keeping it in the connected state. Alternatively, the step of informing includes the steps of transmitting by the CE-capable user equipment information about whether the CE-capable user equipment needs coverage extension or not to a core network entity. In this case, the core network entity provides the received information to the radio base station. For example, the CE-capable user equipment is in a connected state or in an idle state. In a further example, the core network entity is a mobility management entity.

[0113] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the radio base station is triggered to page the CE-capable user equipment by a core network entity that initiates and controls the paging,

preferably wherein the core network entity initiating the paging is a mobility management entity.

[0114] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the steps of performing the radio measurements and of determining whether coverage extension is necessary or not is performed regularly at a pre-configured time interval and/or triggered by the radio base station.

[0115] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the step of informing the radio base station is only performed when the result of the determination is different from the result of the determination previously informed to the radio base station.

[0116] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the radio base station determines whether the CE-capable user equipment needs coverage extension or not based on the radio resources selected by the CE-capable user equipment for initially attaching to the radio base station; for example, based on the selected preamble or access slot used for a random access procedure performed by the CE-capable user equipment when initially attaching to the radio base station.

[0117] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the step of paging the CE-capable user equipment comprises the steps of transmitting by the radio base station a first paging notification at radio resources of a control channel specified by a paging possibility specific to the CE-capable user equipment, and transmitting by the radio base station a second paging message at radio resources of another channel specified by the first paging notification. In a further example, the technique for achieving the coverage extension is applied to both steps of transmitting the first paging notification and of transmitting the second paging message.

[0118] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, upon successfully being paged by the radio base station, the CE-capable user equipment informs the radio base station about the successful paging, and the radio base station can inform a core network entity responsible for initiating the paging about the successful paging.

[0119] Correspondingly, in one general second aspect, the techniques disclosed here feature a user equipment located in a cell controlled by a radio base station in a mobile communication system. The user equipment, in short CE user equipment, supports coverage extension techniques. The radio base station is capable to use one of a plurality of techniques for achieving a coverage extension for the CE-capable user equipment. A processor of the CE user equipment performs radio measurements, and determines whether coverage extension is necessary or not, based on the results of the

radio measurements. A transmitter of the CE user equipment informs the radio base station about whether the CE-capable user equipment needs coverage extension or not, based on the determination result. A receiver of the CE user equipment receives paging from the radio base station, applying or not applying one of the plurality of techniques for achieving coverage extension depending on whether coverage extension is necessary or not.

[0120] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the radio measurements performed by the CE-capable user equipment include measurements of a Reference Signal Received Power, RSRP, and/or Reference Signal Received Quality, RSRQ, and/or a channel quality, and/or a block error rate and/ or HARQ operating point.

[0121] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the processor determines whether coverage extension is necessary or not by comparing the result of the radio measurements with a first threshold to determine whether coverage extension is necessary. For example, the comparison determines that coverage extension is necessary when the result of the radio measurements falls below the first threshold. Furthermore, the result of the radio measurements is compared with a second threshold to determine whether coverage extension is not necessary. For example, the comparison determines that coverage extension is not necessary when the result of the radio measurement exceeds the second threshold.

[0122] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the transmitter informs the radio base station by transmitting information about whether the CE-capable user equipment needs coverage extension or not to the radio base station. For example, the CE-capable user equipment is in a connected state, and furthermore it is avoided that the CE-capable user equipment is changing into the idle state by keeping it in the connected state. Alternatively, information about whether the CE-capable user equipment needs coverage extension or not is transmitted to a core network entity. The core network entity provides the received information to the radio base station, preferably wherein the CE-capable user equipment is in a connected state or in an idle state.

[0123] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the processor performing the radio measurements and determining whether coverage extension is necessary or not is performed regularly at a pre-configured time interval and/or triggered by the radio base station.

[0124] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the transmitter informs the radio base station

only when the result of the determination is different from the result of the determination previously informed to the radio base station.

[0125] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the receiver receiving the paging includes receiving a first paging notification at radio resources of a control channel specific by a paging possibility specific to the CE-capable user equipment, and receiving a second paging message at radio resources of another channel specific by the first paging notification. For example, the technique for achieving the coverage extension is used by the CE user equipment to both receive the first paging notification and receive the second paging message.

[0126] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the transmitter is further adapted to inform the radio base station about the successful paging.

[0127] Correspondingly, in one general second aspect, the techniques disclosed here feature a radio base station for paging a user equipment in a cell controlled by the radio base station in a mobile communication system. The user equipment supports coverage extension techniques. The radio base station is capable to use one of a plurality of techniques for achieving a coverage extension for the CE-capable user equipment. A receiver of the radio base station receives information about whether the CE-capable user equipment needs coverage extension or not. A transmitter of the radio base station, when paging the CE-capable user equipment, applies or not applies one of the plurality of techniques for achieving coverage extension depending on whether coverage extension is necessary or not for the CE-capable user equipment.

[0128] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the receiver receiving the information includes receiving from the CE-capable user equipment or from a core network entity the information about whether the CE-capable user equipment needs coverage extension or not.

According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, the transmitter of the radio base station transmit a first paging notification at radio resources of a control channel specified by a paging possibility specific to the CE user equipment, and transmit a second paging message at radio resources of another channel specified by the first paging notification. For example, the technique for achieving the coverage extension is applied to both the transmitting of the first paging notification and the transmitting of the second paging message.

[0129] According to an advantageous variant of the second aspect which can be used in addition or alternatively to the above, a receiver of the radio base station receives in-

formation about the successful paging of the CE user equipment, and the transmitter of the radio base station informs a core network entity responsible for initiating the paging about the successful paging.

[0130] Additional benefits and advantages of the disclosed embodiments will be apparent from the specification and Figures. The benefits and/or advantages may be individually provided by the various embodiments and features of the specification and drawings disclosure, and need not all be provided in order to obtain one or more of the same.

[0131] These general and specific aspects may be implemented using a system, a method, and a computer program, and any combination of systems, methods, and computer programs.

Brief Description of Drawings

[0132] [fig.1]Fig.1 shows an exemplary architecture of a 3GPP LTE system.

[fig.2]Fig. 2 shows an exemplary overview of the overall E-UTRAN architecture of 3GPP LTE.

[fig.3]Fig. 3 illustrates cyclical paging frames and paging occasions for two different cases.

[fig.4]Fig. 4 shows a system overview and message exchange for a paging which is initiated by the MME and spread across the different tracking areas at which the UE is registered.

[fig.5]Fig. 5 illustrates the UE-specific paging possibilities and CE-specific paging possibilities of two CE-UEs according to one exemplary first embodiment.

[fig.6]Fig. 6 shows a sequence diagram for the UE behavior according to one exemplary first embodiment.

[fig.7]Fig. 7 shows a sequence diagram for the eNB behavior according to one exemplary first embodiment.

[fig.8]Fig. 8 shows a message sequence diagram for a message exchange for measurement reporting and paging according to one exemplary second embodiment.

[fig.9]Fig. 9 shows a sequence diagram for the UE behavior according to one exemplary second embodiment.

[fig.10]Fig. 10 shows a sequence diagram for the eNB behavior according to one exemplary second embodiment.

Description of Embodiments

[0133] A mobile station or mobile node or user terminal or user equipment is a physical entity within a communication network. One node may have several functional entities. A functional entity refers to a software or hardware module that implements and/or offers a predetermined set of functions to other functional entities of a node or the network. Nodes may have one or more interfaces that attach the node to a commu-

nication facility or medium over which nodes can communicate. Similarly, a network entity may have a logical interface attaching the functional entity to a communication facility or medium over which it may communicate with other functional entities or correspondent nodes.

[0134] The term "radio resources" as used in the set of claims and in the application is to be broadly understood as referring to physical radio resources, such as time-frequency resources.

The term "paging possibility" as used in the set of claims and in the application is to be broadly understood as referring to physical radio resources (frequency-time resources) of a control channel (e.g. the PDCCH), which are defined by a radio frame number (also termed paging frame, PF) and a subframe number (also termed paging occasion, PO).

[0135] The expression "coverage-extension UE" (or "CE UE") as used in the set of claims and in the application is to be broadly understood as referring to a UE which requires coverage extension, e.g. because it is in a bad radio condition. The expression "CE-capable UE" shall be used for a UE supporting the coverage extension techniques, irrespective of whether or not the UE indeed requires coverage extension, i.e. a UE can support coverage extension techniques but can still be understood as a "non-CE UE" in case that no coverage extension is currently necessary. From eNB-perspective, it may be unclear at any particular point in time whether a CE-capable UE indeed requires coverage extension or not. The second embodiment is directed at said drawback.

[0136] Correspondingly, the expression "non-CE-UE" as used in the set of claims and in the application is to be broadly understood as referring to a UE which either does not require coverage extension (even when actually supporting the corresponding CE techniques) or does not support coverage extension techniques.

[0137] The expression "UE-specific paging possibility" as used in the set of claims and in the application is to be broadly understood as that paging possibility which is calculated based on the UE-ID (e.g. IMSI), and should be understood in the context of the CE-specific paging possibility which is specific to only coverage extension. As described in the background section, there is only a limited amount of paging possibilities available, across which the UEs are then disposed depending on their IDs. Although a particular paging possibility may be monitored by several UEs, the paging possibilities are UE-specific in the sense that the paging possibility to be monitored by a UE is determined based on the respective UE-ID.

[0138] The terms "paging notification" and "paging message" are distinguished in the set of claims and in the application to respectively refer to the first PDCCH message (which is basically an indication notifying about a paging message e.g. by use of the common P-RNTI) and the subsequent PDSCH message with the actual paging information. The

term "paging" does not make this distinction and shall cover both.

[0139] The term "CE-page" or "CE-paging" as used in the application shall refer broadly to a paging where one out of a plurality of coverage extension techniques is used. For example, when considering the repetition technique as the CE-technique used by an eNB, the "CE-page" will involve repeating the transmission of both paging messages, i.e. the paging notification on the PDCCH and the actual paging message on the PDSCH, for a pre-configured number of times as defined for the repetition technique.

[0140] As explained in the background section, coverage extension techniques are to be implemented for (MTC) devices, and it is unclear how the coverage extension shall be achieved for the paging procedure. However, expenditure is quite high for any of these techniques, such that they should be only used when necessary. For the paging which is initiated by the eNB, and is directed to all UEs in the cell, the currently-implemented paging is applied to all possible paging possibilities so as to reach all UEs. In order to reach also the CE-UEs, a coverage extension technique may be applied to the paging at all possible paging possibilities, which however results in a high expenditure of resources.

[0141] For the paging which is initiated by the NAS, and is directed to one UE only (or a very limited number of UEs), the MME inform the eNB over the S1 interface about the capability of a RRC_Connected UE to allow coverage extension and thus to support the coverage enhancement techniques mentioned above. However, it is unclear whether the UE is actually requiring coverage extension at the time of the page, (e.g. the UE, e.g. MTC device, moved from the cellar to open terrain). Consequently, the eNB might page the UE at the UE-specific paging possibility by using one of the CE techniques, even though the UE is in a good radio condition and would not have needed a coverage extension page. Again, resources are wasted.

[0142] The following exemplary embodiments are conceived by the inventors to mitigate the problems explained above.

[0143] Some of these are to be implemented in the wide specification as given by the 3GPP standards and explained partly in the background section, with the particular key features as explained in the following pertaining to the various embodiments. It should be noted that the embodiments may be advantageously used for example in a mobile communication system, such as 3GPP LTE-A (Release 10/11/12/13) communication systems as described in the Technical Background section above, but the embodiments are not limited to its use in this particular exemplary communication networks.

[0144] The explanations should not be understood as limiting the scope of the disclosure, but as a mere example of embodiments to better understand the present disclosure. A skilled person should be aware that the general principles of the present disclosure as laid out in the claims can be applied to different scenarios and in ways that are not ex-

plicitly described herein. Correspondingly, the following scenarios assumed for explanatory purposes of the various embodiments shall not limit the present disclosure and its embodiments as such.

[0145] In the following a set of embodiments will be explained. Although in the following embodiment, the broad expressions UE, CE-UE, CE-capable UE, are used, the embodiments may be equally applied for MTC devices, i.e. a CE-MTC device or CE-capable MTC device etc.

[0146] First embodiment

According to a first exemplary embodiment, a paging procedure according to which the eNB can page all the UEs in its cell, including those UEs which require coverage extension (and of course also support coverage extension), is presented.

[0147] For this first embodiment it is assumed that the paging is initiated (i.e. triggered) by the eNB itself; in contrast to paging being initiated by the Non-Access-Stratum for which the second embodiment provides an improved paging procedure. As already explained in the background section, paging may be initiated by the eNB for several reasons. For example, system information applicable to the cell may change, and the eNB wants to notify the UEs in its cell such that the UEs may acquire the updated system information immediately from the start of the next modification period. Another reason is that a warning message shall be broadcast in the cell, such as a message from the ETWS or CMAS system, or a message in relation to EAB (Enhanced Access Barring for MTC devices). More detailed information is omitted here, and reference is made to the corresponding passages in the background section which equally apply to the first embodiment.

[0148] Consequently, due to nature of those reasons, the eNB wants to make sure that the paging reaches all UEs in the cell, including those UEs which need coverage extension to be successfully reached. According to the first embodiment, a paging possibility is established for specifically paging those CE-UEs, termed in the following CE-specific paging possibility. More precisely, a CE-specific paging frame and a CE-specific subframe are defined referring to radio resources of the PDCCH that can be used for the CE-paging. In a similarly manner as for the UE-specific paging possibilities defined in the current systems, the CE-specific paging possibility shall occur regularly, e.g. in a cyclic manner according to the paging cycle followed by the UE. The CE-specific paging possibility can be defined in addition to the normal UE-specific paging possibilities already established by the prior art, as discussed in the background section. The CE-specific paging possibility is independent from the UE's identity and shall be the same for a plurality of CE-UEs, e.g. CE-UEs of a particular cell or all CE-UEs in general (or at least all CE-UEs of a specific CE level as will be explained later); this is different from the normal UE-specific paging possibility which – even though

several UEs may monitor the same paging possibility - is specific to the UE due to being calculating based on the ID of the UE(s). This CE-specific paging possibility is known at least to the eNB and the CE-UEs; non-CE-UEs may or may not be informed about this CE-specific paging possibility; however, these non-CE-UEs shall not monitor the CE-specific paging possibility since they may be reached by "normal", i.e. non-CE, paging.

[0149] Furthermore, the paging initiated by the eNB shall reach both UEs in RRC-idle state as well as UEs in RRC-connected state. Consequently, the CE-specific paging possibility shall be monitored by UEs in RRC-idle state and UEs in RRC-connected state.

[0150] The CE-UEs regularly monitor the CE-specific paging possibility to receive the CE-paging, thereby ensuring that they can be successfully paged.

[0151] From the perspective of the eNB, when a page is triggered (e.g. by a system information change), in order to reach the CE-UEs, the eNB will wait for the corresponding paging opportunity given by the CE-specific paging possibility and will then perform a CE page at the CE-specific paging possibility which is monitored by all the CE-UEs in its cell. In a similar manner as for the UE-specific paging possibility, this particularly involves the transmission of the paging notification on the PDCCH at that radio frame and subframe of the CE-specific paging possibility and the corresponding transmission of the paging message on resources of the PDSCH as indicated by the paging notification on the PDCCH. This transmission of the two messages of the CE page is performed by using one appropriate technique of the plurality of CE techniques which are foreseen for achieving the coverage extension, e.g. a repetition technique or a technique where a significantly increased power is used for the transmission.

[0152] The CE-UE(s) in the cell of the eNB monitor the CE-specific paging possibility and thus will receive the paging notification on the PDCCH and subsequently the paging message on the PDSCH. Furthermore, since the eNB will use a coverage extension technique for the paging, which is known to the CE-UE(s), the CE-UE(s) will correspondingly react to the CE-paging by e.g. additionally receiving the repetitions of the paging notification and paging message.

[0153] The paging message will inform the CE-UE(s) about e.g. the system information change or a warning message etc. Depending on the content of the paging message on the PDSCH, the CE-UE will react accordingly, e.g. by acquiring the system information at the next modification period or by providing the warning message to the user of the CE-UE.

[0154] Of course, in a preferred first embodiment the eNB will also want to page the other (non-CE) UEs and for said purpose will page them at all possible paging possibilities, as discussed in the background section, i.e. this will be done without using any CE technique. The non-CE-UEs will each monitor their UE-specific paging possibility and

will thus receive one of the paging performed by the eNB.

[0155] In general, the CE-specific paging possibility may be different from any of the UE-specific paging possibilities, assignable for the UEs, although this is not strictly necessary for the functioning of the first embodiment. For example, only subframes 1, 2, 3, 6, 7, and 8 might be possible for the CE-specific paging possibility, considering that the other subframes 0, 4, 5, 9 are candidates for being selected/calculated as the UE-specific paging possibilities.

[0156] In one possible embodiment, the CE-UEs may keep on regularly monitoring their UE-specific paging possibility, calculated based on their identity as explained in the background section, in addition to the CE-specific paging possibility. Alternatively, the CE-UEs may not monitor the CE-specific paging possibility and the UE-specific paging possibility at the same time, but may only monitor the CE-specific paging possibility.

[0157] Fig. 5 shows, in a similar manner as Fig. 3, the paging possibilities monitored by two different CE-UEs, UE1 and UE2. As apparent from Fig. 5, it is assumed that CE-UE1 monitors a UE-specific paging possibility at radio frame number 76 and number 204 (76+128) etc., respectively at subframe 9 (see also Fig. 3, case B), and that CE-UE2 monitors a UE-specific paging possibility at radio frame number 19 and 147 (19+128) etc., respectively at subframe 4 (see also Fig. 3, case C). In addition, both CE-UE1 and CE-UE2 monitor the same CE-specific paging possibility, which in this exemplary illustration, is assumed to occur at CE-specific paging frames 36, 164 (36+128) etc. and at respective CE-specific subframe 1.

[0158] Fig. 6 shows a sequence diagram for the behavior of a CE-UE for an exemplary variant of the first embodiment. Particularly, it is assumed, in concordance with Fig. 5, that the CE-UE monitors both the CE-specific paging possibility as well as the UE-specific paging possibility, and when it receives the paging notification, the CE-UE will proceed to receive the corresponding paging message at the PDSCH resources indicated by the PDCCH paging notification, either applying or not applying a CE technique. Depending on the content of the paging message, the CE-UE will then react accordingly.

[0159] Fig. 7 shows a sequence diagram for the corresponding behavior of an eNB which wants to perform a paging. After the eNB decides to perform a paging of all UEs in its cell (e.g. due to system information change), it will proceed to perform the usual page at all possible UE-specific paging possibilities to reach all non-CE-UEs, without using any CE technique. On the other hand, to also reach the CE-UEs, the eNB will perform the CE paging at the CE-specific paging possibility, by using one appropriate CE-technique (e.g. repetition or increased transmission power).

[0160] The first embodiment as explained above has the advantage that the use of the

coverage extension technique(s) is limited to one particular CE-specific paging possibility, instead of having to be applied to all possible UE-specific paging possibilities. By using one paging possibility, all (or at least a plurality) of CE-UEs can be paged at the same time. Corresponding downlink resources can thus be saved. Furthermore, the CE-specific paging possibility is independent from the real IMSI of any CE-UE.

[0161] The CE-specific paging possibility can be defined in a number of different ways, but must always provide a CE-specific paging radio frame number and CE-specific paging subframe number, known to both the CE-UE(s) and the eNB(s).

[0162] According to a first variant of the first embodiment, the CE-specific paging possibility is fixed beforehand, e.g. not calculated but directly indicated. In one example, the numbers for the CE-specific paging radio frame and subframe are directly defined e.g. in the CE-UE (e.g. in its USIM, UICC etc) and the eNB; in other words, the CE-UE and the eNB would have information indicating particular radio frame and subframe numbers (such as radio frame number 36 and subframe number 1, as for the example of Fig. 4) for the CE-specific paging possibility. This information need not be pre-stored in the CE-UE (e.g. by use of the USIM) but could also be broadcast by the eNB in its cell, e.g. as part of the system information or indicated with a dedicated message when possible, such that the CE-UE(s) learn about the CE-specific paging possibility to be used for CE-paging from the eNB. This would allow different CE-specific paging possibilities to be used by different eNBs.

[0163] Alternatively, instead of directly indicating the CE-specific subframe number, the parameters Ns and i_s (already known from the calculation of the UE-specific paging possibility) could be reused in said respect. In particular, the following exemplary extended table can be used, which, in comparison with the table available from TS 36.304 as explained in the background section, includes at least one additional row for e.g. Ns= 5 (any other unused Ns number can be used of course) with the possible POs at subframes 1, 2, 3, and 6.

[0164] [Table 3]

Ns	PO when i_s=0	PO when i_s=1	PO when i_s=2	PO when i_s=3
1	9	N/A	N/A	N/A
2	4	9	N/A	N/A
4	0	4	5	9
5	1	2	3	6

[0165] For this alternative, Ns and i_s values would be pre-configured for the CE-specific paging possibility such that the CE-UE and eNB could determine, based on the exemplary table above, which CE-specific paging subframe to use. The CE-specific

paging radio frame would in this example still be directly indicated by a corresponding radio frame number.

[0166] The advantage of this first variant is that the CE-UE(s) would not need to calculate Ns and i_s, but may directly use the indicated numbers for the radio frame and subframe of the CE-specific paging possibility.

[0167] According to a second variant of the first embodiment to define the CE-specific paging possibility vis-a-vis the UE-specific paging possibility, the CE-specific paging possibilities are defined by providing different parameter values to the CE-UE(s) than to the non-CE-UEs. It is assumed, that the CE-specific paging subframe is calculated following the equations and principles explained for the UE-specific paging possibility in the background section. By using different parameter values for the same UE, the calculation of the UE-specific paging subframe yields different subframe numbers than the corresponding subframe numbers of the CE-specific paging possibility. As with the first variant explained above, the radio frame number for the CE-specific paging possibility is fixed.

[0168] In one example, the parameter with the different value is "nB", i.e. indicating the number of paging subframes per paging cycle (across all UEs in the cell), where one value is defined for CE-UEs and another value is defined for non-CE-UEs. There could however be another parameter broadcasted by the network for indicating rather directly the segregation of paging subframes between CE-UEs and non-CE-UEs.

[0169] According to a third variant of the first embodiment to define the CE-specific paging possibility, a CE-specific UE identity (e.g. CE-IMSI) is introduced. When considering the various CE levels a CE-UE can be configured for, a CE-level-specific UE identity can be introduced for each CE level. In any case, the CE-IMSI(s) is known to both the eNB and the CE-UE(s). The CE-specific UE identity(ies) can be provided to the CE-UEs beforehand, e.g. broadcast in the cell, or pre-stored in the SIM/ USIM or UICC or even in the Mobile Device, ME. A particular CE-UE and the network will use one of these identities corresponding to the required level of coverage extension support required e.g. one CE-UE deep down in bad radio and the network will use UE-identity1; whereas the same UE when coming back in relatively better radio, but still requiring CE support, will rather use UE-identity2 which is the corresponding use UE-identity for this level of Coverage Extension required. For this to work, it is important that the UE-identity to be used and the corresponding coverage extension required is known to both the network and the CE-UE e.g. by way of specification, or broadcasting etc. and there is a hand-shake between the CE-UE and the network about what level applies to the particular CE-UE at any given point in time. The hand-shake includes the measurement configuration and reporting as described previously.

[0170] It is assumed that basically the same calculation and principles are applied when cal-

culating the CE-specific paging possibility as explained for the UE-specific paging possibility in the background section. Both the eNB and the CE-UE(s) can calculate the same CE-(level)-specific paging possibility by the CE-(level)-specific IMSI instead of using the CE-UE's real IMSI.

[0171] As already mentioned in the background section, different coverage extension levels can be defined (e.g. 15dB, 13 dB etc.), where the respective coverage extension technique can be adapted appropriately to ensure achieving the corresponding coverage extension level. When e.g. considering the repetition CE technique, a coverage extension level to ensure 15dB might require 100 repetitions, whereas less or more repetitions may be necessary to ensure a different CE level. Similarly considerations apply to the other CE-techniques.

[0172] A particular CE-UE is configured for one of those coverage extension levels. Correspondingly, according to further examples of the first embodiment, one CE-specific paging possibility is defined per CE level, i.e. a CE-level-specific paging possibility, such that a CE-UE will only monitor the CE-level-specific paging possibility of the CE-level for which it is configured but not other CE-level-specific paging possibilities that are defined for other CE-levels.

[0173] A further improvement to the first embodiment is that CE-UEs which are in RRC-connected mode may try to read and receive paging at the UE-specific paging possibilities of other UEs. The UE_ID, which is IMSI mod 1024, can only take up to 1024 different values, and the radio frame is calculated based on "UE_ID mod N" such that only N different radio frames are used in each paging cycle. Consequently, a CE-UE could be configured to monitor some or all of the possible radio frames and subframes available for other UEs. This allows the network to not make as many repetitions as would otherwise be required if the UE was not receiving paging other than the UE-specific paging possibilities.

[0174] A further improvement to the first embodiment focuses on when to actually perform a CE page. Until now it has been (silently) assumed that there would be always a CE-UE in a cell, such that any eNB, at any time when paging is triggered, would perform the CE-paging at the CE-specific paging possibility(ies). The eNB is aware of all (CE-)UEs that are in RRC-Connected mode, since these have an active connection with the eNB, and thus the eNB determines whether a CE-UE that require coverage extension is in its cell or not. However, the eNB is not aware of which CE-UEs in RRC-Idle mode are currently in its cell. Consequently, assuming that no CE-UEs in RRC-Connected mode are in the cell of the eNB, the eNB is unaware of whether there is at least one CE-UE in RRC-Idle mode in its cell. To make sure that any possible CE-UEs in Idle mode are reached too, in these cases, the eNB will always have to performing the CE paging. This however may result in a waste of resources for the

case where no CE-UE(s) in RRC-Idle mode were in its cell either.

[0175] According to this improvement, this waste of resources shall be avoided by providing a procedure that allows the eNB to determine whether any CE-UEs are in its cell, be it in RRC-Idle or RRC-Connected state. To said end, the eNB might first determine whether there are any CE-UEs in RRC-Connected mode, which could be done e.g. by maintaining a table with UE-capability information received from the MME or UE. Subsequently, in case the eNB determines that there are no CE-UEs in RRC-Connected mode, a counting procedure is initiated which allows the eNB to determine/ estimate the number of CE-UEs in RRC-idle state in its cell. In one example of a counting procedure the UEs in RRC-Idle on a more or less round robin fashion go to RRC-Connected state and inform the network about the presence of the CE UE in RRC-Idle mode (i.e. about itself). The round robin method can e.g. be implemented using a persistence check method wherein the Idle UEs compare a randomly drawn number against a number broadcasted by the network. Only the one(s) drawing a smaller value will transit to RRC Connected to inform the network. The network can keep the broadcasted value to be small enough so that only a very small percentage of UEs should really pass this test at a given time. This is similar to what is done in MBMS Counting procedure as depicted in RRC specification 3GPP TS 36.331, current version 12.4.1 incorporated herein by reference.

[0176] In consequence, the eNB will only perform the CE page when it has determined that there is at least one CE-UE in its cell, be it in RRC-Idle or RRC-Connected state. As a result, the additional resources for a CE-page are not used in vain.

[0177] Second embodiment

As explained above, the first embodiment relates to an improvement for a paging procedure initiated by the eNB, which then shall page all UEs in its cell. The second embodiment to be presented relates to an improvement for a paging procedure that is initiated by the NAS (Non-Access-Stratum), e.g. the MME, and which is dedicated to just a single UE, or a rather limited number of UEs.

[0178] In particular, for this second embodiment it is assumed that the paging is initiated by the NAS, for instance in order to establish a call with a particular CE-UE; details in said respect have already been provided in the background section (see also Fig. 4) and apply equally to the second embodiment. In this respect the "call" need not be just a voice call but can also refer to other terminating service like SMS, MMS or Pager etc. For instance, the MME – in response to a corresponding trigger from the SGW in the core network – sends a paging message to all eNBs that belong to the tracking area(s) for which the CE-UE is currently registered. Particularly, the MME does not know where a CE-UE in RRC idle is located. Each eNB belonging to one of the TAs in an associated TA-list, in turn, then has to perform paging so as to page this CE-UE to

which the call is destined. Finally, the CE-UE being paged can then establish a connection with the eNB where it is camped and then proceed to accept the incoming call (see also Fig. 4).

[0179] In the above-described scenario, the MME informs the eNBs (over the S1 interface) about the capability(ies) of a (CE-)UE, e.g. whether the UE is capable of supporting coverage extension (and optionally which level of coverage extension). As explained before, this general capability information however gives no information on whether a particular CE-capable UE indeed requires coverage extension at the moment or not; e.g. while a CE-capable UE might have been in a basement for a long time, i.e. thus requiring coverage extension for compensating the bad radio conditions, this very same CE-capable UE might in mean time have emerged from the basement and thus might no longer require coverage extension or still require coverage extension but corresponding to a less demanding coverage extension level.

[0180] Consequently, according to the second embodiment, a procedure is implemented according to which the eNB can learn whether a CE-capable UE is indeed requiring coverage extension or not at the time of paging. To said end, a new measurement and reporting procedure is implemented between the UE and the eNB as will be explained in detail below.

[0181] The CE-capable UE is configured to perform radio measurements that allow determining whether the CE-capable UE is currently indeed requiring coverage extension or not. The radio measurements could refer for example to one or more of the following: Reference Signal Received Power (RSRP), Reference Signal Received Quality (RSRQ), channel quality etc. e.g. as defined in Chapter 5 of 3GPP TS36.214 v10.1.0(NPL 8), or even current Block Error Rate (BLER) estimates or HARQ operating point and any other suitable measurement target. In any case, a skilled person is well aware of how to determine the current radio conditions of a CE-capable UE that allow, in a subsequent step, to determine whether coverage extension is indeed necessary or not.

[0182] After performing the appropriate radio measurements, the CE-capable UE shall then determine whether coverage extension is necessary based on the results of the measurements. In one example, two appropriate thresholds can be defined, to which the measurements results are compared by the CE-capable UE so as to determine the current CE status of the CE-capable UE. For example, an upper threshold can be defined, where if the measurements results (e.g. RSRP or RSRQ) exceed the upper threshold, the CE-capable UE would determine that it does not require coverage extension, i.e. that it currently is a non-CE-UE. Conversely, a different lower threshold can be defined, where if the measurement results (e.g. again RSRP or RSRQ) fall below the lower threshold, the CE-capable would conclude that it does require

coverage extension, i.e. that is currently is a CE-UE. Instead of using two thresholds, the determination of whether CE is required or not, could of course also be determined by simply using one threshold, where measurements results exceeding the threshold would mean that coverage extension is not necessary, and measurements results falling below the threshold would mean that coverage extension is necessary. The same technique can also be used for other measurement possibility like for HARQ operating point i.e. where HARQ operating point exceeding the corresponding HARQ operating point-threshold would mean that coverage extension is not necessary, and HARQ operating point falling below the HARQ operating point-threshold would mean that coverage extension is necessary.

[0183] The radio measurements and CE status determination can be performed regularly by the CE-capable UE, i.e. at specific, pre-configured, intervals, and/or event triggered (one even for exceeding the threshold in either direction as described above), e.g. , and/or triggered by the eNB. In addition to the absolute threshold for the corresponding measurement, the network might also provide the corresponding Hysteresis and Time to Trigger values as described in 3GPP TS 36.331, current version 12.4.1. Hysteresis basically gives a margin or allowance in breaching the threshold in either direction, and the Time to Trigger (TTT) indicates at least how long the said threshold should remain breached/ exceeded for the UE to trigger the corresponding event.

[0184] Which radio measurements shall be performed, at which intervals, against which threshold(s) the measurement results should be compared, and any other necessary information can be pre-configured in the CE-capable UE or provided to the CE-capable UEs from the eNB, e.g. within a corresponding control message which could be signaled by RRC or Layer2 (MAC) or Layer1 (Physical layer signal) and may contain additional parameters including Hysteresis, TTT and the target object like current/ serving and neighbor cell list.

[0185] The CE-capable UE has to make sure that the eNB is kept updated on the current CE status, i.e. on whether the CE-capable UE needs coverage extension or not. This may be done e.g. by reporting every change of CE status to the eNB, such that the eNB knows at the time of paging whether a coverage extension technique shall be applied to the paging or not. Of course the same information can be used for DL messages other than paging and also to UL messages including paging response and other non-paging related messages. Depending on whether the CE-capable UE is in idle mode or connected mode, the reporting of the CE status to the eNB may be different. If the CE-capable UE is in RRC connected state and thus has an active connection with the eNB, the CE-capable UE can directly transmit a CE-status report, e.g. RRC Measurement Report, to the eNB.

[0186] Since such a direct report is not possible for CE-capable UEs in RRC-IDLE (since no

active connection with the eNB is available), the CE-capable UE in idle will report the CE status to the MME, which thus knows whether coverage extension is indeed required or not (independent from the CE-capability of a UE). The MME may either keep the eNB(s) regularly up to date in said respect, or might only provide the corresponding information to the eNB(s) when also triggering the eNB for paging. Of course, also CE-capable UEs in RRC connected could inform the MME, instead of or in addition to the eNB.

[0187] In another alternative, the CE-capable UE in idle will report the CE status and UE NAS identity directly to the serving eNB where the UE is camped in currently e.g. upon cell Selection and Reselection(s), which thus knows whether coverage extension is indeed required or not by maintaining a new Table including the UE NAS identity and CE-requirement.

[0188] Alternatively, another improvement provides that the CE-capable UEs do not change into RRC-idle state and thus remain all the time in RRC-connected state, such that the CE-capable UE can always transmit the measurement report directly to the eNB. The eNB can ensure that the UE remains in connected state by never sending the RRC Connection Release message to the UE i.e. basically ignoring any inactivity timer in the eNB for this UE.

[0189] In any case, the eNB, when being triggered to page a particular CE-capable UE, will be informed about and will consider whether said CE-capable UE indeed requires coverage extension or not. Based on the thus known current CE status of the UE, the eNB will or will not apply an appropriate CE technique to the paging of the CE-capable UE. As explained in detail for the first embodiment already, applying the CE technique to paging involves applying the CE technique to both the paging notification transmitted on the PDCCH and the actual paging message transmitted on the PDSCH as addressed by the PDCCH.

[0190] In other words, two measurement events are defined, one referring to the case where the radio measurements indicate that coverage extension is required, and the other referring to the case where the radio measurements indicate that coverage extension is not required. When any of the two events occur, this is reported to the eNB (either directly or via the core network entity, e.g. MME).

[0191] Fig. 8 shows a message sequence diagram for an exemplary paging procedure according to the second embodiment. As apparent therefrom, a measurement control message is provided from the eNB to the UE, which is assumed to include all information necessary to configure the UE to perform the radio measurements and to determine the CE-status based on the measurement results. Fig. 8 also shows the measurement report message from the UE to the eNB, which is transmitted to the eNB to allow the eNB to update the CE status of the UE. This allows in consequence that the

eNB performs the paging of the UE by using or not using a CE technique depending on the CE status of the UE.

[0192] Fig. 9 shows a simplified sequence process diagram for the CE-capable UE for one particular exemplary second embodiment as explained above where the measurement and reporting procedure is depicted in parallel to the page monitoring procedure.

[0193] Fig. 10 shows a simplified sequence process diagram for the eNB as explained above including the reception and update procedure for the CE status of the UE, and the parallel paging procedure which depends on the CE status.

[0194] Fig. 8 additionally shows an optional determination of the initial coverage extension status of the UE, which can be done directly upon the initial access of the UE to the eNB (see dashed box). In particular, the UE when initially attaching to a cell (and to the corresponding eNB) usually performs a RACH procedure, which involves e.g. the selection of an appropriate preamble, access slot etc. The CE-capable UE would, during initial access, determine its CE status in order to appropriately select the RACH resources (e.g. preamble, access slot, etc). Now, the eNB can estimate the radio conditions of the UE, and thus the CE status of the UE, based on the parameters, like preambles, preamble format or even the physical resources that the UE selected to perform the RACH procedure.

[0195] Another improvement of the second embodiment, which is also illustrated in Fig. 8 by use of a dashed arrow, refers to a feedback message transmitted from the eNB to the UE about the successful reception of the measurement report, i.e. CE status update, and confirmation that the toggling (between CE and non-CE) is successfully applied at the network side and therefore the UE should also toggle and transmit/ receive according to the new toggled state. By e.g. sending back information on the current CE status, the eNB can make sure that the CE-capable UE and the eNB have the same understanding of the CE status, and behave accordingly in a same manner. For instance, if the measurement report is lost, or decoded incorrectly at the eNB, the eNB would not change the CE status, and the UE and eNB would have different CE status (e.g. until the next, successful, measurement report is received by the eNB). Also, even successful reception of the measurement report is not a guarantee that eNB is fine with the toggling for reasons like admission control or for independent toggling evaluation at the eNB side. In this respect, the triggering of a measurement event is just one of the input parameter for the eNB to decide about the said toggling of CE state, and eNB may take the final decision based on cell and System specific considerations. In absence of the feedback message transmitted from the eNB to the UE about the successful reception of the measurement report and confirming that the toggling (between CE and non-CE) is successfully applied at the network side, obviously, different CE status might lead to a waste of radio resources or to an unsuccessful

paging, which is avoided by providing a feedback on the successful CE status update.

[0196] Still a further improvement of the second embodiment is also illustrated in Fig. 8. As indicated by the dashed arrow, the UE can inform the eNB immediately when a CE page was successful. In particular, instead of waiting to receive e.g. all repetitions of the CE page, as soon as the CE page is successfully received (e.g. the actual paging message was successfully decoded/delivered to the higher layer), the CE-capable UE informs the eNB in said respect. In turn, the eNB can inform the MME in the core network, which may then abort the page in the other eNBs of all the tracking areas (not shown in Fig. 8) pertaining to a corresponding TA-list. Radio resources are thus not wasted by other eNBs.

[0197] Third embodiment

According to a third embodiment, the first embodiment and the second embodiments are combined such that CE devices can be paged both at the NAS level and the AS level (i.e. initiated by NAS and initiated by eNB). Thus, the separation of NAS and AS is maintained as in legacy systems. Furthermore, the first and second embodiments are simple to implement and have no impact on legacy procedures.

[0198] Hardware and Software Implementation of the present disclosure

Other exemplary embodiments relate to the implementation of the above described various embodiments using hardware and software. In this connection a user terminal (mobile terminal) and an eNodeB (base station) are provided. The user terminal and base station is adapted to perform the methods described herein, including corresponding entities to participate appropriately in the methods, such as receiver, transmitter, processors.

[0199] It is further recognized that the various embodiments may be implemented or performed using computing devices (processors). A computing device or processor may for example be general purpose processors, digital signal processors (DSP), application specific integrated circuits (ASIC), field programmable gate arrays (FPGA) or other programmable logic devices, etc. The various embodiments may also be performed or embodied by a combination of these devices.

[0200] Further, the various embodiments may also be implemented by means of software modules, which are executed by a processor or directly in hardware. Also a combination of software modules and a hardware implementation may be possible. The software modules may be stored on any kind of computer readable storage media, for example RAM, EPROM, EEPROM, flash memory, registers, hard disks, CD-ROM, DVD, etc.

[0201] It should be further noted that the individual features of the different embodiments may individually or in arbitrary combination be subject matter to another embodiment.

[0202] It would be appreciated by a person skilled in the art that numerous variations and/or

modifications may be made to the present disclosure as shown in the specific embodiments. The present embodiments are, therefore, to be considered in all respects to be illustrative and not restrictive.

Claims

[Claim 1] A method for paging all user equipments in a cell controlled by a radio base station in a mobile communication system, wherein at least one regularly-occurring coverage-extension-specific paging possibility, in short CE-specific paging possibility, is defined for paging user equipments that require coverage extension, in short CE user equipments, wherein the radio base station is capable to use one of a plurality of techniques for achieving a coverage extension for a CE user equipment, the method comprising the steps of:
regularly monitoring by the CE user equipments in the cell the at least one CE-specific paging possibility,
determining by the radio base station to page all the user equipments in the cell, and
paging by the radio base station the CE user equipments in the cell at the CE-specific paging possibility, using one of the plurality of techniques for achieving the coverage extension.

[Claim 2] The method according to claim 1, wherein a plurality of UE-specific paging possibilities are defined for paging a specific user equipment in the cell of the radio base station, wherein the CE user equipments and non-CE user equipments each monitor a respective UE-specific paging possibility out of the plurality of UE-specific paging possibilities,
wherein the radio base station — upon determining to page all the user equipments in the cell - additionally performs paging at all of the plurality of UE-specific paging possibilities without using one of the plurality of techniques for achieving coverage extension,
preferably wherein each of the plurality of UE-specific paging possibilities is different from the at least one CE-specific paging possibility.

[Claim 3] The method according to claim 1 or 2, wherein the step of paging includes:
transmitting by the radio base station a first paging notification at radio resources of a control channel specified by the at least one CE-specific paging possibility, and
transmitting by the radio base station a second paging message at radio resources of another channel specified by the first paging notification,
preferably wherein the technique for achieving the coverage extension is applied to both steps of transmitting the first paging notification and of transmitting the second paging message.

[Claim 4] The method according to one of claims 1 to 3, wherein each of the at least one CE-specific paging possibility refers to radio resources of a control channel defined by a radio frame number and a subframe number which are pre-configured such that the radio frame number and the subframe number are fixed for the CE-specific paging possibility, preferably wherein information to determine the pre-configured radio frame number and the pre-configured subframe number is stored in a Universal Subscriber Identity Module, USIM, of the CE user equipment, or broadcast by the radio base station in the cell, and preferably wherein the pre-configured subframe number is 1, 2, 3, 6, 7, or 8.

[Claim 5] The method according to one of claims 1 to 3, wherein CE user equipments are assigned a CE-specific user equipment identity based on which the CE-specific paging possibility is calculated by the radio base station and the CE user equipments,
preferably wherein the CE-specific user equipment identity is the same for all CE-configured user equipments,
preferably wherein the CE-specific user equipment identity is stored in a Universal Subscriber Identity Module, USIM, of the CE user equipment or broadcast by the radio base station in the cell;
preferably wherein a plurality of different levels of coverage extension is defined, and wherein for each level of coverage extension a different CE-specific user equipment identity is defined.

[Claim 6] A user equipment located in a cell controlled by a radio base station in a mobile communication system, the user equipment, in short CE user equipment, requiring coverage extension, wherein at least one regularly-occurring coverage-extension-specific paging possibility, in short CE-specific paging possibility, is defined for the CE user equipment, wherein the radio base station is capable to use one of a plurality of techniques for achieving a coverage extension for the CE user equipment, the CE user equipment comprising:
a processor adapted to regularly monitor the at least one CE-specific paging possibility,
a receiver adapted to receive a paging from the radio base station at the CE-specific paging possibility, using one of the plurality of techniques for achieving the coverage extension.

[Claim 7] The user equipment according to claim 6, wherein each of the at least one CE-specific paging possibility refers to radio resources of a control

channel defined by a radio frame number and a subframe number which are pre-configured such that the radio frame number and the subframe number are fixed for the CE-specific paging possibility, preferably wherein a memory of the CE user equipment is adapted to store information to determine the pre-configured radio frame number and the pre-configured subframe number, preferably wherein the memory is a Universal Subscriber Identity Module, USIM, of the CE user equipment, or

preferably wherein the receiver of the CE user equipment is further adapted to receive information to determine the pre-configured radio frame number and the pre-configured subframe number, broadcast by the radio base station in the cell.

[Claim 8] A radio base station for paging all user equipments in a cell controlled by the radio base station in a mobile communication system, wherein at least one regularly-occurring coverage-extension-specific paging possibility, in short CE-specific paging possibility, is defined for paging user equipments that require coverage extension, in short CE user equipments, wherein the radio base station is capable to use one of a plurality of techniques for achieving a coverage extension for a CE user equipment, the radio base station comprising:

a processor adapted to determine whether to page all the user equipments in the cell, and

a transmitter adapted to page the CE user equipments in the cell at the CE-specific paging possibility, using one of the plurality of techniques for achieving the coverage extension.

[Claim 9] A method for paging a user equipment in a cell controlled by a radio base station in a mobile communication system, wherein the user equipment supports coverage extension techniques, wherein the radio base station is capable to use one of a plurality of techniques for achieving a coverage extension for the CE-capable user equipment, the method comprising the steps of:

performing radio measurements by the CE-capable user equipment,

determining by the CE-capable user equipment whether coverage extension is necessary or not, based on the results of the radio measurements,

wherein the radio base station is informed about whether the CE-capable user equipment needs coverage extension or not, based on the determination result,

when paging the CE-capable user equipment, applying or not applying by the radio base station one of the plurality of techniques for achieving coverage extension depending on whether coverage extension is necessary or not for the CE-capable user equipment.

[Claim 10] The method according to claim 9, wherein the radio measurements performed by the CE-capable user equipment include measurements of a Reference Signal Received Power, RSRP, and/or Reference Signal Received Quality, RSRQ, and/or a channel quality, and/or a block error rate and/ or HARQ operating point.

[Claim 11] The method according to claim 9 or 10, wherein the step of determining whether coverage extension is necessary comprises the steps of:
comparing by the CE-capable user equipment the result of the radio measurements with a first threshold to determine whether coverage extension is necessary, preferably wherein the comparison determines that coverage extension is necessary when the result of the radio measurements falls below the first threshold,
comparing by the CE-capable user equipment the result of the radio measurements with a second threshold to determine whether coverage extension is not necessary, preferably wherein the comparison determines that coverage extension is not necessary when the result of the radio measurement exceeds the second threshold.

[Claim 12] The method according to one of claims 9 to 11, wherein the step of paging the CE-capable user equipment comprises the steps of:
transmitting by the radio base station a first paging notification at radio resources of a control channel specified by a paging possibility specific to the CE-capable user equipment, and
transmitting by the radio base station a second paging message at radio resources of another channel specified by the first paging notification, preferably wherein the technique for achieving the coverage extension is applied to both steps of transmitting the first paging notification and of transmitting the second paging message.

[Claim 13] A user equipment located in a cell controlled by a radio base station in a mobile communication system, the user equipment, in short CE user equipment, supporting coverage extension techniques, wherein the radio base station is capable to use one of a plurality of techniques for achieving a coverage extension for the CE-capable user equipment, the user equipment comprising:
a processor adapted to perform radio measurements,

the processor being further adapted to determine whether coverage extension is necessary or not, based on the results of the radio measurements,

a transmitter adapted to inform the radio base station about whether the CE-capable user equipment needs coverage extension or not, based on the determination result,

a receiver adapted to receive paging from the radio base station, applying or not applying one of the plurality of techniques for achieving coverage extension depending on whether coverage extension is necessary or not.

[Claim 14] The user equipment according to claim 13, wherein the transmitter informs the radio base station by:

transmitting information about whether the CE-capable user equipment needs coverage extension or not to the radio base station, preferably wherein the CE-capable user equipment is in a connected state, preferably wherein it is avoided that the CE-capable user equipment is changing into the idle state by keeping it in the connected state, or

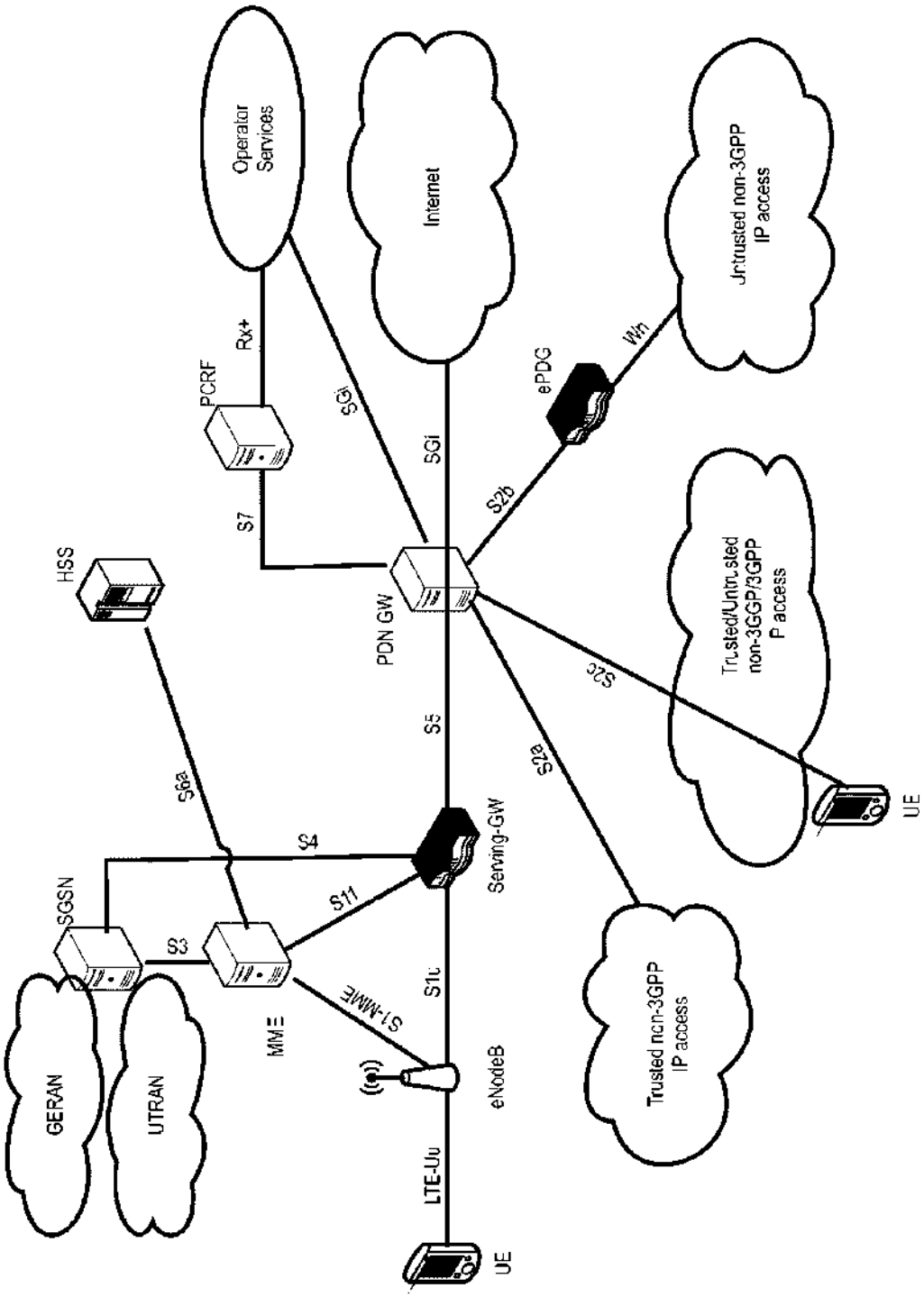
transmitting information about whether the CE-capable user equipment needs coverage extension or not to a core network entity, and wherein the core network entity provides the received information to the radio base station, preferably wherein the CE-capable user equipment is in a connected state or in an idle state.

[Claim 15] A radio base station for paging a user equipment in a cell controlled by the radio base station in a mobile communication system, wherein the user equipment supports coverage extension techniques, wherein the radio base station is capable to use one of a plurality of techniques for achieving a coverage extension for the CE-capable user equipment, the radio base station comprising:

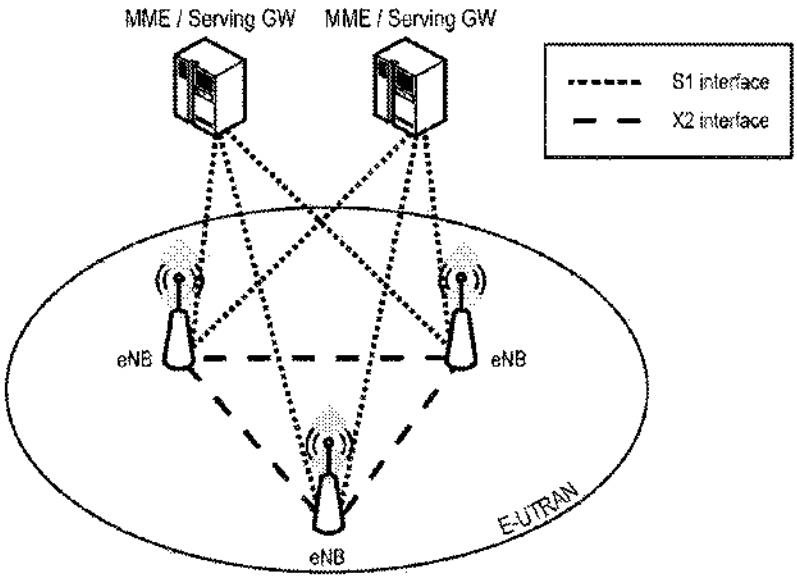
a receiver adapted to receive information about whether the CE-capable user equipment needs coverage extension or not,

a transmitter being adapted to, when paging the CE-capable user equipment, apply or not apply one of the plurality of techniques for achieving coverage extension depending on whether coverage extension is necessary or not for the CE-capable user equipment.

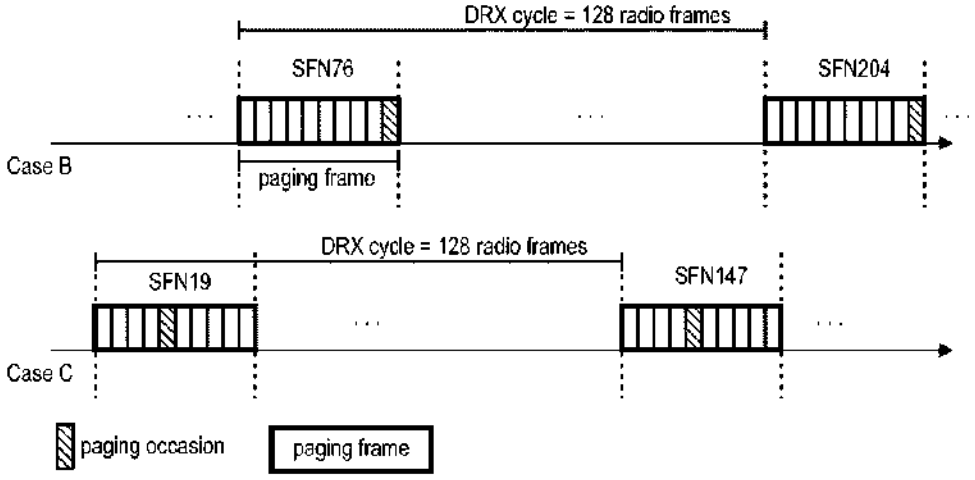
[Fig. 1]


Operator Services
Internet
Untrusted non-3GPP IP access
PCRF
Rx+
SGi
SGi
ePDG
Wn
S7
S2b
HSS
PDN GW
Trusted/Untrusted non-3GPP/3GPP IP access
S2c
S5
S2a
S6a
S4
UE
SGSN
S11
Serving-GW
S3
S1-MME
S1u
GERAN
UTRAN
MME
eNodeB
Trusted non-3GPP IP access
LTE-Uu
UE

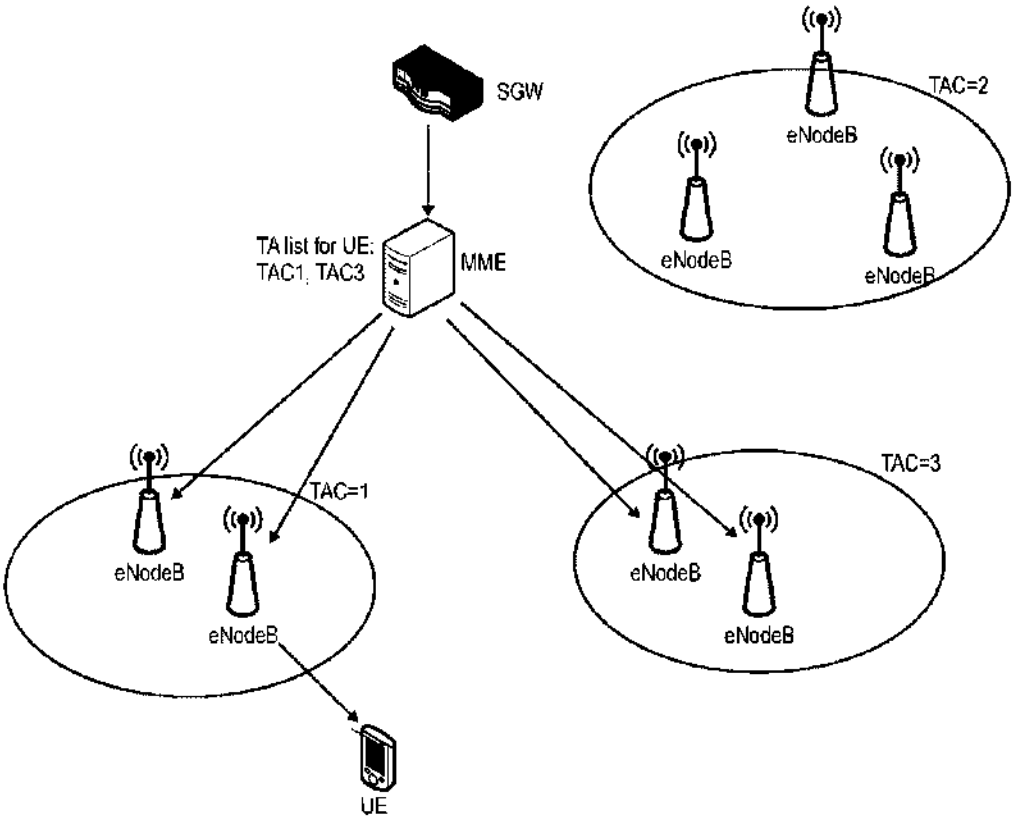
[Fig. 2]


MME / Serving GW
MME / Serving GW
S1 interface
X2 interface
eNB
eNB
eNB
E-UTRAN

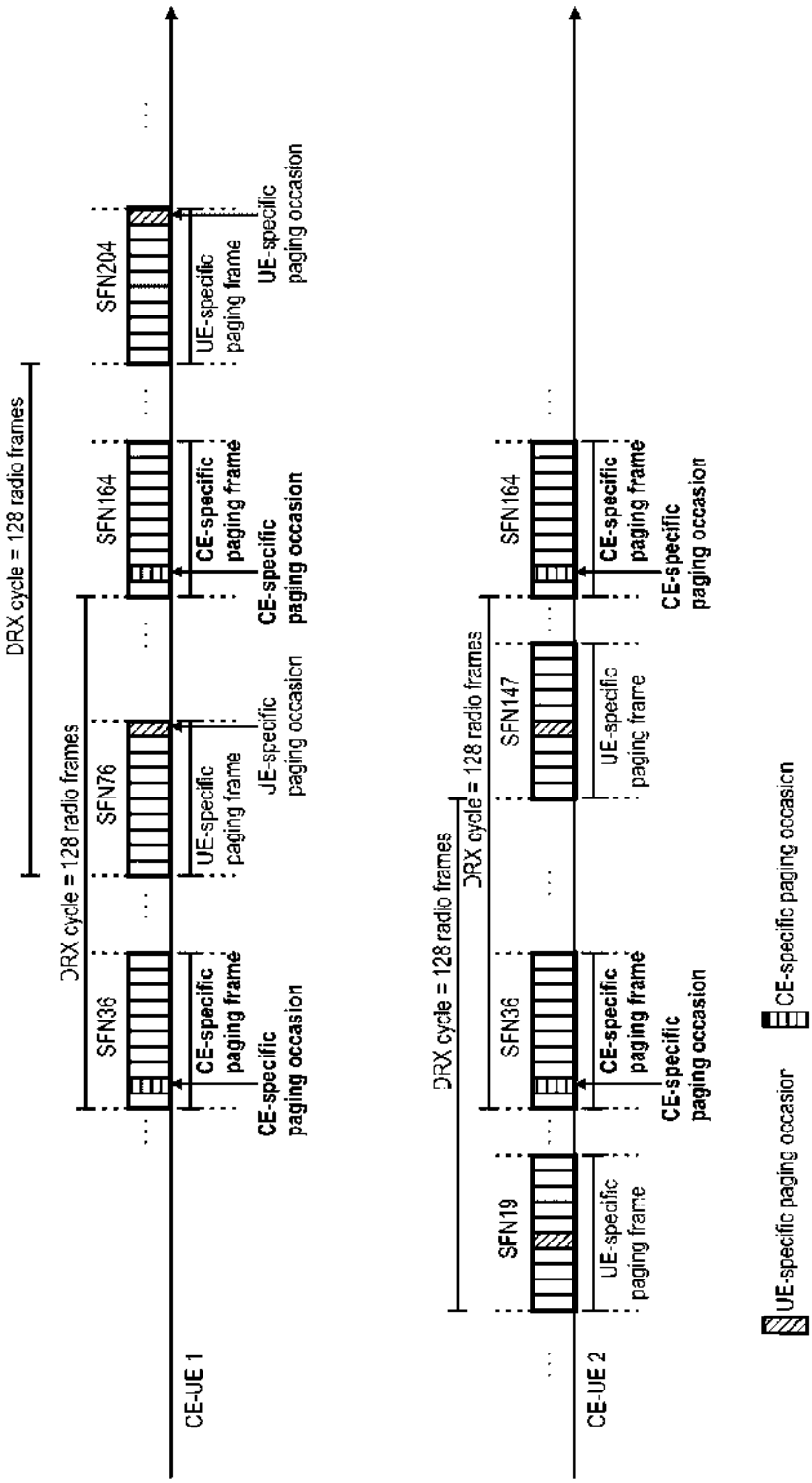
[Fig. 3]


DRX cycle = 128 radio frames
SFN76
SFN204
Case B
paging frame
DRX cycle = 128 radio frames
SFN19
SFN147
Case C
paging occasion
paging frame

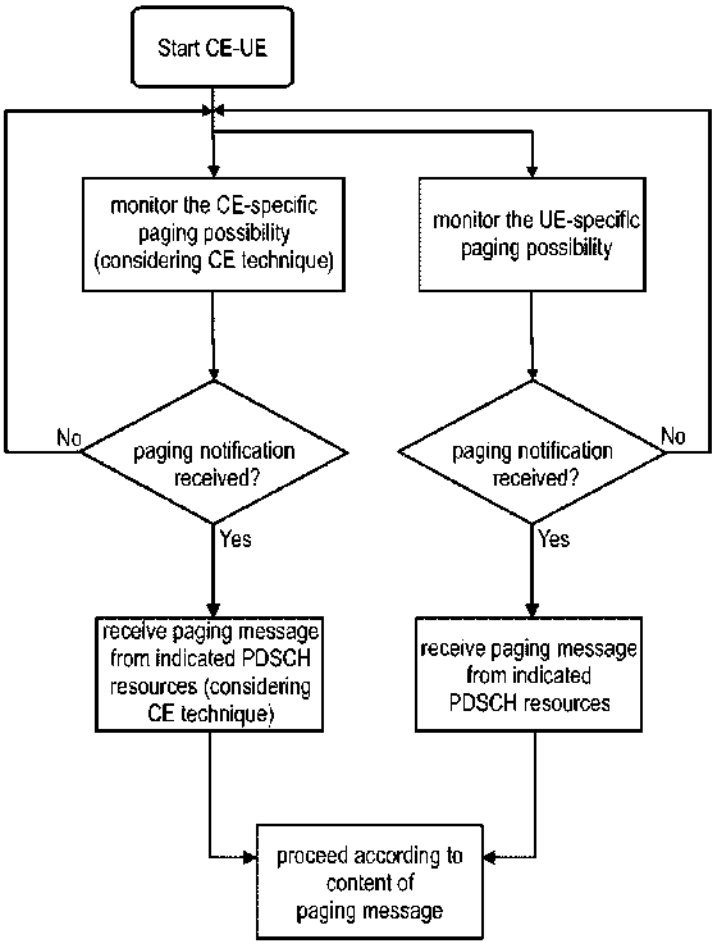
[Fig. 4]


SGW
TA list for UE:
TAC1, TAC3
MME
TAC=1
eNodeB
eNodeB
TAC=2
eNodeB
eNodeB
eNodeB
TAC=3
eNodeB
eNodeB
UE

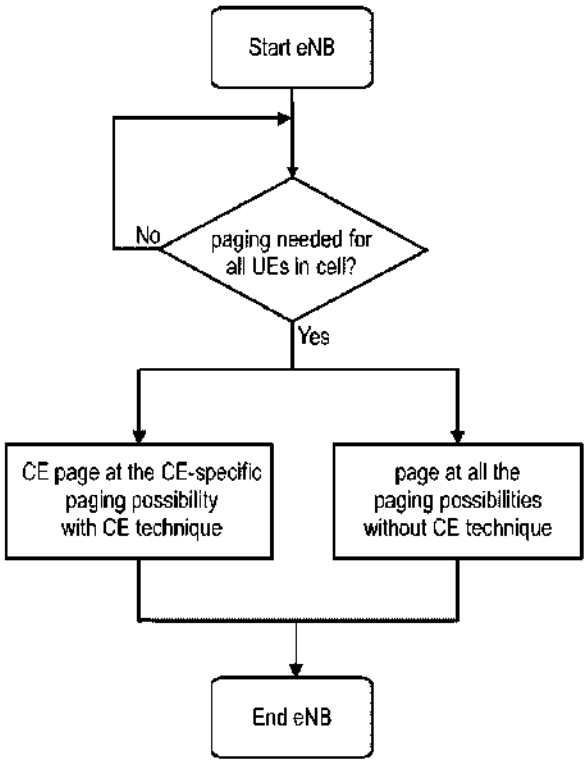
[Fig. 5]


DRX cycle = 128 radio frames
DRX cycle = 128 radio frames
SFN36
SFN76
SFN164
SFN204
CE-specific paging frame
UE-specific paging frame
CE-specific paging occasion
UE-specific paging occasion
CE-UE 1
DRX cycle = 128 radio frames
DRX cycle = 128 radio frames
SFN19
SFN36
SFN147
SFN164
CE-UE 2
UE-specific paging occasion
CE-specific paging occasion

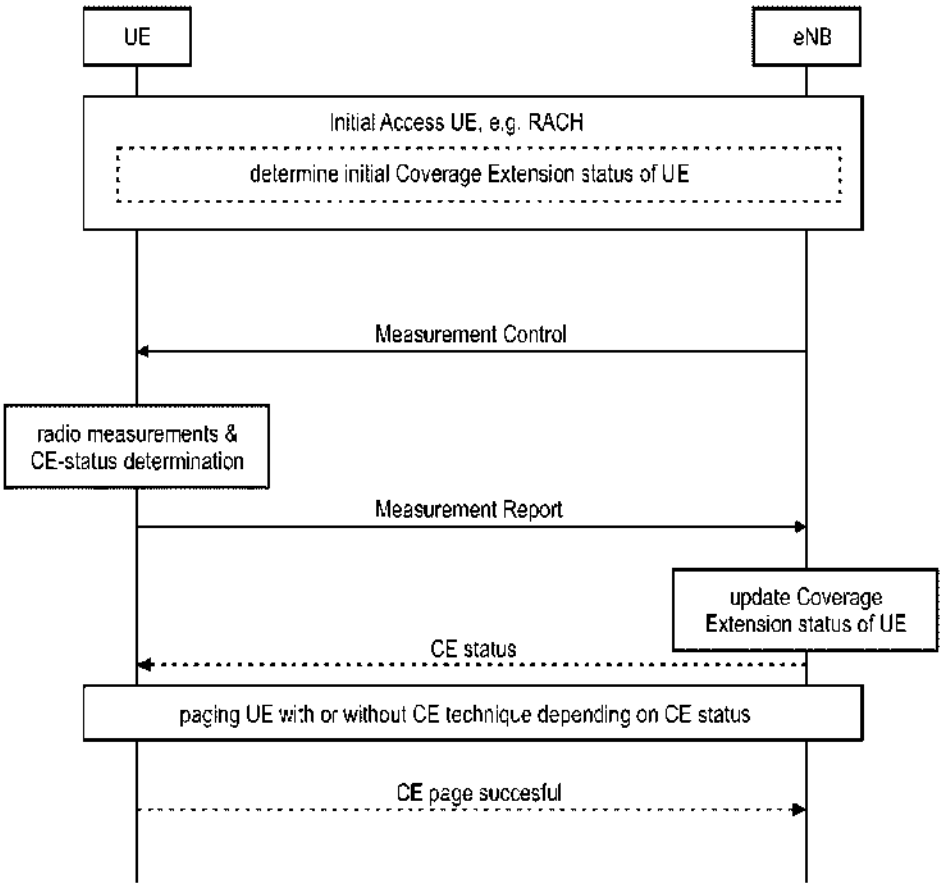
[Fig. 6]


Start CE-UE
monitor the CE-specific paging possibility (considering CE technique)
monitor the UE-specific paging possibility
paging notification received?
No
Yes
paging notification received?
No
Yes
receive paging message from indicated PDSCH resources (considering CE technique)
receive paging message from indicated PDSCH resources
proceed according to content of paging message

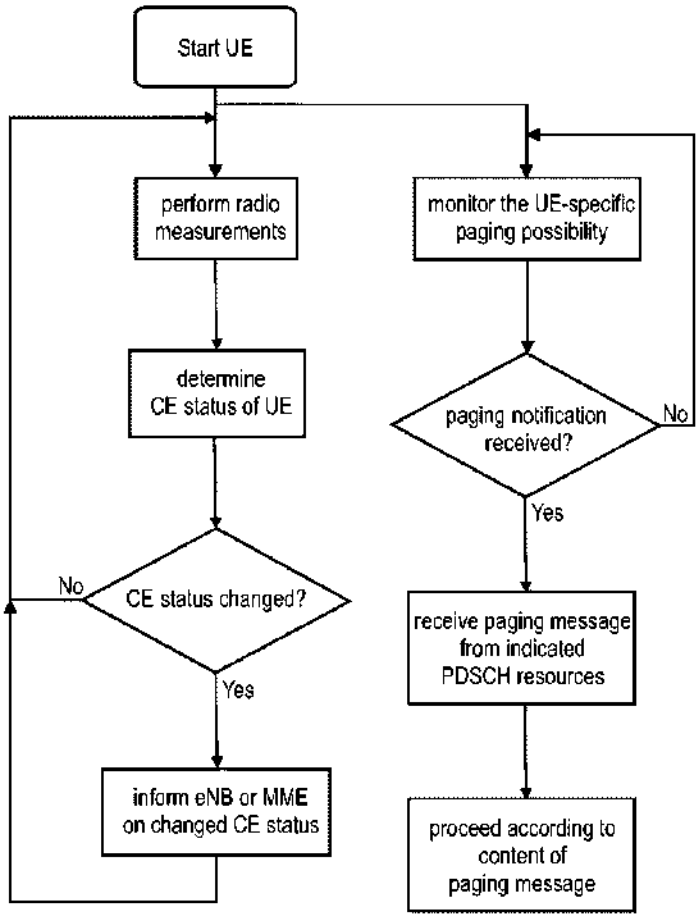
[Fig. 7]


Start eNB
No
paging needed for all UEs in cell?
Yes
CE page at the CE-specific paging possibility with CE technique
page at all the paging possibilities without CE technique
End eNB

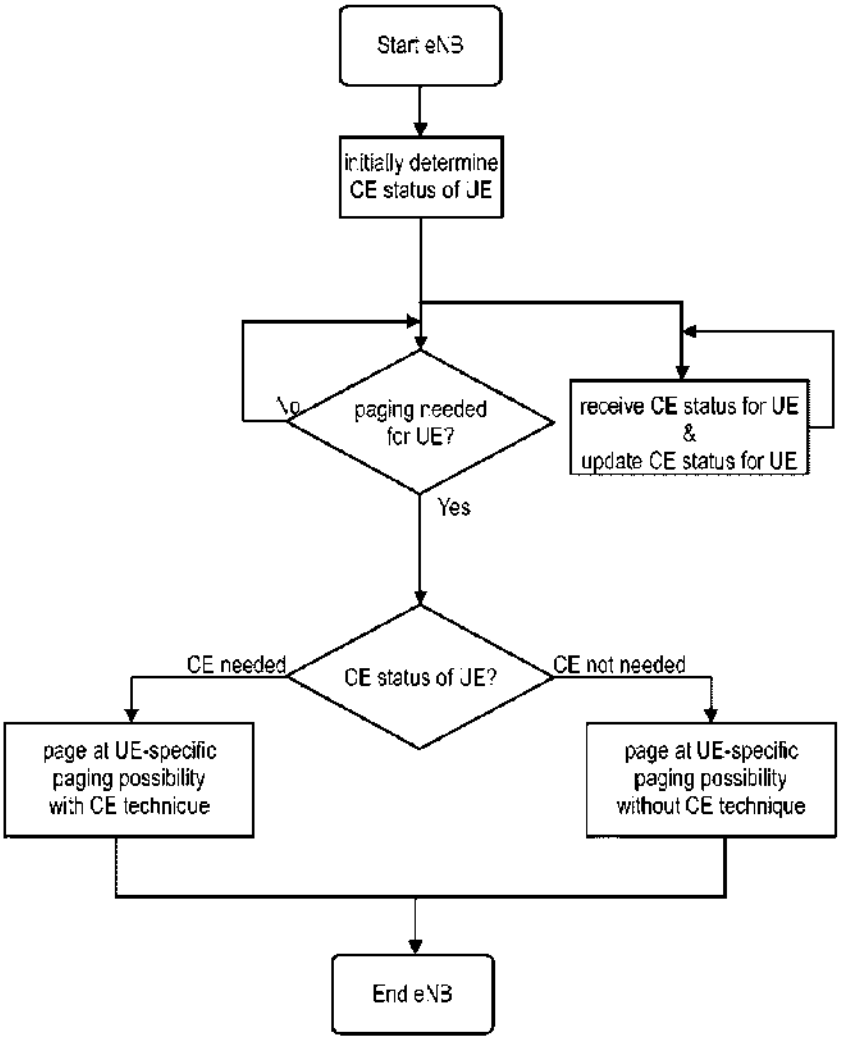
[Fig. 8]


UE
eNB
Initial Access UE, e.g. RACH
determine initial Coverage Extension status of UE
Measurement Control
radio measurements &
CE-status determination
Measurement Report
update Coverage
Extension status of UE
CE status
paging UE with or without CE technique depending on CE status
CE page succesful

[Fig. 9]


Start UE
perform radio measurements
determine CE status of UE
CE status changed?
No
Yes
inform eNB or MME on changed CE status
monitor the UE-specific paging possibility
paging notification received?
No
Yes
receive paging message from indicated PDSCH resources
proceed according to content of paging message

[Fig. 10]


Start eNB
initially determine CE status of UE
paging needed for UE?
No
Yes
receive CE status for UE & update CE status for UE
CE status of UE?
CE needed
CE not needed
page at UE-specific paging possibility with CE technique
page at UE-specific paging possibility without CE technique
End eNB

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/000417

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. H04W68/08(2009.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int.Cl. H04W68/08

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2016
Registered utility model specifications of Japan 1996-2016
Published registered utility model applications of Japan 1994-2016

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2014/0098761 A1 (INTERDIGITAL PATENT HOLDINGS, INC.) 2014.04.10, whole document & JP 2015-537422 A & EP 2904850 A1 & TW 201429174 A & CN 104704884 A & KR 10-2015-0064196 A	1-15
A	Alcatel-Lucent, Alcatel-Lucent Shanghai Bell, Capability signaling for Low Complexity MTC UE [online], 3GPP TSG-RAN WG2#85 R2-140727, URL:http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_85/Docs/R2-140727.zip, 2014.02.01	1-15

☑ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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Date of the actual completion of the international search	Date of mailing of the international search report
12.04.2016	19.04.2016

Name and mailing address of the ISA/JP	Authorized officer
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Alcatel-Lucent, Alcatel-Lucent Shanghai Bell, Coverage enhancement for common control messages[online], 3GPP TSG-RAN WG1#78b R1-144077, URL:http://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_78b/Docs/R1-144077.zip, 2014.09.27	1-15

Espacenet

CN105813200A Method for receiving/transmitting paging information, related network node and user device

Applicants: SHARP KK

Inventors: SHEN XINGYA,XIAO FANGYING,LIU RENMAO

Classifications:

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CPC **H04W4/70 (EP); H04W68/02 (EP,US); H04W72/20 (US); H04W76/27 (US);** H04W4/70 (US); H04W88/02 (US); H04W88/08 (US);

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Application: CN201410843366A·2014-12-30

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Published as: CN105813200A,**US2017339667A1; WO2016107518A1**

Method for receiving/transmitting paging information, related network node and user device

Abstract

The invention discloses a method for receiving/transmitting paging information, a related network node and a user device. The method comprises steps of receiving an indication to a physic resource block set for transmitting the paging information, wherein the index of physic resource block set in a sub frame is determined according to the level of the paging information; and receiving the paging information on the indicated physic resource block set. The technical scheme of the invention provides a paging information transmission mechanism targeting the enhanced coverage MTC user device and/or low complexity or low cost MTC user device.

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H04W 68/00(2009.01)

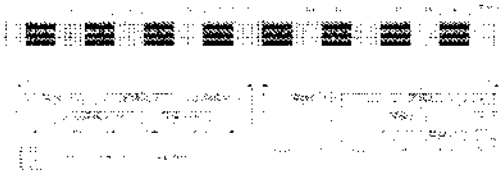
权利要求书1页 说明书11页 附图4页

(54)发明名称

寻呼消息的接收、发送方法及相关网络节点和用户设备

(57)摘要

本发明提供了寻呼消息接收、发送方法以及相应网络节点、用户设备。该方法包括：接收对用户发送寻呼寻呼消息的物理资源块集的指示，其中，所述物理资源块集在子帧中的索引是根据所述寻呼消息的等级确定的；以及在所指示的物理资源块集上接收所述寻呼消息。根据该技术方案，可实现同时对覆盖增强和/或用户设备和/或低复杂度或低成本的MTC用户设备的寻呼消息传输机制。



CN 101841920 A

1. 一种用户设备接收寻呼消息的方法，包括：

接收对用于发送所述寻呼消息的物理资源块集的指示，其中，所述物理资源块集在子帧中的索引是根据所述寻呼消息的等级确定的；以及

在所指示的物理资源块集上接收所述寻呼消息。

2. 根据权利要求1所述的方法，其中，所述寻呼消息的等级是通过以下方式之一获得的：

由基站通过广播信息和/或用户设备专用无线电资源控制信令配置；

由网络侧通过NAS信令配置；以及

由所述用户设备根据其测量结果确定。

3. 根据权利要求1所述的方法，其中，所述物理资源块集在子帧中的索引是指所述物理资源块集的起始资源块在子帧中的索引。

4. 根据权利要求1所述的方法，其中，所述物理资源块集的大小对于不同等级的寻呼消息而言是相同的。

5. 根据权利要求1所述的方法，其中，所述物理资源块集的大小根据所述寻呼消息的等级确定。

6. 根据权利要求1所述的方法，其中，所述寻呼消息的等级还用于确定一个或多个物理下行共享信道，物理上行共享信道，物理下行控制信道和/或增强型物理下行控制信道，物理上行控制信道和物理随机接入信道的重复次数。

7. 根据权利要求1所述的方法，其中，所述寻呼消息的等级还用于确定一个或多个物理下行共享信道，物理上行共享信道，物理下行控制信道和/或增强型物理下行控制信道，物理上行控制信道和物理随机接入信道的传输时间间隔的大小。

8. 根据权利要求1所述的方法，其中，接收对用于发送所述寻呼消息的物理资源块集的指示包括：

通过广播系统信息和/或用户设备专用无线电资源控制信令从基站接收所述物理资源块集在子帧中的索引和/或所述物理资源块集的大小；或

通过非接入层信令从网络侧设备接收所述物理资源块集在子帧中的索引和/或所述物理资源块集的大小。

9. 根据权利要求1所述的方法，其中，所述用户设备使用的系统带宽包括6个物理资源块，以及所述物理资源块集是所述系统带宽的子集。

10. 根据权利要求1所述的方法，其中，当所述用户设备使用的系统带宽大于6个物理资源块时，所述系统带宽包括多个子频带，所述多个子频带中的每一个包含不多于6个的物理资源块，所述寻呼消息在所述多个子频带中由网络节点确定的一个子频带上接收。

11. 一种网络节点发送寻呼消息的方法，包括：

根据所述寻呼消息的等级确定用于发送所述寻呼消息的物理资源块集在子帧中的索引；

向作为所述寻呼消息的接收方的用户设备通知对所述物理资源块集的指示，以及

在所确定的物理资源块集上发送所述寻呼消息。

12. 根据权利要求11所述的方法，其中，所述寻呼消息的等级是通过以下方式之一获得的：

由所述网络节点预先存储；

由上级网络节点通知；或

用户设备根据其测量结果确定并通知所述网络节点。

13. 根据权利要求 11 所述的方法，其中，所述物理资源块集在子帧中的索引是指所述物理资源块集的起始资源块在子帧中的索引。

14. 根据权利要求 11 所述的方法，其中，所述物理资源块集的大小对于不同等级的寻呼消息而言是相同的。

15. 根据权利要求 11 所述的方法，其中，所述物理资源块集的大小根据所述寻呼消息的等级确定。

16. 根据权利要求 11 所述的方法，其中，所述寻呼消息的等级还用于确定一个或多个物理下行共享信道、物理上行共享信道、物理下行控制信道和 / 或增强型物理下行控制信道、物理上行控制信道和物理随机接入信道的重复次数。

17. 根据权利要求 11 所述的方法，其中，所述寻呼消息的等级还用于确定一个或多个物理下行共享信道、物理上行共享信道、物理下行控制信道和 / 或增强型物理下行控制信道、物理上行控制信道和物理随机接入信道的传输时间间隔捆绑大小。

18. 根据权利要求 11 所述的方法，其中，向作为所述寻呼消息的接收方的用户设备通知对所述物理资源块集的指示包括：

如果所述网络节点是基站，通过广播系统信息和 / 或用户设备专用无线电资源控制信令向所述用户设备发送所述物理资源块集在子帧中的索引和 / 或所述物理资源块集的大小；或

如果所述网络节点是网络侧设备，通过非接入层信令向所述用户设备发送所述物理资源块集在子帧中的索引和 / 或所述物理资源块集的大小。

19. 根据权利要求 11 所述的方法，其中，所述网络节点为用户设备分配的系统带宽包括 6 个物理资源块，以及所述物理资源块集是所述系统带宽的子集。

20. 根据权利要求 11 所述的方法，还包括：当所述网络节点为用户设备分配的系统带宽大于 6 个物理资源块时，将所述系统带宽划分为包含不多于 6 个物理资源块的多个子频带，以及确定所述多个子频带中要在其上向所述用户设备发送寻呼消息的一个子频带。

21. 一种用户设备，包括：

接收单元，用于接收对用于发送所述寻呼消息的物理资源块集的指示，以及用于在所指示的物理资源块集上接收所述寻呼消息，其中，所述物理资源块集在子帧中的索引是根据所述寻呼消息的等级确定的。

22. 根据权利要求 21 所述的用户设备，其中，所述寻呼消息的等级是由基站通过广播信息和 / 或用户设备专用无线电资源控制信令配置或由网络侧通过 NAS 信令配置，并通过所述接收单元接收的；或者

所述用户设备还包括：

测量单元，用于测量信道状态；以及

等级确定单元，用于根据所述测量单元的测量结果确定所述寻呼消息的等级。

23. 根据权利要求 21 所述的用户设备，其中，所述物理资源块集在子帧中的索引是指所述物理资源块集的起始资源块在子帧中的索引。

21. 根据权利要求 20 所述的用户设备，其中，所述物理资源块集的大小对于不同等级的寻呼消息而言是相同的。

25. 根据权利要求 21 所述的用户设备，其中，所述物理资源块集的大小由网络节点根据所述寻呼消息的等级确定，并通过广播信息和 / 或用户设备专用无线电资源控制信令由所述接收单元接收。

26. 根据权利要求 21 所述的用户设备，其中，对所述物理资源块集的指示包括所述物理资源块集在子帧中的索引以及所述物理资源块集的大小；以及

所述接收单元还用于通过广播系统信息和 / 或用户设备专用无线电资源控制信令从基站接收所述物理资源块集在子帧中的索引和 / 或所述物理资源块集的大小；或

所述接收单元还用于通过非接入层信令从网络侧设备接收所述物理资源块集在子帧中的索引和 / 或所述物理资源块集的大小。

27. 根据权利要求 21 所述的用户设备，其中，所述用户设备使用的系统带宽包括 6 个物理资源块，以及所述物理资源块集是所述系统带宽的子集。

28. 根据权利要求 21 所述的用户设备，其中，当所述用户设备使用的系统带宽大于 6 个物理资源块时，所述系统带宽包括多个子频带，所述多个子频带中的每一个包含不多于 6 个的物理资源块，所述寻呼消息由所述接收单元 310 在所述多个子频带中由网络节点确定的一个子频带上接收。

29. 一种网络节点，包括：

块集索引确定单元，用于根据寻呼消息的等级确定用于发送所述寻呼消息的物理资源块集在子帧中的索引；以及

发送单元，用于向作为所述寻呼消息的接收方的用户设备通知对所述块集索引确定单元确定的物理资源块集的指示，以及用于在所述确定的物理资源块集上发送所述寻呼消息。

30. 根据权利要求 29 所述的网络节点，还包括接收单元，

其中，所述寻呼消息的等级由所述网络节点预先存储，或者由上级网络节点通知，或者由用户设备根据测量结果确定并通知所述网络节点，并由所述接收单元接收。

31. 根据权利要求 29 所述的网络节点，其中，所述物理资源块集在子帧中的索引是指所述物理资源块集的起始资源块在子帧中的索引。

32. 根据权利要求 29 所述的网络节点，其中，所述物理资源块集的大小对于不同等级的寻呼消息而言是相同的。

33. 根据权利要求 29 所述的网络节点，还包括：块集大小确定单元，用于根据所述寻呼消息的等级确定所述物理资源块集的大小。

34. 根据权利要求 29 所述的网络节点，还包括：重复次数确定单元，用于根据所述寻呼消息的等级确定一个或多个物理下行共享信道、物理上行共享信道、物理下行控制信道和 / 或增强型物理下行控制信道，物理上行控制信道和物理随机接入信道的重复次数。

35. 根据权利要求 29 所述的网络节点，还包括：调制大小确定单元，用于根据所述寻呼消息的等级确定一个或多个物理下行共享信道、物理上行共享信道、物理下行控制信道和 / 或增强型物理下行控制信道、物理上行控制信道和物理随机接入信道的传输时间间隔调制大小。

36. 根据权利要求 29 所述的网络节点，其中，对所述物理资源块集的指示包括所述物理资源块集在子帧中的索引以及所述物理资源块集的大小；以及

如果所述网络节点是基站，所述发送单元通过广播系统信息和 / 或用户设备专用无线电资源控制信令向用户设备发送所述物理资源块集在子帧中的索引和 / 或所述物理资源块集的大小；或

如果所述网络节点是网络侧设备，所述发送单元通过非接入层信令向用户设备发送所述物理资源块集在子帧中的索引和 / 或所述物理资源块集的大小

37. 根据权利要求 29 所述的网络节点，其中，所述网络节点为用户设备分配的系统带宽包括 6 个物理资源块，以及所述物理资源块集是所述系统带宽的子集。

38. 根据权利要求 29 所述的网络节点，还包括：

子频带划分单元，用于当所述网络节点为用户设备分配的系统带宽大于 6 个物理资源块时，将所述系统带宽划分为包含不多于 6 个物理资源块的多个子频带；以及

子频带确定单元，用于确定所述子频带划分单元划分的所述多个子频带中要在其上向用户设备发送上行消息的一个子频带

寻呼消息的接收/发送方法及相关网络节点和用户设备

技术领域

[0001] 本发明涉及无线通信技术领域，更具体地，本发明涉及寻呼消息的接收/发送方法以及相关网络节点/用户设备。

背景技术

[0002] 第三代移动通信合作计划组织(3GPP)部署的长期演进项目(LTE)旨在提供日益多样化的未来移动通信服务，无线宽带通信已经成为大众生活和工作中不可或缺的一部分。在3GPP LTE的第八版(即Release-8)中，引入了正交频分多址(OFDMA)和多天线(MIMO)技术。3GPP的Release-10版本经国际电信联盟的评估和测试，正式成为了第四代全球移动通信标准LTE-Advanced。在LTE-Advanced标准中，引入了载波聚合(CA)和中继技术，增强了上行、下行MIMO技术，同时支持异构网络(HetNet)的部署。

[0003] 为了满足未来家庭设备通信的市场需求和规模庞大的物联网(IOT)部署，3GPP决定在LTE及其升级版本中引入低成本机器间通信技术(MTC:Machine Type Communication)，将MTC服务由目前的GSM网络支持迁移至LTE网络支持，并定义了若干种新的LTE用户设备(UE:User Equipment)的类型，其一称之为低成本MTC用户设备(Low-cost MTC UE)，该MTC用户设备在现有LTE网络的所有双工模式中支持MTC服务，并具有这样的性能：1)单接收天线；2)下行和上行最大的传输模块大小(TBS:Transport Block Size)为1000比特(bit)；下行链路数据信道的基带带宽降低为1.4MHz，下行链路控制信道的带宽与网络侧系统带宽保持一致、上行链路信道带宽以及下行链路的射频部分与现有LTE网络中的用户设备保持一致；3)下行、上行链路控制信道和数据信道的基带带宽降低为1.4MHz。

[0004] MTC是一种不需要人为参与的数据通信服务。大规模的MTC用户设备部署，可以用于安全、跟踪、付账、测量以及消费电子等领域，具体涉及的应用包括视频监控、供货链跟踪、智能电表、远程监控等。MTC用户设备要求较低的功率消耗、支持较低的数据传输速率和较低的移动性。目前LTE系统主要是针对人与人(H2H)的通信服务。因此，实现MTC服务的规模竞争优势及应用前景，关键环节在于LTE网络支持低成本的MTC设备能够低成本、低复杂性的工作。

[0005] 一些MTC用户设备需要安装在居民楼地下室或者由绝缘络层、金属护窗或者传统建筑物的厚墙保护的位置，相比较LTE网络中常规设备终端(如手机、平板电脑等)，这些设备的空中接口将明显遭受更严重的穿透损失。3GPP决定研究LTE网络提供MTC用户设备附加20dB-15dB覆盖增强服务的方案设计与性能评估，值得注意的是，位于精确网络覆盖区域的MTC用户设备具有这样的特点：非常低的数据传输速率、非常宽松的延时要求、以及有限的移动性。针对MTC用户设备特点，LTE网络可以进一步优化一些信令和一些信道用以支持MTC用户设备。3GPP要求为新定义的MTC用户设备以及其他具有MTC服务(如非常宽松的延迟要求)的用户设备提供一定的LTE网络覆盖增强。其中，对于LTE频分双工(FDD)网络提供15dB的网络覆盖增强。另外，并不是所有的运用MTC服务的用户设备都需

发相同网络覆盖增强

[0006] 在2011年6月举行的3GPP RAN#64次全会上，提出了一个新的面向Rel-13的低复杂性和覆盖增强的MTC的工作项目（参见非专利文献：RP-110990New Work Item on Even Lower Complexity and Enhanced Coverage LTE UE For MTC, Ericsson, NSN）。在该工作项目的描述中，LTE Rel-13系统需要支持上下行1.4MHz射频带宽的MTC用户设备（User Equipment，UE，以下称为窄带MTC UE）工作在任意的系统带宽（例如1.4MHz、3MHz、5MHz、10MHz、15MHz、20MHz等等）下，并且为该类MTC用户提供覆盖增强功能。在系统设计时，低成本MTC用户和覆盖增强MTC用户要采用统一的设计方案，降低MTC用户设备的能耗是该工作项目的主要目标之一。

[0007] 针对3GPP LTE用户设备运行MTC业务并处于覆盖增强模式下，物理层信道如PDCCH/PDSCH/PUCCH/PUSCH的覆盖增强设计与配置是一个需要标准化的工作。根据3GPP RAN1#74会议的讨论，在完成初始接入过后，任何一个需要重复传输的物理信道，其配置模式取决于基站端。而MTC用户设备合并解调大量重复数据会引入2至10ms的延迟。这样的延迟会增加MTC用户设备的耗电量。根据3GPP RAN1#76bis会议的决定，对于需要覆盖增强的MTC用户设备数据信道的传输应在控制信道传输完成之后。因此为了减少用户设备的耗电量，对于需要覆盖增强的MTC用户设备的寻呼消息传输可以不需要控制信道。同时由于低复杂度MTC用户设备（Low complexity MTC UE）与覆盖增强的MTC用户设备具有相似的信息传输机制，需要设计一种同时针对覆盖增强MTC用户设备和/或低复杂度或低成本的MTC用户设备的寻呼消息传输机制。因此在Rel-13及其之后版本中，针对覆盖增强模式下MTC用户设备和/或低复杂度或低成本的MTC用户设备的寻呼消息传输需要重新标准化。

发明内容

[0008] 本发明旨在提供同时针对例如覆盖增强MTC用户设备和/或低复杂度或低成本的MTC用户设备的寻呼消息传输机制。

[0009] 根据本发明的一个方案，提供了一种用户设备接收寻呼消息的方法。该方法包括：接收对用于发送所述寻呼消息的物理资源块集的指示，其中，所述物理资源块集在子帧中的索引是根据所述寻呼消息的等级确定的；以及在所指示的物理资源块集上接收所述寻呼消息。

[0010] 根据本发明的另一个方案，提供了一种网络节点发送寻呼消息的方法。该方法包括：根据所述寻呼消息的等级确定用于发送所述寻呼消息的物理资源块集在子帧中的索引；向作为所述寻呼消息的接收方的用户设备通知对所述物理资源块集的指示，以及在所确定的物理资源块集上发送所述寻呼消息。

[0011] 根据本发明的另一个方案，提供了一种用户设备。该用户设备包括：接收单元，用于接收对用于发送所述寻呼消息的物理资源块集的指示，以及用于在所指示的物理资源块集上接收所述寻呼消息，其中，所述物理资源块集在子帧中的索引是根据所述寻呼消息的等级确定的。

[0012] 根据本发明的另一个方案，提供了一种网络节点。该基站包括：块集索引确定单元，用于根据寻呼消息的等级确定用于发送所述寻呼消息的物理资源块集在子帧中的索引；以及发送单元，用于向作为所述寻呼消息的接收方的用户设备通知对所述块集索引确

定单元确定的物理资源块集的指示，以及用于在所述确定的物理资源块集上发送所述寻呼消息。

[0013] 本发明的上述方案简单易行，并且由于用于发送寻呼消息的物理资源块的参数（例如索引）取决于寻呼消息的等级，而该寻呼消息等级同样可用于对MTC用户设备进行覆盖增强，因此该方案同时适用于覆盖增强MTC用户设备和/或低复杂度或低成本的MTC用户设备的寻呼消息传输。

附图说明

[0014] 通过下文结合附图的详细描述，本发明的上述和其它特征将会变得更加明显，其中：

[0015] 图1示出了根据本发明的接收寻呼消息的方法的流程图；

[0016] 图2示出了根据本发明的发送寻呼消息的方法的流程图；

[0017] 图3示出了根据本发明的用于接收寻呼消息的用户设备的示意性框图；

[0018] 图4示出了根据本发明的用于发送寻呼消息的基站的示意性框图；

[0019] 图5示出了不同等级的寻呼消息的占用的相同大小资源块集的示意图；

[0020] 图6示出了不同等级的寻呼消息与相应的资源块起始位置索引的对应关系的示意图；

[0021] 图7示出了不同等级的寻呼消息的占用的不同大小资源块集的示意图；

[0022] 图8示出了不同等级的寻呼消息与相应占用的资源块集的大小的对应关系的示意图；

[0023] 图9示出了不同寻呼等级与相应的资源块起始位置索引的对应关系的另一示意图；

[0024] 图10示出了将系统频带划分为多个子频带的示意图；

具体实施方式

[0025] 以下将结合附图和具体实施例，对本发明所提出的针对需要额外覆盖增强的MTC用户设备或者低复杂度、低成本MTC用户设备的寻呼消息在物理资源上的发送/接收方法、网络节点和用户设备(UE)进行详细阐述。应当注意的是，虽然本发明是针对需要额外覆盖增强或者低复杂度、低成本MTC用户设备来阐述的，但其同样也适用于其他支持延迟容忍服务和/或需要一定覆盖增强的用户设备。应当注意的是，本发明不应局限于下文所述的具体实施例。另外，为了简便起见，省略了对与本发明没有直接关联的公知技术的详细描述，以防止对本发明的理解造成混淆。

[0026] 下文以LTE移动通信系统及其后续的演进版本作为示例应用环境，具体描述了根据本发明的多个实施例。然而，需要指出的是，本发明不限于以下实施例，而是可适用于更多其它的无线通信系统，例如今后的5G蜂窝通信系统或现有的其他通信系统，只要其要求提供同时针对覆盖增强MTC用户设备和/或低复杂度或低成本的MTC用户设备的寻呼消息传输机制。

[0027] 图1示出了根据本发明的一个实施例的寻呼消息接收方法。在图1的步骤110中，用户设备接收对用于发送寻呼消息的物理资源块集的指示，其中，物理资源块集在子帧中

的索引是根据寻呼消息的等级确定的。在步骤 120 中，用户设备在所指示的物理资源块集上接收寻呼消息。

[0028] 在本发明的一些实施例中，寻呼消息的等级是通过以下方式之一获得的：由基站通过广播系统信息和 / 或用户设备专用无线电资源控制信令配置；由网络侧通过 NAS 信令配置；以及由用户设备根据其测量结果确定。

[0029] 在本发明的一些实施例中，物理资源块集在子帧中的索引是指物理资源块集的起始资源块在子帧中的索引。

[0030] 在本发明的一些实施例中，物理资源块集的大小对于不同等级的寻呼消息而言是相同的。

[0031] 在本发明的另一些实施例中，物理资源块集的大小根据寻呼消息的等级确定。

[0032] 在本发明的一些实施例中，寻呼消息的等级还用于确定一个或多个物理下行共享信道，物理下行共享信道，物理下行控制信道和 / 或增强型物理下行控制信道，物理下行控制信道和物理随机接入信道的重复次数。

[0033] 在本发明的一些实施例中，寻呼消息的等级还用于确定一个或多个物理下行共享信道，物理下行共享信道，物理下行控制信道和 / 或增强型物理下行控制信道，物理下行控制信道和物理随机接入信道的传输时间间隔调制大小。

[0034] 在本发明的一些实施例中，接收对用于发送寻呼消息的物理资源块集的指示包括：通过广播系统信息和 / 或用户设备专用的无线电资源控制 (UE dedicated Radio Resource Control) 信令从基站接收物理资源块集在子帧中的索引和 / 或物理资源块集的大小；或通过非接入层 (NAS) 信令从网络侧设备接收物理资源块集在子帧中的索引和 / 或物理资源块集的大小。

[0035] 在本发明的一些实施例中，该用户设备使用的系统带宽包括 6 个物理资源块。在该情况下，物理资源块集是系统带宽的子集。

[0036] 然而，也可能存在系统带宽大于 6 个物理资源块的情况。在本发明的一些实施例中，当系统带宽大于 6 个物理资源块时，系统带宽可包括多个子频带。该多个子频带中的每一个包含不多于 6 个的物理资源块。例如，在系统带宽中包含的物理资源块的数目能够被 6 整除时，该多个子频带中的每一个包含 6 个物理资源块。然而当系统带宽中包含的物理资源块的数目不能够被 6 整除时，该多个子频带中的一个子频带包含的物理资源块可以小于 6 个，而其他子频带可以均包含 6 个物理资源块。也可以存在其他的子频带分配方式，例如在其他通信系统中可以使用除 6 之外的其他物理资源块数目。只要寻呼消息对应的物理资源块的数目小于该子频带具有的资源块的总数目，便可以使用本文上述的方案确定该子频带中用于该寻呼消息的资源块集的起始位置索引和大小。本发明不受限于系统带宽一个子频带中包含的具体资源块的数目。

[0037] 在上述任一情况下，寻呼消息在多个子频带中由网络节点 (例如基站或网络侧) 确定的一个子频带上接收。

[0038] 图 2 示出了根据本发明的一个实施例的网络节点侧的寻呼消息发送方法。在图 2 所示的流程图中，该方法包括：步骤 210，根据寻呼消息的等级确定用于发送寻呼消息的物理资源块集在子帧中的索引；步骤 220，向作为寻呼消息的接收方的用户设备通知对物理资源块集的指示；以及步骤 230，在所确定的物理资源块集上发送寻呼消息。

[0039] 在本发明的一些实施例中，寻呼消息的等级是通过以下方式之一获得的：由网络节点预先存储、由上级网络节点通知（例如，在网络节点是基站的情况下，由网络可通过 S1 寻呼消息指示）；以及用户设备根据其测量结果确定并通知网络节点。

[0040] 在本发明的一些实施例中，物理资源块集在子帧中的索引是指物理资源块集的起始资源块在子帧中的索引。

[0041] 在本发明的一些实施例中，物理资源块集的大小对于不同等级的寻呼消息而言是相同的。

[0042] 在本发明的一些实施例中，物理资源块集的大小根据寻呼消息的等级确定。

[0043] 在本发明的一些实施例中，寻呼消息的等级还用于确定一个或多个物理下行共享信道、物理下行共享信道、物理下行控制信道和 / 或增强型物理下行控制信道、物理下行控制信道和物理随机接入信道的重复次数。

[0044] 在本发明的一些实施例中，寻呼消息的等级还用于确定一个或多个物理下行共享信道、物理下行共享信道、物理下行控制信道和 / 或增强型物理下行控制信道、物理下行控制信道和物理随机接入信道的传输时间间隔捆绑大小。

[0045] 在本发明的一些实施例中，向作为寻呼消息的接收方的用户设备通知对物理资源块集的指示包括：如果网络节点是基站，通过广播系统信息和 / 或用户设备专用的无线电资源控制信令向用户设备发送物理资源块集在子帧中的索引和 / 或物理资源块集的大小；或如果网络节点是网络侧设备，通过下接入层信令向用户设备发送物理资源块集在子帧中的索引和 / 或物理资源块集的大小。然而本发明不限于此，例如基站也可以使用其他的群发机制（例如、多播机制等）来发送物理资源块集在子帧中的索引。

[0046] 在本发明的一些实施例中，网络节点为用户设备分配的系统带宽包括 6 个物理资源块。在该情况下，物理资源块集是所述系统带宽的子集。

[0047] 在本发明的一些实施例中，当网络节点为用户设备分配的系统带宽大于 6 个物理资源块时，将所述系统带宽划分为包含不多于 6 个物理资源块的多个子频带，以及确定所述多个子频带中要在其上向用户设备发送寻呼消息的一个子频带。

[0048] 图 3 示出了用于根据本发明的实施例发送寻呼消息的用户设备。该用户设备至少包括：接收单元 310，用于接收对用于发送寻呼消息的物理资源块集的指示，以用于在所指示的物理资源块集上接收寻呼消息，其中，物理资源块集在子帧中的索引是根据寻呼消息的等级确定的。

[0049] 在本发明的一些实施例中，寻呼消息的等级是由基站通过广播系统信息和 / 或用户设备专用无线电资源控制信令配置或由网络侧通过 NAS 信令配置，并通过接收单元 310 接收的。在本发明的另一些实施例中，用户设备还包括用于测量信道状态的测量单元 320，以及用于根据测量单元的测量结果确定寻呼消息的等级的等级确定单元 330。

[0050] 在本发明的一些实施例中，物理资源块集在子帧中的索引是指物理资源块集的起始资源块在子帧中的索引。

[0051] 在本发明的一些实施例中，物理资源块集的大小对于不同等级的寻呼消息而言是相同的。

[0052] 在本发明的一些实施例中，物理资源块集的大小由网络节点（根据不同的实现，可以是基站或网络侧设备，如移动性管理实体 (MME)）根据寻呼消息的等级确定，并通过广

播系统信息和 / 或用户设备专用无线电资源控制信令由接收单元 310 接收。

[0053] 对物理资源块集的指示可以包括物理资源块集在子帧中的索引以及物理资源块集的大小。在本发明的一些实施例中，接收单元 310 还用于通过广播系统信息和 / 或用户设备专用的无线电资源控制 (RRC, dedicated RRC) 信令从基站接收物理资源块集在子帧中的索引和 / 或物理资源块集的大小。或者在其他一些实施例中，接收单元 310 还用于通过非接入层信令从网络侧设备接收物理资源块集在子帧中的索引和 / 或物理资源块集的大小。

[0054] 在本发明的一些实施例中，用户设备使用的系统带宽包括 6 个物理资源块，以及物理资源块集是所述系统带宽的子集。

[0055] 在本发明的一些实施例中，当用户设备使用的系统带宽大于 6 个物理资源块时，系统带宽包括多个子频带，该多个子频带中的每一个包含不多于 6 个的物理资源块。在该情况下，寻呼消息由接收单元 310 在所述多个子频带中由网络节点（基站或网络侧）确定的一个子频带上接收。

[0056] 在本发明的一些实施例中，用户设备还包括存储器 340，用于存储接收单元 310 接收到的各种信息，例如寻呼消息、物理资源块集的大小、物理资源块集在子帧中的索引以及其他用户设备接收到的信息等。存储器 350 还可以存储测量单元 320、等级确定单元 330 所使用或输出的信息，例如测量单元 320 的测量结果，在该情况下，等级确定单元 330 可从存储器 350 获得该测量结果。存储器 350 还可以存储发送单元 340 要发送的信息，例如等级确定单元 330 确定的寻呼消息的等级。

[0057] 图 1 示出了根据本发明的实施例发送寻呼消息的网络节点。图 1 示出的网络节点至少包括：块集索引确定单元 110，用于根据寻呼消息的等级确定用于发送寻呼消息的物理资源块集在子帧中的索引；以及发送单元 120，用于向作为寻呼消息的接收方的用户设备通知对块集索引确定单元 110 确定的物理资源块集的指示，以及用于在所确定的物理资源块集上发送寻呼消息。

[0058] 在本发明的一些实施例中，网络节点还包括接收单元 130。其中，寻呼消息的等级由网络节点预先存储，或者由上级网络节点通知，或由用户设备根据其测量结果确定并通知网络节点，并由接收单元 130 接收。

[0059] 在本发明的一些实施例中，物理资源块集在子帧中的索引是指物理资源块集的起始资源块在子帧中的索引。

[0060] 在本发明的一些实施例中，物理资源块集的大小对于不同等级的寻呼消息而言是相同的。

[0061] 在本发明的一些实施例中，网络节点还包括：块集大小确定单元 140，用于根据寻呼消息的等级确定物理资源块集的大小。

[0062] 在本发明的一些实施例中，网络节点还包括：重复次数确定单元 150，用于根据寻呼消息的等级确定一个或多个物理下行共享信道，物理上行共享信道，物理下行控制信道和 / 或增强型物理下行控制信道，物理上行控制信道和物理随机接入信道的重复次数。

[0063] 在本发明的一些实施例中，网络节点还包括：捆绑大小确定单元 160，用于根据寻呼消息的等级确定一个或多个物理下行共享信道，物理上行共享信道，物理下行控制信道和 / 或增强型物理下行控制信道，物理上行控制信道和物理随机接入信道的传输时间间隔捆绑大小。

[0064] 在本发明的一些实施例中，如果网络节点是基站，发送单元 120 通过广播系统信息和 / 或用户设备专用的无线电资源控制 (Radio Resource Control, RRC) 信令向用户设备发送物理资源块集在子帧中的索引和 / 或物理资源块集的大小；或者如果网络节点是网络侧设备，发送单元 120 通过非接入层信令向用户设备发送物理资源块集在子帧中的索引和 / 或物理资源块集的大小。

[0065] 在本发明的一些实施例中，网络节点为用户设备分配的系统带宽包括 6 个物理资源块，在该情况下所述物理资源块集是系统带宽的子集。

[0066] 在本发明的一些实施例中，网络节点还包括：子频带划分单元 170，用于当网络节点为用户设备分配的系统带宽大于 6 个物理资源块时，将所述系统带宽划分为包含不多于 6 个物理资源块的多个子频带；以及子频带确定单元 180，用于确定所述子频带划分单元 170 划分的所述多个子频带中要在其上向用户设备发送寻呼消息的一个子频带。

[0067] 在本发明的一些实施例中，网络节点还包括存储器 190。存储器 190 可存储发送单元 120 要发送的信息，如寻呼消息，也可以存储接收单元 130 接收到的信息，例如接收单元 130 从网络侧 (例如 MME) 或用户设备接收到的寻呼消息的等级。存储器 190 还可以存储块集索引确定单元 110、块集大小确定单元 140、重复次数确定单元 150、捆绑大小确定单元 160、子频带划分单元 170、子频带确定单元 180 等单元所需的信息或输出的信息。

[0068] 本发明的上述网络节点可以是基站，也可以是网络侧设备，例如网络侧的移动性管理实体 (MME)。当然，也可以是本领域技术人员通常使用来配置传输一移动性参数的任何网络侧设备。本发明不对此进行限制。

[0069] 需要注意的是，在图 3 和图 4 中描述的用户设备和网络节点仅是为了使本领域技术人员更清楚地理解本发明而作的例，其中省略了一些对理解本发明不必要的模块、组件，本发明的保护范围不应受这些附图的具体细节所限制。此外，实际的设备中可以包括更多的模块、组件，如显示器、操作维护接口 (对于图 4 中的网络节点)、输入输出接口等等。本发明不对这些进行限制。

[0070] 下面将参考图 5 至图 10 来对图 1 和图 2 中示出的方法以及图 3 和图 4 中示出的设备进行更详细地描述。需要注意的是，本发明中多数信息的确定和发送既可以由基站完成，也可以由网络侧设备完成。因此，除非特别说明，在本说明书中可以将术语基站、网络侧设备 (如 MME) 以及网络节点交换使用。此外，如上所述，虽然本发明主要针对需要额外覆盖增强或者低复杂度、低成本 MTC 用户设备来阐述的，但其同样也适用于其他支持延迟容忍服务和 / 或需要一定覆盖增强的用户设备。

[0071] 对覆盖增强 MTC UE 而言，其上、下行物理信道需要多次重复发送，以满足信道的覆盖增强要求。处于不同地理位置的 UE 所需的信道覆盖增强程度不一样，导致处于不同地理位置的 UE 的物理信道所需重复发送的次数不同。因此，可以将物理信道的覆盖增强程度分为若干个不同的覆盖增强等级。而不同覆盖增强等级的物理信道，其所需重复发送的次数不同。例如，可以将物理信道分为四个覆盖增强等级 (CE0、CE1、CE2 和 CE3)，每个覆盖增强等级对应物理信道所需的不同覆盖增强补偿，例如，CE0 指代的是覆盖增强等级 0，即不需要覆盖增强；CE1 指代的是覆盖增强等级 1，即需要例如 1 ～ 5dB 覆盖增强，其物理信道大致需要数次重复传输；CE2 指代的是覆盖增强等级 2，即需要例如 6 ～ 10dB 覆盖增强，其物理信道大致需要十数次重复传输；CE3 指代的是覆盖增强等级 3，即需要例如 11 ～ 15dB 覆盖

增强，其物理信道大致需要数十次重复传输。然而，需要注意的是，本发明的技术方案不限于四个覆盖增强等级，而是可以根据需要采用更多或更少的覆盖增强等级。还需要注意的是，上述物理信道的重复次数仅是为了使本领域技术人员理解本发明而给出的示例，具体系统中使用的重复次数不限于上述次数，而是可以根据系统需求（限制（例如系统资源限制））选择更多或更少的次数。

[0072] 由于寻呼消息对应的控制信道不传输，因此需要给出 UE 用户设备的寻呼消息在频域上的位置。在本发明的技术方案中，网络节点（例如基站）将不同等级的寻呼消息映射到不同的资源块集（RBGroup）来指示寻呼消息在频域上的位置。在本文中，资源块集指的是寻呼消息在子帧上占用的物理资源块的集合。资源块集的大小是指寻呼消息在子帧上占用的资源块的数目。此处资源块集可以是物理资源块集（PRB group），也可以是虚拟资源块集（VRB group），物理资源块与虚拟资源块间的映射关系可参考 3GPP TS36.211v10.2.0.1。本发明不再进行赘述。在本发明的技术方案中，可以对多个资源块进行虚拟连续分配，即虚拟资源块集的集中式分配（virtual resource blocks of localized type）。此处虚拟资源块集的集中式分配指的是将虚拟资源块 n_{VRB} 直接映射到物理资源块 n_{PRB}。而虚拟资源块的大小与物理资源块的大小一致。

[0073] 寻呼消息可以占用多个子帧，不同等级的寻呼消息占用的子帧数目可以不同。不同的用户设备占用的子帧也可以不同，例如，用户设备可根据用户 ID 在不同的子帧上接收寻呼消息，或通过 3GPP 协议中用于寻呼消息的时域复用的方法来进行子帧分配。在本发明的一些实施例中，需要确定确定两个参数，承载寻呼消息的物理资源块集的起始位置及连续分配的资源块数目。然而在另一些实施例中，由于承载寻呼消息的物理资源块集的大小（即，连续分配的资源块数目）被预先确定，且对于不同等级的寻呼消息而言是相同的，仅需要确定物理资源块集的起始位置。

[0074] 再次返回图 2，在图 2 的步骤 210 中，根据寻呼消息的等级确定用于发送寻呼消息的物理资源块集在子帧中的索引。该步骤由图 1 中的块集索引确定单元 410 执行。在本发明中，物理资源块集的起始位置与物理资源块集在子帧中的索引表达相同的概念，可相互交换使用。基于承载不同等级的寻呼消息的资源块集的大小是否一致，本发明提出了两种方案。网络节点和用户设备可同时支持两种方式或其中的一种。

[0075] 图 5 示出了承载不同等级的寻呼消息的资源块集的大小一致的情况。如图 5 所示，系统带宽为 6 个物理资源块大小，且承载不同等级的寻呼消息的资源块集的大小是一样的，相应的资源块集的起始位置由基站和 / 或网络侧（例如 MME）配置，其原则可以是尽量利用子帧中的物理资源块，也可以是本领域技术人员可想到或通常使用的其他原则。在图 5 所示的示例中，资源块集的起始位置与不同等级的寻呼消息的关系可以是：覆盖增强等级 0 的寻呼消息对应的资源块集的起始位置索引为 0 或 1；覆盖增强等级 1 的寻呼消息对应的资源块集的起始位置索引为 1；覆盖增强等级 2 的寻呼消息对应的资源块集的起始位置索引为 2；覆盖增强等级 3 的寻呼消息对应的资源块集的起始位置索引为 3。在图 5 的示例中，相应的承载寻呼消息的资源块集的大小为例如 2 个资源块，然而在其他示例中也可以是更大或更小的其他数目，且可以采用与图 5 不同的索引分配模式。

[0076] 寻呼消息的等级可以由基站通过广播信息和 / 或用户设备专用 RRC 信令配置给用户设备，或者可以由网络侧（例如 MME）通过 NAS 信令配置给用户设备。在一些示例中，寻

呼消息的等级可以由用户设备根据自己的下行链路测量结果确定。例如，用户设备通过测量单元 320 执行信道测量，并使用等级确定单元 330 根据测量得到的下行信道的参考信号接收功率（RSRP）值与特定阈值比较。该特定阈值可以是在 3GPP 技术规范 TS36.101 中规定的阈值，可由用户设备通过接收单元 310 从基站、网络侧先行接收到再、并预先存储在用户设备的存储单元 350 中。如果大于或等于该阈值，则等级确定单元 330 确定寻呼消息等级为 0；小于该阈值 1 ～ 5dB，则确定寻呼消息等级为 1；小于该阈值 6 ～ 10dB，则确定寻呼消息等级为 2；小于该阈值 11 ～ 15dB，则确定寻呼消息等级为 3。

[0077] 可选地，在确定寻呼消息等级之后，用户设备、基站、网络侧可存储该寻呼消息等级，以用于下一次的资源块集起始位置确定或用于其他用途。

[0078] 在块集索引确定单元 410 确定用于发送寻呼消息的物理资源块集在子帧中的索引之后，在步骤 420 中，网络节点向作为寻呼消息的接收方的用户设备通知对物理资源块集的指示。在一些实施例中，该对物理资源块集的指示可包括块集索引确定单元 410 确定的物理资源块集在子帧中的索引，并可选地包括物理资源块集的大小。然而在另一些实施例中，物理资源块集的大小已由被预先通知给了用户设备。

[0079] 承载不同等级的寻呼消息的资源块的数目可以是预定的，并例如可由基站通过广播信息和 / 或用户设备专用 RRC 信令配置给用户设备。在其他一些示例中，承载不同等级的寻呼消息的资源块的数目可以由网络侧（例如，MME）通过 NAS 信令配置。此外，基站可通过广播系统信息和 / 或用户设备专用 RRC 信令通知物理资源块集在子帧中的索引；或网络侧（例如、MME）可通过 NAS 信令通知该索引。在本发明中，子帧中承载寻呼消息的资源块集的索引与这些资源块中起始资源块的索引表达相同的含义，可以互换使用。

[0080] 在一些示例中，寻呼消息的等级可被基站的重复次数的确定单元 150 用于确定一个或多个物理下行共享信道、物理上行共享信道，物理下行控制信道，物理上行控制信道和物理随机接入信道的重复次数。

[0081] 在一些示例中，寻呼消息的等级可被基站的捆绑大小确定单元 160 用于确定一个或多个物理下行共享信道，物理上行共享信道，物理下行控制信道、物理上行控制信道和物理随机接入信道的 TTI bundle(Transmission Time Interval bundle：传输时间间隔捆绑）大小。

[0082] 图 6 示出了不同等级的寻呼消息与相应的资源块起始位置索引的对应关系的另一示意图。然而该图仅是为说明本发明而被出的示例，本发明不应被其所限制。例如，寻呼消息等级也可以对应于两个资源块起始位置，如索引 0 和 1，而不仅限于索引 0。

[0083] 图 7 示出了承载不同等级的寻呼消息的资源块集的大小不一致的情况。如图 7 所示，系统带宽为 6 个物理资源块大小，且承载不同等级的寻呼消息的资源块集的大小是不一样的，相应的资源块集的起始位置由基站和 / 或网络侧（例如、MME）配置，其原则可以是尽量利用子帧中的物理资源块，但可以是本领域技术人员可想到或还需使用的其他原则。在图 7 所示的示例中，资源块集的起始位置与不同等级的寻呼消息的关系可以是：覆盖增强等级 0 的寻呼消息对应的资源块集的起始位置索引为 0；覆盖增强等级 1 的寻呼消息对应的资源块集的起始位置索引为 2；覆盖增强等级 2 的寻呼消息对应的资源块集的起始位置索引为 2；覆盖增强等级 3 的寻呼消息对应的物理资源块集的起始位置索引为 1。

[0084] 在图 7 示出的示例中，承载不同等级的寻呼消息的资源块集的大小不一致，因此

需要对资源块集的大小进行确定。该操作可以由图1中的块集大小确定单元110执行。在一些示例中，承载不同等级的寻呼消息的资源块的数目可以是：覆盖增强等级0的寻呼消息对应的资源块的数目为2；覆盖增强等级1的寻呼消息对应的资源块的数目为3；覆盖增强等级2的寻呼消息对应的资源块的数目为4；覆盖增强等级3的寻呼消息对应的资源块的数目为5。当然，本领域技术人员也可以根据实际需求（例如系统资源限制等）选择不同的资源块集大小分配方案，理论上只要覆盖增强等级较高的寻呼消息对应更多数目的资源块即可。

[0085] 图7所示情形的其他技术特征与图5所示情形相同，在此不再赘述。

[0086] 图8示出了在承载不同等级的寻呼消息的资源块集的大小不一致的情况下，寻呼消息等级与资源块集大小的映射关系。图9示出了在承载不同等级的寻呼消息的资源块集的大小不一致的情况下，寻呼消息等级与资源块起始位置的映射关系。如上所述，这些映射关系都仅是为了说明本发明而做出的示例，本发明不应被其所限制。

[0087] 在块集索引确定单元110确定用于发送寻呼消息的物理资源块集在子帧中的索引以及块集大小确定单元110确定该物理资源块集的大小之后，在步骤220中，网络节点向作为寻呼消息的接收方的用户设备通知对物理资源块集的指示。在一些实施例中，该对物理资源块集的指示可包括块集索引确定单元110确定的物理资源块集在子帧中的索引以及块集大小确定单元110确定的该物理资源块集的大小。

[0088] 在步骤230中，网络单元的发送单元120在所确定的物理资源块集上发送寻呼消息。

[0089] 然而，在3GPP LTE中，也可能存在系统带宽大于6个物理资源块的情况。图10示出了在该情形下根据本发明的处理。如图10所示，当系统带宽大于6个物理资源块时，可将系统带宽分成多个子频带。在每一个子频带中依然可执行图1-9中所示的技术方案。在图10所示情况下，网络节点还需要通过发送单元130向用户设备通知子频带的划分。子频带可以是连续的6个物理资源块。同样地，子频带的划分可以由基站通过广播系统信息和/或用户设备专用无线电资源控制信令配置给用户设备，或者由网络侧（例如MME）通过NAS信令配置给用户设备。

[0090] 作为一般性的实例，可以假设系统带宽包含M个PRB，并可被划分成N个子频带，其中M和N需满足N = floor(M/6)，即N是小于M除以6的最大自然数。这样整个系统带宽可划分为N个带宽大小为6个物理资源块的子频带和一个带宽大小为(M-6*N)个物理资源块的子频带。从上式可以看出，在M不是6的整倍数的情况下，可能包括子频带具有小于6个物理资源的情况。在这种情况下，只要寻呼消息对应的物理资源块的数目小于该子频带具有的资源块的总数目，依然可以使用本文上述的方案确定该子频带中用于该寻呼消息的资源块集的起始位置索引和大小。本发明不受限于系统带宽、子频带中包含的具体资源块的数目。

[0091] 用户设备需要在一个子频带上接收寻呼消息，该子频带是在配置了确定物理资源块集在子帧中的索引和/或物理资源块的大小之前确定的。在本发明的一些实施例中，可以根据寻呼消息的等级来确定用户设备所使用的子频带。例如，通过以下公式：Index of sub-band = (UE_ID) mod (the number of sub-band)来确定用户设备所使用的子频带。其中UE_ID可以是国际移动用户标识(IMSI，International Mobile Subscriber Identity)，

用于在核心网中唯一标识一个用户，该标识存储在 SIM 卡中。当然，在本发明的其他实施例中，本领域技术人员也可以使用唯一标识用户的其他可能的标识符，并对上式进行适应性修改，本发明不对此进行限制。

[0092] 在用户设备侧，用户设备的接收单元 310 在步骤 110 中接收对用于发送寻呼消息的物理资源块集的指示。该指示可以包括其用于接收寻呼消息的物理资源块集在子帧中的索引。在一些情况下，该指示还可以包括物理资源块集的大小。而在另一些情况下，物理资源块集的大小已由网络节点确定并在之前发送给用户设备（例如，物理资源块集的大小对不同寻呼消息等级而言固定的情况下）。

[0093] 然后，在步骤 120 中，用户设备可通过接收单元 310 在所指示的物理资源块集上接收寻呼消息。

[0094] 当用户设备处于 RRC_CONNECT 状态时，基站和 / 或网络侧（例如，MME）已经配置用户设备工作在一个子载带上接收数据。此时，当用户设备需要被寻呼时，该寻呼消息可在当前的子载带上传输，用于发送该寻呼消息的物理资源块集可通过根据本发明附图 1 至 9 中所述的方法来确定。

[0095] 应该理解，本发明的上述实施例可以通过软件、硬件或者软件和硬件两者的结合来实现。例如，上述实施例中的基站和用户设备内部的各种组件可以通过多种器件来实现，这些器件包括但不限于：模拟电路器件、数字电路器件、数字信号处理（DSP）电路、可编程处理器、专用集成电路（ASIC）、现场可编程门阵列（FPGA）、可编程逻辑器件（CPLD）、等等。

[0096] 在本申请中，"基站"是指具有较大发射功率和较广覆盖面积的移动通信数据和控制交换中心，包括资源分配调度、数据接收发送等功能。"用户设备"是指用户移动终端，例如包括移动电话、笔记本等可以与基站或者微站进行无线通信的终端设备。

[0097] 此外，这里所公开的本发明的实施例可以在计算机程序产品上实现。更具体地，该计算机程序产品是如下的一种产品：具有计算机可读介质，计算机可读介质上编码有计算机程序逻辑，当在计算设备上执行时，该计算机程序逻辑提供相关的操作以实现本发明的上述技术方案。当在计算系统的至少一个处理器上执行时，计算机程序逻辑使得处理器执行本发明实施例所述的操作（方法）。本发明的这种设置典型地提供为设置或编码在例如光介质（例如 CD-ROM）、软盘或硬盘等的计算机可读介质上的软件、代码和 / 或其他数据结构，或者诸如一个或多个 ROM 或 RAM 或 PROM 芯片上的固件或微代码的其他介质，或一个或多个模块中的可下载的软件图像、共享数据库等。软件或固件或这种配置可安装在计算设备上，以使得计算设备中的一个或多个处理器执行本发明实施例所描述的技术方案。

[0098] 尽管以上已经结合本发明的优选实施例示出了本发明，但是本领域的技术人员将会理解，在不脱离本发明的精神和范围的情况下，可以对本发明进行各种修改、替换和改变。因此，本发明不应由上述实施例来限定，而应由所附权利要求及其等价物来限定。

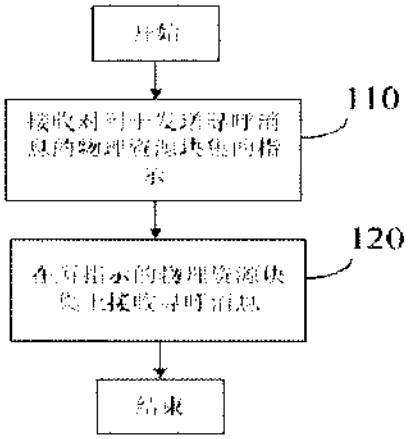

开始
接收对于由于发送寻呼消息的物理资源块集合的指示
110
在该指示的物理资源块集上接收寻呼消息
120
结束

图 1

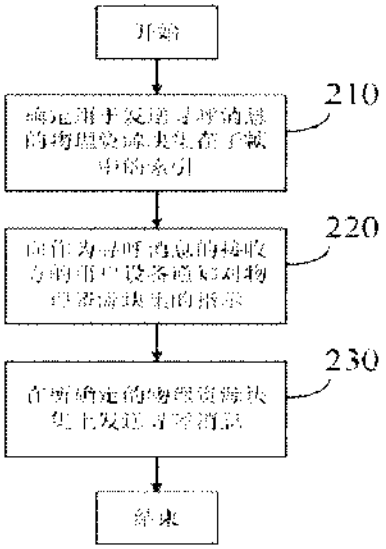

开始
210
220
230
结束

图 2

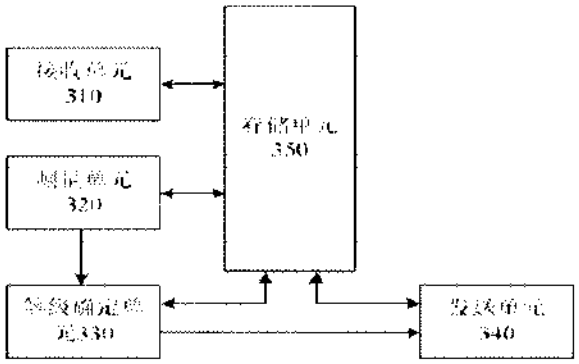

接收单元
310
存储单元
350
处理单元
320
确定单元
330
发送单元
340

图 3

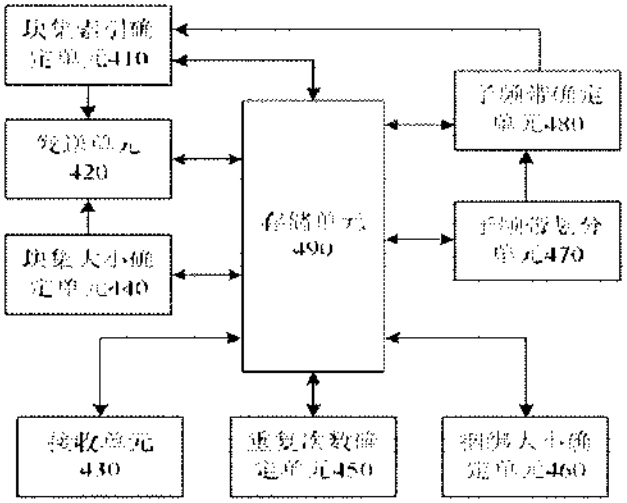


图 4

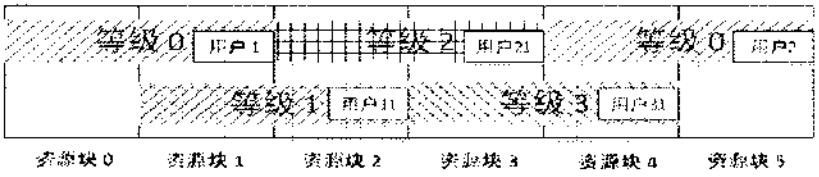


图 5

寻呼消息等级	资源块起始位置
0	0
1	1
2	2
3	3

图 6

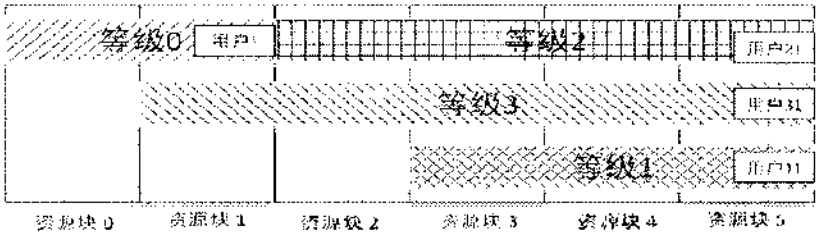


图 7

寻呼消息等级	资源块集大小
0	2
1	3
2	4
3	5

图 8

寻呼消息等级	资源块起始位置
0	0
1	3
2	2
3	1

图 9

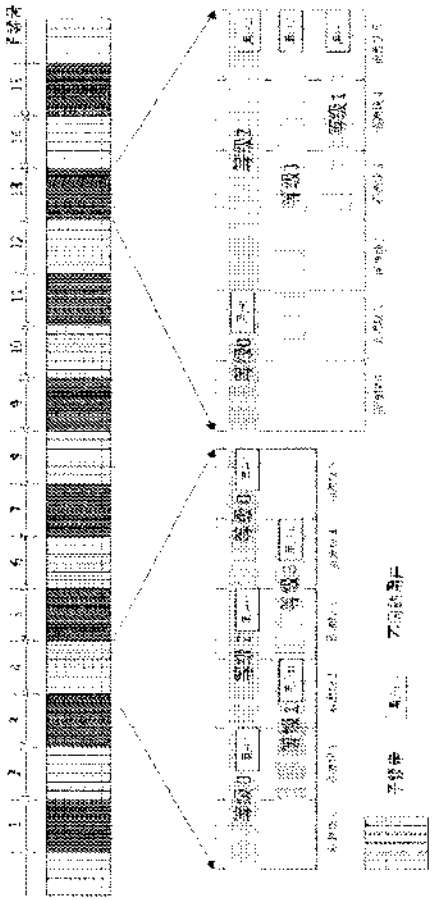


图 10

PTO/SB/08a (01-10)
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(Not for submission under 37 CFR 1.99)

Application Number	17950726
Filing Date	2022-09-22
First Named Inventor	Xiaobo ZHANG
Art Unit	2471
Examiner Name	AHMED ELALLAM
Attorney Docket Number	ZL0205-0004-US-CON3

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	1	10135663	B2	2018-11-20	Huawei Technologies Co Ltd	
	2	10159097	B2	2018-12-18	Qualcomm Inc	
	3	10271295	B2	2019-04-23	InterDigital Patent Holdings Inc	
	4	10419177	B2	2019-09-17	Samsung Electronics Co Ltd	
	5	8644864	B2	2014-02-04	InterDigital Patent Holdings Inc	
	6	10135663	B2	2018-11-20	Huawei Technologies Co Ltd	
	7	10356778	B2	2019-07-16	Asustek Computer Inc	
	8	10448414	B2	2019-10-15	FG Innovation Co Ltd Sharp Corp	

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	9	10462739	B2	2019-10-29	Samsung Electronics Co Ltd	
	10	10660081	B2	2020-05-19	LG Electronics Inc	
	11	10660120	B2	2020-05-19	LG Electronics Inc	
	12	11051293	B2	2021-06-29	InterDigital Patent Holdings Inc	
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	16	9380568	B2	2016-06-28	Harrison et al	

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	1	20180054800	A1	2019-11-26	Samsung Electronics Co Ltd	

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	2	20180070341	A1	2022-02-15	Huawei Technologies Co Ltd	
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	2	106376050	CN	A	2017-02-01	YULONG COMPUTER TELECOMMUNICATION SCIENT SHENZHEN		☒
	3	2016107518	WO	A1	2016-07-07	SHARP KK		☒
	4	2018126401	WO	A1	2018-07-12	Liu et al		☒

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	1	1st Office Action received in Application No. 201710255811.X dated October 9, 2020	☐
	2	1st Search Report in Application No. 201710255811.X dated September27, 2020	☐
	3	Erik Dahlman et al., 4G LTE/LTE-Advanced for Mobile Broadband, 2011	☐
	4	Frank Schaich et al., Subcarrier Spacing - How to Make Use of This Degree of Freedom, 2016 IEEE 83rd Vehicular Technology Conference	☐
	5	Apex Beam Technologies LLC v. Samsung Electronics Co., Ltd. et al., Case No. 2:22-cv-00188-JRG, Dkt. No. 1, Complaint for Patent Infringement (E.D. Tex. June 1, 2022).	☐

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	Attorney Docket Number	ZL0205-0004-US-CON3

	6	Apex Beam Technologies LLC v. Samsung Electronics Co., Ltd. et al., Case No. 2:22-cv-00188-JRG, Plaintiff's Infringement Contentions Claim Chart for U.S. Patent No. 10,462,767, Jan. 5, 2023,	☐
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	8	Apex Beam Technologies LLC v. ZTE Corp., No. 2:22-cv-00031-JRG-RSP, Dkt. No. 37, Docket Control Order (E.D. Tex. Feb. 6, 2023)	☐
	9	Apex Beam Technologies LLC v. Samsung Electronics Co., Ltd. et al., Case No. 2:22-cv-00188-JRG, Plaintiff's Infringement Contentions Cover Pleading (E.D. Tex. Jan. 5, 2023)	☐
	10	3GPP TS 36.211 v11.3.0 ("Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Physical Channels and Modulation (Release 11)") (June 2013)	☐
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	23	Chinese Decision on invalidation Request and its translation, Patent No. 201710255811X, 2023-06-02	☒

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	Filing Date	2022-09-22
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	Art Unit	2471
	Examiner Name	AHMED ELALLAM
	Attorney Docket Number	ZL0205-0004-US-CON3

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OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☐ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/JIALIN ZHONG/	Date (YYYY-MM-DD)	2023-09-24
Name/Print	JIALIN ZHONG	Registration Number	62937

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(71) Applicant: **NEC CORPORATION** [JP/JP]; 7-1, Shiba 5-chome, Minato-ku, Tokyo 108-8001 (JP).

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(74) Agent: **KING & WOOD MALLESONS**; 20th Floor, East Tower, World Financial Centre, No. 1 Dongsanhuan Zhonglu, Chaoyang District, Beijing 100020 (CN).

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(54) Title: METHOD AND DEVICE FOR INDICATING NUMEROLOGY

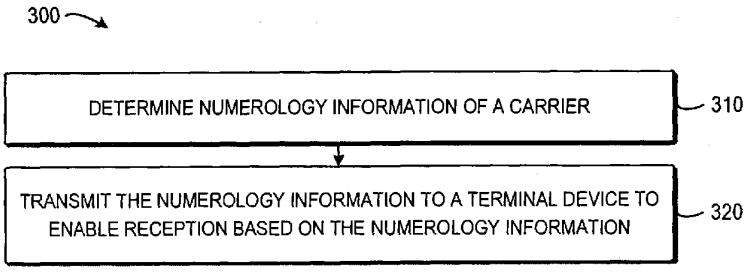


FIG. 3

(57) Abstract: Embodiments of the disclosure provide a method and device for indicating numerology. The method comprises: determining numerology information of a carrier, the numerology information indicating numerologies of one or more basic units for the carrier; and transmitting the numerology information to a terminal device to enable reception based on the numerology information.

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METHOD AND DEVICE FOR INDICATING NUMEROLOGY

FIELD OF THE INVENTION

[0001] Embodiments of the present disclosure generally relate to communication techniques. More particularly, embodiments of the present disclosure relate to a method and device for indicating numerology.

BACKGROUND OF THE INVENTION

[0002] Newly-developed mobile standards call for higher data transfer speeds, greater numbers of connections, and better coverage, among other improvements. The 5G standard, according to the Next Generation Mobile Networks Alliance, is expected to provide data rates of several tens of megabits per second to each of tens of thousands of users, with 1 gigabit per second to tens of workers on an office floor. Several hundreds of thousands of simultaneous connections should be supported in order to support large sensor deployments. Consequently, the spectral efficiency is expected to be enhanced to meet more requirements of the new standards.

[0003] Conventionally, for a single carrier, there is one numerology. Therefore, terminal devices have to employ the same numerology in communication with a network device. This inevitably brings undesired, delays, low spectral efficiency for some kind of traffic.

[0004] Accordingly, there is a need for development of better transmission/processing techniques for wireless data transmission to meet different requirements of different applications/users at the same time.

SUMMARY OF THE INVENTION

[0005] The present disclosure proposes a solution for indicating numerology.

[0006] According to a first aspect of embodiments of the present disclosure, embodiments of the disclosure provide a method performed by a network device. The network device determines numerology information of a carrier. The numerology information indicates numerologies of one or more basic units for the

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carrier. Then the network device transmits the numerology information to a terminal device to enable reception based on the numerology information.

[0007] According to a second aspect of embodiments of the present disclosure, embodiments of the disclosure provide method performed by a terminal device. The terminal device receives numerology information of a carrier from a network device. The numerology information indicates numerologies of one or more basic units for the carrier. Then the terminal device decodes a signal based on the numerology information.

[0008] According to a third aspect of embodiments of the present disclosure, embodiments of the disclosure provide a network device. The network device comprises: a controller configured to determine numerology information of a carrier, the numerology information indicating numerologies of one or more basic units for the carrier; and a transmitter the numerology information to a terminal device to enable reception based on the numerology information.

[0009] According to a fourth aspect of embodiments of the present disclosure, embodiments of the disclosure provide a terminal device. The terminal device comprises: a receiver configured to receive numerology information of a carrier from a network device, the numerology information indicating numerologies of one or more basic units for the carrier; and a decoder configured to decode a signal based on the numerology information.

[0010] Other features and advantages of the embodiments of the present disclosure will also be apparent from the following description of specific embodiments when read in conjunction with the accompanying drawings, which illustrate, by way of example, the principles of embodiments of the disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Embodiments of the disclosure are presented in the sense of examples and their advantages are explained in greater detail below, with reference to the accompanying drawings, where

[0012] FIG. 1 illustrates a schematic diagram of a communication system 100 according to embodiments of the present disclosure;

[0013] FIG. 2A illustrates a diagram 200 of a basic unit in accordance with embodiments of the present disclosure;

[0014] FIG. 2B illustrates a diagram 260 of a basic unit in accordance with further embodiments of the present disclosure;

[0015] FIG. 3 illustrates a flow chart of a method 300 for performing communication according to embodiments of the present disclosure;

[0016] FIG. 4 illustrates a diagram 400 of the distributed indication according to embodiments of the present disclosure;

[0017] FIG. 5 illustrates a diagram 500 of the centralized indication according to embodiments of the present disclosure;

[0018] FIG. 6 illustrates a diagram 600 of a guard band 610 according to embodiments of the present disclosure;

[0019] FIG. 7 illustrates a diagram 700 of indication of a guard band according to embodiments of the present disclosure;

[0020] FIG. 8 illustrates a diagram 800 of indication of a guard band according to embodiments of the present disclosure;

[0021] FIG. 9 illustrates a diagram 900 of a resource unit 910 according to embodiments of the present disclosure;

[0022] FIG. 10 illustrates a diagram 1000 of information transmission according to embodiments of the present disclosure;

[0023] FIG. 11 illustrates a flow chart of a method 1100 for performing communication according to embodiments of the present disclosure;

[0024] FIG. 12 illustrates a schematic diagram of a network device 1200 according to an embodiment of the present disclosure; and

[0025] FIG. 13 illustrates a schematic diagram of a terminal device 1300 according to an embodiment of the present disclosure.

[0026] Throughout the figures, same or similar reference numbers indicate same or similar elements.

DETAILED DESCRIPTION OF EMBODIMENTS

[0027] The subject matter described herein will now be discussed with reference to several example embodiments. It should be understood these embodiments are discussed only for the purpose of enabling those skilled persons in the art to better understand and thus implement the subject matter described herein, rather than suggesting any limitations on the scope of the subject matter.

[0028] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of example embodiments. As used herein, the singular forms "a," "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises," "comprising," "includes" and/or "including," when used herein, specify the presence of stated features, integers, steps, operations, elements and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components and/or groups thereof.

[0029] It should also be noted that in some alternative implementations, the functions/acts noted may occur out of the order noted in the figures. For example, two functions or acts shown in succession may in fact be executed concurrently or may sometimes be executed in the reverse order, depending upon the functionality/acts involved.

[0030] As used herein, the term "communication network" refers to a network following any suitable communication standards, such as Long Term Evolution (LTE), LTE-Advanced (LTE-A), Wideband Code Division Multiple Access (WCDMA), High-Speed Packet Access (HSPA), and so on. Furthermore, the communications between a terminal device and a network device in the communication network may be performed according to any suitable generation communication protocols, including, but not limited to, the first generation (1G), the second generation (2G), 2.5G, 2.75G, the third generation (3G), the fourth generation (4G), 4.5G, the future fifth generation (5G) communication protocols, and/or any other protocols either currently known or to be developed in the future.

[0031] Embodiments of the present disclosure may be applied in various communication systems. Given the rapid development in communications, there

will of course also be future type communication technologies and systems with which the present disclosure may be embodied. It should not be seen as limiting the scope of the present disclosure to only the aforementioned system.

[0032] The term "network device" includes, but not limited to, a base station (BS), a gateway, a management entity, and other suitable device in a communication system. The term "base station" or "BS" represents a node B (NodeB or NB), an evolved NodeB (eNodeB or eNB), a Remote Radio Unit (RRU), a radio header (RH), a remote radio head (RRH), a relay, a low power node such as a femto, a pico, and so forth.

[0033] The term "terminal device" includes, but not limited to, "user equipment (UE)" and other suitable end device capable of communicating with the network device. By way of example, the "terminal device" may refer to a terminal, a Mobile Terminal (MT), a Subscriber Station (SS), a Portable Subscriber Station, a Mobile Station (MS), or an Access Terminal (AT).

[0034] Now some exemplary embodiments of the present disclosure will be described below with reference to the figures. Reference is first made to FIG. 1, which illustrates schematic diagram of a communication system 100 according to embodiments of the present disclosure.

[0035] In the communication system 100, there illustrate a network device (for example, an eNB) 110 that communicates with a terminal device (for example, a UE) 120 by using a certain transmission pattern. The network device 110 sends numerology information to the terminal device 120, wherein the numerology information indicates numerologies of one or more basic units for a carrier. As such, the terminal device 120 is enabled to receive signals from the network device 110 based on the numerology information.

[0036] In the context of the present disclosure, the term "numerology" refers to a set of parameters. In an Orthogonal Frequency Division Multiplexing (OFDM)-based system, the parameters include, for example, but not limited to, a subcarrier spacing, a symbol length, a length of a cyclic prefix (CP), and so on. For instance, a numerology for a subcarrier spacing of 15KHz may include 14 symbols in one subframe, a normal CP, and so on. A numerology for a subcarrier spacing of 30KHz may include 28 symbols in one subframe, a normal CP, and so on. Such a numerology is different from the numerology for the subcarrier spacing of 15KHz.

[0037] The term "basic unit" refers to a block of time-frequency resource. The size of a basic unit may depend on the employed numerology. The basic unit may be determined based on a subcarrier spacing and a symbol length used by subcarriers of the carrier. In a frequency domain, the basic unit may be decided by the largest subcarrier spacing. For example, a physical resource block (PRB) with the largest subcarrier spacing may be the frequency size of a basic unit, and/or the largest symbol length may be the time size of the basic unit.

[0038] FIG. 2A illustrates a diagram of a basic unit 240 in accordance with embodiments of the present disclosure. There are three subcarriers, Sc1-Sc3, illustrated in the example of FIG. 2A. In the frequency domain, the basic unit 240 is determined based on the largest subcarrier spacing, 60KHz. That is, the frequency size of the basic unit 240 equals to one PRB of the subcarrier Sc1 of 60KHz, 2 PRBs of the subcarrier Sc2 of 30KHz, and 4 PRBs of the subcarrier Sc3 of 15KHz.

[0039] In the time domain, the basic unit 240 is determined based on the largest symbol length. Thus, the time size of the basic unit 240 equals to a symbol of Sc3 of 15KHz, which has a largest symbol length among Sc1 to Sc3.

[0040] In addition to the above, the basic unit according embodiments of the present disclosure may be implemented in other suitable forms, for example, multiples of the largest symbol length in time domain, and/or multiples of the largest subcarrier spacing, multiples of a PRB, one or multiples of the smallest subcarrier spacing. FIG. 2B illustrates a diagram 200 of another basic unit 270 in accordance with further embodiments of the present disclosure. In the example shown in FIG. 2B, the basic unit 270 is defined based on the smallest subcarrier spacing in frequency domain. The time domain duration may be indicated by other ways explicitly or implicitly. For instance, the basic unit 270 may have the same duration as the basic unit 240 in the time domain, or the time duration may be multiples of the time duration of the basic unit 240.

[0041] It is to be understood that, the above examples are discussed for purpose of illustration, rather than limitation. Those skilled in the art would appreciate that the basic unit can be implemented other suitable forms with the scope of the subject matter of the present disclosure.

[0042] Conventionally, a carrier employs a single numerology, thus spectrum

utilization may be inefficient when terminal devices have different communication demands. To solve this problem, embodiments of the present disclosure propose a solution as discussed below to employ multiple numerologies in a single carrier. By receiving numerology information indicating numerologies of one or more basic units for the carrier, the terminal devices can receive signals based on the numerology information.

[0043] Now some exemplary embodiments of the present disclosure will be described below with reference to the following figures. FIG. 3 illustrates a flow chart of a method 300 for indicating numerology according to embodiments of the present disclosure. The method 300 may be implemented by the network device 110, for example, an eNB or other suitable device.

[0044] The method 300 is entered at 310, where the network device determines numerology information of a carrier. The numerology information indicates numerologies of one or more basic units for the carrier. At 320, the network device transmits the numerology information to a terminal device to enable reception based on the numerology information.

[0045] According to embodiments of the present disclosure, there may be a variety of ways to indicate numerology. In some embodiments, the numerology information may be indicated in a distributed way, which is also referred to as "distributed indication". In this case, the numerology of each basic unit is indicated. For purpose of illustration, the basic unit 240 of FIG. 2A is discussed in these embodiments. Thus, at 310, the network device may determine numerologies for all the basic units. In some implementations, a bitmap may be used to indicate the numerologies of the basic units, that is, one or more bits may be used to indicate the numerology for each basic unit. For example, two bits may be used to indicate subcarrier spacing 15KHz, 30KHz, 60KHz, and 120KHz, respectively. If the bits are "00", it means that the subcarrier of the numerology is 15KHz *1, and if the bits are "01", it means that the subcarrier of the numerology is 15KHz *2 = 30KHz. At 320, the network device may transmit information about the numerologies for all the basic units to the terminal device. FIG. 4 illustrates a diagram 400 of the distributed indication according to embodiments of the present disclosure. As shown in FIG. 4, there are six basic units in a carrier, namely, basic units 1 to 6, and there are 6

numerology indications are used for each of the basic units 1 to 6. In this way, the numerologies may be indicated in a flexible way.

[0046] In some other embodiments, if the basic unit is defined as the basic unit 270 as discussed with reference to FIG. 2B, when the numerology is changed from a small subcarrier spacing to a larger one, numerologies of at least multiple basic units need to be the same. For example, if the basic unit is based on 15KHz subcarrier spacing, and the numerology is changed from 15KHz to 30KHz, then numerology of at least two adjacent basic units should be same; if the numerology is changed to be 60KHz, then numerology of at least four adjacent basic units should be the same.

[0047] Alternatively, in some embodiments, the numerology information may be indicated in a centralized way, which is also referred to as "centralized indication." In this case, the carrier bandwidth may be divided into several groups, and each group may have a group-specific numerology. One group may include one or more basic units. Details of group division may be defined by a pattern, for example, referred to as a grouping pattern. The grouping pattern may be predefined in several ways, for example, according to the traffic characteristics, similar as Time Division Duplex (TDD) configuration. The grouping pattern may be alternatively defined in specification. In some implementations, the grouping pattern may be carried by system information and/or a Physical broadcast channel (PBCH). In the embodiments, the network device may inform the terminal device the grouping pattern and/or the group-specific numerology. The number of groups may be decided by the grouping pattern. The number may change due to different grouping patterns. The maximum group number may be reserved. In this case, the terminal device may need to firstly decode the grouping pattern, and then decode the corresponding numerology for each group based on the pattern.

[0048] In these embodiments, at 310, the network device may determine a grouping pattern indicating groups of the basic units, and then determine a numerology for each of the groups. At 320, the network device may transmit information about the grouping pattern and/or the numerology for each of the groups to the terminal device. FIG. 5 illustrates a diagram 500 of the centralized indication according to embodiments of the present disclosure. In the example of FIG. 5, there are six basic units in a carrier, namely, basic units 1 to 6, and they are divided into three groups,

namely, groups 1 to 3. As shown, group 1 includes basic units 1 and 2, group 2 includes basic unit 3, and group 3 includes basic units 4-6. A numerology is determined for each of the groups. As such, there are three numerology indications for groups 1, 2 and 3, respectively.

[0049] In some other embodiments, if the basic unit is defined as the basic unit 270 as discussed with reference to FIG. 2B, when the numerology is changed from a small subcarrier spacing to a larger one, the basic units may be divided into groups to guarantee basic units in each group have the same numerology. Still referring to FIG. 5, if basic units 1 to 6 are each defined as the basic unit 270, and basic units 1 and 2 correspond to numerology 1, basic unit 3 corresponds to numerology 2 and basic units 4, 5 and 6 correspond to numerology 3, then the basic units 1 to 6 may be divided into three groups to guarantee basic units in each group have the same numerology when the numerology is changed from 15KHz to 30KHz.

[0050] As a further alternative, the indication may be from a numerology perspective. That is to say, one or more basic units may be indicated for a specific numerology. The indication may be similar to a legacy approach of LTE resource allocation. The basic units corresponding to a numerology may be continuous or discontinuous. In some embodiments, the numerology information may be determined as below. At 310, the network device may determine numerologies for the basic units and determine an association between the numerologies and the basic units. Then, at 320, the network device may transmit information about the numerologies and/or the association to the terminal device. In an embodiment, the numerology information may be implemented in the form of the following table 1.

	NUMEROLOGY ID	BASIC UNIT ID
1	Numerology 1	Basic unit 1, 2
2	Numerology 2	Basic unit 3
3	Numerology 3	Basic unit 4, 5, 6

[0051] Upon receipt of the numerology information, the terminal device would understand that three numerologies (i.e., Numerology 1, 2 and 3) are designed for the carrier, Basic units 1 and 2 are associated with Numerology 1, Basic unit 3 is associated with Numerology 2, and Basic units 4, 5 and 6 are associated with

Numerology 3.

[0052] As a still further alternative, the bandwidth of the carrier may be divided into groups, and each group has the same numerology distribution pattern. A numerology distribution pattern indicating numerologies for basic units in one of the groups. For example, if in a group, the ith basic unit (also referred to as basic unit i, i=1,...M, and M indicates the total number of basic units in the group) has a numerology corresponding to 15KHz, and basic unit i+4 has a numerology corresponding to 60KHz, and basic units i and i+4 within another group share the same numerology 15KHz and 60KHz, respectively, then the numerology distribution patterns are the same for these two groups. In this case, the network device may indicate the numerology distribution pattern for a single group to the terminal device, and/or information about the group division, and/or the like. The numerology distribution pattern and/or information about the group division may be specified by specification, by RRC configuration, or in other suitable ways. The numerology distribution pattern for each group can also be indicated dynamically in downlink control information. In some embodiments, the numerology information may be determined as below. At 310, the network device may divide the basic units into groups and determine a numerology distribution pattern indicating numerologies for basic units in one of the groups. Then, at 320, the network device may transmit information about the numerology distribution pattern and/or information about the groups to the terminal device.

[0053] In accordance with embodiments of the present disclosure, for different adjacent numerologies, puncturing of one or more subcarriers may be used if a guard band is necessary. From efficiency point of view, the smaller subcarrier spacing may be punctured. In some embodiments, if new waveform design can mitigate the necessity of a guard band, then the puncturing may be unnecessary. According to embodiments of the present disclosure, the guard band may be indicated in a variety of ways. A size for a unit of the guard band (also referred to as a "guard band unit" hereafter) in the frequency domain may be a subcarrier, a PRB, or other suitable length, depending on the adjacent numerologies and/or numerology bandwidth and/or transmission direction. One or more guard band units may be indicated as a guard band.

[0054] FIG. 6 illustrates a diagram 600 of a guard band 610 according to embodiments of the present disclosure. As shown in FIG. 6, there is a guard band 610 between different subcarrier spacings, Sc2 of 30KHz and Sc3 of 15 KHz. The size of the guard band unit is a subcarrier/PRB, and the guard band in this example includes 3 guard band units.

[0055] According to embodiments of the present disclosure, optionally, after 320, the network device may further determines guard band information about a guard band between adjacent basic units based on numerologies of the adjacent basic units, and transmits the guard band information to the terminal device for each basic unit.

[0056] According to further embodiments of the present disclosure, optionally, after 320, the network device may further determine guard band information about a guard band between adjacent basic units based on transmission directions of the basic units. For example, a basic unit is used for downlink transmission and the adjacent basic unit is uplink transmission, then there will be a guard band between them. If the transmission direction is changed semi-statically, then the guard band information may be indicated to the terminal device in RRC signaling or PBCH. If the transmission direction, for example, downlink or uplink, is changed dynamically, then the guard band information may be indicated to a terminal device in downlink control information.

[0057] In the determination of the guard band information, the network device may detect whether there is a change between numerologies of the adjacent basic units and then determine occurrence of a guard band between the adjacent basic units based on the detection. In some embodiments, the guard band information may include: a number of subcarriers occupied by the guard band, a number of physical resource blocks occupied by the guard band, a basic unit where the guard band is located, and/or the like. The guard band information may indicate whether a guard band exists. From signaling point of view, even the guard band is to be decided not existent, it can be expressed by indicating the guard band to be 0.

[0058] After determining the guard band information, the network device may transmit the guard band information to the terminal device. In an embodiment, the guard band information may be transmitted together with the numerology information. Referring back to the embodiments of FIG. 4, the guard band information may be transmitted together with the numerology information for each basic unit. In another

embodiment, referring back to the embodiments of FIG. 5, the guard band information may be transmitted together with the numerology information for each group of basic units. More details about the indication of the guard band information will be discussed with the following embodiments with reference to FIGs. 7 and 8.

[0059] In some embodiments, the guard band may be defined by specification. In this case, the guard band may be impacted by adjacent numerology combination, and may be located in the side of the lower subcarrier spacing. For example, when a subcarrier spacing of 30KHz and a subcarrier spacing of 60KHz are located adjacently, no matter the detailed bandwidth for each subcarrier spacing, the guard band is the same and is always located in the 30KHz side. FIG. 7 illustrates a diagram 700 of indication of a guard band according to embodiments of the present disclosure. As shown in FIG. 7, there are two change points of numerologies of basic units 1-6, and two guard bands 710 and 720 defined by specification are located at the change points. In this case, the network device may inform the terminal device information about the numerology, and based on the derived numerology, the terminal device may deduce that there are guard bands 710 and 720.

[0060] Alternatively, in some embodiments, the guard band information and/or the numerology information may be transmitted or indicated by system information/PBCH or Dynamic Control Information (DCI). The indication of the guard band information may be according to the numerology distribution pattern, similar to the indication of the numerology information. In this case, the guard band may be impacted by both the adjacent numerology combination and the bandwidth of each numerology.

[0061] In an embodiment, there is a guard band for each basic unit. The guard band may be zero if no numerology change between adjacent basic units or new wave form adoption. Such guard band information may be transmitted together with the numerology information as discussed with reference to FIG. 4. For each basic unit, the numerology and the guard band are indicated. Both independent indication and joint encoding may be employed. FIG. 8 illustrates a diagram 800 of indication of a guard band according to such an embodiment.

[0062] In an alternative embodiment, there is a guard band for each numerology change. In this case, the guard band information may be transmitted together with

the numerology information as discussed with reference to FIG. 5. For example, the guard band information and/or the numerology information may indicate the numerology distribution pattern. Thus, upon receipt of the information, the terminal device may obtain a change point of numerologies based thereon, and then determine the position of the guard band according to the change point. In this embodiment, the guard band information is transmitted when numerologies of two adjacent basic units change. As such, overhead of transmitting the guard band information is reduced.

[0063] In accordance with embodiments of the present disclosure, the network device may further inform the terminal device information about resource allocation. The allocated resource may be indicated by a common index irrespectively of numerology. Thus, the terminal device may understand the resource allocated to it. In some embodiments, the network device may allocate a resource to one or more terminal devices, and then transmit information about the allocated resource to the terminal device. The information about the allocated resource may include one or more of: an index of a basic unit allocated to the terminal devices, an index of a physical resource block in a basic unit allocated to the terminal devices, and other suitable information.

[0064] In some embodiments, the basic units may be indexed from 0 to N-1, where N is a total number of the basic units. The total number may be determined in several ways. For example, if the carrier bandwidth is B and the bandwidth of the basic frequency variation units is W, then the total number may be calculated below:

$$N = \text{ceil}(B/W),$$

where "ceil" indicates an operation of rounding up.

[0065] The total PRB number (denoted as N_p) within a basic unit may be calculated as:

$$N_p = W/Sc/N_Sc$$

where Sc represents the subcarrier spacing for this basic unit, and N_Sc represents the subcarrier number within a PRB.

[0066] The network device may determine which PRB(s) and/or which basic unit(s) are allocated to terminal devices, and transmit the information about the allocated

resource to the terminal devices. The information may include index of the basic unit(s). A terminal device, for example, the terminal device 120, upon receipt of the information about the allocated resource, may identify the index of the basic unit(s) first. Then, the terminal device may determine which PRBs in the allocated basic unit(s) can be used.

[0067] In some implementations, one or more bits may be used to indicate the index of the basic unit(s). Then, one or more additional bits may be used to indicate PRBs within the basic unit. These bits may be used in both downlink and uplink to indicate the corresponding allocated frequency domain resource.

[0068] Alternatively, in some embodiments, the resource allocation information may be indicated by resource unit(s). The resource unit may be defined based on the smallest subcarrier spacing in frequency domain. For a larger subcarrier spacing, resources allocated to a single UE should consider the relationship between the smallest subcarrier spacing and the larger subcarrier spacing. By way of example, if the resource unit is based on 15KHz subcarrier spacing, and for a 60KHz resource allocation, the allocated resources may be multiple of 4, where 4 is obtained by dividing 60KHz by 15KHz. The time domain duration may be indicated by other ways explicitly or implicitly. For instance, the resource unit may have the same duration as the basic unit discussed above in the time domain, or the time duration may be multiples of the time duration of the basic unit.

[0069] FIG. 9 illustrates a diagram 900 of a resource unit 910 according to embodiments of the present disclosure. In the frequency domain, the resource unit 910 corresponds to the PRB of the smallest subcarrier spacing, namely, Sc3 of 15KHz. In the time domain, the resource unit 910 corresponds to a symbol of the smallest subcarrier spacing.

[0070] With respect the above embodiments, if different channel coding schemes are used for different information block sizes, or if the time domain transmission duration may change due to multi-subframe or mini-slot scheduling, the corresponding Modulation and Coding Scheme (MCS)/Transmission Block Size (TBS) table may change. The chosen of MCS/TBS table may be configured by Radio resource configuration (RRC) signaling.

[0071] In accordance with embodiments of the present disclosure, the network device may transmit the numerology information, and/or the guard band information, and/or the information about resource allocation in a variety of ways. In some embodiments, the network device may transmit the numerology information/guard band information in a region of the carrier corresponding to a reference numerology, and transmit the information about the allocated resource in one or more of the basic units, the region of the carrier for transmitting the reference numerology, and/or the like.

[0072] In some embodiments, the numerology information, the guard band information, and/or the information about resource allocation may be carried by PDCCH/Enhanced PDCCH (ePDCCH). The PDCCH carrying the numerology information and/or guard band information may be shared by a group of UEs, and may be scrambled by a cell specific/beam specific sequence. And the PDCCH carrying the resource allocation information may be scrambled in a UE-specific way. With respect to the terminal device, for example, a UE, it may decode received signals to obtain the numerology information and/or the guard band information. Then, the UE may decode the information about resource allocation to obtain allocated resources, MCS/TBS, transmission duration, and/or the like, which are collectively called as UE specific control information hereafter.

[0073] In some embodiments, the UE specific control information may be located at a time-frequency resource corresponding to a specific numerology. Alternatively, the UE specific control information may also be located at the time-frequency resource corresponding to the reference numerology, combined with the cell/beam-specific control information to be carried in a single PDCCH or scrambled independently to form an independent PDCCH. In some implementations, the PDCCH may occur in a periodical way or in aperiodical way. In the case of the aperiodical implementation, the UE may perform blind detection to identify the PDCCH.

[0074] In some alternative embodiments, the control information may also be carried by PBCH or RRC signaling. As a further alternative, the control information may be carried by a combination of RRC signaling and physical layer control information. In such a case, RRC signaling may be used to indicate a subset of possible

numerologies/guard band configurations, and physical layer control information may be used to indicate the numerology within the subset dynamically.

[0075] FIG. 10 illustrates a diagram 1000 of transmission of UE specific control information 1010 and numerology information/guard band 1020 according to embodiments of the present disclosure. As shown in the example of FIG. 10, the UE specific control information 1010 is transmitted via basic unit 1, and the numerology information/guard band information are transmitted in a region 1030 of the carrier corresponding to the reference numerology.

[0076] Reference is now made to FIG. 11, which illustrates a flow chart of a method 1100 for performing communication according to embodiments of the present disclosure. The method 1100 may be implemented by the terminal device 120, for example, a UE or other suitable device.

[0077] The method 1100 is entered at 1110, where the terminal device receives numerology information of a carrier from a network device. The numerology information may indicate numerologies of one or more basic units for the carrier. The basic unit may be determined based on a subcarrier spacing and a symbol length used by subcarriers of the carrier. For example, in the frequency domain, the basic unit may be determined based on the largest subcarrier spacing. In the time domain, the basic unit 240 may be determined based on the largest symbol length. In another example, the basic unit may also be determined based on the smallest subcarrier spacing in frequency domain, and/or determined based on the smallest symbol length in time domain.

[0078] In some embodiments, at 1110, the terminal device may receive information about numerologies for all the basic units. Alternatively, the terminal device may receive information about a grouping pattern indicating groups of the basic units and/or a numerology for each of the groups. As a further alternative, the terminal device may receive information about numerologies for the basic units and/or an association between the numerologies and the basic units. As a still further alternative, the basic units are divided into groups, and the basic units in each of the groups having the same numerology distribution pattern. In this case, the terminal device may receive at least one of information about a numerology distribution

pattern indicating numerologies for basic units in one of groups of basic units and/or information about the groups.

[0079] At 1120, the terminal device decodes a signal based on the numerology information.

[0080] In some embodiments, optionally, the terminal device may further receive guard band information about a guard band between adjacent basic units. In this case, at 1120, the terminal device may decode the signal based on the numerology information and the guard band information.

[0081] In some embodiments, optionally, the terminal device may further information about allocated resource of one or more terminal devices from the network device. The information about allocated resource may include an index of a basic unit allocated to the terminal devices, an index of a physical resource block in a basic unit allocated to the terminal devices, and/or the like. In this case, at 1120, the terminal device may decode the signal based on the numerology information and the information about allocated resource (also referred to as "information about resource allocation").

[0082] In some embodiments, the numerology information may be received in a region of the carrier for transmitting a reference numerology, and the information about the allocated resource may be received in one or more of the basic units, or in the region of the carrier for transmitting the reference numerology, or other suitable regions.

[0083] FIG. 12 illustrates a schematic diagram of a network device 1200 according to an embodiment of the present disclosure. According to embodiments of the present disclosure, the network device 1200 may be implemented as the network device 110 or other suitable device in the communication system.

[0084] As shown in FIG. 12, the network device 1200 comprises: a controller 1210 configured to determine numerology information of a carrier, the numerology information indicating numerologies of one or more basic units for the carrier; and a transmitter 1220 configured to transmit the numerology information to a terminal device to enable reception based on the numerology information.

[0085] In some embodiments, the basic unit may be determined based on a subcarrier spacing and a symbol length used by subcarriers of the carrier.

[0086] In some embodiments, the controller 1210 may be further configured to determine numerologies for all the basic units, and wherein the transmitter 1220 may be further configured to transmit information about the numerologies for all the basic units to the terminal device.

[0087] In some embodiments, the controller 1210 may be further configured to: determine a grouping pattern indicating groups of the basic units; and determine a numerology for each of the groups, and wherein the transmitter may be further configured to transmit information about the grouping pattern and/or the numerology for each of the groups to the terminal device.

[0088] In some embodiments, the controller 1210 may be further configured to: determine numerologies for the basic units; and determine an association between the numerologies and the basic units, and wherein the transmitter 1220 may be further configured to transmit information about the numerologies and/or the association to the terminal device.

[0089] In some embodiments, the controller 1210 may be further configured to: divide the basic units into groups; and determine a numerology distribution pattern indicating numerologies for basic units in one of the groups, and wherein the transmitter may be further configured to transmit information about the numerology distribution pattern and/or information about the groups to the terminal device.

[0090] In some embodiments, the controller 1210 may be further configured to: determine guard band information about a guard band between adjacent basic units based on numerologies of the adjacent basic units; and wherein the transmitter may be further configured to transmit the guard band information to the terminal device.

[0091] In some embodiments, the controller 1210 may be further configured to: detect whether there is a change between numerologies of the adjacent basic units; and determine occurrence of a guard band between the adjacent basic units based on the detection.

[0092] In some embodiments, the guard band information may further include one or more of: a number of subcarriers occupied by the guard band, a number of physical resource blocks occupied by the guard band, and a basic unit where the guard band is located.

[0093] In some embodiments, the transmitter 1220 may be further configured to transmit the guard band information to the terminal device based on the numerology information.

[0094] In some embodiments, the controller 1210 may be further configured to allocate a resource to one or more terminal devices, and wherein the transmitter 1220 may be further configured to transmit information about the allocated resource to the terminal device, wherein the information about the allocated resource includes at least one of: an index of a basic unit allocated to the terminal devices, and an index of a physical resource block in a basic unit allocated to the terminal devices.

[0095] In some embodiments, the transmitter 1220 may be further configured to: transmit the numerology information in a region of the carrier for transmitting a reference numerology; and transmit the information about the allocated resource in at least one of: one or more of the basic units, and the region of the carrier for transmitting the reference numerology.

[0096] FIG. 13 illustrates a schematic diagram of a terminal device 1300 according to an embodiment of the present disclosure. According to embodiments of the present disclosure, the terminal device 1300 may be implemented as the network device 120 or other suitable device in the communication system.

[0097] As shown in FIG. 13, the terminal device 1300 comprises: a receiver 1310 configured to receive numerology information of a carrier from a network device, the numerology information indicating numerologies of one or more basic units for the carrier; and a decoder 1320 configured to decode a signal based on the numerology information.

[0098] In some embodiments, the basic unit may be determined based on a subcarrier spacing and a symbol length used by subcarriers of the carrier.

[0099] In some embodiments, the receiver 1310 may be further configured to receive at least one of: information about numerologies for all the basic units; information about a grouping pattern indicating groups of the basic units and/or a numerology for each of the groups; information about numerologies for the basic units and/or an association between the numerologies and the basic units; and at least one of information about a numerology distribution pattern indicating numerologies for basic units in one of groups of basic units and/or information about the groups, the basic

units in the groups having the same numerology distribution pattern.

[00100] In some embodiments, the receiver 1310 may be further configured to receive guard band information about a guard band between adjacent basic units, wherein the decoder 1320 may be further configured to decode the signal based on the numerology information and the guard band information.

[00101] In some embodiments, the receiver 1310 may be further configured to receive information about allocated resource of one or more terminal devices from the network device, wherein the information about allocated resource includes at least one of: an index of a basic unit allocated to the terminal devices, and an index of a physical resource block in a basic unit allocated to the terminal devices.

[00102] In some embodiments, wherein the numerology information may be received in a region of the carrier for transmitting a reference numerology, and the information about the allocated resource may be received in at least one of: one or more of the basic units, and the region of the carrier for transmitting the reference numerology.

[00103] It is also to be noted that the device 1200 or 1300 may be respectively implemented by any suitable technique either known at present or developed in the future. Further, a single device shown in FIG. 12 or 13 may be alternatively implemented in multiple devices separately, and multiple separated devices may be implemented in a single device. The scope of the present disclosure is not limited in these regards.

[00104] It is noted that the device 1200 or 1300 may be configured to implement functionalities as described with reference to FIGs. 3-10 or FIG. 11. Therefore, the features discussed with respect to the method 300 may apply to the corresponding components of the device 1200, and the features discussed with respect to the method 1100 may apply to the corresponding components of the device 1300. It is further noted that the components of the device 1200 or 1300 may be embodied in hardware, software, firmware, and/or any combination thereof. For example, the components of the device 1200 or 1300may be respectively implemented by a circuit, a processor or any other appropriate device. Those skilled in the art will appreciate that the aforesaid examples are only for illustration not limitation.

[00105] In some embodiment of the present disclosure, the device 1200 or 1300 may

comprise at least one processor. The at least one processor suitable for use with embodiments of the present disclosure may include, by way of example, both general and special purpose processors already known or developed in the future. The device 1200 or 1300 may further comprise at least one memory. The at least one memory may include, for example, semiconductor memory devices, e.g., RAM, ROM, EPROM, EEPROM, and flash memory devices. The at least one memory may be used to store program of computer executable instructions. The program can be written in any high-level and/or low-level compliable or interpretable programming languages. In accordance with embodiments, the computer executable instructions may be configured, with the at least one processor, to cause the device 1200 to at least perform according to the method 300 as discussed above and to cause the device 1300 to at least perform according to the method 1100 as discussed above.

[00106] Based on the above description, the skilled in the art would appreciate that the present disclosure may be embodied in an apparatus, a method, or a computer program product. In general, the various exemplary embodiments may be implemented in hardware or special purpose circuits, software, logic or any combination thereof. For example, some aspects may be implemented in hardware, while other aspects may be implemented in firmware or software which may be executed by a controller, microprocessor or other computing device, although the disclosure is not limited thereto. While various aspects of the exemplary embodiments of this disclosure may be illustrated and described as block diagrams, flowcharts, or using some other pictorial representation, it is well understood that these blocks, apparatus, systems, techniques or methods described herein may be implemented in, as non-limiting examples, hardware, software, firmware, special purpose circuits or logic, general purpose hardware or controller or other computing devices, or some combination thereof.

[00107] The various blocks shown in FIG. 3 or 11 may be viewed as method steps, and/or as operations that result from operation of computer program code, and/or as a plurality of coupled logic circuit elements constructed to carry out the associated function(s). At least some aspects of the exemplary embodiments of the disclosures may be practiced in various components such as integrated circuit chips and modules, and that the exemplary embodiments of this disclosure may be realized in an apparatus that is embodied as an integrated circuit, FPGA or ASIC that is configurable

to operate in accordance with the exemplary embodiments of the present disclosure.

[00108] While this specification contains many specific implementation details, these should not be construed as limitations on the scope of any disclosure or of what may be claimed, but rather as descriptions of features that may be specific to particular embodiments of particular disclosures. Certain features that are described in this specification in the context of separate embodiments can also be implemented in combination in a single embodiment. Conversely, various features that are described in the context of a single embodiment can also be implemented in multiple embodiments separately or in any suitable sub-combination. Moreover, although features may be described above as acting in certain combinations and even initially claimed as such, one or more features from a claimed combination can in some cases be excised from the combination, and the claimed combination may be directed to a sub-combination or variation of a sub-combination.

[00109] Similarly, while operations are depicted in the drawings in a particular order, this should not be understood as requiring that such operations be performed in the particular order shown or in sequential order, or that all illustrated operations be performed, to achieve desirable results. In certain circumstances, multitasking and parallel processing may be advantageous. Moreover, the separation of various system components in the embodiments described above should not be understood as requiring such separation in all embodiments, and it should be understood that the described program components and systems can generally be integrated together in a single software product or packaged into multiple software products.

[00110] Various modifications, adaptations to the foregoing exemplary embodiments of this disclosure may become apparent to those skilled in the relevant arts in view of the foregoing description, when read in conjunction with the accompanying drawings. Any and all modifications will still fall within the scope of the non-limiting and exemplary embodiments of this disclosure. Furthermore, other embodiments of the disclosures set forth herein will come to mind to one skilled in the art to which these embodiments of the disclosure pertain having the benefit of the teachings presented in the foregoing descriptions and the associated drawings.

[00111] Therefore, it is to be understood that the embodiments of the disclosure are not to be limited to the specific embodiments disclosed and that modifications and

other embodiments are intended to be included within the scope of the appended claims. Although specific terms are used herein, they are used in a generic and descriptive sense only and not for purpose of limitation.

WHAT IS CLAIMED IS:

1. A method performed by a network device, comprising:

determining numerology information of a carrier, the numerology information indicating numerologies of one or more basic units for the carrier; and

transmitting the numerology information to a terminal device to enable reception based on the numerology information.

2. The method according to Claim 1, wherein the basic unit is determined based on a subcarrier spacing and a symbol length used by subcarriers of the carrier.

3. The method according to Claim 1, wherein determining the numerology information comprises: determining numerologies for all the basic units, and

wherein transmitting the numerology information comprises: transmitting information about the numerologies for all the basic units to the terminal device.

4. The method according to Claim 1, wherein determining the numerology information comprises:

determining a grouping pattern indicating groups of the basic units; and

determining a numerology for each of the groups, and

wherein transmitting the numerology information comprises: transmitting information about the grouping pattern and/or the numerology for each of the groups to the terminal device.

5. The method according to Claim 1, wherein determining the numerology information comprises:

determining numerologies for the basic units; and

determining an association between the numerologies and the basic units, and

wherein transmitting the numerology information comprises: transmitting information about the numerologies and/or the association to the terminal device.

6. The method according to Claim 1, wherein determining the numerology information comprises:

dividing the basic units into groups; and

determining a numerology distribution pattern indicating numerologies for basic units in one of the groups, and

wherein transmitting the numerology information comprises: transmitting information about the numerology distribution pattern and/or information about the groups to the terminal device.

7. The method according to Claim 1, further comprising:

determining guard band information about a guard band between adjacent basic units based on numerologies of the adjacent basic units; and

transmitting the guard band information to the terminal device.

8. The method according to Claim 7, wherein determining the guard band information comprises:

detecting whether there is a change between numerologies of the adjacent basic units; and

determining occurrence of a guard band between the adjacent basic units based on the detection.

9. The method according to Claim 7 or 8, wherein the guard band information further includes one or more of:

a number of subcarriers occupied by the guard band,

a number of physical resource blocks occupied by the guard band, and

a basic unit where the guard band is located.

10. The method according to Claim 7, wherein transmitting the guard band information to the terminal device comprises:

transmitting the guard band information to the terminal device based on the numerology information.

11. The method according to Claim 1, further comprising:

allocating a resource to one or more terminal devices; and

transmitting information about the allocated resource to the terminal device,

wherein the information about the allocated resource includes at least one of: an index of a basic unit allocated to the terminal devices, and an index of a physical resource block in a basic unit allocated to the terminal devices.

12. The method according to Claim 11, wherein transmitting the numerology information comprises:

transmitting the numerology information in a region of the carrier for transmitting a reference numerology; and

transmitting the information about the allocated resource in at least one of: one or more of the basic units, and the region of the carrier for transmitting the reference numerology.

13. A method performed by a terminal device, comprising:

receiving numerology information of a carrier from a network device, the numerology information indicating numerologies of one or more basic units for the carrier; and

decoding a signal based on the numerology information.

14. The method according to Claim 13, wherein the basic unit is determined based on a subcarrier spacing and a symbol length used by subcarriers of the carrier.

15. The method according to Claim 13, wherein receiving the numerology information comprises at least one of:

receiving information about numerologies for all the basic units;

receiving information about a grouping pattern indicating groups of the basic units and/or a numerology for each of the groups;

receiving information about numerologies for the basic units and/or an association between the numerologies and the basic units; and

receiving at least one of information about a numerology distribution pattern indicating numerologies for basic units in one of groups of basic units and/or information about the groups, the basic units in the groups having the same numerology distribution pattern.

16. The method according to Claim 13, further comprising:

receiving guard band information about a guard band between adjacent basic units,

wherein decoding the signal comprises: decoding the signal based on the numerology information and the guard band information.

17. The method according to Claim 13, further comprising:

receiving information about allocated resource of one or more terminal devices from the network device, wherein the information about allocated resource includes at least one of: an index of a basic unit allocated to the terminal devices, and an index of a physical resource block in a basic unit allocated to the terminal devices.

18. The method according to Claim 17, wherein the numerology information is received in a region of the carrier for transmitting a reference numerology, and the information about the allocated resource is received in at least one of: one or more of the basic units, and the region of the carrier for transmitting the reference numerology.

19. A network device, comprising:

a controller configured to determine numerology information of a carrier, the numerology information indicating numerologies of one or more basic units for the carrier; and

a transmitter configured to transmit the numerology information to a terminal device to enable reception based on the numerology information.

20. The network device according to Claim 19, wherein the basic unit is determined based on a subcarrier spacing and a symbol length used by subcarriers of the carrier.

21. The network device according to Claim 19, wherein the controller is further configured to determine numerologies for all the basic units, and

wherein the transmitter is further configured to transmit information about the numerologies for all the basic units to the terminal device.

22. The network device according to Claim 19, wherein the controller is further configured to:

determine a grouping pattern indicating groups of the basic units; and

determine a numerology for each of the groups, and

wherein the transmitter is further configured to transmit information about the grouping pattern and/or the numerology for each of the groups to the terminal device.

23. The network device according to Claim 19, wherein the controller is further configured to:

determine numerologies for the basic units; and

determine an association between the numerologies and the basic units, and

wherein the transmitter is further configured to transmit information about the numerologies and/or the association to the terminal device.

24. The network device according to Claim 19, wherein the controller is further configured to:

divide the basic units into groups; and

determine a numerology distribution pattern indicating numerologies for basic units in one of the groups, and

wherein the transmitter is further configured to transmit information about the numerology distribution pattern and/or information about the groups to the terminal device.

25. The network device according to Claim 19, wherein the controller is further configured to:

determine guard band information about a guard band between adjacent basic units based on numerologies of the adjacent basic units; and

wherein the transmitter is further configured to transmit the guard band information to the terminal device.

26. The network device according to Claim 25, wherein the controller is further configured to:

detect whether there is a change between numerologies of the adjacent basic units; and

determine occurrence of a guard band between the adjacent basic units based on the detection.

27. The network device according to Claim 25 or 26, wherein the guard band information further includes one or more of:

a number of subcarriers occupied by the guard band,

a number of physical resource blocks occupied by the guard band, and

a basic unit where the guard band is located.

28. The network device according to Claim 25, wherein the transmitter is further configured to transmit the guard band information to the terminal device based on the numerology information.

29. The network device according to Claim 19, wherein the controller is further configured to allocate a resource to one or more terminal devices, and wherein the transmitter is further configured to transmit information about the allocated resource to the terminal device,

wherein the information about the allocated resource includes at least one of: an index of a basic unit allocated to the terminal devices, and an index of a physical resource block in a basic unit allocated to the terminal devices.

30. The network device according to Claim 29, wherein the transmitter is further configured to:

transmit the numerology information in a region of the carrier for transmitting a reference numerology; and

transmit the information about the allocated resource in at least one of: one or more of the basic units, and the region of the carrier for transmitting the reference numerology.

31. A terminal device, comprising:

a receiver configured to receive numerology information of a carrier from a network device, the numerology information indicating numerologies of one or more basic units for the carrier; and

a decoder configured to decode a signal based on the numerology information.

32. The terminal device according to Claim 31, wherein the basic unit is determined based on a subcarrier spacing and a symbol length used by subcarriers of the carrier.

33. The terminal device according to Claim 31, wherein the receiver is further configured to receive at least one of:

information about numerologies for all the basic units;

information about a grouping pattern indicating groups of the basic units and/or a numerology for each of the groups;

information about numerologies for the basic units and/or an association between the numerologies and the basic units; and

at least one of information about a numerology distribution pattern indicating numerologies for basic units in one of groups of basic units and/or information about the groups, the basic units in the groups having the same numerology distribution pattern.

34. The terminal device according to Claim 31, wherein the receiver is further configured to receive guard band information about a guard band between adjacent basic units,

wherein the decoder is further configured to decode the signal based on the numerology information and the guard band information.

35. The terminal device according to Claim 31, wherein the receiver is further configured to receive information about allocated resource of one or more terminal devices from the network device, wherein the information about allocated resource includes at least one of: an index of a basic unit allocated to the terminal

devices, and an index of a physical resource block in a basic unit allocated to the terminal devices.

36. The terminal device according to Claim 35, wherein the numerology information is received in a region of the carrier for transmitting a reference numerology, and the information about the allocated resource is received in at least one of: one or more of the basic units, and the region of the carrier for transmitting the reference numerology.

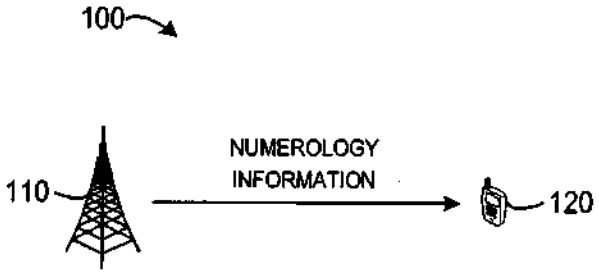

100
110
NUMEROLOGY
INFORMATION
120

FIG. 1

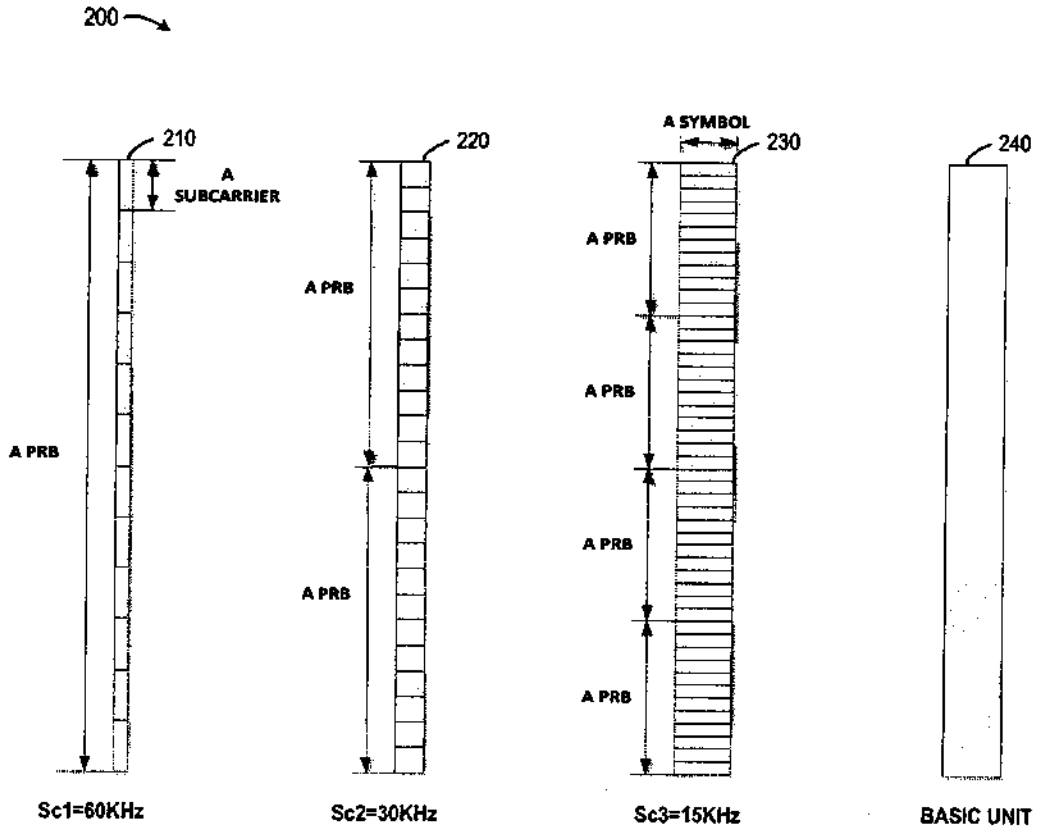

200
210
A
SUBCARRIER
A PRB
Sc1=60KHz
220
A PRB
A PRB
Sc2=30KHz
A SYMBOL
230
A PRB
A PRB
A PRB
A PRB
Sc3=15KHz
240
BASIC UNIT

FIG. 2A

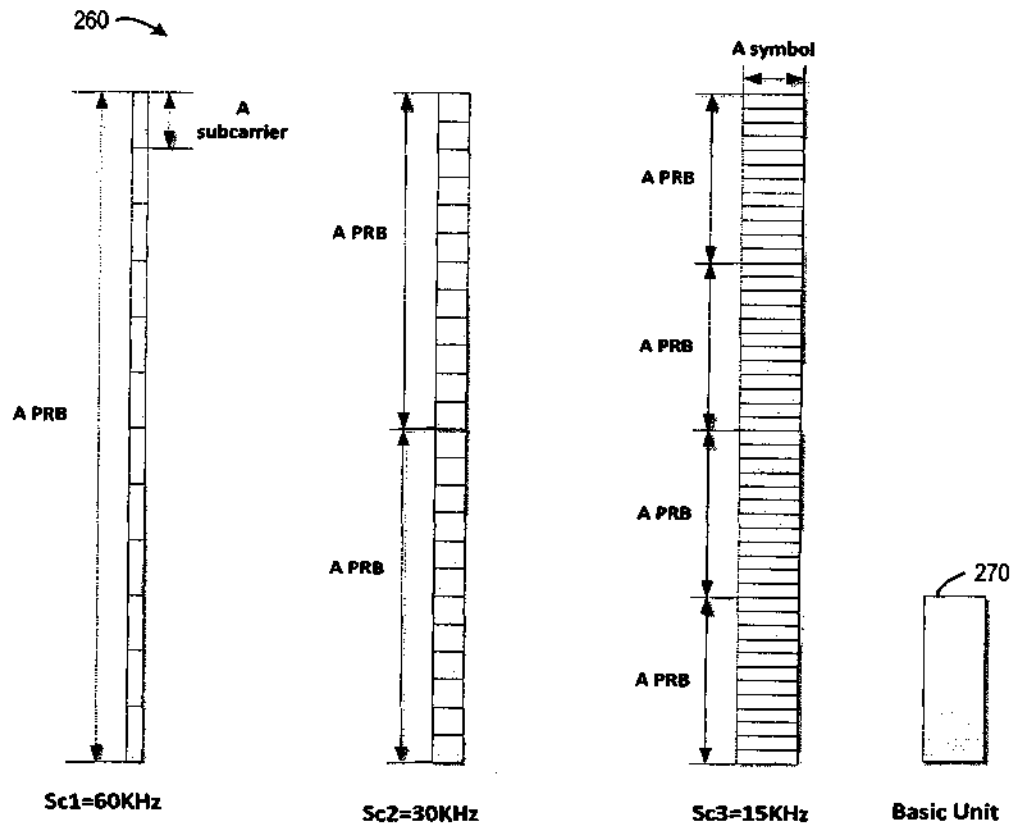

260
A subcarrier
A PRB
A PRB
A PRB
A symbol
A PRB
A PRB
A PRB
A PRB
270
Sc1=60KHz
Sc2=30KHz
Sc3=15KHz
Basic Unit

FIG. 2B

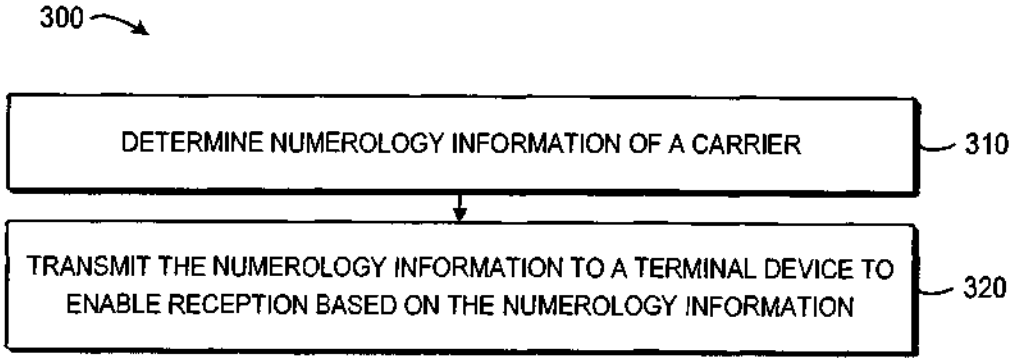

300
DETERMINE NUMEROLOGY INFORMATION OF A CARRIER
310
TRANSMIT THE NUMEROLOGY INFORMATION TO A TERMINAL DEVICE TO ENABLE RECEPTION BASED ON THE NUMEROLOGY INFORMATION
320

FIG. 3

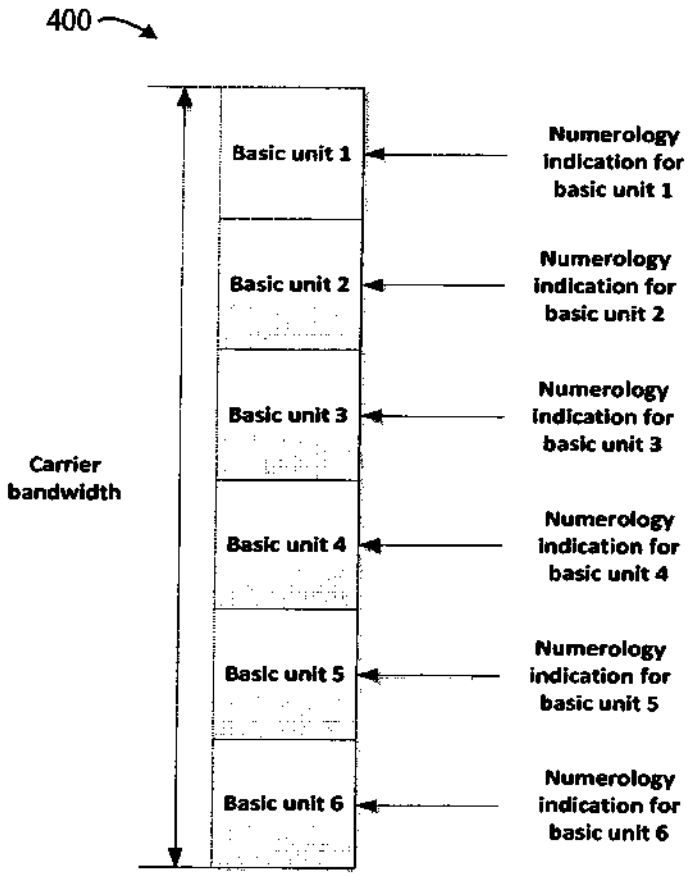

400
Carrier bandwidth
Basic unit 1
Basic unit 2
Basic unit 3
Basic unit 4
Basic unit 5
Basic unit 6
Numerology indication for basic unit 1
Numerology indication for basic unit 2
Numerology indication for basic unit 3
Numerology indication for basic unit 4
Numerology indication for basic unit 5
Numerology indication for basic unit 6

FIG. 4

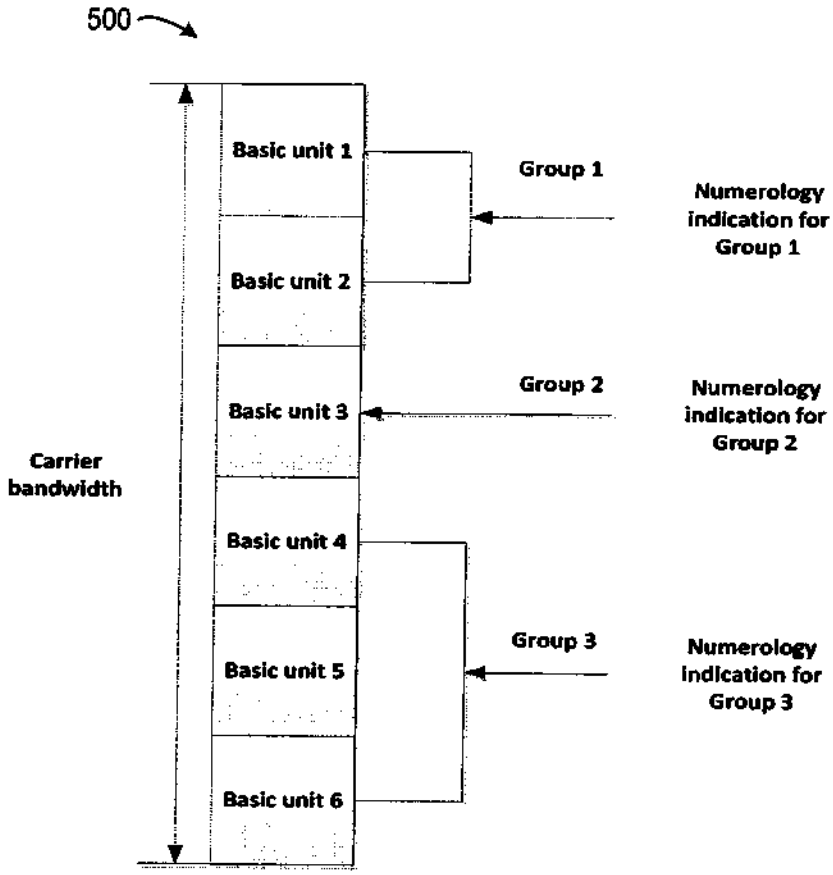

500
Basic unit 1
Basic unit 2
Basic unit 3
Basic unit 4
Basic unit 5
Basic unit 6
Carrier bandwidth
Group 1
Numerology indication for Group 1
Group 2
Numerology indication for Group 2
Group 3
Numerology indication for Group 3

FIG. 5

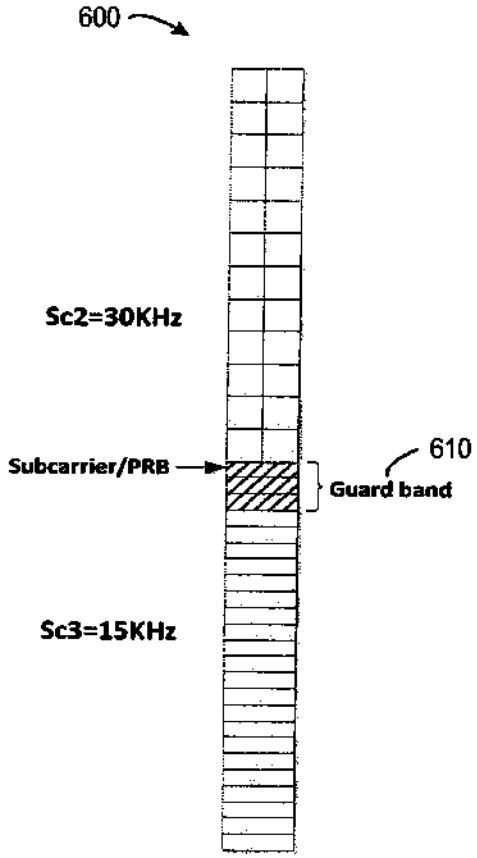


FIG. 6

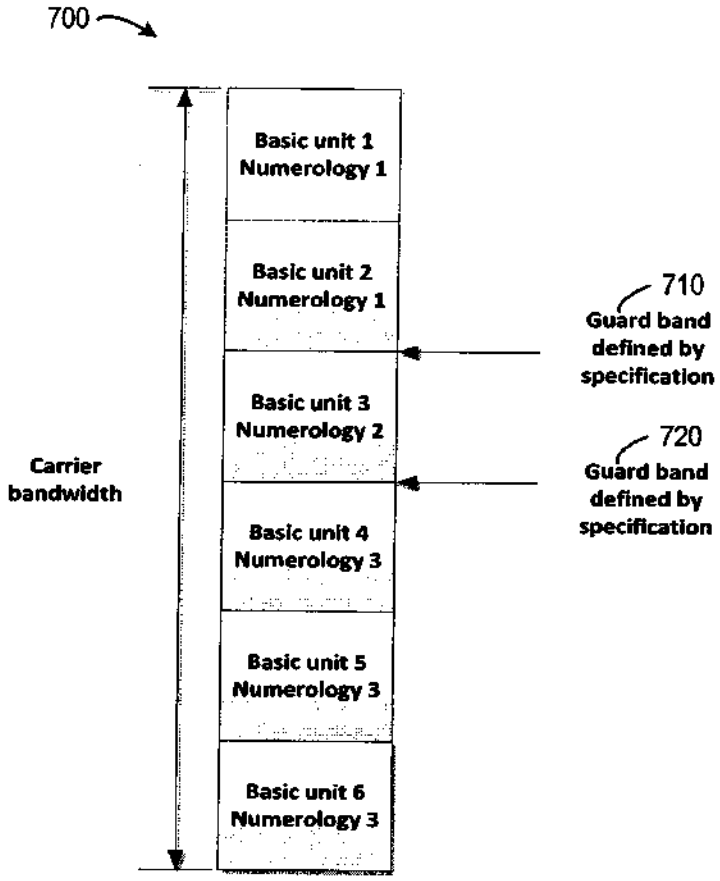

700
Basic unit 1
Numerology 1
Basic unit 2
Numerology 1
Basic unit 3
Numerology 2
Basic unit 4
Numerology 3
Basic unit 5
Numerology 3
Basic unit 6
Numerology 3
Carrier bandwidth
710
Guard band defined by specification
720
Guard band defined by specification

FIG. 7

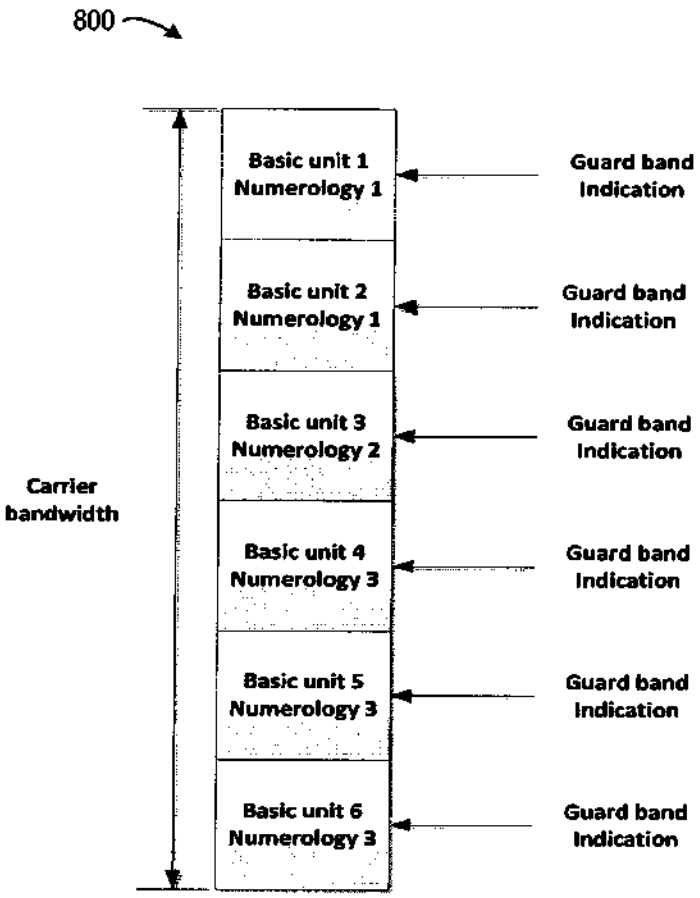

800
Carrier bandwidth
Basic unit 1 Numerology 1
Basic unit 2 Numerology 1
Basic unit 3 Numerology 2
Basic unit 4 Numerology 3
Basic unit 5 Numerology 3
Basic unit 6 Numerology 3
Guard band Indication
Guard band Indication
Guard band Indication
Guard band Indication
Guard band Indication
Guard band Indication

FIG. 8

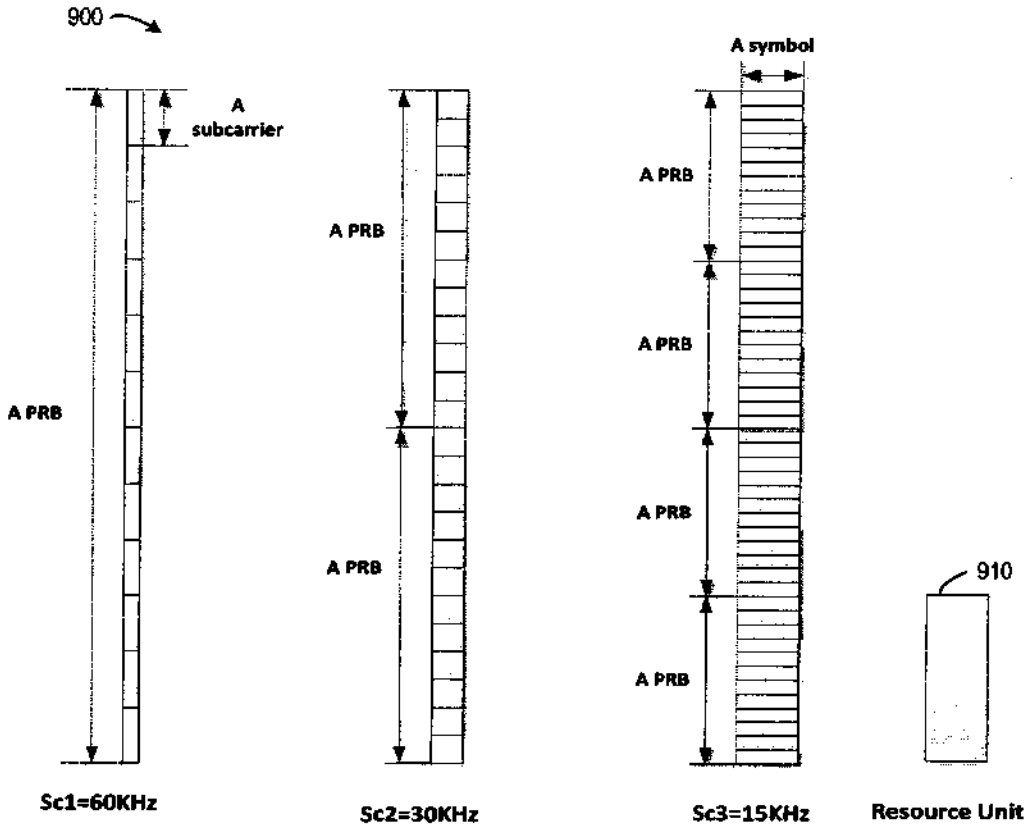

900
A subcarrier
A PRB
A PRB
A PRB
A symbol
A PRB
A PRB
A PRB
A PRB
910
Sc1=60KHz
Sc2=30KHz
Sc3=15KHz
Resource Unit

FIG. 9

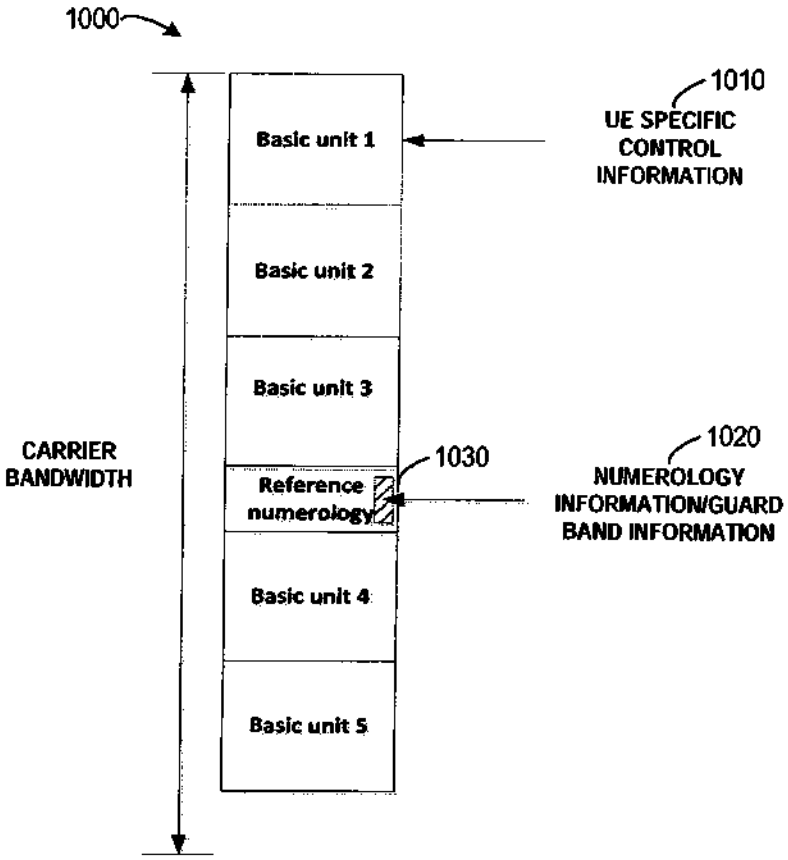

1000
1010
UE SPECIFIC CONTROL INFORMATION
Basic unit 1
Basic unit 2
Basic unit 3
CARRIER BANDWIDTH
1030
1020
NUMEROLOGY INFORMATION/GUARD BAND INFORMATION
Reference numerology
Basic unit 4
Basic unit 5

FIG. 10

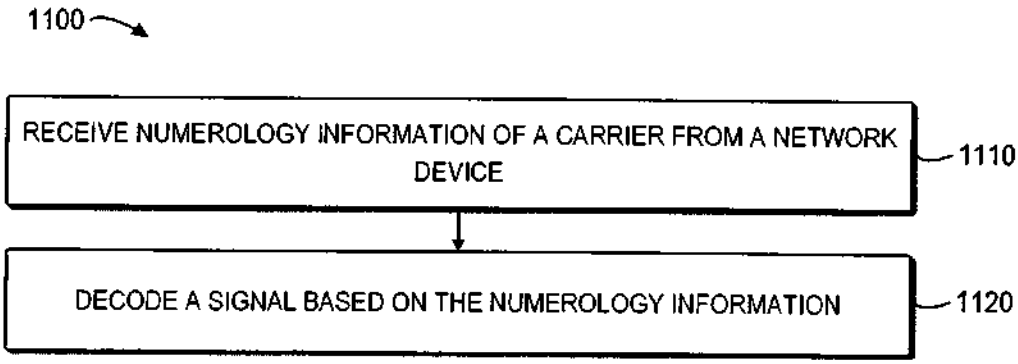

1100
RECEIVE NUMEROLOGY INFORMATION OF A CARRIER FROM A NETWORK DEVICE
1110
DECODE A SIGNAL BASED ON THE NUMEROLOGY INFORMATION
1120

FIG. 11

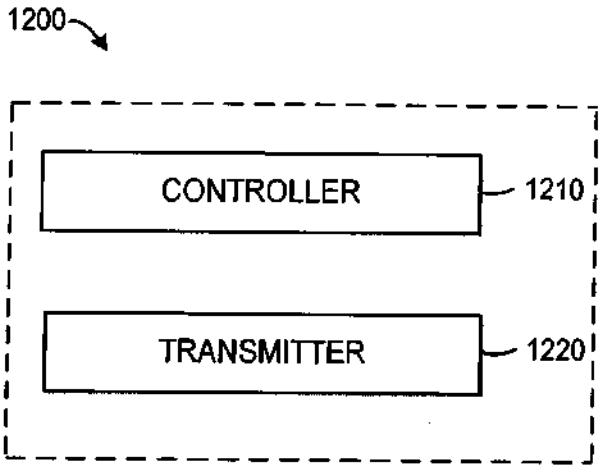

1200
CONTROLLER
1210
TRANSMITTER
1220

FIG. 12

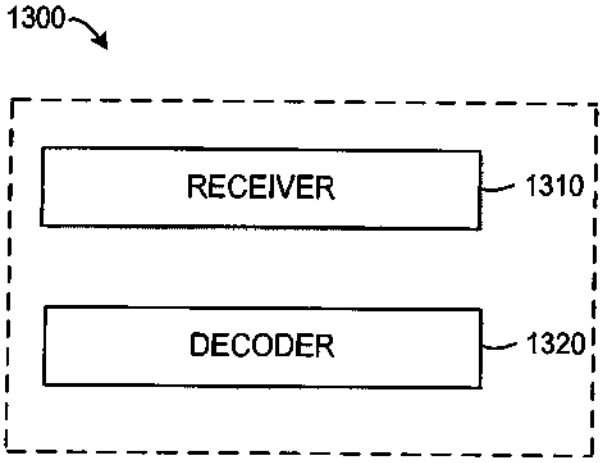

1300
RECEIVER
1310
DECODER
1320

FIG. 13

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2016/000597

A. CLASSIFICATION OF SUBJECT MATTER

H04W 72/04(2009.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04W; H04L; H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI; EPODOC; CNKI; CNPAT; 3GPP: numerology, parameter, carrier, subcarrier, basic unit, subcarrier spacing, symbol length, cyclic prefix, time frequency resource, physical resource block, nodeB, eNodeB, eNB, UE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	PANASONIC. "3GPP TSG-RAN WG1 Meeting #86bis R1-1610217" *Resource assignment for mixed numerologies,* 14 October 2016 (2016-10-14), the whole document	1-36
X	NEC. "3GPP TSG RAN WG1 Meeting #86bis R1-1609145" *Discussion on numerology multiplexing for supporting different service requirements,* 14 October 2016 (2016-10-14), the whole document	1-36
A	US 2015215148 A1 (SAMSUNG ELECTRONICS CO., LTD.) 30 July 2015 (2015-07-30) the whole document	1-36
A	CN 101932104 A (INDUSTRIAL TECHNOLOGY RESEARCH INSTITUTE) 29 December 2010 (2010-12-29) the whole document	1-36

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:

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"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
06 July 2017	**27 July 2017**
Name and mailing address of the ISA/CN **STATE INTELLECTUAL PROPERTY OFFICE OF THE P.R.CHINA** **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088** **China** Facsimile No. **(86-10)62019451**	Authorized officer **LIU,Qingfeng** Telephone No. **(86-10)62413279**

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2016/000597

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
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		KR 20130022523 A	07 March 2013
CN 101932104 A	29 December 2010	TW 201129188 A	16 August 2011
		CN 102932124 A	13 February 2013
		US 2010322175 A1	23 December 2010

Form PCT/ISA/210 (patent family annex) (July 2009)

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(19) 世界知识产权组织
国 际 局

(43) 国际公布日
2017 年 3 月 30 日 (30.03.2017)

WIPO | PCT

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(25) 申请语言: 中文

(26) 公布语言: 中文

(30) 优先权
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(54) Title: METHOD FOR TRANSMITTING AND RECEIVING SYSTEM INFORMATION AND TRANSMITTING AND RECEIVING DEVICES

(54) 发明名称: 系统信息发送方法、接收方法、发送装置及接收装置

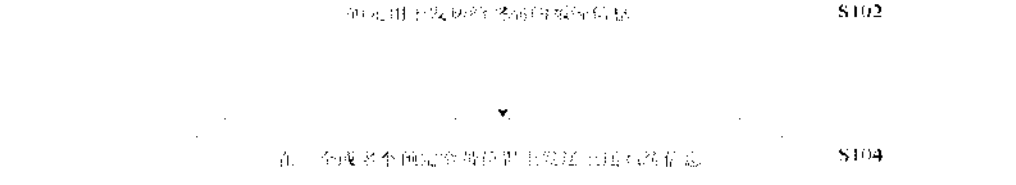


图 1

S102 DETERMINING THE SYSTEM INFORMATION TO BE TRANSMITTED TO A TERMINAL
S104 TRANSMITTING THE SYSTEM INFORMATION ON ONE OR MORE PREDEFINED NARROW BAND LOCATIONS

(57) Abstract: The present invention provides a method for transmitting and receiving system information and transmitting and receiving devices, wherein the method for transmitting system information includes: determining the system information to be transmitted to a terminal; and transmitting the system information on one or more predefined narrow band locations. The present invention solves the transmission method when downlink control information, such as system message change information, ETWS, CMAS and the like, are independently carried out in the related art, realizing an effect of efficient transmission. The present invention also solves the problem of high complexity of terminal blind detection for the downlink control information which carries the system information, thereby achieving the effect of reducing the complexity of terminal blind detection for the system message.

(57) 摘要: 本发明提供了一种系统信息发送方法、接收方法、发送装置及接收装置, 其中, 该系统信息发送方法包括: 确定用于发送给终端的系统信息; 在一个或多个预定义窄带位置上发送该系统信息。通过本发明, 解决了相关技术中独立承载系统消息变更信息、ETWS、CMAS 等消息等控制信息时的发送方式问题, 达到高效发送的效果; 也解决了相关技术中有关终端盲检测承载系统消息的下行控制信息的复杂度高的问题, 进而达到了降低终端盲检测系统消息的复杂度的效果。

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CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW

(84) **指定国** (除另有指明，要求每一种可提供的地区保护): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), 欧亚 (AM, AZ, BY, KG, KZ, RU, TJ, TM), 欧洲 (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG)

本国际公布

包括国际检索报告(条约第21条(3))。

系统信息发送方法、接收方法、发送装置及接收装置

技术领域

本发明涉及通信领域，具体而言，涉及一种系统信息发送方法、接收方法、发送装置及接收装置。

背景技术

机器类型通信（Machine Type Communication，简称为 MTC）用户终端（User Equipment，简称为 UE），又称，机器到机器（Machine to Machine，简称为 M2M）用户通信设备，是主要物联网的主要应用形式。近年来，由于长期演进（Long-Term Evolution，简称为 LTE）高级长期演进系统（Long-Term Evolution Advance，简称为 LTE-Advance 或 LTE-A）的频谱效率高，越来越多的移动运营商选择 LTE/LTE-A 作为宽带无线通信系统的演进方向。基于 LTE/LTE-A 的 MTC 多种类数据业务也将更具吸引力。为了重用 GSM 频谱业务提出了窄带 LTE（Narrowband LTE，简称为 NB-LTE）技术，也可以支持 MTC 多种类型的业务。

现有的 LTE/LTE-A 系统是基于每个子帧动态调度进行传输的，即每个子帧均可以传输不同的控制信息。

LTE/LTE-A 中定义了物理下行控制信道（Physical Downlink Control Channel，简称为 PDCCH）和增强物理下行控制信道（Enhanced Physical Downlink Control Channel，简称为 EPDCCH）。PDCCH/EPDCCH 用于承载下行控制信息（Downlink Control Information，简称为 DCI），包括：上、下行调度信息，以及上行功率控制信息。

通常 MTC 终端可以通过在每个子帧解调 PDCCH/EPDCCH 信道获得 DCI，以便实现对物理下行共享信道（Physical Downlink Share Channel，简称为 PDSCH）的解调和物理上行共享信道（Physical Uplink Share Channel，简称为 PUSCH）的调度指示信息。对于寻呼 Paging 消息，同样是通过 PDSCH 信道承载，由基站通过下行控制信道调度指示在终端相应的寻呼机会（Paging Occasion，简称为 PO）发送 Paging 消息。

在 MTC 应用终端中，至少区分两种类型终端，一类终端由于射频及收发带宽受限除之为低成本终端，另一类为低成本终端所处位置或自身特性受限从而导致覆盖性能显著下降，称之为覆盖增强终端。例如智能抄表类 MTC 终端大多固定安装在地下室等低覆盖场景环境下，其主要发送小包数据，对数据速率的要求低，能够容忍较大的数据传输时延。对于覆盖增强终端通过时域上的多次重复发送等方式来保证数据的正确传输。

无论对于 LTE 系统还是 NB-LTE 系统，低成本终端还是覆盖增强终端，由于有在寻 Paging 消息中的系统消息，如系统消息变更信息、地震和海啸警系统（Earthquake and Tsunami Warning System，简称为 ETWS）通知信息、商业移动告警服务（Commercial Mobile Alert Service，简称为 CMAS）通知信息就立承载在下行控制信息中发送的需求，其由需要考虑对

于该类型的下行控制信息如何发送，采用相关技术中的系统消息的发送方法会增加终端盲检测系统消息的复杂度的问题。

针对相关技术中存在的上述问题，目前尚未有效地解决方案。

发明内容

本发明提供了一种系统信息发送方法、接收方法、发送装置及接收装置，以至少解决相关技术中存在的终端盲检测系统消息的复杂度高的问题。

根据本发明的一个方面，提供了一种系统信息发送方法，包括：确定用于发送给终端的系统信息；在一个或多个预定窄带位置上发送所述系统信息。

可选地，所述系统信息包括以下至少之一：系统消息变更信息、地震和海啸预警系统 ETWS 通知信息、商业移动告警服务 CMAS 通知信息、扩展接入控制 EAB 参数变更通知信息、控制格式指示信息 CFI、时分双工系统配置信息、基站 eNB 支持的最大覆盖增强等级 max CE level、基站 eNB 支持的覆盖增强等级 CE levels、小区接入相关信息、系统消息调度信息、物理随机接入信道 PRACH 配置信息、窄带跳变 Hopping 配置信息、除 PRACH 信道以外其他信道射频资源配置信息、上行频点和带宽信息、多播广播单频网络 MBSFN 子帧配置信息。

可选地，当所述系统信息位于第一下行控制信息 DCI 中，且所述第一 DCI 中仅包括所述系统信息时，在一个或多个预定窄带位置上发送所述系统信息包括：在预定时刻时，在一个或多个预定窄带位置上发送所述第一 DCI。

可选地，所述预定窄带为基站的预定小区内的所有终端均能够接收检测的公有搜索空间 CSS 窄带；所述预定时刻为所述基站的所述预定小区内的所有终端均能够接收检测的寻呼时刻 PO。

可选地，在预定时刻时，在一个或多个预定窄带位置上发送所述第一 DCI 包括：在预先确定的所述系统信息的变更周期内，在一个或多个预定窄带位置上发送一次或多次所述系统信息。

可选地，在发送所述第一 DCI 时，采对应调度的物理下行共享信道 PDSCH。

可选地，当所述系统信息位于第二下行控制信息 DCI 中，且所述第二 DCI 中还包括除所述系统信息外的其他下行控制信息时，在一个或多个预定窄带位置上发送所述系统信息包括：根据所述终端的标识，在一个或多个寻呼时刻 PO 时，在一个或多个所述预定窄带位置上发送所述第二 DCI。

可选地，所述系统信息在所述第二 DCI 中的以下至少之一的位置上：所述第二 DCI 中的预留比特 bit；所述第二 DCI 中的发上行空闲状态的 bit 域；所述第二 DCI 中的处于非空闲状态的 bit 域其余分 bit。

可选地，当将所述系统信息携带在所述第二下行控制信息 DCI 中进行发送时，通过预定

方式指示所述第一DCI的类型：当所述系统信息携带在所述第一DCI中或者承载于物理下行共享信道PDSCH中进行发送时，通过所述预定方式指示所述系统信息位于所述第一DCI中还是承载于所述PDSCH中；其中，所述类型包括未携带所述系统信息的普通DCI、携带所述系统信息和其他下行控制信息的普通DCI；所述预定方式包括以下至少之一：使用所述第一DCI中的空闲比特bit进行指示的方式；将所述第一DCI置于特定状态的方式；利用无线网络临时标识RNTI的特定值的方式。

可选地，在所述第一DCI或所述第二DCI中，还携带有用于指示物理下行共享信道PDSCH的存无的指示信息，其中，在指示为无PDSCH时，相应的具体系统更新消息在系统信息块SIB中发送；在指示为有PDSCH时，相应的具体系统更新消息在PDSCH中发送。

可选地，在一个或多个预定窄带位置上发送所述系统信息之前，还包括：将用于指示所述一个或多个预定窄带位置的指示信息通过系统信息中的主信息块MIB或系统信息块SIB或无线资源控制RRC消息发送给所述终端。

根据本发明的另一方面，提供了一种系统信息接收方法，包括：确定一个或多个预定窄带位置；在确定的所述一个或多个预定窄带位置上接收来自基站的系统信息。

可选地，所述系统信息包括以下至少之一：系统消息变更信息、地震和海啸预警系统ETWS通知信息、商业移动告警服务CMAS通知信息、扩展接入控制EAB参数变更通知信息、控制格式指示信息CFI、时分双工系统配置信息、基站eNB支持的最大覆盖增强等级max CE level、基站eNB支持的覆盖增强等级CE levels、小区接入相关信息、系统消息调度信息、物理随机接入信道PRACH配置信息、窄带跳变Hopping配置信息、除PRACH信道以外其他信道物理资源配置信息、上行频点和带宽信息、多播广播单频网络MBSFN子帧配置信息。

可选地，确定所述一个或多个预定窄带位置包括以下之一：通过系统信息中的消息信息块MIB或系统信息块SIB或无线资源控制RRC消息接收所述基站预先发送的用于指示所述一个或多个预定窄带位置的指示信息，根据所述指示信息确定所述一个或多个预定窄带位置；根据预配置的用于标识所述一个或多个预定窄带位置的协议确定所述位置。

可选地，在确定的所述一个或多个预定窄带位置上接收来自基站的系统信息包括：在预定时刻时，在确定的所述一个或多个预定窄带位置上接收来自基站的承载所述系统信息的第二DCI。

可选地，所述预定窄带为所述基站为预定小区内的所有终端为能够接收检测的公有搜索空间CSS窄带；所述预定时刻为所述基站的所述预定小区内的所有终端为能够接收检测的寻呼时刻PO。

可选地，在预定时刻时，在确定的所述一个或多个预定窄带位置上接收来自基站的承载所述系统信息的所述第二DCI包括：在预先确定的所述系统信息的变更周期内，在一个或多个预定窄带位置上接收一次或多次所述第二DCI。

可选地，在确定的所述一个或多个预定窄带位置上接收来自基站的系统信息包括：在确

定的所述一个或多个预定义带位置上接收来自基站的第四下行控制信息 DCI；根据所述第四 DCI 中的用于进行指示的 bit、所述第四 DCI 的状态以及预先确定的无线网络临时标识 RNTI 的 RNTI 值中的至少之一确定所述第四 DCI 的类型或者确定所述系统信息位于所述第四 DCI 中还是承载于物理下行共享信道 PDSCH 中，其中，所述类型包括未携带所述系统信息的普通 DCI、携带所述系统信息和其他下行控制信息的普通 DCI；根据确定结果接收所述系统信息。

根据本发明的另一方面，提供了一种系统信息发送装置，包括：第一确定模块，设置为确定用于发送给终端的系统信息；第一发送模块，设置为在一个或多个预定义带位置上发送所述系统信息。

可选地，所述系统信息包括以下至少之一：系统消息变更信息、地震和海啸预警系统 ETWS 通知信息、商业移动告警服务 CMAS 通知信息、扩展接入控制 EAB 参数变更通知信息、控制格式指示信息 CFI、时分双工系统配置信息、基站 eNB 支持的最大覆盖增强等级 max CE level、基站 eNB 支持的覆盖增强等级 CE levels、小区接入相关信息、系统消息调度信息、物理随机接入信道 PRACH 配置信息、窄带跳变 Hopping 配置信息、除 PRACH 信道以外其他信道射频资源配置信息、上行频点和带宽信息、多播广播单频网络 MBSFN 子帧配置信息。

可选地，所述装置还包括：第二发送模块，设置为在一个或多个预定义带位置上发送所述系统信息之前，将用于指示所述一个或多个预定义带位置的指示信息通过系统信息中的消息信息块 MIB 或系统信息块 SIB 或无线资源控制 RRC 消息发送给所述终端。

根据本发明的另一方面，提供了一种系统信息接收装置，包括：第二确定模块，设置为确定一个或多个预定义带位置；接收模块，设置为在确定的所述一个或多个预定义带位置上接收来自基站的系统信息。

可选地，所述系统信息包括以下至少之一：系统消息变更信息、地震和海啸预警系统 ETWS 通知信息、商业移动告警服务 CMAS 通知信息、扩展接入控制 EAB 参数变更通知信息、控制格式指示信息 CFI、时分双工系统配置信息、基站 eNB 支持的最大覆盖增强等级 max CE level、基站 eNB 支持的覆盖增强等级 CE levels、小区接入相关信息、系统消息调度信息、物理随机接入信道 PRACH 配置信息、窄带跳变 Hopping 配置信息、除 PRACH 信道以外其他信道射频资源配置信息、上行频点和带宽信息、多播广播单频网络 MBSFN 子帧配置信息。

可选地，所述第二确定模块包括以下之一：第一确定单元，设置为通过系统信息中的消息信息块 MIB 或系统信息块 SIB 或无线资源控制 RRC 消息接收所述基站预先发送的用于指示所述一个或多个预定义带位置的指示信息，根据所述指示信息确定所述一个或多个预定义带位置；第二确定单元，设置为根据预配置的用于标识所述一个或多个预定义带位置的索引确定所述位置。

本发明另一实施例提供了一种计算机存储介质，所述计算机存储介质存储有执行指令，所述执行指令用于执行上述实施例中的方法。

通过本发明，采用确定用于发送给终端的系统信息：在一个或多个预定义带或物理资源

块组位置上发送所述系统信息，解决了相关技术中触发承载系统消息变更信息、ETWS、CMAS等的下行控制信息时的发送方式问题，达到高效发送的效果；还解决了相关技术中存在的终端自检测承载系统消息的下行控制信息的复杂度高的问题，进而达到了降低终端自检测系统消息的复杂度的效果。

附图说明

此处所说明的附图用来提供对本发明的进一步理解，构成本申请的一部分，本发明的示意性实施例及其说明用于解释本发明，并不构成对本发明的不当限定。在附图中：

图 1 是根据本发明实施例的系统信息发送方法的流程图；

图 2 是根据本发明实施例的在公共CSS 空间和公共 PO 时刻位置发送专用 DCI 的示意图；

图 3 是根据本发明实施例的在公共CSS 空间和公共 PO 时刻位置发送专用 DCI 的示意图；

图 4 是根据本发明实施例的系统信息接收方法的流程图；

图 5 是根据本发明实施例的系统信息发送装置的结构框图；

图 6 是根据本发明实施例的系统信息发送装置的优选结构框图；

图 7 是根据本发明实施例的系统信息接收装置的结构框图；

图 8 是根据本发明实施例的系统信息接收装置中第一确定模块 72 的结构框图；

图 9 是根据本发明实施例的在多个 CSS 空间发送含有下行信息的调度寻呼 Paging 消息的DCI 的示意图

具体实施方式

下文中将参考附图并结合实施例来详细说明本发明。需要说明的是，在不冲突的情况下，本申请中的实施例及实施例中的特征可以相互组合。

需要说明的是，本发明的说明书和权利要求书及上述附图中的术语“第一”、“第二”等是用于区别类似的对象，而不必用于描述特定的顺序或先后次序。

在本实施例中提供了一种系统信息发送方法，图 1 是根据本发明实施例的系统信息发送方法的流程图，如图 1 所示，该流程包括如下步骤：

步骤 S102，确定用于发送给终端的系统信息；

步骤 S104，在一个或多个预定寻呼位置上发送上述系统信息。

其中，上述的窄带也可以称为物理资源块组 PRB（Physical Resource Block） group，执行上述操作的可以是基站，上述的一个或多个预定窄带位置也可以是基站和终端预先协商好的位置，在发送上述系统消息时，可以在下行控制信道上承载发送。因此，可以降低终端的盲检测的复杂度。解决了相关技术中缺乏承载系统消息变更信息、ETWS、CMAS 等的下行控制信息时的发送方式问题，达到高效发送的效果；还解决了相关技术中存在的终端盲检测承载系统消息的下行控制信息的复杂度高的问题，进而达到了降低终端盲检测系统消息的复杂度的效果。

在一个可选的实施例中，上述的系统信息可以包括以下至少之一：系统消息变更信息、地震和海啸预警系统 ETWS 通知信息，商业移动告警服务 CMAS、通知信息，扩展接入控制（Extended Access Barring，简称为 EAB）参数变更通知信息、控制格式指示信息（Control format Indicator，简称为 CFI）、时分双工系统配置信息、基站 eNB 支持的最大覆盖增强等级 max CE level、基站 eNB 支持的覆盖增强等级 CE levels、小区接入相关信息、系统消息调度信息、物理随机接入信道（Physical Random Access Channe，简称为 PRACH）配置信息、窄带跳变 Hopping 配置信息、除 PRACH 信道以外其他信道频资源配置信息、上行频点和带宽信息、多播广播单频网络（Multicast Broadcast Single Frequency Network，简称为 MBSFN）子帧配置信息、或小区专有有效子帧配置信息。其中，优选的系统消息组合包括以下组合至少之一：组合 1：系统消息变更信息、ETWS、CMAS；组合 2：系统消息变更信息、ETWS、CMAS、CFI、TDD configuration；组合 3：系统消息变更信息、ETWS、CMAS、max CE level、等等，也可以是其他组合形式，在此不一一列举。

在发送上述系统消息时，可以将上述系统消息作为专用的 DCI（即，专用仅包含上述系统消息的专用 DCI 进行发送）或者作为 DCI 中的一部分，上述的预定窄带优选为 CSS 窄带，即可以通过下行控制信道承载的上述系统消息信息在一个或多个 CSS 窄带中发送。在一个可选的实施例中，当上述系统信息位于第一下行控制信息 DCI 中，且该第一 DCI 中仅包括上述系统信息（该第一 DCI 为专用 DCI）时，在一个或多个预定窄带位置上发送上述系统信息包括：在预定时刻时，在一个或多个预定窄带位置上发送上述第一 DCI，上述系统信息作为专用 DCI，不使用调度普通 Paging 消息的 DCI，即不包含资源分配、调制编码方式等的指示，在预定窄带和预定时刻发送，即发送位置是基站和 UE 所会知上本区分特定 UE 的。

在一个可选的实施例中，上述预定窄带为基站的预定小区内的所有终端均能够接收检测的公有搜索空间 CSS 窄带；上述预定时刻为基站的预定小区内的所有终端均能够接收检测的寻呼时刻 PO，优选地，小区内所有终端在同一 PO 时刻使用相同的一个 CSS 窄带，如图 2 所示，图 2 是根据本发明实施例的在公共 CSS 窄带和公共 PO 时刻位置发送专用 DCI 的示意图一，在相同的 PO 时刻或 PO 时刻组接收相应的上述下行信息，这里的 PO 时刻或 PO 时刻组为所有终端都能够接收的时刻，即，公共接收时刻。在不同的 PO 时刻可以使用相同的一个 CSS 窄带，如图 2 所示，也可以使用不同的 CSS 窄带，如图 3 所示，图 3 是根据本发明实施例的在公共 CSS 窄带和公共 PO 时刻位置发送专用 DCI 的示意图二，但是对于一个确定的 PO 时刻而言，可以仅使用一个 CSS 窄带。

在一个可选的实施例中，在预定时刻时，在一个或多个预定窄带位置上发送所述第一 DCI 包括：在预先确定的所述系统信息的变更周期内，在一个或多个预定窄带位置上发送一次或多次所述系统信息。即，一个所述的变更周期内可以包括一个或多个上述的预定时刻，可以在每个预定时刻内发送上述系统消息，因此，可以在一个变更周期内发送一次或多个上述系统消息。其中，在上述的一次或多次发送系统消息时，系统信息内容未发生变化，使得在系统信息变更周期内发送一次或多次系统消息可以保证小区内所有终端以较大概率接收到上述系统信息。

在一个可选的实施例中，在发送上述第一 DCI 时，无对应调度的物理下行共享信道 PDSCH。可选地，上述第一 DCI 中，专用 DCI 仅承载上述系统信息时，并且无相应的资源分配、调制编码方式等传统下行控制信息所包含的调度指示信息时，此时该专用 DCI 无对应调度的 PDSCH。终端在接收该专用 DCI 之后不再接收相应的 PDSCH 信道

在一个可选的实施例中，在一个或多个预定窄带或物理资源块组位置上发送上述系统消息包括：将上述系统消息承载在物理下行共享信道 PDSCH 上，在一个或多个预定窄带位置上发送上述系统消息。上述系统信息还可以位于普通 DCI 中，其中，该普通 DCI 为调度普通 Paging 消息的 DCI。在一个可选的实施例中，当上述系统信息位于第二下行控制信息 DCI 中，上该第二 DCI 中还包括除上述系统信息外的其他下行控制信息时，在一个或多个预定窄带位置上发送上述系统信息包括：根据上述终端的标识 UE ID，在一个或多个寻呼时刻 PO 时，在一个或多个所述预定窄带位置上发送上述第二 DCI。即，该第二 DCI 为普通 DCI。

在一个可选的实施例中，上述系统信息可以位于 DCI 中或 PDSCH 中，其中该 DCI 可以为调度普通 Paging 消息的 DCI（即，上述的第一 DCI）。优选地，此时有对应调度的 PDSCH 信道，承载相应的部分用户或全部用户的 Paging 消息。基站 eNB 可以根据 UE ID 在一个或多个 CSS 窄带/物理资源块组 PRB group 和一个或多个 PO 发送该 DCI。即基站对于部分用户的 Paging record 信息承载在同一条 Paging 消息中，eNB 根据这些用户（到上述的终端）的 UE ID 均包含所述下行信息的调度该条 Paging 消息在一个 CSS 窄带以及一个或多个 PO 时刻进行发送。对于另一部分用户的 Paging record 信息承载在另一条 Paging 消息中，eNB 根据所述另一部分用户的 UE ID 将包含所述下行信息的调度该条 Paging 消息在另一个 CSS 窄带以及一个或多个 PO 时刻进行发送。如图 3 所示从 eNB 角度来看，发送承载所述下行信息的调度普通 Paging 消息的 DCI 位于多个 CSS 窄带，对于终端而言，在同一 PO 时刻仅能在一个 CSS 窄带中接收所述下行信息。优选的，终端可以通过 UE ID 隐含得到自己需要接收的 CSS 窄带位置。

在一个可选的实施例中，上述系统信息在第二 DCI 中的以下至少之一的位置上：第二 DCI 中的空闲比特 bit；第二 DCI 中的处于空闲状态的 bit 域；第二 DCI 中的处于非空闲状态的 bit 域的部分 bit。下面进行具体说明：使用调度普通 Paging 消息的 DCI 的 padding bit 或空闲状态，具体为当所述 DCI 消息中存在空闲 bit，如 Padding bit，使用空闲 bit 来载上述系统信息，其中下行信息的大小小于或等于空闲 bit 的数量，或者使用普通 DCI 消息的空闲状态，如指示传输功率控制 TPC 的 2bit 信息此时并无具体指示含义，处于空闲状态，此时上述系统信息使用该比特域进行传输，其中系统信息的大小小于或等于空闲状态所对应的 bit 的数量。还可以使用

调度普通 Paging 消息的 DCI 的非空闲状态。具体的如指示资源分配比特或此，指示完所有可能的分配或指示特定后，仍存在状态剩余，使用剩余的状态指示、或者如占用资源分配比特域的部分 bit，资源分配简化指示以及前导部分开销。

在一个可选的实施例中，当将所述系统信息携带在所述第二下行控制信息 DCI 中进行发送时，可以通过预定方式标示该第二 DCI 的类型：当上述系统信息携带在第二 DCI 中或者承载于物理下行共享信道 PDSCH 中进行发送时，也可以通过下述预定方式标示该系统信息位于第二 DCI 中还是承载于 PDSCH 中；其中，该类型包括承载有上述系统信息的普通 DCI、携带上述系统信息和其他下行控制信息的普通 DCI，该预定方式包括以下至少之一：使用第二 DCI 中的空闲比特 bit 进行指示的方式；将上述第二 DCI 置于特定状态的方式；利用无线网络临时标识 RNTI 的特定值的方式。

其中，使用空闲比特指示时，可以使用 padding bit 中的 1bit 指示上述系统信息的第二 DCI 的格式/类型为调度普通 paging 消息的 DCI 还是无相应调度普通 paging 消息的 DCI，或者指示上述系统信息位于 DCI 中还是 PDSCH 中，或者使用 1bit 或 x bit（x 为大于 1 的正整数）指示第二 DCI 格式为承载了具体哪种系统信息组合的系统信息。在使用特定状态指示时，可以使用 padding bit 或资源分配或调制编码方式等之一中的 1 种状态（如全 0 比特、或特别指定的 bit 序列）指示载有上述系统信息的第二 DCI 的格式/类型为调度普通 paging 消息的 DCI 还是无相应调度普通 paging 消息的 DCI，或者指示上述系统信息位于 DCI 中还是 PDSCH 中，或者使用 1 种状态或 x 种状态（x 为大于 1 的正整数）指示上述第二 DCI 格式为承载了具体哪种系统信息组合的系统信息。在使用不同的 RNTI 取值时，可以使用两种不同的 RNTI 取值（其中一种为 P-RNTI 的取值 FFFE）指示第二 DCI 的格式/类型为调度普通 paging 消息的 DCI 还是无相应调度普通 paging 消息的 DCI，或者指示上述系统信息位于 DCI 中还是 PDSCH 中。优选的，使用 P-RNTI 指示上述第二 DCI 的格式/类型为调度普通 paging 消息的 DCI 或者指示上述系统信息位于 PDSCH 中，或者使用 x 种 RNTI 取值（x 为大于等于 2 的正整数）指示上述第二 DCI 格式为承载了具体哪种系统信息组合的系统信息。

在一个可选的实施例中，在上述第一 DCI 或第二 DCI 中，还设置有用于指示物理下行共享信道 PDSCH 的有无的指示信息，其中，在指示为无 PDSCH 时，相应的其他系统更新消息在系统信息块 SIB 中发送；在指示为有 PDSCH 时，相应的其他系统更新消息在 PDSCH 中发送。

在一个可选的实施例中，在一个或多个预定空带位置上发送上述系统信息之前，还包括：将用于指示该一个或多个预定空带位置的指示信息通过系统信息中的主信息块（Master Information Block，简称为 MIB）或系统信息块（System Information Blocks，简称为 SIB 或无线资源控制（Radio Resource Control，简称为 RRC）消息发送给上述终端。还可以根据预配置的用于标识该一个或多个预定空带位置的协议确定上述预定空带的位置。

在本发明实施例中，还提供了一种系统信息接收方法，图 4 是根据本发明实施例的系统信息接收方法的流程图，如图 4 所示，该方法包括如下步骤：

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步骤 S402，确定一个或多个预定窄带位置；

步骤 S404，在确定的上述一个或多个预定窄带位置上接收来自基站的系统信息。

其中，上述的窄带也可以称为物理资源块组 PRB group，约定上述操作的可以是终端，上述的一个或多个预定窄带位置也可以是基站和终端预先协商好的位置，在接收上述系统消息时，可以在确定预定窄带位置上接收，因此，可以降低终端的盲检测的复杂度，从而解决了相关技术中独立承载系统消息变更信息、ETWS、CMAS 等的下行控制信息所需的发送开销大，达到高效发送的效果；还解决了相关技术中存在的终端盲检测承载系统消息的下行控制信息的复杂度高的问题，进而达到了降低终端盲检测系统消息的复杂度的效果。

在一个可选的实施例中，上述系统信息可以包括以下至少之一：系统消息变更信息、地震和海啸预警系统 ETWS 通知信息、商业移动告警服务 CMAS 通知信息、扩展接入控制 EAB 参数变更通知信息、控制格式指示信息 CFI、时分双工系统配置信息、基站 eNB 支持的最大覆盖增强等级 max CE level、基站 eNB 支持的覆盖增强等级 CE levels、小区接入相关信息、系统消息调度信息、物理随机接入信道 PRACH 配置信息、窄带跳变 Hopping 配置信息、除 PRACH 信道以外其他信道初始资源配置信息、上行频点和带宽信息、多播广播单频网络 MBSFN 子帧配置信息（或小区专有的子帧配置信息）。

在一个可选的实施例中，确定上述一个或多个预定窄带位置包括以下之一：通过系统信息中的消息信息块 MIB 或系统信息块类型 SIB 或无线资源控制 RRC 消息接收基站预先发送的用于指示上述一个或多个预定窄带位置的指示信息，根据上述指示信息确定一个或多个预定窄带位置；根据预配置的用于标识上述一个或多个预定窄带位置的协议确定上述位置。

在一个可选的实施例中，在确定的上述一个或多个预定窄带位置上接收来自基站的系统信息包括：在预定时刻时，在确定的上述一个或多个预定窄带位置上接收来自基站的承载上述系统信息的第一 DCI。

在一个可选的实施例中，上述预定窄带为基站的预定小区内的所有终端均能够接收检测的公有搜索空间 CSS 空带；上述预定时刻为基站的预定小区内的所有终端均能够接收检测的寻呼时刻 PO。

在一个可选的实施例中，在预定时刻时，在确定的一个或多个预定窄带位置上接收来自基站的承载上述系统信息的第一 DCI 包括：在预先确定的上述系统信息的变更周期内，在一个或多个预定窄带位置上接收一次或多次上述第一 DCI。

在一个可选的实施例中，在确定的上述一个或多个预定窄带位置上接收来自基站的系统信息包括：在确定的一个或多个预定窄带位置上接收来自基站的第四下行控制信息 DCI；根据该第四 DCI 中的用于通知指示的 bit，该第四 DCI 的状态以及预先确定的无线网络临时标识 RNTI 的 RNTI 值中的至少之一，确定第四 DCI 的类型或者确定系统信息位于上述第四 DCI 中还是承载于物理下行共享信道 PDSCH 中，其中，该类型包括未携带所述系统信息的普通 DCI、携带上述系统信息和其他下行控制信息的普通 DCI；根据确定结果接收上述系统信息。

通过以上的实施方式的描述，本领域的技术人员可以清楚地了解到根据上述实施例的方法可借助软件加必需的通用硬件平台的方式来实现，当然也可以通过硬件，但很多情况下前者是更佳的实施方式。基于这样的理解，本发明的技术方案本质上或者说对现有技术做出贡献的部分可以以软件产品的形式体现出来，该计算机软件产品存储在一个存储介质（如ROM/RAM、磁碟、光盘）中，包括若干指令用以使得一台终端设备（可以是手机，计算机，服务器，或者网络设备等）执行本发明各个实施例所述的方法。

在本实施例中还提供了一种系统信息发送装置，该装置用于实现上述实施例及优选实施方式，已经进行过说明的不再赘述。如以下所使用的，术语“模块”可以实现预定功能的软件和/或硬件的组合。尽管以下实施例所描述的装置较佳地以软件来实现，但是硬件，或者软件和硬件的组合的实现也是可能并被构想的。

图 5 是根据本发明实施例的系统信息发送装置的结构框图，如图 5 所示，该装置包括第一确定模块 52 和第一发送模块 54，下面对该装置进行说明。

第一确定模块 52，设置为确定用于发送给终端的系统信息；第一发送模块 54，连接至上述第一确定模块 52，设置为在一个或多个预定窄带位置上发送上述系统信息。

在一个可选的实施例中，上述系统信息包括以下至少之一：系统消息变更信息、地震和海啸预警系统 ETWS 通知信息、商业移动告警服务 CMAS 通知信息、扩展接入控制 EAB 参数变更通知信息、控制格式指示信息 CFI、时分双工系统配置信息、基站 eNB 支持的最大覆盖增强等级 max CE level、基站 eNB 支持的覆盖增强等级 CE levels、小区接入相关信息、系统消息调度信息、物理随机接入信道 PRACH 配置信息、窄带跳变 Hopping 配置信息、除 PRACH 信道以外其他信道时频资源配置信息、上行频点和指示信息、多播广播单频网络 MBSFN 子帧配置信息（或小区专有有效子帧配置信息）。其中，优选的系统消息组合包括以下组合至少之一：组合 1：系统消息变更信息、ETWS、CMAS；组合 2：系统消息变更信息、ETWS、CMAS、CFI、TDD configuration；组合 3：系统消息变更信息、ETWS、CMAS、max CE level。当然，也可以是其他组合类型，不一一列举。

在发送上述系统消息时，可以将上述系统消息作为专用的 DCI（即，利用仅包含上述系统消息的专用 DCI 进行发送）或者作为 DCI 中的一部分，上述的预定窄带优选为 CSS 窄带，即可以通过下行控制信道承载的上述系统消息信息在一个或多个 CSS 窄带中发送。在一个可选的实施例中，当上述系统信息位于第一下行控制信息 DCI 中，且该第一 DCI 中仅包括上述系统信息（该第一 DCI 为专用 DCI）时，在一个或多个预定窄带位置上发送上述系统信息包括：在预定时刻时，在一个或多个预定窄带位置上发送上述第一 DCI，上述系统信息作为专用 DCI，不使用调度管道 Paging 消息的 DCI，即不包含资源分配、调制编码方式等的指示在预定窄带和预定时刻发送，即发送位置是基站和 UE 所公知且不区分特定 UE 的。

在一个可选的实施例中，上述预定窄带为基站的预定小区内的所有终端均能够接收检测的公有搜索空间 CSS 窄带；上述预定时刻为基站的预定小区内的所有终端均能够接收检测的寻呼时刻 PO。优选地，小区内所有终端在同一 PO 时刻使用相同的一个 CSS 窄带，如图 2 所

示，在相同的 PO 时刻或 PO 时刻组接收相应的所述下行信息，这里的 PO 时刻或 PO 时刻组为所有终端都能够接收的时刻，即，公共接收时刻。在不同的 PO 时刻可以使用相同的一个 CSS 窄带，如图 2 所示，也可以使用不同的 CSS 窄带，如图 3 所示，但是对于一个确定的 PO 时刻而言，可以仅使用一个 CSS 窄带。

在一个可选的实施例中，在预定时刻时，在一个或多个预定窄带位置上发送所述第一 DCI 包括：在预先确定的所述系统信息的变更周期内，在一个或多个预定窄带位置上发送一次或多次所述系统信息，即，上述的变更周期内可以包括一个或多个上述的预定时刻，可以在每个预定时刻均发送上述系统消息，因此，可以在一个变更周期内发送一次或多个上述系统消息，其中，在上述的一次或多次发送系统消息中，系统信息内容未发生变化，优选在系统信息变更周期内发送一次或多次系统消息可以保证小区内所有终端以较大概率接收到上述系统信息。

在一个可选的实施例中，在发送上述第一 DCI 时，无对应调度的物理下行共享信道 PDSCH。可选地，上述第一 DCI（即，专用 DCI）仅承载上述系统信息时，并且无相应的资源分配、调制编码方式等传统下行控制信息所包含的调度指示信息时，此时该专用 DCI 无对应调度的 PDSCH，终端在接收该专用 DCI 之后不再接收相应的 PDSCH 信道。

在一个可选的实施例中，在一个或多个预定窄带或物理资源块组位置上发送上述系统消息包括：将上述系统消息承载在物理下行共享信道 PDSCH 上，在一个或多个预定窄带位置上发送上述系统消息。上述系统信息还可以位于普通 DCI 中，其中，该普通 DCI 为调度普通 Paging 消息的 DCI。在一个可选的实施例中，当上述系统信息位于第一下行控制信息 DCI 中，且该第一 DCI 中还包括除上述系统信息外的其他下行控制信息时，在一个或多个预定窄带位置上发送上述系统信息包括：根据上述终端的标识 UE ID，在一个或多个寻呼时刻 PO 时，在一个或多个所述预定窄带位置上发送上述第一 DCI，即，该第一 DCI 为普通 DCI。

在一个可选的实施例中，上述系统信息可以位于 DCI 中或 PDSCH 中，其中该 DCI 可以为调度普通 Paging 消息的 DCI（即，上述的第一 DCI）。优选地，此时有对应调度的 PDSCH 信道，承载相应的部分用户或全部用户的 Paging 消息。基站 eNB 可以根据 UE ID 在一个或多个 CSS 窄带/物理资源块组 PRB group 和一个或多个 PO 发送该 DCI。例如对于部分用户的 Paging record 信息承载在同一条 Paging 消息中，eNB 根据该部分用户（同上述的终端）的 UE ID 将包含所述下行信息的调度该条 Paging 消息在一个 CSS 窄带以及一个或多个 PO 时刻进行发送。对于另一部分用户的 Paging record 信息承载在另一条 Paging 消息中，eNB 根据同样另一部分用户的 UE ID 将包含所述下行信息的调度该条 Paging 消息在另一个 CSS 窄带以及一个或多个 PO 时刻进行发送。如图 3 所示从 eNB 角度来看，发送承载所述下行信息的调度普通 Paging 消息的 DCI 位于多个 CSS 窄带。对于终端而言，在同一 PO 时刻仅能在一个 CSS 窄带中接收所述下行信息。优选的，终端可以通过 UE ID 隐含得到自己需要接收的 CSS 窄带位置。

在一个可选的实施例中，上述系统信息在第一 DCI 中有以下至少之一的位置上：第一 DCI 中的空闲比特 bit；第一 DCI 中的处于空闲状态的 bit 域；第一 DCI 中的处于上至空闲状态的 bit 域的部分 bit（下面进行具体说明）；使用调度普通 Paging 消息的 DCI 的 padding bit 或空闲状态。

具体为当所述 DCI 消息中存在空闲 bit，如 Padding bit，使用空闲 bit 承载上述系统信息，其中下行信息的大小小于或等于空闲 bit 的数量，或者使用普通 DCI 消息的空闲状态。如指示传输功率控制 TPC 的 2bit 信息此时有无具体指示含义，处于空闲状态，此时上述系统信息使用该比特域进行传输，其中系统信息的大小小于或等于空闲状态所对应的 bit 的数量，还可以使用调度普通 Paging 消息的 DCI 的非空闲状态。具体为如指示资源分配比特域此、指示无所有可能的分配或指示情况后，仍存有状态剩余，使用剩余的状态指示，或者如占用资源分配比特域的部分 bit，资源分配简化指示及而重新部分开销。

在一个可选的实施例中，当将所述系统信息携带在所述第一下行控制信息 DCI 中进行发送时，可以通过预定方式标示该第一 DCI 的类型：当上述系统信息携带在第一 DCI 中或者承载于物理下行共享信道 PDSCH 中进行发送时，也可以通过上述预定方式标示该系统信息位于第一 DCI 中还是承载于 PDSCH 中；其中，该类型包括未携带上述系统信息的普通 DCI，携带上述系统信息和其他下行控制信息的普通 DCI，该预定方式包括以下至少之一：使用第一 DCI 中的空闲比特 bit 进行指示的方式；将上述第一 DCI 置于特定状态的方式；利用无线网络临时标识 RNTI 的特定值的方式。

其中，使用空闲比特指示时，可以使用 padding bit 中的 1bit 指示上述系统信息的第一 DCI 的格式/类型为调度普通 paging 消息的 DCI 还是无相应调度普通 paging 消息的 DCI，或者指示上述系统信息位于 DCI 中还是 PDSCH 中，或者使用 1bit 或 x bit（x 为大于 1 的正整数）指示第一 DCI 格式为承载了具体哪种系统信息组合的系统信息。在使用特定状态指示时，可以使用 padding bit 或资源分配或调制编码方式等之一中的 1 种状态（如全 0 比特，或特别指定的 bit 序列）指示携带上述系统信息的第一 DCI 的格式/类型为调度普通 paging 消息的 DCI 还是无相应调度普通 paging 消息的 DCI，或者指示上述系统信息位于 DCI 中还是 PDSCH 中，或者使用 1 种状态或 x 种状态（x 为大于 1 的正整数）指示上述第一 DCI 格式为承载了具体哪种系统信息组合的系统信息。在使用不同的 RNTI 取值时，可以使用两种不同的 RNTI 取值（其中一种为 P-RNTI 的取值 FFFE）指示第一 DCI 的格式/类型为调度普通 paging 消息的 DCI 还是无相应调度普通 paging 消息的 DCI，或者指示上述系统信息位于 DCI 中还是 PDSCH 中。优选的，使用 P-RNTI 指示上述第一 DCI 的格式/类型为调度普通 paging 消息的 DCI 或者指示上述系统信息位于 PDSCH 中，或者使用 x 种 RNTI 取值（x 为大于等于 2 的正整数）指示上述第一 DCI 格式为承载了具体哪种系统信息组合的系统信息。

在一个可选的实施例中，在上述第一 DCI 或第二 DCI 中，还携带有用于指示物理下行共享信道 PDSCH 的有无的指示信息，其中，在指示为无 PDSCH 时，相应的具体系统更新消息在系统信息块 SIB 中发送；在指示为有 PDSCH 时，相应的具体系统更新消息在 PDSCH 中发送。

图 6 是根据本发明实施例的系统信息发送装置的优选结构框图，如图 6 所示，该装置除包括图 5 所示的所有模块外，还包括第二发送模块 62，下面对该装置进行说明。

第二发送模块 62，连接至上述第一发送模块 54，设置为在一个或多个预定资源位置上发送上述系统信息之前，将用于指示一个或多个预定资源位置的指示信息通过系统信息中的上

信息块 MIB 或系统信息块 SIB 或无线资源控制 RRC 消息发送给终端。

在本发明实施例中，还提供了一种系统信息接收装置，图 7 是根据本发明实施例的系统信息接收装置的结构框图，如图 7 所示，该装置包括第一确定模块 72 和接收模块 74，下面对该装置进行说明。

第一确定模块 72，设置为确定一个或多个预定窄带位置；接收模块 74，连接至上述第一确定模块 72，设置为在确定的上述一个或多个预定窄带位置上接收来自基站的系统信息。

在一个可选的实施例中，上述系统信息可以包括以下至少之一：系统消息变更信息、地震和海啸预警系统 ETWS 通知信息、商业移动告警服务 CMAS 通知信息、扩展接入控制 EAB 参数变更通知信息、控制格式指示信息 CFI、时分双工系统配置信息、基站 eNB 支持的最大覆盖增强等级 max CE level、基站 eNB 支持的覆盖增强等级 CE levels、小区接入相关信息、系统消息调度信息、物理随机接入信道 PRACH 配置信息、窄带跳变 Hopping 配置信息、除 PRACH 信道以外其他信道初始资源配置信息、上行频点和带宽信息、多播广播单频网络 MBSFN 子帧配置信息、或小区专有有效子帧配置信息。

图 8 是根据本发明实施例的系统信息接收装置中第一确定模块 72 的结构框图，如图 8 所示，该第一确定模块 72 包括第一确定单元 82 或第二确定单元 84，下面对该第一确定模块 72 进行说明。

第一确定单元 82，设置为通过系统信息中的消息信息块 MIB 或系统信息块 SIB 或无线资源控制 RRC 消息接收基站预先发送的用于指示上述一个或多个预定窄带位置的指示信息，根据上述指示信息确定一个或多个预定窄带位置；第二确定单元 84，设置为根据预配置的用于标识上述一个或多个预定窄带位置的协议确定上述位置。

在一个可选的实施例中，在确定的上述一个或多个预定窄带位置上接收来自基站的系统信息包括：在预定时刻时，在确定的上述一个或多个预定窄带位置上接收来自基站的承载上述系统信息的第一 DCI。

在一个可选的实施例中，上述预定窄带为基站的预定小区内的所有终端均能够接收检测的公有搜索空间 CSS 窄带；上述预定时刻为基站的预定小区内的所有终端均能够接收检测的寻呼时刻 PO。

在一个可选的实施例中，在预定时刻时，在确定的一个或多个预定窄带位置上接收来自基站的承载上述系统信息的第一 DCI 包括：在预先确定的上述系统信息的变更周期内，在一个或多个预定窄带位置上接收一次或多次上述第一 DCI。

在一个可选的实施例中，在确定的上述一个或多个预定窄带位置上接收来自基站的系统信息包括：在确定的一个或多个预定窄带位置上接收来自基站的第四个行控制信息 DCI；根据该第四 DCI 中的用于进行指示的 bit、该第四 DCI 的状态以及预先确定的无线网络临时标识 RNTI 的 RNTI 值中的至少之一，确定第四 DCI 的类型或者确定系统信息位于上述第四 DCI 中还是承载于物理下行共享信道 PDSCH 中，其中，该类型包括本发明所述系统信息的普通

DCI，携带上述系统信息和其他下行控制信息的普通 DCI；根据确定结果接收上述系统信息。

通过使用本发明实施例中提出的系统信息的传输方法，可以保证在独立承载系统消息变更信息、ETWS、CMAS 等系统信息时的高效发送，且确保在非独立承载上述信息时终端识别该信息不增加盲检复杂度。

以下通过具体实施例进一步说明。在下述实施例中，系统信息也可以称为下行信息，以系统信息为系统消息变更信息、ETWS、CMAS 为例进行说明

实施例 1

本实施例对下行信息传输采用本发明所提供的方法进行详细描述说明。

基站 eNB 确定下行信息内容为系统消息变更信息、ETWS、CMAS，并且下行信息单独形成专用 DCI，在下行控制信道中传输。

eNB 在预定 CSS 空间和预定 PO 时刻中发送所述下行信息。其中，在下行信息变更周期内，所述预定 PO 时刻存在一个或多个位置。对于每个 PO 时刻，eNB 仅在一个 CSS 空带上发送所述下行信息，在 PO 时刻存在多个位置的不同 PO 时刻，所述预定 CSS 空带可以相同或不同。

当覆盖增强时，eNB 在预定 CSS 空带上在多个 PO 时刻重复发送所述下行信息。同一 PO 时刻仅对应一个 CSS 空带位置，不同 PO 时刻的 CSS 空带可以相同或不同，或者以某一跳频图样进行跳频传输，该跳频图样为预定义或 eNB 通知的

终端在预定 CSS 空带和预定 PO 时刻中接收所述下行信息。其中终端可以在一个预定 PO 时刻接收一次所述下行信息，或者在多个预定 PO 时刻接收多次所述下行信息，并且下行信息变更周期内至少接收一次。在同一 PO 时刻，所有终端都在同一 CSS 空带上接收所述下行信息。

当覆盖增强时，终端在预定 CSS 空带上在多个 PO 时刻重复接收所述下行信息。同一 PO 时刻仅对应一个 CSS 空带位置，不同 PO 时刻的 CSS 空带可以相同或不同，或者以某一跳频图样进行跳频传输，该跳频图样为预定义或 eNB 通知的

终端在接收到所述下行信息后，不再接收相应的 PDSCH 消息。如发现系统消息变更，则接收相应 SIB 消息

通过使用本发明所提出的下行信息的传输方法，可以保证在独立承载系统消息变更信息、ETWS、CMAS 的下行控制信息时的高效发送。

实施例 2

可选的，上述下行信息位于 DCI 中或 PDSCH 中，其中该 DCI 为调度普通 Paging 消息的 DCI，优选是同一个对应调度的 PDSCH 信道，承载相应的部分用户或全部用户的 Paging 消息。eNB 根据 UE ID 在一个或多个 CSS 空带/物理资源块组 PRB group 和一个或多个 PO 发送该 DCI。即此时对于部分用户的 Paging record 信息承载在同一条 Paging 消息中，eNB 根据这些用户的 UE ID 将包含所述下行信息的调度该条 Paging 消息在一个 CSS 空带以及一个或多个 PO 时刻进行发送。对于另一部分用户的 Paging record 信息承载在另一条 Paging 消息中，eNB 根据所述另一部分用户的 UE ID 将包含所述下行信息的调度该条 Paging 消息在另一个CSS 空带以及一个或多个 PO 时刻进行发送，如图 9 所示从 eNB 角度来看，发送承载所述下行信息的调度普通 Paging 消息的 DCI 位于多个 CSS 空带。对于终端而言，在同一 PO 时刻仅能在一个 CSS 空带中接收所述下行信息。其中，图 9 是根据本发明实施例的在多个 CSS 空带发送含有下行信息的调度普通 Paging 消息的 DCI 的示意图。优选的，终端通过 UE ID 隐含得到自己需要接收的 CSS 空带位置。

本实施例对下行信息传输采用本发明所提供的方法进行详细描述说明。

eNB 确定下行信息内容为系统消息变更信息、ETWS、CMAS，并且所述下行信息位于调度普通 Paging 消息的 DCI 中，在下行控制信道中传输

eNB 针对 UE1 和 UE2 的 UE ID 换算得到在第一 CSS 空带和确定 PO 时刻向 UE1 以及与 UE1 同寻呼组（第一寻呼组）的终端发送该 DCI，在第二 CSS 空带和确定 PO 时刻向 UE2 以及与 UE2 同寻呼组（第二寻呼组）的终端发送该 DCI。其中，在下行信息变更周期内，所述确定 PO 时刻存在一个或多个位置。对于其中一个 PO 时刻，eNB 对于同一寻呼组仅在一个 CSS 空带上发送所述下行信息，不同寻呼组所对应的 CSS 空带可以相同或不同，即分别在一个 PO 时刻仅有一个 CCS 空带位置，第一 CSS 空带和第二 CSS 空带独立确定，该时刻第一 CSS 空带和第二 CSS 空带可以不同或相同。在不同 PO 时刻，同一寻呼组所对应的 CSS 空带可以相同或不同，在不同 PO 时刻，第一 CSS 空带或第二 CSS 空带所处空带位置可以相同或不同。所述不同寻呼组的多个 PO 时刻位置可以相同或部分相同或完全不同，即第一寻呼组与第二寻呼组的 PO 时刻独立确定，可以相同或部分相同或完全不同。所述 DCI 与不含所述下行信息的调度普通 Paging 消息的 DCI 使用不同的 RNTI 进行加扰或空闲比特/状态指示。

当覆盖增强时，eNB 对于不同寻呼组的 UE1 和 UE2 分别在各自的确定 CSS 空带上以及在各自的多个 PO 时刻重复发送所述下行信息，同一 PO 时刻对于同一寻呼组仅对应一个 CSS 空带位置，不同寻呼组的 CSS 空带位置独立确定，可以相同或不同。不同 PO 时刻其同一寻呼组的 CSS 空带可以相同或不同，或者以是一跳频图样进行跳频传输，该跳频图样为预定义或 eNB 通知的。不同寻呼组的 PO 时刻独立确定，可以相同或部分相同或完全不同

终端在确定 CSS 空带和确定 PO 时刻中接收所述下行信息，即 UE1 在第一寻呼组所对应的第一 CSS 空带以及一个或多个 PO 时刻接收所述下行信息，UE2 在第二寻呼组所对应的第二 CSS 空带以及一个或多个 PO 时刻接收所述下行信息，终端在变更周期内至少有一次接收下行信息的机会。在同一 PO 时刻，第一 CSS 空带和第二 CSS 空带独立确定可以相同或不同。在存在多个 PO 时刻不同 PO 时刻所对应的第一 CSS 空带所在空带位置可以相同或不同，同理

第一 CSS 空间。

当激活增强时，终端在预定 CSS 空间上在多个 PO 时刻重复接收所述下行信息，UE1 在多个 PO 时刻在第一 CSS 空间接收所述下行信息，UE2 在多个 PO 时刻在第二 CSS 空间接收所述下行信息。在一个 PO 时刻所述第一 CSS 空间和第二 CSS 空间位置可以相同或不同。不同 PO 时刻的一个或多个的 CSS 空间可以相同或不同，或者以某一跳频图样进行跳频传输，该跳频图样为预定义或 eNB 通知的。

终端在接收到所述下行信息后，通过控制信息指示接收相应的 PDSCH 消息，所述 PDSCH 中可选的存在具体的系统更新消息内容。

通过使用本发明实施例所提出的下行信息的传输方法，可以保证在非独立承载系统消息变更信息，ETWS、CMAS 信息时终端识别该信息且不增加盲检复杂度。

需要说明的是，上述各个模块是可以通过软件或硬件来实现的，对于后者，可以通过以下方式实现，但不限于此：上述模块均位于同一处理器中；或者，上述模块分别位于多个处理器中。

本发明的实施例还提供了一种存储介质。可选地，在本实施例中，上述存储介质可以被设置为存储用于执行以下步骤的程序代码：

S11，确定用于发送给终端的系统信息；

S12，在一个或多个预定窄带位置上发送上述系统信息。

可选地，存储介质还被设置为存储用于执行以下步骤的程序代码：

S21，确定一个或多个预定窄带位置；

S22，在确定的上述一个或多个预定窄带位置上接收来自基站的系统信息。

可选地，在本实施例中，上述存储介质可以包括但不限于：U 盘、只读存储器（Read-Only Memory，简称为 ROM）、随机存取存储器（Random Access Memory，简称为 RAM）、移动硬盘、磁碟或者光盘等各种可以存储程序代码的介质。

可选地，在本实施例中，处理器根据存储介质中已存储的程序代码执行上述步骤 S11-12。

可选地，在本实施例中，处理器根据存储介质中已存储的程序代码执行上述步骤 S21-22。

可选地，本实施例中的具体示例可以参考上述实施例及可选实施方式中所描述的示例，本实施例在此不再赘述。

显然，本领域的技术人员应该明白，上述的本发明的各模块或各步骤可以用通用的计算装置来实现，它们可以集中在单个的计算装置上，或者分布在多个计算装置所组成的网络上，可选地，它们可以用计算装置可执行的程序代码来实现，从而，可以将它们存储在存储装置

申由自行设定来执行，并且在实际情况下，可以以不同于此处的顺序执行所示出或描述的步骤，或者将它们分别制作成各个集成电路模块，或者将它们中的多个模块或步骤制作成单个集成电路模块来实现。这样，本发明不限制于任何特定的硬件和软件结合。

以上所述仅为本发明的优选实施例而已，并不用于限制本发明，对于本领域的技术人员来说，本发明可以有各种更改和变化。凡在本发明的精神和原则之内，所作的任何修改、等同替换、改进等，均应包含在本发明的保护范围之内。

工业实用性

如上所述，本发明实施例提供的一种系统信息发送方法、接收方法、发送装置及接收装置具有以下有益效果：解决了相关技术中独立承载系统消息变更信息、ETWS、CMAS 等的下行控制信息时的发送方式问题，达到高效发送的效果；还解决了相关技术中存在的终端自检测承载系统消息的下行控制信息的复杂度高的问题，进而达到了降低终端自检测系统消息的复杂度的效果。

权 利 要 求 书

1. 一种系统信息发送方法，包括：

确定用于发送给终端的系统信息；

在一个或多个预定窄带位置上发送所述系统信息。

2. 根据权利要求 1 所述的方法，其中，所述系统信息包括以下至少之一：

系统信息变更信息、地震和海啸预警系统 ETWS 通知信息、商业移动告警服务 CMAS 通知信息、扩展接入控制 EAB 参数变更通知信息、控制格式指示信息 CFI、时分双工系统配置信息、基站 eNB 支持的最大覆盖增强等级 max CE level、基站 eNB 支持的覆盖增强等级 CE levels、小区接入相关信息、系统消息调度信息、物理随机接入信道 PRACH 配置信息、窄带跳变 Hopping 配置信息、除 PRACH 信道以外其他信道射频资源配置信息、上行频点和带宽信息、多播广播单频网络 MBSFN 子帧配置信息。

3. 根据权利要求 1 所述的方法，其中，当所述系统信息位于第一下行控制信息 DCI 中、且所述第一 DCI 中仅包括所述系统信息时，在一个或多个预定窄带位置上发送所述系统信息包括：

在预定时刻时，在一个或多个预定窄带位置上发送所述第一 DCI。

4. 根据权利要求 3 所述的方法，其中：

所述预定窄带为基站的预定小区内的所有终端均能够接收检测的公有搜索空间 CSS 窄带；

所述预定时刻为所述基站的所述预定小区内的所有终端均能够接收检测的寻呼时刻 PO。

5. 根据权利要求 3 所述的方法，其中，在预定时刻时，在一个或多个预定窄带位置上发送所述第一 DCI 包括：

在预先确定的所述系统信息的变更周期内，在一个或多个预定窄带位置上发送一次或多次所述系统信息。

6. 根据权利要求 3 所述的方法，其中，在发送所述第一 DCI 时，无对应调度的物理下行共享信道 PDSCH。

7. 根据权利要求 1 所述的方法，其中，当所述系统信息位于第二下行控制信息 DCI 中、且所述第二 DCI 中还包括除所述系统信息外的其他下行控制信息时，在一个或多个预定窄带位置上发送所述系统信息包括：

根据所述终端的标识，在一个或多个寻呼时刻 PO 时，在一个或多个所述预定窄带位置上发送所述第二 DCI。

8. 根据权利要求 7 所述的方法，其中，所述系统信息在所述第二 DCI 中的以下至少之一的

位置上：

所述第一DCI中的空闲比特bit；

所述第一DCI中的处于空闲状态的bit域；

所述第一DCI中的处于非空闲状态的bit域的部分bit。

9. 根据权利要求7所述的方法，其中，当携带所述系统信息规带在所述第一下行控制信息DCI中进行发送时，通过预定方式标示所述第一DCI的类型；当所述系统信息携带在所述第一DCI中或者承载一物理下行共享信道PDSCH中进行发送时，通过所述预定方式标示所述系统信息位于所述第一DCI中还是承载于所述PDSCH中；其中，所述类型包括表携带所述系统信息的普通DCI、携带所述系统信息和其他下行控制信息的普通DCI，所述预定方式包括以下至少之一：

使用所述第一DCI中的空闲比特bit进行指示的方式；

将所述第一DCI置于特定状态的方式；

采用无线网络临时标识RNTI至指定值的方式。

10. 根据权利要求3或7所述的方法，其中，在所述第一DCI或所述第一DCI中，还携带有用于指示物理下行共享信道PDSCH的存无的指示信息，其中，在指示为无PDSCH时，相应的具体系统更新消息在系统信息块SIB中发送；在指示为有PDSCH时，相应的具体系统更新消息在PDSCH中发送。

11. 根据权利要求1所述的方法，其中，在一个或多个预定空带位置上发送所述系统信息之前，还包括：

将用于指示所述一个或多个预定空带位置的指示信息通过系统信息中的主信息块MIB或系统信息块SIB或无线资源控制RRC消息发送给所述终端。

12. 一种系统信息接收方法，包括：

确定一个或多个预定空带位置；

在确定的所述一个或多个预定空带位置上接收来自基站的系统信息。

13. 根据权利要求12所述的方法，其中，所述系统信息包括以下至少之一：

系统消息变更信息、地震和海啸预警系统ETWS通知信息、商业移动广警服务CMAS、通知信息、扩展接入控制EAB参数变更通知信息、控制格式指示信息CFI、时分双工系统配置信息、基站eNB支持的最大覆盖增强等级max CE level、基站eNB支持的覆盖增强等级CE levels、小区接入相关信息、系统消息调度信息、物理随机接入信道PRACH配置信息、频率跳变Hopping配置信息、除PRACH信道以外其他信道时频资源配置信息、上行响应和带宽信息、多播广播单频网络MBSFN子帧配置信息。

14. 根据权利要求 12 所述的方法，其中，确定所述一个或多个预定窄带位置包括以下之一：

通过系统信息中的消息信息块 MIB 或系统信息块 SIB 或无线资源控制 RRC 消息接收所述基站预先发送的用于指示所述一个或多个预定窄带位置的指示信息，根据所述指示信息确定所述一个或多个预定窄带位置；

根据预配置的用于标识所述一个或多个预定窄带位置的特定确定所述位置。

15. 根据权利要求 12 所述的方法，其中，在确定的所述一个或多个预定窄带位置上接收来自基站的系统信息包括：

在预定时刻时，在确定的所述一个或多个预定窄带位置上接收来自基站的承载所述系统信息的第一 DCI。

16. 根据权利要求 15 所述的方法，其中：

所述预定窄带为所述基站的预定小区内的所有终端均能够接收检测的公有搜索空间 CSS 窄带；

所述预定时刻为所述基站的所述预定小区内的所有终端均能够接收检测的公共时刻 PO。

17. 根据权利要求 15 所述的方法，其中，在预定时刻时，在确定的所述一个或多个预定窄带位置上接收来自基站的承载所述系统信息的所述第一 DCI 包括：

在预先确定的所述系统信息的变更周期内，在一个或多个预定窄带位置上接收一次或多次所述第一 DCI。

18. 根据权利要求 12 所述的方法，其中，在确定的所述一个或多个预定窄带位置上接收来自基站的系统信息包括：

在确定的所述一个或多个预定窄带位置上接收来自基站的第四下行控制信息 DCI；

根据所述第四 DCI 中的用于指示的 bit、所述第四 DCI 的状态以及预先确定的无线网络临时标识 RNTI 的 RNTI 值中的至少之一，确定所述第四 DCI 的类型或者确定所述系统信息位于所述第四 DCI 中还是承载于物理下行共享信道 PDSCH 中，其中，所述类型包括未携带所述系统信息的普通 DCI、携带所述系统信息和其他下行控制信息的普通 DCI；

根据确定结果接收所述系统信息。

19. 一种系统信息发送装置，包括：

第一确定模块，设置为确定用于发送给终端的系统信息；

第一发送模块，设置为在一个或多个预定窄带位置上发送所述系统信息。

20. 根据权利要求 19 所述的装置，其中，所述系统信息包括以下至少之一：

系统消息变更信息、地震和海啸预警系统 ETWS 通知信息、商业移动告警服务 CMAS 通知信息、扩展接入控制 EAB 参数变更通知信息、控制格式指示信息 CFI、时分双工系统配置信息、基站 eNB 支持的最大覆盖增强等级 max CE level、基站 eNB 支持的覆盖增强等级 CE levels、小区接入相关信息、系统消息调度信息、物理随机接入信道 PRACH 配置信息、窄带跳变 Hopping 配置信息、除 PRACH 信道以外其他信道时频资源配置信息、上行频点和带宽信息、多播广播单频网络 MBSFN 子帧配置信息。

21. 根据权利要求 19 所述的装置，其中，还包括：

第二发送模块，设置为在一个或多个预定窄带位置上发送所述系统信息之前，利用于指示所述一个或多个预定窄带位置的指示信息通过系统信息中的消息信息块 MIB 或系统信息块 SIB 或无线资源控制 RRC 消息发送给所述终端。

22. 一种系统信息接收装置，包括：

第三确定模块，设置为确定一个或多个预定窄带位置；

接收模块，设置为在确定的所述一个或多个预定窄带位置上接收来自基站的系统信息。

23. 根据权利要求 22 所述的装置，其中，所述系统信息包括以下至少之一：

系统消息变更信息、地震和海啸预警系统 ETWS 通知信息、商业移动告警服务 CMAS 通知信息、扩展接入控制 EAB 参数变更通知信息、控制格式指示信息 CFI、时分双工系统配置信息、基站 eNB 支持的最大覆盖增强等级 max CE level、基站 eNB 支持的覆盖增强等级 CE levels、小区接入相关信息、系统消息调度信息、物理随机接入信道 PRACH 配置信息、窄带跳变 Hopping 配置信息、除 PRACH 信道以外其他信道时频资源配置信息、上行频点和带宽信息、多播广播单频网络 MBSFN 子帧配置信息。

24. 根据权利要求 22 所述的装置，其中，所述第三确定模块包括以下之一：

第一确定单元，设置为通过系统信息中的消息信息块 MIB 或系统信息块 SIB 或无线资源控制 RRC 消息接收所述基站预先发送的用于指示所述一个或多个预定窄带位置的指示信息，根据所述指示信息确定所述一个或多个预定窄带位置；

第二确定单元，设置为根据预配置的用于标识所述一个或多个预定窄带位置的协议确定所述位置。

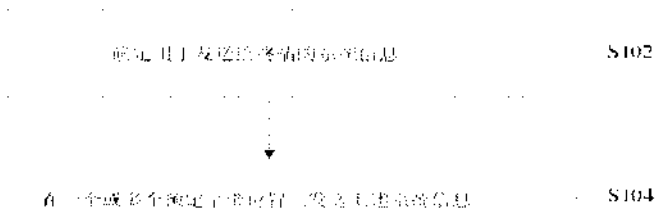


图 1

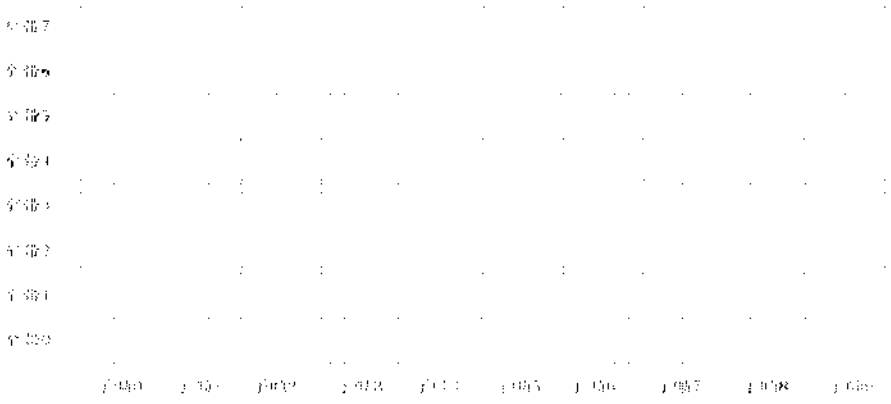


图 2

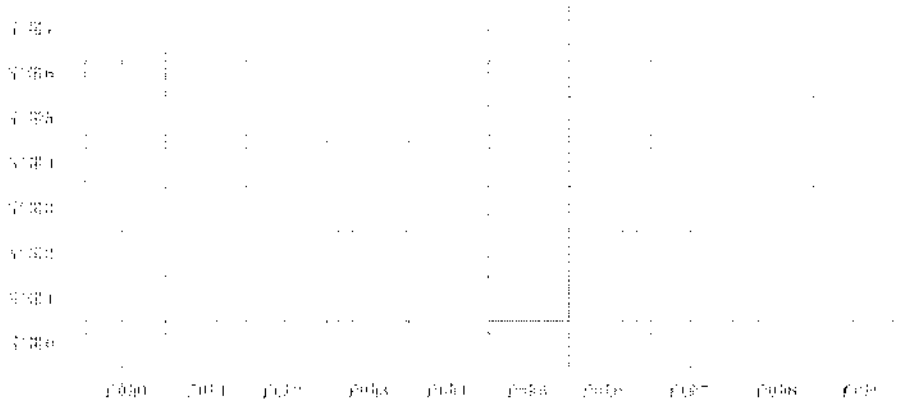


图 3

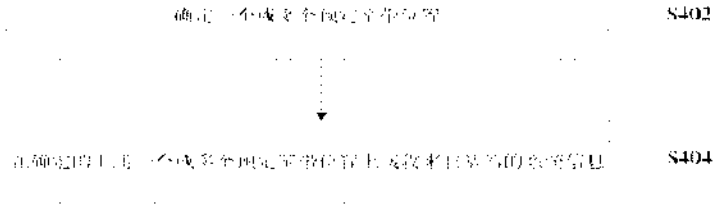


图 4

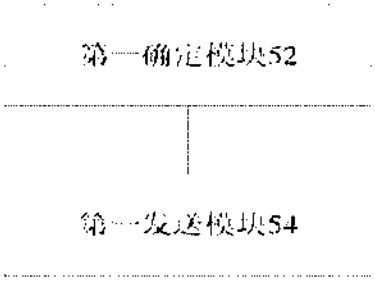

第一确定模块52
第一发送模块54

图 5

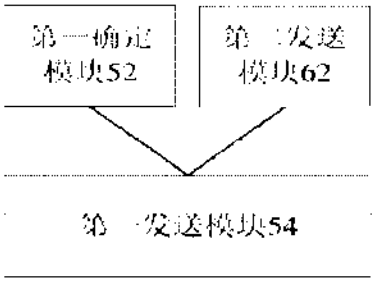

第一确定模块52
第二发送模块62
第一发送模块54

图 6

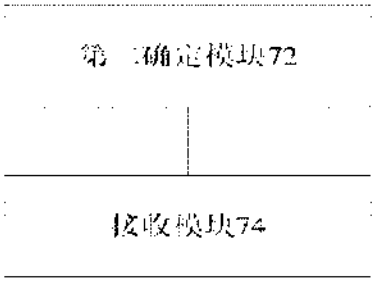

第二确定模块72
接收模块74

图 7

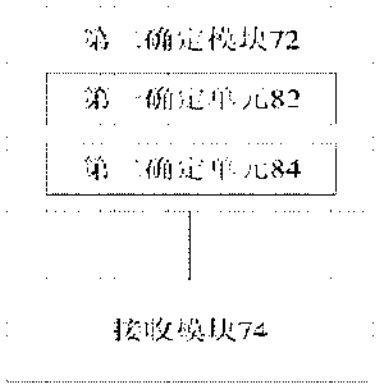


图 8

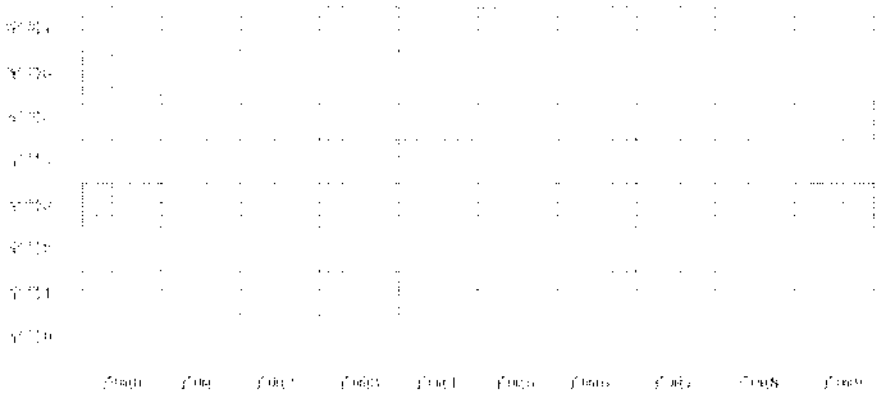


图 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2016/093095

A. CLASSIFICATION OF SUBJECT MATTER

H04W 24/02 (2009.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNPAT; CNKI; WPI; EPODOC; 3GPP; system information, control information, load, beam, cell, SI, SIB, MIB, DCI, downlink control information, extend, bit

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 101772179 A (ZTE CORPORATION) 07 July 2010 (07.07.2010) description, paragraphs [0073]-[0100]	1-7, 11-17, 19-20
A	CN 101610504 A (ZTE CORPORATION) 23 December 2009 (23.12.2009) the whole document	1-21
A	CN 102203324 A (CHINA ACADEMY OF TELECOMMUNICATIONS TECHNOLOGY) 28 September 2011 (28.09.2011) the whole document	1-21
A	US 2009318177 A1 (INTERDIGITAL PATENT HOLDINGS, INCORPORATED) 24 December 2009 (24.12.2009) the whole document	1-21

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 November 2016	30 November 2016
Name and mailing address of the ISA State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No. (86-10) 62019451	Authorized officer ZHANG, Caixia Telephone No. (86-10) 62413376

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No
PCT/CN2016/099098

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 101772170 A	07 July 2010	WO 2011082572 A1	14 July 2011
CN 101610504 A	23 December 2009	US 2012033627 A1	09 February 2012
		JP 2012525743 A	22 October 2012
		CA 2760505 A1	04 November 2010
		RU 2472336 C1	10 January 2013
		WO 2010122628 A1	04 November 2010
		IN CHENP201107889	03 May 2013
CN 102202324 A	28 September 2011	KR 20110026564 A	05 March 2014
		US 2014177556 A1	26 June 2014
		WO 2012155690 A1	22 November 2012
		JP 2014515567 A	30 June 2014
		EP 2713658 A1	02 April 2014
US 2009318177 A1	24 December 2009	WO 2009108768 A1	03 September 2009
		TW 201032647 A	01 September 2010
		TW 200939850 A	16 September 2009
		AR 70732 A	28 April 2010

Form PCT/ISA/210 (patent family annex) (July 2009)

国际检索报告

国际申请号
PCT/CN2015/089058

A. 主题的分类
H04W 24/02(2009.01)i

按照国际专利分类(IPC)或者同时按照国家分类和IPC两种分类

B. 检索领域

检索的最低限度文献(标明分类系统和分类号)
H04W

包含在检索领域中的除最低限度文献以外的检索文献

在国际检索时查阅的电子数据库(数据库的名称,和使用的检索词(如使用))
CNPAT,CNKI,WPI: UE, base station, eNB, eNodeB, 基站, 信息, 消息, 指示, 发送, 接收, 扩展, 比特, bit, beam, estimate, SI, SIB, MIB, DL, downlink control information, extend, bit

C. 相关文件

类型*	引用文件,必要时,指明相关段落	相关的权利要求
A	CN 101772121 A (中兴通讯股份有限公司) 2010年07月07日 (2010-07-07) 说明书第100页第1-10段	1-24
A	CN 101610561 A (中兴通讯股份有限公司) 2009年12月23日 (2009-12-23) 全文	1-24
A	CN 102223729 A (电信科学技术研究院) 2011年10月19日 (2011-10-19) 全文	1-24
A	US 2009318157 A1 (QUALCOMM INCORPORATED) 2009年12月24日 (2009-12-24) 全文	1-24

☐ 其余文件在专利合作组织继续列出

☑ 见同族专利附件。

* 引用文件的具体类型:
"A" 认为不是特别相关的表示了现有技术一般状态的文件
"D" 申请人在国际申请中引用的文件
"E" 在国际申请日的当天或之后公布的在先申请或专利
"L" 可能对优先权要求提出质疑的文件,或为确定另一篇引用文件的公布日而引用的或者因其他特殊理由而引用的文件(如具体说明的)
"O" 涉及口头公开、使用、展览或其他方式公开的文件
"P" 公布日在国际申请日之前但在要求的优先权日之后公布的文件

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"X" 特别相关的文件,单独考虑该文件所记载的发明不具有新颖性或创造性
"Y" 特别相关的文件,当该文件与一篇或者多篇其他这类文件结合并且这种结合对于本领域技术人员来说是显而易见的时,该发明不具有创造性
"&" 同族专利的文件

国际检索实际完成的日期
2016年01月11日

国际检索报告邮寄日期
2016年01月30日

ISA/CN的名称和邮寄地址
中华人民共和国国家知识产权局(ISA/CN)
中国北京市海淀区蓟门桥西土城路6号 100088

传真号 (86-10)62019451

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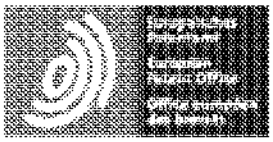
表 PCT/ISA/210 (第二页) (2009年7月)

国际检索报告
关于同族专利的附件

国际申请号
PCT/CN2010/080908

在报告日前公布的专利文件			公布日（年-月-日）	同族专利			公布日（年-月-日）
CN	101772179	A	2010-07-07	WO	2011083573	A1	2011-07-14
CN	101610561	A	2009-12-23	ES	2412613	T3	2013-07-19
				JP	2013507083	A	2013-02-28
				CA	2760507	A1	2010-07-15
				RU	2513116	C2	2014-04-20
				WO	2010081328	A1	2010-07-22
				IN	CHENP2011007880		2015-07-03
CN	102202324	A	2011-09-28	KR	20110126561	A	2011-11-23
				ES	2411377	T3	2013-07-05
				WO	2010133093	A1	2010-11-25
				JP	2012526497	A	2012-10-25
				EP	2434830	A1	2012-03-28
US	2009048477	A1	2009-02-19	WO	2009021408	A1	2009-02-19
				TW	200920207	A	2009-05-01
				JP	2010539870	A	2010-12-16
				AR	070252	A1	2010-03-24

*：PCT/ISA/210（同族专利附件）（2009年7月）



Espacenet

CN106376050A Setting/determining method and device of subcarrier spacing of reference numerology, base station and terminal

Applicants: YULONG COMPUTER TELECOMMUNICATION SCIENTIFIC SHENZHEN CO LTD

Inventors: LI MINGJU;ZHU YAJUN;ZHANG YUNFEI

Classifications:

IPC ***H04W48/08; H04W56/00; H04W72/04;***

CPC **H04W48/08 (CN); H04W56/00 (CN); H04W72/0446 (CN);**

Priorities: CN201610869949A 2016-09-30

Application: CN201610869949A·2016-09-30

Publication: CN106376050A·2017-02-01

Published as: CN106376050A;**CN106376050B**

Setting/determining method and device of subcarrier spacing of reference numerology, base station and terminal

Abstract

The invention provides a setting/determining method and device of subcarrier spacing of reference numerology, a base station and a terminal. The setting method of the subcarrier spacing of reference numerology comprises the steps of setting the subcarrier spacing of the reference numerology to be 2n times of 15 KHz, and informing a terminal device to indicate that the subcarrier spacing of the reference numerology of the terminal device who can have synchronous communication with the base station is 2n times of 15 KHz, wherein n is an integer greater than or equal to -2. Through the technical scheme, the terminal device can determine synchronous signals, reference signals and time-frequency resource granularity of to-be-transmitted resources, particularly, the subcarrier spacing, subframe time units and the like of the reference numerology, on the basis of obtaining the reference numerology, and reliability and accuracy of synchronous communication between the terminal device and a base station device are further improved.

(19)中华人民共和国国家知识产权局

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(51)Int.Cl.
H04W 48/08(2009.01)
H04W 56/00(2009.01)
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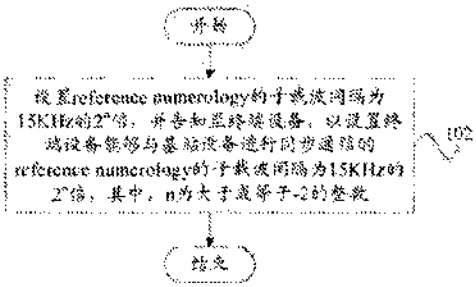
权利要求书5页 说明书20页 附图5页

(54)发明名称

reference numerology的子载波间隔的设置/确定方法、装置、基站和终端

(57)摘要

本发明提供了一种reference numerology的子载波间隔的设置/确定方法、装置、基站和终端，其中，所述reference numerology的子载波间隔的设置方法包括：设置reference numerology的子载波间隔为15KHz的2^n倍，并告知至终端设备，以指示终端设备能够与基站设备进行同步通信的reference numerology的子载波间隔为15KHz的2^n倍，其中，n为大于或等于-2的整数。通过本发明的技术方案，使得终端设备在获取reference numerology的基础上确定同步信号、参考信号和待传输资源为时频资源粒度，尤其是reference numerology的子载波间隔和子帧(subframe)时间单元等，进一步地提升了终端设备和基站设备之间同步通信的可靠性和准确性。



CN 106376050 A

1.一种reference numerology的子载波间隔的设置/确定方法，其特征在于，所述方法包括：

设置reference numerology的子载波间隔为15KHz的2^n倍，并告知至终端设备，以指示所述终端设备能够与基站设备进行同步通信的reference numerology的子载波间隔为15Klz的2^n倍，

其中，所述n为大于或等于-2的整数。

2.根据权利要求1所述的reference numerology的子载波间隔的设置/确定方法，其特征在于，还包括：

给所有所述终端设备在同一个载波上配置相同的reference numerology的子载波间隔。

3.根据权利要求2所述的reference numerology的子载波间隔的设置/确定方法，其特征在于，还包括：

设置特定下行信号占用的子载波间隔为reference numerology，并设置发送所述特定下行信号的第一参考子帧，在所述第一参考子帧内以指定的子载波间隔发送所述特定下行信号，以指示终端设备能够与所述基站设备进行同步通信的reference numerology的子载波间隔即为所述特定下行信号传输的子载波间隔。

4.根据权利要求2所述的reference numerology的子载波间隔的设置/确定方法，其特征在于，还包括：

向所述终端设备发送承载reference numerology的子载波间隔的系统信息，以指示所述终端设备能够与所述基站设备进行同步通信的reference numerology的子载波间隔即为所述系统信息中设置的子载波间隔。

5.根据权利要求2所述的reference numerology的子载波间隔的设置/确定方法，其特征在于，还包括：

根据载波的特征信息设置reference numerology的子载波间隔，并在所述载波上发送特定下行信号，以供所述终端设备根据检测到的所述载波的特征信息、以及预存的载波特征信息与reference numerology的子载波间隔映射表来确定reference numerology的子载波间隔，

其中，所述载波的特征信息包括载波频点和/或载波带宽。

6.根据权利要求3或5所述的reference numerology的子载波间隔的设置/确定方法，其特征在于，

所述特定下行信号为主同步信号/辅同步信号、参考信号、寻呼信号和系统信息中的一个或多个的任意组合。

7.根据权利要求1所述的reference numerology的子载波间隔的设置/确定方法，其特征在于，还包括：

给所有所述终端设备在同一个载波上配置不同的reference numerology的子载波间隔。

8.根据权利要求7所述的reference numerology的子载波间隔的设置/确定方法，其特征在于，还包括：

根据所述终端设备的设备类型和/或需要传输的业务类型向所述终端设备发送无线资

源控制信令或下行控制信令，以通过所述无线资源控制信令或下行控制信令半静态地或动态地通知所述终端设备reference numerology的子载波间隔。

9.根据权利要求1或2所述的reference numerology的子载波间隔的设置/确定方法，其特征在于，还包括：

在所述终端设备确定能够与所述基站设备进行同步通信的reference numerology的子载波间隔后，设置所述终端设备的专用numerology的子载波间隔，并根据所述专用numerology的子载波间隔设置第二参考子帧，以供所述终端设备根据所述专用numerology的子载波间隔和所述第二参考子帧进行上下行数据收发。

10.根据权利要求9所述的reference numerology的子载波间隔的设置/确定方法，其特征在于，还包括：

所述专用numerology的子载波间隔的设置信息为专用numerology的子载波间隔与终端的reference numerology的子载波间隔之间的相对比值，以供所述终端设备根据所述相对比值以及reference numerology的子载波间隔确定所述专用numerology的子载波间隔；

或所述专用numerology的子载波间隔的设置信息为所述专用numerology的子载波间隔的绝对值。

11.根据权利要求9所述的reference numerology的子载波间隔的设置/确定方法，其特征在于，还包括：

根据所述专用numerology的子载波间隔以及所述第二参考子帧，对所述终端设备进行上下行时频资源分配并向所述终端设备发送相应的下行控制信令，

其中，所述下行控制信令用于设置所述终端设备通过物理下行共享信道和/或物理上行共享信道进行数据发送的第一发送时间起点位置和发送时间长度。

12.根据权利要求11所述的reference numerology的子载波间隔的设置/确定方法，其特征在于，

所述第二参考子帧为包含的下行数据的发送子帧时，所述下行控制信令还用于设置所述终端设备接收到的所述下行数据所对应的混合自动重传业务的反馈信息的第二发送时间起点位置。

13.根据权利要求11所述的reference numerology的子载波间隔的设置/确定方法，其特征在于，

所述下行控制信令所在子帧位置加上位置偏移量确定第一偏移子帧，所述下行控制信令所在符号位置加上偏移量确定第一偏移符号，所述第一偏移子帧内的第一偏移符号即为所述第一发送时间起点位置。

14.根据权利要求12所述的reference numerology的子载波间隔的设置/确定方法，其特征在于，

发送所述下行数据的起始位置子帧或结束位置子帧加上偏移量确定所述第二偏移子帧，发送所述下行数据的起始位置符号或结束位置符号加上偏移量确定所述第二偏移符号，所述第二偏移子帧内的第二偏移符号即为所述第二发送时间起点位置。

15.根据权利要求3至5中任一项所述的reference numerology的子载波间隔的设置/确定方法，其特征在于，还包括：

在所述终端设备确定reference numerology的子载波间隔基于所述子载波间隔发送

随机接入前导码后，接收并解析所述终端设备发送的随机接入前导码以实现所述终端设备的随机接入。

16.一种reference numerology的子载波间隔的设置/确定装置，其特征在于，所述装置包括：

设置单元，用于设置reference numerology的子载波间隔为15KHz的2^n倍，并告知至终端设备，以指示所述终端设备能够与基站设备进行同步通信的reference numerology的子载波间隔为15KHz的2^n倍，

其中，所述n为大于或等于-2的整数。

17.根据权利要求16所述的reference numerology的子载波间隔的设置/确定装置，其特征在于，

所述设置单元还用于：给所有所述终端设备在同一个载波上配置相同的reference numerology的子载波间隔。

18.根据权利要求17所述的reference numerology的子载波间隔的设置/确定装置，其特征在于，

所述设置单元还用于：设置特定下行信号占用的子载波间隔为reference numerology，并设置发送所述特定下行信号的第一参考子帧，在所述第一参考子帧内以指定的子载波间隔发送所述特定下行信号，以指示终端设备能够与所述基站设备进行同步通信的reference numerology的子载波间隔即为所述特定下行信号传输的子载波间隔。

19.根据权利要求17所述的reference numerology的子载波间隔的设置/确定装置，其特征在于，还包括：

第一发送单元，用于向所述终端设备发送承载reference numerology的子载波间隔的系统信息，以指示所述终端设备能够与所述基站设备进行同步通信的reference numerology的子载波间隔即为所述系统信息中设置的子载波间隔。

20.根据权利要求17所述的reference numerology的子载波间隔的设置/确定装置，其特征在于，

所述设置单元还用于：根据载波的特征信息设置reference numerology的子载波间隔，并在该载波上发送特定下行信号，以供所述终端设备根据检测到的所述载波的特征信息、以及预存的载波特征信息与reference numerology的子载波间隔映射表来确定reference numerology的子载波间隔，

其中，所述载波的特征信息包括载波频点和/或载波带宽。

21.根据权利要求18或20所述的reference numerology的子载波间隔的设置/确定装置，其特征在于，

所述特定下行信号为主同步信号/辅同步信号、参考信号、寻呼信号和系统信息中的一个或多个的任意组合。

22.根据权利要求16所述的reference numerology的子载波间隔的设置/确定装置，其特征在于，

所述设置单元还用于：给所有所述终端设备在同一个载波上配置不同的reference numerology的子载波间隔。

23.根据权利要求22所述的reference numerology的子载波间隔的设置/确定装置，其

特征在于，还包括：

第二发送单元，用于根据所述终端设备的设备类型和/或需要传输的业务类型向所述终端设备发送无线资源控制信令或下行控制信令，以通过所述无线资源控制信令或下行控制信令半静态地或动态地通知所述终端设备reference numerology的子载波间隔。

24.根据权利要求16或17所述的reference numerology的子载波间隔的设置/确定装置，其特征在于，

所述设置单元还用于：在所述终端设备确定能够与所述基站设备进行同步通信的reference numerology的子载波间隔后，设置所述终端设备的专用numerology的子载波间隔，并根据所述专用numerology的子载波间隔设置第二参考子帧，以供所述终端设备根据所述专用numerology的子载波间隔和所述第二参考子帧进行上下行数据收发。

25.根据权利要求24所述的reference numerology的子载波间隔的设置/确定装置，其特征在于，

所述专用numerology的子载波间隔的设置信息为专用numerology的子载波间隔与终端的reference numerology的子载波间隔之间的相对比值，以供所述终端设备根据所述相对比值以及reference numerology的子载波间隔确定所述专用numerology的子载波间隔；

或所述专用numerology的子载波间隔的设置信息为所述专用numerology的子载波间隔的绝对值。

26.根据权利要求24所述的reference numerology的子载波间隔的设置/确定装置，其特征在于，还包括：

第二发送单元，用于根据所述专用numerology的子载波间隔以及所述第二参考子帧，对所述终端设备进行上下行时频资源分配并向所述终端设备发送相应的下行控制信令，

其中，所述下行控制信令用于设置所述终端设备通过物理下行共享信道和/或物理上行共享信道进行数据发送的第一发送时间起点位置和发送时间长度。

27.根据权利要求26所述的reference numerology的子载波间隔的设置/确定装置，其特征在于，

所述第二参考子帧为已包含的下行数据的发送子帧时，所述下行控制信令还用于设置所述终端设备接收到的所述下行数据所对应的混合自动重传业务的反馈信息的第二发送时间起点位置。

28.根据权利要求26所述的reference numerology的子载波间隔的设置/确定装置，其特征在于，

所述下行控制信令所在子帧位置加上位置偏移量确定第一偏移子帧，所述下行控制信令所在符号位置加上偏移量确定第一偏移符号，所述第一偏移子帧内的第一偏移符号即为所述第一发送时间起点位置。

29.根据权利要求27所述的reference numerology的子载波间隔的设置/确定装置，其特征在于，

发送所述下行数据的起始位置子帧或结束位置子帧加上偏移量确定所述第二偏移子帧，发送所述下行数据的起始位置符号或结束位置符号加上偏移量确定所述第二偏移符号，所述第二偏移子帧内的第二偏移符号即为所述第二发送时间起点位置。

30.根据权利要求18至20中任一项所述的reference numerology的子载波间隔的设

置/确定装置，其特征在于，还包括：

接入单元，用于在所述终端设备确定reference numerology的子载波间隔基于所述子载波间隔发送随机接入前导码后，接收并解析所述终端设备发送的随机接入前导码以实现所述终端设备的随机接入。

31.一种基站设备，其特征在于，包括：

如权利要求16至30中任一项所述的reference numerology的子载波间隔的设置/确定装置。

32.一种reference numerology的子载波间隔的设置/确定方法，其特征在于，包括：

获取基站在第一参考子帧内以指定的子载波间隔发送的特定下行信号；

确定用于传输所述特定下行信号的传输带宽，以及所述传输带宽对应的预存的参数M和N，其中，所述M为所述特定下行信号占用的资源块个数，所述N为每个所述资源块包含的子载波个数数据；

确定所述传输带宽除以所述M再除以所述N之后的商值，所述商值即为所述特定下行信号传输的子载波间隔，也即能够与所述基站设备进行同步通信的reference numerology的子载波间隔。

33.根据权利要求32所述的reference numerology的子载波间隔的设置/确定方法，其特征在于，

所述特定下行信号为主同步信号/辅同步信号、参考信号、寻呼信号和系统信息中的一个或多个的任意组合。

34.一种reference numerology的子载波间隔的设置/确定装置，其特征在于，包括：

获取单元，用于获取基站在第一参考子帧内以指定的子载波间隔发送的特定下行信号；

确定单元，用于确定用于传输所述特定下行信号的传输带宽，以及所述传输带宽对应的预存的参数M和N，其中，所述M为所述特定下行信号占用的资源块个数，所述N为每个所述资源块包含的子载波个数数据；

所述确定单元还用于：确定所述传输带宽除以所述M再除以所述N之后的商值，所述商值即为所述特定下行信号传输的子载波间隔，也即能够与所述基站设备进行同步通信的reference numerology的子载波间隔。

35.根据权利要求34所述的reference numerology的子载波间隔的设置/确定装置，其特征在于，

所述特定下行信号为主同步信号/辅同步信号、参考信号、寻呼信号和系统信息中的一个或多个的任意组合。

36.一种终端设备，其特征在于，包括：

如权利要求34或35所述的reference numerology的子载波间隔的设置/确定装置，

其中，所述终端设备与如权利要求16至30中任一项所述的reference numerology的子载波间隔的设置/确定装置进行同步通信，以确定与如权利要求31所述的基站设备进行同步通信的reference numerology的子载波间隔。

reference numerology的子载波间隔的设置/确定方法、装置、基站和终端

技术领域

[0001] 本发明涉及通信技术领域，具体而言，涉及一种reference numerology的子载波间隔的设置/确定方法、一种reference numerology的子载波间隔的设置/确定装置、一种基站和一种终端。

背景技术

[0002] 未来5G通信主要场景包括以下三种：eMBB、mMTC和URLLC。而这三种场景所针对的业务类型不一样，其需求也不一样。

[0003] 比如eMBB(Enhanced Mobile BroadBand，增强的移动宽带)业务，两个主要的指标是高带宽和低时延(要求4ms)。在未来的高频通信上，可能支持100MHz的大带宽，而且很可能某个时刻整个带宽都直接分配给一个用户，而上行调度时延和HARQ(Hybird Automatic Repeat Request，混合自动重传)技术的反馈时延也会带来时延影响，所以eMBB业务需要较大的子载波间隔和较小的时间粒度。

[0004] 又如mMTC(Massive Machine Type Communications，大量机器类通信)业务，需要的是窄带服务，需要电池寿命很长，这种业务就需要更小粒度的子载波间隔和更宽粒度的时域资源。

[0005] 对于URLLC(Ultra-Reliable and Low Latency Communications，高可靠低时延)业务，时延要求是0.5ms，也需要减少时域调度粒度，上行调度时延和HARQ反馈时延带来的时延影响。

[0006] 在上述5G通信场景中，为了适配多种通信业务的传输需求，例如增大带宽和减少时延，NR(New radio，新无线通信)系统中需要引入多个numerology，比如对于eMBB业务和URLLC业务的numerology子载波间隔需要增大，最小传输单元需要减小。

[0007] 相关技术的LTE方法中，只有一个固定的子载波间隔为15KHz，在这个子载波间隔的前提下，subframe子帧的长度即为1ms。那么用户根据默认的子载波间隔和子帧长度就能根据同步信号比如PSS/SSS，和/或参考信号CRS/CSI-RS/DRS来获得下行时间的同步，即帧同步、子帧同步和符号同步。

[0008] 而在5G NR中，不同的业务可能使用不同的子载波间隔，即在上下行数据发送的时候每个用户使用的子载波间隔和传输时间粒度可能不一样。但是在初始的下行时间同步的过程中，需要所有用户能有一个reference numerology的子载波间隔来获取帧同步和子帧同步等。

[0009] 因此，如何在统一的空口框架下，针对不同的用户设置和/或确定reference numerology的子载波间隔是实现终端设备与基站设备之间的同步通信的核心技术问题。

发明内容

[0010] 本发明正是基于上述技术问题至少之一，提出了一种reference numerology的子

载波间隔的设置/确定方案，通过设置reference numerology的子载波间隔为15KHz的2^n倍，并告知至终端设备，以供终端设备确定能够与基站设备进行同步通信的reference numerology的子载波间隔为15KHz的2^n倍，其中，同步通信是指终端设备获得的数据帧的同步、子帧同步和符号同步。

[0011] 有鉴于此，根据本发明的第一方面的实施例，提出了一种reference numerology的子载波间隔的设置/确定方法，包括：设置reference numerology的子载波间隔为15KHz的2^n倍，并告知至终端设备，以指示终端设备能够与基站设备进行同步通信的reference numerology的子载波间隔为15KHz的2^n倍，其中，n为大于或等于-2的整数。

[0012] 在该技术方案中，通过设置reference numerology的子载波间隔为15KHz的2^n倍，并告知至终端设备，以供终端设备确定能够与基站设备进行同步通信的reference numerology的子载波间隔为15KHz的2^n倍，其中，同步通信是指终端设备获得的数据帧的同步、子帧同步和符号同步。

[0013] 其中，NR系统中子载波间隔的理论范围为3.75KHz～480KHz，而为了适应不同的通信业务的传输需求，基站设备可以根据通信业务的传输需求确定相应的子载波间隔，设置reference numerology的子载波间隔为15KHz的2^n倍，在执行通信业务的同时，告知终端设备进行同步通信的reference numerology的子载波间隔为15KHz的2^n倍，以保证终端设备和基站设备之间实现数据帧的同步、子帧同步和符号同步。

[0014] 在上述技术方案中，优选地，还包括：给所有终端设备在同一个载波上配置相同的reference numerology的子载波间隔。

[0015] 在该技术方案中，同一个载波是指频点相同且带宽相同的一个载波。

[0016] 在上述技术方案中，优选地，还包括：设置特定下行信号占用的子载波间隔为reference numerology，并设置发送特定下行信号的第一参考子帧，在第一参考子帧内以指定的子载波间隔发送特定下行信号，以指示终端设备能够与基站设备进行同步通信的reference numerology的子载波间隔即为特定下行信号传输的子载波间隔。

[0017] 在该技术方案中，通过在第一参考子帧内以指定的子载波间隔发送特定下行信号，以指示终端设备能够与基站设备进行同步通信的reference numerology的子载波间隔即为特定下行信号传输的子载波间隔。

[0018] 具体地，基于reference numerology的子载波间隔的隐式指示的方法，检测到特定下行信号的传输带宽为$(M\times N\times 15\times 2^n)$KHz，其中，M为特定下行信号占用的RB的个数，N为每个RB包含的子载波的个数，这个M和N是终端设备的芯片中预存的，所以根据特定下行信号的传输带宽、M和N能获得reference numerology的子载波间隔。

[0019] 具体地，可以采用隐式指示的方式实现reference numerology的子载波间隔的设置/确定，比如LTE网络的小区搜索过程中，PSS(Primary Synchronization Signal，主同步信号)/SSS(Secondary Synchronization Signal，辅同步信号)信令的numerology的子载波间隔为15KHz，子帧时长为1ms。这时候基站设备设置PSS/SSS信令占用的带宽为72(M×N即6×12，每个RB包含12个子载波，PSS/SSS传输带宽为中心6个RB)个子载波的带宽，即1.08MHz，占用的时长为1个符号即1/14ms。那么当numerology为30KHz时，PSS/SSS信令还是占有带宽为72个子载波，带宽为2.16MHz，占用的时长为1个符号为0.5/14ms。

[0020] 依次类推，PSS/SSS信令占用的带宽为LTE中1.08MHz带宽的2^n倍时，reference

numerology的子载波间隔即为15KHz的2^n倍。

[0021] 另外，NR系统中一个RB(Resource Block，资源块)可能会变成16个子载波，也就是说带宽是reference numerology的子载波间隔为15KHz的PSS/SSS信令的占用带宽(16/12)×2^n倍，reference numerology的子载波间隔即为15KHz的2^n倍，终端设备在确定循环前缀部分占用的时长和/或PSS/SSS信令占用的时长为LTE网络中1/14ms的1/(2^n)时，确定reference numerology的子载波间隔即为15KHz的2^n倍。

[0022] 其中，特定下行信号为主同步信号/辅同步信号、参考信号(包括CRS-Cell Specific Signal，CSI-RS:Channel State Information-Reference Signal，DRS-Discovery Reference Signal以及可能设计的新的参考信号)、寻呼信号和系统信息(包括MIB:Master Information Block和SIB:System Information Block)中的一个或多个的任意组合。

[0023] 在上述技术方案中，优选地，还包括：向终端设备发送承载reference numerology的子载波间隔的系统信息，以指示终端设备能够与基站设备进行同步通信的reference numerology的子载波间隔即为系统信息中设置的子载波间隔。

[0024] 在该技术方案中，终端设备解析系统信息以确定通过系统信息显式指示的reference numerology的子载波间隔。

[0025] 其中，系统信息包括一个Master Information Block(MIB)和多个System Information Blocks(SIBs)。MIB使用一种固定的、具有40ms周期的调度方式，其中40ms周期内发送四次，第一次传输是安排在满足系统帧号SFN mod 4＝0的无线帧的子帧#0中，后面三次是在其他无线帧的子帧#0中重复发送。

[0026] System Information Block Type1应用一种固定的具有80ms周期的调度方式，其中80ms时间内发送四次。第一次传输是安排在满足系统帧号SFN mod 8＝0的无线帧的子帧#5中，后面三次是在满足系统帧号SFN mod 2＝0的其他无线帧的子帧#5中重复发送。

[0027] 值得特别指出的是，如果系统信息指示reference numerology的子载波间隔时，那么特定下行信号比如PSS/SSS的带宽就不一定必须是LTE中1.08MHz的2^r或(16/12)×2^n倍，PSS/SSS的发送时长也不一定是LTE中1/14ms的1/(2^n)了。

[0028] 在上述技术方案中，优选地，还包括：根据载波的特征信息设置reference numerology的子载波间隔，并在载波上发送特定下行信号，以供终端设备根据检测到的载波的特征信息、以及预存的载波特征信息与reference numerology的子载波间隔映射表来确定reference numerology的子载波间隔，其中，载波的特征信息包括载波频点和/或载波带宽。

[0029] 在该技术方案中，终端设备在检测到承载有特定下行信号的载波时，对载波的特征信息如载波频点和/或载波带宽进行解析，终端设备根据载波的特征信息、以及预存的载波特征信息与reference numerology的子载波间隔映射表来确定reference numerology的子载波间隔。

[0030] 在上述技术方案中，优选地，特定下行信号为主同步信号/辅同步信号、参考信号、寻呼信号和系统信息中的一个或多个的任意组合。

[0031] 在上述技术方案中，优选地，还包括：给所有终端设备在同一个载波上配置不同的reference numerology的子载波间隔。

[0032] 在上述技术方案中，优选地，还包括：根据终端设备的设备类型和/或需要传输的业务类型向终端设备发送无线资源控制信令或下行控制信令，以通过无线资源控制信令或下行控制信令半静态地或动态地通知终端设备reference numerology的子载波间隔。

[0033] 在该技术方案中，通过无线资源控制信令或下行控制信令半静态地或动态地通知终端设备reference numerology的子载波间隔，例如：

[0034] (1)基站设备向特定的UE(User Equipment，终端设备)发送RRC(Radio Resource Control，无线资源控制)信令单独通知特定的UE可进行同步通信的reference numerology的子载波间隔，该reference numerology的子载波间隔可以是特定UE处于连接状态时第一个业务需要使用的reference numerology的子载波间隔。这个reference numerology的子载波间隔可以是半静态变化的，比如第一个业务还没结束时，又有第二个业务到达特定UE，那么特定UE继续使用第一个业务的numerology为第二个业务的reference numerology。但是如果第一个业务结束了之后，第二个业务才到达特定UE，那么基站设备可以再次发送用于指示reference numerology的子载波间隔的RRC信令，以定义第二个业务的numerology为该用户的reference numerology，也可以使用随机接入反馈信令来指示reference numerology。

[0035] (2)根据UE的通信能力或UE类型来定义reference numerology的子载波间隔，比如有些UE就是MTC终端，那么这些终端的reference numerology就直接将执行MTC业务时的numerology写入到这些终端的芯片中，比如3.75KHz。又如其它支持eMBB业务和URLLC业务的终端，使用LTE的15KHz为reference numerology或者更高的30KHz或60KHz为reference numerology。reference numerology的子载波间隔的指示方法可以直接是写入UE的硬件芯片，不需要信令通知，或者系统信息通知。

[0036] 在上述技术方案中，优选地，还包括：在终端设备确定能够与基站设备进行同步通信的reference numerology的子载波间隔后，设置终端设备的专用numerology的子载波间隔，并根据专用numerology的子载波间隔设置第二参考子帧，以供终端设备根据专用numerology的子载波间隔和第二参考子帧进行上下行数据收发。

[0037] 在该技术方案中，通过在终端设备确定能够与基站设备进行同步通信的reference numerology的子载波间隔后，设置终端设备的专用numerology的子载波间隔，以供终端设备发送或接收SRS(Sounding Reference Signals，探测参考信号)，或基于专用numerology的子载波间隔接入于各个通信信道，如PRACH(Physical Random Access Channel，随机接入信道)、PDCCH(Physical Downlink Control Channel，下行物理控制信道)、PDSCH(Physical Downlink Shared Channel，下行物理共享信道)、PUCCH(Physical Uplink Control Channel，上行物理控制信道)和PUSCH(Physical Uplink Control Channel，上行物理共享信道)等。

[0038] 其中，专用numerology的子载波间隔可以是基于用户业务类型来配置的。

[0039] 在上述技术方案中，优选地，还包括：专用numerology的子载波间隔的设置信息为专用numerology的子载波间隔与终端的reference numerology的子载波间隔之间的相对比值，以供终端设备根据相对比值以及reference numerology的子载波间隔确定专用numerology的子载波间隔；或专用numerology的子载波间隔的设置信息为专用numerology的子载波间隔的绝对值。

[0040] 在该技术方案中，终端设备在确定Reference numerology的子载波间隔后，基站设备再给终端设备根据业务类型配置装用numerology时，RRC信令或下行控制信令只需给出当前专用numerology的子载波间隔与reference numerology的子载波间隔的比值，该比值为2^m，m为负整数，0和正整数。

[0041] 专用numerology的子载波间隔和子帧长度也可以在随机接入过程Msg.4中或者其它时候的RRC信令中给出。

[0042] 在上述技术方案中，优选地，还包括：根据专用numerology的子载波间隔以及第二参考子帧，对终端设备进行上下行时频资源分配并向终端设备发送相应的下行控制信令，其中，下行控制信令用于设置终端设备通过物理下行共享信道和/或物理上行共享信道进行数据发送的第一发送时间起点位置和发送时间长度。

[0043] 在上述技术方案中，优选地，第二参考子帧为自包含的下行数据的发送子帧时，下行控制信令还用于设置终端设备接收到的下行数据所对应的混合自动重传业务的反馈信息的第二发送时间起点位置。

[0044] 在上述技术方案中，优选地，下行控制信令所在子帧位置加上位置偏移量确定第一偏移子帧，下行控制信令所在符号位置加上偏移量确定第一偏移符号，第一偏移子帧内的第一偏移符号即为第一发送时间起点位置。

[0045] 在该技术方案中，基站设备在指示终端设备确定专用numerology的子帧长度后，DCI(Downlink Control Information，下行控制信令)调度上下行信道发送资源时，需要给出发送资源的时间位置起点和时间长度，时间位置起点给出以DCI信令当前子帧位置为f的话，时间起点位置的子帧位置为f+k，DCI信令当前符号位置为z的话，时间起点位置的符号位置为z+l，同时给出发送时间长度：比如是一个子帧中的14个符号(或者要去除DCI信令占用的符号和gap(间隙)时间以及HARQ反馈时间)，或一个slot即半个子帧的5个或6个符号，或一个mini-slot即2个符号左右，上述f、k和z均为整数。另外，上述f、k和z的指示也可以是使用bit序列来指示，但是bit序列与上述f、k和z的值的映射表必须预先存储在终端设备。

[0046] 其中，发送时间长度的取值为整数个符号，和/或整数个slot(每个slot包含多个符号)和/或整数个mini-slot(每个mini-slot包含多个符号)和/或整数个子帧。

[0047] 在上述技术方案中，优选地，发送下行数据的起始位置子帧或结束位置子帧加上偏移量确定第二偏移子帧，发送下行数据的起始位置符号或结束位置符号加上偏移量确定第二偏移符号，第二偏移子帧内的第二偏移符号即为第二发送时间起点位置。

[0048] 在该技术方案中，自包含的下行数据的发送子帧或者slot，需要给出相应的下行数据发送的HARQ反馈时间，同样给出子帧的偏移值，符号的偏移值，发送时长一般是默认值，不需要额外信令通知。

[0049] 在上述技术方案中，优选地，还包括：在终端设备确定reference numerology的子载波间隔并基于子载波间隔发送随机接入前导码后，接收并解析终端设备发送的随机接入前导码以实现终端设备的随机接入。

[0050] 根据本发明的第二方面的实施例，提出了一种reference numerology的子载波间隔的设置/确定装置，包括：设置单元，用于设置reference numerology的子载波间隔为15KHz的2^n倍，并告知至终端设备，以指示终端设备能够与基站设备进行同步通信的reference numerology的子载波间隔为15KHz的2^n倍，其中，n为大于或等于-2的整数。

[0051] 在该技术方案中，通过设置reference numerology的子载波间隔为15KHz的2^n倍，并告知至终端设备，以供终端设备确定能够与基站设备进行同步通信的reference numerology的子载波间隔为15KHz的2^n倍，其中，同步通信是指终端设备获得的数据帧的同步、子帧同步和符号同步。

[0052] 其中，NR系统中子载波间隔的理论范围为3.75KHz～480KHz，而为了适应不同的通信业务的传输需求，基站设备可以根据通信业务的传输需求确定相应的子载波间隔，设置reference numerology的子载波间隔为15KHz的2^n倍，在执行通信业务的同时，告知终端设备进行同步通信的reference numerology的子载波间隔为15KHz的2^n倍，以保证终端设备和基站设备之间实现数据帧的同步、子帧同步和符号同步。

[0053] 在上述技术方案中，优选地，设置单元还用于：给所有终端设备在同一个载波上配置相同的reference numerology的子载波间隔。

[0054] 在该技术方案中，同一个载波是指频点相同且带宽相同的一个载波。

[0055] 在上述技术方案中，优选地，设置单元还用于：设置特定下行信号占用的子载波间隔为reference numerology，并设置发送特定下行信号的第一参考子帧，在第一参考子帧内以指定的子载波间隔发送特定下行信号，以指示终端设备能够与基站设备进行同步通信的reference numerology的子载波间隔即为特定下行信号传输的子载波间隔。

[0056] 在该技术方案中，通过在第一参考子帧内以指定的子载波间隔发送特定下行信号，以指示终端设备能够与基站设备进行同步通信的reference numerology的子载波间隔即为特定下行信号传输的子载波间隔。

[0057] 具体地，基于reference numerology的子载波间隔的隐式指示的方法，检测到特定下行信号的传输带宽为$(M\times N\times 15\times 2^n)$KHz，其中，M为特定下行信号占用的RB的个数，N为每个RB包含的子载波的个数，这个M和N是终端设备的芯片中预存的，所以根据特定下行信号的传输带宽、M和N能获得reference numerology的子载波间隔。

[0058] 具体地，可以采用隐式指示的方式实现reference numerology的子载波间隔的设置/确定，比如LTE网络的小区搜索过程中，PSS(Primary Synchronization Signal，主同步信号)/SSS(Secondary Synchronization Signal，辅同步信号)信令的numerology的子载波间隔为15KHz，子帧时长为1ms。这时候基站设备设置PSS/SSS信令占用的带宽为72($M\times N$即6×12，每个RB包含12个子载波，PSS/SSS传输带宽为中心6个RB)个子载波的带宽，即1.08MHz，占用的时长为1个符号即1/14ms。那么当numerology为30KHz时，PSS/SSS信令还是占有带宽为72个子载波，带宽为2.16MHz，占用的时长为1个符号为0.5/14ms。

[0059] 依次类推，PSS/SSS信令占用的带宽为LTE中1.08MHz带宽的2^n倍时，reference numerology的子载波间隔即为15KHz的2^n倍。

[0060] 另外，NR系统中一个RB(Resource Block，资源块)可能会变成16个子载波，也就是说带宽是reference numerology的子载波间隔为15KHz的PSS/SSS信令的占用带宽$(16/12)\times 2^n$倍，reference numerology的子载波间隔即为15KHz的2^n倍，终端设备在确定循环前缀部分占用的时长和/或PSS/SSS信令占用的时长为LTE网络中1/14ms的$1/(2^n)$时，确定reference numerology的子载波间隔即为15KHz的2^n倍。

[0061] 其中，特定下行信号为主同步信号/辅同步信号、参考信号、寻呼信号和系统信息中的一个或多个的任意组合。

[0062] 在上述技术方案中，优选地，还包括：第一发送单元，用于向终端设备发送承载reference numerology的子载波间隔的系统信息，以指示终端设备能够与基站设备进行同步通信的reference numerology的子载波间隔即为系统信息中设置的子载波间隔。

[0063] 在该技术方案中，终端设备解析系统信息以确定通过系统信息显式指示的reference numerology的子载波间隔。

[0064] 其中，系统信息包括一个Master Information Block(MIB)和多个System Information Blocks(SIBs)。MIB使用一种固定的、具有40ms周期的调度方式，其中40ms周期内发送四次，第一次传输是安排在满足系统帧号SFN mod 4＝0的无线帧的子帧#0中，后面三次是在其他无线帧的子帧#0中重复发送。

[0065] System Information Block Type1应用一种固定的具有80ms周期的调度方式，其中80ms时间内发送四次。第一次传输是安排在满足系统帧号SFN mod 8＝0的无线帧的子帧#5中，后面三次是在满足系统帧号SFN mod 2＝0的其他无线帧的子帧#5中重复发送。

[0066] 值得特别指出的是，如果系统信息指示reference numerology的子载波间隔时，那么特定下行信号比如PSS/SSS的带宽就不一定必须是LTE中1.08MHz的2^n或$(16/12)\times 2^n$倍，PSS/SSS的发送时长也不一定是LTE中1/14ms的$1/(2^n)$了。

[0067] 在上述技术方案中，优选地，设置单元还用于：根据载波的特征信息设置reference numerology的子载波间隔，并在该载波上发送特定下行信号，以供终端设备根据检测到的载波的特征信息、以及预存的载波特征信息与reference numerology的子载波间隔映射表来确定reference numerology的子载波间隔，其中，载波的特征信息包括载波频点和/或载波带宽。

[0068] 在该技术方案中，终端设备在检测到承载有特定下行信号的载波时，对载波的特征信息如载波频点和/或载波带宽进行解析，终端设备根据载波的特征信息、以及预存的载波特征信息与reference numerology的子载波间隔映射表来确定reference numerology的子载波间隔。

[0069] 在上述技术方案中，优选地，特定下行信号为主同步信号/辅同步信号、参考信号、寻呼信号和系统信息中的一个或多个的任意组合。

[0070] 在上述技术方案中，优选地，设置单元还用于：给所有终端设备在同一个载波上配置不同的reference numerology的子载波间隔。

[0071] 在上述技术方案中，优选地，还包括：第二发送单元，用于根据终端设备的设备类型和/或需要传输的业务类型向终端设备发送无线资源控制信令或下行控制信令，以通过无线资源控制信令或下行控制信令半静态地或动态地通知终端设备reference numerology的子载波间隔。

[0072] 在该技术方案中，通过无线资源控制信令或下行控制信令半静态地或动态地通知终端设备reference numerology的子载波间隔，例如：

[0073] (1)基站设备向特定的UE(User Equipment，终端设备)发送RRC(Radio Resource Control，无线资源控制)信令单独通知特定的UE可进行同步通信的reference numerology的子载波间隔，该reference numerology的子载波间隔可以是特定UE处于连接状态时第一个业务需要使用的reference numerology的子载波间隔。这个reference numerology的子载波间隔可以是半静态变化的，比如第一个业务还没结束时，又有第二个业务到达特定UE，

那么特定UE继续使用第一个业务的numerology为第二个业务的reference numerology。但是如果第一个业务结束了之后，第二个业务才到达特定UE，那么基站设备可以再次发送用于指示reference numerology的子载波间隔的RRC信令，以定义第二个业务的numerology为该用户的reference numerology，也可以使用随机接入反馈信令来指示reference numerology。

[0074] (2)根据UE的通信能力或UE类型来定义reference numerology的子载波间隔，比如有些UE就是MTC终端，那么这些终端的reference numerology就直接将执行MTC业务时的numerology写入到这些终端的芯片中，比如3.75KHz。又如其它支持eMBB业务和URLLC业务的终端，使用LTE的15KHz为reference numerology或者更高的30KHz或60KHz为reference numerology。reference numerology的子载波间隔的指示方法可以直接是写入UE的硬件芯片，不需要信令通知，或者系统信息通知。

[0075] 在上述技术方案中，优选地，设置单元还用于：在终端设备确定能够与基站设备进行同步通信的reference numerology的子载波间隔后，设置终端设备的专用numerology的子载波间隔，并根据专用numerology的子载波间隔设置第二参考子帧，以供终端设备根据专用numerology的子载波间隔和第二参考子帧进行上下行数据收发。

[0076] 在该技术方案中，通过在终端设备确定能够与基站设备进行同步通信的reference numerology的子载波间隔后，设置终端设备的专用numerology的子载波间隔，以供终端设备发送或接收SRS(Sounding Reference Signals，探测参考信号)，或基于专用numerology的子载波间隔接入于各个通信信道，如PRACH(Physical Random Access Channel，随机接入信道)、PDCCH(Physical Downlink Control Channel，下行物理控制信道)、PDSCH(Physical Downlink Shared Channel，下行物理共享信道)、PUCCH(Physical Uplink Control Channel，上行物理控制信道)和PUSCH(Physical Uplink Control Channel，上行物理共享信道)等。

[0077] 其中，专用numerology的子载波间隔可以是基于用户业务类型来配置的。

[0078] 在上述技术方案中，优选地，专用numerology的子载波间隔的设置信息为专用numerology的子载波间隔与终端的reference numerology的子载波间隔之间的相对比值，以供终端设备根据相对比值以及reference numerology的子载波间隔确定专用numerology的子载波间隔；或专用numerology的子载波间隔的设置信息为专用numerology的子载波间隔的绝对值。

[0079] 在该技术方案中，终端设备在确定Reference numerology的子载波间隔后，基站设备再给终端设备配置根据业务类型配置专用numerology时，RRC信令或下行控制信令只需给出当前专用numerology的子载波间隔/reference numerology的子载波间隔的比值，该比值为2^m，m为负整数，0和正整数。

[0080] 专用numerology的子载波间隔和子帧长度也可以在随机接入过程Msg.4中或者其它时候的RRC信令中给出。

[0081] 在上述技术方案中，优选地，还包括：第三发送单元，用于根据专用numerology的子载波间隔以及第二参考子帧，对终端设备进行上下行时频资源分配并向终端设备发送相应的下行控制信令，其中，下行控制信令用于设置终端设备通过物理下行共享信道和/或物理上行共享信道进行数据发送的第一发送时间起点位置和发送时间长度。

[0082] 在上述技术方案中，优选地，第二参考子帧为自包含的下行数据的发送子帧时，下行控制信令还用于设置终端设备接收到的下行数据所对应的混合自动重传业务的反馈信息的第二发送时间起点位置。

[0083] 在上述技术方案中，优选地，下行控制信令所在子帧位置加上位置偏移量确定第一偏移子帧，下行控制信令所在符号位置加上偏移量确定第一偏移符号，第一偏移子帧内的第一偏移符号即为第一发送时间起点位置。

[0084] 在该技术方案中，基站设备在指示终端设备确定专用numerology的子帧长度后，DCI(Downlink Control Information，下行控制信令)调度上下行信道发送资源时，需要给出发送资源的时间位置起点和时间长度，时间位置起点给出以DCI信令当前子帧位置为f的话，时间起点位置的子帧位置为f+k，DCI信令当前符号位置为z的话，时间起点位置的符号位置为z+1，同时给出发送时间长度；比如是一个子帧中的14个符号(或者要去除DCI信令占用的符号和gap时间以及HARQ反馈时间)，或一个slot即半个子帧的5个或6个符号，或一个mini-slot即2个符号左右，上述f、k和z均为整数。另外，当然，上述f、k和z的指示也可以是使用bit序列来指示，但是bit序列与上述f、k和z的值的映射表必须预先存储在终端设备。

[0085] 其中，发送时间长度的取值为整数个符号，和/或整数个slot(每个slot包含多个符号)和/或整数个mini-slot(每个mini-slot包含多个符号)和/或整数个子帧。

[0086] 在上述技术方案中，优选地，发送下行数据的起始位置子帧或结束位置子帧加上偏移量确定第二偏移子帧，发送下行数据的起始位置符号或结束位置符号加上偏移量确定第二偏移符号，第二偏移子帧内的第二偏移符号即为第二发送时间起点位置。

[0087] 在该技术方案中，自包含的下行数据的发送子帧或者slot，需要给出相应的下行数据发送的HARQ反馈时间，同样给出子帧的偏移值，符号的偏移值，发送时长一般是默认值，不需要额外信令通知。

[0088] 在上述技术方案中，优选地，还包括：接入单元，用于在终端设备确定reference numerology的子载波间隔基于子载波间隔发送随机接入前导码后，接收并解析终端设备发送的随机接入前导码以实现终端设备的随机接入。

[0089] 根据本发明的第三方面的实施例，提出了一种基站设备，包括：如上述第二方面中的任一项技术方案所述的reference numerology的子载波间隔的设置/确定装置。

[0090] 根据本发明的第四方面的实施例，提出了一种reference numerology的子载波间隔的设置/确定方法，包括：获取基站在第一参考子帧内以指定的子载波间隔发送的特定下行信号；确定用于传输特定下行信号的传输带宽，以及传输带宽对应的预存的参数M和N，其中，M为特定下行信号占用的资源块个数，N为每个资源块包含的子载波个数数据；确定传输带宽除以M再除以N之后的商值，商值即为特定下行信号传输的子载波间隔，也即能够与基站设备进行同步通信的reference numerology的子载波间隔。

[0091] 在该技术方案中，终端设备基于reference numerology的子载波间隔的隐式指示的方法，检测到特定下行信号的传输带宽为$(M\times N\times 15\times 2^n)$KHz，其中，M为特定下行信号占用的RB的个数，N为每个RB包含的子载波的个数，这个M和N是终端设备的芯片中预存的，所以根据特定下行信号的传输带宽、M和N能获得reference numerology的子载波间隔。

[0092] 在上述技术方案中，优选地，特定下行信号为主同步信号/辅同步信号、参考信号、寻呼信号和系统信息中的一个或多个的任意组合。

[0093] 根据本发明的第五方面的实施例，提出了一种reference numerology的子载波间隔的设置/确定装置，包括：获取单元，用于获取基站在第一参考子帧内以指定的子载波间隔发送的特定下行信号；确定单元，用于确定用于传输特定下行信号的传输带宽，以及传输带宽对应的预存的参数M和N，其中，M为特定下行信号占用的资源块个数，N为每个资源块包含的子载波个数数据；确定单元还用于：确定传输带宽除以M再除以N之后的商值，商值即为特定下行信号传输的子载波间隔，也即能够与基站设备进行同步通信的reference numerology的子载波间隔。

[0094] 在该技术方案中，终端设备基于reference numerology的子载波间隔的隐式指示的方法，检测到特定下行信号的传输带宽为$(M\times N\times 15\times 2^{n})$KHz，其中，M为特定下行信号占用的RB的个数，N为每个RB包含的子载波的个数，这个M和N是终端设备的芯片中预存的，所以根据特定下行信号的传输带宽、M和N能获得reference numerology的子载波间隔。

[0095] 在上述技术方案中，优选地，特定下行信号为主同步信号/辅同步信号、参考信号、寻呼信号和系统信息中的一个或多个的任意组合。

[0096] 根据本发明的第六方面的实施例，提出了一种终端设备，包括：如上述第五方面中的任一项技术方案所述的reference numerology的子载波间隔的设置/确定装置，其中，终端设备与第二方面中的任一项技术方案所述的reference numerology的子载波间隔的设置/确定装置进行同步通信，以确定与第二方面的基站设备进行同步通信的reference numerology的子载波间隔。

[0097] 通过以上技术方案，通过特定下行信号占用的子载波间隔或显式指示信息、或载波的特征信息、或专用numerology、或终端设备的设备类型和/或需要传输的业务类型来指示终端设备reference numerology的子载波间隔，使得终端设备可以获知上下行信道、上下行信号和数据的时频资源粒度，以提高与基站设备的同步通信的准确度和可靠度。

附图说明

[0098] 图1示出了根据本发明的reference numerology的子载波间隔的设置/确定方法的实施例一的流程示意图；

[0099] 图2示出了根据本发明的reference numerology的子载波间隔的设置/确定方法的实施例二的流程示意图；

[0100] 图3示出了根据本发明的reference numerology的子载波间隔的设置/确定方法的实施例三的流程示意图；

[0101] 图4示出了根据本发明的reference numerology的子载波间隔的设置/确定方法的实施例四的流程示意图；

[0102] 图5示出了根据本发明的reference numerology的子载波间隔的设置/确定方法的实施例五的流程示意图；

[0103] 图6示出了根据本发明的reference numerology的子载波间隔的设置/确定方法的实施例六的流程示意图；

[0104] 图7示出了根据本发明的一个实施例的reference numerology的子载波间隔的设置/确定装置的示意框图；

[0105] 图8示出了根据本发明的实施例的基站设备的示意框图；

[0106] 图9示出了根据本发明的另一个实施例的reference numerology的子载波间隔的设置/确定装置的示意框图；

[0107] 图10示出了根据本发明的实施例的终端设备的示意框图；

[0108] 图11示出了根据本发明的一个实施例的reference numerology的子载波间隔的设置/确定方法的一个上行数据的帧结构的示意图；

[0109] 图12示出了根据本发明的一个实施例的reference numerology的子载波间隔的设置/确定装置的一个下行数据的帧结构的示意图；

[0110] 图13示出了根据本发明的一个实施例的reference numerology的子载波间隔的设置/确定装置的另一个上行数据的帧结构的示意图；

[0111] 图14示出了根据本发明的一个实施例的reference numerology的子载波间隔的设置/确定装置的另一个下行数据的帧结构的示意图。

具体实施方式

[0112] 为了能够更清楚地理解本发明的上述目的、特征和优点，下面结合附图和具体实施方式对本发明进行进一步的详细描述。需要说明的是，在不冲突的情况下，本申请的实施例及实施例中的特征可以相互组合。

[0113] 在下面的描述中阐述了很多具体细节以便于充分理解本发明，但是，本发明还可以采用其他不同于在此描述的其他方式来实施，因此，本发明的保护范围并不受下面公开的具体实施例的限制。

[0114] 下面结合图1至图14对根据本发明的reference numerology的子载波间隔的设置/确定方案的多种实施方式进行具体说明。

[0115] 实施例一：

[0116] 如图1所示，根据本发明的实施例的reference numerology的子载波间隔的设置/确定方法，包括：步骤102，设置reference numerology的子载波间隔为15KHz的2^n倍，并告知至终端设备，以指示终端设备能够与基站设备进行同步通信的reference numerology的子载波间隔为15KHz的2^n倍，其中，n为大于或等于-2的整数。

[0117] 在该技术方案中，通过设置reference numerology的子载波间隔为15KHz的2^n倍，并告知至终端设备，以供终端设备确定能够与基站设备进行同步通信的reference numerology的子载波间隔为15KHz的2^n倍，其中，同步通信是指终端设备获得的数据帧的同步、子帧同步和符号同步。

[0118] 其中，NR系统中子载波间隔的理论范围为3.75KHz~480KHz，而为了适应不同的通信业务的传输需求，基站设备可以根据通信业务的传输需求确定相应的子载波间隔，设置reference numerology的子载波间隔为15KHz的2^n倍，在执行通信业务的同时，告知终端设备进行同步通信的reference numerology的子载波间隔为15KHz的2^n倍，以保证终端设备和基站设备之间实现数据帧的同步、子帧同步和符号同步。

[0119] 在上述技术方案中，优选地，还包括：给所有终端设备在同一个载波上配置相同的reference numerology的子载波间隔。

[0120] 在该技术方案中，同一个载波是指频点相同且带宽相同的一个载波。

[0121] 实施例二：

[0122] 如图2所示，根据本发明的实施例的reference numerology的子载波间隔的设置/确定方法，在实施例一的基础上还包括：步骤202，设置特定下行信号占用的子载波间隔为reference numerology，并设置发送特定下行信号的第一参考子帧，在第一参考子帧内以指定的子载波间隔发送特定下行信号，以指示终端设备能够与基站设备进行同步通信的reference numerology的子载波间隔即为特定下行信号传输的子载波间隔。

[0123] 在该技术方案中，通过在第一参考子帧内以指定的子载波间隔发送特定下行信号，以指示终端设备能够与基站设备进行同步通信的reference numerology的子载波间隔即为特定下行信号传输的子载波间隔。

[0124] 具体地，基于reference numerology的子载波间隔的隐式指示的方法，检测到特定下行信号的传输带宽为$(M\times N\times 15\times 2^n)$KHz，其中，M为特定下行信号占用的RB的个数，N为每个RB包含的子载波的个数，这个M和N是终端设备的芯片中预存的，所以根据特定下行信号的传输带宽、M和N能获得reference numerology的子载波间隔。

[0125] 具体地，可以采用隐式指示的方式实现reference numerology的子载波间隔的设置/确定，比如LTE网络的小区搜索过程中，PSS(Primary Synchronization Signal，主同步信号)/SSS(Secondary Synchronization Signal，辅同步信号)信令的numerology的子载波间隔为15KHz，子帧时长为1ms。这时候基站设备设置PSS/SSS信令占用的带宽为72(M×N即6×12，每个RB包含12个子载波，PSS/SSS传输带宽为中心6个RB)个子载波的带宽，即1.08MHz，占用的时长为1个符号即1/14ms。那么当numerology为30KHz时，PSS/SSS信令还是占有带宽为72个子载波，带宽为2.16MHz，占用的时长为1个符号为0.5/14ms。

[0126] 依次类推，PSS/SSS信令占用的带宽为LTE中1.08MHz带宽的2^n倍时，reference numerology的子载波间隔即为15KHz的2^n倍。

[0127] 另外，NR系统中一个RB(Resource Block，资源块)可能会变成16个子载波，也就是说带宽是reference numerology的子载波间隔为15KHz的PSS/SSS信令的占用带宽(16/12)$\times 2^n$倍，reference numerology的子载波间隔即为15KHz的2^n倍，终端设备在确定循环前缀部分占用的时长和/或PSS/SSS信令占用的时长为LTE网络中1/14ms的$1/(2^n)$时，确定reference numerology的子载波间隔即为15KHz的2^n倍。

[0128] 其中，特定下行信号为主同步信号/辅同步信号、参考信号(包括CRS-Cell Specific Signal，CSI-RS:Channel State Information-Reference Signal，DRS-Discovery Reference Signal以及可能设计的新的参考信号)、寻呼信号和系统信息(包括MIB:Master Information Block和SIB:System Information Block)中的一个或多个的任意组合。

[0129] 实施例三：

[0130] 如图3所示，根据本发明的实施例的reference numerology的子载波间隔的设置/确定方法，在实施例一和二的基础上还包括：步骤302，向终端设备发送承载reference numerology的子载波间隔的系统信息，以指示终端设备能够与基站设备进行同步通信的reference numerology的子载波间隔即为系统信息中设置的子载波间隔。

[0131] 在该技术方案中，终端设备解析系统信息以确定通过系统信息显式指示的reference numerology的子载波间隔。

[0132] 其中，系统信息包括一个Master Information Block(MIB)和多个System

Information Blocks(SIBs)。MIB使用一种固定的、具有40ms周期的调度方式，其中40ms周期内发送四次，第一次传输是安排在满足系统帧号SFN mod 4=0的无线帧的子帧#0中，后面三次是在其他无线帧的子帧#0中重复发送。

[0133] System Information Block Type1应用一种固定的具有80ms周期的调度方式，以及在80ms时间内重传方式。其中80ms时间内发送四次。第一次传输是安排在满足系统帧号SFN mod 8=0的无线帧的子帧#5中，后面三次是在满足系统帧号SFN mod2=0的其他无线帧的子帧#5中重复发送。

[0134] 值得特别指出的是，如果系统信息指示reference numerology的子载波间隔时，那么特定下行信号比如PSS/SSS的带宽就不一定必须是LTE中1.08MHz的2^n或$(16/12)\times 2^n$倍，PSS/SSS的发送时长也不一定是LTE中1/14ms的$1/(2^n)$了。

[0135] 实施例四：

[0136] 如图4所示，根据本发明的实施例的reference numerology的子载波间隔的设置/确定方法，在实施例一至三的基础上还包括：步骤402根据载波的特征信息设置reference numerology的子载波间隔，并在载波上发送特定下行信号，以供终端设备根据检测到的载波的特征信息、以及预存的载波特征信息与reference numerology的子载波间隔映射表来确定reference numerology的子载波间隔，其中，载波的特征信息包括载波频点和/或载波带宽。

[0137] 在该技术方案中，终端设备在检测到承载有特定下行信号的载波时，对载波的特征信息如载波频点和/或载波带宽进行解析，终端设备根据载波的特征信息、以及预存的载波特征信息与reference numerology的子载波间隔映射表来确定reference numerology的子载波间隔。

[0138] 在上述技术方案中，优选地，特定下行信号为主同步信号/辅同步信号、参考信号、寻呼信号和系统信息中的一个或多个的任意组合。

[0139] 在上述技术方案中，优选地，还包括：给所有终端设备在同一个载波上配置不同的reference numerology的子载波间隔。

[0140] 实施例五：

[0141] 如图5所示，根据本发明的实施例的reference numerology的子载波间隔的设置/确定方法，在实施例一至四的基础上还包括：步骤502，根据终端设备的设备类型和/或需要传输的业务类型向终端设备发送无线资源控制信令或下行控制信令，以通过无线资源控制信令或下行控制信令半静态地或动态地通知终端设备reference numerology的子载波间隔。

[0142] 在该技术方案中，通过无线资源控制信令或下行控制信令半静态地或动态地通知终端设备reference numerology的子载波间隔，例如：

[0143] (1)基站设备向特定的UE(User Equipment，终端设备)发送RRC(Radio Resource Control，无线资源控制)信令单独通知特定的UE可进行同步通信的reference numerology的子载波间隔，该reference numerology的子载波间隔可以是特定UE处于连接状态时第一个业务需要使用的reference numerology的子载波间隔。这个reference numerology的子载波间隔可以是半静态变化的，比如第一个业务还没结束时，又有第二个业务到达特定UE，那么特定UE继续使用第一个业务的numerology为第二个业务的reference numerology。但

是如果第一个业务结束了之后，第二个业务才到达特定UE，那么基站设备可以再次发送用于指示reference numerology的子载波间隔的RRC信令，以定义第二个业务的numerology为该用户的reference numerology，也可以使用随机接入反馈信令来指示reference numerology。

[0144] (2)根据UE的通信能力或UE类型来定义reference numerology的子载波间隔，比如有些UE就是MTC终端，那么这些终端的reference numerology就直接将执行MTC业务时的numerology写入到这些终端的芯片中，比如3.75KHz。又如其它支持eMBB业务和URLLC业务的终端，使用LTE的15KHz为reference numerology或者更高的30KHz或60KHz为reference numerology。reference numerology的子载波间隔的指示方法可以直接是写入UE的硬件芯片，不需要信令通知，或者系统信息通知。

[0145] 实施例六：

[0146] 如图6所示，根据本发明的实施例的reference numerology的子载波间隔的设置/确定方法，在实施例一至五的基础上还包括：步骤602，在终端设备确定能够与基站设备进行同步通信的reference numerology的子载波间隔后，设置终端设备的专用numerology的子载波间隔，并根据专用numerology的子载波间隔设置第二参考子帧，以供终端设备根据专用numerology的子载波间隔和第二参考子帧进行上下行数据收发。

[0147] 在该技术方案中，通过在终端设备确定能够与基站设备进行同步通信的reference numerology的子载波间隔后，设置终端设备的专用numerology的子载波间隔，以供终端设备发送或接收SRS(Sounding Reference Signals，探测参考信号)，或基于专用numerology的子载波间隔接入于各个通信信道，如PRACH(Physical Random Access Channel，随机接入信道)、PDCCH(Physical Downlink Control Channel，下行物理控制信道)、PDSCH(Physical Downlink Shared Channel，下行物理共享信道)、PUCCH(Physical Uplink Control Channel，上行物理控制信道)和PUSCH(Physical Uplink Control Channel，上行物理共享信道)等。

[0148] 其中，专用numerology的子载波间隔可以是基于用户业务类型来配置的。

[0149] 在上述技术方案中，优选地，还包括：专用numerology的子载波间隔的设置信息为专用numerology的子载波间隔与终端的reference numerology的子载波间隔之间的相对比值，以供终端设备根据相对比值以及reference numerology的子载波间隔确定专用numerology的子载波间隔；或专用numerology的子载波间隔的设置信息为专用numerology的子载波间隔的绝对值。

[0150] 在该技术方案中，终端设备在确定Reference numerology的子载波间隔后，基站设备再给终端设备根据业务类型配置专用numerology时，RRC信令或下行控制信令只需给出当前专用numerology子载波间隔/reference numerology子载波间隔的值，该值为2^m，m为负整数，0和正整数。

[0151] 专用numerology的子载波间隔和子帧长度也可以在随机接入过程Msg.4中或者其它时候的RRC信令中给出。

[0152] 在上述技术方案中，优选地，还包括：根据专用numerology的子载波间隔以及第二参考子帧，对终端设备进行上下行时频资源分配并向终端设备发送相应的下行控制信令，其中，下行控制信令用于设置终端设备通过物理下行共享信道和/或物理上行共享信道进

行数据发送的第一发送时间起点位置和发送时间长度。

[0153] 在上述技术方案中，优选地，第二参考子帧为自包含的下行数据的发送子帧时，下行控制信令还用于设置终端设备接收到的下行数据所对应的混合自动重传业务的反馈信息的第二发送时间起点位置。

[0154] 在上述技术方案中，优选地，下行控制信令所在子帧位置加上位置偏移量确定第一偏移子帧，下行控制信令所在符号位置加上偏移量确定第一偏移符号，第一偏移子帧内的第一偏移符号即为第一发送时间起点位置。

[0155] 在该技术方案中，基站设备在指示终端设备确定专用numerology的子帧长度后，DCI(Downlink Control Information，下行控制信令)调度上下行信道发送资源时，需要给出发送资源的时间位置起点和时间长度，时间位置起点给出以DCI信令当前子帧位置为f的话，时间起点位置的子帧位置为f+k，DCI信令当前符号位置为z的话，时间起点位置的符号位置为z+1，同时给出发送时间长度：比如是一个子帧中的14个符号(或者要去除DCI信令占用的符号和gap时间以及HARQ反馈时间)，或一个slot即半个子帧的5个或6个符号，或一个mini-slot即2个符号左右，上述f、k和z均为整数。其中，上述f、k和z的指示也可以是使用bit序列来指示，但是bit序列与上述f、k和z的值的映射表必须预先存储在终端设备。

[0156] 其中，发送时间长度的取值为整数个符号，和/或整数个slot(每个slot包含多个符号)和/或整数个mini-slot(每个mini-slot包含多个符号)和/或整数个子帧。

[0157] 在上述技术方案中，优选地，发送下行数据的起始位置子帧或结束位置子帧加上偏移量确定第二偏移子帧，发送下行数据的起始位置符号或结束位置符号加上偏移量确定第二偏移符号，第二偏移子帧内的第二偏移符号即为第二发送时间起点位置。

[0158] 在该技术方案中，自包含的下行数据的发送子帧或者slot，需要给出相应的下行数据发送的HARQ反馈时间，同样给出子帧的偏移值，符号的偏移值，发送时长一般是默认值，不需要额外信令通知。

[0159] 在上述技术方案中，优选地，还包括：在终端设备确定reference numerology的子载波间隔并基于子载波间隔发送随机接入前导码后，接收并解析终端设备发送的随机接入前导码以实现终端设备的随机接入。

[0160] 如图7所示，根据本发明的实施例的reference numerology的子载波间隔的设置/确定装置700，包括：设置单元702，用于设置reference numerology的子载波间隔为15KHz的2^n倍，并告知至终端设备，以指示终端设备能够与基站设备进行同步通信的reference numerology的子载波间隔为15KHz的2^n倍，其中，n为大于或等于-2的整数。

[0161] 在该技术方案中，通过设置reference numerology的子载波间隔为15KHz的2^n倍，并告知至终端设备，以供终端设备确定能够与基站设备进行同步通信的reference numerology的子载波间隔为15KHz的2^n倍，其中，同步通信是指终端设备获得的数据帧的同步了帧同步和符号同步。

[0162] 其中，NR系统中子载波间隔的理论范围为3.75KHz～480KHz，而为了适应不同的通信业务的传输需求，基站设备可以根据通信业务的传输需求确定相应的子载波间隔，设置reference numerology的子载波间隔为15KHz的2^n倍，在执行通信业务的同时，告知终端设备进行同步通信的reference numerology的子载波间隔为15KHz的2^n倍，以保证终端设备和基站设备之间实现数据帧的同步、子帧同步和符号同步。

[0163] 在上述技术方案中，优选地，设置单元702还用于：给所有终端设备在同一个载波上配置相同的reference numerology的子载波间隔。

[0164] 在该技术方案中，同一个载波是指频点相同且带宽相同的一个载波。

[0165] 在上述技术方案中，优选地，设置单元702还用于：设置特定下行信号占用的子载波间隔为reference numerology，并设置发送特定下行信号的第一参考子帧，在第一参考子帧内以指定的子载波间隔发送特定下行信号，以指示终端设备能够与基站设备进行同步通信的reference numerology的子载波间隔即为特定下行信号传输的子载波间隔。

[0166] 在该技术方案中，通过在第一参考子帧内以指定的子载波间隔发送特定下行信号，以指示终端设备能够与基站设备进行同步通信的reference numerology的子载波间隔即为特定下行信号传输的子载波间隔。

[0167] 具体地，基于reference numerology的子载波间隔的隐式指示的方法，检测到特定下行信号的传输带宽为$(M\times N\times 15\times 2^{n})$KHz，其中，M为特定下行信号占用的RB的个数，N为每个RB包含的子载波的个数，这个M和N是终端设备的芯片中预存的，所以根据特定下行信号的传输带宽、M和N能获得reference numerology的子载波间隔。

[0168] 具体地，可以采用隐式指示的方式实现reference numerology的子载波间隔的设置/确定，比如LTE网络的小区搜索过程中，PSS(Primary Synchronization Signal，主同步信号)/SSS(Secondary Synchronization Signal，辅同步信号)信令的numerology的子载波间隔为15KHz，子帧时长为1ms。这时候基站设备设置PSS/SSS信令占用的带宽为72(M×N即6×12，每个RB包含12个子载波，PSS/SSS传输带宽为中心6个RB)个子载波的带宽，即1.08MHz，占用的时长为1个符号即1/14ms。那么当numerology为30KHz时，PSS/SSS信令还是占有带宽为72个子载波，带宽为2.16MHz，占用的时长为1个符号为0.5/14ms。

[0169] 依次类推，PSS/SSS信令占用的带宽为LTE中1.08MHz带宽的2^{n}倍时，reference numerology的子载波间隔即为15KHz的2^{n}倍。

[0170] 另外，NR系统中一个RB(Resource Block，资源块)可能会变成16个子载波，也就是说带宽是reference numerology的子载波间隔为15KHz的PSS/SSS信令的占用带宽(16/12)$\times 2^{n}$倍，reference numerology的子载波间隔即为15KHz的2^{n}倍，终端设备在确定循环前缀部分占用的时长和/或PSS/SSS信令占用的时长为LTE网络中1/14ms的$1/(2^{n})$时，确定reference numerology的子载波间隔即为15KHz的2^{n}倍。

[0171] 其中，特定下行信号为主同步信号/辅同步信号、参考信号、寻呼信号和系统信息中的一个或多个的任意组合。

[0172] 在上述技术方案中，优选地，还包括：第一发送单元704，用于向终端设备发送承载reference numerology的子载波间隔的系统信息，以指示终端设备能够与基站设备进行同步通信的reference numerology的子载波间隔即为系统信息中设置的子载波间隔。

[0173] 在该技术方案中，终端设备解析系统信息以确定通过系统信息显式指示的reference numerology的子载波间隔。

[0174] 其中，系统信息包括一个Master Information Block(MIB)和多个System Information Blocks(SIBs)。MIB使用一种固定的、具有40ms周期的调度方式，其中40ms周期内发送四次，第一次传输是安排在满足系统帧号SFN mod 4＝0的无线帧的子帧#0中，后面三次是在其他无线帧的子帧#0中重复发送。System Information Block Type1应用一种

固定的具有80ms周期的调度方式，其中80ms时间内发送四次。第一次传输是安排在满足系统帧号SFN mod 8=0的无线帧的子帧#5中，后面三次是在满足系统帧号SFN mod 2=0的其他无线帧的子帧#5中重复发送。

[0175] 值得特别指出的是，如果系统信息指示reference numerology的子载波间隔时，那么特定下行信号比如PSS/SSS的带宽就不一定必须是LTE中1.08MHz的2^n或$(16/12)\times 2^n$倍，PSS/SSS的发送时长也不一定是LTE中1/14ms的$1/(2^n)$了。

[0176] 在上述技术方案中，优选地，设置单元702还用于：根据载波的特征信息设置reference numerology的子载波间隔，并在该载波上发送特定下行信号，以供终端设备根据检测到的载波的特征信息、以及预存的载波特征信息与reference numerology的子载波间隔映射表来确定reference numerology的子载波间隔，其中，载波的特征信息包括载波频点和/或载波带宽。

[0177] 在该技术方案中，终端设备在检测到承载有特定下行信号的载波时，对载波的特征信息如载波频点和/或载波带宽进行解析，终端设备根据载波的特征信息、以及预存的载波特征信息与reference numerology的子载波间隔映射表来确定reference numerology的子载波间隔。

[0178] 在上述技术方案中，优选地，特定下行信号为主同步信号/辅同步信号、参考信号、寻呼信号和系统信息中的一个或多个的任意组合。

[0179] 在上述技术方案中，优选地，设置单元702还用于：给所有终端设备在同一个载波上配置不同的reference numerology的子载波间隔。

[0180] 在上述技术方案中，优选地，还包括：第二发送单元706，用于根据终端设备的设备类型和/或需要传输的业务类型向终端设备发送无线资源控制信令或下行控制信令，以通过无线资源控制信令或下行控制信令半静态地或动态地通知终端设备reference numerology的子载波间隔。

[0181] 在该技术方案中，通过无线资源控制信令或下行控制信令半静态地或动态地通知终端设备reference numerology的子载波间隔，例如：

[0182] (1)基站设备向特定的UE(User Equipment，终端设备)发送RRC(Radio Resource Control，无线资源控制)信令单独通知特定的UE可进行同步通信的reference numerology的子载波间隔，该reference numerology的子载波间隔可以是特定UE处于连接状态时第一个业务需要使用的reference numerology的子载波间隔。这个reference numerology的子载波间隔可以是半静态变化的，比如第一个业务还没结束时，又有第二个业务到达特定UE，那么特定UE继续使用第一个业务的numerology为第二个业务的reference numerology。但是如果第一个业务结束了之后，第二个业务才到达特定UE，那么基站设备可以再次发送用于指示reference numerology的子载波间隔的RRC信令，以定义第二个业务的numerology为该用户的reference numerology，也可以使用随机接入反馈信令来指示reference numerology。

[0183] (2)根据UE的通信能力或UE类型来定义reference numerology的子载波间隔，比如有些UE就是MTC终端，那么这些终端的reference numerology就直接将执行MTC业务时的numerology写入到这些终端的芯片中，比如3.75KHz。又如其它支持eMBB业务和URLLC业务的终端，使用LTE的15KHz为reference numerology或者更高的30KHz或60KHz为reference

numerology，reference numerology的子载波间隔的指示方法可以直接是写入UE的硬件芯片，不需要信令通知，或者系统信息通知。

[0184] 在上述技术方案中，优选地，设置单元702还用于：在终端设备确定能够与基站设备进行同步通信的reference numerology的子载波间隔后，设置终端设备的专用numerology的子载波间隔，并根据专用numerology的子载波间隔设置第二参考子帧，以供终端设备根据专用numerology的子载波间隔和第二参考子帧进行上下行数据收发。

[0185] 在该技术方案中，通过在终端设备确定能够与基站设备进行同步通信的reference numerology的子载波间隔后，设置终端设备的专用numerology的子载波间隔，以供终端设备发送或接收SRS(Sounding Reference Signals，探测参考信号)，或基于专用numerology的子载波间隔接入于各个通信信道，如PRACH(Physical Random Access Channel，随机接入信道)、PDCCH(Physical Downlink Control Channel，下行物理控制信道)、PDSCH(Physical Downlink Shared Channel，下行物理共享信道)、PUCCH(Physical Uplink Control Channel，上行物理控制信道)和PUSCH(Physical Uplink Control Channel，上行物理共享信道)等。

[0186] 其中，专用numerology的子载波间隔可以是基于用户业务类型来配置的。

[0187] 在上述技术方案中，优选地，专用numerology的子载波间隔的设置信息为专用numerology的子载波间隔与终端的reference numerology的子载波间隔之间的相对比值，以供终端设备根据相对比值以及reference numerology的子载波间隔确定专用numerology的子载波间隔；或专用numerology的子载波间隔的设置信息为专用numerology的子载波间隔的绝对值。

[0188] 在该技术方案中，终端设备在确定Reference numerology的子载波间隔后，基站设备再给终端设备根据业务类型配置专用numerology时，RRC信令或下行控制信令只需给出当前专用numerology子载波间隔/reference numerology子载波间隔的值，该值为2^m，m为负整数，0和正整数。

[0189] 专用numerology的子载波间隔和子帧长度也可以在随机接入过程Msg.4中或者其它时候的RRC信令中给出。

[0190] 在上述技术方案中，优选地，还包括：第三发送单元708，用于根据专用numerology的子载波间隔以及第二参考子帧，对终端设备进行上下行时频资源分配并向终端设备发送相应的下行控制信令，其中，下行控制信令用于设置终端设备通过物理下行共享信道和/或物理上行共享信道进行数据发送的第一发送时间起点位置和发送时间长度。

[0191] 在上述技术方案中，优选地，第二参考子帧为自包含的下行数据的发送子帧时，下行控制信令还用于设置终端设备接收到的下行数据所对应的混合自动重传业务的反馈信息的第二发送时间起点位置。

[0192] 在上述技术方案中，优选地，下行控制信令所在子帧位置加上位置偏移量确定第一偏移子帧，下行控制信令所在符号位置加上偏移量确定第一偏移符号，第一偏移子帧内的第一偏移符号即为第一发送时间起点位置。

[0193] 在该技术方案中，基站设备在指示终端设备确定专用numerology的子帧长度后，DCI(Downlink Control Information，下行控制信令)调度上下行信道发送资源时，需要给出发送资源的时间位置起点和时间长度，时间位置起点给出以DCI信令当前子帧位置为f的

话，时间起点位置的子帧位置为f+k，DCI信令当前符号位置为z的话，时间起点位置的符号位置为z+1，同时给出发送时间长度：如图11和图12所示，比如是一个子帧中的14个符号（或者要去除DCI信令占用的符号和gap时间以及HARQ反馈时间），如图13和图14所示，或一个slot即半个子帧的5个或6个符号，或一个mini-slot即2个符号左右，上述f、k和z均为整数。另外，上述f、k和z的指示也可以是使用bit序列来指示，但是bit序列与上述f、k和z的值的映射表必须预先存储在终端设备。

[0194] 其中，发送时间长度的取值为整数个符号，和/或整数个slot（每个slot包含多个符号）和/或整数个mini-slot（每个mini-slot包含多个符号）和/或整数个子帧。

[0195] 在上述技术方案中，优选地，发送下行数据的起始位置子帧或结束位置子帧加上偏移量确定第二偏移子帧，发送下行数据的起始位置符号或结束位置符号加上偏移量确定第二偏移符号，第二偏移子帧内的第二偏移符号即为第二发送时间起点位置。

[0196] 在该技术方案中，包含的下行数据的发送子帧或者slot，需要给出相应的下行数据发送的HARQ反馈时间，同样给出子帧的偏移值，符号的偏移值，发送时长一般是默认值，不需要额外信令通知。

[0197] 在上述技术方案中，优选地，还包括：接入单元710，用于在终端设备确定reference numerology的子载波间隔基于子载波间隔发送随机接入前导码后，接收并解析终端设备发送的随机接入前导码以实现终端设备的随机接入。

[0198] 如图8所示，根据本发明的实施例的基站设备800，包括：如上述第二方面中的任一项技术方案所述的reference numerology的子载波间隔的设置/确定装置700。

[0199] 适用于终端设备侧的实施例：

[0200] 根据本发明的实施例的reference numerology的子载波间隔的设置/确定方法，包括：获取基站在第一参考子帧内以指定的子载波间隔发送的特定下行信号；确定用于传输特定下行信号的传输带宽，以及传输带宽对应的预存的参数M和N，其中，M为特定下行信号占用的资源块个数，N为每个资源块包含的子载波个数数据；确定传输带宽除以M再除以N之后的商值，商值即为特定下行信号传输的子载波间隔，也即能够与基站设备进行同步通信的reference numerology的子载波间隔。

[0201] 在该技术方案中，终端设备基于reference numerology的子载波间隔的隐式指示的方法，检测到特定下行信号的传输带宽为$(M\times N\times 15\times 2^{n})$KHz，其中，M为特定下行信号占用的RB的个数，N为每个RB包含的子载波的个数，这个M和N是终端设备的芯片中预存的，所以根据特定下行信号的传输带宽、M和N能获得reference numerology的子载波间隔。

[0202] 在上述技术方案中，优选地，特定下行信号为主同步信号/辅同步信号、参考信号、寻呼信号和系统信息中的一个或多个的任意组合。

[0203] 如图9所示，根据本发明的实施例的reference numerology的子载波间隔的设置/确定装置900，包括：获取单元902，用于获取基站在第一参考子帧内以指定的子载波间隔发送的特定下行信号；确定单元904，用于确定用于传输特定下行信号的传输带宽，以及传输带宽对应的预存的参数M和N，其中，M为特定下行信号占用的资源块个数，N为每个资源块包含的子载波个数数据；确定单元904还用于：确定传输带宽除以M再除以N之后的商值，商值即为特定下行信号传输的子载波间隔，也即能够与基站设备进行同步通信的reference numerology的子载波间隔。

[0204] 在该技术方案中，终端设备基于reference numerology的子载波间隔的隐式指示的方法，检测到特定下行信号的传输带宽为$(M\times N\times 15\times 2^{m})$KHz，其中，M为特定下行信号占用的RB的个数，N为每个RB包含的子载波的个数，这个M和N是终端设备的芯片中预存的，所以根据特定下行信号的传输带宽、M和N能获得reference numerology的子载波间隔。

[0205] 在上述技术方案中，优选地，特定下行信号为主同步信号/辅同步信号、参考信号、寻呼信号和系统信息中的一个或多个的任意组合。

[0206] 如图10所示，根据本发明的实施例的终端设备1000，包括：如上述第五方面中的任一项技术方案所述的reference numerology的子载波间隔的设置/确定装置900，其中，终端设备1000与第二方面中的任一项技术方案所述的reference numerology的子载波间隔的设置/确定装置700进行同步通信，以确定与第三方面的基站设备800进行同步通信的reference numerology的子载波间隔。

[0207] 以上结合附图详细说明了本发明的技术方案，考虑到如何在统一的空口框架下针对不同的用户设置和/或确定reference numerology的子载波间隔的核心技术问题。因此，本发明提出了一种reference numerology的子载波间隔的设置/确定方案，通过特定下行信号占用的子载波间隔或显式指示信息、或载波的特征信息、或专用numerology、或终端设备的设备类型和/或需要传输的业务类型来指示终端设备reference numerology的子载波间隔，使得终端设备可以获知上下行信道、上下行信号和数据的时频资源粒度，以提高与基站设备的同步通信的准确度和可靠度。

[0208] 以上所述仅为本发明的优选实施例而已，并不用于限制本发明，对于本领域的技术人员来说，本发明可以有各种更改和变化。凡在本发明的精神和原则之内，所作的任何修改、等同替换、改进等，均应包含在本发明的保护范围之内。

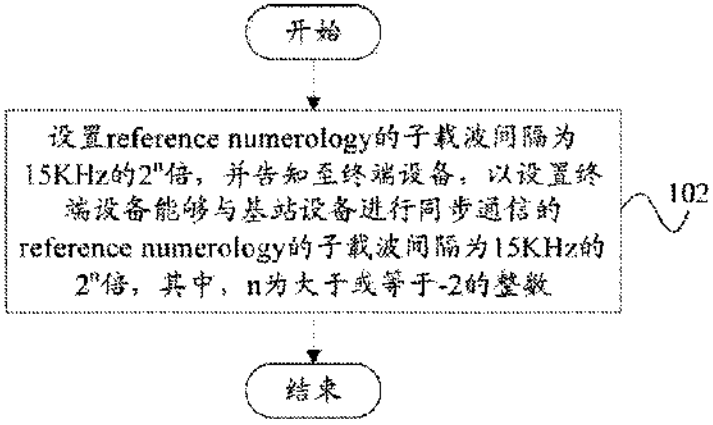

开始
设置reference numerology的子载波间隔为15KHz的2^n倍，并告知至终端设备，以设置终端设备能够与基站设备进行同步通信的reference numerology的子载波间隔为15KHz的2^n倍，其中，n为大于或等于-2的整数
102
结束

图1

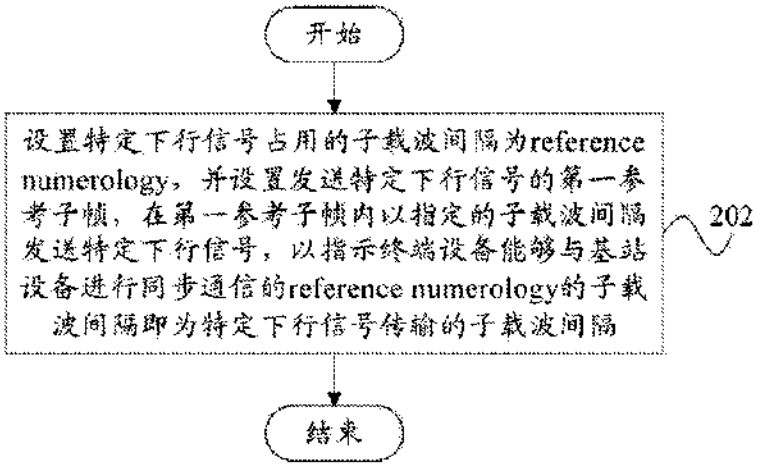

开始
设置特定下行信号占用的子载波间隔为reference numerology，并设置发送特定下行信号的第一参考子帧，在第一参考子帧内以指定的子载波间隔发送特定下行信号，以指示终端设备能够与基站设备进行同步通信的reference numerology的子载波间隔即为特定下行信号传输的子载波间隔
202
结束

图2

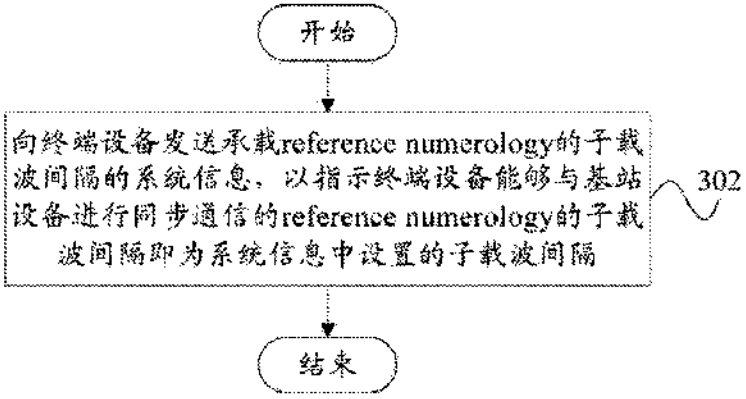

开始
向终端设备发送承载reference numerology的子载波间隔的系统信息，以指示终端设备能够与基站设备进行同步通信的reference numerology的子载波间隔即为系统信息中设置的子载波间隔
302
结束

图3

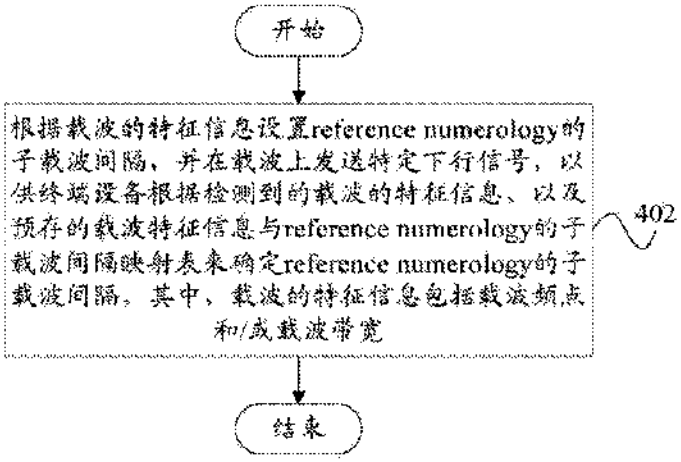

开始
根据载波的特征信息设置reference numerology的子载波间隔，并在载波上发送特定下行信号，以供终端设备根据检测到的载波的特征信息、以及预存的载波特征信息与reference numerology的子载波间隔映射表来确定reference numerology的子载波间隔。其中，载波的特征信息包括载波频点和/或载波带宽
402
结束

图4

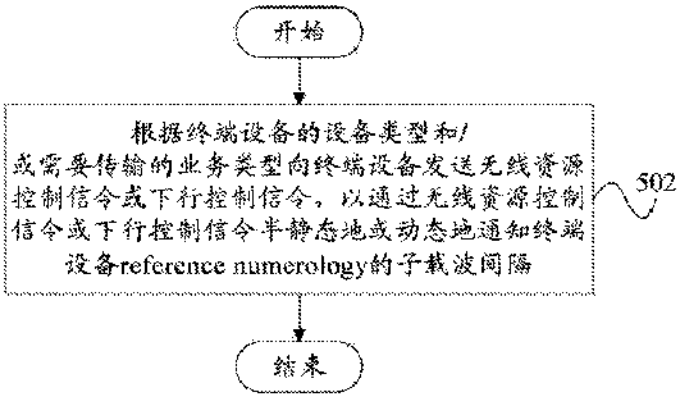

开始
根据终端设备的设备类型和/或需要传输的业务类型向终端设备发送无线资源控制信令或下行控制信令，以通过无线资源控制信令或下行控制信令半静态地或动态地通知终端设备reference numerology的子载波间隔
502
结束

图5

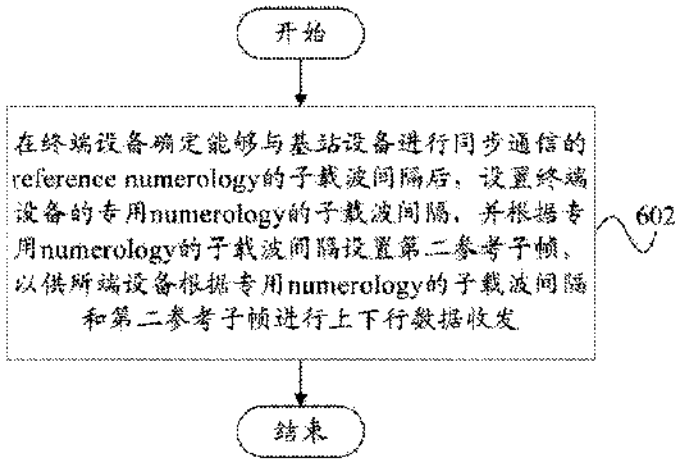

开始
在终端设备确定能够与基站设备进行同步通信的reference numerology的子载波间隔后，设置终端设备的专用numerology的子载波间隔，并根据专用numerology的子载波间隔设置第二参考子帧，以供所述设备根据专用numerology的子载波间隔和第二参考子帧进行上下行数据收发
602
结束

图6

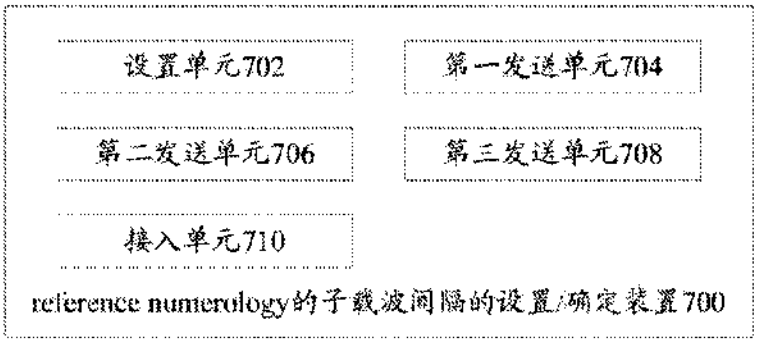

设置单元702
第一发送单元704
第二发送单元706
第三发送单元708
接入单元710
reference numerology的子载波间隔的设置/确定装置700

图7

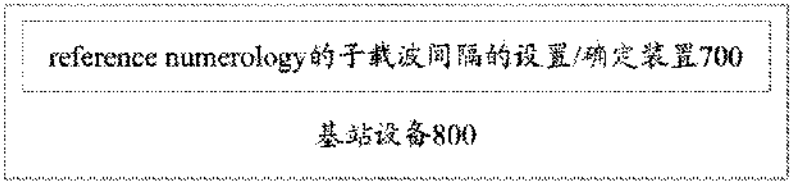

reference numerology的子载波间隔的设置/确定装置700
基站设备800

图8

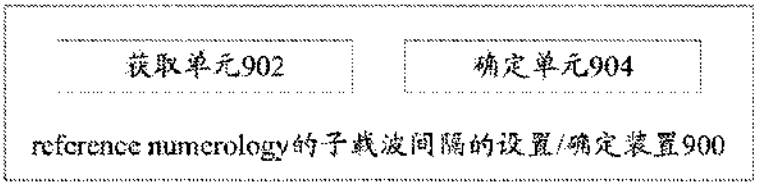

获取单元902
确定单元904
reference numerology的子载波间隔的设置/确定装置900

图9


reference numerology的子载波间隔的设置/确定装置900
终端设备1000

图10

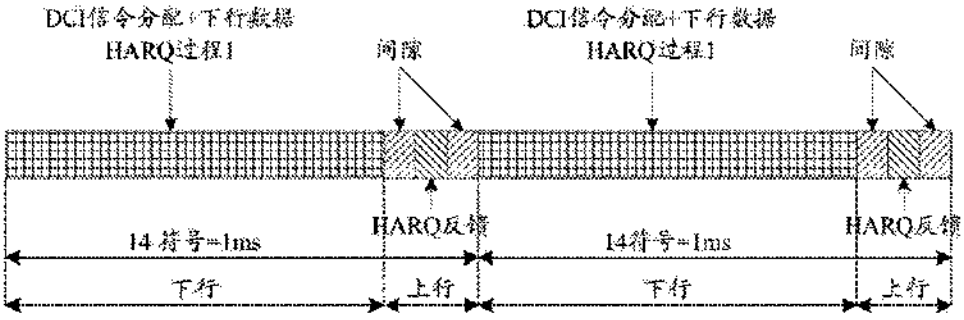

DCI信令分配+下行数据
HARQ过程1
间隙
DCI信令分配+下行数据
HARQ过程1
间隙
HARQ反馈
HARQ反馈
14符号=1ms
14符号=1ms
下行
上行
下行
上行

图11

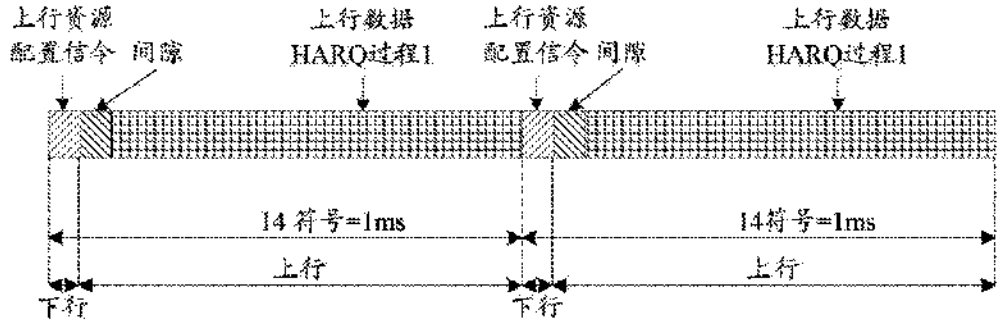

上行资源
配置信令
间隙
上行数据
HARQ过程1
上行资源
配置信令
间隙
上行数据
HARQ过程1
14 符号=1ms
14符号=1ms
上行
上行
下行
下行

图12

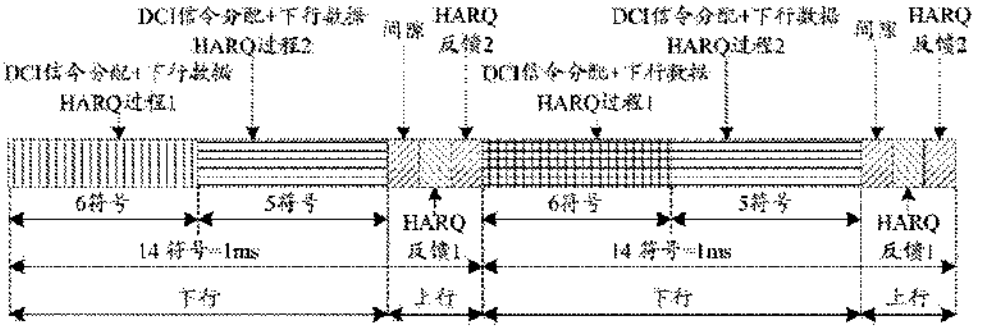

DCI信令分配+下行数据
HARQ过程2
间隙
HARQ
反馈2
DCI信令分配+下行数据
HARQ过程2
间隙
HARQ
反馈2
DCI信令分配+下行数据
HARQ过程1
DCI信令分配+下行数据
HARQ过程1
6符号
5符号
6符号
5符号
HARQ
反馈1
HARQ
反馈1
14 符号=1ms
14 符号=1ms
下行
上行
下行
上行

图13

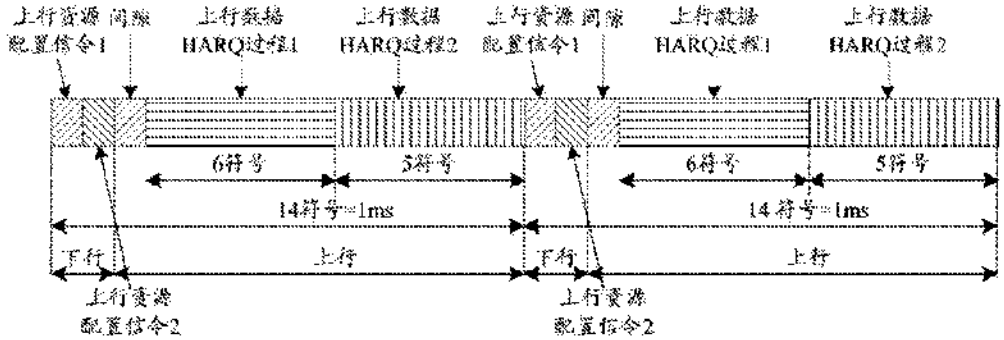

上行资源 间隙
配置信令1
上行数据
HARQ过程1
上行数据
HARQ过程2
上行资源 间隙
配置信令1
上行数据
HARQ过程1
上行数据
HARQ过程2
6符号
5符号
6符号
5符号
14符号=1ms
14 符号=1ms
下行
上行
下行
上行
上行资源
配置信令2
上行资源
配置信令2

图14

Espacenet

CN105979597A Communication resource distribution method, communication resource distribution device, base station and terminal

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Inventors: LI MINGJU,ZHU YAJUN,ZHANG YUNFEI

Classifications:

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CPC **H04L1/1819 (US); H04L5/0064 (EP); H04W4/70 (US); H04W72/0446 (CN,US); H04W72/0453 (CN,US); H04W72/1263 (US); H04W72/23 (US); H04W72/53 (CN); H04W72/543 (EP); H04W76/27 (US); H04W88/02 (CN); H04W88/06 (CN);** H04L67/12 (EP); H04W4/70 (EP); H04W72/044 (EP);

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Application: CN201610482642A·2016-06-27

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Published as: CN105979597A;**CN105979597B; US11129178B2; US2019320450A1; WO2018000712A1**

Communication resource distribution method, communication resource distribution device, base station and terminal

Abstract

The invention provides a communication resource distribution method, a communication resource distribution device, a base station and a terminal, wherein the communication resource distribution method comprises the following steps of determining the service type of a current service when service loading is established; according to the service type of the current service, determining granularity information of time-frequency resources and a frequency domain resource range for the service type; and sending the granularity information of the time-frequency resource and the frequency domain resource range for the service type to the terminal requesting for establishing the service loading. By means of the technical scheme, for different types of services, the granularity of the time-frequency resources and the frequency domain resource range are adjusted flexibly and correspondingly; resource scheduling can be flexibly suitable for different service types; and the resource use rate is increased easily.

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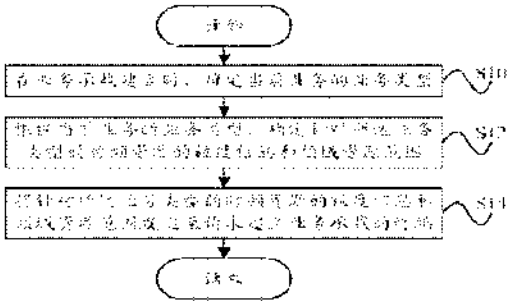
权利要求书 3 页 说明书 10 页 附图 3 页

(54)发明名称

通信资源的分配方法、分配装置、基站和终端

(57)摘要

本发明提供了一种通信资源的分配方法、分配装置、基站和终端，其中，通信资源的分配方法，包括：在业务发起建立时，确定当前业务的业务类型；根据所述当前业务的业务类型，确定针对所述业务类型的时频资源的粒度信息和频域资源范围；将针对所述业务类型的时频资源的粒度信息和频域资源范围发送至请求建立所述业务的终端。本发明的技术方案使得能够针对不同类型的业务，灵活地对时频资源的粒度和频域资源范围进行相应的调整，实现了资源调度能够灵活地适应不同的业务类型，有利于提高资源使用率。



1.一种通信资源的分配方法，其特征在于，包括：

在业务承载建立时，确定当前业务的业务类型；

根据所述当前业务的业务类型，确定针对所述业务类型的时频资源的粒度信息和域域资源范围；

将针对所述业务类型的时频资源的粒度信息和域域资源范围发送至请求建立所述业务承载的终端。

2.根据权利要求1所述的通信资源的分配方法，其特征在于，根据所述当前业务的业务类型，确定针对所述业务类型的时频资源的粒度信息和域域资源范围的步骤，具体包括：

在所述当前业务为LTE业务时，确定时域资源的粒度为1ms、频域资源的粒度为15KHz，频域资源范围为整个带宽的全部或部分范围。

3.根据权利要求1所述的通信资源的分配方法，其特征在于，根据所述当前业务的业务类型，确定针对所述业务类型的时频资源的粒度信息和域域资源范围的步骤，具体包括：

在所述当前业务为eMBB业务时，确定时域资源的粒度为T_1、频域资源的粒度为F_1、频域资源范围为整个带宽的全部或部分范围。

其中，$T_1<1ms$，$F_1\geq 15KHz$。

4.根据权利要求1所述的通信资源的分配方法，其特征在于，根据所述当前业务的业务类型，确定针对所述业务类型的时频资源的粒度信息和域域资源范围的步骤，具体包括：

在所述当前业务为mMTC业务时，确定时域资源的粒度为T_2、频域资源的粒度为F_2、频域资源范围为整个带宽的部分范围。

其中，$T_2\geq 1ms$，$F_2<15KHz$。

5.根据权利要求1所述的通信资源的分配方法，其特征在于，根据所述当前业务的业务类型，确定针对所述业务类型的时频资源的粒度信息和域域资源范围的步骤，具体包括：

在所述当前业务为URLLC业务时，确定时域资源的粒度为T_3、频域资源的粒度为F_3、频域资源范围为整个带宽的部分范围。

其中，$T_3<1ms$，$F_3\geq 15KHz$。

6.根据权利要求1所述的通信资源的分配方法，其特征在于，将针对所述业务类型的时频资源的粒度信息和域域资源范围发送至请求建立所述业务承载的终端的步骤，具体包括：

将整个带宽划分为带宽相等的多个频域资源范围，并向所述终端指示针对所述业务类型的频域资源范围在所述整个带宽上的起始点；或

将整个带宽划分为带宽不等的多个频域资源范围，并向所述终端指示针对所述业务类型的频域资源范围在所述整个带宽上的起始点和带宽大小，或向所述终端指示针对所述业务类型的频域资源范围在所述整个带宽上的起始点和终点。

7.根据权利要求6所述的通信资源的分配方法，其特征在于，所述多个频域资源范围不重叠或部分重叠。

8.根据权利要求1所述的通信资源的分配方法，其特征在于，所述域域资源范围包括用于传输参考信号的第一频域范围和用于传输数据的第二频域范围，其中，所述第一频域范围和所述第二频域范围不重叠、部分重叠或全部重叠。

9.根据权利要求1至8中任一项所述的通信资源的分配方法，其特征在于，通过RRC信令

将针对所述业务类型的时频资源的粒度信息和频域资源范围发送至请求建立所述业务承载的终端。

10.根据权利要求1至8中任一项所述的通信资源的分配方法，其特征在于，还包括：

通过DCI信令指示所述终端在处理所述当前业务时被调度分配使用的资源块信息，所述资源块信息中包含有在针对所述业务类型的频域资源范围中选取的频域资源。

11.一种通信资源的分配方法，其特征在于，包括：

接收基站发送的第一信令和第二信令；

根据所述第一信令获取所述基站根据当前业务的业务类型确定的时频资源的粒度信息和频域资源范围，并根据所述第二信令获取所述基站在所述频域资源范围内选取且分配的频域资源；

根据所述时频资源的粒度信息和所述频域资源，确定所述基站分配的用于处理所述当前业务的资源块信息；

基于所述资源块信息处理所述当前业务。

12.根据权利要求11所述的通信资源的分配方法，其特征在于，所述第一信令为RRC信令，所述第二信令为DCI信令

13.一种通信资源的分配装置，其特征在于，包括：

第一确定单元，用于在业务承载建立时，确定当前业务的业务类型；

第二确定单元，用于根据所述第一确定单元确定的所述当前业务的业务类型，确定针对所述业务类型的时频资源的粒度信息和频域资源范围；

发送单元，用于将所述第二确定单元确定的针对所述业务类型的时频资源的粒度信息和频域资源范围发送至请求建立所述业务承载的终端。

14.根据权利要求13所述的通信资源的分配装置，其特征在于，所述第二确定单元具体用于：

在所述当前业务为LTE业务时，确定时域资源的粒度为1ms、频域资源的粒度为15KHz、频域资源范围为整个带宽的全部或部分范围；

在所述当前业务为eMBB业务时，确定时域资源的粒度为T_1、频域资源的粒度为F_1、频域资源范围为整个带宽的全部或部分范围，其中，$T_1 \leq 1ms$，$F_1 \geq 15KHz$；

在所述当前业务为mMTC业务时，确定时域资源的粒度为T_2、频域资源的粒度为F_2、频域资源范围为整个带宽的部分范围，其中，$T_2 \geq 1ms$，$F_2 \leq 15KHz$；

在所述当前业务为URLLC业务时，确定时域资源的粒度为T_3、频域资源的粒度为F_3、频域资源范围为整个带宽的部分范围，其中，$T_3 \leq 1ms$，$F_3 \geq 15KHz$。

15.根据权利要求13所述的通信资源的分配装置，其特征在于，所述发送单元具体用于：

将整个带宽划分为带宽相等的多个频域资源范围，并向所述终端指示针对所述业务类型的频域资源范围在所述整个带宽上的起始点；或

将整个带宽划分为带宽不等的多个频域资源范围，并向所述终端指示针对所述业务类型的频域资源范围在所述整个带宽上的起始点和带宽大小；或向所述终端指示针对所述业务类型的频域资源范围在所述整个带宽上的起始点和终点。

16.根据权利要求15所述的通信资源的分配装置，其特征在于，所述多个频域资源范围

不重合或部分重合。

17.根据权利要求13所述的通信资源的分配装置，其特征在于，所述频域资源范围包括用于传输参考信号的第一频域范围和用于传输数据的第二频域范围，其中，所述第一频域范围和所述第二频域范围不重合、部分重合或全部重合。

18.根据权利要求13至17中任一项所述的通信资源的分配装置，其特征在于，所述发送单元还用于：

通过DCI信令指示所述终端在处理所述当前业务时被调度分配使用的资源块信息，所述资源块信息中包含有在针对所述业务类型的频域资源范围中选取的频域资源。

19.一种通信资源的分配装置，其特征在于，包括：

接收单元，用于接收基站发送的第一信令和第二信令；

获取单元，用于根据所述第一信令获取所述基站根据当前业务的业务类型确定的时频资源的粒度信息和频域资源范围，并根据所述第二信令获取所述基站在所述频域资源范围内选取并分配的频域资源；

确定单元，用于根据所述时频资源的粒度信息和所述频域资源，确定所述基站分配的用于处理所述当前业务的资源块信息；

处理单元，用于基于所述资源块信息处理所述当前业务。

20.根据权利要求19所述的通信资源的分配装置，其特征在于，所述第一信令为RRC信令，所述第二信令为DCI信令。

21.一种基站，其特征在于，包括：如权利要求13至18中任一项所述的通信资源的分配装置。

22.一种终端，其特征在于，包括：如权利要求19或20所述的通信资源的分配装置。

通信资源的分配方法、分配装置、基站和终端

技术领域

[0001] 本发明涉及通信技术领域，具体而言，涉及一种通信资源的分配方法、一种通信资源的分配装置、一种基站和一种终端。

背景技术

[0002] 现有的4G以及1.5G移动通信技术，都是基于LTE(Long Term Evolution，长期演进)及LTE-A(LTE-Advanced)的无线接入技术、时频资源粒度和帧结构等，比如目前LTE系统能支持的最大单载波带宽为20MHz，暂未支持更大带宽，只能依靠载波聚合(Carrier Aggregation，简称CA)的使用。另外，目前的帧结构主要包括：FDD(Frequency Division Duplexing，频分双工)帧结构、TDD(Time Division Duplexing，时分双工)帧结构和LAA(LTE Assisted Access，LTE辅助接入)非授权载波使用的动态帧结构。不管是哪种帧结构，都包含10个子帧，每个子帧为1ms，每个子帧包含两个slot(时隙)，一个slot为0.5ms，每个slot又包含7个symbol(符号)。频域方面，在LTE系统中，子载波间距主要是15KHz，一个RB(Resource Block，资源块)包含了12个子载波。而在NB-IoT(Narrow Band Internet of Things，基于蜂窝的窄带物联网)R13又提出一种新的3.75KHz的子载波间隔，而且NB-IoT的载波带宽仅有180KHz。

[0003] 在资源分配方面，FDD帧结构和TDD帧结构都是以1ms子帧为时域调度粒度，除了TDD帧结构中的特殊子帧内的DwPTS(Down Link Pilot Time Slot，下行导频时隙)用于传输数据时，时域调度粒度是小于1ms的，同样在LAA非授权载波使用的帧结构中也出现了复用DwPTS作为partial subframe的下行调度时域粒度，同时也使用了1ms整子帧的调度粒度。而在FDD帧结构和TDD帧结构中，除了TDD帧结构中的特殊子帧既有下行发送和上行发送外，其它的子帧都是上行或下行要么时域分开要么频域分开。在LAA非授权载波使用的帧结构中的partial subframe内也会出现同一个子帧前半部分用于下行传输后半部分用于上行传输。

[0004] 另外，在上行调度方面，LTE系统上行发送的UL grant(上行调度指令)和它所传输上行数据的子帧之间的时间间隔一般在4ms，而HARQ(Hybrid Automatic Repeat Request，混合自动重传请求)ACK/NACK反馈一般是在相应的数据发送之后的4ms及以上时间才能发送。

[0005] 可见，目前的帧结构和频域资源的粒度都会使得资源分配不够灵活，而上行调度机制与HARQ反馈机制等的时间间隔又使得时延较大，20MHz带宽很不满足高带宽需求。

[0006] 未来5G通信主要场景包括以下三种：eMBB(Enhanced Mobile Broadband，增强的移动宽带网络)，mMTC(Massive Machine Type Communication，大规模机器类通讯)和URLLC(Ultra Reliable and Low Latency Communications，高可靠低时延通信)。而这三种场景所针对的业务类型不一样，其需求也不一样，比如：eMBB业务的两个主要指标是高带宽和低时延，在未来的5G通信中，eMBB业务可能支持100MHz的大带宽，而且要可能某个时刻整个带宽都直接分配给一个用户使用，而上行调度时延和HARQ反馈时延也会带来时延影响；

mMTC业务需要的是窄带服务，需要电池寿命很长，这种业务就需要更小粒度的频域和更宽粒度的时域资源；对于URLLC业务，也需要减少上行调度时延和HARQ反馈时延带来的时延影响。

[0007] 也就是说由于业务的多样化，使得目前固定的帧结构、固定的频域资源粒度和时域资源粒度会造成较大的上行调度时延和较长的HARQ反馈时延，并且较小的载波带宽也无法满足业务的多样化需求，上述这些都是亟待解决的技术问题。

发明内容

[0008] 本发明正是基于上述技术问题至少之一，提出了一种新的通信资源的分配方案，使得能够针对不同类型的业务，灵活地对时频资源的粒度和频域资源范围进行相应的调整，实现了资源调度能够灵活地适应不同的业务类型，有利于提高资源使用率。

[0009] 有鉴于此，根据本发明的第一方面，提出了一种通信资源的分配方法，包括：在业务承载建立时，确定当前业务的业务类型；根据所述当前业务的业务类型，确定针对所述业务类型的时频资源的粒度信息和频域资源范围；将针对所述业务类型的时频资源的粒度信息和频域资源范围发送至请求建立所述业务承载的终端。

[0010] 在该技术方案中，通过确定当前业务的业务类型，并确定针对该业务类型的时频资源的粒度信息和频域资源范围，并将确定的时频资源的粒度信息和频域资源范围发送至请求建立业务承载的终端，使得能够针对不同类型的业务，灵活地对时频资源的粒度和频域资源范围进行相应的调整，进而能够避免采用固定的时频资源粒度而造成较大的上行调度时延和较长的HARQ反馈时延，同时也能够避免采用较小的频域资源范围(载波带宽)而无法满足5G通信场景中的业务需求，实现了资源调度能够灵活地适应不同的业务类型，有利于提高资源使用率。

[0011] 其中，时频资源的粒度信息包括频域资源的粒度和时域资源的粒度，频域资源的粒度用为子载波间隔(subcarrier spacing)，时域资源的粒度用为传输时间间隔(Transmission Time Interval，简称TTI)。

[0012] 在上述技术方案中，优选地，根据所述当前业务的业务类型，确定针对所述业务类型的时频资源的粒度信息和频域资源范围的步骤，具体包括：在所述当前业务为URLLC业务时，确定时域资源的粒度为1ms、频域资源的粒度为15KHz、频域资源范围为整个带宽的全部或部分范围。

[0013] 在上述任一技术方案中，优选地，根据所述当前业务的业务类型，确定针对所述业务类型的时频资源的粒度信息和频域资源范围的步骤，具体包括：在所述当前业务为eMBB业务时，确定时域资源的粒度为T_1、频域资源的粒度为F_1、频域资源范围为整个带宽的全部或部分范围，其中，$T_1 \leq 1ms$，$F_1 \geq 15KHz$。

[0014] 在该技术方案中，由于eMBB业务的主要指标是高带宽和低时延，为了满足eMBB业务的需求，其频域资源的粒度要大于URLLC业务的时域资源的粒度，即大于15KHz，其时域资源的粒度要小于或等于URLLC业务的时域资源的粒度，即小于或等于1ms。

[0015] 在上述任一技术方案中，优选地，根据所述当前业务的业务类型，确定针对所述业务类型的时频资源的粒度信息和频域资源范围的步骤，具体包括：在所述当前业务为mMTC业务时，确定时域资源的粒度为T_2、频域资源的粒度为F_2、频域资源范围为整个带宽的部分

范围，其中，T_1≥1ms，F_1≥15KHz。

[0016] 在该技术方案中，由于mMTC业务需要的是窄带服务，需要电池寿命很长，这种业务就需要更小粒度的频域和更宽粒度的时域资源，因此其频域资源的粒度要小于或等于LTE业务的时域资源的粒度，即小于或等于15KHz，其时域资源的粒度要大于或等于LTE业务的时域资源的粒度，即大于或等于1ms。

[0017] 在上述任一技术方案中，优选地，根据所述当前业务的业务类型，确定针对所述业务类型的时频资源的粒度信息和频域资源范围的步骤，具体包括：在所述当前业务为URLLC业务时，确定时域资源的粒度为T_2，频域资源的粒度为F_2，频域资源范围为整个带宽的部分范围，其中，T_2<1ms，F_2≥15KHz。

[0018] 在该技术方案中，由于URLLC业务是高可靠低时延业务，需要减少上行调度时延和HARQ反馈时延带来的时延影响，因此为了满足URLLC业务的需求，其频域资源的粒度要大于或等于LTE业务的时域资源的粒度，即大于或等于15KHz，其时域资源的粒度要远小于LTE业务的时域资源的粒度，即远小于1ms。

[0019] 在本发明的一个实施例中，还针对所述业务类型的时频资源的粒度信息和频域资源范围发送至请求建立所述业务承载的终端的步骤，具体包括：将整个带宽划分为带宽相等的多个频域资源范围，并向所述终端指示针对所述业务类型的频域资源范围在所述整个带宽上的起始点，其中，所述多个频域资源范围不重叠或部分重叠。

[0020] 在该实施例中，由于整个带宽已经被划分为带宽相等的多个频域资源范围，因此基站在向终端指示针对业务类型的频域资源范围时仅需指示起始点即可，进而终端能够根据起始点和在整个带宽上划分的每个频域资源范围的带宽来确定针对业务类型的频域资源范围。

[0021] 在本发明的另一个实施例中，还针对所述业务类型的时频资源的粒度信息和频域资源范围发送至请求建立所述业务承载的终端的步骤，具体包括：将整个带宽划分为带宽不等的多个频域资源范围，并向所述终端指示针对所述业务类型的频域资源范围在所述整个带宽上的起始点和带宽大小，或向所述终端指示针对所述业务类型的频域资源范围在所述整个带宽上的起始点和终点，其中，所述多个频域资源范围不重叠或部分重叠。

[0022] 在该实施例中，由于整个带宽被划分为带宽不等的多个频域资源范围，因此基站在向终端指示针对业务类型的频域资源范围时需要指示该频域范围在整个带宽上的起始点和带宽大小，或指示其在整个带宽上的起始点和终点。其中，当向终端指示针对业务类型的频域资源范围在整个带宽上的起始点和终点时，既可以向终端指示整个带宽上连续的多个资源块，也可以指示不连续的多个资源块。

[0023] 在上述任一技术方案中，优选地，所述频域资源范围包括用于传输参考信号的第一频域范围和用于传输数据的第二频域范围，其中，所述第一频域范围和所述第二频域范围全重叠、部分重叠或全部重叠。

[0024] 在该技术方案中，基站向终端指示的针对业务类型的频域资源范围包含了用于传输参考信号的频域范围(即第一频域范围)和用于传输数据的频域范围(即第二频域范围)，这两个频域范围既可以不重叠，也可以部分重叠，还可以全部重叠。其中，所述的参考信号主要是用于同步和RRM(Radio Resource Management，无线资源管理)测量的参考信号。

[0025] 在上述任一技术方案中，优选地，通过RRC(Radio Resource Control，无线资源控

息)信令或针对所述业务类型的时频资源的粒度信息和频域资源范围发送至请求建立所述业务承载的终端。

[0026] 在上述技术方案中，优选地，还包括：通过DCI(Downlink Control Information，下行控制信息)信令指示所述终端在处理所述当前业务时被调度分配使用的资源块信息，所述资源块信息中包含有在针对所述业务类型的频域资源范围中选取的频域资源。

[0027] 根据本发明的第二方面，还提出了一种通信资源的分配方法，包括：接收基站发送的第一信令和第二信令；根据所述第一信令获取所述基站根据当前业务的业务类型确定的时频资源的粒度信息和频域资源范围，并根据所述第二信令获取所述基站在所述频域资源范围内选取并分配的频域资源；根据所述时频资源的粒度信息和所述频域资源，确定所述基站分配的用于处理所述当前业务的资源块信息；基于所述资源块信息处理所述当前业务。

[0028] 在该技术方案中，通过根据第一信令获取基站根据当前业务的业务类型确定的时频资源的粒度信息和频域资源范围，使得能够针对不同类型的业务，灵活地对时频资源的粒度和频域资源范围进行相应的调整，进而能够避免采用固定的时频资源粒度而造成较大的下行调度时延和较长的HARQ反馈时延，同时也能够避免采用较小的频域资源范围(载波带宽)而无法满足5G通信场景中的业务需求，实现了资源调度能够灵活地适应不同的业务类型，有利于提高资源使用率，而通过根据第二信令获取基站在频域资源范围内选取并分配的频域资源，使得能够调度终端来对当前业务进行处理。

[0029] 在上述技术方案中，优选地，所述第一信令为RRC信令，所述第二信令为DCI信令。

[0030] 根据本发明的第三方面，提出了一种通信资源的分配装置，包括：第一确定单元，用于在业务承载建立时，确定当前业务的业务类型；第二确定单元，用于根据所述第一确定单元确定的所述当前业务的业务类型，确定针对所述业务类型的时频资源的粒度信息和频域资源范围；发送单元，用于将所述第二确定单元确定的针对所述业务类型的时频资源的粒度信息和频域资源范围发送至请求建立所述业务承载的终端。

[0031] 在该技术方案中，通过确定当前的业务的业务类型，并确定针对该业务类型的时频资源的粒度信息和频域资源范围，并将确定的时频资源的粒度信息和频域资源范围发送至请求建立业务承载的终端，使得能够针对不同类型的业务，灵活地对时频资源的粒度和频域资源范围进行相应的调整，进而能够避免采用固定的时频资源粒度而造成较大的下行调度时延和较长的HARQ反馈时延，同时也能够避免采用较小的频域资源范围(载波带宽)而无法满足5G通信场景中的业务需求，实现了资源调度能够灵活地适应不同的业务类型，有利于提高资源使用率。

[0032] 其中，时频资源的粒度信息包括频域资源的粒度和时域资源的粒度，频域资源的粒度即为子载波间隔，时域资源的粒度即为传输时间间隔。

[0033] 在上述技术方案中，优选地，所述第二确定单元具体用于：在所述当前业务为LTE业务时，确定时域资源的粒度为1ms、频域资源的粒度为15KHz、频域资源范围为整个带宽的全部或部分范围。

[0034] 在上述任一技术方案中，优选地，所述第二确定单元具体用于：在所述当前业务为eMBB业务时，确定时域资源的粒度为T1、频域资源的粒度为F1、频域资源范围为整个带宽的

个部或部分范围，其中，$T_a \leq 1ms$，$F_b \geq 15KHz$。

[0035] 在该技术方案中，由于eMBB业务的主要指标是高带宽和低时延，为了满足eMBB业务的需求，其频域资源的粒度要大于LTE业务的时域资源的粒度，即大于15KHz，其时域资源的粒度要小于或等于LTE业务的时域资源的粒度，即小于或等于1ms。

[0036] 在上述任一技术方案中，优选地，所述第二确定单元具体用于：在所述当前业务为mMTC业务时，确定时域资源的粒度为T_a、频域资源的粒度为F_b、频域资源范围为整个带宽的部分范围，其中，$T_a \geq 1ms$，$F_b \leq 15KHz$。

[0037] 在该技术方案中，由于mMTC业务需要的是窄带服务，需要电池寿命很长，这种业务就需要更小粒度的频域和更高粒度的时域资源，因此其频域资源的粒度要小于或等于LTE业务的时域资源的粒度，即小于或等于15KHz，其时域资源的粒度要大于或等于LTE业务的时域资源的粒度，即大于或等于1ms。

[0038] 在上述任一技术方案中，优选地，所述第二确定单元具体用于：在所述当前业务为URLLC业务时，确定时域资源的粒度为T_a、频域资源的粒度为F_b、频域资源范围为整个带宽的部分范围，其中，$T_a \leq 1ms$，$F_b \geq 15KHz$。

[0039] 在该技术方案中，由于URLLC业务是超可靠低时延业务，需要减少上行调度时延和HARQ反馈时延带来的时延影响，因此为了满足URLLC业务的需求，其频域资源的粒度要大于或等于LTE业务的时域资源的粒度，即大于或等于15KHz，其时域资源的粒度要远小于LTE业务的时域资源的粒度，即远小于1ms。

[0040] 在本发明的一个实施例中，所述发送单元具体用于：将整个带宽划分为带宽相等的多个频域资源范围，并向所述终端指示针对所述业务类型的频域资源范围在所述整个带宽上的起始点，其中，所述多个频域资源范围不重叠或部分重叠。

[0041] 在该实施例中，由于整个带宽已经被划分为带宽相等的多个频域资源范围，因此基站在向终端指示针对业务类型的频域资源范围时仅需指示起始点即可，进而终端即能根据起始点和在整个带宽上划分的每个频域资源范围的带宽来确定针对业务类型的频域资源范围。

[0042] 在本发明的另一个实施例中，所述发送单元具体用于：将整个带宽划分为带宽不等的多个频域资源范围，并向所述终端指示针对所述业务类型的频域资源范围在所述整个带宽上的起始点和带宽大小，或向所述终端指示针对所述业务类型的频域资源范围在所述整个带宽上的起始点和终点，其中，所述多个频域资源范围不重叠或部分重叠。

[0043] 在该实施例中，由于整个带宽被划分为带宽不等的多个频域资源范围，因此基站在向终端指示针对业务类型的频域资源范围时需要指示该频域范围在整个带宽上的起始点和带宽大小，或指示其在整个带宽上的起始点和终点。其中，当向终端指示针对业务类型的频域资源范围在整个带宽上的起始点和终点时，既可以向终端指示整个带宽上连续的多个资源块，也可以指示不连续的多个资源块。

[0044] 在上述任一技术方案中，优选地，所述频域资源范围包括用于传输参考信号的第一频域范围和用于传输数据的第二频域范围，其中，所述第一频域范围和所述第二频域范围不重叠、部分重叠或全部重叠。

[0045] 在该技术方案中，基站向终端指示的针对业务类型的频域资源范围包含了用于传输参考信号的频域范围(即第一频域范围)和用于传输数据的频域范围(即第二频域范围)，

这两个频域范围既可以不重叠，也可以部分重叠，还可以全部重叠。其中，所述的参考信号为用于同步和RRM测量的参考信号。在上述任一技术方案中，优选地，通过RRC信令进行对所述业务类型的时频资源的粒度信息和频域资源范围发送至请求建立所述业务承载的终端。

[0046] 在上述任一技术方案中，优选地，所述发送单元还用于：通过DCI信令指示所述终端在处理所述当前业务时被调度分配使用的资源块信息，所述资源块信息中包含有在针对所述业务类型的频域资源范围中选取的频域资源。

[0047] 根据本发明的第四方面，还提出了一种通信资源的分配装置，包括：接收单元，用于接收基站发送的第一信令和第二信令；获取单元，用于根据所述第一信令获取所述基站根据当前业务的业务类型确定的时频资源的粒度信息和频域资源范围，并根据所述第二信令获取所述基站在所述频域资源范围内选取并分配的频域资源；确定单元，用于根据所述时频资源的粒度信息和所述频域资源，确定所述基站分配的用于处理所述当前业务的资源块信息；处理单元，用于基于所述资源块信息处理所述当前业务。

[0048] 在该技术方案中，通过根据第一信令获取基站根据当前业务的业务类型确定的时频资源的粒度信息和频域资源范围，使得能够针对不同类型的业务，灵活地对时频资源的粒度和频域资源范围进行相应的调整，进而能够避免采用固定的时频资源粒度而造成较大的上行调度时延和较长的HARQ反馈时延，同时也能够避免采用较小的频域资源范围(载波带宽)而无法满足5G通信场景中的业务需求，实现了资源调度能够灵活地适应不同的业务类型，有利于提高资源使用率，而通过根据第二信令获取基站在频域资源范围内选取并分配的频域资源，使得能够调度终端来对当前业务进行处理。

[0049] 在上述技术方案中，优选地，所述第一信令为RRC信令，所述第二信令为DCI信令。

[0050] 根据本发明的第五方面，还提出了一种基站，包括：如上述第二方面所述的通信资源的分配装置。

[0051] 根据本发明的第六方面，还提出了一种终端，包括：如上述第四方面所述的通信资源的分配装置。

[0052] 通过以上技术方案，使得能够针对不同类型的业务，灵活地对时频资源的粒度和频域资源范围进行相应的调整，实现了资源调度能够灵活地适应不同的业务类型，有利于提高资源使用率。

附图说明

[0053] 图1示出了根据本发明的第一个实施例的通信资源的分配方法的示意流程图；

[0054] 图2示出了根据本发明的第一个实施例的通信资源的分配装置的示意框图；

[0055] 图3示出了根据本发明的实施例的基站的示意框图；

[0056] 图4示出了根据本发明的第二个实施例的通信资源的分配方法的示意流程图；

[0057] 图5示出了根据本发明的第二个实施例的通信资源的分配装置的示意框图；

[0058] 图6示出了根据本发明的实施例的终端的示意框图；

[0059] 图7示出了根据本发明的实施例的通过RRC信令指示RB范围的示意图。

具体实施方式

[0060] 为了能够更清楚地理解本发明的上述目的、特征和优点，下面结合附图和具体实

施方式对本发明进行进一步的详细描述，需要说明的是，在不冲突的情况下，本申请的实施例及实施例中的特征可以相互组合。

[0061] 在下面的描述中阐述了很多具体细节以便于充分理解本发明，但是，本发明还可以采用其他不同于在此描述的其他方式来实施，因此，本发明的保护范围并不受下面公开的具体实施例的限制。

[0062] 图1示出了根据本发明的第一个实施例的通信资源的分配方法的示意流程图，该通信资源的分配方法的执行主体可以是基站。

[0063] 如图1所示，根据本发明的第一个实施例的通信资源的分配方法，包括：

[0064] 步骤S10，在业务承载建立时，确定当前业务的业务类型。

[0065] 在该步骤中，当前业务的业务类型包括但不限于：LTE业务、eMBB业务、mMTC业务和URLLC业务。

[0066] 步骤S12，根据所述当前业务的业务类型，确定针对所述业务类型的时频资源的粒度信息和频域资源范围。

[0067] 其中，时频资源的粒度信息包括频域资源的粒度和时域资源的粒度，频域资源的粒度即为子载波间隔，时域资源的粒度即为传输时间间隔。

[0068] 步骤S14，将针对所述业务类型的时频资源的粒度信息和频域资源范围发送至请求建立所述业务承载的终端。

[0069] 在本发明的一个实施例中，步骤S12具体包括：在所述当前业务为LTE业务时，确定时域资源的粒度为1ms、频域资源的粒度为15KHz、频域资源范围为整个带宽的全部或部分范围。

[0070] 在本发明的一个实施例中，步骤S12具体包括：在所述当前业务为eMBB业务时，确定时域资源的粒度为T_1、频域资源的粒度为F_1、频域资源范围为整个带宽的全部或部分范围，其中，$T_1 \leq 1ms$，$F_1 > 15KHz$。

[0071] 在该实施例中，由于eMBB业务的主要指标是高带宽和低时延，为了满足eMBB业务的需求，其频域资源的粒度要大于LTE业务的时域资源的粒度，即大于15KHz，其时域资源的粒度要小于或等于LTE业务的时域资源的粒度，即小于或等于1ms。

[0072] 在本发明的一个实施例中，步骤S12具体包括：在所述当前业务为mMTC业务时，确定时域资源的粒度为T_2、频域资源的粒度为F_2、频域资源范围为整个带宽的部分范围，其中，$T_2 \geq 1ms$，$F_2 \leq 15KHz$。

[0073] 在该实施例中，由于mMTC业务需要的是零星服务，需要电池寿命很长，这种业务就需要更小粒度的频域和更宽粒度的时域资源，因此其频域资源的粒度要小于或等于LTE业务的时域资源的粒度，即小于或等于15KHz，其时域资源的粒度要大于或等于LTE业务的时域资源的粒度，即大于或等于1ms。

[0074] 在本发明的一个实施例中，步骤S12具体包括：在所述当前业务为URLLC业务时，确定时域资源的粒度为T_3、频域资源的粒度为F_3、频域资源范围为整个带宽的部分范围，其中，$T_3 < 1ms$，$F_3 \geq 15KHz$。

[0075] 在该实施例中，由于URLLC业务是高可靠低时延业务，需要减少上行调度时延和HARQ反馈时延带来的时延影响，因此为了满足URLLC业务的需求，其频域资源的粒度要大于或等于LTE业务的时域资源的粒度，即大于或等于15KHz，其时域资源的粒度要远小于LTE业

务的时域资源的粒度，即远小于1ms。

[0076] 在本发明的一个实施例中，步骤S11具体包括：将整个带宽划分为带宽相等的多个频域资源范围，并向所述终端指示针对所述业务类型的频域资源范围在所述整个带宽上的起始点。其中，所述多个频域资源范围不重叠或部分重叠。

[0077] 在该实施例中，由于整个带宽已经被划分为带宽相等的多个频域资源范围，因此基站在向终端指示针对业务类型的频域资源范围时仅需指示起始点即可，进而终端能够根据起始点和在整个带宽上划分的每个频域资源范围的带宽来确定针对业务类型的频域资源范围。当然，也可以指示起始点和终点，当向终端指示针对业务类型的频域资源范围在整个带宽上的起始点和终点时，既可以向终端指示整个带宽上连续的多个资源块，也可以指示不连续的多个资源块。

[0078] 在本发明的另一个实施例中，步骤S11具体包括：将整个带宽划分为带宽不等的多个频域资源范围，并向所述终端指示针对所述业务类型的频域资源范围在所述整个带宽上的起始点和带宽大小，或向所述终端指示针对所述业务类型的频域资源范围在所述整个带宽上的起始点和终点。其中，所述多个频域资源范围不重叠或部分重叠。

[0079] 在该实施例中，由于整个带宽被划分为带宽不等的多个频域资源范围，因此基站在向终端指示针对业务类型的频域资源范围时需要指示该频域范围在整个带宽上的起始点和带宽大小，或指示其在整个带宽上的起始点和终点。其中，当向终端指示针对业务类型的频域资源范围在整个带宽上的起始点和终点时，既可以向终端指示整个带宽上连续的多个资源块，也可以指示不连续的多个资源块。

[0080] 在上述任一技术方案中，优选地，所述频域资源范围包括用于传输参考信号的第一频域范围和用于传输数据的第二频域范围，其中，所述第一频域范围和所述第二频域范围不重叠、部分重叠或全部重叠。

[0081] 在该技术方案中，基站向终端指示的针对业务类型的频域资源范围包含了用于传输参考信号的频域范围(即第一频域范围)和用于传输数据的频域范围(即第二频域范围)，这两个频域范围既可以不重叠，也可以部分重叠，还可以全部重叠。其中，所述的参考信号指用于同步和RRM测量的参考信号。

[0082] 在上述任一技术方案中，优选地，通过RRC信令将针对所述业务类型的时频资源的粒度信息和频域资源范围发送至请求建立所述业务承载的终端。

[0083] 在上述任一技术方案中，优选地，还包括：通过DCI信令指示所述终端在处理所述当前业务时被调度分配使用的资源块信息，所述资源块信息中包含有在针对所述业务类型的频域资源范围中选取的频域资源。

[0084] 在图1所示的技术方案中，通过确定当前业务的业务类型，并确定针对该业务类型的时频资源的粒度信息和频域资源范围，并将确定的时频资源的粒度信息和频域资源范围发送至请求建立业务承载的终端，使得能够针对不同类型的业务，灵活地对时频资源的粒度和频域资源范围进行相应的调整，进而能够避免采用固定的时频资源粒度而造成较大的上行调度时延和较长的HARQ反馈时延，同时也能够避免采用较小的频域资源范围(载波带宽)而无法满足5G通信场景中的业务需求，实现了资源调度能够灵活地适应不同的业务类型，有利于提高资源使用率。

[0085] 图2示出了根据本发明的第一个实施例的通信资源的分配装置的示意框图。

[0086] 如图2所示，根据本发明的第一个实施例的通信资源的分配装置200，包括：第一确定单元202、第二确定单元204和发送单元206。

[0087] 其中，第一确定单元202用于在业务承载建立时，确定当前业务的业务类型；第二确定单元204用于根据所述第一确定单元202确定的所述当前业务的业务类型，确定针对所述业务类型的时频资源的粒度信息和频域资源范围；发送单元206用于将所述第二确定单元204确定的针对所述业务类型的时频资源的粒度信息和频域资源范围发送至请求建立所述业务承载的终端。

[0088] 在该技术方案中，通过确定当前业务的业务类型，并确定针对该业务类型的时频资源的粒度信息和频域资源范围，并将确定的时频资源的粒度信息和频域资源范围发送至请求建立业务承载的终端，使得能够针对不同类型的业务，灵活地对时频资源的粒度和频域资源范围进行相应的调整，进而能够避免采用固定的时频资源粒度而造成较大的下行调度时延和较长的HARQ反馈时延，同时也能够避免采用较小的频域资源范围(载波带宽)而无法满足5G通信场景中的业务需求，实现了资源调度能够灵活地适应不同的业务类型，有利于提高资源使用率。

[0089] 其中，时频资源的粒度信息包括频域资源的粒度和时域资源的粒度，频域资源的粒度即为子载波间隔，时域资源的粒度即为传输时间间隔。

[0090] 在上述技术方案中，优选地，所述第二确定单元204具体用于：在所述当前业务为LTE业务时，确定时域资源的粒度为1ms、频域资源的粒度为15KHz、频域资源范围为整个带宽的全部或部分范围。

[0091] 在上述任一技术方案中，优选地，所述第二确定单元204具体用于：在所述当前业务为eMBB业务时，确定时域资源的粒度为T_1、频域资源的粒度为F_1、频域资源范围为整个带宽的全部或部分范围，其中，$T_1 \leq 1ms$，$F_1 \geq 15KHz$。

[0092] 在该技术方案中，由于eMBB业务的主要指标是高带宽和低时延，为了满足eMBB业务的需求，其频域资源的粒度要大于LTE业务的时域资源的粒度，即大于15KHz，其时域资源的粒度要小于或等于LTE业务的时域资源的粒度，即小于或等于1ms。

[0093] 在上述任一技术方案中，优选地，所述第二确定单元204具体用于：在所述当前业务为mMTC业务时，确定时域资源的粒度为T_2、频域资源的粒度为F_2、频域资源范围为整个带宽的部分范围，其中，$T_2 > 1ms$，$F_2 \leq 15KHz$。

[0094] 在该技术方案中，由于mMTC业务需要的是窄带服务，需要电池寿命很长，这种业务就需要更小粒度的频域和更宽粒度的时域资源，因此其频域资源的粒度要小于或等于LTE业务的时域资源的粒度，即小于或等于15KHz，其时域资源的粒度要大于或等于LTE业务的时域资源的粒度，即大于或等于1ms。

[0095] 在上述任一技术方案中，优选地，所述第二确定单元204具体用于：在所述当前业务为URLLC业务时，确定时域资源的粒度为T_3、频域资源的粒度为F_3、频域资源范围为整个带宽的部分范围，其中，$T_3 < 1ms$，$F_3 \geq 15KHz$。

[0096] 在该技术方案中，由于URLLC业务是超可靠低时延业务，需要减少上行调度时延和HARQ反馈时延带来的时延影响，因此为了满足URLLC业务的需求，其频域资源的粒度要大于或等于LTE业务的时域资源的粒度，即大于或等于15KHz，其时域资源的粒度要远小于LTE业务的时域资源的粒度，即远小于1ms。

[0097] 在本发明的一个实施例中，所述发送单元206具体用于：将整个带宽划分为带宽相等的多个频域资源范围，并向所述终端指示针对所述业务类型的频域资源范围在所述整个带宽上的起始点。其中，所述多个频域资源范围不重叠或部分重叠。

[0098] 在该实施例中，由于整个带宽已经被划分为带宽相等的多个频域资源范围，因此基站在向终端指示针对业务类型的频域资源范围时仅需指示起始点即可，进而终端能够根据起始点和在整个带宽上划分的每个频域资源范围的带宽来确定针对业务类型的频域资源范围。当然，也可以指示起始点和终点，当向终端指示针对业务类型的频域资源范围在整个带宽上的起始点和终点时，既可以向终端指示整个带宽上连续的多个资源块，也可以指示不连续的多个资源块。

[0099] 在本发明的另一个实施例中，所述发送单元206具体用于：将整个带宽划分为带宽不等的多个频域资源范围，并向所述终端指示针对所述业务类型的频域资源范围在所述整个带宽上的起始点和带宽大小，或向所述终端指示针对所述业务类型的频域资源范围在所述整个带宽上的起始点和终点。其中，所述多个频域资源范围不重叠或部分重叠。

[0100] 在该实施例中，由于整个带宽被划分为带宽不等的多个频域资源范围，因此基站在向终端指示针对业务类型的频域资源范围时需要指示该频域范围在整个带宽上的起始点和带宽大小，或指示其在整个带宽上的起始点和终点。其中，当向终端指示针对业务类型的频域资源范围在整个带宽上的起始点和终点时，既可以向终端指示整个带宽上连续的多个资源块，也可以指示不连续的多个资源块。

[0101] 在上述任一技术方案中，优选地，所述频域资源范围包括用于传输参考信号的第一频域范围和用于传输数据的第二频域范围，其中，所述第一频域范围和所述第二频域范围不重叠、部分重叠或全部重叠。

[0102] 在该技术方案中，基站向终端指示的针对业务类型的频域资源范围包含了用于传输参考信号的频域范围(即第一频域范围)和用于传输数据的频域范围(即第二频域范围)，这两个频域范围既可以不重叠，也可以部分重叠，还可以全部重叠。其中，所述的参考信号指用于同步和RRM测量的参考信号。

[0103] 在上述任一技术方案中，优选地，通过RRC信令将针对所述业务类型的时频资源的粒度信息和频域资源范围发送至请求建立所述业务承载的终端。

[0104] 在上述任一技术方案中，优选地，所述发送单元206还用于：通过DCI信令指示所述终端在处理所述当前业务时被调度分配使用的资源块信息，所述资源块信息中包含有在针对所述业务类型的频域资源范围中选取的频域资源。

[0105] 图3示出了根据本发明的实施例的基站的示意框图。

[0106] 如图3所示，根据本发明的实施例的基站300，包括：如图2中所示的通信资源的分配装置200。

[0107] 图4示出了根据本发明的第一个实施例的通信资源的分配方法的示意流程图，该通信资源的分配方法的执行主体可以是终端。

[0108] 如图4所示，根据本发明的第一个实施例的通信资源的分配方法，包括：

[0109] 步骤S10，接收基站发送的第一信令和第二信令。

[0110] 步骤S12，根据所述第一信令获取所述基站根据当前业务的业务类型确定的时频资源的粒度信息和频域资源范围，并根据所述第二信令获取所述基站在所述频域资源范围

内选取并分配的频域资源。

[0111] 步骤S11，根据所述时频资源的粒度信息和所述频域资源，确定所述基站分配的用于处理所述当前业务的资源块信息。

[0112] 步骤S16，基于所述资源块信息处理所述当前业务。

[0113] 其中，所述第一信令为RRC信令，所述第二信令为DCI信令。

[0114] 在图1所示的技术方案中，通过根据第一信令获取基站根据当前业务的业务类型确定的时频资源的粒度信息和频域资源范围，使得能够针对不同类型的业务，灵活地对时频资源的粒度和频域资源范围进行相应的调整，进而能够避免采用固定的时频资源粒度而造成较大的上行调度时延和较长的HARQ反馈时延，同时也能够避免采用较小的频域资源范围(载波带宽)而无法满足5G通信场景中的业务需求，实现了资源调度能够灵活地适应不同的业务类型，有利于提高资源使用率。而通过根据第二信令获取基站在频域资源范围内选取并分配的频域资源，使得能够调度终端来对当前业务进行处理。

[0115] 图5示出了根据本发明的第二个实施例的通信资源的分配装置的示意框图

[0116] 如图5所示，根据本发明的第二个实施例的通信资源的分配装置500，包括：接收单元502，获取单元501，确定单元506和处理单元508。

[0117] 其中，接收单元502用于接收基站发送的第一信令和第二信令；获取单元501用于根据所述第一信令获取所述基站根据当前业务的业务类型确定的时频资源的粒度信息和频域资源范围，并根据所述第二信令获取所述基站在所述频域资源范围内选取并分配的频域资源；确定单元506用于根据所述时频资源的粒度信息和所述频域资源，确定所述基站分配的用于处理所述当前业务的资源块信息；处理单元508用于基于所述资源块信息处理所述当前业务。

[0118] 其中，所述第一信令为RRC信令，所述第二信令为DCI信令。

[0119] 在该技术方案中，通过根据第一信令获取基站根据当前业务的业务类型确定的时频资源的粒度信息和频域资源范围，使得能够针对不同类型的业务，灵活地对时频资源的粒度和频域资源范围进行相应的调整，进而能够避免采用固定的时频资源粒度而造成较大的上行调度时延和较长的HARQ反馈时延，同时也能够避免采用较小的频域资源范围(载波带宽)而无法满足5G通信场景中的业务需求，实现了资源调度能够灵活地适应不同的业务类型，有利于提高资源使用率。而通过根据第二信令获取基站在频域资源范围内选取并分配的频域资源，使得能够调度终端来对当前业务进行处理。

[0120] 图6示出了根据本发明的实施例的终端的示意框图

[0121] 如图6所示，根据本发明的实施例的终端600，包括：如图5中所示的通信资源的分配装置500。

[0122] 综上所述，本发明的技术方案主要是提出了一种新的通信资源的分配方案，可以针对不同的业务类型，采用相应的时频资源粒度和频域资源范围，以适应于5G通信的需求。

[0123] 具体包括以下几个方面：

[0124] 一、在终端的每个业务承载建立时，基站通过RRC信令向该终端发送关于该业务承载的信息，这些信息包含的内容如下：

[0125] 1、Subcarrier spacing，子载波间隔，也就是频域资源粒度；

[0126] 2、Transmission Time Interval，传输时间间隔，也就是时域资源粒度。其中，LTE

系统中的传输时间间隔一般是1ms；

[0127] 3、可分配的RB范围，此处RB范围主要指的是频域资源的范围。

[0128] 由于5G通信中一个载波的带宽可能很大，比如80MHz或者100MHz，因此如果在RRC信令中限定一个RB范围，那么后续向终端指示具体RB分配时的DCI信令的开销将比较大。对于可分配的RB范围的指示还有一个含义，即该无线业务承载相关的系统信息、参考信号、同步信号等也都在该RB范围内发送，也就是说只需要在该RB范围内进行检测，就能正确处理该无线业务承载。当然用于参考信号和数据发送的RB范围可以不一样。

[0129] 在RRC信令向终端通知的以上三种信息中，Subcarrier spacing和Transmission Time Interval是针对无线业务承载的，也就是说只要是一个业务承载，这两个参数就不会变，而每后一个RB范围，可能根据整体业务情况进行变化，但也可以通过RRC信令进行半静态的调整。

[0130] 1、针对不同的业务类型，上述三个参数的取值具体如下：

[0131] 1、对于传统的LTE业务，上述三个参数的取值依次如下：

[0132] LTE_Subcarrier Spacee=15KHz；

[0133] LTE_tti=1ms；

[0134] LTE_RB为整个带宽的全部或部分范围。

[0135] 2、对于eMBB业务，其三个参数与LTE业务的三个参数比较如下：

[0136] eMBB Subcarrier Spacee≥LTE Subcarrier Spacee；

[0137] eMBB tti≤LTE tti；

[0138] eMBB RB可能是整个带宽也可能是整个带宽的一部分。

[0139] 3、对于mMTC业务，其三个参数与LTE的三个参数比较如下：

[0140] mMTC Subcarrier Spacee≤LTE Subcarrier Spacee；

[0141] mMTC_tti≥LTE_tti；

[0142] mMTC_RB是整个带宽的很小一部分，比如只有180KHz。

[0143] 4、对于URLLC业务，其三个参数与LTE的三个参数比较如下：

[0144] URLLC_Subcarrier Spacee≥LTE_Subcarrier Spacee；

[0145] URLLC_tti≤LTE_tti，即URLLC的tti通常小于LTE的tti；

[0146] URLLC_RB是整个带宽的很小一部分。

[0147] 2、基站在通过RRC信令向终端发送关于该业务承载的信息时，对于RB范围的指示方法具体如下：

[0148] 基站可以先通过RRC信令指示出RB范围在整个带宽上的大致位置，为了后向兼容和同时支持MTC业务(窄带业务)，在整个带宽上RB的大小值是要统一的。因此可以选择一个RB_baseline(RB基准)，其值可能与LTE的RB值一样，即可以是180KHz。那么在RRC信令指示RB范围时，可以以RB_baseline为粒度来进行指示。具体的指示方法如下：

[0149] 1、当整个带宽上划分的多个频域范围的带宽都相同时，比如每个频域范围的带宽都是20MHz，这时只需要指示RB范围的起点即可；

[0150] 2、当整个带宽上划分的多个频域范围的带宽不定时，需要同时指示RB范围的起点和带宽大小，或者指示RB范围的起点和终点。

[0151] 针对以上两种指示方法，若RRC信令针对的业务不同，即对一个终端有多个业务的

话，则可能RRC信令指示的频域资源区域是独立的。另外，上述的多个频域范围可能是完全不重叠的，也可能是有部分重叠的，并且，指示的RB范围可以是一段连续的带宽(如图7所示)，也可能是多段不连续的带宽。

[0152] 2、基站在通过RRC信令向终端指示完RB范围后，通过DCI信令向终端指示具体的RB分配。

[0153] 具体地，比如对于LTE业务，若基站通过RRC信令指示的RB范围包含了110个RB(即20MHz)，则DCI信令可以指示该110个RB中的其中N个RB分配给终端。

[0154] 对于eMBB业务，若RB范围指示了整个带宽为80MHz，那么DCI信令可以指示该80MHz中的其中M个eMBB RB分配给终端。其中，eMBB RB由eMBB的sub-carrier spacing和CP决定，eMBB RB的大小可能是RB base Inc 180KHz的很多倍。

[0155] 对于mMTC业务，若RB范围指示了其中P个RB，那么DCI信令要指示其中的哪些个mMTC RB分配给终端。其中，mMTC RB由mMTC的sub carrier spacing和CP决定，比如类似NB-IoT中，指示的就是哪些个15KHz分配给终端。

[0156] 上述所述的RB范围是针对参考信号和数据发送的。其中，针对参考信号和针对数据发送的RB范围可以是一样的，也可以是不一样的。如果不一样，则需要分成针对参考信号的RB范围和针对数据发送的RB范围。针对参考信号的RB范围主要用来上下行同步和RRM(Radio Resource Management，无线资源管理)测量等，针对数据发送的RB范围主要用来发送和接收数据。对于同一终端来说，针对参考信号的RB范围和针对数据发送的RB范围可以不重叠、部分重叠或完全重叠，也可以是一个范围包含另一个范围。

[0157] 同时，对于不在上述两个范围(即针对参考信号的RB范围和针对数据发送的RB范围)内的频域资源，终端不需要去测量也不需要监听PDCCH(Physical Downlink Control Channel，物理下行控制信道)。

[0158] 此外，对于不同业务类型来说，DCI信令在指示时所使用的bit数和指示方法可以不一样。

[0159] 四、终端的处理过程：

[0160] 1、接收基站发送的RRC信令和DCI信令；

[0161] 2、从RRC信令中获得基站指示的RB范围、当前业务的sub-carrier spacing和CP，比如若是eMBB业务，那么其使用eMBB RB为粒度。

[0162] 3、根据DCI信令中的指示，确定RB范围内具体的频域资源是分配给自己使用的。比如确定哪些个eMBB RB值是分配给自己的

[0163] 4、基于确定的时频资源来处理当前业务。

[0164] 可见，本发明的技术方案通过设计新的RRC信令，以指示不同业务对应的子载波间隔、传输时间间隔，以及使用的RB范围，从而能够更好的为该业务调度资源，并且能够减少DCI信令的开销。

[0165] 以上结合附图详细说明了本发明的技术方案，本发明提出了一种新的通信资源的分配方案，使得能够针对不同类型的业务，灵活且时频资源的粒度和频域资源范围进行相应的调整，实现了资源调度能够更灵活地适应不同的业务类型，有利于提高资源使用率。

[0166] 以上所述仅为本发明的优选实施例而已，并不用于限制本发明，对于本领域的技术人员来说，本发明可以有各种更改和变化。凡在本发明的精神和原则之内，所作的任何修

改、等同替换、改进等，均应包含在本发明的保护范围之内。

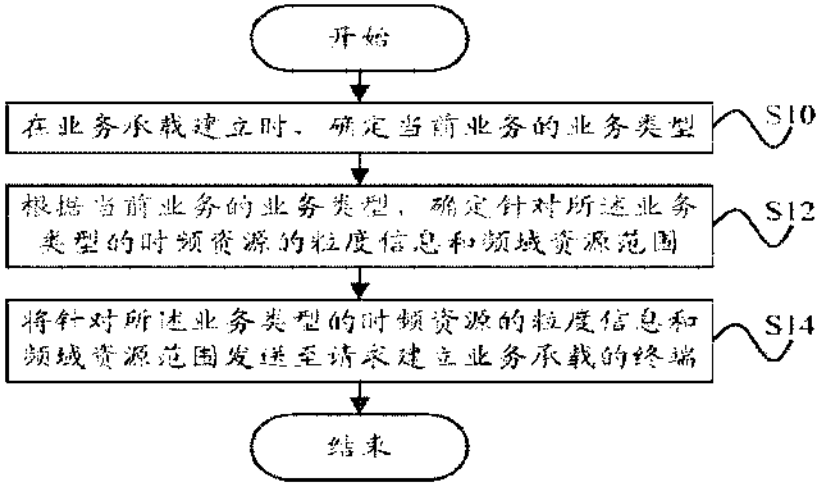

开始
在业务承载建立时，确定当前业务的业务类型
S10
根据当前业务的业务类型，确定针对所述业务类型的时频资源的粒度信息和频域资源范围
S12
将针对所述业务类型的时频资源的粒度信息和频域资源范围发送至请求建立业务承载的终端
S14
结束

图1

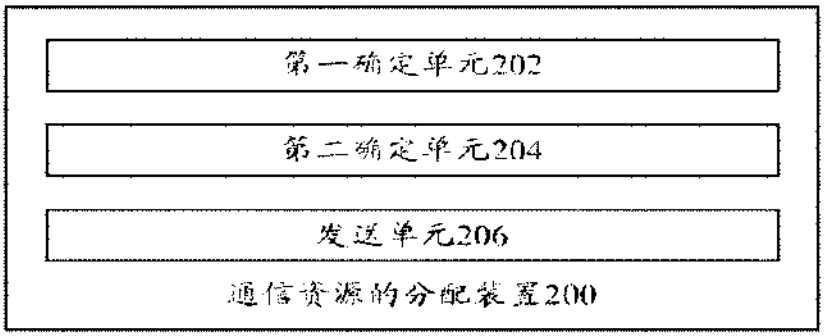

第一确定单元202
第二确定单元204
发送单元206
通信资源的分配装置200

图2

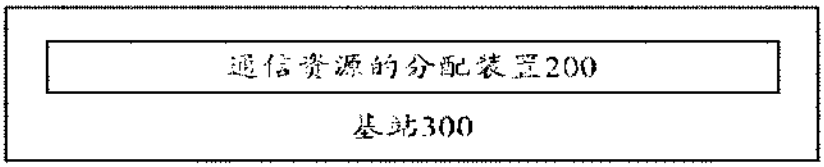

通信资源的分配装置200
基站300

图3

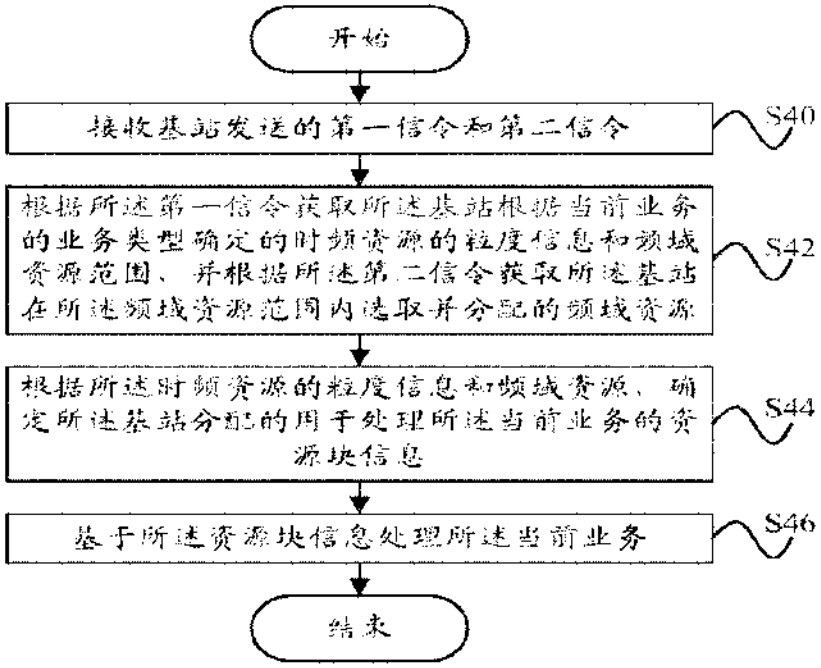

开始
接收基站发送的第一信令和第二信令
S40
根据所述第一信令获取所述基站根据当前业务的业务类型确定的时频资源的粒度信息和频域资源范围，并根据所述第二信令获取所述基站在所述频域资源范围内选取并分配的频域资源
S42
根据所述时频资源的粒度信息和频域资源，确定所述基站分配的用于处理所述当前业务的资源块信息
S44
基于所述资源块信息处理所述当前业务
S46
结束

图4

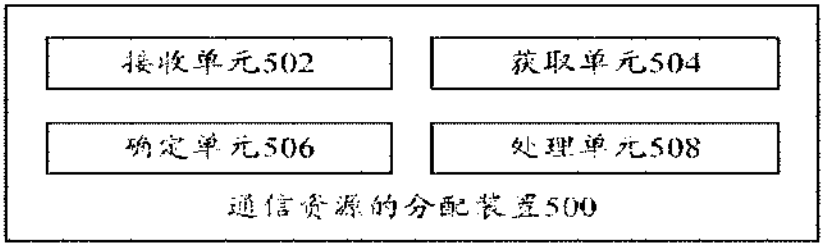

接收单元502
获取单元504
确定单元506
处理单元508
通信资源的分配装置500

图5

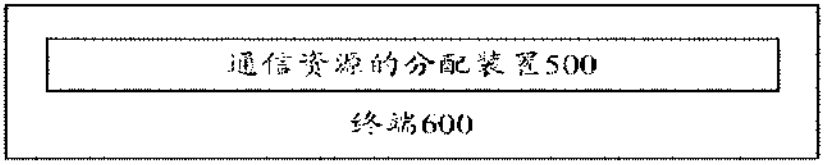

通信资源的分配装置500
终端600

图6

20

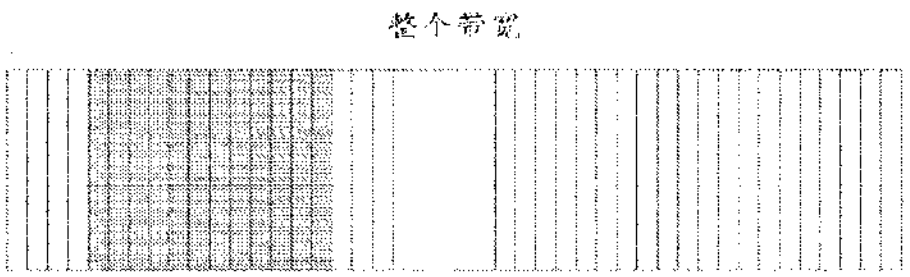


图7

Espacenet

CN106231614A Signal transmission method and related network element

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Signal transmission method and related network element

Abstract

The embodiment of the invention discloses a signal transmission method and a related network element. The method includes steps: when a new radio (NR) business is transmitted on a unauthorized frequency band, a base station performs a listen before talk (LBT) mechanism and determines whether remaining subframes exit in a resource block (RB); if yes, the base station selects the signal type applicable to the NR business on the remaining subframes according to the NR business type; and the base station sends a control signaling of the NR business to a terminal by employing the signal type of the NR business on the remaining subframes. According to the method and the related network element, the control signaling of the NR business is sent by employing the remaining subframes so that the utilization rate of channel resources can be increased.

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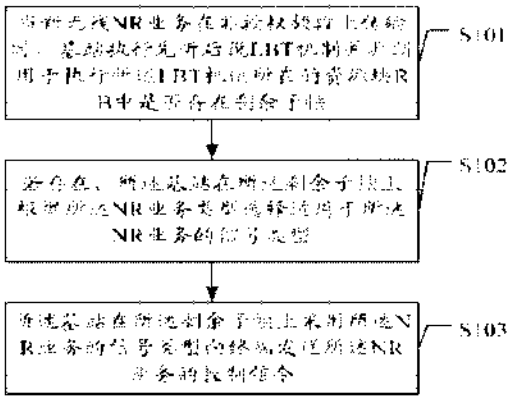
权利要求书 3 页 说明书 12 页 附图 5 页

(54)发明名称

一种信号传输方法及相关网元

(57)摘要

本发明实施例公开了一种信号传输方法及相关网元，其中的方法包括：当新无线NR业务在非授权频段上传输时，基站执行先听后说LBT机制并判断资源块RB中是否存在剩余子帧；若存在，所述基站在所述剩余子帧上根据所述NR业务类型选择适用于所述NR业务的信号类型；所述基站在所述剩余子帧上采用所述NR业务的信号类型的终端发送所述NR业务的控制信令。本发明实施例中，采用剩余子帧发送所述NR业务的控制信令，有利于提高信道资源利用率。



CN 105323611 A

1.一种信号传输方法，其特征在于，所述方法包括：

当新无线NR业务在非授权频段上传输时，基站执行先听后说LBT机制并判断用于执行所述LBT机制所在的资源块RB中是否存在剩余子帧；

若存在，所述基站在所述剩余子帧上根据所述NR业务类型选择适用于所述NR业务的信号类型；

所述基站在所述剩余子帧上采用所述NR业务的信号类型向终端发送所述NR业务的控制信令。

2.根据权利要求1所述的方法，其特征在于，所述基站在所述剩余子帧上根据所述NR业务类型选择适用于所述NR业务的信号类型，包括：

若所述NR业务类型为增强型移动宽带应用eMBB业务，则所述基站在所述剩余子帧上根据所述NR业务类型选择适用于所述eMBB业务的信号类型。

3.根据权利要求1所述的方法，其特征在于，所述基站在所述剩余子帧上根据所述NR业务类型选择适用于所述NR业务的信号类型，包括：

若所述NR业务类型为超可靠及低时延通信URLLC业务，则所述基站在所述剩余子帧上根据所述NR业务类型选择适用于所述URLLC业务的信号类型。

4.根据权利要求1所述的方法，其特征在于，所述基站在所述剩余子帧上根据所述NR业务类型选择适用于所述NR业务的信号类型，包括：

若所述NR业务类型为大量物联网通信mMTC业务，则所述基站在所述剩余子帧上根据所述NR业务类型选择适用于所述mMTC业务的信号类型。

5.根据权利要求1所述的方法，其特征在于，所述用于执行LBT机制的占用资源可以配置在模设子帧位置上。

6.根据权利要求1所述的方法，其特征在于，所述执行LBT机制的信号类型与适用于所述NR业务的信号类型不同。

7.根据权利要求1所述的方法，其特征在于，所述适用于所述NR业务的信号类型是指所述基站根据所述NR业务类型所选择的与所述剩余子帧的子载波间隔，循环前缀长度和传输时间间隔TTI长度上的至少一种相匹配的NR业务的信号类型。

8.根据权利要求1-7任一项所述的方法，其特征在于，所述控制信令包括探测信号、信道探测的参考信号或同步信号。

9.一种信号传输方法，其特征在于，所述方法包括：

当新无线NR业务在非授权频段上传输时，终端执行先听后说LBT机制并判断用于执行所述LBT机制所在的资源块RB中是否存在剩余子帧；

若存在，所述终端向基站发送所述RB中存在剩余子帧的指示消息；

所述终端接收所述基站在所述剩余子帧上采用NR业务的信号类型发送的所述NR业务的控制信令，所述NR业务的信号类型由所述基站在所述剩余子帧上根据所述NR业务类型所选择。

10.根据权利要求9所述的方法，其特征在于，所述终端接收基站在所述剩余子帧上采用NR业务的信号类型发送的所述NR业务的控制信令，包括：

若所述NR业务类型为增强型移动宽带应用eMBB业务，则所述终端接收基站在所述剩余子帧上采用NR业务的信号类型发送的所述eMBB业务的控制信令。

11.根据权利要求9所述的方法，其特征在于，所述终端接收基站在所述剩余子帧上采用NR业务的信号类型发送的所述NR业务的控制信令，包括：

若所述NR业务类型为超可靠及低时延通信URLLC业务，则所述终端接收基站在所述剩余子帧上采用NR业务的信号类型发送的所述URLLC业务的控制信令。

12.根据权利要求9所述的方法，其特征在于，所述终端接收基站在所述剩余子帧上采用NR业务的信号类型发送的适用于所述NR业务的控制信令，包括：

若所述NR业务类型为大规物联网通信mMTC业务，则所述终端接收基站在所述剩余子帧上采用NR业务的信号类型发送的所述mMTC业务的控制信令。

13.根据权利要求9所述的方法，其特征在于，所述用于执行LBT机制的占用资源可以配置在预设子帧位置上。

14.根据权利要求9所述的方法，其特征在于，所述执行LBT机制的信号类型与适用于所述NR业务的信号类型不同。

15.根据权利要求9所述的方法，其特征在于，所述适用于所述NR业务的信号类型是指所述基站根据所述NR业务类型所选择的与所述剩余子帧的子载波间隔、循环前缀长度和传输时间间隔TTI长度中的至少一种相匹配的NR业务的信号类型。

16.根据权利要求9-15任一项所述的方法，其特征在于，所述控制信令包括保留信号、信道探测的参考信号或同步信号。

17.一种基站，其特征在于，所述基站包括：

判断单元，用于当新无线NR业务在上授权频段上传输时，执行先听后说LBT机制并判断资源块RB中是否存在剩余子帧；

选择单元，用于若存在所述剩余子帧，在所述剩余子帧上根据所述NR业务类型选择适用于所述NR业务的信号类型；

发送单元，用于在所述剩余子帧上采用所述NR业务的信号类型向终端发送所述NR业务的控制信令。

18.根据权利要求17所述的基站，其特征在于，所述选择单元具体用于：

若所述NR业务类型为增强型移动宽带应用eMBB业务，则在所述剩余子帧上根据所述NR业务类型选择适用于所述eMBB业务的信号类型。

19.根据权利要求17所述的基站，其特征在于，所述选择单元具体用于：

若所述NR业务类型为超可靠及低时延通信URLLC业务，则在所述剩余子帧上根据所述NR业务类型选择适用于所述URLLC业务的信号类型。

20.根据权利要求17所述的基站，其特征在于，所述选择单元具体用于：

若所述NR业务类型为大规物联网通信mMTC业务，则在所述剩余子帧上根据所述NR业务类型选择适用于所述mMTC业务的信号类型。

21.根据权利要求17所述的方法，其特征在于，所述用于执行LBT机制的占用资源可以配置在预设子帧位置上。

22.根据权利要求17所述的方法，其特征在于，所述执行LBT机制的信号类型与适用于所述NR业务的信号类型不同。

23.根据权利要求17所述的基站，其特征在于，所述适用于所述NR业务的信号类型是指根据所述NR业务类型所选择的与所述剩余子帧的子载波间隔、循环前缀长度和传输时间间

隙TTI长度中的至少一种相匹配的NR业务的信号类型。

21.根据权利要求17-23任一项所述的方法，其特征在于，所述控制信令包括保留信号、信道探测的参考信号或同步信号。

25.一种终端，其特征在于，所述终端包括：

判断单元，用于当新无线NR业务在上授权频段上传输时，执行先听后说LBT机制并判断资源块RB中是否存在剩余子帧；

发送单元，若存在所述剩余子帧，向基站发送所述RB中存在剩余子帧的指示消息；

接收单元，用于接收所述基站在所述剩余子帧上采用NR业务的信号类型发送的所述NR业务的控制信令，所述NR业务的信号类型由所述基站在所述剩余子帧上根据所述NR业务类型所选择。

26.根据权利要求25所述的终端，其特征在于，所述接收单元具体用于：

若所述NR业务类型为增强型移动宽带应用eMBB业务，则接收基站在所述剩余子帧上采用NR业务的信号类型发送的所述eMBB业务的控制信令。

27.根据权利要求25所述的终端，其特征在于，所述接收单元具体用于：

若所述NR业务类型为超可靠及低时延通信URLLC业务，则接收基站在所述剩余子帧上采用NR业务的信号类型发送的所述URLLC业务的控制信令。

28.根据权利要求25所述的终端，其特征在于，所述接收单元具体用于：

若所述NR业务类型为大量物联网通信mMTC业务，则接收基站在所述剩余子帧上采用NR业务的信号类型发送的所述mMTC业务的控制信令。

29.根据权利要求25所述的方法，其特征在于，所述用于执行LBT机制的与用资源可以配置在预设子帧位置上。

30.根据权利要求25所述的方法，其特征在于，所述执行LBT机制的信号类型与适用于所述NR业务的信号类型不同。

31.根据权利要求25所述的终端，其特征在于，所述适用于所述NR业务的信号类型是指根据所述NR业务类型所选择的与所述剩余子帧的子载波间隔，循环前缀长度和传输时间间隙TTI长度中的至少一种的NR业务的信号类型。

32.根据权利要求25-31任一项所述的终端，其特征在于，所述控制信令包括保留信号、信道探测的参考信号或同步信号。

一种信号传输方法及相关网元

技术领域

[0001] 本发明涉及通信技术领域，尤其涉及一种信号传输方法及相关网元。

背景技术

[0002] 无线通信网络的广泛部署可为用户提供各种通信服务，例如语音、视频、分组数据、消息传送、广播等。这些无线网络可以是能够通过共享可用的网络资源来支持多个用户的多址网络。这些多址网络的示例包括码分多址(Code Division Multiple Access,CDMA)网络、时分多址(Time Division Multiple Access,TDMA)网络、频分多址(Frequency Division Multiple Access,FDMA)网络、正交频分多址(Orthogonal Frequency Division Multiple Access,OFDMA)网络和单载波频分多址(Single-carrier Frequency Division Multiple Access,SC-FDMA)网络、以及下一代新无线(New Radio,NR)网络(例如5G)。

[0003] NR的提出带来了新的机遇和挑战，未来NR业务的三大主要应用场景和需求主要包括增强型移动宽带应用(Enhanced mobile broadband,eMBB)、超可靠及低时延通信(Ultra-reliable and low latency communications,URLLC)以及大规物联网通信(Massive machine type communications,mMTC)。针对增强型的移动宽带eMBB这种应用场景下，智能终端用户上网峰值速率要达到10Gbps甚至20Gbps，为虚拟现实、无处不在的视频直播和分享、随时随地的云接入等大带宽应用提供支持。针对大连接物联网mMTC这种场景下，5G网络需要支持100万一平方公里规模的人和物的连接。针对低时延、超可靠通信uRLLC这种场景要求5G网络的时延达到1毫秒，为智能制造、远程机械控制、辅助驾驶和自动驾驶等低时延业务提供强有力的支持。

[0004] 为进一步提高频谱资源的利用，第三代合作伙伴计划(3rd Generation Partnership Project,3GPP)引入了授权频谱辅助接入(Licensed Assisted Access,LAA)的概念，其可以借助长期演进(Long Term Evolution,LTE)甚至NR的授权频谱的帮助来处理非授权频段。同时，为确保LAA能够友好地与现有的接入技术共存，提出了一种先听后说(Listen Before Talk,LBT)机制来避免碰撞。若在非授权频谱上检测到信道处于空闲状态，才能占用该信道进行信号发送。在正常循环前缀(Cyclic Prefix,CP)情况下，一个资源块(Resource Block,RB)在时域上的最小长度是7个正交频分复用(Orthogonal Frequency Division Multiplexing,OFDM)符号，也就是0.5ms。非授权频段上，无线系统(包括后来的NR系统)在使用信道(或者使用RB)之前可以执行LBT机制，用以判断信道是否可用，而执行LBT的时间一般都是微秒级。非LBT事件的引入会产生新的频谱资源利用率的问题。

发明内容

[0005] 本发明实施例提供一种信号传输方法及相关网元，可提高频谱利用率。

[0006] 在第一方面，本发明实施例提供了一种信号传输方法，包括：

[0007] 当新无线NR业务在非授权频段上传输时，终端执行先听后说LBT机制，并判断资源块RB中是否存在剩余子帧；

[0008] 若存在，所述基站在所述剩余子帧上根据所述NR业务类型选择适用于所述NR业务的信号类型；

[0009] 所述基站在所述剩余子帧上采用所述NR业务的信号类型向终端发送所述NR业务的控制信令。

[0010] 在第二方面，本发明实施例提供了一种信号传输方法，包括：

[0011] 当新无线NR业务在非授权频段上传输时，终端执行先听后说LBT机制，并判断用于执行所述LBT机制所在的资源块RB中是否存在剩余子帧；

[0012] 若存在，所述终端向基站发送所述RB中存在剩余子帧的指示消息；

[0013] 所述终端接收所述基站在所述剩余子帧上采用NR业务的信号类型发送的所述NR业务的控制信令，所述NR业务的信号类型由所述基站在所述剩余子帧上根据所述NR业务类型所选择。

[0014] 在第三方面，本发明实施例提供了一种基站，包括：

[0015] 判断单元，用于当新无线NR业务在非授权频段上传输时，执行先听后说LBT机制并判断资源块RB中是否存在剩余子帧；

[0016] 选择单元，用于若存在所述剩余子帧，在所述剩余子帧上根据所述NR业务类型选择适用于所述NR业务的信号类型；

[0017] 发送单元，用于在所述剩余子帧上采用所述NR业务的信号类型向终端发送所述NR业务的控制指令。

[0018] 在第四方面，本发明实施例提供了一种终端，包括：

[0019] 判断单元，用于当新无线NR业务在非授权频段上传输时，执行先听后说LBT机制并判断资源块RB中是否存在剩余子帧；

[0020] 发送单元，用于若存在所述剩余子帧，向基站发送所述RB中存在剩余子帧的指示消息；

[0021] 接收单元，用于接收所述基站在所述剩余子帧上采用NR业务的信号类型发送的所述NR业务的控制信令，所述NR业务的信号类型由所述基站在所述剩余子帧上根据所述NR业务类型所选择。

[0022] 在NR系统中，因为FAA的引入，从而使得在非授权频段上的LBT机制可能只是占用了RB的部分时频位置，从而会出现RB中的OFDM符号的剩余的现象，此剩余的OFDM符号的利用率成为当前亟需讨论的问题。

[0023] 而本发明实施例，当新无线NR业务在非授权频段上传输时，基站执行先听后说LBT机制并判断是否存在剩余子帧，若存在，所述基站在所述剩余子帧上根据所述NR业务类型选择适用于所述NR业务的信号类型，并在所述剩余子帧上采用所述NR业务的信号类型向终端发送所述NR业务的控制信令，本发明实施例采用剩余子帧发送所述NR业务的控制信令，合理地使用了剩余子帧，提高了频谱利用率。

附图说明

[0024] 为了更清楚地说明本发明实施例技术方案，下面将对实施例描述中所需要使用的附图作简单地介绍，显而易见地，下面描述中的附图是本发明的一些实施例，对于本领域普通技术人员来讲，在不付出创造性劳动的前提下，还可以根据这些附图获得其他的附图。

[0025] 图1是本发明实施例提供的信号传输方法的第一实施例流程示意图；

[0026] 图1a是本发明实施例提供的发送NR业务的RB的结构示意图；

[0027] 图2是本发明实施例提供的信号传输方法的第二实施例流程示意图；

[0028] 图2a是本发明实施例提供的重授权频段的频段划分示意图；

[0029] 图2b是本发明实施例提供的发送eMBB业务的RB的结构示意图；

[0030] 图2c是本发明实施例提供的发送URLLC业务的RB的结构示意图；

[0031] 图2d是本发明实施例提供的发送mMTC业务的RB的结构示意图；

[0032] 图3是本发明实施例提供的信号传输方法的第三实施例流程示意图；

[0033] 图4是本发明实施例提供的基站的第一实施例结构示意图；

[0034] 图5是本发明实施例提供的基站的第二实施例结构示意图；

[0035] 图6是本发明实施例提供的终端的第一实施例结构示意图；

[0036] 图7是本发明实施例提供的终端的第二实施例结构示意图。

具体实施方式

[0037] 下面将结合本发明实施例中的附图，对本发明实施例中的技术方案进行清楚、完整地描述。显然，所描述的实施例是本发明一部分实施例，而不是全部的实施例。基于本发明中的实施例，本领域普通技术人员在没有做出创造性劳动前提下所获得的所有其他实施例，都属于本发明保护的范围。

[0038] 需要说明的是，在本发明实施例中使用的术语是仅仅出于描述特定实施例的目的，而非旨在限制本发明。在本发明实施例和所附权利要求书中所使用的单数形式的"一种"、"所述"和"该"也旨在包括多数形式，除非上下文清楚地表示其他含义。还应当理解，本文中使用的术语"和/或"是指并包含一个或多个相关联的列出项目的任何或所有可能组合。

[0039] 需要说明的是，在没有明示的特别说明的情况下，本发明各实施例中的各项技术特征可视为能够进行相互组合或者结合，只要该种组合或者结合不是因为技术的原因而无法实施，为了较为简分的说明本发明，一些示例性的、可选的、或者优选的特征在本发明各实施例中与其他技术特征结合在一起进行描述，但这种结合不是必须的，而应该理解该示例性的、可选的、或者优选的特征与其他的技术特征都是彼此可分离的或者独立的，只要该种可分离或者独立不是因为技术的原因而无法实施。方法实施例中的技术特征的一些功能性描述可以理解为执行该功能、方法或者步骤，装置实施例中的技术特征的一些功能性描述可以理解为使用该种装置来执行该功能、方法或者步骤。

[0040] 无线通信网络可以包括能够支持多个无线用户装置的通信的多个基站。无线用户装置可以通过下行链路和上行链路与基站进行通信。下行链路(或前向链路)是指从基站到无线用户装置的通信链路，而上行链路(或反向链路)是指从无线用户装置到基站的通信链路。

[0041] 无线用户设备(例如，蜂窝电话或者智能电话)可以利用无线通信系统来发射和接收数据以用于双路通信。无线用户设备可以包括用于数据发射的发射机以及用于数据接收的接收机。对于数据发射，发射机可以利用将数据对发射本地振荡器(Local Oscillator，LO)信号进行调制以获得经过调制的射频(Radio Frequency，RF)信号，对经过调制的RF信号进行放

从以获得具有恰当发射功率级别的输出RF信号，并且经由天线来输出RF信号发射给基站。对于数据接收，接收机可以经由天线来获得所接收的RF信号，放大并利用接收IQ信号来将所接收的RF信号下变频，并且处理经下变频的信号以恢复由基站发送的数据。

[0042] 无线用户设备可以支持与不同无线电接入技术(Radio Access Technology,RAT)的多个无线系统的通信(例如LTE、LTE-A和NR)。每个无线系统可能具有某些特性和要求，能够高效地支持利用不同RAT的无线系统的同时通信。无线用户设备还可以被称为用户设备(User Equipment,UE)、移动台、终端、接入终端、用户单元、站点、等等。无线用户设备可以是蜂窝电话、智能电话、平板计算机、无线调制解调器、个人数字助理(Personal Digital Assistant,PDA)、手持式设备、膝上型计算机、智能本、上网本、无绳电话、无线本地回路(wireless local loop,WLL)站点、蓝牙设备、等等。无线用户设备可以能够与无线系统进行通信，还可以能够从广播站、一个或多个全球导航卫星系统(Global Navigation Satellite System,GNSS)中的卫星等接收信号。无线用户设备可以支持用于无线通信的一个或多个RAT，诸如GSM、WCDMA、cdma2000、LTE、LTE-A、802.11、等等。术语"无线电接入技术"、"RAT"、"无线电技术"、"空中接口"和"标准"经常可互换地被使用。

[0043] 需要说明的是，在LTE/LTE-A系统中，上、下行载波分别采用单载波频分多址(Single-carrier Frequency-Division Multiple Access,SC-FDMA)/OFDM以及循环前缀(Cyclic Prefix,CP)。在5G标准中，示例性的，可以对上下行载波进行统一，即上行链路与下行链路均采用OFDM以及CP。另外示例性的，5G中的RB可以被如下配置，1个资源块包含12个子载波，子载波间隔以15kHz为基准，子载波间隔可以是15kHz的N(N=2^n)倍，或者也可以固定为子载波间隔为75kHz。具体而言，传统LTE小区工作在频段上的带宽是由RB构成，RB分别具有固定的子载波间隔和符号长度，比如正常CP下，频域上的大小为180KHz(即：12个15KHz子载波间隔)，时域上，包括7个符号，一个符号的长度约等于71.3us。而在下一代移动通信技术中(例如NR系统中)，不同子载波可以基于业务类型不再具有固定的子载波间隔和固定的符号长度(可以动态变化)。为区别于传统LTE系统中的RB概念，NR系统新定义了"numerology"(参考数值)的概念，它主要包括子载波间隔、CP长度和TTI长度等。目前，NR系统共定义了三种业务类型，分别是eMBB、URLLC和mMTC，不同业务类型的"numerology"类型是可以不同，意味不同类型的子载波间隔、CP长度或TTI长度可能有所不同。示例性的，可以定义下一代移动通信将会支持最大为100MHz的单载波带宽。一个资源块RB在频域上的大小变为900KHz(即：12个75kHz子载波间隔)，而在时域上支持0.1ms。一个无线帧的长度是10ms，但是由50个子帧构成，每个子帧的长度为0.2ms。需要说明的是，本文通信所述的适用于所述NR业务的信号类型，可以是指包括载波间隔、CP长度和TTI长度等相关参数中的至少一种参数的配置。

[0044] 请参照图1和图1a，图1是本发明实施例提供的信号传输方法的第一实施例流程示意图，图1a是本发明实施例提供的发送NR业务的RB句结构示意图。本实施例中所描述的一种信号传输方法，包括步骤S101～S103：

[0045] S101，当新无线NR业务在非授权频段上传输时，基站执行先听后说LBT机制，并判断用于执行所述LBT机制所在的资源块RB中是否存在剩余子帧。

[0046] 具体实现中，当新无线NR业务在非授权频段上传输时，NR业务在占用信道之前都要执行LBT机制，通过能量感知的方式获取目标信道是否空闲。当信道处于空闲状态时，才

能使用该信道进行NR业务传输。由于LBT机制的时间一般微秒级的如LBT机制最短的执行时间是25us，而一个RB是0.5ms，基站一般以两个RB为单位即1ms来调度终端，LBT机制只是占用了RB的部分时频位置，所以，在执行完LBT机制之后，可能会出现剩余子帧。本发明实施例中，当基站需要采用非授权频段上向终端传输NR业务时，基站首先需要执行LBT机制，并在执行LBT机制之后判断RB中是否存在剩余子帧，如图1a所示为发送NR业务的RB的结构示意图，LBT机制的执行占用了1st部分的时频位置，其余的n2为剩余部分子帧，可以用于传输适用于所述NR业务的信号。本发明实施例中，若出现剩余子帧，则可以根据NR业务类型利用剩余子帧来发送与业务类型相匹配的相关控制信令或者是相匹配的数据业务相关指令。在上行链路中，上述LBT机制的执行过程和剩余子帧的判断过程也可以由终端来执行。

[0047] 作为检测目标信道是否处于空闲状态的一种示例性的方式，具体的，当有新无线NR业务需要在非授权频段上传输时，基站检测时间是否有其它设备正在目标信道发送数据，如果该目标载信道已被其它设备占用，可以在下一监听周期到来时继续监听，也可以不再监听；若监听到信道资源空闲，该基站可以立即占用该目标信道。信道占用时间可以是一个固定值，也可以在下一个信道检测位置前设定一个静默时间。优选的，若监听到信道资源繁忙，可以生成一个竞机数1作为退避时间，在这个退避时间内，继续监听目标信道，若检测到1次目标信道处于空闲状态，则退避时间结束，同时该基站就可以占几该目标信道。如果基站检测到信道状态为繁忙（例如已被其它设备占用），则在这个周期内设备不能占用信道，则该基站可以等到下一个周期的固定位置继续检测。

[0048] 作为检测目标信道是否处于空闲状态的另一种示例性的方式，具体的，当有新无线NR业务需要在非授权频段上传输时，触发初始检测，若基站初始检测到目标信道处于空闲状态，即可占用该目标信道，并在基站预先配置一个信道占用时间T；若基站初始检测到目标信道状态为非空闲，则可生成一个推迟周期(defer period)时间，如果在推迟周期时间还是检测到目标信道忙，则继续生成一个推迟周期时间，UE在此次检测时间检测到信道状态为空闲之后可以占用目标信道，占用目标信道时间为T。

[0049] S102，若存在，所述基站在所述剩余子帧上根据所述NR业务类型选择适用于所述NR业务的信号类型。

[0050] S103，所述基站在所述剩余子帧上采用所述NR业务的信号类型向终端发送所述NR业务的控制信令。

[0051] 具体实现中，NR业务类型可以包括eMBB、URLLC、mMTC等，基站可以根据上述业务类型选择与所述剩余子帧的子载波间隔、循环前缀长度和传输时间间隔(Transmission time interval，TTI)长度中至少一种相匹配的NR业务的信号，例如当NR业务类型为eMBB业务时，基站可以选择适用于eMBB业务所支持的参数取值如numerology类型或者频域资源组(Frequency resource group，FRG)类型的信号类型。FRG是指在一个NR载波上连续的或者非连续的频域资源上使用一个numerology类型的频域资源，而numerology类型主要与子载波间隔、循环前缀(Cyclic Prefix，CP)长度和TTI长度相关。所以，FRG的配置也理解为是包括子载波间隔、CP长度和TTI长度等相关参数中的至少一种参数的配置。

[0052] 基站可以在所述剩余子帧上采用所述NR业务的信号类型向终端发送所述NR业务的控制信令。本发明实施例中，控制信令可以包括保留信号，信道探测的参考信号或同步信号，其中，保留信号可以是未携带任何信息的信号，主要用于防止其它无线接入设备在此期

间占用该信道；参考信号主要用于对当前信道的信计以及信道质量的获取，也可在一定程度上防止其它无线接入设备在此期间占用该信道，它可以通过预设的序列生成，也可以以触发方式由基站发送；同步信号则可以防止终端与基站出现业务中断现象。

[0053] 本发明实施例，当NR业务在非授权频段上传输时，基站执行先听后说LBT机制并判断是否存在剩余子帧，若存在，所述基站根据所述NR业务类型选择适用于所述NR业务的信号类型，并在所述剩余子帧上采用所述NR业务的信号类型向终端发送所述NR业务的控制信令，本发明实施例采用剩余子帧发送所述NR业务的控制信令，合理使用了剩余子帧，有利于提高频谱利用率。

[0054] 请参照图2，图2是本发明实施例提供的信号传输方法的第一实施例流程示意图，本实施例中所描述的一种信号传输方法，包括步骤S201～S203。

[0055] S201，当新无线NR业务在非授权频段上传输时，基站执行先听后说LBT机制并判断用于执行所述LBT机制所在的资源块RB中是否存在剩余子帧。

[0056] 具体实现中，当新无线NR业务在非授权频段上传输时，NR业务在占用信道之前都要执行LBT机制，通过能量感知的方式获取目标信道是否空闲。当信道处于空闲状态时，才能使用该信道进行NR业务传输。由于LBT机制的时间一般微秒级的如LBT机制最短的执行时间是25us，而一个RB是0.5ms，基站一般以两个RB为单位即1ms来调度终端，LBT机制只是占用了RB的部分时频位置。所以，在执行完LBT机制之后，RB中可能会出现剩余子帧。在上行链路中，上述LBT机制的执行过程和剩余子帧的判断过程也可以由终端来执行。

[0057] 可选的，所述用于执行LBT机制的占用资源可以配置在预设子帧位置上。

[0058] 需要说明的是，下一代移动通信工作的频段可以包括非授权频段，也就是说，在无线通信系统的通信链路可以包括用于携带上行链路(UL)传输(例如，从UE116到eNB105)的上行链路和/或用于携带下行链路(DL)传输(例如，从基站到UE)的下行链路。UL传输还可以称为反向链路传输，而DL传输还可以称为前向链路传输。可以使用授权的频段(例如，LTE/LTE-A)、非授权的频段或两者来进行下行链路传输。类似地，可以使用授权的频段(例如，LTE/LTE-A)、非授权的频段或两者来进行上行链路传输。但是在非授权频段上，需要考虑到其它无线接入设备的存在，为了更好的与它们实现合理共存，LTE/LTE-A以及NR(例如，5G)系统需要遵守一些规则。比如LBT，即系统在使用非授权频段之前需要通过执行LBT机制用以判断目标信道是否可用。但是考虑到下一代移动通信系统中三种业务类型的特点，即为提高频谱利用率，三种业务类型所对应的"numerology"(数值参数)类型应有所不同。而对于非授权频段，在保证与其它异系统(诸如WiFi、蓝牙等)实现合理共存的同时，还要保证5G系统与LTE系统的兼容性。所以，针对这种情况，非授权频段会出现一种划分频段的情况，其示意图如图2a所示。可以看出，在子帧上被划分出一部分区域作为LBT区域，而另一部分区域作为不同NR类型业务(eMBB、URLLC、mMTC)的承载区域。考虑到LBT机制的执行时间处于微秒级别，所以，针对划分出来的LBT执行区域，可以以多子帧聚合的方式出现，即类似于LBT机制中基于帧结构设计的LBT机制(Frame Based Equipment，FBE)，基站或者终端会在预设若干个，每个无线帧中固定子帧的开头执行FBE；或者在每个无线帧中的一些固定子帧的开头执行FBE。所以，为提高非授权频段的频谱利用率，将划分出来用于执行LBT机制的占用资源，执行LBT机制的占用资源可以配置在预设子帧位置上，也可放在每个无线帧中固定子帧位置上，比如每个无线帧的第0号子帧和第5号子帧上。

[0059] 可选的，所述执行LBT机制的信号类型与适用于所述NR业务的信号类型不同。需要说明的是，考虑到尽可能保证LBT机制在适用于LTE/LTE-A业务的信号和适用于NR业务的信号两者中的兼容性，因此执行LBT机制的信号类型可以与传统的适用于LTE/LTE-A业务的信号保持一致，而与适用于NR业务的信号的类型不相同，此种设计被证明是有益的，可以在向前兼容的情形下同时考虑到新特性的引入，有利于提高频谱的利用效率。

[0060] S202，若存在上所述NR业务类型为增强型移动宽带应用eMBB业务，则从所述基础选择适用于所述eMBB业务的信号类型。

[0061] 具体实现中，为了使NR系统能够支持灵活和多种部署场景，不同"numerology(数值参数)"类型的子载波间隔和CP长度有所不同。同时，不同的"numerology(数值参数)"类型需具有可扩展性，以适应未来系统新增业务的需求，且不同的NR业务对于子帧结构的设计要求也不同。例如对于时延比较敏感的业务采用小数据包的发送或短周期TTI会比较适合。另外，同载波上不同频域范围内的"numerology(数值参数)"类型也可能不同。针对NR系统支持eMBB、URLLC、mMTC三大不同业务场景，业务具体分析如下：

[0062] eMBB主要工作在较宽的频段上，包括中高速的物联网通信(machine type communications,MTC)服务。该业务主要用于热点区域，以为终端用户提供较好的视频服务，通过设定合适的"numerology(数值参数)"类型以更好地适应该业务场景。例如可将该部分频段子载波间隔设置相对较大，以保证能够传输大带宽数业务。从频段特点来看，小于40GHz的频段上，最适合密集的城市宏小区场景中，高于40GHz以上的频段，比较适合室内或者微基站小区部署的城市密集场景。

[0063] URLLC场景主要面向车联网、工业控制等应用需求，其对时延要求和业务的可靠性要求较高。所以，可以适用于一些诸如室内和城市热点的微基站小区之中，例如部署大量小小区的场景中。不同于另外两种业务场景，可以将该场景的"numerology(数值参数)"类型中的TTI长度设置成短周期TTI最为适合。可以通过如下两种方式设置成短周期TTI：一种是在维持当前子载波间隔宽度的情况下，减少一个TTI内的符号数；一种是在维持相同TTI长度的情况下，增加每个符号的子载波间隔。

[0064] mMTC场景主要适用于以传感器和数据采集为主要的应用场景，例如环境监测、智能农业等。目前，它主要用于传输小流量数据包，其具有低功耗和低成本的特点，所以该业务场景的传输信道相对于前面两种业务场景而言，对频段宽度要求不是太高。因此，低于1GHz(如700MHz)的农村场景比较适合。其最佳典型场景和频谱设计可参见如下表1：

[0065]

使用场景	典型部属场景	典型频谱
eMBB	城市宏小区 密集城市场景（包括小小区）	<~40GHz， >~40GHz
URLLC	小小区/室内场景	<~40GHz
mMTC	农村场景	<1GHz（如700MHz）

[0066] 表1

[0067] 若所述NR业务类型为超可靠及低时延通信URLLC业务，则可以根据eMBB业务选择与所述剩余子帧的子载波间隔、循环前缀长度和TTI长度中至少一种相匹配的eMBB业务

的信号类型。

[0068] 可选的，若所述NR业务类型为超可靠及低时延通信URLLC业务，则所述基站可以选择适用于所述URLLC业务的信号类型。若存在剩余子帧且传输业务为URLLC业务，所述基站可以根据URLLC业务选择与所述剩余子帧的子载波间隔、循环前缀长度和TTI长度或者中至少一种相匹配的eMBB业务的信号类型。

[0069] 可选的，若所述NR业务类型为大量物联网通信mMTC业务，则所述基站选择适用于所述mMTC业务的信号类型。若存在剩余子帧且传输业务为mMTC业务时，可以根据mMTC业务选择与所述剩余子帧的子载波间隔、循环前缀长度和TTI长度中至少一种相匹配的mMTC业务的信号。

[0070] 其中，保留信号可以是未携带任何信息的信号，主要用于防止其它无线接入设备在此期间占用该信道；参考信号主要用于对当前信道的估计以及信道质量的获取，也可在一定程度上防止其它无线接入设备在此期间占用该信道，它可以通过预设的序列生成，也可以以触发方式由基站发送；同步信号则可以防止终端与基站出现业务中断现象。

[0071] S203、所述基站在所述剩余子帧上向终端发送适用于所述NR业务的控制信令。

[0072] 具体实现中，若已选择适用于所述NR业务的信号类型，可以在所述剩余子帧上发送适用于所述NR业务的信号。如图2b～2d所示，图2b是本发明实施例提供的发送eMBB业务的RB的结构示意图，图2c是本发明实施例提供的发送URLLC业务的RB的结构示意图，图2d是本发明实施例提供的发送mMTC业务的RB的结构示意图。RB一部分用于LBT机制的执行，另一部分根据不同的NR业务类型发送不同的信号，如eMBB业务的信号、URLLC业务的信号、mMTC业务的信号。其中，上述控制信令可以包括保留信号、信道探测的参考信号或同步信号。

[0073] 本发明实施例，当NR业务在非授权频段上传输时，执行先听后说LBT机制并判断是否存在剩余子帧，若存在且所述NR业务类型为增强型移动宽带应用eMBB业务，则选择适用于所述eMBB业务的信号类型，并在所述剩余子帧上采用所述NR业务的信号类型向终端发送适用于所述NR业务的控制信令，实现了NR业务和LAA共存，并通过合理使用剩余子帧发送NR业务的控制信令，提高了频谱利用率。

[0074] 请参照图3，图3是本发明实施例提供的信号传输方法的第一实施例流程示意图。本实施例中所描述的一种信号传输方法，包括步骤S301～S303。

[0075] S301、当新无线NR业务在非授权频段上传输时，终端执行先听后说LBT机制方法判断用于执行所述LBT机制所在的资源块RB中是否存在剩余子帧。

[0076] 具体实现请参考图1对应的方法实施例的步骤S101以及图2对应的方法实施例的步骤S201的具体解释，在此不再赘述。

[0077] 作为检测目标信道是否处于空闲状态的一种示例性的方式，具体的，当有新无线NR业务需要在非授权频段上传输时，终端检测周围是否有其它设备正在目标信道发送物理上行共享信道(Physical Uplink Shared Channel，PUSCH)数据。如果该目标某信道已被其它设备占用，可以在下一监听周期到来时继续监听，也可以根据指示不再监听；若监听到信道资源空闲，该终端也以立即占用该目标信道。信道占用时间是一个固定值，也可以在下一信道检测位置前设定一个等候时间。优选的，若监听到信道资源繁忙，可以生成一个随机数N作为退避时间，在这个退避时间内，继续监听目标信道，若检测到N次目标信道处于空闲状态，则退避时间结束，同时该终端就可以占用该目标信道。如果终端检测到信道状态为繁忙

(例如已被其它终端占用)，则在这个周期内设备不能占用信道，则该终端可以等到下一个周期的时间点位置继续检测。

[0078] 作为检测目标信道是否处于空闲状态的另一种示例性的方式，具体的，当有新无线NR业务需要在非授权频段上传输时，触发初始检测。若终端初始检测到目标信道处于空闲状态，即可占用该目标信道，并在基站预先配置一个信道占用时间T；若终端初始检测到目标信道状态为非空闲，则可生成一个推迟周期(defer period)时间，如果在推迟周期时间还是检测到目标信道忙，则继续生成一个推迟周期时间。终端在T次检测时间检测到信道状态为空闲之后可以占用目标信道，占用目标信道时间为T。

[0079] S302、若存在，所述终端向基站发送所述RB中存在剩余子帧的指示消息。

[0080] 具体实现中，若所在的RB中存在剩余子帧，则所述终端会向基站发送一个指示消息，该指示消息可以用于告知基站RB中存在剩余子帧，进一步的，该指示消息还可以触发基站在该剩余子帧上发送适用于所述NR业务的信号。

[0081] S303、所述终端接收所述基站在所述剩余子帧上采用NR业务的信号类型发送的所述NR业务的控制信令，所述NR业务的信号类型由所述基站在所述剩余子帧上根据所述NR业务类型所选择。

[0082] 具体实现中，基站获知RB中存在剩余子帧后，会根据NR业务类型选择适用于所述NR业务的信号类型，并在所述剩余子帧上采用NR业务的信号类型向终端发送所述NR业务的控制信令，具体过程请参见图1对应实施例的步骤S102～S103以及图2对应实施例的步骤S202～S203，在此不再赘述。所述终端可以接收所述基站在所述剩余子帧上采用NR业务的信号类型发送的所述NR业务的控制信令。

[0083] 可选的，若所述NR业务类型为增强型移动宽带应用eMBB业务，则所述终端接收基站在所述剩余子帧上采用NR业务的信号类型发送的所述eMBB业务的控制信令

[0084] 可选的，若所述NR业务类型为超可靠及低时延通信URLLC业务，则所述终端接收基站在所述剩余子帧上采用NR业务的信号类型发送的所述URLLC业务的控制信令。

[0085] 可选的，若所述NR业务类型为大量物联网通信mMTC业务，则所述终端接收基站在所述剩余子帧上采用NR业务的信号类型发送的所述mMTC业务的控制信令。

[0086] 可选的，所述适用于所述NR业务的信号类型是指所述基站根据所述NR业务类型所选择的与所述剩余子帧的子载波间隔，循环前缀长度和传输时间间隔TTI长度中的至少一种相匹配的NR业务的信号类型。

[0087] 可选的，所述控制信令包括保留信号、信道探测的参考信号或同步信号。

[0088] 上述可选步骤的具体实现请参考图2对应的方法实施例的具体解释，在此不再赘述。

[0089] 本发明实施例中，当新无线NR业务在非授权频段上传输时，终端执行先听后说LBT机制并判断用于执行所述LBT机制的所在的资源集RB中是否存在剩余子帧，若存在，所述终端接收基站在所述剩余子帧上采用NR业务的信号类型发送的所述NR业务的控制信令，所述NR业务的信号类型由所述基站在所述剩余子帧上根据所述NR业务类型所选择，实现了NR业务和LAA共存，并可以使基站在该剩余子帧上发送NR业务的控制信令，提高了频谱利用率。

[0090] 请参照图4，为本发明实施例提供的基站的第一实施例结构示意图。本发明实施例的基站包括：判断单元101、选择单元102和发送单元103

[0091] 判断单元101，用于当新无线NR业务在非授权频段上传输时，执行先听后说LBT机制并判断资源块RB中是否存在剩余子帧；

[0092] 选择单元102，用于若存在所述剩余子帧，在所述剩余子帧上根据所述NR业务类型选择适用于所述NR业务的信号类型；

[0093] 可选的，所述选择单元102具体用于若所述NR业务类型为增强型移动宽带应用eMBB业务，则在所述剩余子帧上根据所述NR业务类型选择适用于所述eMBB业务的信号类型。

[0094] 可选的，所述选择单元102具体用于若所述NR业务类型为超可靠及低时延通信URLLC业务，则在所述剩余子帧上根据所述NR业务类型选择适用于所述URLLC业务的信号类型。

[0095] 可选的，所述选择单元102具体用于若所述NR业务类型为大量物联网通信mMTC业务，则在所述剩余子帧上根据所述NR业务类型选择适用于所述mMTC业务的信号类型。

[0096] 发送单元103，用于在所述剩余子帧上采用所述NR业务的信号类型向终端发送所述NR业务的控制信令。

[0097] 可选的，所述适用于所述NR业务的信号类型是指根据所述NR业务类型所选择的与所述剩余子帧的子载波间隔，循环前缀长度和传输时间间隔TTI长度中的至少一种相匹配的NR业务的信号类型。

[0098] 可选的，所述控制信令包括保留信号，信道探测的参考信号或同步信号。

[0099] 上述实施例各个单元的具体解释请参见图一-图2所对应的方法实施例，在此不再赘述。

[0100] 请参照图5，是本发明实施例提供的基站的第二实施例结构示意图。本实施例中所描述的基站主要包括：至少一个输入设备1000和输出设备1001；至少一个处理器1002，例如CPU；可选的存储器1003，上述输入设备1000、输出设备1001、处理器1002和可选的存储器1003通过总线1004连接。

[0101] 上述存储器1003可以是高速RAM存储器，也可为非易失性存储器(non-volatile memory，NVM)，例如磁盘存储器。上述存储器1003可用于存储程序代码，上述处理器1002用于调用存储器1003中存储的程序代码，执行如下操作：

[0102] 上述处理器1002，用于当新无线NR业务在非授权频段上传输时，执行先听后说LBT机制并判断资源块RB中是否存在剩余子帧；

[0103] 上述处理器1002，还用于若存在，在所述剩余子帧上根据所述NR业务类型选择适用于所述NR业务的信号类型；

[0104] 上述处理器1002，还用于在所述剩余子帧上采用所述NR业务的信号类型向终端发送所述NR业务的控制信令。

[0105] 可选的，上述处理器1002，具体用于若所述NR业务类型为增强型移动宽带应用eMBB业务，则在所述剩余子帧上根据所述NR业务类型选择适用于所述eMBB业务的信号类型。

[0106] 上述处理器1002，具体用于若所述NR业务类型为超可靠及低时延通信URLLC业务，则在所述剩余子帧上根据所述NR业务类型选择适用于所述URLLC业务的信号类型。

[0107] 上述处理器1002，具体用于若所述NR业务类型为大量物联网通信mMTC业务，则在

所述剩余子帧上根据所述NR业务类型选择适用于所述mMTC业务的信号类型。

[0108] 其中，所述适用于所述NR业务的信号类型是指根据所述NR业务类型所选择的与所述剩余子帧的子载波间隔、循环前缀长度和传输时间间隔TTI长度中的至少一种相匹配的NR业务的信号类型。所述控制信令包括保留信号、信道探测的参考信号或同步信号。

[0109] 具体实现中，本发明实施例中所描述的输入设备1000、输出设备1001和处理器1002可执行本发明实施例提供的信号传输方法的第一实施例、第二实施例中所描述的实现方式，也可执行本发明实施例提供的基站中所描述的终实现方式，在此不再赘述。

[0110] 请参照图6，为本发明实施例提供的终端的第一实施例结构示意图。本发明实施例的终端包括：判断单元201、发送单元202和接收单元203。

[0111] 所述判断单元201，用于当新无线NR业务在非授权频段上传输时，执行先听后说LBT机制并判断资源块RB中是否存在剩余子帧；

[0112] 所述发送单元202，用于若存在所述剩余子帧，向基站发送所述RB中存在剩余子帧的指示消息；

[0113] 所述接收单元203，接收所述基站在所述剩余子帧上采用NR业务的信号类型发送的所述NR业务的控制信令，所述NR业务的信号类型由所述基站在所述剩余子帧上根据所述NR业务类型所选择。

[0114] 可选的，所述接收单元203具体用于若所述NR业务类型为增强型移动宽带应用eMBB业务，则接收基站在所述剩余子帧上采用NR业务的信号类型发送的所述eMBB业务的控制信令。

[0115] 可选的，所述接收单元203具体用于若所述NR业务类型为超可靠及低时延通信URLLC业务，则接收基站在所述剩余子帧上采用NR业务的信号类型发送的所述URLLC业务的控制信令。

[0116] 可选的，所述接收单元203具体用于若所述NR业务类型为大规物联网通信mMTC业务，则接收基站在所述剩余子帧上采用NR业务的信号类型发送的所述mMTC业务的控制信令。

[0117] 可选的，所述适用于所述NR业务的信号类型是指根据所述NR业务类型所选择的与所述剩余子帧的子载波间隔、循环前缀长度和传输时间间隔TTI长度中的至少一种相匹配的NR业务的信号类型。所述控制信令包括保留信号、信道探测的参考信号或同步信号。

[0118] 上述实施例各个单元的具体解释请参见图2所对应的方法实施例，在此不再赘述。

[0119] 请参照图7，是本发明实施例提供的终端的第二实施例结构示意图。本实施例中所描述的终端主要包括：至少一个输入设备2000和输出设备2001；至少一个处理器2002，例如CPU；可选的存储器2003。上述输入设备2000、输出设备2001、处理器2002和可选的存储器2003通过总线2004连接。

[0120] 上述存储器2003可以是高速RAM存储器，也可为NVM，例如磁盘存储器。上述存储器2003可用于存储程序代码，上述处理器2002用于调用存储器2003中存储的程序代码，执行如下操作：

[0121] 上述处理器2002，用于当新无线NR业务在非授权频段上传输时，执行先听后说LBT机制并判断资源块RB中是否存在剩余子帧；

[0122] 上述处理器2002，用于若存在所述剩余子帧，向基站发送所述RB中存在剩余子帧

的指示消息；

[0123] 上述处理器2002，还用于若存在所述剩余子帧，接收所述基站在所述剩余子帧上采用NR业务的信号类型发送的所述NR业务的控制信令，所述NR业务的信号类型由所述基站在所述剩余子帧上根据所述NR业务类型所选择；

[0124] 可选的，上述处理器2002，具体用于若所述NR业务类型为增强型移动宽带应用eMBB业务，则接收基站在所述剩余子帧上采用NR业务的信号类型发送的所述eMBB业务的控制信令。

[0125] 上述处理器2002，具体用于若所述NR业务类型为超可靠及低时延通信URLLC业务，则接收基站在所述剩余子帧上采用NR业务的信号类型发送的所述URLLC业务的控制信令。

[0126] 上述处理器2002，具体用于若所述NR业务类型为大量物联网通信mMTC业务，则接收基站在所述剩余子帧上采用NR业务的信号类型发送的所述mMTC业务的控制信令。

[0127] 其中，所述适用于所述NR业务的信号类型是指根据所述NR业务类型所选择的与所述剩余子帧的子载波间隔、循环前缀长度和传输时间间隔TTI长度中的至少一种相匹配的NR业务的信号类型，所述控制信令包括参考信号、信道探测的参考信号或同步信号。

[0128] 具体实现中，本发明实施例中所描述的输入设备2000、输出设备2001和处理器2002可执行本发明实施例提供的信号传输方法的第二实施例中所描述的实现方式，也可执行本发明实施例提供的终端中所描述的终实现方式，在此不再赘述。

[0129] 本发明实施例方法中的步骤可以根据实际需要进行顺序调整、合并和删减。

[0130] 本发明实施例装置中的单元可以根据实际需要进行合并、划分和删减。

[0131] 本领域普通技术人员可以理解实现上述实施例方法中的全部或部分流程，是可以通过计算机程序来指令相关的硬件来完成，所述的程序可存储于一计算机可读取存储介质中，该程序在执行时，可包括如上述各方法的实施例的流程。其中，所述的存储介质可为磁碟、光盘、只读存储记忆体(Read-Only Memory，ROM)或随机存储记忆体(Random access Memory，RAM)等。

[0132] 以上所揭露的仅为本发明较佳实施例而已，当然不能以此来限定本发明之权利范围，因此依本发明权利要求所作的等同变化，仍属本发明所涵盖的范围。

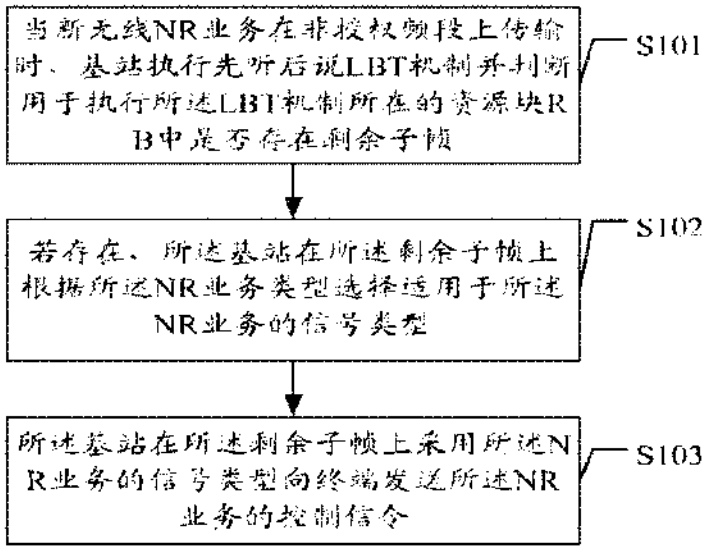

当新无线NR业务在非授权频段上传输时、基站执行先听后说LBT机制并判断用于执行所述LBT机制所在的资源块RB中是否存在剩余子帧
S101
若存在、所述基站在所述剩余子帧上根据所述NR业务类型选择适用于所述NR业务的信号类型
S102
所述基站在所述剩余子帧上采用所述NR业务的信号类型向终端发送所述NR业务的控制信令
S103

图1

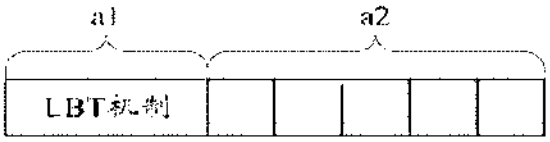

a1
a2
LBT机制

图1a

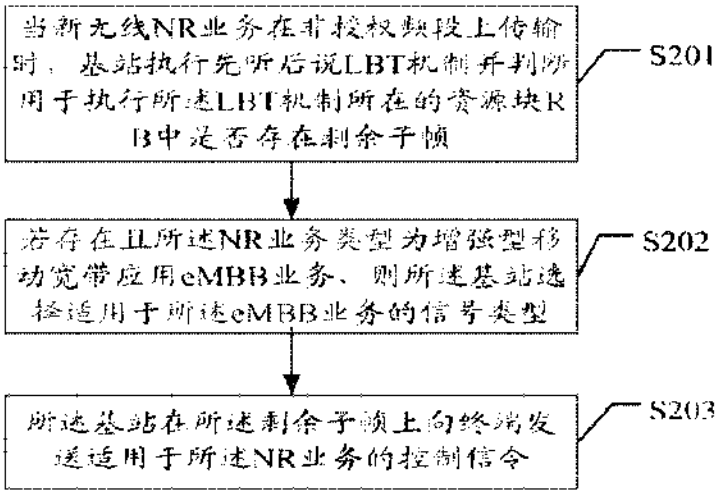

当新无线NR业务在非授权频段上传输时，基站执行先听后说LBT机制并判断用于执行所述LBT机制所在的资源块RB中是否存在剩余子帧
S201
若存在且所述NR业务类型为增强型移动宽带应用eMBB业务，则所述基站选择适用于所述eMBB业务的信号类型
S202
所述基站在所述剩余子帧上向终端发送适用于所述NR业务的控制信令
S203

图2

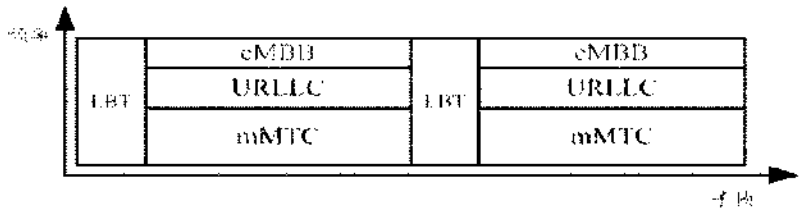

LBT
eMBB
URLLC
mMTC
LBT
eMBB
URLLC
mMTC

图2a

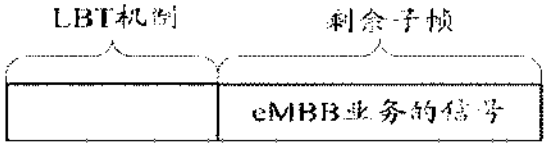

LBT机制
剩余子帧
eMBB业务的信号

图2b

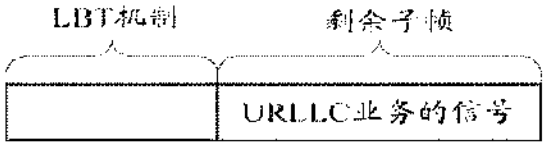

LBT机制
剩余子帧
URLLC业务的信号

图2c

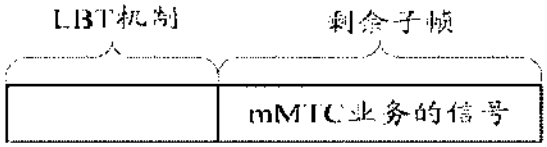

LBT机制
剩余子帧
mMTC业务的信号

图2d

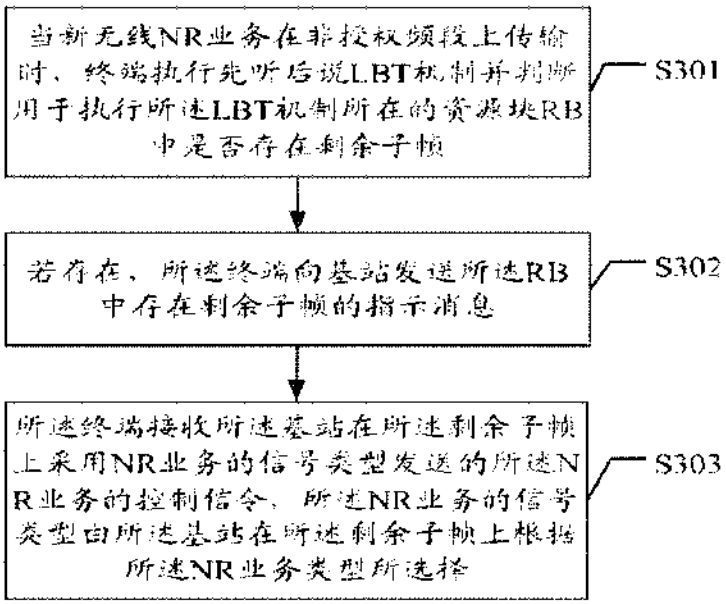

当新无线NR业务在非授权频段上传输时，终端执行先听后说LBT机制并判断用于执行所述LBT机制所在的资源块RB中是否存在剩余子帧
S301
若存在，所述终端向基站发送所述RB中存在剩余子帧的指示消息
S302
所述终端接收所述基站在所述剩余子帧上采用NR业务的信号类型发送的所述NR业务的控制信令，所述NR业务的信号类型由所述基站在所述剩余子帧上根据所述NR业务类型所选择
S303

图3

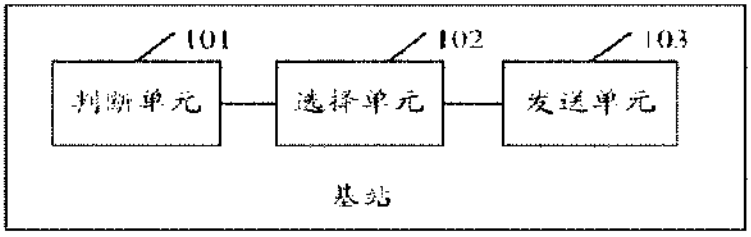

101
判断单元
102
选择单元
103
发送单元
基站

图1

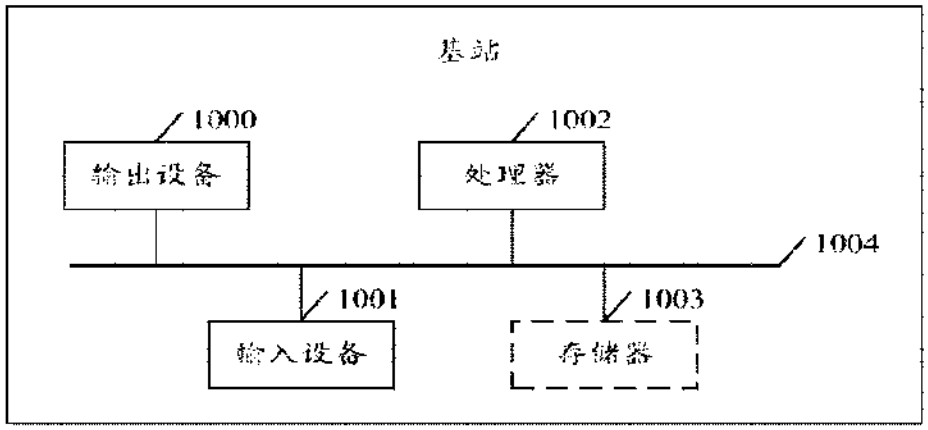

基站
1000
输出设备
1002
处理器
1004
1001
输入设备
1003
存储器

图5

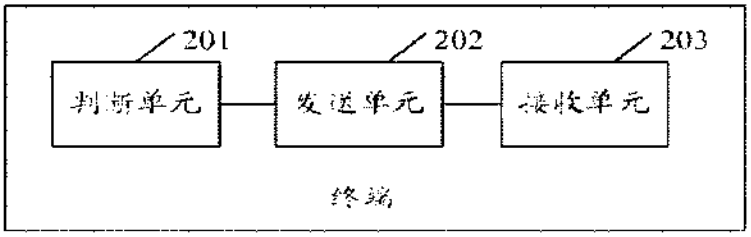

201
判断单元
202
发送单元
203
接收单元
终端

图6

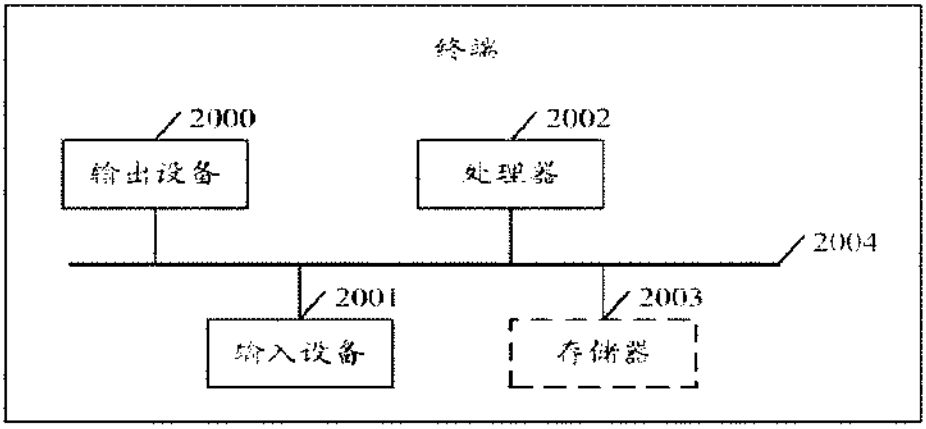


图7

(12) 按照专利合作条约所公布的国际申请

(19) 世界知识产权组织
国 际 局

(43) 国际公布日
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(81) 指定国 (除另有指明, 要求每一种可提供的国家保护): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW。

(84) 指定国 (除另有指明, 要求每一种可提供的地区保护): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), 欧亚 (AM, AZ, BY, KG, KZ, RU, TJ, TM), 欧洲 (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE,

[见续页]

(54) Title: METHOD FOR RECEIVING/SENDING PAGING MESSAGE AND RELATED NETWORK AND USER EQUIPMENT

(54) 发明名称: 寻呼消息的接收/发送方法及相关网络节点和用户设备

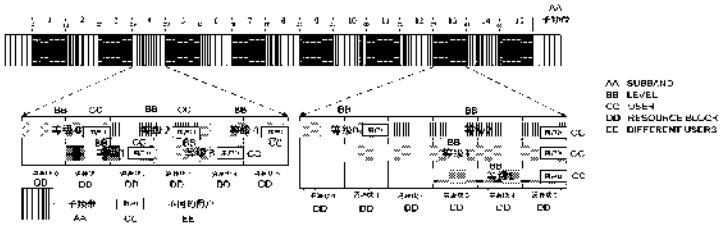


图10 / FIG. 10

(57) Abstract: The present invention provides a method for receiving/sending a paging message and a corresponding network node/user equipment. The method comprises: receiving an indication of a physical resource block set used to send a paging message, an index of the physical resource block set in a subframe being determined according to the level of the paging message; and receiving the paging message on the indicated physical resource block set. According to the technical solution, a paging message transmission mechanism for a coverage enhanced MTC user equipment and/or a low-complexity or low-cost MTC user equipment can be provided.

(57) 摘要: 本发明提供了寻呼消息接收/发送方法以及相应网络节点/用户设备。该方法包括: 接收对用于发送所述寻呼消息的物理资源块集的指示, 其中, 所述物理资源块集在子帧中的索引是根据所述寻呼消息的等级确定的; 以及在所指示的物理资源块集上接收所述寻呼消息。根据该技术方案, 可提供同时针对覆盖增强 MTC 用户设备和/或低复杂度或低成本的 MTC 用户设备的寻呼消息传输机制。

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IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG)。

本国际公布:

— 包括国际检索报告(条约第 21 条(3))。

寻呼消息的接收/发送方法及相关网络节点和用户设备

技术领域

本发明涉及无线通信技术领域。更具体地，本发明涉及寻呼消息的接收/发送方法以及相关网络节点/用户设备。

背景技术

第三代移动通信合作计划组织（3GPP）部署的长期演进项目（LTE）旨在提供日益多样化的未来移动通信服务，无线蜂窝通信日益成为大众生活和工作中不可或缺的一部分。在 3GPP LTE 的第一版（即 Release 8）中，引入了正交频分多址（OFDMA）和多天线（MIMO）技术。3GPP 的 Release 10 版本经国际电信联盟的评估和测试，正式成为了第四代全球移动通信标准 LTE-Advanced。在 LTE-Advanced 标准中，引入了载波聚合（CA）和中继技术，增强了上行/下行 MIMO 技术，同时支持异构网络（HetNet）的部署。

为了满足未来家庭设备通信的市场需求和规模庞大的物联网(IOT)部署，3GPP 决定在 LTE 及其升级版本中引入低成本机器间通信技术（MTC: Machine Type Communication），将 MTC 服务由目前的 GSM 网络支持迁移至 LTE 网络支持，并定义了若干种新的 LTE 用户设备(UE: User Equipment)的类型，其一称之为低成本 MTC 用户设备（Low-cost MTC UE），该 MTC 用户设备在现有 LTE 网络的所有双工模式中支持 MTC 服务，并具有这样的性能：1）单接收天线；2）下行和上行最大的传输模块大小（TBS: Transport Block Size）为 1000 比特；3a）下行链路数据信道的基带带宽降低为 1.4MHz，下行链路控制信道的带宽与网络侧系统带宽保持一致，上行链路信道带宽以及下行链路的射频部分与现有 LTE 网络中的用户设备保持一致；3b）下行/上行链路控制信道和数据信道的基带带宽降低为 1.4MHz。

MTC 是一种不需要人为参与的数据通信服务。大规模的 MTC 用户设备部署，可以用于安全、跟踪、付账、测量以及消费电子等领域，具体涉及的应用包括视频监控、供货链跟踪、智能电表，远程监控等。MTC 用户设备要求较低的功率消耗，支持较低的数据传输速率和较低的移动性。

目前 LTE 系统主要是针对人与人（H2H）的通信服务。因此，实现 MTC 服务的规模竞争优势及应用前景，关键环节在于 LTE 网络支持低成本的 MTC 设备能够低成本，低复杂性的工作。

一些 MTC 用户设备需要安装在居民楼地下室或者由绝缘箔片、金属护窗或者传统建筑物的厚墙保护的位置，相比较 LTE 网络中常规设备终端（如手机，平板电脑等），这些设备的空中接口将明显遭受更严重的穿透损失。3GPP 决定研究 LTE 网络提供 MTC 用户设备附加 20dB/15dB 覆盖增强服务的方案设计与性能评估，值得注意的是，位于糟糕网络覆盖区域的 MTC 用户设备具有这样的特点：非常低的数据传输速率，非常宽松的延时要求，以及有限的移动性。针对 MTC 用户设备特点，LTE 网络可以进一步优化一些信令和/或信道用以支持 MTC 用户设备。3GPP 要求为新定义的MTC用户设备以及其他运行MTC服务(如，非常宽松的延迟要求）的用户设备提供一定的 LTE 网络覆盖增强，其中，对于 LTE 频分双工（FDD）网络提供 15dB 的网络覆盖增强。另外，并不是所有的运用 MTC 服务的用户设备都需要相同网络覆盖增强。

在 2014 年 6 月举行的 3GPP RAN#64 次全会上，提出了一个新的面向 Rel-13 的低复杂性和覆盖增强的 MTC 的工作项目（参见非专利文献：RP-140990 New Work Item on Even Lower Complexity and Enhanced Coverage LTE UE for MTC，Ericsson，NSN）。在该工作项目的描述中，LTE Rel-13 系统需要支持上下行 1.4MHz 射频带宽的 MTC 用户设备（User Equipment，UE，以下称为窄带 MTC UE）工作在任意的系统带宽（例如 1.4MHz、3 MHz、5 MHz、10 MHz、15 MHz、20 MHz 等等）下，并且为该类 MTC 用户提供覆盖增强功能。在系统设计时，低成本 MTC 用户和覆盖增强 MTC 用户要采用统一的设计方案。降低 MTC 用户设备的能耗是该工作项目的主要目标之一。

针对 3GPP LTE 用户设备运行 MTC 业务并处于覆盖增强模式下，物理层信道如(E)PDCCH/PDSCH/PUCCH/PUSCH 的覆盖增强设计与配置是一个需要标准化的工作，根据 3GPP RAN1 #74 会议的讨论，在完成初始接入过后，任何一个需要重复传输的物理信道，其配置模式取决于基站端。而 MTC 用户设备合并解调大量重复数据会引入 2 至 10 秒的延迟。这样的延迟会增加MTC用户设备的耗电量。根据 3GPP RAN1 #74b 会议的决定，

对于需要覆盖增强的 MTC 用户设备数据信道的传输应在控制信道传输完成之后。因此为了减少用户设备的耗电量，对于需要覆盖增强的 MTC 用户设备的寻呼消息传输可以不需要控制信道。同时由于低复杂度 MTC 用户设备（Low complexity MTC UE）与覆盖增强的 MTC 用户设备具有相似的信息传输机制，需要设计一种同时针对覆盖增强 MTC 用户设备和/或低复杂度或低成本的 MTC 用户设备的寻呼消息传输机制。因此在 Rel-12 及其之后版本中，针对覆盖增强模式下 MTC 用户设备和/或低复杂度或低成本的 MTC 用户设备的寻呼消息传输需要重新标准化。

发明内容

本发明旨在提供同时针对例如覆盖增强 MTC 用户设备和/或低复杂度或低成本的 MTC 用户设备的寻呼消息传输机制。

根据本发明的一个方案，提供了一种用户设备接收寻呼消息的方法。该方法包括：接收对用于发送所述寻呼消息的物理资源块集的指示，其中，所述物理资源块集在子帧中的索引是根据所述寻呼消息的等级确定的；以及在所指示的物理资源块集上接收所述寻呼消息。

根据本发明的另一个方案，提供了一种网络节点发送寻呼消息的方法。该方法包括：根据所述寻呼消息的等级确定用于发送所述寻呼消息的物理资源块集在子帧中的索引；向作为所述寻呼消息的接收方的用户设备通知对所述物理资源块集的指示，以及在所确定的物理资源块集上发送所述寻呼消息。

根据本发明的另一个方案，提供了一种用户设备。该用户设备包括：接收单元，用于接收对用于发送所述寻呼消息的物理资源块集的指示，以及用于在所指示的物理资源块集上接收所述寻呼消息，其中，所述物理资源块集在子帧中的索引是根据所述寻呼消息的等级确定的。

根据本发明的另一个方案，提供了一种网络节点。该基站包括：块集索引确定单元，用于根据寻呼消息的等级确定用于发送所述寻呼消息的物理资源块集在子帧中的索引，以及发送单元，用于向作为所述寻呼消息的接收方的用户设备通知对所述块集索引确定单元确定的物理资源块集的指示，以及用于在所述确定的物理资源块集上发送所述寻呼消息。

本发明的上述方案简单易行，并且由于用于发送寻呼消息的物理资源块的参数（例如索引）取决于寻呼消息的等级，而该寻呼消息等级同样可用于对 MTC 用户设备进行覆盖增强，因此该方案同时适用于覆盖增强 MTC 用户设备和/或低复杂度或低成本的 MTC 用户设备的寻呼消息传输。

附图说明

通过下文结合附图的详细描述，本发明的上述和其它特征将会变得更加明显，其中：

图 1 示出了根据本发明的接收寻呼消息的方法的流程图；

图 2 示出了根据本发明的发送寻呼消息的方法的流程图；

图 3 示出了根据本发明的用于接收寻呼消息的用户设备的示意性框图；

图 4 示出了根据本发明的用于发送寻呼消息的基站的示意性框图；

图 5 示出了不同等级的寻呼消息的占用的相同大小资源块集的示意图；

图 6 示出了不同等级的寻呼消息与相应的资源块起始位置索引的对应关系的示意图；

图 7 示出了不同等级的寻呼消息的占用的不同大小资源块集的示意图；

图 8 示出了不同等级的寻呼消息与相应占用的资源块集的大小的对应关系的示意图；

图 9 示出了不同寻呼等级与相应的资源块起始位置索引的对应关系的另一示意图；以及

图 10 示出了将系统频带划分为多个子频带的示意图。

具体实施方式

以下将结合附图和具体实施例，对本发明所提出的针对需要额外覆盖增强的 MTC 用户设备或者低复杂度/低成本 MTC 用户设备的寻呼消息在频域资源上的发送/接收方法、网络节点和用户设备（UE）进行详细阐述。应当注意的是，虽然本发明是针对需要额外覆盖增强或者低复杂度/低成本 MTC 用户设备来阐述的，但其同样也适用于其他支持延迟容忍服务和/或需要一定覆盖增强的用户设备。应当注意的是，本发明不应局限于下文所述的具体实施例。另外，为了简便起见，省略了对与本发明没有直接关联的公知技术的详细描述，以防止对本发明的理解造成混淆。

下文以 LTE 移动通信系统及其后续的演进版本作为示例应用环境，具体描述了根据本发明的多个实施例。然而，需要指出的是，本发明不限于以下实施例，而是可适用于更多其它的无线通信系统，例如今后的 5G 蜂窝通信系统或现有的其他通信系统，只要其要求提供同时针对覆盖增强 MTC 用户设备和/或低复杂度或低成本的 MTC 用户设备的寻呼消息传输机制。

图 1 示出了根据本发明的一个实施例的寻呼消息接收方法。在图 1 的步骤 110 中，用户设备接收对用于发送寻呼消息的物理资源块集的指示，其中，物理资源块集在子帧中的索引是根据寻呼消息的等级确定的。在步骤 120 中，用户设备在所指示的物理资源块集上接收寻呼消息。

在本发明的一些实施例中，寻呼消息的等级是通过以下方式之一获得的：由基站通过广播系统信息和/或用户设备专用无线电资源控制信令配置；由网络侧通过 NAS 信令配置；以及由用户设备根据其测量结果确定。

在本发明的一些实施例中，物理资源块集在子帧中的索引是指物理资源块集的起始资源块在子帧中的索引。

在本发明的一些实施例中，物理资源块集的大小对于不同等级的寻呼消息而言是相同的。

在本发明的另一些实施例中，物理资源块集的大小根据寻呼消息的等级确定。

在本发明的一些实施例中，寻呼消息的等级还用于确定一个或多个物理下行共享信道，物理上行共享信道，物理下行控制信道和/或增强型物理下行控制信道，物理上行控制信道和物理随机接入信道的重复次数。

在本发明的一些实施例中，寻呼消息的等级还用于确定一个或多个物理下行共享信道，物理上行共享信道，物理下行控制信道和/或增强型物理下行控制信道，物理上行控制信道和物理随机接入信道的传输时间间隔捆绑大小。

在本发明的一些实施例中，接收对用于发送寻呼消息的物理资源块集的指示包括：通过广播系统信息和/或用户设备专用的无线电资源控制(UE dedicated Radio Resource Control)信令从基站接收物理资源块集在子帧中的索引和/或物理资源块集的大小；或通过非接入层（NAS）信令从网络侧设备接收物理资源块集在子帧中的索引和/或物理资源块集的大小。

在本发明的一些实施例中，该用户设备使用的系统带宽包括 6 个物理资源块。在该情况下，物理资源块集是系统带宽的子集

然而，也可能存在系统带宽大于 6 个物理资源块的情况。在本发明的一些实施例中，当系统带宽大于 6 个物理资源块时，系统带宽可包括多个子频带。该多个子频带中的每一个包含不多于 6 个的物理资源块。例如，在系统带宽中包含的物理资源块的数目能够被 6 整除时，该多个子频带中的每一个包含 6 个物理资源块。然而当系统带宽中包含的物理资源块的数目不能够被 6 整除时，该多个子频带中的一个子频带包含的物理资源块可以小于 6 个，而其他子频带可以均包含 6 个物理资源块。也可以存在其他的子频带分配方式，例如在其他通信系统中可以使用除 6 之外的其他物理资源块数目。只要寻呼消息对应的物理资源块的数目小于该子频带具有的资源块的总数目，便可以使用本文上述的方案确定该子频带中用于该寻呼消息的资源块集的起始位置索引和大小，本发明不受限于系统带宽/子频带中包含的具体资源块的数目。

在上述任一情况下，寻呼消息在多个子频带中由网络节点（例如基站或网络侧）确定的一个子频带上接收。

图 2 示出了根据本发明的一个实施例的网络节点侧的寻呼消息发送方法。在图 2 所示的流程图中，该方法包括：步骤 210，根据寻呼消息的等级确定用于发送寻呼消息的物理资源块集在子帧中的索引；步骤 220，向作为寻呼消息的接收方的用户设备通知对物理资源块集的指示；以及步骤 230，在所确定的物理资源块集上发送寻呼消息。

在本发明的一些实施例中，寻呼消息的等级是通过以下方式之一获得的：由网络节点预先存储，由上级网络节点通知（例如，在网络节点是基站的情况下，由网络侧通过 S1 寻呼消息指示）；以及用户设备根据其测量结果确定并通知网络节点。

在本发明的一些实施例中，物理资源块集在子帧中的索引是指物理资源块集的起始资源块在子帧中的索引。

在本发明的一些实施例中，物理资源块集的大小对于不同等级的寻呼消息而言是相同的。

在本发明的一些实施例中，物理资源块集的大小根据寻呼消息的等级确定。

在本发明的一些实施例中，寻呼消息的等级还用于确定一个或多个物理下行共享信道，物理上行共享信道，物理下行控制信道和/或增强型物理下行控制信道，物理上行控制信道和物理随机接入信道的重复次数。

在本发明的一些实施例中，寻呼消息的等级还用于确定一个或多个物理下行共享信道，物理上行共享信道，物理下行控制信道和/或增强型物理下行控制信道，物理上行控制信道和物理随机接入信道的传输时间间隔捆绑大小。

在本发明的一些实施例中，向作为寻呼消息的接收方的用户设备通知对物理资源块集的指示包括：如果网络节点是基站，通过广播系统信息和/或用户设备专用的无线电资源控制信令向用户设备发送物理资源块集在子帧中的索引和/或物理资源块集的大小；或如果网络节点是网络侧设备，通过非接入层信令向用户设备发送物理资源块集在子帧中的索引和/或物理资源块集的大小。然而本发明不限于此，例如基站也可以使用其他的群发机制（例如，多播机制等）来发送物理资源块集在子帧中的索引。

在本发明的一些实施例中，网络节点为用户设备分配的系统带宽包括 6 个物理资源块。在该情况下，物理资源块集是所述系统带宽的子集。

在本发明的一些实施例中，当网络节点为用户设备分配的系统带宽大于 6 个物理资源块时，将所述系统带宽划分为包含不多于 6 个物理资源块的多个子频带，以及确定所述多个子频带中要在其上向用户设备发送寻呼消息的一个子频带。

图 3 示出了用于根据本发明的实施例发送寻呼消息的用户设备。该用户设备至少包括：接收单元 310，用于接收对用于发送寻呼消息的物理资源块集的指示，且用于在所指示的物理资源块集上接收寻呼消息，其中，物理资源块集在子帧中的索引是根据寻呼消息的等级确定的。

在本发明的一些实施例中，寻呼消息的等级是由基站通过广播系统信息和/或用户设备专用无线电资源控制信令配置或由网络侧通过 NAS 信令配置，并通过接收单元 310 接收的。在本发明的另一些实施例中，用户设

备还包括用于测量信道状态的测量单元 320，以及用于根据测量单元的测量结果确定寻呼消息的等级的等级确定单元 330。

在本发明的一些实施例中，物理资源块集在子帧中的索引是指物理资源块集的起始资源块在子帧中的索引。

在本发明的一些实施例中，物理资源块集的大小对于不同等级的寻呼消息而言是相同的。

在本发明的一些实施例中，物理资源块集的大小由网络节点（根据不同的实现，可以是基站或网络侧设备，如移动性管理实体（MME））根据寻呼消息的等级确定，并通过广播系统信息和/或用户设备专用无线电资源控制信令由接收单元 310 接收。

对物理资源块集的指示可以包括物理资源块集在子帧中的索引以及物理资源块集的大小。在本发明的一些实施例中，接收单元 310 还用于通过广播系统信息和/或用户设备专用的无线电资源控制(UE dedicated RRC)信令从基站接收物理资源块集在子帧中的索引和/或物理资源块集的大小。或者在其他一些实施例中，接收单元 310 还用于通过非接入层信令从网络侧设备接收物理资源块集在子帧中的索引和/或物理资源块集的大小。

在本发明的一些实施例中，用户设备使用的系统带宽包括 6 个物理资源块，以及物理资源块集是所述系统带宽的子集。

在本发明的一些实施例中，当用户设备使用的系统带宽大于 6 个物理资源块时，系统带宽包括多个子频带，该多个子频带中的每一个包含不多于 6 个的物理资源块。在该情况下，寻呼消息由接收单元 310 在所述多个子频带中由网络节点（基站或网络侧）确定的一个子频带上接收。

在本发明的一些实施例中，用户设备还包括存储器 340，用于存储接收单元 310 接收到的各种信息，例如寻呼消息、物理资源块集的大小、物理资源块集在子帧中的索引以及其他用户设备接收到的信息等。存储器 350 还可以存储测量单元 320、等级确定单元 330 所使用或输出的信息，例如测量单元 320 的测量结果，在该情况下，等级确定单元 330 可从存储器 350 获得该测量结果。存储器 350 还可以存储发送单元 340 要发送的信息，例如等级确定单元 330 确定的寻呼消息的等级。

图 4 示出了根据本发明的实施例发送寻呼消息的网络节点。图 4 示出

的网络节点至少包括：块集索引确定单元 410，用于根据寻呼消息的等级确定用于发送寻呼消息的物理资源块集在子帧中的索引；以及发送单元 420，用于向作为寻呼消息的接收方的用户设备通知对块集索引确定单元 410 确定的物理资源块集的指示，以及用于在所确定的物理资源块集上发送寻呼消息。

在本发明的一些实施例中，网络节点还包括接收单元 430。其中，寻呼消息的等级由网络节点预先存储，或者由上级网络节点通知，或由用户设备根据其测量结果确定并通知网络节点，并由接收单元 430 接收。

在本发明的一些实施例中，物理资源块集在子帧中的索引是指物理资源块集的起始资源块在子帧中的索引。

在本发明的一些实施例中，物理资源块集的大小对于不同等级的寻呼消息而言是相同的。

在本发明的一些实施例中，网络节点还包括：块集大小确定单元 440，用于根据寻呼消息的等级确定物理资源块集的大小。

在本发明的一些实施例中，网络节点还包括：重复次数确定单元 450，用于根据寻呼消息的等级确定一个或多个物理下行共享信道，物理上行共享信道，物理下行控制信道和/或增强型物理下行控制信道，物理上行控制信道和物理随机接入信道的重复次数。

在本发明的一些实施例中，网络节点还包括：捆绑大小确定单元 460，用于根据寻呼消息的等级确定一个或多个物理下行共享信道，物理上行共享信道，物理下行控制信道和、或增强型物理下行控制信道，物理上行控制信道和物理随机接入信道的传输时间间隔捆绑大小。

在本发明的一些实施例中，如果网络节点是基站，发送单元 420 通过广播系统信息和/或用户设备专用的无线电资源控制(UE dedicated RRC)信令向用户设备发送物理资源块集在子帧中的索引和/或物理资源块集的大小；或者如果网络节点是网络侧设备，发送单元 420 通过非接入层信令向用户设备发送物理资源块集在子帧中的索引和/或物理资源块集的大小。

在本发明的一些实施例中，网络节点为用户设备分配的系统带宽包括 6 个物理资源块。在该情况下所述物理资源块集是系统带宽的子集。

在本发明的一些实施例中，网络节点还包括：子频带划分单元 470，用于当网络节点为用户设备分配的系统带宽大于 6 个物理资源块时，将所述系统带宽划分为包含不多于 6 个物理资源块的多个子频带；以及子频带确定单元 480，用于确定所述子频带划分单元 470 划分的所述多个子频带中要在其上向用户设备发送寻呼消息的一个子频带。

在本发明的一些实施例中，网络节点还包括存储器 490。存储器 490 可存储发送单元 420 要发送的信息，如寻呼消息，也可以存储接收单元 430 接收到的信息，例如接收单元 430 从网络侧（例如 MME）或用户设备接收到的寻呼消息的等级。存储器 490 还可以存储块集索引确定单元 410、块集大小确定单元 440、重复次数确定单元 450、捆绑大小确定单元 460、子频带划分单元 470、子频带确定单元 480 等单元所需的信息或输出的信息。

本发明的上述网络节点可以是基站，也可以是网络侧设备，例如网络侧的移动性管理实体（MME），当然，也可以是本领域技术人员通常使用来配置传输/移动性参数的任何网络侧设备。本发明不对此进行限制。

需要注意的是，在图 3 和图 4 中描述的用户设备和网络节点仅是为了使本领域技术人员更清楚地理解本发明而作的图，其中省略了一些对理解本发明不必要的模块/组件，本发明的保护范围不应受这些附图的具体细节所限制。此外，实际的设备中可以包括更多的模块/组件，如显示器、操作维护接口（对于图 4 中的网络节点）、输入输出接口等等。本发明不对这些进行限制。

下面将参考图 5 至图 10 来对图 1 和图 2 中示出的方法以及图 3 和图 4 中示出的设备进行更详细地阐述。需要注意的是，本发明中多数信息的确定和发送既可以由基站完成，也可以由网络侧设备完成。因此，除非特别说明，在本说明书中可以将术语基站、网络侧设备（如 MME）以及网络节点交换使用。此外，如上所述，虽然本发明主要针对需要额外覆盖增强或者低复杂度/低成本 MTC 用户设备来阐述的，但其同样也适用于其他支持延迟容忍服务和/或需要一定覆盖增强的用户设备。

对覆盖增强 MTC UE 而言，其上、下行物理信道需要多次重复发送，以满足信道的覆盖增强要求。处于不同地理位置的 UE 所需的信道覆盖增强程度不一样，导致处于不同地理位置的 UE 的物理信道所需重复发送的

次数不同。因此，可以将物理信道的覆盖增强程度分为若干个不同的覆盖增强等级。而不同覆盖增强等级的物理信道，其所需重复发送的次数不同。例如，可以将物理信道分为四个覆盖增强等级（CE0, CE1, CE2 和 CE3），每个覆盖增强等级对应物理信道所需的不同覆盖增强补偿，例如，CE0 指代的是覆盖增强等级 0，即不需要覆盖增强；CE1 指代的是覆盖增强等级 1，即需要例如 1~5dB 覆盖增强，其物理信道大致需要数次重复传输；CE2 指代的是覆盖增强等级 2，即需要例如 6~10dB 覆盖增强，其物理信道大致需要十数次重复传输；CE3 指代的是覆盖增强等级 3，即需要例如 11~15dB 覆盖增强，其物理信道大致需要数十次重复传输。然而，需要注意的是，本发明的技术方案不限于四个覆盖增强等级，而是可以根据需要采用更多或更少的覆盖增强等级。还需要注意的是，上述物理信道的重复次数仅是为了使本领域技术人员理解本发明而给出的示例，具体系统中使用的重复次数不限于上述次数，而是可以根据系统需求/限制（例如系统资源限制）选择更多或更少的次数。

由于寻呼消息对应的控制信道不传输，因此需要给出 MTC 用户设备的寻呼消息在频域上的位置。在本发明的技术方案中，网络节点（例如基站）将不同等级的寻呼消息映射到不同的资源块集（RBgroup）来指示寻呼消息在频域上的位置。在本文中，资源块集指的是寻呼消息在子帧上占用的物理资源块的集合。资源块集的大小是指寻呼消息在子帧上占用的资源块的数目。此处资源块集可以是物理资源块集（PRB group），也可以是虚拟资源块集（VRB group），物理资源块与虚拟资源块间的映射关系可参考 3GPP TS36.211 6.2.3.1，本发明不再进行赘述。在本发明的技术方案中，可以对多个资源块进行虚拟连续分配，即虚拟资源块集的集中式分配（virtual resource blocks of localized type）。此处虚拟资源块集的集中式分配指的是将虚拟资源块 n_{VRB} 直接映射到物理资源块 n_{PRB}。而虚拟资源块的大小与物理资源块的大小一致。

寻呼消息可以占用多个子帧，不同等级的寻呼消息占用的子帧数目可以不同。不同的用户设备占用的子帧也可以不同。例如，用户设备可根据用户 ID 在不同的子帧上接收寻呼消息，或通过 3GPP 协议中用于寻呼消息的时域复用的方法来进行子帧分配。在本发明的一些实施例中，需要确定确定两个参数，承载寻呼消息的物理资源块集的起始位置及连续分配的

资源块数目。然而在另一些实施例中，由于承载寻呼消息的物理资源块集的大小（即，连续分配的资源块数目）被预先确定，且对于不同等级的寻呼消息而言是相同的，仅需要确定物理资源块集的起始位置。

再次返回图 2，在图 2 的步骤 210 中，根据寻呼消息的等级确定用于发送寻呼消息的物理资源块集在子帧中的索引。该步骤由图 4 中的块集索引确定单元 410 执行。在本发明中，物理资源块集的起始位置与物理资源块集在子帧中的索引表达相同的概念，可相互交换使用。基于承载不同等级的寻呼消息的资源块集的大小是否一致，本发明提出了两种方案。网络节点和用户设备可同时支持两种方式或其中的一种。

图 5 示出了承载不同等级的寻呼消息的资源块集的大小一致的情况。如图 5 所示，系统带宽为 6 个物理资源块大小，且承载不同等级的寻呼消息的资源块集的大小是一样的，相应的资源块集的起始位置由基站和/或网络侧（例如 MME）配置，其原则可以是尽量利用子帧中的物理资源块，也可以是本领域技术人员可想到或通常使用的其他原则。在图 5 所示的示例中，资源块集的起始位置与不同等级的寻呼消息的关系可以是：覆盖增强等级 0 的寻呼消息对应的资源块集的起始位置索引为 0 或 4；覆盖增强等级 1 的寻呼消息对应的资源块集的起始位置索引为 1；覆盖增强等级 2 的寻呼消息对应的资源块集的起始位置索引为 2；覆盖增强等级 3 的寻呼消息对应的资源块集的起始位置索引为 3。在图 5 的示例中，相应的承载寻呼消息的资源块集的大小为例如 2 个资源块，然而在其他示例中也可以是更大或更小的其他数目，且可以采用与图 5 不同的索引分配模式。

寻呼消息的等级可以由基站通过广播信息和/或用户设备专用 RRC 信令配置给用户设备，或者可以由网络侧（例如 MME）通过 NAS 信令配置给用户设备。在一些示例中，寻呼消息的等级可以由用户设备根据自己的下行链路测量结果确定。例如，用户设备通过测量单元 320 执行信道测量，并使用等级确定单元 330 根据测量得到的下行信道的参考信号接收功率（RSRP）值与特定阈值比较。该特定阈值可以是在 3GPP 技术规范 TS36.104 中规定的阈值，可由用户设备通过接收单元 310 从基站/网络侧先行接收到的，并预先存储在用户设备的存储单元 350 中。如果大于或等于该阈值，则等级确定单元 330 确定寻呼消息等级为 0；小于该阈值 1~5dB，则确定寻呼消息等级为 1；小于该阈值 6~10dB，则确定寻呼消息等级为 2；

小于该阈值 11~15dB，则确定寻呼消息等级为 3。

可选地，在确定寻呼消息等级之后，用户设备/基站/网络侧可存储该寻呼消息等级，以用于下一次的资源块集起始位置确定或用于其他用途。

在块集索引确定单元 410 确定用于发送寻呼消息的物理资源块集在子帧中的索引之后，在步骤 220 中，网络节点向作为寻呼消息的接收方的用户设备通知对物理资源块集的指示。在一些实施例中，该对物理资源块集的指示可包括块集索引确定单元 410 确定的物理资源块集在子帧中的索引，并可选地包括物理资源块集的大小。然而在另一些实施例中，物理资源块集的大小已由被预先通知给了用户设备。

承载不同等级的寻呼消息的资源块的数目可以是预定的，并例如可由基站通过广播信息和/或用户设备专用 RRC 信令配置给用户设备。在其他一些示例中，承载不同等级的寻呼消息的资源块的数目可以由网络侧（例如，MME）通过 NAS 信令配置。此外，基站可通过广播系统信息和/或用户设备专用 RRC 信令通知物理资源块集在子帧中的索引；或网络侧（例如，MME）可通过 NAS 信令通知该索引。在本发明中，子帧中承载寻呼消息的资源块集的索引与这些资源块中起始资源块的索引表达相同的含义，可以互换使用。

在一些示例中，寻呼消息的等级可被基站的重复次数确定单元 450 用于确定一个或多个物理下行共享信道，物理上行共享信道，物理下行控制信道，物理上行控制信道和物理随机接入信道的重复次数。

在一些示例中，寻呼消息的等级可被基站的捆绑大小确定单元 460 用于确定一个或多个物理下行共享信道，物理上行共享信道，物理下行控制信道，物理上行控制信道和物理随机接入信道的 TTI bundle（Transmission Time Interval bundle: 传输时间间隔捆绑）大小。

图 6 示出了不同等级的寻呼消息与相应的资源块起始位置索引的对应关系的另一示意图。然而该图仅是为说明本发明而做出的示例，本发明不应被其所限制。例如，寻呼消息等级也可以对应于两个资源块起始位置，如索引 0 和 4，而不仅限于索引 0。

图 7 示出了承载不同等级的寻呼消息的资源块集的大小不一致的情况。如图 7 所示，系统带宽为 6 个物理资源块大小，且承载不同等级的寻呼消息的资源块集的大小是不一样的，相应的资源块集的起始位置由基站和/

或网络侧（例如，MME）配置，其原则可以是尽量利用子帧中的物理资源块，也可以是本领域技术人员可想到或通常使用的其他原则。在图 7 所示的示例中，资源块集的起始位置与不同等级的寻呼消息的关系可以是：覆盖增强等级 0 的寻呼消息对应的资源块集的起始位置索引为 0；覆盖增强等级 1 的寻呼消息对应的资源块集的起始位置索引为 3；覆盖增强等级 2 的寻呼消息对应的资源块集的起始位置索引为 2；覆盖增强等级 3 的寻呼消息对应的物理资源块集的起始位置索引为 1。

在图 7 示出的示例中，承载不同等级的寻呼消息的资源块集的大小不一致，因此需要对资源块集的大小进行确定。该操作可以由图 4 中的块集大小确定单元 440 执行。在一些示例中，承载不同等级的寻呼消息的资源块的数目可以是：覆盖增强等级 0 的寻呼消息对应的资源块的数目为 2；覆盖增强等级 1 的寻呼消息对应的资源块的数目为 3；覆盖增强等级 2 的寻呼消息对应的资源块的数目为 4；覆盖增强等级 3 的寻呼消息对应的资源块的数目为 5。当然，本领域技术人员也可以根据实际需求（例如系统资源限制等）选择不同的资源块集大小分配方案，理论上只要覆盖增强等级较高的寻呼消息对应更多数目的资源块即可。

图 7 所示情形的其他技术特征与图 5 所示情形相同，在此不再赘述。

图 8 示出了在承载不同等级的寻呼消息的资源块集的大小不一致的情况下，寻呼消息等级与资源块集大小的映射关系。图 9 示出了在承载不同等级的寻呼消息的资源块集的大小不一致的情况下，寻呼消息等级与资源块起始位置的映射关系。如上所述，这些映射关系都仅是为了说明本发明而做出的示例，本发明不应被其所限制。

在块集索引确定单元 410 确定用于发送寻呼消息的物理资源块集在子帧中的索引以及块集大小确定单元 440 确定该物理资源块集的大小之后，在步骤 220 中，网络节点向作为寻呼消息的接收方的用户设备通知对物理资源块集的指示。在一些实施例中，该对物理资源块集的指示可包括块集索引确定单元 410 确定的物理资源块集在子帧中的索引以及块集大小确定单元 440 确定的该物理资源块集的大小。

在步骤 230 中，网络单元的发送单元 420 在所确定的物理资源块集上发送寻呼消息。

然而，在 3GPP LTE 中，也可能存在系统带宽大于 6 个物理资源块的

情况。图 10 示出了在该情形下根据本发明的处理。如图 10 所示，当系统带宽大于 6 个物理资源块时，可将系统带宽分成多个子频带。在每一个子频带中依然可执行图 1-9 中所示的技术方案。在图 10 所示情况下，网络节点还需要通过发送单元 430 向用户设备通知子频带的划分。子频带可以是连续的 6 个物理资源块。同样地，子频带的划分可以由基站通过广播系统信息和/或用户设备专用无线电资源控制信令配置给用户设备，或者由网络侧（例如，MME）通过 NAS 信令配置给用户设备。

作为一般性的示例，可以假设系统带宽包含 M 个 PRB，并可被划分成 N 个子频带，其中 M 和 N 需满足 N = floor（M，6），即 N 是小于 M 除与 6 的最大自然数。这样整个系统带宽可划分为 N 个带宽大小为 6 个物理资源块的子频带和一个带宽大小为（M-6*N）个物理资源块的子频带。从上式可以看出，在 M 不是 6 的整倍数的情况下，可能包括子频带具有小于 6 个物理资源的情况。在这种情况下，只要寻呼消息对应的物理资源块的数目小于该子频带具有的资源块的总数目，依然可以使用本文上述的方案确定该子频带中用于该寻呼消息的资源块集的起始位置索引和大小，本发明不受限于系统带宽/子频带中包含的具体资源块的数目。

用户设备需要在一个子频带上接收寻呼消息，该子频带是在配置/确定物理资源块集在子帧中的索引和/或物理资源块的大小之前确定的。在本发明的一些实施例中，可以根据寻呼消息的等级来确定用户设备所使用的子频带。例如可通过以下公式：**[*index of sub-band*] = [*UE ID*] mod [*the number of sub-band*]**来确定用户设备所使用的子频带。其中 UE ID 可以是国际移动用户标识（IMSI，International Mobile Subscriber Identity），用于在核心网中唯一标识一个用户。该标识存储在 SIM 卡中。当然，在本发明的其他实施例中，本领域技术人员也可以使用唯一标识用户的其他可能的标识符，并对上式进行适应性修改，本发明不对此进行限制。

在用户设备侧，用户设备的接收单元 310 在步骤 110 中接收对用于发送寻呼消息的物理资源块集的指示。该指示可以包括其用于接收寻呼消息的物理资源块集在子帧中的索引。在一些情况下，该指示还可以包括物理资源块集的大小。而在另一些情况下，物理资源块集的大小已由网络节点确定并在之前发送给用户设备（例如，物理资源块集的大小对不同寻呼消息等级而言固定的情况下）。

然后，在步骤 120 中，用户设备可通过接收单元 310 在所指示的物理资源块集上接收寻呼消息。

当用户设备处于 RRC CONNECT 状态时，基站和/或网络侧（例如，MME）已经配置用户设备工作在一个子频带上接收数据。此时，当用户设备需要被寻呼时，该寻呼消息可在当前的子频带上传输，用于发送该寻呼消息的物理资源块集可通过根据本发明附图 1 至 9 中所述的方法来确定。

应该理解，本发明的上述实施例可以通过软件、硬件或者软件和硬件两者的结合来实现。例如，上述实施例中的基站和用户设备内部的各种组件可以通过多种器件来实现，这些器件包括但不限于：模拟电路器件、数字电路器件、数字信号处理（DSP）电路、可编程处理器、专用集成电路（ASIC）、现场可编程门阵列（FPGA）、可编程逻辑器件（CPLD），等等。

在本申请中，“基站”是指具有较大发射功率和较广覆盖面积的移动通信数据和控制交换中心，包括资源分配调度、数据接收发送等功能。“用户设备”是指用户移动终端，例如包括移动电话、笔记本等可以与基站或者微基站进行无线通信的终端设备。

此外，这里所公开的本发明的实施例可以在计算机程序产品上实现。更具体地，该计算机程序产品是如下的一种产品：具有计算机可读介质，计算机可读介质上编码有计算机程序逻辑，当在计算设备上执行时，该计算机程序逻辑提供相关的操作以实现本发明的上述技术方案。当在计算系统的至少一个处理器上执行时，计算机程序逻辑使得处理器执行本发明实施例所述的操作（方法）。本发明的这种设置典型地提供为设置或编码在例如光介质（例如 CD-ROM）、软盘或硬盘等的计算机可读介质上的软件、代码和/或其他数据结构、或者诸如一个或多个 ROM 或 RAM 或 PROM 芯片上的固件或微代码的其他介质、或一个或多个模块中的可下载的软件图像、共享数据库等。软件或固件或这种配置可安装在计算设备上，以使得计算设备中的一个或多个处理器执行本发明实施例所描述的技术方案。

尽管以上已经结合本发明的优选实施例示出了本发明，但是本领域的技术人员将会理解，在不脱离本发明的精神和范围的情况下，可以对本发明进行各种修改、替换和改变。因此，本发明不应由上述实施例来限定，而应由所附权利要求及其等价物来限定。

权 利 要 求

1. 一种用户设备接收寻呼消息的方法，包括：

接收对用于发送所述寻呼消息的物理资源块集的指示，其中，所述物理资源块集在子帧中的索引是根据所述寻呼消息的等级确定的；以及

在所指示的物理资源块集上接收所述寻呼消息。

2. 根据权利要求1所述的方法，其中，所述寻呼消息的等级是通过以下方式之一获得的：

由基站通过广播信息和/或用户设备专用无线电资源控制信令配置；

由网络侧通过NAS信令配置；以及

由所述用户设备根据其测量结果确定。

3. 根据权利要求1所述的方法，其中，所述物理资源块集在子帧中的索引是指所述物理资源块集的起始资源块在子帧中的索引。

4. 根据权利要求1所述的方法，其中，所述物理资源块集的大小对于不同等级的寻呼消息而言是相同的。

5. 根据权利要求1所述的方法，其中，所述物理资源块集的大小根据所述寻呼消息的等级确定。

6. 根据权利要求1所述的方法，其中，所述寻呼消息的等级还用于确定一个或多个物理下行共享信道，物理上行共享信道，物理下行控制信道和/或增强型物理下行控制信道，物理上行控制信道和物理随机接入信道的重复次数。

7. 根据权利要求1所述的方法，其中，所述寻呼消息的等级还用于确定一个或多个物理下行共享信道，物理上行共享信道，物理下行控制信道和/或增强型物理下行控制信道，物理上行控制信道和物理随机接入信道的传输时间间隔捆绑大小。

8. 根据权利要求1所述的方法，其中，接收对用于发送所述寻呼消息的物理资源块集的指示包括：

通过广播系统信息和/或用户设备专用无线电资源控制信令从基站接收所述物理资源块集在子帧中的索引和/或所述物理资源块集的大小；或

通过非接入层信令从网络侧设备接收所述物理资源块集在子帧中的

索引和/或所述物理资源块集的大小。

9. 根据权利要求1所述的方法，其中，所述用户设备使用的系统带宽包括6个物理资源块，以及所述物理资源块集是所述系统带宽的子集。

10. 根据权利要求1所述的方法，其中，当所述用户设备使用的系统带宽大于6个物理资源块时，所述系统带宽包括多个子频带，所述多个子频带中的每一个包含不多于6个的物理资源块，所述寻呼消息在所述多个子频带中由网络节点确定的一个子频带上接收。

11. 一种网络节点发送寻呼消息的方法，包括：

根据所述寻呼消息的等级确定用于发送所述寻呼消息的物理资源块集在子帧中的索引；

向作为所述寻呼消息的接收方的用户设备通知对所述物理资源块集的指示，以及

在所确定的物理资源块集上发送所述寻呼消息。

12. 根据权利要求11所述的方法，其中，所述寻呼消息的等级是通过以下方式之一获得的：

由所述网络节点预先存储；

由上级网络节点通知；或

用户设备根据其测量结果确定并通知所述网络节点。

13. 根据权利要求11所述的方法，其中，所述物理资源块集在子帧中的索引是指所述物理资源块集的起始资源块在子帧中的索引。

14. 根据权利要求11所述的方法，其中，所述物理资源块集的大小对于不同等级的寻呼消息而言是相同的。

15. 根据权利要求11所述的方法，其中，所述物理资源块集的大小根据所述寻呼消息的等级确定。

16. 根据权利要求11所述的方法，其中，所述寻呼消息的等级还用于确定一个或多个物理下行共享信道，物理上行共享信道，物理下行控制信道和/或增强型物理下行控制信道，物理上行控制信道和物理随机接入信道的重复次数。

17. 根据权利要求11所述的方法，其中，所述寻呼消息的等级还用于确定一个或多个物理下行共享信道，物理上行共享信道，物理下行控制信

道和/或增强型物理下行控制信道，物理上行控制信道和物理随机接入信道的传输时间间隔捆绑大小。

18. 根据权利要求11所述的方法，其中，向作为所述寻呼消息的接收方的用户设备通知对所述物理资源块集的指示包括：

如果所述网络节点是基站，通过广播系统信息和/或用户设备专用无线电资源控制信令向所述用户设备发送所述物理资源块集在子帧中的索引和/或所述物理资源块集的大小；或

如果所述网络节点是网络侧设备，通过非接入层信令向所述用户设备发送所述物理资源块集在子帧中的索引和/或所述物理资源块集的大小。

19. 根据权利要求11所述的方法，其中，所述网络节点为用户设备分配的系统带宽包括6个物理资源块，以及所述物理资源块集是所述系统带宽的子集。

20. 根据权利要求11所述的方法，还包括：当所述网络节点为用户设备分配的系统带宽大于6个物理资源块时，将所述系统带宽划分为包含不多于6个物理资源块的多个子频带，以及确定所述多个子频带中要在其上向所述用户设备发送寻呼消息的一个子频带。

21. 一种用户设备，包括：

接收单元，用于接收对用于发送所述寻呼消息的物理资源块集的指示，以及用于在所指示的物理资源块集上接收所述寻呼消息，其中，所述物理资源块集在子帧中的索引是根据所述寻呼消息的等级确定的。

22. 根据权利要求21所述的用户设备，其中，所述寻呼消息的等级是由基站通过广播信息和/或用户设备专用无线电资源控制信令配置或由网络侧通过NAS信令配置，并通过所述接收单元接收的；或者

所述用户设备还包括：

测量单元，用于测量信道状态；以及

等级确定单元，用于根据所述测量单元的测量结果确定所述寻呼消息的等级。

23. 根据权利要求21所述的用户设备，其中，所述物理资源块集在子帧中的索引是指所述物理资源块集的起始资源块在子帧中的索引。

24. 根据权利要求21所述的用户设备，其中，所述物理资源块集的大

小对于不同等级的寻呼消息而言是相同的。

25. 根据权利要求21所述的用户设备，其中，所述物理资源块集的大小由网络节点根据所述寻呼消息的等级确定，并通过广播信息和/或用户设备专用无线电资源控制信令由所述接收单元接收。

26. 根据权利要求21所述的用户设备，其中，对所述物理资源块集的指示包括所述物理资源块集在子帧中的索引以及所述物理资源块集的大小；以及

所述接收单元还用于通过广播系统信息和/或用户设备专用无线电资源控制信令从基站接收所述物理资源块集在子帧中的索引和/或所述物理资源块集的大小；或

所述接收单元还用于通过非接入层信令从网络侧设备接收所述物理资源块集在子帧中的索引和/或所述物理资源块集的大小。

27. 根据权利要求21所述的用户设备，其中，所述用户设备使用的系统带宽包括6个物理资源块，以及所述物理资源块集是所述系统带宽的子集。

28. 根据权利要求21所述的用户设备，其中，当所述用户设备使用的系统带宽大于6个物理资源块时，所述系统带宽包括多个子频带，所述多个子频带中的每一个包含不多于6个的物理资源块，所述寻呼消息由所述接收单元310在所述多个子频带中由网络节点确定的一个子频带上接收。

29. 一种网络节点，包括：

块集索引确定单元，用于根据寻呼消息的等级确定用于发送所述寻呼消息的物理资源块集在子帧中的索引；以及

发送单元，用于向作为所述寻呼消息的接收方的用户设备通知对所述块集索引确定单元确定的物理资源块集的指示，以及用于在所述确定的物理资源块集上发送所述寻呼消息。

30. 根据权利要求29所述的网络节点，还包括接收单元，

其中，所述寻呼消息的等级由所述网络节点预先存储，或者由上级网络节点通知，或者由用户设备根据其测量结果确定并通知所述网络节点，并由所述接收单元接收。

31. 根据权利要求29所述的网络节点，其中，所述物理资源块集在子

帧中的索引是指所述物理资源块集的起始资源块在子帧中的索引。

32 根据权利要求29所述的网络节点，其中，所述物理资源块集的大小对于不同等级的寻呼消息而言是相同的。

33. 根据权利要求29所述的网络节点，还包括：块集大小确定单元，用于根据所述寻呼消息的等级确定所述物理资源块集的大小。

34. 根据权利要求29所述的网络节点，还包括：重复次数确定单元，用于根据所述寻呼消息的等级确定一个或多个物理下行共享信道，物理上行共享信道，物理下行控制信道和/或增强型物理下行控制信道，物理上行控制信道和物理随机接入信道的重复次数。

35. 根据权利要求29所述的网络节点，还包括：捆绑大小确定单元，用于根据所述寻呼消息的等级确定一个或多个物理下行共享信道，物理上行共享信道，物理下行控制信道和/或增强型物理下行控制信道，物理上行控制信道和物理随机接入信道的传输时间间隔捆绑大小。

36. 根据权利要求29所述的网络节点，其中，对所述物理资源块集的指示包括所述物理资源块集在子帧中的索引以及所述物理资源块集的大小；以及

如果所述网络节点是基站，所述发送单元通过广播系统信息和/或用户设备专用无线电资源控制信令向用户设备发送所述物理资源块集在子帧中的索引和/或所述物理资源块集的大小；或

如果所述网络节点是网络侧设备，所述发送单元通过非接入层信令向用户设备发送所述物理资源块集在子帧中的索引和/或所述物理资源块集的大小。

37. 根据权利要求29所述的网络节点，其中，所述网络节点为用户设备分配的系统带宽包括6个物理资源块，以及所述物理资源块集是所述系统带宽的子集。

38. 根据权利要求29所述的网络节点，还包括：

子频带划分单元，用于当所述网络节点为用户设备分配的系统带宽大于6个物理资源块时，将所述系统带宽划分为包含不多于6个物理资源块的多个子频带；以及

子频带确定单元，用于确定所述子频带划分单元划分的所述多个子频

带中要在其上向用户设备发送寻呼消息的一个子频带。

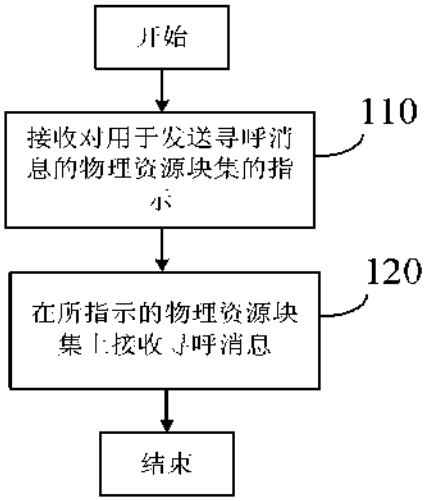

开始
接收对用于发送寻呼消息的物理资源块集的指示
110
在所指示的物理资源块集上接收寻呼消息
120
结束

图1

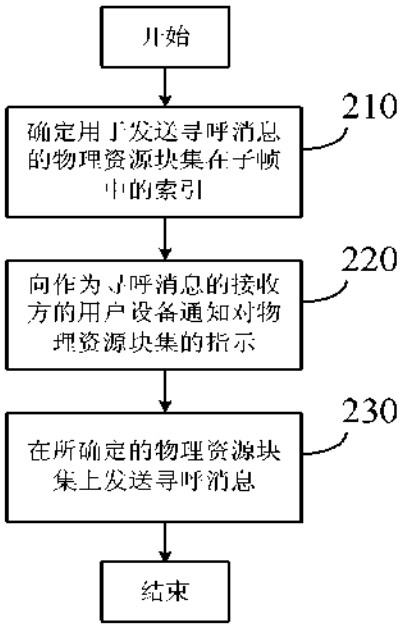

开始
确定用于发送寻呼消息的物理资源块集在子帧中的索引
210
向作为寻呼消息的接收方的用户设备通知对物理资源块集的指示
220
在所确定的物理资源块集上发送寻呼消息
230
结束

图2

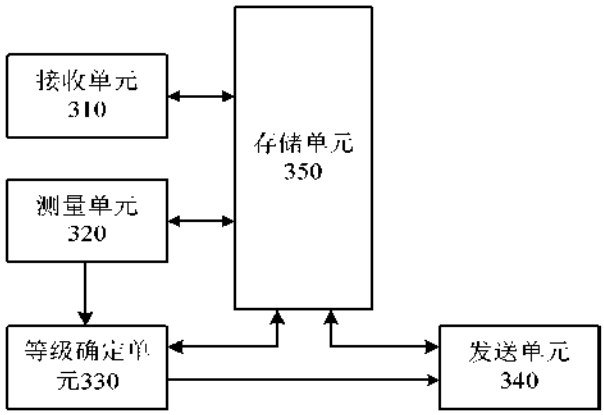

接收单元
310
测量单元
320
存储单元
350
等级确定单元330
发送单元
340

图3

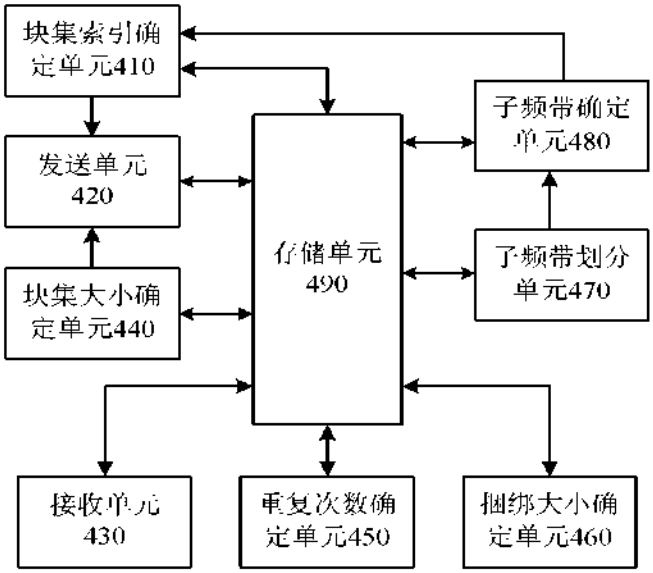

块集索引确定单元410
发送单元
420
块集大小确定单元440
存储单元
490
子频带确定单元480
子频带划分单元470
接收单元
430
重复次数确定单元450
捆绑大小确定单元460

图4

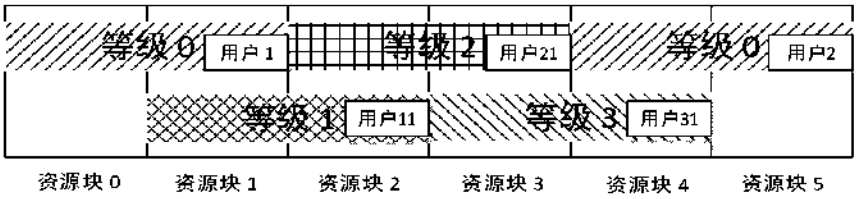


图5

寻呼消息等级	资源块起始位置
0	0
1	1
2	2
3	3

图6

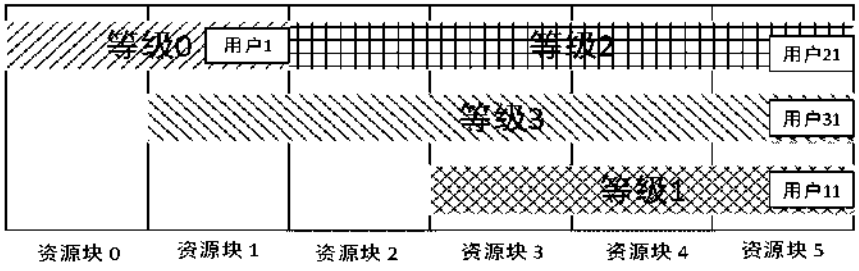


图7

寻呼消息等级	资源块集大小
0	2
1	3
2	4
3	5

图8

寻呼消息等级	资源块起始位置
0	0
1	3
2	2
3	1

图9

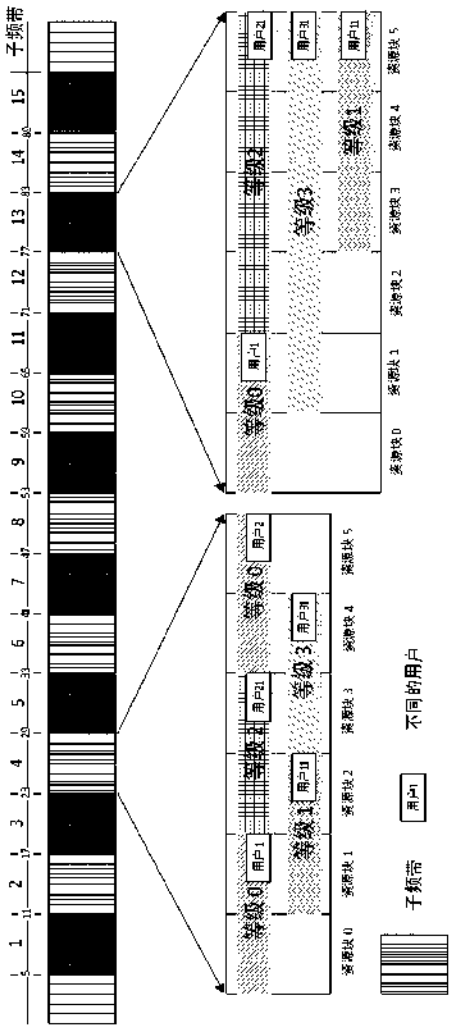

子频带
等级0
等级1
等级2
等级3
用户1
用户2
用户3
资源块0
资源块1
资源块2
资源块3
资源块4
资源块5
子频带
用户
不同的用户

图10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2015/099191

A. CLASSIFICATION OF SUBJECT MATTER

H04W 72/04 (2009.01) i; H04W 4/00 (2009.01) i; H04W 68/00 (2009.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04W; H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNPAT, CNKI, WPI, EPODOC, 3GPP: paging message, machine type, MTC, paging, coverage enhancement, machine type communication, level, physical resource block, instruction, indication, user equipment, network node, index

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 104137635 A (HUAWEI TECHNOLOGIES CO., LTD.), 05 November 2014 (05.11.2014), description, paragraphs [0170]-[0243]	1-38
A	CN 103517420 A (HUAWEI DEVICE CO., LTD.), 15 January 2014 (15.01.2014), the whole document	1-38
A	CN 102223412 A (VIA TELECOM, INC.), 19 October 2011 (19.10.2011), the whole document	1-38
A	US 2012064932 A1 (ELECTRONICS AND TELECOMMUNICATIONS RESEARCH INSTITUTE), 15 March 2012 (15.03.2012), the whole document	1-38

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 March 2016 (18.03.2016)	**29 March 2016 (29.03.2016)**
Name and mailing address of the ISA/CN: State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No.: (86-10) 62019451	Authorized officer **ZHANG, Qi** Telephone No.: (86-10) **62413262**

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2015/099191

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 104137635 A	05 November 2014	EP 2953409 A1	09 December 2015
		WO 2014131167 A1	04 September 2014
		US 2015365914 A1	17 December 2015
CN 103517420 A	15 January 2014	EP 2846594 A1	11 March 2015
		WO 2013185624 A1	19 December 2013
		US 2015092735 A1	02 April 2015
CN 102223412 A	19 October 2011	US 2011310769 A1	22 December 2011
US 2012064932 A1	15 March 2012	KR 20120028197 A	22 March 2012

Form PCT/ISA/210 (patent family annex) (July 2009)

国际检索报告

国际申请号
PCT/CN2015/099191

A. 主题的分类

H04W 72/04(2009.01)i; H04W 4/00(2009.01)i; H04W 68/00(2009.01)i

按照国际专利分类(IPC)或者同时按照国家分类和IPC两种分类

B. 检索领域

检索的最低限度文献(标明分类系统和分类号)

H04W; H04Q

包含在检索领域中的除最低限度文献以外的检索文献

在国际检索时查阅的电子数据库(数据库的名称，和使用的检索词（如使用）)

CNPAT, CNKI, WPI, EPODOC, 3GPP: 寻呼消息，覆盖增强，机器类型，MTC，等级，物理资源块，指示，用户设备，网络节点，索引, paging, coverage enhancement, machine type communication, level, physical resource block, instruction, indication, user equipment, network node, index

C. 相关文件

类 型*	引用文件，必要时，指明相关段落	相关的权利要求
X	CN 104137635 A (华为技术有限公司) 2014年 11月 5日 (2014-11-05) 说明书第[0170]-[0243]段	1-38
A	CN 103517420 A (华为终端有限公司) 2014年 1月 15日 (2014-01-15) 全文	1-38
A	CN 102223412 A (美商威睿电通公司) 2011年 10月 19日 (2011-10-19) 全文	1-38
A	US 2012064932 A1 (ELECTRONICS AND TELECOMMUNICATIONS RESEARCH INSTITUTE) 2012年 3月 15日 (2012-03-15) 全文	1-38

☐ 其余文件在C栏的续页中列出。

☑ 见同族专利附件。

* 引用文件的具体类型：

"A" 认为不特别相关的表示了现有技术一般状态的文件

"E" 在国际申请日的当天或之后公布的在先申请或专利

"L" 可能对优先权要求构成怀疑的文件，或为确定另一篇引用文件的公布日而引用的或者因其他特殊理由而引用的文件（如具体说明的）

"O" 涉及口头公开、使用、展览或其他方式公开的文件

"P" 公布日先于国际申请日但迟于所要求的优先权日的文件

"T" 在申请日或优先权日之后公布，与申请不相抵触，但为了理解发明之理论或原理的在后文件

"X" 特别相关的文件，单独考虑该文件，认定要求保护的发明不是新颖的或不具有创造性

"Y" 特别相关的文件，当该文件与另一篇或者多篇该类文件结合并且这种结合对于本领域技术人员为显而易见时，要求保护的发明不具有创造性

"&" 同族专利的文件

国际检索实际完成的日期	国际检索报告邮寄日期
2016年 3月 18日	2016年 3月 29日
ISA/CN的名称和邮寄地址 中华人民共和国国家知识产权局(ISA/CN) 中国北京市海淀区蓟门桥西土城路6号 100088 传真号 (86-10)62019451	受权官员 张琦 电话号码 (86-10)62413262

表 PCT/ISA/210 (第2页) (2009年7月)

国际检索报告
关于同族专利的信息

国际申请号
PCT/CN2015/099191

检索报告引用的专利文件			公布日（年/月/日）	同族专利			公布日（年/月/日）
CN	104137635	A	2014年 11月 5日	EP	2953409	A1	2015年 12月 9日
				WO	2014131167	A1	2014年 9月 4日
				US	2015365914	A1	2015年 12月 17日
CN	103517420	A	2014年 1月 15日	EP	2846594	A1	2015年 3月 11日
				WO	2013185624	A1	2013年 12月 19日
				US	2015092735	A1	2015年 4月 2日
CN	102223412	A	2011年 10月 19日	US	2011310769	A1	2011年 12月 22日
US	2012064932	A1	2012年 3月 15日	KR	20120028197	A	2012年 3月 22日

表 PCT/ISA/210（同族专利附件）（2009年7月）

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International Bureau

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9 February 2017 (09.02.2017)

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PCT/US2015/066149

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16 December 2015 (16.12.2015)

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(74) Agent: **HAYMOND, Alex, W.**; Thorpe North & Western LLP, c/o CPA Global, P.O. Box 52050, Minneapolis, MN 55402 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to the identity of the inventor (Rule 4.17(i))*

[Continued on next page]

(54) Title: PERFORMING MISSION CRITICAL COMMUNICATIONS AT A USER EQUIPMENT (UE)

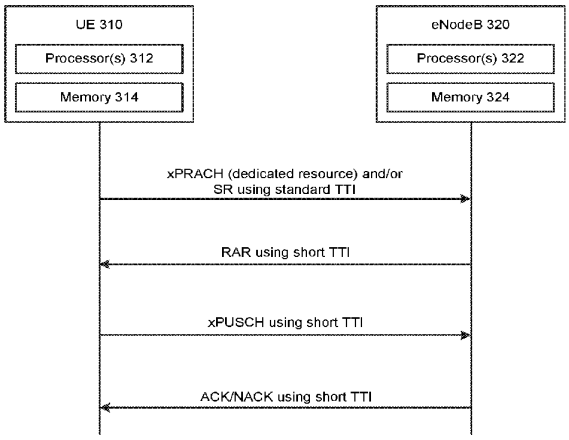


FIG. 3

(57) Abstract: Technology for a user equipment (UE) operable to perform mission critical communications with an eNodeB is disclosed. The UE can transmit a physical random access channel (PRACH) signal to the eNodeB that indicates a mission critical communication to be performed between the UE and the eNodeB. The PRACH signal can be transmitted in accordance with a first transmission time interval (TTI). The UE can receive a random access response (RAR) message from the eNodeB that includes a timing advance (TA) and a resource allocation for the mission critical communication. The RAR message can be transmitted from the eNodeB using a second TTI. The UE can perform the mission critical communication with the eNodeB in an uplink using the TA and the resource allocation indicated in the RAR message. The mission critical communication can be performed using a physical uplink shared channel (PUSCH) and in accordance with the second TTI.

WO 2017/023352 A1

Published:

— *with international search report (Art. 21(3))*

PERFORMING MISSION CRITICAL COMMUNICATIONS AT A USER EQUIPMENT (UE)

BACKGROUND

[0001] Wireless mobile communication technology uses various standards and protocols to transmit data between a node (e.g., a transmission station) and a wireless device (e.g., a mobile device). Some wireless devices communicate using orthogonal frequency-division multiple access (OFDMA) in a downlink (DL) transmission and single carrier frequency division multiple access (SC-FDMA) in uplink (UL). Standards and protocols that use orthogonal frequency-division multiplexing (OFDM) for signal transmission include the third generation partnership project (3GPP) long term evolution (LTE), the Institute of Electrical and Electronics Engineers (IEEE) 1202.16 standard (e.g., 1202.16e, 1202.16m), which is commonly known to industry groups as WiMAX (Worldwide interoperability for Microwave Access), and the IEEE 1202.11 standard, which is commonly known to industry groups as WiFi.

[0002] In 3GPP radio access network (RAN) LTE systems, the node can be a combination of Evolved Universal Terrestrial Radio Access Network (E-UTRAN) Node Bs (also commonly denoted as evolved Node Bs, enhanced Node Bs, eNodeBs, or eNBs) and Radio Network Controllers (RNCs), which communicates with the wireless device, known as a user equipment (UE). The downlink (DL) transmission can be a communication from the node (e.g., eNodeB) to the wireless device (e.g., UE), and the uplink (UL) transmission can be a communication from the wireless device to the node.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] Features and advantages of the disclosure will be apparent from the detailed description which follows, taken in conjunction with the accompanying drawings, which together illustrate, by way of example, features of the disclosure; and, wherein:

[0004] FIG. 1 illustrates a flexible radio access technology (RAT) in accordance with an example;

[0005] FIG. 2 illustrates a subframe structure for low latency applications in accordance

with an example;

[0006] FIG. 3 illustrates a mission critical communication between a user equipment (UE) and an eNodeB in accordance with an example;

[0007] FIG. 4 illustrates a partition of a physical random access channel (PRACH) preamble resource in accordance with an example;

[0008] FIG. 5 illustrates a multiplexing of a physical random access channel (PRACH) signal and a scheduling request (SR) message in a repeated transmission in accordance with an example;

[0009] FIG. 6 illustrates a random access response (RAR) window for repeated transmissions between a user equipment (UE) and an eNodeB in accordance with an example;

[0010] FIGS. 7A to 7C illustrates a resource allocation of a primary partition and a secondary partition within a transmission time interval (TTI) in accordance with an example;

[0011] FIG. 8 illustrates a repeated transmission of a random access response (RAR) message using a short transmission time interval (TTI) in accordance with an example;

[0012] FIG. 9 depicts functionality of a user equipment (UE) operable to perform mission critical communications with an eNodeB in accordance with an example;

[0013] FIG. 10 depicts functionality of a base station operable to receive mission critical communications from a user equipment (UE) in accordance with an example;

[0014] FIG. 11 depicts a flowchart of a machine readable storage medium having instructions embodied thereon for performing mission critical communications between a user equipment (UE) and an eNodeB in accordance with an example;

[0015] FIG. 12 illustrates a diagram of a wireless device (e.g., UE) in accordance with an example; and

[0016] FIG. 13 illustrates a diagram of a wireless device (e.g., UE) in accordance with an example.

[0017] Reference will now be made to the exemplary embodiments illustrated, and specific language will be used herein to describe the same. It will nevertheless be

understood that no limitation of the scope of the technology is thereby intended.

DETAILED DESCRIPTION

[0018] Before the present technology is disclosed and described, it is to be understood that this technology is not limited to the particular structures, process actions, or materials disclosed herein, but is extended to equivalents thereof as would be recognized by those ordinarily skilled in the relevant arts. It should also be understood that terminology employed herein is used for the purpose of describing particular examples only and is not intended to be limiting. The same reference numerals in different drawings represent the same element. Numbers provided in flow charts and processes are provided for clarity in illustrating actions and operations and do not necessarily indicate a particular order or sequence.

EXAMPLE EMBODIMENTS

[0019] An initial overview of technology embodiments is provided below and then specific technology embodiments are described in further detail later. This initial summary is intended to aid readers in understanding the technology more quickly but is not intended to identify key features or essential features of the technology nor is it intended to limit the scope of the claimed subject matter.

[0020] The field of mobile communications has evolved significantly from early voice systems to today's highly sophisticated integrated communication platform. 4G Long Term Evolution (LTE) networks are deployed in more than 100 countries to provide services in various spectrum band allocations depending on spectrum regime. Recently, significant momentum has started to build around the idea of a next generation, i.e., fifth generation (5G) wireless communications technology.

[0021] A wide range of potential applications and services have been identified for the 5G system. Some examples include (1) enhanced mobile broadband, (2) massive machine type communications (MTC), and (3) ultra-reliable and low latency or mission critical communications. In enhanced mobile broadband, increased data rates is expected to be a key driver in network development and evolution for the 5G system. A peak data rate of more than 10 gigabits per second (Gbps) and a minimum guaranteed user data rate of at

least 100 megabits per second (Mbps) are envisioned for the 5G system. With respect to massive MTC, the support of a massive number of Internet of Things (IoT) or MTC devices is expected to be a key feature for the 5G system. MTC devices can be used for a wide variety of applications. MTC devices use low operational power consumption and are expected to communicate with infrequent small burst transmissions. Finally, with respect to ultra-reliable and low latency or mission critical communications, the support of mission critical MTC applications for the 5G system can necessitate a high level of reliable connectivity with guaranteed low latency, availability and reliability-of-service.

[0022] FIG. 1 illustrates an exemplary flexible radio access technology (RAT). The flexible RAT, also referred to as a 5G xRAT, can function to address the diverse features of the 5G system, such as the enhanced mobile broadband, massive MTC, and ultra-reliable and low latency or mission critical communications. The flexible RAT can define a unified framework that supports these diverse applications and services. In addition, the flexible RAT can support multiple frequency bands, multiple application/services, licensed/unlicensed frequency, and multiple RATs.

[0023] As shown in FIG. 1, the flexible RAT can be represented in two dimensions – frequency and time. Multiple RATs/sub-RATs/partitions or applications in the same frequency resources or frequency bands (or different frequency resources or frequency bands) can be multiplexed using time-division multiplexing (TDM), frequency-division multiplexing (FDM), code-division multiplexing (CDM), or a combination of the above.

[0024] In one example, the flexible RAT can include a medium/high frequency band, as well as a low frequency band. In the low frequency band, there can be a primary partition. The primary partition can be in accordance with a standard transmission time interval (TTI). As an example, the standard TTI can be for a Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) Release 8 orthogonal frequency division multiple access (OFDMA) frame structure. The standard TTI can be approximately one millisecond (ms) in duration. Furthermore, in the low frequency band, there can be a first secondary partition and a second secondary partition. The primary partition and the secondary partition can be in both time and frequency. The first secondary partition can be in accordance with a short TTI and the second secondary partition can be in accordance with a long TTI. In general, the short TTI can have a duration that is less than

the standard TTI, and the long TTI can have a duration that is greater than the standard TTI. As non-limiting examples, the short TTI can be approximately 0.1 to 0.2 ms in duration, and the long TTI can be approximately 5 ms in duration. In one example, the primary partition in the flexible RAT can be utilized for non-mission critical communications (e.g., voice, data), and the secondary partition in the flexible RAT can be utilized for mission critical communications.

[0025] In one example, for a carrier frequency below 6 Gigahertz (GHz), the primary partition can reuse existing LTE numerology, while the secondary partition can be designed to support low latency or mission critical MTC applications. In particular, the short TTI can enable the low latency for mission critical MTC communications. In addition, increased subcarrier spacing, e.g., 75 kilohertz (kHz), can be adopted for the secondary partition. In contrast, a 15 KHz subcarrier spacing can be utilized for the primary partition.

[0026] FIG. 2 illustrates an exemplary subframe structure for low latency applications. The subframe structure can be for a secondary partition in a low frequency band, and the secondary partition can be associated with a short TTI of approximately 0.1 to 0.2 ms in duration. In one example, the subframe structure for the secondary partition can be based on an orthogonal frequency division multiplexing (OFDM) waveform.

[0027] In the example shown in FIG. 2, a 0.2ms TTI can be achieved. Within one TTI, 12 OFDM symbols can be grouped together (e.g., symbol 0 to symbol 11). Each OFDM symbol can have a duration of 13.3 micro seconds (us). A cyclic prefix (CP) can be inserted between each OFDM symbol. A CP length can be approximately 3.3 us or 512 samples if a sampling rate is 153.6MHz.

[0028] As described in further detail below, a system and method for mission critical communications in a 5G system is described. The mission critical communication can be performed at a user equipment (UE) in a radio resource control (RRC) idle mode. In one example, the procedure can involve a "keep trying" mechanism in which transmissions are repeated to ensure robust communication. The repeated transmissions can provide the ultra-reliability for the mission critical communication. The procedure can involve using a short transmission time interval (TTI) for signaling between the UE and an eNodeB, thereby providing the low latency for the mission critical communication. In one

example, dedicated resources can be used for a 5G physical random access channel (xPRACH) transmission that triggers or indicates the mission critical communication. The xPRACH transmission can be combined with a contention based scheduling request (SR). In addition, the procedure can involve information content, resource allocation and transmission schemes for random access response (RAR) messages with respect to the mission critical communication.

[0029] FIG. 3 illustrates an exemplary mission critical communication between a user equipment (UE) 310 and an eNodeB 320. In one example, the UE 310 can be a mission critical machine type communication (MTC) device. The UE 310 can initially be in a radio resource control (RRC) idle mode. The UE can include one or more processors 312 and memory 314, and the eNodeB 320 can include one or more processors 322 and memory 324. The mission critical communication between the UE 310 and the eNodeB 320 can include four distinct actions. In a first action, the UE 310 can transmit a fifth generation (5G) physical random access channel (xPRACH) signal to the eNodeB 320 using a dedicated resource to indicate or trigger the mission critical communication. To enable faster uplink access and transmission, the xPRACH signal can be combined together with a scheduling request (SR) message. The xPRACH signal and/or SR message can be transmitted using a standard transmission time interval (TTI) in a primary partition. The standard TTI can be approximately one millisecond (ms) in duration. In addition, the dedicated resource can be represented in the form of an xPRACH preamble signature/sequence, time and frequency resource. In a second action, after successful detection of the xPRACH signal and/or decoding of the SR message, the eNodeB 320 can transmit a random access response (RAR) message using a short TTI in a secondary partition. The short TTI can be approximately 0.1 to 0.2 ms in duration. In general, the short TTI is associated with a time interval that is less than the standard TTI. In one example, the standard TTI can be referred to as a first TTI and the short TTI can be referred to as a second TTI, wherein the second TTI is associated with a time interval that is less than the first TTI. The RAR message may include a timing advance (TA), a resource allocation for an uplink transmission, etc. In a third action, after successfully decoding the RAR message, the UE 310 can transmit uplink data (i.e., the mission critical data) to the eNodeB 320 in a 5G physical uplink shared channel (xPUSCH) using the short TTI in the secondary partition. In other words, the mission critical communication

from the UE 310 to the eNodeB 320 is performed using the 5G xPUSCH and the short TTI. The uplink data in the xPUSCH can be transmitted on the allocated resource in the RAR message. In a fourth action, the eNodeB 320 can transmit acknowledgement (ACK) or negative acknowledgement (NACK) information to the UE 310. The ACK/NACK information can be transmitted in a 5G physical downlink control channel (xPDCCH) or a 5G physical hybrid-ARQ indicator channel (xPHICH) using the short TTI in the secondary partition. The four actions involved in performing the mission critical communication are described in further detail below.

[0030] In one configuration, a transmitter (e.g., the UE 310 or the eNodeB 320) can keep transmitting the signal until a response is received from a receiver (e.g., the eNodeB 320 or the UE 310). This "keep trying" mechanism can ensure high robustness of the reception, which is essential for the mission critical communication. For instance, in the first action, the UE 310 can continue transmitting the xPRACH signal on the dedicated resource until the UE 310 receives the RAR message from the eNodeB 320. The "keep trying" mechanism can be viewed as an early termination of a repeated transmission. In other words, the transmitter can terminate the repeated transmission when the transmitter receives a response/feedback from the receiver. In addition, a maximum repetition number for each action (e.g., actions 1-4 as described above) can be predefined or configured by higher layers via a 5G master information block (xMIB), a 5G system information block (xSIB) or dedicated RRC signaling. When the transmission reaches the maximum repetition number, the UE 310 can perform a random back-off on the xPRACH signal to re-initiate the mission critical communication.

[0031] In one configuration, for each action (e.g., actions 1-4 as described above), the transmitter can repeat the transmission using a fixed number of repetitions (K repetitions). The number of repetitions can be predefined or configured by higher layers via the xMIB, the xSIB or dedicated RRC signaling. In one example, the value of K can be configured as 1, which indicates that no repetition is used for the transmission. When the transmission reaches the fixed repetition number, the UE 310 can perform a random back-off on the xPRACH signal to re-initiate the mission critical communication, or the UE 310 can indicate a random access problem to upper layers in order to trigger corresponding procedure(s).

[0032] In one example, a combination of the above options can be considered for the transmission of channels and signals in each action (e.g., actions 1-4 as described above). In particular, the transmitter can keep sending the signal until the transmitter receives the response from the receiver, wherein each transmission occupies K repetitions. Similar to the above option, the number of repetitions (K) in each transmission can be predefined or configured by higher layers via the xMIB, the xSIB or dedicated RRC signaling.

[0033] In one configuration, a set of dedicated resources can be allocated for the transmission of the xPRACH signal from the UE to indicate or trigger the mission critical communication. The dedicated xPRACH resources can be multiplexed with resources for other applications (i.e., non-mission critical applications) using TDM or FDM or CDM, or a combination of the above. In addition, the partition of the set of dedicated resources for mission critical communications and the resources for other applications can be predefined or configured by higher layer via the xMIB, the xSIB or dedicated RRC signaling.

[0034] In one example, the xPRACH signal can be transmitted using the standard TTI (e.g., 1 ms duration) on the primary partition. Several options can be utilized to allocate the dedicated resource for the transmission of the xPRACH signal. For example, one or a plurality of signatures can be reserved for the xPRACH signal to indicate or trigger the mission critical communication. In addition, to handle the mission critical communication with different applications/services, one or a plurality of dedicated preamble signatures can be reserved for each specific event.

[0035] FIG. 4 illustrates an exemplary partition of a physical random access channel (PRACH) preamble resource. The PRACH preamble resource can include a fifth generation (5G) xPRACH preamble resource. The partition of the xPRACH preamble resource can be for mission critical applications, as well as other applications (i.e., non-mission critical applications). In other words, the xPRACH preamble resource can include a first resource for other applications and a second resource for mission critical applications. In addition, the partition of the xPRACH preamble resource can be associated with different applications and/or events. For example, the xPRACH preamble resource size or the number of reserved sequences for each event can be different. For instance, event #1 in the resource for mission critical applications can correspond to a

mission critical application for earthquake event, and one preamble signature can be reserved for event #1. Event #2 in the resource for mission critical applications can correspond to a mission-critical Vehicular to Vehicular (V2V) application, and five preamble signatures can be reserved for event #2.

[0036] In one example, one or a plurality of frequency resources can be allocated for the xPRACH signal to trigger the mission critical communication. When the UE transmits the xPRACH signal in the dedicated frequency resource, the eNodeB can transmit the corresponding RAR message using the short TTI on the secondary partition. The eNodeB can transmit the corresponding RAR message upon successful detection of xPRACH signal.

[0037] In one example, one or a plurality of time resources can be allocated for the xPRACH signal to trigger the mission critical communication. For example, the xPRACH signal for other applications (i.e., non-mission critical applications) can be transmitted in subframe 0, 2, 4, 6, 8 within one frame, while the xPRACH signal used to trigger the mission critical communication can be transmitted in subframe 1, 3, 5, 7, 9 within one frame.

[0038] In one example, a combination of TDM and/or FDM and/or CDM based multiplexed schemes can be used to separate the resource for mission critical applications and other applications (i.e., non-mission critical applications). For example, a combination of FDM and CDM multiplexing schemes can be utilized, i.e., one additional frequency resource can be reserved for mission critical applications, and within this dedicated frequency resource, different mission critical applications/services can be separated using different xPRACH preamble signatures.

[0039] In another example, a combination of TDM and CDM multiplexing schemes can be utilized. The xPRACH signal for the other application (i.e., a non-mission critical application) can be transmitted in subframe 0, 2, 4, 6, 8 within one frame, while the xPRACH signal used to trigger the mission critical communication can be transmitted in subframe 1, 3, 5, 7, 9 within one frame. Further, different mission critical applications/services can be separated using different xPRACH preamble signatures.

[0040] In one example, with respect to ultra-reliable and low latency communications, multiple mission critical devices can operate as a "single frequency network" (SFN),

which can improve a link level performance for mission critical communication. In this case, the eNodeB can treat multiple mission critical devices as a single mission critical device. For example, the eNodeB can transmit a single RAR message to multiple UEs, and in response, multiple UEs can transmit uplink data (i.e., mission critical data) simultaneously to the eNodeB on the same time and frequency resource.

[0041] In one example, in order to differentiate a typical operation from a "single frequency network" type of operation, different xPRACH resources can be allocated. For example, one event ID or dedicated xPRACH signature can be allocated for the "single frequency network" type of operation. In addition, when repeated transmissions of the xPRACH preamble are used, a starting subframe of the repeated xPRACH transmission can be predefined or configured by higher layers, thereby causing the eNodeB to perform efficient detection of the repeated xPRACH signal.

[0042] A more detailed description is now provided with respect to the first action shown in FIG. 3, in which the UE can transmit the 5G xPRACH signal and/or SR message to the eNodeB using dedicated resources to indicate or trigger the machine critical communication. The xPRACH signal transmission can be combined with a contention based scheduling request (SR) message to allow uplink access in a reduced amount of time, thereby fulfilling the latency constraints for mission critical communications. The contention based SR message can include the UE ID and buffer status report to enable uplink access in the reduced amount of time.

[0043] For mission critical applications, the SR message can be transmitted from the UE to the eNodeB as part of a random access channel (RACH) procedure, which allows for a reduction in connection establishment delay as compared to existing LTE systems. The SR message can be a fixed size and can include several parameters/fields. The SR message can include a mission critical MTC device ID, which can be the same as the UE ID or a different ID. The SR message can include an event ID to indicate an access cause when a same set of xPRACH sequences are allocated for multiple applications/services. The event ID can be included in the SR message to expedite access for the UE. The SR message can include a mission critical MTC device capability, which can include mission critical specific UE radio access capability information, such as carrier aggregation (CA) capability, i.e., component carrier (CC) index(s) that are supported by the UE (e.g., the

mission critical MTC device), supported multiple input multiple output (MIMO) capability, etc. The SR message can include a resource request and modulation and coding scheme (MCS) for an uplink transmission (e.g., mission critical data) from the UE. For example, the SR message can include the resource request in the time and frequency domain, e.g., physical resource block (PRB) index or numbers within one band, or symbol/slot/subframe/frame index or CC index(s) used for the uplink transmission. Alternatively, the UE can indicate the total amount of data for mission critical application and/or channel state information (CSI)/reference signaling measurements, which can subsequently be used for downlink MCS selection and open loop power control calculation.

[0044] In one example, when the resource request of PRB index and MCS are included in the SR message, the eNodeB can feedback 1 bit ACK/NACK information to the UE (or mission critical MTC device). Upon successful ACK detection, the UE can use the resource indicated in the SR message for uplink data transmission based on a predefined timing following a subframe in which the ACK/NACK information is detected.

[0045] In one example, the "keep trying" mechanism or repeated transmission can be employed when transmitting the xPRACH signal and/or SR message to the eNodeB. The same xPRACH preamble signature and the same SR information can be used for the transmission of the xPRACH signal and the SR message during the repetition, respectively. In addition, the SR message can occupy the resource allocated for the SR transmission to further enhance the link level performance.

[0046] In one example, UEs may not have the xPRACH/SR repetition capability, or the function may not be configured at the UE by the eNodeB. In this case, different xPRACH and/or SR resources can be used with respect to (1) an initial transmission that is shared among all UEs and (2) subsequent repeated transmission that is dedicated for UEs enabled with the xPRACH/SR repetition capability. In one example, the resource for the initial transmission of the xPRACH signal and SR message can be selected by the UE within a contention-based resource region, while the resources for subsequent repeated transmissions can be configured by higher-layers (e.g., broadcasted in the xSIB) within a contention-free resource region on the same partition or a different partition.

[0047] In one example, available sets of xPRACH or SR resources reserved for the UE

(e.g., a mission critical MTC device) can be divided into two different regions – a first region can be used for the xPRACH/SR transmission repetition and the second region can be reserved for the xPRACH/SR transmission without repetition. More specifically, an xPRACH signal or SR message can be repeatedly transmitted on a configurable or fixed consecutive xPRACH or SR resources within the first region according to a known pattern (e.g., TDM, CDM or FDM). The number of repetition times can be predefined or configured by higher layers for an individual UE. In addition, one-to-one mapping between the xPRACH repetition level and the xPRACH/SR resource set can be utilized. The UE can select an xPRACH/SR repetition level based on a measurement, such as a reference signal received power (RSRP), and the UE can transmit the xPRACH/SR using the xPRACH/SR resources set according to the selected xPRACH/SR repetition level.

[0048] FIG. 5 illustrates an exemplary multiplexing of a physical random access channel (PRACH) signal and a scheduling request (SR) message in a repeated transmission. The PRACH signal can include a fifth generation (5G) xPRACH signal. Various multiplexing mechanisms, such as time division multiplexing (TDM) or frequency division multiplexing (FDM), can be applied to the xPRACH signal and the SR message. As shown in FIG. 5, TDM multiplexing can be used for repeated transmissions of the xPRACH signal and the SR message, or FDM multiplexing can be used for repeated transmissions of the xPRACH signal and the SR message. In other words, TDM and FDM based multiplexing mechanisms can be applied to the "keep trying" mechanism for repeated transmissions. In addition, the SR message can be transmitted using all the available resource to achieve ultra-reliable communication.

[0049] In one example, with respect to transmission power control mechanism for the transmission of the xPRACH signal and/or the SR message, several options can be used. In one example, when (re)transmitting the xPRACH signal and/or SR message, a maximum transmit power can be used to ensure robust detection at the eNodeB. In another example, an existing power control mechanism can be applied for the transmission and retransmission of the xPRACH signal and/or SR message. In particular, for an initial transmission, the xPRACH transmission power can be set to an initial PRACH power, while for the retransmission, power ramping can be used to increase the actual transmission power.

[0050] In yet another example with respect to transmission power control, repetition level ramping can be applied for the transmission and retransmission of the xPRACH signal and/or SR message. Further, the repetition level ramping mechanism can be combined in conjunction with power ramping to further improve the performance. In one example, the repetition level can be doubled for each retransmission. In the initial transmission, the repetition level can be defined as K, while in the first retransmission, the repetition level can be set to 2K, etc. Additionally, if power ramping is applied on top of the repetition level ramping, the power ramping can be defined so as to account for an increase in the repetition level. Specifically, the power level for the first attempt at a subsequent repetition level can be reduced by a factor of 10*log(numRepL/numRepL-1), wherein numRepL and numRepL-1 are the number of repetitions configured for repetition levels L and L-1, respectively.

[0051] A more detailed description is now provided with respect to the second action shown in FIG. 3, in which the eNodeB can transmit the RAR message to the UE using the short TTI. After identifying the mission critical event based on detection of the xPRACH signal, the eNodeB can dynamically allocate the resource in a secondary partition, and the eNodeB can transmit the corresponding RAR message using the short TTI.

[0052] For mission critical MTC applications, a fixed relationship can be defined between the time (e.g., a last repetition/retransmission) of the xPRACH transmission and a time of the first transmission of the xPDCCH/xPDSCH signal (either scheduling or carrying the RAR message). Additionally, the frequency resource for the xPDCCH (if xPDCCH is not wideband) or xPDSCH can be determined as a function of at least the preamble sequence of the detected xPRACH signal, and possibly also the frequency location of the detected xPRACH signal. If additional flexibility is desired at the eNodeB, then for time-domain scheduling of the RAR message, a short RAR window can be defined in which the UE monitors for the first transmission of the xPDCCH/xPDSCH signal with the RAR message.

[0053] FIG. 6 illustrates an exemplary random access response (RAR) window for repeated transmissions between a user equipment (UE) and an eNodeB. When repeated transmissions are used for the xPRACH signal and/or SR message, the RAR window can be defined such that the UE (e.g., a mission critical MTC device) can monitor for the

RAR message within the RAR window. As shown in FIG. 6, the xPRACH signal and SR message can be transmitted in an uplink in accordance with a standard TTI (e.g., 1 ms in duration). After transmission of the xPRACH signal and SR message, the RAR window can be defined. During the RAR window, the UE can monitor a downlink for the RAR message. The UE can detect the RAR message during the RAR message, wherein the RAR message is transmitted in accordance with a short TTI. In one example, the position of the RAR window can be predefined or configured by higher layer via the xMIB, the xSIB or dedicated RRC signaling. In addition, the starting position of the RAR window can be defined relative to the starting of the last subframe of the repeated xPRACH signal and/or SR message transmission.

[0054] FIGS. 7A to 7C illustrates exemplary resource allocations of a primary partition and a secondary partition within a transmission time interval (TTI). The TTI can be a standard TTI with a duration of one millisecond (ms). Guard bands can be inserted between the primary and secondary partitions in a frequency domain in order to reduce inter-carrier interference.

[0055] As shown in FIG. 7A, a secondary partition using a short TTI (e.g., 0.1 to 0.2 ms) can be allocated after an xPDCCH region. The xPDCCH region can be in the primary partition using the standard TTI. When different numerologies, e.g., subcarrier spacing, are used for the primary and secondary partitions, a guard time may be inserted between the xPDCCH region using the standard TTI and the secondary partition using the short TTI. This option may avoid traffic interruption for the primary partition, as the eNodeB can schedule the downlink and uplink transmission via the xPDCCH within the primary partition.

[0056] As shown in FIG. 7B, a secondary partition using a short TTI (e.g., 0.1 to 0.2 ms) can be allocated after an xPDCCH region. The xPDCCH region can be in the primary partition using the standard TTI. Further, the secondary partition can occupy a full system bandwidth to enhance the link level performance. In this approach, guard times may not be inserted between the xPDCCH region using the standard TTI and the secondary partition using the short TTI.

[0057] As shown in FIG. 7C, a secondary partition using a short TTI (e.g., 0.1 to 0.2 ms) can span a standard TTI (e.g., 1 ms). In this approach, the secondary partition can occupy

a full system bandwidth to enhance the link level performance. In addition, a guard time may be inserted to reduce interference in a primary partition.

[0058] In one example, the resource allocation for the secondary partition can be predefined, or broadcasted in a mission critical specific xSIB message, or indicated in a downlink control information (DCI) format in the xPDCCH using the standard TTI in the primary partition. In the latter case, the UE (e.g., a mission critical MTC device) can monitor the xPDCCH with a cyclic redundancy check (CRC) scrambled by an existing random-access radio network temporary identifier (RA-RNTI) or a newly defined RA-RNTI for mission critical applications. The RA-RNTI can be predefined in the specification or defined as a function of at least one of: the time index, frequency index, preamble sequence, and repetition level used for the detected xPRACH transmission. Upon successful decoding of the xPDCCH signal, the UE can switch to a short TTI mode and decode the RAR message within the secondary partition.

[0059] FIG. 8 illustrates an exemplary repeated transmission of a random access response (RAR) message using a short transmission time interval (TTI). The "keep trying" mechanism or repeated transmissions of the RAR message can be used to improve the link level performance. The repeated RAR transmissions using the short TTI can occur within a secondary partition used for mission critical communication. As shown in FIG. 8, a preamble can be inserted before each transmission of the RAR message to improve a downlink synchronization accuracy, which is useful in view of the higher sampling rate used for the short TTI with large subcarrier spacing (e.g., 15 KHz). The preamble can utilize similar principles as compared to the 5G downlink synchronization channel (xSCH). To differentiate the preamble from the xSCH, independent root sequences can be employed when Zadoff-Chu (ZC) sequences are used for the xSCH.

[0060] In one example, the RAR message can include various parameters. For example, the RAR message can include a timing advance (TA). The eNodeB can estimate an initial TA from the xPRACH signal sent by the UE. The RAR message can include an UL grant for a subsequent uplink transmission. In addition, the UL grant can include a resource allocation of the secondary partition used for the subsequent uplink transmission. When the UE (e.g., a mission critical MTC device) supports carrier aggregation (CA), the resource allocation for multiple component carriers (CCs) can be included in the uplink

grant. The UL grant can include a modulation and coding scheme (MCS) and a power control parameter for the subsequent uplink transmission, as well as the number of repetitions used for the RAR transmission. In one example, the RAR message can include a mission critical MTC device ID, which can be used for contention resolution. The RAR message can include an event ID, which can be obtained from the SR message and used for contention resolution. In addition, the RAR message can include a random access preamble ID that is useful for contention resolution. The random access preamble ID can include a preamble index for the xPRACH transmission.

[0061] In one example, the RAR message can be transmitted in the secondary partition using the short TTI either: (1) on the xPDSCH scheduled by the xPDCCH, or (2) using the xPDCCH directly, or (3) using the xPDSCH directly. With respect to the first option, the xPDCCH can indicate the resource allocation and MCS for the transmission of the xPDSCH signal, while the xPDSCH carries the RAR message. With respect to the second option, the RAR message can be transmitted via the xPDCCH. In this case, the UE (e.g., a mission critical MTC device) can monitor the xPDCCH with the CRC scrambled by the RA-RNTI. With respect to the third option, the RAR message can be transmitted via the xPDSCH using the short TTI. When repeated transmissions or the "keep trying" mechanism is employed for the RAR message, TTI bundling and a predefined redundancy version (RV) pattern (e.g., [0 2 3 1]) can be used when turbo coding is adopted. Further, a scrambling seed for the transmission of the xPDSCH signal can be defined as a function of the RA-RNTI or a group ID with respect to a "single frequency network" (SFN) type of operation. In one example, the group ID can be specified as the event ID.

[0062] In one example, the UE (e.g., a mission critical MTC device) can monitor for the xPDSCH signal using fixed and known values of the MCS and a transport block size (TBS). If a UE processing complexity increase can be accommodated for mission critical devices, then a limited number of options for MCS and TBS for the xPDSCH can be configured, from which the UE can perform blind detection.

[0063] A more detailed description is now provided with respect to the third action shown in FIG. 3, in which the UE can transmit uplink data (i.e., mission critical data) to the eNodeB using the short TTI. A resource allocation for the uplink data transmission can be

indicated in the RAR message. In particular, the resource allocation can be associated with a secondary partition to be used for the uplink data transmission. Further, a scrambling seed for a transmission of the xPUSCH signal can be defined as a function of a mission critical MTC device ID or a group ID with respect to a "single frequency network" type of operation. In one example, the group ID can be specified as the event ID.

[0064] When the repeated transmission is used for the uplink transmission, a gap between the end of a last RAR transmission and a starting subframe of the uplink transmission can be predefined or configured by higher layers via the xMIB, the xSIB or dedicated RRC signaling. Alternatively, to allow additional flexibility, a delay parameter can be indicated in the UL grant of the RAR message, wherein the delay parameter can be of the order of one or more standard or short TTI(s).

[0065] In one example, to improve the robustness of the uplink transmission, the same information can be transmitted on multiple component carriers (CC) simultaneously, or transmitted repeatedly within a CC to fulfil the reliability constraint of the mission critical communication. Further, TTI bundling with a predefined redundancy version (RV) pattern can be employed for performance enhancement. For mission critical applications with small data packet transmissions, tail biting convolution coding (TBCC) can be used as a forward error correction (FEC) scheme as opposed to turbo coding.

[0066] A more detailed description is now provided with respect to the fourth action shown in FIG. 3, in which the eNodeB can transmit ACK/NACK information to the UE using the short TTI. The ACK/NACK can be transmitted via the xPDCCH or the xPHICH using the short TTI on the secondary partition. When repeated transmission are used for the ACK/NACK transmission, a gap between the end of a last uplink data transmission and a starting subframe of the ACK/NACK transmission can be predefined or configured by higher layers via the xMIB, the xSIB or dedicated RRC signaling.

[0067] In one example, when a NACK is received or an ACK is not received, the UE (e.g., a mission critical MTC device) can perform a retransmission of the uplink data. When a maximum number of retransmission is reached, the UE can perform a random back-off and re-initiate the procedure for mission critical communication. Alternatively, assuming that an uplink synchronization has been established via a mission critical

random access procedure, the UE can transmit a scheduling request (SR) using the short TTI on the secondary partition at a next available SR opportunity. In one example, periodically occurring SR opportunities can be defined in the secondary partition. The SR transmission can be based on a physical structure of the xPUSCH or xPUCCH, which are adapted for transmissions using short TTIs. The configuration of the SR opportunities in the secondary partition can be pre-defined or broadcasted using the xSIB. Alternatively, the configuration of the SR opportunities can be indicated via a combination of broadcasted information of system level configurations and UE-specific signaling of the actual configured SR resource periodicity carried in the RAR message.

[0068] In one example, with respect to the "single frequency network (SFN)" type of operation, multiple UEs that are closely co-located (i.e., located within a defined distance from each other) can transmit the xPRACH signal on the same xPRACH resource using the same xPRACH preamble, which can improve the xPRACH detection performance. In response to receiving the xPRACH signal from multiple UEs, the eNodeB can transmit a single RAR message that targets the multiple UEs. In addition, when one or more UEs successfully receive the RAR message, the UEs can transmit the xPUSCH signal simultaneously on the same resource, which can achieve SFN gain.

[0069] In one configuration, a system and method of ultra-reliable and low latency communications for a fifth generation (5G) system is described. A user equipment (UE) can transmit, to an eNodeB, a 5G Physical Random Access Channel (xPRACH) and/or a scheduling request (SR) message to trigger a mission critical communication. The xPRACH and/or SR can be transmitted on a dedicated resource using a standard transmission time interval (TTI) in a primary partition. The UE can receive a random access response (RAR) using a short TTI in a secondary partition. The UE can transmit uplink data to the eNodeB in a 5G physical uplink shared channel (xPUSCH) using the short TTI in the secondary partition. The UE can receive, from the eNodeB, acknowledgement (ACK) or negative acknowledgement (NACK) information in a 5G physical downlink control channel (xPDCCH) or a 5G Physical Hybrid-ARQ Indicator Channel (xPHICH) using the short TTI in the secondary partition.

[0070] In one configuration, a keep trying mechanism is employed between the UE and the eNodeB for ultra-reliable and low latency communication. A transmitter (e.g., the UE

or eNodeB) can keep sending a signal until a response is received from a receiver (e.g., the eNodeB or UE). A maximum repetition number for each transmission can be predefined or configured by higher layers via a 5G master information block (xMIB), a 5G system information block (xSIB) or dedicated RRC signaling.

[0071] In one configuration, a transmitter (e.g., the UE or eNodeB) can repeat the transmission using a fixed number of repetitions. The fixed number of repetitions can be predefined or configured by higher layers via the xMIB, the xSIB or dedicated RRC signaling.

[0072] In one configuration, a transmitter (e.g., the UE or eNodeB) can keep sending the signal until a response is received from a receiver (e.g., the eNodeB or UE). In addition, each transmission can occupy K repetitions, and K is predefined or configured by higher layers via the xMIB, the xSIB or dedicated RRC signaling.

[0073] In one configuration, a set of dedicated xPRACH resources for mission critical communications can be multiplexed with resources for non-mission critical applications using time division multiplexing (TDM) or frequency division multiplexing (FDM) or code division multiplexing (CDM) or a combination of above. In addition, a partition configuration can be predefined or configured by higher layer via the xMIB, the xSIB or dedicated RRC signaling.

[0074] In one configuration, one or more signatures can be reserved for the xPRACH to trigger the mission critical communication.

[0075] In one configuration, one or more time resources can be reserved for the xPRACH to trigger the mission critical communication.

[0076] In one configuration, one or more frequency resources can be reserved for the xPRACH to trigger the mission critical communication.

[0077] In one configuration, one or more xPRACH signatures or time resources or frequency resources can be reserved for "single frequency network" type of operations.

[0078] In one configuration, the SR message can have a fixed size, and the SR can include at least the following parameters or fields: a mission critical machine type communication (MTC) device identifier (ID), an event ID, a mission critical MTC device capability, a resource request, and a modulation and coding scheme (MCS) for

transmission of the uplink data from the UE to the eNodeB. In addition, the resource request can include a physical resource block (PRB) index or numbers within one band, or symbol/slot/subframe/frame index or component carrier (CC) index(s) used for the transmission of the uplink data.

[0079] In one configuration, a resource for an initial transmission of the xPRACH and SR is selected by a given UE within a contention-based resource region, and resources for subsequent repeated transmissions can be configured by higher-layers (e.g.. broadcasted in the xSIB) within a contention-free resource region on a same partition or a different partition.

[0080] In one configuration, a maximum transmit power can be utilized for the transmission and retransmission of the xPRACH signal and/or SR message.

[0081] In one configuration, existing power control mechanisms can be applied for the transmission and retransmission of the xPRACH signal and/or SR message.

[0082] In one configuration, repetition level ramping can be applied for the transmission and retransmission of the xPRACH signal and/or SR message.

[0083] In one configuration, the UE (e.g., a mission critical MTC device) can monitor a random access response (RAR) message within a RAR window. A position of the RAR window can be predefined or configured by higher layers via the xMIB, the xSIB or dedicated RRC signaling.

[0084] In one configuration, a resource allocation of a secondary partition or a RAR transmission is predefined, or broadcasted in a xSIB message, or indicated in a downlink control information (DCI) format in the xPDCCH using a standard TTI in the primary partition.

[0085] In one configuration, the secondary partition can be allocated after the xPDCCH region in the primary partition using the standard TTI (e.g., 1 ms). In addition, the secondary partition can occupy a full system bandwidth.

[0086] In one configuration, the secondary partition can span a standard TTI (e.g., 1 ms). In addition, the secondary partition can occupy a full system bandwidth.

[0087] In one configuration, a preamble can be inserted prior to the transmission of the RAR message. The preamble can be based on a 5G downlink synchronization channel

(xSCH).

[0088] In one configuration, the RAR message can include the following parameters or fields: a timing advance command (TA), an uplink grant, a mission critical MTC device ID, an event ID and a random access preamble ID. The uplink grant can further include a resource allocation of the secondary partition used for a subsequent uplink transmission.

[0089] In one configuration, the RAR message can be transmitted via the xPDSCH using a short TTI. When a repeated transmission mechanism (or "keep trying" mechanism) is employed, TTI bundling and a predefined redundancy version (RV) pattern can be used for the transmission of the RAR message when turbo coding is adopted. In addition, with respect to a "single frequency network" type of operation, a scrambling seed for the transmission of the xPDSCH can be defined as a function of a random access radio network temporary identifier (RA-RNTI), a group ID or an event ID.

[0090] In one configuration, the RAR message can be transmitted via the xPDCCH. The UE (e.g., a mission critical MTC device) can monitor the xPDCCH with a cyclic redundancy check (CRC) scrambled by an RA-RNTI.

[0091] In one configuration, the RAR message can be transmitted via the xPDSCH scheduled by the xPDCCH.

[0092] In one configuration, a gap between an end of a last RAR transmission and a starting subframe of the uplink transmission can be predefined or configured by higher layers via the xMIB, the xSIB or dedicated RRC signaling. In addition, a delay parameter in the order of standard or short TTI can indicated in the UL grant of the RAR message.

[0093] In one configuration, for the uplink transmission, the same information can be transmitted on multiple component carriers (CC) simultaneously or transmitted repeatedly over multiple sets of PRBs within a CC. In one example, TTI bundling with a predefined redundancy version (RV) pattern can be employed for the uplink transmission. In another example, a scrambling seed for the transmission of the xPUSCH can be defined as a function of a mission critical MTC device ID or a group ID for a "single frequency network" type of operation.

[0094] In one configuration, a gap between an end of the uplink data transmission and a starting subframe of the ACK/NACK transmission can be predefined or configured by

higher layers via the xMIB, the xSIB or dedicated RRC signaling.

[0095] In one configuration, when a negative acknowledgement (NACK) is received or an acknowledgement (ACK) is not received, the UE (e.g., a mission critical MTC device) can perform a retransmission of the uplink data. When a maximum number of retransmission is reached, the UE can perform a random back-off and re-initiate the procedure for mission critical communication.

[0096] Another example provides functionality 900 of a user equipment (UE) operable to perform mission critical communications with an eNodeB, as shown in the flow chart in FIG. 9. The UE can comprise one or more processors and memory configured to: transmit, from the UE to the eNodeB, a physical random access channel (PRACH) signal that indicates a mission critical communication to be performed between the UE and the eNodeB, wherein the PRACH signal is transmitted using dedicated PRACH resources and in accordance with a first transmission time interval (TTI), as in block 910. The UE can comprise one or more processors and memory configured to: receive, from the eNodeB, a random access response (RAR) message that includes a timing advance (TA) and a resource allocation for the mission critical communication, wherein the RAR message is transmitted from the eNodeB using a second TTI, wherein the second TTI is associated with a time interval that is less than the first TTI, as in block 920. The UE can comprise one or more processors and memory configured to: decode, at the UE, the RAR message to determine the TA and the resource allocation for the mission critical communication, as in block 930. The UE can comprise one or more processors and memory configured to: perform, at the UE, the mission critical communication with the eNodeB in an uplink using the TA and the resource allocation indicated in the RAR message, wherein the mission critical communication is performed using a physical uplink shared channel (PUSCH) and in accordance with the second TTI, as in block 940.

[0097] Another example provides functionality 1000 of a base station operable to receive mission critical communications from a user equipment (UE), as shown in the flow chart in FIG. 10. The base station can comprise one or more processors and memory configured to: receive, from the UE, a physical random access channel (PRACH) signal that indicates a mission critical communication to be performed between the eNodeB and the UE, wherein the PRACH signal is received using dedicated PRACH resources and in

accordance with a first transmission time interval (TTI), as in block 1010. The base station can comprise one or more processors and memory configured to: transmit, to the UE, a random access response (RAR) message that includes a timing advance (TA) and a resource allocation for the mission critical communication, wherein the RAR message is transmitted from the eNodeB using a second TTI, wherein the second TTI is associated with a time interval that is less than the first TTI, as in block 1020. The base station can comprise one or more processors and memory configured to: receive, from the UE, the mission critical communication on a physical uplink shared channel (PUSCH) and in accordance with the second TTI, wherein the UE is configured to perform the mission critical communication in an uplink using the TA and the resource allocation indicated in the RAR message, as in block 1030. The base station can comprise one or more processors and memory configured to: transmit, to the UE, an acknowledgement (ACK) or a negative acknowledgement (NACK) for the mission critical communication in a physical downlink control channel (PDCCH) or a physical hybrid-ARQ indicator channel (PHICH) channel in accordance with the second TTI, as in block 1040.

[0098] Another example provides at least one machine readable storage medium having instructions 1100 embodied thereon for performing mission critical communications between a user equipment (UE) and an eNodeB, as shown in the flow chart in FIG. 11. The instructions can be executed on a machine, where the instructions are included on at least one computer readable medium or one non-transitory machine readable storage medium. The instructions when executed perform: transmitting, using at least one processor of the UE, a physical random access channel (PRACH) signal to the eNodeB that indicates a mission critical communication to be performed between the UE and the eNodeB, wherein the PRACH signal is transmitted in accordance with a first transmission time interval (TTI), as in block 1110. The instructions when executed perform: receiving, using the at least one processor of the UE, a random access response (RAR) message from the eNodeB that includes a timing advance (TA) and a resource allocation for the mission critical communication, wherein the RAR message is transmitted from the eNodeB using a second TTI, wherein the second TTI is associated with a time interval that is less than the first TTI, as in block 1120. The instructions when executed perform: performing, using the at least one processor of the UE, the mission critical communication with the eNodeB in an uplink using the TA and the resource allocation

indicated in the RAR message, wherein the mission critical communication is performed using a physical uplink shared channel (PUSCH) and in accordance with the second TTI, as in block 1130. The instructions when executed perform: receiving, using the at least one processor of the UE, an acknowledgement (ACK) or a negative acknowledgement (NACK) from the eNodeB for the mission critical communication in a physical downlink control channel (PDCCH) or a physical hybrid-ARQ indicator channel (PHICH) channel in accordance with the second TTI, as in block 1140.

[0099] FIG. 12 provides an example illustration of a user equipment (UE) device 1200, such as a wireless device, a mobile station (MS), a mobile wireless device, a mobile communication device, a tablet, a handset, or other type of wireless device. The UE device 1200 can include one or more antennas configured to communicate with a node or transmission station, such as a base station (BS), an evolved Node B (eNB), a baseband unit (BBU), a remote radio head (RRH), a remote radio equipment (RRE), a relay station (RS), a radio equipment (RE), a remote radio unit (RRU), a central processing module (CPM), or other type of wireless wide area network (WWAN) access point. The UE device 1200 can be configured to communicate using at least one wireless communication standard including 3GPP LTE, WiMAX, High Speed Packet Access (HSPA), Bluetooth, and WiFi. The UE device 1200 can communicate using separate antennas for each wireless communication standard or shared antennas for multiple wireless communication standards. The UE device 1200 can communicate in a wireless local area network (WLAN), a wireless personal area network (WPAN), and/or a WWAN.

[00100] In some embodiments, the UE device 1200 may include application circuitry 1202, baseband circuitry 1204, Radio Frequency (RF) circuitry 1206, front-end module (FEM) circuitry 1208 and one or more antennas 1210, coupled together at least as shown.

[00101] The application circuitry 1202 may include one or more application processors. For example, the application circuitry 1202 may include circuitry such as, but not limited to, one or more single-core or multi-core processors. The processor(s) may include any combination of general-purpose processors and dedicated processors (e.g., graphics processors, application processors, etc.). The processors may be coupled with and/or may include a storage medium 1212, and may be configured to execute instructions stored in the storage medium 1212 to enable various applications and/or operating systems to run on the system.

[00102] The baseband circuitry 1204 may include circuitry such as, but not limited to, one or more single-core or multi-core processors. The baseband circuitry 1204 may include one or more baseband processors and/or control logic to process baseband signals received from a receive signal path of the RF circuitry 1206 and to generate baseband signals for a transmit signal path of the RF circuitry 1206. Baseband processing circuity 1204 may interface with the application circuitry 1202 for generation and processing of the baseband signals and for controlling operations of the RF circuitry 1206. For example, in some embodiments, the baseband circuitry 1204 may include a second generation (2G) baseband processor 1204a, third generation (3G) baseband processor 1204b, fourth generation (4G) baseband processor 1204c, and/or other baseband processor(s) 1204d for other existing generations, generations in development or to be developed in the future (e.g., fifth generation (5G), 6G, etc.). The baseband circuitry 1204 (e.g., one or more of baseband processors 1204a-d) may handle various radio control functions that enable communication with one or more radio networks via the RF circuitry 1206. The radio control functions may include, but are not limited to, signal modulation/demodulation, encoding/decoding, radio frequency shifting, etc. In some embodiments, modulation/demodulation circuitry of the baseband circuitry 1204 may include Fast-Fourier Transform (FFT), precoding, and/or constellation mapping/demapping functionality. In some embodiments, encoding/decoding circuitry of the baseband circuitry 1204 may include convolution, tail-biting convolution, turbo, Viterbi, and/or Low Density Parity Check (LDPC) encoder/decoder functionality. Embodiments of modulation/demodulation and encoder/decoder functionality are not limited to these examples and may include other suitable functionality in other embodiments.

[00103] In some embodiments, the baseband circuitry 1204 may include elements of a protocol stack such as, for example, elements of an evolved universal terrestrial radio access network (EUTRAN) protocol including, for example, physical (PHY), media access control (MAC), radio link control (RLC), packet data convergence protocol (PDCP), and/or radio resource control (RRC) elements. A central processing unit (CPU) 1204e of the baseband circuitry 1204 may be configured to run elements of the protocol stack for signaling of the PHY, MAC, RLC, PDCP and/or RRC layers. In some embodiments, the baseband circuitry may include one or more audio digital signal

processor(s) (DSP) 1204f. The audio DSP(s) 104f may be include elements for compression/decompression and echo cancellation and may include other suitable processing elements in other embodiments. Components of the baseband circuitry may be suitably combined in a single chip, a single chipset, or disposed on a same circuit board in some embodiments. In some embodiments, some or all of the constituent components of the baseband circuitry 1204 and the application circuitry 1202 may be implemented together such as, for example, on a system on a chip (SOC).

[00104] In some embodiments, the baseband circuitry 1204 may provide for communication compatible with one or more radio technologies. For example, in some embodiments, the baseband circuitry 1204 may support communication with an evolved universal terrestrial radio access network (EUTRAN) and/or other wireless metropolitan area networks (WMAN), a wireless local area network (WLAN), a wireless personal area network (WPAN). Embodiments in which the baseband circuitry 1204 is configured to support radio communications of more than one wireless protocol may be referred to as multi-mode baseband circuitry.

[00105] The RF circuitry 1206 may enable communication with wireless networks using modulated electromagnetic radiation through a non-solid medium. In various embodiments, the RF circuitry 1206 may include switches, filters, amplifiers, etc. to facilitate the communication with the wireless network. RF circuitry 1206 may include a receive signal path which may include circuitry to down-convert RF signals received from the FEM circuitry 1208 and provide baseband signals to the baseband circuitry 1204. RF circuitry 1206 may also include a transmit signal path which may include circuitry to up-convert baseband signals provided by the baseband circuitry 1204 and provide RF output signals to the FEM circuitry 1208 for transmission.

[00106] In some embodiments, the RF circuitry 1206 may include a receive signal path and a transmit signal path. The receive signal path of the RF circuitry 1206 may include mixer circuitry 1206a, amplifier circuitry 1206b and filter circuitry 1206c. The transmit signal path of the RF circuitry 1206 may include filter circuitry 1206c and mixer circuitry 1206a. RF circuitry 1206 may also include synthesizer circuitry 1206d for synthesizing a frequency for use by the mixer circuitry 1206a of the receive signal path and the transmit signal path. In some embodiments, the mixer circuitry 1206a of the receive signal path

may be configured to down-convert RF signals received from the FEM circuitry 1208 based on the synthesized frequency provided by synthesizer circuitry 1206d. The amplifier circuitry 1206b may be configured to amplify the down-converted signals and the filter circuitry 1206c may be a low-pass filter (LPF) or band-pass filter (BPF) configured to remove unwanted signals from the down-converted signals to generate output baseband signals. Output baseband signals may be provided to the baseband circuitry 1204 for further processing. In some embodiments, the output baseband signals may be zero-frequency baseband signals, although this is not a requirement. In some embodiments, mixer circuitry 1206a of the receive signal path may comprise passive mixers, although the scope of the embodiments is not limited in this respect.

[00107] In some embodiments, the mixer circuitry 1206a of the transmit signal path may be configured to up-convert input baseband signals based on the synthesized frequency provided by the synthesizer circuitry 1206d to generate RF output signals for the FEM circuitry 1208. The baseband signals may be provided by the baseband circuitry 1204 and may be filtered by filter circuitry 1206c. The filter circuitry 1206c may include a low-pass filter (LPF), although the scope of the embodiments is not limited in this respect.

[00108] In some embodiments, the mixer circuitry 1206a of the receive signal path and the mixer circuitry 1206a of the transmit signal path may include two or more mixers and may be arranged for quadrature down-conversion and/or up-conversion respectively. In some embodiments, the mixer circuitry 1206a of the receive signal path and the mixer circuitry 1206a of the transmit signal path may include two or more mixers and may be arranged for image rejection (e.g., Hartley image rejection). In some embodiments, the mixer circuitry 1206a of the receive signal path and the mixer circuitry 1206a may be arranged for direct down-conversion and/or direct up-conversion, respectively. In some embodiments, the mixer circuitry 1206a of the receive signal path and the mixer circuitry 1206a of the transmit signal path may be configured for super-heterodyne operation.

[00109] In some embodiments, the output baseband signals and the input baseband signals may be analog baseband signals, although the scope of the embodiments is not limited in this respect. In some alternate embodiments, the output baseband signals and the input baseband signals may be digital baseband signals. In these alternate embodiments, the RF circuitry 1206 may include analog-to-digital converter (ADC) and digital-to-analog

converter (DAC) circuitry and the baseband circuitry 1204 may include a digital baseband interface to communicate with the RF circuitry 1206.

[00110] In some dual-mode embodiments, a separate radio IC circuitry may be provided for processing signals for each spectrum, although the scope of the embodiments is not limited in this respect.

[00111] In some embodiments, the synthesizer circuitry 1206d may be a fractional-N synthesizer or a fractional N/N+1 synthesizer, although the scope of the embodiments is not limited in this respect as other types of frequency synthesizers may be suitable. For example, synthesizer circuitry 1206d may be a delta-sigma synthesizer, a frequency multiplier, or a synthesizer comprising a phase-locked loop with a frequency divider.

[00112] The synthesizer circuitry 1206d may be configured to synthesize an output frequency for use by the mixer circuitry 1206a of the RF circuitry 1206 based on a frequency input and a divider control input. In some embodiments, the synthesizer circuitry 1206d may be a fractional N/N+1 synthesizer.

[00113] In some embodiments, frequency input may be provided by a voltage controlled oscillator (VCO), although that is not a requirement. Divider control input may be provided by either the baseband circuitry 1204 or the applications processor 1202 depending on the desired output frequency. In some embodiments, a divider control input (e.g., N) may be determined from a look-up table based on a channel indicated by the applications processor 1202.

[00114] Synthesizer circuitry 1206d of the RF circuitry 1206 may include a divider, a delay-locked loop (DLL), a multiplexer and a phase accumulator. In some embodiments, the divider may be a dual modulus divider (DMD) and the phase accumulator may be a digital phase accumulator (DPA). In some embodiments, the DMD may be configured to divide the input signal by either N or N+1 (e.g., based on a carry out) to provide a fractional division ratio. In some example embodiments, the DLL may include a set of cascaded, tunable, delay elements, a phase detector, a charge pump and a D-type flip-flop. In these embodiments, the delay elements may be configured to break a VCO period up into Nd equal packets of phase, where Nd is the number of delay elements in the delay line. In this way, the DLL provides negative feedback to help ensure that the total delay through the delay line is one VCO cycle.

[00115] In some embodiments, synthesizer circuitry 1206d may be configured to generate a carrier frequency as the output frequency, while in other embodiments, the output frequency may be a multiple of the carrier frequency (e.g., twice the carrier frequency, four times the carrier frequency) and used in conjunction with quadrature generator and divider circuitry to generate multiple signals at the carrier frequency with multiple different phases with respect to each other. In some embodiments, the output frequency may be a LO frequency (fLO). In some embodiments, the RF circuitry 1206 may include an IQ/polar converter.

[00116] FEM circuitry 1208 may include a receive signal path which may include circuitry configured to operate on RF signals received from one or more antennas 1210, amplify the received signals and provide the amplified versions of the received signals to the RF circuitry 1206 for further processing. FEM circuitry 1208 may also include a transmit signal path which may include circuitry configured to amplify signals for transmission provided by the RF circuitry 1206 for transmission by one or more of the one or more antennas 1210.

[00117] In some embodiments, the FEM circuitry 1208 may include a TX/RX switch to switch between transmit mode and receive mode operation. The FEM circuitry may include a receive signal path and a transmit signal path. The receive signal path of the FEM circuitry may include a low-noise amplifier (LNA) to amplify received RF signals and provide the amplified received RF signals as an output (e.g., to the RF circuitry 1206). The transmit signal path of the FEM circuitry 1208 may include a power amplifier (PA) to amplify input RF signals (e.g., provided by RF circuitry 1206), and one or more filters to generate RF signals for subsequent transmission (e.g., by one or more of the one or more antennas 1210.

[00118] FIG. 13 provides an example illustration of the wireless device, such as a user equipment (UE), a mobile station (MS), a mobile wireless device, a mobile communication device, a tablet, a handset, or other type of wireless device. The wireless device can include one or more antennas configured to communicate with a node, macro node, low power node (LPN), or, transmission station, such as a base station (BS), an evolved Node B (eNB), a baseband processing unit (BBU), a remote radio head (RRH), a remote radio equipment (RRE), a relay station (RS), a radio equipment (RE), or other

type of wireless wide area network (WWAN) access point. The wireless device can be configured to communicate using at least one wireless communication standard such as, but not limited to, 3GPP LTE, WiMAX, High Speed Packet Access (HSPA), Bluetooth, and WiFi. The wireless device can communicate using separate antennas for each wireless communication standard or shared antennas for multiple wireless communication standards. The wireless device can communicate in a wireless local area network (WLAN), a wireless personal area network (WPAN), and/or a WWAN. The wireless device can also comprise a wireless modem. The wireless modem can comprise, for example, a wireless radio transceiver and baseband circuitry (e.g., a baseband processor). The wireless modem can, in one example, modulate signals that the wireless device transmits via the one or more antennas and demodulate signals that the wireless device receives via the one or more antennas.

[00119] FIG. 13 also provides an illustration of a microphone and one or more speakers that can be used for audio input and output from the wireless device. The display screen can be a liquid crystal display (LCD) screen, or other type of display screen such as an organic light emitting diode (OLED) display. The display screen can be configured as a touch screen. The touch screen can use capacitive, resistive, or another type of touch screen technology. An application processor and a graphics processor can be coupled to internal memory to provide processing and display capabilities. A non-volatile memory port can also be used to provide data input/output options to a user. The non-volatile memory port can also be used to expand the memory capabilities of the wireless device. A keyboard can be integrated with the wireless device or wirelessly connected to the wireless device to provide additional user input. A virtual keyboard can also be provided using the touch screen.

Examples

[00120] The following examples pertain to specific technology embodiments and point out specific features, elements, or actions that can be used or otherwise combined in achieving such embodiments.

[00121] Example 1 includes an apparatus of a user equipment (UE) operable to perform mission critical communications with an eNodeB, the apparatus comprising one or more processors and memory configured to: transmit, from the UE to the eNodeB, a physical

random access channel (PRACH) signal that indicates a mission critical communication to be performed between the UE and the eNodeB, wherein the PRACH signal is transmitted using dedicated PRACH resources and in accordance with a first transmission time interval (TTI); receive, from the eNodeB, a random access response (RAR) message that includes a timing advance (TA) and a resource allocation for the mission critical communication, wherein the RAR message is transmitted from the eNodeB using a second TTI, wherein the second TTI is associated with a time interval that is less than the first TTI; decode, at the UE, the RAR message to determine the TA and the resource allocation for the mission critical communication; and perform, at the UE, the mission critical communication with the eNodeB in an uplink using the TA and the resource allocation indicated in the RAR message, wherein the mission critical communication is performed using a physical uplink shared channel (PUSCH) and in accordance with the second TTI.

[00122] Example 2 includes the apparatus of Example 1, further configured to receive, from the eNodeB, an acknowledgement (ACK) or a negative acknowledgement (NACK) for the mission critical communication in a physical downlink control channel (PDCCH) or a physical hybrid-ARQ indicator channel (PHICH) channel in accordance with the second TTI.

[00123] Example 3 includes the apparatus of any of Examples 1-2, wherein the first TTI is for a Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) Release 8 orthogonal frequency division multiple access (OFDMA) frame structure and is approximately one millisecond (ms) and the second TTI is approximately 0.1 to 0.2 ms.

[00124] Example 4 includes the apparatus of any of Examples 1-3, wherein the first TTI is associated with a first partition of a low band and the second TTI is associated with a second partition of a low band, wherein the first partition is utilized for non-mission critical communications and the second partition is utilized for mission critical communications.

[00125] Example 5 includes the apparatus of any of Examples 1-4, wherein the UE is configured to: perform repeated transmissions of the PRACH signal to the eNodeB until the RAR message is received from the eNodeB; and perform repeated mission critical communications with the eNodeB until an acknowledgement (ACK) or a negative

acknowledgement (NACK) is received from the eNodeB, wherein a maximum number of repetitions for each transmission from the UE is predefined or configured by higher layers via one of: a master information block (MIB), a system information block (SIB) or dedicated radio resource control (RRC) signaling, wherein the UE performs a random back off and reinitiates a procedure for performing the mission critical communication when the maximum number of repetitions for a defined transmission is reached.

[00126] Example 6 includes the apparatus of any of Examples 1-5, wherein the UE is configured to: repeatedly transmit the PRACH signal to the eNodeB in accordance with a fixed number of repetitions; and repeatedly perform the mission critical communication with the eNodeB in accordance with a fixed number of repetitions, wherein the fixed number of repetitions for each transmission from the UE is predefined or configured by higher layers via one of: a master information block (MIB), a system information block (SIB) or dedicated radio resource control (RRC) signaling.

[00127] Example 7 includes the apparatus of any of Examples 1-6, wherein the dedicated PRACH resources for mission critical communications are multiplexed with PRACH resources for non-mission critical application using at least one of: time division multiplexing (TDM), frequency division multiplexing (FDM) and code division multiplexing (CDM).

[00128] Example 8 includes the apparatus of any of Examples 1-7, wherein a plurality of signatures, time resources and frequency resources are reserved for transmitting the PRACH signal from the UE to trigger the mission critical communication.

[00129] Example 9 includes the apparatus of any of Examples 1-8, wherein the PRACH signal is communicated to the eNodeB with a scheduling request (SR), wherein the SR includes at least one of: a mission critical machine type communication (MTC) device identifier (ID), an event ID, a mission critical MTC device capability, and a resource request and a modulation and coding scheme (MCS) for the mission critical communication in uplink from the UE.

[00130] Example 10 includes the apparatus of any of Examples 1-9, wherein the PRACH signal is transmitted from the UE to the eNodeB in accordance with a maximum transmit power.

[00131] Example 11 includes the apparatus of any of Examples 1-10, wherein the UE is

configured to receive the RAR message from the eNodeB by monitoring a RAR message window, wherein a position of the RAR message window is configured by higher layers via one of: a master information block (MIB), a system information block (SIB) or dedicated radio resource control (RRC) signaling.

[00132] Example 12 includes the apparatus of any of Examples 1-11, further configured to receive a preamble from the eNodeB prior to receiving the RAR message, wherein the preamble functions to improve a downlink synchronization accuracy.

[00133] Example 13 includes the apparatus of any of Examples 1-12, wherein the RAR message received at the UE includes at least one of: the timing advance (TA), an uplink grant that contains the resource allocation for the mission critical communication, a mission critical machine type communication (MTC) device identifier (ID), an event ID, and a random access preamble ID.

[00134] Example 14 includes the apparatus of any of Examples 1-13, wherein: the RAR message is received at the UE via a physical downlink control channel (PDCCH), wherein the UE is configured to monitor the PDCCH using a cyclic redundancy check (CRC) scrambled by a random-access radio network temporary identifier (RA-RNTI); or the RAR message is received at the UE via a physical downlink shared channel (PDSCH) that is scheduled by the PDCCH.

[00135] Example 15 includes the apparatus of any of Examples 1-14, wherein: a gap between a last subframe for a RAR message transmission and a starting subframe of the mission critical communication in uplink is predefined or configured by higher layers via one of: a master information block (MIB), a system information block (SIB) or dedicated radio resource control (RRC) signaling; and a gap between a last subframe of the mission critical communication in uplink and a starting subframe of an acknowledgement (ACK) or a negative acknowledgement (NACK) transmission is predefined or configured by higher layers via one of: the MIB, the SIB, or dedicated RRC signaling.

[00136] Example 16 includes the apparatus of any of Examples 1-15, wherein the UE includes at least one of an antenna, a touch sensitive display screen, a speaker, a microphone, a graphics processor, an application processor, a baseband processor, an internal memory, a non-volatile memory port, and combinations thereof.

[00137] Example 17 includes an apparatus of a base station operable to receive mission

critical communications from a user equipment (UE), the apparatus comprising one or more processors and memory configured to: receive, from the UE, a physical random access channel (PRACH) signal that indicates a mission critical communication to be performed between the eNodeB and the UE, wherein the PRACH signal is received using dedicated PRACH resources and in accordance with a first transmission time interval (TTI); transmit, to the UE, a random access response (RAR) message that includes a timing advance (TA) and a resource allocation for the mission critical communication, wherein the RAR message is transmitted from the eNodeB using a second TTI, wherein the second TTI is associated with a time interval that is less than the first TTI; receive, from the UE, the mission critical communication on a physical uplink shared channel (PUSCH) and in accordance with the second TTI, wherein the UE is configured to perform the mission critical communication in an uplink using the TA and the resource allocation indicated in the RAR message; and transmit, to the UE, an acknowledgement (ACK) or a negative acknowledgement (NACK) for the mission critical communication in a physical downlink control channel (PDCCH) or a physical hybrid-ARQ indicator channel (PHICH) channel in accordance with the second TTI.

[00138] Example 18 includes the apparatus of Example 17, wherein the first TTI is for a Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) Release 8 orthogonal frequency division multiple access (OFDMA) frame structure and is approximately one millisecond (ms) and is associated with a first partition of a low band, wherein the second TTI is approximately 0.1 to 0.2 ms and is associated with a second partition of a low band, wherein the first partition is utilized for non-mission critical communications and the second partition is utilized for mission critical communications.

[00139] Example 19 includes the apparatus of any of Examples 17-18, wherein the dedicated PRACH resources for mission critical communications are multiplexed with PRACH resources for non-mission critical application using at least one of: time division multiplexing (TDM), frequency division multiplexing (FDM) and code division multiplexing (CDM).

[00140] Example 20 includes the apparatus of any of Examples 17-19, wherein: the PRACH signal is received from the UE with a scheduling request (SR), wherein the SR includes at least one of: a mission critical machine type communication (MTC) device

identifier (ID), an event ID, a mission critical MTC device capability, and a resource request and a modulation and coding scheme (MCS) for the mission critical communication in uplink from the UE; and the RAR message transmitted to the UE includes at least one of: the timing advance (TA), an uplink grant that contains the resource allocation for the mission critical communication, a mission critical machine type communication (MTC) device identifier (ID), an event ID, and a random access preamble ID.

[00141] Example 21 includes the apparatus of any of Examples 17-20, wherein the RAR message is transmitted to the UE via a physical downlink control channel (PDCCH) or a physical downlink shared channel (PDSCH).

[00142] Example 22 includes at least one machine readable storage medium having instructions embodied thereon for performing mission critical communications between a user equipment (UE) and an eNodeB, the instructions when executed perform the following: transmitting, using at least one processor of the UE, a physical random access channel (PRACH) signal to the eNodeB that indicates a mission critical communication to be performed between the UE and the eNodeB, wherein the PRACH signal is transmitted in accordance with a first transmission time interval (TTI); receiving, using the at least one processor of the UE, a random access response (RAR) message from the eNodeB that includes a timing advance (TA) and a resource allocation for the mission critical communication, wherein the RAR message is transmitted from the eNodeB using a second TTI, wherein the second TTI is associated with a time interval that is less than the first TTI; performing, using the at least one processor of the UE, the mission critical communication with the eNodeB in an uplink using the TA and the resource allocation indicated in the RAR message, wherein the mission critical communication is performed using a physical uplink shared channel (PUSCH) and in accordance with the second TTI; and receiving, using the at least one processor of the UE, an acknowledgement (ACK) or a negative acknowledgement (NACK) from the eNodeB for the mission critical communication in a physical downlink control channel (PDCCH) or a physical hybrid-ARQ indicator channel (PHICH) channel in accordance with the second TTI.

[00143] Example 23 includes the at least one machine readable storage medium of Example 22, wherein the UE is configured to initiate performance of the mission critical

communication when in a radio resource control (RRC) idle mode.

[00144] Example 24 includes the at least one machine readable storage medium of any of Examples 22-23, wherein the first TTI is approximately one millisecond (ms) and is associated with a first partition of a low band, wherein the second TTI is approximately 0.1 to 0.2 ms and is associated with a second partition of a low band, wherein the first partition is utilized for non-mission critical communications and the second partition is utilized for mission critical communications.

[00145] Example 25 includes the at least one machine readable storage medium of any of Examples 22-24, further comprising instructions which when executed perform the following: performing repeated transmissions of the repeatedly transmit the PRACH signal to the eNodeB until the RAR message is received from the eNodeB; and performing repeated mission critical communications with the eNodeB until an acknowledgement (ACK) or a negative acknowledgement (NACK) is received from the eNodeB.

[00146] Various techniques, or certain aspects or portions thereof, may take the form of program code (i.e., instructions) embodied in tangible media, such as floppy diskettes, compact disc-read-only memory (CD-ROMs), hard drives, non-transitory computer readable storage medium, or any other machine-readable storage medium wherein, when the program code is loaded into and executed by a machine, such as a computer, the machine becomes an apparatus for practicing the various techniques. A non-transitory computer readable storage medium can be a computer readable storage medium that does not include signal. In the case of program code execution on programmable computers, the computing device may include a processor, a storage medium readable by the processor (including volatile and non-volatile memory and/or storage elements), at least one input device, and at least one output device. The volatile and non-volatile memory and/or storage elements may be a random-access memory (RAM), erasable programmable read only memory (EPROM), flash drive, optical drive, magnetic hard drive, solid state drive, or other medium for storing electronic data. The node and wireless device may also include a transceiver module (i.e., transceiver), a counter module (i.e., counter), a processing module (i.e., processor), and/or a clock module (i.e., clock) or timer module (i.e., timer). One or more programs that may implement or utilize

the various techniques described herein may use an application programming interface (API), reusable controls, and the like. Such programs may be implemented in a high level procedural or object oriented programming language to communicate with a computer system. However, the program(s) may be implemented in assembly or machine language, if desired. In any case, the language may be a compiled or interpreted language, and combined with hardware implementations.

[00147] As used herein, the term "circuitry" may refer to, be part of, or include an Application Specific Integrated Circuit (ASIC), an electronic circuit, a processor (shared, dedicated, or group), and/or memory (shared, dedicated, or group) that execute one or more software or firmware programs, a combinational logic circuit, and/or other suitable hardware components that provide the described functionality. In some embodiments, the circuitry may be implemented in, or functions associated with the circuitry may be implemented by, one or more software or firmware modules. In some embodiments, circuitry may include logic, at least partially operable in hardware.

[00148] It should be understood that many of the functional units described in this specification have been labeled as modules, in order to more particularly emphasize their implementation independence. For example, a module may be implemented as a hardware circuit comprising custom very-large-scale integration (VLSI) circuits or gate arrays, off-the-shelf semiconductors such as logic chips, transistors, or other discrete components. A module may also be implemented in programmable hardware devices such as field programmable gate arrays, programmable array logic, programmable logic devices or the like.

[00149] Modules may also be implemented in software for execution by various types of processors. An identified module of executable code may, for instance, comprise one or more physical or logical blocks of computer instructions, which may, for instance, be organized as an object, procedure, or function. Nevertheless, the executables of an identified module may not be physically located together, but may comprise disparate instructions stored in different locations which, when joined logically together, comprise the module and achieve the stated purpose for the module.

[00150] Indeed, a module of executable code may be a single instruction, or many instructions, and may even be distributed over several different code segments, among

different programs, and across several memory devices. Similarly, operational data may be identified and illustrated herein within modules, and may be embodied in any suitable form and organized within any suitable type of data structure. The operational data may be collected as a single data set, or may be distributed over different locations including over different storage devices, and may exist, at least partially, merely as electronic signals on a system or network. The modules may be passive or active, including agents operable to perform desired functions.

[00151] Reference throughout this specification to "an example" or “exemplary” means that a particular feature, structure, or characteristic described in connection with the example is included in at least one embodiment of the present technology. Thus, appearances of the phrases "in an example" or the word “exemplary” in various places throughout this specification are not necessarily all referring to the same embodiment.

[00152] As used herein, a plurality of items, structural elements, compositional elements, and/or materials may be presented in a common list for convenience. However, these lists should be construed as though each member of the list is individually identified as a separate and unique member. Thus, no individual member of such list should be construed as a de facto equivalent of any other member of the same list solely based on their presentation in a common group without indications to the contrary. In addition, various embodiments and example of the present technology may be referred to herein along with alternatives for the various components thereof. It is understood that such embodiments, examples, and alternatives are not to be construed as defacto equivalents of one another, but are to be considered as separate and autonomous representations of the present technology.

[00153] Furthermore, the described features, structures, or characteristics may be combined in any suitable manner in one or more embodiments. In the following description, numerous specific details are provided, such as examples of layouts, distances, network examples, etc., to provide a thorough understanding of embodiments of the technology. One skilled in the relevant art will recognize, however, that the technology can be practiced without one or more of the specific details, or with other methods, components, layouts, etc. In other instances, well-known structures, materials, or operations are not shown or described in detail to avoid obscuring aspects of the

technology.

[00154] While the forgoing examples are illustrative of the principles of the present technology in one or more particular applications, it will be apparent to those of ordinary skill in the art that numerous modifications in form, usage and details of implementation can be made without the exercise of inventive faculty, and without departing from the principles and concepts of the technology. Accordingly, it is not intended that the technology be limited, except as by the claims set forth below.

CLAIMS

What is claimed is:

1. An apparatus of a user equipment (UE) operable to perform mission critical communications with an eNodeB, the apparatus comprising one or more processors and memory configured to:

transmit, from the UE to the eNodeB, a physical random access channel (PRACH) signal that indicates a mission critical communication to be performed between the UE and the eNodeB, wherein the PRACH signal is transmitted using dedicated PRACH resources and in accordance with a first transmission time interval (TTI);

receive, from the eNodeB, a random access response (RAR) message that includes a timing advance (TA) and a resource allocation for the mission critical communication, wherein the RAR message is transmitted from the eNodeB using a second TTI, wherein the second TTI is associated with a time interval that is less than the first TTI;

decode, at the UE, the RAR message to determine the TA and the resource allocation for the mission critical communication; and

perform, at the UE, the mission critical communication with the eNodeB in an uplink using the TA and the resource allocation indicated in the RAR message, wherein the mission critical communication is performed using a physical uplink shared channel (PUSCH) and in accordance with the second TTI.

2. The apparatus of claim 1, further configured to receive, from the eNodeB, an acknowledgement (ACK) or a negative acknowledgement (NACK) for the mission critical communication in a physical downlink control channel (PDCCH) or a physical hybrid-ARQ indicator channel (PHICH) channel in accordance with the second TTI.

3. The apparatus of claim 1, wherein the first TTI is for a Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) Release 8 orthogonal frequency division multiple access (OFDMA) frame structure and is approximately one millisecond (ms) and the second TTI is approximately 0.1 to

0.2 ms.

4. The apparatus of claim 1, wherein the first TTI is associated with a first partition of a low band and the second TTI is associated with a second partition of a low band, wherein the first partition is utilized for non-mission critical communications and the second partition is utilized for mission critical communications.

5. The apparatus of any of claims 1 to 4, wherein the UE is configured to:

perform repeated transmissions of the PRACH signal to the eNodeB until the RAR message is received from the eNodeB; and

perform repeated mission critical communications with the eNodeB until an acknowledgement (ACK) or a negative acknowledgement (NACK) is received from the eNodeB,

wherein a maximum number of repetitions for each transmission from the UE is predefined or configured by higher layers via one of: a master information block (MIB), a system information block (SIB) or dedicated radio resource control (RRC) signaling,

wherein the UE performs a random back off and reinitiates a procedure for performing the mission critical communication when the maximum number of repetitions for a defined transmission is reached.

6. The apparatus of claim 1, wherein the UE is configured to:

repeatedly transmit the PRACH signal to the eNodeB in accordance with a fixed number of repetitions; and

repeatedly perform the mission critical communication with the eNodeB in accordance with a fixed number of repetitions,

wherein the fixed number of repetitions for each transmission from the UE is predefined or configured by higher layers via one of: a master information block (MIB), a system information block (SIB) or dedicated radio resource control (RRC) signaling.

7. The apparatus of claim 1, wherein the dedicated PRACH resources for mission critical communications are multiplexed with PRACH resources for non-mission critical application using at least one of: time division multiplexing (TDM), frequency division multiplexing (FDM) and code division multiplexing (CDM).

8. The apparatus of claim 1, wherein a plurality of signatures, time resources and frequency resources are reserved for transmitting the PRACH signal from the UE to trigger the mission critical communication.

9. The apparatus of claim 1, wherein the PRACH signal is communicated to the eNodeB with a scheduling request (SR), wherein the SR includes at least one of: a mission critical machine type communication (MTC) device identifier (ID), an event ID, a mission critical MTC device capability, and a resource request and a modulation and coding scheme (MCS) for the mission critical communication in uplink from the UE.

10. The apparatus of claim 1, wherein the PRACH signal is transmitted from the UE to the eNodeB in accordance with a maximum transmit power.

11. The apparatus of claim 1, wherein the UE is configured to receive the RAR message from the eNodeB by monitoring a RAR message window, wherein a position of the RAR message window is configured by higher layers via one of: a master information block (MIB), a system information block (SIB) or dedicated radio resource control (RRC) signaling.

12. The apparatus of claim 1, further configured to receive a preamble from the eNodeB prior to receiving the RAR message, wherein the preamble functions to improve a downlink synchronization accuracy.

13. The apparatus of claim 1, wherein the RAR message received at the UE includes at least one of: the timing advance (TA), an uplink grant that contains the resource allocation for the mission critical communication, a mission critical machine type

communication (MTC) device identifier (ID), an event ID, and a random access preamble ID.

14. The apparatus of claim 1, wherein:

the RAR message is received at the UE via a physical downlink control channel (PDCCH), wherein the UE is configured to monitor the PDCCH using a cyclic redundancy check (CRC) scrambled by a random-access radio network temporary identifier (RA-RNTI); or

the RAR message is received at the UE via a physical downlink shared channel (PDSCH) that is scheduled by the PDCCH.

15. The apparatus of any of claims 6 to 14, wherein:

a gap between a last subframe for a RAR message transmission and a starting subframe of the mission critical communication in uplink is predefined or configured by higher layers via one of: a master information block (MIB), a system information block (SIB) or dedicated radio resource control (RRC) signaling; and

a gap between a last subframe of the mission critical communication in uplink and a starting subframe of an acknowledgement (ACK) or a negative acknowledgement (NACK) transmission is predefined or configured by higher layers via one of: the MIB, the SIB, or dedicated RRC signaling.

16. The apparatus of claim 1, wherein the UE includes at least one of an antenna, a touch sensitive display screen, a speaker, a microphone, a graphics processor, an application processor, a baseband processor, an internal memory, a non-volatile memory port, and combinations thereof.

17. An apparatus of a base station operable to receive mission critical communications from a user equipment (UE), the apparatus comprising one or more processors and memory configured to:

receive, from the UE, a physical random access channel (PRACH) signal that indicates a mission critical communication to be performed between the

eNodeB and the UE, wherein the PRACH signal is received using dedicated PRACH resources and in accordance with a first transmission time interval (TTI);

transmit, to the UE, a random access response (RAR) message that includes a timing advance (TA) and a resource allocation for the mission critical communication, wherein the RAR message is transmitted from the eNodeB using a second TTI, wherein the second TTI is associated with a time interval that is less than the first TTI;

receive, from the UE, the mission critical communication on a physical uplink shared channel (PUSCH) and in accordance with the second TTI, wherein the UE is configured to perform the mission critical communication in an uplink using the TA and the resource allocation indicated in the RAR message; and

transmit, to the UE, an acknowledgement (ACK) or a negative acknowledgement (NACK) for the mission critical communication in a physical downlink control channel (PDCCH) or a physical hybrid-ARQ indicator channel (PHICH) channel in accordance with the second TTI.

18. The apparatus of claim 17, wherein the first TTI is for a Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) Release 8 orthogonal frequency division multiple access (OFDMA) frame structure and is approximately one millisecond (ms) and is associated with a first partition of a low band, wherein the second TTI is approximately 0.1 to 0.2 ms and is associated with a second partition of a low band, wherein the first partition is utilized for non-mission critical communications and the second partition is utilized for mission critical communications.

19. The apparatus of claim 17, wherein the dedicated PRACH resources for mission critical communications are multiplexed with PRACH resources for non-mission critical application using at least one of: time division multiplexing (TDM), frequency division multiplexing (FDM) and code division multiplexing (CDM).

20. The apparatus of any of claims 17 to 19, wherein:

the PRACH signal is received from the UE with a scheduling request (SR),

wherein the SR includes at least one of: a mission critical machine type communication (MTC) device identifier (ID), an event ID, a mission critical MTC device capability, and a resource request and a modulation and coding scheme (MCS) for the mission critical communication in uplink from the UE; and

the RAR message transmitted to the UE includes at least one of: the timing advance (TA), an uplink grant that contains the resource allocation for the mission critical communication, a mission critical machine type communication (MTC) device identifier (ID), an event ID, and a random access preamble ID.

21. The apparatus of claim 17, wherein the RAR message is transmitted to the UE via a physical downlink control channel (PDCCH) or a physical downlink shared channel (PDSCH).

22. At least one machine readable storage medium having instructions embodied thereon for performing mission critical communications between a user equipment (UE) and an eNodeB, the instructions when executed perform the following:

transmitting, using at least one processor of the UE, a physical random access channel (PRACH) signal to the eNodeB that indicates a mission critical communication to be performed between the UE and the eNodeB, wherein the PRACH signal is transmitted in accordance with a first transmission time interval (TTI);

receiving, using the at least one processor of the UE, a random access response (RAR) message from the eNodeB that includes a timing advance (TA) and a resource allocation for the mission critical communication, wherein the RAR message is transmitted from the eNodeB using a second TTI, wherein the second TTI is associated with a time interval that is less than the first TTI;

performing, using the at least one processor of the UE, the mission critical communication with the eNodeB in an uplink using the TA and the resource allocation indicated in the RAR message, wherein the mission critical communication is performed using a physical uplink shared channel (PUSCH) and in accordance with the second TTI; and

receiving, using the at least one processor of the UE, an acknowledgement

(ACK) or a negative acknowledgement (NACK) from the eNodeB for the mission critical communication in a physical downlink control channel (PDCCH) or a physical hybrid-ARQ indicator channel (PHICH) channel in accordance with the second TTI.

23. The at least one machine readable storage medium of claim 22, wherein the UE is configured to initiate performance of the mission critical communication when in a radio resource control (RRC) idle mode.

24. The at least one machine readable storage medium of claim 22, wherein the first TTI is approximately one millisecond (ms) and is associated with a first partition of a low band, wherein the second TTI is approximately 0.1 to 0.2 ms and is associated with a second partition of a low band, wherein the first partition is utilized for non-mission critical communications and the second partition is utilized for mission critical communications.

25. The at least one machine readable storage medium of any of claims 22 to 24, further comprising instructions which when executed perform the following:

performing repeated transmissions of the PRACH signal to the eNodeB until the RAR message is received from the eNodeB; and

performing repeated mission critical communications with the eNodeB until an acknowledgement (ACK) or a negative acknowledgement (NACK) is received from the eNodeB.

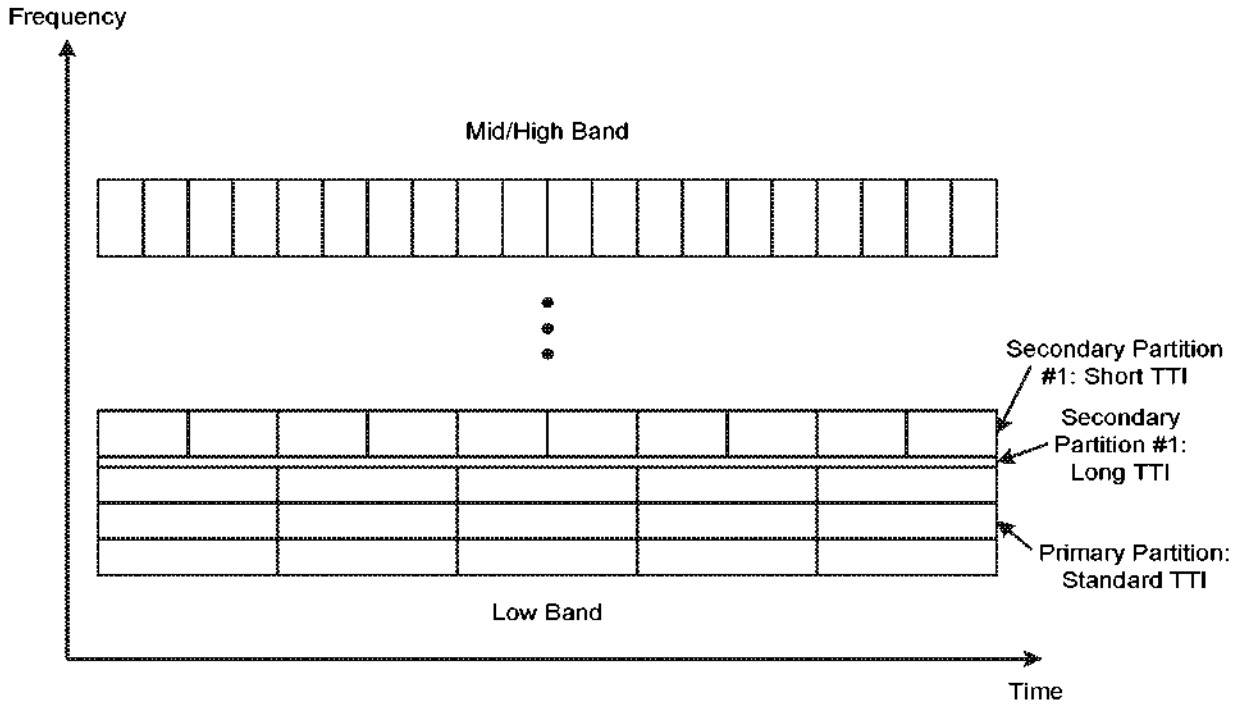

Frequency
Mid/High Band
Secondary Partition #1: Short TTI
Secondary Partition #1: Long TTI
Primary Partition: Standard TTI
Low Band
Time

FIG. 1

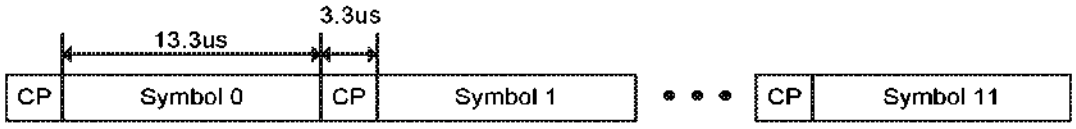

3.3us
13.3us
CP
Symbol 0
CP
Symbol 1
CP
Symbol 11

FIG. 2

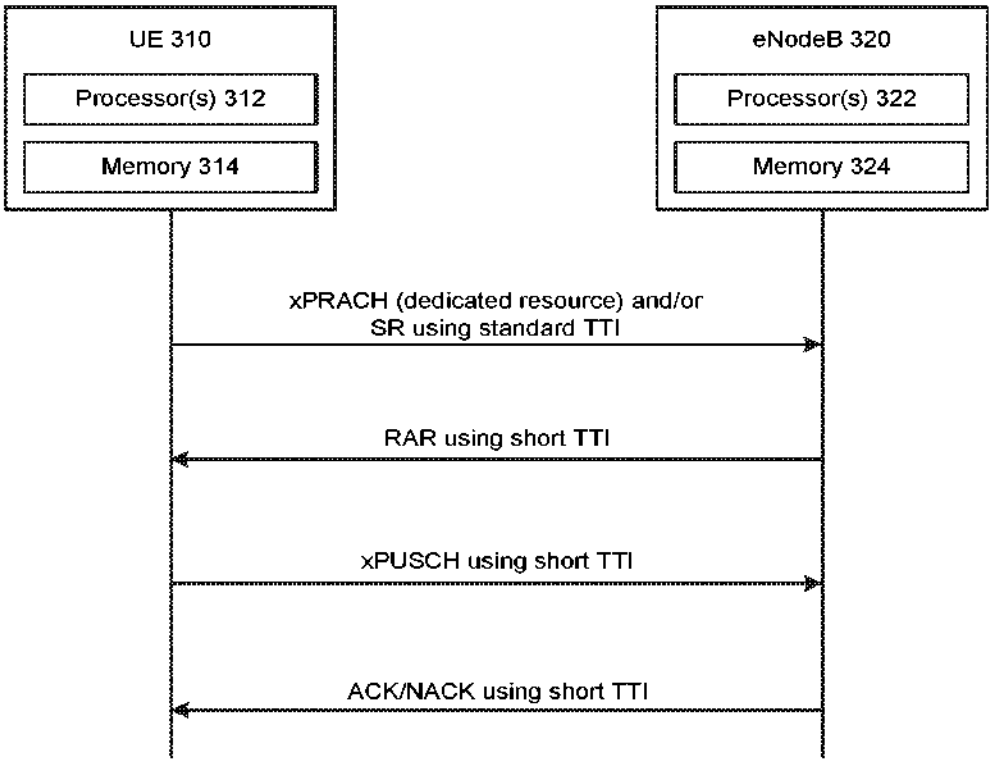

UE 310
Processor(s) 312
Memory 314
eNodeB 320
Processor(s) 322
Memory 324
xPRACH (dedicated resource) and/or
SR using standard TTI
RAR using short TTI
xPUSCH using short TTI
ACK/NACK using short TTI

FIG. 3

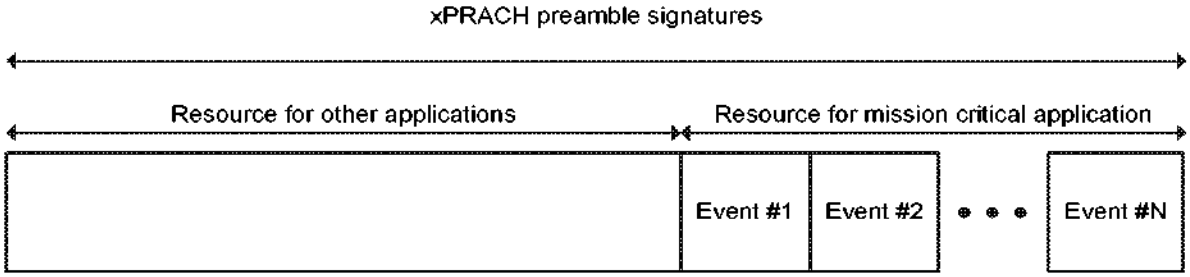

xPRACH preamble signatures
Resource for other applications
Resource for mission critical application
Event #1
Event #2
Event #N

FIG. 4

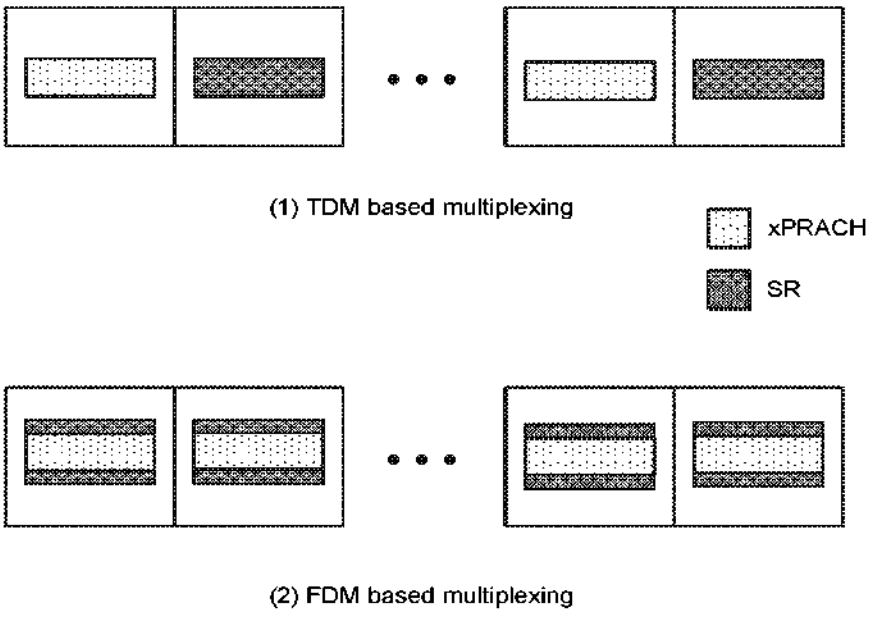

(1) TDM based multiplexing
xPRACH
SR
(2) FDM based multiplexing

FIG. 5

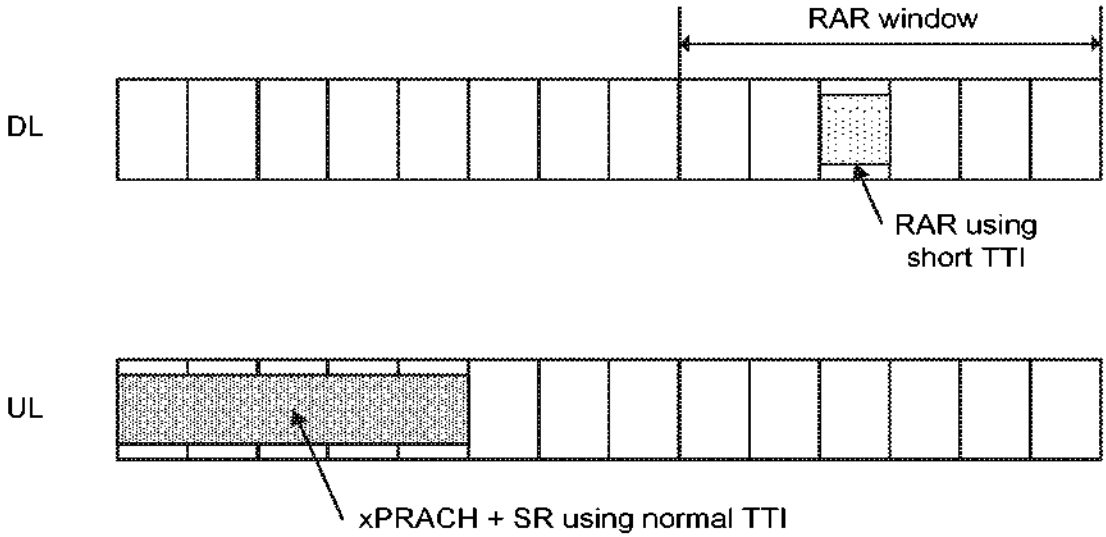

RAR window
DL
RAR using
short TTI
UL
xPRACH + SR using normal TTI

FIG. 6

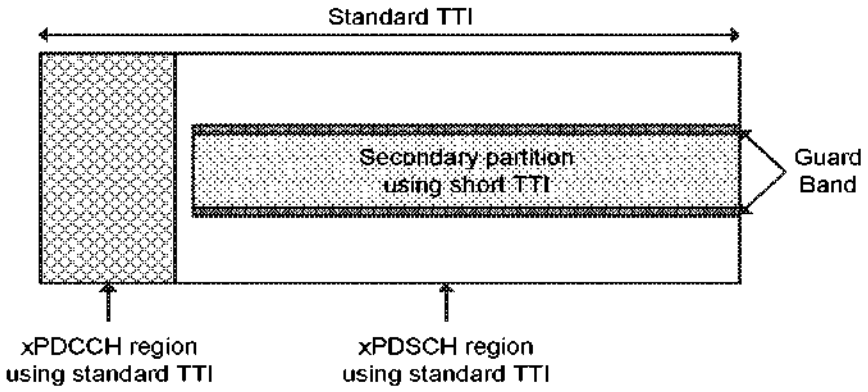


FIG. 7A

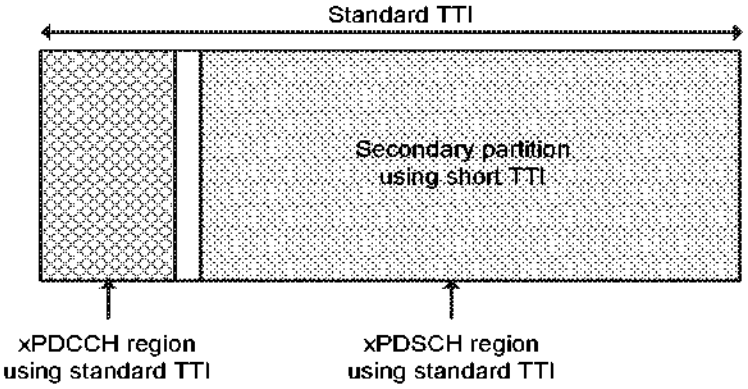


FIG. 7B

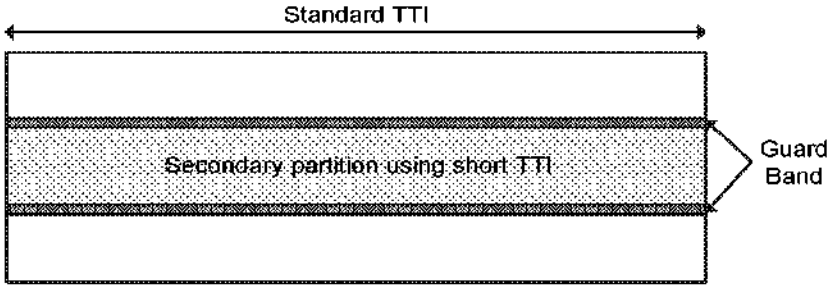


FIG. 7C

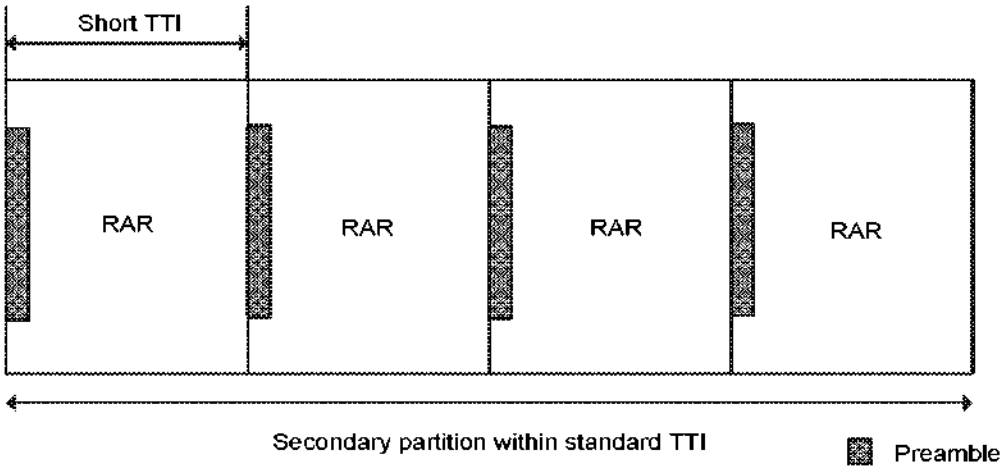

Short TTI
RAR
RAR
RAR
RAR
Secondary partition within standard TTI
Preamble

FIG. 8

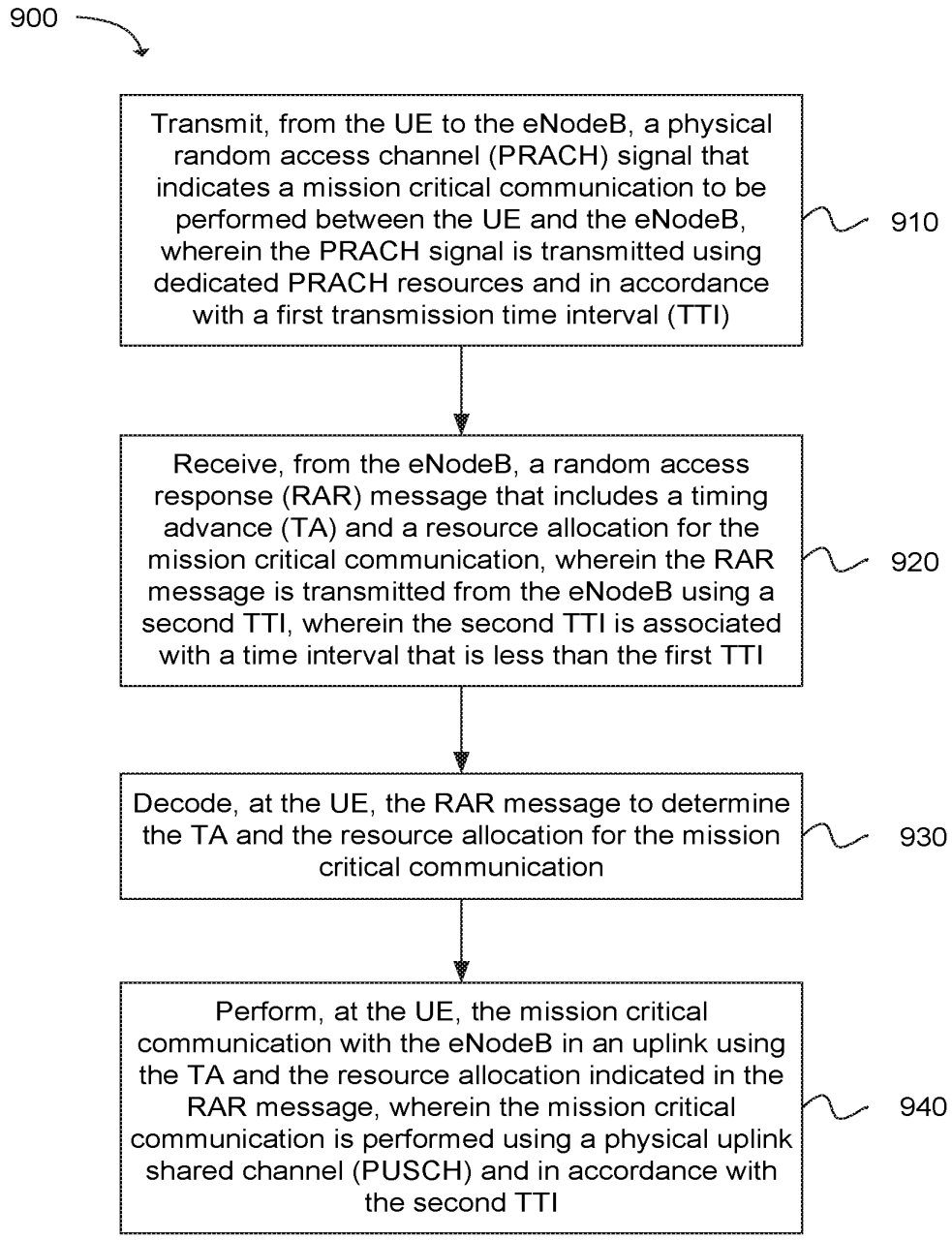

900
Transmit, from the UE to the eNodeB, a physical random access channel (PRACH) signal that indicates a mission critical communication to be performed between the UE and the eNodeB, wherein the PRACH signal is transmitted using dedicated PRACH resources and in accordance with a first transmission time interval (TTI)
910
Receive, from the eNodeB, a random access response (RAR) message that includes a timing advance (TA) and a resource allocation for the mission critical communication, wherein the RAR message is transmitted from the eNodeB using a second TTI, wherein the second TTI is associated with a time interval that is less than the first TTI
920
Decode, at the UE, the RAR message to determine the TA and the resource allocation for the mission critical communication
930
Perform, at the UE, the mission critical communication with the eNodeB in an uplink using the TA and the resource allocation indicated in the RAR message, wherein the mission critical communication is performed using a physical uplink shared channel (PUSCH) and in accordance with the second TTI
940

FIG. 9

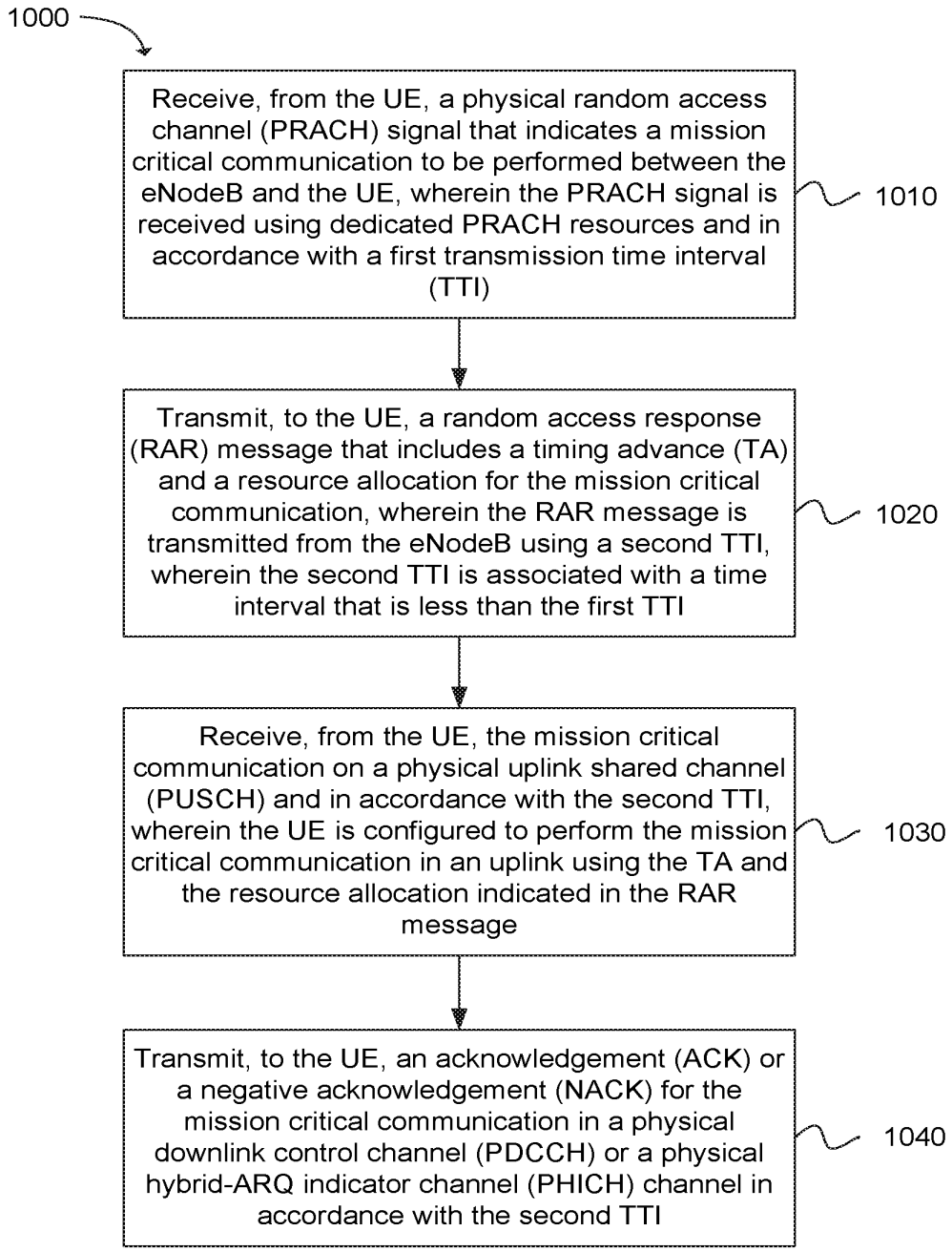

1000
Receive, from the UE, a physical random access channel (PRACH) signal that indicates a mission critical communication to be performed between the eNodeB and the UE, wherein the PRACH signal is received using dedicated PRACH resources and in accordance with a first transmission time interval (TTI)
1010
Transmit, to the UE, a random access response (RAR) message that includes a timing advance (TA) and a resource allocation for the mission critical communication, wherein the RAR message is transmitted from the eNodeB using a second TTI, wherein the second TTI is associated with a time interval that is less than the first TTI
1020
Receive, from the UE, the mission critical communication on a physical uplink shared channel (PUSCH) and in accordance with the second TTI, wherein the UE is configured to perform the mission critical communication in an uplink using the TA and the resource allocation indicated in the RAR message
1030
Transmit, to the UE, an acknowledgement (ACK) or a negative acknowledgement (NACK) for the mission critical communication in a physical downlink control channel (PDCCH) or a physical hybrid-ARQ indicator channel (PHICH) channel in accordance with the second TTI
1040

FIG. 10

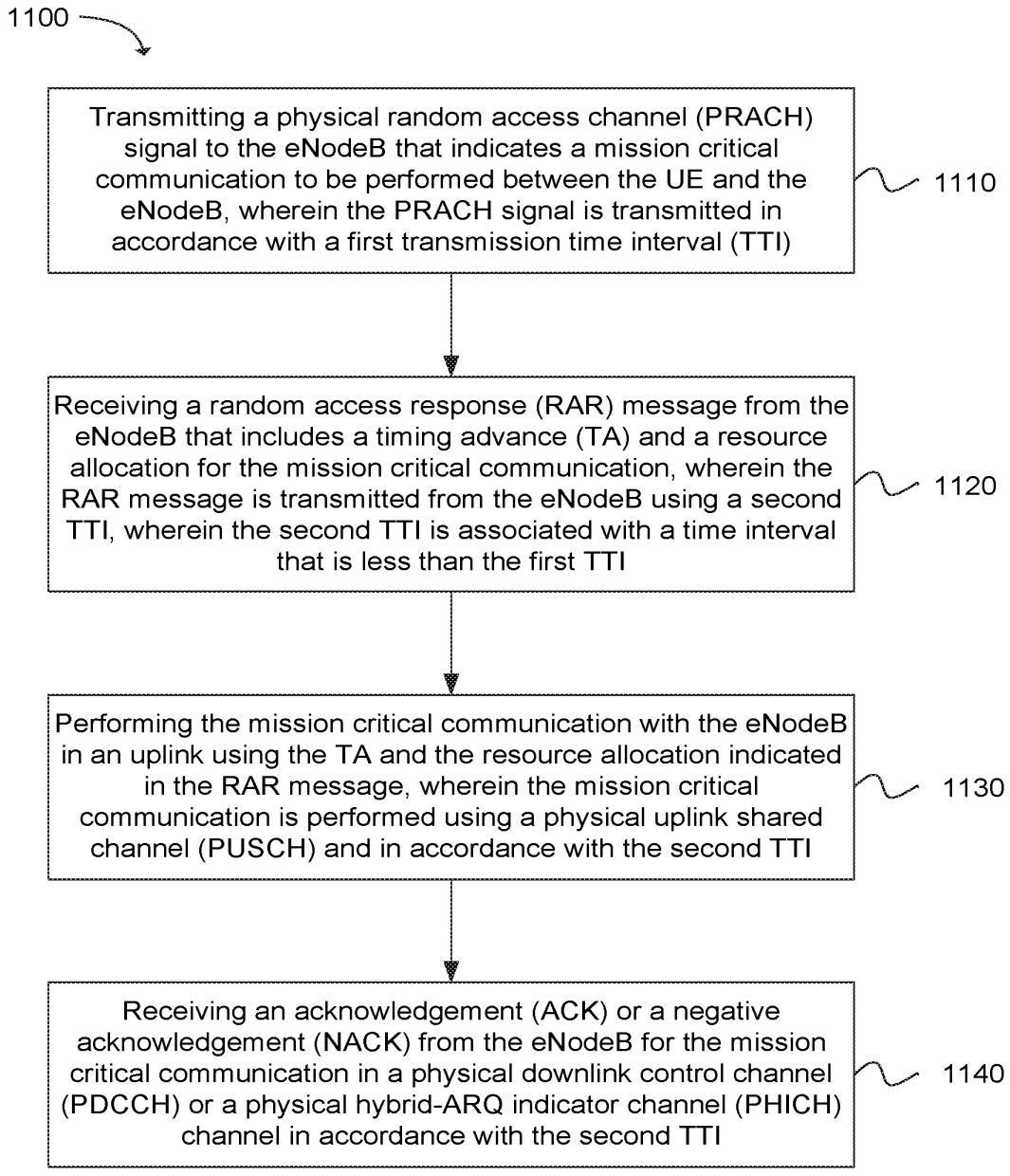

1100
Transmitting a physical random access channel (PRACH) signal to the eNodeB that indicates a mission critical communication to be performed between the UE and the eNodeB, wherein the PRACH signal is transmitted in accordance with a first transmission time interval (TTI)
1110
Receiving a random access response (RAR) message from the eNodeB that includes a timing advance (TA) and a resource allocation for the mission critical communication, wherein the RAR message is transmitted from the eNodeB using a second TTI, wherein the second TTI is associated with a time interval that is less than the first TTI
1120
Performing the mission critical communication with the eNodeB in an uplink using the TA and the resource allocation indicated in the RAR message, wherein the mission critical communication is performed using a physical uplink shared channel (PUSCH) and in accordance with the second TTI
1130
Receiving an acknowledgement (ACK) or a negative acknowledgement (NACK) from the eNodeB for the mission critical communication in a physical downlink control channel (PDCCH) or a physical hybrid-ARQ indicator channel (PHICH) channel in accordance with the second TTI
1140

FIG. 11

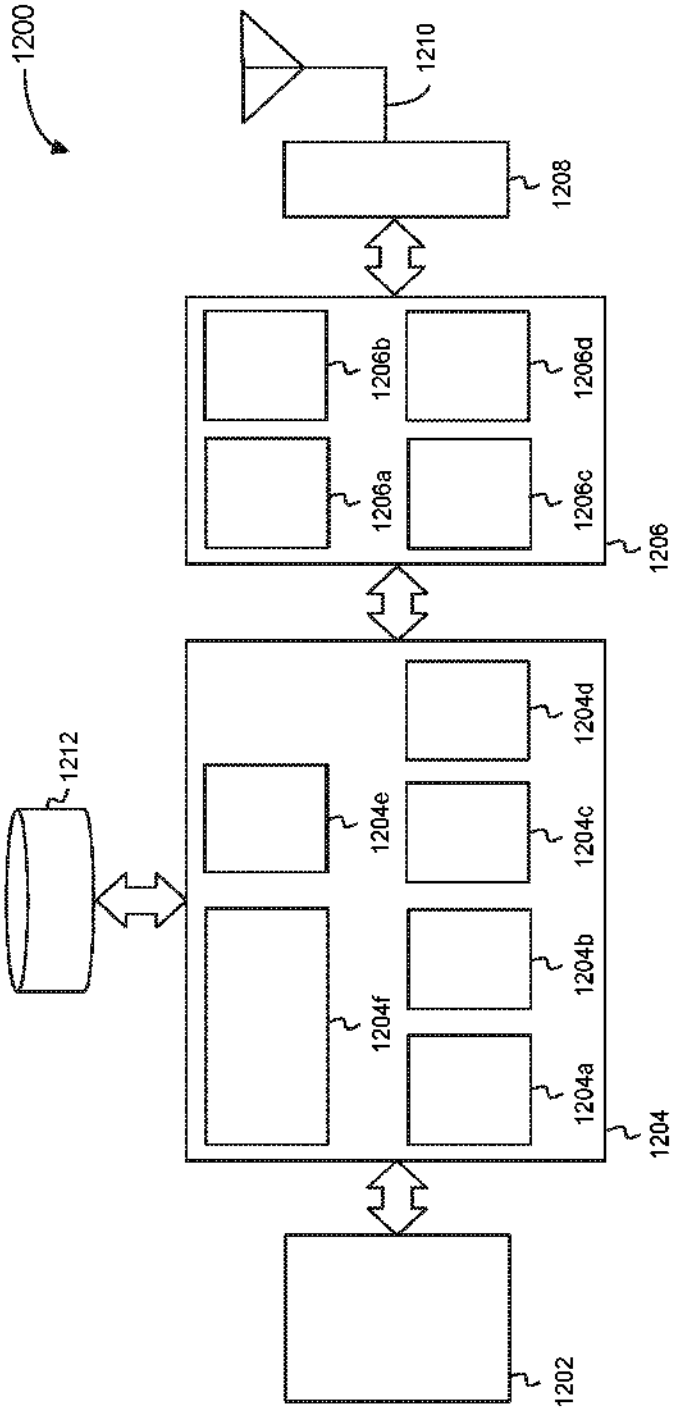

1200
1210
1208
1206b
1206d
1206a
1206c
1206
1212
1204d
1204e
1204c
1204f
1204b
1204a
1204
1202

FIG. 12

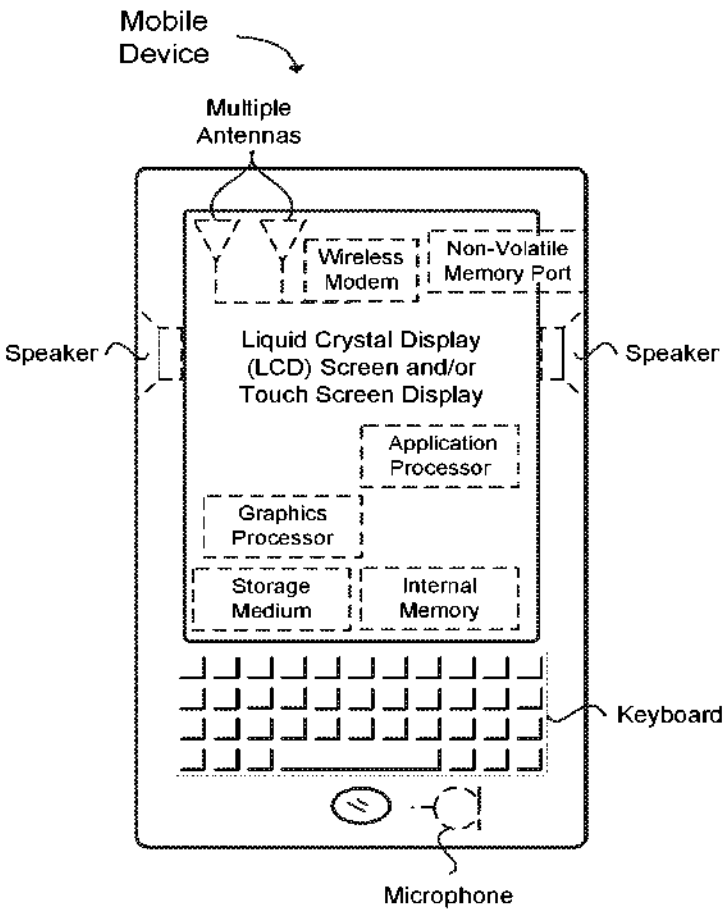

Mobile Device
Multiple Antennas
Wireless Modem
Non-Volatile Memory Port
Speaker
Liquid Crystal Display (LCD) Screen and/or Touch Screen Display
Speaker
Application Processor
Graphics Processor
Storage Medium
Internal Memory
Keyboard
Microphone

FIG. 13

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/066149

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W74/08 H04W72/04
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 2011/087274 A2 (SAMSUNG ELECTRONICS CO LTD [KR]; JEONG KYEONG-IN [KR]; KIM SOENG-HUN [) 21 July 2011 (2011-07-21) figures 2-4, 8-12 paragraphs [0005], [0006] paragraphs [0008], [0009], [0013], [0015] paragraphs [0018], [0019] paragraphs [0036] - [0042] paragraphs [0045] - [0057] paragraphs [0061] - [0072] paragraphs [0076], [0077], [0082] paragraphs [0114] - [0125] paragraphs [0126], [0127] paragraphs [0152], [0156], [0157] paragraphs [0168], [0170], [0177] paragraph [0191] ----- -/--	1-8, 10-19, 21-25 9,20

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 April 2016	04/05/2016

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Bouton, Eric

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Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	"3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2 (Release 12)", 3GPP STANDARD; 3GPP TS 36.300, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG2, no. V12.0.0, 10 January 2014 (2014-01-10), pages 1-208, XP050729408, [retrieved on 2014-01-10] Section 10.1.5; pages 73-77 -----	1-25
A	"3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Medium Access Control (MAC) protocol specification (Release 12)", 3GPP STANDARD; 3GPP TS 36.321, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG2, no. V12.0.0, 6 January 2014 (2014-01-06), pages 1-57, XP050729377, [retrieved on 2014-01-06] Section 5.1; pages 13-17 -----	1-25
A	"3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and modulation (Release 12)", 3GPP STANDARD; 3GPP TS 36.211, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG1, no. V12.0.0, 14 December 2013 (2013-12-14), pages 1-120, XP050729027, [retrieved on 2013-12-14] Section 5.7; pages 46-55 ----- -/--	1-25

1

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	MOTOROLA: "Synchronized Random Access Channel and Scheduling Request", 3GPP DRAFT; R1-062664 SYNCHRACH_SR, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG1, no. Seoul, Korea; 20061006, 6 October 2006 (2006-10-06), XP050103157, [retrieved on 2006-10-06] figure 3 Section 4 -----	9,20

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2011087274 A2	21-07-2011	EP 2524564 A2	21-11-2012
		KR 20110083547 A	20-07-2011
		US 2012320842 A1	20-12-2012
		WO 2011087274 A2	21-07-2011

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(54) Title: DEVICE AND METHODS FOR MULTIPLEXING TRANSMISSIONS WITH DIFFERENT TTI DURATION

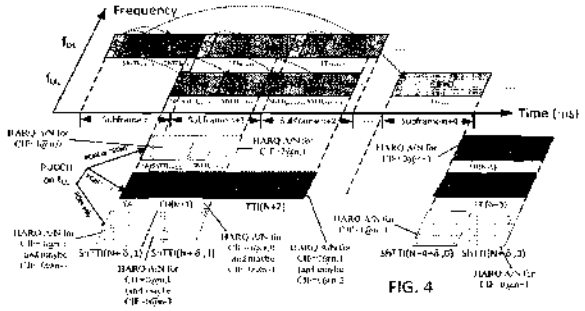


FIG. 4

(57) Abstract: A wireless transmit/receive unit, WTRU and methods of using a WTRU within a wireless communications network include communicating with a serving cell in the wireless communications network and determining, based on downlink control information whether the WTRU shall transmit with a first transmission time interval, TTI, length, using a first set of transmission resources, or a second TTI length, using a second set of transmission resources. Alternatively, determining based on said DCI, that the serving cell has indicated that the WTRU should use a first TTI on a physical uplink channel to communicate with the serving cell, or whether said DCI indicates that the WTRU should use a second TTI that is less than the first transmission time interval to communicate with the wireless communication network on the physical uplink channel or whether the WTRU should transmit using carrier aggregation.

WO 2017/079530 A1

DEVICE AND METHODS FOR MULTIPLEXING TRANSMISSIONS WITH DIFFERENT TTI DURATION

BACKGROUND

[0001] In a wireless communication network, such as a Long Term Evolution (LTE) system or New Radio (NR), a wireless transmit/receive unit (WTRU) device may access resources of the communication system. Latency associated with transmission of data in a communication system may have one or more latency components. A latency component may be the time to perform the transmission of a transport block, which time may be referred to as a Transmission Time Interval (TTI). Such TTI may be tied to a specific numerology associated with the transmission method and to a specific number of transmission symbols associated with the transmission. Other latency components may include processing time at a receiver, e.g., time decoding a transmission, transmission of feedback (e.g. ACK or NACK) and/or one or more retransmissions with one or more latency components.

SUMMARY

[0002] Systems, methods, and instrumentalities are disclosed for multiplexing transmissions with different durations, for example transmissions that are associated with different TTI lengths. Latency may be reduced (e.g., in an LTE system and/or in a NR system), for example, by multiplexing transmissions with different TTI durations or associated with different transmission numerologies. TTI duration may be modeled based on defining one or more cell(s) for a given carrier frequency, for example that may be associated with different TTI lengths and/or transmission durations. For example, the different transmission durations may be achieved by time-shifting one or more of the cells. In order to support signaling techniques that allow for concurrent and/or complementary scheduling of transmissions associated with different duration, a logical structure for the physical layer resources (e.g., a cell, a spectrum block, etc.) may configured to correspond to a secondary cell ("SCell"). A primary cell ("PCell") may logically maintain a first transmission duration (e.g., a first TTI length such as a legacy TTI length). The SCell may be configured with a second transmission duration (e.g., a second TTI length or a shortened TTI length). One or more of a PCell or an SCell may be configured with either the legacy or shortened TTI length (e.g., a shorter duration TTI (ShTTI).

[0003] By associating different TTI lengths with different cells, the LTE carrier aggregation framework can be utilized to support multiplexing of transmissions of different durations. For example, carrier aggregation signaling, including cross-carrier scheduling mechanisms, can be used to different scheduling grants and assignments of varying length. For example, a WTRU may determine a TTI duration (e.g., first or second TTI length) applicable to a transmission. For example, a WTRU may determine a TTI duration using cross-carrier scheduling. A WTRU may be configured to associate a given cell identity (e.g., servCellID) with a given transmission duration. Different cell identities (e.g., different servCellIDs) may be associated with different transmission durations/different TTI lengths. When a WTRU receives scheduling information applicable to a given cell identity, the WTRU may determine the associated TTI length based on the configuration received for that cell identity.

[0004] A WTRU may determine a TTI length and/or transmission duration based on one or more parameters and/or received fields. For example, a WTRU may associate a given TTI duration with a given transmission mode (TM). A TTI duration may be indicated by a Carrier Indicator Field (CIF), for example where certain values of the CIF are associated with SCells configured with a given TTI durations such as a ShTTI. The CIF may also be referred to as a Carrier Indicator Field (CIF). The TTI duration may be indicated by a field that indicates a set of resources such as a set of PRBs, a carrier, a serving cell of the WTRU's configuration, and/or a spectrum block. A TTI duration may be determined from an identity of a PRB subset associated with the transmissions and/or to a time-shifted cell within a subset of PRBs for a concerned carrier frequency. An applicable TTI duration and/or the identity of a slot/period applicable to a transmission within a subframe may be determined using a medium access control (MAC) Activation/Deactivation control element. MAC Activation/Deactivation CE may be used to toggle between first and second TTIs (e.g. legacy TTI and ShTTIs) or between slot-based ShTTIs and/or may be used to determine zero, one or more TTI (e.g. ShTTI) period(s) within a subframe.

[0005] HARQ processing may be performed according to a first behavior (e.g. legacy behavior) for one or more (e.g. each) time-shifted cell(s), although there may be exceptions. An exception may be timing-relationships, which may be scaled according to an applicable TTI duration. HARQ A/N feedback formats may use LTE Carrier Aggregation (CA) formats and/or (e.g. legacy) subframe-based timing relationships or a timing relationship associated with the HARQ process. Downlink Control Information (DCI) signaling may use a first (e.g. legacy) format, although, for example, interpretation of fields such as the CIF and/or fields that indicate the PRBs applicable for the transmission may be different than the interpretations of the first

(e.g. legacy) format. MAC activation/deactivation signaling may be applicable for time-shifted cells. DRX Timers associated with DRX may scale to HARQ A/N timing according to an applicable TTI duration and/or to the cell associated with an HARQ process. Physical random access channel (PRACH) resources and/or physical downlink control channel (PDCCH) order for RACH may or may not be supported for time-shifted SCells. Timing advance for uplink transmission may be time shifted, for example, according to a shift applied to the TTI associated with a cell. Time shift may be relative to PCell timing, e.g. a PCell may remain a DL timing reference for an SCell with the additional offset corresponding to the start of the ShTTI for those cells.

[0006] A method of using a wireless transmit/receive unit within a wireless communications network that is capable of aggregating different sets of physical layer resources (e.g., such as carrier aggregation, for example) may include communicating with a serving cell in the wireless communications network and determining that the serving cell has indicated that the WTRU should use a first transmission time interval on a physical uplink channel to communicate with the serving cell. The method may also include determining whether downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment) indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network (e.g., on the physical uplink channel). The method may further include communicating with the wireless communications network using the second transmission time interval.

[0007] The method may include determining that a downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment) indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network (e.g, on the physical uplink channel) comprises determining based on a carrier indicator field in received downlink control information.

[0008] The method may include communicating with the wireless communications network using the second transmission time interval comprises communicating with the serving cell using the second transmission time interval.

[0009] The method may include wherein communicating with the wireless communications network using the second transmission time interval includes communicating with a secondary cell using the second transmission time interval.

[0010] The method may include determining that a downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment) indicates that the WTRU should use a third

transmission time interval that is less than the first transmission time interval to communicate with a secondary cell in the wireless communications network. The shorten transmission time interval may correspond to at least one of at least one symbol or at least one resource block. The first transmission time interval may be one millisecond.

[0011] The method may include determining a time to transmit with the second transmission time interval based on the downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment). The time to transmit may defined by a time partition (e.g., a slot in a subframe and/or one or more time symbols, (e.g., OFDM symbols), an arrangement of symbols, a min-slot, or other time for a sub-carrier spacing).

[0012] The method may include determining whether a first downlink control information (e.g., using carrier aggregation fields such as the CIF) indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network (e.g., on the physical uplink channel) or whether the WTRU should transmit using carrier aggregation comprises determining with cross-carrier scheduling.

[0013] A wireless transmit/receive unit (WTRU) for use within a wireless communications network that is capable of carrier aggregation may have a processor having executable instructions that communicate with a serving cell in the wireless communications network and determine that the serving cell has indicated that the WTRU should use a first transmission time interval on an uplink channel (e.g., physical uplink channel) to communicate with the serving cell. The processor instructions may include determining whether a downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment) indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network (e.g., on the physical uplink channel). The WTRU processor instructions may include communicating with the wireless communications network using the second transmission time interval.

[0014] The WTRU processor instructions that determine that a first downlink control information (e.g, carrier aggregation field such as the CIF) indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network (e.g., on the physical uplink channel) may comprise determining based on a carrier indicator field in received downlink control information.

[0015] The WTRU processor executable instructions that communicate with the wireless communications network using the second transmission time interval may comprise communicating with the serving cell using the second transmission time interval.

[0016] The WTRU processor executable instructions that communicate with the wireless communications network using the second transmission time interval may comprise communicating with a secondary cell using the second transmission time interval.

[0017] The WTRU processor executable instructions may include determining that a downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment) indicates that the WTRU should use a third transmission time interval that is less than the first transmission time interval to communicate with a secondary cell in the wireless communications network. The shorten transmission time interval may correspond to at least one of at least one symbol or at least one resource block. The first transmission time interval may be one millisecond.

[0018] The WTRU processor executable instructions may include determining a time to transmit with the second transmission time interval based on the downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment). The time to transmit may be defined by a slot in a subframe.

[0019] The WTRU processor executable instructions that determine whether a downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment) indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network (e.g., on the physical uplink channel).

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] FIG. 1A is a system diagram of an example communications system in which disclosed subject matter may be implemented.

[0021] FIG. 1B is a system diagram of an example wireless transmit/receive unit (WTRU) that may be used in a communications system.

[0022] FIG. 1C is a system diagram of an example radio access network and an example core network that may be used in a communications system.

[0023] FIG. 1D is a system diagram of an example radio access network and an example core network that may be used in a communications system.

[0024] FIG. 1E is a system diagram of an example radio access network and an example core network that may be used in a communications system.

[0025] FIG. 2 shows an example of DL physical layer channels.

[0026] FIG. 3 shows an example of UL physical layer channels.

[0027] FIG. 4 is an example of scheduling with time-shifted cells.

DETAILED DESCRIPTION

[0028] A detailed description of illustrative embodiments will now be described with reference to the various figures. Although this description provides a detailed example of possible implementations, it should be noted that the details are intended to be exemplary and in no way limit the scope of the application.

[0029] FIG. 1A is a diagram of an example communications system 100 in which one or more disclosed embodiments may be implemented. The communications system 100 may be a multiple access system that provides content, for example voice, data, video, messaging, broadcast, etc., to multiple wireless users. The communications system 100 may enable multiple wireless users to access such content through the sharing of system resources, including wireless bandwidth. For example, the communications systems 100 may employ one or more channel access methods, for example code division multiple access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), orthogonal FDMA (OFDMA), single-carrier FDMA (SC-FDMA), and the like.

[0030] As shown in FIG. 1A, the communications system 100 may include wireless transmit/receive units (WTRUs) 102a, 102b, 102c, and/or 102d (which generally or collectively may be referred to as WTRU 102), a radio access network (RAN) 103/104/105, a core network 106/107/109, a public switched telephone network (PSTN) 108, the Internet 110, and other networks 112, though it will be appreciated that the disclosed embodiments contemplate any number of WTRUs, base stations, networks, and/or network elements. Each of the WTRUs 102a, 102b, 102c, 102d may be any type of device configured to operate and/or communicate in a wireless environment. By way of example, the WTRUs 102a, 102b, 102c, 102d may be configured to transmit and/or receive wireless signals and may include a user equipment (WTRU), a mobile station, a fixed or mobile subscriber unit, a pager, a cellular telephone, a personal digital assistant (PDA), a smartphone, a laptop, a netbook, a personal computer, a wireless sensor, consumer electronics, and the like.

[0031] The communications systems 100 may also include a base station 114a and a base station 114b. Each of the base stations 114a, 114b may be any type of device configured to wirelessly interface with at least one of the WTRUs 102a, 102b, 102c, 102d to facilitate access to

one or more communication networks, for example the core network 106/107/109, the Internet 110, and/or the networks 112. By way of example, the base stations 114a, 114b may be a base transceiver station (BTS), a Node-B, an eNode B, a Home Node B, a Home eNode B, a site controller, an access point (AP), a wireless router, and the like. While the base stations 114a, 114b are each depicted as a single element, it will be appreciated that the base stations 114a, 114b may include any number of interconnected base stations and/or network elements.

[0032] The base station 114a may be part of the RAN 103/104/105, which may also include other base stations and/or network elements (not shown), for example a base station controller (BSC), a radio network controller (RNC), relay nodes, etc. The base station 114a and/or the base station 114b may be configured to transmit and/or receive wireless signals within a particular geographic region, which may be referred to as a cell (not shown). The cell may further be divided into cell sectors. For example, the cell associated with the base station 114a may be divided into three sectors. Thus, in one embodiment, the base station 114a may include three transceivers, i.e., one for each sector of the cell. In an embodiment, the base station 114a may employ multiple-input multiple output (MIMO) technology and, therefore, may utilize multiple transceivers for each sector of the cell.

[0033] The base stations 114a, 114b may communicate with one or more of the WTRUs 102a, 102b, 102c, 102d over an air interface 115/116/117, which may be any suitable wireless communication link (e.g. radio frequency (RF), microwave, infrared (IR), ultraviolet (UV), visible light, etc.). The air interface 115/116/117 may be established using any suitable radio access technology (RAT).

[0034] More specifically, as noted above, the communications system 100 may be a multiple access system and may employ one or more channel access schemes, for example CDMA, TDMA, FDMA, OFDMA, SC-FDMA, and the like. For example, the base station 114a in the RAN 103/104/105 and the WTRUs 102a, 102b, 102c may implement a radio technology such as Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access (UTRA), which may establish the air interface 115/116/117 using wideband CDMA (WCDMA). WCDMA may include communication protocols such as High-Speed Packet Access (HSPA) and/or Evolved HSPA (HSPA+). HSPA may include High-Speed Downlink Packet Access (HSDPA) and/or High-Speed Uplink Packet Access (HSUPA).

[0035] In an embodiment, the base station 114a and the WTRUs 102a, 102b, 102c may implement a radio technology such as Evolved UMTS Terrestrial Radio Access (E-UTRA), which may establish the air interface 115/116/117 using Long Term Evolution (LTE) and/or LTE-Advanced (LTE-A).

[0036] In an embodiment, the base station 114a and the WTRUs 102a, 102b, 102c may implement radio technologies such as IEEE 802.16 (i.e., Worldwide Interoperability for Microwave Access (WiMAX)), CDMA2000, CDMA2000 1X, CDMA2000 EV-DO, Interim Standard 2000 (IS-2000), Interim Standard 95 (IS-95), Interim Standard 856 (IS-856), Global System for Mobile communications (GSM), Enhanced Data rates for GSM Evolution (EDGE), GSM EDGE (GERAN), New Radio (NR) and the like. The descriptions and example provided herein apply to any of the air interface and communications standards that have been implemented although the terminology may differ among them for the functional components.

[0037] The base station 114b in FIG. 1A may be a wireless router, Home Node B, Home eNode B, or access point, for example, and may utilize any suitable RAT for facilitating wireless connectivity in a localized area, for example a place of business, a home, a vehicle, a campus, and the like. In one embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.11 to establish a wireless local area network (WLAN). In an embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.15 to establish a wireless personal area network (WPAN). In yet an embodiment, the base station 114b and the WTRUs 102c, 102d may utilize a cellular-based RAT (e.g. WCDMA, CDMA2000, GSM, LTE, LTE-A, etc.) to establish a picocell or femtocell. As shown in FIG. 1A, the base station 114b may have a direct connection to the Internet 110. Thus, the base station 114b may not be required to access the Internet 110 via the core network 106/107/109.

[0038] The RAN 103/104/105 may be in communication with the core network 106/107/109, which may be any type of network configured to provide voice, data, applications, and/or voice over internet protocol (VoIP) services to one or more of the WTRUs 102a, 102b, 102c, 102d. For example, the core network 106/107/109 may provide call control, billing services, mobile location-based services, pre-paid calling, Internet connectivity, video distribution, etc., and/or perform high-level security functions, for example user authentication. Although not shown in FIG. 1A, it will be appreciated that the RAN 103/104/105 and/or the core network 106/107/109 may be in direct or indirect communication with other RANs that employ the same RAT as the RAN 103/104/105 or a different RAT. For example, in addition to being connected to the RAN 103/104/105, which may be utilizing an E-UTRA radio technology, the core network 106/107/109 may also be in communication with a RAN (not shown) employing a GSM radio technology.

[0039] The core network 106/107/109 may also serve as a gateway for the WTRUs 102a, 102b, 102c, 102d to access the PSTN 108, the Internet 110, and/or other networks 112. The

PSTN 108 may include circuit-switched telephone networks that provide plain old telephone service (POTS). The Internet 110 may include a global system of interconnected computer networks and devices that use common communication protocols, for example the transmission control protocol (TCP), user datagram protocol (UDP) and the internet protocol (IP) in the TCP/IP internet protocol suite. The networks 112 may include wired or wireless communications networks owned and/or operated by other service providers. For example, the networks 112 may include a core network connected to one or more RANs, which may employ the same RAT as the RAN 103/104/105 or a different RAT.

[0040] Some or all of the WTRUs 102a, 102b, 102c, 102d in the communications system 100 may include multi-mode capabilities, i.e., the WTRUs 102a, 102b, 102c, 102d may include multiple transceivers for communicating with different wireless networks over different wireless links. For example, the WTRU 102c shown in FIG. 1A may be configured to communicate with the base station 114a, which may employ a cellular-based radio technology, and with the base station 114b, which may employ an IEEE 802 radio technology.

[0041] FIG. 1B is a system diagram of an example WTRU 102. As shown in FIG. 1B, the WTRU 102 may include a processor 118, a transceiver 120, a transmit/receive element 122, a speaker/microphone 124, a keypad 126, a display/touchpad 128, non-removable memory 130, removable memory 132, a power source 134, a global positioning system (GPS) chipset 136, and other peripherals 138. It will be appreciated that the WTRU 102 may include any sub-combination of the foregoing elements while remaining consistent with an embodiment. Also, embodiments contemplate that the base stations 114a and 114b, and/or the nodes that base stations 114a and 114b may represent, for example but not limited to transceiver station (BTS), a Node-B, a site controller, an access point (AP), a home node-B, an evolved home node-B (eNodeB), a home evolved node-B (HeNB), a home evolved node-B gateway, and proxy nodes, among others, may include some or each of the elements depicted in FIG. 1B and described herein.

[0042] The processor 118 may be a general purpose processor, a special purpose processor, a conventional processor, a digital signal processor (DSP), a plurality of microprocessors, one or more microprocessors in association with a DSP core, a controller, a microcontroller, Application Specific Integrated Circuits (ASICs), Field Programmable Gate Array (FPGAs) circuits, any other type of integrated circuit (IC), a state machine, and the like. The processor 118 may perform signal coding, data processing, power control, input/output processing, and/or any other functionality that enables the WTRU 102 to operate in a wireless environment. The processor 118 may be coupled to the transceiver 120, which may be coupled to the

transmit/receive element 122. While FIG. 1B depicts the processor 118 and the transceiver 120 as separate components, it will be appreciated that the processor 118 and the transceiver 120 may be integrated together in an electronic package or chip.

[0043] The transmit/receive element 122 may be configured to transmit signals to, or receive signals from, a base station (e.g. the base station 114a) over the air interface 115/116/117. For example, in one embodiment, the transmit/receive element 122 may be an antenna configured to transmit and/or receive RF signals. In an embodiment, the transmit/receive element 122 may be an emitter/detector configured to transmit and/or receive IR, UV, or visible light signals, for example. In yet an embodiment, the transmit/receive element 122 may be configured to transmit and receive both RF and light signals. It will be appreciated that the transmit/receive element 122 may be configured to transmit and/or receive any combination of wireless signals.

[0044] In addition, although the transmit/receive element 122 is depicted in FIG. 1B as a single element, the WTRU 102 may include any number of transmit/receive elements 122. More specifically, the WTRU 102 may employ MIMO technology. Thus, in one embodiment, the WTRU 102 may include two or more transmit/receive elements 122 (e.g. multiple antennas) for transmitting and receiving wireless signals over the air interface 115/116/117.

[0045] The transceiver 120 may be configured to modulate the signals that are to be transmitted by the transmit/receive element 122 and to demodulate the signals that are received by the transmit/receive element 122. As noted above, the WTRU 102 may have multi-mode capabilities. Thus, the transceiver 120 may include multiple transceivers for enabling the WTRU 102 to communicate via multiple RATs, for example UTRA and IEEE 802.11, for example.

[0046] The processor 118 of the WTRU 102 may be coupled to, and may receive user input data from, the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128 (e.g. a liquid crystal display (LCD) display unit or organic light-emitting diode (OLED) display unit). The processor 118 may also output user data to the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128. In addition, the processor 118 may access information from, and store data in, any type of suitable memory, for example the non-removable memory 130 and/or the removable memory 132. The non-removable memory 130 may include random-access memory (RAM), read-only memory (ROM), a hard disk, or any other type of memory storage device. The removable memory 132 may include a subscriber identity module (SIM) card, a memory stick, a secure digital (SD) memory card, and the like. In an embodiment, the processor 118 may access information from, and store data in, memory that is not physically located on the WTRU 102, for example on a server or a home computer (not shown).

[0047] The processor 118 may receive power from the power source 134, and may be configured to distribute and/or control the power to the other components in the WTRU 102. The power source 134 may be any suitable device for powering the WTRU 102. For example, the power source 134 may include one or more dry cell batteries (e.g. nickel-cadmium (NiCd), nickel-zinc (NiZn), nickel metal hydride (NiMH), lithium-ion (Li-ion), etc.), solar cells, fuel cells, and the like.

[0048] The processor 118 may also be coupled to the GPS chipset 136, which may be configured to provide location information (e.g. longitude and latitude) regarding the current location of the WTRU 102. In addition to, or in lieu of, the information from the GPS chipset 136, the WTRU 102 may receive location information over the air interface 115/116/117 from a base station (e.g. base stations 114a, 114b) and/or determine its location based on the timing of the signals being received from two or more nearby base stations. It will be appreciated that the WTRU 102 may acquire location information by way of any suitable location-determination method while remaining consistent with an embodiment.

[0049] The processor 118 may further be coupled to other peripherals 138, which may include one or more software and/or hardware modules that provide additional features, functionality and/or wired or wireless connectivity. For example, the peripherals 138 may include an accelerometer, an e-compass, a satellite transceiver, a digital camera (for photographs or video), a universal serial bus (USB) port, a vibration device, a television transceiver, a hands free headset, a Bluetooth® module, a frequency modulated (FM) radio unit, a digital music player, a media player, a video game player module, an Internet browser, and the like.

[0050] FIG. 1C is a system diagram of the RAN 103 and the core network 106 according to an embodiment. As noted above, the RAN 103 may employ a UTRA radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 115. The RAN 103 may also be in communication with the core network 106. As shown in FIG. 1C, the RAN 103 may include Node-Bs 140a, 140b, 140c, which may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 115. The Node-Bs 140a, 140b, 140c may each be associated with a particular cell (not shown) within the RAN 103. The RAN 103 may also include RNCs 142a, 142b. It will be appreciated that the RAN 103 may include any number of Node-Bs and RNCs while remaining consistent with an embodiment.

[0051] As shown in FIG. 1C, the Node-Bs 140a, 140b may be in communication with the RNC 142a. Additionally, the Node-B 140c may be in communication with the RNC142b. The Node-Bs 140a, 140b, 140c may communicate with the respective RNCs 142a, 142b via an Iub interface. The RNCs 142a, 142b may be in communication with one another via an Iur interface.

Each of the RNCs 142a, 142b may be configured to control the respective Node-Bs 140a, 140b, 140c to which it is connected. In addition, each of the RNCs 142a, 142b may be configured to carry out or support other functionality, for example outer loop power control, load control, admission control, packet scheduling, handover control, macro diversity, security functions, data encryption, and the like.

[0052] The core network 106 shown in FIG. 1C may include a media gateway (MGW) 144, a mobile switching center (MSC) 146, a serving GPRS support node (SGSN) 148, and/or a gateway GPRS support node (GGSN) 150. While each of the foregoing elements are depicted as part of the core network 106, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

[0053] The RNC 142a in the RAN 103 may be connected to the MSC 146 in the core network 106 via an IuCS interface. The MSC 146 may be connected to the MGW 144. The MSC 146 and the MGW 144 may provide the WTRUs 102a, 102b, 102c with access to circuit-switched networks, for example the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, 102c and traditional land-line communications devices.

[0054] The RNC 142a in the RAN 103 may also be connected to the SGSN 148 in the core network 106 via an IuPS interface. The SGSN 148 may be connected to the GGSN 150. The SGSN 148 and the GGSN 150 may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, for example the Internet 110, to facilitate communications between and the WTRUs 102a, 102b, 102c and IP-enabled devices.

[0055] As noted above, the core network 106 may also be connected to the networks 112, which may include other wired or wireless networks that are owned and/or operated by other service providers.

[0056] FIG. 1D is a system diagram of the RAN 104 and the core network 107 according to an embodiment. As noted above, the RAN 104 may employ an E-UTRA radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 116. The RAN 104 may also be in communication with the core network 107.

[0057] The RAN 104 may include eNode-Bs 160a, 160b, 160c, though it will be appreciated that the RAN 104 may include any number of eNode-Bs while remaining consistent with an embodiment. The eNode-Bs 160a, 160b, 160c may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 116. In one embodiment, the eNode-Bs 160a, 160b, 160c may implement MIMO technology. Thus, the eNode-B 160a, for example, may use multiple antennas to transmit wireless signals to, and receive wireless signals from, the WTRU 102a.

[0058] Each of the eNode-Bs 160a, 160b, 160c may be associated with a particular cell (not shown) and may be configured to handle radio resource management decisions, handover decisions, scheduling of users in the uplink and/or downlink, and the like. As shown in FIG. 1D, the eNode-Bs 160a, 160b, 160c may communicate with one another over an X2 interface.

[0059] The core network 107 shown in FIG. 1D may include a mobility management gateway (MME) 162, a serving gateway 164, and a packet data network (PDN) gateway 166. While each of the foregoing elements are depicted as part of the core network 107, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

[0060] The MME 162 may be connected to each of the eNode-Bs 160a, 160b, 160c in the RAN 104 via an S1 interface and may serve as a control node. For example, the MME 162 may be responsible for authenticating users of the WTRUs 102a, 102b, 102c, bearer activation/deactivation, selecting a particular serving gateway during an initial attach of the WTRUs 102a, 102b, 102c, and the like. The MME 162 may also provide a control plane function for switching between the RAN 104 and other RANs (not shown) that employ other radio technologies, for example GSM or WCDMA.

[0061] The serving gateway 164 may be connected to each of the eNode-Bs 160a, 160b, 160c in the RAN 104 via the S1 interface. The serving gateway 164 may generally route and forward user data packets to/from the WTRUs 102a, 102b, 102c. The serving gateway 164 may also perform other functions, for example anchoring user planes during inter-eNode B handovers, triggering paging when downlink data is available for the WTRUs 102a, 102b, 102c, managing and storing contexts of the WTRUs 102a, 102b, 102c, and the like.

[0062] The serving gateway 164 may also be connected to the PDN gateway 166, which may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, for example the Internet 110, to facilitate communications between the WTRUs 102a, 102b, 102c and IP-enabled devices.

[0063] The core network 107 may facilitate communications with other networks. For example, the core network 107 may provide the WTRUs 102a, 102b, 102c with access to circuit-switched networks, for example the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, 102c and traditional land-line communications devices. For example, the core network 107 may include, or may communicate with, an IP gateway (e.g. an IP multimedia subsystem (IMS) server) that serves as an interface between the core network 107 and the PSTN 108. In addition, the core network 107 may provide the WTRUs 102a, 102b, 102c with access to

the networks 112, which may include other wired or wireless networks that are owned and/or operated by other service providers.

[0064] FIG. 1E is a system diagram of the RAN 105 and the core network 109 according to an embodiment. The RAN 105 may be an access service network (ASN) that employs IEEE 802.16 radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 117. As will be further discussed below, the communication links between the different functional entities of the WTRUs 102a, 102b, 102c, the RAN 105, and the core network 109 may be defined as reference points.

[0065] As shown in FIG. 1E, the RAN 105 may include base stations 180a, 180b, 180c, and an ASN gateway 182, though it will be appreciated that the RAN 105 may include any number of base stations and ASN gateways while remaining consistent with an embodiment. The base stations 180a, 180b, 180c may each be associated with a particular cell (not shown) in the RAN 105 and may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 117. In one embodiment, the base stations 180a, 180b, 180c may implement MIMO technology. Thus, the base station 180a, for example, may use multiple antennas to transmit wireless signals to, and receive wireless signals from, the WTRU 102a. The base stations 180a, 180b, 180c may also provide mobility management functions, for example handoff triggering, tunnel establishment, radio resource management, traffic classification, quality of service (QoS) policy enforcement, and the like. The ASN gateway 182 may serve as a traffic aggregation point and may be responsible for paging, caching of subscriber profiles, routing to the core network 109, and the like.

[0066] The air interface 117 between the WTRUs 102a, 102b, 102c and the RAN 105 may be defined as an R1 reference point that implements the IEEE 802.16 specification. In addition, each of the WTRUs 102a, 102b, 102c may establish a logical interface (not shown) with the core network 109. The logical interface between the WTRUs 102a, 102b, 102c and the core network 109 may be defined as an R2 reference point, which may be used for authentication, authorization, IP host configuration management, and/or mobility management.

[0067] The communication link between each of the base stations 180a, 180b, 180c may be defined as an R8 reference point that includes protocols for facilitating WTRU handovers and the transfer of data between base stations. The communication link between the base stations 180a, 180b, 180c and the ASN gateway 182 may be defined as an R6 reference point. The R6 reference point may include protocols for facilitating mobility management based on mobility events associated with each of the WTRUs 102a, 102b, 102c.

[0068] As shown in FIG. 1E, the RAN 105 may be connected to the core network 109. The communication link between the RAN 105 and the core network 109 may defined as an R3 reference point that includes protocols for facilitating data transfer and mobility management capabilities, for example. The core network 109 may include a mobile IP home agent (MIP-HA) 184, an authentication, authorization, accounting (AAA) server 186, and a gateway 188. While each of the foregoing elements are depicted as part of the core network 109, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

[0069] The MIP-HA may be responsible for IP address management, and may enable the WTRUs 102a, 102b, 102c to roam between different ASNs and/or different core networks. The MIP-HA 184 may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, for example the Internet 110, to facilitate communications between the WTRUs 102a, 102b, 102c and IP-enabled devices. The AAA server 186 may be responsible for user authentication and for supporting user services. The gateway 188 may facilitate interworking with other networks. For example, the gateway 188 may provide the WTRUs 102a, 102b, 102c with access to circuit-switched networks, for example the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, 102c and traditional land-line communications devices. In addition, the gateway 188 may provide the WTRUs 102a, 102b, 102c with access to the networks 112, which may include other wired or wireless networks that are owned and/or operated by other service providers.

[0070] Although not shown in FIG. 1E, it will be appreciated that the RAN 105 may be connected to other ASNs and the core network 109 may be connected to other core networks. The communication link between the RAN 105 the other ASNs may be defined as an R4 reference point, which may include protocols for coordinating the mobility of the WTRUs 102a, 102b, 102c between the RAN 105 and the other ASNs. The communication link between the core network 109 and the other core networks may be defined as an R5 reference, which may include protocols for facilitating interworking between home core networks and visited core networks.

[0071] Systems, methods, and instrumentalities are disclosed for multiplexing transmissions with different durations, for example such as transmission that utilize different TTI lengths. Latency reduction for some transmissions may achieved, for example, by multiplexing transmissions with different TTI durations. Although examples may be described with respect to multiplexing of an LTE legacy TTI (e.g., 1 ms) with a shortened TTI length (e.g., less than 1 ms), the techniques described herein may be generally applicable to the multiplexing of other

types of transmissions that are of different/varying lengths. For example, the examples may be described with respect to transmissions that contain one transport block (TB), but the examples may be equally applicable to transmissions that include a portion of a TB, transmissions that contain multiple TBs, etc. Thus, as may be appreciated, although specific examples herein may be described with respect to multiplexing transmissions associated with a "legacy" 1 ms TTI with transmissions that are less than 1 ms, these examples are not limited to the specific embodiments described and may be applied to transmissions of varying length that include varying amounts of data. Additionally, although examples may be described with respect to multiplexing shorter than 1 ms transmissions into a legacy LTE system that utilizes a legacy TTI length of 1 ms, the techniques may be applied to other types of transmission configurations, for example such as the NR system that may be utilized for 5G cellular communications.

[0072] Transmissions of different length may be realized in multiple ways and be consistent with this disclosure. For example, multiple TTI lengths may be defined, and the system may be configured to multiplex transmissions associated with the different TTI lengths over a common set of transmission resources. In example, rather than or in addition to defining different TTI lengths, transmissions of different durations may be supported, for example where one or more of the transmissions durations may or may not correspond to a TTI. Transmission duration may be defined in a number of ways, for example an amount of time over which the transmission occurs, (e.g., a specific duration or a time partition), a number of symbols over which the transmission occurs (e.g., 14 OFDM symbols, 12 OFDM symbols, 1 OFDM symbol, etc.), a slot, a minislot, a time partition for a sub-carrier spacing, and/or in terms of a specific numerology associated with the transmissions. For example, the numerology may be defined based on one or more of a sub-carrier spacing (e.g., different sub-carrier spacing may lead to different time durations for a symbol), a symbol length, a waveform type, etc.

[0073] Examples may also be described with respect to one or more cells. However, the techniques described herein may be equally applicable to other types of resource partitions. For example, in LTE cells may be defined based on certain OFDM time-frequency resources that are defined for a certain operating band for the cell. However, the multiplexing techniques described herein may be applied to physical resources that may or may not be defined using the cell construct. For example, the techniques described herein may apply of a subset of the physical resources in a cell and/or to physical resources that are not defined using the cell construct.

[0074] In order to TTI duration may be modeled using one or more time-shifted cell(s) for a given carrier frequency, e.g. in an LTE system such as a legacy LTE system. A "logical" cell structure may correspond to an SCell (e.g., a legacy SCell). A PCell may logically maintain

a TTI (e.g., a first TTI such as a legacy TTI that may be 1 ms) or may be (e.g. also) configured with a second duration TTI (e.g., a shorter duration TTI (ShTTI) that may be less than 1 ms).

[0075] In an example, a WTRU may determine a TTI duration (e.g. first or second TTI) applicable to a transmission. A determination may be, for example, a function of one or more facts, factors, and/or parameters. For example, a WTRU may determine a TTI duration using cross-carrier scheduling information. A WTRU may associate a certain TTI duration with a certain cell identity (e.g. servCellID). A WTRU may associate a certain TTI duration with certain a transmission mode (TM). A TTI duration may be indicated by a CIF included in DCI. For example, a first cell identity (e.g., servCellID = 1) may be associated with a first TTI duration and a second cell identity (e.g., servCellID = 2) may be associated with a second TTI duration. When the CIF field indicates that the received DCI is applicable to the first cell identity (e.g., CIF = '001' - servCellID = 1), the WTRU may determine that the scheduled transmission is associated with the first TTI duration. When the CIF field indicates that the received DCI is applicable to the second cell identity (e.g., CIF = '010' - servCellID = 2), the WTRU may determine that the scheduled transmission is associated with the second TTI duration. In this matter, carrier aggregation signaling methods may be reused/reinterpreted in order to support multiple TTI length.

[0076] A TTI duration may be determined from an identity of a PRB subset associated with the transmissions and/or to a time-shifted cell within a subset of PRBs for a concerned carrier frequency. An applicable TTI duration and/or the identity of a slot/period applicable to a transmission within a subframe may be determined using MAC Activation/Deactivation. MAC Activation/Deactivation may be used to toggle between first and second TTIs (e.g. between a legacy TTI and one or more ShTTIs). For example, a WTRU may utilize a first TTI length for a first cell prior to receiving MAC Activation/Deactivation control element. Upon receiving the MAC Activation/Deactivation control element for the first cell, the WTRU may toggle to a second TTI length. In an example, the MAC Activation/Deactivation control element may be used to toggle between different slots used for a ShTTI transmission in a legacy suframe. For example, the MAC Activation/Deactivation control element may be used to switch between the first and second slots for the shortened TTI transmission. MAC Activation/Deactivation may be used to determine zero, one or more ShTTIs period(s) within a subframe.

[0077] HARQ processing may remain according to a first behavior (e.g. legacy behavior) for one or more (e.g. each) time-shifted cell(s), although there may be exceptions. In an example, an exception may be timing-relationships, which may be scaled according to an applicable TTI duration. HARQ A/N feedback formats may use LTE Carrier Aggregation (CA)

formats and/or (e.g., legacy) subframe-based timing relationships or a timing relationship associated with the HARQ process. Downlink Control Information (DCI) signaling may use a first (e.g., legacy) format, although, for example, interpretation of fields such as the CIF and/or PRBs applicable for the transmission may be different than the first (e.g., legacy) format. MAC activation/deactivation signaling may be applicable for time-shifted cells. DRX Timers associated with DRX may scale to HARQ A/N timing according to an applicable TTI duration and/or to the cell associated with an HARQ process. PRACH resources and/or PDCCH order for RACH may or may not be supported for time-shifted SCells. Timing advance for uplink transmission may be time shifted, for example, according to a shift applied to the TTI associated with a cell. Time shift may be relative to PCell timing, e.g., a PCell may remain a DL timing reference for an SCell with the additional offset corresponding to the start of the ShTTI for those cells.

[0078] A device may access resources of a communication system. Latency associated with transmission of data may have one or more latency components. A latency component may be the time to perform the transmission of a transport block, which time may be referred to as a Transmission Time Interval (TTI). A latency component may be processing time at a receiver, e.g., time decoding a transmission. Receiver processing time may be tied to implementation complexity and may be accounted for using a fixed timing relationship between different events associated with the transmission of a data unit. A timing relationship may be fixed, for example, when time-division duplex (TDD) is used for a carrier and/or synchronous Hybrid ARQ (HARQ) operation (e.g., such as for LTE in the uplink).

[0079] There may be additional latency components, for example, when a transmission is not successfully decoded. For example, additional components may include transmission of feedback (e.g. HARQ ACK or NACK), processing time at the receiver and/or one or more retransmissions with one or more latency components.

[0080] Latency components may be measured in integer multiples of a basic time interval (BTI). For example, latency components may be measured in TTIs, e.g., in LTE.

[0081] Latency in wireless networks may be caused by multiple factors. Latency may be affected, e.g., at lower layers, by a need for highly reliable transmissions, which may be obtained using HARQ. One or more retransmissions may affect the latency of a transmission, for example, given that retransmissions may not be performed in adjacent time periods.

[0082] A WTRU may incur processing time, for example, for downlink (DL) transmission, to determine whether a transmission was decoded properly, which may lead to a time interval between reception of a DL transmission and transmission of an ACK or NACK. An eNB may

incur processing time, for example, to determine whether an ACK or NACK was transmitted by the WTRU and/or whether a retransmission is required. A similar consumption of processing time may occur for uplink (UL) transmissions. Processing times may be cumulative. There may be a tradeoff between latency and implementation complexity.

[0083] A system (e.g. LTE) may accommodate processing times in a timing relationship between a first transmission for a transport block and its corresponding ACK-NACK HARQ response for downlink and/or uplink operation and possible retransmission.

[0084] Time Division Duplex (TDD) and Frequency Division Duplex (FDD) DL scheduling timing may be the same, such that a WTRU may receive a scheduling grant for a DL transmission in the same subframe or transmission time interval (TTI).

[0085] A WTRU may transmit a corresponding Physical UL Shared Channel (PUSCH), e.g., in subframe n+4, for example, upon detection of a Physical DL Control Channel PDCCH or enhanced PDCCH (EPDCCH) with UL Downlink Control Information (DCI) format and/or Physical Hybrid ARQ Indicator Channel (PHICH) transmission in subframe n, e.g., in an FDD UL transmission intended for the WTRU. A HARQ ACK/NACK response for a DL or UL transmission in subframe n may be provided in subframe n+4.

[0086] A WTRU may transmit a corresponding PUSCH in subframe n+k, for example, upon detection of a (E)PDCCH with UL DCI format and/or PHICH transmission in subframe n, e.g., for a UL transmission in a TDD system intended for the WTRU. The value of k may depend on the TDD UL/DL configuration, the subframe where the UL DCI and/or PHICH was transmitted and/or the PHICH resource and the MSB or LSB of the UL index in the (E)PDCCH, e.g., in TDD UL/DL configuration 0. A HARQ ACK/NACK response for a DL or UL transmission in subframe n may be provided in subframe n+k, where k may depend on the value of n and the TDD UL/DL configuration. Bundling may be used to provide HARQ for multiple transmissions in one instance.

[0087] Processing time available to a WTRU may depend, for example, on the value of the timing advance or on the distance between the WTRU and the eNB. In an example, an LTE system may have a distance of 100km between a WTRU and an eNB, which may correspond to a (e.g. a maximum) timing advance of 0.67ms. In an example, there may be approximately 2.3 ms left for terminal processing. An eNB may have, for example, 3 ms processing time available, which may be on the same order as that of the terminal.

[0088] FIG. 2 shows an example of DL physical layer channels. In a DL example with reference to the example shown in FIG. 2, there may be three channel areas in a subframe to support DL Shared Channel (DL-SCH) and UL-SCH. Three channel areas may comprise a PDCCH (which may include Physical Control Format Indicator Channel (PCFICH) and PHICH),

a Physical DL Shared Channel (PDSCH) and an EPDCCH. An EPDCCH may include scheduling information for a WTRU while taking advantage of the benefits of the PDSCH region, such as beamforming gain and frequency domain Inter-Cell Interference Coordination (ICIC) and/or improving PDCCH capacity.

[0089] FIG. 3 shows an example of UL physical layer channels. In a UL example with reference to the example shown in FIG. 3, there may be two channel areas in a subframe to support DL-SCH and UL-SCH. Two channel areas may comprise a PUSCH and a PDSCH. These channel areas may be transmitted in different RBs in each time slot (e.g. frequency hopping of PUSCH), for example, to increase robustness in frequency selective channels.

[0090] A transmission time interval (TTI) duration may be based on and/or defined by one or more symbols. A TTI duration may be defined in terms of a number of OFDM symbols. For example, a TTI duration may be defined as an entire (legacy) subframe and/or a pair of physical resource blocks (PRBs). In the legacy 1 ms TTI length, there may be 14 OFDM symbols for normal cyclic prefix and 12 OFDM symbols for extended cyclic prefix. For example when multiplexing ShTTI transmissions with legacy TTI transmissions of 1 ms, a ShTTI may be made as short as a single ODFM symbol. Symbol-based categorization may be referred to as symbol-based TTI durations.

[0091] A TTI duration may be based on time-varying symbol duration. TTI durations may have a fixed number of symbols (e.g., 14 symbols) while symbol duration may vary in time. For example, variable time symbol-based TTI duration may be achieved by modifying subcarrier spacing. In an example, a first TTI duration may be achieved with a first subcarrier spacing and a second TTI duration may be achieved with a second subcarrier spacing. Different bandwidth portions (e.g. PRBs) of a carrier may support different subcarrier spacing, thus enabling different TTI duration for different bandwidth portions (e.g. PRBs). Multiplexing transmissions associated with different sub-carrier spacing and/or symbol duration may be applicable to 5G systems such as NR. Such techniques may also be used in LTE-Advanced.

[0092] A TTI duration may be based on a time slot. A TTI duration may be defined in terms of a time slot (e.g. 7 OFDM symbols for normal cyclic prefix and 6 OFDM symbols for extended cyclic prefix). For example, if a ShTTI is defined as the length of one slot, two ShTTI transmissions may be time multiplexed into a legacy 1 ms TTI length.

[0093] A TTI duration may be based on time. A TTI duration may be defined in terms of a time value (e.g. 1ms legacy TTI or a 100ms ShTTI).

[0094] A TTI duration may be based on a hybrid, such as a combination of forgoing TTI duration bases. In an example of a hybrid method of achieving variable TTI durations, a different number of symbols and different symbol durations may be used.

[0095] Latency may be improved. It may be beneficial to decrease the TTI duration of different channels. A decrease in TTI duration may enable a decrease in WTRU processing time and may permit a WTRU to begin processing data sooner. Such a scenario may enable a shorter HARQ timeline. Different channels may have different TTI durations. A TTI duration shorter than one subframe for one or more of the EPDCCH, PDSCH, PUCCH, PDSCH, etc. may be provided. Effective HARQ feedback for PDSCH and PUSCH transmissions using shorter than (e.g., legacy 1ms) subframe TTI durations may be provided. Shorter TTIs may be referred to as ShTTI.

[0096] ShTTI and/or a combination of TTI and ShTTI may be supported for a given WTRU, for example, to minimize the impact of other aspects related to WTRU transmissions, such as scheduling (e.g., formats of DCIs), HARQ (e.g., related processing/process identities), feedback formats and determination of an applicable TTI duration. For example, the configuration of ShTTIs and/or the signaling of DCI for ShTTIs may utilize certain signaling originally defined for purposes of carrier aggregation in order to limit the amount of complexity at the WTRU and/or facilitated TTI length multiplexing in a backwards compatible manner. One or more latency components may be reduced, for example, to minimize the impact on WTRU implementations.

[0097] A WTRU may (e.g., based on a determination) operate with a one or more TTI durations, such as subframe TTI duration (e.g., 1 ms), a timeslot TTI duration (e.g., 0.5 ms), a symbol-based TTI duration (e.g., one or more OFDM symbols in duration), and/or other shorter than 1 ms TTI durations. In an example, a WTRU may be configured to operate with specific but different TTI duration configuration in downlink and uplink. In an example, a WTRU may be configured to permit the same TTI duration configuration to be used in downlink and uplink for applicable transmissions. For example, if the WTRU receives a configuration that indicates a first cell is associated with a first TTI duration in the downlink, the WTRU may determine that the uplink TTI duration is also the first TTI duration unless the configuration indicates otherwise.

[0098] A TTI duration may be WTRU specific. A WTRU may operate with a TTI duration during a given period. A WTRU may be configured to operate according to one or more of a plurality of possible TTI durations and may operate with the one or more TTI durations for a specific period of time, e.g., based on an L3 (e.g., radio resource control (RRC)) reconfiguration. A TTI duration may be fixed (e.g. statically, semi-statically or dynamically) for a (e.g. every) transmission to and from a WTRU.

[0099] Multiple TTI durations may be concurrently configured and/or used. A WTRU may be configured to operate for transmissions of different TTI durations concurrently. Different TTI durations may be based on, for example, semi-static allocation (e.g. configuration of a subset of frames/subframes dedicated to different TTI durations based on a semi-persistent grant or assignment) and/or dynamic allocation (e.g. based on detection and/or reception of downlink control signaling).

[0100] A TTI duration may be cell/cell group (CG)-specific. Configuration may be applicable per cell of a WTRU's configuration, for a subset of cells of a WTRU's configuration, and/or for all cells of the same timing advance group (TAG) and/or all cells of the same cell group (CG). For example, upon adding a new cell, the TTI duration may be defined for the new cell. As an example, if the WTRU adds an SCell, the SCell configuration may indicated that the WTRU is to utilize a shortened TTI duration for the SCell. The HARQ instances associated with a specific MAC entity may be configured with a similar configuration for TTI duration. A similar or same configuration for TTI duration may be used, for example, for cells associated with the same channel(s) (e.g. PUCCH, PUSCH) for uplink control signaling.

[0101] TTI duration may be modeled using one or more time-shifted cell(s) for a given carrier frequency. Modeling may enable co-existence between WTRUs operating according to different TTI durations, e.g. in legacy LTE systems. A "logical" cell structure may correspond to the use of one or more serving cell(s). Serving cells may include secondary cells, such as an SCell type or a PSCell type defined for LTE CA. A PCell may logically maintain a first (e.g., legacy) TTI such as 1 ms or may be (e.g., also) configured as a ShTTI.

[0102] Multiple serving cells may be associated with a specific TTI duration. A WTRU may support multiple TTI durations based on one or more functions and/or characteristic associated to a serving cell.

[0103] A WTRU may determine the duration of a downlink control region, e.g., according to a first (e.g., legacy) behavior for LTE. A reception of PDCCH may be a first (e.g., legacy) behavior for downlink subframes. In an example, the first ShTTI in a subframe may include a control region, e.g., in case of slot-based operation, such as two slots of 7 symbols where the first slot include 1-3 symbols for PDCCH. In an example, the ShTTI duration may exclude the control region, e.g., in case of symbol-based ShTTIs. In an example, an offset in time or in symbol from the start of a subframe may be used to indicate the start of an ShTTI (e.g., in the DCI).

[0104] In an example, a WTRU may operate on a given carrier frequency (e.g., for downlink and/or uplink) according to at least one of the following: TTI duration per Transmission

Mode (TM), TTI duration per Serving Cell Identity (servCellID), and/or TTI duration per Serving Cell.

[0105] In an example of TTI duration per Transmission Mode (TM), a WTRU may be configured with multiple transmission modes (TM), e.g., one for each applicable TTI duration.

[0106] In an example of TTI duration per Serving Cell Identity (servCellID), a WTRU may be configured with multiple serving cell identities (e.g., servCellIDs), e.g., one for each applicable TTI duration.

[0107] In an example of TTI duration per Serving Cell, a WTRU may be configured with multiple serving cells for a given carrier frequency, e.g. one for each applicable TTI duration.

[0108] Combinations may be made using different types of serving cells. For example, a WTRU may be configured according to any of the following examples or other examples.

[0109] In a first case or example, a WTRU may be configured with one PCell and one SCell (or PSCell). A WTRU may perform a transmission associated with a PCell using a first ShTTI and a transmission associated with the SCell/PSCell using a second ShTTI. A WTRU may transmit Uplink Control Information (UCI) for a transmission associated with a specific cell using the uplink resources associated with the concerned cell (e.g., according to a first (e.g. legacy) behavior or processing time associated with the ShTTI), for example, when an SCell is configured with PUCCH resources or when the WTRU is configured with PSCell. A WTRU may perform the transmission of UCI using resources of the PCell (e.g., according to a first (e.g., legacy) behavior), for example, otherwise. In either case or other cases, a WTRU may transmit UCI using the TTI applicable to the uplink configuration of the concerned cell or according to the ShTTI applicable the received transmission.

[0110] In a second case or example, a WTRU may be configured with one PCell and two SCells. A WTRU may perform a transmissions associated with a PCell using a first TTI (e.g., a legacy 1ms TTI) and a transmission associated with an SCell using a second TTI (e.g., an ShTTI). A WTRU may transmit UCI for a transmission associated with a specific cell using the uplink resources associated with the concerned cell (e.g., according to a first (e.g., legacy) behavior or processing time associated with the ShTTI), for example, when an SCell is configured with PUCCH resources. A WTRU may perform the transmission of UCI using resources of the PCell (e.g., according to a first (e.g., legacy) behavior), for example, otherwise. In either case or other cases, a WTRU may transmit UCI using the TTI applicable to the uplink configuration of the concerned cell or according to the ShTTI applicable to the received transmission.

[0111] In a third case or example, a WTRU may be configured with one PCell and multiple SCells. A configuration may be a generalization of either of the first and second examples,

whereby more than two TTI durations may be supported (e.g., within a first (e.g., legacy) subframe).

[0112] In an example involving a PSCell, a different Cell Radio Network Temporary Identifier (C-RNTI) than that applicable for a PCell may indicate the duration of the TTI. Examples presented and other examples may be used separately or in combination. Other realizations and/or combinations are possible.

[0113] Examples for handling of downlink control region for case 1 with slot-based operation are described.

[0114] A WTRU may be configured with a (e.g., DL) control region of zero symbols for a serving cell used for the purpose of ShTTI, e.g., for the serving cell that corresponds to a second slot in case of slot-based operation. A WTRU may determine that a serving cell is configured for the purpose of ShTTI, for example, based on reception of signaling that indicates such value for the duration of the control region. A WTRU may determine that a serving cell is configured as an ShTTI for the second slot, for example, based on reception of signaling that indicates such value for the duration of the control region. A WTRU may determine that a PCell configuration is used for ShTTI for the first slot.

[0115] Different procedures or algorithms may be used to determine applicable TTI duration, e.g., independent of modeling. For example, a WTRU may determine the TTI duration (e.g. legacy duration such as 1ms or shorter (e.g., ShTTI)) applicable to a transmission as a function of one or more of the following: (a) a WTRU may determine TTI duration using cross-carrier scheduling; (b) a WTRU may associate a TTI duration with a serving cell identity; (c) a TTI duration may be indicated by a Carrier Indicator Field (CIF); (d) a TTI duration may be indicated by C-RNTI applicable to control signaling associated with the allocation of resources; (e) a TTI duration may be determined from the identity of a PRB subset applicable to the transmissions and/or to the time-shifted cell within the entire subset of PRBs for the carrier frequency; (f) a MAC Activation/Deactivation may be used to determine the applicable TTI duration and/or the identity of the slot/period applicable to a transmission within a subframe. A MAC Activation/Deactivation may be used, for example, to toggle between multiple TTIs (e.g. a legacy TTI and one or more ShTTIs), toggle between slot-based ShTTIs and/or to determine zero, one or more ShTTIs period(s) within a subframe.

[0116] HARQ processing may be used (e.g., according to a first (e.g., legacy) behavior) for time-shifted cell(s), although, in an example, timing-relationships may be scaled according to an applicable TTI duration. HARQ A/N feedback formats may reuse LTE CA formats, first (e.g., legacy) subframe-based timing relationships and/or timing relationship associated with the HARQ

process. DCI signaling may reuse a first (e.g., legacy) format, although, in an example, interpretation of fields such as the CIF and/or PRBs applicable for the transmission may be different. MAC activation/deactivation signaling may be applicable for time-shifted cells. DRX Timers associated with DRX may scale to HARQ A/N timing according to an applicable TTI duration and/or to the cell associated with the HARQ process. Physical Random Access Channel (PRACH) resources and/or PDCCH order for RACH may or may not be supported for time-shifted SCells. Timing advance for uplink transmission may be time shifted according to the shift applied to the TTI associated with a cell, for example, when such time shift is relative to the PCell timing (e.g., the PCell remains the DL timing reference for such SCell with the additional offset corresponding to the start of the ShTTI for those cells).

[0117] Any procedure or algorithm that may operate with or indicate a TTI duration may be applicable as a procedure or algorithm to operate with or to indicate a subcarrier spacing.

[0118] Support may be provided for transmissions with different TTI duration. A WTRU may be configured for operation with the LTE physical layer. A WTRU may be configured, for example, for operation according to a first (e.g., legacy) LTE behavior or for operation together with a 5gFLEX configuration, e.g., a configuration that supports a physical layer operating with other variants of potentially filtered OFDM transmissions, such as Universal Filtered OFDM (UF-OFDM), Filtered Based OFDM (FB-OFDM), etc.

[0119] In an example of LTE FDD, a radio frame may consist of 10 subframes of 1ms each with a TTI of 1ms. Each TTI may consist of two 0.5ms slots of 7 symbols for a configuration with a normal cyclic prefix. In the downlink, there may be 8 asynchronous HARQ processes numbered 0-7 that may be addressed by means of downlink DCI. In the uplink, there may be 8 synchronous HARQ processes per RTT, which identity may be tied to the subframe timing. A WTRU may be configured for 1 to 3 symbols at the beginning of the first slot used for control signaling (PDCCH). Control signaling may span the entire bandwidth for a given cell. A TTI duration may be fixed, e.g., at 1ms, as an aspect of the LTE physical layer.

[0120] Different cells of a WTRU's configuration may be (e.g. explicitly) associated with a TTI duration/offset shift. Support for different TTI durations may be realized, for example, by maintaining a unique association between a cell and a TTI duration in a WTRU's configuration. Timing associated with the cell (e.g. a cell of the LTE CA SCell type) may be shifted and/or offset in time with respect to the timing of a reference cell. A reference cell may be the PCell of the WTRU's configuration. The PCell may be considered to have a zero time shift, e.g., by default. In an example of dual connectivity, a PSCell may be considered to have a zero time shift (e.g., by

default), for example, when a secondary group of cells is configured and when the PSCell is used as the timing reference.

[0121] In an example, a time-shifted/TTI duration/offset shift may be associated with an identity. For example, a time-shifted cell may be configured with a serving cell identity, with an offset in time relative to the start of a cell-specific subframe (e.g. where timing may be based on the PCell used as a downlink timing reference) and with a TTI duration (e.g. shorter than a first (e.g. legacy) timing that may be referred to as a shorter TTI or ShTTI).

[0122] TTI duration may be a configuration aspect of a WTRU, such as part of a configured transmission mode associated with the physical layer configuration for the cell.

[0123] Cells using a timing relationship may be configured as part of the same timing advance group (TAG). Cells (e.g., SCells) in a secondary TAG (STAG) supporting ShTTIs may use one of the cells in the same TAG as a timing reference (e.g., a cell used may be a configuration aspect of a WTRU) or may use the PCell as the timing reference (e.g., otherwise).

[0124] Support may be provided for multiplexing transmissions in a cell and/or for a specific WTRU. Support for transmissions using different TTI duration may be for concurrent transmissions in the same cell. For example, transmission may correspond to a single TTI duration for each WTRU at any given time while some WTRUs may have different TTI duration than other WTRUs. Support may be for transmissions for a given WTRU within the same subframe (e.g., within a first (e.g., legacy) subframe such as 1 ms) where different transmissions may be performed according to different TTI durations by the concerned WTRU.

[0125] Procedures may be applicable for uplink and/or downlink transmission and may be a configuration aspect for a WTRU.

[0126] An ShTTI-based transmission mode (TM) and cell timing configuration may be provided. For example, a WTRU may be configured with a PCell (e.g., according to first (e.g., legacy) behavior). For example, a WTRU may operate on a PCell carrier frequency using a first TM (e.g., a TM in the range of 1-10) associated with a first TTI duration (e.g., legacy 1ms). The WTRU may receive a RRC Connection Reconfiguration message that may reconfigure the WTRU according to at least one of the following: the WTRU may reconfigure the PCell and/or may configure at least one SCell.

[0127] In an example of reconfiguring a PCell, the WTRU may reconfigure the PCell such that a second TTI (e.g., ShTTI) of a duration shorter than previously used by the WTRU for the PCell is supported. For example, the WTRU may reconfigure (or add) a TM associated to the PCell. For example, a TM (e.g., TM = 11) may be associated with a TTI duration different than previously used by the WTRU for the PCell.

[0128] For example, a WTRU may configure a TTI duration according to one of the following. In an example, an ShTTI duration may be equal to 1 slot (0.5ms). This may be applicable, for example, to the first case. In another example, an ShTTI may be a duration expressed as an integer multiple of 1 symbol. A duration may include the control region, for example, when the configuration includes a start offset for the ShTTI and such offset is equal to zero. In another example, an ShTTI may be a duration expressed as an integer value in time, e.g. 100 μs or 125μs. Whether an ShTTI duration may include the control region may be determined as a function the value of a start offset for the ShTTI when applicable. A control region may be a separate aspect of a WTRU's configuration for a cell when an offset is equal to a non-zero value.

[0129] For example, a TM may support transmissions in (e.g., only in) the first slot of a first (e.g., legacy) subframe for the concerned ShTTI duration. A WTRU may determine an aspect as a function of the type of cell (e.g., PCell) associated with the TM. A TM may support WTRU-specific demodulation reference signals (e.g., DM-RS) such that their location and density may be better suited for ShTTI operation.

[0130] In an example of reconfiguring a PCell, transmissions on the PCell using a first (e.g., legacy) TTI such as 1ms may be enabled. This may be applicable, for example, in the second case, e.g., when a WTRU may be configured such that PCell operation supports transmissions using a first (e.g. legacy) 1ms TTI and one or more SCells support operation using ShTTI.

[0131] A WTRU may configure a PCell with an additional cell identity to the PCell in the PCell's configuration such that DCI may indicate, for example, "CIF=0" for a transmission on PCell using a first TTI (e.g., 1ms) and "CIF=1" for a transmission on PCell using a second TTI (e.g. a slot-based ShTTI of 0.5ms or similar). This may be applicable, for example, in the first case.

[0132] In an example of reconfiguring at least one SCell, the WTRU may configure an SCell such that an associated TTI duration (e.g., ShTTI) is less than that of a first (e.g., legacy) subframe duration (e.g., less than 1ms). For example, the WTRU may configure a TM associated with the SCell. For example, a TM (e.g., TM = 11) may be associated with a TTI duration similar to that of the PCell (e.g., ShTTI). For example, a ShTTI duration may be equal to 1 slot (0.5ms). This may be applicable, for example, in the first case. A TM (e.g., TM = 11+x) may be (e.g. alternatively) associated with a TTI duration different than that of the PCell, for example, when the TTI duration of such SCell may differ from that of the PCell.

[0133] Combinations of slot-based TTI (e.g., 0.5ms for a PCell) and non slot-based TTIs (e.g., 5 SCells of 100ms each) may be applicable for a given WTRU. Another example may be of a WTRU configured with symbol-based TTIs such that a different number of symbols may be used for each of the control regions (e.g,. 3 symbols), the TTI duration for the PCell (e.g., 5 symbols)

and for a number of SCells of x symbols in duration (e.g., 3 SCells each 2 symbols in TTI duration). Other combinations and/or other values are possible.

[0134] Example procedures may be applicable to any of the cases described above. Procedures may be applicable for uplink and/or downlink transmission and may be a configuration aspect for a WTRU.

[0135] TTI duration may be determined as a function of a Carrier Indicator Field (CIF) in a DCI on PDCCH. A TTI duration may be signaled as a function of the indicated cell identity in the DCI (e.g., by CIF or similar for a given carrier frequency of the WTRU's configuration). A determination or indication may be achieved, for example, by associating a second identity with a cell of the WTRU's configuration or by duplication of a serving cell configuration for a given carrier frequency. The WTRU may determine that the DCI of a given transmission (e.g., PDDCH transmission, serving cell transmission, received downlink control information, or scheduling information) has indicated that the WTRU should use a first transmission time interval on a physical uplink channel to communicate with the serving cell. For example, the determination may be based on the CIF field of the DCI, as the CIF may refer to a serving cell identity that has been configured to utilize the first transmission time interval. In this manner, downlink control information (e.g., a DCI field, DCI message, CIF field, PRB assignment) may be re-used for scheduling of transmissions associated with the first TTI length. Similarly, the WTRU may determine that the DCI of a given transmission (e.g., PDDCH transmission, serving cell transmission, received downlink control information, or scheduling information) has indicated that the WTRU should use a second transmission time interval on a physical uplink channel to communicate with a second serving cell. For example, the determination may be based on the CIF field of the DCI, as the CIF may refer to the second serving cell identity and the second serving cell may have been configured to utilize the second transmission time interval. One or more of the first or second transmission time intervals may correspond a shortened TTI that is less than the legacy transmission time interval. The first and second serving cells may configured to utilize the same frequency band and/or carrier frequency.

[0136] In an example using slot-based TTI duration, a WTRU may be configured with a PCell with CIF=0, an SCell with CIF=1 and an SCell with CIF=2 for a given carrier frequency. Both SCells may be configured with carrier aggregation cross-carrier scheduling such that scheduling information for the associated resources may be received on the PDCCH associated with the PCell. A WTRU may receive signaling that schedules a transmission on such PDCCH. A WTRU may determine that a TTI duration is according to first (e.g., legacy) operation (e.g., 1ms), for example, when the WTRU determines that the CIF applicable to the transmission is that

of the PCell. The WTRU may determine that the transmission is applicable to the first slot of the concerned subframe, for example, when the WTRU determines that the CIF=1. The WTRU may determine that the transmission is for the second slot of the concerned subframe, for example, when CIF=2.

[0137] Example procedures may be applicable to any of the cases described above. Procedures may be applicable for uplink and/or downlink transmission and may be a configuration aspect for a WTRU.

[0138] A start offset for ShTTI may be a function of CIF in the DCI on PDCCH. In an example, determination of the applicable location in time (e.g., slot in the subframe, applicable starting symbol and/or all applicable symbols or similar) may be enabled for a transmission, for example, when a TTI duration shorter than that of the subframe duration is configured for a given cell.

[0139] A start offset or applicable location in time may be based on signaling received by the WTRU. The WTRU may perform such determination as a function of the indicated cell identity in the DCI, e.g., by Carrier Indicator Field (CIF) or similar for a given carrier frequency of the WTRU's configuration. An indication or determination may be achieved, for example, by associating a specific offset in the subframe with an identity of a cell of the WTRU's configuration or by configuring multiple serving cells for a given carrier frequency each with a different identity and a different offset.

[0140] For example, an offset may indicate one of a first slot or a second slot of a cell-specific subframe or it may indicate an offset in terms of a starting symbol in a subframe or an offset in absolute time (e.g. 500ms). An offset may be applied from the start of a cell-specific subframe. An offset may implicitly indicate a TTI duration (or vice-versa).

[0141] Example procedures may be applicable to any of the cases described above. Procedures may be applicable for uplink and/or downlink transmission and may be a configuration aspect for a WTRU.

[0142] A TTI duration may be a function of PRB(s) for a transmission. In an example, a WTRU may be configured such that a number of PRBs (e.g. a subset of the total set of system-specific PRBs for the concerned carrier frequency) may be associated with a cell of the WTRU's configuration for which the WTRU is operating with shorter than 1ms TTI duration e.g. configured with ShTTI.

[0143] A WTRU may determine an applicable TTI duration as a function of the PRB(s) indicated by the scheduling information. A PRB may correspond to the starting PRB for the resource allocation for the transmission. A set of PRBs may correspond to a range of PRBs. A

WTRU may use the TTI duration associated with a set of PRB(s), for example, when such range includes (e.g., only includes) PRB(s) associated with the concerned set. A WTRU may (e.g., otherwise) use a different TTI duration (e.g., a first (e.g. legacy) TTI duration, such as 1ms, or a configured duration), for example, when such range includes PRBs associated with different sets of PRBs or when such range does not include PRBs associated with any such sets. Sets of PRBs may be a configuration aspect of a WTRU's configuration. For example, a serving cell may be associated with a set of one or more PRBs, for example, when a serving cell is configured for ShTTI operation for a carrier frequency. A WTRU may use the TTI duration associated with such a cell or associated with the concerned PRBs. Scheduling information may be received dynamically in a DCI on PDCCH. Scheduling information may be semi-statically configured. For example, an entire (e.g., system-specific) set of PRBs for a PCell configured with a first (e.g., legacy) operation may be 110 PRBs. A WTRU may (e.g., alternatively) be configured with one or more subsets of PRBs, where each set may be associated with a specific TTI duration.

[0144] A WTRU may (e.g., first) determine the cell configured with ShTTI applicable to the transmission and/or the duration of the TTI (e.g., determining as described herein) and may determine the set of applicable PRBs therefrom (e.g., determining using a configuration of sets of PRBs as discussed herein).

[0145] Example procedures (e.g., operation) may be applicable to any of the cases described above. Procedures may be applicable for uplink and/or downlink transmission and may be a configuration aspect for a WTRU. For example, a procedure may be associated with a transmission mode for downlink and/or uplink. For example, a procedure may be associated with a serving cell of the WTRU's configuration. For example, a WTRU may determine that a configuration is specific to a serving cell of a WTRU's configuration, e.g., a determination may be made that a TTI configuration applies to both DL and UL frequencies. For example, a WTRU may determine that a configuration is specific to a specific direction of a configuration for a given serving cell of the WTRU's configuration, e.g., a determination may be made that a TTI configuration is provided separately for the DL direction and for the UL direction.

[0146] A determination may be made about the start offset time for a transmission. Cell de-activation may control availability of ShTTI. In an example, a first (e.g., legacy) cell activation-deactivation mechanism (e.g., procedure or algorithm) may control the duration (e.g., first or second TTI such as a legacy TTI or an ShTTI duration) of a transmission, e.g., by activating and deactivating the transmission. A WTRU may associate an activation state with an ShTTI, a slot and/or a resource.

[0147] In an example, a WTRU configured using ShTTI cells may receive a first (e.g., legacy) MAC activation/deactivation control element. A WTRU may use the activation/deactivation element as a mechanism to determine the availability of the ShTTI. For example, a WTRU may use a first (e.g., 1ms) TTI duration, e.g., when the WTRU is configured with a single SCell with ShTTI and when the SCell is in a deactivated state when the WTRU determines that it needs to perform a transmission. A WTRU may (e.g., otherwise) use a second TTI duration (e.g., ShTTI) for a transmission, e.g., when the SCell is active. The WTRU may perform a transmission using the second TTI duration (e.g. ShTTI), for example, according to scheduling information independently of the scheduled slot. This example may be extended to apply to the case where a symbol-based TTI duration is used instead of a time duration such as transmission slots.

[0148] In an example where multiple SCells may be used to indicate slot-based transmissions, a WTRU may determine that a first TTI duration is applicable when all cells configured with ShTTI are in a deactivated state. A WTRU may determine (e.g., otherwise) the applicable slot based on the activation state associated with each SCell and associated with each slot. This example may be extended to apply to the case where a symbol-based TTI duration is used, e.g., instead of using time duration such as transmission slots.

[0149] A WTRU may transmit HARQ feedback and/or other Uplink Control Information (UCI) (e.g. CQI, PMI, RI or similar), for example, taking into consideration the configuration of the TTI duration.

[0150] A TTI duration applicable to the transmission of UCI may be a function of at least one of the following: scheduling information, configuration information, TTI applicable to a serving cell, a default configuration for UCI transmission, etc.

[0151] Scheduling information may indicate whether a WTRU has resources for a PUSCH transmission and (e.g., if so) the TTI duration associated with such transmission, which may be determined according to procedures described herein.

[0152] Configuration information may indicate whether a WTRU is configured for simultaneous PUSCH and PUCCH transmission.

[0153] A TTI may be applicable to a serving cell associated with a UCI transmission in the subframe for the concerned UCI transmission.

[0154] A TTI may be applicable (e.g., in duration and/or offset) to a serving cell associated with a UCI transmission in the subframe for a downlink transmission pertaining to the feedback (e.g., in case of HARQ A/N feedback).

[0155] A default configuration for the transmission of UCI may be, for example, for the transmission of UCI on PUCCH (e.g., always a first TTI such as 1 ms TTI on PCell).

[0156] Further examples are provided below.

[0157] An applicable resource may be a PUSCH or PUCCH resource. A WTRU may determine a physical channel to perform the transmission of UCI using any technique, procedure or algorithm. For example, a WTRU may determine that UCI may be included in a PUSCH transmission when the transmission is scheduled, when simultaneous PUSCH and PUCCH transmissions are not configured or on a PUCCH transmission (e.g., otherwise).

[0158] An applicable resource may be a PUSCH resource. A WTRU may perform the transmission of UCI on a PUSCH transmission according to a TTI duration associated with a PUSCH transmission, which may be determined using procedures described herein.

[0159] An applicable resource may be a PUCCH resource. A WTRU may determine that a PUCCH resource may be used for transmission of UCI according to any technique, procedure or algorithm applicable to LTE CA. For example, selection of a resource may be based on the first CCE of the DCI that scheduled a downlink transmission or based on a configuration (e.g. PUCCH format 3 or similar). Bundling and/or multiplexing may be applied, for example, when configured.

[0160] An applicable TTI may be function of the type of transmissions on the carrier frequency PUSCH or PUCCH. Transmission of UCI may use the principles of LTE CA whereby UCI corresponding to transmission on different cells, e.g., including time-shifted cells, maybe multiplexed on a single transmission using a format that supports the required number of information bits (e.g., PUCCH format 3).

[0161] A PUCCH transmission may be performed on a PCell with a first (e.g., 1 ms TTI), where the first TTI may be a fixed TTI. A WTRU may perform PUCCH transmission on resources of an applicable serving cell (e.g., a PCell) according to a TTI duration associated with a concerned (e.g., pertinent) PCell, which may be determined using procedures described herein. In an example, a WTRU may transmit HARQ feedback using a single PUCCH transmission, which may use resources associated with a PCell (e.g. using a 1ms TTI duration), for example, when a WTRU has HARQ A/N feedback to transmit for two slot-based time-shifted cells using PUCCH on the PCell according to a configuration for a given carrier frequency where the PCell uses a first (e.g., 1ms) TTI.

[0162] A PUCCH transmission may be performed on a PCell with alignment in time with TTI being reported. A WTRU may perform PUCCH transmission on resources of an applicable serving cell (e.g. a PCell) according to a TTI duration associated with transmission(s) for which feedback is transmitted. A WTRU may have, for example, HARQ A/N feedback to transmit for

two slot-based time-shifted cells using PUCCH on the PCell according to a configuration for a given carrier frequency. In an example, a WTRU may transmit in the first slot a HARQ feedback for a transmission associated with the first slot and may transmit the HARQ feedback for the other transmission in the second slot for the concerned subframe.

[0163] A PUCCH transmission may be performed on a PCell with TTI/ShTTI of the PCell. A WTRU may perform a PUCCH transmission on resources of an applicable serving cell (e.g. a PCell) according to a TTI duration associated with the PCell, which may be determined using procedures described herein. A PCell may be (e.g., otherwise) configured with a default TTI, such as a first (e.g., 1 ms) TTI or an ShTTI. A WTRU may have HARQ A/N feedback to transmit for two slot-based time-shifted cells using PUCCH on the PCell, e.g., according to a configuration for a given carrier frequency where the PCell uses ShTTI in the concerned subframe (e.g., based on a configuration aspect and/or an activation state such as ShTTI activated for a time-shifted SCell for the concerned subframe). In an example, a WTRU may transmit HARQ feedback using a single PUCCH transmission, which may use resources associated with the PCell using a ShTTI duration with an offset applicable to the PCell.

[0164] A WTRU may transmit HARQ A/N feedback, for example, based on an applicable WTRU processing time for a concerned (e.g., pertinent) HARQ process in a given subframe.

[0165] Processing time associated with a HARQ process may be specific to a TTI associated with a transmissions for a concerned process. Processing time may be specific to a serving cell, a transmission mode or may be indicated by DCI (e.g., from servCellID or CIF) associated with such transmissions for a concerned HARQ process. In an example, HARQ processing time may be the same for all HARQ processes associated with a serving cell configured with a specific TTI (e.g., an ShTTI). Processing time may be a fixed value (e.g., 1ms), a multiple of an ShTTI, etc. Processing time may be determined for a transmission using ShTTI in subframe, the first available occasion in subframe n+2, where an occasion may correspond to a PUCCH or a PUSCH transmission with duration according to a first TTI or second TTI (e.g., ShTTI).

[0166] Systems, methods, and instrumentalities have been disclosed for multiplexing transmissions with different TTI duration. Latency may be reduced (e.g., in an LTE system), for example, by multiplexing transmissions with different TTI durations. TTI duration may be modeled using one or more time-shifted cell(s) for a given carrier frequency. A "logical" cell structure may correspond to an SCell. A PCell may logically maintain a TTI (e.g,. a first TTI) or may be configured with a second duration TTI (e.g., a shorter duration TTI (ShTTI)).

[0167] In an example, a WTRU may determine a TTI duration (e.g., first or second TTI) applicable to a transmission. For example, a WTRU may determine a TTI duration using cross-

carrier scheduling. A WTRU may associate a TTI duration with a cell identity (e.g. servCellID). A WTRU may associate a TTI duration with a transmission mode (TM). A TTI duration may be indicated by Carrier Indicator Field (CIF). A TTI duration may be determined from an identity of a PRB subset applicable to transmissions and/or to a time-shifted cell within a subset of PRBs for a concerned carrier frequency. An applicable TTI duration and/or the identity of a slot/period applicable to a transmission within a subframe may be determined using MAC Activation/Deactivation. MAC Activation/Deactivation may be used to toggle between first and second TTIs (e.g. legacy TTI and ShTTIs) or between slot-based ShTTIs and/or may be used to determine zero, one or more TTI (e.g. ShTTI) period(s) within a subframe.

[0168] HARQ processing may be performed according to a first behavior (e.g. legacy behavior) for one or more (e.g. each) time-shifted cell(s), although there may be exceptions. An exception may be timing-relationships, which may be scaled according to an applicable TTI duration. HARQ A/N feedback formats may use LTE Carrier Aggregation (CA) formats and/or (e.g., legacy) subframe-based timing relationships or a timing relationship associated with the HARQ process. Downlink Control Information (DCI) signaling may use a first (e.g., legacy) format, although, for example, interpretation of fields such as the CIF and/or PRBs applicable for the transmission may be different than the first (e.g., legacy) format. MAC activation/deactivation signaling may be applicable for time-shifted cells. DRX Timers associated with DRX may scale to HARQ A/N timing according to an applicable TTI duration and/or to the cell associated with an HARQ process. PRACH resources and/or PDCCH order for RACH may or may not be supported for time-shifted SCells. Timing advance for uplink transmission may be time shifted, for example, according to a shift applied to the TTI associated with a cell. Time shift may be relative to PCell timing, e.g. a PCell may remain a DL timing reference for an SCell with the additional offset corresponding to the start of the ShTTI for those cells.

[0169] A different TTI may be used in LTE R14 and NR. Multiple serving cells may be configured on the same carrier for a single WTRU. There may be an association between a serving cell and a TTI duration (or more generally – a numerology-related aspect). A WTRU can be configured with multiple such cells on a given carrier to support (*e.g.*, dynamically) a change in transmission duration. A field in downlink control signaling (DCI), *e.g.*, on a downlink control channel (*e.g.*, PDCCH), such as the CIF field in a DCI, may be used to dynamically schedule specific TTI durations for same or later subframes, for UL or DL transmissions.

[0170] The WTRU may be configured with a plurality of transmission methods, where at least two of the configured transmission methods differ in at least the applicable TTI duration.

[0171] A transmission may be associated with a transmission timing (start offset) relative to a timing reference.

[0172] A WTRU transmission mode may be indicated in downlink control information (DCI) signaling.

[0173] WTRU transmissions may be configured for each of a plurality of PRBs in the WTRU's configuration. Each of a plurality of PRBs may correspond to a serving cell of the WTRU's configuration. Each of a plurality of PRBs may correspond to a given carrier.

[0174] An applicable transmission duration/timing may be determined from a serving cell ID indicated in DCI signaling.

[0175] The WTRU may determine the set of resources, transmission duration, and/or uplink control information for a transmission based on a previous combination of received downlink signaling and received transmission duration.

[0176] A WTRU may determine whether a control region (*e.g.*, single control region) (*e.g.*, single level PDCCH) or multiple control regions (*e.g.*, multi-level PDCCH) are applicable and whether they are a function of the PDCCH configuration applicable to the concerned cell(s). A WTRU can determine the location of CCEs with respect to the timing reference (*e.g.*, in support of either self-scheduling or cross-TTI scheduling).

[0177] A WTRU may support mini-slots (*e.g.*, 125usec), slots (*e.g.*, 0.5ms), subframe (*e.g.*, 1ms) and multi-slots (*e.g.*, Multiples of other durations), and transmission durations and use different (*e.g.*, shortened) TTI's based on these time allocations. This may provide a low latency mode, a throughput mode and/or a coverage mode.

[0178] FIG. 4 depicts a scheduling example with time shifted-cells. As shown, there is a frequency axis and a time axis. In Fig. 4, the time is measured in milliseconds and divided into subframes. Other time units can be used such as slots, minislots, symbols, and PRB lengths. The frequency axis shows downlink (DL) and uplink (UL) transmissions. The time axis shows subframes. N, n+1, N=3, etc.... As shown for the DL frequency, for one or more subframes, the WTRU may receive DCI. For subframe n, the DCI may indicate two allocations, for example two ShTTI allocations (*e.g.*, $ShTTI_{DL(n,0)}$ and $ShTTI_{DL(n,1)}$). As an example, setting the CIF equal to 1 may indicate that the allocation is for $ShTTI_{DL(n,0)}$ and setting the CIF equal to 2 may indicate the allocation is for $ShTTI_{DL(n,1)}$. Other values of the CIF may be used to indicate no ShTTI transmissions and/or different transmission durations. For example, the DCI in Subframe

n+1 may indicate that for DL subframe n+1, the transmission has a duration corresponding to the entire subframe by using the value CIF=0 (*see e.g.*, a $TTI_{DL(N+1)}$).

[0179] A similar signaling mechanism can be used for indicating different durations of uplink transmissions. For example, DCI in DL subframe n may indicate that the WTRU has recieved two uplink grants. For example, a first grant for subframe n+1 may be indicate a CIF=1, which may be configured to correspond to $ShTTI_{(n+an\ offset,0)}$, while a CIF equal to 2 may indicate a grant for $ShTTI_{(n+an\ offset,0)}$. Similarly, a different value of the CIF (*e.g.*, CIF = 0) in this example may indicate that the transmissions duration spans an entire legacy TTI as illustrated in FIG. 4. Thus, by associating different CIF values with different transmission durations, the DCI may be used to indicate different transmission durations by referencing the different CIF values. Although the CIF field is used for purposes of illustration, other DCI fields may be used and may have values mapped to/associated with transmissions of different duration.

[0180] FIG. 4 also shows for an example of the PUCCH on the uplink frequency. For the PCell or SCell there may be a HARQ A/N for CIF = 1 at (n, 0) and a HARQ A/N for CIF = 2 at n, 1. For the PCell, (*e.g.*, PCell only), there may be a HARQ A/N for CIF = 0 at (n, 0) or CIF = 0 at n-3. Also, for the PCell, (*e.g.*, PCell only), there may be a HARQ A/N for CIF = 1 at (n, 0) or CIF = 0 at n-3 for the $ShTTI_{(n+?,\ 0)}$ and HARQ A/N for CIF = 2 at (n, 1) or CIF = 0 at n-3 for the $ShTTI_{(n+?,\ 1)}$.

[0181] FIG. 4 shows an example with time shifted cells with an offset of symbols. In this example, the symbol offset is based on CIF. FIG. 4 shows a single HARQ addressing space per TTI duration and start offset in a given subframe. MAC activation/deactivation may be applied by a HARQ process space or CIF value. FIG. 4 also shows a UCI example with time-shifted cells. The first CCE of the DCI on the example channel, PDCCH, may be used for legacy PUCCH resource allocation at TTI or ShTTI. Configured LTE CA PUCCH, PUCCH on an SCell, and/or ARI may be used for UCI using different TTIs. As shown, the WTRU interprets the DCI TTI indication differently in the FIG. 4 example for SCells and PCells to use ShTTI for the SCells. FIG. 4 also shows an example of the frequency being the same for the PCell and SCell. The FIG. 4 example dynamically varies the scheduled TTI for a WTRU and uses the appropriate HARQ signaling. Also, resource allocation for associated control information is resolved and there is flexibility to adapt different time offsets in a subframe and with different ShTTIs.

[0182] Although features and elements are described above in particular combinations, one of ordinary skill in the art will appreciate that each feature or element may be used alone or in any combination with the other features and elements. In addition, the methods described herein

may be implemented in a computer program, software, or firmware incorporated in a computer-readable medium for execution by a computer or processor. Examples of computer-readable media include electronic signals (transmitted over wired or wireless connections) and computer-readable storage media. Examples of computer-readable storage media include, but are not limited to, a read only memory (ROM), a random access memory (RAM), a register, cache memory, semiconductor memory devices, magnetic media such as internal hard disks and removable disks, magneto-optical media, optical media such as CD-ROM disks, and digital versatile disks (DVDs). A processor in association with software may be used to implement a radio frequency transceiver for use in a WTRU, WTRU, terminal, base station, RNC, or any host computer.

CLAIMS

What Is Claimed:

1. A method implemented by a wireless transmit/receive unit (WTRU) for supporting transmissions of different durations, the method comprising:

receiving a first configuration associated with a first set of transmission resources, the first configuration indicating a first transmission time interval (TTI) length for use with the first set of transmission resources;

receiving a second configuration associated with a second set of transmission resources, the second configuration indicating a second transmission time interval (TTI) length for use with the second set of transmission resources;

receiving downlink control information (DCI), wherein the DCI comprises a field that indicates whether the DCI is applicable to first set of transmission resources or the second set of transmission resources; and

determining that a transmission associated with the DCI utilizes the first TTI length on condition that the field indicates that the DCI is applicable to the first set of transmission resources or that the transmission associated with the DCI utilizes the second TTI length on condition that the field indicates that the DCI is applicable to the second set of transmission resources.

2. The method of claim 1, wherein the first set of transmission resources correspond to a first serving cell and the second set of transmission resources correspond to a second serving cell.

3. The method of claim 2, wherein the field corresponds to a carrier indicator field.

4. The method of claim 2, wherein the first serving cell and the second serving cell are associated with the same carrier frequency.

5. The method of claim 2, wherein each of the first and second serving cells are configured as secondary cells (SCells).

6. The method of claim 2, wherein the first serving cell corresponds to a primary cell (PCell), the second serving cells is configured as a secondary cells (SCell), the first TTI length corresponds to 1 millisecond (ms), and the second TTI length corresponds to less than 1 ms.

7. The method of claim 1, wherein the DCI further comprises a physical resource block (PRB) assignment field, and the PRB assignment field is interpreted differently depending on whether the transmission is associated with the first TTI length or the second TTI length.

8. The method as in claim 1, wherein at least the second configuration is received via a radio resource control (RRC) message, and the DCI is received via a physical downlink control channel.

9. The method as in claim 1, wherein a hybrid automatic repeat request timing used for the transmission is dependent on whether the transmission is associated with the first TTI length or the second TTI length.

10. A method implemented by a wireless transmit/receive unit (WTRU) for supporting transmissions of different durations, the method comprising:

receiving downlink control information from a first serving cell in the wireless communications network;

determining that the received downlink control information indicates that the WTRU should use a first transmission time interval to transmit data information to the first serving cell;

determining whether the received downlink control information indicates that the WTRU should use a second transmission time interval that is different than the first transmission time interval to communicate with the wireless communication network on the physical uplink channel or whether the WTRU should transmit using carrier aggregation; and

communicating with the wireless communications network using the second transmission time interval.

11. The method of claim 10, wherein determining that the received downlink control information indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network on the physical uplink channel comprises determining based on a carrier indicator field in the received downlink control information.

12. The method of claim 10, wherein communicating with the wireless communications network using the second transmission time interval comprises communicating with the first serving cell using the second transmission time interval.

13. The method of claim 10, wherein communicating with the wireless communications network using the second transmission time interval comprises communicating with a secondary cell using the second transmission time interval.

14. The method of claim 10, further comprising determining that the WTRU should use a third transmission time interval that is less than the first transmission time interval to communicate with a secondary cell in the wireless communications network.

15. The method of claim 10, wherein the shorten transmission time interval corresponds to at least one of at least one symbol or at least one resource block.

16. The method of claim 10, wherein the first transmission time interval is one millisecond.

17. The method of claim 10, wherein the first transmission time interval is greater than the first transmission time interval.

18. The method of claim 10, wherein the first transmission time interval corresponds to a first sub-carrier spacing and the second transmission time interval corresponds to a second subcarrier spacing.

19. The method of claim 10, wherein the first transmission time interval corresponds to a first number of transmission symbols and the second transmission time interval corresponds to a second number of transmission symbols.

20. The method of claim 10, further comprising the WTRU communicating with the first serving cell and a second serving cell using the same carrier frequency.

21. The method of claim 10, further comprising determining a time to transmit with the second transmission time interval based on the received downlink control information.

22. The method of claim 21, wherein the time to transmit is defined by a slot in a subframe.

23. The method of claim 10, wherein determining whether the received downlink control information indicates that the WTRU should use a second transmission time interval that

is less than the first transmission time interval to communicate with the wireless communication network on the physical uplink channel or whether the WTRU should transmit using carrier aggregation comprises determining with cross-carrier scheduling.

24. A wireless transmit/receive unit (WTRU) for use within a wireless communications network that is capable of carrier aggregation, comprising:

a processor having executable instructions that:

determine that downlink control information from a first serving cell in the wireless communications network has been received;

determine that the received downlink control information indicates that the WTRU should use a first transmission time interval to transmit data information to the first serving cell;

determine whether the received downlink control information indicates that the WTRU should use a second transmission time interval that is different than the first transmission time interval to communicate with the wireless communication network on the physical uplink channel or whether the WTRU should transmit using carrier aggregation; and

communicate with the wireless communications network using the second transmission time interval.

25. The WTRU of claim 24, wherein the processor further comprises executable instructions that determine that the received downlink control information indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network on the physical uplink channel comprises determining based on a carrier indicator field in the received downlink control information.

26. The WTRU of claim 24, wherein the executable instructions that communicate with the wireless communications network using the second transmission time interval comprise communicating with the first serving cell using the second transmission time interval.

27. The WTRU of claim 24, wherein the executable instructions that communicate with the wireless communications network using the second transmission time interval comprise communicating with a secondary cell using the second transmission time interval.

28. The WTRU of claim 24, wherein the processor further comprises executable instructions that determine that the WTRU should use a third transmission time interval that is less than the first transmission time interval to communicate with a secondary cell in the wireless communications network.

29. The WTRU of claim 24, wherein the shorten transmission time interval corresponds to at least one of at least one symbol or at least one resource block.

30. The WTRU of claim 24, wherein the first transmission time interval is one millisecond.

31. The WTRU of claim 24, wherein the processor further comprises executable instructions that determine a time to transmit with the second transmission time interval based on the received downlink control information.

32. The WTRU of claim 31, wherein the time to transmit is defined by a slot in a subframe.

33. The WTRU of claim 24, wherein the executable instructions that determine whether the received downlink control information indicates that the WTRU should use a second transmission time interval that is less than the first transmission time interval to communicate with the wireless communication network on the physical uplink channel or whether the WTRU should transmit using carrier aggregation comprise determining with cross-carrier scheduling.

34. The WTRU of claim 24, wherein the first transmission time interval is greater than the first transmission time interval.

35. The method of claim 24, wherein the first transmission time interval corresponds to a first sub-carrier spacing and the second transmission time interval corresponds to a second subcarrier spacing.

36. The method of claim 24, wherein the first transmission time interval corresponds to a first number of transmission symbols and the second transmission time interval corresponds to a second number of transmission symbols.

37. The method of claim 24, further comprising the WTRU communicating with the first serving cell and a second serving cell using the same carrier frequency.

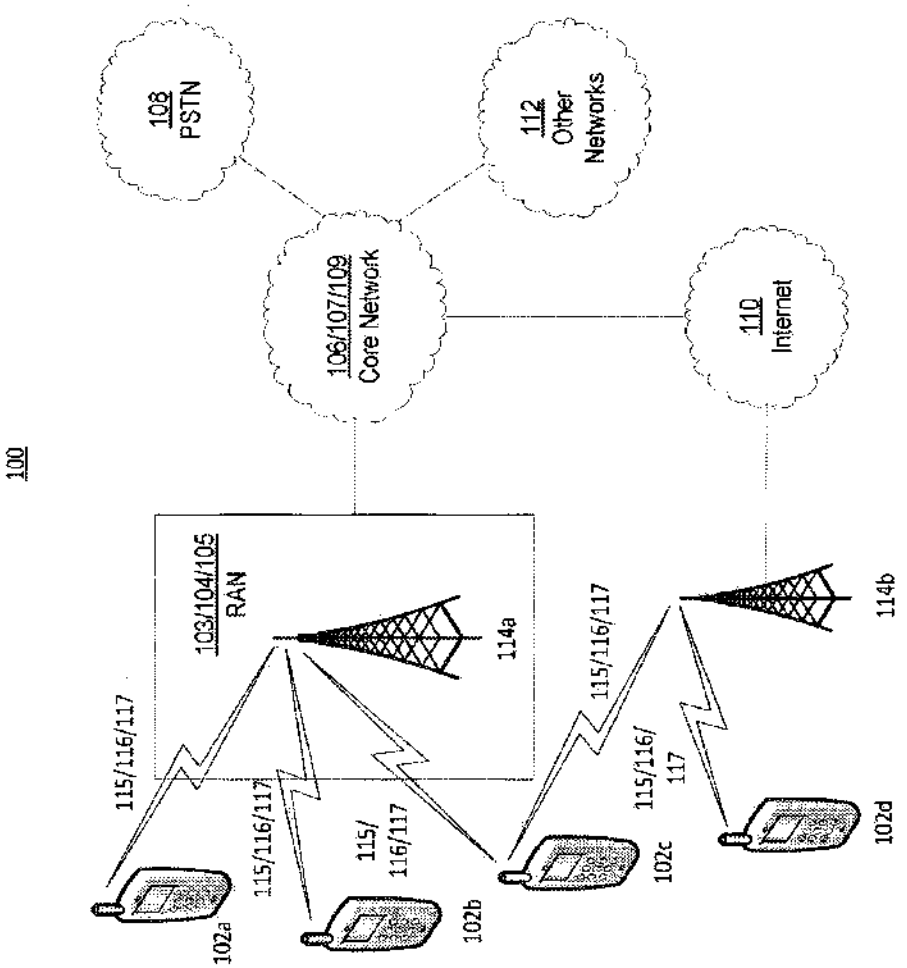

100
108 PSTN
112 Other Networks
106/107/109 Core Network
110 Internet
103/104/105 RAN
114a
114b
115/116/117
115/116/117
115/116/117
115/116/117
115/116/117
102a
102b
102c
102d

FIG. 1A

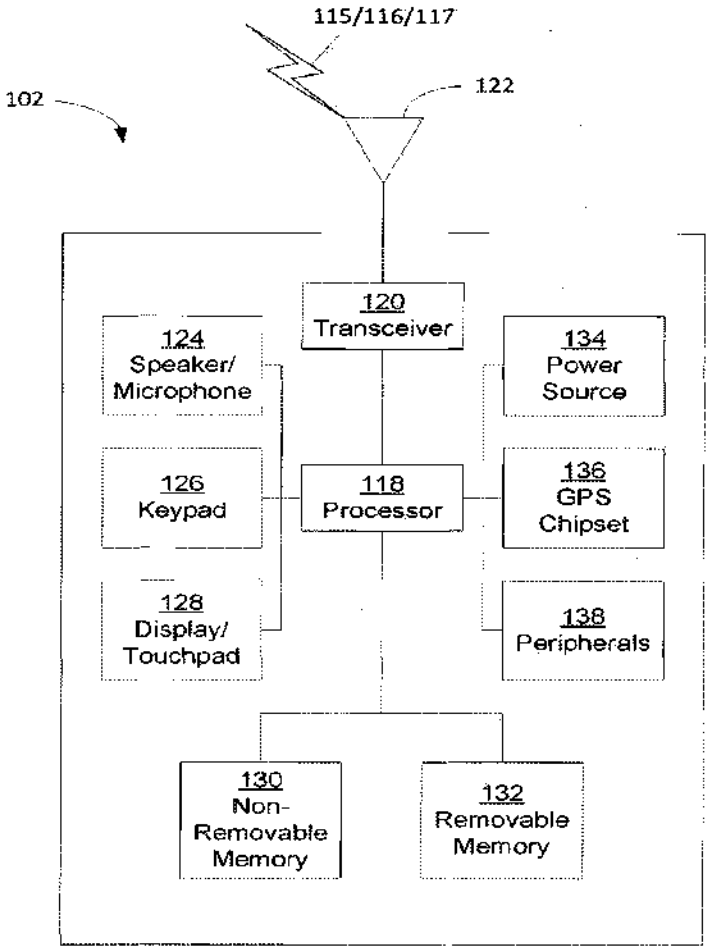

115/116/117
122
102
120
Transceiver
124
Speaker/
Microphone
134
Power
Source
126
Keypad
118
Processor
136
GPS
Chipset
128
Display/
Touchpad
138
Peripherals
130
Non-
Removable
Memory
132
Removable
Memory

FIG. 1B

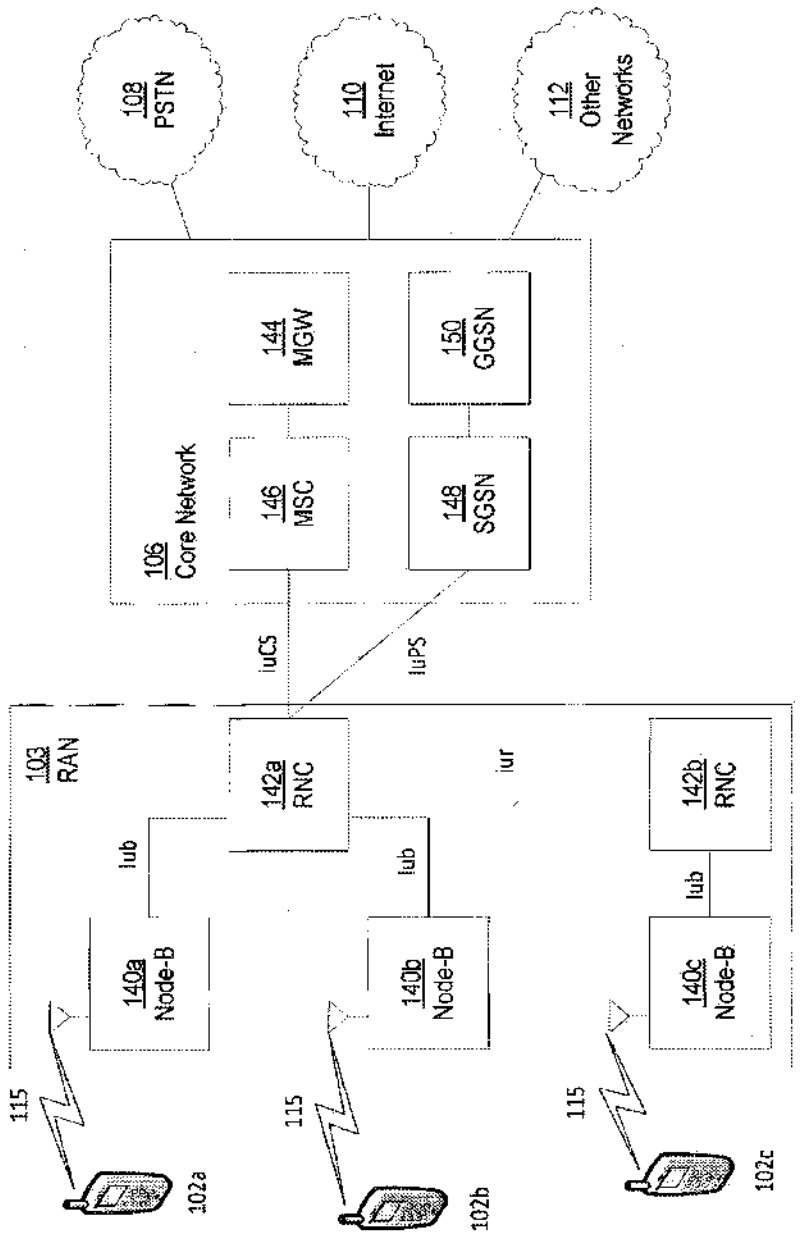

108 PSTN
110 Internet
112 Other Networks
106 Core Network
144 MGW
150 GGSN
146 MSC
148 SGSN
IuCS
IuPS
103 RAN
142a RNC
142b RNC
Iur
Iub
140a Node-B
140b Node-B
140c Node-B
115
102a
102b
102c

FIG. 1C

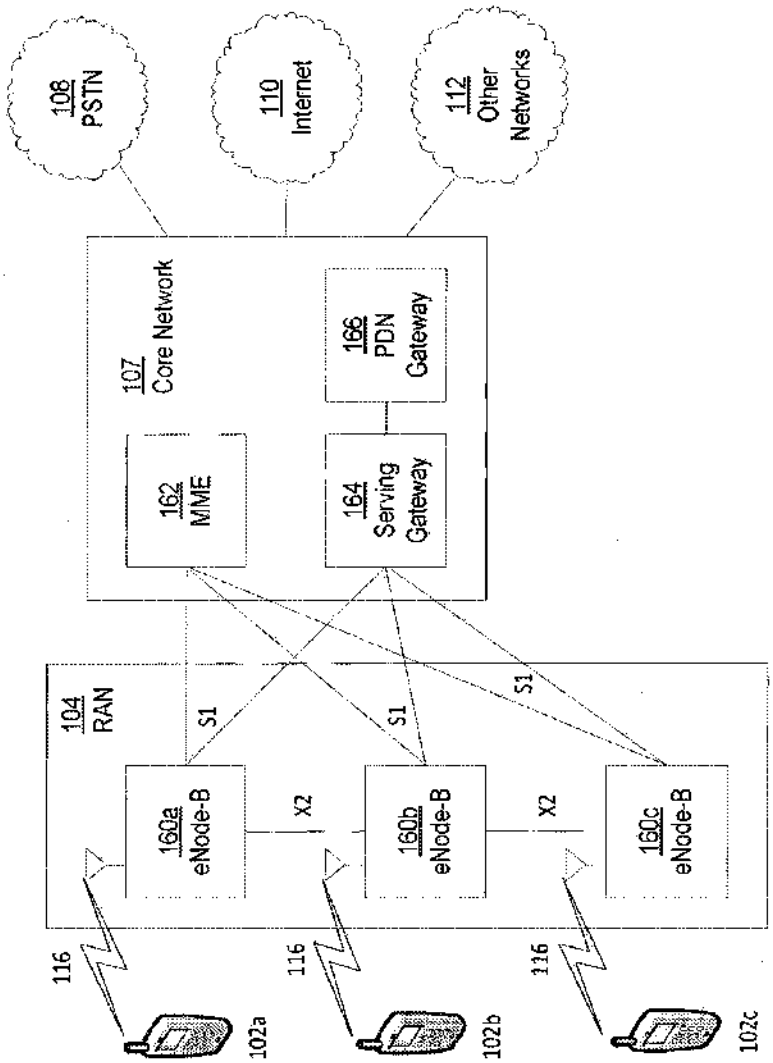

108 PSTN
110 Internet
112 Other Networks
107 Core Network
166 PDN Gateway
162 MME
164 Serving Gateway
104 RAN
S1
S1
S1
160a eNode-B
160b eNode-B
160c eNode-B
X2
X2
116
116
116
102a
102b
102c

FIG. 1D

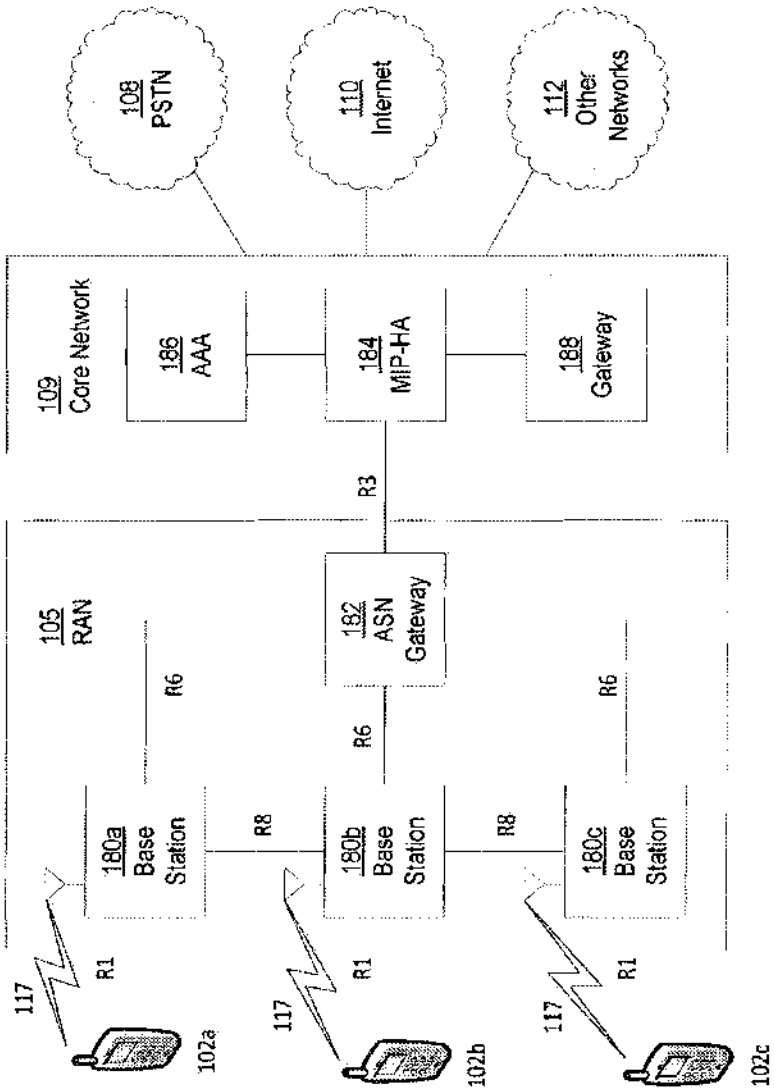

108 PSTN
110 Internet
112 Other Networks
109 Core Network
186 AAA
184 MIP-HA
188 Gateway
R3
105 RAN
182 ASN Gateway
R6
R6
R6
180a Base Station
180b Base Station
180c Base Station
R8
R8
R1
R1
R1
117
117
117
102a
102b
102c

FIG. 1E

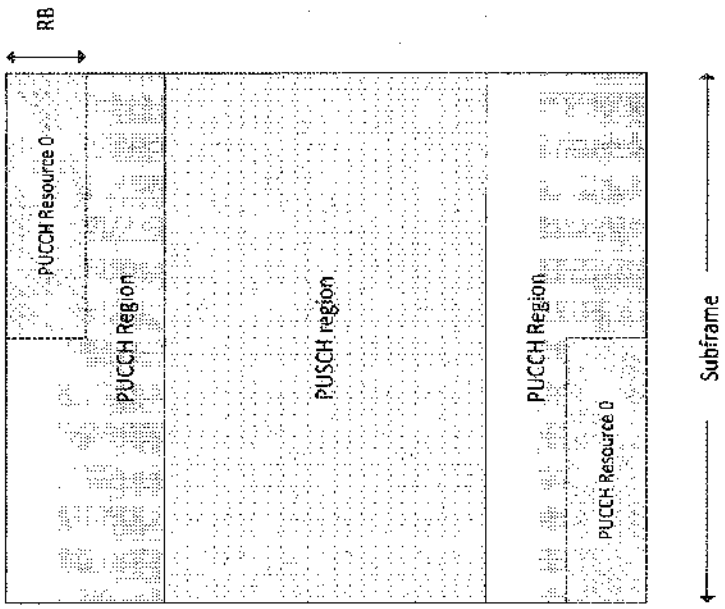

RB
PUCCH Resource 0
PUCCH Region
PUSCH region
PUCCH Region
PUCCH Resource 0
Subframe

FIG. 3

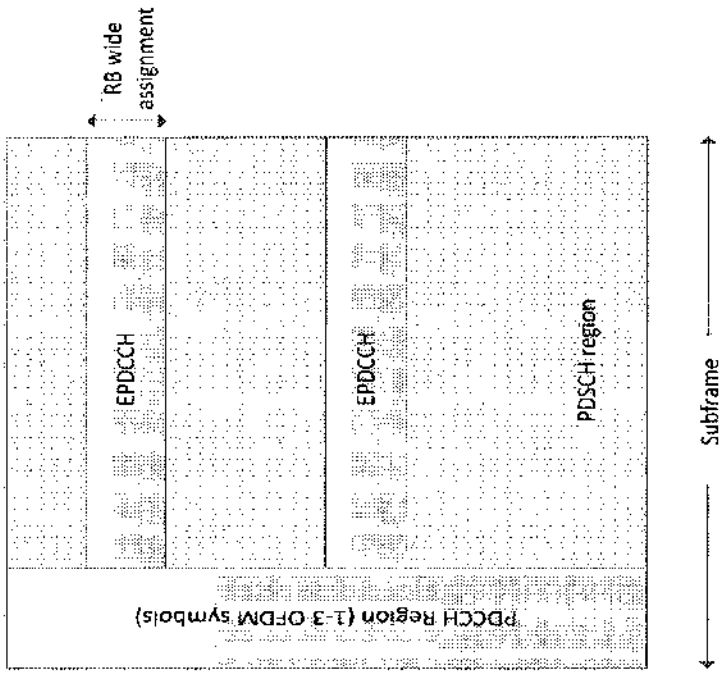

RB wide assignment
EPDCCH
EPDCCH
PDSCH region
PDCCH Region (1-3 OFDM symbols)
Subframe

FIG. 2

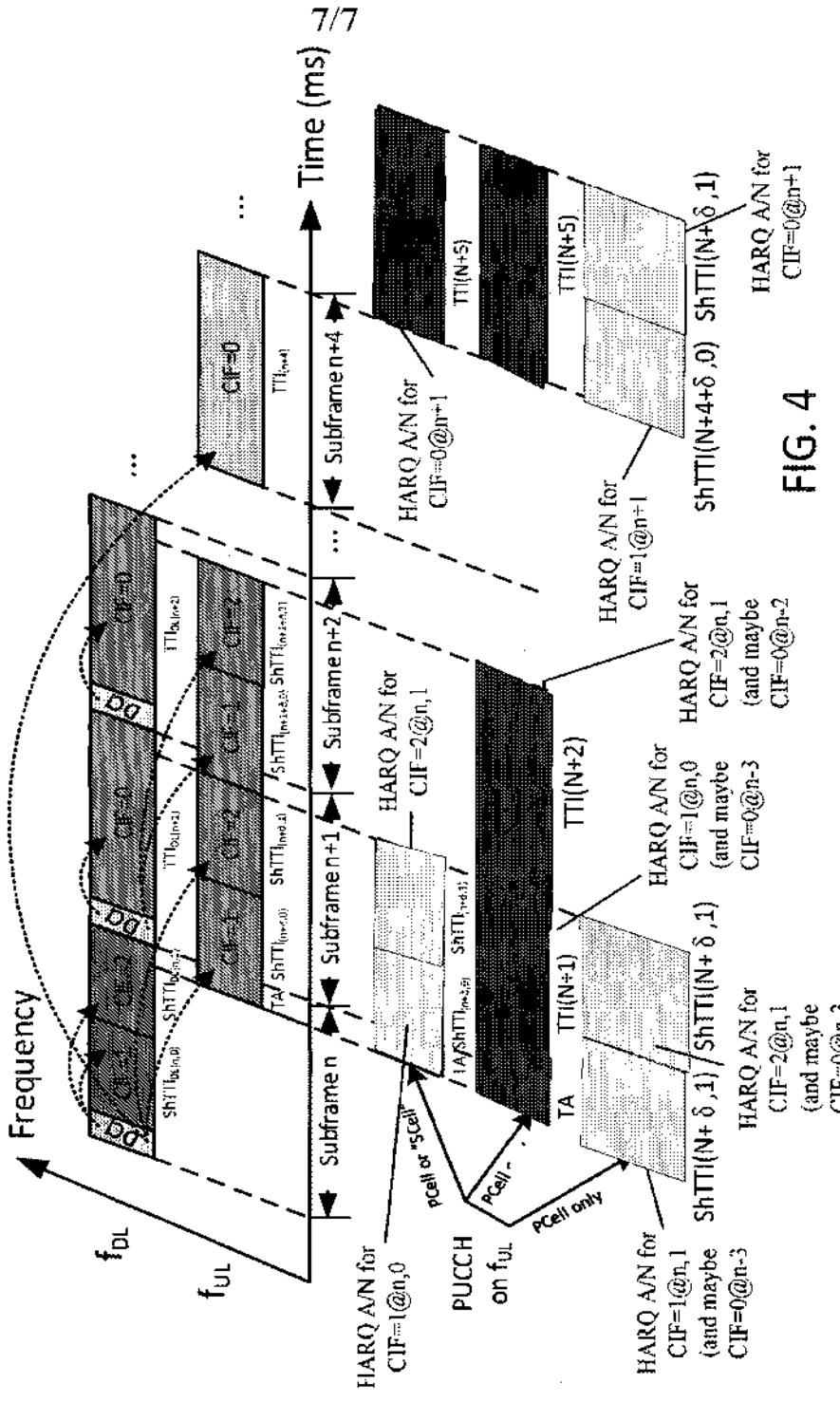

Frequency
Time (ms)
f_{DL}
f_{UL}
Subframe n
Subframe n+1
Subframe n+2
Subframe n+4
CIF=0
CIF=1
CIF=2
TTI(N+1)
TTI(N+2)
TTI(N+5)
TA
PUCCH on f_{UL}
PCell only
HARQ A/N for CIF=1@n,0
HARQ A/N for CIF=2@n,1
HARQ A/N for CIF=1@n,1 (and maybe CIF=0@n-3
HARQ A/N for CIF=2@n,1 (and maybe CIF=0@n-3
HARQ A/N for CIF=1@n,0 (and maybe CIF=0@n-3
HARQ A/N for CIF=2@n,1 (and maybe CIF=0@n-2
HARQ A/N for CIF=0@n+1
HARQ A/N for CIF=1@n+1
HARQ A/N for CIF=0@n+1
ShTTI(N+δ ,1)
ShTTI(N+4+δ ,0)
ShTTI(N+4+δ ,1)

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/060481

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W72/12
ADD. H04W28/06 H04L1/18

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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Date of the actual completion of the international search	Date of mailing of the international search report
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Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/060481

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2016/060481

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(54) Title: METHOD AND DEVICE FOR PAGING A MACHINE TO MACHINE DEVICE

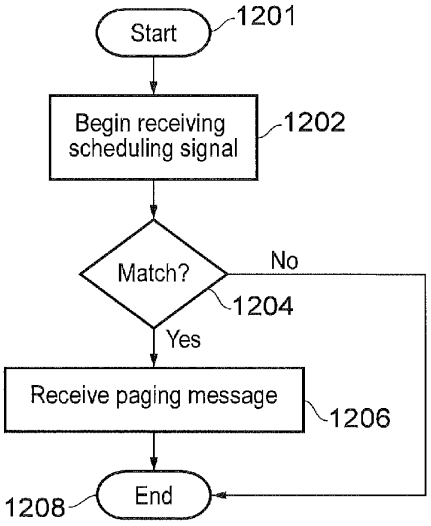


FIG. 12

(57) Abstract: A terminal device for use with a wireless telecommunications network comprising: a transceiver; and a controller. Receiving, during one of a plurality of periodic paging occasions associated with the terminal, a paging scheduling signal for one or more terminal devices, each paging occasion being associated with a value of a characteristic of the scheduling signal which is unique to that paging occasion. Determining whether the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the of periodic paging occasions associated with the terminal device; and control the transceiver to receive the paging message scheduled by the received scheduling message.

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METHOD AND DEVICE FOR PAGING A MACHINE TO MACHINE DEVICE

BACKGROUND

Field of Disclosure

The present disclosure relates to a terminal device, infrastructure equipment, methods and integrated circuitry for use with a wireless telecommunications network.

Description of Related Art

The "background" description provided herein is for the purpose of generally presenting the context of the disclosure. Work of the presently named inventors, to the extent it is described in this background section, as well as aspects of the description which may not otherwise qualify as prior art at the time of filing, are neither expressly or impliedly admitted as prior art against the present disclosure.

Third and fourth generation wireless communications systems, such as those based on the third generation project partnership (3GPP) defined UMTS and Long Term Evolution (LTE) architecture are able to support sophisticated services such as instant messaging, video calls as well as high speed internet access. For example, with the improved radio interface and enhanced data rates provided by LTE systems, a user is able to enjoy high data rate applications such as mobile video streaming and mobile video conferencing that would previously only have been available via a fixed line data connection. The demand to deploy third and fourth generation networks is therefore strong and the coverage area of these networks, i.e. geographic locations where access to the networks is possible, is expected to increase rapidly. However, whilst fourth generation networks can support communications at high data rate and low latencies from devices such as smart phones and tablet computers, it is expected that future wireless communications networks will need to support communications to and from a much wider range of devices, including reduced complexity devices, machine type communication devices, devices which require little or no mobility, high resolution video displays and virtual reality headsets. As such, supporting such a wide range of communications devices can represent a technical challenge for a wireless communications network.

A current technical area of interest to those working in the field of wireless and mobile communications is known as "The Internet of Things" or IoT for short. The 3GPP has proposed to develop technologies for supporting narrow band (NB)-IoT using an LTE or 4G wireless access interface and wireless infrastructure. Such IoT devices are expected to be low complexity and inexpensive devices requiring infrequent communication of relatively low bandwidth data. It is also expected that there will be an extremely large number of IoT devices which would need to be supported in a cell of the wireless

communications network. Furthermore such NB-IoT devices are likely to be deployed indoors and /or in remote locations making radio communications challenging.

SUMMARY OF THE DISCLOSURE

According to a first embodiment, the present technique provides a terminal device for use with a wireless telecommunications network, the terminal device comprising: a transceiver; and a controller operable: to control the transceiver to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging one or more terminal devices of the wireless telecommunications network, each periodic paging occasion associated with the terminal device being associated with a value of a characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network; to determine whether the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device; and if the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device, to control the transceiver to receive the paging message scheduled by the received scheduling message.

According to the first embodiment, the present technique also provides infrastructure equipment for use with a wireless telecommunications network, the infrastructure equipment comprising: a transceiver; and a controller operable: to control the transceiver to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device, wherein a value of a characteristic of the scheduling signal is associated with the one of the plurality of periodic paging occasions associated with the terminal device, each periodic paging occasion associated with the terminal device being associated with a value of the characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network.

According to a second embodiment, the present technique provides a terminal device for use with a wireless telecommunications network, the terminal device comprising: a transceiver; and a controller operable: to control the transceiver to begin receiving, during one of a plurality of periodic paging

occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging the terminal device; wherein the scheduling signal is repeatedly transmitted by the network a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin receiving the scheduling signal; and the controller is operable to control the transceiver to receive the repetitions of the scheduling signal over the predetermined plurality of separate time periods.

According to the second embodiment, the present technique also provides infrastructure equipment for use with a wireless telecommunications network, the infrastructure equipment comprising: a transceiver; and a controller operable: to control the transceiver to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device; wherein the controller is operable to control the transceiver to repeatedly transmit the scheduling signal a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin transmitting the scheduling signal.

The foregoing paragraphs have been provided by way of general introduction, and are not intended to limit the scope of the following claims. The described embodiments, together with further advantages, will be best understood by reference to the following detailed description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the disclosure and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein like reference numerals designate identical or corresponding parts throughout the several views, and wherein:

Figure 1 is a schematic block diagram illustrating an example of a mobile telecommunication system;

Figure 2 is a schematic representation illustrating a frame structure of a downlink of a wireless access interface according to an LTE standard;

Figure 3 is a schematic representation illustrating a frame structure of an uplink of wireless access interface according to an LTE standard;

Figure 4 is a schematic representation of a terminal device and infrastructure equipment;

Figure 5 is a schematic representation of an NB-PDCCH search space;

Figure 6 is a schematic representation of a plurality of paging occasions during which groups of UEs may search the NB-PDCCH search space;

Figure 7 is a schematic representation of an NB-PDCCH search space overlapping paging occasions associated with separate groups of UEs;

Figure 8 is a schematic representation an NB-PDCCH search space overlapping paging occasions associated with the same group of UEs;

Figure 9 is a schematic representation of segmentation of the NB-PDCCH according to a first example;

Figure 10 is a schematic representation of segmentation of the NB-PDCCH according to a second example;

Figure 11 is a schematic representation of segmentation of the NB-PDCCH according to a third example; and

Figure 12 illustrates a flow chart schematically showing a first method; and

Figure 13 illustrates a flow chart schematically showing a second method.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Conventional Communications System

Figure 1 provides a schematic diagram illustrating some basic functionality of a mobile telecommunications network / system 100 operating in accordance with LTE principles and which may be adapted to implement embodiments of the disclosure as described further below. Various elements of Figure 1 and their respective modes of operation are well-known and defined in the relevant standards administered by the 3GPP (RTM) body, and also described in many books on the subject, for example, Holma H. and Toskala A [1]. It will be appreciated that operational aspects of the telecommunications network which are not specifically described below may be implemented in accordance with any known techniques, for example according to the relevant standards.

The network 100 includes a plurality of base stations 101 connected to a core network 102. Each base station provides a coverage area 103 (i.e. a cell) within which data can be communicated to and from communications devices 104. Data is transmitted from base stations 101 to communications devices 104 within their respective coverage areas 103 via a radio downlink. Data is transmitted from communications devices 104 to the base stations 101 via a radio uplink. The uplink and downlink

communications are made using radio resources that are licenced for exclusive use by the operator of the network 100. The core network 102 routes data to and from the communications devices 104 via the respective base stations 101 and provides functions such as authentication, mobility management, charging and so on. Communications devices may also be referred to as mobile stations, user equipment (UE), user device, mobile radio, terminal device and so forth. Base stations may also be referred to as transceiver stations / infrastructure equipment / NodeBs / eNodeBs (eNB for short), and so forth.

Wireless communications systems such as those arranged in accordance with the 3GPP defined Long Term Evolution (LTE) architecture use an orthogonal frequency division modulation (OFDM) based interface for the radio downlink (so-called OFDMA) and a single carrier frequency division multiple access scheme (SC-FDMA) on the radio uplink.

Figure 2 provides a simplified schematic diagram of the structure of a downlink of a wireless access interface that may be provided by or in association with the eNB of Figure 1 when the communications system is operating in accordance with the LTE standard. In LTE systems the wireless access interface of the downlink from an eNB to a UE is based upon an orthogonal frequency division multiplexing (OFDM) access radio interface. In an OFDM interface the resources of the available bandwidth are divided in frequency into a plurality of orthogonal subcarriers and data is transmitted in parallel on a plurality of orthogonal subcarriers, where bandwidths between 1.4MHz and 20MHz bandwidth may be divided into 128 to 2048 orthogonal subcarriers for example. Each subcarrier bandwidth may take any value but in LTE it is conventionally fixed at 15kHz. However it has been proposed in the future [2][3] to provide also a reduced subcarrier spacing of 3.75 kHz for certain parts of the LTE wireless access interface for the uplink. As shown in Figure 2, the resources of the wireless access interface are also temporally divided into frames where a frame 200 lasts 10ms and is subdivided into 10 subframes 201 each with a duration of 1ms. Each subframe is formed from 14 OFDM symbols and is divided into two slots each of which comprise six or seven OFDM symbols depending on whether a normal or extended cyclic prefix is being utilised between OFDM symbols for the reduction of inter symbol interference. The resources within a slot may be divided into resources blocks 203 each comprising 12 subcarriers for the duration of one slot and the resources blocks further divided into resource elements 204 which span one subcarrier for one OFDM symbol, where each rectangle 204 represents a resource element. More details of the downlink structure of the LTE wireless access interface are provided in Annex 1.

Figure 3 provides a simplified schematic diagram of the structure of an uplink of an LTE wireless access interface that may be provided by or in association with the eNB of Figure 1. In LTE networks the uplink wireless access interface is based upon a single carrier frequency division multiplexing FDM (SC-FDM) interface and downlink and uplink wireless access interfaces may be provided by frequency division duplexing (FDD) or time division duplexing (TDD), where in TDD implementations subframes switch

between uplink and downlink subframes in accordance with predefined patterns. However, regardless of the form of duplexing used, a common uplink frame structure is utilised. The simplified structure of Figure 3 illustrates such an uplink frame in an FDD implementation. A frame 300 is divided in to 10 subframes 301 of 1ms duration where each subframe 301 comprises two slots 302 of 0.5ms duration. Each slot is then formed from seven OFDM symbols 303 where a cyclic prefix 304 is inserted between each symbol in a manner equivalent to that in downlink subframes. In Figure 3 a normal cyclic prefix is used and therefore there are seven OFDM symbols within a subframe, however, if an extended cyclic prefix were to be used, each slot would contain only six OFDM symbols. The resources of the uplink subframes are also divided into resource blocks and resource elements in a similar manner to downlink subframes. More details of the LTE uplink represented in Figure 3 are provided in Annex 1.

Narrowband Internet of Things

As explained above, it has been proposed to develop an adaptation of a mobile communications network to accommodate narrow band communications within an existing wireless access interface which has been developed to provide broadband wireless communications. For example, in 3GPP a project relating to improvements to LTE wireless access interfaces to provide for a Narrowband Internet of Things (NB-IoT) was agreed [2]. This project is aimed at improved indoor coverage, support for massive number of low throughput devices, low delay sensitivity, ultra-low device cost, low device power consumption and (optimised) network architecture. An example of such a device is a smart meter. It has been proposed that an NB-IoT communications system supports a bandwidth of only 180 kHz and can have three operational modes:

1. 'Stand-alone operation' utilizing for example the spectrum currently being used by GERAN systems as a replacement of one or more GSM carriers
2. 'Guard band operation' utilizing the unused resource blocks within a LTE carrier's guard-band
3. 'In-band operation' utilizing resource blocks within a normal LTE carrier

Figure 4 provides an example schematic block diagram of a terminal device or UE 104 and an infrastructure equipment or eNB 101 according to embodiments of the present technique. As shown in Figure 4, the UE 104 includes a transmitter 401 and a receiver 402 (which together form a transceiver) which are controlled by a controller 403. The UE 104 also comprises a storage medium 420 for storing data. Correspondingly, the eNB 101 includes a transmitter 411 and a receiver 412 (which together form a transceiver) which are controlled by a controller 413 (which can also implement a scheduler function). The eNB 101 also comprises a storage medium 422 for storing data. As explained above, the UE 104 transmits and receives signals to and from the eNB 101 via a wireless access interface provided by the

eNB as part of the wireless communications network. Each of the UE 104 and eNB 101 are configured to exchange signals with each other using NB-IoT.

One of the objectives of NB-IoT is to provide extended coverage of up to 20 dB. The main mechanism to extend coverage is to perform numerous repetitions of a message to be received at a receiving device, such that the receiver can accumulate the signal energy over the repetitive samples in order for it to have an increased signal-to-noise ratio (SNR), which increases the likelihood of successful decoding of the message at the receiving device. Such a mechanism is known as coverage enhancement (CE).

Coverage enhancement (CE) may have several levels. For example, it may provide one of 5 dB, 15 dB and 20 dB additional coverage enhancement. In NB-IoT, the CE levels may be referred to as the targeted MCL (Max Coupling Loss, the achievable coupling loss (accounting for, for example, path loss, feeder losses and/or antenna gains) between transmitter and receiver) of, for example, 144 dB, 154 dB and 164 dB (so that the higher the targeted MCL, the greater the additional coverage enhancement).

As previously mentioned, repetitions of a signal so that a receiver can accumulate energy of the signal over numerous repetitive samples is the basic method used for coverage enhancement. The number of repetitions required is dependent upon the CE level. Thus, a UE at a lower CE level, such as at 144 dB, MCL requires less repetition compared to one at a higher CE level, such as at 154 dB MCL. The power spectral density, PSD (mW/Hz) of a transmission also affects the number of repetitions required, that is, the larger the PSD, the less the required number of repetitions.

The NB-PDCCH (Narrow Band Physical Downlink Control Channel) is a control channel that is used to schedule downlink resources (downlink grant) and uplink resources (uplink grant) for a NB-PDSCH (Narrow Band Physical Downlink Shared Channel) and a NB-PUSCH (Narrow Band Physical Uplink Shared Channel) that carry data traffic. An NB-PDCCH search space consists of multiple NB-PDCCH candidates wherein each candidate has a specific starting time, set of subcarriers, a defined number of repetitions and an aggregation level (the aggregation level relating to the number of frequency resources occupied by the candidate such that when the candidate occupies a higher number of frequency resources, the aggregation level is higher, and when the candidate occupies a lower number of frequency resources, the aggregation level is lower). Candidates that have a larger number of repetitions and a higher aggregation level are more robust and can reach a UE at poorer coverage compared to candidates that have a smaller number of repetitions and a lower aggregation level.

The eNB uses one of the candidates in the search space to carry the NB-PDCCH. The UE is not aware which candidate is used and so it must blind decode all the candidates in the search space in order to find the candidate used by the eNB for the NB-PDCCH. An example of a typical NB-PDCCH search space is

shown in Figure 5. Here, the search space has 4 repetition levels {R1, R2, R3, R4} where R4 = 2×R3 = 4×R2 = 8×R1. It should be appreciated that an NB-PDCCH search space with other repetition levels is also possible. As an example the eNB can use any of the 15 candidates (labelled as C1 to C15) to carry the NB-PDCCH and the UE has to blind decode for all 15 candidates. The max repetition R_{MAX} (in Figure 5, R_{MAX} = R4) of the search space is assigned to the UE based on the UE's radio condition. Thus, for example, if the UE is in a poorer quality radio coverage location, then the eNB can configure a search space with a larger value of R_{MAX}, and if the UE is in a better quality radio coverage location, then the eNB can configure a search space with a smaller value of R_{MAX}. Typically, a set of NB-PDCCH search spaces is predefined in which each NB-PDCCH search space of the set consists of a set of candidates and a value of R_{MAX}. The UE is then assigned one NB-PDCCH search space in the set of NB-PDCCH search spaces. The maximum repetition R_{MAX} of an NB-PDCCH search space can be selected from the set of values {1, 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024, 2048}, for example.

In NB-IoT, paging is performed when a UE is in idle mode. More specifically, when in idle mode, the UE monitors an NB-PDCCH CSS (Common Search Space) which, in the case that a paging message is to be transmitted to the UE, contains an NB-PDCCH that schedules that paging message (the paging message being carried by an NB-PDSCH). In order to reduce power consumption, the UE monitors the NB-PDCCH CSS during each of a plurality of periodic Paging Occasions (PO) rather than constantly monitoring the NB-PDCCH CCS. The PO occurs periodically for a particular UE (or particular group of UEs), wherein the period is configured by the network, for example. In an embodiment, the network can configure multiple POs in which the specific PO that a UE monitors depends on an identifier of that that UE (UE-ID), for example, the UE's International Mobile Subscriber Identifity (IMSI). This enables the network to spread the paging load. For example in Figure 6, the eNB configures four POs where each PO has a period T_{PO}. The UE thus wakes up every T_{PO} ms to monitor for possible paging. The PO is assigned to the UE based on the UE's ID, using a **MOD** function of the number of POs, for example (thus, in the case of Figure 6, the PO assigned to a particular UE is given by UE_ID **MOD** 4).

As described previously, repetition of the paging CSS can reach 2048. A problem with this is that a PO can overlap another PO, causing confusion for UEs reading the PO. For example in Figure 7, two POs are configured. PO 1 begins at time t_1, where UE 1 belonging to this PO will start monitoring for NB-PDCCH in the paging CSS. This paging CSS ends at time t_3. If the repetition of NB-PDCCH is very long (for example, if the paging CSS ending at time t_3 has the structure shown in Figure 5, and the NB-PDDCH is received via the candidate C15 with the largest number of repetitions) , it will overlap into PO 2 at time t_2. At time t_2 UE 2 belonging to PO 2 will start monitoring for NB-PDCCH and will start to accumulate repetition samples from the NB-PDCCH intended for UE 1 (belong to PO 1). If UE 2 is in a better radio condition than UE 1, it may decode the NB-PDCCH and start to accumulate and decode the corresponding NB-PDSCH containing the paging message. UE 2 will not find any paging indication in

this paging message and would waste battery power accumulating and decoding the NB-PDSCH. This is because the paging message contains an identifier of each UE to be paged. If a paging message is not intended for UE 2, then the identifier of UE 2 will not be included in the paging message and thus UE 2 will not be paged. However, since UE 2 has received the NB-PDCCH during its paging occasion, it will still attempt to read the paging message scheduled by the NB-PDCCH by accumulating and decoding the NB-PDSCH, thus wasting battery power. It should be noted that the NB-PDSCH is also repeated.

It should also be appreciated that if the PO period T_{PO} is shorter than the NB-PDCCH repetition, the PO may overlap itself, as shown in an example in Figure 8, in which the NB-PDCCH for PO 1 starts at time t_1 but the repetition doesn't end till time t_4. It overlaps the next PO 1 at time t_3. In this scenario, the UE belonging to PO 1 is confused as to whether to continue accumulating samples from the previous PO 1 (started at time t_1) or start a new accumulation starting at time t_3. Furthermore, in an embodiment, the NB-PDSCH starting subframe is indicated in the downlink control information (DCI) of the NB-PDCCH, this NB-PDSCH starting subframe being defined relative to the end of the NB-PDCCH that schedules this NB-PDSCH. In order to determine the end of an NB-PDCCH transmission, the repetition of the NB-PDCCH is indicated in the DCI of that NB-PDCCH. For example, in Figure 5, if candidate C11 is used to carry the NB-PDCCH (including the DCI), then the NB-PDSCH scheduled by the NB-PDCCH will start at k subframes after time t_6 (t_6 marking the end of the NB-PDCCH carried by candidate C11) where k is indicated in the DCI. Since the UE can decode a message with less repetition when it has a good radio condition, however, the UE may decode C11 at time t_5 and mistake candidate C11 for candidate C5. The UE will thereby use the wrong reference point for the start of the NB-PDSCH. To avoid this, the repetition of the NB-PDCCH is indicated in the DCI so that the UE will not mistake candidate C11 for C5. However, this does not solve the problem shown in Figure 8 in which the search space overlaps itself. In this case, although the UE will know the repetition of the NB-PDCCH from the DCI information, the UE does not know whether the NP-PDCCH repetitions started at time t_1 or at time t_3. This causes confusion at the UE regarding the candidates.

In LTE Release-13 eMTC (enhanced Machine Type Communication), the POs are separated far apart so that they do not overlap. This is possible because the repetition used in this case is not as large as that used in NB-IoT. Furthermore, eMTC can use different narrowbands for different groups of UEs and avoid overlapping. In contrast, only the anchor NB-IoT can contain the paging CSS and paging message, and therefore problem of overlapping of the NB-PDCCH between different POs requires a new solution.

In an embodiment of the present technique, an indicator is used to distinguish one PO from another. The UE belonging to a PO then uses this indicator to determine whether the NB-PDCCH belongs to it or to another PO.

In one embodiment, the said indicator is a PO index in the DCI (carried by the NB-PDCCH). A new field in the DCI would indicate which PO the DCI (that is, the NB-PDCCH) belongs to. The UE, after accumulating the NB-PDCCH, will then decode the DCI and check the PO index to see whether it matches the PO that the UE belongs to.

In another embodiment, different versions of the same PO are also indicated in the DCI. This is to help overcome the issue of uncertainty at the UE regarding when the search space starts when a NB-PDCCH repetition is larger than the PO period T_{PO} (as described in Figure 8). For example, in Figure 8, PO 1 at time t_1 can be version 1 and PO 1 at time t_3 can be version 2, these versions being distinguishable from each other by the PO identifier in the DCI so the UE is clear where the search space starts. This helps to avoid confusion of the candidates in the search space.

In another embodiment the starting time of the CSS is indicated in the DCI. This is similar to indicating the PO index (which indirectly indicates the starting time of the CSS). After decoding the DCI, the UE will determine whether the starting time of the decoded NB-PDCCH belongs to the CSS that starts at its PO or another PO. If the CSS starts at a time belonging to another PO, the UE can discard the decoded DCI.

In another embodiment, a different P-RNTI (Paging Radio Network Temporary Identifier) is used for one or more of each respective PO and each respective PO version. The P-RNTI of each respective PO and/or each respective PO version can be signalled either explicitly or implicitly (that is, derived from a reference P-RNTI). For example, in the case that a different P-RNTI is used for each respective PO, the eNB may signal a single reference P-RNTI and PO 1 will use this P-RNTI, PO 2 will use this reference P-RNTI + 1, PO 3 will use P-RNTI + 2, and so on.

In another embodiment, a scrambling applied to the NB-PDCCH is dependent upon the PO. The UE then applies a descrambler depending upon which PO it belongs to. A different scrambling may be applied to each respective PO (so as to distinguish, for example, PO 1 from PO 2, but not distinguish between different versions of PO 1 or PO 2). Alternatively, or in addition, a different scrambling may be applied to each respective PO version (so that different versions of, for example, PO 1 or PO 2 may be distinguished from each other).

It will be appreciated that various features of these embodiments may be combined as appropriate. For example, it may be the case that each respective PO is distinguished by a different scrambling, but then each version of that PO is further distinguished in the DCI.

In another embodiment of the present technique, two or more different NB-PDCCH search spaces (that is, Common Search Spaces) are configured wherein at least one of these search spaces has max repetition $R1_{MAX}$ greater than the time between two adjacent POs T_S (thus potentially causing the overlapping issue described in Figure 7) whilst the remaining search spaces have max repetition $R2_{MAX}$ smaller than T_S. In this way the search space with $R1_{MAX}$ can be segmented and interleaved with search spaces with $R2_{MAX}$. An example is shown in Figure 9, where each PO is associated with one of two types of NB-PDCCH Common Search Space (CSS) with $R1_{MAX}$ and $R2_{MAX}$, respectively. CSS1 belongs to PO1, starts at time t_1 and has a max repetition of $R1_{MAX}$ where $R1_{MAX} > T_S$, (meaning that, if measures are not taken, then CSS1 will overlap with the adjacent PO (that is, PO2)). Using the method of an embodiment, CSS1 (belonging to the first version of PO1) is segmented into 3 segments, wherein the 1st segment starts at time t_1 and ends at time t_2. The 2nd segment occupies the time t_3 to t_4, which avoids overlapping CSS2 (belonging to the first version of PO2) between time t_2 and t_3. The 3rd segment occupies time t_5 to t_6, which avoids overlapping CSS3 (belonging to the second version of PO1) between time t_4 and t_5. The segments of CSS1 are therefore interleaved with CSS2 and CSS3. CSS3 and CSS4 belong to PO1 (the second and third versions of PO1, respectively) but with a smaller maximum repetition, that is, $R2_{MAX} < T_S$, and therefore do not overlap with any adjacent PO. CSS3 and CSS4 are thus not segmented. CSS5 belongs to PO2 (in particular, the second version of PO2), and since its max repetition is greater that T_S, it is segmented and interleaved in a similar manner as that for CSS1. The example in Figure 9 shows two types of CSS (that is, with two different max repetition values). However, it should be appreciated this method is also applicable for more than two different max repetition CSSs. Also, the segments of CSS1 can be interleaved using a different pattern, for example, interleaved with different CSSs such as CSS3 and CSS4 (as shown in Figure 10).

In an embodiment, different POs have different max CSS repetitions. For example, the CSS for PO1 may have repetition $R1_{MAX} > T_S$ whilst the CSS for PO2 may have max repetition $R2_{MAX} < T_S$. In this embodiment, the CSS for PO1 is segmented and interleaved with the un-segmented CSS for PO2.

In another embodiment, all CSSs have $R1_{MAX} > T_S$. Each CSS (with $R1_{MAX}$) is segmented and the segment occupies multiple POs. That is, the CSS is spread among multiple POs. An example is shown in Figure 11, where CSS1 (belonging to PO1) has $R1_{MAX} > T_S$ and is segmented into two segments. The first segment occupies time t_1 to t_2 and the 2nd segment occupies time t_4 to t_5. Similarly, CSS5 (belonging to PO2) has $R1_{MAX} > T_S$ and is segmented into two segments. The first segment occupies time t_2 to t_3 and the 2nd segment occupies time t_6 to t_7. It should be noted that the 2nd segment length of each of CSS1 and CSS2 is less than T_S in this example.

In another embodiment, the overlapping problem shown in Figure 8 can be overcome by ensuring the Paging Occasion period $T_{PO} >$ R1max. Note that this is easier to achieve than to ensure that $T_S > R1_{MAX}$,

since T_{PO} can be much larger than T_S (for example, up to 2560 subframes) and multiple different POs may fit within the T_{PO}.

In embodiments, the segments of the NB-PDCCH search space can be defined by a predetermined pattern, this pattern being configured by the network and, for example, transmitted to the UE 104 from the eNB 101 as system information (in the System Information Block (SIB), for example). In an embodiment, the pattern may vary depending on the number of repeats of the NB-PDCCH, an identifier of the CSS which is used, or any other parameter which the UE may discern from the CSS or NB-PDCCH. The relationship between the predetermined pattern and the CSS or NB-PDCCH may be determined and transmitted to the UE 104 by the eNB 101 and may be in the form of a lookup table of the like. In another embodiment, the pattern may be fixed for the set of paging occasions associated with the UE (again, information indicative of this fixed pattern may be determined and transmitted to the UE 104 by the eNB 101).

It will thus be appreciated that, in a first embodiment, the present technique provides a terminal device 104 for use with a wireless telecommunications network. The terminal device comprises a transceiver 401, 402 and a controller 403. The controller is operable to control the transceiver to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device (for example, the plurality of periodic paging occasions PO1 or PO2), a scheduling signal (carried by the NB-PDCCH, for example) scheduling a paging message for paging one or more terminal devices of the wireless telecommunications network. Each periodic paging occasion associated with the terminal device is associated with a value of a characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network. The controller is operable to determine whether the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device, and, if the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device, to control the transceiver to receive the paging message scheduled by the received scheduling message.

In one example, the characteristic of the scheduling signal is a paging occasion identifier identified by the scheduling signal. All periodic paging occasions associated with the terminal device may be associated with the same identifier of the scheduling signal (thus, for example, each paging occasion in the plurality of paging occasions PO1 may have the same index, each paging occasion in the plurality of paging occasions PO2 may have the same index, and so on). Alternatively, each periodic paging occasion

associated with the terminal device may be associated with an identifier of the scheduling signal which is different from the identifier of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device (thus, for example, each paging occasion in the plurality of paging occasions PO1 may have a version number which distinguishes it from the other paging occasions in the plurality PO1, each paging occasion in the plurality of paging occasions PO2 may have a version number which distinguishes it from the other paging occasions in the plurality PO1, and so on). Any suitable identifier may be used as the paging occasion identifier, including, for example, an identifier comprising one or more of a PO index, PO version number or P-RNTI number, as previously discussed.

In another example, the characteristic of the scheduling signal is a scrambling of the scheduling signal. All periodic paging occasions associated with the terminal device may be associated with the same scrambling of the scheduling signal (thus, for example, each paging occasion in the plurality of paging occasions PO1 may be associated with the same scrambling of the scheduling signal, each paging occasion in the plurality of paging occasions PO2 may be associated with the same scrambling of the scheduling signal, and so on). Alternatively, each periodic paging occasion associated with the terminal device may be associated with a scrambling of the scheduling signal which is different from the scrambling of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device (thus, for example, each paging occasion in the plurality of paging occasions PO1 may be associated with a different scrambling of the scheduling signal to the scrambling of the scheduling signal associated with the other paging occasions in the plurality PO1, each paging occasion in the plurality of paging occasions PO2 may be associated with a different scrambling of the scheduling signal to the scrambling of the scheduling signal associated with the other paging occasions in the plurality PO2, and so on).

In another example, the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate, and the controller is operable to control the transceiver to attempt to receive the scheduling signal from each candidate of the radio search space. For example, the radio search space may be a CSS and the scheduling signal may be the repeatedly transmitted NB-PDCCH. In this case the characteristic of the scheduling signal is a starting time of the radio search space indicated by the scheduling signal, and the controller is operable to determine, on the basis of the starting time of the radio search space and a starting time of the scheduling signal, whether the scheduling signal belongs to a radio search space with a starting time which matches the starting time of the one of the plurality of periodic paging occasions associated with the terminal device, wherein the controller determines a match when the scheduling signal is determined to belong to a radio search space

with a starting time which matches the starting time of the one of the plurality of periodic paging occasions associated with the terminal device.

In this first embodiment, the present technique also provides infrastructure equipment 101 for use with a wireless telecommunications network. The infrastructure equipment comprises a transceiver 411, 412 and a controller 413. The controller is operable to control the transceiver to begin transmitting, during the one of the plurality of periodic paging occasions associated with the terminal device 104, the scheduling signal scheduling the paging message for paging the terminal device in the way as described.

It will also be appreciated that, in a second embodiment, the present technique provides a terminal device 101for use with a wireless telecommunications network. The terminal device comprises a transceiver 401, 402 and a controller 403. The controller is operable to control the transceiver to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device (for example, the plurality of periodic paging occasions PO1 or PO2), a scheduling signal (carried by the NB-PDCCH, for example) scheduling a paging message for paging the terminal device. The scheduling signal is repeatedly transmitted by the network a predetermined number of times over a predetermined plurality of separate time periods (in other words, the periodic repeats of the scheduling signal are segmented, as shown in Figures 9 to 11, for example), each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin receiving the scheduling signal. The controller is operable to control the transceiver to receive the repetitions of the scheduling signal over the predetermined plurality of separate time periods.

In one example, the total time taken for the scheduling signal to be repeatedly transmitted by the network is greater than the time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated. Scheduling signals with a duration of that of CSS1 or CSS 5 (shown in Figures 9 to 11) are examples of such scheduling signals.

In one example, the plurality of periodic paging occasions associated with the terminal device are interleaved with the plurality of periodic paging occasions associated with any other terminal device of the wireless telecommunications network. This is shown, for example, in Figures 9 to 11, in which paging occasions belonging to the plurality PO1 are interleaved with paging occasions belonging to the plurality PO2.

In one example, the controller is operable to control the transceiver to receive a signal from the wireless telecommunications network indicative of the predetermined plurality of separate time periods. In this case, for example, information indicative of the predetermined plurality of separate time periods (in other words, the segmentation pattern of the repeatedly transmitted scheduling signal) is stored in the storage medium 422 of the infrastructure equipment 101 and is signalled to the terminal device 104 using the transceiver 411, 412. The transceiver 401, 402 of the terminal device then receives the signal and the information indicative of the predetermined plurality of separate time periods is stored in the storage medium 420.

In one example, the number of other terminal devices of the wireless telecommunications network with which a plurality of periodic paging occasions is associated is one or more, and the plurality of periodic paging occasions associated with the one or more other terminal devices is different to the plurality of periodic paging occasions associated with the terminal device. In this case, for example, there are at least two terminal devices in the wireless telecommunications network, wherein one terminal device is associated with the plurality of periodic paging occasions PO1 and the other terminal device is associated with the plurality of periodic paging occasions PO2, as shown in Figures 9 to 11. In another example, there may be no other terminal devices associated with a plurality of different periodic paging occasions (in which case, the only paging occasions present are those associated with the terminal device 104). It is noted that the present technique will still work in this case, in that if the terminal device knows the predetermined plurality of separate time periods over which the scheduling signal is repeatedly transmitted, the terminal device will know which paging occasion a particular set of repeats of the scheduling signal belongs to (thus avoiding the confusion arising from the situation shown in Figure 8, for example).

In this second embodiment, the present technique also provides infrastructure equipment 101 for use with a wireless telecommunications network. The infrastructure equipment comprises a transceiver 411, 412 and a controller 413. The controller is operable to control the transceiver to begin transmitting, during the one of the plurality of periodic paging occasions associated with a terminal device 104, the scheduling signal scheduling the paging message for paging the terminal device in the way as described.

Figure 12 illustrates a flow chart schematically showing a method according to the first embodiment of the present technique. The method starts at step 1201. At step 1202, the terminal device 104 begins receiving a scheduling signal during one of a plurality of periodic paging occasions associated with the terminal device. At step 1204, it is determined whether a value of a predetermined characteristic associated with each of the received scheduling signal and the one of the plurality of paging occasions matches. In the case that there is no match, the method ends at step 1208. On the other hand, in the case

that there is a match, the method moves on to step 1206, in which the terminal device receives a paging message scheduled by the scheduling signal. The method then ends at step 1208.

Figure 13 illustrates a flow chart schematically showing a method according to the second embodiment of the present technique. The method starts at step 1301. At step 1302, the terminal device 104 begins receiving a scheduling signal during one of a plurality of periodic paging occasions associated with the terminal device. At step 1303, the terminal device receives a predetermined number of repeats of the scheduling signal over a predetermined plurality of separate time periods. At step 1304, the terminal device receives a paging message scheduled by the scheduling signal. The method then ends at step 1305.

Features of various embodiments of the present technique are described by the following numbered clauses:

1. A terminal device for use with a wireless telecommunications network, the terminal device comprising:

a transceiver; and

a controller operable:

to control the transceiver to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging one or more terminal devices of the wireless telecommunications network, each periodic paging occasion associated with the terminal device being associated with a value of a characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network;

to determine whether the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device; and

if the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device, to control the transceiver to receive the paging message scheduled by the received scheduling message.

2. A terminal device according to clause 1, wherein the characteristic of the scheduling signal is a paging occasion identifier identified by the scheduling signal.

3. A terminal device according to clause 2, wherein all periodic paging occasions associated with the terminal device are associated with the same identifier of the scheduling signal.

4. A terminal device according to clause 2, wherein each periodic paging occasion associated with the terminal device is associated with an identifier of the scheduling signal which is different from the identifier of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device.

5. A terminal device according to clause 1, wherein the characteristic of the scheduling signal is a scrambling of the scheduling signal.

6. A terminal device according to clause 5, wherein all periodic paging occasions associated with the terminal device are associated with the same scrambling of the scheduling signal.

7. A terminal device according to clause 5, wherein each periodic paging occasion associated with the terminal device is associated with a scrambling of the scheduling signal which is different from the scrambling of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device.

8. A terminal device according to any preceding clause, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate, and wherein the controller is operable to control the transceiver to attempt to receive the scheduling signal from each candidate of the radio search space.

9. A terminal device according to clause 1, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate, and wherein the controller is operable to control the transceiver to attempt to receive the scheduling signal from each candidate of the radio search space, wherein the characteristic of the scheduling signal is a starting time of the radio search space indicated by the scheduling signal, and the controller is operable to determine, on the basis of the starting time of the radio search space and a starting time of the scheduling signal, whether the scheduling signal belongs to a radio search space with a starting time which matches the starting time of the one of the plurality of periodic paging occasions associated with the terminal device, wherein the controller determines a match when the scheduling signal is determined to belong to a

radio search space with a starting time which matches the starting time of the one of the plurality of periodic paging occasions associated with the terminal device.

10. A terminal device according to any preceding clause, wherein the terminal device is a Narrow Band Internet of Things (NB-IoT) terminal device and the scheduling signal is carried by a Narrow Band Physical Downlink Control Channel (NB-PDCCH).

11. Infrastructure equipment for use with a wireless telecommunications network, the infrastructure equipment comprising:

a transceiver; and

a controller operable:

to control the transceiver to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device, wherein a value of a characteristic of the scheduling signal is associated with the one of the plurality of periodic paging occasions associated with the terminal device, each periodic paging occasion associated with the terminal device being associated with a value of the characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network.

12. Infrastructure equipment according to clause 11, wherein the characteristic of the scheduling signal is a paging occasion identifier identified by the scheduling signal.

13. Infrastructure equipment according to clause 12, wherein all periodic paging occasions associated with the terminal device are associated with the same identifier of the scheduling signal.

14. Infrastructure equipment according to clause 12, wherein each periodic paging occasion associated with the terminal device is associated with an identifier of the scheduling signal which is different from the identifier of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device.

15. Infrastructure equipment according to clause 11, wherein the characteristic of the scheduling signal is a scrambling of the scheduling signal.

16. Infrastructure equipment according to clause 15, wherein all periodic paging occasions associated with the terminal device are associated with the same scrambling of the scheduling signal.

17. Infrastructure equipment according to clause 15, wherein each periodic paging occasion associated with the terminal device is associated with a scrambling of the scheduling signal which is different from the scrambling of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device.

18. Infrastructure equipment according to any one of clauses 11 to 17, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate.

19. Infrastructure equipment according to clause 11, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate, , wherein the characteristic of the scheduling signal is a starting time of the radio search space indicated by the scheduling signal, the starting time of the radio search space matching the starting time of the one of the plurality of periodic paging occasions associated with the terminal device.

20. Infrastructure equipment according to any one of clauses 11 to 19, wherein the terminal device is a Narrow Band Internet of Things (NB-IoT) terminal device and the scheduling signal is carried by a Narrow Band Physical Downlink Control Channel (NB-PDCCH).

21. A method of operating a terminal device for use with a wireless telecommunications network, the method comprising:

controlling a transceiver of the terminal device to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging one or more terminal devices of the wireless telecommunications network, each periodic paging occasion associated with the terminal device being associated with a value of a characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network;

determining whether the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device; and

if the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device, controlling the transceiver to receive the paging message scheduled by the received scheduling message.

22. A method of operating infrastructure equipment for use with a wireless telecommunications network, the method comprising:

controlling a transceiver of the infrastructure equipment to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device, wherein a value of a characteristic of the scheduling signal is associated with the one of the plurality of periodic paging occasions associated with the terminal device, each periodic paging occasion associated with the terminal device being associated with a value of the characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network.

23. Integrated circuitry for a terminal device for use with a wireless telecommunications network, the integrated circuitry comprising:

a transceiver element; and

a controller element operable:

to control the transceiver element to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging one or more terminal devices of the wireless telecommunications network, each periodic paging occasion associated with the terminal device being associated with a value of a characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network;

to determine whether the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device; and

if the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device, to control the transceiver element to receive the paging message scheduled by the received scheduling message.

24. Integrated circuitry for infrastructure equipment for use with a wireless telecommunications network, the integrated circuitry comprising:

a transceiver element; and

a controller element operable:

to control the transceiver element to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device, wherein a value of a characteristic of the scheduling signal is associated with the one of the plurality of periodic paging occasions associated with the terminal device, each periodic paging occasion associated with the terminal device being associated with a value of the characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network.

25. A wireless telecommunications network comprising a terminal device according to clause 1 and infrastructure equipment according to clause 11.

26. A terminal device for use with a wireless telecommunications network, the terminal device comprising:

a transceiver; and

a controller operable:

to control the transceiver to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the scheduling signal is repeatedly transmitted by the network a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin receiving the scheduling signal; and

the controller is operable to control the transceiver to receive the repetitions of the scheduling signal over the predetermined plurality of separate time periods.

27. A terminal device according to clause 26, wherein the total time taken for the scheduling signal to be repeatedly transmitted by the network is greater than the time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated.

28. A terminal device according to clause 26 or 27, wherein the plurality of periodic paging occasions associated with the terminal device are interleaved with the plurality of periodic paging occasions associated with any other terminal device of the wireless telecommunications network.

29. A terminal device according to any one of clauses 26 to 28, wherein the controller is operable to control the transceiver to receive a signal from the wireless telecommunications network indicative of the predetermined plurality of separate time periods.

30. A terminal device according to any one of clauses 26 to 29, wherein the number of other terminal devices of the wireless telecommunications network with which a plurality of periodic paging occasions is associated is one or more, and the plurality of periodic paging occasions associated with the one or more other terminal devices is different to the plurality of periodic paging occasions associated with the terminal device.

31. A terminal device according to any one of clauses 26 to 30, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate, and wherein the controller is operable to control the transceiver to attempt to receive the scheduling signal from each candidate of the radio search space.

32. A terminal device according to any one of clauses 26 to 31, wherein the terminal device is a Narrow Band Internet of Things (NB-IoT) terminal device and the scheduling signal is carried by a Narrow Band Physical Downlink Control Channel (NB-PDCCH).

33. Infrastructure equipment for use with a wireless telecommunications network, the infrastructure equipment comprising:

a transceiver; and

a controller operable:

to control the transceiver to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the controller is operable to control the transceiver to repeatedly transmit the scheduling signal a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin transmitting the scheduling signal.

34. Infrastructure equipment according to clause 33, wherein the total time taken for the scheduling signal to be repeatedly transmitted by the transceiver is greater than the time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated.

35. Infrastructure equipment according to clause 33 or 34, wherein the plurality of periodic paging occasions associated with the terminal device are interleaved with the plurality of periodic paging occasions associated with any other terminal device of the wireless telecommunications network.

36. Infrastructure equipment according to any one of claims 33 to 35, wherein the controller is operable to control the transceiver to transmit a signal to the terminal device indicative of the predetermined plurality of separate time periods.

37. Infrastructure equipment according to any one of clauses 33 to 36, wherein the number of other terminal devices of the wireless telecommunications network with which a plurality of periodic paging occasions is associated is one or more, and the plurality of periodic paging occasions associated with the one or more other terminal devices is different to the plurality of periodic paging occasions associated with the terminal device.

38. Infrastructure equipment according to any one of clauses 33 to 37, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate..

39. Infrastructure equipment according to any one of clauses 33 to 38, wherein the terminal device is a Narrow Band Internet of Things (NB-IoT) terminal device and the scheduling signal is carried by a Narrow Band Physical Downlink Control Channel (NB-PDCCH).

40. A method of operating a terminal device for use with a wireless telecommunications network, the method comprising:

controlling a transceiver of the terminal device to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the scheduling signal is repeatedly transmitted by the network a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin receiving the scheduling signal; and

transceiver is controlled to receive the repetitions of the scheduling signal over the predetermined plurality of separate time periods.

41. A method of operating infrastructure equipment for use with a wireless telecommunications network, the method comprising:

controlling a transceiver of the infrastructure equipment to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the transceiver is controlled to repeatedly transmit the scheduling signal a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin transmitting the scheduling signal.

42. Integrated circuitry for a terminal device for use with a wireless telecommunications network, the integrated circuitry comprising:

a transceiver element; and

a controller element operable:

to control the transceiver element to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the scheduling signal is repeatedly transmitted by the network a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver element is controlled to begin receiving the scheduling signal; and

the controller element is operable to control the transceiver element to receive the repetitions of the scheduling signal over the predetermined plurality of separate time periods.

43. Integrated circuitry for operating infrastructure equipment for use with a wireless telecommunications network, the integrated circuitry comprising:

a transceiver element; and

a controller element operable:

to control the transceiver element to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the controller element is operable to control the transceiver to repeatedly transmit the scheduling signal a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver element is controlled to begin transmitting the scheduling signal.

44. A wireless telecommunications network comprising a terminal device according to clause 26 and infrastructure equipment according to clause 33.

Numerous modifications and variations of the present disclosure are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the disclosure may be practiced otherwise than as specifically described herein.

In so far as embodiments of the disclosure have been described as being implemented, at least in part, by software-controlled data processing apparatus, it will be appreciated that a non-transitory machine-readable medium carrying such software, such as an optical disk, a magnetic disk, semiconductor memory or the like, is also considered to represent an embodiment of the present disclosure.

It will be appreciated that the above description for clarity has described embodiments with reference to different functional units, circuitry and/or processors. However, it will be apparent that any suitable distribution of functionality between different functional units, circuitry and/or processors may be used without detracting from the embodiments.

Described embodiments may be implemented in any suitable form including hardware, software, firmware or any combination of these. Described embodiments may optionally be implemented at least partly as computer software running on one or more data processors and/or digital signal processors. The elements and components of any embodiment may be physically, functionally and logically implemented in any suitable way. Indeed the functionality may be implemented in a single unit, in a plurality of units or as part of other functional units. As such, the disclosed embodiments may be implemented in a single unit or may be physically and functionally distributed between different units, circuitry and/or processors.

Although the present disclosure has been described in connection with some embodiments, it is not intended to be limited to the specific form set forth herein. Additionally, although a feature may appear to be described in connection with particular embodiments, one skilled in the art would recognize that various features of the described embodiments may be combined in any manner suitable to implement the technique.

Annex 1:

The simplified structure of the downlink of an LTE wireless access interface presented in Figure 2, also includes an illustration of each subframe 201, which comprises a control region 205 for the transmission of control data, a data region 206 for the transmission of user data , reference signals 207 and synchronisation signals which are interspersed in the control and data regions in accordance with a predetermined pattern. The control region 204 may contain a number of physical channels for the transmission of control data, such as a physical downlink control channel PDCCH, a physical control format indicator channel PCFICH and a physical HARQ indicator channel PHICH. The data region may contain a number of physical channel for the transmission of data, such as a physical downlink shared channel PDSCH and a physical broadcast channels PBCH. Although these physical channels provide a wide range of functionality to LTE systems, in terms of resource allocation and the present disclosure PDCCH and PDSCH are most relevant. Further information on the structure and functioning of the physical channels of LTE systems can be found in [1].

Resources within the PDSCH may be allocated by an eNodeB to UEs being served by the eNodeB. For example, a number of resource blocks of the PDSCH may be allocated to a UE in order that it may receive data that it has previously requested or data which is being pushed to it by the eNodeB, such as radio resource control RRC signalling. In Figure 2, UE1 has been allocated resources 208 of the data region 206, UE2 resources 209 and UE resources 210. UEs in a an LTE system may be allocated a fraction of the available resources of the PDSCH and therefore UEs are required to be informed of the location of their allocated resources within the PDCSH so that only relevant data within the PDSCH is detected and estimated. In order to inform the UEs of the location of their allocated communications resources, resource control information specifying downlink resource allocations is conveyed across the PDCCH in a form termed downlink control information DCI, where resource allocations for a PDSCH are communicated in a preceding PDCCH instance in the same subframe. During a resource allocation procedure, UEs thus monitor the PDCCH for DCI addressed to them and once such a DCI is detected, receive the DCI and detect and estimate the data from the relevant part of the PDSCH.

Each uplink subframe may include a plurality of different channels, for example a physical uplink shared channel PUSCH 305, a physical uplink control channel PUCCH 306, and a physical random access channel PRACH. The physical Uplink Control Channel PUCCH may carry control information such as ACK/NACK to the eNodeB for downlink transmissions, scheduling request indicators SRI for UEs wishing to be scheduled uplink resources, and feedback of downlink channel state information CSI for example. The PUSCH may carry UE uplink data or some uplink control data. Resources of the PUSCH are granted via PDCCH, such a grant being typically triggered by communicating to the network the amount of data ready to be transmitted in a buffer at the UE. The PRACH may be scheduled in any of the

resources of an uplink frame in accordance with a one of a plurality of PRACH patterns that may be signalled to UE in downlink signalling such as system information blocks. As well as physical uplink channels, uplink subframes may also include reference signals. For example, demodulation reference signals DMRS 307 and sounding reference signals SRS 308 may be present in an uplink subframe where the DMRS occupy the fourth symbol of a slot in which PUSCH is transmitted and are used for decoding of PUCCH and PUSCH data, and where SRS are used for uplink channel estimation at the eNodeB. Further information on the structure and functioning of the physical channels of LTE systems can be found in [1].

In an analogous manner to the resources of the PDSCH, resources of the PUSCH are required to be scheduled or granted by the serving eNodeB and thus if data is to be transmitted by a UE, resources of the PUSCH are required to be granted to the UE by the eNodeB. At a UE, PUSCH resource allocation is achieved by the transmission of a scheduling request or a buffer status report to its serving eNodeB. The scheduling request may be made, when there is insufficient uplink resource for the UE to send a buffer status report, via the transmission of Uplink Control Information UCI on the PUCCH when there is no existing PUSCH allocation for the UE, or by transmission directly on the PUSCH when there is an existing PUSCH allocation for the UE. In response to a scheduling request, the eNodeB is configured to allocate a portion of the PUSCH resource to the requesting UE sufficient for transferring a buffer status report and then inform the UE of the buffer status report resource allocation via a DCI in the PDCCH. Once or if the UE has PUSCH resource adequate to send a buffer status report, the buffer status report is sent to the eNodeB and gives the eNodeB information regarding the amount of data in an uplink buffer or buffers at the UE. After receiving the buffer status report, the eNodeB can allocate a portion of the PUSCH resources to the sending UE in order to transmit some of its buffered uplink data and then inform the UE of the resource allocation via a DCI in the PDCCH. For example, presuming a UE has a connection with the eNodeB, the UE will first transmit a PUSCH resource request in the PUCCH in the form of a UCI. The UE will then monitor the PDCCH for an appropriate DCI, extract the details of the PUSCH resource allocation, and transmit uplink data , at first comprising a buffer status report, and/or later comprising a portion of the buffered data, in the allocated resources.

Although similar in structure to downlink subframes, uplink subframes have a different control structure to downlink subframes, in particular the upper 309 and lower 310 subcarriers/frequencies/resource blocks of an uplink subframe are reserved for control signalling rather than the initial symbols of a downlink subframe. Furthermore, although the resource allocation procedure for the downlink and uplink are relatively similar, the actual structure of the resources that may be allocated may vary due to the different characteristics of the OFDM and SC-FDM interfaces that are used in the downlink and uplink respectively. In OFDM each subcarrier is individually modulated and therefore it is not necessary that frequency/subcarrier allocation are contiguous however, in SC-FDM subcarriers are modulation in

combination and therefore if efficient use of the available resources are to be made contiguous frequency allocations for each UE are preferable.

As a result of the above described wireless interface structure and operation, one or more UEs may communicate data to one another via a coordinating eNodeB, thus forming a conventional cellular telecommunications system. Although cellular communications system such as those based on the previously released LTE standards have been commercially successful, a number of disadvantages are associated with such centralised systems. For example, if two UEs which are in close proximity wish to communicate with each other, uplink and downlink resources sufficient to convey the data are required. Consequently, two portions of the system's resources are being used to convey a single portion of data. A second disadvantage is that an eNodeB is required if UEs, even when in close proximity, wish to communicate with one another. These limitations may be problematic when the system is experiencing high load or eNodeB coverage is not available, for instance in remote areas or when eNodeBs are not functioning correctly. Overcoming these limitations may increase both the capacity and efficiency of LTE networks but also lead to the creations of new revenue possibilities for LTE network operators.

References

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CLAIMS

1. A terminal device for use with a wireless telecommunications network, the terminal device comprising:

a transceiver; and

a controller operable:

to control the transceiver to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging one or more terminal devices of the wireless telecommunications network, each periodic paging occasion associated with the terminal device being associated with a value of a characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network;

to determine whether the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device; and

if the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device, to control the transceiver to receive the paging message scheduled by the received scheduling message.

2. A terminal device according to claim 1, wherein the characteristic of the scheduling signal is a paging occasion identifier identified by the scheduling signal.

3. A terminal device according to claim 2, wherein all periodic paging occasions associated with the terminal device are associated with the same identifier of the scheduling signal.

4. A terminal device according to claim 2, wherein each periodic paging occasion associated with the terminal device is associated with an identifier of the scheduling signal which is different from the identifier of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device.

5. A terminal device according to claim 1, wherein the characteristic of the scheduling signal is a scrambling of the scheduling signal.

6. A terminal device according to claim 5, wherein all periodic paging occasions associated with the terminal device are associated with the same scrambling of the scheduling signal.

7. A terminal device according to claim 5, wherein each periodic paging occasion associated with the terminal device is associated with a scrambling of the scheduling signal which is different from the scrambling of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device.

8. A terminal device according to claim 1, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate, and wherein the controller is operable to control the transceiver to attempt to receive the scheduling signal from each candidate of the radio search space.

9. A terminal device according to claim 1, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate, and wherein the controller is operable to control the transceiver to attempt to receive the scheduling signal from each candidate of the radio search space, wherein the characteristic of the scheduling signal is a starting time of the radio search space indicated by the scheduling signal, and the controller is operable to determine, on the basis of the starting time of the radio search space and a starting time of the scheduling signal, whether the scheduling signal belongs to a radio search space with a starting time which matches the starting time of the one of the plurality of periodic paging occasions associated with the terminal device, wherein the controller determines a match when the scheduling signal is determined to belong to a radio search space with a starting time which matches the starting time of the one of the plurality of periodic paging occasions associated with the terminal device.

10. A terminal device according to claim 1, wherein the terminal device is a Narrow Band Internet of Things (NB-IoT) terminal device and the scheduling signal is carried by a Narrow Band Physical Downlink Control Channel (NB-PDCCH).

11. Infrastructure equipment for use with a wireless telecommunications network, the infrastructure equipment comprising:

a transceiver; and

a controller operable:

to control the transceiver to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device, wherein a value of a characteristic of the scheduling signal is associated with the one of the plurality of periodic paging occasions associated with the terminal device, each periodic paging occasion associated with the terminal device being associated with a value of the characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network.

12. Infrastructure equipment according to claim 11, wherein the characteristic of the scheduling signal is a paging occasion identifier identified by the scheduling signal.

13. Infrastructure equipment according to claim 12, wherein all periodic paging occasions associated with the terminal device are associated with the same identifier of the scheduling signal.

14. Infrastructure equipment according to claim 12, wherein each periodic paging occasion associated with the terminal device is associated with an identifier of the scheduling signal which is different from the identifier of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device.

15. Infrastructure equipment according to claim 11, wherein the characteristic of the scheduling signal is a scrambling of the scheduling signal.

16. Infrastructure equipment according to claim 15, wherein all periodic paging occasions associated with the terminal device are associated with the same scrambling of the scheduling signal.

17. Infrastructure equipment according to claim 15, wherein each periodic paging occasion associated with the terminal device is associated with a scrambling of the scheduling signal which is different from the scrambling of the scheduling signal associated with each of the other periodic paging occasions associated with the terminal device.

18. Infrastructure equipment according to claim 11, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate.

19. Infrastructure equipment according to claim 11, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate, , wherein the characteristic of the scheduling signal is a starting time of the radio search space indicated by the scheduling signal, the starting time of the radio search space matching the starting time of the one of the plurality of periodic paging occasions associated with the terminal device.

20. Infrastructure equipment according to claim 11, wherein the terminal device is a Narrow Band Internet of Things (NB-IoT) terminal device and the scheduling signal is carried by a Narrow Band Physical Downlink Control Channel (NB-PDCCH).

21. A method of operating a terminal device for use with a wireless telecommunications network, the method comprising:

controlling a transceiver of the terminal device to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging one or more terminal devices of the wireless telecommunications network, each periodic paging occasion associated with the terminal device being associated with a value of a characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network;

determining whether the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device; and

if the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device, controlling the transceiver to receive the paging message scheduled by the received scheduling message.

22. A method of operating infrastructure equipment for use with a wireless telecommunications network, the method comprising:

controlling a transceiver of the infrastructure equipment to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device, wherein a value of a characteristic of the scheduling signal is associated with the one of the

plurality of periodic paging occasions associated with the terminal device, each periodic paging occasion associated with the terminal device being associated with a value of the characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network.

23. Integrated circuitry for a terminal device for use with a wireless telecommunications network, the integrated circuitry comprising:

a transceiver element; and

a controller element operable:

to control the transceiver element to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging one or more terminal devices of the wireless telecommunications network, each periodic paging occasion associated with the terminal device being associated with a value of a characteristic of the scheduling signal which is different from a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network;

to determine whether the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device; and

if the value of the characteristic of the received scheduling signal matches the value of the characteristic of the scheduling signal associated with the one of the plurality of periodic paging occasions associated with the terminal device, to control the transceiver element to receive the paging message scheduled by the received scheduling message.

24. Integrated circuitry for infrastructure equipment for use with a wireless telecommunications network, the integrated circuitry comprising:

a transceiver element; and

a controller element operable:

to control the transceiver element to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device, wherein a value of a characteristic of the scheduling signal is associated with the one of the plurality of periodic paging occasions associated with the terminal device, each periodic paging occasion associated with the terminal device being associated with a value of the characteristic of the scheduling signal which is different from

a value of the characteristic of the scheduling signal associated with one or more of each of the other periodic paging occasions associated with the terminal device and each of periodic paging occasions associated with one or more other terminal devices of the wireless telecommunications network.

25. A wireless telecommunications network comprising a terminal device according to claim 1 and infrastructure equipment according to claim 11.

26. A terminal device for use with a wireless telecommunications network, the terminal device comprising:

a transceiver; and

a controller operable:

to control the transceiver to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the scheduling signal is repeatedly transmitted by the network a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin receiving the scheduling signal; and

the controller is operable to control the transceiver to receive the repetitions of the scheduling signal over the predetermined plurality of separate time periods.

27. A terminal device according to claim 26, wherein the total time taken for the scheduling signal to be repeatedly transmitted by the network is greater than the time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated.

28. A terminal device according to claim 26, wherein the plurality of periodic paging occasions associated with the terminal device are interleaved with the plurality of periodic paging occasions associated with any other terminal device of the wireless telecommunications network.

29. A terminal device according to claim 26, wherein the controller is operable to control the transceiver to receive a signal from the wireless telecommunications network indicative of the predetermined plurality of separate time periods.

30. A terminal device according to claim 26, wherein the number of other terminal devices of the wireless telecommunications network with which a plurality of periodic paging occasions is associated is one or more, and the plurality of periodic paging occasions associated with the one or more other terminal devices is different to the plurality of periodic paging occasions associated with the terminal device.

31. A terminal device according to claim 26, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate, and wherein the controller is operable to control the transceiver to attempt to receive the scheduling signal from each candidate of the radio search space.

32. A terminal device according to claim 26, wherein the terminal device is a Narrow Band Internet of Things (NB-IoT) terminal device and the scheduling signal is carried by a Narrow Band Physical Downlink Control Channel (NB-PDCCH).

33. Infrastructure equipment for use with a wireless telecommunications network, the infrastructure equipment comprising:

a transceiver; and

a controller operable:

to control the transceiver to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the controller is operable to control the transceiver to repeatedly transmit the scheduling signal a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin transmitting the scheduling signal.

34. Infrastructure equipment according to claim 33, wherein the total time taken for the scheduling signal to be repeatedly transmitted by the transceiver is greater than the time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated.

35. Infrastructure equipment according to claim 33, wherein the plurality of periodic paging occasions associated with the terminal device are interleaved with the plurality of periodic paging occasions associated with any other terminal device of the wireless telecommunications network.

36. Infrastructure equipment according to claim 33, wherein the controller is operable to control the transceiver to transmit a signal to the terminal device indicative of the predetermined plurality of separate time periods.

37. Infrastructure equipment according to claim 33, wherein the number of other terminal devices of the wireless telecommunications network with which a plurality of periodic paging occasions is associated is one or more, and the plurality of periodic paging occasions associated with the one or more other terminal devices is different to the plurality of periodic paging occasions associated with the terminal device.

38. Infrastructure equipment according to claim 33, wherein the scheduling signal is transmitted using a candidate of a radio search space, the radio search space being defined by a plurality of candidates and each candidate of the radio search space being defined by a set of time and/or frequency radio resources for use in repeatedly transmitting the scheduling signal a number of times associated with that candidate..

39. Infrastructure equipment according to claim 33, wherein the terminal device is a Narrow Band Internet of Things (NB-IoT) terminal device and the scheduling signal is carried by a Narrow Band Physical Downlink Control Channel (NB-PDCCH).

40. A method of operating a terminal device for use with a wireless telecommunications network, the method comprising:

controlling a transceiver of the terminal device to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the scheduling signal is repeatedly transmitted by the network a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the

plurality of periodic paging occasions during which the transceiver is controlled to begin receiving the scheduling signal; and

transceiver is controlled to receive the repetitions of the scheduling signal over the predetermined plurality of separate time periods.

41. A method of operating infrastructure equipment for use with a wireless telecommunications network, the method comprising:

controlling a transceiver of the infrastructure equipment to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the transceiver is controlled to repeatedly transmit the scheduling signal a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver is controlled to begin transmitting the scheduling signal.

42. Integrated circuitry for a terminal device for use with a wireless telecommunications network, the integrated circuitry comprising:

a transceiver element; and

a controller element operable:

to control the transceiver element to begin receiving, during one of a plurality of periodic paging occasions associated with the terminal device, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the scheduling signal is repeatedly transmitted by the network a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver element is controlled to begin receiving the scheduling signal; and

the controller element is operable to control the transceiver element to receive the repetitions of the scheduling signal over the predetermined plurality of separate time periods.

43. Integrated circuitry for operating infrastructure equipment for use with a wireless telecommunications network, the integrated circuitry comprising:

a transceiver element; and

a controller element operable:

to control the transceiver element to begin transmitting, during one of a plurality of periodic paging occasions associated with a terminal device of the wireless telecommunications network, a scheduling signal scheduling a paging message for paging the terminal device; wherein

the controller element is operable to control the transceiver to repeatedly transmit the scheduling signal a predetermined number of times over a predetermined plurality of separate time periods, each of the separate time periods having a duration less than or equal to a time period between consecutive periodic paging occasions associated with the terminal device and with any other terminal device of the wireless telecommunications network with which a plurality of periodic paging occasions is associated, and one of the separate time periods being during a periodic paging occasion or between periodic paging occasions other than the one of the plurality of periodic paging occasions during which the transceiver element is controlled to begin transmitting the scheduling signal.

44. A wireless telecommunications network comprising a terminal device according to claim 26 and infrastructure equipment according to claim 33.

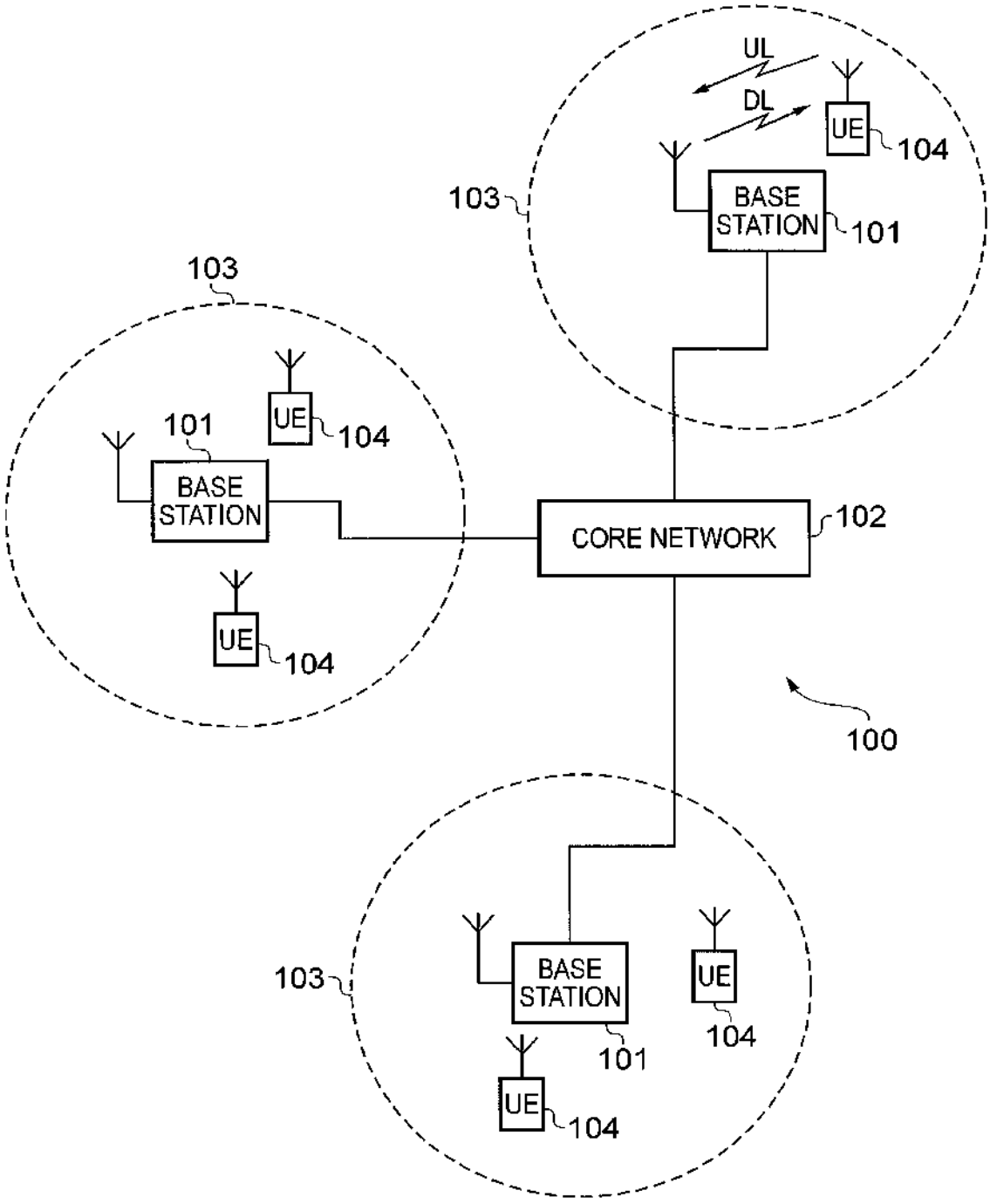

UL
DL
UE
104
103
BASE STATION
101
103
101
UE
104
BASE STATION
CORE NETWORK
102
UE
104
100
103
BASE STATION
UE
101
104
UE
104

FIG. 1

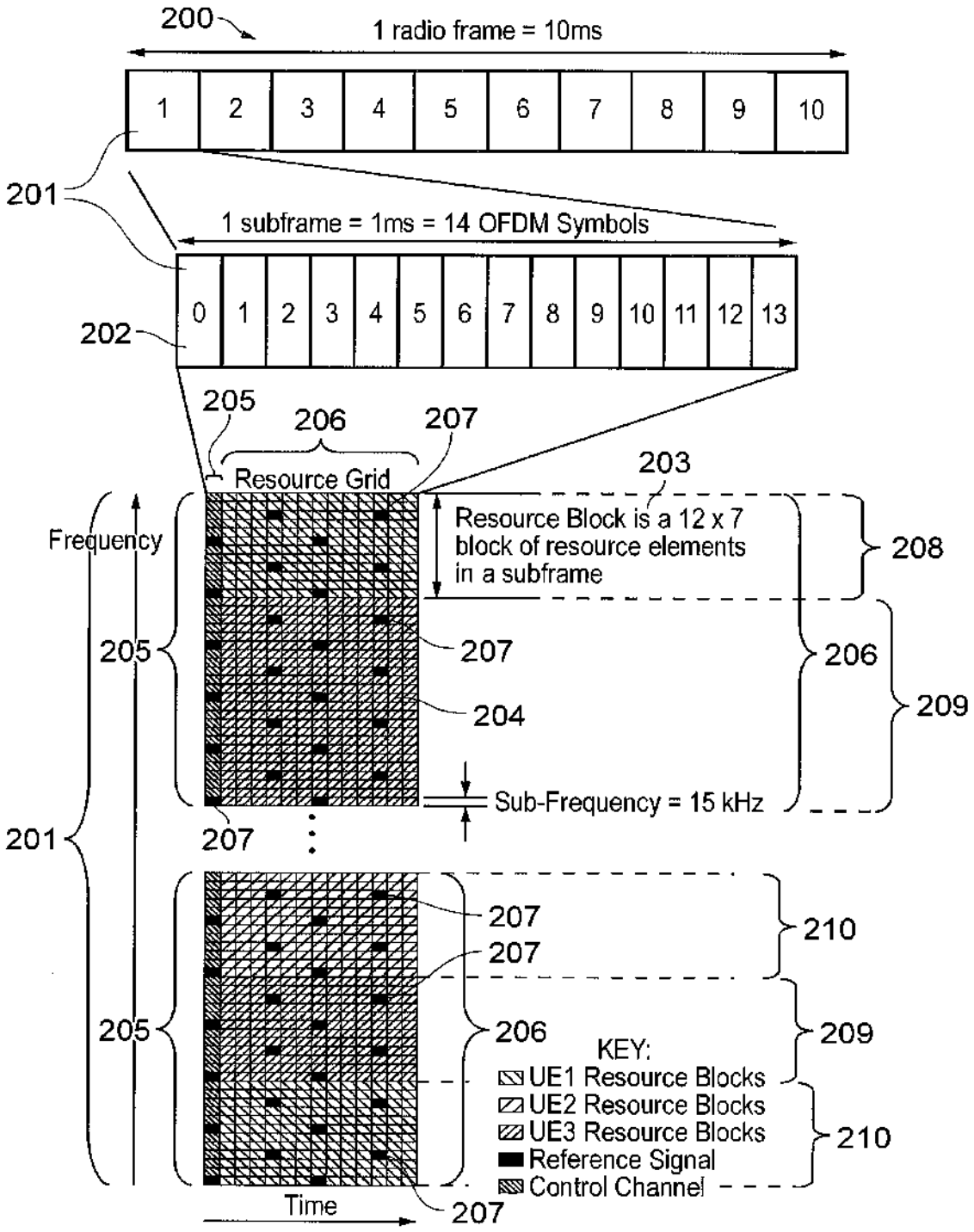

200
1 radio frame = 10ms
1
2
3
4
5
6
7
8
9
10
201
1 subframe = 1ms = 14 OFDM Symbols
0
1
2
3
4
5
6
7
8
9
10
11
12
13
202
205
206
207
Resource Grid
203
Frequency
Resource Block is a 12 x 7 block of resource elements in a subframe
208
205
207
206
209
204
Sub-Frequency = 15 kHz
201
207
207
207
210
205
206
209
KEY:
UE1 Resource Blocks
UE2 Resource Blocks
UE3 Resource Blocks
Reference Signal
Control Channel
210
Time
207

FIG. 2

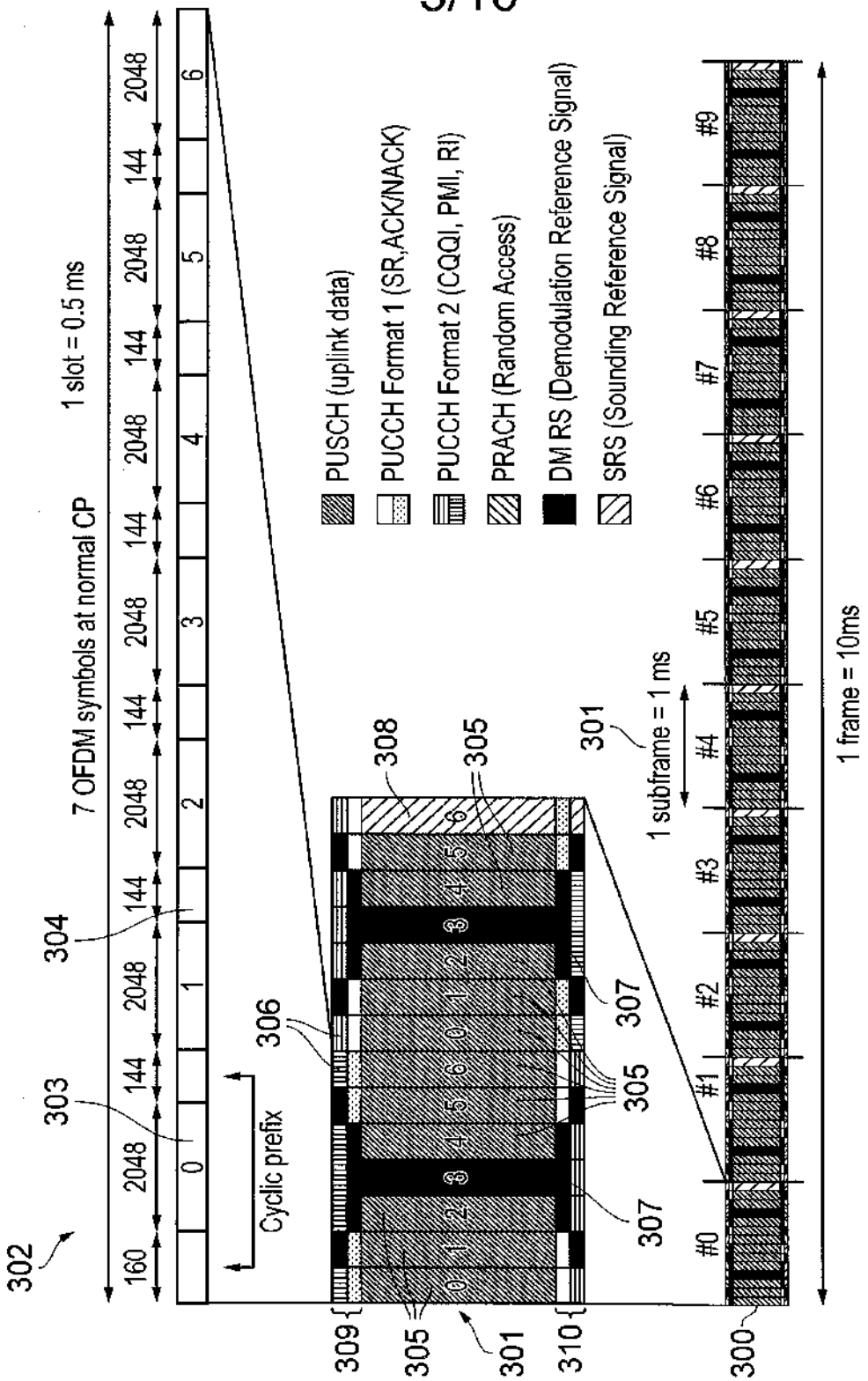

PUSCH (uplink data)
PUCCH Format 1 (SR,ACK/NACK)
PUCCH Format 2 (CQQI, PMI, RI)
PRACH (Random Access)
DM RS (Demodulation Reference Signal)
SRS (Sounding Reference Signal)
7 OFDM symbols at normal CP
1 slot = 0.5 ms
Cyclic prefix
1 subframe = 1 ms
1 frame = 10ms
160
2048
144
0
1
2
3
4
5
6
#0
#1
#2
#3
#4
#5
#6
#7
#8
#9
300
301
302
303
304
305
306
307
308
309
310

FIG. 3

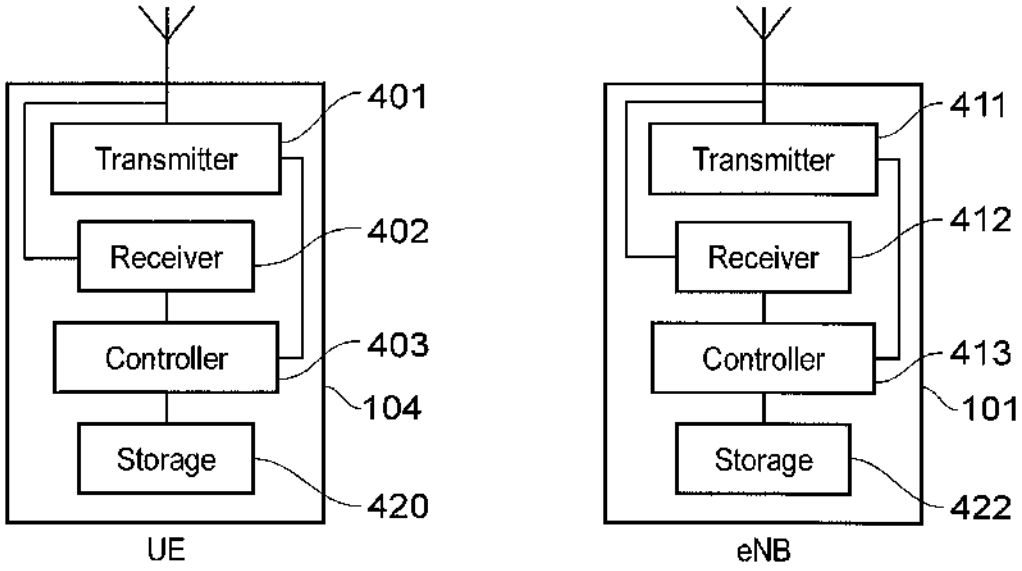

Transmitter
Receiver
Controller
Storage
401
402
403
104
420
UE
Transmitter
Receiver
Controller
Storage
411
412
413
101
422
eNB

FIG. 4

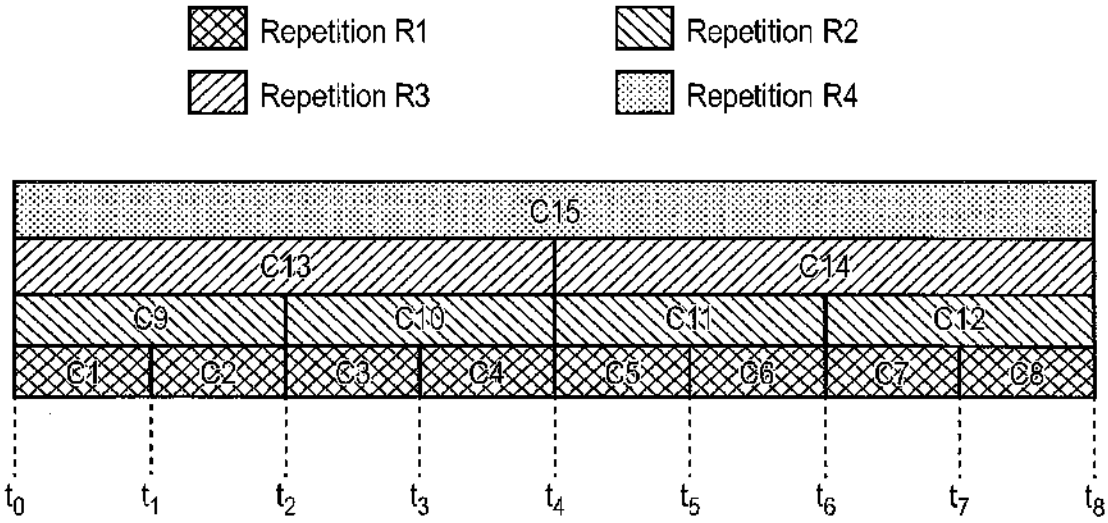

Repetition R1
Repetition R2
Repetition R3
Repetition R4
C15
C13
C14
C9
C10
C11
C12
C1
C2
C3
C4
C5
C6
C7
C8
t0
t1
t2
t3
t4
t5
t6
t7
t8

FIG. 5

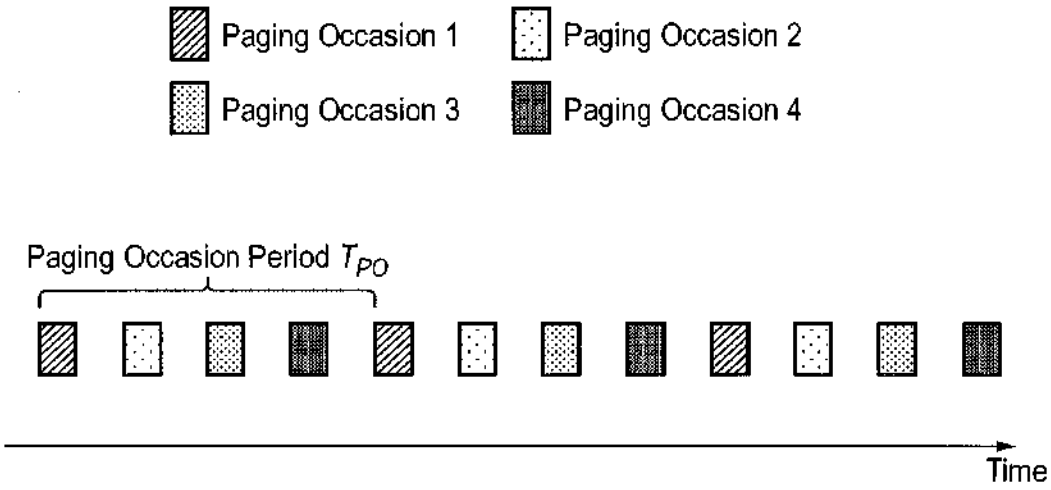

Paging Occasion 1
Paging Occasion 2
Paging Occasion 3
Paging Occasion 4
Paging Occasion Period T_{PO}
Time

FIG. 6

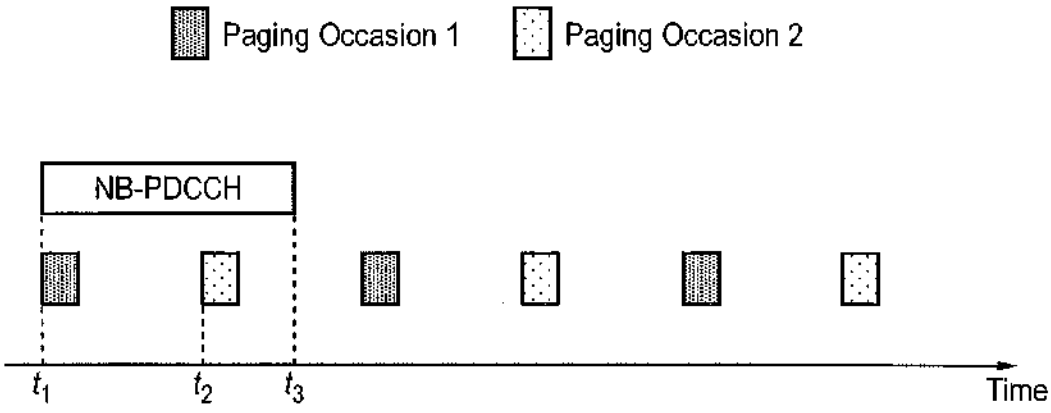

Paging Occasion 1
Paging Occasion 2
NB-PDCCH
t_1
t_2
t_3
Time

FIG. 7

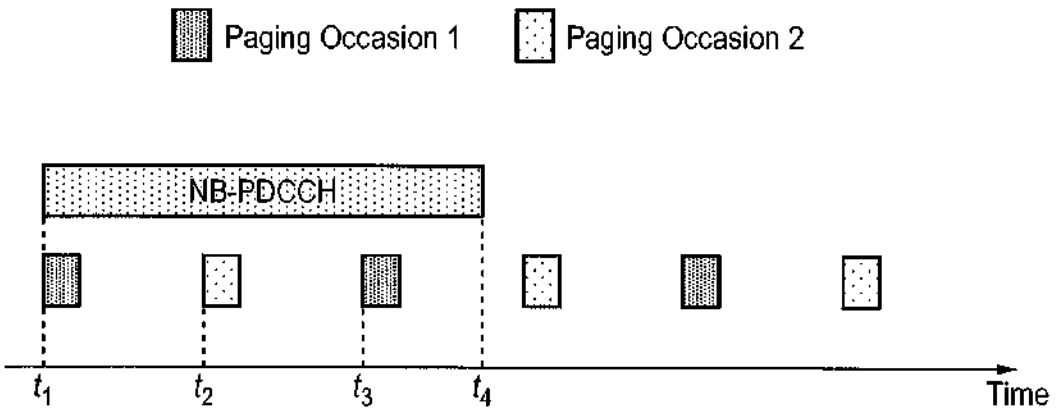

Paging Occasion 1
Paging Occasion 2
NB-PDCCH
t_1
t_2
t_3
t_4
Time

FIG. 8

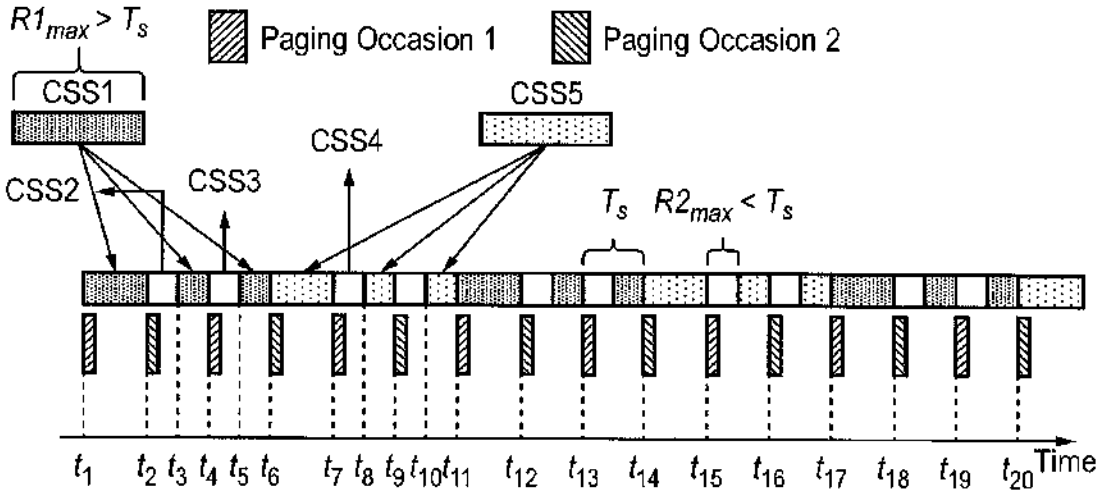

$R1_{max} > T_s$
Paging Occasion 1
Paging Occasion 2
CSS1
CSS5
CSS4
CSS2
CSS3
T_s
$R2_{max} < T_s$
t_1 t_2 t_3 t_4 t_5 t_6 t_7 t_8 t_9 t_{10} t_{11} t_{12} t_{13} t_{14} t_{15} t_{16} t_{17} t_{18} t_{19} t_{20}
Time

FIG. 9

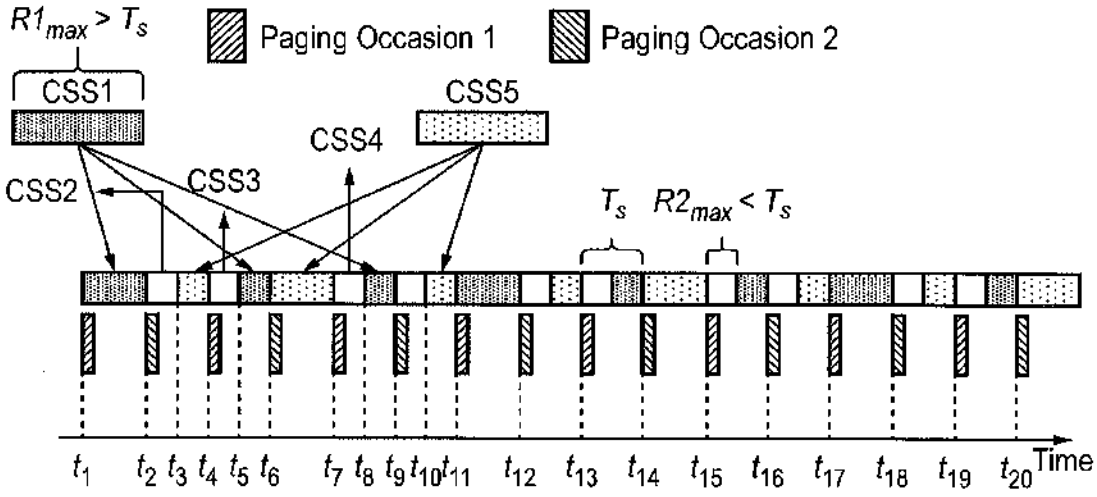

$R1_{max} > T_s$
Paging Occasion 1
Paging Occasion 2
CSS1
CSS5
CSS4
CSS2
CSS3
T_s
$R2_{max} < T_s$
t_1 t_2 t_3 t_4 t_5 t_6 t_7 t_8 t_9 t_{10} t_{11} t_{12} t_{13} t_{14} t_{15} t_{16} t_{17} t_{18} t_{19} t_{20} Time

FIG. 10

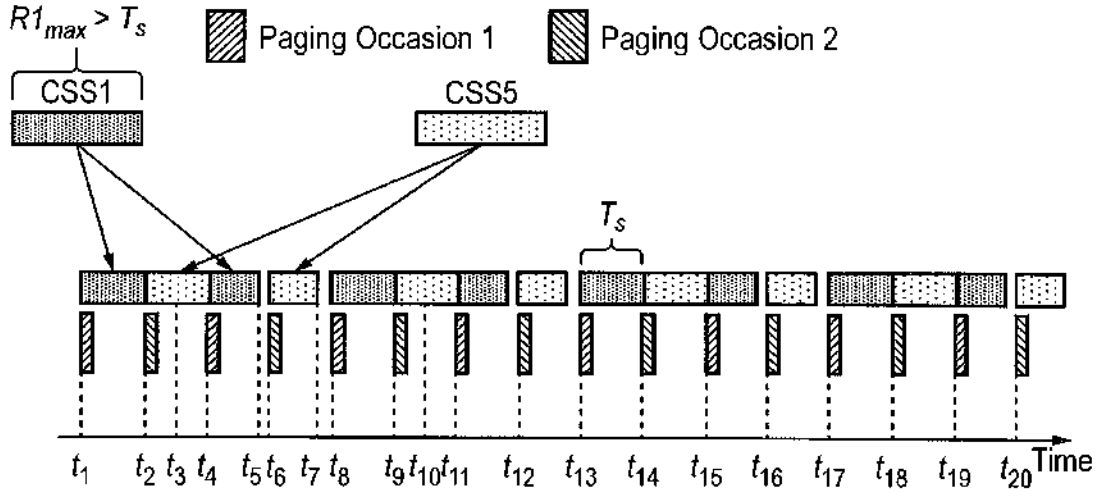

$R1_{max} > T_s$
Paging Occasion 1
Paging Occasion 2
CSS1
CSS5
T_s
t_1 t_2 t_3 t_4 t_5 t_6 t_7 t_8 t_9 t_{10} t_{11} t_{12} t_{13} t_{14} t_{15} t_{16} t_{17} t_{18} t_{19} t_{20} Time

FIG. 11

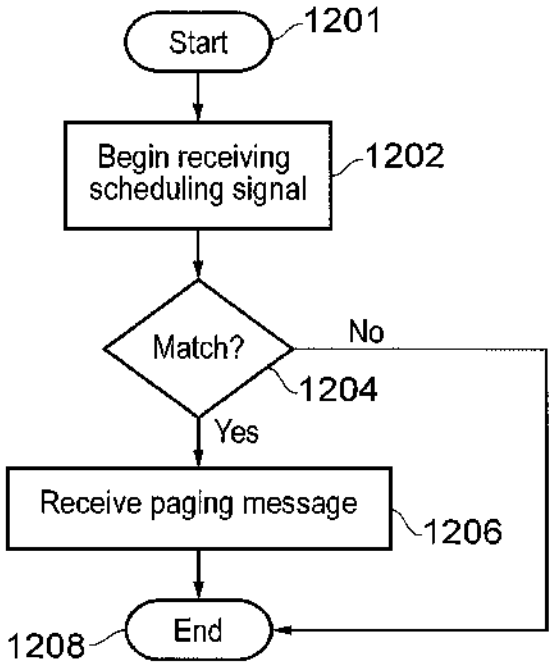

Start
1201
Begin receiving scheduling signal
1202
Match?
No
1204
Yes
Receive paging message
1206
End
1208

FIG. 12

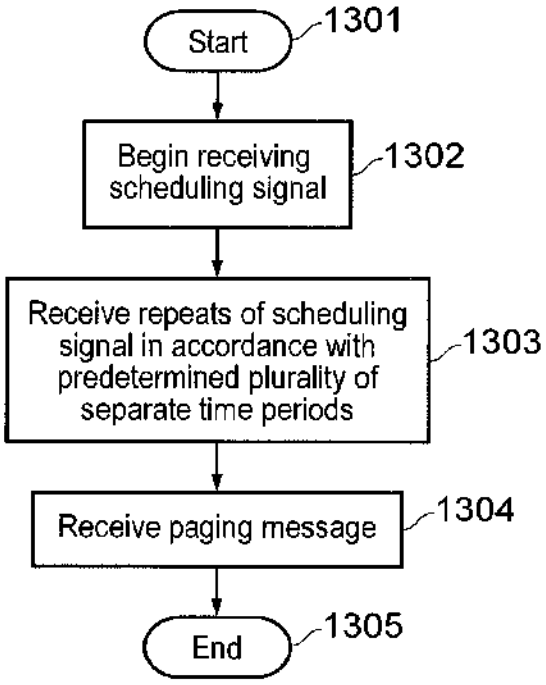

Start
1301
Begin receiving scheduling signal
1302
Receive repeats of scheduling signal in accordance with predetermined plurality of separate time periods
1303
Receive paging message
1304
End
1305

FIG. 13

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/057758

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W68/00
ADD. H04W4/00 H04W68/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 2 999 280 A2 (APPLE INC [US]) 23 March 2016 (2016-03-23) paragraphs [0100] - [0159] ----- -/--	1-25

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 July 2017	20/07/2017

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Bocking, Philip

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Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	ZTE: "Remaining Issues on NB-PDCCH Design of NB-IoT", 3GPP DRAFT; R1-160467 NB-PDCCH, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. St Julian's, Malta; 20160215 - 20160219 5 February 2016 (2016-02-05), XP051063789, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_84/Docs/ [retrieved on 2016-02-05] paragraphs [0004] - [05.2]; figures 4,7 -----	26-44
A	ERICSSON: "Paging and DRX in Idle mode in NB-IoT", 3GPP DRAFT; R2-161311 PAGING AND DRX IN IDLE MODE IN NB-IOT, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG2, no. St. Julian, Malta; 20160215 - 20160219 6 February 2016 (2016-02-06), XP051065779, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_93/Docs/ [retrieved on 2016-02-06] the whole document -----	1-44
A	ZTE: "Issues for PF/PO in NB-IOT", 3GPP DRAFT; R2-160411 ISSUES FOR PAGING IN NB-IOT-FINAL, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG2, no. Budapest, HU; 20160119 - 20160121 13 January 2016 (2016-01-13), XP051066437, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_AHs/2016_01_LTE_NB_IoT/Docs/ [retrieved on 2016-01-13] the whole document ----- -/--	1-44

2

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	INTEL CORPORATION: "Remaining open aspects on NBIOT Paging", 3GPP DRAFT; R2-160445_NB-IOT_PAGING_INTELV04, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG2, no. Budapest, HU; 20160119 - 20160121 18 January 2016 (2016-01-18), XP051054733, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN2/Docs/ [retrieved on 2016-01-18] the whole document -----	1-44
A	NOKIA NETWORKS: "Paging procedure for NB-IoT", 3GPP DRAFT; R2-160495 NB IOT PAGING PROCEDURE, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG2, no. Budapest, HU; 20160119 - 20160121 12 January 2016 (2016-01-12), XP051066428, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_AHs/2016_01_LTE_NB_IoT/Docs/ [retrieved on 2016-01-12] the whole document -----	1-44
A	ERICSSON: "Physical channels for paging in NB-IoT", 3GPP DRAFT; R2-160452 PHYSICAL CHANNELS FOR PAGING IN NB-IOT, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG2, no. Budapest, HU; 20160119 - 20160121 13 January 2016 (2016-01-13), XP051066469, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_AHs/2016_01_LTE_NB_IoT/Docs/ [retrieved on 2016-01-13] the whole document ----- -/--	1-44

2

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	ERICSSON: "NB-IoT - Paging", 3GPP DRAFT; R1-160084 - NB-IOT - PAGING, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. Budapest, HU; 20160118 - 20160120 12 January 2016 (2016-01-12), XP051064699, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_AH/LTE_NB-IoT_1601/Docs/ [retrieved on 2016-01-12] the whole document -----	1-44

2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2017/057758

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-25

   Identification of paging/scheduling signal for a given mobile terminal

   ---

2. claims: 26-44

   Avoiding interference for paging where paging signals are transmitted multiple times (Coverage Enhancement)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2017/057758

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 2999280 A2	23-03-2016	CN 105392197 A	09-03-2016
		EP 2999280 A2	23-03-2016
		JP 2016052127 A	11-04-2016
		US 2016066296 A1	03-03-2016
		US 2017135067 A1	11-05-2017

Form PCT/ISA/210 (patent family annex) (April 2005)

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
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(43) International Publication Date
30 March 2017 (30.03.2017)

WIPO | PCT

(10) International Publication Number
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(22) International Filing Date:
21 September 2016 (21.09.2016)

(25) Filing Language: English

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(30) Priority Data:
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62/251,759 6 November 2015 (06.11.2015) US

(71) Applicant: **LG ELECTRONICS INC.** [KR/KR]; 128, Yeoui-daero, Yeongdeungpo-gu, Seoul 07336 (KR).

(72) Inventors: **YOU, Hyangsun**; IP Center, LG Electronics Inc., 19, Yangjae-daero 11gil, Seocho-gu, Seoul 06772 (KR). **YI, Yunjung**; IP Center, LG Electronics Inc., 19, Yangjae-daero 11gil, Seocho-gu, Seoul 06772 (KR).

(74) Agents: **KIM, Yong In** et al.; KBK & Associates, 7th Floor, 82 Olympic-ro, Songpa-ku, Seoul 05556 (KR).

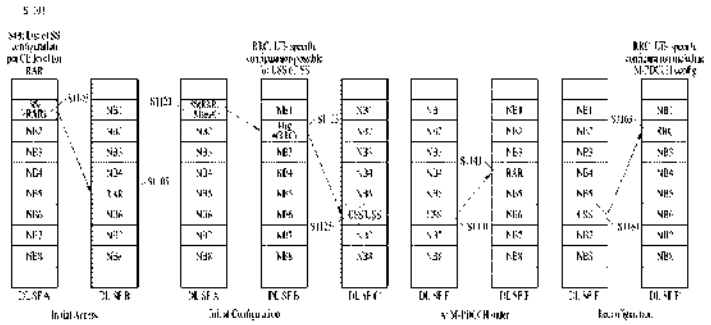
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(54) Title: METHOD AND USER EQUIPMENT FOR RECEIVING DOWNLINK CONTROL INFORMATION, AND METHOD AND BASE STATION FOR TRANSMITTING DOWNLINK CONTROL INFORMATION



(57) **Abstract:** A search space (hereinafter, CSS) for a control channel for scheduling a random access response may be configured by a system information block. A user equipment (UE) may attempt to receive a control channel for a random access response on the assumption that CSS is configured in accordance with a configuration based on the system information block. The UE may attempt to receive the control channel within a UE-specific search space (USS) by assuming that the USS is configured in accordance with the configuration of the CSS until a configuration for the USS is received.

WO 2017/052199 A1

Description

Title of Invention: METHOD AND USER EQUIPMENT FOR RECEIVING DOWNLINK CONTROL INFORMATION, AND METHOD AND BASE STATION FOR TRANSMITTING DOWNLINK CONTROL INFORMATION

Technical Field

[1] The present invention relates to a wireless communication system, and more particularly, to a method for transmitting or receiving downlink control information and a device therefor.

Background Art

[2] With appearance and spread of machine-to-machine (M2M) communication and a variety of devices such as smartphones and tablet PCs and technology demanding a large amount of data transmission, data throughput needed in a cellular network has rapidly increased. To satisfy such rapidly increasing data throughput, carrier aggregation technology, cognitive radio technology, etc. for efficiently employing more frequency bands and multiple input multiple output (MIMO) technology, multi-base station (BS) cooperation technology, etc. for raising data capacity transmitted on limited frequency resources have been developed.

[3] A general wireless communication system performs data transmission/reception through one downlink (DL) band and through one uplink (UL) band corresponding to the DL band (in case of a frequency division duplex (FDD) mode), or divides a prescribed radio frame into a UL time unit and a DL time unit in the time domain and then performs data transmission/reception through the UL/DL time unit (in case of a time division duplex (TDD) mode). A base station (BS) and a user equipment (UE) transmit and receive data and/or control information scheduled on a prescribed time unit basis, e.g. on a subframe basis. The data is transmitted and received through a data region configured in a UL/DL subframe and the control information is transmitted and received through a control region configured in the UL/DL subframe. To this end, various physical channels carrying radio signals are formed in the UL/DL subframe. In contrast, carrier aggregation technology serves to use a wider UL/DL bandwidth by aggregating a plurality of UL/DL frequency blocks in order to use a broader frequency band so that more signals relative to signals when a single carrier is used can be simultaneously processed.

[4] In addition, a communication environment has evolved into increasing density of nodes accessible by a user at the periphery of the nodes. A node refers to a fixed point

capable of transmitting/receiving a radio signal to/from the UE through one or more antennas. A communication system including high-density nodes may provide a better communication service to the UE through cooperation between the nodes.

Disclosure of Invention

Technical Problem

[5] Due to introduction of new radio communication technology, the number of user equipments (UEs) to which a BS should provide a service in a prescribed resource region increases and the amount of data and control information that the BS should transmit to the UEs increases. Since the amount of resources available to the BS for communication with the UE(s) is limited, a new method in which the BS efficiently receives/transmits uplink/downlink data and/or uplink/downlink control information using the limited radio resources is needed.

[6] The technical objects that can be achieved through the present invention are not limited to what has been particularly described hereinabove and other technical objects not described herein will be more clearly understood by persons skilled in the art from the following detailed description.

Solution to Problem

[7] A search space (hereinafter, CSS_RAR) for a control channel for scheduling a random access response may be configured by a system information block. A user equipment (UE) may attempt to receive a control channel for a random access response by assuming that CSS_RAR is configured in accordance with a configuration based on the system information block. If the UE receives the control channel for a random access response, the UE may receive the random access response to a random access preamble transmitted therefrom in accordance with control information carried by the control channel. The UE may attempt to receive a control channel within a UE-specific search space (hereinafter, USS) by assuming that the USS is configured in accordance with the configuration of the CSS until a configuration for the USS is received.

[8] In an aspect of the present invention, provided herein is a method for receiving, by a user equipment (UE), downlink control information (DCI) for the UE. The method comprises: receiving, by the UE, a common search space configuration for a common search space; receiving, by the UE, a first physical downlink control channel (PDCCH) scheduling a random access response; and receiving, by the UE, a second PDCCH carrying the DCI for the UE. The UE can monitor first PDCCH candidates of the common search space according to the common search space configuration in order to receive the first PDCCH. The UE can monitor second PDCCH candidates of a UE-specific search space in order to receive the second PDCCH. The UE can assume that configuration of the UE-specific search space is the same as that of the common search

space until the UE receives a UE-specific search space configuration.

[9] In another aspect of the present invention, provided herein is a method for transmitting, by a base station (BS), downlink control information (DCI) for a user equipment (UE). The method comprises: transmitting, by the BS, common search space configuration for a common search space; transmitting, by the BS to the UE, a first physical downlink control channel (PDCCH) scheduling a random access response; and transmitting, by the BS to the UE, a second PDCCH carrying the DCI for the UE. The BS can transmit the first PDCCH by using one of first PDCCH candidates of the common search space according to the common search space configuration. The BS can transmit the second PDCCH by using one of second PDCCH candidates of a UE-specific search space. The BS can configure the UE-specific search space according to the same configuration as the common search space configuration until the BS transmits a UE-specific search space configuration to the UE.

[10] In still another aspect of the present invention, provided herein a user equipment (UE) for receiving downlink control information (DCI) for the UE. The UE comprises a radio frequency (RF) unit and a processor connected to the RF unit. The processor can be configured to control the RF unit to receive common search space configuration for a common search space; control the RF unit to receive a first physical downlink control channel (PDCCH) scheduling a random access response; and control the RF unit to receive a second PDCCH carrying the DCI for the UE. The processor can be configured to monitor first PDCCH candidates of the common search space according to the common search space configuration in order to detect the firs PDCCH. The processor can be configured to monitor second PDCCH candidates of a UE-specific search space in order to detect the second PDCCH. The processor can be configured to assume that configuration of the UE-specific search space is the same as that of the common search space until the UE receives a UE-specific search space configuration.

[11] In a further aspect of the present invention, provided herein a base station (BS) for transmitting downlink control information (DCI) for a user equipment (UE). The BS comprises a radio frequency (RF) unit and a processor connected to the RF unit. The processor can be configured to control the RF unit to transmit common search space configuration for a common search space; control the RF unit to transmit a first physical downlink control channel (PDCCH) scheduling a random access response; and control the RF unit to transmit a second PDCCH carrying the DCI for the UE. The processor can be configured to control the RF unit to transmit the first PDCCH using one of first PDCCH candidates of the common search space according to the common search space configuration. The processor can be configured to control the RF unit to transmit the second PDCCH using one of second PDCCH candidates of a UE-specific search space. The processor can configure the UE-specific search space according to

the same as that of the common search space until the BS transmits a UE-specific search space configuration.

[12] In each aspect of the present invention, the common search space configuration can include information on a narrowband for the common search space. The second PDCCH candidates of the UE-specific search space can be configured on the same narrowband as the narrowband for the common search space until the UE-specific search space configuration is transmitted to the UE.

[13] In each aspect of the present invention, the common search space configuration can include information on a maximum number of repetitions for the first common search space. The second PDCCH candidates of the UE-specific search space can be configured based on the same number as the maximum number of repetitions for the common search space until the UE-specific search space configuration is transmitted to the UE.

[14] In each aspect of the present invention, the common search space configuration can include information on a first physical resource block (PRB) set for transmitting the first PDCCH. The same physical resource block set as the first PRB set can be used for the second PDCCH candidates until the UE-specific search space configuration is transmitted to the UE

[15] In each aspect of the present invention, the first PDCCH candidates of the common search space can be configured according to aggregation levels larger than or equal to 8 among a plurality of aggregation levels, whereas the second PDCCH candidates of the UE-specific search space can be configured according to the plurality of aggregation levels.

[16] In each aspect of the present invention, the UE can transmit a random access preamble using a physical random access channel (PRACH) resource. The UE can monitor the first PDCCH candidates in response to transmission of the random access preamble. The UE can receive the random access response according to control information carried by the first PDCCH. The BS can receive a random access preamble using a physical random access channel (PRACH) resource. The BS can transmit the first PDCCH in response to reception of the random access preamble. The BS can transmit the random access response according to control information carried by the first PDCCH.

[17] The above technical solutions are merely some parts of the embodiments of the present invention and various embodiments into which the technical features of the present invention are incorporated can be derived and understood by persons skilled in the art from the following detailed description of the present invention.

Advantageous Effects of Invention

[18] According to the present invention, uplink/downlink signals can be efficiently transmitted/received. Therefore, overall throughput of a radio communication system can be improved.

[19] According to one embodiment of the present invention, a low cost/complexity UE can perform communication with a BS at low cost while maintaining compatibility with a legacy system.

[20] According to one embodiment of the present invention, the UE can be implemented at low cost/complexity.

[21] According to one embodiment of the present invention, coverage can be enhanced.

[22] According to one embodiment of the present invention, the UE and the BS can perform communication with each other at a narrowband.

[23] It will be appreciated by persons skilled in the art that that the effects that can be achieved through the present invention are not limited to what has been particularly described hereinabove and other advantages of the present invention will be more clearly understood from the following detailed description.

Brief Description of Drawings

[24] The accompanying drawings, which are included to provide a further understanding of the invention, illustrate embodiments of the invention and together with the description serve to explain the principle of the invention.

[25] FIG. 1 illustrates the structure of a radio frame used in a wireless communication system.

[26] FIG. 2 illustrates the structure of a downlink (DL)/uplink (UL) slot in a wireless communication system.

[27] FIG. 3 illustrates a radio frame structure for transmission of a synchronization signal (SS).

[28] FIG. 4 illustrates the structure of a DL subframe used in a wireless communication system.

[29] FIG. 5 illustrates the structure of a UL subframe used in a wireless communication system.

[30] FIG. 6 illustrates an example of a signal band for MTC.

[31] FIG. 7 illustrates repeated transmission of a channel for coverage enhancement.

[32] FIG. 8 illustrates a configuration of a common search space (CSS) for paging according to the present invention.

[33] FIG. 9 illustrates a configuration of a common search space (CSS) for random access response (RAR) according to the present invention.

[34] FIG. 10 illustrates the example of the monitoring time region of USS and CSS.

[35] FIG. 11 illustrates a procedure of configuring a search space according to the present

invention.

[36] FIG. 12 illustrates a configuration of M-PDCCH repeated transmission according to the present invention.

[37] FIG. 13 is a block diagram illustrating elements of a transmitting device 10 and a receiving device 20 for implementing the present invention.

Mode for the Invention

[38] Reference will now be made in detail to the exemplary embodiments of the present invention, examples of which are illustrated in the accompanying drawings. The detailed description, which will be given below with reference to the accompanying drawings, is intended to explain exemplary embodiments of the present invention, rather than to show the only embodiments that can be implemented according to the invention. The following detailed description includes specific details in order to provide a thorough understanding of the present invention. However, it will be apparent to those skilled in the art that the present invention may be practiced without such specific details.

[39] In some instances, known structures and devices are omitted or are shown in block diagram form, focusing on important features of the structures and devices, so as not to obscure the concept of the present invention. The same reference numbers will be used throughout this specification to refer to the same or like parts.

[40] The following techniques, apparatuses, and systems may be applied to a variety of wireless multiple access systems. Examples of the multiple access systems include a code division multiple access (CDMA) system, a frequency division multiple access (FDMA) system, a time division multiple access (TDMA) system, an orthogonal frequency division multiple access (OFDMA) system, a single carrier frequency division multiple access (SC-FDMA) system, and a multicarrier frequency division multiple access (MC-FDMA) system. CDMA may be embodied through radio technology such as universal terrestrial radio access (UTRA) or CDMA2000. TDMA may be embodied through radio technology such as global system for mobile communications (GSM), general packet radio service (GPRS), or enhanced data rates for GSM evolution (EDGE). OFDMA may be embodied through radio technology such as institute of electrical and electronics engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20, or evolved UTRA (E-UTRA). UTRA is a part of a universal mobile telecommunications system (UMTS). 3rd generation partnership project (3GPP) long term evolution (LTE) is a part of evolved UMTS (E-UMTS) using E-UTRA. 3GPP LTE employs OFDMA in DL and SC-FDMA in UL. LTE-advanced (LTE-A) is an evolved version of 3GPP LTE. For convenience of description, it is assumed that the present invention is applied to 3GPP LTE/LTE-A. However, the

technical features of the present invention are not limited thereto. For example, although the following detailed description is given based on a mobile communication system corresponding to a 3GPP LTE/LTE-A system, aspects of the present invention that are not specific to 3GPP LTE/LTE-A are applicable to other mobile communication systems.

[41] For example, the present invention is applicable to contention based communication such as Wi-Fi as well as non-contention based communication as in the 3GPP LTE/LTE-A system in which an eNB allocates a DL/UL time/frequency resource to a UE and the UE receives a DL signal and transmits a UL signal according to resource allocation of the eNB. In a non-contention based communication scheme, an access point (AP) or a control node for controlling the AP allocates a resource for communication between the UE and the AP, whereas, in a contention based communication scheme, a communication resource is occupied through contention between UEs which desire to access the AP. The contention based communication scheme will now be described in brief. One type of the contention based communication scheme is carrier sense multiple access (CSMA). CSMA refers to a probabilistic media access control (MAC) protocol for confirming, before a node or a communication device transmits traffic on a shared transmission medium (also called a shared channel) such as a frequency band, that there is no other traffic on the same shared transmission medium. In CSMA, a transmitting device determines whether another transmission is being performed before attempting to transmit traffic to a receiving device. In other words, the transmitting device attempts to detect presence of a carrier from another transmitting device before attempting to perform transmission. Upon sensing the carrier, the transmitting device waits for another transmission device which is performing transmission to finish transmission, before performing transmission thereof. Consequently, CSMA can be a communication scheme based on the principle of "sense before transmit" or "listen before talk". A scheme for avoiding collision between transmitting devices in the contention based communication system using CSMA includes carrier sense multiple access with collision detection (CSMA/CD) and/or carrier sense multiple access with collision avoidance (CSMA/CA). CSMA/CD is a collision detection scheme in a wired local area network (LAN) environment. In CSMA/CD, a personal computer (PC) or a server which desires to perform communication in an Ethernet environment first confirms whether communication occurs on a network and, if another device carries data on the network, the PC or the server waits and then transmits data. That is, when two or more users (e.g. PCs, UEs, etc.) simultaneously transmit data, collision occurs between simultaneous transmission and CSMA/CD is a scheme for flexibly transmitting data by monitoring collision. A transmitting device using CSMA/CD adjusts data transmission thereof by sensing data transmission performed by another

device using a specific rule. CSMA/CA is a MAC protocol specified in IEEE 802.11 standards. A wireless LAN (WLAN) system conforming to IEEE 802.11 standards does not use CSMA/CD which has been used in IEEE 802.3 standards and uses CA, i.e. a collision avoidance scheme. Transmission devices always sense carrier of a network and, if the network is empty, the transmission devices wait for determined time according to locations thereof registered in a list and then transmit data. Various methods are used to determine priority of the transmission devices in the list and to re-configure priority. In a system according to some versions of IEEE 802.11 standards, collision may occur and, in this case, a collision sensing procedure is performed. A transmission device using CSMA/CA avoids collision between data transmission thereof and data transmission of another transmission device using a specific rule.

[42] In the present invention, a user equipment (UE) may be a fixed or mobile device. Examples of the UE include various devices that transmit and receive user data and/or various kinds of control information to and from a base station (BS). The UE may be referred to as a terminal equipment (TE), a mobile station (MS), a mobile terminal (MT), a user terminal (UT), a subscriber station (SS), a wireless device, a personal digital assistant (PDA), a wireless modem, a handheld device, etc. In addition, in the present invention, a BS generally refers to a fixed station that performs communication with a UE and/or another BS, and exchanges various kinds of data and control information with the UE and another BS. The BS may be referred to as an advanced base station (ABS), a node-B (NB), an evolved node-B (eNB), a base transceiver system (BTS), an access point (AP), a processing server (PS), etc. In describing the present invention, a BS will be referred to as an eNB.

[43] In the present invention, a node refers to a fixed point capable of transmitting/receiving a radio signal through communication with a UE. Various types of eNBs may be used as nodes irrespective of the terms thereof. For example, a BS, a node B (NB), an e-node B (eNB), a pico-cell eNB (PeNB), a home eNB (HeNB), a relay, a repeater, etc. may be a node. In addition, the node may not be an eNB. For example, the node may be a radio remote head (RRH) or a radio remote unit (RRU). The RRH or RRU generally has a lower power level than a power level of an eNB. Since the RRH or RRU (hereinafter, RRH/RRU) is generally connected to the eNB through a dedicated line such as an optical cable, cooperative communication between RRH/RRU and the eNB can be smoothly performed in comparison with cooperative communication between eNBs connected by a radio line. At least one antenna is installed per node. The antenna may mean a physical antenna or mean an antenna port, a virtual antennIn the present invention, a cell refers to a prescribed geographical area to which one or more nodes provide a communication service. Accordingly, in the present invention, communicating with a specific cell may mean communicating with an eNB

or a node which provides a communication service to the specific cell. In addition, a DL/UL signal of a specific cell refers to a DL/UL signal from/to an eNB or a node which provides a communication service to the specific cell. A node providing UL/DL communication services to a UE is called a serving node and a cell to which UL/DL communication services are provided by the serving node is especially called a serving cell. Furthermore, channel status/quality of a specific cell refers to channel status/ quality of a channel or communication link formed between an eNB or node which provides a communication service to the specific cell and a UE. The UE may measure DL channel state received from a specific node using cell-specific reference signal(s) (CRS(s)) transmitted on a CRS resource and/or channel state information reference signal(s) (CSI-RS(s)) transmitted on a CSI-RS resource, allocated by antenna port(s) of the specific node to the specific node. Detailed CSI-RS configuration may be understood with reference to 3GPP TS 36.211 and 3GPP TS 36.331 documents.

[44] Meanwhile, a 3GPP LTE/LTE-A system uses the concept of a cell in order to manage radio resources and a cell associated with the radio resources is distinguished from a cell of a geographic region.

[45] A "cell" of a geographic region may be understood as coverage within which a node can provide service using a carrier and a "cell" of a radio resource is associated with bandwidth (BW) which is a frequency range configured by the carrier. Since DL coverage, which is a range within which the node is capable of transmitting a valid signal, and UL coverage, which is a range within which the node is capable of receiving the valid signal from the UE, depends upon a carrier carrying the signal, the coverage of the node may be associated with coverage of the "cell" of a radio resource used by the node. Accordingly, the term "cell" may be used to indicate service coverage of the node sometimes, a radio resource at other times, or a range that a signal using a radio resource can reach with valid strength at other times. The "cell" of the radio resource will be described later in more detail.

[46] 3GPP LTE/LTE-A standards define DL physical channels corresponding to resource elements carrying information derived from a higher layer and DL physical signals corresponding to resource elements which are used by a physical layer but which do not carry information derived from a higher layer. For example, a physical downlink shared channel (PDSCH), a physical broadcast channel (PBCH), a physical multicast channel (PMCH), a physical control format indicator channel (PCFICH), a physical downlink control channel (PDCCH), and a physical hybrid ARQ indicator channel (PHICH) are defined as the DL physical channels, and a reference signal and a synchronization signal are defined as the DL physical signals. A reference signal (RS), also called a pilot, refers to a special waveform of a predefined signal known to both a BS and a UE. For example, a cell-specific RS (CRS), a UE-specific RS (UE-RS), a po-

sitioning RS (PRS), and channel state information RS (CSI-RS) may be defined as DL RSs. Meanwhile, the 3GPP LTE/LTE-A standards define UL physical channels corresponding to resource elements carrying information derived from a higher layer and UL physical signals corresponding to resource elements which are used by a physical layer but which do not carry information derived from a higher layer. For example, a physical uplink shared channel (PUSCH), a physical uplink control channel (PUCCH), and a physical random access channel (PRACH) are defined as the UL physical channels, and a demodulation reference signal (DM RS) for a UL control/data signal and a sounding reference signal (SRS) used for UL channel measurement are defined as the UL physical signals.

[47] In the present invention, a physical downlink control channel (PDCCH), a physical control format indicator channel (PCFICH), a physical hybrid automatic retransmit request indicator channel (PHICH), and a physical downlink shared channel (PDSCH) refer to a set of time-frequency resources or resource elements (REs) carrying downlink control information (DCI), a set of time-frequency resources or REs carrying a control format indicator (CFI), a set of time-frequency resources or REs carrying downlink acknowledgement (ACK)/negative ACK (NACK), and a set of time-frequency resources or REs carrying downlink data, respectively. In addition, a physical uplink control channel (PUCCH), a physical uplink shared channel (PUSCH) and a physical random access channel (PRACH) refer to a set of time-frequency resources or REs carrying uplink control information (UCI), a set of time-frequency resources or REs carrying uplink data and a set of time-frequency resources or REs carrying random access signals, respectively. In the present invention, in particular, a time-frequency resource or RE that is assigned to or belongs to PDCCH/PCFICH/PHICH/PDSCH/PUCCH/PUSCH/PRACH is referred to as PDCCH/PCFICH/PHICH/PDSCH/PUCCH/PUSCH/PRACH RE or PDCCH/PCFICH/PHICH/PDSCH/PUCCH/PUSCH/PRACH time-frequency resource, respectively. Therefore, in the present invention, PUCCH/PUSCH/PRACH transmission of a UE is conceptually identical to UCI/uplink data/random access signal transmission on PUSCH/PUCCH/PRACH, respectively. In addition, PDCCH/PCFICH/PHICH/PDSCH transmission of an eNB is conceptually identical to downlink data/DCI transmission on PDCCH/PCFICH/PHICH/PDSCH, respectively.

[48] Hereinafter, OFDM symbol/subcarrier/RE to or for which CRS/DMRS/CSI-RS/SRS/UE-RS/TRS is assigned or configured will be referred to as CRS/DMRS/CSI-RS/SRS/UE-RS/TRS symbol/carrier/subcarrier/RE. For example, an OFDM symbol to or for which a tracking RS (TRS) is assigned or configured is referred to as a TRS symbol, a subcarrier to or for which the TRS is assigned or configured is referred to as a TRS subcarrier, and an RE to or for which the TRS is

assigned or configured is referred to as a TRS RE. In addition, a subframe configured for transmission of the TRS is referred to as a TRS subframe. Moreover, a subframe in which a broadcast signal is transmitted is referred to as a broadcast subframe or a PBCH subframe and a subframe in which a synchronization signal (e.g. PSS and/or SSS) is transmitted is referred to a synchronization signal subframe or a PSS/SSS subframe. OFDM symbol/subcarrier/RE to or for which PSS/SSS is assigned or configured is referred to as PSS/SSS symbol/subcarrier/RE, respectively.

[49] In the present invention, a CRS port, a UE-RS port, a CSI-RS port, and a TRS port refer to an antenna port configured to transmit a CRS, an antenna port configured to transmit a UE-RS, an antenna port configured to transmit a CSI-RS, and an antenna port configured to transmit a TRS, respectively. Antenna ports configured to transmit CRSs may be distinguished from each other by the locations of REs occupied by the CRSs according to CRS ports, antenna ports configured to transmit UE-RSs may be distinguished from each other by the locations of REs occupied by the UE-RSs according to UE-RS ports, and antenna ports configured to transmit CSI-RSs may be distinguished from each other by the locations of REs occupied by the CSI-RSs according to CSI-RS ports. Therefore, the term CRS/UE-RS/CSI-RS/TRS ports may also be used to indicate a pattern of REs occupied by CRSs/UE-RSs/CSI-RSs/TRSs in a predetermined resource region. In the present invention, both a DMRS and a UE-RS refer to RSs for demodulation and, therefore, the terms DMRS and UE-RS are used to refer to RSs for demodulation.

[50] FIG. 1 illustrates the structure of a radio frame used in a wireless communication system.

[51] Specifically, FIG. 1(a) illustrates an exemplary structure of a radio frame which can be used in frequency division multiplexing (FDD) in 3GPP LTE/LTE-A and FIG. 1(b) illustrates an exemplary structure of a radio frame which can be used in time division multiplexing (TDD) in 3GPP LTE/LTE-A.

[52] Referring to FIG. 1, a 3GPP LTE/LTE-A radio frame is 10ms ($307,200T_s$) in duration. The radio frame is divided into 10 subframes of equal size. Subframe numbers may be assigned to the 10 subframes within one radio frame, respectively. Here, T_s denotes sampling time where T_s=1/(2048*15kHz). Each subframe is 1ms long and is further divided into two slots. 20 slots are sequentially numbered from 0 to 19 in one radio frame. Duration of each slot is 0.5ms. A time interval in which one subframe is transmitted is defined as a transmission time interval (TTI). Time resources may be distinguished by a radio frame number (or radio frame index), a subframe number (or subframe index), a slot number (or slot index), and the like.

[53] A radio frame may have different configurations according to duplex modes. In FDD mode for example, since DL transmission and UL transmission are discriminated

according to frequency, a radio frame for a specific frequency band operating on a carrier frequency includes either DL subframes or UL subframes. In TDD mode, since DL transmission and UL transmission are discriminated according to time, a radio frame for a specific frequency band operating on a carrier frequency includes both DL subframes and UL subframes.

[54] Table 1 shows an exemplary UL-DL configuration within a radio frame in TDD mode.

[55] [Table 1]

DL-UL configuration	Downlink-to-Uplink Switch-point periodicity	Subframe number									
		0	1	2	3	4	5	6	7	8	9
0	5ms	D	S	U	U	U	D	S	U	U	U
1	5ms	D	S	U	U	D	D	S	U	U	D
2	5ms	D	S	U	D	D	D	S	U	D	D
3	10ms	D	S	U	U	U	D	D	D	D	D
4	10ms	D	S	U	U	D	D	D	D	D	D
5	10ms	D	S	U	D	D	D	D	D	D	D
6	5ms	D	S	U	U	U	D	S	U	U	D

[56] In Table 1, D denotes a DL subframe, U denotes a UL subframe, and S denotes a special subframe. The special subframe includes three fields, i.e. downlink pilot time slot (DwPTS), guard period (GP), and uplink pilot time slot (UpPTS). DwPTS is a time slot reserved for DL transmission and UpPTS is a time slot reserved for UL transmission. Table 2 shows an example of the special subframe configuration.

[57] [Table 2]

Special subframe configuration	Normal cyclic prefix in downlink			Extended cyclic prefix in downlink		
	DwPTS	UpPTS		DwPTS	UpPTS	
		Normal cyclic prefix in uplink	Extended cyclic prefix in uplink		Normal cyclic prefix in uplink	Extended cyclic prefix in uplink
0	$6592 \cdot T_s$	$2192 \cdot T_s$	$2560 \cdot T_s$	$7680 \cdot T_s$	$2192 \cdot T_s$	$2560 \cdot T_s$
1	$19760 \cdot T_s$			$20480 \cdot T_s$		
2	$21952 \cdot T_s$			$23040 \cdot T_s$		
3	$24144 \cdot T_s$			$25600 \cdot T_s$		
4	$26336 \cdot T_s$			$7680 \cdot T_s$	$4384 \cdot T_s$	$5120 \cdot T_s$
5	$6592 \cdot T_s$	$4384 \cdot T_s$	$5120 \cdot T_s$	$20480 \cdot T_s$		
6	$19760 \cdot T_s$			$23040 \cdot T_s$		
7	$21952 \cdot T_s$			$12800 \cdot T_s$		
8	$24144 \cdot T_s$			-	-	-
9	$13168 \cdot T_s$			-	-	-

[58] FIG. 2 illustrates the structure of a DL/UL slot structure in a wireless communication system.

[59] Referring to FIG. 2, a slot includes a plurality of orthogonal frequency division multiplexing (OFDM) symbols in the time domain and includes a plurality of resource blocks (RBs) in the frequency domain. The OFDM symbol may refer to one symbol duration. Referring to FIG. 2, a signal transmitted in each slot may be expressed by a resource grid including $N^{DL/UL}_{RB} * N^{RB}_{sc}$ subcarriers and $N^{DL/UL}_{symb}$ OFDM symbols. N^{DL}_{RB} denotes the number of RBs in a DL slot and N^{UL}_{RB} denotes the number of RBs in a UL slot. N^{DL}_{RB} and N^{UL}_{RB} depend on a DL transmission bandwidth and a UL transmission bandwidth, respectively. N^{DL}_{symb} denotes the number of OFDM symbols in a DL slot, N^{UL}_{symb} denotes the number of OFDM symbols in a UL slot, and N^{RB}_{sc} denotes the number of subcarriers configuring one RB.

[60] An OFDM symbol may be referred to as an OFDM symbol, a single carrier frequency division multiplexing (SC-FDM) symbol, etc. according to multiple access schemes. The number of OFDM symbols included in one slot may be varied according to channel bandwidths and CP lengths. For example, in a normal cyclic prefix (CP) case, one slot includes 7 OFDM symbols. In an extended CP case, one slot includes 6

OFDM symbols. Although one slot of a subframe including 7 OFDM symbols is shown in FIG. 2 for convenience of description, embodiments of the present invention are similarly applicable to subframes having a different number of OFDM symbols. Referring to FIG. 2, each OFDM symbol includes $N^{DL/UL}_{RB} * N^{RB}_{sc}$ subcarriers in the frequency domain. The type of the subcarrier may be divided into a data subcarrier for data transmission, a reference signal (RS) subcarrier for RS transmission, and a null subcarrier for a guard band and a DC component. The null subcarrier for the DC component is unused and is mapped to a carrier frequency f_0 in a process of generating an OFDM signal or in a frequency up-conversion process. The carrier frequency is also called a center frequency f_c.

[61] One RB is defined as $N^{DL/UL}_{symb}$ (e.g. 7) consecutive OFDM symbols in the time domain and as N^{RB}_{sc} (e.g. 12) consecutive subcarriers in the frequency domain. For reference, a resource composed of one OFDM symbol and one subcarrier is referred to a resource element (RE) or tone. Accordingly, one RB includes $N^{DL/UL}_{symb} * N^{RB}_{sc}$ REs. Each RE within a resource grid may be uniquely defined by an index pair (k, l) within one slot. k is an index ranging from 0 to $N^{DL/UL}_{RB} * N^{RB}_{sc} - 1$ in the frequency domain, and l is an index ranging from 0 to $N^{DL/UL}_{symb} - 1$ in the time domain.

[62] Meanwhile, one RB is mapped to one physical resource block (PRB) and one virtual resource block (VRB). A PRB is defined as N^{DL}_{symb} (e.g. 7) consecutive OFDM or SC-FDM symbols in the time domain and N^{RB}_{sc} (e.g. 12) consecutive subcarriers in the frequency domain. Accordingly, one PRB is configured with $N^{DL/UL}_{symb} * N^{RB}_{sc}$ REs. In one subframe, two RBs each located in two slots of the subframe while occupying the same N^{RB}_{sc} consecutive subcarriers are referred to as a physical resource block (PRB) pair. Two RBs configuring a PRB pair have the same PRB number (or the same PRB index).

[63] FIG. 3 illustrates a radio frame structure for transmission of a synchronization signal (SS). Specifically, FIG. 3 illustrates a radio frame structure for transmission of an SS and a PBCH in frequency division duplex (FDD), wherein FIG. 3(a) illustrates transmission locations of an SS and a PBCH in a radio frame configured as a normal cyclic prefix (CP) and FIG. 3(b) illustrates transmission locations of an SS and a PBCH in a radio frame configured as an extended CP.

[64] If a UE is powered on or newly enters a cell, the UE performs an initial cell search procedure of acquiring time and frequency synchronization with the cell and detecting a physical cell identity N^{cell}_{ID} of the cell. To this end, the UE may establish synchronization with the eNB by receiving synchronization signals, e.g. a primary synchronization signal (PSS) and a secondary synchronization signal (SSS), from the eNB and obtain information such as a cell identity (ID).

[65] An SS will be described in more detail with reference to FIG. 3. An SS is categorized

into a PSS and an SSS. The PSS is used to acquire time-domain synchronization of OFDM symbol synchronization, slot synchronization, etc. and/or frequency-domain synchronization and the SSS is used to acquire frame synchronization, a cell group ID, and/or CP configuration of a cell (i.e. information as to whether a normal CP is used or an extended CP is used). Referring to FIG. 3, each of a PSS and an SSS is transmitted on two OFDM symbols of every radio frame. More specifically, SSs are transmitted in the first slot of subframe 0 and the first slot of subframe 5, in consideration of a global system for mobile communication (GSM) frame length of 4.6 ms for facilitation of inter-radio access technology (inter-RAT) measurement. Especially, a PSS is transmitted on the last OFDM symbol of the first slot of subframe 0 and on the last OFDM symbol of the first slot of subframe 5 and an SSS is transmitted on the second to last OFDM symbol of the first slot of subframe 0 and on the second to last OFDM symbol of the first slot of subframe 5. A boundary of a corresponding radio frame may be detected through the SSS. The PSS is transmitted on the last OFDM symbol of a corresponding slot and the SSS is transmitted on an OFDM symbol immediately before an OFDM symbol on which the PSS is transmitted. A transmit diversity scheme of an SS uses only a single antenna port and standards therefor are not separately defined. That is, a single antenna port transmission scheme or a transmission scheme transparent to a UE (e.g. precoding vector switching (PVS), time switched transmit diversity (TSTD), or cyclic delay diversity (CDD)) may be used for transmit diversity of an SS.

[66] Upon detecting a PSS, a UE may discern that a corresponding subframe is one of subframe 0 and subframe 5 because the PSS is transmitted every 5ms but the UE cannot discern whether the subframe is subframe 0 or subframe 5. Accordingly, the UE cannot recognize the boundary of a radio frame only by the PSS. That is, frame synchronization cannot be acquired only by the PSS. The UE detects the boundary of a radio frame by detecting an SSS which is transmitted twice in one radio frame with different sequences.

[67] The UE, which has determined time and frequency parameters necessary for demodulating a DL signal and transmitting a UL signal at an accurate time by performing a cell search procedure using PSS/SSS, can communicate with the eNB only after acquiring system information necessary for system configuration of the UE from the eNB.

[68] The system information is configured by a master information block (MIB) and system information blocks (SIBs). Each SIB includes a set of functionally associated parameters and is categorized into an MIB, SIB Type 1 (SIB 1), SIB Type 2 (SIB2), and SIB3 to SIB17 in accordance with the parameters.

[69] The MIB includes most frequently transmitted parameters which are essential for

initial access of the UE to a network of the eNB. The UE may receive the MIB through a broadcast channel (e.g. PBCH). The MIB includes a DL bandwidth (BW), PHICH configuration, and a system frame number (SFN). Accordingly, the UE may be explicitly aware of information about the DL BW, SFN, and PHICH configuration by receiving the MIB. Meanwhile, information which may be implicitly recognized by the UE through reception of the PBCH includes the number of transmit antenna ports of the eNB. Information about the number of transmit antennas of the eNB is implicitly signaled by masking (e.g. XOR operation) a sequence corresponding to the number of transmit antennas to a 16-bit cyclic redundancy check (CRC) used for error detection of the PBCH.

[70] The SIB1 includes parameters needed to determine if a specific cell is suitable for cell selection, as well as information about time-domain scheduling of the other SIBs. The SIB1 is received by the UE through broadcast signaling or dedicated signaling.

[71] DL carrier frequency and corresponding system bandwidth may be acquired by the MIB carried by the PBCH. UL carrier frequency and corresponding system bandwidth may be acquired by system information which is a DL signal. The UE which has received the MIB applies a DL BW value within the MIB to a UL-bandwidth (UL BW) until system information block type 2 (SystemInformationBlockType2, SIB2) is received if there is no valid system information stored in a corresponding cell. For example, the UE may identify a full UL system band, which may be used by itself for UL transmission, through UL-carrier frequency and UL-bandwidth information within the SIB2 by acquiring system information block type 2 (SystemInformationBlockType2, SIB2).

[72] In the frequency domain, a PSS/SSS and a PBCH are transmitted only in a total of 6 RBs, i.e. a total of 72 subcarriers, irrespective of actual system BW, wherein 3 RBs are in the left and the other 3 RBs are in the right centering on a DC subcarrier on corresponding OFDM symbols. Therefore, the UE is configured to detect or decode the SS and the PBCH irrespective of DL BW configured for the UE.

[73] After initial cell search, the UE may perform a random access procedure to complete access to the eNB. To this end, the UE may transmit a preamble through a physical random access channel (PRACH) and receive a response message to the preamble through a PDCCH and a PDSCH. In contention based random access, the UE may perform additional PRACH transmission and a contention resolution procedure of a PDCCH and a PDSCH corresponding to the PDCCH.

[74] After performing the aforementioned procedure, the UE may perform PDDCH/PDSCH reception and PUSCH/PUCCH transmission as general uplink/downlink transmission procedures.

[75] The random access procedure is also called RACH (random access channel)

procedure. The random access procedure is used for initial access, uplink synchronization adjustment, resource assignment, handover, etc. The random access procedure is classified into a contention-based process and a dedicated (i.e. non-contention-based) process. The contention-based random access procedure includes initial access and is normally used, whereas the dedicated random access procedure is limitedly used for handover. In the contention-based random access procedure, a UE randomly select a RACH preamble sequence. Accordingly, a plurality of UEs can simultaneously transmit the same RACH preamble sequence and thus a contention resolution procedure is not needed. In the dedicated random access procedure, a UE uses a RACH preamble sequence uniquely allocated thereto by an eNB. Accordingly, the UE can perform the random access procedure without colliding with other UEs.

[76] The contention-based random access procedure has the following four steps. Hereinafter, messages transmitted in steps 1 to 4 may be respectively referred to as Msg 1 to Msg 4.

[77] - Step 1: RACH preamble (via PRACH) (UE to eNB)

[78] - Step 2: Random access response (RAR) (via PDCCH and PDSCH) (eNB to UE)

[79] - Step 3: Layer 2/Layer 3 message (via PUSCH) (UE to eNB)

[80] - Step 4: Contention resolution message (eNB to UE)

[81] The dedicated random access procedure includes the following three steps. Hereinafter, uplink transmission (i.e. step 3) corresponding to a RAR may be performed as a part of the random access procedure. The dedicated random access procedure can be triggered using a PDCCH (hereinafter, referred to as PDCCH order) used for an eNB to command RACH preamble transmission.

[82] - Step 0: PACH preamble allocation through dedicated signaling (eNB to UE)

[83] - Step 1: RACH preamble (via PRACH) (UE to eNB)

[84] - Step 2: RAR (via PDCCH and PDSCH) (eNB to UE)

[85] After transmission of RACH preamble, the UE attempts to receive a random access response (RAR) within a predetermined time window. Specifically, the UE attempts to detect a PDCCH (hereinafter, referred to as RA-RNTI PDCCH) having an RA-RNTI (Random Access RNTI) (e.g., CRC is masked with RA-RNTI in the PDCCH) within the time window. The UE checks whether a RAR therefor is present in a PDSCH corresponding to the RA-RNTI PDCCH during RA-RNTI PDCCH detection. The RAR includes timing advance (TA) information indicating timing offset information for UL synchronization, UL resource allocation information (UL grant information), a temporary UE identifier (e.g., temporary cell-RNTI, TC-RNTI), etc. The UE can perform UL transmission (e.g., Msg3) in accordance with resource allocation information and TA value in the RAR. HARQ is applied to UL transmission corresponding to the RAR. Accordingly, the UE can receive acknowledgement information

(e.g., PHICH) corresponding to Msg 3 after transmission of Msg 3.

[86] The random access preamble, i.e., RACH preamble consists of a cyclic prefix of length T_{CP} and a sequence part of length T_{SEQ} in the physical layer. T_{CP} and T_{SEQ} depend on the frame structure and the random access configuration. The preamble format is controlled by higher layers. The following table shows examples of T_{CP} and T_{SEQ}.

[87] [Table 3]

Preamble format	T_{CP}	T_{SEQ}
0	$3168 \cdot T_s$	$24576 \cdot T_s$
1	$21024 \cdot T_s$	$24576 \cdot T_s$
2	$6240 \cdot T_s$	$2 \cdot 24576 \cdot T_s$
3	$21024 \cdot T_s$	$2 \cdot 24576 \cdot T_s$
4(see NOTE)	$448 \cdot T_s$	$4096 \cdot T_s$
NOTE: Frame structure type 2 and special subframe configuration with UpPTS lengths $4384 \cdot T_s$ and $5120 \cdot T_s$ only.		

[88] The random access preamble is transmitted in UL subframe(s). The transmission of a random access preamble is restricted to certain time and frequency resources. These resources are called PRACH resources. The PRACH resources, are enumerated in increasing order of the subframe number within the radio frame and the PRBs in the frequency domain such that index 0 correspond to the lowest numbered PRB and subframe within the radio frame. PRACH resources within the radio frame are indicated by a PRACH configuration index.

[89] For frame structure type 1 with preamble format 0-3, for each of the PRACH configurations there is at most one random access resource per subframe. The following table shows examples of the preamble formats and the subframes in which random access preamble transmission is allowed for a given configuration in frame structure type 1. The PRACH configuration index is given by a higher layer signal (transmitted by an eNB).

[90] [Table 4]

PRACH Configuration Index	Preamble Format	SFN	Subframe number	PRACH Configuration Index	Preamble Format	SFN	Subframe number
0	0	Even	1	32	2	Even	1
1	0	Even	4	33	2	Even	4
2	0	Even	7	34	2	Even	7
3	0	Any	1	35	2	Any	1
4	0	Any	4	36	2	Any	4
5	0	Any	7	37	2	Any	7
6	0	Any	1,6	38	2	Any	1,6
7	0	Any	2,7	39	2	Any	2,7
8	0	Any	3,8	40	2	Any	3,8
9	0	Any	1,4,7	41	2	Any	1,4,7
10	0	Any	2,5,8	42	2	Any	2,5,8
11	0	Any	3,6,9	43	2	Any	3,6,9
12	0	Any	0,2,4,6,8	44	2	Any	0,2,4,6,8
13	0	Any	1,3,5,7,9	45	2	Any	1,3,5,7,9
14	0	Any	0,1,2,3,4, 5,6,7,8.9	46	N/A	N/A	N/A
15	0	Even	9	47	2	Even	9
16	1	Even	1	48	3	Even	1
17	1	Even	4	49	3	Even	4
18	1	Even	7	50	3	Even	7
19	1	Any	1	51	3	Any	1
20	1	Any	4	52	3	Any	4
21	1	Any	7	53	3	Any	7
22	1	Any	1,6	54	3	Any	1,6
23	1	Any	2,7	55	3	Any	2,7
24	1	Any	3,8	56	3	Any	3,8
25	1	Any	1,4,7	57	3	Any	1,4,7

26	1	Any	2,5,8	58	3	Any	2,5,8
27	1	Any	3,6,9	59	3	Any	3,6,9
28	1	Any	0,2,4,6,8	60	N/A	N/A	N/A
29	1	Any	1,3,5,7,9	61	N/A	N/A	N/A
30	N/A	N/A	N/A	62	N/A	N/A	N/A
31	1	Even	9	63	3	Even	9

[91] In Table 4, SFN denotes a system frame number.

[92] The first PRB, n^{RA}_{PRB}, allocated to the PRACH opportunity considered for preamble formats 0, 1, 2 and 3 is defined by $n^{RA}_{PRB}=n^{RA}_{PRBoffset}$, where the PRACH frequency offset $n^{RA}_{PRBoffset}$ is a PRB configured by higher layers and satisfies $0\leq n^{RA}_{PRBoffset}\leq N^{UL}_{RB}-6$.

[93] In case of frame structure type 2 with preamble formats 0 to 4, a plurality of random access resources may exist within UL subframe (or UpPTS for preamble format 4) in accordance with UL/DL configuration. The random access resources for the frame structure type 2 are defined in accordance with PRACH configuration index (see 3GPP TS 36.211 standard document).

[94] FIG. 4 illustrates the structure of a DL subframe used in a wireless communication system.

[95] Referring to FIG. 4, A DL subframe is divided into a control region and a data region in the time domain. Referring to FIG. 4, a maximum of 3 (or 4) OFDM symbols located in a front part of a first slot of a subframe corresponds to the control region. Hereinafter, a resource region for PDCCH transmission in a DL subframe is referred to as a PDCCH region. OFDM symbols other than the OFDM symbol(s) used in the control region correspond to the data region to which a physical downlink shared channel (PDSCH) is allocated. Hereinafter, a resource region available for PDSCH transmission in the DL subframe is referred to as a PDSCH region.

[96] Examples of a DL control channel used in 3GPP LTE include a physical control format indicator channel (PCFICH), a physical downlink control channel (PDCCH), a physical hybrid ARQ indicator channel (PHICH), etc.

[97] The PCFICH is transmitted in the first OFDM symbol of a subframe and carries information about the number of OFDM symbols available for transmission of a control channel within a subframe. The PCFICH notifies the UE of the number of OFDM symbols used for the corresponding subframe every subframe. The PCFICH is located at the first OFDM symbol. The PCFICH is configured by four resource element groups (REGs), each of which is distributed within a control region on the basis of cell ID. One REG includes four REs.

[98] A set of OFDM symbols available for the PDCCH at a subframe is given by the following Table.

[99] [Table 5]

Subframe	Number of OFDM symbols for PDCCH when $N^{DL}_{RB}>10$	Number of OFDM symbols for PDCCH when $N^{DL}_{RB}\leq 10$
Subframe 1 and 6 for frame structure type 2	1, 2	2
MBSFN subframes on a carrier supporting PDSCH, configured with 1 or 2 cell-specific antenna ports	1, 2	2
MBSFN subframes on a carrier supporting PDSCH, configured with 4 cell-specific antenna ports	2	2
Subframes on a carrier not supporting PDSCH	0	0
Non-MBSFN subframes (except subframe 6 for frame structure type 2) configured with positioning reference signals	1, 2, 3	2, 3
All other cases	1, 2, 3	2, 3, 4

[100] A subset of downlink subframes within a radio frame on a carrier for supporting PDSCH transmission may be configured as MBSFN subframe(s) by a higher layer. Each MBSFN subframe is divided into a non-MBSFN region and an MBSFN region. The non-MBSFN region spans first one or two OFDM symbols, and its length is given by Table 5. The same CP as cyclic prefix (CP) used for subframe 0 is used for transmission within the non-MBSFN region of the MBSFN subframe. The MBSFN region within the MBSFN subframe is defined as OFDM symbols which are not used in the non-MBSFN region.

[101] The PCFICH carries a control format indicator (CFI), which indicates any one of values of 1 to 3. For a downlink system bandwidth $N^{DL}_{RB}>10$, the number 1, 2 or 3 of OFDM symbols which are spans of DCI carried by the PDCCH is given by the CFI. For a downlink system bandwidth $N^{DL}_{RB}\leq 10$, the number 2, 3 or 4 of OFDM symbols which are spans of DCI carried by the PDCCH is given by CFI+1. The CFI is coded in accordance with the following Table.

[102] [Table 6]

CFI	CFI code word<b_0, b_1, ..., b_{31}>
1	<0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1>
2	<1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0>
3	<1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1>
4(Reserved)	<0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0>

[103] The PHICH carries a HARQ (Hybrid Automatic Repeat Request) ACK/NACK (acknowledgment/negative-acknowledgment) signal as a response to UL transmission. The PHICH includes three REGs, and is scrambled cell-specifically. ACK/NACK is indicated by 1 bit, and the ACK/NACK of 1 bit is repeated three times. Each of the repeated ACK/NACK bits is spread with a spreading factor (SF) 4 or 2 and then mapped into a control region.

[104] The control information transmitted through the PDCCH will be referred to as downlink control information (DCI). The DCI includes resource allocation information for a UE or UE group and other control information. Transmit format and resource allocation information of a downlink shared channel (DL-SCH) are referred to as DL scheduling information or DL grant. Transmit format and resource allocation information of an uplink shared channel (UL-SCH) are referred to as UL scheduling information or UL grant. The size and usage of the DCI carried by one PDCCH are varied depending on DCI formats. The size of the DCI may be varied depending on a coding rate. In the current 3GPP LTE system, various formats are defined, wherein formats 0 and 4 are defined for a UL, and formats 1, 1A, 1B, 1C, 1D, 2, 2A, 2B, 2C, 3 and 3A are defined for a DL. Combination selected from control information such as a hopping flag, RB allocation, modulation coding scheme (MCS), redundancy version (RV), new data indicator (NDI), transmit power control (TPC), cyclic shift, cyclic shift demodulation reference signal (DM RS), UL index, channel quality information (CQI) request, DL assignment index, HARQ process number, transmitted precoding matrix indicator (TPMI), precoding matrix indicator (PMI) information is transmitted to the UE as the DCI. The following table shows examples of DCI formats.

[105] [Table 7]

DCI format	Description
0	Resource grants for the PUSCH transmissions (uplink)
1	Resource assignments for single codeword PDSCH transmissions
1A	Compact signaling of resource assignments for single codeword PDSCH
1B	Compact signaling of resource assignments for single codeword PDSCH
1C	Very compact resource assignments for PDSCH (e.g. paging/broadcast system information)
1D	Compact resource assignments for PDSCH using multi-user MIMO
2	Resource assignments for PDSCH for closed-loop MIMO operation
2A	Resource assignments for PDSCH for open-loop MIMO operation
2B	Resource assignments for PDSCH using up to 2 antenna ports with UE-specific reference signals
2C	Resource assignment for PDSCH using up to 8 antenna ports with UE-specific reference signals
3/3A	Power control commands for PUCCH and PUSCH with 2-bit/1-bit power adjustments
4	Scheduling of PUSCH in one UL Component Carrier with multi-antenna port transmission mode

[106] Other DCI formats in addition to the DCI formats defined in Table 7 may be defined.

[107] A plurality of PDCCHs may be transmitted within a control region. A UE may monitor the plurality of PDCCHs. An eNB determines a DCI format depending on the DCI to be transmitted to the UE, and attaches cyclic redundancy check (CRC) to the DCI. The CRC is masked (or scrambled) with an identifier (for example, a radio network temporary identifier (RNTI)) depending on usage of the PDCCH or owner of the PDCCH. For example, if the PDCCH is for a specific UE, the CRC may be masked with an identifier (for example, cell-RNTI (C-RNTI)) of the corresponding UE. If the PDCCH is for a paging message, the CRC may be masked with a paging identifier (for example, paging-RNTI (P-RNTI)). If the PDCCH is for system information (in more detail, system information block (SIB)), the CRC may be masked with system information RNTI (SI-RNTI). If the PDCCH is for a random access response, the CRC may be masked with a random access RNTI (RA-RNTI). For example, CRC masking

(or scrambling) includes XOR operation of CRC and RNTI at the bit level.

[108] Generally, a DCI format, which may be transmitted to the UE, is varied depending on a transmission mode configured for the UE. In other words, certain DCI format(s) corresponding to the specific transmission mode not all DCI formats may only be used for the UE configured to a specific transmission mode.

[109] For example, a transmission mode is semi-statically configured for the UE by a higher layer so that the UE may receive a PDSCH transmitted in accordance with one of a plurality of transmission modes which are previously defined. The UE attempts to decode a PDCCH using DCI formats only corresponding to its transmission mode. In other words, in order to maintain UE operation load according to blind decoding attempt, at a certain level or less, all DCI formats are not searched by the UE at the same time. Table 8 illustrates transmission modes for configuring multi-antenna technology and DCI formats for allowing a UE to perform blind decoding at the corresponding transmission mode. Particularly, Table 8 illustrates a relation between PDCCH and PDSCH configured by C-RNTI (Cell RNTI(Radio Network Temporary Identifier)).

[110] [Table 8]

Transmission mode	DCI format	Search Space	Transmission scheme of PDSCH corresponding to PDCCH
Mode 1	DCI format 1A	Common andUE specific by C-RNTI	Single-antenna port, port 0
	DCI format 1	UE specific by C-RNTI	Single-antenna port, port 0
Mode 2	DCI format 1A	Common andUE specific by C-RNTI	Transmit diversity
	DCI format 1	UE specific by C-RNTI	Transmit diversity
Mode 3	DCI format 1A	Common andUE specific by C-RNTI	Transmit diversity
	DCI format 2A	UE specific by C-RNTI	Large delay CDD or Transmit diversity
Mode 4	DCI format 1A	Common andUE specific by C-RNTI	Transmit diversity
	DCI format 2	UE specific by C-RNTI	Closed-loop spatial multiplexing or Transmit diversity
Mode 5	DCI format 1A	Common andUE specific by C-RNTI	Transmit diversity
	DCI format 1D	UE specific by C-RNTI	Multi-user MIMO
Mode 6	DCI format 1A	Common andUE specific by C-RNTI	Transmit diversity
	DCI format 1B	UE specific by C-RNTI	Closed-loop spatial multiplexing using a single transmission layer
Mode 7	DCI format	Common andUE	If the number of PBCH antenna ports

	1A	specific by C-RNTI	is one, Single-antenna port, port 0 is used, otherwise Transmit diversity
	DCI format 1	UE specific by C-RNTI	Single-antenna port, port 5
Mode 8	DCI format 1A	Common andUE specific by C-RNTI	If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used, otherwise Transmit diversity
	DCI format 2B	UE specific by C-RNTI	Dual layer transmission, port 7 and 8 or single-antenna port, port 7 or 8
Mode 9	DCI format 1A	Common andUE specific by C-RNTI	Non-MBSFN subframe: If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used, otherwise Transmit diversity.MBSFN subframe: Single-antenna port, port 7
	DCI format 2C	UE specific by C-RNTI	Up to 8 layer transmission, ports 7-14 or single-antenna port, port 7 or 8
Mode 10	DCI format 1A	Common andUE specific by C-RNTI	Non-MBSFN subframe: If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used, otherwise Transmit diversity.MBSFN subframe: Single-antenna port, port 7
	DCI format 2D	UE specific by C-RNTI	Up to 8 layer transmission, ports 7-14 or single antenna port, port 7 or 8

[111] Although transmission modes 1 to 10 are listed in Table 8, other transmission modes in addition to the transmission modes defined in Table 8 may be defined.

[112] Referring to Table 8, a UE configured to a transmission mode 9, for example, tries to decode PDCCH candidates of a UE-specific search space (USS) to a DCI format 1A, and tries to decode PDCCH candidates of a common search space (CSS) and the USS to a DCI format 2C. The UE may decode a PDSCH in accordance with DCI based on the DCI format successfully decoded. If DCI decoding from one of a plurality of PDCCH candidates to the DCI format 1A is successfully performed, the UE may decode the PDSCH by assuming that up to 8 layers from antenna ports 7 to 14 are transmitted thereto through the PDSCH, or may decode the PDSCH by assuming that a single layer from the antenna port 7 or 8 is transmitted thereto through the PDSCH.

[113] The PDCCH is allocated to first m number of OFDM symbol(s) within a subframe.

In this case, m is an integer equal to or greater than 1, and is indicated by the PCFICH.

[114] The PDCCH is transmitted on an aggregation of one or a plurality of continuous control channel elements (CCEs). The CCE is a logic allocation unit used to provide a coding rate based on the status of a radio channel to the PDCCH. The CCE corresponds to a plurality of resource element groups (REGs). For example, one CCE corresponds to nine resource element groups (REGs), and one REG corresponds to four REs. Four QPSK symbols are mapped to each REG. A resource element (RE) occupied by the reference signal (RS) is not included in the REG. Accordingly, the number of REGs within given OFDM symbols is varied depending on the presence of the RS. The REGs are also used for other downlink control channels (that is, PCFICH and PHICH).

[115] Assuming that the number of REGs not allocated to the PCFICH or the PHICH is N_{REG}, the number of available CCEs in a DL subframe for PDCCH(s) in a system is numbered from 0 to N_{CCE}—1, where $N_{CCE} = \text{floor}(N_{REG}/9)$.

[116] A PDCCH format and the number of DCI bits are determined in accordance with the number of CCEs. The CCEs are numbered and consecutively used. To simplify the decoding process, a PDCCH having a format including n CCEs may be initiated only on CCEs assigned numbers corresponding to multiples of n. The number of CCEs used for transmission of a specific PDCCH is determined by a network or the eNB in accordance with channel status. For example, one CCE may be required for a PDCCH for a UE (for example, adjacent to eNB) having a good downlink channel. However, in case of a PDCCH for a UE (for example, located near the cell edge) having a poor channel, eight CCEs may be required to obtain sufficient robustness. Additionally, a power level of the PDCCH may be adjusted to correspond to a channel status.

[117] In a 3GPP LTE/LTE-A system, a set of CCEs on which a PDCCH can be located for each UE is defined. A CCE set in which the UE can detect a PDCCH thereof is referred to as a PDCCH search space or simply as a search space (SS). An individual resource on which the PDCCH can be transmitted in the SS is called a PDCCH candidate. A set of PDCCH candidates that the UE is to monitor is defined in terms of SSs, where a search space $S^{(L)}_k$ at aggregation level $L \in \{1,2,4,8\}$ is defined by a set of PDCCH candidates. SSs for respective PDCCH formats may have different sizes and a dedicated SS and a common SS are defined. The dedicated SS is a UE-specific SS (USS) and is configured for each individual UE. The common SS (CSS) is configured for a plurality of UEs.

[118] The following table shows an example of aggregation levels for defining SS.

[119] [Table 9]

Search space $S^{(L)}_k$			Number of PDCCH candidates $M^{(L)}$
Type	Aggregation level L	Size [in CCEs]	
UE-specific	1	6	6
	2	12	6
	4	8	2
	8	16	2
Common	4	16	4
	8	16	2

[120] For each serving cell on which PDCCH is monitored, the CCEs corresponding to PDCCH candidates m of the search space $S^{(L)}_k$ are configured by "$L*\{Y_k+m'\}$ mod floor($N_{CCE,k}/L$}+i", where i=0,...,L—1. For the common search space $m'=m$. For the PDCCH UE specific search space, for the serving cell on which PDCCH is monitored, if the monitorng UE is configured with carrier indicator field then $m'=m+M^{(L)}*n_{CI}$ where n_{CI} is the carrier indicator field (CIF) value, else if the monitoring UE is not configured with carrier indicator field then $m'=m$, where m=0,1,...,$M^{(L)}$—1. $M^{(L)}$ is the number of PDCCH candidates to monitor at aggregation level L in the given search space. The carrier indication field value can be the same as a serving cell index (*ServCellIndex*). For the common search space, Y_k is set to 0 for the two aggregation levels L=4 and L=8. For the UE-specific search space $S^{(L)}_k$ at aggregation level D, the variable Y_k is defined by "$Y_k = (A\cdot Y_{k-1})$ mod D", where $Y_{-1}=n_{RNTI}\neq 0$, A=39827, D=65537 and k =floor($n_s/2$). n_s is the slot number within a radio frame.

[121] The eNB transmits an actual PDCCH (DCI) on a PDCCH candidate in a search space and the UE monitors the search space to detect the PDCCH (DCI). Here, monitoring implies attempting to decode each PDCCH in the corresponding SS according to all monitored DCI formats. The UE may detect a PDCCH thereof by monitoring a plurality of PDCCHs. Basically, the UE does not know the location at which a PDCCH thereof is transmitted. Therefore, the UE attempts to decode all PDCCHs of the corresponding DCI format for each subframe until a PDCCH having an ID thereof is detected and this process is referred to as blind detection (or blind decoding (BD)).

[122] For example, it is assumed that a specific PDCCH is CRC-masked with a radio network temporary identity (RNTI) 'A' and information about data transmitted using a radio resource 'B' (e.g. frequency location) and using transport format information 'C' (e.g. transmission block size, modulation scheme, coding information, etc.) is transmitted in a specific DL subframe. Then, the UE monitors the PDCCH using RNTI

information thereof. The UE having the RNTI 'A' receives the PDCCH and receives the PDSCH indicated by 'B' and 'C' through information of the received PDCCH.

[123] FIG. 5 illustrates the structure of a UL subframe used in a wireless communication system.

[124] Referring to FIG. 5, a UL subframe may be divided into a data region and a control region in the frequency domain. One or several PUCCHs may be allocated to the control region to deliver UCI. One or several PUSCHs may be allocated to the data region of the UE subframe to carry user data.

[125] In the UL subframe, subcarriers distant from a direct current (DC) subcarrier are used as the control region. In other words, subcarriers located at both ends of a UL transmission BW are allocated to transmit UCI. A DC subcarrier is a component unused for signal transmission and is mapped to a carrier frequency f_0 in a frequency up-conversion process. A PUCCH for one UE is allocated to an RB pair belonging to resources operating on one carrier frequency and RBs belonging to the RB pair occupy different subcarriers in two slots. The PUCCH allocated in this way is expressed by frequency hopping of the RB pair allocated to the PUCCH over a slot boundary. If frequency hopping is not applied, the RB pair occupies the same subcarriers.

[126] The PUCCH may be used to transmit the following control information.

[127] - Scheduling request (SR): SR is information used to request a UL-SCH resource and is transmitted using an on-off keying (OOK) scheme.

[128] - HARQ-ACK: HARQ-ACK is a response to a PDCCH and/or a response to a DL data packet (e.g. a codeword) on a PDSCH. HARQ-ACK indicates whether the PDCCH or PDSCH has been successfully received. 1-bit HARQ-ACK is transmitted in response to a single DL codeword and 2-bit HARQ-ACK is transmitted in response to two DL codewords. A HARQ-ACK response includes a positive ACK (simply, ACK), negative ACK (NACK), discontinuous transmission (DTX), or NACK/DRX. HARQ-ACK is used interchangeably with HARQ ACK/NACK and ACK/NACK.

[129] - Channel state information (CSI): CSI is feedback information for a DL channel. CSI may include channel quality information (CQI), a precoding matrix indicator (PMI), a precoding type indicator, and/or a rank indicator (RI). In the CSI, MIMO-related feedback information includes the RI and the PMI. The RI indicates the number of streams or the number of layers that the UE can receive through the same time-frequency resource. The PMI is a value reflecting a space characteristic of a channel, indicating an index of a preferred precoding matrix for DL signal transmission based on a metric such as an SINR. The CQI is a value of channel strength, indicating a received SINR that can be obtained by the UE generally when the eNB uses the PMI.

[130] A general wireless communication system performs data transmission/reception through one downlink (DL) band and through one uplink (UL) band corresponding to

the DL band (in case of a frequency division duplex (FDD) mode), or divides a prescribed radio frame into a UL time unit and a DL time unit in the time domain and then performs data transmission/reception through the UL/DL time unit (in case of a time division duplex (TDD) mode). Recently, to use a wider frequency band in recent wireless communication systems, introduction of carrier aggregation (or BW aggregation) technology that uses a wider UL/DL BW by aggregating a plurality of UL/DL frequency blocks has been discussed. A carrier aggregation (CA) is different from an orthogonal frequency division multiplexing (OFDM) system in that DL or UL communication is performed using a plurality of carrier frequencies, whereas the OFDM system carries a base frequency band divided into a plurality of orthogonal subcarriers on a single carrier frequency to perform DL or UL communication. Hereinbelow, each of carriers aggregated by carrier aggregation will be referred to as a component carrier (CC).

[131] For example, three 20MHz CCs may be aggregated on each of a UL and a DL to support a bandwidth of 60MHz. The respective CCs may be contiguous or non-contiguous in the frequency domain. For convenience, although it has been described that the bandwidth of UL CC and the bandwidth of DL CC are the same as each other and symmetric to each other, the bandwidth of each CC may be independently determined. Asymmetrical carrier aggregation in which the number of UL CCs is different from the number of DL CCs may be implemented. DL/UL CC limited to a specific UE may be referred to as a serving UL/DL CC configured for the specific UE.

[132] Meanwhile, the 3GPP LTE-A standard uses the concept of a cell to manage radio resources. The "cell" associated with the radio resources is defined by combination of downlink resources and uplink resources, that is, combination of DL CC and UL CC. The cell may be configured by downlink resources only, or may be configured by downlink resources and uplink resources. If carrier aggregation is supported, linkage between a carrier frequency of the downlink resources (or DL CC) and a carrier frequency of the uplink resources (or UL CC) may be indicated by system information. For example, combination of the DL resources and the UL resources may be indicated by linkage of system information block type 2 (SIB2). In this case, the carrier frequency means a center frequency of each cell or CC. A cell operating on a primary frequency may be referred to as a primary cell (Pcell) or PCC, and a cell operating on a secondary frequency may be referred to as a secondary cell (Scell) or SCC. The carrier corresponding to the Pcell on downlink will be referred to as a downlink primary CC (DL PCC), and the carrier corresponding to the Pcell on uplink will be referred to as an uplink primary CC (UL PCC). A Scell means a cell that may be configured after completion of radio resource control (RRC) connection establishment and used to provide additional radio resources. The Scell may form a set of serving cells for the UE

together with the Pcell in accordance with capabilities of the UE. The carrier corresponding to the Scell on the downlink will be referred to as downlink secondary CC (DL SCC), and the carrier corresponding to the Scell on the uplink will be referred to as uplink secondary CC (UL SCC). Although the UE is in RRC-CONNECTED state, if it is not configured by carrier aggregation or does not support carrier aggregation, a single serving cell configured by the Pcell only exists.

[133] The eNB may activate all or some of the serving cells configured in the UE or deactivate some of the serving cells for communication with the UE. The eNB may change the activated/deactivated cell, and may change the number of cells which is/are activated or deactivated. If the eNB allocates available cells to the UE cell-specifically or UE-specifically, at least one of the allocated cells is not deactivated unless cell allocation to the UE is fully reconfigured or unless the UE performs handover. Such a cell which is not deactivated unless CC allocation to the UE is fully reconfigured will be referred to as Pcell, and a cell which may be activated/deactivated freely by the eNB will be referred to as Scell. The Pcell and the Scell may be discriminated from each other on the basis of the control information. For example, specific control information may be set to be transmitted and received through a specific cell only. This specific cell may be referred to as the Pcell, and the other cell(s) may be referred to as Scell(s).

[134] A configured cell refers to a cell in which carrier aggregation is performed for a UE based on measurement report from another eNB or UE among cells of an eNB and is configured per UE. The cell configured for the UE may be a serving cell in terms of the UE. For the cell configured for the UE, i.e. the serving cell, resources for ACK/NACK transmission for PDSCH transmission are reserved in advance. An activated cell refers to a cell configured to be actually used for PDSCH/PUSCH transmission among cells configured for the UE and CSI reporting and SRS transmission for PDSCH/PUSCH transmission are performed in the activated cell. A deactivated cell refers to a cell configured not to be used for PDSCH/PUSCH transmission by the command of an eNB or the operation of a timer and, if a cell is deactivated, CSI reporting and SRS transmission are also stopped in the cell.

[135] For reference, a carrier indicator (CI) denotes a serving cell index (*ServCellIndex*), CI=0 is applied to Pcell. The serving cell index is a short ID used to identify a serving cell. For example, any one of integers from 0 to 'maximum number of carrier frequencies which can be configured for the UE at a time - 1' may be allocated to one serving cell as the serving cell index. That is, the serving cell index may be a logical index used to identify a specific serving cell among cells allocated to the UE rather than a physical index used to identify a specific carrier frequency among all carrier frequencies.

[136] Meanwhile, the 3GPP LTE-A standard uses the concept of a cell to manage radio

resources.

[137] The cell mentioned in the present invention means a cell of carrier aggregation which is combination of UL CC and DL CC unless specifically noted.

[138] Meanwhile, since one serving cell is only present in case of communication based on a single carrier, a PDCCH carrying UL/DL grant and corresponding PUSCH/PDSCH are transmitted on one cell. In other words, in case of FDD under a single carrier environment, a PDCCH for a DL grant for a PDSCH, which will be transmitted on a specific DL CC, is transmitted on the specific CC, and a PDCCH for a UL grant for a PUSCH, which will be transmitted on a specific UL CC, is transmitted on a DL CC linked to the specific UL CC. In case of TDD under a single carrier environment, a PDCCH for a DL grant for a PDSCH, which will be transmitted on a specific DL CC, is transmitted on the specific CC, and a PDCCH for a UL grant for a PUSCH, which will be transmitted on a specific UL CC, is transmitted on the specific CC.

[139] On the contrary, since a plurality of serving cells may be configured in a multi-carrier system, transmission of UL/DL grant through a serving cell having a good channel status may be allowed. In this way, if a cell carrying UL/DL grant which is scheduling information is different from a cell where UL/DL transmission corresponding to the UL/DL grant is performed, this will be referred to as cross-carrier scheduling.

[140] Hereinafter, the case where the cell is scheduled from itself and the case where the cell is scheduled from another cell will be referred to as self-CC scheduling and cross-CC scheduling, respectively.

[141] For data transmission rate enhancement and stable control signaling, the 3GPP LTE/LTE-A may support aggregation of a plurality of CCs and a cross carrier-scheduling operation based on the aggregation.

[142] If cross-carrier scheduling (or cross-CC scheduling) is applied, a PDCCH for downlink allocation for a DL CC B or DL CC C, that is, carrying a DL grant may be transmitted through a DL CC A, and a corresponding PDSCH may be transmitted through the DL CC B or DL CC C. For cross-CC scheduling, a carrier indicator field (CIF) may be introduced. The presence or absence of the CIF within the PDCCH may be semi-statically and UE-specifically (or UE-group-specifically) configured by higher layer signaling (e.g., RRC signaling).

[143] Meanwhile, if RRH technology, cross-carrier scheduling technology, etc. are introduced, the amount of PDCCH which should be transmitted by the eNB is gradually increased. However, since a size of a control region within which the PDCCH may be transmitted is the same as before, PDCCH transmission acts as a bottleneck of system throughput. Although channel quality may be improved by the introduction of the aforementioned multi-node system, application of various communication schemes, etc., the introduction of a new control channel is required to apply the legacy commu-

nication scheme and the carrier aggregation technology to a multi-node environment. Due to the need, a configuration of a new control channel in a data region (hereinafter, referred to as PDSCH region) not the legacy control region (hereinafter, referred to as PDCCH region) has been discussed. Hereinafter, the new control channel will be referred to as an enhanced PDCCH (hereinafter, referred to as EPDCCH).

[144] The EPDCCH may be configured within rear OFDM symbols starting from a configured OFDM symbol, instead of front OFDM symbols of a subframe. The EPDCCH may be configured using continuous frequency resources, or may be configured using discontinuous frequency resources for frequency diversity. By using the EPDCCH, control information per node may be transmitted to a UE, and a problem that a legacy PDCCH region may not be sufficient may be solved. For reference, the PDCCH may be transmitted through the same antenna port(s) as that(those) configured for transmission of a CRS, and a UE configured to decode the PDCCH may demodulate or decode the PDCCH by using the CRS. Unlike the PDCCH transmitted based on the CRS, the EPDCCH is transmitted based on the demodulation RS (hereinafter, DMRS). Accordingly, the UE decodes/demodulates the PDCCH based on the CRS and decodes/demodulates the EPDCCH based on the DMRS. The DMRS associated with EPDCCH is transmitted on the same antenna port $p \in \{107,108,109,110\}$ as the associated EPDCCH physical resource, is present for EPDCCH demodulation only if the EPDCCH transmission is associated with the corresponding antenna port, and is transmitted only on the PRB(s) upon which the corresponding EPDCCH is mapped. For example, the REs occupied by the UE-RS(s) of the antenna port 7 or 8 may be occupied by the DMRS(s) of the antenna port 107 or 108 on the PRB to which the EPDCCH is mapped, and the REs occupied by the UE-RS(s) of antenna port 9 or 10 may be occupied by the DMRS(s) of the antenna port 109 or 110 on the PRB to which the EPDCCH is mapped. In other words, a certain number of REs are used on each RB pair for transmission of the DMRS for demodulation of the EPDCCH regardless of the UE or cell if the type of EPDCCH and the number of layers are the same as in the case of the UE-RS for demodulation of the PDSCH.

[145] For each serving cell, higher layer signalling can configure a UE with one or two EPDCCH-PRB-sets for EPDCCH monitoring. The PRB-pairs corresponding to an EPDCCH-PRB-set are indicated by higher layers. Each EPDCCH-PRB-set consists of set of ECCEs numbered from 0 to $N_{ECCE,p,k}-1$, where $N_{ECCE,p,k}$ is the number of ECCEs in EPDCCH-PRB-set p of subframe k. Each EPDCCH-PRB-set can be configured for either localized EPDCCH transmission or distributed EPDCCH transmission.

[146] The UE shall monitor a set of EPDCCH candidates on one or more activated serving cells as configured by higher layer signaling for control information.

[147] The set of EPDCCH candidates to monitor are defined in terms of EPDCCH UE-

specific search spaces. For each serving cell, the subframes in which the UE monitors EPDCCH UE-specific search spaces are configured by higher layers.

[148] An EPDCCH UE-specific search space $ES^{(L)}_k$ at aggregation level $L\in\{1,2,4,8,16,32\}$ is defined by a set of EPDCCH candidates.

[149] For an EPDCCH-PRB-set p, the ECCEs corresponding to EPDCCH candidate m of the search space $ES^{(L)}_k$ are given by the following equation.

[150] [Math.1]

$$L\left\{(Y_{p,k}+\left\lfloor\frac{m\cdot N_{ECCE,p,k}}{L\cdot M_p^{(L)}}\right\rfloor+b)\bmod\left\lfloor N_{\mathrm{ECCE},p,k}/L\right\rfloor\right\}+i$$

[151] where $i=0,\ldots,L-1$. $b=n_{CI}$ if the UE is configured with a carrier indicator field for the serving cell on which EPDCCH is monitored, otherwise $b=0$. n_{CI} is the carrier indicator field (CIF) value, which is the same as a serving cell index (*ServCellIndex*). $m=0,1,\ldots,M^{(L)}_p-1$. $M^{(L)}_p$ is the number of EPDCCH candidates to monitor at aggregation level L in EPDDCH-PRB-set p. The variable $Y_{p,k}$ is defined by '$Y_{p,k}=(A_p\cdot Y_{p,k-1})\bmod D$', where $Y_{p,-1}=n_{RNTI}\neq 0$, $A_0=39827$, $A_1=39829$, $D=65537$ and $k=\mathrm{floor}(n_s/2)$. n_s is the slot number within a radio frame.

[152] A UE is not expected to monitor an EPDCCH candidate, if an ECCE corresponding to that EPDCCH candidate is mapped to a PRB pair that overlaps in frequency with a transmission of either PBCH or PSS/SSS in the same subframe.

[153] An EPDCCH is transmitted using an aggregation of one or several consecutive enhanced control channel elements (ECCEs). Each ECCE consists of multiple enhanced resource element groups (EREGs). EEREGs are used for defining the mapping of enhanced control channels to resource elements. There are 16 EREGs, numbered from 0 to 15, per physical resource block (PRB) pair. Number all resource elements (REs), except resource elements carrying DMRS (hereinafter EPDCCH DMRS) for demoduation of the EPDCCH, in a physical resource-block pair cyclically from 0 to 15 in an increasing order of first frequency, then time. Therefore all the REs, except REs carrying the EPDCCH DMRS, in the PRB pair has any one of numbers 0 to 15. All REs with number i in that PRB pair constitutes EREG number i.As described above, it is noted that EREGs are distributed on frequency and time axes within the PRB pair and an EPDCCH transmitted using aggregation of one or more ECCEs, each of which includes a plurality of EREGs, is also distributed on frequency and time axes within the PRB pair.

[154] The number of ECCEs used for one EPDCCH depends on the EPDCCH format as given by Table 10, the number of EREGs per ECCE is given by Table 11. Table 10 shows an example of supported EPDCCH formats, and Table 11 shows an example of

the number of EREGs per ECCE, N^{EREG}_{ECCE}. Both localized and distributed transmission is supported.

[155] [Table 10]

EPDCCH format	Number of ECCEs for one EPDCCH, N^{ECCE}_{EPDCCH}			
	Case A		Case B	
	Localized transmission	Distributed transmission	Localized transmission	Distributed transmission
0	2	2	1	1
1	4	4	2	2
2	8	8	4	4
3	16	16	8	8
4	-	32	-	16

[156] [Table 11]

Normal cyclic prefix			Extended cyclic prefix	
Normal subframe	Special subframe,configuration3, 4, 8	Special subframe,configuration1, 2, 6, 7, 9	Normal subframe	Special subframe,configuration1, 2, 3, 5, 6
4		8		

[157] An EPDCCH can use either localized or distributed transmission, differing in the mapping of ECCEs to EREGs and PRB pairs. One or two sets of PRB pairs which a UE shall monitor for EPDCCH transmissions can be configured. All EPDCCH candidates in EPDCCH set S_p (i.e., EPDCCH-PRB-set) use either only localized or only distributed transmission as configured by higher layers. Within EPDCCH set S_p in subframe k, the ECCEs available for transmission of EPDCCHs are numbered from 0 to $N_{ECCE,p,k}-1$. ECCE number n is corresponding to the following EREG(s):

[158] - EREGs numbered $(n \bmod N^{ECCE}_{RB})+jN^{ECCE}_{RB}$ in PRB index $\text{floor}(n/N^{ECCE}_{RB})$ for localized mapping, and

[159] - EREGs numbered $\text{floor}\ (n/N^{Sp}_{RB})+jN^{ECCE}_{RB}$ in PRB indices $(n+j\max(1,N^{Sp}_{RB}/N^{EREG}_{ECCE}))\bmod N^{Sp}_{RB}$ for distributed mapping.

[160] where $j=0,1,\ldots,N^{EREG}_{ECCE}-1$, N^{EREG}_{ECCE} is the number of EREGs per ECCE, and $N^{ECCE}_{RB}=16/N^{EREG}_{ECCE}$ is the number of ECCEs per RB pair. The PRB pairs constituting EPDCCH set S_p are assumed to be numbered in ascending order from 0 to $N^{Sp}_{RB}-1$.

[161] Case A in Table 10 applies when:

[162] - DCI formats 2, 2A, 2B, 2C or 2D is used and $N^{DL}_{RB}\geq 25$, or

[163] - any DCI format when n_{EPDCCH}<104 and normal cyclic prefix is used in normal subframes or special subframes with configuration 3, 4, 8.

[164] Otherwise case B is used. The quantity n_{EPDCCH} for a particular UE is defined as the number of downlink resource elements (k,l) in a PRB pair configured for possible EPDCCH transmission of EPDCCH set S_0 and and fulfilling all of the following criteria,

[165] - they are part of any one of the 16 EREGs in the physical resource-block pair,

[166] - they are assumed by the UE not to be used for CRSs or CSI-RSs,

[167] - the index l in a subframe fulfils $l \geq l_{EPDCCHStart}$.

[168] where $l_{EPDCCHStart}$ is given based on higher layer signaling '*epdcch*-StartSymbol-r11', higher layer signaling '*pdsch*-Start-r11', or CFI value carried by PCFICH.

[169] The mapping to resource elements (k,l) on antenna port p meeting the criteria above is in increasing order of first the index k and then the index l, starting with the first slot and ending with the second slot in a subframe.

[170] For localized transmission, the single antenna port p to use is given by Table 12 with $n' = n_{ECCE,low} \bmod N^{ECCE}_{RB} + n_{RNTI} \bmod \min(N^{ECCE}_{EPDCCH}, N^{ECCE}_{RB})$, where $n_{ECCE,low}$ is the lowest ECCE index used by this EPDCCH transmission in the EPDCCH set, n_{RNTI} corresponds to the RNTI associated with the EPDCCH transmission, and N^{ECCE}_{EPDCCH} is the number of ECCEs used for this EPDCCH.

[171] [Table 12]

n'	Normal cyclic prefix		Extended cyclic prefix
	Normal subframes,Special subframes,configurations3, 4, 8	Special subframes, configurations1, 2, 6, 7, 9	Any subframe
0	107	107	107
1	108	109	108
2	109	-	-
3	110	-	-

[172] For distributed transmission, each resource element in an EREG is associated with one out of two antenna ports in an alternating manner where $p \in \{107,109\}$ for normal cyclic prefix and $p \in \{107,108\}$ for extended cyclic prefix.

[173] Recently, machine type communication (MTC) has come to the fore as a significant communication standard issue. MTC refers to exchange of information between a machine and an eNB without involving persons or with minimal human intervention. For example, MTC may be used for data communication for measurement/

sensing/reporting such as meter reading, water level measurement, use of a surveillance camera, inventory reporting of a vending machine, etc. and may also be used for automatic application or firmware update processes for a plurality of UEs. In MTC, the amount of transmission data is small and UL/DL data transmission or reception (hereinafter, transmission/reception) occurs occasionally. In consideration of such properties of MTC, it would be better in terms of efficiency to reduce production cost and battery consumption of UEs for MTC (hereinafter, MTC UEs) according to data transmission rate. Since the MTC UE has low mobility, the channel environment thereof remains substantially the same. If an MTC UE is used for metering, reading of a meter, surveillance, and the like, the MTC UE is very likely to be located in a place such as a basement, a warehouse, and mountain regions which the coverage of a typical eNB does not reach. In consideration of the purposes of the MTC UE, it is better for a signal for the MTC UE to have wider coverage than the signal for the conventional UE (hereinafter, a legacy UE).

[174] When considering the usage of the MTC UE, there is a high probability that the MTC UE requires a signal of wide coverage compared with the legacy UE. Therefore, if the eNB transmits a PDCCH, a PDSCH, etc. to the MTC UE using the same scheme as a scheme of transmitting the PDCCH, the PDSCH, etc. to the legacy UE, the MTC UE has difficulty in receiving the PDCCH, the PDSCH, etc. Therefore, the present invention proposes that the eNB apply a coverage enhancement scheme such as subframe repetition (repetition of a subframe with a signal) or subframe bundling upon transmission of a signal to the MTC UE having a coverage issue so that the MTC UE can effectively receive a signal transmitted by the eNB. For example, the PDCCH and PDSCH may be transmitted to the MTC UE having the coverage issue in a plurality of subframes (e.g. about 100 subframes).

[175] FIG. 6 illustrates an example of signals band for MTC.

[176] As one method for reducing the cost of the MTC UE, an operation of the MTC UE may be performed at a reduced UE downlink and uplink bandwidth of 1.4 MHz, for example, regardless of an operating system bandwidth of a cell. At this time, a subband (narrowband) for operating the MTC UE may always be located at the center (e.g., 6 center PRBs) of a cell as shown in FIG. 6(a), or several subbands for MTC may be provided for one subframe to multiplex MTC UEs as shown in FIG. 6(b), whereby the UEs may use their respective subbands different from each other or the UEs use the same subband not the subband of 6 center PRBs.

[177] In this case, the MTC UE cannot receive a legacy PDCCH transmitted through a full system band normally, and transmission of PDCCH for the MTC UE from an OFDM symbol region within which the legacy PDCCH is transmitted may not be preferable due to multiplexing issue with a PDCCH transmitted to another UE. As one method for

solving this, it is required to introduce a control channel transmitted within a subband where MTC is operated for the MTC UE. As a downlink control channel for such a low-complexity MTC UE, the legacy EPDCCH may be used as it is. Or, M-PDCCH for the MTC UE which is a control channel of a modified type of the legacy PDCCH/ EPDCCH may be introduced. Hereinafter, in the present invention, the legacy EPDCCH or M-PDCCH for the low-complexity MTC UE or normal complexity MTC UE will be referred to as M-PDCCH. Also, MTC-EPDCCH is hereinafter used to refer to M-PDCCH.

[178] A data channel (e.g., PDSCH, PUSCH) and/or a control channel (e.g., M-PDCCH, PUCCH, PHICH) may be transmitted for coverage enhancement (CE) of the UE by using a repetition or TTI bundling scheme through multiple subframes. The control/ data channel may be transmitted by additionally using cross-subframe channel estimation and frequency (narrowband) hopping for CE. In this case, cross-subframe channel estimation means a channel estimation method means channel estimation using a reference signal within a subframe of a corresponding channel and a reference signal within neighboring subframe(s).

[179] The MTC UE may need CE of 15dB, for example. However, all MTC UEs do not exist in an environment that CE is needed. Also, the same requirements of QoS are not applied to all MTC UEs. For example, since devices such as sensor and meter have low mobility and are likely to be located in a shaded area even while having a small amount of data transmission and reception, the devices may need high CE. However, wearable devices such as smart watch may have mobility and are likely to be located in a place not a shaded area while having a relatively large amount of data transmission and reception. Therefore, all MTC UEs do not need CE of high level, and their requirement capability may be varied depending on their type.

[180] In the present invention, an operation for monitoring M-PDCCH by means of an MTC UE (which needs coverage enhancement (CE)) will be suggested. Hereinafter, M-PDCCH monitoring, search space monitoring, or M-PDCCH candidates monitoring may mean that reception or detection of M-PDCCH is attempted within a corresponding search space or from one of M-PDCCH candidates configuring the corresponding search space.

[181] In the following embodiments, the expression "assume" may mean that an entity for transmitting a channel transmits the channel to be suitable for the corresponding "assumption". An entity for receiving the channel may receive or decode the channel to be suitable for the corresponding "assumption" provided that the channel has been transmitted to be suitable for the corresponding "assumption".

[182] FIG. 7 illustrates repeated transmission of a channel for coverage enhancement.

[183] A search space for M-PDCCH may be configured over a plurality of downlink

subframes. For example, M-PDCCH search space having an aggregation level L and a repetition level R is defined by a set of M-PDCCH candidates. In this case, each M-PDCCH candidate may be repeated within a set of R number of consecutive downlink subframes. Referring to FIG. 7, in an example of maximum repetitions R_{max}=8 and a possible repetition level of $R \in \{1, 2, 4, 0\}$, a UE may attempt decoding of M-PDCCH by assuming that repetition of M-PDCCH (transmitted at an aggregation level L) exists in each of R number of consecutive downlink subframes. For example, the UE may attempt decoding of M-PDCCH by regarding signals received from each of 8 subframes as those of the same M-PDCCH in case of a repetition level $R = 8$ and attempt decoding of different M-PDCCHs in each of 8 subframes in case of a repetition level $R = 1$.

[184] In FIG. 7, repetition of a channel is performed over consecutive downlink subframes. However, a data channel and/or a control channel (hereinafter, data/control channel) transmitted to/from the MTC UE which needs CE may be transmitted by being repeated through non-consecutive subframes. For example, the control/data channel for a specific MTC UE may not be in all downlink subframes but may be restricted to some downlink subframes. Non-consecutive downlink subframes available at the MTC UE may be configured in such a manner that a downlink subframe group comprised of one or more consecutive downlink subframes is repeated with a periodicity greater than the number of subframes within the downlink subframe group. In other words, the data/control channel may be transmitted not in physically consecutive subframes, but transmitted in transmitted in each of physically non-consecutive subframes (excluding uplink subframes in case of downlink transmission, downlink subframes in case of uplink transmission, and/or subframes except subframe used for other purpose of use and cannot be used for data/control channel transmission). Use of non-consecutive (downlink or uplink) subframes for repeated transmission of the data/control channel of the MTC UE may increase transmission/reception latency. However, as time diversity effect is obtained in the time domain by use of non-consecutive subframes, the number of repetitions or the number of subframes used for channel transmission may be reduced as compared with transmission based on consecutive subframes. Therefore, overall system throughput may be increased. The embodiments of the present invention, which will be described later, suggest UE operation and transmission subframe during transmission/reception of a corresponding channel when a data/control channel transmitted from MTC UE is transmitted with repetition through consecutive subframes or non-consecutive subframes.

[185] In the following embodiments, each search space within an interval where a UE monitors M-PDCCH (CSS and/or USS) may be configured over one or more (consecutive or non-consecutive) downlink subframes. That is, a search space for

reception of the same M-PDCCH may be configured in each of one or more downlink subframes.

[186] For example, referring to FIG. 8, in case of no CE or CE having a repetition level = 1, each of CSSs of FIG. 8 may be CSS on which a respective M-PDCCH can be transmitted. At this time, a CSS starting subframe may mean a first subframe of paging occasions for allowing a UE to monitor M-PDCCH for a paging message. As another example, referring to FIG. 9, in case of no CE or CE having a repetition level = 1, each of CSSs of FIG. 9 may be CSS on which a respective M-PDCCH can be transmitted. At this time, a CSS starting subframe may mean a first subframe of a RAR window for allowing a UE to monitor M-PDCCH for scheduling RAR.

[187] In case of coverage enhancement (CE), M-PDCCH may be transmitted by being repeated once or multiple times. Therefore, a search space where M-PDCCH (hereinafter, paging M-PDCCH) will be monitored may be configured repeatedly over a plurality of downlink subframes, and a UE may attempt repeated reception of M-PDCCH within search spaces within the plurality of downlink subframes. If CE having a repetition level greater than 1 is applied, for example, each CSS shown in FIG. 8 may be a plurality of consecutive subframes that may have repetitions of M-PDCCH. If CE having a repetition level greater than 1 is applied, as another example, a plurality of CSSs within the same paging occasion shown in FIG. 8 may be CSSs for repetitions of the same M-PDCCH. If CE having a repetition level greater than 1 is applied, as still another example, a plurality of CSSs over a plurality of paging occasions shown in FIG. 8 may be CSSs for repetitions of the same M-PDCCH.

[188] ■ Section 1. M-PDCCH CSS for paging message scheduling

[189] In Section 1, details on M-PDCCH CSS for paging message scheduling are discussed.

[190] The paging message is used to notify UE(s) under RRC_IDLE and UE(s) under RRC_CONNECTED of system information modification.

[191] An eNB initiates a paging process by transmitting the paging message at a paging occasion of a UE. The eNB may address a plurality of UEs within the paging message by including a paging record (*PagingRecord*) per UE. The paging record may include information indicating NAS (non-access stratum) identifier of a UE which is paged and information indicating the origin of paging. One paging occasion means a subframe having P-RNTI transmitted on PDCCH/M-PDCCH addressing the paging message. A paging frame (PF) means one radio frame that includes one or a plurality of paging occasion(s).

[192] The UE may use discontinuous reception (DRX) in an idle mode to reduce power consumption. If DRX is used, the UE monitors only one paging occasion per DRX cycle.

[193] The paging message may be transmitted through a PDSCH, and the PDSCH carrying the paging message may be scheduled by PDCCH/M-PDCCH.

[194] For paging message scheduling, multiple narrowbands can be configured by eNB. Then, a narrowband location for a paging occasion monitoring of a UE is determined by at least UE ID at least for paging record(s). However, the narrowband location and paging occasion for common signal transmission (e.g., SI update, earthquake and tsunami warning system (ETWS), and/or commercial mobile alert system (CMAS)) is not determined yet. To reduce UE complexity, it would be beneficial to apply the same paging occasion and narrowband location for paging record(s) reception and other information reception such as SI update, ETWS, and CMAS. For example, the UE may attempt reception of M-PDCCH for scheduling the paging message on the same narrowband at the same paging occasion for SI update and reception of ETWS and CMAS instead of monitoring different paging occasions and/or different narrowbands for SI update and reception of ETWS and CMAS.

[195] FIG. 8 illustrates a configuration of a common search space (CSS) for paging according to the present invention.

[196] Under the assumption that a paging occasion is a time region for M-PDCCH monitoring for paging message scheduling, a UE can monitor a common search space (CSS) within a paging occasion to check paging message transmission. Depending on duration of paging occasion and period of CSS starting subframe, there can be multiple CSS monitoring opportunities within a paging occasion as shown in FIG. 8. The period and offset of CSS starting subframe location can be configured by eNB. In this case, offset k_{offset} of the CSS starting subframe may mean a difference from a reference subframe n (e.g., subframe 0) to a subframe $n+k_{offset}$ in which the CSS starting subframe is first applied.

[197] The composition of decoding candidates (i.e. M-PDCCH candidates) and a subset of $\{L, R\}$ for CSS for paging should be composed to supports all UEs with different CE levels. In this case, L indicates an aggregation level, and M-PDCCH of the aggregation level L is transmitted using aggregation of L number of M-CCEs. ECCE may be used as M-CCE, and CCE for MTC UE may newly be defined as M-CCE for MTC UE.

[198] To transmit paging message adapt to the target CE level, a subset of $\{L, R\}$ of CSS for paging needs to be composed to cover all range of CE levels or all range of repetition numbers. One simple configuration is $\{8, R1\}$, $\{16, R1\}$, $\{24, R1\}$, $\{24, R2\}$, $\{24, R3\}$, $\{24, R4\}$ where $R1 = 1$ and $R4$ is the maximum repetition level.

[199] In the present invention, a paging occasion may be defined as an interval where a UE monitors a paging M-PDCCH. For example, the UE may attempt reception of (same) paging M-PDCCH (or M-PDCCH scrambled by P-RNTI) within CSS(s) existing in the paging occasion or paging M-PDCCH search space(s) as shown in FIG. 8. Since the

paging M-PDCCH may be transmitted in any one of CSS(s) within the paging occasion, the UE continuously monitors the CSS(s) within the paging occasion. If the paging M-PDCCH (or M-PDCCH scrambled by P-RNTI) is received within the corresponding interval, the UE may receive a PDSCH carrying the corresponding paging message even though a paging message scheduled by the corresponding M-PDCCH, that is, a PDSCH carrying paging is transmitted outside a paging occasion interval.

[200] A duration of the paging occasion may be configured to be a multiple of the number of subframes configuring CSSs or search spaces on which the paging M-PDCCH is transmitted. For example, if the paging M-PDCCH search space is configured in each of R number of (consecutive or non-consecutive) downlink subframes, the paging occasion may be configured to have a duration of R*X number of subframes (where X is a positive integer).

[201] ■ Section 2. M-PDCCH CSS for RAR scheduling

[202] FIG. 9 illustrates a configuration of a common search space (CSS) for RAR according to the present invention.

[203] There would be multiple narrowbands for CSS for RAR scheduling, and the narrowband location of a UE for RAR monitoring is determined by PRACH resource set.

[204] After transmitting PRACH, a UE would try to receive RAR. Similar to paging occasion, there can be multiple CSS regions within a RAR window as depicted in Figure 9. So, the UE can monitor M-PDCCH scheduling RAR in CSS region(s) within the RAR window.

[205] A subset of $\{L, R\}$ and composition of decoding candidates of CSS for RAR can depend on CE level of corresponding PRACH resource set. For example, for each CE level, PRACH resource set(s) and available repetition level(s) may be configured. In this case, the UE may monitor a CSS, that is, M-PDCCH in accordance with a set of $\{L, R\}$ configured for a CE level associated with a PRACH resource used for a successful RACH procedure. Regardless of CSS and USS, same composition of decoding candidates and same subset of $\{L, R\}$ can be used for same CE level of the search space. For example, the UE may monitor a CSS and a USS in accordance with $\{L, R\}$ of the same set with respect to the same CE level.

[206] The present invention suggests that a RAR window interval should be defined as an interval where a UE monitor M-PDCCH (hereinafter, RAR M-PDCCH) for scheduling RAR. That is, as shown in FIG. 9, the UE may attempt reception of RAR M-PDCCH (e.g., M-PDCCH scheduled by RA-RNTI) on CSS(s) existing within a RAR window or a search space(s) (hereinafter, RAR M-PDCCH search space) on which RAR M-PDCCH is transmitted. If the UE receives RAR M-PDCCH within the corresponding interval, the UE may receive a PDSCH through which the corresponding RAR is

transmitted, even though RAR (e.g., PDSCH carrying RAR) scheduled by the corresponding M-PDCCH is transmitted outside the RAR window interval.

[207] A duration of the RAR window may be configured to become a multiple of the number of subframes configuring CSSs or RAR M-PDCCH search spaces. For example, if RAR M-PDCCH search space is configured in each of R number of (consecutive or non-consecutive) downlink subframes, the RAR window may be configured to have a duration of R*X number of subframes (in this case, X is a positive integer).

[208] ■ Section 3. M-PDCCH CSS for other purposes

[209] M-PDCCH CSS can be used to transmit DCIs for other purposes except paging message and RAR scheduling. For example, M-PDCCH CSS can be used for transmission of DCI for unicast data, DCI for TPC, DCI for enhanced interference management and traffic adaptation (eIMTA), and DCI for enhanced PHICH (EPHICH). If CSS is used to transmit these DCIs, the narrowband location, monitoring subframe location, and decoding candidates composition need to be specified. Hereinafter, the CSS will be referred to as CSS_regular or CSS_others.

[210] CSS for these purposes (i.e. CSS_regular) can be located in the same narrowband to USS. Then, a UE does not need to re-tune its operating frequency to monitor this CSS.

[211] To reconfigure CE level of a UE, the CSS needs to support the maximum CE level of the cell considering CE level reconfiguration message can be transmitted by this CSS. Therefore, CE level or a subset of $\{L, R\}$ composing the CSS should support all CE level of the cell.

[212] FIG. 10 illustrates the example of the monitoring time region of USS and CSS.

[213] Period of starting subframe for M-PDCCH USS monitoring and CSS monitoring can be configured independently. The period of CSS monitoring can be longer than the period of USS, since CE level of USS and CSS can be different and CSS can be occurred sparsely to reduce UE complexity.

[214] Referring to Math Figure 1 which is a hashing function, it is noted that $Y_{p,k}$ is varied depending on n_{RNTI} which is UE ID. In this way, CCE(s) or ECCE(s) configuring decoding candidates in the USS is(are) determined UE-specifically to be monitored by a specific UE. M-PDCCH CSS can be monitored by a group of MTC UEs. Therefore, for CSS, there should not be a hashing function to randomize the starting ECCE location composing a search space UE-specifically.

[215] ■ Section 4. Coverage enhancement level of CSS

[216] For transmission of a broadcast PDSCH (e.g., paging, RAR), CSSs for other purposes such as unicast data, TPC, eIMTA DCI and EPHICH may exist, and USS where a UE monitors unicast data may exist. Hereinafter, a coverage enhancement level of corresponding search spaces will be described.

[217] The present invention suggests that a plurality of SS types exist as follows in accordance with a coverage enhancement level supported by a search space or repetitions of M-PDCCH.

[218] - Method 1.

[219] In view of the UE, two types of search spaces (SSs) may exist as follows:

[220] * SS type 1: SS supporting all coverage enhancement levels or all repetitions of M-PDCCH, and

[221] * SS type 2: SS where the number of repetitions of M-PDCCH which is supported is varied depending on a coverage enhancement level of the UE.

[222] In this case, the UE may assume that CSS for paging and/or CSS_regular has SS type 1, and CSS and/or USS for RAR has SS type 2.

[223] Alternatively, as SS monitored by the UE, one SS having SS type 1 and one SS having SS type 2 may exist. CSS for paging and/or CSS_regular may be the same as SS having SS type 1, and CSS and/or USS for RAR may be the same as SS having SS type 2.

[224] - Method 2.

[225] When N number of coverage enhancement levels (or the number of repetitions of M-PDCCH) supported by a cell exist, in view of the cell, a plurality of SS types may exist as follows:

[226] * SS type 1: SS supporting coverage enhancement level 1 (or the number of repetitions R_1 of M-PDCCH),

[227] * SS type 2: SS supporting coverage enhancement level 2 (or the number of repetitions R_2 of M-PDCCH),

[228] ...

[229] * SS type N: SS supporting coverage enhancement level N (or the number of repetitions R_N of M-PDCCH),

[230] * SS type N+1: SS supporting all coverage enhancement levels (or all repetitions for M-PDCCH).

[231] In this case, SS supporting the coverage enhancement level n may mean SS supporting the coverage enhancement levels 1 to n or the maximum number of repetitions R_n of M-PDCCH.

[232] In this case, the UE may assume that the CSS for paging and CSS_regular has SS type N+1, and the CSS for RAR and/or USS has SS type k if the coverage enhancement level of the UE is k.

[233] ■ Section 5. Relationship between search spaces

[234] **CSS for paging (i.e., CSS_paging)**

[235] It is a CSS for paging monitoring in RRC_IDLE state. Since UEs in different CE levels monitor the same CSS for paging scheduling, it should be designed to cover all

the CE levels. CSS_paging are configured by SIB. In other words, the configuration of CSS_paging may be transmitted through SIB. The UE may identify the configuration of CSS_paging by reading SIB. The UE may monitor M-PDCCH candidates of CSS within subframe(s) and/or narrowband(s) according to the CSS_paging configuration.

[236] **CSS for** RAR corresponding to initial RACH procedure (i.e., CSS_RAR)

[237] Using CSS for RAR, a UE can monitor RAR, Msg3 (for retransmission), and Msg4. Though it can be considered to allow separate SS configurations for Msg3 re-transmission and Msg4 scheduling M-PDCCH from the SS configuration for RAR, given that those (i.e. RAR, Msg3 and Msg4) will be used only for initial access, the present invention proposes that the same configuration is used for initial RACH procedure. Required configurations for CSS_RAR can be configured by SIB per CE level. Then, in a UE perspective, configurations for CSS_RAR can be determined based on the CE level of PRACH resource set used for the latest PRACH transmission.

[238] **CSS for others (i.e., CSS_others or CSS_regular)**

[239] M-PDCCH CSS can be used to transmit DCIs for other purposes except paging message and initial RAR scheduling. For example, CSS is required to transmit TPC, unicast data for reconfiguration (such as CE level, transmission mode, USS reconfiguration), a DCI transmitting multiple HARQ-ACK corresponding to PUSCH to multiple UEs (if supported), transmit RAR corresponding to PRACH triggered by M-PDCCH order. CSS for these purposes can be located in the same narrowband to USS once a UE is connected to the network. Then, a UE does not need to re-tune its operating frequency to monitor this CSS. A UE can monitor CSS_others (i.e., CSS_regular) and USS simultaneously.

[240] If there is a complexity issue, TDM of CSS and USS monitoring can be considered. In other words, CSS and USS are time-division multiplexed, whereby the CSS and the USS may not be monitored at the same time.

[241] If CSS for other purposes are not defined, legacy PUCCH TPC via DCI format 3/3A cannot be supported. Then, if downlink traffic is occurred sparsely, it could be difficult to adopt PUCCH power since PUCCH TPC is accomplished by accumulated way. So, other way to handle this issue needs to be considered such as absolute PUCCH TPC via DL grant or unicast DCI for PUCCH TPC transmitted by USS. Thus, at least for CE mode A (for TCP and reconfiguration), CSS_others needs to be supported.

[242] **USS**

[243] USS is a search space for unicast data scheduling. Configurations for USS can be configured by SIB and Msg4. If necessary, reconfiguration can be utilized by radio resource control (RRC) layer (i.e. RRC signal). Configurations for USS also can be applied for CSS_others. In this case, individual configurations for CSS_others and USS may not be required.

[244] FIG. 11 illustrates a procedure of configuring a search space according to the present invention.

[245] Referring to FIG. 11, the UE may receive a list of search space (SS) configurations per CE level for RAR through SIB (S1101). The UE may transmit RACH preamble through PRACH by using a PRACH resource. PRACH resource(s) per CE level may be configured by SIB. The UE may monitor M-PDCCH for scheduling a response to the RACH preamble transmitted therefrom, that is, a response to transmission of the PRACH in a search space (S1103). The UE may assume that a search space for M-PDCCH scheduling the RAR depends on SS configuration (e.g., CSS_RAR configuration) received through the SIB. The UE which has received RAR M-PDCCH may receive RAR in accordance with DCI carried by the RAR M-PDCCH (S1105).

[246] Initial configuration for RAR, Msg3 and/or Msg4 may depend on SS configuration per CE level received (S1101) through SIB (S1121). The UE may monitor M-PDCCH for scheduling Msg4, which includes CSS configuration/reconfiguration and/or USS configuration/reconfiguration parameters, in the SS according to initial configuration through SIB (S1121). For example, the UE may monitor Msg4 M-PDCCH by assuming that the maximum number of repetitions, narrowband, PRB-set, etc. which are the same as those of CSS for RAR, are also applied to M-PDCCH (hereinafter, Msg4 M-PDCCH) for scheduling Msg4 (S1121). The UE which has received Msg4 M-PDCCH may receive Msg4 in accordance with DCI of the Msg4 M-PDCCH (S1123). The Msg4 may carry RRC message that includes UE-specific configuration for USS and/or CSS. In this case, the UE may monitor M-PDCCH by applying the UE-specific SS configuration instead of initial SS configuration (S1125).

[247] The UE may monitor M-PDCCH order within the CSS according to the UE-specific CSS configuration (S1141). The UE which has received the M-PDCCH order may receive RAR in accordance with scheduling information carried by the M-PDCCH order (S1143).

[248] The UE may monitor M-PDCCH for scheduling RRC message having UE-specific reconfiguration parameter(s) within the CSS according to the UE-specific CSS configuration (S1161). The UE-specific reconfiguration may include M-PDCCH configuration. The UE which has received the M-PDCCH may receive a PDSCH carrying the RRC message in accordance with scheduling information (that is, DCI) of the M-PDCCH (S1163). The UE may reconfigure M-PDCCH search space in accordance with the UE-specific reconfiguration.

[249] Table 13 illustrates parameters and configuration details required for search spaces. All or some of the parameters illustrated in Table 13 may be configured and/or re-configured in accordance with Table 13.

[250] [Table 13]

Parameters	Configuration details				Description
	CSS_paging	CSS_RAR	CSS_others	USS	
Subset of L	Fixed to {8, 16, 24}			{1, 2, 4, 8, 16, 24}	
R_{max}	Configurable by SIB.	Configured by SIB per CE level (configuration can be shared for CSS_RAR, CSS_others, USS).For CSS_others/USS, it can be reconfigured by RRC.			Subset of repetition numbers is determined based on R_{max}. Details are described in Subsection 5.1.
PRB-sets	Configured by SIB.	Configured by SIB per CE level specific and cell-specific.	Alt 1. Configured by Msg4 per UE.Alt 2. Configured by SIB per CE level (in this case, same configuration for CSS_RAR, CSS_others, USS).It can be reconfigured by RRC.		This configuration includes the number of PRB-sets, PRB size/ location of each PRB-set.
Transmission type	Configured by SIB per PRB-set.	Configured by SIB per PRB-set.	Alt 1. Configured by Msg4 per UE (the network ensures the same type is used beween CSS_others and USS in case both are monitored at the same time).Alt 2. Configured by SIB per CE level (in this case, same configuration for CSS_RAR, CSS_others, USS).It can be reconfigured by RRC.		
Narrowband	Determined	Based on	Default value can be		

	by UE ID among paging narrowbands configured by SIB.	PRACH resource set where RAR narrowband corresponding to each PRACH resource set is configured by SIB.	CSS_RAR's narrowband location. Configurable by Msg 4 per UEIt can be reconfigured by RRC.	
M-PDCCH monitoring starting	Alt 1. Configured by SIB per CE level.Alt 2. Configured by SIB regardless of CE level (one maximum value to reset monitoring starting subframe).			See FIG. 7 and Subsection 5.1.
M-PDCCH starting subframe	Determined by repetition number R per repetition number R.	Alt 1. Determined by R_{max} for CE Mode A, determined by repetition number R per repetition number R for CE Mode B.Alt 2. Determined by repetition number R per repetition number R.		See FIG. 7 and Subsection 5.1.

[251] In Table 13, a merged cell means that the configuration can be shared by corresponding search spaces, so individual configuration is not needed for each search space. For example, referring to Table 13, "Fixed to {8, 16, 24}" which is the description of a subset of an aggregation level *L* exists within a cell merged for CSS_paging, CSS_RAR and CSS_others (i.e., CSS_regular), and thus means that a corresponding parameter is not required to be configured individually for CSS_paging, CSS_RAR and CSS_others(i.e. CSS_reguar) and a common parameter is applied to CSS_paging, CSS_RAR and CSS_others. According to Table 13, the UE may attempt reception of M-PDCCH at an aggregation level $L \in \{8, 16, 24\}$ for CSS_paging, CSS_RAR and CSS_others, and may attempt reception of M-PDCCH at $L \in \{1, 2, 4, 8, 16, 24\}$ for the USS.

[252] Reconfigurable parameters in Table 13 mean that the same value as initial configuration or default configuration is applied until a corresponding parameter is reconfigured, whereby search space(s) is(are) configured.

[253] For example, referring to Table 13, the maximum number of repetitions R_{max} of M-PDCCH may be provided through SIB as a configuration for CSS_RAR. The UE may monitor CSS_RAR, CSS_others and/or USS by assuming that R_{max} included in the SIB is applied to CSS_RAR, CSS_others, and USS. That is, the UE may monitor rep-

etitions of M-PDCCH in SS within maximum R_{max} number of subframes. According to Table 13, since R_{max} for CSS_others and/or USS (hereinafter, CSS_others/USS) may be reconfigured, if R_{max} for CSS_others/USS is reconfigured by RRC signal, the UE may monitor CSS_others/USS in accordance with the reconfigured R_{max}. In other words, the UE may monitor CSS_others/USS in accordance with R_{max} for CSS_RAR until R_{max} for CSS_others/USS is received.

[254] For another example, referring to parameters of PRB-sets in Table 13, PRBs on which PRB-set(s) for CSS_RAR, that is, RAR M-PDCCH may be transmitted may be configured CE level-specifically and cell-specifically by SIB. Referring to Alt 2, these PRB-sets configured per CE level may be applied to CSS_others and USS by SIB. Since PRB-set parameter for CSS_others and USS may be reconfigured by RRC, the UE may monitor CSS_others/USS by applying PRB-set(s) for CSS_RAR until reconfiguration PRB-set parameter for CSS_others/USS is received, and may monitor CSS_others/USS by applying the reconfiguration PRB-set parameter if the reconfiguration PRB-set parameter for CSS_others/USS is received. For example, if PRB-set(s) of CSS_RAR are fixed to 6, the UE may monitor M-PDCCH USS by assuming all PRBs within a narrowband according to CSS_RAR configuration as PRB-set(s) for USS until configuration of separate PRB-set(s) for USS is received.

[255] For still another example, referring to a narrowband parameter of Table 13, a narrowband (hereinafter, RAR narrowband) having CSS_RAR may be determined based on a PRACH resource set. In this case, a corresponding RAR narrowband per PRACH resource set is configured by SIB. A default narrowband location of CSS_others and/or USS may be a narrowband location of CSS_RAR. A narrowband for CSS_others/USS may be configured per UE by Msg4, and may be reconfigured by RRC. Therefore, the UE may monitor CSS_others/USS on the same narrowband as that for CSS_RAR until a narrowband parameter for CSS_others/USS is received, and if Msg4 for CSS_others/USS or reconfiguration RRC message is received, may monitor CSS_others/USS on a narrowband according to the Msg4 or the RRC message.

[256] □ Subsection 5.1. Aggregation levels and repetition numbers

[257] Search space configuration parameters of Table 13 may be applied as follows in view of an aggregation level and the number of repetitions. For example, a subset (and/or starting subframe of M-PDCCH SS and/or starting subframe of M-PDCCH) of the number of repetitions R based on R_{max} may be determined in accordance with the following description.

[258] **CSS for paging (i.e., CSS_paging)**

[259] - Aggregation levels:

[260] Since data transmission scheduled by CSS is targeted to multicast/broadcast, similar

to PDCCH CSS, some high aggregation levels can be supported. Aggregation levels (ALs) {8, 16, 24} can be supported for normal CP and ALs {4, 8, 12} can be supported for extended CP.

[261] - Repetition numbers:

[262] A subset of R for CSS for paging monitoring depends on the maximum R (i.e., R_{max}) where R_{max} is configured by SIB. To support wide range of repetition numbers, the subset of R monitored for CSS_paging can be {$R_{max}/64$, $R_{max}/16$, $R_{max}/4$, R_{max}}.

[263] **CSS for** RAR corresponding to initial RACH procedure (i.e., CSS_RAR)

[264] - Aggregation levels:

[265] Similar to CSS_paging, ALs $L\in\{8, 16, 24\}$ can be supported for normal CP and ALs $L\in\{4, 8, 12\}$ can be supported for extended CP.

[266] - Repetition numbers:

[267] For CSS scheduling RAR, the subset of R depends on the maximum R (i.e., R_{max}) where R_{max} is configured by SIB per CE level. The subset of R monitored for CSS_RAR can be {$R_{max}/4$, $R_{max}/2$, R_{max}}.

[268] **CSS for others (i.e., CSS_others)**

[269] - Aggregation levels:

[270] Similar to CSS_paging, ALs $L\in\{8, 16, 24\}$ can be supported for normal CP and ALs $L\in\{4, 8, 12\}$ can be supported for extended CP.

[271] - Repetition numbers:

[272] For CSS_others, the subset of R depends on the maximum R (i.e., R_{max}) where R_{max} is configured by SIB per CE level or Msg4. R_{max} can be reconfigured by RRC if necessary. The subset of R monitored for CSS_others can be {$R_{max}/4$, $R_{max}/2$, R_{max}}. Or, to reduce UE complexity, the subset of R monitored for CSS_others can be {$R_{max}/2$, R_{max}}.

[273] **USS**

[274] - Aggregation levels:

[275] For CE Mode A, ALs $L\in\{1, 2, 4, 8, 16, 24\}$ are supported for normal CP. ALs $L\in\{1, 2, 4, 8, 12\}$ are supported for extended CP. For CE Mode B, ALs $L\in\{8, 16, 24\}$ is supported for normal CP. ALs $L\in\{4, 8, 12\}$ are supported for extended CP.

[276] - Repetition numbers:

[277] For USS, the subset of R depends on the maximum R (i.e., R_{max}) where R_{max} is configured by SIB per CE level or Msg4. R_{max} can be reconfigured by RRC if necessary. The subset of R monitored for USS can be {$R_{max}/4$, $R_{max}/2$, R_{max}}. Or, to support higher R to CSS_others for CE level reconfiguration reliably, subset of R monitored for USS can be {$R_{max}/8$, $R_{max}/4$, $R_{max}/2$}.

[278] ■ Section 6. Collision of M-PDCCH(s)

[279] If there are some subframes not available for downlink transmission, M-

PDCCH/PDSCH transmission or repetitions can be postponed till the next available subframe. It can be applied in case unavailable subframes are aligned between eNB and UE.

[280] FIG. 12 illustrates a configuration of M-PDCCH repeated transmission according to the present invention.

[281] If a small interval (e.g., cycle of starting subframe of M-PDCCH search space) of M-PDCCH search space is configured or a large number of invalid subframes, which cannot have M-PDCCH, are provided between M-PDCCH search space starting subframes, M-PDCCH2 transmission may not end until next starting subframe of the search space, in the same manner as M-PDCCH2 transmission of FIG. 12. That is, the subframes configuring two search spaces may be overlapped with each other. In this case, the UE may be in the status that the UE should perform monitoring for M-PDCCH transmitted in a previous search space and monitoring for M-PDCCH transmitted in a next search space. However, this operation may not be preferable due to buffer size and complexity issue of the UE. In this case, the UE may perform reception of M-PDCCH as follows.

[282] - Method 1. If a starting time (hereinafter, subframe #n) of next search space occurs before reception of M-PDCCH is ended, the UE may assume that the M-PDCCH is transmitted up to subframe #n-1 and is not transmitted in subframe #n. In this case, the UE may attempt reception of the M-PDCCH by using repetitions smaller than the number of expected repetitions of M-PDCCH.

[283] - Method 2. If a starting time (hereinafter, subframe #n) of next search space occurs before reception of M-PDCCH is ended, the UE may determine that the M-PDCCH that the UE is receiving is invalid, and may not perform reception of the corresponding M-PDCCH.

[284] - Method 3. If subframe(s) configuring two search spaces are overlapped with each other, the UE may determine that a search space existing at an earlier time is invalid, and may not perform reception of M-PDCCH for one of the two search space, which is first started in a time domain.

[285] FIG. 13 is a block diagram illustrating elements of a transmitting device 10 and a receiving device 20 for implementing the present invention.

[286] The transmitting device 10 and the receiving device 20 respectively include Radio Frequency (RF) units 13 and 23 capable of transmitting and receiving radio signals carrying information, data, signals, and/or messages, memories 12 and 22 for storing information related to communication in a wireless communication system, and processors 11 and 21 operationally connected to elements such as the RF units 13 and 23 and the memories 12 and 22 to control the elements and configured to control the memories 12 and 22 and/or the RF units 13 and 23 so that a corresponding device may

perform at least one of the above-described embodiments of the present invention.

[287] The memories 12 and 22 may store programs for processing and controlling the processors 11 and 21 and may temporarily store input/output information. The memories 12 and 22 may be used as buffers.

[288] The processors 11 and 21 generally control the overall operation of various modules in the transmitting device and the receiving device. Especially, the processors 11 and 21 may perform various control functions to implement the present invention. The processors 11 and 21 may be referred to as controllers, microcontrollers, microprocessors, or microcomputers. The processors 11 and 21 may be implemented by hardware, firmware, software, or a combination thereof. In a hardware configuration, application specific integrated circuits (ASICs), digital signal processors (DSPs), digital signal processing devices (DSPDs), programmable logic devices (PLDs), or field programmable gate arrays (FPGAs) may be included in the processors 11 and 21. Meanwhile, if the present invention is implemented using firmware or software, the firmware or software may be configured to include modules, procedures, functions, etc. performing the functions or operations of the present invention. Firmware or software configured to perform the present invention may be included in the processors 11 and 21 or stored in the memories 12 and 22 so as to be driven by the processors 11 and 21.

[289] The processor 11 of the transmitting device 10 performs predetermined coding and modulation for a signal and/or data scheduled to be transmitted to the outside by the processor 11 or a scheduler connected with the processor 11, and then transfers the coded and modulated data to the RF unit 13. For example, the processor 11 converts a data stream to be transmitted into K layers through demultiplexing, channel coding, scrambling, and modulation. The coded data stream is also referred to as a codeword and is equivalent to a transport block which is a data block provided by a MAC layer. One transport block (TB) is coded into one codeword and each codeword is transmitted to the receiving device in the form of one or more layers. For frequency up-conversion, the RF unit 13 may include N_t (where N_t is a positive integer) transmit antennas.

[290] A signal processing process of the receiving device 20 is the reverse of the signal processing process of the transmitting device 10. Under control of the processor 21, the RF unit 23 of the receiving device 20 receives radio signals transmitted by the transmitting device 10. The RF unit 23 may include N_r (where N_r is a positive integer) receive antennas and frequency down-converts each signal received through receive antennas into a baseband signal. The processor 21 decodes and demodulates the radio signals received through the receive antennas and restores data that the transmitting device 10 intended to transmit.

[291] The RF units 13 and 23 include one or more antennas. An antenna performs a function for transmitting signals processed by the RF units 13 and 23 to the exterior or receiving radio signals from the exterior to transfer the radio signals to the RF units 13 and 23. The antenna may also be called an antenna port. Each antenna may correspond to one physical antenna or may be configured by a combination of more than one physical antenna element. The signal transmitted from each antenna cannot be further deconstructed by the receiving device 20. An RS transmitted through a corresponding antenna defines an antenna from the view point of the receiving device 20 and enables the receiving device 20 to derive channel estimation for the antenna, irrespective of whether the channel represents a single radio channel from one physical antenna or a composite channel from a plurality of physical antenna elements including the antenna. That is, an antenna is defined such that a channel carrying a symbol of the antenna can be obtained from a channel carrying another symbol of the same antenna. An RF unit supporting a MIMO function of transmitting and receiving data using a plurality of antennas may be connected to two or more antennas.

[292] In the embodiments of the present invention, a UE operates as the transmitting device 10 in UL and as the receiving device 20 in DL. In the embodiments of the present invention, an eNB operates as the receiving device 20 in UL and as the transmitting device 10 in DL. Hereinafter, a processor, an RF unit, and a memory included in the UE will be referred to as a UE processor, a UE RF unit, and a UE memory, respectively, and a processor, an RF unit, and a memory included in the eNB will be referred to as an eNB processor, an eNB RF unit, and an eNB memory, respectively.

[293] The eNB processor of the present invention may configure or reconfigure CSS_paging in accordance with section 1, section 5 and/or section 6. The eNB processor may control the eNB RF unit to transmit SIB or RRC message, which includes configuration for CSS_paging, to the UE in accordance with section 1, section 5 and/or section 6. The eNB processor may control the eNB RF unit to transmit M-PDCCH for scheduling a paging message within CSS_paging according to CSS_paging configuration. The UE processor of the present invention may control the UE RF unit to receive configuration or reconfiguration information on CSS_paging from the eNB in accordance with section 1, section 5 and/or section 6. The UE may attempt reception of paging M-PDCCH from CSS_paging according to the CSS_paging configuration.

[294] The eNB processor of the present invention may configure or reconfigure CSS_RAR in accordance with section 2, section 5 and/or section 6. The eNB processor may control the eNB RF unit to transmit SIB or RRC message, which includes configuration for CSS_RAR, to the UE in accordance with section 2, section 5 and/or section 6. The eNB processor may control the eNB RF unit to transmit M-PDCCH for

scheduling RAR, Msg3 and/or Msg4 within a CSS according to CSS_RAR configuration. The UE processor of the present invention may control the UE RF unit to receive configuration or reconfiguration information on CSS_RAR from the eNB in accordance with section 2, section 5 and/or section 6. The UE may attempt reception of RAR M-MPDCCH, Msg3 M-PDCCH and/or Msg4 M-PDCCH from the CSS according to the CSS_RAR configuration.

[295] The eNB processor of the present invention may configure or reconfigure CSS_others in accordance with section 3, section 5 and/or section 6. The eNB processor may control the eNB RF unit to transmit SIB or RRC message, which includes configuration for CSS_others, to the UE in accordance with section 3, section 5 and/or section 6. The eNB processor may control the eNB RF unit to transmit M-PDCCH for other purpose within a CSS according to CSS_others configuration. The UE processor of the present invention may control the UE RF unit to receive configuration or reconfiguration information on CSS_others from the eNB in accordance with section 3, section 5 and/or section 6. The UE may attempt reception of M-PDCCH for other purpose from the CSS according to the CSS_others configuration.

[296] The eNB processor of the present invention may transmit initial configuration for CSS through SIB in accordance with section 6. The eNB processor may configure CSS and/or USS in accordance with the initial configuration until the other configuration (e.g., UE-specific configuration/reconfiguration) for SS is transmitted. The initial configuration may include a configuration (e.g., narrowband, PRB-set(s), starting subframe and/or period, and the number of maximum repetitions of SS) of time-frequency resources of SS. The eNB processor may transmit M-PDCCH in accordance with the initial configuration until the other configuration for SS is transmitted. For example, the eNB processor may control the eNB RF unit to transmit M-PDCCH by applying the number of repetitions R based on maximum R_{max} according to the initial configuration within the PRB-set according to the initial configuration on a narrowband according to the initial configuration. If the other configuration for SS is transmitted, the eNB processor may control the eNB RF unit to transmit M-PDCCH on the SS configured in accordance with the other configuration. The UE processor may receive the initial configuration for CSS through SIB in accordance with section 6. The UE processor may assume that CSS and/or USS is configured in accordance with the initial configuration until the other configuration (e.g., UE-specific configuration/reconfiguration) for SS is received. The UE processor may monitor M-PDCCH in accordance with the initial configuration until the other configuration for SS is transmitted. For example, the UE processor may control the UE RF unit to receive or monitor M-PDCCH by applying the number of repetitions R based on maximum R_{max} according to the initial configuration within the PRB-set according to the initial con-

figuration on a narrowband according to the initial configuration. If the other configuration for SS is received, the UE processor may control the UE RF unit to receive or monitor M-PDCCH on the SS configured in accordance with the other configuration.

[297] As described above, the detailed description of the preferred embodiments of the present invention has been given to enable those skilled in the art to implement and practice the invention. Although the invention has been described with reference to exemplary embodiments, those skilled in the art will appreciate that various modifications and variations can be made in the present invention without departing from the spirit or scope of the invention described in the appended claims. Accordingly, the invention should not be limited to the specific embodiments described herein, but should be accorded the broadest scope consistent with the principles and novel features disclosed herein.

Industrial Applicability

[298] The embodiments of the present invention are applicable to a BS, a UE, or other devices in a wireless communication system.

Claims

[Claim 1] A method for receiving, by a user equipment (UE), downlink control information (DCI) for the UE, the method comprising:
receiving, by the UE, a common search space configuration for a common search space;
receiving, by the UE, a first physical downlink control channel (PDCCH) scheduling a random access response by monitoring first PDCCH candidates of the common search space according to the common search space configuration; and
receiving, by the UE, a second PDCCH carrying the DCI for the UE by monitoring second PDCCH candidates of a UE-specific search space,
wherein the second PDCCH candidates of the UE-specific search space are monitored according to the same configuration as the common search space configuration until the UE receives a UE-specific search space configuration.

[Claim 2] The method according to claim 1,
wherein the common search space configuration includes information on a narrowband for the common search space, and
wherein the second PDCCH candidates of the UE-specific search space are monitored on the same narrowband as the narrowband for the common search space until the UE receives a UE-specific search space configuration.

[Claim 3] The method according to claim 1 or 2,
wherein the common search space configuration includes information on a maximum number of repetitions for the common common search space, and
wherein the second PDCCH candidates of the UE-specific search space are monitored based on the same number as the maximum number of repetitions for the common search space until the UE receives a UE-specific search space configuration.

[Claim 4] The method according to any one of claims 1 to 3,
wherein the common search space configuration includes information on a first physical resource block (PRB) set for monitoring the first PDCCH, and
wherein the same physical resource block set as the first PRB set is used for monitoring the second PDCCH candidates until the UE receives a UE-specific search space configuration.

[Claim 5] The method according to any one of claims 1 to 4,
wherein the first PDCCH candidates of the common search space are monitored according to aggregation levels larger than or equal to 8 among a plurality of aggregation levels, and the second PDCCH candidates of the UE-specific search space are monitored according to the plurality of aggregation levels.

[Claim 6] A method for transmitting, by a base station (BS), downlink control information (DCI) for a user equipment (UE), the method comprising:
transmitting, by the BS, common search space configuration for a common search space;
transmitting, by the BS to the UE, a first physical downlink control channel (PDCCH) scheduling a random access response by using one of first PDCCH candidates of the common search space according to the common search space configuration; and
transmitting, by the BS to the UE, a second PDCCH carrying the DCI for the UE by using one of second PDCCH candidates of a UE-specific search space,
wherein the second PDCCH candidates of the UE-specific search space are configured according to the same configuration as the common search space configuration until a UE-specific search space configuration is transmitted to the UE.

[Claim 7] The method according to claim 6,
wherein the common search space configuration includes information on a narrowband for the common search space, and
wherein the second PDCCH candidates of the UE-specific search space are configured on the same narrowband as the narrowband for the common search space until the UE-specific search space configuration is transmitted to the UE.

[Claim 8] The method according to claim 6 or 7,
wherein the common search space configuration includes information on a maximum number of repetitions for the first common search space, and
wherein the second PDCCH candidates of the UE-specific search space are configured based on the same number as the maximum number of repetitions for the common search space until the UE-specific search space configuration is transmitted to the UE.

[Claim 9] The method according to any one of claims 6 to 8,
wherein the common search space configuration includes information

on a first physical resource block (PRB) set for transmitting the first PDCCH, and
wherein the same physical resource block set as the first PRB set is used for the second PDCCH candidates until the UE-specific search space configuration is transmitted to the UE.

[Claim 10] The method according to any one of claims 6 to 9,
wherein the first PDCCH candidates of the common search space are configured according to aggregation levels larger than or equal to 8 among a plurality of aggregation levels, and the second PDCCH candidates of the UE-specific search space are configured according to the plurality of aggregation levels.

[Claim 11] A user equipment (UE) for receiving downlink control information (DCI) for the UE, the UE comprising:
a radio frequency (RF) unit, and
a processor connected to the RF unit, the processor configured to:
control the RF unit to receive common search space configuration for a common search space;
control the RF unit to receive a first physical downlink control channel (PDCCH) scheduling a random access response by monitoring first PDCCH candidates of the common search space according to the common search space configuration; and
control the RF unit to receive a second PDCCH carrying the DCI for the UE by monitoring second PDCCH candidates of a UE-specific search space,
wherein the second PDCCH candidates of the UE-specific search space are monitored according to the same configuration as the common search space configuration until the UE receives a UE-specific search space configuration.

[Claim 12] The UE according to claim 11,
wherein the common search space configuration includes information on a narrowband for the common search space, and
wherein the second PDCCH candidates of the UE-specific search space are monitored on the same narrowband as the narrowband for the common search space until the UE receives a UE-specific search space configuration.

[Claim 13] The UE according to claim 11 or 12,
wherein the common search space configuration includes information on a maximum number of repetitions for the common common search

space, and
wherein the second PDCCH candidates of the UE-specific search space are monitored based on the same number as the maximum number of repetitions for the common search space until the UE receives a UE-specific search space configuration.

[Claim 14] The UE according to any one of claims 11 to 13,
wherein the common search space configuration includes information on a first physical resource block (PRB) set for monitoring the first PDCCH, and
wherein the same physical resource block set as the first PRB set is used for monitoring the second PDCCH candidates until the UE receives a UE-specific search space configuration.

[Claim 15] The UE according to any one of claims 11 to 14,
wherein the first PDCCH candidates of the common search space are monitored according to aggregation levels larger than or equal to 8 among a plurality of aggregation levels, and the second PDCCH candidates of the UE-specific search space are monitored according to the plurality of aggregation levels.

[Claim 16] A base station (BS) for transmitting downlink control information (DCI) to a user equipment (UE), the BS comprising:
a radio frequency (RF) unit, and
a processor connected to the RF unit, the processor configured to:
control the RF unit to transmit common search space configuration for a common search space;
control the RF unit to transmit, to the UE, a first physical downlink control channel (PDCCH) scheduling a random access response by using one of first PDCCH candidates of the common search space according to the common search space configuration; and
control the RF unit to transmit, to the UE, a second PDCCH carrying the DCI for the UE by using one of second PDCCH candidates of a UE-specific search space,
wherein the second PDCCH candidates of the UE-specific search space are configured according to the same configuration as the common search space configuration until a UE-specific search space configuration is transmitted to the UE.

[Claim 17] The BS according to claim 16,
wherein the common search space configuration includes information on a narrowband for the common search space, and

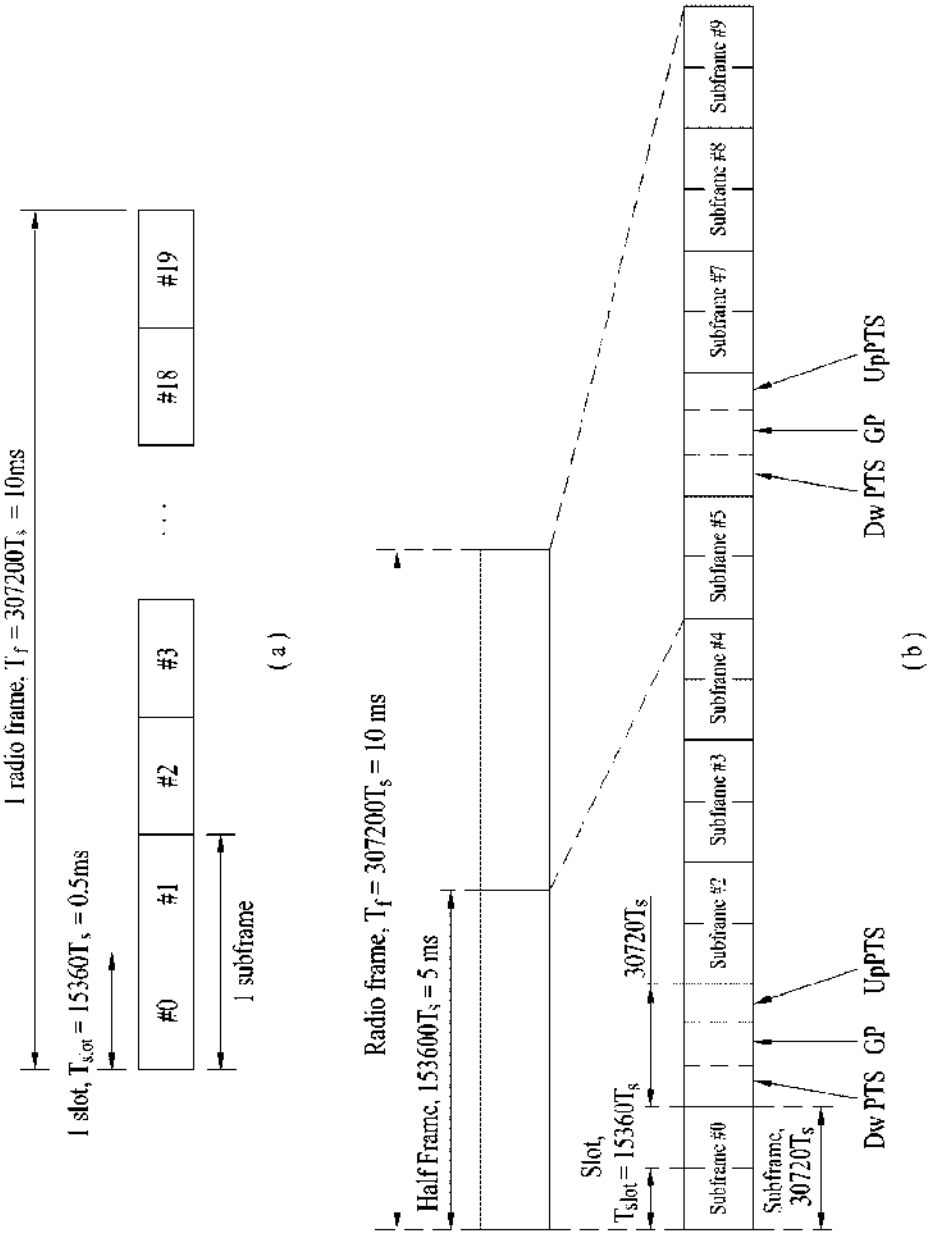
wherein the second PDCCH candidates of the UE-specific search space are configured on the same narrowband as the narrowband for the common search space until the UE-specific search space configuration is transmitted to the UE.

[Claim 18] The BS according to claim 16 or 17,
wherein the common search space configuration includes information on a maximum number of repetitions for the first common search space, and
wherein the second PDCCH candidates of the UE-specific search space are configured based on the same number as the maximum number of repetitions for the common search space until the UE-specific search space configuration is transmitted to the UE.

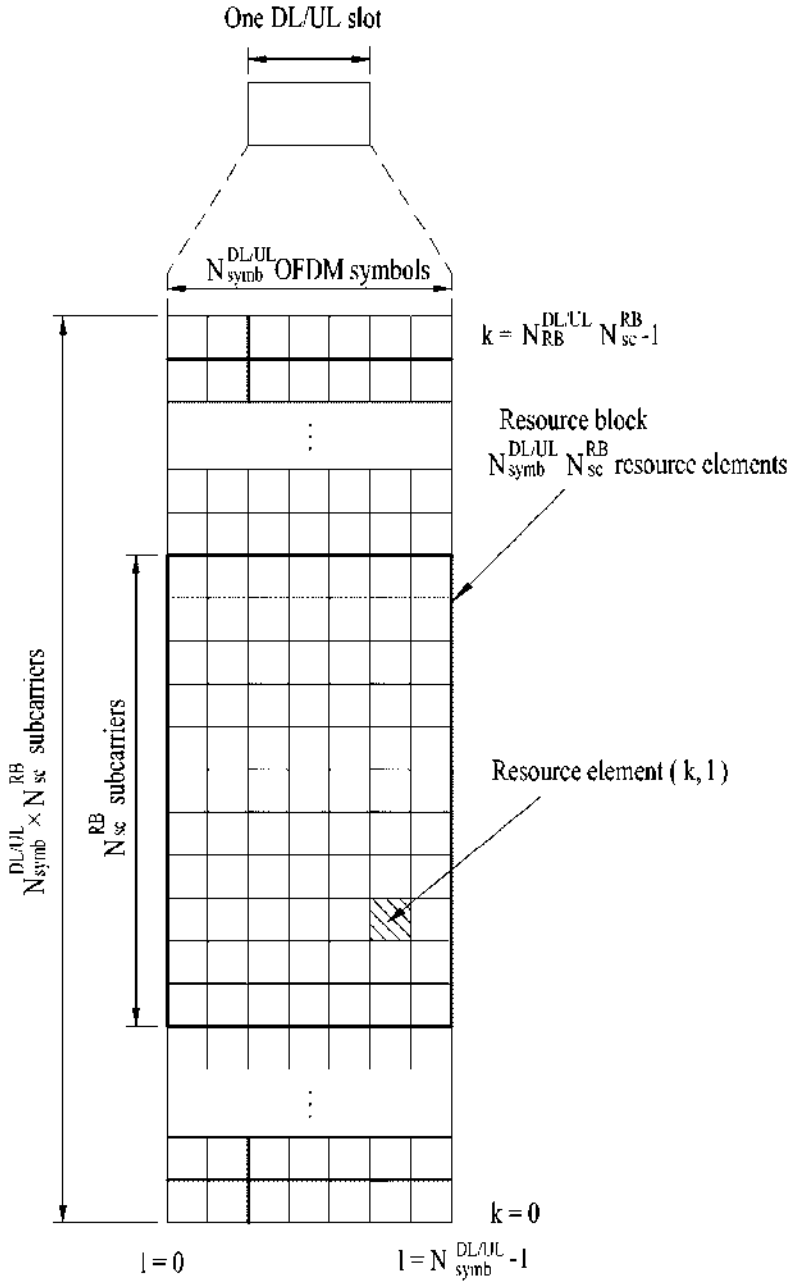
[Claim 19] The BS according to any one of claims 16 to 18,
wherein the common search space configuration includes information on a first physical resource block (PRB) set for transmitting the first PDCCH, and
wherein the same physical resource block set as the first PRB set is used for the second PDCCH candidates until the UE-specific search space configuration is transmitted to the UE.

[Claim 20] The BS according to any one of claims 16 to 19,
wherein the first PDCCH candidates of the common search space are configured according to aggregation levels larger than or equal to 8 among a plurality of aggregation levels, and the second PDCCH candidates of the UE-specific search space are configured according to the plurality of aggregation levels.

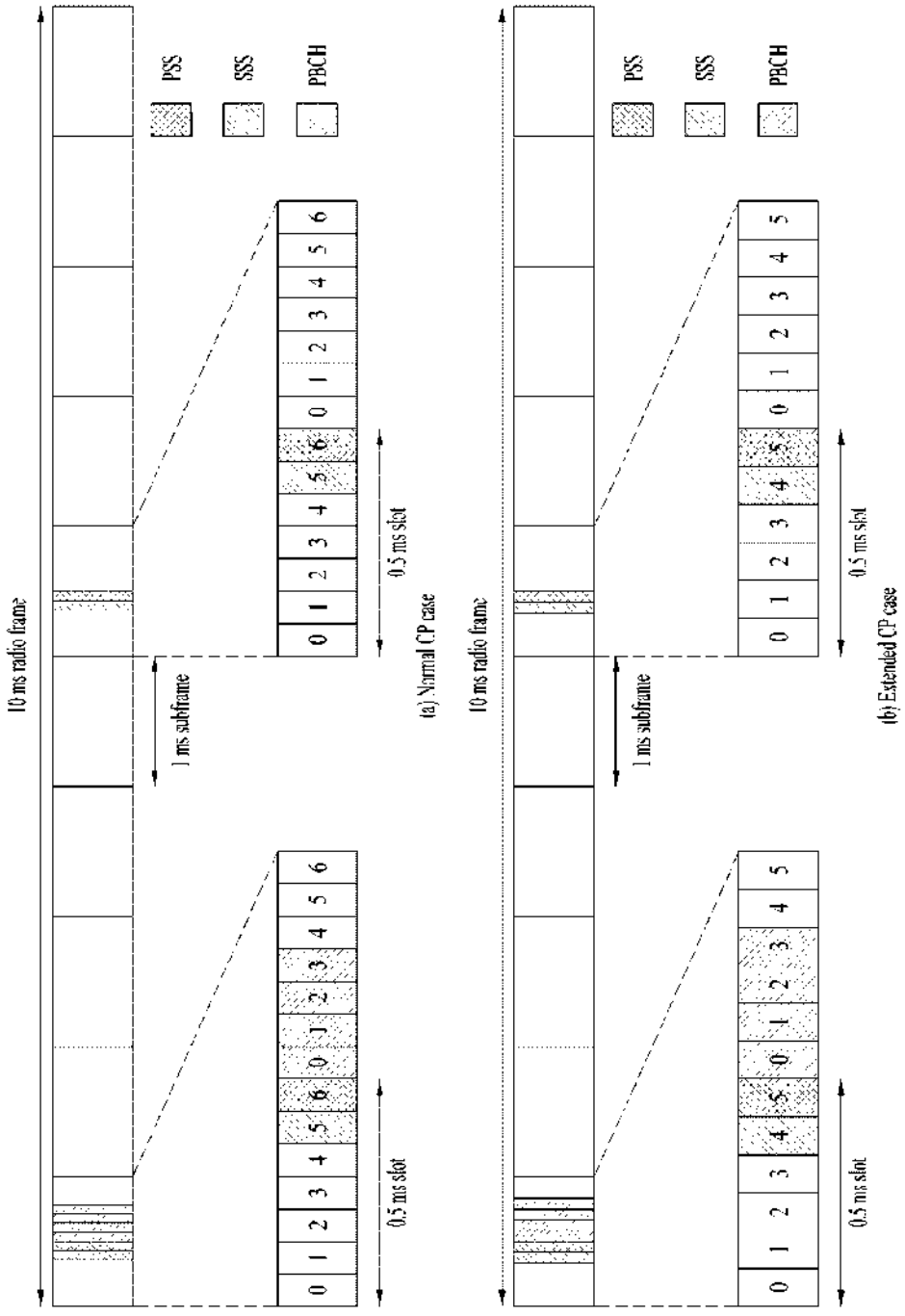
[Fig. 1]


1 radio frame, $T_f = 307200T_s = 10ms$
1 slot, $T_{slot} = 15360T_s = 0.5ms$
#0
#1
#2
#3
#18
#19
1 subframe
(a)
Radio frame, $T_f = 307200T_s = 10$ ms
Half Frame, $153600T_s = 5$ ms
Slot, $T_{slot} = 15360T_s$
$30720T_s$
Subframe #0
Subframe #2
Subframe #3
Subframe #4
Subframe #5
Subframe #7
Subframe #8
Subframe #9
Subframe, $30720T_s$
Dw PTS
GP
UpPTS
(b)

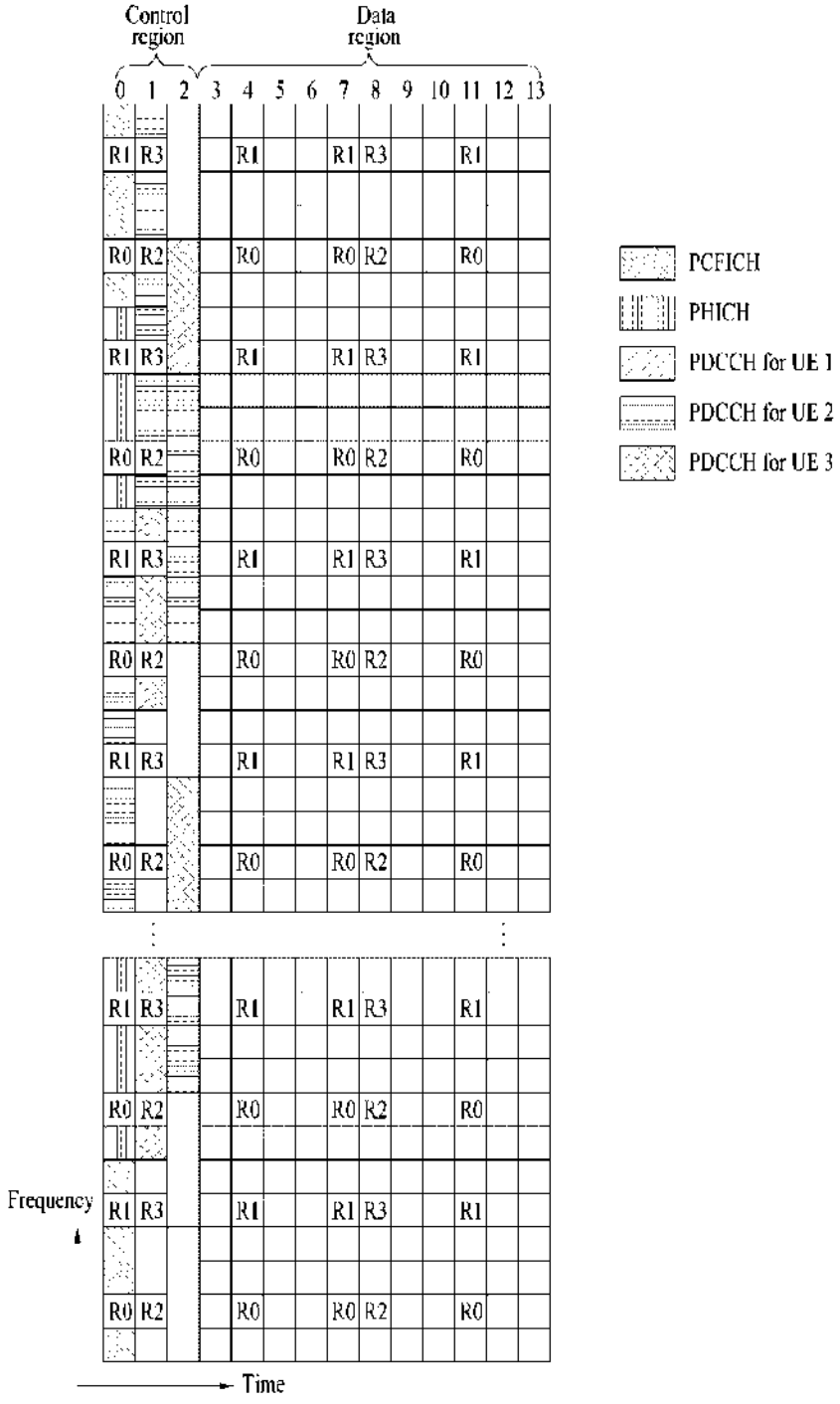
[Fig. 2]


One DL/UL slot
$N_{symb}^{DL/UL}$ OFDM symbols
$k = N_{RB}^{DL/UL} N_{sc}^{RB} - 1$
Resource block
$N_{symb}^{DL/UL} N_{sc}^{RB}$ resource elements
Resource element (k, l)
$N_{symb}^{DL/UL} \times N_{sc}^{RB}$ subcarriers
N_{sc}^{RB} subcarriers
k = 0
l = 0
$l = N_{symb}^{DL/UL} - 1$

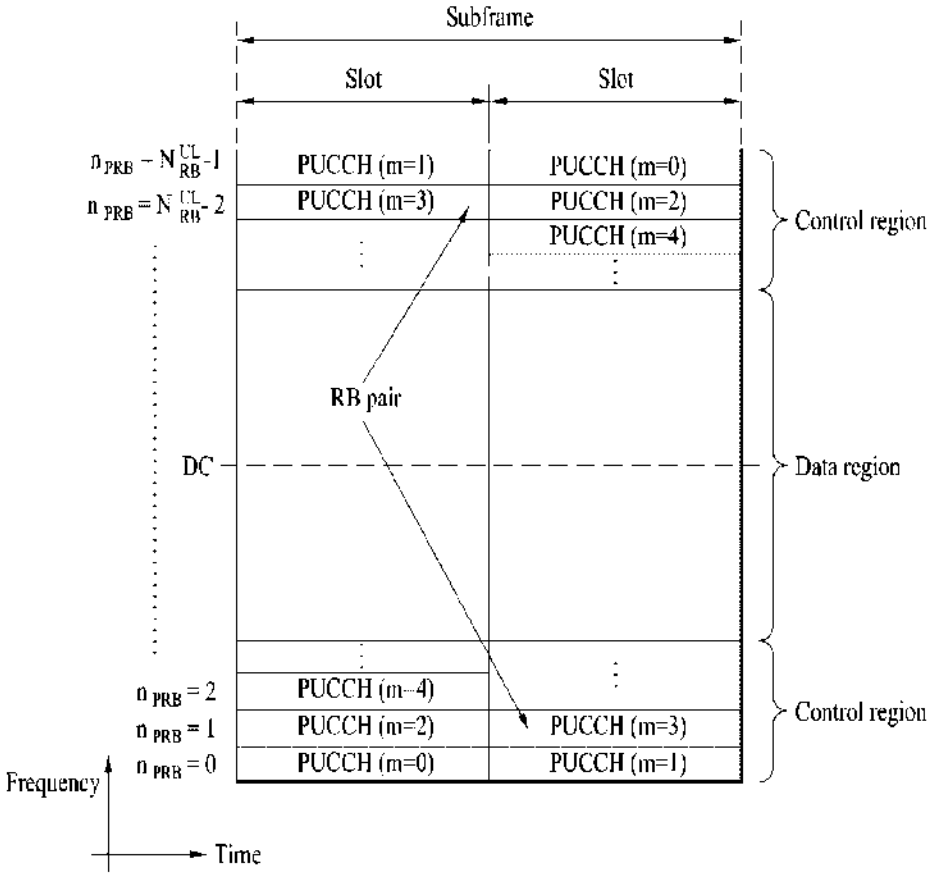
[Fig. 3]


PSS
SSS
PBCH
10 ms radio frame
1 ms subframe
0.5 ms slot
(a) Normal CP case
(b) Extended CP case

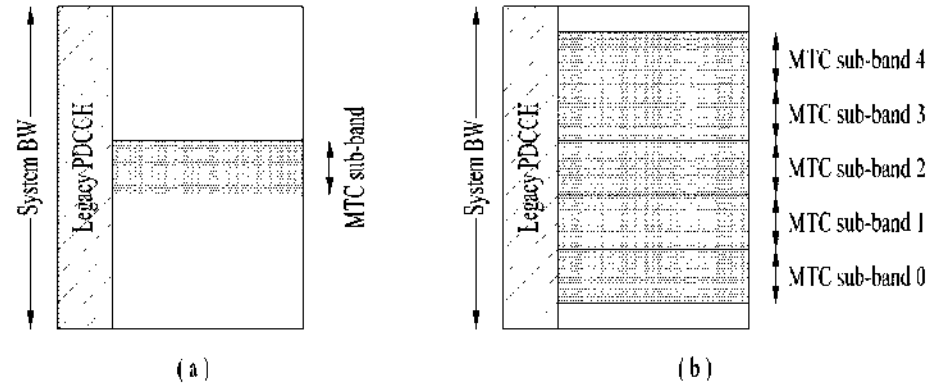
[Fig. 4]


Control region
Data region
0 1 2 3 4 5 6 7 8 9 10 11 12 13
R1 R3
R0 R2
PCFICH
PHICH
PDCCH for UE 1
PDCCH for UE 2
PDCCH for UE 3
Frequency
Time

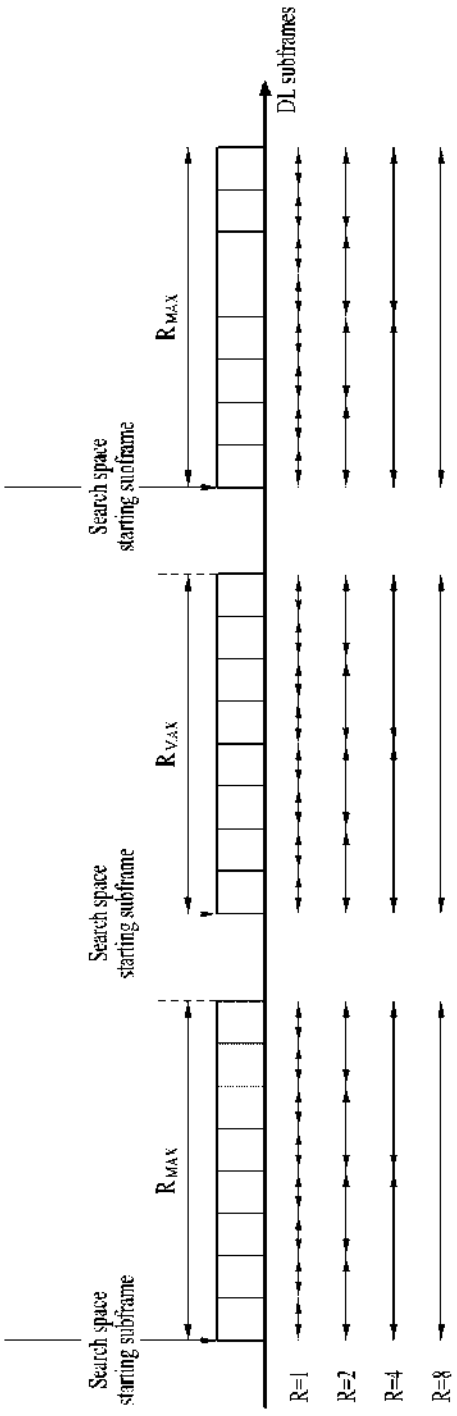
[Fig. 5]


Subframe
Slot
Slot
$n_{PRB} = N_{RB}^{UL} - 1$
$n_{PRB} = N_{RB}^{UL} - 2$
PUCCH (m=1)
PUCCH (m=0)
PUCCH (m=3)
PUCCH (m=2)
PUCCH (m=4)
Control region
RB pair
DC
Data region
$n_{PRB} = 2$
$n_{PRB} = 1$
$n_{PRB} = 0$
PUCCH (m=4)
PUCCH (m=2)
PUCCH (m=0)
PUCCH (m=3)
PUCCH (m=1)
Control region
Frequency
Time

[Fig. 6]


System BW
Legacy PDCCH
MTC sub-band
(a)
System BW
Legacy PDCCH
MTC sub-band 4
MTC sub-band 3
MTC sub-band 2
MTC sub-band 1
MTC sub-band 0
(b)

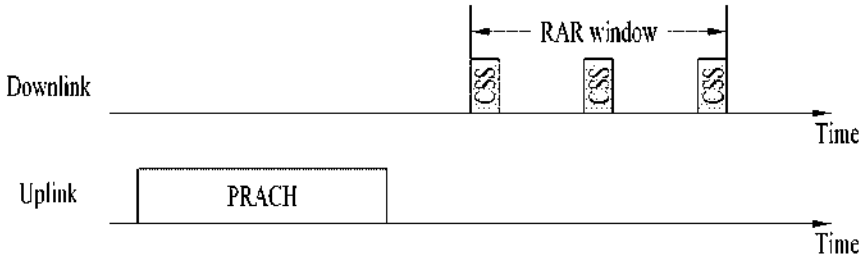
[Fig. 7]


DL subframes
Search space starting subframe
Search space starting subframe
Search space starting subframe
R_{MAX}
R_{MAX}
R_{MAX}
R=1
R=2
R=4
R=8

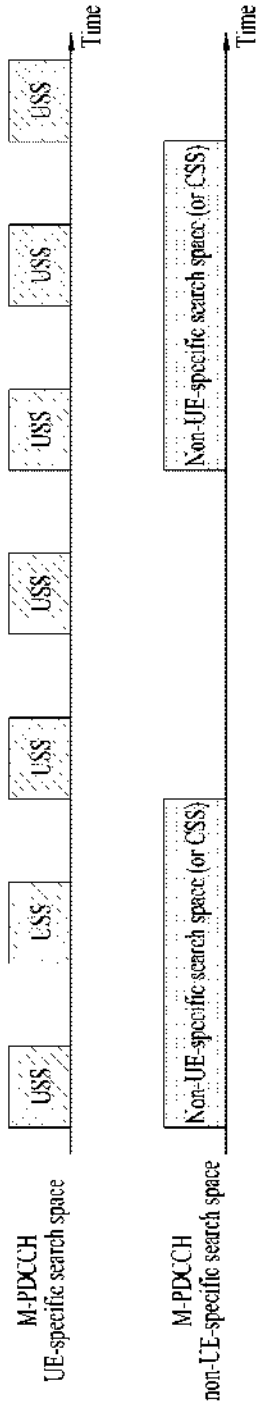
[Fig. 8]


Time
CSS
CSS
CSS
Paging occasion
CSS
CSS
CSS
Paging occasion

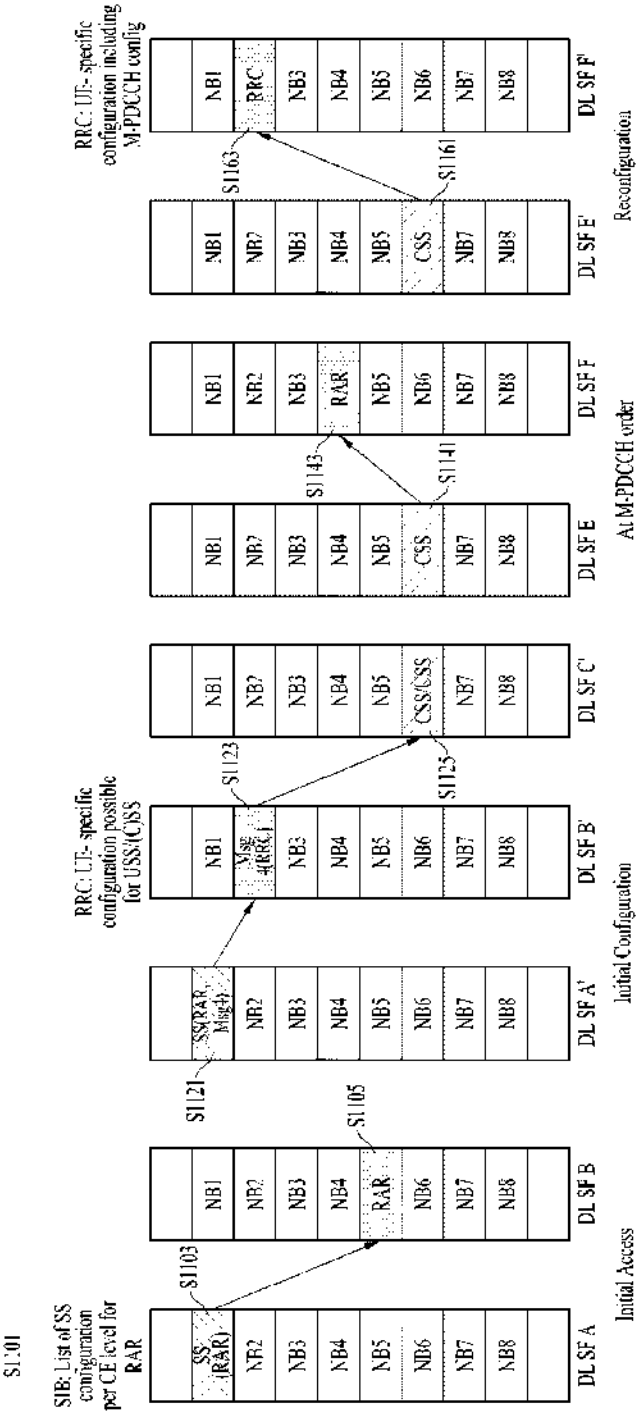
[Fig. 9]


RAR window
Downlink
CSS
CSS
CSS
Time
Uplink
PRACH
Time

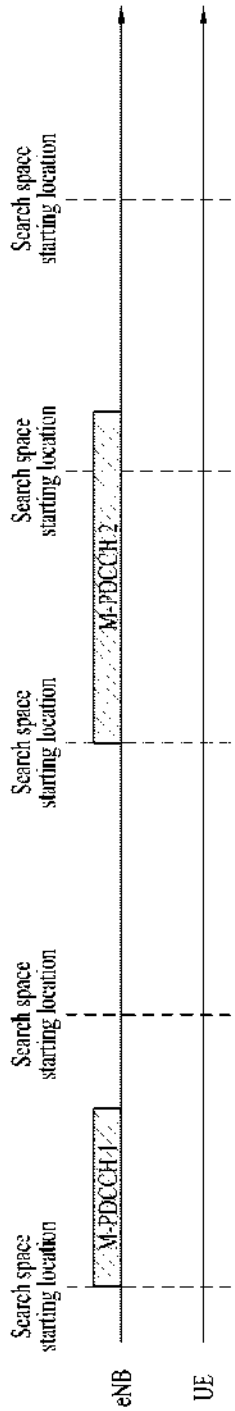
[Fig. 10]


Time
USS
USS
USS
USS
USS
USS
USS
M-PDCCH
UE-specific search space
Time
Non-UE-specific search space (or CSS)
Non-UE-specific search space (or CSS)
M-PDCCH
non-UE-specific search space

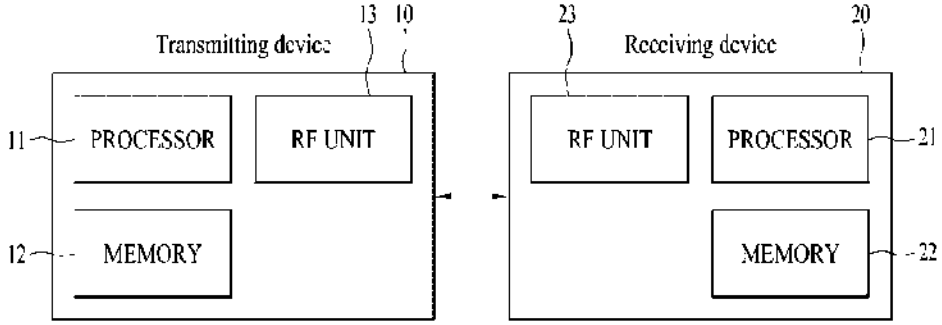
[Fig. 11]


S1101
SIB: List of SS configuration per CE level for RAR
DL SF A
SS (RAR)
NB2
NB3
NB4
NB5
NB6
NB7
NB8
Initial Access
S1103
DL SF B
NB1
NB2
NB3
NB4
RAR
NB6
NB7
NB8
S1105
S1121
DL SF A'
SS(RAR, Msg4)
NB2
NB3
NB4
NB5
NB6
NB7
NB8
Initial Configuration
RRC: UE- specific configuration possible for USS/CSS
DL SF B'
NB1
Msg 4(RRC)
NB3
NB4
NB5
NB6
NB7
NB8
S1123
S1125
DL SF C'
NB1
NB2
NB3
NB4
NB5
CSS/USS
NB7
NB8
DL SF E
NB1
NB2
NB3
NB4
NB5
CSS
NB7
NB8
At M-PDCCH order
S1143
S1141
DL SF F
NB1
NB2
NB3
RAR
NB5
NB6
NB7
NB8
DL SF E'
NB1
NB2
NB3
NB4
NB5
CSS
NB7
NB8
Reconfiguration
S1163
S1161
DL SF F'
NB1
RRC
NB3
NB4
NB5
NB6
NB7
NB8
RRC: UE- specific configuration including M-PDCCH config

[Fig. 12]


Search space starting location
Search space starting location
Search space starting location
Search space starting location
M-PDCCH 1
M-PDCCH 2
eNB
UE

[Fig. 13]


Transmitting device
13
10
11
PROCESSOR
RF UNIT
12
MEMORY
Receiving device
23
20
RF UNIT
PROCESSOR
21
MEMORY
22

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2016/010542

A. CLASSIFICATION OF SUBJECT MATTER

H04L 5/00(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04L 5/00; H04W 72/04; H04W 24/08

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: common search space configuration, UE-specific search space, random access response, first PDCCH candidates, downlink control information, second PDCCH candidates, monitor, same configuration

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	ERICSSON, "EPDCCH initialization for MTC", R1 153731, 3GPP TSG RAN WG1 Meeting #82, Beijing, China, 15 August 2015 See sections 2.3.1; and fig. 1.	1,2,6,7,11,12,16,17
A		3-5,8-10,13-15,18-20
Y	LG ELECTRONICS, "Discussion on Resource configuration for low complexity MTC UEs", R1-154229, 3GPP TSG RAN WG1 Meeting #82, Beijing, China, 15 August 2015 See sections 2, 3; and figs. 2, 3.	1,2,6,7,11,12,16,17
A	ZTE, "Further considerations on M-PDCCH for MTC", R1-154432, 3GPP TSG RAN WG1 Meeting #82, Beijing, China, 15 August 2015 See sections 2-3.3.	1-20
A	US 2014-0307560 A1 (LG ELECTRONICS INC.) 16 October 2014 See paragraphs [0102]-[0149]; and figs. 6, 7.	1-20
A	US 2015-0181577 A1 (FUJITSU LIMITED) 25 June 2015 See paragraphs [0145]-[0153]; and fig. 7.	1-20

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 December 2016 (21.12.2016)	**22 December 2016 (22.12.2016)**

Name and mailing address of the ISA/KR	Authorized officer
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Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/KR2016/010542

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		CN 104025532 A	03/09/2014
		EP 2779556 A2	17/09/2014
		EP 2779556 A4	05/08/2015
		EP 2779557 A2	17/09/2014
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		KR 10-1612207 B1	12/04/2016
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		WO 2013-066084 A3	27/06/2013
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		EP 2693677 A1	05/02/2014
		JP 2015-527840 A	17/09/2015
		KR 10-2015-0024926 A	09/03/2015
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Declarations under Rule 4.17:

— *as to the identity of the inventor (Rule 4.17(i))*

Published:

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(54) **Title**: DEVICE, SYSTEM AND METHOD EMPLOYING UNIFIED FLEXIBLE 5G AIR INTERFACE

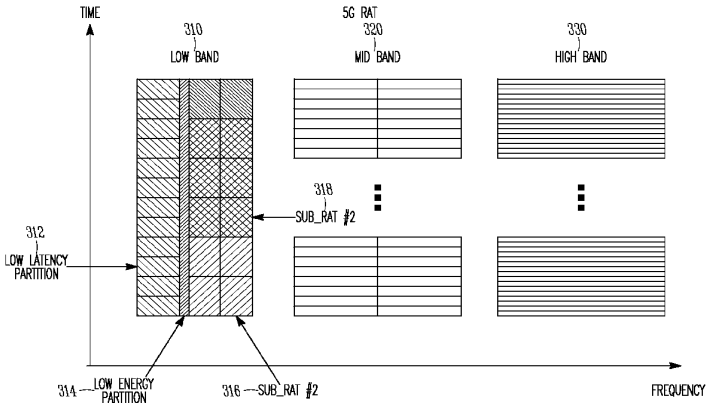


FIG. 3

(57) **Abstract**: An eNodeB (eNB), user equipment (UE) and method of providing a flexible Radio Access Technology (FRAT) are generally described. The information (resource allocation, partition information and numerology) of at least one of a plurality of RATs used by the eNB is provided to a UE. Each RAT has a flexible subcarrier spacing and symbol duration, which are integer multiples of a base subcarrier spacing and symbol duration, and is associated with at least one of different temporal and frequency resources. The symbol and/or frame structure of each RAT are independent. A Transmission Time Interval (TTI) boundary between the RATs is common, and the RATs comprise a common reference TTI duration. The information of the RATs is provided either via a different RAT than the RAT used by the UE for communication or via a dedicated carrier in the RAT used by the UE for communication.

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DEVICE, SYSTEM AND METHOD EMPLOYING UNIFIED FLEXIBLE 5G AIR INTERFACE

PRIORITY CLAIM

[0001] This application claims the benefit of priority to United States Provisional Patent Application Serial No. 62/114,733, filed February 11, 2015, and entitled "UNIFIED FLEXIBLE 5G NEW AIR INTERFACE DESIGN," which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] Embodiments pertain to radio access networks. Some embodiments relate to a unified communication framework using Radio Access Technologies (RAT) in 5th generation (5G) cellular networks.

BACKGROUND

[0003] The use of personal communication devices has increased astronomically over the last several decades. The penetration of mobile devices in modern society has continued to drive demand for a wide variety of networked devices in a number of disparate environments. The variety of available applications, especially video-related applications, has led to a concomitant increase in demand for increased bandwidth beyond that provided by Third Generation Partnership Project Long Term Evolution (3GPP LTE) and LTE advanced (LTE-A) systems.

[0004] The next generation wireless communication system, 5G, may provide access to information and sharing of data using a network that may be required to meet vastly different and sometimes conflicting performance dimensions and services driven by different services and use cases. It is therefore desirable that the next generation communication system be flexible and capable of providing high speed communications services for a wide ambit of devices under a multiplicity of circumstances.

BRIEF DESCRIPTION OF THE FIGURES

[0005] In the figures, which are not necessarily drawn to scale, like numerals may describe similar components in different views. Like numerals having different letter suffixes may represent different instances of similar components. The figures illustrate generally, by way of example, but not by way of limitation, various embodiments discussed in the present document.

[0006] FIG. 1 is a functional diagram of a 3GPP network in accordance with some embodiments.

[0007] FIG. 2 is a block diagram of a 3GPP device in accordance with some embodiments.

[0008] FIG. 3 illustrates one embodiment of a flexible Radio Access Technology (FRAT) of a 5G system in accordance with some embodiments.

[0009] FIG. 4 illustrates a unified frame structure in accordance with some embodiments.

[0010] FIG. 5 illustrates a Transmission Time Interval (TTI) boundary alignment in accordance with some embodiments.

[0011] FIG. 6 illustrates a symbol structure in accordance with some embodiments.

[0012] FIG. 7 illustrates frame structures within a TTI in accordance with some embodiments.

[0013] FIGS. 8A and 8B illustrate flowcharts of a uniform framework utilization method in accordance with some embodiments.

DETAILED DESCRIPTION OF THE INVENTION

[0014] The following description and the drawings sufficiently illustrate specific embodiments to enable those skilled in the art to practice them. Other embodiments may incorporate structural, logical, electrical, process, and other changes. Portions and features of some embodiments may be included in, or substituted for, those of other embodiments. Embodiments set forth in the claims encompass all available equivalents of those claims.

[0015] FIG. 1 is a functional diagram of a 3GPP network in accordance with some embodiments. The network may comprise a radio access network (RAN) (e.g., as depicted, the E-UTRAN or evolved universal terrestrial radio

access network) 100 and the core network 120 (e.g., shown as an evolved packet core (EPC)) coupled together through an S1 interface 115. For convenience and brevity sake, only a portion of the core network 120, as well as the RAN 100, is shown.

[0016] The core network 120 includes mobility management entity (MME) 122, serving gateway (serving GW) 124, and packet data network gateway (PDN GW) 126. The RAN 100 includes eNBs 104 (which may operate as base stations) for communicating with UE 102. The eNBs 104 may include macro eNBs and low power (LP) eNBs.

[0017] The MME is similar in function to the control plane of legacy Serving GPRS Support Nodes (SGSN). The MME manages mobility aspects in access such as gateway selection and tracking area list management. The serving GW 124 terminates the interface toward the RAN 100, and routes traffic packets (such as data packets or voice packets) between the RAN 100 and the core network 120. In addition, it may be a local mobility anchor point for inter-eNB handovers and also may provide an anchor for inter-3GPP mobility. Other responsibilities may include lawful intercept, charging, and some policy enforcement. The serving GW 124 and the MME 122 may be implemented in one physical node or separate physical nodes. The PDN GW 126 terminates a SGi interface toward the packet data network (PDN). The PDN GW 126 routes traffic packets between the EPC 120 and the external PDN, and may be a key node for policy enforcement and charging data collection. It may also provide an anchor point for mobility with non-LTE accesses. The external PDN can be any kind of IP network, as well as an IP Multimedia Subsystem (IMS) domain. The PDN GW 126 and the serving GW 124 may be implemented in one physical node or separated physical nodes.

[0018] The eNBs 104 (macro and micro) terminate the air interface protocol and may be the first point of contact for a UE 102. The eNBs 104 may communicate both with UEs 102 in a normal coverage mode and UEs 104 in one or more enhanced coverage modes. In some embodiments, an eNB 104 may fulfill various logical functions for the RAN 100 including but not limited to RNC (radio network controller functions) such as radio bearer management, uplink and downlink dynamic radio resource management and traffic packet

scheduling, and mobility management. In accordance with some embodiments, UEs 102 may be configured to communicate via orthogonal multiple access (OMA) communications such as Time Division Multiple Access (TDMA), Frequency Division Multiple Access (FDMA) Orthogonal FDMA (OFDMA), SC-FDMA or other communication signals with an eNB 104 over a multicarrier communication channel in accordance with the appropriate communication technique. The OFDM signals may comprise a plurality of orthogonal subcarriers. In accordance with some embodiments, UEs 102 may be configured to communicate via non-orthogonal multiple access (NOMA) signals.

[0019] The S1 interface 115 is the interface that separates the RAN 100 and the EPC 120. It is split into two parts: the S1-U, which carries traffic packets between the eNBs 104 and the serving GW 124, and the S1-MME, which is a signaling interface between the eNBs 104 and the MME 122.

[0020] With cellular networks, LP cells are typically used to extend coverage to indoor areas where outdoor signals do not reach well, or to add network capacity in areas with very dense phone usage, such as train stations. As used herein, the term low power (LP) eNB refers to any suitable relatively low power eNB for implementing a narrower cell (narrower than a macro cell) such as a femtocell, a picocell, or a micro cell. Femtocell eNBs are typically provided by a mobile network operator to its residential or enterprise customers. A femtocell is typically the size of a residential gateway or smaller and generally connects to the user's broadband line. Once plugged in, the femtocell connects to the mobile operator's mobile network and provides extra coverage in a range of typically 30 to 50 meters for residential femtocells. Thus, a LP eNB might be a femtocell eNB since it is coupled through the PDN GW 126. Similarly, a picocell is a wireless communication system typically covering a small area, such as in-building (offices, shopping malls, train stations, etc.), or more recently in-aircraft. A picocell eNB can generally connect through the X2 link to another eNB such as a macro eNB through its base station controller (BSC) functionality. Thus, LP eNB may be implemented with a picocell eNB since it is coupled to a macro eNB via an X2 interface. Picocell eNBs or other LP eNBs may incorporate some or all functionality of a macro eNB. In some cases, this may be referred to as an access point base station or enterprise femtocell.

[0021] As indicated in more detail below, communication over a 4G LTE network may be split up into 10ms frames, each of which may contain ten 1ms subframes. Each subframe of the frame, in turn, may contain two slots of 0.5ms. The eNB may schedule uplink and downlink transmissions over a variety of frequency bands. The allocation of resources in subframes used in one frequency band and may differ from those in another frequency band. Each slot of the subframe may contain 6-7 symbols, depending on the system used. In some embodiments, the subframe may contain 12 or 24 subcarriers. A resource grid may be used for downlink and uplink transmissions between an eNB and a UE. The resource grid may be a time-frequency grid, which is the physical resource in each slot. The smallest time-frequency unit in a resource grid may be denoted as a resource element (RE). Each column and each row of the resource grid may correspond to one OFDM symbol and one OFDM subcarrier, respectively. The resource grid may contain resource blocks (RBs) that describe the mapping of physical channels to resource elements and physical RBs (PRBs). A PRB may be the smallest unit of resources that can be allocated to a UE in the current 3GPP standard. A resource block may be 180 kHz wide in frequency and 1 slot long in time. In frequency, resource blocks may be either 12 x 15 kHz subcarriers or 24 x 7.5 kHz subcarriers wide. For most channels and signals, 12 subcarriers may be used per resource block, dependent on the system bandwidth. The duration of the resource grid in the time domain corresponds to one subframe or two resource blocks. Each resource grid may comprise 12 (subcarriers) *14 (symbols) =168 resource elements for normal cyclic prefix (CP) case. Several different physical channels may be conveyed using such resource blocks. As discussed in more detail below, in a 5G network, the sizes of the resource blocks, resource elements, and symbols, among others, may vary.

[0022] There may be several different physical downlink channels that are conveyed using such resource blocks, including the physical downlink control channel (PDCCH) and the physical downlink shared channel (PDSCH). Each subframe may contain a PDCCH, physical hybrid-ARQ indicator channel (PHICH), physical control format indicator channel (PCFICH) and the PDSCH. The PDCCH may normally occupy the first up to three symbols (four in the case

of narrow bandwidths of 1.4MHz) of each subframe and carry, among other things, information about the transport format and resource allocations related to the PDSCH channel and uplink scheduling grants for a physical uplink shared channel (PUSCH) transmission. The PHICH may be used to signal HARQ information in response to a PUSCH transmission. The PCFICH may inform the UE the control region size (e.g. one, two or three OFDM symbols) in each downlink subframe. The PDSCH may carry user data and higher layer signaling to a particular UE and occupy the remainder of the downlink subframe to avoid the resources in which downlink control channels (PDCCH/PHICH/PCFICH) are transmitted. Typically, downlink scheduling (assigning control and shared channel resource blocks to UEs within a cell) may be performed at the eNB based on channel quality information provided by the UEs, and then the downlink resource assignment information may be sent to a scheduled UE on the PDCCH used for (assigned to) PDSCH reception of the UE.

[0023] The PDCCH may contain downlink control information (DCI) in one of a number of formats that tell the UE where to find and how to decode the data, transmitted on PDSCH in the same subframe, from the resource grid. The DCI may provide details such as the number of resource blocks, resource allocation type, modulation scheme, transport block, redundancy version, coding rate etc. Each DCI format may have a cyclic redundancy code (CRC) and be scrambled with a Radio Network Temporary Identifier (RNTI) that identifies the target UE for which the PDSCH is intended. Use of the RNTI, which may be UE-specific, may limit decoding of the DCI information (and hence the corresponding PDSCH) to only the intended UE. The PDCCH may be located in any of a number of frequency/temporal regions, depending on whether the PDCCH is UE-Specific or common, as well as the aggregation level. The set of possible candidate locations for the PDCCH is defined in terms of search spaces. A search space is defined by a set of Control Channel Element (CCE) candidates with a number of aggregation level $L \in \{1,2,4,8\}$ where the UE may monitor to find its PDCCHs. A common search space may carry DCIs that are common for all UEs; for example, system information (using the SI-RNTI), paging (P-RNTI), PRACH responses (RA-RNTI), or UL TPC commands (TPC-PUCCH/PUSCH-RNTI). A UE-specific search space may carry DCIs for UE-

specific allocations using a Cell Radio-Network Temporary Identifier (C-RNTI) assigned to the UE, a semi-persistent scheduling (SPS C-RNTI), or an initial allocation (temporary C-RNTI). When configuring an SPS (either uplink or downlink), the SPS C-RNTI is provided by the eNB and the UE is configured by higher layers to decode a PDCCH with a CRC scrambled by the SPS C-RNTI. The UE may monitor the PDCCH having a CRC scrambled by the SPS C-RNTI in every subframe as the eNB can activate/re-activate/release the SPS at any time using a DCI format with a CRC scrambled by an SPS C-RNTI. The received DCI format with a CRC scrambled by the SPS C-RNTI can be a grant/assignment for a retransmission or for activation/re-activation/release of the SPS. 3GPP Technical Specification 36.213 has tabulated the validation procedure for activation/re-activation/release of SPS.

[0024] In addition to the PDCCH, an enhanced PDCCH (EPDCCH) may be used by the eNB and UE. The PDSCH may thus contain data in some of the resource blocks (RBs) and then EPDCCH contains the downlink control signals in others of the RBs of the bandwidth supported by the UE. Different UEs may have different EPDCCH configurations. The sets of RBs corresponding to EPDCCH may be configured, for example, by higher layer signaling such as Radio Resource Control (RRC) signaling for EPDCCH monitoring.

[0025] The Physical Uplink Control Channel (PUCCH) may be used by the UE to send Uplink Control Information (UCI) to the eNB. The PUCCH may be mapped to an UL control channel resource defined by an orthogonal cover code and two resource blocks (RBs), consecutive in time, with hopping potentially at the boundary between adjacent slots. The PUCCH may take several different formats, with the UCI containing information dependent on the format. Specifically, the PUCCH may contain a scheduling request (SR), acknowledgement responses/retransmission requests (ACK/NACK) or a Channel Quality Indication (CQI)/Channel State Information (CSI). The CQI/CSI may indicate to the eNB an estimate of the current downlink channel conditions as seen by the UE to aid channel-dependent scheduling and, if one MIMO transmission mode is configured to the UE, may include MIMO-related feedback (e.g. Precoder matrix indication, PMI).

[0026] FIG. 2 is a functional diagram of a 3GPP device in accordance with some embodiments. The device may be a UE or eNB, for example. In some embodiments, the eNB may be a stationary non-mobile device. The 3GPP device 200 may include physical layer circuitry 202 for transmitting and receiving signals using one or more antennas 201. The 3GPP device 200 may also include medium access control layer (MAC) circuitry 204 for controlling access to the wireless medium. The 3GPP device 200 may also include processing circuitry 206 and memory 208 arranged to perform the operations described herein.

[0027] In some embodiments, mobile devices or other devices described herein may be part of a portable wireless communication device, such as a personal digital assistant (PDA), a laptop or portable computer with wireless communication capability, a web tablet, a wireless telephone, a smartphone, a wireless headset, a pager, an instant messaging device, a digital camera, an access point, a television, a medical device (e.g., a heart rate monitor, a blood pressure monitor, etc.), or other device that may receive and/or transmit information wirelessly. In some embodiments, the mobile device or other device can be a UE 102 or eNB 104 configured to operate in accordance with 3GPP standards. In some embodiments, the mobile device or other device may be configured to operate according to other protocols or standards, including IEEE 802.11 or other IEEE standards. In some embodiments, the mobile device or other device may include one or more of a keyboard, a display, a non-volatile memory port, multiple antennas, a graphics processor, an application processor, speakers, and other mobile device elements. The display may be an LCD screen including a touch screen.

[0028] The antennas 201 may comprise one or more directional or omnidirectional antennas, including, for example, dipole antennas, monopole antennas, patch antennas, loop antennas, microstrip antennas or other types of antennas suitable for transmission of RF signals. In some multiple-input multiple-output (MIMO) embodiments, the antennas 201 may be effectively separated to take advantage of spatial diversity and the different channel characteristics that may result.

[0029] Although the 3GPP device 200 is illustrated as having several separate functional elements, one or more of the functional elements may be combined and may be implemented by combinations of software-configured elements, such as processing elements including digital signal processors (DSPs), and/or other hardware elements. For example, some elements may comprise one or more microprocessors, DSPs, field-programmable gate arrays (FPGAs), application specific integrated circuits (ASICs), radio-frequency integrated circuits (RFICs) and combinations of various hardware and logic circuitry for performing at least the functions described herein. In some embodiments, the functional elements may refer to one or more processes operating on one or more processing elements.

[0030] Embodiments may be implemented in one or a combination of hardware, firmware and software. Embodiments may also be implemented as instructions stored on a computer-readable storage device, which may be read and executed by at least one processor to perform the operations described herein. A computer-readable storage device may include any non-transitory mechanism for storing information in a form readable by a machine (e.g., a computer). For example, a computer-readable storage device may include read-only memory (ROM), random-access memory (RAM), magnetic disk storage media, optical storage media, flash-memory devices, and other storage devices and media. Some embodiments may include one or more processors and may be configured with instructions stored on a computer-readable storage device.

[0031] The term "machine readable medium" may include a single medium or multiple media (e.g., a centralized or distributed database, and/or associated caches and servers) configured to store one or more instructions. The term “machine readable medium” may include any medium that is capable of storing, encoding, or carrying instructions for execution by the 3GPP device 200 and that cause it to perform any one or more of the techniques of the present disclosure, or that is capable of storing, encoding or carrying data structures used by or associated with such instructions. The term “transmission medium” shall be taken to include any intangible medium that is capable of storing, encoding or carrying instructions for execution, and includes digital or analog

communications signals or other intangible medium to facilitate communication of such software.

[0032] As above, the upcoming 5G wireless communications technology systems may have a number of unique challenges, including carrying the inherent ability to provide different performances requirements for numerous different types of wireless devices. Higher data rates in particular may continue to drive network development and evolution for 5G system. It may be desirable for a 5G system to support a peak data rate of more than 10Gps and a minimum guaranteed user data rate of at least 100Mbps. In addition, it may be desirable for the 5G system to support the huge increase in variety and number of Internet of Things (IoT) and Machine-Type Communication (MTC)-type devices. MTC devices have been increasingly employed for different applications, using low operational power consumption and infrequent small burst transmissions. Moreover, it may be desirable for the 5G system to provide an extremely high level of reliable connectivity with guaranteed low latency, availability and reliability-of-service for mission critical MTC use cases.

[0033] In general, 5G systems may use a plurality of Radio Access Technologies (RATs), unlike previous 2G, 3G and 4G, systems. For example, an enormous amount of spectrum may be available through the use of higher frequency bands. In one example, the use of millimeter wave (mmWave) frequency bands ranging from 30 to 300GHz may provide the desired scalability, capacity and density for the 5G system. In this case, a new RAT may be defined for the mmWave band to achieve low latency and higher peak data rate. The RAT for mmWave band communications may differ from the RAT for one or more of the other frequency bands used to provide communication services. In some embodiments, the RATs may be used simultaneously by a single eNB for communications with different UEs.

[0034] In some embodiments, a 5G system may be provided that contains multiple RATs in a unified framework to support diverse applications, use cases and services and inter-networking in multiple frequency bands, including both licensed and unlicensed frequency bands. The RATs used in the licensed and unlicensed may be independent of each other. In some embodiments, flexible subcarrier spacing and symbol duration (i.e., configurable

numerology) may be provided across the frequency bands used in the 5G system. In addition, the 5G system may include mechanisms to multiplex multiple RATs, sub-RATs and other partitions in different or the same frequency resource or frequency bands.

[0035] The inter-networking in the unified frame structure may include, in some embodiments, a Transmission Time Interval (TTI) boundary alignment between multiple RATs may be provided to allow seamless scheduling, fallback and support of different RATs. In some embodiments, a TTI is the smallest unit of time in which the eNB is capable of scheduling any UE for uplink or downlink transmission. In some embodiments, the TTI boundary alignment may occur at a subframe or frame boundary. As used herein, a unified RAT with flexible air interface for the 5G system is referred to as a flexible Radio Access Technology (FRAT). A UE that communicates with an eNB operating using the FRAT may remain using a single air interface technology (i.e., RAT) or may switch between different RATs.

[0036] In some embodiments, a unified RAT with configurable numerologies may be used in the 5G system in which a base subcarrier spacing (Δf) and symbol duration (T) can be defined in the FRAT. In one example, to maintain the backward compatibility for existing LTE and LTE-Advanced systems, a base subcarrier spacing and symbol duration can be specified as Δf = 15KHz and T=66.7μs. Moreover, for convenience in some embodiments a single oscillator may be used, with the subcarrier spacing and symbol duration for different RATs specified as an integer number of the base subcarrier spacing and symbol duration, respectively.

[0037] Similarly, when a low latency use case and service is desired, a shortened symbol duration may be employed to reduce the latency by using larger subcarrier spacing. The subcarrier spacing and symbol duration may in this case be defined as $\Delta f_i = K*\Delta f$ and $T_i=(1/K)*T$. In one example, for frequency band between 6GHz and 30GHz, K can be chosen as 10, leading to a subcarrier spacing and symbol duration of 150KHz and 6.67μs, respectively. This may result in a 0.1ms TTI for low latency use case. In another example, for frequency bands below 6GHz, which includes the current LTE frequency range,

K can be selected by the network to be 2 or 4, and the corresponding subcarrier spacing and symbol duration changed proportional to the selected K value. Alternatively, the same subcarrier spacing and symbol duration can be defined for frequency bands below 6GHz (i.e., K =1), but a shorter TTI can be considered, e.g., with a fewer number of symbols, to support low latency use cases.

[0038] To efficiently support a massive number of MTC devices used in the 5G network, in other embodiments, the subcarrier spacing and symbol duration can be defined as $\Delta f_i = (1/K)*\Delta f$ and $T_i=K*T$. In such embodiments, K can be selected to be 10, and the subcarrier spacing and symbol duration 1.5KHz and 667μs, respectively. In this case, the subframe duration for MTC use cases can be defined to be 10ms, in the current generation LTE systems the length of a typical frame, rather than the typical 1ms. This may reduce the power consumption of MTC UEs by reducing the amount of time the MTC UE is active, thereby increasing the battery life of the MTC UEs.

[0039] A UE may be initially assigned the appropriate RAT by the eNB or other network device (such as the MME). In some embodiments, the UE may be configurable to communicate using any of the RATs, as indicated via the eNB, and can configure the subcarrier spacing and symbol duration accordingly. In some embodiments, the UE may be limited to communicating only using a subset of the RATs, and perhaps only a single RAT, e.g., when the UE is an MTC UE having a limited bandwidth and capabilities. The RAT may depend on the type of UE as well as the operating mode of the UE. For example, some UEs may change mode between a normal mode and an enhanced coverage mode in situations in which the link budget to the nearest serving eNB is worse than a typical link budget value in the network and additional link budget is to be obtained without increasing transmission power. Enhanced coverage mode may be employed by a variety of UEs, including a normal UE (e.g., a smartphone or the like), a machine-to-machine (M2M) UE or a stationary wireless UE (i.e., a UE that remains indefinitely in a single location) using MTC. The UE may determine whether additional link budget is desired, as well as how much additional link budget is desired, and enter an appropriate enhanced coverage mode (that provides the appropriate additional link budget). The different

enhanced coverage modes may correspond to different RATs. Some UEs, such as low cost, low complexity MTC UEs, further may be band limited and operate in a narrow bandwidth of e.g., to 1.4 MHz, for both control and data channels, leading to the ability to operate, e.g., in a single RAT unless the RAT is modified by the network.

[0040] FIG. 3 illustrates one embodiment of a FRAT of a 5G system in accordance with some embodiments. The FRAT 300 may contain one or more partitions in different frequency band regions 310, 320, 330. In one example, the low frequency band 310 may include frequencies used in 4G systems (up to 6 GHz), the mid-frequency band 320 may include higher frequencies (e.g., 6-30 GHz) and the high frequency band 330 may include the highest frequencies in the 5G system (e.g., mmWave, above 30 GHz). Although the RATs of only a low frequency band 310, a mid-frequency band 320, and a high frequency band 330 are shown, any number of RATs of different frequency bands may exist. The various RATs in frequency bands may each have a subcarrier spacing and symbol duration that is independent of the subcarrier spacing and symbol duration of another RAT in another frequency band (i.e., the RATs have configurable numerologies). Moreover, within each frequency band, one or more sub-RATs and partitions 312, 314, 316, 318 may be present with each sub-RAT or partition 312, 314, 316, 318 having a subcarrier spacing and symbol duration independent of the subcarrier spacing and symbol duration of another sub-RAT or partition 312, 314, 316, 318 and independent of the RAT in other frequency bands. As shown in FIG. 3, the sub_RATs 316, 318 in the low frequency band 310 may have the same subcarrier spacing and symbol duration and may be separated by frequency and/or time, while partitions 312, 314 may have different subcarrier spacings and symbol durations from each other and the sub_RATs 316, 318 and may be separated by frequency and/or time. Although the low frequency band 310 is shown as having multiple partitions 312, 314 and sub_RATs 316, 318, the mid frequency band 320 is shown as having two sub_RATs and the high frequency band 330 is shown as having no sub_RATs, the eNB may establish the number and type of RATs used within a particular frequency band differently.

[0041] In some embodiments, RATs and sub-RATs with same or different numerologies can be multiplexed. The multiplexing may be via Time-Division Multiplexing (TDM), Frequency-Division Multiplexing (FDM), code-division multiplex (CDM), spatial division multiplex (SDM), other possible orthogonal or non-orthogonal multiplexing schemes, or any combination thereof. For example, multiple RATs, sub-RATs or partitions with same or different numerologies can be multiplexed in a TDM manner. Each RAT, sub-RAT and partition may have a numerology, access scheme and modulation scheme that is independent of the numerology, access scheme and modulation scheme of the other RATs, sub-RATs and partitions. The numerologies, resource allocation and partition information in the time domain can be predefined or configured by higher layer signaling, e.g. via a Master Information Block (MIB), System Information Block (SIB) or UE-specific dedicated RRC signaling. If a MIB is used to indicate the partition configuration for multiple RATs, sub-RATs or partitions, the resource for the transmission physical broadcast channel (PBCH) used to carry the MIB may be predefined and known at the UEs. In some embodiments, the PBCH may be transmitted in a predetermined RAT, independent of the UE or number of RATs, sub-RATs or partitions supported. Once the UE receives the configuration information via the PBCH on the predetermined RAT, the UE may use a different RAT for further control and data communications; that is, the predetermined RAT and the RAT used by the UE to communicate may be independent.

[0042] In some embodiments, multiple RATs, sub-RATs or partitions with same or different numerologies can be multiplexed in a FDM manner. To minimize the interference between multiple RATs, sub-RATs or partitions with different numerologies, guard bands may be inserted at the edge of frequency resources allocated for the RATs, sub-RATs or partitions. Similar to the above, the numerologies and/or resource partition for multiple RATs, sub-RATs or partitions may be predefined or configured by high layer signaling via a MIB, SIB or UE-specific dedicated RRC signaling.

[0043] In embodiments in which numerologies and/or resource partition for multiple RATs, sub-RATs or partitions is predefined or dedicated carriers are allocated for different RATs, a dedicated downlink synchronization signal and

PBCHs may be transmitted on each RAT, sub-RAT or partition. In embodiments in which the numerologies and/or resource partition for multiple RATs, sub-RATs or partitions is configured using a MIB or SIB, a single MIB or SIB may be transmitted on one of the RAT, sub-RAT or partition. After successfully decoding the MIB or SIB, the UEs may be able to derive the resource information or numerologies for other RATs, sub-RATs or partitions. Thus, information provided from the eNB to the UE via a single transmission in a particular RAT, sub-RAT or partition may enable communications using different RATs, sub-RATs or partitions.

[0044] Particular RATs/sub-RATs/partitions may be used for different types of communications, with each having independently sized resource blocks. For example, as shown, the resources in a first partition 312 may be used for low-latency communications while the resources in a second partition 314 may be used for low energy communications. The first and second partitions 312, 314 may be multiplexed, as shown, using FDM such that the first and second partitions 312, 314 occupy the same time but different frequency resources. The first partition 312 may be associated with low latency communications in which the UE operates in a low latency mode and may have a short symbol duration and TTI, while the second partition 314 may be associated with low energy communications in which the UE operates in a low energy mode and may have a long symbol duration and TTI.

[0045] Other sub-RATs 316, 318 may similarly be FDM multiplexed with the first and second partitions 312, 314 and TDM multiplexed with each other. The sub-RATs 316, 318 may have a symbol duration and TTI between those associated with the first and second partitions 312, 314.

[0046] The RATs 320, 330 for the mid- and high- frequency band may be supported simultaneously with each other and the RAT 310 for low frequency band, while maintaining TTI boundary alignment between the different RATs 310, 320, 330. The RATs 320, 330 may similarly be FDM multiplexed with the first and second partitions 312, 314 and sub-RATs 316, 318. The RATs 320, 330 may have a symbol duration and TTI smaller than those associated with the first partition 312. As shown in FIG. 3, in some embodiments, the amount of temporal and/or frequency resources associated with the different RATs, sub-

RATs and partitions may differ among the different types, and the same type may be associated either with different amounts of temporal and/or frequency resources (e.g., as partitions 312, 314) or the same amount of temporal and/or frequency resources (e.g., as sub-RATs 316, 318). A given frequency and temporal range may be associated with a particular frame and symbol structure (as well as subcarrier spacing and symbol duration), with the frame and symbol structures of the frequency and temporal range independent of the frame and symbol structures of other frequency and temporal ranges.

[0047] FIG. 4 illustrates a unified frame structure in accordance with some embodiments. The unified frame structure contains frames 400, subframes 410, slots 420 and symbols 430. More specifically, each frame 400 may contain L subframes of equal duration and have an overall duration of X ms. Each subframe 410 may similarly comprise N slots of equal duration and have an overall duration of Y ms. Each slot may, in turn, comprise M symbols of equal duration. The slot and symbol durations may be different between subframes of different RATs depending on specific use cases, frequency bands and deployment scenarios. The frame structure of each of RAT may be independent of the frame structure of the other RATs. Thus, a particular RAT may have one or more of different L, N and/or M values, as well as different X and/or Y values, as the other RATs. This may also apply to the sub-RATs and partitions shown in FIG. 3.

[0048] FIG. 5 illustrates a Transmission Time Interval (TTI) boundary alignment in accordance with some embodiments. In some embodiments of the unified frame structure, it may be beneficial from a simplified design standpoint to periodically align the TTI boundary 530 between different RATs 510, 520, e.g., at a particular subframe or frame boundary after a predetermined number of subframes or frames. Thus, in some embodiments an integral number of TTIs 540 of a RAT 510 having a smaller TTI duration (low latency RAT) may be disposed within a single TTI 550 of a RAT 520 having a larger TTI duration. In the example shown in FIG. 5, the smaller TTI duration RAT 510 may have a TTI 540 of 0.1ms while the larger TTI RAT 520 may have a TTI 550 of 1ms. By implementing a TTI of 1ms, a low latency RAT TTI may align with the existing LTE specification TTI boundary. Having a common TTI boundary may support

cross-carrier/RAT scheduling for high frequency band RATs from low frequency band RATs based an anchor booster architecture. This is to say that, in some embodiments for cross-carrier/RAT scheduling, as shown a common PDCCH may be used to schedule other RATs, with the UE switching to a particular RAT to obtain the scheduling and then switching to another RAT to communicate and perhaps to obtain further scheduling information using that RAT. In some embodiments, the other RAT may contain a PDCCH for additional scheduling, while in other embodiments the other RAT may not contain a PDCCH, in which case the UE may periodically switch to the scheduling RAT to obtain scheduling information for the other RAT. In some embodiments, a UE may obtain initial scheduling information (e.g., when it initially powers on or otherwise accesses the eNB) from the initial RAT (e.g., a conventional 4G system RAT) and from then on, after switching to its assigned RAT, obtains scheduling information using that RAT. In other embodiments, each RAT may contain a PDCCH and scheduling is performed for the UE operating on the RAT. A licensed low frequency band RAT may provide reliable coverage for control signaling as an anchor cell, using the PDCCH shown in FIG. 5, while a high frequency band RAT may provide opportunistic boosting in data rate when channel conditions are favorable as booster cell.

[0049] FIG. 6 illustrates a symbol structure in accordance with some embodiments. FIG. 6 shows an OFDM symbol 610 and a unique word (UW) OFDM symbol 620. Each OFDM symbol 610 may contain a cyclic prefix (CP) 612 that comprises a replication of the initial portion of the OFDM symbol 610. The CP 612 may range in size from 1/4 to 1/32 of the symbol period 614. The CP 612 may be disposed at the end of the symbol or outside the symbol, depending on specific waveform, thereby creating a guard between the symbol and the adjacent symbol. In some embodiments, when OFDM downlink and SC-FDMA uplink waveforms are selected for a 5G RAT, the CP 612 may be inserted outside the symbol 610. In embodiments in which a UW OFDM symbol 620 or UW Discrete Fourier transform-Spread-Orthogonal Frequency Division Multiplexing (UW-DFT-s-OFDM) symbol is used, the UW 622 may be inserted within one symbol duration 624. The symbol structure may be independent for each of the RATs, such that whether or not a particular RAT a

CP or UW and whether the CP or UW is outside or within a symbol is independent of the symbol structure of any other RAT.

[0050] As shown in FIG. 6, the UW-OFDM 620 may be used to support different UW lengths based on different channel delay spreads while maintaining the same symbol duration (or FFT size). This enables both shorter UW 622 and longer UW 626 to be used in the same size symbol 624 as the UW 622, 624 is inserted within the FFT instead of being adding after the FFT size. The ability to maintain the same symbol duration may provide a greater flexibility to support a unified RAT design. In one example, using an OFDM symbol for a low frequency band (below 6GHz), a subcarrier spacing of 60KHz (i.e., K = 4, Δf =60KHz) may be used to achieve a 0.1ms TTI. This translates to OFDM symbols of T=16.7μs (66.7μs/K). Thus, 5 OFDM symbols may be able to be accommodated within one subframe (83.5μs) with a CP length of approximately 3.3μs (0.1ms - 83.5μs =16.5μs/5 CPs).

[0051] FIG. 7 illustrates frame structures within a TTI in accordance with some embodiments. In FIG. 7, various TTIs 710, 720, 730, 740 are illustrated in which the TTIs 710, 720, 730, 740 comprise UW-OFDM waveforms. The first TTI 710 shown in FIG. 7 may comprise a UW 712 and symbol 714 of typical length. In this example, the subcarrier spacing may be 15KHz and the symbol duration 716 may be 66.7μs. A total of 3 OFDM symbols 716 may be present in a TTI 710 of 200μs.

[0052] The second TTI 720 shown in FIG. 7 may comprise a low latency TTI 720 with short symbol duration. Such a TTI 720 can be used for use cases such as mission critical MTC applications and Vehicle–to-Vehicle applications, among others. The UW 722 and symbol 724 may each be smaller than the first TTI 710. In this example, the subcarrier spacing may be 30KHz and the symbol duration 726 may be 33.3μs. For a TTI 720 of the same length as the first TTI (e.g., 200μs), a total of 6 short OFDM symbols 726 may be present.

[0053] The third TTI 730 shown in FIG. 7 may comprise another low latency TTI 730 similar to the low latency TTI 720. The UW 732 and symbol 734 may each be smaller than the first TTI 710, the subcarrier spacing may be 30KHz and the symbol duration 736 may be 33.3μs. However, in this example

the TTI 730 may only be half the length as the first TTI (i.e., 100μs), corresponding to a total of 3 short OFDM symbols 736.

[0054] The fourth TTI 740 shown in FIG. 7 may comprise a low energy TTI 740, e.g., for use by MTC UEs. The UW 742 and symbol 744 may each have a longer duration smaller than the first TTI 710. In one example, the subcarrier spacing may be 5KHz and the symbol duration 746 may be 200μs. In this example, the TTI 740 may be 1ms, corresponding to a total of 5 long OFDM symbols 746.

[0055] The above TTIs 710, 720, 730, 740 may be FDM or TDM multiplexed based on the FRAT design. One or more of the UW-OFDM waveforms may be replaced by other waveforms so long as the same symbol duration is maintained. Other examples of OFDM waveforms may include ZT-OFDM and UW-DFTs-OFDM, among others. When different waveforms are used in the same carrier, multi-RATs can be supported where each RAT may have different waveform design. In some embodiments, existing LTE waveforms may be reused, i.e., OFDM waveforms may be used for downlink and SC-FDMA waveforms may be used for uplink communications. In some embodiments, OFDM may be used both downlink and uplink communications. In some embodiments, UW-based waveforms may be used both downlink and uplink communications. For example, UW-OFDM waveforms may be used for downlink communications and UW-DFT-s-OFDM waveforms may be used for uplink communications or either UW-OFDM or UW-DFT-s-OFDM waveforms may be used for both downlink and uplink communications. In some embodiment, filtered OFDM and filter-bank multiple carrier (FBMC) may be used. FBMC waveforms are produced using a nonrectangular sub-channel pulse shape in the time domain during OFDM-offset quadrature amplitude modulation (OQAM) transmission (in which the real part of QAM symbols are mapped to ½ of the multi-carrier symbols and the imaginary parts are mapped to an interlaced 1/2 of the multi-carrier symbols) and may lack a CP.

[0056] Tables 1-3 below illustrate various examples of 5G numerology.

Frequency Band	Subcarrier spacing	TTI	DL waveform	UL waveform

<3GHz (low power or MTC)	1.5KHz	10ms	OFDM	SC-FDMA
<3GHz	15KHz	1ms	OFDM	SC-FDMA
[3-6]GHz	75KHz	0.2ms	UW-OFDM	UW-DFT-s-OFDM
[6-30]GHz	480KHz	0.1ms	UW-OFDM	UW-DFT-s-OFDM
>30GHz	1.5MHz	0.1ms	DFT-s-OFDM	DFT-s-OFDM

Table 1: First 5G numerology example

Frequency Band	Subcarrier spacing	TTI	DL waveform	UL waveform
<3GHz (low power or MTC)	1.5KHz	10ms	UW-OFDM	UW-OFDM
<3GHz	15KHz	1ms	UW-OFDM	UW-OFDM
[3-6]GHz	75KHz	0.2ms	UW-OFDM	UW-OFDM
[6-30]GHz	480KHz	0.1ms	UW-DFT-s-OFDM	UW-DFT-s-OFDM
>30GHz	1.5MHz	0.1ms	OFDM	OFDM

Table 2: Second 5G numerology example

Frequency Band	Subcarrier spacing	TTI	DL waveform	UL waveform
<3GHz (low power or MTC)	1.5KHz	10ms	OFDM	OFDM
<3GHz	15KHz	1ms	OFDM	OFDM
[3,6]GHz	75KHz	0.2ms	OFDM	OFDM
[6,30]GHz	480KHz	0.1ms	UW-DFT-s-OFDM	UW-DFT-s-OFDM
>30GHz	1.5MHz	0.1ms	UW-DFT-s-OFDM	UW-DFT-s-OFDM

Table 3: Third 5G numerology example

[0057] FIGS. 8A and 8B illustrate flowcharts of a uniform framework utilization method in accordance with some embodiments. FIG. 8A in particular illustrates a flowchart of a uniform framework utilization method of an eNB such as the eNB shown in FIGS. 1 or 2 in accordance with some embodiments. As shown in FIG. 8A, the eNB may determine the unified framework at operation 802. The unified framework may include access scheme, modulation

scheme, frame structure, symbol structure, and configurable numerology including subcarrier spacing and symbol duration. The different frame and symbol structures may be associated with different temporal and/or frequency resources multiplexed respectively in a TDM or FDM manner.

[0058] At operation 804, the eNB may communicate specific unified framework configuration information of a particular RAT to one or more UEs serviced by the eNB. Different RAT information may be provided to different UEs attached to the eNB, in which different RATs may be associated with different frequency bands and/or time spans. The eNB may determine the configuration information to be provided to a particular UE based on the device type and/or data to be communicated between the UE and the eNB. The frequency bands may include both licensed and unlicensed frequency bands. The RAT information may include access and modulation scheme, frame and symbol structure, as well as numerology. The RAT information may also include resource allocation and partition information. The unified framework configuration information provided to each UE may be independent of the unified framework configuration information provided to any other UE. The RAT indicated by the eNB to the UE may be dependent on the type and/or operating mode of the UE.

[0059] The eNB may communicate with the UE at operation 806 using the RAT provided at operation 804. The information may include data and/or control information. For example, downlink communications from the eNB to the UE may include paging or control signals for channel estimation on the PDCCH and voice or video data from another UE on the PDSCH. The RAT information may be provided using a dedicated RAT that is different from the RAT used for communication with the UE or using a dedicated carrier on the RAT used for communication with the UE.

[0060] The eNB may, subsequent to communicating with the UE, receive an indication from the UE of a change of operating state of the UE at operation 808. The UE may, for example, be configured to operate in one or more of a normal mode, a low latency and low energy mode. The eNB may, at operation 804, assign the RAT to the UE based on the initial mode of the UE and

determine that an update of the operation mode of the UE has occurred at operation 808.

[0061] In response to determining at operation 808 that an update of the operation mode of the UE has occurred, the eNB may determine a new RAT and transmit the updated unified framework configuration information of the new RAT to the UE at operation 810. The new RAT may include a different frame and/or symbol structure and use a different frequency spectrum and/or time range. The eNB may then continue to communicate with the UE at operation 806.

[0062] FIG. 8B illustrates a uniform framework utilization method as performed by a UE in accordance with some embodiments. The UE may be the UE shown in FIGS. 1 or 2 and may attach to the eNB prior to communicating data. During the attachment, the UE may transmit the initial operation conditions to the eNB at operation 812. In particular, the UE may provide a UE type and/or operating mode during attachment. For example, the UE may be a MTC UE. The UE may moreover be configured to operate in a low latency and/or low energy mode. In some embodiments, a MTC UE may operate in an enhanced coverage, low energy mode.

[0063] In response to transmitting the operating conditions, unified framework configuration (RAT) information may be received by a particular UE at operation 814. The RAT information may be dependent on the type and/or operating mode of the UE. The RAT may be associated with a particular frequency band and/or time range. For example, when the UE operates in the low latency mode, a larger subcarrier spacing and shorter symbol duration may be indicated by the unified framework configuration information; while when the UE operates in the low energy mode, a smaller subcarrier spacing and longer symbol duration may be indicated by the unified framework configuration information.

[0064] Once the RAT received by the UE, the UE may then communicate using the RAT at operation 816. The UE may, for example, adjust FFT operating conditions and processing to meet the RAT information provided at operation 814. The UE may communicate with the eNB or may communicate directly with other UEs using device-to-device communication (D2D)

communication. The information may include uplink and downlink data and/or control information. For example, the information may include uplink communications of voice or video data for another UE or measurements of control signals for channel estimation.

[0065] The UE may, subsequent to communicating with the eNB, determine that a change of operating conditions is warranted at operation 818. For example, the UE may transition between the normal and enhanced coverage/low energy mode dependent on UE location, or between the normal and low latency mode dependent on the type of communication to transmit.

[0066] In response to determining that a change of operating conditions is warranted at operation 818, at operation 820 the UE may transmit an indication to the eNB indicating the change of operating state of the UE. The UE may instead determine that a change of operating conditions is desired at operation 820 and wait to change operating state until a new RAT is assigned to the UE.

[0067] In response to transmitting the indication at operation 820, the UE may return to operation 814 and receive a new RAT at operation 810. The new RAT may include a different frame and/or symbol structure and use a different frequency spectrum and/or time range. The eNB may then continue to communicate with the UE at operation 816.

[0068] Various examples of the disclosure are provided below. These examples are not intended to in any way limit the disclosure herein. In Example 1, user equipment (UE) may comprise processing circuitry configured to: configure a transceiver to receive a resource allocation from a network using a first Radio Access Technology (RAT), the first RAT selected from a plurality of RATs of a flexible RAT (FRAT) employed by the network, the plurality of RATs of the FRAT each comprising configurable numerology with flexible subcarrier spacing and symbol duration and associated with at least one of different temporal and frequency resources, the transceiver configurable to communicate using the plurality of RATs and configure the subcarrier spacing and symbol duration based on the numerology; and configure the transceiver to communicate using the first RAT.

[0069] In Example 2, the subject matter of Example 1 can optionally include that the processing circuitry is further configured to configure the transceiver to receive from an enhanced NodeB (eNB) higher layer signaling associated with the FRAT, the higher layer signaling indicating numerologies, resource allocation and partition information in at least one of a time and frequency domain.

[0070] In Example 3, the subject matter of one or any combination of Examples 1-2 can optionally include that the FRAT comprises a base subcarrier spacing and symbol duration, and at least one of the subcarrier spacing and symbol duration for different RATs of the FRAT is respectively specified as an integer number of the base subcarrier spacing or symbol duration.

[0071] In Example 4, the subject matter of one or any combination of Examples 1-3 can optionally include that the UE is a Machine-Type Communication (MTC) UE configured to operate in at least one of a low latency and low energy mode, and the first RAT comprises a larger subcarrier spacing and shorter symbol duration when the UE operates in the low latency mode and comprises a smaller subcarrier spacing and longer symbol duration when the UE operates in the low energy mode.

[0072] In Example 5, the subject matter of one or any combination of Examples 1-4 can optionally include that at least one of the plurality of RATs of the FRAT comprises at least one of a plurality of sub-RATs and partitions, each of the at least one of the plurality of sub-RATs and partitions comprising an independent configurable numerology with flexible subcarrier spacing and symbol duration and associated with at least one of different temporal and frequency resource, and the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are combined using at least one of a Time-Division Multiplexing (TDM), Frequency-Division Multiplexing (FDM), Code-Division Multiplexing (CDM), and Spatial Division Multiplexing (SDM).

[0073] In Example 6, the subject matter of one or any combination of Examples 1-6 can optionally include that the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are combined using TDM, and numerologies, resource allocation and partition information in a time domain are at least one of predefined or configured by higher-layer signaling via Master

Information Block (MIB), System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling, or the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are combined using FDM, guard bands are inserted at an edge of frequency resources allocated for the plurality of RATs and the at least one of the plurality of sub-RATs and partitions, and at least one of numerologies and resource partition for the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are at least one of predefined or configured by the higher-layer signaling.

[0074] In Example 7, the subject matter of one or any combination of Examples 1-6 can optionally include that a Transmission Time Interval (TTI) boundary between different RATs of the plurality of RATs is common, and the plurality of RATs comprise a common reference TTI duration.

[0075] In Example 8, the subject matter of one or any combination of Examples 1-7 can optionally include that a symbol structure of each of the plurality of RATs comprises a cyclic prefix (CP) or unique word (UW) outside or within a symbol, and the symbol structure of each of the plurality of RATs is independent of the symbol structure of the other RATs. ‘

[0076] In Example 9, the subject matter of one or any combination of Examples 1-8 can optionally include that the processing circuitry is further configured to configure the transceiver to communicate using Orthogonal Frequency-Division Multiplexing (OFDM) for downlink communications and one of Single Carrier Frequency-Division Multiple Access (SC-FDMA) and OFDM for uplink communications, and configure the transceiver to communicate using at least one of UW-OFDM and UW Discrete Fourier transform-Spread-Orthogonal Frequency Division Multiplexing (UW-DFT-s-OFDM).

[0077] In Example 10, the subject matter of one or any combination of Examples 1-9 can optionally include that a frame structure in each of the plurality of RATs comprises a frame comprising L subframes, each subframe comprising N slots, each slot comprising M symbols, and the frame structure of each of the plurality of RATs is independent of the frame structure of the other RATs.

[0078] In Example 11, the subject matter of one or any combination of Examples 1-10 can optionally include that the processing circuitry is further configured to configure the transceiver to receive numerologies, resource allocation and partition information via Master Information Block (MIB) carried by a physical broadcast channel (PBCH), a System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling in a second RAT, the first and second RATs being different.

[0079] In Example 12, the subject matter of one or any combination of Examples 1-11 can optionally include that the processing circuitry is configured to configure the transceiver to receive numerologies, resource allocation and partition information via a dedicated carrier in the first RAT, a dedicated carrier allocated for each of the plurality of RATs, and a dedicated downlink synchronization signal and physical broadcast channel (PBCH) is able to be received on each of the plurality of RATs.

[0080] In Example 13, the subject matter of one or any combination of Examples 1-12 can optionally include an antenna configured to transmit and receive communications between the transceiver and the eNB.

[0081] Example 14 comprises an apparatus of an eNode B (eNB) comprising processing circuitry configured to: configure a transceiver to transmit resource allocations for different Radio Access Technologies (RATs) to a plurality of user equipment (UE), at least two of the UEs associated with a different RAT, each RAT comprising an independent subcarrier spacing, symbol duration, frame structure and symbol structure; and configure the transceiver to communicate with each UE using the RAT associated with the UE.

[0082] In Example 15, the subject matter of Example 14 can optionally include that the processing circuitry is configured to configure the transceiver to transmit higher layer signaling indicating numerologies, resource allocation and partition information via Master Information Block (MIB) carried by a physical broadcast channel (PBCH), a System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling in a same RAT to each of the plurality of UEs.

[0083] In Example 16, the subject matter of one or any combination of Examples 14-15 can optionally include that the processing circuitry is

configured to configure the transceiver to transmit numerologies, resource allocation and partition information via a dedicated carrier allocated for each of the RATs, and a dedicated downlink synchronization signal and physical broadcast channel (PBCH) is able to be received on each of the RATs.

[0084] In Example 17, the subject matter of one or any combination of Examples 14-16 can optionally include that at least one of the subcarrier spacing and symbol duration for each of the RATs is respectively specified as an integer number of a base subcarrier spacing or symbol duration.

[0085] In Example 18, the subject matter of one or any combination of Examples 14-17 can optionally include that the RATs comprise a first RAT comprising a larger subcarrier spacing and shorter symbol duration configured for a UE operating in a low latency mode and a second RAT comprising a smaller subcarrier spacing and longer symbol duration configured for a UE operating in a low energy mode.

[0086] In Example 19, the subject matter of one or any combination of Examples 14-18 can optionally include that a Transmission Time Interval (TTI) boundary between the RATs is common, and the RATs comprise a common reference TTI duration.

[0087] In Example 20, the subject matter of one or any combination of Examples 14-19 can optionally include that a symbol structure of each of the RATs comprises a cyclic prefix (CP) or unique word (UW) outside or within a symbol, and the symbol structure of each of the RATs is independent of the symbol structure of the other RATs.

[0088] In Example 21, the subject matter of one or any combination of Examples 14-20 can optionally include that the processing circuitry is configured to at least one of: configure the transceiver to communicate using Orthogonal Frequency-Division Multiplexing (OFDM) for downlink communications and one of Single Carrier Frequency-Division Multiple Access (SC-FDMA) and OFDM for uplink communications, and configure the transceiver to communicate using at least one of UW-OFDM and UW Discrete Fourier transform-Spread-Orthogonal Frequency Division Multiplexing (UW-DFT-s-OFDM).

[0089] In Example 22 a non-transitory computer-readable storage medium that stores instructions for execution by one or more processors of a user equipment (UE) to configure the UE to communicate with an enhanced Node B (eNB), the one or more processors to configure the UE to: receive resource allocation, partition information and numerology, including subcarrier spacing and symbol duration, for a first Radio Access Technology (RAT) of a plurality of RATs used by the eNB, the UE configurable to configure the subcarrier spacing and symbol duration based on the numerology and to communicate using the plurality of RATs; and communicate using the first RAT.

[0090] In Example 23, the subject matter of Example 22 can optionally include that at least one of: a) at least one of the subcarrier spacing and symbol duration for the RATs is respectively specified as an integer number of a base subcarrier spacing or symbol duration, b) the UE is configured to operate in at least one of a low latency and low energy mode, and the first RAT comprises a larger subcarrier spacing and shorter symbol duration when the UE operates in the low latency mode and comprises a smaller subcarrier spacing and longer symbol duration when the UE operates in the low energy mode, and c) a Transmission Time Interval (TTI) boundary between the RATs is common, and the RATs comprise a common reference TTI duration.

[0091] In Example 24, the subject matter of one or any combination of Examples 22-23 can optionally include that at least one of: a) a symbol structure of each of the RATs comprises a cyclic prefix (CP) or unique word (UW) outside or within a symbol, and the symbol structure of each of the RATs is independent of the symbol structure of the other RATs, and b) a frame structure in each of the RATs comprises a frame comprising L subframes, each subframe comprising N slots, each slot comprising M symbols, and the frame structure of each of the RATs is independent of the frame structure of the other RATs.

[0092] In Example 25, the subject matter of one or any combination of Examples 22-24 can optionally include that the numerology, resource allocation and partition information is received via Master Information Block (MIB) carried by a physical broadcast channel (PBCH), a System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling in a second RAT, the first and second RATs being different.

[0093] Although an embodiment has been described with reference to specific example embodiments, it will be evident that various modifications and changes may be made to these embodiments without departing from the broader spirit and scope of the present disclosure. Accordingly, the specification and drawings are to be regarded in an illustrative rather than a restrictive sense. The accompanying drawings that form a part hereof show, by way of illustration, and not of limitation, specific embodiments in which the subject matter may be practiced. The embodiments illustrated are described in sufficient detail to enable those skilled in the art to practice the teachings disclosed herein. Other embodiments may be utilized and derived therefrom, such that structural and logical substitutions and changes may be made without departing from the scope of this disclosure. This Detailed Description, therefore, is not to be taken in a limiting sense, and the scope of various embodiments is defined only by the appended claims, along with the full range of equivalents to which such claims are entitled.

[0094] Such embodiments of the inventive subject matter may be referred to herein, individually and/or collectively, by the term “invention” merely for convenience and without intending to voluntarily limit the scope of this application to any single invention or inventive concept if more than one is in fact disclosed. Thus, although specific embodiments have been illustrated and described herein, it should be appreciated that any arrangement calculated to achieve the same purpose may be substituted for the specific embodiments shown. This disclosure is intended to cover any and all adaptations or variations of various embodiments. Combinations of the above embodiments, and other embodiments not specifically described herein, will be apparent to those of skill in the art upon reviewing the above description.

[0095] In this document, the terms "a" or "an" are used, as is common in patent documents, to include one or more than one, independent of any other instances or usages of "at least one" or "one or more." In this document, the term "or" is used to refer to a nonexclusive or, such that "A or B" includes "A but not B," "B but not A," and "A and B," unless otherwise indicated. In this document, the terms "including" and "in which" are used as the plain-English equivalents of the respective terms "comprising" and "wherein." Also, in the following claims, the

terms "including" and "comprising" are open-ended, that is, a system, UE, article, composition, formulation, or process that includes elements in addition to those listed after such a term in a claim are still deemed to fall within the scope of that claim. Moreover, in the following claims, the terms "first," "second," and "third," etc. are used merely as labels, and are not intended to impose numerical requirements on their objects.

[0096] The Abstract of the Disclosure is provided to comply with 37 C.F.R. §1.72(b), requiring an abstract that will allow the reader to quickly ascertain the nature of the technical disclosure. It is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims. In addition, in the foregoing Detailed Description, it can be seen that various features are grouped together in a single embodiment for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted as reflecting an intention that the claimed embodiments require more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive subject matter lies in less than all features of a single disclosed embodiment. Thus the following claims are hereby incorporated into the Detailed Description, with each claim standing on its own as a separate embodiment.

CLAIMS

What is claimed is:

1. User equipment (UE) comprising:

processing circuitry configured to:

configure a transceiver to receive a resource allocation from a network using a first Radio Access Technology (RAT), the first RAT selected from a plurality of RATs of a flexible RAT (FRAT) employed by the network, the plurality of RATs of the FRAT each comprising configurable numerology with flexible subcarrier spacing and symbol duration and associated with at least one of different temporal and frequency resources, the transceiver configurable to communicate using the plurality of RATs and configure the subcarrier spacing and symbol duration based on the numerology; and

configure the transceiver to communicate using the first RAT.

2. The UE of claim 1, wherein the processing circuitry is configured to:

configure the transceiver to receive from an enhanced NodeB (eNB) higher layer signaling associated with the FRAT, the higher layer signaling indicating numerologies, resource allocation and partition information in at least one of a time and frequency domain.

3. The UE of claim 1, wherein:

the FRAT comprises a base subcarrier spacing and symbol duration, and

at least one of the subcarrier spacing and symbol duration for different RATs of the FRAT is respectively specified as an integer number of the base subcarrier spacing or symbol duration.

4. The UE of claim 3, wherein:

the UE is a Machine-Type Communication (MTC) UE configured to operate in at least one of a low latency and low energy mode, and

the first RAT comprises a larger subcarrier spacing and shorter symbol duration when the UE operates in the low latency mode and comprises a smaller

subcarrier spacing and longer symbol duration when the UE operates in the low energy mode.

5. The UE of claim 1, wherein:

at least one of the plurality of RATs of the FRAT comprises at least one of a plurality of sub-RATs and partitions, each of the at least one of the plurality of sub-RATs and partitions comprising an independent configurable numerology with flexible subcarrier spacing and symbol duration and associated with at least one of different temporal and frequency resource, and

the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are combined using at least one of a Time-Division Multiplexing (TDM), Frequency-Division Multiplexing (FDM), Code-Division Multiplexing (CDM), and Spatial Division Multiplexing (SDM).

6. The UE of claim 5, wherein one of:

the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are combined using TDM, and numerologies, resource allocation and partition information in a time domain are at least one of predefined or configured by higher-layer signaling via Master Information Block (MIB), System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling, or

the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are combined using FDM, guard bands are inserted at an edge of frequency resources allocated for the plurality of RATs and the at least one of the plurality of sub-RATs and partitions, and at least one of numerologies and resource partition for the plurality of RATs and the at least one of the plurality of sub-RATs and partitions are at least one of predefined or configured by the higher -layer signaling.

7. The UE of claim 1, wherein:

a Transmission Time Interval (TTI) boundary between different RATs of the plurality of RATs is common, and

the plurality of RATs comprise a common reference TTI duration.

8. The UE of claim 1, wherein:

a symbol structure of each of the plurality of RATs comprises a cyclic prefix (CP) or unique word (UW) outside or within a symbol, and

the symbol structure of each of the plurality of RATs is independent of the symbol structure of the other RATs.

9. The UE of claim 1, wherein the processing circuitry is configured to at least one of:

configure the transceiver to communicate using Orthogonal Frequency-Division Multiplexing (OFDM) for downlink communications and one of Single Carrier Frequency-Division Multiple Access (SC-FDMA) and OFDM for uplink communications, and

configure the transceiver to communicate using at least one of UW-OFDM and UW Discrete Fourier transform-Spread-Orthogonal Frequency Division Multiplexing (UW-DFT-s-OFDM).

10. The UE of claim 1, wherein:

a frame structure in each of the plurality of RATs comprises a frame comprising L subframes, each subframe comprising N slots, each slot comprising M symbols, and

the frame structure of each of the plurality of RATs is independent of the frame structure of the other RATs.

11. The UE of claim 1, wherein the processing circuitry is configured to:

configure the transceiver to receive numerologies, resource allocation and partition information via Master Information Block (MIB) carried by a physical broadcast channel (PBCH), a System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling in a second RAT, the first and second RATs being different.

12. The UE of claim 1, wherein:

the processing circuitry is configured to configure the transceiver to receive numerologies, resource allocation and partition information via a dedicated carrier in the first RAT, a dedicated carrier allocated for each of the plurality of RATs, and

a dedicated downlink synchronization signal and physical broadcast channel (PBCH) is able to be received on each of the plurality of RATs.

13. The UE of claim 1, further comprising an antenna configured to transmit and receive communications between the transceiver and the eNB.

14. An apparatus of an eNode B (eNB) comprising:

processing circuitry configured to:

configure a transceiver to transmit resource allocations for different Radio Access Technologies (RATs) to a plurality of user equipment (UE), at least two of the UEs associated with a different RAT, each RAT comprising an independent subcarrier spacing, symbol duration, frame structure and symbol structure; and

configure the transceiver to communicate with each UE using the RAT associated with the UE.

15. The apparatus of claim 14, wherein the processing circuitry is configured to:

configure the transceiver to transmit higher layer signaling indicating numerologies, resource allocation and partition information via Master Information Block (MIB) carried by a physical broadcast channel (PBCH), a System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling in a same RAT to each of the plurality of UEs.

16. The apparatus of claim 14, wherein the processing circuitry is configured to:

configure the transceiver to transmit numerologies, resource allocation and partition information via a dedicated carrier allocated for each of the RATs, and

a dedicated downlink synchronization signal and physical broadcast channel (PBCH) is able to be received on each of the RATs.

17. The apparatus of claim 14, wherein:

at least one of the subcarrier spacing and symbol duration for each of the RATs is respectively specified as an integer number of a base subcarrier spacing or symbol duration.

18. The apparatus of claim 14, wherein:

the RATs comprise a first RAT comprising a larger subcarrier spacing and shorter symbol duration configured for a UE operating in a low latency mode and a second RAT comprising a smaller subcarrier spacing and longer symbol duration configured for a UE operating in a low energy mode.

19. The apparatus of claim 14, wherein:

a Transmission Time Interval (TTI) boundary between the RATs is common, and

the RATs comprise a common reference TTI duration.

20. The apparatus of claim 14, wherein:

a symbol structure of each of the RATs comprises a cyclic prefix (CP) or unique word (UW) outside or within a symbol, and

the symbol structure of each of the RATs is independent of the symbol structure of the other RATs.

21. The apparatus of claim 14, wherein the processing circuitry is configured to at least one of:

configure the transceiver to communicate using Orthogonal Frequency-Division Multiplexing (OFDM) for downlink communications and one of Single Carrier Frequency-Division Multiple Access (SC-FDMA) and OFDM for uplink communications, and

configure the transceiver to communicate using at least one of UW-OFDM and UW Discrete Fourier transform-Spread-Orthogonal Frequency Division Multiplexing (UW-DFT-s-OFDM).

22. A non-transitory computer-readable storage medium that stores instructions for execution by one or more processors of a user equipment (UE) to configure the UE to communicate with an enhanced Node B (eNB), the one or more processors to configure the UE to:

receive resource allocation, partition information and numerology, including subcarrier spacing and symbol duration, for a first Radio Access Technology (RAT) of a plurality of RATs used by the eNB, the UE configurable to configure the subcarrier spacing and symbol duration based on the numerology and to communicate using the plurality of RATs; and

communicate using the first RAT.

23. The medium of claim 22, wherein at least one of:

a) at least one of the subcarrier spacing and symbol duration for the RATs is respectively specified as an integer number of a base subcarrier spacing or symbol duration,

b) the UE is configured to operate in at least one of a low latency and low energy mode, and

the first RAT comprises a larger subcarrier spacing and shorter symbol duration when the UE operates in the low latency mode and comprises a smaller subcarrier spacing and longer symbol duration when the UE operates in the low energy mode, and

c) a Transmission Time Interval (TTI) boundary between the RATs is common, and

the RATs comprise a common reference TTI duration.

24. The medium of claim 22, wherein at least one of:

a) a symbol structure of each of the RATs comprises a cyclic prefix (CP) or unique word (UW) outside or within a symbol, and

the symbol structure of each of the RATs is independent of the symbol structure of the other RATs, and

b) a frame structure in each of the RATs comprises a frame comprising L subframes, each subframe comprising N slots, each slot comprising M symbols, and

the frame structure of each of the RATs is independent of the frame structure of the other RATs.

25. The medium of claim 22, wherein:

the numerology, resource allocation and partition information is received via Master Information Block (MIB) carried by a physical broadcast channel (PBCH), a System Information Block (SIB) or UE-specific dedicated Radio Resource Control (RRC) signaling in a second RAT, the first and second RATs being different.

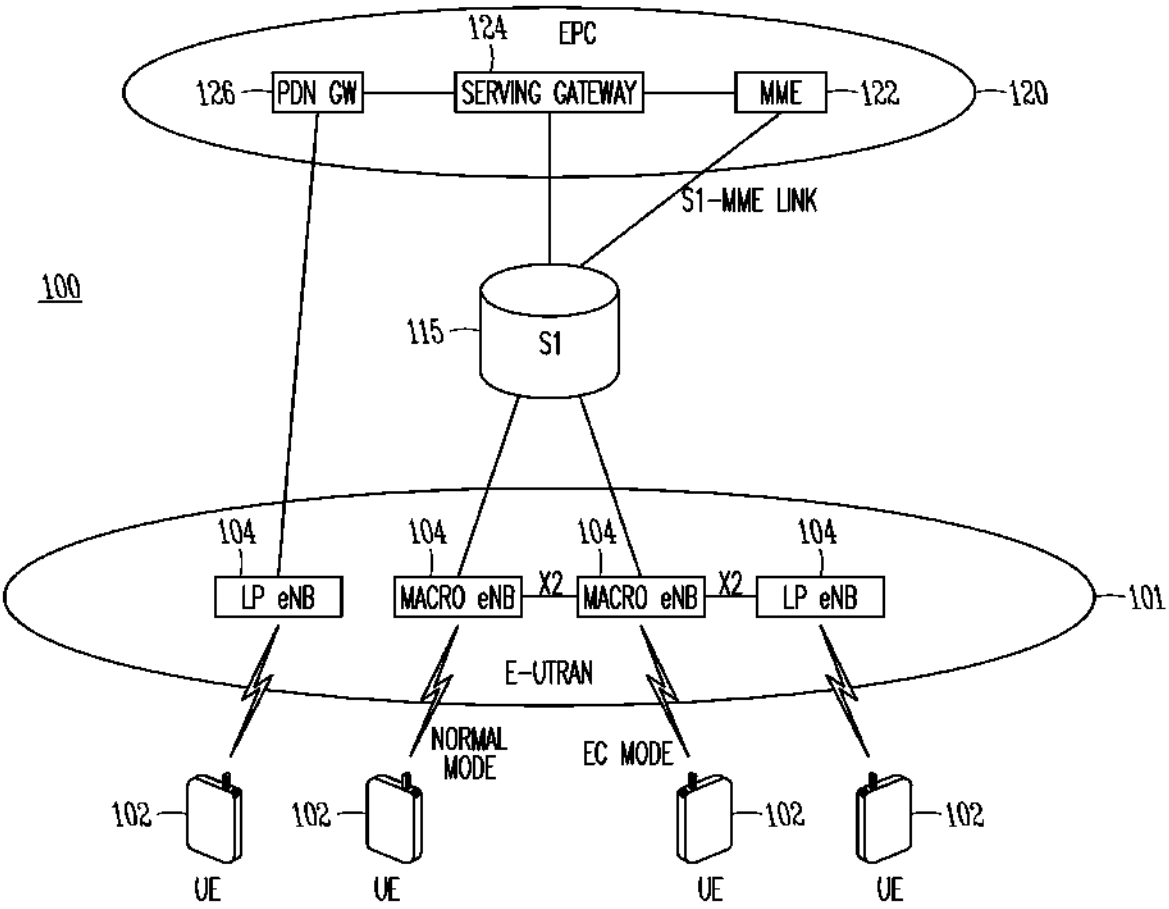

124
EPC
126
PDN GW
SERVING GATEWAY
MME
122
120
S1-MME LINK
100
115
S1
104
104
104
104
LP eNB
MACRO eNB
X2
MACRO eNB
X2
LP eNB
101
E-UTRAN
NORMAL MODE
EC MODE
102
102
102
102
UE
UE
UE
UE

FIG. 1

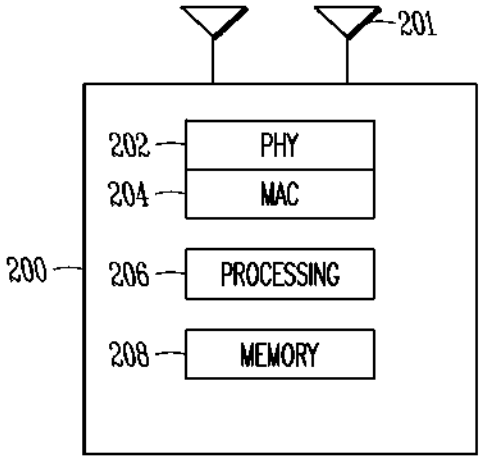


FIG. 2

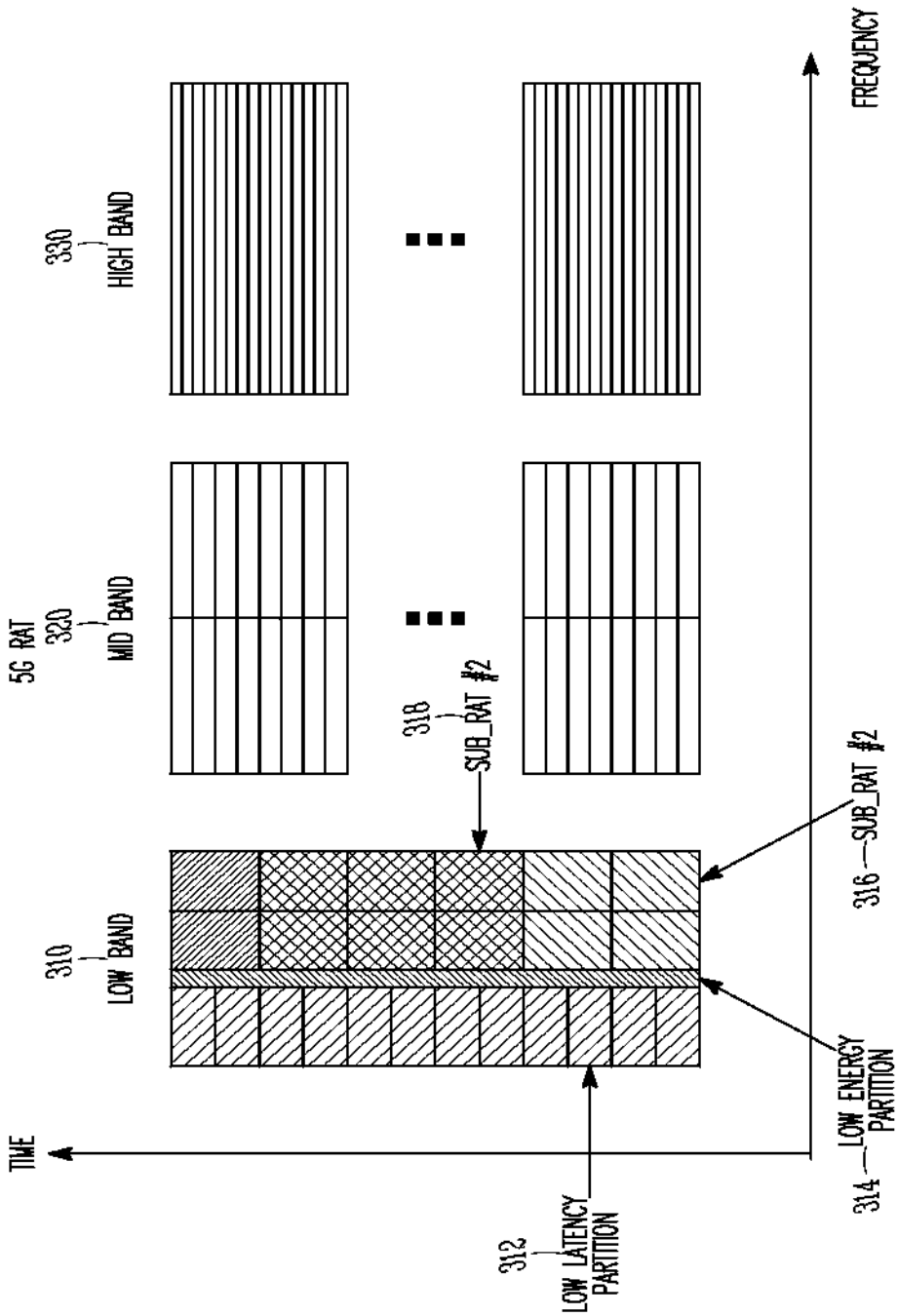

FREQUENCY
330
HIGH BAND
5G RAT
320
MID BAND
318
SUB_RAT #2
310
LOW BAND
316
SUB_RAT #2
TIME
314
LOW ENERGY PARTITION
312
LOW LATENCY PARTITION

FIG. 3

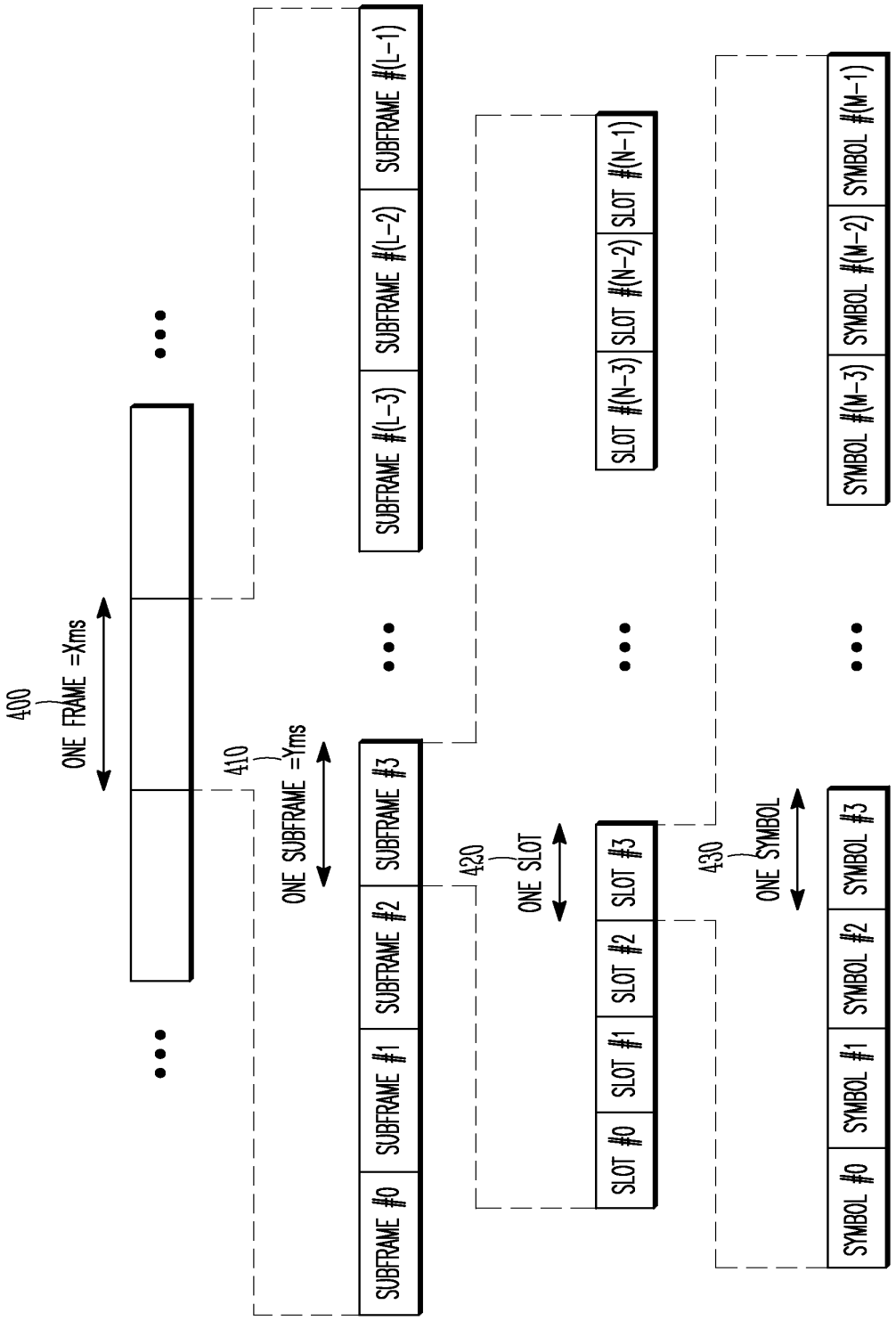

400
ONE FRAME =Xms
410
ONE SUBFRAME =Yms
SUBFRAME #0
SUBFRAME #1
SUBFRAME #2
SUBFRAME #3
SUBFRAME #(L-3)
SUBFRAME #(L-2)
SUBFRAME #(L-1)
420
ONE SLOT
SLOT #0
SLOT #1
SLOT #2
SLOT #3
SLOT #(N-3)
SLOT #(N-2)
SLOT #(N-1)
430
ONE SYMBOL
SYMBOL #0
SYMBOL #1
SYMBOL #2
SYMBOL #3
SYMBOL #(M-3)
SYMBOL #(M-2)
SYMBOL #(M-1)

FIG. 4

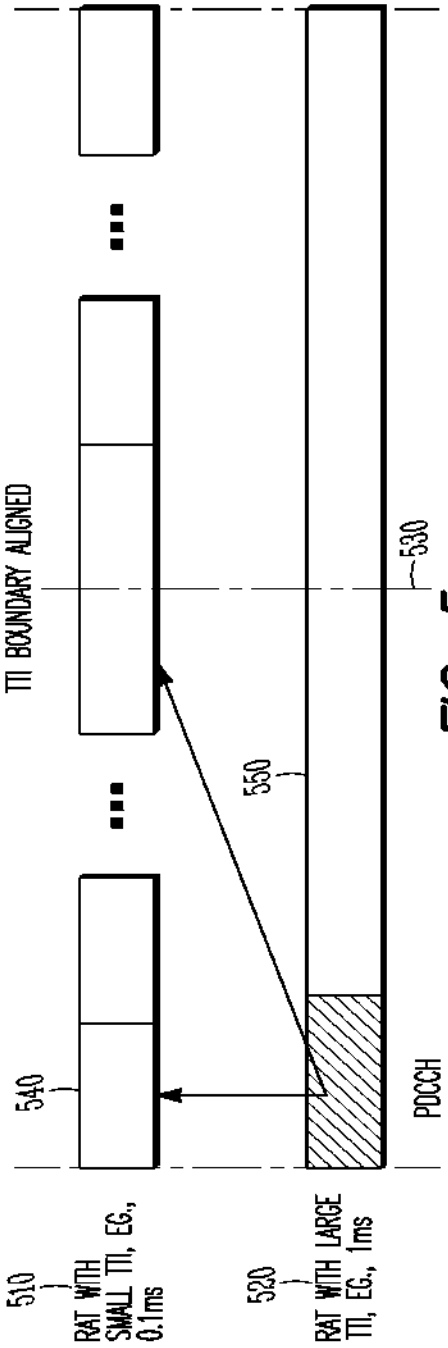

TTI BOUNDARY ALIGNED
530
550
540
PDCCH
510
RAT WITH SMALL TTI, EG., 0.1ms
520
RAT WITH LARGE TTI, EG., 1ms

FIG. 5

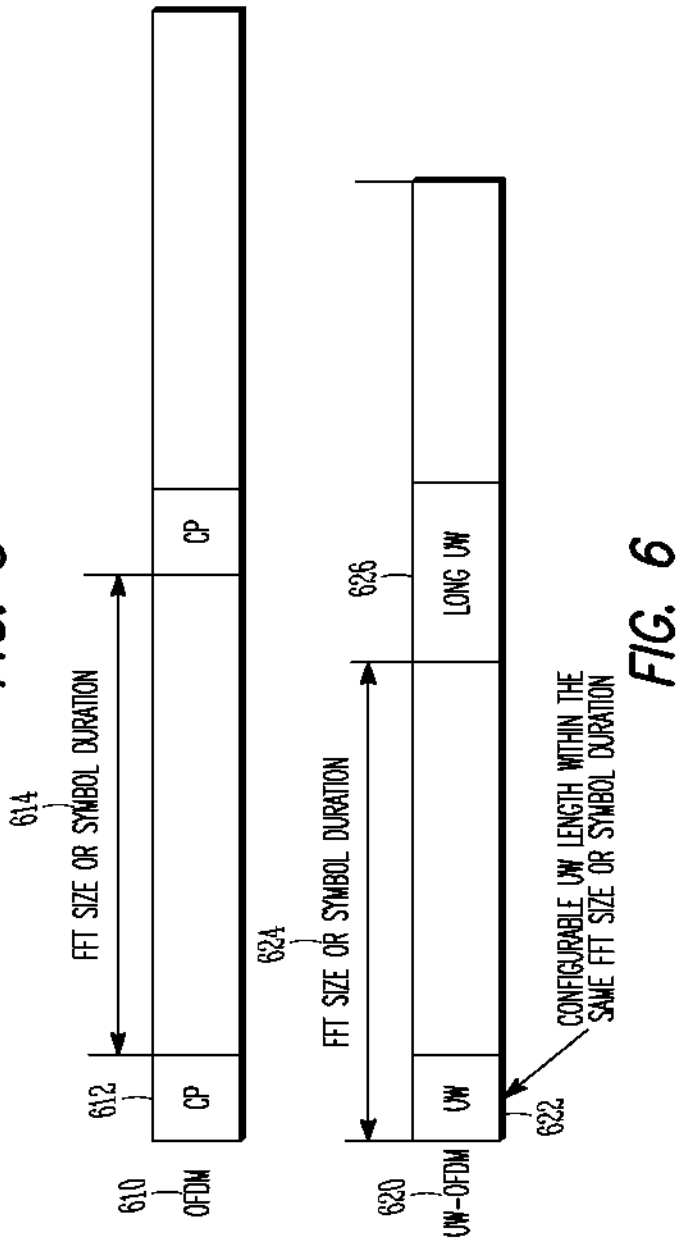

614
FFT SIZE OR SYMBOL DURATION
CP
612
OFDM
610
624
FFT SIZE OR SYMBOL DURATION
626
LONG UW
UW
622
CONFIGURABLE UW LENGTH WITHIN THE SAME FFT SIZE OR SYMBOL DURATION
UW-OFDM
620

FIG. 6


712
714 ONE TTI = 200 US = 3 OFDM LONG SYMBOLS—710
UW
SYMBOL #0
UW
SYMBOL #1
UW
SYMBOL #2
ONE SYMBOL = 66.67 US—716
722
724 ONE TTI = 200 US = 6 OFDM SHORT SYMBOLS—720
UW SYMBOL #0 UW SYMBOL #1 UW SYMBOL #2 UW SYMBOL #3 UW SYMBOL #4 UW SYMBOL #5
ONE SHORT SYMBOL = 33.33 US—726
732
734 ONE TTI = 100 US = 3 OFDM SHORT SYMBOLS—730
UW SYMBOL #0 UW SYMBOL #1 UW SYMBOL #2
ONE SHORT SYMBOL = 33.33 US—736
742
744 ONE TTI = 1MS = 5 OFDM LONG SYMBOLS—740
UW
SYMBOL #0
UW
SYMBOL #4
ONE LONG SYMBOL = 200 US—746

FIG. 7

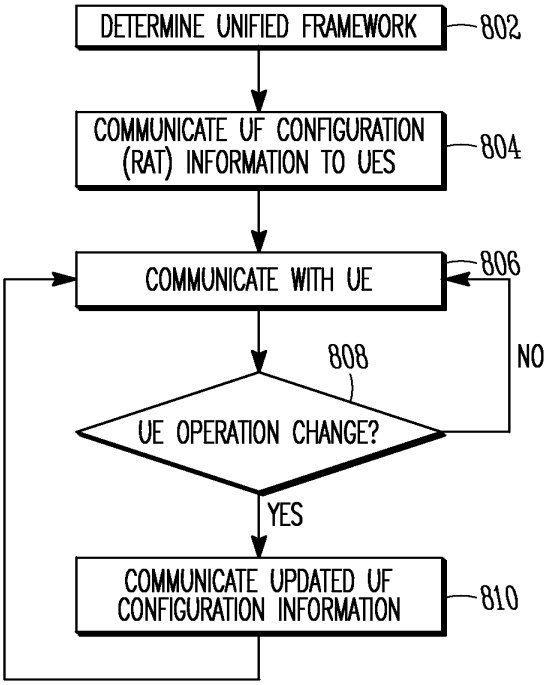

DETERMINE UNIFIED FRAMEWORK
802
COMMUNICATE UF CONFIGURATION (RAT) INFORMATION TO UES
804
COMMUNICATE WITH UE
806
808
UE OPERATION CHANGE?
NO
YES
COMMUNICATE UPDATED UF CONFIGURATION INFORMATION
810

FIG. 8A

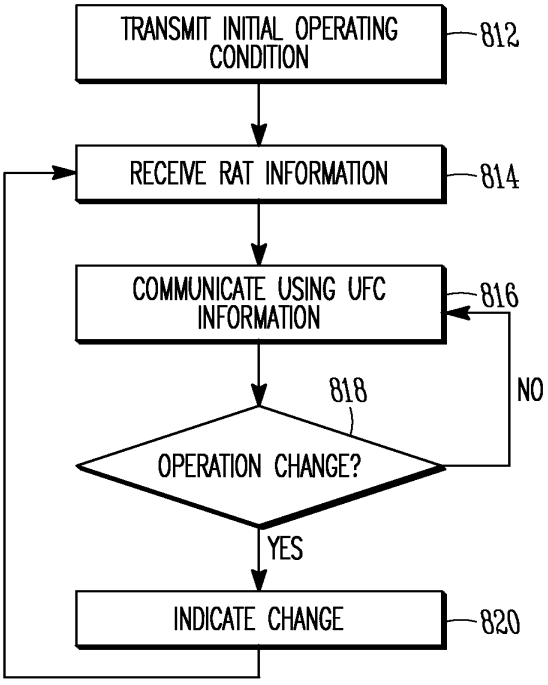

TRANSMIT INITIAL OPERATING CONDITION
812
RECEIVE RAT INFORMATION
814
COMMUNICATE USING UFC INFORMATION
816
818
OPERATION CHANGE?
NO
YES
INDICATE CHANGE
820

FIG. 8B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/044628

A. CLASSIFICATION OF SUBJECT MATTER

H04W 72/04(2009.01)i, H04W 92/10(2009.01)i, H04W 88/06(2009.01)i, H04W 88/08(2009.01)i, H04B 7/26(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W 72/04; H04L 5/00; H04Q 7/00; H04W 88/06; H04L 27/26; H04W 92/10; H04W 88/08; H04B 7/26

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: radio access technology (RAT), FRAT (flexible RAT), flexible subcarrier spacing and symbol duration, numerology, MTC, low latency, low energy, sub-RAT, partition, combination, TTI, unique word (UW), UW-OFDM, UW-DFT-s-OFDM, synchronization, broadcast

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2008-0130570 A1 (YOUNG-HO JUNG et al.) 5 June 2008 See paragraphs [0011], [0033]-[0045]; claims 1, 7; and figures 3-5.	1-25
Y	EEVA LAHETKANGAS et al., 'On the Flexible 5G Dense Deployment Air Interface for Mobile Broadband', In: 5G for Ubiquitous Connectivity (5GU), 2014 1st International Conference on, Page(s): 57-61, 26-28 November 2014 See pages 1-3; and figures 1, 4.	1-25
Y	US 2015-0029990 A1 (INTERDIGITAL PATENT HOLDINGS, INC.) 29 January 2015 See paragraphs [0066]-[0082]; and figure 1.	7,19
Y	US 2014-0140194 A1 (STEFAN FECHTEL) 22 May 2014 See paragraph [0024]; and figures 2A, 2B.	8,9,20,21
A	WO 2014-139562 A1 (NOKIA SOLUTIONS AND NETWORKS OY) 18 September 2014 See page 11, lines 19-32; claims 1, 8, 12; and figures 4, 5.	1-25

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:
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"E" earlier application or patent but published on or after the international filing date
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INTERNATIONAL SEARCH REPORT

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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[Continued on next page]

(54) Title: IDENTIFICATION OF DOWNLINK MESSAGES USING REPEATED TRANSMISSION

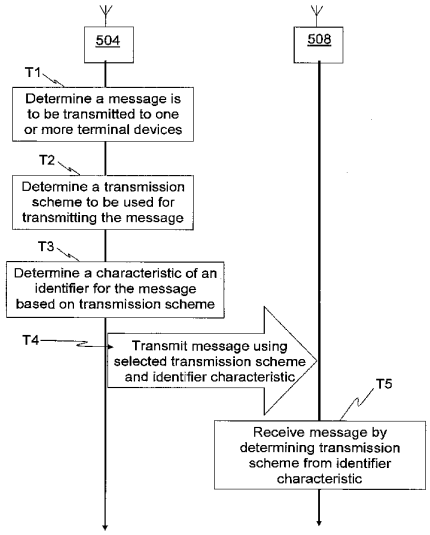


Fig. 9

(57) Abstract: A wireless telecommunication system comprises a base station arranged to communicate messages to one or more terminal devices over a radio interface. The radio interface has a radio frame structure comprising a plurality of subframes, wherein a message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes (e.g. one subframe) or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes (e.g. with repeat transmissions in a plurality of subframes). The message is transmitted in association with an identifier to indicate a terminal device to which the message is addressed. A characteristic for the identifier, for example a value or control region search space for the identifier, is dependent on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme. A terminal device to which the message is addressed determines the transmission scheme from the characteristic of the identifier and receives the message accordingly.

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IDENTIFICATION OF DOWNLINK MESSAGES USING REPEATED TRANSMISSION

BACKGROUND

Field

The present disclosure relates to telecommunications apparatus and methods. In particular, certain embodiments relate to schemes for communicating allocations of transmission resources of a shared channel in a wireless telecommunications system.

Description of Related Art

The "background" description provided herein is for the purpose of generally presenting the context of the disclosure. Work of the presently named inventors, to the extent it is described in this background section, as well as aspects of the description which may not otherwise qualify as prior art at the time of filing, are neither expressly or impliedly admitted as prior art against the present invention.

Mobile communication systems have evolved over the past ten years or so from the GSM System (Global System for Mobile communications) to the 3G system and now include packet data communications as well as circuit switched communications. The third generation partnership project (3GPP) is developing a fourth generation mobile communication system referred to as Long Term Evolution (LTE) in which a core network part has been evolved to form a more simplified architecture based on a merging of components of earlier mobile radio network architectures and a radio access interface which is based on Orthogonal Frequency Division Multiplexing (OFDM) on the downlink and Single Carrier Frequency Division Multiple Access (SC-FDMA) on the uplink.

Third and fourth generation mobile telecommunication systems, such as those based on the 3GPP defined UMTS and Long Term Evolution (LTE) architecture are becoming able to support more sophisticated services than simple voice and messaging services offered by previous generations of mobile telecommunication systems. For example, with the improved radio interface and enhanced data rates provided by LTE systems, a user is able to enjoy high data rate applications such as mobile video streaming and mobile video conferencing that would previously only have been available via a fixed line data connection. The demand to deploy third and fourth generation networks is therefore strong and there is a corresponding desire to extend the coverage available in such telecommunications systems (i.e. there is a desire to provide more reliable access to wireless telecommunications systems for terminal devices operating in coverage-limited locations).

A typical example of a coverage-limited terminal device might be a so-called machine type communication (MTC) device, such as a smart meter located in a customer's house and periodically transmitting information back to a central MTC server relating to the customer's consumption of a utility, such as gas, water, electricity and so on. Such a terminal device might operate in a coverage-limited location because, for example, it may be located in a basement or other location with relatively high penetration loss. Further information on characteristics of MTC-type devices can be found, for example, in the corresponding standards, such as ETSI TS 122 368 V10.530 (2011-07) / 3GPP TS 22.368 version 10.5.0 Release 10) [1]. Some typical characteristics of MTC type terminal devices / MTC type data might include, for example, characteristics such as low mobility, high delay tolerance, small data transmissions, infrequent transmission and group-based features, policing and addressing.

In some situations a terminal device in a coverage-limited situation in a particular communication cell served by a base station might be unable to receive communications from the base station unless specific provision is made for it to do so. One way to increase coverage in this situation would be for the base station to increase the power of its transmissions. However, a blanket increase in transmission power from a base station could be expected to give rise to increased interference in neighbouring communication cells. An alternative approach would be for the base station to in effect focus / concentrate its available transmission power budget into a subset of transmission resources (e.g. in terms of frequency) which are selected from within the base station's overall transmission resources and allocated for transmissions to coverage-limited terminal devices. However, this approach can again lead to increased interference in neighbouring cells and may in some cases require increased coordination among base stations to optimise performance.

Another approach for providing coverage extension is to rely on repeated transmissions of signalling in multiple subframes. A terminal device may then combine the signalling received for a plurality of repeated transmissions to increase the likelihood of successfully decoding the signalling, e.g. using chase combining / maximal ratio combining techniques. This repeated transmission approach may be applied for control signalling (e.g. sent on a physical downlink control channel such as PDCCH in LTE) and / or other signalling (e.g. sent on a physical downlink shared channel such as PDSCH in LTE).

One draw-back of a repeated transmission approach for providing coverage extension is a corresponding increase in the amount of transmission resources needed to communicate with terminal devices, particularly in the amount of transmission resources needed to provide control messages to the terminal devices, and the inventors have recognised how this issue can be especially significant for certain types of communications, as discussed further below. There is therefore a need for schemes which can allow for communications with terminal devices to be made over a number of subframes with a reduction in the overall amount of transmission resources needed to support this as compared to conventional techniques.

SUMMARY

According to a first aspect of the present disclosure, there is provided a method of operating a terminal device communicating with a base station in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the method comprises receiving a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel, determining a validity period for the control message, and receiving a plurality of other messages from the base station on the downlink data channel using the allocated transmission resources within the validity period for the control message.

According to a second aspect of the present disclosure, there is provided a terminal device for communicating with a base station in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the

downlink data channel, and wherein the terminal device comprises a controller unit and a transceiver unit configured to operate together to receive a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to receive a plurality of other messages from the base station on the downlink data channel using the allocated transmission resources within the validity period for the control message.

According to a third aspect of the present disclosure, there is provided circuitry for a terminal device communicating with a base station in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to cause the terminal device to receive a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to receive a plurality of other messages from the base station on the downlink data channel using the allocated transmission resources within the validity period for the control message

According to a forth aspect of the present disclosure, there is provided a method of operating a base station communicating with a terminal device in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the method comprises transmitting a control message to the terminal device conveying an indication of allocated transmission resources on the downlink data channel, determining a validity period for the control message, and transmitting a plurality of other messages to the terminal device on the downlink data channel using the allocated transmission resources within the validity period for the control message.

According to a fifth aspect of the present disclosure, there is provided a base station for communicating with a terminal device in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the base station comprises a controller unit and a transceiver unit configured to operate together to transmit a control message to the terminal device conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to transmit a plurality of other messages to the terminal device on the downlink data channel using the allocated transmission resources within the validity period for the control message.

According to a sixth aspect of the present disclosure, there is provided circuitry for a base station communicating with a terminal device in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the

downlink data channel, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to cause the base station to transmit a control message to the terminal device conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to transmit a plurality of other messages to the terminal device on the downlink data channel using the allocated transmission resources within the validity period for the control message.

According to a seventh aspect of the present disclosure, there is provided a method of operating a base station for communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein the method comprises selecting a characteristic for the identifier in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

According to an eighth aspect of the present disclosure, there is provided a base station for communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the base station comprises a controller unit and a transceiver unit configured to operate together such that the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein a characteristic for the identifier is selected in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

According to a ninth aspect of the present disclosure, there is provided circuitry for a base station communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the circuitry comprises a controller element and a transceiver element configured to operate together such that the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein a characteristic for the identifier is selected in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

According to a 10th aspect of the present disclosure, there is provided a method of operating a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission

resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the method comprises determining from an identifier associated with the message that the message is addressed to the terminal device, and further determining from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

According to an 11th aspect of the present disclosure, there is provided a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the terminal device comprises a controller unit and a transceiver unit configured to operate together to determine from an identifier associated with the message that the message is addressed to the terminal device, and to further determine from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

According to a twelfth aspect of the present disclosure, there is provided circuitry for a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to determine from an identifier associated with the message that the message is addressed to the terminal device, and to further determine from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

Further respective aspects and features are defined by the appended claims.

The foregoing paragraphs have been provided by way of general introduction, and are not intended to limit the scope of the following claims. The described embodiments, together with further advantages, will be best understood by reference to the following detailed description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the disclosure and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein like reference numerals designate identical or corresponding parts throughout the several views, and wherein:

Figure 1 provides a schematic diagram illustrating an example of a mobile telecommunication system;

Figure 2 provides a schematic diagram illustrating a LTE radio frame;

Figure 3 provides a schematic diagram illustrating an example of a LTE downlink radio subframe;

Figure 4 provides a schematic diagram illustrating a LTE "camp-on" procedure;

Figure 5 schematically represents a wireless telecommunications system according to an embodiment of the disclosure;

Figure 6 schematically represents a series of downlink subframes for communicating with a terminal device operating in the wireless telecommunications system of Figure 5;

Figure 7 schematically represents a series of downlink subframes for communicating with a terminal device operating in the wireless telecommunications system of Figure 5 in accordance with an embodiment of the disclosure;

Figure 8 is a signalling ladder diagram representing communications between a base station and a terminal device operating in accordance with an embodiment of the disclosure; and

Figure 9 is a signalling ladder diagram representing communications between a base station and a terminal device operating in accordance with another embodiment of the disclosure.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Figure 1 provides a schematic diagram illustrating some basic functionality of a mobile telecommunications network / system 100 operating in accordance with LTE principles and which may be adapted to implement embodiments of the disclosure as described further below. Various elements of Figure 1 and their respective modes of operation are well-known and defined in the relevant standards administered by the 3GPP (RTM) body and also described in many books on the subject, for example, Holma H. and Toskala A [2]. It will be appreciated that operational aspects of the telecommunications network which are not specifically described below may be implemented in accordance with any known techniques, for example according to the relevant standards.

The network 100 includes a plurality of base stations 101 connected to a core network 102. Each base station provides a coverage area 103 (i.e. a cell) within which data can be communicated to and from terminal devices 104. Data is transmitted from base stations 101 to terminal devices 104 within their respective coverage areas 103 via a radio downlink. Data is transmitted from terminal devices 104 to the base stations 101 via a radio uplink. The core network 102 routes data to and from the terminal devices 104 via the respective base stations 101 and provides functions such as authentication, mobility management, charging and so on. Terminal devices may also be referred to as mobile stations, user equipment (UE), user terminal, mobile radio, and so forth. Base stations may also be referred to as transceiver stations / nodeBs / e-nodeBs, and so forth.

Mobile telecommunications systems such as those arranged in accordance with the 3GPP defined Long Term Evolution (LTE) architecture use an orthogonal frequency division modulation (OFDM) based interface for the radio downlink (so-called OFDMA) and a single carrier frequency division multiple access scheme (SC-FDMA) on the radio uplink. Figure 2 shows a schematic diagram illustrating an OFDM based LTE downlink radio frame 201. The LTE downlink radio frame is transmitted from a LTE base station

(known as an enhanced Node B) and lasts 10 ms. The downlink radio frame comprises ten subframes, each subframe lasting 1 ms. A primary synchronisation signal (PSS) and a secondary synchronisation signal (SSS) are transmitted in the first and sixth subframes of the LTE frame. A physical broadcast channel (PBCH) is transmitted in the first subframe of the LTE frame.

Figure 3 is a schematic diagram of a grid which illustrates the structure of an example conventional downlink LTE subframe. The subframe comprises a predetermined number of symbols which are transmitted over a 1ms period. Each symbol comprises a predetermined number of orthogonal subcarriers distributed across the bandwidth of the downlink radio carrier.

The example subframe shown in Figure 3 comprises 14 symbols and 1200 subcarriers spread across a 20MHz bandwidth and in this example is the first subframe in a frame (hence it contains PBCH). The smallest allocation of physical resource for transmission in LTE is a resource block comprising twelve subcarriers transmitted over one subframe. For clarity, in Figure 3, each individual resource element is not shown, instead each individual box in the subframe grid corresponds to twelve subcarriers transmitted on one symbol.

Figure 3 shows in hatching resource allocations for four LTE terminals 340, 341, 342, 343. For example, the resource allocation 342 for a first LTE terminal (UE 1) extends over five blocks of twelve subcarriers (i.e. 60 subcarriers), the resource allocation 343 for a second LTE terminal (UE2) extends over six blocks of twelve subcarriers (i.e. 72 subcarriers), and so on.

Control channel data can be transmitted in a control region 300 (indicated by dotted-shading in Figure 3) of the subframe comprising the first "n" symbols of the subframe where "n" can vary between one and three symbols for channel bandwidths of 3MHz or greater and where "n" can vary between two and four symbols for a channel bandwidth of 1.4MHz. For the sake of providing a concrete example, the following description relates to host carriers with a channel bandwidth of 3MHz or greater so the maximum value of "n" will be 3 (as in the example of Figure 3). The data transmitted in the control region 300 includes data transmitted on the physical downlink control channel (PDCCH), the physical control format indicator channel (PCFICH) and the physical HARQ indicator channel (PHICH). These channels transmit physical layer control information. Control channel data can also or alternatively be transmitted in a second region of the subframe comprising a number of subcarriers for a time substantially equivalent to the duration of the subframe, or substantially equivalent to the duration of the subframe remaining after the "n" symbols. The data transmitted in this second region is transmitted on the enhanced physical downlink control channel (EPDCCH). This channel transmits physical layer control information which may be in addition to that transmitted on other physical layer control channels.

PDCCH and EPDCCH contain control data indicating which subcarriers of the subframe have been allocated to specific terminals (or all terminals or subset of terminals). This may be referred to as physical-layer control signalling / data. Thus, the PDCCH and/or EPDCCH data transmitted in the control region 300 of the subframe shown in Figure 3 would indicate that UE1 has been allocated the block of resources identified by reference numeral 342, that UE2 has been allocated the block of resources identified by reference numeral 343, and so on.

PCFICH contains control data indicating the size of the control region (i.e. between one and three symbols for channel bandwidths of 3 MHz or greater and between two and four symbols for channel bandwidths of 1.4 MHz).

PHICH contains HARQ (Hybrid Automatic Request) data indicating whether or not previously transmitted uplink data has been successfully received by the network.

Symbols in a central band 310 of the time-frequency resource grid are used for the transmission of information including the primary synchronisation signal (PSS), the secondary synchronisation signal (SSS) and the physical broadcast channel (PBCH). This central band 310 is typically 72 subcarriers wide (corresponding to a transmission bandwidth of 1.08 MHz). The PSS and SSS are synchronisation signals that once detected allow a LTE terminal device to achieve frame synchronisation and determine the physical layer cell identity of the enhanced Node B transmitting the downlink signal. The PBCH carries information about the cell, comprising a master information block (MIB) that includes parameters that LTE terminals use to properly access the cell. Data transmitted to terminals on the physical downlink shared channel (PDSCH), which may also be referred to as a downlink data channel, can be transmitted in other resource elements of the subframe. In general PDSCH conveys a combination of user-plane data and non-physical layer control-plane data (such as Radio Resource Control (RRC) and Non Access Stratum (NAS) signalling). The user-plane data and non-physical layer control-plane data conveyed on PDSCH may be referred to as higher layer data (i.e. data associated with a layer higher than the physical layer).

Figure 3 also shows a region of PDSCH containing system information and extending over a bandwidth of R344. A conventional LTE subframe will also include reference signals which are discussed further below but not shown in Figure 3 in the interests of clarity.

The number of subcarriers in a LTE channel can vary depending on the configuration of the transmission network. Typically this variation is from 72 sub carriers contained within a 1.4MHz channel bandwidth to 1200 subcarriers contained within a 20MHz channel bandwidth (as schematically shown in Figure 3). As is known in the art, data transmitted on the PDCCH, PCFICH and PHICH is typically distributed on the subcarriers across the entire bandwidth of the subframe to provide for frequency diversity. Therefore a conventional LTE terminal must be able to receive the entire channel bandwidth in order to receive and decode the control region.

Figure 4 illustrates a LTE “camp-on” process, that is, the process followed by a terminal so that it can decode downlink transmissions which are sent by a base station via a downlink channel. Using this process, the terminal can identify the parts of the transmissions that include system information for the cell and thus decode configuration information for the cell.

As can be seen in Figure 4, in a conventional LTE camp-on procedure, the terminal first synchronizes with the base station (step 400) using the PSS and SSS in the centre band and then decodes the PBCH (step 401). Once the terminal has performed steps 400 and 401, it is synchronized with the base station.

For each subframe, the terminal then decodes the PCFICH which is distributed across the entire bandwidth of carrier 320 (step 402). As discussed above, a LTE downlink carrier can be up to 20 MHz wide (1200 subcarriers) and a standard LTE-compliant terminal therefore has to have the capability to receive and decode transmissions on a 20 MHz bandwidth in order to decode the PCFICH. Accordingly, at the PCFICH decoding stage, with a 20MHz carrier band, the terminal operates at a larger bandwidth

(bandwidth of R320) than during steps 400 and 401 (bandwidth of R310) relating to synchronization and PBCH decoding.

The terminal then ascertains the PHICH locations (step 403) and decodes the PDCCH (step 404), in particular for identifying system information transmissions and for identifying its dedicated allocation grants. The allocation grants are used by the terminal to locate system information and to locate its data in the PDSCH. Both system information and dedicated allocations are transmitted on PDSCH and scheduled within the carrier band 320. Steps 403 and 404 also require a standard LTE-compliant terminal to operate on the entire bandwidth R320 of the carrier band. Allocation grants may also or alternatively be decoded from EPDCCH.

At steps 402 to 404, the terminal decodes information contained in the control region 300 of a subframe. As explained above, in LTE, the three control channels mentioned above (PCFICH, PHICH and PDCCH) can be found across the control region 300 of the carrier where the control region extends over the range R320 and occupies the first one, two or three OFDM symbols of each subframe as discussed above. In a subframe, typically the control channels do not use all the resource elements within the control region 300, but they are scattered across the entire region, such that a LTE terminal has to be able to simultaneously receive the entire control region 300 for decoding each of the three control channels.

The terminal can then decode the PDSCH (step 405) which contains system information or data transmitted for this terminal.

As explained above, in a LTE subframe the PDSCH generally occupies groups of resource elements which follow the control region. The data in the blocks of resource elements 340, 341, 342, 343 allocated to the different mobile communication terminals (UEs) and the system information data in the block of resources 344 shown in Figure 3 have a smaller bandwidth than the bandwidth of the entire carrier. To decode these blocks a terminal first receives the PDCCH spread across the frequency range R320 and/or the EPDCCH to determine if the (E)PDCCH indicates there are PDSCH resources in the subframe that need to be decoded by the UE. The intended recipient(s) for (E)PDCCH signalling in LTE is established through the use of radio network temporary identifiers (RNTI). (E)PDCCH signalling is addressed to a particular RNTI by using the RNTI to scramble cyclic redundancy check (CRC) bits associated with the (E)PDCCH signalling. Each connected UE in a cell is associated with a Cell RNTI (C-RNTI) that may be used to address PDCCH signalling to that particular UE. In addition there are other RNTIs defined and these may be used to simultaneously address groups of terminal devices. For example, a System Information RNTI (SI-RNTI) is defined and PDSCH transmissions comprising SI are allocated by (E)PDCCH signalling addressed to SI-RNTI. Various other RNTIs are defined for various other types of signalling. Some examples include a random-access RNTI (RA-RNTI), a Paging RNTI (P-RNTI), a Transmit Power Control Physical Uplink Control Channel RNTI (TPC-PUCCH-RNTI) and a Transmit Power Control Physical Uplink Shared Channel-RNTI (TPC-PUSCH-RNTI).

Thus, once a UE has received a downlink subframe, the UE searches for (E)PDCCH signalling associated with any RNTI that apply for the UE in the subframe to identify any corresponding allocations of transmission resources on PDSCH. If there is an allocation message addressed to the UE on (E)PDCCH the UE will proceed to decode the PDSCH in the relevant frequency range (if any) indicated by the PDCCH. So for example, UE 1 discussed above decodes the whole control region 300 to

determine its resource allocation and then extracts the relevant data from the corresponding resource block 342.

Figure 5 schematically shows a telecommunications system 500 according to an embodiment of the disclosure. The telecommunications system 500 in this example is based broadly on a LTE-type architecture. As such many aspects of the operation of the telecommunications system 500 are standard and well understood and not described here in detail in the interest of brevity. Operational aspects of the telecommunications system 500 which are not specifically described herein may be implemented in accordance with any known techniques, for example according to the established LTE-standards and known variations thereof.

The telecommunications system 500 comprises a core network part (evolved packet core) 502 coupled to a radio network part. The radio network part comprises a base station (evolved-nodeB) 504, a first terminal device 506 and a second terminal device 508. It will of course be appreciated that in practice the radio network part may comprise a plurality of base stations serving a larger number of terminal devices across various communication cells. However, only a single base station and two terminal devices are shown in Figure 5 in the interests of simplicity.

As with a conventional mobile radio network, the terminal devices 506, 508 are arranged to communicate data to and from the base station (transceiver station) 504. The base station is in turn communicatively connected to a serving gateway, S-GW, (not shown) in the core network part which is arranged to perform routing and management of mobile communications services to the terminal devices in the telecommunications system 500 via the base station 504. In order to maintain mobility management and connectivity, the core network part 502 also includes a mobility management entity (not shown) which manages the enhanced packet service, EPS, connections with the terminal devices 506, 508 operating in the communications system based on subscriber information stored in a home subscriber server, HSS. Other network components in the core network (also not shown for simplicity) include a policy charging and resource function, PCRF, and a packet data network gateway, PDN-GW, which provides a connection from the core network part 502 to an external packet data network, for example the Internet. As noted above, the operation of the various elements of the communications system 500 shown in Figure 5 may be broadly conventional apart from where modified to provide functionality in accordance with embodiments of the disclosure as discussed herein.

In this example, it is assumed the first terminal device 506 is a conventional smart-phone type terminal device communicating with the base station 504. Thus, and as is conventional, this first terminal device 506 comprises a transceiver unit 506a for transmission and reception of wireless signals and a controller unit 506b configured to control the smart phone 506. The controller unit 506b may comprise a processor unit which is suitably configured / programmed to provide the desired functionality using conventional programming / configuration techniques for equipment in wireless telecommunications systems. The transceiver unit 506a and the controller unit 506b are schematically shown in Figure 5 as separate elements. However, it will be appreciated that the functionality of these units can be provided in various different ways, for example using a single suitably programmed general purpose computer, or suitably configured application-specific integrated circuit(s) / circuitry. As will be appreciated the conventional terminal device 506 will in general comprise various other elements associated with its operating functionality.

In this example, it is assumed the second terminal device 508 is a machine-type communication (MTC) terminal device according to an embodiment of the disclosure and located in an area of restricted coverage. As discussed above, MTC devices may be typically characterised as semi-autonomous or autonomous wireless communication devices communicating small amounts of data. Examples include so-called smart meters which, for example, may be located in a customer's house and periodically transmit information back to a central MTC server data relating to the customer's consumption of a utility such as gas, water, electricity and so on. MTC devices may in some respects be seen as devices which can be supported by relatively low bandwidth communication channels having relatively low quality of service (QoS), for example in terms of latency. It is assumed here the MTC terminal device 508 in Figure 5 is such a device. It will, however, the appreciated that embodiments of the disclosure may also be implemented for other types of terminal device.

As with the smart phone 506, the MTC device 508 comprises a transceiver unit 508a for transmission and reception of wireless signals and a controller unit 508b configured to control the MTC device 508. The controller unit 508b may comprise a processor unit which is suitably configured / programmed to provide the desired functionality described herein using conventional programming / configuration techniques for equipment in wireless telecommunications systems. The transceiver unit 508a and the controller unit 508b are schematically shown in Figure 5 as separate elements for ease of representation. However, it will be appreciated that the functionality of these units can be provided in various different ways, for example using a single suitably programmed general purpose computer, or suitably configured application-specific integrated circuit(s) / circuitry, or using a plurality of discrete circuitry / processing elements for providing different elements of the desired functionality. It will be appreciated the MTC device 508 will in general comprise various other elements associated with its operating functionality in accordance with established wireless telecommunications techniques (e.g. a power source, possibly a user interface, and so forth).

The base station 504 comprises a transceiver unit 504a for transmission and reception of wireless signals and a controller unit 504b configured to control the base station 504. The controller unit 504b may comprise a processor unit which is suitably configured / programmed to provide the desired functionality described herein using conventional programming / configuration techniques for equipment in wireless telecommunications systems. The transceiver unit 504a and the controller unit 504b are schematically shown in Figure 5 as separate elements for ease of representation. However, it will be appreciated that the functionality of these units can be provided in various different ways, for example using a single suitably programmed general purpose computer, or suitably configured application-specific integrated circuit(s) / circuitry or using a plurality of discrete circuitry / processing elements for providing different elements of the desired functionality. It will be appreciated the base station 504 will in general comprise various other elements associated with its operating functionality. For example, the base station 504 will in general comprise a scheduling entity responsible for scheduling communications. The functionality of the scheduling entity may, for example, be subsumed by the controller unit 504b.

Thus, the base station 504 is configured to communicate data with the smart phone 506 over a first radio communication link 510 and communicate data with the MTC device 508 over a second radio communication link 512. Both radio links may be supported within a single radio frame structure associated with the base station 504. It is assumed here the base station 504 is configured to communicate with the smart phone 506 over the first radio communication link 510 in accordance with the

established principles of LTE-based communications and to communicate with the MTC-device 506 over the second radio communication link 512 in accordance with embodiments of the disclosure as described herein. It will be appreciated the base station may readily obtain information indicating the different classes of terminal device which are attached to the base station in accordance with conventional techniques. That is to say, the base station will be aware that the smart phone is of a device class that includes conventional smartphones and the MTC device is of a device class that includes MTC devices. Furthermore, the base station may establish using conventional techniques that the MTC device 508 is a device operating in a coverage limited situation such that steps are needed to increase the likelihood of the MTC device being able to decode downlink transmissions.

As noted above, in a LTE-based wireless telecommunications system some of the fundamental information required for a terminal device to operate in a cell is transmitted on PBCH in the Master Information Block (MIB). Other information regarding the system configuration is divided among System Information Blocks (SIBs) referred to as SIB1, SIB2, SIB3,...etc. (there are 16 SIBs defined as of Release 11 LTE). The SIBs are transmitted in system information (SI) messages, which, apart from SIB1, may contain multiple SIBs (termed first SI, second SI, etc.). There may be one or several SI messages transmitted at different periodicities. Each SI message may convey multiple SIBs suitable for scheduling with the same periodicity. The timings for SIB1 message transmissions are fixed on an 80 ms period and they occur in the fifth subframe of radio frames when System Frame Number (SFN) is a multiple of 8 (i.e. SFN mod 8 = 0). There are retransmissions of SIB1 messages provided in every other radio frame within the 80 ms period. The timings for other SIB transmission messages are configured in SIB1. The transmission resource allocations for the SI messages on PDSCH within a subframe are provided to terminal devices using PDCCH allocation messages addressed to SI-RNTI (System Information Radio Network Temporary Identifier - currently 0xFFFF in LTE). At higher layers, SI is carried on the logical broadcast control channel (BCCH).

In LTE the SI messages are transmitted within periodically occurring time domain windows (referred to as SI-windows) using dynamic scheduling. Each SI message is associated with a SI-window and the SI-windows of different SI messages do not overlap. That is, within one SI-window only the corresponding SI message is transmitted. The length of the SI-window is common for all SI messages, and is configurable. Within the SI-window, the corresponding SI message can be transmitted a number of times in any subframe other than MBSFN (multicast-broadcast single frequency network) subframes, uplink subframes in TDD (time division duplex), and subframe #5 of radio frames for which SFN (system frame number) mod 2 = 0. Terminal devices acquire the detailed time-domain scheduling (and other information, e.g. frequency-domain scheduling, transport format) from decoding SI-RNTI on PDCCH. A single SI-RNTI is used to address SystemInformationBlockType1 as well as all SI messages. SystemInformationBlockType1 configures the SI-window length and the transmission periodicity for the SI messages.

The system information in a cell may be changed, although typically this happens rarely with system information perhaps remaining unchanged for hours, days, or even weeks.

For changes of system information other than those related to EAB (Extended Access Barring), ETWS (Earthquake Tsunami Warning System) and CMAS (Commercial Mobile Alert System), there is a BCCH modification period defined (which may be referred to as a “SI modification period”). SI modification period boundaries are defined on radio frames for which SFN mod q = 0, for a cell-specific value of q.

When there is a change in system information, the new system information is transmitted from the start of a new SI modification period.

The general process for implementing a change in system information in a LTE-based network is described, for example, in Section 5.2.1.3 of ETSI TS 136 331 V11.4.0 (2013-07) / 3GPP TS 36.331 version 11.4.0 Release 11 [3]. In summary, a base station indicates a change of system information as follows.

1. When the network changes system information it notifies terminal devices about the change by transmitting a PDCCH resource allocation message addressed to the paging RNTI (P-RNTI). This directs the terminal devices to decode PDSCH resources containing a Paging message with a SystemInfoModification flag set to true. This may be done, for example, throughout one SI modification period. Both RRC_IDLE and RRC_CONNECTED terminal devices check for paging messages periodically. It may be noted that EAB alterations, ETWS and CMAS notifications may be separately modified with separate flags in a paging message (but can also be modified along with other SIBs).

2. In a following SI modification period, the network transmits the modified system information, and may increment a SystemInfoValueTag in SIB1. This value tag can indicate changes in any SIB, but it might not be used for EAB, ETWS, CMAS and some regularly changing SI parameters such as CDMA2000 system time. Terminal devices can use SystemInfoValueTag to verify if currently stored system information is still valid, for example on return from being out of coverage when the UE may have missed a system information change notification in paging.

More details on system information and changes in system information in a LTE-based system can be found in ETSI TS 136 331 V11.4.0 (2013-07) / 3GPP TS 36.331 version 11.4.0 Release 11 [3].

As discussed above, it has been proposed to improve coverage for terminal devices in a wireless telecommunications system by introducing repetitions of a transmission which a terminal device may combine to provide an increased likelihood of successful decoding.

Figure 6 schematically represents an approach for providing coverage extension through repeated transmissions for an SI message in accordance with existing techniques. Figure 6 schematically shows a sequence of LTE downlink subframes (labelled as subframes "A", "B", "C", …, "L" to aid explanation) with shading to schematically indicate which regions in which subframes are used to convey system information. The subframes represented in Figure 6 comprise four groups of three contiguous subframes with spaces between the groups as schematically indicated by dotted lines and discussed further below. Although not shown in Figure 6, the gaps between the groups comprise a continuing sequence of subframes used for other communications that are not relevant to the system information messaging considered here. As discussed above, each subframe comprises a control region 600 and a PDSCH region 602. The control regions 600 for the respective subframes are labelled in Figure 6 with the identification letter for the relevant subframe, i.e. as 600A, 600B, 600C, etc. The PDSCH regions for the respective subframes are similarly labelled in Figure 6 as 602A, 602B, 602C, etc. Each subframe represented in Figure 6 is in essence a simplified version of what is represented in Figure 3. Thus, the control regions 600 support the PCFICH, PHICH and PDCCH channels as discussed above while the PDSCH regions 602 support user-plane data and system information (among other things) and the EPDCCD if implemented. The most significant aspect of the control region 600 in the context of

embodiments of the present disclosure relate to the PDCCH and so for simplicity the control regions 600 may sometimes be referred to herein as PDCCH regions 600.

Before explaining the repeated transmissions approach to providing coverage extension represented in Figure 6 it is considered helpful to clarify some aspects of the terminology to be used herein. The term "repeat transmission" (and related terms) will be used to refer to a transmission in an individual subframe which is part of a sequence of transmissions that are being repeated for the purposes of providing coverage extension for a message being conveyed between a base station and a terminal device (such as a PDCCH message or a PDSCH message). Thus in a coverage extension context, the transmission of a (E)PDCCH message comprises a plurality of "repeat transmissions" on (E)PDCCH and the transmission of a PDSCH message comprises a plurality of "repeat transmissions" on PDSCH. The term "re-transmission" (and related terms) will be used to refer to the transmission of a message that has already been sent at least once before. These terms should be interpreted accordingly unless the context demands otherwise.

For the example repeat transmission approach to coverage extension represented in Figure 6 it is assumed for ease of representation the approach relies on providing only three repeat transmissions for each PDCCH message and each PDSCH message. It will, however, be appreciated that in practice larger numbers of repeat transmissions will typically be involved, for example there may be tens or hundreds of repeats comprising each message to provide a correspondingly higher degree of coverage extension. Furthermore, it will be appreciated that PDCCH messages and PDSCH messages may comprise different numbers of repeat transmissions (for example because different coding schemes are adopted meaning that different numbers of repeat transmissions are needed for a given probability of successful reception).

Thus, referring to Figure 6, subframes A, B and C are used to signal a PDCCH message addressed to SI-RNTI by sending three repeat PDCCH transmissions in the respective PDCCH regions 600A, 600B, 600C. Each PDCCH repeat transmission addressed to SI-RNTI in the PDCCH regions 600A, 600B, 600C in effect comprises a duplication of the same downlink control information which a terminal device can combine to seek to establish the content of the PDCCH message. For this example repeat-transmission based coverage extension scheme it is assumed a particular type of message subject to repeat transmissions is addressed to the same RNTI (e.g. SI-RNTI for a system information related type of messages) as if the same type of message were subject to conventional single-subframe transmission. However, as discussed further below, in accordance with certain embodiments of the disclosure identifiers having different characteristics (e.g. values) may be used for a given type of message depending on whether the messages to be sent in accordance with a first transmission scheme (e.g. using a conventional single subframe based transmission approach) or a second transmission scheme (e.g. using a repeat-transmission scheme for coverage extension). Furthermore, it will be appreciated the approach of using identifiers associated with a particular type of message having different characteristics according to what transmission scheme is to be used to transmit the message can be used in accordance with embodiments of the disclosure with or without the use of validity periods as disclosed herein.

The PDCCH message comprising the three repeat transmissions in the PDCCH regions of subframes A, B and C indicates resource blocks to be used for a subsequent PDSCH message comprising the transmission of system information. This PDSCH message itself comprises a plurality of repeat transmissions, and, in this example, are represented by shading in the PDSCH regions 602D, 602E and 602F of subframes D, E and F. The transmission resources, for example in terms of specific resource

elements, used to convey the repeat transmissions of the system information message in the PDSCH regions 602D, 602E and 602F are indicated in the corresponding PDCCH message addressed to SI-RNTI and comprising the repeat transmissions in PDCCH regions 600A, 600B, 600C in accordance with conventional resource allocation techniques in the context of coverage extension using repeat transmissions. Whilst the shading in Figure 6 schematically represents the same frequency resources being used for each repeat transmission in the respective PDSCH regions 602D, 602E and 602F of the subframes D, E, F, in principle the repeat-transmission approach may be configured to include frequency hopping for the different repeat transmissions comprising the PDSCH message sent in subframes D, E, F. The nature of any such frequency hopping may be pre-defined, for example it may be pre-specified according to an operating standard for the wireless telecommunications system, or it may be established in previous RRC (radio resource control) signalling, or it may be indicated in the PDCCH message.

As schematically represented in Figure 6 there is a gap between subframes C and D. This follows the currently-proposed approaches for repeat-transmission coverage extension whereby the transmission of a PDSCH message comprising a plurality of repeat transmissions does not start until after all repeat transmissions of the corresponding PDCCH message have been sent. This is to help reduce the buffering requirements at the terminal device. Furthermore, current proposals indicate there should be no overlap between the end of the repeat transmissions comprising the PDCCH message and the start of the repeat transmissions comprising the PDSCH message. It will, however, be appreciated the specific implementation of such aspects of a repeat transmission approach for providing coverage extension are not significant to the principles underlying the present disclosure. That is to say, the principles described herein may equally be implemented in association with other repeat transmission approaches (e.g. with repeat transmissions of PDCCH and its corresponding PDSCH occurring in the same subframe).

In subframes following the transmission of the system information message as schematically indicated in subframes D, E and F in Figure 6, the wireless telecommunications system continues to operate in accordance with its normal operating techniques until subframe G represented. Subframe G represents the beginning of another system information message. As noted above, system information messages can be regularly retransmitted in accordance with LTE techniques, and in this regard the system information message beginning at subframe G is considered in this example to be a re-transmission of the system information message transmitted using subframes A to F as discussed above. The specific timing of the re-transmission of system information (i.e. the timing of subframe G relative to subframe A) may follow any conventional system information re-transmission schedule. The principles underlying the re-transmission of the system information message starting from subframe G follow those described above. Thus, a PDCCH message addressed to SI-RNTI is sent using the PDCCH regions 600G, 600H and 600I of subframes G, H and I to allocate resources for a PDSCH message comprising three repeat transmissions in the PDSCH regions 602J, 602K and 602L in subframes J, K and L as indicated by shading in Figure 6. It may be noted in this example the frequencies of the resource elements for the re-transmission of the system information message on PDSCH in subframes J, K, L is different from that used in subframes D, E, F for the previous transmission, but this is not of any particular significance. Furthermore, the transmissions of the PDSCH message in subframes D, E, F, J, K, L may comprise different so-called redundancy versions of the PDSCH message comprising different combinations of information bits and redundancy bits arising from a forward error correction coding process.

It will be appreciated the transmission resources represented in Figure 6 which are not involved in the SI message signalling discussed above can be used for other communications in the network in the usual manner. In particular, it will be appreciated that although the entirety of the PDCCH regions associated with repeat transmissions of the PDCCH for the system information messages are shown shaded in Figure 6, this is merely to highlight those subframes in which a PDCCH for the system information messages is transmitted compared to those where it is not, and in practice these regions will comprise multiple PDCCH messages addressing different terminal devices for allocating resources for various different types of communication on PDSCH.

System information signalling in LTE is sent on what is approaching a more or less continuous basis. This means there is a considerable amount of PDSCH traffic for broadcasting system information messages comprising the SIBs. There is a corresponding requirement for PDCCH signalling to schedule the PDSCH resources for system information messages. The inventors have recognised that this can become a significant issue in a coverage extension scenario where a number of repetitions are expected, as illustrated in Figure 6. This is because for each PDSCH message comprising a plurality of PDSCH repeat transmissions (i.e. the PDSCH message sent using resources in subframes D, E and F and the PDSCH message sent using resources in subframes J, K and L) there is a corresponding SI-RNTI PDCCH message comprising a plurality of PDCCH repeat transmissions (i.e. the PDCCH message sent using resources in subframes A, B and C and the PDCCH message sent using resources in subframes G, H and I). With the potential for perhaps a hundred or more repeat transmissions to provide coverage extension to the edge of a base station's corresponding cell for system information messages a large fraction of the available control region resources will be needed to support this function following the approach of Figure 6. There is of course a corresponding increase in the use of PDSCH resources with the approach represented in Figure 6, but it is to be expected that in many situations it will be PDCCH resources that are more at a premium owing to the limited resources available in the control channel region for PDCCH and the priority typically given to PDSCH over EPDCCH in the PDSCH region. This is especially likely in networks supporting large numbers of MTC devices since these are likely to have a higher ratio of control signalling to data signalling as compared to the traffic profiles typically associated with conventional terminal devices. The increased PDCCH and/or EPDCCH resources needed to support repeat transmissions of system information messages could ultimately make it difficult to schedule unicast PDSCH transmissions to terminal devices operating within the system because of a lack an availability of control region resources to indicate the allocation of PDSCH resources and/or a lack of PDSCH region resource to indicate the allocation of PDSCH resources.

To address this type of issue there have been proposals to stop using PDCCH and EPDCCH messages resource allocations for PDSCH messages comprising system information (i.e. for system information messages). One proposal (described in the 3GPP document R1-135422, "On the need of PDCCH for SIB and other Common Channel", Mediatek, RAN1#75, San Francisco, November 2013 [4]) is to avoid providing any scheduling information in respect of system information-carrying PDSCH transmissions. Instead, a terminal device will be expected to perform blind searching of the PDSCH region to identify if there are any relevant system information transmissions. A drawback with this approach is a significant increase in the processing load required for terminal devices. To reduce the processing load required at the terminal device to a more manageable level the system information messages could be confined to a restricted subset of transmission resources comprising the PDSCH region. However, this approach still requires additional processing tasks to be performed by the terminal device and introduces reduced

scheduling flexibility. Another proposal (described in the 3GPP document R1-134207, "Coverage enhancement techniques for PBCH", Alcatel-Lucent, Alcatel-Lucent Shanghai Bell, RAN1#74bis, Guangzhou, October 2013 [5]) is to avoid using PDCCH messages to provide scheduling information in respect of system information-carrying PDSCH messages. Instead it is proposed that some of the spare bits currently available in the Master Information Block (MIB) in LTE are used for providing scheduling indications for system information messages. However, there are a limited number of spare bits available for this and so the approach does not allow for any significant degree of flexibility in scheduling system information messages, and furthermore the approach further reduces the number of spare bits available for other uses.

In view of these issues, the inventors have developed an alternative approach for reducing the amount of control signalling required to support resource allocations for higher-layer transmissions in a wireless telecommunications system. In particular, but not exclusively, the inventors have developed an approach which may be applied for reducing the amount of control-channel signalling required to support resource allocations for downlink messages, such as system information messages, and in particular for messages which may be subject to re-transmissions on a defined schedule and which may, in some cases, be sent using a repeat transmission approach to provide a degree of coverage extension.

Figure 7 is similar to, and represents various aspects that will be understood from, Figure 6, but shows an approach in accordance with certain embodiments of the present disclosure. Figure 8 is a signalling ladder diagram schematically representing modes of operation for the terminal device 508 and the base station 504 schematically represented in Figure 5 in accordance with some embodiments of the present disclosure for implementing an approach of the kind represented in Figure 7. In broad summary, some embodiments of the disclosure introduce the concept of a validity period for a PDCCH message to thereby indicate transmission resources that may be used for a plurality of PDSCH messages within the validity period. That is to say the control message transmitted on the PDCCH is considered valid for a period that is longer than the period needed to transmit a single PDSCH message (whether in one subframe or with repeat transmissions in a plurality of subframes to provide coverage extension). This means multiple PDSCH messages can in effect be scheduled using the control-region resources of only a single PDCCH message. There are various different ways in which the validity period may be established/determined, as discussed further below.

For the example represented in Figure 7, and as with Figure 6, it is assumed system information is being transmitted from a base station to a terminal device with a repeat transmission approach to providing coverage extension. Again the example approach to coverage extension represented in Figure 7 is assumed for ease of representation to rely on providing only three repeat transmissions for each PDCCH and PDSCH message. However, as noted above, it will be appreciated that in practice larger numbers of repeat transmissions will typically be involved, for example there may be tens or hundreds of repeats comprising each message to provide a correspondingly higher degree of coverage extension. Furthermore, it will be appreciated that PDCCH messages and PDSCH messages need not necessarily comprise the same number of repeat transmissions (for example different coding schemes may be adopted meaning that different numbers of repeat transmissions are appropriate to provide a desired probability of successful reception for each message).

Thus Figure 7 schematically represents an approach for providing coverage extension through repeated transmissions for a plurality of SI messages with reduced control signalling overhead in accordance with

an embodiment of the disclosure. Figure 7 schematically shows a sequence of LTE downlink subframes (labelled as subframes "O", "P", "Q", …, "Z" to aid explanation) with shading to schematically indicate which regions in which subframes are used to convey messages associated with the system information. The subframes represented in Figure 7 comprise four groups of three contiguous subframes with spaces between the groups as schematically indicated by dotted lines. Although not shown in Figure 7, the gaps between the groups comprise a continuing sequence of subframes used for other communications that are not relevant to the system information messaging considered here. As discussed above, each subframe comprises a control region 700 and a PDSCH region 702. The control regions 700 for the respective subframes are labelled in Figure 7 with the identification letter for the relevant subframe, i.e. as 700O, 700P, 700Q, etc. The PDSCH regions for the respective subframes are similarly labelled in Figure 6 as 702O, 702P, 702Q, etc.

As already noted above, aspects of the operation of a wireless telecommunications system in accordance with embodiments of the disclosure, for example as shown in Figure 7 and 8, which are not specifically described herein may be implemented in accordance with any conventional techniques. In this regard, insofar as the operation of embodiments of the disclosure follow conventional techniques the respective subframes represented in Figure 7 may be similar to that is represented in Figure 3. Thus, the control regions 700 support PCFICH, PHICH and PDCCH channels as discussed above while the PDSCH regions 702 support user-plane data and system information (among other things) and EPDCCH if implemented. The most significant aspect of the control region 700 in the context of embodiments of the present disclosure relate to the PDCCH and so for simplicity the control regions 700 may sometimes be referred to herein as PDCCH regions 700.

Thus referring to Figure 7 subframes O, P and Q are used to signal a PDCCH message addressed to SI-RNTI by sending three repeat PDCCH transmissions in the respective PDCCH regions 700O, 700P, 700Q. Each PDCCH repeat transmission addressed to SI-RNTI in the PDCCH regions 700O, 700P, 700Q in effect comprises a duplication of the same downlink control information which a terminal device can combine to seek to establish the content of the PDCCH message addressed to SI-RNTI in accordance with conventional techniques for coverage extension through repeat transmissions. For this example implementation of a repeat-transmission based coverage extension scheme it is again assumed a particular type of message subject to repeat transmissions is addressed to the same RNTI (e.g. SI-RNTI for a system information related type of messages) as if the same type of message were subject to conventional single-subframe transmission. However, as discussed further below, in accordance with certain embodiments of the disclosure identifiers having different characteristics (e.g. in terms of their value or control region search space) may be used for a given type of message depending on whether the messages to be sent in accordance with a first transmission scheme (e.g. using a conventional single subframe based transmission approach) or a second transmission scheme (e.g. using a repeat-transmission scheme for coverage extension). Furthermore, it will be appreciated the approach of using identifiers associated with a particular type of message having different characteristics according to the transmission scheme is to be used in accordance with embodiments of the disclosure may or may not also implement an approach using validity periods as disclosed herein.

The PDCCH message sent in subframes O, P and Q in Figure 7 differs from a conventional PDCCH message, for example of the kind transmitted in subframes A, B and C of Figure 6, in that it is associated with a validity period that is sufficient to span the transmission of a plurality of PDSCH messages. This is

different from the conventional approach in which a PDCCH message is simply associated with a single PDSCH message. The validity period for the PDCCH message is known to both the base station and the terminal device. For example, the validity period may be based on a defined standard for operations in accordance with an embodiment of the disclosure, whereby the base station and the terminal device can each determine the validity period from the defined standard. In other embodiments the base station may have flexibility to select the validity period, for example according to current scheduling requirements, and to communicate an indication of the validity period to the terminal device(s) to which the PDCCH message is addressed. Some example implementation of this approach are discussed further below.

The PDCCH message comprising the three repeat transmissions in the PDCCH regions of subframes O, P and Q indicate transmission resource blocks to be used for a subsequent PDSCH message comprising the transmission of system information. This PDSCH message itself comprises a plurality of repeat transmissions, and, in this example, are represented by shading in the PDSCH regions 702R, 702S and 702T of subframes D, E and F. The manner in which the PDCCH message indicates the corresponding PDSCH resources in subframes R, S and T may be in accordance with conventional techniques/signalling protocols. That is to say, the transmission resources, for example in terms of specific resource elements, used to convey the repeat transmissions of the system information message in the PDSCH regions 702R, 702S and 702T may be indicated in the corresponding PDCCH message addressed to SI-RNTI and comprising the repeat transmissions in PDCCH regions 700O, 700P, 700Q in accordance with conventional resource allocation techniques in the context of coverage extension using repeat transmissions. Whilst the shading in Figure 7 schematically represents the same frequency resources being used for each repeat transmission in the respective PDSCH regions 702R, 702S and 702T of the subframes R, S and T, in principle the repeat-transmission approach may be configured to include frequency hopping for the different repeat transmissions comprising the PDSCH message sent in subframes R, S and T. The nature of any such frequency hopping may be pre-defined, for example it may be pre-specified according to an operating standard for the wireless telecommunications system, or it may be established in previous RRC (radio resource control) signalling, or it may be indicated in the PDCCH message.

As schematically represented in Figure 7 there is a gap between subframes C and D. This again follows the currently-proposed approaches for repeat-transmission coverage extension whereby the transmission of a PDSCH message comprising a plurality of repeat transmissions does not start until after all repeat transmissions of the corresponding PDCCH message have been sent. Furthermore, some proposals indicate there should be no overlap between the end of the repeat transmissions comprising the PDCCH message and the start of the repeat transmissions comprising the PDSCH message. It will, however, be appreciated the specific implementation of such aspects of a repeat transmission approach for providing coverage extension are not significant to the principles underlying the present disclosure. That is to say, the principles described herein may equally be implemented in association with other repeat transmission approaches (e.g. with repeat transmissions of PDCCH and an associated PDSCH occurring in the same subframe).

Thus, the communication of the PDCCH message in subframes O, P and Q and the corresponding communication of the PDSCH message conveying system information in subframes R, S and T as represented in Figure 7 may follow the same general principles as the approach represented in Figure 6. Similarly, in subframes following the repeat-transmission approach for transmitting the system information

message as schematically indicated in subframes R, S and T in Figure 7, the wireless telecommunications system may continue to operate in accordance with its normal operating techniques for conveying other messages.

As noted above, system information messages are regularly retransmitted in accordance with LTE techniques, and the approach of Figure 7 differs from the approach of Figure 6 in respect of how a subsequent transmission of system information is scheduled on PDSCH in subframes X, Y and Z. In particular, the approach of Figure 7 differs from the approach of Figure 6 if the subsequent retransmission of system information occurs within the validity period associated with the previously-received PDCCH message in subframes O, P and Q initially sent in association with the previously-received system information message on PDSCH in subframes R, S and T. In LTE the transmission of system information follows a defined timing schedule, for example based on the system information window defined for the relevant system information. Thus, a base station and a terminal device are able to independently determine in which subframe a system information message will be transmitted on PDSCH (or which plurality of subframes in the case of coverage extension through repeat-transmissions as in this example). Thus, in the example of Figure 7, a terminal device to which the system information is addressed can determine that a system information message is to be transmitted in subframes X, Y and Z.

Referring back to Figure 6, the terminal device receiving the system information on PDSCH in subframes J, K and L can similarly determine in accordance with conventional techniques that the transmission will occur in these subframes. However, to determine the specific resources (e.g. in terms of specific OFDM carriers / resource blocks) on which the transmissions will occur within the relevant subframe(s) the terminal device must first receive the corresponding PDCCH allocation message sent in subframes G, H and I.

However, in the approach of Figure 7 in accordance with an embodiment of the present disclosure the resource allocation used for the PDSCH transmissions of the system information message on subframes X, Y and Z is determined from the previous resource allocation message sent on PDCCH in subframes O, P and Q. For example, in accordance with one approach the specific PDSCH resources (e.g. in terms of frequency) to be used for transmitting the subsequent system information message in subframes X,Y and Z are assumed to be the same as the specific PDSCH resources (e.g. in terms of frequency) used for transmitting the system information message in subframes R, S and T and indicated in the PDCCH message sent in subframes O, P and Q. However, it will be appreciated that other mappings can be adopted. For example, the frequencies to be used can be configured to shift in accordance with a predefined pattern for each retransmission within the validity period for the PDCCH message.

Thus, in accordance with an embodiment of the disclosure, and in contrast to the approach in the corresponding subframes in Figure 6, there is no PDCCH message sent in subframes U, V and W to support the system information message sent on PDSCH in subframes X, Y and Z. Instead it is determined that a previous PDCCH message remains valid (because its associated validity period has yet to expire), and the resources used for conveying the system information message on PDSCH in subframes X, Y and Z are derived from the previous PDCCH.

This approach has an advantage of freeing up the control-channel resources, in particular in subframes U, V and W for the example subframes represented in Figure 7. The approach can also help reduce the

amount of processing required by the terminal device (since the terminal device does not need to decode a separate PDCCH message for each and every PDSCH message). Furthermore the approach can reduce latency in situations that require high repetition numbers because there is no need to wait to receive a series of PDCCH repetitions before receiving each series of PDSCH repetitions.

It will be appreciated the transmission resources represented in Figure 7 that are not involved in the SI message signalling discussed above can be used for other communications in the network in the usual manner. In particular, it will be appreciated that although the entirety of the PDCCH regions associated with repeat transmissions of the PDCCH for the system information messages are shown shaded in Figure 7, this is merely to highlight those subframes in which a PDCCH for the system information messages is transmitted compared to those where it is not, and in practice these regions will comprise multiple PDCCH messages addressing different terminal devices for allocating resources for various different types of communication on PDSCH.

Thus, to summarise an approach in accordance with an embodiment of the disclosure as represented in Figure 7, and with reference to Figure 8, a base station 504 is transmitting system information messages to terminal devices, including terminal device 508, according to a pre-defined timing schedule. The predefined timing schedule may follow conventional LTE techniques for transmitting system information. It is assumed the processing represented in Figure 8 starts just prior to subframe O at the beginning of the series of subframes represented in Figure 7 and while there is no currently valid PDCCH message for the relevant system information. Thus, in a first step S1 in Figure 8 the base station determines a validity period that is to apply for an upcoming control-plane message that is to be transmitted to allocate resources for system information messages on PDSCH. The duration of a validity period for a given PDCCH message may be fixed / predetermined according to a specific implementation, for example by a network operator, or may be selectable by a base station according to current conditions. The validity period might be relatively short, for example it might only comprise the time required to transmit two PDSCH messages to provide a potential saving of one PDCCH message transmission. On the other hand, the validity period might be significant number, for example hundreds, thousands, tens of thousands, or even more subframes. In general a longer validity period may be preferred to reduce the number of PDCCH message transmissions, while an overly-long validity period may be considered to overly restrict scheduling flexibility. An appropriate validity period in a given situation may depend on current traffic conditions within a cell supported by a base station. For example, if a base station is currently supporting a large number of terminal devices it may be more appropriate to select a relatively long validity period to provide a correspondingly large saving in PDCCH message transmissions. However, if a base station is currently supporting only a small number of terminal devices with low traffic requirements (i.e. such that PDCCH congestion is not an overly significant concern), it may be more appropriate to select a relatively short validity period to provide a corresponding increase in scheduling flexibility (example to take better account of fluctuations in radio propagation conditions or traffic changes). In one example a current proportion of non-MTC traffic may be used to help determine an appropriate validity period for a repeated PDCCH. Generally speaking, the higher this proportion, the higher the proportion of non-delay-tolerant non-small-message terminal devices in the cell whose performance may be disrupted by a heavy use of control channel resources due to repeated PDCCH transmission. Therefore, as the proportion of relatively higher priority terminal devices (e.g. non-MTC terminal devices) increases, the base station may opt for longer PDCCH validity times, especially for use in association with SI-messages.

In step S2 the base station transmits a control-plane message, which can also be referred to as a control message (using repeat transmissions for coverage extension in this example) to allocate the resources for subsequent system information messages on PDSCH. This control message is received and decoded by the terminal device 508. This aspect of the operation may be based generally on conventional techniques, for example using a PDCCH message addressed to an SI-RNTI in LTE. Furthermore, the specific resources selected by the base station for allocation to the system information messages may be selected in accordance with established scheduling techniques in wireless communication systems. Thus, step S2 correspond with the transmissions made in subframes O, P and Q of Figure 7.

In step S3 the terminal device determines the validity period for the control-plane message received in step S2. There are various ways in which the terminal device may determine the validity period for the control-plane resource allocation message in accordance with various embodiments of the disclosure, and some examples are discussed further below.

In step S4 the base station proceeds to transmit a system information message (using repeat transmissions for coverage extension in this example) in accordance with the resource allocation identified by the control-plane (PDCCH) message of step S2. This aspect of the operation may be made broadly in accordance with conventional techniques. The terminal device seeks to receive and decode this system information message (SI message #1) in accordance with conventional techniques.

In step S5 the base station determines it is time to transmit another system information message (SI message #2) according to the predefined timing for periodic system information transmissions in the wireless telecommunications system. The base station further determines the validity period for the control-plane message sent in step S2 has not yet expired. Accordingly, the base station does not send any new control-plane message to support the new system information message that is about to be transmitted (SI message#2). Instead the base station proceeds to transmit the system information message (using repeat transmissions for coverage extension in this example) in accordance with resource allocations derived from the previously-sent control-plane (PDCCH) message of step S2. For example, the base station may be configured to simply use the same frequency resources for transmitting SI message #2 in step S5 as were used for transmitting SI message #1 in step S2. The terminal device likewise determines the expected transmission timing for the new system information message (SI message #2) from the predefined timing for system information transmissions and also determines the validity period for the previous control-plane message received in step S2 has not expired. Accordingly, the terminal device need not seek to receive a new control-plane message to indicate the PDSCH resources for the new system information message that is to be next transmitted (SI message#2). Instead the terminal device simply assumes the transmission is to be made in the relevant subframes (determined according to the predefined timing) on frequency resources derived from the previously-sent control-plane (PDCCH) message of step S2. Once the terminal device has determined the specific resources on which to expect the system information message in step S5 (SI message #2) it may proceed to receive and decode the system information message in accordance with conventional PDSCH transmission techniques.

As noted above the timing s for specific SI messages in LTE are based on SI windows. Conventionally it is the transmission of an associated PDCCH message addressed to the relevant system information RNTI which determines the precise subframe(s) in which the system information message PDSCH is transmitted. However, in accordance with certain embodiments of the disclosure there can be PDSCH

messages conveying system information in an SI windows without there being a corresponding PDCCH message in that SI window. There are a number of different ways in which a terminal device can determine the relevant subframe for a further PDSDH message transmitted within the validity period of a previously-received PDCCH message in accordance with embodiments of the disclosure. In one case, the base station may be configured to send the PDSCH message in a predefined subframe of the SI window. In principle this could be permanently fixed for all PDSCH system information messages at the cost of reduced scheduling flexibility. In another case the subframe(s) could be based on the subframe(s) used in association with the initial PDCCH message. For example, if the initial PDCCH indicates a system information message is to be sent in subframe number n (or starting in subframe n for repeat transitions for coverage extension) within a particular SI window, subsequent PDSCH messages within the validity period of the PDCCH might also be sent in (or start in) subframe n of the relevant SI window. In another example, the base station may retain the flexibility to send (or start sending when using repeat transmissions) the subsequent system information message in any subframe within the SI window. In this case a terminal device may check for a newly addressed PDCCH message in the subframes in the SI window in the normal way, and if a new PDCCH message is not found, the terminal device may decode the PDSCH resources indicated in accordance with a previously-received still valid PDCCH message in the same subframe(s) relative to the SI window as for the previous transmission. In principle, with sufficient processing power, the terminal device could simply seek to decode the relevant resources in all subframes of an SI window to see if an SI message can be decoded.

The process of the base station sending further system information messages, and the terminal device receiving the further information messages, based on transmission resource allocation information indicated in the control-plane message of step S2 may continue (as schematically indicated in step S6 for transmitting SI message #n) until the validity period for the control-plane message received in step S2 has expired, as schematically indicated in step S7.

Following step S7 the processing in effect cycles back to where it started prior to step S1. The base station may thus determine a new validity period for a new control message to be sent in a further step corresponding with step S2 (the base station determines that a new PDCCH message is required because the previous one has expired). Processing may then continue from this point in the manner discussed above.

Thus, the various example schemes represented in Figures 7 and 8, and described above, provide an approach in which control-plane messages, and in particular SI-messages, are associated with a validity period that extends for more than one message transmission of the associated PDSCH. For example, for SIBs in SI-messages, one SI-RNTI addressed PDCCH message can provide the control information for multiple transmissions of SIBs, and in general over multiple SI-windows. Similar operation for other types of message, for example messages addressed to other common search-space RNTIs, may be adopted in accordance with other examples. This kind of approach can help reduce control resource requirements, which can be especially important in the context of coverage extension where according to conventional techniques PDCCH (comprising multiple repeat transmissions) messages would have to be transmitted every time an SI-message (comprising multiple repeat transmissions) needed to be sent.

As noted above, SIBs in system information messages can in some cases remain unchanged for extended period, for example a few hours. A terminal device may thus combine system information message transmissions from across multiple SI-windows if it does not successfully decode an SI-

message at first attempt and with a sufficiently long validity period this can be achieved in accordance with the approaches described herein with reduced control signalling requirements than current schemes.

As noted above, there are various different ways in which the validity period for a PDCCH message may be established. In one simple example the period may be defined according to an operating standard of the wireless telecommunications system. Both the base station and the terminal device can in effect be hardwired with the validity period (or multiple validity periods associated with different types of messages). In another example the base station may have flexibility for determining a suitable validity period according to the implementation and traffic conditions at hand. In this case there are various different ways in which the validity period could be conveyed to a terminal device.

In one example the base station may be configured to convey a selected validity period to terminal devices by selecting a particular transmission characteristic, for example timing, for the PDCCH message with which the validity period is associated. According to current proposals for repeat transmission coverage extension in LTE, the starting subframe of a PDCCH message being transmitted in multiple subframes should be confined to a subset of subframes. This is because in some circumstances the terminal device may be required to blindly search over the possible numbers of repetitions the PDCCH might comprise. If it were allowed for a PDCCH messages comprising an arbitrary number of repeat transmissions to start in an arbitrary subframe this could be expected to give rise to significant complexity in the processing required of the terminal device. To address this there has been proposed an approach in which, for example, a PDCCH message comprising N repeats can only begin in subframes having a subframe number that is a multiple of N (i.e. 0, N, 2N, 3N,...). This reduces the set of possible repetition numbers the UE needs to consider per subframe. Thus, a similar approach could be used to convey information on PDCCH validity. This can be done by linking the validity period to the starting subframe number of the associated PDCCH message. For example, a PDCCH message commencing in subframe M might be taken to indicate a validity period corresponding to M SI-windows for the relevant system information. Thus, a terminal device can readily establish the relevant validity period from the timing of the relevant control-claim message. It may be noted that in some circumstances it may be preferable to assign longer PDCCH validity periods to PDSCH messages that comprise high numbers of repetitions.

In another example the base station may be configured to convey a selected validity period to terminal devices through explicit signalling, for example in the downlink control information (DCI) of the relevant PDCCH message. Thus, the DCI may comprise an indication of a number of subframes / radio frames corresponding to the validity period or may comprise an indication of a specific subframe / radio frame in which the validity period is to expire. In the application to the transmission of system information messages it may be preferable to indicate timings in respect of a number of SI-windows of validity.

In yet another example the terminal devices may be configured to simply assume the validity period for a given PDCCH message addressed to a given RNTI (e.g. SI-RNTI) extends until a subsequent PDCCH message addressed to the relevant RNTI is received. That is to say, the PDCCH message may be considered to remain valid until it is replaced by another PDCCH message. In this respect, in terms of the processing schematically represented in Figure 8, this corresponds with the terminal device determining the validity period for the control message (corresponding to step S3) at the same time at which the validity period expires (responding to step S7), with this being triggered by a new PDCCH message being received by the terminal device. In this approach a terminal device may thus monitor for a new PDCCH message addressed to the relevant RNTI in each subframe of each SI-window in the normal way until a

new PDCCH message is received to in effect define the end the validity period for the previous PDCCH message addressed to that RNTI.

Thus, one principle of the approaches described above in accordance with some embodiments of the disclosure is to associate a PDCCH message with a time defining its validity, that time being extensible beyond the time taken to convey a corresponding PDSCH message. A terminal device may thus assume the PDSCH resource allocation, MCS (modulation and coding scheme), TBS (transport block size), etc. in the DCI of the PDCCH message is valid for receiving multiple PDSCH messages during the PDCCH validity time. No further PDCCHs for multiple PDSCH messages need be sent during the validity time. Thus, in the case of SIB transmissions, the transmission of all SI-messages (including all transmissions within a SI-window of a particular SI-message), may be scheduled with a single transmission of SI-RNTI PDCCH with an appropriately configured validity period.

One particular situation in which approaches in accordance with the embodiments described above might be expected to be useful is where the transmissions are used to provide coverage extension on both PDCCH and PDSCH. However, similar principles can be applied where coverage extension is not being used, for example in respect of messages sent within single subframes.

Whilst the above-described embodiments have focused on system information messages, it will be appreciated that similar principles can be applied for other types of messages in wireless telecommunications systems, and especially for messages which rely on resource allocations occurring with some degree of predictable timing. For example, similar principles can be used for control signalling addressed to other common search space RNTIs, such as RA-RNTI and P-RNTI.

Thus a random access RNTI addressed PDCCH message received by a terminal device during an initial cell access may be associated with a validity period such that the transmission resources identified in association with the random access RNTI PDCCH message are taken to apply for later random access procedures in accordance with the principles set out above. The specific subframe of a RAR (random access response) window in which a subsequent RAR arrives can be established in a manner similar to that described above for system information within a predefined series of subframes comprising an SI-window

Similarly, a paging RNTI addressed PDCCH message may be associated with an extended validity in accordance with the principles described above. Thus a PDSCH resource allocation associated with a PDCCH message addressed to a paging RNTI transmitted in one subframe may be taken to indicate a PDSCH resource allocation in a subsequent subframe within a validity period associated with the PDCCH message. This may be especially appropriate for paging when a terminal device is in idle mode since there is a higher degree of predictability as to when paging messages may be sent according to a currently configured DRX, discontinuous reception, cycle. That is to say, the concept of PDDCH validity timers as discussed herein may be applied to the most recent P-RNTI PDCCH used to decode a paging message by an RRC_IDLE UE. An RRC_IDLE UE is only expected to monitor specific subframes for P-RNTI and is in DRX for other subframes. If the relevant PDCCH validity timer expires before a subsequent paging message is to be sent, the base station may provide a new P-RNTI PDCCH message to schedule the next paging message as normal. Otherwise the IDLE UE may assume the most recent such PDCCH is still valid. For an RRC_CONNECTED UE, there is less predictability as regards whether a particular subframe should contain P-RNTI PDCCH or not. For a connected mode terminal device the

principles described herein for paging messages might, for example, be used for subframes in which the UE would check for P-RNTI if it were in fact in IDLE mode. In other subframes the base station may send conventional paging signalling using PDCCH to page the UE in connected mode.

In a wireless telecommunications using repeat-transmissions for coverage extension there may be terminal devices which are not in coverage-limited locations and able to successfully decode individual ones of the PDCCH (or EPDCCH) repeat transmissions in each subframe. For example, and referring to Figure 7, a non-coverage-limited terminal device may be able to successfully decode the individual PDCCH repeat transmission in the control region 700O of subframe O. If this terminal device is not aware of the use of repeat-transmissions for coverage extension (for example because it is a legacy / conventional terminal device) it might be expected to assume the PDCCH information derived from the control region 700O subframe O applies to a system information transmission on PDSCH in the same subframe (i.e. in PDSCH region 702O). However, the terminal device would fail to receive the system information transmission (because it is not sent in accordance with this particular repeat-transmission protocol). Potentially this terminal device could seek to do this for each and every repeat transmission and so waste a considerable amount of processing effort needlessly decoding individual PDCCH repeat transmissions and associated PDSCH resources in the expectation of receiving system information messages which are not in fact being sent in those subframes. This is an issue which applies generally for repeat transmission approaches for coverage extension and is not specific to approaches based on validity periods as discussed herein.

Thus in accordance with certain embodiments of the disclosure an identifier (RNTI) having different characteristics (e.g. in terms of value or associated control region search space) may be associated with SI messages sent using a repeat transmission approach as compared to SI messages sent without using a repeat transmission approach. More generally, in a wireless telecommunications system supporting different transmission schemes for a given type (classification / category) of message (e.g. a message comprising a given radio resource control, RRC, information element, such as a system information related message or a paging request related message), a characteristic of an identifier associated with the message (i.e. an identifier to indicate which terminal device(s) the message is for) may be selected according to the transmission scheme used for the message. This approach may be implemented in accordance with certain embodiments of the disclosure regardless of whether the wireless telecommunications system also implements an approach using validity periods as described herein (i.e. the approach may be implemented in association with the principles of the repeat transmission scheme represented in Figure 6 as well as that represented in Figure 7). That is to say, the concept of associating a validity period with a control message and the concept of using different identifier characteristics according to a transmission scheme being used may be used together in combination or separately from one another in accordance with different embodiments of the disclosure.

A terminal device having the ability to receive transmissions using the repeat transmission approach can identify the transmissions as such directly from the associated identifier characteristic and receive the message accordingly. The characteristic for the identifier can be selected so that a terminal device not having the ability to receive transmissions using a repeat transmission approach, for example a legacy terminal device, does not recognise the message as being addressed to the terminal device, and so in effect ignores it. Such a terminal device may in effect ignore the message because, for example, the identifier has a value which is not recognised as a value relevant to the terminal device or because a search space for a control message conveying the identifier is not searched by the terminal device.

Thus, if in a particular implementation it is assumed that a repeat transmission approach to coverage extension is intended primarily for MTC-type devices, an MTC-specific system information radio network temporary identifier (MTC-SI-RNTI) may be established. PDCCH messages associated with repeat transmissions for conveying system information messages may thus be addressed to MTC-SI-RNTI instead of an SI-RNTI used for conveying system information that is not sent using repeat transmissions. More generally some embodiments of the disclosure propose introducing other repetition specific RNTIs to address messages that rely on repetitions for coverage extension to complement corresponding RNTIs in existing systems. Thus, system information messages to be sent in accordance with a non-repeat transmission technique may be associated with a conventional system information identifier (e.g. SI-RNTI) while system information messages to be sent in accordance with a repeat-transmission technique may be associated with a modified system information identifier (e.g. REPEAT-SI-RNTI).

Similar issues can arises for other common RNTIs associated with other types of message that may be sent using a repeat transmission approach. Thus corresponding RNTIs having different characteristics may also be established for these. For example, for each of SI-RNTI, P-RNTI, RA-RNTI, TPC-PUCCH-RNTI, TPC-PUSCH-RNTI and M-RNTI to be used for addressing non-repeat transmission messages, there may be established a corresponding RNTI having a different value to be used for addressing repeat-transmission messages (e.g. what might be generally referred to as REPEAT-RNTIs, such as REPEAT-SI-RNTI, REPEAT-P-RNTI, REPEAT-RA-RNTI, REPEAT-TPC-PUCCH-RNTI, REPEAT-TPC-PUSCH-RNTI and REPEAT-M-RNTI). Thus an approach in accordance with an embodiment of the disclosure may be used in association with messages selected from the group comprising: (i) a message associated with transmitting system information; (ii) a message associated with transmitting a paging message; (iii) a message associated with transmitting a random access response message; (iv) a message associated with transmitting power control information for an uplink control channel; (v) a message associated with transmitting power control information for an uplink data channel; and (vi) a message associated with a broadcast and / or multicast service. A similar approach can be taken for types of message associated with other common RNTIs which may be introduced in future.

In some implementations in which a message to be transmitted using a repeat-transmission approach in association with an identifier having a characteristic selected to indicate this, a component part of the message (e.g. a repeat transmission) may also be transmitted in one, or more, subframes in association with an identifier having a characteristic that would be used if the message were being transmitted using a conventional single-transmission approach. This will allow legacy terminal devices who are able to receive the message from only a single repeat transmission to in effect receive the message based on one of the repeat transmissions.

One advantage of associating identifiers for a given type of message with different characteristics based on the transmission scheme is the potential for more complete use of the available transmission resources. For example, referring to Figure 7, the initial SI-RNTI addressed PDCCH repeat transmission in the control region 700O of subframe O is part of a repeat transmission comprising three repeat transmissions in the respective control regions of subframes O, P and Q. This PDCCH message identifies resources (and other parameters) associated with a PDSCH message to be subsequently transmitted starting from subframe R as discussed above. As previously noted, it is expected for repeat-transmission based coverage extension there will be no PDSCH signalling associated with the PDCCH message until after the repeat transmissions comprising the PDCCH message had been made. In principle the PDSCH

transmission resources in the PDSCH regions 702O, 702P and 702Q of subframes O, P and Q corresponding to the resources allocated by the PDCCH message for use in subframe starting from subframe R could be used to support other transmissions. For example, the respective control regions 700O, 700P, 700R could include conventional single-subframe PDCCH messages allocating the relevant PDSCH transmission resources for another purpose, for example unicast data. However, it would be confusing for a legacy terminal device to decode a unicast PDCCH message and a SI PDCCH message resource allocation identifying the same resources in the same subframe. Thus by preventing the legacy terminal device from decoding the SI PDCCH signalling (through use of an appropriate distinguishing characteristic for the identifier as discussed herein), the legacy terminal device is free to receive unicast data on the relevant PDSCH resources (in association with an appropriately addressed PDCCH transmission indicating these resources).

In implementations in which the distinguishing characteristic for the identifier is its value (i.e. with one value, such as SI-RNTI, indicating conventional single-subframe transmission, and another value, such as REPEAT-SI-RNTI, indicating repeat-transmission coverage extension), the "new" REPEAT-RNTIs may be defined in accordance with an operating standard for the wireless telecommunications network in parallel with the corresponding RNTIs. For example, as noted above, in LTE the SI-RNTI has a fixed value 0xFFFF. In accordance with an embodiment of the disclosure a fixed value for a REPEAT-SI-RNTI may be selected from one of the currently reserved RNTIs in LTE (from 0xFFF4 to 0xFFC). Thus, if, for example, a value 0xFFF5 is allocated as REPEAT-SI-RNTI (i.e. an identifier for a system information related message sent using repeat transmissions), a PDCCH addressed to 0xFFFF can be identified as corresponding to a system information message sent without repetition whereas a PDCCH addressed to 0xFFF5 can be identified as corresponding to a system information message sent using repetition. A terminal device that is unaware of repetition will in effect ignore the PDCCH addressed to 0xFFF5 as this will not be recognised as a valid RNTI for the terminal device. Corresponding principles apply where EPDCCH is used.

In the above-described example the value of the RNTI is the characteristic used to distinguish between the different transmission schemes. However, in accordance with other embodiments of the disclosure, other characteristics can be used to distinguish identifiers to indicate different transmission schemes. For example, in LTE there are currently eight "spare" values that could be used as new REPEAT-RNTIs. This is a sufficient number of values to provide a corresponding RNTI to be used in association with a transmission scheme comprising repeat transmissions for all currently-existing common RNTIs. However, it may be considered preferable in some cases to avoid using these "spare" values so they remain free for other uses, or there may be a need for more REPEAT-RNTIs (for example, to provide multiple extra RNTI for a given type of message, e.g. a system information message, to indicate another aspect of the transmission scheme, for example the number of repeats). Thus, in accordance with some embodiments a REPEAT-RNTI may in fact have a value that is the same as its corresponding "conventional" RNTI (e.g. 0xFFFF for SI-RNTI and REPEAT-SI-RNTI) but be associated with a different search space. As is well known a terminal device will typically search a defined subset of control region resources to seek to identify any control messages associated with an identifier (RNTI) common to a plurality of terminal devices. The subset of control region resources is known as a search space and comprises a plurality of candidate PDCCH for the terminal device to check. This search space approach is taken to reduce the amount of processing required by the terminal device to seek to identify any relevant control messages. Thus, PDCCH signalling associated with the existing common RNTIs are constrained to a particular set of

candidate PDCCH comprising the common search space. In accordance with some embodiments of the disclosure the characteristic of the identifier which is used to distinguish the different potential transmission schemes may be based on the specific PDCCH resources used.

For example, a PDCCH message to be transmitted in accordance with a conventional single-subframe approach may be associated with an identifier, such as SI-RNTI, in the common search space in the usual way. However, a PDCCH message to be transmitted in accordance with a repeat-transmission approach may instead be associated with the same value of identifier, such as SI-RNTI, but transmitted on PDCCH resources outside the common search space. Thus in accordance with some implementations the distinguishing characteristic for the identifier based on the transmission scheme may be a search space with which the identifier is associated. Thus a PDCCH message addressed to SI-RNTI within a particular search space (e.g. the common search space in LTE) can be identified as corresponding to a system information message sent without repetition whereas a PDCCH transmission addressed to SI-RNTI outside the particular search space (e.g. outside the common search space in LTE) can be identified as corresponding to a system information message sent using repetition. A terminal device that is unaware of repetition will in effect ignore the PDCCH addressed to SI-RNTI outside the common search space as the terminal device will not search for the SI-RNTI outside the common search. Corresponding principles apply where EPDCCH is used. Thus in effect, identifiers associated with repeat transmissions may be associated with a newly-defined search space which is outside the search space used for the corresponding identifiers for conventional single-subframe transmissions. In some examples the new search space may support only a single aggregation level, for example an aggregation level 8 (the high aggregation level being appropriate in view of the coverage extension context). The new search space may be smaller (i.e. comprise fewer candidate PDCCH) than the search space for existing common RNTIs. This can help reduce the blind search load associated with the repeat transmissions comprising a message transmitted using a repeat transmission for coverage extension.

It will appreciated the advantages of establishing a new search space comprising a reduced number of candidate PDCCHs with a single relatively high aggregation level to be used in association with identifiers for repeat transmission messages can be applied even in circumstances where different identifier values are associated with the different transmission schemes. In such cases the repeat-specific identifier values may be selected from among the values that are available for use as identifiers in the wireless telecommunications system. In one example, as referred to above, a repeat-specific identifier values may simply match its corresponding non-repeat specific identify value (e.g. SI-RNTI) with the different search space in which a control message associated with the identifier is transmitted providing the distinguishing characteristic for the identifier for the selected transmission scheme. However, in another implementation the repeat-specific identifier values may be selected from, for example, identifiers available for other uses, for example in LTE from identifiers available for cell-specific RNTIs (which may range from 0x001 to 0xFFF3). This approach can in principle provide a relatively large number of repeat-specific identifiers. For example, one or more of the values normally used for C-RNTI can be in effect reserved as one or more repeat-specific RNTIs, such as REPEAT-SI-RNTI in the terminology used above, and likewise for types / classes / classifications of messages other than system information related messages, such as paging messages and random access a response messages etc. Thus a base station could in effect reserve (re-allocate) in its cell a number of RNTI values for one purpose as actually being for use as repeat-specific RNTIs. If any of the re-allocated subset of RNTIs comprising the repeat-specific RNTI is detected by a terminal device as addressing a PDCCH in the newly-defined search space, the terminal

device may be configured to interpret this as a repeat-specific RNTI. This may be based on the base station conveying in previous signalling to terminal devices that support repeat-transmission communications an indication of the relevant RNTI(s). Alternatively, or in addition, the relevant RNTI(s) may be defined in accordance with an operating standard of the network for reallocation within the new search space. If the PDCCH candidates comprising the new search space do not overlap with those of the pre-existing common search space and UE-specific search space used by legacy devices, then the RNTIs allocated as repeat-specific RNTIs within the new search space could continue to be used in the other search space without giving rise to the potential for confusion for legacy terminal devices. If, on the other hand, the PDCCH candidates comprising the new search space do overlap with those of the pre-existing common search space or UE-specific search space, then the base station may be configured to avoid allocating any of a currently re-allocated RNTI to terminal devices in accordance with the usual function for the RNTI (i.e. a C-RNTI reallocated for use as a repeat-specific identifier should not be allotted to a terminal device for use as a C-RNTI). This can be remedied as a straightforward matter of RNTI scheduling (for example, the base station can in effect simply treat the re-allocated RNTIs as being already allotted for use).

If multiple RNTI are made available for use for a given type of message, the particular RNTI selected for use in association with a particular message may be used to indicate a further characteristic of the message, for example a number of repeats or a specific PDCCH validity period where implemented. This can provide the base station with a simple mechanism for modifying the specific repeat and all validity period parameters associated with a particular message, thereby improving overall flexibility.

Determining which identifiers a terminal device should search for to seek to identify messages to be sent to the terminal device using a repeat transmission scheme can be done in accordance with the usual principles by linking it to transmission mode (TM) configuration. In one implementation the repeat-specific RNTIs provided in accordance with embodiments of the disclosure might apply in all transmission modes as the principles governing their use will in many respects be similar to conventional, search space RNTIs. There could also be a link with the category/type of the terminal device. For example, a new terminal device category identifier could be introduced (e.g. category 0) to indicate the terminal device is a particular type of terminal device, for example an MTC-based terminal device. The repeat-specific identifiers may then be considered to apply to all transmission modes for terminal devices of category 0 (if the repeat-transmission based scheme is limited to category 0 terminal devices), as well as for additional terminal device categories if the use of the repeat-transmission based scheme is more widely supported.

Figure 9 is a signalling ladder diagram schematically representing modes of operation for the terminal device 508 and the base station 504 schematically represented in Figure 5 in accordance with some embodiments of the present disclosure.

Processing begins in step T1 when the base station determines that a message is to be transmitted to one or more terminal devices. The message may, for example, be a broadcast message or a multicast message. The determination that a message is to be transmitted may be made in accordance with conventional operating procedures for the wireless communications system. For example, if the message is a system information message, step T1 may arise in accordance with a conventional timing schedule for transmitting system information messages. If the message is a paging message, step T1 may arise because an event has arisen which requires a terminal device to be paged. In this example it is assumed the message which is to be transmitted is a system information message which is relevant for (i.e.

address to an identifier associated with) terminal device 508. Furthermore, it is assumed the message may be transmitted in accordance with either one of a first transmission scheme using transmission resources in a first number of radio subframes (e.g. using conventional single-subframe transmission) or a second transmission scheme using transmission resources in a plurality radio subframes (e.g. using repeat-transmission for coverage extension).

In step T2 the base station determines which of the first and second transmission schemes are to be used for transmitting the message. That is to say, in this example, the base station determines whether or not a conventional single subframe approach or a repeat-transmission approach for coverage extension will be used for the message. There are a number of factors that may govern this determination, either individually or in combination. For example, the terminal devices in the wireless telecommunication system may comprise a first set of terminal devices and a second set of terminal devices step and T2 may be based on whether the one or more terminal devices to which the message is to be sent comprises terminal devices in the first or second sets. For example, the first set of terminal devices may comprise terminal devices that do not require coverage extension techniques to receive messages (or simply do not support coverage extension), whereas the second set of terminal devices may comprise terminal devices that do require coverage extension techniques to receive messages (and support repeat-transmission based coverage extension). Whether or not a specific terminal device requires coverage extension may, for example, be based on a measured radio propagation metric associated with the terminal device, for example a path loss, block error rate, a bit error rate, a packet error rate, a frame error rate, a symbol error rate, or negative or positive acknowledgement signalling rate (ACK/NACK) associated with communications with the terminal device. In another implementation the decision may take account of a specific identity or category for the one or more terminal devices to which the messages to be sent.

In step T3 the base station determines a characteristic of an identifier for the message based on the transmission scheme determined in step T2. This characteristic may be selected in accordance with any of the principles discussed above (e.g. use of different values for the identifier or different search spaces to be used with the identifier).

In step T4 the message is transmitted in accordance with the transmission scheme determined in step T2 and in association with an identifier, e.g. RNTI, having the characteristic determined in step T3. For example, the message may be transmitted in accordance with a repeat-transmission scheme as described herein with an identifier selected to have a characteristic to identify this, for example in accordance with any of the principles discussed above. In this regard the message may comprise one or other or both of a control message transmitted on a downlink control channel, e.g. a PDCCH message and another message transmitted on a downlink data channel, e.g. PDSCH (i.e. such that the identifier is transmitted separately from the message).

In step T5 the terminal device receives the transmitted signalling from the base station and determines the transmission scheme being used from the characteristic of the identifier. The terminal device may then proceed to receive and decode the message in accordance with the transmission scheme being used.

Thus, the process represented in Figure 9 demonstrates a mechanism by which a base station can readily indicates to terminal devices the transmission scheme being used for a given message. Once the terminal device has determined the transmission scheme, subsequent operation, for example in terms of

receiving the message, they be performed in accordance with conventional principles for receiving such messages. Furthermore, these techniques may be modified to incorporate a validity period approach such as discussed above.

Thus there has been described a wireless telecommunication system that comprises a base station and a terminal device communicating over a radio interface. The radio interface supports a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel (e.g. a physical downlink shared channel) for conveying other messages from the base station to the terminal device. The control messages convey information on resource allocations for the other messages on the downlink data channel. The other messages may comprise user-plane messages or control-plane messages. The terminal device is configured to receive a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel and determine a validity period for the control message. During the validity period for the control message the terminal device is configured to receive a plurality of the other messages from the base station on the downlink data channel using the allocated transmission resources.

There has also been described a wireless telecommunication system that comprises a base station arranged to communicate messages to one or more terminal devices over a radio interface. The radio interface has a radio frame structure comprising a plurality of subframes, wherein a message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes (e.g. one subframe) or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes (e.g. with repeat transmissions in a plurality of subframes). The message is transmitted in association with an identifier to indicate a terminal device to which the message is addressed. A characteristic for the identifier, for example a value or control region search space for the identifier, is dependent on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme. A terminal device to which the message is addressed determines the transmission scheme from the characteristic of the identifier and receives the message accordingly.

Further particular and preferred aspects of the present invention are set out in the accompanying independent and dependent claims. It will be appreciated that features of the dependent claims may be combined with features of the independent claims in combinations other than those explicitly set out in the claims.

Thus, the foregoing discussion discloses and describes merely exemplary embodiments of the present invention. As will be understood by those skilled in the art, the present invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. Accordingly, the disclosure of the present invention is intended to be illustrative, but not limiting of the scope of the invention, as well as other claims. The disclosure, including any readily discernible variants of the teachings herein, define, in part, the scope of the foregoing claim terminology such that no inventive subject matter is dedicated to the public.

Respective features of the present disclosure are defined by the following two groups of numbered paragraphs:

Group 1 of numbered paragraphs:

Paragraph 1. A method of operating a terminal device communicating with a base station in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the method comprises receiving a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel, determining a validity period for the control message, and receiving a plurality of other messages from the base station on the downlink data channel using the allocated transmission resources within the validity period for the control message.

Paragraph 2. The method of paragraph 1, wherein the other messages comprise system information messages.

Paragraph 3. The method of any preceding paragraph, wherein the system information messages comprise one or more system information blocks.

Paragraph 4. The method of any preceding paragraph, wherein the radio interface is based on a radio frame structure comprising a plurality of subframes, wherein each subframe comprises a control channel region for supporting the downlink control channel and a shared channel region for supporting the downlink data channel, and wherein respective ones of the control and / or the other messages comprise transmissions over a plurality of subframes.

Paragraph 5. The method of any preceding paragraph, wherein the validity period for the control message is determined in dependence on an identifier used in association with the control message.

Paragraph 6. The method of paragraph 5, wherein the identifier comprises an indication of one or more terminal devices to which the control message is addressed.

Paragraph 7. The method of any preceding paragraph, wherein the validity period for the control message is determined in dependence on a transmission characteristic of the control message.

Paragraph 8. The method of paragraph 7, wherein the transmission characteristic of the control message comprises a transmission time associated with the control message.

Paragraph 9. The method of any preceding paragraph, wherein the radio interface is based on a radio frame structure comprising a plurality of subframes, and wherein the timing of a subframe used to convey a first one of the plurality of other messages is used to determine the timing of a subframe used to convey a second one of the plurality of other messages within the validity period for the control message.

Paragraph 10. The method of any preceding paragraph, wherein the timing of a subframe used to convey the first one of the plurality of other messages relative to a first predefined range of subframes is used to determine the timing of a subframe used to convey the second one of the plurality of other messages relative to a second predefined range of subframes.

Paragraph 11. The method of any preceding paragraph, wherein the validity period is determined in dependence on a validity period indicator received in association with the control message.

Paragraph 12. The method of any preceding paragraph, wherein the validity period is determined in dependence on the time at which a subsequent control message is received.

Paragraph 13. The method of any preceding paragraph, wherein the other messages comprise random access response messages and / or paging messages..

Paragraph 14. A terminal device for communicating with a base station in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the terminal device comprises a controller unit and a transceiver unit configured to operate together to receive a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to receive a plurality of other messages from the base station on the downlink data channel using the allocated transmission resources within the validity period for the control message.

Paragraph 15. Circuitry for a terminal device communicating with a base station in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to cause the terminal device to receive a control message from the base station conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to receive a plurality of other messages from the base station on the downlink data channel using the allocated transmission resources within the validity period for the control message

Paragraph 16. A method of operating a base station communicating with a terminal device in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the method comprises transmitting a control message to the terminal device conveying an indication of allocated transmission resources on the downlink data channel, determining a validity period for the control message, and transmitting a plurality of other messages to the terminal device on the downlink data channel using the allocated transmission resources within the validity period for the control message.

Paragraph 17. A base station for communicating with a terminal device in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the base station comprises a controller unit and a transceiver unit configured to operate together to transmit a control message to the terminal device conveying an indication of allocated transmission resources on the downlink data

channel, to determine a validity period for the control message, and to transmit a plurality of other messages to the terminal device on the downlink data channel using the allocated transmission resources within the validity period for the control message.

Paragraph 18. Circuitry for a base station communicating with a terminal device in a telecommunications system over a radio interface supporting a downlink control channel for conveying control messages from the base station to the terminal device and a downlink data channel for conveying other messages from the base station to the terminal device, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to cause the base station to transmit a control message to the terminal device conveying an indication of allocated transmission resources on the downlink data channel, to determine a validity period for the control message, and to transmit a plurality of other messages to the terminal device on the downlink data channel using the allocated transmission resources within the validity period for the control message.

Group 2 of numbered paragraphs:

Paragraph 1. A method of operating a base station for communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein the method comprises selecting a characteristic for the identifier in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

Paragraph 2. The method of any preceding paragraph, wherein the first number of radio subframes comprises a single radio subframe and the second number of radio subframes comprises a plurality of radio subframes.

Paragraph 3. The method of any preceding paragraph, wherein terminal devices in the wireless telecommunications system comprise a first set of terminal devices and a second set of terminal devices, and wherein the method comprises determining whether to transmit the message in accordance with the first transmission scheme or the second transmission scheme in dependence on whether a terminal device to which the message is to be transmitted is a member of the first set of terminal devices or the second set of terminal devices.

Paragraph 4. The method of any preceding paragraph, wherein the method comprises determining whether to transmit the message in accordance with the first transmission scheme or the second transmission scheme in dependence on a radio propagation parameter associated with radio communications between the base station and a terminal device to which the message is to be transmitted.

Paragraph 5. The method of paragraph 4, wherein the radio propagation parameter is selected from the group comprising: a path loss; an error rate; a positive acknowledgment, ACK, signalling rate; and a negative acknowledgment signalling, NACK, rate.

Paragraph 6. The method of any preceding paragraph, wherein the method comprises determining whether to transmit the message in accordance with the first transmission scheme or the second transmission scheme in dependence on an identity and / or type of a terminal device to which the message is to be transmitted.

Paragraph 7. The method of any preceding paragraph, wherein the radio interface supports a downlink control channel for conveying control messages from the base station to terminal devices and a downlink data channel for conveying other messages from the base station to terminal devices, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the message comprises a control message transmitted on the downlink control channel.

Paragraph 8. The method of any preceding paragraph, wherein the radio interface supports a downlink control channel for conveying control messages from the base station to terminal devices and a downlink data channel for conveying other messages from the base station to terminal devices, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the message comprises one of the other messages transmitted on the downlink data channel.

Paragraph 9. The method of any preceding paragraph, wherein the identifier to indicate a terminal device to which the message is addressed is transmitted separately from the message.

1 Paragraph 0. The method of any preceding paragraph, wherein the identifier comprises a radio network temporary identifier, RNTI.

Paragraph 11. The method of any preceding paragraph, wherein the identifier is a common to a plurality of terminal devices.

Paragraph 12. The method of any preceding paragraph, wherein the message comprises a broadcast message.

Paragraph 13. The method of any preceding paragraph, wherein the message comprises a multicast message.

Paragraph 14. The method of any preceding paragraph, wherein for a given type of message the characteristic for the identifier is selected from a first predefined characteristic for the identifier associated with the given type of message and a second predefined characteristic for the identifier associated with the given type of message according to whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

Paragraph 15. The method of any preceding paragraph, wherein the message is selected from the group comprising: (i) a message associated with transmitting system information; (ii) a message associated with transmitting a paging message; (iii) a message associated with transmitting a random access response message; (iv) a message associated with transmitting power control information for an uplink control

channel; (v) a message associated with transmitting power control information for an uplink data channel; and (vi) a message associated with a broadcast and / or multicast service.

Paragraph 16. The method of any preceding paragraph, wherein for a message to be transmitted in accordance with the second transmission scheme, a component of the message transmitted in one of the second number of subframes is associated with a characteristic for the identifier corresponding to that which would be used if the message were to be transmitted in accordance with the first transmission scheme.

Paragraph 17. The method of any preceding paragraph, wherein the characteristic for the identifier comprises a value for the identifier.

Paragraph 18. The method of any preceding paragraph, wherein the characteristic for the identifier comprises a search space in which a terminal device searches using the identifier to determine if a message has been addressed to the terminal device.

Paragraph 19. The method of any preceding paragraph, wherein the method comprises selecting the characteristic for the identifier from a plurality of different characteristics associated with different types of message.

Paragraph 20. The method of any preceding paragraph, wherein the characteristic for the identifier to be selected for a message to be transmitted in accordance with the second transmission scheme is defined in accordance with an operating standard for the wireless telecommunications system.

Paragraph 21. The method of any preceding paragraph, further comprising the base station pre-defining the characteristic for the identifier to be selected for a message to be transmitted in accordance with the second transmission scheme.

Paragraph 22. The method of paragraph 21, wherein the pre-defining the characteristic for the identifier is a value for the identifier selected from among a plurality of values.

Paragraph 23. A base station for communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the base station comprises a controller unit and a transceiver unit configured to operate together such that the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein a characteristic for the identifier is selected in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

Paragraph 24. Circuitry for a base station communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the circuitry comprises a controller element and a transceiver element configured to operate together such that the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of

radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein a characteristic for the identifier is selected in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

Paragraph 25. A method of operating a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the method comprises determining from an identifier associated with the message that the message is addressed to the terminal device, and further determining from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

Paragraph 26. A terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the terminal device comprises a controller unit and a transceiver unit configured to operate together to determine from an identifier associated with the message that the message is addressed to the terminal device, and to further determine from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

Paragraph 27. Circuitry for a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to determine from an identifier associated with the message that the message is addressed to the terminal device, and to further determine from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

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CLAIMS

What is claimed is:

1. A method of operating a base station for communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein the method comprises selecting a characteristic for the identifier in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

2. The method of claim 1, wherein the first number of radio subframes comprises a single radio subframe and the second number of radio subframes comprises a plurality of radio subframes.

3. The method of claim 1, wherein terminal devices in the wireless telecommunications system comprise a first set of terminal devices and a second set of terminal devices, and wherein the method comprises determining whether to transmit the message in accordance with the first transmission scheme or the second transmission scheme in dependence on whether a terminal device to which the message is to be transmitted is a member of the first set of terminal devices or the second set of terminal devices.

4. The method of claim 1, wherein the method comprises determining whether to transmit the message in accordance with the first transmission scheme or the second transmission scheme in dependence on a radio propagation parameter associated with radio communications between the base station and a terminal device to which the message is to be transmitted.

5. The method of claim 4, wherein the radio propagation parameter is selected from the group comprising: a path loss; an error rate; a positive acknowledgment, ACK, signalling rate; and a negative acknowledgment signalling, NACK, rate.

6. The method of claim 1, wherein the method comprises determining whether to transmit the message in accordance with the first transmission scheme or the second transmission scheme in dependence on an identity and / or type of a terminal device to which the message is to be transmitted.

7. The method of claim 1, wherein the radio interface supports a downlink control channel for conveying control messages from the base station to terminal devices and a downlink data channel for conveying other messages from the base station to terminal devices, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the message comprises a control message transmitted on the downlink control channel.

8. The method of claim 1, wherein the radio interface supports a downlink control channel for conveying control messages from the base station to terminal devices and a downlink data channel for conveying other messages from the base station to terminal devices, wherein the control messages convey information on resource allocations for the other messages on the downlink data channel, and wherein the message comprises one of the other messages transmitted on the downlink data channel.

9. The method of claim 1, wherein the identifier to indicate a terminal device to which the message is addressed is transmitted separately from the message.

10. The method of claim 1, wherein the identifier comprises a radio network temporary identifier, RNTI.

11. The method of claim 1, wherein the identifier is a common to a plurality of terminal devices.

12. The method of claim 1, wherein the message comprises a broadcast message.

13. The method of claim 1, wherein the message comprises a multicast message.

14. The method of claim 1, wherein for a given type of message the characteristic for the identifier is selected from a first predefined characteristic for the identifier associated with the given type of message and a second predefined characteristic for the identifier associated with the given type of message according to whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

15. The method of claim 1, wherein the message is selected from the group comprising: (i) a message associated with transmitting system information; (ii) a message associated with transmitting a paging message; (iii) a message associated with transmitting a random access response message; (iv) a message associated with transmitting power control information for an uplink control channel; (v) a message associated with transmitting power control information for an uplink data channel; and (vi) a message associated with a broadcast and / or multicast service.

16. The method of claim 1, wherein for a message to be transmitted in accordance with the second transmission scheme, a component of the message transmitted in one of the second number of subframes is associated with a characteristic for the identifier corresponding to that which would be used if the message were to be transmitted in accordance with the first transmission scheme.

17. The method of claim 1, wherein the characteristic for the identifier comprises a value for the identifier.

18. The method of claim 1, wherein the characteristic for the identifier comprises a search space in which a terminal device searches using the identifier to determine if a message has been addressed to the terminal device.

19. The method of claim 1, wherein the method comprises selecting the characteristic for the identifier from a plurality of different characteristics associated with different types of message.

20. The method of claim 1, wherein the characteristic for the identifier to be selected for a message to be transmitted in accordance with the second transmission scheme is defined in accordance with an operating standard for the wireless telecommunications system.

21. The method of claim 1, further comprising the base station pre-defining the characteristic for the identifier to be selected for a message to be transmitted in accordance with the second transmission scheme.

22. The method of claim 21, wherein the pre-defining the characteristic for the identifier is a value for the identifier selected from among a plurality of values.

23. A base station for communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the base station comprises a controller unit and a transceiver unit configured to operate together such that the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein a characteristic for the identifier is selected in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

24. Circuitry for a base station communicating a message to one or more terminal devices in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the circuitry comprises a controller element and a transceiver element configured to operate together such that the message may be transmitted in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, wherein the message is associated with an identifier to indicate a terminal device to which the message is addressed, and wherein a characteristic for the identifier is selected in dependence on whether the message is to be transmitted in accordance with the first transmission scheme or the second transmission scheme.

25. A method of operating a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the method comprises determining from an identifier associated with the message that the message is addressed to the terminal device, and further determining from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

26. A terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the terminal device comprises a controller unit and a transceiver unit configured to operate together to determine from an identifier associated with the message that the message is addressed to the terminal device, and to further determine from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

27. Circuitry for a terminal device for receiving a message from a base station in a wireless telecommunications system over a radio interface having a radio frame structure comprising a plurality of subframes, wherein the message may be transmitted by the base station in accordance with a first transmission scheme using transmission resources in a first number of radio subframes or transmitted by the base station in accordance with a second transmission scheme using transmission resources in a second number of radio subframes, wherein the second number is greater than the first number, and wherein the circuitry comprises a controller element and a transceiver element configured to operate together to determine from an identifier associated with the message that the message is addressed to the terminal device, and to further determine from a characteristic of the identifier whether the message transmission is in accordance with the first transmission scheme or the second transmission scheme.

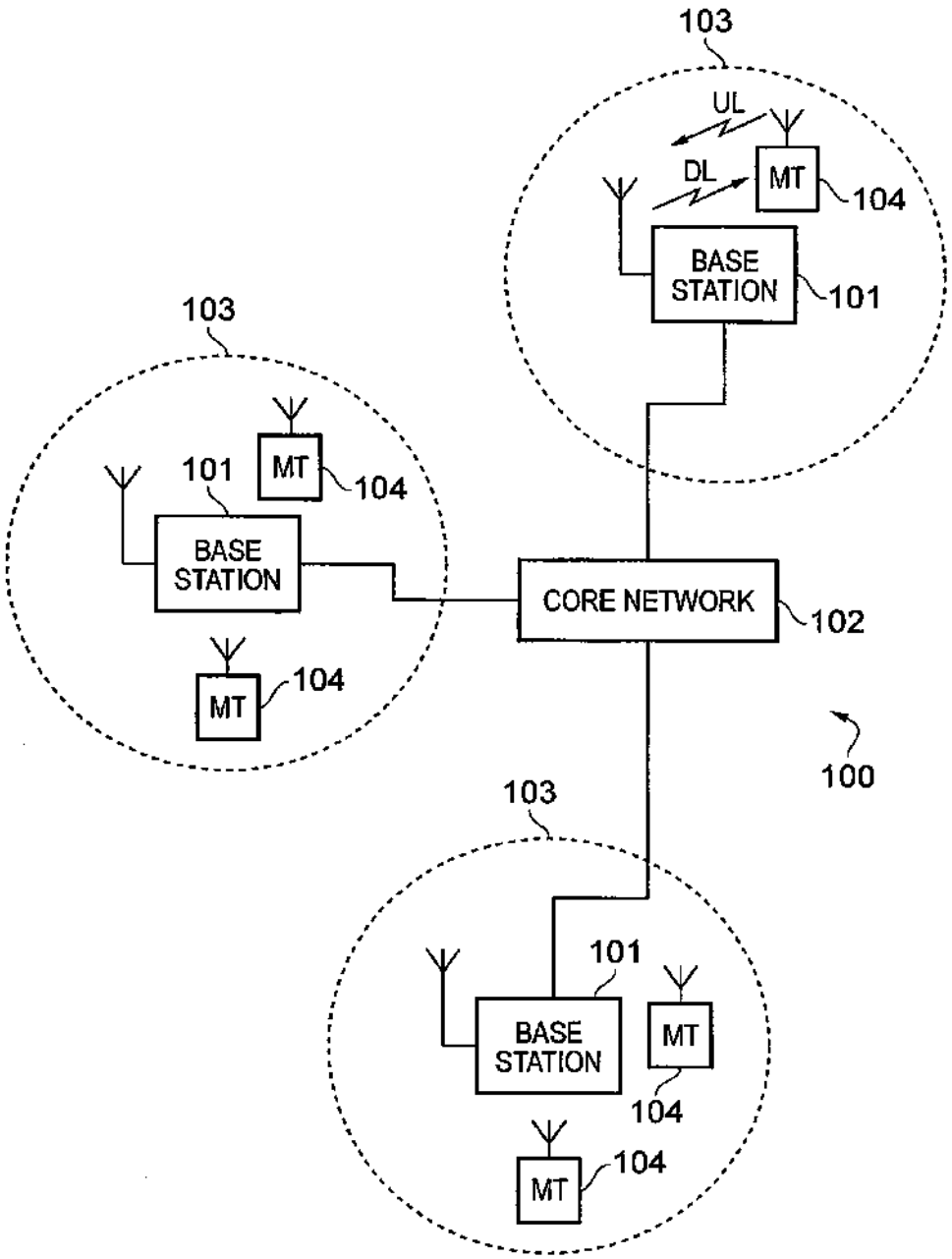

103
UL
DL
MT
104
BASE STATION
101
103
101
MT
104
BASE STATION
CORE NETWORK
102
MT
104
100
103
101
BASE STATION
MT
104
MT
104

FIG. 1

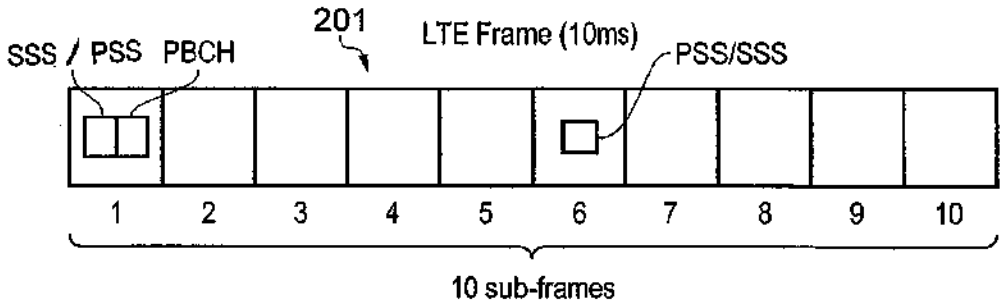

201
LTE Frame (10ms)
SSS / PSS
PBCH
PSS/SSS
1
2
3
4
5
6
7
8
9
10
10 sub-frames

FIG. 2

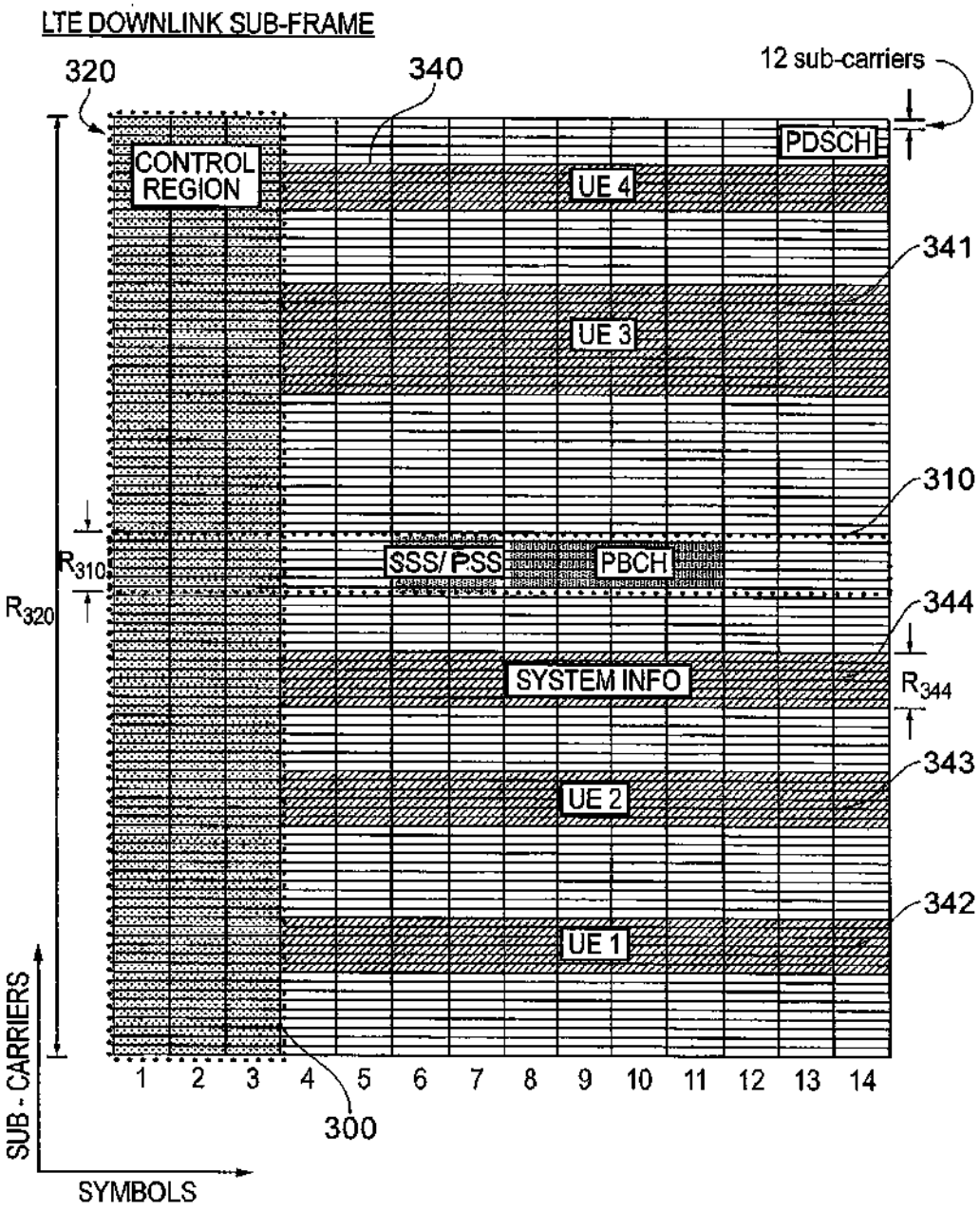

LTE DOWNLINK SUB-FRAME
320
340
12 sub-carriers
CONTROL REGION
PDSCH
UE 4
341
UE 3
310
R_{310}
SSS/ PSS
PBCH
R_{320}
344
SYSTEM INFO
R_{344}
343
UE 2
342
UE 1
SUB - CARRIERS
1 2 3 4 5 6 7 8 9 10 11 12 13 14
300
SYMBOLS

FIG. 3

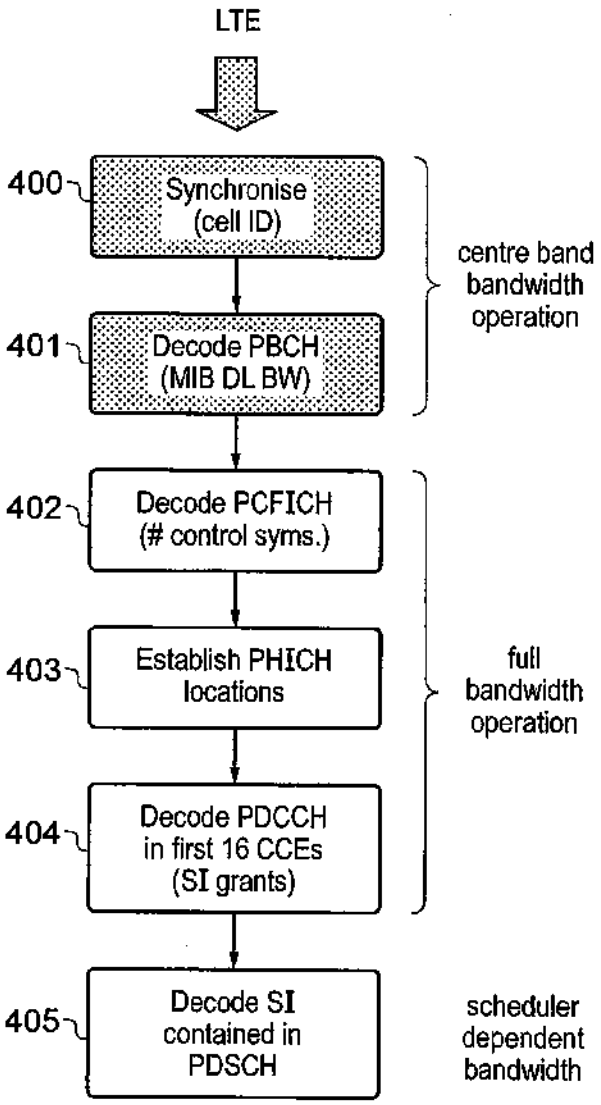

LTE
400
Synchronise (cell ID)
401
Decode PBCH (MIB DL BW)
centre band bandwidth operation
402
Decode PCFICH (# control syms.)
403
Establish PHICH locations
404
Decode PDCCH in first 16 CCEs (SI grants)
full bandwidth operation
405
Decode SI contained in PDSCH
scheduler dependent bandwidth

FIG. 4

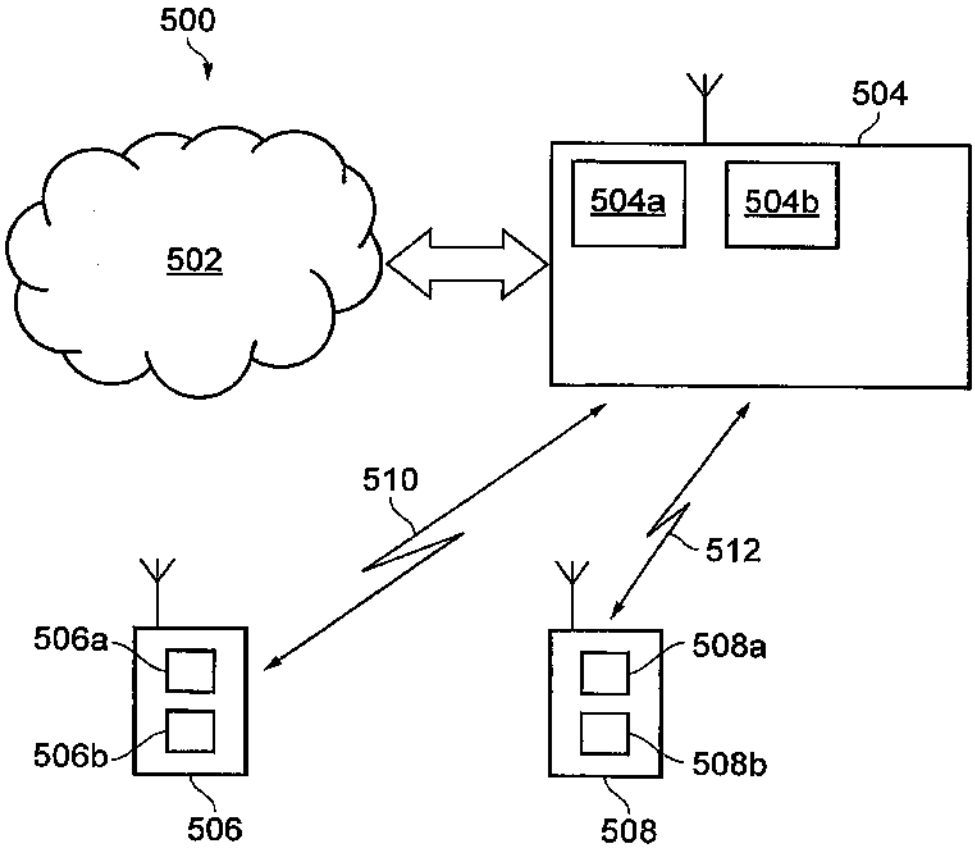


FIG. 5

Fig. 6

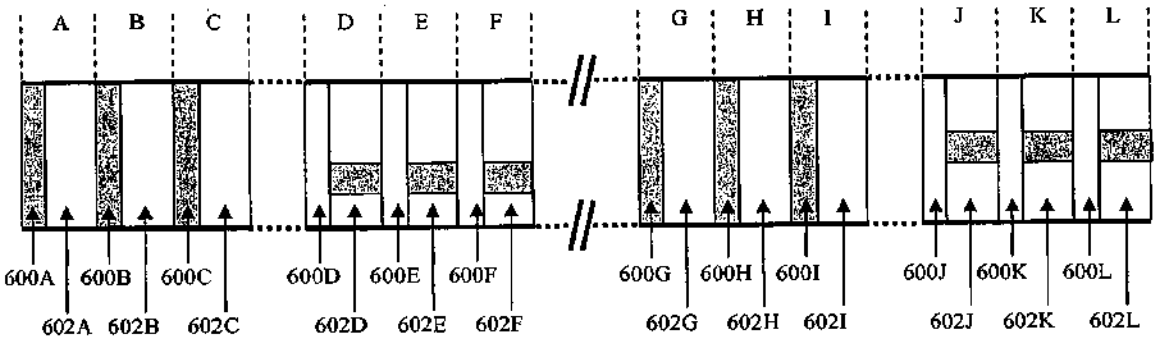
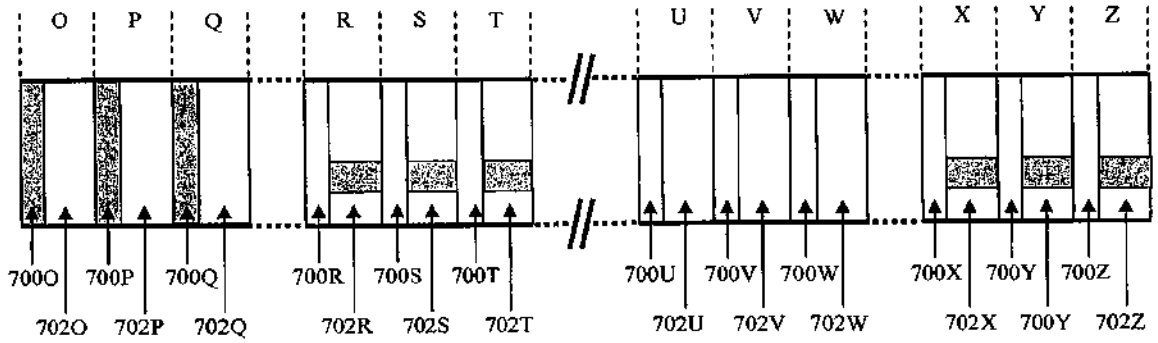

A
B
C
D
E
F
G
H
I
J
K
L
600A
600B
600C
600D
600E
600F
600G
600H
600I
600J
600K
600L
602A
602B
602C
602D
602E
602F
602G
602H
602I
602J
602K
602L

Fig. 7


O
P
Q
R
S
T
U
V
W
X
Y
Z
700O
700P
700Q
700R
700S
700T
700U
700V
700W
700X
700Y
700Z
702O
702P
702Q
702R
702S
702T
702U
702V
702W
702X
702Y
702Z

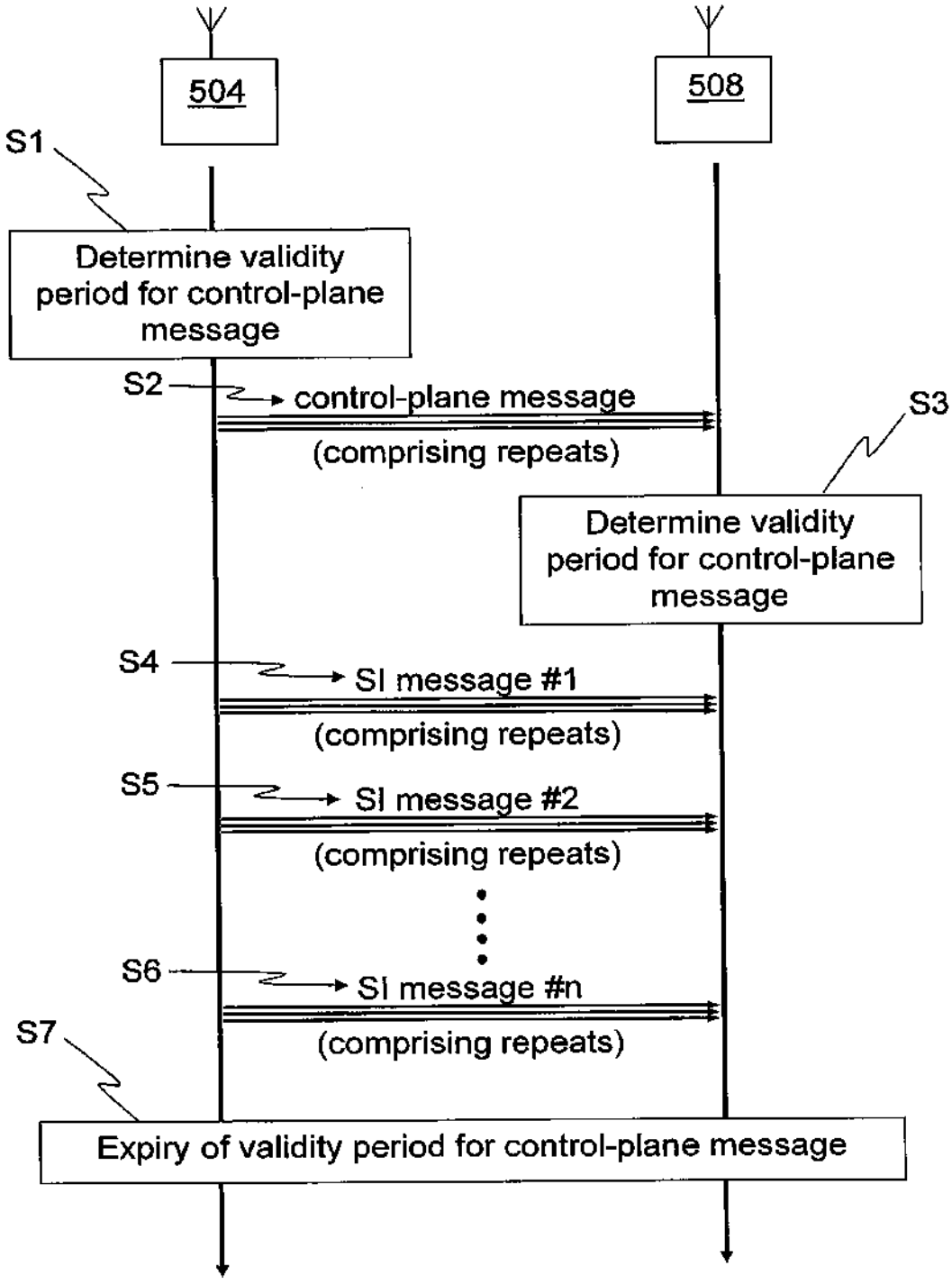

504
508
S1
Determine validity period for control-plane message
S2
control-plane message
(comprising repeats)
S3
Determine validity period for control-plane message
S4
SI message #1
(comprising repeats)
S5
SI message #2
(comprising repeats)
S6
SI message #n
(comprising repeats)
S7
Expiry of validity period for control-plane message

Fig. 8

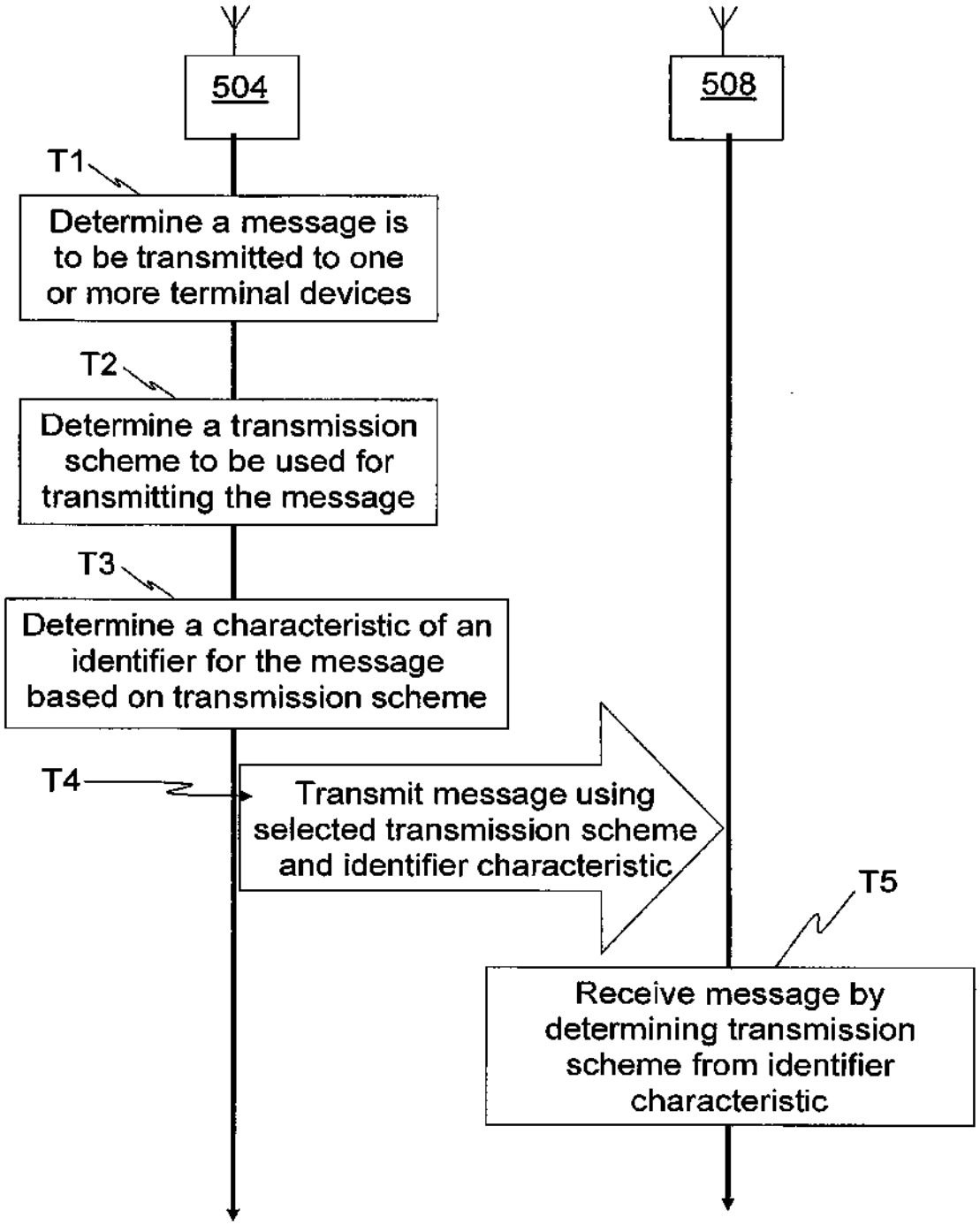

504
508
T1
Determine a message is to be transmitted to one or more terminal devices
T2
Determine a transmission scheme to be used for transmitting the message
T3
Determine a characteristic of an identifier for the message based on transmission scheme
T4
Transmit message using selected transmission scheme and identifier characteristic
T5
Receive message by determining transmission scheme from identifier characteristic

Fig. 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2014/074456

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W72/04
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W H04B H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2013/315159 A1 (XIA JINHUAN [CN] ET AL) 28 November 2013 (2013-11-28) paragraph [0005] - paragraph [0006] paragraph [0036]; figure 5 paragraph [0045]; figure 7 paragraph [0052] paragraph [0062]	1-27

X	EP 2 611 244 A2 (QUALCOMM INC [US]) 3 July 2013 (2013-07-03)	1,23-27
A	paragraph [0029]; figures 3,10 paragraph [0075]	2-22

	-/--	

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 February 2015	04/03/2015

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Cortés Gómez, F

1

Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	SONY: "PDSCH baseband bandwidth reduction for low complexity MTC UE", 3GPP DRAFT; R1-135763, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. San Francisco, USA; 20131111 - 20131115 13 November 2013 (2013-11-13), XP050735408, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN/RAN1/Docs/ [retrieved on 2013-11-13]	1,23-27
A	Section 2.1 Section 2.5 -----	2-22
X	NTT DOCOMO: "Discussion on Multi-level PRACH Coverage Enhancement", 3GPP DRAFT; R1-135509 PRACH_COVERAGE, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. San Francisco, USA; 20131111 - 20131115 13 November 2013 (2013-11-13), XP050735182, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN/RAN1/Docs/ [retrieved on 2013-11-13]	1,23-27
A	Section 5 -----	2-22

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2014/074456

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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Form PCT/ISA/210 (patent family annex) (April 2005)

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H04L 27/26 (2006.01) *H04W 84/00* (2009.01)

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PCT/US2015/000466

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26 December 2015 (26.12.2015)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/203,301 10 August 2015 (10.08.2015) US

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(74) Agent: **OLSON, Jared**; Ledell Ansari, LLP, c/o Cpa Global, P.O. Box 52050, Minneapolis, MN 55402 (US).

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(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

(54) **Title**: ENHANCED PHYSICAL SIGNAL STRUCTURE FOR LTE V2V COMMUNICATIONS

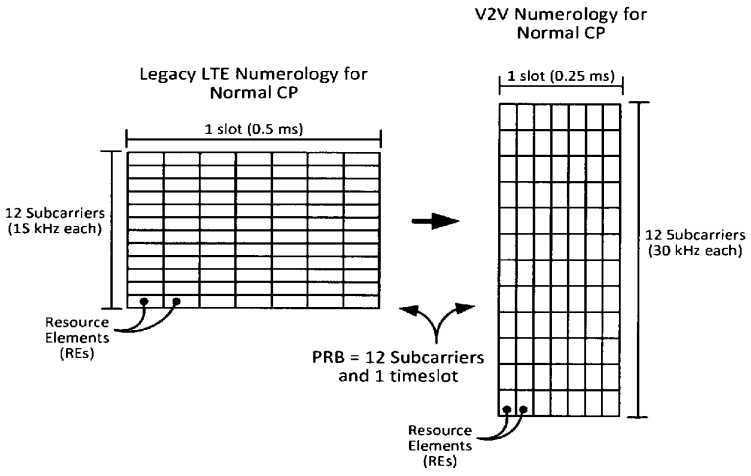


Fig. 4

(57) **Abstract**: A vehicle may wirelessly communicate with another vehicle via a physical channel (a vehicle-to-vehicle (V2V) channel) that is robust and reliable under high mobility propagation conditions. The physical channel may be created by modifying an existing long-term evolution (LTE) physical channel, such as an LTE sidelink (SL) channel. For instance, the V2V physical channel may be created by increasing, by a particular factor, the subcarrier spacing of legacy LTE channels (e.g., from 15 kilohertz (kHz) to 30 kHz). Additionally, a symbol duration and a fast Fourier transform (FFT) size for the V2V physical channel may each be reduced by the same factor. Doing so may enable the V2V physical channel to be implemented without significant modifications to other aspects of the LTE standard.

WO 2017/026983 A1

ENHANCED PHYSICAL SIGNAL STRUCTURE FOR LTE V2V COMMUNICATIONS

RELATED APPLICATIONS

The present application claims the benefit of U.S. Provisional Patent Application No. 62/203,301, which was filed on August 10, 2015, the contents of which are hereby incorporated by reference as though fully set forth herein.

BACKGROUND

The so-called "connected car concept" includes the idea that vehicles may be enabled to communicate wirelessly with one another. The 3GPP (3rd Generation Partnership Project) Long Term Evolution (LTE) communications standard has been proposed as the communication standard for implementing the connected car concept (also referred to as vehicle-to-vehicle (V2V) communications). V2V communications include one vehicle establishing a direct connection with one or multiple other vehicles.

Examples of such connections may include an LTE sidelink connection (also referred as direct connection, a proximity services (ProSe) connection, a device-to-device (D2D) connection, etc.). Once connected, vehicles may communicate a variety of information to each other, such as location information, velocity information, acceleration information, directional information, performance information, and more. Such information may be used to provide a variety of functionalities, such as preventing car accidents, determining driving conditions (e.g., traffic jams, icy roads, car accidents, etc.), determining optimal routes for driving from one location to another, etc.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments described herein will be readily understood by the following detailed description in conjunction with the accompanying drawings. To facilitate this description, like reference numerals may designate like structural elements. Embodiments are illustrated by way of example and not by way of limitation in the figures of the accompanying drawings.

Fig. 1 is a diagram of an example environment in which systems and/or methods described herein may be implemented;

Fig. 2 is a diagram illustrating an example process for sending information to another vehicle;

Fig. 3 is a diagram illustrating an example process for receiving information from another vehicle;

Fig. 4 is a diagram of an example physical resource block (PRB) of a legacy long term evolution (LTE) numerology and an example PRB of a vehicle-to-vehicle (V2V) numerology, under normal cyclic prefix (CP) conditions;

Fig. 5 is a diagram of an example PRB of a legacy LTE numerology and an example PRB of a V2V numerology, under extended CP conditions;

Fig. 6 is a diagram of example PRB pairs of a legacy LTE numerology and example PRB pairs of a V2V numerology, under normal CP conditions;

Fig. 7 is a diagram of example PRB pairs of a legacy LTE numerology and PRB pairs of a V2V numerology, under extended CP conditions;

Figs. 8A-8D are diagrams of example PRBs according to one or more embodiments described herein;

Figs. 9A-9D are diagrams of example PRBs according to one or more embodiments described herein;

Fig. 10 is a table of example characteristics of a legacy LTE numerology and a V2V numerology with 30 kilohertz (kHz) subcarrier spacing;

Fig. 11 is a table of example characteristics of a legacy LTE numerology and a V2V numerology with 60 kHz subcarrier spacing;

Fig. 12 is a table representing an example of legacy LTE and V2V transmission multiplexing; and

Fig. 13 illustrates, for one embodiment, example components of an electronic device.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The following detailed description refers to the accompanying drawings. The same reference numbers in different drawings may identify the same or similar elements. It is to be understood that other embodiments may be utilized and structural or logical changes may be made without departing from the scope of the present disclosure. Therefore, the following detailed description is not to be taken in a limiting sense, and the scope of embodiments defined by the appended claims and their equivalents.

As mentioned above, the 3GPP (3rd Generation Partnership Project) Long Term Evolution (LTE) communications standard has been proposed as the communication standard for vehicle-to-vehicle (V2V) communications. One reason behind the proposal is the reliability and high data rate capabilities of LTE technology. However, the current LTE standard includes

certain limitations when it comes to enabling vehicles to communicate with one another directly. For example, legacy LTE sidelink (SL) physical channels (also referred to as PC5 channels or device-to-device (D2D) channels) are considered to be used or enable V2V communications. At the same time, the legacy SL physical channels were designed with an assumption of substantially lower mobility conditions than the ones considered to be used for V2V communication (e.g., a scenario in which two vehicles are driving toward one another at 140 kilometers per hour (km/h) each). As a result, when subjected to wireless propagation in high mobility conditions (that may cause high Doppler fading and/or frequency shifts), legacy LTE physical channels may experience an unacceptably high block error rate (BLER) performance and/or use an unacceptably high signal-to-interference-noise ratio (SINR) to achieve reliable performance for V2V wireless communication.

Techniques described herein may be used to provide a physical channel (referred to herein as "V2V physical channel") of greater robustness and reliability when subjected to the high mobility conditions of V2V communications. For example, a V2V physical channel may have increased subcarrier spacing (e.g., 30 kilohertz (kHz) subcarriers) instead of the 15 kHz subcarrier spacing used in legacy LTE SL physical channels. The increased subcarrier spacing may improve physical channel robustness (particularly under high mobility wireless propagation effects) via a reduction of the impacts of frequency offset errors on the subcarriers orthogonality, reduced channel variations on the packet transmission duration, etc.

In some embodiments, the V2V physical channel may include additional alterations from current LTE SL physical channels. For example, the V2V physical channel may include a reduced symbol duration (e.g., a single-carrier frequency-division multiple access (SC-FDMA) symbol duration, etc.). The decrease in symbol duration may be proportional to the increased subcarrier spacing. For instance, if the subcarrier spacing of the V2V physical channel is twice as large as subcarrier spacing of a legacy LTE SL physical channel (e.g., 30 kHz instead of 15 kHz), the symbol duration for the V2V physical channel may be halved. Additionally, the decrease in symbol duration may be accompanied by a similar decrease (e.g., half) to a fast Fourier transform (FTT) size.

Additionally, since LTE air interfaces currently implement physical resource blocks (PRBs) as a fundamental unit of allocation for air interface resources, the techniques described herein may include one or more PRB formats for implementing the enhancements described above regarding modified subcarrier spacing and symbol duration of the V2V physical channels. For instance, a PRB of the V2V physical channel may

include time-domain changes, such as a change in the duration of each PRB and/or the number of slots per PRB. Similarly, a PRB of the V2V channel may include frequency-domain changes, such as the number of subcarriers per PRB, the PRB size in terms of frequency, etc. PRB formats may be discussed herein in terms of numerologies (e.g., legacy LTE numerologies and V2V numerologies), which may include a representation of subcarriers, slot durations, and resource elements (REs) of a PRB or PRB pair.

In some embodiments, the techniques described herein may be implemented within the context of cyclic prefixing (CP). For example, in the 3GPP LTE communication standard, CP may include copying a portion of one symbol (e.g., an end portion of the symbol) and adding the copied portion to a beginning portion of the symbol, such that the symbol begins and ends with the same portion. Doing so may, for example, reduce inter-symbol interference.

Fig. 1 is a diagram of an example environment 100 in which systems and/or methods described herein may be implemented. Environment 100 may include one or more vehicles with vehicle-to-X (V2X) devices 110, user equipment devices (UEs) 120, and network 130.

V2X device 110 may include a computing and communication device installed in a vehicle, such as a car, a truck, a sports utility vehicle (SUV), etc. V2X device 110 may be capable of gathering, processing, and communicating information regarding the vehicle in which V2X device 110 is installed. Examples of such information may include vehicle performance information, vehicle location information, vehicle usage information, vehicle status information, vehicle diagnostic information, etc. In some embodiments, V2X device 110 may be capable over gathering, processing, and communicating other types of information, such as information relating to a driver or passenger of the vehicle. V2X device 110 may be an example of user equipment device (UE) or another type of end terminal.

As shown, V2X device 110 may be capable of communicating with one or more networks or devices, such as UE 120, the V2X device of another vehicle, network 130, etc. In some embodiments, V2X device 110 may do so by establishing a connection that is based on a particular communications standard, such as the 3GPP LTE communication standard. For instance, V2X device 110 may establish a vehicle-to-pedestrian (V2P) connection with UE 120, which may include a D2D connection, an LTE SL connection, or other type of direct connection. V2X device 110 may also, or alternatively, establish a vehicle-to-infrastructure/network (V2I) connection with network 130. The V2I connection may include a standard connection with a base station (e.g., an evolved Node B (eNB)), a wireless access point (AP), or another device capable of enabling V2X device 110 to communicate with network 130.

As such, the "X" in "V2X device," may represent an ability of V2X device 110 to communicate with one or more types of devices (e.g., other V2X devices, UEs 120, a base station, a network access point (AP), etc.).

Additionally, or alternatively, V2X device 110 may establish a V2V connection with the V2X device of another vehicle. The V2V connection may include a D2D connection, an LTE SL connection, or other type of direct connection between UEs (e.g., a connection that does not, for example, include network 130). In some embodiments, V2X device 110 may be capable of communicating with other V2X devices using one or more of the techniques described herein. For example, V2X device 110 may be capable of using a V2V physical channel that ensure improved robustness and reliability when subjected to the high mobility conditions of V2V communications. The V2V physical channel may, for example, include greater subcarrier spacing and reduced symbol durations to, for example, improve demodulation performance including BLER reduction but still operating within the framework of an established communications standard (such as the 3GPP LTE communications standard).

UE 120 may include a portable computing and communication device, such as a personal digital assistant (PDA), a smart phone, a cellular phone, a laptop computer with connectivity to a cellular wireless network, a tablet computer, etc. UE 120 may also include non-portable computing devices, such as a desktop computer, a consumer or business appliance, or other devices that have the ability to connect to network 130. UE 120 may also include a computing and communication device that may be worn by a user (also referred to as wearable devices) as a watch, a fitness band, a necklace, glasses, an eyeglass, a ring, a belt, a headset, or another type of wearable device. As shown, UE 120 may establish a direct connection (e.g., a D2D connection) with V2X device 110. Additionally, UE 120 may communicate with V2X device 110 regarding the vehicle of V2X device 110, a driver or passenger of the vehicle, a user of UE 120, a location of the vehicle with respect to the user of UE 120, etc.

Network 130 may include one or more wired and/or wireless networks. For example, network 130 may include an LTE network. In some embodiments, network 130 may include one or more additional networks, such as a cellular network (e.g., a second generation (2G) network, a third generation (3G) network, a fourth generation (4G) network, a fifth generation (5G) network, a global system for mobile (GSM) network, a code division multiple access (CDMA) network, an evolution-data optimized (EVDO) network, or the like), a public land mobile network (PLMN), and/or another network. Additionally, or alternatively, network 150 may include a local area network (LAN), a wireless LAN (WLAN), a wide area network (WAN), a metropolitan network (MAN), the Public Switched Telephone Network (PSTN), an

ad hoc network, a managed IP network, a virtual private network (VPN), an intranet, the Internet, a fiber optic-based network, and/or a combination of these or other types of networks.

The quantity of devices and/or networks, illustrated in Fig. 1, is provided for explanatory purposes only. In practice, there may be additional devices and/or networks; fewer devices and/or networks; different devices and/or networks; or differently arranged devices and/or networks than illustrated in Fig. 1. Alternatively, or additionally, one or more of the devices of environment 100 may perform one or more functions described as being performed by another one or more of the devices of system 100. Furthermore, while "direct" connections are shown in Fig. 1, these connections should be interpreted as logical communication pathways, and in practice, one or more intervening devices (e.g., routers, gateways, modems, switches, hubs, etc.) may be present.

Additionally, while some of the techniques described herein may involve V2V communications as an example, the techniques described herein may be applied to various scenarios and/or other types of communications. For example, techniques described herein may be applicable to time division duplexing (TDD) or frequency division duplexing (FDD) communications. In some embodiments, techniques described herein may be applied to all of downlink (DL), uplink (UL), and sidelink (SL) communications, while other embodiments may only apply the techniques described herein to DL or UL or SL communications. Additionally, while the techniques described herein may be described within the context of the 3GPP LTE communications standard, the techniques may also be applied to other communication standards. Additionally, while examples provided herein may include enabling vehicles to communicate with one another more reliably, the techniques described herein may be applied to other scenarios as well (such as another system or device that may experience significant Doppler fading conditions when attempting to communicate wirelessly).

Fig. 2 is a diagram illustrating an example process 200 for sending information to another vehicle. Process 200 may be particularly appropriate for devices capable of wireless communications that may be subjected to high mobility propagation conditions (e.g., wireless propagation in high mobility conditions characterized by high Doppler fading and/or frequency shifts that may jeopardize the integrity or reliability of the wireless communications). Process 200 may be implemented by, for example, V2X device 110. Additionally, process 200 provides an example of how a V2V physical channel may be used; however, it should be noted that the V2V physical channel, as described herein, may

be used in additional and alternative ways, which may include fewer, additional, and/or alternative operations than the operations described below with reference to Fig. 2.

As shown, process 200 may include identifying a physical channel that is appropriate for communicating with another vehicle (block 210). For example, in some embodiments, V2X device 110 may be capable of using multiple physical channels for communicating with another vehicle. As described above, examples of such channels may include an LTE SL physical channel, a V2V physical channel (as described herein), etc. In some embodiments, V2X device 110 may identify the appropriate physical channel based on one or more factors.

Examples of such factors may include whether the physical channel will likely be subjected to high mobility propagation conditions. For instance, if the vehicle of the V2X device 110 and/or the other vehicle are traveling at a high speed, V2X device 110 may determine that communications between the vehicles are likely to be subjected to such conditions. As such, a V2V physical channel (as opposed to, for example, a legacy LTE SL channel) may be appropriate for communicating with the other vehicle.

Another example of a factor that may be considered by V2X device 110 may include the communication capabilities of the other vehicle. For example, V2X device 110 may determine the types of physical channels that the other vehicle is capable of using and select the most appropriate physical channel from on the physical channels that the other vehicle is capable of using. In some embodiments, determining the communication capabilities of the other vehicle may include determining what type of communications device is being implemented by the other vehicle (e.g., a V2X device or another type of communications device).

Additional examples of factors that may be used to identify an appropriate physical channel may include physical channel availability (e.g., whether V2X device is already using one or more physical channels), a measure of importance regarding the information (or type of information) that is to be sent to the other vehicle (e.g., less important information may be allocated with less reliable physical channels), a measure of importance of other information that is to communicated to a different vehicle, etc. In yet another example, V2X device may implement one or more rules for prioritizing which type of physical channel (e.g., an LTE SL channel, a V2V physical channel, etc.) should be implemented in light of one or more of the factors described above.

Process 200 may include generating information to communicate to the vehicle (block 220). For example, V2X device 110 may generate the information that is to be

transmitted to the other vehicle. Examples of such information may include vehicle performance information, vehicle location information, vehicle usage information, vehicle status information, vehicle diagnostic information, information relating to a driver or passenger of the vehicle, etc.

Process 200 may include processing the information based on the physical channel identified for communicating with the other vehicle (block 230). For example, V2X device 110 may arrange the information in accordance with a particular PRB format, which may be particular to the type of physical channel identified as the suitable for communicating with the other vehicle. For instance, if the identified physical channel corresponds to a currently available physical channel (such as an LTE LS physical channel), the information may be allocated to accommodate a format where a PRB includes 12 subcarriers (also referred to herein as frequency REs) with 15 kHz subcarrier spacing and 1 slot of 0.5 ms duration in time. However, if the identified physical channel corresponds to a V2V physical channel, the information may be allocated to accommodate a format where a PRB includes 12 subcarriers with 30 kHz subcarrier spacing and 1 slot of 0.25 ms duration in time. Alternatively, for V2V physical channel, the information may be allocated to accommodate a format where a PRB includes 12 subcarriers with 60 kHz subcarrier spacing and 1 slot of 0.125 ms duration in time. Additional examples of PRB formats are discussed below with reference to Figs. 4-9.

Process 200 may include using the physical channel to communicate information to vehicle (block 240). For example, V2X device 110 may use the physical channel identified as being appropriate for communicating with the vehicle to transmit the information to the vehicle. As described above, the physical channel may include a legacy channel (such as an LTE SL channel) or a V2V physical channel, and the information may be formatted in accordance with a format (e.g., a PRB format) that is particular to the physical channel used to transmit the information.

Fig. 3 is a diagram illustrating an example process 300 for receiving information from another vehicle. Process 300 may be particularly appropriate for devices capable of wireless communications that may be subjected to high mobility conditions (e.g., that may cause high Doppler fading and/or frequency shifts) during V2V communications. Process 300 may be implemented by, for example, V2X device 110.

As shown, process 300 may include receiving information from another vehicle via a physical channel (block 310). For example, V2X device 110 may be capable of using physical channels for communicating with another vehicle. As described above, examples

of such channels may include an LTE SL channel, a V2V physical channel, etc. The information sent and received between vehicles may include vehicle performance information, vehicle location information, vehicle usage information, vehicle status information, vehicle diagnostic information, information relating to a driver or passenger of the vehicle, etc.

Process 300 may include determining a physical channel type corresponding to the physical channel (block 320). For example, V2X device 110 may identify the type of physical channel (e.g., an LTE SL channel, a V2V channel, etc.) used to receive the information. In some embodiments, V2X device 110 may determine the manner in which the information is arranged in the physical channel based on the physical channel type may include. For example, if the physical channel corresponds to an LTE SL physical channel, the information may be formatted into PRBs that include 12 subcarriers with 15 kHz subcarrier spacing and 1 slot of 0.5 ms duration in time. In another example, if the physical channel corresponds to a V2V physical channel, the information may be formatted into PRBs that include 12 subcarriers with 30 kHz subcarrier spacing and 1 slot of 0.25 ms duration in time. Alternatively, for a V2V physical channel, the information may be allocated to accommodate a format where a PRB includes 12 subcarriers with 60 kHz subcarrier spacing and 1 slot of 0.125 ms duration in time. Additional examples of PRB formats are discussed below with reference to Figs. 4-9.

Process 300 may include interpreting the information based on the physical channel type of the physical channel (block 330). For example, V2X device 110 may interpret the information, received from another vehicle, based on a type of physical channel used to communicate the information. For instance, if the physical channel corresponds to an LTE LS physical channel, the information may be interpreted based on the assumption that the information was formatted into PRBs that include 12 subcarriers with 15 kHz subcarrier spacing and 1 slot of 0.5 ms duration in time. By contrast, if the physical channel corresponds to a V2V physical channel, the information may be interpreted based on the assumption that the information was formatted into PRBs that include 12 subcarriers with 30 kHz subcarrier spacing and 1 slot of 0.25 ms duration in time. Alternatively, for V2V physical channel, the information may be interpreted based on the assumption that the information was formatted into PRBs that include 12 subcarriers with 60 kHz subcarrier spacing and 1 slot of 0.125 ms duration in time.

Fig. 4 is a diagram of an example PRB of a legacy LTE numerology and an example PRB of a V2V numerology, under normal CP conditions. The legacy LTE numerology may correspond to a legacy LTE physical channel (e.g., an LTE SL channel), while the V2V

numerology may correspond to a V2V physical channel. A numerology, as discussed herein, may include parameters and characteristics of a physical channel (e.g., a legacy LTE SL channel or a V2V physical channel).

Such parameters and characteristics may include a bandwidth supported by the physical channel, a number of subcarriers per channel, a subcarrier spacing, a fast Fourier transform (FFT) size, a symbol duration, a slot duration, a subframe duration. Additional examples of numerological parameters and characteristics may include a direct, or indirect, description of a PRB and/or PRB pair of the physical channel, such as a number of subcarriers per PRB, a PRB duration (e.g., a number of slots per PRB), a number of resource elements (REs) per PRB, a number of symbols per PRB, etc.

Additionally, in the 3GPP LTE communication standard, CP may include copying a small portion of one symbol (e.g., an end portion of the symbol) and adding the copied portion to a beginning portion of the symbol, such that the symbol begins and ends with the same portion. Normal CP (as depicted in Figs. 4 and 6) may be implemented for wireless communications over shorter distances, while extended CP (as depicted in Figs. 5 and 7) may be implemented for wireless communications over longer distances. As such, normal CP may include a PRB of more symbols (or REs) per slot in time domain (e.g., 7), while extended CP may include a PRB of fewer symbols (or REs) per slot in time domain (e.g., 6).

As shown in Fig. 4, a PRB of the legacy LTE numerology for normal CP may include 12 subcarriers with 15 kHz subcarrier spacing, a slot of 0.5 ms in time domain comprising 7 consecutive symbols, and 84 REs in total. By contrast, the PRB of the V2V numerology for normal CP may include 12 subcarriers with 30 kHz subcarrier spacing, 1 slot of 0.25 ms in the time domain, comprising 7 consecutive symbols, and 84 REs in total. As such, each subcarrier of a V2V physical channel PRB may have twice as much subcarrier spacing as the subcarriers of the legacy LTE channel PRB; however, the duration of the slot of the V2V physical channel may be half the duration of the slot of the legacy LTE physical channel. As mentioned above, the decrease in slot duration may be accompanied by a similar decrease (e.g., a factor of 2, 4, etc.) to the FTT size associated with the V2V physical channel. Doing so may help ensure that the sampling time and/or sampling frequency of the V2V physical channel remains the same as the sampling time and sampling frequency of the legacy LTE channel.

For example, sampling time, as described herein, may include the basic time unit for the corresponding physical channel. For instance, in the 3GPP LTE communication standard, sampling time may be represented by "Ts" and may be equal to 1/(subcarrier spacing x FFT

size) (e.g., 1/(1500Hz x 2048)). By contrast, sampling frequency, as described herein, may include the basic frequency unit for a particular physical channel. For example, in the 3GPP LTE communication standard, sampling frequency may be represented by "Fs" and may be equal to subcarrier spacing (e.g., 15 kHz) multiplied by the number of FFT time samples (e.g., 2048).

As described above, a V2V channel may have increased subcarrier spacing (e.g., 30 kHz or 60 kHz instead of 15 kHz) but still be implemented within the LTE framework since decreasing symbol duration and FFT size proportionally may help ensure that sampling frequency and sampling time for the V2V channel are the same as the sampling frequency and sampling time of legacy LTE channels (e.g., an LTE SL channel). For example, since sampling time is equal to the inverse of subcarrier spacing multiplied by the corresponding FFT size, increasing the subcarrier spacing by a factor of two (e.g., from 15 kHz to 30 kHz) or four (e.g., from 15 kHz to 60 kHz) does not change the sampling time so long as the FFT size is reduced by the same factor (e.g., from 2048 to 1024 for factor of two or from 2048 to 512 for factor of four). The same can be said for sampling frequency since sampling frequency may be equal to subcarrier spacing multiplied by the corresponding FFT size. As such, the arrow depicted in Fig. 4 may represent that the techniques described herein may enable legacy LTE channels to be modified (or replaced) by V2V channels (which may be more robust and reliable in high mobility conditions (e.g., that may cause high Doppler fading and/or frequency shifts)) without affecting other aspects of the LTE communications standard.

For example, in some embodiments, the duration for a single subframe of a V2V channel may be set to 0.5 ms, such that the subframe may include 2 slots at 0.25 ms each. In such an implementation, relatively few (if any) modifications to the 3GPP LTE communication standard may implement the V2V channel since, for example, legacy LTE channels also include 2 slots per subframe. In other embodiments, the duration for a single subframe of the V2V channel may be set to 1.0 ms (for example), which may result in a subframe including 4 slots at 0.25 ms each. In such embodiments, certain modifications to the 3GPP LTE communications standard may be beneficial, such as modifications to the size of transport blocks, the transport block sizes (TBS) tables, etc.

Fig. 5 is a diagram of an example PRB of a legacy LTE numerology and an example PRB of a V2V numerology, under extended CP conditions. The legacy LTE numerology may correspond to a legacy LTE channel (e.g., an LTE SL channel), while the V2V numerology may correspond to a V2V channel. As shown, a PRB of the legacy LTE numerology for extended CP may include 12 subcarriers of 15 kHz each, a slot of 0.5 ms, and 72 REs (6 symbols or (REs)

per slot). By contrast, the PRB of the V2V numerology for normal CP may include 12 subcarriers of 30 kHz each, 1 slot of 0.25 ms, and 84 REs. As such, each subcarrier of a V2V channel PRB may include twice as much bandwidth as the subcarriers of the legacy LTE channel PRB; however, the slot of the V2V channel PRB may be half the duration of the slot of the legacy LTE channel PRB. As mentioned above, the decrease in slot duration may be accompanied by a similar decrease (e.g., a factor of 2, 4, etc.) to the FTT size associated with the V2V channel. The sampling frequency of the V2V channel may remain the same as the sampling frequency of the legacy LTE channel. As such, the arrow depicted in Fig. 5 may represent that the techniques described herein may enable legacy LTE channels to be modified (or replaced) by V2V channels (which may be more robust and reliable in high mobility conditions) without affecting other aspects of the LTE communications standard.

Fig. 6 is a diagram of example PRB pairs of a legacy LTE numerology and example PRB pairs of a V2V numerology, under normal CP conditions. As shown, the legacy LTE numerology and the V2V numerology may each include 4 PRBs, PRB 6.1 through PRB 6.4 and PRB 6.5 through 6.8, respectively. Each PRB of the legacy LTE numerology, and each PRB of the V2V numerology, may be similar to the corresponding PRBs discussed above with reference to Fig. 4. Additionally, the PRBs of Fig. 6 may corresponds to normal CP conditions since the PRB format includes 7 symbols (or REs) for each slot.

In the legacy LTE numerology, the PRB pairs may be differentiated from one another in the frequency domain, such that PRB 6.1 and PRB 6.2 include one pair (e.g., a 1st PRB pair) and PRB 6.3 and PRB 6.4 are another pair (e.g., a 2nd PRB pair). By contrast, in V2V numerology, the PRB pairs may be differentiated from one another in the time domain, such that PRB 6.5 and PRB 6.6 include one pair (e.g., a 1st PRB pair) and PRB 6.7 and PRB 6.8 are another pair (e.g., a 2nd PRB pair). Similar to the arrows in Fig. 4 and Fig. 5, the arrow depicted in Fig. 6 may represent that the techniques described herein may enable legacy LTE channels to be modified (or replaced) by V2V channels affecting other aspects of the LTE communications standard.

Fig. 7 is a diagram of example PRB pairs of a legacy LTE numerology and PRB pairs of a V2V numerology, under extended CP conditions. As shown, the legacy LTE numerology and the V2V numerology may each include 4 PRBs, PRB 7.1 through PRB 7.4 and PRB 7.5 through 7.8, respectively. Each PRB of the legacy LTE numerology, and each PRB of the V2V numerology, may be similar to the corresponding PRBs discussed above with reference to Fig. 5. Additionally, the PRBs of Fig. 7 may correspond to extended CP conditions since the PRB format includes 6 symbols (or REs) for each slot.

In the legacy LTE numerology, the PRB pairs may be differentiated from one another in the frequency domain, such that PRB 7.1 and PRB 7.2 include one pair (e.g., a 1st PRB pair) and PRB 6.3 and PRB 6.4 are another pair (e.g., a 2nd PRB pair). By contrast, in V2V numerology, the PRB pairs may be differentiated from one another in the time domain, such that PRB 7.5 and PRB 7.6 include one pair (e.g., a 1st PRB pair) and PRB 7.7 and PRB 7.8 are another pair (e.g., a 2nd PRB pair). Similar to the arrow in Fig. 6, the arrow depicted in Fig. 7 may represent that the techniques described herein may enable legacy LTE channels to be modified (or replaced) by V2V channels affecting other aspects of the LTE communications standard.

Figs. 8A-8D are diagrams of example PRBs according to one or more embodiments described herein. Additionally, the PRBs of Figs. 8A-8D may corresponds to normal CP conditions since each PRB includes 7 symbols per slot in time domain. The example PRB of Fig. 8A may correspond to the V2V channel PRB described above with reference to Fig. 4. The example PRBs of Fig. 8B may include a PRB pair (PRB 8.1 and PRB 8.2), similar to the V2V channel PRB pairs described above with reference to Fig. 5. Fig. 8C may include an example PRB that is similar to the PRB of Fig. 8A, except that the example PRB of Fig. 8C includes only 6 subcarriers (also, "REs in frequency" or "Frequency REs") of 30 kHz each. Similarly, Fig. 8D may include an example PRB pair (PRB 8.3 and PRB 8.4) that is similar to the PRB pair of Fig. 9B, except that the example PRBs of Fig. 8D include only 6 subcarriers with 30 kHz subcarrier spacing. In some embodiments, reducing the number of subcarriers per V2V channel may increase the number of transmission channels that may be used for V2V communications, which may in turn increase V2V system capacity (e.g., in a location with a high number of vehicles, such as a traffic jam on a freeway or major intersection).

Figs. 9A-9D are diagrams of example PRBs according to one or more embodiments described herein. Additionally, the PRBs of Figs. 9A-9D may correspond to extended CP conditions since each PRB includes 6 symbols per slot. The example PRB of Fig. 9A may correspond to the V2V channel PRB described above with reference to Fig. 5. The example PRBs of Fig. 9B may include a PRB pair (PRB 9.1 and PRB 9.2), similar to the V2V channel PRB pairs described above with reference to Fig. 5. Fig. 9C may include an example PRB that is similar to the PRB of Fig. 9A, except that the example PRB of Fig. 9C includes only 6 subcarriers (also, "REs in frequency" or "Frequency REs") of 30 kHz each. Similarly, Fig. 9D may include an example PRB pair (PRB 9.3 and PRB 9.4) that is similar to the PRB pair of Fig. 9B, except that the example PRBs of Fig. 9D include only 6 (instead of 12) subcarriers of 30 kHz each. As described above with reference to Figs. 8A-8D, in some embodiments, reducing

the number of subcarriers per V2V channel may increase the number of transmission channels that may be used for V2V communications, which may in turn increase the level of V2V system capacity (e.g., in a location with a high number of vehicles, such as a traffic jam on a freeway or major intersection).

Fig. 10 is a table of example characteristics of a legacy LTE numerology and a V2V numerology with 30 kHz subcarrier spacing. As shown, the table of Fig. 10 includes a Channel Characteristics column, a Legacy LTE Channel Numerology column, and a V2V Channel numerology column. Fig. 10 provides a non-limiting example of differences and similarities that may exists between a legacy LTE channel and a V2V channel.

For example, a legacy LTE channel may include a subcarrier spacing of 15 kHz, while a V2V channel may include a subcarrier spacing of 30 kHz. Both channels may support the same bandwidths; however, the channels may only support some of the same FTT sizes. For instance, only the legacy LTE channel may use FTT sizes of 1536 and 2048, and the V2V channel may use FTT sizes of 64 and 768. As such, the FFT size for the legacy LTE channel may include a lower limit of 128 for the 1.4 MHz bandwidth and an upper limit of 2048 for 20 MHz bandwidth, while the FFT size for the V2V channel (with 30 kHz subcarrier spacing), may include a lower limit of 64 for 1.4 MHz bandwidth and an upper limit of 1024 for the 20 MHz bandwidth. As described above, this is due to reducing the FTT sizes for the V2V channel by the same factor (e.g., "2") that was used to increase the subcarrier spacing of the V2V channel. The following table may represent a logical relationship between different BWs, legacy LTE FFT sizes, and V2V channel FFT sizes (when the subcarrier spacing for the V2V channel is 30 kHz).

Bandwidth (BW)	Nominal FFT Size	
	Legacy LTE Channel	V2V Channel with 30 kHz
1.4 MHz	128	64
3 MHz	256	128
5 MHz	512	256
10 MHz	1024	512
15 MHz	1536	768
20 MHz	2048	1024

Since the same factor was used to increase and decrease the subcarrier spacing and FFT size (respectively), both channels may have the same sampling time (Ts) of 32.55 nanoseconds

(ns) because sampling time may be calculated by taking the inverse of the product of the subcarrier spacing and the FFT size (e.g., Ts = 1/(subcarrier spacing x FFT size). In some embodiments, for similar reasons, both channels may also have the same sampling frequency (Fs) (e.g., Fs = subcarrier spacing x FFT size). As mentioned above, maintaining the same sampling time and sampling frequency as the legacy LTE channel may help ensure that the V2V channel can be implemented in an LTE environment without having to make significant adjustments to other aspects of the 3GPP LTE communication standard.

Similar to the change in FFT size, the symbol durations for the V2V channel may also be reduced by the same factor (e.g., "2") that was used to increase the subcarrier spacing of the V2V channel. As shown in Figs. 6-7, this may enable PRBs and PRB pairs to be formatted in a manner that enables the V2V channel to reduce the slot duration by half (e.g., from 0.5 ms to 0.25 ms) and output PRBs at the same rate as the legacy LTE channel, even though the subcarrier spacing for the V2V channel was doubled. Similar to maintaining the same sampling time and sampling frequency, maintaining a similar output rate as the legacy LTE channel, may help reduce the impact of the V2V channel on other aspects of the 3GPP LTE communication standard.

Additionally, the single subframe duration for the legacy LTE channel may be 1.0 ms, whereas the single subframe duration for the V2V channel may be 0.5 or 1.0 ms. A single subframe duration of 0.5 ms may enable the V2V channel to have two slots per subframe since the slot duration for the V2V channel was reduced to 0.25 ms. Additionally, since a PRB duration may be 0.25 ms (which corresponds to 1 slot), a 0.5 ms subframe may consist of one PRB pair (i.e., two 0.25 ms PRBs). In other words, the V2V channel may have a subframe-to-PRB-pair ratio of 1:1 when the subframe duration of the V2V channel is 0.5 ms, which may reduce the impact of the V2V channel on the 3GPP LTE communication standard since, for example, the legacy LTE channel also has a subframe-to-PRB-pair ratio of 1:1.

By contrast, a single subframe duration of 1.0 ms may enable the V2V channel to have four slots per subframe since the slot duration for the V2V channel was reduced to 0.25 ms. As such, the subframe may include four slots. In other words, a subframe duration of 1.0 ms, as opposed to the 0.5 ms subframe scenario above, may give rise to a relative increase in the amount of information that may be communicated in one subframe. As a result, implementing a 1.0 ms subframe may additional modifications to the 3GPP LTE communication standard, including changes to the design of physical channels, such as modifications to the size of transport blocks, the transport block sizes (TBS) tables, etc.

As shown in Fig. 10, whether the legacy LTE channel and the V2V channel have the same number of subcarriers per PRB may depend on the scenario or embodiment. For example, both channels may have 12 subcarriers for each PRB. Additionally, or alternatively, the V2V channel may have 6 subcarriers per PRB. In some embodiments, while allocating 6 subcarriers (instead of 12) to each PRB may decrease the rate at which a channel may transmit data, doing so may also increase the number of V2V channels that are available for V2X devices 110 to communicate with other V2X devices, UEs, etc. As such, allocating 6 subcarriers to each V2V channel may be beneficial in scenarios where V2V channels might not benefit from a high data rate connections and/or a vehicle with a V2X device is in a traffic jam, rush hour traffic, or in another situation involving a lot of V2X devices 110, UEs 110, etc., that within range of one another.

Fig. 11 is a table of example characteristics of a legacy LTE numerology and a V2V numerology with 60 kHz subcarrier spacing. As shown, the table of Fig. 11 includes a Channel Characteristics column, a Legacy LTE Channel Numerology column, and a V2V Channel numerology column. Fig. 11 provides a non-limiting example of differences and similarities that may exists between a legacy LTE channel and a V2V channel.

For example, a legacy LTE channel may include a subcarrier spacing of 15 kHz, while a V2V channel may include a subcarrier spacing of 60 kHz. Both channels may support the same bandwidths; however, the channels may only support some of the same FTT sizes. For instance, only the legacy LTE channel may support FTT sizes of 1024, 1536, and 2048, and only the V2V channel may support an FTT size of 32, 64, and 384. As such, the FFT size for the legacy LTE channel may include a lower limit of 128 and an upper limit of 2048, while the FFT size for the V2V channel (with 60 kHz subcarrier spacing), may include a lower limit of 32 kHz and an upper limit of 512 kHz. This may be due to reducing the FTT sizes for the V2V channel by the same factor (e.g., "4") that was used to increase the subcarrier spacing of the V2V channel. The following table may represent a logical relationship between different BWs, legacy LTE FFT sizes, and V2V channel FFT sizes (when the subcarrier spacing for the V2V channel is 30 kHz).

Bandwidth (BW)	Nominal FFT Size	
	Legacy LTE Channel	V2V Channel with 60 kHz
1.5 MHz	128	32
3 MHz	256	64
5 MHz	512	128
10 MHz	1024	256

15 MHz	1536	384
20 MHz	2048	512

Since the same factor was used to increase and decrease the subcarrier spacing and FFT size (respectively), both channels may have the same sampling time (Ts) of 32.55 nanoseconds (ns) because sampling time may be calculated by taking the inverse of the product of the subcarrier spacing and the FFT size (e.g., Ts = 1/(subcarrier spacing x FFT size). In some embodiments, for similar reasons, both channels may also have the same sampling frequency (Fs) (e.g., Fs = subcarrier spacing x FFT size). As mentioned above, maintaining the same sampling time and sampling frequency as the legacy LTE channel may help ensure that the V2V channel can be implemented in an LTE environment without having to make significant adjustments to other aspects of the 3GPP LTE communication standard.

Similar to the change in FFT size, the symbol durations for the V2V channel may also be reduced by the same factor (e.g., "4") that was used to increase the subcarrier spacing of the V2V channel. This may enable PRBs and PRB pairs to be formatted in a manner that enables the V2V channel to reduce the slot duration by one-fourth (e.g., from 1.0 ms to 0.125 ms) and output PRBs at the same rate as the legacy LTE channel, even though the subcarrier spacing for the V2V channel was quadrupled. Similar to maintaining the same sampling time and sampling frequency, maintaining a similar output rate as the legacy LTE channel, may help reduce the impact of the V2V channel on other aspects of the 3GPP LTE communication standard.

Additionally, the single subframe duration for the legacy LTE channel may be 1.0 ms, whereas the single subframe duration for the V2V channel may be 0.25 or 1.0 ms. A single subframe duration of 0.25 ms may enable the V2V channel to have two slots per subframe since the slot duration for the V2V channel was reduced to 0.125 ms. Additionally, since a PRB duration may be 0.125 ms (which corresponds to 1 slot), a 0.25 ms subframe may consist of one PRB pair (i.e., two 0.125 ms PRBs). In other words, the V2V channel may have a subframe-to-PRB-pair ratio of 1:1 when the subframe duration of the V2V channel is 0.25 ms, which may reduce the impact of the V2V channel on the 3GPP LTE communication standard since, for example, the legacy LTE channel also has a subframe-to-PRB-pair ratio of 1:1.

By contrast, a single subframe duration of 1.0 ms may enable the V2V channel to have eight slots per subframe since the slot duration for the V2V channel was reduced to 0.125 ms. As such, the subframe may include eight slots. In other words, a subframe duration of 1.0 ms, as opposed to the 0.25 ms subframe scenario above, may give rise to a relative increase in the amount of information that may be communicated in one subframe. As a result, implementing a

1.0 ms subframe may additional modifications to the 3GPP LTE communication standard, including changes to the design of physical channels, such as modifications to the size of transport blocks, the transport block sizes (TBS) tables, etc.

As shown in Fig. 11, whether the legacy LTE channel and the V2V channel have the same number of subcarriers per PRB may depend on the scenario or embodiment. For example, both channels may have 12 subcarriers for each PRB. Additionally, or alternatively, the V2V channel may have 3 or 6 subcarriers per PRB. In some embodiments, while allocating 3 or 6 subcarriers (instead of 12) to each PRB may decrease the rate at which a channel may transmit data, doing so may also increase the number of V2V channels that are available for V2X devices 110 to communicate with other V2X devices, UEs, etc. As such, allocating 3 or 6 subcarriers to each V2V channel may be beneficial in scenarios where V2V channels might not benefit from high data rate connections and/or a vehicle with a V2X device is in a traffic jam, rush hour traffic, or in another situation involving a lot of V2X devices 110, UEs 110, etc., that within range of one another.

Fig. 12 is a table representing an example of legacy LTE and V2V transmission multiplexing. As shown, Fig. 12 may include a vertical axis representing frequency and a horizontal axis representing time. V2V devices 110, UEs 110, etc., may support both legacy and V2V PHY numerologies (e.g. for cellular and V2V operation). Time domain multiplexing of legacy and V2V transmissions at one UE 110 may be used for these purposes. To facilitate efficient use of resources the minimum granularity for time domain multiplexing may be a multiple of legacy subframe granularity (e.g., 1.0 ms).

In one example, subframes for legacy LTE and V2V operation may be semi-statically, higher-layer configured, by an eNB (e.g., via radio resource control (RRC) protocol), on a per V2V device basis (or V2V device group basis). Semi-statically may include, for example, physical channels that are predefined by the eNB and assigned to a particular V2V device 210 or UE in a given scenario. In another example, subframes for legacy LTE and V2V operation may be dynamically assigned. In yet another example, subframes for legacy LTE and V2V operation may be specified by a communications standard (such as the 3GPP LTE communication standard).

A V2V transmissions (e.g., transmissions with a V2V numerology) may take place in either TDD or FDD modes. In the latter case, the transmissions may be configured in either a DL or a UL spectrum and can be configured independently (e.g., V2V transmissions on a UL spectrum may not impose use of V2V numerology in a DL spectrum in the same time resources).

In some embodiments, V2V device 110, UE 110, etc., may implement an autonomous selection capability for the numerology for the V2V transmissions (e.g., either a legacy LTE numerology or a V2V numerology) based on one or more instructions, conditions, or other criteria. As such, a V2V receiver (or another type of communication component) may either be informed on the type of the transmission in advance or may dynamically detect the transmission type. In embodiments where the transmission type is dynamically detected, a receiver (or another component of V2V device 110) may attempt to receive information under different hypothesis simultaneously (e.g., attempt to receive a signal under both a 15 kHz subcarrier spacing assumption and a 30 kHz subcarrier spacing assumptions)

As used herein, the term "circuitry" or "processing circuitry" may refer to, be part of, or include an Application Specific Integrated Circuit (ASIC), an electronic circuit, a processor (shared, dedicated, or group), and/or memory (shared, dedicated, or group) that execute one or more software or firmware programs, a combinational logic circuit, and/or other suitable hardware components that provide the described functionality. In some embodiments, the circuitry may be implemented in, or functions associated with the circuitry may be implemented by, one or more software or firmware modules. In some embodiments, circuitry may include logic, at least partially operable in hardware.

Embodiments described herein may be implemented into a system using any suitably configured hardware and/or software. Fig. 13 illustrates, for one embodiment, example components of an electronic device 1300. In embodiments, the electronic device 1300 may be a UE, an eNB, a WLAN AP, or some other appropriate electronic device. In some embodiments, the electronic device 1300 may include application circuitry 1302, baseband circuitry 1304, Radio Frequency (RF) circuitry 1306, front-end module (FEM) circuitry 1308 and one or more antennas 1360, coupled together at least as shown.

The application circuitry 1302 may include one or more application processors. For example, the application circuitry 1302 may include circuitry such as, but not limited to, one or more single-core or multi-core processors. The processor(s) may include any combination of general-purpose processors and dedicated processors (e.g., graphics processors, application processors, etc.). The processors may be coupled with and/or may include memory/storage, such as storage medium 1303, and may be configured to execute instructions stored in the memory/storage to enable various applications and/or operating systems to run on the system. In some implementations, storage medium 1303 may include a non-transitory computer-readable medium. Application circuitry 1302 may, in some embodiments, connect to or include one or more sensors, such as environmental sensors, cameras, etc.

Baseband circuitry 1304 may include circuitry such as, but not limited to, one or more single-core or multi-core processors. The baseband circuitry 1304 may include one or more baseband processors and/or control logic to process baseband signals received from a receive signal path of the RF circuitry 1306 and to generate baseband signals for a transmit signal path of the RF circuitry 1306. Baseband processing circuitry 1304 may interface with the application circuitry 1302 for generation and processing of the baseband signals and for controlling operations of the RF circuitry 1306. For example, in some embodiments, the baseband circuitry 1304 may include a second generation (2G) baseband processor 1304a, third generation (3G) baseband processor 1304b, fourth generation (4G) baseband processor 1304c, and/or other baseband processor(s) 1304d for other existing generations, generations in development or to be developed in the future (e.g., fifth generation (5G), 6G, etc.). The baseband circuitry 1304 (e.g., one or more of baseband processors 1304a-d) may handle various radio control functions that enable communication with one or more radio networks via the RF circuitry 1306. The radio control functions may include, but are not limited to, signal modulation/demodulation, encoding/decoding, radio frequency shifting, etc. In some implementations, baseband circuitry 1304 may be associated with storage medium 1303 or with another storage medium.

In some embodiments, modulation/demodulation circuitry of the baseband circuitry 1304 may include FFT, precoding, and/or constellation mapping/demapping functionality. In some embodiments, encoding/decoding circuitry of the baseband circuitry 1304 may include convolution, tail-biting convolution, turbo, Viterbi, and/or Low Density Parity Check (LDPC) encoder/decoder functionality. Embodiments of modulation/demodulation and encoder/decoder functionality are not limited to these examples and may include other suitable functionality in other embodiments. In some embodiments, the baseband circuitry 1304 may include elements of a protocol stack such as, for example, elements of an evolved universal terrestrial radio access network (E-UTRAN) protocol including, for example, physical (PHY), MAC, radio link control (RLC), packet data convergence protocol (PDCP), and/or radio resource control (RRC) elements. A central processing unit (CPU) 1304e of the baseband circuitry 1304 may be configured to run elements of the protocol stack for signaling of the PHY, MAC, RLC, PDCP and/or RRC layers. In some embodiments, the baseband circuitry may include one or more audio digital signal processor(s) (DSP) 1304f. The audio DSP(s) 1304f may be include elements for compression/decompression and echo cancellation and may include other suitable processing elements in other embodiments.

The baseband circuitry 1304 may further include memory/storage 1304g. The memory/storage 1304g may be used to load and store data and/or instructions for operations

performed by the processors of the baseband circuitry 1304. Memory/storage for one embodiment may include any combination of suitable volatile memory and/or non-volatile memory. The memory/storage 1304g may include any combination of various levels of memory/storage including, but not limited to, read-only memory (ROM) having embedded software instructions (e.g., firmware), random access memory (e.g., dynamic random access memory (DRAM)), cache, buffers, etc. The memory/storage 1304g may be shared among the various processors or dedicated to particular processors.

Components of the baseband circuitry may be suitably combined in a single chip, a single chipset, or disposed on a same circuit board in some embodiments. In some embodiments, some or all of the constituent components of the baseband circuitry 1304 and the application circuitry 1302 may be implemented together such as, for example, on a system on a chip (SOC).

In some embodiments, the baseband circuitry 1304 may provide for communication compatible with one or more radio technologies. For example, in some embodiments, the baseband circuitry 1304 may support communication with an E-UTRAN and/or other wireless metropolitan area networks (WMAN), a WLAN, a wireless personal area network (WPAN). Embodiments in which the baseband circuitry 1304 is configured to support radio communications of more than one wireless protocol may be referred to as multi-mode baseband circuitry.

RF circuitry 1306 may enable communication with wireless networks using modulated electromagnetic radiation through a non-solid medium. In various embodiments, the RF circuitry 1306 may include switches, filters, amplifiers, etc. to facilitate the communication with the wireless network. RF circuitry 1306 may include a receive signal path which may include circuitry to down-convert RF signals received from the FEM circuitry 1308 and provide baseband signals to the baseband circuitry 1304. RF circuitry 1306 may also include a transmit signal path which may include circuitry to up-convert baseband signals provided by the baseband circuitry 1304 and provide RF output signals to the FEM circuitry 1308 for transmission.

In some embodiments, the RF circuitry 1306 may include a receive signal path and a transmit signal path. The receive signal path of the RF circuitry 1306 may include mixer circuitry 1306a, amplifier circuitry 1306b and filter circuitry 1306c. The transmit signal path of the RF circuitry 1306 may include filter circuitry 1306c and mixer circuitry 1306a. RF circuitry 1306 may also include synthesizer circuitry 1306d for synthesizing a frequency for use by the mixer circuitry 1306a of the receive signal path and the transmit signal path. In some

embodiments, the mixer circuitry 1306a of the receive signal path may be configured to down-convert RF signals received from the FEM circuitry 1308 based on the synthesized frequency provided by synthesizer circuitry 1306d. The amplifier circuitry 1306b may be configured to amplify the down-converted signals and the filter circuitry 1306c may be a low-pass filter (LPF) or band-pass filter (BPF) configured to remove unwanted signals from the down-converted signals to generate output baseband signals.

Output baseband signals may be provided to the baseband circuitry 1304 for further processing. In some embodiments, the output baseband signals may be zero-frequency baseband signals. In some embodiments, mixer circuitry 1306a of the receive signal path may comprise passive mixers, although the scope of the embodiments is not limited in this respect.

In some embodiments, the mixer circuitry 1306a of the transmit signal path may be configured to up-convert input baseband signals based on the synthesized frequency provided by the synthesizer circuitry 1306d to generate RF output signals for the FEM circuitry 1308. The baseband signals may be provided by the baseband circuitry 1304 and may be filtered by filter circuitry 1306c. The filter circuitry 1306c may include a low-pass filter (LPF), although the scope of the embodiments is not limited in this respect.

In some embodiments, the mixer circuitry 1306a of the receive signal path and the mixer circuitry 1306a of the transmit signal path may include two or more mixers and may be arranged for quadrature downconversion and/or upconversion respectively. In some embodiments, the mixer circuitry 1306a of the receive signal path and the mixer circuitry 1306a of the transmit signal path may include two or more mixers and may be arranged for image rejection (e.g., Hartley image rejection). In some embodiments, the mixer circuitry 1306a of the receive signal path and the mixer circuitry 1306a may be arranged for direct downconversion and/or direct upconversion, respectively. In some embodiments, the mixer circuitry 1306a of the receive signal path and the mixer circuitry 1306a of the transmit signal path may be configured for super-heterodyne operation.

In some embodiments, the output baseband signals and the input baseband signals may be analog baseband signals, although the scope of the embodiments is not limited in this respect. In some alternate embodiments, the output baseband signals and the input baseband signals may be digital baseband signals. In these alternate embodiments, the RF circuitry 1306 may include analog-to-digital converter (ADC) and digital-to-analog converter (DAC) circuitry and the baseband circuitry 1304 may include a digital baseband interface to communicate with the RF circuitry 1306.

In some dual-mode embodiments, a separate radio IC circuitry may be provided for processing signals for each spectrum, although the scope of the embodiments is not limited in this respect.

In some embodiments, the synthesizer circuitry 1306d may be a fractional-N synthesizer or a fractional N/N+6 synthesizer, although the scope of the embodiments is not limited in this respect as other types of frequency synthesizers may be suitable. For example, synthesizer circuitry 1306d may be a delta-sigma synthesizer, a frequency multiplier, or a synthesizer comprising a phase-locked loop with a frequency divider.

The synthesizer circuitry 1306d may be configured to synthesize an output frequency for use by the mixer circuitry 1306a of the RF circuitry 1306 based on a frequency input and a divider control input. In some embodiments, the synthesizer circuitry 1306d may be a fractional N/N+6 synthesizer.

In some embodiments, frequency input may be provided by a voltage controlled oscillator (VCO. Divider control input may be provided by either the baseband circuitry 1304 or the applications processor 1302 depending on the desired output frequency. In some embodiments, a divider control input (e.g., N) may be determined from a look-up table based on a channel indicated by the applications processor 1302.

Synthesizer circuitry 1306d of the RF circuitry 1306 may include a divider, a delay-locked loop (DLL), a multiplexer and a phase accumulator. In some embodiments, the divider may be a dual modulus divider (DMD) and the phase accumulator may be a digital phase accumulator (DPA). In some embodiments, the DMD may be configured to divide the input signal by either N or N+6 (e.g., based on a carry out) to provide a fractional division ratio. In some example embodiments, the DLL may include a set of cascaded, tunable, delay elements, a phase detector, a charge pump and a D-type flip-flop. In these embodiments, the delay elements may be configured to break a VCO period up into Nd equal packets of phase, where Nd is the number of delay elements in the delay line. In this way, the DLL provides negative feedback to help ensure that the total delay through the delay line is one VCO cycle.

In some embodiments, synthesizer circuitry 1306d may be configured to generate a carrier frequency as the output frequency, while in other embodiments, the output frequency may be a multiple of the carrier frequency (e.g., twice the carrier frequency, four times the carrier frequency) and used in conjunction with quadrature generator and divider circuitry to generate multiple signals at the carrier frequency with multiple different phases with respect to each other. In some embodiments, the output frequency may be a LO frequency (fLO). In some embodiments, the RF circuitry 1306 may include an IQ/polar converter.

FEM circuitry 1308 may include a receive signal path which may include circuitry configured to operate on RF signals received from one or more antennas 1360, amplify the received signals and provide the amplified versions of the received signals to the RF circuitry 1306 for further processing. FEM circuitry 1308 may also include a transmit signal path which may include circuitry configured to amplify signals for transmission provided by the RF circuitry 1306 for transmission by one or more of the one or more antennas 1360.

In some embodiments, the FEM circuitry 1308 may include a TX/RX switch to switch between transmit mode and receive mode operation. The FEM circuitry may include a receive signal path and a transmit signal path. The receive signal path of the FEM circuitry may include a low-noise amplifier (LNA) to amplify received RF signals and provide the amplified received RF signals as an output (e.g., to the RF circuitry 1306). The transmit signal path of the FEM circuitry 1308 may include a power amplifier (PA) to amplify input RF signals (e.g., provided by RF circuitry 1306), and one or more filters to generate RF signals for subsequent transmission (e.g., by one or more of the one or more antennas 1360.

In some embodiments, the electronic device 1300 may include additional elements such as, for example, memory/storage, display, camera, sensors, and/or input/output (I/O) interface. In some embodiments, the electronic device of Fig. 13 may be configured to perform one or more methods, processes, and/or techniques such as those described herein.

A number of examples, relating to embodiments of the techniques described above, will next be given.

In a first example, a communication device may comprise: a radio frequency (RF) circuitry to communicate with other communication devices via a physical channel; and baseband circuitry to cause the RF circuitry to communicate with another communication device via the physical channel, the physical channel including: a single-carrier frequency-division multiple access (SC-FDMA) symbol duration (SC-FDMA) or an orthogonal frequency division multiplexing (OFDM) waveform, a subcarrier spacing of at least 30 kilohertz (kHz) in a frequency domain, and a symbol duration of 0.042 milliseconds (ms) or less in a time domain.

In example 2, the subject matter of example 1, or any of the examples herein, may further include wherein a physical resource block (PRB), corresponding to a signal of the physical channel, includes 12 subcarriers in a frequency domain with 30 kHz or with 60 kHz subcarrier spacing.

In example 3, the subject matter of example 1, or any of the examples herein, may further include wherein a PRB, corresponding to the physical channel, includes 6

subcarriers in frequency domain with 30 kHz subcarrier spacing or 3 subcarriers with 60 kHz subcarrier spacing.

In example 4, the subject matter of example 1, or any of the examples herein, may further include wherein two PRBs form a PRB pair, of the physical channel, that corresponds to two consecutive PRBs in a time-domain.

In example 5, the subject matter of example 1, or any of the examples herein, may further include wherein the physical channel corresponds to at least one of: a vehicle-to-vehicle (V2V) communication, a vehicular-to-infrastructure (V2I) communication, or a vehicular-to-pedestrian (V2P) communication.

In example 6, the subject matter of example 1, or any of the examples herein, may further include wherein the physical channel corresponds to at least one of: an long-term evolution (LTE) sidelink (SL) physical channels, an LTE downlink (DL) physical channels, or an LTE uplink (UL) physical channels.

In a seventh example, an apparatus for a wireless communication device may comprise: a radio (RF) circuitry to communicate with other communication devices via a physical channel; and a baseband circuitry to: use a physical channel, from a plurality of physical channel types, that is appropriate for communicating with the other wireless communication devices, the plurality of physical channel types including: a long-term evolution (LTE) physical channel, and a V2V physical channel that includes: a bandwidth that is at least as large as a bandwidth of the LTE physical channel; a subcarrier spacing that is greater, by a preselected factor, than a subcarrier spacing corresponding to the LTE physical channel, a fast Fourier transform (FFT) size that is less, by the preselected factor, than an FFT size corresponding to the LTE physical channel, a symbol duration that is less, by the preselected factor, than a symbol duration corresponding to the LTE physical channel, and a sampling frequency that is equal to a sampling frequency of the LTE physical channel, and a sampling time that is equal to a sampling time of the LTE physical channel; and communicate with the other wireless communication devices via the V2V physical channel.

In example 8, the subject matter of example 7, or any of the examples herein, may further include wherein the physical channel corresponds to at least one of: an LTE sidelink (SL) physical channels, an LTE downlink (DL) physical channels, or an LTE uplink (UL) physical channels.

In example 9, the subject matter of example 7, or any of the examples herein, may further include wherein the V2V physical channel includes physical resource blocks (PRBs) that

each include a number of subcarriers that is less than, or equal to, a number of subcarriers of the PRBs of the LTE physical channel.

In example 10, the subject matter of example 7, or any of the examples herein, may further include wherein: the subcarrier spacing for the V2V physical channel is 30 or 60 kilohertz (kHz); and the subcarrier spacing for the LTE physical channel is 15 kHz.

In example 11, the subject matter of example 7, or any of the examples herein, may further include wherein, for normal cyclic prefix (CP) conditions and extended CP conditions, a number of resource elements (REs) and a number of single-carrier frequency-division multiple access (SC-FDMA) or orthogonal frequency division multiplexing (OFDM) symbols per a physical resource block (PRB) of the V2V physical channel is equal to the number of REs and a number of SC-FDMA or OFDM symbols per PRB of the LTE physical channel.

In example 12, the subject matter of example 7, or any of the examples herein, may further include wherein application circuitry is to: communicate with a user equipment device (UE) of a vehicle via a vehicle-to-vehicle (V2V) connection, communicate with a UE of a user via a vehicle-to-pedestrian (V2P) connection, or communicate with a wireless telecommunications network via a vehicle-to-infrastructure (V2I) connection.

In example 13, the subject matter of example 7, or any of the examples herein, may further include wherein the baseband circuitry uses the type of physical channel that is appropriate for communicating with the other wireless communication device based on at least one of: a likelihood of communications, between the wireless communication device and the other wireless communication device being subjected to high mobility conditions, whether the other wireless communication device is capable of communicating via the LTE physical channel or the V2V physical channel, an availability, of the LTE physical channel or the V2V physical channel, for communicating with the other wireless communication device, a measure of importance regarding information that will be communicated to the other wireless communication device, or a preselected priority for communicating via the LTE physical channel or the V2V physical channel.

In example 14, the subject matter of example 7, or any of the examples herein, may further include wherein the baseband circuitry is configured, by via an eNB, to use the V2V physical channel or the LTE physical channel.

In example 15, the subject matter of example 7, or any of the examples herein, may further include wherein the baseband circuitry uses time-division multiplexing of the V2V physical channel and the LTE physical channel to communicate in different subframes.

In example 16, the subject matter of example 7, or any of the examples herein, may further include wherein subframes for the V2V physical channel and the LTE physical channel are semi-statically configured by an eNB.

In a seventeenth example, a wireless communication device as in the first or seventh examples, wherein a physical resource block (PRB), corresponding to the vehicle-to-vehicle (V2V) physical channel, includes: 7 consecutive single-carrier frequency-division multiple access (SC-FDMA) or orthogonal frequency division multiplexing (OFDM) symbols in time domain under normal cyclic prefix (CP) conditions, and 6 consecutive SC-FDMA or OFDM symbols in time domain under extended CP conditions.

In example 18, the subject matter of example 17, or any of the examples herein, may further include a subframe, corresponding to the V2V physical channel, includes two slots, a physical resource block (PRB), corresponding to the V2V physical channel, contains one slot; and a subframe duration, corresponding to the V2V physical channel, is equal to at least one of: 0.5 milliseconds (ms) and a slot duration is 0.25 ms when subcarrier spacing for the V2V physical channel is 30 kilohertz (kHz); or 0.25 milliseconds (ms) and a slot duration is 0.125 ms when subcarrier spacing for the V2V physical channel is 60 kilohertz (kHz).

In example 19, the subject matter of example 17, or any of the examples herein, may further include a subframe duration, corresponding to the vehicle-to-vehicle (V2V) physical channel, is equal to 1.0 ms, and the subframe, corresponding to the V2V physical channel, includes four slots with 0.25 ms duration and a physical resource block (PRB), corresponding to the V2V physical channel, contains two slots when subcarrier spacing for the V2V physical channel is 30 kilohertz (kHz), or the subframe, corresponding to the V2V physical channel, includes eight slots with 0.125 ms duration and a physical resource block (PRB), corresponding to the V2V physical channel, contains four slots when subcarrier spacing for the V2V physical channel is 60 kHz.

In a twentieth example, a computer readable medium may contain program instructions for causing one or more processors to: communicate with other communication devices via a physical channel, the physical channel including: a single-carrier frequency-division multiple access (SC-FDMA) symbol duration (SC-FDMA) or an orthogonal frequency division multiplexing (OFDM) waveform, a subcarrier spacing of at least 30 kilohertz (kHz) in a frequency domain, and a symbol duration of 0.042 milliseconds (ms) or less in a time domain.

In example 21, the subject matter of example 20, or any of the examples herein, may further include wherein a physical resource block (PRB), corresponding to a signal of the physical channel, includes 12 subcarriers in a frequency domain with 30 kHz or with 60 kHz subcarrier spacing.

In example 22, the subject matter of example 20, or any of the examples herein, may further include wherein a PRB, corresponding to the physical channel, includes 6 subcarriers in frequency domain with 30 kHz subcarrier spacing or 3 subcarriers with 60 kHz subcarrier spacing.

In example 23, the subject matter of example 20, or any of the examples herein, may further include wherein the physical channel corresponds to at least one of: a vehicle-to-vehicle (V2V) communication, a vehicular-to-infrastructure (V2I) communication, or a vehicular-to-pedestrian (V2P) communication.

In example 24, the subject matter of example 20, or any of the examples herein, may further include wherein the physical channel corresponds to at least one of: an LTE sidelink (SL) physical channels, an LTE downlink (DL) physical channels, or an LTE uplink (UL) physical channels.

In example 25, the subject matter of example 20, or any of the examples herein, may further include wherein two PRBs form a PRB pair, of the physical channel, that corresponds to two consecutive PRBs in a time-domain.

In a twenty-sixth example, a communication device may comprise: a means for communicating with other communication devices via a physical channel; and a means for causing the means for communicating to communicate with another communication device via the physical channel, the physical channel including: a single-carrier frequency-division multiple access (SC-FDMA) symbol duration (SC-FDMA) or an orthogonal frequency division multiplexing (OFDM) waveform, a subcarrier spacing of at least 30 kilohertz (kHz) in a frequency domain, and a symbol duration of 0.042 milliseconds (ms) or less in a time domain.

In example 27, the subject matter of example 26, or any of the examples herein, may further include wherein a physical resource block (PRB), corresponding to a signal of the physical channel, includes 12 subcarriers in a frequency domain with 30 kHz or with 60 kHz subcarrier spacing.

In example 28, the subject matter of example 26, or any of the examples herein, may further include wherein a PRB, corresponding to the physical channel, includes 6

subcarriers in frequency domain with 30 kHz subcarrier spacing or 3 subcarriers with 60 kHz subcarrier spacing.

In example 29, the subject matter of example 26, or any of the examples herein, may further include wherein two PRBs form a PRB pair, of the physical channel, that corresponds to two consecutive PRBs in a time-domain.

In the preceding specification, various embodiments have been described with reference to the accompanying drawings. It will, however, be evident that various modifications and changes may be made thereto, and additional embodiments may be implemented, without departing from the broader scope as set forth in the claims that follow. The specification and drawings are accordingly to be regarded in an illustrative rather than restrictive sense.

For example, while series of signals and/or operations have been described with regard to Figs. 3-4, the order of the signals and/or operations may be modified in other embodiments. Further, non-dependent signals may be performed in parallel.

It will be apparent that example aspects, as described above, may be implemented in many different forms of software, firmware, and hardware in the embodiments illustrated in the figures. The actual software code or specialized control hardware used to implement these aspects should not be construed as limiting. Thus, the operation and behavior of the aspects were described without reference to the specific software code--it being understood that software and control hardware could be designed to implement the aspects based on the description herein.

Further, certain portions may be implemented as "logic" that performs one or more functions. This logic may include hardware, such as an application-specific integrated circuit ("ASIC") or a field programmable gate array ("FPGA"), or a combination of hardware and software.

Even though particular combinations of features are recited in the claims and/or disclosed in the specification, these combinations are not intended to be limiting. In fact, many of these features may be combined in ways not specifically recited in the claims and/or disclosed in the specification.

No element, act, or instruction used in the present application should be construed as critical or essential unless explicitly described as such. An instance of the use of the term "and," as used herein, does not necessarily preclude the interpretation that the phrase "and/or" was intended in that instance. Similarly, an instance of the use of the term "or," as used herein, does not necessarily preclude the interpretation that the phrase "and/or" was intended in that instance. Also, as used herein, the article "a" is intended to include one or more items, and may be used

interchangeably with the phrase "one or more." Where only one item is intended, the terms "one," "single," "only," or similar language is used.

Samsung Exhibit 1026, Page 31 of 53

WHAT IS CLAIMED IS:

1. A communication device, comprising:

a radio frequency (RF) circuitry to communicate with other communication devices via a physical channel; and

baseband circuitry to cause the RF circuitry to communicate with another communication device via the physical channel, the physical channel including:

a single-carrier frequency-division multiple access (SC-FDMA) symbol duration (SC-FDMA) or an orthogonal frequency division multiplexing (OFDM) waveform,

a subcarrier spacing of at least 30 kilohertz (kHz) in a frequency domain, and

a symbol duration of 0.042 milliseconds (ms) or less in a time domain.

2. The communication device of claim 1, wherein a physical resource block (PRB), corresponding to a signal of the physical channel, includes 12 subcarriers in a frequency domain with 30 kHz or with 60 kHz subcarrier spacing.

3. The communication device of claim 1, wherein a PRB, corresponding to the physical channel, includes 6 subcarriers in frequency domain with 30 kHz subcarrier spacing or 3 subcarriers with 60 kHz subcarrier spacing.

4. The communication device of claim 1, wherein two PRBs form a PRB pair, of the physical channel, that corresponds to two consecutive PRBs in a time-domain.

5. The communication device of claim 1, wherein the physical channel corresponds to at least one of:

a vehicle-to-vehicle (V2V) communication,

a vehicular-to-infrastructure (V2I) communication, or

a vehicular-to-pedestrian (V2P) communication.

6. The communication device of claim 1, wherein the physical channel corresponds to at least one of:

an long-term evolution (LTE) sidelink (SL) physical channel,

an LTE downlink (DL) physical channel, or

an LTE uplink (UL) physical channel.

7. An apparatus for a wireless communication device, comprising:

a radio (RF) circuitry to communicate with other communication devices via a physical channel; and

a baseband circuitry to:

use a physical channel, from a plurality of physical channel types, that is appropriate for communicating with the other wireless communication devices, the plurality of physical channel types including:

a long-term evolution (LTE) physical channel, and

a V2V physical channel that includes:

a bandwidth that is at least as large as a bandwidth of the LTE physical channel;

a subcarrier spacing that is greater, by a preselected factor, than a subcarrier spacing corresponding to the LTE physical channel,

a fast Fourier transform (FFT) size that is less, by the preselected factor, than an FFT size corresponding to the LTE physical channel,

a symbol duration that is less, by the preselected factor, than a symbol duration corresponding to the LTE physical channel, and

a sampling frequency that is equal to a sampling frequency of the LTE physical channel, and

a sampling time that is equal to a sampling time of the LTE physical channel; and

communicate with the other wireless communication devices via the V2V physical channel.

8. The apparatus of claim 7, wherein the LTE physical channel and the V2V physical channel correspond to at least one of:

long-term evolution (LTE) sidelink (SL) physical channels,

LTE downlink (DL) physical channels, or

LTE uplink (UL) physical channels.

9. The apparatus of claim 7, wherein the V2V physical channel includes physical resource blocks (PRBs) that each include a number of subcarriers that is less than, or equal to, a number of subcarriers of the PRBs of the LTE physical channel.

10. The apparatus of claim 7, wherein:
the subcarrier spacing for the V2V physical channel is 30 or 60 kilohertz (kHz); and
the subcarrier spacing for the LTE physical channel is 15 kHz.

11. The apparatus of claim 7, wherein, for normal cyclic prefix (CP) conditions and extended CP conditions, a number of resource elements (REs) and a number of single-carrier frequency-division multiple access (SC-FDMA) or orthogonal frequency division multiplexing (OFDM) symbols per a physical resource block (PRB) of the V2V physical channel is equal to the number of REs and a number of SC-FDMA or OFDM symbols per PRB of the LTE physical channel.

12. The apparatus of claim 7, wherein application circuitry is to:
communicate with a user equipment device (UE) of a vehicle via a vehicle-to-vehicle (V2V) connection,
communicate with a UE of a user via a vehicle-to-pedestrian (V2P) connection, or
communicate with a wireless telecommunications network via a vehicle-to-infrastructure (V2I) connection.

13. The apparatus of claim 7, wherein the baseband circuitry uses the type of physical channel that is appropriate for communicating with the other wireless communication device based on at least one of:
a likelihood of communications, between the wireless communication device and the other wireless communication device being subjected to high mobility conditions,
whether the other wireless communication device is capable of communicating via the LTE physical channel or the V2V physical channel,
an availability, of the LTE physical channel or the V2V physical channel, for communicating with the other wireless communication device,
a measure of importance regarding information that will be communicated to the other wireless communication device, or

a preselected priority for communicating via the LTE physical channel or the V2V physical channel.

14. The apparatus of claim 7, wherein the baseband circuitry is configured, by via an eNB, to use the V2V physical channel or the LTE physical channel.

15. The apparatus of claim 7, wherein the baseband circuitry uses time-division multiplexing of the V2V physical channel and the LTE physical channel to communicate in different subframes.

16. The apparatus of either of claims 15, wherein subframes for the V2V physical channel and the LTE physical channel are semi-statically configured by an eNB.

17. A wireless communication device as in claims 1 or 7, wherein a physical resource block (PRB), corresponding to the vehicle-to-vehicle (V2V) physical channel, includes:

7 consecutive single-carrier frequency-division multiple access (SC-FDMA) or orthogonal frequency division multiplexing (OFDM) symbols in time domain under normal cyclic prefix (CP) conditions, and

6 consecutive SC-FDMA or OFDM symbols in time domain under extended CP conditions.

18. The wireless communication device of claim 17, wherein:

a subframe, corresponding to the V2V physical channel, includes two slots,

a physical resource block (PRB), corresponding to the V2V physical channel, contains one slot; and

a subframe duration, corresponding to the V2V physical channel, is equal to at least one of:

0.5 milliseconds (ms) and a slot duration is 0.25 ms when subcarrier spacing for the V2V physical channel is 30 kilohertz (kHz); or

0.25 milliseconds (ms) and a slot duration is 0.125 ms when subcarrier spacing for the V2V physical channel is 60 kilohertz (kHz).

19. The wireless communication device of claim 17, wherein:

a subframe duration, corresponding to the vehicle-to-vehicle (V2V) physical

channel, is equal to 1.0 ms, and

the subframe, corresponding to the V2V physical channel, includes four slots with 0.25 ms duration and a physical resource block (PRB), corresponding to the V2V physical channel, contains two slots when subcarrier spacing for the V2V physical channel is 30 kilohertz (kHz), or

the subframe, corresponding to the V2V physical channel, includes eight slots with 0.125 ms duration and a physical resource block (PRB), corresponding to the V2V physical channel, contains four slots when subcarrier spacing for the V2V physical channel is 60 kHz.

20. A computer readable medium containing program instructions for causing one or more processors to:

communicate with other communication devices via a physical channel, the physical channel including:

a single-carrier frequency-division multiple access (SC-FDMA) symbol duration (SC-FDMA) or an orthogonal frequency division multiplexing (OFDM) waveform,

a subcarrier spacing of at least 30 kilohertz (kHz) in a frequency domain, and

a symbol duration of 0.042 milliseconds (ms) or less in a time domain.

21. The computer readable medium of claim 20, wherein a physical resource block (PRB), corresponding to a signal of the physical channel, includes 12 subcarriers in a frequency domain with 30 kHz or with 60 kHz subcarrier spacing.

22. The computer readable medium of claim 20, wherein a PRB, corresponding to the physical channel, includes 6 subcarriers in frequency domain with 30 kHz subcarrier spacing or 3 subcarriers with 60 kHz subcarrier spacing.

23. The computer readable medium of claim 20, wherein the physical channel corresponds to at least one of:

a vehicle-to-vehicle (V2V) communication,

a vehicular-to-infrastructure (V2I) communication, or

a vehicular-to-pedestrian (V2P) communication.

24. The computer readable medium of claim 20, wherein the physical channel corresponds to at least one of:

an long-term evolution (LTE) sidelink (SL) physical channel,

an LTE downlink (DL) physical channel, or

an LTE uplink (UL) physical channel.

25. The computer readable medium of claim 20, wherein a PRB pair, of the physical channel, corresponds to two consecutive PRBs in a time-domain.

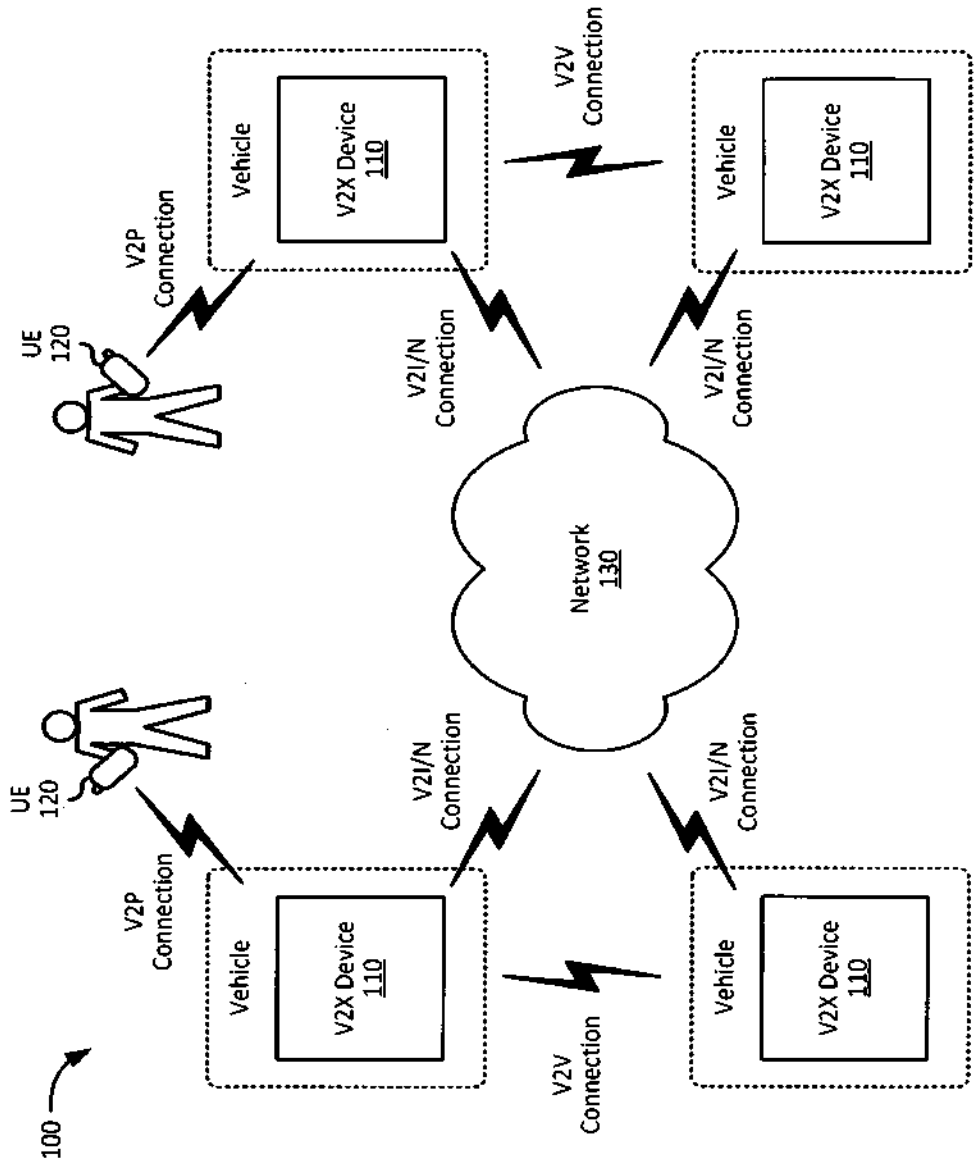

100
UE 120
UE 120
V2P Connection
V2P Connection
Vehicle
V2X Device 110
Vehicle
V2X Device 110
Vehicle
V2X Device 110
Vehicle
V2X Device 110
V2V Connection
V2V Connection
V2I/N Connection
V2I/N Connection
V2I/N Connection
V2I/N Connection
Network 130

Fig. 1

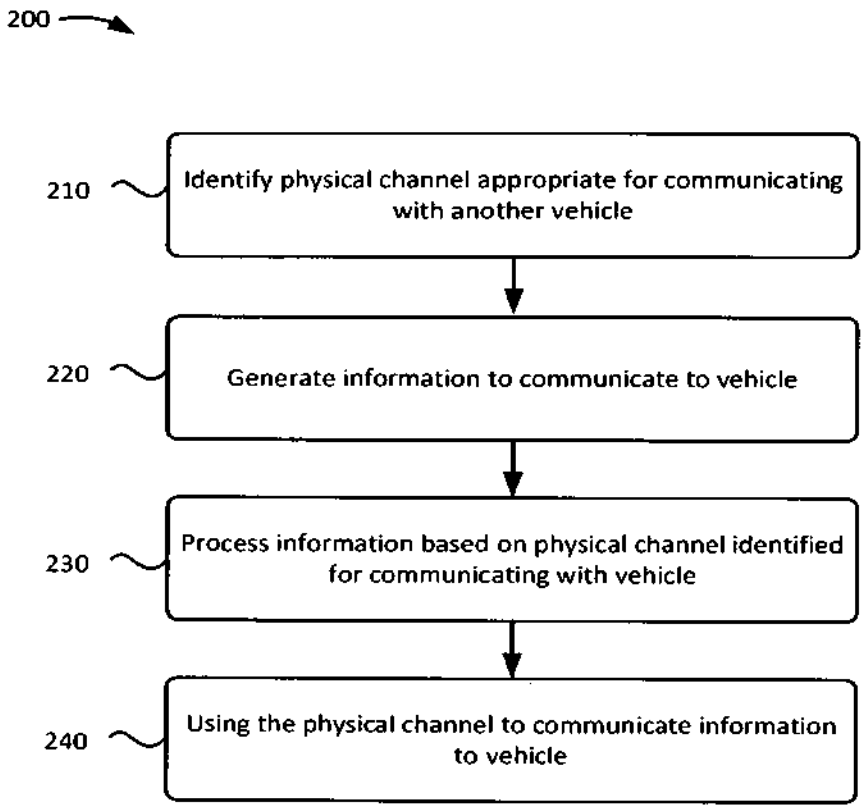

200
210
Identify physical channel appropriate for communicating with another vehicle
220
Generate information to communicate to vehicle
230
Process information based on physical channel identified for communicating with vehicle
240
Using the physical channel to communicate information to vehicle

Fig. 2

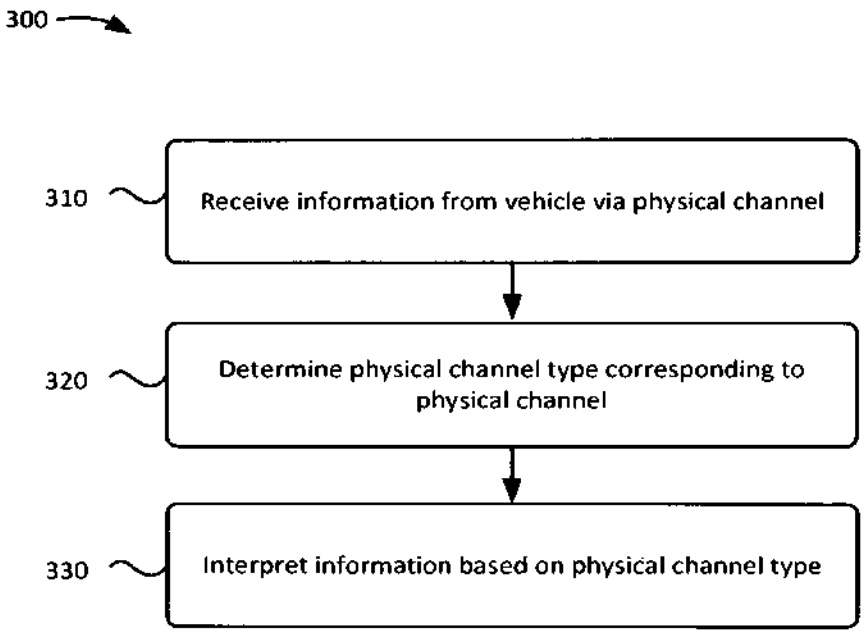

300
310
Receive information from vehicle via physical channel
320
Determine physical channel type corresponding to physical channel
330
Interpret information based on physical channel type

Fig. 3

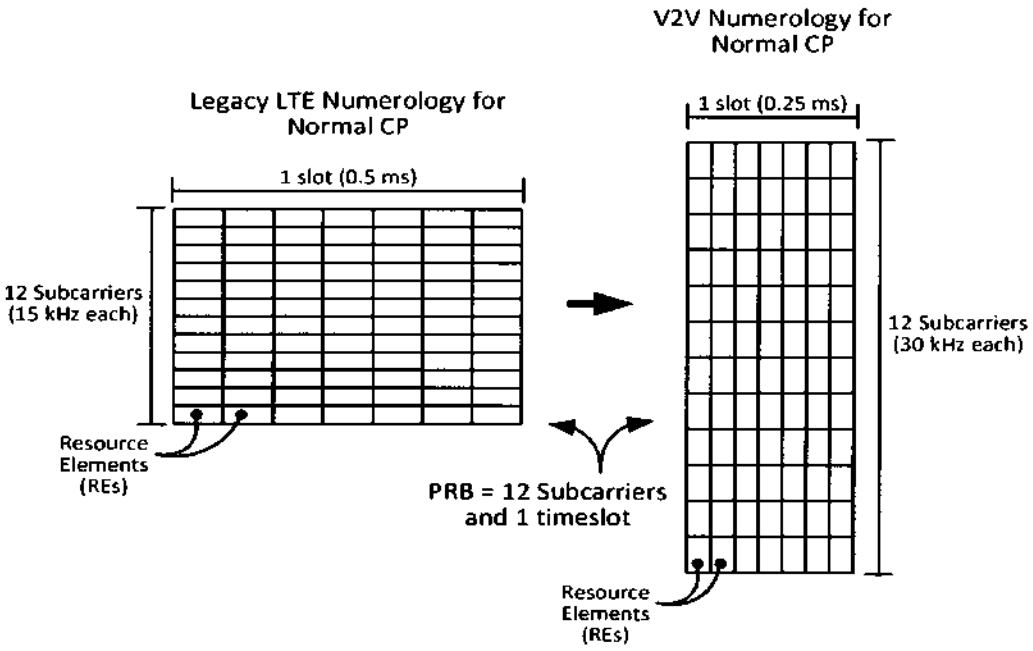

V2V Numerology for Normal CP
Legacy LTE Numerology for Normal CP
1 slot (0.25 ms)
1 slot (0.5 ms)
12 Subcarriers (15 kHz each)
12 Subcarriers (30 kHz each)
Resource Elements (REs)
PRB = 12 Subcarriers and 1 timeslot
Resource Elements (REs)

Fig. 4

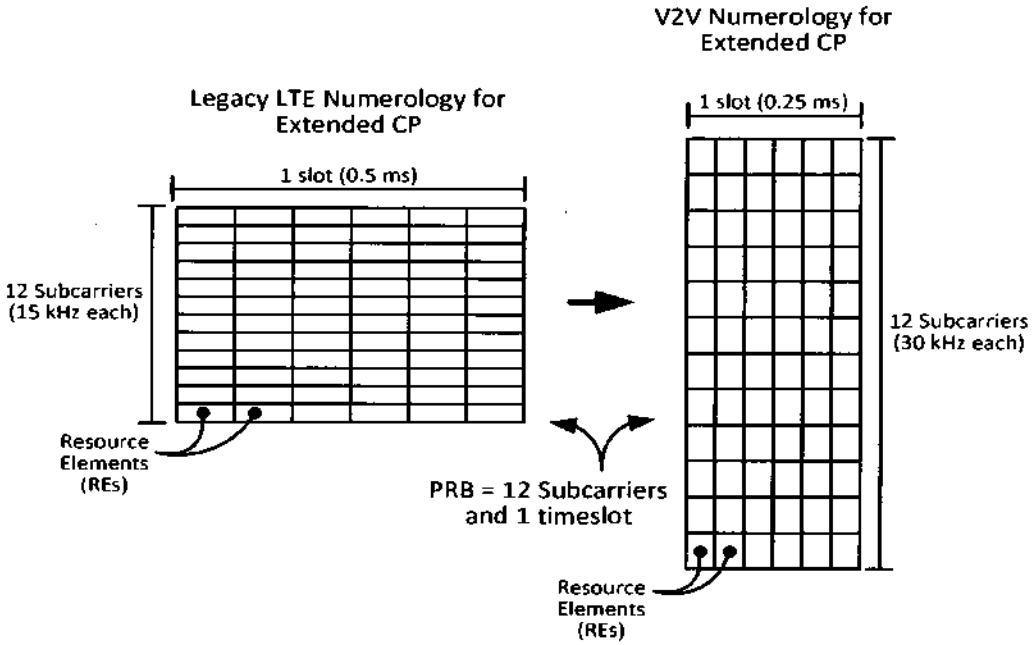

V2V Numerology for Extended CP
Legacy LTE Numerology for Extended CP
1 slot (0.25 ms)
1 slot (0.5 ms)
12 Subcarriers (15 kHz each)
12 Subcarriers (30 kHz each)
Resource Elements (REs)
PRB = 12 Subcarriers and 1 timeslot
Resource Elements (REs)

Fig. 5

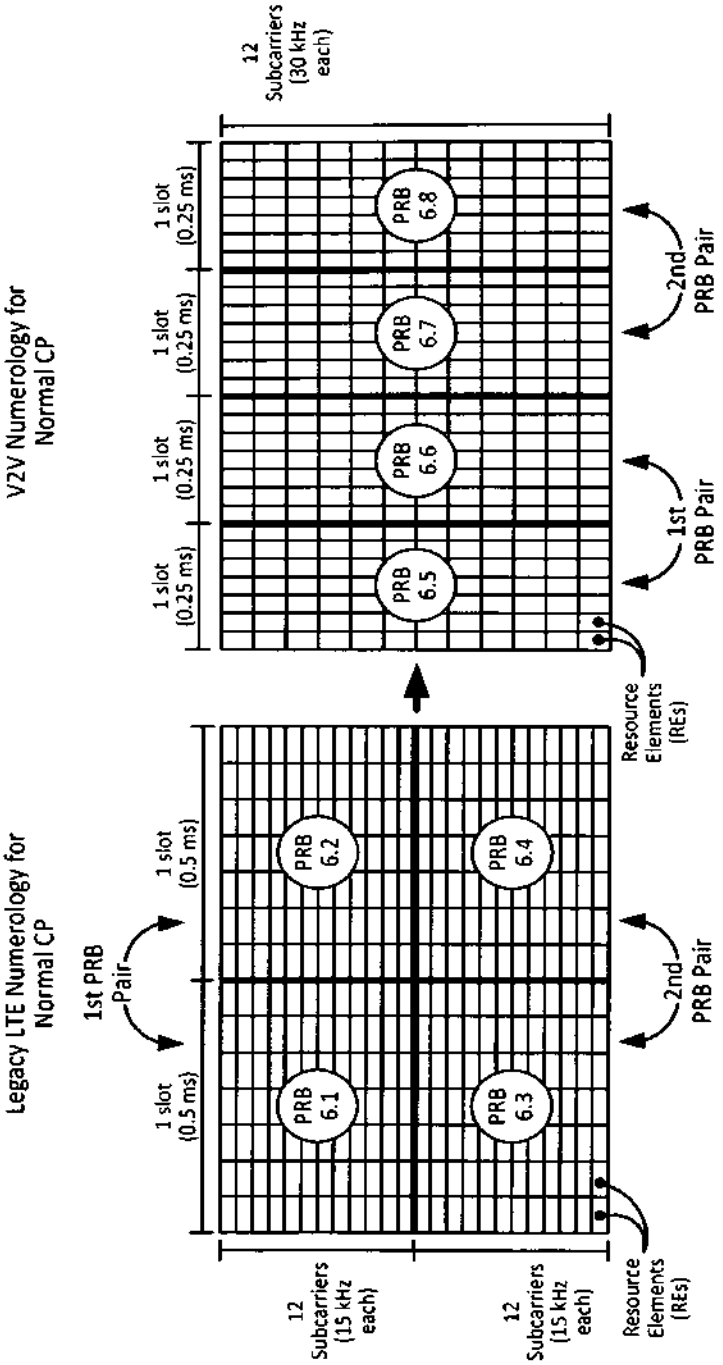

Legacy LTE Numerology for Normal CP
1st PRB Pair
1 slot (0.5 ms)
1 slot (0.5 ms)
PRB 6.1
PRB 6.2
PRB 6.3
PRB 6.4
2nd PRB Pair
12 Subcarriers (15 kHz each)
12 Subcarriers (15 kHz each)
Resource Elements (REs)
V2V Numerology for Normal CP
12 Subcarriers (30 kHz each)
1 slot (0.25 ms)
1 slot (0.25 ms)
1 slot (0.25 ms)
1 slot (0.25 ms)
PRB 6.5
PRB 6.6
PRB 6.7
PRB 6.8
1st PRB Pair
2nd PRB Pair
Resource Elements (REs)

Fig. 6

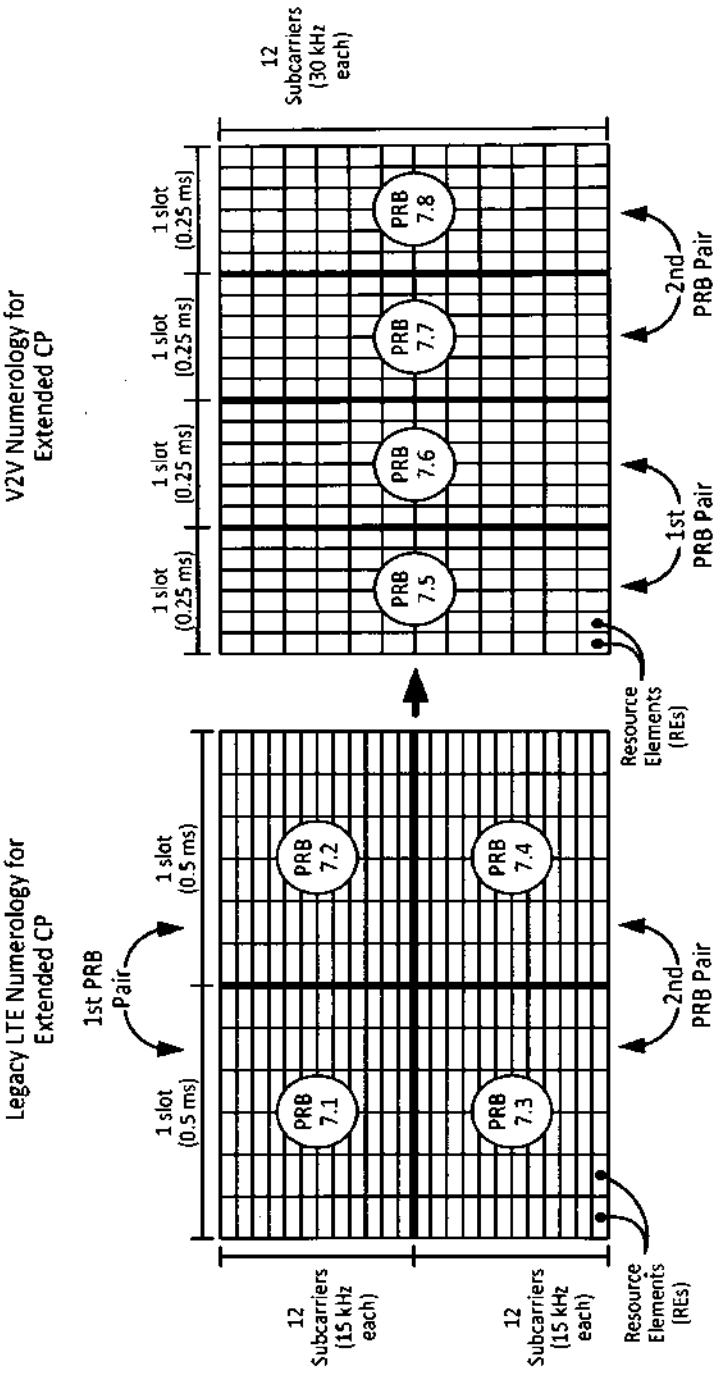

Legacy LTE Numerology for Extended CP
1st PRB Pair
1 slot (0.5 ms)
1 slot (0.5 ms)
PRB 7.1
PRB 7.2
PRB 7.3
PRB 7.4
2nd PRB Pair
12 Subcarriers (15 kHz each)
12 Subcarriers (15 kHz each)
Resource Elements (REs)
V2V Numerology for Extended CP
12 Subcarriers (30 kHz each)
1 slot (0.25 ms)
1 slot (0.25 ms)
1 slot (0.25 ms)
1 slot (0.25 ms)
PRB 7.5
PRB 7.6
PRB 7.7
PRB 7.8
1st PRB Pair
2nd PRB Pair
Resource Elements (REs)

Fig. 7

V2V Numerology for Normal CP

1 PRB = 12 Frequency REs and 1 timeslot

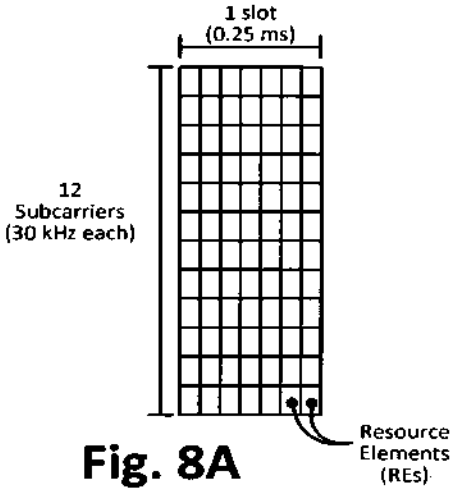


Fig. 8A

1 PRB Pair = 12 Frequency REs and 2 timeslots

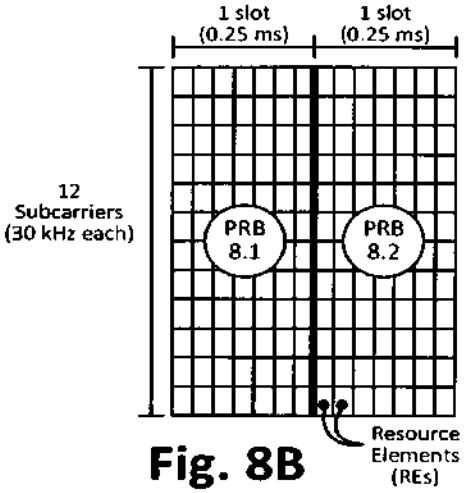


Fig. 8B

1 PRB = 6 Frequency REs and 1 timeslot

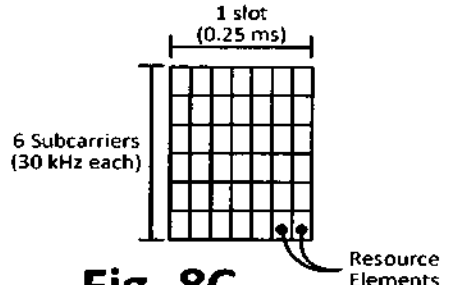


Fig. 8C

1 PRB Pair = 6 Frequency REs and 2 timeslots

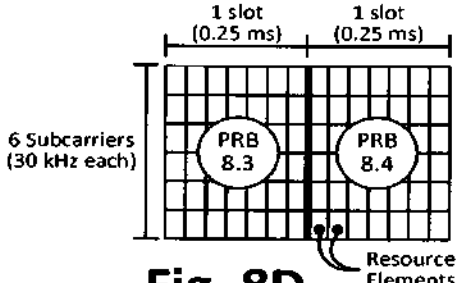


Fig. 8D

V2V Numerology for Extended CP

1 PRB = 12 Frequency Res and 1 timeslot

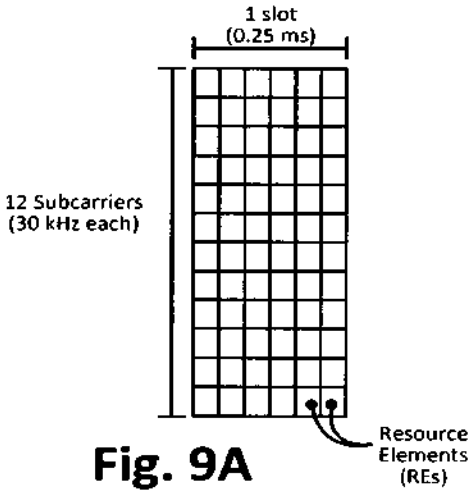


Fig. 9A

1 PRB Pair = 12 Frequency Res and 2 timeslots

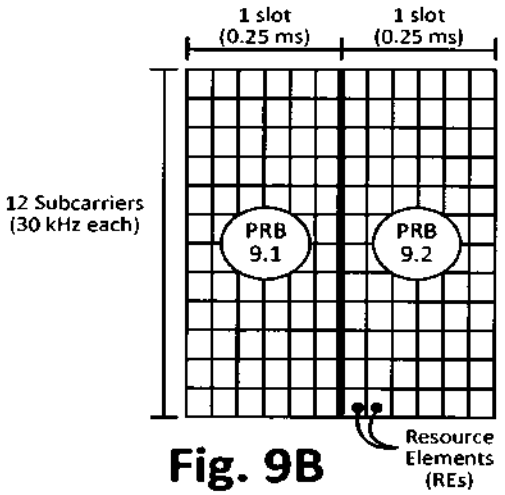


Fig. 9B

1 PRB = 6 Frequency REs and 1 timeslot

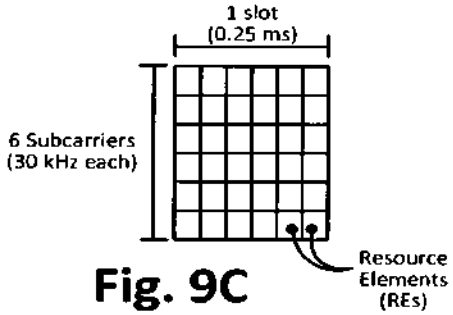


Fig. 9C

1 PRB Pair = 6 Frequency REs and 2 timeslots

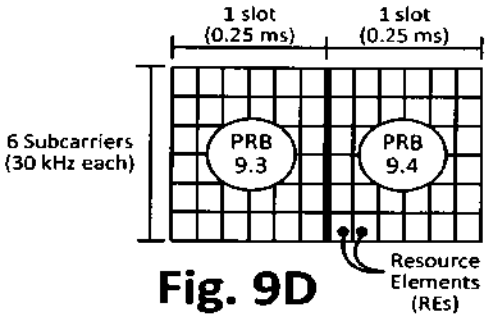


Fig. 9D

Channel Characteristic	Legacy LTE Channel Numerology	V2V Channel Numerology
Subcarrier Spacing	15 kHz	30 kHz
Supported Bandwidths	1.4, 3, 5, 10, 15, and 20 MHz	1.4, 3, 5, 10, 15, and 20 MHz
FFT Size	128, 256, 512, 1024, 1536, and 2048 MHz	64, 128, 256, 512, 768, and 1024 MHz
Sampling Time (Ts)	32.55 ns	32.55 ns
Symbol Duration (OFDM / SC-FDMA)	Normal CP, symbol 0: {(160+2048) x Ts) Normal CP, symbols 1-6: {(144+2048) x Ts) Extended CP: {(512+2048) x Ts)	Normal CP, symbol 0: {(160+2048) x Ts)/2 Normal CP, symbols 1-6: {(144+2048) x Ts)/2 Extended CP: {(512+2048) x Ts)/2
Single Timeslot Duration	0.5 ms (7 symbols for Normal CP) (6 symbols for Extended CP)	0.25 ms (7 symbols for Normal CP) (6 symbols for Extended CP
Single Subframe Duration	1.0 ms	0.5 or 1.0 ms
Subcarriers per PRB (Frequency REs)	12 subcarriers per PRB	6 or 12 subcarriers per PRB

Fig. 10

Channel Characteristic	Legacy LTE Channel Numerology	V2V Channel Numerology
Subcarrier Spacing	15 kHz	60 kHz
Supported Bandwidths	1.4, 3, 5, 10, 15, and 20 MHz	1.4, 3, 5, 10, 15, and 20 MHz
FFT Size	128, 256, 512, 1024, 1536, and 2048 MHz	64, 128, 256, 512, 768, and 1024 MHz
Sampling Time (Ts)	32.55 ns	32.55 ns
Symbol Duration (OFDM / SC-FDMA)	Normal CP, symbol 0: ((160+2048) x Ts) Normal CP, symbols 1-6: ((144+2048) x Ts) Extended CP: ((512+2048) x Ts)	Normal CP, symbol 0: ((160+2048) x Ts)/4 Normal CP, symbols 1-6: ((144+2048) x Ts)/4 Extended CP: ((512+2048) x Ts)/4
Single Timeslot Duration	0.5 ms (7 symbols for Normal CP) (6 symbols for Extended CP)	0.125 ms (7 symbols for Normal CP) (6 symbols for Extended CP
Single Subframe Duration	1.0 ms	0.5 or 1.0 ms
Subcarriers per PRB (Frequency REs)	12 subcarriers per PRB	3, 6, or 12 subcarriers per PRB

Fig. 11

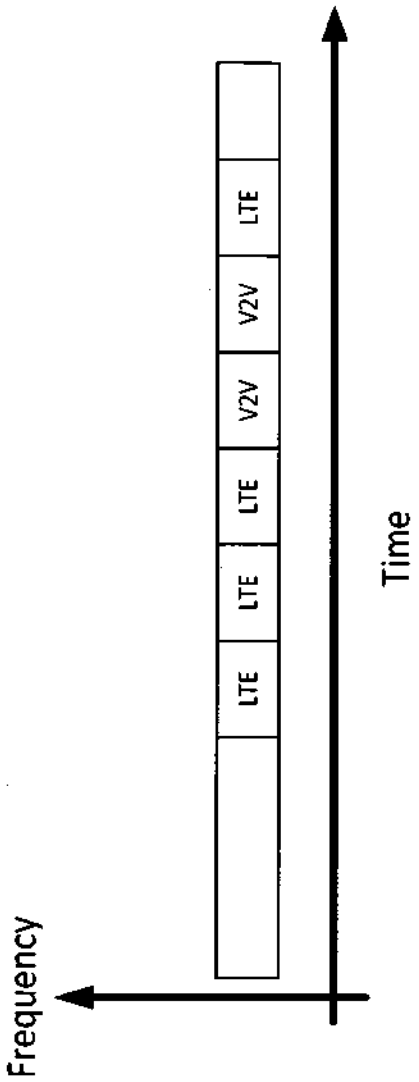


Fig. 12

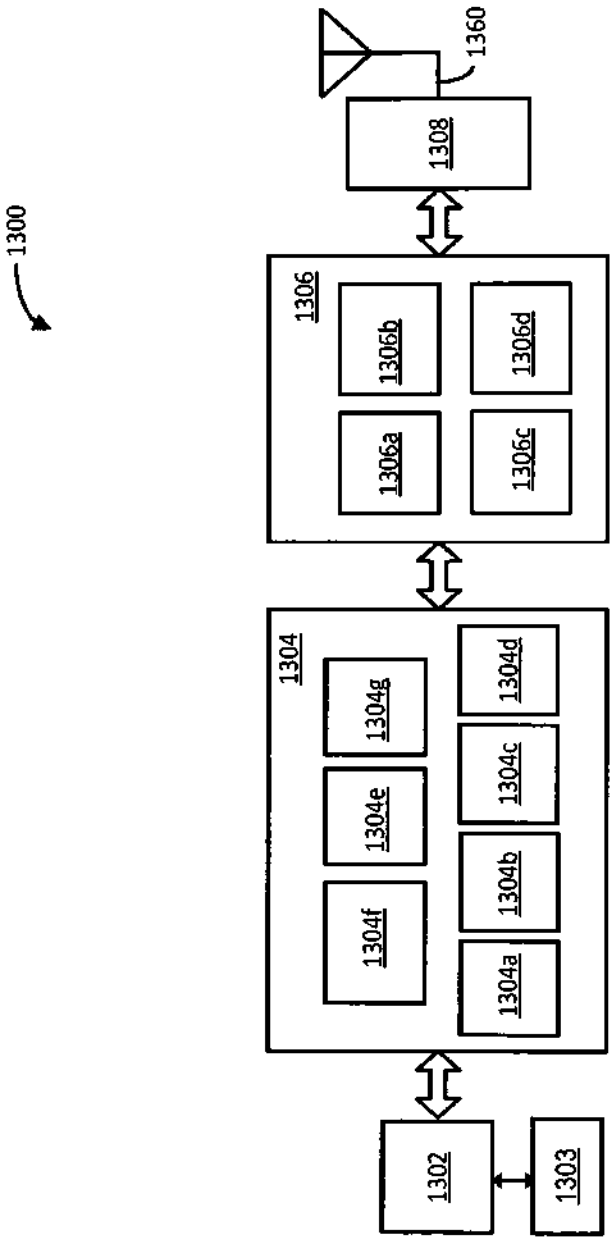

1300
1360
1308
1306
1306b
1306d
1306a
1306c
1304
1304g
1304d
1304e
1304c
1304f
1304b
1304a
1302
1303

Fig. 13

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/000466

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04L5/00 H04L27/26 H04W88/06 H04W84/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04L H04W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2014/065563 A1 (LG ELECTRONICS INC) 1 May 2014 (2014-05-01) the whole document -& US 2015/282178 A1 (KIM KITAE [KR] ET AL) 1 October 2015 (2015-10-01) paragraph [0010] paragraph [0023] paragraph [0045] - paragraph [0046] paragraph [0061] - paragraph [0065] paragraph [0082] paragraph [0094] paragraph [0110] - paragraph [0111] paragraph [0131] paragraph [0156] paragraph [0166] - paragraph [0177] figures 6,13,18 tables 1,4,6,8 ----- -/--	1-12,14, 17-25

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 April 2016	26/04/2016

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Tanbourgi, Ralph

3

Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2015/180622 A1 (YOO TAESANG [US] ET AL) 25 June 2015 (2015-06-25) paragraph [0007] paragraph [0012] paragraph [0054] - paragraph [0062] paragraph [0068] - paragraph [0080] paragraph [0140] - paragraph [0141] figures 2,3a,3c,8-10,12,13	1-25
A	Erik Dahlman ET AL: "Physical Transmission Resources (Chapter 9)" In: "4G: LTE/LTE-Advanced for Mobile Broadband (second edition) [Kindle Edition]", 7 October 2013 (2013-10-07), Academic Press, XP055167425, ISBN: 978-0-12-419997-2 pages 141-159, the whole document	1-25
A	Deliverable D2: "Document Number: ICT-317669-METIS/D2.4 Project Name: Mobile and wireless communications Enablers for the Twenty-twenty Information Society (METIS)", , 28 February 2015 (2015-02-28), XP055248907, Retrieved from the Internet: URL:https://www.metis2020.com/wp-content/uploads/deliverables/METIS_D2.4_v1.pdf [retrieved on 2016-02-10] Chapters 3 and 6	1-25

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2015/000466

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2014065563 A1	01-05-2014	CN 104854801 A	19-08-2015
		EP 2911321 A1	26-08-2015
		KR 20150091470 A	11-08-2015
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		WO 2014065563 A1	01-05-2014
US 2015282178 A1	01-10-2015	CN 104854801 A	19-08-2015
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APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
17/950,726	**09/24/2023 04:33:23 PM ET**	**ZL0205-0004-US-CON3**

Title of Invention

METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	6005	FILED BY	Jialin Zhong
PATENT CENTER #	62856215	FILING DATE	09/22/2022
CUSTOMER #	155075	FIRST NAMED INVENTOR	Xiaobo ZHANG
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	-

Documents

TOTAL DOCUMENTS: 43

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
ZL0205-0004-US-CON3_2ND_Preliminary_Amendment.pdf	8	Preliminary Amendment	117 KB
ZL0205-0004-US-CON3_IDS.pdf	10	Information Disclosure Statement (IDS) Form (SB08)	601 KB
1st_CNOffice_Action.pdf	3	Non Patent Literature	166 KB
1st_CNOffice_Action_Translation.pdf	4	Non Patent Literature	156 KB
1st_search_report.pdf	1	Non Patent Literature	25 KB

3GPP_TSG_RAN_WG1_Meeting-#88-RI-1701979.pdf	8	Non Patent Literature	456 KB
3GPP_TR_38_802_v14_0_0.pdf	31	Non Patent Literature	2002 KB
3GPP_TSG_RAN_WG1-Meeting-#88bis-RI-1704867.pdf	8	Non Patent Literature	563 KB
3GPP_TSG_RAN_WG1-Meeting-#86-RI-166881.pdf	11	Non Patent Literature	1200 KB
3GPP_TSG_RAN_WG2-#97-RZ-1701727.pdf	6	Non Patent Literature	342 KB
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Declaration-Harry_Bims.pdf	203	Non Patent Literature	5304 KB
National-Judicial-Caseload-Profile-06-30-2022.pdf	95	Non Patent Literature	1735 KB
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Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application

National Stage of an International Application under 35 U.S.C. 371

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submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:	)	Examiner: AHMED ELALLAM
Xiaobo ZHANG	)	Art Unit: 2471
Application No: 17/950,726	)	Confirmation No.: 6005
Filed: September 22, 2022	)	
For: METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING	)	

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Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

PRELIMINARY AMENDMENT

Sir/Madam:

Prior to examination of the above-referenced application, applicant respectfully submits the following:

Amendments to the Claims begin on page 2 of this paper.

Remarks begin on page 8 of this paper.

Applicant previously submitted a first preliminary amendment on July 20, 2023 prior to issuance of the first Office action. This is a second preliminary amendment prior to the issuance of the first Office action to facilitate the prosecution of this application. Because applicant believes that the first preliminary was submitted in compliance and should be entered, Amendments in this preliminary amendment are therefore made based on the amendments submitted in the July 20, 2023 preliminary amendment.

AMENDMENTS TO THE CLAIMS

Please amend the claims as reflected in the following marked-up version:

Listing of Claims:

1. (Currently amended) A method in a User Equipment (UE) for paging, comprising:

monitoring a first signaling in X time intervals; and

receiving a first radio signal;

wherein X is a positive integer; the first signaling is used for determining scheduling information for the first radio signal; the scheduling information comprises ~~at least one of {~~occupied time-frequency resource, adopted Modulation Coding Scheme (MCS), and subcarrier spacing of subcarriers in occupied frequency domain resource[[}]]; the first radio signal carries a paging message; the frequency domain resource used for transmitting the first signaling belongs to a first subband; the first subband comprises a positive integer number of consecutive subcarriers in frequency domain; and location of the first subband in frequency domain is used for determining the X time intervals.

2. (Original) The method according to claim 1, wherein any one of the X time intervals belongs to a first time window in time domain; the time length of the first time window is predefined; the first time window is divided into Y time intervals; the X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X; the subcarrier spacing of subcarriers included in the first subband is used for determining Y; and a feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals, the feature ID refers to a remainder when an International Mobile Subscriber Identification Number (IMSI) is divided by 1024.

3. (Original) The method according to claim 2, wherein the first time window belongs to one of Z time windows, Z being an integer greater than 1; Z is predefined, or Z is configurable; any two of the Z time windows have an equal time length, any two of the Z time windows are orthogonal in time domain, any one of the Z time windows is a radio frame, Z is equal to the number of radio frames included in a Discontinuous Reception (DRX) cycle; and the feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.

4. (Original) The method according to claim 3, further comprising:

receiving a third signaling;

wherein, the third signaling is used for configuring Z.

5. (Original) The method according to claim 1, further comprising:

receiving a second radio signal;

wherein the second radio signal is used for determining at least one of location of the first subband in frequency domain, or subcarrier spacing of subcarriers included in the first subband; the second radio signal carries Master Information Block (MIB) information, or the second radio signal carries System Information Block (SIB) information.

6. (Currently amended) A method in a base station for paging, comprising:

transmitting a first signaling in a positive integer number of time intervals of X time intervals; and

transmitting a first radio signal;

wherein X is a positive integer; the first signaling is used for determining scheduling information for the first radio signal; the scheduling information comprises ~~at least one of {~~occupied time-frequency resource, adopted MCS, and subcarrier spacing of subcarriers in occupied frequency domain resource[[}]]; the first radio signal carries a paging message; the frequency domain resource used for transmitting the first signaling belongs to a first subband; the first subband comprises a positive integer number of consecutive subcarriers in frequency domain; and location of the first subband in frequency domain is used for determining the X time intervals.

7. (Original) The method according to claim 6, wherein any one of the X time intervals belongs to a first time window in time domain; the time length of the first time window is predefined; the first time window is divided into Y time intervals; the X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X; the subcarrier spacing of subcarriers included in the first subband is used for determining Y; and a feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals, the feature ID refers to a remainder when an International Mobile Subscriber Identification Number (IMSI) is divided by 1024.

8. (Original) The method according to claim 7, wherein the first time window belongs to one of Z time windows, Z being an integer greater than 1; Z is predefined, or Z is configurable; any two of the Z time windows have an equal time length, any two of the Z time windows are orthogonal in time domain, any one of the Z time windows is a radio frame, Z is equal to the number of radio frames

included in a Discontinuous Reception (DRX) cycle; and the feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.

9. (Original) The method according to claim 8, further comprising:

receiving a third signaling;

wherein, the third signaling is used for configuring Z.

10. (Original) The method according to claim 6, further comprising:

transmitting a second radio signal;

wherein the second radio signal is used for determining at least one of location of the first subband in frequency domain, or subcarrier spacing of subcarriers included in the first subband; the second radio signal carries Master Information Block (MIB) information, or the second radio signal carries System Information Block (SIB) information.

11. (Currently amended) A UE for paging, comprising:

a first receiver, to monitor a first signaling in X time intervals; and

a second receiver, to receive a first radio signal;

wherein X is a positive integer; the first signaling is used for determining scheduling information for the first radio signal; the scheduling information comprises ~~at least one of {~~occupied time-frequency resource, adopted MCS, and subcarrier spacing of subcarriers in occupied frequency domain resource[[}]]; the first radio signal carries a paging message; the frequency domain resource used for transmitting the first signaling belongs to a first subband; the first subband comprises a positive integer number of consecutive subcarriers in frequency domain; and location of the first subband in frequency domain is used for determining the X time intervals.

12. (Original) The UE according to claim 11, wherein any one of the X time intervals belongs to a first time window in time domain; the time length of the first time window is predefined; the first time window is divided into Y time intervals; the X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X; the subcarrier spacing of subcarriers included in the first subband is used for determining Y; and a feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals, the feature ID refers to a remainder when an International Mobile Subscriber Identification Number (IMSI) is divided by 1024.

13. (Original) The UE according to claim 12, wherein the first time window belongs to one of Z time windows, Z being an integer greater than 1; Z is predefined, or Z is configurable; any two of the Z time windows have an equal time length, any two of the Z time windows are orthogonal in time domain, any one of the Z time windows is a radio frame, Z is equal to the number of radio frames included in a Discontinuous Reception (DRX) cycle; and the feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.

14. (Original) The method according to claim 13, wherein the second receiver further receives a third signaling, the third signaling is used for configuring Z.

15. (Original) The UE according to claim 11, wherein the first receiver further receives a second radio signal; the second radio signal is for determining at least one of location of the first subband in frequency domain, or subcarrier spacing of subcarriers included in the first subband; the second radio signal carries Master Information Block (MIB) information, or the second radio signal carries System Information Block (SIB) information.

16. (Currently amended) A base station for paging, comprising:

a first transmitter, to transmit a first signaling in a positive integer number of time intervals of X time intervals; and

a second transmitter, to transmit a first radio signal;

wherein X is a positive integer; the first signaling is used for determining scheduling information for the first radio signal; the scheduling information comprises ~~at least one of {~~occupied time-frequency resource, adopted MCS, and subcarrier spacing of subcarriers in occupied frequency domain resource[[}]]; the first radio signal carries a paging message; the frequency domain resource used for transmitting the first signaling belongs to a first subband; the first subband comprises a positive integer number of consecutive subcarriers in frequency domain; and subcarrier spacing of subcarriers included in the first subband location of the first subband in frequency domain is used for determining the X time intervals.

17. (Original) The base station according to claim 16, wherein any one of the X time intervals belongs to a first time window in time domain; the time length of the first time window is predefined; the first time window is divided into Y time intervals; the X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X; the subcarrier spacing of subcarriers included

in the first subband is used for determining Y; and a feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals, the feature ID refers to a remainder when an International Mobile Subscriber Identification Number (IMSI) is divided by 1024.

18. (Original) The base station according to claim 17, wherein the first time window belongs to one of Z time windows, Z being an integer greater than 1; Z is predefined, or Z is configurable; any two of the Z time windows have an equal time length, any two of the Z time windows are orthogonal in time domain, any one of the Z time windows is a radio frame, Z is equal to the number of radio frames included in a Discontinuous Reception (DRX) cycle; and the feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.

19. (Original) The method according to claim 18, wherein the second transmitter further transmits a third signaling, the third signaling is used for configuring Z.

20. (Original) The base station according to claim 16, wherein the first transmitter further transmits a second radio signal; the second radio signal is for determining at least one of location of the first subband in frequency domain, or subcarrier spacing of subcarriers included in the first subband; the second radio signal carries Master Information Block (MIB) information, or the second radio signal carries System Information Block (SIB) information.

21. (Previously presented) The method according to claim 1, wherein the location of the first subband in frequency domain and the subcarrier spacing of subcarriers included in the first subband are used for determining the X time intervals.

22. (Previously presented) The method according to claim 6, wherein the location of the first subband in frequency domain and the subcarrier spacing of subcarriers included in the first subband are used for determining the X time intervals.

23. (Previously presented) The UE according to claim 11, wherein the location of the first subband in frequency domain and the subcarrier spacing of subcarriers included in the first subband are used for determining the X time intervals.

24. (Previously presented) The base station according to claim 16, wherein the location of the first subband in frequency domain and the subcarrier spacing of subcarriers included in the first subband are used for determining the X time intervals.

REMARKS

Prior to the present preliminary amendment, Applicant submitted a first preliminary amendment on July 20, 2023. Applicant respectfully submits the present preliminary amendment based on the assumption that the first preliminary amendment will be entered.

Claims 1, 6, 11, and 16 are amended. No claims are added. No claims are canceled. Therefore, claims 1 - 24 are presently pending.

Applicant respectfully submits that the amendments to the claims do not add new matters and respectfully requests the entry of the amendments to claims.

An early and favorable action is respectfully requested. If the Examiner believes that issues may be resolved by a telephone interview, the Examiner is invited to telephone the undersigned at (908) 591-2738. The undersigned also may be contacted via e-mail at zhong@zhong-law.com. All correspondence should be directed to our address listed below.

The Commissioner is hereby authorized to charge any fees that may be required, or credit any overpayment, to Deposit Account No. 60-2313.

Respectfully submitted,

ZHONG LAW, LLC
Attorneys/Agents for Applicants

Date: September 24, 2023

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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 17/950,726	Filing Date 09/22/2022	☐ To be Mailed

ENTITY: ☐ LARGE ☑ SMALL ☐ MICRO

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A		N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A		N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*		x $50 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*		x $240 =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).				
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))					
* If the difference in column 1 is less than zero, enter "0" in column 2.				TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT	09/24/2023	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 24	Minus	** 24	= 0		x $40 =	0
	Independent (37 CFR 1.16(h))	* 4	Minus	*** 4	= 0		x $192 =	0
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	0

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=		x $0 =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=		x $0 =	
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.	LIE
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".	/LAVINIA D JOHNSON/
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".	
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.	

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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I20237NL52148018	2202	CLAIMS IN EXCESS OF 20	$160.00	Deposit Account

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ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
17/950,726	**07/20/2023 04:56:41 PM ET**	**ZL0205-0004-US-CON3**

Title of Invention

METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	6005	FILED BY	Jialin Zhong
PATENT CENTER #	62477980	FILING DATE	09/22/2022
CUSTOMER #	155075	FIRST NAMED INVENTOR	Xiaobo ZHANG
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	-

Documents

TOTAL DOCUMENTS: 1

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
ZL0205-0004-US-CON3_Preliminary_Amendment.pdf	9	Preliminary Amendment	122 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
ZL0205-0004-US-CON3_Preliminary_Amendment.pdf	71384F14300B937D6551BADEBA808AAD79F57B07E051009287 6D695B82FC5E438A5C6457305F660364D5749F18E2C40DDE24 E492150F4EA4E295740FC834D8F8

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If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Attorney Docket No.: ZL0205-0004-US-CON3

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:	)	Examiner: AHMED ELALLAM
Xiaobo ZHANG	)	Art Unit: 2471
Application No: 17/950,726	)	Confirmation No.: 6005
Filed: September 22, 2022	)	
For: METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING	)	

Filed Electronically
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

PRELIMINARY AMENDMENT

Sir/Madam:

Prior to examination of the above-referenced application, applicant respectfully submits the following:

Amendments to the Specification begin on page 2 of this paper.

Amendments to the Claims begin on page 3 of this paper.

Remarks begin on page 8 of this paper.

AMENDMENTS TO THE SPECIFICATION

Please amend the first paragraph as reflected in the following marked-up version:

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This disclosure is a continuation of the application 17/180,885 (issued as U.S. Patent 11,457,426), filed on February 22,2021, which is the continuation of the application 16/577,854 (issued as U.S. Patent 10,966,178), filed on September 20,2019, which is the continuation of the application 15/956,742 (issued as U.S. Patent 10,462,767), filed on April 18,2018, and claims the priority benefit of Chinese Patent Application 201710255811.X, filed on April 19, 2017, all of which [[is]] are incorporated herein by reference.

AMENDMENTS TO THE CLAIMS

Please amend the claims as reflected in the following marked-up version:

Listing of Claims:

1. (Currently amended) A method in a User Equipment (UE) for paging, comprising:

monitoring a first signaling in X time intervals; and

receiving a first radio signal;

wherein X is a positive integer; the first signaling is used for determining scheduling information for the first radio signal; the scheduling information comprises at least one of {occupied time-frequency resource, ~~and~~ adopted Modulation Coding Scheme (MCS), subcarrier spacing of subcarriers in occupied frequency domain resource}; the first radio signal carries a paging message; the frequency domain resource used for transmitting the first signaling belongs to a first subband; the first subband comprises a positive integer number of consecutive subcarriers in frequency domain; and location of the first subband in frequency domain ~~subcarrier spacing of subcarriers included in the first subband~~ is used for determining the X time intervals~~; all subcarriers included in the first subband have an equal subcarrier spacing, any two of the X time intervals are orthogonal in time domain; the first signaling is transmitted through a PDCCH, the PDCCH has a Cyclic Redundancy Check (CRC) scrambled by a Paging Radio Network Temporary Identity (P-RNTI), the first radio signal is transmitted through a Physical Downlink Shared Channel (PDSCH); the PDCCH is transmitted in a Common Search Space (CSS)~~.

2. (Original) The method according to claim 1, wherein any one of the X time intervals belongs to a first time window in time domain; the time length of the first time window is predefined; the first time window is divided into Y time intervals; the X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X; the subcarrier spacing of subcarriers included in the first subband is used for determining Y; and a feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals, the feature ID refers to a remainder when an International Mobile Subscriber Identification Number (IMSI) is divided by 1024.

3. (Original) The method according to claim 2, wherein the first time window belongs to one of Z time windows, Z being an integer greater than 1; Z is predefined, or Z is configurable; any two of the Z time windows have an equal time length, any two of the Z time windows are orthogonal in time

domain, any one of the Z time windows is a radio frame, Z is equal to the number of radio frames included in a Discontinuous Reception (DRX) cycle; and the feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.

4. (Original) The method according to claim 3, further comprising:

receiving a third signaling;

wherein, the third signaling is used for configuring Z.

5. (Original) The method according to claim 1, further comprising:

receiving a second radio signal;

wherein the second radio signal is used for determining at least one of location of the first subband in frequency domain, or subcarrier spacing of subcarriers included in the first subband; the second radio signal carries Master Information Block (MIB) information, or the second radio signal carries System Information Block (SIB) information.

6. (Currently amended) A method in a base station for paging, comprising:

transmitting a first signaling in a positive integer number of time intervals of X time intervals; and

transmitting a first radio signal;

wherein X is a positive integer; the first signaling is used for determining scheduling information for the first radio signal; the scheduling information comprises at least one of {occupied time-frequency resource, ~~and~~ adopted MCS, subcarrier spacing of subcarriers in occupied frequency domain resource}; the first radio signal carries a paging message; the frequency domain resource used for transmitting the first signaling belongs to a first subband; the first subband comprises a positive integer number of consecutive subcarriers in frequency domain; and ~~subcarrier spacing of subcarriers included in the first subband~~ location of the first subband in frequency domain is used for determining the X time intervals~~; all subcarriers included in the first subband have an equal subcarrier spacing, any two of the X time intervals are orthogonal in time domain; the first signaling is transmitted through a PDCCH, the PDCCH has a Cyclic Redundancy Check (CRC) scrambled by a Paging Radio Network Temporary Identity (P-RNTI), the first radio signal is transmitted through a Physical Downlink Shared Channel (PDSCH) ; the PDCCH is transmitted in a Common Search Space (CSS)~~.

7. (Original) The method according to claim 6, wherein any one of the X time intervals belongs to a first time window in time domain; the time length of the first time window is predefined; the first time

window is divided into Y time intervals; the X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X; the subcarrier spacing of subcarriers included in the first subband is used for determining Y; and a feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals, the feature ID refers to a remainder when an International Mobile Subscriber Identification Number (IMSI) is divided by 1024.

8. (Original) The method according to claim 7, wherein the first time window belongs to one of Z time windows, Z being an integer greater than 1; Z is predefined, or Z is configurable; any two of the Z time windows have an equal time length, any two of the Z time windows are orthogonal in time domain, any one of the Z time windows is a radio frame, Z is equal to the number of radio frames included in a Discontinuous Reception (DRX) cycle; and the feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.

9. (Original) The method according to claim 8, further comprising:

receiving a third signaling;

wherein, the third signaling is used for configuring Z.

10. (Original) The method according to claim 6, further comprising:

transmitting a second radio signal;

wherein the second radio signal is used for determining at least one of location of the first subband in frequency domain, or subcarrier spacing of subcarriers included in the first subband; the second radio signal carries Master Information Block (MIB) information, or the second radio signal carries System Information Block (SIB) information.

11. (Currently amended) A UE for paging, comprising:

a first receiver, to monitor a first signaling in X time intervals; and

a second receiver, to receive a first radio signal;

wherein X is a positive integer; the first signaling is used for determining scheduling information for the first radio signal; the scheduling information comprises at least one of {occupied time-frequency resource, ~~and~~ adopted MCS, subcarrier spacing of subcarriers in occupied frequency domain resource}; the first radio signal carries a paging message; the frequency domain resource used for transmitting the first signaling belongs to a first subband; the first subband comprises a positive integer number of consecutive subcarriers in frequency domain; and ~~subcarrier spacing of subcarriers~~

~~included in the first subband~~ location of the first subband in frequency domain is used for determining the X time intervals~~; all subcarriers included in the first subband have an equal subcarrier spacing, any two of the X time intervals are orthogonal in time domain; the first signaling is transmitted through a PDCCH, the PDCCH has a Cyclic Redundancy Check (CRC) scrambled by a Paging Radio Network Temporary Identity (P-RNTI), the first radio signal is transmitted through a Physical Downlink Shared Channel (PDSCH) ; the PDCCH is transmitted in a Common Search Space (CSS)~~.

12. (Original) The UE according to claim 11, wherein any one of the X time intervals belongs to a first time window in time domain; the time length of the first time window is predefined; the first time window is divided into Y time intervals; the X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X; the subcarrier spacing of subcarriers included in the first subband is used for determining Y; and a feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals, the feature ID refers to a remainder when an International Mobile Subscriber Identification Number (IMSI) is divided by 1024.

13. (Original) The UE according to claim 12, wherein the first time window belongs to one of Z time windows, Z being an integer greater than 1; Z is predefined, or Z is configurable; any two of the Z time windows have an equal time length, any two of the Z time windows are orthogonal in time domain, any one of the Z time windows is a radio frame, Z is equal to the number of radio frames included in a Discontinuous Reception (DRX) cycle; and the feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.

14. (Original) The method according to claim 13, wherein the second receiver further receives a third signaling, the third signaling is used for configuring Z.

15. (Original) The UE according to claim 11, wherein the first receiver further receives a second radio signal; the second radio signal is for determining at least one of location of the first subband in frequency domain, or subcarrier spacing of subcarriers included in the first subband; the second radio signal carries Master Information Block (MIB) information, or the second radio signal carries System Information Block (SIB) information.

16. (Currently amended) A base station for paging, comprising:

a first transmitter, to transmit a first signaling in a positive integer number of time intervals of X time intervals; and

a second transmitter, to transmit a first radio signal;

wherein X is a positive integer; the first signaling is used for determining scheduling information for the first radio signal; the scheduling information comprises at least one of {occupied time-frequency resource, ~~and~~ adopted MCS, subcarrier spacing of subcarriers in occupied frequency domain resource}; the first radio signal carries a paging message; the frequency domain resource used for transmitting the first signaling belongs to a first subband; the first subband comprises a positive integer number of consecutive subcarriers in frequency domain; and subcarrier spacing of subcarriers included in the first subband location of the first subband in frequency domain is used for determining the X time intervals~~; all subcarriers included in the first subband have an equal subcarrier spacing, any two of the X time intervals are orthogonal in time domain; the first signaling is transmitted through a PDCCH, the PDCCH has a Cyclic Redundancy Check (CRC) scrambled by a Paging Radio Network Temporary Identity (P-RNTI), the first radio signal is transmitted through a Physical Downlink Shared Channel (PDSCH) ; the PDCCH is transmitted in a Common Search Space (CSS)~~.

17. (Original) The base station according to claim 16, wherein any one of the X time intervals belongs to a first time window in time domain; the time length of the first time window is predefined; the first time window is divided into Y time intervals; the X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X; the subcarrier spacing of subcarriers included in the first subband is used for determining Y; and a feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals, the feature ID refers to a remainder when an International Mobile Subscriber Identification Number (IMSI) is divided by 1024.

18. (Original) The base station according to claim 17, wherein the first time window belongs to one of Z time windows, Z being an integer greater than 1; Z is predefined, or Z is configurable; any two of the Z time windows have an equal time length, any two of the Z time windows are orthogonal in time domain, any one of the Z time windows is a radio frame, Z is equal to the number of radio frames included in a Discontinuous Reception (DRX) cycle; and the feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.

19. (Original) The method according to claim 18, wherein the second transmitter further transmits a third signaling, the third signaling is used for configuring Z.

20. (Original) The base station according to claim 16, wherein the first transmitter further transmits a second radio signal; the second radio signal is for determining at least one of location of the first subband in frequency domain, or subcarrier spacing of subcarriers included in the first subband; the second radio signal carries Master Information Block (MIB) information, or the second radio signal carries System Information Block (SIB) information.

21. (New) The method according to claim 1, wherein the location of the first subband in frequency domain and the subcarrier spacing of subcarriers included in the first subband are used for determining the X time intervals.

22. (New) The method according to claim 6, wherein the location of the first subband in frequency domain and the subcarrier spacing of subcarriers included in the first subband are used for determining the X time intervals.

23. (New) The UE according to claim 11, wherein the location of the first subband in frequency domain and the subcarrier spacing of subcarriers included in the first subband are used for determining the X time intervals.

24. (New) The base station according to claim 16, wherein the location of the first subband in frequency domain and the subcarrier spacing of subcarriers included in the first subband are used for determining the X time intervals.

REMARKS

The Specification is amended to add priority information. Claims 1, 6, 11, and 16 are amended. Claim 21-24 have been added without adding new matter. No claims are canceled. Therefore, claims 1 - 24 are presently pending.

Applicant respectfully submits that the amendments to the claims do not add new matters and respectfully requests the entry of the amendments to claims.

An early and favorable action is respectfully requested. If the Examiner believes that issues may be resolved by a telephone interview, the Examiner is invited to telephone the undersigned at (908) 591-2738. The undersigned also may be contacted via e-mail at zhong@zhong-law.com. All correspondence should be directed to our address listed below.

The Commissioner is hereby authorized to charge any fees that may be required, or credit any overpayment, to Deposit Account No. 60-2313.

Respectfully submitted,

ZHONG LAW, LLC
Attorneys/Agents for Applicants

Date: July 20, 2023

/ Jialin Zhong/
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51 JFK Parkway, First Floor West
Short Hills, New Jersey 07078

AMENDMENTS TO THE CLAIMS

Please amend the claims as reflected in the following marked-up version:

Listing of Claims:

1. (Currently amended) A method in a User Equipment (UE) for paging, comprising:

monitoring a first signaling in X time intervals; and

receiving a first radio signal;

wherein X is a positive integer; the first signaling is used for determining scheduling information for the first radio signal; the scheduling information comprises at least one of {occupied time-frequency resource, ~~and~~ adopted Modulation Coding Scheme (MCS), subcarrier spacing of subcarriers in occupied frequency domain resource}; the first radio signal carries a paging message; the frequency domain resource used for transmitting the first signaling belongs to a first subband; the first subband comprises a positive integer number of consecutive subcarriers in frequency domain; and location of the first subband in frequency domain ~~subcarrier spacing of subcarriers included in the first subband~~ is used for determining the X time intervals~~; all subcarriers included in the first subband have an equal subcarrier spacing, any two of the X time intervals are orthogonal in time domain; the first signaling is transmitted through a PDCCH, the PDCCH has a Cyclic Redundancy Check (CRC) scrambled by a Paging Radio Network Temporary Identity (P-RNTI), the first radio signal is transmitted through a Physical Downlink Shared Channel (PDSCH); the PDCCH is transmitted in a Common Search Space (CSS)~~.

2. (Original) The method according to claim 1, wherein any one of the X time intervals belongs to a first time window in time domain; the time length of the first time window is predefined; the first time window is divided into Y time intervals; the X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X; the subcarrier spacing of subcarriers included in the first subband is used for determining Y; and a feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals, the feature ID refers to a remainder when an International Mobile Subscriber Identification Number (IMSI) is divided by 1024.

3. (Original) The method according to claim 2, wherein the first time window belongs to one of Z time windows, Z being an integer greater than 1; Z is predefined, or Z is configurable; any two of the Z time windows have an equal time length, any two of the Z time windows are orthogonal in time

domain, any one of the Z time windows is a radio frame, Z is equal to the number of radio frames included in a Discontinuous Reception (DRX) cycle; and the feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.

4. (Original) The method according to claim 3, further comprising:

receiving a third signaling;

wherein, the third signaling is used for configuring Z.

5. (Original) The method according to claim 1, further comprising:

receiving a second radio signal;

wherein the second radio signal is used for determining at least one of location of the first subband in frequency domain, or subcarrier spacing of subcarriers included in the first subband; the second radio signal carries Master Information Block (MIB) information, or the second radio signal carries System Information Block (SIB) information.

6. (Currently amended) A method in a base station for paging, comprising:

transmitting a first signaling in a positive integer number of time intervals of X time intervals; and

transmitting a first radio signal;

wherein X is a positive integer; the first signaling is used for determining scheduling information for the first radio signal; the scheduling information comprises at least one of {occupied time-frequency resource, ~~and~~ adopted MCS, subcarrier spacing of subcarriers in occupied frequency domain resource}; the first radio signal carries a paging message; the frequency domain resource used for transmitting the first signaling belongs to a first subband; the first subband comprises a positive integer number of consecutive subcarriers in frequency domain; and ~~subcarrier spacing of subcarriers included in the first subband~~ location of the first subband in frequency domain is used for determining the X time intervals~~; all subcarriers included in the first subband have an equal subcarrier spacing, any two of the X time intervals are orthogonal in time domain; the first signaling is transmitted through a PDCCH, the PDCCH has a Cyclic Redundancy Check (CRC) scrambled by a Paging Radio Network Temporary Identity (P-RNTI), the first radio signal is transmitted through a Physical Downlink Shared Channel (PDSCH) ; the PDCCH is transmitted in a Common Search Space (CSS)~~.

7. (Original) The method according to claim 6, wherein any one of the X time intervals belongs to a first time window in time domain; the time length of the first time window is predefined; the first time

window is divided into Y time intervals; the X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X; the subcarrier spacing of subcarriers included in the first subband is used for determining Y; and a feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals, the feature ID refers to a remainder when an International Mobile Subscriber Identification Number (IMSI) is divided by 1024.

8. (Original) The method according to claim 7, wherein the first time window belongs to one of Z time windows, Z being an integer greater than 1; Z is predefined, or Z is configurable; any two of the Z time windows have an equal time length, any two of the Z time windows are orthogonal in time domain, any one of the Z time windows is a radio frame, Z is equal to the number of radio frames included in a Discontinuous Reception (DRX) cycle; and the feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.

9. (Original) The method according to claim 8, further comprising:

receiving a third signaling;

wherein, the third signaling is used for configuring Z.

10. (Original) The method according to claim 6, further comprising:

transmitting a second radio signal;

wherein the second radio signal is used for determining at least one of location of the first subband in frequency domain, or subcarrier spacing of subcarriers included in the first subband; the second radio signal carries Master Information Block (MIB) information, or the second radio signal carries System Information Block (SIB) information.

11. (Currently amended) A UE for paging, comprising:

a first receiver, to monitor a first signaling in X time intervals; and

a second receiver, to receive a first radio signal;

wherein X is a positive integer; the first signaling is used for determining scheduling information for the first radio signal; the scheduling information comprises at least one of {occupied time-frequency resource, ~~and~~ adopted MCS, subcarrier spacing of subcarriers in occupied frequency domain resource}; the first radio signal carries a paging message; the frequency domain resource used for transmitting the first signaling belongs to a first subband; the first subband comprises a positive integer number of consecutive subcarriers in frequency domain; and ~~subcarrier spacing of subcarriers~~

~~included in the first subband~~ location of the first subband in frequency domain is used for determining the X time intervals~~; all subcarriers included in the first subband have an equal subcarrier spacing, any two of the X time intervals are orthogonal in time domain; the first signaling is transmitted through a PDCCH, the PDCCH has a Cyclic Redundancy Check (CRC) scrambled by a Paging Radio Network Temporary Identity (P-RNTI), the first radio signal is transmitted through a Physical Downlink Shared Channel (PDSCH) ; the PDCCH is transmitted in a Common Search Space (CSS)~~.

12. (Original) The UE according to claim 11, wherein any one of the X time intervals belongs to a first time window in time domain; the time length of the first time window is predefined; the first time window is divided into Y time intervals; the X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X; the subcarrier spacing of subcarriers included in the first subband is used for determining Y; and a feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals, the feature ID refers to a remainder when an International Mobile Subscriber Identification Number (IMSI) is divided by 1024.

13. (Original) The UE according to claim 12, wherein the first time window belongs to one of Z time windows, Z being an integer greater than 1; Z is predefined, or Z is configurable; any two of the Z time windows have an equal time length, any two of the Z time windows are orthogonal in time domain, any one of the Z time windows is a radio frame, Z is equal to the number of radio frames included in a Discontinuous Reception (DRX) cycle; and the feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.

14. (Original) The method according to claim 13, wherein the second receiver further receives a third signaling, the third signaling is used for configuring Z.

15. (Original) The UE according to claim 11, wherein the first receiver further receives a second radio signal; the second radio signal is for determining at least one of location of the first subband in frequency domain, or subcarrier spacing of subcarriers included in the first subband; the second radio signal carries Master Information Block (MIB) information, or the second radio signal carries System Information Block (SIB) information.

16. (Currently amended) A base station for paging, comprising:

a first transmitter, to transmit a first signaling in a positive integer number of time intervals of X time intervals; and

a second transmitter, to transmit a first radio signal;

wherein X is a positive integer; the first signaling is used for determining scheduling information for the first radio signal; the scheduling information comprises at least one of {occupied time-frequency resource, ~~and~~ adopted MCS, subcarrier spacing of subcarriers in occupied frequency domain resource}; the first radio signal carries a paging message; the frequency domain resource used for transmitting the first signaling belongs to a first subband; the first subband comprises a positive integer number of consecutive subcarriers in frequency domain; and subcarrier spacing of subcarriers included in the first subband location of the first subband in frequency domain is used for determining the X time intervals~~; all subcarriers included in the first subband have an equal subcarrier spacing, any two of the X time intervals are orthogonal in time domain; the first signaling is transmitted through a PDCCH, the PDCCH has a Cyclic Redundancy Check (CRC) scrambled by a Paging Radio Network Temporary Identity (P-RNTI), the first radio signal is transmitted through a Physical Downlink Shared Channel (PDSCH) ; the PDCCH is transmitted in a Common Search Space (CSS)~~.

17. (Original) The base station according to claim 16, wherein any one of the X time intervals belongs to a first time window in time domain; the time length of the first time window is predefined; the first time window is divided into Y time intervals; the X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X; the subcarrier spacing of subcarriers included in the first subband is used for determining Y; and a feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals, the feature ID refers to a remainder when an International Mobile Subscriber Identification Number (IMSI) is divided by 1024.

18. (Original) The base station according to claim 17, wherein the first time window belongs to one of Z time windows, Z being an integer greater than 1; Z is predefined, or Z is configurable; any two of the Z time windows have an equal time length, any two of the Z time windows are orthogonal in time domain, any one of the Z time windows is a radio frame, Z is equal to the number of radio frames included in a Discontinuous Reception (DRX) cycle; and the feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.

19. (Original) The method according to claim 18, wherein the second transmitter further transmits a third signaling, the third signaling is used for configuring Z.

20. (Original) The base station according to claim 16, wherein the first transmitter further transmits a second radio signal; the second radio signal is for determining at least one of location of the first subband in frequency domain, or subcarrier spacing of subcarriers included in the first subband; the second radio signal carries Master Information Block (MIB) information, or the second radio signal carries System Information Block (SIB) information.

21. (New) The method according to claim 1, wherein the location of the first subband in frequency domain and the subcarrier spacing of subcarriers included in the first subband are used for determining the X time intervals.

22. (New) The method according to claim 6, wherein the location of the first subband in frequency domain and the subcarrier spacing of subcarriers included in the first subband are used for determining the X time intervals.

23. (New) The UE according to claim 11, wherein the location of the first subband in frequency domain and the subcarrier spacing of subcarriers included in the first subband are used for determining the X time intervals.

24. (New) The base station according to claim 16, wherein the location of the first subband in frequency domain and the subcarrier spacing of subcarriers included in the first subband are used for determining the X time intervals.

REMARKS

The Specification is amended to add priority information. Claims 1, 6, 11, and 16 are amended. Claim 21-24 have been added without adding new matter. No claims are canceled. Therefore, claims 1 - 24 are presently pending.

Applicant respectfully submits that the amendments to the claims do not add new matters and respectfully requests the entry of the amendments to claims.

An early and favorable action is respectfully requested. If the Examiner believes that issues may be resolved by a telephone interview, the Examiner is invited to telephone the undersigned at (908) 591-2738. The undersigned also may be contacted via e-mail at zhong@zhong-law.com. All correspondence should be directed to our address listed below.

The Commissioner is hereby authorized to charge any fees that may be required, or credit any overpayment, to Deposit Account No. 60-2313.

Respectfully submitted,

ZHONG LAW, LLC
Attorneys/Agents for Applicants

Date: July 20, 2023

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AMENDMENTS TO THE CLAIMS

Please amend the claims as reflected in the following marked-up version:

Listing of Claims:

1. (Currently amended) A method in a User Equipment (UE) for paging, comprising:

monitoring a first signaling in X time intervals; and

receiving a first radio signal;

wherein X is a positive integer; the first signaling is used for determining scheduling information for the first radio signal; the scheduling information comprises at least one of {occupied time-frequency resource, ~~and~~ adopted Modulation Coding Scheme (MCS), subcarrier spacing of subcarriers in occupied frequency domain resource}; the first radio signal carries a paging message; the frequency domain resource used for transmitting the first signaling belongs to a first subband; the first subband comprises a positive integer number of consecutive subcarriers in frequency domain; and location of the first subband in frequency domain ~~subcarrier spacing of subcarriers included in the first subband~~ is used for determining the X time intervals~~; all subcarriers included in the first subband have an equal subcarrier spacing, any two of the X time intervals are orthogonal in time domain; the first signaling is transmitted through a PDCCH, the PDCCH has a Cyclic Redundancy Check (CRC) scrambled by a Paging Radio Network Temporary Identity (P-RNTI), the first radio signal is transmitted through a Physical Downlink Shared Channel (PDSCH); the PDCCH is transmitted in a Common Search Space (CSS)~~.

2. (Original) The method according to claim 1, wherein any one of the X time intervals belongs to a first time window in time domain; the time length of the first time window is predefined; the first time window is divided into Y time intervals; the X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X; the subcarrier spacing of subcarriers included in the first subband is used for determining Y; and a feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals, the feature ID refers to a remainder when an International Mobile Subscriber Identification Number (IMSI) is divided by 1024.

3. (Original) The method according to claim 2, wherein the first time window belongs to one of Z time windows, Z being an integer greater than 1; Z is predefined, or Z is configurable; any two of the Z time windows have an equal time length, any two of the Z time windows are orthogonal in time

domain, any one of the Z time windows is a radio frame, Z is equal to the number of radio frames included in a Discontinuous Reception (DRX) cycle; and the feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.

4. (Original) The method according to claim 3, further comprising:

receiving a third signaling;

wherein, the third signaling is used for configuring Z.

5. (Original) The method according to claim 1, further comprising:

receiving a second radio signal;

wherein the second radio signal is used for determining at least one of location of the first subband in frequency domain, or subcarrier spacing of subcarriers included in the first subband; the second radio signal carries Master Information Block (MIB) information, or the second radio signal carries System Information Block (SIB) information.

6. (Currently amended) A method in a base station for paging, comprising:

transmitting a first signaling in a positive integer number of time intervals of X time intervals; and

transmitting a first radio signal;

wherein X is a positive integer; the first signaling is used for determining scheduling information for the first radio signal; the scheduling information comprises at least one of {occupied time-frequency resource, ~~and~~ adopted MCS, subcarrier spacing of subcarriers in occupied frequency domain resource}; the first radio signal carries a paging message; the frequency domain resource used for transmitting the first signaling belongs to a first subband; the first subband comprises a positive integer number of consecutive subcarriers in frequency domain; and ~~subcarrier spacing of subcarriers included in the first subband~~ location of the first subband in frequency domain is used for determining the X time intervals~~; all subcarriers included in the first subband have an equal subcarrier spacing, any two of the X time intervals are orthogonal in time domain; the first signaling is transmitted through a PDCCH, the PDCCH has a Cyclic Redundancy Check (CRC) scrambled by a Paging Radio Network Temporary Identity (P-RNTI), the first radio signal is transmitted through a Physical Downlink Shared Channel (PDSCH) ; the PDCCH is transmitted in a Common Search Space (CSS)~~.

7. (Original) The method according to claim 6, wherein any one of the X time intervals belongs to a first time window in time domain; the time length of the first time window is predefined; the first time

window is divided into Y time intervals; the X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X; the subcarrier spacing of subcarriers included in the first subband is used for determining Y; and a feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals, the feature ID refers to a remainder when an International Mobile Subscriber Identification Number (IMSI) is divided by 1024.

8. (Original) The method according to claim 7, wherein the first time window belongs to one of Z time windows, Z being an integer greater than 1; Z is predefined, or Z is configurable; any two of the Z time windows have an equal time length, any two of the Z time windows are orthogonal in time domain, any one of the Z time windows is a radio frame, Z is equal to the number of radio frames included in a Discontinuous Reception (DRX) cycle; and the feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.

9. (Original) The method according to claim 8, further comprising:

receiving a third signaling;

wherein, the third signaling is used for configuring Z.

10. (Original) The method according to claim 6, further comprising:

transmitting a second radio signal;

wherein the second radio signal is used for determining at least one of location of the first subband in frequency domain, or subcarrier spacing of subcarriers included in the first subband; the second radio signal carries Master Information Block (MIB) information, or the second radio signal carries System Information Block (SIB) information.

11. (Currently amended) A UE for paging, comprising:

a first receiver, to monitor a first signaling in X time intervals; and

a second receiver, to receive a first radio signal;

wherein X is a positive integer; the first signaling is used for determining scheduling information for the first radio signal; the scheduling information comprises at least one of {occupied time-frequency resource, ~~and~~ adopted MCS, subcarrier spacing of subcarriers in occupied frequency domain resource}; the first radio signal carries a paging message; the frequency domain resource used for transmitting the first signaling belongs to a first subband; the first subband comprises a positive integer number of consecutive subcarriers in frequency domain; and ~~subcarrier spacing of subcarriers~~

~~included in the first subband~~ location of the first subband in frequency domain is used for determining the X time intervals~~; all subcarriers included in the first subband have an equal subcarrier spacing, any two of the X time intervals are orthogonal in time domain; the first signaling is transmitted through a PDCCH, the PDCCH has a Cyclic Redundancy Check (CRC) scrambled by a Paging Radio Network Temporary Identity (P-RNTI), the first radio signal is transmitted through a Physical Downlink Shared Channel (PDSCH) ; the PDCCH is transmitted in a Common Search Space (CSS)~~.

12. (Original) The UE according to claim 11, wherein any one of the X time intervals belongs to a first time window in time domain; the time length of the first time window is predefined; the first time window is divided into Y time intervals; the X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X; the subcarrier spacing of subcarriers included in the first subband is used for determining Y; and a feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals, the feature ID refers to a remainder when an International Mobile Subscriber Identification Number (IMSI) is divided by 1024.

13. (Original) The UE according to claim 12, wherein the first time window belongs to one of Z time windows, Z being an integer greater than 1; Z is predefined, or Z is configurable; any two of the Z time windows have an equal time length, any two of the Z time windows are orthogonal in time domain, any one of the Z time windows is a radio frame, Z is equal to the number of radio frames included in a Discontinuous Reception (DRX) cycle; and the feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.

14. (Original) The method according to claim 13, wherein the second receiver further receives a third signaling, the third signaling is used for configuring Z.

15. (Original) The UE according to claim 11, wherein the first receiver further receives a second radio signal; the second radio signal is for determining at least one of location of the first subband in frequency domain, or subcarrier spacing of subcarriers included in the first subband; the second radio signal carries Master Information Block (MIB) information, or the second radio signal carries System Information Block (SIB) information.

16. (Currently amended) A base station for paging, comprising:

a first transmitter, to transmit a first signaling in a positive integer number of time intervals of X time intervals; and

a second transmitter, to transmit a first radio signal;

wherein X is a positive integer; the first signaling is used for determining scheduling information for the first radio signal; the scheduling information comprises at least one of {occupied time-frequency resource, ~~and~~ adopted MCS, subcarrier spacing of subcarriers in occupied frequency domain resource}; the first radio signal carries a paging message; the frequency domain resource used for transmitting the first signaling belongs to a first subband; the first subband comprises a positive integer number of consecutive subcarriers in frequency domain; and subcarrier spacing of subcarriers included in the first subband location of the first subband in frequency domain is used for determining the X time intervals~~; all subcarriers included in the first subband have an equal subcarrier spacing, any two of the X time intervals are orthogonal in time domain; the first signaling is transmitted through a PDCCH, the PDCCH has a Cyclic Redundancy Check (CRC) scrambled by a Paging Radio Network Temporary Identity (P-RNTI), the first radio signal is transmitted through a Physical Downlink Shared Channel (PDSCH) ; the PDCCH is transmitted in a Common Search Space (CSS)~~.

17. (Original) The base station according to claim 16, wherein any one of the X time intervals belongs to a first time window in time domain; the time length of the first time window is predefined; the first time window is divided into Y time intervals; the X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X; the subcarrier spacing of subcarriers included in the first subband is used for determining Y; and a feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals, the feature ID refers to a remainder when an International Mobile Subscriber Identification Number (IMSI) is divided by 1024.

18. (Original) The base station according to claim 17, wherein the first time window belongs to one of Z time windows, Z being an integer greater than 1; Z is predefined, or Z is configurable; any two of the Z time windows have an equal time length, any two of the Z time windows are orthogonal in time domain, any one of the Z time windows is a radio frame, Z is equal to the number of radio frames included in a Discontinuous Reception (DRX) cycle; and the feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.

19. (Original) The method according to claim 18, wherein the second transmitter further transmits a third signaling, the third signaling is used for configuring Z.

20. (Original) The base station according to claim 16, wherein the first transmitter further transmits a second radio signal; the second radio signal is for determining at least one of location of the first subband in frequency domain, or subcarrier spacing of subcarriers included in the first subband; the second radio signal carries Master Information Block (MIB) information, or the second radio signal carries System Information Block (SIB) information.

21. (New) The method according to claim 1, wherein the location of the first subband in frequency domain and the subcarrier spacing of subcarriers included in the first subband are used for determining the X time intervals.

22. (New) The method according to claim 6, wherein the location of the first subband in frequency domain and the subcarrier spacing of subcarriers included in the first subband are used for determining the X time intervals.

23. (New) The UE according to claim 11, wherein the location of the first subband in frequency domain and the subcarrier spacing of subcarriers included in the first subband are used for determining the X time intervals.

24. (New) The base station according to claim 16, wherein the location of the first subband in frequency domain and the subcarrier spacing of subcarriers included in the first subband are used for determining the X time intervals.

REMARKS

The Specification is amended to add priority information. Claims 1, 6, 11, and 16 are amended. Claim 21-24 have been added without adding new matter. No claims are canceled. Therefore, claims 1 - 24 are presently pending.

Applicant respectfully submits that the amendments to the claims do not add new matters and respectfully requests the entry of the amendments to claims.

An early and favorable action is respectfully requested. If the Examiner believes that issues may be resolved by a telephone interview, the Examiner is invited to telephone the undersigned at (908) 591-2738. The undersigned also may be contacted via e-mail at zhong@zhong-law.com. All correspondence should be directed to our address listed below.

The Commissioner is hereby authorized to charge any fees that may be required, or credit any overpayment, to Deposit Account No. 60-2313.

Respectfully submitted,

ZHONG LAW, LLC
Attorneys/Agents for Applicants

Date: July 20, 2023

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PTO/SB/06 (09-11)
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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 17/950,726	Filing Date 09/22/2022	☐ To be Mailed

ENTITY: ☐ LARGE ☑ SMALL ☐ MICRO

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A		N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A		N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*		x $50 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*		x $240 =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).				
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))					
* If the difference in column 1 is less than zero, enter "0" in column 2.				TOTAL	

APPLICATION AS AMENDED - PART II

AMENDMENT	07/20/2023	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 24	Minus	** 20	= 4		x $40 =	160
	Independent (37 CFR 1.16(h))	* 4	Minus	*** 4	= 0		x $192 =	0
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	160

AMENDMENT		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=		x $0 =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=		x $0 =	
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.	LIE
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".	/LAVINIA D JOHNSON/
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".	
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.	

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
17/950,726	09/22/2022	Xiaobo ZHANG	ZL0205-0004-US-CON3

CONFIRMATION NO. 6005

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Zhong Law, LLC
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PUBLICATION NOTICE

Date Mailed: 07/13/2023

Title:METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

Publication No.US-2023-0224857-A1
Publication Date:07/13/2023

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
17/950,726	09/22/2022	2683	920	ZL0205-0004-US-CON3	20	4

CONFIRMATION NO. 6005

UPDATED FILING RECEIPT

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OC00000005730742

Date Mailed: 04/07/2023

Receipt is acknowledged of this non-provisional utility patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

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Inventor(s)

Xiaobo ZHANG, Shanghai, CHINA;

Applicant(s)

APEX BEAM TECHNOLOGIES LLC, MARSHALL, TX;

Assignment For Published Patent Application

APEX BEAM TECHNOLOGIES LLC, MARSHALL, TX

Power of Attorney: The patent practitioners associated with Customer Number 155075

Domestic Priority data as claimed by applicant

This application is a CON of 17/180,885 02/22/2021 PAT 11,457,426
which is a CON of 16/577,854 09/20/2019 PAT 10,966,178
which is a CON of 15/956,742 04/18/2018 PAT 10,462,767

Foreign Applications (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.)
CHINA 201710255811.X 04/19/2017 No Access Code Provided

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 10/05/2022

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 17/950,726**

Projected Publication Date: 07/13/2023

Non-Publication Request: No

Early Publication Request: No
**** SMALL ENTITY ****
Title

METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

Preliminary Class

340

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

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For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific

countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

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NOT GRANTED

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The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop

technology, manufacture products, deliver services, and grow your business, visit http://www.SelectUSA.gov or call +1-202-482-6800.

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 17/950,726

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	64		N/A	
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	280		N/A	
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	320		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	20 minus 20 =	* 0	x =	0	OR		
INDEPENDENT CLAIMS (37 CFR 1.16(h))	4 minus 3 =	* 1	x 192 =	192			
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			0			
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				0			
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	856		TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT A	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE($)	ADDITIONAL FEE($)	OR	RATE($)	ADDITIONAL FEE($)
AMENDMENT B	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

IN THE UNITED STATES
PATENT AND TRADEMARK OFFICE

Application No.	: 17/950,726	Confirmation No. 6005
Inventors	: Xiaobo Zhang	
Filed	: September 22, 2022	
Docket No.	: ZL0205-0004-US-CON3	

Title : METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

Commissioner for Patents
PO Box 1450
Alexandria, Virginia 22313-1450.

RESPONSE TO NOTICE TO FILE MISSING PARTS

Sir:

In response to the Notice to file Missing Parts dated October 6, 2022, submitted herewith are the following fees:

□ Basic filing fee ($64)

□ Application search fee ($280)

□ Application examination fee ($320)

□ Surcharge ($64)

□ 1 independent claims over 3 ($192)

Also submitted herewith is a 4 month extension of time.

The Commissioner is hereby authorized to charge any additional fees or credit any overpayment to Deposit Account 60-2313.

Respectfully submitted,

ZHONG LAW, LLC
Attorneys/Agents for Applicants

Date: April 5, 2023

/Jialin Zhong/
Jialin Zhong
Registration No. 62,937

51 JFK Parkway, 1st Floor West
Short Hills, New Jersey 07078

Electronic Patent Application Fee Transmittal

Application Number:	17950726
Filing Date:	22-Sep-2022
Title of Invention:	METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING
First Named Inventor/Applicant Name:	Xiaobo ZHANG
Filer:	Jialin Zhong/Eddie Rowell
Attorney Docket Number:	ZL0205-0004-US-CON3

Filed as Small Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
UTILITY FILING FEE (ELECTRONIC FILING)	4011	1	64	64
UTILITY SEARCH FEE	2111	1	280	280
UTILITY EXAMINATION FEE	2311	1	320	320
Pages:				
Claims:				
INDEPENDENT CLAIMS IN EXCESS OF 3	2201	1	192	192
Miscellaneous-Filing:				
LATE FILING FEE FOR OATH OR DECLARATION	2051	1	64	64

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Extension - 4 months with $0 paid	2254	1	928	928
Miscellaneous:				
		Total in USD ($)		**1848**

Electronic Acknowledgement Receipt

EFS ID:	47793398
Application Number:	17950726
International Application Number:	
Confirmation Number:	6005
Title of Invention:	METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING
First Named Inventor/Applicant Name:	Xiaobo ZHANG
Customer Number:	155075
Filer:	Jialin Zhong/Eddie Rowell
Filer Authorized By:	Jialin Zhong
Attorney Docket Number:	ZL0205-0004-US-CON3
Receipt Date:	05-APR-2023
Filing Date:	22-SEP-2022
Time Stamp:	15:34:59
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$1848
RAM confirmation Number	E202345F35438802
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Applicant Response to Pre-Exam Formalities Notice	Response_to_Notice_to_File_Missing_Parts.pdf	23831 78f46e23ff6c26078833ed41d84c137e2ceb8e2cd	no	2
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	51134 a799e27e330a948a1619784bcdd079cc70e89a5b	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	74965		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
17/950,726	09/22/2022	2683	0	ZL0205-0004-US-CON3	20	4

CONFIRMATION NO. 6005

CORRECTED FILING RECEIPT

155075
Zhong Law, LLC
51 JFK Parkway
1st Floor West
Short Hills, NJ 07078

OC000000049850548

Date Mailed: 10/19/2022

Receipt is acknowledged of this non-provisional utility patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

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Inventor(s)

Xiaobo ZHANG, Shanghai, CHINA;

Applicant(s)

APEX BEAM TECHNOLOGIES LLC, MARSHALL, TX;

Assignment For Published Patent Application

APEX BEAM TECHNOLOGIES LLC, MARSHALL, TX

Power of Attorney: The patent practitioners associated with Customer Number 155075

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This application is a CON of 17/180,885 02/22/2021 PAT 11,457,426
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which is a CON of 15/956,742 04/18/2018 PAT 10,462,767

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CHINA 201710255811.X 04/19/2017 No Access Code Provided

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 10/05/2022

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 17/950,726**

Projected Publication Date: Reprint Filing Receipt

Non-Publication Request: No

Early Publication Request: No
**** SMALL ENTITY ****
Title

METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

Preliminary Class

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countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

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Title 37, Code of Federal Regulations, 5.11 & 5.15

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NOT GRANTED

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technology, manufacture products, deliver services, and grow your business, visit http://www.SelectUSA.gov or call +1-202-482-6800.

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 17/950,726

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	80		N/A	
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	350		N/A	
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	400		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	20 minus 20 =	* 0	x =	0	OR		
INDEPENDENT CLAIMS (37 CFR 1.16(h))	4 minus 3 =	* 1	x 240 =	240			
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			0			
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				0			
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	1070		TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT A	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE($)	ADDITIONAL FEE($)	OR	RATE($)	ADDITIONAL FEE($)
AMENDMENT B	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
17/950,726	09/22/2022	2683	0	ZL0205-0004-US-CON3	20	4

CONFIRMATION NO. 6005

155075
Zhong Law, LLC
51 JFK Parkway
1st Floor West
Short Hills, NJ 07078

FILING RECEIPT

OC000000049447598

Date Mailed: 10/06/2022

Receipt is acknowledged of this non-provisional utility patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

Please verify the accuracy of the data presented on this receipt. If an error is noted on this Filing Receipt, please submit a written request for a corrected Filing Receipt, including a properly marked-up ADS showing the changes with strike-through for deletions and underlining for additions. If you received a "Notice to File Missing Parts" or other Notice requiring a response for this application, please submit any request for correction to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections provided that the request is grantable.

Inventor(s)

Xiaobo ZHANG, Shanghai, CHINA;

Applicant(s)

APEX BEAM TECHNOLOGIES LLC, MARSHALL, TX;

Assignment For Published Patent Application

APEX BEAM TECHNOLOGIES LLC, MARSHALL, TX

Power of Attorney: The patent practitioners associated with Customer Number 155075

Domestic Priority data as claimed by applicant

This application is a CON of 17/180,885 02/22/2021 PAT 11,457,426
which is a CON of 16/577,854 09/20/2019 PAT 10,966,178
which is a CON of 15/956,742 04/18/2018 PAT 10,462,767

Foreign Applications (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.)
CHINA 201710255811.X 04/19/2017 No Access Code Provided

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

Projected Publication Date: To Be Determined - pending completion of Missing Parts

Non-Publication Request: No

Early Publication Request: No
**** SMALL ENTITY ****
Title

METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

Preliminary Class

340

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

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The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop technology, manufacture products, deliver services, and grow your business, visit http://www.SelectUSA.gov or call +1-202-482-6800.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
17/950,726	09/22/2022	Xiaobo ZHANG	ZL0205-0004-US-CON3

CONFIRMATION NO. 6005

155075
Zhong Law, LLC
51 JFK Parkway
1st Floor West
Short Hills, NJ 07078

FORMALITIES LETTER

OC000000049447600

Date Mailed: 10/06/2022

NOTICE TO FILE MISSING PARTS OF NONPROVISIONAL APPLICATION

FILED UNDER 37 CFR 1.53(b)

Filing Date Granted

An application number and filing date have been accorded to the above-identified nonprovisional application. The item(s) indicated below, however, are missing. Applicant is given **TWO MONTHS** from the date of this Notice within which to file all required items below to avoid abandonment. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

- The statutory basic filing fee has not been received.
- The application search fee must be submitted.
- The application examination fee must be submitted.
- Additional claim fees of $**240** as a small entity, including any required multiple dependent claim fee, are required. Applicant must submit the additional claim fees or cancel the additional claims for which fees are due.
- Surcharge as set forth in 37 CFR 1.16(f) has not been received.

  The surcharge is due for any one of:
  - late submission of the basic filing fee, search fee, or examination fee,
  - late submission of inventor's oath or declaration,
  - filing an application that does not contain at least one claim on filing, or
  - submission of an application filed by reference to a previously filed application.

SUMMARY OF FEES DUE:

The fee(s) required (including the fees noted above) are as follows. Small entity discount is in effect. If applicant is qualified for micro entity status, an acceptable Certification of Micro Entity Status must be submitted to establish micro entity status. (See 37 CFR 1.29 and forms PTO/SB/15A and 15B.)

- $**80** basic filing fee.
- $**80** surcharge.
- $**350** search fee.
- $**400** examination fee.
- $**240** for 1 independent claims over 3.
- $(**0**) previous unapplied payment amount.

- $**1150** TOTAL FEE BALANCE DUE.

Replies must be received in the USPTO within the set time period or must include a proper Certificate of Mailing or Transmission under 37 CFR 1.8 with a mailing or transmission date within the set time period. For more information and a suggested format, see Form PTO/SB/92 and MPEP 512.

Replies should be addressed to:

Mail Stop Missing Parts
Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

REPLY VIA ELECTRONIC FILING

A reply may be submitted via electronic filing only by registered users of the appropriate USPTO patent electronic filing system and must include:

- A separate document having the document description, "**Applicant response to Pre-Exam Formalities Notice**"; and
- the item(s) for which a reply period is set forth above.

For more information about electronic filing, contact the Patent Electronic Business Center (EBC) 1-866-217-9197 or visit https://www.uspto.gov/ebc

NOTE: If the reply is not being submitted electronically, a copy of this notice must be included.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/symohammed/

Doc Code: PA..
Document Description: Power of Attorney

PTO/AIA/82B (07-13)
Approved for use through 01/31/2018. OMB 0651-0035
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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POWER OF ATTORNEY BY APPLICANT

I hereby revoke all previous powers of attorney given in the application identified in either the attached transmittal letter or the boxes below.

Application Number	Filing Date

(Note: The boxes above may be left blank if information is provided on form PTO/AIA/82A.)

☑ I hereby appoint the Patent Practitioner(s) associated with the following Customer Number as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above: 155075

OR

☐ I hereby appoint Practitioner(s) named in the attached list (form PTO/AIA/82C) as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the patent application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above. (Note: Complete form PTO/AIA/82C.)

Please recognize or change the correspondence address for the application identified in the attached transmittal letter or the boxes above to:

☑ The address associated with the above-mentioned Customer Number

OR

☐ The address associated with Customer Number:

OR

☐ Firm or Individual Name					
Address					
City		State		Zip	
Country					
Telephone		Email			

I am the Applicant (if the Applicant is a juristic entity, list the Applicant name in the box):

APEX BEAM TECHNOLOGIES LLC

☐ Inventor or Joint Inventor (title not required below)

☐ Legal Representative of a Deceased or Legally Incapacitated Inventor (title not required below)

☑ Assignee or Person to Whom the Inventor is Under an Obligation to Assign (provide signer's title if applicant is a juristic entity)

☐ Person Who Otherwise Shows Sufficient Proprietary Interest (e.g., a petition under 37 CFR 1.46(b)(2) was granted in the application or is concurrently being filed with this document) (provide signer's title if applicant is a juristic entity)

SIGNATURE of Applicant for Patent

The undersigned (whose title is supplied below) is authorized to act on behalf of the applicant (e.g., where the applicant is a juristic entity).

Signature	Deepak Kumar Sharma	Date (Optional)	11/10/2021
Name	Deepak Sharma		
Title	Managing Director		

NOTE: Signature - This form must be signed by the applicant in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. If more than one applicant, use multiple forms.

☑ Total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Acknowledgement Receipt

EFS ID:	46670789
Application Number:	17950726
International Application Number:	
Confirmation Number:	6005
Title of Invention:	METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING
First Named Inventor/Applicant Name:	Xiaobo ZHANG
Customer Number:	155075
Filer:	Jialin Zhong/Eddie Rowell
Filer Authorized By:	Jialin Zhong
Attorney Docket Number:	ZL0205-0004-US-CON3
Receipt Date:	22-SEP-2022
Filing Date:	
Time Stamp:	16:37:57
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Application Data Sheet	ZL0205-0004-US-CON3_ADS.pdf	1256637 b7cfcfb66371c6d439e6824a61626d6638d6caba	no	8

Warnings:

Information:					
2		155075_17180885_2021-02-22_SPEC.pdf	1936153 057fec1d4cb0ccfcfe10da900af9455649fb3480	yes	36
	Multipart Description/PDF files in .zip description				
	Document Description		**Start**	**End**	
	Specification		1	31	
	Application Data Sheet		32	35	
	Abstract		36	36	
Warnings:					
Information:					
3	Drawings-only black and white line drawings	155075_17180885_2021-02-22_DRW.pdf	118071 702deb71fce24270deba9b556bb510cbcd9e60ec	no	6
Warnings:					
Information:					
4	Oath or Declaration filed	155075_17180885_2021-02-22_OATH.pdf	75306 b52d2eba9bdac9d4e40461c6f51b54dec51b52d3	no	1
Warnings:					
Information:					
5	Power of Attorney	ZL0205_82A.pdf	229735 4289709912579091b55ae9f7a1dc280410429148	no	1
Warnings:					
Information:					
6	Power of Attorney	POA82B_Apex_ex.pdf	1100582 d420eaec9e65ed86bfe977d519b96e062166a185	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	4716484		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/AIA/14 (02-18)
Approved for use through 11/30/2020. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	ZL0205-0004-US-CON3
	Application Number	
Title of Invention	METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2:

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1 — Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Xiaobo		ZHANG	

Residence Information (Select One) US Residency ● Non US Residency Active US Military Service

City	Shanghai	Country of Residence [i]	CN

Mailing Address of Inventor:

Address 1	ROOM 601, BUILDING 34, NO. 2777 EAST JINXIU ROAD		
Address 2	Pudong District		
City	Shanghai	**State/Province**	
Postal Code	201206	**Country** [i]	CN

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

☐ **An Address is being provided for the correspondence Information of this application.**

Customer Number	155075		
Email Address	zhong@zhong-law.com	Add Email	Remove Email
Email Address	ip@remotedocket.com	Add Email	Remove Email

Application Information:

Title of the Invention	METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING		
Attorney Docket Number	ZL0205-0004-US-CON3	**Small Entity Status Claimed**	☒
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	6	**Suggested Figure for Publication (if any)**	

PTO/AIA/14 (02-18)
Approved for use through 11/30/2020. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	ZL0205-0004-US-CON3
	Application Number	
Title of Invention	METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING	

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	● Customer Number	US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	155075		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.
When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
	Continuation of	17180885	2021-02-22

PTO/AIA/14 (02-18)
Approved for use through 11/30/2020. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	ZL0205-0004-US-CON3
	Application Number	
Title of Invention	METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING	

Prior Application Status	Patented				Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
17180885	Continuation of	16577854	2019-09-20	10966178	2021-03-30
Prior Application Status	Patented				Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
16577854	Continuation of	15956742	2018-04-18	10462767	2019-10-29

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button. Add

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)[i] the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Remove

Application Number	Country[i]	Filing Date (YYYY-MM-DD)	Access Code[i] (if applicable)
201710255811.X	CN	2017-04-19	

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button. Add

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.
NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

PTO/AIA/14 (02-18)
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	ZL0205-0004-US-CON3
	Application Number	
Title of Invention	METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING	

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METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

BACKGROUND

Cross Reference to Related Application

This disclosure is a continuation of the application 16/577,854, filed on September 20,2019 which is the continuation of the application 15/956,742, filed on April 18,2018, and claims the priority benefit of Chinese Patent Application 201710255811.X, filed on April 19, 2017, all of which is incorporated herein by reference.

TECHNICAL FIELD

[0001] The present disclosure relates to transmission schemes in wireless communication systems, and in particular to a method and a device for paging transmission in a communication system supporting multiple numerologies.

RELATED ART

[0002] Application scenarios of future wireless communication systems are becoming increasingly diversified, and different application scenarios have different performance demands on systems. In order to meet different performance requirements of various application scenarios, the 3rd Generation Partner Project (3GPP) Radio Access Network (RAN) #72 plenary session decided to conduct the study of New Radio (NR). The working item of 5G NR was agreed as an approved project to standardize the 5G NR at the 3GPP RAN #75 session.

[0003] In order to be applied to various different application scenarios flexibly, future wireless communication systems, especially 5G NR, will support various numerologies. The various numerologies refer to various subcarrier spacings, various symbol time lengths, various Cyclic Prefix (CP) lengths, etc. In order to simplify the design of systems and to reduce the complexity of User Equipment (UE) implementation, the overall design of the system physical layer would best adopt a unified structure for different numerologies.

SUMMARY

[0004] In existing LTE systems, transmission opportunities of paging are defined through a Paging Frame (PF) and a Paging Occasion (PO) uniformly. The PF is a radio frame which is likely to transmit a paging message, and the PO is used for determining a subframe which is likely to transmit a paging message in the PF. The radio frame in LTE has a fixed time length of

10 milliseconds, and the subframe has a fixed time length of 1 millisecond. Since an LTE network generally employs a single numerology or the numerology basically does not change in a long time in the network, the definition of the possible time of paging using the PF and PO having a fixed time length can simplify the design of system, under the premise of guaranteeing the paging capacity and not increasing the power consumption of UE. Under the 5G NR, a network supports different numerologies, thus, a given time length, for example, 1 millisecond, probably includes multiple basic scheduling units (for example, slot). If the legacy design of the current paging opportunity is employed, the UE would detect the paging message different times for different numerologies within the 1 millisecond. Therefore, power consumption in some numerology would be greatly increased. Meanwhile, the paging capacity varies greatly due to the adoption of different numerologies.

[0005] In order to solve the above design problem of paging when multiple numerologies are employed in the 5G NR, the present disclosure provides a solution, which determines the transmission opportunities of paging according to the numerology employed by the paging, thereby guaranteeing that the UE has a small difference in the complexity and power consumption of monitoring the paging message under different numerologies and that the paging capacity basically remains the same. It should be noted the embodiments of the UE of the present disclosure and the characteristics in the embodiments may be applied to the base station if no conflict is caused, and vice versa. Further, the embodiments of the present disclosure and the characteristics in the embodiments may be mutually combined if no conflict is caused.

[0006] The present disclosure discloses a method in a UE used for paging. The method includes the following:

[0007] monitoring a first signaling in X time intervals; and

[0008] receiving a first radio signal.

[0009] Herein, X is a positive integer. The first signaling is used for determining scheduling information for the first radio signal. The scheduling information includes at least one of {occupied time-frequency resource, adopted Modulation Coding Scheme (MCS), subcarrier spacing of subcarriers in occupied frequency domain resource}. The first radio signal carries a paging message. The frequency domain resource used for transmitting the first signaling belongs to a first subband. The first subband includes a positive integer number of consecutive subcarriers in frequency domain. At least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband} is used for determining the X time intervals.

[0010] In one embodiment, with the above method, the UE can determine the time interval of monitoring a transmitted paging message according to a subcarrier spacing adopted to transmit the paging message, thereby saving power consumption.

[0011] In one embodiment, the above method designs a uniform calculation approach of paging opportunity based on different subcarrier spacings. Meanwhile, the paging capacity remains the same when different subcarrier spacings are adopted to transmit the paging message.

[0012] In one embodiment, the paging message includes a feature ID of a paged UE.

[0013] In one embodiment, the first signaling is detected P times at most in each one of the X time intervals, P is a positive integer.

[0014] In one embodiment, any two of the X time intervals have an equal time length.

[0015] In one embodiment, two of the X time times have different time lengths.

[0016] In one embodiment, any one of the X time intervals is a slot.

[0017] In one embodiment, any two of the X time intervals have an equal time length, and the time length of each one of the X time intervals is correlated to the subcarrier spacing of subcarriers included in the first subband.

[0018] In one embodiment, any one of the X time intervals comprises M Orthogonal Frequency Division Multiplexing (OFDM) symbols, M is a positive integer smaller than 14.

[0019] In one embodiment, any one of the X time intervals comprises M OFDM symbols, M is a positive integer smaller than 7.

[0020] In one embodiment, any two of the X time intervals are orthogonal in time domain, the orthogonality refers that there is no time unit that belongs to any two of the X time intervals simultaneously.

[0021] In one embodiment, two of the X time intervals are discrete in time domain.

[0022] In one embodiment, the first signaling is a physical layer signaling.

[0023] In one embodiment, the first signaling is Downlink Control Information (DCI).

[0024] In one embodiment, the first signaling is transmitted through a Physical Downlink Control Channel (PDCCH).

[0025] In one embodiment, the first signaling is transmitted through a New Radio Physical Downlink Control Channel (NR-PDCCH).

[0026] In one embodiment, the first signaling is transmitted through a PDCCH. The PDCCH is transmitted in a Common Search Space (CSS).

[0027] In one embodiment, the first signaling is transmitted through a PDCCH, the PDCCH is transmitted in a UE-Specific Search Space (USS).

[0028] In one embodiment, the first signaling is transmitted through a PDCCH, the PDCCH has a Cyclic Redundancy Check (CRC) scrambled by a Paging Radio Network Temporary Identity (P-RNTI).

[0029] In one embodiment, the MCS includes one of {QPSK, 16QAM, 64QAM, 256QAM, 1024QAM}.

[0030] In one embodiment, the subcarrier spacing is equal to 15kHz multiplied by 2 to the Kth power, where K is an integer.

[0031] In one embodiment, the first subband includes a positive integer multiple of 12 subcarriers.

[0032] In one embodiment, all subcarriers included in the first subband have an equal subcarrier spacing.

[0033] In one embodiment, the location of the first subband in frequency domain refers to the location of the first subband in a carrier where the first subband is located.

[0034] In one embodiment, the location of the first subband in frequency domain refers to the location of a carrier where the first subband is located in frequency domain.

[0035] In one embodiment, the location of the first subband in frequency domain refers to a subband index of the first subband in a carrier where the first subband is located.

[0036] In one embodiment, the location of the first subband in frequency domain refers to the location of the first subband in a frequency resource corresponding to a band where the first subband is located.

[0037] In one embodiment, at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband} is used for the UE to determine the X time intervals.

[0038] In one embodiment, at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband} is used for the UE to determine the X time intervals based on a given mapping rule.

[0039] In one embodiment, the first radio signal is transmitted through a Downlink Shared

Channel (DL-SCH).

[0040] In one embodiment, the first radio signal is transmitted through a Physical Downlink Shared Channel (PDSCH).

[0041] In one embodiment, a first bit block is subjected to a modulation mapper, a layer mapper, precoding, a resource element mapper and OFDM single generation in sequence to obtain the first radio signal; the first bit block includes the output obtained after a code block is subjected to channel coding. In one subembodiment, the code block is a Transport Block (TB). In one subembodiment, the code block is one part of a TB.

[0042] According to one aspect of the present disclosure, the above method is characterized in that any one of the X time intervals belongs to a first time window in time domain; The time length of the first time window is predefined; The first time window is divided into Y time intervals; The X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X; The subcarrier spacing of subcarriers included in the first subband is used for determining Y; A feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals.

[0043] In one embodiment, the time length of the first time window is fixed.

[0044] In one embodiment, the first time window includes a positive integer number of consecutive multi-carrier symbols.

[0045] In one embodiment, the multi-carrier symbol includes a data symbol and a CP.

[0046] In one embodiment, the first time window has a time length of 1 millisecond.

[0047] In one embodiment, the first time window has a time length of 10 milliseconds.

[0048] In one embodiment, the first time window is a subframe.

[0049] In one embodiment, the first time window is a radio frame.

[0050] In one embodiment, any two of the Y time intervals have an equal time length.

[0051] In one embodiment, two of the Y time intervals have different time lengths.

[0052] In one embodiment, Y is greater than X.

[0053] In one embodiment, Y is proportional to the subcarrier spacing of subcarriers included in the first subband.

[0054] In one embodiment, the subcarrier spacing of subcarriers included in the first subband is used for the UE to determine Y.

[0055] In one embodiment, the subcarrier spacing of subcarriers included in the first subband is used for the UE to determine Y based on a given mapping relationship.

[0056] In one embodiment, the feature ID of the monitor of the first signaling is used for the UE to determine the X time intervals in the Y time intervals.

[0057] In one embodiment, the feature ID of the monitor of the first signaling is used for the UE to determine the X time intervals in the Y time intervals based on a given mapping relationship.

[0058] In one embodiment, the feature ID refers to an International Mobile Subscriber Identification Number (IMSI).

[0059] In one embodiment, the feature ID refers to a remainder when the IMSI is divided by 1024.

[0060] In one embodiment, the feature ID refers to a remainder when the IMSI is divided by 4096.

[0061] In one embodiment, the feature ID refers to a remainder when the IMSI is divided by 16384.

[0062] In one embodiment, the feature ID refers to a Cell Radio Network Temporary Identity (C-RNTI).

[0063] In one embodiment, a physical cell ID of a cell transmitting the first signaling is used for determining the X time intervals in the Y time intervals.

[0064] According to one aspect of the present disclosure, the above method is characterized in that the first time window belongs to one of Z time windows, Z being an integer greater than 1; Z is predefined, or Z is configurable; Any two of the Z time windows have an equal time length; The feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.

[0065] In one embodiment, Z is equal to 10.

[0066] In one embodiment, any two of the Z time windows are orthogonal in time domain.

[0067] In one embodiment, any one of the Z time windows is a subframe, Z is equal to 10,

[0068] In one embodiment, any one of the Z time windows is a radio frame, Z is equal to the number of radio frames included in a Discontinuous Reception (DRX) cycle.

[0069] In one embodiment, the above method further includes the following:

[0070] receiving a third signaling.

[0071] Herein, the third signaling is used for configuring Z.

[0072] In one embodiment, the feature ID of the monitor of the first signaling is used for the UE to determine the first time window in the Z time windows.

[0073] In one embodiment, the feature ID of the monitor of the first signaling is used for the UE to determine the first time window in the Z time windows based on a given mapping relationship.

[0074] In one embodiment, any one of the Z time windows is a radio frame; The first time window is obtained by the following formula.

[0075] SFN mod Z= (Z div N)*(UE_ID mod N)

[0076] Herein, SFN is a frame number of a radio frame corresponding to the first time window, N= min(Z,nB), nB is equal to one of {4Z, 2Z, Z, Z/2, Z/4, Z/8, Z/16, Z/32, Z/64, Z/128, Z/256, Z/512, Z/1024}.

[0077] According to one aspect of the present disclosure, the above method further includes the following:

[0078] receiving a second radio signal;

[0079] Herein, the second radio signal is used for determining at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband}.

[0080] In one embodiment, the second radio signal includes a Primary Synchronization Signal (PSS).

[0081] In one embodiment, the second radio signal includes a Second Synchronization Signal (SSS).

[0082] In one embodiment, the second radio signal is transmitted through a Broadcast Channel (BCH).

[0083] In one embodiment, the second radio signal is transmitted through a Physical Broadcast Channel (PBCH).

[0084] In one embodiment, the second radio signal is transmitted through a PDSCH.

[0085] In one embodiment, the second radio signal carries Master Information Block (MIB) information.

[0086] In one embodiment, the second radio signal carries System Information Block (SIB) information.

[0087] In one embodiment, the information carried by the second radio signal is transmitted cyclically.

[0088] In one embodiment, the information carried by the second radio signal is transmitted on-demand.

[0089] In one embodiment, the second radio signal carries first information; The first information is used for determining at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband}.

[0090] In one embodiment, the second radio signal carries first information; The first information indicates at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband}.

[0091] In one embodiment, the second radio signal is used for the UE to determine at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband}.

[0092] In one embodiment, the second radio signal indicates at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband}.

[0093] According to one aspect of the present disclosure, the above method further includes the following:

[0094] receiving a second signaling;

[0095] Herein, the second signaling is used for determining Q subbands, Q being a positive integer; The first subband belongs to one of the Q subbands; Any one of the Q subbands includes a positive integer number of consecutive subcarriers; The feature ID of the monitor of the first signaling is used for determining the first subband in the Q subbands.

[0096] In one embodiment, in any one of the Q subbands, all the included subcarriers have an equal subcarrier spacing.

[0097] In one embodiment, in any two of the Q subbands, the subcarriers have different subcarrier spacings.

[0098] In one embodiment, in two of the Q subbands, the subcarriers have an equal subcarrier spacing .

[0099] In one embodiment, any two of the Q subbands have an equal frequency domain width.

[00100] In one embodiment, two of the Q subbands have different frequency domain widths.

[00101] In one embodiment, the Q subbands all belong to one same carrier.

[00102] In one embodiment, two of the Q subbands belong to different carriers.

[00103] In one embodiment, the second signaling is a high layer signaling.

[00104] In one embodiment, the second signaling is a physical layer signaling.

[00105] In one embodiment, the second signaling is transmitted through a BCH.

[00106] In one embodiment, the second signaling is transmitted through a PBCH.

[00107] In one embodiment, the second signaling is transmitted through a PDSCH.

[00108] In one embodiment, the second signaling is a Radio Resource Control (RRC) signaling.

[00109] In one embodiment, the second signaling is an SIB.

[00110] In one embodiment, the second signaling is transmitted through a DCI.

[00111] In one embodiment, the feature ID of the monitor of the first signaling is used for the UE to determine the first subband in the Q subbands.

[00112] In one embodiment, the feature ID of the monitor of the first signaling is used for the UE to determine the first subband in the Q subbands based on a specific mapping relationship.

[00113] The present disclosure discloses a method in a base station used for paging. The method includes the following:

[00114] transmitting a first signaling in a positive integer number of time intervals of X time intervals; and

[00115] transmitting a first radio signal.

[00116] Herein, X is a positive integer; The first signaling is used for determining scheduling information for the first radio signal; The scheduling information includes at least one of {occupied time-frequency resource, adopted MCS, subcarrier spacing of subcarriers in occupied frequency domain resource}; The first radio signal carries a paging message; The frequency domain resource used for transmitting the first signaling belongs to a first subband; The first subband includes a positive integer number of consecutive subcarriers in frequency domain; At least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband} is used for determining the X time intervals.

[00117] According to one aspect of the present disclosure, the above method is characterized in

that any one of the X time intervals belongs to a first time window in time domain; The time length of the first time window is predefined; The first time window is divided into Y time intervals; The X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X; The subcarrier spacing of subcarriers included in the first subband is used for determining Y; A feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals.

[00118] According to one aspect of the present disclosure, the above method is characterized in that the first time window belongs to one of Z time windows, Z being an integer greater than 1; Z is predefined, or Z is configurable; Any two of the Z time windows have an equal time length; The feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.

[00119] According to one aspect of the present disclosure, the above method further includes the following:

[00120] transmitting a second radio signal;

[00121] Herein, the second radio signal is used for determining at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband}.

[00122] According to one aspect of the present disclosure, the above method further includes the following:

[00123] transmitting a second signaling;

[00124] Herein, the second signaling is used for determining Q subbands, Q being a positive integer; The first subband belongs to one of the Q subbands; Any one of the Q subbands includes a positive integer number of consecutive subcarriers; The feature ID of the monitor of the first signaling is used for determining the first subband in the Q subbands.

[00125] The present disclosure discloses a UE used for paging. The UE includes:

[00126] a first receiver module, to monitor a first signaling in X time intervals; and

[00127] a second receiver module, to receive a first radio signal.

[00128] Herein, X is a positive integer. The first signaling is used for determining scheduling information for the first radio signal; The scheduling information includes at least one of {occupied time-frequency resource, adopted MCS, subcarrier spacing of subcarriers in occupied frequency domain resource}; The first radio signal carries a paging message; The frequency domain resource used for transmitting the first signaling belongs to a first subband; The first

subband includes a positive integer number of consecutive subcarriers in frequency domain; At least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband} is used for determining the X time intervals.

[00129] According to one aspect of the present disclosure, the above UE is characterized in that any one of the X time intervals belongs to a first time window in time domain; The time length of the first time window is predefined; The first time window is divided into Y time intervals; The X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X; The subcarrier spacing of subcarriers included in the first subband is used for determining Y; A feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals.

[00130] According to one aspect of the present disclosure, the above UE is characterized in that the first time window belongs to one of Z time windows, Z being an integer greater than 1; Z is predefined, or Z is configurable; Any two of the Z time windows have an equal time length; The feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.

[00131] According to one aspect of the present disclosure, the above UE is characterized in that the first receiver module further receives a second radio signal; The second radio signal is used for determining at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband}.

[00132] According to one aspect of the present disclosure, the above UE is characterized in that the first receiver module further receives a second signaling; The second signaling is used for determining Q subbands, Q being a positive integer; The first subband belongs to one of the Q subbands; Any one of the Q subbands includes a positive integer number of consecutive subcarriers; The feature ID of the monitor of the first signaling is used for determining the first subband in the Q subbands.

[00133] The present disclosure discloses a base station device used for paging. The base station device includes:

[00134] a first transmitter module, to transmit a first signaling in a positive integer number of time intervals of X time intervals respectively; and

[00135] a second transmitter module, to transmit a first radio signal;

[00136] Herein, X is a positive integer; The first signaling is used for determining scheduling information for the first radio signal; The scheduling information includes at least one of {occupied time-frequency resource, adopted MCS, subcarrier spacing of subcarriers in occupied

frequency domain resource}; The first radio signal carries a paging message; The frequency domain resource used for transmitting the first signaling belongs to a first subband; The first subband includes a positive integer number of consecutive subcarriers in frequency domain; At least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband} is used for determining the X time intervals.

[00137] According to one aspect of the present disclosure, the above base station device is characterized in that any one of the X time intervals belongs to a first time window in time domain; The time length of the first time window is predefined; The first time window is divided into Y time intervals; The X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X; The subcarrier spacing of subcarriers included in the first subband is used for determining Y; A feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals.

[00138] According to one aspect of the present disclosure, the above base station device is characterized in that the first time window belongs to one of Z time windows, Z being an integer greater than 1; Z is predefined, or Z is configurable; Any two of the Z time windows have an equal time length; The feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.

[00139] According to one aspect of the present disclosure, the above base station device is characterized in that the first transmitter module further transmits a second radio signal; The second radio signal is used for determining at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband}.

[00140] According to one aspect of the present disclosure, the above base station device is characterized in that the first transmitter module further transmits a second signaling; The second signaling is used for determining Q subbands, Q being a positive integer; The first subband belongs to one of the Q subbands; Any one of the Q subbands includes a positive integer number of consecutive subcarriers; The feature ID of the monitor of the first signaling is used for determining the first subband in the Q subbands.

BRIEF DESCRIPTION OF THE DRAWINGS

[00141] Other features, purposes and advantages of the present disclosure will become more apparent from the detailed description of non-restrictive embodiments taken in conjunction with the following drawings.

[00142] FIG. 1 is a flowchart illustrating the transmission of a first signaling and a first radio signal according to one embodiment of the present disclosure.

[00143] FIG. 2 is a diagram illustrating a network architecture according to one embodiment of the present disclosure.

[00144] FIG. 3 is a diagram illustrating a radio protocol architecture of a user plane and a control plane according to one embodiment of the present disclosure.

[00145] FIG. 4 is a diagram illustrating a base station device and a UE according to one embodiment of the present disclosure.

[00146] FIG. 5 is a flowchart illustrating the transmission of a radio signal according to one embodiment of the present disclosure.

[00147] FIG. 6 is a diagram illustrating a relationship between Z time windows and Q subbands according to one embodiment of the present disclosure.

[00148] FIG. 7 is a diagram illustrating a relationship between a first time window and X time intervals according to one embodiment of the present disclosure.

[00149] FIG. 8 is a diagram illustrating a relationship among a first signaling, a first radio signal and a second radio signal according to one embodiment of the present disclosure.

[00150] FIG. 9 is a structure block diagram illustrating a processing device in a UE according to one embodiment of the present disclosure.

[00151] FIG. 10 is a structure block diagram illustrating a processing device in a base station according to one embodiment of the present disclosure.

DESCRIPTION OF THE EMBODIMENTS

[00152] The technical scheme of the present disclosure is described below in further detail in conjunction with the drawings. It should be noted that the embodiments in the disclosure and the characteristics of the embodiments may be arbitrarily combined if there is no conflict.

[00153] Embodiment 1

[00154] Embodiment 1 illustrates an example of a flowchart for the transmission of a first signaling and a first radio signal according to one embodiment of the present disclosure, as shown in FIG. 1. In FIG. 1, each box represents a step. In Embodiment 1, the UE of the present disclosure first monitors a first signaling in X time intervals, and then receives a first radio signal, wherein X is a positive integer; The first signaling is used for determining scheduling information for the first radio signal; The scheduling information includes at least one of

{occupied time-frequency resource, adopted MCS, subcarrier spacing of subcarriers in occupied frequency domain resource}; The first radio signal carries a paging message; The frequency domain resource used for transmitting the first signaling belongs to a first subband; The first subband includes a positive integer number of consecutive subcarriers in frequency domain; At least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband} is used for determining the X time intervals.

[00155] In one embodiment, any one of the X time intervals belongs to a first time window in time domain; The time length of the first time window is predefined; The first time window is divided into Y time intervals; The X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X; The subcarrier spacing of subcarriers included in the first subband is used for determining Y; A feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals.

[00156] In one embodiment, any one of the X time intervals belongs to a first time window in time domain; The time length of the first time window is predefined; The first time window is divided into Y time intervals; The X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X; The subcarrier spacing of subcarriers included in the first subband is used for determining Y; A feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals; The first time window belongs to one of Z time windows, Z being an integer greater than 1. Z is predefined, or Z is configurable; Any two of the Z time windows have an equal time length; The feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.

[00157] In one embodiment, the method further includes the following:

[00158] receiving a second radio signal;

[00159] Herein, the second radio signal is used for determining at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband}.

[00160] In one embodiment, the method further includes the following:

[00161] receiving a second signaling;

[00162] The second signaling is used for determining Q subbands, Q being a positive integer; The first subband belongs to one of the Q subbands; Any one of the Q subbands includes a positive integer number of consecutive subcarriers; The feature ID of the monitor of the first signaling is used for determining the first subband in the Q subbands.

[00163] Embodiment 2

[00164] Embodiment 2 illustrates an example of a diagram for a network architecture, as shown in FIG. 2. FIG. 2 is a diagram illustrating a system network architecture 200 of NR 5G, LTE and Long-Term Evolution Advanced (LTE-A). The NR 5G or LTE network architecture 200 may be called an Evolved Packet System (EPS) 200. The EPS 200 may include one or more UEs 201, a Next Generation-Radio Access Network (NG-RAN) 202, an Evolved Packet Core /5G-Core Network (EPC/5G-CN) 210, a Home Subscriber Server (HSS) 220 and an Internet Service 230. The EPS may be interconnected with other access networks. For simple description, the entities/interfaces are not shown. As shown in FIG. 2, the EPS provides packet switching services. Those skilled in the art are easy to understand that various concepts presented throughout the present disclosure can be extended to networks providing circuit switching services or other cellular networks. The NG-RAN includes an NR node B (gNB) 203 and other gNBs 204. The gNB 203 provides user plane and control plane protocol terminations towards the UE 201. The gNB 203 may be connected to other gNBs 204 via an Xn interface (for example, backhaul). The gNB 203 may be called a base station, a base transceiver station, a radio base station, a radio transceiver, a transceiver function, a Basic Service Set (BSS), an Extended Service Set (ESS), a TRP or other appropriate terms. The gNB 203 provides an access point of the 5G-CN/EPC 210 for the UE 201. Examples of UE 201 include cellular phones, smart phones, Session Initiation Protocol (SIP) phones, laptop computers, Personal Digital Assistants (PDAs), Satellite Radios, Global Positioning Systems (GPSs), multimedia devices, video devices, digital audio player (for example, MP3 players), cameras, games consoles, unmanned aerial vehicles, air vehicles, narrow-band physical network equipment, machine-type communication equipment, land vehicles, automobiles, wearable equipment, or any other devices having similar functions. Those skilled in the art also can call the UE 201 a mobile station, a subscriber station, a mobile unit, a subscriber unit, a wireless unit, a remote unit, a mobile device, a wireless device, a radio communication device, a remote device, a mobile subscriber station, an access terminal, a mobile terminal, a wireless terminal, a remote terminal, a handset, a user agent, a mobile client, a client or other appropriate terms. The gNB 203 is connected to the EPC/5G-CN 210 via an S1/NG interface. The EPC/5G-CN 210 includes a Mobility Management Entity/Authentication Management Field/User Plane Function (MME/AMF/UPF) 211, other MMEs/AMFs/UPFs 214, a Service Gateway (S-GW) 212 and a Packet Data Network Gateway (P-GW) 213. The MME/AMF/UPF 211 is a control node for processing a signaling between the UE 201 and the 5G-CN/EPC 210. Generally, the MME/AMF/UPF 211 provides bearer and connection management. All user Internet Protocol (IP) packets are transmitted through the S-GW 212. The S-GW 212 is connected to the P-GW

213. The P-GW 213 provides UE IP address allocation and other functions. The P-GW 213 is connected to the internet service 230. The internet service 230 includes IP services corresponding to operators, specifically including internet, intranet, IP Multimedia Subsystems (IP IMSs) and PS Streaming Services (PSSs).

[00165] In one embodiment, the UE 201 corresponds to the UE in the present disclosure.

[00166] In one embodiment, the UE 201 supports the transmission based on multiple numerologies.

[00167] In one embodiment, the gNB 203 corresponds to the base station device in the present disclosure.

[00168] In one embodiment, the gNB 203 supports the transmission based on multiple numerologies.

[00169] Embodiment 3

[00170] Embodiment 3 is a diagram illustrating an embodiment of a radio protocol architecture of a user plane and a control plane according to the present disclosure, as shown in FIG. 3. FIG. 3 is a diagram illustrating an embodiment of a radio protocol architecture of a user plane and a control plane. In FIG. 3, the radio protocol architecture of a UE and a base station device (gNB or eNB) is presented by three layers, which are a layer 1, a layer 2 and a layer 3 respectively. The layer 1 (L1) is the lowest layer and performs signal processing functions of a PHY layer. The layer 1 is called PHY 301 in this paper. The layer 2 (L2) 305 is above the PHY 301, and is in charge of the link between the UE and the gNB via the PHY 301. In the user plane, the L2 305 includes a Medium Access Control (MAC) sublayer 302, a Radio Link Control (RLC) sublayer 303, and a Packet Data Convergence Protocol (PDCP) sublayer 304. All the three sublayers end at the gNB of the network side. Although not described in FIG.3, the UE may include several higher layers above the L2 305, such as network layer (i.e. IP layer) ending at a P-GW of the network side and an application layer ending at the other side of the connection (i.e. a peer UE, a server, etc.). The PDCP sublayer 304 provides multiplexing among variable radio bearers and logical channels. The PDCP sublayer 304 also provides a header compression for a higher layer packet so as to reduce a radio transmission overhead. The PDCP sublayer 304 provides security by encrypting a packet and provides support for UE handover between gNBs. The RLC sublayer 303 provides segmentation and reassembling of a higher layer packet, retransmission of a lost packet, and reordering of a lost packet to as to compensate the disordered receiving caused by Hybrid Automatic Repeat Request (HARQ). The MAC sublayer 302 provides multiplexing between logical channels and transport channels. The MAC sublayer

302 is also responsible for allocating between UEs various radio resources (i.e., resource block) in a cell. The MAC sublayer 302 is also in charge of HARQ operation. In the control plane, the radio protocol architecture of the UE and the gNB is almost the same as the radio protocol architecture in the user plane on the PHY 301 and the L2 305, but there is no header compression for the control plane. The control plane also includes a Radio Resource Control (RRC) sublayer 306 in the layer 3 (L3). The RRC sublayer 306 is responsible for acquiring radio resources (i.e. radio bearer) and configuring the lower layers using an RRC signaling between the gNB and the UE.

[00171] In one embodiment, the radio protocol architecture shown in FIG. 3 is applicable to the UE in the present disclosure.

[00172] In one embodiment, the radio protocol architecture shown in FIG. 3 is applicable to the base station device in the present disclosure.

[00173] In one embodiment, the first signaling in the present disclosure is generated by the PHY 301.

[00174] In one embodiment, the first signaling in the present disclosure is generated by the MAC 302.

[00175] In one embodiment, the first signaling in the present disclosure is generated by the RRC 306.

[00176] In one embodiment, the second signaling in the present disclosure is generated by the PHY 301.

[00177] In one embodiment, the second signaling in the present disclosure is generated by the MAC 302.

[00178] In one embodiment, the second signaling in the present disclosure is generated by the RRC 306.

[00179] In one embodiment, the first radio signal in the present disclosure is generated by the RRC 306.

[00180] In one embodiment, the first radio signal in the present disclosure is generated by the MAC 302.

[00181] In one embodiment, the first radio signal in the present disclosure is generated by the PHY 301.

[00182] In one embodiment, the second radio signal in the present disclosure is generated by

the RRC 306.

[00183] In one embodiment, the second radio signal in the present disclosure is generated by the MAC 302.

[00184] In one embodiment, the second radio signal in the present disclosure is generated by the PHY 301.

[00185] Embodiment 4

[00186] Embodiment 4 illustrates a diagram of a base station device and a given UE according to the present disclosure, as shown in FIG. 4. FIG. 4 is a block diagram of a gNB 410 in communication with a UE 450 in an access network.

[00187] The base station device 410 includes a controller/processor 440, a memory 430, a receiving processor 412, a transmitter/receiver 416 and a transmitting processor 415. The transmitter/receiver 416 includes an antenna 420. A packet from a higher layer is provided to the controller/processor 440. The controller/processor 440 provides header compression/decompression, encryption/decryption, packet segmentation and reordering, multiplexing/de-multiplexing between a logical channel and a transport channel, to implement the L2 protocol used for the user plane and the control plane. The packet from a higher layer may include data or control information, for example, DL-SCH or UL-SCH. The transmitting processor 455 performs signal transmitting processing functions of an L1 layer (that is, PHY), including encoding, interleaving, scrambling, modulation, power control/allocation, precoding, generation of physical layer control signaling (including PBCH, PDCCH, PHICH, PCFICH, reference signal), etc. The receiving processor 412 performs signal receiving processing functions of the L1 layer (that is, PHY), including decoding, de-interleaving, descrambling, demodulation, decoding, extraction of physical layer control signaling, etc. The transmitter 416 is configured to convert a baseband signal provided by the transmitting processor 415 into a radio-frequency signal and transmit the radio-frequency signal via the antenna 420. The receiver 416 is configured to convert a radio-frequency signal received via the antenna 420 into a baseband signal and provide the baseband signal to the receiving processor 412.

[00188] The UE 450 includes a controller/processor 490, a memory 480, a receiving processor 452, a transmitter/receiver 456, a transmitting processor 455, and a data source 467. The transmitter/receiver 456 includes an antenna 460. The data source 467 provides a packet from a higher layer packet to the controller/processor 490. The controller/processor 490 provides header compression/decompression, encryption/decryption, packet segmentation and reordering, multiplexing/de-multiplexing between a logical channel and a transport channel, to implement

the L2 protocol used for the user plane and the control plane. The packet from a higher layer may include data or control information, for example, DL-SCH or UL-SCH. The transmitting processor 490 performs signal transmitting processing functions of an L1 layer (that is, PHY), including encoding, interleaving, scrambling, modulation, power control/allocation, precoding, generation of physical layer control signaling, etc. The receiving processor 452 performs signal receiving processing functions of the L1 layer (that is, PHY), including decoding, de-interleaving, descrambling, demodulation, decoding, extraction of physical layer control signaling, etc. The transmitter 456 is configured to convert a baseband signal provided by the transmitting processor 455 into a radio-frequency signal and transmit the radio-frequency signal via the antenna 460. The receiver 456 is configured to convert a radio-frequency signal received via the antenna 460 into a baseband signal and provide the baseband signal to the receiving processor 452.

[00189] In Downlink (DL) transmission, a packet DL-SCH from a higher layer, which includes the first radio signal, the second radio signal and the second signaling in the present disclosure, is provided to the controller/processor 440. The controller/processor 440 performs functions of a layer 2. In downlink transmission, the controller/processor 440 provides header compression, encryption, packet segmentation and reordering, multiplexing between a logical channel and a transport channel, and radio resource allocation for the UE 450 based on various priorities. The controller/processor 440 is also in charge of HARQ operation, retransmission of a lost packet, and a signaling to the UE450. The transmitting processor 415 performs signal processing functions of the layer 1, including the generation of the first signaling in the present disclosure. The generation of the second signaling and the generation of the physical layer signals of the first radio signal and second radio signal are accomplished at the transmitting processor 415. The signal processing function includes decoding and interleaving, so as to ensure an FEC (Forward Error Correction) and a demodulation corresponding to a modulation scheme (i.e., BPSK, QPSK, etc.) at the UE 450 side. The modulated signals are divided into parallel streams. Each of the parallel streams is mapped into a corresponding subcarrier of multi-carriers and/or multi-carrier symbol. Then the transmitting processor 415 maps the parallel stream into the antenna 420 via the transmitter 416 to as to transmit the parallel stream in the form of Radio Frequency (RF) signals. At the receiving side, every receiver 456 receives a radio frequency signal via the corresponding antenna 460. Every receiver 456 recovers the baseband information modulated to the RF carrier and provides the baseband information to the receiving processor 452. The receiving processor 452 performs signal receiving processing functions of the layer 1, including the detection of the first signaling in the present disclosure, the receiving of the first radio signal and the second radio signal, the receiving of the physical layer signal of the second

signaling, etc. Demodulation is conducted corresponding to a modulation scheme (i.e., BPSK, QPSK, etc.) through the multi-carrier symbol in the multi-carrier symbol stream, then decoding and de-interleaving are conducted to recover the data or control signal transmitted by the gNB 410 on the physical channel, and then the data and control signal are provided to the controller/processor 490. The controller/processor 490 performs functions of the layer 2. The controller/processor can be connected to a memory 480 that stores program code and data. The memory 480 is a computer readable media.

[00190] In one embodiment, the UE 450 corresponds to the UE in the present disclosure.

[00191] In one embodiment, the gNB 410 corresponds to the base station device in the present disclosure.

[00192] In one embodiment, the UE 450 device includes at least one processor and at least one memory. The at least one memory includes computer program codes. The at least one memory and the computer program codes are configured to be used in collaboration with the at least one processor. The UE 450 device at least monitors a first signaling in X time intervals and receives a first radio signal, wherein X is a positive integer; The first signaling is used for determining scheduling information for the first radio signal; The scheduling information includes at least one of {occupied time-frequency resource, adopted MCS, subcarrier spacing of subcarriers in occupied frequency domain resource}; The first radio signal carries a paging message; The frequency domain resource used for transmitting the first signaling belongs to a first subband; The first subband includes a positive integer number of consecutive subcarriers in frequency domain; At least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband} is used for determining the X time intervals.

[00193] In one embodiment, the UE 450 includes a memory that stores a computer readable instruction program. The computer readable instruction program generates an action when executed by at least one processor. The action includes monitoring a first signaling in X time intervals and receiving a first radio signal, wherein X is a positive integer; The first signaling is used for determining scheduling information for the first radio signal; The scheduling information includes at least one of {occupied time-frequency resource, adopted MCS, subcarrier spacing of subcarriers in occupied frequency domain resource}; The first radio signal carries a paging message; The frequency domain resource used for transmitting the first signaling belongs to a first subband; The first subband includes a positive integer number of consecutive subcarriers in frequency domain; At least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband} is used for

determining the X time intervals.

[00194] In one embodiment, the gNB 410 device includes at least one processor and at least one memory. The at least one memory includes computer program codes. The at least one memory and the computer program codes are configured to be used in collaboration with the at least one processor. The gNB 410 at least transmits a first signaling in a positive integer number of time intervals of X time intervals and transmits a first radio signal, wherein X is a positive integer; The first signaling is used for determining scheduling information for the first radio signal; The scheduling information includes at least one of {occupied time-frequency resource, adopted MCS, subcarrier spacing of subcarriers in occupied frequency domain resource}; The first radio signal carries a paging message; The frequency domain resource used for transmitting the first signaling belongs to a first subband; The first subband includes a positive integer number of consecutive subcarriers in frequency domain; At least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband} is used for determining the X time intervals.

[00195] In one embodiment, the gNB 410 device includes a memory that stores a computer readable instruction program. The computer readable instruction program generates an action when executed by at least one processor. The action includes transmitting a first signaling in a positive integer number of time intervals of X time intervals and transmitting a first radio signal, wherein X is a positive integer; The first signaling is used for determining scheduling information for the first radio signal; The scheduling information includes at least one of {occupied time-frequency resource, adopted MCS, subcarrier spacing of subcarriers in occupied frequency domain resource}; The first radio signal carries a paging message; The frequency domain resource used for transmitting the first signaling belongs to a first subband; The first subband includes a positive integer number of consecutive subcarriers in frequency domain. At least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband} is used for determining the X time intervals.

[00196] In one embodiment, the receiver 456 (including the antenna 460) and the receiving processor 452 are configured to monitor the first signaling in the present disclosure.

[00197] In one embodiment, the receiver 456 (including the antenna 460), the receiving processor 452 and the controller/processor 490 are configured to receive the first radio signal in the present disclosure.

[00198] In one embodiment, the receiver 456 (including the antenna 460), the receiving processor 452 and the controller/processor 490 are configured to receive the second radio signal in the present disclosure.

[00199] In one embodiment, the receiver 456 (including the antenna 460), the receiving processor 452 and the controller/processor 490 are configured to monitor the second signaling in the present disclosure.

[00200] In one embodiment, the transmitter 416 (including the antenna 420) and the transmitting processor 415 are configured to transmit the first signaling in the present disclosure.

[00201] In one embodiment, the transmitter 416 (including the antenna 420), the transmitting processor 415 and the controller/processor 440 are configured to transit the first radio signal in the present disclosure.

[00202] In one embodiment, the transmitter 416 (including the antenna 420), the transmitting processor 415 and the controller/processor 440 are configured to transit the second radio signal in the present disclosure.

[00203] In one embodiment, the transmitter 416 (including the antenna 420), the transmitting processor 415 and the controller/processor 440 are configured to transit the second signaling in the present disclosure.

[00204] Embodiment 5

[00205] Embodiment 5 illustrates an example of a flowchart for the transmission of a radio signal according to an embodiment of the present disclosure, as shown in FIG. 5. In FIG. 5, the base station N1 is a maintenance base station for a serving cell of the UE U2. Steps marked in a dotted box are optional.

[00206] The base station N1 transmits a second radio signal in S11, transmits a second signaling in S12, transmits a first signaling in a positive integer number of time intervals of X time intervals in S13, and transmits a first radio signal in S14.

[00207] The UE U2 receives the second radio signal in S21, receives the second signaling in S22, monitors the first signaling in X time intervals in S23, and receives the first radio signal in S24.

[00208] In Embodiment 5, X is a positive integer; The first signaling is used for determining scheduling information for the first radio signal; The scheduling information includes at least one of {occupied time-frequency resource, adopted MCS, subcarrier spacing of subcarriers in occupied frequency domain resource}; The first radio signal carries a paging message; The frequency domain resource used for transmitting the first signaling belongs to a first subband; The first subband includes a positive integer number of consecutive subcarriers in frequency

domain; At least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband} is used for determining the X time intervals; The second radio signal is used for determining at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband}; The second signaling is used for determining Q subbands, Q being a positive integer; The first subband belongs to one of the Q subbands; Any one of the Q subbands includes a positive integer number of consecutive subcarriers; A feature ID of a monitor of the first signaling is used for determining the first subband in the Q subbands.

[00209] In one embodiment, any one of the X time intervals belongs to a first time window in time domain; The time length of the first time window is predefined; The first time window is divided into Y time intervals; The X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X; The subcarrier spacing of subcarriers included in the first subband is used for determining Y; The feature ID of the monitor of the first signaling is used for determining the X time intervals in the Y time intervals.

[00210] In one embodiment, the first time window belongs to one of Z time windows, Z being an integer greater than 1; Z is predefined, or Z is configurable; Any two of the Z time windows have an equal time length; The feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.

[00211] In one embodiment, the paging message includes a feature ID of a paged UE.

[00212] In one embodiment, the MCS includes one of {QPSK, 16QAM, 64QAM, 256QAM, 1024QAM}.

[00213] In one embodiment, the subcarrier spacing is equal to 15kHz multiplied by 2 to the Kth power. K is an integer.

[00214] In one embodiment, the first subband includes a positive integer multiple of 12 subcarriers.

[00215] In one embodiment, all subcarriers included in the first subband have an equal subcarrier spacing.

[00216] In one embodiment, the location of the first subband in frequency domain refers to the location of the first subband in a carrier where the first subband is located.

[00217] In one embodiment, the location of the first subband in frequency domain refers to the location of a carrier where the first subband is located in frequency domain.

[00218] In one embodiment, the location of the first subband in frequency domain refers to a

subband index of the first subband in a carrier where the first subband is located.

[00219] In one embodiment, the location of the first subband in frequency domain refers to the location of the first subband in a frequency resource corresponding to a band where the first subband is located.

[00220] In one embodiment, the second signaling is a high layer signaling.

[00221] In one embodiment, the second signaling is a physical layer signaling.

[00222] In one embodiment, the second signaling is transmitted through a BCH.

[00223] In one embodiment, the second signaling is transmitted through a PBCH.

[00224] In one embodiment, the second signaling is transmitted through a PDSCH.

[00225] In one embodiment, the second signaling is an RRC signaling.

[00226] In one embodiment, the second signaling is an SIB.

[00227] In one embodiment, the second signaling is transmitted through a DCI.

[00228] Embodiment 6

[00229] Embodiment 6 illustrates an example of a diagram for a relationship between Z time windows and Q subbands according to one embodiment of the present disclosure, as shown in FIG. 6. In FIG. 6, the horizontal axis represents time, the vertical axis represents frequency, each rectangle represents a time interval, the rectangles filled by oblique lines represent X1 time intervals monitored by a UE#1 in a time window #a, the rectangles filled by cross lines represent X2 time intervals monitored by a UE#2 in a time window #b, the rectangles filled by crossed oblique lines represent X3 time intervals monitored by a UE#3 in a time window #c.

[00230] In embodiment 6, the UE#1 monitors a first signaling in X1 time intervals respectively. The frequency domain resource used for transmitting the first signaling belongs to the subband #1. The subband #1 includes a positive integer number of consecutive subcarriers in frequency domain. At least one of {location of the subband #1 in frequency domain, subcarrier spacing of subcarriers included in the subband #1} is used for determining the X1 time intervals. Any one of the X1 time intervals belongs to the time window #a in time domain. The time length of the time window #a is predefined. The time window #a is divided into Y1 time intervals. The X1 time intervals are X1 time intervals of the Y1 time intervals, Y1 being a positive integer not smaller than X1. The subcarrier spacing of subcarriers included in the subband #1 is used for determining Y1. A feature ID of the UE#1 is used for determining the X1 time intervals in the Y1 time intervals. The time window #a belongs to one of Z time windows, Z being an integer

greater than 1. Z is predefined, or Z is configurable. Any two of the Z time windows have an equal time length. The feature ID of the UE#1 is used for determining the time window #a in the Z time windows. The subband #1 belongs to one of the Q subbands, Q being a positive integer. Any one of the Q subbands includes a positive integer number of consecutive subcarriers. The feature ID of the UE#1 is used for determining the subband #1 in the Q subbands.

[00231] In one embodiment, Z is equal to 10.

[00232] In one embodiment, any two of the Z time windows are orthogonal in time domain.

[00233] In one embodiment, any one of the Z time windows is a subframe. Z is equal to 10,

[00234] In one embodiment, any one of the Z time windows is a radio frame. Z is equal to the number of radio frames included in a DRX cycle.

[00235] In one embodiment, any one of the Z time windows is a radio frame. The time window #a is obtained by the following formula.

[00236] SFN mod Z= (Z div N)*(UE_ID mod N)

[00237] Herein, SFN is a frame number of a radio frame corresponding to the time window #a, N= min(Z,nB), nB is equal to one of {4Z, 2Z, Z, Z/2, Z/4, Z/8, Z/16, Z/32, Z/64, Z/128, Z/256, Z/512, Z/1024}.

[00238] In one embodiment, in any one of the Q subbands, all the included subcarriers have an equal subcarrier spacing.

[00239] In one embodiment, in any two of the Q subbands, the subcarriers have different subcarrier spacings.

[00240] In one embodiment, in two of the Q subbands, the subcarriers have an equal subcarrier spacing .

[00241] In one embodiment, any two of the Q subbands have an equal frequency domain width.

[00242] In one embodiment, two of the Q subbands have different frequency domain widths.

[00243] In one embodiment, the Q subbands all belong to one same carrier.

[00244] In one embodiment, two of the Q subbands belong to different carriers.

[00245] Embodiment 7

[00246] Embodiment 7 illustrates an example of a diagram for a relationship between a first time window and X time intervals according to one embodiment of the present disclosure, as

shown in FIG. 7. FIG. 7 lists the index of X=1 time interval in the first time window according to different Y values and different UE feature IDs.

[00247] In embodiment 7, the UE monitors a first signaling in X time intervals respectively. Any one of the X time intervals belongs to a first time window in time domain. The time length of the first time window is predefined. The first time window is divided into Y time intervals. The X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X. The subcarrier spacing of subcarriers included in the first subband is used for determining Y. The feature ID of the UE is used for determining the X time intervals in the Y time intervals.

[00248] In one embodiment, the first signaling is detected P times at most in each one of the X time intervals. P is a positive integer.

[00249] In one embodiment, any two of the X time intervals have an equal time length.

[00250] In one embodiment, two of the X time times have different time lengths.

[00251] In one embodiment, any one of the X time intervals is a slot.

[00252] In one embodiment, any two of the X time intervals have an equal time length, and the time length of each one of the X time intervals is correlated to the subcarrier spacing of subcarriers included in the first subband.

[00253] In one embodiment, any one of the X time intervals is M OFDM symbols. M is a positive integer smaller than 14.

[00254] In one embodiment, any one of the X time intervals is M OFDM symbols. M is a positive integer smaller than 7.

[00255] In one embodiment, any two of the X time intervals are orthogonal in time domain. The orthogonality refers that there is no time unit that belongs to any two of the X time intervals simultaneously.

[00256] In one embodiment, two of the X time intervals are discrete in time domain.

[00257] In one embodiment, the time length of the first time window is fixed.

[00258] In one embodiment, the first time window includes a positive integer number of consecutive multi-carrier symbols.

[00259] In one embodiment, the multi-carrier symbol includes a data symbol and a CP.

[00260] In one embodiment, the first time window has a time length of 1 millisecond.

[00261] In one embodiment, the first time window has a time length of 10 milliseconds.

[00262] In one embodiment, the first time window is a subframe.

[00263] In one embodiment, the first time window is a radio frame.

[00264] In one embodiment, any two of the Y time intervals have an equal time length.

[00265] In one embodiment, Y is proportional to the subcarrier spacing of subcarriers included in the first subband.

[00266] In one embodiment, the feature ID refers to an IMSI.

[00267] In one embodiment, the feature ID refers to a remainder when the IMSI is divided by 1024.

[00268] In one embodiment, the feature ID refers to a remainder when the IMSI is divided by 4096.

[00269] In one embodiment, the feature ID refers to a remainder when the IMSI is divided by 16384.

[00270] In one embodiment, the feature ID refers to a C-RNTI.

[00271] Embodiment 8

[00272] Embodiment 8 illustrates an example of a diagram for a relationship among a first signaling, a first radio signal and a second radio signal according to one embodiment of the present disclosure, as shown in FIG. 8. In FIG. 8, the horizontal axis represents time, the vertical axis represents frequency, the rectangle filled by oblique lines represents a time-frequency resource occupied by the second radio signal, the rectangle filled by cross lines represents a time-frequency resource occupied by the first signaling, the rectangle filled by crossed oblique lines represents a time-frequency resource occupied by the first radio signal, and the dotted arrow represents a specific usage relationship.

[00273] In embodiment 8, the first signaling is used for determining scheduling information for the first radio signal. The scheduling information includes at least one of {occupied time-frequency resource, adopted MCS, subcarrier spacing of subcarriers in occupied frequency domain resource}.The frequency domain resource used for transmitting the first signaling belongs to a first subband. The first subband includes a positive integer number of consecutive subcarriers in frequency domain. The second radio signal is used for determining at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband}.

[00274] In one embodiment, the first signaling is a physical layer signaling.

[00275] In one embodiment, the first signaling is DCI.

[00276] In one embodiment, the first signaling is transmitted through an NR-PDCCH.

[00277] In one embodiment, the first signaling is transmitted through a PDCCH. The PDCCH has a CRC scrambled by a P-RNTI.

[00278] In one embodiment, the first radio signal is transmitted through a DL-SCH.

[00279] In one embodiment, the first radio signal is transmitted through a PDSCH.

[00280] In one embodiment, a first bit block is subjected to a modulation mapper, a layer mapper, precoding, a resource element mapper and OFDM single generation in sequence to obtain the first radio signal. The first bit block includes the output obtained after a code block is subjected to channel coding. In one subembodiment, the code block is a TB. In one subembodiment, the code block is one part of a TB.

[00281] In one embodiment, the second radio signal includes a PSS.

[00282] In one embodiment, the second radio signal includes an SSS.

[00283] In one embodiment, the second radio signal is transmitted through a BCH.

[00284] In one embodiment, the second radio signal is transmitted through a PBCH.

[00285] In one embodiment, the second radio signal carries MIB information.

[00286] In one embodiment, the second radio signal carries SIB information.

[00287] In one embodiment, the information carried by the second radio signal is transmitted cyclically.

[00288] In one embodiment, the information carried by the second radio signal is transmitted on-demand.

[00289] In one embodiment, the second radio signal carries first information. The first information is used for determining at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband}.

[00290] In one embodiment, the second radio signal carries first information. The first information indicates at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband}.

[00291] Embodiment 9

[00292] Embodiment 9 illustrates an example of a structure block diagram for a processing device in a UE, as shown in FIG. 9. In FIG. 9, the processing device 900 for the UE is mainly

composed of a first receiver module 901 and a second receiver module 902. The first receiver module 901 includes the transmitter/receiver 456 (including the antenna 460), the receiving processor 452 and the controller/processor 490 shown in FIG. 4. The second receiver module 902 includes the transmitter/receiver 456 (including the antenna 460), the receiving processor 452 and the controller/processor 490 shown in FIG. 4.

[00293] In embodiment 9, the first receiver module 901 monitors a first signaling in X time intervals, and the second receiver module 902 receives a first radio signal, wherein X is a positive integer; The first signaling is used for determining scheduling information for the first radio signal; The scheduling information includes at least one of {occupied time-frequency resource, adopted MCS, subcarrier spacing of subcarriers in occupied frequency domain resource}; The first radio signal carries a paging message; The frequency domain resource used for transmitting the first signaling belongs to a first subband; The first subband includes a positive integer number of consecutive subcarriers in frequency domain; At least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband} is used for determining the X time intervals.

[00294] In one embodiment, any one of the X time intervals belongs to a first time window in time domain; The time length of the first time window is predefined; The first time window is divided into Y time intervals; The X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X; The subcarrier spacing of subcarriers included in the first subband is used for determining Y; A feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals.

[00295] In one embodiment, the first time window belongs to one of Z time windows, Z being an integer greater than 1; Z is predefined, or Z is configurable; Any two of the Z time windows have an equal time length; The feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.

[00296] In one embodiment, the first receiver module 901 further receives a second radio signal; The second radio signal is used for determining at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband}.

[00297] In one embodiment, the first receiver module 901 further receives a second signaling; The second signaling is used for determining Q subbands, Q being a positive integer; The first subband belongs to one of the Q subbands; Any one of the Q subbands includes a positive integer number of consecutive subcarriers; The feature ID of the monitor of the first signaling is used for determining the first subband in the Q subbands.

[00298] Embodiment 10

[00299] Embodiment 10 illustrates an example of a structure block diagram for a processing device in a base station, as shown in FIG. 10. The processing device 1000 for the base station is mainly composed of a first transmitter module 1001 and a second transmitter module 1002. The first transmitter module 1001 includes the transmitter/receiver 416 (including the antenna 420), the transmitting processor 415 and the controller/processor 440 shown in FIG. 4. The second transmitter module 1002 is mainly composed of the transmitter/receiver 416 (including the antenna 420), the transmitting processor 415 and the controller/processor 440 shown in FIG. 4.

[00300] In embodiment 10, the first transmitter module 1001 transmits a first signaling in a positive integer number of time intervals of X time intervals, and the second transmitter module 1002 transmits a first radio signal, wherein X is a positive integer; The first signaling is used for determining scheduling information for the first radio signal; The scheduling information includes at least one of {occupied time-frequency resource, adopted MCS, subcarrier spacing of subcarriers in occupied frequency domain resource}; The first radio signal carries a paging message; The frequency domain resource used for transmitting the first signaling belongs to a first subband; The first subband includes a positive integer number of consecutive subcarriers in frequency domain; At least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband} is used for determining the X time intervals.

[00301] In one embodiment, any one of the X time intervals belongs to a first time window in time domain; The time length of the first time window is predefined; The first time window is divided into Y time intervals; The X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X; The subcarrier spacing of subcarriers included in the first subband is used for determining Y; A feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals.

[00302] In one embodiment, the first time window belongs to one of Z time windows, Z being an integer greater than 1; Z is predefined, or Z is configurable; Any two of the Z time windows have an equal time length; The feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.

[00303] In one embodiment, the first transmitter module 1001 further transmits a second radio signal; The second radio signal is used for determining at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband}.

[00304] In one embodiment, the first transmitter module 1001 further transmits a second

signaling; The second signaling is used for determining Q subbands, Q being a positive integer; The first subband belongs to one of the Q subbands; Any one of the Q subbands includes a positive integer number of consecutive subcarriers; The feature ID of the monitor of the first signaling is used for determining the first subband in the Q subbands.

[00305] The ordinary skill in the art may understand that all or part steps in the above method may be implemented by instructing related hardware through a program. The program may be stored in a computer readable storage medium, for example Read-Only Memory (ROM), hard disk or compact disc, etc. Optionally, all or part steps in the above embodiments also may be implemented by one or more integrated circuits. Correspondingly, each module unit in the above embodiment may be realized in the form of hardware, or in the form of software function modules. The present disclosure is not limited to any combination of hardware and software in specific forms. The UE and terminal in the present disclosure include but not limited to mobile phones, tablet computers, notebooks, network cards, low-power equipment, eMTC equipment, NB-IoT equipment, unmanned aerial vehicles, telecontrolled aircrafts, vehicle-mounted communication equipment and other wireless communication equipment. The base station in the present disclosure includes but not limited to macro-cellular base stations, micro-cellular base stations, home base stations, relay base station, eNB, gNB, TRP and other radio communication equipment.

[00306] The above are merely the preferred embodiments of the present disclosure and are not intended to limit the scope of protection of the present disclosure. Any modification, equivalent substitute and improvement made within the spirit and principle of the present disclosure are intended to be included within the scope of protection of the present disclosure.

CLAIMS

WHAT IS CLAIMED IS:

1. A method in a User Equipment (UE) for paging, comprising:

monitoring a first signaling in X time intervals; and

receiving a first radio signal;

wherein X is a positive integer; the first signaling is used for determining scheduling information for the first radio signal; the scheduling information comprises occupied time-frequency resource and adopted Modulation Coding Scheme (MCS); the first radio signal carries a paging message; the frequency domain resource used for transmitting the first signaling belongs to a first subband; the first subband comprises a positive integer number of consecutive subcarriers in frequency domain; and subcarrier spacing of subcarriers included in the first subband is used for determining the X time intervals；all subcarriers included in the first subband have an equal subcarrier spacing, any two of the X time intervals are orthogonal in time domain; the first signaling is transmitted through a PDCCH, the PDCCH has a Cyclic Redundancy Check (CRC) scrambled by a Paging Radio Network Temporary Identity (P-RNTI), the first radio signal is transmitted through a Physical Downlink Shared Channel (PDSCH); the PDCCH is transmitted in a Common Search Space (CSS).

2. The method according to claim 1, wherein any one of the X time intervals belongs to a first time window in time domain; the time length of the first time window is predefined; the first time window is divided into Y time intervals; the X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X; the subcarrier spacing of subcarriers included in the first subband is used for determining Y; and a feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals, the feature ID refers to a remainder when an International Mobile Subscriber Identification Number (IMSI) is divided by 1024.

3. The method according to claim 2, wherein the first time window belongs to one of Z time windows, Z being an integer greater than 1; Z is predefined, or Z is configurable; any two of the Z time windows have an equal time length, any two of the Z time windows are orthogonal in time domain, any one of the Z time windows is a radio frame, Z is equal to the number of radio frames included in a Discontinuous Reception (DRX) cycle; and the feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.

4. The method according to claim 3, further comprising:

receiving a third signaling;

wherein, the third signaling is used for configuring Z.

5. The method according to claim 1, further comprising:

receiving a second radio signal;

wherein the second radio signal is used for determining at least one of location of the first subband in frequency domain, or subcarrier spacing of subcarriers included in the first subband; the second radio signal carries Master Information Block (MIB) information, or the second radio signal carries System Information Block (SIB) information.

6. A method in a base station for paging, comprising:

transmitting a first signaling in a positive integer number of time intervals of X time intervals; and

transmitting a first radio signal;

wherein X is a positive integer; the first signaling is used for determining scheduling information for the first radio signal; the scheduling information comprises occupied time-frequency resource and adopted MCS; the first radio signal carries a paging message; the frequency domain resource used for transmitting the first signaling belongs to a first subband; the first subband comprises a positive integer number of consecutive subcarriers in frequency domain; and subcarrier spacing of subcarriers included in the first subband is used for determining the X time intervals； all subcarriers included in the first subband have an equal subcarrier spacing, any two of the X time intervals are orthogonal in time domain; the first signaling is transmitted through a PDCCH, the PDCCH has a Cyclic Redundancy Check (CRC) scrambled by a Paging Radio Network Temporary Identity (P-RNTI), the first radio signal is transmitted through a Physical Downlink Shared Channel (PDSCH) ; the PDCCH is transmitted in a Common Search Space (CSS).

7. The method according to claim 6, wherein any one of the X time intervals belongs to a first time window in time domain; the time length of the first time window is predefined; the first time window is divided into Y time intervals; the X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X; the subcarrier spacing of subcarriers included in the first subband is used for determining Y; and a feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals, the feature ID refers to a remainder when an International Mobile Subscriber Identification Number (IMSI) is divided by 1024.

8. The method according to claim 7, wherein the first time window belongs to one of Z time windows, Z being an integer greater than 1; Z is predefined, or Z is configurable; any two of the Z time windows have an equal time length, any two of the Z time windows are orthogonal in time domain, any one of the Z time windows is a radio frame, Z is equal to the number of radio frames included in a Discontinuous Reception (DRX) cycle; and the feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.

9. The method according to claim 8, further comprising:

receiving a third signaling;

wherein, the third signaling is used for configuring Z.

10. The method according to claim 6, further comprising:

transmitting a second radio signal;

wherein the second radio signal is used for determining at least one of location of the first subband in frequency domain, or subcarrier spacing of subcarriers included in the first subband; the second radio signal carries Master Information Block (MIB) information, or the second radio signal carries System Information Block (SIB) information.

11. A UE for paging, comprising:

a first receiver, to monitor a first signaling in X time intervals; and

a second receiver, to receive a first radio signal;

wherein X is a positive integer; the first signaling is used for determining scheduling information for the first radio signal; the scheduling information comprises occupied time-frequency resource and adopted MCS; the first radio signal carries a paging message; the frequency domain resource used for transmitting the first signaling belongs to a first subband; the first subband comprises a positive integer number of consecutive subcarriers in frequency domain; and subcarrier spacing of subcarriers included in the first subband is used for determining the X time intervals; all subcarriers included in the first subband have an equal subcarrier spacing, any two of the X time intervals are orthogonal in time domain; the first signaling is transmitted through a PDCCH, the PDCCH has a Cyclic Redundancy Check (CRC) scrambled by a Paging Radio Network Temporary Identity (P-RNTI), the first radio signal is transmitted through a Physical Downlink Shared Channel (PDSCH) ; the PDCCH is transmitted in a Common Search Space (CSS).

12. The UE according to claim 11, wherein any one of the X time intervals belongs to a first time window in time domain; the time length of the first time window is predefined; the first time window is divided into Y time intervals; the X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X; the subcarrier spacing of subcarriers included in the first subband is used for determining Y; and a feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals, the feature ID refers to a remainder when an International Mobile Subscriber Identification Number (IMSI) is divided by 1024.

13. The UE according to claim 12, wherein the first time window belongs to one of Z time windows, Z being an integer greater than 1; Z is predefined, or Z is configurable; any two of the Z time windows have an equal time length, any two of the Z time windows are orthogonal in time domain, any one of the Z time windows is a radio frame, Z is equal to the number of radio frames included in a Discontinuous Reception (DRX) cycle; and the feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.

14. The method according to claim 13, wherein the second receiver further receives a third signaling, the third signaling is used for configuring Z.

15. The UE according to claim 11, wherein the first receiver further receives a second radio signal; the second radio signal is for determining at least one of location of the first subband in frequency domain, or subcarrier spacing of subcarriers included in the first subband; the second radio signal carries Master Information Block (MIB) information, or the second radio signal carries System Information Block (SIB) information.

16. A base station for paging, comprising:

a first transmitter, to transmit a first signaling in a positive integer number of time intervals of X time intervals; and

a second transmitter, to transmit a first radio signal;

wherein X is a positive integer; the first signaling is used for determining scheduling information for the first radio signal; the scheduling information comprises occupied time-frequency resource and adopted MCS; the first radio signal carries a paging message; the frequency domain resource used for transmitting the first signaling belongs to

a first subband; the first subband comprises a positive integer number of consecutive subcarriers in frequency domain; and subcarrier spacing of subcarriers included in the first subband is used for determining the X time intervals； all subcarriers included in the first subband have an equal subcarrier spacing, any two of the X time intervals are orthogonal in time domain; the first signaling is transmitted through a PDCCH, the PDCCH has a Cyclic Redundancy Check (CRC) scrambled by a Paging Radio Network Temporary Identity (P-RNTI), the first radio signal is transmitted through a Physical Downlink Shared Channel (PDSCH) ; the PDCCH is transmitted in a Common Search Space (CSS).

17. The base station according to claim 16, wherein any one of the X time intervals belongs to a first time window in time domain; the time length of the first time window is predefined; the first time window is divided into Y time intervals; the X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X; the subcarrier spacing of subcarriers included in the first subband is used for determining Y; and a feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals, the feature ID refers to a remainder when an International Mobile Subscriber Identification Number (IMSI) is divided by 1024.

18. The base station according to claim 17, wherein the first time window belongs to one of Z time windows, Z being an integer greater than 1; Z is predefined, or Z is configurable; any two of the Z time windows have an equal time length, any two of the Z time windows are orthogonal in time domain, any one of the Z time windows is a radio frame, Z is equal to the number of radio frames included in a Discontinuous Reception (DRX) cycle; and the feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.

19. The method according to claim 18, wherein the second transmitter further transmits a third signaling, the third signaling is used for configuring Z.

20. The base station according to claim 16, wherein the first transmitter further transmits a second radio signal; the second radio signal is for determining at least one of location of the first subband in frequency domain, or subcarrier spacing of subcarriers included in the first subband; the second radio signal carries Master Information Block (MIB) information, or the second radio signal carries System Information Block (SIB) information.

ABSTRACT

The present disclosure provides a method and a device in a User Equipment (UE) and a base station used for paging. The UE first monitors a first signaling in X time intervals respectively, and then receives a first radio signal. The first signaling is used for determining scheduling information for the first radio signal. The scheduling information includes at least one of {occupied time-frequency resource, adopted MCS, subcarrier spacing of subcarriers in occupied frequency domain resource}. The first radio signal carries a paging message. The frequency domain resource is used for transmitting the first signaling belongs to a first subband. The first subband includes a positive integer number of consecutive subcarriers in frequency domain. At least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband} is used for determining the X time intervals.

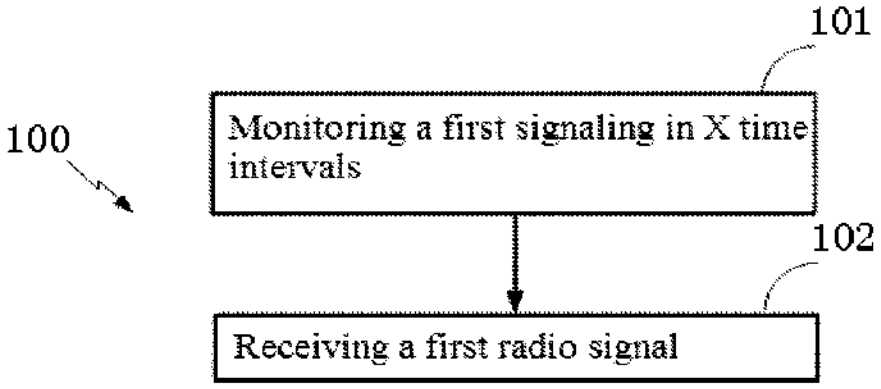

101
100
Monitoring a first signaling in X time intervals
102
Receiving a first radio signal

FIG. 1

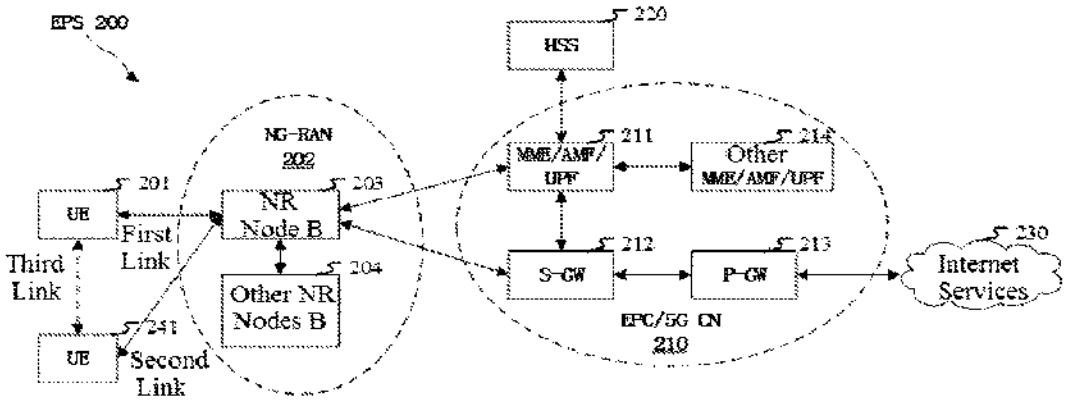

EPS 200
HSS
220
NG-RAN
202
MME/AMF/
UPF
211
Other
MME/AMF/UPF
214
UE
201
NR
Node B
208
First
Link
Third
Link
Other NR
Nodes B
204
S-GW
212
P-GW
213
Internet
Services
230
UE
241
Second
Link
EPC/5G CN
210

FIG. 2

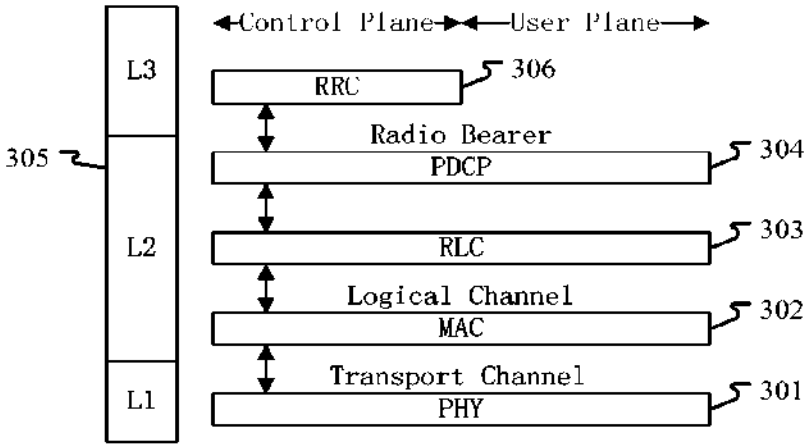

Control Plane
User Plane
L3
L2
L1
305
RRC
306
Radio Bearer
PDCP
304
RLC
303
Logical Channel
MAC
302
Transport Channel
PHY
301

FIG. 3

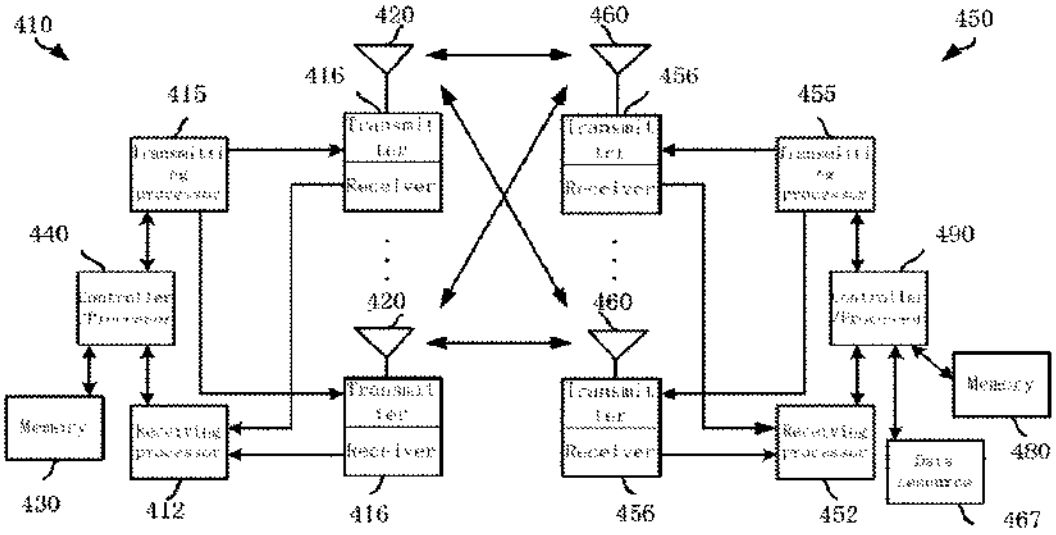

410
420
460
450
416
456
415
455
440
490
420
460
Memory
Memory
480
430
412
416
456
452
467

FIG. 4

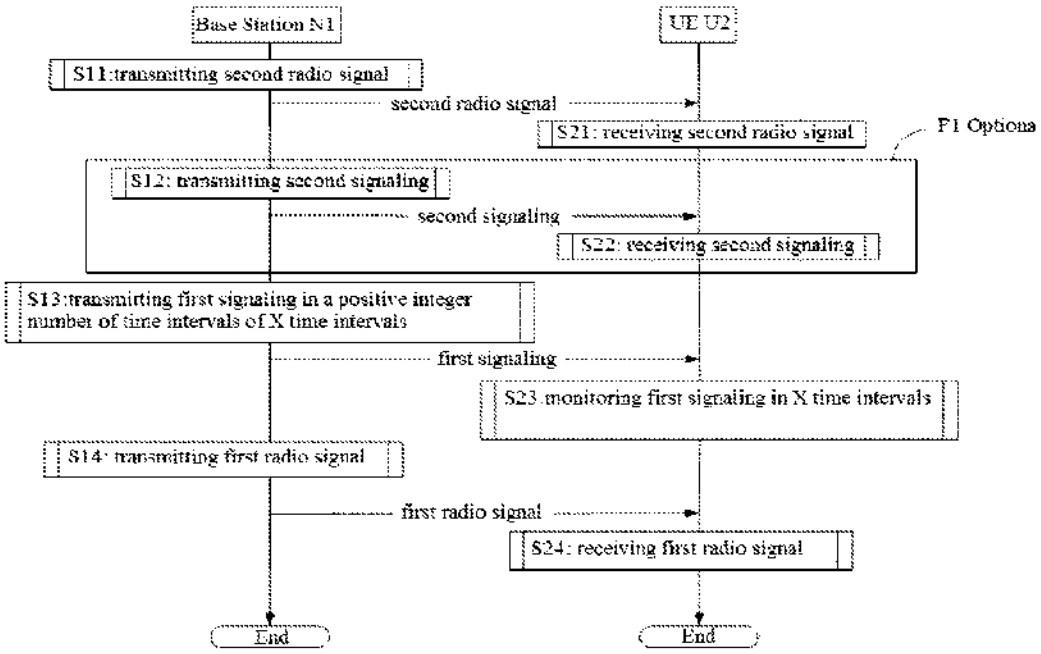

Base Station N1
UE U2
S11:transmitting second radio signal
second radio signal
S21: receiving second radio signal
P1 Options
S12: transmitting second signaling
second signaling
S22: receiving second signaling
S13:transmitting first signaling in a positive integer number of time intervals of X time intervals
first signaling
S23: monitoring first signaling in X time intervals
S14: transmitting first radio signal
first radio signal
S24: receiving first radio signal
End
End

FIG. 5

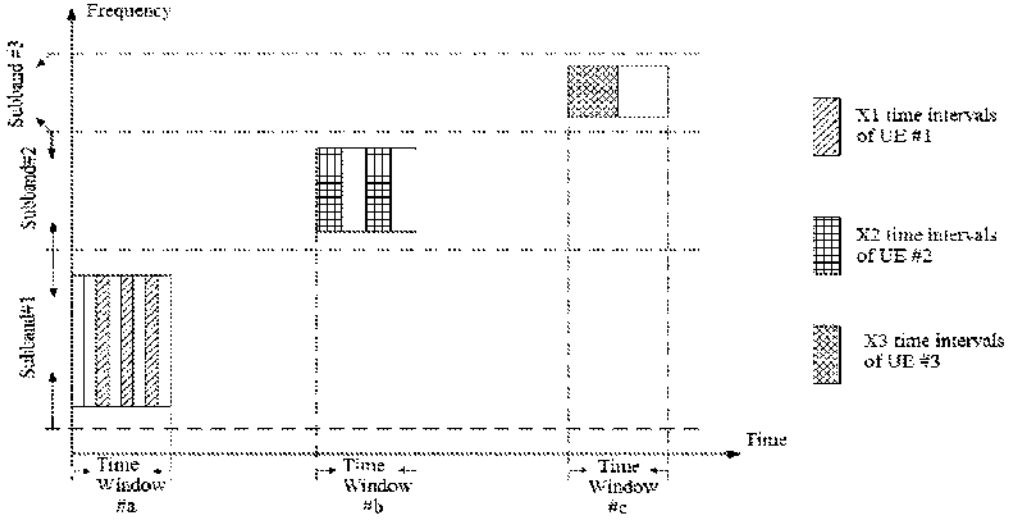


FIG. 6

	Index of X=1 time interval in the first time window			
	Feature ID=a	Feature ID=b	Feature ID=c	Feature ID=d
Y=1	0	0	0	0
Y=2	0	1	0	1
Y=4	0	1	2	3
Y=8	1	3	5	7
Y=16	2	6	10	14

FIG. 7

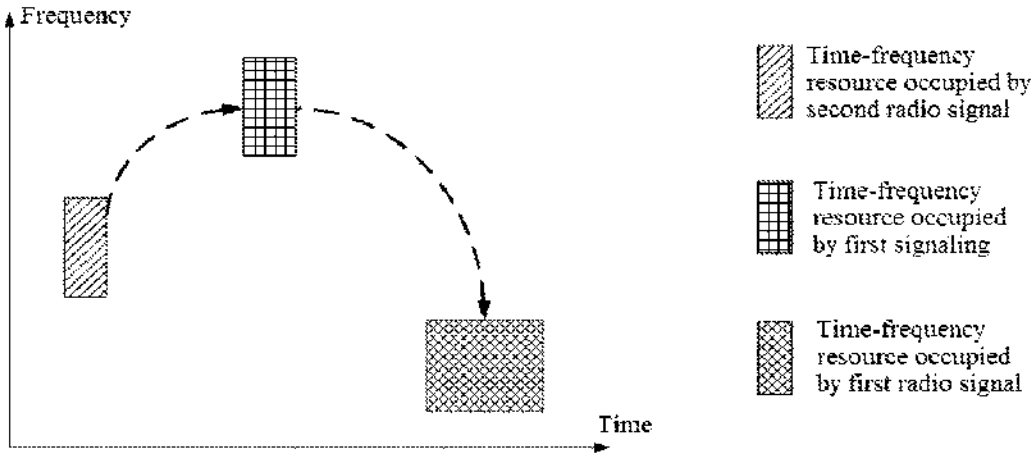

Frequency
Time
Time-frequency resource occupied by second radio signal
Time-frequency resource occupied by first signaling
Time-frequency resource occupied by first radio signal

FIG. 8

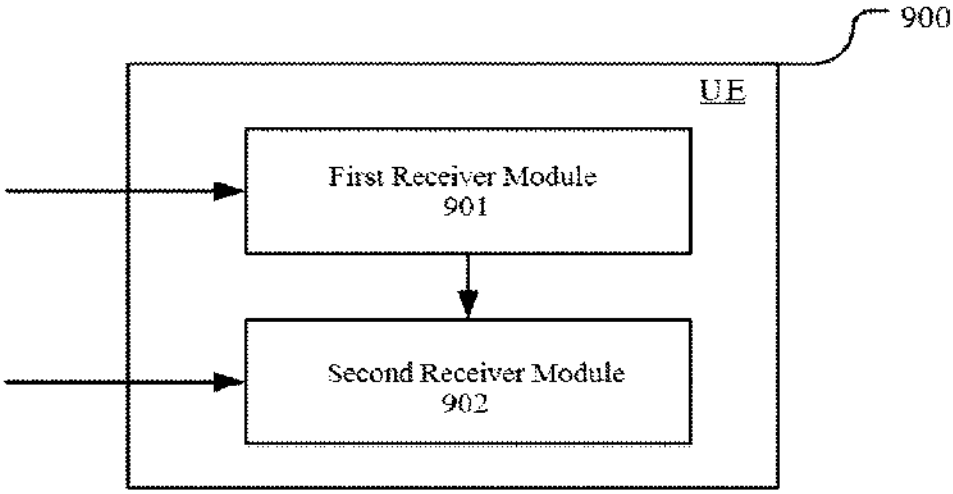

900
UE
First Receiver Module
901
Second Receiver Module
902

FIG. 9

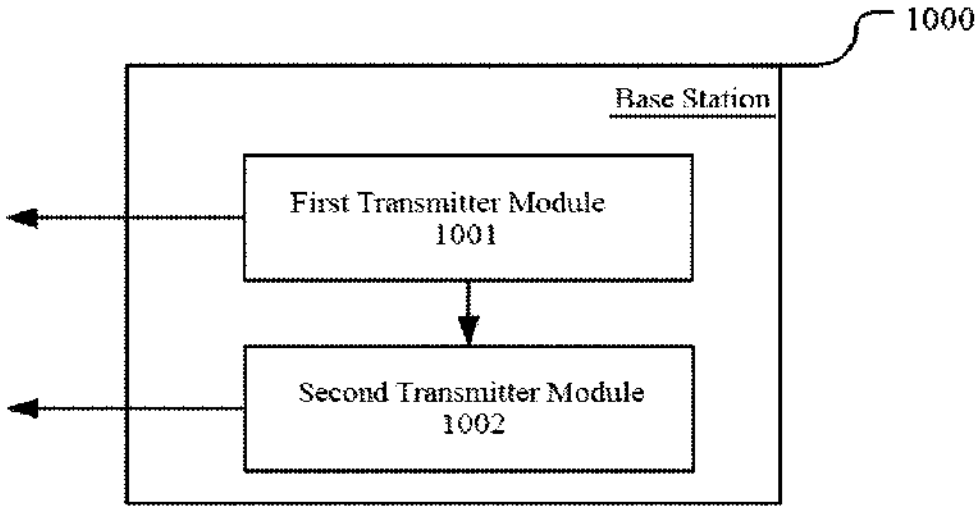

1000
Base Station
First Transmitter Module
1001
Second Transmitter Module
1002

FIG. 10

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DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

Title of Invention	METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

As the below named inventor, I hereby declare that:

This declaration is directed to:

- [x] The attached application, or
- [ ] United States application or PCT international application number _____ filed on _____.

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

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LEGAL NAME OF INVENTOR

Inventor: XiaoBo ZHANG Date (Optional): Apr. 12 2018

Signature: XiaoBo ZHANG

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Application Number	
Filing Date	
First Named Inventor	Xiaobo ZHANG
Title	METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING
Art Unit	
Examiner Name	
Attorney Docket Number	ZL0205-0004-US-CON3

SIGNATURE of Applicant or Patent Practitioner

Signature	/Jialin Zhong/	Date (Optional)	
Name	Jialin Zhong	Registration Number	62937
Title (if Applicant is a juristic entity)	Registered Patent Attorney		
Applicant Name (if Applicant is a juristic entity)	APEX BEAM TECHNOLOGIES LLC		

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